5. SITE 35

The Shipboard Scientific Party[1]

SITE BACKGROUND

The Escanaba Trough, the median valley of Gorda Ridge, represents the only known equivalent on the East Pacific Rise system of the Rift Valley of the Mid-Atlantic Ridge. Located just north of the Mendocino Fracture Zone, the Trough has associated with it the wide positive magnetic anomaly, the band of earthquake epicenters, and the high heat flow values that characterize a median valley. Site 35 was proposed in the Escanaba Trough in order to obtain a sample of the median valley of the mid-ocean ridge system.

Continuous coring of the sediment section and a sampling of the basement rock were proposed at this site in order to assure at least one sampling site for evaluation of the nature of the axial material and for comparison of axial and flank material. Although basement had not been reached at all of the earlier sites, the thick section of terrigenous material at Site 35 could be compared with the sediment sections at Sites 32 and 34, south of the Mendocino and Pioneer Fracture Zones.

On the basis of the Site Survey (Appendix III), a tentative site was located in the western part of the Escanaba Trough. Here, at a water depth of just over 3200 meters, the floor of the Trough is about 18 kilometers across between the bordering ridges, which have a relief of 200 to 400 meters above the Trough floor. Seismic reflection profiles taken during the Site Survey revealed a buried ridge running approximately north-south up the center of the Trough with a covering of highly faulted sediments. Somewhat thicker accumulations of less disturbed sediment occur both east and west of the buried ridge. Near-surface sediment cored during the Site Survey is a dark greenish-gray plastic to slightly fissile clay with some sand layers, and it contains Pleistocene coccoliths.

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Site 35 was approached by moving northward to the latitude of the site where a profiling run was made to the west across the Trough. The drilling site was located in deeper sediment to the west of the buried ridge which runs along the axis of the Trough.

The on-station seismic reflection profile (Figure 1) shows the first fairly distinct reflector at a depth of 0.14 second below the sea floor. Subsequent coring revealed that the upper part of the section is composed of numerous sand layers, and this reflector appears to represent a thick sand sequence at about 100 meters (in the interval 79 to 107 meters). A second reflector at 0.28 second is apparently the top of a sequence of alternating sands and clays (194 to 256 meters). The major reflector is at 0.34 second below the sea floor, and it seems to represent the top of a sequence of alternating sands and clays which contains a greater percentage of sands than does the overlying sequence. The deepest reflector at 0.43 second was initially thought to be basement, but instead was the top of a thick sand (373 to 390 meters) which was partially cored but not fully penetrated.

An additional objective at this site was to obtain in-hole measurements of the *in situ* temperature of the sediment which would permit determination of the heat flow in the Escanaba Trough. Consequently, upon completion of coring at Hole 35.0, a northerly course was run for approximately 18 kilometers along the Trough to Hole 35.1 where the buried ridge was located beneath 0.38 second of sediment. The on-station seismic reflection profile (Figure 2) indicates some indistinct reflectors between the sea floor and the top of the buried ridge at 0.38 second.

Location

Hole 35.0 is located at latitude 40° 40.42′N., longitude 127° 28.48′W., and Hole 35.1 is located at latitude 40° 50.35′N., longitude 127° 31.21′W. Both sites are in the Escanaba Trough, the median valley of Gorda Rise.

OPERATIONS

The drilling summary for Hole 35.0 is presented in Table 1. Coring began with a surface core (0 to 9 meters) on 29 April. The first four cores (to a depth of 97 meters) were taken with rapid rates of penetration, on the order of 2 feet per minute. Periodic increase in the

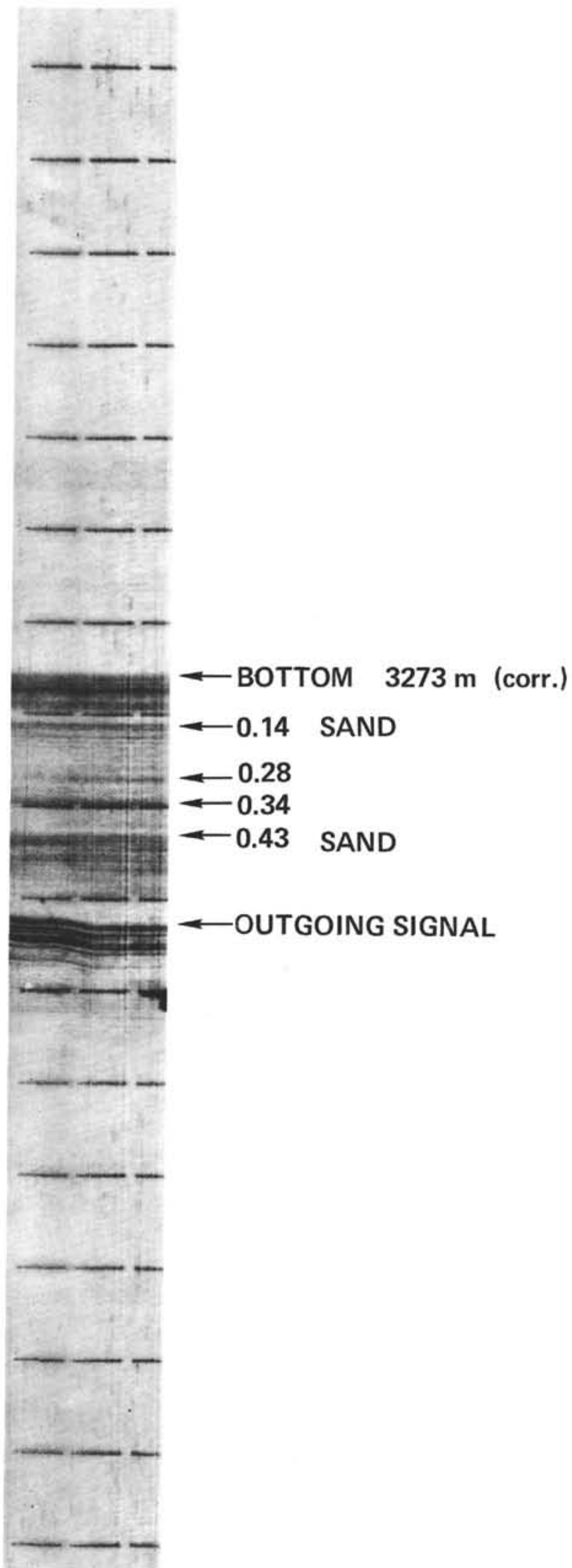

Figure 1. *On-site seismic reflection profile at the site of Hole 35 (40° 40.42'N, 127° 28.48'W; 5 second sweep; 29 April 1969).*

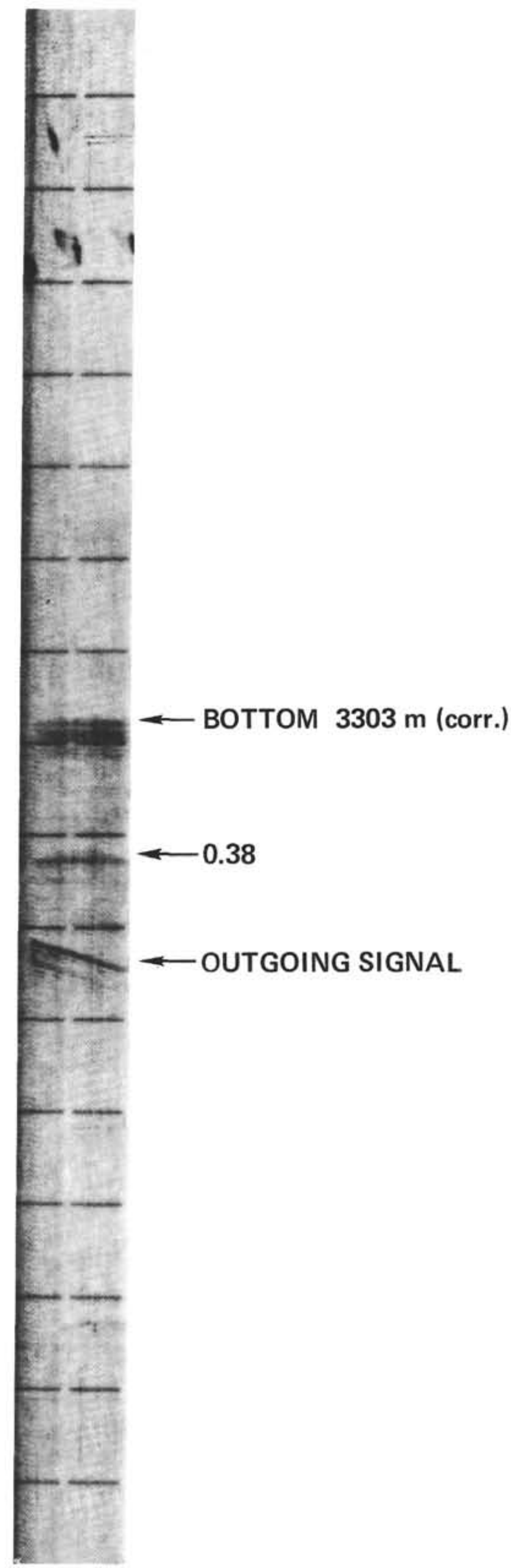

Figure 2. *On-site seismic reflection profile at the site of Hole 35.1 (40° 50.35'N, 127° 31.21'W; 5 second sweep; 3 May 1969).*

TABLE 1
Drilling Summary of Leg 5, Hole 35.0

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
29 April	1	0-9	10,763-10,793	30	9.1	30	9.1	100
	2	39-48	10,892-10,922	30	9.1	30	9.1	100
30 April	3	79-88	11,024-11,054	30	9.1	30	9.1	100
	4	88-97	11,054-11,084	30	9.1	10	3.1	33
	5	97-107	11,084-11,114	30	9.1	22	6.7	73
	6	157-166	11,277-11,307	30	9.1	30	9.1	100
	7	233-237	11,525-11,540	15	4.6	15	4.6	100
	8	256-261	11,603-11,618	15	4.6	4	1.2	27
1 May	9	280-289	11,680-11,710	30	9.1	13	4.0	43
	10	289-298	11,710-11,740	30	9.1	4	1.2	13
	11	298-307	11,740-11,770	30	9.1	27	8.2	90
	12	323-330	11,820-11,846	26	7.9	26	7.9	100
2 May	13	345-353	11,896-11,920	24	7.3	24	7.3	100
	14	354-362	11,926-11,951	25	7.6	15	4.6	60
	15	362-371	11,951-11,981	30	9.1	21	6.4	70
	16	372-382	11,986-12,016	30	9.1	10	3.1	33
	17	382-390	12,016-12,041	25	7.6	2	0.6	8
			Totals	460	139.7	313	95.3	68

Sonic water depth (corrected): 3273 m; 10,735 ft.; 1789 fathoms.
Driller's depth: 10,763 ft.

circulation during the taking of Core 4 (88 to 97 meters) may have resulted in the relatively low recovery percentage for the core. The continuous coring represented by Cores 3, 4 and 5 (79 to 107 meters) was done in an attempt to identify the 0.14 second reflector in the seismic reflection profile. The sand sequence in Core 5 (97 to 107 meters) apparently is the source of the reflector, and caused a reduction of about one-half in the rate of penetration as compared to the two other cores in this group. Most of the rest of the hole was cored by spot coring. In the lower part of Core 7 (233 to 237 meters), the coring rate dropped sharply as firm, stiff, fissile clay was encountered. Below this horizon the drilling and coring rate generally decreased, although circulation and weight increased. Continuous coring was resumed as the deepest reflector (0.43 second) was approached. Cores 11 (298 to 307 meters) and 12 (323 to 330 meters) exuded a vapor when extruded. The vapor had a sulfur smell and was sampled for analysis.

No cores were taken at Hole 35.1. On May 4, down-hole geothermal measurements were begun. After these measurements were completed, the intention was to core the basal sediments and the basement rock. Rough seas on the morning of 5 May, however, forced the abandonment of the hole even before the geothermal measurements had been completed.

Down-Hole Logging

Four down-hole logs were run at Hole 35.0: an acoustic log, a caliper log, a gamma-ray log, and an electric (spontaneous potential and resistivity) log. The acoustic and caliper logs were run concurrently from a depth of 120 meters below the sea floor to the bottom of the hole (Figure 3). The gamma-ray and electric logs were also run concurrently (Figure 3); gamma-ray measurements began at a depth of 93 meters below the sea floor, and electric log measurements started at 101.5 meters below the sea floor.

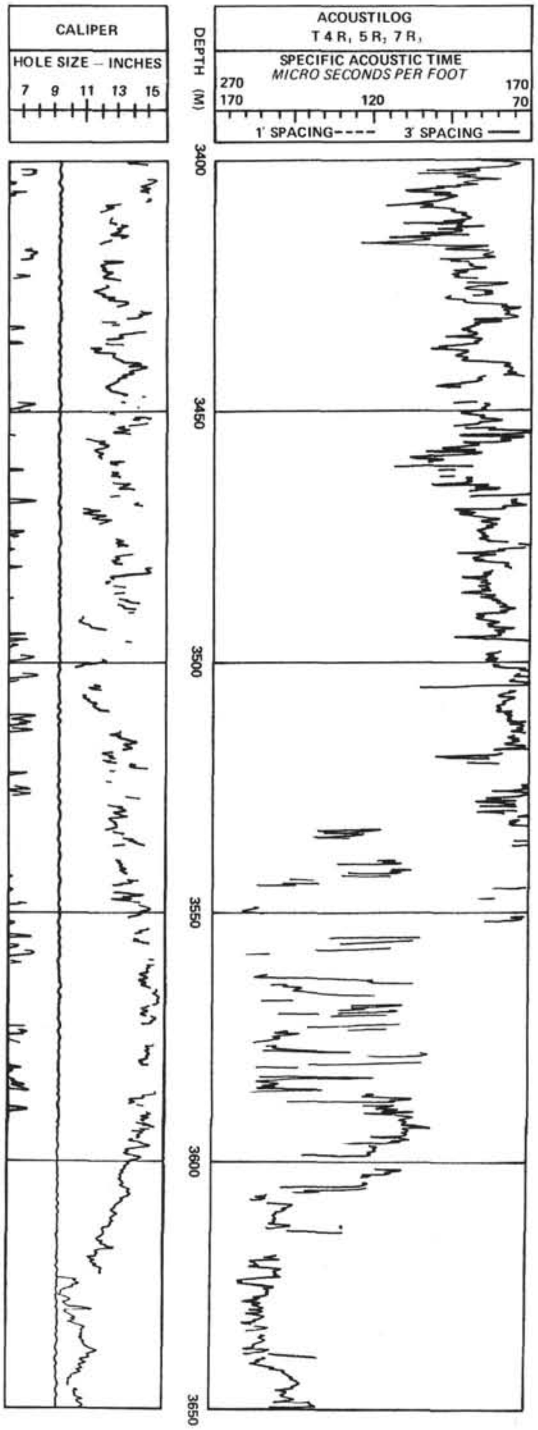

Figure 3. *Well logs from Hole 35.0.*

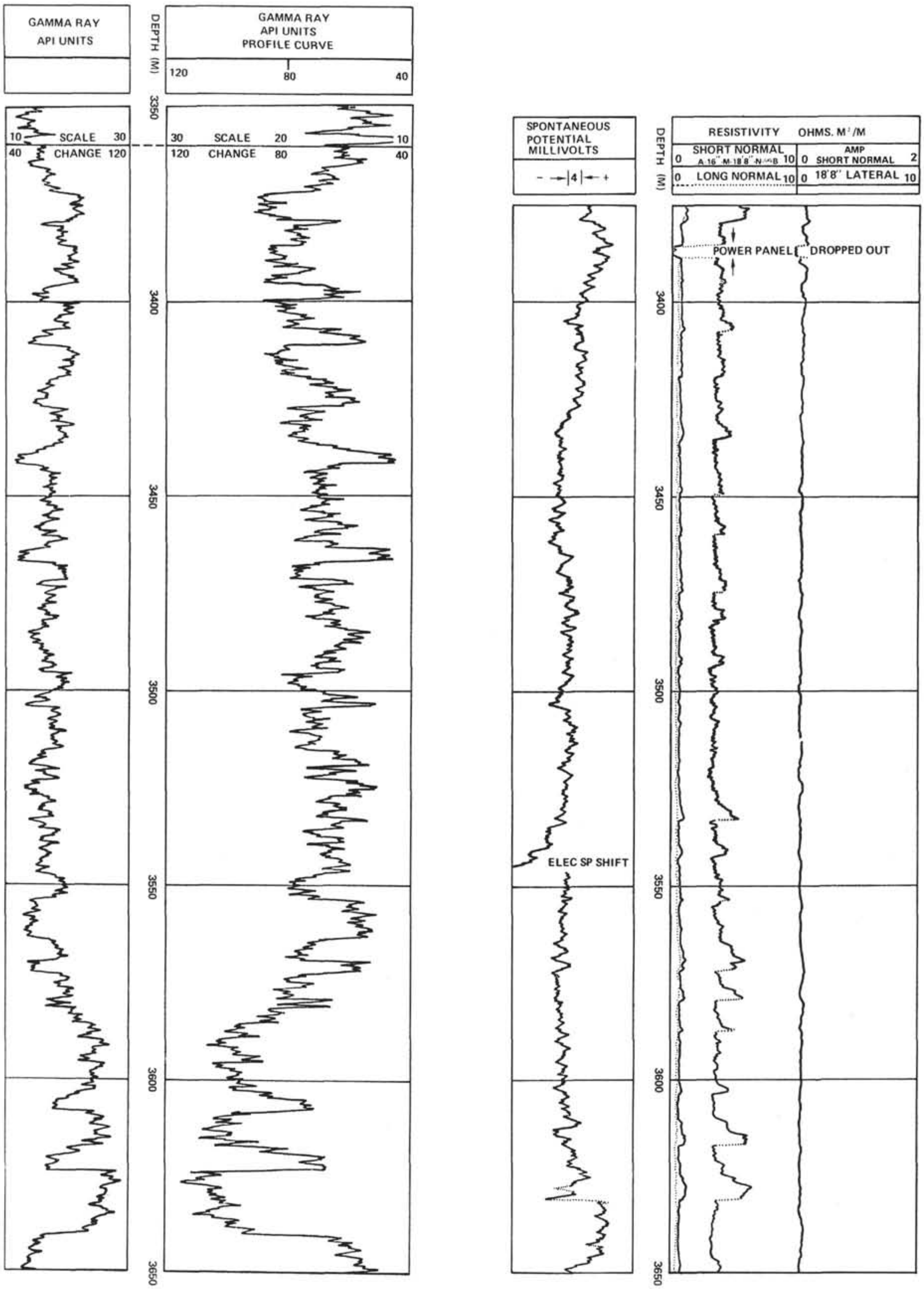

Figure 4. *Well logs from Hole 35?*

Shipboard studies of these logs are only preliminary. However, each log contributes significantly to a greater understanding of the lithologic relationships.

