6. SITE 345

The Shipboard Scientific Party[1]
With Additional Contributions From

Svein B. Manum, Universitetet i Oslo, Oslo, Norway
and
H.-J. Schrader, Der Universität Kiel, Kiel, Germany

SITE DATA

Position: 69°50.23'N; 01°14.26'W

Water Depth (from sea level): 3195.0 corrected meters (echo sounding)

Bottom Felt at: 3216.0 meters (drill pipe)

Penetration: 802.0 meters

Number of Holes: 1

Number of Cores: 36

Total Length of Cored Section: 336.5 meters

Total Core Recovered: 189.8 meters

Percentage of Core Recovery: 56.4%

Oldest Sediment Cored:
Depth below sea floor: 762.0 meters
Nature: Red sandstones
Age: Eocene(?) (Core 32)
Measured velocity: ≅6.0 km/sec

Basement:
Depth below sea floor: 762.0 meters (drilled)
Nature: Altered aphyric basalt breccia
K/Ar age: 28 m.y. (late Oligocene)

Principal Results: This site was located in the Lofoten Basin near the eastern flank of Mohns Ridge. The sediments consist of a "glacial" and Miocene sequence, overlying an Oligocene and late Eocene sequence. "Glacial" sediments extend from the top to a depth of 36 meters and are dominately muds, sandy muds, and sands. Miocene sediments extend from 36 to 169(?) meters, and consist of clays, muds, and siliceous oozes. The fauna is siliceous. The Oligocene section extends from 169.5(?) meters to 530(?) meters. The late Eocene sediments consist of mudstones and sandstones in the lower part. Often lithified and soft sequences alternate. From 764 meters, the basement consists of tuff breccias, and below, highly altered basalt and amygdaloidal basalt.

BACKGROUND AND OBJECTIVES

Site 345 lies near the base of Mohns Ridge close to the southwestern margin of the Lofoten Basin. The Jan Mayen Fracture Zone consists of two segments. Site 345 lies east of the younger (northern) segment and north of the older segment (see Figure 1 in Chapter 1, this volume) of this fracture zone. As originally selected, the site lies near the boundary of the abyssal plain in the Lofoten Basin.

From the reflection profiler records (Figure 1), a series of horizontal layers (presumably turbidites) in the abyssal plain abut against a folded transparent sequence, which in turn lies above basement. In order to minimize the depth to basement, and to be sure that basement was actually discernible in the reflection records, the actual site was selected as the point shown in Figure 1, so that the objective of coring the turbidite sequence and dating the underlying angular unconformity was not lost. However, coring through the "transparent" sequence of sediments was expected to yield information about the history of sedimentation in the Lofoten Basin. Samples of basement were sought in order to learn about its nature and age. The sea-floor spreading types of linear anomalies are not very clear in this area, and it has not been possible to date the basement accurately from them.

OPERATIONS

Approach to Site 345

Site 345 was approached from the northeast after steaming 460.4 n mi, including surveying, in 52 hr, 39 min at an average speed of 8.7 knots from Site 344. At 0159Z, the course was altered to 254° and the speed reduced to 150 rpm. The original site was at the edge of an abyssal plain, however, this site was not selected because basement was not clear on *Glomar Challenger*'s profiler records. The ship continued on the same course just off the abyssal plain when the reflection corresponding to basement was again visible on the records. However, at this latter location, the layered sequence of sediments (presumably turbidites) was absent. The beacon was dropped at 0817Z, and the ship continued

---

[1] Manik Talwani, Lamont-Doherty Geological Observatory, Palisades, New York; Gleb B. Udintsev, P.P. Shirshov Institute of Oceanology, Moscow, USSR; Kjell Bjørklund, Universitetet i Bergen, Bergen, Norway; V.N.D. Caston, British Petroleum Company Ltd., Middlesex, England; Richard W. Faas, Lafayette College, Easton, Pennsylvania; Jan E. van Hinte, Esso Production Research Company, Begles, France; G.N. Kharin, Atlantic Branch of Oceanology Institute, Kaliningrad, USSR; David A. Morris, Phillips Petroleum Company, Bartlesville, Oklahoma; Carla Müller, Geologisch-Paleontologisches Institut der Johann Wolfgang Goethe-Universität, Frankfurt am Main, Germany; Tor H. Nilsen, U.S. Geological Survey, Menlo Park, California; Detlef A. Warnke, California State University, Hayward, California; Stan M. White, University of California at San Diego, La Jolla, California.

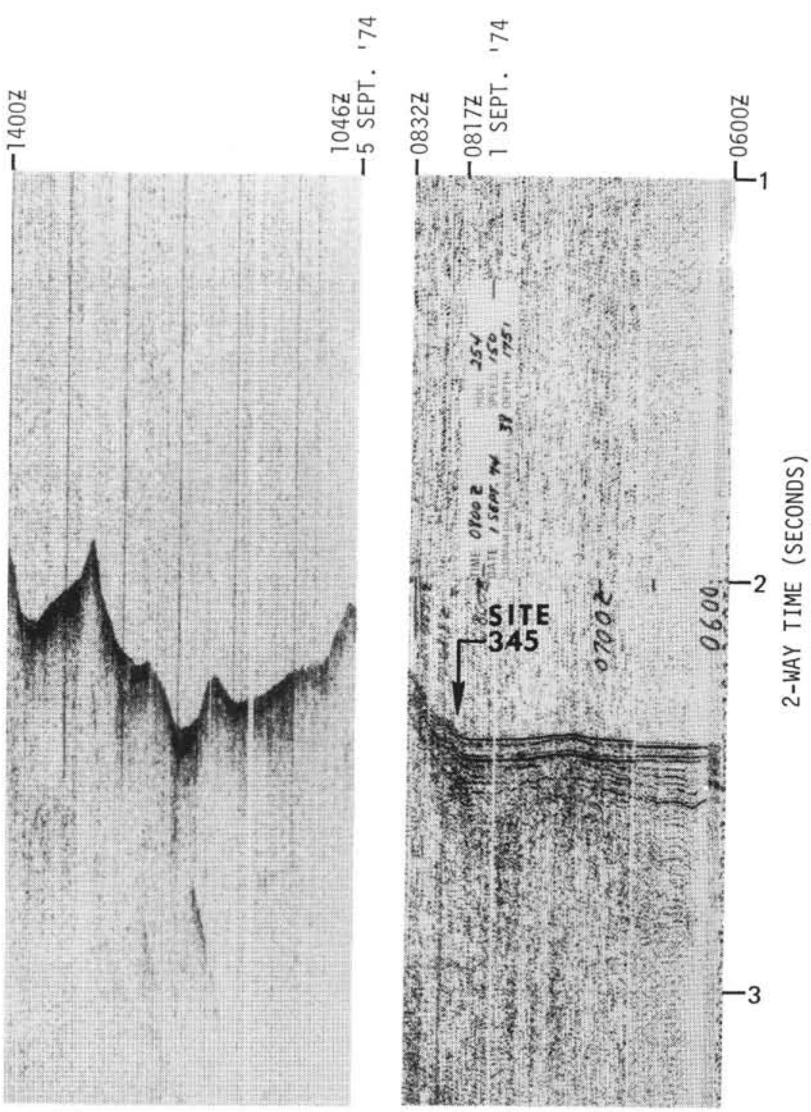


Figure 1. *Profiler record – Site 345.*

on the same speed and course until 0832Z. At this time, the profiling and magnetic gear was pulled in, and the ship maneuvered to reoccupy its position over the beacon (Figure 2).

Drilling Operations

A 13.5-kHz beacon was dropped at 0817 hr, 1 September. Estimated sediment thickness (750 m minimum) was somewhat greater than expected. The on-site weather was expected to be good for a minimum of 2 days. The standard 3 × LSB BHA was run, with the Lynes RFT and circulating sub included above the CB.

The sea bed was contacted at 3216 meters, and continuous coring undertaken to 3262 meters. Recoveries were less than expected due to the presence of thin ooze and sandy mud which extruded through the soft-style catcher and sock. The use of a hard-style catcher, with less fingertip gap, improved recoveries.

From 3252.5 to 3927 meters, the wash and core method was adopted, including multiple washes, as core evidence dictated. During this 684-meter interval, 23 control cores were taken. Reasonably good recoveries were obtained from the generally homogeneous material (Table 1).

Continuous coring was adopted at 3927 meters (720.5 m BSB) in advance of estimated earliest basement depth. The transition zone from 3974.5 meters was successfully cored and recovered. Basalt was cored from 3978 meters to final depth at 4018 meters. This represents an interval of 43.5 meters, with 13.5 meters recovery, or 31% (Table 1). Recoveries from the basalt section were disappointingly low due to the severely fractured nature of the brecciated material. The basalt was probably also undergoing further fragmentation and jamming in the core barrel.

Overall penetration was 802 meters of which 336.5 meters was cored with 189.8 meters recovery, or 56.4% (Table 1). The hole remained clean throughout. There was no evidence of hydrocarbons, and the hole was abandoned according to regulations. The *Glomar Challenger* was underway to Site 346 at 1113 hr, 5 September.

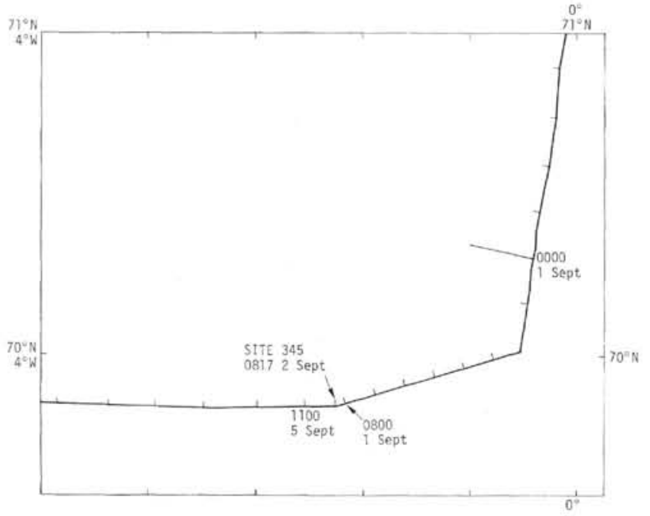


Figure 2. *Track chart – Site 345.*

LITHOLOGY

The hole penetrated 762 meters of sediments: clays, muds, sands, diamictons, and their lithified equivalents. This sediment column has been subdivided into three units (Table 2 and Figure 3).

Unit Descriptions

Unit 1

Unit 1 consists of gray and brown clastic sediments including muds, sandy muds, sands, and diamictons. The unit also contains volcanic ash and foraminiferal ooze. A sequence of graded beds exists at the base of Core 5, Section 4 (average thickness 15 cm), with a total thickness of 63 cm. The sediments are mainly terrigenous, i.e., glacial marine as well as sediments deposited from suspensoids, or deposited by other mass transport mechanisms. The age of this unit is given as Holocene-Pliocene (to early Miocene?).

Unit 2

The unit is described in the following two subunits (Table 2). Subunit A consists mainly of gray and green clays, also muds, and transitional biogenic siliceous sediments (diatomaceous muds and muddy diatom ooze). Foraminiferal ooze and volcanic ash are also present. Bioturbation is present, but not as clearly identifiable as in the lower portions of Unit 2.

Subunit B is similar to Subunit A in color; however, the variety is not quite as great (Table 2). It consists mainly of muds and clays (i.e., slightly coarser than Subunit A), and their lithified equivalents. The coring deformation for this subunit is slight to intense, and variable in a core. Alternations of lithified and non-lithified units are characteristic. Volcanic ash, pyrite, and siderite nodules are present, but not dominant. Bioturbation exists everywhere within the unit.

Unit 3

The unit consists of two subunits, as described below: Subunit A has a great variety of colors, mainly in shades of gray and green, black, and shades of orange, purple, and brown. The subunit is mainly a mudstone. Other lithologies include mud, sandy mudstone, some calcareous sandy mudstone, sandstone, and limestone. Characteristic is the ubiquitous nature of bioturbation; identifiable types of burrows include *Zoophycos*, *Chondrites*, *Helminthoida*. Volcanic ash and its derivatives, as well as limestone and siderite (?) fragments, are present. Towards the base of this subunit, a number of turbidite sequences are present (Table 2).

Subunit B colors include a great variety of shades of gray and brown, and towards the base of the unit, shades of red (Table 2). It consists of claystone to sandstone of various types, diamictites, and volcanic ash. The fine-grained lithologies particularly exhibit bioturbation and identifiable lebensspuren including *Zoophycos*. Cross-bedding and graded bedding are the most important characteristics of this subunit, which consists for the most part of turbidites (identifiable Bouma sequences). These grade near the base into diamictites of different origin. The diamictites include exotic pebbles, particularly chert, quartzite, and granitic rocks.

Interpretation

The sediments at Site 345 consist of an accumulation primarily of clastic sediments, accumulated by mechanical processes from Eocene to Recent time. Biogenic materials form a subordinate component. The reddish-brownish pebbly mudstones and diamictites above the basaltic basement are interpreted as slump or similar deposits, transported and deposited mainly by gravity. The high degree of roundness of many of the pebbles, near the base of Subunit 3B, indicates that running water or surf action played an important role in the transport history of this material. Ultimately, the pebbles and finer sized materials were incorporated into the slump deposits. The low degree of sorting suggests that very little winnowing took place. Because these slump deposits are directly overlain by turbidites, it may be assumed that slumping took place in the marine environment. No fossils are present to indicate either an exact age or a depth range. The size of the pebbles (1.2 cm), however, suggests a near-shore environment, or the proximal part of a fan associated with a submarine canyon.

These pebbly mudstones and diamictites are overlain by a series of turbidites, indicating either increasing water depth, increased distance from the source, reduced transport energy, or a combination of these parameters. Extensive bioturbation in the fine-grained rocks above each turbidite unit indicates quiet water conditions between the occurrences of turbidity currents. Occasional pyrite concretions suggest that reducing conditions existed below the habitat occupied by the burrowing organisms.

The number of total thicknesses of turbidites apparently diminishes from Subunit 3B into the upper portions of Subunit 3A. Transport mechanisms other than turbidity currents assumed greater importance, i.e., settling out of sediment particles from suspensoids. Volcanic ash contributed to the sediment make-up through "Unit 3 time."

TABLE 1
Coring Summary, Site 345

Core	Date (September 1974)	Time	Depth From Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
1	1	1800	3216.0-3224.0	0-8.0	8.0	5.9	75
2	1	1902	3224.0-3233.5	8.0-17.5	9.5	4.4	46.3
3	1	2005	3233.5-3243.0	17.5-27.0	9.5	4.0	42.1
4	1	2105	3243.0-3252.5	27.0-36.5	9.5	3.0	31.6
5	1	2215	3252.5-3262.0	36.5-46.0	9.5	6.0	63.1
Washed			3262.0-3271.5	46.0-55.5			
6	1	2312	3271.5-3281.0	55.5-65.0	9.5	3.0	31.6
Washed			3281.0-3290.5	65.0-74.5			
7	2	0030	3290.5-3300.0	74.5-84.0	9.5	2.0	21
Washed			3300.0-3309.5	84.0-93.5			
8	2	0208	3309.5-3319.0	93.5-103.0	9.5	5.7	60
Washed			3319.0-3328.5	103.0-112.5			
9	2	0346	3328.5-3338.0	112.5-122.0	9.5	5.5	57.9
Washed			3338.0-3347.5	122.0-131.5			
10	2	1525	3347.5-3357.0	131.5-141.0	9.5	9.5	100
Washed			3357.0-3376.0	141.0-160.0			
11	2	0700	3376.0-3385.5	160.0-169.5	9.5	9.5	100
Washed			3385.5-3404.5	169.5-188.5			
12	2	0850	3404.5-3414.0	188.5-198.0	9.5	2.2	23.1
Washed			3414.0-3433.0	198.0-217.0			
13	2	1230	3433.0-3442.5	217.0-226.5	9.5	1.5	15.8
Washed			3442.5-3461.5	226.5-245.5	9.5	6.0	63
Washed			3471.0-3509.0	255.0-293.0			
15	2	1645	3509.0-3518.5	293.0-302.5	9.5	1.3	13.7
Washed			3518.5-3547.0	302.5-331.0			
16	2	2033	3547.0-3556.5	331.0-340.5	9.5	5.6	56.9
Washed			3556.5-3585.0	340.5-369.0			
17	2	2255	3585.0-3594.5	369.0-378.5	9.5	5.7	60
Washed			3594.5-3623.0	378.5-407.0			
18	3	0120	3623.0-3632.5	407.0-416.5	9.5	1.0	10.5
Washed			3632.5-3661.0	416.5-445.0			
19	3	0345	3661.0-3670.5	445.0-454.5	9.5	9.5	100
Washed			3670.5-3699.0	454.5-483.0			
20	3	0555	3699.0-3708.5	483.0-492.5	9.5	4.1	43
Washed			3708.5-3737.0	492.5-521.0			
21	3	0855	3737.0-3746.5	521.0-530.5	9.5	8.0	84.2
Washed			3746.5-3775.0	530.5-559.0			
22	3	1130	3775.0-3784.5	559.0-568.5	9.5	7.1	75
Washed			3784.5-3813.0	568.5-597.0			
23	3	1420	3813.0-3822.5	597.0-606.5	9.5	9.7	100
Washed			3822.5-3851.0	606.5-635.0			
24	3	1730	3851.0-3860.5	635.0-644.5	9.5	9.5	100
Washed			3860.5-3889.0	644.5-673.0			
25	3	1953	3889.0-3898.5	673.0-682.5	9.5	9.5	100
26	3	2120	3898.5-3908.0	682.5-692.0	9.5	6.8	71.6
Washed			3908.0-3927.0	692.0-711.0			
27	3	2325	3927.0-3936.5	711.0-720.5	9.5	3.1	33
28	4	0240	3936.5-3946.0	720.5-730.0	9.5	9.6	100
29	4	0445	3946.0-3955.5	730.0-739.5	9.5	2.5	26.3
30	4	0645	3955.5-3965.0	739.5-749.0	9.5	7.0	73.7
31	4	0835	3965.0-3974.5	749.0-758.5	9.5	8.0	84.2
32	4	1035	3974.5-3980.0	758.5-764.0	5.5	4.0	81.8
33	4	1235	3980.0-3989.5	764.0-773.5	9.5	3.8	40
34	4	1510	3989.5-3999.0	773.5-783.0	9.5	2.5	26.3
35	4	1825	3999.0-4008.5	783.0-792.5	9.5	2.3	17.9
36	4	2240	4008.5-4018.0	792.5-802.0	9.5	1.0	0
Total			4018.0	802.0	336.5	189.8	56.4

TABLE 2
Lithologic Summary, Site 345

Unit	Depth (m) and Core Numbers[a]	Age	Characteristics
1	0-46 (1-1 to 5-4)	Holocene, Plio-Pleistocene to Early Miocene	Muds, sandy muds, sandy diamictons (pebbles are present throughout most of this unit), foram ooze; colors are extremely varied; volcanic ash is scattered throughout this unit; at the base of Section 5-4 a sequence of graded beds exists (average 15 cm thick), sandy muds to muds (or clays)
2	46-331 (6-1 to 15-6)	Early Miocene-Oligocene	Mainly clays, muds and diatomaceous muds; volcanic ash; bioturbation prominent.
Subunit 2A	46-160.0 (6-1 to 10-6)	Early Miocene and E. Miocene or late Oligocene	Mainly clays, also muds, transitional biogenic siliceous sediments, foram ooze, volcanic ash; burrows
Subunit 2B	160-331 (11-0 to 15-6)	Oligocene (?)	Mainly mud, some clay, and their lithified equivalents in alternating units; bioturbation throughout; volcanic ash; pyrite and siderite nodules
3	331-762 (16-1 to 32-2)	Oligocene and L. Eocene-Eocene	Mudstone to sandstones, diamictites, some limestone, pebbles particularly in lower part of unit; turbidites increasing in importance towards base of unit; volcanic ash, bioturbation and recognizable burrows throughout
Subunit 3A	331-711 (16-1 to 26-6)	Oligocene-late Eocene-Eocene (?)	Mainly mudstone. Other lithologies include mud, sandy mudstone, some calcareous sandy mudstone, sandstone, and limestone; the subunit is characterized by omnipresent bioturbation, and identifiable burrows; volcanic ash, altered ash, and devitrified volcanic glass is present at many levels; limestone (fragments?) and siderite (and rhodochrosite?) fragments or concretions are also present; a number of turbidites are recognized in this subunit
Subunit 3B	711-762 (27-1 to 32-2)	Eocene (?)	Claystone, mudstone, sandy and pebbly mudstone, sandstone, with various admixtures of coarser and finer components, diamictites; volcanic ash; most of the the fine-grained lithologies are extensively bioturbated; *Zoophycos* and rind burrows are also present; Cross-bedding and graded bedding are the most important characteristics of this subunit which consists, for the most part, of a series of turbidite sequences (Bouma sequences), grading towards the base into diamictites of different origin; calcareous sandstones and limestone pebbles are also present, especially near the base of the subunit, as are well-rounded pebbles of exotic origin (at least 1 pebble of granitic composition); pebbles in Section 31-6 are equidimensional (<1 cm), very well rounded, and consist of chert, quartzite, and granitic rocks (?); core 32 is largely a pebbly sandstone, of reddish-br brownish colors, with scattered subrounded pebbles (about 1.2 cm in length), lithology similar to above

[a] Core numbers in parentheses.

The trend to quiet-water conditions continued into Unit 2 time. In Subunit 2b, muds and some clays are dominant, bioturbation is extensive. "Pelagic sedimentation" without biogenic contributions was the determining factor, i.e., slow settling of individual mineral particles through the water column. Later detailed investigations of the core may change this concept, but it may serve as a useful working hypothesis.

Subunit 2a, of lower Miocene age or upper Oligocene age shows a continuation of quiet water conditions. Clays predominate; volcanic ash is also present. Transitional biogenic siliceous sediments, mainly diatomaceous "muds," also contribute to the sediment mass, perhaps indicating that sedimentation rates were slow enough to prevent complete masking by dilution of the biogenic components. Other factors may have

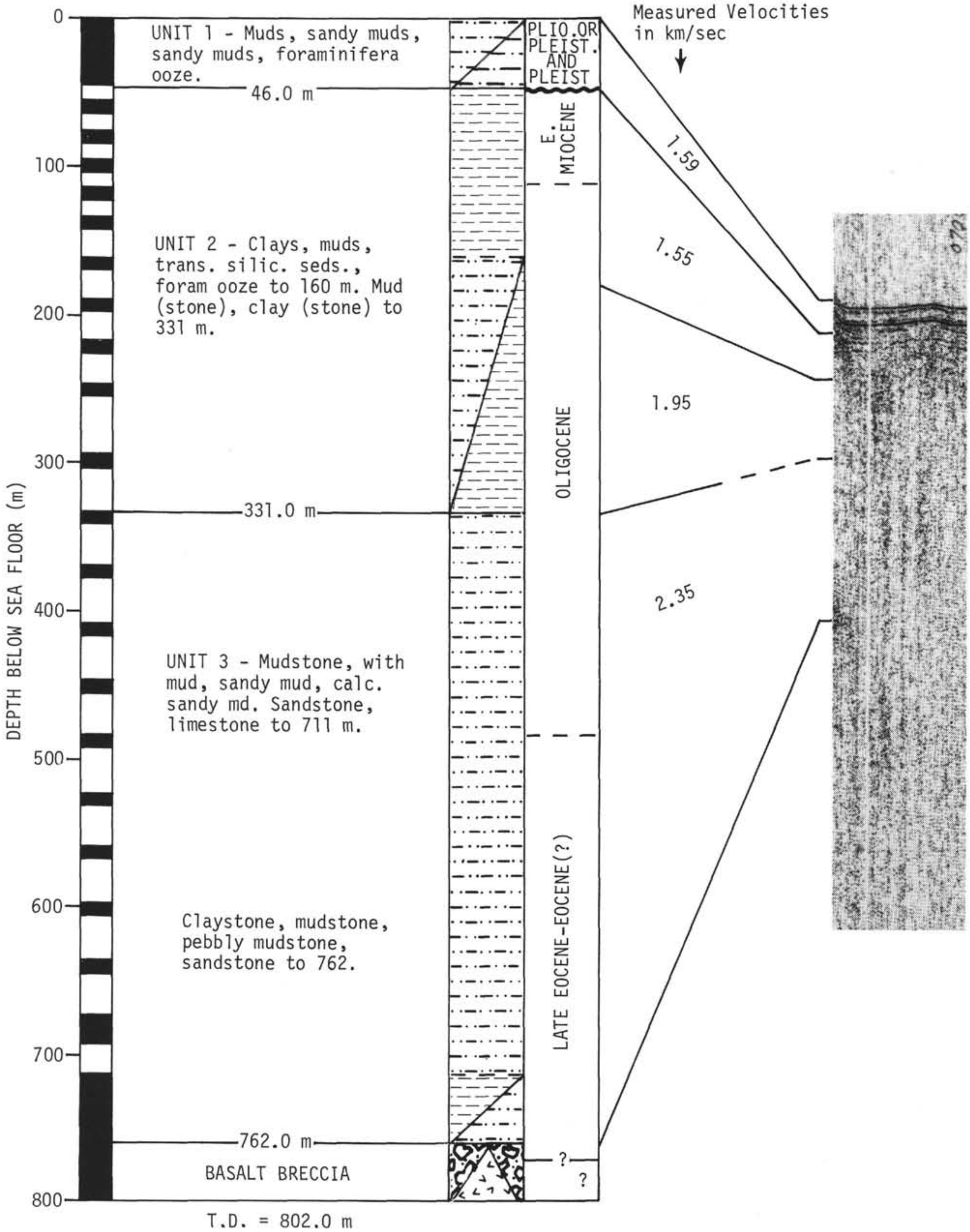


Figure 3. *Lithologic summary and seismic profile – Site 345.*

contributed to the increased influx of biogenic components; perhaps climatic deterioration increased the intensity of circulation, hence increasing upwelling and primary production, or perhaps cooling placed stress on the marine ecosystem, simplifying the food web, and leading to an increased rate of "outfall" from the first trophic level of the system (Warnke, 1970; Warnke et al., 1973). The question remains unanswered.

Unit 1 is an accumulation of glacial-marine sediments, of Holocene to Plio-Pleistocene age. The base of this unit (Core 5) is of early Miocene age thus perhaps signaling the initiation of glacial-marine sedimentation during the Miocene, i.e., prior to about 5 m.y. ago, but it must be emphasized that: (a) the faunal determination of the age of the material may not be very secure; (b) a general, intensive climatic deterioration took place only in Gauss time, as indicated by the deposition of the first ground moraine in Iceland, "just prior to the mammoth event" (McDougall and Wensink, 1966); (c) initiation of ice rafting in the North Atlantic is placed at about the same time (Berggren, 1972); and (d) the identification of glacial-marine sediments is not entirely unequivocal (no exotic pebbles have yet been identified from the very base of Unit 1).

IGNEOUS PETROGRAPHY-PETROLOGY

General Description

Rocks of acoustic basement in Hole 345 were penetrated at 762 meters. Five cores (32, 33, 34, 35, and 36) contained 6.5 meters of sedimentary-tuff breccia, and 3.8 meters of basalt.

In the 762.75 to 763.1 meter interval, the boundary between the sedimentary series and the basement rocks is present. The breccia, which is found below this boundary, contains round and angular fragments of weathered basalt, with hematite, zeolite, and calcite (0.5-6 cm). The breccia matrix is a moderate yellowish sandy silt, with white calcite veins (1-3 mm). The basalt fragments are grayish-red (5R4/2), with grayish and pale blue-green zeolite rims.

Above this breccia, is a moderate brown sandstone with rare, round zeolite fragments. Below the breccia, there is a tuff-breccia horizon with thin sedimentary layers. The tuff-breccia series consists of 13 rhythmic layers from 0.3 to 1 meter in thickness. The lower portion of this rhythmic layering is represented by a very coarse grained (5-10 cm), angular, altered, gray and grayish-red aphyric basalt, with smectite and zeolite. In the upper portion of the rhythmic layered series, there are small (0.2-2 cm), angular and round fragments of smectite, zeolite, and altered basalt.

The breccia matrix consists of dusky blue-green to grayish-bluegreen smectite-chlorite-zeolite, with thin calcite veins. Thin laminae of sandstone and siltstone with fragments of basalt and zeolite are present in upper and central portions of rhythmic layered tuff-breccia (Samples 33-3, 8-17 cm, and 30-37 cm). The angle of inclination of the sedimentary layer is near 30°. There are branching veins of white calcite (1-10 mm), and cavity walls have zeolite and calcite crystals. Rare goethite veins (1-3 mm) were observed.

The basalt (Cores 34-2, 35-1, 35-2, and 36-1) has a vesicular aphyric, aphanitic texture, is medium gray (N5) to medium light gray (N6) in color, with patches of grayish-red and pale blue-green. White calcite and green-yellowish zeolite veins, and cavities with walls coated by calcite and zeolite crystals, are present. There are slickensides, which have a blackish-red, clay-like material (zeolite with basaltic dust) on their walls.

Petrography

Based on the data from megascopic and microscopic descriptions the following types of basement rock are present: (1) zeolitized basalt tuff-breccia; (2) sedimentary (tuff)-breccia; (3) altered hyalobasalt; (4) amygdaloidal basalt.

A brief description of these types follows:

Sedimentary (Tuff)-Breccia

This unit is found between the basalt tuff-breccia in Sections 32-3 and 33-3. The rock is multicolored, moderate brown to light brown, with grayish blue-green spots. Coarse, angular fragments are zeolite-smectite and basalt. The matrix is sandy silt and silty sand, with round quartz and plagioclase grains. Very rare radiolarian and diatom fragments were observed.

Zeolitized Basalt Tuff-Breccia

This is present in top of the cored section (Sections 32-3, 33-2, 33-3, 34-1, 34-2). It is very coarse grained and very often only one fragment of this breccia is contained in a thin section. The fragments are represented by altered (zeolitized, smectized, and oxidized) basalt; stripped and rosetted zeolite (near isotropic and isotropic, $N = 1.500$), Hematite, goethite, and altered olivine are replaced by chlorite, smectite, and calcite. The smaller basalt fragments have a greater degree of alteration than the larger fragments. The zeolite-smectite fragments have a concentric structure, which probably represents the sequential replacement of volcanic glass. The fragment form generally is angular.

The breccia cement is smectite and zeolite, with hematite and goethite dust. Very often thick calcite veins cut through the breccia. The zeolite-smectite cement is also replaced by calcite.

Altered Hyalobasalt

This rock type is present in the lower portion of the cored section (Sections 34-2, 35-1, 35-2, 36-1). The basalt has aphanitic, microporphyric, variolitic, microhyalophytic, and microintersertal textures. One can see a taxitic heterogeneity of the rock conditioned by irregular crystallization of magma. Rare phenocrysts and glomeroporphyritic clusters are present, consisting of altered olivine (up to 3%-5%) and plagioclase (up to 10%).

The groundmass consists of twinned plagioclase laths (0.1-1 mm long). The plagioclase is labradorite (An 60-68, having a maximum extinction angle 33°-38° in zone ⊥010), and sometimes with a trachite arrangement. Very often the plagioclase laths are skeletal, with an isotropic and near isotropic matrix inside. This material is probably devitrified volcanic glass. Between plagioclase laths, a microlitic felt of plagioclase is present, submerged into an altered glassy matrix. Sometimes it is marked the fine underdeveloped prisms of clinopyroxene which accretes together with plates of an iron mineral. Also the clinopyroxene forms thin laths which are interlaced with plagioclase laths. C:Ng(γ) of this clinopyroxene is 40°. Olivine phenocrysts are represented by euhedral crystals (0.3-0.5 mm), replaced by iddingsite, calcite, with a goethite matrix.

Plagioclase phenocrysts have prismatic and tabular forms. The grains often are zonal. The central part of zonal phenocrysts is replaced by fine plate aggregate of hydromica. Thin peripheral edging is clean and transparent. In center of phenocrysts the plagioclase is bytownite An 74 (Ng[γ] = 1.574), and on periphery—andesine, An 48 (Np[α] = 1.553) (Sample 36-1, 98-100 cm).

The intergranular groundmass consists of a slightly recrystallized matrix material, probably zeolitized-smectized glass ($N<1.55$). Zeolite, calcite, smectite, and chlorite very often fill veins, cavities, and amygdules. The number of amygdules sometimes is very high (~10%) and hyalobasalt has amygdaloidal character. The basalt is very highly altered. Nearly half of the plagioclase is replaced by hydromica, zeolite, and calcite. Olivine is completely replaced by calcite, smectite(?), zeolite, and goethite.

Amygdaloidal Basalt

This basalt is very similar to the altered basalt, but contains more than 10% amygdules (0.2-2 mm). These are filled by zeolite, smectite, plus rare calcite.

Summary

Rocks of acoustic basement in Hole 345 are basalt tuff-breccia, sedimentary (tuff-sedimentary) breccia, hyalobasalt, amygdaloidal basalt. The tuff breccia and sedimentary breccia originated in submarine conditions. They contain weathered basalt and altered pyroclastic products. The hyalobasalt and amygdaloidal basalt probably represent a submarine flow, exposed to secondary hydrothermal alteration and weathering. However, it is possible that the flow may represent a subaerial, or a shallow submarine flow. The high degree of oxidation and weathering of the basalt supports this conclusion.

PHYSICAL PROPERTIES

Bulk Density, Porosity, and Water Content

Figure 4 shows the variation in sonic velocity and density with depth. Data plotted are uncorrected GRAPE analog data (values from 40, 80, 120 cm averaged together/core section) and uncorrected sonic velocity. Figure 5 shows syringe water content and acoustic impedance. A number of units possessing different physical properties are seen. Table 3 gives means and standard deviations for all the different units.

Shear Strength

Figure 6 shows the combined shear and unconfined compression strength profile for this site. Shear strength values show considerable scatter in Cores 1-8, and an anomalous reversal in strength in Core 1. However, Core 1 was intensely deformed.

Unconfined compressive strength shows a pattern of orderly and regular increase from Cores 2 to 13. Below Core 16, values exceed the limit of measurement of the penetrometer (4.5 TSF).

GEOCHEMICAL MEASUREMENTS

Inorganic Geochemistry

The results of analysis of interstitial water samples are found in Table 4.

Organic Geochemistry

Neither the presence of gas nor hydrocarbons was detected at Site 345.

BIOSTRATIGRAPHY

Biostratigraphic Summary

"Glacial" sediments (Pliocene to Pleistocene) were encountered in Cores 1 to 4 (0-36.5 m) with nannoplankton, foraminifera, and traces of radiolarians. Nannofossils are restricted to some horizons. Reworked Cretaceous and Paleogene pollen, spores, and nannofossils are present in differing amounts.

A hiatus exists between Pliocene and the early Miocene of about 13 m.y. The early Pliocene was determined in Cores 5 to 11 (36.5-169.5 m) based on diatoms, silicoflagellates, dinoflagellates, and radiolarians. However, according to silicoflagellates Cores 9 and 10 belong to the upper Oligocene-lower Miocene which is supported by dinoflagellates and foraminifera. Sediments below contain only arenaceous foraminifera and dinoflagellates, which in some horizons become frequent. They indicate an Oligocene age for Cores 12 to 21 (188.5-530.5 m), and probably a late Eocene age for Cores 22 to 32 (559-764 m).

Foraminifera

"Glacial," Pleistocene, Cores 1 through 5, Section 4

The "glacial" section is fossiliferous throughout, fossils becoming rare in Core 5. The amount of ice-rafted material relative to foraminiferal tests varies greatly between washed residues; some samples have practically nothing but quartz, rock fragments (common basalt), and *Inoceramus* prisms, whereas the residue of others largely consists of foraminiferal tests. All faunas are dominated by *Neogloboquadrina pachyderma* (95%, 94%, 100%, and 97% sinistral, respectively, in 1, CC; 2, CC; 3, CC; and 4, CC). *Globigerina quinqueloba* is present in most samples and at some levels *G. bulloides* occurs. Sample 1, CC seems to be the "warmest" having, in addition to the above, *Globorotalia inflata* and *Orbulina inversa*.

Benthos is very rare and in most samples constitutes less than 1% of the fauna. The most conspicuous species are *Pyrgo rotalaria*, *P. williamsoni*, and "*Cibicides*" *wuellerstorfi* but small *Eponides umbonatus* is probably more abundant. Other species found are: *Cassidulina subglobosa*, *Melonis zaandamae*, and species of *Den-*

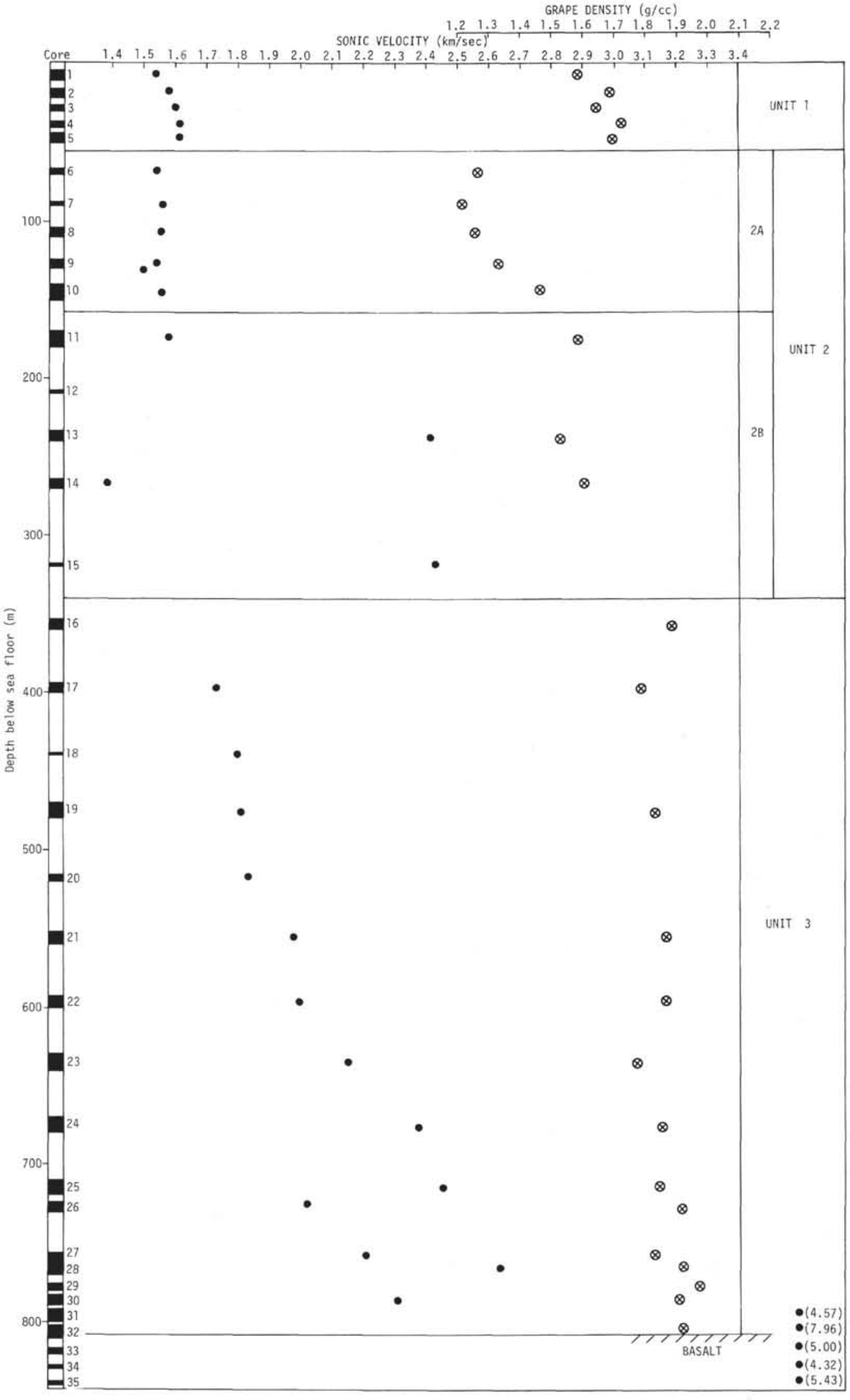


Figure 4. *Density and sonic velocity.*

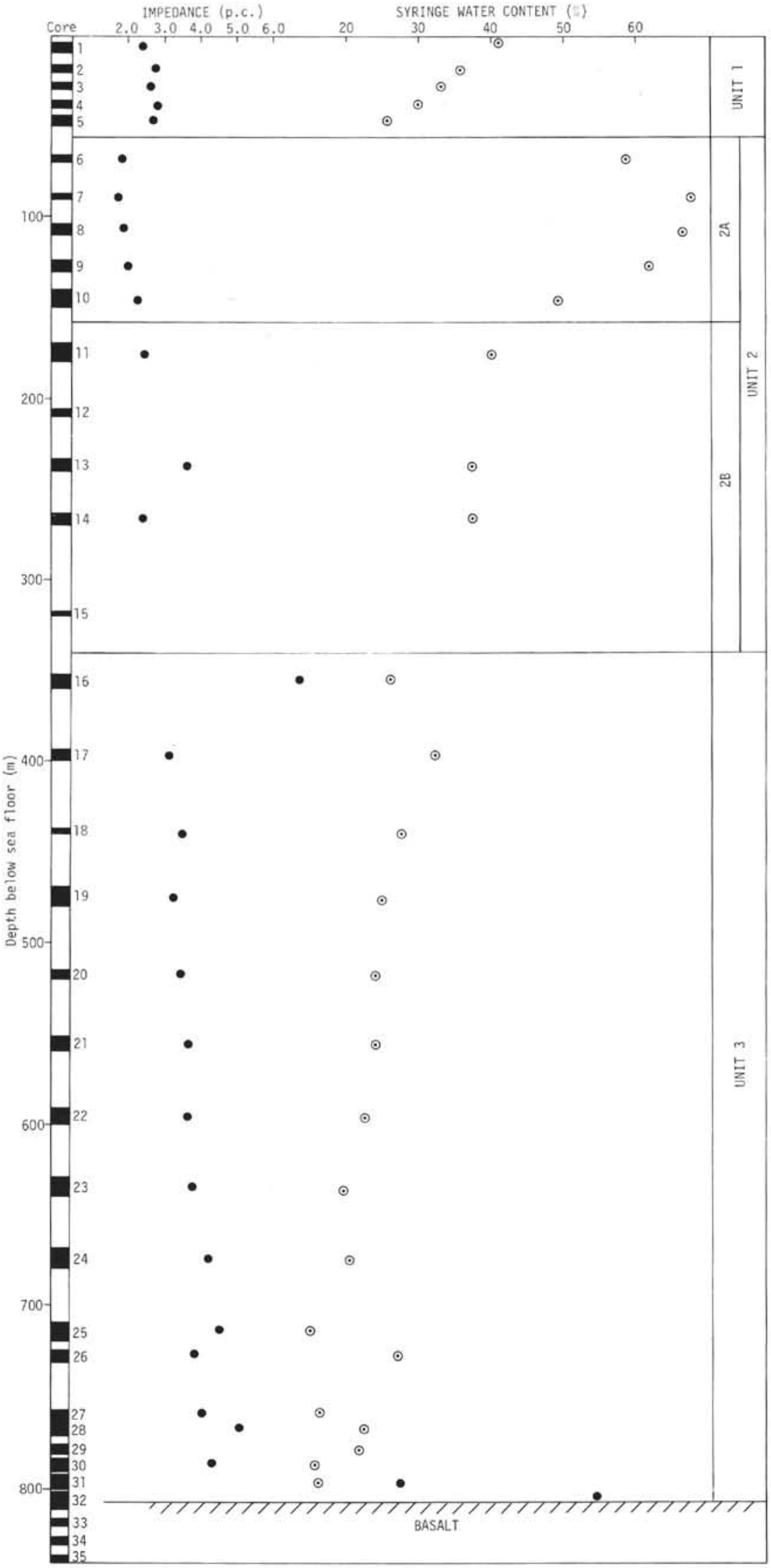


Figure 5. *Impedance and Syringe Water Content.*

TABLE 3
Physical Property Averages

		GRAPE					
Unit		ρ(g/cc)	η(%)	S(TSF)	Pc(TSF)	ρc	c(km/sec)
1	x	1.66	64.81	0.14	0.51	2.65	1.59
	s	0.05	3.46	0.06	0.16	0.13	0.03
2A	x	1.35	85.43	0.15	1.40	2.09	1.55
	s	0.14	9.28	0.05	0.80	0.24	0.02
2B	x	1.56	71.38	0.20	2.25	2.94	1.90
	s	0.06	3.85	–	2.43	1.03	0.73
3	x	1.86	51.45	0.20	4.50	4.29^{a}	2.35^{a}
	s	0.06	3.86	–	–	1.02	0.73

Note: ρ = GRAPE bulk (wet) density; η = GRAPE porosity; s = Shear strength (equals cohesion in saturated sediments); Pc = Compressive strength; ρc = Acoustic impedance; c = Sonic velocity; x = Arithmetic mean; s = Standard deviation.

