5. SITE 113

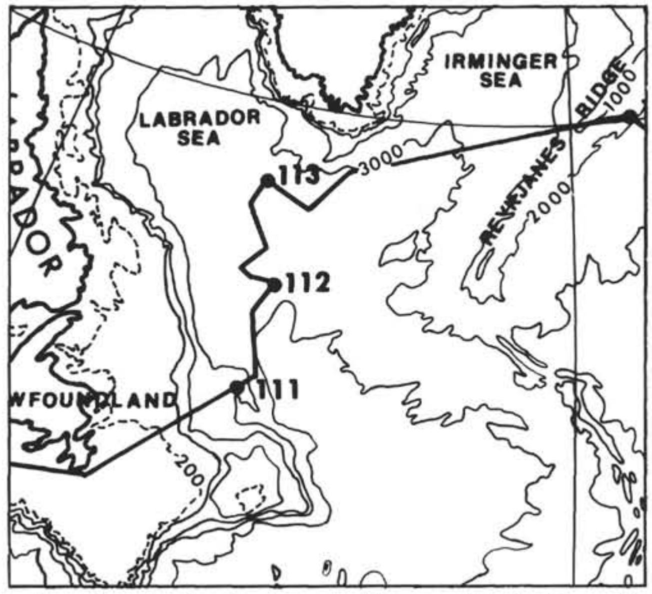
The Shipboard Scientific Party[1]

Location: Axis of Labrador Sea.

Position: 56° 47.40′N, 48° 19.91′W; (Satellite navigation).

Depth of water: 3619 meters (corrected).

Total penetration: 923 meters.



SITE BACKGROUND AND OBJECTIVES

Seismic reflection profiles across the Labrador Sea by *Vema*-19 and *Charcot*-5 have revealed a rugged basement topography almost entirely buried by sediments up to 2000 meters thick (Drake, Campbell, Sander and Nafe, 1963; Le Pichon, Hyndman and Pautot, 1971). A valley in the basement runs approximately down the center part of the central Labrador Sea, but south of Greenland it runs E-W nearer to the Greenland shelf. It was first suggested by Drake *et al.* (1963) that this was the median valley of a mid-Labrador Sea ridge where oceanic crust was generated during the last phase of opening of the Labrador Sea but which is now virtually inactive and covered by sediment.

Magnetic survey data by air (Godby, Baker, Bower and Hood, 1966) and by sea (Manchester, 1964; Mayhew, 1969; Avery, Vogt and Higgs, 1969; and Le Pichon *et al.*, 1971) have shown that a symmetrical pattern of magnetic anomalies exists on either side of the median valley. Both valleys and anomalies are offset by a number of fracture zones trending NE-SW. South of Cape Farewell, the magnetic pattern bends sharply to run N-S parallel to the mid-Atlantic Ridge.

The geophysical data has been interpreted by Mayhew (1969), Johnson, Vogt and Schneider (1971) and Le Pichon *et al.* (1971) in terms of the separation of the Greenland and Labrador tectonic plates in various stages. All agree that spreading is no longer active but Mayhew concluded that spreading stopped about 65 million years ago, whereas Le Pichon *et al.* and Johnson *et al.* arrived at a figure of 49 million years before a very substantial slowing down, stopping perhaps at 20 million years. These differences arise mainly from the identification of a group of prominent magnetic anomalies which are best mapped south of the median valley. In Figure 1, the prominent positive anomalies are indicated and the correlations are confirmed by further data from Avery *et al.* (1969). Magnetic profiles across the area from *Vema*-17 (Mayhew, 1969) and *Charcot*-5 (Le Pichon, *et al.*) are shown in Figures 2 and 3. The principle objective of a hole at Site 113 was, therefore, to date the latest phase of opening of the Labrador Sea by dating basement near this prominent anomaly pattern.

The choice of a site where basement could be dated by sampling sediments that were believed to be the same age as the basement was difficult. Two seismic reflection profiles were available prior to Leg 12. *Vema*-17 profile was shot in 1961 with explosive charges and basement reflections were very weak. *Charcot*-5 achieved greater penetration with the Flexotir system, but it was difficult to distinguish basement from the deeper sedimentary layers. Both profiles showed substantial sediment thickness over most of the basement. Site 113 was eventually chosen in a local valley 8 kilometers south of a small knoll believed, from the *Vema*-17 record, to be a basement high. It was hoped that the

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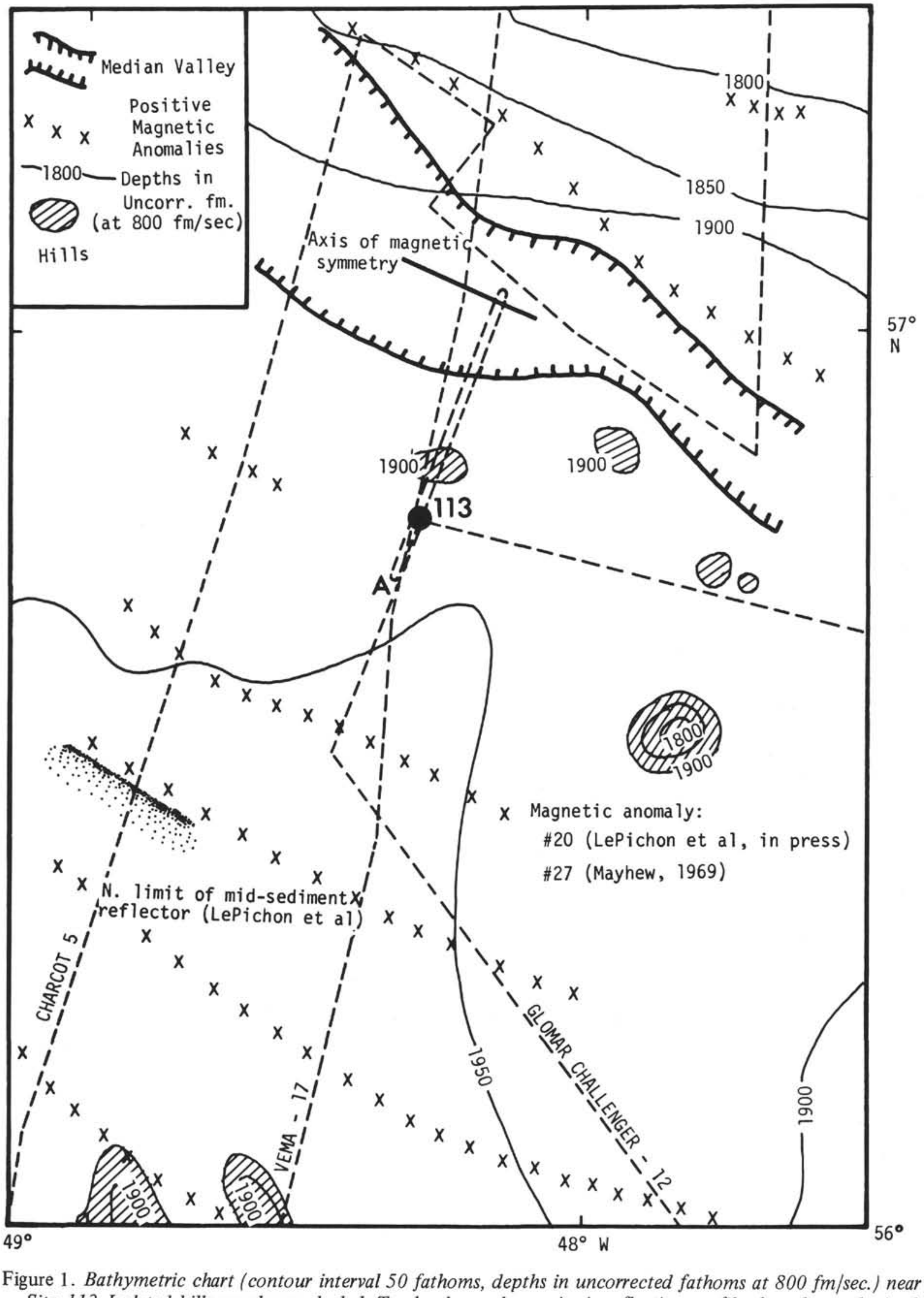

Figure 1. *Bathymetric chart (contour interval 50 fathoms, depths in uncorrected fathoms at 800 fm/sec.) near Site 113. Isolated hills are shown shaded. Tracks show where seismic reflection profiles have been obtained. Location of buried median valley and prominent positive magnetic anomalies are indicated.*

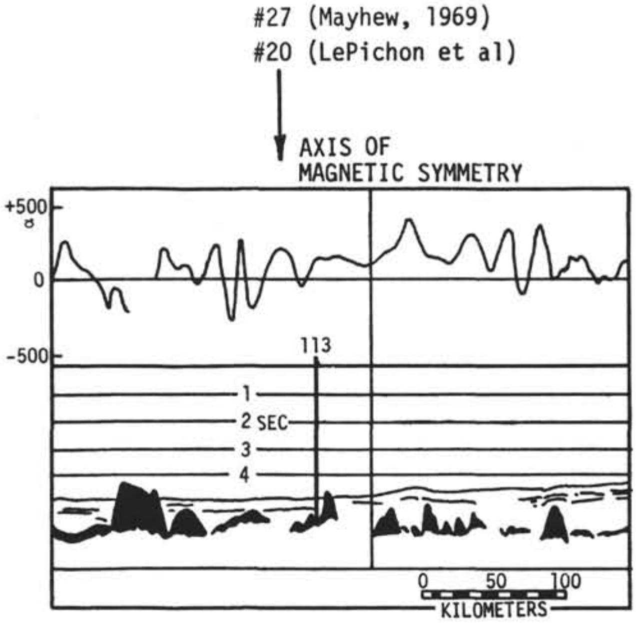

Figure 2. *Seismic reflection profile across Site 113 by* Vema-*17 (from Drake, Campbell, Sander and Nafe, 1963) and magnetic profile (from Mayhew, 1969).*

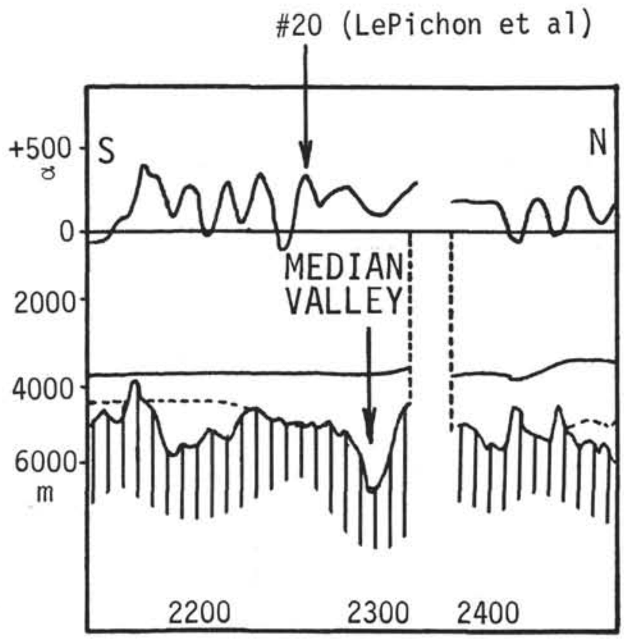

Figure 3. *Seismic reflection and magnetic profile west of Site 113 by* Charcot-*5 (from Le Pichon, Hyndman and Pautot, 1971) showing discontinuity of mid-sediment reflection in the vicinity of the buried median valley.*

sediments lying above basement in the valley would have been deposited shortly after the formation of the basement.

A second objective was to obtain more data on the initiation of glaciation in the Labrador Sea.

In summary, the objectives were:

(a) To sample and date the oldest sediments over basement and relate their age to the magnetic anomalies in the vicinity.

(b) To find and date the base of glacial-derived sediments.

SURVEY DATA

On the passage from Site 112, the seismic profile crossed a broad basement ridge at about 55.5°N, 47°W, which we believe to be part of the NE-SW fracture zone crossing the central part of the Labrador Sea. Northwest of this ridge, the basement got steadily deeper until it could no longer be seen on the record. At the same time, the transparent layer with a wavy top surface typical of the sediment body sampled at Site 112 thinned out and was overlain by a highly reflecting series of beds. The top surface of these beds was flat, but the lower beds were undulating. This may be due either to a buried wavy surface similar to that seen east of the fracture zone, or it may result from the progressive infilling of valleys, the draping of topographic highs and perhaps also differential compaction of the valley infill due to overburden pressures.

The course to choose a site suitable to achieve the objectives of the hole took us across the small hill which had appeared on the *Vema*-17 seismic profile as a basement high protruding through the sediment cover 20 kilometers south of the axis of the mid-Labrador Sea Ridge. We believed that a valley near this basement high would contain the sediments laid down soon after basement was formed thereby dating it. The northwards track showed such a valley between the hill and another buried high to the south. On this run any possible basement reflection was obscured by the first multiple of the bottom, which was subsequently removed by gating. We ran south across the features at 5 knots, once more locating the valley, then turned north to occupy a site in the center (Figure 1).

The reflectivity of the sea bed at Site 113 was considerably higher than that at Site 112, probably due to the high terrigenous content of the upper sediments. The record (Figure 4) showed numerous subbottom reflections down to about 0.5 second. Below this little could be seen except faint hyperbolic echoes from the buried high. Neither this buried high, nor the hill to the north gave the appearance of basement as seen in earlier profiles. Very little energy was reflected from these highs, which were outlined by an absence of the coherent reflecting horizons. The depth of the valley between the hills was estimated at about 1.0 second equivalent to about 900 meters using a mean velocity of 1.8 km/sec (derived from data in other holes). The lowest core at 860 meters showed a hard gray clay of Miocene age, and subsequent drilling to 927 meters did not encounter any major drilling break, before the hole had to be abandoned due to ship control problems. Hence, no *in situ* velocity checks were possible from the drilling data.

After recovery of the drill string, the ship steamed ESE on passage to the Reykjanes Ridge. Courses were chosen to define the limits of the sediment sequence drilled at Site 112, to cross the fracture zone and to cross the possible axis of the mid-Labrador Sea Ridge east of the fracture zone.

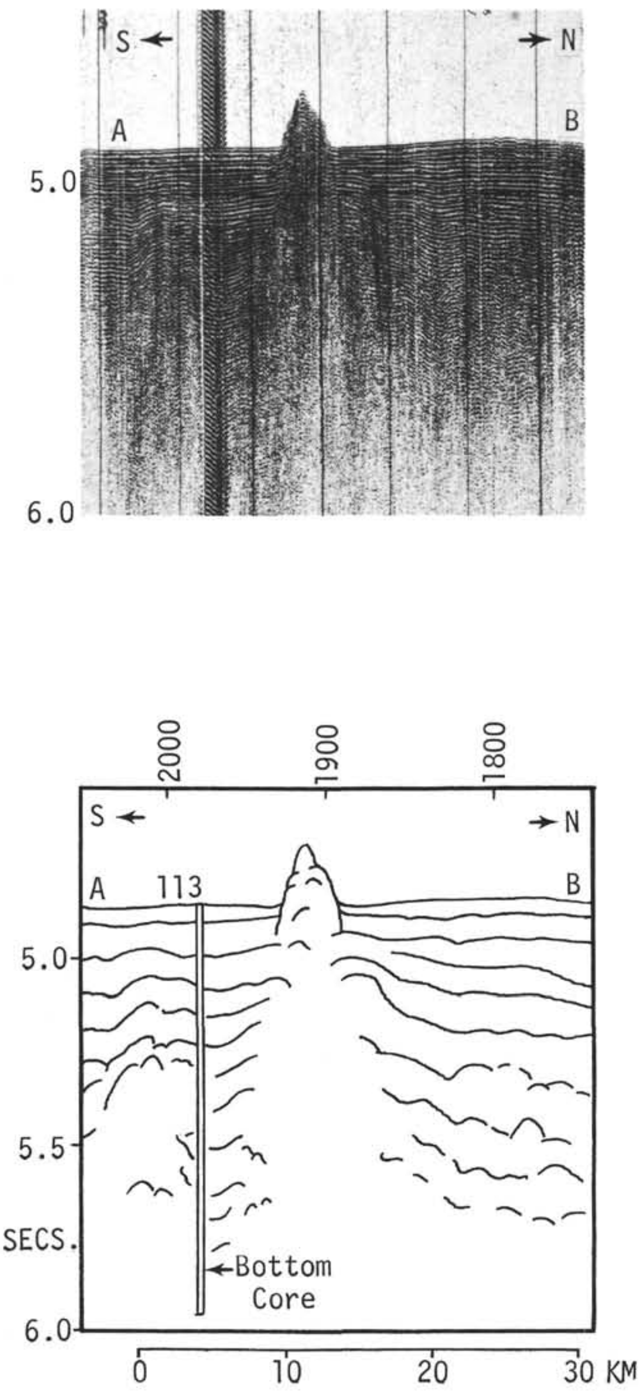

Figure 4. *Seismic reflection profile across Site 113 by* Glomar Challenger-*12 showing penetration achieved in Hole 113 in relation to hill to the north.*

Basement became visible on the records 70 kilometers from Site 113 where it was covered with a thin transparent sediment layer which eventually emerged from under the multi-layered flat sediments to form the wavy surfaced sea floor.

DRILLING OPERATIONS

The beacon was dropped and drilling operations began at 2130 hours on July 4th in a water depth of 3619 meters (3629 meters below drill floor). A Smith 3-Cone tungsten carbide insert bit was used beneath 7 drill collars and 3 bumper-subs.

The bottom was too soft to be felt by the drill string, and after 20 meter excess pipe was lowered, penetration into the bottom was demonstrated by the circulation pressure. The first core was cut at 50 meters below the sea bed with little resistance.

While running the sand line to recover the core, the bottom beacon failed. The drill string was rapidly withdrawn to the mud line while a new beacon was prepared and laid within an hour. A comparison of satellite positions on the old and new beacons showed a movement of 300 meters. Since only one core had been cut in the first hole, no new hole number was given to the second hole.

Cores were taken at 50-meter intervals down to 250 meters. Drilling was very easy and fast through silty clays, the top part of the section containing some glacial debris. While cutting cores, minimum pump pressure was used to avoid washing out the somewhat incoherent sediment. No drilling discontinuities were noticed at the reflecting horizons which were, however, rather poorly defined.

A core at 400 meters produced coarse sand and gravel, which threatened to close in on the drill when circulation was broken to take a core. Drilling remained extremely easy with circulation down to 630 meters when it started to stiffen up. Alternating bands of harder and less hard drilling were experienced between 630 and 670 meters. A core at 663 meters gave hard gray mudstone. After this, a center bit was dropped between cores which were taken at 50 meter intervals down to 860 meters. Some hard bands were met, but drilling remained fairly easy down to hole bottom, except while coring when the circulation was reduced. All the cores have a hard clayey mudstone–sometimes with thin siliceous bands, and at 863 meters a collection of erratic pebbles.

Since none of the cores so far had shown that we had progressed below the upper Tertiary, and time was running out, a bid was made to reach some kind of drilling discontinuity, whether it be basement (which was not defined acoustically) or the lower Tertiary, and to take a core at that point. A harder patch was reached at 902 meters but it was passed.

At 923 meters, the dynamic positioning system started to be troublesome and had to be put into the semiautomatic mode. On the advice of the Cruise Operations Manager, and in view of the time factor and of the uncertainty of how far below was basement, it was decided to withdraw from the hole. Progress had been getting slower and the cores recovered at that point had been so poor in nannoplankton and foraminifera as to be very difficult to date. With the increasing depth of hole, drilling problems also became more severe. The hole was terminated at 923 meters at 0300 hours, and all pipe was on board and stowed by 1245 hours on July 8th.

Twelve cores totalling 76 meters had been cut yielding 30.5 meters of sediment (40 per cent recovery).

LITHOLOGY

At Site 113, 923 meters of sediments were penetrated. These are mainly of terrigenous or of volcanic origin. They

TABLE 1
Cores Cut at Site 113

Hole	Core	Cored Interval (m, subbottom)	Core Recovered (m)
113	1	50-59	6.37
113	2	99-108	3.15
113	3	156-165	3.25
113	4	204-207	1.75
113	5	254-257	0.50
113	6	395-404	1.80
113	7	545-558	2.60
113	8	663-669	5.73
113	9	710-714	3.56
113	10	759-766	cc only
113	11	810-815	1.80
113	12	860-863	cc only

be divided according to their visual appearance into at least four sections. On the other hand, there are many similarities in respect to their mineral composition, except for the sand of Core 6 which is rich in heavy minerals. For instance, most of the sediments have in common a considerable, sometimes dominant, amount of volcanic minerals like glass, plagioclase, and their alteration products chlorite and zeolite. Palagonite, however, is only of some importance in the mudstone from Cores 8 to 12. The generally present angular pyroxene and hornblende may be mostly considered as volcanogenic; while quartz, which is common to dominant in all smear slides, scattered mica, heavy minerals and rock fragments must be derived from land sources, especially since from X-ray diffactometer investigations there has been found no proof for tridymite. Uncorrected sedimentation rate is very high at this site. It is approximately 10 cm/1000 yrs in the Pleistocene Cores 1 through 4, and goes up to 35 cm/1000 yrs in the Upper Pliocene Cores 5 and 6.

The following sediment types, numbered from bottom to top will be described:

1) Upper Miocene to Mid-Pliocene more or less well-laminated mudstone from Cores 8 to 12.

2) Pliocene, mudflow breccia from Core 7, Section 2 with reworked Eocene to Pliocene nannofossil clay and ooze.

3) Mid-Pliocene, silty heavy mineral-rich turbidite sand from Core 6.

4) Upper Pliocene to Pleistocene, silty clay and clayey silt with a variable content of micro and nannofossils from Cores 1 through 5.

Upper Miocene to Mid-Pliocene Mudstone

These cores consist of a dark brownish-gray to black, more or less finely-laminated silty mudstone or clayey silt stone and smooth mudstone (Plate 1). The graded laminae are approximately 0.5 to 1.0 millimeters thick (several well-laminated portions were counted), consisting of light gray basal silt bands with a sharp lower boundary passing upwards into a clay band. There is some synsedimentary miniature faulting observable. Depressions caused by down-thrusting are filled up with crossbedded silty mudstone. Convolute lamination is quite common in some portions, especially in Core 8, Section 2. The convolute portions of 1 to 5 centimeters thickness are overlain by very regular horizontal laminae. Throughout the whole mudstone sequence there is little evidence of mud inhabiting benthos except for a few pyritized or chloritized burrows, the latter filled with iron oxides.

Judging from approximately 40 smear slides and 10 freeze-dried, impregnated thin sections, the mudstone sequence consists—except for dominant clay minerals (including a rather high percentage of chlorite)—mainly of detrital quartz. Feldspar, mainly plagioclase, is rare to abundant. It generally has a fresh appearance but is chloritized and apparently also zeolitized in some cases. Volcanic glass is rare to common in practically all samples and partly devitrified. Palagonite is rare to abundant in only 12 slides while zeolites are rare to abundant in most slides. They can be found as separate small crystals or growing within altered glass and palagonite. Pyrite and authigenic carbonate are common in all samples. In some light gray silt layers of Core 11, carbonate is dominant.

As typical accessory minerals goethite, heavy minerals and mica flakes should be mentioned. A coarse-fraction sample from the core catcher of Core 10 reveals 90 per cent quartz and 5 per cent mica together with pyrite, 5 per cent hornblende, and other heavy minerals and a few planktonic foraminifera. The composition of some freeze-dried, impregnated thin sections are noted in the Core Summary Sheets. It can be seen quite clearly that the lamination is due to nothing but grain size sorting. In many cases lamination is emphasized by interstitial or nodular pyrite and iron oxides. In general the light gray bands consist mainly of detrital quartz, feldspar and zeolite, with a considerable amount of glass. Some of these bands, especially in Core 11, are made of predominantly authigenic carbonate.