The caliper log indicates that a large diameter hole developed between depths of 120 and 359 meters. From 359 meters to the bottom of the hole, the diameter was smaller. The acoustic log was strongly affected by the hole size and probably represents true sonic velocities only below 359 meters. The electric log was affected by the hole size to a lesser degree; it is difficult to interpret the SP log above 359 meters. The resistivity log was apparently unaffected by the hole size. It has four scales: a short normal (16-inch scale), an amplified short normal, a long normal (64-inch scale), and a lateral (18-foot, 8-inch scale). The amplified short normal scale gives the best indication of lithologic change. The gamma-ray log readings also reflect the hole size. However, relative sizes of peaks probably can be used with some degree of confidence to interpret the gamma-ray emission from the sediments.

The resistivity and gamma-ray logs were most useful for lithologic interpretations. In most comparisons of depth intervals between these logs, high resistivities corresponded to low gamma-ray counts, and low resistivities corresponded to high gamma-ray counts. Interpretation of the logs was aided by shipboard laboratory measurements. Laboratory measurements of gamma-ray emissions from the cores were related to lithologic core descriptions. It was observed that zeolitic clayey muds generally had high gamma readings, and sand and silt of the turbidite sequences had relatively lower gamma-ray readings. The lithologies and gamma-ray counts of the cores were then compared with the gamma-ray counts of the down-hole log.

In summary, the logging runs at Hole 35.0 were successful and informative. Results from the caliper log show that drilling operations affect the size of the hole in soft deep-sea sediments which, in turn, affects log interpretations. When compared to known gamma-ray emissions and to lithologies, gamma-ray and resistivity logs showed striking relationships which made it possible to interpret the lithologies of intervals that were not cored.

LITHOLOGY

At Site 35, seventeen cores were taken from the interval between the sea floor and the bottom of the hole at 390 meters. Recovery was irregular after the first two cores and many cores were partly void or contained large quantities of fluid. Only 28 of 64 sections were cut and described. Sixty-six smear slides were examined.

Terrigenous sediments comprise the entire sedimentary column. Two major alternating units could be distinguished: sands, silts, and silty muds of turbidite origin; plus, muds and laminated muds of probable turbidite origin.

Typical fine-grained muds and laminated muds were recovered in Cores 6, 8 and 12 through 15 (157 to 166, 256 to 261, and 323 to 371 meters, respectively). Colors range from dark greenish-gray to medium gray. Major components are clays, characterized by negative relief and low birefringence and small plates or patches of carbonate. In Core 6 (beginning at 159 meters) and again in Core 9 (280 to 289 meters), the muds are laminated (rhythmically banded). This banding may be caused by injection of material during coring, or the banding is primary. Thin 1 to 5-millimeter dark gray beds are interlayered with thicker (2 to 10-centimeter) medium gray beds. No differences in either mineralogy or texture could be ascertained from shipboard smear slide studies.

The sand, silt and silty mud sequences of turbidite origin were observed in Cores 2 through 5, 7, 11, 16 and 17 (39 to 107, 233 to 237, 298 to 307, and 372 to 390 meters). Unfortunately, most bedding relationships and other sedimentary structures were destroyed during coring operations. In Section 2 of Core 6 (158 meters), the contact between a sandy silt and underlying mud is sharp. This may be a critical section for later studies of grading and investigations of bedding planes.

The sands are fine to medium-grained, display poor to moderate sorting, and are mineralogically immature. Preliminary studies indicate a significant amount of heavy minerals which suggest source rocks in the Cascades and possible transport from the Columbia River.

Surprisingly, no ash beds were noted in the cores. Trace amounts of glass shards do occur in a few smear slides. Age determinations are hindered by a sparsity of fossils and a lack of basement recovery.

PALEONTOLOGY

Nannoplankton

In Hole 35.0, calcareous and siliceous nannofossils occur sparingly and scattered through Cores 1 to 6, and a few rare calcareous nannoplankton are found in Core 12. The other parts of this hole lacked observable nannofossils. Where they are found, the nannofossils characterize the *Coccolithus carteri* Zone of the Pleistocene.

The upper part of this hole (down through Core 2) contains sporadic occurrences of small diatoms, including, *Coscinodiscus curvatulus* Grunow, *Thalassiosira decipiens* (Grunow) Jørgensen, *Melosira sulcata* (Ehrenberg) Kützing and *Denticula seminae* Simonsen and

Kanaya. Of interest is the occurrence of the diatom *Melosira granulata* (Ehrenberg) Ralfs in Core 2 and the calcareous platelets and pentaliths of *Braarudosphaera bigelowi* (Gran and Braarud) in Cores 2 and 3. *B. bigelowi* is generally considered a neritic marine species and is not commonly found in deep-sea sediments. *Melosira granulata* has been found in deep sediments but is thought to be indicative of a fresh water habitat (Lohmann, 1941; Kolbe, 1956). The occurrence of these inshore forms indicates that at least part of the thick section of sediments from this site was derived from a near-shore area, probably associated with river outflow material.

The aspect of the assemblage of the siliceous nannofossils in the top part of this site is quite similar to those observed in Core 1 of Hole 32 and part of Section 1, Core 1, Hole 34. In addition, these assemblages contain a fairly high content of derived forms from a littoral marine to fresh water environment.

Foraminifera

Foraminifera are absent in the majority of samples examined from this site. Where present, they occur very rarely.

Core 2, Core catcher sample:
Globigerina bulloides d'Orbigny, *Globigerina pachyderma* (Ehrenberg), *Globigerina quinqueloba* Natland, *Globigerina rubescens* Hofker, *Globigerinita glutinata* (Egger), *Globigerinita uvula* (Ehrenberg).

Core 3, Core catcher sample:
Globigerina bulloides, Globigerina pachyderma.

Core 6, Section 2, 14-16 cm:
Globigerina bulloides, Globigerina pachyderma.

Core 6, Section 4, 15-17 cm:
Globigerina bulloides.

Core 6, Section 5, 19-21 cm:
Globigerina bulloides, Globigerina pachyderma.

Core 6, Section 6, 17-19 cm:
Same as above.

Radiolaria

Radiolaria were not found in any of the cores from this hole.

SUMMARY

The sediment sequence at Hole 35.0 consists basically of alternating deposits of fine to coarse-grained turbidites throughout most of the section. Six stratigraphic units are recognized on the basis of the core descriptions and the down-hole logs (Table 2). As basement was not reached, nor even identified on the seismic reflection profile, the portion of the complete sediment section represented by these units is unknown. However, as the site lies in the medial valley of the Gorda Ridge, an age deduction from the magnetic anomaly suggests that the entire section is Pleistocene and less than 700,000 years old. Most of unit 4 and much of units 5 and 6 were nonfossiliferous, so that an age is unverified for the lower part of the sequence.

The lowest unit, unit 6 (Cores 16 and 17, 371 to 390 meters) contains silty mud and silty sand in which coring terminated. Greenish-gray silty sand in the lower part apparently grades upward into a greenish-gray silty mud which has carbonate concretions 1-centimeter in diameter. This unit appears to represent a time of pronounced turbidity current deposition in the Escanaba Trough.

Unit 5 (Cores 8 through 15, 256 to 371 meters) is composed of very firm to hard mud with some interbedded silty mud. The 0.34 second reflector on the seismic reflection profile appears to correlate with the top of the unit. The down-hole logs suggest that sand beds may also form a significant part of the unit. The mud is medium gray in the lower part and olive gray in the upper part where Core 9 (280 to 289 meters) contains rhythmic laminations of olive gray and olive black muds. The darker laminae are 1 to 5 millimeters thick and the lighter ones are 2 to 10 centimeters thick. Although the laminations are assumed to be primary, the possibility cannot be discounted of their having been formed during the coring operations. The calcareous component of the mud, the significance of which is as yet unknown, is present in the form of small patches and plates of carbonate. The gas that was sampled in Cores 11 and 12 (323 to 330 meters and 298 to 307 meters) has not yet been analyzed.

Unit 4 (Cores 6 and 7, 233 to 237 meters and 157 to 166 meters) extends from 128 to 256 meters as determined from the down-hole logs, and consists of alternating silty sands, silty muds, and muds. The muds contain particles of carbonate and, at least in Core 6 (157 to 166 meters), are rhythmically laminated. Above Core 7 (233 to 237 meters), the sediments are much softer. Where the contact between the mud and the overlying silty sand is observed, it is sharp. This unit apparently represents a period of relatively frequent, though intermittent, turbidity current deposition.

Unit 3, from 107 to 128 meters, is based entirely on the down-hole logs and is interpreted as a sequence of silty muds with perhaps fewer turbidite sands than in unit 4.

In unit 2 (Cores 3, 4 and 5, 79 to 107 meters) a dark greenish-gray to greenish-black, medium-grained sand

TABLE 2
Stratigraphic Units at Site 35

Unit	Depth (m)	Cores	Age	Description
1	0-48	1-2	Pleistocene	Interbedded silty muds and muds.
2	79-107	3-5	Pleistocene	Thick-bedded fine sand and silty mud.
3	107-128		Pleistocene	Silty mud.
4	128-256	6-7	Pleistocene	Interbedded silty sand, silty mud, and mud.
5	256-371	8-15	Pleistocene ?	Mud with some silty mud interbeds.
6	371-390	16-17	Pleistocene ?	Silty mud and silty sand.

at the base is overlain by silty sand and sandy silty mud containing Pleistocene fossils. Not only do the detrital mineral grains suggest a size grading, but fossils in the muds of Core 3 (79 to 88 meters) include some displaced neritic and fresh-water forms. These are hydrodynamically equivalent to the finer terrigenous detritus with which they are associated. This unit is correlated with the 0.14 second reflector on the seismic reflection profile and apparently marks a major event of turbidite deposition in the Escanaba Trough.

Unit 1 (Cores 1 and 2, 39 to 48 and 0 to 9 meters) consists of alternating silty muds and muds. The same displaced neritic and fresh-water floras found in Core 3 are present in this unit.

The section at Site 35 appears to be a Pleistocene terrigenous sequence of alternating fine and mineralogically immature coarser detritus. Without time correlations, the succession of coarser turbidites (units 1 and 2) and the fine detritus in the other units cannot be equated with events outside the Trough. The only paleoclimatological evidence is the presence of cold-water foraminiferal faunas.

Considerable post-depositional alteration may be recorded in the fine material, as suggested by the gas content, high bulk density, attenuation of acoustic energy in the laboratory analyses, and the apparent absence of all types of fossils in the lower part of the section. The significance of carbonate particles which were observed in the mud is uncertain. Other distinctive aspects of the material, such as, high gamma-ray emission and rhythmic laminations, may be of primary origin.

The sedimentation rate has been very high. Because basement was not encountered at the bottom of the hole, the estimate of sedimentation rate must be regarded as a minimal figure. If the 700,000 year age of the Bruhnes normal is accepted for the axial anomaly of the Gorda Ridge, the rate would be 560 m/m.y. Sedimentation at present, however, is not sufficiently rapid to bury the low fault scarps on the sea floor. The sequence in the Trough is block faulted with the blocks away from the Trough axis being the upthrown.

REFERENCES

Kolbe, R. N., 1956. Diatoms from Equitorial Atlantic cores. *Swed. Deep-Sea Exped. Rept.* **7** (3), 151.

Lohman, K. E., 1941. Diatomaceae, Part 3. In Bradley *et al.*, Geology and biology of North Atlantic deep-sea between Newfoundland and Ireland. *U. S. Geol. Surv. Profess. Paper 196-B.*

THE CORES RECOVERED FROM SITE 35

The following pages present a graphic summary of the results of drilling and coring at Site 35. Fig. 5, a summary of Site 35 is at the back of the book. Figures 6 to 22 are summaries of the individual cores recovered. A key to the lithologic symbols is given in the Introduction (Chapter 1).