[a] Velocity and ρc values are presented for a unit in which they are greatly changing. They should not be interpreted to characterize the unit at any given point.

talina, *Recurvoides*, and *Triloculina*. Rare specimens of *Nonion labradoricum* and *Elphidiella groenlandica* probably are ice rafted.

Plio-Miocene (?), Cores 5, CC, 6, Section 1

Sample 5, CC differs from the samples above and below. It yielded an arenaceous fauna with a few *Cyclammina* sp., *Haplophragmoides* sp., and fragments of *Martinotiella communis* and numerous fish teeth. The rusty brown color of the specimens, dark crusty (manganese) fragments of undisintegrated zeolitic sediment and the common occurrence of fish teeth all suggest a very low to zero rate of sediment accumulation below the carbonate compensation surface. This arenaceous assemblage differs from the usual Miocene *Martinotiella* assemblage and might be of Pliocene or Miocene age. Core 6, Section 1 does have somewhat similar residues in having fish remains, but lacks the foraminifera, rusty color, and crusty fragments.

Miocene, Core 6, Section 2 through Core 10, Section 6 (?)

This interval is poor in microfauna. The washed residues are extremely small to nonexistent; some spicules, radiolarians, and diatoms can be present. Core 6, Section 2 through Core 8 have *Spirosigmoilinella* sp., *Spirolocammina* sp., and *Karreriella siphonella*, but no *Martinotiella* and might be of early rather than middle or late Miocene age. All 11 samples of Core 9 through Core 10, Section 6 are barren.

Late Oligocene, Cores 10, CC through 14

Of the 17 samples from this interval only two yielded an arenaceous foraminiferal fauna: *Haplophragmoides* sp., *Saccorhiza* sp., *Bathysiphon* sp., *Ammolagena* sp. and *Karreriella siphonella*. The washed residues differ from above in having mica and pyrite; the latter occurs in tubular form in many samples and may have replaced siliceous foraminiferal tests. From Core 13 down, very fine quartz grains are present. An Oligocene-early Miocene age was assigned with dinoflagellates (Core 14), diatoms (Core 11), and silicoflagellates (Core 10).

Oligocene, Cores 15 through 32

This interval with numerous turbidites is characterized by the common to abundant occurrence of an arenaceous foraminiferal assemblage that in literature has been referred to as "flysch fauna" or "*Rhabdammina* fauna." Of the 94 samples examined from this interval only one (18, CC) additionally had some calcareous tests: *Turrilina alsatica*, *Nodosaria soluta*, "*Cibicides*" sp., and *Quinqueloculina* sp. allowing to assign an early or middle Oligocene age to this level. The calcareous fossils are very well preserved and therefore probably were displaced with the density currents from shallower depths where conditions on the sea floor were less corrosive to carbonate. No further age-diagnostic fossils are present, but the absence of the Eocene marker *Spiroplectammina spectabilis* (which is present at other sites in similar facies) and the presence of *Spirosigmoilinella* (down through Core 27) suggest that the lowest sediment is of Oligocene age.

The washed residues largely consist of rounded and angular quartz grains (at some levels coarse) with some chert grains and from Core 28 down with fragments of metamorphic rocks. Pyrite is a common constituent down to 27, CC.

A local biostratigraphic subdivision can be based on slight changes in relative frequences of different forms and will not have regional value. The fauna of Core 15 through Core 21, Section 3 has species of the genera *Saccorhiza*, *Rhabdammina*, *Bathysiphon*, *Haplophragmoides*, *Hormosina*, "*Trochammina*," some *Reophax*, *Tylopammina* (or *Ammolagena*), *Psammosphaera*, *Spirosigmoilinella*, *Spirolocammina*, and *Karreriella siphonella*.

A similar fauna occurs from Core 21, Section 4 through Core 25 without *Karreriella siphonella* (except for one specimen found in 22-3, 83-85), with only rare *Spirosigmoilinella*; but with *Cyclammina* spp. and *Hyperammina* sp. added.

A further change occurs between Core 25, Section 6 and Core 26, Section 2 from which level down *Psammosphaera* is numerically important in most samples. Several samples from this interval (mainly of Core 28) are barren and/or have washed residues largely consisting of (?) weathered volcanic material (?).

From Core 30, Section 3 down the sand portion of the washed residues increases rapidly and coarsely arenaceous tests of *Psammosphaera* and *Rhabdammina* outnumber the others.

Nannoplankton

Nannofossils were found in Cores 1 to 4 (0-36.5 m). They are abundant in nannofossil ooze layers intercalated in Quaternary sediments. Core 1 belongs to the *Emiliania huxleyi* Zone (NN 21). The following species were determined: *Emiliania huxleyi*, *Coccolithus pelagicus*, *Gephyrocapsa ericsonii*, and few specimens of *Syracosphaera pulchra*, *Cyclococcolithus leptoporus*, and *Helicosphaera carteri*. The same assemblage was observed in Core 2 but without *Emiliania huxleyi*. This core may belong to the *Gephyrocapsa oceanica* Zone (NN 20). *Pseudoemiliania lacunosa* is present from Sample 3-2, 35-36 cm to Sample 4-2, 42-43 cm, indicating a late Pliocene to Pleistocene age.

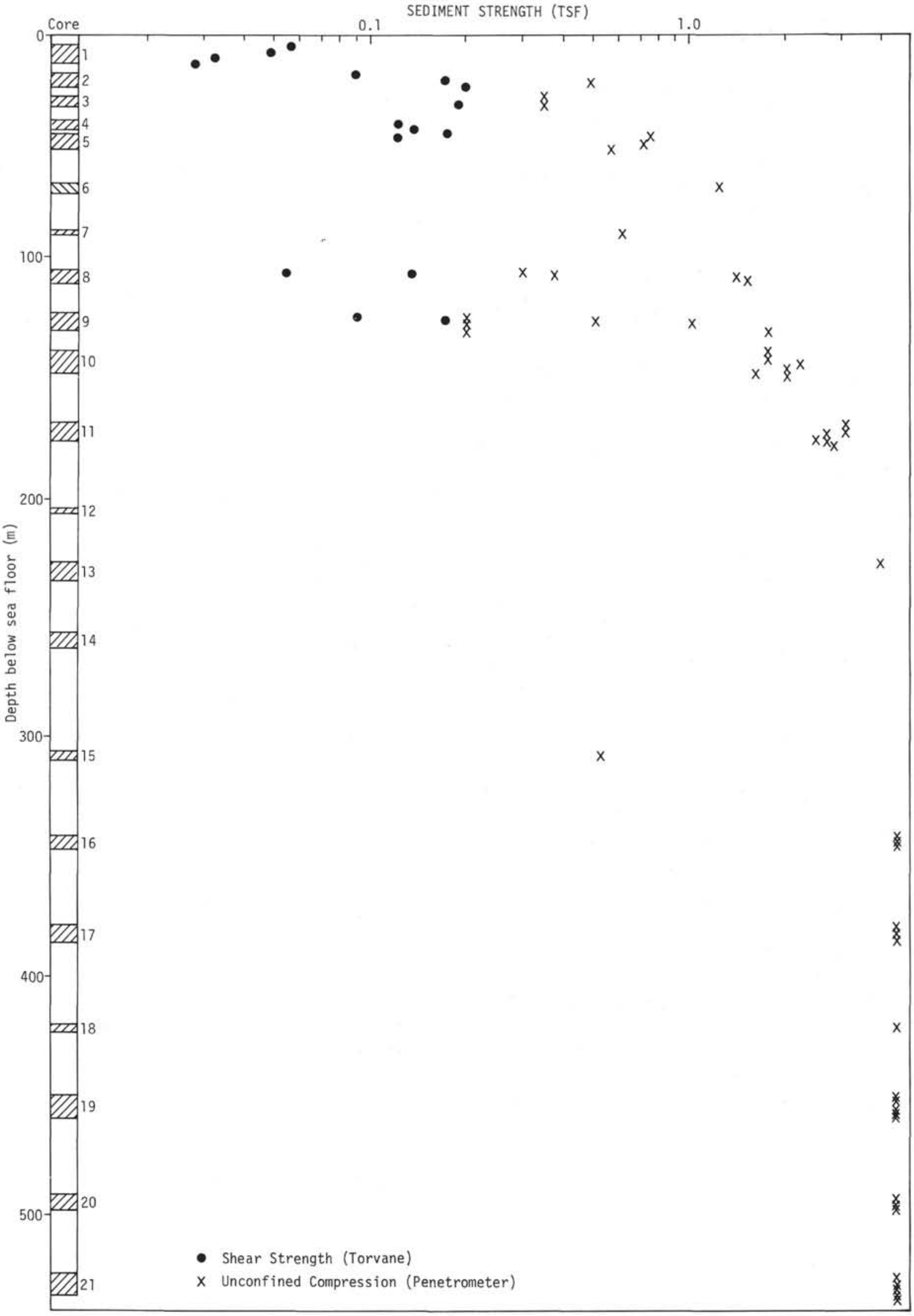


Figure 6. *Shear Strength Profile.*

TABLE 4
Summary of Shipboard Geochemical Data, Site 345

Sample (Interval in cm)	Subdepth (m)	pH	Alkalinity (meq/Kg)	Salinity $(^\circ/_{oo})$	Ca^{++} (mmoles/1)	Mg^{++} (mmoles/1)
Surface Seawater			2.31	35.2	10.25	53.13
1-1, 143-150	1.5	7.41	3.23	34.9	11.28	53.18
4-1, 124-130	28.3	7.44	3.99	35.2	13.51	48.35
7-1, 144-150	76.0	8.13	3.07	35.2	15.23	45.44
10-4, 141-150	137.5	7.34	2.33	34.6	18.49	39.95
14-3, 142-150	250.0	–	1.97	33.3	27.63	26.57
16-5, 141-150	338.0	8.03	1.67	33.6	32.73	20.13
19-4, 140-150	451.0	8.61	1.09	32.7	43.51	10.17
20-2, 138-150	486.0	8.72	0.77	32.7	43.62	9.69
21-4, 140-150	527.0	8.88	0.90	33.0	51.56	5.02
23-5, 140-150	604.5	–	0.54	34.9	59.50	3.33

Preservation of the nannoplankton is good in the nannofossil ooze but they are slightly etched in other samples. Reworked Cretaceous and Eocene species were found in all samples. Below Core 4 (36.5-802 m) nannofossils are absent.

Diatoms (H.-J.S.)

Diatoms were only found in the interval of Unit 2 (Samples 6-2, 68 cm to 11-3, 50 cm) with well-preserved diversified assemblages in Cores 6-9, and poor to moderate preserved assemblages in Cores 9-11. Freshwater diatoms were observed in Samples 8-1, 79 cm; 10-1, 40 cm; and 10-3, 50 cm.

Age-diagnostic species were found only in the interval between Samples 6-2, 68 cm to 8-1, 79 cm with *Coscinodiscus vigilans*, *Goniothecium tenue*, *Opephora gemmata*, and *Thalassiosira fraga*. Therefore, Samples 6-2, 68 cm to 7-2, 59 cm have been placed into the *Rhizosolenia bulbosa* Partial Range Zone, and Samples 8-1, 79 cm to 8-3, 62 cm into the *Thalassiosira fraga* Partial Range Zone. Only a tentative early early Miocene age could be assigned to the interval between Samples 9-3, 30 cm to 11-3, 50 cm with an absolute age older than 19.5 m.y. B.P.

Radiolarians

Three units could be identified based on the occurrence of radiolarians. Unit 1 (Cores 1 through 5) is characterized by poor radiolarian fauna. Traces of radiolarians were found in Core 1, mostly fragments, and only *Spongotrochus glacialis* could be identified.

Unit 2 (Cores 6-1, 43-45 through 10, CC) is characterized by a well to moderately preserved radiolarian fauna. Assuming Site 338 to be the reference hole for the radiolarian stratigraphy, the boundary between the *Gondwanaria japonica* Zone and the *Velicucullus oddgurneri* Zone is situated between 10-1, 35-37 and 10-2, 30-32, which is close to the Miocene-Oligocene boundary. A *Spongomelissa* (?) sp. was frequently found in Samples 8-2, 118-120 to 8, CC. This species was very rare at Site 338, but it occurred in low numbers in Sample 13, CC, of an uppermost early Miocene age. This unit can be age determined to early Miocene, Samples 6, CC through 10-1, 35-37, and possibly late Oligocene, from Samples 10-2, 30-32 to 10, CC.

Unit 3 (Cores 11 through 32) is characterized by being barren of radiolarians.

Silicoflagellates

Silicoflagellates were first noted in Sample 6-1, 123-124 cm (56.5 m): *Mesocena apiculata*, *Cannopilus hemisphaericus*, *Distephanus speculum*, *Distephanus crux*, and *Distephanus longispinus* indicating a middle Miocene age (probably *Corbisema triacantha* Zone).

Corbisema triacantha and *Naviculopsis quadratum* are present in Sample 8-1, 139-140 cm (85.5 m) together with the same species as in Cores 6 and 7. According to Martini, 1972, *Naviculopsis quadratum* in its typical form indicates an early Miocene age. One specimen of *Naviculopsis lata* was found in Sample 8-4, 70-71 cm.

In Core 9 only very few silicoflagellates are present like *Distephanus crux*, *Corbisema triacantha*, *Distephanus speculum*, and *Naviculopsis lata*. They become more frequent in the upper part of Core 10. The assemblage with *Corbisema triacantha*, *Distephanus crux*, *Dictyocha fibula*, *Naviculopsis lata*, *Distephanus speculum*, *Mesocena apiculata* indicates a late Oligocene to early Miocene age (*Naviculopsis lata* Zone). In the lower part of Core 10 silicoflagellates are present only sporadically Below Core 10 they are missing. Archaeomonads are common in some samples.

Palynology (S.B.M.)

Dinocysts

Workable assemblages with zone-diagnostic species occur only in Sections 9-3 to 7-2. A tentative zonation is suggested for Cores 26 to 11 which gave only infrequent specimens of a few diagnostic species (Figure 7). Since all palynomorphs in assemblages from Core 14 and below are corroded and darkened, alteration is considered to have taken place in situ, even though some of the material is certainly reworked. From Core 9 upwards, preservation of indigenous fossils appears normal.

In Core 26, Section 3 *Deflandrea phosphoritica*, *Meiourogonyaulax* sp., and *Cyclonephelium ordinatum* occur in association with frequent *Phthanoperidinium resistente,* indicating Zones IV to V (the last species perhaps more suggestive of Zone V). It is suggested that the IV to V interval also includes Core 23, Section 3 and Core 22, Section 3, since *D. phosphoritica* and *C. ordinatum* occur together. Below Core 26 only *D. phosphoritica* has been observed very infrequently down to Core 30.

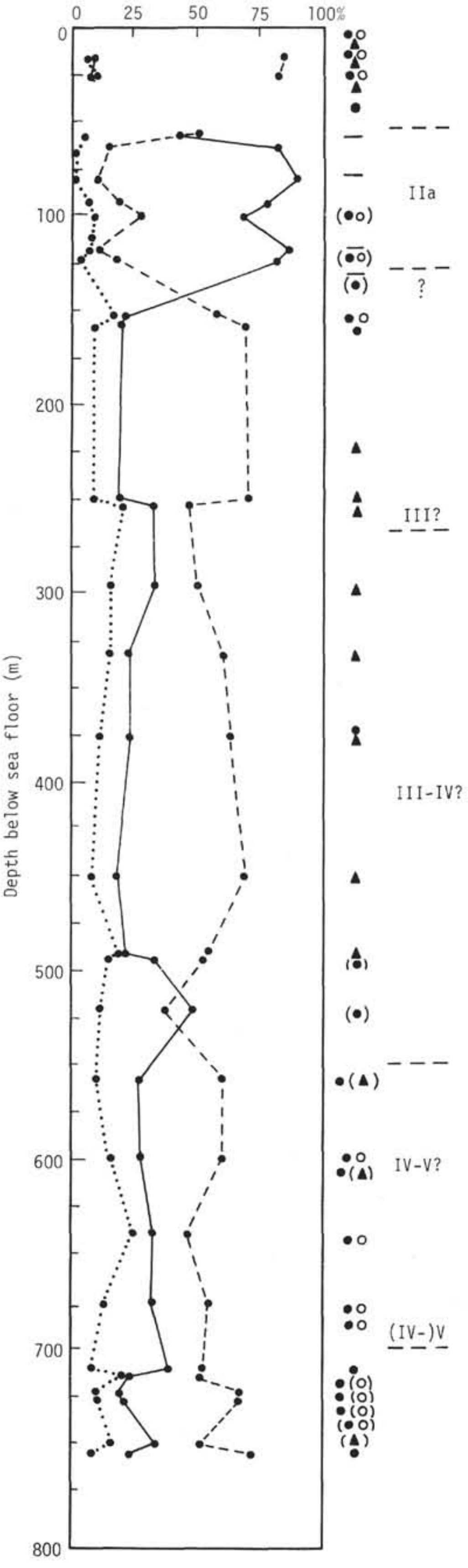


Figure 7. *Relative palynomorph abundance, palynodebris composition, and dinocyst zonation (as established for 338). – Dinocysts; - - Pollen + spores; excl. saccates; . . . Saccate pollen. Terrestrial plant debris: Mixed cuticular and tracheidal; ▲ altered (dark color); ʌ unaltered; Sorted, tracheidal mainly ● carbonized (opaque); ○ noncarbonized; – No recognizable debris; ( ) Debris present but not dominating in prep. residue. Symbol only: debris dominating.*

The interval, Cores 21 to 15, has an association of infrequent specimens of a few species which either belong to Zone IV and lower (e.g., c.f. *Gonyaulacysta giuseppei*, *D. phosphoritica*, and *Leptodinium* sp. I), or to Zone III and higher (e.g., *Chiropteridium dispersum* and *Impletosphaeridium* sp. I).

At Site 336, Sections 20-5 to 18-2, a somewhat similar situation was observed, with *D. phosphoritica* and *C. dispersum* occurring together. Intense bioturbation in part of this particular interval at Site 345 may explain assemblage mixing. This, together with relative paucity of the assemblages, hinders zonation, but the interval is tentatively referred to Zones III-IV. In Core 14, Section 1, by far the commonest cyst is *Leptodinium* sp. II comparable to the base of Zone III at Site 338. However, since *D. phosphoritica* also occurs seemingly indigenous, Core 14, Section 1 is referred to Zone III with reservation. In Cores 13 and 11 extremely rare observations of *Dinocyst.* sp. V and *C. dispersum* suggest Zone III.

The interval, Core 9, Section 3 to Core 6, Section 2, has essentially similar assemblage composition throughout, comparable with Zone IIa. Key species are: *Leptodinium* spp. II and III, both frequent. They are, however, unassociated in 338, sp. II having its last appearance in IIa, sp. III its first in Ic. Further significant species are *Cyclonephelium* sp. II which is quite common (occurrence in 338 at top of IIa only), and *Hystrichosphaeropsis* cf. *obscurum* and cf. *Batiacasphaera baculata* (in 338 occurring in IIa to Ia and IIb to Ic, respectively). Other species occurring range from III to I (*Hystrichokolpoma rigaudae*, *Problematicum* I, cf., *Heteraulacysta campanula*, cf. *Plathycystidia* sp. II).

Core 6, Section 1 has a rather poor assemblage of long-ranging Zone III to I species, while Core 5 and higher is unproductive.

Debris, Reworked Material

Noticeable changes in terrestrial plant debris occur in Cores 20, 11, and 5. Age-diagnostic reworked palynomorphs are rare, but the source of reworked material appears predominantly to be lower Tertiary to late Upper Cretaceous. From Core 4 upwards it appears to be more distinctly pre-Tertiary (lower [?] Cretaceous).

Sedimentation Rates

Plio/Pleistocene sediments were determined in Cores 1 to 4 (0-36.5 m) but were mainly of Pleistocene age. Using 3 m.y. as the basal age, the "glacial deposits" accumulated at an average rate of 1.3 cm/1000 yr. A hiatus of approximately 13 m.y. exists between the "glacial sediments" and the early Miocene (Core 5) including the middle-upper Miocene and probably the largest part of the Pliocene. Dating the top of the early Miocene at 16 m.y. and the base at 22.5 m.y., the sedimentation rate of this sequence is 2.1 cm/1000 yr. The Oligocene rate is 2.2 cm/1000 yr assuming a complete section. Since the exact age of the base of sediments is not known (Eocene?), only a very tentative sediment accumulation can be determined for the post-Oligocene sequence. If it is of probable late Eocene age, a sedimentation rate of 3.7 cm/1000 yr is assumed. None of these rates has been corrected for compaction, which for the sedimentary section may make a significant difference.

SUMMARY AND CONCLUSIONS

Summary

At this site in the Lofoten Basin at a depth of 3195 meters, a depth of 802 meters was penetrated of which 762 meters was in sediments, and the remainder in basalt. The sediments consisted of thin "glacial" and Miocene sequences, overlying a very thick Oligocene sequence. Late Eocene(?) and Eocene(?) sediments underlie the Oligocene.

"Glacial"

The "glacial" extends down to nearly the bottom of Core 4 (about 36 m). The sediments are dominantly muds, sandy muds, and sands, although volcanic ash and foraminiferal oozes are also present. Left-coiling *Neogloboquadrina pachyderma* dominates the fauna. Nannoplankton are also present, although they are restricted to some horizons, and only reworked species are present in others. Only traces of radiolarians, mainly fragments, are found.

Miocene

The Miocene extends from about 36 meters to possibly 169 meters. It is possible that a hiatus exists at the upper portion of the Miocene, where Pliocene sediments overlie early Miocene sediments. There is a small, but definite decrease downwards in sonic velocity at this interface (from 1.61 km/sec to 1.54 km/sec), and a much larger decrease in density (from 1.7 g/cc to below 1.3 g/cc). The density, however, increases very rapidly in depth within the Miocene. The sediments consist of clays, muds, and biogenic siliceous oozes. The fauna is siliceous, and age determination is based on radiolarians, silicoflagellates, and siliceous-arenaceous foraminifera.

Oligocene

The Oligocene extends from the base of the Miocene at about 169.5 meters(?), to 530.5 meters(?). A 28.5 meter uncored interval underlies the Oligocene. The upper contact of the Oligocene to the Miocene is gradational. Some distance below (at 160 or 180(?) m) a change in lithology is apparent. The mud and clay now seem to be present in alternating sequences with their lithified equivalents, which would explain the wide variations in sonic velocity down to about 330 meters. The Oligocene sediments are barren in calcareous fossils, as well as in radiolarians and silicoflagellates. The only fauna that appears to be present consists of arenaceous foraminifera. Even these are scarce in the upper Oligocene, which extends down to about 255 meters.

The undivided Oligocene which extends below 255 meters consists of mudstones and sandstones without the alternating soft sequences found in the upper Oligocene. Turbidites exist and increase in volume towards the base of this lithologic unit (Unit 3). Pebbles are also particularly prominent towards the base. The reddish-brownish pebbly mudstones above basaltic basement are interpreted as a slump or similar deposit. There is a marked and regular increase in sonic velocity downwards (from 1.74 km/sec at 400 m to 2.45 km/sec at 720 m). Density remains the same, or perhaps shows a slight increase downwards. The arenaceous foraminifera found in the upper Oligocene increase considerably in the undivided Oligocene. Other fauna are absent, except chitinous forms. Also, in Sample 18, CC calcareous foraminifera are observed.

Basement

Basement from 762 to 780(?) meters consists of tuff breccias including coarse angular fragments of zeolite and basalt. This breccia was laid down in submarine conditions. Below 780 meters to the base of the hole at 802 meters lies very highly altered basalt and amygdaloidal basalt.

The age of the oldest sediments above basement is somewhat uncertain. Although some of the articles in this report speculate that the age might be as old as late Eocene, the best evidence is probably from foraminiferal studies which point out the absence of Eocene fossils. Hence lower Oligocene may actually be the best estimate of the oldest sediments at this site. Radiometric studies (Russian Group) suggest a somewhat younger age of 27 ±3 m.y.

Discussion and Conclusions

The following calculation is made to compare the reflection profiler travel time to basement with that obtained from measured sample velocities.

a) Lithologic Unit 1 to 46 meters, corresponding to Physical Properties Unit 1. Cores 1 to 5; 0-46 meters; average velocity = 1.592 km/sec; travel time = 0.058 sec.

b) Physical Properties Unit 2A. Core 6 to Cores 10/11; 46 to 150 meters; average velocity = 1.550 km/sec; travel time = 0.133 sec.

c) Physical Properties Unit 2B, equivalent to remainder of Lithologic Unit 2. Cores 10/11 to 15/16; 150 to 331 meters; average velocity (extremely variable) = 1.947 km/sec; travel time = 0.186 sec.

d) Lithologic Unit 3, corresponding to Physical Properties Unit 3. Cores 15/16 to 25; 331 to 762 meters; average velocity (considerable progressive increase downwards) = 2.013 km/sec; travel time = 0.428 sec.

Total calculated time to basement = 0.805 sec. Profiler record is somewhat indistinct, and basement appears to be at 0.9 sec. If this is true, velocities have to be revised to be about 12% slower than those obtained from the sample measurements.

The presence of tuff layers and the high degree of weathering and oxidation, suggest that the basalt was extruded under very shallow or perhaps even subaerial conditions. The nature of the overlying sediments (pebbly mudstones overlain by turbidites) argues for water depths that were originally shallow, but gradually deepened. Turbidites generally gave way to pelagic sedimentation, but with mainly nonbiogenic components. Otherwise, the conditions under which sedimentation took place appear to have been monotonous, as reflected in the profiler records. The source of the large amounts of terrigenous material and the high sedimentation rates are not explained as yet.

It may be possible to envisage an island, that the Jan Mayen Fracture Zone stood above sea level at the time of creation of ocean floor at Site 345 and may have been a source of terrigenous sediments.

The age of basement calculated from the age of the overlying sediments is not firm. The oldest sediments appear to be perhaps lower Oligocene. A corresponding age for basement is in accord with what we know of the magnetic lineations in this area.

REFERENCES

Berggren, W.A., 1972. Late Pliocene-Pleistocene glaciation. *In* Laughton, A.S., Berggren, W.A., et al., Initial Reports of the Deep Sea Drilling Project, Volume 12: Washington (U.S. Government Printing Office), p. 953-963.

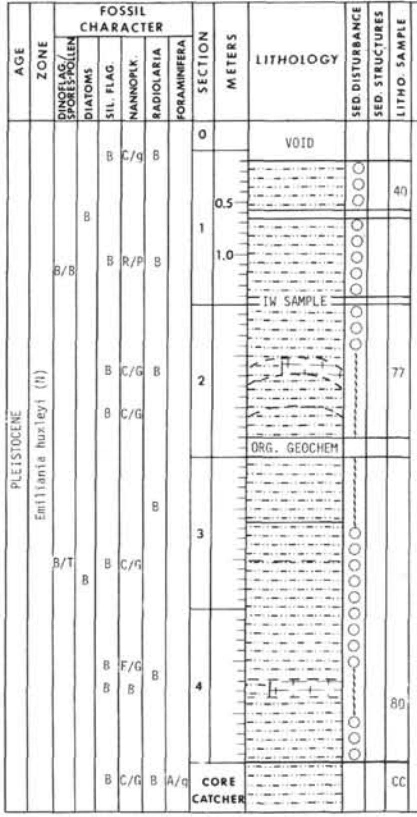
Martini, E., 1972. Silicoflagellate zones in the late Oligocene and early Miocene of Europe: Senchenberg. Letheae, v. 53, p. 119-122.

McDougall, I. and Wensink, H., 1966. Paleomagnetism and geochronology of the Pliocene-Pleistocene lavas in Iceland: Earth Planet. Sci. Lett., v. 1, p. 232-236.

Warnke, D.A., 1970. Changing rates of biogenic sedimentation in the Southern Ocean: results of a stressed ecosystem: Geol. Soc. Am. Abstract with Programs, v. 2, p. 715.

Warnke, D.A., Richter, J., and Oppenheimer, C.H., 1973. Characteristics of the nearshore environment off the south coast of Anvers Island, Antarctic Peninsula: Limnol. Oceanogr., v. 18, p. 131-142.

SITE 345 HOLE CORE 1 CORED INTERVAL: 0.0-6.0 m



LITHOLOGIC DESCRIPTION

10YR 5/4
5Y 4/1
N4
5Y 5/1
5Y 4/1
N5
5Y 4/1
10YR 5/4
5Y 4/1
N6
5YR 4/4
10YR 4/2

Dark yellowish brown (10YR 4/2), moderate yellowish brown (10YR 5/4), olive gray (5Y 4/1), medium light gray (N6), medium dark gray (N4), light olive gray (5Y 5/1). Drilling breccia to intense deformation.

MAJOR LITHOLOGIES

a) MUD (Smears 1-40, CC)

10-20% Sand	0-35% Quartz
30-40% Silt	0- 7% Feldspar
40-60% Clay	0- 5% Mica
	2- 5% Heavy minerals
	0- 3% Foraminifera
	0-15% Palagonite
	50-80% Clay minerals

b) MARLY FORAMINIFERA OOZE (Smears 2-77, 4-80)

50% Sand	3-17% Quartz
10-25% Silt	1- 3% Feldspar
25-40% Clay	2- 5% Heavy minerals
	5-23% Clay minerals
	49-50% Foraminifera
	2-40% Nannofossils

Carbon-Carbonate (DSDP)
2-60 (2.4, 0.3, 17)

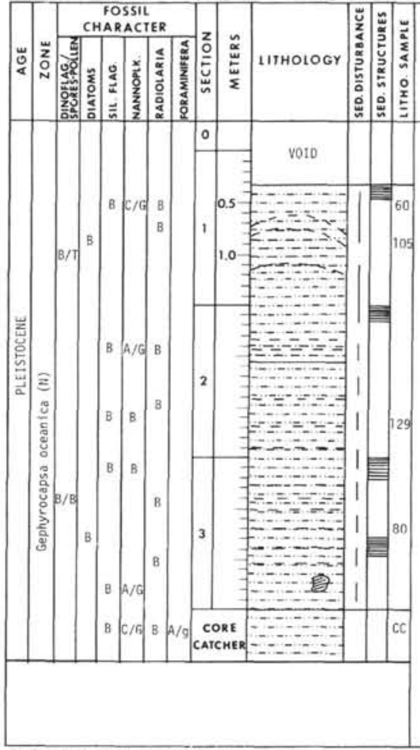
Carbon-Carbonate (PP)
1-2 (top) (0.28, 3.01)
1-2 (bottom) (0.54, 1.09)

Grain Size (DSDP)
2-90 (20.8, 33.5, 45.7)

X-Ray (BP)
2-110

14%	Mont.
53%	Ill.
15%	Kaol.
18%	Chlo.
A	Quar.
P	Micas, Plag., Calc.
TR%	Ortho., Siderite, Dolo.

SITE 345 HOLE CORE 2 CORED INTERVAL: 8.0-17.5 m



LITHOLOGIC DESCRIPTION

5Y 4/1
N4
5Y 5/1
5Y 4/1
10YR 4/2
N4/N5
5YR 4/1
N4
N3
5YR 4/1
N4
5YR 4/1
5Y 4/1
10YR 4/2

Colors: medium dark gray (N4), olive gray (5Y 4/1), medium gray (N5), light olive gray (5Y 5/1), brownish gray (5YR 4/1), dark yellowish brown (10YR 4/2). Moderate-slight deformation, variegated colors and color bands.

MAJOR LITHOLOGIES

a) MUD (Smears 1-60, 2-129, 3-80, CC)

0- 1% Sand	3- 4% Quartz
10-20% Silt	1- 5% Feldspar
70-90% Clay	0- 2% Mica
	2% Heavy minerals
	0- 1% Foraminifera
	0-10% Carbonate
	43-59% Clay minerals

(Carbonate higher in some slides.)

b) SANDY MUD (Smear 1-105)

50% Sand	30% Quartz
30% Silt	10% Feldspar
20% Clay	1% Mica
	4% Heavy minerals
	5% Foraminifera
	50% Clay minerals

Carbon-Carbonate (DSDP)
3-70 (1.6, 1.3, 3)

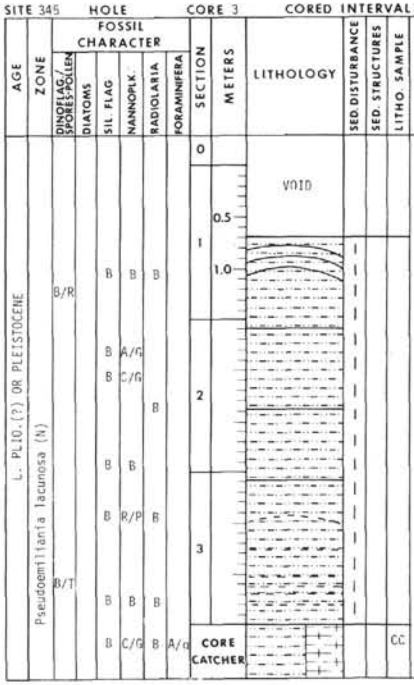
Grain Size (DSDP)
3-20 (0.4, 17.1, 82.5)

X-Ray (BP)
3-10

18%	Mont.
45%	Ill.
16%	Kaol.
20%	Chlo.
A	Quar.
P	Micas, Plag.
TR%	Siderite

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 3 CORED INTERVAL: 17.5-27.0 m



LITHOLOGIC DESCRIPTION

5Y 4/1
N4
5Y 4/1 -
5GY 6/1
N4
5Y 5/1
5Y 4/1
N4
N4
5YR 6/1
5Y 5/1 - N6
N4
5GY 6/1
N4
10YR 4/2

Colors: olive gray (5Y 4/1), medium dark gray (N4), light olive gray (5Y 5/1) to greenish gray (5GY 6/1), medium gray (N6). Variegated colors. Slight deformation.

MAJOR LITHOLOGY

MUD

MINOR LITHOLOGY

TRANSITIONAL CALCAREOUS MUD (MARLY CALCAREOUS OOZE) (Smear CC)

40% Sand	35% Quartz
40% Silt	5% Feldspar
20% Clay	10% Heavy minerals and Mica
	15% Clay minerals
	30% Foraminifera
	5% Nannofossils

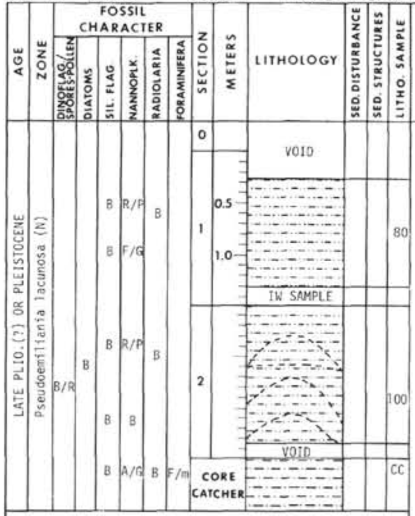
Carbon-Carbonate (DSDP)
2-30 (4.6, 0.2, 36)

Grain Size (DSDP)
2-58 (18.7, 28.4, 52.8)

X-Ray (BP)
2-55

12%	Mont.
47%	Ill.
16%	Kaol.
24%	Chlo.
A	Quar.
P	Micas, Plag., Calc.

SITE 345 HOLE CORE 4 CORED INTERVAL: 27.0-36.5 m



LITHOLOGIC DESCRIPTION

N5
5Y 5/1
5Y 4/1
N6
10YR 4/2
10YR 7/4
N3
5Y 4/1
10YR 5/4
5Y 4/1

Colors: medium gray (N5) to light olive gray (5Y 5/1), olive gray (5Y 4/1) to medium light gray (N6), dark yellowish brown (10YR 4/2), grayish orange (10YR 7/4), dark gray (N3), moderate yellowish brown (10YR 5/4).

MAJOR LITHOLOGY

MUD (Smears 1-80, 2-100)

5-15% Sand	5-15% Quartz
25-30% Silt	1- 3% Mica
55-70% Clay	1-TR% Heavy minerals
	1- 3% Opaques
	TR% Volcanic glass
	70-71% Clay minerals
	2% Zeolites
	5-15% Carbonates
	5% Nannofossils
	3% Feldspar

Carbon-Carbonate (DSDP)
2-69 (0.4, 0.2, 2)

Carbon-Carbonate (PP)
4-1 (top) (0.24, 1.27)
4-1 (bottom) (0.17, 1.66)

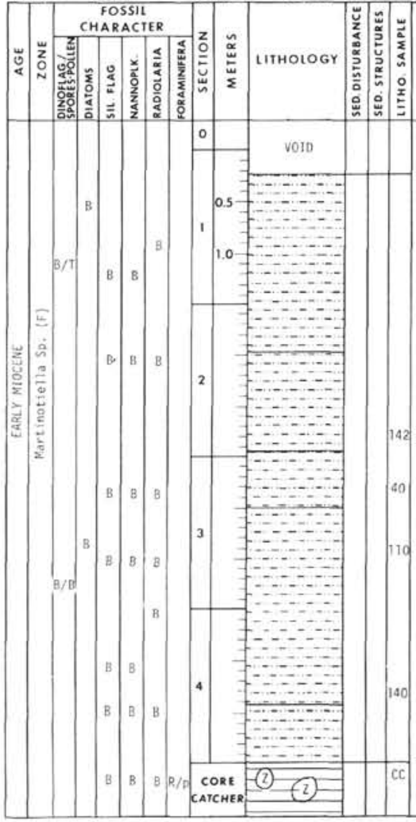
Grain Size (DSDP)
2-79 (14.7, 32.7, 52.6)

X-Ray (BP)
2-74

6%	Mont.
40%	Ill.
20%	Kaol.
33%	Chlo.
A	Quar.
P	Mica, Plag.

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 5 CORED INTERVAL: 36.5-46.0 m



LITHOLOGIC DESCRIPTION

5Y 4/1
5GY 6/1
N3
N4
5Y 4/1
5Y 5/1
5GY 6/1, 5B 5/1
N3
5Y 5/1
5YR 7/2
5GY 6/1
10YR 6/6

Colors: olive gray (5Y 4/1), greenish gray (5GY 6/1), dark gray (N3), medium dark gray (N4), light olive gray (5Y 5/1) greenish gray (5GY 6/1), medium bluish gray (5B 5/1), grayish orange pink (5YR 7/2).

MAJOR LITHOLOGIES

a) MUD (Smears 2-142, 3-40, 3-110, 4-140)

0- 5% Sand	10-20% Quartz
50-60% Silt	1- 2% Feldspar
35-50% Clay	2- 5% Mica
	0- 1% Heavy minerals
	1- 5% Opaques
	62-83% Clay minerals
	0- 1% Glauconite
	0- 2% Micronodules
	1- 2% Zeolites
	0- 1% Carbonate
	0-10% Nannofossils
	0-TR% Volcanic glass

b) ZEOLITE(?) CLAY (Smear CC)

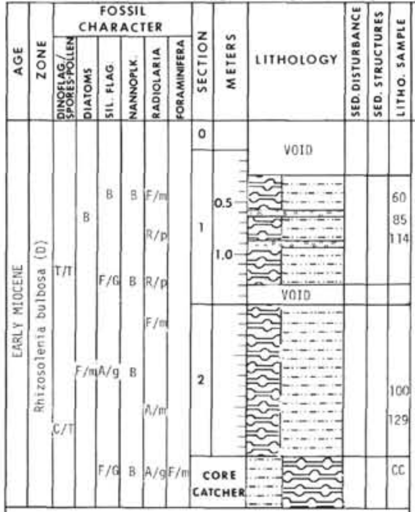
2% Sand	3% Quartz
8% Silt	2% Mica
90% Clay	25% Clay minerals
	10% Hematite platelets
	60% Zeolites

Carbon-Carbonate (DSDP)
2-130 (6.7, 0.7, 0)

Grain Size (DSDP)
2-109 (0.3, 57.6, 42.1)

X-Ray (BP)
2-119
36% Mont.
14% Ill.
25% Kaol.
24% Chlo.
A Quar.
P Micas, Plag.

SITE 345 HOLE CORE 6 CORED INTERVAL: 55.5-65.0 m



LITHOLOGIC DESCRIPTION

5BG 5/2 to
5BG 7/2
5BG 3/2
5BG 5/2
5BG 7/2
N6
5G 6/1

Colors: grayish blue green (5BG 5/2) to pale blue green (5BG 7/2), dusky blue green (5BG 3/2), medium light gray (N6), greenish gray (5G 6/1).

MAJOR LITHOLOGY

SILICEOUS MUD (Smears 1-85, 2-100, 2-129)

5% Sand	1- 5% Quartz
5-10% Silt	0- 1% Feldspar
85-90% Clay	5-10% Mica
	1% Opaques
	0-10% Volcanic glass
	65-78% Clay minerals (including Glauconite)
	TR-20% Diatoms
	0-10% Radiolarians
	2- 3% Sponge spicules

MINOR LITHOLOGIES

a) VOLCANIC ASH (Smears 1-60, 1-114)

70% Sand	2- 5% Quartz
20% Silt	0- 1% Heavy minerals
10% Clay	1-50% Opaques
	45-95% Volcanic glass
	0- 1% Carbonate

b) TRANSITIONAL SILICEOUS OOZE (Smear CC)

5% Sand	3% Quartz
15% Silt	1% Feldspar
80% Clay	2% Mica
	TR% Heavy minerals
	2% Opaques
	5% Volcanic glass
	30% Clay minerals
	57% Diatoms, Radiolarians Sponge spicules

Carbon-Carbonate (DSDP)
2-50 (0.2, 0.2, 0)

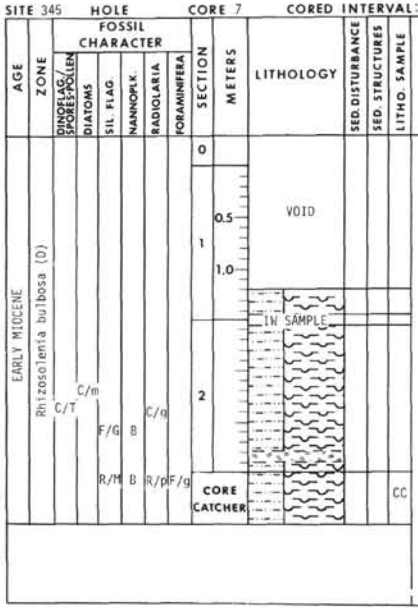
Carbon-Carbonate (PP)
6-1 (top) (0.35, 0.09)
6-1 (bottom) (0.19, 0.06)

Grain Size (DSDP)
2-89 (0.2, 25.7, 74.2)

X-Ray (BP)
45% Mont.
13% Ill.
25% Kaol.
16% Chlo.
P Quar., Micas

Explanatory notes in Chapter 1

SITE 345 **HOLE** **CORE** 7 **CORED INTERVAL**: 74.5-84.0 m



LITHOLOGIC DESCRIPTION

Colors: greenish gray (5G 6/1), pale blue green (5BG 7/2).

MAJOR LITHOLOGY

5BG 7/2

TRANSITIONAL DIATOM OOZE (Smear CC)
3% Sand — 3% Quartz
22% Silt — 2% Mica
75% Clay — 1% Heavy minerals
1% Opaques
TR% Volcanic glass
40% Clay minerals
1% Authigenic carbonate
42% Diatoms
10% Radiolarians

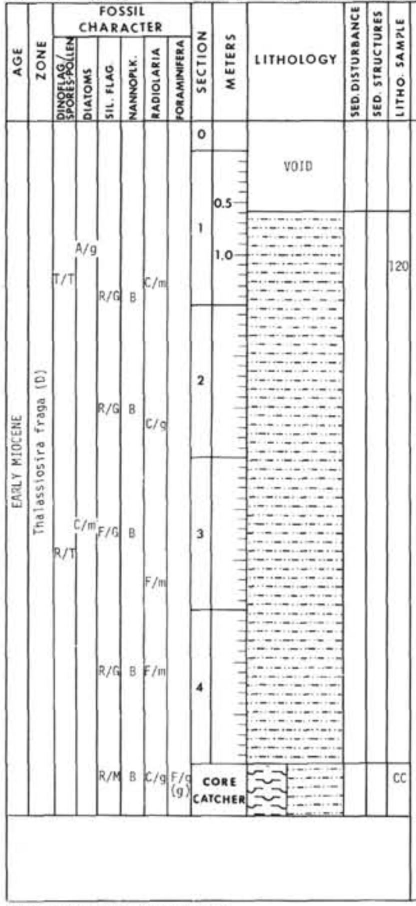
Carbon-Carbonate (DSDP)
2-82 (0.3, 0.3, 0)

Grain Size (DSDP)
2-99 (0.8, 26.1, 73.1)

5G 6/1

X-Ray (BP)
2-59
36% Mont.
20% Ill.
22% Kaol.
21% Chlo.
A Quar.
P Micas
TR% Plag.

