6. SITE 27

The Shipboard Scientific Party[1]

SETTING AND PURPOSE

The northern margin of the Demerara Abyssal Plain is bordered by a low ESE-WNW trending rise known as the Barracuda Ridge. North of South America, the eastern margin of the Demerara Abyssal Plain is formed by the Barbados Ridge. An extensive sedimentary section of the Barbados Ridge is exposed on the island of Barbados and consists of a series of radiolarian to planktonic foraminiferal and calcareous nannofossil biogenic sediments interlayered with ash beds. This series, known as the Oceanic Formation, has been described in detail by Jukes, Brown and Harrison (1892), Beckmann (1953) and Saunders and Cordey (1968). The pelagic sediments of the Oceanic Formation range in age from Lower or Middle Eocene through Miocene, and rest with angular and erosional unconformity on complex contorted flysch-like sedimentary strata, almost devoid of fossils, referred to as the Scotland Group.

The nature of the sediments and basement in the northern part of the Demerara Abyssal Plain to the east of the Barbados Ridge has been thought to differ markedly from those to the west and south. Profiler records along a traverse at about 16°N latitude, made by *H.M.S. Vidal* in 1965 (Collette *et al.,* 1969), show the sediments to the east, in the northern part of the Demerara Abyssal Plain, to have a different appearance from those of the Barbados Ridge; the underlying "basement" is not as smooth as is typical for regions adjacent to the continental margin off eastern North and South America (Ewing *et al.,* 1966).

To determine the nature of the sediments and "basement," Site 27 was selected on the northern margin of the Demerara Abyssal Plain, south of the Barracuda Ridge. At the site, a rather rough "basement" is overlain by 0.3 to 0.6 second of acoustically transparent sediment. The site also lies in the region traversed by the North Equatorial Current in the western Atlantic Basin, and it was expected that the distribution of planktonic fossils in cores from this site would aid in correlation between the Mediterranean and Caribbean provinces.

SITE SURVEY

Survey operations in this area were carried out by the *R/V Vema* between February 20 and 24, 1969. Figure 1, constructed from *Vema* echo-sounder measurements, shows the topography surrounding the site, the location of two reflection profiler transects, and the location of the drilling site on the southern flank of the Barracuda Ridge.

Figures 2 and 3 are the two reflection profiler transects; they show two subbottom reflectors present above a rough basement. The uppermost and strongest reflector, at 0.08 second, appears to correlate with two turbidite layers sampled between 67 and 70 meters during the coring operation. The second and weaker reflector, at 0.28 second, correlates with turbidite beds sampled at 236 to 248 meters in the section. The depths at which appropriate reflecting sediments were sampled indicate sonic velocities of 1.71 km/sec and 1.74 km/sec for the upper and intermediate sediment series. Below these reflectors, at a depth varying between 0.3 and 0.6 second in this area, lies a rough "basement" reflector.

At Site 27, the depth to basement was approximately 0.53 second. Assuming that the hard limestone at a depth of 473 meters (1552 feet) is the "basement" seen on profiler records, an interval velocity of 1.85 km/sec for the overlying sediments between the "basement" and the lower intermediate reflector is obtained.

The approach to Site 27 by the *Glomar Challenger* was made from east to west, beginning at 1020 hours on February 23. On the initial crossing (on course 270) between 1020 and 1109 hours, a reflection profiler record over the site was obtained which showed "basement" at about 0.5 second, and the lower and upper intermediate reflectors at 0.25 and 0.06 second, respectively. The bottom along this transect was relatively flat at a depth of 2775 fathoms (uncorrected).

The towed gear was retrieved at the western end of this transect, and the ship returned eastward to the site position guided by radar control from *Vema.* At 1346 hours, the ship stopped to check the depth of the "basement" reflector using the air gun and phones