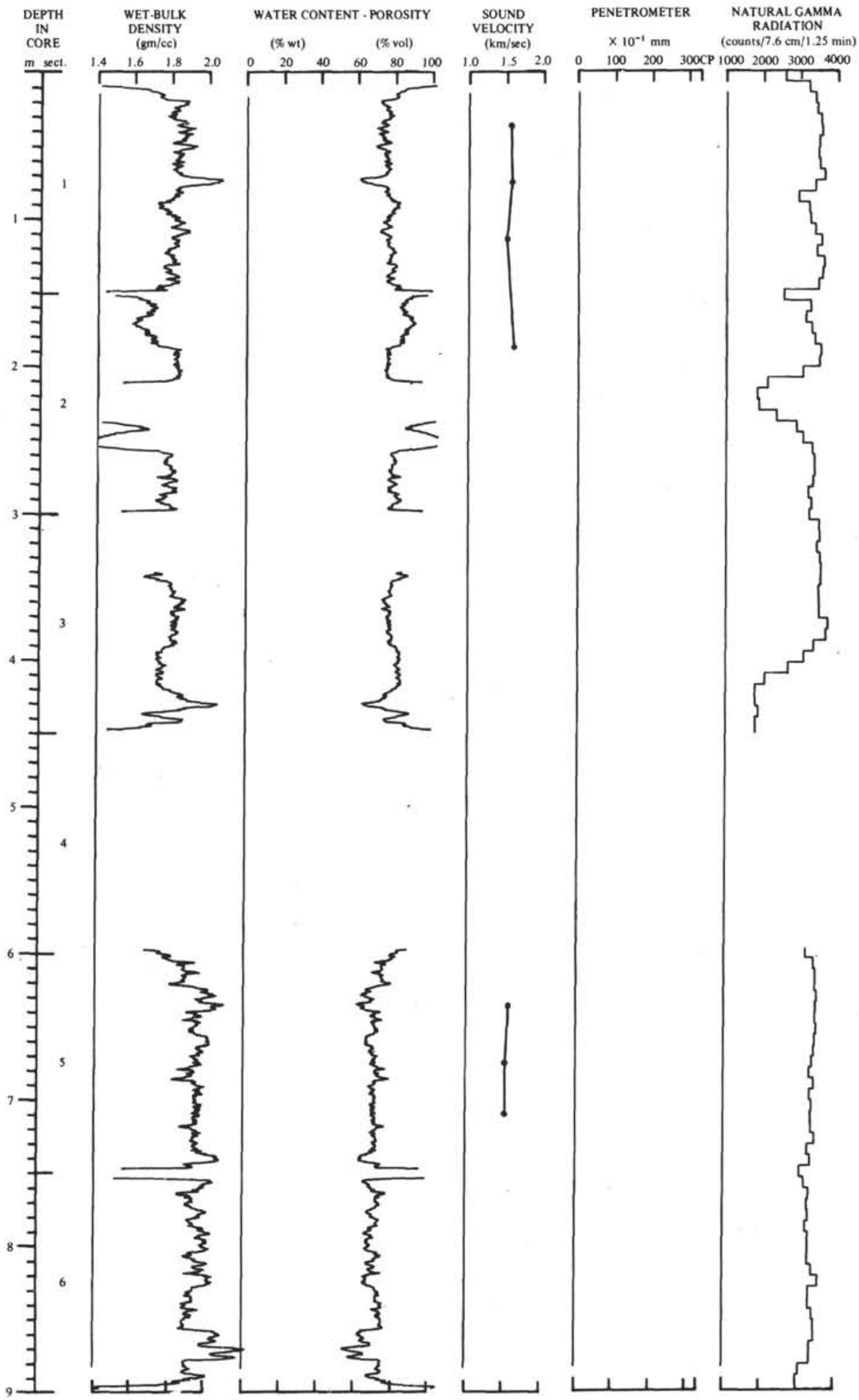

Figure 6A. *Physical Properties of Core 1, Hole 35.*

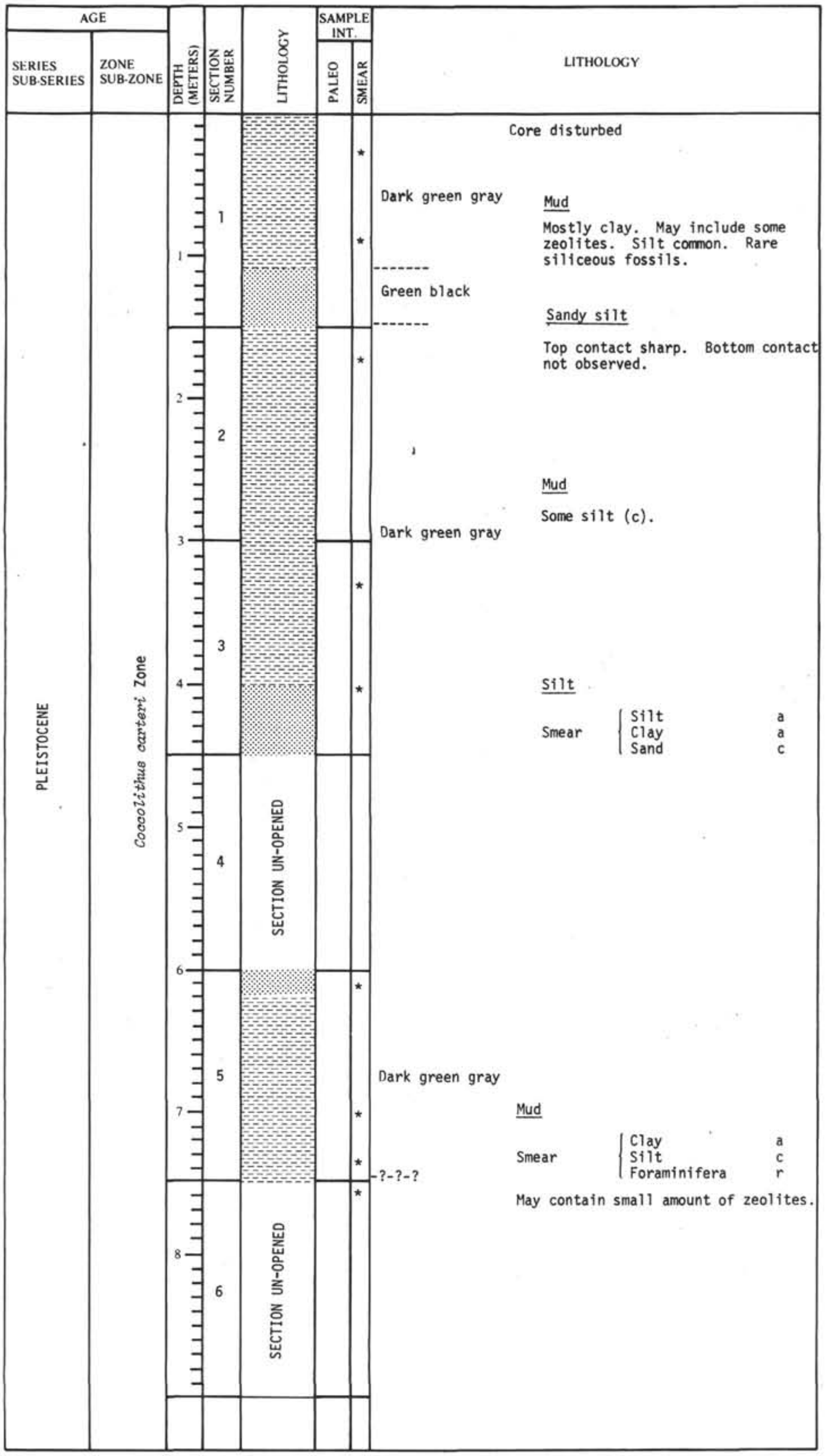

Figure 6B. *Core 1, Hole 35 (0-9 m Below Seabed).*

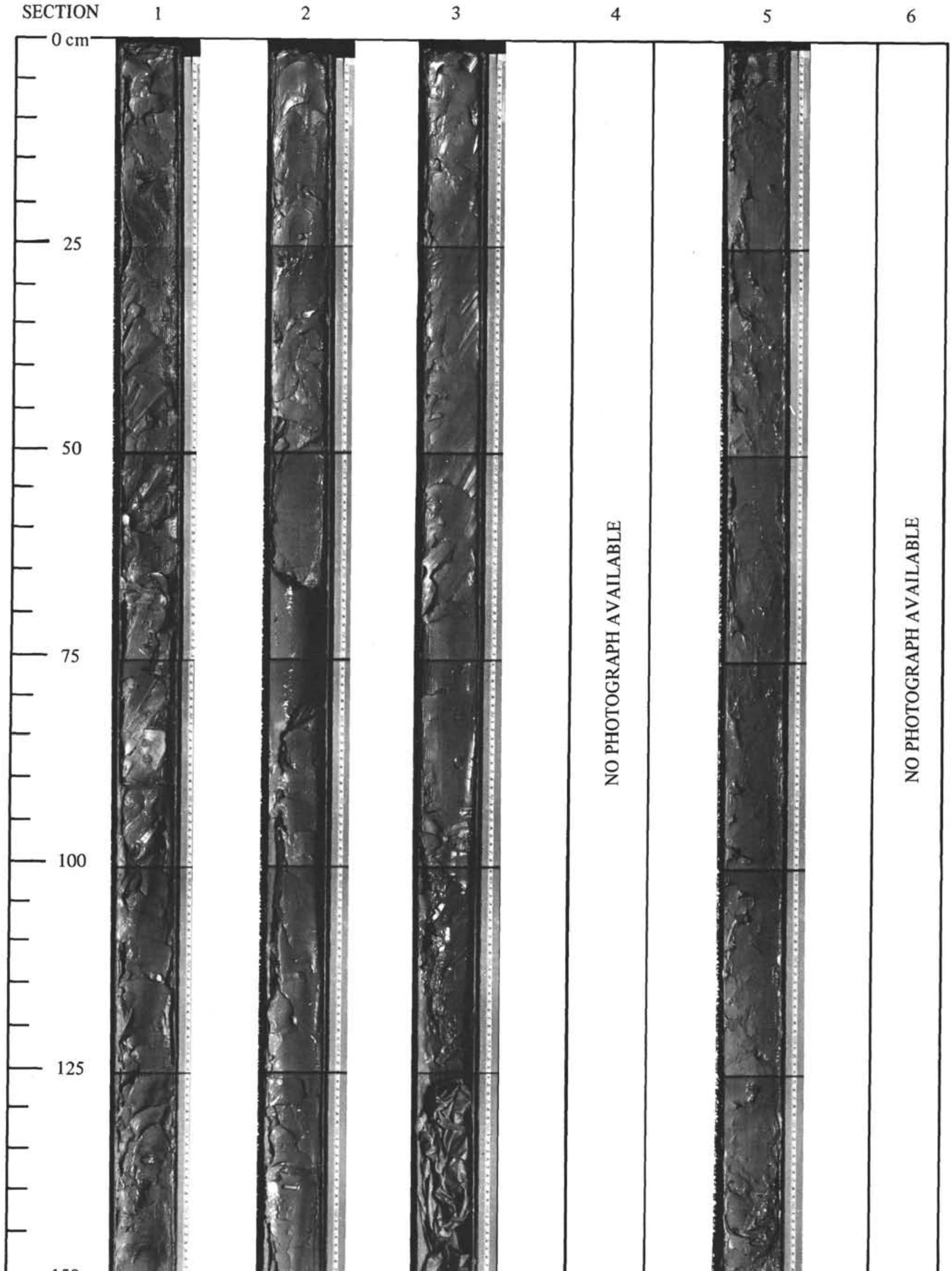

Plate 1. *Core 1, Hole 35.*

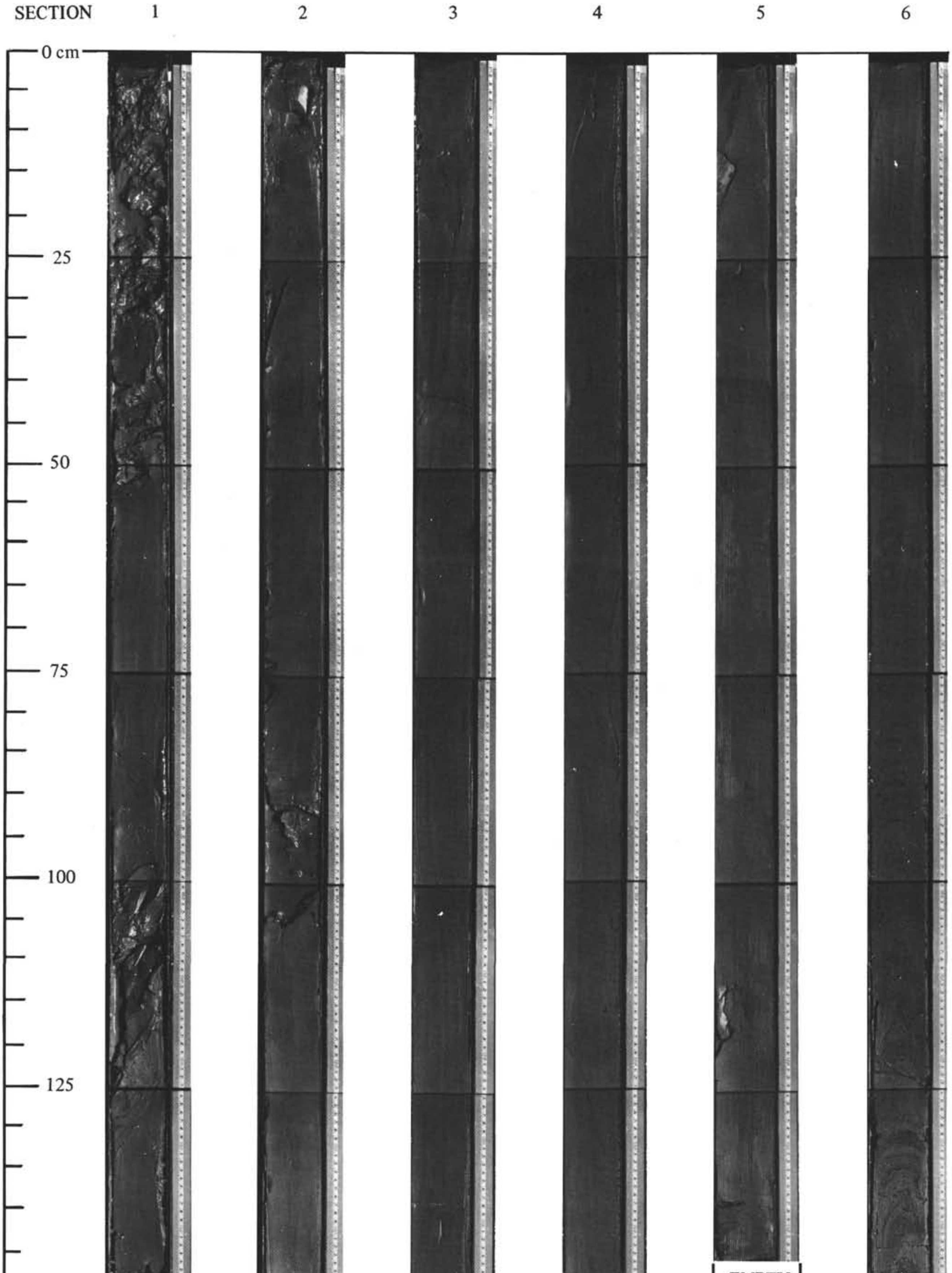

Plate 2. *Core 2, Hole 35.*

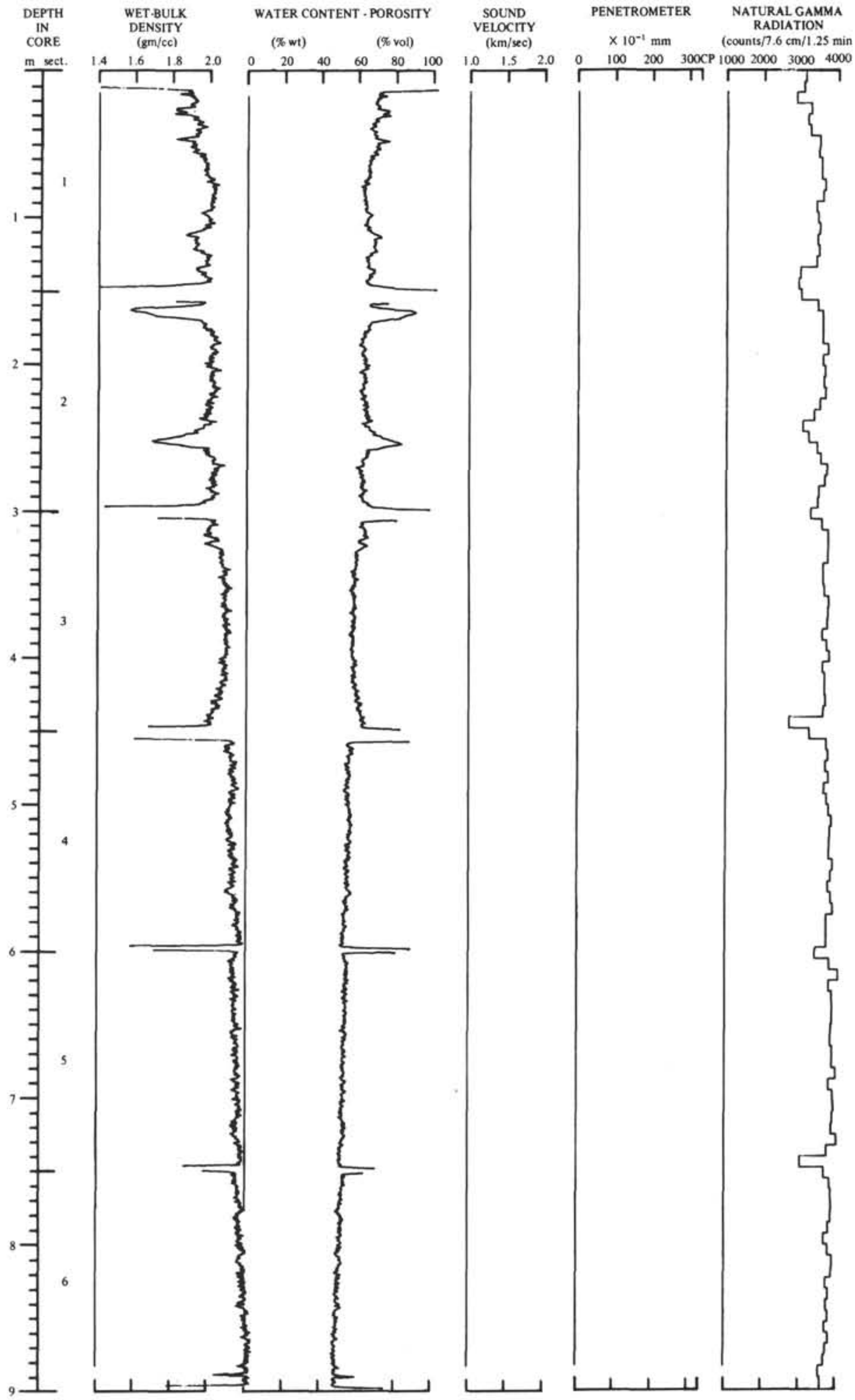

Figure 7A. *Physical Properties of Core 2, Hole 35.*

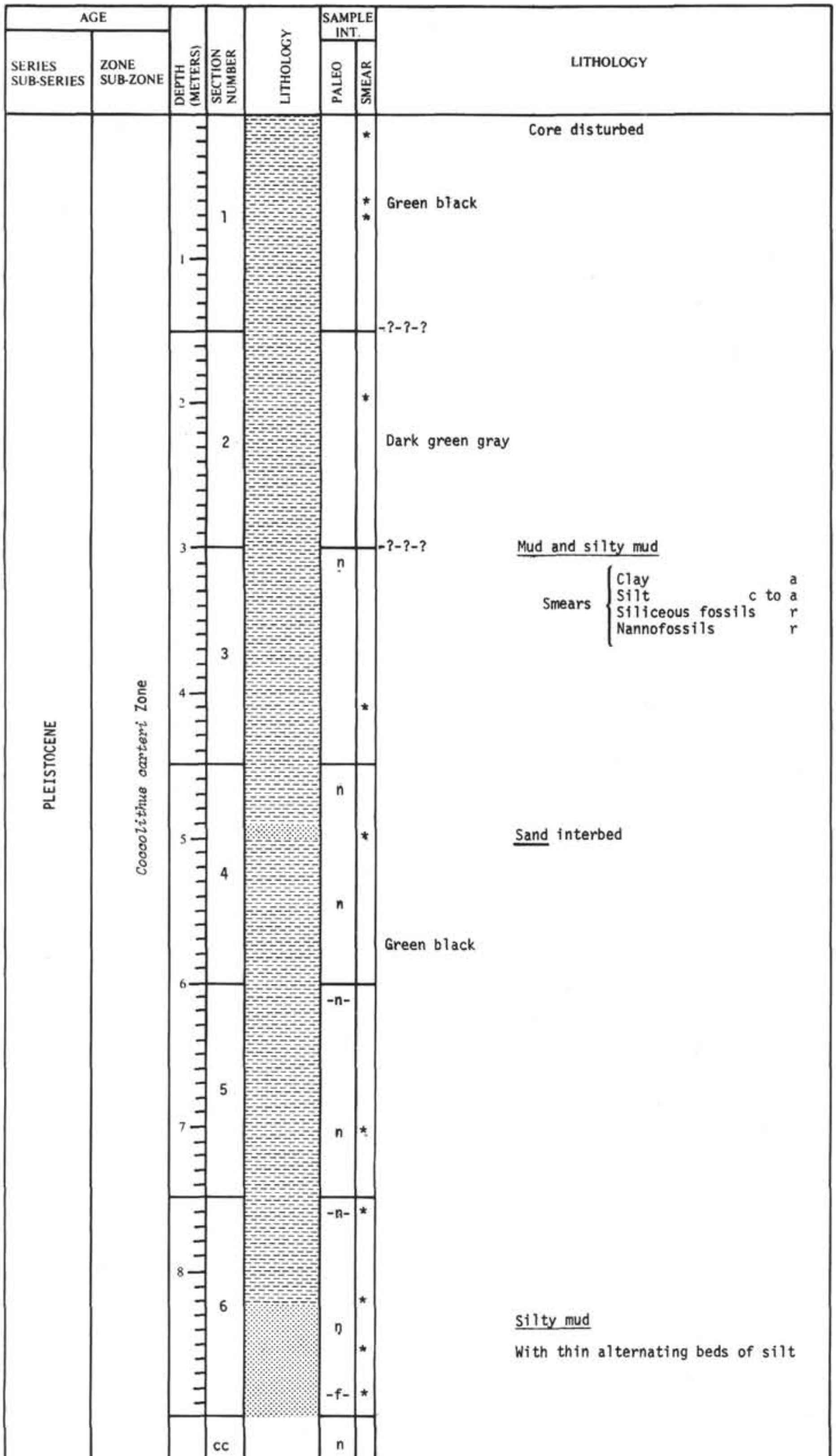

Figure 7B. *Core 2, Hole 35 (39-48 m Below Seabed).*