SITE 345 **HOLE** **CORE** 8 **CORED INTERVAL**: 93.5-103.0 m



LITHOLOGIC DESCRIPTION

Colors: greenish gray (5G 6/1), medium light gray (N6), grayish blue green (5BG 5/2), dark gray (N3), brownish gray (5YR 4/1).

MAJOR LITHOLOGY

5G 6/1

MUD (Smear 1-120)
1- 5% Sand — 5% Quartz
20% Silt — 1% Feldspar
75% Clay — 5% Mica
1% Opaques
1% Volcanic glass
79% Clay minerals
TR% Glauconite
5% Diatoms
1% Radiolarians
2% Sponge spicules

N6,
5BG 5/2
N3

MINOR LITHOLOGY

DIATOMACEOUS MUD (Smear CC)
5% Sand — 2% Quartz
20% Silt — 1% Feldspar
75% Clay — 5% Mica
TR% Heavy minerals
1% Opaques
2% Volcanic glass
47% Clay minerals
35% Diatoms
5% Radiolarians
2% Sponge spicules

N3

Carbon-Carbonate (DSDP)
3-81 (0.3, 0.4, 0)

N3,
5YR 4/1

Carbon-Carbonate (PP)
8-3 (top) (0.31, 1.61)
8-3 (bottom) (0.34, 0.04)

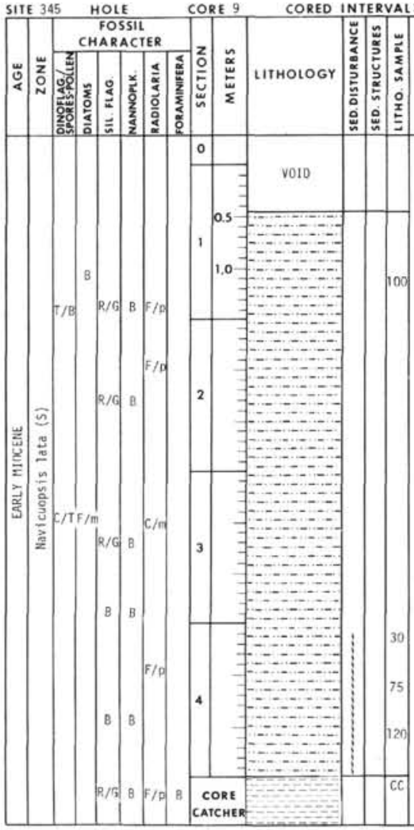
Grain Size (DSDP)
3-79 (0.1, 23.7, 76.1)

5G 6/1

X-Ray (BP)
3-75
29% Mont.
38% Ill.
16% Kaol.
16% Chlo.
A Quar.
P Micas
TR% Plag., Siderite

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 9 CORED INTERVAL: 112.5-122.0 m



LITHOLOGIC DESCRIPTION

Colors: grayish blue green (5BG 5/2), brownish gray (5YR 4/1), grayish orange (10YR 9/4). Some intense deformation.

MAJOR LITHOLOGY

5BG 5/2

5YR 4/1
10YR 9/4

MUD (Smears 1-100, 4-30, 4-75, 4-120)

1- 5% Sand	3- 5% Quartz
10-25% Silt	0- 1% Feldspar
75-80% Clay	2- 5% Mica
	TR% Heavy minerals
	1- 2% Opaques
	1- 3% Volcanic glass
	59-79% Clay minerals
	1- 5% Zeolites
	5-15% Diatoms
	1- 5% Radiolarians
	1- 2% Sponge spicules
	0- 1% Silicoflagellates

MINOR LITHOLOGY

CLAY (Smear CC)

1% Sand	1% Quartz
5% Silt	3% Mica
94% Clay	1% Opaques
	93% Clay minerals
	TR% Diatoms

Carbon-Carbonate (DSDP)
3-85 (0.4, 0.4, 0)

Grain Size (DSDP)
3-89 (0.1, 25.2, 74.7)

5Y 4/1

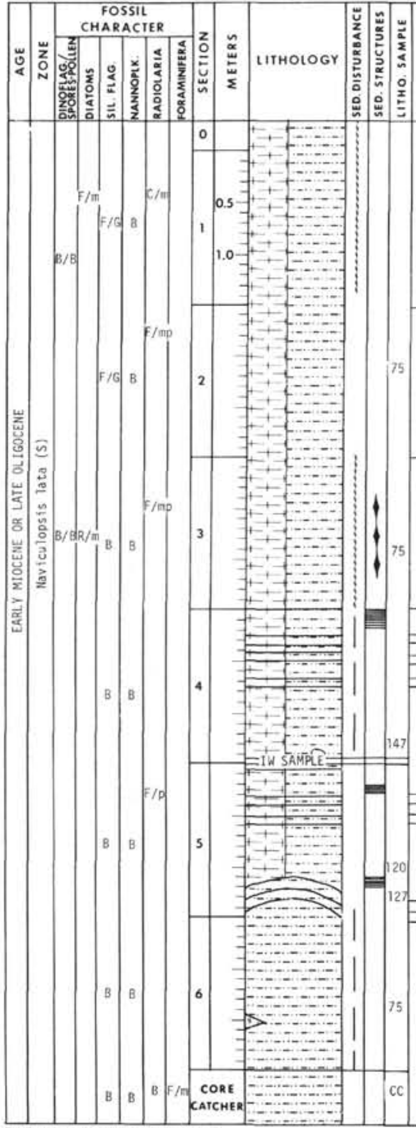
X-Ray (BP)
3-74

5G 6/1

47%	Mont.
21%	Ill.
16%	Kaol.
15%	Chlo.
A	Quar.
P	Micas
TR%	Plag., Siderite

5G 4/1

SITE 345 HOLE CORE 10 CORED INTERVAL: 131.5-141.0 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5G 4/1), greenish gray (5G 6/1), grayish blue green (5BG 5/2), olive gray (5Y 4/1), medium yellow brown (10YR 5/4). Some intense deformation. Brownish gray (5YR 4/1).

5G 4/1
with
5G 6/1

MAJOR LITHOLOGIES

a) MUD (Smears 5-127, 6-75, CC)

0- 5% Sand	5% Quartz
15-20% Silt	3- 5% Mica
80-85% Clay	TR% Heavy minerals
	1- 3% Opaques
	87-89% Clay minerals

5G 4/1

5BG 5/2

b) TRANSITIONAL SILICEOUS (DIATOMACEOUS?) MUD (Smears 2-75, 3-75, 5-120)

3- 5% Sand	2- 3% Quartz
7-12% Silt	1- 5% Feldspar
85-88% Clay	2- 5% Mica
	1% Opaques
	0- 5% Volcanic glass
	62-75% Clay minerals
	0- 1% Glauconite
	2- 5% Zeolites
	5-10% Diatoms
	2- 3% Radiolarians
	4- 5% Sponge spicules

5G 4/1

5Y 4/1

5BG 3/2

5BG 5/2
5BG 5/2
5BG 5/2

5G 4/1
with
5Y 4/1

MINOR LITHOLOGY

FORAMINIFERAL OOZE(?) (Smear 4-147)

10YR 5/4

98% Sand	0- 1% Feldspar
1% Silt	0- 1% Mica
1% Clay	0- 1% Glauconite
	98% Foraminifera(?)

5BG 5/2
with
5G 6/1

Carbon-Carbonate (DSDP)
3-40 (0.4, 0.4, 0)

5G 4/1
5Y 4/1

Carbon-Carbonate (PP)
10-5 (top) (0.32, 0.02)
10-5 (bottom) (0.26, 0.03)

5YR 4/1

Grain Size (DSDP)
3-60 (0.0, 23.8, 76.1)

5GY 4/1

5Y 4/1
streaks of
5YR 4/1

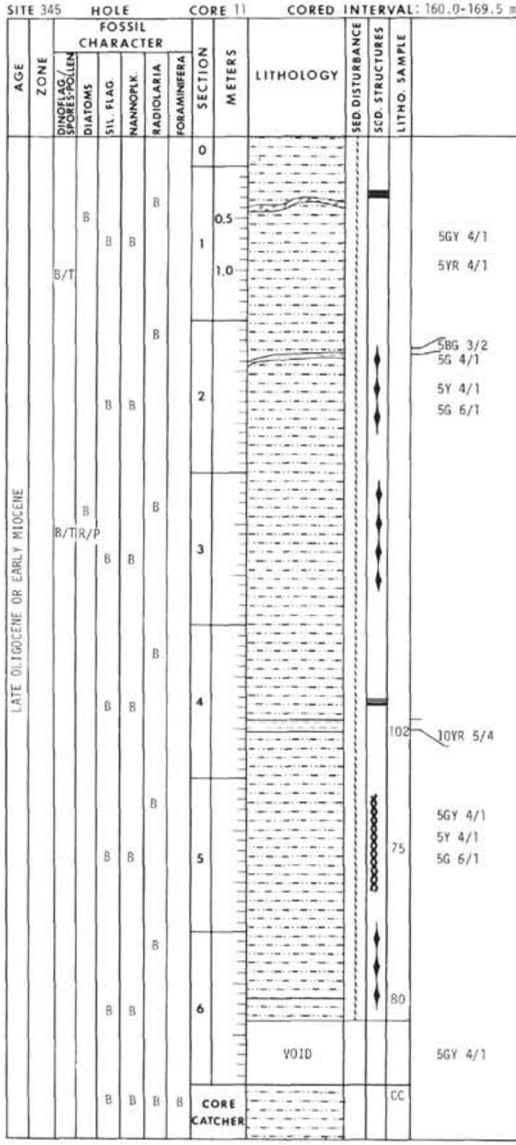
X-Ray (BP)
3-89

28%	Mont.
37%	Ill.
17%	Kaol.
17%	Chlo.
P	Quar., Mica
TR%	Plag., Siderite

5GY 4/1

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 11 CORED INTERVAL: 160.0-169.5 m



LITHOLOGIC DESCRIPTION

Colors: olive gray (5Y 4/1), brownish gray (5YR 4/1), dark greenish gray (5GY 4/1) and (5G 4/1), dusky blue green (5BG 3/2), greenish gray (5G 6/1). Intense deformation. Sec. 5 - composite burrows at 50 cm pyrite nodule at 20 cm. Sec. 6 - pyritized worm burrows and evidence for bioturbation.

MAJOR LITHOLOGY

MUD (Smears 4-102, 5-75, 6-80, CC)

0- 5% Sand	5-10% Quartz
20-30% Silt	0- 2% Feldspar
65-75% Clay	0- 3% Mica
	0- 6% Heavy minerals
	0- 2% Opaques
	80-86% Clay minerals
	0- 1% Glauconite
	0- 4% Zeolites
	0- 1% Authigenic carbonate

MINOR LITHOLOGY

CLAY (Smear 2-35)

2% Sand	3% Quartz
3% Silt	1% Heavy minerals
95% Clay	1% Opaques
	90% Clay minerals
	4% Zeolites

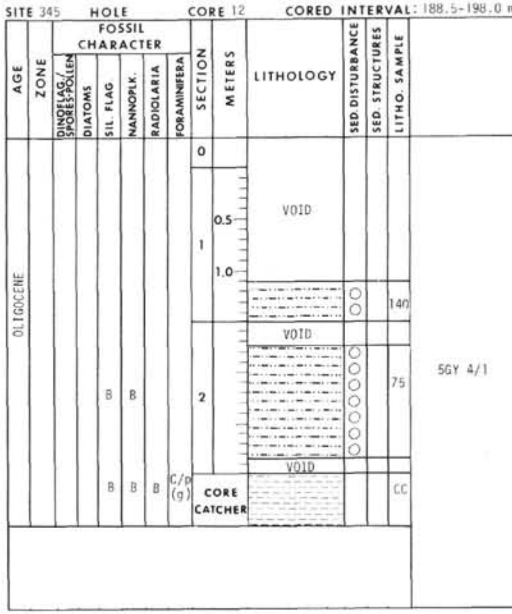
Carbon-Carbonate (DSDP)
3-40 (0.4, 0.4, 0)

Grain Size (DSDP)
3-60 (0.2, 33.3, 66.5)

X-Ray (BP)
3-89

71%	Mont.
13%	111.
8%	Kaol.
6%	Chlo.
A	Quar.
P	Micas
TR%	Plag.

SITE 345 HOLE CORE 12 CORED INTERVAL: 188.5-198.0 m



LITHOLOGIC DESCRIPTION

Color: dark greenish gray (5GY 4/1). Intense deformation, soupy.

MAJOR LITHOLOGY

MUD (Smear 2-75)

5% Sand	1% Quartz
35% Silt	10% Feldspar
60% Clay	1- 2% Mica
	0- 1% Heavy minerals
	2- 3% Opaques
	85% Clay aggregates
	0- 1% Glauconite

MINOR LITHOLOGIES

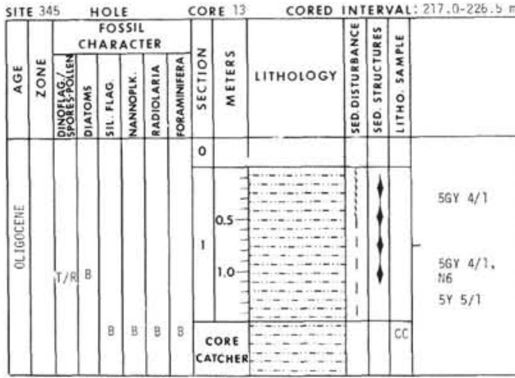
a) SILTSTONE (MUDSTONE) FRAGMENT
(Smear from fragment at 1-140)

10% Sand	1- 2% Quartz
40% Silt	8-10% Feldspar
50% Clay	2% Mica
	0- 1% Heavy minerals
	80-85% Clay aggregates
	2- 3% Opaques

b) TERRIGENOUS CLAY (Smear CC)

3% Sand	0- 3% Quartz
4% Silt	5% Feldspar
93% Clay	0- 3% Mica
	1% Opaques
	91% Clay minerals

SITE 345 HOLE CORE 13 CORED INTERVAL: 217.0-226.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), medium gray (N6), light olive gray (5Y 5/1). Slight to intense deformation. Extensively bioturbated, abundant composite burrows - Helminthoidea, Chondrites?

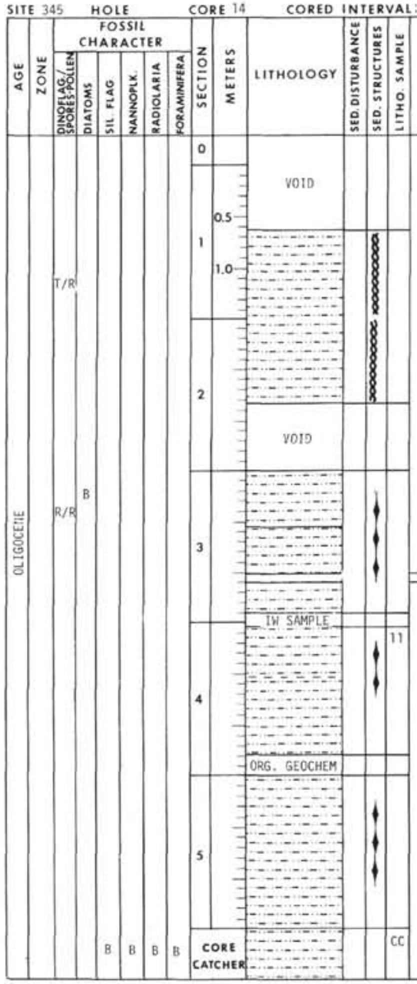
MAJOR LITHOLOGY

MUD (Smear CC)

5% Sand	21% Quartz
20% Silt	1% Feldspar
75% Clay	3% Heavy minerals
	75% Clay minerals

Explanatory notes in Chapter 1

SITE 345 **HOLE** **CORE** 14 **CORED INTERVAL:** 245.5-255.0 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), dusky olive green (5BG 3/2), yellowish gray (5Y 8/1). Some slight deformation. Burrows in Secs. 1 and 2. Helminthoides at 2 (37-38 cm), (31-32 cm), (42-44 cm), (46-47 cm?). Bioturbation, mainly Chondrites? in Sec. 3. Composite burrows in upper 30 cm of Sec. 4. Sec. 5 - intensely bioturbated.

5GY 4/1
5BG 3/2
5GY 4/1
5GY 4/1
5GY 4/1
5GY 4/1
5GY 4/1
5Y 8/1

MAJOR LITHOLOGY

MUD (Smears 4-11, CC)

0- 5% Sand	12-20% Quartz
20-30% Silt	1- 2% Feldspar
65-75% Clay	7- 8% Heavy minerals
	70-80% Clay minerals

Carbon-Carbonate (DSDP)
3-10 (0.5, 0.5, 0)

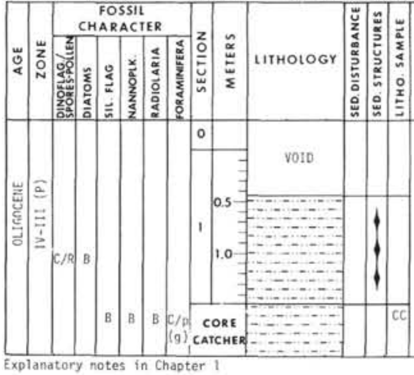
Carbon-Carbonate (PP)
14-4 (top) (0.51, 0.13)
14-4 (bottom) (0.58, 0.13)

Grain Size (DSDP)
3-20 (0.6, 38.2, 61.2)

X-Ray (BP)
3-30

67%	Mont.
23%	Ill.
4%	Kaol.
5%	Chlo.
P	Quar., Micas
TR%	Plag.
?	Gyps.

SITE 345 **HOLE** **CORE** 15 **CORED INTERVAL:** 293.0-302.5 m



LITHOLOGIC DESCRIPTION

Color: dark greenish gray (5GY 4/1). Bioturbation throughout section, composite burrows (some Chondrites?). At 145 cm prominent halo burrow.

5GY 4/1

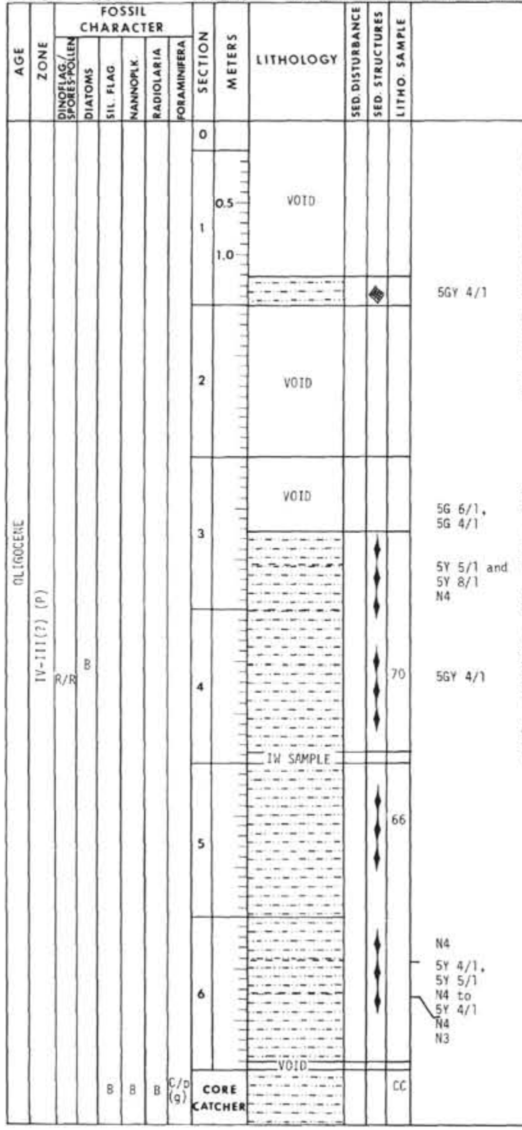
MAJOR LITHOLOGY

MUD (Smear CC)

10% Sand	12% Quartz
10% Silt	1% Feldspar
80% Clay	7% Heavy minerals
	80% Clay minerals

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 16 CORED INTERVAL: 331.0-340.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), olive gray (5Y 5/1), yellowish gray (5Y 8/1), greenish gray (5G 6/1), light olive gray (5Y 5/1), olive black (5Y 2/1), medium dark gray (N4), dark gray (N3). Fragments of mudstone in Sec. 1; variegated, bioturbated mudstone in Sec. 3; bioturbated (Sec. 4); bioturbated (Sec. 5) and volcanic ash(?) through Sec. 5; bioturbated (Helminthoidea?) in Sec. 6.

MAJOR LITHOLOGY

MUD (Smear 4-70, 5-66, CC)

2- 5% Sand	5-15% Quartz
30-40% Silt	1- 2% Feldspar
55-68% Clay	1% Mica
	3- 7% Heavy minerals
	0-25% Volcanic ash(?)
	60-80% Clay minerals
	0- 1% Volcanic glass
	0- 1% Palagonite

Carbon-Carbonate (DSDP)
4-35 (0.6, 0.0, 5)

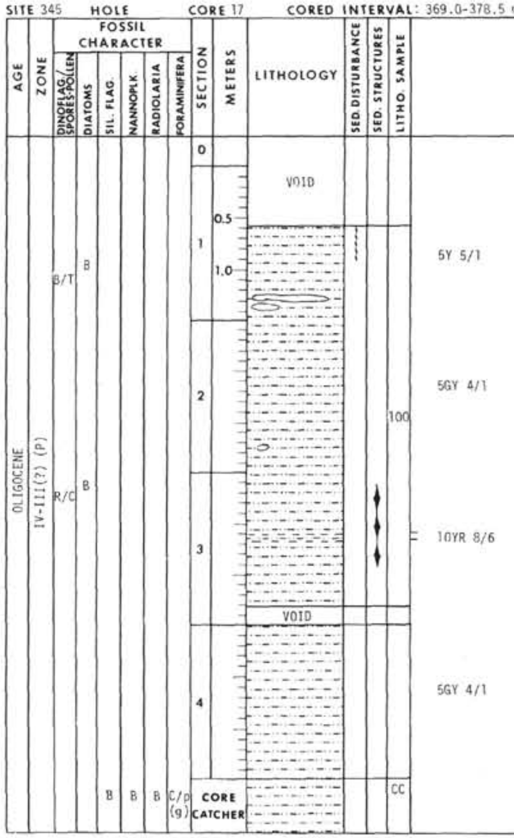
Carbon-Carbonate (PP)
16-4 (top) (0.49, 0.07)
16-4 (bottom) (0.38, 0.04)

Grain Size (DSDP)
4-40 (2.3, 46.3, 51.4)

X-Ray (BP)
4-44

49%	Mont.
30%	Ill.
11%	Kaol.
8%	Chlo.
A	Quar.
P	Micas
TR%	Plag., Calc.

SITE 345 HOLE CORE 17 CORED INTERVAL: 369.0-378.5 m



LITHOLOGIC DESCRIPTION

Colors: olive gray (5Y 5/1), greenish gray (5GY 4/1), pale yellowish orange (10YR 8/6). Some intense deformation. Calcareous concretions Sec. 1; pyrite nodule, Sec. 2; bioturbated zone in Sec. 3.

MAJOR LITHOLOGY

MUD (Smears 2-100, CC)

1- 5% Sand	7-18% Quartz
30-40% Silt	0- 1% Feldspar
55-69% Clay	0- 8% Heavy minerals (including Mica)
	0- 2% Opaques
	TR% Volcanic glass
	73-90% Clay minerals
	TR% Glauconite
	TR% Palagonite
	TR% Fecal pellets
	TR% Zeolites

Carbon-Carbonate (DSDP)
3-65 (0.7, 0.4, 3)

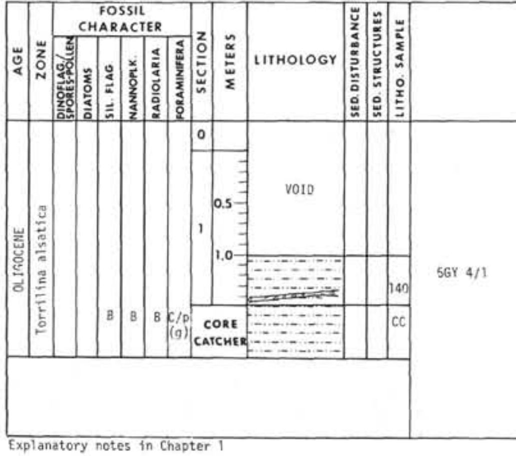
Carbon-Carbonate (PP)
17-3 (top) (0.03, 0.02)
17-3 (bottom) (0.23, 0.04)

Grain Size (DSDP)
3-79 (1.1, 41.5, 57.4)

X-Ray (BP)
3-74

68%	Mont.
16%	Ill.
8%	Kaol.
6%	Chlo.
A	Quar.
TR%	Plag.
P	Micas

SITE 345 HOLE CORE 18 CORED INTERVAL: 407.0-416.5 m



LITHOLOGIC DESCRIPTION

Color: dark greenish gray (5GY 4/1).

MAJOR LITHOLOGY

MUD (Smear CC)

7% Sand	10% Quartz
30% Silt	2% Feldspar
63% Clay	2% Mica
	TR% Heavy minerals
	2% Opaques
	3% Volcanic glass
	66% Clay minerals
	15% Authigenic carbonate (dolomite?)
	TR% Sponge spicules

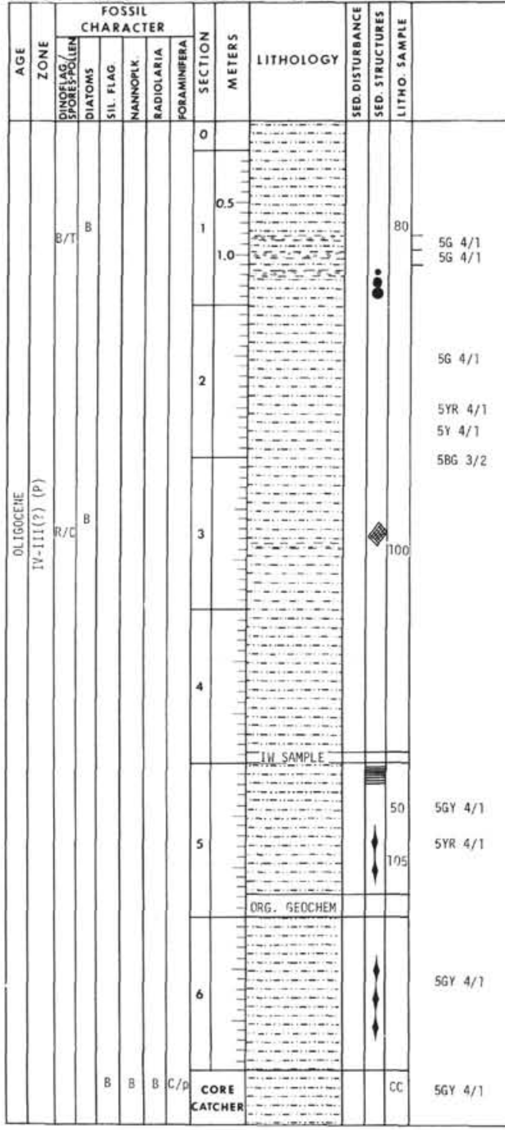
MINOR LITHOLOGY

ALTERED ASH (Smear 1-140)

100% Clay	100% Altered ash

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 19 CORED INTERVAL: 445.0-454.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5G 4/1), brownish gray (5YR 4/1), olive gray (5Y 4/1), light olive gray (5Y 5/1), dusky blue green (5BG 3/2). Little or no deformation. Ash beds in Sec. 1 at 80 cm, 55-98 cm, 114-116 cm, the last two graded. Secs. 5 and 6 with extensive bioturbation.

MAJOR LITHOLOGY

MUD OR MUDSTONE (Smears 3-100, 5-50, 5-105, CC)

5% Sand	5- 7% Quartz
35% Silt	1% Feldspar
60% Clay	3- 7% Mica
	TR- 1% Heavy minerals
	76-80% Clay minerals
	2- 3% Volcanic glass
	0- 2% Palagonite
	TR% Glauconite
	0- 3% Micronodules
	0- 2% Carbonate

MINOR LITHOLOGY

TERRIGENOUS CLAY (ALTERED VOLCANIC ASH) (Smear 1-80)

4% Sand	TR% Quartz
5% Silt	5% Feldspar
91% Clay	1% Mica
	2% Heavy minerals
	1% Opaques
	91% Clay minerals

Carbon-Carbonate (DSDP)
2-75 (0.4, 0.3, 1)

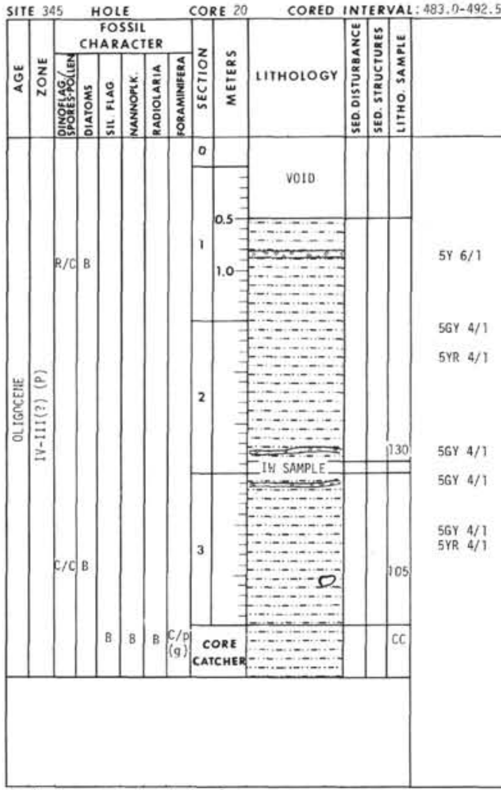
Carbon-Carbonate (PP)
19-5 (top) (0.42, 0.08)
19-5 (bottom) (0.40, 0.04)

Grain Size (DSDP)
2-45 (1.6, 43.4, 55.0)

X-Ray (BP)
2-75

50%	Mont.
30%	Ill.
5%	Kaol.
13%	Chlo.
A	Quar.
P	Plag., Micas

SITE 345 HOLE CORE 20 CORED INTERVAL: 483.0-492.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), brownish gray (5YR 4/1), yellow gray (5Y 6/1). Carbonate concretion Sec. 3 (105 cm).

MAJOR LITHOLOGY

MUD-MUDSTONE (Smear CC)

2- 5% Sand	7% Quartz
30-40% Silt	2% Feldspar
55-69% Clay	10% Mica
	1% Heavy minerals
	5% Opaques
	5% Devitrified glass
	TR% Glauconite
	5% Carbonate
	65% Clay minerals

MINOR LITHOLOGIES

a) CARBONATE CONCRETION (Smear 3-105)

10% Silt	5% Quartz
90% Clay	95% Authigenic carbonate

b) VOLCANIC ASH (Smear 2-130)

1% Sand	TR% Quartz
2% Silt	3% Feldspar
97% Clay	97% Devitrified ash(?)

Carbon-Carbonate (DSDP)
3-20 (0.4, 0.3, 0)

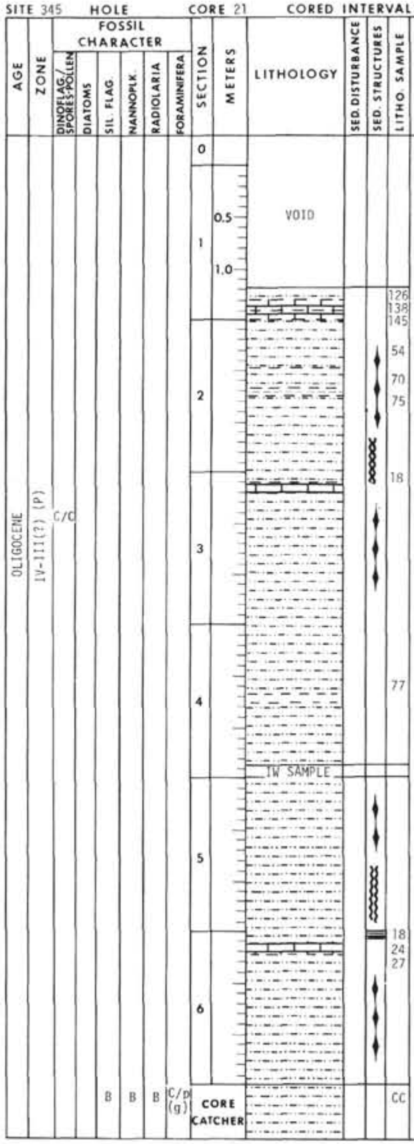
Grain Size (DSDP)
3-70 (2.4, 43.8, 53.7)

X-Ray
3-14

59%	Mont.
26%	Ill.
6%	Kaol.
7%	Chlo.
A	Quar.
P	Micas, Plag.

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 21 CORED INTERVAL: 521.0-530.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), light olive gray (5Y 5/1), brownish gray (5YR 4/1), very dusky purple (5P 2/2). Sec. 1 - drill blocks lithified mudstone, limestone, burrowed; Sec. 2 - basic section is mudstone, extensive bioturbation (composite, Halo, *Zoophycus*) all subhorizontal burrows; (50-75 cm) - turbidite bed, Bouma ADE (possibly A-E); Sec. 3 - mudstone as per Sec. 2 - with extensive burrows: (1) *Scolithus* - white, calcareous (0.1-0.5 mm); (2) inclined to subhorizontal, dark filled = *Zoophycus*(?); (3) compressed ellipsoidal (1-5 mm), *Chondrites*(?), also elongate (1-3 mm diam.); (4) *Helminthoida*; (5) rind burrows; Sec. 4 - massive mudstone, *Zoophycus*, possibly reburrowed; Sec. 5 - Massive mudstone, worm tubes; Sec. 6 - massive mudstone with possible tectonic fault at 10-20 cm; contorted calcite mass = rip-off breccia (10-20 cm) - thin - very thinly interstratified (20-30 cm) - massive siltstone with fault?, (30-150 cm) - bioturbated mudstone, irregular burrows; *Teichichnus* burrows.

5GY 4/1
5YR 4/1

MAJOR LITHOLOGY

MUDSTONE (Smears 2-54, 2-75, 6-24, 6-27, CC)

0-10% Sand	1-18% Quartz
7-40% Silt	2-15% Feldspar
60-83% Clay	1- 2% Mica
	1- 5% Heavy minerals
	75-88% Clay minerals
	1- 2% Opaques

OTHER LITHOLOGIES NOTED

LIMESTONE (Smear 1-138) (=Dolomite);
(Smears 1-126, 1-145, 3-18, 6-18)
CLAYSTONE (Smear 2-70)
VOLCANIC ASH (Smear 4-77)

Carbon-Carbonate (DSDP)
3-8 (0.4, 0.3, 0)

Carbon-Carbonate (PP)
21-5 (top) (0.29, 0.05)
21-5 (bottom) (0.27, 0.03)

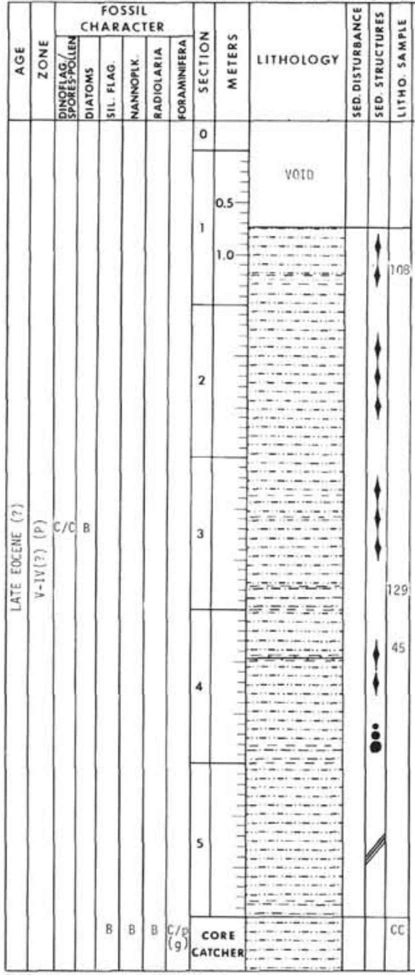
Grain Size (DSDP)
3-3 (1.6, 43.9, 54.5)

X-Ray (BP)
3-6

78%	Mont.
9%	Ill.
6%	Kaol.
6%	Chlo.
A	Quar.
P	Micas
TR%	Plag.

5GY 4/1

SITE 345 HOLE CORE 22 CORED INTERVAL: 559.0-568.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), olive black (5Y 2/1), pale yellow brown (10YR 6/2), very pale orange (10YR 8/2), medium gray (N5). Sec. 1 - mudstone, abundant burrows (rind, tubes); Sec. 2 - mudstone, irregular bioturbation; Sec. 3 - mudstone bioturbated; (35-55 cm) - significant brown-orange colors; Sec. 4 - bioturbated mudstone with graded sandy mud at 130-150 cm = distal turbidite; Sec. 5 - bioturbated mudstone, with x-stratified sand/silt mudstone at 135 cm.

5GY 4/1
5Y 2/1

MAJOR LITHOLOGIES

5GY 4/1

a) SANDY MUDSTONES (Smears 3-129, CC)

40% Sand	20% Quartz
20% Silt	10% Feldspar
40% Clay	25% Mica
	45% Clay minerals

b) MUDSTONES

MINOR LITHOLOGIES

10YR 6/2
10YR 8/2

a) CLAYSTONE (Smear 1-108)
b) LIMESTONES(?) (Smear 4-45)

X-Ray (BP)
3-53

83%	Mont.
12%	Ill.
P	Quar.

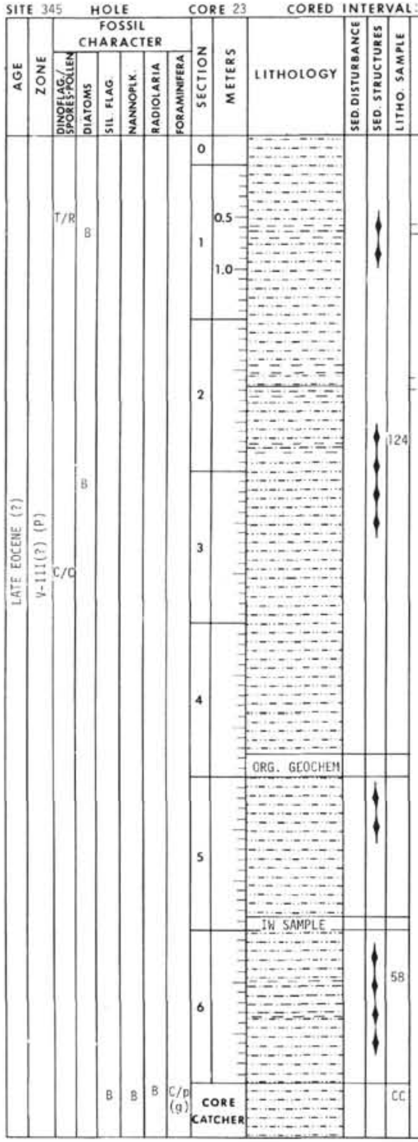
N5

5GY 4/1
5Y 2/1

5GY 4/1

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 23 CORED INTERVAL: 597.0-606.5 m



LITHOLOGIC DESCRIPTION

5Y 5/1

5GY 4/1
5Y 2/1

5Y 8/1

5GY 4/1
5Y 2/1

5GY 4/1
5Y 2/1

5GY 4/1
5Y 2/1
N5

5GY 4/1

Colors: dark greenish gray (5GY 4/1), olive black (5Y 2/1), light olive gray (5Y 5/1), yellowish gray (5Y 8/1), medium gray (N5). Massive mudstone with extensive bioturbation throughout, unconf. at 2-7 - rip-up clasts.

MAJOR LITHOLOGY

MUDSTONE (Smear CC)

10% Sand	30% Quartz
30% Silt	2% Feldspar
60% Clay	8% Heavy minerals
	60% Clay minerals
	TR% Palagonite, Glauconite, Diatoms

MINOR LITHOLOGIES

a) VOLCANIC ASH (Smear 2-124)

20% Sand	20% Quartz
20% Silt	10% Feldspar
60% Clay	20% Opaques
	50% Devitrified glass

b) SANDY MUDSTONE (Smear 6-58)

50% Sand	3- 5% Quartz
30% Silt	35-40% Feldspar
20% Clay	30% Biotite
	3% Heavy minerals
	8% Opaques
	20% Clay minerals

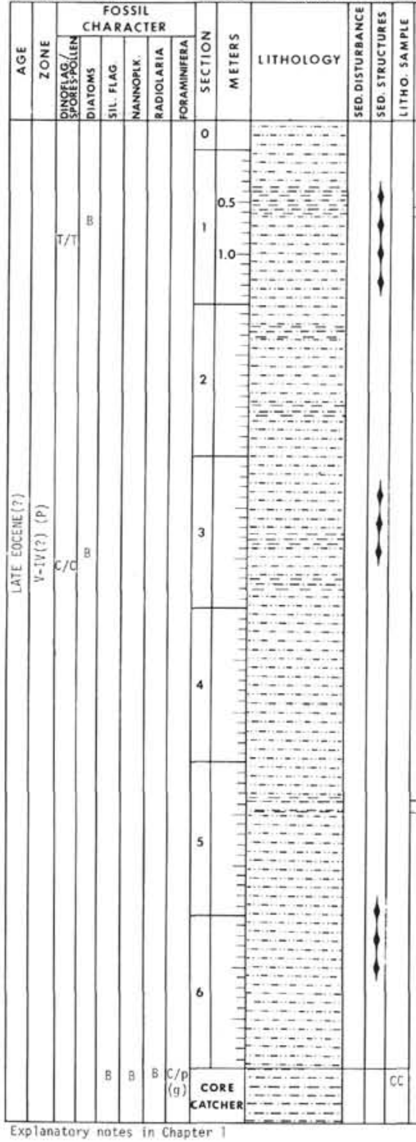
Carbon-Carbonate (DSDP)
4-35 (0.4, 0.4, 1)

Carbon-Carbonate (PP)
23-4 (top) (0.63, 0.03)
23-4 (bottom) (0.36, 0.04)

X-Ray (BP)
3-88

87%	Mont.
8%	Ill.
A	Quar.
P	Micas
TR%	Plag.

SITE 345 HOLE CORE 24 CORED INTERVAL: 635.0-644.5 m



LITHOLOGIC DESCRIPTION

10YR 7/4

5GY 4/1
5Y 2/1

10YR 7/4

5GY 4/1
5Y 2/1

5GY 4/1

Colors: dark greenish gray (5GY 4/1), olive black (5Y 2/1), grayish orange (10YR 7/4), yellow brown (10YR 5/4). Color graded zone (25-30 cm, Sec. 2) with pale green, gray black, green shades (also at 100-110). Extensive bioturbation, halo burrows. A&E sequence in "0" Section, Sec. 1 - 30 cm, 120 cm; ABE - Sec. 2 (25-30, 95-105 cm); DE - (75-80 cm), in Sec. 3 and 125-130 in Sec. 3.

