4. SITE 34

The Shipboard Scientific Party[1]

SITE BACKGROUND

Site 34 had been located by the JOIDES Pacific Advisory Panel to be over a negative magnetic anomaly (31 million years B.P.) immediately to the east of Anomaly 10 (Site 33). The primary objective was to obtain samples of basement and basal sediment to provide comparison between adjacent positive and negative magnetic anomalies. A second objective was to obtain samples which would permit an analysis of the variability in sediment over relatively short distances (about 10 miles). Although basement had not been reached at Site 33 because of the unexpected chert, the use of a massive diamond bit at Site 34 permitted coring through the chert to basement at 383 meters below the sea floor. Even though the near basement sections of the paired sites (33 and 34) could not be compared, comparison would be possible above the chert layer.

From the *Argo* site survey (Appendix III) Site 34 is somewhat similar to Site 33. However, it lies on a small abyssal plain adjacent to the abyssal hill-flank location of Site 33. This abyssal plain may represent a flat embayed surface constructed as a distal portion of Delgada Fan. Contrasted with Site 33, *Argo* reported that stratification was more apparent at Site 34 and, in the relatively transparent section, there is a strong reflector at 0.18 second. No special core or measurement of heat flow was made at this site during the site survey.

The approach by the drilling ship was made along an easterly course from Site 33. The magnetometer was monitored until readings reached a minimum at about 50,600 gammas total field intensity. This marked the axis of the negative magnetic anomaly, and the location of the drilling site.

The on-site seismic reflection profile (Figure 1) shows a strong first reflector at a depth of 0.18 second below the sea floor. Subsequent coring revealed that this reflector represents a sequence of turbidite sands at least

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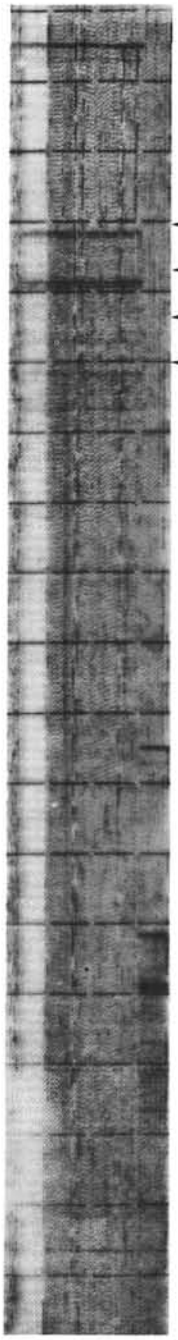

Figure 1. *On-site seismic reflection profile, Site 34.*

9 meters thick (at 125 to 134 meters in Core 6). A second, much weaker, reflector (0.39 second) indicates the location of the hard mudstone and chert which was followed continuously in the seismic reflection profile taken during the run from Site 33 to Site 34. The basement reflector is at a depth of 0.5 second (383 meters) below the sea floor.

Location

Site 34 is located at latitude 39° 28.21'N, longitude 127° 16.54'W on a small abyssal plain at the distal end of Delgada Fan.

OPERATIONS

The drilling summary for Site 34 is presented in Table 1. Coring began on 23 April and the first core was taken at a depth of approximately 20 to 29 meters below the bottom. A surface core was not attempted because sea conditions produced a considerable heave in the drill string. As it was, the water depth to the bottom, as based on the driller's depth, is uncertain. All of the core depths at this site are somewhat uncertain because of this initial problem in determining the exact location of the sea floor.

Spot coring, with intervening washing down with the drill string, was carried out to a depth of 107 meters. Cores 4 through 7 (107 to 143 meters) were taken as a continuous series in order to sample the strong 0.18 second reflector. All coring and drilling to this depth were at a relatively high rate of penetration, although there was a higher torque from Core 4 on.

TABLE 1
Drilling Summary of Leg 5, Site 34

Date	Core	Depth Below Sea Floor (m)	Depth Below Rig Floor (ft)	Core Cut (ft)	Core Cut (m)	Core Recovered (ft)	Core Recovered (m)	Per Cent Recovered
23 April	1[a]	20-29	14,287-14,317	30	9.1	30	9.1	100
	2	29-38	14,317-14,347	30	9.1	30	9.1	100
	3	75-84	14,467-14,497	30	9.1	30	9.1	100
24 April	4	107-116	14,571-14,601	30	9.1	30	9.1	100
	5	116-125	14,601-14,631	30	9.1	30	9.1	100
	6	125-134	14,631-14,661	30	9.1	30	9.1	100
	7	134-143	14,661-14,691	30	9.1	30	9.1	100
	8	165-174	14,760-14,790	30	9.1	30	9.1	100
	9	212-221	14,915-14,945	30	9.1	30	9.1	100
25 April	10	269-278	15,103-15,133	30	9.1	30	9.1	100
	11[b]	278-284	15,133-15,152	19	5.8	10	3.1	53
	12	284-294	15,152-15,182	30	9.1	8	2.4	27
	13	297-306	15,192-15,222	30	9.1	5	1.5	17
26 April	14	337-345	15,324-15,350	26	7.9	6	1.8	23
	15	345-348	15,350-15,359	9	2.7	6	1.8	67
	16	348-352	15,359-15,374	15	4.6	7	2.1	47
27 April	17	352-356	15,374-15,386	12	3.7	2	0.6	17
28 April	18	383-384	15,477-15,481	4	1.2	3	0.9	75
			Totals	445	135.1	347	105.2	78

[a]Mud line difficult to detect.
[b]Beginning of chert.

Note: Sonic water depth (corrected): 4322 meters; 14.175 feet; 2360 fathoms.
Driller's depth: 14,223 feet.

The 0.18 second reflector appears to represent a sand sequence of the turbidite type, although this was not determined until the cores were opened. The coring operations showed only a slightly slower rate of penetration in this part of the section.

The interval between 143 and 269 meters was sampled by two spot cores (Core 8 at 165 to 174 meters; Core 9 at 212 to 221 meters) with intervening very rapid washing. Continuous coring was resumed at 269 meters to sample the 0.39 second reflector. The main cherty sequence began in Core 11 (278 to 284 meters) where additional weight and the use of the pump were necessary in order to penetrate the harder layers. The smaller core recovery in Cores 11 and 12 suggests that softer material interbedded with the chert was being lost from the core because of the increased circulation.

The center bit was dropped after Core 12 and the interval from 194 to 297 meters was drilled at a very slow rate of penetration. Core 13 (297 to 306 meters) was taken at a slow, irregular rate of penetration using even higher pump pressure than in Core 12. Although the percentage core recovery was very low for Core 13, fragments of very hard calcareous-clayey mudstone were obtained.

Following the somewhat slower drilling with the center bit from 306 to 337 meters, continuous coring was begun. The rate of penetration in Cores 14 through 17 (337 to 356 meters) was slow and rather irregular. Increasing weight and pump pressure were required for coring and the core recovery was a very low percentage of the footage cut. Subsequent drilling with the center bit was initially at a slow rate, but from approximately 361 to 383 meters, the drilling rate was more rapid. The final core (383 to 384 meters) was taken in altered basalt of the basement at a very slow rate of penetration. The final core barrel became jammed in the bottom of the hole and the drill string had to be pulled in order to free the barrel. This pulling of the pipe prevented the hole from being logged.

LITHOLOGY

At Site 34, 106 meters of sediment were cored between the sea floor and the bottom of the hole at 384 meters. Good core recovery was obtained in fairly regular intervals throughout most of the hole with continuous recovery from Cores 4 through 7 (107 to 143 meters). Spotty recovery was experienced below 269 meters where some resistant beds were encountered. With the exception of some of these resistant beds, most cores are too badly deformed by the coring process to allow for interpretation of sedimentary structures.

The lithology at Site 34 is dominated by detrital sediments of varying shades of olive, gray, or blue-green, many of which are muds containing mostly clay-sized material. The remaining detrital component is sand of presumed turbidite origin which occurs throughout most of Core 6 (125 to 134 meters). It consists of 2 meters of very fine to fine, well-sorted friable sand in beds 5 to 30 centimeters thick. These beds have sharp upper and lower contacts and usually exhibit graded bedding. The turbidite sands are interbedded with thin beds of silty mud siliceous-fossil ooze. A few deformed pods of fine sand are also present in Core 2 (29 to 38 meters).

Approximately 35 to 40 per cent of the sediment is biogenous material represented by diatoms, silicoflagellates, radiolarians, sponge spicules, planktonic foraminifera, coccoliths, discoasters and other calcareous nannofossils. Most of the biogenous constituents (over two-thirds) are siliceous fossils which appear in varying proportions in Cores 1 through 13. They appear in greatest abundance in Cores 6 through 12 where they occur as siliceous-fossil mud, mud siliceous-fossil ooze, and siliceous-fossil ooze.

The calcareous fossils are represented mostly by nannoplankton which occur throughout all except the last core. Locally they are dominant enough to form discrete beds of nannofossil ooze and mud nannofossil ooze as in Cores 3, 4, 10, 16 and 17. In other cores they appear mostly as traces. Foraminifera occur only in traces in Cores 1 through 8 but are more numerous in Cores 16 and 17 (352 and 356 meters).

Several minor lithologic components are present at different intervals in the hole. Beds of volcanic ash occur in Cores 1, 5, 8 and 13; an ash bed in Core 8 (165 to 174 meters) is 7 centimeters thick and shows excellent graded bedding. The combined thickness of all ash beds is about 0.5 meter.

Several varieties of authigenic minerals are found at Site 34. Zeolite pods and zeolitic muds containing from a trace to 90 per cent zeolites occur in Cores 14 and 15 (337 to 348 meters) and 17 (352 to 356 meters). Some are obvious replacement products of ash beds. Dolomite rhombs in small quantities are evident in Core 14 (337 to 345 meters) and Core 16 (348 to 352 meters). In much of the hole where siliceous fossils are found, minor replacement by pyrite has occurred. Rare pyritized mud nodules and burrow tubes can be seen in Core 5 (116 to 125 meters).

Indurated to hard, well-cemented equivalents of the biogenous sediments occur locally as cherty, silicified or calcareous mudstone in Cores 10 through 17. Silicified or calcareous nodules are present in Cores 9, 10 and 11 (212 to 284 meters). This interval partly coincides with the interval of the first seismic reflector. Core 12 (284 to 294 meters) contains a hard silicified streak, and the core catcher of Core 13 (306 meters) recovered about 40 centimeters of very hard calcareous-clayey mudstone.

Bedding dips and some sedimentary structures are visible in the harder strata commencing with Core 13 (306 meters). In this core, level strata and slight burrow mottling can be seen. Strata in Core 16 (352 meters) dip at 15 degrees. Dips of 13 degrees, and slight to great burrow mottling, appear in Core 17 (356 meters). Whether the measured dip values represent true dip is not certain. The drill has a tendency to deviate from the vertical upon encountering hard strata which would exaggerate the true dip. Possibilities of penecontemporaneous deformation must also not be overlooked.

Core 18 (384 meters) penetrated about 50 centimeters of basement rock and recovered large pieces of a medium gray altered basalt containing chlorite-filled microamygdules. Fractures in the rock are filled with carbonate and chloritic minerals. This core also recovered 20 centimeters of soft sediments which contained some hard nodular streaks. Colors of these sediments are yellow, orange, green and dark gray. The dark gray sediments are a mud. The others consist mostly of carbonate, probably calcite, and some chloritic minerals.

PALEONTOLOGY

Nannofossils

Calcareous and siliceous nannofossils are present in all of the recovered intervals at this site except in the zeolitic muds of Cores 14 and 15. The occurrence and frequency of calcareous nannoplankton are quite variable in the sediments at this site. The calcareous nannofossils are common-to-abundant and well-preserved in the more calcareous sediments of Cores 3, 11 and 13, and where sometimes they are associated with fine-grained calcareous and coccolith debris. Cores 8 and 10 are fairly calcareous and contain frequent to common calcareous nannoplankton, some of which exhibit slight etching and disaggregation. The samples from Cores 1, 2, 4, 5, 6, 7 and 9 are either void of calcareous nannofossils, or they contain frequent or common fairly well-preserved specimens–although a number of specimens often show solution effects or etching and missing parts in these less calcareous sediments. Samples from Core 12 lack calcareous nannofossils; and, the more indurated materials of Cores 16 and 17 contain few-to-frequent but less well-preserved calcareous forms, yet still in an adequate condition to allow identification of a substantial assemblage of species.

Some reworked older calcareous nannofossils are recognized in the upper sequence at this site. The most frequent and diverse reworked forms occur in Cores 5 and 7 and in the top and bottom of Core 6, in proximity to the sandy interval. Less frequent reworked calcareous forms are present in Cores 2 and 3, and rare reworked calcareous specimens are recorded from Cores 1 and 9.

Siliceous nannofossils, mostly diatoms and silicoflagellates, plus the remains of other siliceous skeletal organisms (radiolarians, sponges, etc.) form an important part of the sediment at this site. More complete and identifiable specimens become frequent below the lower part of Core 4 and are a common constituent of the sediment from the lower part of Core 5 down through Core 13. A few rare less well-preserved siliceous nannofossils are present in the lowest part of Core 17. A fair proportion of the matrix of some samples is composed of fine-grained detritus as well as fragments and parts of siliceous skeletal material. In fact, the microfossil content of some samples is essentially composed of this fine debris and contains only a few pieces or specimens of heavier or larger individuals, which can be identified. Also present are scattered fish scale fragments and rare palynomorphs. This condition is most evident in the higher cores (Cores 1 through 7). A fairly large number of displaced siliceous nannofossils indicative of neritic or littoral environments (Cupp, 1943; Hendey, 1937 and 1964; Hustedt, 1930) are associated with these nannofossil assemblages down through Core 13. Some of these displaced forms are quite frequent at intervals and include: *Arachnoidiscus ehrenbergii* Bailey and vars.; *Biddulphia* spp.; valves and inner plates of *Campyloneis grevillei* (Wm. Smith) Grunow and vars.; *Cocconeis* spp.; *Diploneis* spp.; *Navicula* spp.; chaetoceroid resting spores of *Chaetoceros* spp. and *Xanthiopyxis* spp.; and, *Stephanopyxis* spp. Also present are frequent specimens and fragments of diatoms and some silicoflagellates that are coated with a very fine-grained iron and/or manganese oxide and associated with oxide micronodules. This oxide material and coating is quite common in, or associated with, the coarser sediments at this site. This suggests that these coated siliceous nannofossils were in near-surface material for sometime where this alteration took place, followed by emplacement within the rapidly accumulated sediments at this site. However, *in situ* diagenetic alteration could account for some of this oxide coating since occasional distinct pyritic incrustations are present on the larger siliceous skeletal parts of sponges and radiolarians. This siliceous microfossil detritus, oxide-coated material, and the presence of displaced forms appear to be more common in the sediments above Core 11, though some of these features are still evident in Cores 11, 12 and 13.

Most of the siliceous nannofossils, coated, displaced or otherwise, have a stratigraphic occurrence comparable to that reported from the peripheral part of the North Pacific. The only possible exception is the presence of some siliceous forms in the Pleistocene and the Upper Pliocene, which is above their reported occurrence from Western North America.

The siliceous nannofossil assemblages are quite diversified from Core 5 through Core 13, including numerous species of coscinodiscids. Some of the identified forms occurring through this interval include: *Ebria antiqua* Schulz *E. a. rectangularis* Schulz; parts of *Ethmodiscus rex* (Rattray) Hendey; *Coscinodiscus lineatus* Ehrenberg; *C. marginatus* Ehrenberg; *C. oculus-iridis* Ehrenberg and vars.; *C. radiatus* Ehrenberg; *C. vetustissimus* Pantocsek; *Hemidiscus cuneiformis* Wallich; *Thalassiosira decipiens* (Grunow) Jørgensen and related forms; *Thalassiothrix longissima* Cleve and Grunow and related forms; *Denticula hustedtii* Simonsen and Kanaya (lowest occurrence in Core 13); *D. lauta* Bailey–more scattered occurrences above Core 10 probably represent reworked specimens; *Actinocyclus octonarius* Ehrenberg; *Actinoptychus senarius* Ehrenberg; and, *Melosira sulcata* (Ehrenberg) Kützing, at least part of the specimens of the latter three species are also probably displaced.

The Pleistocene, *Coccolithus carteri* Zone, recovered at this site (Cores 1 and 2) contains infrequent or rather scattered occurrences of nannofossils. Calcareous nannofossils are present in samples from the upper and basal parts of Core 1 and the lower part of Core 2. The most diverse calcareous assemblage in Core 1 occurs in Section 3 and includes: *Coccolithus carteri* (Wallich), *C. doronicoides* Black and Barnes?, *C. pelagicus* (Wallich), *Cyclococcolithus leptoporus* (Murray and Blackman)–mostly var. B of McIntyre, Bé and Preikstas, *Discolithina japonica* Takayama, *Gephyrocapsa* spp., and *Pseudoemiliania lacunosa* (Kamptner). The more extensive calcareous assemblage from the lower part of Core 2 is composed of this same suite of species plus *Ceratolithus cristatus* Kamptner, *Cyclococcolithus leptoporus macintyrei* Bukry and Bramlette, and *Helicopontosphaera kamptneri* Hay and Mohler. Few to frequent siliceous nannofossils are present in the uppermost and basal parts of Core 1 and through a fair portion of Core 2. The more consistently occurring forms include *Coscinodiscus lineatus* var. *leptopus* Grunow, *C. marginatus, Hemidiscus cuneiformis,* and *Thalossiosira decipiens* or related forms. The intervening samples, as well as those containing recognizable microfossils, contain fine siliceous skeletal debris which forms a greater proportion of the matrix in the lower part of Core 2.

Some poorly preserved reworked older calcareous nannofossils are present in Section 3, Core 1 and Sections 5 and 6 of Core 2, where they are associated with common fine calcareous detritus and include: *Discoaster* sp. indet. and *Reticulofenestra pseudoumbilica* (Gartner). In the lower part of Core 2, specimens of probably reworked *Helicopontosphaera sellii* Bukry and Bramlette occur, and two broken specimens of *Discoaster brouweri* Tan var. are present in the basal part of Core 2. A rather diverse suite of siliceous nannofossils are present in the lower part (Sections 4, 5, 6 and core catcher) of Core 2 with a number represented by broken or incomplete specimens. It is probable that most of these specimens are reworked from older material and some are obviously displaced as well. They are represented by the following: *Campyloneis grevillei* and vars.–which also occurs in Section 3; *Coscinodiscus vetustissimus* Pantocsek; *Denticula hustedtii; D. kamtschatica* Zabelina; *D. lauta;* the resting spores of *Chaetoceros cinctum* Gran and *C. lorenzianum* Grunow; *Xanthiopyxis* spp.–including *X. diaphana* Forti, *X. ovalis* Lohman, *X. umbonata* Greville, *X.* sp. B of Wornardt, *X.* sp. C. of Wornardt, *X.* sp. 5 of Kanaya; *Stephanopyxis* spp.–including *S. appendiculata* Ehrenberg and *S.* cf. *S. nipponica* Gran and Yendo of Kanaya; *Fragilariopsis pliocena* (Brun) Sheshuk.; *Dictyocha fibula aspera* Lemmermann; *Distephanus gracilis* (Kützing); and, *D. speculum pentagonus* Lemmermann.

Coarser silty material in Section 1, Core 1, contains a siliceous assemblage with a slightly different aspect. Frequent *Melosira* spp., including *M. sulcata* and possibly parts of frustules and colonies of *M. granulata* (Ehrenberg) Ralfs, are present as well as complete specimens of *Navicula lyra* Ehrenberg. This appears to represent a similar depositional episode as that recorded in the highest cored material at Site 32 and in Core 1 at Site 33.

The Upper Pliocene *Discoaster brouweri* Zone is represented by Core 3 at this site and is characterized as a highly calcareous sediment dominated by the common small coccolith, *Coccolithus doronicoides?.* Other significant forms are: *Cyclococcolithus leptoporus* and vars.–including *C. l. macintyrei; Discoaster brouweri* and vars.; *Coccolithus pelagicus; Ceratolithus rugosus* Bukry and Bramlette var.; and, *Discolithina japonica.* Less frequent occurring forms are: *Ceratolithus cristatus; Discoaster* cf. *D. challengeri* Bramlette and Riedel–with weakly expressed bifurcations; *D.* sp. aff. *D. exilis* Martini and Bramlette; *D. surculus* Martini and Bramlette–with tenuous trifurcations; *D. variabilis* Martini and Bramlette var.; *Helicopontosphaera kamptneri, H. sellii;* and, *Pseudoemiliania lacunosa.* A few siliceous nannofossils are scattered throughout this Upper Pliocene sequence. They are *Coscinodiscus lineatus* var. *leptopus, C. marginatus, Thalassiosira decipiens,* and *Thalassiothrix longissima.*

Besides the presence of some fine siliceous skeletal debris in the matrix of this Upper Pliocene material, some intervals have appreciable amounts of fine calcareous and coccolith debris. This is most obvious in Sections 3 and 5, where ragged-edged coccoliths with modified or missing central parts are evident, and may be reworked *Reticulofenestra pseudoumbilica*. Associated in these intervals are rare, often oxide-coated siliceous nannofossils that are probably reworked, and include *Deuticula lauta*–Section 5; and *Distephanus aculeatus* (Ehrenberg) var. D–Section 3. Displaced and possibly reworked *Xanthiopyxis ovalis* is present in Section 1.

Single occurrences of other siliceous nannofossils include: *Dictyocha fibula* Ehrenberg–Section 5; *Distephanus gracilis*–Section 3; and, *Mesocena elliptica* (Ehrenberg)–Section 2.

The recovered Lower Pliocene represents the *Ceratolithus rugosus–Reticulofenestra pseudoumbilica* Subzone in Cores 4 through 6 and most of Core 7. Some samples within this interval contain quite rare specimens, or are essentially void of calcareous nannofossils; but, fortunately, the top and bottom portions contain common calcareous forms and allow the recognition of this biostratigraphic unit based on its primary criteria. The intervals lacking calcareous forms or those containing rare ones are: the bottom of Section 5 and the top of Section 4 of Core 4; Section 1, Section 5, and the lowest part of Core 5; through most of the sandy sequence of Core 6 (lower Section 1 to upper Section 6); and, the lower part of Section 2 and the upper part of Section 3 of Core 7. Where present, the calcareous assemblage is similar to that of the Upper Pliocene, except for a marked reduction in the frequency of *Coccolithus doronicoides?*, and the addition of *Ceratolithus tricorniculatus* Gartner, unquestionable *Discoaster challengeri*, and common *Reticulofenestra pseudoumbilica.* Scattered infrequent specimens of *Sphenolithus abies* Deflandre and *Discoaster brouweri rutellus* Gartner occur in the sediments of this subzone; and, rare to few specimens of *D. calcaris* Gartner, *D. quinquerimus* Gartner, and *D. variabilis s.s.* are found in Sections 3 and 4 of Core 7.

Some reworked incomplete or distinctly differently preserved calcareous forms are evident within this Lower Pliocene interval in proximity to the sandy section. The most frequent are in Sections 2 and 3 of Core 5, the top and basal parts of Core 6, and Sections 3 and 4 of Core 7. Some of the identifiable forms include: *Coccolithus bisectus* (Hay, Mohler, and Wade), *C.* aff. *C. bisectus* of Bramlette and Wilcoxon, *Cyclococcolithus neogammation* Bramlette and Wilcoxon, *Discoaster exilis* and var., *D. variabilis s.s.*, *Reticulofenestra umbilica* (Levin), and incomplete specimens of the siliceous form *Actinocyclus ingens* Rattray. These suggest reworking from a Middle Miocene to Oligocene source.

Core 4 contains only scattered occurrences of siliceous nannofossils, though they are more frequent than in Core 3. In addition to the same suite of diatoms found in Core 3 are *Coscinodiscus vetustissimus, Denticula hustedtii* and *D. kamtschatica.* Other siliceous nannofossils found here are: *Dictyocha fibula, Distephanus speculum pentagonus, Mesocena elliptica*–quite frequent in Section 4, and *M. diodon* Ehrenberg–a single occurrence in Section 4. Some displaced individuals are evident in Core 4 represented by *Xanthiopyxis* spp. including *X.* sp. B of Wornardt, *X.* sp. C. of Wornardt–Section 5, *X. ovalis*–Section 4, and *Rhaphoneis amphiceros* var. *angularis* (Lohman)–Section 5.

The siliceous nannofossil assemblage becomes more frequent and diverse in Core 5, where the highest continuous occurrence of a number of forms is found. These include: *Actinocyclus octonarius* var. *tenellus* (Brébisson) Hustedt, *Coscinodiscus rothii* (Ehrenberg) Grunow, *Fragilariopsis pliocena, Lithodesmium cornigerum* Brun, *L. minusculum* Grunow, *Dictyocha fibula aspera, D. f. brevispina* Lemmermann, *D. f. rhombica* Schulz, *D. f. pentagonalis* Aurivillius, *D. pseudofibula* Schulz, *Distephanus aculeatus* vars. B, C and D, *D. binoculus* (Ehrenberg), *Mesocena quadrangula* Ehrenberg–restricted to the lower part of this subzone, and rare infrequent *M. triangula* (Ehrenberg). Other distinctive forms characteristic of the lower part of this subzone are: *Coscinodiscus lineatus* var. *leptopus;* the more finely areolate form of *C. vetustissimus; Denticula hustedtii; D. kamtschatica;* and, *D. lauta*–probably reworked; *Dictyocha fibula; Distephanus gracilis*–with basal ring becoming heavier; *D. speculum pentagonus; Mesocena elliptica;* and, *M. diodon* among many other species. The highest occurrence of *Actinocyclus ellipticus* Grunow is in Section 2 of Core 6. Large heavy coscinodiscids with coarse areolation are quite common in the finer material intercolated within the sands of Core 6, and include: *Coscinodiscus radiatus, C. marginatus,* and *C. asteromphalus* Ehrenberg. Fairly frequent displaced specimens are present in the siliceous microfossil-rich samples below Core 4, some of which represent their highest position of continuous occurrence at this site. Displaced representatives are: *Campyloneis grevillei* and vars.; *Navicula optima* Hanna; *Diploneis taschenbergeri* (Schmidt) Hustedt–probably reworked as well; *Rhaphoneis amphiceros* var. *angularis; R. a.* var. *elongata* Peragallo; *Cocconeis* sp. indet.; resting spores of *Chaetoceros* spp.–including *C. cinctum, C. lorenzianum,* and *C. subsecundum* (Grunow) Hustedt; *Xanthiopyxis diaphana; X. lacera* Forti, *X. oblonga* Ehrenberg; *X. ovalis; X.* sp. A, B, C, and D of Wornardt; *X.* sp. 5 of Kanaya; *Stephanopyxis* cf. *S. nipponica;* and, *S. turris* (Greville and Arnott) Ralfs.

