10. SITE 119

The Shipboard Scientific Party[1]

Location: Cantabria Seamount, Bay of Biscay.

Position: 45° 01.90′N, 7° 58.49′W; (satellite navigation).

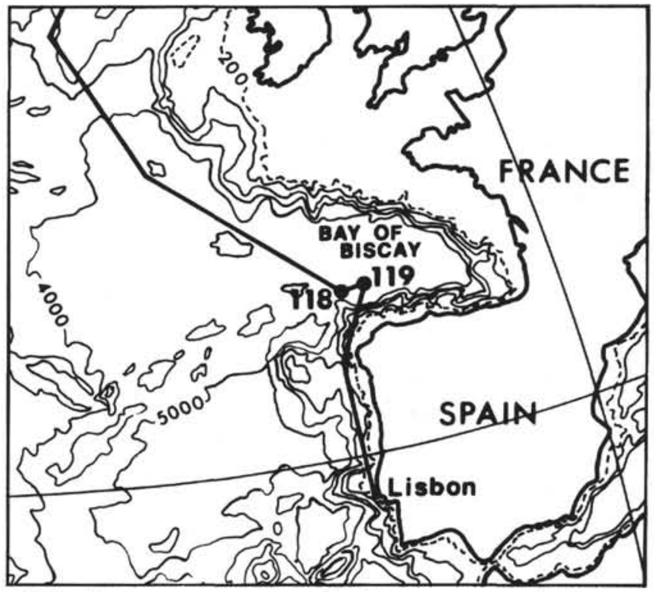
Depth of water: 4447 meters (corrected).

Total penetration: 711 meters.

SITE BACKGROUND AND OBJECTIVES

The origin of the Bay of Biscay (Golfe de Gascogne) has been discussed extensively in the past few years but there is no generally accepted mechanism by which it was produced. On the one hand it is proposed that the bay has been formed by the anticlockwise rotation of Spain and the consequent growth of oceanic crust by sea-floor spreading in the center. This view has been held in general by geophysicists and workers familiar with the oceanic crust. On the other hand, evidence from the neighboring continental geology, especially from the Aquitaine basin at the eastern end of Biscay, and from deep penetration reflection profiles across the Bay has been used to support a hypothesis of a sunken and oceanized continent underlying the thick sediments. These opposing views are discussed more fully in Chapter 9, Site 118 and the evidence is summarized in Montadert *et al.* (1971), and Debyser, Le Pichon and Montadert (1971).

The Bay of Biscay is extensively covered with thick sediments which make it difficult to sample the deeper layers. There are however four seamounts which rise above the abyssal plain. In the eastern Bay, "3270" Seamount (4.5°W) and Gascony Seamount (5.5°W) have not been studied in great detail. Recent profiles across Gascony Seamount suggest that it is underlain by downwarped continental rocks of Mesozoic age and older (Montadert *et al.*, 1971). Both seamounts lie east of the region in which there is good seismic, gravity and magnetic control to support evidence for an oceanic crust. At the western end of Biscay, Biscay Seamount (10°W) lies outside the region which would have been formed by the simple anticlockwise rotation of Spain, although it does lie parallel to the fan-shaped magnetic anomaly pattern of the bay.



Cantabria Seamount (8°W), on the other hand, lies well within the Bay at about 80 kilometers from the base of the continental slope north of Spain (Figure 1), on a prominent E-W negative magnetic anomaly (Matthews and Williams, 1968, Le Borgne and Le Mouël, 1970) and over typical oceanic crust (Bacon, Gray and Matthews, 1969). It was first surveyed with 5-mile spaced lines by *Discovery*-11 in 1966 (Jones and Funnell, 1968) and the western end with 3-mile spaced lines by *Charcot* in the same year (Vanney, 1967). Subsequent surveys have been made by *Vema*-27 and by the Institute Francais du Petrole (IFP) in 1969. The bathymetric chart (Figure 2) is based on British and French soundings up to 1969.

Seismic reflection profiles by airgun from *Discovery*-11 showed a prominent reflector (1) overlain by about 0.4 second of a relatively transparent layer, dipping southward beneath the abyssal plain (Jones and Funnell, 1968). On the north steep scarp reflector 1 outcropped. Similar records were obtained by *Vema*-27 also with an air gun. However two crossings were made by *Charcot*-9 in 1969 using the Flexotir system, giving about 2 seconds penetration using a lower frequency (about 20 Hz). One section (Figure 3) was across the strike of reflector 1. At this frequency, reflector 1 and the overlying transparent sediments are not so clear. In the "transparent" zone there are distinct reflectors dipping southwards, which lie unconformably on reflector 1 which dips more steeply. Beneath reflector 1, there is a series of parallel reflectors to 2 seconds dipping to

[1]A. S. Laughton, National Institute of Oceanography, United Kingdom; W. A. Berggren, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; Richard Benson, Augustana College, Rock Island, Illinois; T. A. Davies, Scripps Institution of Oceanography, La Jolla, California; Ulrich Franz, Technische Hochschule, Munchen, W. Germany; Lillian Musich, Scripps Institution of Oceanography, La Jolla, California; Katharina Perch-Nielsen, University Institute for Historical Geology and Paleontology, Copenhagen, Denmark; Alan Ruffman, Bedford Institute, Dartmouth, Nova Scotia (Present address: Seascope Consultants, Box 15-6-52, Purcell's Cove, Nova Scotia); J. E. Van Hinte, Imperial Oil Enterprises, Ltd., Calgary, Alberta; R. B. Whitmarsh, National Institute of Oceanography, United Kingdom.

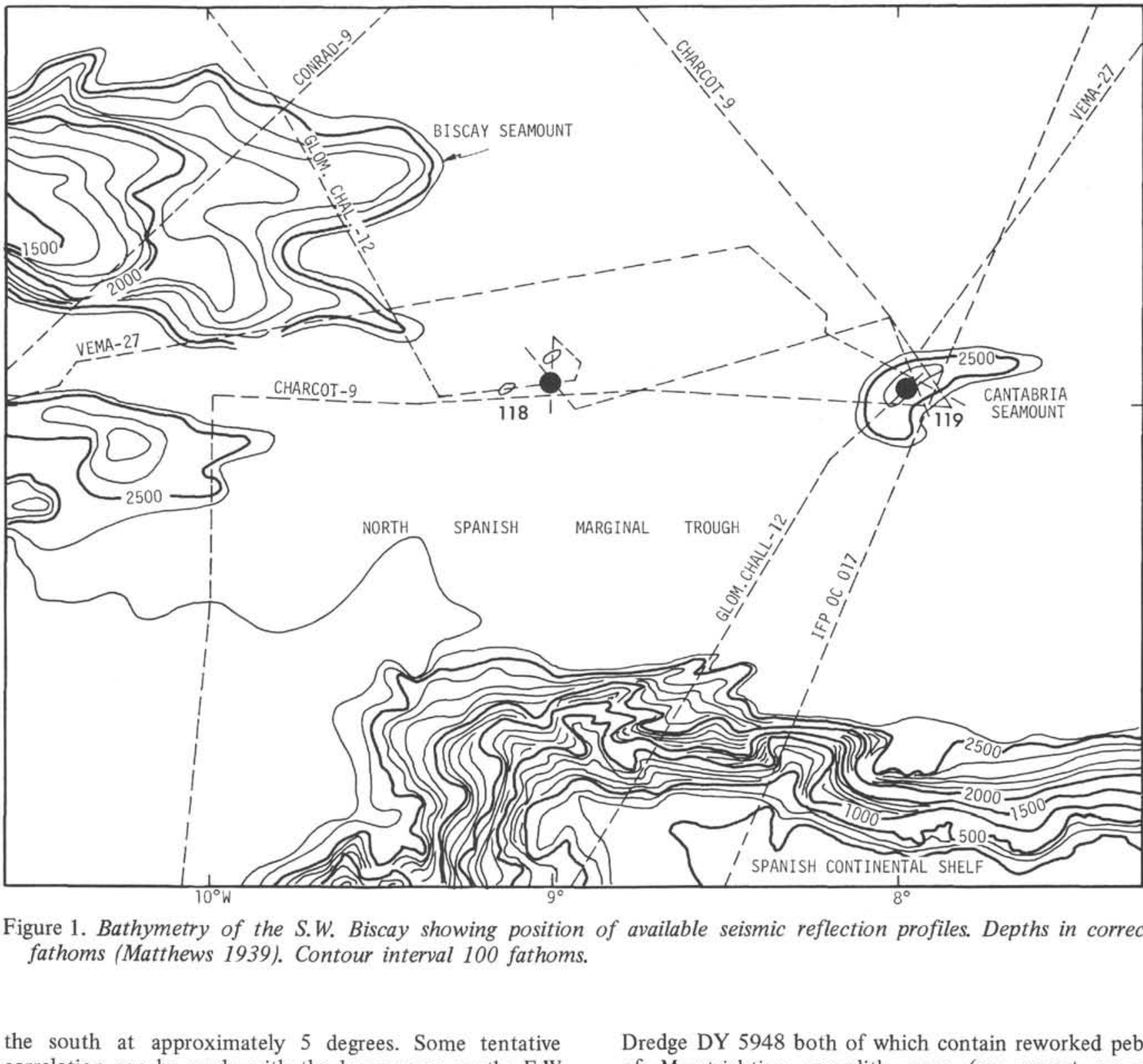


Figure 1. *Bathymetry of the S.W. Biscay showing position of available seismic reflection profiles. Depths in corrected fathoms (Matthews 1939). Contour interval 100 fathoms.*

the south at approximately 5 degrees. Some tentative correlation can be made with the layers seen on the E-W approach track of *Charcot*-9 (Figure 4), but no continuity exists between these and the abyssal plain formations further west. Indeed it is likely that whole of formation R and the top of formations 2 and 3 (defined by Montadert *et al.*, 1971) pinch out here against Cantabria Seamount.

A processed Flexotir profile (OC 017) was shot by IFP across the seamount further east, in which nearly 3 seconds penetration was obtained (Figure 5). Gently dipping stratification was seen in the center section to 2 seconds. Montadert *et al.* (1971) correlate the formation between 0.3 and 2.3 seconds below the bottom as belonging to formations 2 and 3 found under the abyssal plain, although no continuity can be seen (Figure 6). Since Hole 119 penetrates 0.8 second, on this interpretation the lower part of the hole sampled formation 2.

On the north scarp, cores and a dredge haul were made on *Discovery*-11 to sample reflector 1 where it outcrops. Jones and Funnell (1968) describe Core DY 5946 and Dredge DY 5948 both of which contain reworked pebbles of Maestrichtian coccolith ooze (see report on reexamination of this material in later section). Although these are quoted to have been derived from 2400 uncorrected fathoms (4526 corrected meters), that is near the top of the cliff, further investigation shows that this was the echosounder depth derived from the side echo of the cliff and that the corer below the ship probably sampled the base of the cliff (Figure 7). It is possible therefore that these samples do not in fact represent reflector 1 but some layer below it. Further attempts have been made to verify the existence of Cretaceous outcrops on Cantabria by IFP (Montadert, personal communication) and *Vema*-27, but the oldest sediment found has been Paleocene (Figure 2).

The principle objective, therefore, of drilling a hole on Cantabria Seamount was to sample reflector 1 (believed at that time to be Cretaceous) and to drill further into the layered sequence below it to obtain data on the older strata in the Bay of Biscay, since this site was the only place in Biscay where such old strata came within reach of drilling.

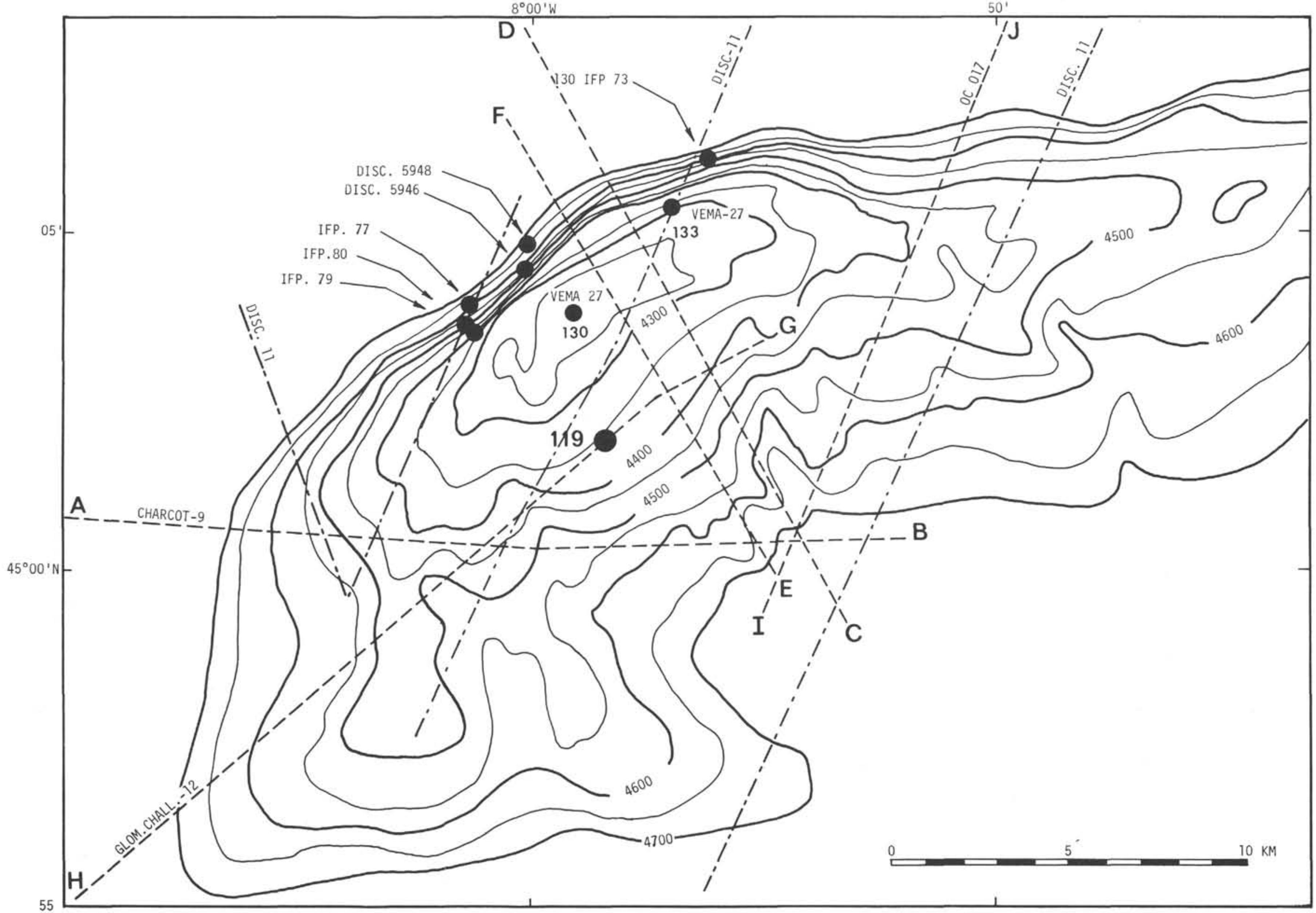


Figure 2. *Bathymetry of Cantabria Seamount after Montadert (personal communication) showing position of available seismic profiles, and core and dredge samples. Depths in uncorrected meters at 1463 m/sec. Contour interval 50 meters.*

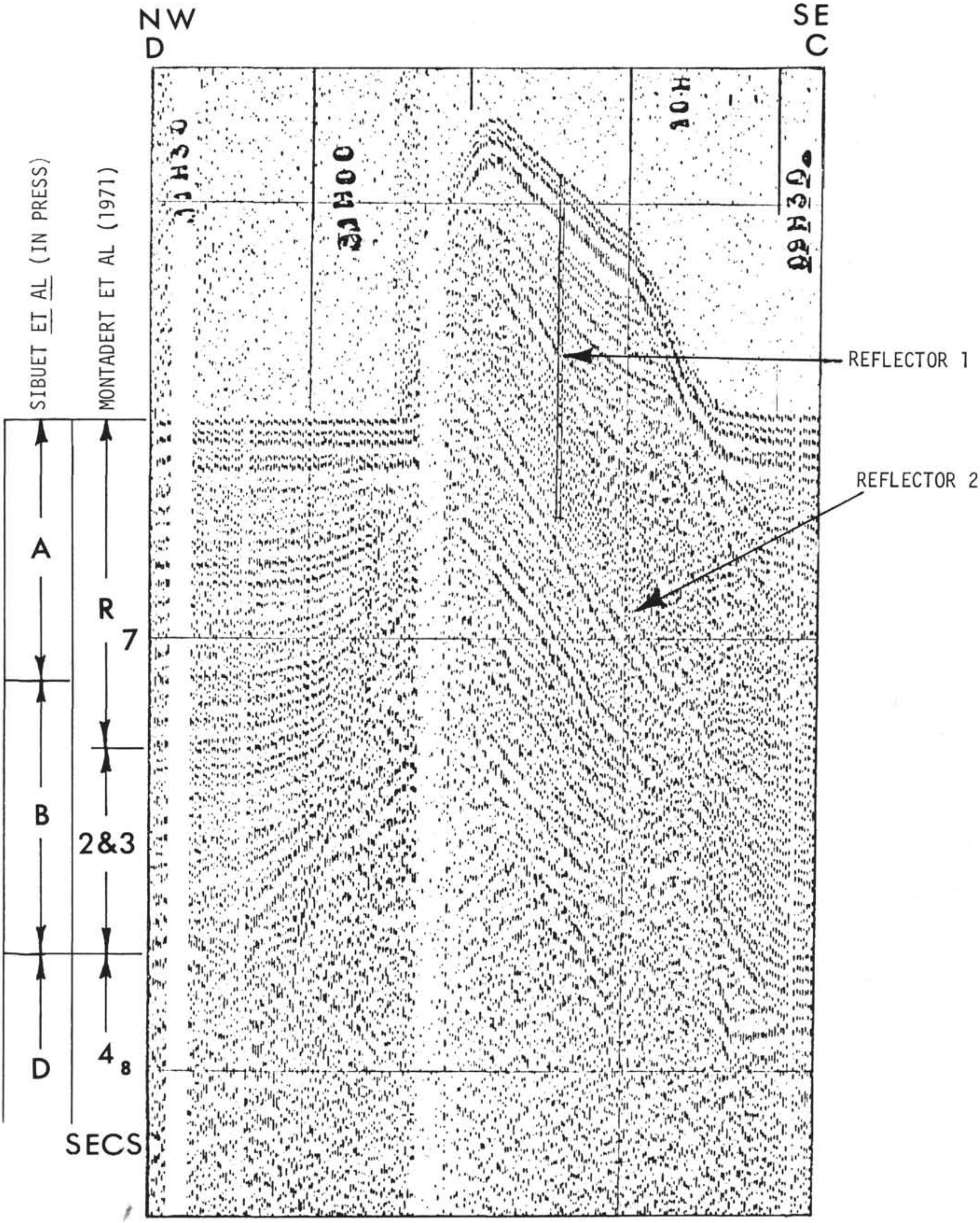


Figure 3. *SE-NW seismic reflection profile CD (Flexotir) by* Charcot-9 *across strike of Cantabria Seamount. Interpretation of layering by Montadert* et al. *(1971) and by Sibuet* et al. *(1971). (Record by courtesy of C.N.E.X.O., France.)*

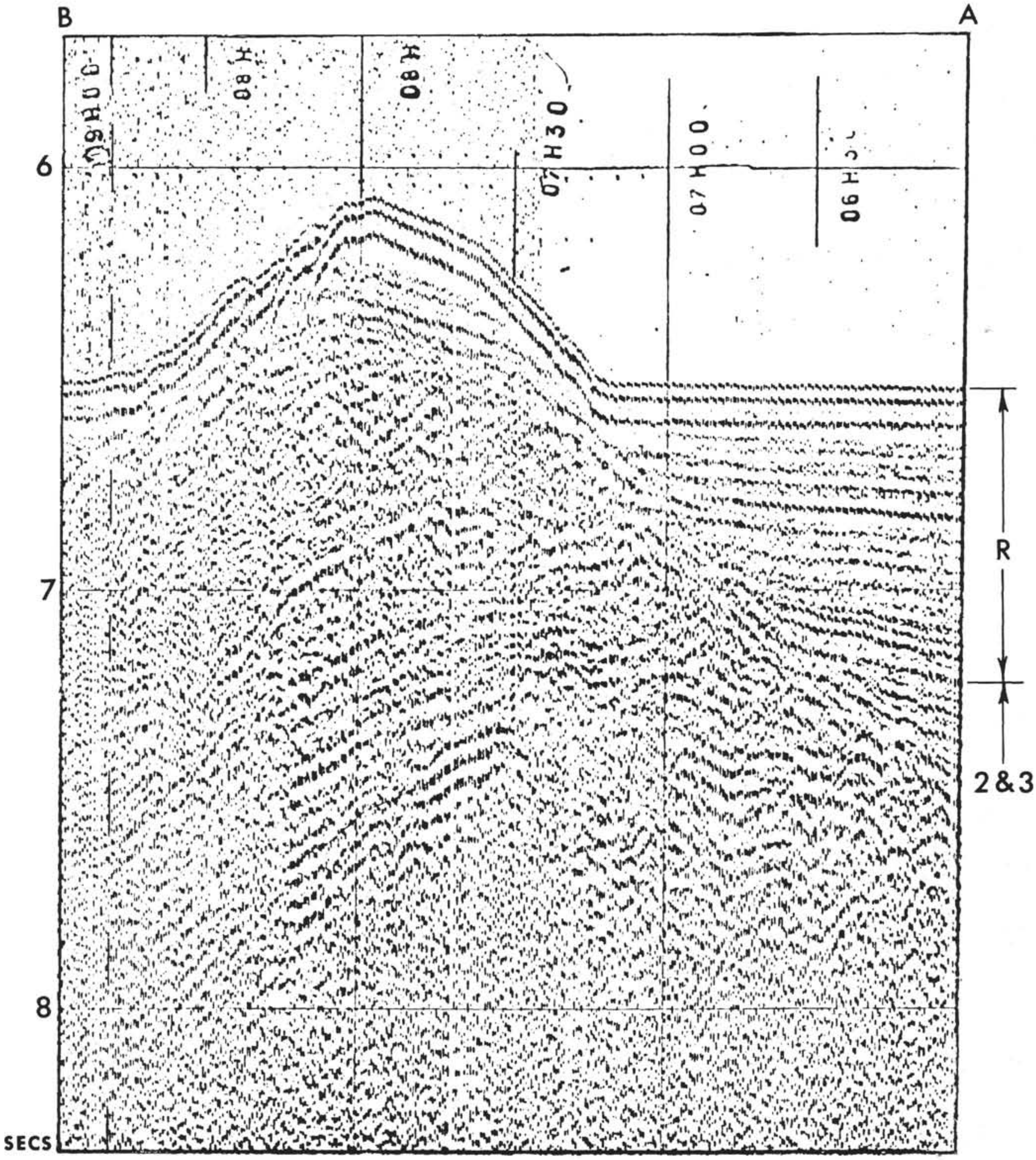


Figure 4. *E-W seismic reflection profile AB (Flexotir) by* Charcot-*9 across SW end of Cantabria Seamount. (Record by courtesy of C.N.E.X.O., France.)*

Even so it was realized that at least 500 to 1000 meters of stratified sediments would lie below the depth which could be sampled. A secondary objective was to deduce the age of tectonic movement which thrust up Cantabria, if indeed it was at one time part of the deep-sea bed and not a continental remnant. In summary the objectives were:

(a) To sample Maestrichtian and older sediments indicated by the reflection profiles.

(b) To date the tectonic uplift of Cantabria Seamount.

SURVEY DATA

The approach to Cantabria Seamount was made from the northwest. With no adequate navigation system on board, this had to be made by dead reckoning from Site 118, some 50 miles away, with one poor sun position line half way along. A traverse of the seamount at 6 knots to the southeast normal to the strike direction was compared with the bathymetric chart based on the *Discovery*-11

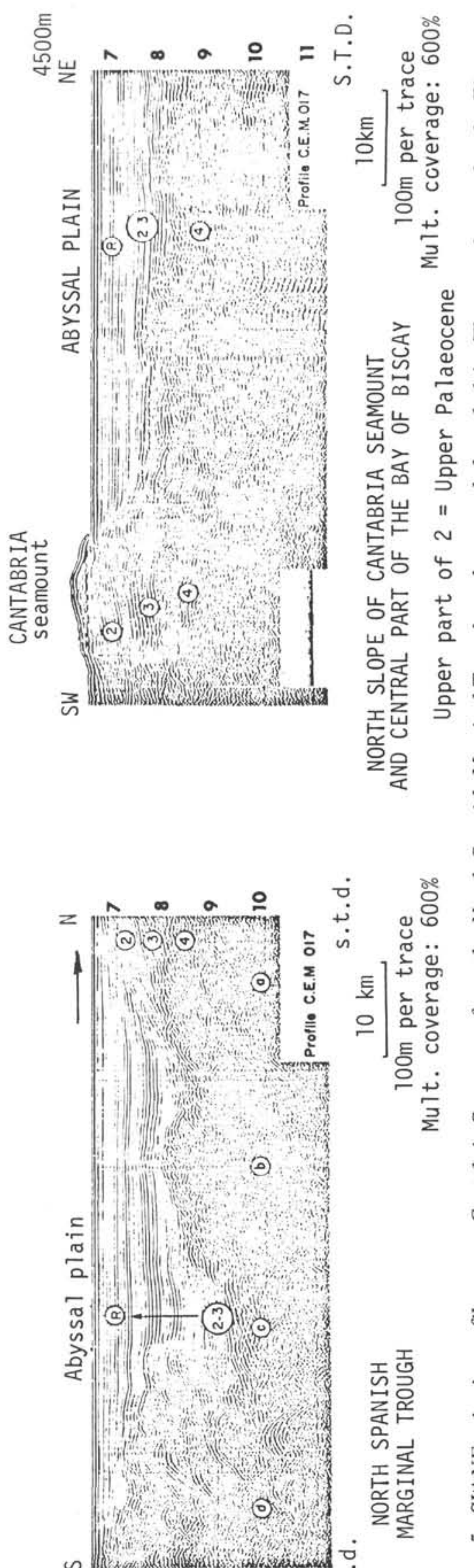


Figure 5. *SW-NE seismic profile across Cantabria Seamount from the North Spanish Marginal Trough to the central abyssal plain. The record was taken by* Florence *(017) using Flexotir and signal processing. (From Montadert* et al., *1971.)*

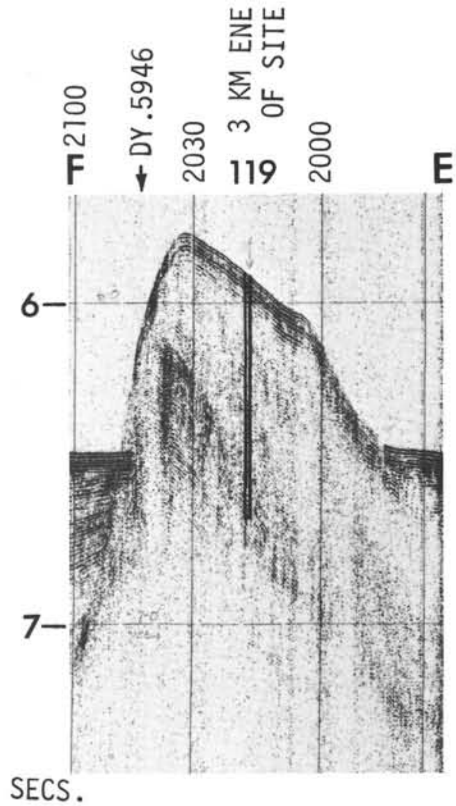


Figure 6. *NW-SE seismic profile FE by* Glomar Challenger *(80-160 Hz).*

survey (the IFP chart was not at this time available); and it showed that we had crossed the most shallow area, and enabled an approximate position of the track to be determined. However, just as we started to cross the north cliff, the hydrophone eel became very noisy and had to be changed. It was necessary to replace it, by which time the seismic section was spoiled. The track was therefore reversed and a second profile made to the northwest, this time at 4 knots to give reduced noise and a more extended section. On this profile (Figure 6), the dipping reflectors which had been seen on the *Charcot*-9 record were clearly seen, and a site for drilling was chosen at a depth of 4447 meters (corrected). The traverse was completed onto the abyssal plain, the track reversed again, and the seismic gear was recovered after we had once more reached the crest of the seamount. The beacon was finally dropped when the echo-sounder recorded a depth of 4447 meters (corrected).

On completion of drilling, a profile across the beacon was made at 5.5 knots, from a point 2 miles to the northeast of the beacon in a direction 230 degrees thought to be approximately along the strike of the ridge of Cantabria Seamount, and for 11 miles until well onto the abyssal plain.

Although navigation at the time was by celestial observation and dead reckoning, satellite fixes were recorded but not computed on board. A track plot using the satellite

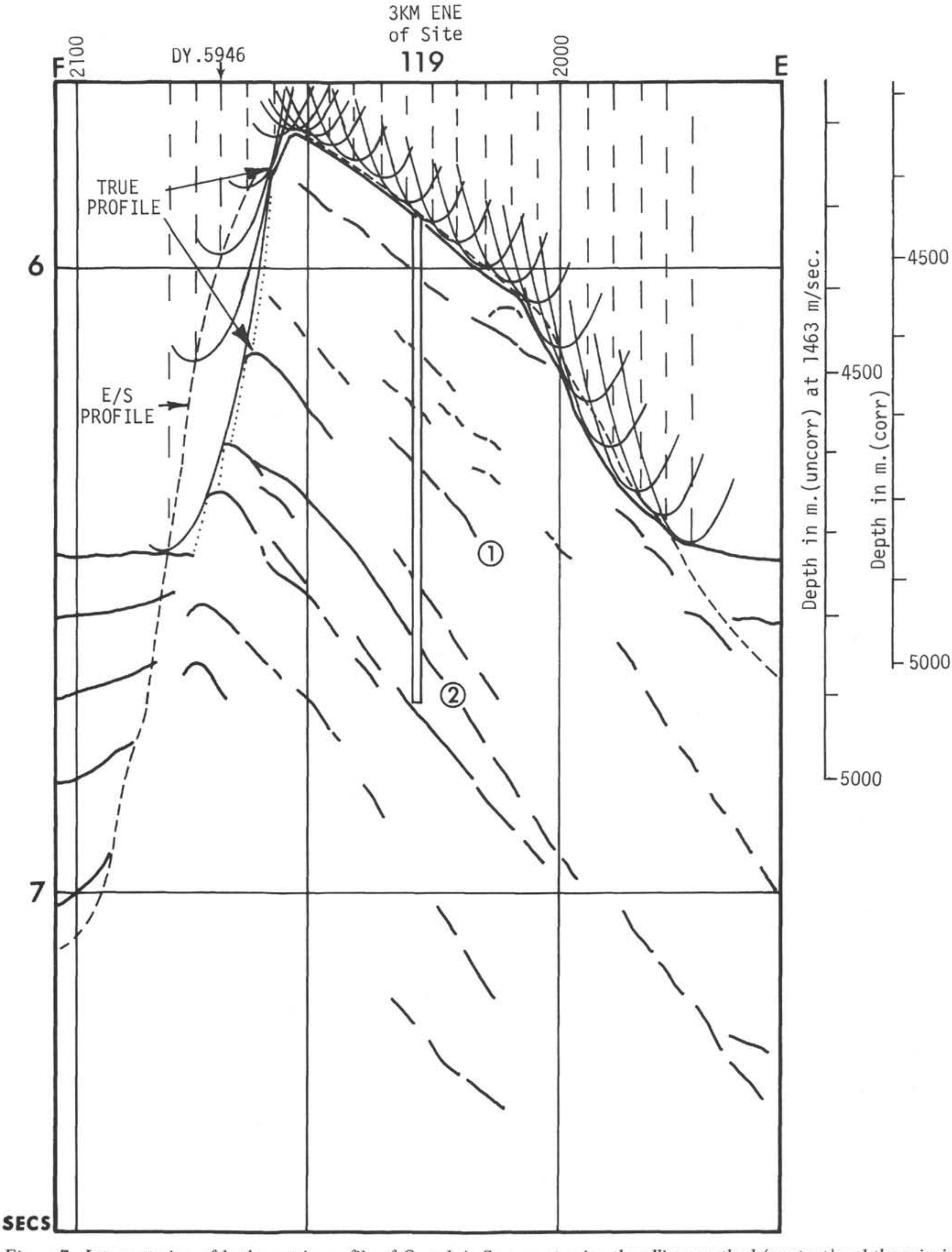


Figure 7. *Interpretation of bathymetric profile of Cantabria Seamount using the ellipse method (see text) and the principal reflecting horizons of profile EF.*

fixes computed subsequently required a current of 0.6 knots from the northeast in order to make the track consistent with the topography. The relative position of the profiles of *Glomar Challenger*-12 and *Charcot*-9 shown to be about one mile apart in Figure 2, is therefore open to some error. Furthermore, the beacon position lies west of both profiles shown in Figures 3 and 6. The hole positions have been shown in these figures at the equivalent water depth.

Profile EF (Figure 7) has been corrected for beam angle by the ellipse method, which profoundly modifies the shape of the north cliff. Because the sound transmitted to the sea bed is not a narrow vertical pencil, echoes can be received from targets ahead, astern, or abeam of the ship. When crossing a linear feature at right angles, a geometrical construction can be used to translate the record into a profile which largely eliminates this effect. An ellipse is constructed which defines all points ahead and astern that lie at the range indicated by the echo time. By placing the apex of the ellipse on the recorded reflection at successive points, and tracing the ellipse onto the record, the true profile is formed by the envelope of the ellipses. It can be seen that all the echoes on the northern scarp are reflected from near the crest of the seamount. A mean slope of 17 degrees has been calculated from the edge of the abyssal plain to the first reflecting point. However the echo-sounder record indicates some intermediate flatter areas and, hence, there must also be some steeper slopes.

The seismic reflection record of the profile EF (Figure 6) showed a number of reflectors dipping to the southeast. Below the position of the site projected northeast onto this profile, the first major reflector is at 0.40 second below the sea bed. Although it is not continuously strong, it can be traced (Figure 7) to the north scarp where it would outcrop at approximately 0.45 second above the abyssal plain (that is, 4536 corrected meters). This reflector correlates with reflector 1 of Jones and Funnell (1968) which is shown on their isopach map to lie at approximately the same depth along strike of the ridge. With this map, therefore, it can be correlated with the reflector shown on the *Charcot* record at approximately 0.4 second at an equivalent position.

However, the profile along the strike, (Figure 8) obtained after leaving the site, showed that reflector 1 was very much more complex. A series of hyperbolae to the northeast of the hole indicate that the region between 0.3 and 0.5 second is very distorted or fractured and that horizons although sometimes strong cannot be followed very far. There is some evidence that reflector 1 is at about 0.45 second below Site 119. To the southwest of the hole, these hyperbolae are not seen, but this may be due to lack of energy. Assuming a velocity of 1.71 km/sec, reflector 1 could correlate approximately with either the unconformity at 365 meters or with the harder layers drilled and cored at 420 meters and below.

The next major reflector (2) on the *Glomar Challenger* profile EF was at 0.69 second dipping more steeply than reflector 1. This does not correlate with the strong reflector which shows at 0.32 second above the plain on the north slope and which is probably an exposed shelf. Considerable energy is reflected in the 0.3 second below this shelf, perhaps because the transmitted sound enters the bottom at a favorable angle. The 0.69-second reflector (reflector 2) below the site more likely correlates with the shelf 0.18-second reflector above the plain (at depth 4745 corrected meters). On the *Charcot* record (Figure 3), the equivalent reflector appears to be at 0.85 second and can be traced continuously to the base of the scarp. In the strike section, reflector 2 is more continuous under the site than reflector 1, and can be followed for 20 kilometers to the southwest. In Hole 119, hard siliceous limestones and hard clay beds were encountered at 592 meters and were drilled and cored for 116 meters below. The sudden reduction in drilling rate from 15 to 4 m/hr indicates the change of lithology which could correlate with reflector 2 giving a mean velocity from sea bed to reflector 2 of 1.71 km/sec. These hard formations are partially silicified limestones, silt and mudstones of Upper Paleocene age and turbidite facies.

Below reflector 2, parallel dipping reflectors can be seen on the *Glomar Challenger* records (especially the 40 to 80 Hz record) down to 1.3 seconds below site. On the *Charcot* record, they extend to about 1.9 seconds below sea bed. However on the *Glomar Challenger* record after drilling, the reflectors at 1.3 second below site converge with reflector 1 until a confused series of reflectors appears at the southwestern end of Cantabria.

The geophysical data indicates, therefore, that Cantabria Seamount cannot be considered to be a simple tilted block of stratified sediments. Both along strike and across it, there are zones of multiple hyperbolae indicating severe tectonism or diapiric intrusion. Strata can be correlated only over limited ranges and cannot be followed into the abyssal plain area.

DRILLING OPERATIONS

The beacon was dropped at 2225 hours on August 2nd in a water depth of 4447 meters (corrected). The bottom hole assembly of a Smith 3-cone tungsten carbide insert bit, 10 drill collars and 3 bumper-subs weighed 40,000 pounds.

Bottom was felt at 0825 hours August 3rd, and a core was recovered from 10 to 19 meters. Thereafter cores were taken at 50-meter intervals until 250 meters. Recovery of these cores was not good, being less than 50 per cent. An attempt to increase recovery by coring extremely slowly with little weight, failed to improve this. Drilling became somewhat firmer at 200 meters.

During the day on August 3rd, the beacon began to malfunction and transmitted on low power. A second beacon was dropped and there was no loss of position.

Below 250 meters, continuous cores were taken in order to find and identify the unconformity suggested from the seismic profiling in the region of 250 to 350 meters. It was expected that the Paleocene lay close to the unconformity and that the Maestrichtian lay close beneath this. However this was not to be. An unconformity was indeed found at 356 meters but between Lower Oligocene and lower Middle Eocene. Paleocene was not reached until 400 meters at about which level some harder patches were encountered. Cores were cut with 20 to 30 Klb on the bit and with 5 to 10 s.p.m. on one pump.

Continuous cores were cut down to 433 meters, but still we were in the Upper Paleocene. Hard layers were found between 370 and 440 meters which could explain the

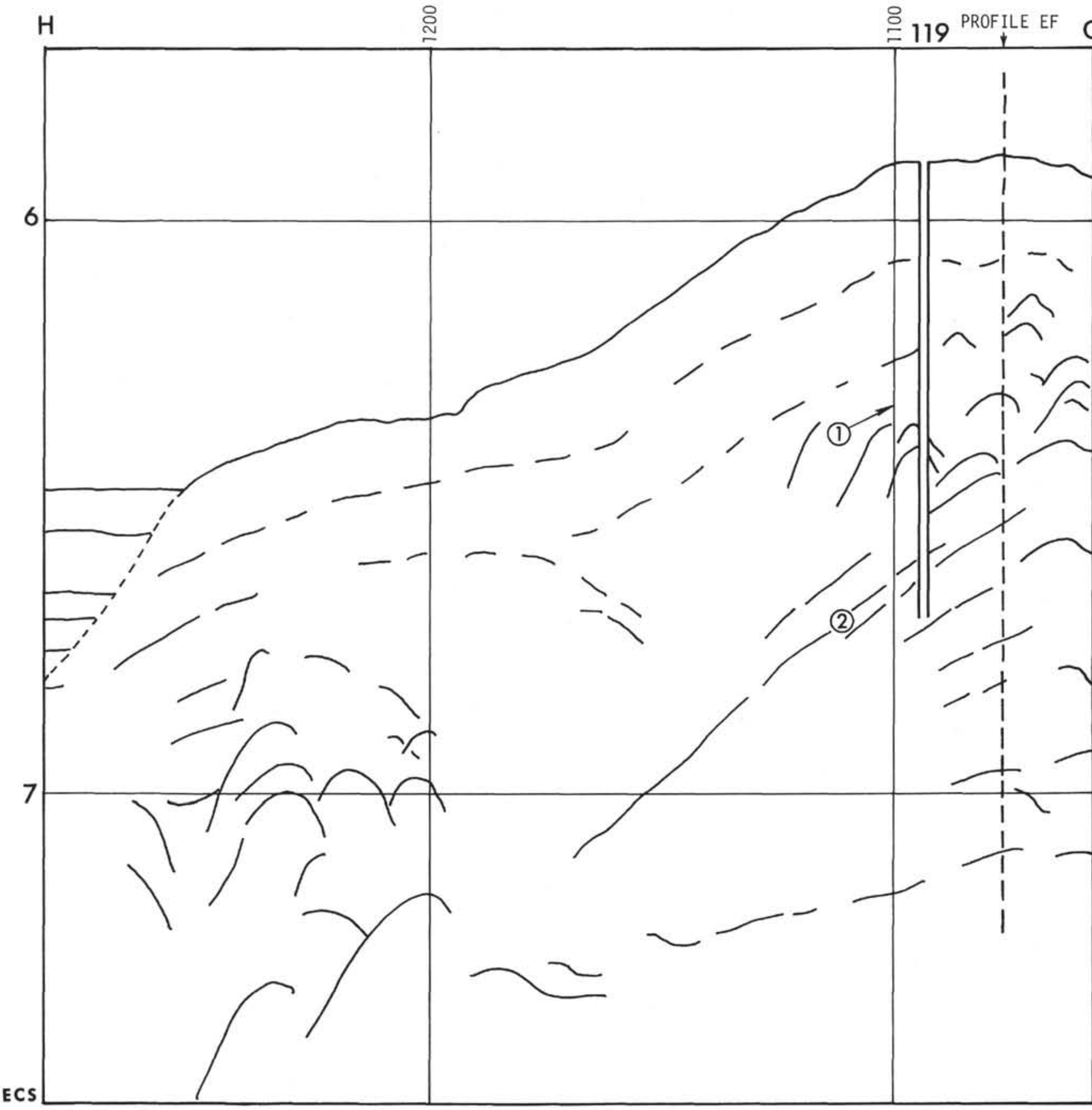


Figure 8. *Interpretation of seismic reflection GH by* Glomar Challenger *after leaving Site 119.*

reflectors thought to be Maestrichtian on the basis of correlation up-dip to the *Discovery*-11 core sample, but these turned out to be due to the upper part of a thick Paleocene turbidite sequence containing silty limestones. The rate of cutting core decreased from 60 m/hr to about 30 m/hr. Several times when the rate of cutting dropped very low it thought to be due to balling up of clay on the bit, but on slicing the cores, hard silicified layers were found.

The increased rate of sedimentation in the Upper Paleocene led us to open out the coring interval. Drilling proceeded with the core barrel in, but with high circulation, and to cut the core the circulation was reduced. The theory was that no core would be recovered with high circulation, but in fact the harder layers were recovered and the softer layers were washed away. Cores 28 to 32 (433 to 594 meters) were cut this way. There is doubt about where, in the drilling plus coring interval, the core actually came from; and, the convention was used here that it all came from the coring interval. Penetration was about 15 to 20 m/hr.

Core 33 (594 to 600 meters) cut extremely slowly, and high circulation was needed to make progress at 6 m/hr. The core barrel was withdrawn because we wanted to know the nature of the hard layer. It was gray muddy silicified limestone, of lower Upper Paleocene age.

TABLE 1
Cores Cut at Site 119

Hole	Core	Cored Interval (m. subbottom)	Core Recovered (m)
119	1	10-19	3.25
119	2	50-59	6.61
119	3	100-109	2.85
119	4	150-159	2.57
119	5	198-207	4.20
119	6	240-249	4.88
119	7	249-258	4.50
119	8	258-267	6.87
119	9	267-276	2.57
119	10	276-284	5.38
119	11	284-293	3.85
119	12	293-302	3.85
119	13	302-311	4.87
119	14	311-320	7.14
119	15	320-329	7.26
119	16	329-338	6.08
119	17	338-347	6.98
119	18	347-356	9.25
119	19	356-365	6.10
119	20	365-374	4.40
119	21	374-383	9.28
119	22	383-392	1.65
119	23	392-401	0.65
119	24	401-410	3.51
119	25	410-419	2.18
119	26	419-428	3.00
119	27	428-433	1.38
119	28	443-452	1.90
119	29	459-465	5.13
119	30	493-502	8.00
119	31	543-552	7.27
119	32	592-594	1.85
119	33	594-600	3.85
119	34	622-630	0.95
119	35*	630-645	4.56
119	36*	648-662	5.05
119	37*	662-674	4.90
119	38	674-683	4.54
119	39*	686-699	7.52
119	40*	699-711	7.50

*More than 9 meters cored, see text.

In order to progress, perhaps faster, the center bit was run down instead of the core barrel for the interval 600 to 622 meters. Circulation pressure had to be reduced to prevent the drill string "bouncing" too hard on the bottom. The center bit was recovered in anticipation of taking a core, but when the core barrel was down, faster progress was made for a while before it became hard again.

After Core 34 was recovered at 2315 hours, August 6th, the drill string was lifted off the bottom of the hole and drilling stopped. Winds up to 35 knots made it necessary to transfer power from the drill platform to run the main propulsion. The winds moderated at 0245 hours, August 7th and drilling was resumed.

From the top of Core 35 (630 meters) to the bottom of the hole at Core 40 (711 meters) drilling became progressively slower varying from 4 to 2 m/hr using moderate circulation. The coring interval varied from 12 to 18 meters, and core recovery of hard limestone and siltstone averaged about 6 meters, representing the harder layers encountered in the coring interval. Cores were obtained about every 6 hours. The last one, Core 40 (699 to 711 meters) was brought to the surface at 1755 hours, August 8th, 5.5 days after the first core.

During the last phase of cutting Core 40, the circulation became blocked. Gray clay was recovered from the bit when it was brought to the surface. Clay from the jets in the bit was sampled separately as it must represent the lower strata in the hole.

The bit was not worn too badly, and it had been drilling in the hard strata for over 2 days. A total of 192 meters of core was recovered out of 368 meters cut in 40 cores (52.2 per cent).

The weather at the site varied from flat calm and light northerly winds to 35 to 40 knot winds from the southwest with heavy rain squalls. Swell was small.

LITHOLOGY

Core descriptions for each of the 40 cores recovered from Site 119 are given in an appendix to this chapter.

The sedimentary section cored on Cantabria Seamount can be divided into two main parts: calcareous silty clays (Cores 1 to 18) above and red clays and turbidites (Cores 19 to 40) below. The hole terminated at 711 meters below the seabed in the turbidite sequence. These two lithologic sections can be separated on the basis of visual examination. Paleontological studies (q.v.) show that the upper sequence is Oligocene to Recent in age, whereas, the lower is Paleocene to Middle Eocene, clearly indicating a hiatus in deposition. Further subdivision of the section is difficult, but each of the two parts can be broadly subdivided as shown on the following page. However, the transition from one lithology to another is gradual and compositionally these units are not discretely defined (Figure 9). Appendix A shows the results of an examination of the smear slides.

As with the other sites, preliminary analyses of grain size and carbonate content were made on samples taken from the cores in order to better define the lithologies. The results are shown in Figures 9 and 10 and Appendices B and

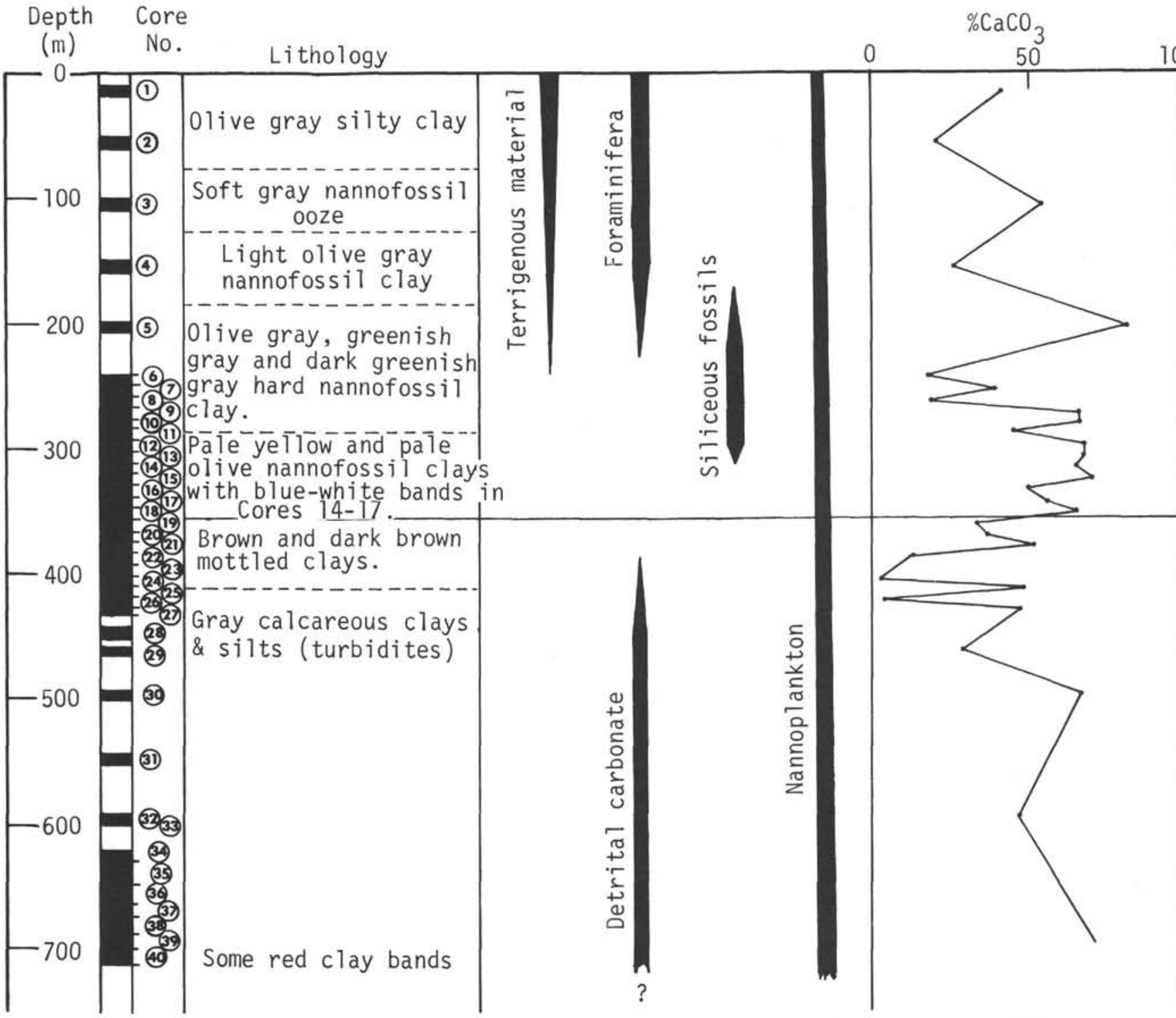


Figure 9. *Summary of the section sampled at Site 119, showing variations in carbonate content and in occurrence of prominent sedimentary components.*

		Depth Below Seabed (m)
Oligocene – Recent silty clays	Olive gray silty clays (Cores 1 and 2)	
		75
	Gray, greenish-gray and yellow nannofossil clays (Cores 3 to 18)	
		355
Paleocene – Eocene sediments	Red brown and gray clays (Cores 19 to 24)	
		410
	Turbidites	

C. The coarse fraction recovered in the course of grain size analysis was examined and the results are displayed in Figure 11.

The Paleocene and Eocene Sediments (Red Clays and Turbidites)

These sediments are all recrystallized, indurated calcareous sediments. The turbidites beds form a series of gray marls and soft calcarenites, alternating with red clays and soft calcarenites, and with intervening layers of pelagic sediment (Figure 12). In many places the turbidites show lamination, convolute bedding and other primary sedimentary structures (load casts, etc.), see Plate 1. Some samples suggest grading, but this is not so clearly developed as in the turbidites sampled at Site 118. Recrystallized foraminifera and large lumps of soft, chalky limestone are the dominant coarse sedimentary components, suggesting that, like the Miocene turbidites sampled in Cores 7 and 8

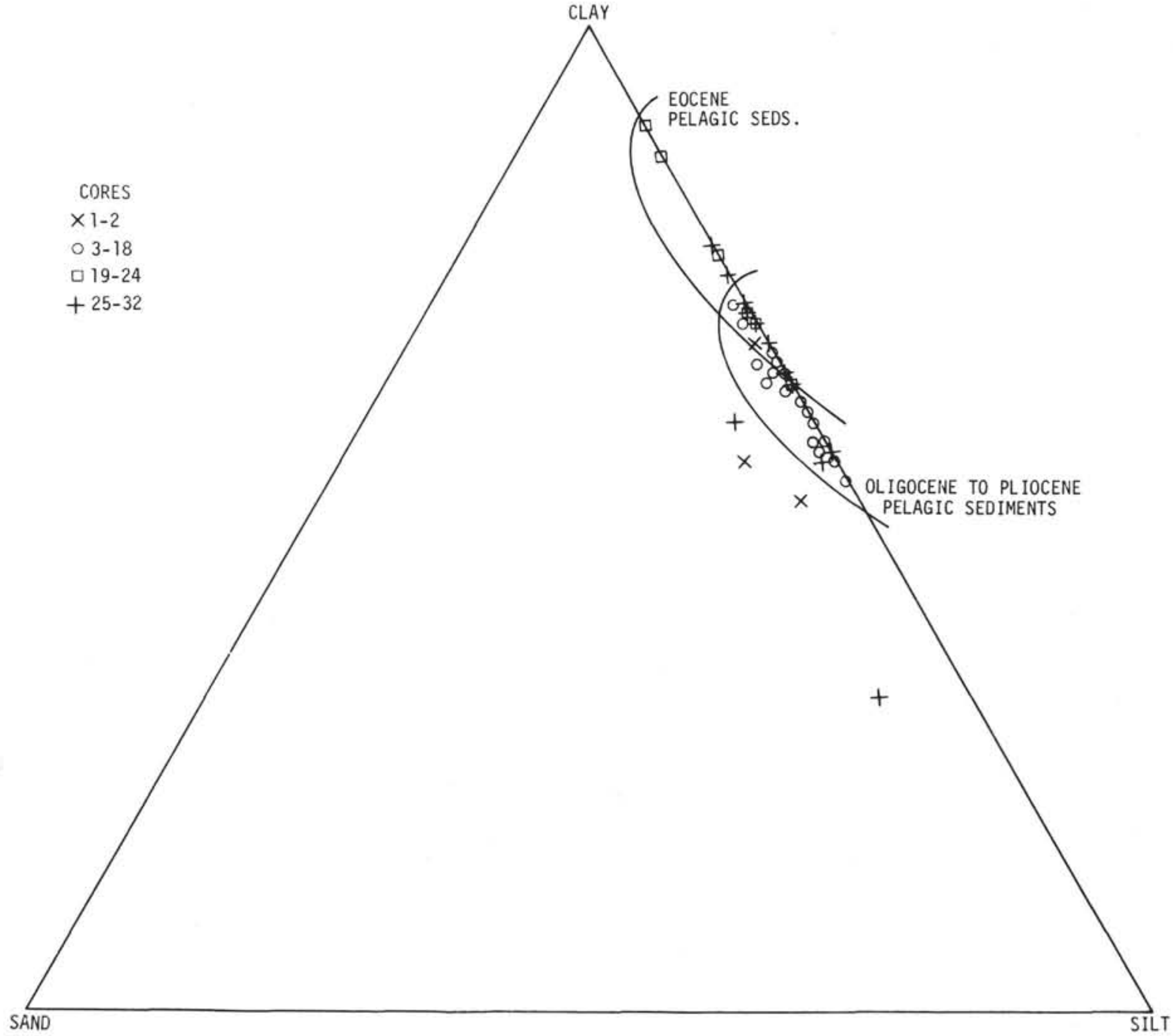


Figure 10. *Texture of samples from Site 119.*

at Site 118, these turbidites are derived from loosely consolidated calcareous shelf deposits. A possible source for these sediments is the northern part of the Aquitaine Basin which shoaled and changed shape considerably at the end of the Mesozoic (Bonnard *et al.*, 1958). The major earth movements in the Aquitaine are Eocene. In addition to the carbonate, some quartz grains, volcanic glass, pyrite and nannofossils were seen. The finer part of the turbidites consists in some places of a gray marl and, in other parts of the section, especially nearer the bottom, of a brick red clay. The gray marl presumably represents normal, fine-grained calcareous pelagic sediment derived either from the shelf or from the deeper parts of the Bay of Biscay traversed by the turbidity currents. The red clays, on the other hand, are probably derived from areas with metamorphosed ("baked") sediment or from areas of lateritic weathering. Since the red clays in this part of the section are confined to the finer parts of discrete turbidite beds, it can be assumed that alteration of the clays took place before their deposition as a part of the turbidite sequence. If, as seems more plausible, the clays are in fact the product of mild metamorphism or "baking," this could have taken place either in the marine environment (Boström and Peterson, 1969) or on land, since Post-Mesozoic basalt intrusions are known on the neighboring continents. It might be suggested that the alternation of red and gray clays suggests deposition near the "compensation depth" and that this depth varied from time to time. However, it should be emphasized that the red and gray clays form the upper parts of turbidites and that comparable variations are not seen in the intervening pelagic sediments. This sediment is a smooth indurated nannofossil marl, pale green in the lower part of the section, but darker green toward the top. The pelagic sediments have been extensively burrowed (alectorurid type), the burrows being flattened along the bedding planes by subsequent compaction (Plate 2). The beds appear to dip at 10 to 20 degrees, and slickensides were seen in Core

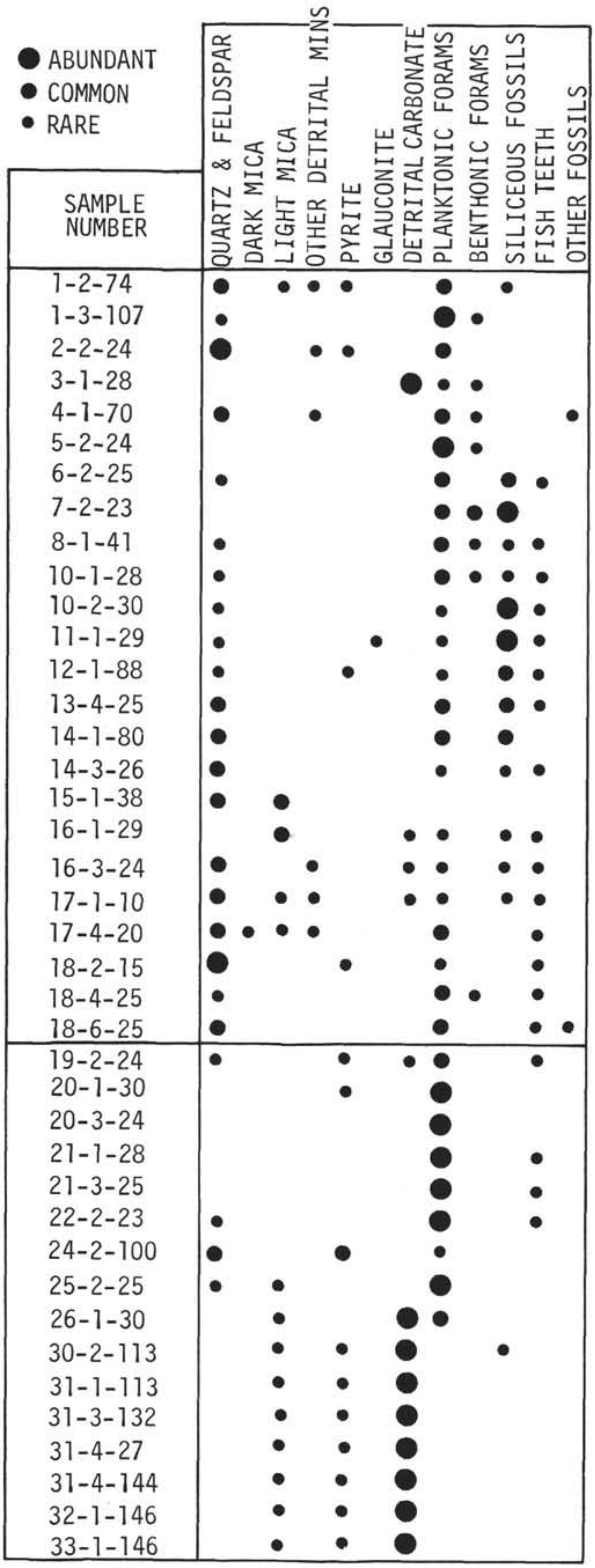


Figure 11. *Composition of the coarse fraction of samples from Site 119.*

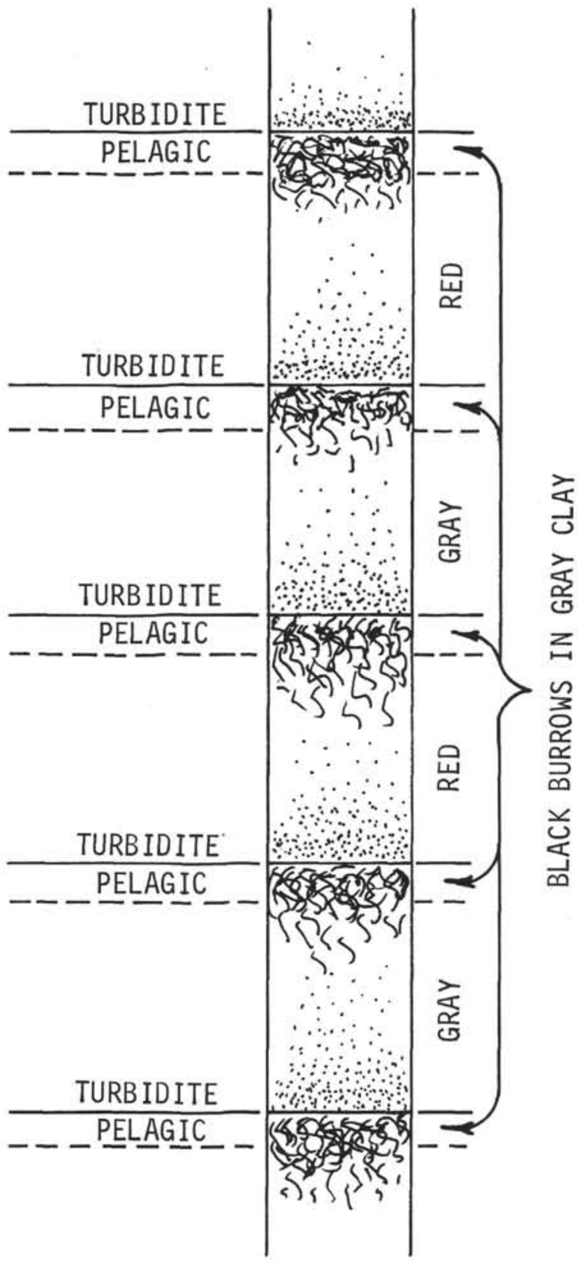


Figure 12. *Schematic section of turbidite sequence, showing relationship between variously colored lithologies.*

37, further suggesting deformation (Plate 3). The carbonate content of both pelagic sediments and turbidites is highly variable and ranges from 4 to 84 per cent.

For about 50 meters above the turbidite sequence there are red, white, brown and gray-brown clays. These are essentially the same in composition as the fine sediments in the turbidite sequence, being mostly composed of detrital carbonate and clay minerals, but they have a conspicuous contribution of hematite and limonite indicating oxidizing conditions (relative to the dark green pelagic sediment in the upper part of the turbidite sequence). A few foraminifera and fish debris are the only significant coarse constituents. Since the boundaries of the different colored clays are irregular and apparently unrelated to bedding (compare with red clays in turbidite sequence below), it seems likely that the red coloration and associated mineralogy of these clays could be associated with nearby volcanism, rather than being a function of depositional conditions (Boström and Peterson, 1969). These clays are of similar age and lithology to the altered red clays found in Cores 15 through 19 (685 to 750 meters subbottom) from Site 118.

Nannofossil Clays

Above the brown and red clays, at 355 meters subbottom, is clearly a hiatus in deposition for the character of the sediments changes abruptly and the paleontology indicates a break in the stratigraphy. The sediments above the break, from 75 to 355 meters below the seabed are nannofossil clays, hard but not lithified or recrystallized. Furthermore, the characteristic structures and textures resulting from turbidity current deposition disappear. This suggests that it was during the hiatus in sedimentation that Cantabria Seamount was affected by earthmovements and changed from a topographic low receiving abundant turbidite sediments to a topographic high receiving only pelagic sediment. It might be pointed out that this point in time coincides with the major earth movements in the Pyrenees and the Aquitaine (Bonnard *et al.*, 1958).

Nannofossils remain the dominant constituent of the sediments, along with pyrite and clay minerals. Volcanic glass is a noticeable constituent at many levels, especially in Cores 8, 9 and 15. Siliceous fossils (Radiolaria and sponge spicules) are noticeable in Cores 5 through 13 and foraminifera down to Core 5, below which they become rare. Fish debris is common throughout, probably a result of the slow rate of accumulation of these sediments. These sediments, even in the coarse fraction, still contain noticeable amounts of quartz, feldspar and mica flakes and have a certain detrital aspect with rare grains of garnet, tourmaline, etc. Thus, it is more appropriate to call them nannofossil clays rather than oozes (compare Sites 116 and 117). Texturally they are classed as silty clays and can be distinguished from the pelagic sediments found in the Paleocene and Eocene (see Figure 10). The carbonate content of these sediments is variable but seems to generally decrease upwards in the succession, indicating an increased contribution of mineral material through time. The terrigenous (mineral) material must be brought from the shelf off Brittany and the Aquitaine by either suspended transport in the water mass of the Bay of Biscay, or from the dilute tops of turbidity currents which must occasionally overtop the seamount. The increase in the amount of terrigeneous material with time suggests the latter may be the case.

These sediments are burrowed more or less extensively (chondrites type) throughout.

Silty Clays

The top 75 meters of sediment cored (Cores 1 and 2) consist of olive gray silty clays. These are the same as the nannofossil clays below, but the terrigenous component is markedly greater. The higher rate of sedimentation both here and at Site 118 during the late Pliocene and Pleistocene indicates that turbidity currents have been more active, associated presumably with the erosion of the continental shelf during the period of lowered sea level during glaciation. Ice-rafting may also have increased the sedimentation rate.

The presence of reworked Cretaceous and Oligocene nannoplankton in the Pleistocene silty clays indicates that the tops of these turbidity currents traveling on the abyssal plain contribute to the sediment on top of the seamount.

PHYSICAL PROPERTIES

The physical properties of the sediments at this site are well defined because of the large number of cores recovered. Disturbed or watery cores were rarely encountered (mostly Cores 119-1, 119-2 and Sections 119-10-6, 119-11-6, 119-19-4, 119-19-6, 119-20-3, 119-21-6), but many of the harder cores became fragmented by transverse breaks during drilling and this is noticeable from Core 28 onwards. The above two effects gave rise to aberrant low GRAPE densities, and these have been allowed for in drawing trend lines on the density, impedance and porosity plots.

