4. SITE 112

The Shipboard Scientific Party[1]
With Additional Reports From
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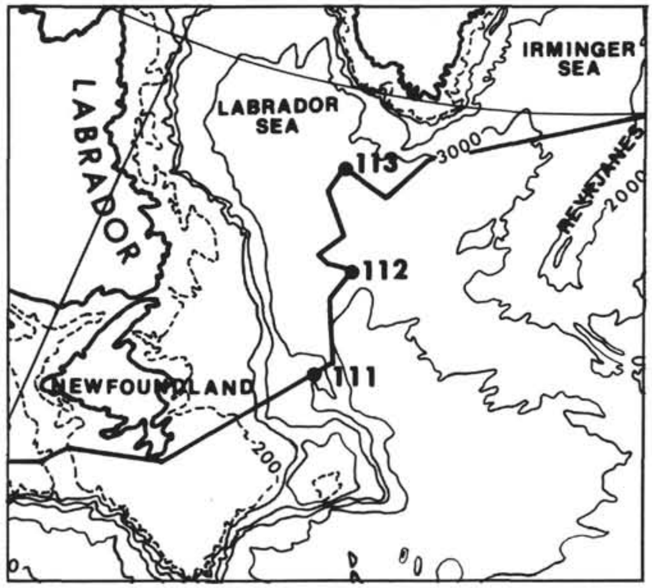
Location: Near basement ridge in the Southern Labrador Sea.

Position: 54° 01.00'N, 46° 36.24'W; (Satellite navigation).

Depth of water: 3657 meters (corrected).

Total penetration: 664 meters



SITE BACKGROUND AND OBJECTIVES

The Labrador Sea is believed to have been formed during the earlier stages of the opening of the northern North Atlantic, prior to the growth of the Reykjanes Ridge and the consequent separation of Greenland and North West Europe. A virtually inactive arm of the mid-Atlantic Ridge has been located beneath the sediments in the axis of the Labrador Sea by seismic profiling techniques (Drake, Campbell, Sander and Nafe, 1963; Le Pichon, Hyndman and Pautot, 1971) and by the interpretation of magnetic profiles (Manchester, 1964; Godby, Baker, Bower and Hood, 1966; Le Pichon *et al.*, 1971; Vogt, Avery, Morgan, Johnson, Schneider and Higgs, 1969; Johnson, Closuit and Pew, 1969). The magnetic data indicate that whereas the separation of Greenland from northwestern Europe began about 60 million years ago (Magnetic Anomaly 24), the Labrador Sea had already substantially opened by this time. The age of the earliest opening of the Labrador Sea has been variously estimated by different authors, depending upon the identification on the Heirtzler (Heirtzler, Dickson, Herron, Pitman and Le Pichon, 1968) time scale of the group of relatively high amplitude anomalies that have been found either side of the mid-Labrador Sea Ridge Axis. Mayhew identifies the oldest of these as 75 million years (Anomaly 32) and suggests a late Cretaceous start to the spreading, assuming that Anomaly 32 represents the edge of the initial break. A similar age of opening is derived by Le Pichon *et al.* (1971).

In contrast, Johnson, Vogt and Schneider (1971) have suggested the initiation of rifting in the Jurassic based on evidence of early Jurassic dikes (164 million years old) on the west coast of Greenland and shallow water Cretaceous deposits on the Greenland Continental shelf. They interpret the oldest of the group of large anomalies as being 60 million years (Anomaly 24), but point out the large areas of the Labrador Sea outside this anomaly that must be older.

This uncertainty in assigning the correct age to the prominent anomalies and hence in deducing the age of opening of the Labrador Sea prompted the search for a region where more positive data could be obtained by drilling for sediments lying immediately above the

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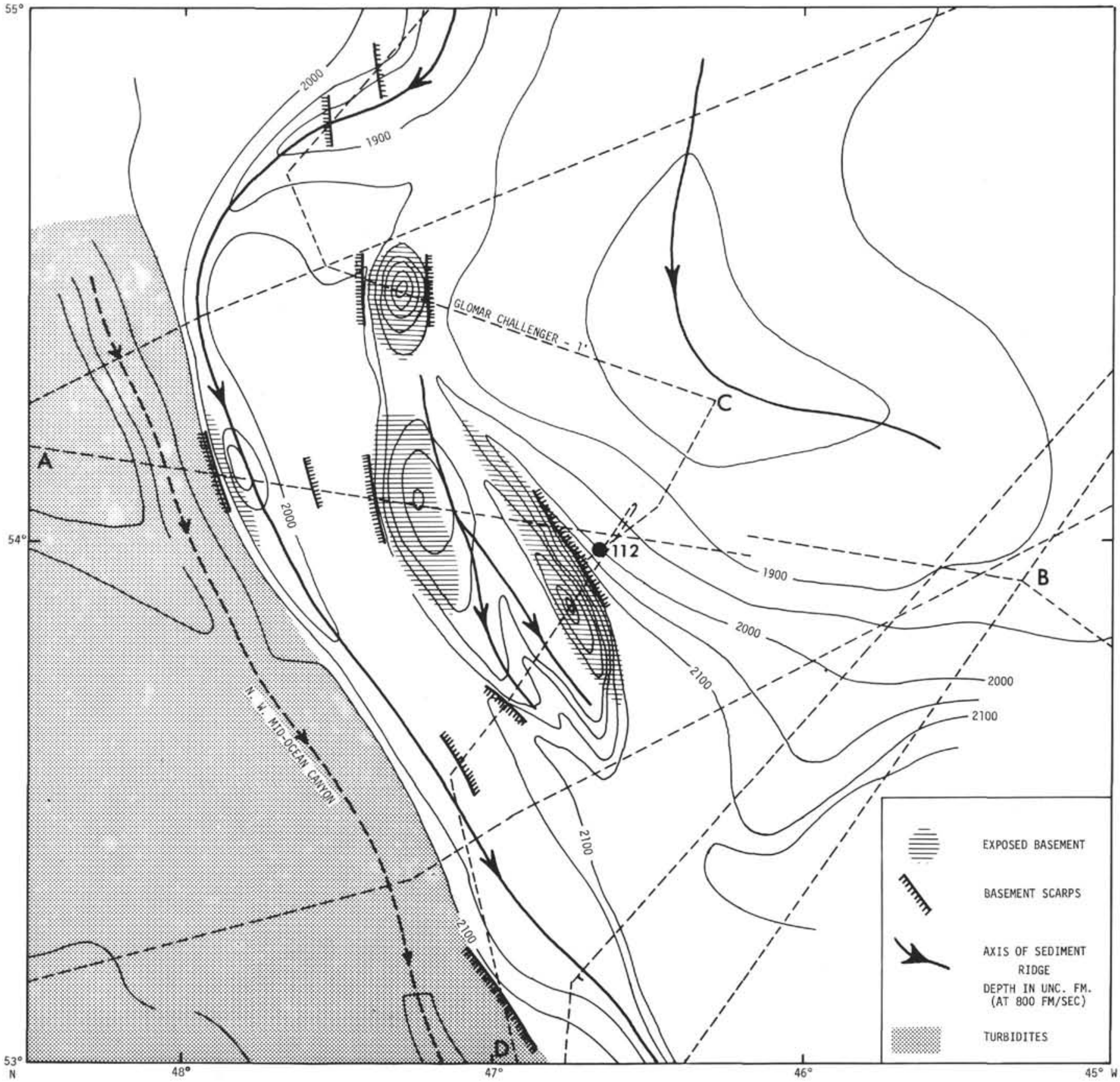

Figure 1. *Bathymetric chart in the vicinity of Site 112, showing exposed basement ridge, buried scarps, the NW Atlantic mid-ocean canyon and the crests of sediment ridges. Profiles AB and CD are illustrated in Figures 2 and 3.*

basement. Seismic reflection data indicated that a large part of the bottom of the Labrador Sea was covered by thick sediments derived from land, too thick to be penetrated with existing techniques. However in the southeastern Labrador Sea, where it joins the North Atlantic, an E-W profile by *Vema*-27 (Figure 2) showed a basement high, 300 kilometers from the foot of the continental slope. West of this the terrigenous sediments were too thick to penetrate, but the high provided a barrier preventing terrigenous sediments reaching the east side. Site 112 was chosen immediately east of the basement high in a region where basement could be clearly recognized and was within reach. An alternative site on the high itself was rejected because of the ambiguity that could arise in interpreting the results.

Dating of the oceanic crust cannot be done on samples of the basaltic basement since these have been shown often to be 'weathered' or chemically and physically altered since they were solidified (the degree of weathering depending on the age and, hence, on the distance from the ridge axis), and therefore do not retain the argon released by K^{40} decay. Furthermore, in some unweathered basalts, excess radiogenic argon has been found, attributed to incomplete degassing during emplacement (Funkhauser, Fisher and Bonatti, 1968) leading to excessive ages.

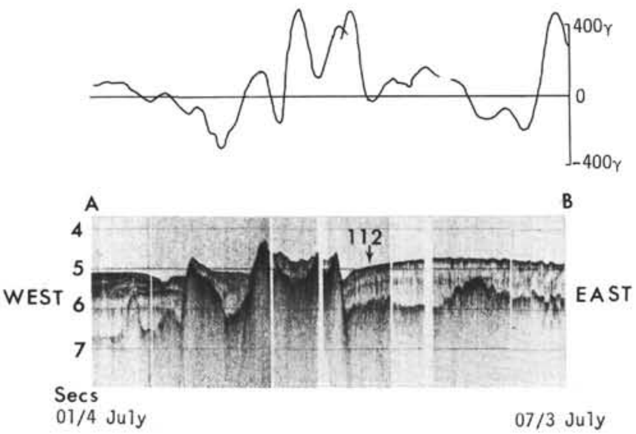

Figure 2. *Magnetic and seismic reflection profiles (E-W) across Site 112 by* Vema-27 *(courtesy Lamont-Doherty Geological Observatory).*

The age determination depends, therefore, on the biostratigraphic age of the sediments lying immediately above basement. This method, however, assumes implicitly that sedimentation started on the crust soon after it was formed. If the basement was a topographic high at this time, sediments may have been prevented from accumulating there by ocean currents (as they are so prevented from many topographic highs on the mid-ocean ridges today). In order to obtain a viable age it is necessary to demonstrate that the sediments lay in a local basin, or else make a suitable correction for local topography. With no knowledge about the nature of the basement high west of Site 112, the age of sediments found in the small basins on top would have told us little about the age of the oceanic crust.

The location of Site 112 is shown in Figure 2 in relation to the local topography, the contours having been drawn after completion of the hole, using *Glomar Challenger* and other data. The site lies on the southwestern margin of a sedimentary sequence (Figures 2 and 3) which can be traced continuously over a large area (20,000 sq km) of the southeastern Labrador Sea, and whose limits have been defined subsequently by *Glomar Challenger* and other ships. A N-S section across this sequence was described and discussed by Jones, Ewing, Ewing and Eittreim (1970) who recognized a single diffuse reflector half way down an otherwise transparent layer. They tentatively assigned a middle Late Eocene age to this reflector by correlation with similar reflectors found elsewhere. They recognized the presence of 'giant ripples' in the sequence and deduced that it was largely built up soon after the Labrador Basin was created, since the sequence is overlapped by turbidites on its southern margin. A more complete discussion of this important sequence of sediments will be found in Chapter 11 on sedimentation and in Chapter 20 where the history of the Labrador Basin is discussed. A second objective of the hole at Site 112 was, therefore, to identify the nature of this sedimentary sequence and to deduce the mechanism by which the sediments were deposited, and also to date the widespread mid-sediment reflector.

The magnetic profile along the E-W track of *Vema*-27 through the site (Figure 2) shows two prominent anomalies associated with the basement ridge. Further east, the magnetic anomalies can be related to a group (Anomaly Numbers 19 through 24) associated with the E-W spreading from the mid-Atlantic Ridge. The anomalies near Site 112, however, do not follow on this sequence and hence a third objective of the hole was to identify the pair of anomalies so as to relate them to the spreading history of this area.

In summary the objectives were:

(a) To date the basement by sampling and dating the oldest sediments.

(b) Hence, to identify the magnetic anomaly pair just west of the site and to relate this to the spreading history of Labrador Sea.

(c) To date the mid-sediment reflector.

(d) To deduce the sedimentary mechanism by which this widespread sediment body was deposited.

SURVEY DATA

No site survey was available before sailing, so the approach track across the site was made SW-NE to complement *Vema*-27 data. The track was continued beyond the site onto the extensive sediment sequence, and the mid-sediment reflector was recognized together with an indication of basement. The exact site was chosen on the basis of this run and the beacon was laid. At the site position basement was believed to be at 0.82 second. After completion of the hole, another crossing of the beacon along a SW-NE track, using higher gain and at slower speed, showed that this hole penetrated a basement high between 0.75 and 0.80 seconds (Figure 4), being about 0.2 second shallower than the mean depth of basement in the vicinity. The basement reflections consisted of a series of overlapping hyperbolae indicating rugged relief. The echo at 0.75 second is the side of a hyperbola which may not in fact represent the basement below the beacon, so it is believed that the true basement is at 0.80 second, which is the time to the first reflector below the hyperbola. This times gives a mean interval velocity from sea bed to basement of 1.65 km/sec.

In contrast, the mid-sediment reflection at 0.41 second was relatively smooth and parallel to the surface of the sea bed. Over short ranges it was sharp and coherent, but over longer ranges it was discontinuous. This may be the result of focusing and defocusing effects of undulations on the sea bed. These undulations were of wavelength of about 1 kilometer and amplitude 10 meters. Immediately below the sea bed there are some reflections but these were not easily resolved. Otherwise the sediment above and below the mid-sediment reflector is relatively transparent.

North of the basement high (seen at 1700 hours) a deeper reflector at 0.90 second, dipping gently to the south, can be seen which abuts the basement high. This indicates that the oldest sediments in the area were ponded into valleys in the basement topography and not draped over it. This fact is of importance in assigning a probable age to basement from the ages of sediments sampled.

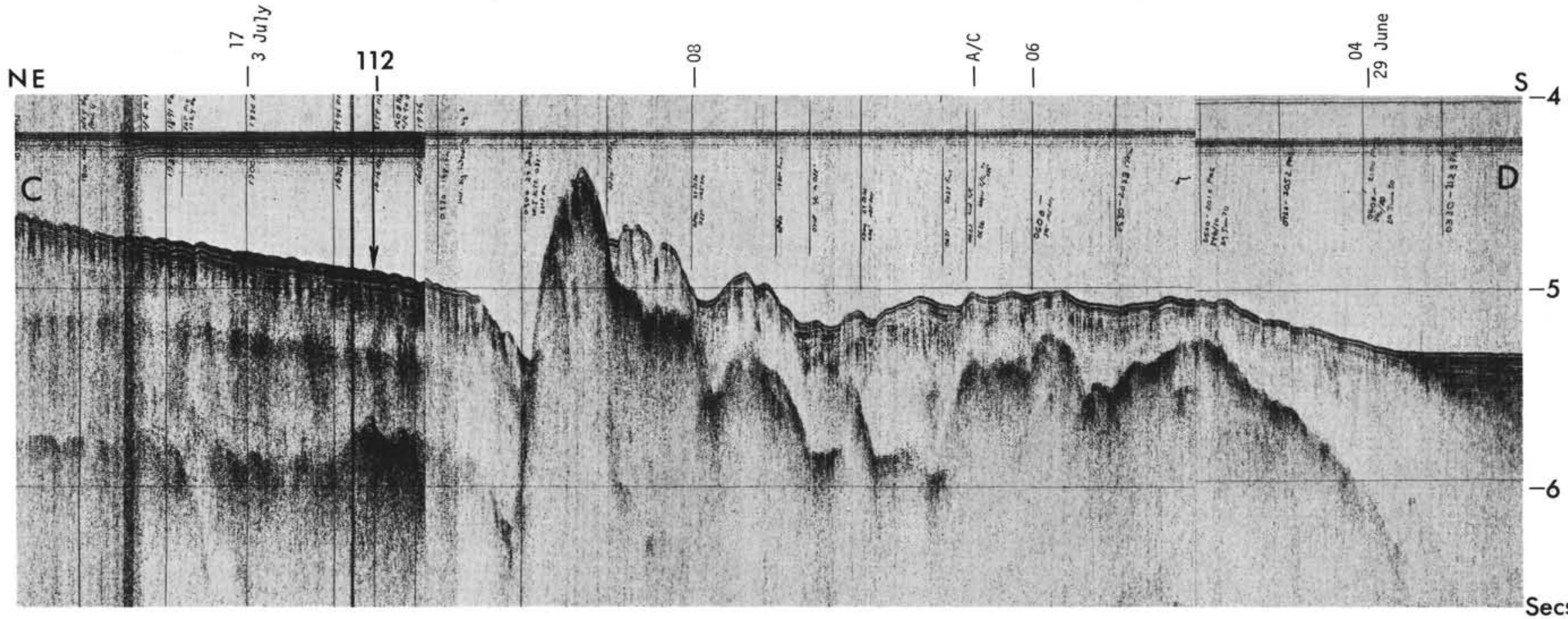

Figure 3. *Seismic reflection profile (N-S) across Site 112 by* Glomar Challenger-*12.*

DRILLING OPERATIONS

Drilling operations started on site at 1030 hours on June 29th in 3657 meters water depth (3667 meters below drill floor). A Smith 3-Cone tungsten carbide insert bit was used beneath 11 drill collars and 3 bumper-subs.

Although a sea bed surface sample was intended, the drill did not feel bottom until a penetration of 28 meters had occurred relative to the echo sounder depth. The first core between 28 and 37 meters, as well as the weakness of the echo sounder signal, indicated that the bottom was very soft and that the drill was likely to have penetrated the bottom before collapsing the first bumper-sub. It was therefore assumed that the depth by echo sounder was correct.

Although the top section of the sediment column contained glacial material, the drilling was not as jerky as at Site 111 and only two thin hard layers were encountered down to about 330 meters, in spite of the transition from Pliocene-Pleistocene glacial material through to stiff Oligocene coccolith clays.

In the zone of the mid-sediment reflector between about 300 and 400 meters drilling generally became somewhat harder, showing a certain variability, corresponding to the alternating layers of more or less compacted sediment.

From 400 to 540 meters, drilling became easier. Then at 540 meters, a thin very hard layer was encountered and had to be penetrated by increasing the bit load, after which the bottom reverted to its previous character.

At 547 meters, the drill became stuck. This apparently was due to the loading of the circulating water outside the string by the suspension of fine clay material, which initiated back flow while breaking joints, resulting in partial hole collapse. In order to overcome this, drilling mud was spotted into the circulation water before making each break. The coring policy was somewhat modified by this difficulty since many cores required many breaks in the drill string and hence the use of a lot of mud. So below Core 15 at 587 meters, we aimed to reach basement with minimum coring.

A center bit was dropped for drilling, and on recovery before a core at 650 meters, it gave a sample of red clay and green-gray marl. While coring 650 to 659 meters, the top part was easy to drill but the bottom became hard due to penetration into a hard red clay overlying a thin basalt sill. A center bit again was dropped to drill on towards basement but after only 2 meters more penetration, a very hard layer was encountered, a basalt chip was recovered in the center bit, and Core 17 from 661 to 664 meters showed the drill to be in solid basaltic rock, assumed to be basement. A penetration of 3 meters into basement took 1.5 hours and gave 1.2 meters of basalt.

Further penetration into the basalt seemed unprofitable so the drill string was withdrawn to the mud line, and Hole 112A was drilled in order to delineate more closely the Pliocene-Pleistocene boundary and the onset of glaciation in Pliocene. Five cores were taken between 79 and 124 meters. No core was recovered from Core 2 because a glacial erratic pebble was jammed in the core catcher. In Core 3, the liner broke during extraction and somewhat disturbed the sample.

TABLE 1
Cores Cut at Site 112

Hole	Core	Cored Interval (m, subbottom)	Core Recovered (m)
112	1	28-37	4.6
112	2	100-109	8.8
112	3	150-159	7.7
112	4	100-209	3.0
112	5	270-279	8.9
112	6	279-288	5.0
112	7	288-297	2.3
112	8	297-306	0.4
112	9	306-315	7.5
112	10	315-324	2.9
112	11	324-333	5.4
112	12	384-393	2.2
112	13	441-450	6.8
112	14	499-508	6.4
112	15	578-587	1.2
112	16	652-659	1.1
112	17	661-664	1.2
112A	1	79-88	7.8
112A	2	88-97	cc only
112A	3	97-106	9.2
112A	4	106-115	7.9
112A	5	115-124	7.5

During this sequence of coring the weather deteriorated and the wind speed rose to 25 knots. The power required maintain position approached the maximum available. Prior to this the weather had been extremely calm throughout drilling.

The hole was terminated at 0500 hours on July 3rd having obtained the samples required. One hundred and ninety meters were cored yielding 107 meters of samples (56 per cent recovery). Departure from the site was at 1445 hours on July 3rd.

LITHOLOGY

At Holes 112 and 112A the following sediment types were cored down to the basaltic basement. They will be described in their normal stratigraphic sequence from the basement.

1) Basalt (Core 17, Hole 112).

2) ? Paleocene indurated red clay and claystone with two palagonite sills (Core 16, Hole 112, and center bit below Core 116).

3) Eocene to Lower Oligocene indurated gray pelagic nannofossil clay and marl, burrow mottled with an intercalation of burrowed dusky red clay (Cores 12 to 15, Hole 112).

4) Lower Oligocene to Miocene gray, pelagic, burrow mottled siliceous nannofossil clay and silt, and siliceous ooze (Cores 3 to 11, Hole 112).

5) Lower pliocene gray, pelagic, silty to sandy foraminiferal nannofossil marl and ooze, with an intercalation of terrigenous sandy clay (Core 5, Hole 112A).

6) Mid-Pliocene to Pleistocene gray terrigenous silty to muddy clay with ice-rafted pebbles, interbedded with hemipelagic silty nannofossil clay and marl (Cores 1 and 2, Hole 112 and Cores 1 to 4, Hole 112A).

Basalt from Core 17

Preliminary petrography

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Core 17, Section 1, Samples
from 17-19, 19-24 and 94-95 centimeters

All three samples consist of rather altered porphyritic variolitic to microlitic basalt. Phenocrysts are of plagioclase in two size populations, clinopyroxene, and olivine altered to chlorite. The larger plagioclase crystals (up to 3 millimeters across) have cores of composition An_{70} and are strongly zoned. The calcic cores are sometimes saussuritized. The smaller plagioclase crystals (up to 1 × 0.2 millimeters) are more sodic (An_{60}), and are fresh. They often form glomerocrystal aggregates with clinopyroxene. The ground mass is very fine-grained, with plagioclase laths, anhedral clinopyroxene, altered olivine, and iron ore grains sometimes distinguishable. Vesicles are filled with green or brown chloritic material. Veins of green, fibrous radiating chlorite traverse the specimens.

Trace element analyses yielded the following results (in ppm):

Ti	Rb	Sr	Y	Zr	Nb
6000	1.5	94	19	45	1.0

The samples represent rapidly cooled basalt magma, subsequently somewhat weathered. Petrographically, they resemble closely samples of ocean floor basalt, in particular, rather more weathered material dredged at some distance from the ridge crests, though phenocrysts of clinopyroxene are not often encountered in ocean floor basalts on the whole. Their appearance is quite consistent with their being fragments of oceanic volcanic basement, of the kind now seen in process of formation at mid-ocean ridge crests, underlying the sediments of the Labrador Sea. More precise conclusions must await geochemical study on larger specimens of the core, but these observations encourage the conclusion that the Labrador Sea has been formed by the same ocean floor spreading processes that have given rise to other oceanic regions. The age of the basalts is not easy to estimate from the degree of weathering, and the samples are not suitable for either potassium-argon or fission track dating.

Opaque Mineralogy

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Examination of polished sections has been carried out using a Reichert Zeto Pan microscope. Total magnification was ×1350. In the descriptions given below titanomagnetite deuteric (high temperature) oxidation is quoted on a 1 to 6 scale, where is:

Class 1:	homogenous titanomagnetite
Class 2 and 3:	magnetite with increasing amount of ilmenite lamellae
Class 4:	oxidation of ilmenite lamellae to ferrirutile and titanohematite
Class 5:	appearance of black spinel spicules in remaining magnetite
Class 6:	complete replacement of titanomagnetite by titanohematite, pseudobrookite and/or ferri-rutile

Sample 112-17-1, 19-24 centimeters

Abundant small brown skeletal titanomagnetitism Class 1 deuteric oxidation state. Magnetite grain size usually less than 10 microns. A few much larger hematite grains of uncertain origin.

Sample 112-17-1, 94-95 centimeters

As for 17-1, 19-24 but additionally with large, hematite filled, vesicles and veins.

Sample 112-17-1, 109-110 centimeters

Skeletal brown Class 1 titanomagnetite, usually very small but a few grains up to 50-micron size.

Paleocene Red Sediments

Sediments recovered from the centerbit below Core 16 (659 to 661 meters below sea floor) and from Core 16 are significantly metamorphosed by post-depositional basaltic intrusion.

Some pieces of palagonitic material with a high content of volcanic glass, authigenic carbonate and ? tridymite, and pieces of bright red "baked" claystones with some glass, some authigenic carbonate and very few badly preserved nannofossils were recovered from the center bit. Hematite is the dominant coloring agent in these pieces (compare with opaque mineralogy results, where hematite from the basalt is mentioned several times).

Recovery of Core 16 was poor making available only one section plus a core catcher sample. From the core catcher we recovered 23 centimeters of indurated, slightly burrowed, red "baked claystone" with large patches of creamy white yellowish claystone and veinlets of fibrous or sparry calcite as well as palagonite. The claystone (Plate 1) is barren of organic remains except for a few badly preserved nannofossils and consequently contains much authigenic calcite. Some ? tridymite was observed. The red coloring is due to a rather high content of hematite, some goethite and amorphous ferromanganese oxides. Hematite increases toward the bottom, where the contact with a dark green 2-centimeter thick sill of palagonite is exposed. X-ray investigation shows that the palagonite consists dominantly of montmorillonite with some zeolite. Glass shards show thick alteration rims. Section 1 of Core 16 consists of a faintly laminated, and slightly burrowed, indurated reddish-brown clay with some yellowish calcisiltite bands and clasts and a thin sill of dark green palagonite with cryptocrystalline quartz and zeolite at 75 to 79 centimeters. The coloring agents of the clay are predominantly hematite, together with goethite and amorphous ferromanganese oxides. Due to its cryptocrystalline nature, the quartz was difficult to identify from smear slides but, according to the X-ray results it represents up to 75 per cent of all crystalline material. Unfortunately, the nature of alteration is thus far unknown; but for various reasons it must be considered authigenic, though whether it recrystallized from dissolved detrital grains or originated from spilitization of the intrusive magma has not been determined. According to the X-ray results the montmorillonite/mica (illite) ratio in a sample from Core 16, Section 1, is 1:4, which is surprisingly low in comparison with the average ratio in the sediments at the top (from Core 15 up to Core 5) which is about 1:1, and it is very low in comparison with some additional X-ray samples from Core 15 as well as 16, where montmorillonite was found to be dominant especially from the palagonite. If the low ratio 1:4 from one sample is correct it might be explained by a partially irreversible, early illitization, under abnormal P/T conditions in the vicinity of intrusive basaltic sills. A few coccoliths are the only organic remains in the red clay and claystone.

The assumption is made that the original sediment has been something like a normal gray pelagic nannoplankton clay which has been metamorphosed by the baking effect of post-depositional intrusion of hot basaltic clay sills.

The fortunate recovery of a contact of red baked hematitic clay with palagonite in the core catcher of Core 16 can be taken as a direct proof for the justification of this assumption.

As indirect proof, there is the fact that a similar sediment type was not found in any other Leg 12 hole drilled in the North Atlantic, except in close association with basalt. Other occurrences would be expected if coloring and alteration of the red clays from Hole 112 were the result of deposition below the compensation depth. It would be interesting to consider the possibility that a great part of the "red deep-sea clay" may be reworked red baked clay which was metamorphosed by the intrusion of hot basaltic sills into normal sediments. This is suggested by evidence from Sites 112 and 118 and several literature sources (see Bostrom and Peterson, 1969, von der Borch and Rex, 1970, and especially Nayudu and Wienke, 1971). Also Pimm, Garrison and Boyce (1971) have demonstrated the close relationship between brown clay and volcanic material. It might be pointed out that basaltic sills and dikes can penetrate sediments over great distances from their sources of origin. Their baking effect, however, may not necessarily be the same wherever a sill or dike comes into contact with sediments; there are enough field-geological observations to prove the fact that the surface of distal parts of sills or dikes can cool to such an extent that the zone of contact metamorphization is very narrow and that nearly unaltered mollusc shells out of the sediment might become filled with basalt, as personally observed in coastal exposures of Portugal. Sills intruding the sea floor sediments have not only been drilled at Sites 112 and 118 but also at the impressive re-entry Sites 146 and 149 of Leg 15, from where Edgar *et al.* (1971) have reported a 140-centimeter thick dolerite sill overlain by "dark-brown volcanic and organic-rich layers" and underlain by "metamorphosed limestone".

Seismic profiler records should be carefully investigated for such evidence making sure that a "basement" reflector is not a "sill" reflector wedging out laterally. The age of the basement at Site 112 cannot be precisely identified by the overlying sediment. Other reasons are mentioned in the Chapter 4, Discussion.

Eocene to Lower Oligocene Gray Pelagic Nannofossil Clays and Marls

Cores 12 to 15 can be distinguished from the overlying sediments by a higher grade of lithification and burrowing, increase of authigenic calcite, pyrite, and goethite, decrease of foraminifera as well as sponge spicules, scarce content of diatoms and the absence of radiolarians. The carbonate content ranges between 10 and 40 per cent. The sediments are called pelagic in spite of some terrigenous influence indicated by detrital quartz. Apparently a diagenetic process of dissolution of most siliceous tests and a great part of the calcareous remains has occurred. The comparatively resistant nannoplankton constitute up to 50 per cent of the sediment, but reveal a rather high grade of fragmentation by chemical corrosion especially in samples with a high content of authigenic calcite. Half of the samples contain corroded fragments of pelagic foraminifera among a few well-preserved ones. From coarse fraction investigation it was determined that usually 70 to 80 per cent of the coarse fraction consists of planktonic foraminifera and 10 to 30 per cent, more or less well-preserved, benthonic foraminifera of numerous genera including arenaceous ones. The few diatoms are usually pyritized. Pyrite, goethite, detrital quartz, volcanic glass, some palagonite and zeolites are present in many smear slides and some samples seem to contain ? siderite. Montmorillonite and mica (illite), together make up to 40 to 60 per cent of all crystalline components in the X-ray samples, the ratio being about 1:1, though montmorillonite is dominant in the lower part of Core 15. Chlorite was also found in samples from Core 15. The lowermost part of Core 14 shows an intercalation of hard, geothitic, reddish-brown, slightly laminated nannofossil marl mottled light gray. Bioturbation (? *Zoophycos* and another unidentified type of burrow, according to Seilacher's examination of some Polaroid photographs) is more intense in this section than elsewhere, possible because of a higher content of oxygen in the sediment. The burrow fillings are gray because of reduction of the sediment by passage through the digestive tracks of benthonic organisms. It can be observed that angular pieces of sediment up to 3 centimeters across have been torn loose and distorted by burrowing activity (Plate 2, B).

Lower Oligocene to Miocene Pelagic Sediments

The lower Oligocene to Miocene burrowed pelagic sediments of Cores 4 to 11, Hole 112, are rather uniform in visual appearance and composition. They are in general described as greenish to bluish gray, burrow-mottled, siliceous nannofossil clay and silt and siliceous ooze, corresponding to their varying content of nannofossils, diatoms, radiolarians and silieous sponge spicules. In Cores 4 and 5, mottling of gray with dusky red can be seen. The consistency becomes stiff to friable with increasing depth and with increase of siliceous tests and siliceous sponge spicules. Laminations, frequently destroyed by burrowing, were observed. The percentage of nannofossils, diatoms, radiolarians and siliceous sponge spicules is rather high throughout, except for Core 3, where nannofossils became dominant; siliceous remains are common only in Section 5. Planktonic foraminifera are usually rare and severely corroded, yet heterohelicids seem to be more resistant towards chemical corrosion because they are well preserved in many smear slides. (A similar observation has been made from lithified chalk sediments of Site 116.)

A coarse fraction sample of Core 4 contains, 30 per cent quartz, 20 per cent siliceous sponge spicules, 30 per cent partly calcified or pyritized radiolarians, 20 per cent of usually fragmented, and corroded ?reworked benthonic foraminifera of the genera *Dentalina, Nodosaria, Melonis, Cibicides, Eponides, Bulimina, Lenticulina, Fissurina, Haplophragmoides* etc., mixed with a few globigerinids, echinoid spines and fish teeth. A smaller amount of benthonic foraminifera can also be found in coarse fraction samples from Cores 5, 7, 9 and 11 where radiolarian tests make up 80 to 90 per cent of the residue. The carbonate content generally ranges from 10 to 25 per cent reaching up to 40 per cent in Core 11. A slight terrigenous influence in the sediments from Cores 4 to 11 can be concluded from a rare to common content of detrital quartz and mica. More or less altered volcanic glass was found in all smear slides, but large palagonite aggregates are quite rare; they have probably disintegrated into the clay-sized fraction. From X-ray investigations it was learned that montmorillonite makes up an average of 20 per cent of all crystalline components, with a decreasing trend toward the top of this sediment sequence; while mica (illite) is increasing, so that the montmorillonite/mica-ratio is nearly 1:3 in Core 4. Plagioclase feldspar was found in all X-ray samples, although it could be identified in only a few smear slides. Finally, pyroxene, which can be found in many smear slides, should be mentioned among the volcanic minerals. Zeolites are rare in the upper portion of the sediment unit and chlorite was identified from smear slides as well as in two X-ray samples. Pyrite is common, as in all gray sediments.

The uncorrected sedimentation rate is approximately 2 cm/1000 yrs in Core 4 and ~1.5 cm/1000 yrs from Core 5 downwards.

Lower Pliocene Sediments From Core 5, Hole 112A

The Pliocene sediments recovered in Core 5, Hole 112 are to be distinguished from those above and below because they separate the thick pelagic sequence of Cores 6 to 16 from those above Core 5, which reveal a terrigenous influence and ice-rafted pebbles due to the onset of glaciation. The sediments from Core 5 are light gray, silty to sandy foraminiferal nannofossil marls and oozes, with an intercalation of sandy clay in Section 3. Organic carbonate composes up to 70 per cent of the ooze layers, represented by a rich, and well preserved, nannoflora and microfauna. In the sandy clay, the carbonate content is very low due to dilution of organic calcareous remains by a strong influx of terrigenous material. The sand fraction of the sandy clay is made up mostly of detrital quartz. Detrital mica was also observed in smear slides. Other minerals are pyroxene, feldspar, some volcanic glass, zeolite sand much pyrite. No siliceous tests nor sponge spicules were found in Core 5, as in the cores above.

From lithological and faunal evidence (see also this chapter, Appendix F) the conclusion can be drawn that the sediments from Core 5 were laid down in a period of lowering surface water temperatures prior to the onset of ice rafting. Consequently they might be called deep sea equivalents of chemical preglacial sediments. The sudden increase of terrigenous material in the intercalated sandy clay beds of Section 3 may be considered the reflection of an initial phase of lowering temperature, connected with an increase of erosion on land and possibly, a change of the current pattern. Little more than speculation can be made about the relationship between the sandy clay and turbidite activity since no turbidite structures could be observed in Core 5, due to disturbance by drilling, and the lack of grain-size analyses at this state of investigation.

Mid-Pliocene to Pleistocene Sediments

The mid-Pliocene to Pleistocene sediments of Cores 1 and 2, Hole 112 and Cores 1 to 4, Hole 112A are gray, terrigenous, silty to sandy clay with ice-rafted pebbles, interbedded with hemipelagic silty nannofossil clay and marl. Planktonic foraminifera are usually rare, becoming abundant in some horizons only. They are often corroded, as are the coccoliths. Diatoms and some radiolarians were only found in Core 1, Hole 112. The carbonate content is very low in the clay beds, but it can go up to 60 per cent in the more fossiliferous layers. Authigenic calcite and pyrite are present throughout. Calcite is abundant in some smear slides, as a result of total solution of foraminifera and some coccoliths. Dolomite constitutes up to 2 to 6 per cent of all crystalline material in X-ray samples from Cores 1 and 2, Hole 112 and from Cores 1 and 3, Hole 112A. It cannot be concluded whether this dolomite is authigenic or detrital, but from the fact that in X-ray samples considerable quantities of dolomite were usually observed in terrigenously influenced sediments of Pliocene-Pleistocene age or of turbidite origin from all Leg 12 cores, it is suggested that the dolomite is detrital.[2]

[2]Beall & Fischer (1969) have made equivalent suggestions concerning the source of dolomite in paraglacial terrigenous sediments.

Volcanic glass reveals a scattered distribution, palagonite is rare in Cores 3 and 5, Hole 112A only, and zeolites are absent. Detrital quartz is ubiquitous and is sometimes dominant. In a coarse fraction sample it constitutes up to 90 per cent of the residue. Some heavy minerals were also observed. Plagioclase feldspar was noticed in only a few smear slides, but from X-ray investigation it was learned that it represents about 15 per cent of all crystalline material. As expected in terrigenous sediments, the clay fraction consists mainly of micas with minor montmorillonite and some chlorite. Sedimentation rate is about 2.5 cm/1000 yrs in the Upper Pliocene cores and 4.5 cm/1000 yrs in the Pleistocene cores. This is rather high compared to that of all other sediments of Site 112, but can be explained by an increasing terrigenous influence.

Discussion

In general it should be mentioned that sedimentation in the area of Site 112 must have taken place around the lysocline (Berger, 1968) but not below the compensation depth. The striking differences of fossil content between the above described sediment portions cannot thoroughly by explained without further detailed studies. Some approach to explaining the sedimentation mechanism from Pleistocene to Recent could be made, but conclusions about sediments older than Pleistocene should be regarded as being increasingly tenuous, especially considering the paleogeographical effects of sea floor spreading. This is discussed further in Chapter 21. From the nature of the sediments and evaluation of various seismic profiler records (see Chapter 21) we can assume that sedimentation in the area of Site 112 has been influenced, at least since Oligocene times, by a bottom current which brought arctic bottom water and sediment particles into the Labrador Sea. Assuming that the current was controlled by the bottom topography, which is represented by a semicircle of basement ridges on the Labrador Sea floor (see Chapter 20, Fig. 3), it must have move in a southeasterly direction in the area of Site 112. Within the ridges it discharged the sediments most probably out of the "nepheloid layer" whose existence through the Cenozoic might be assumed. Almost only by such a sedimentation mechanism persisting over a long time, can the relative uniformity of the sediments in respect to their primary mineral composition be explained. L. Burckle (this chapter) is inclined to take bottom currents into account for the considerable breakage, low taxonomic diversity and the predominance of the more robust forms of diatoms from Hole 112.