The Upper Miocene *Ceratolithus tricorniculatus* Zone is represented at this site by the lower part of Core 7 and all of Core 8. Samples from this sequence are quite fossiliferous with calcareous nannofossils well represented except in the basal-most part of Core 7 and the lower part of Section 5, Core 8. The diverse calcareous assemblage of this zone is dominated or characterized by *Ceratolithus tricorniculatus, Coccolithus pelagicus, Cyclococcolithus leptoporus* and vars., *Discoaster brouweri* and var., *D. challengeri, D.* sp. aff. *D. exilis, D. variabilis* and var., *Helicopontosphaera sellii, Reticulofenestra pseudoumbilica,* and *Sphenolithus abies.* Other species, which are less frequent or scattered in their distribution, include: *Coccolithus doronicoides?, Discoaster brouweri rutellus, D. calcaris, D. quinquerimus, D. pentaradiatus* Tan, *D. surculus, Discolithina vigintiforata* (Kamptner), and *Helicopontosphaera kamptneri.*

The siliceous nannofossil assemblage is also extensive in this zone becoming abundantly varied on reaching Core 8, where a flood of *Thalassiothrix longissima* and related forms is found. Core 8 is where the highest occurrence of a number of species is recorded, including: *Actinocyclus ellipticus* var. *javanica* Reinhold; *Coscinodiscus endoi* Kanaya; *Fragilariopsis* sp. aff. *F. pliocena; Lithodesmium californicum* Grunow; *Rouxia californica* Peragallo; *Triceratium cinnamoneum* Greville-top in core catcher of Core 7; *Distephanus aculeatus* var. A, *D. ornamentum* (Ehrenberg); *D. speculum* (Ehrenberg)–top in Section 4 of Core 8; and, *D. crux* (Ehrenberg)–top in Section 5 of Core 8. The remainder of the siliceous assemblage is similar to the suite occurring above in Cores 5 through 7. This zone contains the lowest occurrence at this site of *Denticula kamtschatica, Fragilariopsis pliocena s.s., Lithodesmium cornigerum, Distephanus binoculus,* and unquestionable specimens of *D. aculeatus* var. C. Again, a rather diverse group of displaced forms are evident in the sediment of this zone. These are: *Actinoptychus splendens* (Shadb.) Ralfs var.; *Campyloneis grevillei* and vars.; *Cocconeis antiqua* Tempère and Brun; *Diploneis major* Cleve; *Navicula optima; Rhaphoneis amphiceros* var. *angularis; R. a.* var. *elongata*; large parts of the tabellarioids *Rhabdonema japonicum* var. *sparsicostatum* Tempère and Brun, and *Entopya australis* var. *gigantea* (Greville) Fricke–both possibly reworked; *Stephanopyxis appendiculata; S.* cf. *S. nipponica; S. turris;* and resting spores of *Chaetoceros cinctum; C. subsecundum; Xanthiopyxis acrolopha* Forti, *X. oblonga, X.* sp. B, C, and D of Wornardt; *X.* sp. 5 of Kanaya; and, the lowest occurrences of *X. diaphana, X. ovalis,* and *X.* sp. A of Wornardt.

Core 9 represents the Upper Miocene *Discoaster variabilis–D. challengeri* Subzone and has an abundant and diverse siliceous nannofossil content. The calcareous nannofossil content is variable in this core, and nannofossils are absent in the lower part of Section 4 and the upper part of Section 5. The calcareous assemblage is quite similar to that in Core 8 except for the absence of *Ceratolithus tricorniculatus*, a substantial drop in the frequency of *Cyclococcolithus leptoporus* and vars. and the presence of *Discoaster exilis* var. and scattered occurrences of *D.* aff. *D. bollii* Martini and Bramlette and *D. subsurculus* Gartner. Some reworked forms are evident in Section 6 where ragged specimens of *Coccolithus* aff. *C. bisectus* and *Cyclococcolithus neogammation* occur.

Of the siliceous nannofossils, *Distephanus diommata* (Ehrenberg), *Mesocena circulus* (Ehrenberg)–restricted to this core, and *M. c. apiculata* Lemmermann have their highest occurrence in Core 9. Others have their highest occurrence in the lower part of the core, and include: *Actinocyclus ingens* var.–lower part of Section 5 (lacking distinct corrugated valves); *A. tsugaruensis* Kanaya–Section 6; *Asteromphalus moronensis* (Greville) Rattray var.–base of core; *Distephanus crux longispira* Schulz–Section 6; and, parts of *Rutilaria epsilon* (Kitton) Greville–base of core (displaced?). Rare specimens of *Coscinodiscus yabei* Kanaya occur in Sections 2 and 6 of Core 9. A number of distinctive siliceous nannofossils have their lowest distribution in Core 9. These include: *Actinocyclus octonarius* var. *tenellus; Coscinodiscus lineatus* var. *leptopus*–upper part of Section 6; *C. rothii*; finer areolate forms of *C. vetustissimus; Dictyocha fibula pentagonalis; Distephanus aculeatus* var. B and a few near var. C, but most are transitional forms with a higher apical ring as *D. a.* cf. var. C; *D. gracilis*–with heavy basal ring; *Lithodesmium minusculum; Mesocena triangula;* and, *Rouxia californica.* Besides the presence of the small form with bluntly rounded ends indicated as *Fragilariopsis* sp. aff. *F. pliocena,* other slightly larger specimens with fairly narrow ends occur in this core and are catagorized as *F.* cf. *F. pliocena.* Displaced forms present are: *Biddulphia* spp.–including *B. tuomeyi* (Bailey) Roper; *Campyloneis grevillei* and vars.; *Navicula hennedyi* W. Smith; *Rhaphoneis amphiceros* var. *angularis*–lowest occurrence; frequent smaller pieces and fragments of tabellarioids not specifically determinable; probably displaced specimens of *Stictodiscus californicus* Greville; *Stephanopyxis appendiculata; S.* cf. *C. nipponica; S. turris;* resting spores of *Chaetoceros cinctum; C. subsecundum*–lowest occurrence; *Xanthiopyxis lacera; X. oblonga; X.* sp. B–lowest occurrence; *X.* sp. C, and D of Wornardt; and, *X.* sp. 2 and sp. 5 of Kanaya.

The upper part of the Middle Miocene, *Discoaster exilis–Reticulofenestra pseudoumbilica* Subzone, is represented by the fossiliferous material in Cores 10, 11 and the uppermost part of Core 12. The calcareous nannofossils are dominated by the *Discoaster exilis* group, including: *D. exilis s.s., D. exilis* var., and *D.* sp. aff. *D. exilis*, and *Reticulofenestra pseudoumbilica.* Less frequent but persistent forms include: *Cyclococcolithus leptoporus* and vars.; *Sphenolithus abies; Discoaster brouweri rutellus; D. challengeri; D.* cf. *D. divaricatus* Hay–with quite weak widely forked to U-shaped bifurcations; *D. variabilis*; and, *D.* cf. *D. brouweri*–quite small with flat rays and irregular enlarged ray ends and a larger central knob. Scattered occurrences of *Discolithina vigintiforata*–upper part of Core 10, *Discoaster subsurculus*, and *D. kugleri* Martini and Bramlette var. are present.

A number of distinctive siliceous nannofossils characterize part or all of this subzone at this site. The upper limits of *Actinocyclus ingens s.s., Asteromphalus moronensis s.s.,* coarser areolate forms of *Coscinodiscus vetustissimus, Distephanus crux longispina* Schulz, and the heavy forms of *Mesocena elliptica* and *M. diodon* with very thick basal rings are found in the recovered uppermost part of this subzone. The lowest occurrences of *Actinocyclus ellipticus* and *A. e.* var. *javanica, Asteromphalus moronensis s.s.* (base of var. form in the upper part of Core 10), *Dictyocha fibula aspera* and *Distephanus aculeatus* var. D are in the basal part of the subzone. Other forms characterize the upper part of the subzone with their lowest occurrence near the middle of the subzone or are found only in this part of the sequence. These are *Coscinodiscus curvatulus* var. *odontodiscus* (Grunow) Hustedt, *Dictyocha pseudofibula, Distephanus ornamentum, D. pseudocrux* Schulz, *Fragilariopsis* sp. aff. *F. pliocena,* and *Lithodesmium californicum.* The lower part of the subzone is characterized by the presence of *Mesocena hexagona* Haeckel and the closely related *M. septenaria* Schulz. The distinctive *Dictyocha paradistephanus* Tsumura is restricted to the basal part of the subzone. A large number of the displaced forms are found only in the upper part (Core 10) of the subzone. These are *Biddulphia toumeyi, Campyloneis grevillei* and vars., *Stephanopyxis turris, Xanthiopyxis oblonga, X.* sp. D of Wornardt, and *X.* sp. 5 of Kanaya. Other displaced forms found less frequently in the lower part or throughout the subzone include: *Arachnoidiscus ehrenbergii, Anaulus mediterraneus* var. *intermedia* Grunow, *Cocconeis antiqua, Rhaphoneis amphiceros* (Ehrenberg) Ehrenberg, *Stephanopyxis appendiculata, S.* cf. *S. nipponica,* resting spores of *Chaetoceros cinctum,* and *Xanthiopyxis* spp.–including *X. lacera* and *X. umbonata* Greville.

Although Core 12 lacks calcareous nannofossils, the boundary between the subzones of the *Discoaster exilis* Zone is within this core, as indicated by superposition. The boundary is placed within Core 12 according to the relationship exhibited at Site 33 for this interval. At Site 33 the boundary approximates the upper limit of *Dictyocha triommata* Ehrenberg and *Halicalyptra virginica* Ehrenberg, and is just below the occurrence of the distinctive form *Dictyocha paradistephanus.*

The portion of the Middle Miocene *Discoaster exilis–Cyclococcolithus neogammation* Subzone containing calcareous nannoplankton (Core 13) represents the lower part of the subzone. Here it is characterized by common *C. neogammation* and fairly frequent representatives of the *Discoaster exilis* group. In addition, less frequent, but characteristic forms include: *D. brouweri rutellus; D. challengeri; D. divaricatus; D.* cf. *D. deflandrei* Bramlette and Riedel–with weakly developed ray terminations; *D.* cf. *D. variabilis*–heavy form; *Coccolithus eopelagicus* (Bramlette and Riedel); *C. pelagicus; Cyclococcolithus leptoporus* and vars.; and, *Reticulofenestra pseudoumbilica.*

Some of the siliceous nannofossils characteristic of this subzone are: *Actinocyclus ingens* and vars.–quite frequent; *A. tsugaruensis; Coscinodiscus endoi; C. lewisianus* Greville; coarsely areolate *C. vetustissimus; C. yabei; Denticula lauta; Dictyocha triommata; Distephanus crux; D. c. longispina;* and *Halicalyptra virginica.* A number of other siliceous forms occur in Core 12 and represents their lowest occurrence at this site. These are unquestionable *Denticula hustedtii, Dictyocha fibula, D. f. brevispina, D. f. rhombica, Mesocena circulus apiculata, M. hexagona,* the heavy forms of *M. elliptica* and *M. diodon,* and *Triceratium cinnamomeum. Craspedodiscus coscinodiscus* Ehrenberg occurs in the lower part of Core 12, and a single specimen of *Distephanus speculum pentagonus* with very heavy skeletal parts is present in Core 13. Most of the displaced forms are evident in the more siliceous skeletal bearing sediments of Core 12. These are *Arachnoidiscus ehrenbergii, Anaulus mediterraneus* var. *intermedia, Stephanopyxis* cf. *S. nipponica,* and *Xanthiopyxis lacera.* Fewer displaced forms are evident in Core 13, and include small specimens of *X.* spp. and *Stephanopyxis appendiculata.*

Core 16 represents the lower part of the *Triquetrorhabdulus carinatus* Zone, as indicated by the fairly diverse calcareous nannofossil assemblage and the degree of development of the asteroliths and sphenoliths (Bramlette and Wilcoxon, 1967; Hay *et al.*, 1967; Maxwell *et al.*, 1970). The assemblage is dominated by *Cyclococcolithus neogammation, Coccolithus* aff. *C. bisectus, C. pelagicus, Discoaster deflandrei* and the closely related form *D. saundersi* Hay. Other less frequent forms include *D. adamanteus* Bramlette and Wilcoxon, *D.* cf. *D. challengeri*–small heavy form, *D. druggi* Bramlette and Wilcoxon, *Coccolithus eopelagicus, Discolithina* cf. *D. anisotrema* (Kamptner) of Bramlette and Wilcoxon, *Sphenolithus abies, S.* sp. aff. *S. belemnos* Bramlette and Wilcoxon, *S. moriformis* (Bronnimann and Stradner)–subconic form, and *Triquetrorhabdulus carinatus* Martini.

The nannofossils in the samples from Core 17 are not as well-preserved as those in Core 16. However, two samples from near the middle of the short recovery of Core 17 contain a somewhat diverse assemblage of fair preservation. The calcareous assemblage is essentially the same as in Core 16 with the addition of rare-to-few specimens of *Discoaster adamanteus obtusus* Gartner, *Helicopontosphaera intermedia* (Martini), *Coccolithus* cf. *C. scissurus* (Hay, Mohler and Wade) of Bramlette and Wilcoxon, and large (greater than 12 microns) coccoliths with only part of their center still intact–which are probably *C. bisectus s.s.* These latter two forms are indicative of the Oligocene *C. bisectus* Zone, and this assemblage is equivalent to the *C. bisectus–Triquetrorhabdulus carinatus* Subzone (see Site 42). Quite rare and poorly preserved siliceous microfossils occur in the lowest softer material recovered in Core 17, where calcareous forms are absent. They are coated and/or replaced by iron and/or manganese-oxide material and constitute radiolarian parts, incomplete diatoms and some silico-flagellates. The identified siliceous nannofossils include *Coscinodiscus marginatus,* part of a *Distephanus* cf. *D. aculeatus* and several specimens of *Rocella gemma* Hanna. This latter species is reported from only the type area in the Eastern Pacific. It was described from a piece of float collected in an arroyo in Baja California, Mexico, and presumed to represent the San Gregorio Formation, which is considered of Lower Miocene or Oligocene age (Allison, 1964; Durham and Allison, 1960; Weaver *et al.*, 1944). G. Dallas Hanna (personal communication, 1970) presently considers the associated assemblage of the type material to be Miocene or older, but possibly as old as Upper Eocene. With the experience encountered on comparable preserved siliceous microfossils at this and other sites, there is a question whether this siliceous assemblage represents autochthonous material.

Foraminifera

Foraminifera are present, sometimes rarely and sometimes commonly, in Cores 1, 2, 3 and 4. Below these cores, foraminifera occur rarely; and they are absent in Cores 11 through 15. Cores 16 and 17 contain an abundance of foraminifera in chalk layers. Cores 1 through 10 were apparently affected by selective solution because the majority of small and thin wall forms are absent.

The foraminiferal species present in Cores 16 and 17 appear to indicate an early Oligocene age. The calcareous nannofossil data, on the other hand, seems to suggest a late Oligocene to early Miocene age. The two different results in age determinations are unresolved at this time. It is suggested that climatic factors may play a part, but until Oligocene-Miocene biostratigraphy is more clearly understood in the northern mid-latitude sections of the Pacific it is difficult to resolve this problem. The absence of the genus *Globigerinoides* which does appear in the mid-latitude sections of the southern hemisphere would argue against a Miocene age (pre-*Globigerinoides* datum). Species present at this site with Oligocene ranges in low-latitude sections include *Globigerina ampliapertura* Bolli, *Globigerina anguliofficinalis* Blow, *Globigerina ouachitaensis ciperoensis* Bolli, *Globigerinita martini martini* Blow and Banner and *Globigerina officinalis* Subbotina.

Identification of Species:

Sample 34-1-1, 21-23 cm:
Globigerina bulloides d'Orbigny, *Globigerina pachyderma* (Ehrenberg), *Globorotalia acostaensis pseudopima* Blow, *Globorotalia crassaformis* s.l. (Galloway and Wissler), *Globorotalia inflata* (d'Orbigny).

Sample 34-1-1, 104-106 cm:
Planktonic foraminifera absent.

Sample 34-1-1, 20-22 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia acostaensis pseudopima, Globorotalia crassaformis s.l.

Sample 34-1-2, 104-106 cm:
Planktonic foraminifera absent.

Sample 34-1-3, 20-22 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia acostaensis pseudopima, Globorotalia crassaformis s.l.

Sample 34-1-3, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-1-4, 30-32 cm:
Globigerina bulloides.

Sample 34-1-4, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-1-5, 30-32 cm:
Globigerina bulloides, Globigerina pachyderma.

Sample 34-1-5, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-1-6, 30-32 cm:
Globigerina bulloides, Globigerina pachyderma.

Sample 34-1-6, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-2-1, 23-25 cm:
Globigerina bulloides, Globigerina pachyderma, Orbulina universa d'Orbigny.

Sample 34-2-1, 104-106 cm:
Planktonic foraminifera absent.

Sample 34-2-2, 25-27 cm:
Globigerina bulloides, Globigerina pachyderma, Orbulina universa.

Sample 34-2-2, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-2-3, 32-34 cm:
Globigerina bulloides, Globorotalia crassaformis s.l.

Sample 34-2-3, 100-102 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia acostaensis pseudopima, Globorotalia crassaformis s.l.

Sample 34-2-4, 20-22 cm:
Planktonic foraminifera absent.

Sample 34-2-4, 110-112 cm:
Same as above.

Sample 34-2-5, 16-18 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia crassaformis s.l., *Orbulina universa.*

Sample 34-1-2, 104-106 cm:
Planktonic foraminifera absent.

Sample 34-1-3, 20-22 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia acostaensis pseudopima, Globorotalia crassaformis s.l.

Sample 34-1-3, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-1-4, 30-32 cm:
Globigerina bulloides.

Sample 34-1-4, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-1-5, 30-32 cm:
Globigerina bulloides, Globigerina pachyderma.

Sample 34-1-5, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-1-6, 30-32 cm:
Globigerina bulloides, Globigerina pachyderma.

Sample 34-1-6, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-2-1, 23-25 cm:
Globigerina bulloides, Globigerina pachyderma, Orbulina universa d'Orbigny.

Sample 34-2-1, 104-106 cm:
Planktonic foraminifera absent.

Sample 34-2-2, 25-27 cm:
Globigerina bulloides, Globigerina pachyderma, Orbulina universa.

Sample 34-2-2, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-2-3, 32-34 cm:
Globigerina bulloides, Globorotalia crassaformis s.l.

Sample 34-2-3, 100-102 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia acostaensis pseudopima, Globorotalia crassaformis, s.l.

Sample 34-2-4, 20-22 cm:
Planktonic foraminifera absent.

Sample 34-2-4, 110-112 cm:
Same as above.

Sample 34-2-5, 16-18 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia crassaformis s.l., *Orbulina universa.*

Sample 34-2-5, 100-102 cm:
Globigerina bulloides, Globigerina dutertrei d'Orbigny–4 chambered variant–*Orbulina universa.*

Sample 34-2-6, 23-25 cm:
Globigerina bulloides, Globigerina pachyderma, Globorotalia acostaensis humerosa Takayanagi and Saito, *Globorotalia acostaensis pseudopima, Globorotalia crassaformis* s.l., *Orbulina universa.*

Sample 34-2-6, 103-105 cm:
Globigerina bulloides.

Sample 34-3-1, 20-22 cm:
Globigerina bulloides, Globigerina calida praecalida Blow, *Globigerina pachyderma, Globorotalia crassaformis* s.l., *Globorotalia hirsuta praehirsuta* Blow, *Orbulina universa.*

Sample 34-3-1, 100-102 cm:
Globigerina bulloides, Globigerina dutertrei–4 chambered variant–*Globigerina quinqueloba* Natland, *Globorotalia acostaensis acostaensis* Blow, *Globorotalia crassaformis ronda* Blow, *Globorotalia* cf. *G. puncticulata* (Deshayes).

Sample 34-3-2, 30-32 cm:
Globigerina bulloides, Globorotalia crassaformis ronda, Globorotalia hirsuta praehirsuta, Globigerinoides ruber d'Orbigny, *Orbulina universa.*

Sample 34-3-2, 100-102 cm:
Globigerina bulloides, Globigerina decoraperta Takayanagi and Saito, *Globigerina dutertrei*–4 chambered variant–*Globigerina quinqueloba, Globorotalia crassaformis ronda, Globorotalia* cf. *G. puncticulata.*

Sample 34-3-3, 25-27 cm:
Globigerina bulloides, Globorotalia crassaformis ronda, Globigerinoides ruber, Orbulina universa.

Sample 34-3-3, 103-105 cm:
Globigerina bulloides, Globigerina dutertrei–4 chambered variant–*Globorotalia acostaensis acostaensis, Globorotalia* cf. *G. acostaensis pseudopima, Globorotalia crassaformis ronda, Globorotalia* cf. *G. puncticulata, Orbulina universa.*

Sample 34-3-4, 25-27 cm:
Globigerina bulloides, Globorotalia crassaformis ronda, Orbulina universa.

Sample 34-3-3, 100-102 cm:
Globigerina bulloides, Globigerina quinqueloba, Globorotalia crassaformis ronda, Orbulina universa.

Sample 34-3-5, 20-22 cm:
Globigerina bulloides, Globorotalia crassaformis ronda, Orbulina universa.

Sample 34-3-5, 110-112 cm:
Globigerina bulloides, Globigerina dutertrei–4 chambered variant–*Globorotalia acostaensis acostaensis, Globorotalia crassaformis ronda, Orbulina universa.*

Sample 34-3-6, 20-22 cm:
Globigerina bulloides, Globigerina dutertrei–4 chambered variant–*Globigerina quinqueloba, Globorotalia acostaensis acostaensis, Globorotalia acostaensis pseudopima, Globorotalia crassaformis ronda, Globorotalia* cf. *G. puncticulata, Globigerinita glutinata* (Egger), *Orbulina universa.*

Sample 34-3-6, 104-106 cm:
Globigerina bulloides, Globorotalia acostaensis acostaensis, Globorotalia miozea conoidea Walters, *Globigerinita glutinata, Globigerinita* sp., *Orbulina universa.*

Sample 34-4-1, 20-22 cm:
Globigerina bulloides, Globorotalia crassaformis s.l., *Globorotalia miozea conoidea, Globorotalia puncticulata* (Deshayes), *Orbulina universa.*

Sample 34-4-1, 100-102 cm:
Globigerina bulloides, Globorotalia miozea conoidea, Globorotalia puncticulata, Orbulina universa.

Sample 34-4-2, 23-25 cm:
Globigerina bulloides, Globorotalia crassaformis s.l., *Globorotalia miozea conoidea, Orbulina universa.*

Sample 34-4-2, 112-114 cm:
Planktonic foraminifera absent.

Sample 34-4-3, 31-33 cm:
Globigerina bulloides, Globorotalia hirsuta praehirsuta, Globorotalia miozea conoidea, Orbulina universa.

Sample 34-4-3, 103-104 cm:
Globigerina bulloides, Globorotalia miozea conoidea, Globorotalia puncticulata, Orbulina universa.

Sample 34-4-4, 25-27 cm:
Globigerina bulloides, Globorotalia miozea conoidea.

Sample 34-4-4, 118-120 cm:
Globigerina bulloides, Globorotalia miozea conoidea, Globorotalia puncticulata, Orbulina universa.

Sample 34-4-5, 18-20 cm:
Globigerina bulloides, Orbulina universa.

Sample 34-4-5, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-4-6, 20-22 cm:
Globigerina bulloides, Globorotalia hirsuta praehirsuta, Globorotalia miozea conoidea, Globorotalia puncticulata, Orbulina universa.

Sample 34-4-6, 103-105 cm:
Planktonic foraminifera absent.

Sample 34-5-1, 15-17 cm:
Globigerina bulloides, Globorotalia puncticulata, Globorotalia cf. *G. scitula* (Brady), *Orbulina universa.*

Sample 34-5-1, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-5-2, 37-39 cm:
Globigerina bulloides, Globorotalia margaritae Bolli and Bermudez, *Globorotalia miozea conoidea, Globorotalia puncticulata, Orbulina universa.*

Sample 34-5-2, 103-105 cm:
Planktonic foraminifera absent.

Sample 34-5-3, 20-22 cm:
Same as above.

Sample 34-5-3, 100-102 cm:
Same as above.

Sample 34-5-4, 28-30 cm:
Globigerina bulloides, Globigerina parabulloides Blow, *Globorotalia* cf. *G. acostaensis acostaensis, Globorotalia miozea conoidea, Globorotalia puncticulata, Orbulina universa.*

Sample 34-5-4, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-5-5, 10-12 cm:
Same as above.

Sample 34-5-5, 101-103 cm:
Same as above.

Sample 34-5-6, 20-22 cm:
Globigerina bulloides, Orbulina universa.

Sample 34-5-6, 100-102 cm:
Planktonic foraminifera absent.

Sample 34-6-1, 20-22 cm:
Same as above.

Sample 34-6-2, 42-44 cm:
Same as above.

Sample 34-6-3, 73-75 cm:
Globigerina bulloides, Globorotalia crassaformis s.l., *Orbulina universa.*

Sample 34-6-5, 110-112 cm:
Planktonic foraminifera absent.

Sample 34-6-6, 100-102 cm:
Orbulina universa.

Sample 34-7-3, 116-118 cm:
Globigerina bulloides, Globigerina praebulloides Blow, *Globigerina* sp., *Orbulina universa.*

Sample 34-7-4, 28-30 cm:
Globigerina bulloides, Globigerina sp., *Globorotalia scitula* (Brady), *Orbulina universa.*

Sample 34-7-6, 110-112 cm:
Globigerina bulloides, Globigerina microstoma Cita, Premoli Silva and Rossi, *Globigerina nepenthes* Todd, *Globigerina* sp., *Globorotalia scitula, Orbulina universa.*

Sample 34-8-1, 105-107 cm:
Globigerina bulloides, Globigerina praebulloides, Globorotalia scitula, Globorotalia cf. *G. subscitula* Conato, *Orbulina universa.*

Sample 34-8-2, 45-47 cm:
Orbulina universa.

Sample 34-8-2, 91-93 cm:
Globigerina bulloides, Globorotalia cf. *G. miozea* Finlay, *Globorotalia scitula, Globigerinita glutinata, Sphaeroidinellopsis subdehiscens* (Blow), *Orbulina universa.*

Sample 34-8-4, 31-33 cm:
Planktonic foraminifera absent.

Sample 34-8-4, 105-107 cm:
Globigerina bulloides, Globigerina sp., *Globorotalia miozea* s.l. Finlay, *Globigerinoides obliquus extremus* Bolli and Bermudez, *Sphaeroidinellopsis seminulina* (Schwager), *Orbulina universa.*

Sample 34-8-5, 34-36 cm:
Globorotalia miozea s.l.

Sample 34-8-5, 102-104 cm:
Planktonic foraminifera absent.

Sample 34-8-6, 54-56 cm:
Orbulina universa.

Sample 34-8-6, 118-120 cm:
Globigerina microstoma, Globorotalia miozea s.l., *Sphaeroidinellopsis seminulina, Sphaeroidinellopsis subdehiscens.*

Sample 34-9-1, 23-25 cm:
Planktonic foraminifera absent.

Sample 34-9-3, 70-72 cm:
Globigerina bulloides.

Sample 34-9-4, 7-9 cm:
Planktonic foraminifera absent.

Sample 34-9-5, 14-16 cm:
Same as above.

Sample 34-9-6, 20-22 cm:
Globigerina bulloides, Globigerina nepenthes, Globigerinita glutinata, Orbulina universa.