In the first 300 meters density increases on average from 1.5 to 1.85 gm/cc. Velocity measurements and the penetrometer similarly indicate increasing firmness of the sediment over this interval. In detail, however, density appears to increase more rapidly between 10 and 50 meters and between 260 and 300 meters with a less rapidly changing region between 50 and 260 meters, but the reason for this is not apparent. The gamma activity measured within the interval zero to 300 meters is extremely variable but averages about 1300 counts. Although the onset of glaciation must lie above 150 meters, it is not apparent from the gamma activity when this occurred. Even though Cores 1 and 2 have higher counts than Core 3, other cores immediately below 3 also have higher activity than this core. In the lower part of the interval gamma activity increases to 2500 counts in Section 119-9-2 then abruptly drops to around 1500 counts. The higher counts seem to be associated with a greenish-gray clay. The drop in activity is associated with an abrupt lightening of sediment color. The fairly constant lower gamma activity below 270 meters seems to be due to a higher carbonate content since 7 spot values from Cores 9 to 13 gave contents between 46 and 70 per cent, while 3 samples from Cores 6 to 8 gave values between 18 and 40 per cent.

The interval 300 to 356 meters is occupied by Oligocene sediments. Density decreases on average in this interval from 1.9 to 1.8 gm/cc. Velocity is fairly constant but also decreases in the interval 348 to 356 meters from 1.7 to 1.6 km/sec. The reason for these two trends is not clear but they are not associated with a decrease in grain size, or with a softening of the sediment according to the penetrometer which shows a continuing increase in firmness around this depth. The Oligocene clays show extraordinary high gamma activity with several sharp peaks, the highest of which reaches 4650 counts. Strangely, the three biggest peaks in Cores 14 and 15, and three lesser peaks in Core 17, are associated not with dark sediment but with pale blue or pale olive bands in a pale yellow nannofossil clay. The only carbonate measurements in these cores (66 per cent at 119-14-1-59, and 70 per cent at 119-15-1-13) were associated with counts of 1000 and 500. The first measurement rules out the possibility that the peaks are due to a lack of carbonate, and enrichment in uranium, thorium or potassium is suspected.

At 356 meters, there is an abrupt increase in gamma counts between Cores 18 and 19 from 450 to 1700 counts. At the same depth, density and velocity also increase. These changes are due to crossing an unconformity separating the Oligocene nannofossil clays from brown and dark brown mottled Eocene clays. Sediment firmness does not increase noticeably across the boundary.

Below the unconformity density fluctuates between 1.8 and 2.0 gm/cc and shows no systematic trend. Between 400 and 450 meters velocity starts to increase and does so steadily to the bottom of the hole. The average gamma activity seems to decrease below the unconformity from about 1200 to about 600 counts, although there are several peaks well above this average level. The greatest of these peaks (3600 counts) occurs at 405 meters in association with a brown clay band. The sedimentation rate at this time was about 0.25 cm/1000 yrs. The nearest carbonate sample (119-24-2-88) contained 2 per cent carbonate yet gave a count of only 1900. Therefore it seems highly likely that the peak at 405 meters is due to uranium and thorium enrichment. There are five distinct peaks below the biggest one. The uppermost four (119-29-2-109, 119-35-3-45, 119-36-2-86, 119-37-4-64) are all associated with dark gray clay lying immediately over a much lighter colored clay with a sharp boundary in between. These horizons are clearly the bases of turbidity current layers and presumably contain concentrations of radioactive detrital minerals. The deepest peak is at 119-38-4-124 and occurs in a red brown clay.

The cores at this site show the correlation between natural gamma activity and darkness of the sediment very well. Numerous examples can be found throughout the hole, especially in the Paleocene, possibly indicating reducing conditions at the sea floor. Nevertheless the X-ray results from Cores 9, 18, 19 and 29 suggest that darker sediments contain more mica, and this may be partly responsible for the correlation since biotite often contains inclusions of radioactive accessory minerals as well as potassium which is also present in muscovite. The concurrence of light blue sediments with high gamma activity in the Oligocene is unique to this site for Leg 12.

Depth of Reflectors

Two reflectors were picked from the reflection profile crossing the site. Reflector 1 at 0.45 second is discontinuous, and adjacent profiles show it to have an irregular surface. The impedance plot suggests that the unconformity at 356 meters gives rise to this reflection since the impedance changes just above it. The second reflector was observed at 0.69 second and is relatively continuous laterally. It appears very likely that this reflection comes from the same depth where the drilling rate suddenly decreased. At this depth (595 meters) velocities of up to 2.7 km/sec were encountered for the first time. These reflector data are summarized in Figure 13.

PALEONTOLOGY AND BIOSTRATIGRAPHY

General

The hole bottomed at 711 meters in indurated limestones of Early to Late Paleocene age (approximately the Danian-Thanetian boundary), short of an anticipated rendezvous with the Cretaceous-Tertiary boundary.

In contrast to the site in the abyssal plain in the Bay of Biscay (Site 118), the sedimentologic sequence appears to be reversed here, that is, the upper 400 meters are essentially of pelagic origin, whereas an approximately 300-meter thick Upper Paleocene sequence of turbidites occurs below.

The stratigraphic sequence is probably complete from the Pleistocene to the Lower Oligocene. An unconformity at about 360 meters separates Lower Oligocene from Middle Eocene sediments. Below the Pleistocene the cores exhibit evidence of selective solution as indicated by the fact that the planktonic foraminiferal fauna is strongly reduced in most of the Oligocene, Miocene and Pliocene samples and virtually absent in the Paleocene and Eocene samples. This would suggest that this site has been at or below calcium carbonate compensation depths throughout most of the Cenozoic.

A summary of the foraminiferal biostratigraphy at Site 119 is presented in Figure 14.

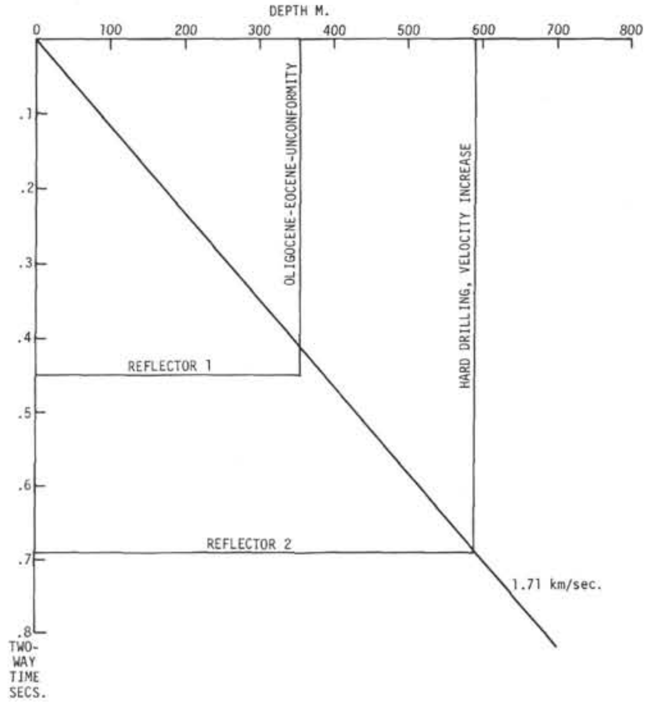


Figure 13. *Two-way travel times below the sea bed of observed reflections plotted against the downhole depths of horizons believed to have given rise to these reflections. The mean velocity to the deepest reflection associated with a definite depth is given close to the line representing this velocity.*

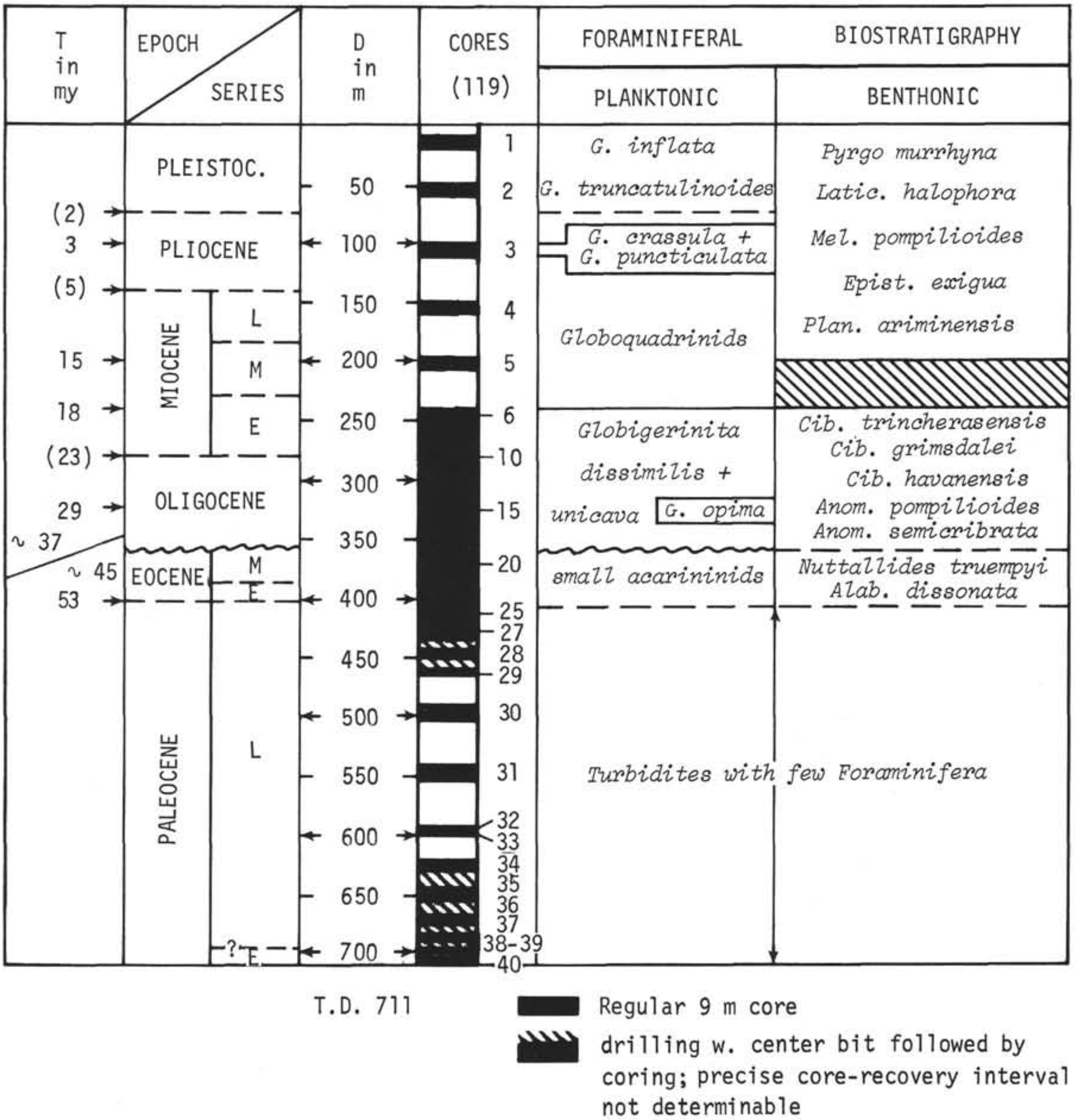


Figure 14. *Foraminiferal biostratigraphy at Site 119.*

Discussion

Foraminifera

Pleistocene

The Pleistocene is represented by Cores 1 (10 to 19 meters) and 2 (50 to 59 meters). Temperate-water planktonic faunas in these cores are dominated by *Globorotalia inflata, G. crassaformis, Globigerina bulloides* and *Orbulina universa. Globigerina pachyderma* occurs in both cores in moderate numbers. The presence of *Globorotalia truncatulinoides* in both cores supports the Pleistocene age determination. Such deep-water benthonic foraminifera as *Pyrgo murrhyna, Melonis pompilioides, Epistominella exigua, Eponides tener, Laticarinina halophora* characterize these cores.

Pliocene

The Pliocene-Pleistocene boundary is drawn at about 75 meters on the basis of upward extrapolation of sedimentation rates (using an age estimate of 3 million years for Core 3 at 100 to 109 meters). Core 3 contains a rich planktonic foraminiferal fauna which is subtly different from the Pleistocene faunas in Cores 1 and 2. The association of *Globorotalia puncticulata, Globorotalia crassula* and early forms of *G. crassaformis* (similar to *G. crassaformis ronda* of Blow) is similar to that observed at other sites in the course of Leg 12. In pre-Upper Pliocene sediments the occurrence of typical *Globigerinoides obliqua* also suggests a Pliocene age and this is supported by the assignment of Core 3 to the *Discoaster surculus* Zone (see below).

The benthonic microfauna of Cores 1 to 3 and, indeed, of the succeeding cores below (4 and 5) consist primarily of deep-water fauna belonging to the genera *Gyroidina, Pullenia, Melonis, Cibicidoides, Pyrgo, Eponides, Planulina, Laticarinina, Eggerella, Ehrenbergia,* and *Stilostomella*; various nodosariids and lagenids are also present. Many of these forms appear to have been recorded from piston cores from the Gulf of Biscay by French paleontologists and it is not surprising to see these forms extending back into the Miocene and Pliocene in this area.

Miocene

The Miocene-Pliocene boundary is drawn at approximately 140 meters (on the basis of extrapolation of sedimentation rates). The Miocene is represented by Cores 4 (150 to 159 meters) through 10 (276 to 285 meters). The Oligocene-Miocene boundary has been tentatively drawn at about 280 meters (that is within Core 10) again on the basis of extrapolated average sedimentation rates.

Core 4 is of Late Miocene age based on age determination of calcareous nannoplankton. The planktonic foraminiferal fauna contains *Globigerina praebulloides, G. atlantica* and *G. nepenthes,* which indicates merely that Core 4 can be placed within the limits of Zones N14 through N16. The planktonic foraminifera in Core 5 (198 to 207 meters) are mostly dissolved. A few specimens of *Globoquadrina dehiscens* and a globorotaliid similar to *G. acostaensis* were found in the Core Catcher sample. Core 5 is of Middle Miocene age according to the calcareous nannoplankton flora.

A significant change in fauna can be seen between Cores 5 (198 to 207 meters) and 6 (240 to 249 meters). Core 6 is of Early Miocene age, at least in its lower part where planktonic foraminiferal fauna containing *Globigerinita dissimilis, G. unicava, Globoquadrina praedehiscens, G. dehiscens,* and *Globorotalia siakensis,* among other forms, occurs. The benthonic foraminiferal fauna is also distinctly different from that occurring above and has its closest affinities with Oligocene-Miocene foraminiferal faunas found below. Among the forms identified from Core 6 are *Anomalinoides pompilioides, A. semicribrata, Cibicidoides trincherasensis,* and *C. grimsdalei*. Core 6 is the highest level at which these various benthonic foraminifera occur at Site 119. The planktonic foraminiferal association indicates an age not younger than Zone N6 *Globigerinita dissimilis* becomes extinct at the top of Zone N6. The bottom of Core 6 has been assigned to the *Helicopontosphaera ampliaperta* Zone (see report below). According to the Leg 12 shipboard correlation chart the *H. ampliaperta* Zone correlates with Zones N7 and N8. The present data suggest that the base of the *H. ampliaperta* Zone may overlap the upper part of Zone N6.

Continuous coring was initiated with Core 6 (240 to 249 meters) and extended over almost 200 meters to Core 27 (428 to 433 meters). Planktonic foraminifera are rare in the Lower Miocene sediments which consist primarily of gray calcareous clay and silts with abundant radiolarians (see report below). When they occur, the forms present are referable to *Globigerinita (G. dissimilis* and *G. unicava)* and *Globoquadrina (G. praedehiscens* and *G. dehiscens).*

Oligocene

It is not possible to draw an Oligocene-Miocene boundary on the basis of planktonic or benthonic foraminifera at Site 119. On the basis of extrapolated sedimentation rates and Oligocene-Miocene boundary is drawn at about 280 meters, that is, within Core 10. This agrees with the age assignment of Cores 8 through 11 to the *Discoaster druggi-Triquetrorhabdulus carinatus* Zones, and of Cores 12 to 14 to the *Sphenolithus ciperoensis* Zone (see below). The Oligocene is represented by Cores 11 (285 to 294 meters) to the upper part of Core 19 (356 to 365 meters). The unconformity between Lower Oligocene and Middle Eocene is put at about 360 meters (within Core 19). *Globigerinita dissimilis* and *G. unicava* are the dominant forms in the generally impoverished planktonic assemblage in the Oligocene. An important biostratigraphic marker, *Globorotalia opima,* occurs in Core 14 (311 to 320 meters). This is the youngest occurrence of *G. opima* at this site and its occurrence together with chiloguembelinids suggests that Core 14 is equivalent to the lower part of Zone P21.

Cores 16 (329 to 338 meters) through 19 (356 to 365 meters) contains poor planktonic faunas in general. An exception was noted within Core 17, where although the diversity is low, *Globorotalia opima nana* occurs quite commonly. Solution is believed to be responsible for the relative paucity of planktonic foraminifera in these as well as other cores at Site 119.

The benthonic foraminiferal fauna in the Eocene, Oligocene and Lower Miocene at Site 119 exhibits a continuity of development, which attests to the stability of the deep sea environment, despite possible tectonic movements between Middle Eocene and Early Oligocene time. These faunas exhibit a marked affinity with Lower and Mid-Cenozoic faunas described from the Caribbean region. In particular, the Eocene and Oligocene faunas show a strong affinity with those described by Beckmann (1953) from the Middle Eocene-Oligocene sections on Barbados. The similar association of planktonic and benthonic foraminifera, radiolarians and calcareous nannofossils here in what must have been abyssal depths during the Eocene-Oligocene and Early Miocene strongly supports the idea that the Barbados section also was deposited at similar depths. The Eocene faunas (Cores 19 through 24) are characterized by the following forms: *Nuttallides truempyi, Alabamina dissonata, Bulimina grata, Cibicidoides havanensis, Cibicidoides trinitatensis, Oridorsalis ecuadorensis* and various stilostomellids, nodosarellids and ellipsodimorphinids. In particular the stilostomellids appear to dominate the benthonic fauna quantitatively, although *Nuttallides truempyi* is the single dominant species. This group of forms is supplemented, and in some cases replaced, by additional forms in the Oligocene such as: *Cibicidoides grimsdalei, Cibicidoides martinezensis, Gyroidina octocamerata, Gyroidina perampla, Anomalina alazanensis,* and *Vulvulina jarvisi.* Various species of the agglutinated genera *Gaudryina, Karreriella* and *Dorothia* occur commonly in the Eocene, Oligocene and Lower Miocene assemblages. They appear to have been described originally from the Trinidad area and their presence here in the Bay of Biscay testifies to their widespread distribution.

Eocene

Cores 19 (356 to 365 meters) to 24 (401 to 410 meters) are tentatively assigned to the Middle and Early Eocene, the benthonic and planktonic foraminiferal faunas becoming gradually poorer as one proceeds downwards and it is not possible to draw a clear distinction between the Early and Middle Eocene.

Paleocene

The Paleocene-Eocene boundary is tentatively drawn at about 410 meters (between Cores 24 and 25). A thick (about 275 meters) Paleocene turbidite sequence is developed from about 410 meters (Core 25) to about 675 meters (Core 37). With the exception of Core 25 (410 to 419 meters) there are practically no foraminifera within this entire stratigraphic interval, with the exception of minute, usually indeterminable forms in the fine fraction of the residues. Core 25 (410 to 419 meters) contains *Globigerina triangularis, G. velascoensis, Globorotalia aequa, Globorotalia pasionensis,* and *Acarinina coalingensis* and is assigned to Zone P5 (Late Paleocene).

The lower part of the Upper Paleocene was found in Core 38 (674 to 686 meters) based on the presence of *Globorotalia pseudobulloides, G. varianta, G. angulata, G. conicotruncata, G. ehrenbergi,* and *Globigerina triloculinoides.* This faunal association indicates a level within the upper part of Zone P3. Cores 39 (689 to 699 meters) and 40 (699 to 711 meters) may have penetrated somewhat older sediments. The association of *Globigerina spiralis* and *Globorotalia angulata* in Core 40 suggests that the oldest sediments cored at this site are of earliest late Paleocene age and referable to the top of Zone P2 or base of Zone P3.

Calcareous Nannoplankton

A fairly complete sedimentary sequence from Paleocene to Pleistocene was cored at this site, with only the Late Eocene missing. The sediments consist of pelagic clays (sometimes with glacial influence, sometimes with a touch of turbidite) and turbidites.

The site on Cantabria Seamount was chosen, among other reasons, with reference to previous descriptions (Jones and Funnell, 1968) of Late Cretaceous sediments recovered from the Cantabria Seamount. As the Late Cretaceous was not reached where it was expected, if it outcropped on the seamount (see Figure 7), the sediments described by Jones and Funnell (1968) were re-examined together with other cores taken subsequently by *Vema*-27 and IFP. Examination of these samples leads to the conclusion that there is no evidence that Late Cretaceous sediments have been recovered on Cantabria Seamount. An account of these further studies follows this section.

The rather high percentage of Cretaceous coccoliths in some of the Leg 12 samples is noteworthy. In all cases, younger coccoliths were found together with the Cretaceous forms. At Site 118, which lies on the abyssal plain 75 kilometers from Site 119, the highest core, taken 100 meters below the sea floor, contains up to 90 percent Cretaceous coccoliths besides the Pleistocene assemblage. Such a sample, taken by dredging or a surface core, might well be mistaken as Cretaceous with Pleistocene contamination.

Pleistocene

Cores 1 and 2 contain rather poor Pleistocene coccolith assemblages. They represent the *Gephyrocapsa oceanica* and the *Coccolithus jaramillensis* Zones. In both cores, a minor amount of reworked Late Cretaceous and Oligocene coccoliths was found. The assemblages are, in fact, as poor as those from the Northern Atlantic Pleistocene. *Scapholithus fossilis* and *Cyclococcolithus macintyrei* are present in Core 2 but missing in Core 1. *Coccolithus pelagicus* is again present in different varieties.

Pliocene

No attempt was made to sample the Pliocene-Pleistocene boundary or the onset of glaciation at this site. The Pliocene-Pleistocene boundary was placed arbitrarily halfway between Cores 2 and 3. As there also occurs a change in lithology between these two cores it is reasonable to put the onset of the influence of glaciation in the Bay of Biscay there, too. In Core 3, there is no evidence of glacial rafting and it can be assigned to the *Discoaster surculus* Zone. Thus, the glacial influence must have started later than this, which means at the same time or maybe only a little later than at the other sites where the onset of glaciation was dated. This was expected. With the data available from this leg, no more precise time can be given than between 3 and about 1.5 million years ago.

The Pliocene is represented only by Core 3, that contains an assemblage including *Discoaster surculus* but lacking *Reticulofenestra pseudoumbilica.* Reworked coccoliths include *Prediscosphaera cretacea* (Cretaceous) and *Cyclococcolithus neogammation* (Oligocene-Miocene).

Miocene

Cores 4 to 11? contain Miocene assemblages; from Core 6 on, coring was continuous. In Core 4, a rich discoaster flora is present, but it is composed solely of long-ranging species. It contains very well-preserved discoasters similar to *D. subsurculus,* but with the branches of the arms almost touching each other. Similar discoasters were found in Hole 111A, together with *Discoaster quinqueramus.* As in the latter hole, *Triquetrorhabdulus rugosus* is also present. Core 4 is therefore regarded as representing Late Miocene. In Core 5, the discoasters are not as well preserved as in Core 4. They include *D. deflandrei, D. aulakos* and *D. exilis,* suggesting assignment of the core to the *D. exilis* Zone of the Middle Miocene. In Core 6, the *Sphenolithus heteromorphus* and the *Helicopontosphaera ampliaperta* Zones are present. Core 7 represents the *Sphenolithus belemnos* Zone, while in Core 8 *Triquetrorhabdulus carinatus* is present. The Miocene-Oligocene boundary lies somewhere between Core 9 and Core 13 and cannot be determined with calcareous nannofossils at this site. Generally, the Miocene assemblages are somewhat richer in discoasters than those found in the northern Atlantic. An exception to this is the Middle and Late Miocene of Site 111, where similar abundance and greater diversity occurred.

Oligocene

While the very top of the Oligocene lies somewhere in the interval Cores 9 to 13, in the lower part of Core 14, we find the *Sphenolithus distentus* Zone, that also is represented by Core 15. The normal succession continues downward with the *Sphenolithus predistentus* Zone in Cores 16 and 17, the *Helicopontosphaera reticulata* Zone in Cores 17 and the upper part of 18 and the *Ericsonia obruta* Zone in the lower part of Core 18. In most samples sphenoliths are quite common, but never abundant. The short-ranging forms as *S. ciperoensis, S. distentus* and *S. predistentus* are far less common than the small, undescribed sphenoliths and *S. moriformis* that has a very long range. Generally the assemblages are monotonous and the preservation of the coccoliths is only fair throughout the continuously cored Oligocene. Reworked coccoliths include Eocene and Late Cretaceous forms in small amounts.

Eocene

Eocene is represented by Cores 19 to 24. Apparently, the uppermost Eocene is missing. Throughout the Eocene, calcareous nannoplankton is represented mainly by discoasters, the coccoliths having been dissolved. Among the coccoliths that sometimes are present are different species of *Chiasmolithus, Ericsonia cava, E. Alternans* and *Reticulofenestra* sp. The uppermost third of Core 19 is believed to belong to the *Discoaster tani nodifer* Zone; while in the lower part, this uncommon species is missing. The *Nannotetrina fulgens* Zone is represented by part of Core 19 to Core 22. In this core 22 *Nannotetrina* is missing in a sample with a very poor assemblage in Section 2 and in a somewhat richer, gray-brown sediment of the core catcher. In cream-colored sediments of the core catcher, however, *Nannotetrina cristata* is present again. The top of Core 23 has a discoaster assemblage typical for the *Discoaster lodoensis* Zone. Thus the *Discoaster sublodoensis* Zone is either missing or represented in the interval between Cores 22 and 23 that was not recovered. In Core 23, the *Marthasterites tribrachiatus* Zone is also represented. Core 24 is barren with the exception of the core catcher that contains a discoaster assemblage typical for the *Discoaster binodosus* Zone of the Early Eocene. The *Marthasterites contortus* Zone was not found but could be present in the interval between Cores 24 and 25 that was not recovered.

Paleocene

The change in lithology between Cores 24 and 25 also defines a change in the content in calcareous nannofossils. Coccoliths are preserved together with the discoasters in the turbidite samples, while discoasters are relatively more abundant in the pelagic upper part of the turbidites (see Figure 15). The flora found in the Paleocene of this site, especially in the upper part, is very rich and in some samples very well preserved. It is similar in content to the Paleocene described by Hay and Mohler (1967) and Martini (1961) from Pont Labau in Southwestern France and by Bramlette and Sullivan (1961) from the Lodo Formation of California.

The stratigraphic assignment of Cores 25 to 40 is shown in Figure 15, together with the occurrence of selected species. Especially diverse in this section are the fasciculiths. These small bodies, that in the light microscope look very simply constructed, showed a greater diversity than previously known. In addition to the three known species, nine new ones are described from this site (Perch-Nielsen, 1971). Work in progress with the scanning electron microscope also revealed a variety of *Cruciplacolithus tenuis* with prominent extensions to one side of each quarter of the central cross (See Chapter 15). In the genus *Chiasmolithus*, we find a small X to H over a small central opening in the lower part of the section (Cores 37, 38) together with forms with a large, wide H over a more extended central area. At least from Core 28 upward, a net may be present and preserved between the bars of the H. Beside *Ellipsolithus macellus* and *E. distichus*, another coccolith, perhaps belonging to *Ellipsolithus*, was found (see Chapter 15). In this section, it seems possible to find the early evolution of the Sphenolithaceae and the Fasciculithaceae, as well as, the Discoasteracea, Heliolithacea and the Tertiary part of the Zygodiscaceae and Pontosphaeraceae. The other two big Tertiary families, the Coccolithaceae and the Prinsciaceae have their development earlier than the age of the oldest sediments recovered.

From Core 28 downward, *Braarudosphaera*, represented by the species *B. bigelowi, B. discula* and *B. imbricata*, became more abundant and may constitute up to 20 per cent of the coccolith assemblage in a few samples in Core 39. This could indicate restricted conditions of the sea in the Bay of Biscay at this time. The amount of reworked—and well preserved—coccoliths varies throughout the hole, but, except for the cores of Eocene age, reworked coccoliths are always present, even in pelagic oozes. This reflects the fact that turbidity current derived deposits have been laid down in the abyssal plain in the Paleocene and again at least since the Oligocene (see discussion of sedimentation rates). Even if no coarse material has been deposited on the seamount itself, older coccoliths were mixed with the water and settled down with the coccoliths of the time. As for the Paleocene turbidities, the coarser fraction is also present and contains a nannoflora of mixed Paleocene and Late Cretaceous.

Re-examination of Discovery-*11 Material and Cores by* Vema-*27 and Institute Français du Pétrole*

Introduction

In 1966, *Discovery*-11 attempted to sample reflector 1 on Cantabria Seamount. The following account summarizes the findings of Jones and Funnell (1968). The core taken at Station Dy5947 proved to consist of a Pleistocene calcareous ooze without signs of contamination by Tertiary or Cretaceous microfossils. Bottom photographs nearby had shown many light-colored angular or subangular pebbles and occasional boulders lying on a sediment-covered slope, without clear evidence of rock outcrops. The core taken at Station Dy5946 consists in the lower part of a conglomerate of calcareous ooze and clay of different shades of white, gray, and red set in a clayey matrix. The calcareous nannoplankton yielded by the white, off-white and light gray pebbles consisted of abundant Upper Cretaceous genera including *Arkhangelskiella, Microrhabdulus, Micula, Zygrhablithus, Braarudosphaera* and *Zygolithus.* Dark pebbles consisted of unfossiliferous clay. In the matrix, lower and/or middle Tertiary discoasters and coccoliths were found together with Cretaceous forms. The few foraminifera found are small and represent the Upper Cretaceous, lower/middle Tertiary and the Pleistocene and are mixed together.

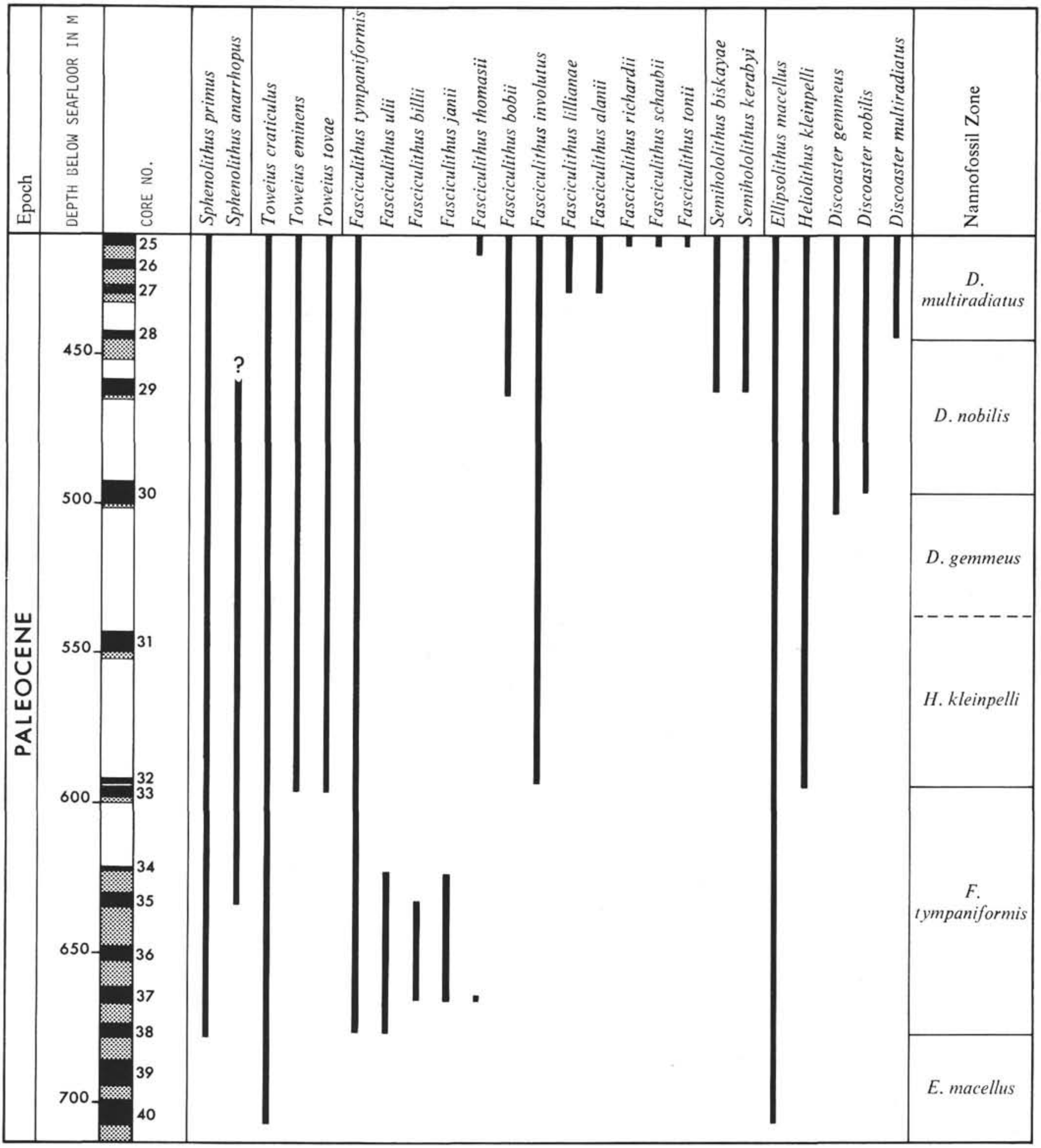


Figure 15. *Nannofossil distribution chart.*

The uppermost 80 centimeters of this core consist of almost entirely noncalcareous and unfossiliferous clays. The top two centimeters however contain calcareous nannoplankton of middle to late Tertiary age. Small foraminifera of middle Tertiary and Pleistocene age were also found.

The dredge Station D5948 yielded approximately 50 discrete lumps of clay and slightly indurated ooze. Here too, Upper Cretaceous, most probably Maestrichtian calcareous nannoplankton was found, while foraminifera of Late Cretaceous age were absent or rare and Pleistocene foraminifera were abundant.

In conclusion, Jones and Funnell (1968) suggested, that fine parts of Maestrichtian turbidite sediments had been sampled at a near-outcrop and that reflector 1 is Late Cretaceous, probably Maestrichtian in age. As the Late Cretaceous on Site 119 was not reached where it was to be expected if it did outcrop on the seamount (see Figure 7), the sediments described by Jones and Funnell (1968) were re-examined. Also examined were samples from cores collected by *Vema*-27 and by the Institut Francais du Pétrole in 1969 in an attempt to sample further Late Cretaceous sediments from Cantabria Seamount. The samples from *Vema*-27 were kindly provided by the Lamont-Doherty Geological Observatory.

CONCLUSIONS

The results of the re-examination of the samples collected by *Discovery*-11, *Vema*-27 and IFP are listed in Table 2. No attempt was made to determine the age of the samples down to the zone, because the purpose of the re-examination was mainly to check on the evidence for outcropping Late Cretaceous sediments. In the samples studied, no such evidence could be found. The samples with up to 90 percent Late Cretaceous coccoliths all also contain Paleocene or younger coccoliths. On Site 119, no such high percentages of reworked Late Cretaceous coccoliths were found in the Paleocene turbidites. However on Site 118, 100 below the bottom, the Pleistocene turbidites also contain about 90 percent Late Cretaceous coccoliths. Jones and Funnell (1968) have already suggested that their Late Cretaceous sediments are fine parts of turbidites. This opinion is supported by the results of drilling at Site 119, however the age of the turbidites is younger than Late Cretaceous; most probably the oldest pebbles belong to the Early Paleocene (*Cruciplacolithus tenuis* Zone), while other pebbles show Late Paleocene assemblages including *Fasciculithus*. (Neogene coccoliths, where present, are rare and probably the result of contamination when the conglomerate was formed.) The dark clay-pebbles might represent the pelagic part of the Paleocene turbidites that were deposited below the calcium carbonate compensation depth, since in the Paleocene turbidites of Site 119, it was observed that the dark pelagic part had very few coccoliths compared to the predominantly coccolith composition of the fine material at the top of the lower part. However, burrowing has in some instances obscured this pattern. Calcite (or dolomite) rhombohedrons are present both in the *Discovery*, *Vema* and IFP samples, and the Paleocene turbidites of Site 119. They seem here to be restricted to Paleocene sediments and unfossiliferous sediments where no age assignment was possible.

Also the samples provided by *Vema*-27 and IFP show no evidence for Late Cretaceous sediments outcropping or within reach of surface cores.

Cenozoic Radiolaria

Well-preserved, common to abundant radiolarians are present only in the Lower Miocene of Hole 119. As a result of downhole caving these assemblages also occur, often abundantly but mainly in core catcher samples, from as low in Hole 119 as Core 25 (Upper Paleocene). Occasional contaminant specimens are found from within the cores themselves. Zeolitized, silicified and corroded radiolarians are present in most of the remaining cores (Oligocene-Paleocene), but only the silicified and/or corroded Paleocene specimens are biostratigraphically diagnostic. Several well-preserved middle Eocene species occur as contaminants in 119-36-CC, but no source for these was found higher in the Eocene section of the hole.

Miocene

The first downhole occurrence of radiolarians is in Core 5 which is dated tentatively as middle Miocene on the presence of digitately branched *Oroscena* spines. Although assemblages from 119-6, Sections 1 and 2 (78 to 79 centimeters) include most of the species present in the *Calocycletta virginis* Zone, the very rare occurrence of *Calocycletta costata* (Riedel) suggests the inclusion of this interval within the *C. costata* Zone of early Miocene age (Chapter 16, Table 2). The interval 119-6-3 through 119-7-CC is placed questionably within the *C. virginis* Zone because of the occurrence in 119-7-CC of a specimen of *C. costata*, but because of the known downhole contamination in Hole 119 little significance should be placed on the presence of this species in a core catcher sample. Cores 119-8 through 119-11-1, 69 to 70 centimeters contain well-developed assemblages typical of the *Calocycletta virginis* Zone of early Miocene age.

Oligocene-Eocene

The interval from 119-11-2, 75 to 76 centimeters through 119-12-CC is dated as Oligocene on the absence of typical Lower Miocene species and the presence of *Cyclampterium* (?) sp. cf. *C.* (?) *milowi* Riedel and Sanfilippo. The remaining Oligocene and all Eocene cores (13 through 18 and 19 through 24, respectively) contain poorly to moderately preserved, undiagnostic radiolarians. Alterations of the siliceous skeletons ranges from minor corrosion through silicification through complete replacement by zeolite. In this interval radiolarians are generally rare or absent but are common to abundant in some samples from Cores 16, 19 and 25. Several fish teeth are present in 119-24-2 and 3 (Eocene). Many resemble those illustrated by Helms and Riedel (1971), particularly their D-types.

Paleocene

The highest occurrence of Paleocene radiolarians in Hole 119 is in Core 26-2, 81 to 82 centimeters. The silicified and/or corroded assemblages, which may comprise perhaps 25 to 30 species in some samples, are rare to common through Core 30, absent in Cores 31 through 34, rare to common in Cores 35 and 36, and absent in Cores 37 through 40. Zeolitized radiolarians are more abundant than the silicified or corroded forms. Diagnostic Paleocene species present include *Lithocampium* sp. A Riedel and Sanfilippo (in press), which is the dominant species, *Phormocyrtis striata* Brandt, and *Bekoma bidarfensis* Riedel and Sanfilippo (in press, Plate 7, Figure 7). In addition, one specimen of (?)*Amphipyndax stocki* (Campbell and Clark) was observed from the Lower Paleocene of Hole 119, Core 36, CC. (See Chapter 16, Plate 2, Figures 10, 11).

TABLE 2
Results of the re-examination of smearslides of samples collected by *Discovery*-11, *Vema*-27 and IFP

				Late Cretaceous Coccoliths				Tertiary Coccoliths					Remarks	Age of the Sediment		
Collector	Samples	Clay	Calcite rhombohedrons	*Eiffellithus*	Arkhangelskiellaceae	*Cribrosphaera*	Others	*Cruciplacolithus tenuis*	*Chiasmolithus danicus*	*Ericsonia cava*	*Fasciculithus*	Discoasters		P = Paleocene	N = Neogene	T = Tertiary
Discovery 11, 5946, Core	1.B									x		x	Miocene?		N	
	2.B	x											No coccoliths			
	3.B	x											No coccoliths			
	4.B	x											No coccoliths			
	5.B	x											No coccoliths			
	6.B	x	x									x	Very few coccoliths			T
	7.B	x	x										No coccoliths			
	8.B	x	x										No coccoliths			
	9.B	x	x										No coccoliths			
	10.B						x	x		x			Few Cretaceous coccoliths in Paleocene	P		
	11.B		x	x	x	x	x	x	x	x			90% Cretaceous coccoliths 10% Paleocene	P		
	12.B			x	x	x	x	x	x	x			Few Cretaceous coccoliths in Paleocene	P		
	13.B		x				x	x		x	x		Few Cretaceous coccoliths in Paleocene	P		
	14.B	x	x									x	Very few coccoliths		N	
	15.B				x		x	x		x			Few Cretaceous coccoliths in Paleocene	P		
	16.B				x		x	x		x	x		Few Cretaceous coccoliths in Paleocene	P		
	17.B		x	x	x	x	x	x	x	x	x		Few Cretaceous coccoliths in Paleocene	P		
	18.B		x			x	x			x		x	Few Cretaceous coccoliths in Paleocene	P?		T
	19.B			x	x	x	x	x	x	x	x		90% Cretaceous coccoliths 10% Paleocene	P		
	20.B		x	x	x	x	x	x	x	x	x		90% Cretaceous coccoliths 10% Paleocene	P		
Discovery 11, 5948, Dredge	7d	x	x										Very few coccoliths – Tertiary			T
	8b		x				x	x		x		x	Few coccoliths, *D. multiradiatus*	P		
	9b	x	x										Very few coccoliths – Tertiary			T
	12		x										Very few coccoliths – Tertiary			T
	13b			x	x	x	x	x	x	x			Cretaceous & Paleocene	P		
	28b		x	x			x			x	x		Cretaceous & Paleocene	P		
	35b	x	x							x			Tertiary		N?	T
	39b		x		x		x		x				Paleocene & few Cretaceous coccoliths	P		
	41b			x	x	x	x		x	x			Paleocene & few Cretaceous coccoliths	P		
	43b		x		x		x	x	x	x	x		Paleocene & Cretaceous	P		
	47d							x		x			Paleocene & Neogene	P	N	
	48		x		x	x	x	x		x			Cretaceous & Paleocene	P		

TABLE 2 – *Continued*

Collector	Samples	Clay	Calcite rhombohedrons	Late Cretaceous Coccoliths				Tertiary Coccoliths					Remarks	Age of the Sediments		
				Eiffellithus	Arkhangelskiellaceae	*Cribrosphaera*	Others	*Cruciplacolithus tenuis*	*Chiasmolithus danicus*	*Ericsonia cava*	*Fasciculithus*	Discoasters		P = Paleocene	N = Neogene	T = Tertiary
I.F.P.	73		x			x	x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	79/1		x				x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	79/2		x	x			x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	79/3		x	x			x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	80/1		x		x		x	x	x	x	x		Few coccoliths, Paleocene & few Cretaceous	P		
	80/2				x		x		x	x	x		Few coccoliths, Paleocene & few Cretaceous			
Vema-27, 130	Top				x								Pleistocene & few Cretaceous		N	
	15 cm						x						Pleistocene & few Cretaceous		N	
	40 cm						x					x	Pliocene & few Cretaceous coccoliths		N	
	70 cm											x	Pliocene		N	
	110 cm			x	x	x	x		x	x	x	x	Cretaceous, Paleocene, Eocene, Oligocene			T
	140 cm		x	x	x		x		x	x	x	x	Few coccoliths, Paleocene & few Cretaceous	P		
	180 cm		x		x	x	x	x	x	x	x	x	Paleocene & few Cretaceous coccoliths	P		
	220 cm		x			x	x		x	x	x	x	Paleocene & few Cretaceous coccoliths	P		
	240 cm						x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
Vema-27, 132	4 cm											x	Miocene-Pliocene		N	
	14 cm											x	Miocene		N	
	20 cm											x	Miocene		N	
	32 cm											x	Miocene		N	
	35 cm												No coccoliths			
	70 cm											x	Miocene		N	
	150 cm											x	Miocene		N	
	249 cm											x	Miocene		N	
Vema-27, 133	30 cm												Few coccoliths, Pleistocene		N	
	70 cm		x										No coccoliths			
	90 cm		x										No coccoliths			
	120 cm		x		x	x	x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	150 cm		x				x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	180 cm		x		x	x	x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	220 cm		x		x	x	x	x	x	x			Paleocene & few Cretaceous coccoliths	P		
	240 cm				x	x	x	x	x	x	x		Paleocene & few Cretaceous coccoliths	P		
	280 cm			x	x	x	x	x		x			Paleocene & 70% Cretaceous coccoliths	P		

Downhole Contamination

Ample evidence of downworking of sediments from above in Hole 119 during drilling and coring operations exists in the presence of Lower Miocene radiolarian assemblages representing the *Calocycletta virginis* Zone in samples as old as Upper Paleocene. Downworking is suspected even within the *C. virginis* Zone in core catcher samples from Cores 8, 9 and 10. Very rare to abundant radiolarians from this zone occur in core catcher samples of Cores 11 through 16, 19, 21, 22, and 25. In fact, the best assemblage representing the *C. virginis* Zone occurs as contamination in 19-CC (Eocene). Minor contamination occurs also within the cores themselves in the following samples: 13-3, 70-71 cm; 14-4, 72-73 cm; 15-4, 71-73 cm; 16-3, 0-1 cm; 20-3, 2-3 cm; 21-2, 84-85 cm; and 26-2, 81-82 cm. The origin of this contamination may be from a rind immediately adjacent to the inner surface of the core liner.

Middle Eocene Contaminants

There is a rather mysterious contamination of Middle Eocene radiolarians from the *Theocampe mongolfieri* Zone (see Riedel and Sanfilippo, 1970) in one sample from the core catcher of Core 36. Some 25 to 30 species of well-preserved Radiolaria are represented by only one or two individuals each. No other samples from the core catcher have these contaminants. Examination of samples from the Eocene interval of Hole 119 (Cores 19 through 24) revealed only a few very poorly preserved specimens *in situ.* The source of the Eocene contaminants apparently is not to be found in Hole 119. Perhaps some of the coring equipment which may have cored radiolarian-rich Middle Eocene sediments on a previous leg of the Deep Sea Drilling Project is to blame. Just a small amount of such sediment left in a core catcher would be enough to supply the observed contaminants. It should be noted that none of these well-preserved species were found at any of the other Leg 12 sites drilled.

ESTIMATED RATES OF SEDIMENTATION

It would appear that average rates of sediment accumulation at Site 119 were relatively high during the Paleocene and during the Late Pliocene and Pleistocene. The average rates during the Eocene, Oligocene, Miocene and Early Pliocene were relatively low. The differences in rate can probably be ascribed to the following causes: Paleocene—turbidite deposition; Late Pliocene-Pleistocene—larger terrigenous component owing to glaciation; Eocene-Early Pliocene—pelagic deposition coupled with the modifying effects of calcium carbonate solution.

Age determinations, upon which the estimated average rates of sedimentation have been calculated for Site 119 are as follows: 1) 3 million years. Core 3 (100 to 109 meters); early Late Pliocene (*D. surculus* Zone); 2) 15 million years. Core 6 (240 to 249 meters; Early Miocene based on assignment to upper part of Zone N6; 3) 29 million years. Core 14 (311 to 320 meters; early Late Oligocene based on assignment to lower part of Zone P21; 4) 53 million years. Core 24 (401 to 410 meters), Paleocene-Eocene boundary based on approximated boundary between *D. multiradiatus* and *D. binodosus* Zones (calcareous nannofossils); 5) 59 million years. Core 38 (674 to 686 meters), early Late Paleocene based on assignment to upper part of Zone P3.

It can be seen from Figure 16 that rates of sedimentation have varied considerably during the Cenozoic on the site of Cantabria Seamount. Paleocene turbidites yield expectedly high rates of sedimentation. These are followed by the lower rates normally associated with deep-sea pelagic sedimentation, but the effect of calcium carbonate solution has certainly played a major role in lowered sedimentation rates due to the removal of the planktonic foraminiferal elements. The fluctuating rates during the Late Oligocene, Miocene and Early Pliocene may reflect real conditions which existed in the seas at the time or they may reflect minor inaccuracies in the time scale used in our calculations. Alternatively, they may indicate stratigraphic hiatuses, but no evidence of this is seen from the faunas which we have examined.

A hiatus does occur, however, at about 360 meters, and separates Lower Oligocene from Middle Eocene. The approximate time represented by this hiatus is about 8 million years and it is during this time that Cantabria Seamount was uplifted above the level of the abyssal plain.

During the Late Pliocene and Pleistocene the rates increased to about 3.7 cm/1000 yrs (uncorrected), reflecting the increased amount of terrigenous detritus in the form of glacially-rafted debris as well as the larger contribution of clay and silt from the increased turbidity current activity during lowered sea level. Higher productivity is also associated with Pliocene-Pleistocene glaciation.

In Figure 16, dates derived from coccolith determinations (in millions of years) for Holes 118 and 119 are plotted against depth (in meters). Successive points for each hole are connected by a line.

Only above 300 meters does there seem to be a systematic density gradient, and this gradient of 0.00120 gm/cc/m can be used for correcting sedimentation rates above 300 meters for the effects of natural consolidation. The 3.1 cm/1000 yrs rate above 100 meters becomes 3.5 cm/1000 yrs, and the average rate between 100 and 300 meters increases from 0.9 to 1.5 cm/1000 yrs.

DISCUSSION

Forty cores were taken at Site 119. A total of 192.4 meters were recovered from the 368 meters cored. The hole bottomed at 711 meters in indurated limestones of early Late Paleocene age.

A relatively complex sequence of Cenozoic sediments appears to be present on Cantabria Seamount. An unconformity which separates Lower Oligocene and Middle Eocene strata was encountered at about 360 meters. This hiatus represents a time-interval of about 8 million years. The uplift and tilting of Cantabria Seamount probably occurred during this interval.

The sequence of sedimentation appears to be reversed at Site 119 compared to Site 118. The upper 400 meters of sediment on Cantabria Seamount are primarily of pelagic origin. Below 400 meters, a thick (approximately 300 meters) sequence of turbidites of Late Paleocene age was encountered.

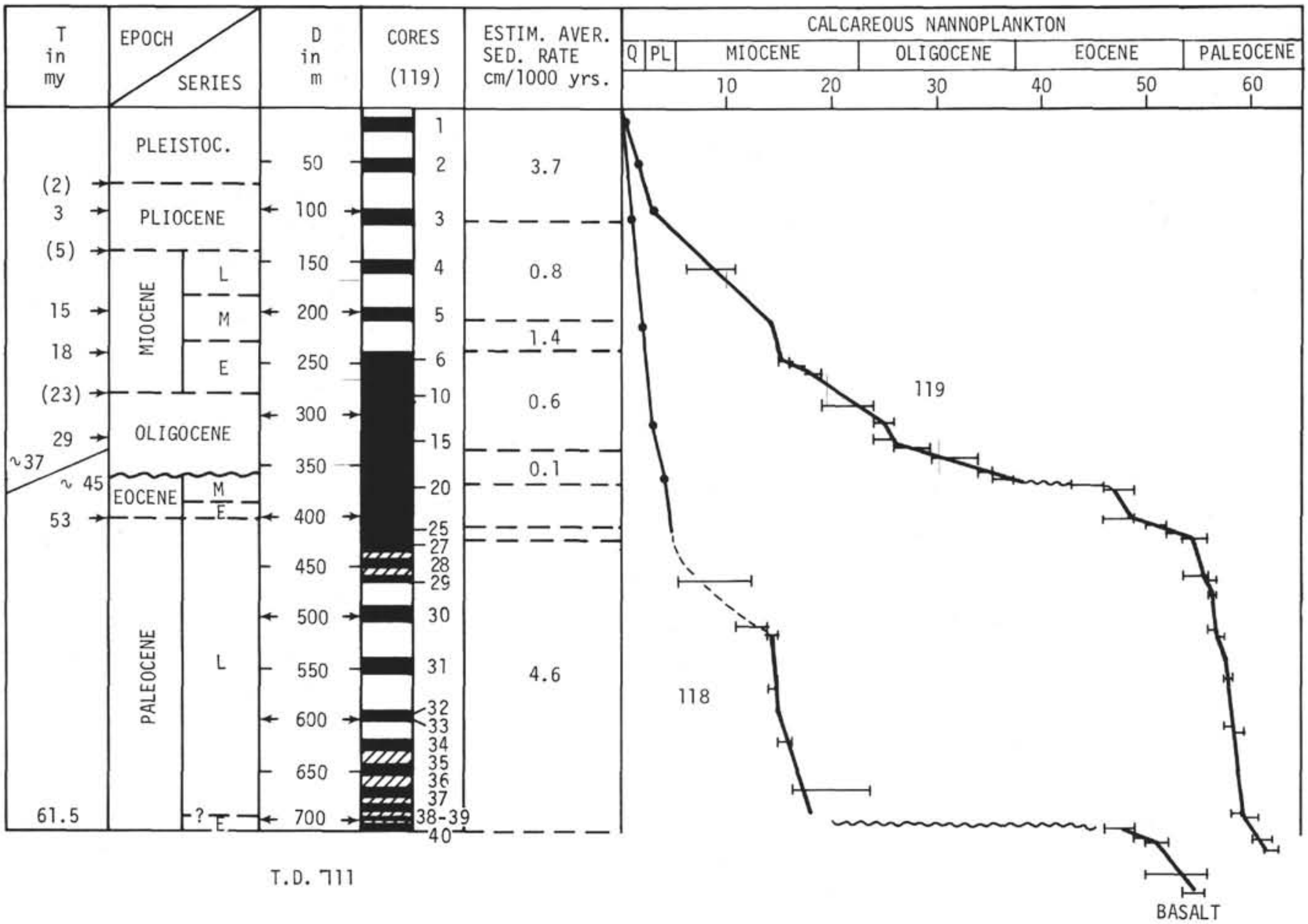


Figure 16. *Estimated average sedimentation rate at Site 119.*

Identification of reflecting horizons

Two principle reflecting horizons have been noted on the seismic profiles of Cantabria Seamount, although many others exist above and below them. They have been discussed in detail in the section on survey data. Reflector 1 marks the top of a sequence of beds apparently dipping to the southeast overlain unconformably by beds dipping less steeply in this direction (Figure 3). Along strike, the reflector is not continuous and may have been eroded subsequent to the uplift of Cantabria Seamount or perhaps fractured by tectonic activity, although the continuity of deeper reflectors opposes this explanation. Under Site 119, it is at 0.45 second, equivalent to 380 meters at 1.71 km/sec, although this depth could be in error by ±30 meters. At 356 meters, there is an unconformity of 9 million years between Middle Eocene turbidites and red clays, and Oligocene nannofossil clays. Drilling met hard layers from 367 meters onwards and these changes are reflected in the impedance plots from the physical properties. Reflector 1 is associated therefore with the top of the sediment sequence which accumulated prior to uplift of Cantabria Seamount in the Middle to Late Eocene. Some erosion may have removed any Late Eocene sediments. Alternatively, Late Eocene sediments initially may have accumulated after the uplift in a depression on the southeastern flank of the seamount, and the unconformity under Site 118 kept clear of sediments by bottom currents until this depression filled. This would explain the onlap of the upper sediments.

Sibuet *et al.* (1971) distinguish three formations (A, B and C) above the unconformity. Formation A, of 200 meters thickness, is thought to lie on a minor discordance of Upper Miocene age, for which we find no evidence. Formations B and C are interpreted as pelagic sediments lying on top of the unconformity but slumped to the southeast following further tectonic disturbances. Sibuet *et al.* correlate formations A, B and C with the flat-bedded turbidite sequences of the surrounding abyssal plain which at Site 118 were sampled as far down as Lower Miocene, but which may extend into the Oligocene. Although this correlation may be valid from the point of view of age, the facies above reflector 1 in Hole 119 is markedly different from that of the top 700 meters of Hole 118.

Reflector 2 is widespread and continuous below central Cantabria Seamount and outcrops at a depth of 4745 meters on the northwestern scarp (130 meters above the abyssal plain). At Site 119, it was at 0.69 second and has been correlated with the sudden reduction of drilling rate at 590 meters when the hole penetrated the indurated clays, limestones and calcarenites. The increase in acoustic impedance at this depth would explain the reflector. The age of this horizon is Late Paleocene (58 million years).

Sibuet *et al.* (1971) divide the sediments below reflector 1 into Upper D and Lower D formations. Reflector 2 lies in the lower part of Upper D formation. The boundary between Upper D and Lower D outcrops on the northwestern scarp at the level of the abyssal plain, and is dated by Sibuet *et al.* as the top of the Maestrichtian on the basis of Jones and Funnell (1968). However, a re-examination of this material, described above, concludes that the samples of Jones and Funnell, are Paleocene and that the Maestrichtian coccoliths have been transported from elsewhere.

An extrapolation of a mean sedimentation rate of 4.6 cm/1000 yrs (measured for the Late Paleocene) throughout the Paleocene would place the Maestrichtian-Paleocene boundary at 955 meters. At a mean velocity below reflector 2 of 2.5 km/sec, the boundary should be at 0.98 second. This corresponds with the boundary between Upper and Lower D formations which would barely outcrop at the foot of the northeastern scarp.

Sediment horizons can be seen on the *Charcot*-9 record down to 1.6 seconds below the sea bed at Site 119. Assuming a velocity of 2.5 km/sec, this would be at a depth of 1700 meters. At a sedimentation rate of 5 cm/1000 yrs for the Upper Cretaceous, the age of the deepest horizon would be 80 million years.

The Search for Maestrichtian Sediments

An objective of Hole 119 was to penetrate reflector 1, believed before we drilled, to be Maestrichtian and outcropping on the northeastern scarp (Jones and Funnell, 1968). The failure to reach Maestrichtian at 711 meters, well below reflector 1, prompted a re-examination of the *Discovery*-11 data which Jones and Funnell studied. Two points emerged.

(1) Although the recorded echo sounder depth at the time of coring Station 5946 was 4256 meters (corrected), thereby placing the sample near the top of the northeastern scarp, this was probably, in fact, a side echo. An analysis of the profile (Figure 7) shows the probable depth under Station 5946 to have been about 4800 meters (corrected), that is, near the base of the scarp. The correlation by Jones and Funnell with their reflector 1, is therefore probably erroneous.

(2) A re-examination of samples from Stations 5946 and 5948 by K. Perch-Nielsen in direct comparison with Hole 119 cores led her to the conclusion that the oldest samples were Paleocene although containing up to 90 per cent reworked Cretaceous coccoliths (see report above). Jones and Funnell recognized that the Cretaceous material was reworked but suggested that it has been locally derived. The presence of Cretaceous contamination throughout the stratigraphy of Hole 119, suggests that the contamination comes from further afield. The erosion of Cretaceous outcrops (Stride *et al.* 1969) on the continental margins around the Bay of Biscay by turbidity currents could provide this material. Turbidity currents could be considerably slowed down by meeting the north cliff of Cantabria Seamount and some of the suspended sediment load could be deposited, the finer material reaching the top.

Tectonic Uplift of Cantabria Seamount

The sediments below the Middle Eocene/Oligocene unconformity have been recognized as turbidites and pelagic red clays deposited below the carbonate compensation depth, whereas those above are pelagic nannofossil clays. The sediments indicate a tectonic uplift of Cantabria at this time as discussed above. The unconformity probably represents an erosional surface after the uplift of Cantabria Seamount during the Middle or Late Eocene. The underlying sediments show evidence of this tectonic disturbance.

Comparison of Sedimentation Conditions at Sites 118 and 119

Graphs of sediment accumulation against time are shown in Figure 16, and a comparison of the two resulting curves leads to the following conclusions and speculations.

In Paleocene time a thick turbidite sequence accumulated at Site 119, whereas at Site 118 volcanic rock was exposed or being formed (?). The location of 119 apparently was deeper than 118, the lower site receiving turbidite sediments. During latest Paleocene and Early Eocene time pelagic sediments were deposited at both sites, whereas a part of the Middle and Late Eocene were times of erosion and subsequent nondeposition. At Site 118 the period of nondeposition continued until Middle Miocene time. This is probably due to the topography of the basement, Site 118 being on the side of a basement high and, as can be seen on the seismic profile, (Figure 5) sediments were deposited on the lower parts of the basement south of Sites 118 and 119. Extrapolating mean sedimentation rates of Miocene turbidites found at Site 118 (4 cm/1000 yrs) to the maximum thickness of the layered sediments in the north Spanish Marginal Trough (2.5 seconds equivalent to 3000 meters at 2.4 km/sec), one can conclude that they are of Cretaceous age. The apparent continuity of layering suggests a continuity of sedimentation there since Cretaceous. Paleocene turbidites at Cantabria Seamount show that this was subject to the same sedimentation regime, whereas the Eocene/Paleocene red clays of Site 118 suggest that this was a local ridge during this period. Tectonic uplift of Sites 118 and 119 probably occurred simultaneously in the Middle to Late Eocene. After this, Site 119 was practically free of turbidites until the Middle Miocene; and, it may be assumed that the seamount stood well above the sea floor in Oligocene and Early Miocene time, receiving pelagic sediments only. From Middle Miocene until the present day, the influence of the upper part of the turbidity currents might be the reason for the progressively higher sedimentation rate. This could indicate that the seamount did not rise further relative to its surroundings, its relief becoming less and less pronounced because the sediments were being deposited around it at a high rate.

The Evolution of the Bay of Biscay

The Bay of Biscay has received considerable attention in the last few years, both on the continental margins, especially in the Aquitaine Basin in the southeastern corner, and in the deep ocean. Much new data is currently being published (cf. I.F.P.;C.N.E.X.O. Symposium sur l'histoire structural du Golfe de Gascogne/Debyser *et al*, 1971, and it is inappropriate here to do more than make some observations based on Holes 118 and 119. Le Pichon *et al.* (1970; in press) have developed theories of the relative plate movements of Spain and France, and the formation of the Pyrenees. Sibuet and Le Pichon (1971) discuss the north Spanish Marginal Trough.

A comparison of the tectonic movements of Sites 118 and 119 during the Late Eocene with those reported in the Aquitaine basin (Bonnard *et al.*, 1958) suggests that they occurred at the same time (Figure 17). Following each phase of earth movements the Biscay abyssal plain received floods of turbidites (getting progressively finer upwards) of carbonate debris which had accumulated up-slope probably off the Aquitaine, prior to the earth movements. The formation of red clays, accumulated at both 118 and 119 prior to the interruption of sedimentation, might be associated with volcanism nearby, preceding the tectonic disturbance, as suggested by Boström and Peterson (1969).

The data of 118 and 119 provide some key dates for the development of the Bay of Biscay, but a complete understanding of its history must await the synthesis of these with the theories both of the Biscay region and of the north Atlantic as a whole (for example: Pitman and Talwani, in press, Williams and McKenzie, 1971, and Laughton, 1971.

REFERENCES

Bacon, M., Gray, F. and Matthews, D. H., 1969. Crustal structure studies in the Bay of Biscay. *Earth and Planet Sci. Letters*, **6**, 377.

Beckmann, J. P., 1953. Die Foraminiferen der Oceanic Formation (Eocaen-Oligocaen) von Barbados, *Kl. Antillen. Ecl. Geol. Helv.* **46** (2), 301, 30 pls.

Bonnard, E., Debourle, A., Hlauschek, H., Michel, P., Perebaskine, V., Schoeffler, J., Seronie-Vivien, R. and Vigneaux, M., 1958. The Aquitanian Basin, Southwest France. **In** *Habitat of Oil.* Weeks, L. G. (Ed.). Tulsa (Am. Assoc. Petrol. Geol.) 1091.

Boström, K. and Peterson, M. N. A., 1969. The origin of aluminum-poor ferromanganoan sediments in areas of high heat flow on the East Pacific Rise. *Marine Geol.* **7**, 427.

Bramlette, M. N. and Sullivan, F. R., 1961. Coccolithophorids and related nannoplankton of the early Tertiary in California. *Micropaleontology.* **7**, 129.

Debyser, J., Le Pichon, X, and Montadert, L. (eds). 1971. Histoire Structurale du Golfe de Gascogne, Editions Technip, Paris 2 vols.

Hay, W. W. and Mohler, H. P., 1967. Calcareous nannoplankton from early Tertiary rocks of Pont Labau, France, and Paleocene-Early Eocene correlations, *J. Paleontol.* **41**, 1505.

Helms, P. B. and Riedel, W. R., 1971. Skeletal debris of fishes. **In** *Initial Reports of the Deep Sea Drilling Project, Volume VII.* Washington (U.S. Government Printing Office.).

Jones, E. J. W. and Ewing, J. I., 1969. Age of the Bay of Biscay; evidence from seismic profiles and bottom samples. *Science.* **166**, 102.

Jones, E. J. W. and Funnell, B. N., 1968. Association of a deep seismic reflector and upper Cretaceous sediment in the Bay of Biscay. *Deep-Sea Res.* **15**, 701.

Laughton, A. S., 1971. The Southern Labrador Sea—a key to the Mesozoic and early Tertiary evolution of the North Atlantic. *Nature.* 232, 612.

Le Borgne, E. and Le Mouel, J., 1970. Cartographie aeromagnetique du Golfe de Gascogne. *C. R. Acad. Sci. Paris.* **271**(D), 1167.

Le Pichon, X., Bonin, J., Francheteau, J. and Sibuet, J. C., 1971. Une hypothese d'evolution tectonique du Golfe de Gascogne. *Histoire structurale du Golfe de Gascogne., Paris.*

Le Pichon, X., Bonnin, J. and Sibuet, J.-C., 1970. La Faille nordpyrénéenne: faille transformante liée a l'overture du Golfe de Gascogne. *C.R. Acad. Sci. Paris.* **271**, 1941.

Martini, 1961. Nannoplankton ans dem Tertiär und der obersten Kreide von SW-Frankreich Senckenbergiana Lethea, Vol. 42 No. 1/2 p. 1-41.

Matthews, D. H. and Williams, C. A., 1968. Linear magnetic anomalies in the Bay of Biscay: a qualitative interpretation. *Earth and Planet Sci. Letters.* **4**, 315.

Matthews, D. J., 1939. Tables of the velocity of sound in pure water and sea water. *Hydrographic Dept. Adm.* H. D. 282.

Montadert, L., Damotte, B., Debyser, J., Fail, J. P., Delteil, J. R. and Valery, P., 1971. The continental margin in the Bay of Biscay. **In** I.C.S.U./S.C.O.R. Working Party 31 Symposium, Cambridge 1970: the geology of the East Atlantic Continental Margin: 3 Europe (continued). F. M. Delaney (Ed.). *Inst. Geol. Sci.* Rep. No. 70/15, 106 pp.

Perch-Nielsen, K., 1971. Einige neue Coccolithen aus dem Paleozän der Bucht von Biskaya, *Meddel. Dansk Geol. Foren.* **20**, 347.

Pitman, W. C. and Talwani, M., in press. Sea floor spreading in the North Atlantic. *Bull. Geol. Soc. Am.*

Riedel, W. R. and Sanfilippo, A., 1970. Radiolaria, Leg 4, Deep Sea Drilling Project. **In** Bader, R. G. *et al.*, 1970, *Initial Reports of the Deep Sea Drilling Project, Volume IV.* Washington (U. S. Government Printing Office), 503.