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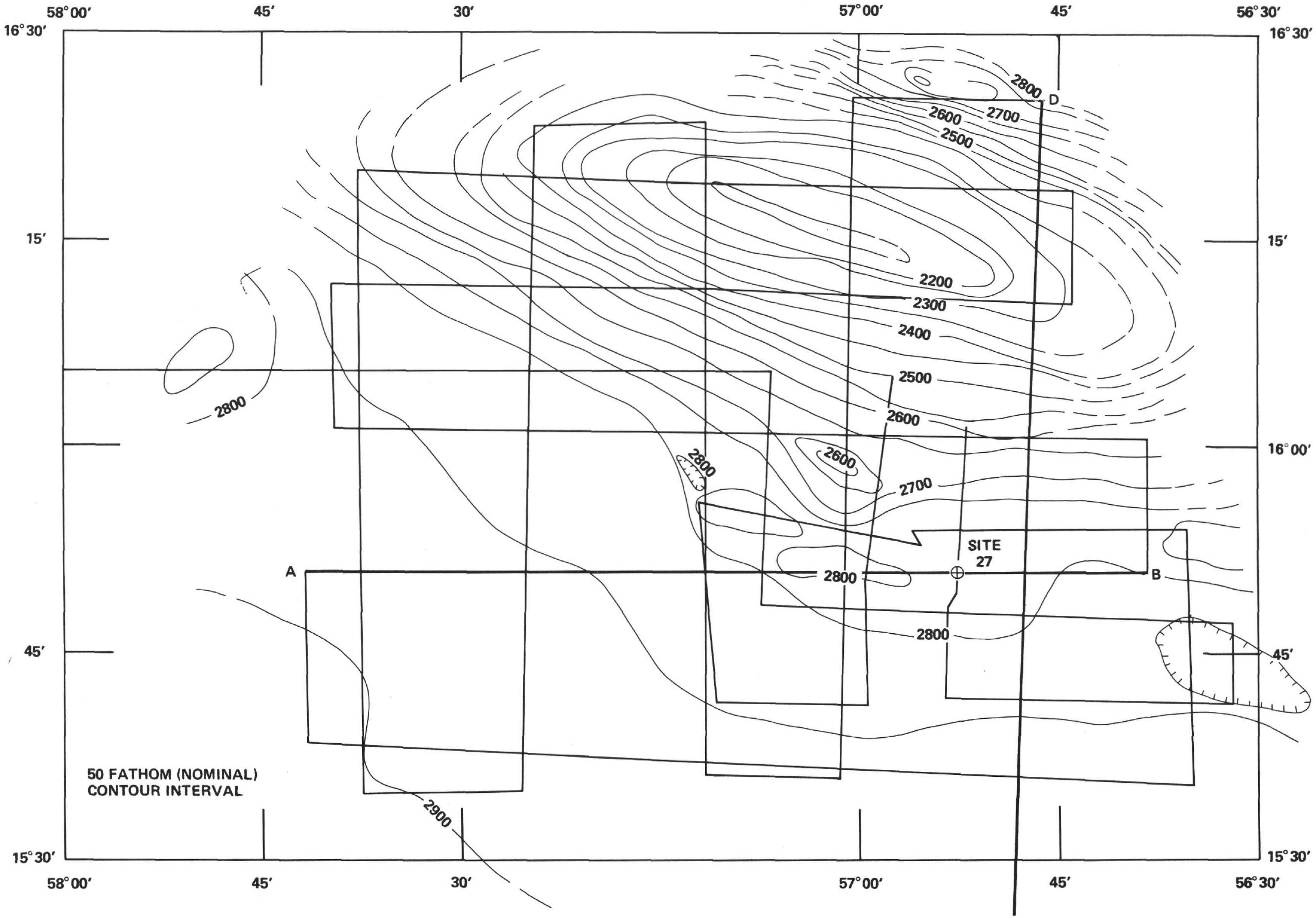

Figure 1. *Topographic chart of the area surrounding Site 27 constructed from* R/V Vema *echo-sounder measurements. Line A-B and C-D show the location of reflection profiler transects (Figures 2 and 3).*