As for the organogenic content, it can be observed that in most samples coccoliths are usually rare, partly abundant, and more or less corroded or disintegrated. Coccoliths are usually rare if the percentage of authigenic calcite is high, proving that the carbonate was precipitated from dissolved coccoliths. Planktonic and a few benthonic foraminifera or their corroded fragments can be observed in a few samples of Cores 7 and 8 as well as of Core 11. Some pyritized diatom fragments were found only in two samples of Core 7 and more of them in the core catcher of Core 10. Sponge spicules are abundant only in one sample of Core 11.

D. Wall (W.H.O.I.) reported that there are quite a few dinoflagellates and reworked spores as well as pollen and some plant debris in several samples. The spores and pollen represent a mixed assemblage from Permian to Late Tertiary.

W. Deuser (W.H.O.I.) made available some measurements of the relative enrichment of O^{18} and C^{13} (δO^{18} and δC^{13} as defined in Culkin (1965)) which are listed in Table 2.

TABLE 2
δO^{18} and δC^{13} Determinations on Samples from Site 113

Sample	Depth (m)	δO^{18}	δC^{13}
12-113-8-2, 81 cm	665	1.0	-2.6
12-113-8-2, 131 cm	665	1.8	-2.1
12-113-9-1, 106 cm	711	-0.8	-5.3
12-113-9-2, 80 cm	712	-0.8	-4.8
12-113-11-2, 25 cm	812	+0.1	-7.5
12-133-11-2, 106 cm	813	+1.3	-8.9

These results can be interpreted to mean that the mudstone sequence was ponded in an anaerobic or at least partly anaerobic depression between some hills in a rugged basement area of the Labrador Sea with hardly any bottom life except for anaerobic bacteria and a few burrowing organisms.

Lamination of a deep-sea sediment going along with convolute and crossbedding is usually explained as the result of sedimentation in the distal part of a turbidite. If this scheme were applied here, there should be at least some coarser layers with a higher content of heavy minerals and some grading in a larger scale than 0.5 to 1 millimeters. There should also be a much higher mineral diversification between samples from various parts of the mudstone sequence.

It seems most likely that the mudstone is a product of sediment ponding of the nepheloid layer of a contour current, an explanation which is gaining more ground as more data about the phenomenon of close to bottom sediment transport in the nepheloid layer is collected.

We know that various sediment ridges in the North Atlantic, like the close-by Eirik Ridge, are building up by the activity of Arctic bottom water currents. Yet it is obvious that the current velocity decreases rapidly within deep depressions of the sea floor. Air gun profiler records have proven the existence of such a pre-Miocene depression in the region of Site 113. Only grains up to silt size can be transported under these conditions, and they will settle out of the nepheloid layer as silt at a certain critical current velocity. Slight meandering, or just further decrease of flow velocity, will cause the clay fraction to settle on top of the silt bed, and this mechanism can be repeated over and over, piling up hundreds of meters of more or less laminated mud in a depression with anaerobic conditions until the depression is filled up. Diagenetic processes in a slightly reducing environment, with authigenic mineralization, will turn the mud into a mudstone.

The remarkably high content of volcanogenic minerals, together with detrital quartz of the same grain size in the area of what was, at that time, an extinct mid-ocean ridge can be easily explained. The Artic undercurrent came and is still coming out of an area northeast of Site 113 where ocean basalts are exposed on the sea floor over a large area, where volcanic ash rained into the sea over a long time (from Iceland, for instance) and where, on the other hand, detrital quartz and other detrital minerals together with Permian and younger plant remains are supplied from reworked East Greenland sandstones, metamorphic and igneous rocks.

Mid-Pliocene Mud Flow Breccia

In the lowermost part of Section 2, Core 7 the erosional contact between the mudstone sequence and a mud flow has been exposed (Plate 2). This section consists of: alternating 10 to 15 centimeters thick "layers" of mixed Eocene and Pliocene gray-green coccolith clay; and, breccia "layers" of similar thickness composed of light and dark, angular to flattened clasts, up to 0.5 centimeter across, of Eocene, Oligocene, and Pliocene age in an ill-sorted clayey matrix, which again contains many heavy minerals, much glass and plagioclase, partly altered to phillipsite and chlorite.

The contacts between the mixed clay and breccia are sharp, generally horizontal, sometimes angular and dipping. Also, sand coating can be observed on the clay layers suggesting that they may in fact be boulders similar to coated mud balls.

In ten smear slides taken from clasts and matrix, quartz is common or dominant, and some pyroxene and hornblende also was observed. There is no palagonite, but a lot of zeolite. Beside coccoliths there are some partly corroded planktonic foraminifera and a few pyritized diatoms. A coarse-fraction sample from a clast, Section 2 (90 centimeters), reveals 70 per cent mica and 30 per cent quartz. At 140 centimeters of Section 2, the residue is 60 per cent planktonic and a few benthonic foraminifera, 30 per cent mica and 10 per cent quartz.

Section 1 of Core 7 consists of a gray silty or sandy clay matrix with clasts (up to 2 centimeters) of reworked Eocene, coccolith clay and ooze. The lower part has an increasing amount of glass and phillipsite. The only planktonic foraminifera are heterohelicids. From the rarity of quartz and the high percentage of nannofossils, making a carbonate content of up to 60 per cent, it can be concluded that the reworked Eocene clasts are a pelagic sediment which was laid down in the deep sea.

The reworked clasts from Core 7, Section 1 and 2 could consequently be derived from nearby topographic highs, where they might have been eroded as a result of high speed turbidity currents first reaching this area. It is suggested that such turbidity currents are associated with the onset of glaciation, accompanied by strong sea level changes. The base of the glacial sediments would then be between Cores 7 and 8 (ie., between 550 and 665 meters) although nannofossil evidence suggests that the core catcher of Core 7 penetrated pre-glacial sediments.

Mid-Pliocene Turbidite Sand

This is a slightly silty coarse to fine-grained sand, consisting mainly of quartz (up to 70 per cent, many grains well rounded), much plagioclase, some orthoclase and mica, fragments of metamorphic rocks (including hornblende gneiss) and basaltic rocks, and between 10 and 25 per cent heavy minerals. Shell fragments are not uncommon. Results of special heavy mineral investigations are not yet available but amphibole, garnet, opaque ore minerals, clinopyroxene and orthopyroxene are most frequent. Other minerals are rutile, titanite, apatite, epidote, staurolite, hornblende, biotite and ?tourmaline.

Organic components include reworked benthonic Tertiary foraminifera, fragments of Pliocene-Pleistocene molluscs from shallow water, such as *Cyprina* cf. *islandica* (partly with algal borings), ? *Crepidula* sp. and many fragments of *Balanus,* a cirriped which lives in shallow water only.

From the observations it might be concluded that the sand was transported from a litoral environment into the deep sea by a turbidite mechanism. The shell fragments of shallow water organisms strongly support this interpretation, and the high concentration of heavy minerals could be explained by reworking of beach placers.

Pliocene-Pleistocene Silty Clays

All silty or clayey sediments from Cores 1 to 5 show a strong terrigenous influence as a result of turbidite activity and ice rafting. The volcanogenic components, which are present throughout, were probably brought into the region by currents. Intercalation of hemipelagic beds with a considerable amount of the remains of pelagic organisms is typical for this sequence. Nannofossils and planktonic foraminifera are present all over, but siliceous tests of radiolarians and diatoms and also sponge spicules are of some importance only in Cores 4 and 5.

The sediments from Cores 4 and 5 consist of gray, silty foraminiferal-nannofossil diatom radiolarian clay, and some sandy silt with a variable fossil content and heavy minerals. The planktonic and benthonic foraminifera are usually corroded by dissolution, and the percentage of nannofossils is usually not high. The core catcher sample of Core 5 contains planktonic Pliocene foraminifera and reworked benthonic Eocene foraminifera, such as *Virginulinopsis decorata,* an index fossil of the North European Eocene. Also, an echinoid spine was found. Quartz is dominant, feldspar rare, pyroxene and hornblende, other heavy minerals, glass, pyrite and authigenic carbonate are quite common in Cores 4 and 5. There are also some rock fragments in the graded turbidite layers, and zeolite is very rare.

Cores 1 to 3 are represented by partly laminated gray clayey silt, silty clay and silty turbidite sand with some nannofossil marls in Core 1. The mineral composition is very similar to Cores 4 and 5 especially in respect to the common heavy mineral content. Some glass was found from Section 4 of Core 1 downwards, palagonite is missing in Cores 4 to 7. Chlorite and zeolite are of some importance, partly replacing feldspar twins in Core 3. Thus, there can be made the same observation as in Site 112 and 114: that chloritization and zeolitization will start only under a minimum sediment cover, approximately 150 meters in this case. Coincidently, there are indications for onset of major ice-rafting by glacial pebbles only from this depth on to the top of the hole. However, sedimentation rate, glaciation and age appear to be less important factors to start zeolitization and chloritization than the burden of overlying sediments resulting in a certain degree of compaction and a certain interstitial water chemistry.

Planktonic foraminifera are common throughout these top three cores and, in part, severely corroded. Diatoms and Radiolaria seem to have been dissolved before reaching the sea floor, and sponge spicules are present only in a few samples.

PHYSICAL PROPERTIES

The low average recovery (40 per cent) and generally disturbed nature of the widely spaced cores only allow a description of the most obvious variations of physical properties. The most disturbed sections (113-1-1, 113-1-2, 113-4-1, and 113-7-1) have aberrant low densities and these were allowed for in drawing trend lines on the density, impedance and porosity plots. The density of Core 9 is apparently low on the site plot due to the fragmented nature of the core.

Density increases steadily with depth from 1.6 gm/cc (glacial clays) to 2.05 gm/cc (laminated mudstones). In detail, various sandy, silty or shaly beds show up as denser features as in 113-1-5, 113-2-2 and 113-4, respectively. Graded bedding is indicated in Cores 2 and 3 by linear density gradients over distances up to about 1 meter. The available velocity data also indicate an increase from 1.5 to 2.0 km/sec over 800 meters.

Natural gamma activity is fairly high in all the cores and generally exceeds 1000 counts. The relatively low activity of Core 4 (up to 1200 counts), which two spot samples indicate has no more than 10 per cent carbonate, probably reflects the high proportion of nonradioactive organic silica in this core. An association of high mica content with high gamma activity is likely since, besides the potassium in biotite and muscovite, biotite often contains inclusions of radioactive accessory minerals. Cores 8 and 9 exhibit the highest values (up to 2400 counts) of the hole, and these values seem to be associated with dark laminated mudstones which contain the highest proportions of mica found in the X-ray samples of this site (40 and 48 per cent, respectively). Core 11 is a similar laminated mudstone but according to the lithologic core summary it is gray (that is, less dark), and X-ray measurements show it to contain only 16 per cent mica which may explain its lower activity of up to 1400 counts.

Depth of Reflectors

About six seismic reflectors were identified on the air-gun records collected around Site 113, but due to a lack of data no correlations of these reflectors with measured changes in acoustic impedance nor a determination of mean sediment velocity are possible.

PALEONTOLOGY AND BIOSTRATIGRAPHY

General

Twelve cores were taken at Site 113. The hole terminated at 923 meters in sediments of Late Miocene or Early Pliocene age.

The first seven cores (to a depth of 559 meters) recovered sediments of turbidity current origin; these turbidites are, in turn, related to the Late Pliocene and Pleistocene glaciation of adjacent land masses. Core 7 contains Eocene and Oligocene sediments intercalated in the Upper Pliocene turbidite sequence. The remainder of the cores (8 through

12) consist of indurated micaceous silty mudstones with relatively small planktonic foraminiferal faunas (globigerinids). Calcareous nannofossils are the primary basis for age determination in this sequence of rapidly deposited sediments. Diatoms are present in many samples in varying amounts.

Discussion

The general foraminiferal faunal associations are shown in Figure 5.

Foraminifera

Pleistocene

The Pleistocene is about 200 meters thick at Site 113. The boundary between the Pliocene and Pleistocene is placed within Core 4 on the basis of calcareous nannoplankton (see report in this section). Cores 1 through 4 contain a planktonic foraminiferal fauna characterized by *Globigerina pachyderma* (sinistral), *G. bulloides*, and rarely, *Globorotalia inflata*. Typical benthonic elements include *Melonis pompilioides, M. barleeanum, Cibicidoides pseudoungeriana, C. cicatricosa, Pyrgo murrhyna, Eponides umbonatus, Eponides tener, Planulina wuellerstorfi, Planulina bradii, Eggerella bradyi, Epistominella exigua, Uvigerina hollicki,* and *Laticarininina halophora.* Planktonic foraminifera are extremely rare in Core 3 (156 to 165 meters), and probably indicate severe climatic conditions.

Pliocene

Core 4 (200 to 209 meters) and Core 5 (254 to 257 meters) are characterized by an extremely high quartz content and the presence of a single planktonic foraminiferal species referred to here as *Globigerina atlantica.* This is the same form as that recorded from the Pliocene sediments of Sites 111 and 112. Specimens of this species bear a gross morphologic resemblance to *Globigerina pachyderma.* They differ, however, in being consistently larger, more robust, thicker-shelled, and in being more evolute. In Core 6 (395 to 404 meters), the fauna is less diagnostic. Small-and moderate-sized forms are assigned to *Globigerina pachyderma* and *G. atlantica; Globorotalia scitula* is a rare element. Both Cores 5 and 6 show evidence of having been deposited by turbidity currents (the presence of molluscan and echinoid shell fragments and displaced shallow-water benthic foraminifera). Core 7 (549 to 558 meters) contains a Pliocene fauna (*Globigerina atlantica*), and contains several layers of mud-flow derived sediments, in which globigerinids with reticulate wall surface (similar to *Globigerina galavisi, G. angiporoides, Pseudohastigerina*, and globigerinitids) indicate reworking of Upper Eocene sediments. Pliocene benthonic foraminifera are similar to those recorded from the Pleistocene above. Core 8 through 11 consist primarily of dark finer-laminated silty mudstone, which, with the exception of rare broken fragments of foraminifera, are essentially unfossiliferous.

? Miocene-Pliocene

Core 12 (860 to 863 meters) consists of silty micaceous mudstone with a few benthonic and planktonic foraminifera. Several specimens referable to *Globorotalia acostaensis* and by extrapolation, suggest that the age of the sediments at the bottom of the hole (923 meters) may be of Late Miocene age (see also report on calcareous nannofossils).

The low planktonic foraminiferal diversity in the Pliocene and Pleistocene at this site is probably a reflection of the turbidity of the water or the restricted nature of environment. Alternatively the more northerly location in the Labrador Sea and greater proximity to the influence of glaciation may have also played a role in the low diversity.

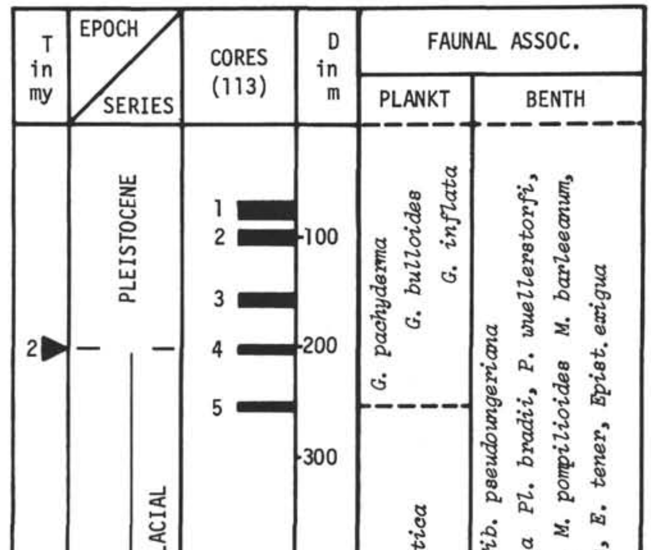

Figure 5. *Late Pliocene-Pleistocene foraminiferal faunal associations at Site 113 (Labrador Sea).*

Calcareous Nannoplankton

At Site 113, the coccolith assemblages are generally poor. Late Miocene?, Pliocene and Pleistocene are present. The Late Pliocene and Pleistocene are developed in glacial facies.

Pleistocene

The poor assemblage of Core 1 consists mainly of *Coccolithus pelagicus* and small coccoliths, few *Cyclococcolithus leptoporus, Helicopontosphaera kamptneri* and *Gephyrocapsa oceanica. Syracosphaera* sp. and *Rhabdosphaera clavigera* are only present in some of the sections. The samples from Core 2 and 3 are only little richer. Cores 3 and 4 include *Pseudomiliania lacunosa, Pontosphaera scutellum* and *P. disopera. Cyclococcolithus macintyrei* also occurs, but might be reworked, together with *Sphenolithus abies* and *Reticulofenestra* sp. *Coccolithus pelagicus* appears in varieties with a small opening, a bar or a central cross spanning over the opening. Of Core 4, only Section 1 is believed to belong to the Pleistocene.

Pliocene

The Pliocene-Pleistocene boundary was set within Core 4, above the highest occurrence of *Discoaster brouweri.* The coccolith assemblage is also poor in the Pliocene part of the hole. No *Scyphosphaera* or *Scaphelithus* was found. *Rhabdosphaera* occurs in a few samples, while *Syracosphaera* was found in some samples. Discoasters are extremely rare, probably due both to dilution by glacial clays and by primary reduced production at high latitudes. Reworked Eocene and Oligocene coccoliths occur in some samples. Of special interest in this regard is Core 7-2, as it contains "mudflow" sediments with components of Eocene and Oligocene age in Pliocene sandy clays. Figure 6 shows the samples examined from this core and the age diagnostic coccoliths found in them. Generally the dark, clay-parts contain more Pliocene coccoliths than Paleogene forms, while in the brecciated layers there are more Paleogene coccoliths present. Some of the components in the breccia are barren, while especially the light ones contain Eocene and Oligocene coccolith assemblages.

The contact between the layers of silty clay and the layers with clay-pebbles (breccia) is rather sharp. The matrix of the latter tends to be more sandy at the base of a layer, especially in the lower part of the section. No graded bedding was visible otherwise. The flat components are up to 18 millimeters in diameter. The core above this one, 7-1, consists of Pliocene sandy clay with only a few Eocene clay pebbles. They are up to 20 millimeters in diameter and are also flat. This section is disturbed by drilling. The core catcher of Core 7 contains a richer Pliocene assemblage, including *Ceratolithus* sp., *Discoaster surculus, D. variabilis* and *Reticulofenestra pseudoumbilica.* It is therefore suggested that it represents preglacial Pliocene. The "mudflow" of 113-7-2 might thus mark the beginning of glaciation. The rest of the Pliocene (Cores 8 to 11) is again represented by a poor assemblage of *Coccolithus pelagicus, Cyclococcolithus leptoporus,* occasionally *C. macintyrei, Helicopontosphaera kamptneri, H. sellii, Pontosphaera scutellum* and *P. discopora.* Discoasters and sphenoliths are rare, as well as rhabdoliths. Most samples contain reworked Oligocene or Eocene coccoliths in minor quantities, and only long-ranging Pliocene forms, not permitting a zonation of this interval.

Pliocene? – Miocene?

The lowermost core (Core 12) contains an assemblage with discoasters similar to *D. bollii*, sphenoliths, *Coronocyclus* sp. and *Reticulofenestra pseudoumbilica.* It might represent mid- to late Miocene; however, the evidence for this age assignment is weak.

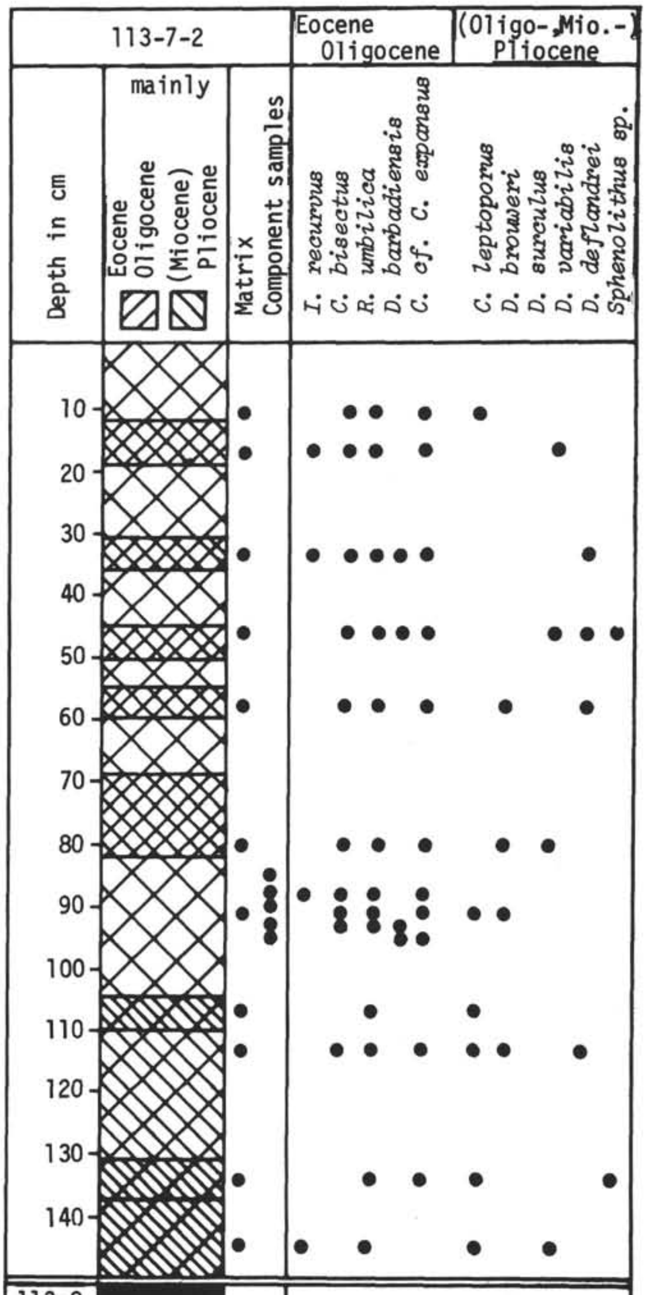

Figure 6. *Distribution of coccoliths in 113-7-2 note reworking of Eocene-Oligocene elements in Pliocene sediments.*

Oligocene – Eocene

Although Core 12, as the deepest core, is of questionable Miocene age, the deposition of pelagic Oligocene and Eocene near the site drilled is probable. The "clay-pebbles" in the Pliocene breccia of Core 7-2 contained Oligocene and

Eocene assemblages. The Eocene assemblages are similar to the Danish flora of the same age, including *Naninfula deflandrei.*

The Oligocene assemblage is similar to the one met at Site 112 and rather poor in species. The region of original deposition of these pelagic Paleogene sediments probably was on the basement high just beside the valley in which Site 113 was drilled (see seismic profile Figure 4).

Radiolaria

Radiolarians from Hole 113 are present only in Cores 1, 4, 5, 6 and 7 where they are very rare as a result of their dilution due to the extremely high clastic sedimentation rates discussed below. The meager assemblages include representatives of the typical Late Tertiary high latitude species present at other Leg 12 sites. No age diagnostic species are present.

Radiolarians from Core 1 are dominated by *Theocalyptra davisiana* (Ehrenberg), but include *Stylodictya validispina* Joergensen, *Spongopyle osculosa* Dreyer, *Phorticium pylonium* (Haeckel?) Cleve, *Spongodiscus* spp., *Actinomma* spp., and *Artostrobium miralestense* (Campbell and Clark).