________, 1971. Cenozoic Radiolaria from the Western Tropical Pacific, DSDP Leg VII. **In** *Initial Reports of the Deep Sea Drilling Project, Volume VII.* Washington (U. S. Government Printing Office.)

Sibuet, J. C. and Le Pichon, X., 1971. Structure gravimetrique du Golfe de Gascogne et le fosse marginal nord-Espagnol. *Histoire structurale du Golfe de Gascogne, Paris, 1970.*

Sibuet, J. C., Pautot, G. and Le Pichon, X., in press. Interpretation structurale du Golfe de Gascogne a partir des profils de sismique. *Histoire structurale du Golfe de Gascogne, Paris, VI–10, 1.*

Stride, A. H., Curray, J. R., Moore, D. G. and Belderson, R. H., 1969. The marine geology of the Atlantic Continental margin of Europe. *Phil. Trans. Roy. Soc. A.* **264**, 31.

Williams, C. A. and McKenzie, D., 1971. The evolution of the N.E. Atlantic. *Nature*, 232, 168.

Vanney, J. R., 1967. La montagne sous-marine "Cantabria" (Golfe de Gascogne). *Trav. Centre. Rech. d'Etude Oceanographique.* **7**, 19.

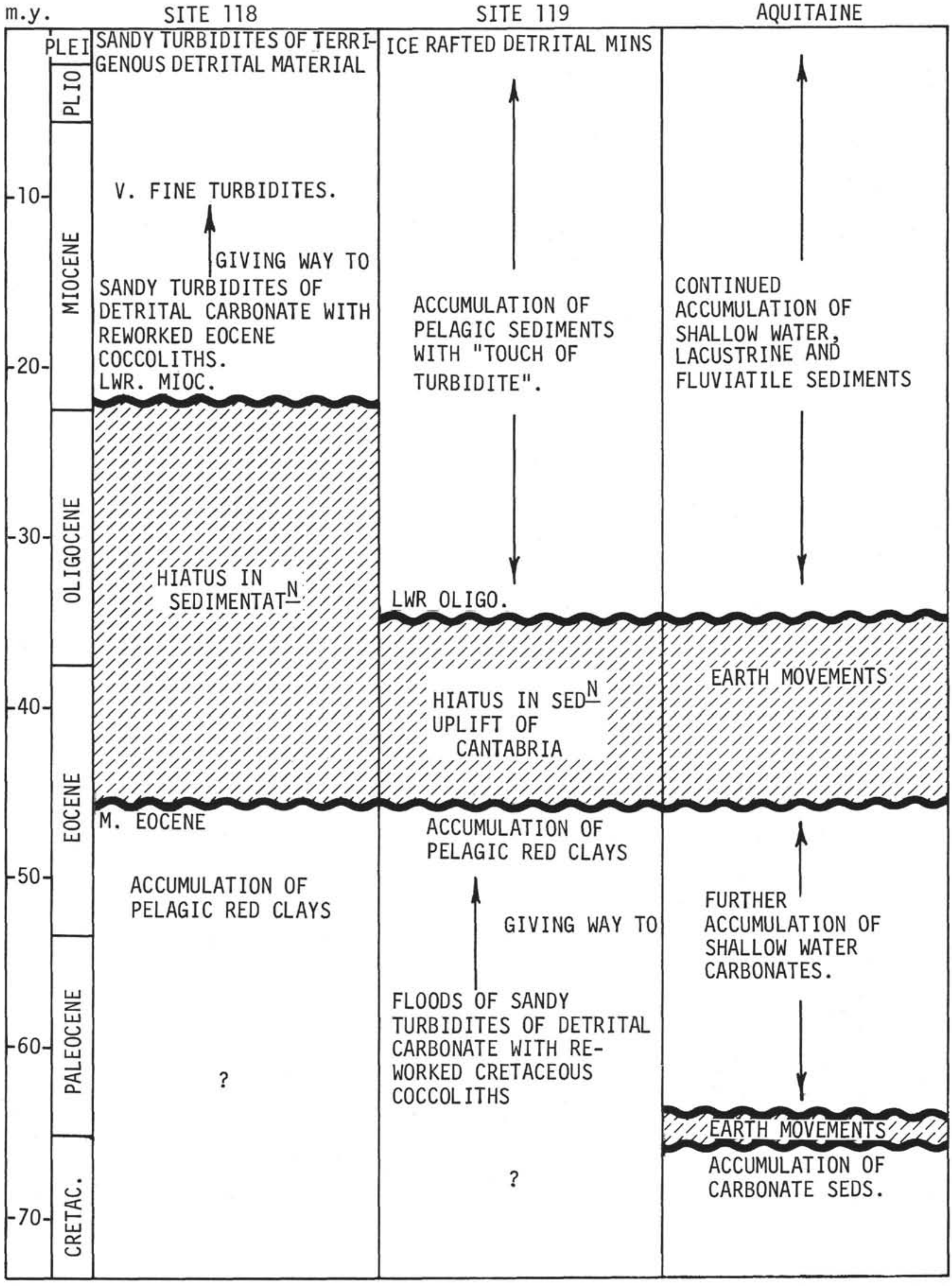
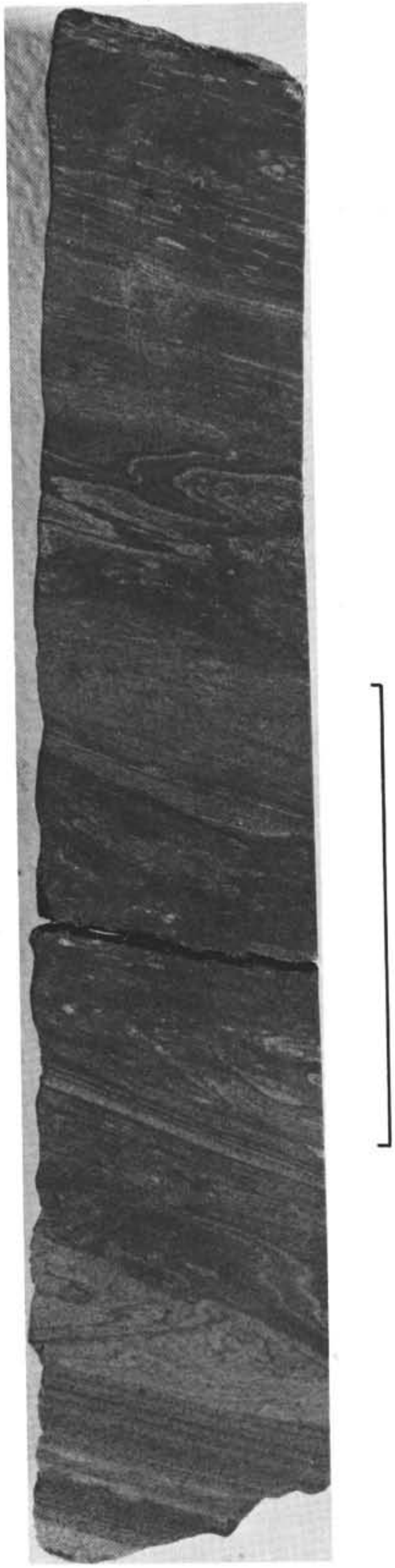


Figure 17. *Sedimentation and tectonic events at Site 118, Site 119 and in the Aquitaine. Data for the Aquitaine is taken from Bonnard* et al., *1958.*

PLATE 1

119-29-2, 35-50 cm



119-36-2, 70-80 cm

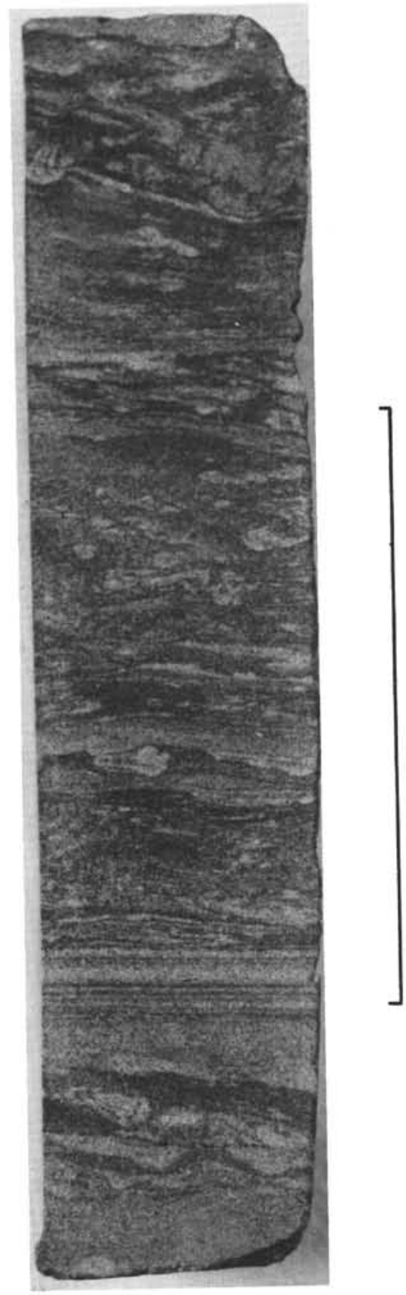


Plate 1. *Primary sedimentary structures in the turbidites, Site 119.*

PLATE 2

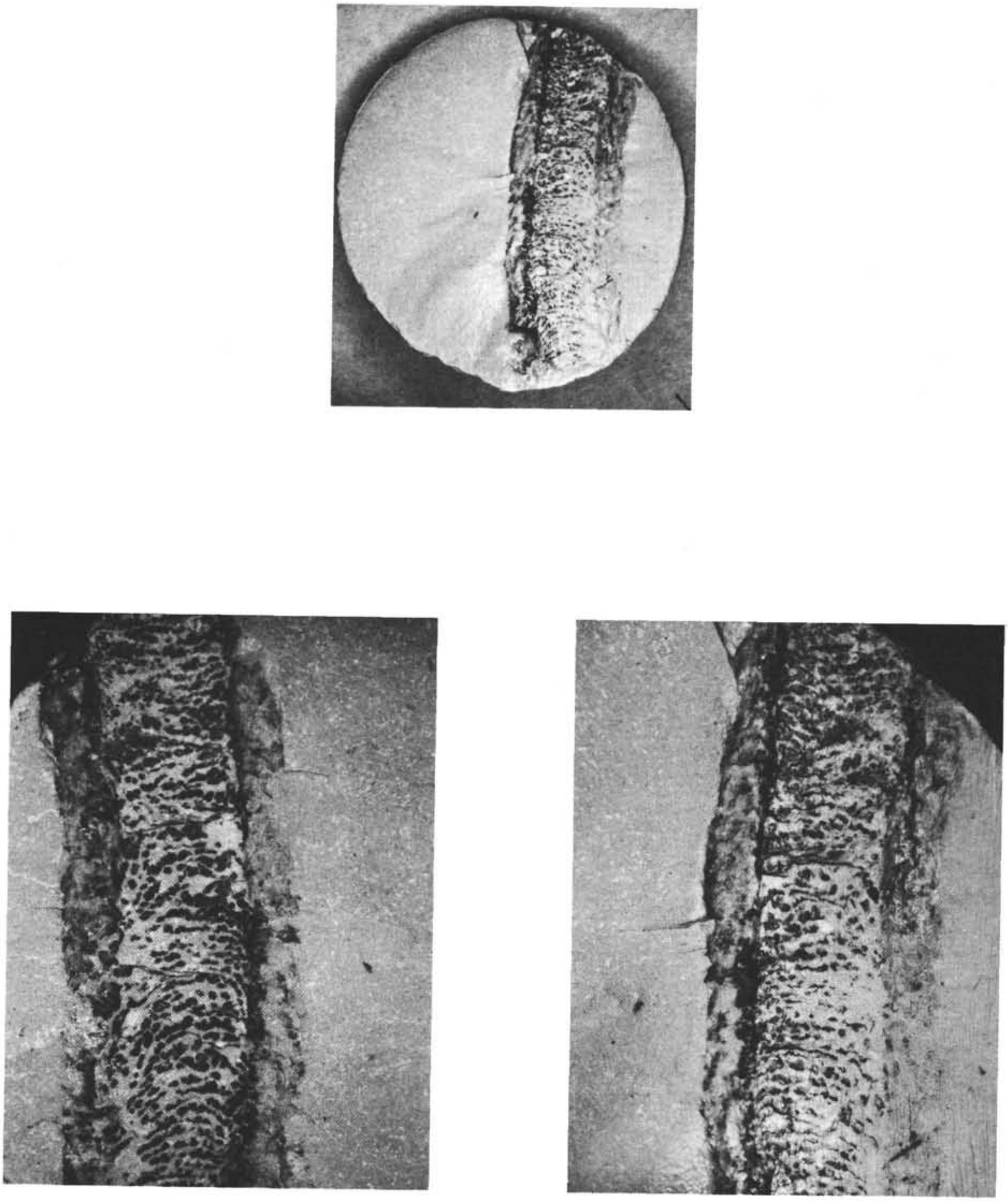
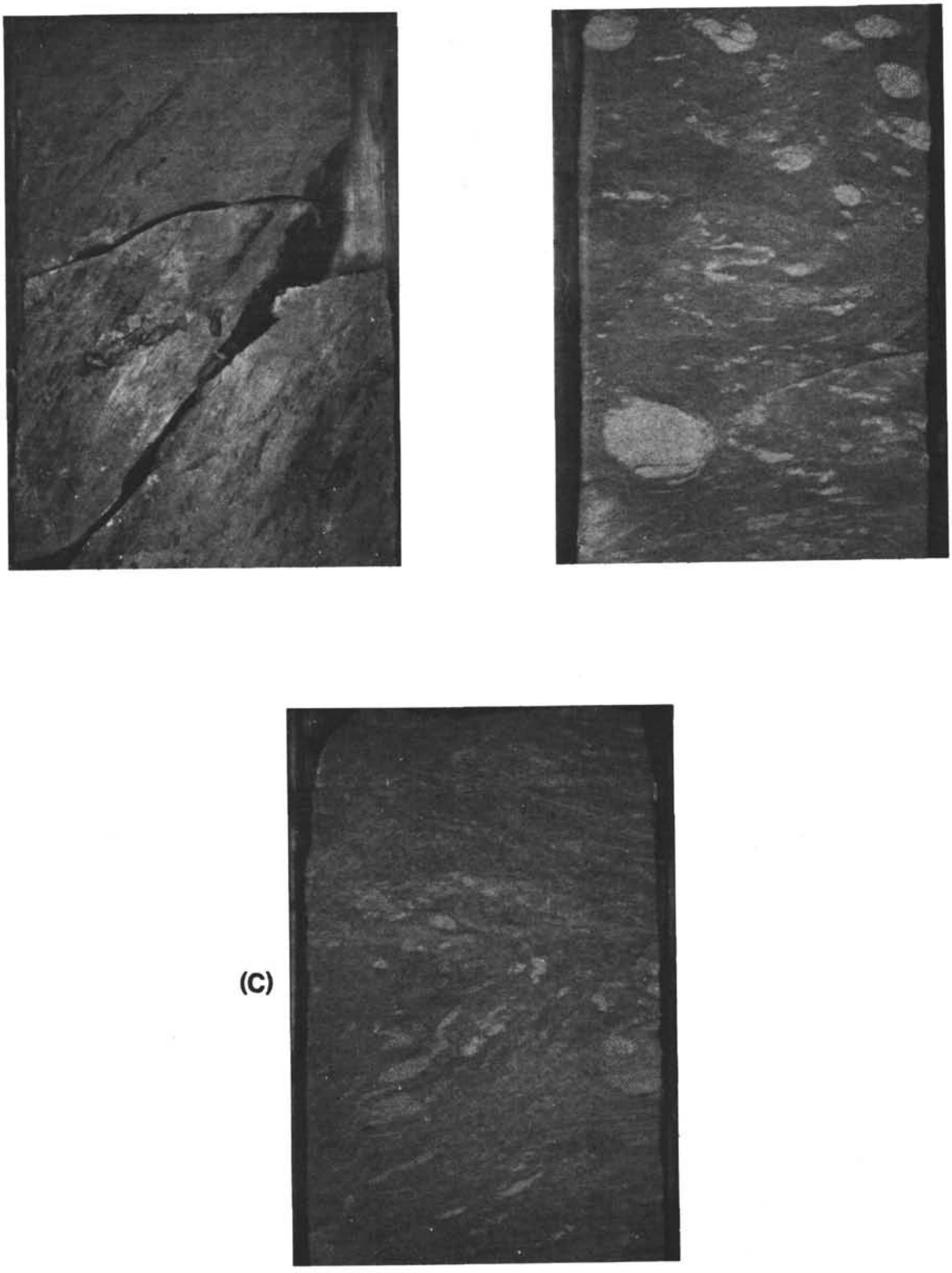


Plate 2. *Worm trail in Paleocene turbidite top (Core 34, Hole 119), enlargement of piece and counterpiece ×2. (Photos, J. v. Hinte, courtesy of Imperial Oil Enterprises, Ltd.).*

PLATE 3



(A) (B) (C)

Plate 3. *(A) Slickenslides in clayey sediment (119-37-3, 15-25 cm); (B) Burrowed, convoluted fine sediment (119-37-3, 56-66 cm); (C) Burrowed fine sediment, slightly deformed by Tectonic movement (119-37-3, 93-103). (Photos, J. v. Hinte, courtesy of Imperial Oil Enterprises, Ltd.).*

APPENDIX A. SHIPBOARD SMEAR SLIDE OBSERVATIONS

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonates	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonates	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
119	1	2	30		A	A	R											R	R			C		X	R	75	C	A			C			Silty clay; limonite, hornblende.
119	1	2	100	C	A	A	R	R		R						R		R	C			R		X	R	60	C	C						Sandy silt; hornblende, limonite, zircon.
119	1	3	35	R	A	A	R											R	C							35		R						Silty clay; limonite, hornblende.
119	1	3	75	C	A	A	R							R		R		R	C			C				45	C	A						Sandy silt; limonite, hornblende.
119	1	3	150	C	A	A	R			R						R		R								75	C	A						Slightly sandy, silty clay; limonite.
119	2	CC			C	D	R	R			R							R								85	C	A						Slightly silty clay; limonite.
119	2	1	130	C	A	A	R											R	R			C					C	C	C	A				Sandy silty clay; hornblende.
119	2	2		C	A	C		C		R				A				C	R			R				15		C						Sandy silt.
119	2	2	98	R	C	A				R				R				R	R			C				85	C	D						Silty clay.
119	2	3	90		C	A		C		R				R				R				R				60	C	A						Slightly silty clay; rare limonite.
119	2	5	20	R	C	A				R				R				R	R			R				75	C	A						Silty clay.
119	2	5	80	C	C	A				R								R				R				80	C	A						Slightly sandy clay.
119	3	CC			C	A		R							R			R								85	A	A						Slightly silty clay; limonite.
119	3	1	130	C	A	A	R			R								R				C				75	C	A						Silty clay.
119	3	1	40	C	A	A	R			R								R				C				85	C	A						Sandy silt; zircon.
119	3	2	75	R	A	A	R							R				R				C				85	C	A						Silty clay.
119	4	CC			R	A		R								R		R								85	C	A						Clay; limonite.
119	4	1	75		A	A	R	R						R				R	R			C				90	R	D						Silty clay; tourmaline, limonite.
119	4	2	80	R	C	A		R						R		R		C	C			C				75	R	A						Silty clay; limonite.
119	5	CC			R	A		R										R	C							85	R	A			R			Clay.
119	5	3	75		C	D				R				R				R				C						D			R			Slightly silty clay.
119	6	1	130		A	A	R	R						C				R				C				45		A		R	C			Silty clay.
119	6	3	75		A	A																C				80		A			R			Silty clay.
119	7	1	55		A	A		R		R				R				R								75		A			C			Silty clay.
119	7	2	75		A	A								R				R				C				85	R	A			C			Silty clay.
119	7	3	75		A	A				R				R				R				C				85		A			C			Silty clay.
119	8	1	80		A	A		R		R				C				C				C				20		C			C			Silty clay.
119	8	2	140	R	A	A								R								R				85		A	C	C	C			Silty clay.

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

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonates	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonates	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
119	8	2	148	R	A	A		R		R				R				R								75		A	R	R	C			Silty clay, rare tourmaline.
119	8	3	75		A	A				R				R				R								85		A			C			Silty clay.
119	8	3	110	C	A	A				R				A				R				C				35		C			A			Sandy silt.
119	8	4	30		A	A								R				R				R				75		A			C			Silty clay.
119	8	4	100	C	A	A		R		R			C	A		R		C				C				20		C	C		C			Sandy silt; limonite.
119	8	5	40	C	A	A				C			C	A				C				C				15		R		C	C			Sandy silt.
119	9	2	50	R	A	A		R		R				C								C				60		A			C			Silty clay.
119	9	2	100		A	A				R				R	R			R				C				75		A			C			Silty clay.
119	10	0			A	A		R						R	R			R				R				70		A		R	C			Silty clay.
119	10	1	70		A	A				R				R				R				R				75		A		R	C			Silty clay.
119	10	2	50	C	A	A		R		R								R				C				60		A			C			Sandy silt.
119	11	1	75	C	A	A				R				R				R				R				80		A		R	R			Slightly sandy silt.
119	12	2	75		A	A		R		R				R				R				R				85		A			R			Silty clay; limonite.
119	13	2	75		C	A				R				R				R				R				85		A			R			Silty clay; limonite.
119	14	2	75		C	A				R				R				R				R				90		D						Slightly silty; rare limonite.
119	15	CC			D	R	R												R							90		D						Coccolith ooze; very clean pelagic sediment.
119	15	4			C	A	C					R		R					R					X		10		R						Silty clay; other minerals - clay minerals (D).
119	15	4			C	D	C											R								5		R						Clay.
119	15	3	75		A	A				R				R				R				R				90		D						Silty clay.
119	15	4	12		C	A		R						R				R			R					90		D						Silty clay.
119	15	4	70		C	A		R					R					R				R				90		D						Silty clay.
119	15	5	111	R	C	A		C						C				R								90		D						Sandy silty clay.
119	16	2	75		C	A				R				R				R				R				85		D						Silty clay.
119	17	CC			D	A	C			R	R			C				R	C					X		60		D			R			Nannofossil-marl ooze; very small quartz and glass grains with alteration rim; other minerals - limonite (R).
119	17	4	75	R	C	A				R				R	R							C				85		D						Silty clay.
119	18	CC			D	R	R											R	C							90		D						Coccolith chalk ooze; very clean and much recrystallized.
119	18	5	75		C	A								R								C				85		D						Silty clay.
119	19	CC			A	D	R		R			R		C				C	R							30		D		C	C			Silty nannofossil clay.

APPENDIX A – *Continued*

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonates	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonates	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
119	19	2	75		C	A				R				R				R	R			C				75		D						Silty clay; rare limonite.
119	20	CC			A	A	R							R	R			R	R					X		60		D			R			Nannoplankton-marl ooze; other minerals - limonite.
119	20	1	75		C	A				R				R				R	R			C				75		D						Silty clay; limonite.
119	21	3	75		C	A								R				R								75		D						Silty clay; limonite.
119	22	CC			A	D	R					R		R	R			R	R					X		40		D						Nannofossil-marl ooze; calcite or dolomite rhombs; other minerals - limonite (R).
119	22	2	75		C	A				R				R				R				R				75		D						Silty clay; limonite.
119	23	CC			A	A	C		R					A	R				R					X		60		A						Silty clay (nannopl. marl ooze); all glass, palagonite and quartz shows alteration rims (quartz uncertain but anisotropic with wavey extintion); many small calcite or dolomite rhombs; other minerals - limonite (C).
119	24	CC			A	D	R			R				C	A			R	C					X		60		D						Silty nannofossil clay; many calcite or dolomite rhombs; limonite (C).
119	25	CC			D	C	R							R	R			R	A							80		D						Nannofossil chalk ooze.
119	26	1	70		D	A	R											R	C			R				50	R	D						Marly coccolith clay.
119	26	1	110		C	D	C		R			R		R				C	A							40	R	D						Silty marly clay.
119	27	CC			C	D	D					R	R	R	C			R	R		R			X										Silty clay; quartz shows alteration rim; other minerals - limonite (R).
119	27	1	75		A	C	R							R				R	C							70	R	D						Coccolith marl ooze.
119	28	2	75		D	C	R				R			C				R	C		R					70		D						Coccolith ooze.
119	29	CC			D	R	R												D							90		D						Coccolith chalk ooze; much recrystallized; other minerals - limonite (R).
119	29	1	120		D	C	R												D							70	R	A						Recrystallized coccolith ooze.
119	29	3	75		D	R	R							R				R	D							90		C						Recrystallized coccolith ooze.
119	29	4	80		D	C	R							R	R				D							75		A						Recrystallized coccolith marl.
119	30	CC			D	C	R		R		R							R	D					X		90	R	R	R					Carbonate silt (recrystallized); other minerals - limonite (R).
119	30	1	110		D	A	R							R					D							60		C						Coccolith marl (recrystallized).
119	30	2	75		D	C								R	C				D							80		C						Recrystallized coccolith marl.
119	30	4	75		D	C	R					R		R	R			R	D							70		D						Coccolith marl (recrystallized); other minerals - limonite (R).
119	30	4	85				R					R		C	R			C	D					X		70		D						Recrystallized coccolith marl; other minerals - limonite (R).
119	30	4	90		D	C	R							R	C			R	D							70		C						Recrystallized coccolith marl.

Site Hole	Core	Section	Interval (cm)	Sand	Silt	Clay	Quartz	Feldspar	Pyroxene	Chlorite	Dark Mica	Light Mica	Dark Glass	Light Glass	Palagonite	Glauconite	Phosphorous	Pyrite	Authigenic Carbonates	Barite	Phillipsite	Other Zeolites	Micronodules	Other Minerals	Abundance	Estimated Carbonates	Foraminifera	Calcareous Nannofossils	Diatoms	Radiolaria	Sponge Spicules	Plant Debris	Fish Debris	Lithology and Comments
119	30	5	71		D	C								R				R	D							70		C						Recrystallized coccolith marl.
119	30	6	75		D	R	C					R						R	D							80		C						Recrystallized coccolith marl.
119	31	CC			D	C													A							90		D						Pure nannofossil chalk ooze.
119	31	1	75		D	C						R		C				R	D							80		C						Recrystallized coccolith marl.
119	31	5	75	R	D	R	R								R				A							90	R	D						Coccolith chalk ooze.
119	31	5	75		D	C	R											R	D							90	R	D						Coccolith chalk ooze.
119	32	2	20		D	C								R				R	D							70		C						Recrystallized coccolith marl.
119	32	2	93		D	C	R							R					D							80		C						Recrystallized coccolith marl.
119	32	4	32		A	A	C		R	R		R						R	A							50	C	A		R	R			Silty coccolith foraminiferal clay.
119	34	CC			D	C	R							R				R	D							80		C						Recrystallized coccolith marl.
119	34	1	57		D	C	R							R	R				D							80		C						Recrystallized nannofossil marl.
119	36	CC			D	R								R					D							80		D						*Braarudosphaera* marl ooze; very much recrystallized.
119	37	4	65		D	A	A	R	R					C				R	C					X		50	R	D						Nannofossil marl; other minerals - heavy minerals (R).
119	38	3	52		D	C	R					R		R					D					X		70	R	D						Nannofossil marl; other minerals - hematite (R).
119	38	3	125		D	C	R							C					D					X		75	C	D						Coccolith marl (recrystallized); other minerals - hematite (R).
119	38	4	20		D	C	R	R						R					D					X		70	R	D	R					Nannofossil marl (Recrystallized); other minerals - hematite (R).
119	38	4	125		D	R	R											R	D							80		R						Marly limestone (Recrystallized coccolith ooze).
119	39	CC			A	A											X	R	C							70		D						Nannofossil marl.
119	39	5	50		D	C								C	R				D							85		C						Recrystallized nannofossil marl.
119	40	CC			D	A	C							R					D							60		C						Recrystallized nannofossil marl.
119	40	1	75		D	C								C					D							90		R						Recrystallized nannofossil marl.
119	40	1	75		D	C								R				R	D							90		A						Recrystallized nannofossil marl.
119	40	3	75		D	C	R							R					D							70		C						Recrystallized nannofossil marl.

APPENDIX B. GRAIN SIZE DETERMINATIONS ON SAMPLES FROM SITE 119[1]

Site	Core	Section	Interval	Per Cent Sand	Per Cent Silt	Per Cent Clay	Classification
119	1	2	74.0	1.5	30.8	67.7	Silty clay
119	1	3	107.0	4.6	43.2	52.2	Silty clay
119	2	2	24.0	8.0	36.0	56.0	Silty clay
119	3	1	28.0	0.2	37.9	61.8	Silty clay
119	4	1	70.0	0.2	34.6	65.2	Silty clay
119	5	2	24.0	0.3	32.5	67.2	Silty clay
119	6	2	25.0	0.3	33.6	66.1	Silty clay
119	7	2	23.5	0.7	40.9	58.4	Silty clay
119	8	1	41.0	1.2	41.5	57.3	Silty clay
119	10	1	28.0	0.8	34.7	64.5	Silty clay
119	10	2	30.0	0.7	34.3	65.1	Silty clay
119	11	1	29.0	1.2	34.3	64.5	Silty clay
119	12	1	88.0	1.0	27.1	71.9	Silty clay
119	13	4	25.0	0.5	43.2	56.3	Silty clay
119	14	1	80.0	0.5	38.8	60.7	Silty clay
119	14	3	26.0	0.5	45.8	53.8	Silty clay
119	15	1	38.0	0.5	39.6	59.9	Silty clay
119	16	1	29.0	0.9	36.1	63.0	Silty clay
119	16	3	24.0	0.6	41.5	57.9	Silty clay
119	17	1	10.0	1.5	28.9	69.6	Silty clay
119	17	4	20.0	1.8	32.2	66.0	Silty clay
119	18	2	15.0	0.2	32.3	67.4	Silty clay
119	18	6	25.0	0.1	44.0	55.9	Silty clay
119	19	2	24.0	0.1	30.4	69.6	Silty clay
119	20	1	30.0	0.1	22.9	76.9	Clay
119	20	3	24.0	0.0	30.3	69.6	Silty clay
119	21	1	28.0	0.0	29.0	70.9	Silty clay
119	21	3	25.0	0.0	36.5	63.5	Silty clay
119	22	2	23.0	0.0	12.9	87.1	Clay
119	24	2	100.0	0.0	9.7	90.3	Clay
119	25	2	25.0	7.4	60.4	32.2	Clayey silt
119	26	1	30.0	0.1	25.2	74.7	Silty clay
119	27	1	124.0	0.0	43.1	56.9	Silty clay
119	30	2	113.0	6.7	33.3	60.0	Silty clay
119	30	5	Bottom	0.0	35.8	64.2	Silty clay
119	31	1	113.0	0.2	31.9	67.9	Silty clay
119	31	3	60.0	0.0	27.6	72.3	Silty clay
119	31	3	132.0	0.2	29.4	70.4	Clay
119	31	4	27.0	1.1	42.8	56.1	Silty clay
119	31	4	144.0	0.2	34.8	65.1	Silty clay
119	32	1	146.0	0.5	42.8	56.7	Silty clay
119	32	2	91.0	0.0	21.7	78.3	Clay
119	33	1	46.0	0.5	29.9	65.5	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 CONTENT OF SAMPLES FROM SITE 119[1]

Site	Core	Section	Top Interval	Hole Depth	Total Carbon	Organic Carbon	C_aC0_3
119	1	2	25.0	11.8	4.9	0.0	41
119	2	2	15.0	51.7	2.9	0.4	20
119	3	1	23.0	100.2	6.7	0.2	54
119	4	1	54.0	150.5	3.4	0.2	26
119	5	2	13.0	199.6	9.9	0.0	82
119	6	2	15.0	241.6	2.3	0.1	18
119	7	2	15.0	250.6	4.9	0.1	40
119	8	1	16.0	258.2	2.5	0.2	19
119	9	2	140.0	269.9	6.8	0.1	56
119	10	1	15.0	276.1	7.0	0.1	58
119	10	2	15.0	277.6	6.8	0.1	55
119	11	1	15.0	284.1	5.6	0.1	46
119	12	1	97.0	294.0	8.3	0.1	68
119	13	2	15.0	303.6	8.1	0.1	66
119	13	4	15.0	306.6	8.5	0.1	70
119	14	1	59.0	311.6	8.0	0.1	66
119	15	1	13.0	320.1	8.6	0.2	70
119	16	1	15.0	329.1	4.7	0.0	39
119	16	3	14.0	332.1	7.4	0.1	61
119	17	1	10.0	338.1	4.4	0.1	36
119	17	4	20.0	342.7	9.1	0.1	75
119	18	2	15.0	348.6	6.5	0.1	54
119	18	4	15.0	351.6	8.2	0.1	67
119	18	6	15.0	354.6	9.6	0.1	79
119	19	2	15.0	357.6	4.0	0.1	33
119	20	1	21.0	365.2	3.1	0.1	25
119	20	3	15.0	368.1	6.2	0.1	51
119	21	1	15.0	374.1	6.1	0.1	49
119	21	3	16.0	377.2	6.5	0.1	53
119	22	2	15.0	384.6	1.5	0.0	12
119	24	2	88.0	403.4	0.4	0.1	2
119	25	2	15.0	411.6	5.9	0.1	48
119	26	1	20.0	419.2	0.6	0.1	4
119	27	1	14.5	428.1	6.1	0.2	49
119	29	2	105.0	461.5	3.8	0.3	29
119	30	5	30.0	499.3	8.2	0.2	67
119	32	1	146.0	593.5	6.0	0.4	47
119	39	2	79.0	688.3	6.8	0.1	56
119	39	4	40.0	690.9	10.2	0.1	84

[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 119

Sample 12-119-1-1, 40-43 cm:
Rich planktonic foraminiferal fauna with effects of calcium carbonate solution visible.
PF: *Orbulina universa* (dominant, abundant), *Globorotalia hirsuta, G. inflata, G. truncatulinoides, G. crassaformis, Globigerina bulloides, G. pachyderma, Globigerinoides rubra.*
BF: *Gyroidina* sp., *Pullenia* sp., *Eponides* sp., milolids.
Also present: Relatively abundant ice-rafted quartz and other detrital rock fragments.
Age: Pleistocene.

Sample 12-119-1-3, 147-150 cm:
Lithology similar to sample above but greater predominance of cold-water species in this sample at the expense of temperate and warm-water species.
PF: *Globigerina bulloides* (dominant, abundant), *G. pachyderma, Globorotalia hirsuta, G. inflata.*
BF: Rich and diverse, including *Melonis pompilioides, Epistominella exigua, Pullenia* sp., *Uvigerina* sp., various cibicidids.
Also present: Abundant ice-rafted quartz and other detritus.
Age: Pleistocene.

Sample 12-119-1, Bottom Section 3, No Core Catcher Sample:
PF: *Globigerina bulloides* (dominant, abundant), *G. pachyderma, Globorotalia hirsuta, G. inflata, G. crassaformis, G. truncatulinoides.*
BF: *Pyrgo murrhyna, Melonis pompilioides, M. parkerae, Pullenia* sp., *Epistominella exigua, Eponides tener*, uvigerinids, dentalinids, miliolids.
Also present: Relatively abundant ice-rafted quartz and other detrital rock fragments.
Age: Pleistocene.

Sample 12-119-2, Top:
Radiolaria and siliceous sponge spicules present. Planktonic foraminifera represented by scattered, broken fragments caused by solution.
Age: Pleistocene (by interpolation).

Sample 12-119-2-1, 147-150 cm:
PF: *Globigerina pachyderma* (dominant, abundant), *G. bulloides, Orbulina universa, Globorotalia inflata, Hastigerina siphonifera.*
BF: *Pyrgo murrhyna, Eponides* sp., cibicidids, *Epistominella exigua.*
Also present: Ice-rafted quartz.
Age: Pleistocene.

Sample 12-119-2-2, 147-150 cm:
Lithology and fauna essentially similar to above but including also *Globorotalia crassaformis* and *Globorotalia truncatulinoides* (relatively common).
Also present: Ice-rafted quartz and rock fragments.
Age: Pleistocene.

Sample 12-119-2-3, 116-119 cm:
Planktonic fauna characterized by overwhelming dominance of *Globigerina pachyderma* (sinistrally coiled) and minor amounts of *Globigerina bulloides* and *Globorotalia inflata.*
Also present: Ice-rafted quartz.
Age: Pleistocene.

Sample 12-119-2, Core Catcher:
PF: *Orbulina universa* (dominant, abundant), *Globigerina bulloides, G. pachyderma, Globorotalia inflata, G. crassula, G. truncatulinoides, Hastigerina siphonifera, Globigerinoides conglobata, G. rubra, Globorotalia crassaformis.*
BF: *Pyrgo murrhyna, Eponides tener, Eggerella* sp., cibicidids, miliolids.
Also present: Ice-rafted quartz and other rock fragments.
Age: Pleistocene.
Remarks: This is a calcareous ooze with varying amounts of ice-rafted detritus. Solution effects are visible on the tests of the planktonic foraminifera.

Sample 12-119-3-1, 148-151 cm:
PF: *Orbulina universa, Globigerina bulloides, Globorotalia crassula, G. crassaformis, G. scitula, G. puncticulata, Globigerinoides obliqua.*
BF: Rich and diverse, dominated by large and robust specimens of *Cassidulina subglobosa, Pyrgo murrhyna, Melonis pompilioides, Epistominella exigua.*
Age: Pliocene.

Sample 12-119-3-2, 144-147 cm:
Essentially the same fauna as above but strong effects of calcium carbonate solution visible in planktonic fauna. *Globorotalia puncticulata* common, and this appears to be one of the more resistant species.
Age: Pliocene.

Sample 12-119-3, Core Catcher:
PF: *Orbulina universa, Globigerina bulloides, Globorotalia crassula, G. crassaformis, G. puncticulata, Globigerinoides sacculifera, G. obliqua.*
BF: *Gyroidina* spp., *Laticarinina halophora, Pyrgo murrhyna, Eponides* sp., *Melonis pompilioides, Ehrenbergina* sp., *Eggerella* sp., *Epistominella exigua.*
Also present: Abundant pyrite clusters.
Age: Pliocene.
Remarks: *Globorotalia puncticulata* occurs relatively commonly in this core and its presence together with *Globigerinoides obliqua* supports a Pliocene age determination for Core 3. This is also supported by the assignment of Core 3 to the *Discoaster surculus* Zone by K.P–N.

Sample 12-119-4, Core Catcher:
PF: *Orbulina universa, Globigerina praebulloides, G. atlantica, G. nepenthes, Globigerinoides* sp. cf. *G. canimarensis.*
BF: *Gyroidina* sp., *Planulina ariminensis, Melonis pompilioides, Pyrgo murrhyna, Stilostomella abyssorum, Stilostomella* spp., *Eggerella* sp., *Pleurostomella* sp.
Age: Late Miocene.

Sample 12-119-5, Top:
PF: Rare, mostly dissolved.
BF: Large robust, *Gyroidina* sp., *Melonis pompilioides, Planulina ariminensis, Eggerella* sp., *Lingulina* sp., *Stilostomella abyssorum, Cyclammina* sp.
Also present: Abundant, very small, circular, spiney, calcareous, spheres, echinoid spines, shark teeth, and a few sponge spicules, and a few Radiolaria.
Similar faunas to above were found in the following samples:
Sample 12-119-5-1, 128-131 cm
Sample 12-119-5-2, 144-147 cm
Sample 12-119-5-3, 146-149 cm

Sample 12-119-5, Core Catcher:
PF: Rare, mostly dissolved; *Globoquadrina dehiscens, Globorotalia* sp. cf. *G. acostaensis.*
BF: *Cassidulina* sp. (common), *Eponides* sp., *Eggerella* sp., *Gyroidina* sp., *Planulina* (common), siphonodosariids, *Vaginulina* sp., *Melonis pompilioides.*
Also present: As above.
Age: ?Middle Miocene (based upon calcareous nannofossils).
Remarks: Radiolarians are relatively common in this core. The effects of solution are evident in the fact that almost all the planktonic foraminifera have been dissolved. The solution effect can also be seen on the tests of some benthonic foraminifera. The benthonic foraminiferal fauna consists wholly of abyssal forms such as *Gyroidina* sp., *Planulina*, and *Melonis.*

Sample 12-119-6-1, 147-150 cm:
Radiolarian ooze with no planktonic foraminifera.

Sample 12-119-6-2, 146-149 cm:
Radiolarian ooze; no planktonic foraminifera.
BF: *Gyroidina* sp., *Siphonodosaria* sp.

Sample 12-119-6-3, 144-147 cm:
As above.

Sample 12-119-6-4, 146-149 cm:
Lithology essentially similar to samples above but planktonic foraminifera are also present.
PF: *Globorotalia peripheroronda, G. siakensis, Globorotalia* sp. cf. *G. praescitula, Globoquadrina dehiscens.*
BF: As above.
Age: Early-Middle Miocene.

Sample 12-119-6, Core Catcher:
Radiolarian ooze with moderate planktonic and benthonic foraminiferal fauna.
PF: *Globigerinita dissimilis, G. unicava, Globoquadrina praedehiscens, G. dehiscens, G. baroemoenensis, Globigerinoides* sp. cf. *G. diminuta, Globorotalia siakensis.*
BF: *Anomalinoides pompilioides, A. semicribrata, Cibicidoides trincherasensis, C. grimsdalei, Gyroidina* sp., *Stilostomella* spp. *Vulvulina* sp.
Age: Early Miocene (Zone N6).
Remarks: Core 6 contains the highest occurrence at this site of *Globigerinita dissimilis* and *G. unicava* and several benthonic forms which are characteristic of the Caribbean region. Specimens referred here to *Globorotalia siakensis* have a distinct loop-shaped aperture and bear a strong resemblance to *Globorotalia semivera* Jenkins described from the Lower Miocene of the Aquitaine Basin.

Sample 12-119-7-1, 146-149 cm:
Radiolarian ooze, few calcareous benthonic foraminifera, no planktonic foraminifera.
BF: *Anomalinoides semicribrata, Cassidulina* sp., *Oridorsalis ecuadorensis.*
Age: Early Miocene (see below).

Sample 12-119-7-2, 146-149 cm:
Essentially same as above. Large dentalinids present.
Age: Early Miocene.

Sample 12-119-7-3, 145-148 cm:
Essentially the same as above. Some foraminifera preserved, including *Globoquadrina dehiscens.*
Age: Early Miocene.

Sample 12-119-7, Core Catcher:
Radiolarian ooze with moderate benthonic and planktonic fauna.
PF: *Globigerinita dissimilis, G. unicava, Globoquadrina praedehiscens, G. dehiscens.*
BF: *Cibicidoides trincherasensis, C. grimsdalei, Stilostomella* spp., *Anomalinoides semicribrata, Gyroidina complanata, G. girardana.*
Age: Early Miocene.
Remarks: The planktonic and benthonic foraminiferal fauna of Core 7 is essentially the same as that occurring in Core 6.

Sample 12-119-8-1, 146-149 cm:
Radiolarian ooze with few scattered broken fragments of planktonic and benthonic foraminifera.
BF: *Anomalinoides pompilioides, A. semicribrata,* stilostomellids, *Cassidulina subglobosa, Gyroidina complanata.*
Age: Early Miocene.

Sample 12-119-8-3, 145-148 cm:
Essentially the same as preceding sample above.

Sample 12-119-8-4, 147-150 cm:
Greenish-gray clay with abundant Radiolaria, no calcareous fauna preserved.

Sample 12-119-8-5, Top:
Lithology same as preceding sample above.

Sample 12-119-8-5, 63-66 cm:
Lithology same as above but with some planktonic foraminiferal elements (*Globorotalia inflata*, orbulinids) and benthonic foraminifera from higher levels representing contamination.

Sample 12-119-8, Core Catcher:
Benthonic and planktonic foraminifera as described from Cores 6 and 7 above, but including also Pliocene-Pleistocene planktonic and benthonic foraminiferal contaminants from above, such as *Orbulina universa, Globorotalia crassula, G. puncticulata, Globigerina bulloides, G. pachyderma, Melonis pompilioides,* etc.
Remarks: Quartz grains are relatively abundant in the fine fraction in samples in Core 8, with the exception of the Core Catcher sample for reasons difficult to explain. Section 5 and the Core Catcher were found to contain contaminants from Pliocene/Pleistocene levels above.

Sample 12-119-9-1, 148-151 cm:
Radiolarian ooze with few fragments of calcareous benthonic forms: primarily fragments of *Ellipsonodosaria, Gyroidina* and *Eponides.*

Sample 12-119-9-2, 146-149 cm:
Radiolarian ooze with few fragments of calcareous benthonic forms; gyroidinids primarily.

Sample 12-119-9-3, 130-133 cm:
Essentially the same as preceding sample above.

Sample 12-119-9, Core Catcher:
Radiolarian ooze, with rare planktonic foraminifera.
BF: *Cassidulina subglobosa, Pullenia* sp., *Anomalinoides semicribrata, Cibicidoides trincherasensis, Vulvulina* sp., *Gyroidina* spp., siphonodosariids, *Stilostomella* spp.
Age: Early Miocene (by interpolation).

Sample 12-119-10-1, 147-150 cm:
Radiolarian ooze, no observable calcareous fauna preserved.

Sample 12-119-10-2, 146-149 cm:
Lithology same as above, few gyroidinids, cassidulinids.

Sample 12-119-10-3, 6-9 cm:
Same as above.

Sample 12-119-10, Core Catcher:
Radiolarian ooze with sparse planktonic and benthonic fauna.
PF: *Globigerinita dissimilis* (very rare).
BF: Siphonodosariids, *Vulvulina* sp., *Gyroidina* sp., *Planulina renzi, Melonis* sp., *Eponides* sp., *Karreriella* sp., *Cassidulina subglobosa, Oolina* sp.
Age: Late Oligocene or Early Miocene.
Remarks: Core 10 is a radiolarian ooze in which the calcareous foraminifera are present in rare to moderate numbers. Quartz occurs commonly in the fine fraction.

Sample 12-119-11-1, 145-148 cm:
Radiolarian ooze with few foraminiferal fragments preserved.

Sample 12-119-11-2, 147-150 cm:
Radiolarian ooze with abundant siliceous sponge spicules and few scattered benthonic foraminifera (*Gyroidina, Pullenia, Siphonodosaria, Stilostomella*).

Sample 12-119-11-3, 87-90 cm:
Lithology and fauna essentially the same as above.

Sample 12-119-11, Core Catcher:
Radiolarian ooze with moderate benthonic foraminiferal fauna, planktonic foraminifera rare.
PF: *Globigerinita unicava, Globigerina* sp.
BF: *Gyroidina* sp., *Anomalinoides semicribrata, Karreriella* sp., *Vulvulina* sp., *Cibicidoides trincherasensis, Planulina* sp., siphonodosariids.
Also present: Some contaminants from Pliocene to Pleistocene (planktonic foraminifera).
Age: Late Oligocene to Early Miocene (calcareous nannoplankton).
Remarks: Core 11 consists of radiolarian ooze with a moderate benthonic foraminiferal fauna. Quartz is a common component in

the fine fraction. In the absence of diagnostic planktonic foraminifera age determination is based on calcareous nannoplankton.

Sample 12-119-12-1, 147-150 cm:
Radiolarian ooze with abundant siliceous sponge spicules and scattered benthonic foraminifera.

Sample 12-119-12-2, 148-151 cm:
Radiolarian ooze with abundant sponge spicules and benthonic and planktonic foraminifera.
PF: *Globigerinita unicava, Globigerina* sp.
BF: *Gyroidina, Cassidulina, Cibicidoides, Vulvulina, Karreriella, Stilostomella, Siphonodosaria.*
Age: Late Oligocene (calcareous nannoplankton).

Sample 12-119-12-3, 147-150 cm:
PF: *Globigerinita dissimilis, G. unicava, Globorotalia opima nana, G. siakensis.*
BF: *Karreriella* sp., *Ellipsonodosaria* sp., *Angulogerina* sp., *Gyroidina* sp.
Age: Late Oligocene.

Sample 12-119-12, Core Catcher:
Radiolarian ooze with moderate benthonic and rare planktonic foraminiferal fauna.
PF: *Globigerinita unicava, G. dissimilis, Globorotalia opima nana,*
BF: *Cibicidoides* sp. (with central umbilical plug), *Cassidulina* sp., *Gyroidina* sp., *Eponides* sp., *Planulina* sp.
Age: Late Oligocene (calcareous nannoplankton).
Remarks: As in the case of cores above, Core 12 is composed of radiolarian ooze in which most of the calcareous foraminiferal fauna has been dissolved. Quartz and mica flakes are abundant in the fine fraction.

Sample 12-119-13-1, 147-150 cm:
Buff-colored calcareous ooze with abundant radiolarian and sponge spicules.
PF: *Globigerinita unicava, G. dissimilis*
BF: *Gyroidina* sp., *Cassidulina* sp., *Siphonodosaria* sp., *Karreriella* sp., *Pleurostomella* sp., *Stilostomella* sp., *Cibicidoides* sp.
Age: Late Oligocene (calcareous Nannoplankton).

Sample 12-119-13-2, 146-149 cm:
Lithology and fauna as above.

Sample 12-119-13-4, 147-150 cm:
Lithology as above.

Sample 12-119-13, Core Catcher:
Tan calcareous ooze with abundant radiolarian and sponge spicules. Abundant quartz and mica in the fine fraction.
PF: Rare, including *Globigerinita dissimilis* and *G. unicava.*
BF: *Gyroidina complanata, G. girardana, Cassidulina subglobosa (common), Oridorsalis ecuadorensis, Cibicidoides* sp.
Age: Late Oligocene (calcareous nannoplankton).

Sample 12-119-14-1, 144-147 cm:
Calcareous ooze; residue of abundant quartz in the fine fraction; foraminifera rare. (*Gyroidina* sp., *Pleurostomella* sp., *Cassidulina* sp., *Oridorsalis ecuadorensis, Cibicidoides* spp.).
Also present: Abundant sponge spicules.
Age: Late Oligocene (calcareous nannoplankton).

Sample 12-119-14-3, 148-151 cm:
Calcareous ooze with abundant quartz in fine fraction. Foraminifera rare (*Gyroidina* sp., *Pleurostomella* sp., *Cassidulina* sp.), scattered small planktonic foraminifera.

Sample 12-119-14-5, 148-150 cm:
Lithology and fauna essentially the same above, including *Globigerinita unicava* and *G. dissimilis.* Calcareous foraminifera strongly recrystallized. Abundant quartz in fine fraction.

Sample 12-119-14, Core Catcher:
Calcareous ooze, strongly recrystallized with a rich planktonic foraminiferal fauna. Most of the planktonic foraminifera exhibits varying degrees of dissolution, ranging from partial to extreme.
PF: *Globigerinita dissimilis, G. unicava* (abundant), *Chiloguembelina* (rare), *Globigerina tripartita, Globorotalia opima,* small nonkeeled globorotaliids.
BF: *Siphonodosaria* spp., *Gyroidina* sp., *Planulina* sp., *Melonis* sp., *Karreriella* sp., *Vulvulina* sp., *Oridorsalis ecuadorensis, Lenticulina* sp., *Anomalinoides semicribrata, Cassidulina subglobosa.*
Age: Late Oligocene (Zone P21).
Remarks: The occurrence together of *Globorotalia opima* and *Chiloguembelina* in the Core Catcher sample suggests that this part of Core 14 (at least) is within the lower part of Zone P21. This agrees well with the assignment of the lower part of Core 14 to the *Sphenolithus distentus* Zone by K.P–N.

Sample 12-119-15-1, 145-148 cm:
Tan calcareous marl with abundant quartz in fine fraction. Radiolarians and sponge spicules also present in the fine fraction. Scattered small benthonic foraminifera, (gyroidinids, stilostomellids, ellipsonodosariids, *Pullenia, Cibicidoides,* cassidulinids) and various planktonic foraminifera (globigerinitids, too small for identification).

Sample 12-119-15-3, 147-150 cm:
Tan calcareous marl with abundant quartz in fine fraction. Radiolarians and sponge spicules also present in fine fraction. Scattered small benthonic foraminifera (gyroidinids, stilostomellids, siphonodosariids, cassidulinids) and planktonic (globigerinitids) fauna.

Sample 12-119-15-4, 150-152 cm:
Lithology and fauna essentially the same as preceding samples above.
Age: Late Oligocene (calcareous nannofossils).

Sample 12-119-15-5, 149-151 cm:
Lithology and fauna essentially the same as preceding samples above including *Cibicidoides grimsdalei.*

Sample 12-119-15-6, 140-143 cm:
Lithology and fauna essentially the same as above, including various agglutinated genera such as *Karreriella* sp. and *Vulvulina* sp.

Sample 12-119-15, Core Catcher:
Tan calcareous marl with abundant quartz in pan fraction.
PF: *Globigerinita dissimilis, G. unicava, Globorotalia opima nana, Globigerina tripartita, G. selli, Globorotaloides suteri.*
BF: *Gyroidina* sp., *Siphonodosaria* sp., *Oridorsalis ecuadorensis, Textilaria* sp., *Vulvulina* sp., *Anomalinoides semicribrata, Pleurostomella* sp., *Cassidulina* sp.
Age: Late Oligocene (calcareous nannofossils).
Remarks: Planktonic and benthonic foraminifera are relatively abundant in Core 15. Globigerinitids are the dominant planktonic foraminiferal element. Specimens exhibit evidence of recrystallization. Quartz and mica are abundant in the fine fraction.

Sample 12-119-16-1, 144-146 cm:
PF: *Globigerinita dissimilis, G. unicava, Globorotalia opima nana, Globorotalia opima.*
BF: *Cibicidoides* spp., *Cassidulina* sp.
Age: Late Oligocene (Zone P21).

Sample 12-119-16-2, 119-121 cm:
Lithology and fauna essentially the same except a large number of agglutinated forms assignable to *Bathysiphon* and *Hyperammina.* Gyroidinids, pleurostomellids and siphonodosariids common. Quartz and mica very abundant in fine fraction.
Age: Late Oligocene (Zone P21).

Sample 12-119-16-3, 146-149 cm:
Lithology and fauna essentially as preceding sample above.
BF: *Cibicidoides havanensis, Ellipsoglandulina multicostata, Gyroidina girardana, Pleurostomella* sp., *Nodosarella* sp., and agglutinated forms as indicated above.
Age: Late Oligocene (Zone P21).

Sample 12-119-16-4, 131-134 cm:
Lithology and fauna as above.
Age: Late Oligocene (Zone P21).

Sample 12-119-16, Core Catcher:
PF: *Globigerinita dissimilis, G. unicava, Globorotaloides suteri, Globorotalia opima nana.*
BF: Relatively rich and diverse, including among others, *Cibicidoides grimsdalei, Vulvulina jarvisi, Dorothia brevis, Ellipsoglandulina* sp., *Anomalina alazanensis, Gyroidina girardana, Anomalinoides semicribrata.*
Age: Late Oligocene (Zone P21).
Remarks: Core 16 contains a relatively rich and diverse benthonic foraminiferal fauna. Quartz (in an aggregate form) and mica are abundant in the fine fraction.

Sample 12-119-17-2, 149-152 cm:
PF: *Globigerinita dissimilis, G. unicava, Globorotalia opima nana, Globorotaloides suteri.*
BF: Relatively rich and diverse as in Core 16 above.
Age: Early-Late Oligocene.

Sample 12-119-17-3, 150-151 cm:
Lithology and fauna essentially the same as above. *Globorotalia opima nana* particularly abundant in this sample.
BF: Rich and diverse, including among others, *Oridorsalis ecuadorensis, Cibicidoides grimsdalei, Gyroidina girardana, Vulvulina jarvisi, Stilostomella* spp., *Pleurostomella* spp., *Nodosarella* spp.
Age: Early-Late Oligocene.

Sample 12-119-17-4, 145-148 cm:
Lithology and fauna essentially the same as above, including *Nodosarella mappa.*
Age: Early-Late Oligocene.

Sample 12-119-17-5, 146-149 cm:
Lithology and fauna as above.
Age: Early-Late Oligocene.

Sample 12-119-17, Core Catcher:
PF: *Globigerinita dissimilis, G. unicava, Globorotalia opima nana, Globorotaloides suteri.*
BF: Rich and diverse, including among others, *Stilostomella verneuili, Stilostomella subspinosa, Nodosarella subnodosa, Siphogenerina* sp., *Cibicidoides grimsdalei, Oridorsalis ecuadorensis, Karreriella* sp., *Vulvulina jarvisi.*
Age: Early-Late Oligocene (?*H. reticulata* Zone, according to calcareous nannoplankton).
Remarks: Core 17 contains a rich and diverse benthonic foraminiferal fauna, and a relatively low diversity planktonic foraminiferal fauna in which *Globorotalia opima nana* is the dominant form. Quartz and mica are abundant in the fine fraction, often in aggregate form.

Sample 12-119-18-1, 145-148 cm:
PF: *Globigerinita dissimilis, G. unicava, Globorotalia opima nana.*
BF: Relatively diverse but present primarily in fine fraction. Specimens too small for identification.
Age: Early Oligocene (calcareous nannoplankton).

Sample 12-119-18-2, 144-147 cm:
Fauna and lithology essentially as in sample above. Benthonic fauna includes, *Cibicidoides grimsdalei, Oridorsalis ecuadorensis, Karreriella* sp., various stilostomellids.
Age: Early Oligocene.

Sample 12-119-18-3, 146-149 cm:
Lithology and fauna essentially as above.
Age: Early Oligocene.

Sample 12-119-18-4, 144-148 cm:
Lithology and fauna essentially as above. Many specimens show effects of solution.
Age: Early Oligocene.

Sample 12-119-18-5, 145-148 cm:
Lithology and fauna as above.
Age: Early Oligocene.

Sample 12-119-18-6, 146-148 cm:
Lithology and fauna as above.
Age: Early Oligocene.

Sample 12-119-18, Core Catcher:
PF: Planktonic foraminifera extremely rare. Present primarily in the pan fraction; globigerinitids.
BF: Rich and diverse, well-preserved benthonic foraminiferal fauna, including among others, *Cibicidoides grimsdalei, Oridorsalis ecuadorensis, Stilostomella abyssorum, Vulvulina jarvisi, Ellipsodimorphina subcompacta, Gyroidina octocamerata, Gyroidina perampla, Anomalina alazanensis, Cibicidoides martinizensis, Ellipsoglandulina* sp., *Ellipsoglandulina multicostata, Stilostomella subspinosa, Stilostomella verneuili.*
Age: Early Oligocene.

Sample 12-119-19-1, 6-8 cm:
Essentially unfossiliferous. A few fish fragments and teeth and a residue of black elongate (? manganese) fragments.

Sample 12-119-19-1 143-146 cm:
Small residue, consisting of agglutinated foraminifera, *Cibicidoides havanensis, Gyroidina* sp., *Bulimina* sp. cf. *B. grata, Globigerina* sp. cf. *G. linaperta.*
Age: Eocene.

Sample 12-119-19-2, 146-149 cm:
Residue confined mostly to small fraction. A few larger agglutinated forms in coarser fraction. Fauna consists of various benthonic foraminifera including *Nuttallides truempyi, Bulimina grata,* various cibicidids and chiloguembelinids.

Sample 12-119-19, Core Catcher:
Residue of fine particulate carbonate matter. Radiolaria, sponge spicules and diverse benthonic foraminiferal fauna.
PF: Rare, including *Globigerinita* sp., *Globorotalia centralis.*
BF: *Nuttallides truempyi, Nodosarella subnodosa, Anomalinoides* sp.
Age: Middle Eocene.
Remarks: Core 19 contains a relatively diverse benthonic foraminiferal fauna but most elements are confined to the finer fractions and/or broken rendering specific determination difficult. The presence of *Nuttallides truempyi* and *Bulimina grata* indicate an Eocene age for Core 19, and the presence in the Core Catcher of *Globorotalia centralis* confirms this determination.

Sample 12-119-20-1, 147-150 cm:
Foraminiferal fauna confined essentially to the fine fraction and containing, among other forms, *Nuttallides truempyi, Cibicidoides trinitatensis* (=*C. tuxpamensis*).
Age: Middle Eocene.

Sample 12-119-20-2, 146-149 cm:
Lithology and fauna essentially the same as sample above.

Sample 12-119-20-3, 93-96 cm:
Relatively rich benthonic foraminiferal fauna, including among others, *Alabamina dissonata, Nuttallides truempyi, Bulimina grata, Ellipsodimorphina subcompacta, Dorothia* sp. *Acarinina coalingensis,* (=*A. triplex* = *A. primitiva*) also observed.
Age: Middle Eocene.

Sample 12-119-20-3, 93-96 cm:
Lithology and fauna essentially the same as sample above.

Sample 12-119-20, Core Catcher:
BF: *Cibicidoides trinitatensis, Alabamina dissonata, Nuttallides truempyi, Dorothia* sp., *Gaudryina* sp., *Oridorsalis ecuadorensis, Bulimina grata, Karreriella* sp., *Ellipsodimorphina subcompacta.*
Remarks: Core 20 is characterized by relatively diverse benthonic foraminiferal fauna, in which the dominant and characteristic elements are *Nuttallides truempyi, Alabamina dissonata,* and *Bulimina grata.* Planktonic foraminifera are essentially absent from the samples in this core, probably owing to the effects of solution.

Sample 12-119-21-1, 146-149 cm:
PF: Rare (Probably owing to the effects of calcium carbonate solution); *Globigerina senni.*
BF: *Nuttallides truempyi, Alabamina dissonata, Oridorsalis ecuadorensis, Bulimina grata.*
Age: Middle Eocene.

Sample 12-119-21-2, 147-150 cm:
Relatively diverse benthonic foraminiferal fauna consisting of, among others: *Nuttallides truempyi, Alabamina dissonata, Bulimina grata, Cassidulina* sp., *Pullenia* sp., *Gaudryina* sp., *Dorothia* sp., *Gyroidina* sp.
Age: Middle Eocene.

Sample 12-119-21-3, 146-149 cm:
Lithology and age essentially the same as sample above.

Sample 12-119-21-4, 145-148 cm:
Lithology and fauna essentially the same as above. Fish bones and teeth abundant.
Age: Middle Eocene.

Sample 12-119-21, Core Catcher:
PF: Not observed.
BF: Relatively diverse and well-preserved benthonic fauna, consisting of *Eponides truempyi, Alabamina dissonata, Vulvulina* sp., *Stilostomella gracillima, Stilostomella abyssorum, Gaudryina* sp., *Nodosarella* sp., *Nodosarella mappa, Vulvulina jarvisi, Dorothia* sp., *Plectina cubensis, Bathysiphon* sp., *Cibicidoides trinitatensis Karreriella* sp., *Eggerella* sp.
Age: Middle Eocene.
Remarks: As in Cores 19 and 20, this core is characterized by rich and well-preserved benthonic foraminiferal fauna dominated by *Eponides truempyi* and *Alabamina dissonata*. Planktonic foraminifera are absent, probably owing to the effects of solution.

Sample 12-119-22-2, 144-147 cm:
PF: Not observed.
BF: *Nuttallides truempyi, Aragonia* sp., *Alabamina dissonata.*
Age: Middle Eocene.

Sample 12-119-22, Core Catcher:
PF: *Globigerina senni, Acarinina coalingensis.*
BF: *Nuttallides truempyi, Cibicidoides havanensis, Bathysiphon irregularis, Nodosarella* sp., *Cibicidoides trinitatensis, Dorothia* sp., *Gaudryina* sp., *Bulimina grata.*
Also present: Abundant shark teeth.
Age: Middle Eocene.
Remarks: The lithology and fauna of Core 22 is essentially the same as the cores immediately above. Data from the calcareous nannoplankton suggest that Cores 19 through 22 are, in fact, of approximately the same age, that is, assignable to the same calcareous nannoplankton zone.

Sample 12-119-23, Core Catcher:
Residue consisting primarily of fine quartz and mica and fragments of a black mineral with red-brown oxidized coating and abundant shark teeth. No planktonic foraminifera observed. Benthonic fauna contains *Eponides truempyi, Verneuilina* sp. and various small, mostly broken fragments.
Age: Early Eocene (calcareous nannoplankton).
Remarks: Only the Core Catcher sample was studied from Core 23. Planktonic foraminifera are absent from this sample and the benthonic foraminifera are confined primarily to the very fine fraction.

Sample 12-119-24-1, 23-26 cm:
Residue of fine quartz, mica and abundant shark teeth. Benthonic foraminifera rare, indeterminable.

Sample 12-119-24-2, 142-145 cm:
Lithology and fauna same as preceding sample above.

Sample 12-119-24, Core Catcher:
Quartz residue with rare benthonic foraminiferal fauna consisting of agglutinated forms assignable to *Gaudryina* sp. and *Dorothia* sp. Shark teeth also present.
Age: Basal part of Early Eocene (according to calcareous nannoplankton).
Remarks: Core 24 contains a very small and relatively poorly preserved benthonic foraminiferal fauna. This core would appear to contain the upper limit of the thick turbidite section developed in Cores 25 to 40 below.

Sample 12-119-25-1, 84-86 cm:
Sample essentially barren of foraminifera.

Sample 12-119-25-1, 142-145 cm:
Residue of abundant, but extremely small, planktonic foraminifera, primarily species of *Globigerina, Globorotalia (G. subbotinae)* and acarininids.
Age: Late Paleocene (calcareous nannoplankton).

Sample 12-119-25-2, 94.5-97.0 cm:
Planktonic foraminifera rare and poorly preserved. Residue of quartz sand (in aggregate form) and mica and sparse planktonic foraminiferal fauna.
PF: *Globigerina triangularis, G. velascoensis, Globorotalia aequa, Globorotalia pasionensis, Acarinina coalingensis.*
Age: Late Paleocene.

Sample 12-119-26-1, 141-144 cm:
Residue of fine sand and abundant Radiolaria. Planktonic foraminifera very rare, primarily small globigerinids and acarininids.

Sample 12-119-26-2, 146-149 cm:
Residue of fine sand and abundant Radiolaria. Planktonic foraminifera rare, primarily small globorotaliids and acarininids and globigerinids.

Sample 12-119-26, Core Catcher:
Quartz sand residue with no determinable foraminiferal elements. Foraminifera essentially restricted to pan fraction. Chert, chalk and manganese fragments observed.
Remarks: Core 26 consists primarily of sand- and silt-sized fragments in aggregate form with a poor foraminiferal fauna. The sediments are of turbidite origin.

Sample 12-119-27-1, 144-147 cm:
Data as above.

Sample 12-119-27, Core Catcher:
Quartz residue with rare planktonic foraminifera, primarily confined to the pan fraction.
PF: *Globigerina velascoensis, Acarinina esnaensis.*
BF: Virtually absent.

Sample 12-119-28-2, 120-123 cm:
Quartz residue with rare planktonic foraminifera, with the exception of chiloguembelinids, which are relatively common but poorly preserved.

Sample 12-119-28, Core Catcher:
Essentially barren. Large silt-sand fraction and abundant recrystallized radiolarians. No age determination possible in Core 28.

Sample 12-119-29-1, 148-150 cm:
Foraminifera rare, recrystallized Radiolaria abundant.

Sample 12-119-29-2, 67-70 cm:
Essentially barren.