MAJOR LITHOLOGIES

a) MUDSTONE

b) SANDY MUDSTONE/MUDSTONE (Smear CC)

10-30% Sand	1- 2% Quartz
40% Silt	15% Feldspar
30-50% Clay	2- 3% Mica
	1- 2% Heavy minerals
	2- 3% Opaques
	75% Clay minerals
	1% Glauconite

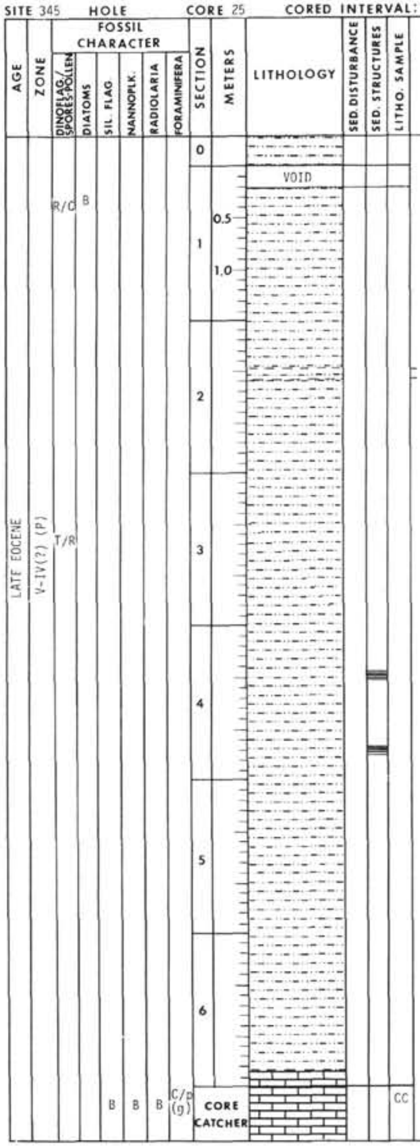
Carbon-Carbonate (DSDP)
3-123 (0.4, 0.3, 1)

X-Ray (BP)
3-124

86%	Mont.
8%	Ill.
A	Quar.
P	Micas
TR%	Plag.

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 25 CORED INTERVAL: 673.0-682.5 m



5Y 5/1

5GY 4/1
5Y 2/1

5G 6/1

5GY 6/1

LITHOLOGIC DESCRIPTION

Colors: greenish gray (5GY 6/1), dark greenish gray (5GY 4/1), olive black (5Y 2/1), light olive gray (5Y 5/1). Unconf. Sec. 3 (100 cm), Sec. 4 has thin laminations.

MAJOR LITHOLOGY

MUDSTONE

MINOR LITHOLOGY

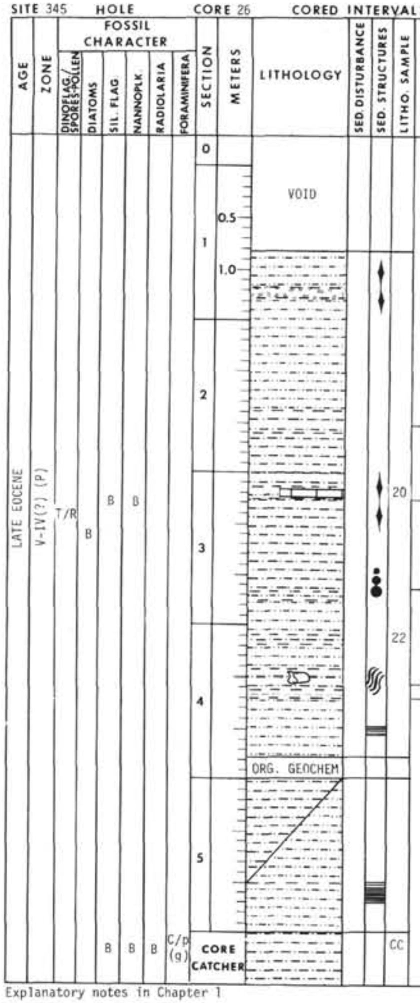
LIMESTONE (Smear CC)

40% Silt	98% Carbonate
60% Clay	0- 1% Feldspar
	0- 1% Mica

Carbon-Carbonate (DSDP)
2-58 (0.7, 0.4, 2)

X-Ray (BP)
2-42
35% Mont.
28% Ill.
17% Kaol.
18% Chlo.
A Quar.
P Micas
TR% Plag.

SITE 345 HOLE CORE 26 CORED INTERVAL: 682.5-692.0 m



5GY 4/1
5Y 2/1

5G 6/1

5G 6/1

5GY 4/1
5Y 2/1

5BG 7/2

5GY 4/1
5Y 2/1

5GY 4/1

LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), olive black (5Y 2/1), greenish gray (5G 6/1). Massive mudstone with extensive bioturbation. Some scattered laminae/graded laminae (Sec. 1, 87-150); calcareous units (Sec. 3, 13-130 cm); Sec. 4 - rip-up, distorted beds, siderite(?) concretion, finely laminated beds (color laminations); Sec. 5 - fine laminations at 102-150 cm. Turbidites: Sec. 2 - DE (70-75 cm), DE (90-110 cm); Sec. 3 - Bouma A-E, flutes, load casts, ss at base, (0-30 cm) - composite at 30-120 cm - DE sequence graded; DE (120-130 cm); Sec. 4 - DE (15-25 cm), BCDE (55-70 cm).

MAJOR LITHOLOGIES

a) MUDSTONES

b) SANDY MUDSTONES (Smears 4-22, CC)

10-25% Sand	10-20% Quartz
35% Silt	2% Feldspar
40-55% Clay	10% Mica (Chlorite?)
	1- 2% Opaques
	3- 5% Glass (Volcanic)
	64-70% Clay minerals
	TR% Glauconite

MINOR LITHOLOGY

MUDDY LIMESTONE (Smear 3-20)

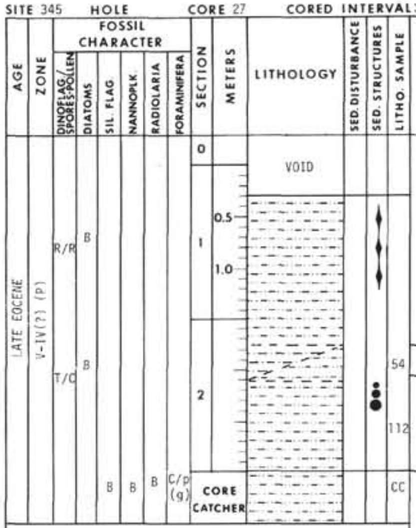
5-15% Sand	5-10% Quartz
5-25% Silt	1% Feldspar
60-90% Clay	0- 1% Mica
	0- 1% Heavy minerals
	30-47% Clay minerals
	40-64% Carbonate

Carbon-Carbonate (PP)
26-4 (top) (0.29, 0.02)
26-4 (bottom) (0.22, 0.02)

X-Ray (BP)
3-57
83% Mont.
16% Ill.
TR% Quar.
TR% Micas

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 27 CORED INTERVAL: 711.0-720.5 m



LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1), olive gray (5Y 4/1), brownish gray (5GY 4/1). Generally massive bioturbated mudstone. Sec. 2 (25-55 cm) - turbidite units, DE (Bouma) zones - graded, siltstone, siltstone-mudstone.

5GY 4/1
5Y 4/1
5GY 4/1

MAJOR LITHOLOGIES

a) SANDY MUDSTONES (Smear 2-54)

40% Sand	7% Quartz
30% Silt	45% Opaques(?)
30% Clay	3% Volcanic glass
	30% Clay minerals
	15% Carbonate

5GY 4/1
5Y 4/1
5GY 4/1

b) MUDSTONES (Smears 2-112, CC)

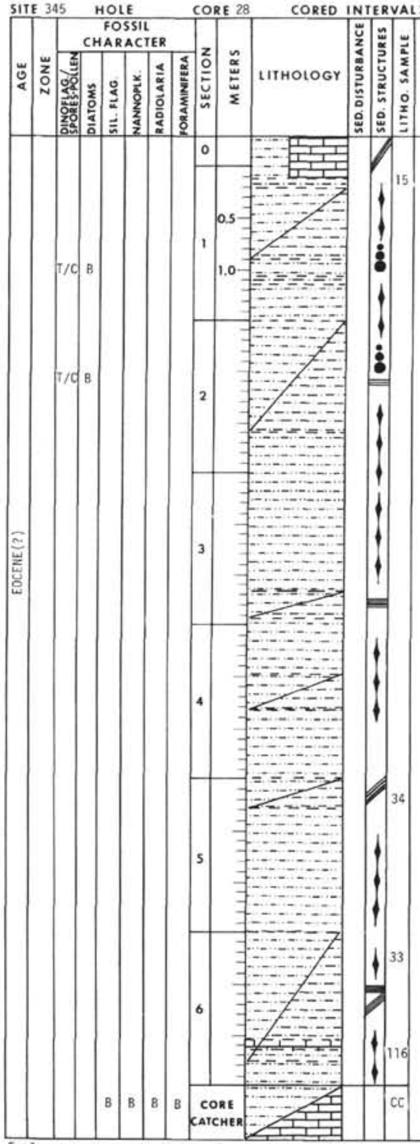
5% Sand	5% Quartz
25% Silt	0- 1% Feldspar
70% Clay	5% Mica
	TR% Heavy minerals
	2% Opaques
	85-86% Clay minerals
	1% Micronodules
	1% Carbonate

5GY 4/1

Carbon-Carbonate (DSDP)
2-52 (1.6, 0.1, 13)

X-Ray (BP)
2-78
75% Mont.
17% Ill.
A Quar.
P Micas
TR%? Plag.

SITE 345 HOLE CORE 28 CORED INTERVAL: 720.5-730.0 m



LITHOLOGIC DESCRIPTION

Colors: greenish gray (5G 6/1), olive gray (5Y 4/1), dark greenish gray (5GY 4/1), medium gray (N6), light bluish gray (5B 7/1), light gray (N7). Sec. 0 (5Y 5/1) - calcareous turbidite (C,D,E units, cross beds); Sec. 1 (0-10 cm) - base of calc. turbidite of "0" Sec.; (10-20 cm) - bioturbated mudstone; (20-90 cm) - turbidite sections, EDC, EDA, ED, EDA; graded, load casts, rip-up clasts; (90-150 cm) - massive bioturbated mudstone; Sec. 2 (0-110 cm) - turbidite sequences (EDA, EDC, ED with pyrite nodule, ED, D or B, and EDB), graded, parallel stratification; massive bioturbated mudstone; (110-150 cm) - rind burrows; Sec. 3 (0-120) - massive bioturbated mudstone; (120-150) - // stratified siltstone (sandy mudstone→mudstone→claystone) DE units, not clear graded; Sec. 4 (0-50, 85-150) - massive bioturbated mudstone 85-150 cm unit may be top of turbidite sequence in Sec. 4; turbidite? (DE) 50-85 cm; Sec. 5 (0-30 cm) - calcareous turbidite sequence = base of unit in Sec. 4 - contorted x-bed; (30-150) - massive bioturbated mudstone; Sec. 6 (0-10) - massive bioturbated mudstone; (10-130) - turbidite sequences E, D, CBA, EDCB, ED, EDCA, EA, ED, EDCA, EDC), parallel stratification x-beds, flute-groove casts; (130-150 cm) - massive bioturbated mudstone.

5Y 4/1
5B 7/1
5GY 4/1

MAJOR LITHOLOGIES

a) SANDY MUDSTONES (Smears 1-15, 5-34, 6-33)

40% Sand	5-25% Quartz
10% Silt	2% Feldspar
50% Clay	3-10% Mica
	0- 1% Heavy minerals
	2- 3% Opaques
	63-73% Clay minerals
	0-10% Glauconite
	5-10% Carbonate

b) MUDSTONES (Smear CC)

5G 6/1

MINOR LITHOLOGY

(MUDDY) LIMESTONE (Smears 6-116, CC)

5GY 4/1
5G 6/1
5Y 4/1

Carbon-Carbonate (DSDP)
3-80 (0.3, 0.3, 0)

Grain Size (DSDP)
2-60 (3.8, 44.5, 51.7)
4-84 (37.8, 10.1, 52.1)

N7

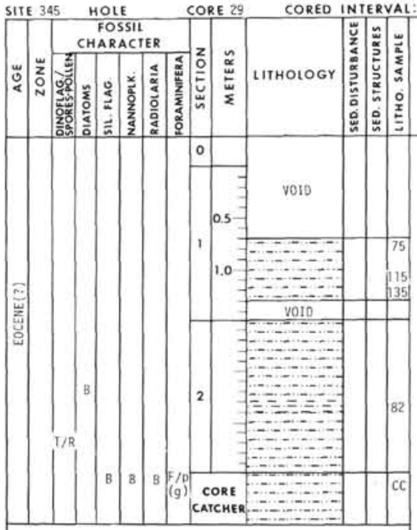
X-Ray (BP)

2-64		2-149	
91%	Mont.	60%	Mont.
5%	Ill.	31%	Ill.
A	Quar.	A	Quar.
P	Micas	P	Micas
TR%	Plag.	TR%	Plag., Gyps.

5G 6/1

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 29 CORED INTERVAL: 730.0-739.5 m



5GY 4/1

LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1).

Sec. 1 (67-137 cm) - Turbidite sandstone-mudstone bed about 60 cm thick, forms Bouma ACDE sequence; E unit - massive, unbioturbated dark greenish gray (5GY 4/1) mudstone different than typical bioturbated olive gray mudstone below and above of hemipelagic origin; D unit - very thinly interlaminated to very thinly interstratified fine-grained - very fine grained sandstone, siltstone, and mudstone; sandstone 10% of unit, in laminae <4 mm thick, medium gray (N5), mudstone dark greenish gray (5GY 4/1); C unit - thin ripple x-stratified fine→very fine sandstone, amplitude 0.8 cm, length 1.5 cm, incline <30°; medium dark gray (N4); migrating current ripples; A unit - coarse→medium sandstone at base with subangular mudstone rip-up clasts up to 1 cm in diam. from bed below; medium gray (N5); large rip-up clast near base extending completely across core, may be (1) ripped by turbidity current off bottom, (2) underlying sandstone intruded as a sill into mudstone, (3) part of flame structure of mudstone up into sandstone during load casting activity. Cannot tell from core which one, or combination of 3 caused "rip-up"; olive gray (5Y 4/1) bioturbated mudstone; tubes, burrows extremely flattened, appears to be laminated because of compaction.

Sec. 2 - olive black (5Y 2/1), massive, extensive bioturbated mudstone, rind burrows. Zoophycus - silty laminae at 82 cm, 2 cm thick = DE(?) sequence.

MAJOR LITHOLOGIES

a) MUDSTONE (Smears 1-75, CC)

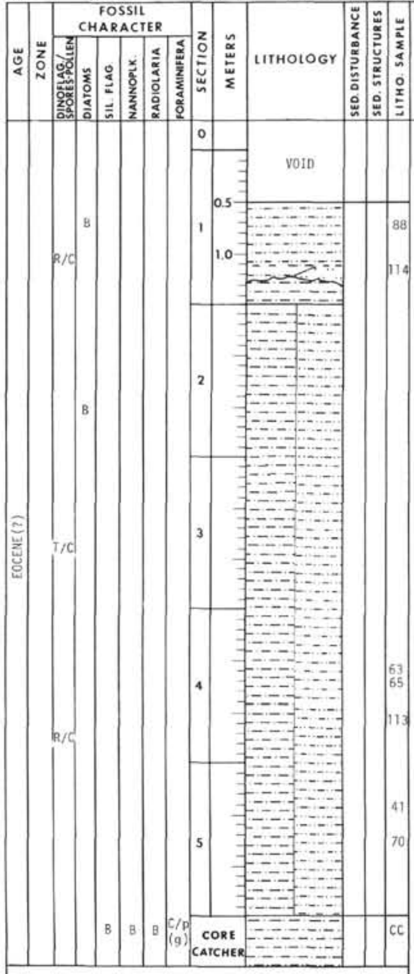
5%	Sand	7-10%	Quartz
20-35%	Silt	2%	Feldspar
60-75%	Clay	5%	Mica
		2- 5%	Opaques
		74-86%	Clay minerals
		TR%	VOlcanic glass
		TR- 2%	Micronodules
		0- 2%	Carbonate

b) SANDY MUD (MUDDY SAND) (Smears 1-115, 1-135, 2-82)

Carbon-Carbonate (PP)
29-1 (top) (0.35, 0.05)
29-1 (bottom) (0.53, 0.01)

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 30 CORED INTERVAL: 739.5-749.0 m



LITHOLOGIC DESCRIPTION

Colors: brownish gray (5YR 4/1), dark greenish gray (5GY 4/1), olive black (5Y 2/1).

Sec. 1 (50-110, 125-150 cm) - massive mudstone, extensive bioturbation. Subhorizontal burrows, some pyrite-filled, no bioturbation (125-150 cm); 110-150 cm) = turbidite sequence, sandstone-mudstone unconformable basal contact, upward grading.

5GY 4/1
5Y 2/1

Sec. 2 (0-25 cm) - lower part of graded turbidite; upper part in base of 30-1 (mudstone-claystone); basal massive fine-medium sandstone 2 cm thick, medium gray (N6) overlying ∥ laminated (very thin, <0.1 mm) very fine-fine sandstone, 7 cm thick, medium dark gray (N4); overlying massive, unbioturbated, possibly some small cross beos (amp 0.4 cm) grading up into very fine ss, siltstone, mudstone, olive black (5Y 2/1); (25-33 cm) graded turbidite unit; upper 7 cm massive mudstone-claystone, E unit; (33-73 cm) parallel stratified and irregularly stratified, very fine, fine, medium, and locally coarse-grained sandstone; above 50 cm, abundant thin mudstone-claystone laminae <1.0 cm thick; finer grain sizes in upper part of unit; large burrows or possibly dikes (irregular shape) at 60-62 cm filled with medium-grained sandstone; DBA units; (73-78 cm) basal unit of irregularly len-shaped fine-medium grained sandstone in mudstone; either bioturbated, brecciated, or depositional gradational with burrows or load casts; (78-100 cm) - large, thick, turbidite-grain flow(?) deposit extending downward into 30-3; (1) upper 20 cm thinly to very thinly laminated mudstone-claystone with moderate yellowish brown (10YR 5/4) and pale yellowish brown (siderite? or rhodochrosite?-bearing ∥ laminated unit from 85-92 cm; D unit; (100-150 cm) middle unit, 100 cm-150 cm, mixed up, disrupted unit that may be a composite turbidite, containing abundant claystone and mudstone, rip-up clasts and possibly lenses of mudstone fine to coarse-grained sandstone matrix; rip-up clasts locally deformed, contorted; clastic pebbles of quartz also scattered, A and C unit; lower 15 cm probably x-stratified amplitudes up to 5 cm.

Sec. 3 - continued mixed up, disrupted units, claystone, mudstone clasts, clastic pebbles (round), quartz (1 cm diameter), poss. cross beds, dish. structures. A & C units - poor sorted medium grained sand, mud. Grade to coarse sand at 105-109 cm. (110-150) - very thin stratified mud/stone, claystone, olive black (5Y 2/1), bioturb. *Zoophycus* burrows. Smear at 3-117 = mudstone.

Sec. 4 (0-15 cm) - olive black (5Y 2/1) mudstone grading down to fine- to coarse-grained sandstone, unconformable or underlying mudstone-claystone; one large rounded quartz pebble at 8 cm, 1.1 cm diameter; (15-30 cm) - thick coarse-grained turbidite unit that includes parallel-stratified and massive conglomeratic, coarse- to very coarse-grained sandstone, thin olive black (5Y 2/1) parallel stratified claystone mudstone with mudstone, strata 0.2 mm to 3 cm thick, D and E unit; (30-103 cm) - diffused parallel laminated medium- to very coarse-grained and granule-sized conglomeratic sandstone; no shale rip-ups, all clastic sand-sized material; laminae defined by textural and color variations; Scolithus at 31 cm, undoubtedly as a clast; scattered pebbles of quartz, feldspar(?), chert(?), volcanic lithics mafic fragments(?); rounded and definitely clastic, reworked. Lower 15 cm relatively massive, probably Bouma A unit; erosional base, possibly flute or channel into underlying sandy mudstone; (103-115 cm) - bioturbated pebbly, sandy, mudstone; sand grains within elongate subhorizontal lens-shaped burrows within olive black (5Y 2/1) sandy, probably mudstone; (115-120 cm) cgl, cs sandstone, medium gray (N5) at base, 1 cm thick, pebbles up to 3 mm, micaceous, overlain by sandy, massive mudstone 3-4 cm thick, E,A unit; (120-130 cm) basal medium dark to dark gray (N4-N3) cgl sandstone with 1-2 mm granule grading up into parallel stratified + laminated very fine ss, siltstone, mudstone; sandy, pebbly (<4 mm) massive mudstone, unstratified and unlayered, scattered pebbles and sand grains, no current-formed sed structures, probably intensely bioturbated. Probably poorly sorted, bimodally or polymodally distributed mudstone without pebbles lowest 3 cm.

Sec. 5 (0-20 cm) - fine pebbly mudstone, rounded quartz, lithic, and feldspar(?) clasts <3 mm massive, no stratification, no visible burrows or sed structures; base unconformable and channeled into underlying mudstone; generally fining upward; (20-25 cm) - graded parallel-laminated Bouma DE sequence, olive gray (5Y 4/1) fine grained ss, irregularly ll laminated, grading up into more irregularly parallel stratified massive olive black (5Y 2/1) mudstone-claystone, E,D unit; (25-33 cm) - parallel-laminated very fine-grained sandstone, well-sorted, no pebbles or larger sand grains, medium gray (N5), grades upward into very thinly irregular mudstone and claystone, olive black (5Y 2/1). E, D? unit; (33-63 cm) - massive, ungraded, pebbly and sandy mudstone with abundant Scolithus type tubes, possibly some arenaceous foraminifera; lithic pebbles up to 1.1 cm length, plus elongate white clasts. Brownish gray (5YR 4/1) color generally, medium dark gray (N4) at base, which is very coarse grained, granule-sized, and very fine pebble-sized while arenaceous forams and/or fragments; (63-74 cm) - turbidite or pebbly mudstone unit similar to above, basal medium dark gray (N4) unit containing abundant fragments oriented *parallel to one another*, *obviously* clasts with *massive ungraded pebbly mudstone with tubes and pebbles up to 1/2 cm in length*; *(74-130 cm) - massive pebbly* mudstone, containing well-rounded clasts of quartz, lithic fragments, and possibly arenaceous forams; large lens-shaped burrows sub-parallel to bedding, ~1 cm x 3-4 cm, flattened, lighter colored (light brownish gray, 5YR 4/1) within brownish gray (5YR 4/1) to medium dark gray (N4) pebbly mudstone; very abundant tubes in situ in pebbly mudstone, one in place conspicuously at 80 cm; pebbles as long as 1.1 cm; no grading or stratification; (130-150 cm) light brown (5YR 5/6) and moderate brown (5YR 4/4) very lithified calcareous sandstone-siltstone; prominent cross-strata near top of unit worked by prominent moderate brown laminae; abundant small vertical Scolithus-sized tubes in upper 3 cm; massive in center, scattered lithic clasts and possible burrows, swirly lamination; basal 5 cm massive fine-medium calc ss.

Core catcher: grayish brown, sandy mudstone, burrows, (poss. detrital), micaceous, clasts>1 mm absent.

5Y 3/2

MUDSTONE (Smears 1-88, 1-114)

5-10% Sand	10-12% Quartz, Feldspar
15-20% Silt	0-10% Mica
70-80% Clay	8-10% Heavy minerals
	70-80% Clay minerals

SANDSTONE (Smear 4-63)

40% Sand	50% Quartz
10% Mud	40% Heavy minerals, Opaques
	10% Clay minerals

SANDY MUDSTONES (Smears 4-65, 4-113)
(MUDDY SANDS)

25-40% Sand	35-60% Quartz
10-20% Silt	0- 5% Feldspar
40-65% Clay	0- 5% Mica
	1-15% Heavy minerals, Opaques
	23-50% Clay minerals

MUDSTONES (Smear 5-41)

SANDY MUDSTONE (Smears 5-70, CC)

Carbon-Carbonate (DSDP)
5-130 (5.2, 0.1, 43)

Grain Size (DSDP)
1-121 (23.8, 11.5, 64.7)

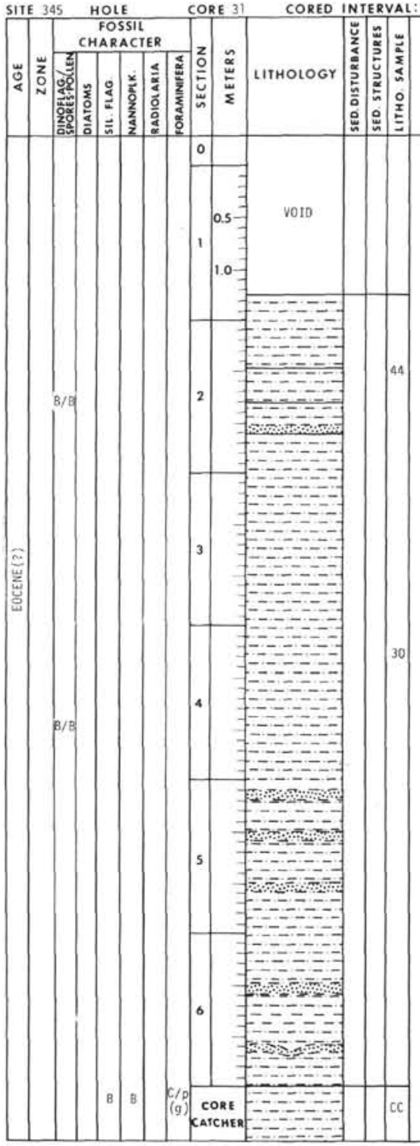
X-Ray (BP)

4-7		5-82	
55%	Mont.	68%	Mont.
20%	Ill.	19%	Ill.
10%	Kaol.	11%	K/C
14%	Chlo.	A	Quar.
A	Quar.	P	Micas, Plag.
P	Micas	TR%?	Calc.
TR%	Plag.		

5YR 4/1

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 31 CORED INTERVAL: 749.0-758.5 m



LITHOLOGIC DESCRIPTION

5YR 3/7
5YR 4/1
5YR 4/1
5YR 3/4
5YR 3/2
5YR 3/4
5YR 4/1
N5
5YR 3/4
5YR 4/4
10R 4/2
10R 4/6

Colors: grayish brown (5YR 3/7), brownish gray (5YR 4/1), medium gray (N5), medium brown (5YR 3/4), grayish brown (5YR 3/2), olive black (5Y 2/1).

Sec. 1 - sandy mudstone to muddy sandstones, massive, thinly interstratified, 31 cm thick, burrows abundant;

Sec. 2 (0-45 cm) - massive, structureless, pebbly sandy mudstone, 1-2 cm N5 bands with gradational contacts. Pebbles ⨯ rounded; chert. Heavy mineral conglomerate at base; (45-75 cm) - pebbly sandy mudstone; (75-100) - pebbly sandy mudstone, scattered chert, worm tubes-white chitin.-phosphatic? material, some claystone rip-up clasts - gradational at 100 cm to soft sandstone (3 cm) - subrounded. (105-150 cm) - pebbly, sandy mudstone massive, structureless, coarsens upward with large round lithics (0.5 cm) - scattered chert (black) pebbles.

Sec. 3 - massive, structureless, pebbly, sandy, mudstone to muddy ss - 1-3 cm thick, lighter color strata, less mud, better sorted, micaceous, pebbles maximum 0.7 cm, abundant worm tubes, rare claystone clasts.

Sec. 4 - as per Sec. 3 - sandy strata with biotite, heavy laminae; irregularly mottled - large burrowed areas;

Sec. 5 - pebbly micaceous sandy mudstone, scattered worm tubes, chert pebbles plus granite pebble (6 cm), well rounded, low orthoclase, sandstone layers;

Sec. 6 - as per Sec. 5 - sandy mudstone with sandstones = well sorted, quartzose, rounded subrounded chert pebbles (<1 cm) micaceous - pebbly at base - chert, quartzite granite;

Core catcher - massive, blotchy, pebbly medium grained ss, no structures, grayish red (10R 4/2), medium red brown (10R 4/6), pale red (10R 6/2) blotches.

LITHOLOGIES

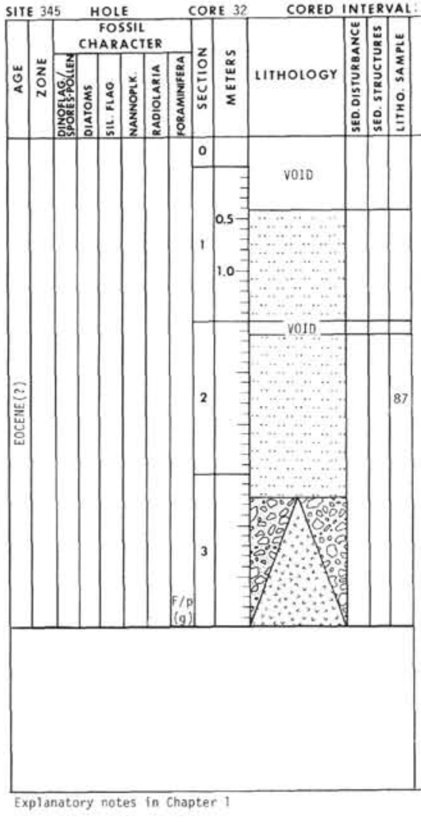
SANDY MUD (Smears 2-44, 4-30, CC)
(CC has 50% sand, 20% silt, 30% clay with 54% Fe-oxide/clay.)

Grain Size (DSDP)
3-31 (16.6, 25.7, 57.7)

X-Ray (BP)

3-44		6-2	
41%	Mont.	85%	Mont.
33%	Ill.	6%	Ill.
12%	Kaol.	7%	K/C
12%	Chlo.	A	Quar.
A	Quar.	P	Micas
P	Micas	TR%	Plag.
P	Plag.		
TR%?	Calc.		

SITE 345 HOLE CORE 32 CORED INTERVAL: 758.5-764.0 m



LITHOLOGIC DESCRIPTION

10R 4/6
10R 3/4
5Y 3/2
5YR 3/7
5BG 3/2

Colors: moderate reddish brown (10R 4/6), dark reddish brown (10R 3/4).

Sec. 1 - pebbly sandstone, scattered subrounded pebbles (<1.2 cm), open framework, random orientation, locally blotchy/mottled, lessens >70 cm, no structures, fe-oxide mottled tubular areas, possible worm tubes.

Sec. 2 - as per Sec. 1 - scattered chert pebbles.

Sec. 3 (0-25 cm) - moderate brown to grayish brown siltstone with round quartz grains. Grayish blue green to dusky blue green siltstone. Siltstone with chlorite-calcite fragments (0.5-1 cm); (25-62 cm) - breccia; angular and near round basalt fragments and pieces of pale blue green chlorite, white calcite (1-6 mm); (62-90 cm) - breccia; angular fragments of weathered grayish red basalt, cemented by grayish red matrix; (90-150 cm) - drill pebbles of breccia, angular chloritized and chlorite fragments (0.5-10 cm), cemented by a chlorite-smectite-calcite matrix.

MAJOR LITHOLOGY

SILTSTONE (Smear 3-87)

10% Sand	70% Quartz
90% Silt	10% Heavy minerals
	5% Opaques
	10% Clay minerals

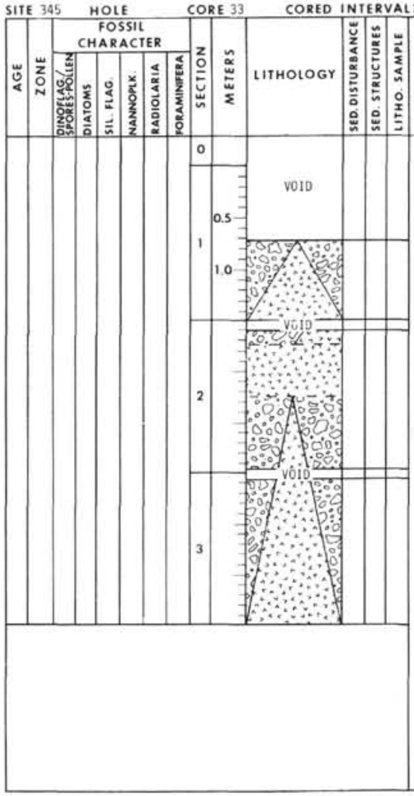
Grain Size (DSDP)
2-110 (7.6, 86.2, 6.2)

X-Ray (BP)

2-123	
89%	Mont.
8%	Ill.
1%	K/C
P	Quar.
TR%	Micas
TR%	Plag.

Explanatory notes in Chapter 1

SITE 345 HOLE CORE 33 CORED INTERVAL: 764.0-773.5 m



LITHOLOGIC DESCRIPTION

BASALT BRECCIA

Sec. 1 (75-150 cm) - greenish black (5GY 2/2) to dusky blue green (5BG 3/2) breccia; angular and round fragments of blackish red and dark gray aphyric basalts (0.1 to 5 cm) cemented by chlorite-smectite matrix with calcite.

Thin Section - angular, weathered, zeolite, hematite, goethite, altered olivine replaced by chlorite-smectite, calcite matrix.

Sec. 2 (10-30 cm) - breccia; angular of blackish red fragments of basalt, cemented by a chlorite-smectite matrix; (30-75 cm) - dark gray (N3) to brownish gray (5YR 4/1) basalt, brecciated (probably fragment of breccia) with white calcite veins and zeolite(?)-calcite amygdules; (75-125 cm) - breccia as above but with goethite vein in 123-126 cm interval; (125-150 cm) - brecciated basalt-chlorite-calcite-smectite veins. Probably basalt is the breccia fragment.

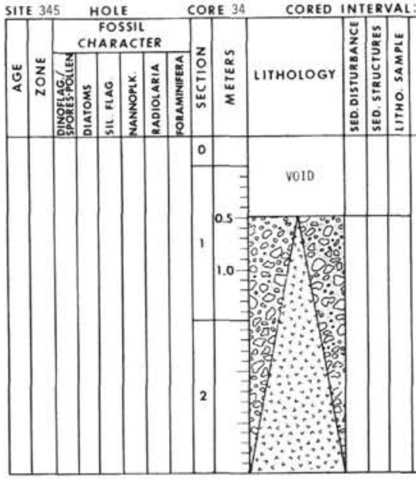
Thin Section - breccia, altered basalt, hyalophitic, variolitic, trachytoid texture. aphanitic, very fine grained (0.01-0.1 mm). Plagioclase laths (20%), also glomeroporphyritic pyroxene (20%), altered olivine phenocrysts (5%) altered (zeolite) glass. Secondary smectite, chlorite, zeolite, calcite, albite.

Sec. 3 (0-50 cm) - sedimentary breccia with sandy cement with quartz grains and radiolarians. Fragments of breccia are angular and round of grayish red basalt and grayish blue green chlorite-smectite; (50-150 cm) - breccia with angular and round fragments. Dark gray and grayish red aphyric basalt, cemented by chlorite-smectite(?) matrix.

Thin Section - as pen Sec. 2 - some hematized basalt, zeolite, altered olivine - zeolite, smectite(?) cement.

5GY 2/1
5BG 3/2
5R 2/2
5Y 4/1
N3
5YR 3/4
5YR 5/6
5BG 3/2
5BG 5/2

SITE 345 HOLE CORE 34 CORED INTERVAL: 773.5-783.0 m



LITHOLOGIC DESCRIPTION

BASALT BRECCIA

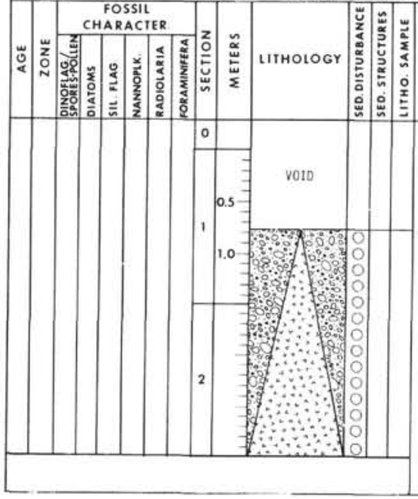
Sec. 1 (45-150 cm) - breccia in Core 33 with angular fragments of altered olivine basalt, cemented by a chlorite-smectite mass.

Thin Section - angular fragments, altered basalt, zeolite, altered olivine-smectite, goethite, calcite. Zeolite-smectite cement.

Sec. 2 (0-100 cm) - breccia is similar to Sec. 1; (100-150 cm) - drill fragments of medium gray (N5) to medium light gray (N6) basalt. There are grayish red and pale blue green spots in basalt.

Thin Section - breccia, angular weathered (altered) basalt, hematite basalt, zeolite, zeolite-smectite cement. Basalt - hyalophitic, interstadial texture, chlorite, zeolite, smectite amygdules (3-5%), olivine (2%) replaced by smectite, calcite-goethite. Plagioclase (20-30%).

SITE 345 HOLE CORE 35 CORED INTERVAL: 783.0-792.5 m



LITHOLOGIC DESCRIPTION

BASALT BRECCIA

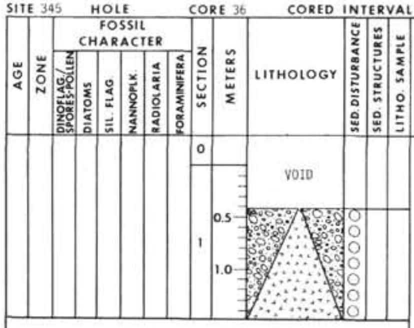
Sec. 1 (75-150 cm) - basalt with vesicles and amygdules, filled by smectite. Slickensides with black clayish material on walls.

Thin Section - altered amygdaloidal basalt subophitic, fine grained; plagioclase (30%) - albite, labradorite (An_{69}), pyroxene (20%), altered glass, chlorite, smectite, calcite, zeolite, goethite. Amygdules (10-15%) filled by smectite, zeolite.

Sec. 2 (0-100 cm) - smectite-calcite vein in drill fragments of amygdaloidal basalt with grayish green and pale yellowish veins and spots of calcite-smectite. Smectite(?) veins; (100-150 cm) - amygdaloidal phyric basalt. Slickensides.

Thin Section - altered amygdaloidal basalt, subophitic, variolitic texture; Plagioclase (20-30%) - An_{68} - magnetite (1-2%), altered glass, smectite, chlorite, zeolite, calcite amygdules (10-15%).

SITE 345 HOLE CORE 36 CORED INTERVAL: 792.5-802.0 m



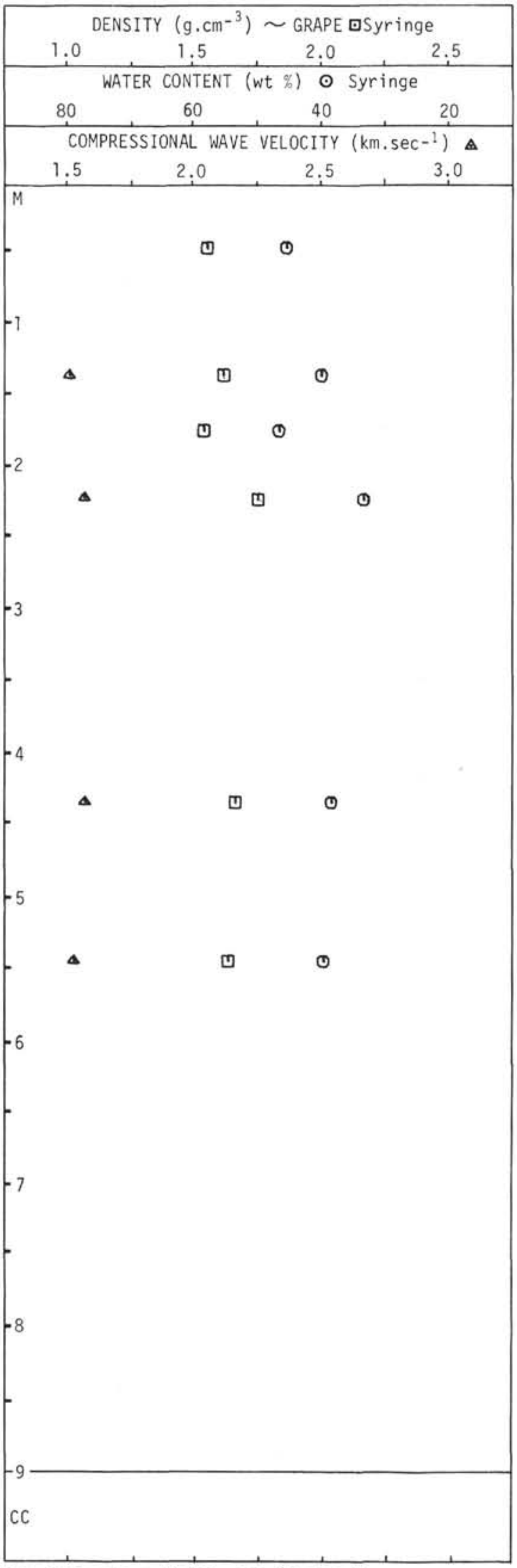
LITHOLOGIC DESCRIPTION

BASALT BRECCIA

Sec. 1 (40-50 cm) - drill pebbles of basalt and two pieces of moderate yellowish fine-grained dolomite; (50-150 cm) - brecciated basalt with calcite veins and small smectite-calcite amygdules and vesicles. Brecciated altered hyalobasalt.

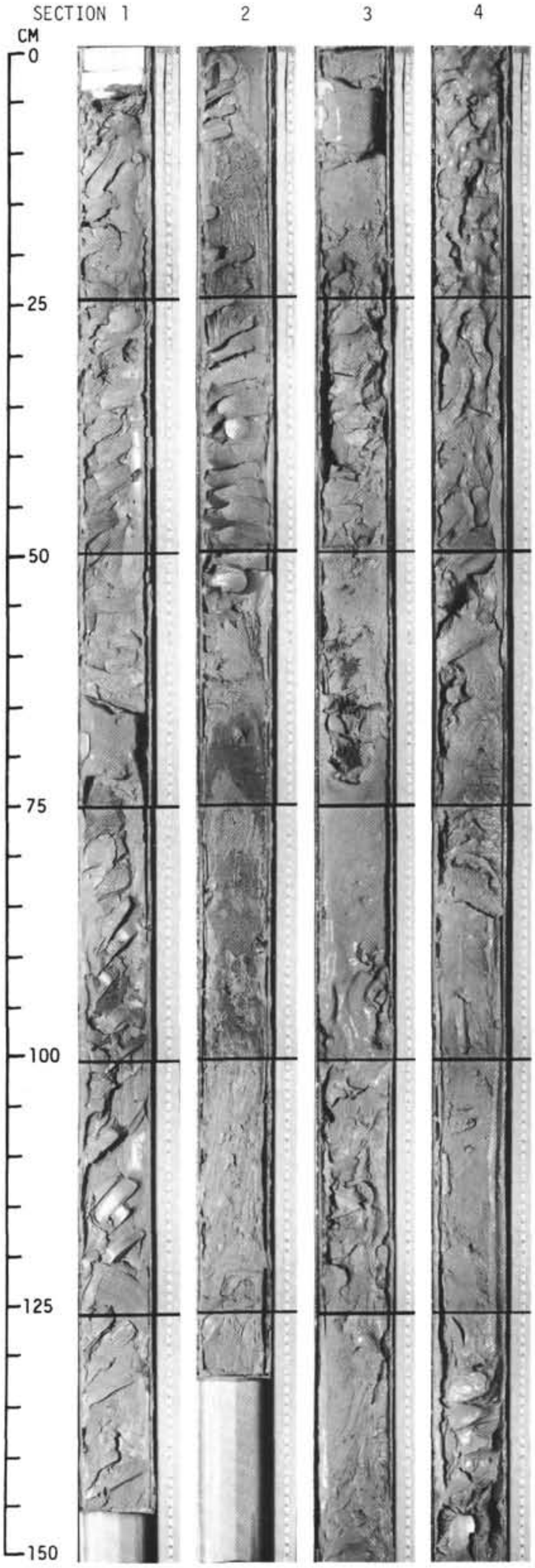
Thin Section - altered amygdaloidal basalt, with glomeroporphyritic clusters of olivine and plagioclase.