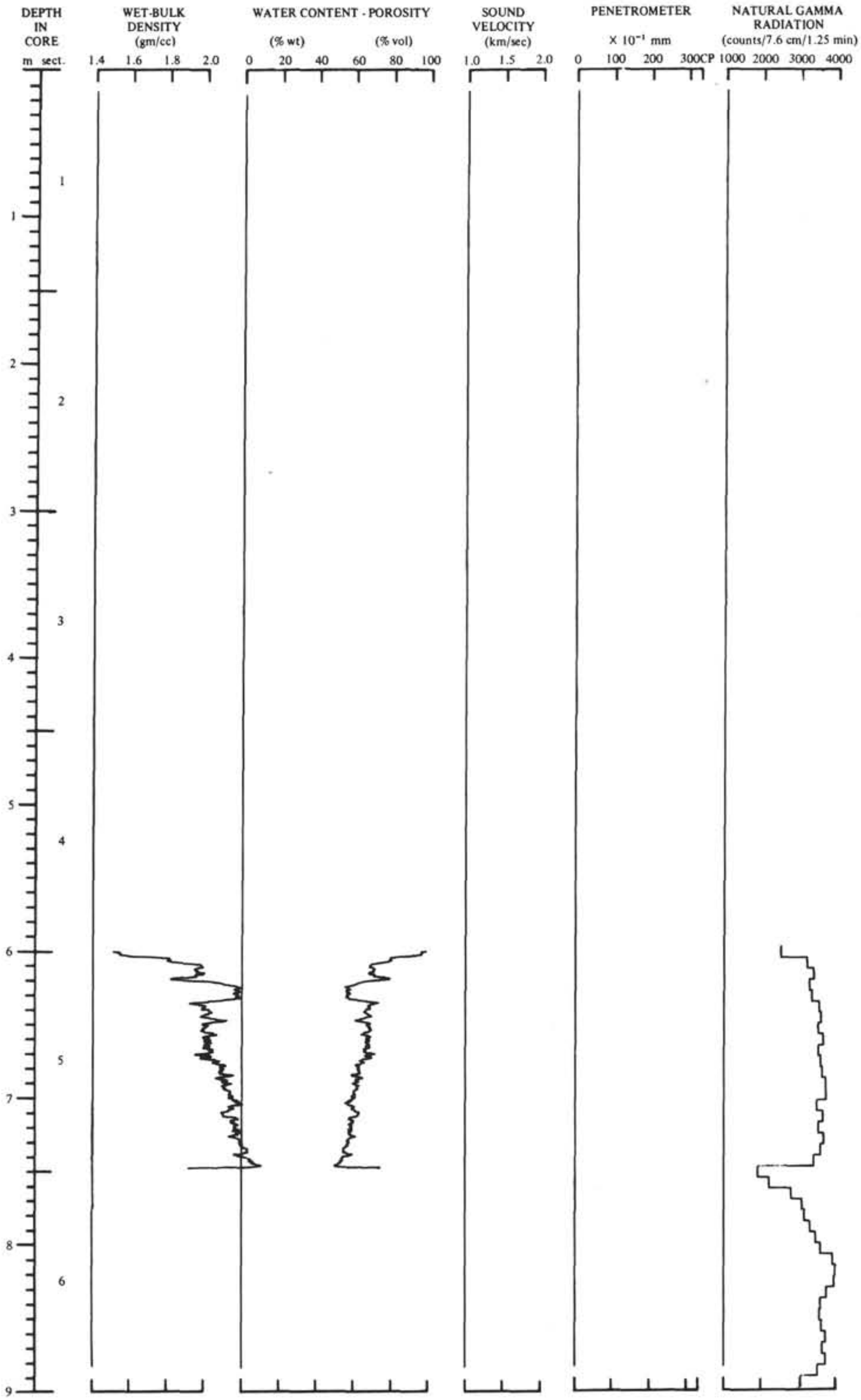

Figure 8A. *Physical Properties of Core 3, Hole 35.*

AGE: SERIES SUB-SERIES	AGE: ZONE SUB-ZONE	DEPTH (METERS)	SECTION NUMBER	LITHOLOGY	SAMPLE INT.: PALEO	SAMPLE INT.: SMEAR	LITHOLOGY
PLEISTOCENE	*Coccolithus carteri* Zone	0–1.5	1	SECTION UN-OPENED			Core is greatly disturbed and watery. No bedding remains
		1.5–3	2				
		3–4.5	3				Observations through the core liner indicate that dominant lithologies are <u>silty sands</u> and <u>sandy silty muds</u>.
		4.5–6	4				Green black
		6–7.5	5				
		7.5–9	6		n		
			cc		n		