Sample 12-119-29-3, 100-107 cm:
Foraminifera extremely rare. Residue consists of essentially silicified Radiolaria (abundant).

Sample 12-119-29-4, 54-58 cm:
Residue of silicified Radiolaria (abundant) and planktonic foraminifera (keeled globorotaliids and acarininids). Poor preservation makes specific identification impossible.

Sample 12-119-29, Core Catcher:
Quartz sand in aggregate form of turbidite origin. Abundant extremely small recrystallized planktonic and benthonic foraminifera in the pan fraction. Planktonic forms include keeled globorotaliids of the *acuta-velascoensis* group. Benthonic forms include *Bolivina, Melonis*, and *Discorbis* types, as well as nodosariids. Chiloguembelinids relatively common also.
Age: Late Paleocene.

Sample 12-119-30-3, 0-7 cm:
Quartz sand residue with abundant and poorly preserved Radiolaria; planktonic foraminifera present, but in general poorly preserved.
PF: *Acarinina soldadoensis, Globigerina triangularis, Globorotalia* ex gr. *acuta-velascoensis.*
Age: Late Paleocene.

Sample 12-119-30-5, 45-48 cm:
Quartz sand residue with abundant mica and extremely small specimens of chiloguembelinids, globigerinids, and acarininids.

Sample 12-119-30-6, 63-66 cm:
Quartz sand residue with abundant but poorly preserved chiloguembelinids and small globigerinids.

Sample 12-119-30, Core Catcher:
Fine silty recrystallized fragments and Radiolaria. Foraminifera extremely rare. A single specimen of a keeled globorotaliid (*velascoensis* type) observed.

Sample 12-119-31-1, 104-108 cm:
Residue of quartz sand, mica and small poorly preserved chiloguembelinids, acarininids, globigerinids and bolivinids.

Sample 12-119-31-4, 146-150 cm:
Residue of aggregate quartz silt and mica. Foraminifera rare and poorly preserved, primarily acarininids and chiloguembelinids.

Sample 12-119-31-5, 92-95 cm:
Lithology and fauna essentially as in preceding sample above.

Sample 12-119-32-1, 30-33 cm:
Residue of quartz silt with abundant mica and relatively common carbonaceous fragments; foraminifera rare and poorly preserved (recrystallized).

Sample 12-119-32, Core Catcher:
Foraminifera rare, including *Globigerina triloculinoides, G. triangularis.*
BF: *Eponides?, Pullenia, Osangularia.*
Age: Paleocene.
Remarks: The presence of *Globigerina triloculinoides* in the Core Catcher of sample suggests that this core is no younger than mid-Paleocene (Zone P4). This is supported by the assignment of Core 32 to the *Heliolithus kleinpelli* Zone.

Sample 12-119-33, Core Catcher:
Hard quartz silt and mica. Barren of foraminifera.

Sample 12-119-34, Core Catcher:
Residue of quartz grains, mica, manganese nodules, echinoid fragments. Essentially barren of foraminifera.

Sample 12-119-35-1, 73-75 cm:
Small residue of quartz silt and silicified Radiolaria.

Sample 12-119-35, Core Catcher:
Hard, very fine-grained siltsone. Barren of foraminifera.

Sample 12-119-36-2, 113-116 cm:
Residue of quartz silt; planktonic foraminifera rare (keeled globorotaliids and chiloguembelinids).
Age: Late Paleocene.

Sample 12-119-36-4, 56-62 cm:
Gray siltstone with few specimens of Radiolaria present.Essentially barren of foraminifera.

Sample 12-119-36-5, 33-36 cm:
Gray siltstone with small fauna of poorly preserved globigerinids.

Sample 12-119-36, Core Catcher:
Gray siltstone, essentially barren of foraminifera.

Sample 12-119-37-4, 64-69 cm:
Residue of very small planktonic foraminifera (globigerinids and globorotaliids) and mica, with moderate amounts of carbonaceous material.
Age: Late Paleocene.

Sample 12-119-37-4, 142-145 cm:
Silty, sandy quartz fragments; white chalky marl fragments; essentially barren of foraminifera.

Sample 12-119-37, Core Catcher:
Silty, sandy, quartz fragments, white chalky marl fragments, essentially barren of foraminifera.

Sample 12-119-38-2, 120-121 cm:
Recrystallized carbonate and quartz residue with few planktonic foraminifera in fine fraction (compressed globigerinids and non-keeled globorotaliids and chiloguembelinids).
Age: Late Paleocene.

Sample 12-119-38, Top Section 4:
Quartz residue with a few planktonic foraminifera: *Globigerina triloculinoides,* chiloguembelinids, small compressed globorotaliids similar to *G. imitata.*
Age: Late Paleocene.

Sample 12-119-38-4, 60-65 cm:
Recrystallized carbonate and quartz residue; essentially barren of foraminifera.

Sample 12-119-38, Core Catcher:
Chalky sediment with moderate planktonic foraminiferal fauna.
PF: *Globorotalia pseudobulloides, G. varianta, G. angulata, G. conicotruncata, G. ehrenbergi, Globigerina triloculinoides.*
BF: Rare and extremely small, indeterminable.
Age: Late Paleocene (Zone P3, *G. pusilla-angulata*), probably upper part.
Remarks: The presence of *Globorotalia angulata* and *conicotruncata* in Core 38 provides one of the few reference points in the sequence of Paleocene cores from 24 to 40. The occurrence of these two forms together indicate that Core 38 is of early Late Paleocene age and this is confirmed by the assignment of the upper part of Core 38 to the *Fasciculithus tympaniformis* Zone and the lower part to the *Ellipsolithus macellus* Zone (calcareous nannoplankton zonation).

Sample 12-119-39-1, 16-20 cm:
Chalky, marly sediment with small and poorly preserved planktonic foraminiferal fauna.
PF: *Globigerina triloculinoides, Globorotalia pseudobulloides, G. varianta, G.* ex gr. *compressa-ehrenbergi.*

Sample 12-119-39-2, 83-89 cm:
Chalky, marly sediment. Barren of foraminifera.

Sample 12-119-39-3, 111-116 cm:
Chalky, marly sediment with small foraminiferal fauna.
PF: Minute globigerinids and non-keeled globorotaliids, specifically indeterminate.
BF: *Ammodiscus* sp.

Sample 12-119-39-4, 50-55 cm:
Lithology and fauna essentially the same as preceding sample above.

Sample 12-119-39, Core Catcher:
Chalky, marly sediment with small planktonic foraminiferal fauna in pan fraction.
PF: *Chiloguembelinids, Globigerina triloculinoides, Globorotalia pseudobulloides,* small keeled globorotaliids (*? angulata*) and smooth 3 and 4-chambered forms.
Age: Basal part Late Paleocene (post Danian).

Sample 12-119-40-1, 0-4 cm:
Chalky, recrystallized residue; essentially barren of foraminifera.

Sample 12-119-40-3, 0-4 cm:
Chalky, recrystallized residue with rich planktonic foraminiferal fauna.
PF: *Globigerina triloculinoides, G. spiralis, Globorotalia pseudobulloides, G. compressa, G. angulata.*
Age: Earliest Late Paleocene.
Remarks: The association of *Globigerina spiralis* and *Globorotalia angulata* in Core 40 indicates that the oldest sediments cored at this site are of earliest Late Paleocene age and referable to the top of Zone P2 or the base of Zone P3.

APPENDIX E. COCCOLITH SPECIES AND STRATIGRAPHIC ASSIGNMENT OF SITE 119

David Bukry

Hole 119

Upper Pleistocene

12-119-1-2, 143-144 cm; depth 12 m:
Coccolithus pelagicus, Cyclococcolithina leptopora, Gephyrocapsa spp., *Helicopontosphaera kamptneri.* Reworked Upper Cretaceous taxa: *Chiastozygus disgregatus* (Stover), *Cretarhabdus crenulatus, Prediscosphaera cretacea cretacea.*

Middle Miocene
(*Discoaster exilis* Zone)

12-119-5-1, 132-133 cm; depth 199 m:
Coccolithus eopelagicus, Cyclococcolithina leptopora, Discoaster exilis, Discoaster subsurculus Gartner, *Helicopontosphaera granulata, H. kamptneri, Reticulofenestra pseudoumbilica, Sphenolithus neoabies, Triquetrorhabdulus rugosus.*

Middle Oligocene
(*Sphenolithus distentus* Zone)

12-119-14-5, 148-150 cm; depth 318 m:
Chiasmolithus altus, Coccolithus eopelagicus, C. fenestratus, Cyclococcolithina neogammation, Dictyococcites abisectus, D. bisectus, D. scrippsae, Discoaster deflandrei, Reticulofenestra gartneri, Sphenolithus distentus (Martini), *S. moriformis, S. predistentus.* Reworked Cretaceous taxon: *Cretarhabdus crenulatus.*

Lower Oligocene
(*Helicopontosphaera reticulata* Zone)

12-119-18-3, 142-143 cm; depth 353 m:
Chiasmolithus altus, C. oamaruensis, Coccolithus eopelagicus, C. fenestratus, Cyclococcolithina neogammation, Dictyococcites bisectus, D. scrippsae, Discoaster deflandrei, D. tani nodifer, D. tani tani Bramlette and Riedel, *Helicopontosphaera compacta, Isthmolithus recurvus, Reticulofenestra hillae, R. umbilica, ?Rhabdosphaera tenuis* [stems].

Middle Eocene
(*Chiphragmalithus quadratus* Zone)

12-119-19-1, 140-141 cm; depth 357 m:
Campylosphaera dela, Chiasmolithus gigas, C. grandis, Chiphragmalithus mexicanus (Stradner), *C.* sp. cf. *C. spinosus* (Stradner), *Cyclococcolithina formosa, Discoaster barbadiensis, D. martinii* Stradner, *D. saipanensis, D. tani nodifer, D. wemmelensis, Reticulofenestra samodurovi.*

Middle Eocene
(*Discoaster sublodoensis* Zone)

12-119-21-1, 143-144 cm; depth 375 m:
Chiasmolithus grandis, Chiphragmalithus cristatus, Coccolithus pseudogammation, C. staurion, Discoaster barbadiensis, D. mirus Stradner, *D. sublodoensis, D. wemmelensis, Rhabdosphaera inflata, Sphenolithus radians, Triquetrorhabdulus inversus.*

Lower Eocene
(*Discoaster lodoensis* Zone)

12-119-21-4, 149-150 cm: depth 380 m:
Coccolithus sp. [rim fragments resulting from solution], *Discoaster barbadiensis, D. lodoensis, D. nonaradiatus, D. septemradiatus* (klumpp), *Discoasteroides kuepperi.*

Lower Eocene
(*Tribrachiatus orthostylus* Zone)

12-119-23-1, 141-142 cm; depth 392 m:
Coccolithus sp. [rare rim fragment], *Discoaster barbadiensis, D. lodoensis, D. nonaradiatus* [rare], *Discoasteroides kuepperi, Tribrachiatus orthostylus* [abundant, late variety].

Series unknown

12-119-24-1, 21-22 cm; depth 401 m:
Barren.

12-119-24-2, 139-140 cm; depth 402 m:
Barren.

12-119-24-3, 94-95 cm; depth 402 m:
Barren.

Upper Paleocene
(*Discoaster multiradiatus* Zone)

12-119-26-1, 144-145 cm; depth 420 m:
Braarudosphaera bigelowi, Campylosphaera eodela, Chiasmolithus bidens, C. californicus (Sullivan), *C. consuetus, Discoaster delicatus* Bramlette and Sullivan, *D. falcatus* Bramlette and Sullivan, *D. helianthus* Bramlette and Sullivan, *D. limbatus* Bramlette and Sullivan, *D. multiradiatus, Discolithina plana, D. Solida* (Deflandre), *Ellipsolithus distichus, Fasciculithus involutus* Bramlette and Sullivan, *F. schaubi* Hay and Mohler, *Scapholithus apertus* Hay and Mohler, *Toweius eminens, Zygodiscus plectopons* Bramlette and Sullivan, *Z. sigmoides* Bramlette and Sullivan, *Zygolithus chiastus* Bramlette and Sullivan, *Z. distentus* Bramlette and Sullivan, *Z. junctus* Bramlette and Sullivan, *Zygrhablithus bijugatus, Z. simplex* Bramlette and Sullivan. The preservation and diversity of this assemblage matches that of the lower Lodo Formation in California (Bramlette and Sullivan, 1961). Reworked Upper Cretaceous taxa: *Arkhangelskiella cymbiformis, Prediscosphaera cretacea cretacea, Zygodiscus deflandrei* Bukry.

Upper Paleocene
(*Discoaster mohleri* Zone)

12-119-30-6, 63-64 cm; depth 500 m:
Braarudosphaera bigelowi, Chiasmolithus bidens, C. californicus, C. consuetus, Coccolithus pelagicus s. l., Discoaster mohleri Bukry and Percival, *Discoasteroides megastypus* Bramlette and Sullivan, *Ellipsolithus distichus, E. macellus, Fasciculithus tympaniformis, Heliolithus kleinpellii, H. riedelii* Bramlette and Sullivan, *Scapholithus apertus, Toweius eminens, Zygodiscus plectopons, Zygolithus chiastus.* Reworked Upper Cretaceous taxa: *Broinsonia parca, Watznaueria barnesae.*

Upper Paleocene
(*Heliolithus kleinpellii* Zone)

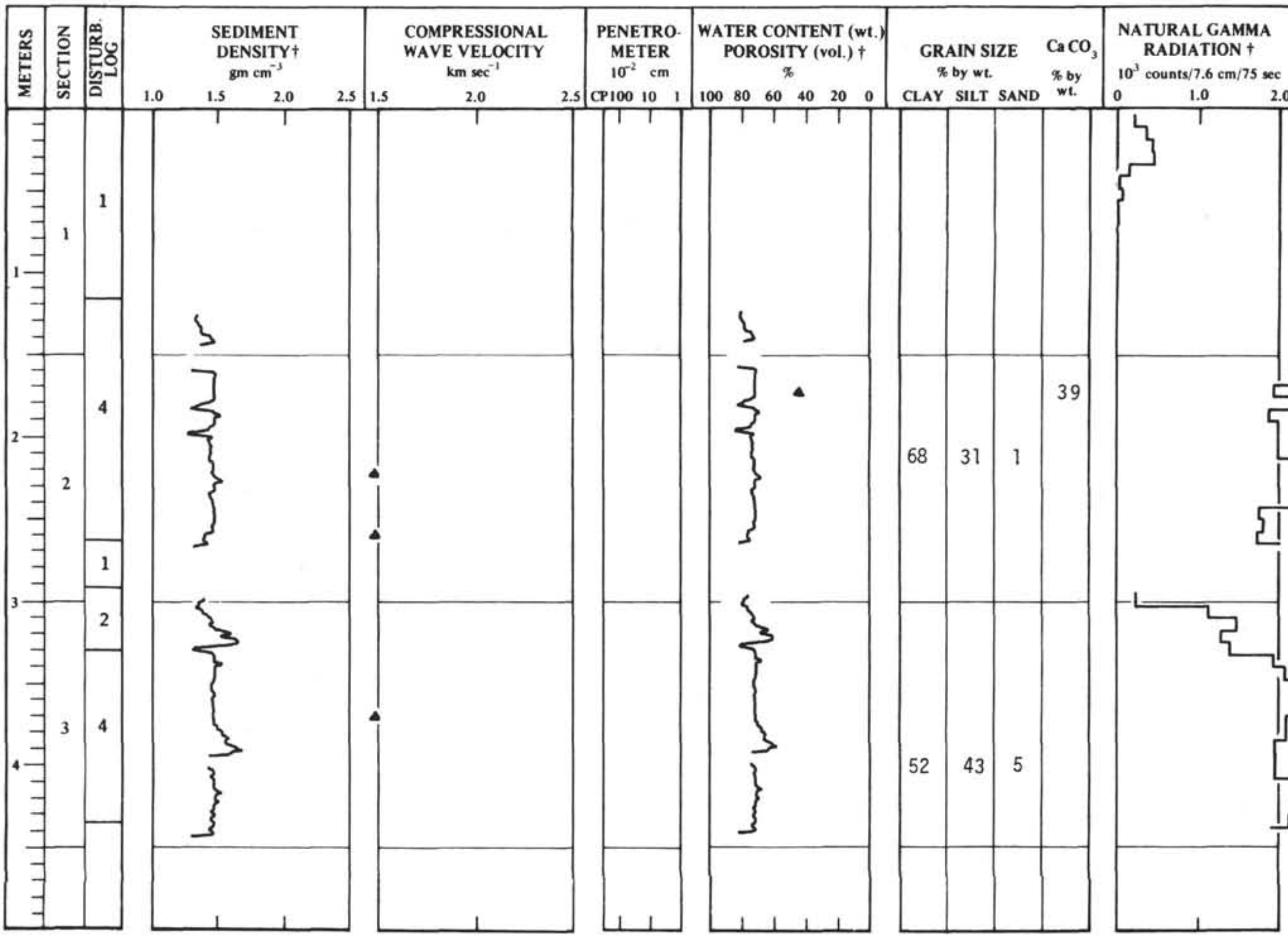
12-119-31-1, 104-108 cm; depth 544 m:
Chiasmolithus sp. cf. *C. bidens, C. consuetus, Cruciplacolithus tenuis* (Stradner), *Cyclolithella* sp. cf. *C. robusta* (Bramlette and Sullivan), *Ellipsolithus macellus, Fasciculithus involutus, F. tympaniformis, Heliolithus kleinpellii, H. riedelii* [rare], *Toweius eminens, Zygodiscus* sp. aff. *Z. plectopons* Bramlette and Sullivan, *Z. sigmoides, Zygolithus chiastus.* Reworked Upper Cretaceous taxa: *Broinsonia parca, Micula decussata, Watznaueria barnesae.*

Lower Paleocene
(*Cruciplacolithus tenuis* Zone)

12-119-40-4, 51-56 cm; depth 704 m:
Braarudosphaera bigelowi, Coccolithus pelagicus s.l., Cruciplacolithus tenuis, Ericsonia? subpertusa Hay and Mohler, *Zygodiscus sigmoides.* Reworked Upper Cretaceous taxa: *Prediscosphaera cretacea cretacea, Watznaueria barnesae.*

HOLE 119

CORE 1



†Adjusted data, see Chapter 2

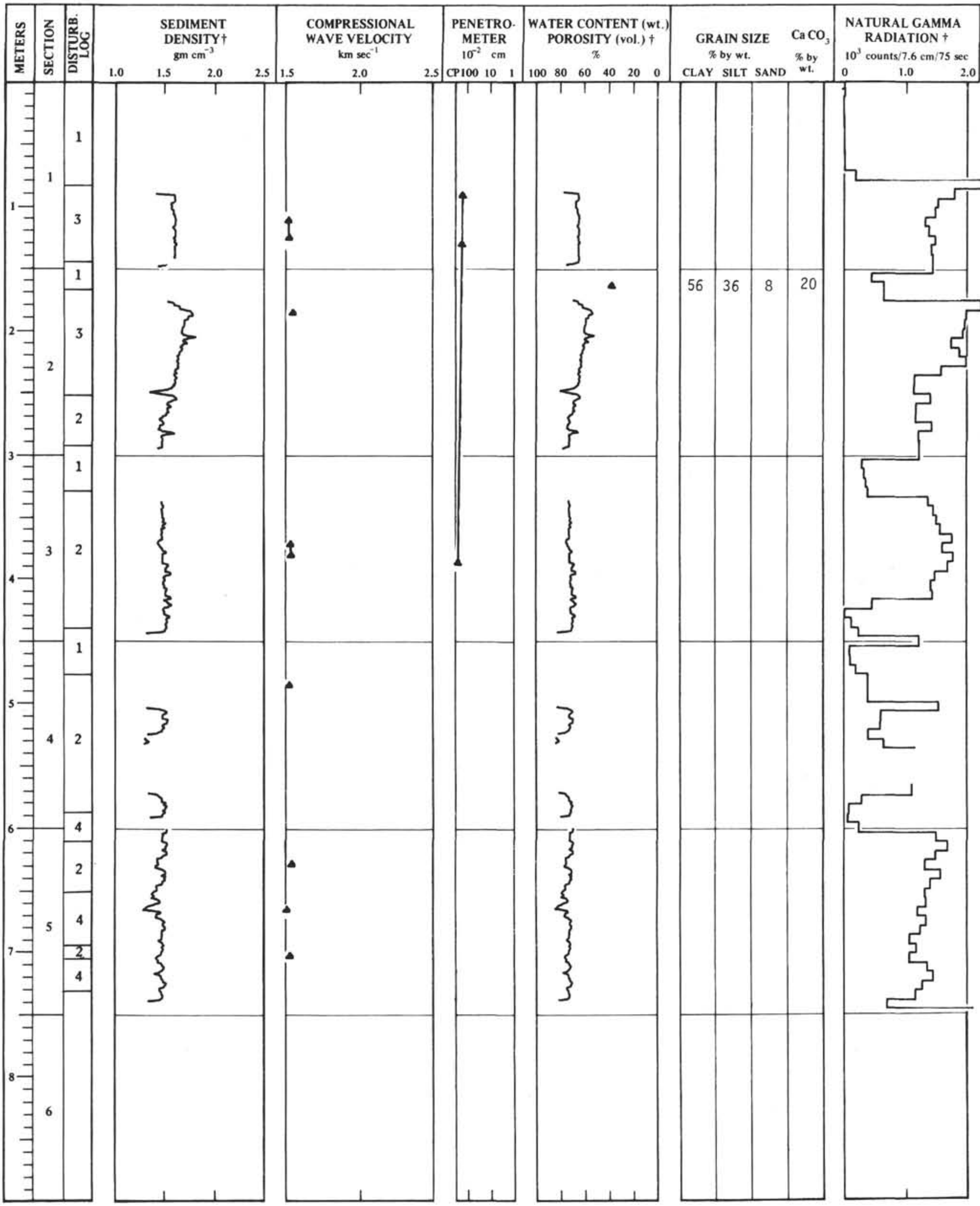
HOLE 119 10 **TO** 19 **m**

CORE 1

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	EMPTY / EMPTY	N F	10YR 7/4 — Foram-nannofossil mud	Flora: *Coccolithus pelagicus, Cyclococcolithus leptoporus, Helicopontosphaera kamptneri, Syracosphaera* sp., *Gephyrocapsa aperta, G.* cf. *oceanica* plus reworked Cretaceous coccoliths: *Prediscosphaera cretacea, Microrhabdulus decoratus, Watznaueria barnesae* Forams: *G. hirsuta, G. inflata, G. crassaformis, G. pachyderma, G. bulloides*	N22	
1.5–3	2		N XM N	10YR 7/4; 10YR 7/4; 5Y 5/1 — Soft foram nannofossil mud, gray and grayish orange. Coarse fraction mineral grains and forams. 5Y 6/2 — Soft, disrupted silty clay.	Flora similar to above, plus *Helicopontosphaera sellii*; no reworked coccoliths Flora similar to above, plus reworked Tertiary coccoliths: *Coccolithus eopelagicus*		
3–4.5	3		N N F	5Y 5/2 — Soft silty ooze, coarse fraction practically all forams. 5Y 6/1 — X-ray Mineralogy (Bulk): Calc. 28.6; Dolo. 3.3; Qtz. 24.3; Plag. 4.5; Kaol. 3.7; Mica 31.5; Chl. 1.8; Mont. 2.4; Amorph. 61.7	Flora similar to Sect. 2-108. Flora similar to above, reworked Tertiary coccoliths Foram fauna as above	*Gephyrocapsa oceanica* ?	PLEISTOCENE
	CC		N		Core Catcher: Flora similar to above, plus reworked Cretaceous and Tertiary coccoliths		

HOLE 119

CORE 2



†Adjusted data, see Chapter 2

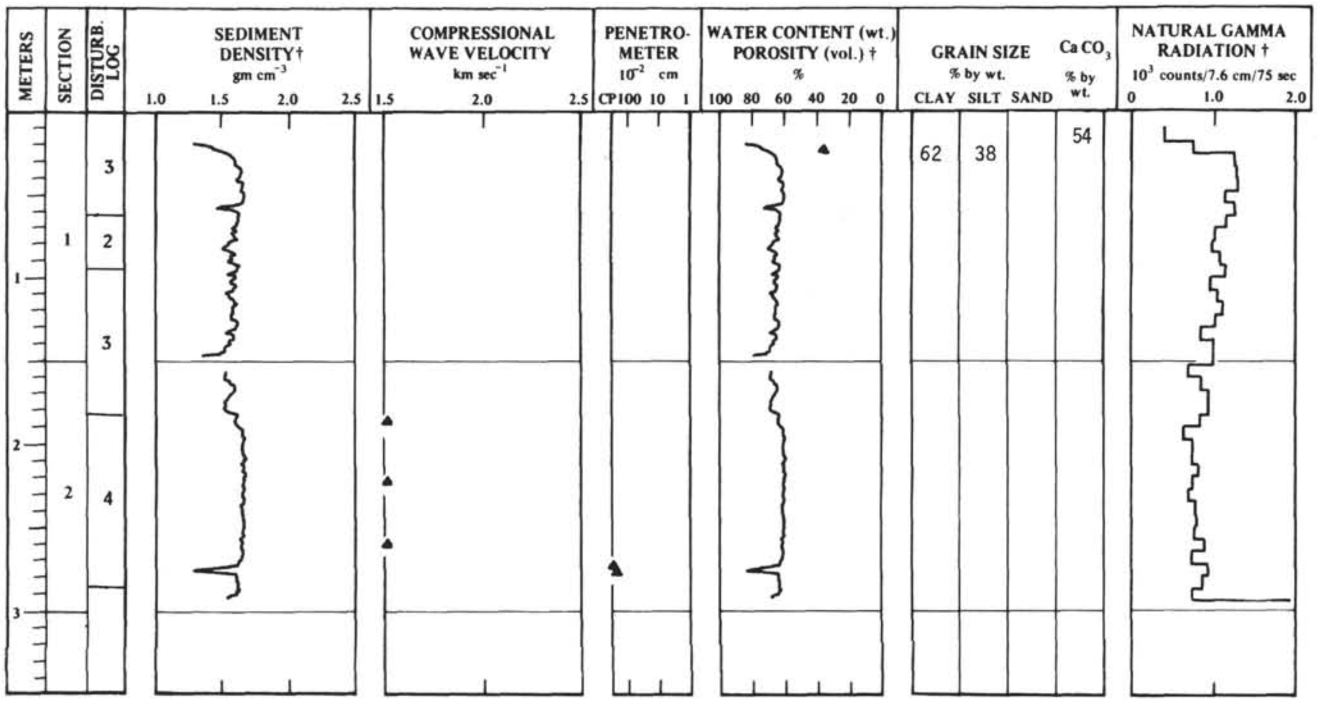
HOLE 119 50 TO 59 m

CORE 2

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	EMPTY	F		Forams: *G. pachyderma, G. bulloides, G. inflata, Hast. siphonifera*	N22	PLEISTOCENE
1–1.5	1		N, N	5Y 5/3 → 5Y 6/2 → 5Y 6/3 → 5Y 7/1 → Variable X-ray Mineralogy (Bulk) Calc. 27.6 Qtz 23.2 Plag. 2.7 Kaol. 3.9 Mica 39.5 Chl. 3.1 Amorph. 53.0 Soft, olive silty clay much disturbed by flow-in. Coarse fraction is a mixture of mineral grains, forams and rock fragments.	Only small coccoliths. Flora: *Cyclococcolithus leptoporus, "Coccolithus jaramillensis", Scapholithus fossilis, Syracosphaera* sp., *Pontosphaera discopora, Helicopontosphaera kamptneri, H. sellii, Pseudoemiliania lacunosa*		
1.5–3	2		N,XM F	Pyritized worm burrow at 48 cm in Sec. 2.	Flora similar to above Foram fauna as above; *G. pachyderma* (abund.) Flora similar to above		
3–4.5	3	EMPTY (lower part)	N XM	Completely disrupted soft mud. X-ray Mineralogy (Bulk) Calc. 76.5 Qtz. 7.4 Kaol. 1.1 Mica 15.1 Amorph. 46.2		*Coccolithus jaramillensis* (*P. lacunosa*)	
4.5–6	4	SECTION NOT OPENED					
6–7.5	5		N N	5Y 6/2 N8 Olive gray and light gray silty clay.	Flora poorer than above Flora similar to above, plus *Rhabdosphaera clavigera*		
	CC		F N R		Core Catcher: Foram fauna as above. Flora similar to above, plus few *Coccolithus pelagicus* No radiolarians		

HOLE 119

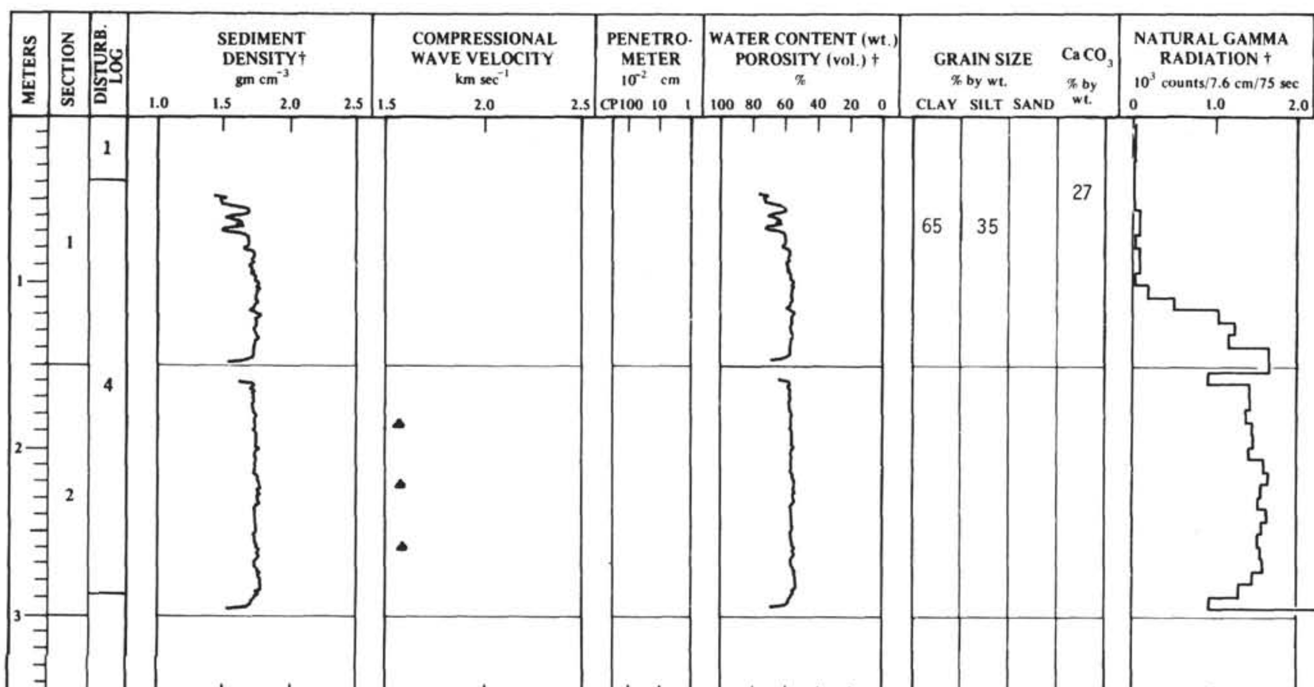
CORE 3



†Adjusted data, see Chapter 2

HOLE 119

CORE 4



†Adjusted data, see Chapter 2

HOLE 119 100 **TO** 109 **m**

CORE 3

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1 2	1 2 CC	EMPTY	XM N F N F R N F	5Y 6/2 N8 5Y 8/1	Disturbed gray and very light gray soft nannofossil ooze. Coarse fraction consists of broken and corroded forams and a few fish teeth. Yellowish gray, soft nannofossil ooze. <u>X-ray Mineralogy</u> (Bulk) Calc. 73.9 Qtz. 7.5 Kaol. 1.1 Mica 17.5	Flora: *Discoaster brouweri, Discoaster surculus, Helicopontosphaera kamptneri, H. sellii, Rhabdolithus* sp., *Pseudoemiliania lacunosa, Syracosphaera* sp. *Pontosphaera discopora, Thoracosphaera* sp., Flora: *Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei,* plus few reworked coccoliths Forams: *G. bulloides, G. crassula, G. crassaformis, G. scitula, G. puncticulata,* Flora similar to above Foram fauna as above; strong solution effects Core Catcher: No radiolarians Flora similar to above Foram fauna as above.	*Discoaster surculus*	PLIOCENE

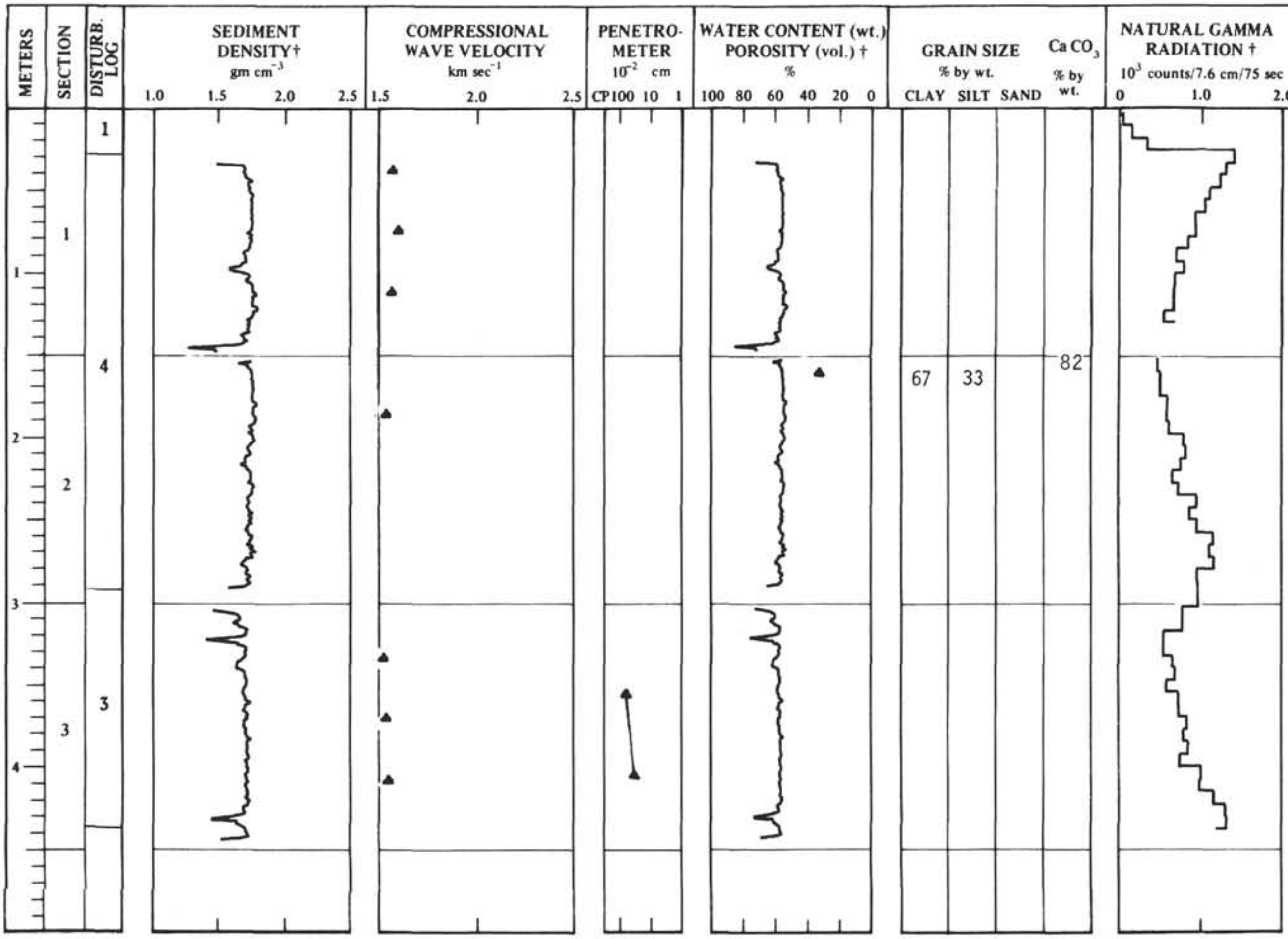
HOLE 119 150 **TO** 159 **m**

CORE 4

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1 2	1 2 CC	EMPTY	N XM N F N R	5Y 6/2	Light olive gray dense nannofossil clay, mottled with medium bluish gray (5B 5/1). Coarse fraction is broken and corroded forams and a few mineral grains. <u>X-ray Mineralogy</u> (Bulk) Calc. 54.3 Qtz. 15.1 Kaol. 4.5 Mica 26.1 Amorph. 60.1	Flora: *Discoaster variabilis, D. challengeri, D.* cf. *bollii, Coccolithus pelagicus, Cyclococcolithus leptoporus, C. macintyrei, Reticulofenestra pseudoumbilica, Helicopontosphaera kamptneri* Flora similar to above, plus *Triquetrorhabdulus rugosus* Forams: *Globigerina atlantica, G. nepenthes, G. praebulloides, G.* cf. *canimarensis* Core Catcher: Flora similar to above, plus few reworked coccoliths (Eocene and Cretaceous). No radiolarians.		LATE MIOCENE

HOLE 119

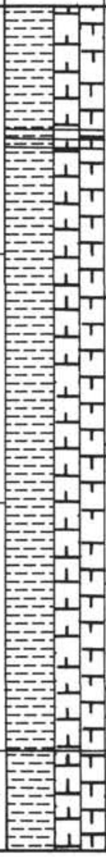
CORE 5



†Adjusted data, see Chapter 2

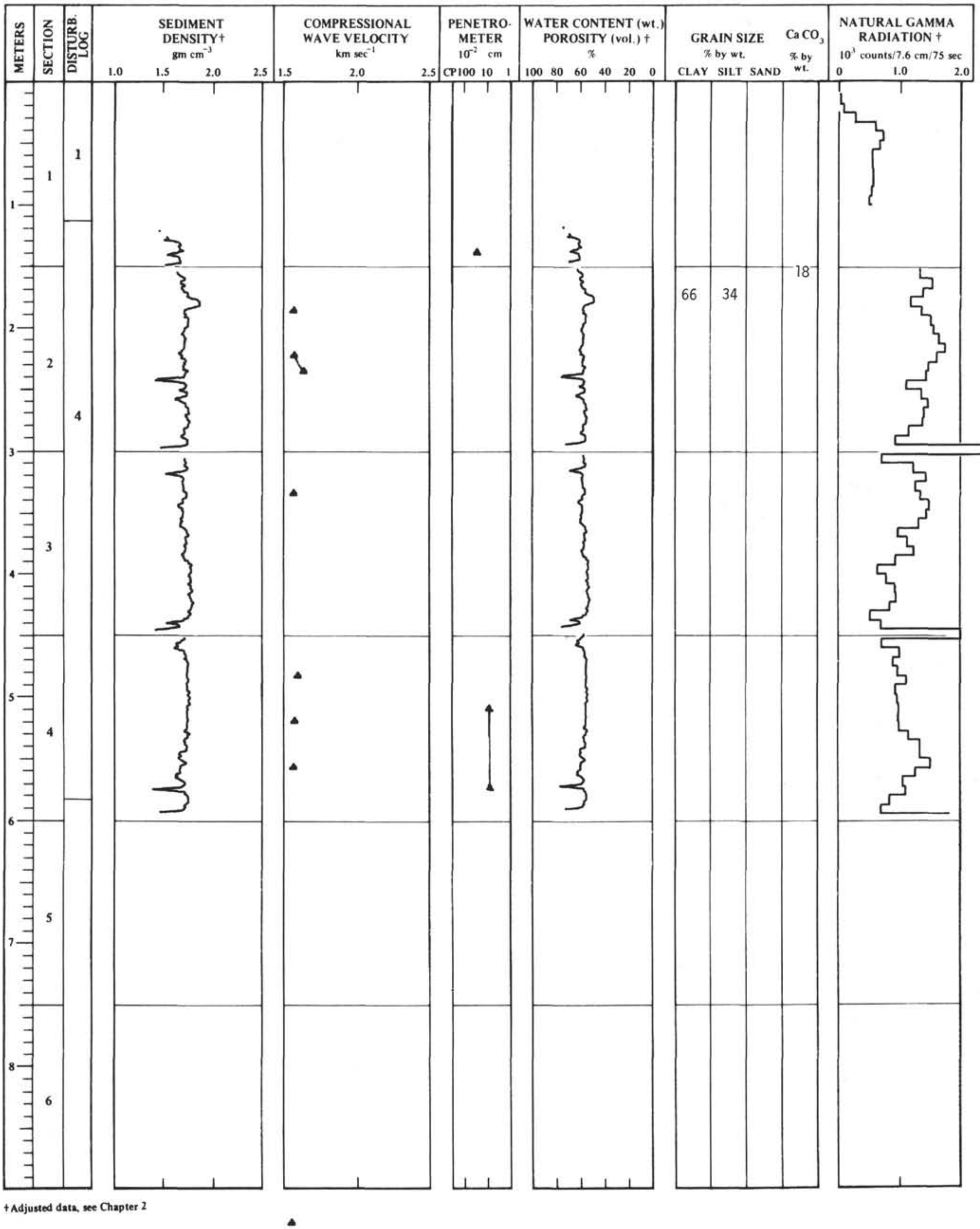
HOLE 119 198 **TO** 207 **m**

CORE 5

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1		F, N, F,R	5G 8/1; 5B 8/1; 5B 7/1; Light greenish gray firm nannofossil clay with light bluish gray bands as indicated. Yellowish gray mottled at 113-118 cm in Sec.1 and 122-125 cm in Sec. 2. Coarse fraction is forams and foram fragments.	Foram fauna mostly dissolved Flora: *Coccolithus pelagicus, C. eopelagicus, Cyclococcolithus leptoporus, Reticulofenestra pseudoumbilica, Discoaster exilis, D. deflandrei, D. extensus, Sphenolithus* sp., *Cyclococcolithus neogammation, C. macintyrei* Forams as above Radiolarians very rare. Digitately branched *Oroscena* spines.	*Discoaster exilis*	MIDDLE MIOCENE
2	2		N,R, XM, F	5G 8/1; 5G 6/1 X-ray Mineralogy (Bulk) Calc. 72.2 Qtz. 6.7 Kaol. 2.5 Mica 17.0 Mont. 1.5 Amorph. 45.2	Flora similar to above Radiolarians same Forams as above.		
3–4	3		N, R, F	5B 8/1	Flora similar to above. Radiolarians rare, as above. Forams as above.		
	CC		R, N, F		Core Catcher: Radiolarians common. Digitately branched *Oroscena* spines, *Cyrtocapsella tetrapera, C. japonica, Calocyclas margatensis*. Flora similar to above. Forams rare, mostly dissolved; *Gl. dehiscens, Gl.* cf. *acostaensis*		

HOLE 119

CORE 6



†Adjusted data, see Chapter 2

HOLE 119 240 **TO** 249 **m**

CORE 6

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	EMPTY			Flora: *Discoaster deflandrei*, *Discoaster* cf. *aulakos*, *D. challengeri*, *Coccolithus pelagicus*, *C. eopelagicus*, *Coronocyclus nitescens*, *Sphenolithus heteromorphus*, *Reticulofenestra pseudoumbilica*, *Cyclococcolithus neogammation*	*Calocycletta costata*	EARLY MIOCENE
			N F R	5Y 4/1 and 5Y 6/1	No Foraminifera. Radiolarians abundant. *Calocycletta costata*, *C. virginis*, *Stichocorys armata*, *S. wolffii*, *S. delmontensis*, *Cyclampterium* (?) *leptetrum*, *Cyrtocapsella japonica*, *C. cornuta*, *C. tetrapera*, *Lychnocanium bipes*, *Cannartus tubarius*, *Calocyclas margatensis*		
2	2		N R XM F	5Y 4/1 and 5Y 6/1	Flora similar to above Radiolarians abundant as above plus *Dorcadospyris simplex*, *Cannartus prismaticus*, *Carpocanopsis cingulatum* No planktonic forams; *Gyroidina*, *Siphonodosaria* present		
3–4	3		R N F	5Y 8/1 and 5Y 6/1	Radiolarians common, similar to above plus *Cannartus violina*, less *Calocycletta costata* Flora similar to above Foram fauna as above	*Sphenolithus heteromorphus*	
5	4		R N F	5Y 8/1 and 5GY 6/1; 5Y 8/1, 5B 7/1, 5Y 6/1, 5G 6/1, 5Y 8/1	Radiolarians abundant, similar to above plus *Carpocanopsis bramlettei* Flora similar to above Forams: *G. peripheroronda*, *G. siakensis*, *G.* cf. *praescitula*, *Gl. dehiscens*	? *Calocycletta virginis*	
	CC		F N R		Core Catcher: Forams: *Gl. dissimilis*, *G. unicava*, *Gl. praedehiscens*, *G. dehiscens*, *G. baroemoenensis*, *Gl. siakensis* Flora similar to above plus *Helicopontosphaera ampliaperta* Radiolarians very abundant, similar assemblage plus *Carpocanopsis favosum*	*Helicopontosphaera ampliaperta*	

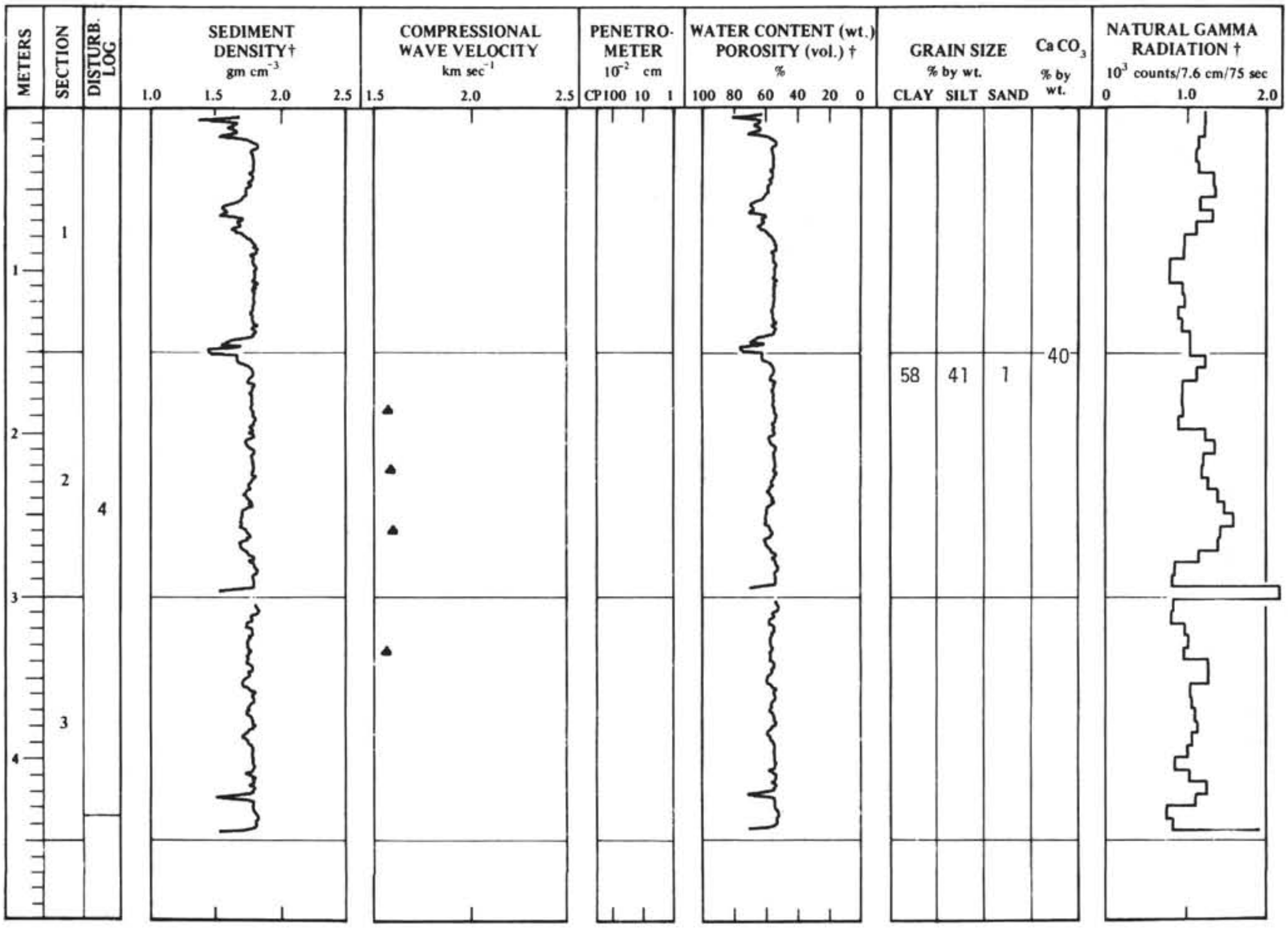
LITHOLOGY: Light olive gray and olive gray dense silty clay mottled with medium bluish gray. Some yellowish gray clay in Sec. 3.

X-ray Mineralogy (Bulk)

Calc.	58.9
Qtz.	10.4
Kaol.	3.5
Mica	22.1
Mont.	5.2
Amorph.	56.5

HOLE 119

CORE 7



†Adjusted data, see Chapter 2

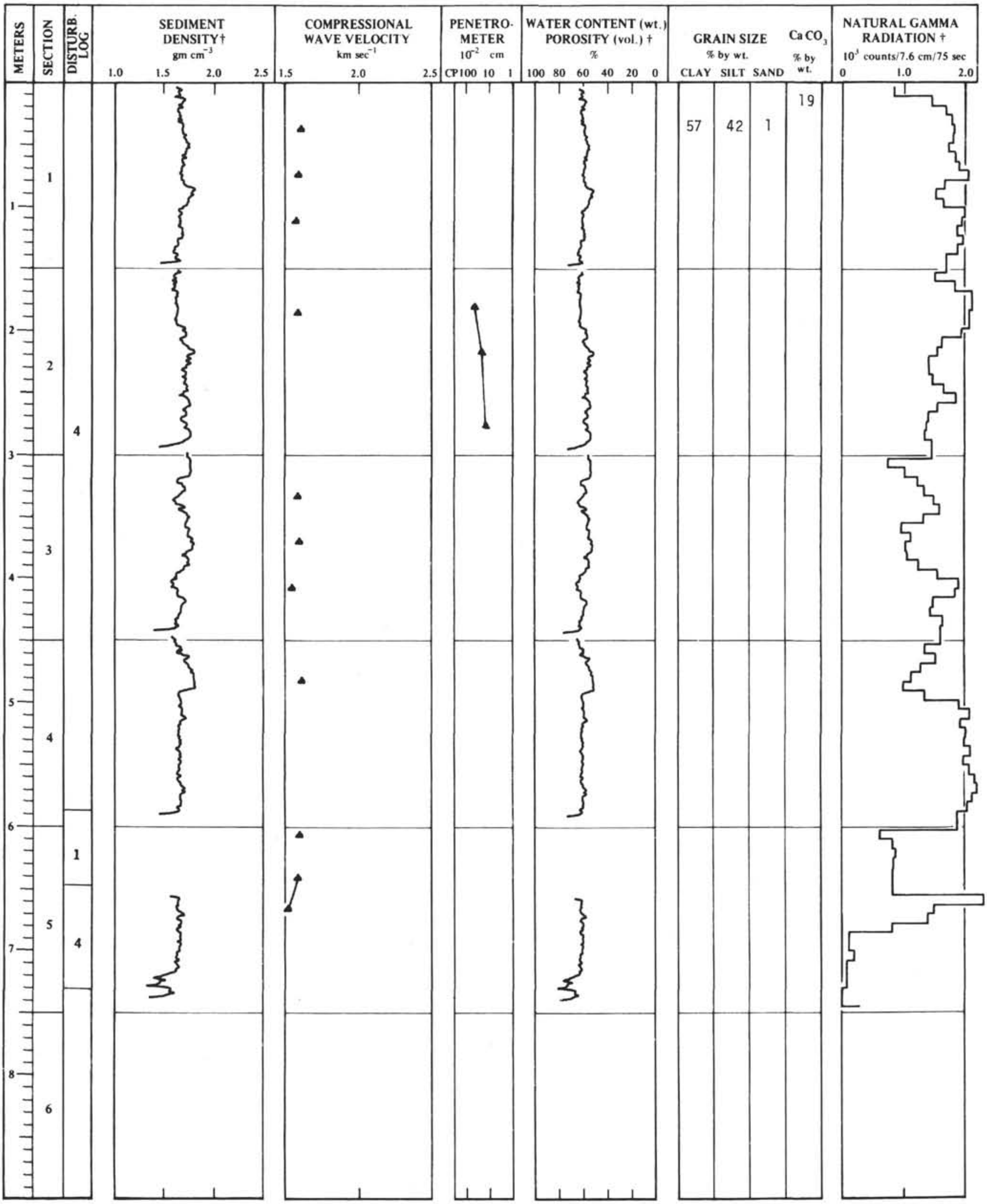
HOLE 119 249 TO 258 m

CORE 7

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		R N F	5Y 8/1 with 5B 7/1 and 5G 6/1 Yellowish gray dense clay with light bluish gray and greenish gray mottled.	Radiolarians common. *Cyrtocapsella japonica, C. cornuta, C. tetrapera, Calocycletta virginis, Stichocorys delmontensis, S. diploconus, S. wolffii, Dorcadospyris simplex, Lychnocanium bipes, Carpocanopsis cingulatum* Flora: *Coccolithus pelagicus, C. eopelagicus, Cyclococcolithus neogammation, Discoaster deflandrei, Triquetrorhabdulus carinatus, Coronocyclus nitescens, Sphenolithus moriformis, S. belemnos, Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica*	*Sphenolithus belemnos*	EARLY MIOCENE
1.5–3	2		N R XM F	passing down into light gray dense clay with light bluish gray and greenish gray mottles and greenish gray bands. 5Y 7/2	No planktonic forams Flora similar to above Radiolarians abundant. Same assemblage plus *Cyclampterium* (?) *leptetrum, Cannartus tubarius, C. prismaticus, Calocyclas margatensis, Carpocanopsis bramlettei* Foram fauna as above		
3–4.5	3		N R F	5G 6/1, 5Y 7/2, 5G 6/1, 5Y 7/2 X-ray Mineralogy (Bulk): Calc. 37.1; Qtz. 12.5; Plag. 1.4; Kaol. 7.4; Mica 31.0; Mont. 10.5; Amorph. 60.2	Flora similar to above Radiolarians common. Same assemblage. Foram fauna mostly dissolved; *Gl. dehiscens* (rare)	? *Calocycletta virginis*	
	CC		R N F		Core Catcher: Radiolarians very abundant. Same assemblage plus *Cannartus violina* and one *Calocycletta costata* (contaminant?) Flora similar to above Forams: *G. dissimilis, G. unicava, G. praedehiscens, G. dehiscens*		

HOLE 119

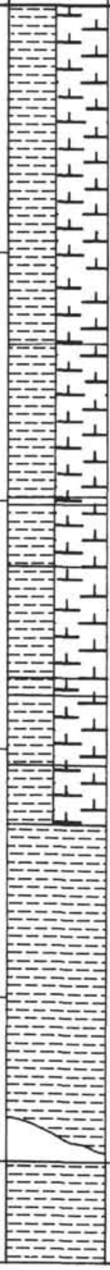
CORE 8



†Adjusted data, see Chapter 2

HOLE 119 258 **TO** 267 **m**

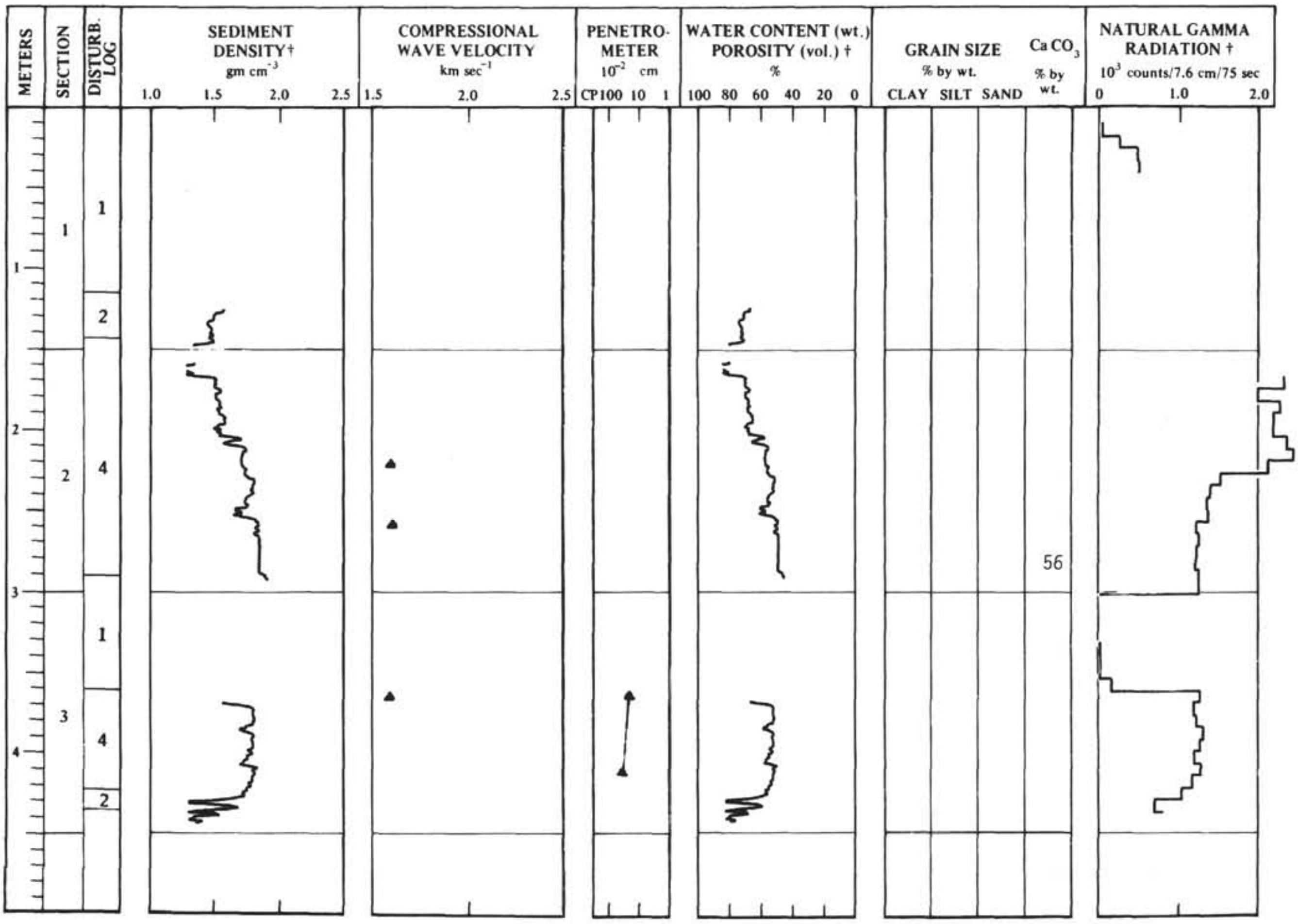
CORE 8



METERS	SECTION	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	R,XM; N; F	5Y 8/1; 5G 6/1; 5G 4/1; 5GY 8/1; 5G 6/1; 5G 5/1	Radiolarians abundant. Same assemblage as Core 7. Flora: *Coccolithus pelagicus, C. eopelagicus, Cyclococcolithus neogammation, Reticulofenestra pseudoumbilica, Discoaster deflandrei, D. druggi, Triquetrorhabdulus carinatus, Sphenolithus belemnos, Coronocyclus nitescens* Planktonic forams mostly dissolved.	*Calocycletta virginis* *Triquetrorhabdulus carinatus*	EARLY MIOCENE
1.5–3	2	R; N	5G 8/1 Firm, hard greenish gray nannofossil clay, almost an ooze. Highly burrowed throughout.	Radiolarians abundant. Similar to above plus *Cyclampterium* (?) *pegetrium*. Flora similar to above		
3–4.5	3	XM; N; R; F	5G 6/1; 5G 8/1; 5G 4/1; 5GY 9/1; 5G 4/1; 5Y 6/1; 5GY 9/1; 5Y 6/1 X-ray Mineralogy (Bulk): Calc. 24.2; Qtz. 19.0; Plag. 2.1; Kaol. 6.5; Mica 38.6; Mont. 9.6; Amorph. 64.4	Flora similar to above Radiolarians abundant. Similar assemblage plus *Dorcadospyris ateuchus*. Foram fauna as above		
4.5–6	4	XM; N; R; XM; F; N,F	5B 9/1; 5GY 4/1	Flora similar to above Radiolarians abundant. Similar assemblage plus *Cannartus violina, Cyclampterium* (?) sp. cf. *C.* (?) *milowi* Foram fauna as above No coccoliths		
6–7.5	5	N; R; F	5G 5/1	No coccoliths Foram fauna as above (plus Pleist. contaminants) Radiolarians common, similar to above.		
	CC	R; N; F		Core Catcher: Dark: Flora similar to above Light: Flora similar to above Foram fauna as above plus Pleistocene contaminants Radiolarians very abundant, similar to above. Possible downhole contamination indicated by very rare specimens of *Lithopera renzae* and *Calocycletta costata*		

HOLE 119

CORE 9



†Adjusted data, see Chapter 2

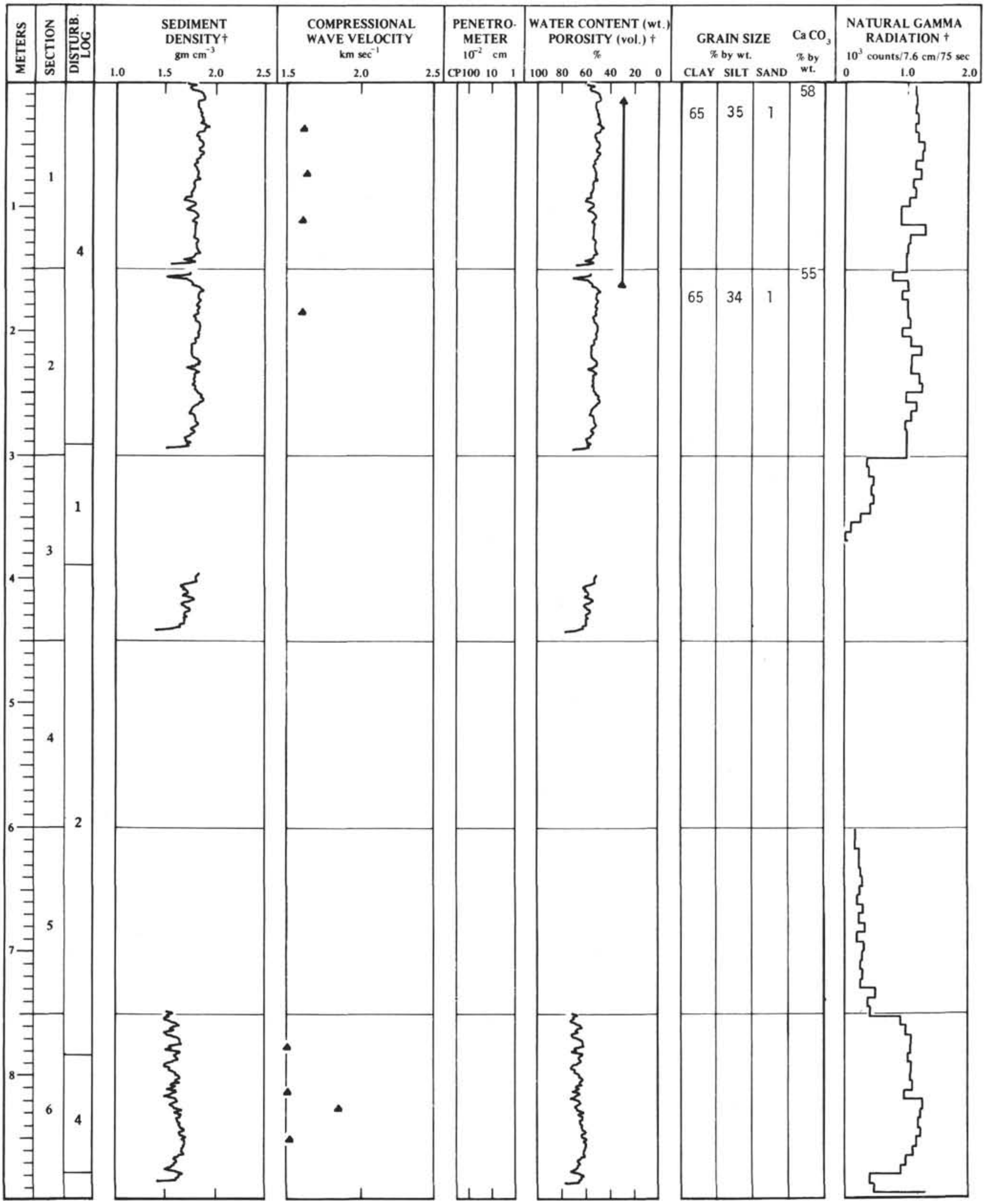
HOLE 119 267 **TO** 276 **m**

CORE 9

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	EMPTY	R N F XM	5G 6/1	X-ray Mineralogy (Bulk) Calc. 15.5 Qtz. 24.2 Plag. 3.8 Kaol 6.9 Mica 35.2 Mont. 14.4 Amorph. 69.0 Mottled and disturbed greenish gray clay. ↓ Darker	Flora: *Coccolithus pelagicus, C. eopelagicus, Cyclococcolithus neogammation, Reticulofenestra pseudoumbilica, Discoaster deflandrei, Triquetrorhabdulus carinatus* No foram fauna Radiolarians rare. *Dorcadospyris simplex, D. ateuchus, Stichocorys delmontensis, Cyrtocapsella japonica, C. cornuta, C. tetrapera,* (?) *Calocycletta virginis, Cyclampterium* (?) sp. cf. *C.* (?) *milowi, C.* (?) *pegetrium, Lychnocanium bipes, Cannartus prismaticus, Calocyclas margatensis*	*Calocycletta virginis* *Triquetrorhabdulus carinatus*	EARLY MIOCENE
2	2		R,XM N F	5G 4/1 5G 9/1 5Y 6/1 5Y 8/1 5B 5/1	↓ Dark green-gray clay ↓ Lighter ↓ Mottled light olive gray clay Yellowish and bluish gray clay Slickensides on two perpendicular planes at 105 cm in Sec. 2.	Flora similar to above, plus reworked Eocene No planktonic forams; rare benthonics		
3–4	3	EMPTY	N R	5Y 8/1 5B 7/1 5Y 6/1	Firm greenish gray and light olive gray clay Slickenside at 100 cm in Sec. 3.	Flora similar to above, plus reworked Eocene Radiolarians rare, similar assemblage.		
	CC		R N F		X-ray Mineralogy (Bulk) Calc. 0 Qtz. 25.6 Plag. 3.2 Kaol. 7.7 Mica 47.7 Mont. 15.9 Amorph. 67.4	Core Catcher: Radiolarians abundant, similar assemblage plus *Cyclampterium* (?) *leptetrum* and *Cyrtocapsella elongata.* Minor contamination from up the hole. Flora similar to above Planktonic foram fauna sparse; *Anom. semicribrata, Cib. trincherasensis,* stilostomellids		