Sample 34-10-2, 23-25 cm:
Globigerina bulloides, Globigerina praebulloides.

Sample 34-10-3, 26-28 cm:
Small globigerines.

Sample 34-10-4, 19-21 cm:
Planktonic foraminifera absent.

Sample 34-10-5, 22-24 cm:
Globigerina bulloides.

Sample 34-10-6, 18-20 cm:
Globigerina hexagona Natland, *Globigerina praebulloides.*

Sample 34-11-2, 42-44 cm:
Planktonic foraminifera absent.

Sample 34-11-3, 30-32 cm:
Same as above.

Sample 34-12-1, 130-132 cm:
Same as above.

Sample 34-12-2, 14-16 cm:
Same as above.

Sample 34-13-2, 34-36 cm:
Same as above.

Sample 34-14-2, 30-32 cm:
Same as above.

Sample 34-15-2, 128-130 cm:
Same as above.

Sample 34-16-1, 75-77 cm:
Globigerina ampliapertura Bolli, *Globigerina angulioffícinalis* Blow, *Globigerina galavisi* Bermudez, *Globigerina officinalis* Subbotina, *Globigerina praebulloides, Globigerinita dissimilis* (Cushman and Bermudez), *Globigerinita martini martini* Blow and Banner, *Globigerinita unicava* (Bolli, Loeblich, and Tappan).

Sample 34-16, core catcher:
Globigerina ampliapertura, Globigerina angulioffícinalis, Globigerina officinalis, Globigerina ouachitaensis Howe, *Globigerina ciperoensis* Bolli, *Globigerina praebulloides lesoyi* Blow and Banner, *Globorotalia gemma* Jenkins, *Globigerinita dissimilis, Globigerinita martini martini, Globigerinita unicava.*

Sample 34-17-1, fragments:
Globigerinita dissimilis, Globigerinita martini martini, Globigerinita unicava.

Radiolaria

Radiolaria are present in Cores 1 to 13. In Cores 8 to 11, they are common to abundant, but they are scarce to rare in the remaining cores. The faunule is essentially the same as at Site 33, and species that were identified but not included in the Biostratigraphy Chart are listed below:

Sample 34-4-3, 13-15 cm:
Dendrospyris damaecornis, Clathrocyclas bicornis, Pterocanium trilobum.

Sample 34-5-4, 70-72 cm:
Clathrocyclas bicornis, Dendrospyris damaecornis, Pterocanium trilobum, Eucyrtidium acuminatum, Saturnalis circularis.

Sample 34-6-5, 81-83 cm:
Clathrocyclas bicornis, Dendrospyris damaecornis, Pterocanium trilobum.

Sample 34-7-6, 1-3 cm:
Dendrospyris damaecornis, Eucyrtidium acuminatum, Clathrocyclas bicornis, Tholospyris scaphipes, Pterocanium trilobum.

Sample 34-8-6, 48-50 cm:
Clathrocyclas bicornis, Tholospyris scaphipes, Eucyrtidium acuminatum, Pterocanium trilobum, Dendrospyris damaecornis, Dorcadospyris pentagona.

Sample 34-9-3, 66-68 cm:
Pterocanium trilobum, Clathrocyclas bicornis, Tholospyris scaphipes, Saturnalis circularis, Dendrospyris damaecornis, Tholospyris infericosta, Tholospyris kantiana, Eucyrtidium acuminatum.

Sample 34-10-4, 6-8 cm:
Dendrospyris damaecornis, Tholospyris scaphipes, Dendrospyris stabilis, Tholospyris infericosta, Pterocanium trilobum.

Sample 34-11-2, 145-147 cm:
Dendrospyris damaecornis, Pterocanium trilobum, Tholospyris cortinisca.

Sample 34-12-1, 89-91 cm:
Clathrocyclas bicornis, Dendrospyris stabilis.

SUMMARY

The 383 meter thick sediment section at Site 34 consists of a complex association of lithologies intercalated in varying amounts of dark greenish-gray mud. This section ranges in age from Pleistocene to at least Oligocene at 27 meters above the basement. Seven stratigraphic units are recognized (Table 2).

The lowest unit (unit 7, Core 18, 384 meters) consists of about 50 centimeters of altered glassy basalt containing microamygdules of chlorite and fractures filled with carbonate and chloritic minerals.

Unit 6 is represented by 20 centimeters composed largely of mud with carbonate grains in Core 18 (383 meters). The sediment-basement contact was destroyed by the coring operations. These sediments are dark gray, yellow, orange and green in color, all being fine-grained. The gray material appears to be a mud, whereas the yellow, orange and green material consists mostly of calcite with admixtures of chloritic minerals in the green sediments. All are soft and none contains fossils. Further study is required to determine whether the sediments reflect diagenetic changes due to baking by the basalt or intrusion of material similar to that filling the basement fractures.

Unit 5 (Cores 14 through 17, 321 to 356 meters) had poor core recovery. This unit has a diverse lithology and is quite different from unit 6. Consequently, it would be difficult to interpolate the lithology in the uncored interval between units 5 and 6 (i.e., 357 to 382 meters). Unit 5 is dominated by firm to hard interbeds of dark greenish-gray mud, zeolitic mud, mud nannofossil ooze and nannofossil ooze. The age of unit 5 is Lower Miocene/Oligocene.

This sequence also contains relatively pure zeolites in whitish pods and irregular layers, which may represent altered ash. One fragment of altered ash was recovered in Core 17 (352 to 356 meters); however, ash is more common above unit 5. Dolomite rhombs are also present in the muds but not in the zeolite bearing sediments.

Unit 4 (Cores 11, 12 and 13, 278 to 321 meters[1]) is a grayish-green interval marked by a moderate number of siliceous-fossils and few nannofossils. It contains siliceous-fossil mud with various intercalations: hard calcareous mudstone, ash beds of partially devitrified glass, mud, nannofossil-siliceous ooze, mud siliceous-fossil ooze, and thin silicified mudstone layers. This unit of Middle Miocene age is characterized by the cementation and hardness of some of the material recovered, the poor core recovery, and the slow coring and drilling rate. The top of this unit can be correlated with the 0.39 second reflector on the seismic profile, the reflector at the top of the silicified mudstone at Site 33.

Unit 3 (Core 10, Section 5 through Core 10, Section 6, 275 to 278 meters) is a thin nannofossil-rich interval represented by greenish-gray and bluish-gray mud nannofossil ooze and nannofossil-siliceous ooze. This unit is also of Middle Miocene age.

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[1]Interpolated depth.

TABLE 2
Stratigraphic Units at Site 34

Unit	Depth (m)	Cores	Age	Description
1	20-125	1-5	Pleistocene Lower Pliocene	Greenish-gray dominantly mud unit. Muds with some siliceous-fossil. Prominent nannofossil mud and mud nannofossil ooze in middle. Local ash layer and sand pods in upper portion. Pyrite nodules ash pods in lower portion.
2	125-275	6.0-10.4	Lower Pliocene Middle Miocene	Greenish-gray dominantly siliceous-fossil rich interval with siliceous-fossil ooze, mud siliceous-fossil ooze and siliceous-fossil mud. Sands with silty mud siliceous-fossil ooze in upper part. Prominent ash bed in middle. First occurrence mudstone pebbles in lower part.
3	275-278	10.5-10.6	Middle Miocene	Greenish-gray and bluish-gray mud nannofossil ooze and nannofossil siliceous-fossil ooze.
4	278-321±	11-13	Middle Miocene	Greenish-gray and bluish-gray interval with moderate amounts siliceous-fossils as mud siliceous-fossil ooze and siliceous-fossil mud. Also some nannofossil. Local silicified cherty and limy mudstones throughout. Volcanic ash near bottom.
5[a]	321±-356	14-17	Lower Miocene/ Oligocene	Dark greenish-gray to greenish-gray mud, zeolitic mud with mud nannofossil ooze and nannofossil ooze near base. Local dolomite rhombs. Some zeolitic ash also burrow mottles and 13° dips noted.
6[a]	383	18	?	Contact between sediments? and basalt is not preserved. Sediments? are calcite with some chlorite and clay. No fossils noted.
7	384	18	?	Basement rocks are dark gray altered basalt having chlorite and calcite filled fractures.

[a] Extreme variability of units 5 and 6 precludes extrapolating lithology into the uncored interval between them.

Unit 2 (Core 6 through Core 10, Section 4, 125 to 275 meters) is characterized by its high siliceous-fossil content throughout. Greenish-gray interbeds of siliceous-fossil mud, mud siliceous-fossil ooze and siliceous-fossil ooze are prominent in this interval which spans the period from Middle Miocene through part of the Early Pliocene. One thin bed of nannofossil mud is found in Core 7 (134 to 143 meters).

Within Core 6 (125 to 134 meters) there are interbeds of moderately well-sorted sand in graded beds 5 to 30 centimeters thick having sharp lower and upper contacts. These beds are intercalated with silty mud siliceous-fossil ooze. This sandy interval within unit 2 can be correlated with the 0.18 second reflector on the seismic profile. The presence of well-developed turbidite sands is not unexpected, as this site is located on the distal portion of the Delgada Fan. A 7-centimeter thick ash bed with graded bedding occurs in Core 8 at 173 meters. It is composed of fresh glass, which contrasts with the partially to totally devitrified ashes in lower units. Some silicified mudstone nodules were found in Cores 9 and 10, indicating that some silicification also occurred at depths above the main development in unit 4. The Middle-Upper Miocene boundary falls within the unit, between Cores 9 and 10.

Unit 1 encompasses Cores 1 through 5, 20 to 125 meters) and ranges from Early Pliocene to Pleistocene in age. The greenish-gray clay muds generally have a low biogenous content. An exception occurs in Core 3 (84 to 75 meters) where nannofossil mud and mud nannofossil ooze are found. The muds contain sand pods, a few clayey silts and a thin ash bed in the Pleistocene portion of this unit. Other ash beds, abundant glass shards and pyrite nodules are found in Core 5 (116 to 125 meters). This core also has a siliceous-fossil mud at the base which is transitional to the underlying siliceous fossil-rich unit 2.

The Pleistocene age of Cores 1 and 2 (20 to 38 meters) is based on calcareous nannoplankton. The planktonic foraminifera indicate that the cold-water phase of the Pleistocene extends only to the bottom of Core 1.

The original nature of the oldest sediments in Core 18 at Site 34 is difficult to determine due to diagenetic alteration. However, the overlying Lower Miocene/Upper Oligocene deposits in Core 17 consist of fine terrigenous material with some nannofossil oozes. Considerable volcanic debris was also deposited which later altered to zeolites.

Either the calcareous oozes deposited in unit 5 during the Early Miocene/Late Oligocene were subsequently removed by solution or else productivity was very low at this time. In the lower part of the Middle Miocene the fine-terrigenous material continued to be deposited together with more abundant siliceous and calcareous fossil remains and some ash. Later, the sediments were partly altered to silicified and calcareous mudstones.

Deposition of siliceous fossils became dominant in the upper part of the Middle Miocene and continued into the Early Pliocene. During the latter period the deposition of turbidite sands took place.

Except for a brief interval of nannofossil production in Late Pliocene time, the remainder of Cenozoic time was characterized by terrigenous mud deposition.

Volcanic activity periodically produced ash beds during parts of the Pliocene and Pleistocene.

The negative magnetic anomaly drilled at this site was adjacent to the positive magnetic anomaly at Site 33. The predicted age for this anomaly is 31 million years. On the basis of paleontological data in Core 17 (356 meters), the age of the oldest fossiliferous sediment is Late Oligocene (23.5 to 27 million years) or Early Oligocene (32 to 36 million years). There is an undated interval of 28 meters to basalt in the basal sediments at Site 34.

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THE CORES RECOVERED FROM SITE 34

The following pages present a graphic summary of the results of drilling and coring at Site 34. Fig. 2, a summary of Site 34 is at the back of the book. Figures 3 to 20 are summaries of the individual cores recovered. A key to the lithologic symbols is given in the Introduction (Chapter 1).