Core 4 is dominated, in order, by *Spongopyle osculosa* Dreyer, *Spongodiscus* spp., *Druppatractus irregularis* Popofsky, and *Actinomma* spp. Also present are ellipsoidal, thick-walled, siliceous cysts (?) which according to Riedel (personal communication) may be parts of sponge skeletons, but Huang (1967) suggested that these are radiolarians and described one form which he named *Hataina ovata* Huang. This form plus several others (four or five) are present at other Leg 12 sites and have been recorded simply as siliceous cysts. They do not appear to have undergone any significant evolutionary changes, but in many samples they contribute notably to the total biogenous silica.

Only a few spongodiscids and siliceous cysts are present in Core 5, which is of doubtful Pliocene age.

The rare radiolarian assemblage from Core 6 is dominated by *Druppatractus irregularis* Popofsky and also includes a few specimens of *Spongodiscus* spp., *Actinomma* spp., and *Theopilium* (?) sp.

On the basis of the nannofossil evidence it has been established that sediments of Eocene age were reworked (transported *en masse* ?) into the Pliocene section of Core 7. Three specimens of *Theocalyptra davisiana* (Ehrenberg) were recovered from an autochthonous Pliocene mudstone layer. However, no biogenous silica was encountered from an autochthonous Eocene intraclast, but a fair number of dinoflagellate cysts were observed. Also present in the latter are some pollen(?) grains and opaque (pyritic?) spheres of possible biological origin.

No radiolarians were encountered in the remaining cores from Hole 113. Examination of the meager residues of samples from Cores 9 through 12 revealed the presence of a fair amount of organic matter, mostly carbonaceous, in some instances with reticulate structures preserved. This material probably had a terrigenous source. One scolecodont jaw was found in a sample from Core 12.

ESTIMATED RATES OF SEDIMENTATION

The Pliocene-Pleistocene (approximately 2 million years) boundary is placed at about 200 meters (within Core 4). This gives an average rate of sedimentation of 10 cm/1000 yrs for the Pleistocene (Figure 7).

On the assumption that Core 7 (at about 550 meters), containing the oldest sediments of turbidity current origin, heralds the onset of glaciation at this site, an estimate of 3 million years is made for this level. An average sedimentation rate (shown in parentheses because of the tenuous nature of the calculation) of 35 cm/1000 yrs is then obtained for the glacial Pliocene.

The very high sedimentation rate in the glacial Pliocene and the evidence of Core 7 could indicate that a portion of the sediments is derived from mudflows rather than from normal turbidite sedimentation, even under a glacial regime. Despite the poor base for the calculation of these rates, we can observe a very high rate of sedimentation throughout the entire section, which contains no pelagic ooze, except for the Oligocene and Eocene components in the Pliocene breccia. We might therefore reconstruct the sedimentation around this site as follows:

From at least Middle to mid-late Eocene up to the Oligocene and perhaps even early Miocene, sedimentation of calcareous ooze occurred. Tectonic movements between the Oligocene and mid-late Miocene may have created the hill and the valley in which the hole was drilled. Sedimentation into the valley started then and still continues, including mostly clastic sediments deriving from southern Greenland (?) with only a small pelagic component. Mudflows occurred and turbidity currents also reached the place.

Due to the relatively uniform lithology and uniformly increasing density with depth at this site, it is possible to correct the observed average sedimentation rate of 18.3 cm/1000 yrs for the effects of natural consolidation (Chapter 2) using an average density gradient of 0.00068 gm/cc/m. The corrected rate is 23.2 cm/1000 yrs.

DISCUSSION

Introduction

Twelve cores totalling 76 meters were taken at this site; 30.5 meters of sediment were recovered. The hole terminated at 923 meters due to dynamic positioning trouble, the bottom core being at 863 meters in ?Miocene sediments. The site is located just south of a topographic high thought to be part of the south side of the median valley of the mid-Labrador Sea ridge; the lower part of the hole is in a valley between this high and a buried high to the south.

The sedimentary sequence is characterized by a high proportion of terrigenous sediments derived by turbidity currents. Rapid rates of deposition in an anaerobic deep-sea basin may have been responsible for the fact that the lower part of the stratigraphic column is essentially unfossiliferous.

Lithology

Site 113 was the locus of deposition of over 900 meters of Late Miocene to Pleistocene terrigenous sediments. The upper 550 meters are related to Late Pliocene-Pleistocene glaciation and consist of silts, sands, clays and abundant rafted pebbles. The lower part of the sequence consists of laminated mudstones and siltstones. The origin of much of the sequence is attributed to turbidity currents derived

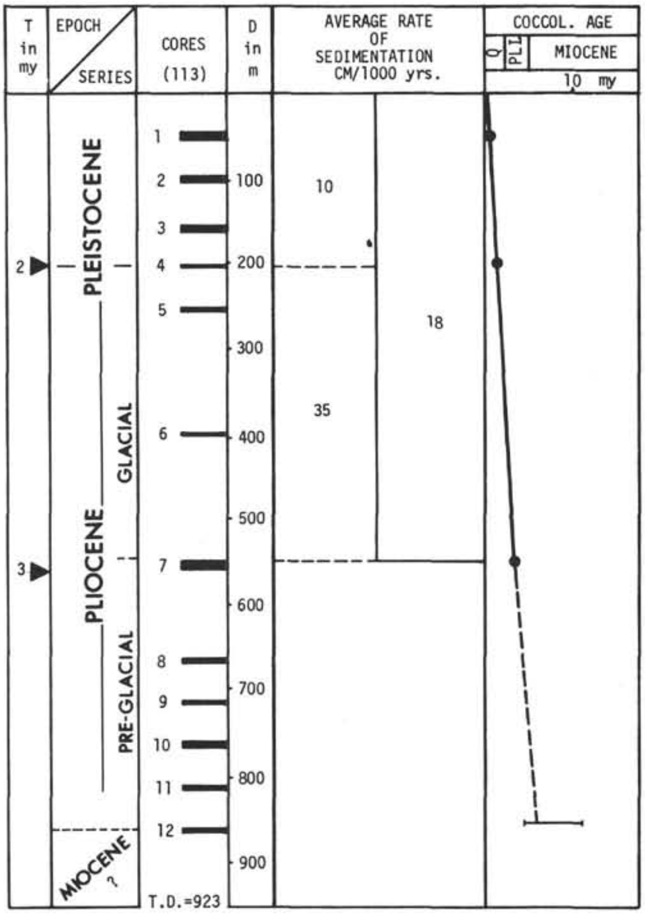

Figure 7. *Average estimated rate of sedimentation at Site 113 (Labrador Sea).*

from Greenland and Labrador. Sediments of the lower half of the hole were trapped within the confines of a narrow valley which was probably anaerobic during the deposition of the lower turbidite sequence.

Of particular interest is a mudflow sequence found in Core 7 (at about 550 meters). Alternating layers of gray-green micaceous clay and "breccia" layers (each 10 to 15 centimeters thick), composed of light and dark angular to flattened clasts (up to 0.5 centimeter across), contain reworked coccoliths as old as Eocene. The sedimentary sequence has been explained as the result of stripping of exposed Eocene to Pliocene sediments on the nearby hill which might be topped by uplifted early Tertiary sediments.

The mudstone sequence over 300 meters thick (from 550 to 863 meters) exhibits a distinct laminated pattern with an average thickness of a single lamina of less than 1 millimeter. The sequence may have been the result of periodic deposition from the distal parts of turbidity currents, or from nepheloid layers associated with bottom currents.

Basement Age

The first objective of this hole—to determine the age of the basement near the axis of spreading of the Labrador Sea—was not achieved. Contrary to ideas previous to drilling, we do not now believe that the hills protruding above the ponded sediments are igneous basement. The reflections from the hill immediately north of Site 113 and from below the stratified sediments are not strong enough to be igneous basement. Indeed on the *Glomar Challenger* seismic profiles, the base of the stratified layers was determined from an absence of reflectors, and the existence of a basement topography was inferred from the warping of the stratified layers above. The bottom of Hole 113 penetrated well into the valley between the hills and yet produced sediments no older than ?Miocene. If igneous basement was close beneath, the age of the oldest sediments at the site would be Late Miocene (10 million years) which would conflict with the interpretations of Le Pichon *et al.* (1971) and Mayhew (1969) based on magnetic chronology.

However, some clue to the tectonic development of the region can be gained from the brecciated mud flows recorded in Core 7 at 550 meters. Clasts of Oligocene and Eocene pelagic sediments were contained in a matrix of Pliocene clay. These are believed to have been derived locally from the erosion of the nearby hill by turbidity currents from the continental margin triggered off under the low sea level conditions of the early glacial period. Upstanding parts of the hill during the late Pliocene, therefore, must, have had exposures of Oligocene and Eocene sediments. The absence of appreciable quantities of displaced Miocene sediments in the breccia suggests that tectonic activity in the Oligocene (say 30 million years ago) uplifted the central region of the Labrador Sea exposing both Oligocene and Eocene pelagic sediments (Figure 8). Similar tectonically produced ridges, not so deeply buried by sediments, are seen some 300 kilometers to the east either side of the median valley (see Chapter 20). On the outer flanks of these asymmetrical ridges there is an uplifted and tilted transparent sediment layer.

Le Pichon *et al.* note a prominent reflector R which is found throughout the Labrador Sea at about 400 meters below sea bed, but which disappears in the zone 60 kilometers to either side of the median valley. The lack of continuity of this reflector in the central zone may be the result of this tectonic activity. If this is the explanation, then reflector R must be dated as early Oligocene or pre-Oligocene.

However, it is also possible that this tectonism was accompanied by volcanicity in the central axis which gave rise to a change in chemical composition in the water and, hence, to a change in the chemical and physical properties of the sediments resulting in reflector R, which would only be detectable where the sediments were still flat lying. A somewhat similar reflector was found in the extensive sediment body 200 kilometers southeast of Site 113, and which was sampled at Site 112. It was here found to be Lower Oligocene and associated with increased pyritization and recrystallization in an otherwise unchanging lithology. Although the mechanism of deposition of the sediments at Site 112 differs from that at Site 113, chemical changes in the sea water resulting from tectonism and volcanism could "label" the Oligocene sediments over a widespread area regardless of how they were deposited.

We have no direct evidence of what lies beneath the sediments sampled at Hole 113. If the oldest sediments in the region are Middle to Upper Eocene as sampled in the

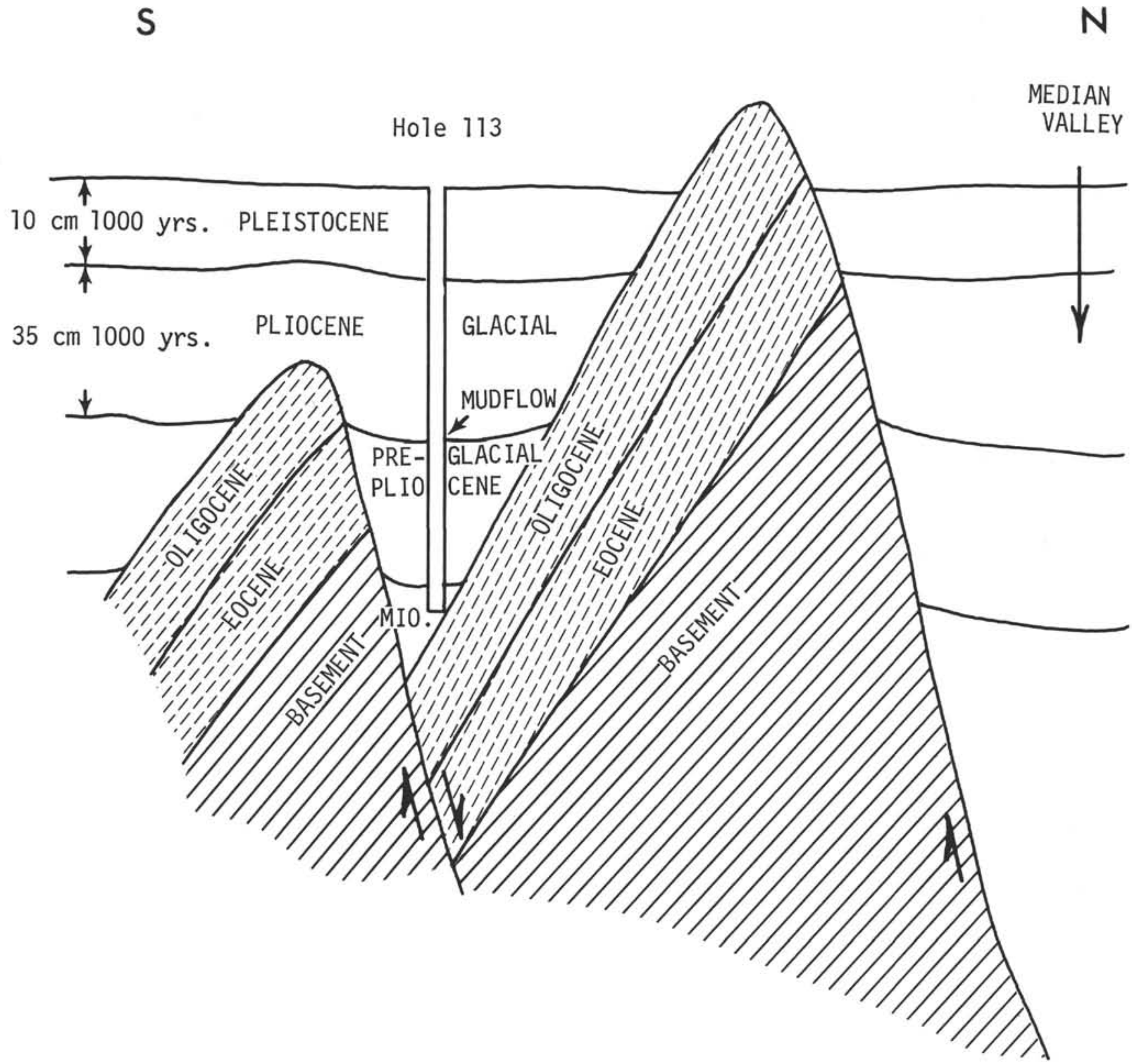

Figure 8. *Diagrammatic interpretation of sedimentary and tectonic history at Site 113.*

breccia, then the basement is at least 45 million years old, consistent with the magnetic anomaly age of 47 million years for the site based on Le Pichon *et al.* anomaly identification. If, on the other hand, considerably older sediments exist there which have not been sampled, these could support an early Paleocene age as suggested by Mayhew (1969).

However, an analysis of the magnetic anomaly pattern of the whole Labrador Sea in relation to the North Atlantic, discussed in Chapter 20, supports the theory that spreading effectively ceased in the Labrador Sea 47 million years ago in the Middle Eocene, and therefore by chance the oldest sediments were in fact sampled.

Sedimentation History

From Middle Eocene, when the basement was probably formed during the last phases of sea floor spreading in the Labrador Sea, until the Oligocene tectonic upheaval, pelagic sediments accumulated at the site with a rate probably not very different from the normal pelagic rate of 1 cm/1000 yrs since the site would have been on a mid-ocean ridge type of structure.

During the Oligocene, the tectonism may have created and raised the valley of Site 113 higher than neighboring valleys (for example, the deeper median valley to the north may have been formed at this time), and sedimentation throughout the 20 million years of the Miocene may also have been relatively slow. In the late Miocene, the progressive burial of the topography in the Labrador Sea may have reached the level of the Site 113 value and made it accessible to bottom current transported sediments. Throughout the pre-glacial Pliocene, laminated sediments were ponded into the valley in an area of restricted water circulation, as suggested by the anaerobic conditions discussed in the lithological description. Nepheloid layers from contour currents, or the distal parts of turbidity currents may have provided the sediment. If the Miocene-Pliocene boundary is assumed to occur at 850 meters, then the sedimentation rate in the pre-glacial Pliocene is 15 cm/1000 yrs.

With the onset of glaciation and the associated fall of sea level, intense turbidity current activity from the surrounding continental margins increased the sedimentation rate to 35 cm/1000 yrs. Some of these washed against upstanding hills and eroded older sediments, depositing the mixed breccias of Core 7, and the coarse sands of Core 6, in which shallow water mollusc fragments were found.

The presence of a normal bathyal benthonic microfauna in the cores above 550 meters and the virtual absence of any benthonic microfauna below this depth suggest that the deep water circulation pattern may have been radically altered at about this time. The essentially stagnant, anaerobic conditions associated with the pre-glacial mudstones and silts below 550 meters may well have been replaced by oxygenated bottom currents as a result of more vigorous circulation patterns (sinking of cold, dense surface water) brought about by the initiation of glaciation in this region.

During the Pleistocene, a lower but still high sedimentation rate of 10 cm/1000 yrs possibly reflects the dwindling source of supply of the terrigenous sediments as the continental shelves were cut progressively deeper.

A considerable contribution to the sediments today may come from the deep water circulation and its associated sediment load. The North Atlantic Deep water derives in part from Norwegian Sea water flowing over the Denmark Strait and along the continental slope off the east coast of Greenland (Mann, 1969 and Worthington, 1969). The currents turn to the northwest around Cape Farewell and in so doing deposit much of their sediment load to form the Eirik Ridge (Johnson and Schneider, 1969; Jones, Ewing, Ewing and Eittreim, 1970). Site 113 is just southwest of the Eirik Ridge (Figure 9). The deep water rotates anticlockwise around the Labrador Basin (Swallow and Worthington, 1969; Worthington and Wright, 1970), and Site 113 lies centrally between the northwest and southeast going currents (Figure 10). It is possible, therefore, that in this region the lower current velocities due to entrainment between adjacent water masses result in sedimentation that has contributed both to the Eirik Ridge and to the flatter areas southwest of it. Furthermore, a high sedimentation rate on the Eirik Ridge may lead to metastable sedimentary deposits which could, from time to time, produce local slumps and turbidity currents. These would transport some of the sediment to the abyssal plain around Site 113 via the submarine canyons that have been noted on the south edge of the Eirik Ridge.

The present day sedimentation appears therefore to derive from gravity controlled turbidity currents both locally derived from the Eirik Ridge and from the more distant continental margins, material suspended in deep water currents controlled primarily by salinity and temperature characteristics and originating in the Denmark Strait, from the glacial debris of melting icebergs, and from the biomass of the water above.

Evidence on the Base of the Glacially Derived Sediments

Because of the nature of the sedimentary process at this site it was not possible to achieve objective (b), namely to locate and date the base of the glacially derived sediment by paleontologic criteria. Although lithologic features suggests that the preglacial/glacial boundary lies between Cores 7 and 8 (between 550 to 665 meters), calcareous nannoplankton evidence indicates, in fact, that this boundary may lie within Core 7 (at approximately 550 meters).

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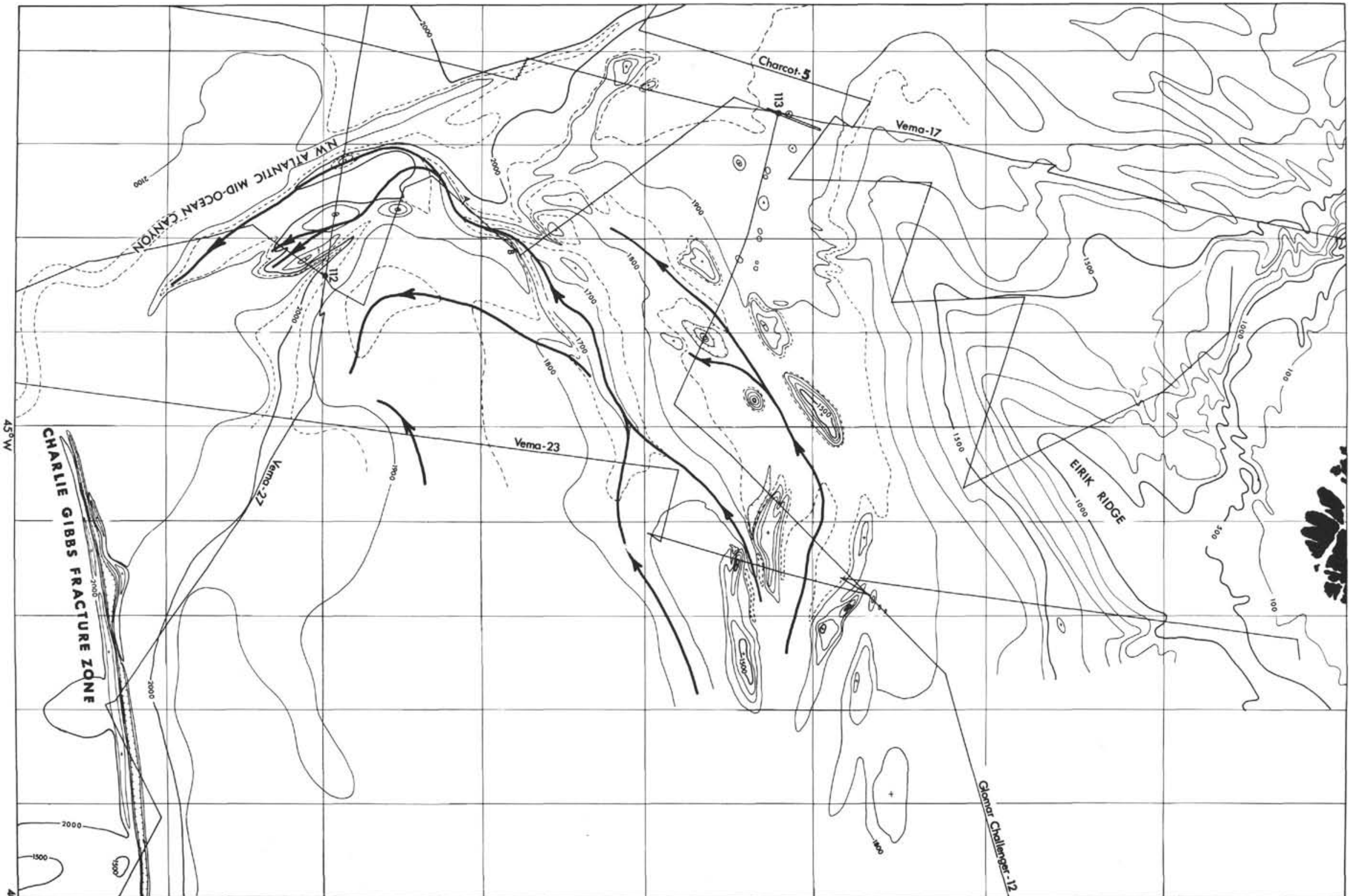


Figure 9. *Bathymetry of the south Labrador Sea (modified from Johnson, Vogt and Schneider, 1971) showing Site 113 in relation to the Eirik Ridge. Contours in uncorrected fathoms (at 800 fm/sec) at 100 fathoms (full line) and 50 fathoms (dashed line) intervals. Tracks show position of seismic reflection profiles. Heavy lines with arrows show position of ridges associated with bottom currents associated with the sediment body sampled at Site 112.*