HOLE 119

CORE 10



†Adjusted data, see Chapter 2

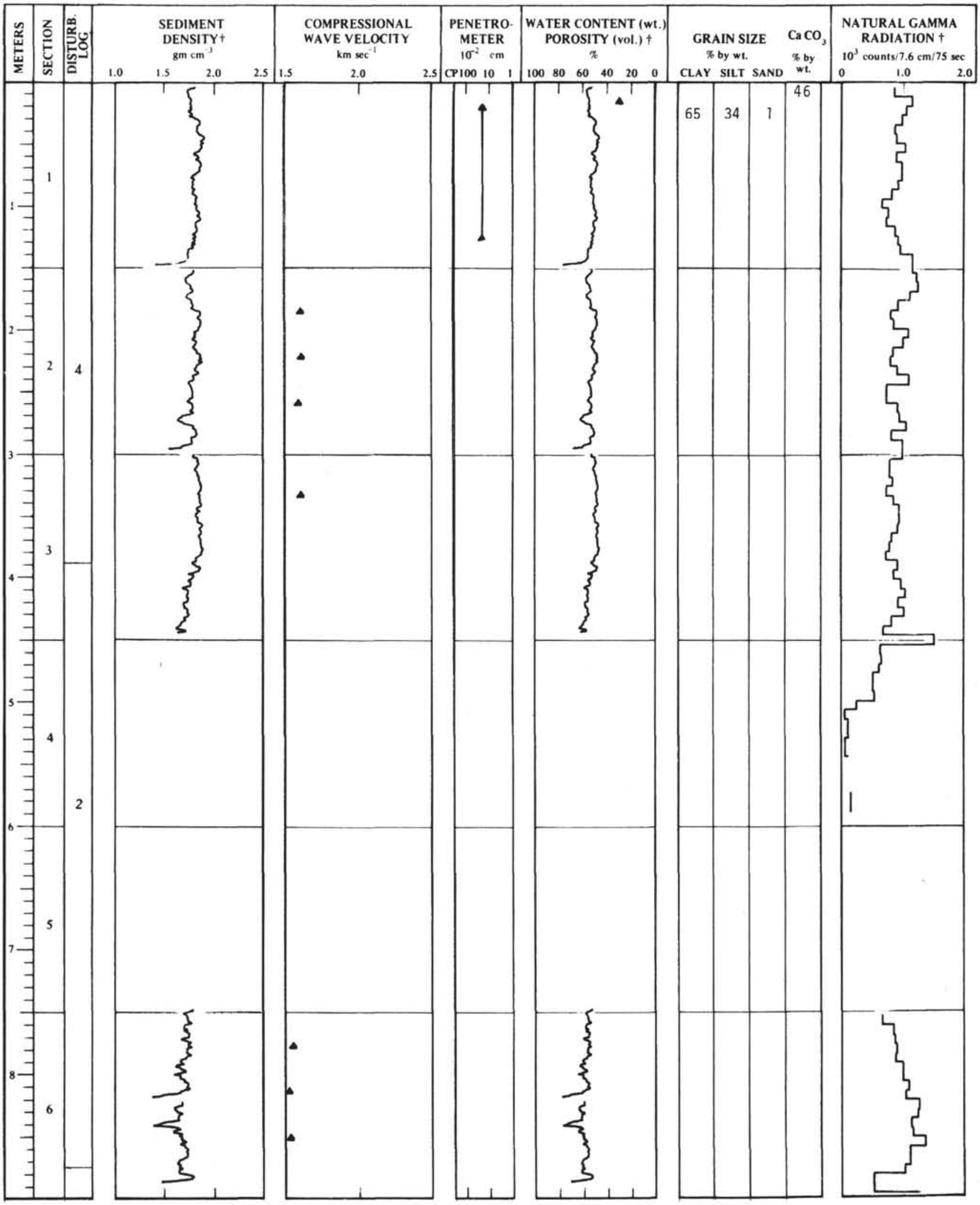
HOLE 119 276 **TO** 284 **m**

CORE 10

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		R XM N XM,F	5B 7/1 5Y 8/1 5Y 6/2 X-ray Mineralogy (Bulk) Calc. 55.2 Qtz. 11.0 Plag. 1.5 Kaol. 3.4 Mica 23.3 Mont. 5.6 Amorph. 52.0 Firm, highly mottled nannofossil ooze, yellowish-gray and light olive gray. Coarse fraction is sponge spicules, forams, radiolarians, mineral grains and fish debris.	Radiolarians rare. Assemblage similar to Core 9. Flora: *Coccolithus pelagicus, C. eopelagicus, Cyclococcolithus neogammation, Reticulofenestra pseudoumbilica, Sphenolithus moriformis, Triquerorhabdulus carinatus, Discoaster deflandrei* No forams	*Calocycletta virginis* *Triquetrorhabdulus carinatus*	EARLY MIOCENE
1.5–3	2		N R XM F N,F R	5Y 6/2 5Y 5/3 5Y6/2 5Y 5/3 5Y 6/2	Flora similar to above Radiolarians rare, similar to above. Benthonic forams only Flora similar to above Radiolarians rare, similar to above.		
3–4.5	3	EMPTY		Highly distrubed X-ray Mineralogy (Bulk) (277.5 meters) Calc. 52.1 Qtz. 9.7 Kaol. 5.0 Mica 30.1 Mont. 3.2 Amorph. 53.2 X-ray Mineralogy (Bulk) (278.5 meters) Calc. 43.4 Qtz. 13.4 Plag. 1.6 Kaol. 5.0 Mica 29.8 Mont. 6.7 Amorph. 59.6			
4.5–6	4	SECTION NOT OPENED					
6–7.5	5	SECTION NOT OPENED					
7.5–9	6			Completely disrupted nannofossil ooze			
	CC		R N F		Radiolarians very abundant, assemblage similar to Core 9. Minor contamination from up the hole. Flora similar to above Forams sparse; *G. dissimilis*		

HOLE 119

CORE 11



†Adjusted data, see Chapter 2

HOLE 119 284 **TO** 293 **m**

CORE 11

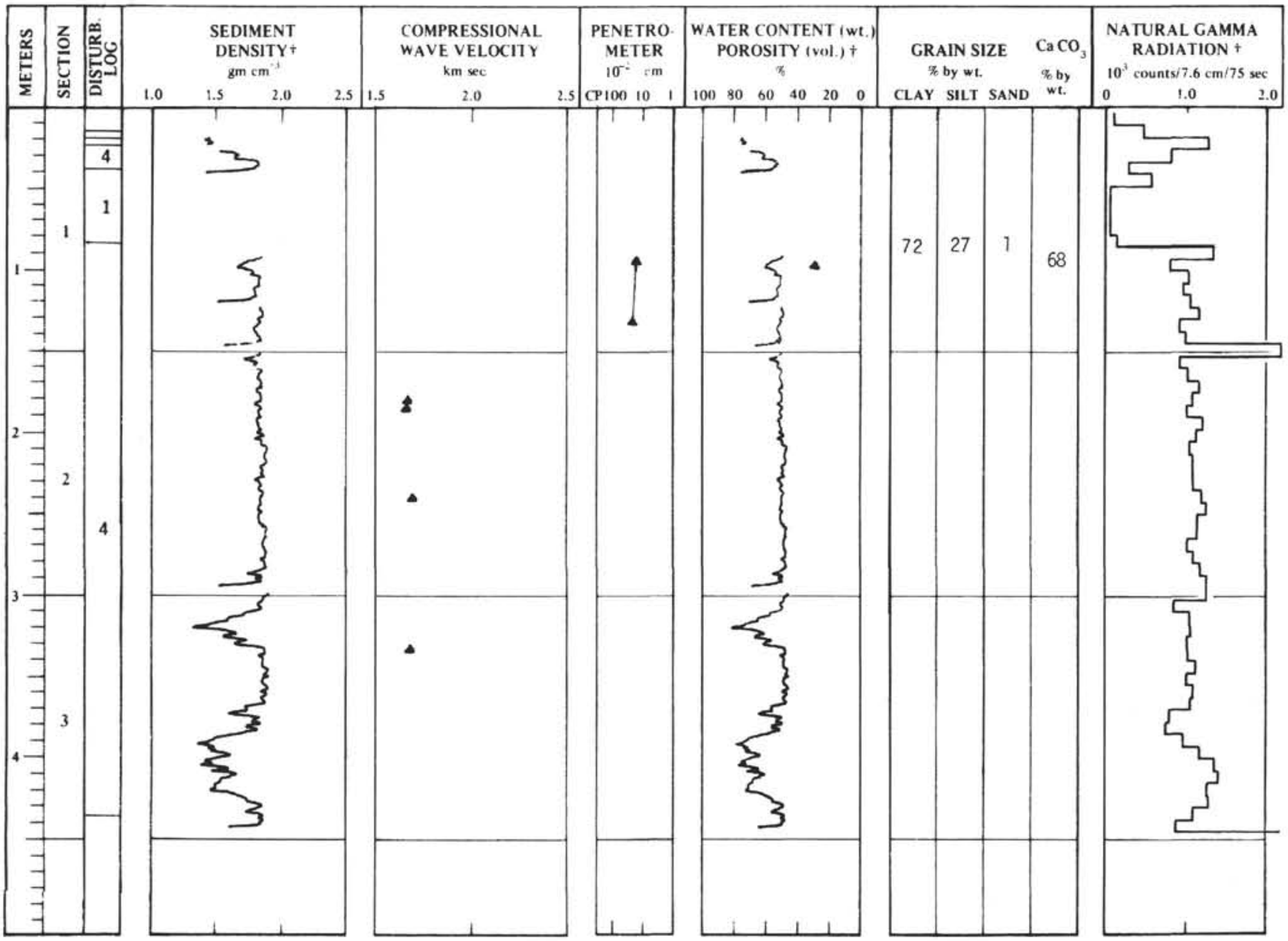
METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–4.5	1, 2, 3		R, XM, N, F; N, R; N; N, R, F	5Y 7/2; 5B 9/1; 5Y 7/2; 5B 9/1; 5Y 8/1; 5Y 7/3; 5Y 7/3. Firm yellow-gray and gray, slightly mottled nannofossil ooze. Disrupted	Radiolarians common. *Cyrtocapsella cornuta, C. tetrapera, Dorcadospyris simplex, D. ateuchus,* (?) *Stichocorys delmontensis,* (?) *S. wolffii,* (?) *S. diploconus, Lychnocanium bipes, Cyclampterium* (?) *pegetrum, C.* (?)sp. cf. *C.* (?) *milowi, Cannartus prismaticus, Theocyrtis annosa, Theocorys spongoconum, Carpocanopsis cingulatum* Flora: *Coccolithus pelagicus, C. eopelagicus, Reticulofenestra pseudoumbilica, Cyclococcolithus neogammation, Coccolithus* cf. *bisectus, Sphenolithus moriformis, S. belemnos, Discoaster deflandrei, Triquetrorhabdulus carinatus* Few foram fragments Flora similar to above Radiolarians very rare. *Cyclampterium* (?) sp. cf. *C.* (?) *milowi.* Above species absent. Flora similar to above Scattered benthonic forams: *Gyroidina, pullenia, Siphonodosaria, Stilostomella* Flora similar to above Radiolarians same as above. Forams fauna as above	*Calocycletta virginis*; *Triquetrorhabdulus carinatus*	EARLY MIOCENE
4.5–6	4	SECTION NOT OPENED					
6–7.5	5	SECTION NOT OPENED					
7.5–9	6			Completely disrupted pale yellow and light bluish gray nannofossil clay	Abundant contaminant radiolarians from the *C. virginis* zone above.		
	CC		R, N, F		dark: Flora similar to above light: Flora similar to above Forams: *Globigerinita dissimilis, G. unicava*		

X-ray Mineralogy (Bulk)

Calc.	70.5
Qtz.	7.5
Kaol.	2.6
Mica	16.4
Mont.	3.0
Amorph.	48.1

HOLE 119

CORE 12



†Adjusted data, see Chapter 2

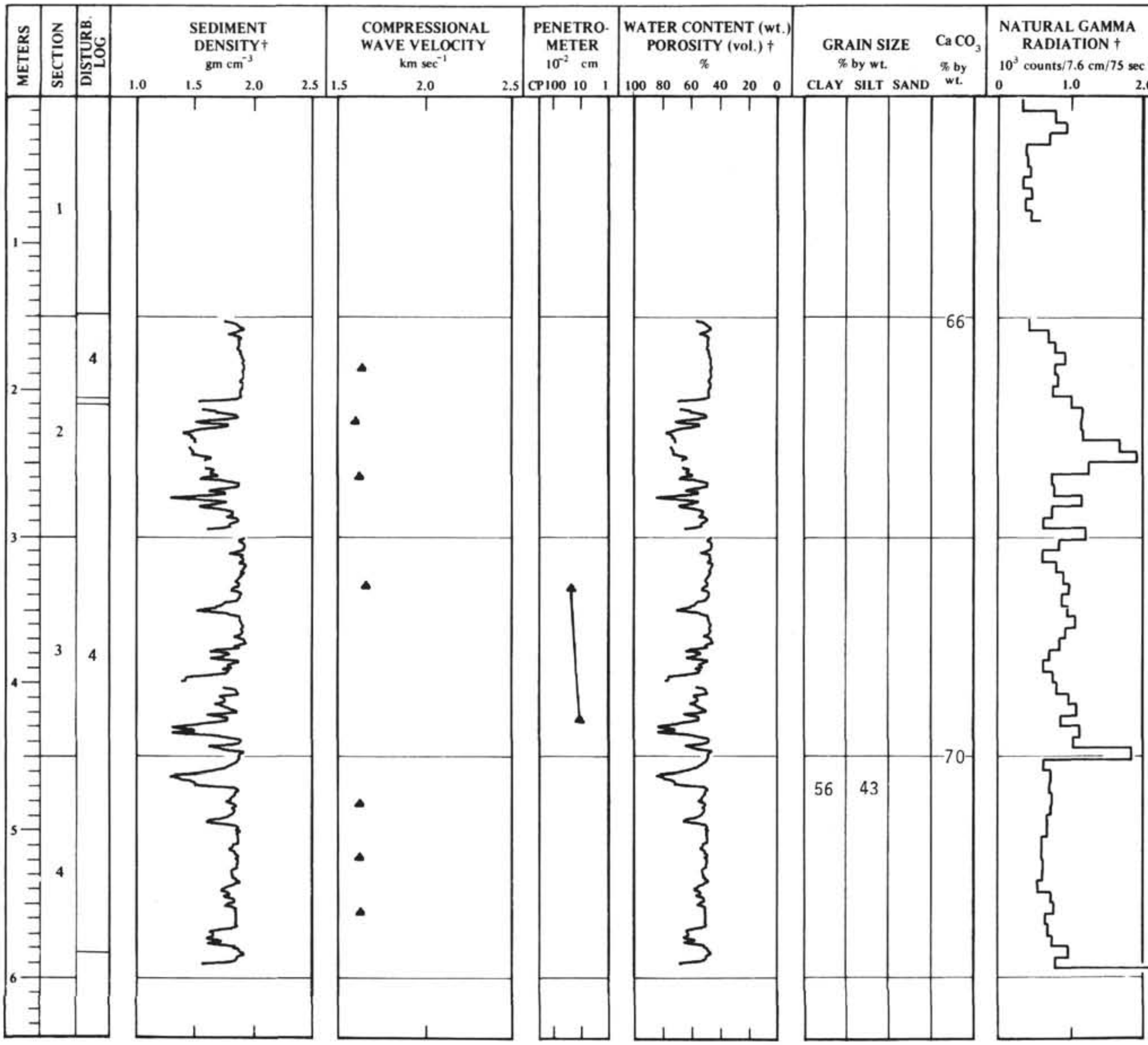
HOLE 119 293 TO 302 m

CORE 12

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	EMPTY	XM N R F	5Y 8/2 5Y 8/3	Flora: *Coccolithus pelagicus*, *C. eopelagicus*, *C.* aff. *bisectus*, *C. bisectus*, *Sphenolithus moriformis*, *Sphenolithus* sp., *Cyclococcolithus neogammation*, *Discoaster deflandrei*, *Triquetrorhabdulus carinatus* Radiolarians very rare. *Cyclampterium* (?) sp. cf. *C.* (?) *milowi*, orosphaerids Scattered, small benthonic forams	*Sphenolithus ciperoensis* ?	OLIGOCENE
2–3	2		N,R F	5Y 8/3 ← 5Y 7/3 → 5Y 7/4 Pale yellow and white or light bluish gray, slightly mottled, hard, firm nannofossil ooze X-ray Mineralogy (Bulk) Calc. 60.1 Qtz. 9.6 Plag. 1.3 Kaol. 3.5 Mica 23.6 Mont. 1.8 Amorph. 54.1	Flora similar to above Radiolarians the same. Forams: *Globigerinita unicava*		
3–4	3		N,XM N R F	5Y 7/4 5B 7/1 5Y 7/4	Flora similar to above Flora similar to above Radiolarians very rare. (?) *Cyrtocapsella tetrapera*, *Calocyclas margatensis*, orosphaerids. Forams: *G. dissimilis*, *G. unicava*, *G. opima nana*, *G. siakensis*		
	CC		R N F		Core Catcher: A few contaminant radiolarians from above. Flora similar to above. Foram fauna as above.		

HOLE 119

CORE 13



†Adjusted data, see Chapter 2

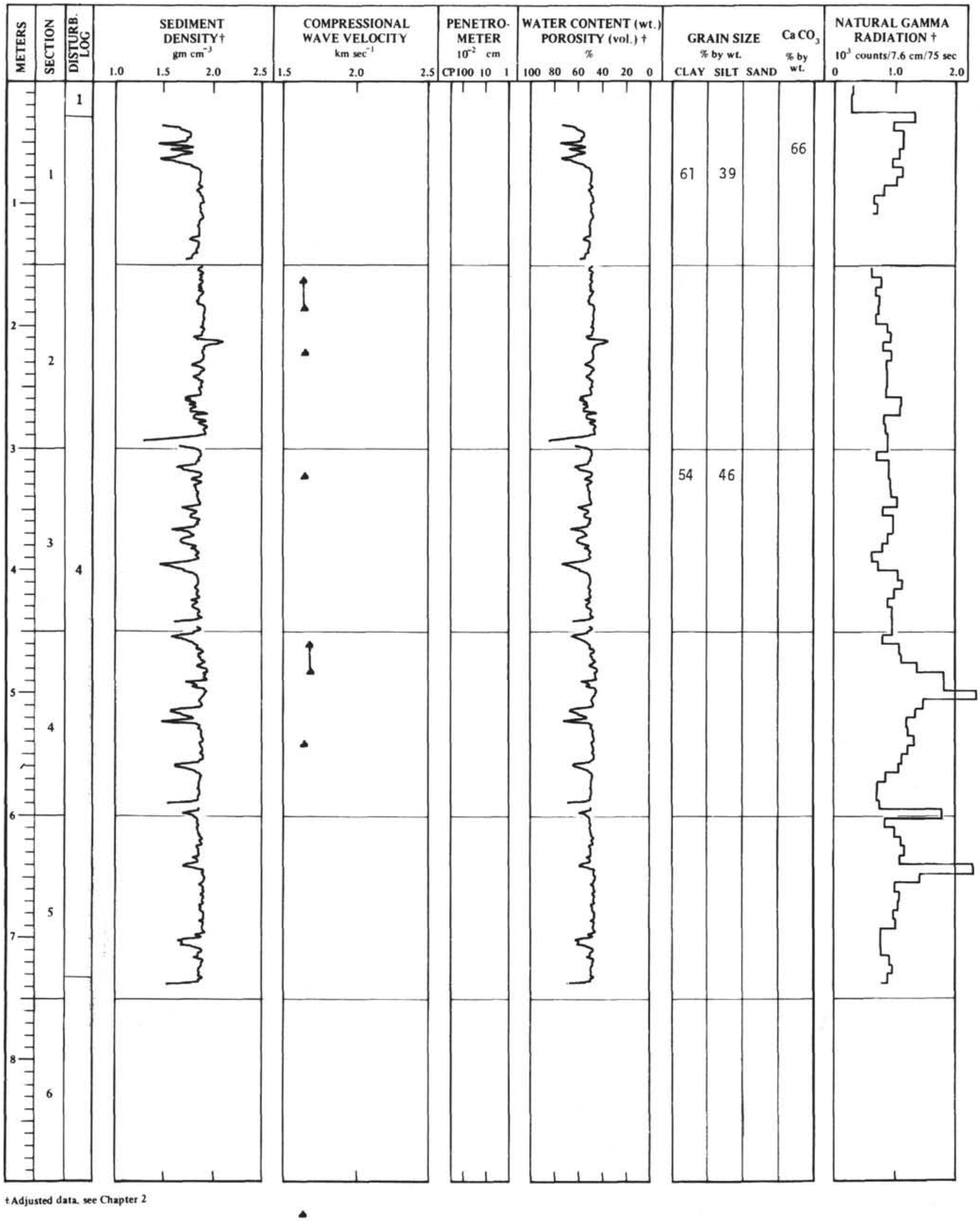
HOLE 119 302 TO 311 m

CORE 13

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	EMPTY	N F,R N	5Y 7/4 MOTTLED WITH 5B 7/1 Dense, pale yellow nannofossil ooze. Coarse fraction is sponge spicules, forams, fish debris and mineral grains. X-ray Mineralogy (Bulk) Calc. 79.0 Qtz. 6.1 Kaol. 1.8 Mica 11.9 Clin. 1.2 Amorph. 44.8	Flora: *Coccolithus pelagicus, C. eopelagicus, C. bisectus, C.* aff. *bisectus, Cyclococcolithus neogammation, Sphenolithus moriformis, Sphenolithus* sp., *Discoaster deflandrei* Forams: *G. dissimilis, G. unicava* No radiolarians Flora similar to above	*Sphenolithus ciperoensis* ?	OLIGOCENE
1.5–3	2		R XM F		A few zeolitized spumellarians. Foram fauna as above		
3–4.5	3		N R N		Flora similar to above plus *Triquetrorhabdulus carinatus* A few zeolitized radiolarians. One contaminant *C. tetrapera* Flora similar to Sect. 3-46		
4.5–6	4		N R XM		Flora similar to above No radiolarians.		
	CC		R N F		Core Catcher: Very rare contaminant radiolarians from the *C. virginis* zone above. Flora similar to Sect. 3-46. Foram Fauna as above.		

HOLE 119

CORE 14



†Adjusted data, see Chapter 2

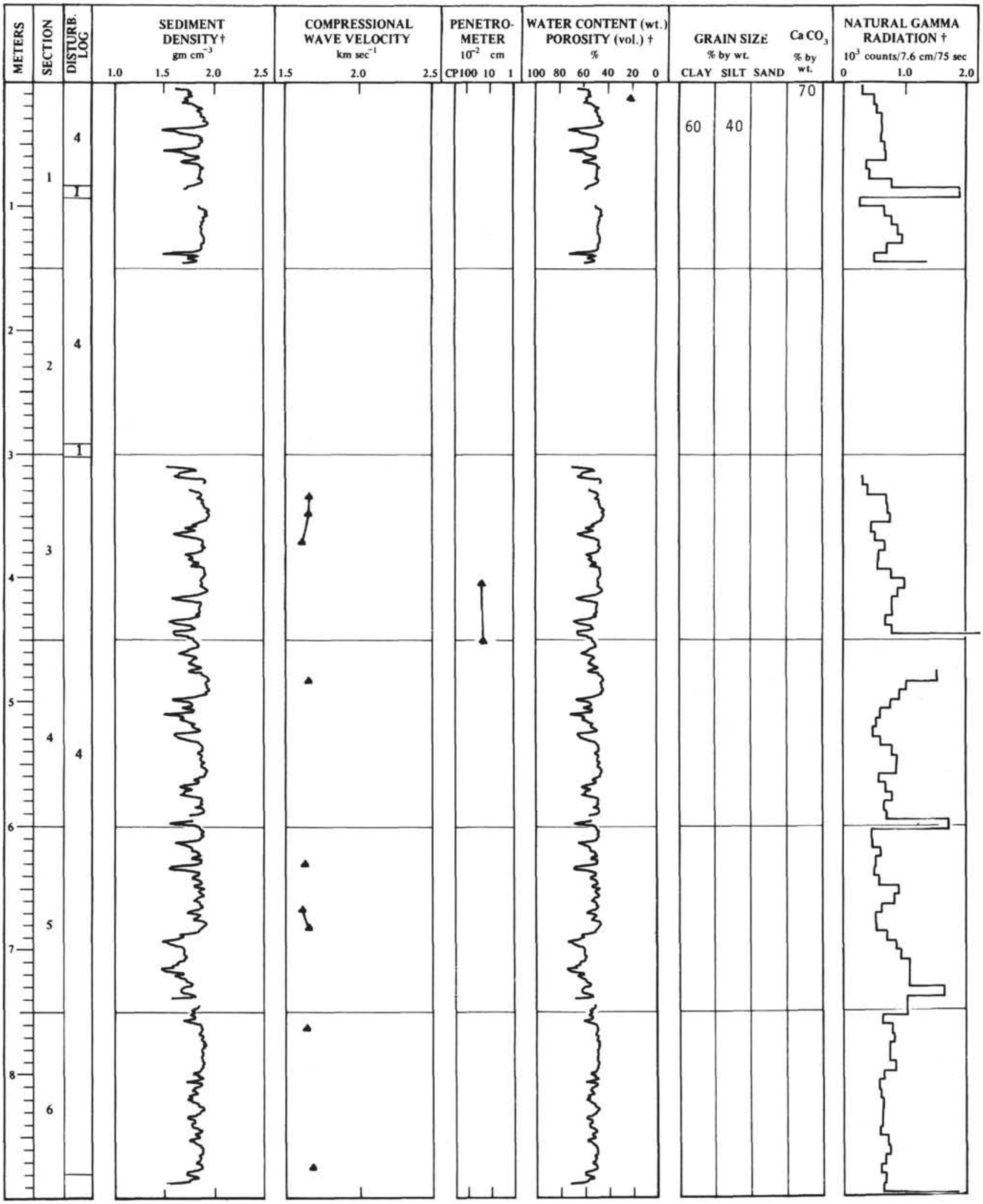
HOLE 119 311 TO 320 m

CORE 14

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	EMPTY	N,XM R F	Pale yellow and pale olive, dense, firm nannofossil clay, slightly mottled very pale blue (5B 8/2). Coarse fraction contains abundant mineral grains. 5Y 6/3 and 5Y 7/3	Flora: *Coccolithus pelagicus, C. eopelagicus, C. bisectus, C.* aff. *bisectus, Cyclococcolithus neogammation, Triquetrorhabdulus carinatus, Sphenolithus moriformis, Sphenolithus* sp., *Discoaster deflandrei* No radiolarians Forams: *Gyrcidina, Pleurostomella, Oridorsalis ecuadorensis*	*Sphenolithus ciperoensis*	LATE OLIGOCENE
2	2		N R	X-ray Mineralogy (Bulk) Calc. 73.2 Qtz. 7.1 Kaol. 2.3 Mica 16.0 Clin. 1.3 Amorph. 47.8	Flora similar to above, less *Triquetrorhabdulus carinatus* Very rare zeolitized radiolarians.		
3, 4	3		N R XM N F		Flora similar to Sect. 2 plus reworked Cretaceous: *Arkhangelskiella cymbiformis* No radiolarians Flora similar to above plus *Triquetrorhabdulus carinatus* Foram fauna as above		
5, 6	4		N XM R N XM	5B 8/2 6/3 and 5Y 7/3 5Y 6/3 and 5Y 7/3	Flora similar to above, less *T. carinatus*, plus *Sphenolithus distentus* Very rare contaminant radiolarians from the *C. virginis zone above.* Flora similar to Sect. 4-35.	*Sphenolithus distentus*	
7	5		XM N XM N	5B 8/2 5Y 6/3 and 5Y 7/3	Flora similar to Sect. 4-35, plus *Coronocyclus nitescens, Reticulofenestra laevis, Discolithina* sp. Flora similar to Sect. 5-47		
	CC		R N F		Core Catcher: Very rare contaminants from the *C. virginis* zone above Flora similar to Sect. 5-47, plus *Chiasmolithus* sp. Forams: *G. dissimilis, G. unicava, Chiloquembelina, Gl. opima, G. tripartita*		

HOLE 119

CORE 15



†Adjusted data, see Chapter 2

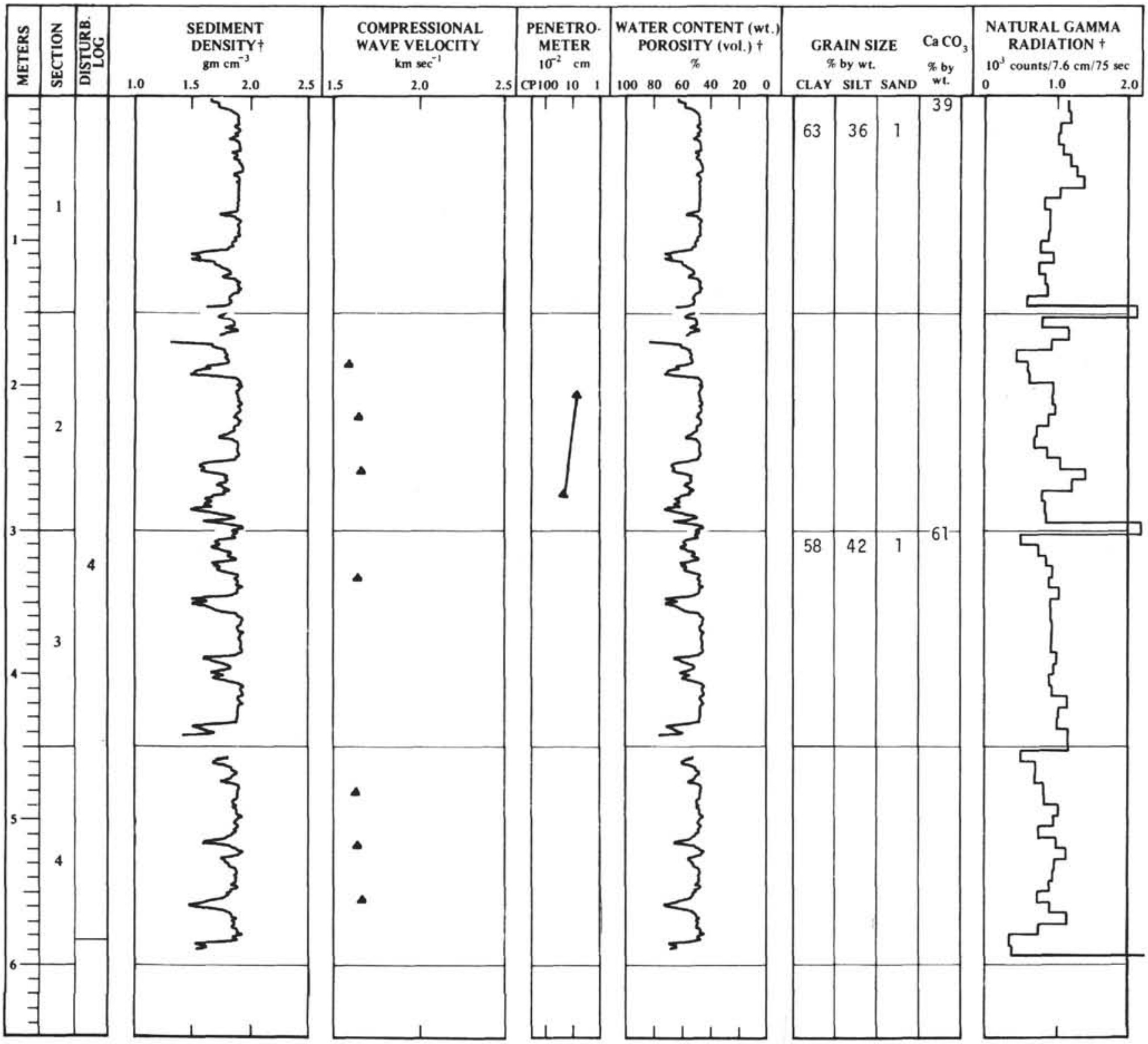
HOLE 119 | 320 **TO** 329 **m**

CORE 15

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1		N XM F	5Y 7/3 X-ray Mineralogy (Bulk) Calc. 81.0 Qtz. 5.9 Kaol. 1.6 Mica 9.9 Clin. 1.6 Amorph. 43.2	Flora: *Coccolithus pelagicus, C. eopelagicus, C. bisectus, C.* aff. *bisectus, Cyclococcolithus neogammation, Sphenolithus* sp. *S. distentus, Discoaster deflandrei, Reticulofenestra laevis* Scattered in determinate forams.	*Sphenolithus distentus* ?	EARLY-LATE OLIGOCENE
2	2	EMPTY					
3–4	3		N N N XM	5B 9/1 5Y 7/3 5GY 8/1 Firm, uniform, slightly mottled pale yellow nannofossil clay with bands of white and bluish white. Coarse fraction contains abundant mineral grains, forams and mica flakes.	Flora similar to above, plus *Triquetrorhabdulus* cf. *carinatus* Flora similar to Sect. 3-98 Flora similar to above, plus *Sphenolithus* cf. *predistentus, Chiasmolithus* sp.		
5–6	4		N,R F	5Y 7/3	Flora similar to Sect. 4-1 Very abundant zeolitized radiolarians. Foram fauna as above		
6–7	5		N XM N	5Y 8/2 5Y 8/2	Flora similar to Sect. 4-1 Flora similar to Sect. 4-1		
8	6		N N F	5B 9/1 5Y 8/1	Flora similar to Sect. 4-1 Flora similar to Sect. 4-1 Foram fauna as above gray: Flora similar to Sect. 4-1 cream: Flora similar to Sect. 4-1		
	CC		N F R		Foram fauna as above plus *G. sellii, G. suteri* Zeolitized radiolarians very rare. Common contaminant radiolarians from the *C. virginis* zone above.		

HOLE 119

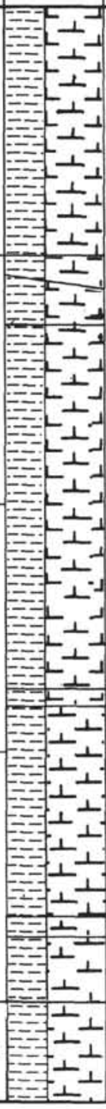
CORE 16



†Adjusted data, see Chapter 2

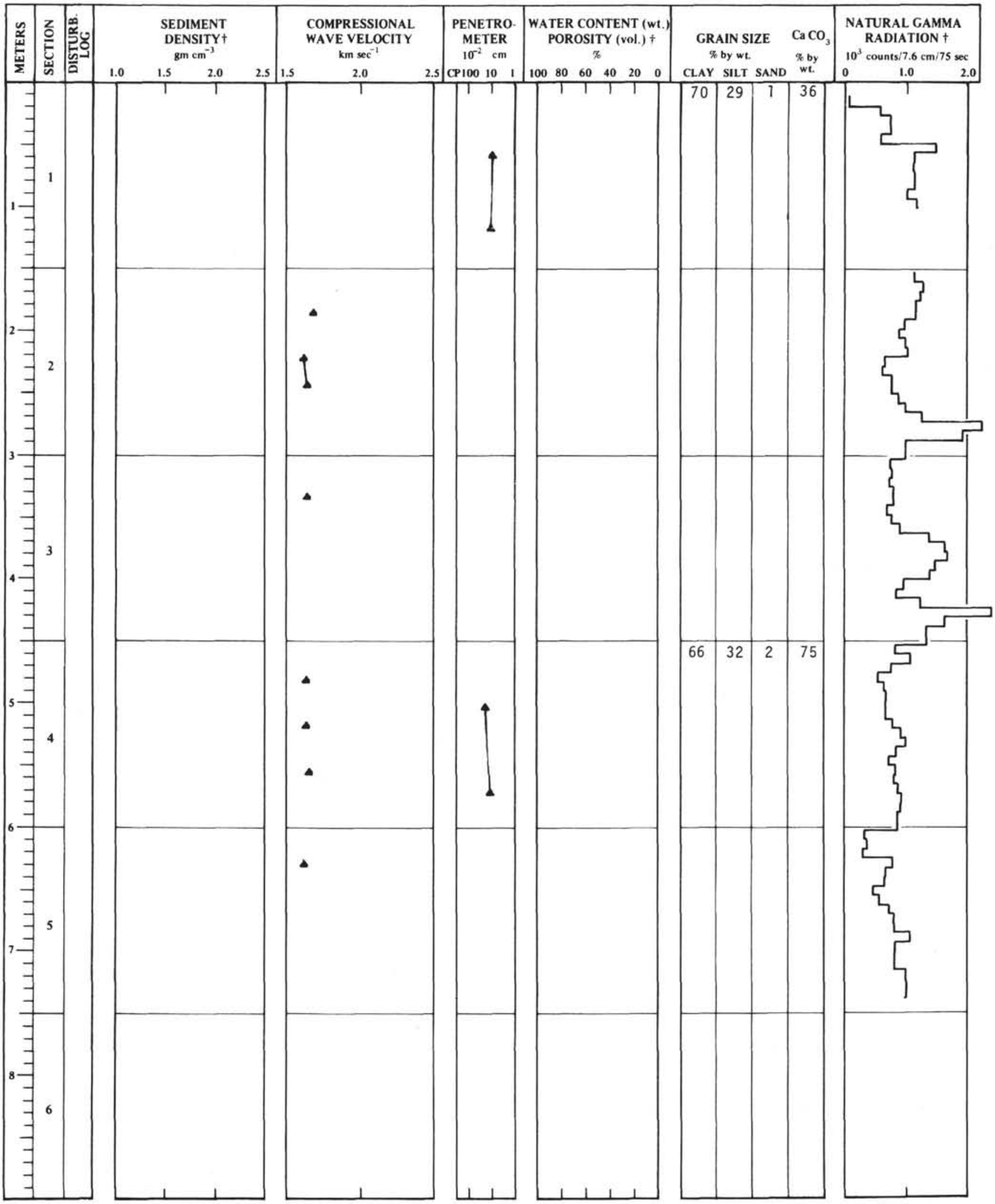
HOLE 119 329 TO 338 m

CORE 16

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1		N XM F	5Y 6/3 to 5Y 7/3 10YR 7/4 X-ray Mineralogy (Bulk) Calc. 69.6 Qtz. 8.8 Kaol. 2.6 Mica 17.2 Clin. 1.8 Amorph. 54.6	Flora: *Coccolithus bisectus, C.* aff. *bisectus, Cyclococcolithus neogammation, Sphenolithus* sp., *S. predistentus, Discoaster deflandrei* Forams: *G. dissimilis, G. unicava, G. opima, G. opima nana*	*Sphenolithus predistentus*	LATE OLIGOCENE
2 3	2		N N F R	N9 5Y 7/3 Pale yellow to pale olive hard, uniform nannofossil clay, slightly mottled. White layers as indicated. Coarse fraction includes abundant mineral grains, sponge spicules, fish debris and some forams.	Flora similar to above, plus *Coccolithus pelagicus* Flora similar to above Foram fauna as above plus abundant *Bahtysiphon* and *Hyperammina* Zeolitized radiolarians common. A few Lower Miocene contaminants.		
4	3		N XM F	5Y 8/1 5Y 7/3	Flora similar to above, plus *Coccolithus pelagicus, C. eopelagicus* Foram fauna as above		
5	4		N N F	5Y 8/1	Flora similar to above Flora similar to above, plus *Chiasmolithus* sp. Foram fauna as above		
	CC		R N F		Core Catcher: Zeolitized radiolarians, very rare. Very rare contaminants from *C. virginis* zone above. Flora similar to above. Forams: *G. dissimilis, G. unicava, G. suteri, G. opima nana*		

HOLE 119

CORE 17

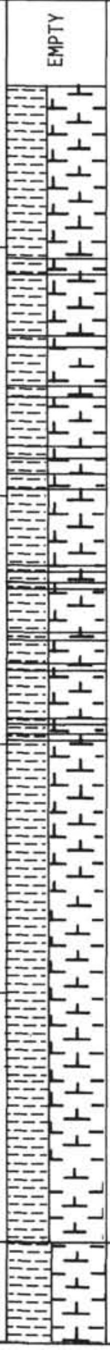


†Adjusted data, see Chapter 2

HOLE 119 338 **TO** 347 **m**

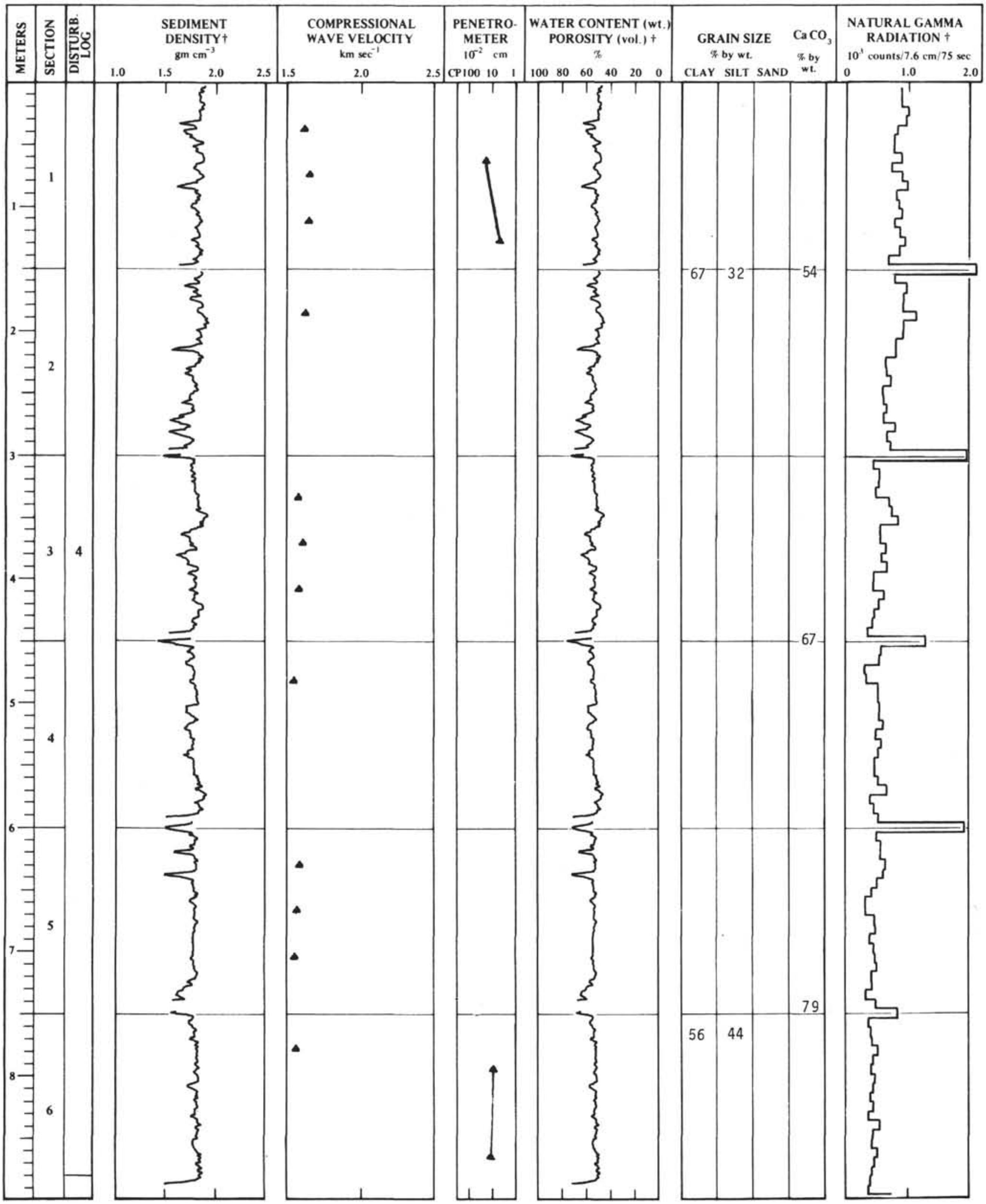
CORE 17

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	EMPTY	XM N R	5Y 7/3 and 5Y 6/3	Flora: *Coccolithus pelagicus, C. bisectus, C.* aff. *bisectus, C. eopelagicus, Cyclococcolithus neogammation, Reticulofenestra laevis, Rhabdolithus* sp. *Sphenolithus* sp. *S. predistentus, Discoaster deflandrei, D. tani ornatus* Silicified radiolarians very rare.	*Sphenolithus predistentus*	MIDDLE OLIGOCENE
1.5–3	2		N,R XM N F	5B 8/1 5B 8/1 5B 8/1 5B 8/1 5B 8/1 Pale yellow and pale olive nannofossil clay with light bluish gray bands. Section is burrowed and mottled.	Flora similar to above Radiolarians same. Flora similar to above, plus *Chiasmolithus* sp. Forams: *G. dissimilis, G. unicava, G. opima nana, G. suteri*		
3–4.5	3		R N F	5B 6/1 5B 6/1 5B 6/1 5B 6/1 5B 6/1 5B 6/1 X-ray Mineralogy (Bulk) Calc. 65.5 Qtz. 11.1 Kaol. 2.1 Mica 18.4 Clin. 2.9 Amorph. 55.4	Radiolarians same. Flora similar to above, plus reworked Cretaceous coccoliths Forams as above; *G. opima nana* abundant		
4.5–6	4		N R XM F	Dense pale yellow and pale olive nannofossil clay, slightly mottled with light bluish gray.	Flora similar to above No radiolarians Foram fauna as above		
6–7.5	5		N R N F		Flora similar to above No radiolarians. Flora similar to above, plus *Reticulofenestra umbilica* Foram fauna as above	*Helicopontosphaera reticulata* ?	? EARLY
	CC		R N F		Core Catcher: No radiolarians. Flora similar to above, plus *Reticulofenestra umbilica* Forams: *G. dissimilis, G. unicava, G. opima nana, G. suteri*		



HOLE 119

CORE 18



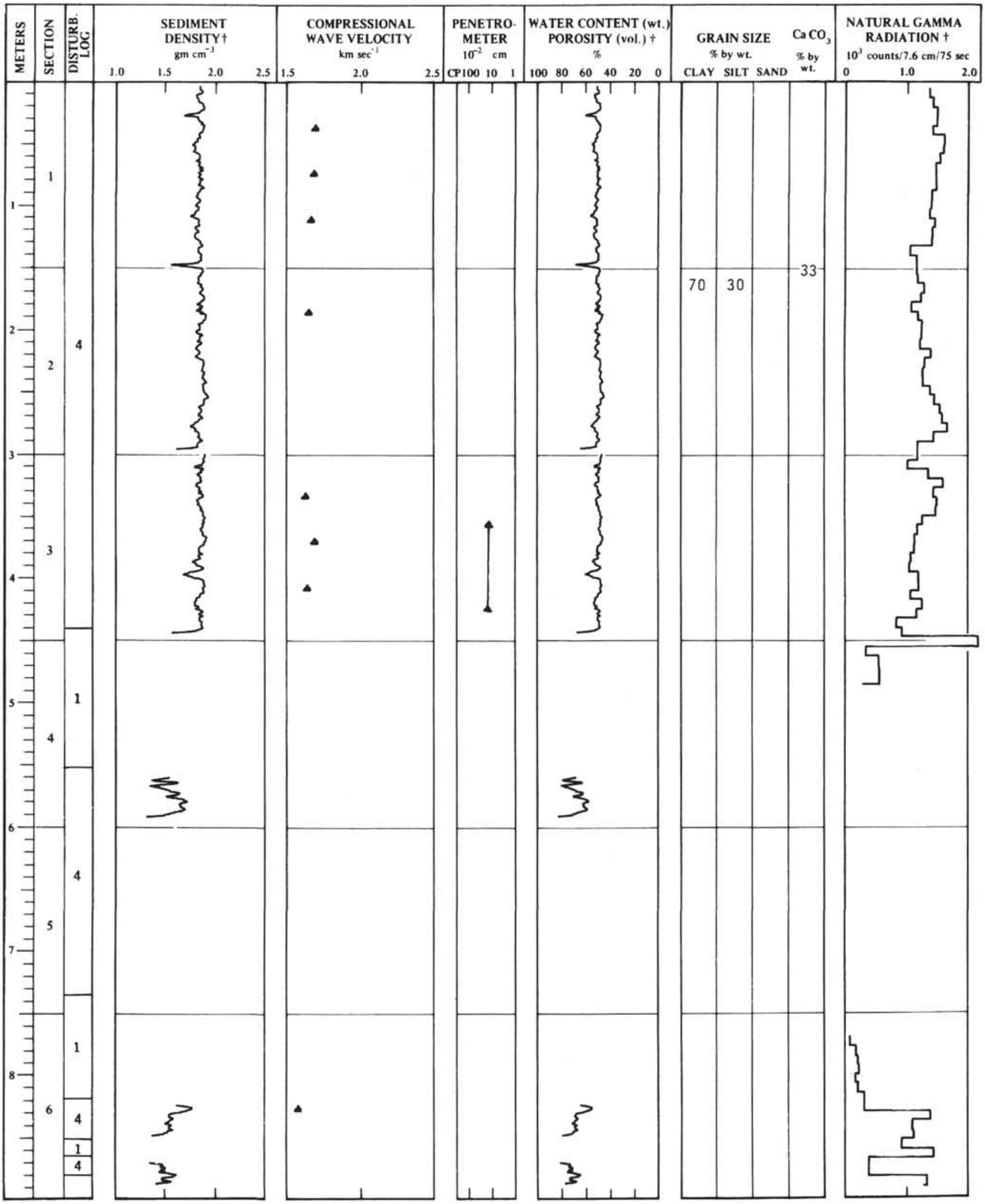
†Adjusted data, see Chapter 2

HOLE 119 347 TO 356 m
CORE 18

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N R N F	5Y 8/4 and 5Y 7/4 PASSING INTO	Flora: *Isthmolithus recurvus, Coccolithus eopelagicus, C. bisectus, C.* aff. *bisectus, Cyclococcolithus neogammation, Discoaster deflandrei, Chiasmolithus* sp., *Sphenolithus* sp., *S. predistentus, Discoaster barbadiensis* (reworked?) No identifiable radiolarians Flora similar to above, plus *Discoaster tani, Reticulofenestra umbilica* Forams: *G. dissimilis, G. unicava, G. opima nana*	*Helicopontosphaera Reticulata ?*	EARLY OLIGOCENE
1.5–3	2		N N R N F	2.5Y 7/6 and 2.5Y 8/6 PASSING INTO Pale yellow, dense, nannofossil clay, highly burrowed, some mottling in pale blue (5PB 7/2). X-ray Mineralogy (Bulk) Calc. 79.7 Qtz. 5.7 Kaol. 1.1 Mica 12.2 Clin. 1.3 Amorph. 48.4	Flora similar to above, less *D. barbadiensis*, plus *Reticulofenestra umbilica* No identifiable radiolarians Flora similar to above, plus *Ericsonia obrutam, Neococcolithes* sp., *Discoaster tani*, less *D. barbadiensis* Flora similar to Sect. 2-68, plus *Chiasmolithus oamaruensis, Markalius inversus* Foram fauna as above; *Cib. grimsdalei, oridorsalis ecuadorensis*	*Ericsonia subdisticha*	
3–4.5	3		N R N F	2.5Y 8/2 and 2.5Y 8/4	Flora similar to Sect. 2-68, plus *Reticulofenestra umbilica* No identifiable radiolarians Flora similar to Sect. 3-41. Foram fauna as above		
4.5–6	4		N R N XM F	White and pale yellow clay, some burrowing, becoming less noticeable downwards. Coarse fraction is forams and fish debris, some mineral grains.	Flora similar to Sect. 3-41 No identifiable radiolarians Flora similar to Sect. 3-41. Foram fauna as above		
6–7.5	5		N N R N F		Flora similar to Sect. 3-41, plus *Discoaster saipanensis, Ericsonia alternans, Helicopontosphaera* sp. Flora similar to Sect. 3-41, plus *Ericsonia alternans* Very rare silicified spumellarians. Flora similar to Sect. 5-70. Foram fauna as above		
7.5–9	6		N R XM N F		Flora similar to Sect. 5-70, plus reworked Cretaceous (*Cribrosphaerella ehrenbergi*), plus *Zygrhablithus bijugatus, Rhabdolithus tenuis* No radiolarians Flora similar to Sect. 6-40. Foram fauna as above.		
	CC		R N F		A few silicified radiolarians. Flora similar to Sect. 6-40. Forams: Planktonics rare; BF: *Cib. grimsdalei, Orid. ecuadorensis, Cib. martinizensis*, Stilostomellids, *Anom. alazanensis*, gyroidinids		

HOLE 119

CORE 19



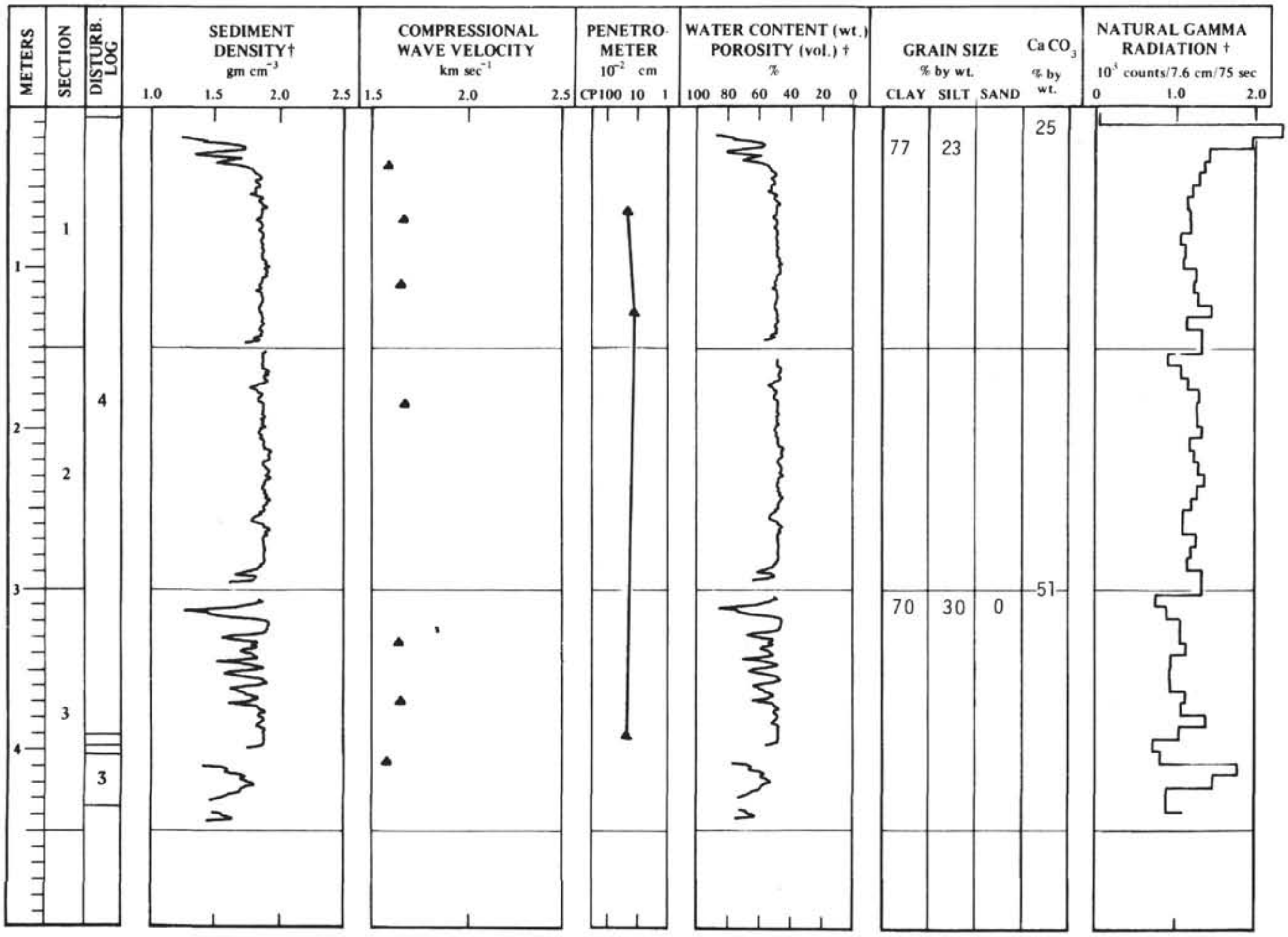
†Adjusted data, see Chapter 2

HOLE 119 356 TO 365 m
CORE 19

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1		N,F N R N	2.5Y 5/2 and 2.5Y 8/4	Dense gray brown clay with some swirls, mottles and bands of pale yellow, some black mottles. Highly burrowed	No coccoliths Foram fauna barren Flora: *Discoaster barbadiensis, Discoaster* sp. *Nannotetrina pappi, N. cristata, Reticulofenestra umbilica, Ericsonia ovalis, Chiasmolithus* sp., *Discoaster tani, D. wemmelensis* Flora similar to above, plus *Coccolithus eopelagicus, Chiasmolithus californicus*	*Discoaster tani* s.l.	MIDDLE EOCENE
1–3	2		F N R N F		passing into	Agglutinated forams plus gyroidinids Flora similar to above Silicified and zeolitized radiolarians rare Flora similar to above, plus *Ericsonia alternana* Forams: *Nuttallides truempyi, Bul. grata*		
3–4.5	3		N N N,XM R F	2.5Y 8/4 and 2.5Y 3/2	light brown gray and gray brown clay with interbedded lumps of white and gray. These could be contaminants X-ray Mineralogy (Bulk) Calc. 42.5 Qtz. 13.5 Kaol. 4.1 Mica 34.6 Mont. 3.5 Clin. 1.9 Amorph. 68.9	Flora similar to above, plus *Sphenolithus* sp., *Chiasmolithus californicus* Flora similar to Sect. 3-38 Zeolitized radiolarians common. Foram fauna as above	*Nannotetrina fulgens*	
4.5–6	4							
6–7.5	5	EMPTY						
7.5–9	6				Gray brown and light brown clay with pebbles of gray and white clay--probably cavings samples by lifting bit off bottom and putting it down again.	Zeolitized radiolarians abundant. Very abundant contaminant radiolarians from the *C. virginis* zone above.		
	CC		R N F			Flora similar to Sect. 3-38 Forams: Globigerinitids, *Gl. centralis, Nuttallides truempyi, Nodosarella subnodosa*		

HOLE 119

CORE 20



†Adjusted data, see Chapter 2

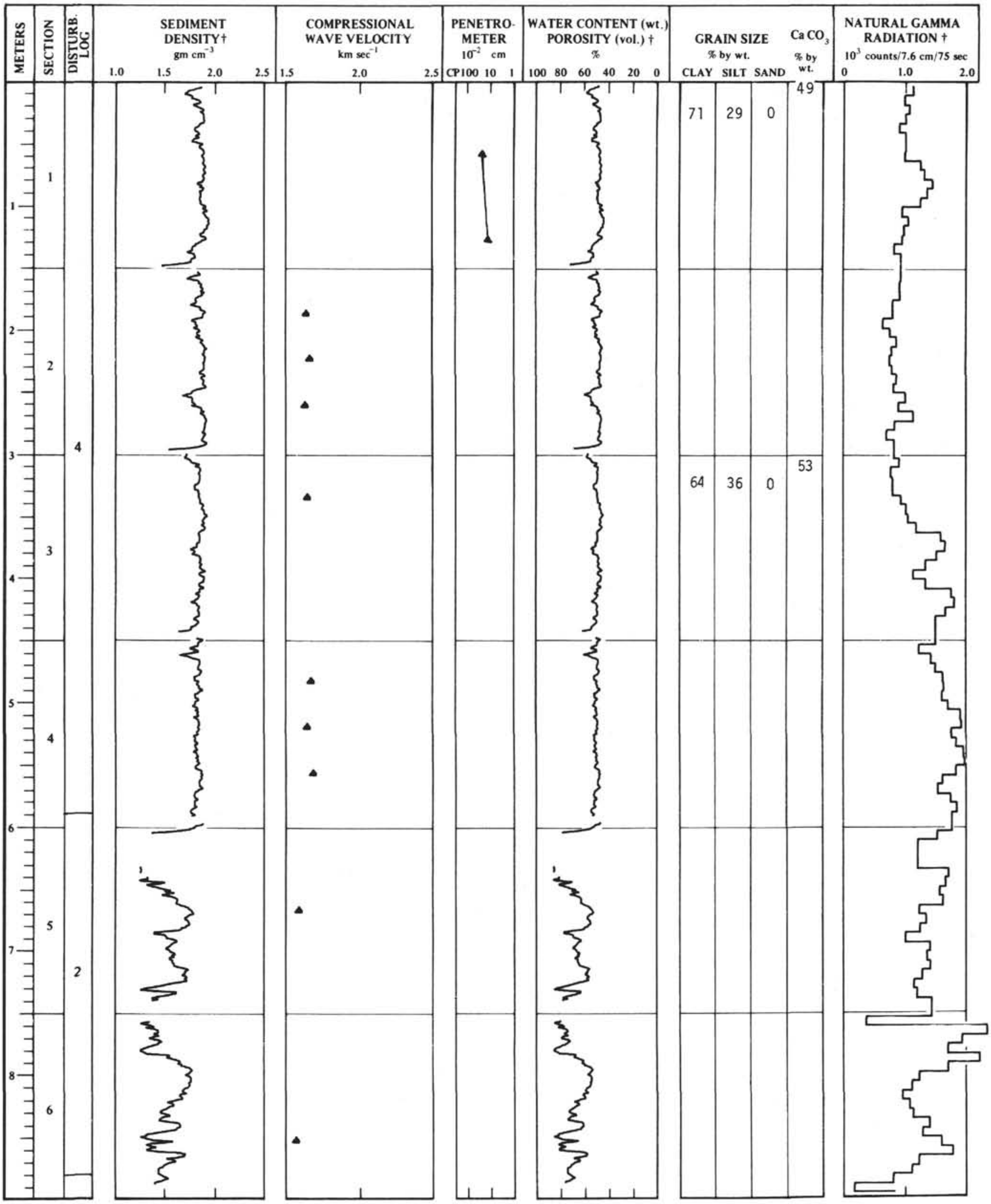
HOLE 119 365 TO 374 m

CORE 20

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1		XM R N N N,F	2.5Y 5/2 with N2, 2.5Y 3/2, 2.5Y 8/2 and 2.5Y N7 Dense grayish brown clay with swirls, mottling and bands of white, black, and gray. Black appears only as mottles in the gray brown clay. Gray brown clay thoroughly burrowed while white clays are not.	Flora: *Ericsonia ovalis, E. alternans, Nannotetrina cristata, Discoaster barbadiensis, D. saipanensis, Sphenolithus* sp. *Coccolithus eopelagicus, Chiasmolithus californicus, Chiasmolithus* sp. Flora similar to above, plus *Nannotetrina fulgens* Zeolitized radiolarians common. Flora similar to above Forams *Nuttallides truempyi, Cib. trinitatensis*	*Nannotetrina fulgens*	MIDDLE EOCENE
2	2		N N F N,F		Flora similar to above Flora similar to above Foram fauna as above Flora similar to above		
3 4	3		R N N F,XM	2.5Y 8/2 2.5Y 5/2 Color banded, dense brown silty clay 2.5Y 8/2 2.5Y 5/2 2.5Y 8/2 2.5Y 5/2 2.5Y 8/2 Last 50 cm highly disturbed.	Zeolitized radiolarians very rare. A few contaminants from the *C. virginis* zone Flora similar to above Flora similar to above, Neogene contamination? and reworked Cretaceous coccoliths (*Micula staurophora*) Foram fauna as above plus *Albamina dissonata, Bul. grata, Acarinina coalingensis*		
	CC		F	X-ray Mineralogy (Bulk) Calc. 56.6 Qtz. 8.8 Kaol. 3.0 Mica 24.5 Paly. 5.9 Clin. 1.2 Amorph. 62.0	Core Catcher: Forams: *Cib. trinitatensis, Alab. dissonata, Nuttallides truempyi, Oridorsalis ecuadorensis*		

HOLE 119

CORE 21



† Adjusted data, see Chapter 2

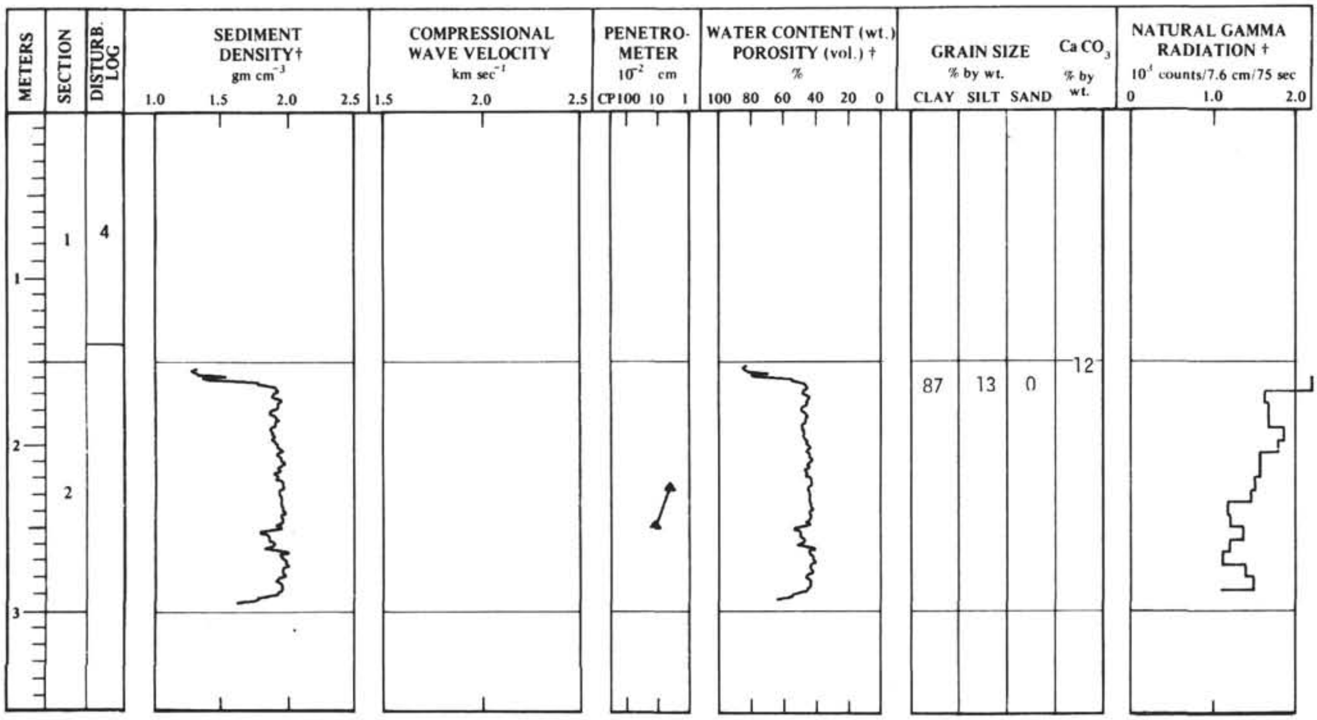
HOLE 119 374 **TO** 383m

CORE 21

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N N XM F	2.5YR 5/2 10YR 8/3 2.5YR 5/2 10YR 8/3 2.5YR 5/2 Alternating layers of very pale brown and grayish brown hard, dense clay. Pale brown areas only slightly burrowed, gray-brown areas thoroughly burrowed. Coarse fraction is forams and fish debris.	Flora: *Reticulofenestra* sp., *Discoaster barbadiensis*, *D. binodosus*, *D. sublodoensis*, *D. wemmelensis*, *Nannotetrina cristata*, *Coccolithus eopelagicus*, *Chiasmolithus eograndis*, *C. californicus*, *Ericsonia ovalis*, *E. alternans*, *Sphenolithus* sp. *Triquetrorhabdulus inversus* Flora similar to above Forams *G senni*, *Nuttallides truempyi*, *Alabamina dissonata*, *Oridorsalis ecuadorensis*, *Bulimina grata*	*Nannotetrina fulgens*	MIDDLE EOCENE
1.5–3	2		N,R F	10YR 8/3 Very pale brown, burrowed clay X-ray Mineralogy (Bulk) Calc. 41.9 Qtz. 11.0 Plag. 1.4 Kaol. 6.2 Mica 34.0 Mont. 1.3 Paly 4.1 Amorph. 63.7	Flora similar to above Zeolitized radiolarians very rare A few contaminants from *C. virginis* zone above. Foram fauna as above		
3–4.5	3		N R XM F	10YR 8/1 10YR 8/4 10YR 7/4 White to yellow brown, burrowed clay. 10YR 8/4 10YR 6/4	Flora similar to above Zeolitized radiolarians very rare. Foram fauna as above		
4.5–6	4		N	10YR 6/3 10YR 5/3 10YR 6/3 7.5YR 10YR 5/3 7.5YR 10YR 5/3 Firm burrowed clay in alternating shades of brown.	Flora similar to above, plus *Chiasmolithus calatus*		
6–7.5	5	SECTION NOT OPENED	N	Very wet brown clay	Flora similar to above		
7.5–9	6			Cuttings of pale brown and blue gray clay.			
	CC		R N F		Very rare contaminants from the *Calocycletta virginis* zone above. Flora similar to above Foram fauna as above		