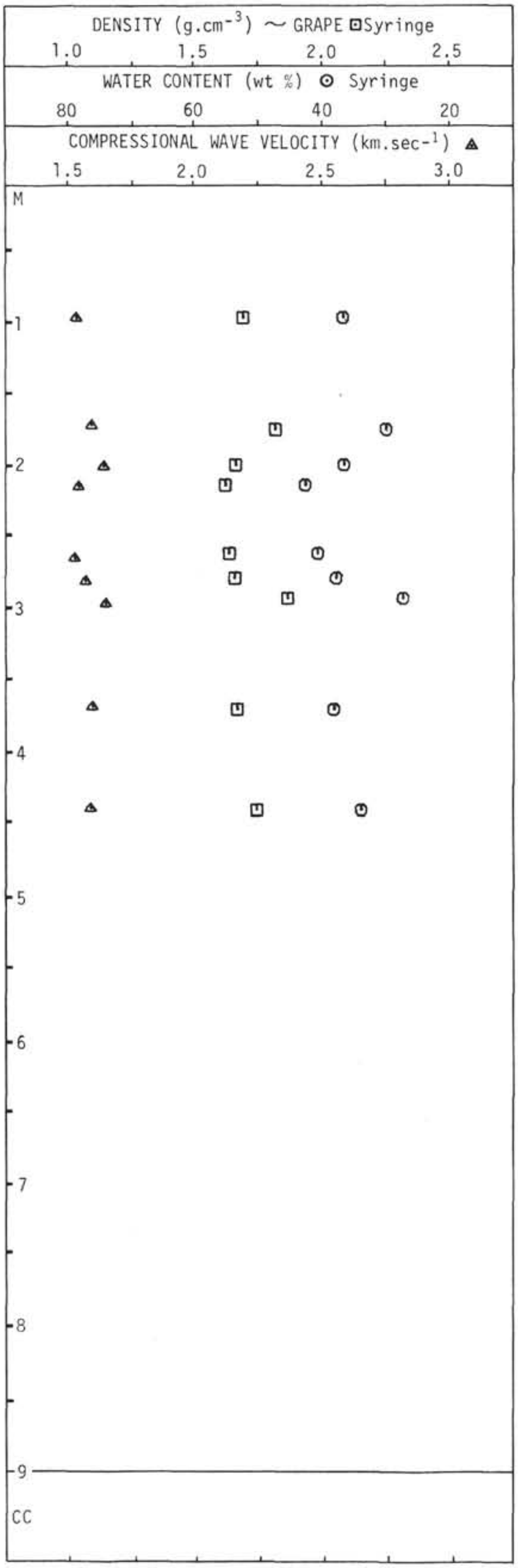
Explanatory notes in Chapter 1



For Explanatory Notes, see Chapter 1

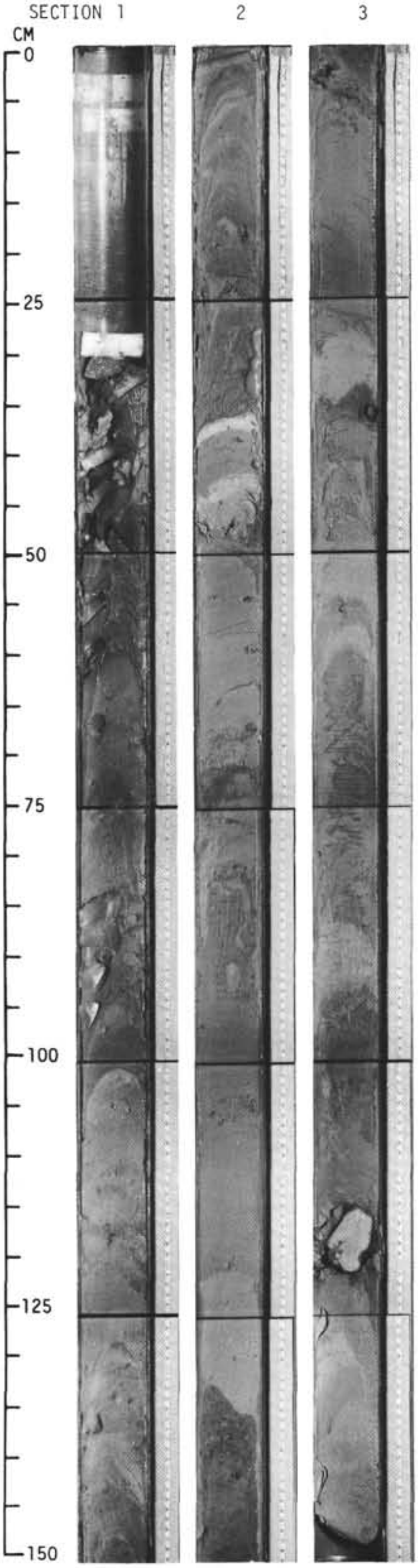
345-1

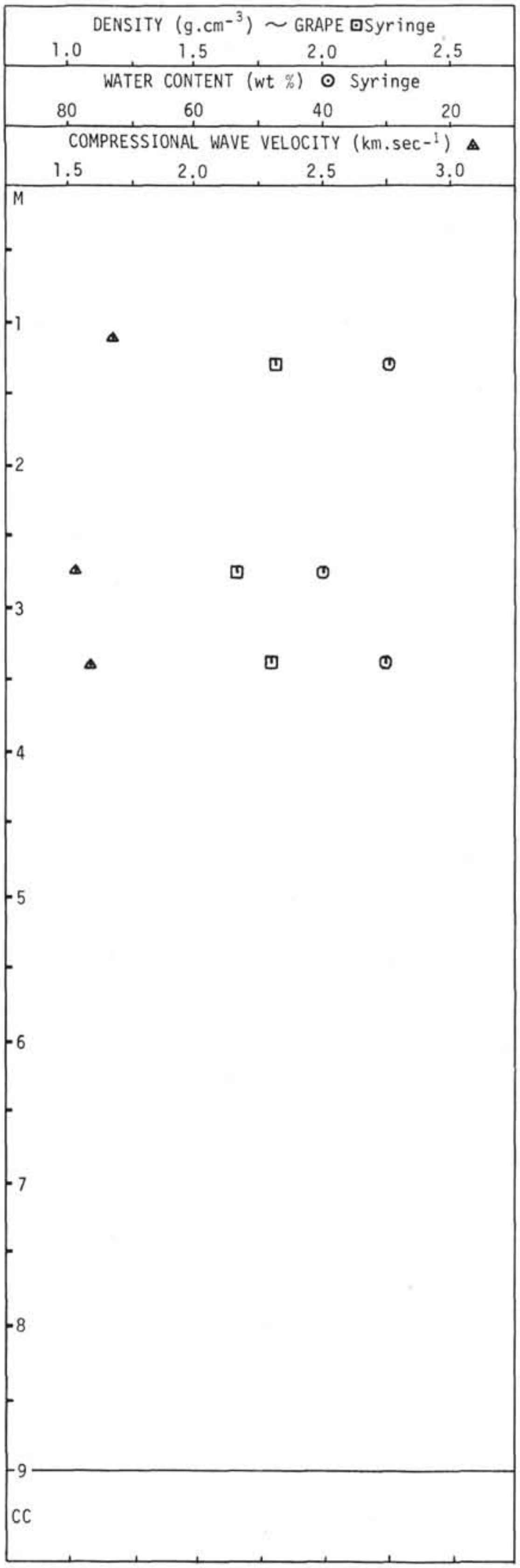




For Explanatory Notes, see Chapter 1

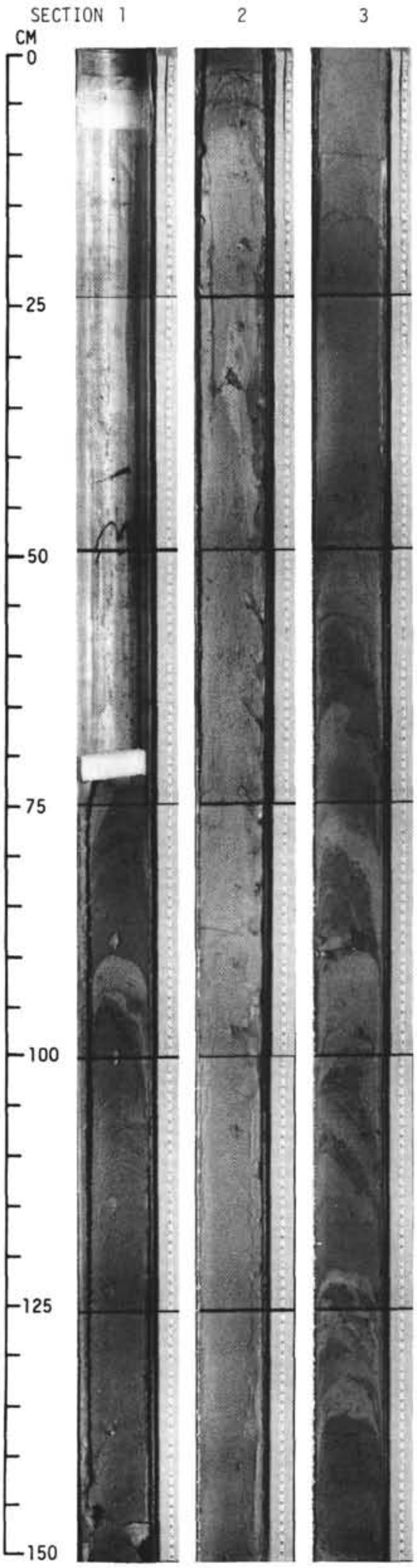
345-2

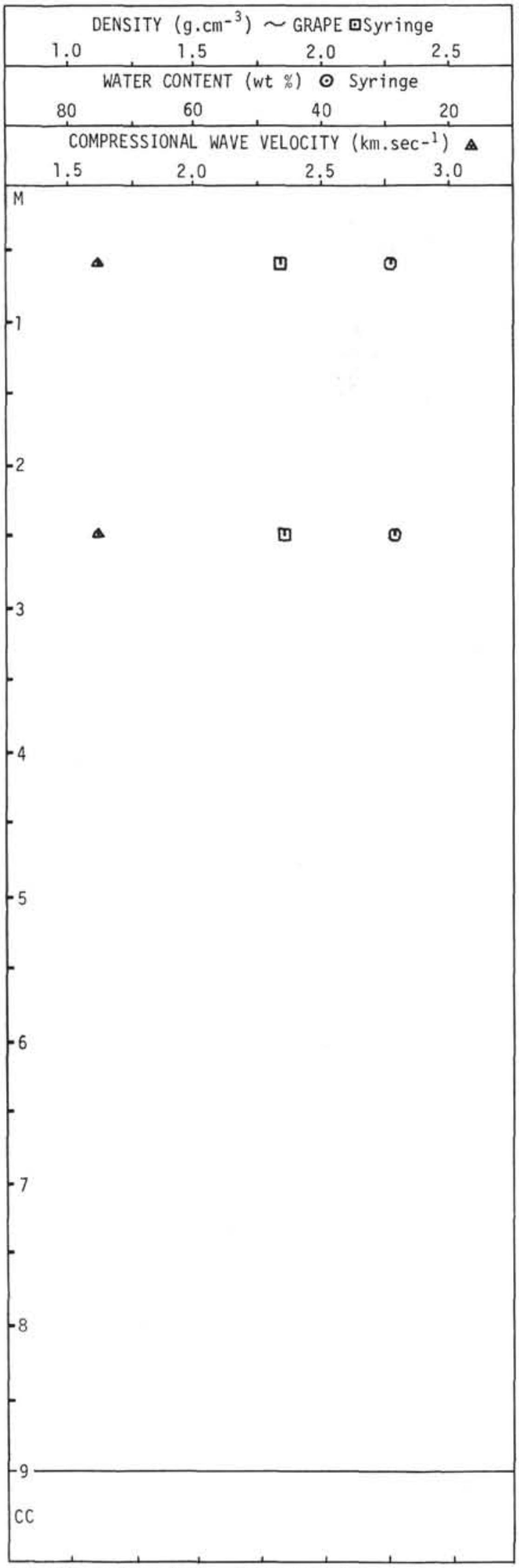




For Explanatory Notes, see Chapter 1

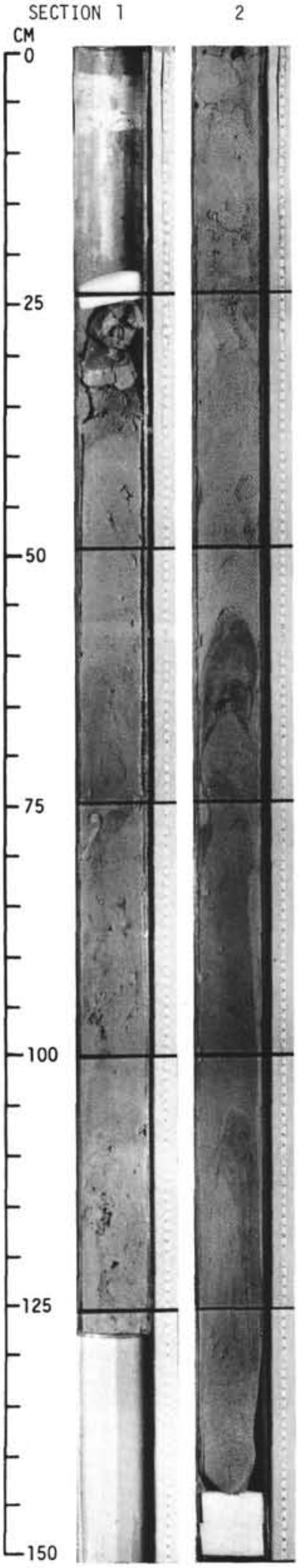
345-3

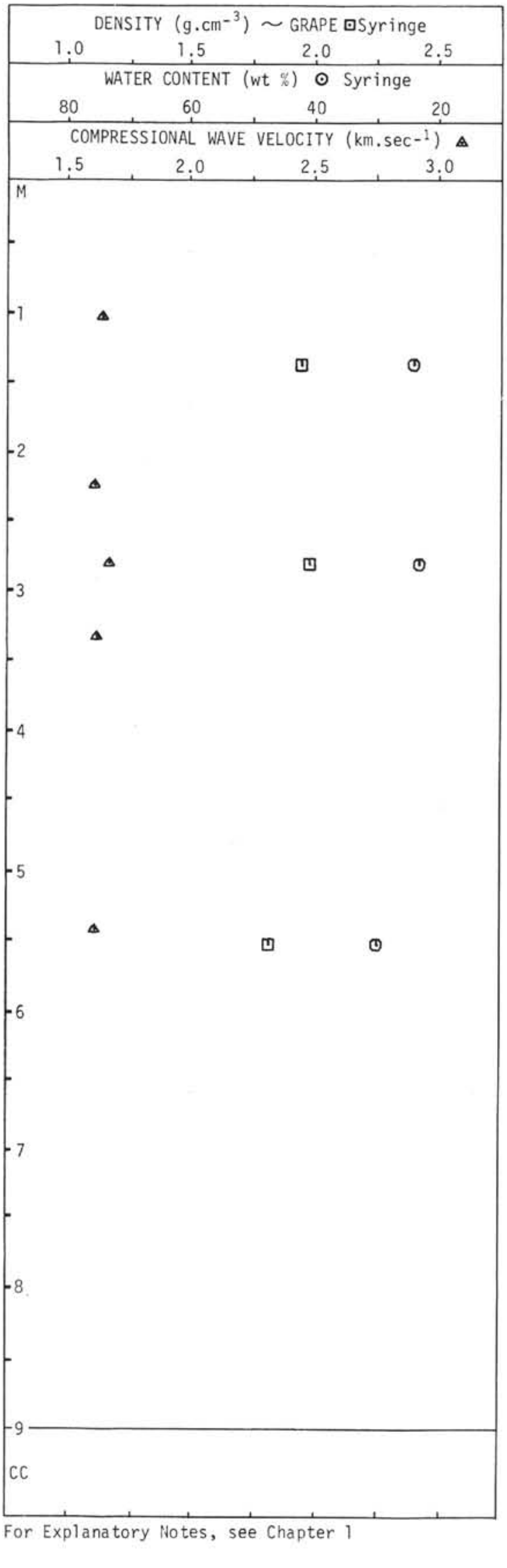




For Explanatory Notes, see Chapter 1

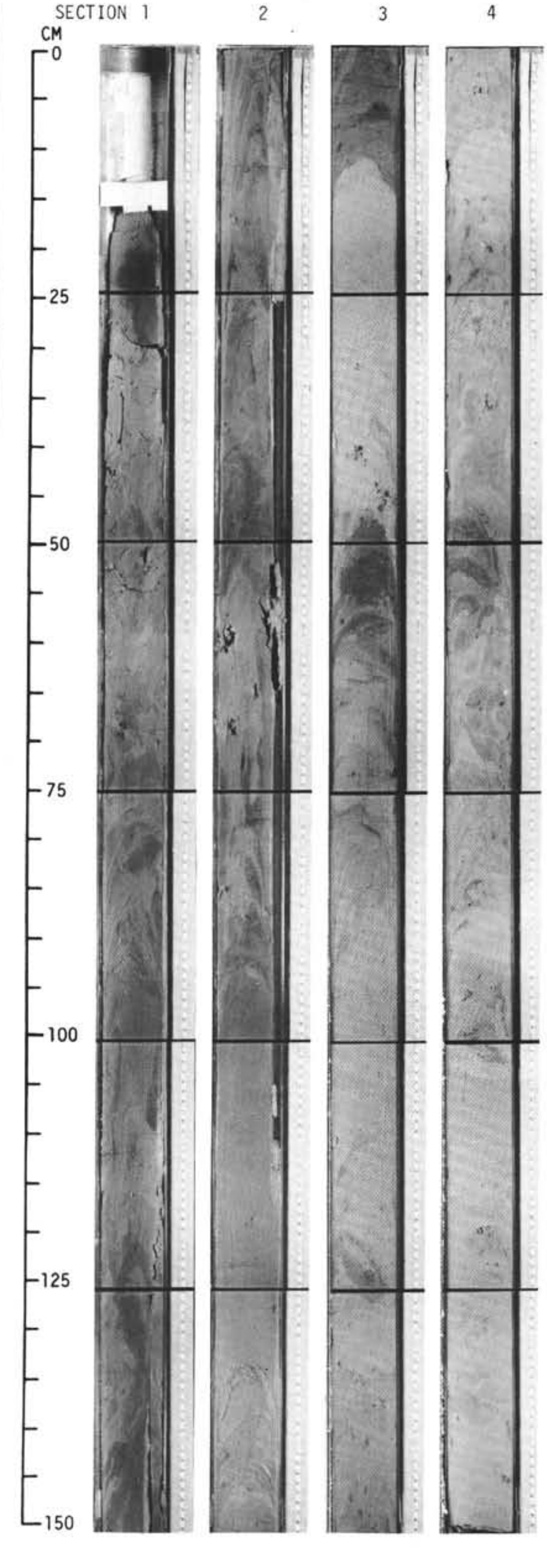
345-4

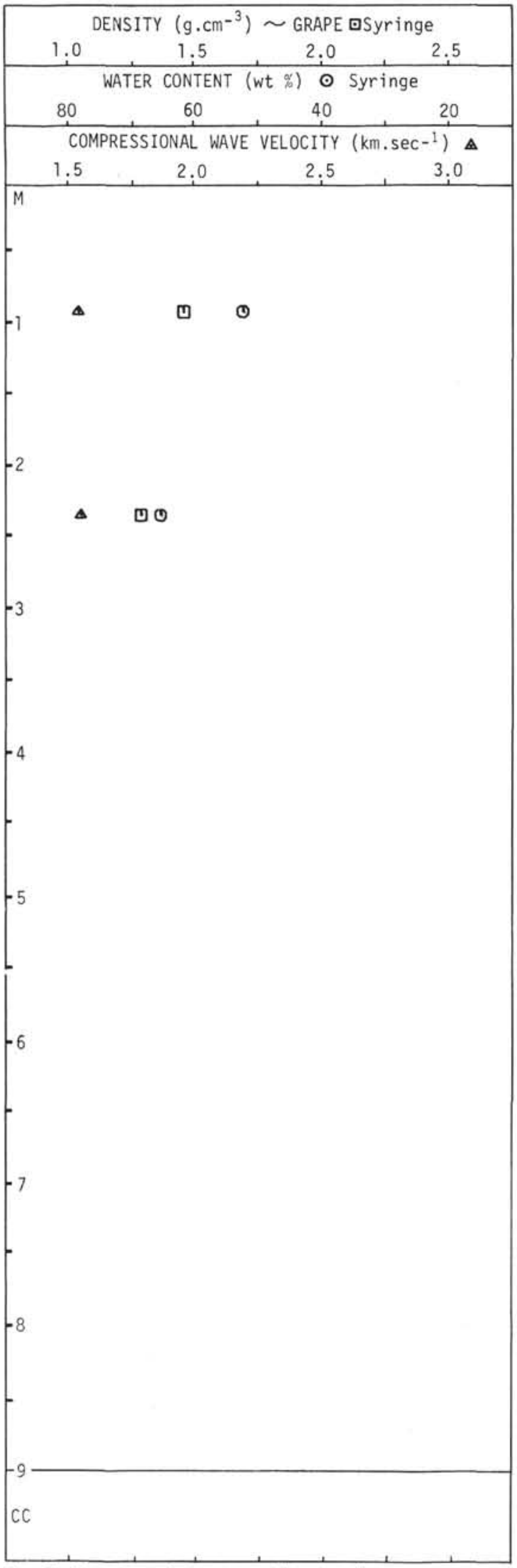




For Explanatory Notes, see Chapter 1

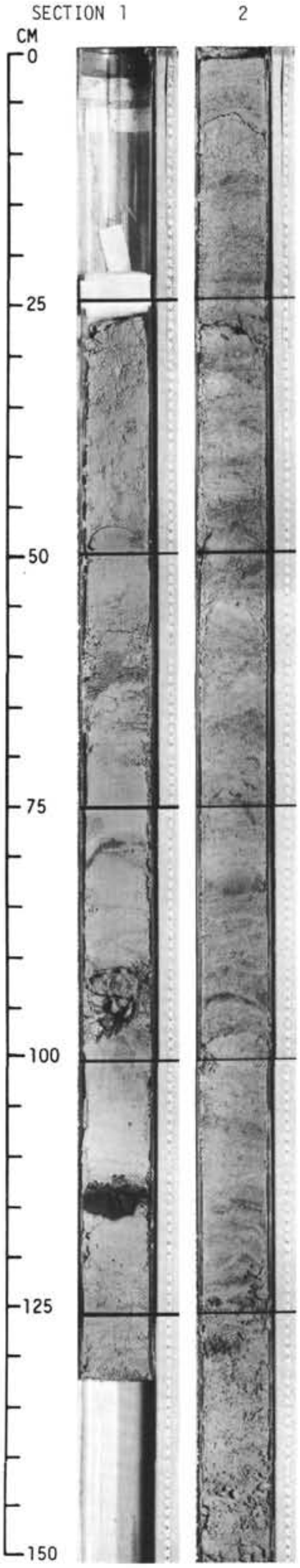
345-5

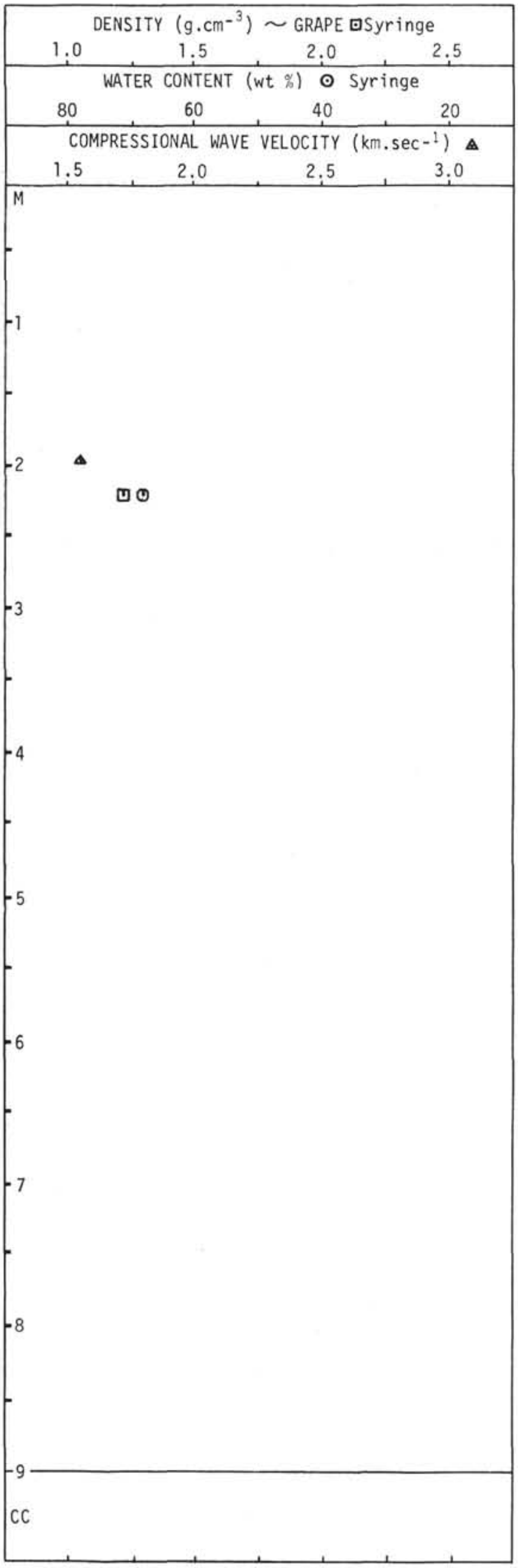




For Explanatory Notes, see Chapter 1

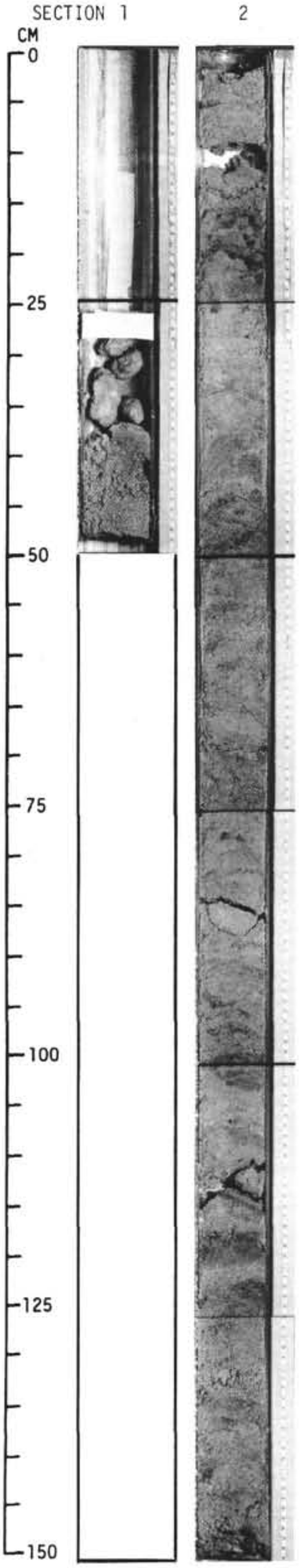
345-6

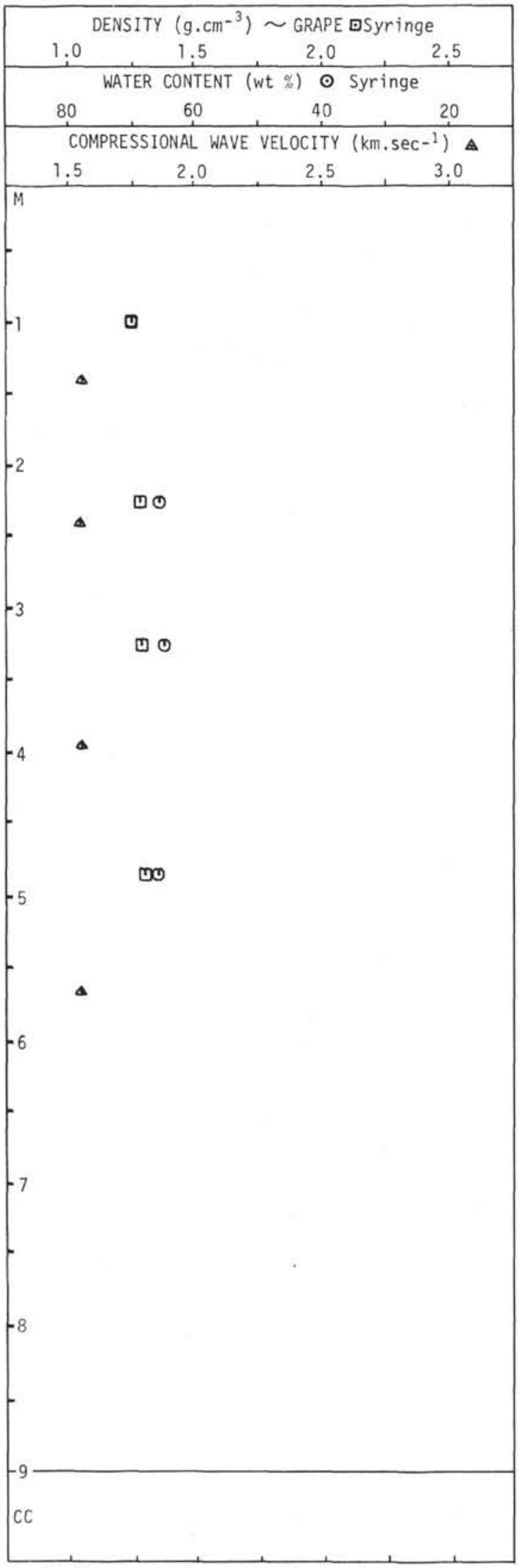




For Explanatory Notes, see Chapter 1

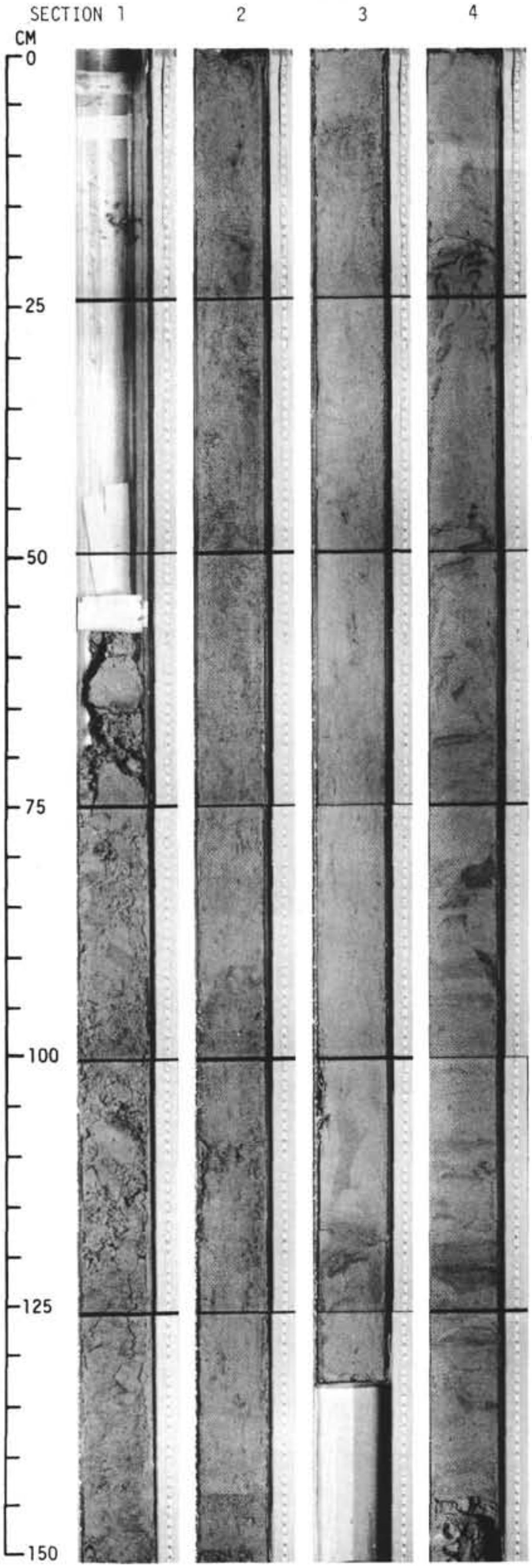
345-7

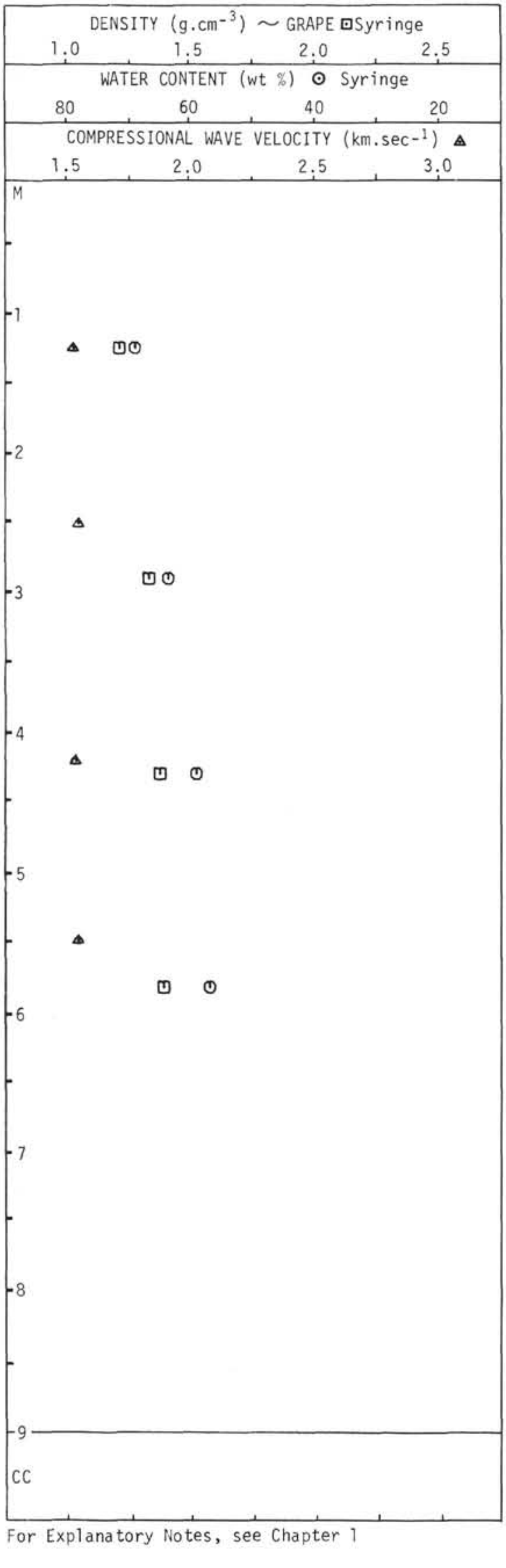




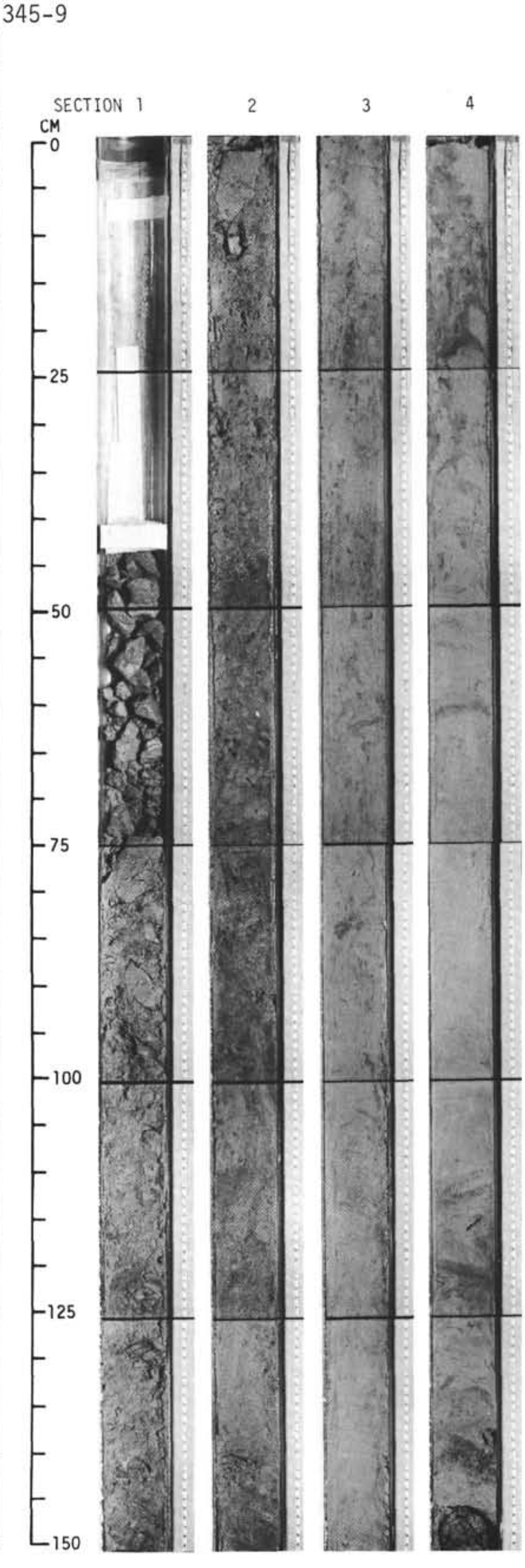
For Explanatory Notes, see Chapter 1

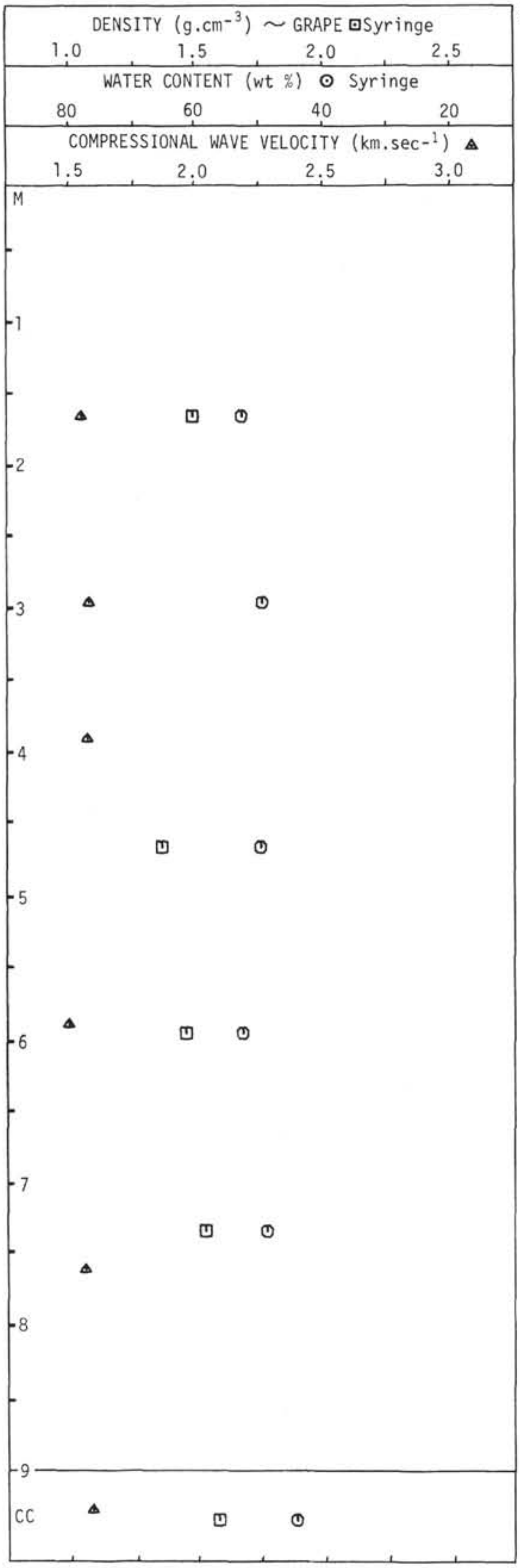
345-8





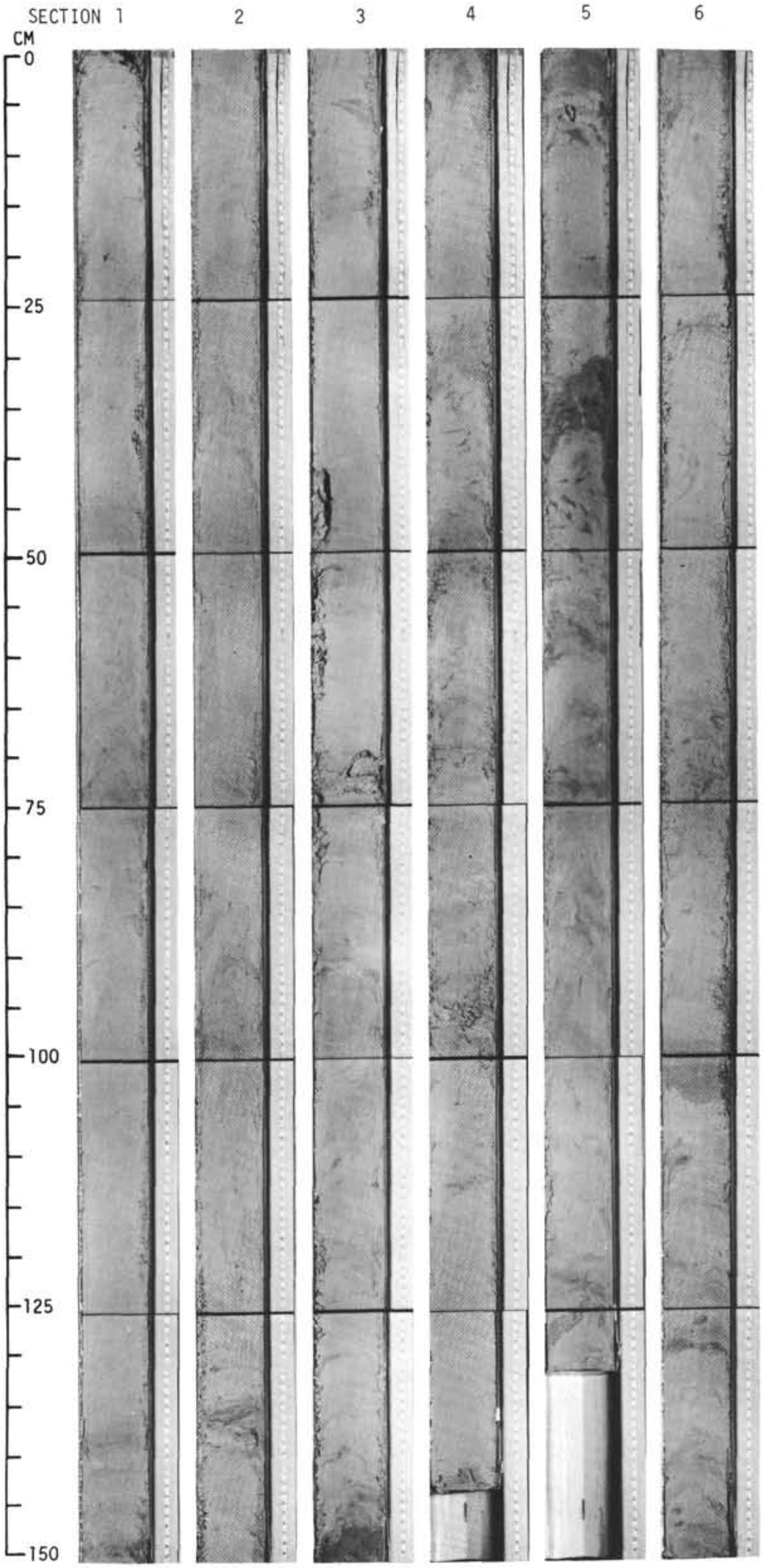