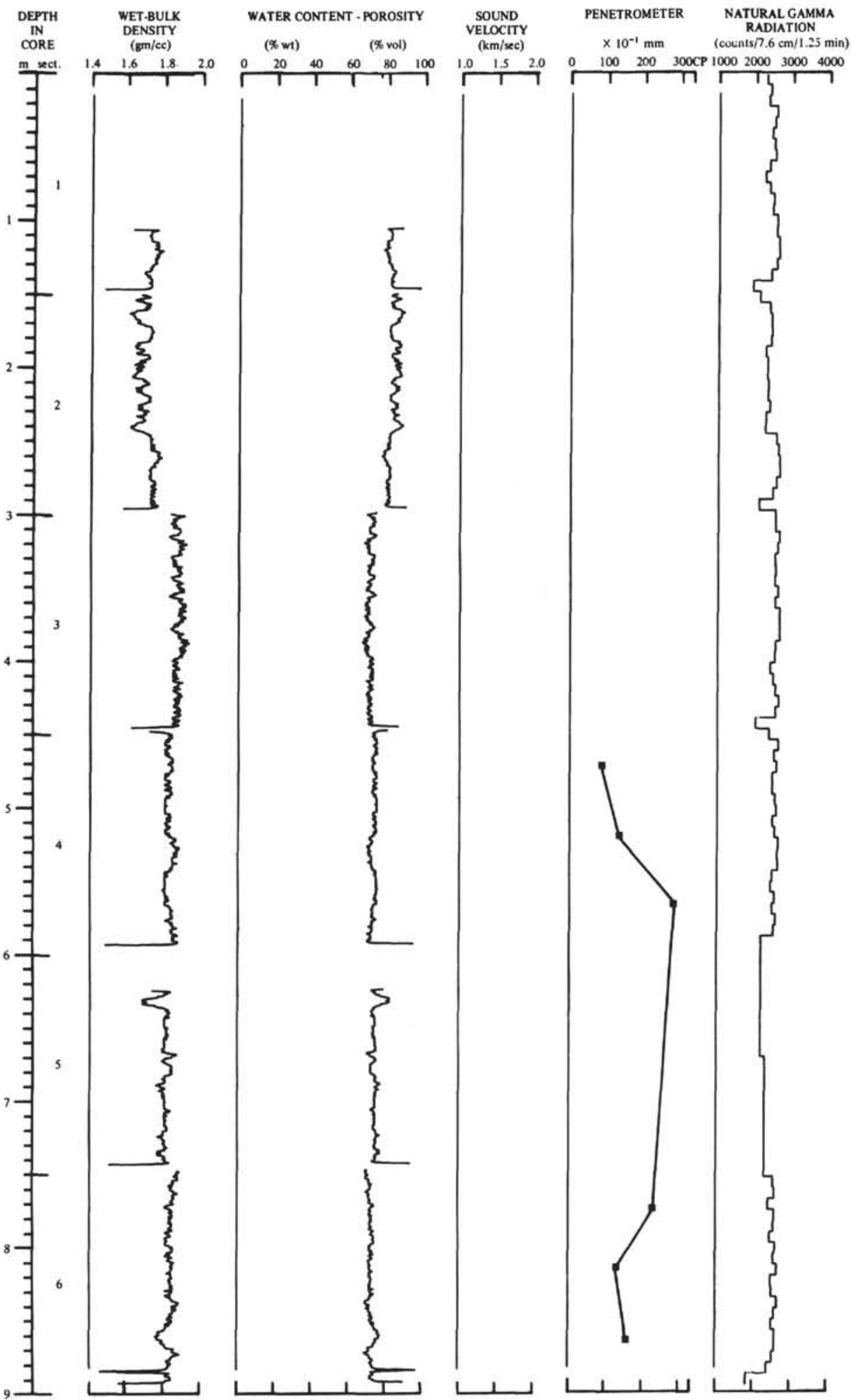


Figure 3A. *Physical Properties of Core 1, Hole 34*

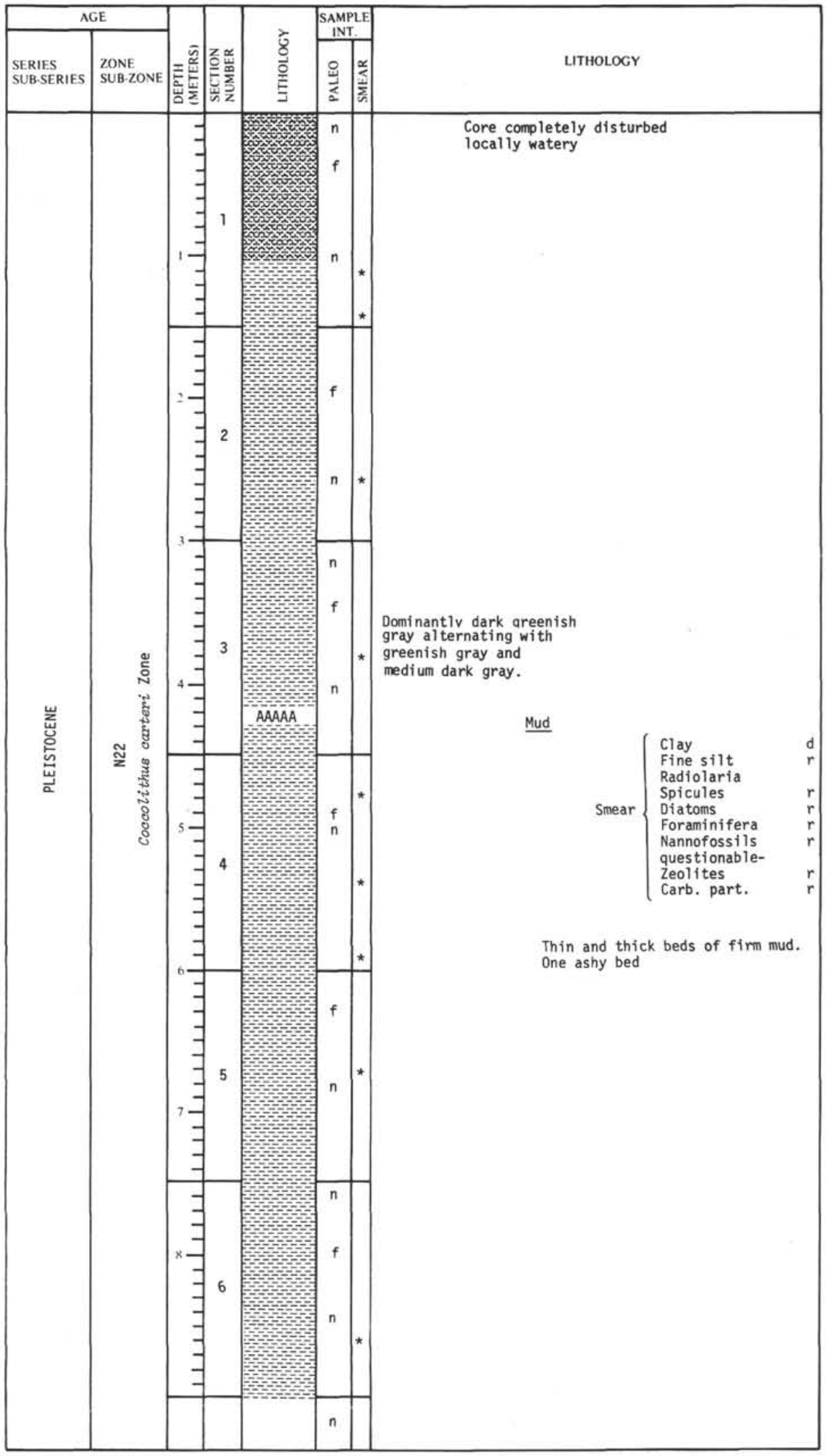


Figure 3B. *Core 1, Hole 34 (20-29 m Below Seabed)*

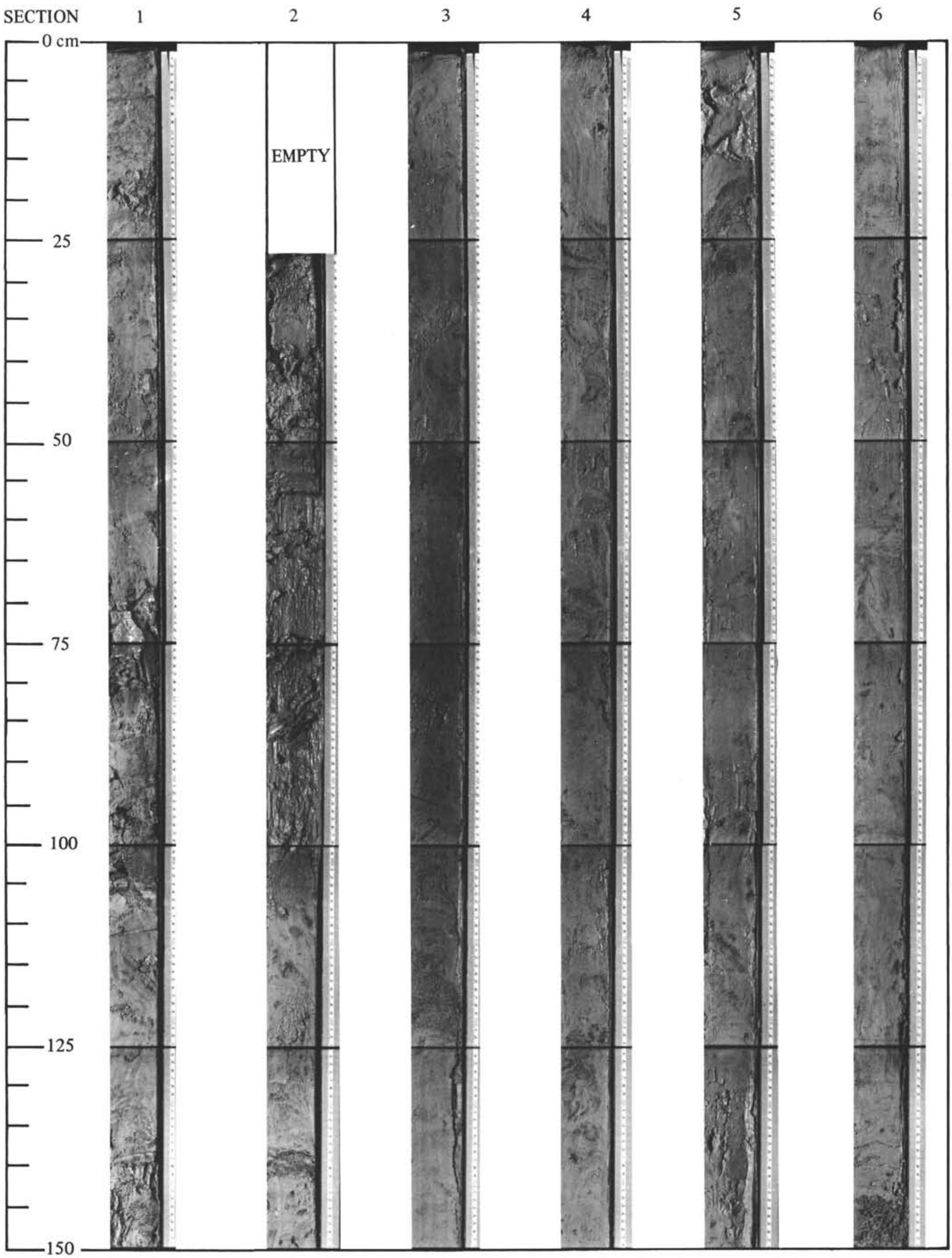


Plate 1. *Core 1, Hole 34*

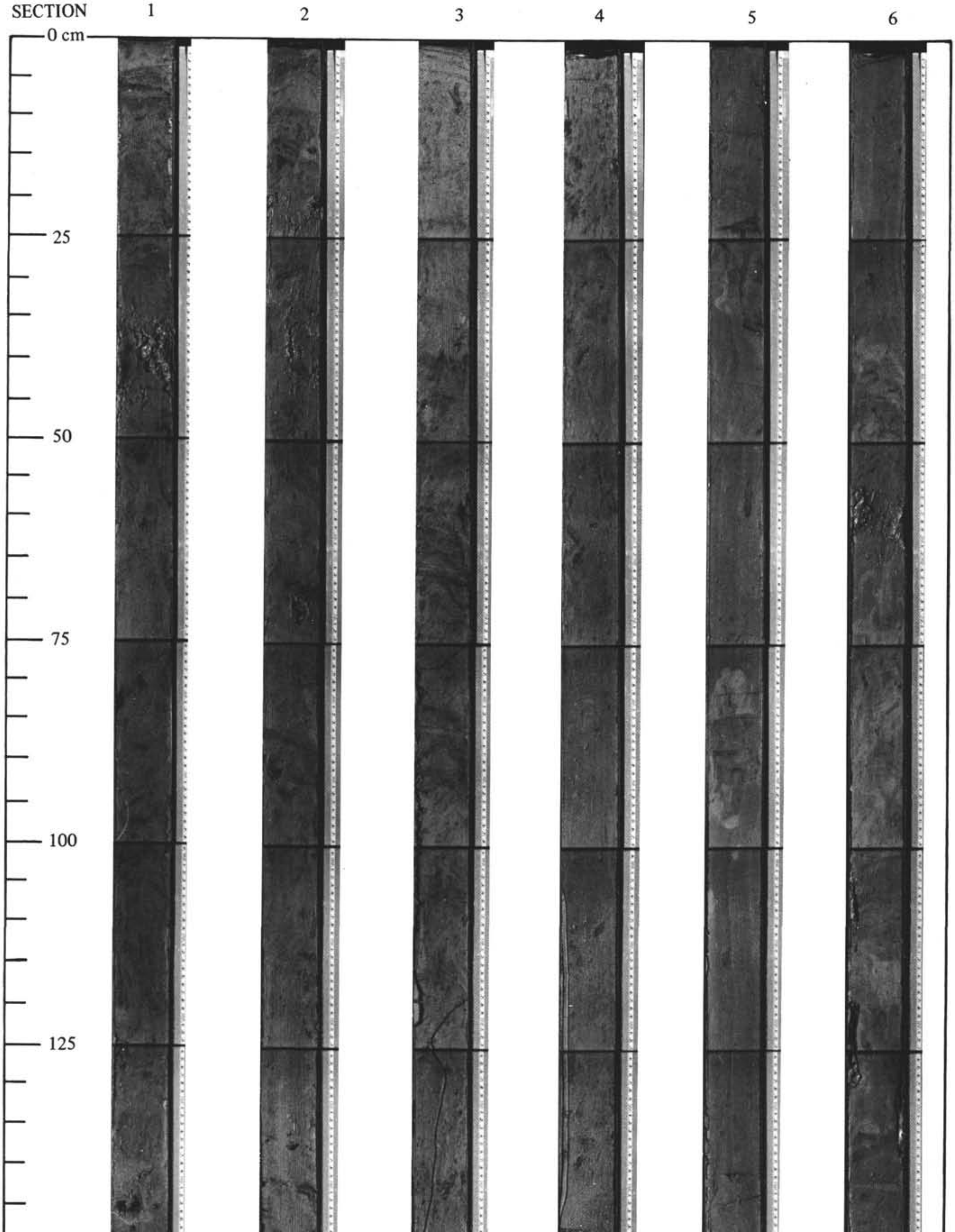


Plate 2. *Core 2, Hole 34*

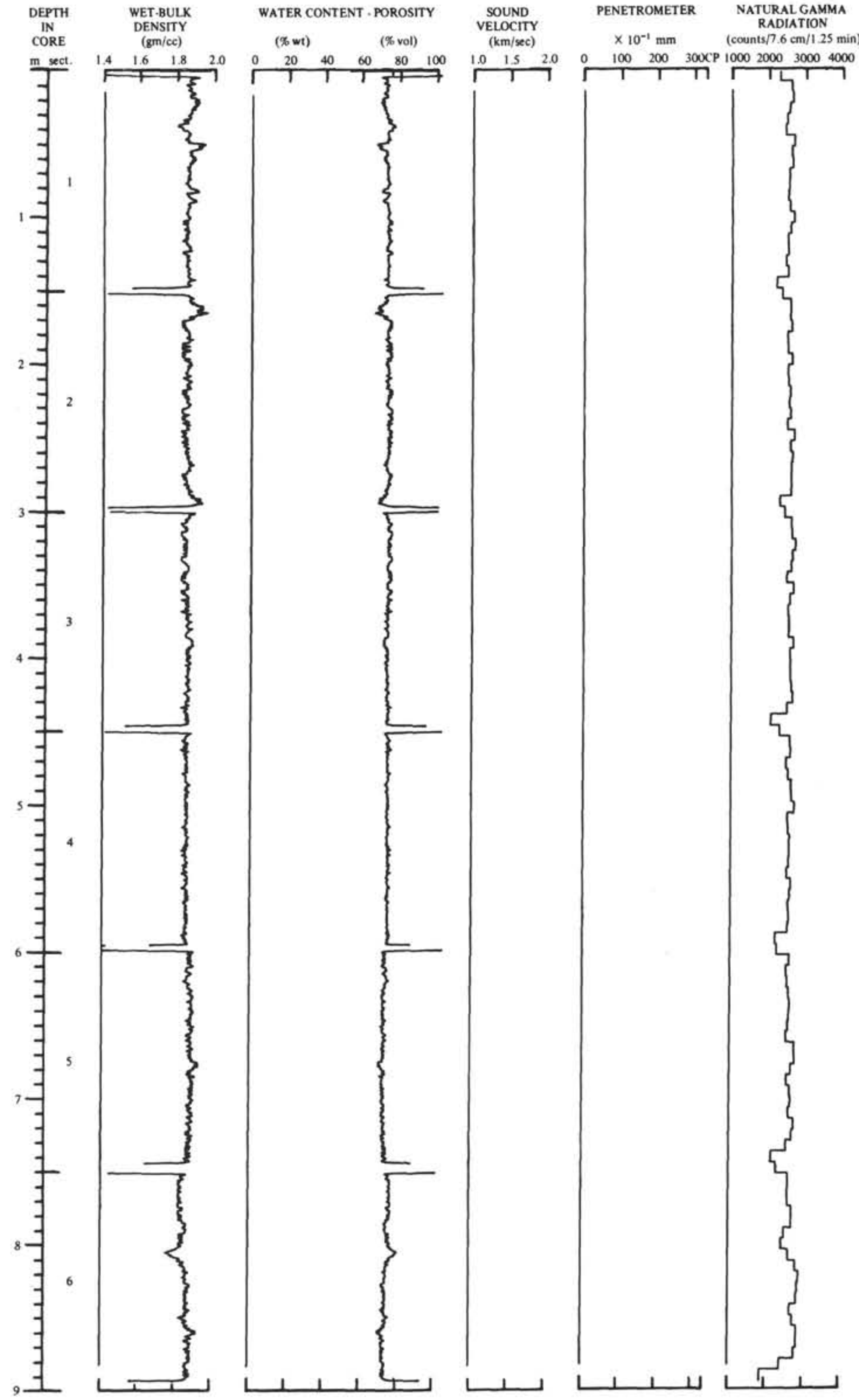


Figure 4A. *Physical Properties of Core 2, Hole 34*

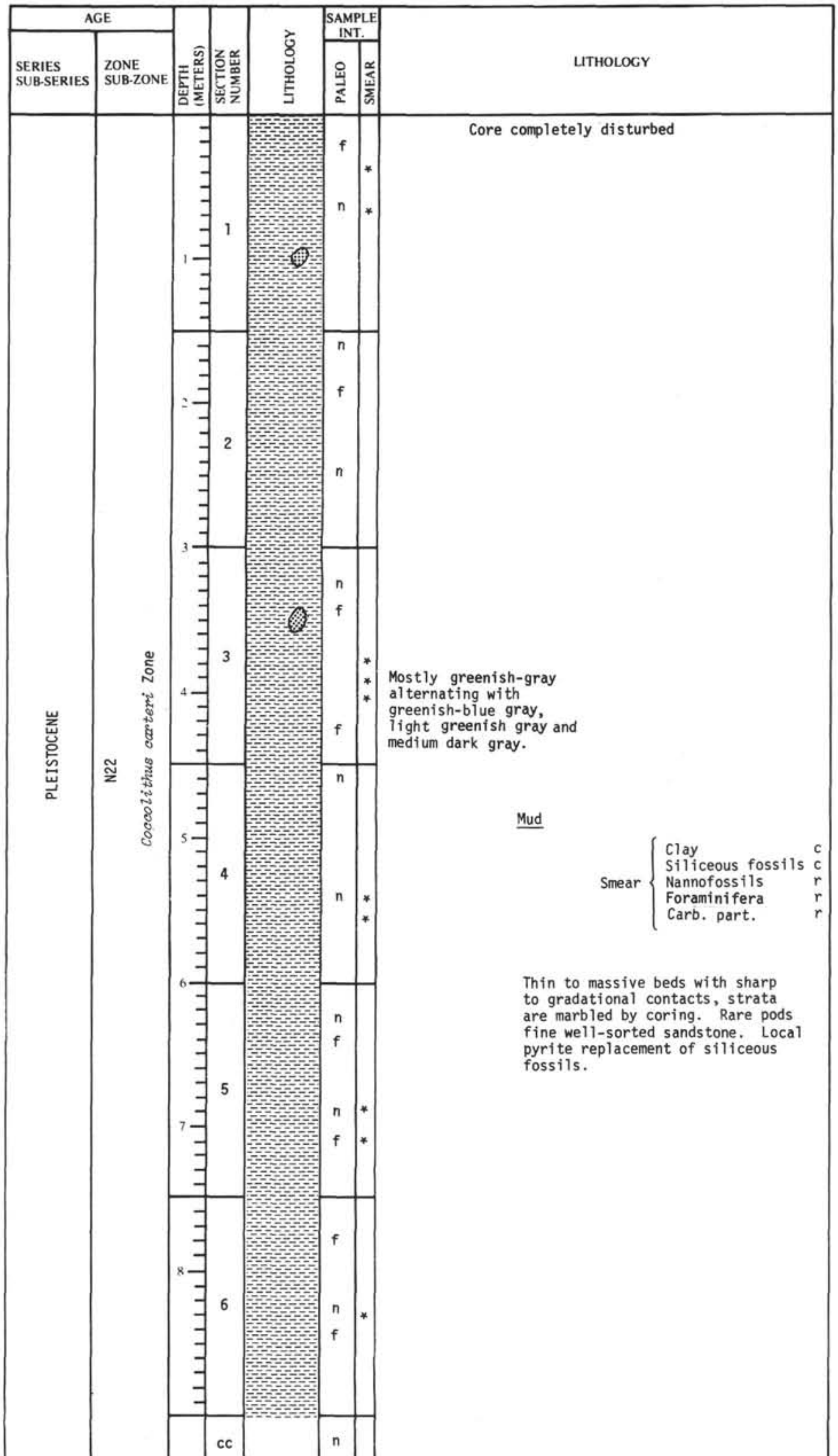


Figure 4B. *Core 2, Hole 34 (29-38 m Below Seabed)*

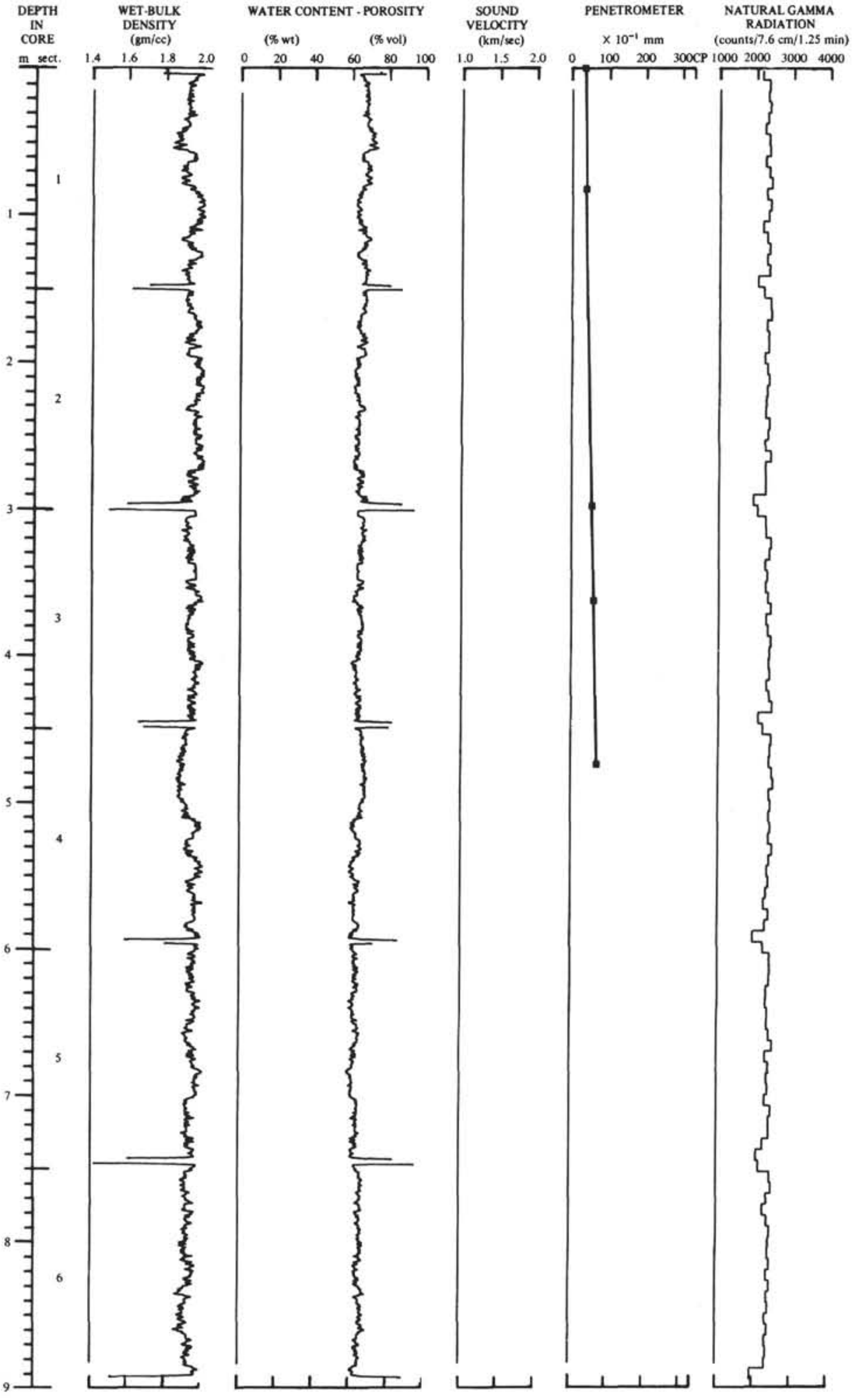


Figure 5A. *Physical Properties of Core 3, Hole 34*