HOLE 119

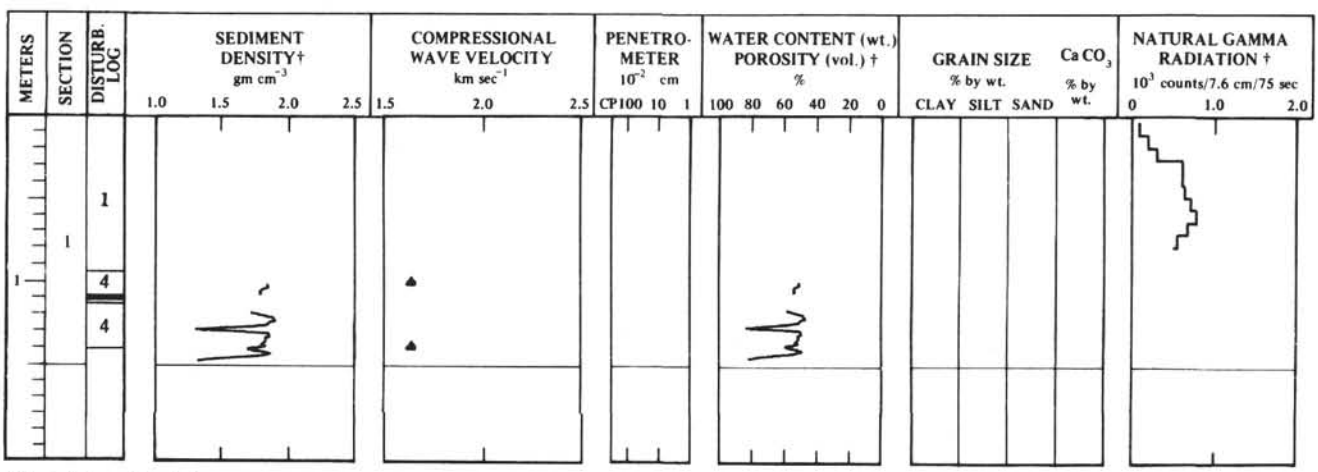
CORE 22



†Adjusted data, see Chapter 2

HOLE 119

CORE 23



†Adjusted data, see Chapter 2

HOLE 119 383 TO 392 m

CORE 22

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	SECTION NOT OPENED			10 cm of disturbed brown clay			
2	2		N R XM F	10YR 5/3 with 10YR 6/4 and 10YR 4/1	Dense brown clay with light yellowish brown bands and mottles and dark gray burrows. X-ray Mineralogy (Bulk) Calc. 62.8 Qtz. 4.8 Kaol. 4.7 Mica 16.9 Mont. 2.9 Paly. 6.5 Clin. 1.4 Amorph. 59.7	Flora: *Discoaster lodoensis*? *D. barbadiensis* *D. sublodoensis*, *Ericsonia* sp.(rims) No radiolarians No planktonic forams; BF: *Nuttallides truempyi*, *Alabamina dissonata*, *Aragonia* sp.	*Nannotetrina fulgens*	MIDDLE EOCENE
	CC		F N R			Core Catcher: Forams: *Globigerina senni*, *Acarinina coalingensis*, *Nutt. truempyi*, *Cib. havanensis* cream: *Discoaster barbadiensis*, *D. lodoensis*, *D. sublodoensis*, *Nannotetrina cristata*, *Chiasmolithus expansus*, *Cococcolithus eopelagicus*, *Ericsonia ovalis*, *Sphenolithus* sp., *Triquetrorhabdulus inversus* grey-brown: *Discoaster lodoensis*, *D. barbadiensis*, *D. kuepperi*, *D. sublodoensis*, rims of *Ericsonia ovalis* Rare contaminant radiolarians from the *Calocycletta virginis* zone above		

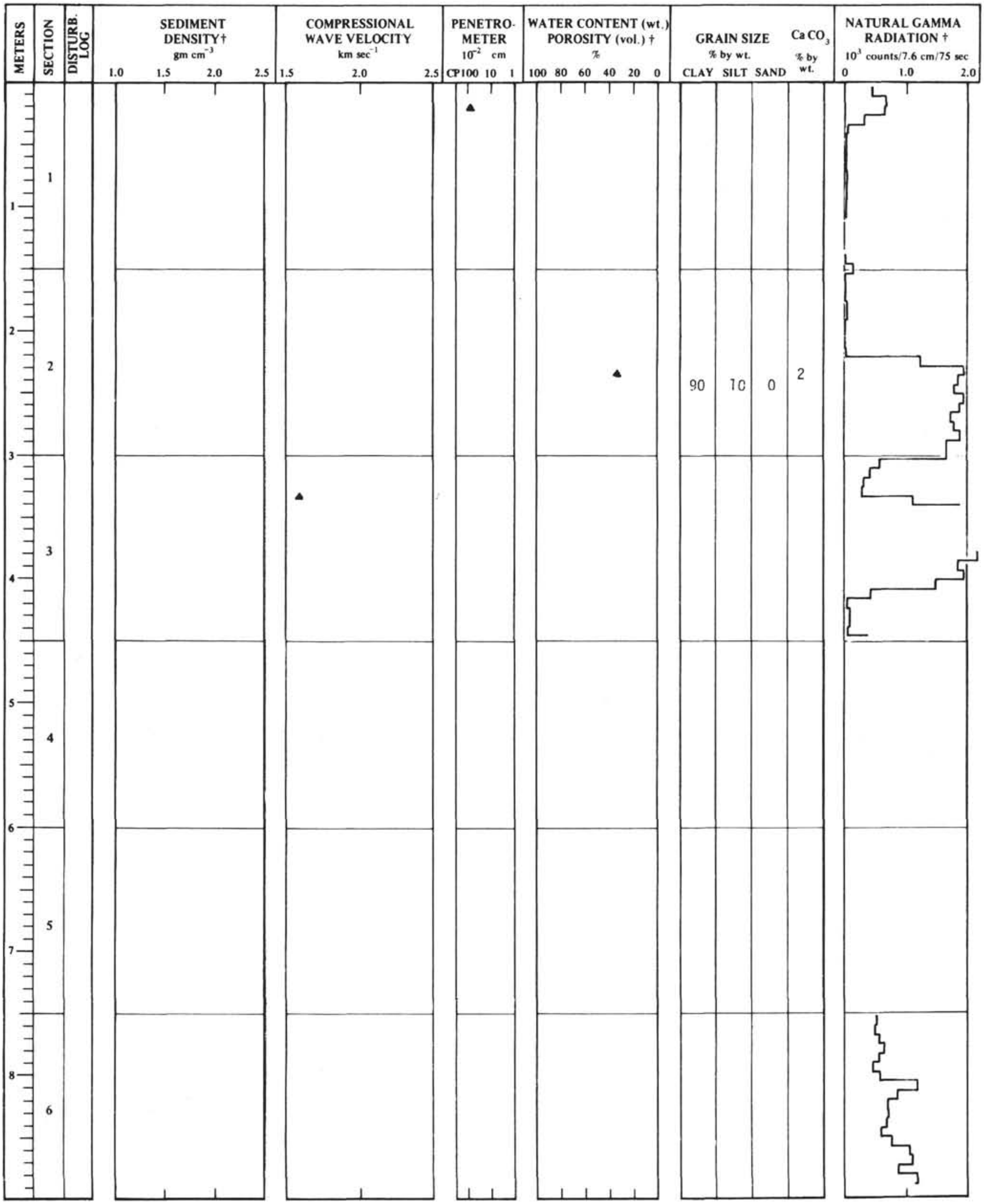
HOLE 119 392 TO 401m

CORE 23

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	EMPTY	N R N	10YR 5/3 with 10YR 6/4 and 10YR 4/1	Dense, brown clay with yellowish brown bands and mottles, dark gray burrows	Flora: *Discoaster lodoensis*, *D. barbadiensis*, *D. wemmelensis*, *D. binodosus*, *D. kuepperi*, *Ericsonia ovalis* Flora similar to above plus *Marthasterites tribrachiatus* No radiolarians	*Discoaster lodoensis*	EARLY EOCENE
	CC		R N F			Core Catcher: No radiolarians, Flora similar to Sect. 1-138 No planktonic forams	*Marthasterites tribrachiatus*	

HOLE 119

CORE 24



†Adjusted data, see Chapter 2

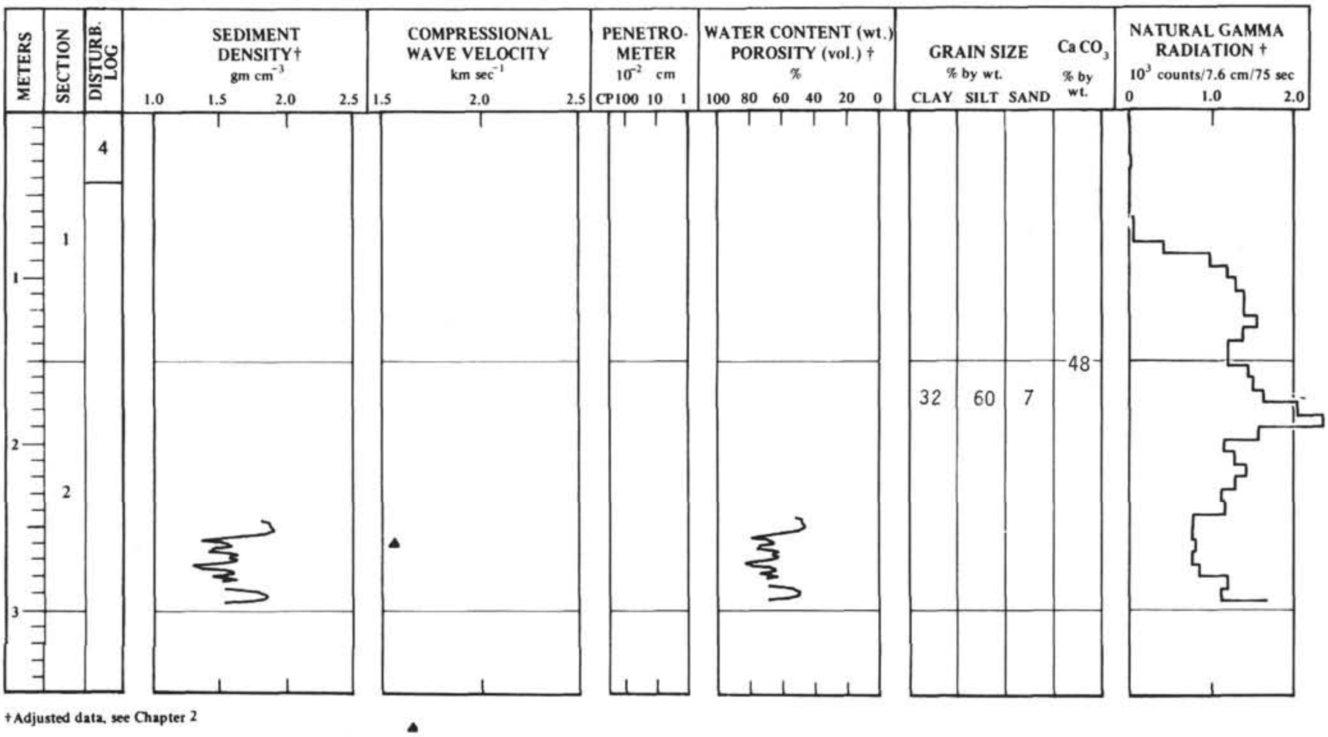
HOLE 119 401 **TO** 410 **m**

CORE 24

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	EMPTY	N R F	10YR 3/3 Dense, dark brown clay, burrowed dark gray with light yellowish brown mottles. Coarse fraction consists of a few fish teeth and pyritized worm tubes	No coccoliths No radiolarians Rare benthonic forams		
2	2		N R N F		No coccoliths No radiolarians. Rare fish teeth. No coccoliths Fauna as above		
3 4	3		N R N XM	Alternating brown and very pale brown dense clay bands, average 5 cm thick. 10YR 4/3 Grayish-green (5G 6/1) 10YR 6/4 band at 100-105 cm in and Sect. 3 10YR 8/4	No coccoliths No radiolarians-Fish teeth rare to common. No coccoliths		
5 6	4	NO CORE					
7	5						
8	6	SECTION NOT OPENED		Sloppy, disturbed brown clay.		*Discoaster binodosus*	EARLY EOCENE
	CC		F N R		Rare benthonic forams: *Geudryina, Dorothia* Flora: *Discoaster multiradiatus, D. binodosus, D. gemmeus, D.* cf. *falcatus, D. lenticularus, Ericsonia ovalis, Fasciculithus* sp. No radiolarians		

HOLE 119

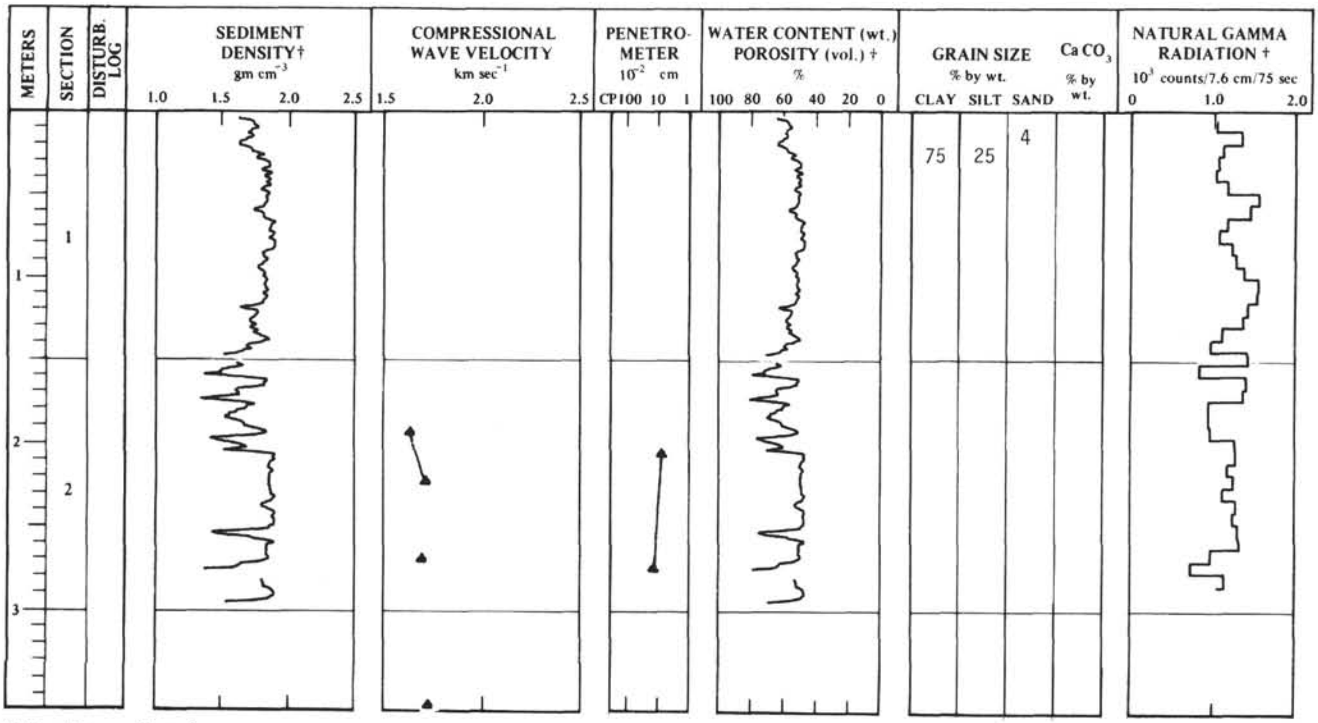
CORE 25



†Adjusted data, see Chapter 2

HOLE 119

CORE 26



†Adjusted data, see Chapter 2

HOLE 119 CORE 25 410 TO 419 m

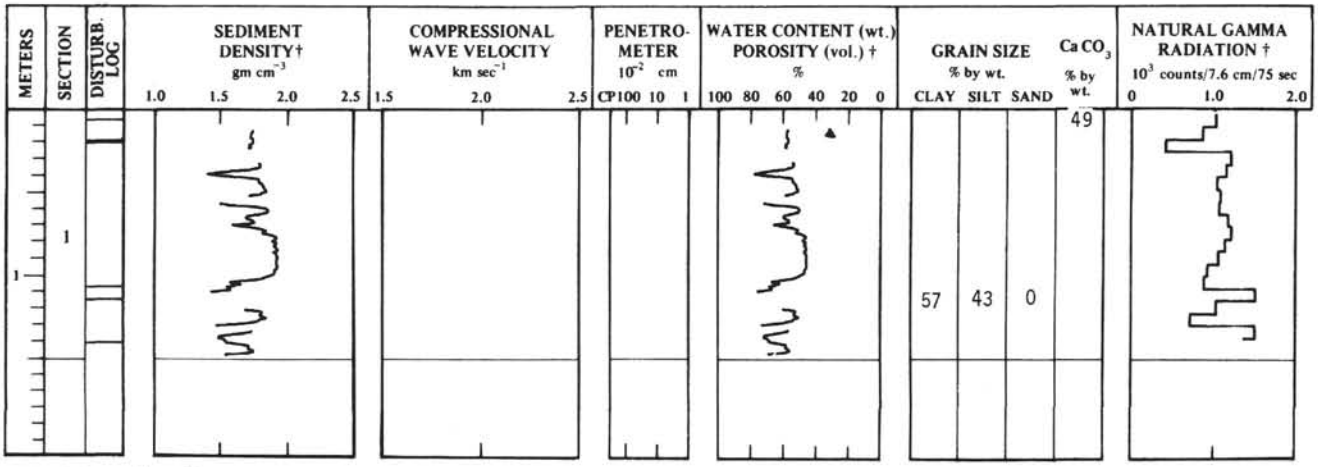
METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
	1		N,F R N N,F N	5Y 6/1 Dense, light olive gray clay with yellowish brown clay at the top and mottled yellow/brown in places. 5YR 5/4 5GY 6/1 Greenish gray clay, mottled with light bluish gray.	Flora: *Discoaster multiradiatus, D. gemmeus, D. helianthus, D. falcatus, D. lenticularis, Ericsonia cava, E. subpertusa, Chiasmolithus californicus, Scapholithus apertus, Toweius eminens, T. craticulus, T. tovae, Fasciculithus tympaniformis, F. involutus, F. schaubi, Semihololithus kerabyi, S. biskayae, Ellipsolithus macellus, E. distichus, Heliolithus kleinpelli, Sphenolithus primus, Neococcolithus* sp. *Zygodiscus plectopons, Braarudosphaera discula* and reworked Cretaceous coccoliths	*Discoaster multiradiatus*	LATE PALEOCENE
	2		N N F N XM N	5GY 4/1 5GY 6/1 5GY 4/1 Alternating layers of greenish 5GY 6/1 gray and dark greenish gray 5GY 4/1 clay. 5GY 6/1 Silicified limestone layers at 138-140 in Sec. 2 5GY 4/1	*Discoaster multiradiatus, D. helianthus, D. falcatus, Ericsonia cava* Flora similar to above (Sect. 1) Foram fauna: Rare planktonics: *G. subbotinae, G. aequa, G. pasionensis, Acar. coalingensis* Flora similar to above		
	CC		R N	X-ray Mineralogy (Bulk) Calc. 66.1 Qtz. 5.9 Plag. 1.7 Mica 14.8 Mont. 2.2 Clin. 9.2 Amorph. 53.1	Flora similar to above Zeolitized radiolarians common. Core Catcher: Zeolitized radiolarians common. Flora similar to above		

HOLE 119 CORE 26 419 TO 428 m

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
	1		N R N XM	5GY 4/1 5Y 6/1 Alternating bands of gray, 5GY 4/1 greenish gray and white dense 5GY 6/1 clay. Silicified limestone bands at 15-16 and 127-128. 5Y 4/1 5Y 8/1 5GY 4/1 5Y 6/1	No radiolarians. Flora: *Discoaster multiradiatus, D. nobilis, D. gemmeus, D. lenticularis, D. falcatus, Toweius eminens, T. tovae, T. craticulus, Sphenolithus primus, Fasciculithus involutus, F. tympaniformis, Semihololithus kerabyi, S. biskayae, Ellipsolithus macellus, E. distichus, Discolithina plana, Zygodiscus sigmoides, Z. adamas, Z. plectopons, Scapholithus apertus, Neococcolithus protenus, N. concinnus, N. junctus, Chiasmolithus danicus, C.* aff. *gigas, Ericsonia cava* + reworked Cretaceous coccoliths	*Discoaster multiradiatus*	LATE PALEOCENE
	2		R N N F	5Y 6/2 Dense, uniform,gray pale olive and white clay. 5Y 6/1 5Y 8/1 5Y 6/1	Flora similar to above Zeolitized radiolarians very abundant. Silicified and corroded Paleocene radiolarians include *Lithocampium* sp. A, *Phormocyrtis striata* One contaminant *L. bipes* from *C. virginis zone.*		
	CC		R N F	X-ray Mineralogy (Bulk) Calc. 33.4 Qtz. 12.9 Plag. 5.4 Mica 32.6 Chl. 1.2 Mont. 3.0 Clin. 11.6 Amorph. 57.4	Flora similar to above Rare planktonic forams Core Catcher: Zeolitized, silicified and corroded radiolarians abundant. *Lithocampium* sp. A abundant, *Phormocyrtis striata*. Flora similar to above. No forams.		

HOLE 119

CORE 27



+Adjusted data, see Chapter 2

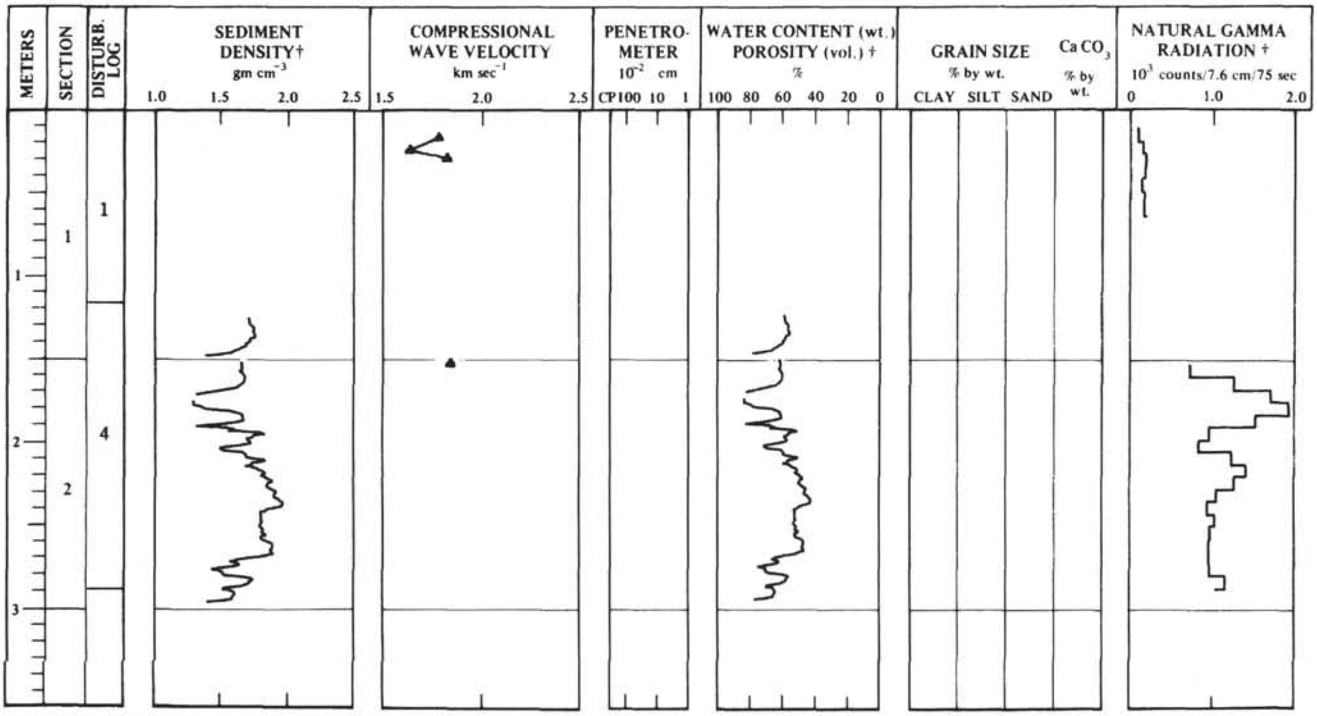
HOLE 119 428 TO 433m

CORE 27

METERS	SECTION	LITHOL.	SAMPLES		LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1 CC		R N XM N,F F N,R R N F	2.5Y 4/1; 5Y8/1; 5Y 5/1	Alternating bands of uniform hard gray clay X-ray Mineralogy (Bulk) Calc. 51.3 Dolo. 6.5 Qtz. 8.1 Plag. 4.9 Mica 27.3 Mont. 2.0 Amorph. 51.9	Silicified and corroded radiolarians rare. Zeolitized radiolarians very rare. *Lithocampium* sp. A, *Bekoma bidarfensis*, *Phormocyrtis striata* Flora: *Discoaster multiradiatus*, *D. nobilis D. gemmeus*, *D. lenticularis*, *D. falcatus*, *Toweius eminens*, *T. tovae*, *T. craticulus*, *Sphenolithus primus*, *Fasciculithus involutus*, *F. tympaniformis*, *Semiholothus kerabyi*, *S. biskayae*, *Ellipsolithus macellus E. distichus*, *Discolithina plana*, *Zygodiscus sigmoides*, *Z. adamas Z. plectopons*, *Scapholithus apertus*, *Neococcolithus protenus*, *N. concinnus*, *N. junctus*, *Chiasmolithus danicus*, *Ericsonia cava*, plus reworked Cretaceous coccoliths No coccoliths No forams Silicified and corroded radiolarians very rare. *Lithocampium* sp. A, (?) *P. striata* Core Catcher: Zeolitized radiolarians very abundant. Silicified and corroded radiolarians very rare-*Lithocampium* sp. A. Flora similar to above Forams: *Globigerina velascoensis*, *Acarinina esnaensis*	*Discoaster multiradiatus*	LATE PALEOCENE

HOLE 119

CORE 28



†Adjusted data, see Chapter 2

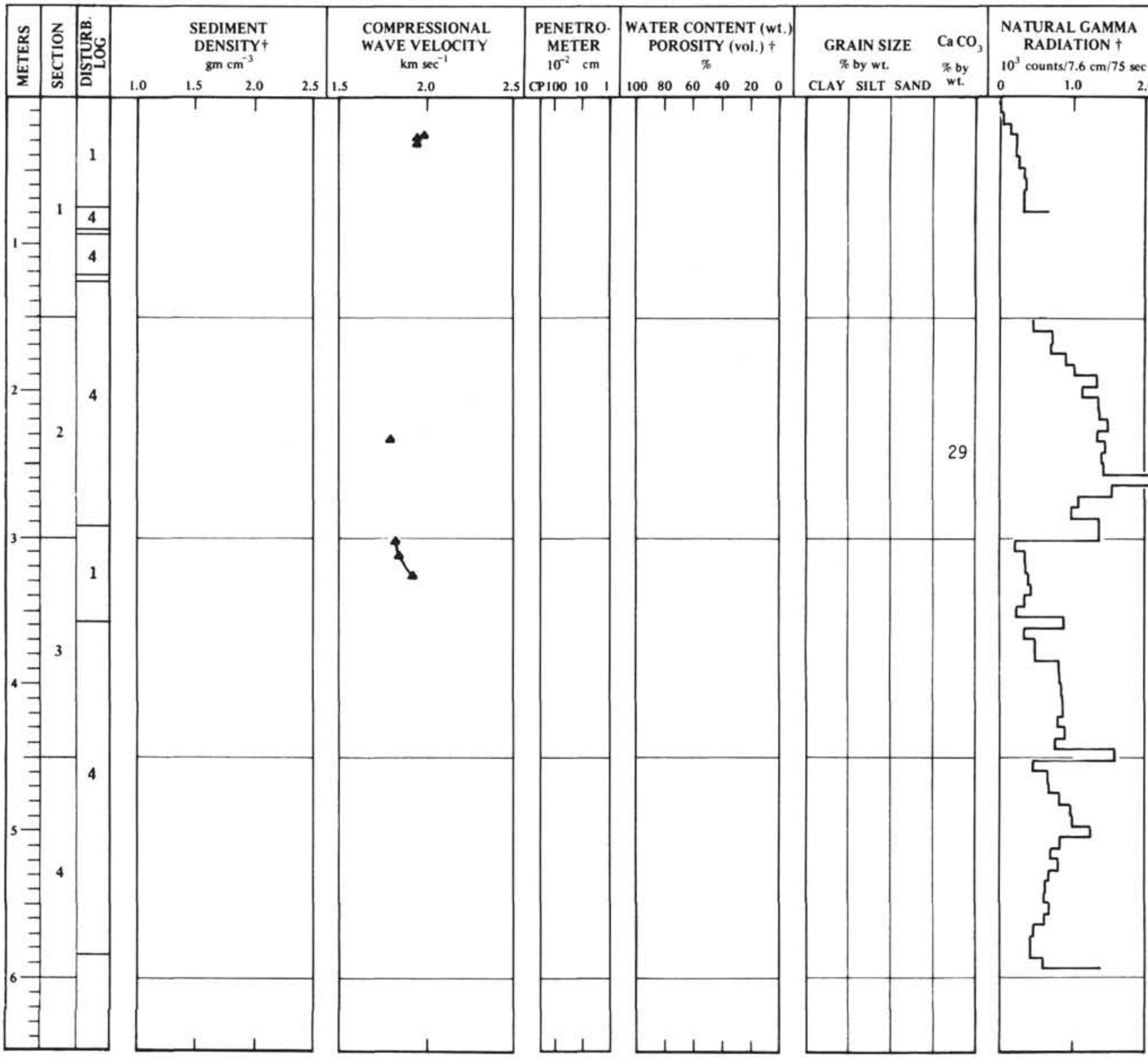
HOLE 119   443 **TO** 452 m

CORE 28

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	EMPTY					
2	2		XM N,R F N	N8 NF 5GY 6/1 5Y 4/1 5Y 8/1 5Y 4/1 5Y 6/1 5Y 7/1 Beds of uniform clay in various shades of gray. Calcareous burrows at 0-22. Very hard sandstone layers at 55-60 in Section 2. X-ray Mineralogy (Bulk) Calc. 54.1 Qtz. 10.9 Plag. 1.6 Mica 8.1 Mont. 3.0 Clin. 3.4 Cris. 18.8 Amorph. not calculated	Flora: *D. nobilis, Discoaster multiradiatus, D. gemmeus, D.* cf. *falcatus, Sphenolithus primus, Fasciculithus involutus, F. tympaniformis, Toweius craticulus, T. tovae, T. eminens, Chiasmolithus bidens, C. danicus, C. eograndis, Ericsonia cava, Semihololithus biskayae, S. kerabyi, Heliolithus kleinpelli, Ellipsolithus distichus, E. macellus, Zygodiscus plectopons, Neococcolithus* sp. Flora similar to above Zeolitized radiolarians common. A few silicified spumellarians. Forams: *Chiloguembelinids*, rare planktonics	*Discoaster multiradiatus*	PALEOCENE
	CC		R N F		Core Catcher: Zeolitized radiolarians common. Corroded and silicified radiolarians common (20-30 species): *Lithocampium* sp. A, *Bekoma bidarfensis, Phormocyrtis striata, Stichomitra* (?) sp. Flora similar to above, less *Discoaster multiradiatus* Barren of forams	Core Catcher ↓ *Discoas-ternobilis*	

HOLE 119

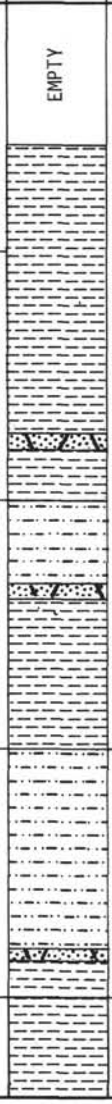
CORE 29



†Adjusted data, see Chapter 2

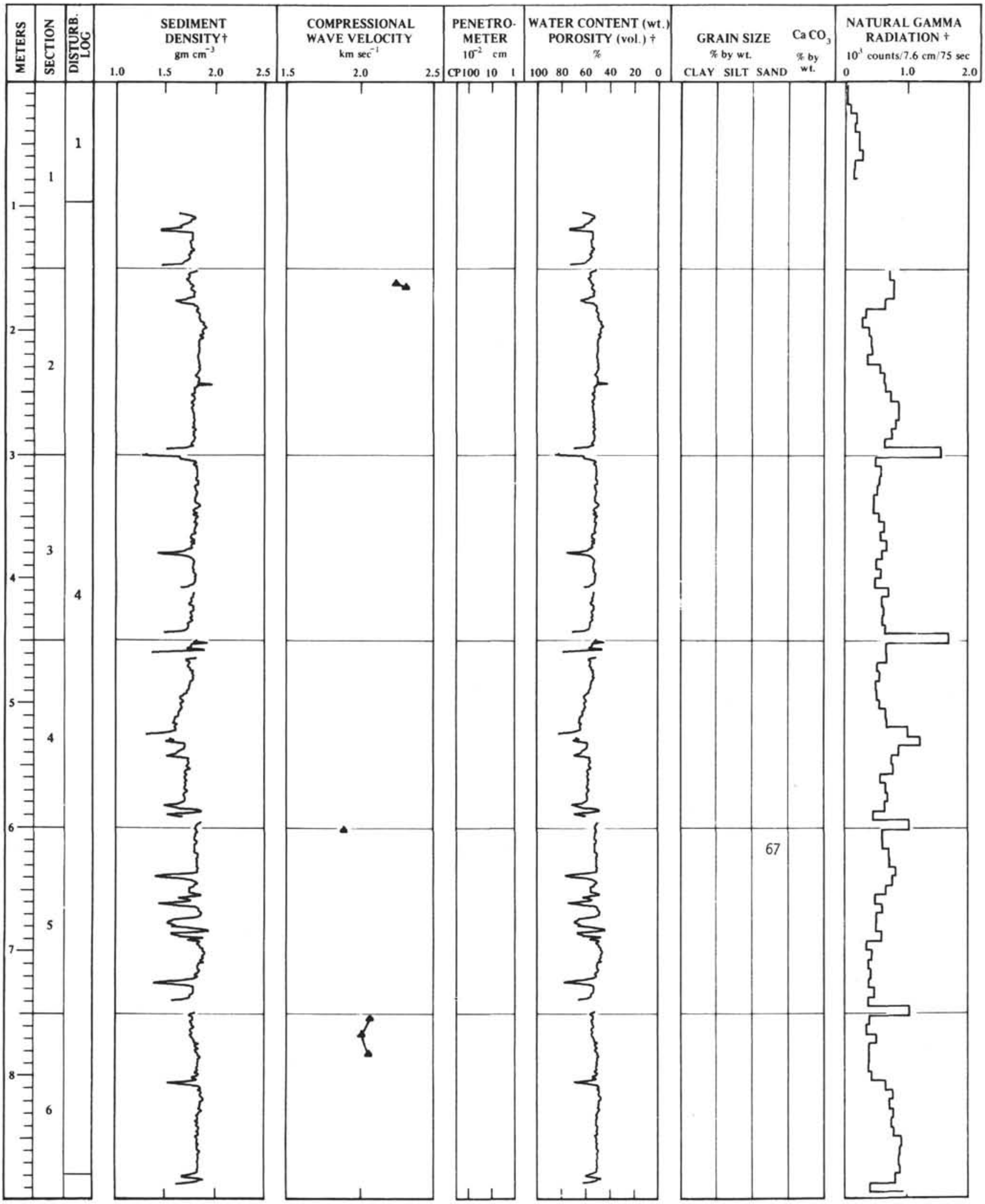
HOLE 119 459 **TO** 465 m

CORE 29

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1		N F	5Y 7/1 Light gray silty clay; hard, laminated, slightly burrowed	Flora: *Discoaster gemmeus, D. nobilis, Fasciculithus tympaniformis, F. involutus Semiholoithus kerabyi, S. biskayae, Sphenolithus primus, Toweius craticulus, T. eminens, Ellipsolithus distichus, R. macellus, Heliolithus kleinpelli, H.* cf. *riedeli, Discolithina plana, Ericsonia cava, Chiasmolithus bidens, C.* aff. *gigas, Cruciplacolithus inseadus, Scapholithus apertus, Neococcolithus* sp., plus reworked Cretaceous coccoliths Indeterminable forams	*Discoaster nobilis*	PALEOCENE
2	2		N,F XM N	5Y 4/1 Dark gray indurated clay 5Y Cross bedded calcareous, sandstone. 5Y7/1 Light gray uniform clay	Flora similar to above, less *Semihololithus biskayae, S. kerabyi* Fauna essentially barren Flora similar to Sect. 2-65.		
3–4	3		N	5Y 6/1 Silty clay Calcareous sandstone 5Y 7/1 Indurated light gray clay 5G 6/1 Slightly burrowed green gray clay	Flora similar to Sect. 2-65		
5	4		N	5Y 6/1 Dense gray silty clay Calcareous sandstone 5Y 6/1 Indurated green-gray clay	Flora similar to Sect. 2-65		
	CC		R N F	X-ray Mineralogy (Bulk) Calc. 26.4 Qtz. 14.8 Plag. 5.7 Mica 39.0 Mont. 2.4 Clin 11.8 Amorph. 52.5	Core Catcher: Silicified radiolarians rare. *Lithocampium* sp. A Flora similar to Sect. 2-65 Forams: *G. acuta-velascoensis* gp plus *Bolivina, Melonis,* discorbids, chiloguembelinids		

HOLE 119

CORE 30



†Adjusted data, see Chapter 2

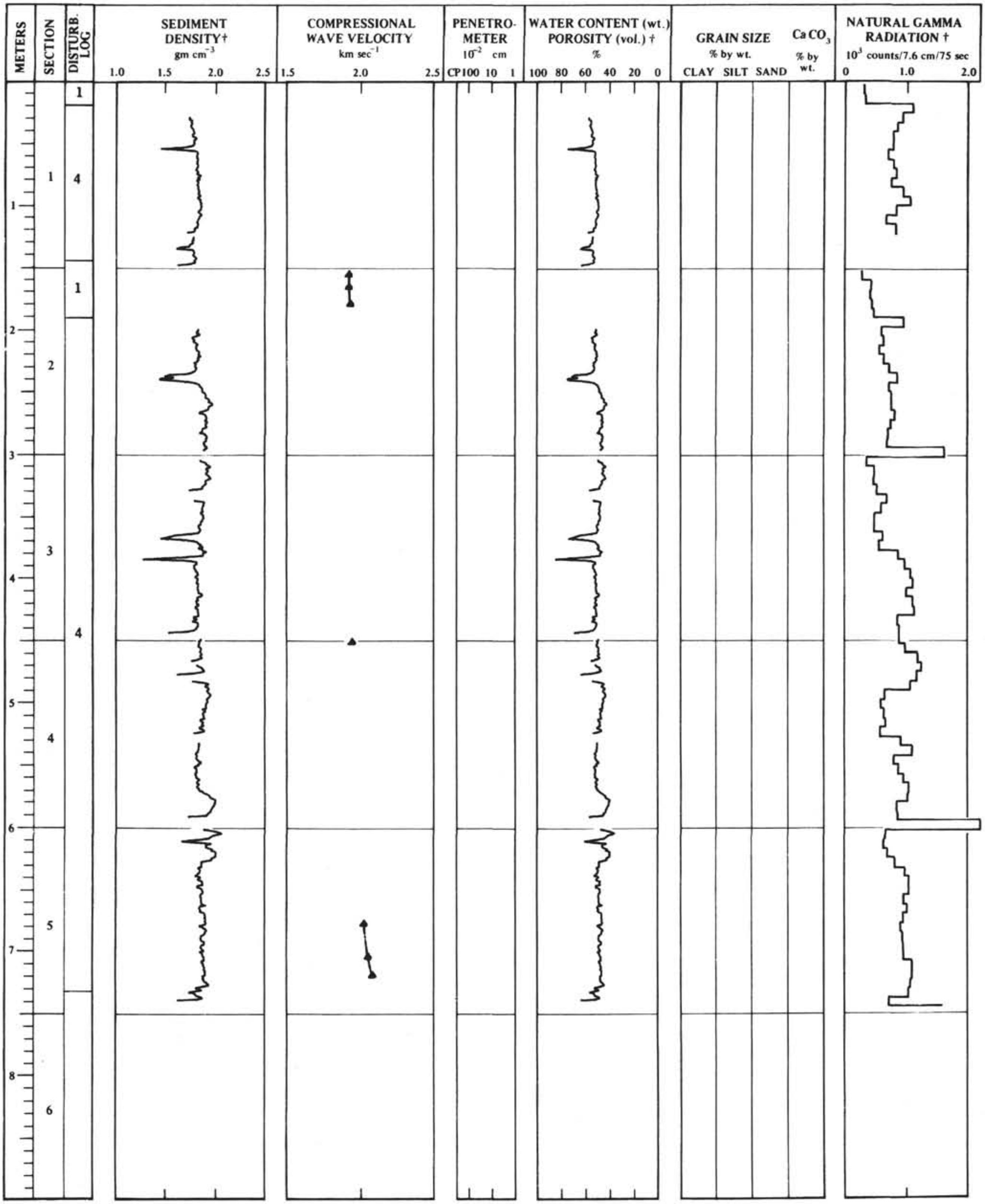
HOLE 119 493 **TO** 502 m

CORE 30

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY		DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	EMPTY			Whole core consists of short sections of solid rock.		*Discoaster nobilis*	LATE PALEOCENE
1–2			N	N7 ---	Whole core is indurated dense clay. Dip ~10° at bottom of Section 1	Flora: *Discoaster gemmeus, D. nobilis, Fasciculithus tympaniformis, F. involutus, Sphenolithus primus, S. anarthopus, Chiasmolithus danicus, Toweius eminens, T. craticulus, T. tovae, Ellipsolithus macellus, E. distichus, Ericsonia cava, Thoracosphaera* sp. *Neococcolithus* sp. *Braarudosphaera imbricata, B. bigelowi,* plus reworked Cretaceous coccoliths		
2–3	2		XM	N8 N7 N8 N8	Burrowed at 0-37 and 86-150 in Section 2			
3–4.5	3		N	5Y 6/1 ↓ 5Y 4/1 ---	Dark olive gray laminations at 0-10 and 85-90 in Section 3 laminations dip at ~10° X-ray Mineralogy (Bulk) Calc. 79.1 Qtz. 4.6 Mica 9.2 Mont. 3.8 Clin. 3.4 Amorph. 41.6	Flora similar to above		
4.5–6	4		N	5Y 6/1 N3 N3 and 5GY 6/1 N3		Flora similar to above, less *Discoaster nobilis*	*Discoaster gemmeus*	
6–7.5	5		XM N	5Y 6/1 --- 5Y 7/1 ↓ 5GY 8/1	Dark gray laminations at 50-60 and around 75 in Section 5 Small faults cut laminations? compaction	Flora similar to Sect. 4		
7.5–9	6		N F	↓ 5Y 6/1	Some laminae in Section 6 dip at ~15°.	Flora similar to Sect. 4 Forams: Chiloguembelinids and small globigerinids		
	CC		R N F			Zeolitized radiolarians common. Silicified and corroded radiolarians rare: *Lithocampium* sp. A, (?) ?*Stichomitra alamedaensis* Flora similar to Sect. 4 Forams rare; *Globorotalia velascoensis*		

HOLE 119

CORE 31



†Adjusted data, see Chapter 2

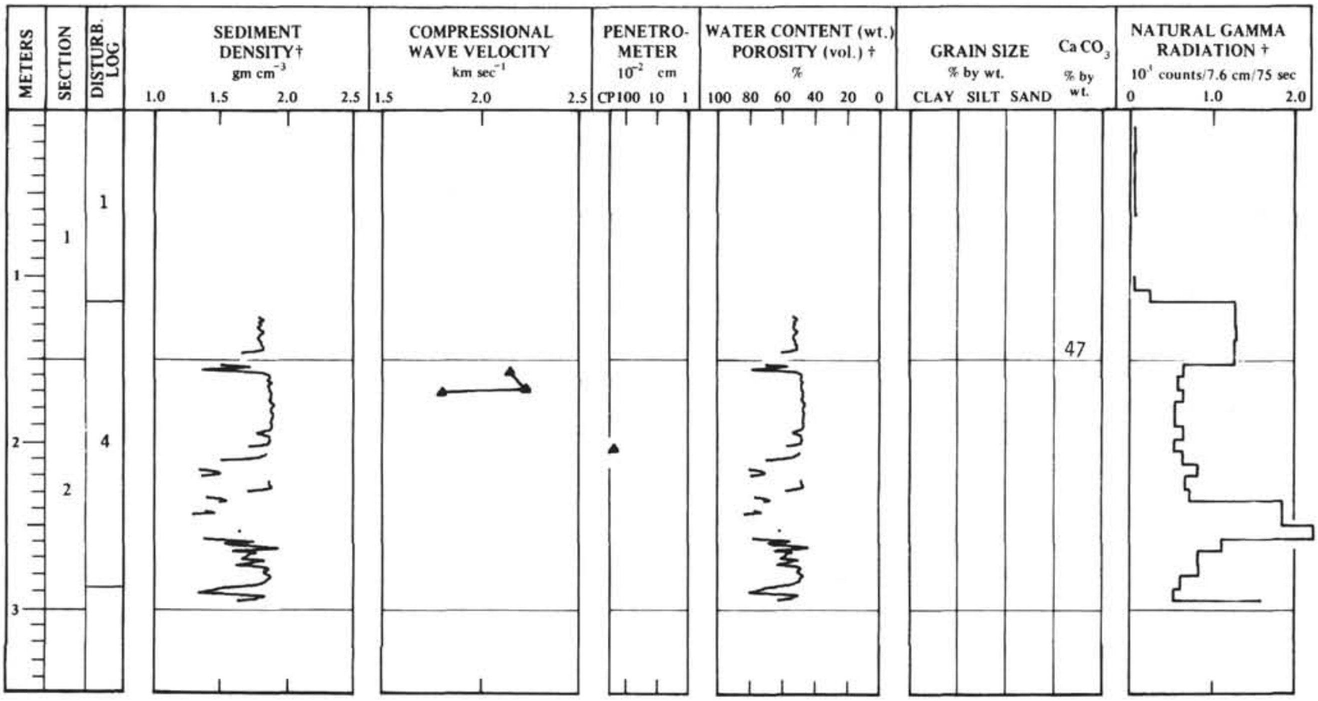
HOLE 119 543 **TO** 552 **m**

CORE 31

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	EMPTY	XM N XM	5GY 6/1 5Y 5/1 Whole core consists of several pieces of solid rock. All dense, indurated gray clay. Laminae dip ~10° N4 5GY 6/1	Flora: *Heliolithus kleinpelli, H.* cf. *riedeli, Fasciculithus tympaniformis, F. involutus, Toweius tovae, T. eminens, T. craticulus, Ellipsolithus distichus, E. macellus, Sphenolithus primus, S. anarrhopus, Scapholithus apertus, Braarudosphaera bigelowi, B. discula, Cruciplacolithus tenuis, Chiasmolithus danicus, C. bidens, C.* aff. *gigas, Zygodiscus plectopons, Ericsonia cava, E. subpertusa, Thoracosphaera* sp. *Neococcolithus* sp. plus reworked Cretaceous coccoliths	*Heliolithus kleinpelli*	PALEOCENE
2 3	2		N	5GY 6/1 N3 Laminae of dark gray immediately below dark gray layer N7 White mottles	Flora similar to above, less *Zygodiscus plectopons*		
4	3		XM XM N	N8 5G 8/1 Laminae dip ~10° 5G 8/1 White mottles 5Y 5/1			
5 6	4		XM XM N	5Y 6/1 5GY 7/1 5Y 6/1 X-ray Mineralogy (Bulk): Calc. 59.4; Qtz. 7.8; Plag. 3.6; Mica 20.7; Mont. 5.7; Clin. 2.8; Amorph. 48.0	Flora similar to Sect. 2 Flora similar to Sect. 2		
7	5		N	5GY 6/1 Laminae dip ~7° 5G 7/1	Flora similar to Sect. 2		
	CC		R N F		Core Catcher: Very rare silicified radiolarians. Flora similar to Sect. 2 Fauna: Barren		

HOLE 119

CORE 32



†Adjusted data, see Chapter 2

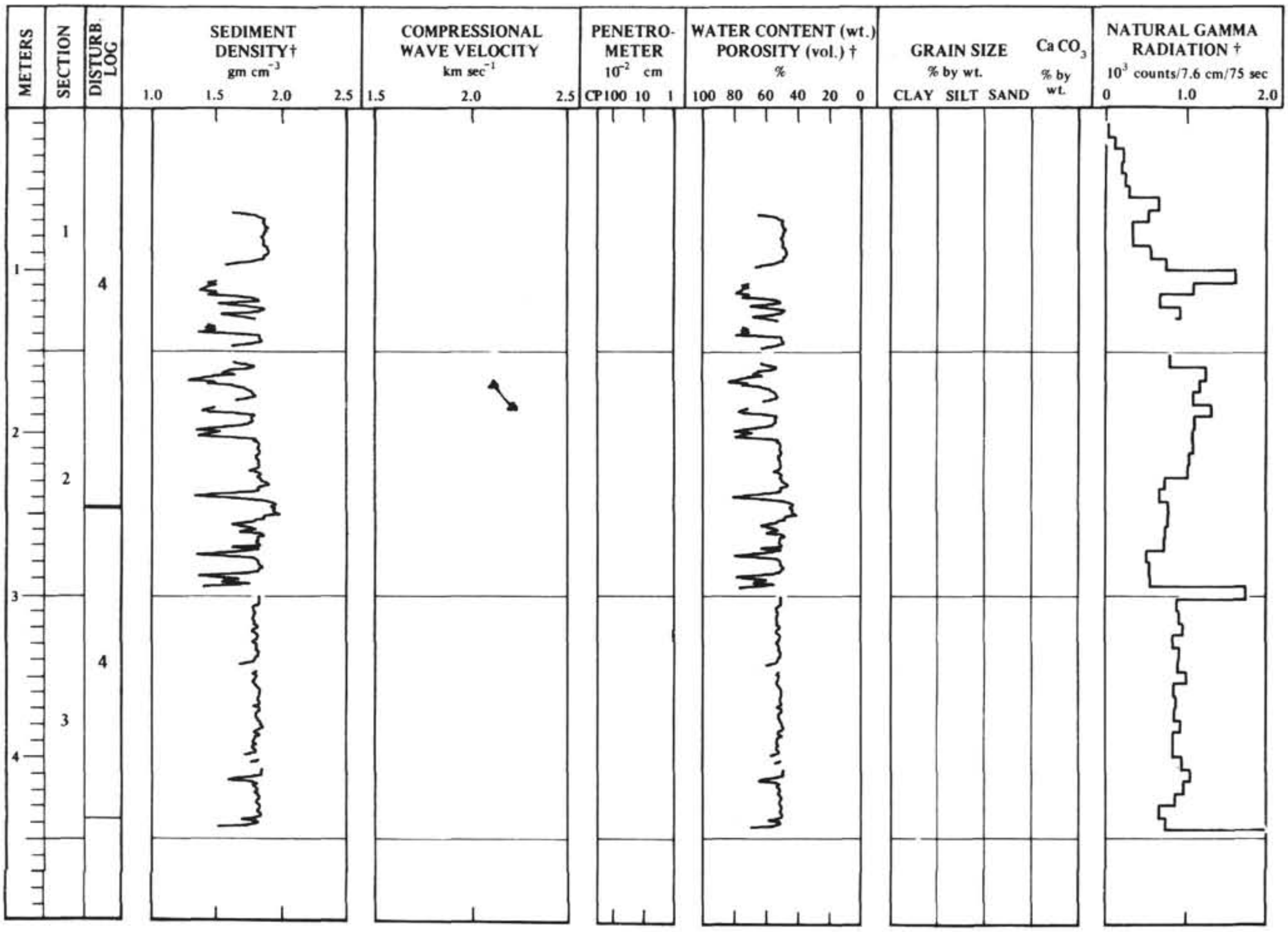
HOLE 119 592 **TO** 594 **m**

CORE 32

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	EMPTY	N	Whole core is short sections of solid rock. 5Y 6/1 5Y 5/2 Dense indurated gray clay.	Flora: *Heliolithus kleinpelli, H.* cf. *riedeli, Fasciculithus involutus, F. tympaniformis, Toweius craticulus, T. tovae, T. eminens, Cruciplacolithus tenuis, Chiasmolithus danicus, C. bidens, Ericsonia cava, E. subpertusa, Sphenolithus primus, S. anarrhopus, Zygodiscus sigmoides, Z.* cf. *plectopons, Ellipsolithus macellus, E. distichus, Thoracosphaera* sp., *Neococcolithus* sp., *Cyclolithus? robustus*, plus reworked Cretaceous coccoliths	*Heliolithus kleinpelli*	LATE PALEOCENE
2	2		N	Intense burrowing at 5-18 and 127-150 in Section 2. 5G 8/1 5Y 5/1 5G 8/1 Laminae dip at ~10° 5Y 5/1	Flora similar to above, plus *Braarudosphaera bigelowi, B. imbricara, Micrantholithus crenulatus, Markalius inversus*		
	CC		R N F		Core Catcher: No radiolarians. Flora similar to Sect. 2. Forams: *Globigerina triloculinoides, G. triangularis*		

HOLE 119

CORE 33



†Adjusted data, see Chapter 2

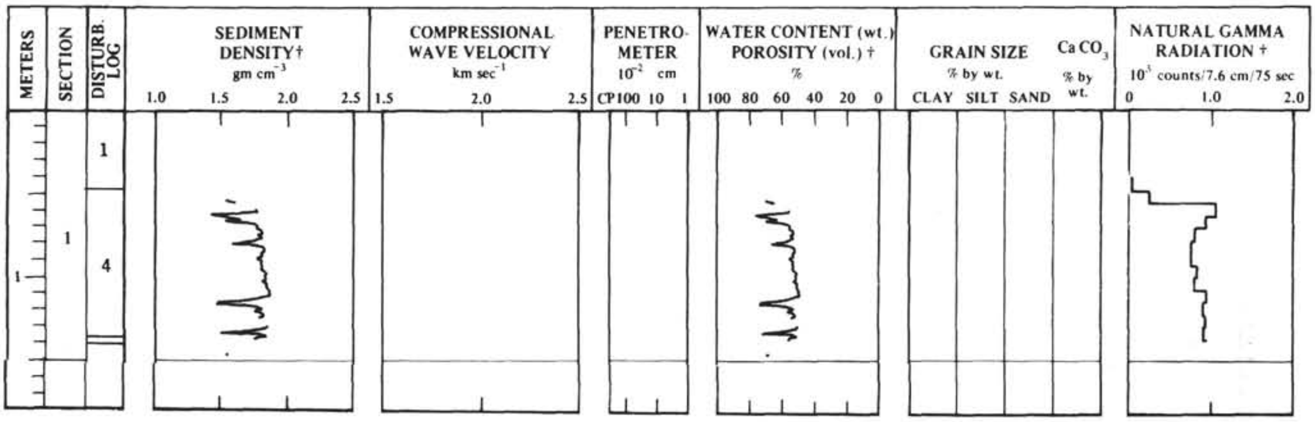
HOLE 119 594 **TO** 600^{m}

CORE 33

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1	GAP	N	N8 N5 5GY 6/1 N7 5GY 6/1 Whole core is several short sections of solid rock Dense indurated gray clay and calcarenite Calcarenite has convolute bedding and lamination	Flora: *Fasciculithus tympaniformis, Toweius eminens, T. tovae, T. craticulus, Ellipsolithus distichus, E. macellus, Ericsonia cava, E. subpertusa, Cyclolithus robustus, Chiasmolithus* sp. *Cruciplacolithus tenuis, Zygodiscus sigmoides, Sphenolithus primus, S. anarrhopus, Thoracosphaera* sp., *Neococcolithus* sp., *N. junctus* plus reworked Cretaceous coccoliths	*Fasciculithus tympaniformis*	PALEOCENE
2	2		N	5Y 5/1 5Y 6/1 5Y 5/1 5Y 6/1 5Y 5/1 5Y 6/1 Slickensides at 100-127 in Section 2 5Y 4/1 5Y 6/1	Flora similar to above, poorer		
3			N		Flora similar to above, less *Toweius eminens, T. tovae*		
4	3			5Y 5/1 5Y 4/1 White "mottling" at 50-150 in Section 3 5Y 5/1			
	CC		R N F		Core Catcher: No radiolarians Flora similar to above, less *Toweius eminens, T. tovae* Fauna: Barren		

HOLE 119

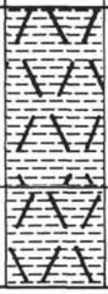
CORE 34



†Adjusted data, see Chapter 2

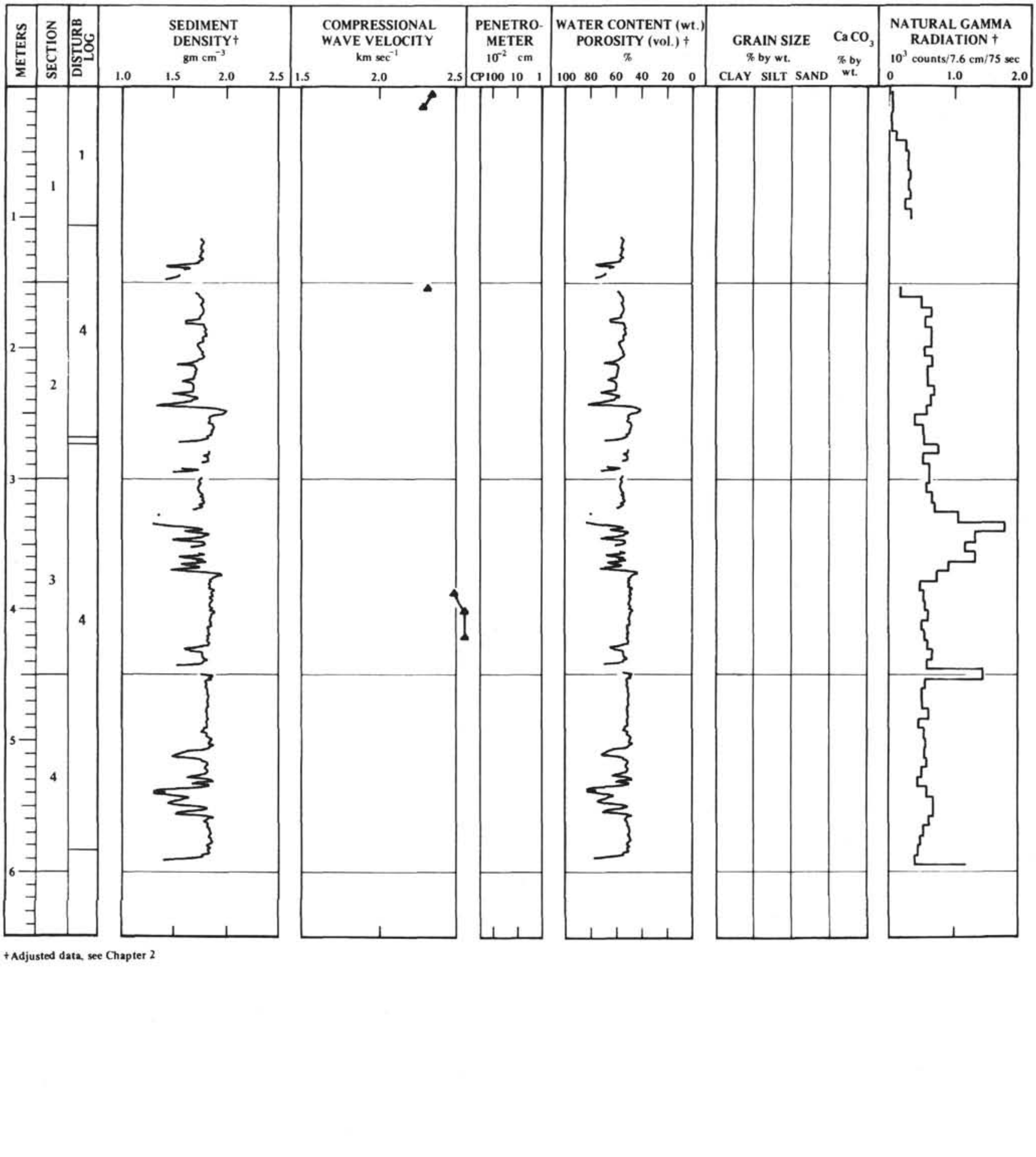
HOLE 119 622 **TO** 630**m**

CORE 34

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1		XM N	5GY 6/1 5GY 4/1 Greenish gray, very hard, fine grained marly clay. Indurated Burrowed horizons have sharp top and transitional lower part. Pyritized burrow at 45 Dip ∿20°	Flora: *Ericsonia cava*	*Fasciculithus tympaniformis*	LATE PALEOCENE
	CC		F N R	X-ray Mineralogy (Bulk) Calc. 70.8 Qtz. 4.0 Mica 3.6 Mont. 2.9 Cris. 18.8 Amorph. 46.9	Core Catcher: Fauna: Barren Flora: *Fasciculithus tympaniformis, Markalius inversus, Braarudosphaera bigelowi, Prinsius bisulcus, Cruciplacolithus tenuis, Chiasmolithus danicus, Cyclolithus robustus, Ericsonia cava, Ellipsolithus distichus Scapholithus apertus, Sphenolithus primus, S. anarrhopus, Neococcolithus* sp. *N. junctus, Thoracosphaera* sp. plus reworked Cretaceous coccoliths Corroded and silicified radiolarians rare.		