For Explanatory Notes, see Chapter 1

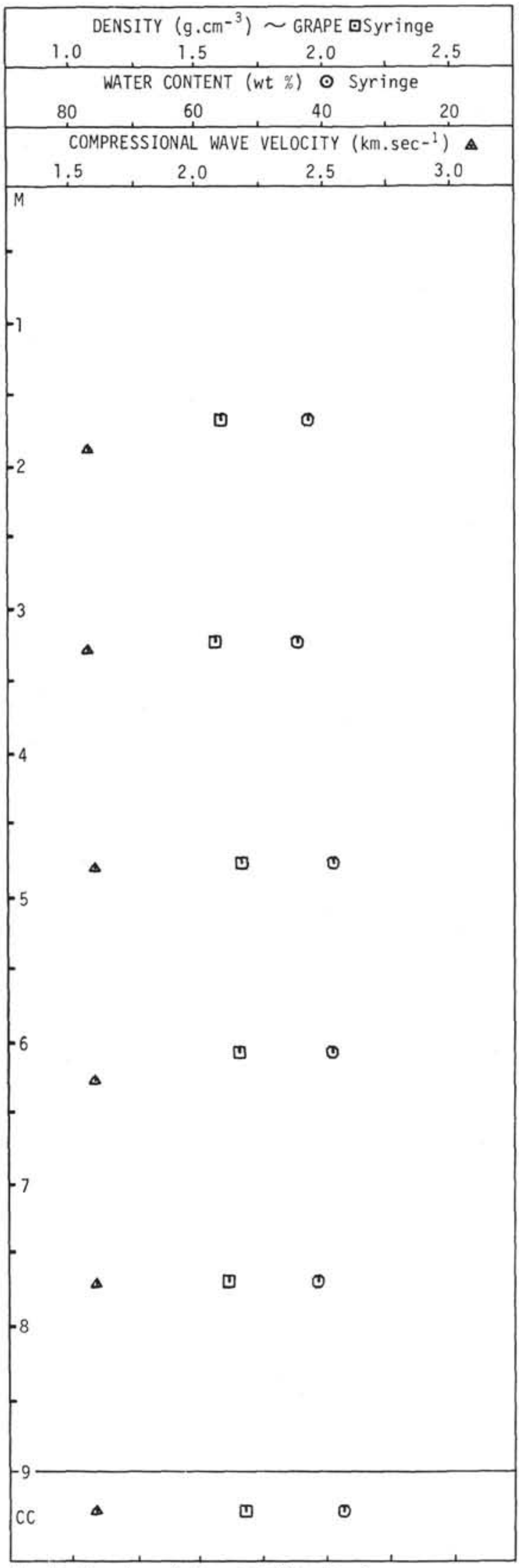




For Explanatory Notes, see Chapter 1

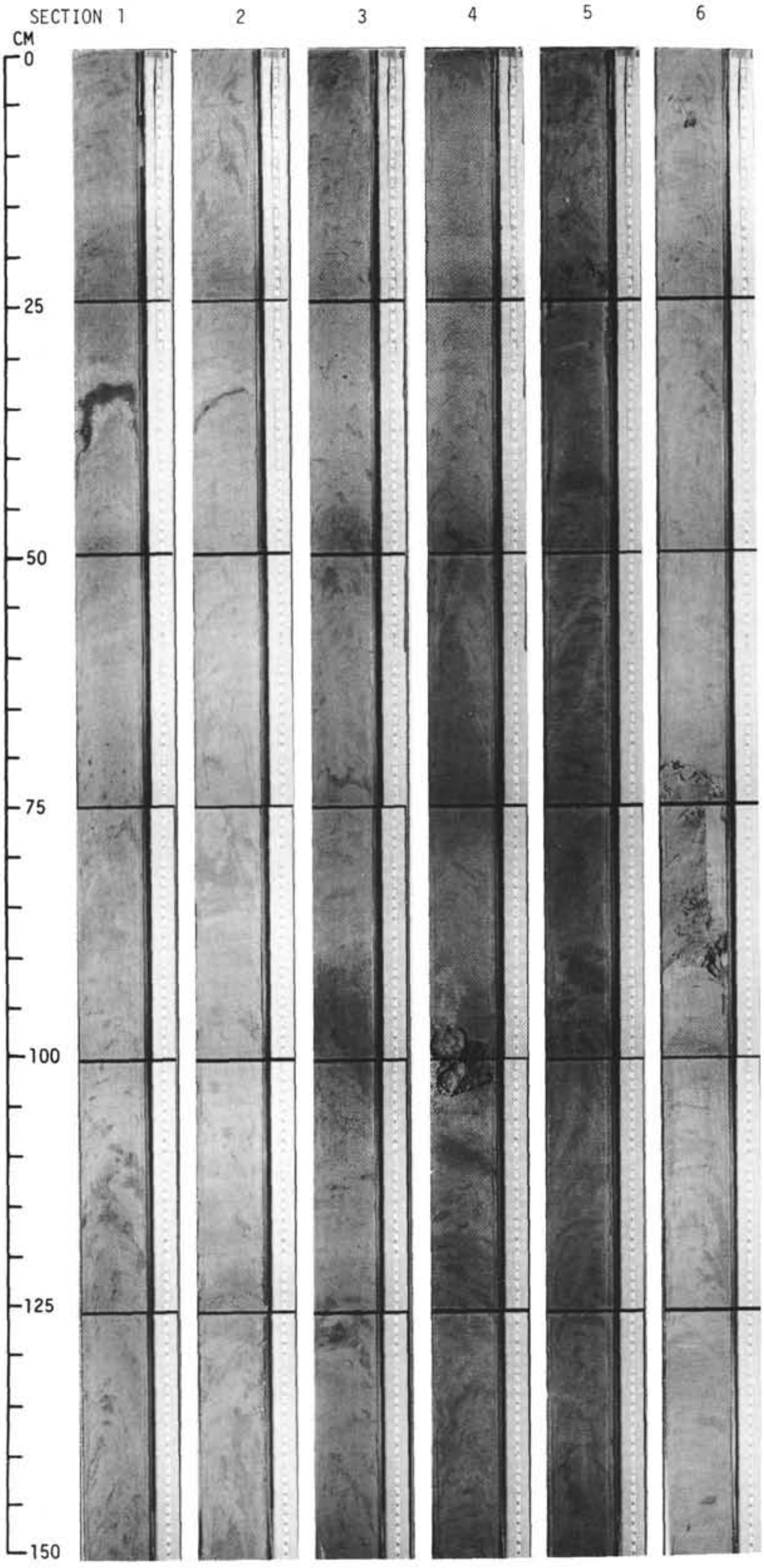
345-10

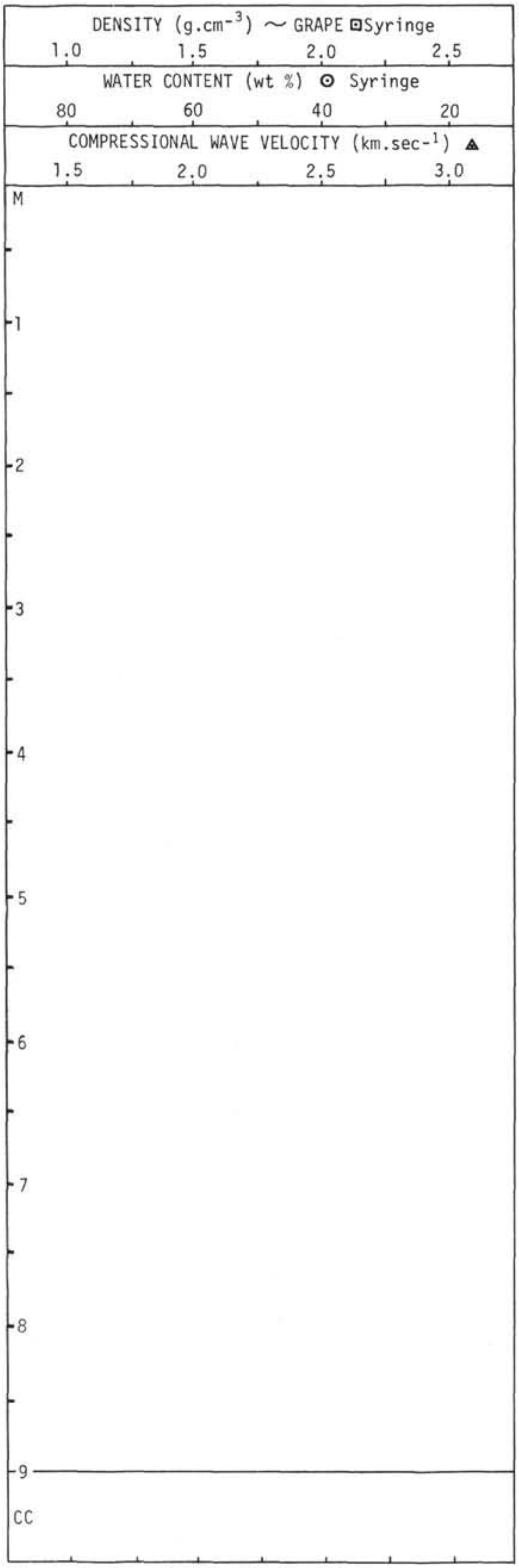




For Explanatory Notes, see Chapter 1

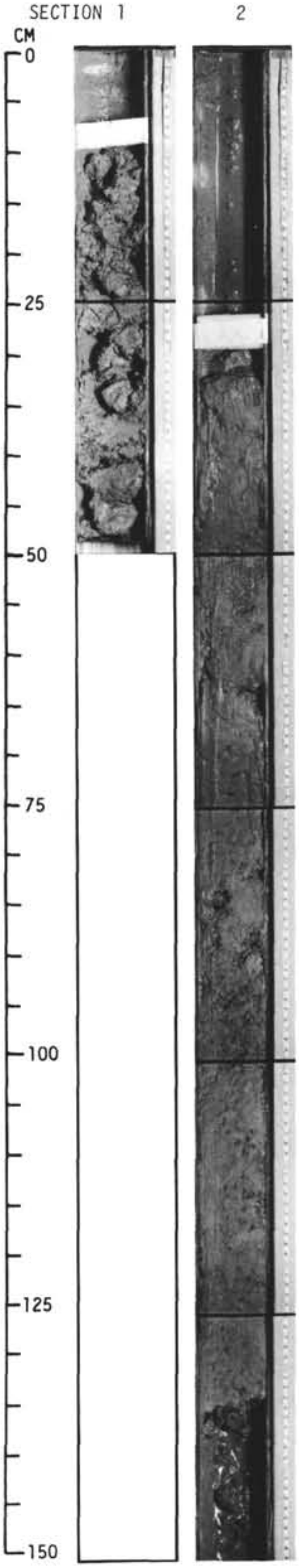
345-11

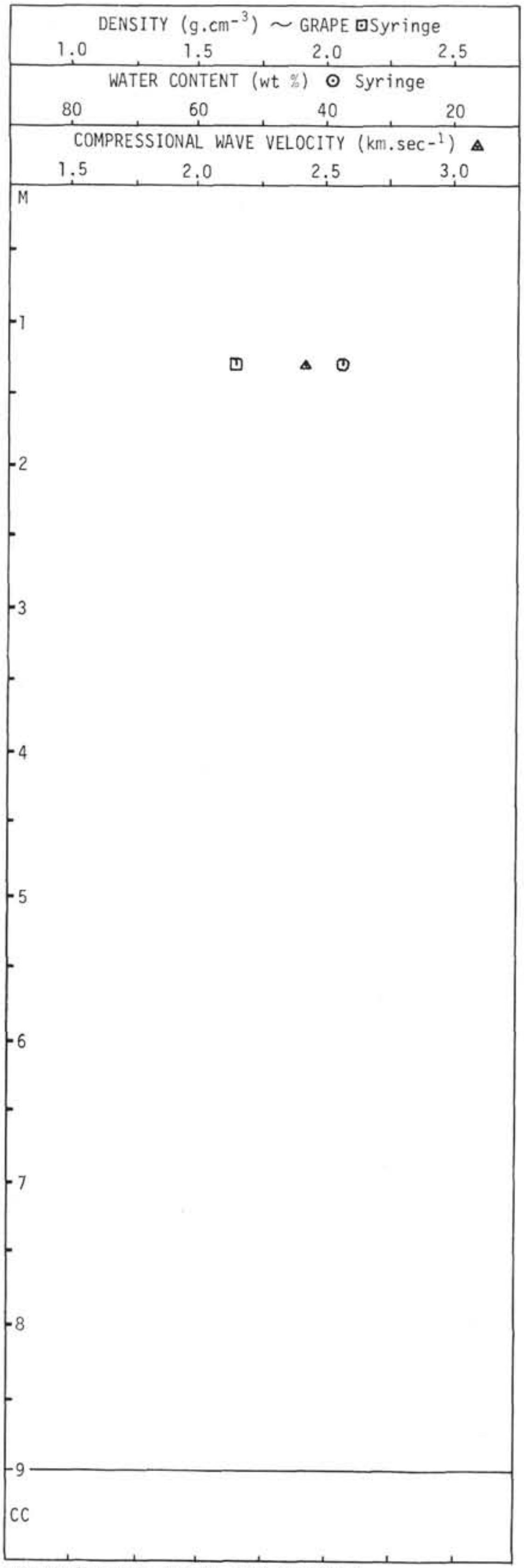




For Explanatory Notes, see Chapter 1

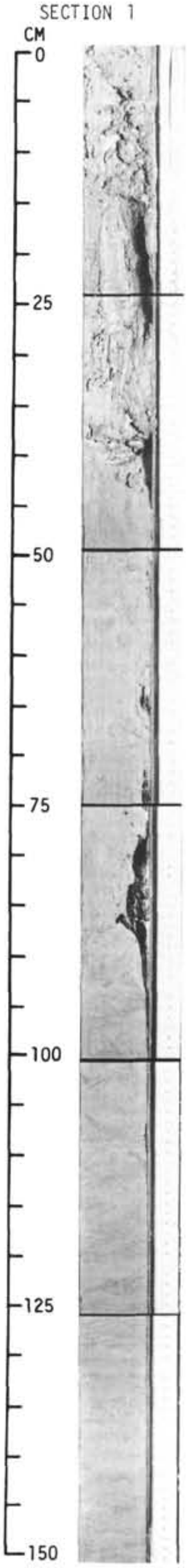
345-12

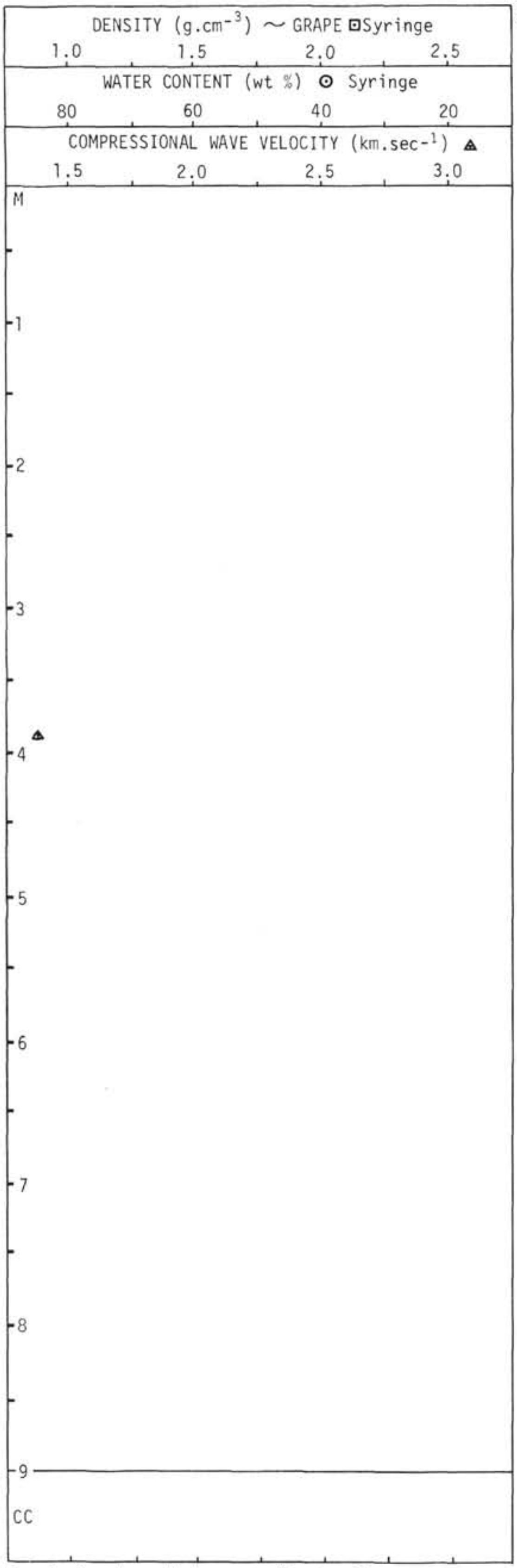




For Explanatory Notes, see Chapter 1

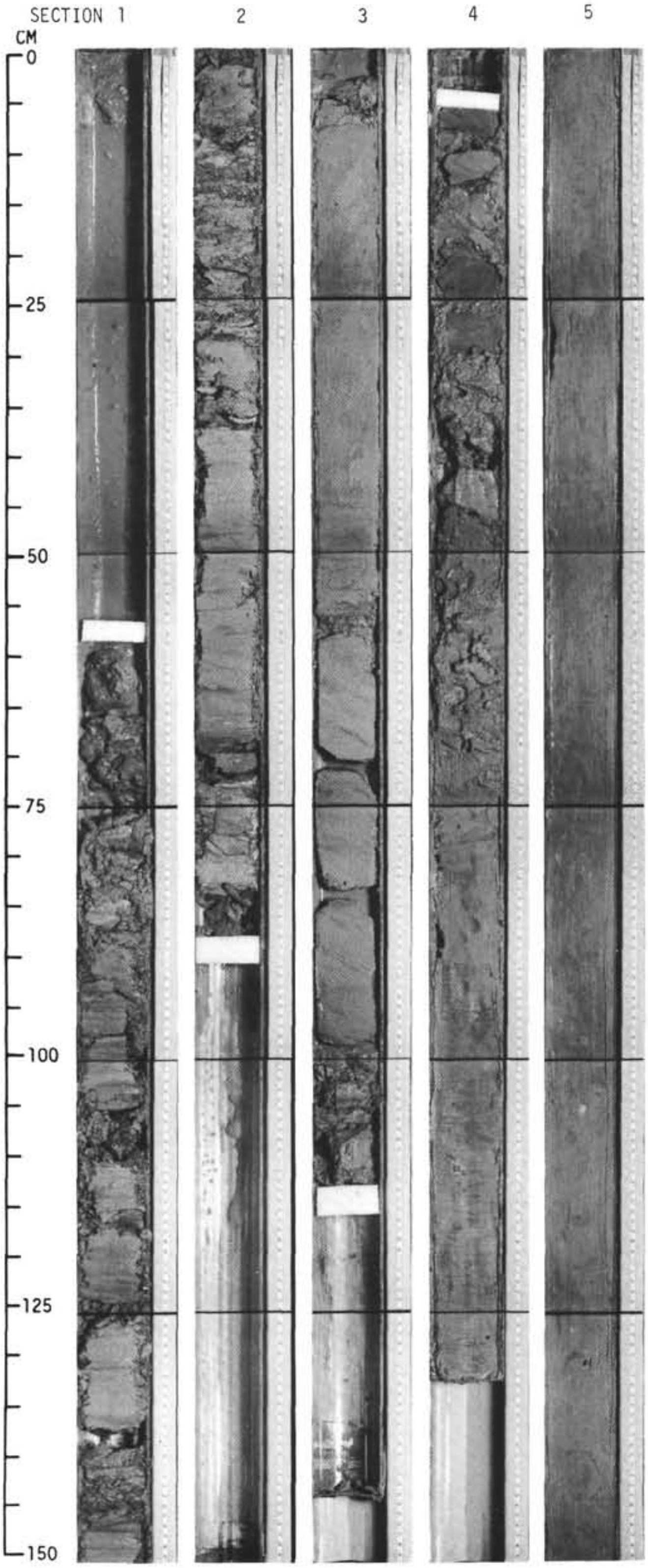
345-13

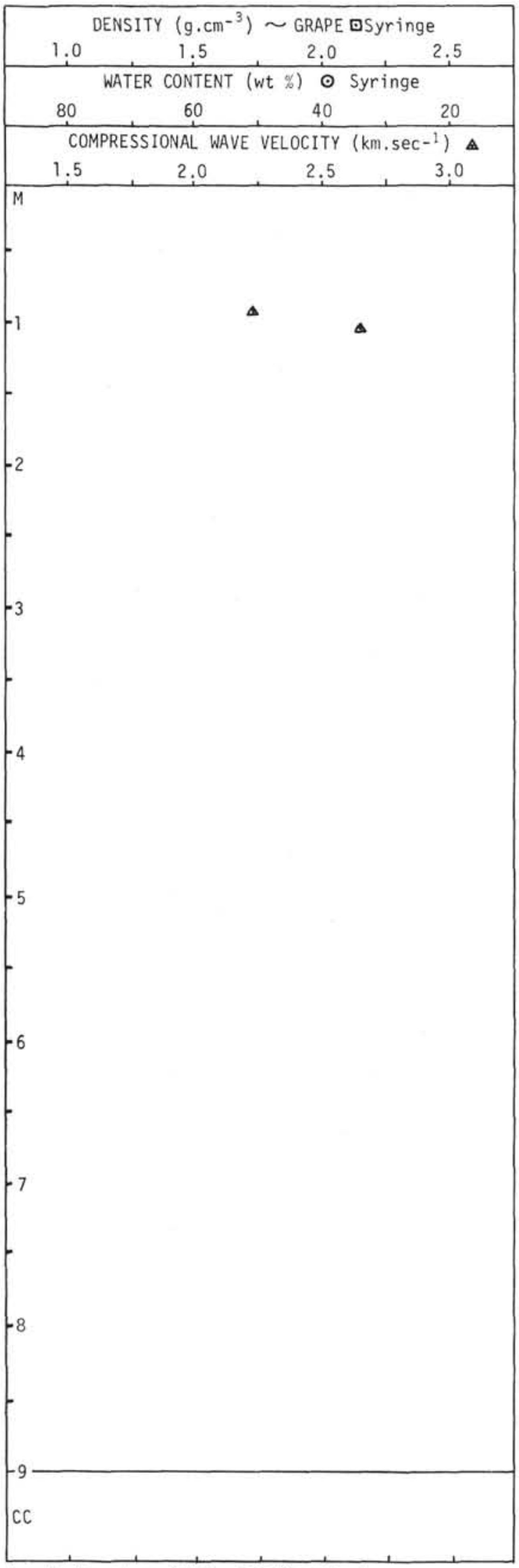




For Explanatory Notes, see Chapter 1

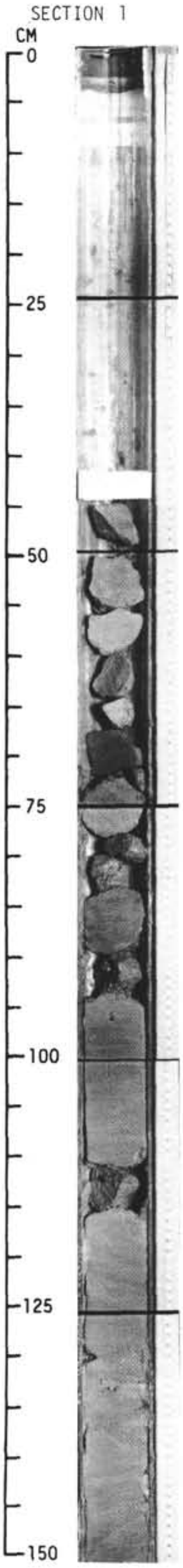
345-14

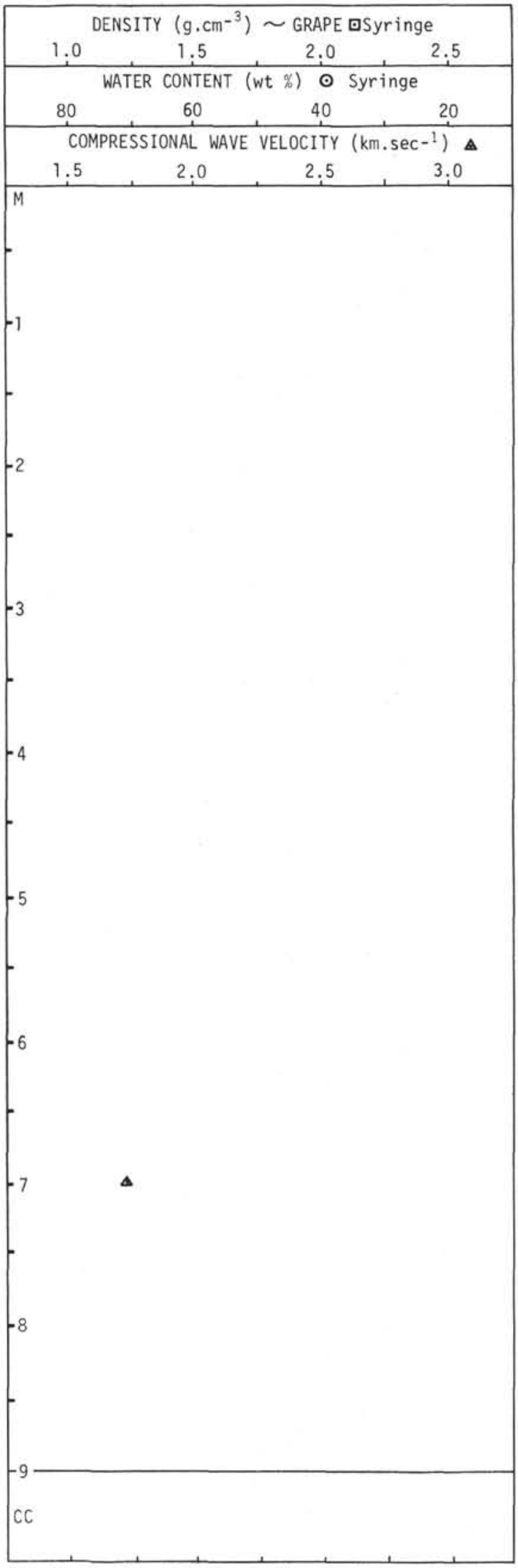




For Explanatory Notes, see Chapter 1

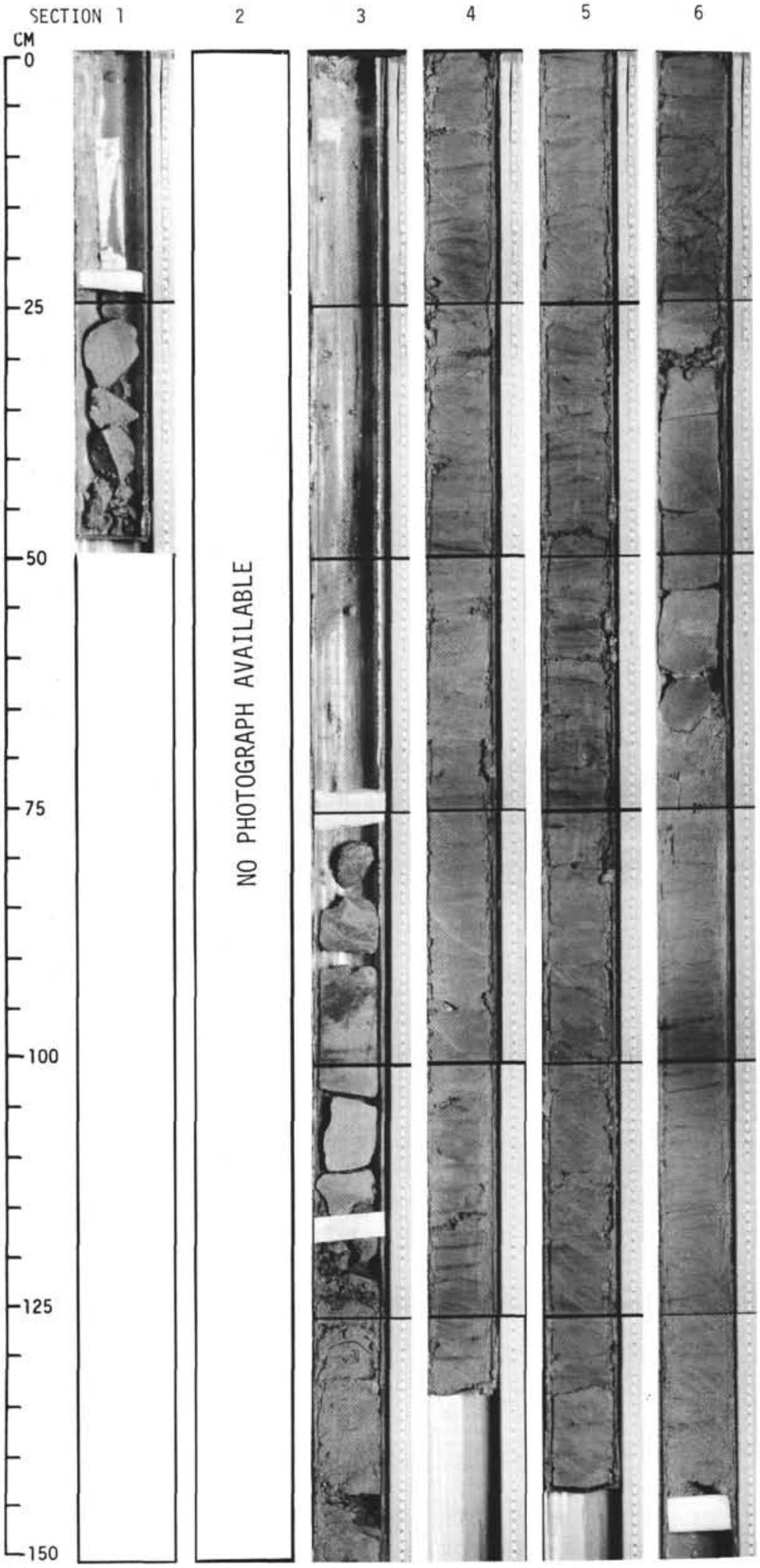
345-15

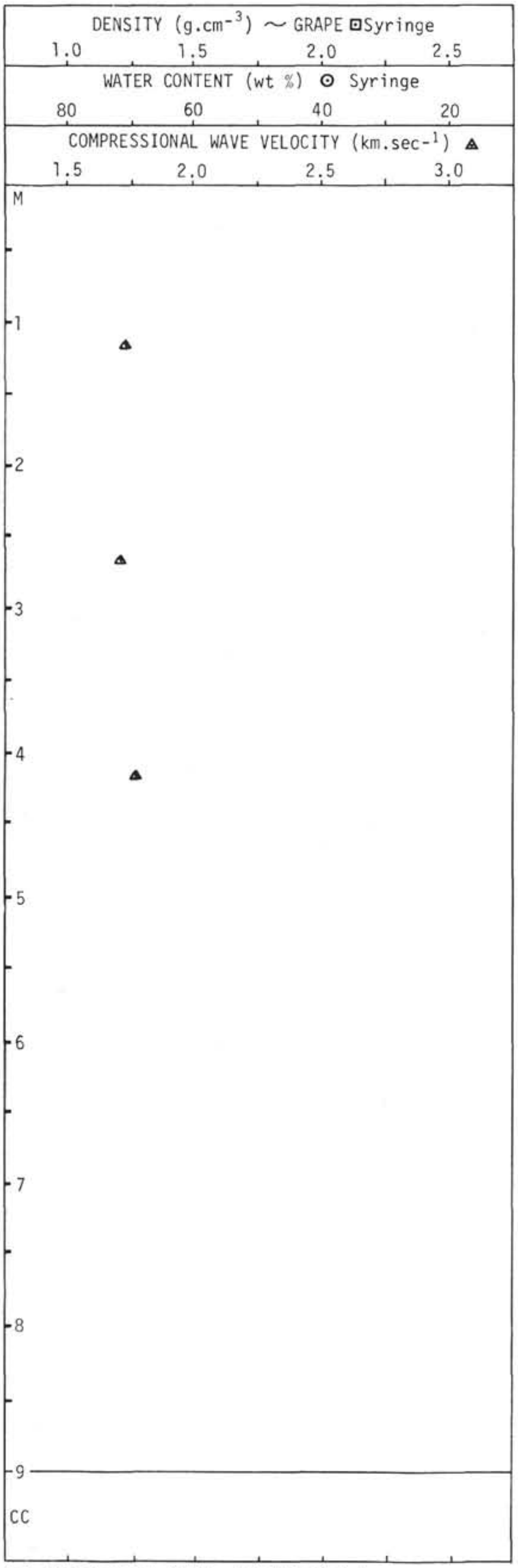




For Explanatory Notes, see Chapter 1

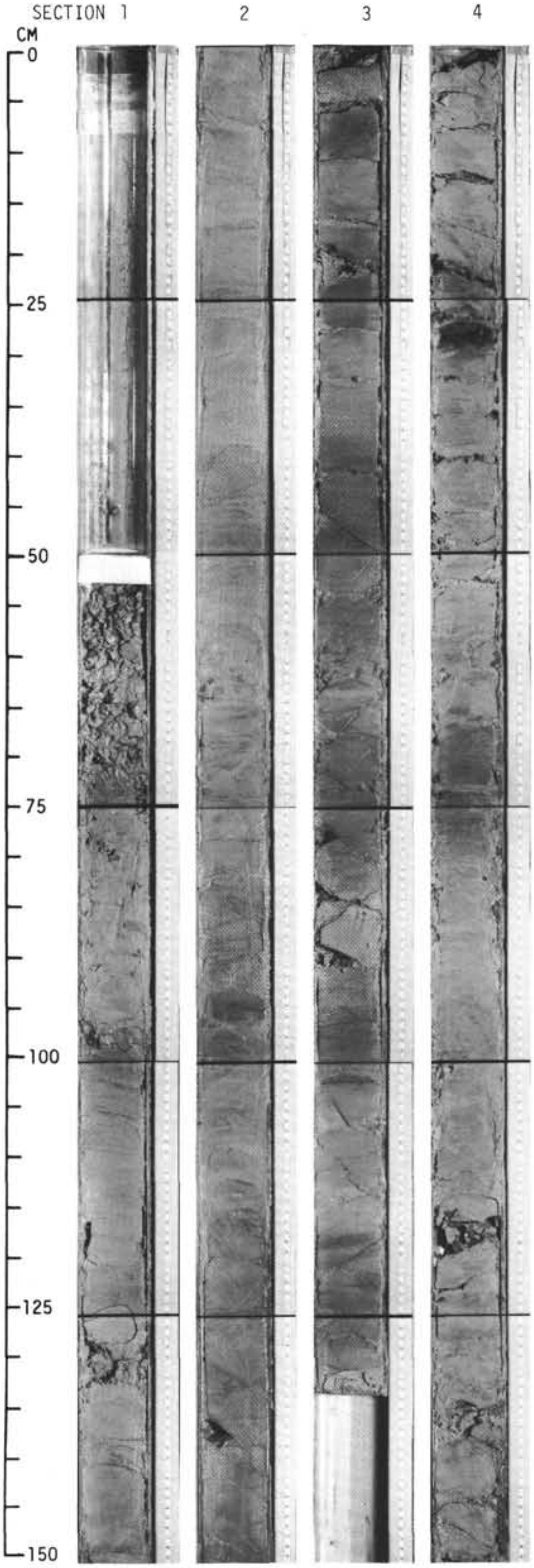
345-16

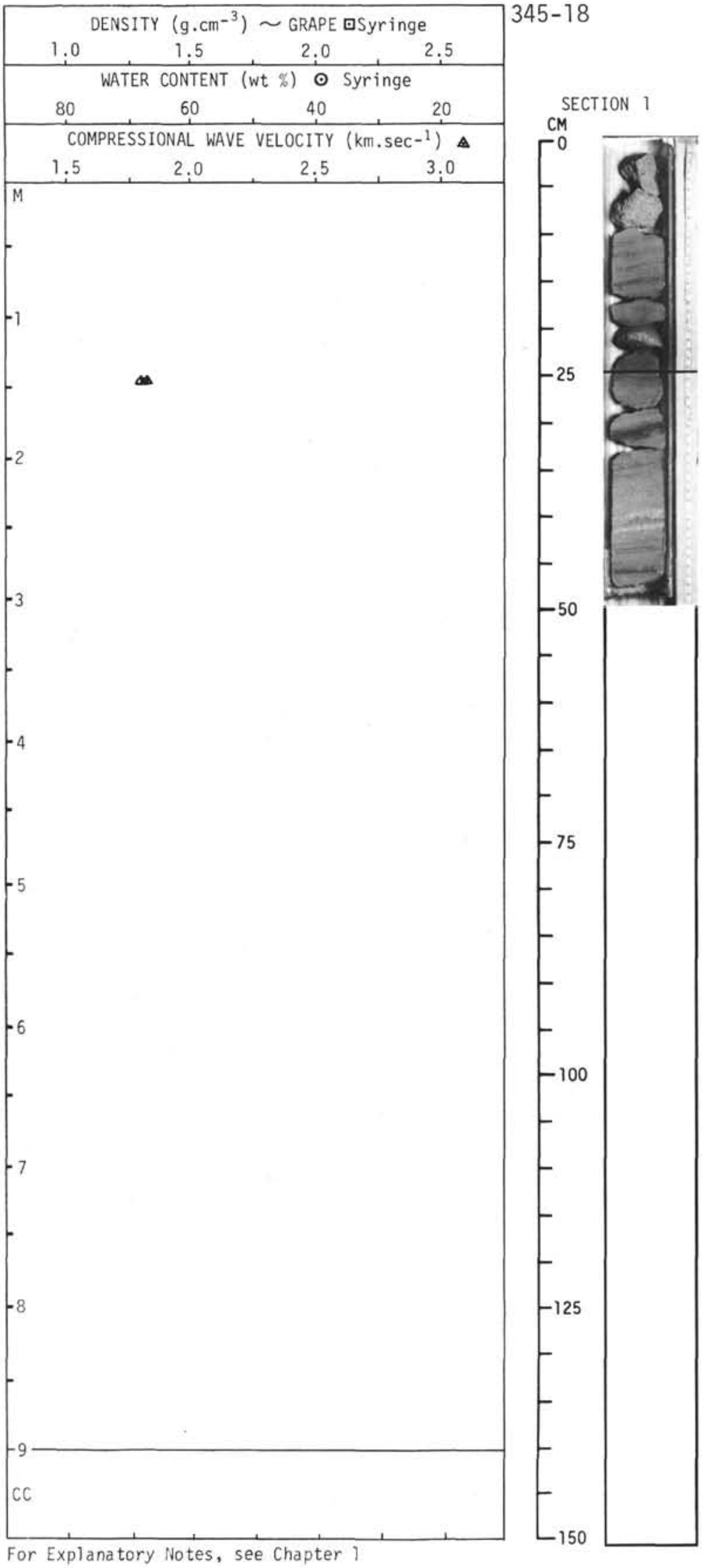




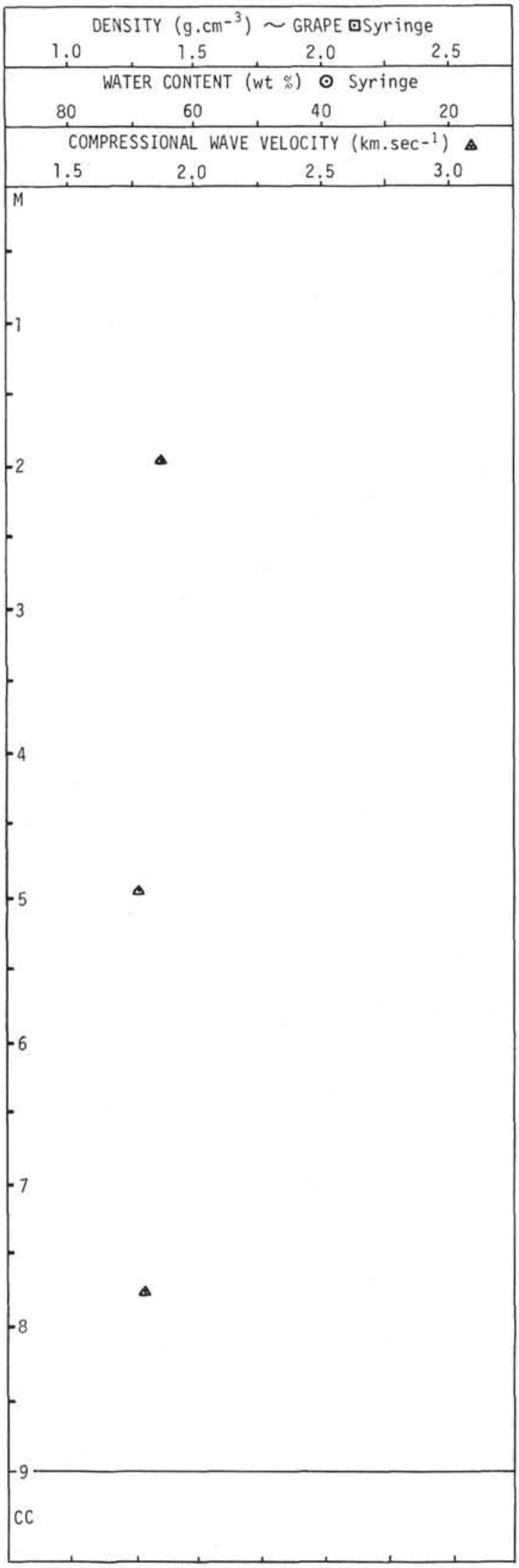
For Explanatory Notes, see Chapter 1

345-17



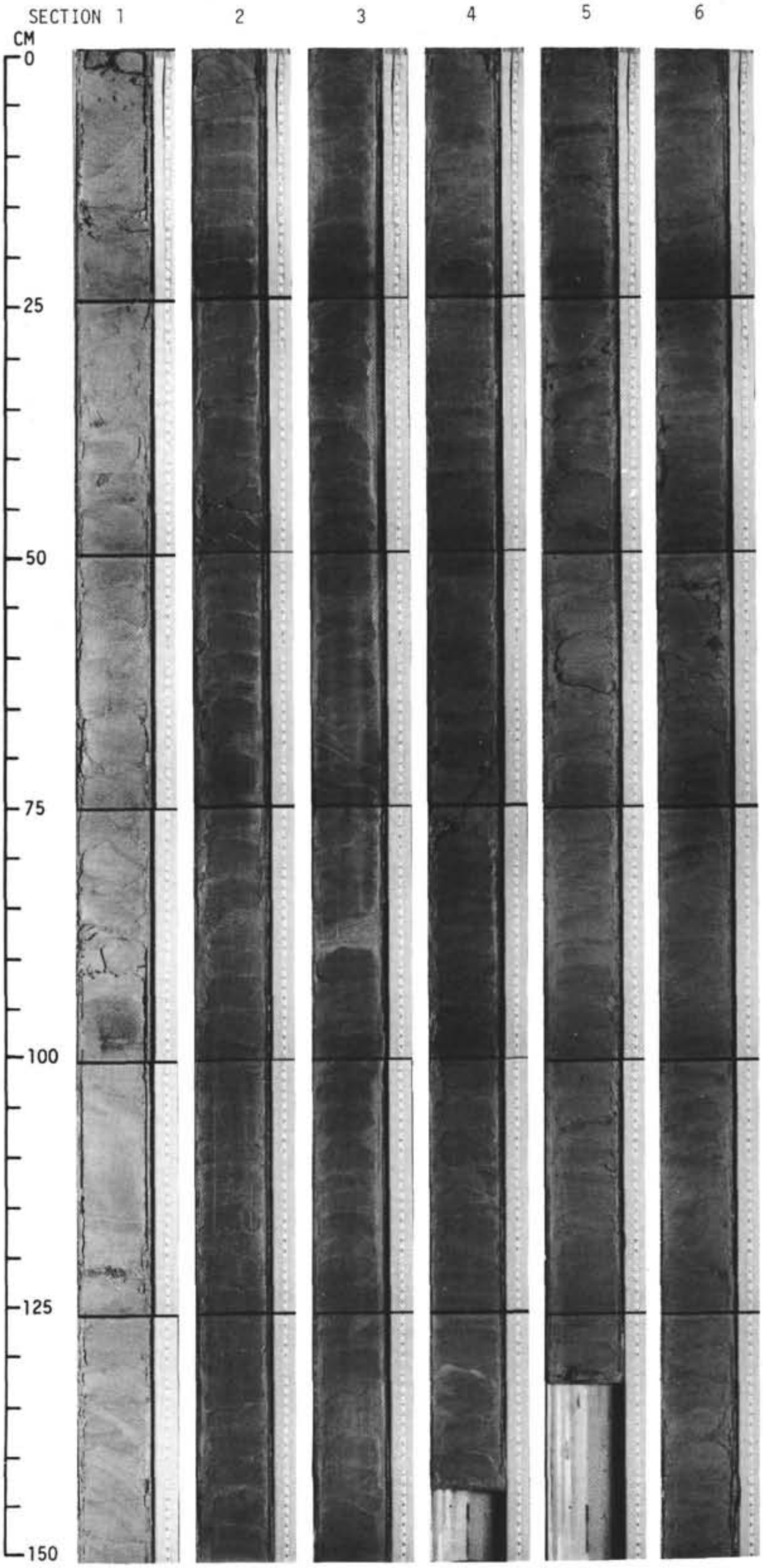