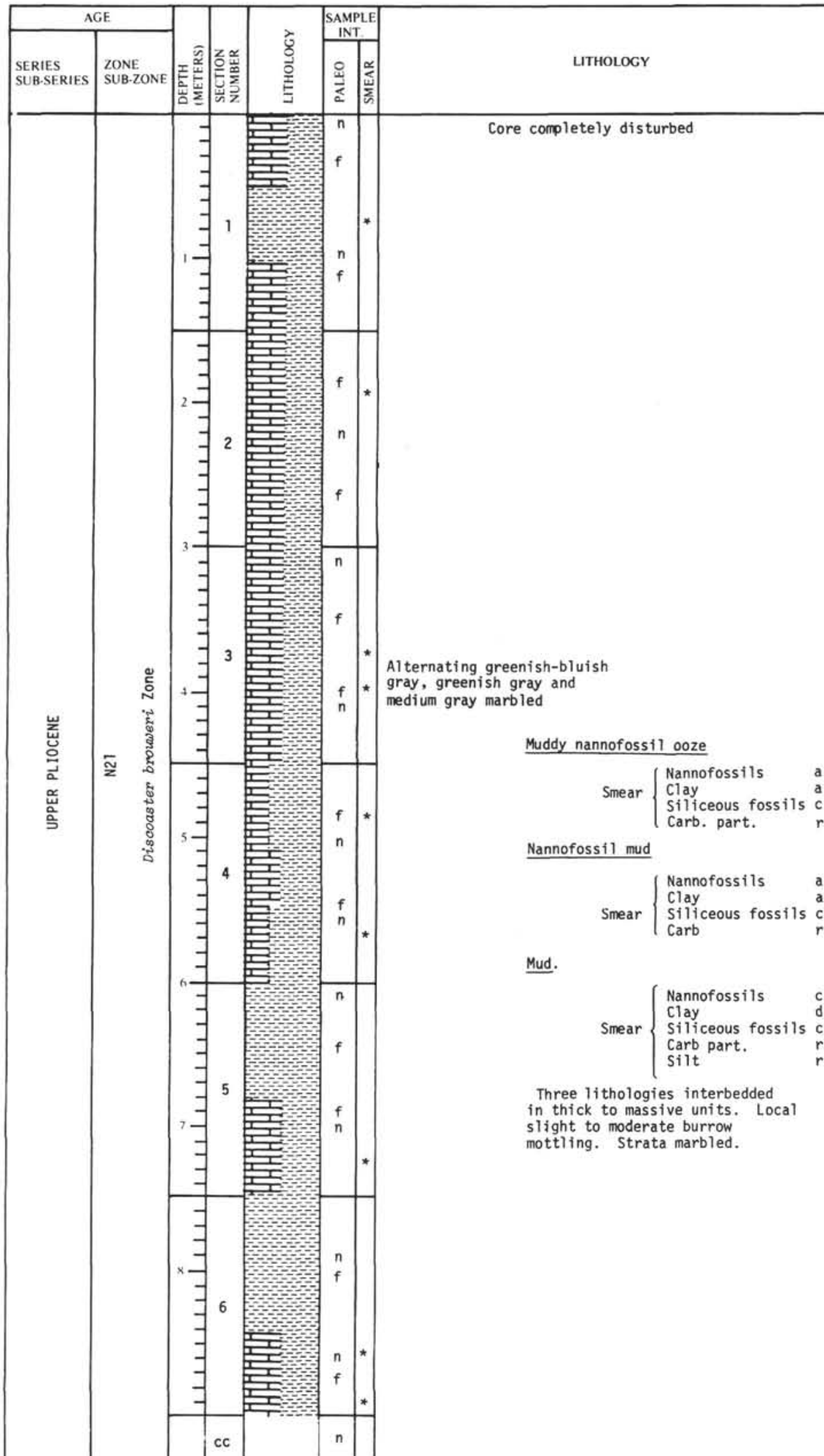


Figure 5B. *Core 3, Hole 34 (75-84 m Below Seabed)*

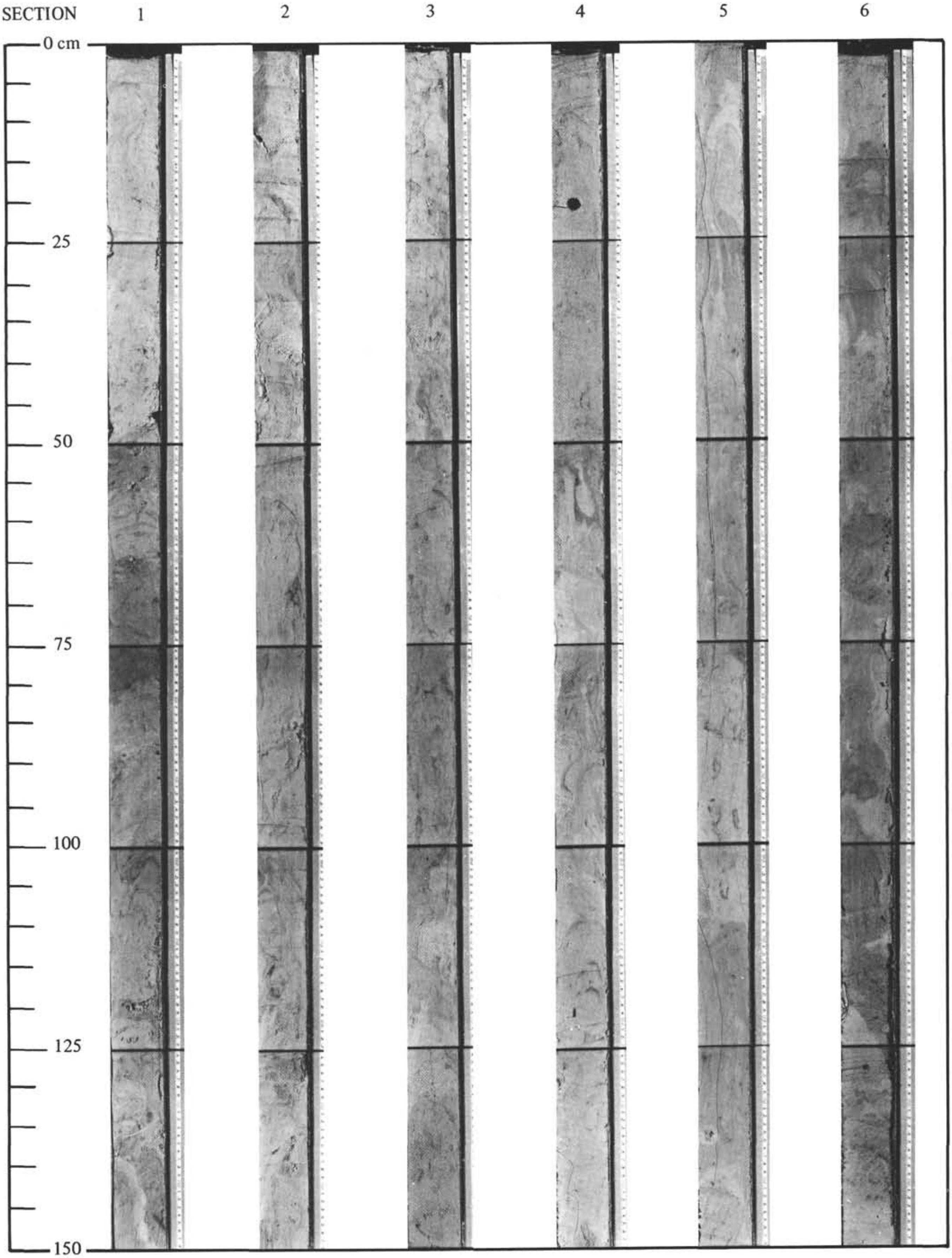


Plate 3 *Core 3, Hole 34*

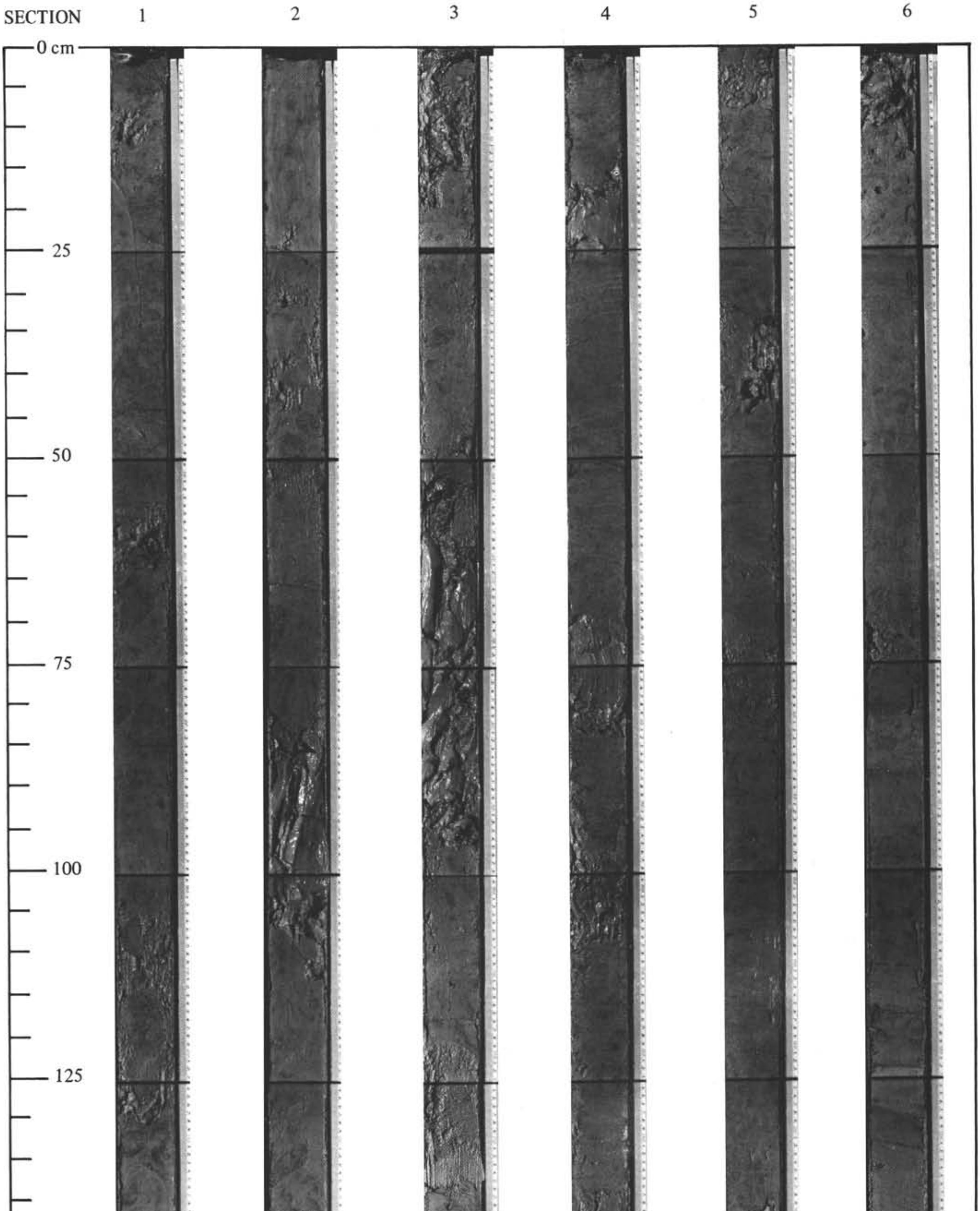


Plate 4. *Core 4, Hole 34*

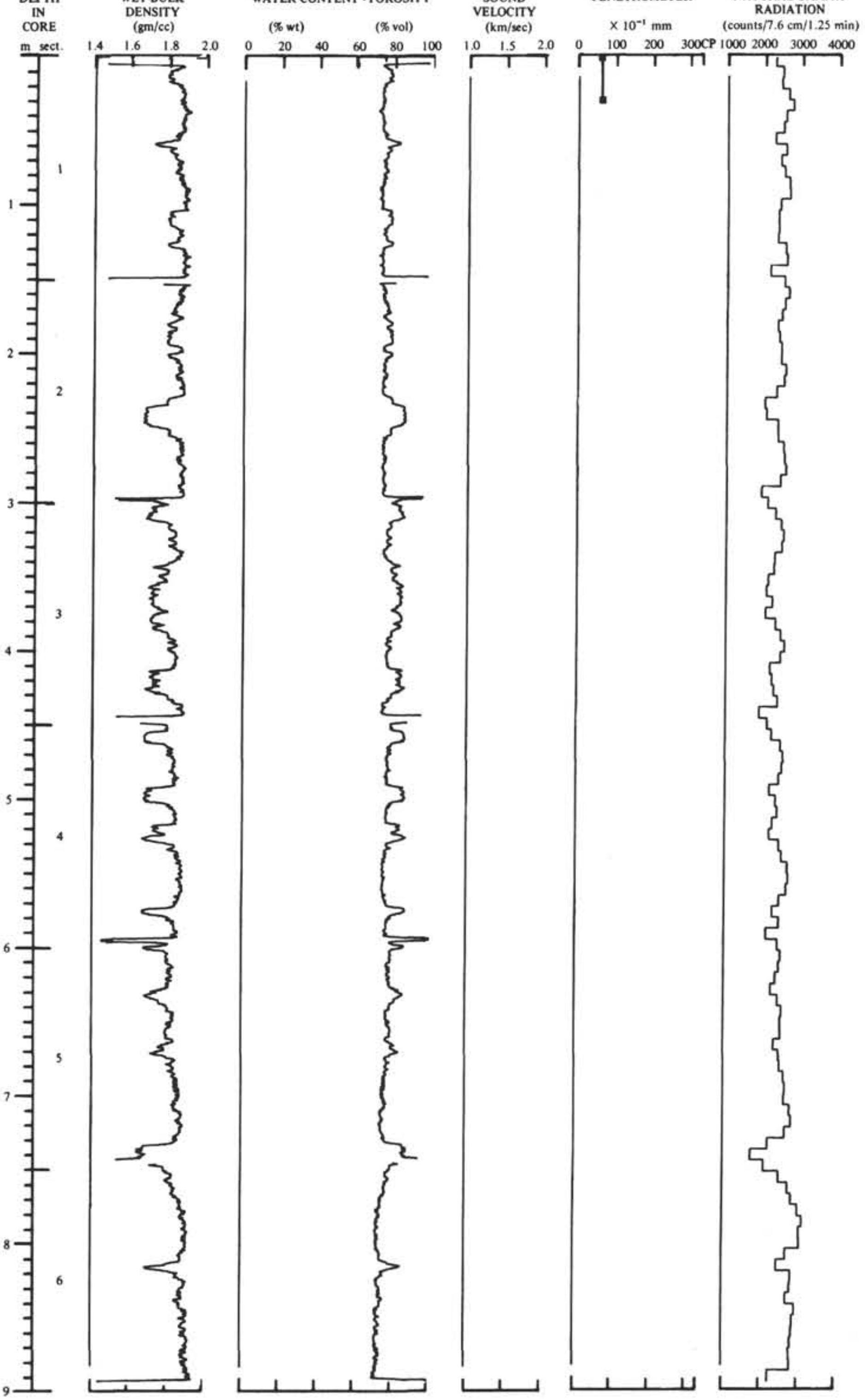


Figure 6A. *Physical Properties of Core 4, Hole 34*

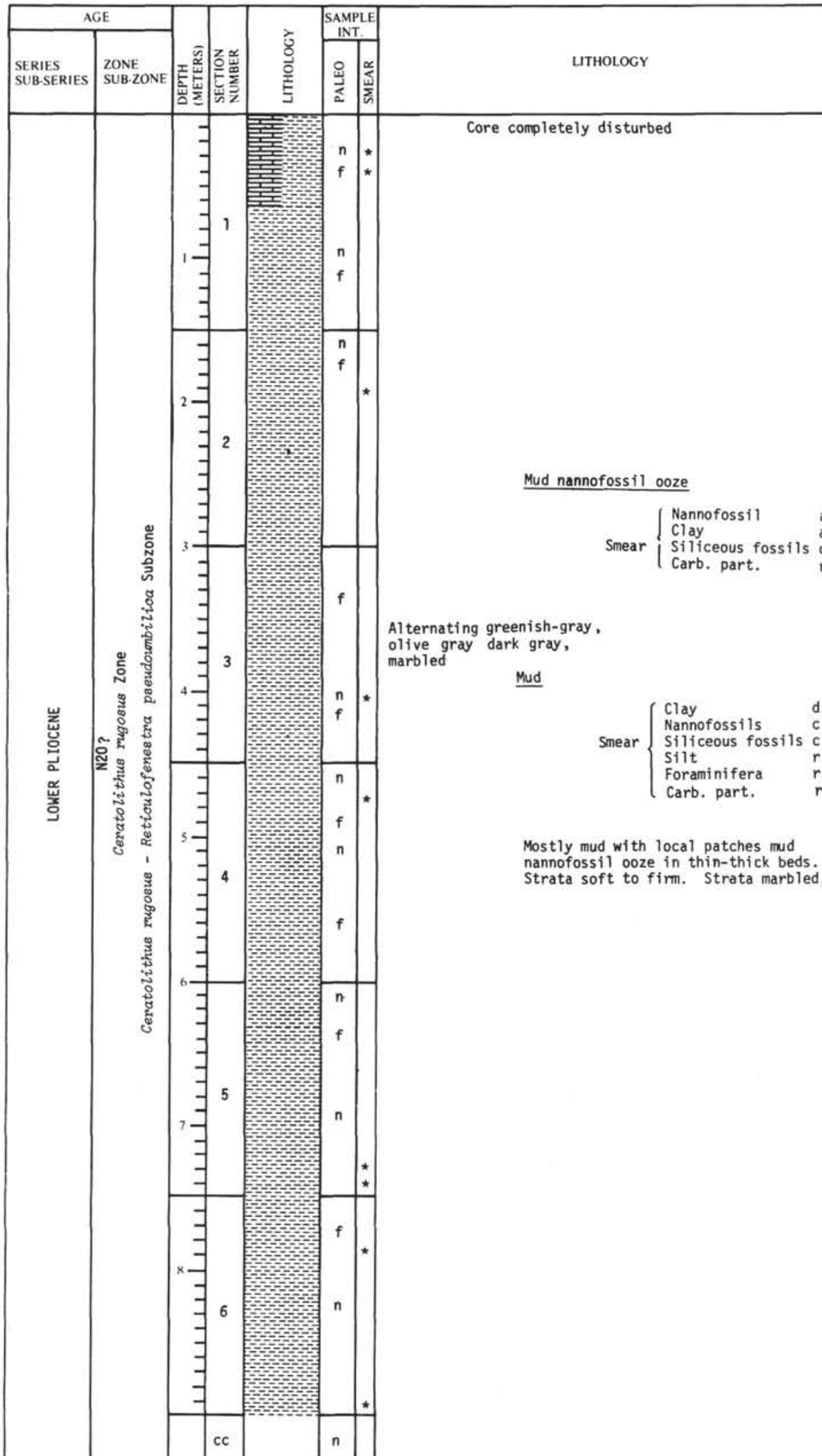


Figure 6B. *Core 4, Hole 34 (107-116 m Below Seabed)*

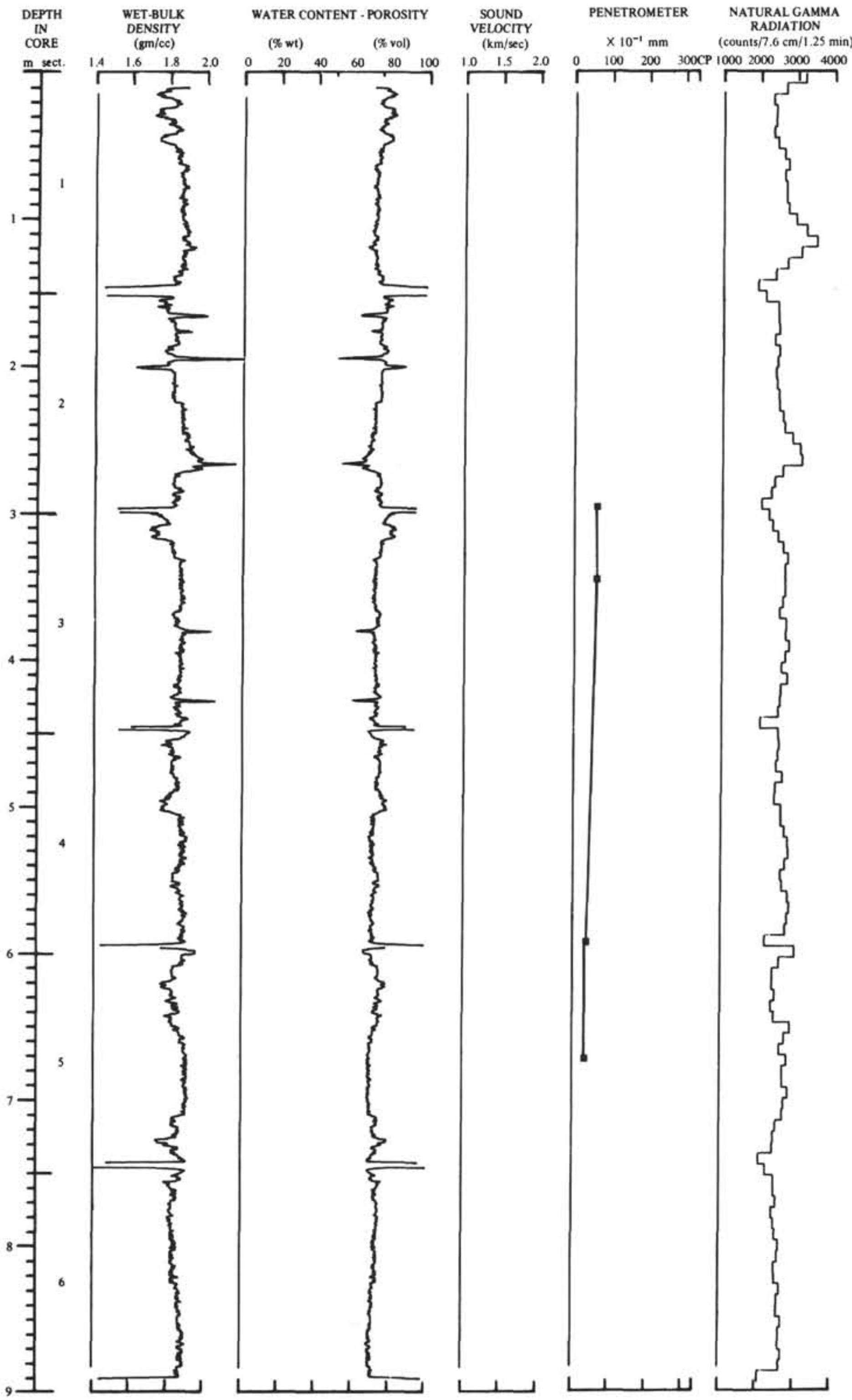


Figure 7A. *Physical Properties of Core 5, Hole 34*

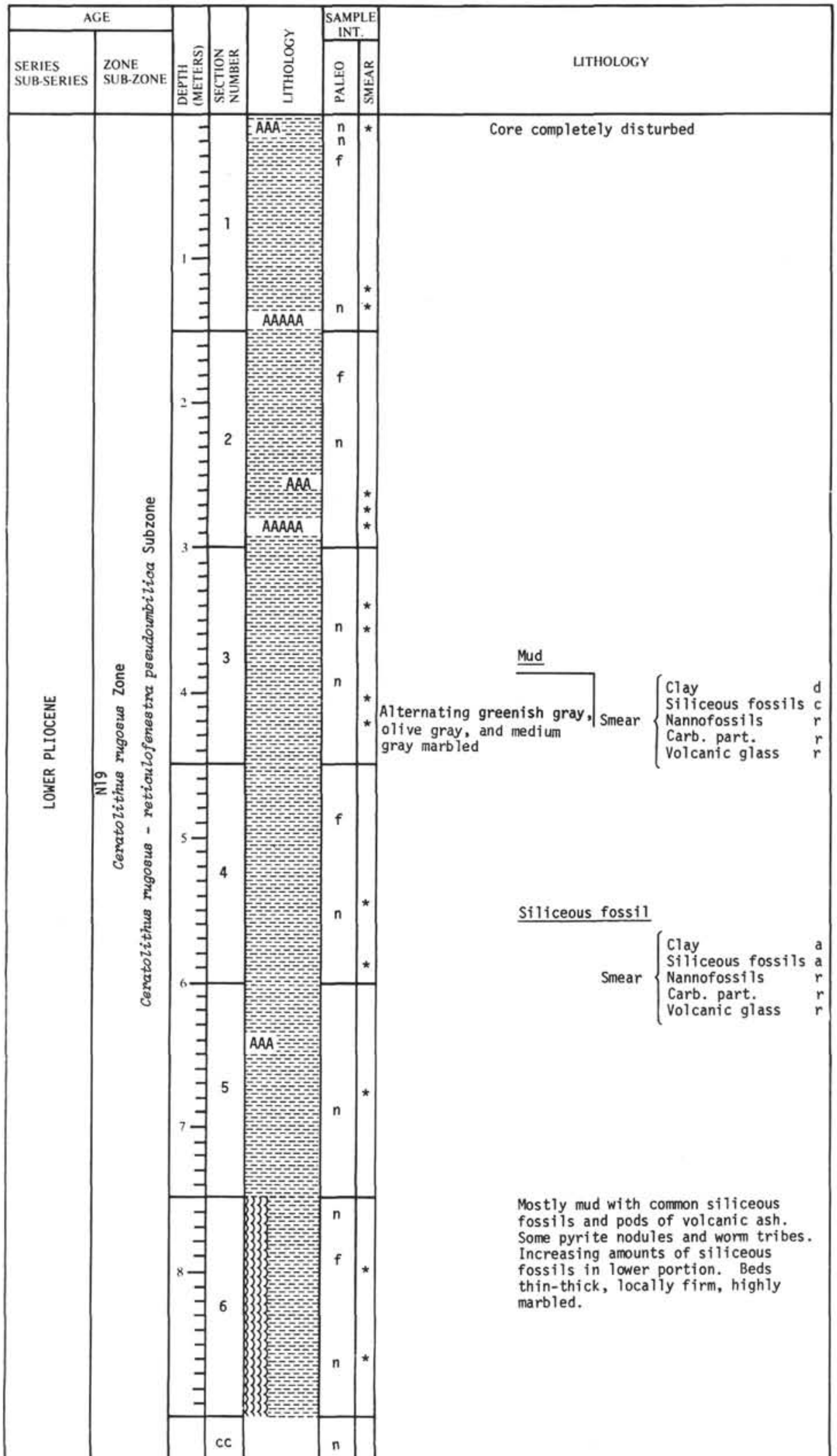


Figure 7B. *Core 5, Hole 34 (116-125 m Below Seabed)*