HOLE 119

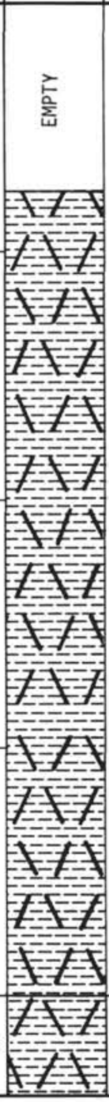
CORE 35



†Adjusted data, see Chapter 2

HOLE 119 630 **TO** 648 **m**

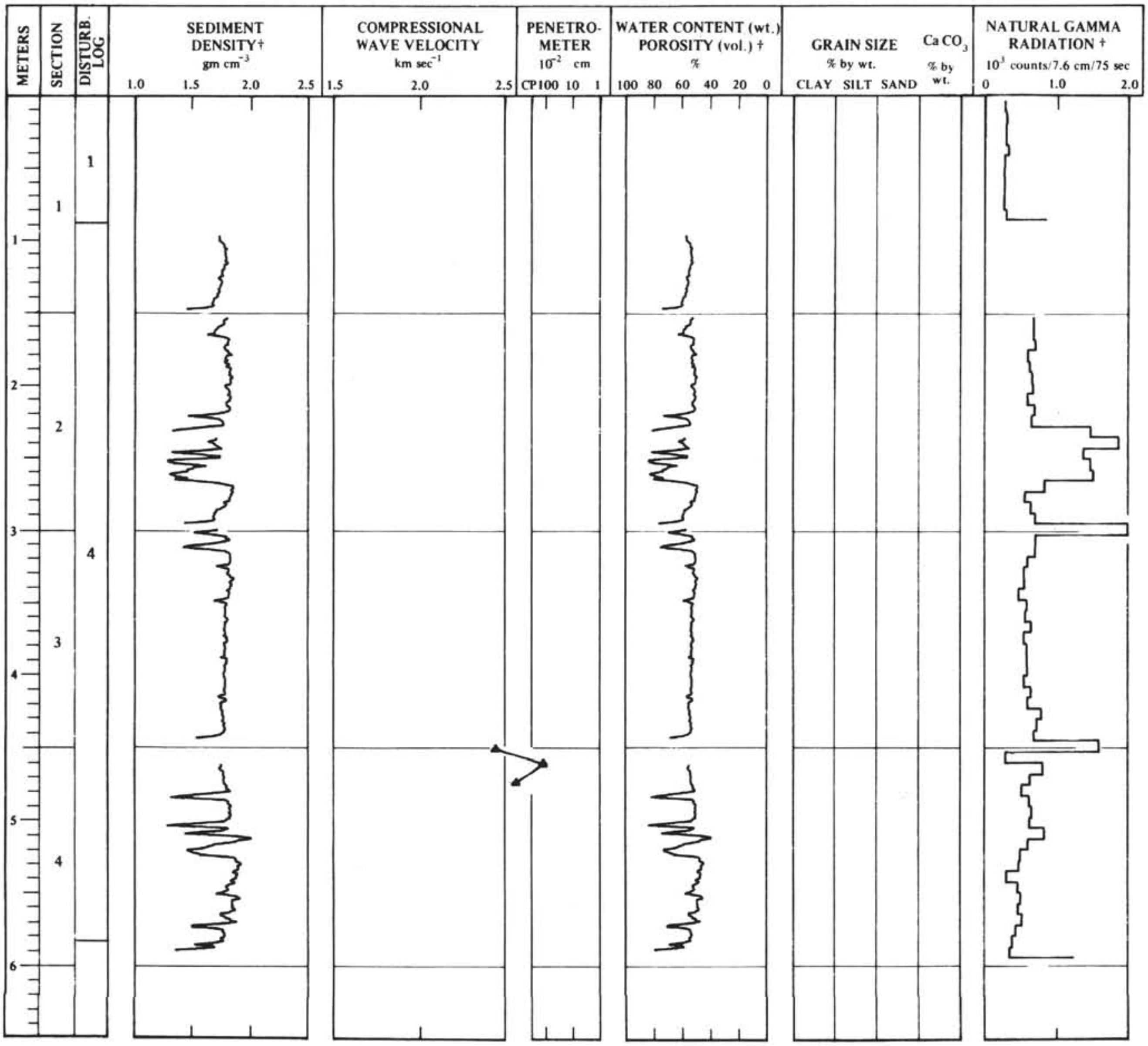
CORE 35



METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1	EMPTY	N	This core is in several short sections of solid rock.	Flora: *Fasciculithus tympaniformis*, *F. ulii*, *F. janii*, *Sphenolithus primus*, *S. anarrhopus*, *Toweius* cf. *craticulus*, *Ellipsolithus distichus*, *E. macellus*, *Cruciplacolithus tenuis*, *C. inseadus*, *Cyclolithus robustus*, *Zygodiscus sigmoides*, *Neococcolithes* sp., *N. junctus* plus reworked Cretaceous coccoliths	*Fasciculithus tympaniformis*	LATE PALEOCENE
1–3	2		N XM	5GY 5/1 Compact, indurated laminated clay 5GY 4/1 Burrowed, dark olive clay. 5Y 5/1 Indurated gray clay	Flora similar to above, plus *Braarudosphaera bigelowi*, *B. discula*, *B. imbricata*		
3–4.5	3		N XM XM	Dense indurated claystone 5Y 4/1 Dark gray clay Light olive clay 5Y 6/2 5Y 6/1 Slightly mottled dense indurated claystone 5Y 5/1	Flora similar to Sect. 2, plus *Fasciculithus billii*		
4.5–6	4		XM N XM	5Y 5/1 5Y 7/2 Green/gray laminated claystone 5Y 5/1 5Y 7/1 5Y 5/1 Dense, indurated uniform, fine grained claystone 5Y 7/2	Flora similar to above plus *Fasciculithus billii*		
	CC		R N F	X-ray Mineralogy (Bulk) Calc. 72.2 Qtz. 4.6 Mica 3.3 Cris. 20.0 Amorph. 44.5	Core Catcher: Zeolitized radiolarians common: *Stichomitra* sp. Corroded and silicified radiolarians rare: *Lithocampium* sp. A. Flora similar to above, plus *Prinsius martinii*, *Ericsonia cava*, *Fasciculithus billii* Fauna: Barren		

HOLE 119

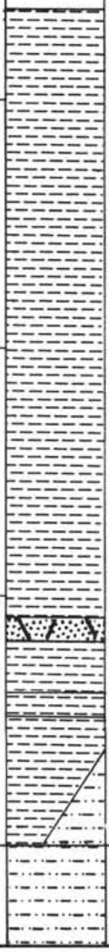
CORE 36



†Adjusted data, see Chapter 2

HOLE 119 648 **TO** 662 **m**

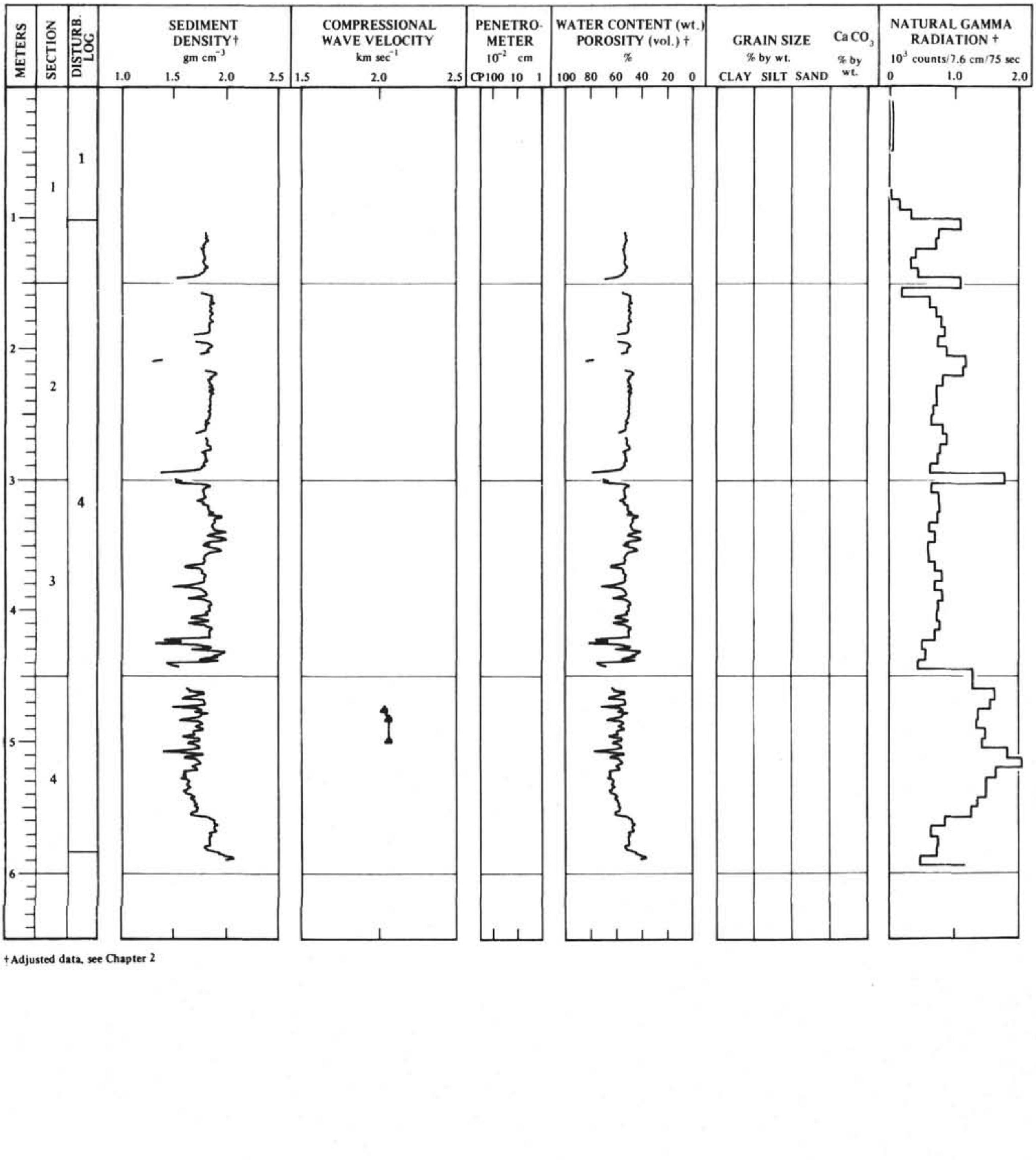
CORE 36



METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	EMPTY		Dense, lithified claystone with loadcasts, etc.	Flora: *Fasciculithus tympaniformis, F. billii, F. ulii, F. janii, Sphenolithus primus, Toweius craticulus, Ellipsolithus macellus, Ericsonia cava, E. robusta, Braarudosphaera bigelowi, Chiasmolithus danicus, Cruciplacolithus tenuis, Neococcolithes* sp. *Thoracosphaera* sp. plus reworked Cretaceous coccoliths	*Fasciculithus tympaniformis*	PALEOCENE
1.5–3	2			5Y 5/1			
				5Y 4/1 — Hard dark gray claystone			
			N	5Y 4/1	Flora poorer than above		
			N	5Y 6/1 — Lithified claystone with black burrows	Flora poorer than above		
3–4.5	3		N	5Y 4/1			
				5G 8/1 — Burrowed pale green			
				5Y 4/1 — passing into			
				Hard indurated gray clay			
4.5–6	4			5Y 5/1 — Sandstone			
			N	5G 8/1 — Gray green burrowed clay	Flora poorer than above		
				5G 8/1 — Slightly burrowed gray green clay			
				5Y 5/1 — passing into Uniform gray clay getting siltier towards base			
	CC		R N F		Core Catcher: Silicified and corroded radiolarians common: *Lithocampium* sp. A, *Bekoma bidarfensis, Phormocyrtis striata, Amphipyndax stocki* Rare, well preserved contaminant Middle Eocene species from the *Theocampe mongolfieri* zone (25-30 species). Flora similar to above, plus *Braarudosphaera discula, Zygodiscus sigmoides* Fauna: Barren		

HOLE 119

CORE 37



†Adjusted data, see Chapter 2

HOLE 119 662 **TO** 674m

CORE 37

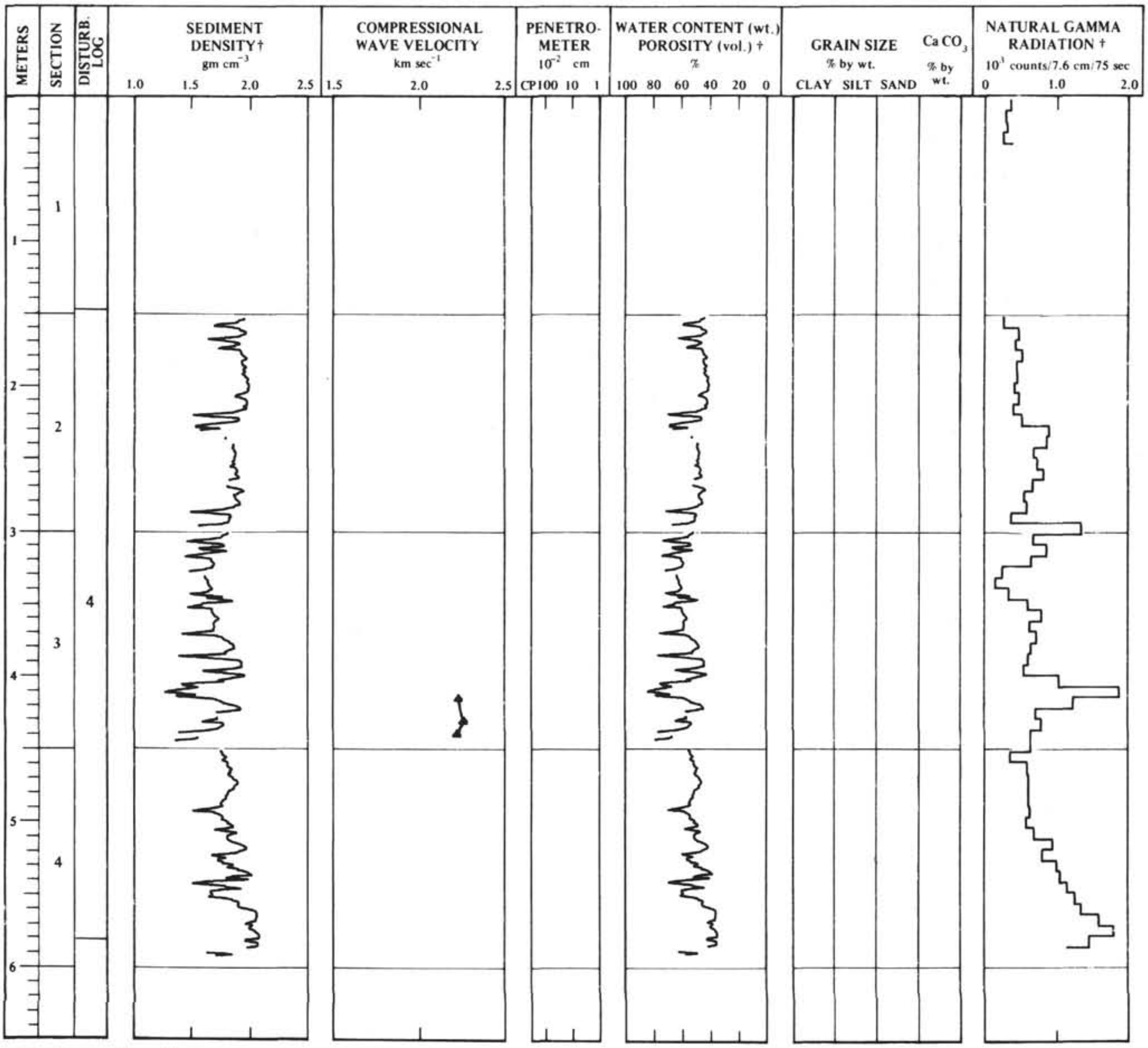
METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY		DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1	GAP	N, N	5Y 5/1	Uniform lithified gray claystone	Flora: *Ericsonia cava, Fasciculithus tympaniformis, F. ulii, F. billii, F. janii, Sphenolithus primus, Toweius craticulus, Prinsius martinii, P. bisulcus, Cyclolithus robustus, Braarudosphaera discula, B. bigelowi, B. imbricata, Markalius inversus, Cruciplacolithus tenuis, Chiasmolithus danicus, C. bidens, Zygodiscus sigmoides, Ellipsolithus macellus, Neococcolithes* sp. plus reworked Cretaceous coccoliths	*Fasciculithus tympaniformis*	PALEOCENE
1.5–3	2			5Y 5/1 → 5Y 4/1	Gray lithified claystone with load casts and other primary structures Slickensides dipping at ~25°	Flora similar to above		
3–4.5	3		N	5Y 4/1	Slickensides along entire length	Flora similar to above		
				5Y 5/1	Gray lithified claystone			
				5Y 4/1	Slickensides at 120-130			
				5Y 6/1	Gray sandy claystone			
4.5–6	4		XM, N	5Y 4/1	Dark gray indurated clay	Flora similar to above		
			N	5GY 6/1	Greenish gray claystone dipping ~25°	Flora similar to above		
				5Y 7/1				
	CC		R, N, F			Core Catcher: No radiolarians Flora similar to above Fauna: Barren		

X-ray Mineralogy (Bulk)

Calc.	32.9
Dolo.	2.0
Qtz.	10.9
Plag.	9.9
Mica	34.1
Mont.	10.1
Amorph.	51.7

HOLE 119

CORE 38



†Adjusted data, see Chapter 2

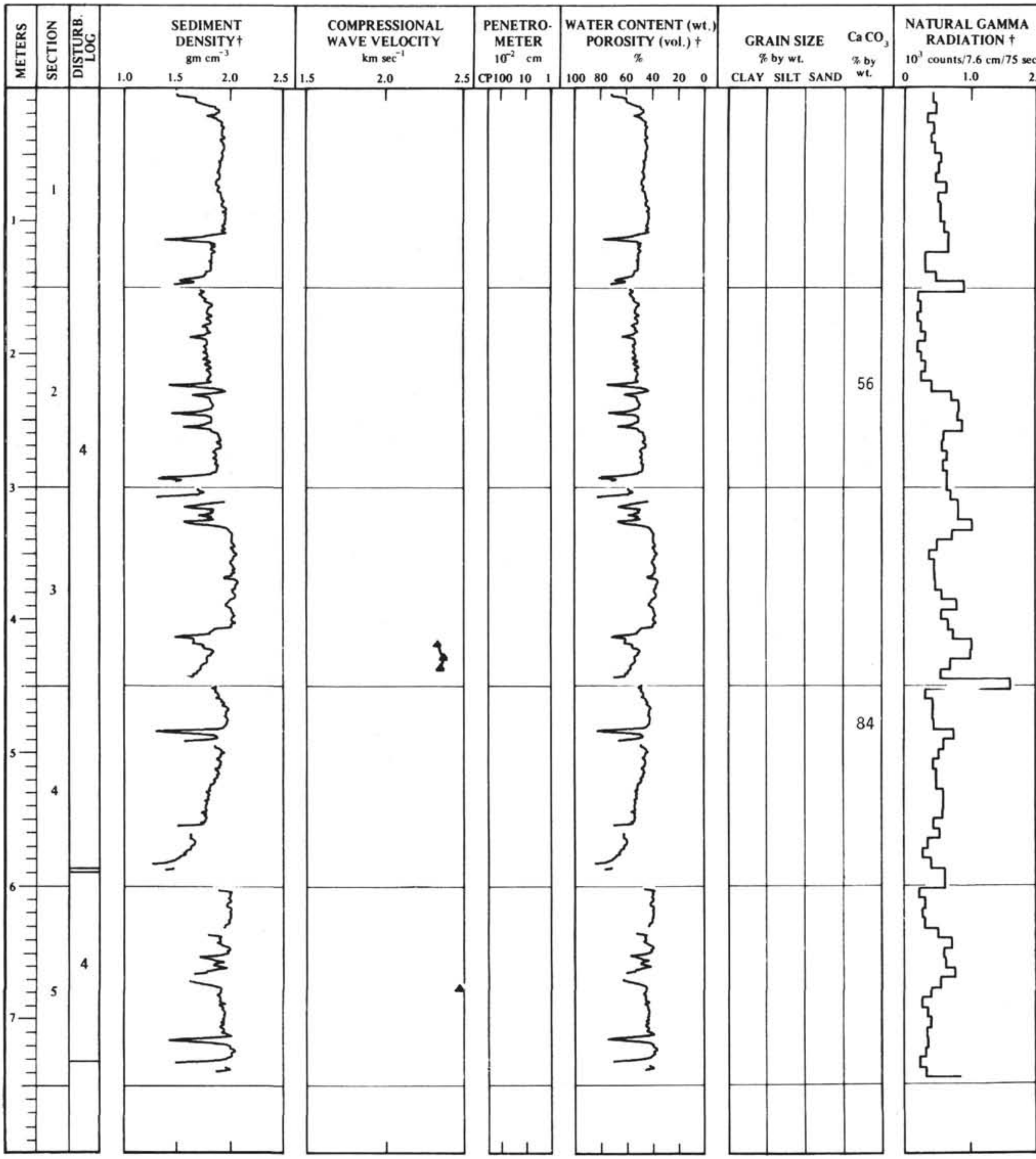
HOLE 119 674 **TO** 686 **m**

CORE 38

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1	1			5Y 6/1 Gray indurated claystone X-ray Mineralogy (Bulk) Calc. 68.3 Qtz. 12.4 K-Feld 1.4 Plag. 10.2 Mica 7.8 Amorph. 32.6		*Fasciculithus tympaniformis*	LATE PALEOCENE
2	2		N N	Dense lithified claystone 5Y 6/1	Flora: *Fasciculithus tympaniformis, F. ulii Sphenolithus primus, Toweius craticulus, Braarudosphaera bigelowi, Ericsonia cava, Cyclolithus robustus* plus reworked Cretaceous coccoliths Flora similar to above plus *Ellipsolithus macellus, E. distichus*		
3	3		N N	5Y 7/1 Gray burrowed claystone 5Y 5/1 5Y 8/1 2.5YR 5/4 Laminated red/brown claystone	Flora similar to above Flora similar to above Flora similar to above		
4			N,XM N	2.5YR 3/4	Flora similar to above, no *Fasciculithus* plus *Ellipsolithus macellus, E. distichus*	*Ellipsolithus macellus*	
5	4		F N XM	2.5YR 5/4 Red brown claystone Alternating layers of red-brown and gray clay. Red layers are mottled, gray layers have sedimentary structures 5Y 5/1	Forams: *Globigerina triloculinoides*, chiloguembelinids Flora similar to Sect. 3-116	P3	
	CC		R N F	X-ray Mineralogy (Bulk) Calc. 82.5 Dolo. 1.3 Qtz. 4.7 Mica 6.9 Mont. 4.6 Amorph. 45.5	Core Catcher: No radiolarians. Flora similar to Sect. 3-116 Forams: *G. pseudobulloides, G. varianta, G. angulata, G. conicotruncata, G. ehrenbergi, G. triloculinoides*		

HOLE 119

CORE 39



†Adjusted data, see Chapter 2

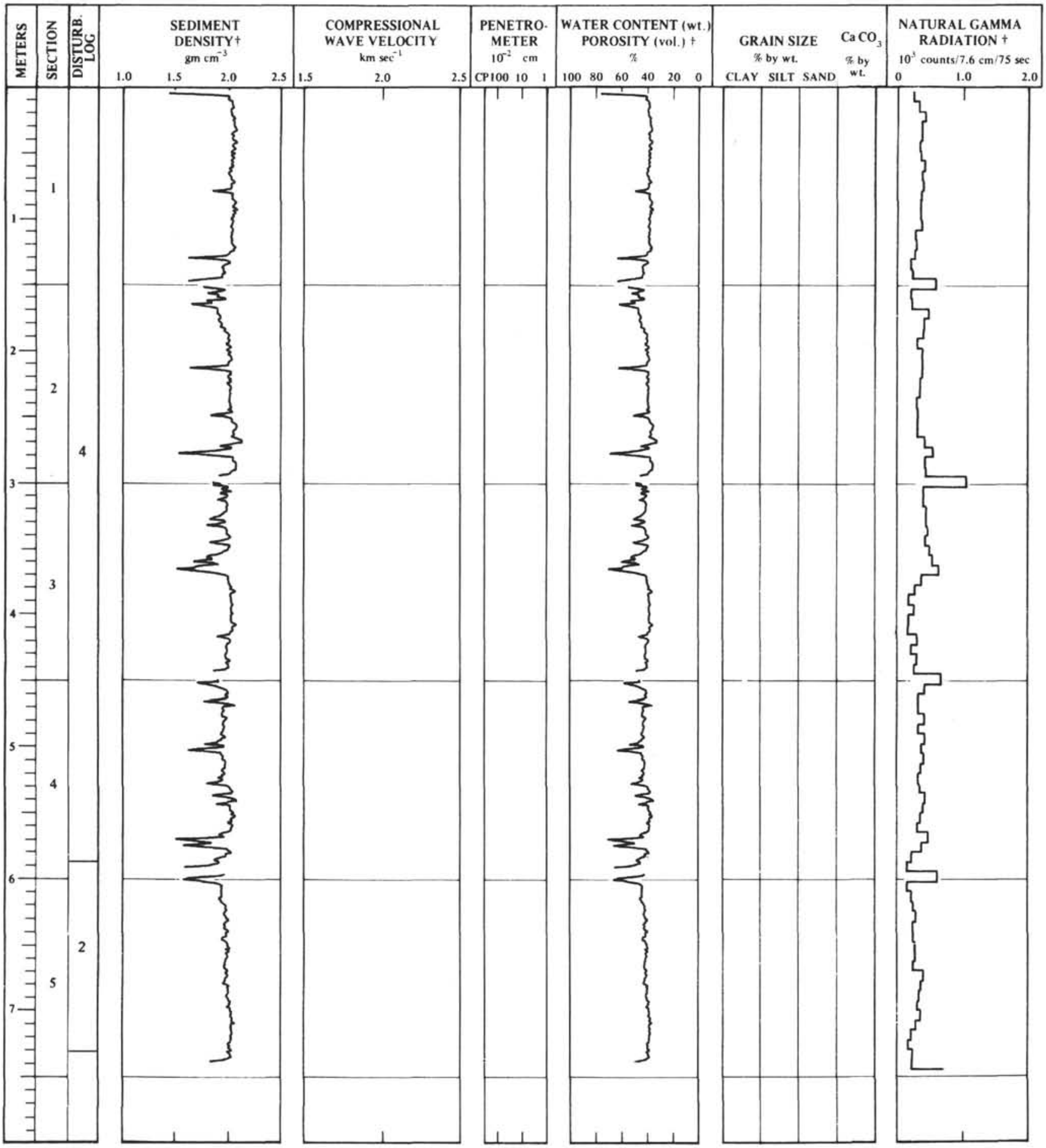
HOLE 119   686 **TO** 699 **m**

CORE 39

METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
0–1.5	1		N	N7 Light gray and white lithified claystone Dip ~ 20°	Flora: *Toweius craticulus, Ellipsolithus distichus, Zygodiscus sigmoides, Markalius inversus, Braarudosphaera bigelowi, B. discula, B. imbricata, Prinsius bisulcus, Micrantolithus* sp. *Chiasmolithus danicus, Cruciplacolithus tenuis, Ericsonia cava, Cyclolithus* cf. *robustus, Neococcolithes* sp. plus reworked Cretaceous coccoliths	P3 *Ellipsolithus macellus* ?	LATE PALEOCENE
				--- Mottling			
			N		Flora similar to above		
1.5–3	2			N9 X-ray Mineralogy (Bulk): Calc. 98.6; Qtz. 1.4; Amorph. 27.9			
			XM N,F	--- N7 ---	Flora similar to above Fauna: Barren		
3–4.5	3			2.5YR 5/4 Gray and red-brown claystone ----			
				N7 Alternating gray and red brown claystone			
			N	--- N6 / N7 / --- N6	Flora similar to above		
4.5–6	4			2.5YR 5/4			
			XM N	--- Mottling	Flora similar to above		
				N7 ---			
				N8 Gray indurated clay, moderately mottled			
6–7.5	5		N N	X-ray Mineralogy (Bulk): Calc. 80.7; Dolo. 1.8; Qtz. 3.3; Mica 9.1; Amorph. 34.6	Flora similar to above; Flora similar to above		
				--- N7 --- N8			
	CC		R N F		Core Catcher: Two silicified radiolarians Flora similar to above Forams: Chiloguembelinids, *G. triloculinoides, G. pseudobulloides,* Keeled globorotaliids (?*angulata*)		

HOLE 119

CORE 40

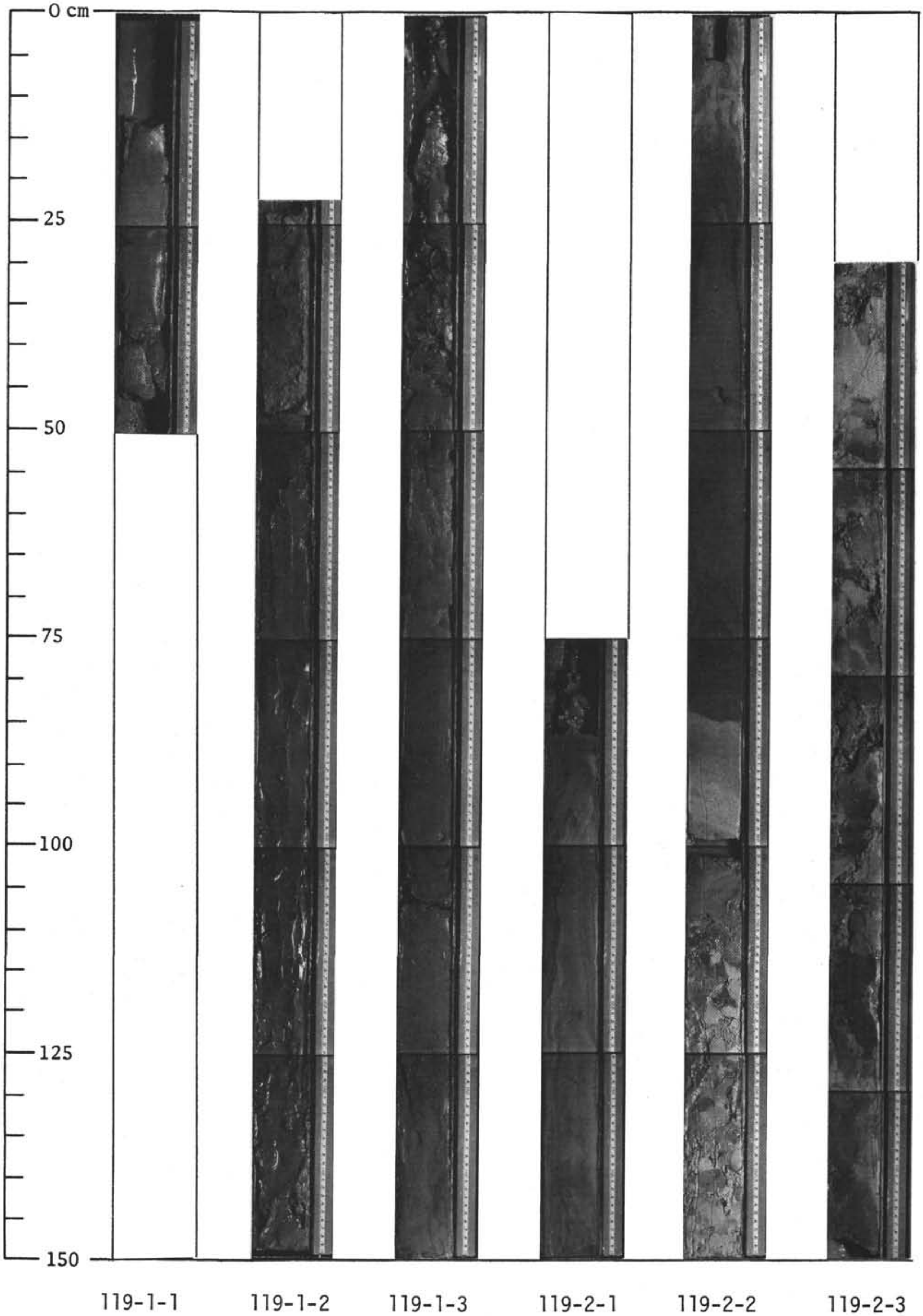


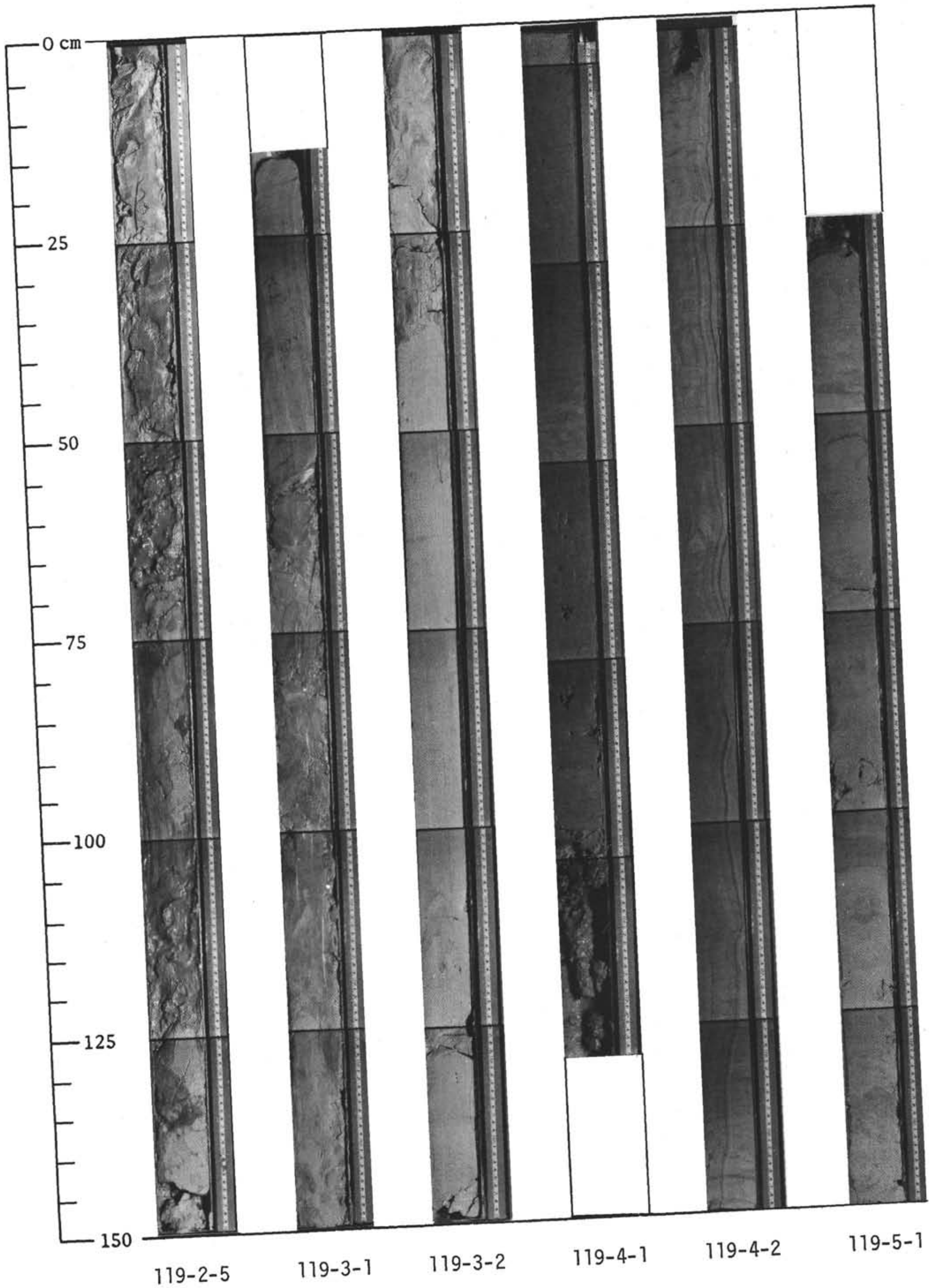
†Adjusted data, see Chapter 2

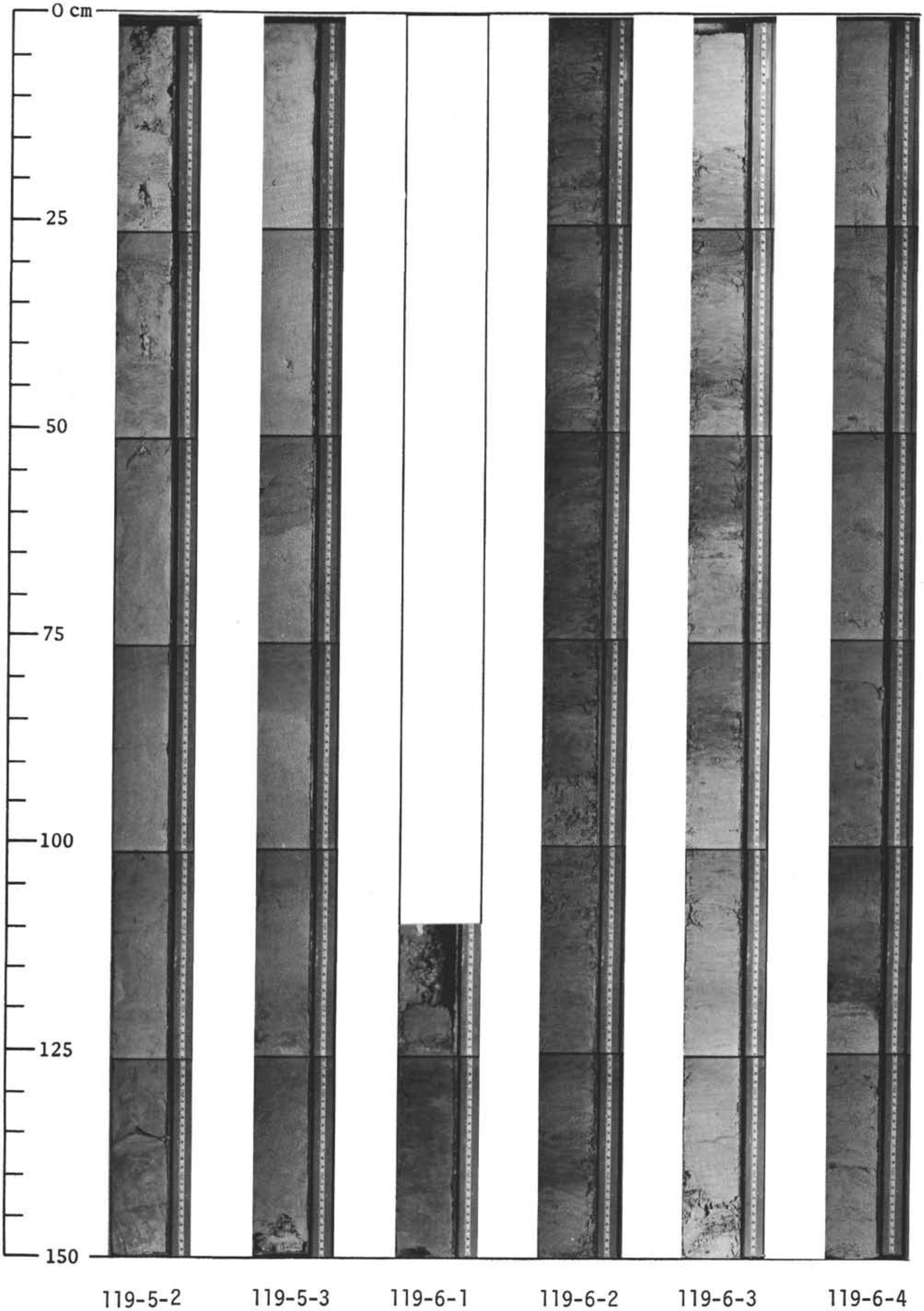
HOLE 119 699 **TO** 711 **m**

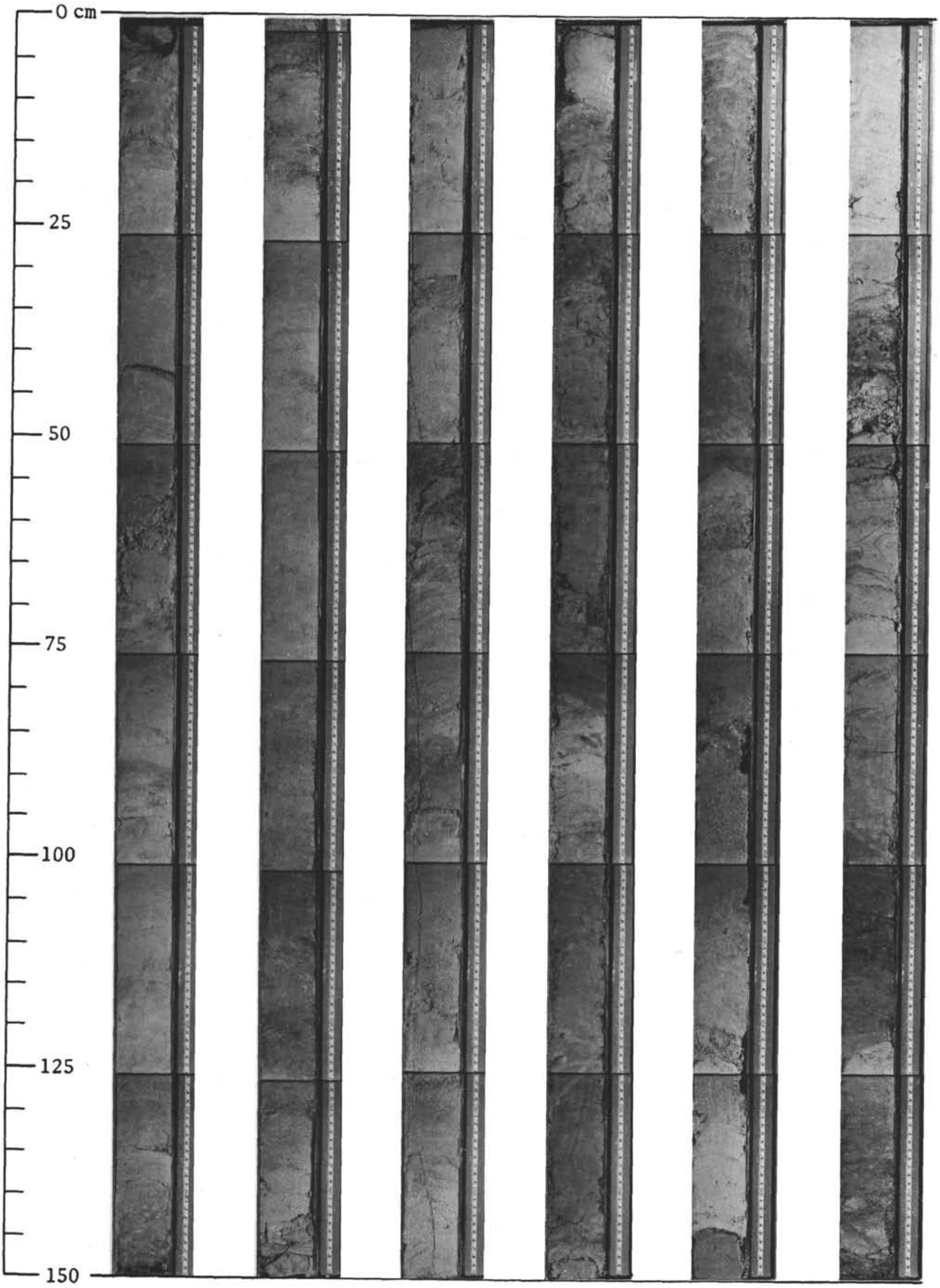
CORE 40

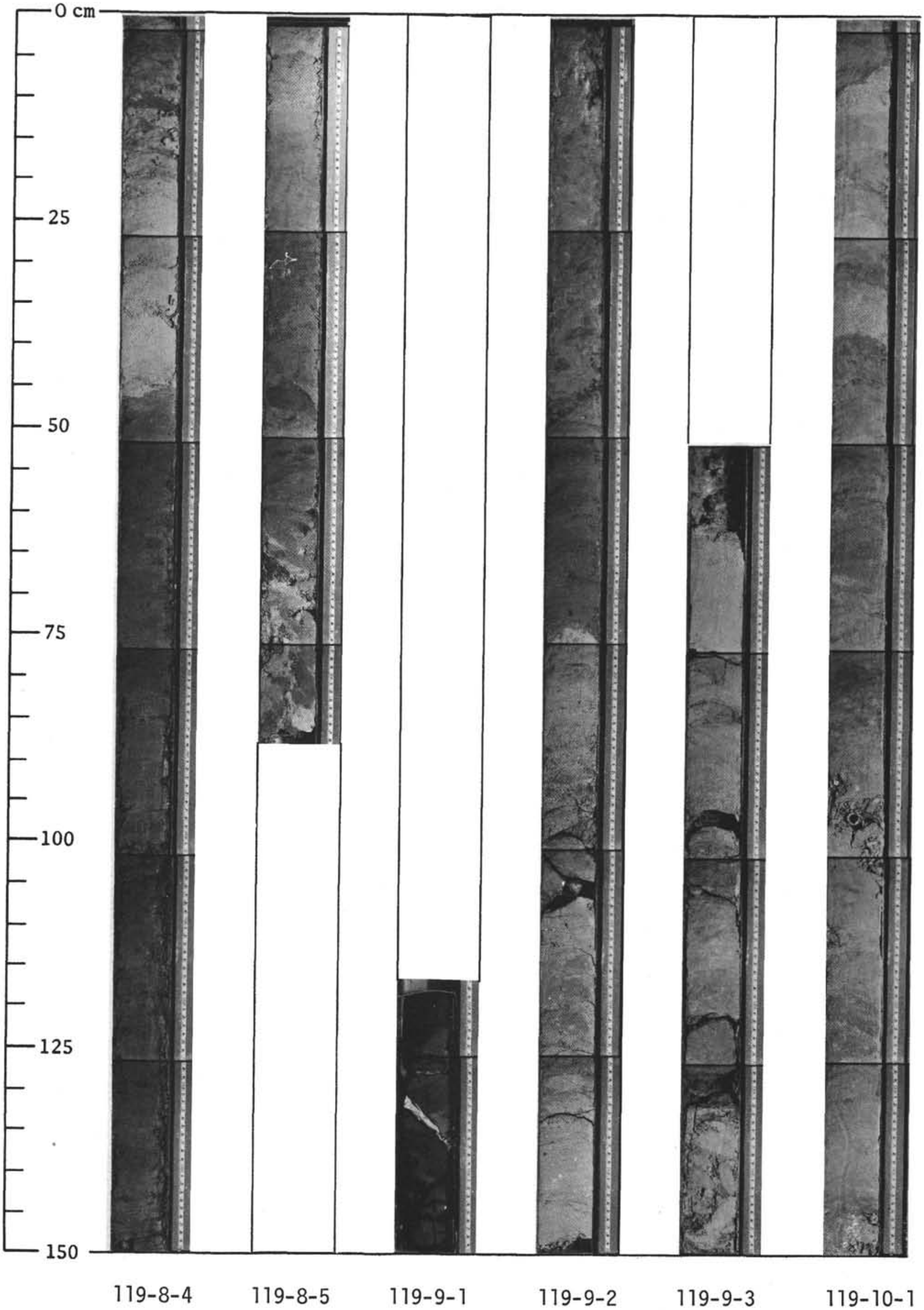
METERS	SECTION	LITHOL.	SAMPLES	LITHOLOGY	DIAGNOSTIC FOSSILS	BIO-STRAT.	TIME STRAT.
1	1			N7 -- N8 Light gray lithified clay, uniform at the top but many load casts and slump structures towards the bottom of Section 1	Flora: *Ellipsolithus macellus, Ericsonia cava, Zygodiscus sigmoides, Cyclolithus robustus, Prinsius martinii, Braarudosphaera bigelowi, Micrantolithus* sp., *Cruciplacolithus tenuis, Neococcolithes* sp. plus reworked Cretaceous coccoliths	*Ellipsolithus macellus*	PALEOCENE
2	2		N	Sandy indurated claystone --- N7	Flora similar to above Flora similar to above		
3 4	3		N N	Light gray indurated claystone with several widely spaced laminae dipping at ~15°	Flora similar to above		
5 6	4		N N	N6 to N5	Flora similar to above, less *Ellipsolithus macellus* Flora similar to above, less *Ellipsolithus macellus*		
7	5	SECTION NOT OPENED					
	CC		N R		Core Catcher: Flora similar to above, plus *Chiasmolithus danicus,* less *Ellipsolithus macellus* No radiolarians		

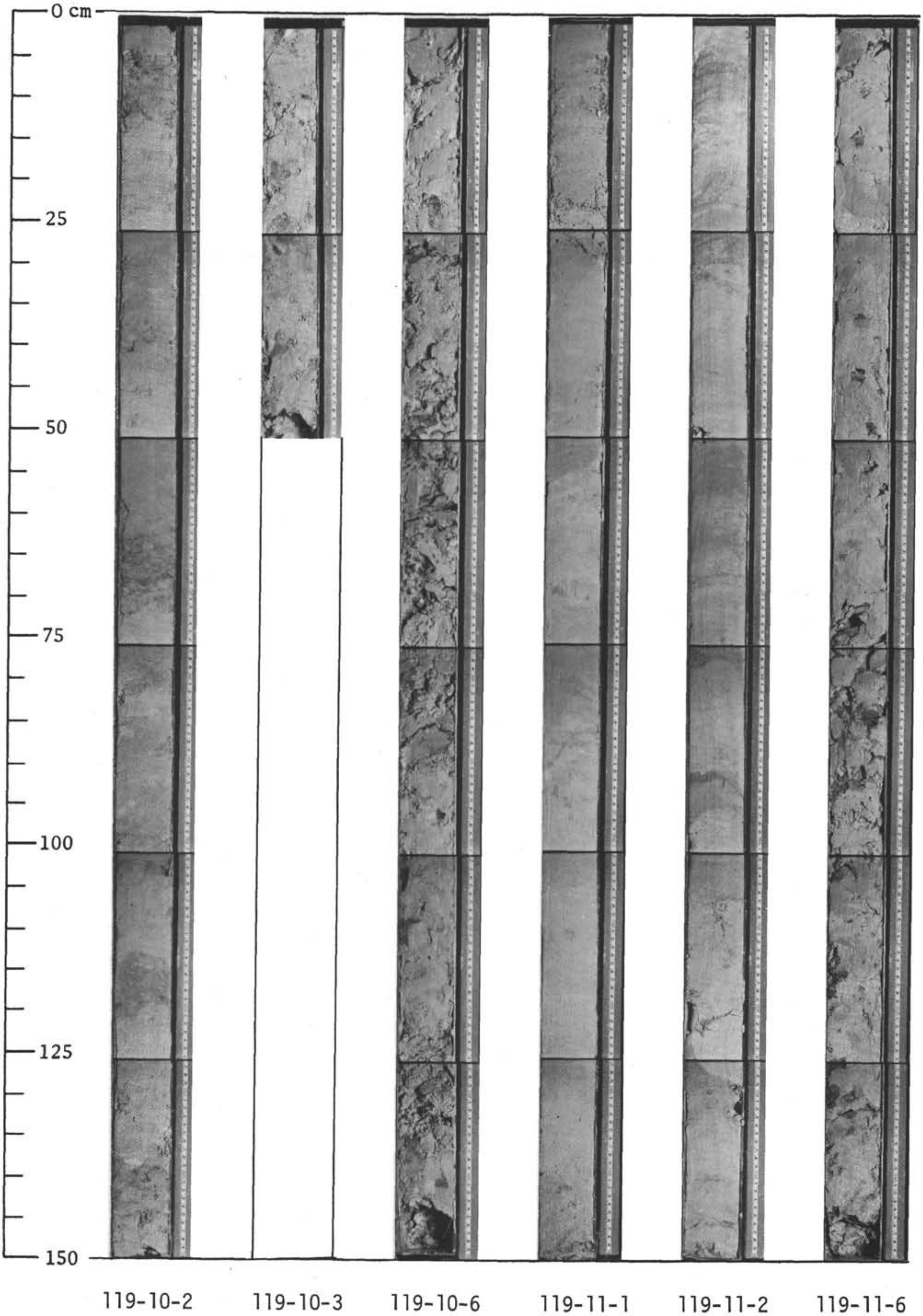

0 cm
25
50
75
100
125
150
119-1-1
119-1-2
119-1-3
119-2-1
119-2-2
119-2-3

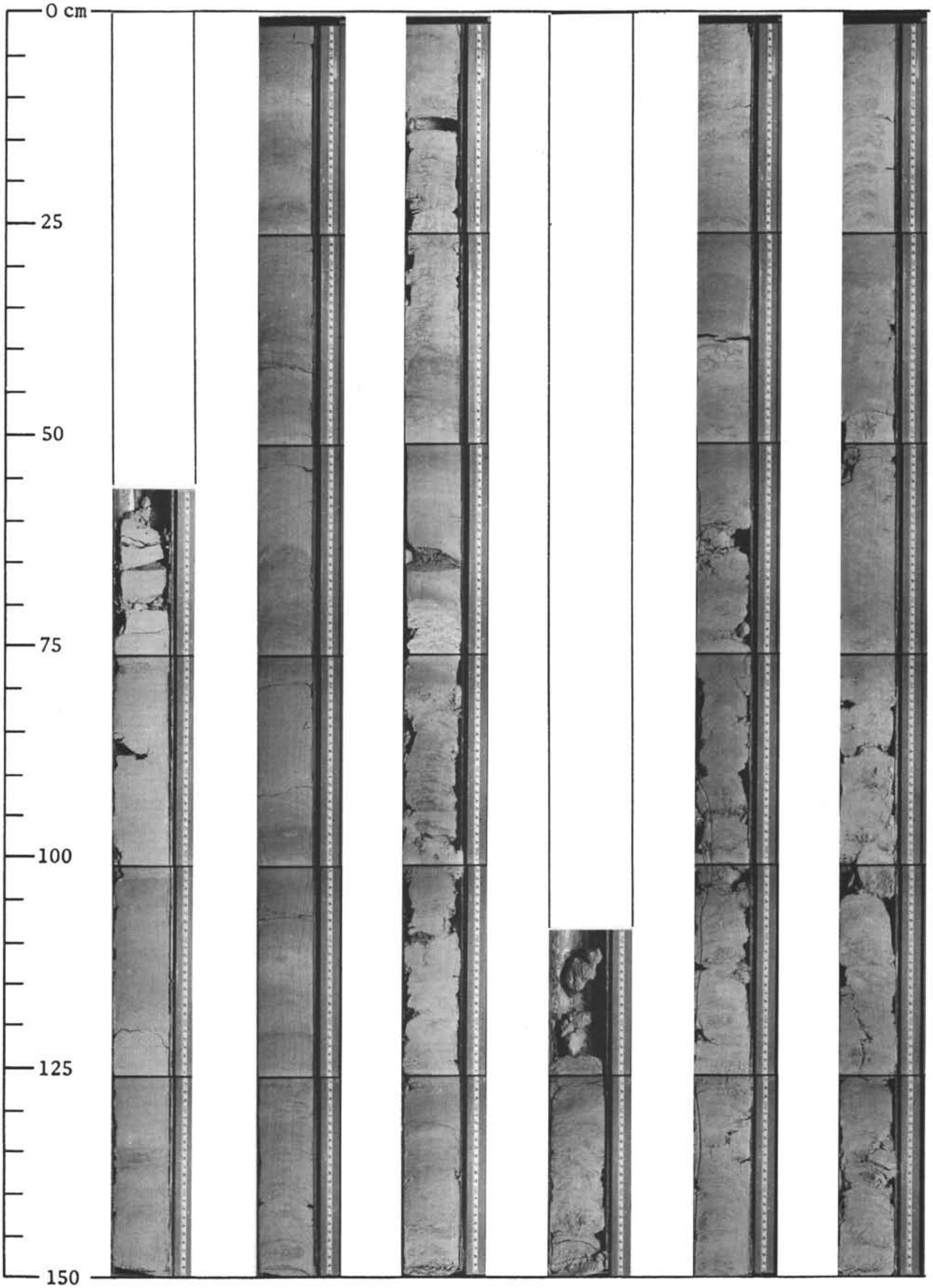

0 cm
25
50
75
100
125
150
119-2-5
119-3-1
119-3-2
119-4-1
119-4-2
119-5-1


0 cm
25
50
75
100
125
150
119-5-2
119-5-3
119-6-1
119-6-2
119-6-3
119-6-4

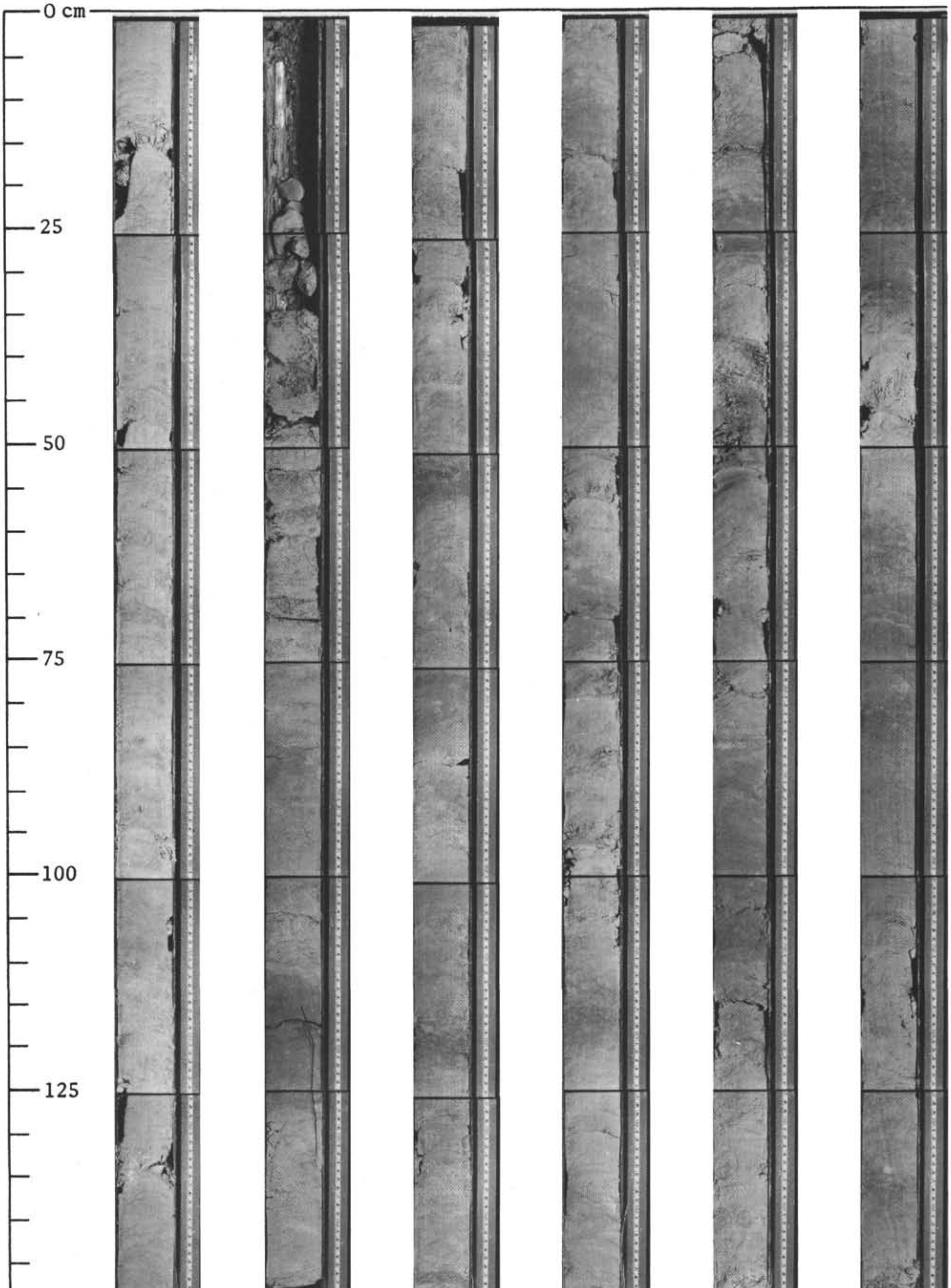

0 cm
25
50
75
100
125
150
119-7-1
119-7-2
119-7-3
119-8-1
119-8-2
119-8-3

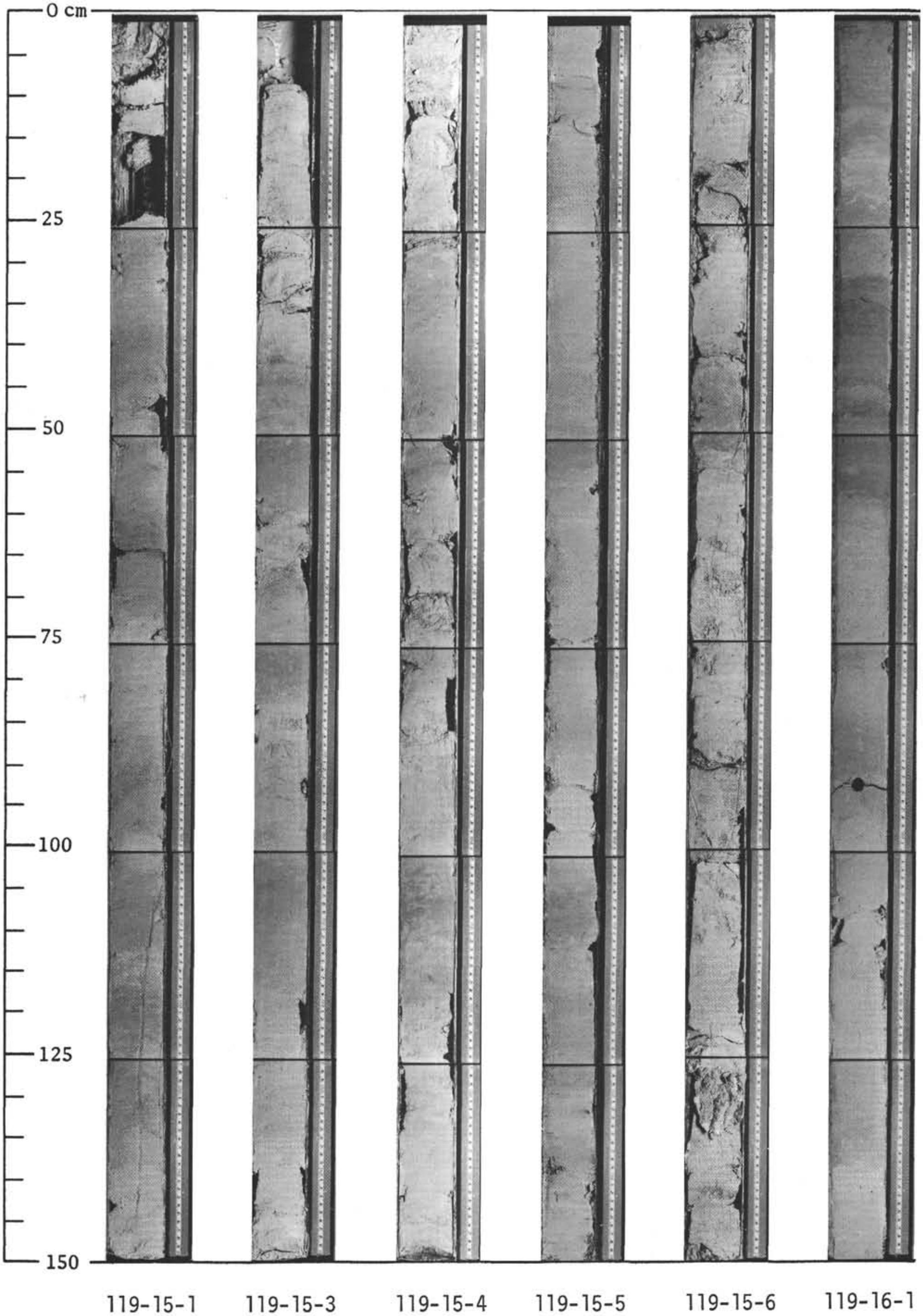

0 cm
25
50
75
100
125
150
119-8-4
119-8-5
119-9-1
119-9-2
119-9-3
119-10-1

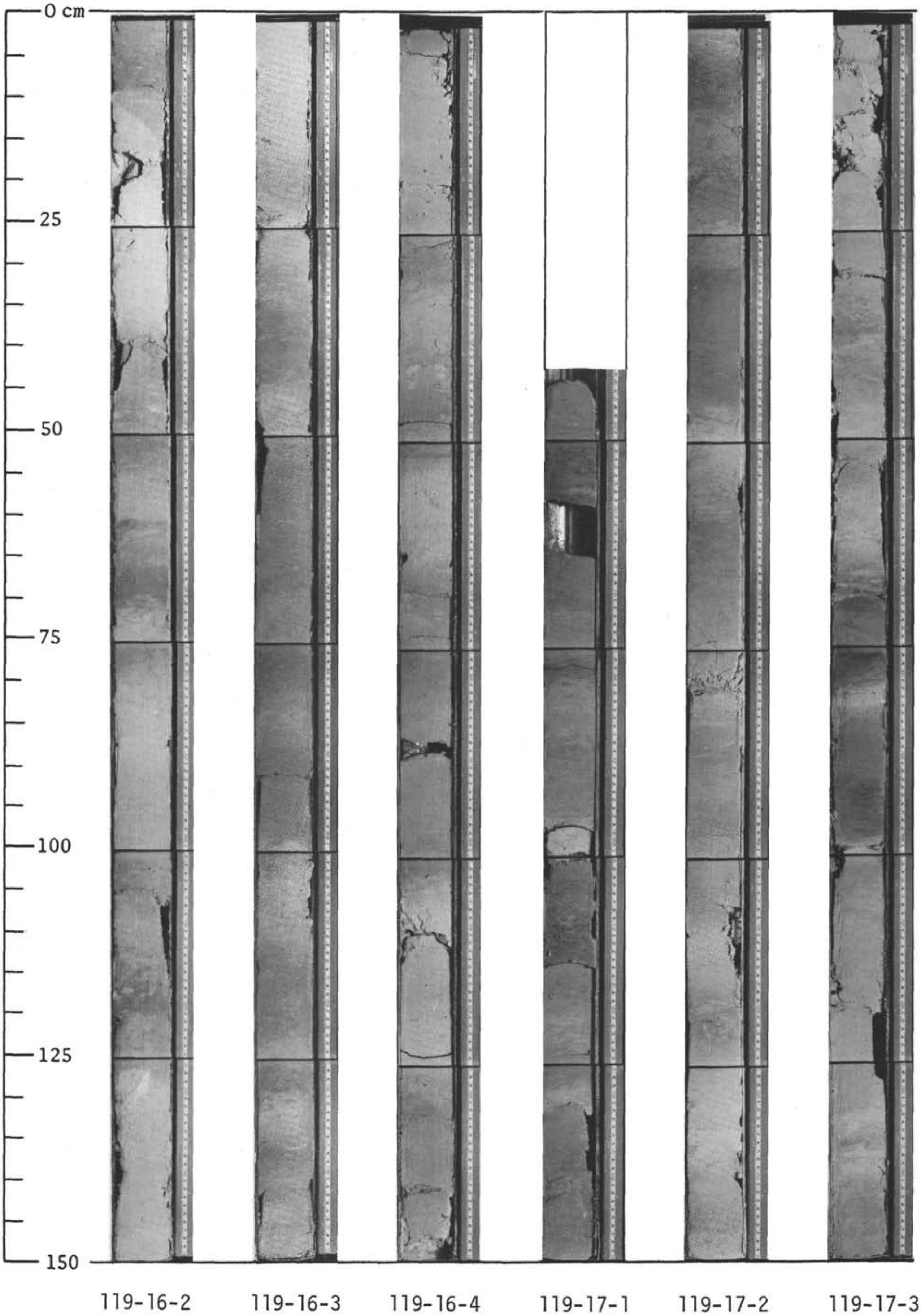

0 cm
25
50
75
100
125
150
119-10-2
119-10-3
119-10-6
119-11-1
119-11-2
119-11-6

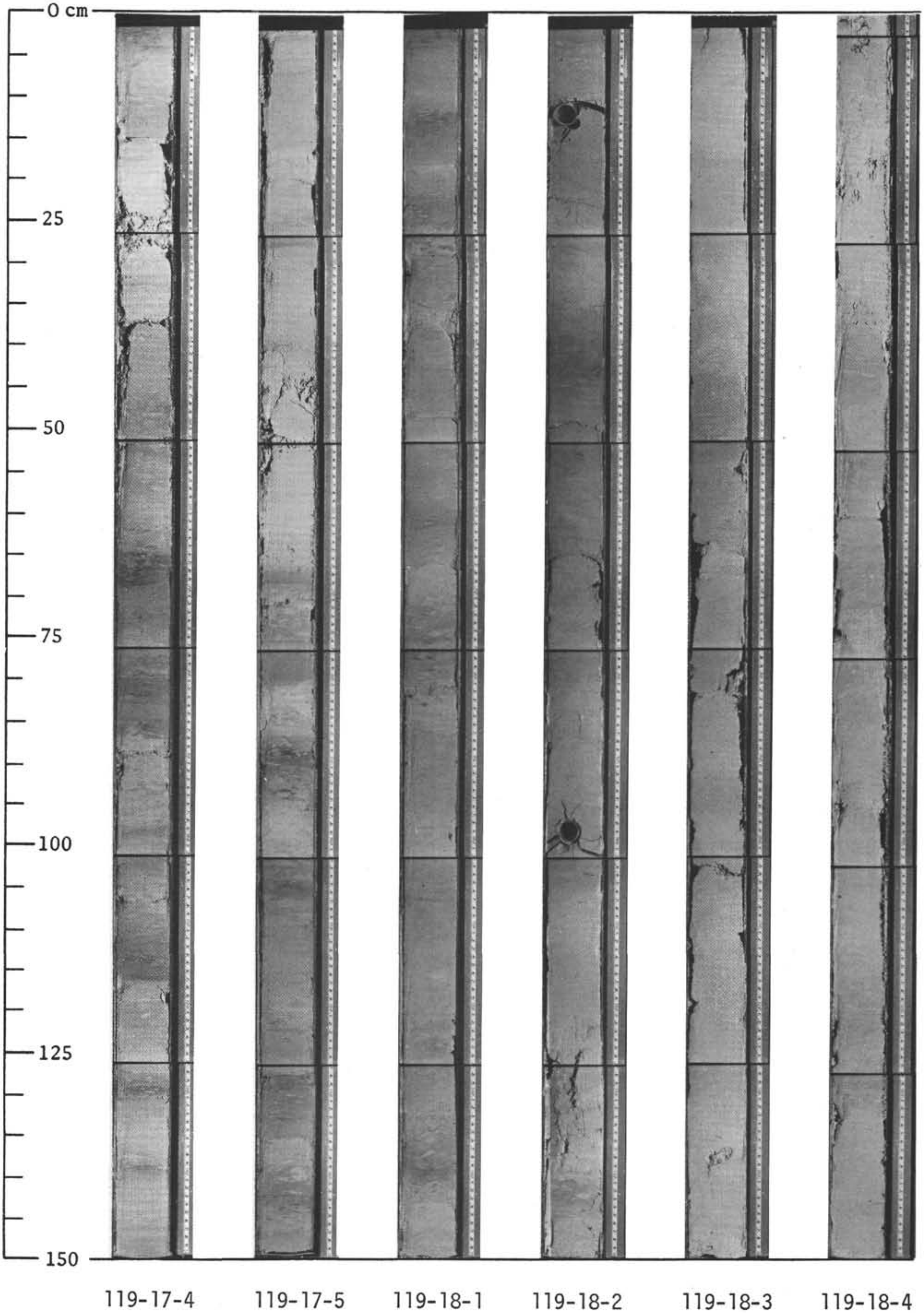


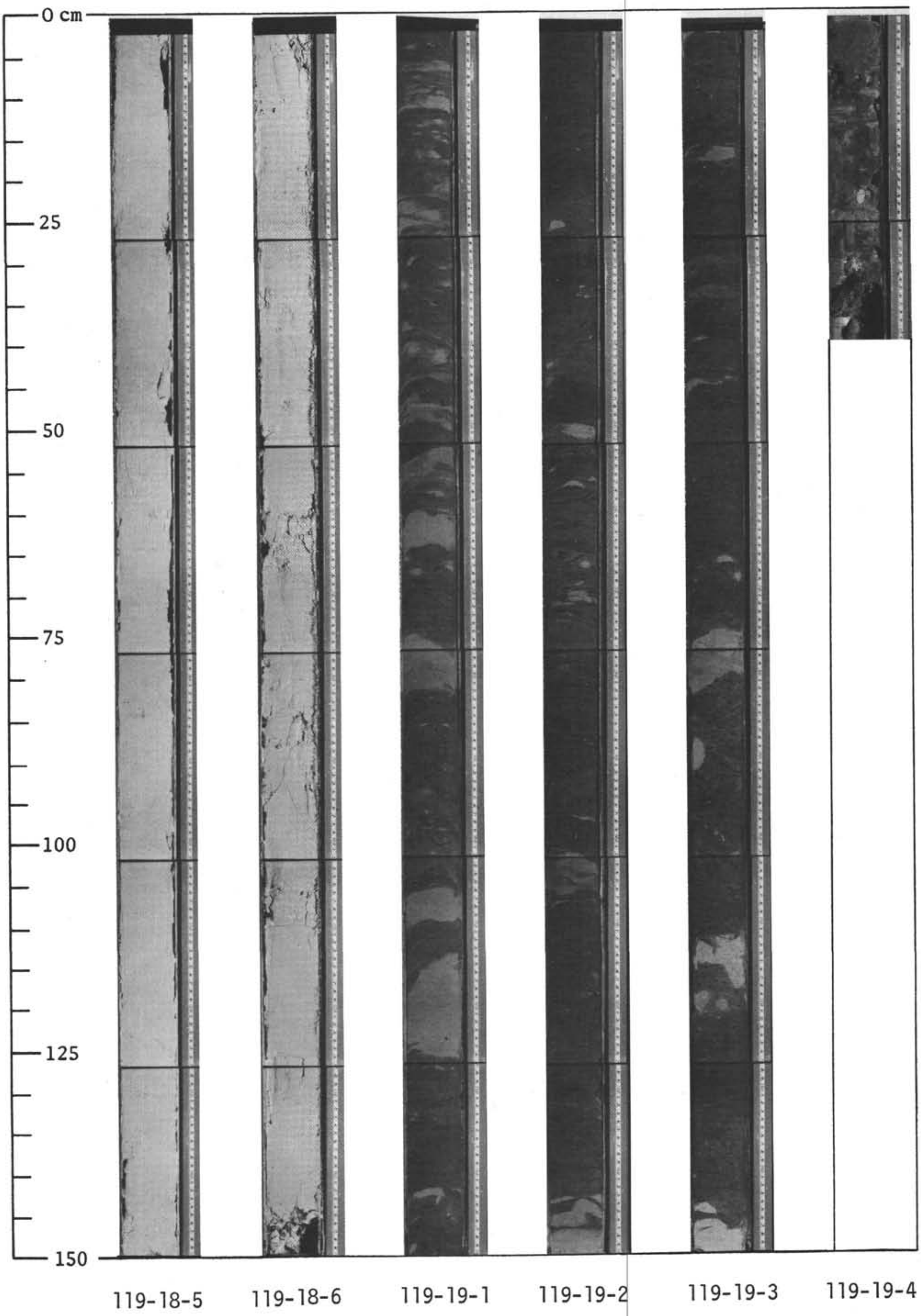
119-12-1 119-12-2 119-12-3 119-13-1 119-13-2 119-13-3