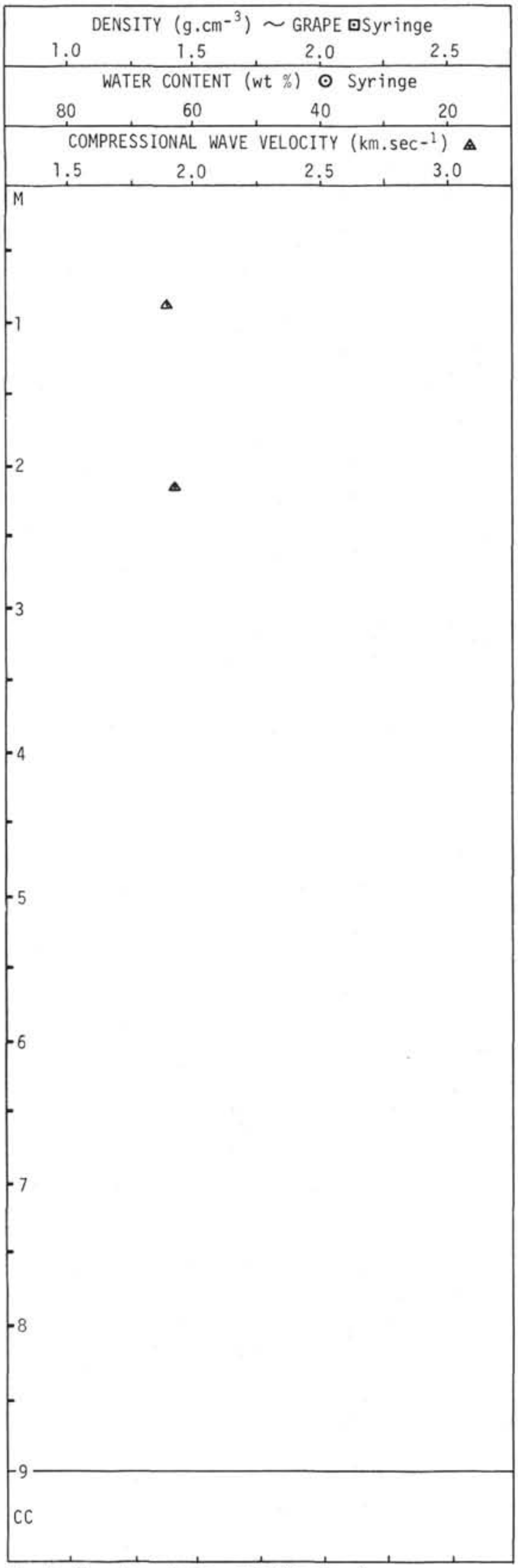
For Explanatory Notes, see Chapter 1



For Explanatory Notes, see Chapter 1

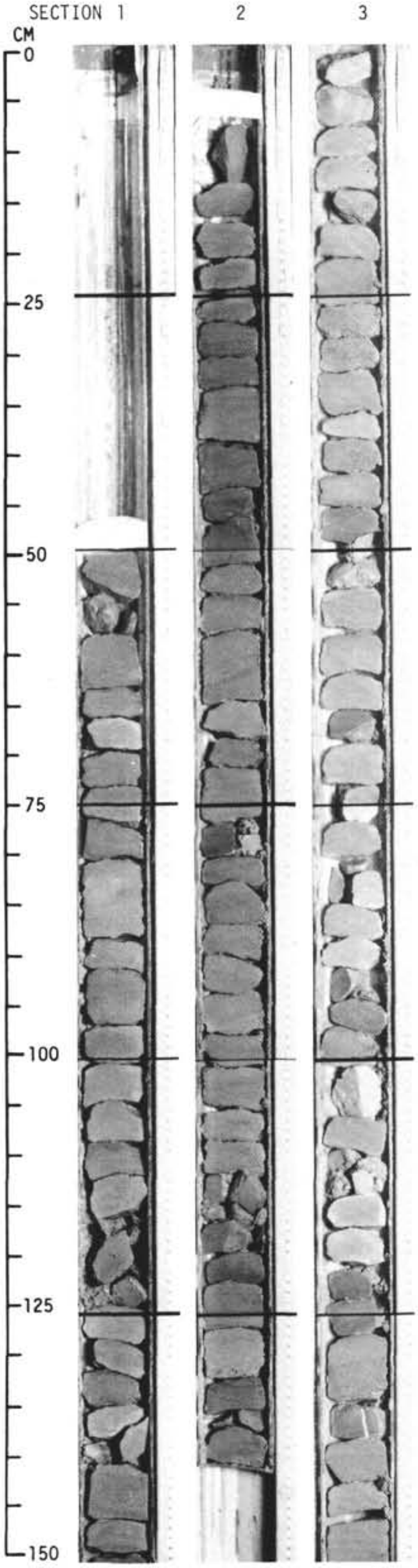
345-19

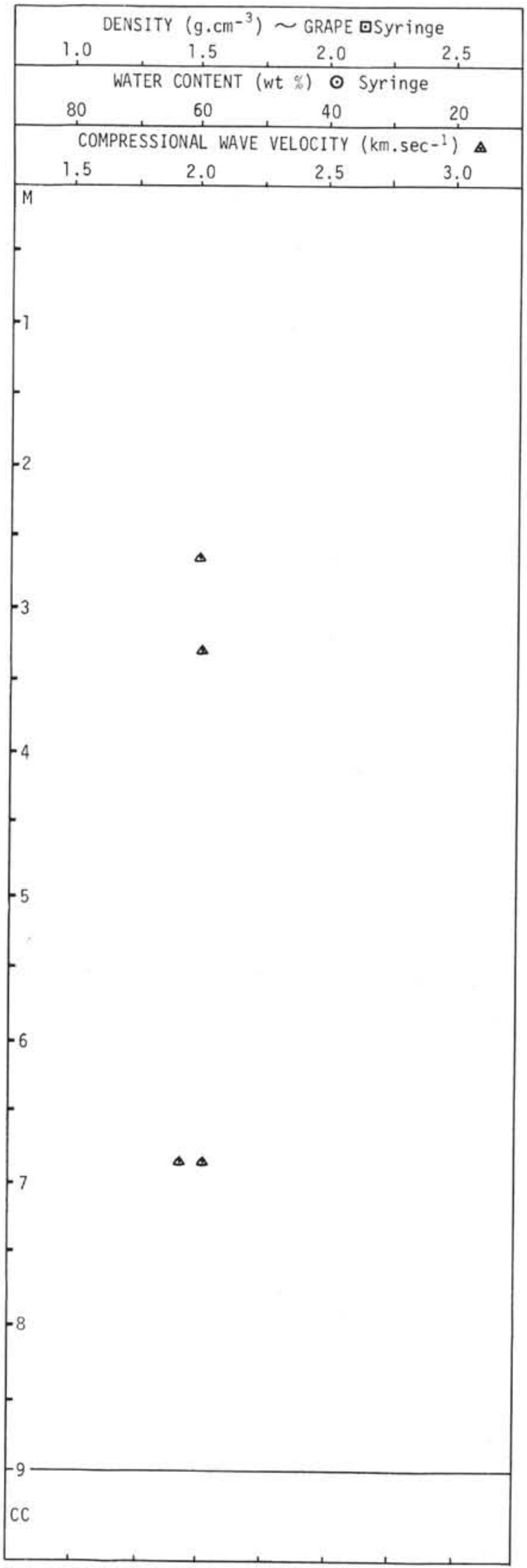




For Explanatory Notes, see Chapter 1

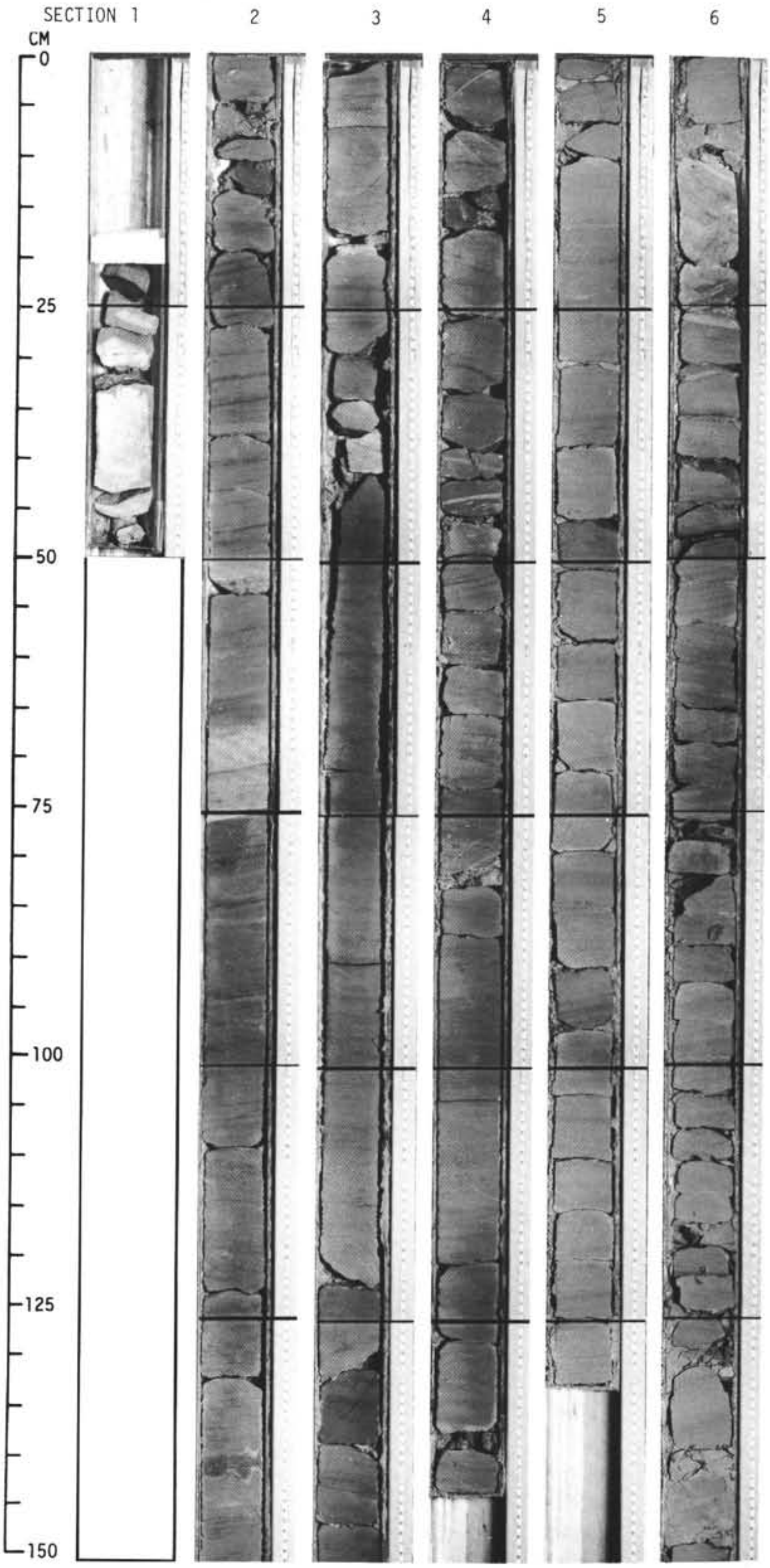
345-20

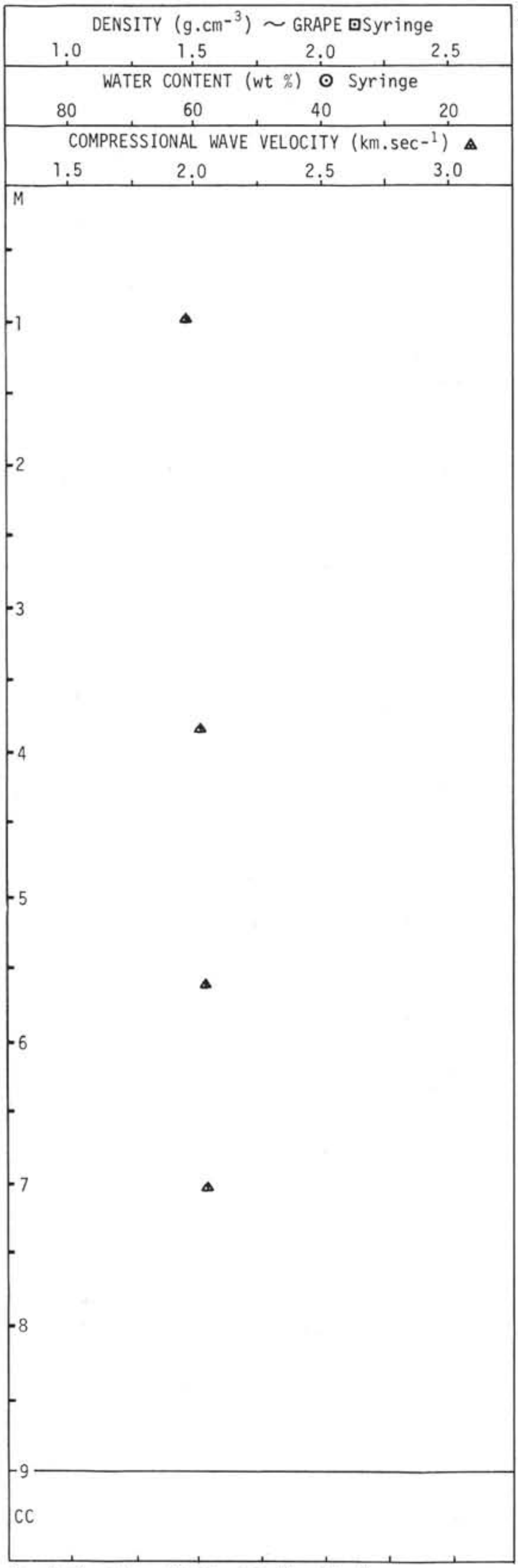




For Explanatory Notes, see Chapter 1

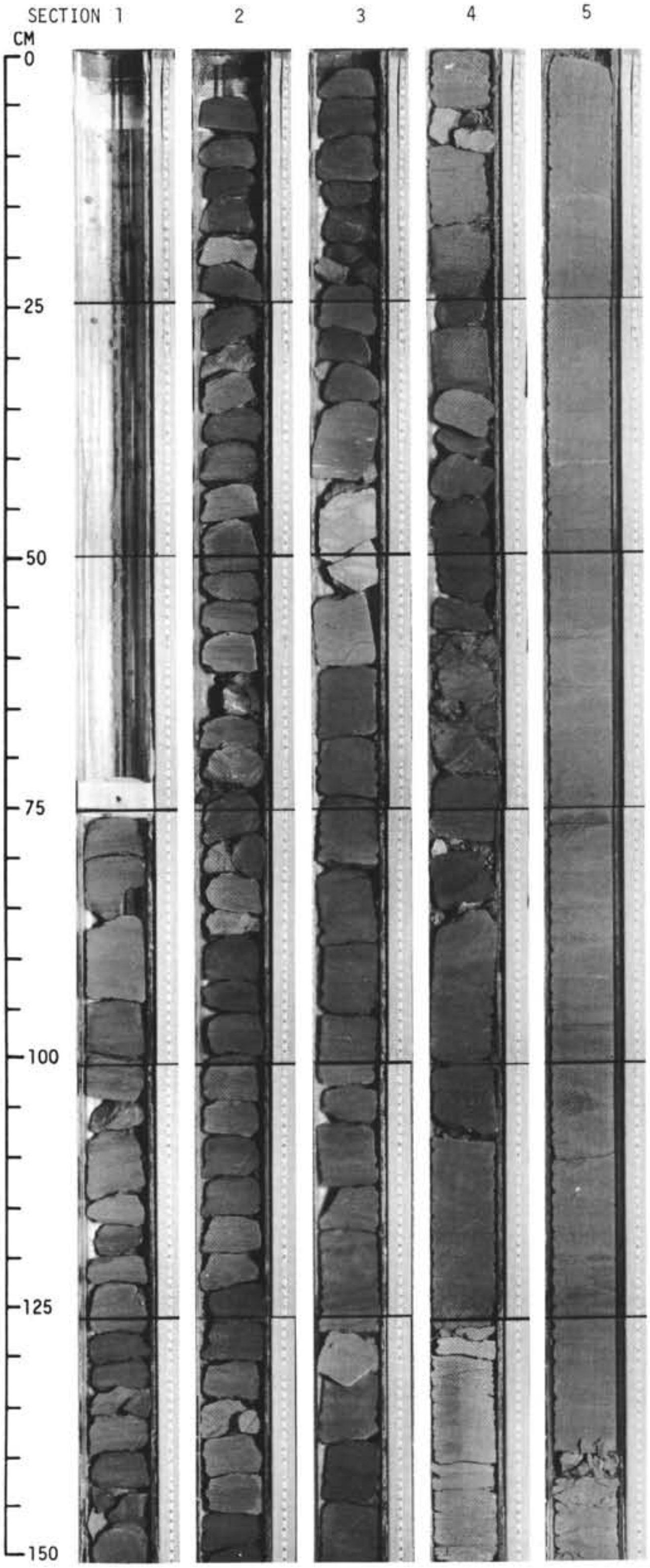
345-21

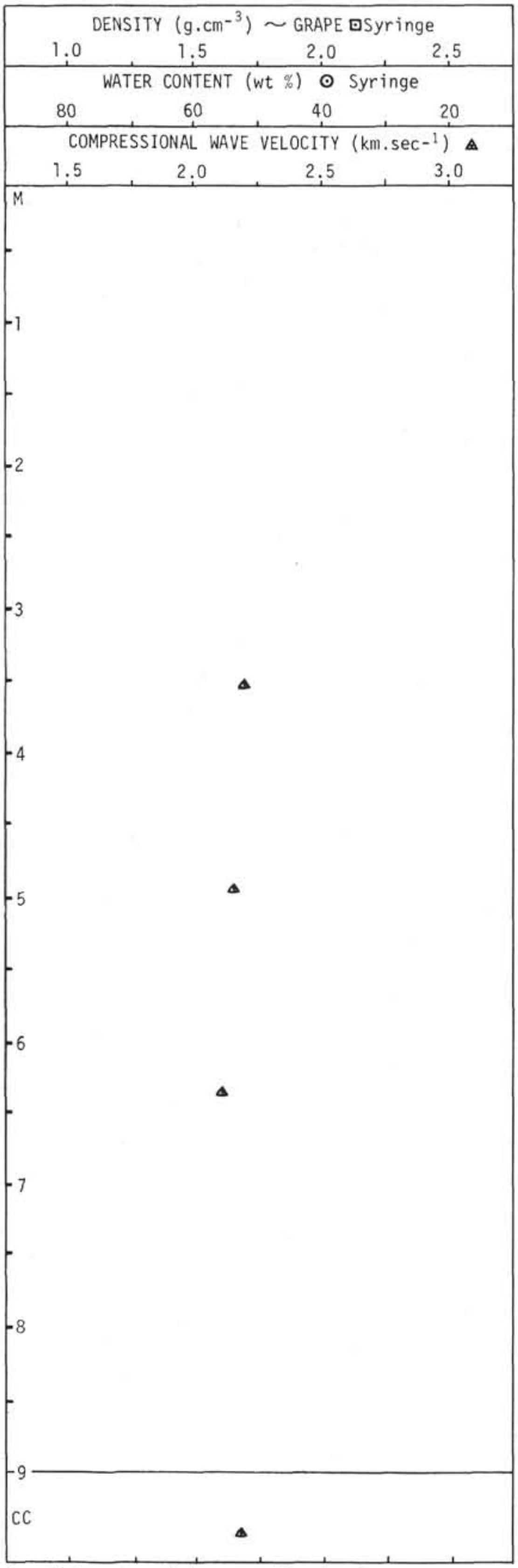




For Explanatory Notes, see Chapter 1

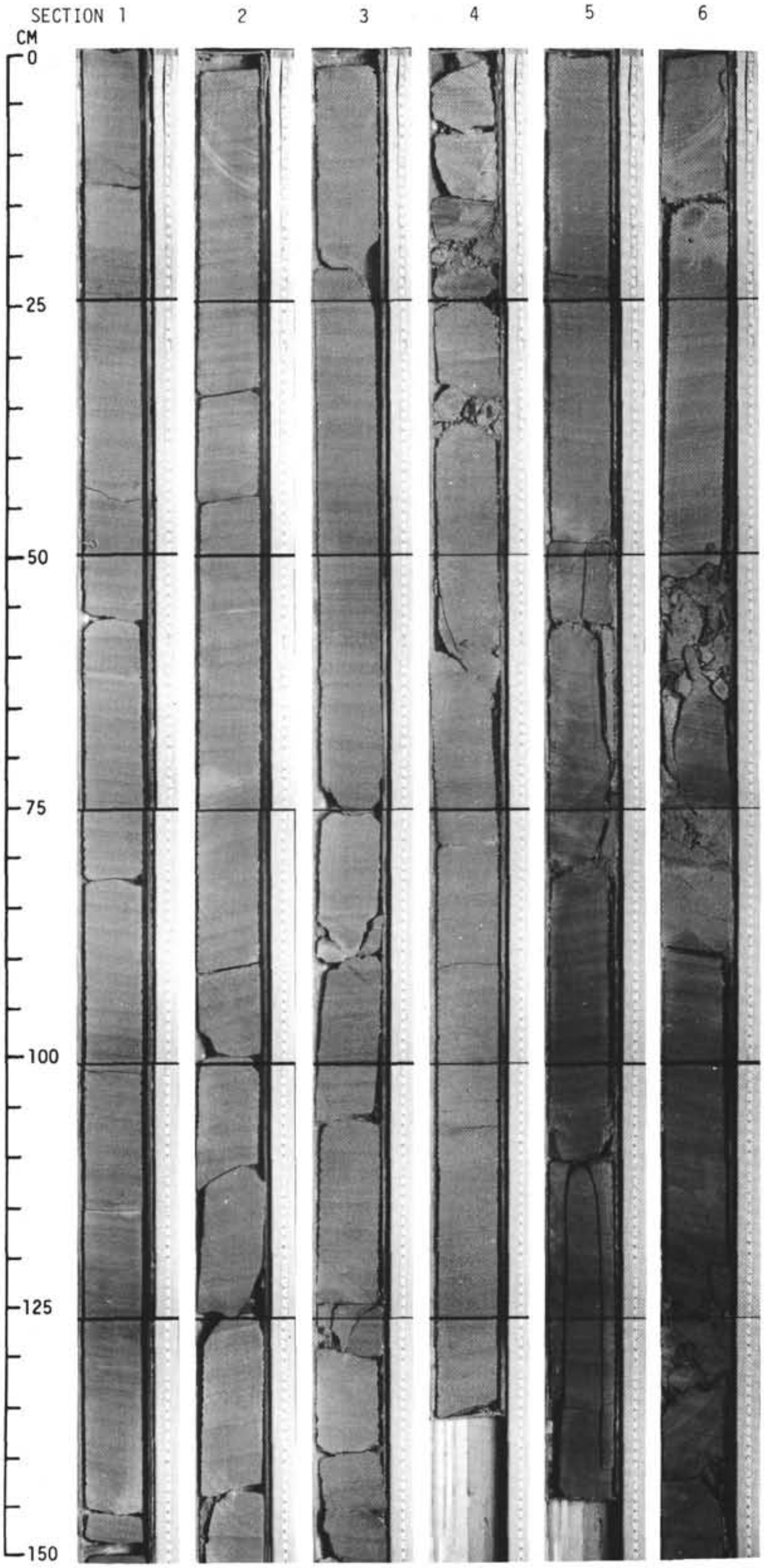
345-22

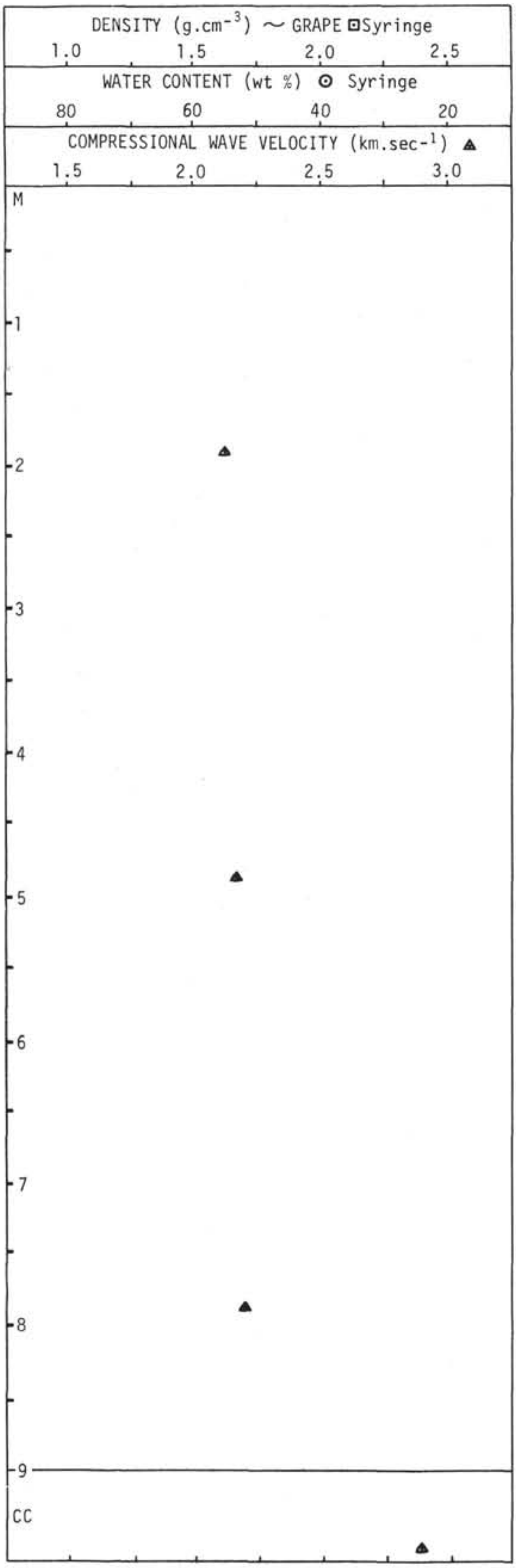




For Explanatory Notes, see Chapter 1

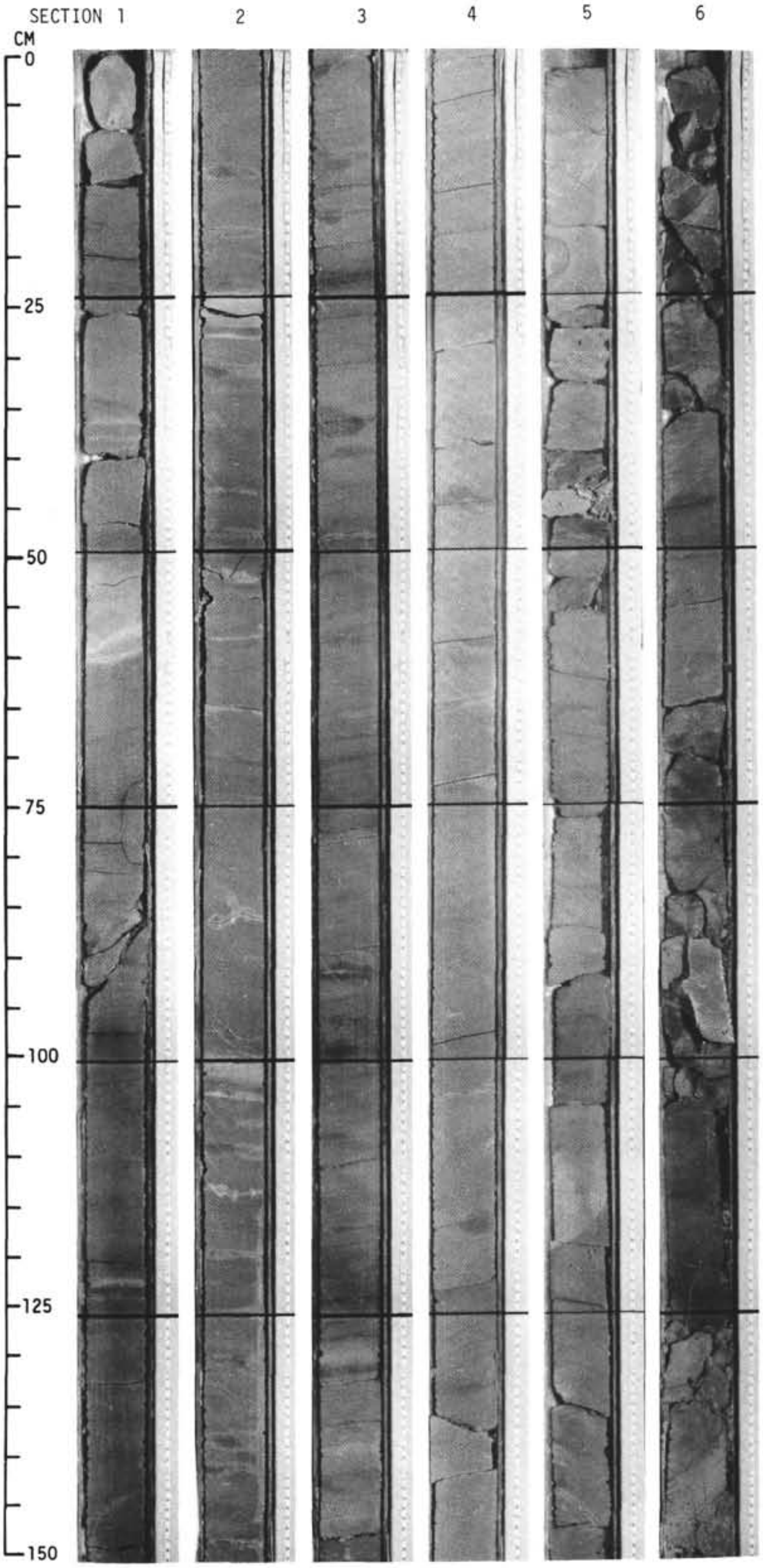
345-23

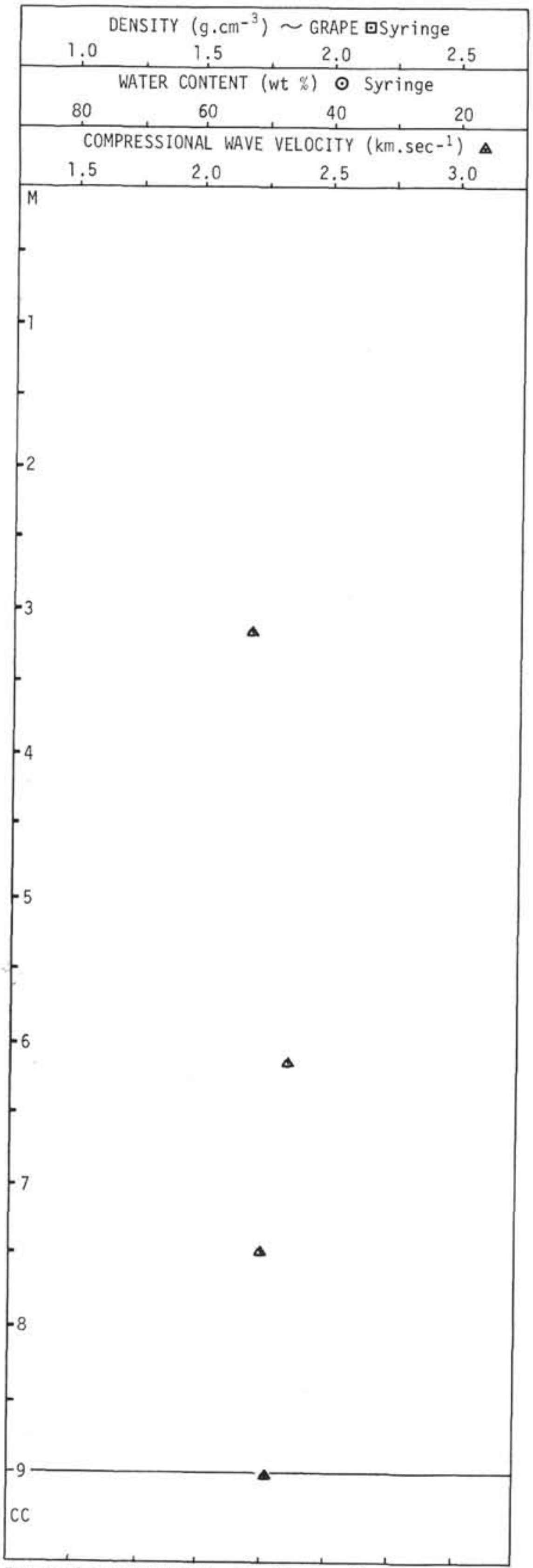




For Explanatory Notes, see Chapter 1

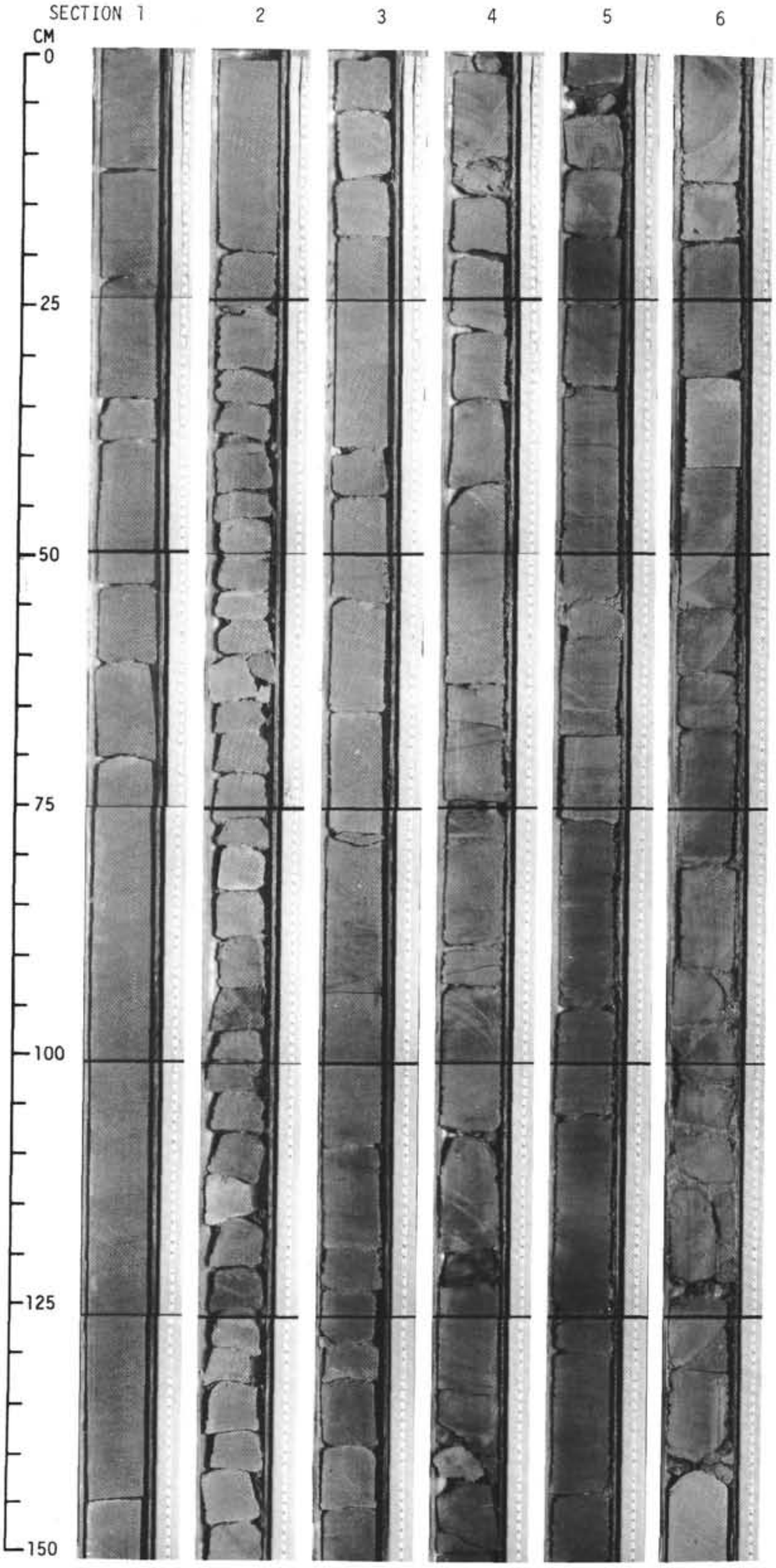
345-24

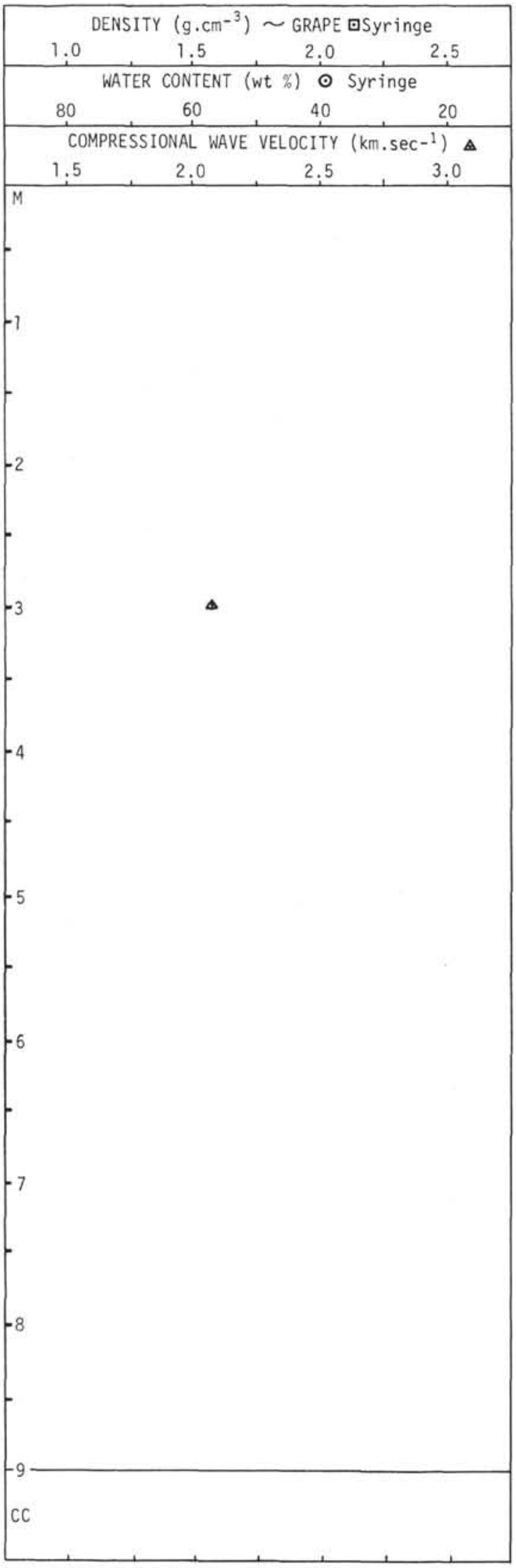




For Explanatory Notes, see Chapter 1

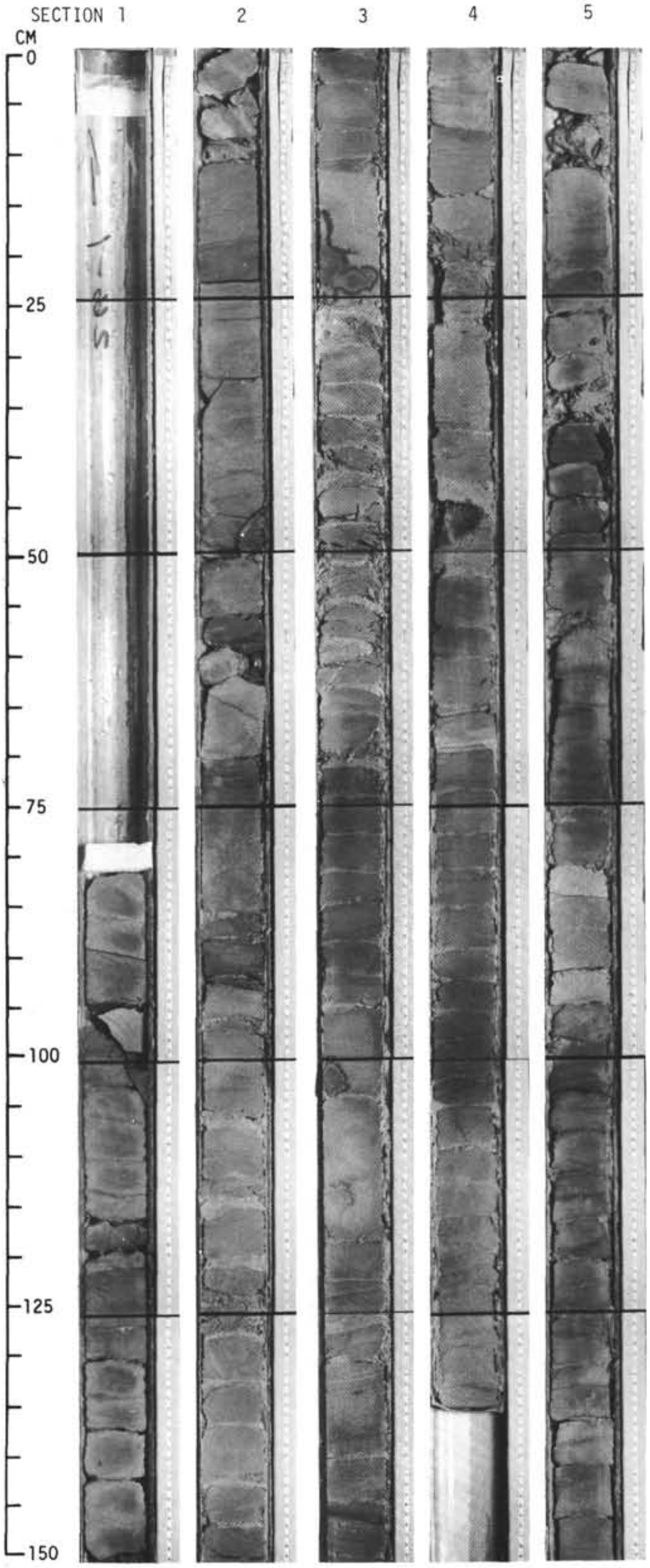
345-25

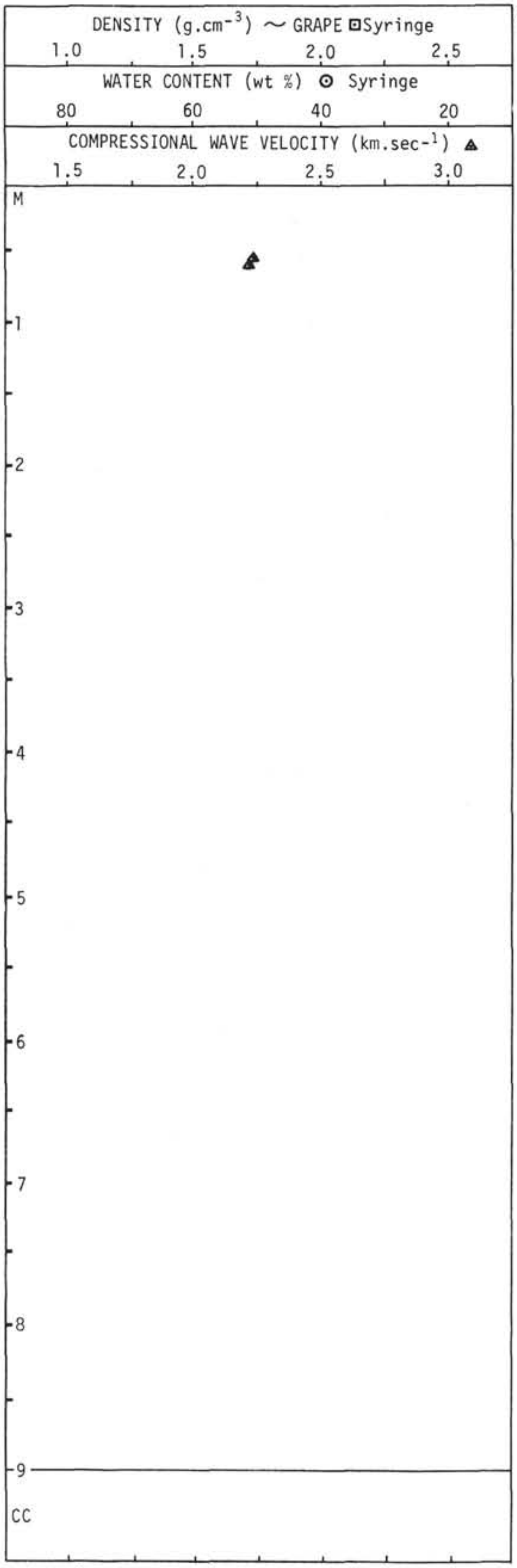




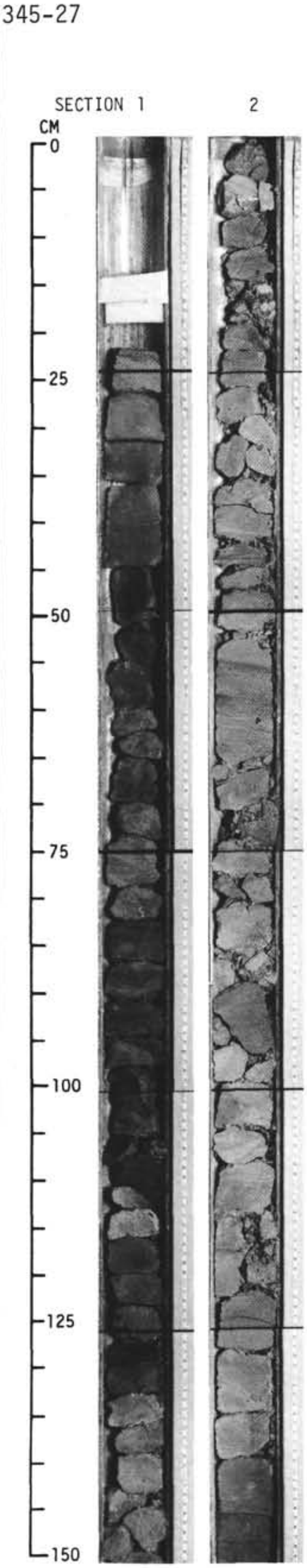
For Explanatory Notes, see Chapter 1

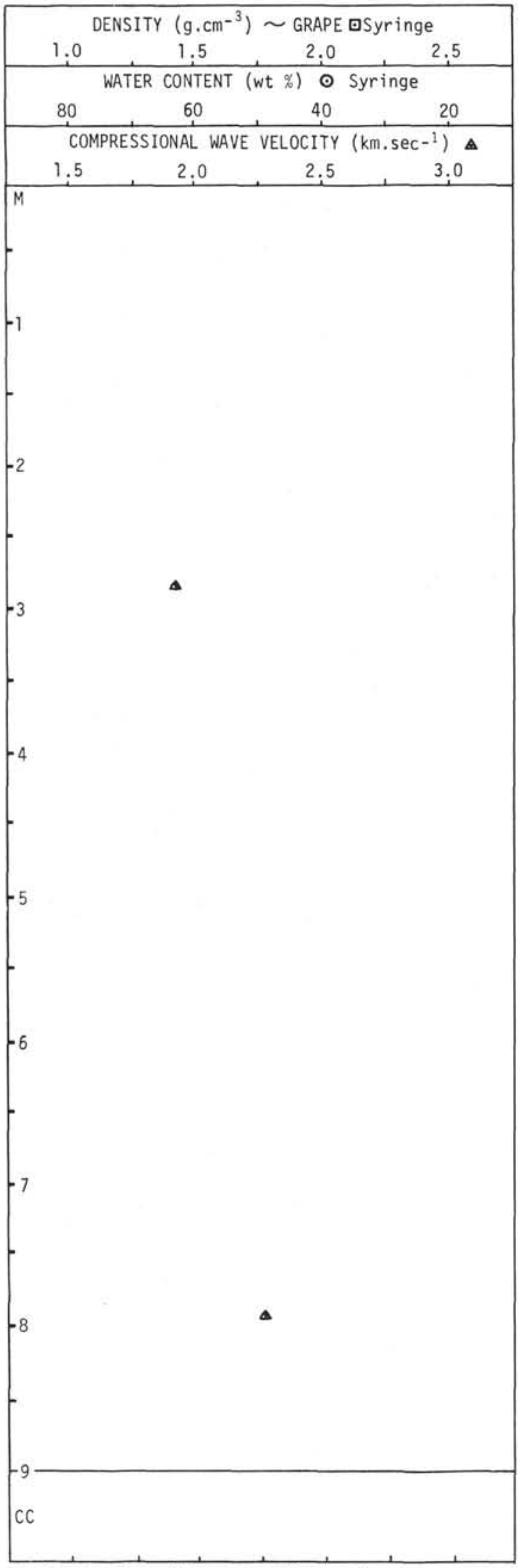
345-26