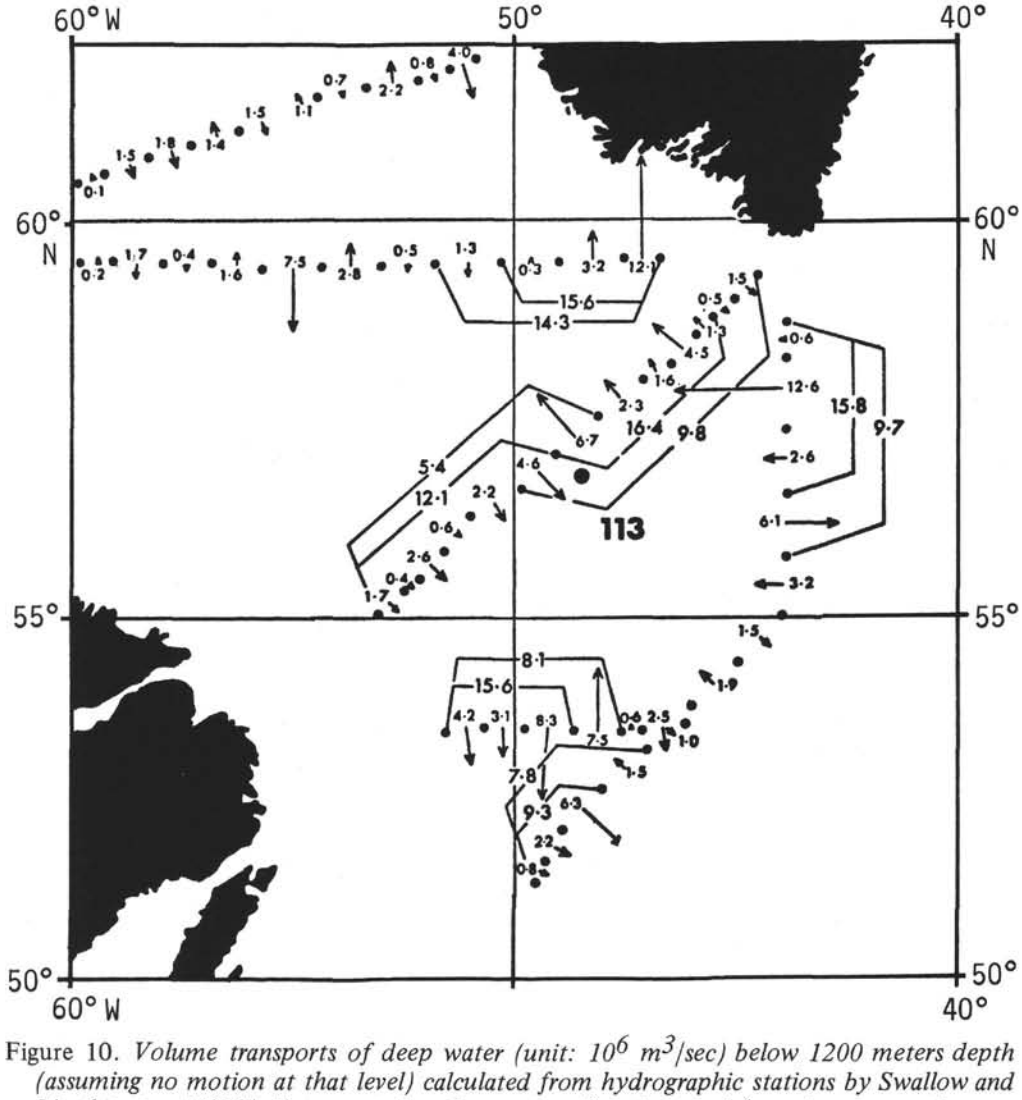


Figure 10. *Volume transports of deep water (unit: 10^6 m^3/sec) below 1200 meters depth (assuming no motion at that level) calculated from hydrographic stations by Swallow and Worthington (1969). Transports based on pairs of stations and from larger groupings are indicated.*

PLATE 1

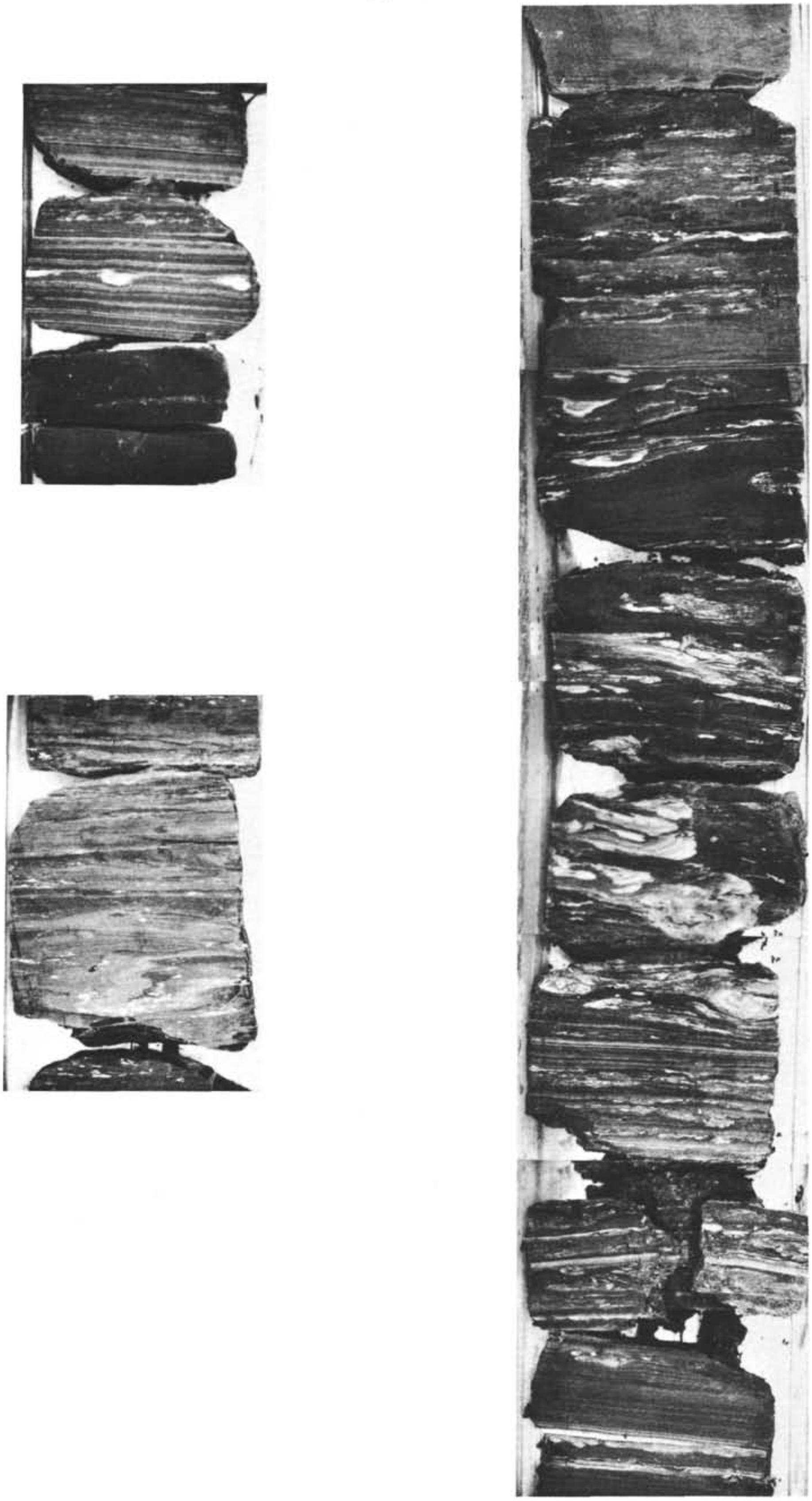


Plate 1. *Laminated mudstones and siltstones from Core 8, Site 113. (Photos J. v. Hinte, courtesy Imperial Oil Enterprises Ltd.)*

PLATE 2

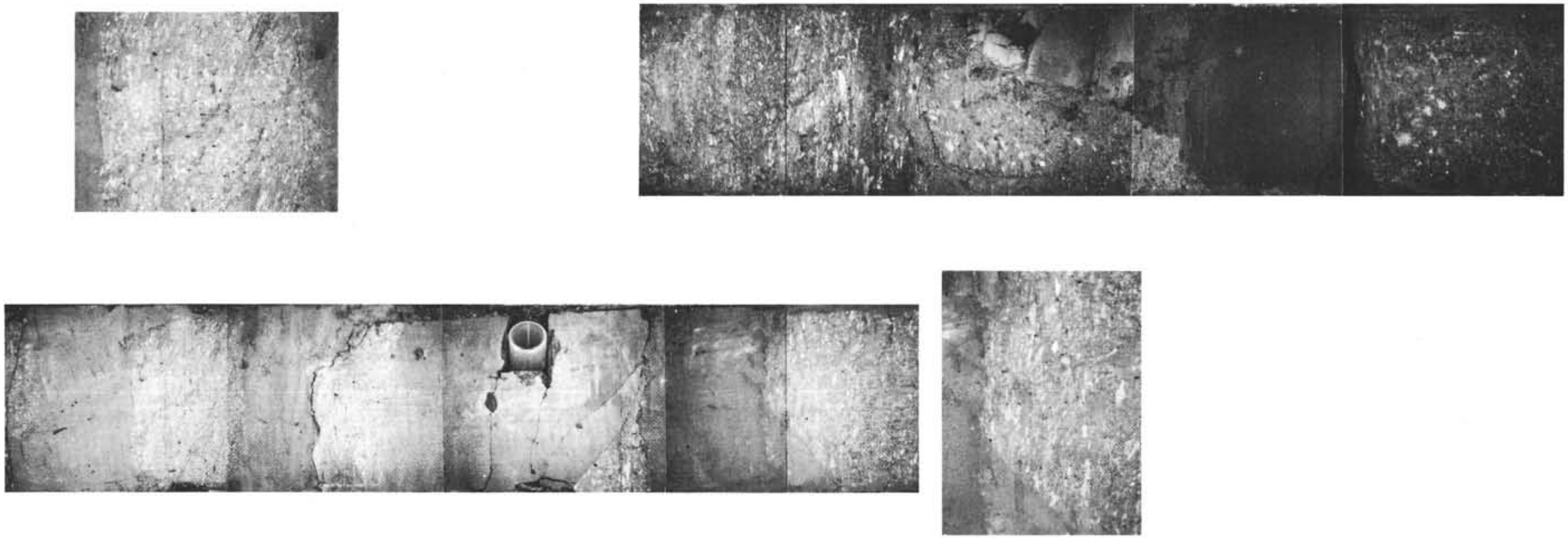


Plate 2. *Mudflow. Small fragments and medium-light gray matrix is Oligocene and Eocene ooze; dark gray clay is Pliocene; sandy base is mixture.* *(Core 7, 549 to 558 meters; Pliocene)* *Details are twice size of main photograph.* *(Photos J. v. Hinte, courtesy Imperial Oil Enterprises, Ltd.)*

APPENDIX A. SHIPBOARD SMEAR SLIDE OBSERVATIONS

Site	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
113	1	CC		R	D	A	D	R	C	C	C	C		C				R	R					X		10	C	C	C		C			Nannofossil-foraminiferal clayey silt; heavy minerals common
113	1	1	130	D	A	R	A	R	C		R	R						C	C					X		20	R				R			Silty sand; heavy minerals common.
113	1	1	136				D	R																X		45	A	D			C			Sandy silty nannofossil-foraminiferal marl; heavy minerals common.
113	1	2	75	C	A	C	A	C																X		15	A	A						Sand silt clay; heavy minerals common.
113	1	2	75		C	D	D	R																		20	R	A						Silty clay; glacial minerals not described.
113	1	3	75		A	D	D	R											A							40	R	A						Silty nannofossil marl; glacial minerals not described.
113	1	4	75	R	C	C	D	C	C	C		R		C		R		C						X		45	R	D						Clayey silt; other minerals include common heavy minerals.
113	1	5	20	R	C	C	D	C		R																40	C	D				R		Clayey nannofossil-foraminiferal silt.
113	1	5	144		A	D	D	R	C					R	A				C					X			R	R	R		R			Silty clay; glacial minerals not described; feldspar partly altered; palagonite, heavily altered; other minerals include rare heavy minerals.
113	2	CC		R	A	A	D	R	C	R	R	C		R	C			C			C			X	R	5	R	R			R			Laminated silty clay; acid residue coarse fraction composed almost entirely of some olivine and hornblende; quartz and feldspar grains intensely altered by zeolitization; some heavy minerals and metamorphic schist fragments.
113	2	1	140		D	A	D	R	C					R					R					X		5	R	R			C			Clayey silt; glacial minerals not described, heavy minerals common.
113	2	2	27		D	A	D	R		R				R							C			X			R				R			Clayey silt; foraminifera mixed benthonic and planktonic; some zeolitization of feldspar; heavy minerals common.
113	2	2	75	R	D	A	D	C	C	R				D		R		C			C					40	R	C						Clayey silt with much glass.
113	2	3	105		I	C	A	R	R										D							65		D						Silty nannofossil marl; microsparry nannofossils recrystallized; glacial minerals not described.
113	2	3	113	D	R	R	D	R		C				C	C						R			X		5	C							Silty sand with glass; palagonite chloritized; glacial minerals not described in detail; heavy minerals common.
113	2	3	129	R	C	D	D	R	A					C				A						X		5								Silty clay with pyrite; heavy minerals common.
113	2	3	135	R	C	D	D	R	R					R					C		A			X		15		R						Silty clay; glacial minerals not described in detail; other minerals-heavy, min(c), limonite(c).
113	3	CC		R	A	D	C	R	C	R	R			R	R			C	R		C			X		20	R	D						Sandy marly nannofossil coccolith ooze; pleagic sediment mixed with much glacial material containing benthonic foraminifera; other minerals include metamorphic schist fragments (c).
113	3	1	143	R	D	R	C	R	R									R								5	R							Sandy silty clay.
113	3	2	47		C	A	C	R		C		C		C	R			C			A			X		5		R						Silty clay; zeolite pseudomorphs after feldspar, some twins replaced by chlorite also chlorite after zeolite; other minerals include heavy min (r).
113	3	3	70	R	C	A	A	R		C	R	C		C							C			X		70		A						Silty clay; other minerals include heavy min (r).

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

Site	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pryoxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonate	Barite	Philipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonate	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
113	3	2	130	A	A	C	D	R	C	C		R						C	R		C		X			75	R	R						Silty sand, feldspar laths replaced by chlorite; feldspars heavily altered by zeolitization and chloritization; other minerals include heavy *min* (C).
113	3	3	40	C	C	A	D	R	R	C								C			C		R				R	R						Silty sandy clay; pseudomorphs of chlorite after coccoliths; other minerals-heavy min (C).
113	3	3	107		A	D	C	R	C	C		R						C	C		C		X			40		D						Silty clay; nannofossil fragments replaced by chlorite and philipsite; feldspars severely altered by replacement chlorite and zeolite in perthitic intergrowth; other minerals-heavy mins (C).
113	3	3	130	D	A	C	R		C										C		C					60	R	D						Marly coccolith ooze; fragments of foraminifera; most coccoliths replaced in part by chlorite, central part of coccoliths filled with zeolite, perthitic intergrowth of chlorite and phillipsite.
113	4	CC		C	D	A	A	A	C	C		C		R				C			C			X		10	R	D	R	R	C			Gray sandy clayey silt; with turbidite material; other minerals-heavy min (C) and metam. schist fragments (C).
113	4	1	122	R	C	D	C	R		C								C	R		R					10	R	A	C	R	R			Silty nannofossil diatom clay; silicoflagellates are rare, some radiolarians replaced by zeolites.
113	4	1	137			D	C	R	R	C				R				C	R		C			X		5		D	R	C	C			Nannofossil diatom radiolarian clay; very small radiolarina, sponge spicules, diatoms very small, also clay min (D) hematite (R).
113	4	2	75	C	R	A	A	R	C	C				C	C			C	R		C			X		5	R		R	C	C			Sandy radiolarian clay; radiolarian replaced by zeolites also silicispongia; other minerals-heavy min (A).
113	5	CC		R	D	A	D	R	A	R								C						X		10	C	C			R			Slightly sandy clayey silt with coccoliths and planktonic foraminifera; contaminated with few benthonic tertiary foraminifera, for instance *V. decorata* from Eocene, in turbidite material; other mins-metam schist fragments.(R).
113	5	1	125	D	R		A	C	C												X			X		5		A	R	R	C			Soft sand; nannofossils are small size; other minerals-heavy (C), including hornblende.
113	5	1	150	A	A	C	A	R	A	R				R				R						X		5	C	A			C			Clayey sandy silt; other minerals - heavy min (C), including hornblende.
113	6	CC		D	A	C	D	C	A	A	A	C												X			C							Gray silty clayey sand; reworked near-shore sand (cirriped and mollusc fauna derived from highly metamorphic schist area, transported into deep sea by turbidites, there mixed up with deep sea planktonic foraminifera rich clay, few Eocene benthonic foraminifera; otner mins: hornblende (C), metam. schist fragments (C), *Cypruna sp.* (F), Burrowed fragment *Crepidula sp.* (F), *Balanus* (C).

APPENDIX A – *Continued*

Site	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
113	6	2		D	C	R	D	R	C															X										Slightly silty sand with many heavy minerals; quartz grains partly rounded; other minerals - heavy min (C).
113	6	4		D	C	R	D	C	C															X										Slightly silty sand with many heavy minerals, grains partly rounded.
113	7	CC		R	A	D	D	R	R			C		D												70	C	D						Silty nannofossil-foraminiferal clay.
113	7	1	82	R		D	A	R	R	D														X										Sandy clay, green; other minerals - heavy min (C).
113	7	1	112	R		D	C	R				C						C						X		60		D						Marly nannofossil ooze; other minerals - heavy min (R).
113	7	1	111		A	D												R			R			X		60		D						Silty clay; other minerals - clay min (D).
113	7	1	141		C	D	D	R						C				C			A			X		20		A						Silty clay; glass with phillipstie rim, also light greenish glass; other mins. - Sphalerite (R).
113	7	1			A	D	C	R			R	R		R				C						X		60	R	D						Silty nannofossil marl; other minerals - clay min (D).
113	7	2	30	C	C	D	D	R	C	C				R	C			C			C					5	R	C						Mudstone breccia pebble - sandy silty clay.
113	7	2	37		C	D	D	R	C	C				A	C			C	R		C	C					R	R						Silty clay with many volcanic minerals.
113	7	2	48	R	A	D	D	C	C	C			R	A	R			C	C		C	C				25	R	A						Silty clay (gray); palagonite full of phillipsite; quartz partly altered, all grains with auth. calcite rim.
113	7	2	73	R	R	D	D	C	R	C								C	C					X	D	75		C						Silty clay; fragments of coccoliths; other minerals - clay min (C), Sphalerite (R).
113	7	2	107	R	C	D	D	C	C					C	C				R			A				15		A						Gray silty clay with very small mineral grains.
113	7	2	105	C	D	C	D	R	C	R		R		C	C			C	R		C			X		5		R						Sandy silt from white lamina; other minerals - heavy min (R).
113	7	2	130	R	D	A	D	R	C	C		R		R				C	R		A					10								Clay-silt; feldspar severely altered, chlorite and phillipsite inclusions; pseudomorph of chlorite after discoaster; coccoliths (C).
113	7	2	145	D	A	C	D	R		C		R		C				C	R					X		20	C	C						Silty sand; plagioclase, foraminifera recrystallized, many planktonic fragments recrystallized; other minerals - olivine (R).
113	8	CC			A	D	D	C	C						C			C	R							5		A						Silty clay; pyrite nodule with glass, palagonite and zeolites from surrounding clay.
113	8	1	80											C	C			D			C													
113	8	1	83	R	C	D	D	C	C	C		R		R				C	C		A													Phillipsite pseudomorphic after feldspar (plagioclase); quartz silt; feldspar highly altered with chlorite and phillipsite inclusions, some twinning observable.
113	8	2	57	R	C	D	D	R	C	C				A	R			C	C					X		10		D						Silty sand.

Site	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pryoxene	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
113	8	2	85	C	D		D	R	A	C				A	C			C	C		C			X		5								Sandy quartz silt; most plagioclases unaltered or little altered, some completely replaced by phillipsite (pseudomorphic) with chlorite along cleavage; chlorite also in cleavage of hornblende; auth. calcite and ?dolomote common; other minerals - heavy min (R).
113	8	3	75		C	D	D	R	R	R				R				A			R							R						Silty clay.
113	8	4	75		R	D	D		R	A				C	R			A			A					5		A						Clay.
113	9	CC		R	C	D	C	C	R	C				D	A			C	C		R	A		X										Silty gray clay; other minerals - heavy min (C), sphalerite (R).
113	9	1	86	C	C	D	D	R	C	C				C	C			C	R		C					5		R						Sandy silty clay.
113	9	1	110		C	D	D	R	C	R				R	R			C	C		C					5		R						Silty clay.
113	9	2	80		R	D	D	R										C						X		15		A						Gray clay; coccoliths as fragments; other minerals - clay min (C).
113	9	3	10		A	D	A	R		R		R						C	C		R			X		20		A						Silty clay; fragments of coccoliths; other minerals - limonite (R).
113	9	3	11		A	D	R	R	R	R								C	R		R			X				X						Silty clay; whole coccoliths rare, fragments abundant; other minerals - clay min (D), limonite (R).
113	9	3	120		C	D	A		C	C				R				C			R			X										Zeolitic silty clay or clayey silt; zeolites dominant nearly all glass is zeolitized, also seolite pseudomorphs after plag. and chlorite pseudomorphs of coccoliths.
113	10	CC		R	A	A	D	R	C	A		R		R	R			C	R		D					5		C	C					Zeolitic silty clay other minerals - limonite (R).
113	10	CC		C	D	R	D	R	C	C		C		R	X			C	C		C			X										Sandy silt.
113	10	CC			C	D	C	R	R					R				C	R		C					5		C						Silty clay.
113	11	1	130	C	C	A	D	C	C	C				C				C	C		R					15		A						Clay-silt.
113	11	2	140		D	A	D	R	R	C				R				C	R									R						Clayey silt; coccolith fragments.
113	11	2	2		D	C	D	R	R	C			C					A																Clayey silt; feldspar very small grains.
113	11	2	45	A	R	C	D	R	C	C				R				C	R				R											Clayey sand.
113	11	2	100		D	R	D	R	C	R				R	R						R													Quartz silt; phillipsite and chlorite in altered feldspar and palagonite.
113	11	2	106	C	D	R	A	R	R	R				R				C	D							55	R	C						Sandy silt; calcite dominates, foraminifera fragments recrystallized, common nannofossil fragments, recrystallized; little feldspar alteration.
113	11	2	108	C	C	R	R	R	C	C				R	R			C	A							60		R						Sandy carbonate silt; carbonate mostly calcite, recrystallized coccoliths; chloritized burrow filled with limonite; other minerals - limonite (C).

APPENDIX A – *Continued*

Site	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
113	11	2	132				R	R		D				R									X											
113	11	2	132	R	D		D	R	C	A				R	C			C	R		A								A					Clayey silt; feldspar partly twinned (Albite) altered and made isotropic by cloudy zeolitization and chloritization (internally); many zeolite crystals pseudomorph after plagioclase; little clear glass or palagonite.
113	11	2	132		A	D	C	R		A			C	C	C			C			C													Silty clay; very small fragments or phillipsite; chlorite very fine and dispersed; fine chlorite crystals generally in palagonite or altered feldspar.
113	11	2	145		R	D	R	R		A								C			C		X			10			A					Silty clay; fragments of nannofossils - results of solution; other minerals - clay min (A), limonite (R).