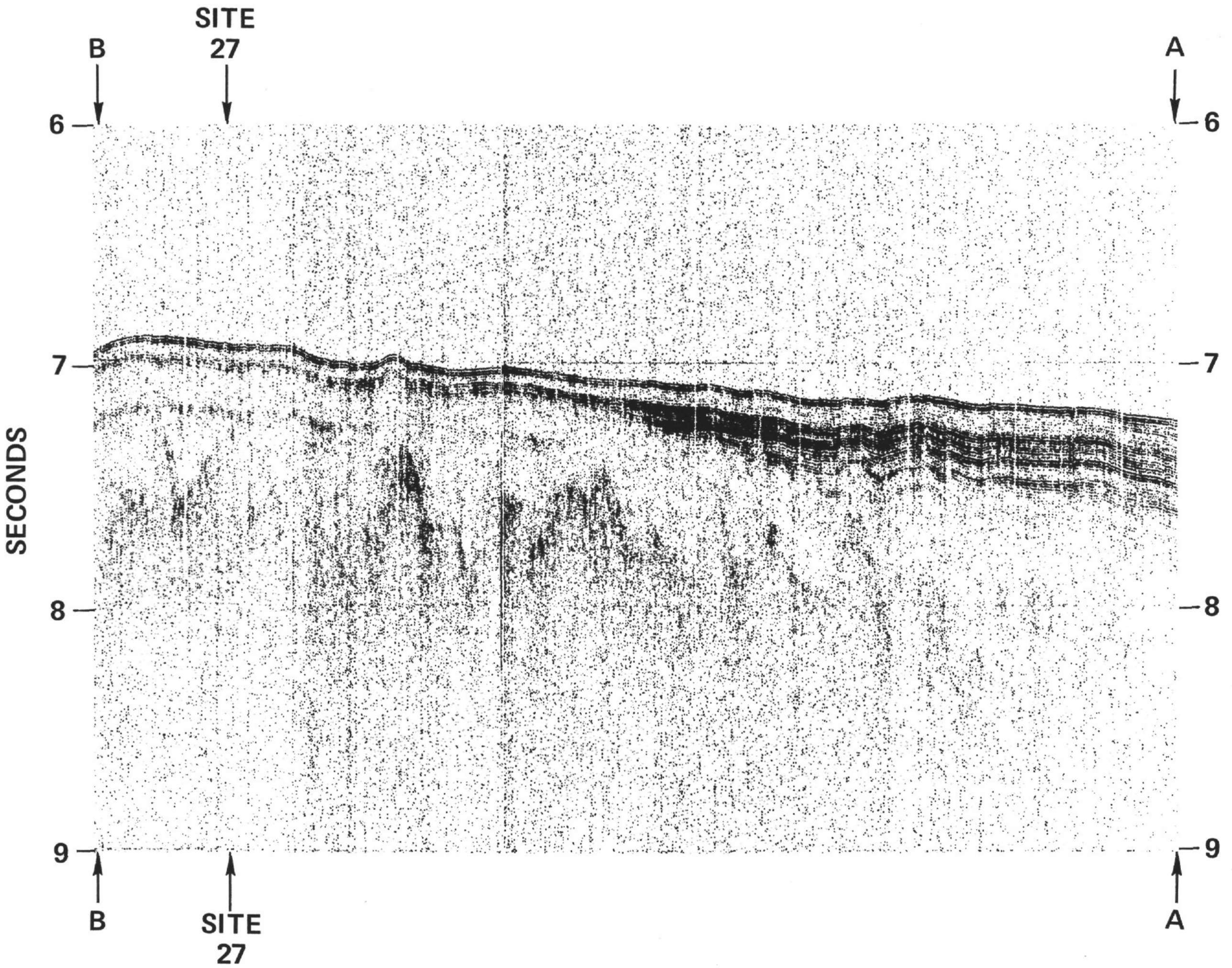

Figure 2. *Reflection profiler record along an E-W transect through Site 27 taken aboard the* R/V Vema *February 23, 1969 (see Figure 1 for location). Two smooth intermediate reflectors are observed above a rough "basement" reflector at the site.*