Figure 8B. *Core 3, Hole 35 (79-88 m Below Seabed).*

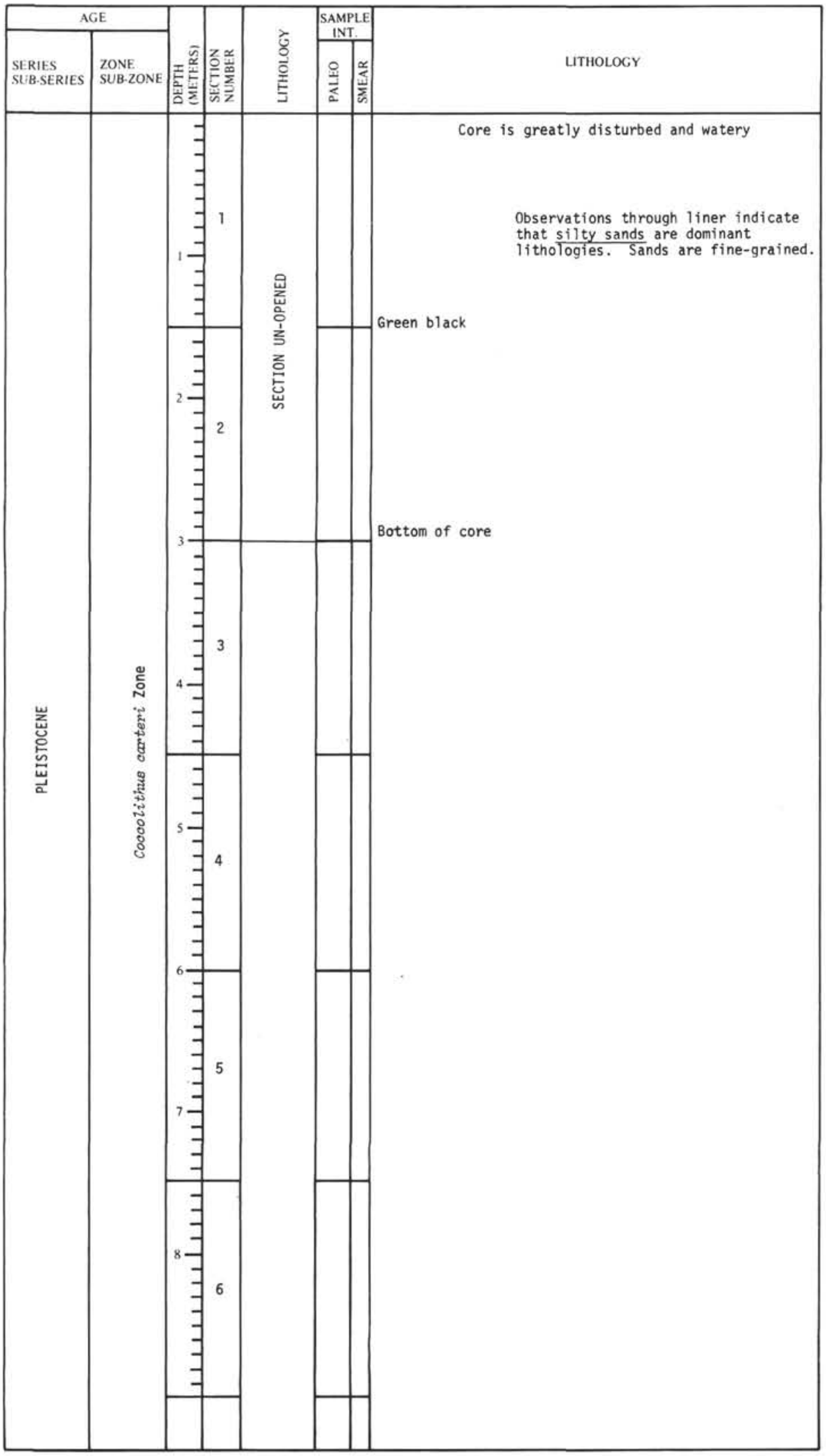

Figure 9. *Core 4, Hole 35 (88-97 m Below Seabed).*

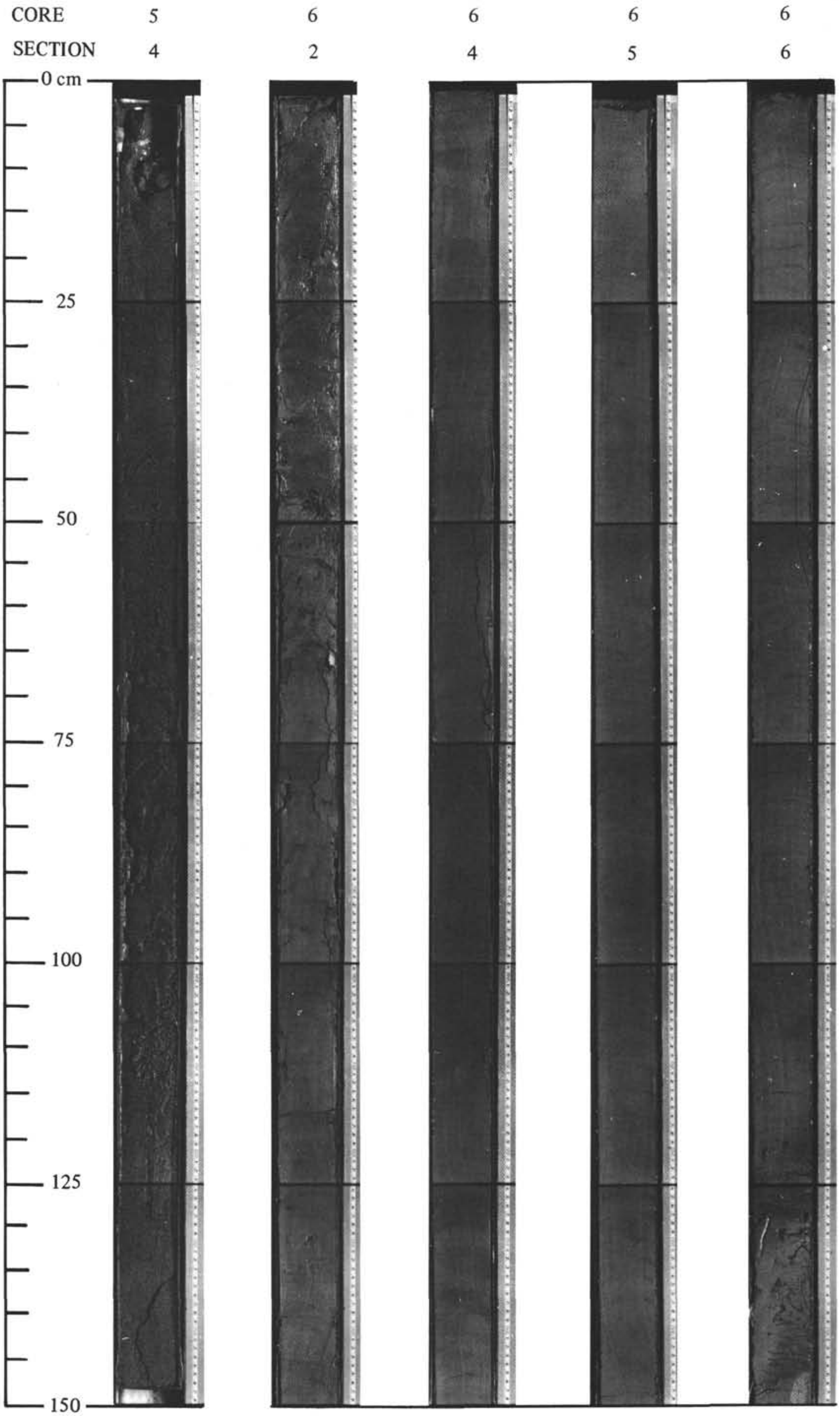

Plate 3. *Cores 5 and 6, Hole 35.*

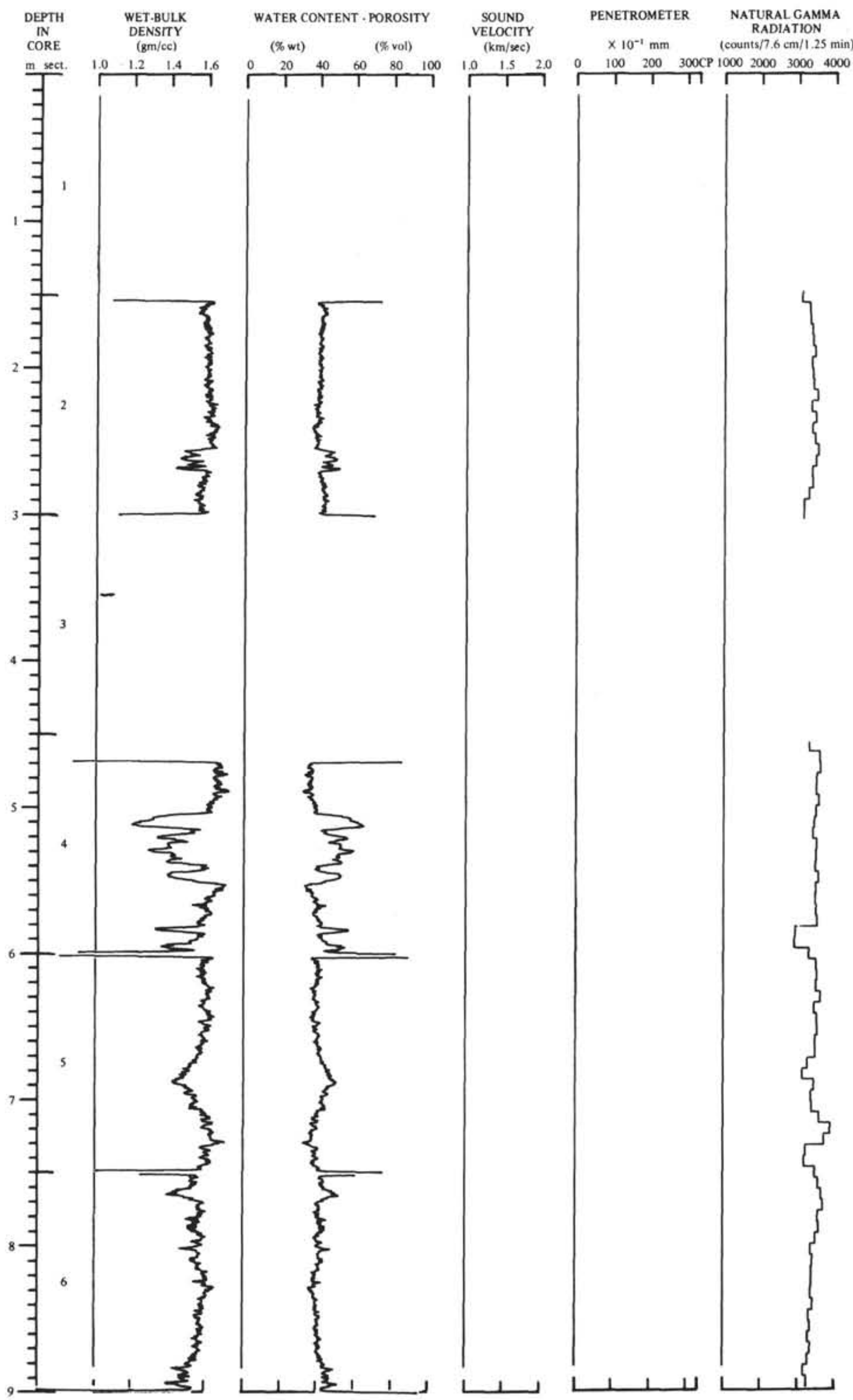

Figure 10A. *Physical Properties of Core 5, Hole 35.*

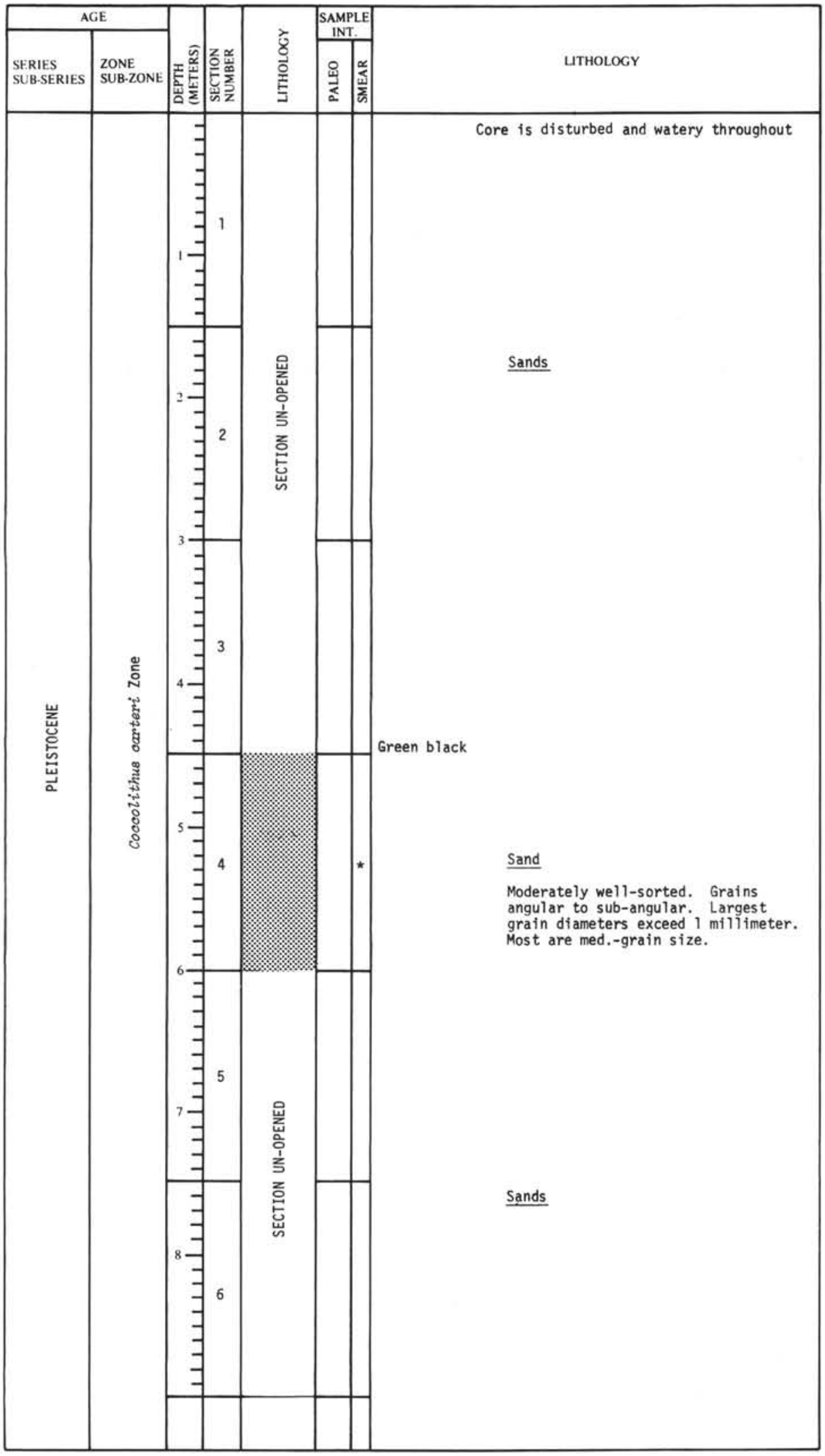

Figure 10B. *Core 5, Hole 35 (97-107 m Below Seabed).*

Figure 11A. *Physical Properties of Core 6, Hole 35.*

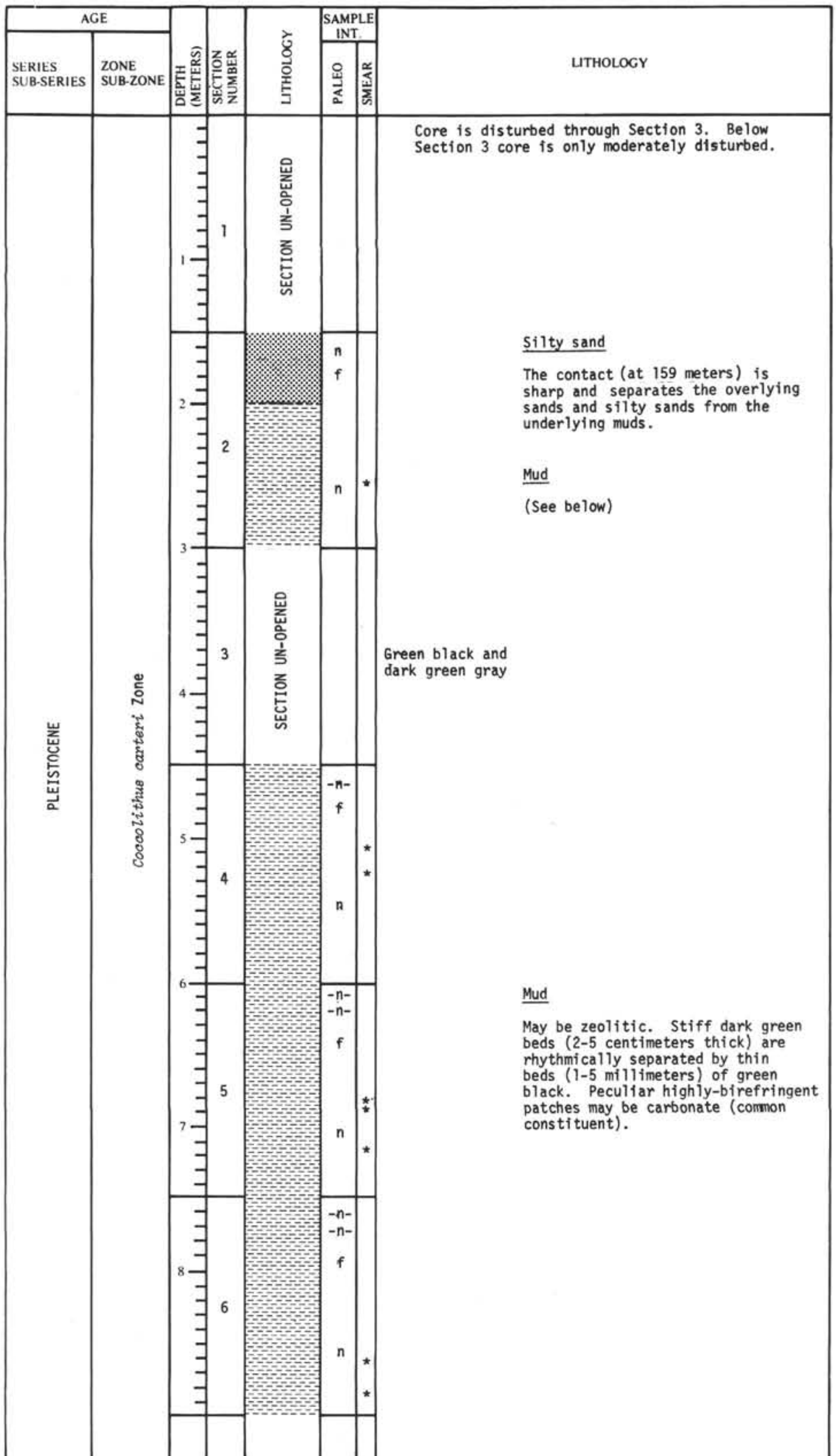

Figure 11B. *Core 6, Hole 35 (157-166 m Below Seabed).*

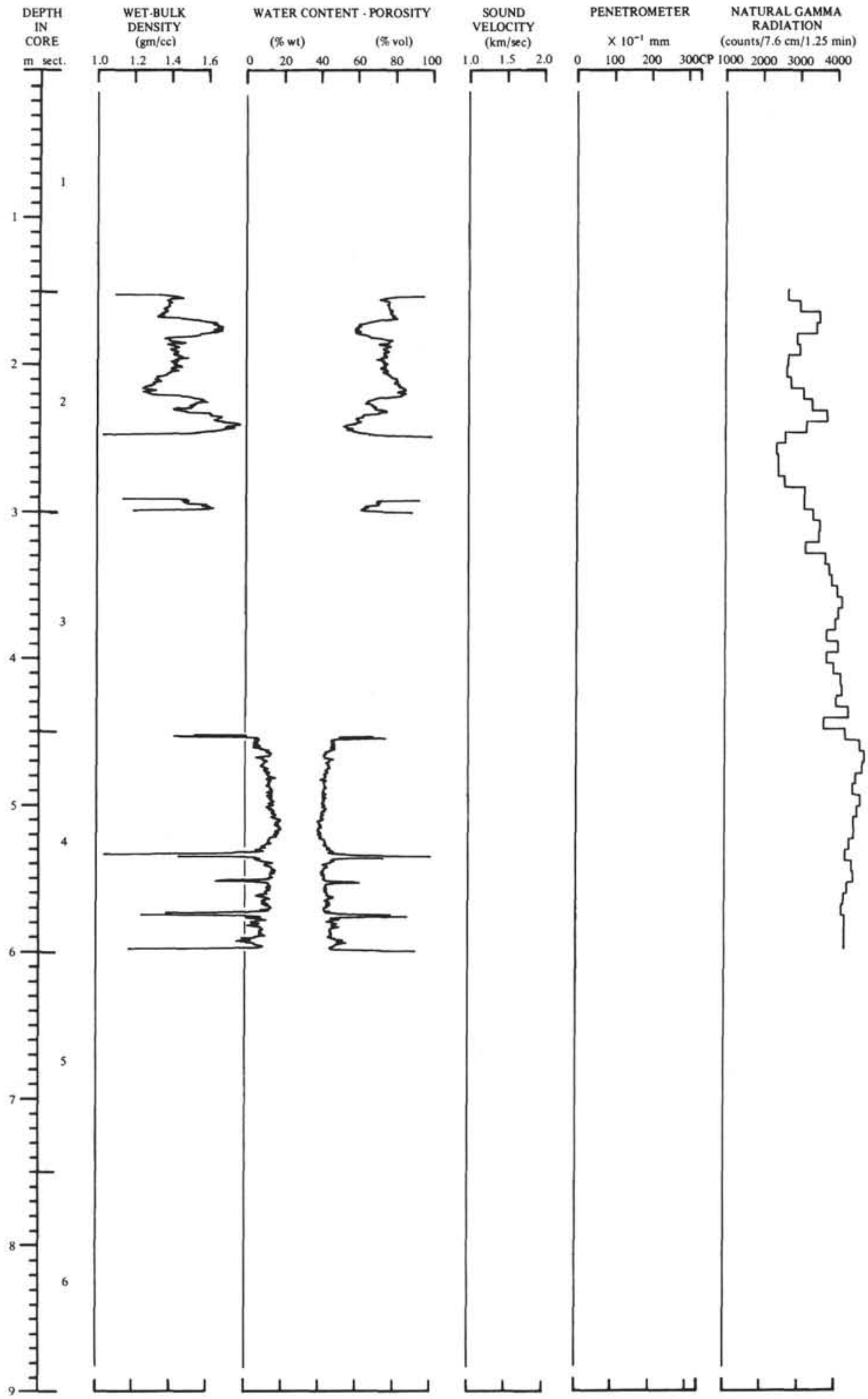