It is more difficult to explain the differences with respect to the total organic content of the sediments. Certainly this was partly controlled by the surface "Gulf Stream" which must have gone the opposite way relative to the bottom current, thus circling dextrally in the Labrador Sea through Mesozoic and Cenozoic times until glaciation started in the Pliocene. This could be learned from the evaluation of the Site 111 faunas. Apparently the Gulf Stream must have transported plankton in a generally northerly direction. But it is yet totally uncertain what happened to plankton tests after sinking, especially how far they were transported back in the bottom current before settling and to what degree they were dissolved between death and burial at various times.

As for the Eocene to Lower Oligocene sediments from Cores 12 and 15, it is nearly impossible to make any guess at the paleobiotope and the amount of dissolution of all organic remains during sinking or after deposition. But corrosion of siliceous and carbonaceous tests, calcification of radiolarians, pyritization of diatoms and the obvious increase of pyrite together with authigenic calcite are proof of the increasing importance of diagenetic processes with increasing age. Generally, a relation might be seen between high silica solution rates in high latitudes and precipitation of silica (layer A) in lower latitudes during the Eocene.

The increase of organic siliceous material in the Oligocene to Miocene (Cores 3 to 11) might be explained by a change of biotope or by a decrease of silica solution, but rather more likely by selective solution of carbonate in the cool undercurrent, which is indicated by the poor preservation and solution remnants of foraminifera and even nannoplankton. Core 3 is an exception though, because in most samples of this core nannofossils are dominant and the siliceous tests are of no importance.

With the onset of glaciation in the Pliocene, the situation changed. The Arctic bottom current still kept flowing in approximately the same direction, but on the surface the warm Gulf Stream was replaced by the cold East Greenland and Labrador streams. The absence of siliceous tests and sponge spicules in the Site 112A, Pliocene-Pleistocene cores could thus be explained by a radical change of biotope. This explanation, however, becomes irrelevant when the plankton content of the cores concerned is compared with cores of the same age from Sites 111, 113 and 114 which do not have this peculiarity. The absence of siliceous microfossils in the Pliocene-Pleistocene cores could be explained by dissolution during the sinking process—as described by Berger (1968)—or solution after deposition. It cannot be assumed that in one of the nutrient-rich areas of the present world's oceans planktonic life would be represented exclusively by carbonate producing organisms.

PHYSICAL PROPERTIES

The rather scattered distribution of cores down the hole and the proportion of watery cores give a rather poor coverage of physical property measurements. The watery cores have aberrant low densities, and these have been taken into account in drawing the trend lines on the density, porosity and impedance plots. The sections most affected are: 112-1-1, 112-1-6, 112A-1-5, 112A-1-6, Core 112A-3, 112A-5-2 to 112A-5-4, and Cores 112-6 and 112-7. Similarly, the low gamma readings from 101 to 104 meters are from unsplit cores and are probably, but not necessarily, due to free water.

The onset of glaciation at 115 meters is strongly indicated by an increase of gamma activity from about 1100 counts below 115 meters to values in excess of 1800 above. This increase reflects an increasing proportion of terrigenous material. There is also a correlation between density and gamma activity in the upper 150 meters suggesting that gamma activity is due to dense detrital minerals which also significantly affect sediment density.

Below 160 meters there is apparently a general decrease in density (and velocity) culminating in a minimum of 1.3 gm/cc at around 280 meters. The lithology from 160 to 335 meters is a silty clay, often marly, with a high percentage of diatoms and Radiolaria. The presence of this opaline (hydrous) silica would cause the GRAPE density to be low, but this effect can only partly explain the range of 1.3-1.45 gm/cc found from Core 112-4 to Core 112-9. However, it may well be the explanation for the low density (1.4-1.5 gm/cc) of Core 11, which also exhibits gamma activity below 950 counts. The available grain-size measurements do not suggest that the low density of Cores 4 to 9 is due to a trend to a smaller grain size, and an explanation must be sought elsewhere. The gamma activity over this interval lies in the approximate range 1300 ± 300 counts except for a sharp peak of 2480 counts at 308 meters associated with a 7 per cent carbonate content in Section 112-9-2.

Below 330 meters density increases fairly uniformly with depth from 1.5 to 1.85 gm/cc at 450 meters, below which density remains fairly constant. The only other features of note are a peak in gamma activity at 505 meters (2300 counts) associated with a 13-centimeter band of dark blue-green nannofossil marl in Section 112-14-5, and another peak at 652 meters (1940 counts) associated with yellow bands in a red clay in Section 112-16-1. The former peak is 900 counts higher than 30 centimeters up the core where 10 per cent carbonate was determined, and the latter peak is 450 counts higher than 30 centimeters up the core where zero carbonate was measured so that the peaks are not attributable to an absence of carbonate. The dark sediment of the first occurrence is suggestive of uranium and thorium enrichment. Some uranium and thorium minerals do have a yellow color, and the second occurrence may have a similar origin.

Paleomagnetic measurements were made by J. Ade-Hall on three oriented specimens of basalt from Core 17. He found that the upper part of the core was normally magnetized and two specimens from the lower part of the core were reversely magnetized. The results are summarized in Table 2.

TABLE 2

Specimen	Polarity
112-17-1, 19 to 24 cm.	N
112-17-1, 94 to 95 cm.	R
112-17-1, 109 to 110 cm.	R

Depth of Reflectors

Depending on the interpretation of hyperbolic echoes from the seismic reflection records at Site 112, the main reflector lies at 0.75 or 0.80 seconds and is confidently associated with the basaltic basement. An important object of the drilling was to date a diffuse reflector seen here at 0.41 second. A hard layer was encountered, but not cored, at 315 meters. In this region also the impedance begins to increase steadily with depth and therefore the top of the diffuse reflector is assigned to this depth. These data are summarized in Figure 5.

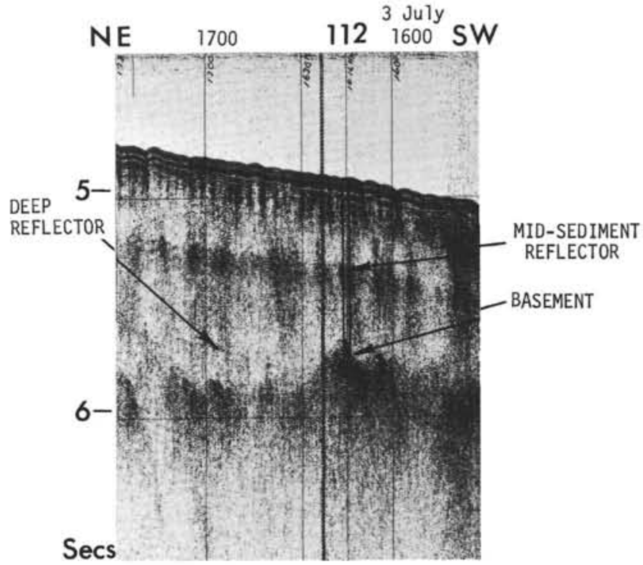

Figure 4. *Detail of seismic reflection profile across Site 112 showing mid-sediment reflector, basement and deep reflector.*

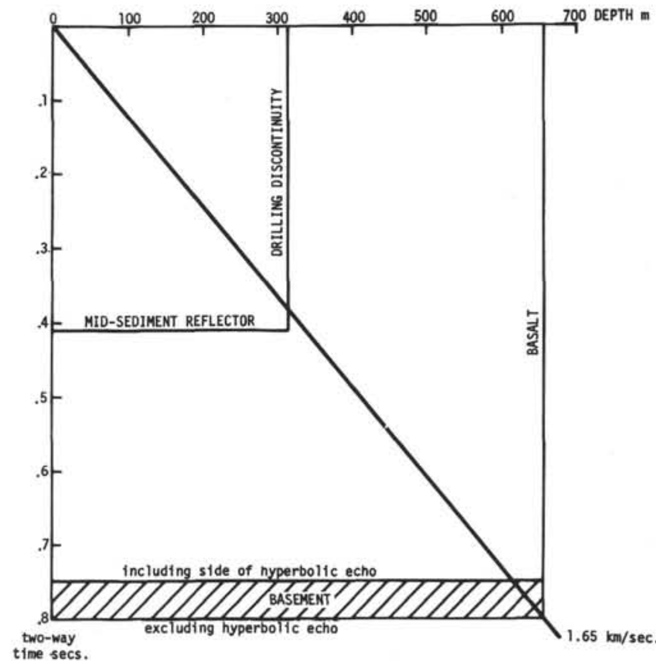

Figure 5. *Two-way travel times below the sea-bed of observed reflections plotted against the downhole depths of horizons believed to have given rise to these reflections. The mean velocity to the deepest reflection associated with a definite depth is given close to the line representing this velocity.*

PALEONTOLOGY AND BIOSTRATIGRAPHY

General

Characteristic of this site is the poverty of calcareous microfossils; planktonic foraminifera are scarce in most pre-Pliocene levels; nannofossils, though generally common, are in many cases poorly preserved. Much of the stratigraphic section, in particular the Oligocene, contains siliceous microfossils (diatoms and radiolarians). The nonfossiliferous Paleocene (?) red clay that overlies the basaltic basement is overlain, in turn, by Lower and Middle Eocene clays. A thick Oligocene section, composed of diatom-radiolarian clays (estimated depth in Hole 112 is about 240 to 400 meters) is covered by approximately 105 meters of Middle Miocene (about 135 to 240 meters). This is, in turn, succeeded by the Pliocene (approximately 90 to 135 meters) and Pleistocene (approximately 0 to 90 meters). The contact between preglacial and glacial Pliocene was cored at approximately 115 meters. The glacial Pleistocene and Upper Pliocene sediments are thus about 30 meters thinner at this site than at Site 111.

The existence of two unconformities at this site is suggested on the basis of significant time-stratigraphic separation over a short stratigraphic interval at this site: 1) between 125 and 150 meters, in which mid-Pliocene (Core 5, Hole 112A) lies above Middle Miocene (Core 3, Hole 112), and 2) between 210 and 270 meters, in which Middle Miocene (Core 4, Hole 112) overlies Upper Oligocene (Core 5, Hole 112.

Discussion

Foraminifera

Although the sedimentary section is not complete, sediments of each of the Cenozoic epochs were recovered at Site 112. General foraminiferal paleontology and biostratigraphy will be discussed in terms of each epoch starting with the Pleistocene (Figure 6).

Neogene

The Pleistocene is represented by 112-1 and 112A-1 (part). Sediments consist essentially of soft terrigenous clays and silts containing glacially-rafted debris; at varying intervals interbedded coccolith marls occur. The dominant faunal element is *Globigerina bulloides*; associated with this form are *Globigerina pachyderma* (predominately sinistrally coiled) and *Globorotalia inflata*. Among the deep-water benthonic forms present are *Melonis pompilioides, M. barleeanum, Planulina wuellerstorfi, Gyroidina neosoldanii,* and *Pyrgo murrhyna*.

The Pliocene is probably incomplete at Site 112. The Pliocene/Pleistocene boundary is drawn on the basis of calcareous nannoplankton within Core 1, Hole 112A, at about 90 meters. The contact between preglacial and glacial Pliocene was cored at approximately 115 meters, between Cores 4 and 5 in Hole 112A. The base of Core 5 is at 124 meters, and is within the *Reticulofenestra pseudoumbilica* Zone.

The upper part of Core 3 in Hole 112 (top is at 150 meters) is assigned questionably to the *Discoaster neohamatus* Zone and the lower part is assigned to the

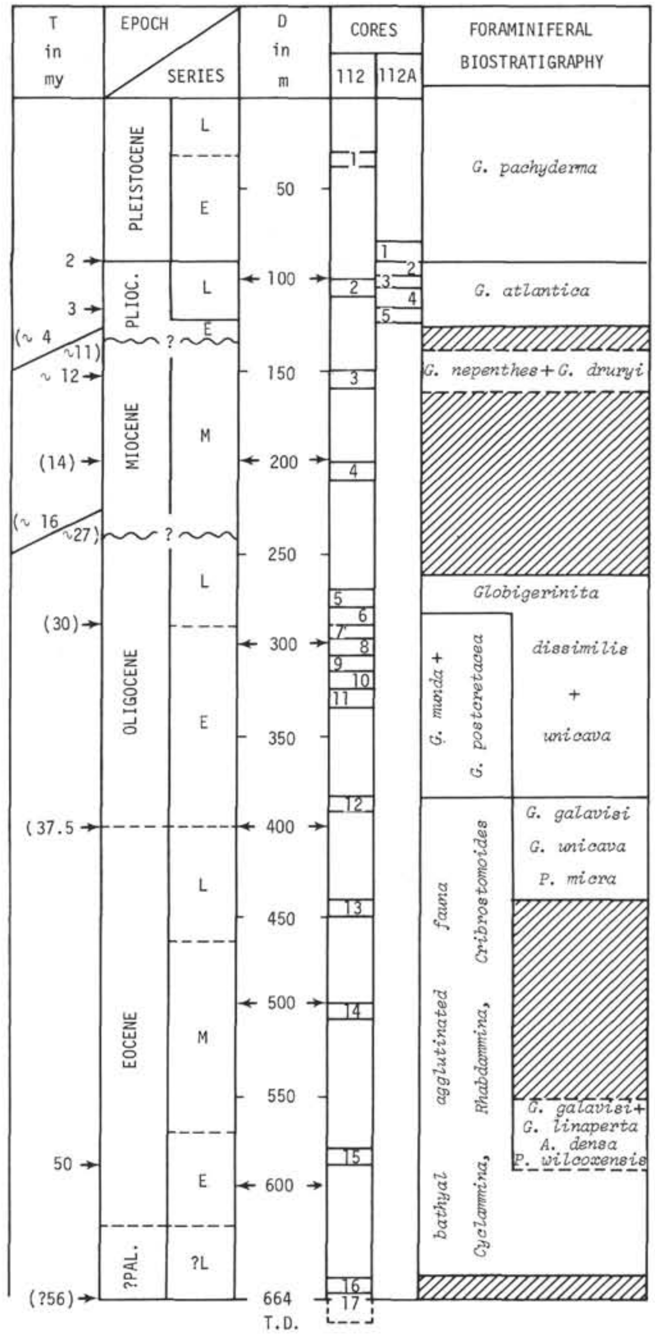

Figure 6. *Foraminiferal biostratigraphy at Site 112 (Labrador Sea).*

Discoaster hamatus Zone. This agrees well with the estimate made here based upon planktonic foraminifera that Core 3, Hole 112, is approximately equivalent to Zone N14 of Middle Miocene age. Thus we have at 125 meters Lower Pliocene overlying at 150 meters Middle Miocene. An unconformity is suggested between these two levels and an arbitrary depth of approximately 135 meters is chosen. Therefore, the Pliocene, as estimated here, extends from approximately 90 to 135 meters. The dominant planktonic foraminiferal element in the Pliocene is *Globigerina* *atlantica*. In the lower part of Core 3 and in Core 4, Hole 112A, the planktonic fauna consists almost entirely of this form. Within Core 3, *Globigerina atlantica* is gradually replaced by the smaller, thinner-walled *Globigerina pachyderma*. *Globorotalia tosaensis* has been observed within Core 3, supporting the Late Pliocene age determination for this core based upon calcareous nannoplankton. This is the northernmost known occurrence of this species to date.

Between Core 4 (106 to 115 meters) and Core 5 (115 to 124 meters) in Hole 112A, a pronounced change in lithology was noted from dark gray firm clay with ice-rafted pebbles and coarse sand (above) to a light gray clay ooze (below) with a rich planktonic foraminiferal fauna. Although this clay ooze apparently contains some silt-sized quartz in the fine fraction, it is believed to represent a preglacial or transitional sequence prior to the initial phase of glaciation above. The microfauna of this clay ooze, however, in contrast to that found in the preglacial Pliocene carbonate lutite at Site 111, consists primarily of temperate species. Three distinct assemblages occur in this core, and the changes between the lower two have been indicated by "level 1" and "level 2" (see Figure 7). The lower assemblage (part of Section 4 and Section 5) is characterized by the presence of keeled globorotaliids (*G. conoidea, G.* aff. *miocenica*) and *Globigerinoides conglobata, Sphaeroidinella dehiscens*, and *Sphaeroidinellopsis subdehiscens*. This interval correlates with the lower part of Section 2, and the upper part of Section 3 of Core 6 in Hole 111A, at which level these forms disappear due to the onset of glaciation. The middle faunal assemblage is characterized by the persistence of *Globorotalia crassaformis, G. inflata, G. scitula,* and *Globigerina bulloides* and *Orbulina universa* and the absence of the keeled globorotaliids and other forms listed above. The forms characteristic of the middle faunal assemblage range as high as the upper part of Section 2, Core 5. The upper faunal assemblage consists almost solely of *Globigerina atlantica* (sinistrally coiled). It would appear that we have here a gradational sequence of local extinction of faunal elements due to lowering of temperature prior to the onset of glaciation (which is seen in Core 4 above). A comparison between the planktonic foraminiferal faunal characteristics of Sites 111 and 112 in the Labrador Sea is shown in Figure 8.

Middle Miocene occurs in Cores 3 and 4 in Hole 112. As indicated above, Core 3 is approximately equivalent to Zone N14. Diagnostic planktonic foraminifera were not found in Core 4; however, the absence of *Globigerina nepenthes* in Core 4 suggests that this level may be somewhat older than Zone N14. This is in agreement with the questionable assignment of Core 4 to the *Discoaster exilis* Zone (which is approximately equivalent to Zone N11 and the lower part of Zone N12). The fact that the base of Core 4 (at about 209 meters) and the top of Core 5 (270 meters) separates Middle Miocene and Upper Oligocene sediments suggests a marked unconformity between these two cores. An arbitrary depth of 240 meters (between 210 and 270 meters) is chosen for this unconformity, and an estimate is made of a thickness of about 105 meters for that part of the Middle Miocene present at Site 112. It should be borne in mind that the Middle Miocene is probably bounded above and below by unconformities.

Paleogene

Planktonic foraminifera play a minor role in the biostratigraphy of this site throughout the remainder of the stratigraphic section.

Oligocene

The Oligocene is represented by Cores 5 through 12, Hole 112. The interval from 270 to 333 meters was cored continuously (Cores 5 through 11). These cores consist predominately of diatom oozes with relatively minor amounts of planktonic foraminifera. Among the interesting observations based on a preliminary study of this material we can cite the following: 1) Species of the genus *Globigerinita*, and in particular *G. dissimilis*, appear to be the most common forms in the Oligocene. 2) The presence of *Globorotalia munda* and *Globorotalia postcretacea* in Core 7 and below suggests that these strata are of Early Oligocene age. *Globorotalia munda*, in particular, is a form useful in recognizing strata of Lattorfian and Rupelian age in northwestern Europe, although this form does extend into strata of Chattian age. 3) *Pseudohastigerina micra* was found as high as Core 12 (in the Early Oligocene *Ericsonia obruta* Zone).

Eocene

The Eocene is estimated to lie between about 400 and 620 meters. An upper Eocene sample (Core 13, 441 to 451 meters, Hole 112) yielded a rather rich fauna of low diversity, composed of *Globigerina galavisi, Globigerinita unicava* and *Pseudohastigerina micra*. A Lower Eocene sample (Core 15, 578-581 meters, Hole 112) yielded a fairly rich globigerinid assemblage, composed of *Globigerina frontosa* (=*G. boweri*), *G. linaperta, G. patagonica, Acarinina collactea, A. densa,* and *Pseudohastigerina wilcoxensis*. The faunal association suggests that this level is probably of latest Early Eocene age and it is correlated here with Zone P9 (*A. densa* Zone). This level has been placed in the *Discoaster sublodoensis* Zone.

Deep-water agglutinated assemblages are the dominant foraminiferal faunal element in the Eocene cores, with a few specimens extending into Core 12 of Lower Oligocene age. The agglutinated genera present include *Cribrostomoides, Glomospira, Ammodiscus, Cyclammina, Bolivinopsis,* and *Rhabdammina*. The presence of *Nuttallides truempyi* in Core 15 is also noted. This bathyal form appears to have achieved extensive geographic distribution during the Eocene in the Atlantic and Mediterranean regions. Core 16 consists of chemically altered reddish (hematitic, limonitic) and greenish (chloritic) pelagic clay with agglutinated benthonic foraminiferal tests (*Cyclammina* sp., *Cribrostomoides* sp., *Ammodiscus* sp., *Glomospira* sp., *Bolivinopsis* sp., *Rhabdammina* sp., *Haplophragmoides* sp.). No planktonic foraminifera were observed and no age determination has been possible.

Calcareous nannofossils from the center bit sample contain a mixed flora of Early Eocene and ?Late Paleocene age. Using rates of sedimentation calculated for the Eocene in this hole, an age of Mid-Late Paleocene is estimated for

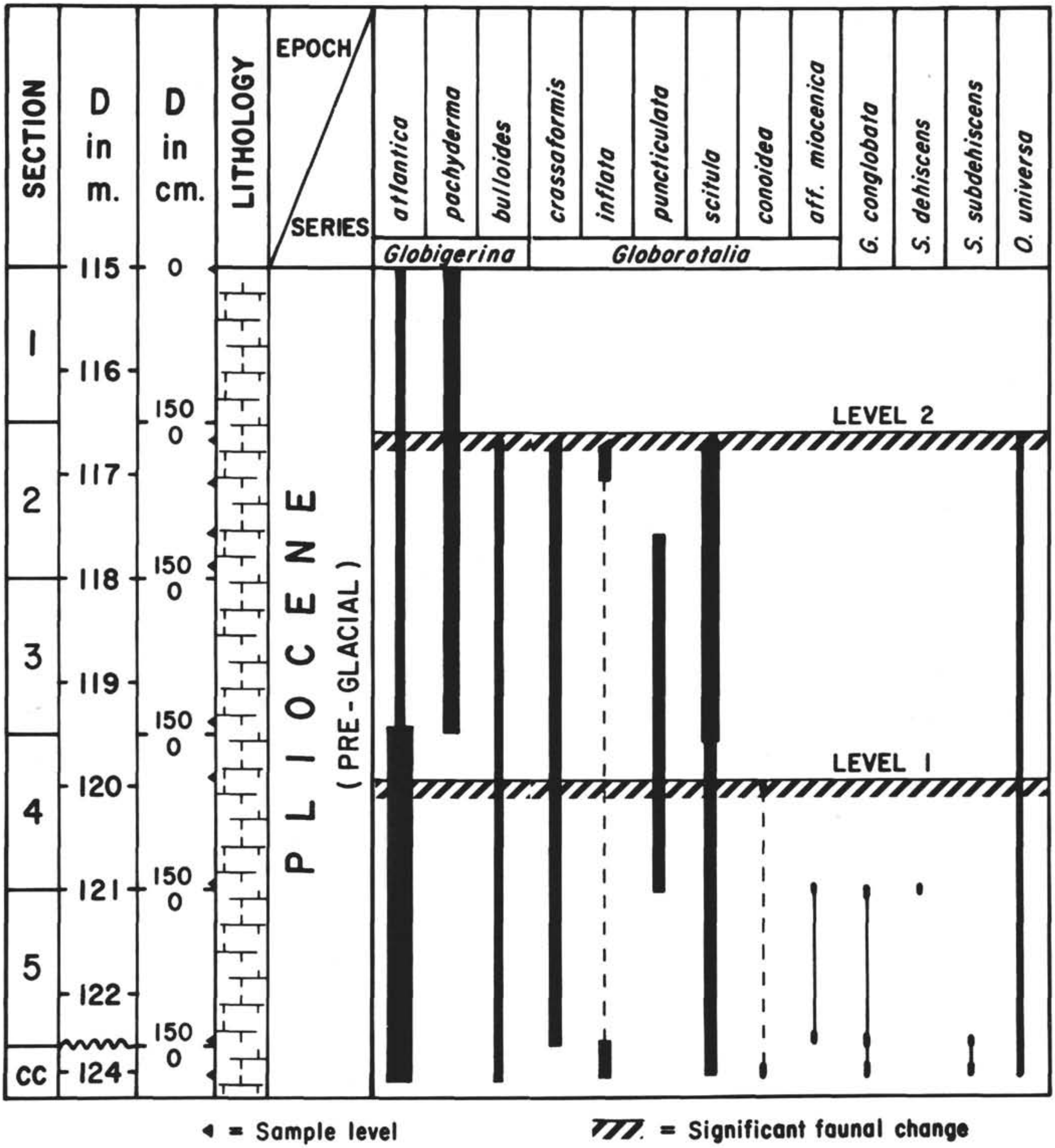

Figure 7. *Distribution of planktonic foraminiferal species in 112A-5 (Labrador Sea). Relative abundance indicated by width of bar.*

the age of the oldest sediment (Core 16) and basement at this location.

The general poverty of planktonic foraminiferal faunas in the Cenozoic at Site 112 may be due to either: a) the effects of cold, oxygenated currents rich in carbon dioxide dissolving the carbonate in the tests, b) low productivity among the planktonic foraminifera in this area during the Cenozoic, or c) transport by bottom currents. If the cause lies with (a) above one would expect to find evidence of partially dissolved tests in the residues. These are, however, rare from a preliminary analysis of sample material. On the other hand, if the correct explanation lies with (b) above it is difficult to account for the fact that during the Late Pliocene and Pleistocene – during an interval of markedly colder climatic conditions – planktonic foraminifera flourished in this area. The generic composition of the rich agglutinated benthonic

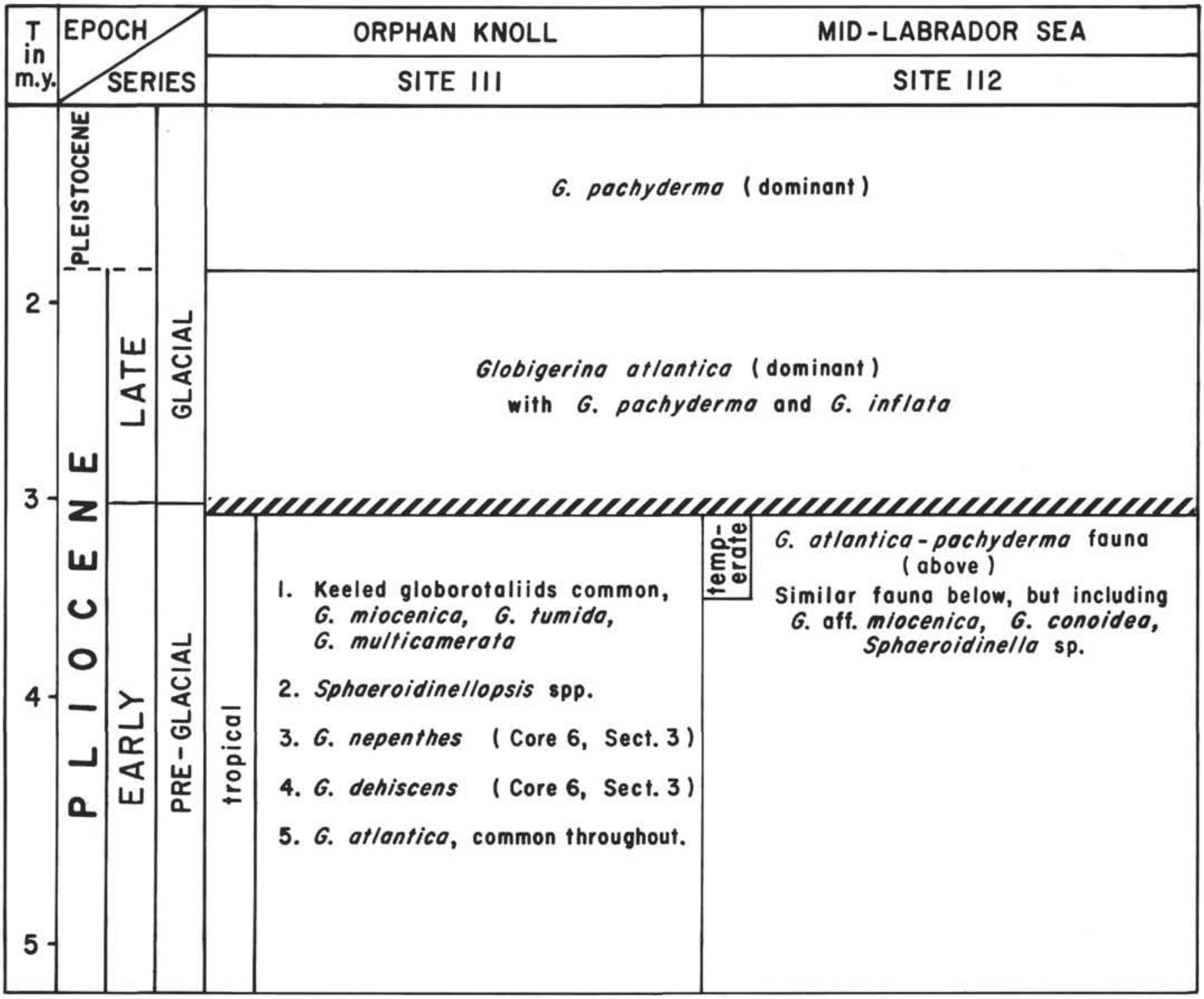

Figure 8. *Comparison of late Pliocene-Pleistocene planktonic foraminiferal assemblages at Sites 111 and 112 (Labrador Sea).*

foraminiferal fauna of the Eocene indicate considerable depth of deposition. These forms are characteristics of bathyal depths in deep basins. The rich siliceous (diatom-radiolarian) oozes of the Oligocene indicate considerable depth of deposition. These forms are characteristic of bathyal depths in deep basins. The rich siliceous (diatom-radiolarian) oozes of the Oligocene indicate high productivity in the central Labrador Sea during the Mid-Cenozoic. Planktonic foraminiferal productivity was probably also high, although taxonomic diversity may have been low. Selective removal by solution and/or the movement of deep currents is probably the likely explanation for the observed low percentage of planktonic foraminifera in the Cenozoic at this site. Support for the latter suggestion comes from the relatively high percentage of disaggregated diatom values observed in the sediments (see report on diatoms below).

Cenozoic Calcareous Nannoplankton

Pleistocene

Cores 112-1 and 112A-1 contain Pleistocene coccolith assemblages in glacial clays and silts. In 112-1, *Gephyrocapsa oceanica* indicates the presence of the zone of this name, while in 112A-1 this species is lacking and *Pseudoemiliania lacunosa* is present, indicating the core belongs to the *P. lacunosa* Zone. The assemblages are essentially the same as in the Pleistocene of Site 111.

Pliocene

Hole 112A was drilled to core the Pliocene/Pleistocene boundary and the onset of glaciation at this site.

The Pliocene-Pleistocene boundary was placed in Hole 112A-1, just above the last occurrence of *Discoaster brouweri*. Due to the dilution effect of the glacial clays and silts or reduced production of discoasters, they are also very rare here, and the boundary might be set too low. Besides the *Discoaster brouweri* Zone, the *D. pentaradiatus* Zone is also present in Core 112A-1. The latter zone is also present in Cores 2, 3 and the upper part of Core 4, while the lower part of this core belongs to the *Discoaster surculus* Zone. The *Reticulofenestra pseudoumbilica* Zone is represented in Core 112A-5.

The onset of glaciation can be observed between Cores 4 and 5 of 112A, between the *Reticulofenestra pseudoumbilica* Zone and the *Discoaster surculus* Zone. This is at the same time as in Hole 111. Again, *Sphenolithus abies* and *Reticulofenestra pseudoumbilica* disappear at the boundary, while ceratoliths were found in some samples, all the way up to the lowermost Pleistocene. Again we have to bear in mind, that the extinction of *R. pseudoumbilica* and *S. abies* here probably occurred earlier than in places where the glaciation had less influence in the Pliocene. On the other hand, there is no sign of gradual disappearance of species towards the onset of the glaciation, as can be observed in the foraminifera in Core 112A-5.

Miocene

Cores 112-3 and 4 represent the Miocene found at this site. In Core 3, *Discoaster hamatus* and *Triquetrorhabdulus rugosus* suggest the presence of the *Discoaster hamatus* Zone. Still, discoasters constitute only a minor part of the total of coccolith specimens, normally far less than 1 per cent. The coccolith assemblage in Core 4 includes only long ranging species, and the core is tentatively assigned to the *Discoaster exilis* Zone. The samples of this core contain diatoms, and the preservation of the coccoliths that are common is rather bad. Compared to the Miocene assemblages on Sites 116, 118 and 119, the assemblages are less diverse on this site.

Oligocene

The Oligocene is represented by Cores 5 through 12 in Hole 112. With the exception of Core 12, the samples contain abundant diatoms together with a coccolith assemblage, where the number of species is rather limited. In Cores 5, 6 and 7, *Sphenolithus distentus* is present in most of the samples. In Core 10, *Sphenolithus predistentus* was found. Besides *Sphenolithus moriformis*, a long ranging species of the genus, the sphenoliths that have proved excellent zone-fossils, are absent or rare. Also discoasters are rare or absent. Core 12 contains no diatoms, but a somewhat richer nannoflora than the higher Oligocene samples. The presence of *Isthmolithus recurvus* in this core, and the absence of *Discoaster barbadiensis* and *D. saipanensis* indicate an early Oligocene age rather than late Eocene.

Eocene

Cores 13, 14 and 15 contain fairly rich Eocene coccolith assemblages and no diatoms. Core 13 still contains *I. recurvus*, here together with disc-shaped discoasters, and thus is considered to be of late Eocene age. In Core 14, *I. recurvus* is missing, but *Coccolithus bisectus* is present, together with *C. expansus*, also indicating a late Eocene age for this core. As in Site 111, the forms used in lower latitudes for further zonation in the late Eocene are not present here. Core 15 contains coccoliths typical for the *Discoaster sublodoensis* Zone.

The center bit was taken up before coring Core 16, and contained red-brown clay and the green gray marl. The latter probably lies on top of the unfossiliferous red clay that overlies the basaltic basement reached in Core 16 and 17. The green gray marl contains a somewhat mixed flora of early Eocene and ? late Paleocene age. *Ellipsolithus macellus*, *Sphenolithus* sp., *Discoaster gemmeus* and an undescribed discoaster were found; however, *D. multiradiatus* is absent. Thus, the oldest dateable sediment above the basalt seems to be of (?) late Paleocene to early Eocene age. The after-site survey showed, however, that the hole had been placed on top of a basement high and that older sediments are preserved in the basin adjacent to the high.

Radiolaria

From Hole 112, radiolarians were recovered from sediments of Pleistocene (Core 1), middle Miocene (Core 4), and Oligocene (Cores 5 through 11) ages. In addition, masses of zeolite (?) or silica in the shape of radiolarian tests (mostly spheroidal forms) are present in residues from the Lower Eocene (Core 15) and from the Paleocene (?) (center bit sample between Cores 25 and 16). Because of the absence or near absence of radiolarians in Cores 2 and 3 of Hole 112, no samples were taken from Hole 112A.

Pleistocene

The very rare occurrence of radiolarians from Core 1 of Pleistocene age is represented by a high latitude assemblage dominated by *Spongopyle osculosa* Dreyer. Other species present include *Phorticium pylonium* (Haeckel?) Cleve, *Lithelius minor* Joergensen, *Cenosphaera* spp., *Actinomma* spp., *Theocalyptra davisiana* (Ehrenberg), *Druppatractus* sp. cf. *D. pyriformis* (Bailey), and *Stylodictya validispina* Joergensen.

Middle Miocene

Although radiolarians are absent in Core 3, those species present in Core 4 do not negate the assignment of Core 4 to the Middle Miocene on the basis of the nannofossil evidence. The rare occurrence of digitately branched spines of *Oroscena* sp. suggests a middle Miocene to early late Miocene age for Core 4 (Friend and Riedel, 1967; Kling, 1971). The common occurrence of *Cyrtocapsella tetrapera* Haeckel, however, indicates a minimum age of middle Miocene for this core (Riedel and Sanfilippo, 1970, Figure 3). Rare occurrences of other species indicating the same minimum age include *Cyrtocapsella cornuta* Haeckel (which may range into the Upper Miocene), *C. japonica* (Nakaseko) and a questionable specimen of *Cannartus laticonus* Riedel (or possibly *Ommatartus antepenultimus* Riedel). Other Miocene species present include *Stichocorys delmontensis* (Campbell and Clark) and specimens of *Solenosphaera* sp. that conform to Figure 21, Plate 1A of Riedel and Sanfilippo's (1971) synchronopticon.

Lower Oligocene

Although the continuously cored (Cores 5 through 11) Lower Oligocene section is characterized by a high content of radiolarians, only two positively identified species of known Oligocene to early Miocene age are present but very rare in Cores 5 through 20, namely *Artophormis gracilis* Riedel and *Dorcadospyris ateuchus* (Ehrenberg). According to Riedel and Sanfilippo (1971, Figure 2) both species occur concurrently with greatest probability in the *D. ateuchus* Zone of early Oligocene age; but, in an earlier publication (Riedel and Sanfilippo, 1970, Figure 3), they indicate that both species range concurrently from the

Theocyrtis tuberosa through *Lychnocanium bipes* Zones. According to Moore (in press), the latter zone includes the boundary between the Oligocene and Miocene.

A few specimens resembling *Artophormis barbadiensis* (Ehrenberg) were noted along with very rare specimens of *Cyclampterium* (?) sp. cf. *C.* (?) *milowi* Riedel and Sanfilippo. The latter differs from *C.* (?) *milowi* in that its abdomen is more inflated and shorter (truncate conical), and it has three robust solid feet with only a few proximal pores (Chap. 16, Plate 2, Figures 1-4).

Negative evidence for an Oligocene age of Cores 5 through 11 is the absence of the typical Miocene species *Cyrtocapsella tetrapera, C. cornuta, C. japonica,* and *Stichocorys delmontensis.*

A few specimens of tholoniids are present as low in Hole 112 as Core 10. These occurrences extend the range of this family downward from the base of the Pliocene into the Lower Oligocene.

Cores 5 through 10 represent a fairly homogeneous radiolarian assemblage dominated by spumellarians both in terms of numbers of individuals (80 to 90 per cent) as well as total mass of biogenous silica. The predominant groups of this suborder include orsphaerids (fragments only), liosphaerids, stylosphaerids, cubosphaerids, astrosphaerids, litheliids, and spongodiscids. In Core 11 the assemblage undergoes a fairly abrupt change signified by a decrease in the above spumellarians and a moderate increase in the number of species but not individuals of nassellarians. (See report on diatoms by Burckle, this chapter). Included in the latter are *Eucyrtidium* spp. and other theoperids plus several artostrobiids. Along with this change there is an increased abundance of larger diatoms (greater than 63 microns). These changes may reflect a higher productivity of biogenous silica in Core 11, perhaps due to an upwelling phenomenon, and this in turn may have favored certain nassellarian species at the expense of spumellarians. This apparently is characteristic of those Quaternary sediments in the Gulf of California that have high percentages of diatoms (Benson, 1966). Such areas coincide with regions of active upwelling in the Gulf.