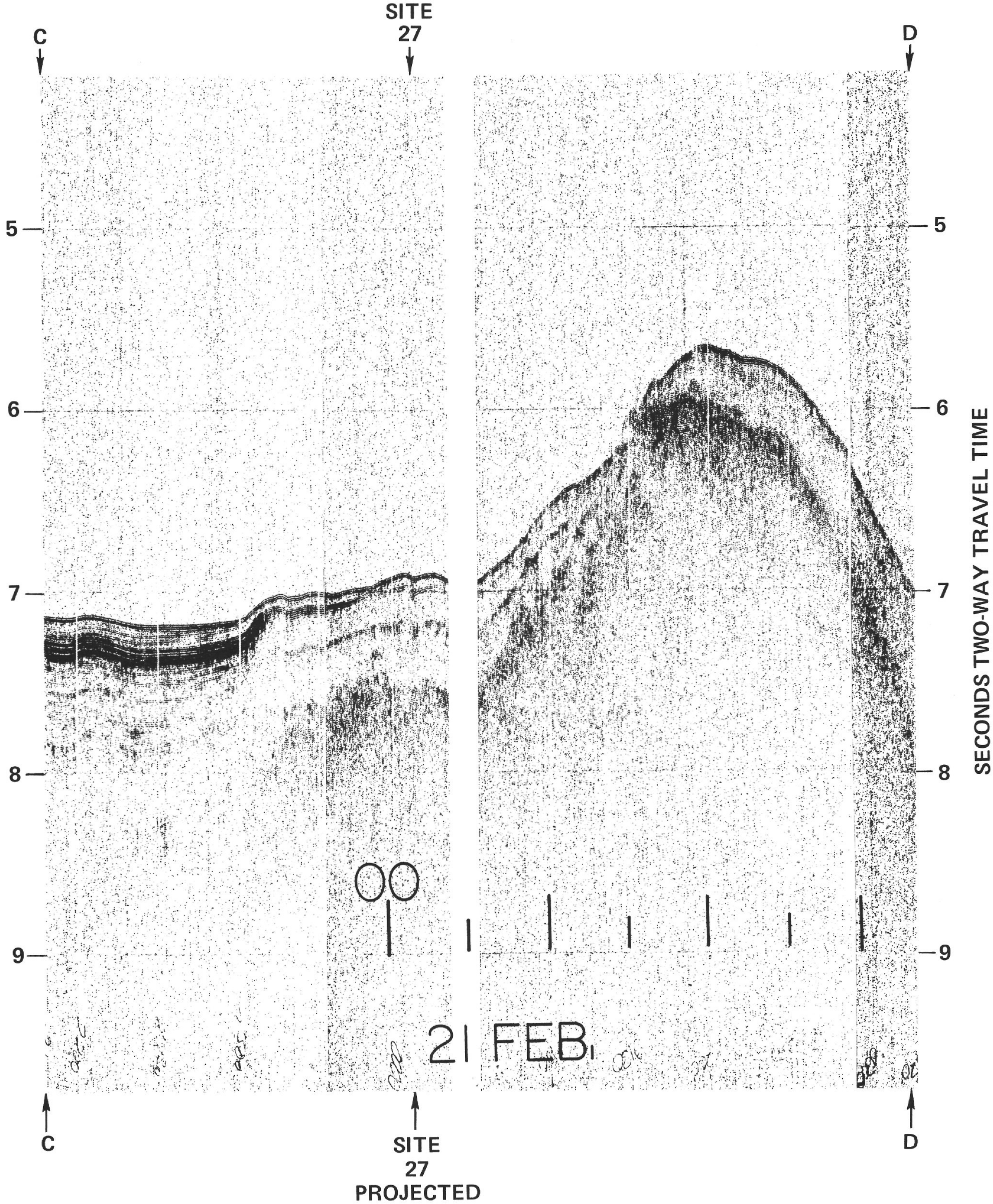

Figure 3. *Reflection profiler record along a N-S transect near Site 27 taken aboard* R/V Vema, *February 21, 1969 (see Figure 1 for location). A crossing of the Barracuda Ridge is observed at the northern end of the section.*

drifted aft with buoys. The on-site record obtained confirmed the reflector depths to be suitable for the survey objectives, and a PPM/beacon (Pulse Position Method) was prepared. The beacon was dropped at 1440 hours, and the automatic positioning system was in operation at 1515 hours. The beacon signal, although distorted, was acceptable to the positioning system, and the ship remained at this location for the duration of the work at this site. The coordinates for Site 27 were later determined by a series of satellite navigator fixes with the accepted location at latitude 15° 51.39′N, and longitude 56° 52.76′W.

DRILLING AND CORING OPERATIONS

The drill string was started down at 1530 hours on February 23, and spudded in at 0800 hours on the following day. A Hycalog massive diamond bit was used in anticipation of reaching hard formations at depth. In order to avoid the hazards of coring before the tool stem had been properly buried, the plan was to drill to the first reflector, estimated at about 61 meters (200 feet), and then begin coring. Upon reaching 84 meters (275 feet) with no apparent drilling breaks, coring was begun. The first core, 9 meters (30 feet) of brown clay of Pleistocene age, was brought up at 1230 hours. Alternate drilling and coring progressed without event, and the formation became firmer with depth. Table 1 summarizes the coring and drilling of Site 27.

At 2145 hours, while drilling with the center bit in place, the first hard formation at this site was encountered at a depth of 474 meters (1554 feet). The center bit was replaced with the core barrel, and a one-meter (3-foot) interval was cored. The core barrel was brought up at 0345 hours on the 26th with a 3-foot core of laminated clay limestone, which may represent the "basement" formation seen in the reflection profiler records.

TABLE 1
Cores Recovered from Hole 27
(Using a Diamond Bit)

Core	Drill String (m)	Penetration (m)	Core Recovered (m)
1	5337-5346	84-93	9.1
2	5394-5403	141-150	4.0
3	5489-5498	235-244	3.0
4	5498-5507	244-254	4.3
5	5622-5631	369-378	5.5
6	5707-5716	454-463	2.4
7	5727-5728	474-475	0.9
		Total	29.2

TABLE 1 – *Continued*
Cores Recovered from Hole 27A
(Using a Diamond Bit)

Core	Drill String (m)	Penetration (m)	Core Recovered (m)
1	5279-5298	25-34	9.1
2	5298-5307	45-54	3.2
3	5307-5316	54-63	3.0
4	5316-5325	63-72	9.1
5	5325-5335	72-81	6.7
		Total	31.1

Drilling at Hole 27 terminated with this core, and the drill string was withdrawn to the mud line. Hole 27A was spudded in at 0800 hours on 26 February without moving the ship from the initial site location. The objectives of this hole were to sample the upper section of the sediments down to 275 feet (80.8 meters), the depth at which coring commenced at Hole 27. Special emphasis was placed upon trying to sample the material composing the upper reflector, which had been drilled without a break on the earlier hole.

It is evident from the coring data (Table 1) that core recovery was higher at this site than at previous sites on this leg. Holes 27 and 27A list core recoveries of 53 and 68 per cent, respectively. There are two chief reasons for this improvement: 1) the sediment in the upper 366 meters (1200 feet) was a relatively soft plastic clay which was readily cored and retained; and, 2) where harder clay sediment was encountered, the inner core barrel was used without a liner. This decreased the tendency of the cored material to jam the lower portion of the core barrel, thus preventing the further entrance of sediment.

Hole 27A terminated at 1755 hours on February 26, after completing the coring of the upper sediment section at this site. The drill string was tripped to the surface and the tools laid down at 0550 hours on the 27th. At 0600, the ship was under way for San Juan.

LITHOLOGIC SUMMARY

For detailed lithology and paleontology see Hole Summaries. (See pages 112-123).

Coring at Site 27 began at 83 feet (25.3 meters) below the sea floor in beds of late Pleistocene age and ended at 1557 feet (474.6 meters) in beds of late Eocene. Four general lithologic types were encountered: 1) "deep-sea" clays, brown to greenish-gray, with very little silt, interbedded with 2) thin scattered turbidites of fine sand to silty clay; 3) calcareous clays; and, 4) laminated waxy clays, noncalcareous at the top, calcareous and cemented to hard laminated claystone or impure limestone at the bottom.