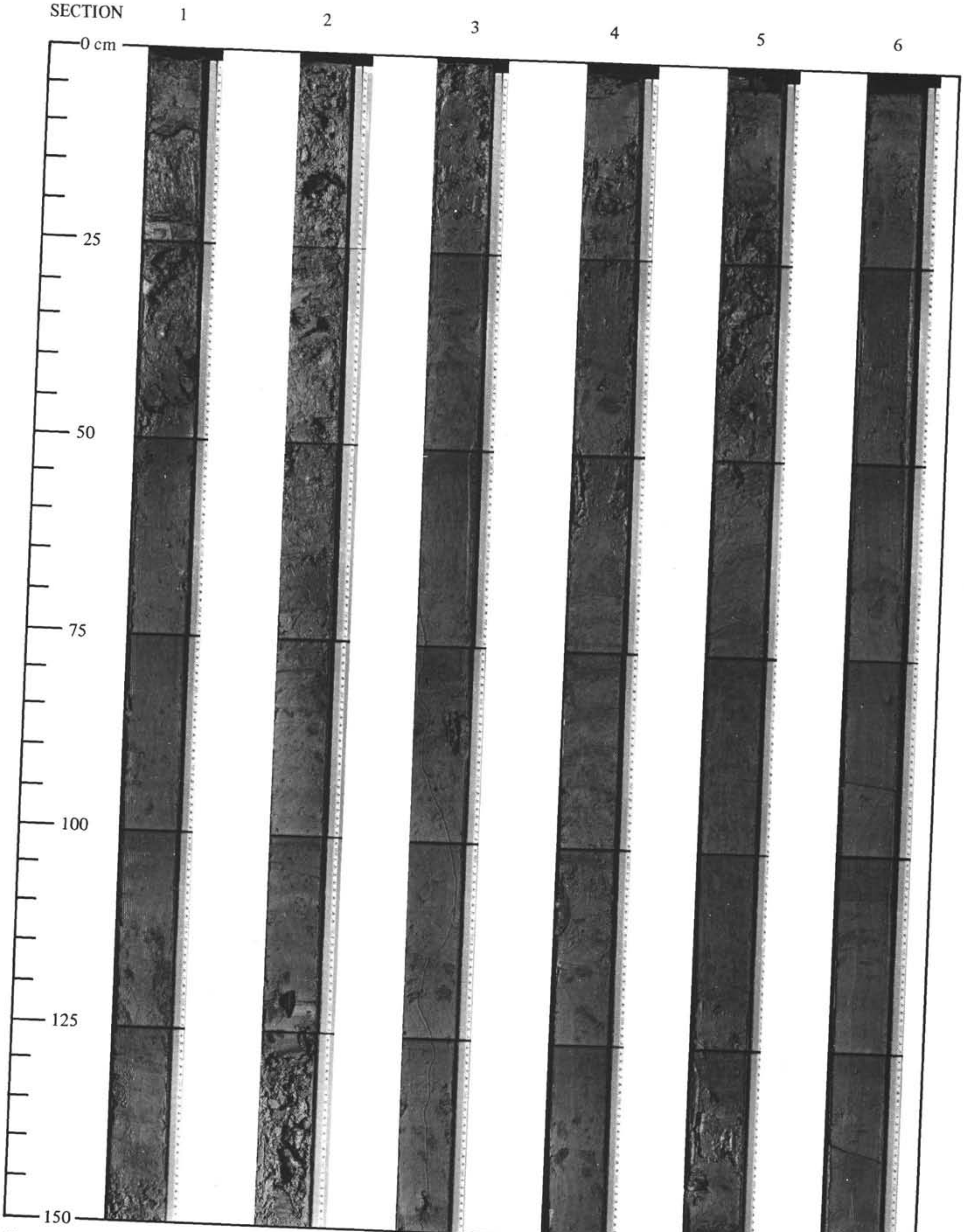


Plate 5. *Core 5, Hole 34*

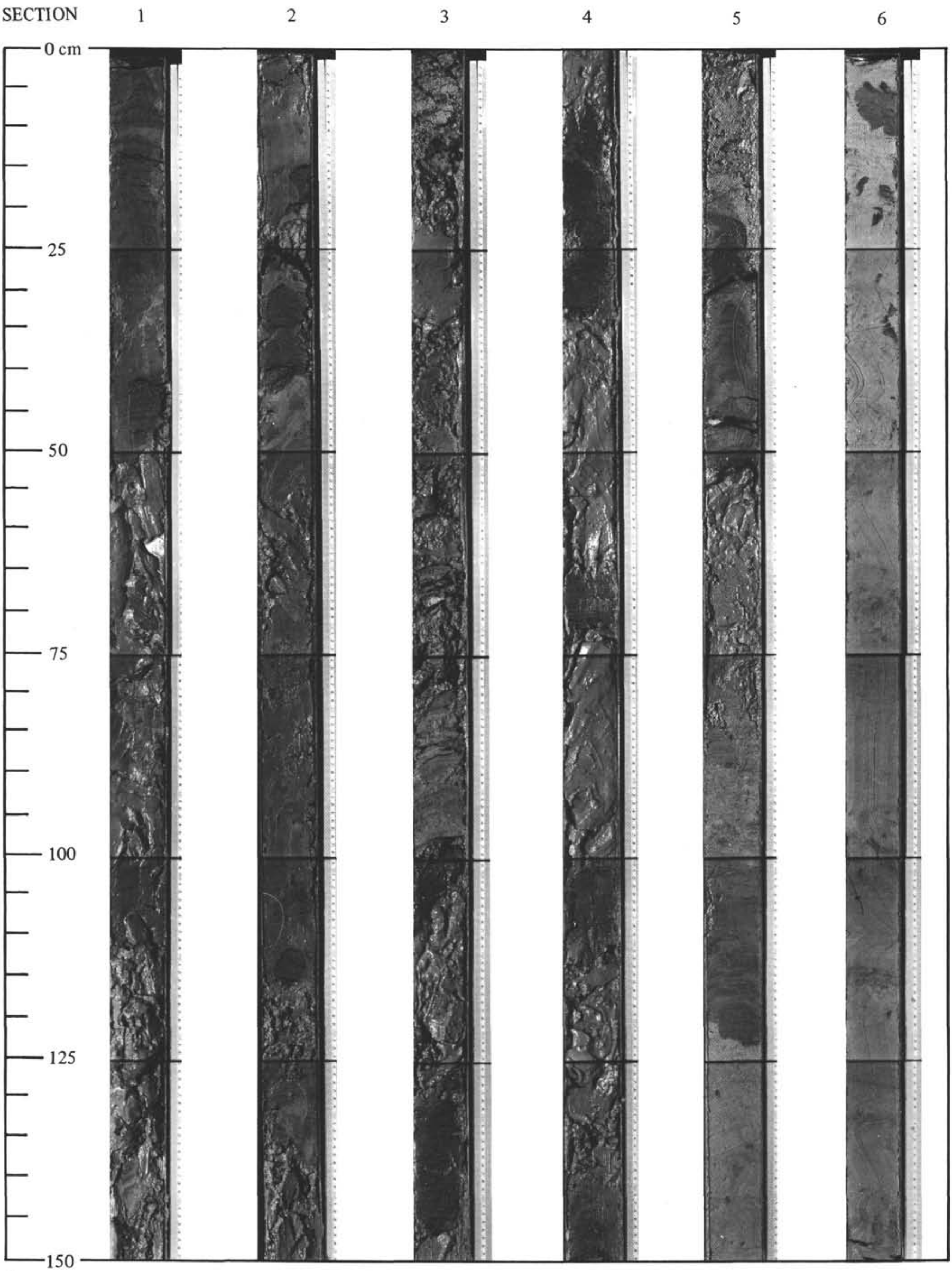


Plate 6. *Core 6, Hole 34*

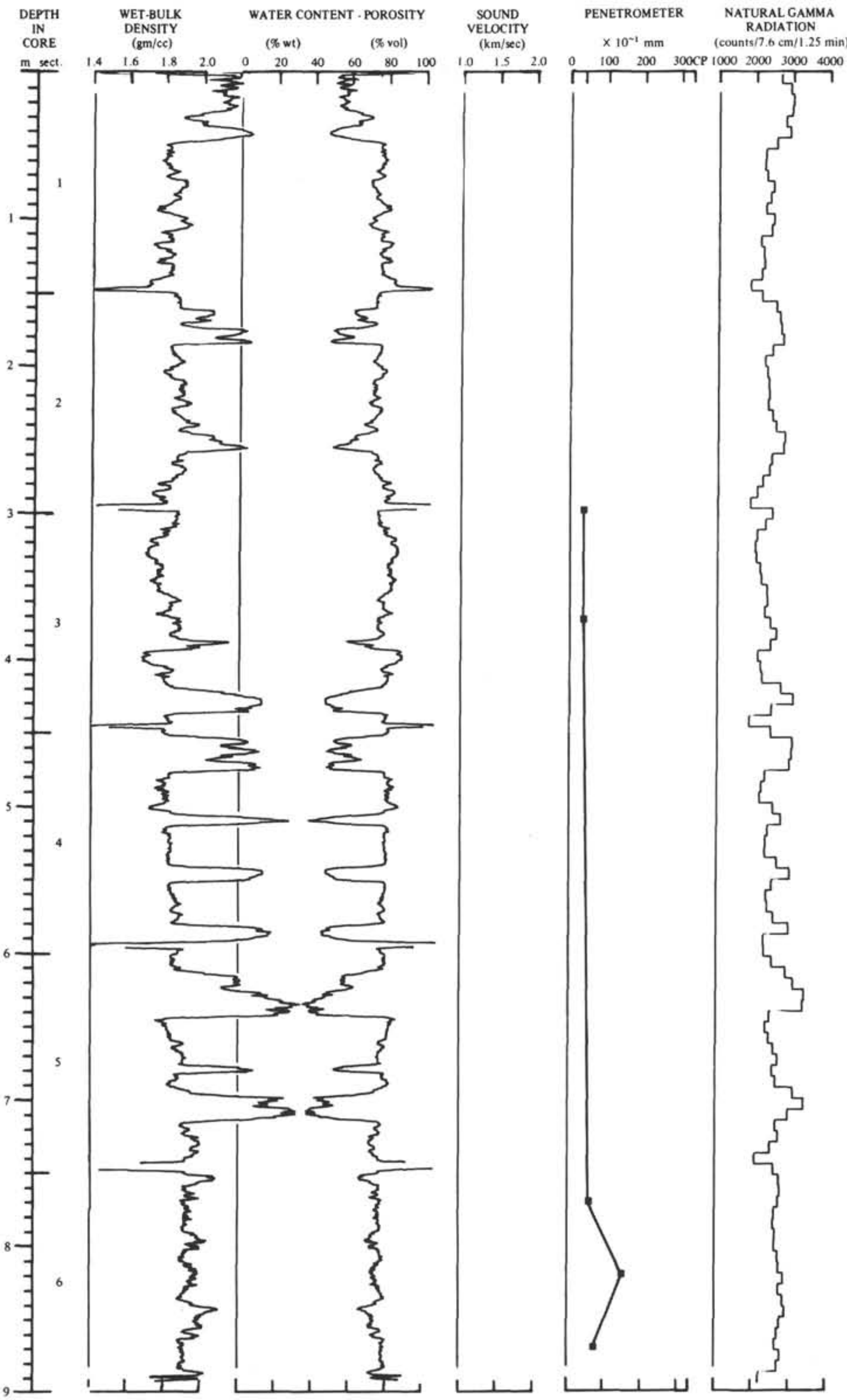


Figure 8A. *Physical Properties of Core 6, Hole 34*

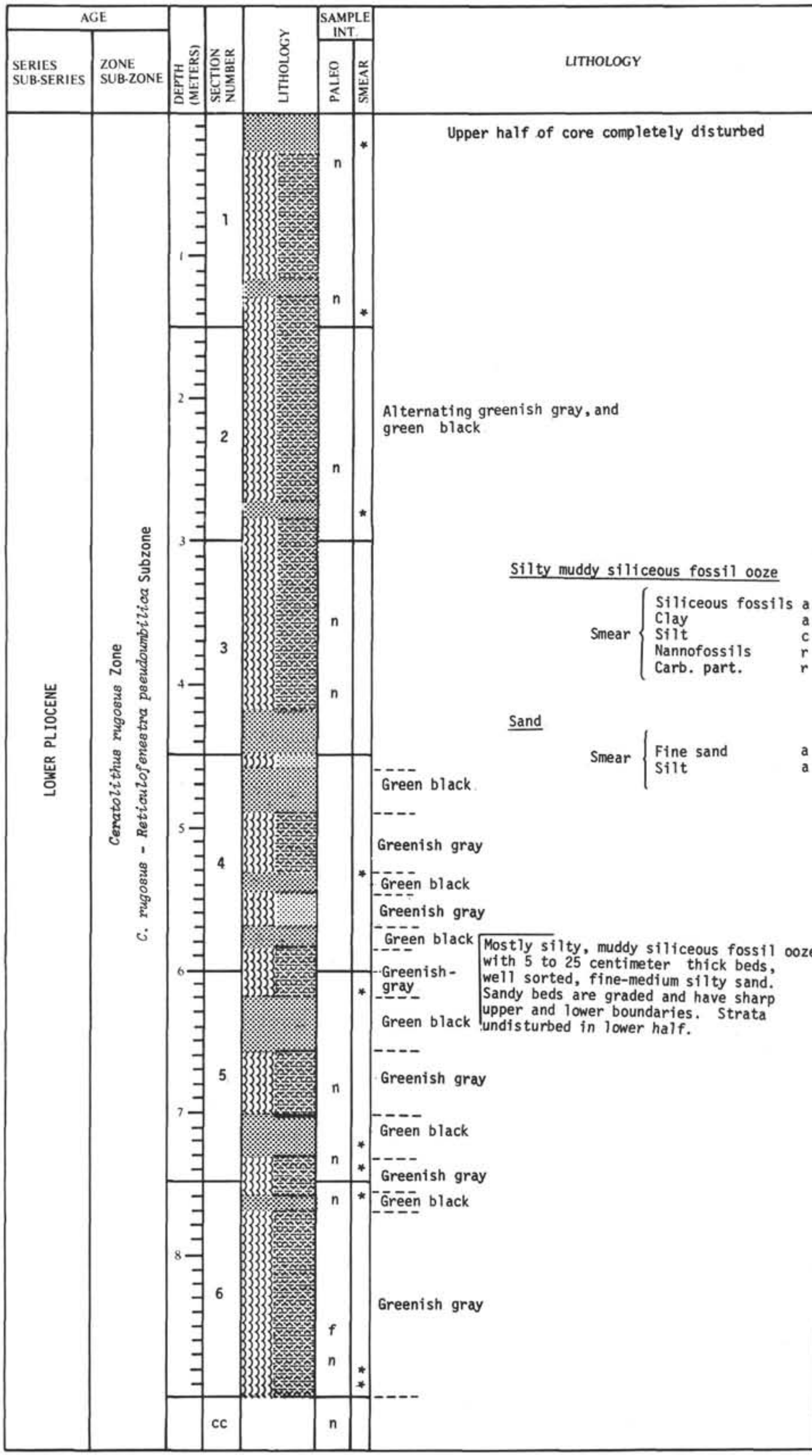


Figure 8B. *Core 6, Hole 34 (125-134 m Below Seabed)*

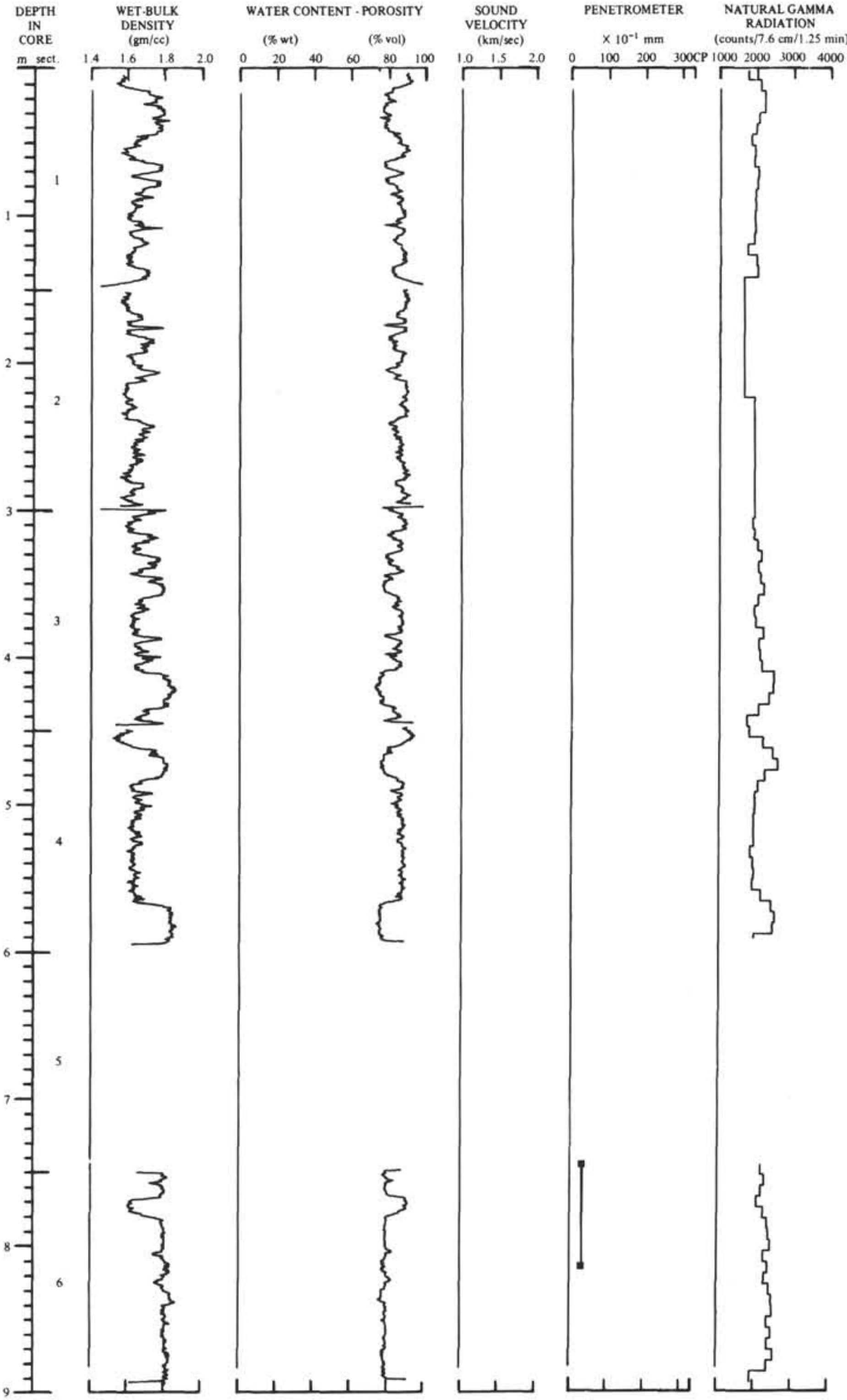


Figure 9A. *Physical Properties of Core 7, Hole 34*

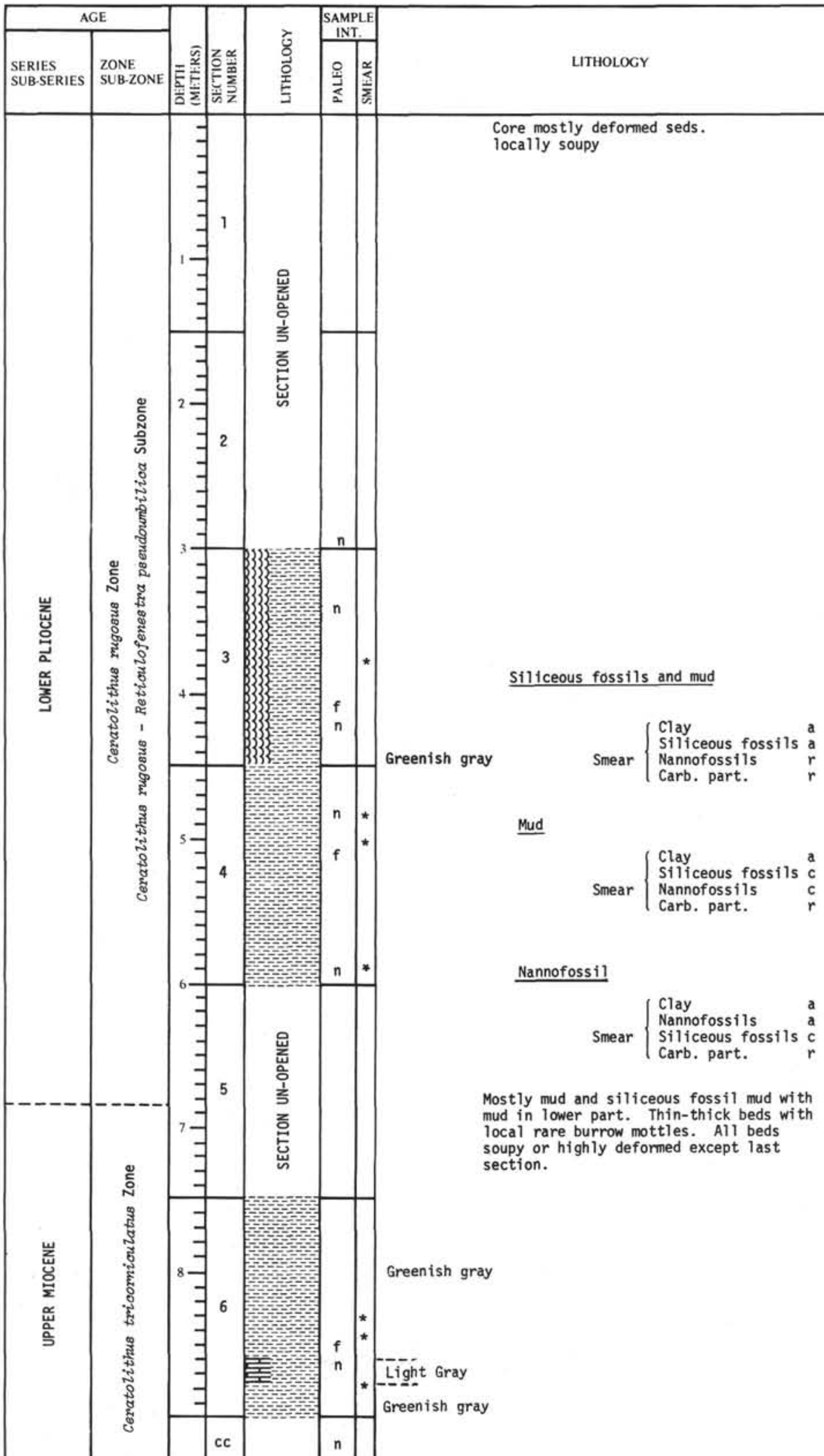


Figure 9B. *Core 7, Hole 34 (134-143 m Below Seabed*

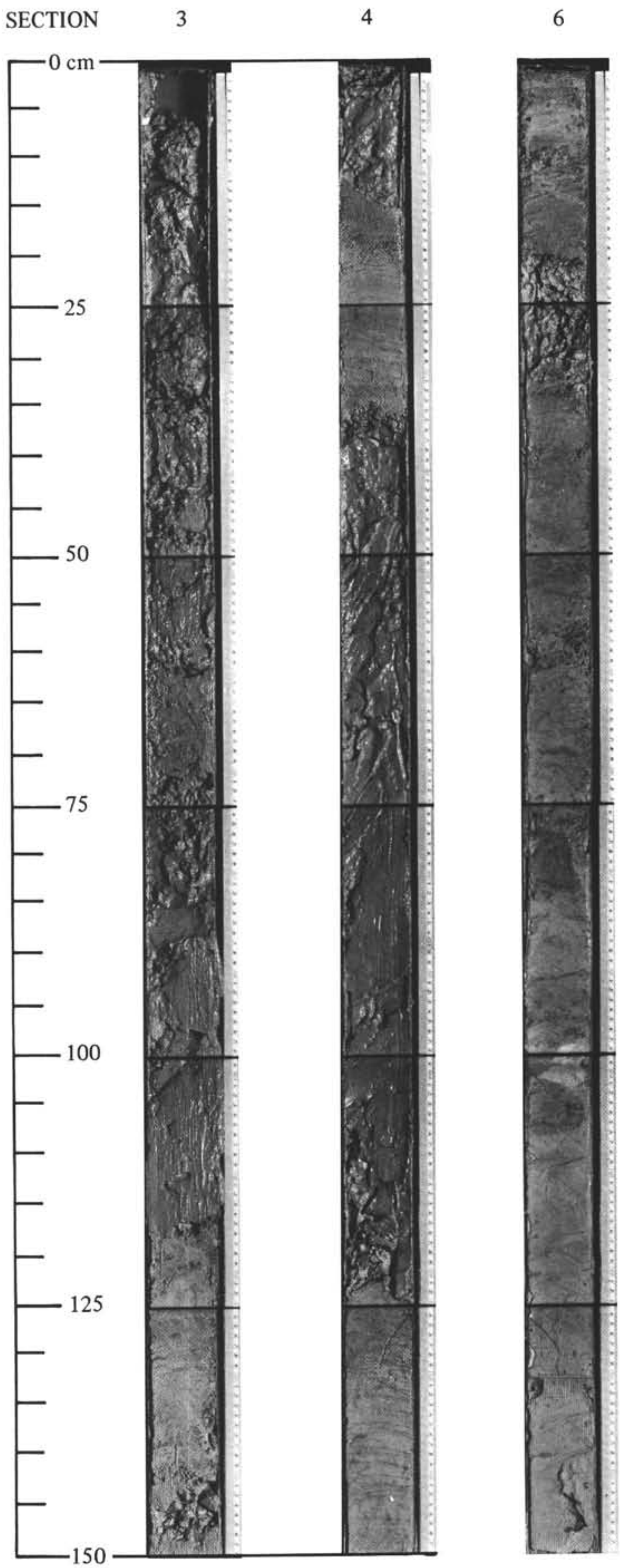
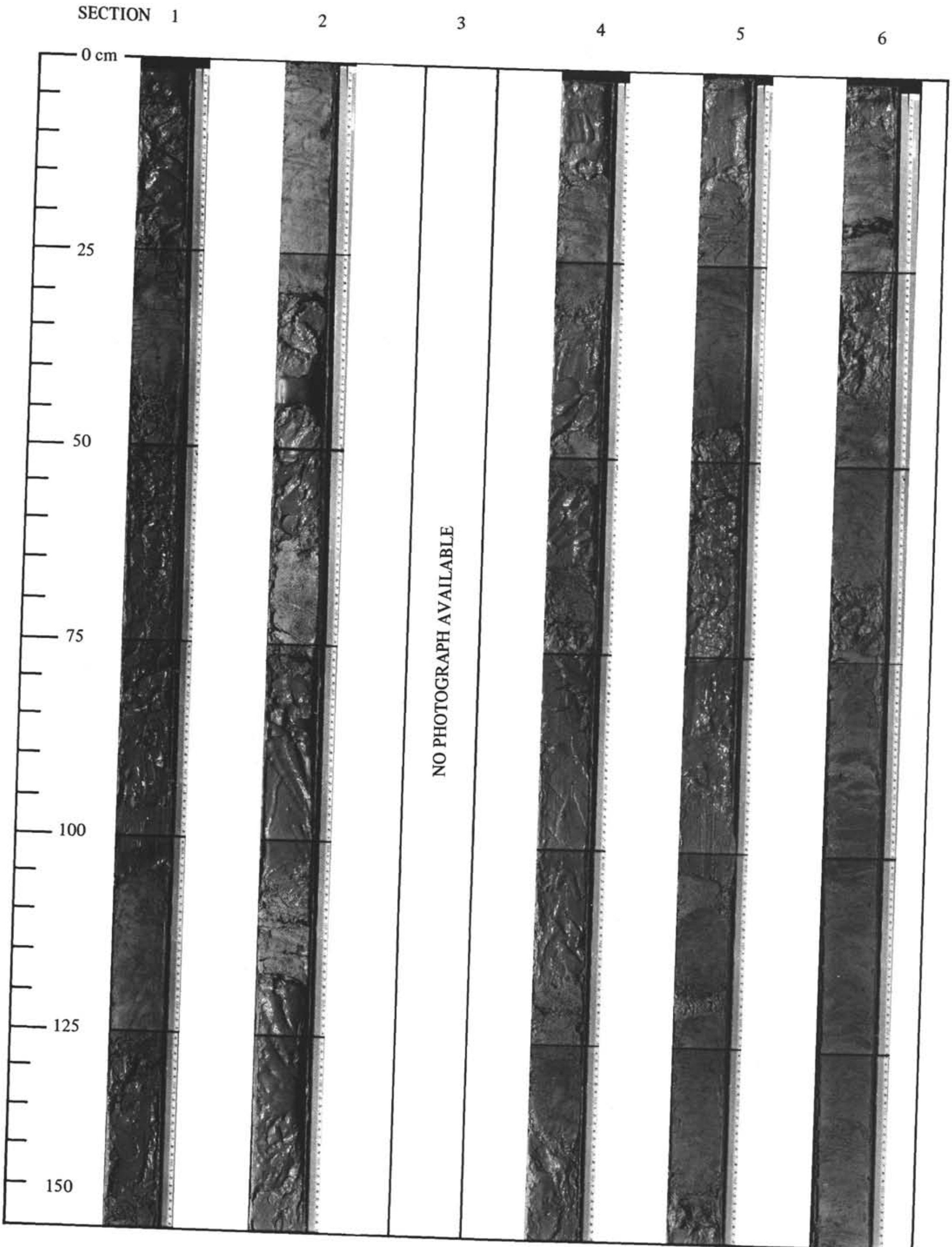