Eocene - (?) Paleocene

No radiolarians are present below Core 11 with the exception of several zeolitized (?) specimens in Core 15 (Lower Eocene) and silicified and zeolitized (?) forms from the center bit sample between Cores 15 and 16 (? Paleocene). In the latter, one specimen in the shape of *Phormocyrtis striata* Brandt was noted.

Radiolaria are not present in the red clay overlying the basalt in Core 17.

Summary of Diatoms in Hole 112 (Table 3)

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Palisades, New York

Only one hole in Leg 12 contained significant concentrations of diatoms to warrant consideration. This was the Late Eocene and Oligocene section of Site 112 in the Labrador Sea. In selecting sample levels from this interval I was guided by the shipboard notes of K. Perch-Nielson to whom I am most grateful.

Standard samples were taken and placed in dilute solutions of hydrochloric acid. When the calcareous components had been dissolved, the sample was washed over a period of several days to remove the acid. Separation of diatoms and clay and silt particles was achieved by standard techniques. Water was placed in the beaker containing the disaggregated sample to a depth of 10 centimeters. This was brought into suspension and allowed to stand for 10 seconds after which the material still in suspension was carefully decanted into another beaker. This process was repeated three times with the diatoms and lighter components being concentrated in the suspended material. Two permanent slides were made for each level sampled.

Discussion

Diatom concentrations in the samples studied ranged from few to abundant. Taxonomic diversity is low with only a few species predominating at each level although some 10 to 15 species were observed in most samples. In most cases, *Stephanopyxis turris* was the most common form. Of special note is the fact that this species becomes extremely abundant in all samples below Sample 112-11-1,130 to 131 centimeters. This may mark an environmental change or some change in the sedimentological milieu.

On the basis of diatoms, the samples studied can be placed in latest Eocene or earliest Oligocene. Species which lead to this conclusion include: *Hemiaulus polycystinorum, Pyxilla aculeifera, P. dubia, P. gracilis, Triceratium barbadense* and *Hercotheca (?)* sp. The rate occurrence (2 specimens) of *Macrora stella* is viewed with suspicion since this species appears to be restricted to the Early Miocene in other localities.

Finally, note must be taken of the condition of the diatom valves. Considerable breakage has taken place suggesting that the diatoms were transported laterally over some distance. This transport may have been via bottom currents or by slumping from nearby continental slopes. If slumping (hence, rapid burial) was the chief agent of transport, one would expect somewhat higher diversity and better preservation of the more fragile forms. The fact that diversity is low and the predominance of the more robust forms suggest that bottom waters played a role in transporting the diatoms. This view should be considered as tentative in light of the fact that only one hole was examined.

ESTIMATED RATES OF SEDIMENTATION

The Pliocene/Pleistocene boundary (about 2 million years) is drawn at about 90 meters (within Core 1, Hole 112A) on paleontologic data. The glacial boundary (=*surculus/pseudoumbilica* Zone, about 3 million years) is drawn at 115 meters (between Cores 4 and 5, Hole 112A). This yields estimated rates of sedimentation of 4.5 cm/1000 yrs and 2.5 cm/1000 yrs for the Pleistocene and Late Pliocene, respectively.

There may be an unconformity between 125 and 150 meters in which mid-Pliocene (Core 5, Hole 112A) lies above Middle Miocene (top Core 3, Hole 112). The

TABLE 3
Diatoms Present in Samples From Hole 112

Hole	Core	Section	Interval (cm)	Species
112	4	2	150-151	Few diatoms. Diatoms include: *Stephanopyxis turris* and *S. turris* var. *intermedia Pyxilla dubia, P. gracilis, P. oligocaenica, Hemiaulus polycystinorum, Coscinodiscus lineatus, C. argus* and *Hendeya dehiscens*
112	5	3	148-150	Diatoms abundant. Diatoms include: *Stephanopyxis turris, Hemiaulus polycystinorum, Pyxilla gracilis. P. oligocaenica, Diploneis* cf. *D. smithii* var. *minor, Macrora stella* (1 specimen), *Coscinodiscus argus, Stitodiscus* sp. and *Raphoneis* sp.
112	5	4	148-150	Diatoms common, Diatoms include: *Stephanopyxis turris, Hemiaulus polycystinorum, Pyxilla gracilis, Cosinodiscus argus, Melosira sulcata, Raphoenis* sp. and *Stictodiscus* sp.
112	5	6	148-150	Diatoms abundant. Diatoms include: *Stephanopyxis turris, Hemiaulus polycystinorum. Tirceratium barbadense. Coscinodiscus argus, Xanthiopyxis ovalis, Melosira sulcata, Raphoneis* sp, and *Biddulphia* sp.
112	6	2	148-150	Diatoms frequent. Diatoms include: *Stephanopyxis turris, Pyxilla dubia P. gracilis, Diploneis* cf. *D. smithii* var. *minor, Melosira sulcata, Raphoneis* sp.
112	6	4	148-150	Diatoms common. Diatoms include: *Stephanopyxis turris, Hemiaulus polycystinorum, Pyxilla gracilis, Diploneis* cf. *D. smithii* var. *minor Rutilaria* sp. (frag.), *Melosira granulata* (1 specimen) and *Melosira sulcata*
112	7	1	136-137	Diatoms frequent. Diatoms include: *Stephanopyxis turris, Hemiaulus polycystinorum, Coscinodiscus argus, Melosira sulcata. Stictodiscus* sp. and *Hercotheca* (?) sp.
112	7	2	50-51	Diatoms common. Diatoms include: *Stephanopyxis turris, Coscinodiscus argus, Raphoneis* sp. and *Stictodiscus* sp.
112	9	2	98-100	Diatoms frequent. Diatoms include: *Stephanopyxis turris, Hemiaulus polycystinorum, Pyxilla gracilis, Melosira sulcata, Macrora stella* (1 specimen) and *Actinoptychus senarius*
112	10	0	18-20	Few diatoms. Diatoms include: *Stephanopyxis turris* and *Melosira sulcata*
112	11	1	90-91	Diatoms frequent. Diatoms include: *Stephanopyxis turris, Pyxilla aculeifera, P. dubia, P. gracilis, Hemiaulus polycystinorum, Melosira sulcata, Diploneis* cf. *D. smithii* var. *minor, Coscinodiscus argus* and *Actinoptychus senarius*
112	11	1	130-131	Diatoms abundant. Diatoms include: *Stephanopyxis turris* very abundant. Other diatoms include: *Hemiaulus polycystinorum, Pyxilla dubia, P. gracilis, P. oligocaenica, Diploneis* cf. *D. smithii* var. *minor, Actinoptychus senarius* and *Coscinodiscus argus*
112	11	2	140-142	Diatoms abundant. Diatoms include: *Stephanopyxis turris* very abundant. Other diatoms include: *Hemiaulus polycystinorum, Pyxilla dubia, P. oligocaenica, Diploneis* cf *D. smithii* var. *minor* and *Coscinodiscus argus*
112	11	4	102-103	Diatoms frequent. Diatoms include: *Stephanopyxis turris* most abundant. Other diatoms include: *Hemiaulus polycystinorum, Pyxilla dubia, P. gracilis, P. oligocaenica, Diploneis* cf *D. smithii* var. *minor, Coscinodiscus argus* and *Raphoneis* sp.
112	11	4	130-131	Diatoms abundant. Diatoms include: *Stephanopyxis turris* dominant. Other diatoms include: *Hemiaulus polycystinorum, Pyxilla dubia, P. gracilis, P. oligocaenica, Actinoptychus senarius, Diploneis* cf. *D. smithii* var. *minor, Coscinodiscus argus* and *Stephanopyxis marginata*

unconformity is arbitrarily drawn at 135 meters. Downward extrapolation of the sedimentation rate calculated for the Late Pliocene suggests that the sediments just above the unconformity are about 4 million years old (that is, Early Pliocene in age). This rate and the estimated age are shown in parentheses and with a question mark to indicate the uncertainty of these estimates.

On the basis of rather tenuous paleontologic data Core 3, Hole 112 is estimated to be about 12 million years old and Core 4, Hole 112 about 14.5 million years old. This yields a sedimentation rate of about 2 cm/1000 yrs between 150 to 210 meters. Upward extrapolation of this sedimentation rate suggests that the sediments immediately below the unconformity at 135 meters are about 11 million years old. Thus, the unconformity which may separate mid-Pliocene from Middle Miocene involves about 7 million years (see Figure 9). An alternative to the suggestion of a possible unconformity between Cores 3 and 4 is a markedly lower rate of average sedimentation within this same interval.

There may be another unconformity between 210 and 270 meters, in which Middle Miocene (Core 4, Hole 112) overlies Upper Oligocene (Core 5, Hole 112). This unconformity is arbitrarily drawn at 240 meters. Downward extrapolation of the same sedimentation rate calculated for the Middle Miocene (2 cm/1000 yrs) suggests that the sediments immediately above the unconformity are about 16 million years old.

An age of 30 million years (Early/Late Oligocene boundary) is estimated for Core 7, Hole 112 on the basis of rather tenuous paleontologic data. The Eocene/Oligocene boundary (37.5 million years) is drawn at 400 meters, a short distance below Core 12, Hole 112, which is Early Oligocene in age. This yields an estimated sedimentation rate of 1.5 cm/1000 yrs for the Early Oligocene. Upward extrapolation of this rate (shown in parentheses and with a question mark in Figure 9) suggests that the sediments immediately below the unconformity at 240 meters are about 27 million years old. Thus this unconformity involves 11 million years of missing sediments. Again, an alternate explanation would be markedly slower sedimentation rate between Cores 4 and 5.

Core 15, Hole 112 (578 to 587 meters) is estimated to be 50 million years old on relatively reliable paleontologic data. This yields an estimated sedimentation rate of about 1.5 cm/1000 yrs for the Eocene. Thus it would appear that sedimentation rates were relatively constant (1.5 cm/1000 yrs) at Site 112 for at least 13 million years (Middle and Late Eocene) and, in all likelihood, probably for the interval from Middle Eocene to latest Oligocene (50 to 27 million years), or about 27 million years.

Downward extrapolation of the same sedimentation rate of 1.5 cm/1000 yrs below Core 15, Hole 112 (shown in parentheses and with a question mark in Figure 9) suggests that the oldest sediments at this site (sediment/basement contact is at 664 meters) are about 54 million years old (that is, Upper Paleocene). If this is true, a relatively constant rate of sedimentation of 1.5 cm/1000 yrs continued for over 30 million years at this location during the Paleogene.

No systematic increase in density occurs downhole at this site so that corrections to sedimentation rates for the effects of natural consolidation were not made.

DISCUSSION

Introduction

Two holes were drilled at Site 112. The first bottomed at 664 meters in basalt, which was overlain by ?mid-Paleocene to Lower Eocene red clay; the second bottomed at 124 meters near the preglacial/glacial boundary in the mid-Pliocene. Seventeen cores were taken in Hole 112, covering 124 meters of section, of which 75.1 meters were recovered. Of the five cores taken in Hole 112A, a total of 32.27 meters was recovered.

Micropaleontologic studies suggest that there is a stratigraphic hiatus between Lower Pliocene and Middle Miocene (between Cores 2 and 3) at about 135 to 140 meters, and another hiatus between Middle Miocene and Lower Oligocene (between Cores 4 and 5) at about 250 meters.

The boundary between the preglacial and glacial Pleistocene was once again cored at this location. In contrast to Site 111, where the transition was marked by a change from a tropical-subtropical fauna to a cold temperate one, the preglacial Pliocene at this site is characterized by temperate forms. Faunal diversity is less than half (in the planktonic foraminifera) that at comparable levels at Site 111. It may be that we have here a climatically controlled species diversity gradient between these two sites, which are approximately 360 kilometers apart.

The Lower Oligocene is developed as a radiolarian-diatom ooze at this site; these sediments form the mid-sediment reflector visible on seismic records in this area. The Eocene, represented by the interval between approximately 400 to 620 meters, is generally poorly fossiliferous, but contains an agglutinated foraminiferal assemblage indicating bathyal depths. The Paleocene, below 620 meters, is developed as an unfossiliferous dark red clay which may be autochthonous or an alteration product of palagonite below.

The Age of the Basement

The basement samples of oceanic basalt were too altered to enable potassium-argon or fission track dating to be used. An assessment of their age must therefore be made from the oldest sediments lying above them. Core 16, within 10 meters of the basement, contained a hard (baked?) red marl devoid of organic material and hence not datable. However in drilling down from Core 15 to Core 16, the center bit on recovery contained green-gray marl which is thought to come from the zone above the red marls and which is dated as Late Paleocene to Early Eocene (that is, 50 to 56 million years). Although it is possible that this sample came from a level near to Core 15, the rather constant sedimentation rate prior to the Oligocene (Figure 9) would suggest an age of the sediments above basement of 54 million years, consistent with the sample belonging to a level of about 650 meters.

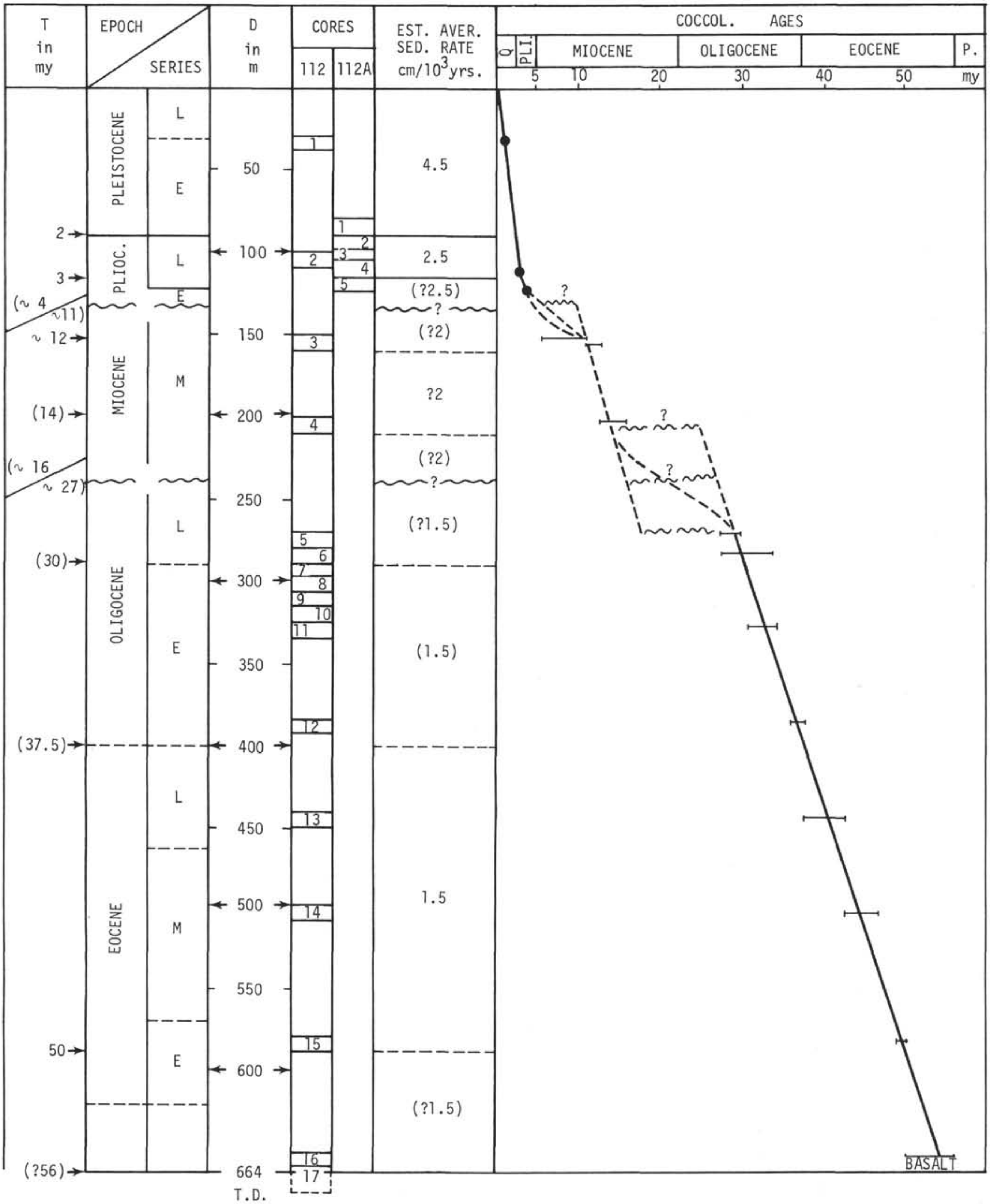

Figure 9. *Estimated average rates of sedimentation at Site 112 (Labrador Sea).*

The basement sampled was on the side of a basement high, corresponding to a two-way reflection time below sea bed of 0.80 second (Figure 4). The gently dipping deep reflector to the north of the site abuts the basement high and indicates clearly that the sediments have been ponded into local depressions before the basement high became buried. The age of the basement must therefore be deduced from the maximum age of the sediments in the neighboring depressions. The basement here lies 1.0 second below the sea bed, and thus the sediment lying below that sampled at the bottom of Hole 112 is 0.2 second (180 meters at 1.8 km/sec) thick.

If a constant sedimentation rate of 1.5 cm/1000 yrs is extrapolated back to a depth of 840 meters, the age of the bottom sediments would be 65 million years, being the minimum age for the basement in the vicinity. A lower mean sedimentation rate before 54 million years would give a greater basement age.

Magnetic Anomaly Field Near 112

The chart of magnetic anomalies in the vicinity of Site 112 (Figure 10) has been compiled from the rather few tracks crossing the area, and shows that the anomalies over the ridges west of Site 112 trend approximately parallel to these ridges. This NW-SE trend can be followed further northwest into the detailed survey area of Avery, Vogt and Higgs (1969). Difficulties in contouring the two tracks crossing at Site 112 suggests that there may be a fracture zone running through here. If the fracture zone mapped by Johnson (1967) on the mid-Atlantic Ridge at 54°N is continued westward parallel to the Gibbs Fracture Zone (Olivet, Sichler, Thonon, Le Pichon, Martinais and Pautot, 1970) it runs through Site 112. This is shown in Figure 10 as a heavy dashed line.

In contrast to this trend, 90 kilometers to the east the magnetic anomalies run N-S parallel to the mid-Atlantic Ridge spreading axis. In Chapter 20, the magnetic anomaly map of the Southern Labrador Sea (Chapter 20, Figure 9) is interpreted in terms of the evolution of the North Atlantic and Labrador Sea. Here it will be seen that these N-S anomalies can be numbered with some confidence up to 24 (60 million years) which runs along 45°20'W. A paleogeographic reconstruction of the North Atlantic prior to this time, based on identified magnetic anomaly isochrons, suggests that the NW-SE trending magnetic anomalies and the associated basement ridges are the remains of a now inactive mid-ocean ridge that existed prior to 60 million years. A measure of symmetry can be seen in magnetic profiles across the ridge projected perpendicular to the ridge (Figure 11) confirming this suggestion. The pair of positive anomalies on the *Vema*-27 track referred to in the objectives of Site 112 are then a symmetrical pair produced by the last period of normal magnetization of the ridge before it migrated to a new position. The change in ridge position and trend is discussed in Chapter 20 and is related to the initiation of spreading between Rockall Plateau and Greenland resulting in the development of a triple junction to the north 60 million years ago.

The identification of the age of the anomaly pair cannot be done unambiguously on the basis of a comparison with a synthetic profile using the Héirtzler *et al.*, 1968 time scale, since the profiles are not long enough. However, a basement age of 65 million years at Site 112 suggests that the

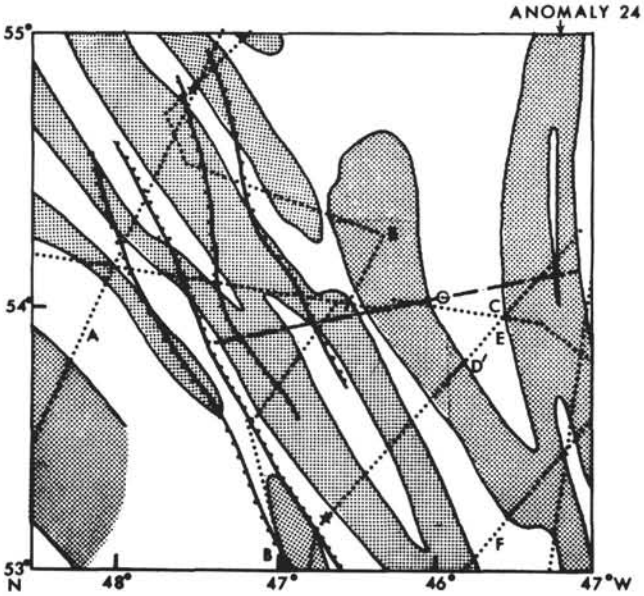

Figure 10. *Magnetic anomalies in the vicinity of Site 112. (Labrador Sea).*

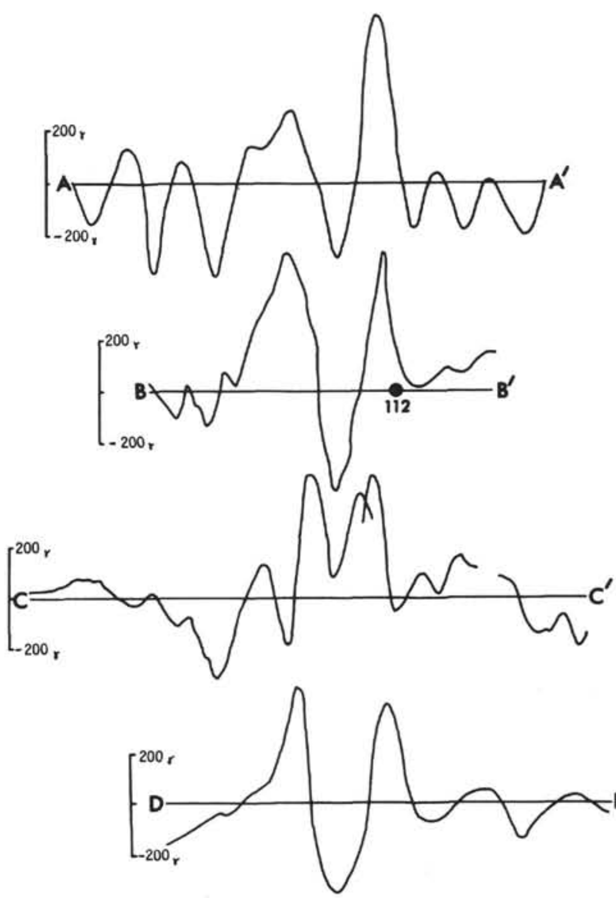

Figure 11. *Magnetic anomalies across ridge near Site 112 projected perpendicular to trend 330°.*

anomaly is Number 26; and this is supported by the relatively smooth magnetic field outside this pair which could relate to the quiet period from 64.5 to 67 million years. The central negative anomaly would then be 64 million years old, and defines the last period of spreading about this axis. The first identified magnetic anomaly of the new trend is 24 (60 million years), indicating the time taken for the new geometry to be established.

The Mid-Sediment Reflector

The mid-sediment reflector is in some places strong and sharply defined and in other places it is weak and diffuse. Immediately beneath Site 112, it has a sharp beginning at 0.41 second. At a velocity of 1.54 km/sec, this corresponds to a depth of 317 meters. At a depth of 315 meters, a band with hard drilling characteristics was encountered at the top of Core 10 which contained some hard clay fragments, mixed with a watery soft clay believed to be the result of drilling disturbance. Lithologically, there is no pronounced difference between the cores immediately above and below 315 meters. Core 12 at 384 meters showed increased pyrite and recrystallized calcite, suggesting a lithological transition in the region 333 to 384 meters which might be related to the mid-sediment reflector.

Nannoplankton determine the age of the sediments at the first echo at 320 meters to be mid-Oligocene (32 million years), and at the center of the energy of the reflection at 350 meters to be Early Oligocene (35 million years). The widespread occurrence of this reflector in the southern Labrador Sea helps to determine its evolutionary history.

Mechanism of Sediment Deposition

The sediment body penetrated in Hole 112 has been delineated over a large area of the southern Labrador Sea from 53-58°N, 43-48°W, both by *Vema*-23 and *Vema*-27 profiles, and by passage tracks of *Glomar Challenger* (Chapter 20, Figure 3). The bathymetry modified and extended from Johnson, Vogt and Schneider (1971) is shown in Chapter 20 (Figure 1). The body has certain features which characterize it and enable it to be discussed as a single unit.

(a) It has a relatively uniform thickness of about 1 second two-way travel time and lies over a relatively flat basement.

(b) Where there are basement highs, the sediment is not draped over them but is ponded.

(c) There are crested ridges of a relative relief of a few hundred meters, which can be traced for several hundred kilometers.

(d) Marginal valleys, or moats are found against basement protrusions.

(e) The top surface and many internal reflectors are wavy with a characteristic wavelength of 2 kilometers and amplitude of 50 meters.

(f) The body is relatively transparent acoustically apart from a prominent mid-sediment reflector.

The body is largely confined within a semicircle of basement ridges to the north, west and south which appear to have acted as barriers to the sediment transport. In places the sequence can be followed over these barriers and plunges beneath highly stratified terrigenous sediments from the continental margins.

These features all point to a deposition mechanism controlled by oceanic currents near to the bottom, similar to that discussed by Heezen, Hollister and Ruddiman (1966), Schneider, Fox, Hollister, Needham and Heezen (1967) for the western North Atlantic, and by Johnson and Schneider (1969) and Jones, Ewing, Ewing, and Eittreim (1970) for the northern North Atlantic. The direction of these currents can be deduced from the axes of the sediment ridges (Figure 1). In the vicinity of Site 112, the current appears to have flowed in a southeasterly direction on both sides of the basement ridge. Between Hole 112 and the ridge (Figure 3), the deep marginal valley results from the acceleration of flow due to the restriction caused by the ridge and, hence, the current becomes either nondepositional or possibly erosional. The accumulation of sediment on the ridges arises from deposition from a sediment loaded current when its velocity falls below a certain critical value for the grain size. The ridges must therefore be found on the margins of the axes of maximum current. Where the current is controlled principally by Coriolis forces, it will tend to keep to the right (in the northern hemisphere) and hence will follow the contours. However, in this area other factors, such as horizontal pressure gradients, also appear to control its path.

Further evidence for the activity of bottom currents comes from the general poverty of planktonic foraminiferal faunas in the Cenozoic (discussed in the section on foraminifera) and from the low diversity and predominance of the more robust forms of diatoms and the broken condition of the diatom valves (discussed in the section on diatoms).

If bottom currents have been responsible for the deposition of this sediment body, fluctuations in space of the currents will control the rate of sedimentation at any one place. The two unconformities may have resulted from a change in current path leading to a period of nondeposition. However the constant sedimentation rate prior to mid-Oligocene suggests that the oceanic circulation during this period was remarkably constant.

A wider discussion of this sediment body in relation to the evolutionary history of the Labrador Sea and of the paleo-oceanographic interpretation is given in Chapters 11 and 20.

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PLATE 1

Paleocene Sediments and Basement. (Core 16, Site 112)

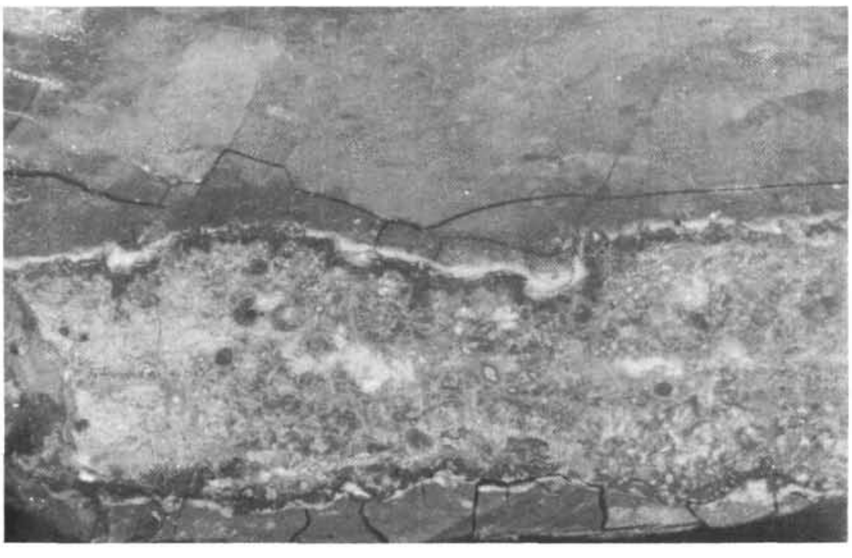
A. Section 1, 70-80 cm.
Red clay with limonitic streaks and with patchy palagonite (originally ash) ca. × 1.5.

B. Basal part of 3; ca. × 4.5.

C. Core catcher sample. Red clay on basaltic basement (weathered, palagonite). Red clay shows patchiness of chemical alterations. White vein in upper part is calcite.

PLATE 1

A



B

C

PLATE 2

Burrowed Upper Eocene Nannofossil marl. (Core 13, Site 112)

A. Section 5, 102-125 cm.

B. Section 4, 16-26 cm.

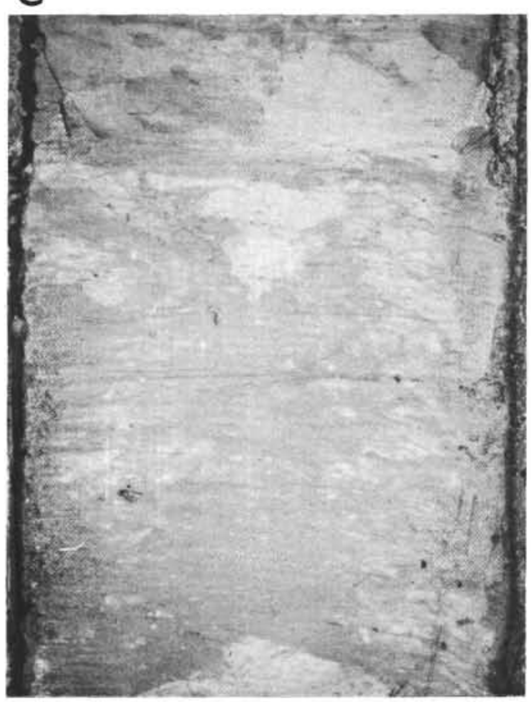
C. Section 4, 102-112 cm.

PLATE 2

A

B

C



APPENDIX A. SHIPBOARD SMEAR SLIDE OBSERVATIONS

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonate	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonate	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
112	1	CC		R	C	D	R	R			R			C												35	R	A	R					Silty clay; rare grains of reddish mineral may be limonite.
112	1	6	75	A	D	A	D		R	R				R				C				R				5	C	C	D	R				Diatomaceous clayey silt.
112	2	CC		D	C	A	D		C	R				C				C			S			X		30	A	D	C		R			Silty marly clay; other minerals - limonite (R).
112	2	2	80	A	D	A	D		C	R												C		X										Clayey silt.
112	2	2	80	R	D	A	D	R	C	R								R																Silty nannofossil marl; other minerals - Blue kyanite (C).
112	2	3	75	C	A	D	D		S	R		C		A				C			R	C				10	R	D						Silty nannofossil clay.
112	3	CC		R	A	A	C			R		C		C	C						C	R				20	X	D			R			Silty clay; a few discoasters present, many coccoliths.
112	3	1	150	C	D	C	R		R	C		C		A	A			R			C	R		X		20	R	D						Clayey marly nannofossil silt; other minerals - kyanite (R).
112	3	2	100	R	A	D	R		R			R		A	C	R		R			C			X		30		D						Silty nannofossil clay; other minerals kyanite (R).
112	3	2	75	R	A	D	R		R	R			R	D	R			C			A					20	R	D	C					Silty diatomaceous nannofossil clay.
112	3	4	15	R	D	C	R		C	A			C	D							C					20		D						Marly nannofossil silt.
112	3	4	130																									D						Same as 3-4-15CM (marly nannofossil silt).
112	3	5	14	R	A	A	R		R	C				A							R			X		10	R	A	A	C	C			Green clayey silty diatom mannofossil ooze; other minerals-disperse green iron oxides.
112	3	5	15	R	D	A			C	A			C	A	C											20		D						Clayey marly nannofossil silt.
112	3	6	118	R	D	R			R	C		R		D							R					10		D						Marly nannofossil silt.
112	3	6	140						R	C				D	C			R								10		D						Silty nannofossil clay.
112	4	CC		R	C	D								C				C			C	R		X		20		D	A	R	R			Marly diatom clay.
112	4	2		R	A	A	R		R					D	R			C			R			X		5		A.	A	R	C			Silty diatom nannofossil clay; other minerals-limonite (C).
112	5	CC		R	A	D	R					R		A				C								20		A	D	R	C			Diatomaceous nannofossil clay.
112	5	1	15	R	A	A	R		R	R		R	C										R			10	R	A	A	C	C			Silty nannofossil diatom clay.
112	5	2	15																							10								Same as 5-1 silty nannofossil diatom clay.
112	5	3	75	R	D	C	R			R				D	R							R				5	R	A	D	R	C			Clayey silty nannofossil diatom ooze.
112	5	6	75	R	D	A	C		R	C								C								5	R	A	A	R	C			Clayey nannofossil diatom silt.
112	6	CC		R	C	D	R		R	R				R				R			R	R		X		20	R	D	A	R	C		R	Nannofossil clay; other minerals - ?dolomite rhombs (R), shark teeth (R).
112	6	4		A	A																					30		C	C	C	C			Silty clay; mostly radiolarian, sponge and diatom fragments, some clays.
112	6	4	88		A	A								R											C	30		C	C	C	C			Silty clay; mostly radiolarian and diatom fragments, some clays and glass.

D = Dominant, 65+%; A = Abundant, 41%–65%; C = Common, 16%–40%; R = Rare, 0%–15%.

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonate	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonate	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
112	7	2			A	A																				30		C	C	C	C			Silty clay; mostly radiolarian and diatom fragments, some clay and detrital minerals.
112	8	1	150		A	A						R	R												C	30		C	C	C	C			Silty clay; mostly radiolarian, sponge and diatom fragments, some glass and clay.
112	9	CC			A	A			R	R				D	R			R						X		10	C	D	A	C	C			Marly silty nannofossil diatom clay; other minerals - limonite (C).
112	9	2	1		A	A										R									C	25		C	C	C	C			Silty clay; mostly radiolarian and diatom fragments, some clay and glauconite.
112	9	2	27		A	A								R												20		C	C	C	C			Silty clay; mostly diatom and radiolarian fragments with clay aggregates.
112	9	4	150		A	A							R			C									C	20		C	C	C	C			Silty clay; mostly radiolarian and diatom fragments, some glass and glauconite grains.
112	9	5			A	A																			C	25		C	C	C	C			Silty clay; mostly diatom, radiolarian and sponge fragments.
112	10	CC		R	A	A				R				D				R								20		D	A	A	C			Marly nannofossil diatom radiolarian clay.
112	10	3			A	A		R				R														20		C	C	C	C			Silty clay; mostly radiolarian and sponge fragments with diatoms and clay.
112	11	CC		R	D	A	R							C								R				10		D	A	A	C			Silty nannofossil diatom radiolarian clay.
112	11	1	45		A	A										C										20	R	C	C	C	C			Silty clay; many opaque grains, could be glauconite or pyrite or manganese.
112	11	1	70		A	A								R												25		C	C	C	C			Silty clay; similar to slides from cores above.
112	11	1	140		A	A										R								X		20		C	C	C	C			Silty clay; mostly radiolarian, sponge and diatom fragments with clays and other minerals.
112	11	2	83		A	A																			C	25		C	C	C	C			Silty clay; similar to cores above.
112	11	3	75		A	A																				20		C	C	C	C			Silty clay; mostly radiolarian and sponge fragments.
112	11	4	75	R	D	A	R		R					C				C			R					10	R	A	A	C	C			Clayey nannofossil diatom radiolarian silt.
112	11	5	75		C	Z										R									C	20		C						Silty clay; mostly nannofossils and clay with some glauconite.
112	12	1	75		A	A	R				R							C	R		R					40		D						Marly nannofossil debris ooze.
112	12	2	20		A	D	R			C				C				C			R	R				20	R	D			R			Marly coccolith clay.
112	13	CC		R	A	D	C		R	C				C				C			R					15		D						Silty nannofossil clay.
112	13	CC			D													D										C						Pyrite silt; thin layer within clay composed of opaque pyrite octahedra and nodules.
112	13	2	75	R	D	A	R		R	R			C	C				C	R		R					50	R	D			R			Coccolith ooze.

APPENDIX A – *Continued*

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonate	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonate	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
112	13	2	95		D	A	R							R	R				A		R			X		60		D						Calcilutite consisting of coccolith fragments and authigenic carbonate rhombs, other minerals include a fibrous mineral with high BIFR colors.
112	13	3	95		C	A													A						A	25		C						Silty clay; mostly calcite rhombs and clay minerals, few fossils.
112	13	4	140		D	A				R				R				C								60		D						Coccolith ooze.
112	13	5	75		R	A				C								C	C						C	40		A						Silty clay; mostly nannofossils and clay with some calcite rhombs and glauconite.
112	14	CC			C	D	R																	X		10		D						Reddish brown slightly silty nannofossil clay, other minerals-limonite (C).
112	14	2	75																							40		D						Clayey silt; mostly nannofossils and clays with common glauconite.
112	14	3	118																							40		D						Silt; mostly nannofossils with some clay and glauconite.
112	14	3	75							A																40		D						Clayey silt; mostly nannofossils with clay.
112	14	5	150		C	D				R				C				C			R			X		20		D						Dark red marly coccolith clay; other minerals - limonite (C).
112	14	5	96		A	D	R			C				R	R			C			R					30		D						Light gray silty marly nannofossil clay.
112	15	CC																								40		D						Clay; mostly nannofossils with clay.
112	15	6	75	R	D	A	R								R			C				R				50	R	D						Gray coccolith marl.
112	15	6	136	R	D	C													D									R						Dolomite silt consists of authigenic (?) dolomite rhombs.
112	16	CC	6							A					D																			Green veinlet of chloritic palagonite.
112	16	CC	7																D							99								Calcisparite veinlet in red clay, partly fibrous.
112	16	CC	7		C	D	R							C	C				A					X		10		R						Limonitic red clay with authigenic sparry calcite; coccoliths are sometimes visible as ghosts in clay lumps, all dissolved; sparry recrystallization partly fibrous; other minerals-limonite (A) and hematite (C).
112	16	CC	12		R	D	R	C		R				R				R			C					5								Light yellowish clay.
112	16	CC	21		R	D			R	C				R	C									X										Lumpy red clay, free from any fossils, from contact with palagonitic layer; baked hematite, other minerals: serpentine (C), hematite (A), limonite (D).
112	16	CC	22	C	A	A				C			C	A	D			C			C													Sandy clayey silt; palagonitic ash layer containing only minerals of volcanic origin; alteration rims of palagonite glass in all phases observable; phillipsite with honeycomb structure.
112	16	CC	22	R	A	D	R	R						R	A			R			R													Silty sericitic palagonitic serpentine clay, green gray, from below palagonite ash layer.