Except for a 10-foot interval between 220 and 230 feet (67.1 to 70.1 meters), the Pleistocene beds from 83 to 305 feet (25.3 to 93.0 meters) consist largely of grayish brown and brown plastic clays with some dolomite, very low silt content, and few fossils. The scarce detrital minerals are of silt-size, and are largely quartz with minor amounts of feldspar and micas, including chlorite. Small "patches" and streaks (probably beds disturbed by the coring) of light bluish-gray clay occur in many places. Some of the blue clay is crumbly and has the waxy look of bentonite. Interbedded with the clay are occasional very thin stringers of medium gray fine sand, silt, and silty clay that are probably small turbidites.

Between 220 and 230 feet (67.1 and 70.1 meters) are two turbidite beds, two to three feet thick. These consist of medium-gray, fine-grained sand and silt grading up into dark gray, silty and non-silty clay. The sand consists of about 75 per cent quartz, mostly angular, but a few grains are well-rounded. The remaining 25 per cent is mostly plagioclase feldspar, muscovite and chlorite, plus small amounts of a wide variety of other minerals; these include: biotite, chert, pyrite, pyroxene, hornblende, apatite, zircon, olivine, tourmaline and calcite, both as angular fragments and small crystal aggregates. Some of the olivine and pyroxene fragments are the centers of pieces of chlorite or aggregates of clay minerals. The olivine and possibly the pyroxene suggest a different source area from that which contributed the bulk of the sand.

The hole was not cored from 305 to 462 feet (93.0 to 140.8 meters). Most of the Pliocene must be within this interval.

Beds of Miocene age were cored from 462 to 492 feet (140.8 to 150.0 meters) and from 772 to 817 feet (235.3 to 249.0 meters), the bottom of the latter interval being either early Miocene or late Oligocene. The beds consist largely of grayish-brown to olive-gray, silty to slightly sandy plastic clays with some glauconite and pyrite. At about 775 and 815 feet (236.2 and 248.4 meters) there are two turbidite beds, each about 10 centimeters thick, consisting of fine sandy silt grading upward into silty clay. The mineral composition is similar to that of the Pleistocene turbidites, and the beds also contain plant "trash".

The hole was not cored from 817 to 1210 feet (249.0 to 368.8 meters). Oligocene beds from 1210 to 1240 feet (368.8 to 378.9 meters) are greenish-gray, slightly silty, calcareous clays with abundant nannoplanktonic fossils but no foraminifera. These beds are probably deposited near the bottom of the zone of carbonate compensation; the foraminifera were dissolved, but the nannoplankton remained intact.

The interval from 1240 to 1488 feet (378.0 to 453.5 meters) was not sampled. Upper Eocene beds were cored from 1488 to 1518 feet (453.5 to 462.7 meters), and from 1554 to 1557 feet (473.7 to 474.6 meters). The upper interval consisted of laminated tan and bluish-green, fairly hard waxy clay that looks like bentonite[2], with radiolarian fossils and minor detrital grains of quartz and feldspar. The beds are remarkably similar to the Oceanic Formation (Upper Eocene) of Barbados. The lower interval consists of calcareous clay that grades down into light-colored, finely laminated, hard calcareous claystone or impure limestone with radiolarian and nannoplanktonic fossils. Within the limestone there are beds 1 to 2 millimeters thick which look graded—coarser at the bottom to fine at the top—even though all the noncalcareous material appears to be clay plus radiolarians. The top of many of these beds appear to be truncated by the base of the next overlying beds. Some of the thin beds show undulating cross-bedding suggestive of ripple marks. The bedding dips at about 24° to the axis of the core; either the drill angled sharply between the upper and lower cored intervals in the bentonite, or there is an angular unconformity between the noncalcareous and the calcareous beds.

Despite the dip, the beds are free of fractures and joints that would suggest any severe structural deformation since deposition.

The presence of Radiolaria and nannoplankton, the absence of foraminifera, and the partial cementation by carbonate suggest that deposition was near the bottom of the zone of carbonate compensation.

PHYSICAL AND CHEMICAL PROPERTIES

Natural gamma-radiation in the upper portions of the holes drilled at Site 27 is similar to that found at other sites for clay sediment (1800-2300 counts/1.25 min.). Significantly higher values were recorded in Cores 3

[2]In fact, so strongly does this clay resemble bentonite that it was identified as such on shipboard and was so reported in the preliminary report on Leg 4 in *Geotimes* (August, 1969, pp. 14-15). However, a "rapid" chemical analysis, X-ray powder pictures and electron microscope photographs, provided through the courtesy of Charles Milton, George Washington University, and L. Shapiro, M. Mrose and E. J. Dwornik of the U.S. Geological Survey, show that the clay consists mostly of kaolinite and quartz with minor montmorillonite and possibly very small amounts of ferri-sepiolite and calcium apatite. From the small specimen examined it was not possible to say whether the assemblage represents *in situ* alteration of volcanic material or whether it is a detrital sedimentary clay derived from a land source.

and 4 (up to 3300 counts). The organic carbon content of samples from Sections 1 and 2 of Core 4 is relatively high (0.8 and 0.4 per cent, respectively). As at Site 26, very high gamma-ray intensities correlate with relatively high organic carbon content.