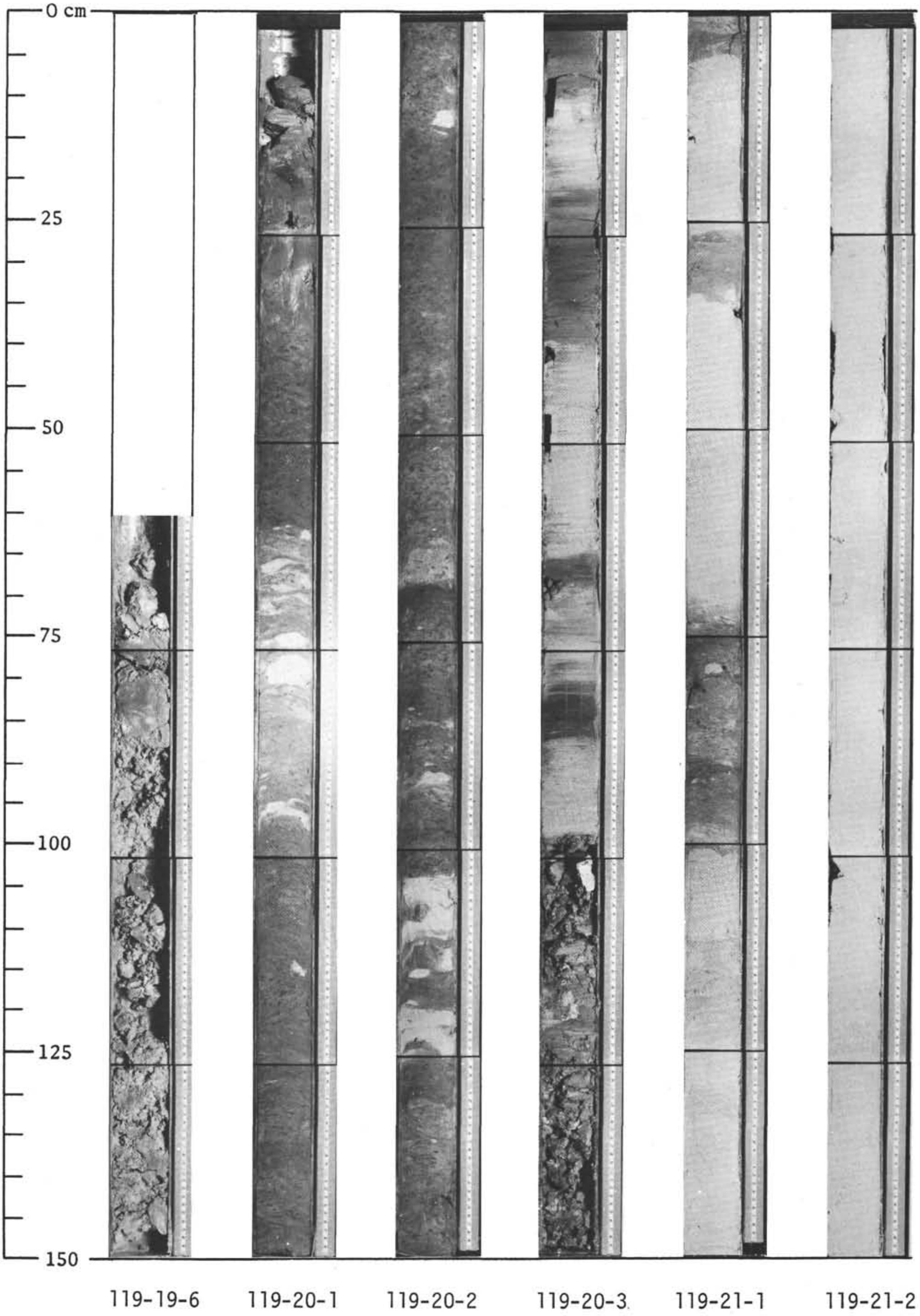

0 cm
25
50
75
100
125
150
119-13-4
119-14-1
119-14-2
119-14-3
119-14-4
119-14-5

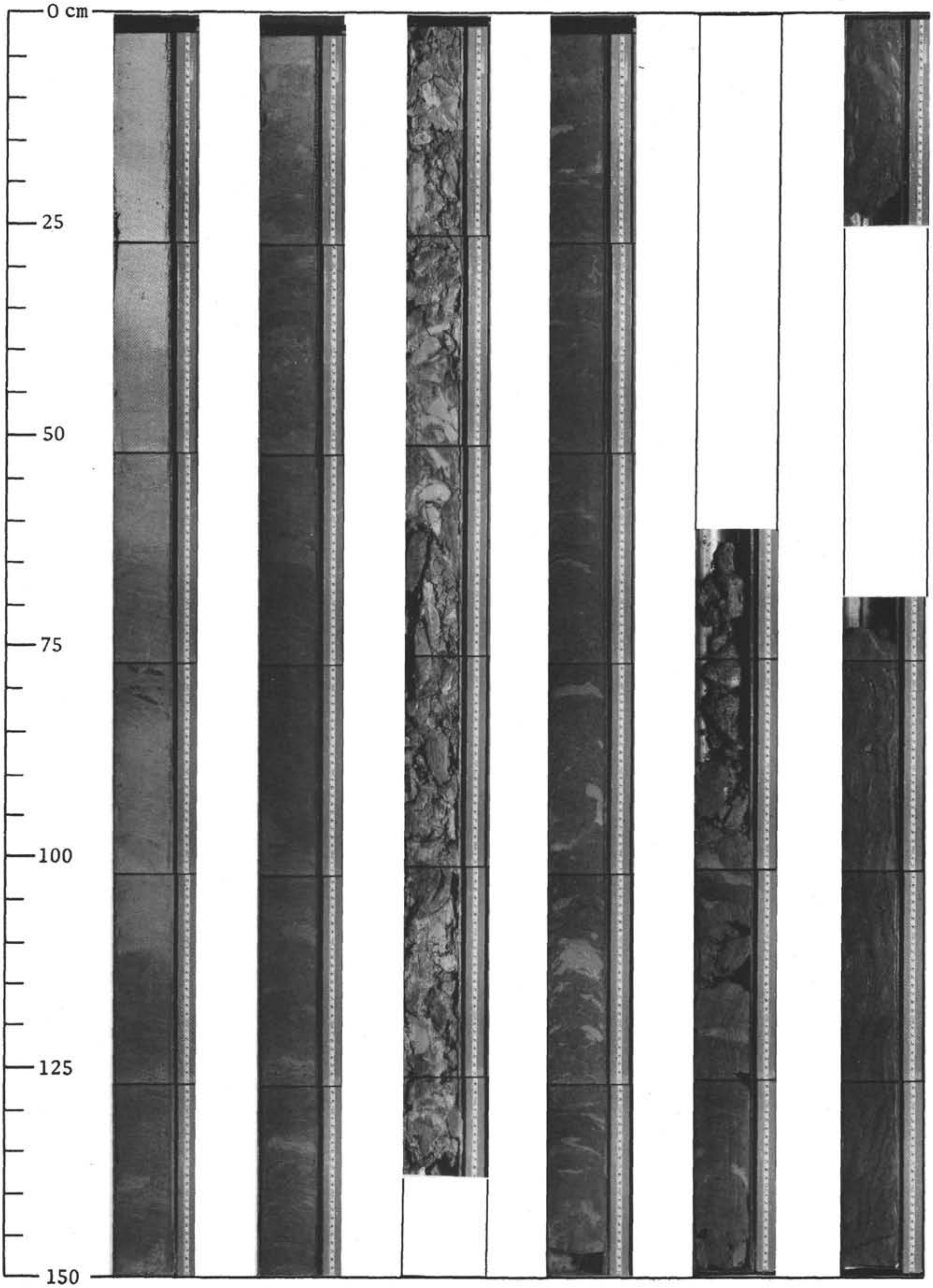

0 cm
25
50
75
100
125
150
119-15-1
119-15-3
119-15-4
119-15-5
119-15-6
119-16-1


0 cm
25
50
75
100
125
150
119-16-2
119-16-3
119-16-4
119-17-1
119-17-2
119-17-3

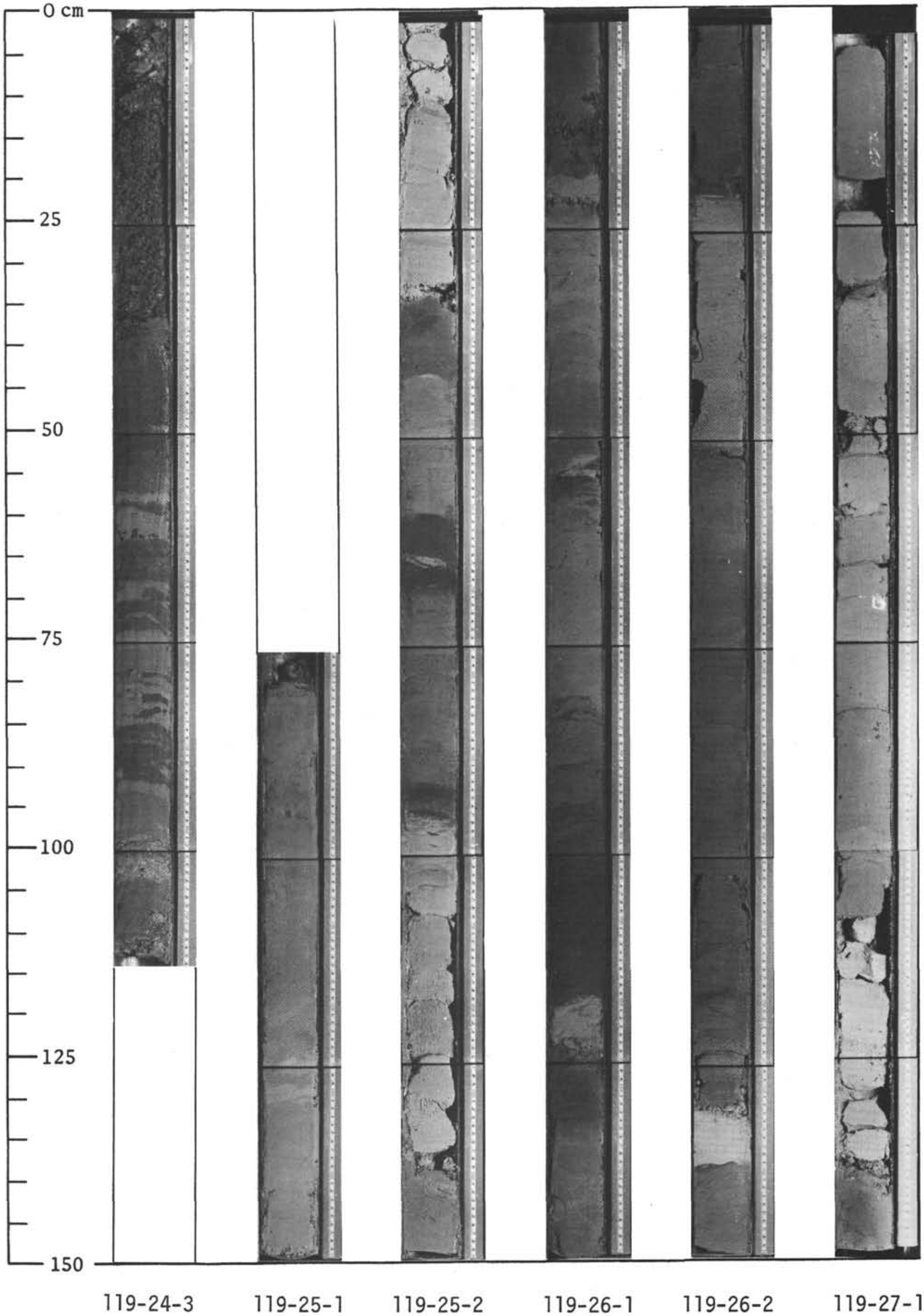

0 cm
25
50
75
100
125
150
119-17-4
119-17-5
119-18-1
119-18-2
119-18-3
119-18-4

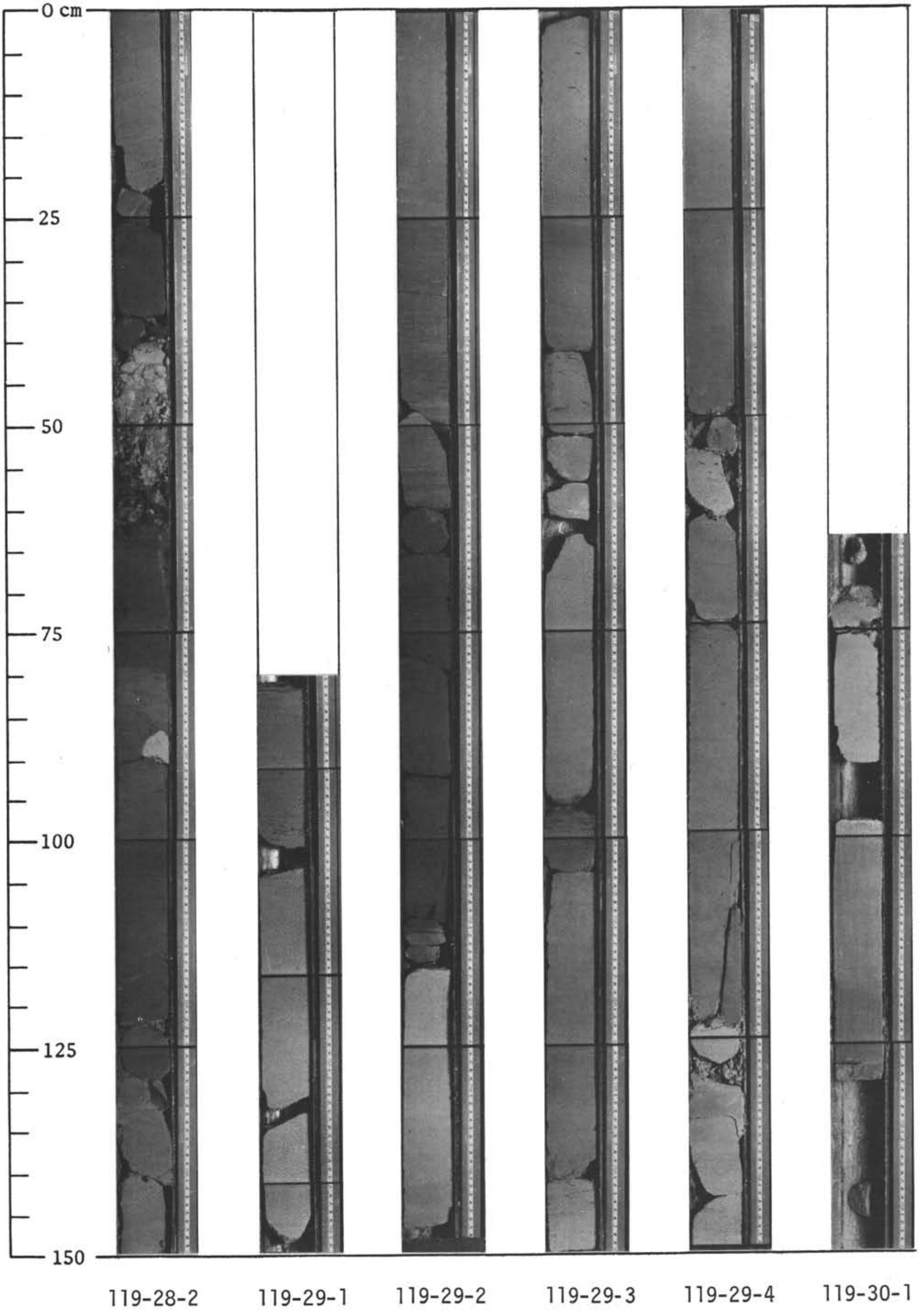

0 cm
25
50
75
100
125
150
119-18-5
119-18-6
119-19-1
119-19-2
119-19-3
119-19-4

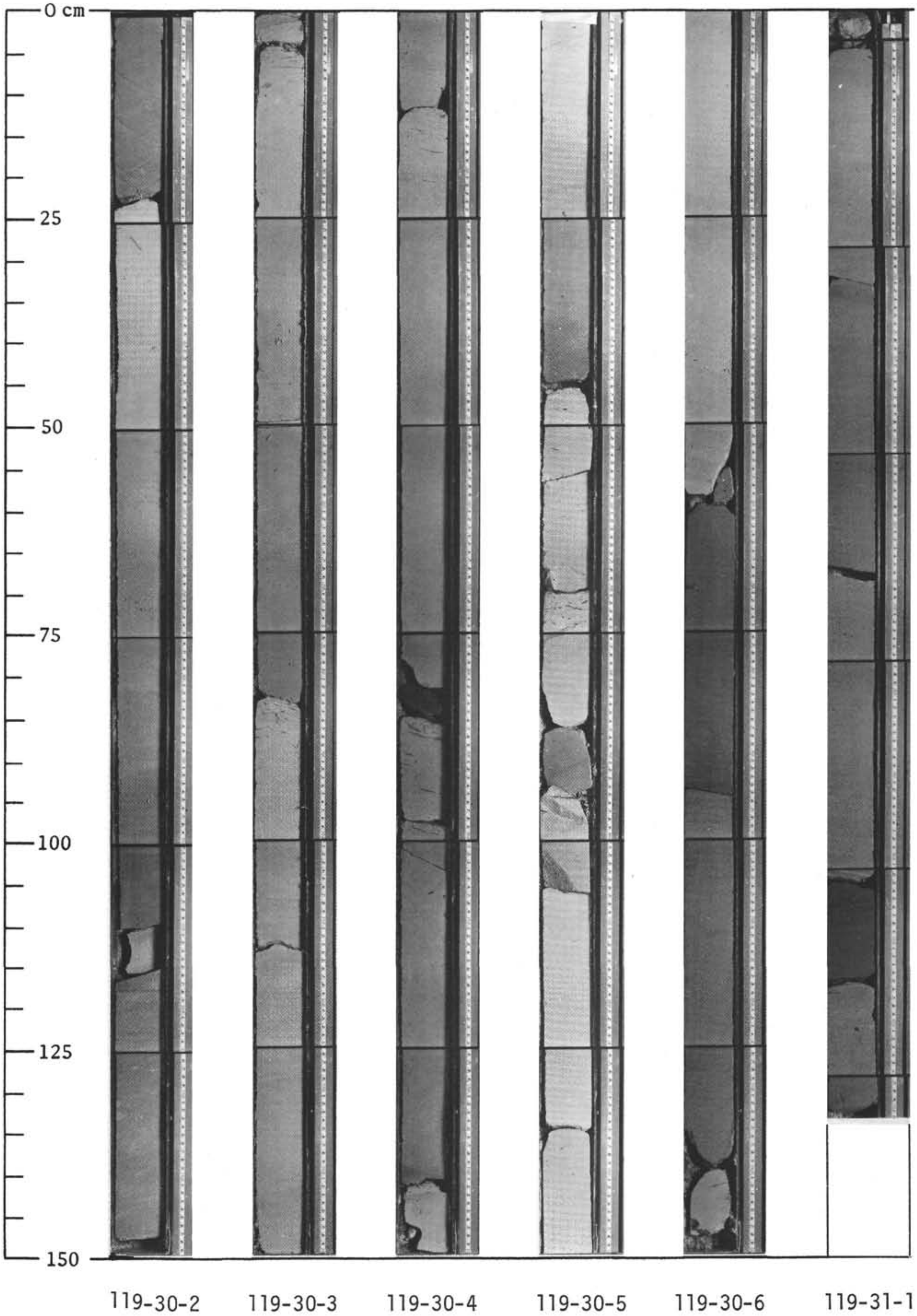

0 cm
25
50
75
100
125
150
119-19-6
119-20-1
119-20-2
119-20-3
119-21-1
119-21-2

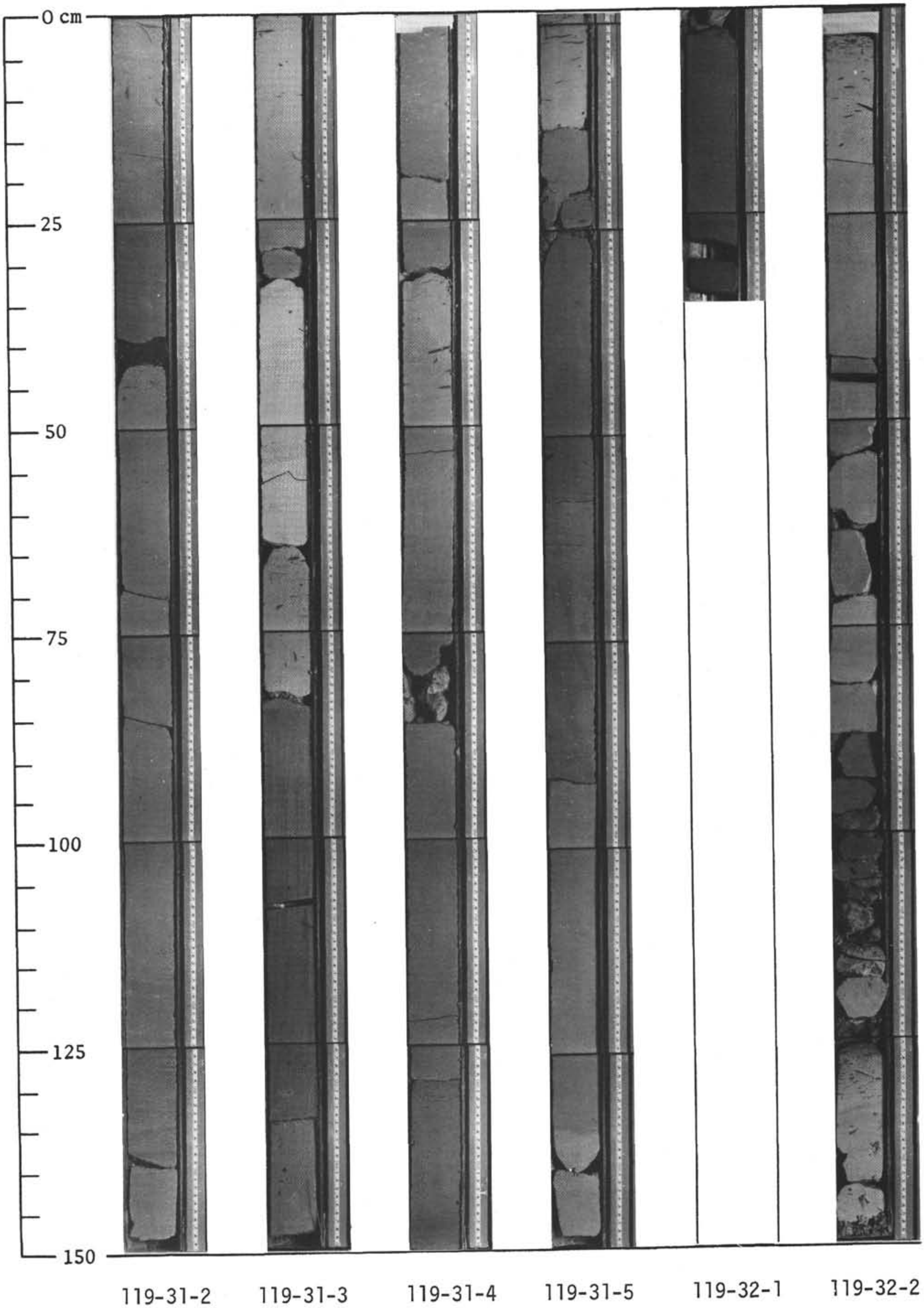


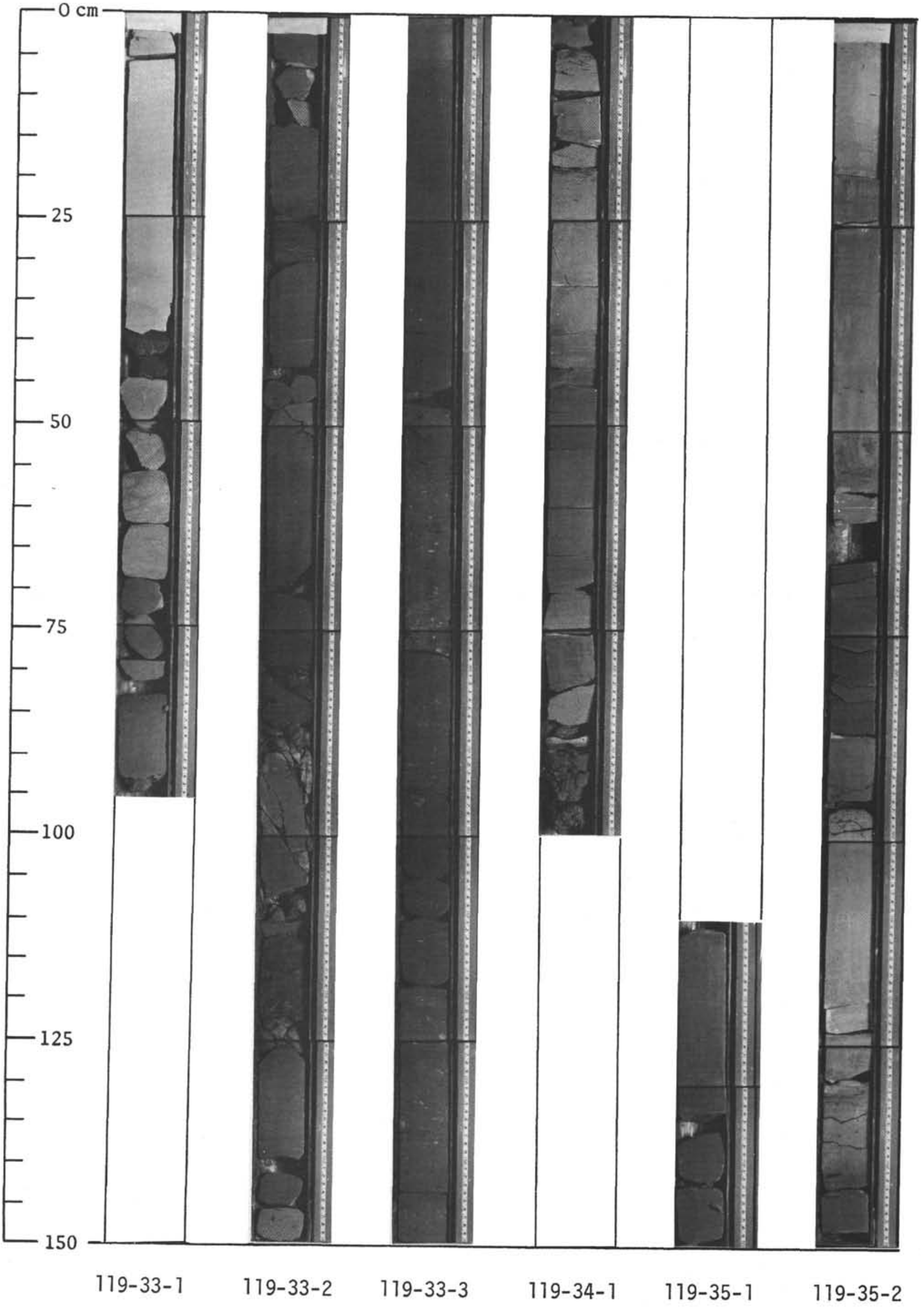
119-21-3 119-21-4 119-21-6 119-22-2 119-23-1 119-24-1 119-24-2

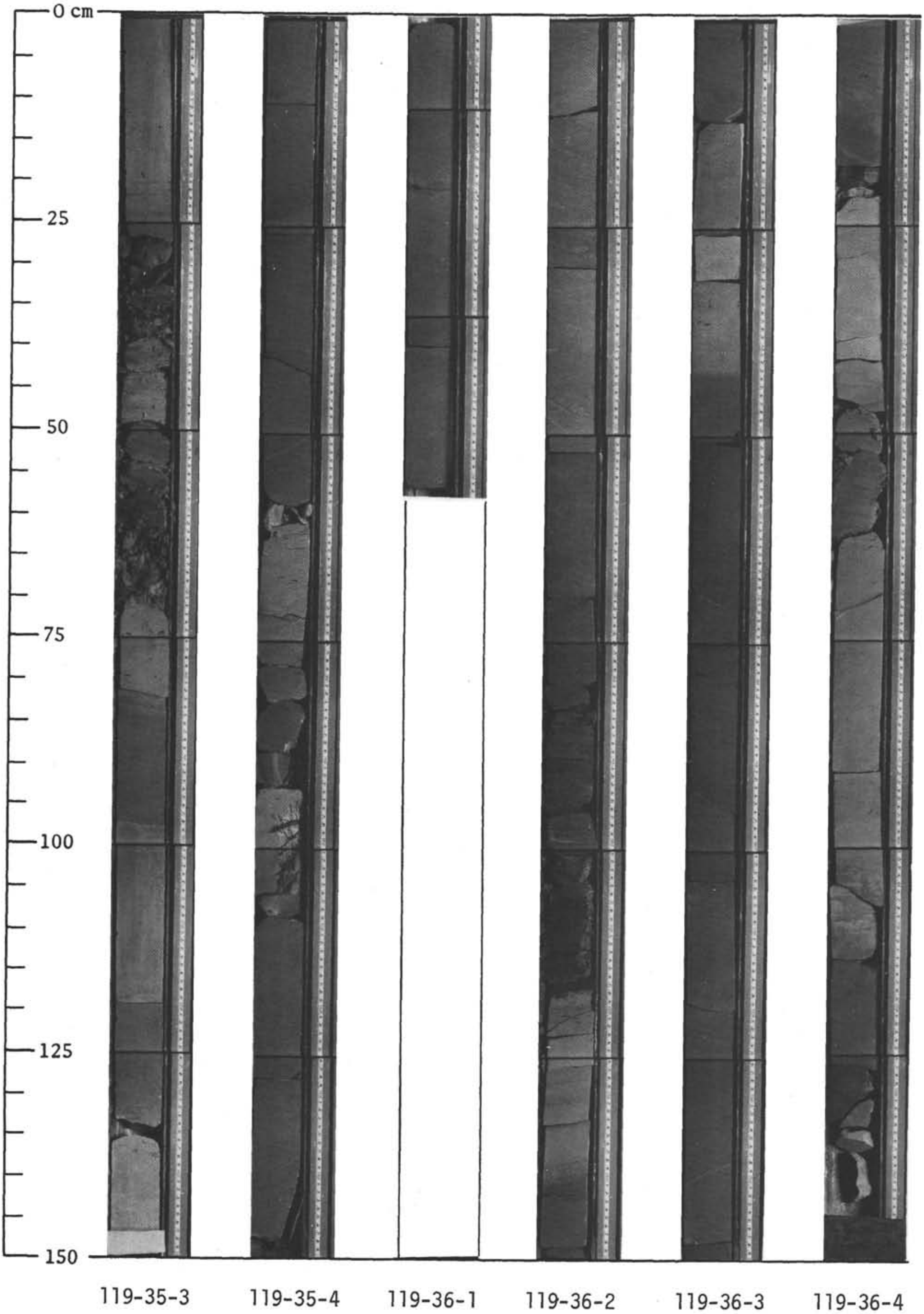

0 cm
25
50
75
100
125
150
119-24-3
119-25-1
119-25-2
119-26-1
119-26-2
119-27-1

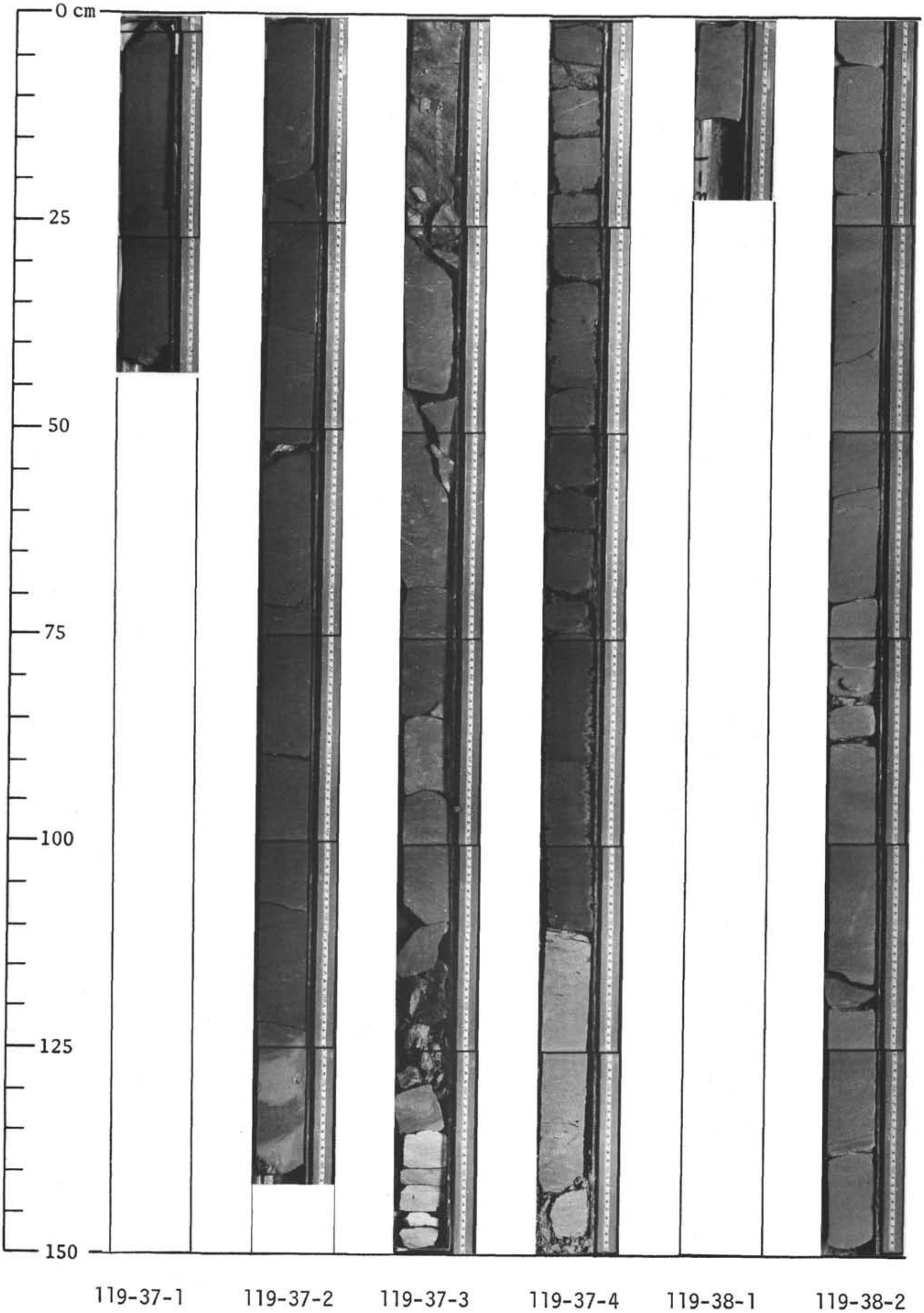

0 cm
25
50
75
100
125
150
119-28-2
119-29-1
119-29-2
119-29-3
119-29-4
119-30-1

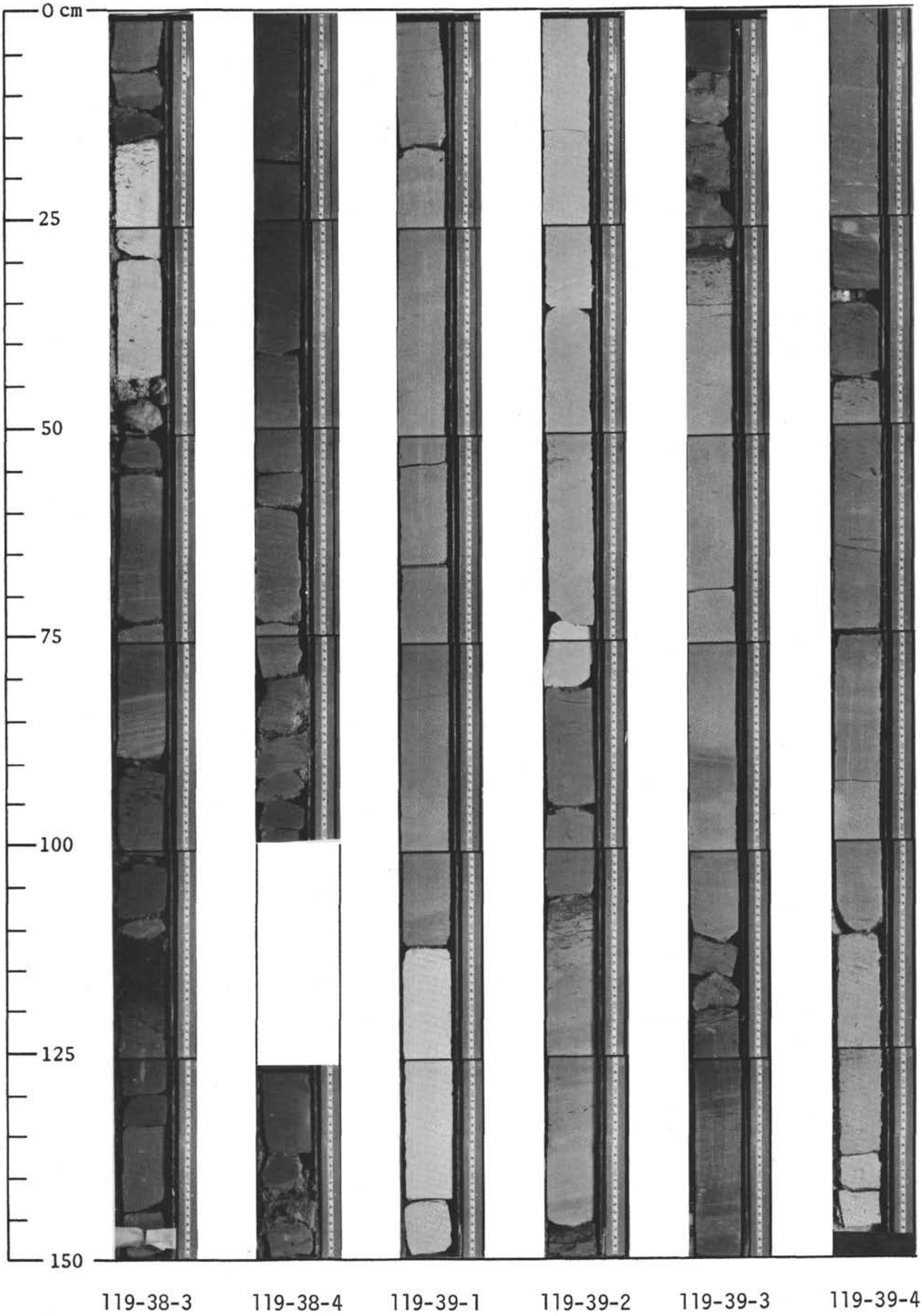

0 cm
25
50
75
100
125
150
119-30-2
119-30-3
119-30-4
119-30-5
119-30-6
119-31-1

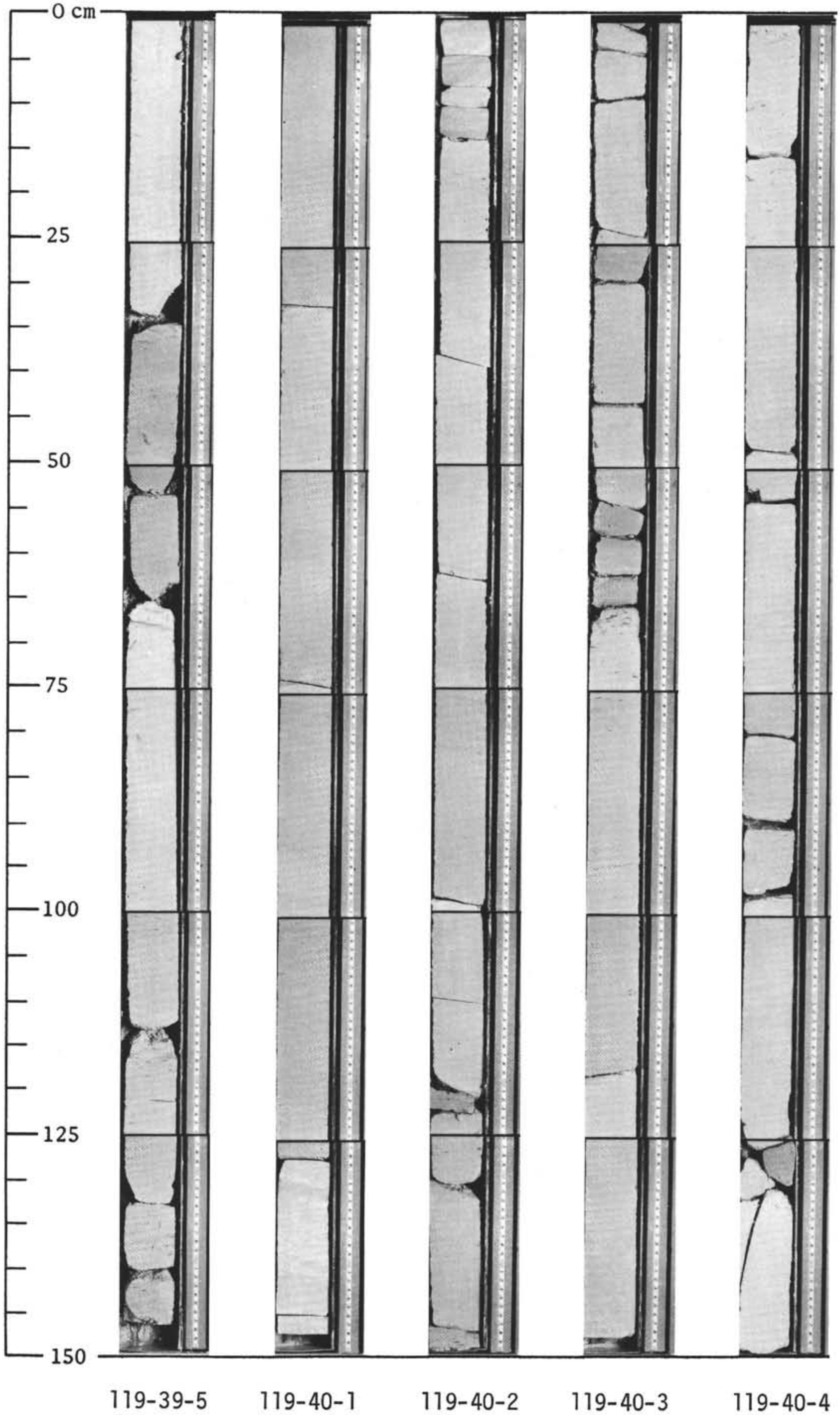

0 cm
25
50
75
100
125
150
119-31-2
119-31-3
119-31-4
119-31-5
119-32-1
119-32-2


0 cm
25
50
75
100
125
150
119-33-1
119-33-2
119-33-3
119-34-1
119-35-1
119-35-2


0 cm
25
50
75
100
125
150
119-35-3
119-35-4
119-36-1
119-36-2
119-36-3
119-36-4

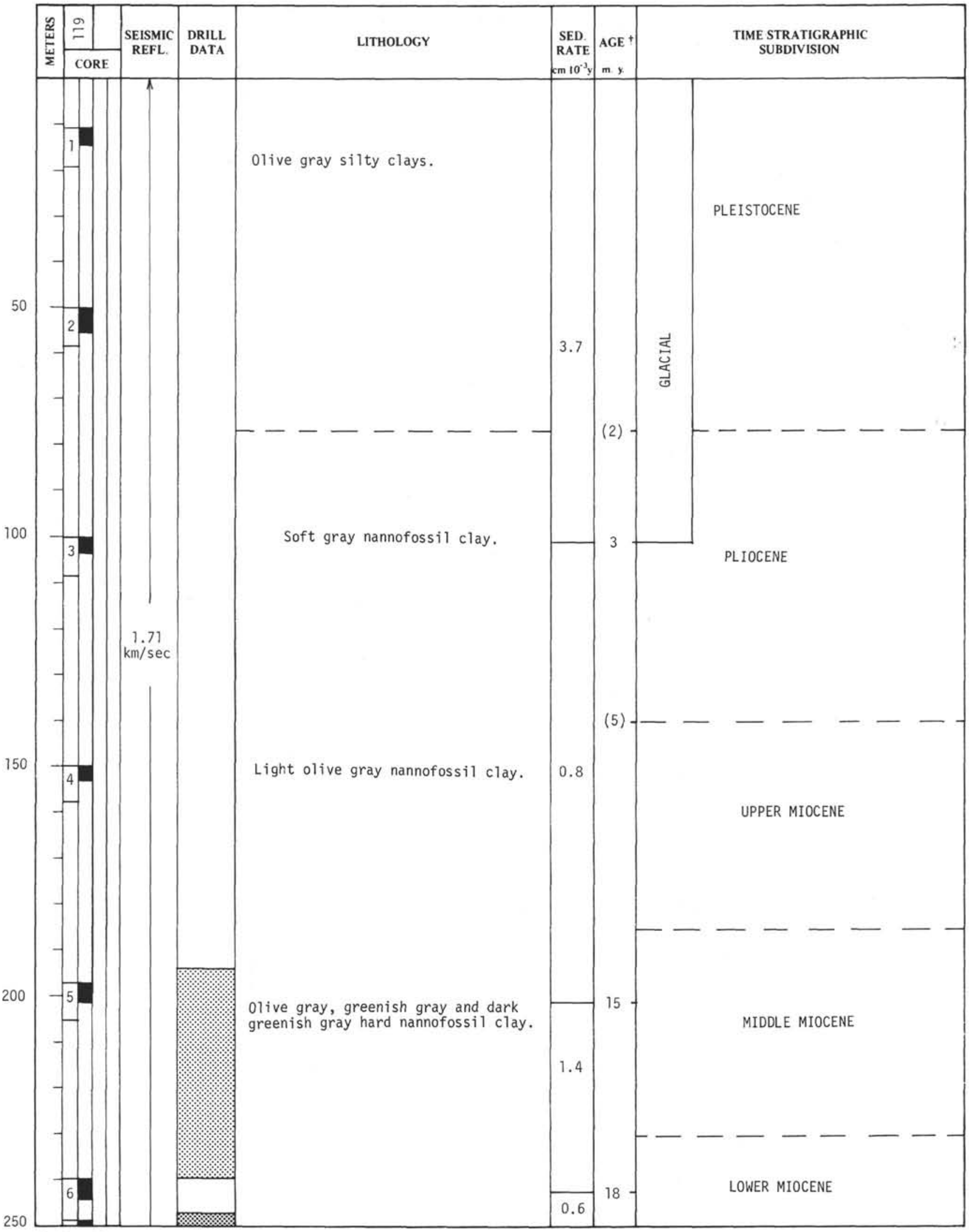

0 cm
25
50
75
100
125
150
119-37-1
119-37-2
119-37-3
119-37-4
119-38-1
119-38-2


0 cm
25
50
75
100
125
150
119-38-3
119-38-4
119-39-1
119-39-2
119-39-3
119-39-4


0 cm
25
50
75
100
125
150
119-39-5
119-40-1
119-40-2
119-40-3
119-40-4

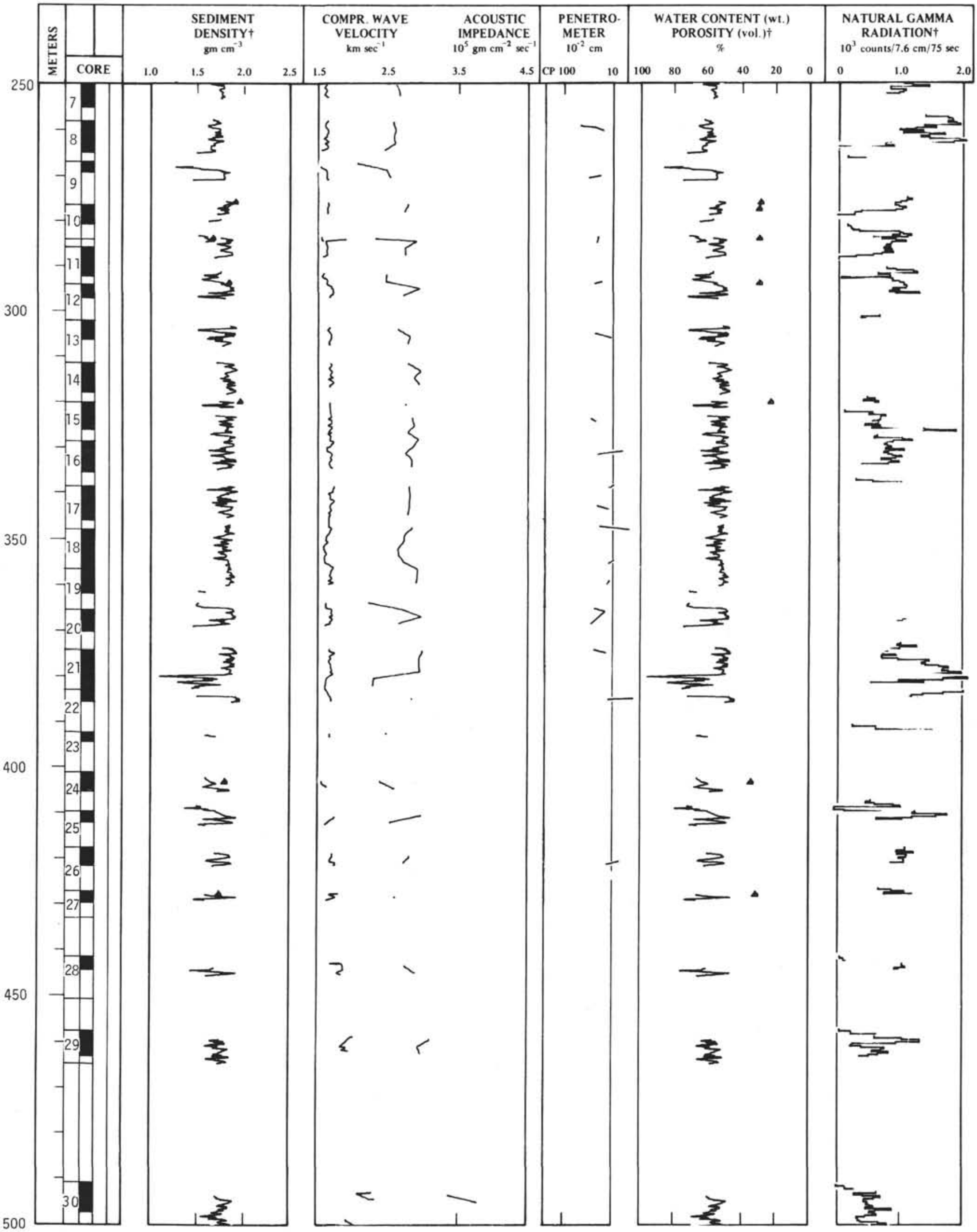
† Adjusted data, see Chapter 2

SITE 119 0 TO 250 m



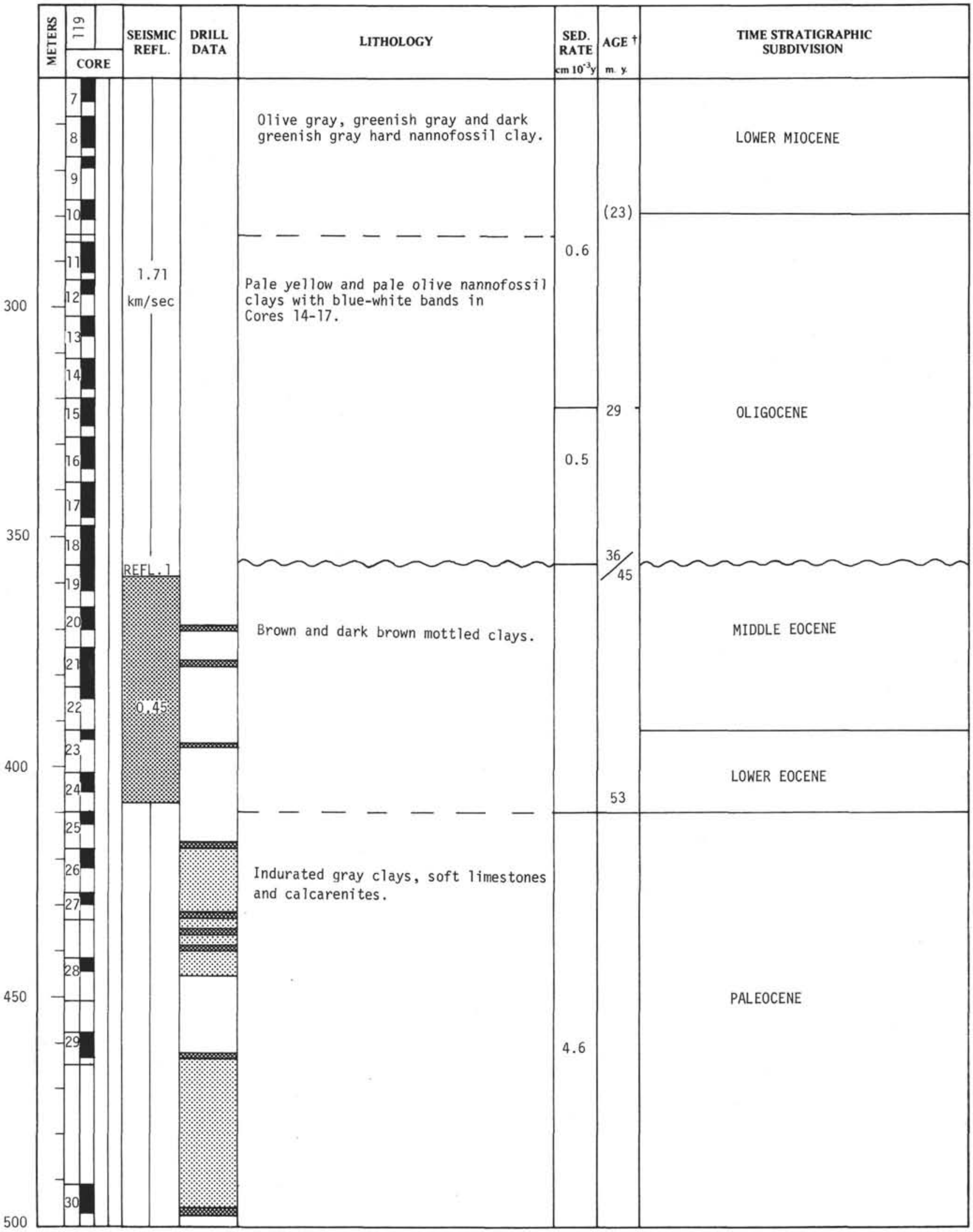
†See Chapter 2 (explanatory notes)

SITE 119 250m TO 500m

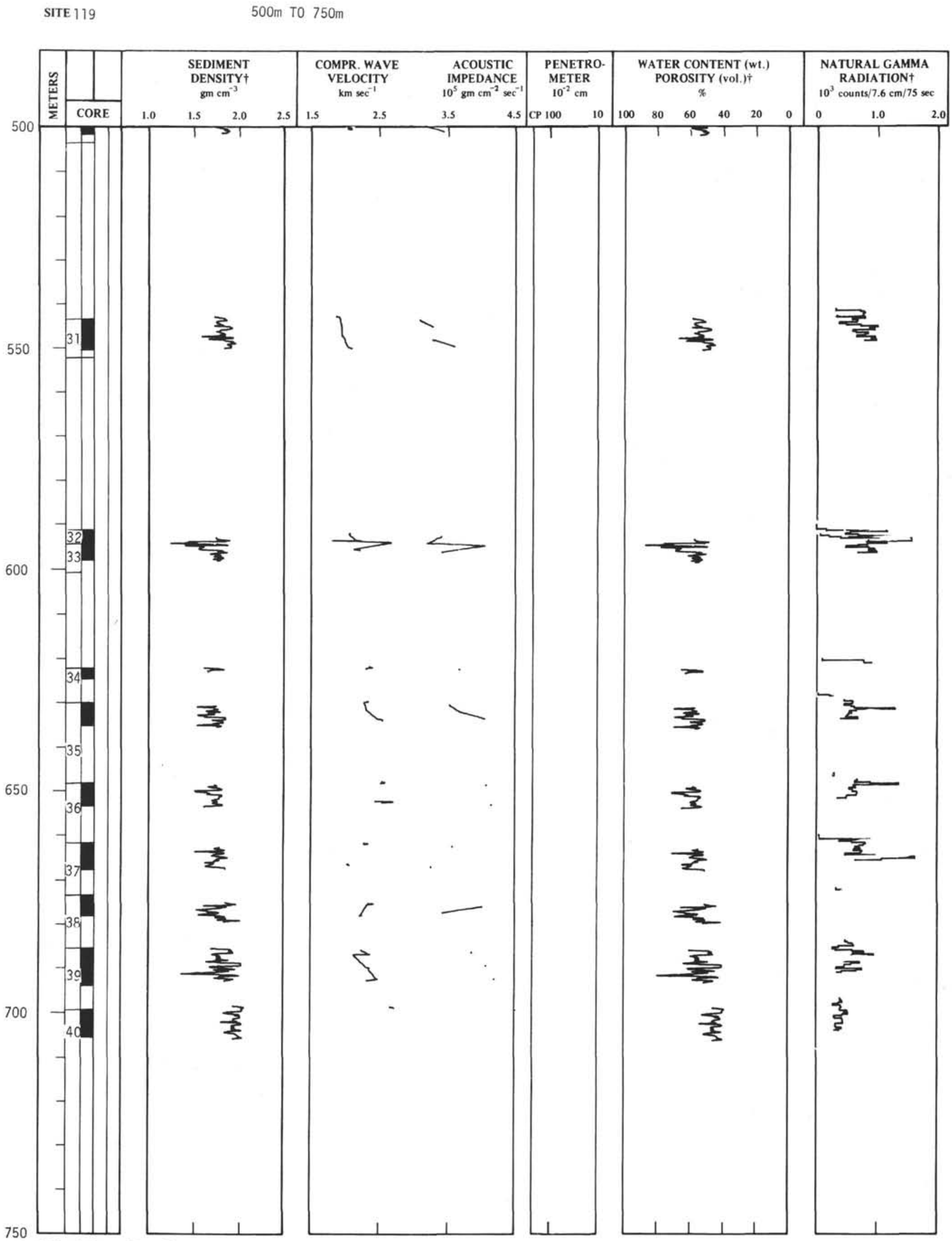


†Adjusted data, see Chapter 2

SITE 119 250 TO 500 m

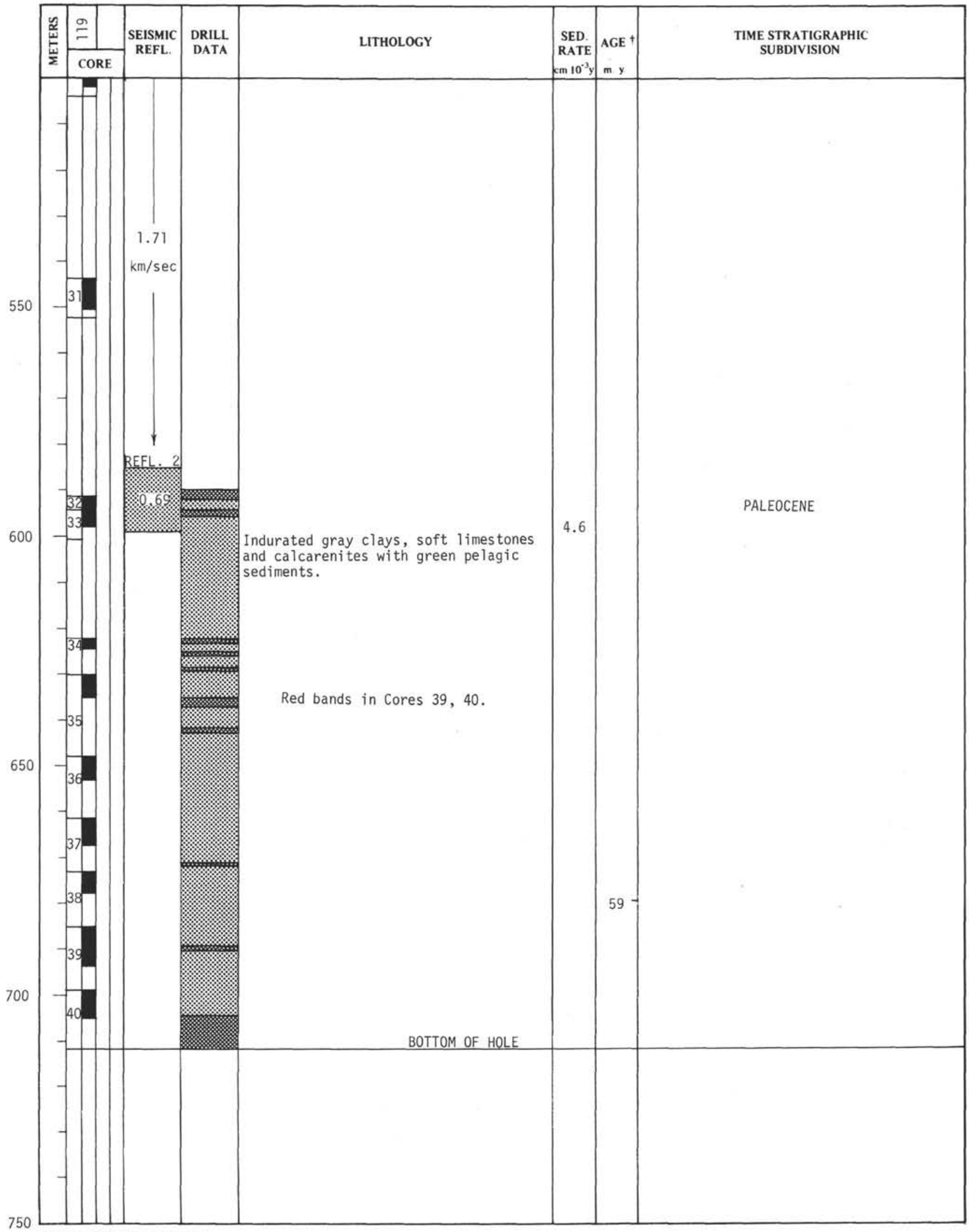


†See Chapter 2 (explanatory notes)



†Adjusted data, see Chapter 2

SITE 119 500 TO 750 m



†See Chapter 2 (explanatory notes)