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonate	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonate	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
112	16	1	10		R	D	R							R	R									X										Indurated hematitic red clay; other minerals-hematite (A), limonite (C).
112	16	1	20		R	D	R	C	R					R							R			X				R						Red limonitic clay; other minerals - limonite (D).
112	16	1	76	C	D	R	R	R		A				A	D			C			A													Palagonitic sandy silt.
112	16	1	98	C	D	R	R												D					X		90								Yellow calcisparritic sandy silt; other minerals - hematite (R).
112	CB					D		R											A					X				R						Lumpy indurated light red hematitic clay, apparently baked at a basalt contact coccolith contamination from different horizon.
112	CB							A						D	C			C			C													Fragment of hard tuffaceous layer.
112A	1	CC		C	A	D	C	R	C	R		R		A							C					20	C	D						Marly silty clay.
112A	1	1	140	A	D	A	C	C	A	A			C	A							C					15								Sandy clayey silt.
112A	1	21	75	C	D	A	D	R	C	C				C					C							40	A	D						Gray marly sandy silt.
112A	1	3	75	R	D	R	A		C										D							60		C						Marly silt.
112A	1	4	75	R	D	A	A		C	R								C	D							60		D						Marly clayey silt.
112A	1	5	75	R	A	D	C		C	C								C	D							50	R	D						Marly silty clay.
112A	1	6	75	C	D	A		R	C	R				C	R			C			C					30	C	A						Marly silty clay.
112A	2	CC		C	A	A	D	R	A	R								C								15	R	C						Silty clay.
112A	3	1	75	A	C	D	D	C	C	R								C								10	C	C						Sandy clay.
112A	3	3	75	A	R	D	C	A	R	C								C	R							5	R	R						Sandy clay.
112A	3	6	75	C	A	D	A	R	C	R								C	R							10		R						Marly silty clay.
112A	4	3	75	C	C	D	D	R	R	R								A								5								Sandy clay.
112A	5	2	75	A	D	C	A	R	C	R		D		A	C									X		60	A	D						Sandy clayey silt; forams mostly fragmented, detrital minerals common.
112A	5	3	75	C	C	D	C	D	C	C		R		R				A			R					5	R	R						Sandy clay.
112A	5	4	20	R	A	D	R	R	R	R								C								70	R	D						Silty nannofossil marl; mainly coccolith debris.
112A	5	5	75				R	R	C	C								A								70	A	D						Clayey nannofossil marl.

APPENDIX B. GRAIN SIZE DETERMINATIONS ON SAMPLES FROM SITE 112[1]

Site	Core	Section	Interval (cm)	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
112	2	6	24.0	14.1	29.1	56.8	Silty clay
112	4	2	25.0	0.1	44.9	55.0	Silty clay
112	5	1	50.0	4.5	43.1	42.5	Silty clay
112	5	2	25.0	3.5	49.1	47.5	Clayey silt
112	5	3	25.0	2.8	49.9	47.3	Clayey silt
112	5	6	89.0	2.4	50.2	47.4	Clayey silt
112	6	4	119.0	0.2	51.7	48.0	Clayey silt
112	7	2	103.0	3.2	52.6	44.2	Clayey silt
112	9	2	39.0	1.0	37.7	61.2	Silty clay
112	11	1	115.0	0.3	39.4	60.2	Silty clay
112	11	2	20.0	0.1	38.7	61.1	Silty clay
112	11	4	111.0	0.1	42.0	57.9	Silty clay
112	12	1	52.0	0.0	17.9	82.0	Clay
112	13	2	29.0	0.1	12.9	87.0	Clay
112	13	4	140.0	0.2	11.9	87.9	Clay
112	13	5	28.0	0.0	13.2	86.8	Clay
112	14	2	25.0	0.3	12.3	87.4	Clay
112	14	5	23.0	0.1	9.2	90.7	Clay
112	16	1	25.0	0.0	11.5	88.5	Clay

[1]Analyses carried out under the supervision of G. W. Bode and R. E. Boyce, Scripps Institution of Oceanography.

APPENDIX C. CARBON-CARBONATE DETERMINATIONS ON SAMPLES FROM SITE 112[1]

Site	Core	Section	Top Interval	Hole Depth	Total Carbon	Organic Carbon	$CaCO_3$
112	2	6	14.0	107.6	2.8	0.2	21
112	4	2	15.0	201.6	1.9	0.3	13
112	5	1	35.0	270.4	2.1	0.3	15
112	5	2	15.0	271.6	2.2	0.3	16
112	5	3	15.0	273.1	1.9	0.3	13
112	5	6	102.0	278.5	2.4	0.4	17
112	6	4	94.0	284.4	2.4	0.3	18
112	7	2	118.0	290.7	3.2	0.2	25
112	9	2	20.0	307.7	1.3	0.4	7
112	11	1	80.0	324.8	5.4	0.3	42
112	11	2	15.0	325.6	5.3	0.3	42
112	11	4	15.0	328.6	2.6	0.3	20
112	12	1	52.0	384.5	4.5	0.3	35
112	12	2	14.0	385.6	3.6	0.3	28
112	13	2	18.0	442.7	2.8	0.3	21
112	13	4	140.0	446.9	3.2	0.3	24
112	13	4	75.0	447.8	3.0	0.3	22
112	14	2	20.0	450.7	3.7	0.3	28
112	14	5	16.0	455.2	1.5	0.3	10
112	15	6	90.0	586.4	3.5	0.3	27
112	16	1	15.0	652.2	0.1	0.1	0

[1]Analyses carried out under the supervision of G. W. Bode and R. E. Boyce, Scripps Institution of Oceanography.

APPENDIX D. LISTS OF SELECTED PLANKTONIC AND BENTHONIC FORAMINIFERA AND AGE DETERMINATIONS

W. A. Berggren

Hole 112

Sample 12-112-1-1, 142-144.5 cm:
PF: *Globigerina bulloides, Globigerina pachyderma* (sinistral and dextral), *Globorotalia inflata, Globorotalia crassaformis* (rare), *Orbulina universa.*
BF: *Melonis barleeanum, M. pompilioides, Planulina* sp., *Gyroidina neosoldanii.*
Also present: Ice-rafted debris.
Age: Pleistocene (glacial).

Sample 12-112-1-6, 143-145.5 cm:
Foraminiferal fauna and lithology essentially same as above.

Sample 12-112-1, Core Catcher:
PF: *Globigerina bulloides, Globigerina pachyderma* (sinistral and dextral), *Globorotalia inflata.*
BF: *Melonis pompiloides, Planulina wuellerstorfi.*
Also present: Glacially-rafted debris, echinoid spines.
Age: Pleistocene (glacial).

Remarks: This core consists essentially of soft terrigenous clays and silts containing glacially rafted debris interbedded with coccolith marl. The dominant faunal element is *Globigerina bulloides.*

Sample 12-112-2-2, 144.5-148 cm:
PF: *Globorotalia inflata, G. hirsuta, Globigerina pachyderma* (dextral), *Globigerina bulloides.*
BF: *Pyrgo* sp., *Melonis pompilioides, Gyroidina neosoldanii.*
Also present: Abundant ice-rafted debris.
Age: Late Pliocene (glacial) (age determination based on calcareous nannoplankton).

Sample 12-112-2-3, 146-148.5 cm:
Lithology and fauna essentially the same as preceding sample above. *Globorotalia inflata* common.
Age: Late Pliocene (glacial).

Sample 12-112-2-5, 145.5-148 cm:
PF: *Globigerina pachyderma* (dextral), *G. bulloides, Globorotalia hirsuta.*
BF: *Melonis pompilioides. Uvigerina hollicki, Sphaeroidina bulloides, Pyrgo murrhyna.*
Age: Late Pliocene.

Sample 12-112-2-5, 145.5-148 cm:
Note: This sample is essentially a pure nannofossil-foraminiferal ooze with only minor traces of quartz.

Sample 12-112-2-6, 145-147.5 cm:
PF: *Globigerina bulloides, G. pachyderma* (dextral), *Globorotalia scitula.*
BF: *Melonis pompilioides, Eponides tenera, Pyrgo murrhyna.*
Also present: Abundant ice-rafted debris.
Age: Late Pliocene (glacial).

Sample 12-112-2, Core Catcher:
PF: *Globigerina atlantica* (sinistral, dominant, abundant).
BF: *Melonis barleeanum, M. pompilioides, Sigmoilopsis schlumbergeri.*
Also present: Abundant ice-rafted debris.
Age: Late Pliocene (glacial).

Remarks: Core 2 consists essentially of gray terrigenous silty clays, containing moderate to abundant amounts of glacially-rafted detritus. The dominant faunal element, in general, is *Globigerina pachyderma* (dextral); in the core catcher *G. atlantica* (sinistral) is the dominant form.

Sample 12-112-3-2, 146-148.5 cm:
PF: *Globigerina praebulloides, G. bulloides, G. nepenthes, Globorotalia miozea.*
BF: *Gyroidina neosoldanii, Stilostomella* sp., *Planulina wuellerstorfi*, dentalinids, nodosariids, *Melonis barleeanum, Cassidulina subglobosa, Eggerella bradyi, Cibicidoides pseudoungeriana.*
Age: Middle Miocene.

Sample 12-112-3-3, 145-147.5 cm:
PF: *Globigerina praebulloides, G. nepenthes, G. woodi, Globoquadrina dehiscens.*
BF: *Pullenia* sp., *Gyroidina* sp., *Cassidulina subglobosa, Laticarinina halophora.*
Also present: Large amount of mica flakes.
Age: Middle Miocene.

Sample 12-112-3-4, 142-144.5 cm:
PF: *Globigerina nepenthes, G. praebulloides, G. parabulloides, Globorotalia continuosa, Sphaeroidinellopsis seminulina.*
BF: *Uvigerina* sp., *Anomalinoides pompilioides*, cibicidids, dentalinids.
Age: Middle Miocene.

Sample 12-112-3-5, 143-145.5 cm:
PF: *Globigerina nepenthes, G. praebulloides, G. druryi, G. woodi, Globorotalia continuosa, Orbulina universa.*
BF: *Laticarinina halophora, Eponides* sp., *Gyroidina* sp., *Cibicidoides* sp., *Melonis* sp., *Uvigerina asperula, Uvigerina* sp., *Epistominella exigua.*
Age: Middle Miocene.

Sample 12-112-3-6, 132-133.5 cm:
Micaceous clay and silt fragments. Only few foraminiferal specimens preserved; none determinable.
Age: No determination (Middle Miocene by interpolation).

Sample 12-112-3-6, 142-144.5 cm:
Data same as preceding sample above.
Age: No age determination (Middle Miocene by interpolation).

Sample 12-112-3, Core Catcher:
Tan silty marl, only a few foraminifera preserved; no planktonic foraminifera.
BF: *Siphonodosaria* sp., *Vulvulina* sp., *Gyroidina* sp., *Cibicidoides* sp., *Planulina wuellerstorfi, Anomalina* sp.
Also present: Echinoid spine fragments.
Age: No age determination (Middle Miocene by interpolation and on calcareous nannofossils).

Remarks: The oldest stratigraphic occurrence of *Globigerina nepenthes* is noted here in Core 3. The co-occurrence of *Globigerina nepenthes, G. druryi* and *Globorotalia continuosa* suggest that this level is approximately equivalent to Zone N14 and to Core 7 in Hole 116 (Hatton-Rockall Basin). The presence of Mid-Pliocene sediments at the bottom of the cored section (Core 5) in Hole 112A and of Middle Miocene sediments here in Core 3 of Hole 112 indicate a marked unconformity within the stratigraphic interval represented by these two cores.

Sample 12-112-4-2, 132.5-135 cm:
Silty marl with few foraminifera preserved.
PF: *Globigerina praebulloides, G.* sp.
BF: *Planulina wuellerstorfi, Cassidulina subglobosa.*
Age: Middle Miocene.

Sample 12-112-4, Core Catcher:
Silty marl with sparse foraminiferal fauna.
PF: *Globigerina praebulloides, Globigerina* spp., *Globorotalia mayeri, Globorotalia* sp. cf. *G. acrostoma* (high arched aperture with thickened apertural rim, *Globigerinoides* sp., *Globoquadrina* sp.
BF: Sparse, including *Pullenia* sp., *Cibicidoides heminwayae, Cassidulina subglobosa, Planulina wuellerstorfi.*
Age: Middle Miocene.

Remarks: The sparse fauna in this core is characterized by globigerinids and unkeeled globorotaliids, which are difficult to determine from the literature. In particular globorotaliids with high arching aperture and a non-keeled globorotaliid with a high oblique arching aperture and a thick apertural rim (*G.* cf. *acrostoma*) occur in the core catcher sample. The absence of *Globigerina nepenthes* in Core 4 suggests that this level may be somewhat older than Zone N14. This is in agreement with the questionable assignation of Core 4 to the *Discoaster exilis* Zone (which is approximately equivalent to Zones N11 and the lower part of Zone 12.

Cores 5 through 11 are essentially diatom oozes with large numbers of calcareous nannoplankton and Radiolaria also present. Planktonic foraminifera are sparse throughout these cores. The following samples were examined from Core 5.

Sample 12-112-5-1, 139-141 cm
Sample 12-112-5-2, 144.5-147 cm
Sample 12-112-5-3, 140-142.5 cm
Sample 12-112-5-4, 145-147.5 cm
Sample 12-112-5-5, 145-148 cm
Sample 12-112-5-6, 144-146.5 cm
Sample 12-112-5, Core Catcher

All samples contain a rich diatom assemblage and a very sparse foraminiferal fauna consisting of small globigerinids and globigerinitids, which are assigned here to *Globigerinita dissimilis.* Age indeterminate (Late Oligocene, based on calcareous nannoplankton).

The following samples were studied from Core 6:

Sample 12-112-6-2, 146-149 cm
Sample 12-112-6-4, 145-147.5 cm
Sample 12-112-6, Core Catcher

Lithology and fauna as above in Core 5.
Age: Late Oligocene (based upon calcareous nannoplankton).

The following samples were studied from Core 7:

Sample 12-112-7-1, 143-146 cm
Sample 12-112-7-2, 139-141 cm
Sample 12-112-7, Core Catcher

The lithology and fauna of these samples is essentially the same as in Cores 5 and 6 above. Core Catcher was found to contain planktonic foraminifera in somewhat greater abundance than in the other samples in Core 7. The following species have been recorded from the core catcher:

PF: *Globigerinita dissimilis, Globorotalia postcretacea, Globorotalia munda, Globigerina officinalis, Globigerina ciperoensis.*

Age: Oligocene.

Remarks: Core 7 contains the highest observed occurrence of *Globorotalia munda,* a form useful in recognizing strata of Lattorfian and Rupelian age in northwestern Europe, although this form does extend into strata of Chattian age.

Sample 12-112-8, Core Catcher:

Lithology as above. Planktonic foraminiferal fauna sparse and consisting almost entirely of a single species, *Globigerinita dissimilis.* Benthonic fauna consisting of *Siphonodosaria* sp., *Uvigerina* sp. and *Pullenia* sp.

Age: Oligocene.

The following samples were studied from Core 9:

Sample 12-112-9-2, 146-148.5 cm

Sample 12-112-9, Core Catcher

Lithology and fauna as above. Planktonic fauna rare and consisting of *Globigerinita dissimilis.* Benthonic fauna contains a few siphonodosariids.

Age: Oligocene.

Sample 12-112-10, Core Catcher:

Lithology and fauna essentially as above but more diverse.

PF: *Globigerinita dissimilis, Globorotalia postcretacea, G. munda, Globorotaloides suteri.*

BF: *Eponides* sp., *Gyroidina* sp., *Oolina* sp., *Cassidulina* sp.

Age: Oligocene.

The following samples were studied from Core 11:

Sample 12-112-11-1, 145-147.5 cm

Sample 12-112-11-2, 146-148.5 cm

Sample 12-112-11-4, 145-147 cm

Sample 12-112-11, Core Catcher

Lithology as above. Planktonic foraminiferal fauna sparse and consists almost entirely of *Globigerinita dissimilis.* Benthonic foraminiferal fauna sparse and consists primarily of siphonodosariids and *Gyroidina* sp.

Age: Oligocene.

Sample 12-112-12-1, 145.5-148 cm:

PF: Sparse, consisting of *Globigerinita dissimilis.*

BF: Relatively diverse containing among others nodosariids, siphonodosariids, *Eggerella* sp., *Recurvoides* sp., *Cyclammina* sp., *Cibicidoides perlucida.*

Age: Early Oligocene (based on calcareous nannofossils).

Sample 12-112-12-1, Base Section:

BF: *Globigerinita dissimilis, G. unicava, Globorotaloides suteri, Pseudohastigerina micra.*

BF: Siphonodosariids, *Gyroidina* sp.

Age: Early Oligocene (based on calcareous nannofossils).

Sample 12-112-12-2, 42-45 cm:

Diatomaceous clay with few foraminifera preserved. Siphonodosariids.

Age: Early Oligocene (based on calcareous nannoplankton).

Sample 12-112-12, Core Catcher:

PF: *Globigerina officinalis, Globigerinita* spp.

BF: *Ammodiscus* sp., *Siphonodosaria* sp., *Gyroidina* sp.

Age: Early Oligocene (based on calcareous nannoplankton).

Sample 12-112-13-2, 141.5-144 cm:

Small residue, few foraminifera, no planktonics.

BF: *Cyclammina* sp., indeterminate agglutinated species.

Age: No age determination.

Sample 12-112-13-4, 141-144 cm:

PF: *Globigerina galavisi, Chiloguembelina* sp.

BF: Siphonodosariids.

Age: Late Eocene.

Sample 12-112-13-5, 146-149 cm:

PF: Planktonic foraminifera present in fine fraction only (larger forms may have been dissolved), *Globigerina galavisi, Pseudohastigerina micra.*

BF: *Cyclammina* sp., *Glomospira* sp., *Ammodiscus* sp., *Bolivinopsis* sp., *Rhabdammina* sp., *Siphonodosaria* sp.

Also present: Shark teeth.

Age: Late Eocene.

Sample 12-112-13, Core Catcher:

PF: *Globigerina galavisi, Globigerinita unicava, Pseudohastigerina micra.*

BF: *Cyclammina* sp., *Rhabdammina* sp., *Glomospira* sp., *Cibicidoides* sp., *Gyroidina* sp.

Also present: Shark teeth.

Age: Late Eocene.

Remarks: Although a few specimens are present in Core 12 above, Core 13 essentially marks the upper limit of the diverse agglutinated benthonic foraminiferal assemblage characteristic of the Middle and Upper Eocene sediments in Hole 112. Such deep water forms as *Cyclammina, Rhabdammina,* and *Glomospira* point to bathyal depositional depths during the Eocene in this region.

Sample 12-112-14-2, 144-146.5 cm:

Small residue containing few foraminifera.

PF: *Globigerina galavisi, G. senilis, Globigerinita* sp., *Chiloguembelina* sp.

BF: *Cyclammina* sp., *Rhabdammina* sp., *Siphonodosaria* sp., *Oridorsalis ecuadorensis.*

Age: Late Eocene.

Sample 12-112-14-3, 141-144 cm:

PF: Rare in coarser fractions, abundant but indeterminate in fine fraction. *Globigerina galavisi, Globigerina* spp., *Globigerinita* sp.

BF: *Anomalinoides pompilioides, Siphonodosaria* sp., *Ammodiscus* sp.

Age: Late Eocene.

Sample 12-112-14-5, 144-147 cm:

Residue consists essentially of agglutinated foraminifera.

PF: Small indeterminate globigerinids.

BF: *Cyclammina* sp., *Bolivinopsis* sp., *Glomospira* sp., *Cribrostomoides* sp., *Rhabdammina* sp., *Ammodiscus* sp., *Osangularia pteromphalia,* siphonodosariids.

Also present: Shark teeth.

Age: Late Eocene.

Sample 12-112-14, Core Catcher:

PF: No planktonic foraminifera preserved.

BF: *Cribrostomoides* (dominant), *Glomospira Ammodiscus, Cyclammina, Bolivinopsis, Rhabdammina* sp., *Gyroidina* sp., *Pullenia* sp., *Uvigerina* sp.

Age: Late Eocene.

Remarks: Core 14 is characterized by moderate to large amounts of agglutinated benthonic foraminifera and the absence of extreme rarity of planktonic foraminifera. It is suggested that solution has removed most of the calcium carbonate secreting forms.

Sample 12-112-15-1, 46-48 cm:

PF: *Globigerina patagonica, Pseudohastigerina wilcoxensis, Acarinina* sp.

BF: *Glomospira* sp., *Rhabdammina* sp.

Age: Early Eocene.

Sample 12-112-15-6, 144-146.5 cm:

Residue insufficient for determination.

Sample 12-112-15, Core Catcher:

PF: *Globigerina frontosa (=boweri), G. linaperta, G. patagonica, Acarinina collactea, A. densa, Pseudohastigerina wilcoxensis.*

BF: *Cyclammina* sp., *Ammodiscus* sp., *Rhabdammina* sp., *Glomospira* sp., *Cribrostomoides* sp., *Nuttallides truempyi, Gyroidina* sp., nodosariids, *Stilostomella* sp.

Age: Early Eocene.

Remarks: The association of *Globigerina patagonica, G. linaperta,* and *G. frontosa (=boweri),* and *Pseudohastigerina wilcoxensis* indicates that this level is probably of latest Early Eocene age. It is correlated here with Zone P9 (*A. densa* Zone). This level has been placed in the *Discoaster sublodoensis* Zone.

Sample 12-112-16-1, 46-49 cm:
Chemically altered reddish (hematitic, limonitic) and greenish (chloritic) pelagic clay with agglutinated benthonic foraminiferal tests. No planktonic foraminifera observed.
BF: *Cyclammina* sp., *Cribrostomoides* sp., *Ammodiscus* sp., *Glomospira* sp., *Bolivinopsis* sp., *Rhabdammina* sp., *Haplophragmoides* sp.
Age: No age determination (probably mid-Paleocene based on sedimentation rate extrapolation).

Sample 12-112-16-1, 78-81 cm:
Green (chloritic) clay. Scattered agglutinated benthonic foraminifera consisting essentially of the forms listed above.
Age: No age determination (probably mid-Paleocene, see above).

Sample 12-112-16-1, 108-111 cm:
Red (hematitic) clay; unfossiliferous.
Age: No age determination (probably mid-Paleocene, see above).

Sample 12-112-16, Core Catcher:
Green (chloritic) palagonite and clay; unfossiliferous.
Age: No age determination (probably mid-Paleocene based on sedimentation rate extrapolation).

Remarks: Core 16, which rests directly upon basement in this hole is unfossiliferous. Using rates of sedimentation calculated for the Eocene in this hole an age of mid-Paleocene is estimated for the oldest sediment (Core 16) at this location.

Micropaleontological Determinations, Hole 112A

Sample 12-112A-1-1, 146-149 cm:
PF: *Globigerina pachyderma* (dominant, abundant, predominantly dextral), *G. bulloides, Globorotalia inflata, G. truncatulinoides, G. hirsuta, G. scitula.*
BF: Sparse, including *Eponides tenera, E. umbonatus, Planulina wuellerstorfi, Melanis barleeanum, Sphaeroidina bulloides, Anomalinoides cicatricosa.*
Also present: Ice-rafted detritus.
Age: Pleistocene (glacial).

Sample 12-112A-1-2, 147-150 cm:
PF: Similar to preceding sample above.
BF: As above, plus *Sigmoilopsis schlumbergeri, Bulimina notovata, Uvigerina hollicki, Epistominella exigua.*
Also present: Ice-rafted detritus.
Age: Pleistocene (glacial).

Sample 12-112A-1-3, 142-145 cm:
Data essentially same as above.
Age: Pleistocene (glacial).

Sample 12-112A-1-4, 146-149 cm:
Essentially same as above; *G. inflata* abundant.
Age: Pleistocene (glacial).

Sample 112-112A-1-6, 143-146 cm:
Essentially same as above, *G. inflata* abundant.
Age: Pleistocene (glacial).

Sample 12-112A-1, Core Catcher:
PF: *Globorotalia inflata, Globigerina pachyderma* (dextral), *G. bulloides, Globorotalia hirsuta, G. scitula.*
BF: Sparse, including *Uvigerina hollicki, Planulina wuellerstorfi, Eponides tenera.*
Also present: Abundant ice-rafted detritus.
Age: Pleistocene (glacial).

Remarks: Core 1, Hole 112A, is dominated by dextrally coiled *Globigerina pachyderma* and *Globorotalia inflata.* Forms intermediate between *G. pachyderma* and *G. dutertrei* also occur in the samples from this core. The presence of *Globorotalia truncatulinoides* in this core (Section 1) supports the Pleistocene age determination based on calcareous nannofossils (see section by K.P-N.). Characteristic benthonic faunal elements include *Planulina wuellerstorfi* and *Uvigerina hollicki.*

Sample 12-112A-2, Core Catcher:
PF: Sparse, including *Globigerina pachyderma* (dextral), *G. dutertrei, G. bulloides, G. inflata.*
BF: Sparse.
Also present: Abundant ice-rafted detritus.
Age: Late Pliocene (based on calcareous nannofossils; glacial).

Sample 12-112A-3-1, 143-146 cm:
PF: *Globigerina pachyderma* (dextral), *G. atlantica, Globorotalia tosaensis, G. crassaformis, Globigerinoides conglobata, Orbulina universa.*
BF: *Uvigerina hollicki, Eggerella bradyi, Planulina bradii.*
Also present: Abundant ice-rafted detritus.
Age: Late Pliocene (glacial).

Sample 12-112A-3-2, 143-146 cm:
Data essentially same as preceding sample above.

Sample 12-112A-3-3, 121-124 cm:
Fauna sparse, essentially same as above, including *Globorotalia tosaensis.*
Also present: Abundant ice-rafted detritus.
Age: Late Pliocene (glacial).

Sample 12-112A-3-6, 145-148 cm:
PF: *Globigerina pachyderma* (sinistral), *G. atlantica, G. bulloides.*
BF: As above.
Also present: Abundant ice-rafted detritus.
Age: Late Pliocene (glacial).

Sample 12-112A-3, Core Catcher:
PF: *Globigerina atlantica, G. pachyderma.*
BF: Sparse, including *Cibicidoides pseudoungeriana, Planulina wuellerstorfi,* nodosariids.
Also present: Abundant ice-rafted detritus.
Age: Late Pliocene (glacial).

Remarks: This core is characterized by dextrally coiled *Globigerina pachyderma* (Sections 1-3). In Section 6 and in the core catcher sample the dominant element is a thick-walled 4-chambered form referred to as *Globigerina atlantica.* It is consistently sinistral coiling. Typical *G. pachyderma* is rare or absent below Core 3 in this hole. The presence of *Globorotalia tosaensis* (Sections 1 and 3) suggests a Late Pliocene age for this core. This is the northernmost known occurrence of this species to date.

Sample 12-112A-4-3B, 146-149 cm:
PF: Essentially barren, few broken foraminiferal test fragments.
Also present: Abundant ice-rafted detritus.
Age: No determination (Late Pliocene (glacial) by interpolation).

Sample 12-112A-4-5B, 147-150 cm:
PF: Sparse, consisting entirely of *Globigerina atlantica.*
BF: Sparse.
Also present: Abundant ice-rafted detritus.
Age: Late Pliocene (glacial).

Sample 12-112A-4, Core Catcher:
Only few fragments of foraminifera present among abundant ice-rafted detrital debris.

Remarks: Core 4, Hole 112A, is characterized by large quantities of ice-rafted detritus and the presence of a single form, referred to above as *Globigerina atlantica*. The absence of other diagnostic forms in this core would suggest that during the time the sediments present in this core were deposited, glacial expansion had occurred and that icebergs were abundant in the central Labrador Sea. Sections 1, 2, 3A, 4, 5A of Core 4 were not opened on board the *Challenger* due to their soft inconsistent nature.

Sample 12-112A-5, Top Core Liner:
PF: *Globigerina atlantica, Orbulina universa, Globorotalia* sp. cf. *G. hirsuta.*
BF: *Eponides tenera, Laticarinina halophora, Cassidulina subglobosa, Uvigerina hollicki, Melonis pompilioides, Sigmoilopsis schlumbergeri.*

Also present: Scattered quartz grains, mica flakes (ice-rafted?); sediment is primarily a "foraminiferal-nannofossil" ooze. Pieces of consolidated "foraminiferal" ooze contain abundant broken (?dissolved) tests.
Age: Late Pliocene.

Sample 12-112A-5-2, 17-20 cm:
PF: *Globigerina atlantica, G. bulloides, Globorotalia crassaformis, G. inflata, G. scitula, Orbulina universa.*
BF: As above, plus *Ehrenbergina trigona, Cibicidoides kullenbergi, Eponides tener, Planulina wuellerstorfi, P. bradii.*
Age: Pliocene (mid).

Sample 12-112A-5-2, 57-60 cm:
Data essentially same as preceding sample above.
Age: Pliocene (mid).

Sample 12-112A-5-2, 103-106 cm:
PF: Data essentially same as above; *Globorotalia puncticulata* present, *G. inflata* apparently absent.
BF: As above.
Age: Pliocene (mid).

Sample 12-112A-5-2, 136-139 cm:
PF: Data same as above.
BF: Data same as above.
Age: Pliocene (mid).

Sample 12-112A-5-3, 139-142 cm:
Data same as above.
Age: Pliocene (mid).

Sample 12-112A-5-4, 41-44 cm:
PF: *Globigerina atlantica, G. bulloides, Globorotalia crassaformis, G. tumida* (predominantly sinistral), *G. scitula.*
BF: As above.
Age: Pliocene (mid).

Sample 12-112A-5-4, 144-147 cm:
PF: *Globigerina atlantica, G. bulloides, Globorotalia crassaformis, G. inflata, G. puncticulata, Globigerinoides conglobata, Spheroidinella dehiscens* (with small aperture), *Orbulina universa, Globorotalia* sp. aff. *G. miocenica* (rare).
BF: As above, sparse.
Age: Pliocene (mid).

Sample 12-112A-5-5, 143-146 cm:
PF: As above, including rare *Globorotalia* sp. aff. *G. miocenica, G. conglobata, G. crassaformis* (common).
BF: As above.
Age: Pliocene (mid).

Sample 12-112A-5, Core Catcher:
PF: *Globigerina atlantica, G. bulloides, Globorotalia inflata, G. tumida* (sinistral), *G. scitula, Globigerinoides conglobata, Sphaeroidinellopsis subdehiscens.*
BF: *Melonis pompilioides, Cassidulina subglobosa, Cibicidoides pseudoungerianus, Eponides umbonatus, Uvigerina* sp., *Laticarinina halophora, Sigmoilopsis schlumbergeri, Pullenia* sp., *Planulina wuellerstorfi, P. ariminensis.*
Age: Pliocene (mid).

Remarks: Core 5, the lowest core taken in Hole 112A, contains an interesting assemblage. Several features may be noted. The dominant element throughout is the variable form distinguished here as *Globigerina atlantica.* Three distinct assemblages occur in this core and the changes between the lower two have been indicated by "level 1" and "level 2" (see Figure 7 in section on Biostratigraphy, Site 112). The lower faunal assemblage (part of Section 4 and Section 5) is characterized by the presence of keeled globorotaliids (*G. tumida, G.* aff. *miocenica*), *Globigerinoides conglobata, Sphaeroidinella dehiscens* and *Sphaeroidinellopsis subdehiscens.* The middle faunal assemblage is characterized by the persistence of *Globorotalia crassaformis, G. inflata, G. scitula* and *Globigerina bulloides* and *Orbulina universa* and the absence of the keeled globorotaliids and other forms listed above. The forms characteristic of the middle faunal assemblage range as high as the upper part of Section 2, Core 5.

The upper faunal assemblage consists solely of the form *Globigerina atlantica,* which ranges throughout the interval and into younger levels above.

It would appear that we have here a gradational sequence of local extinction of faunal elements due to lowering of temperature prior to the onset of glaciation (which is seen in Core 4 above).

APPENDIX E. COCCOLITH SPECIES AND STRATIGRAPHIC ASSIGNMENT OF SITE 112

David Bukry

Hole 112

Lower Pleistocene
(*Coccolithus doronicoides* Zone)

12-112-1-1, 147-148 cm; depth 28 m:
Coccolithus pelagicus, Cyclococcolithina leptopora, C. macintyrei, Gephyrocapsa caribbeanica Boudreaux and Hay, *Helicopontosphaera kamptneri, H. sellii, Rhabdosphaera clavigera, Scapholithus* sp.

Upper Pliocene
(*Discoaster brouweri* Zone)

12-112-2-2, 142-143 cm; depth 103 m:
Coccolithus pelagicus, Cyclococcolithina leptopora, C. macintyrei, Discoaster brouweri, Discolithina japonica, Emiliania annula, Helicopontosphaera kamptneri, H. sellii, Rhabdosphaera clavigera, Syracosphaera sp.

Upper Miocene
(*Discoaster neohamatus* Zone)

12-112-3-3, 142-143 cm; depth 153 m:
Cyclococcolithina leptopora, C. macintyrei, Discoaster bellus Bukry and Percival, *D. bollii* Martini and Bramlette, *D. braaruddii, D. brouweri s.l., D. calcaris* Gartner, *D. neohamatus* Bukry and Bramlette, *D. obtusus* Gartner, *D. prepentaradiatus* Bukry and Percival, *D. variabilis variabilis, Reticulofenestra pseudoumbilica, Sphenolithus neoabies, Triquetrorhabdulus rugosus* Bramlette and Wilcoxon.

Upper Miocene
(*Discoaster hamatus* Zone)

12-112-3-6, 129-131 cm; depth 158 m:
Cyclococcolithina leptopora, Discoaster bellus, D. braarudii, D. hamatus Martini and Bramlette, *D. variabilis variabilis, R. pseudoumbilica, Triquetrorhabdulus rugosus.*

Middle Miocene
(*Discoaster exilis* Zone)

12-112-4-2, 138-139 cm; depth 203 m:
Braarudosphaera bigelowi [rare, transported?], *Coccolithus eopelagicus* (Bramlette and Riedel), *Cyclococcolithina leptopora, Discoaster deflandrei* Bramlette and Riedel, *D. exilis, D. variabilis variabilis, Reticulofenestra pseudoumbilica, Triquetrorhabdulus rugosus.*

Middle Oligocene
(*Sphenolithus distentus* Zone)

12-112-5-1, 136-137 cm; depth 271 m:
Chiasmolithus altus Bukry and Percival, *Coccolithus eopelagicus, Cyclococcolithina neogammation* (Bramlette and Wilcoxon), *Dictyococcites abisectus* (Müller), *D. bisectus* (Hay, Mohler and Wade), *D. scrippsae* Bukry and Percival, *Discoaster deflandrei* [5-and 6-rayed], *Reticulofenestra gartneri* Roth and Hay, *Sphenolithus moriformis* (Brönnimann and Stradner).

12-112-11-4, 144-145 cm; depth 329 m:
Cyclococcolithina neogammation, Dictyococcites bisectus, Reticulofenestra gartneri.

Lower Oligocene
(lower *Helicopontosphaera reticulata* Zone)

12-112-12-1, 141-142 cm; depth 385 m:
Chiasmolithus altus, C. oamaruensis (Deflandre), *Coccolithus eopelagicus, Dictyococcites bisectus, D. scrippsae, Discoaster tani nodifer* Bramlette and Riedel, *Helicopontosphaera* sp. cf. *H. intermedia* Martini, *H. reticulata* Bramlette and Wilcoxon, *Isthmolithus recurvus* Deflandre, *Polycladolithus* sp., *Reticulofenestra hillae* Bukry and Percival, *R. insignita* Roth and Hay, *R. umbilica* (Levin), *?Rhabdosphaera tenuis* Bramlette and Sullivan [stems], *R. spinula* Levin and Joerger, *Sphenolithus moriformis* [small], *Transversopontis ponticulus* (Deflandre).

Upper Eocene
(*Discoaster barbadiensis* Zone)

12-112-13-2, 138-140 cm; depth 443 m:
Chiasmolithus oamaruensis, Coccolithus eopelagicus, Cyclococcolithina neogammation, Cyclococcolithina sp. cf. *C. reticulata* (Gartner and Smith), *Dictyococcites bisectus, D. scrippsae, Discoaster barbadiensis, D. saipanensis* Bramlette and Riedel, *Isthmolithus recurvus, Pontosphaera vadosa* Hay, Mohler and Wade, *Reticulofenestra hillae, R. umbilica, Transversopontis pulcheroides.*

12-112-14-2, 142-144 cm; depth 499 m:
Campylosphaera dela [rare], *Chiasmolithus* sp. cf. *C. expansus, Coccolithus eopelagicus, C. fenestratus* (Deflandre), *Cyclococcolithina formosa* (Kamptner), *C. neogammation, C.* sp. cf. *C. reticulata, Dictyococcites bisectus, D. scrippsae, Discoaster barbadiensis, D. distinctus, D. saipanensis, Goniolithus fluckigeri* Deflandre, *Helicopontosphaera compacta* (Bramlette and Wilcoxon), *H.* sp. cf. *H. intermedia, ?Isthmolithus recurvus, Markalius inversus* (Deflandre), *Micrantholithus stradneri* Chang, *Reticulofenestra samodurovi, R. umbilica, Rhabdosphaera spinula, ?R. tenuis* [stems], *Sphenolithus predistentus* Bramlette and Wilcoxon, *Transversopontis pulcher, T. pulcheroides, Zygolithus dubius.*

Middle Eocene
(*Discoaster sublodoensis* Zone)

12-112-15-1, 47-48 cm; depth 578 m:
Chiasmolithus expansus, C. solitus, Coccolithus pseudogammation Bouché, *C. staurion* Bramlette and Sullivan, *Cyclococcolithina formosa, C. luminis* (Sullivan), *Discoaster barbadiensis, D. nonaradiatus* Klumpp, *D. saipanensis, D. sublodoensis* Bramlette and Sullivan, *Rhabdosphaera inflata* Bramlette and Sullivan, *Transversopontis pulcher, Zygolithus dubius, Zygrhablithus bijugatus* Deflandre.

Hole 112A

Lower Pleistocene
(*Coccolithus doronicoides* Zone)

12-112A-1A-1, 144-145 cm; depth 79 m:
Coccolithus doronicoides, C. pelagicus, Cyclococcolithina leptopora, C. macintyrei, Discolithina japonica, Emiliania annula, Helicopontosphaera kamptneri, H. sellii.