APPENDIX B. GRAIN SIZE DETERMINATIONS ON SAMPLES FROM SITE 113[1]

Site	Core	Section	Interval	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
113	1	3	28.0	7.8	33.7	58.5	Silty clay
113	1	4	24.0	6.9	34.3	58.7	Silty clay
113	1	5	24.0	10.5	37.9	51.6	Silty clay
113	2	3	50.0	0.0	73.7	26.3	Clayey silt
113	2	3	119.0	0.4	41.5	58.1	Silty clay
113	2	3	131.0	6.1	35.7	58.2	Silty clay
113	3	2	110.0	0.3	82.6	17.0	Silt
113	3	3	30.0	-0.0	75.3	24.7	Silt
113	4	1	120.0	0.1	45.9	54.0	Silty clay
113	4	2	29.0	0.0	84.1	15.9	Silt
113	5	1	106.0	55.4	39.8	4.8	Silty clay
113	6	1	0.0	95.3	1.7	3.1	Sand
113	6	2	0.0	92.7	2.7	4.6	Sand
113	6	3	0.0	97.0	0.6	2.4	Sand
113	6	4	0.0	95.3	2.2	2.5	Sand
113	6	5	0.0	98.3	0.2	1.4	Sand
113	6	6	0.0	91.7	3.0	5.3	Sand
113	8	1	29.0	0.1	37.7	62.3	Silty clay
113	10	CC	0.0	0.6	47.8	51.6	Silty 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 113[1]

Site	Core	Section	Top Interval	Hole Depth	Total Carbon	Organic Carbon	$CaCO_3$
113	1	3	14.0	53.1	1.8	0.2	13
113	1	4	14.0	54.6	2.5	0.2	19
113	1	5	14.0	56.1	3.5	0.2	28
113	2	2	14.0	100.6	0.4	0.2	2
113	2	3	14.0	102.1	0.6	0.2	4
113	3	2	90.0	158.4	0.5	0.2	3
113	3	3	138.0	160.4	4.3	0.2	35
113	4	1	114.0	205.1	1.6	0.4	9
113	4	2	15.0	205.6	0.4	0.2	1
113	5	1	112.0	255.1	0.8	0.1	5
113	7	2	47.0	551.0	1.7	0.4	11
113	7	2	53.0	551.0	1.8	0.4	12
113	8	1	115.0	664.2	0.6	0.4	2
113	8	3	4.0	666.0	1.0	0.3	5
113	9	2	83.0	712.3	0.7	0.6	1
113	10	7	0.0	768.0	0.9	0.5	4

[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 113

Sample 12-113-1-1, 147-149.5 cm:
PF: *Globigerina pachyderma* (sinistral), *G. bulloides.*
BF: *Melonis pompilioides, M. barleeanum.*
Also present: Abundant ice-rafted detritus.
Age: Pleistocene (glacial).

Sample 12-113-1-2, 145.5-148 cm:
PF: *Globigerina pachyderma* (sinistral) exclusively.
BF: *Melonis pompilioides, Cibicidoides pseudoungeriana, Gyroidina neosoldanii.*
Also present: Abundant ice-rafted detritus.
Age: Pleistocene (glacial).

Sample 12-113-1-3, 147-149 cm:
Lithology and fauna as above.
Age: Pleistocene (glacial).

Sample 12-113-1-4, 144-147 cm:
Lithology and fauna as above.
Age: Pleistocene (glacial).

Sample 12-113-1-5, 127-130 cm:
Lithology and fauna as above.
Age: Pleistocene (glacial).

Sample 12-113-1, Core Catcher:
PF: *Globigerina pachyderma* (dominant, abundant, sinistral), *G. bulloides, Globorotalia inflata* (rare): *Globigerina quinqueloba* (in smaller fractions).
BF: Extremely rare, *Paromalina.*
Also present: Abundant glacially-rafted detritus.
Age: Pleistocene (glacial).

Remarks: Core 1 is characterized by common to abundant occurrences of sinistrally coiled *Globigerina pachyderma,* almost to the exclusion of other planktonic species.

Sample 12-113-2-1, 147-149 cm:
PF: Moderate planktonic fauna including *Globigerina pachyderma* (predominantly sinistral), *G. bulloides, Globorotalia inflata.*
BF: *Pyrgo murrhyna, Pyrgo* sp. cf. *P. denticulata, Nummoloculina irregularis, Eponides umbonatus, Lenticulina* sp., *Eggerella bradyi, Cibicidoides* sp.
Age: Pleistocene (? interglacial).

Sample 12-113-2-2, 146-149 cm:
Terrigenous silty clay with planktonic foraminiferal fauna.
PF: *Globigerina pachyderma* (predominantly sinistral), *G. bulloides, Globorotalia inflata* (rare).
Age: Pleistocene (? interglacial).

Sample 12-113-2-3, 58-61 cm:
Lithology as above. Planktonic foraminifera present only in smaller mesh size (less than 149 microns).
PF: *Globigerina pachyderma* (primarily sinistral), *G. bulloides.*
Age: Pleistocene (? interglacial).

Sample 12-113-2-3, 99-102 cm:
Light layer (98 to 102 centimeters of nannofossil-foraminiferal ooze) in otherwise dark gray silty clay sequence.
PF: *Globigerina pachyderma* (predominantly sinistral), *G. bulloides, Globorotalia crassaformis.*
BF: *Planulina wuellerstorfi, Melonis pompilioides, Eponides umbonatus, Pyrgo murrhyna, Eggerella bradyi.*
Age: Pleistocene (interglacial).

Sample 12-113-2-3, 147-150 cm:
PF: Globigerina pachyderma (sinistral).
Also present: High percentage glacially-rafted quartz and other mineral fragments.
Age: Pleistocene (glacial).

Sample 12-113-2, Core Catcher:
PF: *Globigerina pachyderma* (sinistral), *G. bulloides, Globorotalia inflata.*
BF: *Planulina wuellerstorfi, Eponides umbonatus, Epistominella exigua, Cibicidoides* sp. *Lenticulina* sp., *Melonis barleeanum, Pyrgo murrhyna, Eggerella bradyi, Pullenia bulloides.*
Also present: Ice-rafted detritus.
Age: Pleistocene (glacial).

Sample 12-113-3-1, 140-142.5 cm:
Quartz, mica, clay silt, ice-rafted. Essentially unfossiliferous (few benthonic foraminiferal fragments present).
Age: No age determination (Pleistocene, by interpolation).

Sample 12-113-3-2, 145.5-147.5 cm:
Micaceous clay silt, few planktonic foraminifera preserved only in pan fraction.
PF: *Globigerina pachyderma.*
Age: Pleistocene (glacial).

Sample 12-113-3-3, 143-145 cm:
Quartz, mica, clay silt, planktonic foraminifera essentially absent.
BF: *Melonis pompilioides, M. barleeanum, Planulina wuellerstorfi.*
Age: Pleistocene (glacial).

Sample 12-113-3, Core Catcher:
Quartz, clay silt; planktonic foraminifera essentially absent.
BF: *Uvigerina hollicki, Eponides umbonatus, Cibicidoides pseudoungeriana, Melonis pompilioides, Cibicidoides cicatricosa.*
Age: Pleistocene (glacial).

Sample 12-113-4-1, 145-148 cm:
Quartz and clay silt, small residue, few foraminifera.
PF: *Globigerina* sp.
Age: Pleistocene (glacial).

Sample 12-113-4-2, 115-118 cm:
Glacially-rafted quartz and clay silt. Few foraminifera.
PF: *Globigerina atlantica.*
Age: Late Pliocene (glacial).

Sample 12-113-4, Core Catcher:
Quartz, clay silt, few foraminifera.
PF: One specimen *Globigerina atlantica.*
BF: *Laticarinina halophora, Uvigerina* sp. cf. *U. hollicki, Epistominella exiqua, Melonis pompilioides.*
Age: Late Pliocene (glacial).

Remarks: The Pliocene/Pleistocene boundary is placed between Sections 1 and 2 (based on calcareous nannoplankton). It is significant that *Globigerina atlantica* has its highest occurrence just below this level, in Section 2.

Sample 12-113-5-1, 147-149.5 cm:
Almost pure quartz sand and glacially derived minerals, few foraminifera present.
PF: *Globigerina atlantica.*
BF: *Melonis barleeanum.*
Age: Late Pliocene (based on calcareous nannofossils).

Sample 12-113-5, Core Catcher:
Almost pure quartz sand and glacially derived mineral grains.
PF: *Globigerina atlantica* (sinistral).
BF: *Cibicidoides* sp., *Cibicides* sp., *Gyroidina* sp., *Melonis barleeanum, Cibicidoides robertsoniana, Hoeglundina elegans, Uvigerina* sp. cf. *U. hollicki, Elphidium* sp.
Also present: Echinoid spine fragments and molluscan shell fragments.
Age: Late Pliocene.

Remarks: Core 5 is characterized by an extremely high quartz content and the presence of a single species of *Globigerina,* referred here to as *Globigerina atlantica*. This is the same form as that recorded from Pliocene sediments of Sites 111 and 112. Specimens of this species bear a gross morphological resemblance to *Globigerina pachyderma*. They differ, however, in being consistently larger, more robust and thicker-shelled, and in displaying a larger range of morphologic variation (from open to nearly closed umbilical region). The core catcher sample of Core 5 is almost certainly a turbidite.

Sample 12-113-6, Core Catcher:
High percentage of glacially-derived quartz and other mineral fragments, molluscan and echinoid shell fragments.
PF: *Globigerina pachyderma* (sinistral), *Globigerina atlantica, Globorotalia scitula* (rare).
BF: *Hoeglundina elegans, Melonis barleeanum, Cibicidoides* sp.
Age: Late Pliocene (glacial).
Note: This sample is almost certainly turbidite derived. The specimens of typical *Globigerina pachyderma* are small and white in color and resemble those seen above in Cores 1 through 4. It is possible that these specimens are contaminants.

Sample 12-113-7-1, 142-145 cm:
Quartz sand and clay silt with a high percentage of mica and few foraminifera: *Globigerina atlantica, Globorotalia scitula.*
PF: Globigerinids with reticulate wall surface; specimens appear close to *Globigerina galavisi* and *G. angiporoides* and *Globigerinita.*
Age: Pliocene (glacial) with Upper Eocene reworking.

Sample 12-113-7-2, 14-16 cm:
Silty clay sample with abundant mica. Essentially unfossiliferous; few planktonic foraminiferal specimens attributable to *Globigerina atlantica.*
Age: Pliocene.

Sample 12-113-7-2, 57.5-60 cm:
Lithology and data essentially the same as sample above.
Age: Pliocene.

Sample 12-113-7-2, 73-74 cm:
Data essentially the same as samples above.

Sample 12-113-7-2, 84.5-87 cm:
Tan and green silty clay and mudstone fragments in clay matrix.
PF: *Globigerina bulloides, G. atlantica, Globigerina* with reticulate wall surface similar to *Globigerina galavisi, Pseudohastigerina wilcoxensis* (in pan fraction only).
BF: *Melonis barleeanum, M. pompilioides, Pyrgo murrhyna, Eponides umbonatus.*
Age: Pliocene with reworked Upper Eocene forms.

Sample 12-113-7-2, 112-114 cm:
Gray silty marl with large amounts of mica. Abundant planktonic foraminifera.
PF: *Globigerina atlantica* (dominant, abundant, sinistral), *G. bulloides* (rare), *Globorotalia scitula* (common), *G. crassaformis, Orbulina universa.*
BF: *Melonis barleeanum, M. pompilioides, Pullenia* sp., *Planulina wuellerstorfi, Cibicidoides* sp., *Eggerella bradyi, Sphaeroidina bulloides, Pyrgo murrhyna,* polymorphinids, nodosariids.
Age: Pliocene.

Sample 12-113-7-2, 143-145.5 cm:
Lithology and fauna similar to sample above plus *Uvigerina* sp. cf. *U. asperula, Cibicidoides lobatula* (common).
Age: Pliocene.

Sample 12-113-7, Core Catcher:
Tan colored silty micaceous clay with relatively abundant foraminiferal fauna.
PF: *Globigerina atlantica* (sinistral), *Globorotalia inflata, Orbulina universa.*
BF: *Cibicidoides lobatula,* polymorphinids, *Eggerella bradyi, Elphidium* sp., miliolids, *Laticarinina halophora, Melonis pompilipides.*
Age: Pliocene.

Remarks: Core 7 contains evidence of reworking of Upper Eocene planktonic foraminifera (*Pseudohastigerina wilcoxensis* and reticulate-walled globigerinids) in Pliocene sandy clays. The Pliocene planktonic foraminiferal fauna consists almost entirely of *Globigerina atlantica* (large, robust, thick-walled, 4-5 chambers).

The following samples from Core 8 were found to be unfossiliferous:

Sample 12-113-8-1, 110-112 cm
Sample 12-113-8-2, 127-129 cm
Sample 12-113-8-3, 2-4 cm
Sample 12-113-8-4, 147-148 cm
Sample 12-113-8, Core Catcher

Remarks: Core 8 consists of dark, finely-laminated silty mudstone. A few specimens of planktonic foraminifera were found in the core catcher sample but it is uncertain whether these are indigenous or derived. No age determinations were possible on any of the samples in this core.

The following samples from Core 9 were found to be essentially unfossiliferous

Sample 12-113-9-1, 128-129 cm
Sample 12-113-9-2, 130-132 cm
Sample 12-113-9-3, 37-41 cm
Sample 12-113-9, Core Catcher

Remarks: Core 9 consists of dark, finely-laminated silty mudstone with the exception of rare broken fragments; foraminifera are absent in this core.

Sample 12-113-11, Core Catcher:
Unfossiliferous. No age determination.

Sample 12-113-12, Core Catcher:
Silty micaceous mudstone with few benthonic and planktonic foraminifera.
PF: *Globorotalia acostaensis, Globigerina* sp.
BF: *Cibicidoides* sp., *Gyroidina* sp., *Melonis* sp., miliolids.
Also present: Molluscan shell fragments (pelecypods).
Age: Late Miocene/Pliocene.

Remarks: Several specimens referable to *Globorotalia acostaensis* were found in the core catcher sample of Core 12. These form the only basis for estimating an approximate age of Late Miocene to Early Pliocene for the oldest sediments at Site 113.

APPENDIX E. COCCOLITH SPECIES AND STRATIGRAPHIC ASSIGNMENT OF SITE 113

David Bukry

Hole 113

Upper Pleistocene
(*Gephyrocapsa oceanica* Zone)

12-113-1-1, 145-146 cm: depth 50 m:
Coccolithus pelagicus, Coccolithus sp. [tiny], *Gephyrocapsa* sp. cf. *G. caribbeanica, G. oceanica* Kamptner, *Syracosphaera* sp. Reworked Eocene or Oligocene taxa: *Dictyococcites scrippsae, Reticulofenestra hillae.*

Upper Pliocene?

12-113-3-3, 141-142 cm; depth 159 m:
Coccolithus pelagicus, Coccolithus sp. cf. *C. neohelis* McIntyre, *Cyclococcolithina macintyrei* [well-preserved].

Upper Pliocene
(*Discoaster brouweri* Zone)

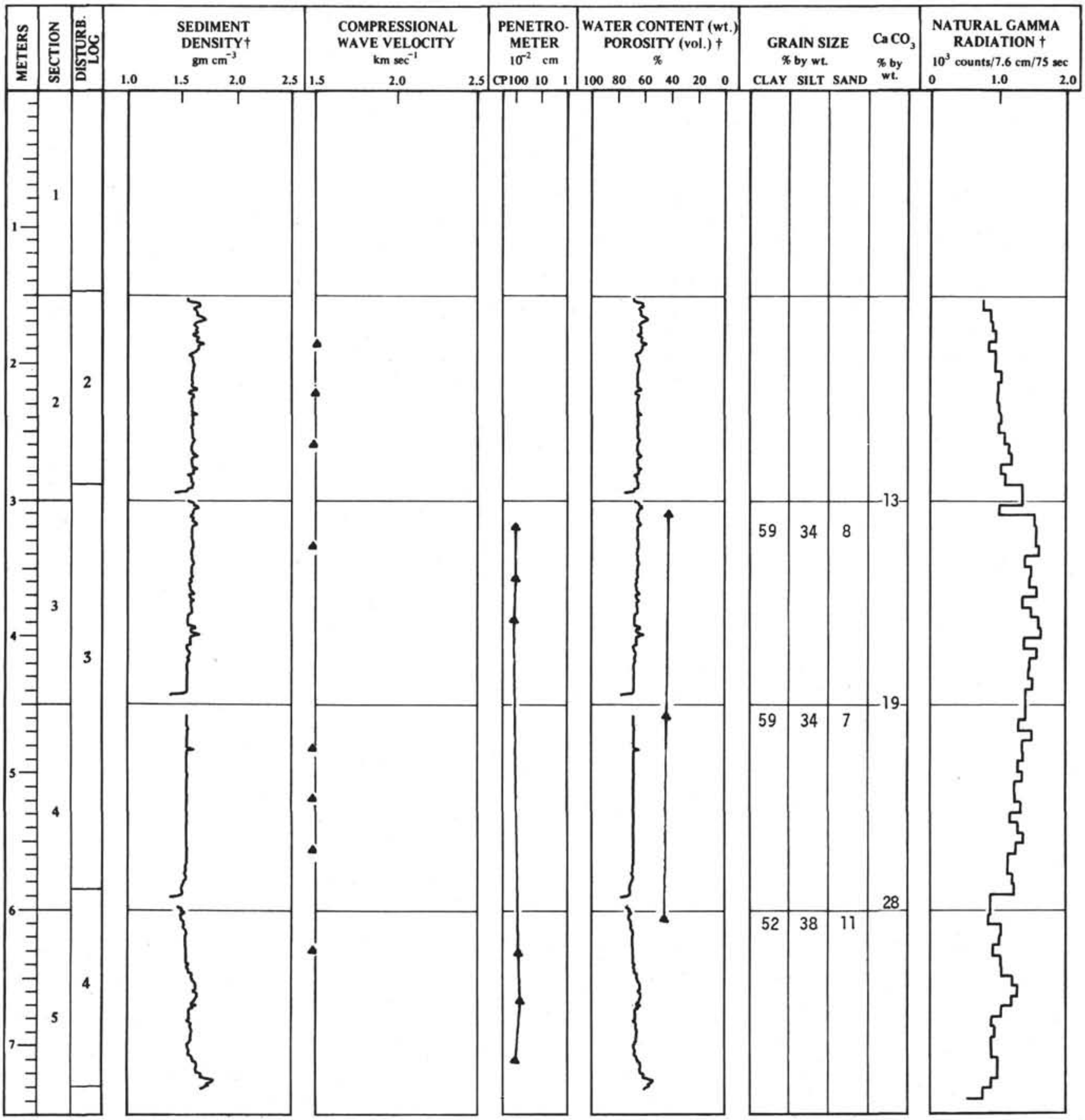
12-113-4-2, 114-115 cm; depth 206 m:
Coccolithus pelagicus, Cyclococcolithina macintyrei, Discoaster brouweri, Discoaster sp. cf. *D. variabilis variabilis.*

Upper Miocene or Lower Pliocene

12-113-5-1, 144-145 cm; depth 254 m:
12-113-8-4, 13-15 cm; depth 667 m:
12-113-9-3, 6-9 cm; depth 712 m:
12-113-11-2, 100-110 cm; depth 811 m:
The above samples contain rare specimens of long-ranging coccoliths. The most common taxa are *Coccolithus pelagicus, Cyclococcolithina leptopora, C. macintyrei,* and *Reticulofenestra pseudoumbilica*; also present are *Discoaster* fragments assigned to *D. pentaradiatus* and *D. surculus.*

HOLE 113

CORE 1



†Adjusted data, see Chapter 2

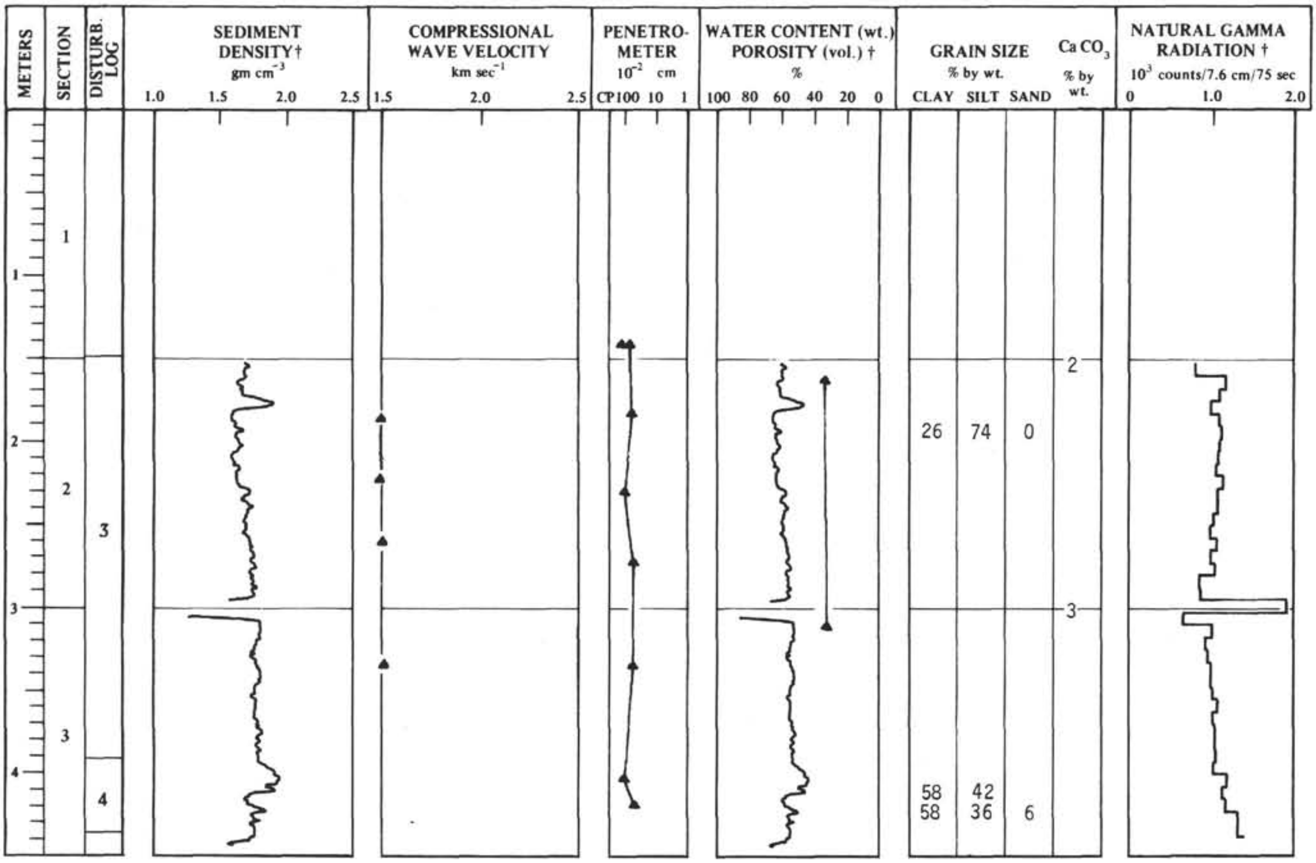
HOLE 113 50 **TO** 59 **m**

CORE 1

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NO CORE	N F	N4	Medium dark gray to medium olive gray, soft, totally disturbed, foram-nannofossil silty clay. Contains much quartz, some plagioclase, a considerable amount of heavy minerals and a variable amount of authigenic carbonate, which is generally high in organically poor layers and low in organic-rich clays. Total organic or authigenic carbonate can exceed 30% in marly layers. X-ray Mineralogy (bulk) Calc. 25.1 Dolo. 4.4 Qtz. 15.4 Plag. 20.0 Kaol. 2.6 Mica 21.7 Chl. 1.1 Augite 6.3 Amph 3.4 Amor. 70.6	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Helicopontosphaera kamptneri, Gephyrocapsa oceanica, G. aperta* *Globigerina pachyderma, G. bulloides*	*Gephyrocapsa oceanica*	PLEISTOCENE
1.5–3	2		N N,F			Flora similar to above Flora similar to above *G. pachyderma* exclusively		
3–4.5	3		N XM F	5Y 5/1		Flora similar to above, + *Syracosphaera* sp. Fauna similar to above		
4.5–6	4		N XM F			Flora similar to above + *Rhabdosphaera clavigera, Helicopontosphaera sellii* Fauna as above		
6–7.5	5		N XM N	N6 N5 5Y 4/1 N6 N5 5Y 4/1	Medium light gray silty foraminifera nannofossil clay with two firm, slightly disturbed sandy layers. Composition similar to above description but there is additional glass, some diatoms & siliceous sponge spicules. Total carbonate content up to 30%, falling to less than 10% in sandy layers.	Flora similar to sect. 4 Flora similar to sect. 3		
	CC		R N F	N6	**Core Catcher:** Gray, firm, clayey silt, with foraminifera, diatoms, radiolarias & siliceous sponge spicules.	**Core Catcher:** Radiolarians, rare. *Theocalyptra davisiana, Spongopyle osculosa, Stylodictya validispina, Phorticium pylonium, Spongodiscus* spp., *Actinomma* spp., *Artostrobium miralestense* Flora similar to sect.1 *Globigerina pachyderma, G. bulloides, G. quinqueloba, Globorotalia inflata*		