Densities range from 1.60 to 2.01 gm/cc; water content ranges from 41.6 to 21.6 per cent; porosity ranges from 64.3 to 39.0 per cent. All samples show considerable scatter. Mean values for each core are presented in Figure 4 and show strong trends with depth. The scatter observed in individual samples is probably indicative of disturbance of the sediment during drilling. Sonic velocities range from that of sea water (25°C, 1 atmosphere) to 1644 m/sec; as with the other measurements the scatter is large even though the lithology changes little.

With the exception of Sections 3 and 4 of Core 5, the carbonate content of the clays ranges from nil to 2.8 per cent. In the latter two sections the carbonate content averages 30 per cent. The carbonate in these sections is biogenic; considering the water depth of 5251 meters, the water must have been shallower during the time of deposition (Eocene) or the material has been transported into the area by turbidity currents. The latter seems more likely as the carbonate content of Core 6 is similar to that of Cores 1 through 4.

The organic carbon content is low (nil to 0.1 per cent) except for Sections 1 and 2 of Core 4 and 1, 2 and 3 of Core 5, in which it ranges from 0.4 to 0.8 per cent.

Total salinities are about the same or somewhat less than that of the bottom water in the area, ranging from 33.0 to 34.7 per mil (see Figure 5). Samples from Cores 4 and 5, which appear to have relatively high organic carbon contents, do not exhibit the low salinities found at Site 26. It appears that these organic rich layers may be relatively isolated horizons. If this is the case then diffusion should have effectively erased any salinities markedly lower than the bulk of the interstitial solutions.

The *p*H values of the solutions range from 7.20 to 7.85 with the exception of one sample (27-3-2) which has a *p*H of 8.25. The latter solution was expressed from a calcareous clay. The variation in Eh, *p*H, total carbon dioxide and total salinity with depth is presented in Figure 5. The *p*H values of the solutions vary widely but show a slight overall decrease with depth. There is only a very rough correspondence between low *p*H and high carbon dioxide content, and this is contradicted by the overall decrease in both quantities with depth. Total carbon dioxide contents range from approximately one-quarter that of surface sea water (12.5 μl/ml) at 374 meters to 3.5 times that of surface sea water (162 μl/ml) at 145 meters. Eh values appear to mirror *p*H values, showing a slight increase with depth; values range from +420 to +495 millivolts. The Eh and *p*H of the interstitial water, expressed from a core containing finely disseminated pyrite (27-4-1), were +450 millivolts and 7.85, respectively.

These values (Eh and *p*H) cannot represent a solution in equilibrium with pyrite. In view of the difficulty in obtaining meaningful Eh measurements and the above case, it appears that the Eh values recorded must be considered as being of very questionable reliability.

Seven thermal conductivity measurements were taken on the Site 27 cores (Table 2). The values ranged from 2.33 to 3.30 $\times 10^{-3}$ cal/°C/cm/sec. The normal trend of increasing thermal conductivity downward in the section is observed. The values for Core 5, Sections 3 and 4, are among the highest measured on Leg 4. These observations were made in a stiff clay, which also exhibited high density and low water content.

TABLE 2
Thermal Conductivity Data

Hole	Core	Section	Sample Depth Below Bottom (feet)	Sample Depth Below Bottom (meters)	Lithology	Thermal Conductivity $\times 10^{-3}$ cal/°C/cm/sec
27A	1	1	83-113	25.3-34.4	Brown plastic clay, low silt content.	2.50
27A	4	2	207-237	63.1-72.2		2.90
27A	5	3	237-267	72.2-81.4		2.33
27	1	6	275-305	83.8-93.0	Plastic clay.	2.41
27	4	3	802-832	244.5-253.6	Silty clay.	2.62
27	5	3	1210-1240	368.8-378.0	Dense greenish clay.	3.30
27	5	4	1210-1240	368.8-378.0		3.26