Upper Pliocene
(*Discoaster brouweri* Zone)

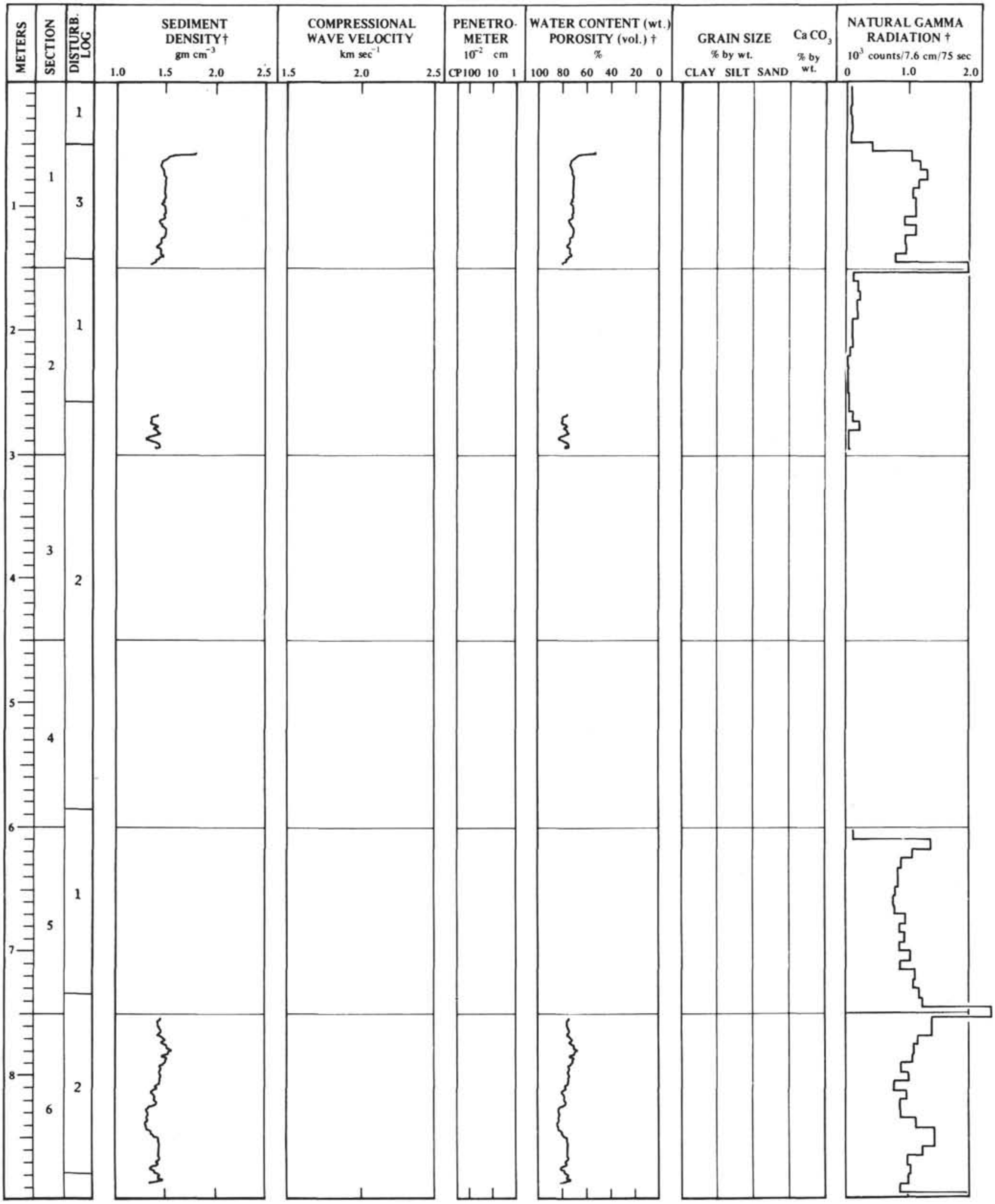
12-112A-3A-1, 140-141 cm; depth 98 m:
Coccolithus doronicoides, C. pelagicus, Cyclococcolithina leptopora, C. macintyrei, Discoaster brouweri [rare], *Discolithina japonica, Emiliania annula, Helicopontosphaera sellii.*

Lower Pliocene
(*Reticulofenestra pseudoumbilica* Zone)

12-112A-5A-5, 139-140 cm; depth 122 m:
Ceratolithus rugosus, Coccolithus pelagicus, Coccolithus sp. [tiny], *Cyclococcolithina leptopora, C. macintyrei, Discoaster brouweri, D. challengeri* Bramlette and Riedel, *D. pentaradiatus, D. surculus, D. variabilis pansus* Bukry and Percival, *Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica, Rhabdosphaera procera* Martini, *Sphenolithus abies.*

HOLE 112

CORE 1



†Adjusted data, see Chapter 2

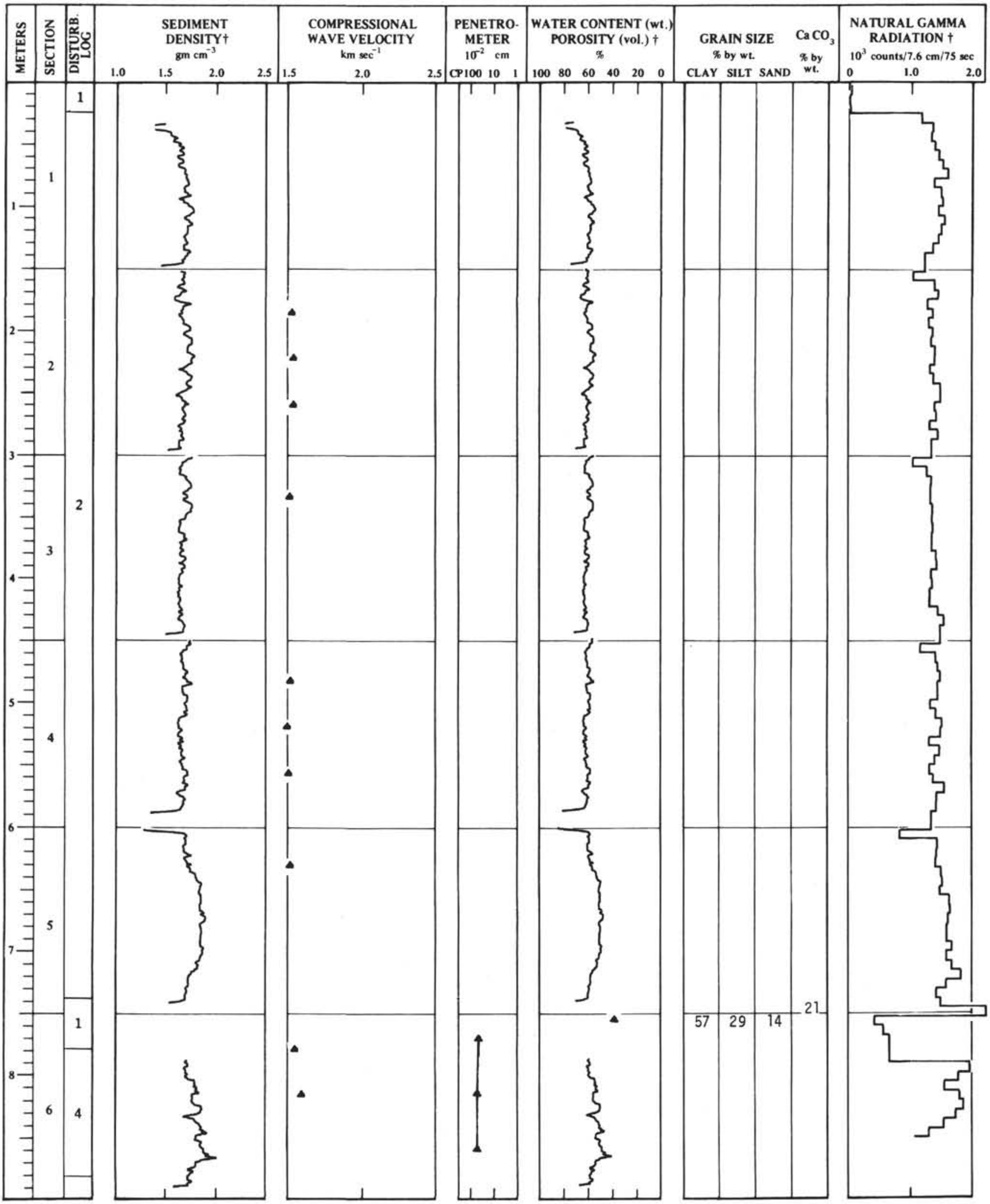
HOLE 112 28 TO 37 m

CORE 1

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N	Medium olive gray silty clay with ice rafted pebbles, abundant detrital quartz, some heavy minerals, pyrite, and authigenic carbonate. Nannofossils dominant, with some foraminifera, diatoms, and radiolaria. Sections are soupy & disturbed.	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Gephyrocapsa oceanica, G. aperta, Rhabdosphaera clavigera, Syracosphaera* sp., *Helicopontosphaera kamptneri, Pontosphaera scutellum*	*Gephyrocapsa oceanica*	PLEISTOCENE
			F	5Y5/1	*Globigerina bulloides, G. pachyderma, Globorotalia inflata, G. crassaformis*		
1.5–3	2						
3–4.5	3	NO CORE					
4.5–6	4	NO CORE					
6–7.5	5			5Y5/1 Light gray clayey nannofossil silt with corroded fragments of foraminifera and some diatoms.			
			N,XM	X-ray Mineralogy (Bulk): Calc. 31.5; Dolo. 6.5; Qtz. 17.4; Plag. 17.1; Kaol. 2.1; Mica 19.4; Chl: 1.4; Amph. 4.6; Amorph. 62.6	Flora similar to above		
7.5–9	6		N	10YR6/1	Flora similar to above		
					Fauna similar to above		
			F		Radiolarians rare. *Spongopyle osculosa, Phorticium pylonium, Lithelius minor, Theocalyptra davisiana, Stylodictya validispina, Druppatractus* sp. cf., *D. pyriformis*		
	CC		R				
			N		Flora similar to above		
			F		*G. bulloides, G. pachyderma, G. inflata*		

HOLE 112

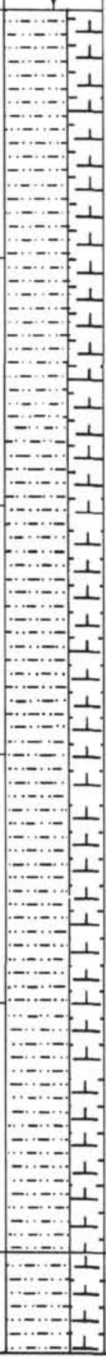
CORE 2



†Adjusted data, see Chapter 2

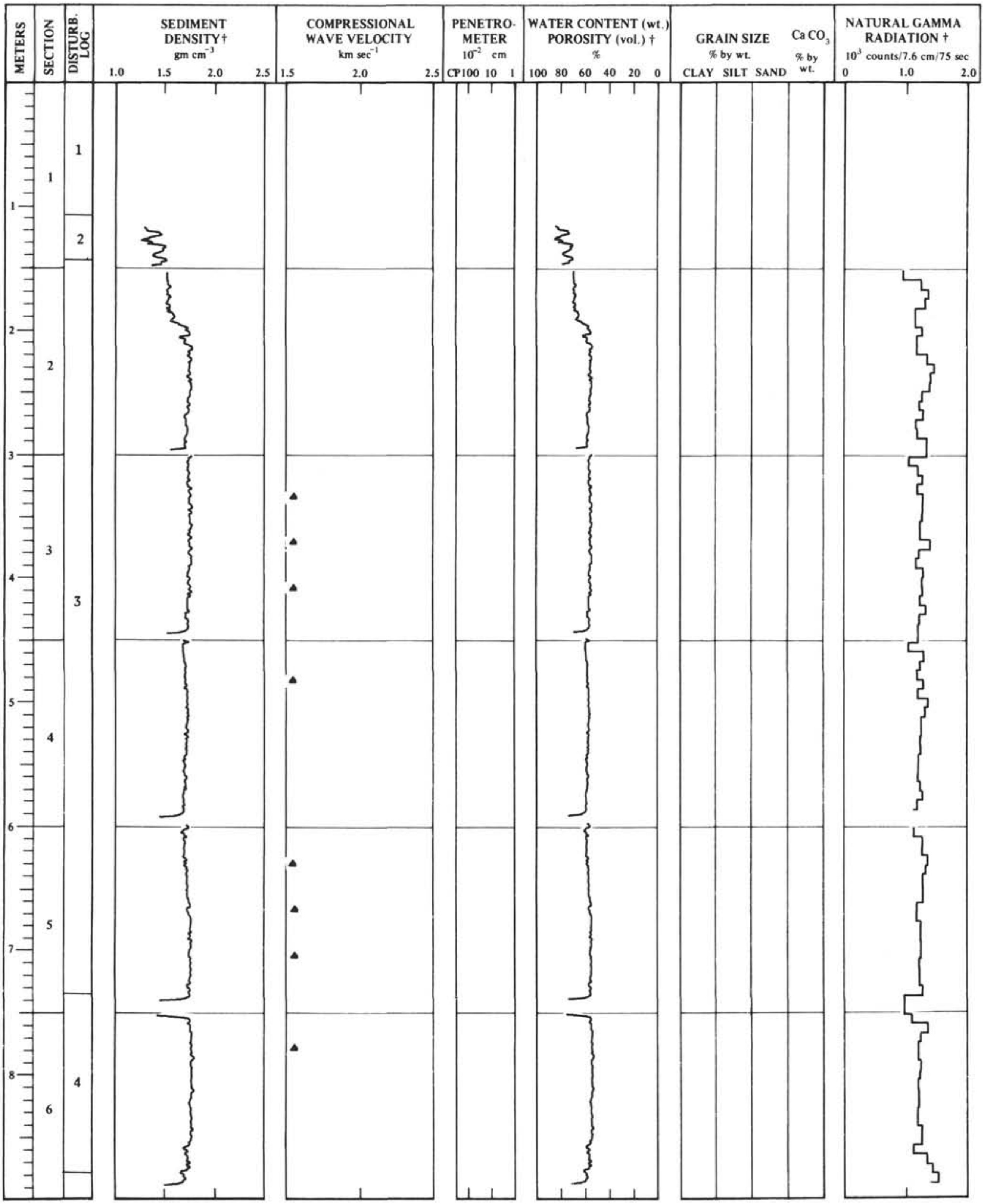
HOLE 112 100 **TO** 109 **m**

CORE 2

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NOT SPLIT	N	Gray, very soft, disturbed clay	*Discoaster brouweri, Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Rhabdosphaera clavigera, Aspidorhabdus stylifer, Syracosphaera* sp. *Helicopontosphaera kamptneri, H. sellii, Pontosphaera discopora, P. scutellum, Pseudoemiliania lacunosa, Thoracosphaera* sp.	*Discoaster brouweri*	PLIOCENE
1.5–3	2		N	Medium light gray silty nannofossil clay, containing much quartz, pyroxene, glass, some heavy minerals, zeolite & chlorite, with pellets of light gray nannofossil marl (40% carbonate) & dark gray clay. Section 2 contains glacial pebbles & a few foraminifera & sponge spicules.	Flora similar to above		
			F		*Globorotalia inflata, G. hirsuta, Globigerina pachyderma, G. bulloides*		
3–4.5	3		N	2.5YR5	Flora similar to above		
			F		Fauna similar to above; *G. inflata* common		
4.5–6	4		N		Flora similar to above		
6–7.5	5		N	Gray, slightly disturbed silty foram-nannofossil clay with small pellets (up to 10 mm ϕ) of gray silt and white nannofossil ooze.	Flora similar to above		
			N		No coccoliths		
			N,F		Flora similar to above *G. pachyderma, G. bulloides, G. hirsuta*		
7.5–9	6		N	X-ray Mineralogy (bulk): Calc. 27.8; Dolo. 1.6; Qtz. 26.4; Plag. 12.4; Kad. 3.0; Mica 18.5; Chl. 1.3; Mont. 7.3; Amph. 1.7; Amorph. 66.8	Flora similar to above + *Ceratolithus cristatus*		
			N XM	5Y3.5-5/1	Flora similar to above		
			F		Fauna similar to above		
	CC		R		No radiolarians		
			N		Flora similar to above		
			F		*Globigerina atlantica*		

HOLE 112

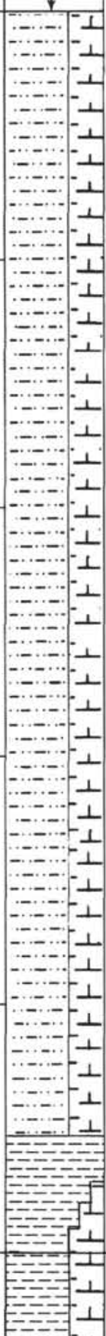
CORE 3



†Adjusted data, see Chapter 2

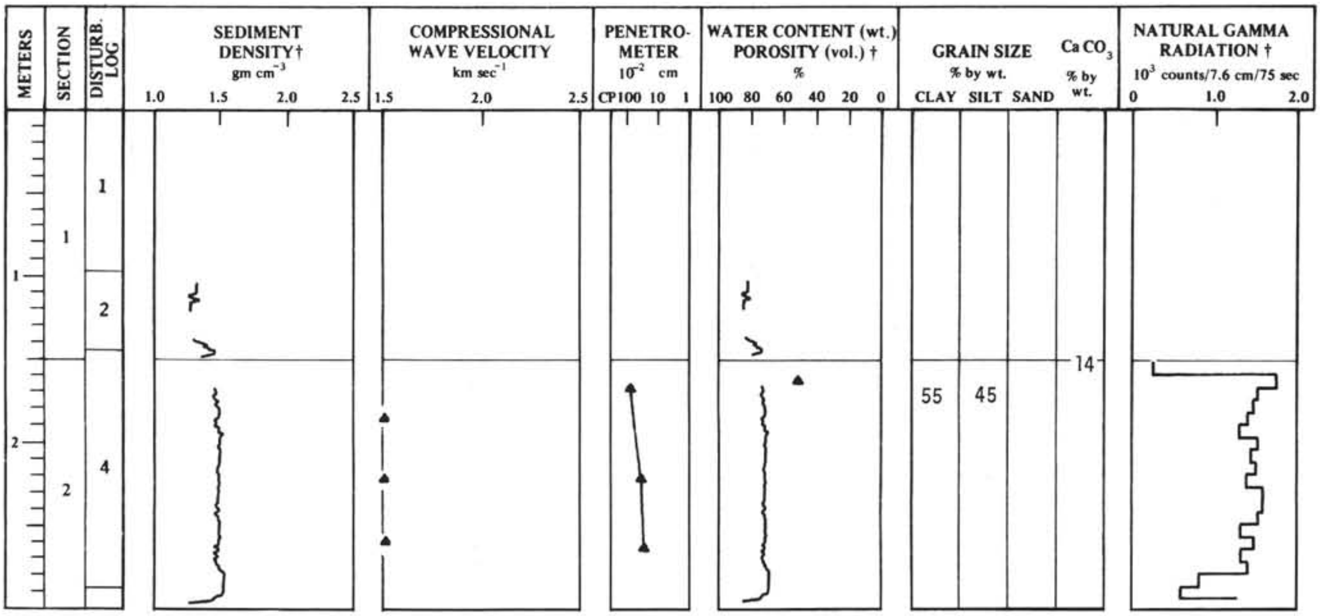
HOLE 112 150 **TO** 159 **m**

CORE 3

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NOT SPLIT			*Discoaster brouweri, D. quinqueramus, D. pentaradiatus, D. variabilis, D. hamatus, D.* cf. *bollii, Sphenolithus abies, Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Pontosphaera discopora, Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica, Triquetrorhabdulus rugosus*	*Discoaster hamatus*	MIOCENE
1.5–3	2		N N R XM F	5GY6/1 Greenish gray, silty nannofossil clay with a considerable amount of volcanic glass, zeolites, and some corroded foraminifera, diatoms, radiolaria & sponge spicules, in sec. 5. X-ray Mineralogy (bulk) Calc. 40.2 Qtz 21.1 Plag. 7.5 Kaol. 5.4 Mica 16.5 Mont. 9.3 Amorph. 64.3	Flora similar to above No radiolarians *Globigerina praebulloides, G. bulloides, G. nepenthes, Globorotalia miozea*		
3–4.5	3		NR XM F		Flora similar to above No radiolarians Fauna similar to above plus *Globoquadrina dehiscens*		
4.5–6	4		NR XM F		Flora similar to above No radiolarians Fauna similar to above plus *Sph. seminula*		
6–7.5	5		NR XM F		Flora similar to above No radiolarians *G. nepenthes, G. druryi, G. praebulloides, G. woodi, G. continuosa, O. universa.*		
7.5–9	6		N R XM N F XMF	10GY5/2 5GY6/1 5Y5.1/1 Greenish gray clay becoming darker, mottled & more marly toward bottom of core.	Flora similar to above No radiolarians Flora similar to above Foram fragments only		
	CC		R N F		No radiolarians Flora similar to above No planktonic foraminifera		

HOLE 112

CORE 4



†Adjusted data, see Chapter 2

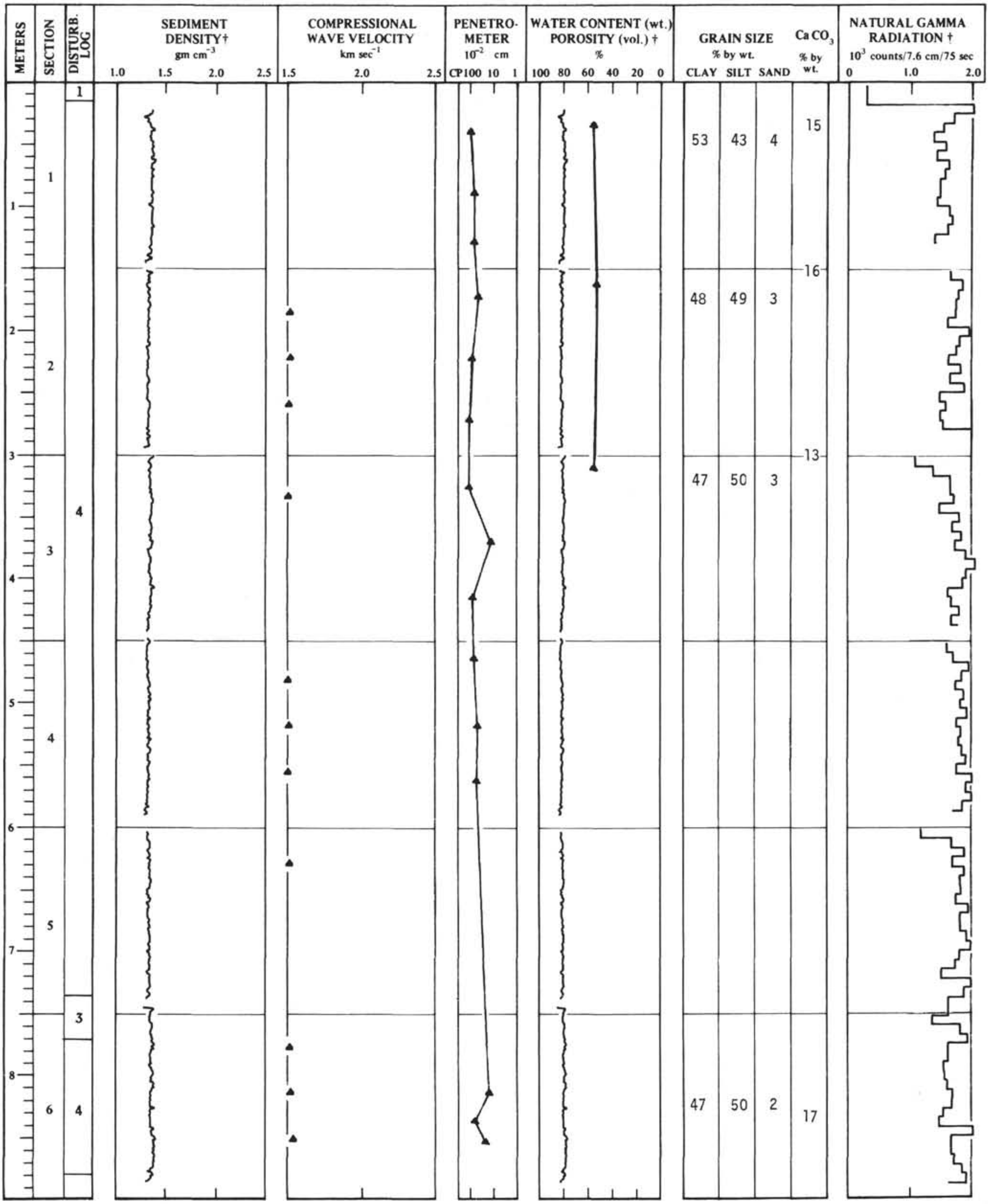
HOLE 112 200 **TO** 209 **m**

CORE 4

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	NOT SPLIT		5GY4/1	Dark, greenish gray, soupy, disturbed clay.	*Discoaster brouweri, D. exilis, Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Pontosphaera discorpora, Sphenolithus abies, Helicopontoshpaera kamptneri, Reticulofenestra pseudoumbilica*	*Discoaster exilis* ?	MIOCENE
2	2		N N R XM F	5G6/1 5G4/1 5R3/4	Greenish gray silty siliceous nannofossil clay with mottles & laminations of dark greenish gray and dusky red clay in the upper half of the section. The clay is friable with denser, more cohesive layers at 48-50 cm, 68-69 cm, & 107-110 cm. Pyroxene, glass, zeolites & pyrite are common in smear slides. Nannofossils & diatoms are abundant	Flora similar to above Radiolarians rare. *Cyrtocapsella tertapera, digitately branched Oroscena spines.* *Globigerina praebulloides*		
	CC		R N F		X-ray mineralogy (bulk) Calc. 31.8 Qtz. 20.6 Plag. 7.2 Kaol. 8.8 Mica 19.1 Mont. 12.6 Amorph. 72.1	**Core Catcher:** Radiolarians rare. *Cyrtocapsella tetrapera, C. cornuta, C. japonica, digitately branched Oroscena* spines, *Stichocorys delmontensis*, (?) *Cannartus laticonus, Calcyclas margatensis* Flora similar to above *Globigerina praebulloides, Globorotalia mayeri, G.* cf. *acrostoma*		

HOLE 112

CORE 5



† Adjusted data, see Chapter 2

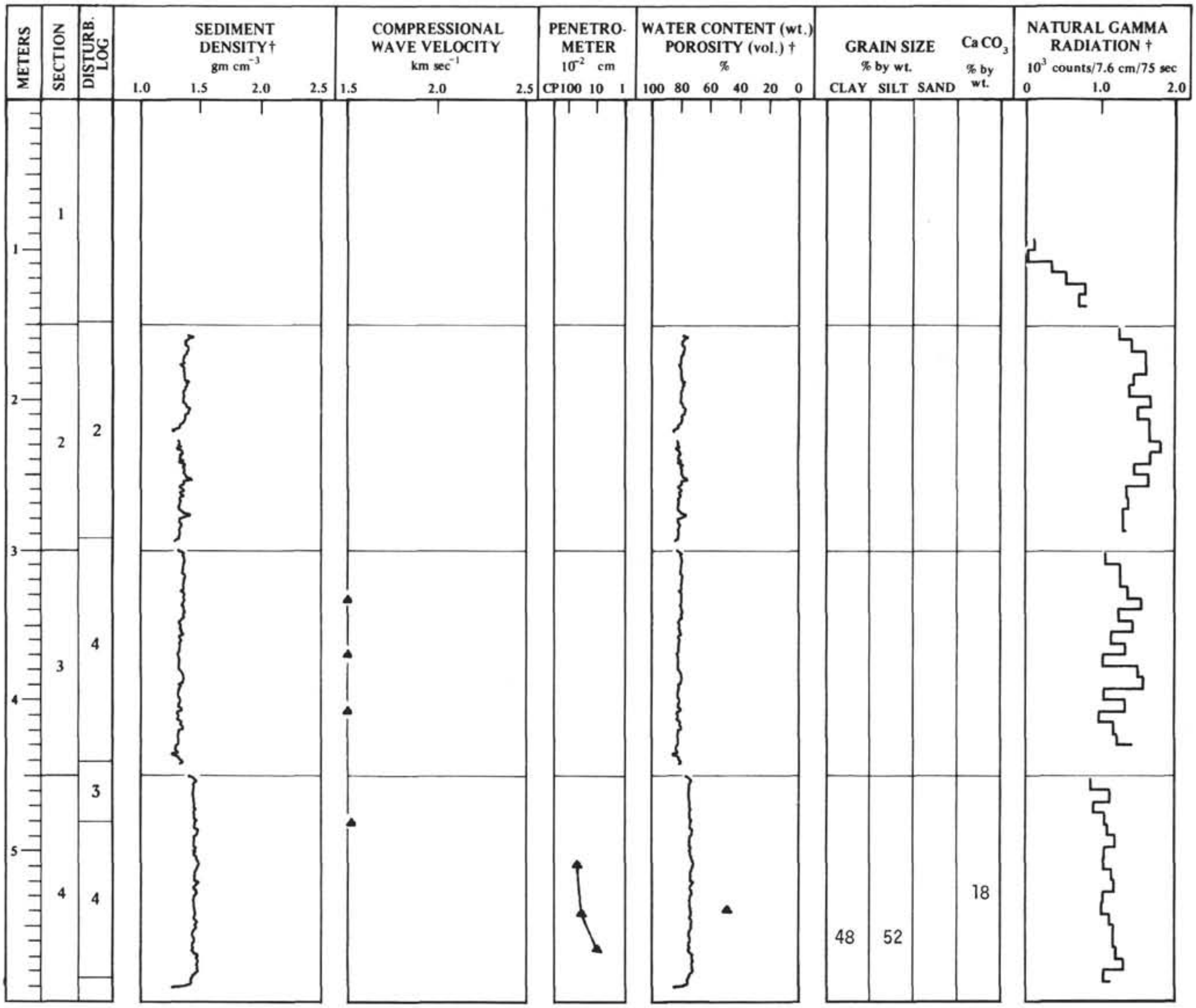
HOLE 112 270 **TO** 279 **m**

CORE 5

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N XM	Greenish gray, burrowed silty siliceous nannofossil clay mottled dark greenish gray and dusky red. Nannofossils, diatoms, radiolaria & sponges spicules are present X-ray Mineralogy (bulk) Calc. 25.8 Qtz. 21.6 Plag. 9.4 Kaol. 2.3 Mica 19.0 Chl. 1.9 Mont. 20.0 Amorph. 73.6 5GY6/1 5GY4/1	*Coccolithus* aff. *C. bisectus*, *C. bisectus*, *C. pelagicus*, *Reticulofenestra* sp. *Chiasmolithus* sp. *Discoaster deflandrei*, *Sphenolithus moriformis*, *S. distentus*, *Discolithina multipora*	*Sphenolithus distentus*	OLIGOCENE
1.5–3	2		N XM		Flora similar to above		
3–4.5	3		N XM		Flora similar to above		
4.5–6	4		N XM	5GY4/1	Flora similar to above		
6–7.5	5		N		Flora similar to above		
7.5–9	6		N XM	5GY4/1 5GY6/1	Flora similar to above		
	CC		N R		Flora similar to above. Radiolarians abundant. Predominantly spheroidal and discoidal spumellarians. *Artophormis gracilis*, (?) *Dorcadospyris ateuchus*		

HOLE 112

CORE 6



†Adjusted data, see Chapter 2

HOLE 112 279 **TO** 288 **m**

CORE 6

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	NO CORE			*Coccolithus bisectus, C.* aff. *bisectus, Sphenolithus moriformis Chiasmolithus* sp. *Reticulofenestra insignita, laevis*?	*Sphenolithus distentus*	OLIGOCENE
1–1.5	1	NOT SPLIT					
1.5–3	2		N N	5G5/1 Medium greenish gray siliceous clay, consisting of hard lumps of clay in a soupy matrix.	Flora similar to above.		
3–4.5	3	NOT SPLIT					
4.5–6	4		N N N	5G4/1 Slightly disturbed dark, stiff, greenish gray clayey siliceous nannofossil silt. The silt is laminated and moderately mottled. Nannofossils, diatoms, radiolaria, and siliceous sponge spicules are common to abundant.	Flora similar to above Flora similar to above Flora similar to above		
	CC		R N	5G4/1			

X-ray Mineralogy (bulk)

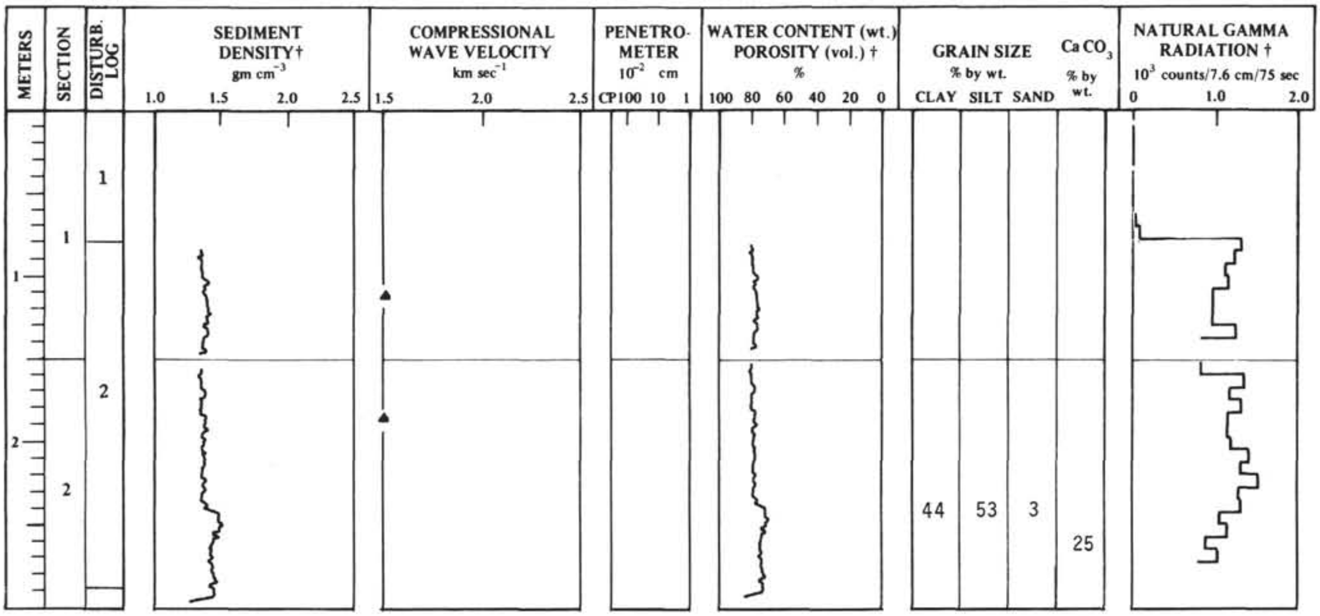
Calc.	36.1
Qtz.	15.2
Plag.	4.8
Kaol.	5.0
Mica	16.1
Mont.	22.8
Amorph.	69.5

Core Catcher:
Dark greenish gray, stiff, siliceous nannofossil clay with many diatoms & some fish debris.