Figure 12A. *Physical Properties of Core 7, Hole 35.*

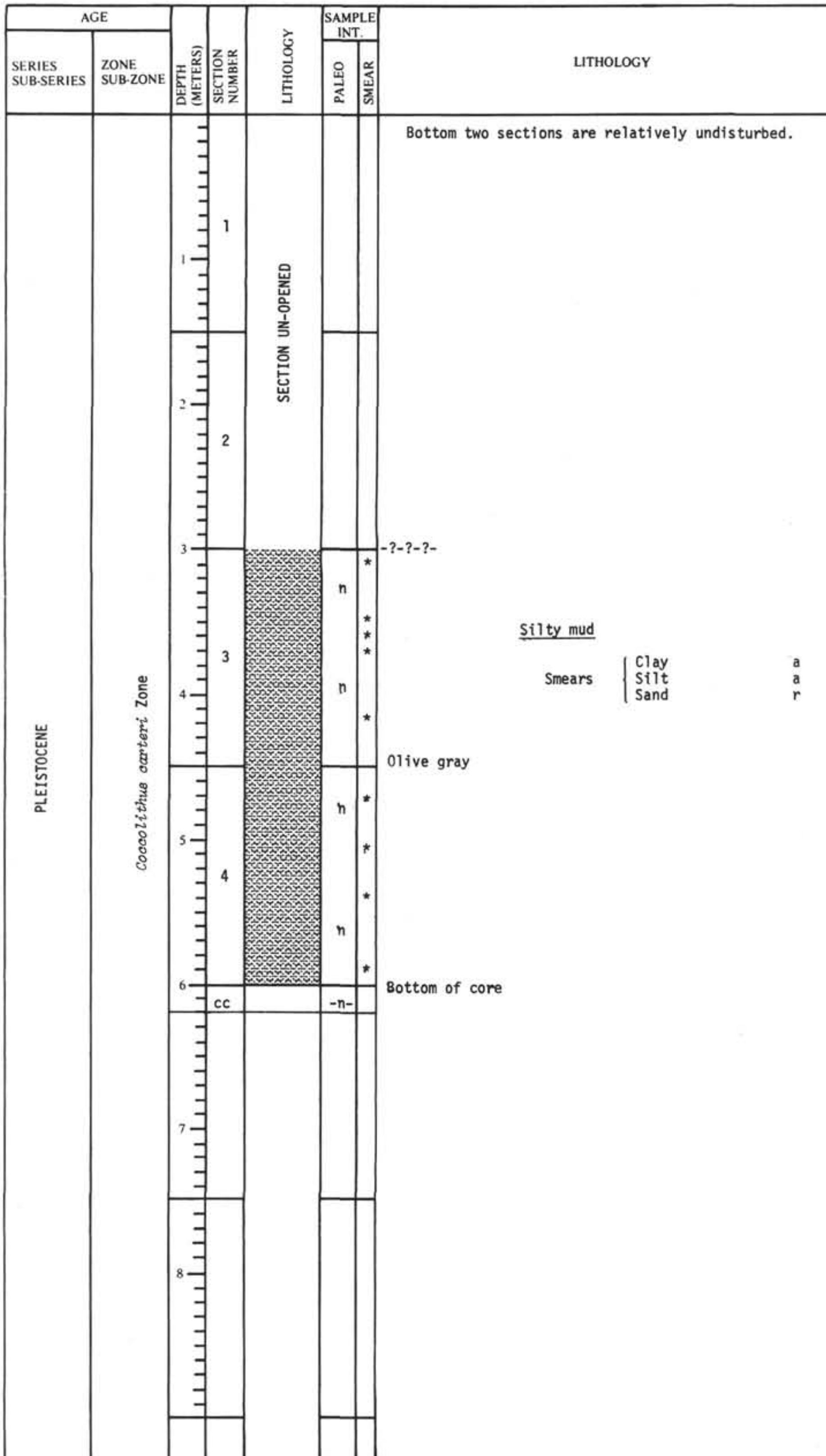

Figure 12B. *Core 7, Hole 35 (233-237 m Below Seabed).*

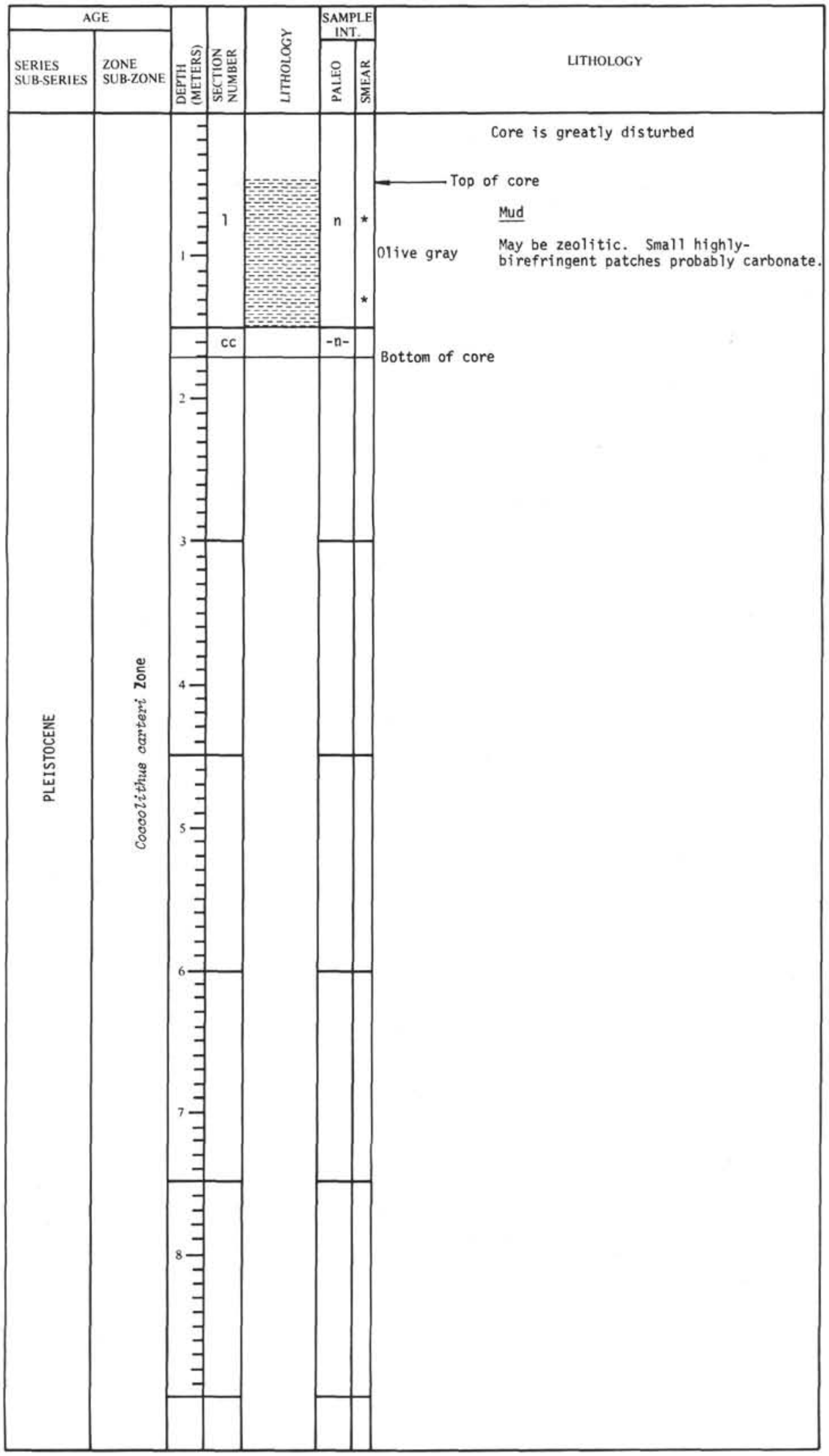

Figure 13. *Core 8, Hole 35 (256-261 m Below Seabed).*

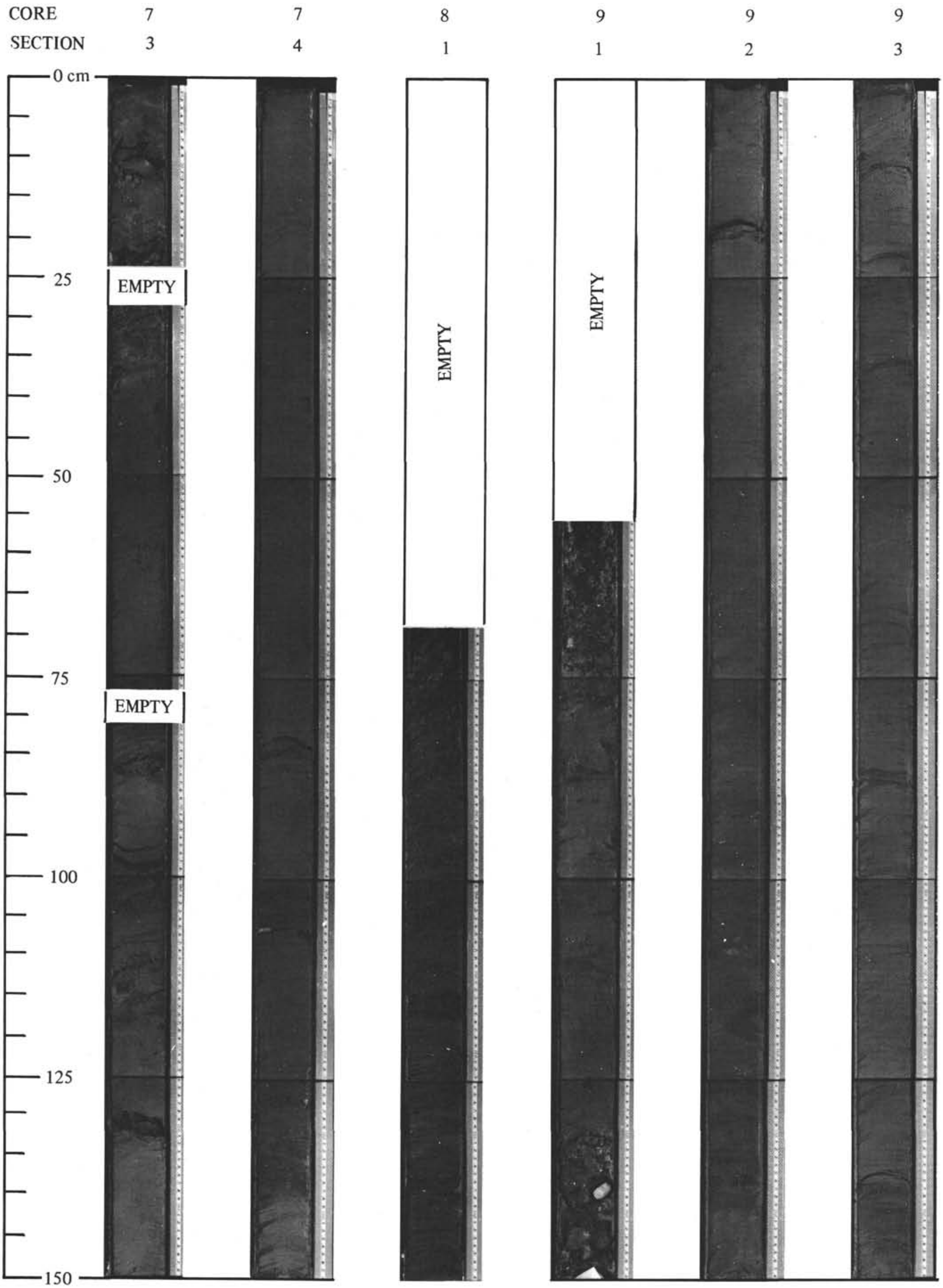

Plate 4. *Sections of Cores 7, 8 and 9, Hole 35.*

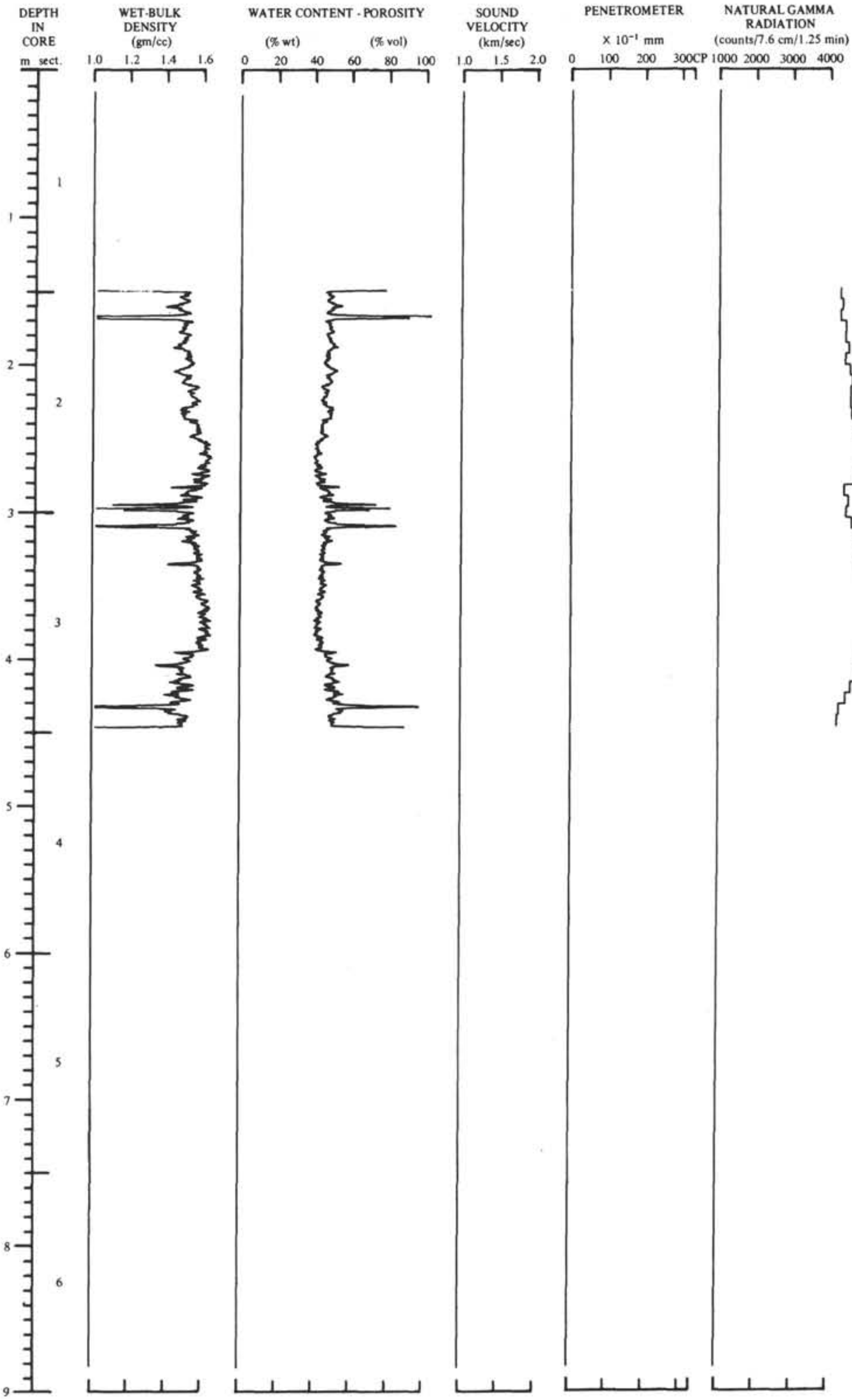

Figure 14A. *Physical Properties of Core 9, Hole 35.*

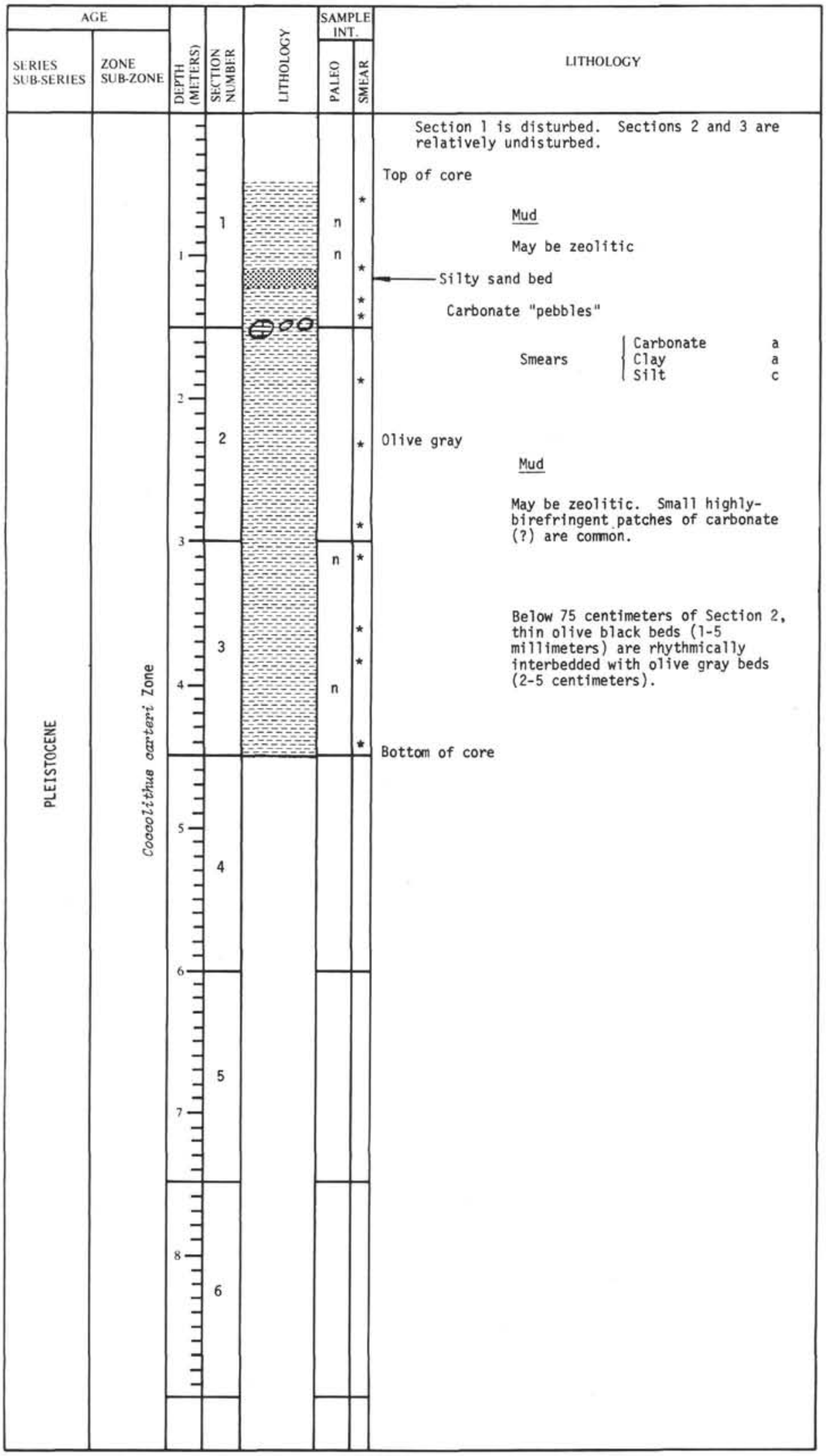

Figure 14B. *Core 9, Hole 35 (280-289 m Below Seabed).*

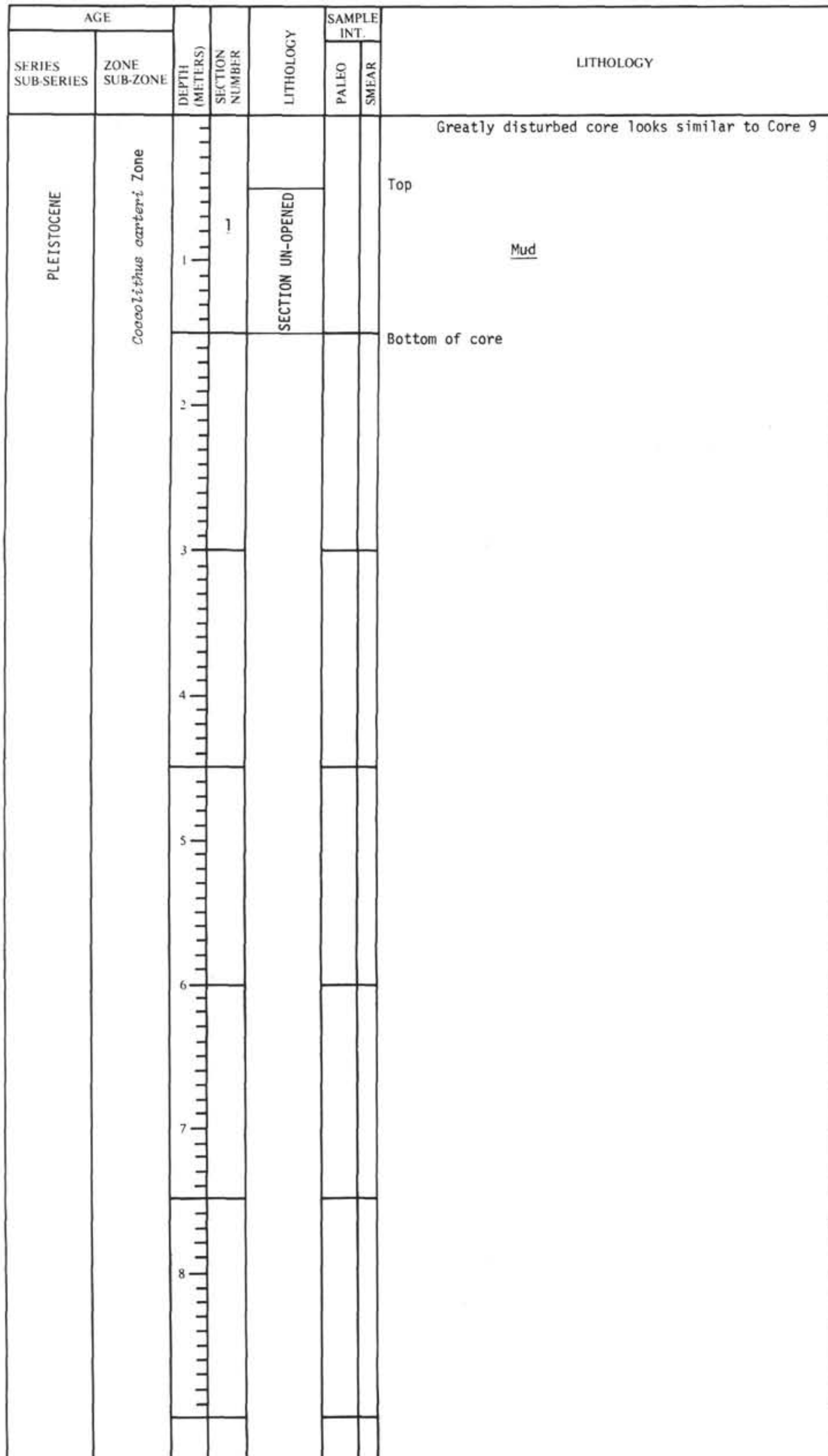

Figure 15. *Core 10, Hole 35 (289-298 m Below Seabed).*

AGE: SERIES SUB-SERIES	AGE: ZONE SUB-ZONE	DEPTH (METERS)	SECTION NUMBER	LITHOLOGY	SAMPLE INT.: PALEO	SAMPLE INT.: SMEAR	LITHOLOGY
PLEISTOCENE	*Coccolithus carteri* Zone	0–1	1	VOID; SECTION UN-OPENED			Core contains many voids. Section 6 is only moderately disturbed.
		2	2	SECTION UN-OPENED			
		3–4	3	SECTION UN-OPENED			
		5	4	SECTION UN-OPENED			
		6–7	5	SECTION UN-OPENED			
		8	6				Olive gray Silty mud May be zeolitic. Beds are banded similar to Core 9, except an increase in silt content is noticeable **Unopened** sections appear similar to Section 6. Carbonate patches are common.