HOLE 113

CORE 2



†Adjusted data, see Chapter 2

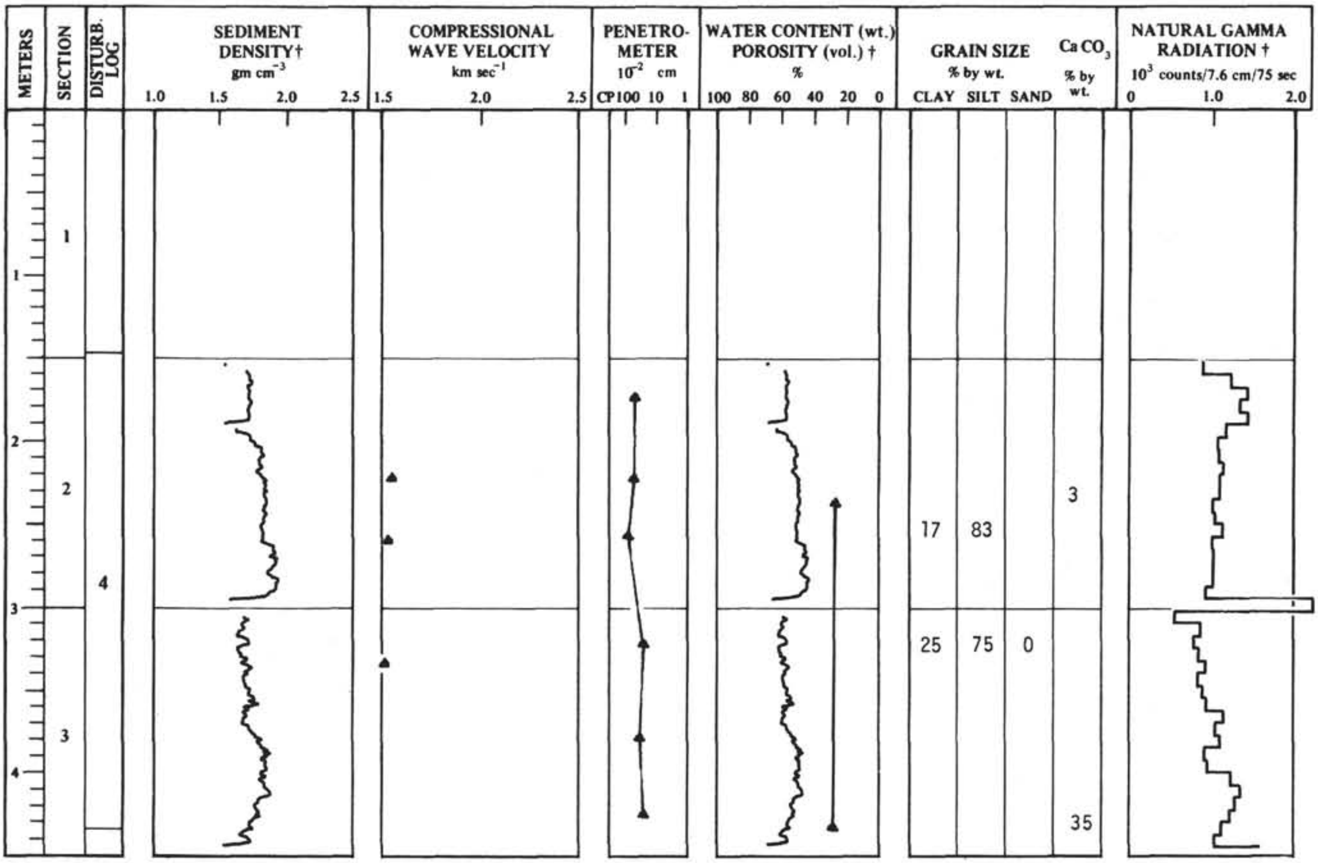
HOLE 113   99 **TO** 108 **m**

CORE 2

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	NO CORE				*Pseudoemiliania lacunosa*	PLEISTOCENE
1			N,F	5Y 4/1 ↕ 5G 2/1 Dark greenish gray, firm, slightly disturbed, silty clay & clayey silt. Contains glacial pebbles, much quartz and heavy minerals. Low foram, nannofossil, & siliceous sponge spicule content. Intercalations of silt in Sections 2 & 3.	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa, Helicopontosphaera kamptneri, H. sellii, Pontosphaera discopora, P. scutellum, Reticulofenestra* ? sp. *Sphenolithus neoabies* *Globigerina pachyderma, G. bulloides, Globorotalia inflata*		
2	2		N		Flora similar to above		
			F	X-ray Mineralogy (bulk) Calc. 2.6 Dolo. 1.3 Qtz. 18.6 Plag. 33.6 Kaol. 3.1 Mica. 19.6 Chl. 1.6 Mont. 3.0 Augite 10.3 Amph. 6.4 Amorph. 71.8	Fauna as above		
3			N	5GY 4/1	Flora similar to above, poorer		
	3		N XM		Flora similar to above		
4			N,F XM XM N,F	5Y 6/1 5Y 4/1	No coccoliths Fauna similar to above plus *G. crassaformis* Flora similar to above, poorer *Globigerina pachyderma*		
	CC		R N F	5Y 4/1 **Core Catcher:** Silty clay, description same as above	**Core Catcher:** No radiolarians Flora similar to above, poorer *G. bulloides, G. pachyderma, G. inflata*		

HOLE 113

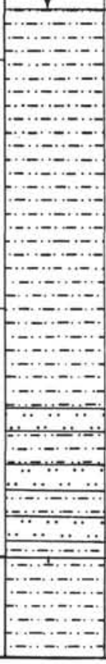
CORE 3



†Adjusted data, see Chapter 2

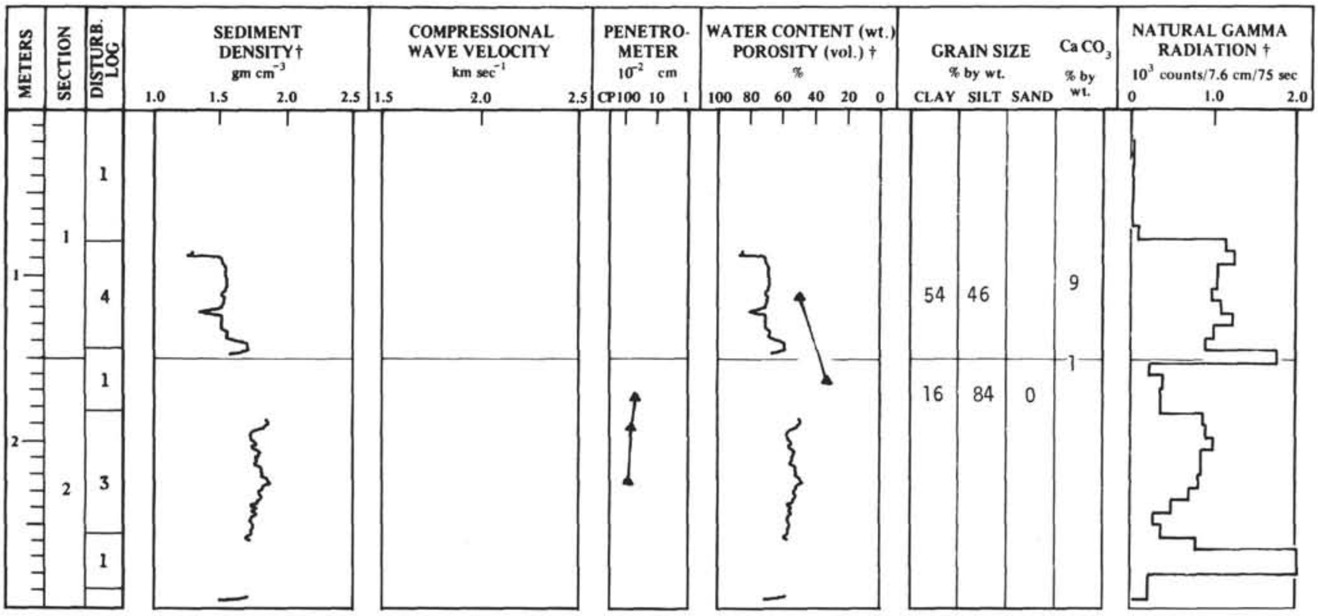
HOLE 113 156 TO 165 m

CORE 3

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	NO CORE			*Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa*	*Pseudoemiliania lacunosa*	PLEISTOCENE
1–3	2		N,F N XM F	5Y 4/1 Olive gray, laminated, slightly disturbed clayey silt and silty clay. Contains much quartz & heavy minerals, some glass, zeolites, pyrite & plagioclase. Graded beds, with clay grading into laminated calcareous silt. Silty clay contains glacial pebbles. X-ray Mineralogy (bulk) Calc. 8.7 Dolo. 2.1 Qtz. 18.6 Plag. 29.9 Kaol. 2.8 Mica 17.2 Chl. 1.3 Mont. 3.4 Augite 11.5 Amph. 4.4 Amorph. 66.9	Fauna essentially barren Flora similar to above, + *Helicopontosphaera kamptneri, H. sellii, Syracosphaera* sp. *Pontosphaera discopora* Few planktonic forams in fine-fraction		
3–4.5	3		XM N XM N F		Flora similar to sect. 2 Flora similar to sect. 2 + *Scyphosphaera* sp., *Cyclococcolithus macintyrei*		
	CC		R N F	5Y 4/1 **Core Catcher:** Silty clay, same description as above.	Fauna: Planktonic foram fauna essentially barren **Core Catcher:** No radiolarians Flora similar to sect. 1. Plankt. foram essentially barren; B.F.: *Uvigerina hollicki, Eponides umbonatus, Cib. pseudoungeriana, Mel. pompilioides*		

HOLE 113

CORE 4



†Adjusted data, see Chapter 2

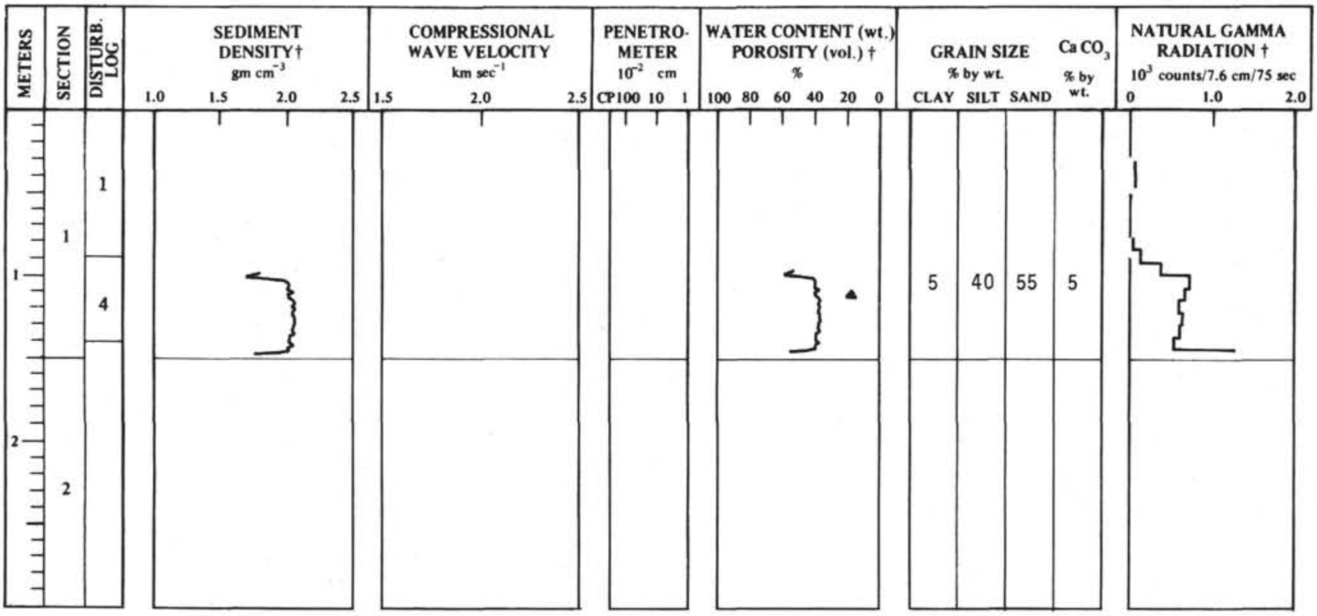
HOLE 113 204 **TO** 207 **m**

CORE 4

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	NO CORE	N XM F	5Y 2/1	*Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Helicopontosphaera kamptneri, H. sellii* *Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa, Globigerina* sp.	*Pseudoemiliania lacunosa*	PLEISTOCENE
2	2		N XM F	5Y 4/1 Olive black to olive gray, firm, partly disturbed silty clay with two hard shaly beds in sec. 1. Foraminifera (planktonic & benthonic) are rare and usually corroded; nannofossils are abundant, but poorly preserved. Diatoms & sponge spicules are common & Radiolarian are rare.	Flora similar to sect. 1-105, + *Discoaster* sp. *Globigerina* sp. aff. *pachyderma*	*Discoaster browweri*	LATE PLIOCENE
	CC		R N F	<u>X-ray Mineralogy</u> (bulk) Qtz. 18.5 Plag. 34.9 Kaol. 1.6 Mica 15.2 Chl. 1.5 Mont. 4.3 Augite 19.6 Amph. 4.4 Amorph. 64.2 **Core Catcher:** Silty clay, same description as above.	**Core Catcher:** Radiolarians rare. *Spongopyle osculosa, Spongodiscus* spp., *Druppatractus irregularis, Phorticium pylonium, Actinomma* spp. Only small coccoliths PLANKT. Foram rare: *Globigerina* sp. aff. *pachyderma*		

HOLE 113

CORE 5



†Adjusted data, see Chapter 2

HOLE 113 254 TO 257 m

CORE 5

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	NO CORE	N,XM F	5Y 4/1 Olive gray, disturbed muddy sand with much quartz and heavy minerals. Nannoplankton and foraminifera are rare, sometimes corroded. Diatoms, echinoid spines, radiolaria and siliceous sponge spicules are also present.	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa, Reticulofenestra* sp. *Globigerina atlantica*	*Reticulofenestra pseudoumbilica?*	PLIOCENE
	CC		R N F	5Y 4/1			

X-ray Mineralogy (bulk)

Calc.	1.9
Qtz.	31.7
Plag.	50.0
Mica	6.8
Augite	4.6
Amph.	5.0
Amorph.	46.1

Core Catcher: Gray, clayey silt, with benthonic and planktonic foraminifera, nannoplankton & sponge spicules.

Core Catcher: Radiolarians rare. *Spongodiscus* spp., *Stylodictya validispina* Flora similar to above, + *Discoaster brouweri, Syracosphaera* sp., *Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica, Globigerina atlantica*

HOLE 113

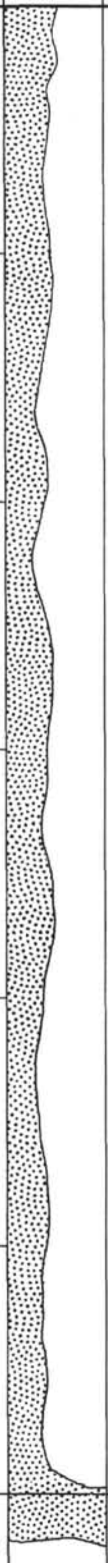
CORE 6

METERS	SECTION	DISTURB. LOG	SEDIMENT DENSITY† gm cm^{-3} 1.0 1.5 2.0 2.5	COMPRESSIONAL WAVE VELOCITY km sec^{-1} 1.5 2.0 2.5	PENETRO-METER 10^{-2} cm CP100 10 1	WATER CONTENT (wt.) POROSITY (vol.) † % 100 80 60 40 20 0	GRAIN SIZE % by wt. CLAY	SILT	SAND	Ca CO_3 % by wt.	NATURAL GAMMA RADIATION † 10^3 counts/7.6 cm/75 sec 0 1.0 2.0
1	1						5	3	93		
2	2						2	1	97		
3, 4	3						3	2	95		
5	4						1		98		
6, 7	5						5	3	92		
8	6										

†Adjusted data, see Chapter 2

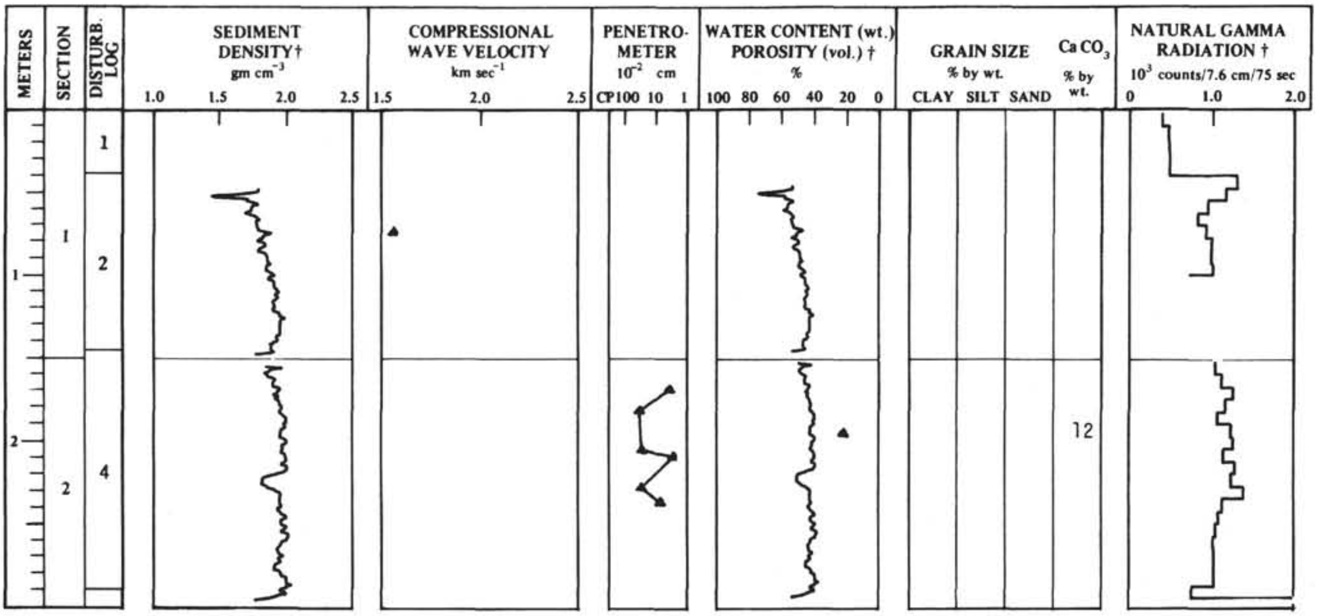
HOLE 113 395 **TO** 404 **m**

CORE 6

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N	N7	Light gray, wet, uncohesive, sand. Heavy mineral content up to 25%, some rock fragments, foraminifera, and shallow water shell fragments, especially *Balanus*.	Water: *Discoaster* sp. *Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania lacunosa, Reticulofenestra pseudoumbilica, Cyclococcolithus macintyrei*	*Reticulofenestra pseudoumbilica*	PLIOCENE
1.5–3	2		N			Flora similar to above		
3–4.5	3		N			Flora similar to above		
4.5–6	4		N			Flora similar to above, + *Pontosphaera discopora, P. scutellum*		
6–7.5	5		N			Flora similar to sect. 3, + *Discoaster brouweri, Helicopontosphaera kamptneri, H. sellii*		
7.5–9	6		N			Flora similar to sect. 4		
						Flora similar to sect. 4 + *Gephyrocapsa aperta.* (?)		
			N			Radiolarians rare. *Druppatractus irregularis, Spongodiscus* spp.		
	CC		R N F		Sand, same description as above.	Flora similar to sect.4, + *Sphenolithus neoabies* *Globigerina atlantica, G. pachyderma, Globorotalia scitula*		

HOLE 113

CORE 7



†Adjusted data, see Chapter 2

HOLE 113 549 **TO** 558 **m**

CORE 7

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1 2	1 2 CC		N R F N,XM N,F N,XM N N,F N,XM R,XM N,F N,F N N,F R N N N,F F N R	5Y 4/1 5G 4/1 10Y 8/2 — Olive gray to grayish green to greenish yellow, soft, disturbed sandy pelletal mud. Pellets of reworked Eocene nannofossil clay & marl (one pellet containing heterohelicids and abundant nannofossils) in a matrix of reworked Eocene to Pliocene sediment with approx. 3% heavy minerals. 5G 4/1 5Y 4/1 N3 — Alternation of grayish green mudstone beds (flattened boulders 5-15 cm. thick) with a mixed nannofossil assemblage of Eocene to Pliocene age & olive gray to dark gray mud breccia. Breccia beds are of similar thickness & consist of angular to rounded clasts of Eocene to Pliocene age in a muddy matrix of reworked Eocene to Pliocene sediments. 5YR 2/1 — Mudstone is brownish black, finely laminated (each laminae <1 mm thick) consisting of a silt band over a mud or clay band. Some corroded fragments of foraminifera & nannofossils present. Erosional contact between laminated mudstone & overlying mudflow is visible in lower part of Sec. 2.	No radiolarians. *Coccolithus pelagicus, Cyclococcolithus leptoporus, Reticulofenestra pseudoumbilica, Pontosphaera discopora, Globigerina atlantica, Globorotalia scitula and G. galavisi, G. angiporoides* (reworked Upper Eocene) Allochthonous intraclast: No radiolarians; dinoflagellate cysts. For flora descriptions see section sheet Autochthonous mudstone: *Theocalyptra davisiana* VR., *Globigerina bulloides, G. atlantica,* and reworked Upper Eocene Globigerinids and Pseudohastigerina sp. Fauna similar to above **Core Catcher:** *Globigerina atlantica, Globorotalia inflata, Orb. universa Discoaster brouweri, D. surculus, D. variabilis, Coccolithus pelagicus, Cyclococcolithus leptoporus, Reticulofenestra pseudoumbilica, Sphenolithus neoabies, Pontosphaera discopora.* No radiolarians.	*Reticulofenestra pseudoumbilica ?*	PLIOCENE

X-ray Mineralogy (bulk)