Plate 7. *Sections of Core 7, Hole 34*



Core 8, Hole 34

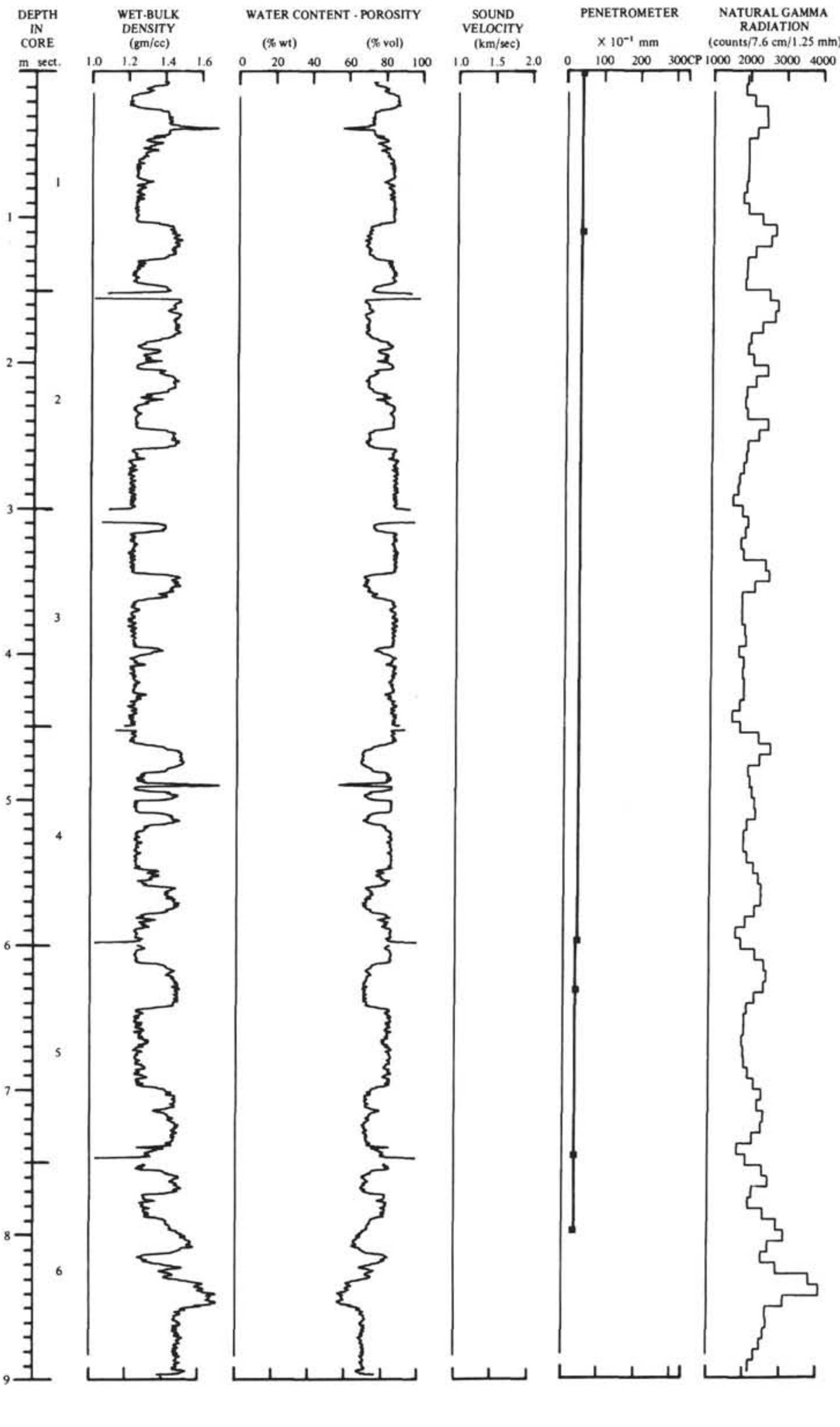


Figure 10A. *Physical Properties of Core 8, Hole 34*

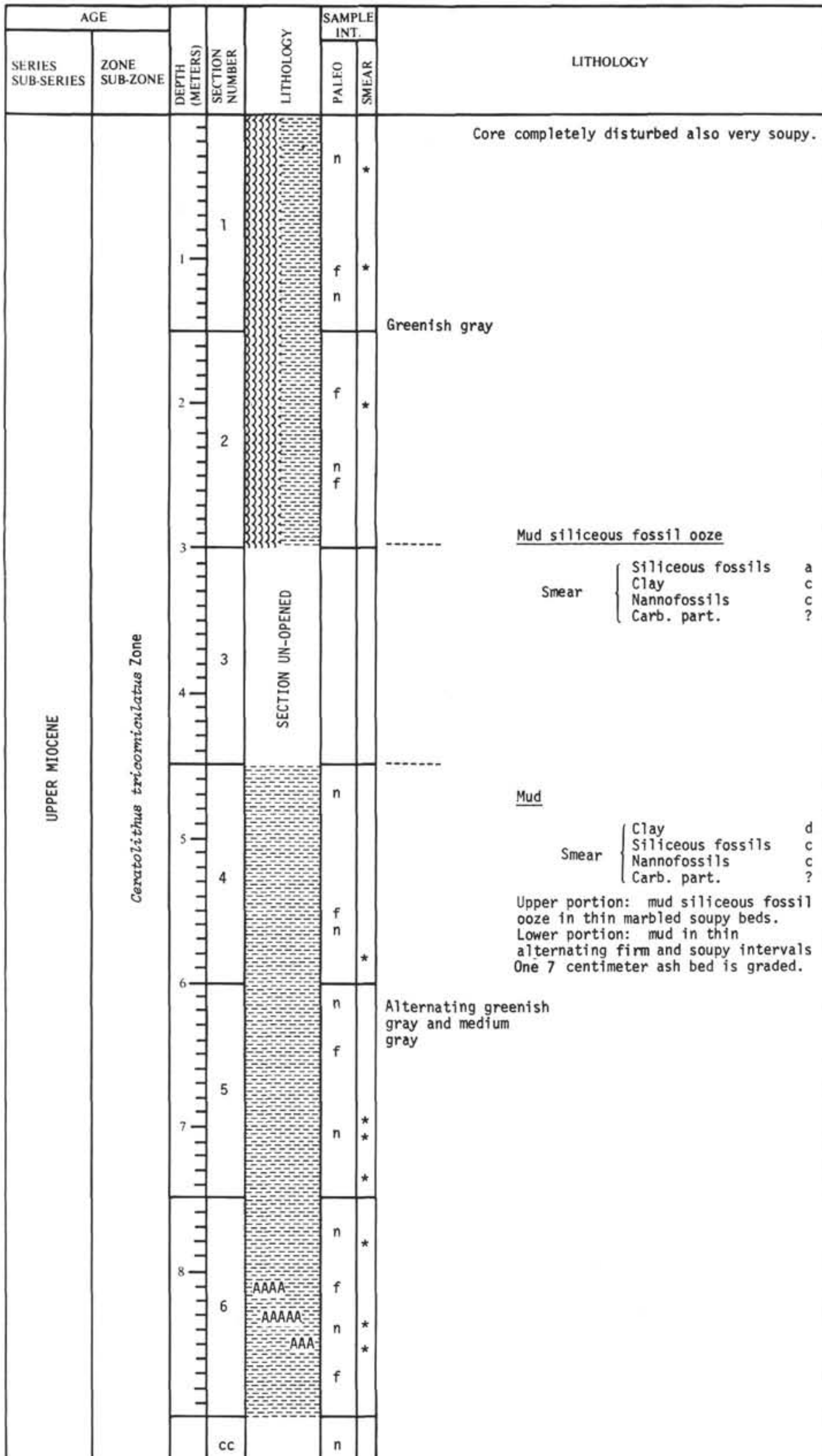


Figure 10B. *Core 8, Hole 34 (165-174 m Below Seabed)*

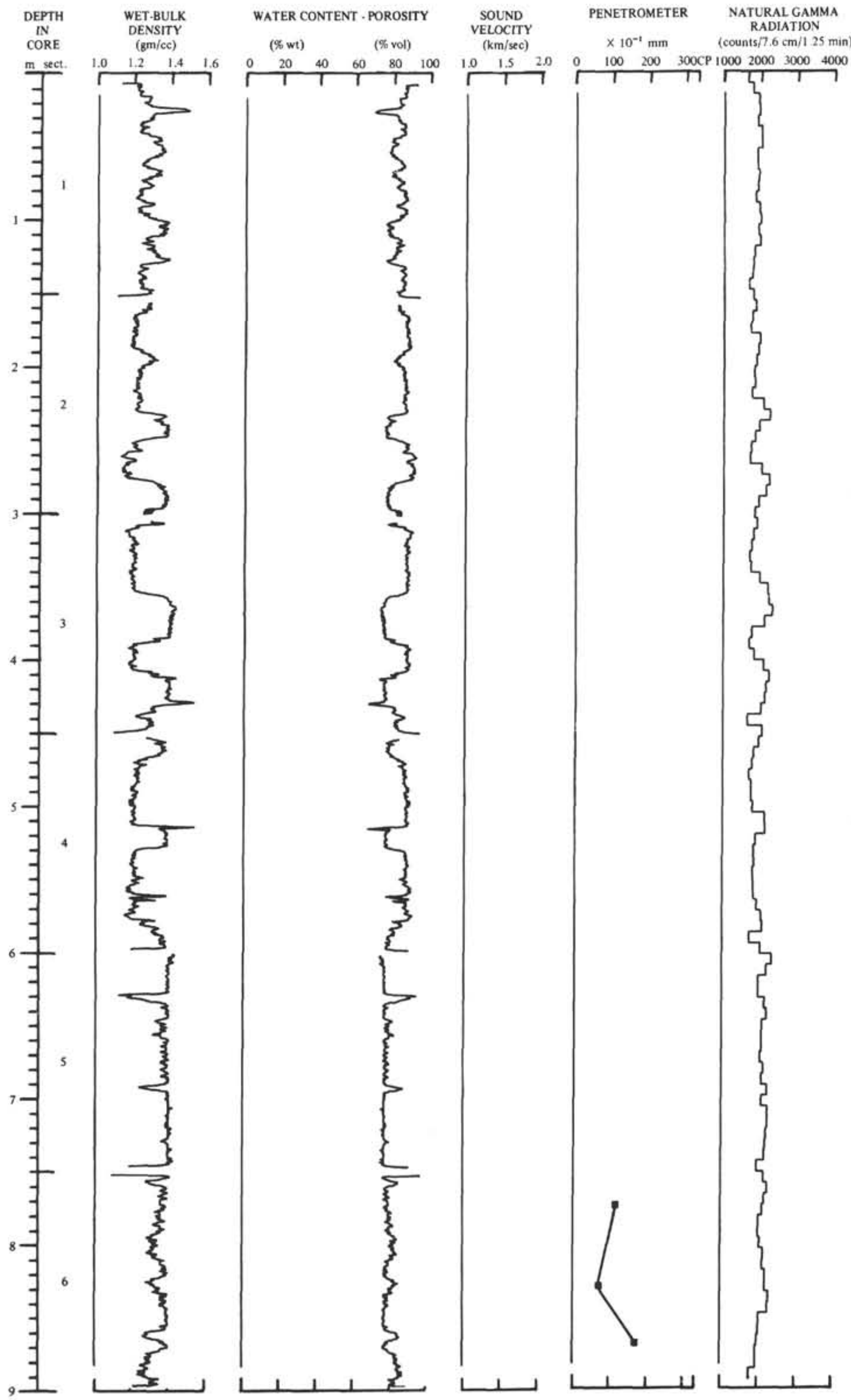


Figure 11A. *Physical Properties of Core 9, Hole 34*

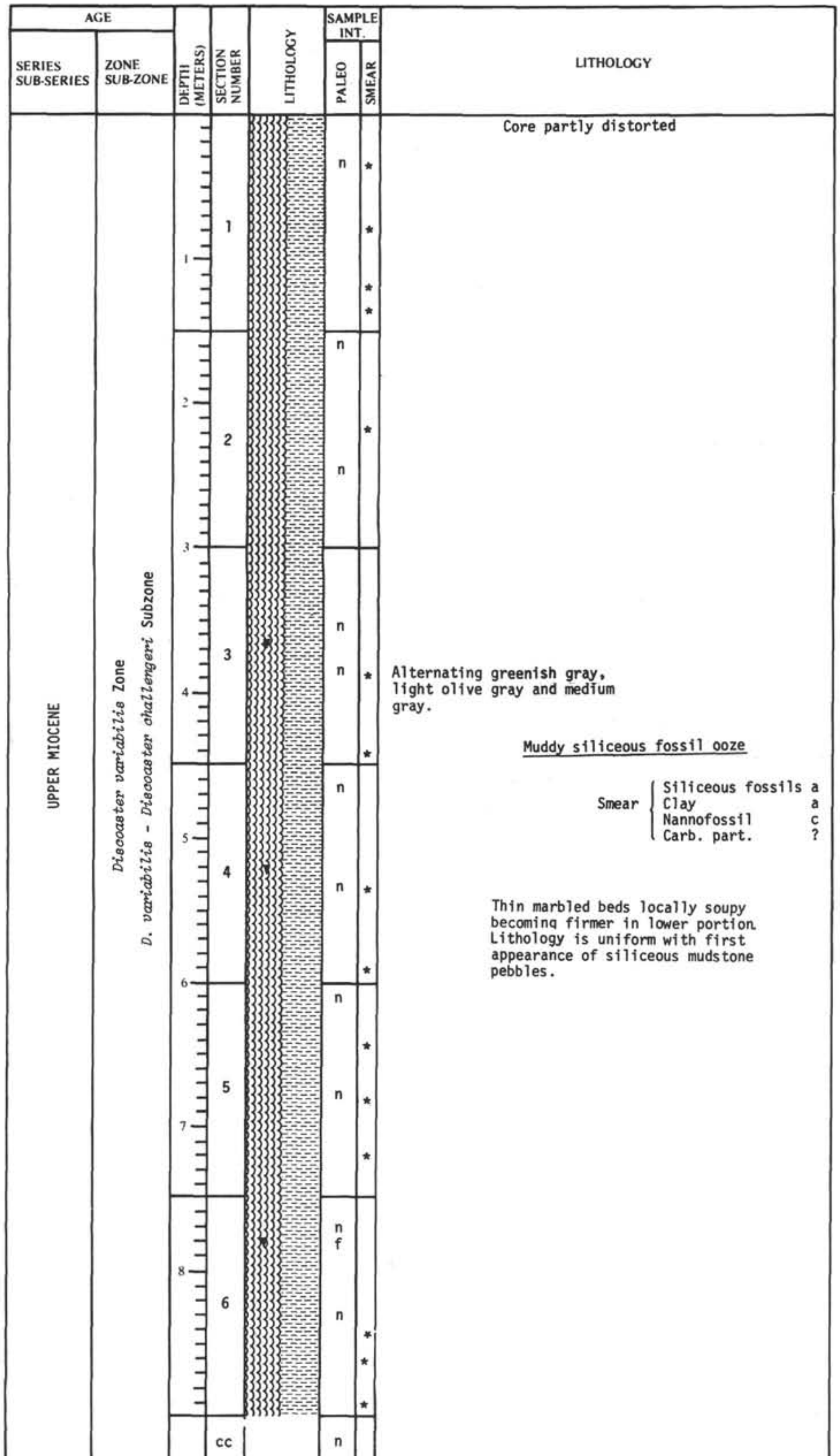


Figure 11B. *Core 9, Hole 34 (212-221 m Below Seabed)*

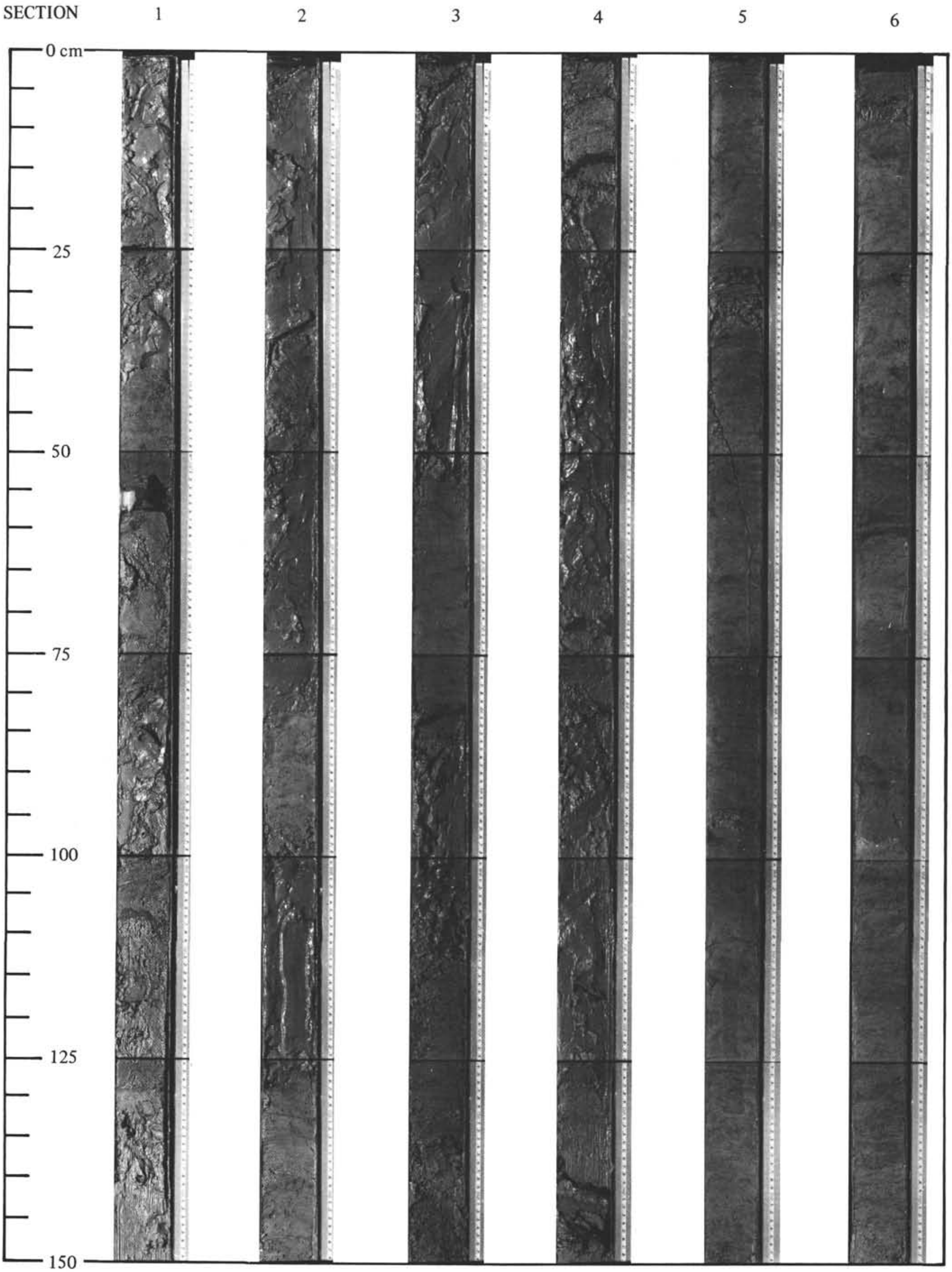


Plate 9. *Core 9, Hole 34*

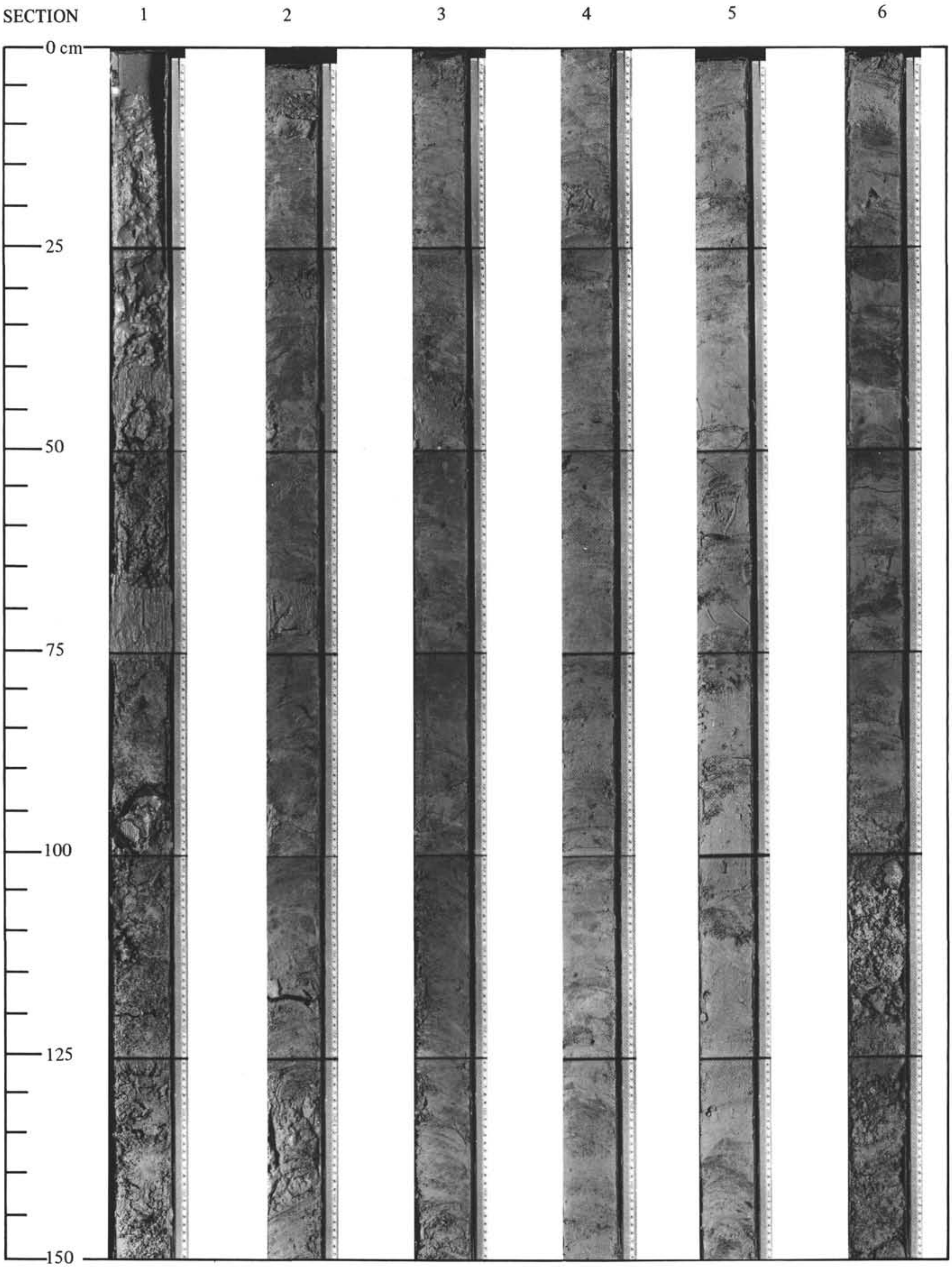


Plate 10. *Core 10, Hole 34*

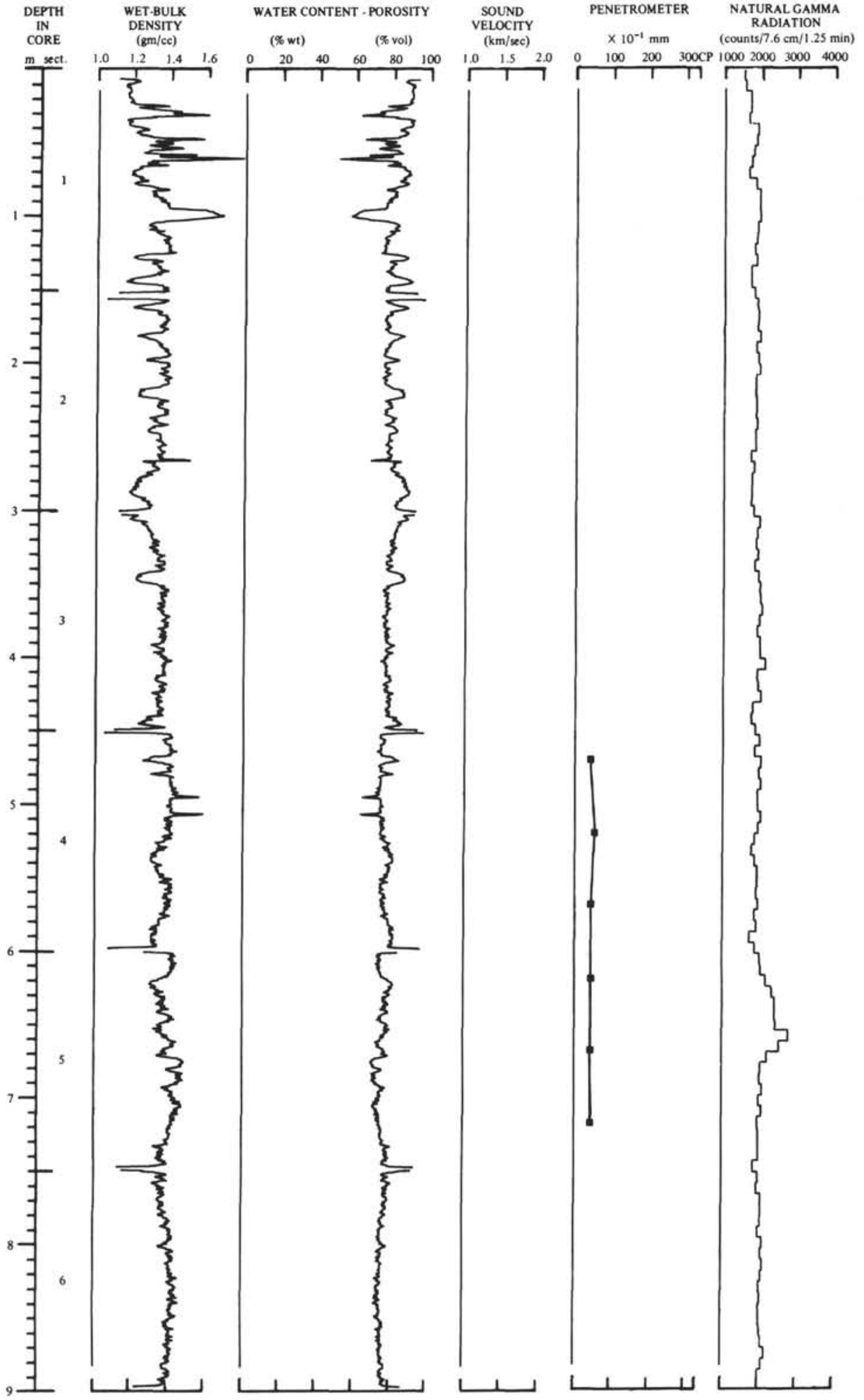


Figure 12A. *Physical Properties of Core 10, Hole 34*

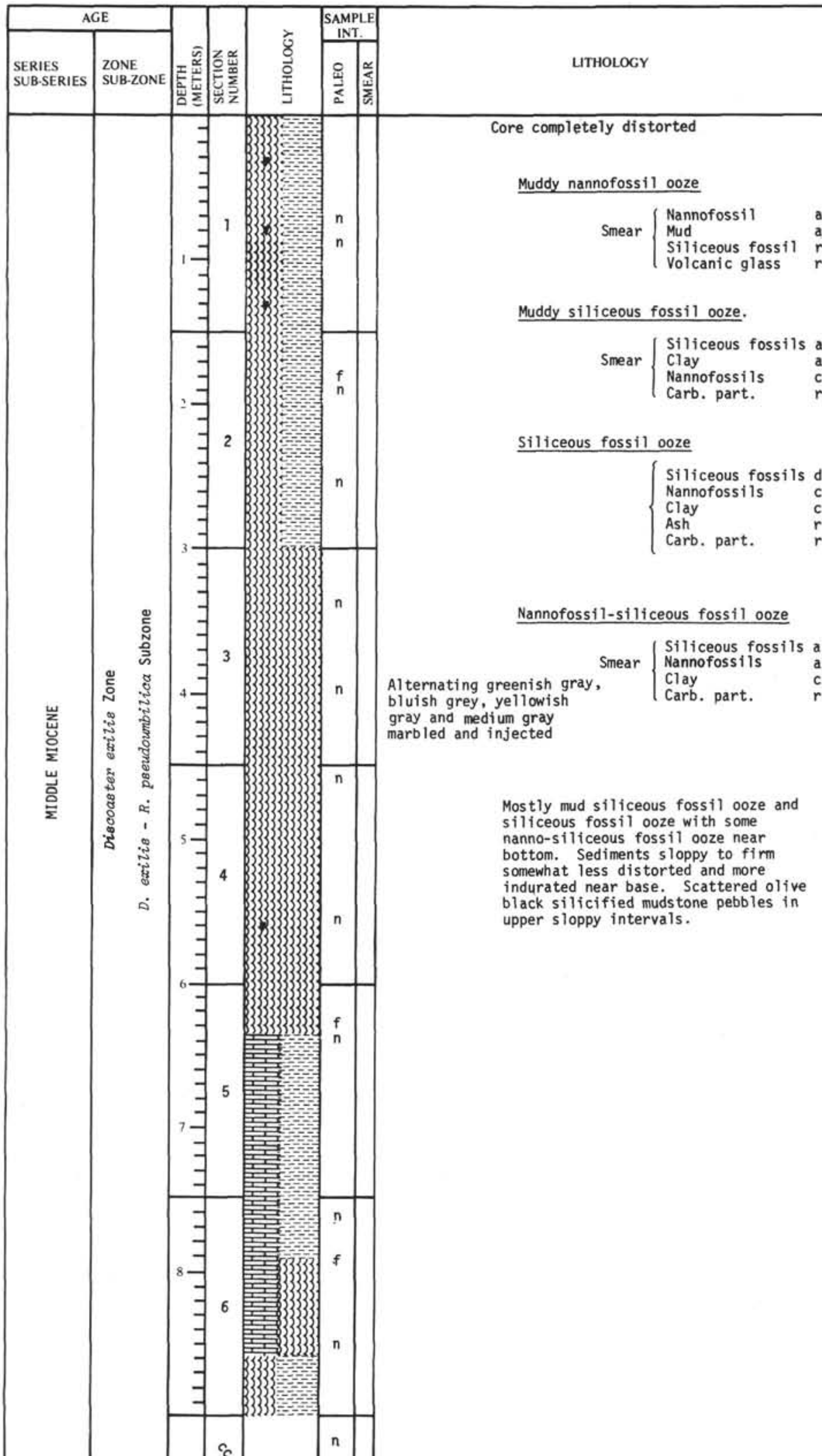


Figure 12B. *Core 10, Hole 34 (269-278 m Below Seabed)*

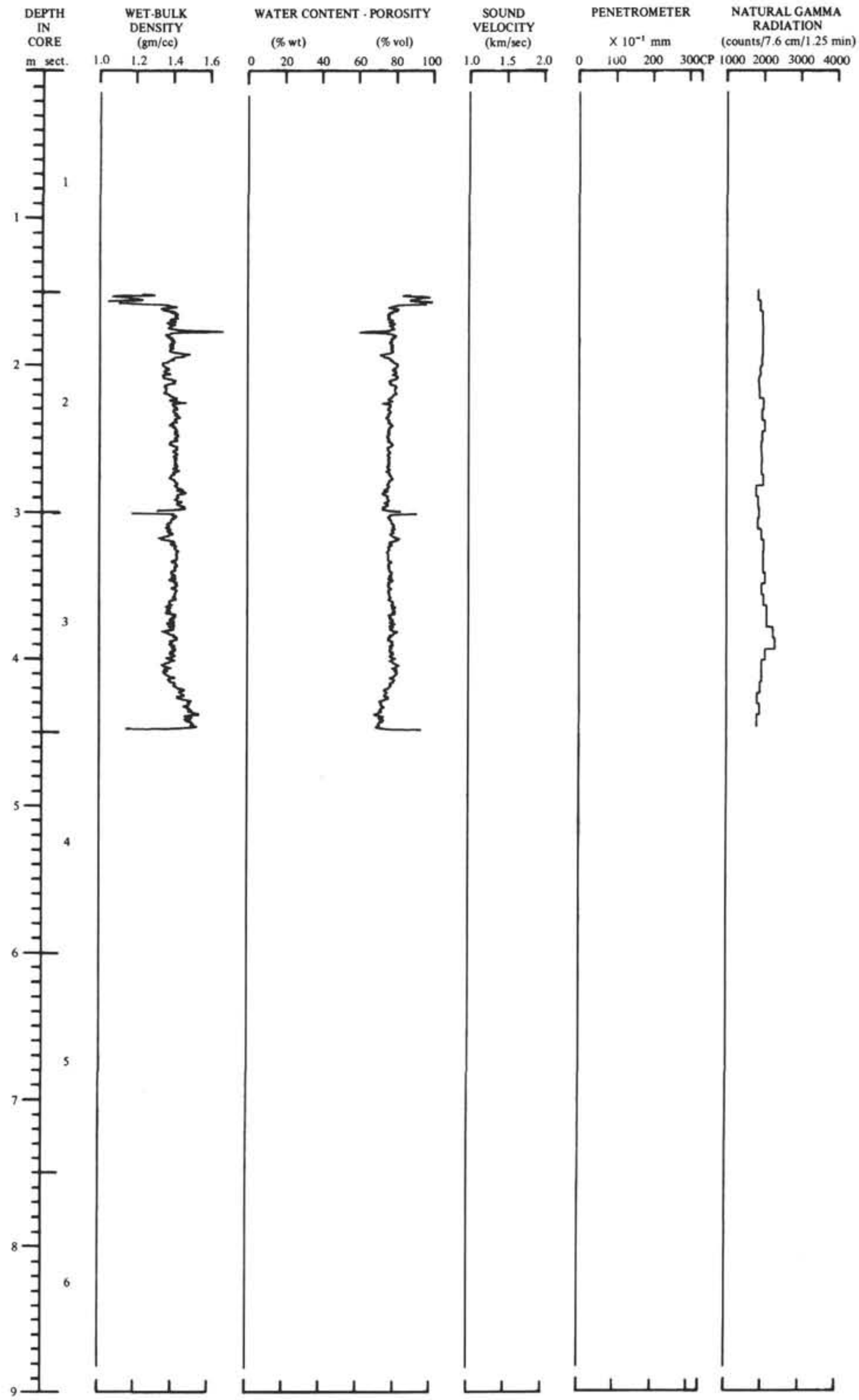


Figure 13A. *Physical Properties of Core 11, Hole 34*

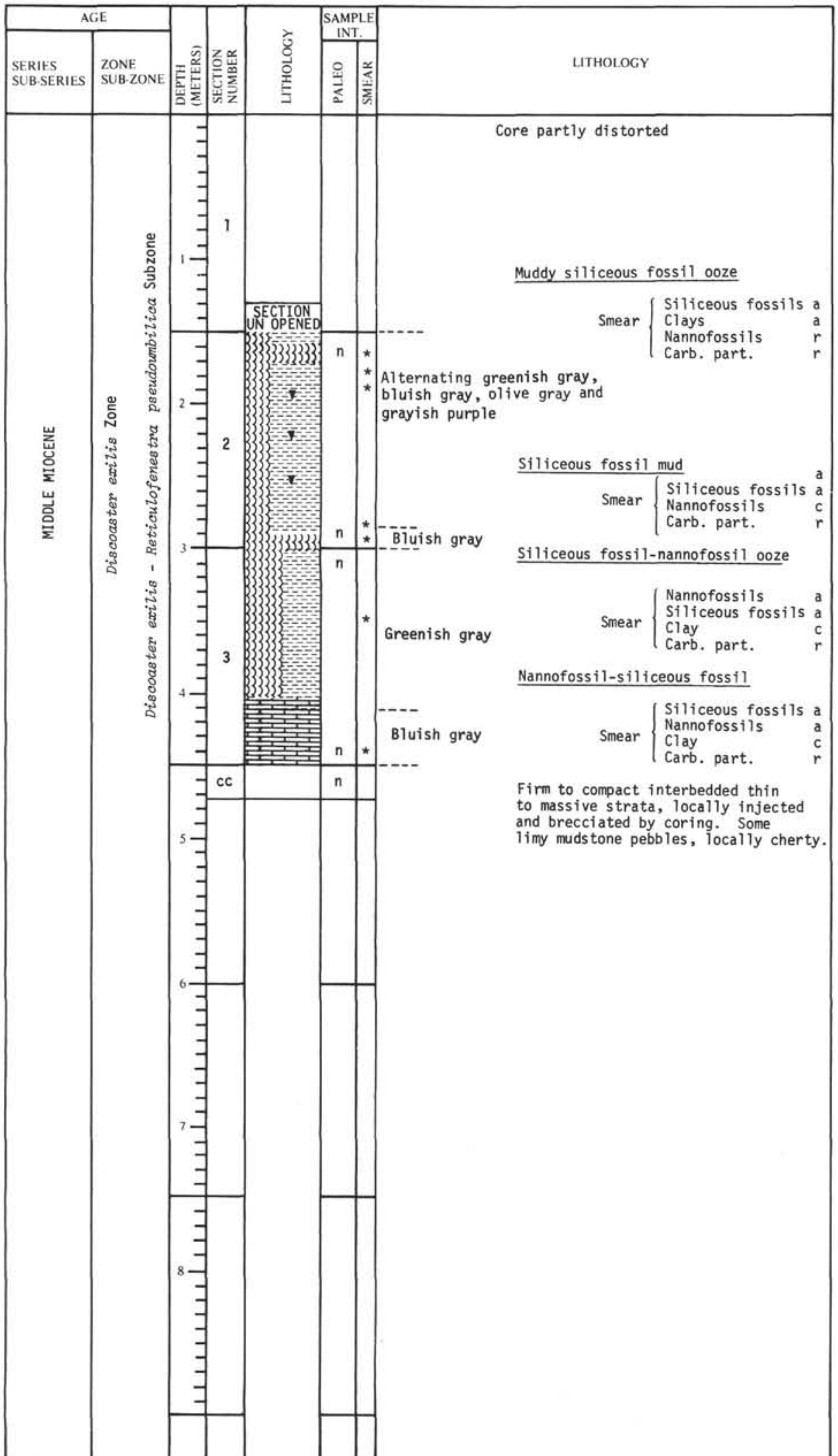


Figure 13B. *Core 11, Hole 34 (278-284 m Below Seabed)*

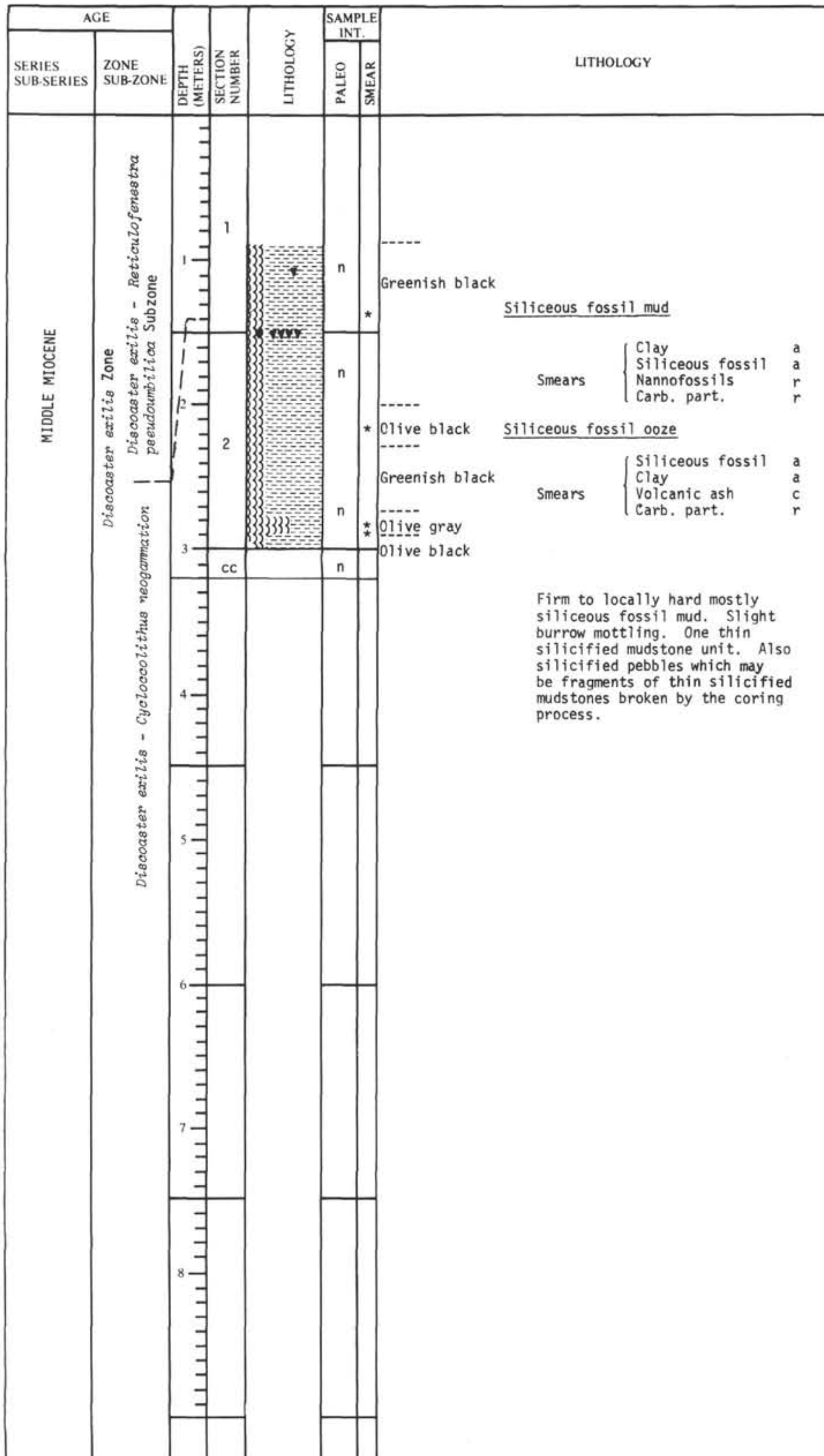


Figure 14. *Core 12, Hole 34 (284-294 m Below Seabed)*

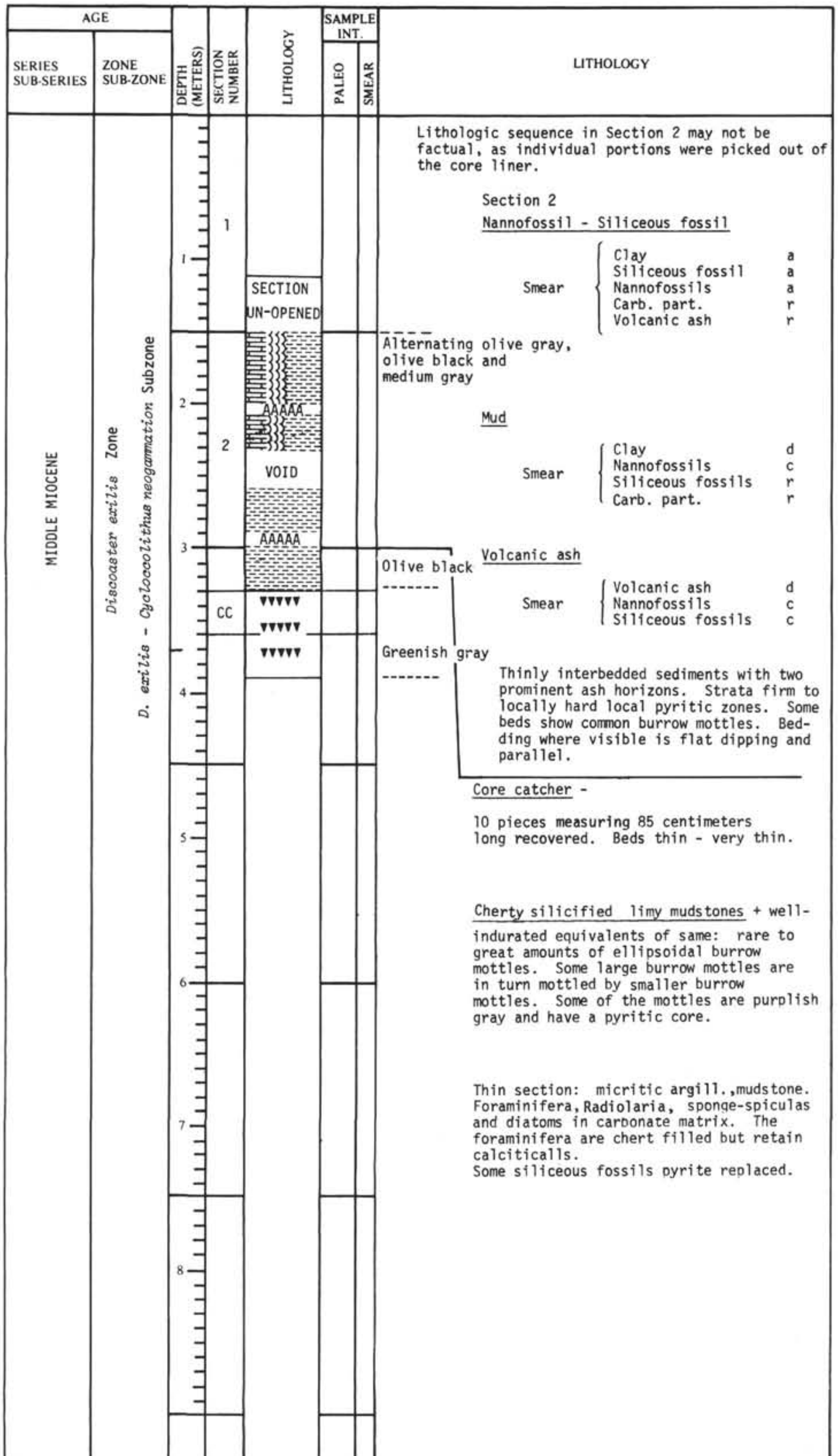


Figure 15. *Core 13, Hole 34 (297-306 m Below Seabed)*

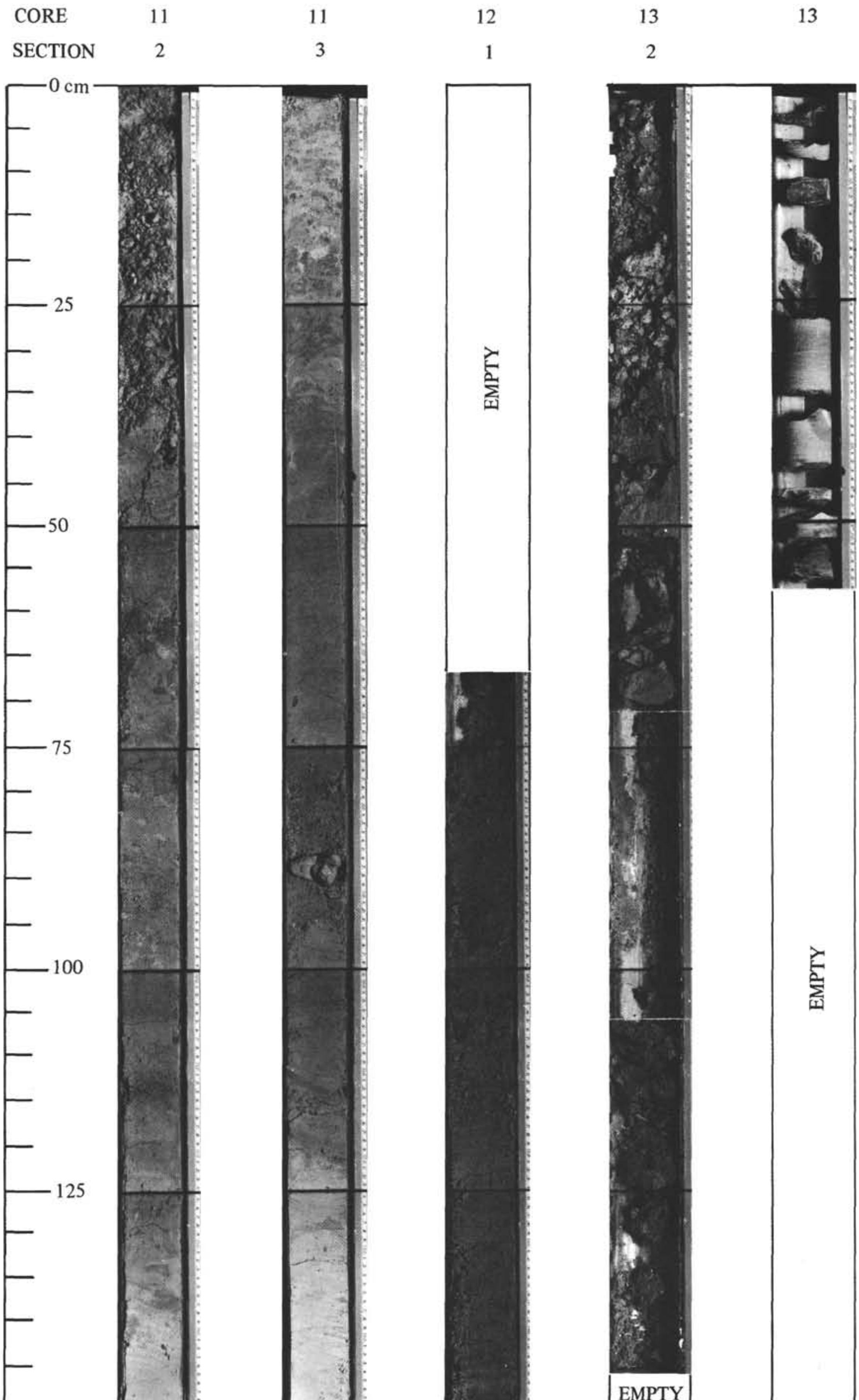


Plate 11. *Section of Cores 11, 12 and 13, Hole 34*

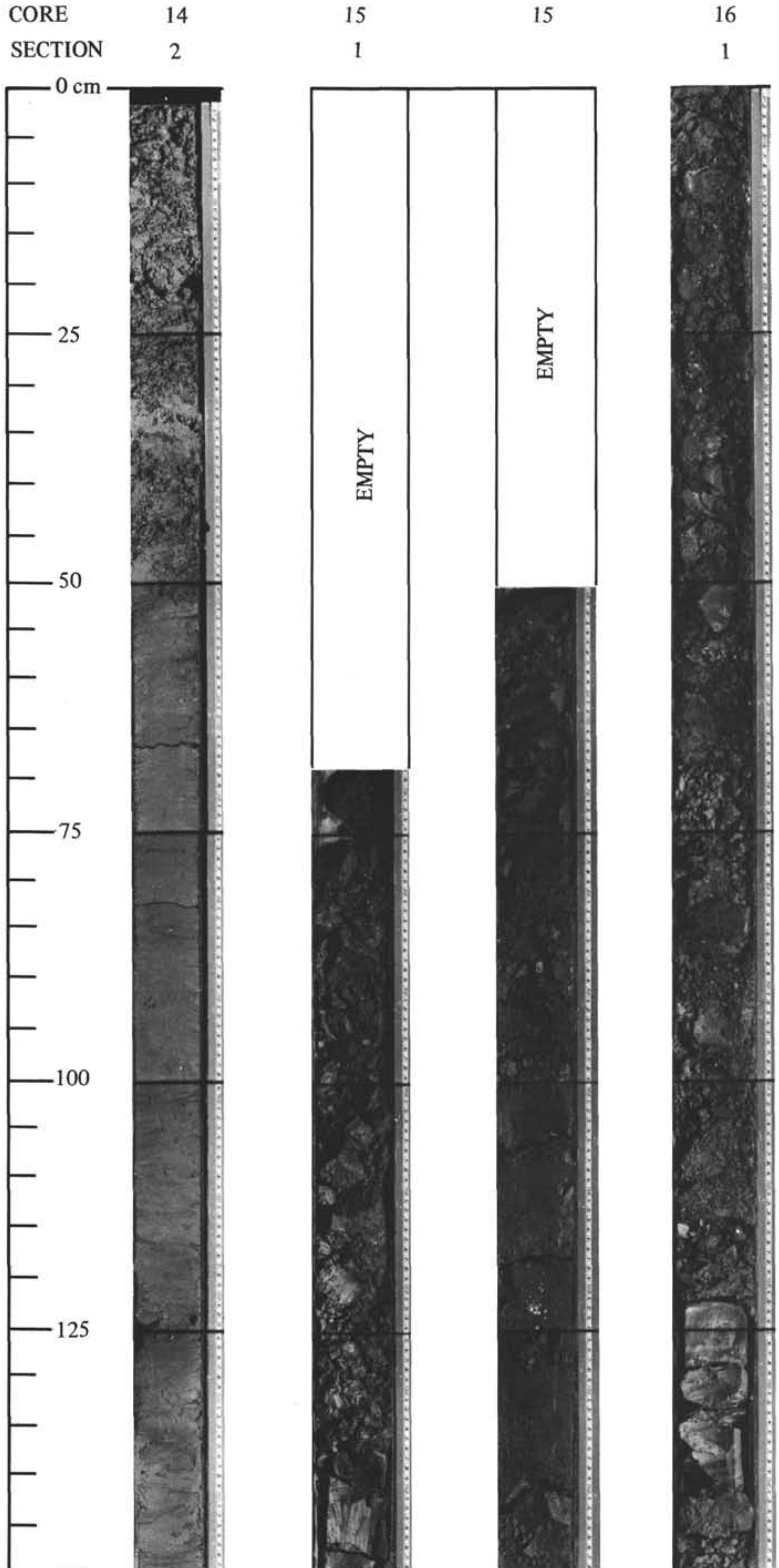


Plate 12. *Sections of Cores 14, 15 and 16, Hole 34*

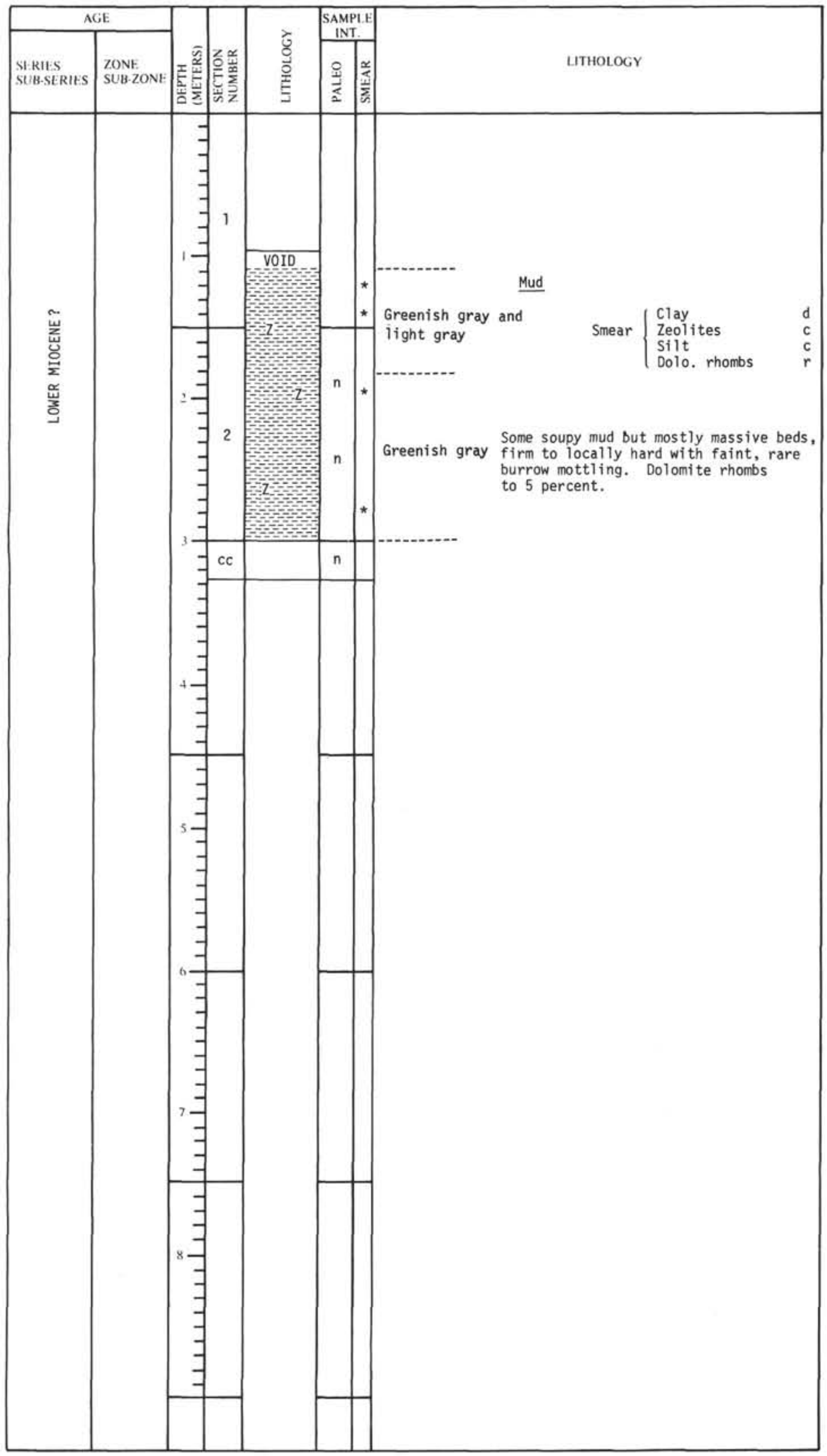


Figure 16. *Core 14, Hole 34 (337-345 m Below Seabed)*

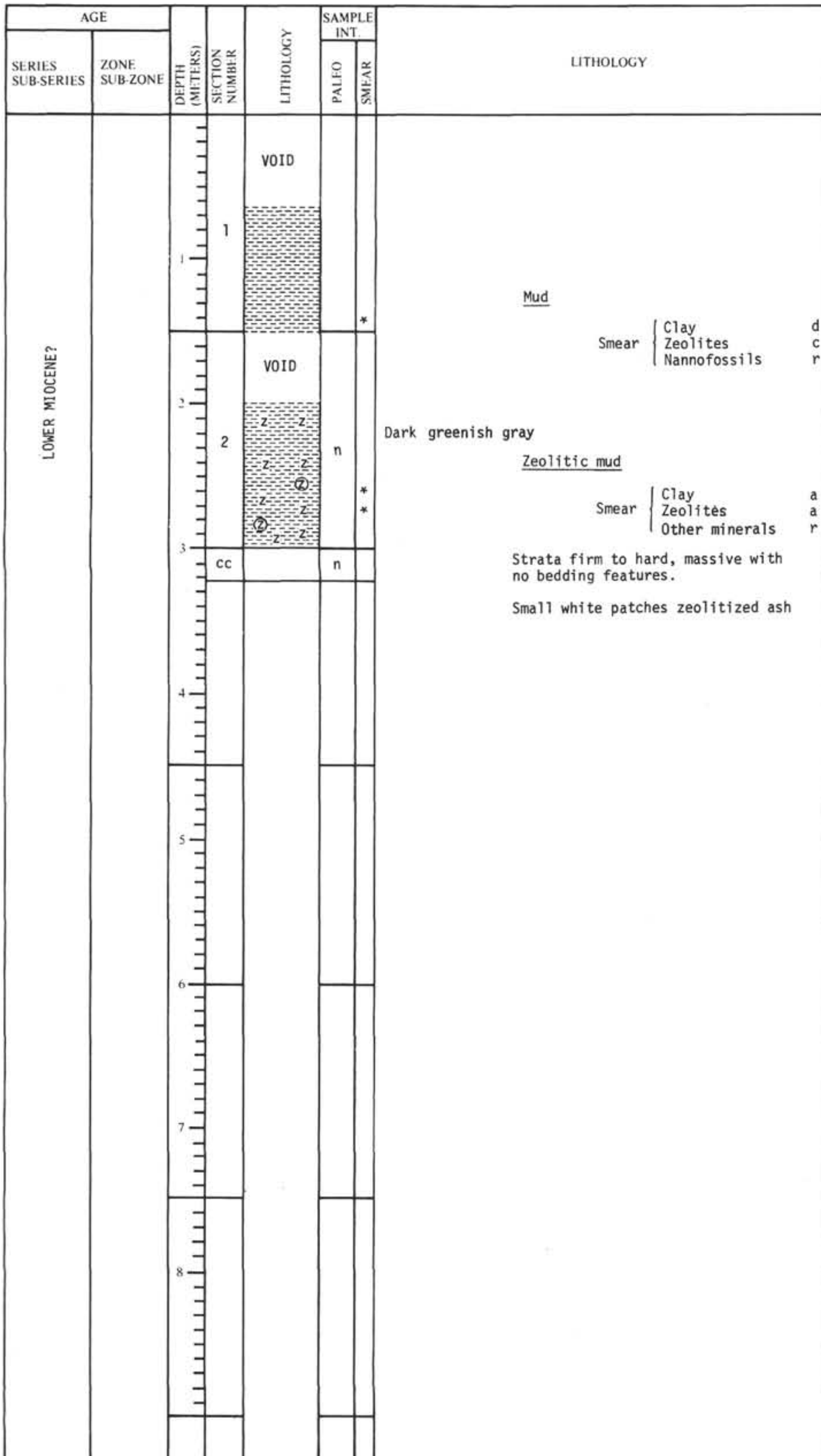


Figure 17. *Core 15, Hole 34 (345-348 m Below Seabed)*

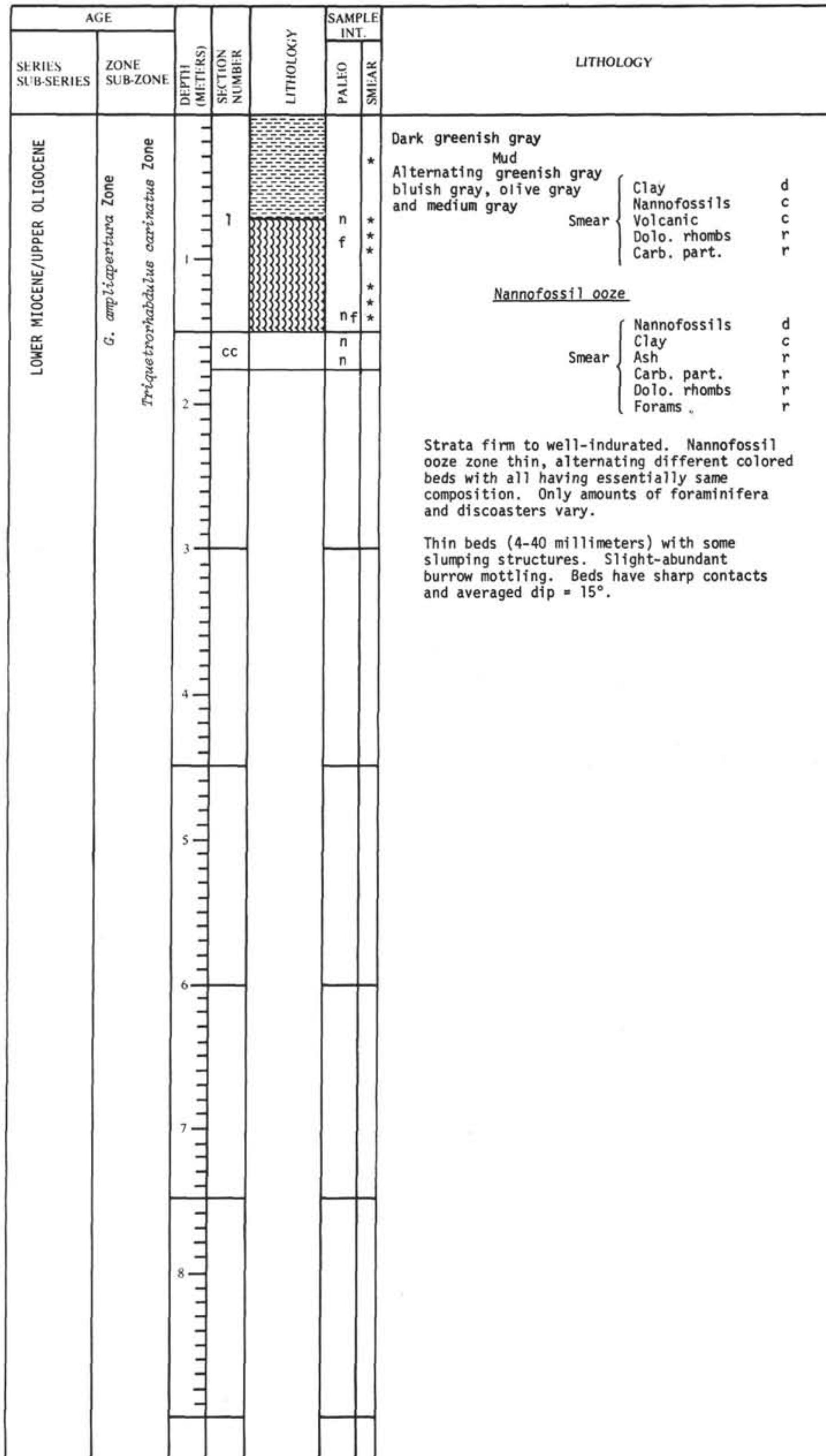


Figure 18. *Core 16, Hole 34 (348-352 m Below Seabed)*