Figure 16. *Core 11, Hole 35 (298-307 m Below Seabed).*

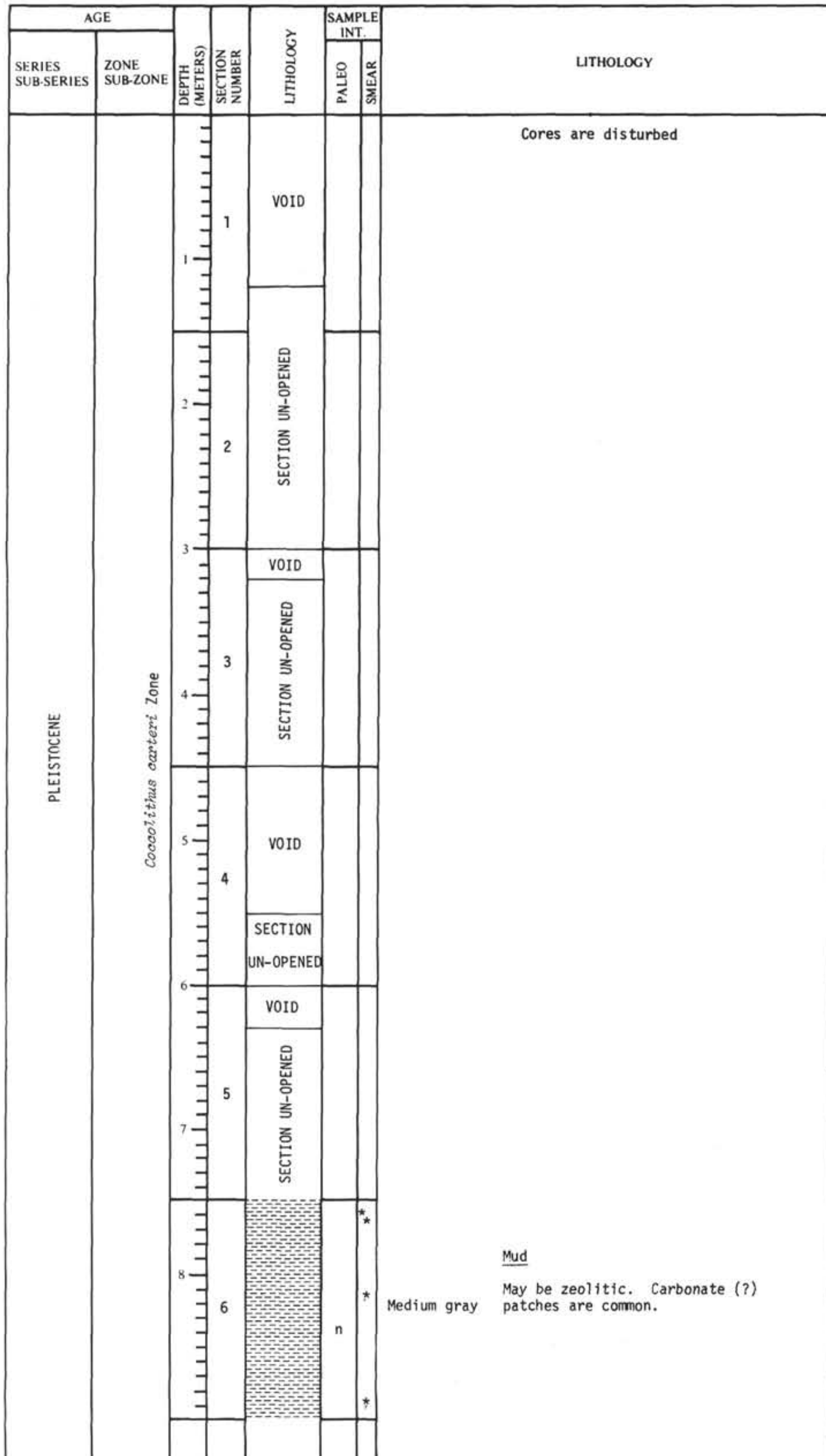

Figure 17. *Core 12, Hole 35 (323-330 m Below Seabed).*

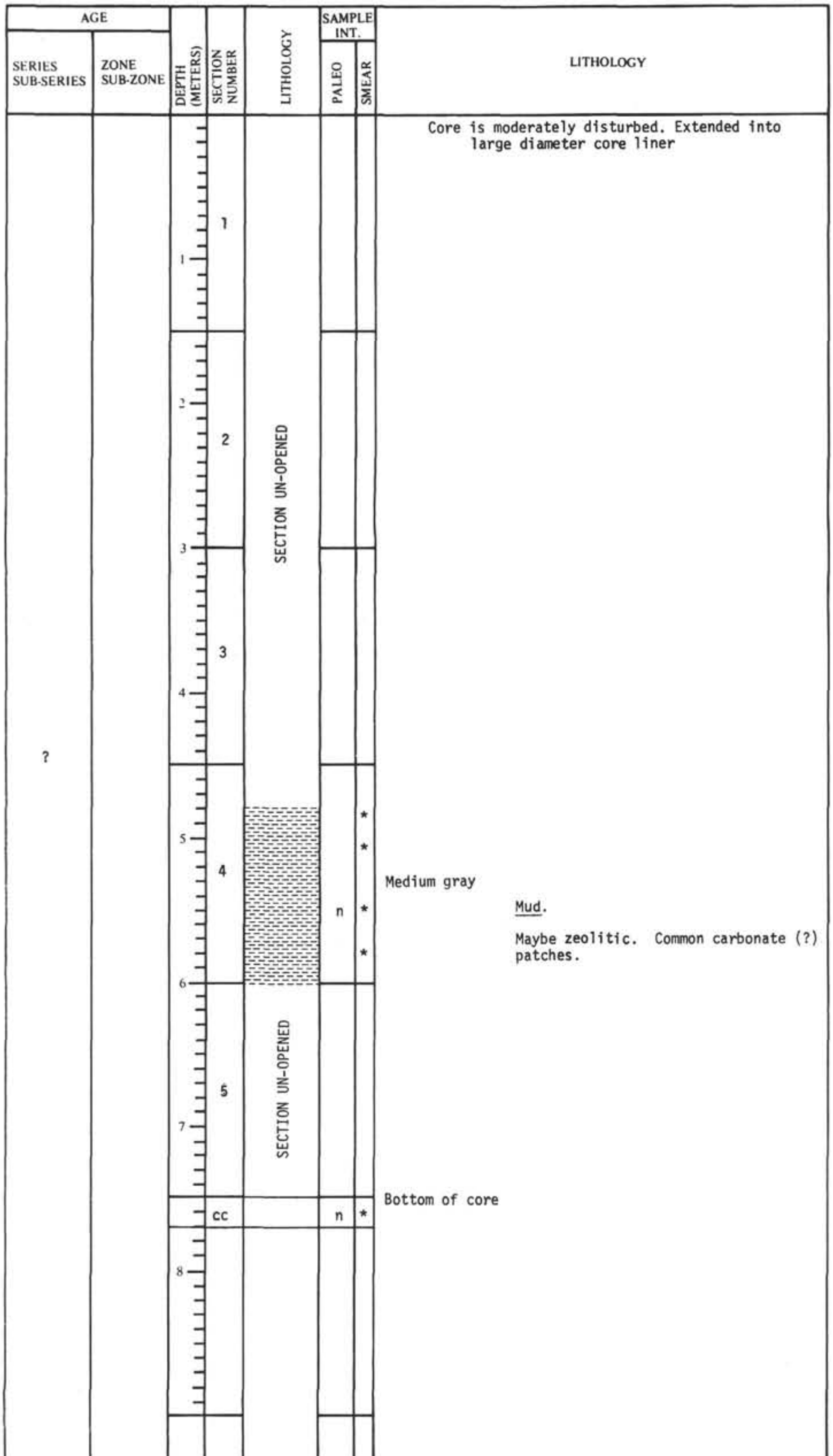

Figure 18. *Core 13, Hole 35 (345-354 m Below Seabed).*

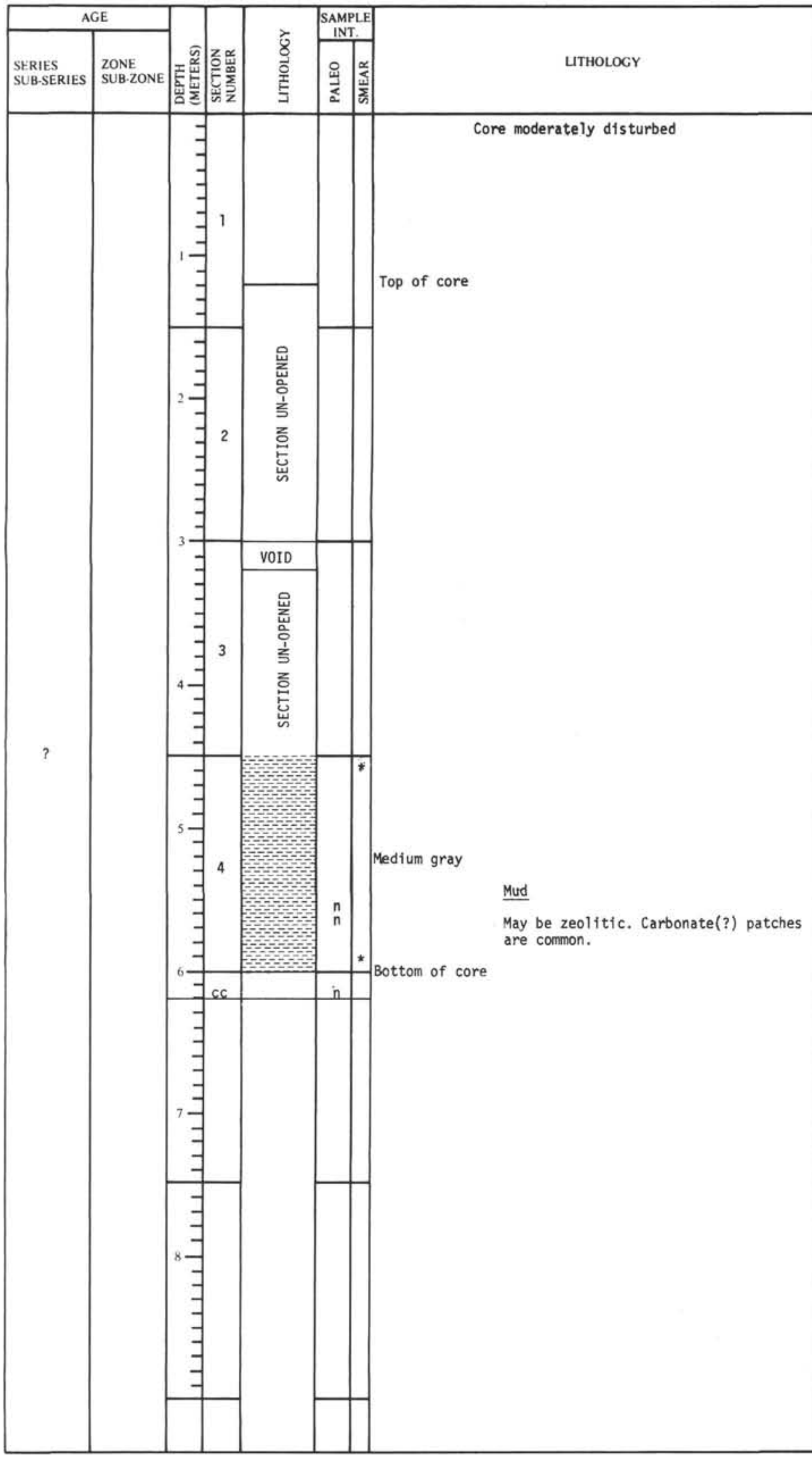

Figure 19. *Core 14, Hole 35 (354-362 m Below Seabed).*

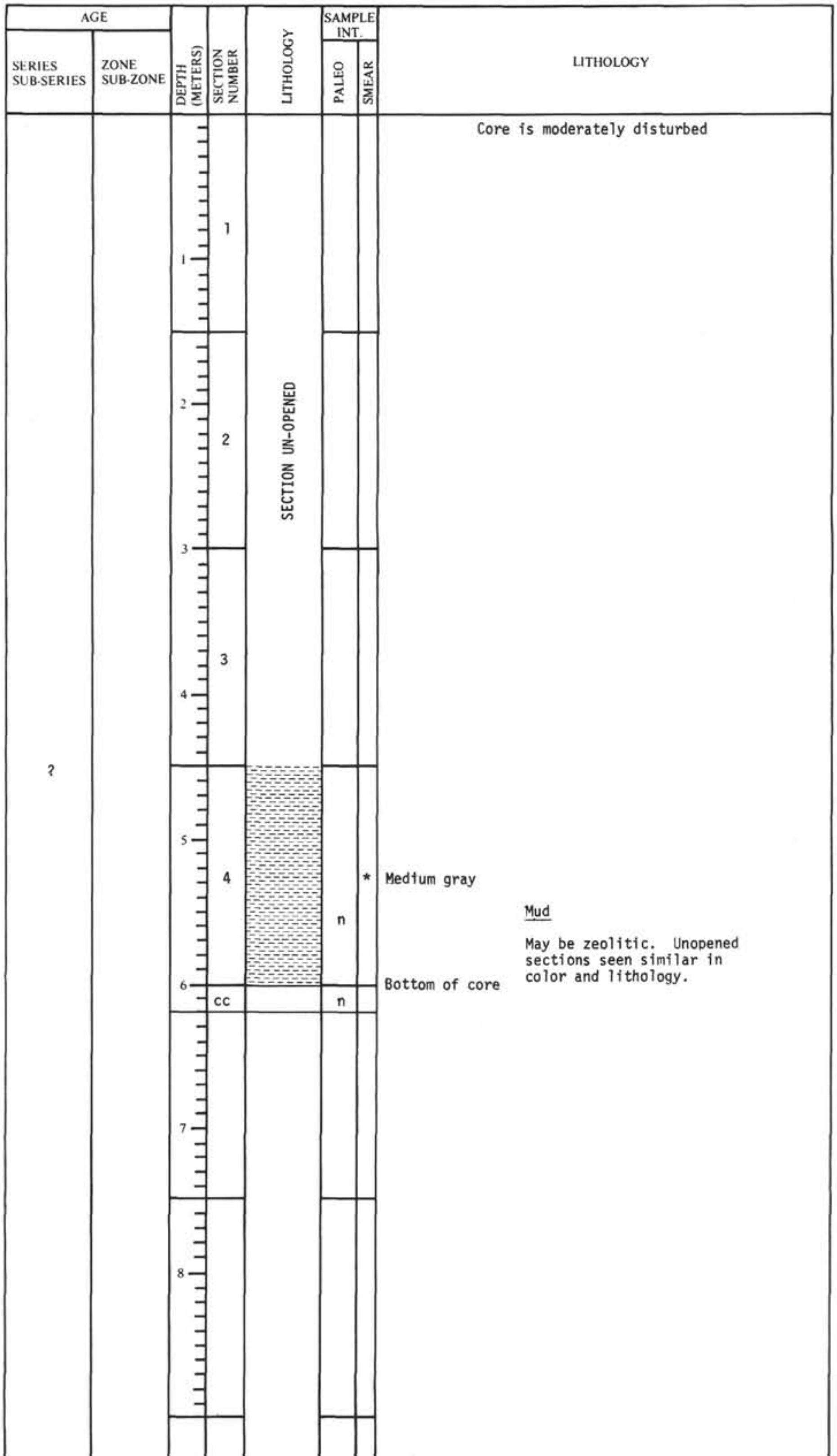

Figure 20. *Core 15, Hole 35 (363-371 m Below Seabed).*

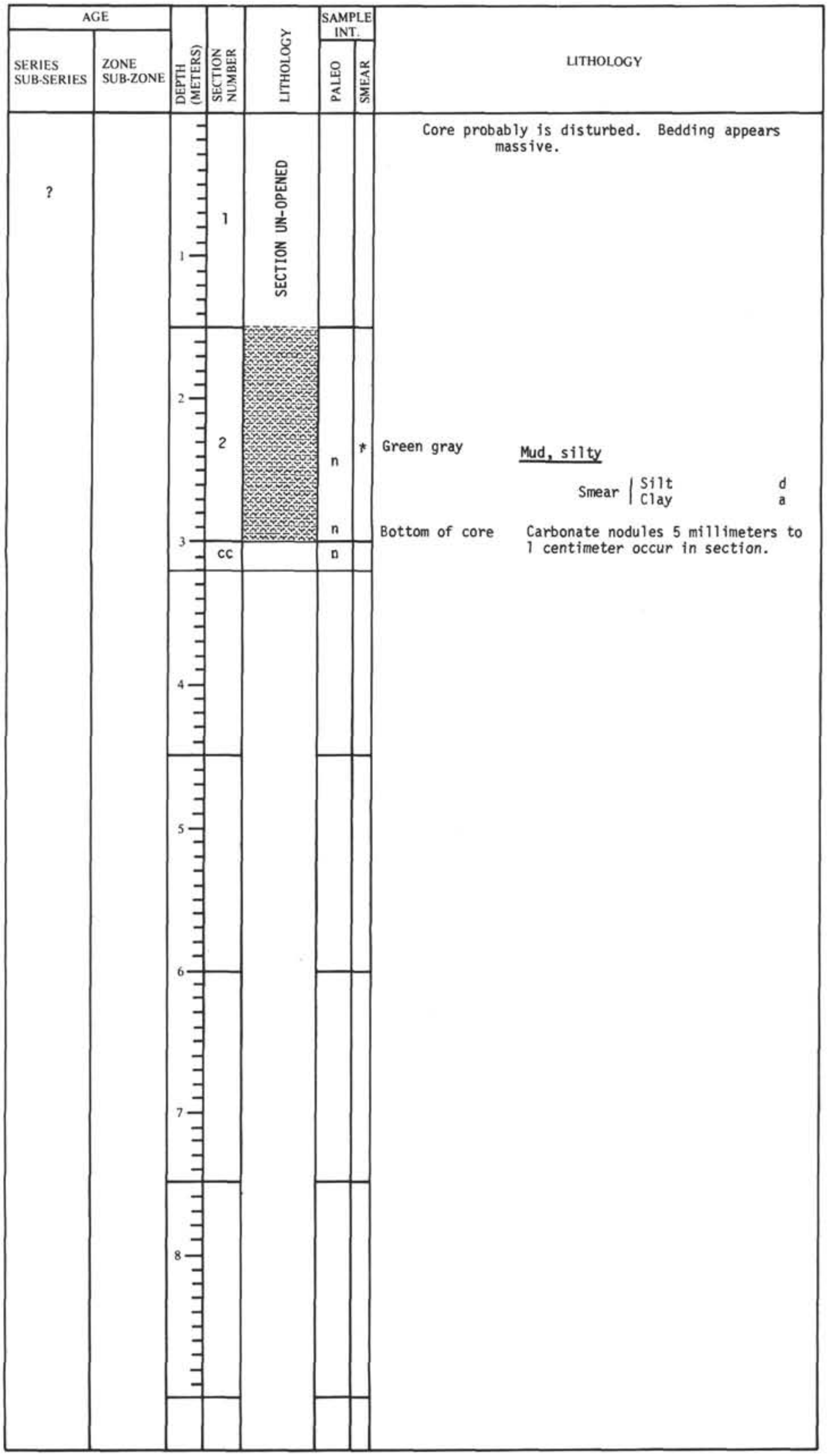

Figure 21. *Core 16, Hole 35 (372-382 m Below Seabed).*

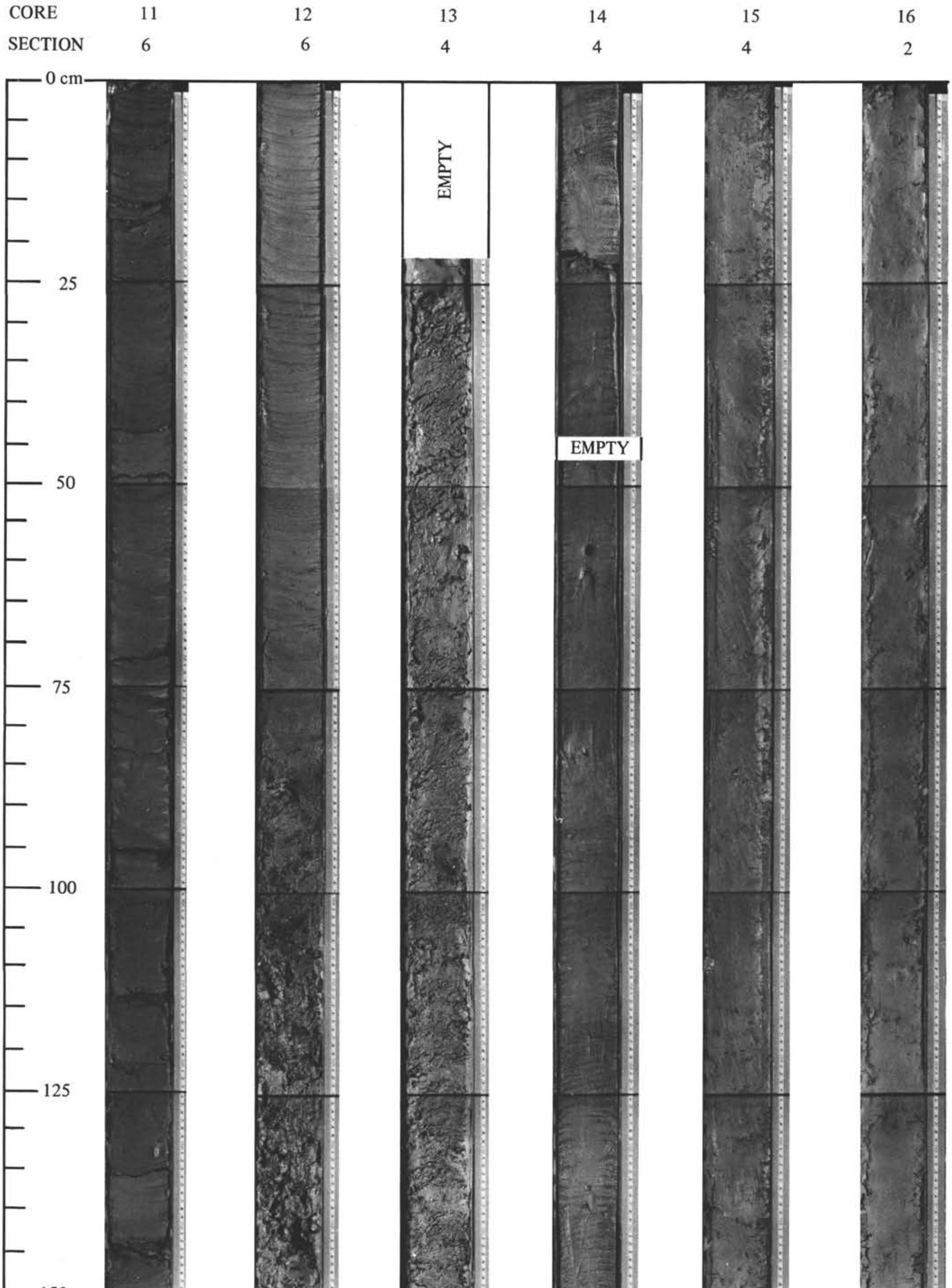

Plate 5. *Sections of Cores 11-16, Hole 35.*

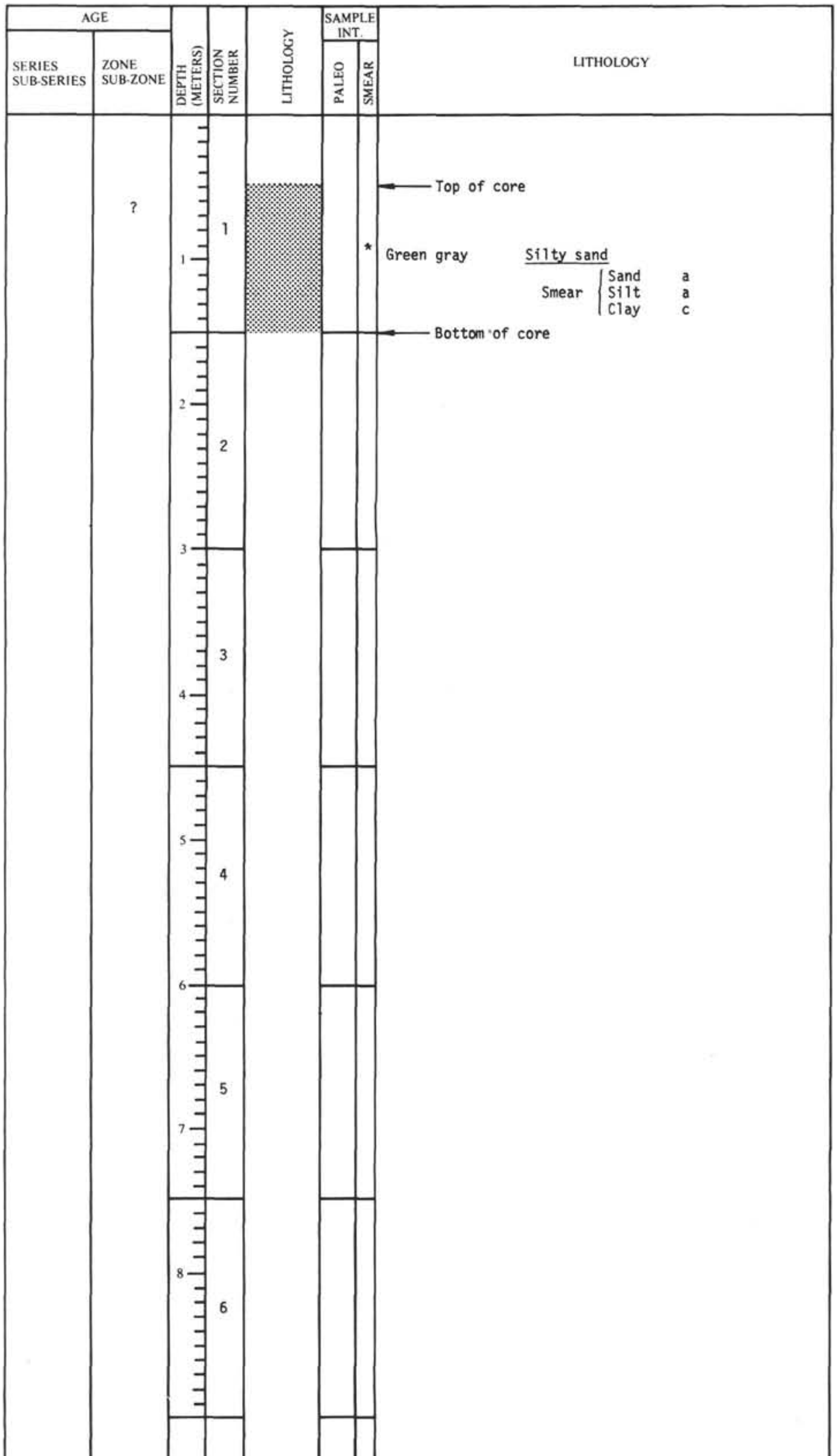

Figure 22. *Core 17, Hole 35 (382-390 m Below Seabed).*