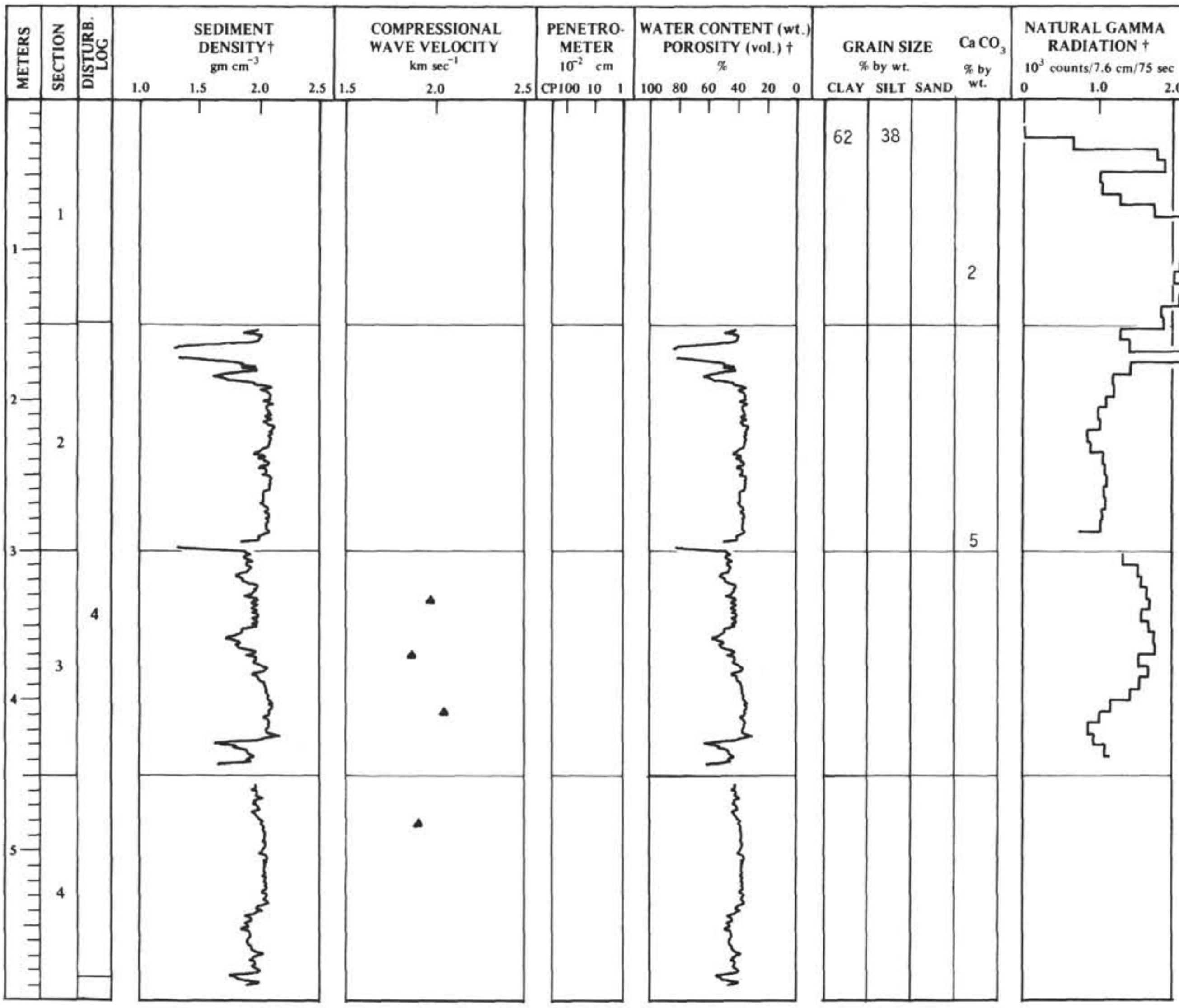
Mineral	Depth (m)			
	550.47	550.97	551.03	551.23
Calc.	3.1	18.0	20.9	0
Qtz.	16.4	16.6	17.6	22.6
Plag.	28.1	29.1	19.3	12.5
Kaol.	0	2.1	2.3	7.8
Mica	27.9	23.8	22.9	24.6
Chl.	4.7	1.7	1.7	1.8
Mont.	15	4.1	10.7	29.2
Clin.	0	1.9	2.0	0
Amph.	4.8	2.6	2.6	1.5
Amorph.	66.7	70.1	71.6	75.5

Core Catcher:

Mudstone, description, above

HOLE 113

CORE 8



†Adjusted data, see Chapter 2

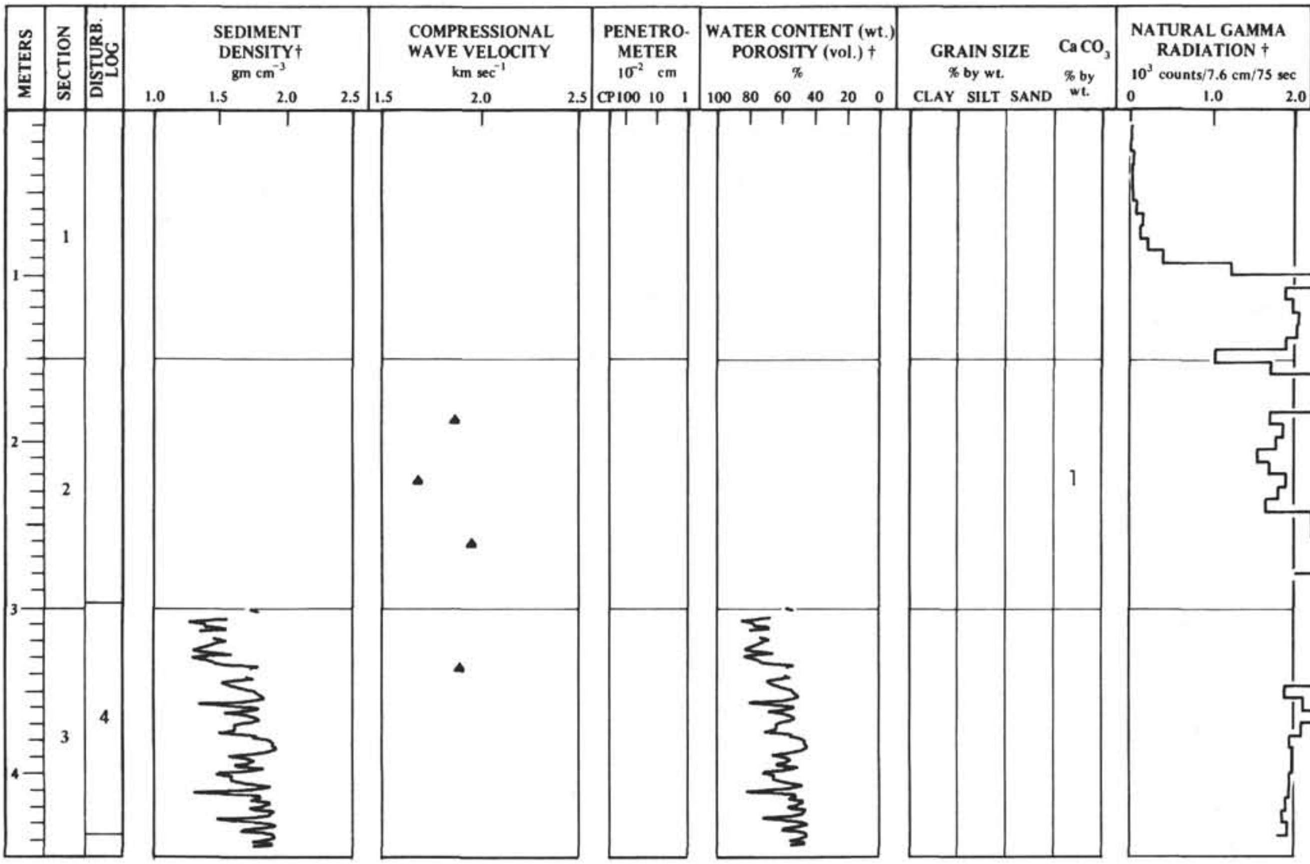
HOLE 113 663 **TO** 669 **m**

CORE 8

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	NO CORE 	N XM F,XM	N5 N3 Medium gray to dark gray mudstone ranging to olive gray in nannofossil-rich layer in Section 2, and brownish black in the lower part of the core. Mudstone is finely laminated (each laminae <1mm thick) consisting of a light gray silt band passing upward into a darker silty clay band. Small scale cross laminations, lenticular laminations & convolutions are common. Pyritized burrows in Sec. 3 (22-270m).	*Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Reticulofenestra pseudoumbilica* Fauna: barren		PLIOCENE
1.5–3	2		N F	5Y 4/1- 5Y 6/1 Nannofossils are usually rare, abundant only in middle part of Sec. 2. Foraminifera are very rare and corroded. Silt layers consist mainly of angular quartz grains (<40μ), some mica and glass or palagonite with pyrite, zeolite, & chlorite.	Flora similar to above, + *Rhabdolithus* sp. Fauna: barren		
3–4.5	3		N,F, XM	5YR 2/1 X-ray Mineralogy (bulk) Calc. 3.0 Qtz. 21.7 Plag. 21.2 Kaol. 2.9 Mica 27.8 Chl. 2.3 Mont. 14.2 Clin. 3.0 Amph. 3.8 Amorph. 67.4	Flora similar to above Fauna: barren		
4.5–6	4		N F		Flora similar to above, + *Sphenolithus neoabies* Fauna: barren		
	CC		R N F	**Core Catcher:** Mudstone, description above	**Core Catcher:** No radiolarians Fauna: minute, indeterminable forms Flora similar to above, + *Sphenolithus abies, Rhabdolithus* sp., *Helicopontosphaera kamptneri, Pontosphaera* sp.		

HOLE 113

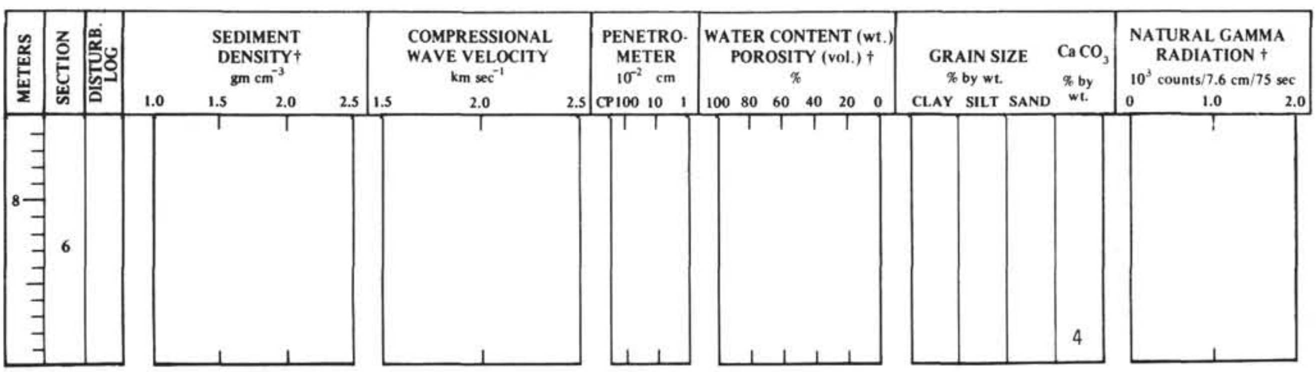
CORE 9



†Adjusted data, see Chapter 2

HOLE 113

CORE 10



†Adjusted data, see Chapter 2

HOLE 113 | 710 **TO** 714 **m**

CORE 9

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
	1	NO CORE	N F N		Dark gray to medium gray to olive black & greenish black smooth or faintly laminated mudstone & claystone. Pyrite nodules up to 2 mm. Nannofossils usually rare and poorly preserved, carbonate content very low (≤5%).	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Pontosphaera scutellum, Reticulofenestra pseudoumbilica* Fauna: barren Flora similar to above		PLIOCENE ?
1 2	2		XM F	N3 N5 5Y 2/1 5GY 2/1 5G 2/1	X-ray Mineralogy (Bulk) Qtz. 22.1 Plag. 17.8 Kaol. 3.6 Mica 34.3 Chl. 3.9 Mont. 13.0 Clin. 3.4 Amph. 1.9 Amorph. 69.9			
3 4	3		N F XM			Fauna: barren Flora similar to above Fauna: barren		
	CC		R N F		Mudstone, description above	No radiolarians. Minor amounts of carbonaceous material. Flora similar to above Fauna: barren		

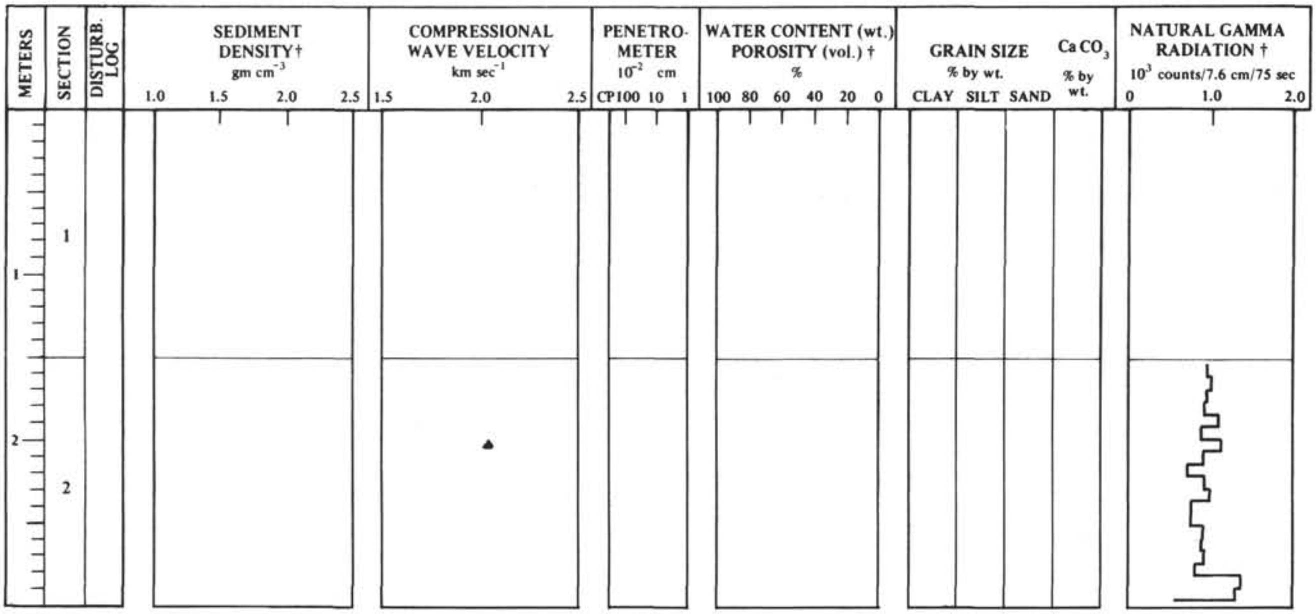
HOLE 113 | 759 **TO** 766 **m**

CORE 10

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
	CC		XM N R	5GY 2/1 5G 2/1	Greenish black laminated mudstone X-ray Mineralogy (Bulk) Calc. 3.9 Qtz. 25.3 Plag. 19.1 Mica 26.1 Chl. 2.0 Mont. 20.2 Clin. 1.8 Amph. 1.6 Amorph. 67.9	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Reticulofenestra pseudoumbilica, Sphenolithus neoabies, Helicopontosphaera kamptneri* No radiolarians. Minor amounts of carbonaceous material.		PLIOCENE?

HOLE 113

CORE 11



†Adjusted data, see Chapter 2

HOLE 113 810 **TO** 815 **m**

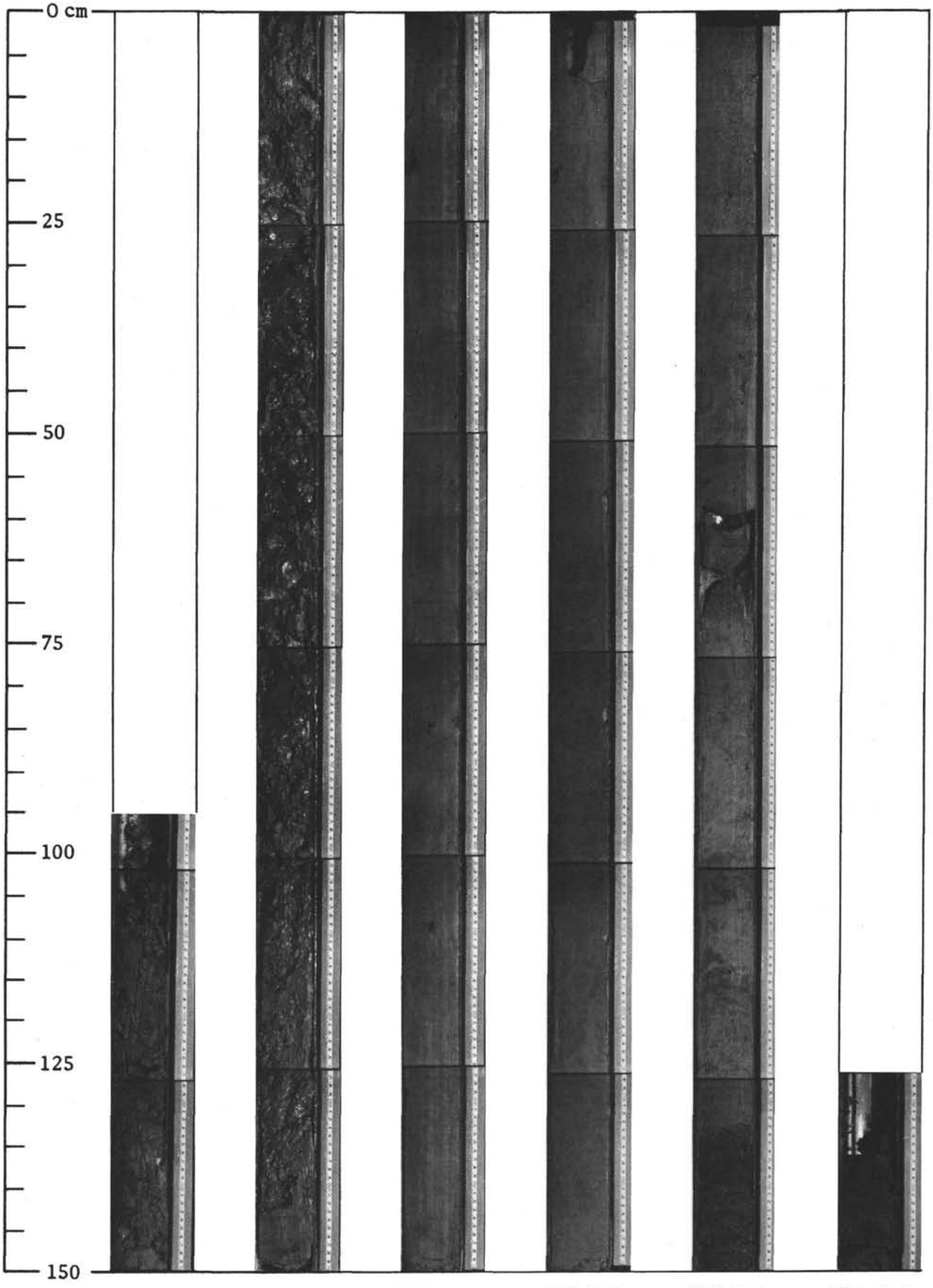
CORE 11

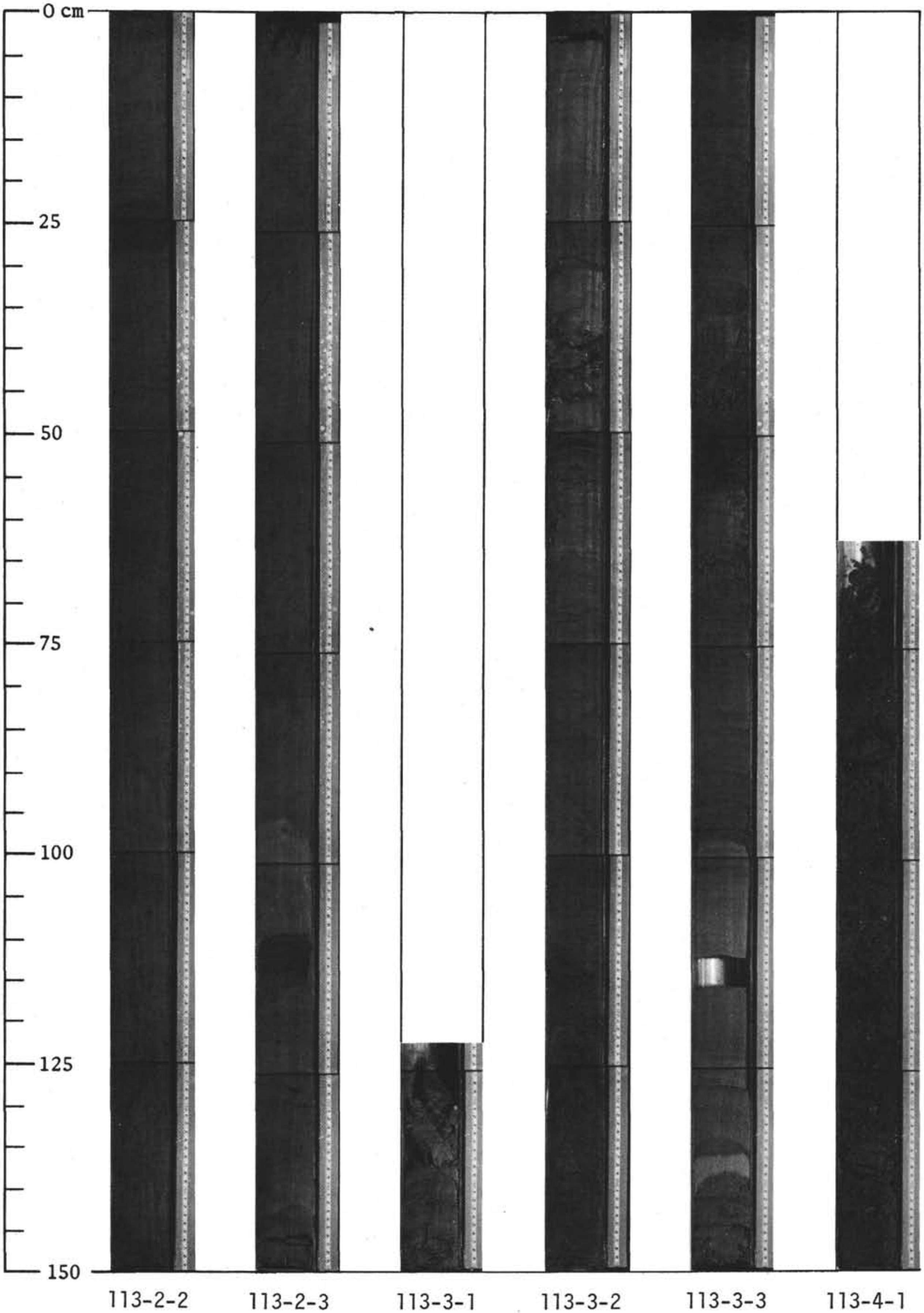
METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1 2	1 2	NO CORE	N N N	N3 N5 5Y 6/4 5Y 2/1	Dark gray, medium gray, dusky yellow, & olive black, faintly laminated (at top) mudstone with some convolutions in lower section & some pyritized burrows. Similar to core 8, except for silt band in Sec. 2, consisting predominantly of authigenic carbonate with some corroded fragments of foraminifera and nannofossils. X-ray Mineralogy (bulk) Calc. 1.5 Qtz. 13.3 Plag. 22.7 Kaol. 2.1 Mica 9.9 Mont. 47.3 Amph. 3.2 Amorph. 55.8	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Reticulofenestra umbilica, Helicopontosphaera kamptneri* Flora similar to above, + *Sphenolithus* sp. cf. *moriformis* Flora similar to above		MIOCENE? - PLIOCENE ?
	CC		F N R		**Core Catcher:** Mudstone, description above.	**Core Catcher:** Fauna: Barren Flora similar to above, + *Discoaster* sp., *Sphenolithus* sp. cf. *moriformis, Helicopontosphaera kamtneri, H. sellii, Pontosphaera discopora* No radiolarians. Minor amounts of carbonaceous and bituminous (?) material.		