AGE: SERIES SUB-SERIES	AGE: ZONE SUB-ZONE	DEPTH (METERS)	SECTION NUMBER	LITHOLOGY	SAMPLE INT.: PALEO	SAMPLE INT.: SMEAR	LITHOLOGY
UPPER OLIGOCENE	*G. ampliapertura* Zone; *Coccolithus bisectus* Zone; *C. bisectus* - *Triquetrorhabdulus carinatus* Subzone	1	1		n		Partial section consists of broken rock fragments.
					nf	* *	
			cc		n		
		2, 3, 4, 5, 6, 7, 8					

Partial section consists of broken rock fragments.

<u>Mud</u>

Smear { Clay
Analcite ?

Alternating greenish gray, greenish black and medium gray

<u>Muddy nannofossil ooze</u>

Smear { Nannofossil a
Clay c
Carb. part. r

Strata thick-thin beds or laminated. Some fragments almost completely burrow-mottled with small mottles within larger mottles. All are hard to partly cemented.

Figure 19. *Core 17, Hole 34 (352-356 m Below Seabed)*

AGE		DEPTH (METERS)	SECTION NUMBER	LITHOLOGY	SAMPLE INT.		LITHOLOGY
SERIES SUB-SERIES	ZONE SUB-ZONE				PALEO	SMEAR	
?		1 2 3 4 5 6 7 8	1			*	Core extruded in 5 to 20 centimeters long fragments of basement and several small lumps of sediment. Most of core (50 centimeters) consists of basalt with felty to variolitic texture. Chlorite filled amygdules. Medium gray Basement fragments pervaded by small and large fractures filled with carb., chlorite (some serpentine- like mins.) A contact between the sediments and basement rocks was not preserved. The sediments are dark gray yellow, rusty red and locally dark green. They consist mostly of a a carbonate mineral (probably calcite). The dark green material appears to be a chlorite mineral and the dark gray sediment is probably a clay. All told about 20 centimeters of sediment were recovered.

Figure 20. *Core 18, Hole 34 (383-384 m Below Seabed)*