Core Catcher:
Radiolarians abundant. Same assemblage as 5-cc. *A. gracilis, D. ateuchus*
Flora similar to above

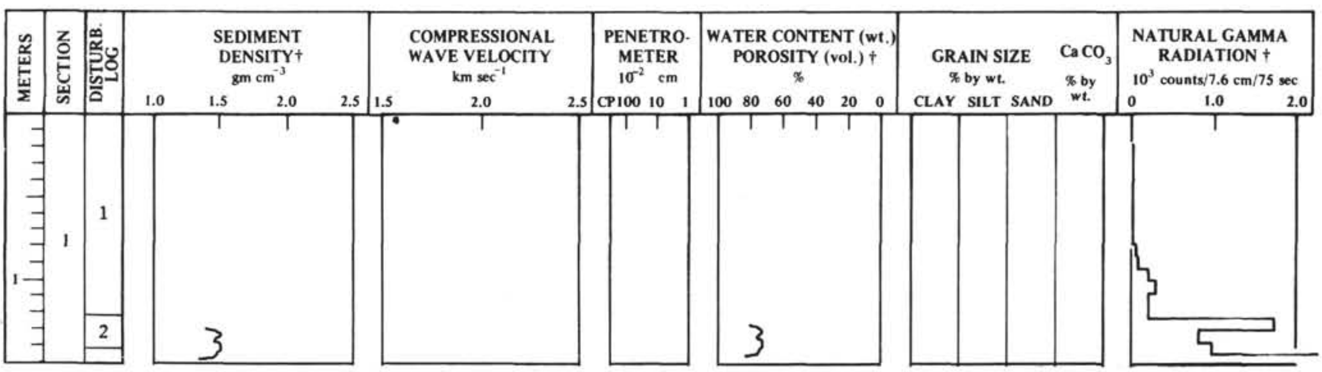
HOLE 112

CORE 7



HOLE 112

CORE 8



†Adjusted data, see Chapter 2

HOLE 112 288 **TO** 297 **m**

CORE 7

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1		N	N5 5GY4/1 Medium gray to dark greenish gray, disturbed silty siliceous clay lumps in a watery matrix.	*Coccolithus bisectus, C.* aff. *bisectus, Sphenolithus moriformis, Chiasmolithus* sp. *Reticulofenestra insignita, R. laevis?, Discoaster deflandrei*	*Sphenolithus distentus*	OLIGOCENE
2	2		N XM	5GY6/1 Greenish gray, hard, slightly laminated and moderately mottled siliceous clayey nannofossil silt. Nannofossils, diatoms, radiolarians & siliceous sponge spicules are common.	Flora similar to above		
	CC		R N F	5GY6/1 X-ray Mineralogy (bulk) Calc. 36.3 Qtz. 16.8 Plag. 8.8 Kaol. 4.8 Mica 16.8 Mont. 16.6 Amorph. 67.2			
				Core Catcher: Greenish gray siliceous silty clay.	**Core Catcher:** Radiolarians abundant. Assemblage similar to 5 cc. *A. gracilis* Flora similar to above. *Globigerinita dissimilis, Globorotalia postcretacea, G. munda, Globigerina officinalis, G. ciperoensis*		

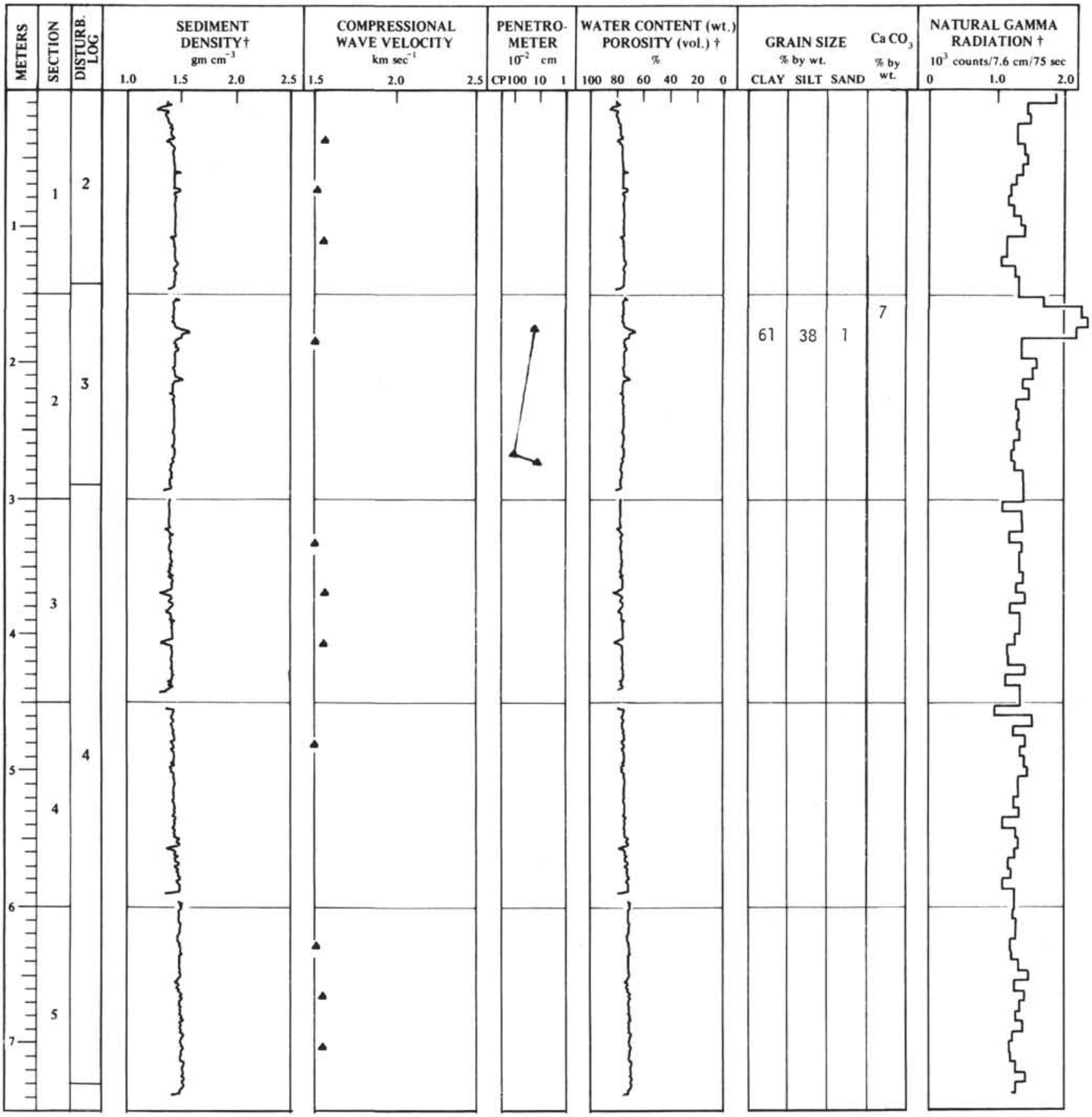
HOLE 112 297 **TO** 306 **m**

CORE 8

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	NOT SPLIT	N	30 cm of dark greenish gray siliceous silty clay. Core consists of lumps of stiff clay in a watery matrix with nannofossils, diatoms & radiolaria occurring commonly & some corroded fragments of foraminifera	*Coccolithus bisectus, C.* aff. *bisectus, C. pelagicus, Chiasmolithus* sp. *Sphenolithus moriformis, Discoaster deflandrei, Reticulofenestra insignita, R. laevis?, Discolithina multipora*	*henolithus predistentus*	OLIGOCENE
	CC		R N	5GY4/1			
				Core Catcher: Dark greenish gray siliceous silty clay.	**Core Catcher:** Radiolarians abundant. Assemblage similar to 5-cc. *A. gracilis, A.* sp. cf. *A. barbadensis, D. ateuchus, Cyclampterium* (?) sp. cf. *C.* (?) *milowi*. Flora similar to above.		

HOLE 112

CORE 9



† Adjusted data, see Chapter 2

HOLE 112 306 **TO** 315 **m**

CORE 9

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NOT SPLIT			*Coccolithus bisectus, C.* aff. *bisectus, C. pelagicus, Chiasmolithus* sp., *Sphenolithus moriformis, Discoaster deflandrei, Reticulofenestra insignita, R. laevis*?, *Discolithina multipora*	*Sphenolithus predistentus* ?	OLIGOCENE
1.5–3	2		N	5Y6/2 5Y5/1 Stiff, slightly disturbed, moderately mottled, gray silty siliceous clay & diatom ooze. Nannoplankton, radiolarian, & sponge spicules occur commonly. X-ray Mineralogy (bulk) Calc. 10.3 Qtz. 20.7 Plag. 10.3 Mica 22.7 Chl. 2.7 Mont. 33.2 Amorph. 75.0			
3–4.5	3						
4.5–6	4	NOT SPLIT	N		Flora similar to above		
6–7.5	5		N		Flora similar to above		
			N		Flora similar to above		
	CC		R N	**Core Catcher:** 5GY6/1 Silty, siliceous, stiff, nannofossil clay.	**Core Catcher:** Radiolarians abundant. Assemblage similar to 5-cc. *A. gracilis, Cyclampterium* (?) sp. cf. , C. (?) milowi Flora similar to above		

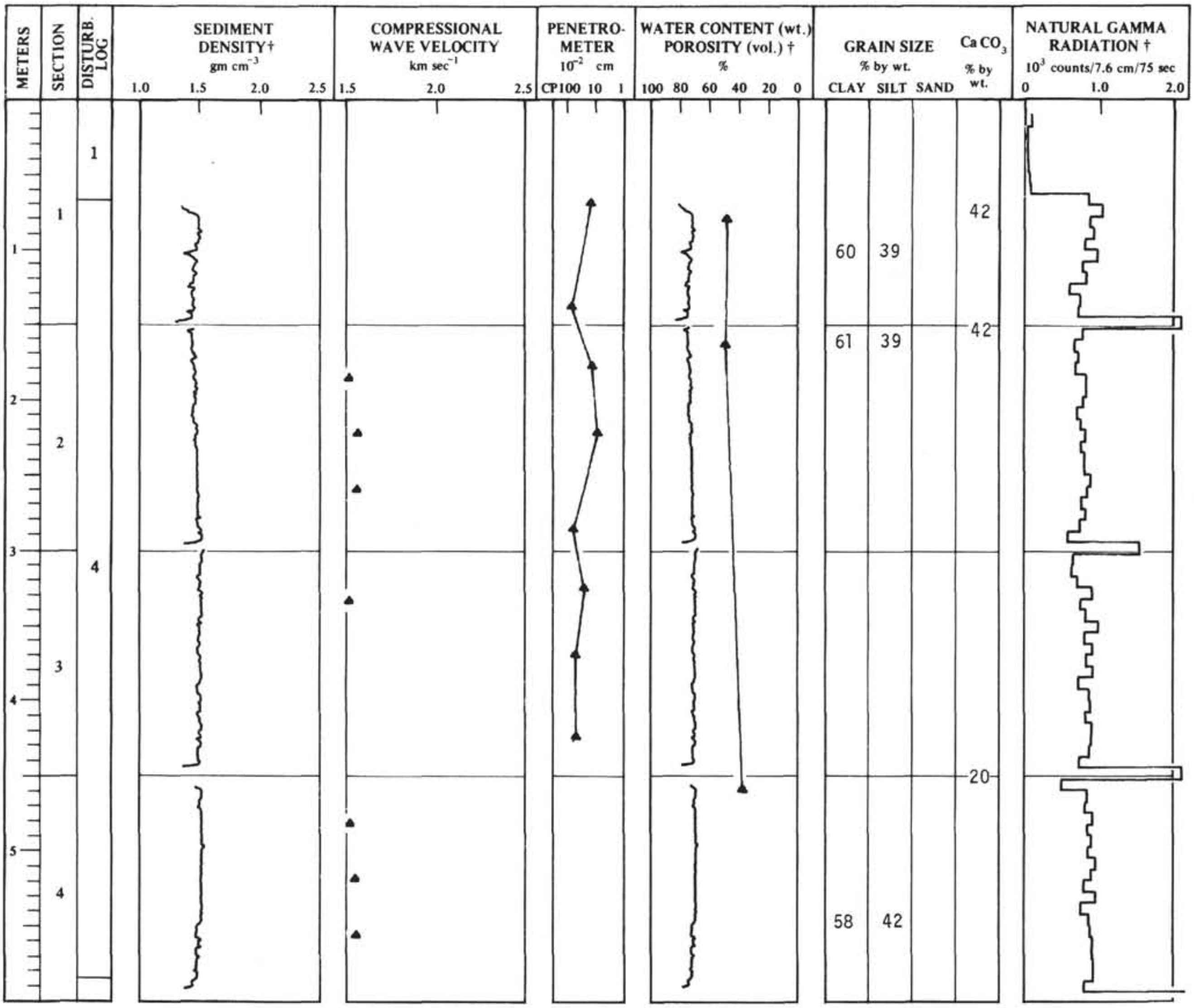
HOLE 112 315 TO 324 m

CORE 10

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	NOT SPLIT		Zero section of this core was split and consists of 18 cm of hard clay fragments in a watery silty clay matrix. Watery matrix is assumed to be the result of disturbance.			
2	2			The six unsplit sections consist of muddy water			
3	3						
4–5	4						
6–7	5						
8	6						
	CC		F N R	Grey, siliceous nannofossil clay with abundant diatoms, radiolaria, & some sponge spicules	*Coccolithus bisectus, C.* aff. *bisectus, C. pelagicus, Chiasmolithus* sp. *Sphenolithus moriformis, S. pre - distentus, Reticulofenestra insignita, R. laevis*?, *Discolithina multipora, Discoaster* sp. Radiolarians abundant. *A. gracilis, A.* sp. cf. *A. barbadiensis, Cyclampterium* (?) sp. cf. *C.* (?) *milowi Globigerinita dissimilis, Globorotalis postcretacea, G. munda, Globorotaloides suteri*	*S. pre disten-tus*	OLIGO-CENE

HOLE 112

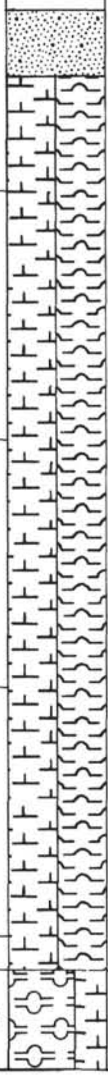
CORE 11



†Adjusted data, see Chapter 2

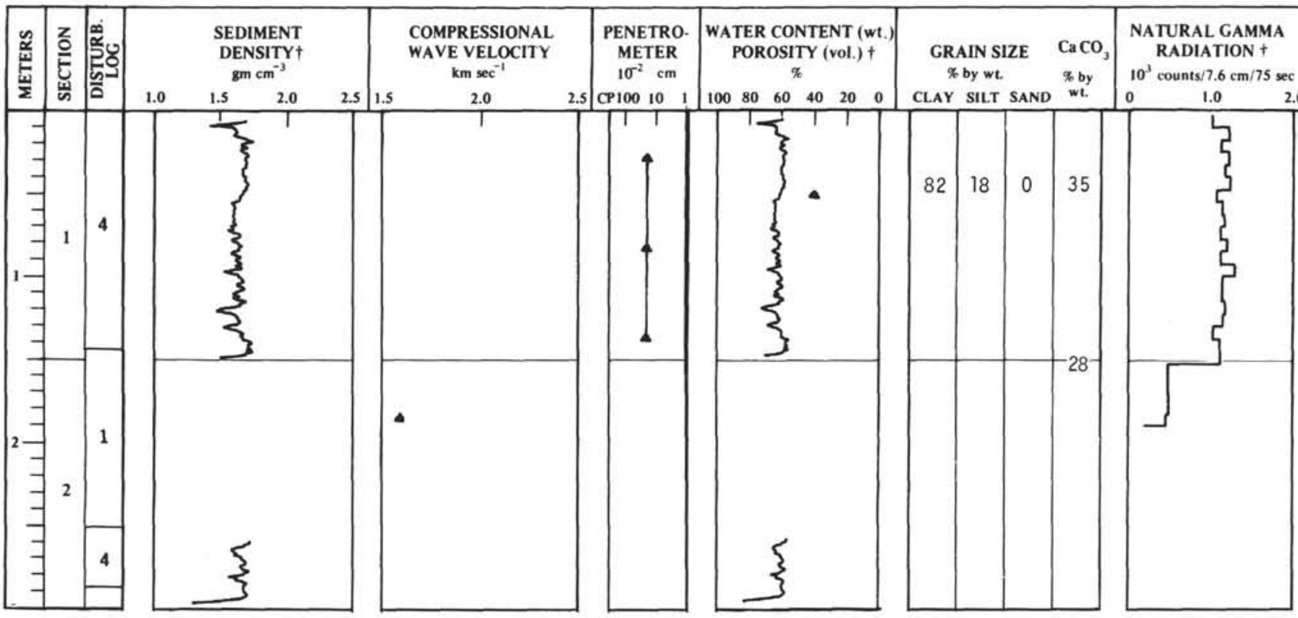
HOLE 112 324 **TO** 333 **m**

CORE 11

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0		NO CORE					
	1			5GY4/1 Partially indurated, greenish gray sandy silt fragments.			
1			N,XM	Greenish gray, fairly hard, burrowed, siliceous silty nannofossil clay & siliceous ooze.	*Coccolithus bisectus*, *C.* aff. *bisectus*, *C. pelagicus*, *Chiasmolithus* sp. *Sphenolithus moriformis*, *Reticulofenestra insignita*, *R. laevis*?, *Discoaster* sp.	*Sphenolithus predistentus* ?	
			F	Sediment is mottled light greenish gray & dark gray. The ooze consists almost entirely of nannofossils, diatoms, radiolaria, & sponge spicules, mixed with some foraminifera in section 1. Carbonate content decreases toward bottom of core.	Fauna sparce: *G. dissimilis*		
2	2		N		Flora similar to above		
			XM				
			F	X-ray Mineralogy (bulk) 5G6/1 Calc. 55.1 5G8/1 Qtz. 8.2 N3 Plag. 1.8 Mica 11.1 Mont. 23.8 Amorph. 59.3	Fauna sparse: *G. dissimilis*		
3	3						
4			XM				
5	4		N		Flora similar to above		
6			F		Fauna sparse: *G. dissimilis*		
	CC		R N F	**Core Catcher:** Gray, stiff, siliceous silty nannofossil clay with abundant radiolaria	**Core Catcher:** Radiolarians abundant, undiagnostic. Increase in nassellarian species. Decrease in spheroidal spumellarians. Flora similar to above Fauna sparse: *G. dissimilis*		

HOLE 112

CORE 12



†Adjusted data, see Chapter 2

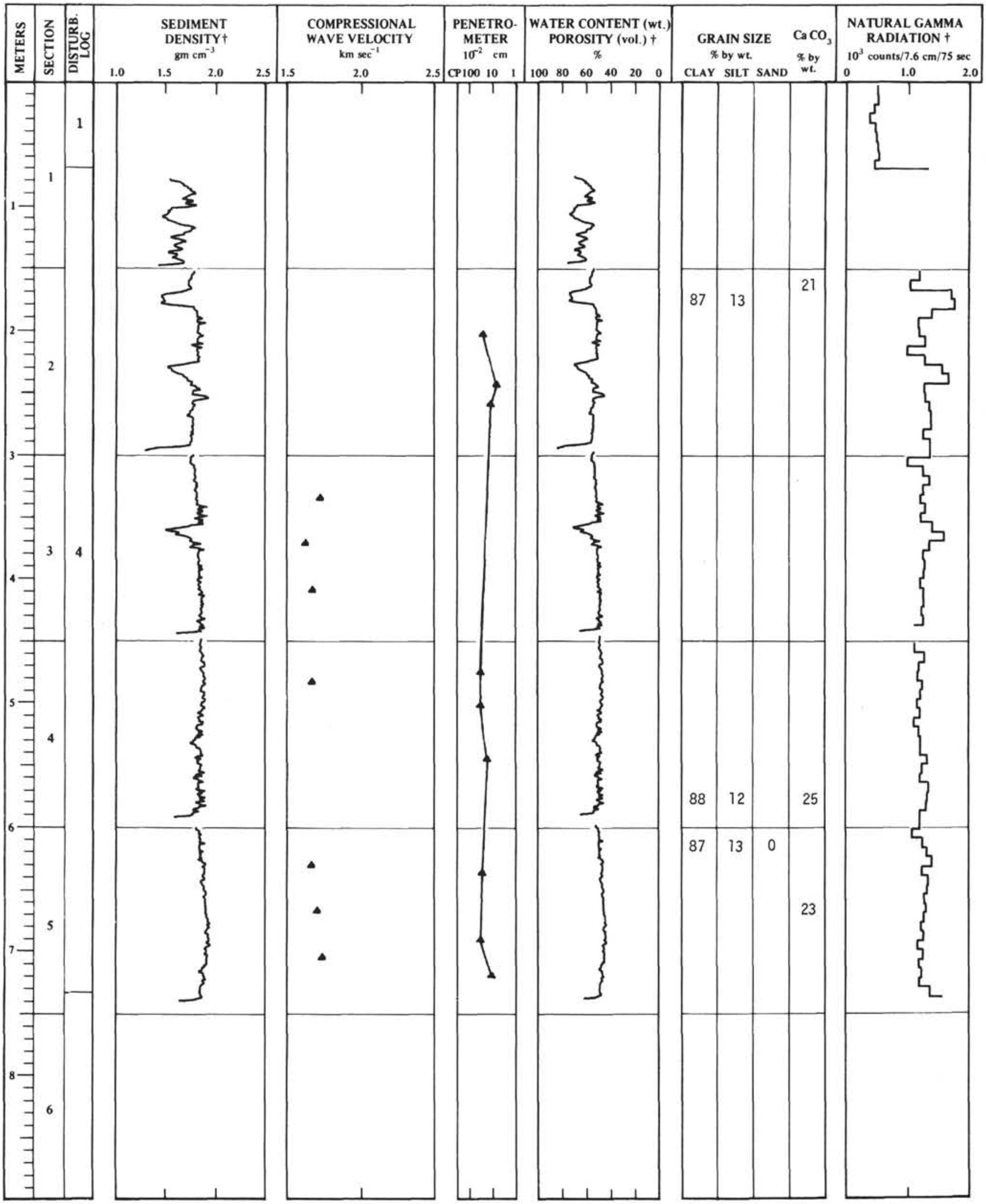
HOLE 112 384 **TO** 393 **m**

CORE 12

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1		N XM F R N XM	5GY6/ 5GY4/1 N3 Greenish gray & gray mottled, intensely burrowed, silty nannofossil clay. Coarse fraction consists of very abundant foraminifera with small quantities of sponge spicules, fish debris, & radiolaria. X-ray Mineralogy (bulk) Calc. 45.4 Qtz. 13.3 Mica 17.6 Mont. 23.7 Amorph. 57.6	*Isthmolithus recurvus, Reticulofenestra umbilica, Coccolithus bisectus, C.* aff. *bisectus, Ericsonia ovalis, E. subdisticha, E. fenestrata Zygrhablithus bijugatus, Rhabdolithus* sp. Fauna sparse; *G. dissimilis, G. unicava, G. suteri, Pseudoh. micra* No radiolarians. Flora similar to above Fauna sparse: Siphonodororiids	*Ericsonia subdisticha*	OLIGOCENE
	CC		F R N F	**Core Catcher:** Gray, stiff, nannofossil clay	**Core Catcher:** No radiolarians. Flora similar to above Sparse, *Globigerinita* spp., *Globigerina officinalis*		

HOLE 112

CORE 13



†Adjusted data, see Chapter 2

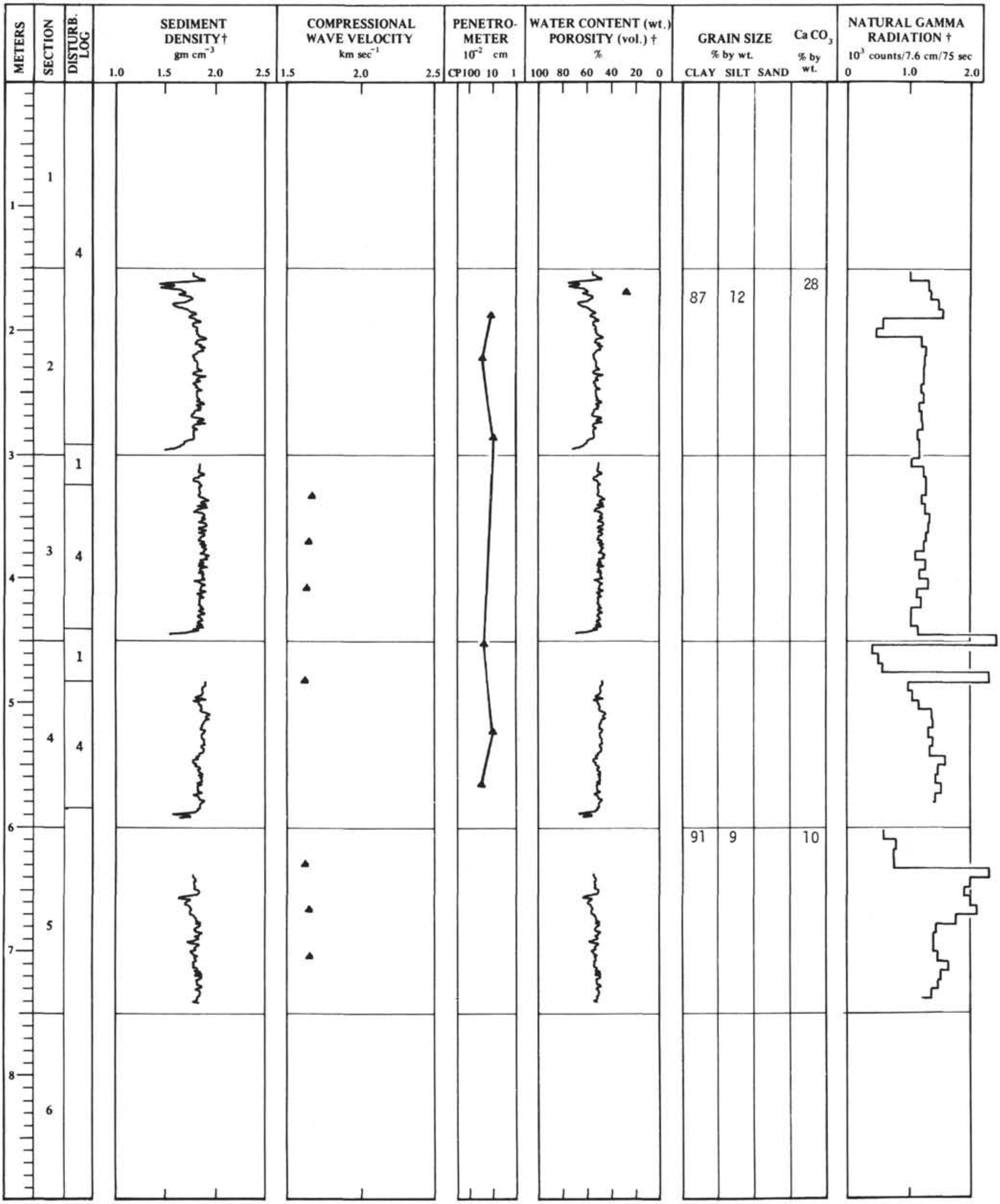
HOLE 112 441 TO 450 m

CORE 13

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NOT SPLIT			*Isthmolithus recurvus, Discoaster barbadiensis, Reticulofenestra umbilica, R. reticulata, Discoaster saipanensis, Coccolithus bisectus, C.* cf. *C. scissurus, Discolithina multipora*	*Isthmolithus recurvus* s.l.	LATE EOCENE
1.5–3	2		N N XM F	Greenish gray nannofossil clay burrow mottled light olive gray and olive gray in section 2, and dark greenish gray or greenish gray mottled with olive gray in sections 4 and 5. 5GY6/1 5Y6/1 5Y4/1 X-ray Mineralogy (bulk) Calc. 35.7 Qtz. 18.4 Mica 14.5 Mont. 31.5 Amorph. 61.9	Flora similar to above Fauna sparse, no planktonics		
3–4.5	3	NOT SPLIT					
4.5–6	4		N N F XM	5GY4/1 5G4/1	Flora similar to above Flora similar to above *Globigerina galavisi, Chiloguembelina* sp.		
6–7.5	5		N XM F	5G6/1 5Y4/1	Flora similar to above *Globigerina galavasi, Pseudohastigerina micra*		
7.5–9	6	NOT SPLIT					
	CC		R N F		No radiolarians Flora similar to above *G. galavisi, G. unicava. Ps. micra*		

HOLE 112

CORE 14



† Adjusted data, see Chapter 2

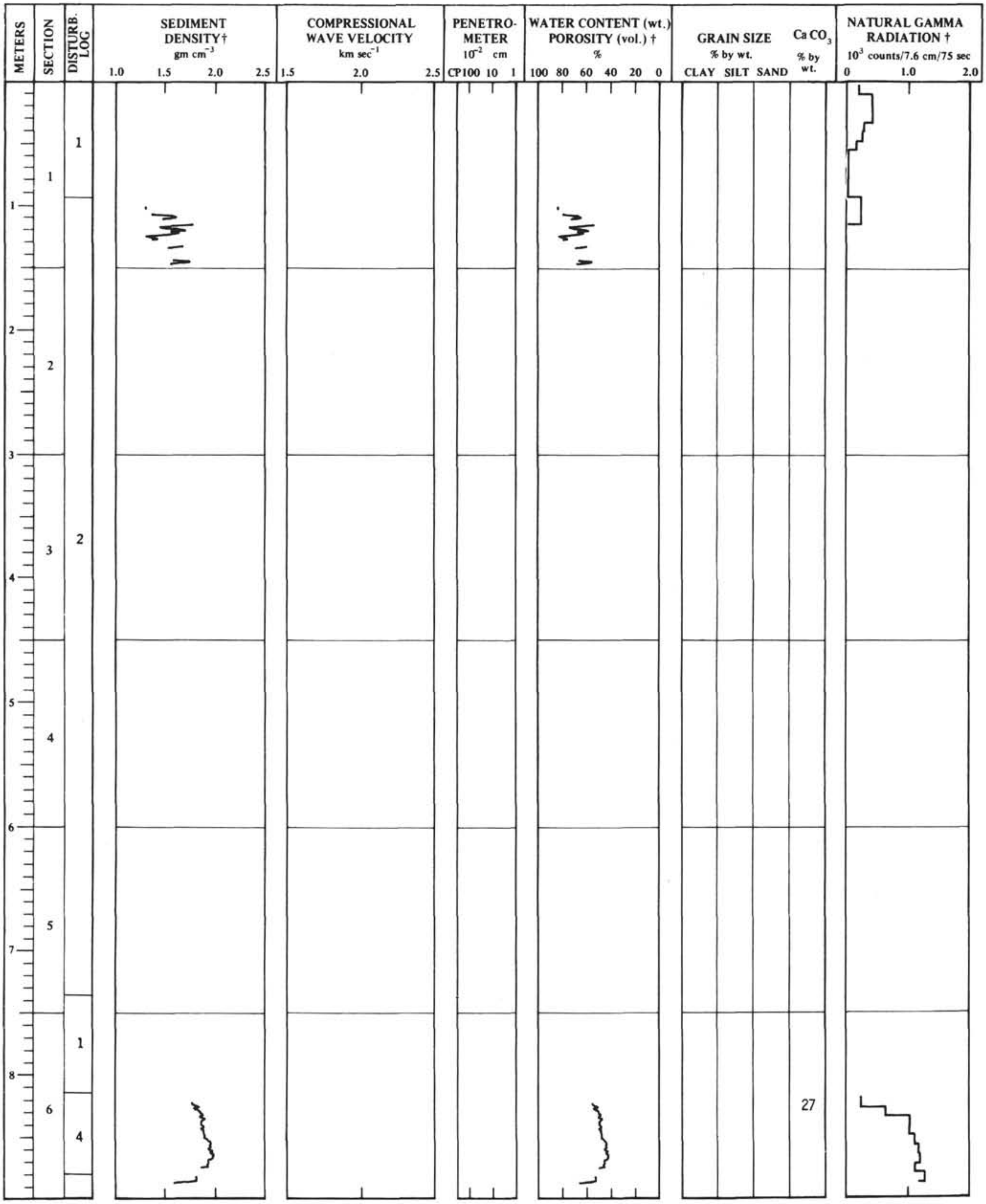
HOLE 112 499 **TO** 508 **m**

CORE 14

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	NO CORE			*Reticulofenestra umbilica, R. reticulata, Ericsonia ovalis, E. fenestrata, Zygrhablithus bijugatus, Chiasmolithus expansus, Discoaster barbadiensis, Micrantholithus snavelyi, Rhabdolithus* sp.	*Discoaster tani* s.l.	LATE EOCENE
1–1.5	1	NOT SPLIT					
1.5–3	2		N N XM	Grayish blue green to medium bluish gray burrowed, nannofossil clay & marl, mottled with light olive gray hard, indurated layers at 117-120 cm & at 140-142 cm in section 3. Considerable amount of pyrite, some authigenic carbonate (including siderite (?)) 5BG5/2 5B5/1 5Y5/2 X-ray Mineralogy (bulk) Calc. 40.6 Qtz. 23.4 Mica 10.7 Mont. 25.3 Amorph. 59.1	Flora similar to above		
3–4.5	3		F F		*G. galavisi, G. senilis, Globigerinita* sp., *Chiloquembelina* sp. Fauna in fine fraction only *Globigerinita* spp., *Globigerina galavisi*		
4.5–6	4	NOT SPLIT					
6–7.5	5		N N XM F	Medium bluish gray nannofossil clay with intense burrow mottling of greyish blue green & dusty red, upper third of core is dark bluish green, middle third is light gray green with dusky red mottles. Nannofossils are poorly preserved. Much pyrite present. 5B5/1 BG5/2 5R3/4	Flora similar to above Flora poorer than above		
7.5–9	6	NOT SPLIT		Dusky red hard nannofossil clay mottled light gray, slightly laminated, with much pyrite, some goethite & pyritized diatoms. 5R3/4	Small indeterminate globigerinids; agglutinated benthonics: *Cyclammina, Glomospira, Cribrostomoides, Rhabdammina, Osangularia pteromphalia*		
	CC		R N F	Dark reddish brown hard nannofossil clay with goethite & amorphous iron oxide. 10R3/4	No radiolarians Flora similar to above No planktonics; benthonics as above		

HOLE 112

CORE 15



†Adjusted data, see Chapter 2

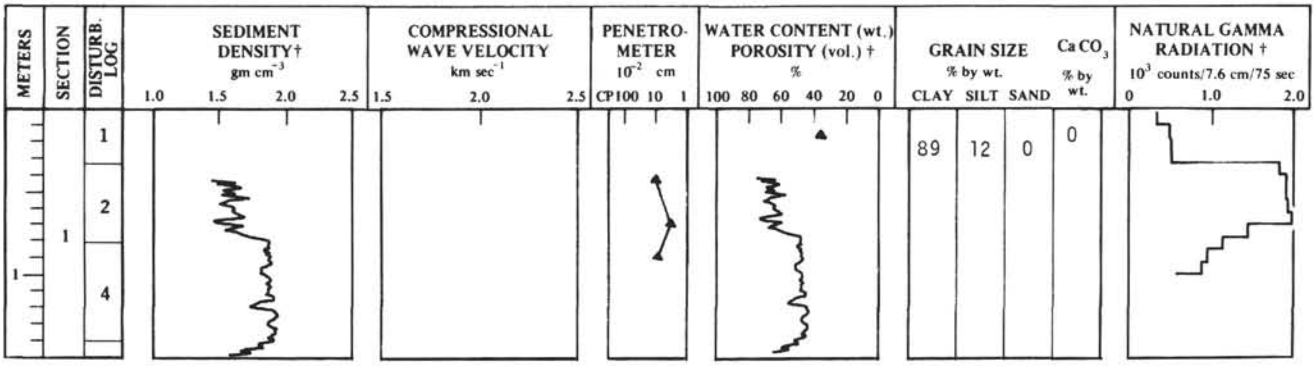
HOLE 112 578 TO 587 m

CORE 15

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N N,XM F	5Y4/1 5YR4/1 Olive gray, stiff, intensely burrowed mottled brownish gray nannofossil clay. (Fragments in a watery matrix - probably all cavings. X-ray Mineralogy (bulk) (no percentages available) Calc. Abundant Qtz. Common Mica Rare Chl. Rare Mont. Rare	*Discoaster sublodoensis, D. barbadiensis, Neococcolithes dubius, Lophodolithus nascens, Chiasmolithus eograndis, Rhabdolithus inflatus, Zygrhabdolithus bijugatus, Micrantholithus vesper, Sphenolithus radians, Transversopontis pulcheroides, T. pulcher*? *Globigerina petagonica, Pseudohastigerina wilcoxensis, Acarinina* sp.	*Discoaster sublodoensis*	LOWER EOCENE
1.5–7.5	2, 3, 4, 5	NO CORE					
7.5–9	6		XM N F	5G6/1 5GY4/1 5YR4/1 N8 Greenish gray & dark greenish gray nannofossil marl with mottles of brownish gray, some fragments of foraminifera present. Very light gray indurated patch of authigenic calcite at 136 cm. X-ray Mineralogy (bulk) Calc. common Qtz. common Mica very rare Chl. rare Mont. abundant	Flora similar to above Insufficient faunal residue Zeolitized radiolarians rare.		
	CC		R N F	N7 Light gray nannofossil marl with much authigenic calcite & some corroded foraminifera fragments	Flora similar to above *Globigerina frontosa, G. linaperta, G. patagonica, Ac. collactea, A. densa, Pseudoh, wilcoxensis* C.B.: Rare silicified and zeolitized radiolarians. (?)*Phormocyrtis striata*		

HOLE 112

CORE 16



†Adjusted data, see Chapter 2

HOLE 112 652 **TO** 659 **m**

CORE 16

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	PPPP	N F XM F F XM	10R3/4	Dark reddish brown, indurated clay. Clay is faintly laminated from 50 to 75 cm, slightly burrowed from 80 to 110. Yellowish bands at 42, 43, 53 and 74 cm. Dark green palagonite sill at 75-79 cm. White calcisiltite bleb at 99 cm. Coloring agent is predominantly hematite together with goethite and amorphous iron-manganese oxides Only organic remains are a few nannofossils.	*Ericsonia ovalis, Markalius inversus, Fasciculithus* sp.,*Discoaster* cf. *kuepperi, Marthasterites tribrachiatus, D. gemmeus*?, *Toweius* sp. *Cruciplacolithus* sp. *Chiasmolithus* sp. *Thoracosphaera* sp. *Neococcolithes* sp. *Ellipsolithus macellus* *		
	CC	PPPP	R F,XM	5R4/6 5Y8/4	<u>X-ray mineralogy</u> (bulk) Calc. 1.7 Qtz. 79.8 Mica 7.5 Mont. 3.0 Hema 7.9 Amorph. 62.9	No planktonic foraminifera; BF: *Cyclammina, Cribrostomoides, Ammodiscus, Glomospira, Bolivinopsis, Rhabdammina*		
					Core Catcher: Moderate red, indurated, slightly mottled claystone, with large patches of indurated grayish yellow clay, slightly mottled with green clay. Clay contains vienlets of calcisparite, green material (montmorillonite?), hematite & goethite, cryptocrystalline quartz grains (tridymite?), some glass, "palagonite", zeolite, authigenic calcite, pyrite, & a few nannofossils. A dusky blue green sill at the bottom of the core is palagonite consisting of montmorillonite with some zeolite.	**Core Catcher:** No radiolarians. Fauna: Barren		

* Mixed Late Paleocene - Early Eocene assemblage of coccoliths from the centerbit before coring Core 16

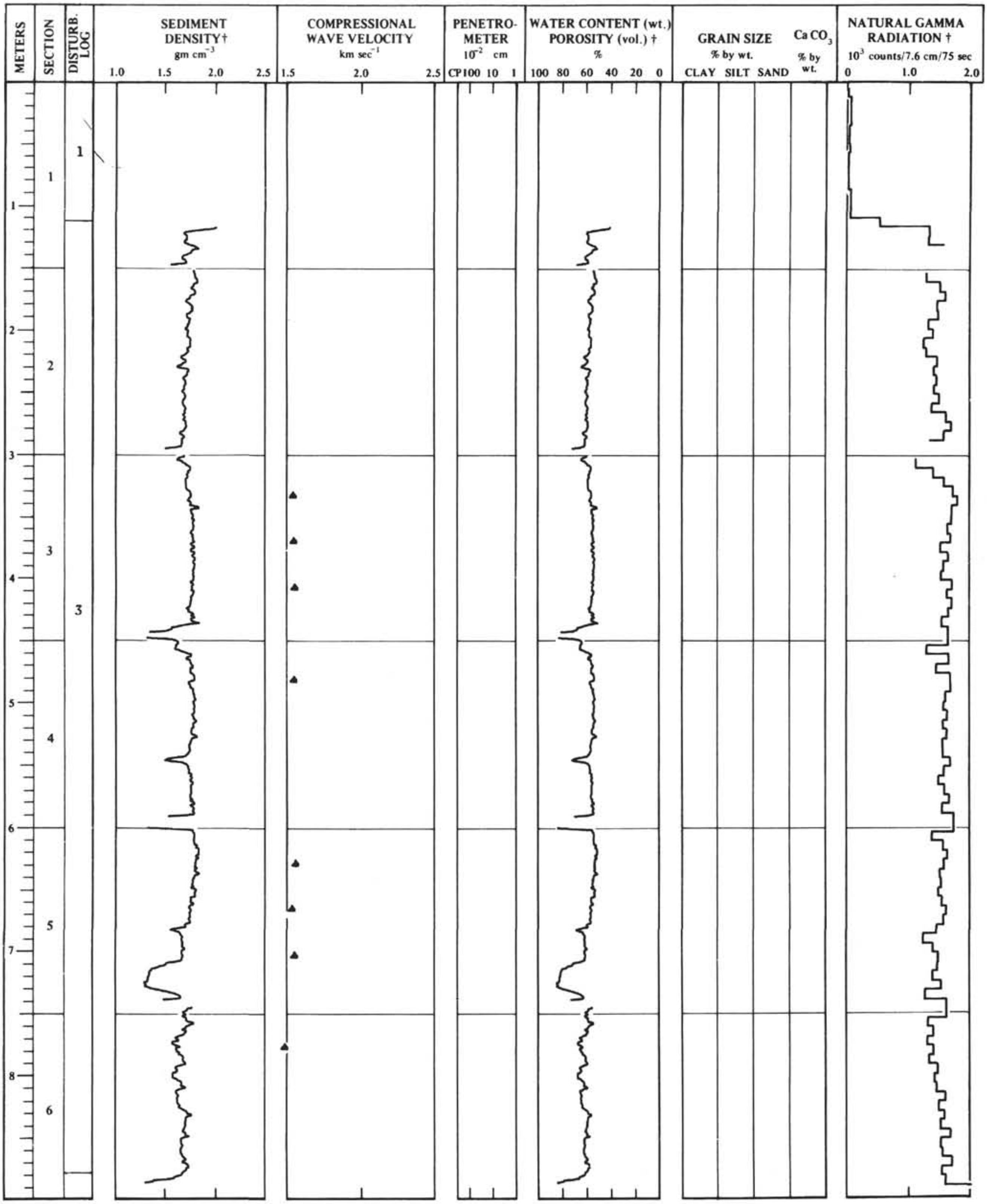
HOLE 112 661 **TO** 664 **m**

CORE 17

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	NO CORE		Black, hard, porphyritic, variolitic to microlitic basalt, altered in patches and stringers to a soft, green, chloritic material. There are some white veinlets of calcite.	No coccoliths No foraminifera		