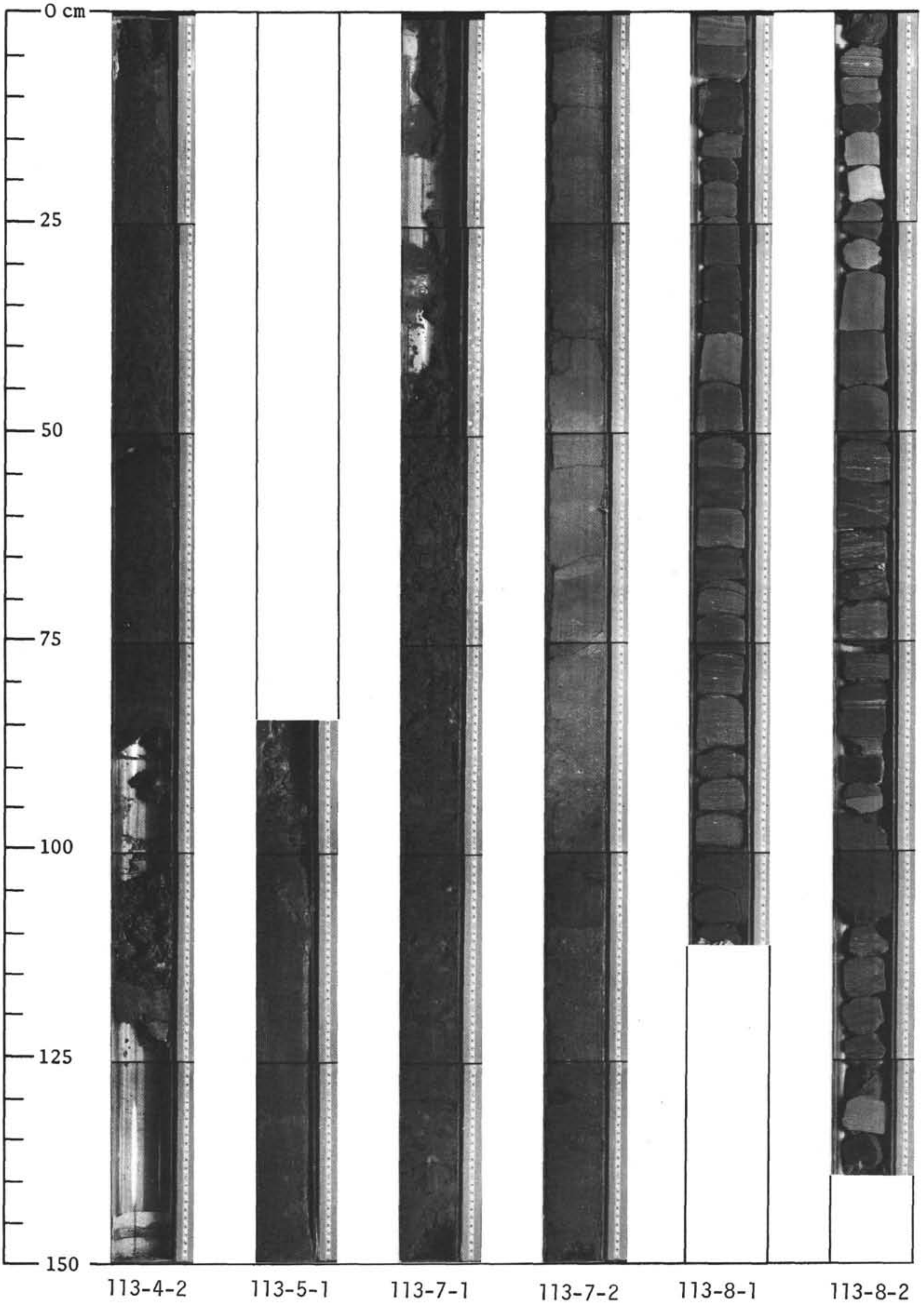
HOLE 113 860 **TO** 863 **m**

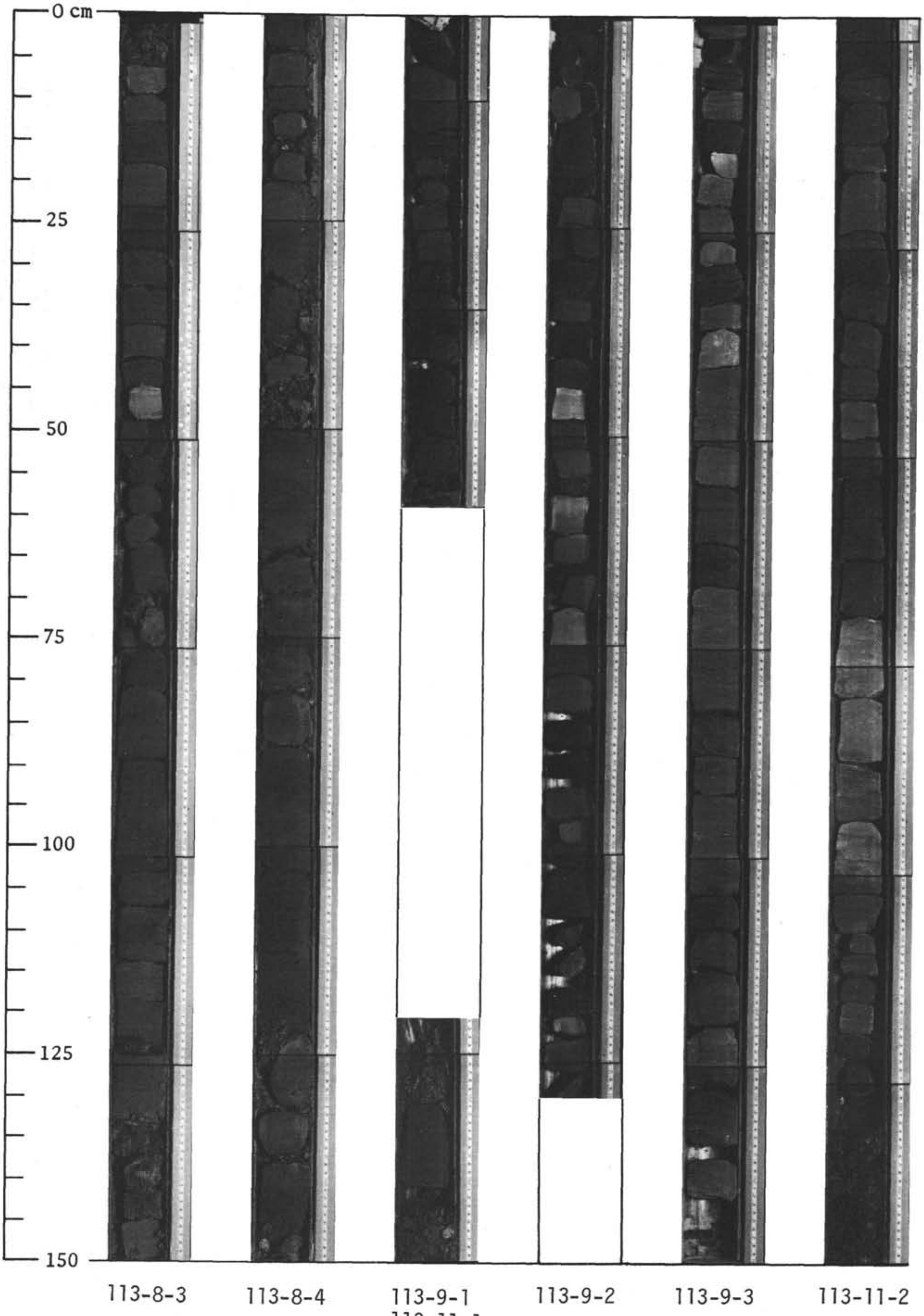
CORE 12

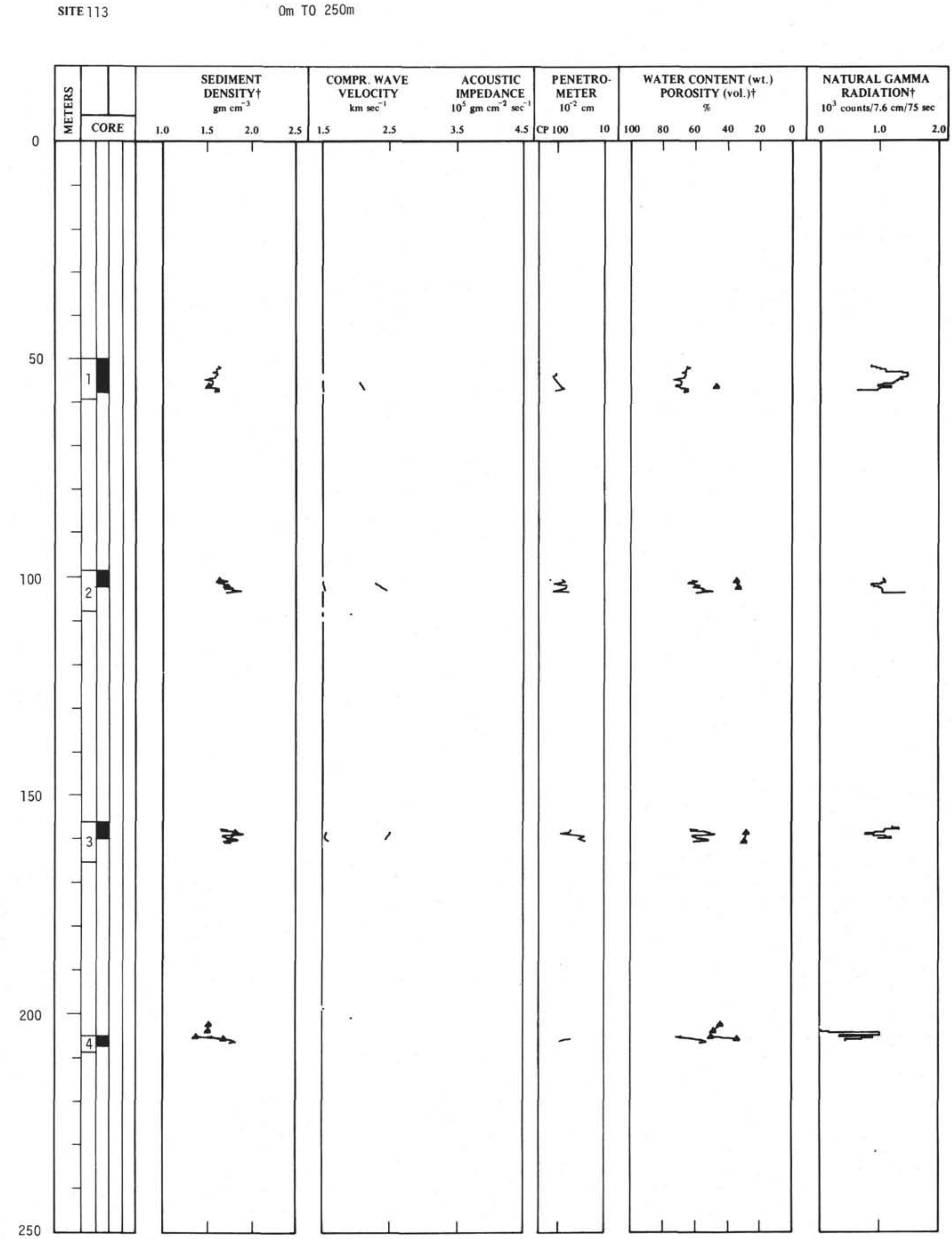
METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
	CC		F N R	5G 2/1	Greenish black, finely laminated mudstone with a few clay pellets & small rock fragments.	Fauna: *Globorotalia acostaensis, Globigerina* sp. *Coccolithus pelagicus, Cyclococcolithus leptoporus, Discoaster brouweri, D. challengeri, D.* cf. *bollii, Sphenolithus abies, Reticulofenestra pseudoumbilica, Helicopontosphaera kamptneri, Pontosphaera discopora* No radiolarians. Carbonaceous material. One *scolecodont*.		MIOCENE?


0 cm
25
50
75
100
125
150
113-1-1
113-1-2
113-1-3
113-1-4
113-1-5
113-2-1


0 cm
25
50
75
100
125
150
113-2-2
113-2-3
113-3-1
113-3-2
113-3-3
113-4-1


0 cm
25
50
75
100
125
150
113-4-2
113-5-1
113-7-1
113-7-2
113-8-1
113-8-2


0 cm
25
50
75
100
125
150
113-8-3
113-8-4
113-9-1
113-11-1
113-9-2
113-9-3
113-11-2



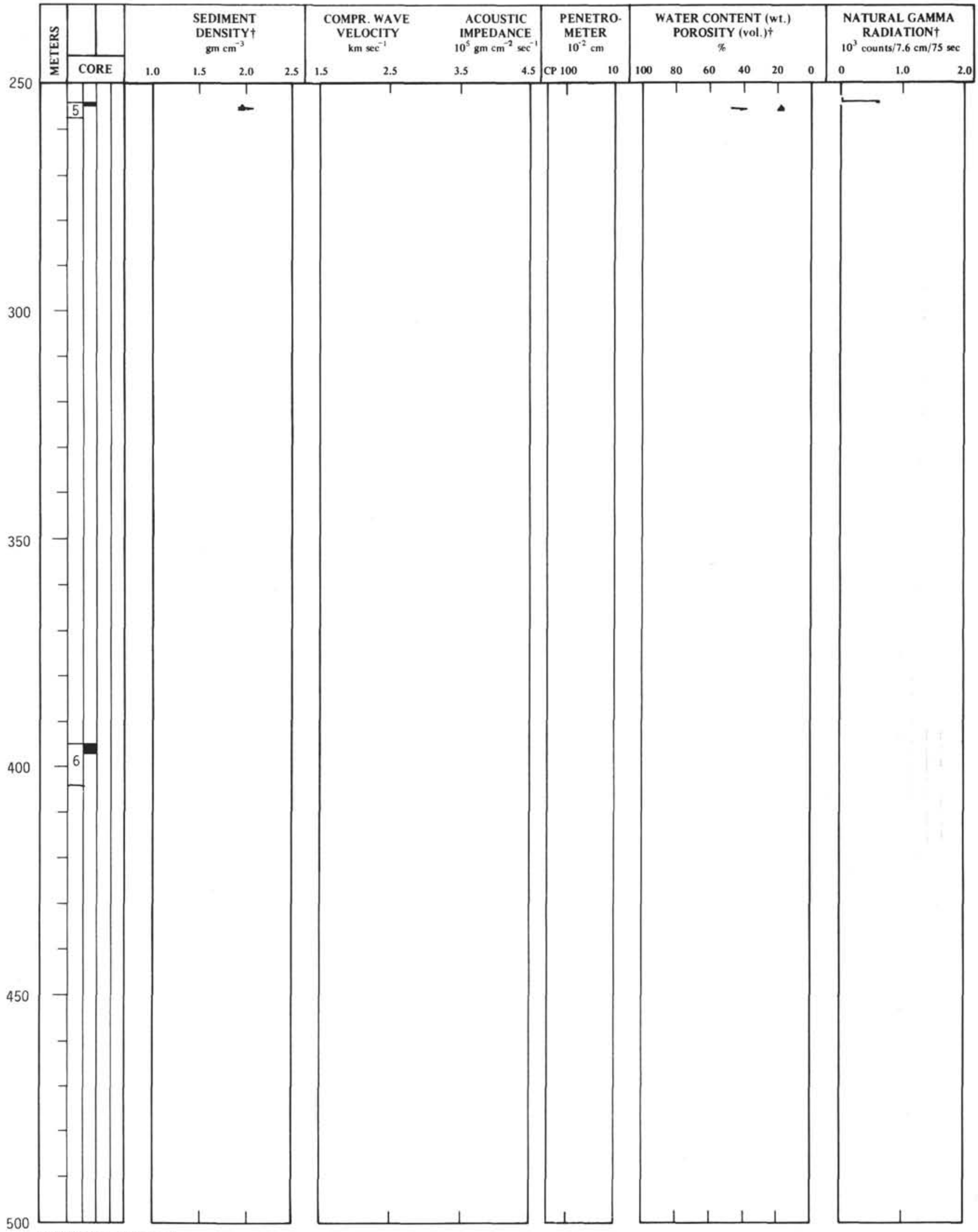
†Adjusted data, see Chapter 2

SITE 113 0 TO 250 m

METERS	113 CORE	SEISMIC REFL.	DRILL DATA	LITHOLOGY	SED. RATE cm 10^{-3}y	AGE † m. y.	TIME STRATIGRAPHIC SUBDIVISION
		REFLECTORS AT 0.06, 0.12, 0.43, 0.89 and 0.97 SECS.	DEPTHS CANNOT BE ASSIGNED SINCE VELOCITY UNKNOWN	Gray silty clay and clayey silt or sand with a strong terrigenous influence due to ice-rafting and turbidite activity, intercalated with hemipelagic calcareous nannofossil foraminiferal clay and marl. Silicious tests and sponge spicules of some importance only in Cores 4 and 5.			
50	1						
100	2				10		PLEISTOCENE
150	3						
200	4					2	
					35		PLIOCENE
250							

†See Chapter 2 (explanatory notes)

SITE 113 250m TO 500m



† Adjusted data, see Chapter 2

SITE 113 250 **TO** 500 **m**

METERS	113 CORE	SEISMIC REFL.	DRILL DATA	LITHOLOGY	SED. RATE cm 10^{-3}y	AGE† m. y.	TIME STRATIGRAPHIC SUBDIVISION
	5			Grey silty clay and claey silt or sand with a strong terrigeneous influence due to ice-rafting and turbidite activity intercalated with hemipelagic calcareous nannofossil foraminiferial clay and marl. Silicous tests and sponge spicules of some importance only in Cores 4 and 5.			
300							
350					35		PLIOCENE
400	6			Silty turbidite sand with a heavy mineral content of up to 25% and shallow water shell fragments.			
450							
500							

†See Chapter 2 (explanatory notes)

SITE 113 500m TO 750m

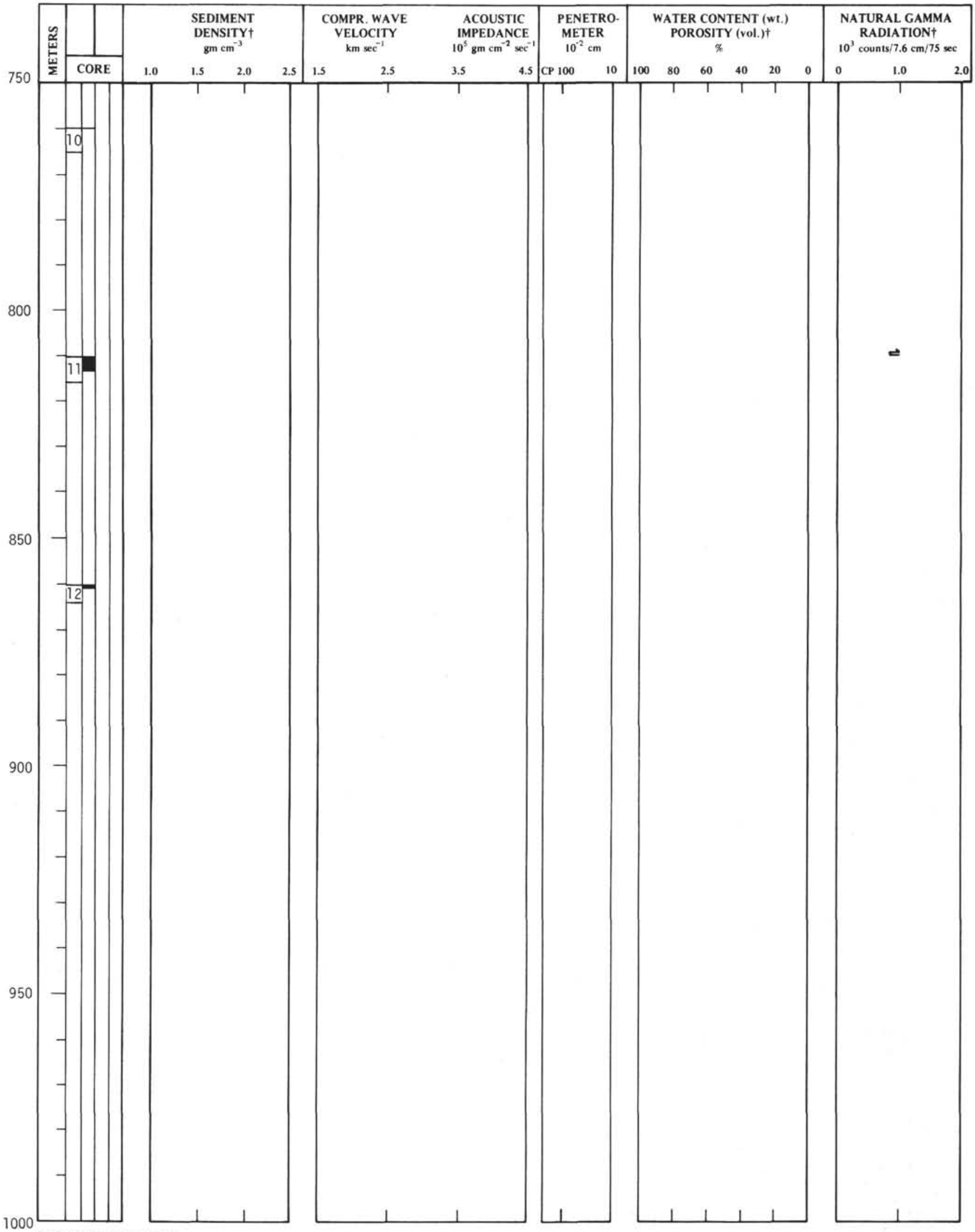
†Adjusted data, see Chapter 2

SITE 113 500 TO 750 m

METERS	113 CORE	SEISMIC REFL.	DRILL DATA	LITHOLOGY	SED. RATE cm 10^{-3}y	AGE† m.y.	TIME STRATIGRAPHIC SUBDIVISION
					35		GLACIAL
550	7			Mudflow breccia with reworked Eocene, Oligocene and Pliocene clay and nannofossil clasts, in a matrix consisting of a mixture of Eocene and Pliocene sediments.		3.0	PRE-GLACIAL
600				In the lowermost part, the erosional contact between the underlying mudstone and the mudflow could be seen.			PLIOCENE
				Dark brownish gray to black, more or less finely laminated pyritic mudstone or silty claystone. Laminae in in the laminated parts are 0.5 to 1.0 mm thick, consisting of a light gray basal silt band (mostly quartz, some glass, authigenic carbonate feldspar and zeolite) passing over into a zeolitic clay band.	11.5		
650	8						
700	9						
750							

†See Chapter 2 (explanatory notes)

SITE 113 750m TO 1000m



†Adjusted data, see Chapter 2

SITE 113 750 TO 1000 m

METERS	CORE 113	SEISMIC REFL.	DRILL DATA	LITHOLOGY	SED. RATE cm 10^{-3}y	AGE † m. y.	TIME STRATIGRAPHIC SUBDIVISION
	10			Dark brownish gray to black, more or less finely laminated pyritic mudstone or silty claystone. Laminae in the laminated parts are 0.5 to 1.0 mm thick, consisting of a light gray basal silt band (mostly quartz, some glass, authigenic carbonate feldspar and zeolite) passing over into a zeolitic clay band.			
800	11				11.5		PLIOCENE
850	12					5	?
							MIOCENE
900				BOTTOM OF HOLE			
950							
1000							

†See Chapter 2 (explanatory notes)