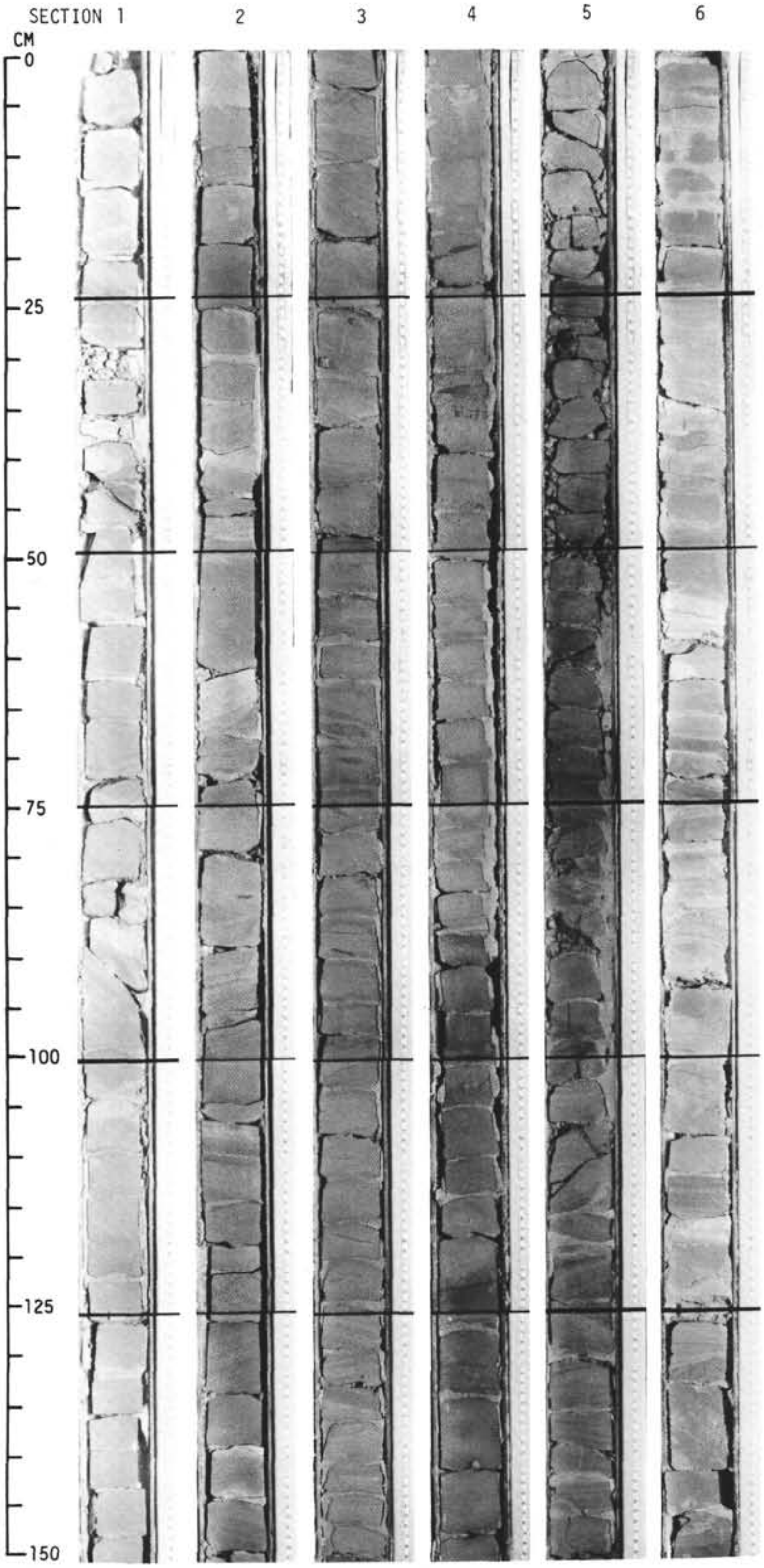
For Explanatory Notes, see Chapter 1

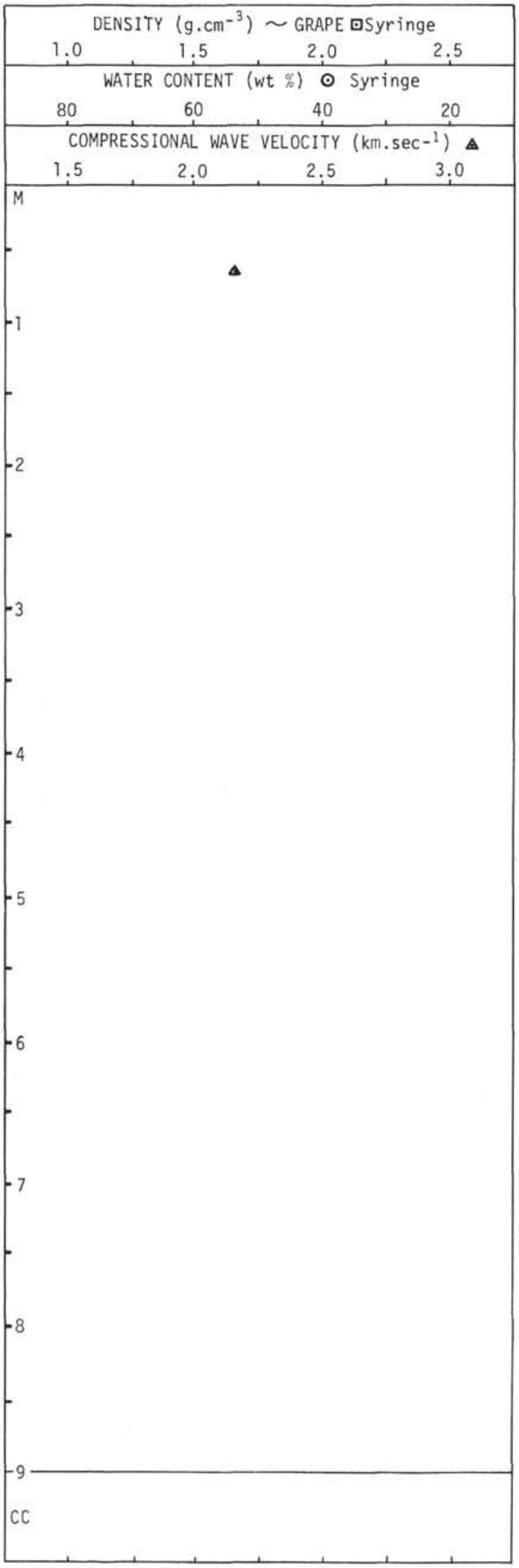




For Explanatory Notes, see Chapter 1

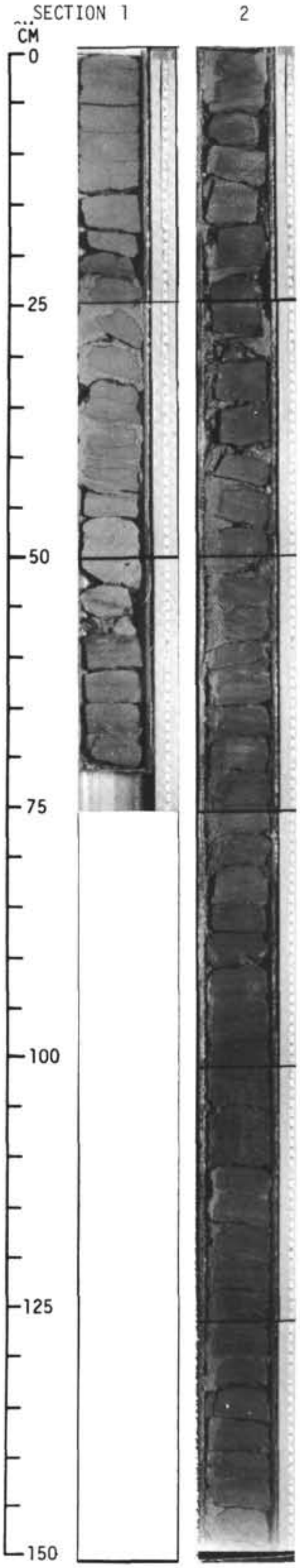
345-28

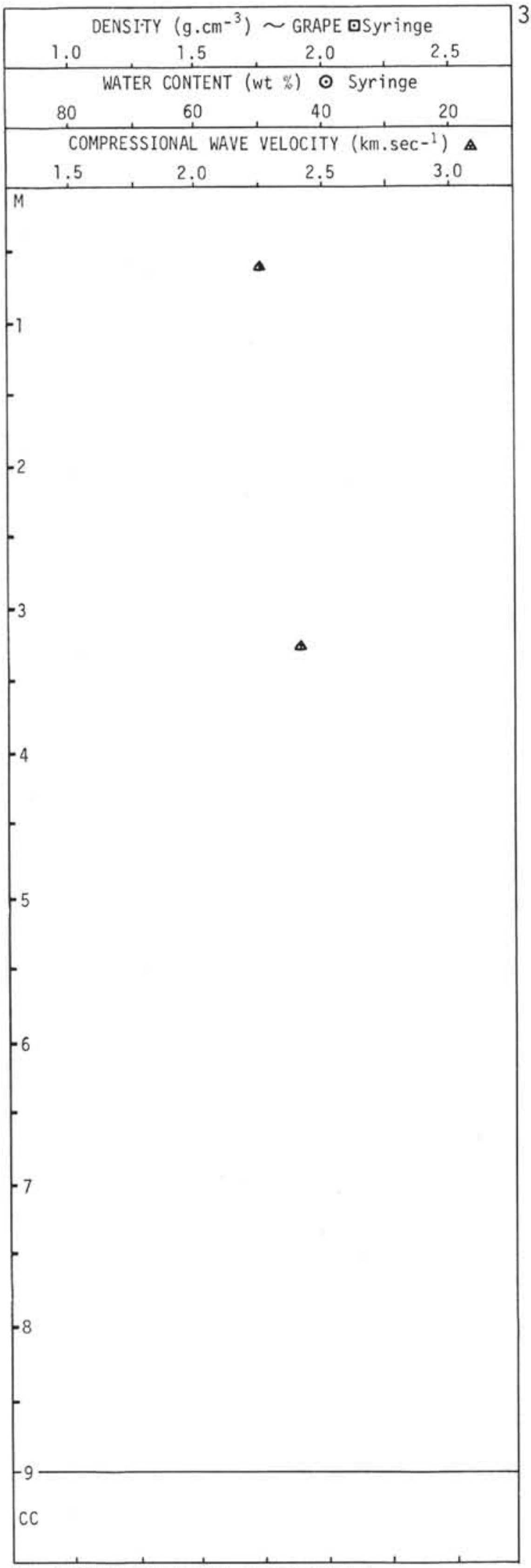




For Explanatory Notes, see Chapter 1

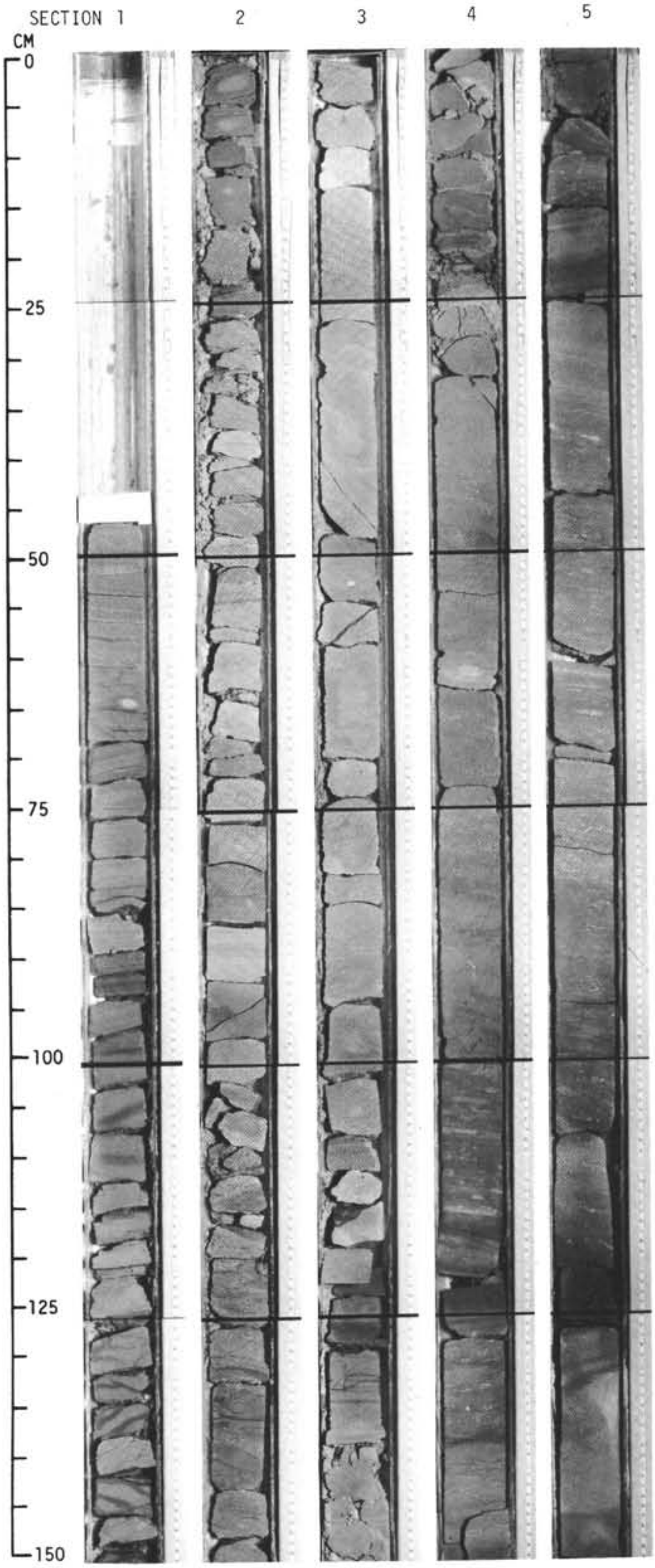
345-29

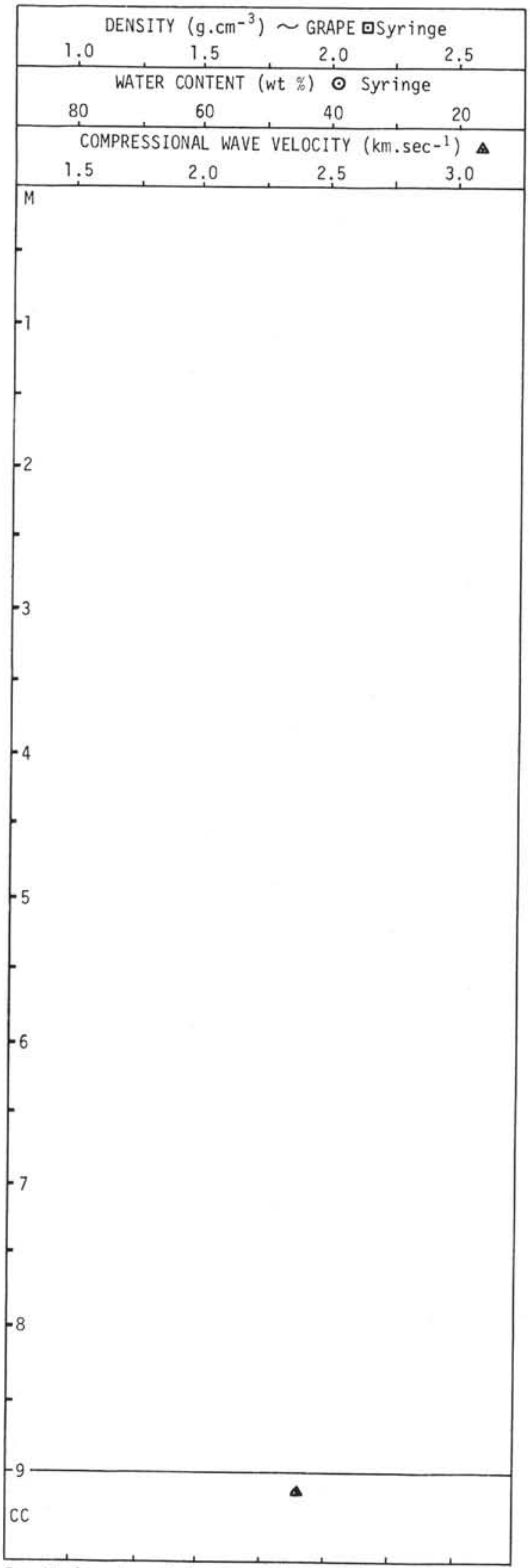




For Explanatory Notes, see Chapter 1

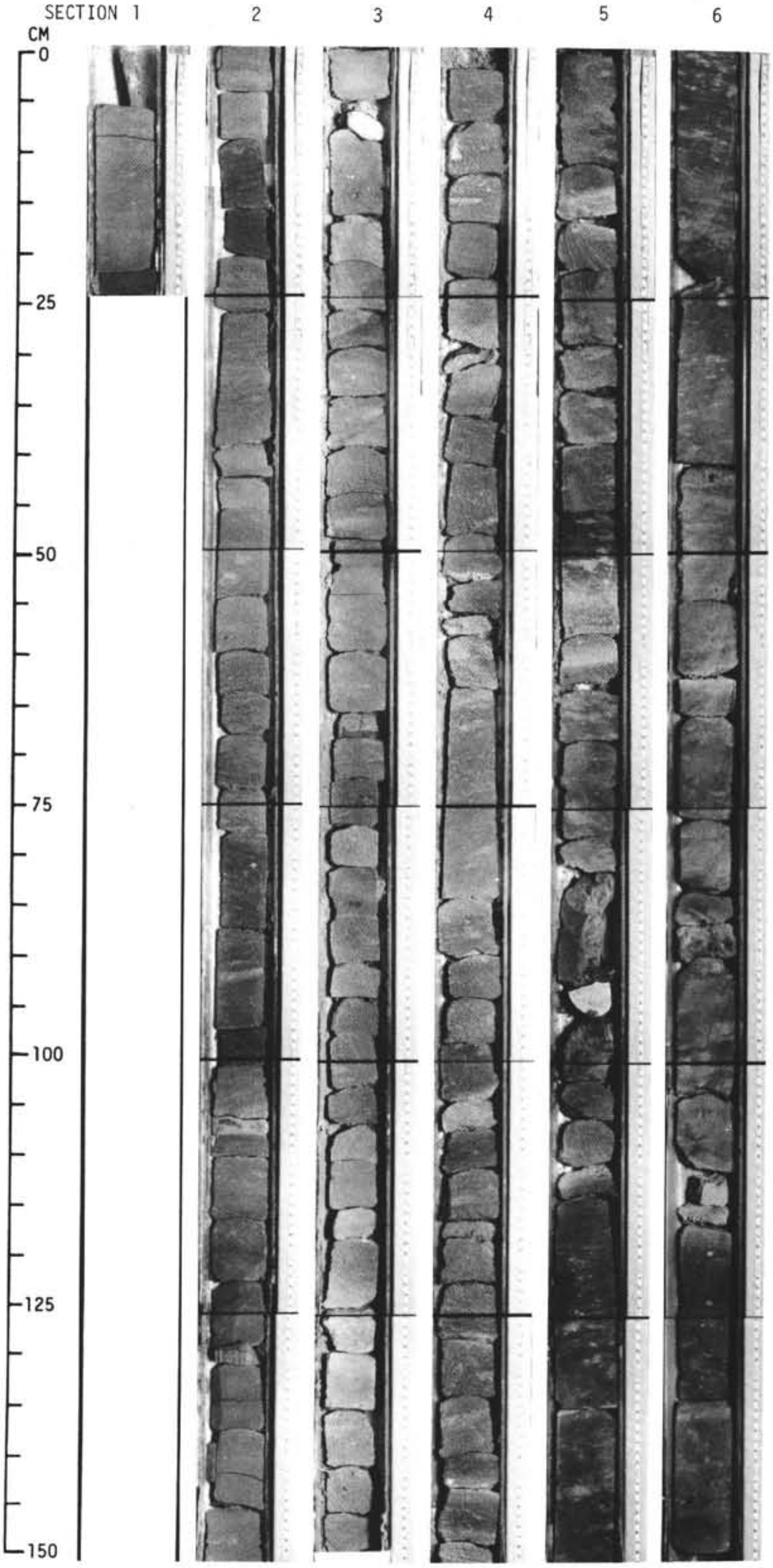
345-30

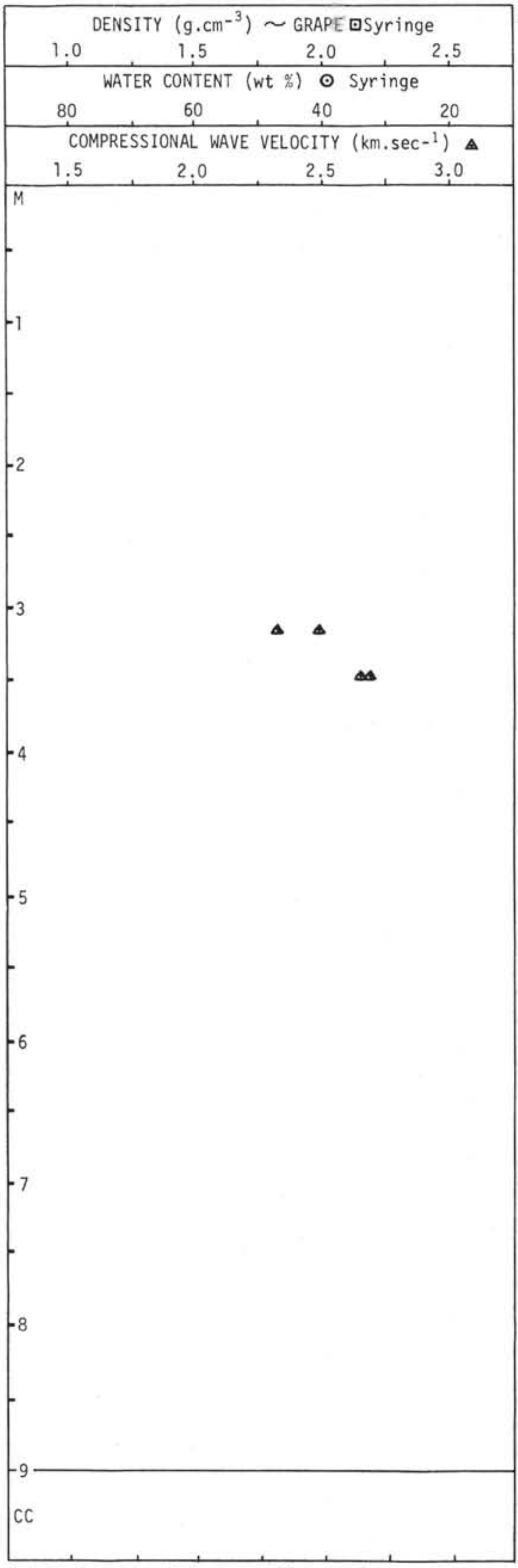




For Explanatory Notes, see Chapter 1

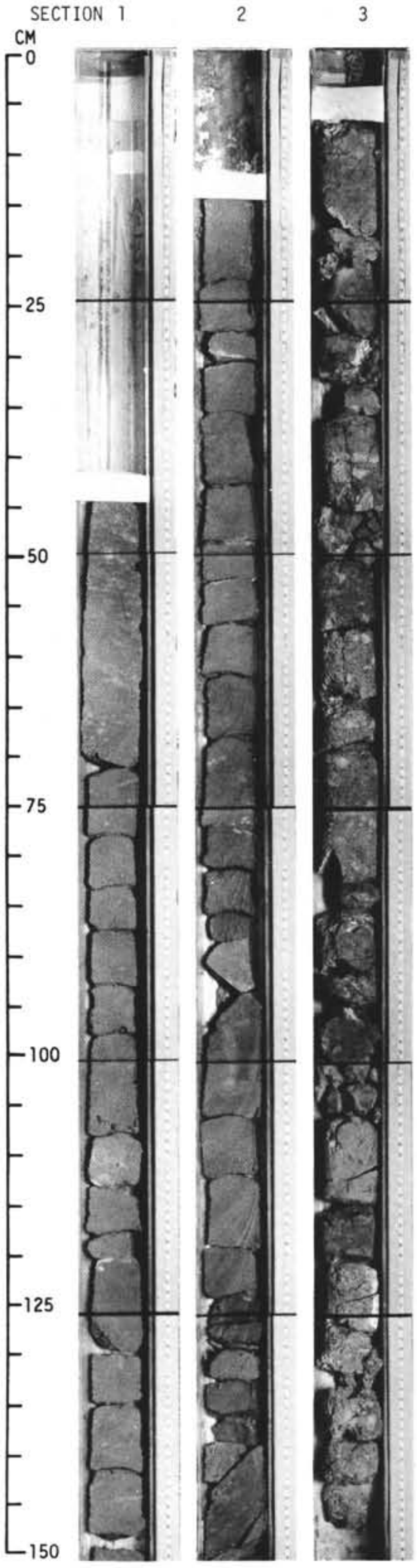
345-31



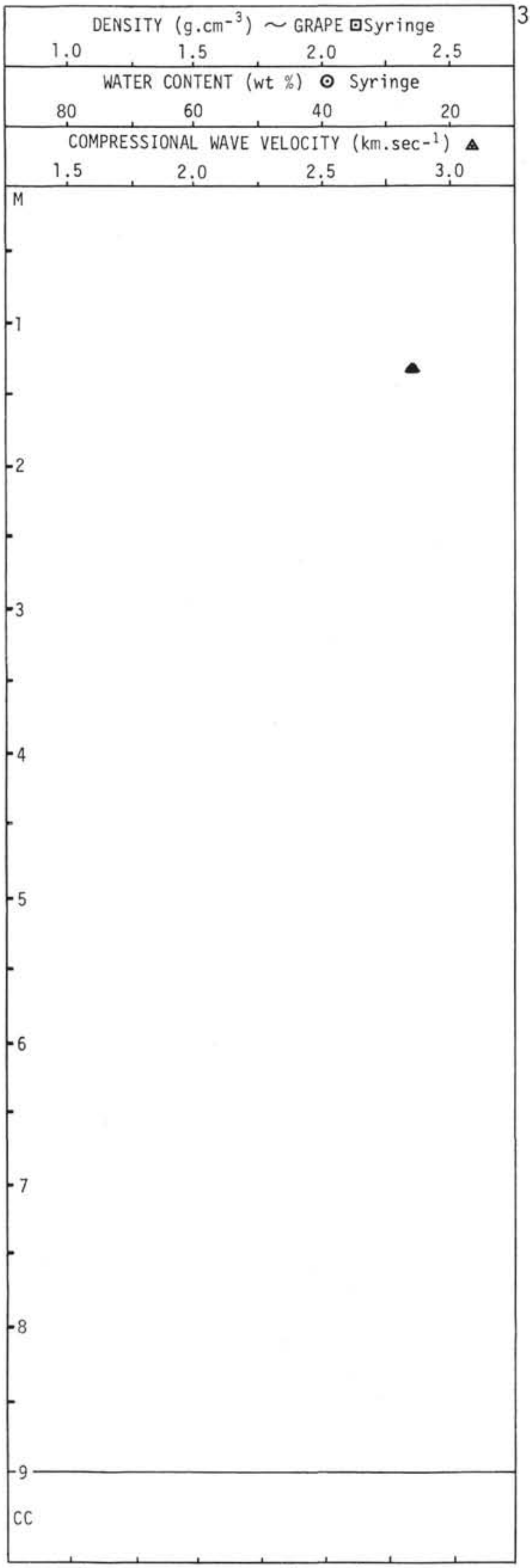


For Explanatory Notes, see Chapter 1

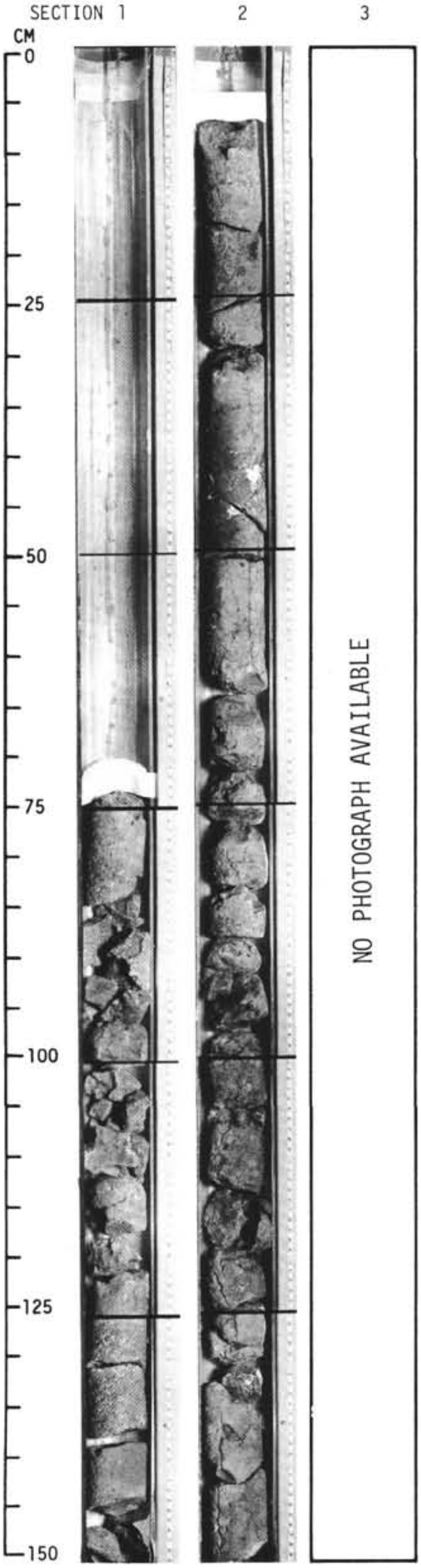
345-32



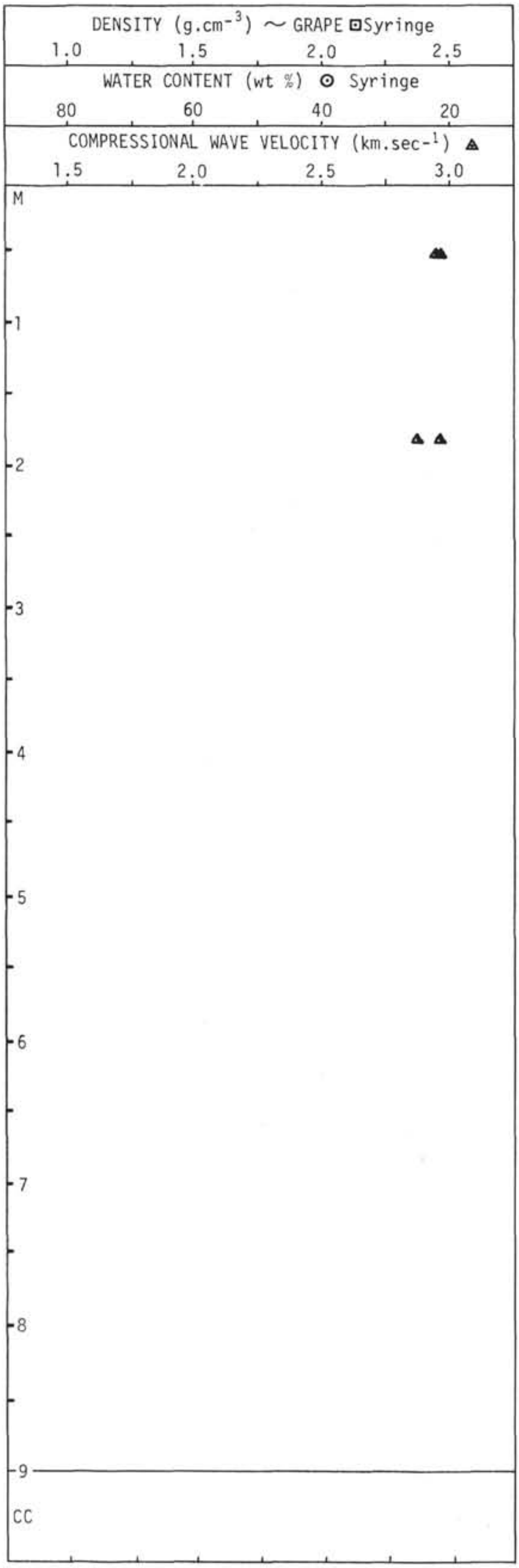
345-33



For Explanatory Notes, see Chapter 1

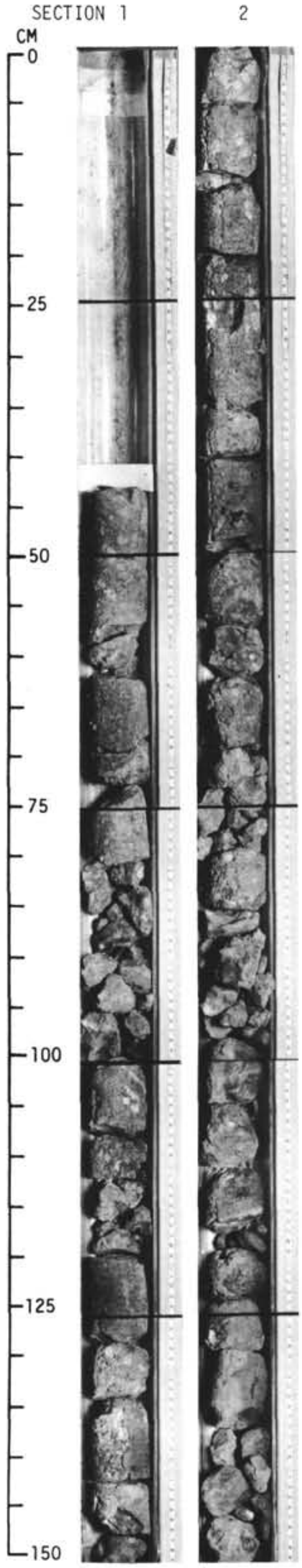


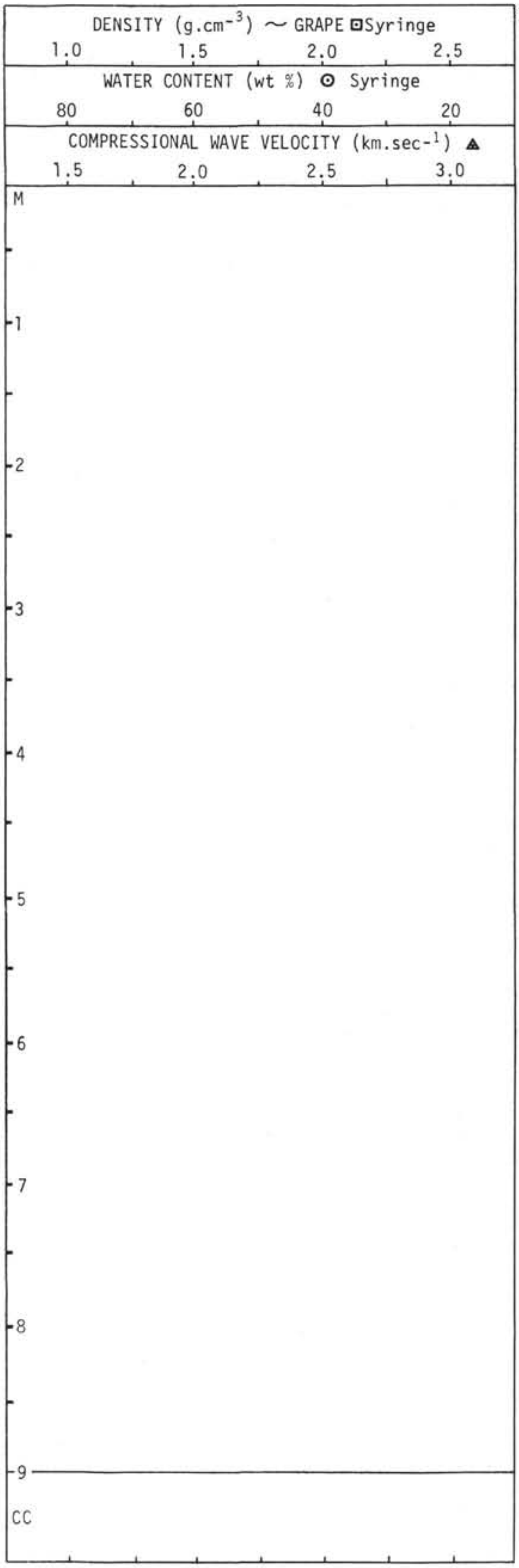
NO PHOTOGRAPH AVAILABLE



For Explanatory Notes, see Chapter 1

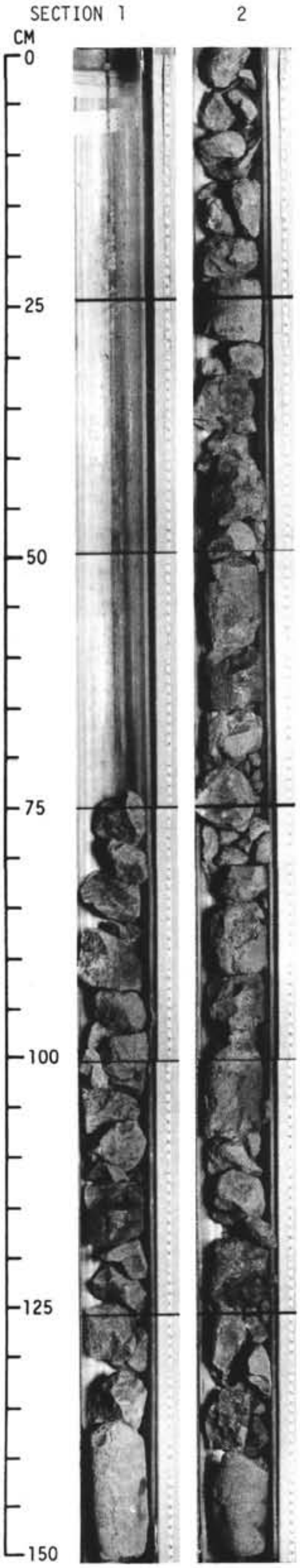
345-34

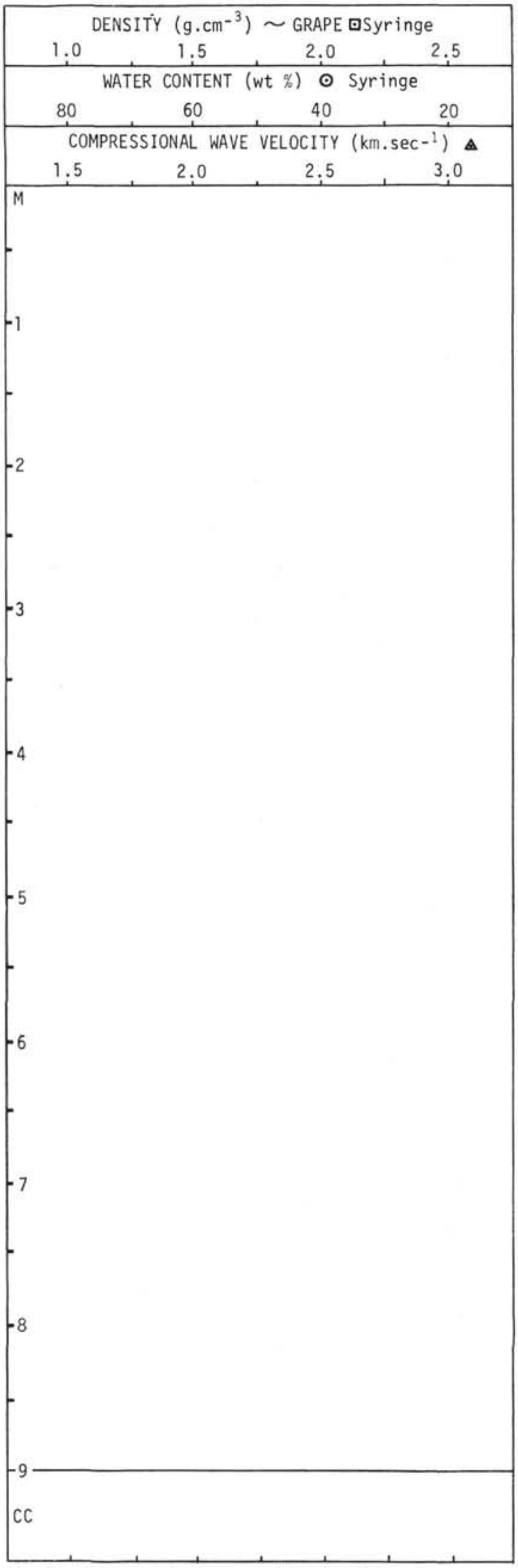




For Explanatory Notes, see Chapter 1

345-35





For Explanatory Notes, see Chapter 1

345-36