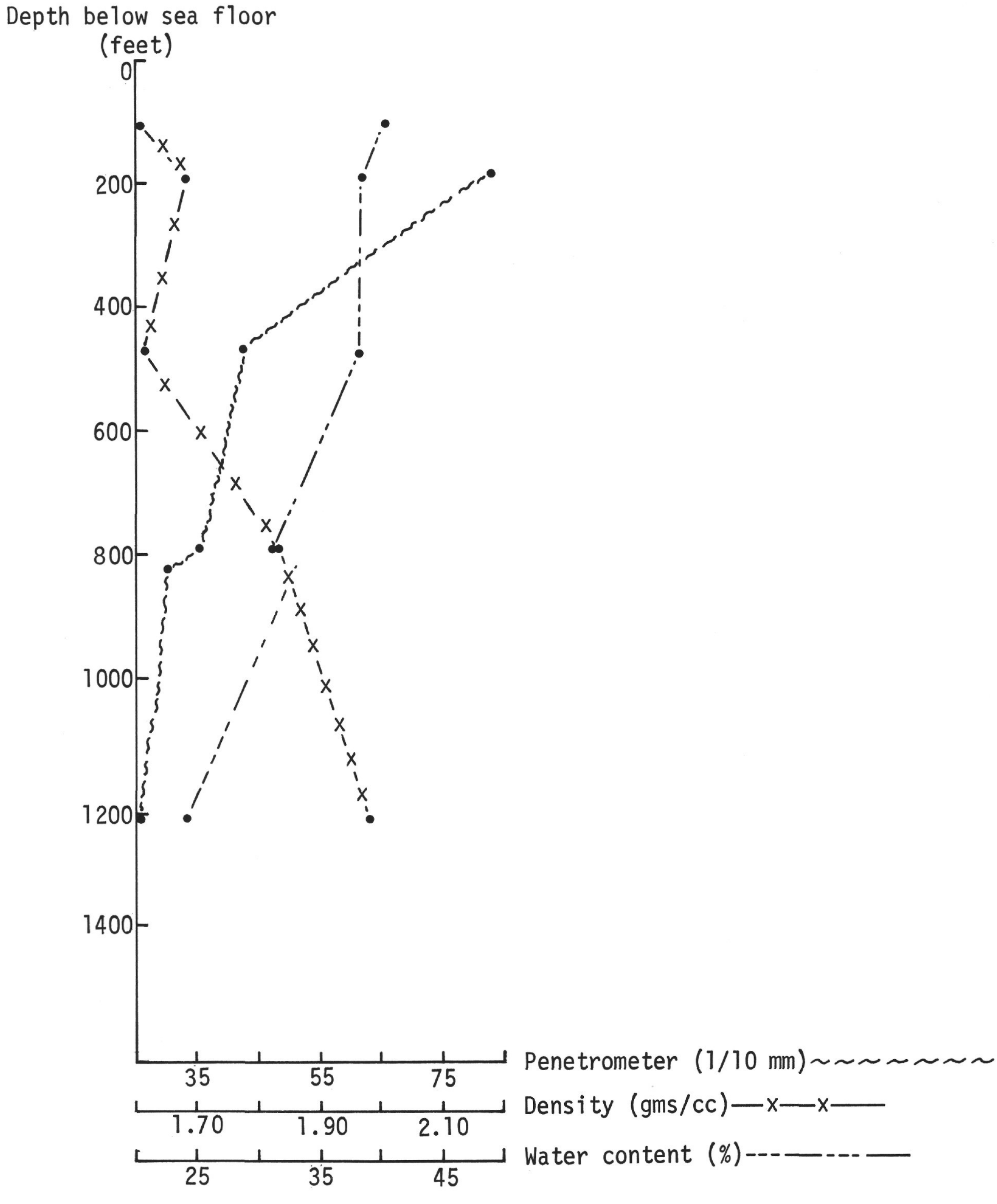

Figure 4. *Summary of physical properties, Site 27.*

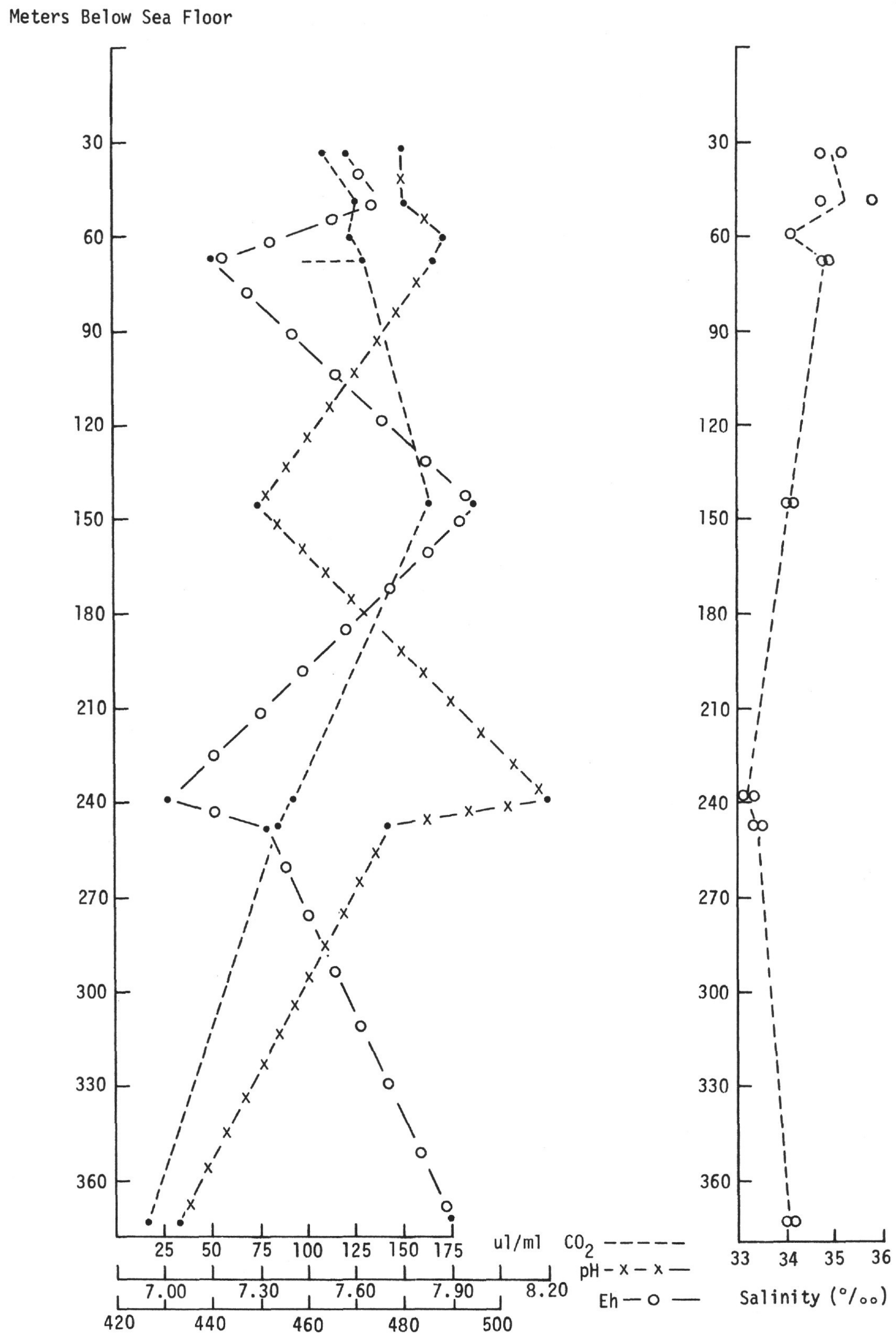