HOLE 112A

CORE 1



†Adjusted data, see Chapter 2

HOLE 112 A **79 TO 88 m**

CORE 1

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NO CORE	N	5GY5/1. Greenish gray, soft, disturbed clayey silt, with glacial pebbles, much quartz, some mica, glass, pyrite, authigenic carbonate and poorly preserved nannofossils	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa, Pontosphaera scutellum, P. discopora, Syracosphaera* sp. *Helicopontosphaera kamptneri, H. sellii, Thoracosphaera* sp.	*Pseudoemiliania lacunose*	PLEISTOCENE
1.5–3	2		N	5GY4/1, 5GY5/1. Greenish gray to dark greenish gray, soft, disturbed, silty nannofossil marl. Contains glacial pebbles, varying amounts of quartz, pyroxene, mica, and other heavy minerals, some glass, pyrite, and much authigenic carbonate. Total carbonate content between 40 & 60%. Abundance of corroded planktonic foraminifera in Sec. 2.	Flora similar to above, + *Rhabdosphaera clavigera, Cyclococcolithus macintyrei*		
3–4.5	3		N		Flora poorer than above		
4.5–6	4		N		Flora similar to sect. 2		
6–7.5	5		N		Flora similar to sect. 2, + *Scapholithus fossilis*		
7.5–9	6		N	5GY4/1. Dark greenish gray silty firm nannoplankton clay, with glacial pebbles, quartz, glass, feldspar, pyroxene, some authigenic carbonate (total carbonate up to 20%) & corroded fragments of foraminifera.	Flora similar to sect. 2, + *Scyphosphaera* sp. *Discoaster brouweri*	*Discoaster brouweri*	PLIOCENE
	CC		N		Flora similar to sect.6, + *Discoaster pentaradiatus*	*Discoaster Pentaradiatus*	

X-ray Mineralogy (bulk)

Calc.	3.3
Dolo.	6.0
Qtz.	34.8
Plag.	19.4
Kaol.	4.3
Mica	22.2
Chl.	2.6
Mont.	4.3
Amph.	3.1
Amorph.	65.5

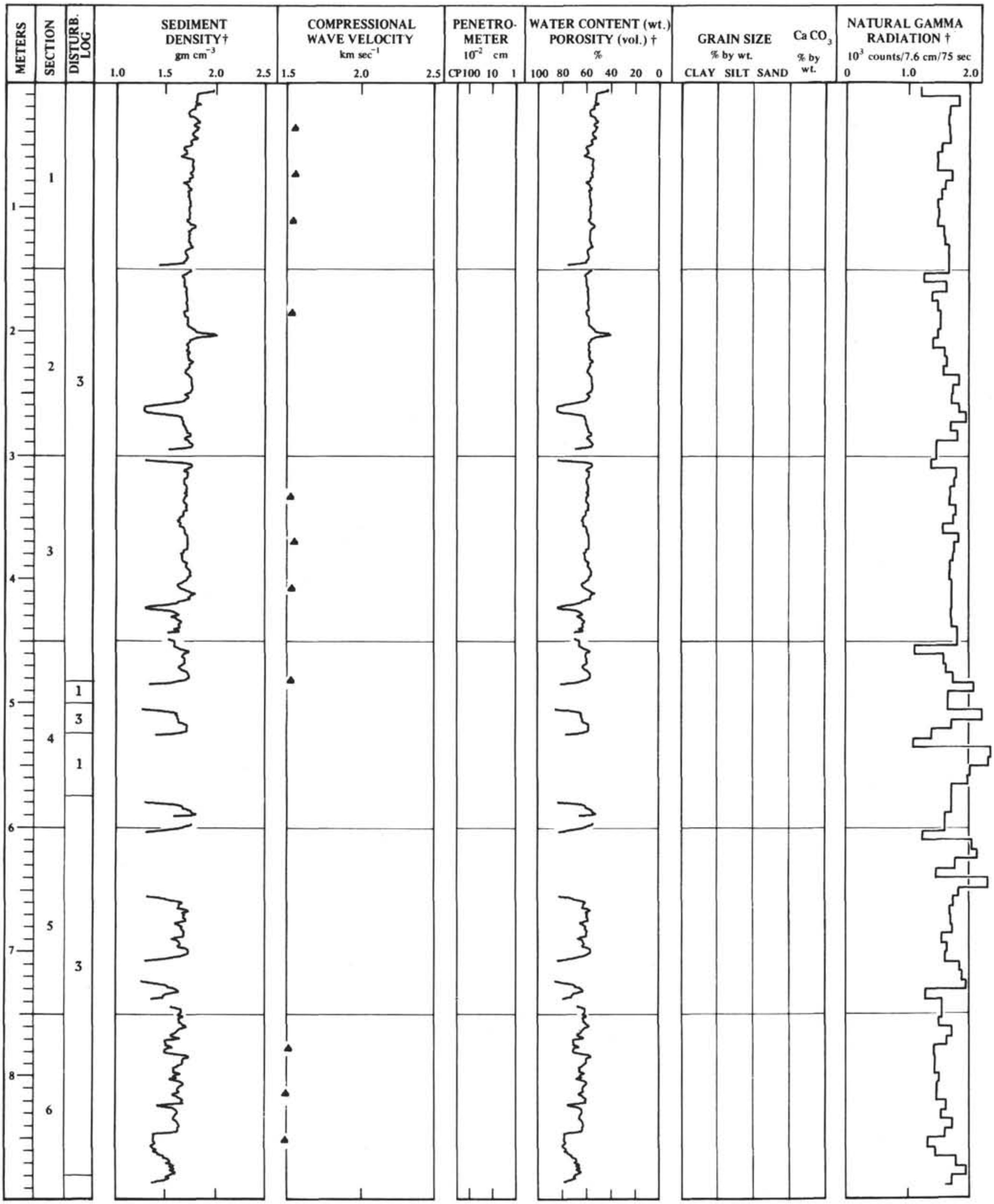
HOLE 112 A 88 **TO** 97 **m**

CORE 2

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
	CC		N	5Y4/1	Olive gray, soft, disturbed silty clay with large (15 cm) erratic pebble, much quartz, some heavy minerals, foraminifera & nannofossils, carbonate content 15%.	*Discoaster brouweri, Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Rhabdosphaera clavigera, Helicopontosphaera kamptneri, Pontosphaera discopora, Pseudoemiliania lacunosa, Thoracosphaera* sp.	*Discoaster Pentaradiatus*	PLIOCENE

HOLE 112A

CORE 3



†Adjusted data, see Chapter 2

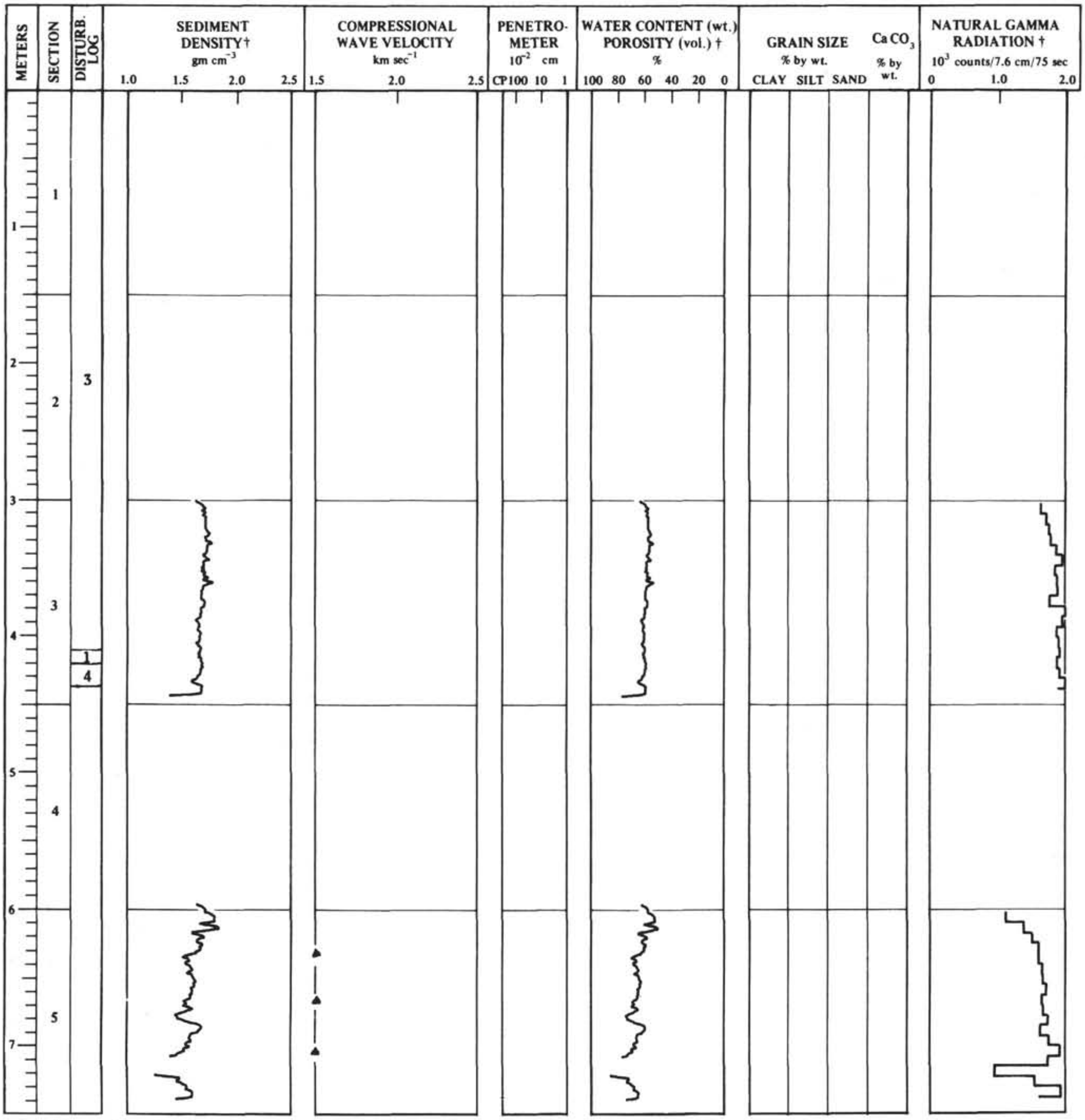
HOLE 112A 97 **TO** 106 **m**

CORE 3

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1		N	N4	Medium dark gray, soft, very wet, highly disturbed, silty and sandy clay. Contains glacial pebbles of limestone & igneous rock, much quartz, some heavy minerals, glass, and palagonite. There is a considerable amount of pyrite and authigenic carbonate throughout. Nannofossils generally rare and foraminifera only in Sec. 1. X-ray Mineralogy (bulk) Calc. 3.0 Dolo. 4.5 Qtz. 34.5 Plag. 17.1 Kaol. 5.7 Mica 24.5 Chl. 1.7 Mont. 7.0 Amph. 2.1 Amorph. 69.6	*Discoaster brouweri*, *Coccolithus pelagicus*, *Cyclococcolithus leptoporus*, *C. macintyrei*, *Helicopontosphaera kamptneri*, *H. sellii*, *Pontosphaera scutellum*, *Thoracosphaera* sp., *Syracosphaera* sp.	*Discoaster pentaradiatus*	PLIOCENE
2	2		N			Flora poorer than above		
3			XM					
4	3		N			Flora poorer than above		
5	4	NOT SPLIT						
6								
7	5		N			Flora poorer than above		
			N			Flora poorer than above		
8	6		N	N4		Flora poorer than above		
	CC		N			Flora similar to above		

HOLE 112A

CORE 4



†Adjusted data, see Chapter 2

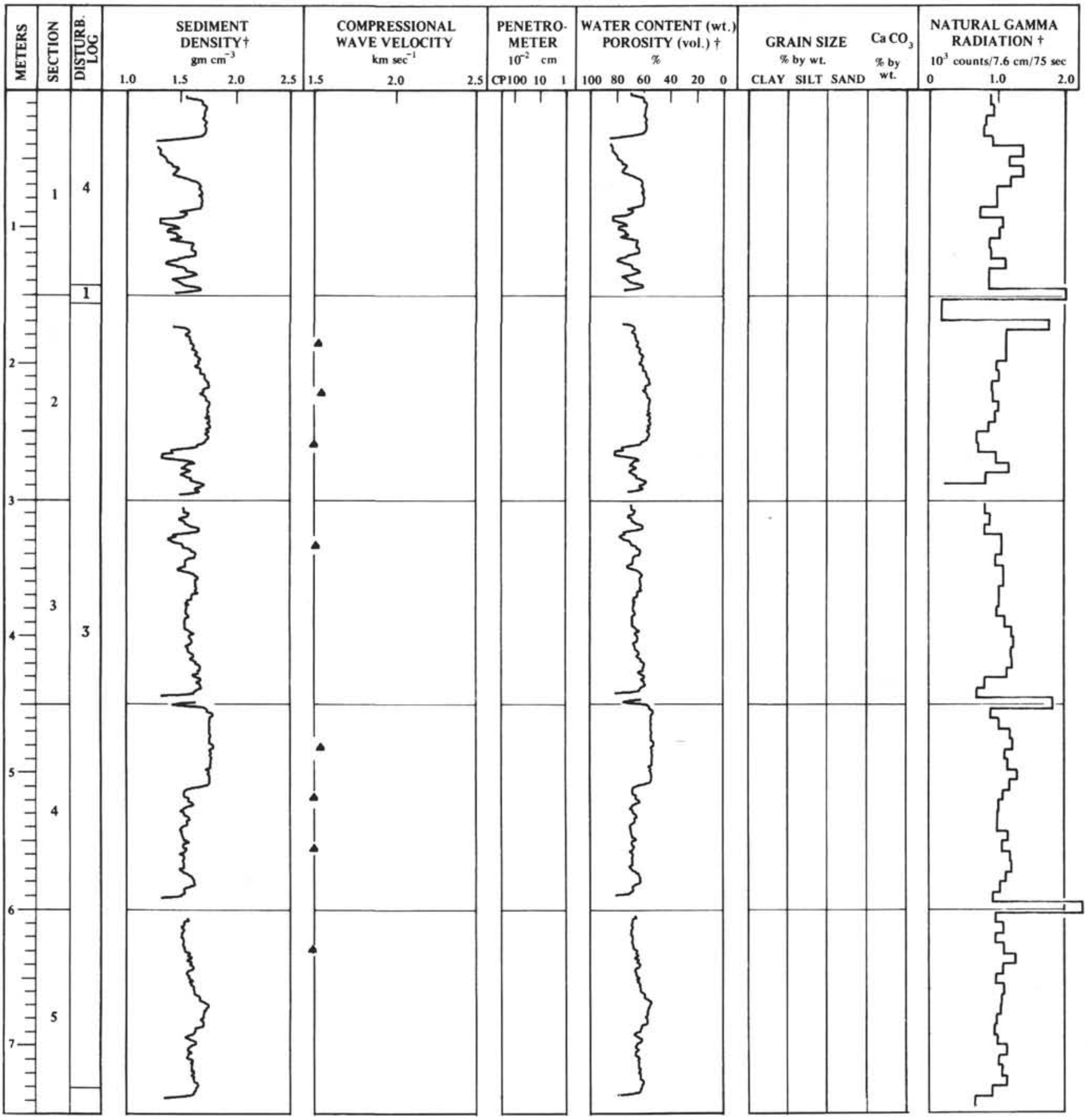
HOLE 112 A 106 **TO** 115 **m**

CORE 4

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	NOT SPLIT	N			*Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa*	*Discoaster pentaradiatus*	PLIOCENE
2	2							
3	3 A		N N	N4	Medium dark gray, firm, highly disturbed (core liner broken when removed from barrel) silty clay with glacial pebbles, much quartz & pyrite, some plagioclase, authigenic carbonate and few nannofossils. Note: Sections 3 & 5 "expanded" after core was divided, hence Section 3 consists of a 30-cm A part, and a 150-cm B part, and Section 5 consists of a 60-cm A part & a 150-cm B part. Sections 3 & 5 are not drawn to scale.	Flora poorer than above Flora poorer than above		
4	3 B		N			Flora poorer than above, + *Discoaster brouweri*		
5	4	NOT SPLIT						
6	5 A		N N	N4		*Discoaster brouweri, Coccolithus pelagicus, Cyclococcolithus leptoporus, Helicopontosphaera kamptneri* *Discoaster brouweri, D. pentaradiatus, D. surculus, Ceratolithus* sp. *Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Helicopontosphaera kamptneri, H. sellii, Pseudoemiliana lacunosa?*		
7	5 B		N				*Discoaster surculus*	
	CC		N	N4		**Core Catcher:** Flora similar to Sect. 1		

HOLE 112A

CORE 5

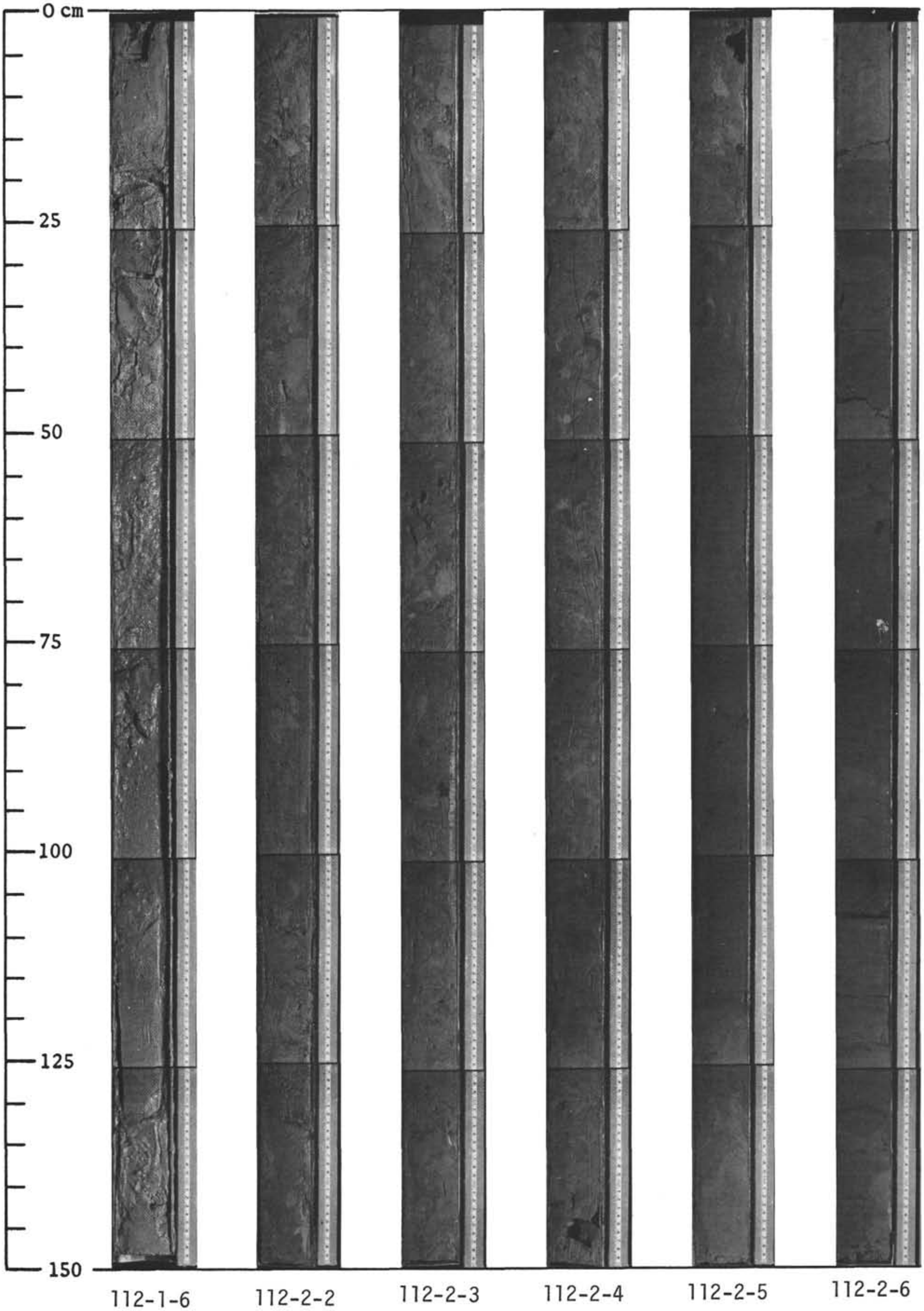


†Adjusted data, see Chapter 2

HOLE 112A 115 **TO** 124 **m**

CORE 5

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NOT SPLIT			*Discoaster brouweri, Discoaster pentaradiatus, D. surculus, D.* cf. *variabilis, Ceratolithus cristatus, C. rugosus, Sphenolithus abies, S. neoabies, Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Helicopontoshpaera kamptneri, H. sellii, Pontosphaera discopora, Reticulofenestra pseudoumbilica, Scyphosphaera* sp.	*Reticulofenestra pseudoumbilica*	PLIOCENE
1.5–3	2		N N N N	5GY6/1 Greenish gray, soft, disturbed, silty to sandy foraminifera nannoplankton marl & ooze. Contains much quartz & pyrite, some glass and palagonite,& a carbonate content of up to 70%	Flora similar to above Flora similar to above Flora similar to above		
3–4.5	3		N	N7 Light gray, soft, disturbed, sandy clay with high content of detrital minerals & pyrite. Total carbonate content is less than 10%. There are few foraminifera as well as nannoplankton.	Flora similar to above		
4.5–6	4		N N	5GY6/1 N6 Greenish gray silty to sandy foraminiferal nannoplankton marl ooze. Lithology same as Section 2.	Flora similar to above Flora similar to above		
6–7.5	5		N		Flora similar to above		
	CC		N		**Core Catcher:** Flora similar to above		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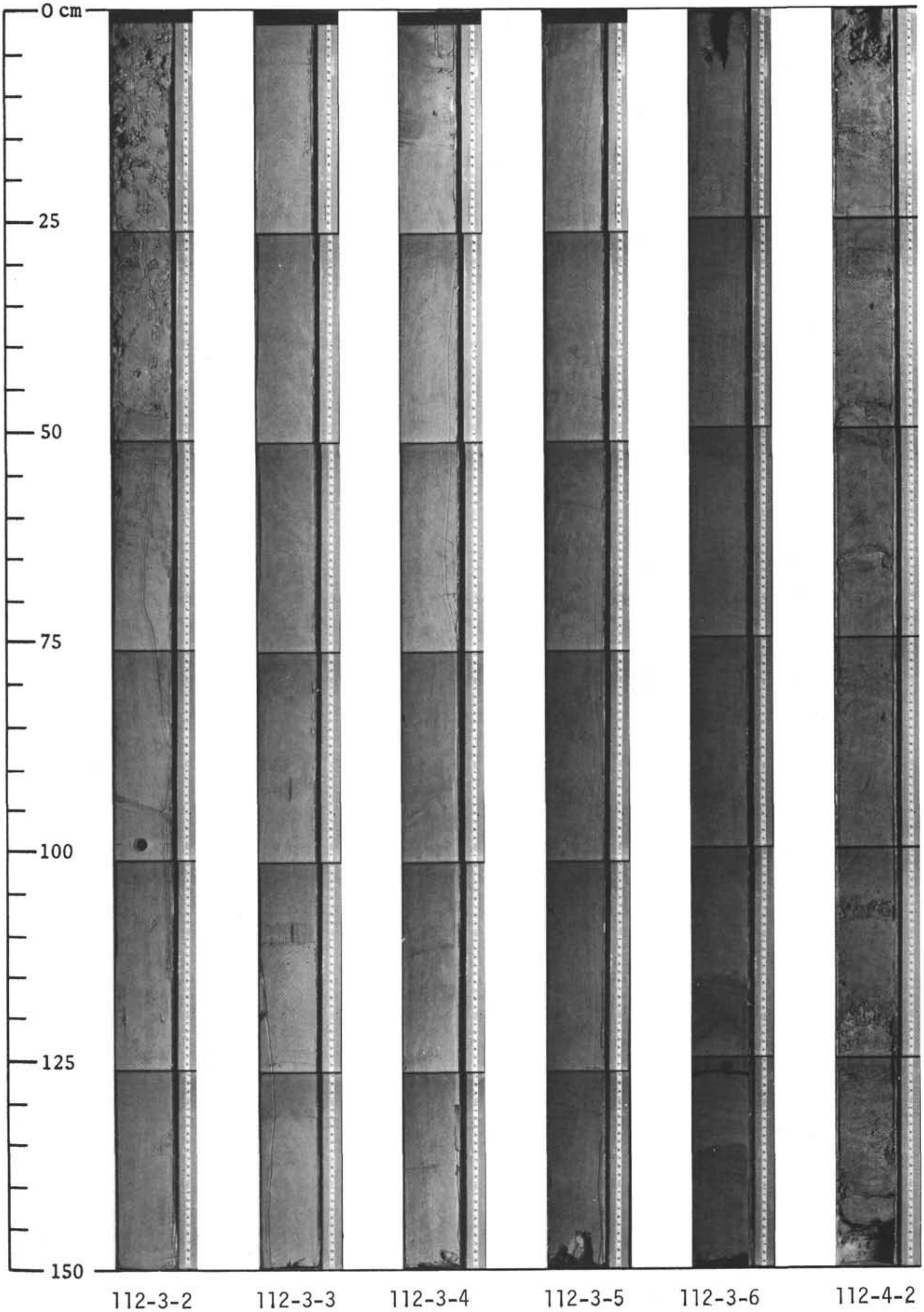
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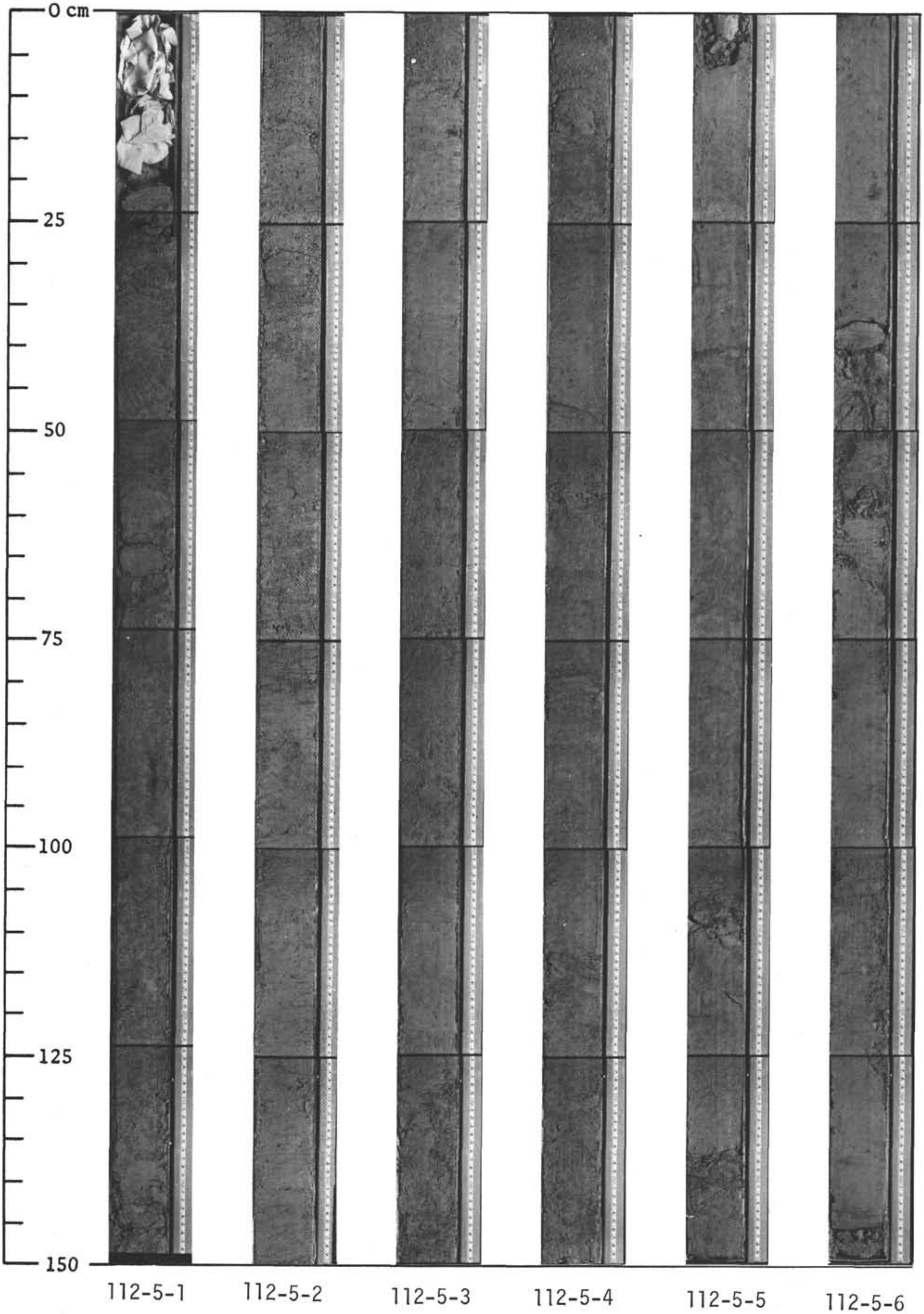
112-4-2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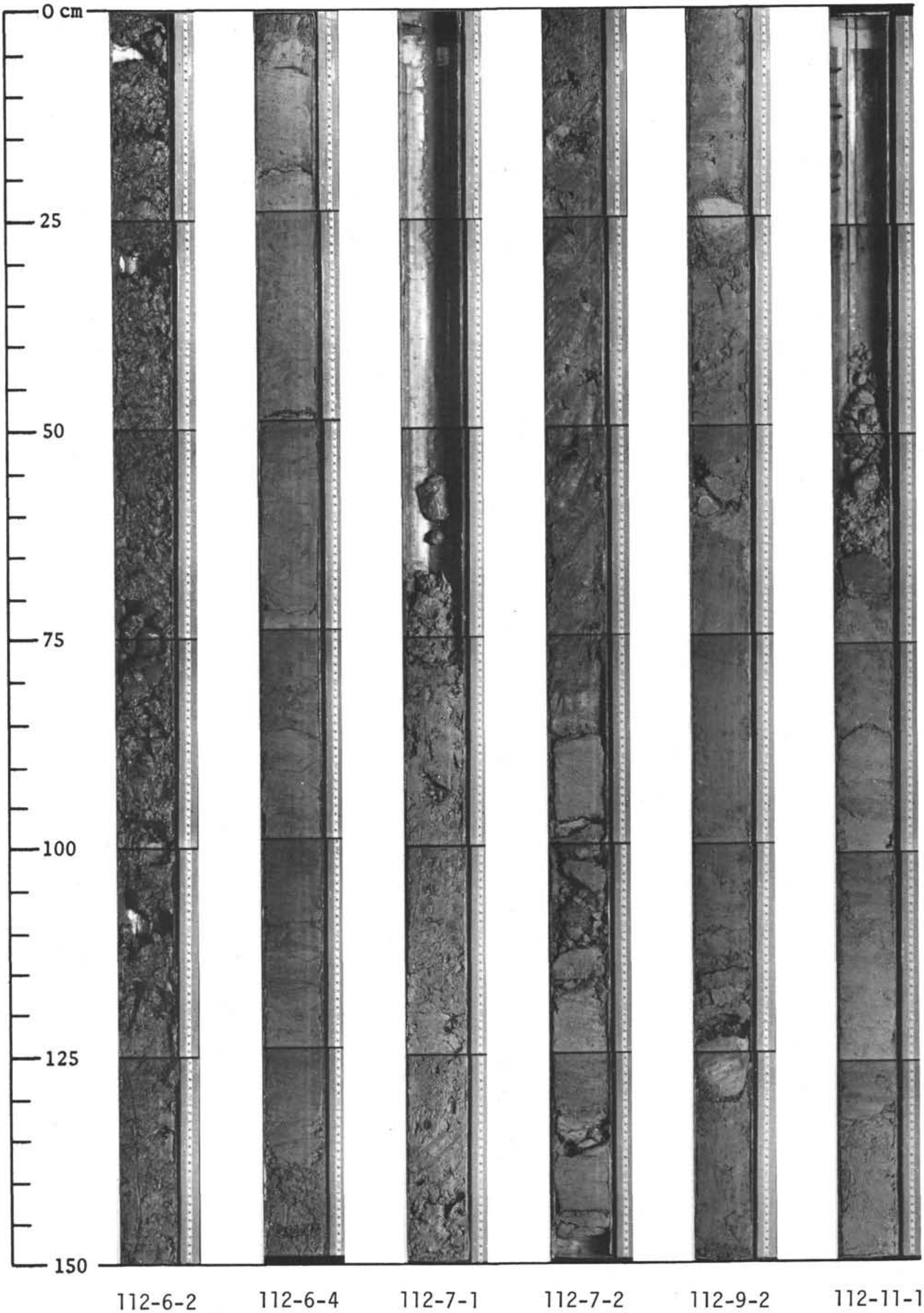
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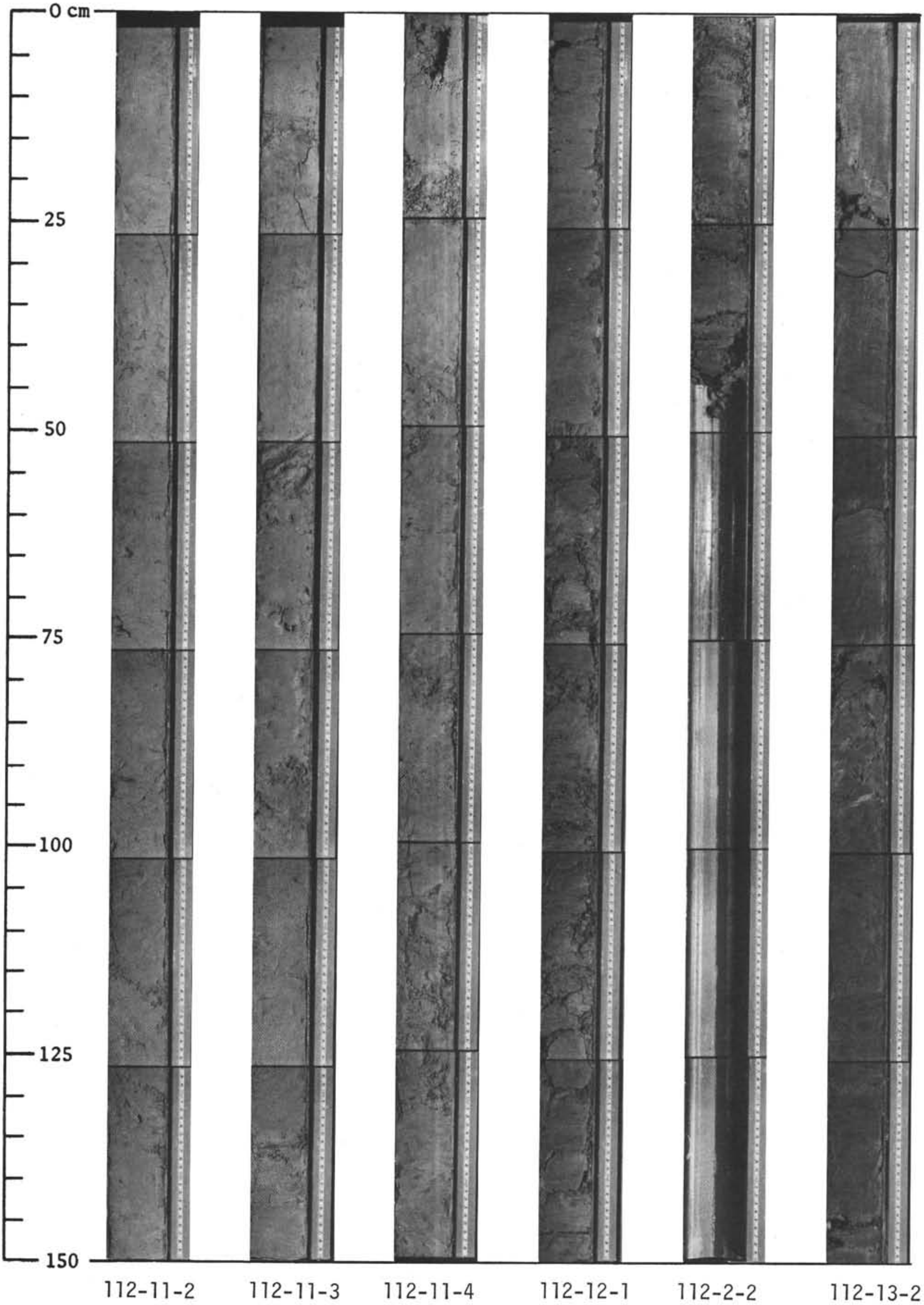
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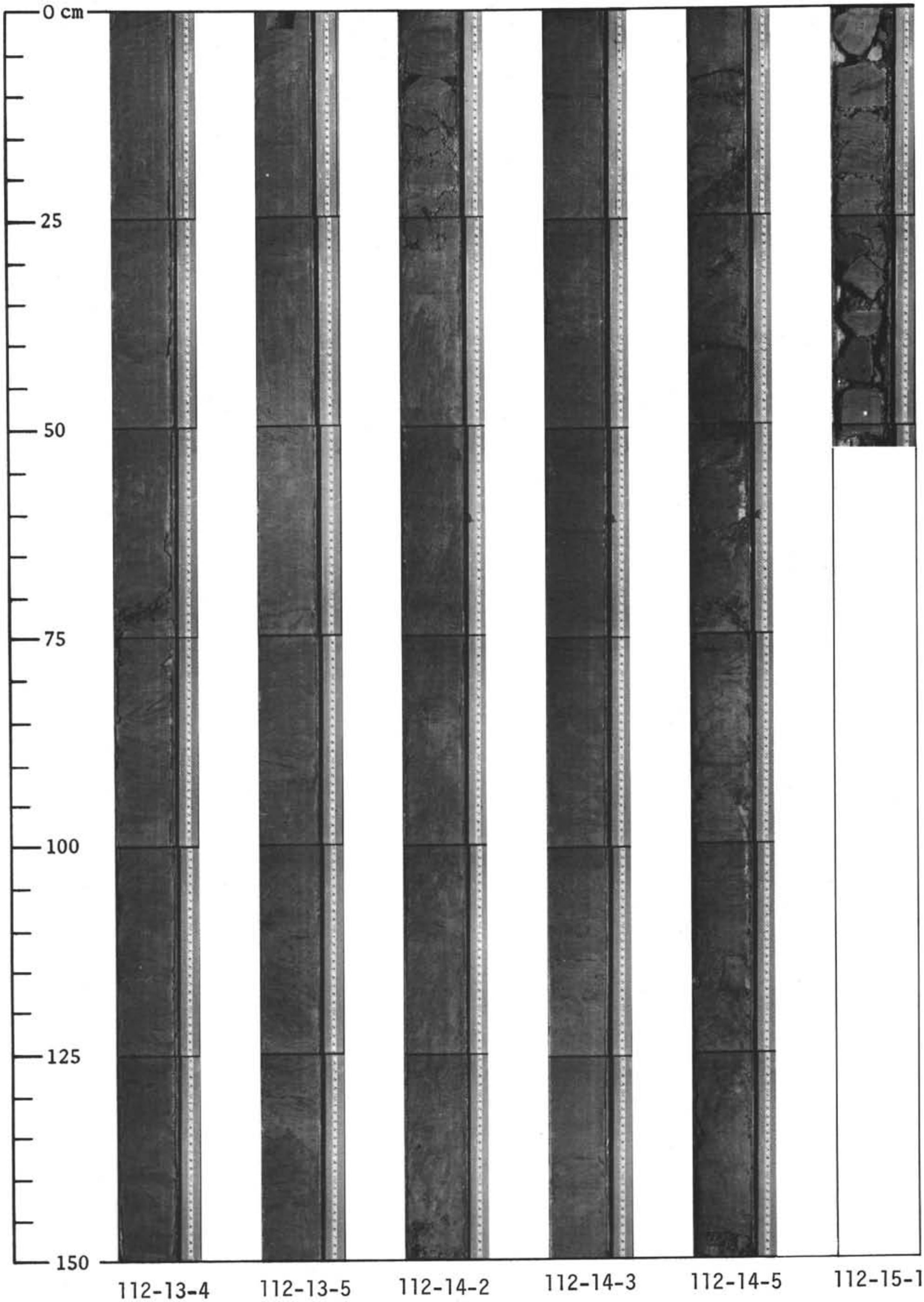
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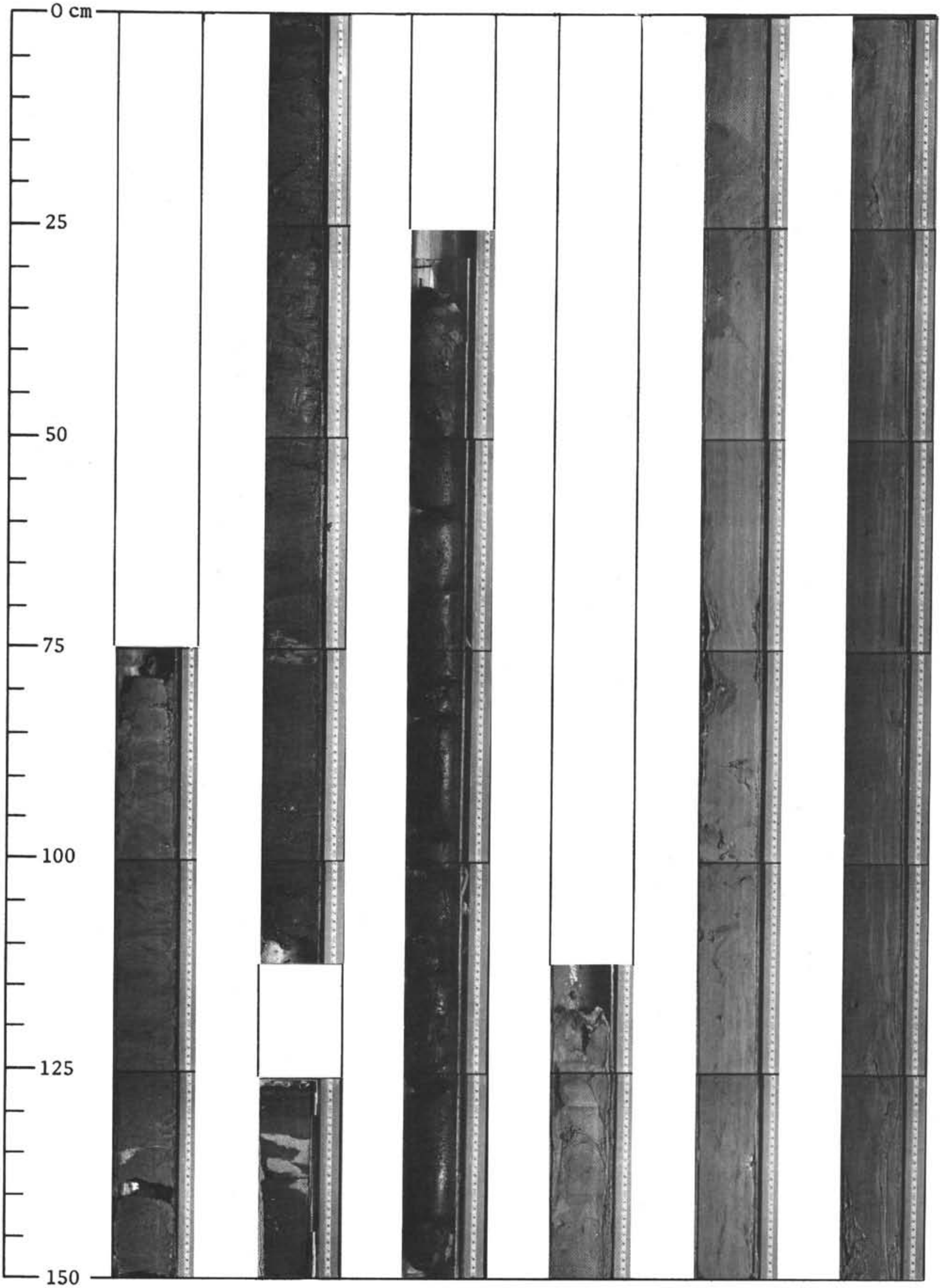

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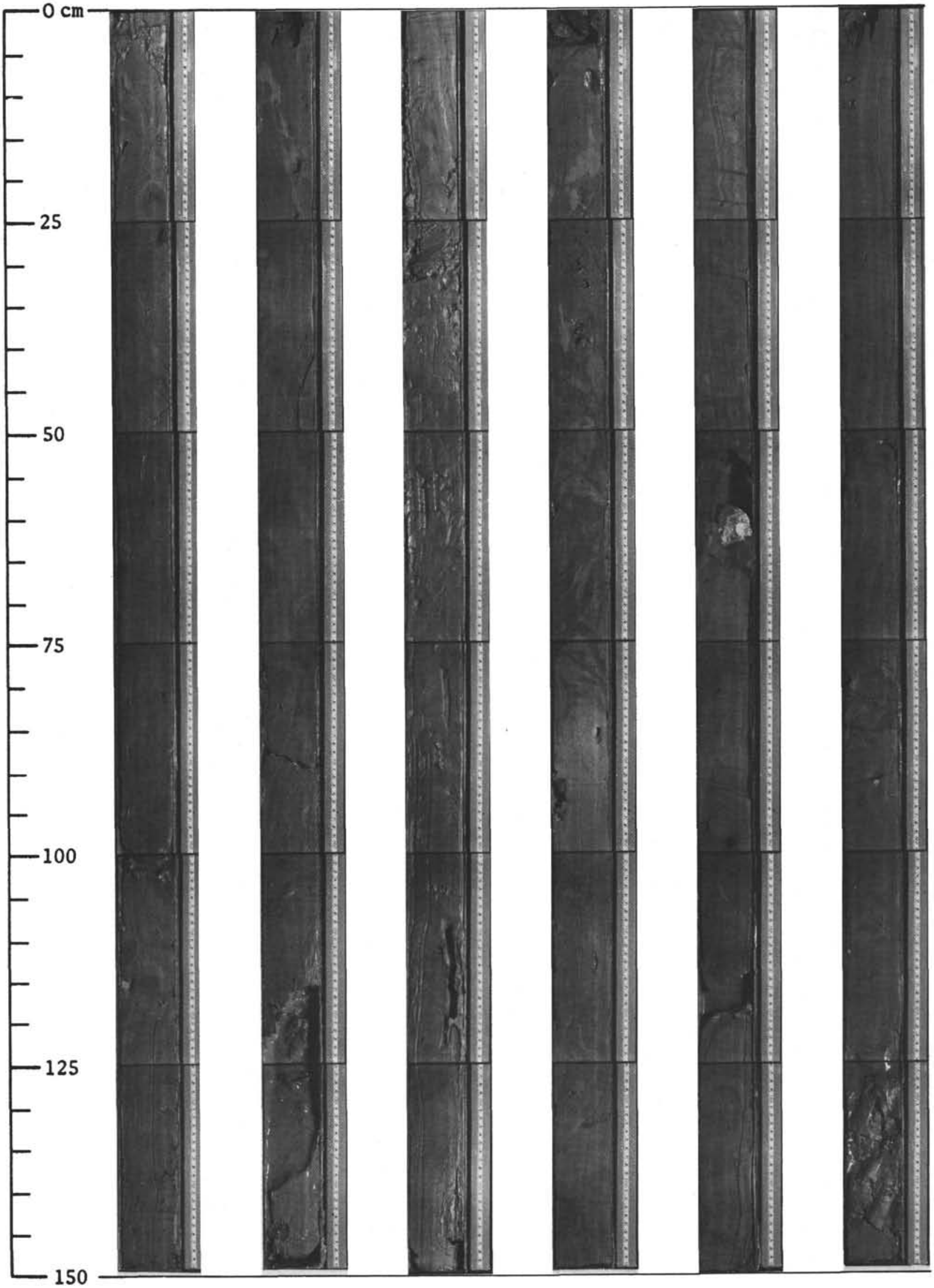

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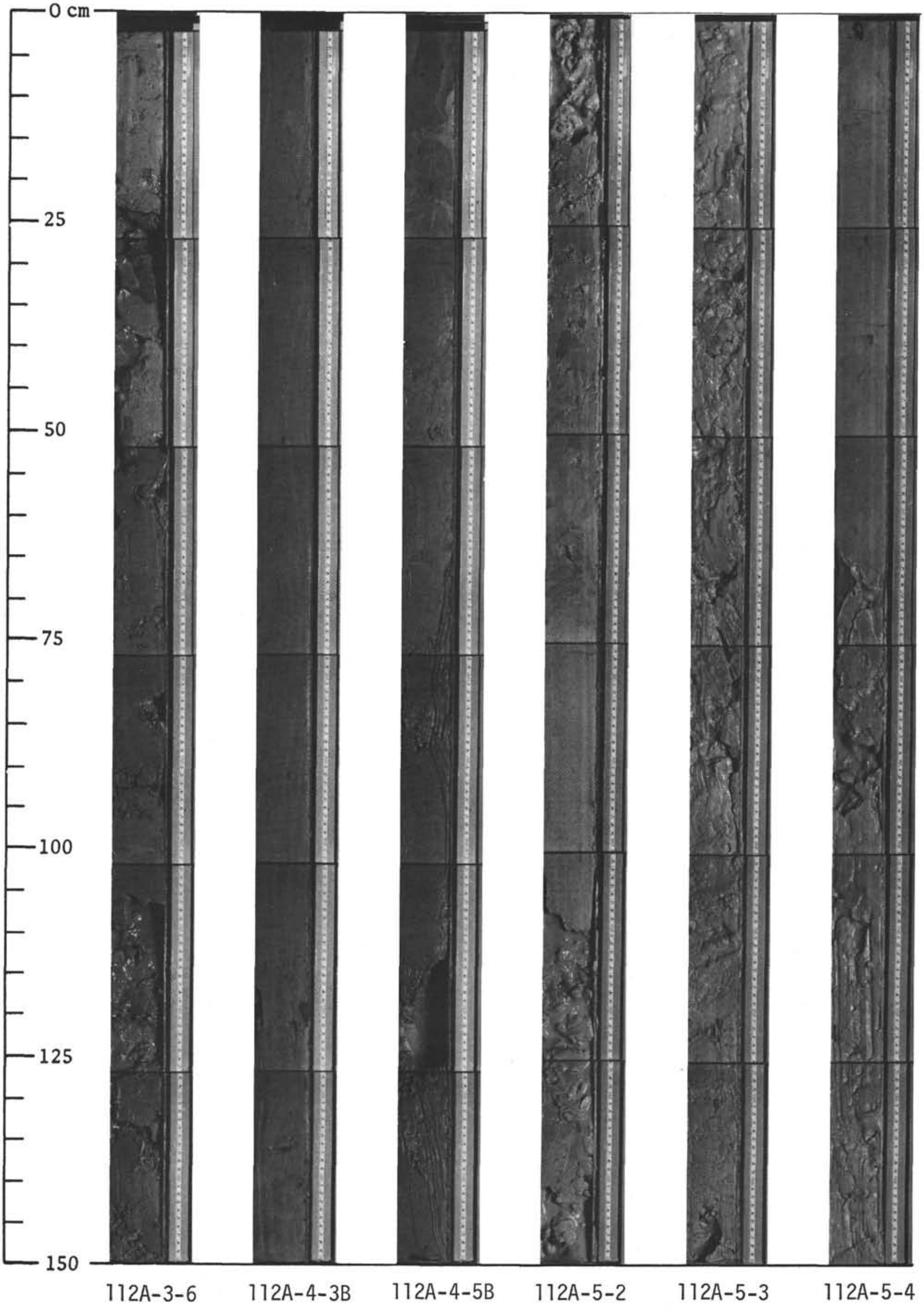
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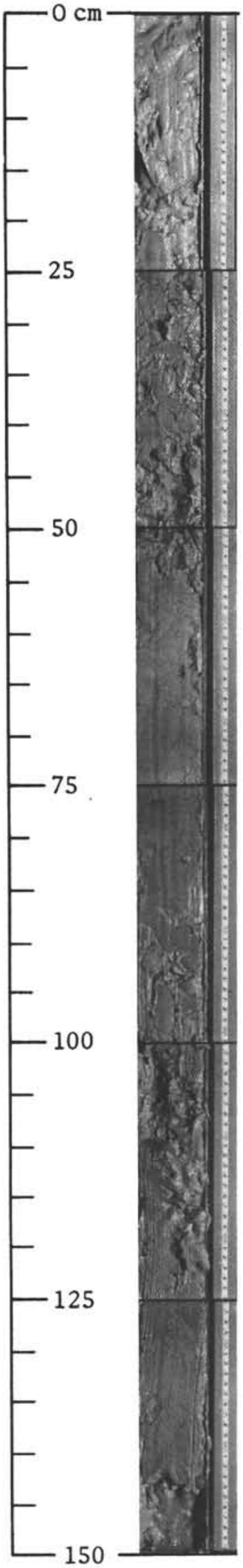
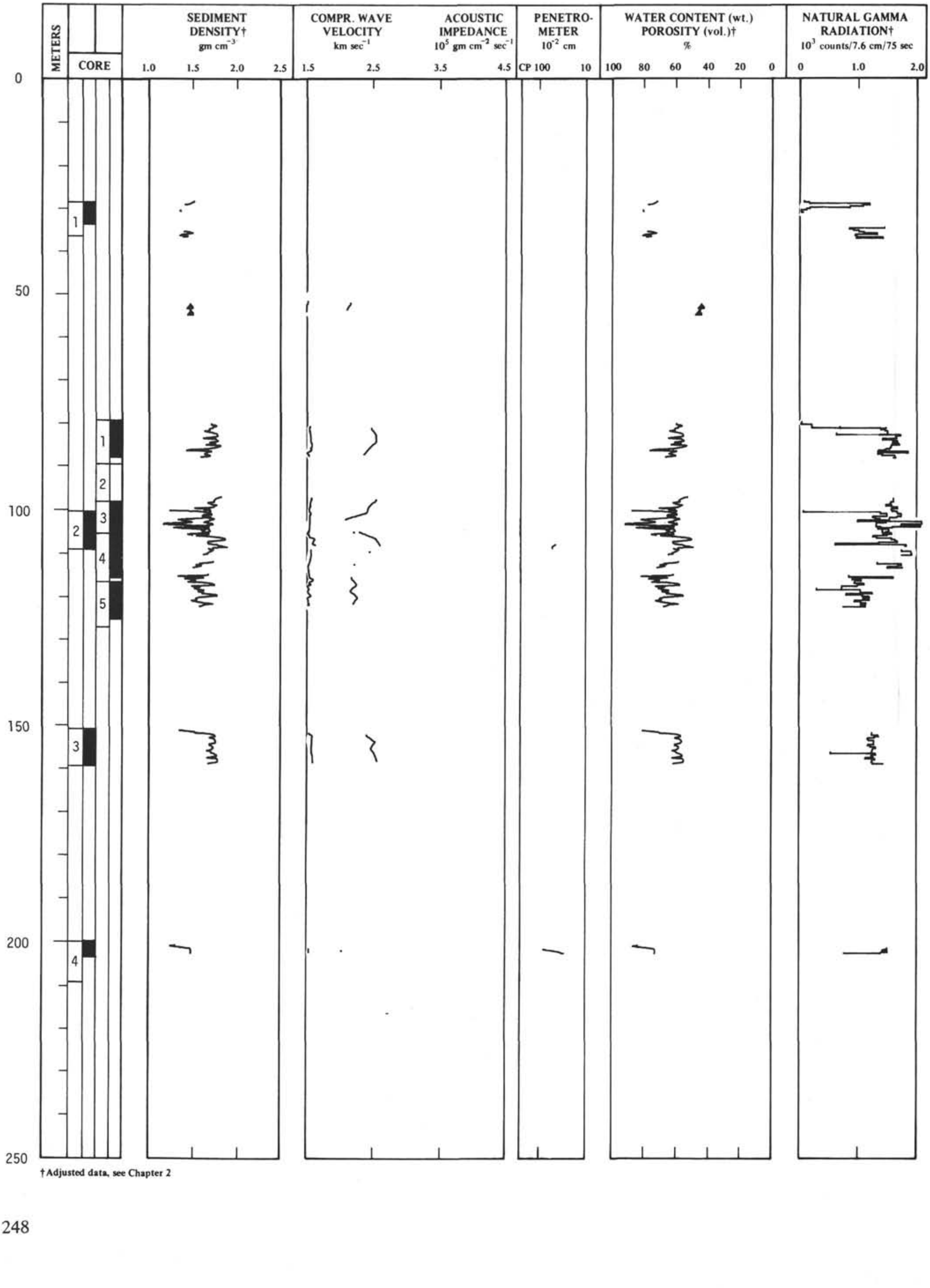
50
75
100
125
150
112A-3-6
112A-4-3B
112A-4-5B
112A-5-2
112A-5-3
112A-5-4



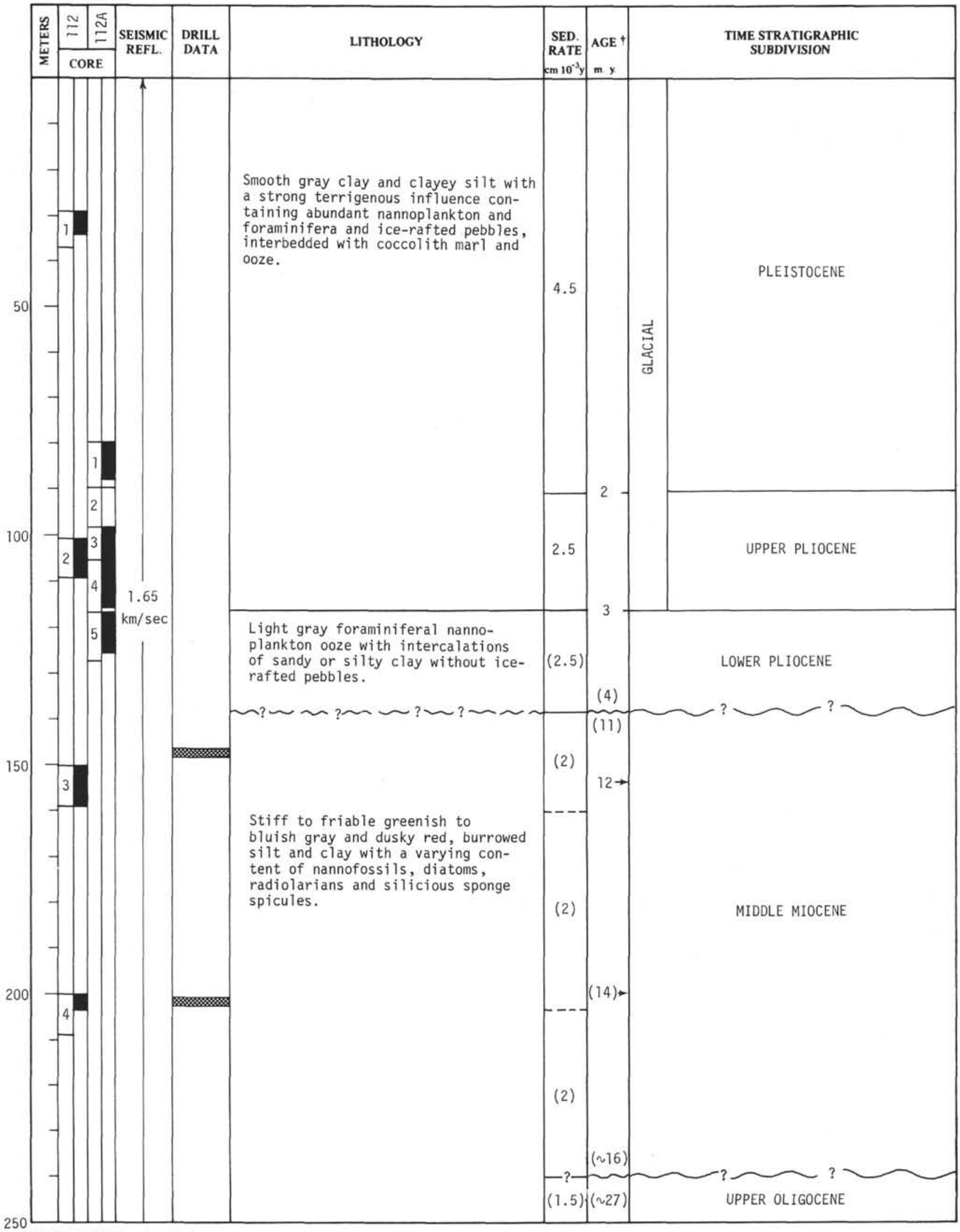
112A-5-5

SITE 112 0m TO 250m



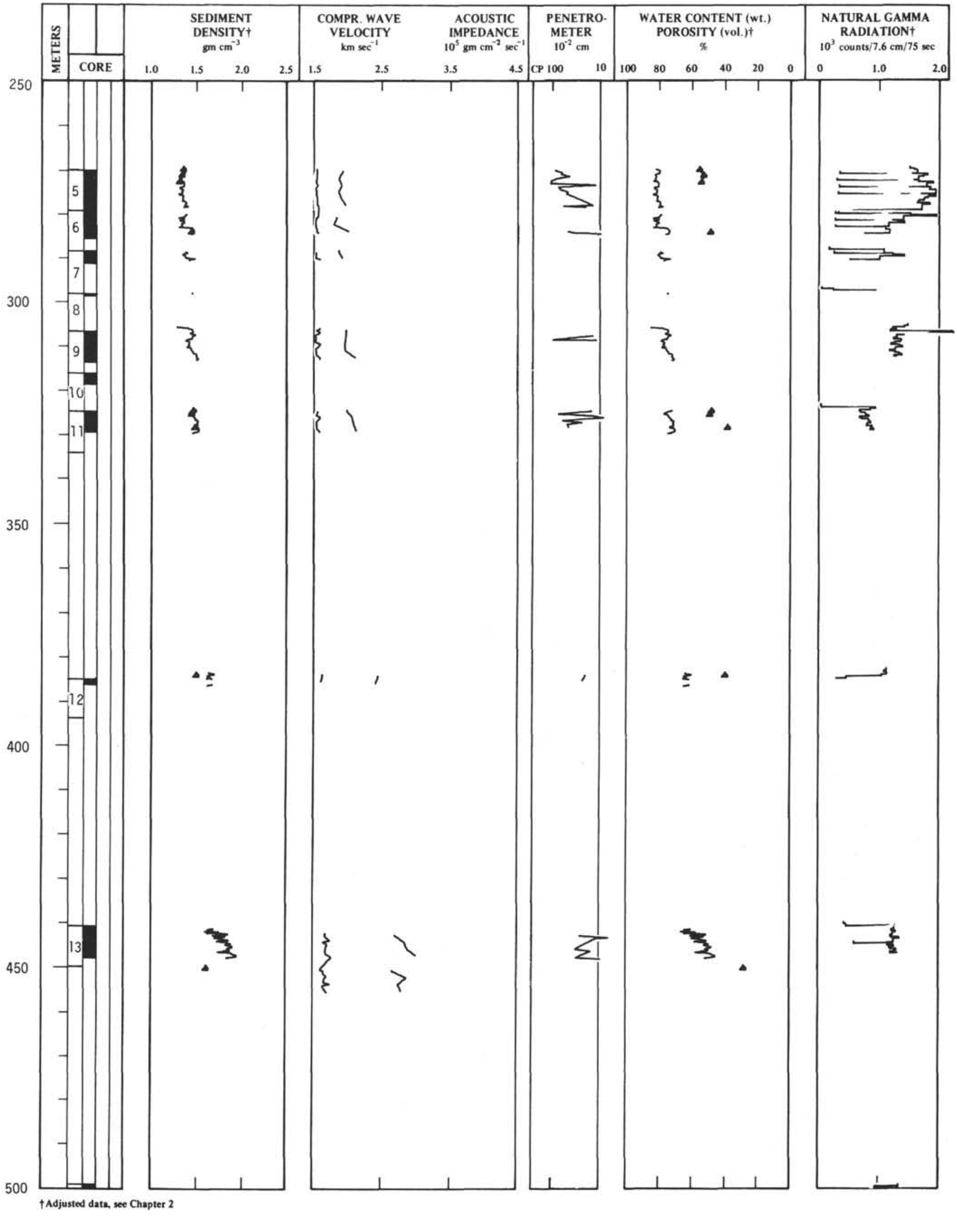
†Adjusted data, see Chapter 2

SITE 112 0 TO 250 m



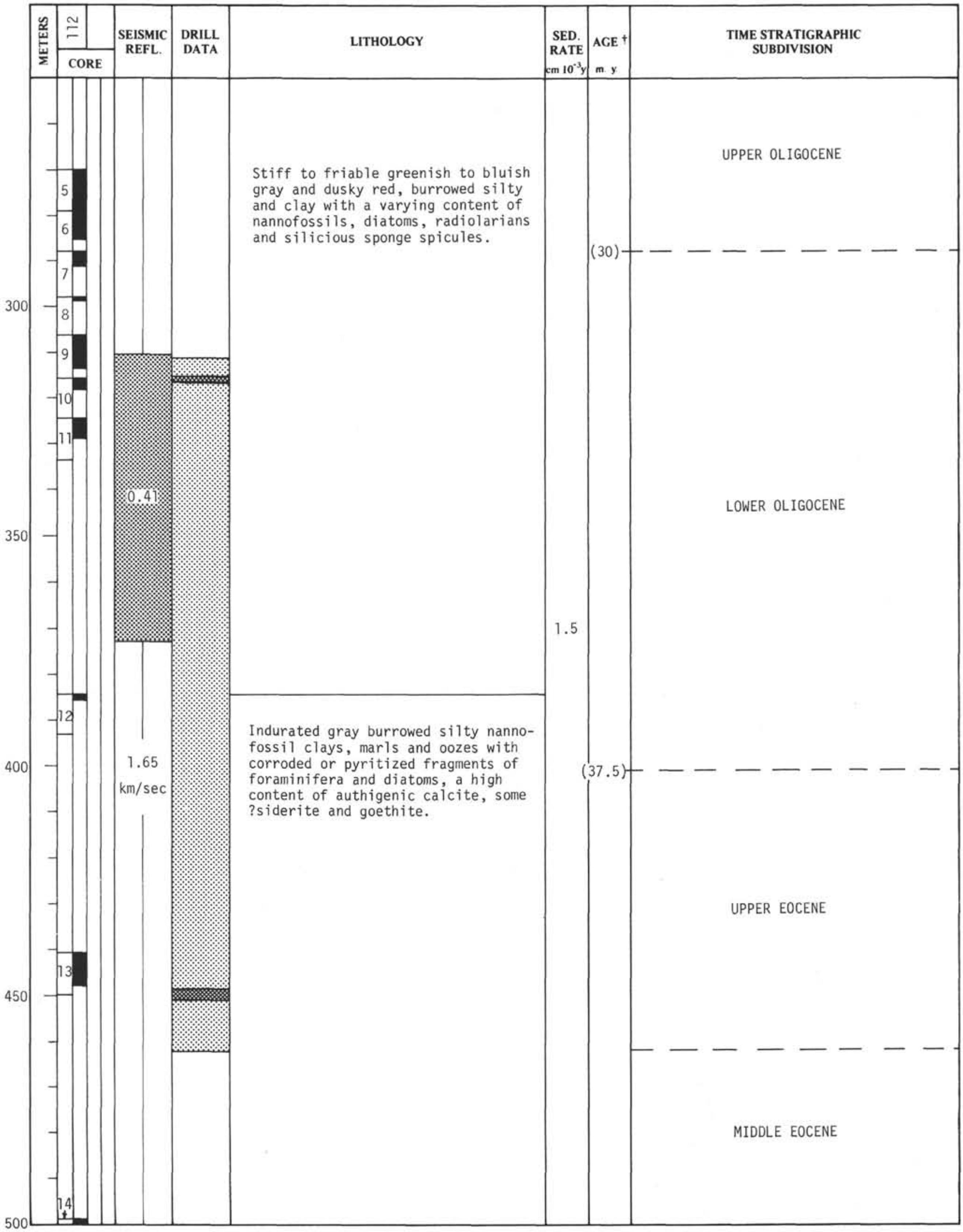
†See Chapter 2 (explanatory notes)

SITE 112 250m TO 500m



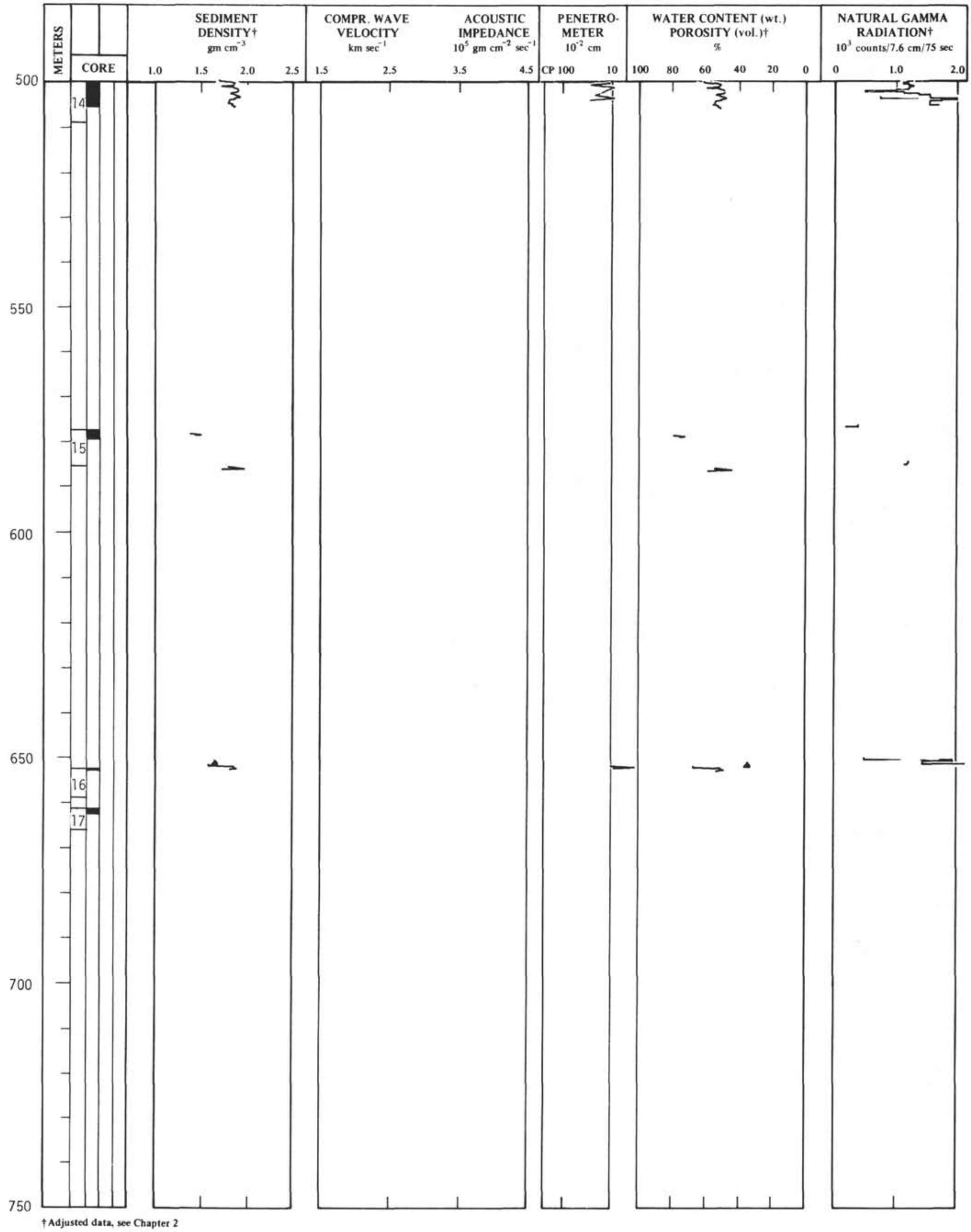
†Adjusted data, see Chapter 2

SITE 112 250 TO 500 m



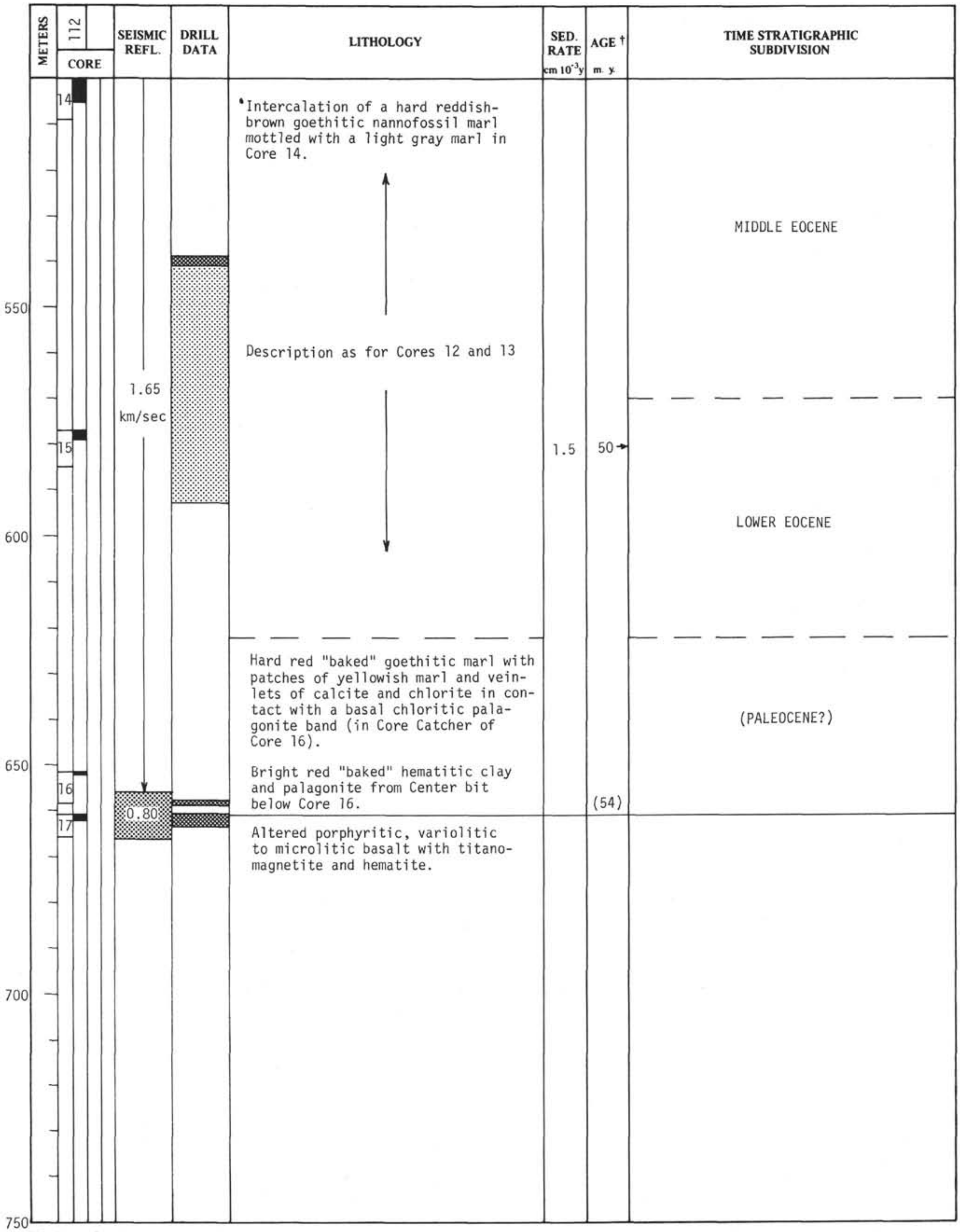
†See Chapter 2 (explanatory notes)

SITE 112 500m TO 750m



† Adjusted data, see Chapter 2

SITE 112 500 TO 750 m



†See Chapter 2 (explanatory notes)