Figure 5. *Summary of chemical properties, Site 27.*

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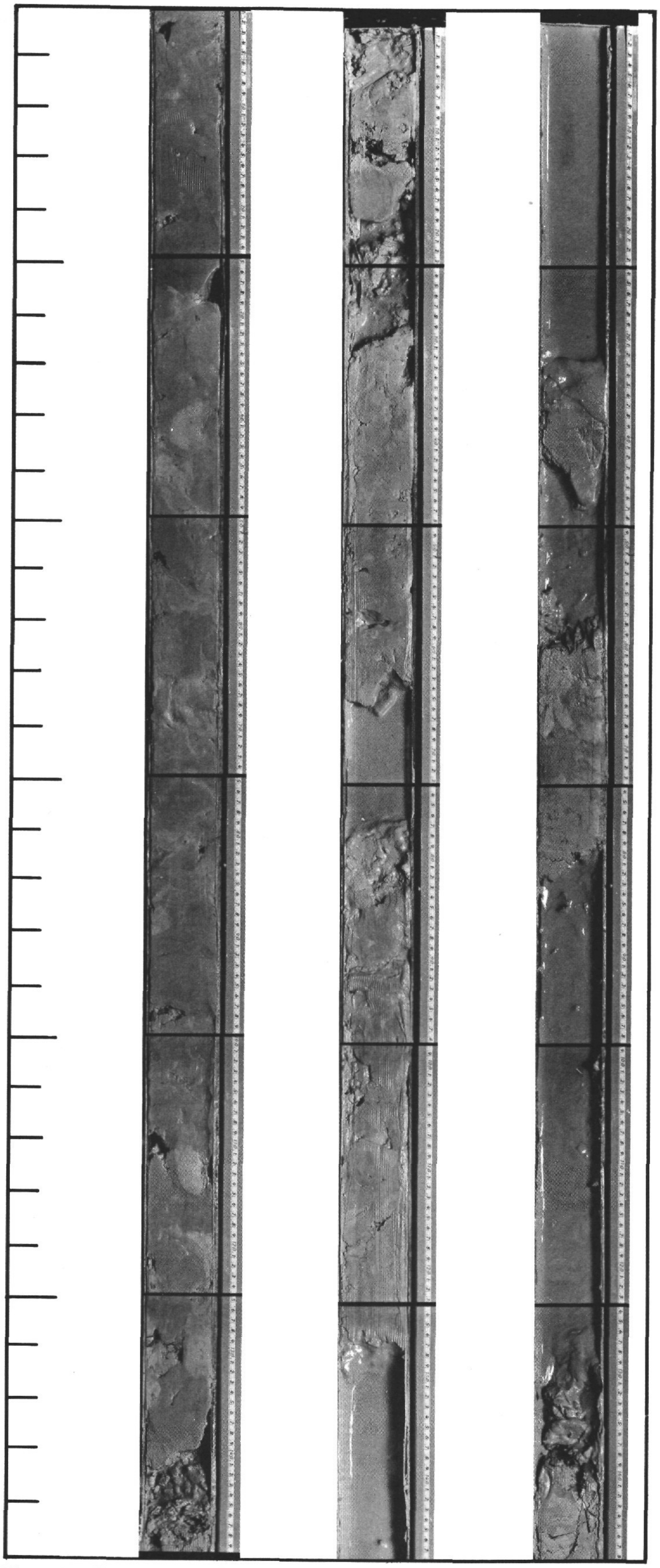


Plate 1. *Core 1, Hole 27.*

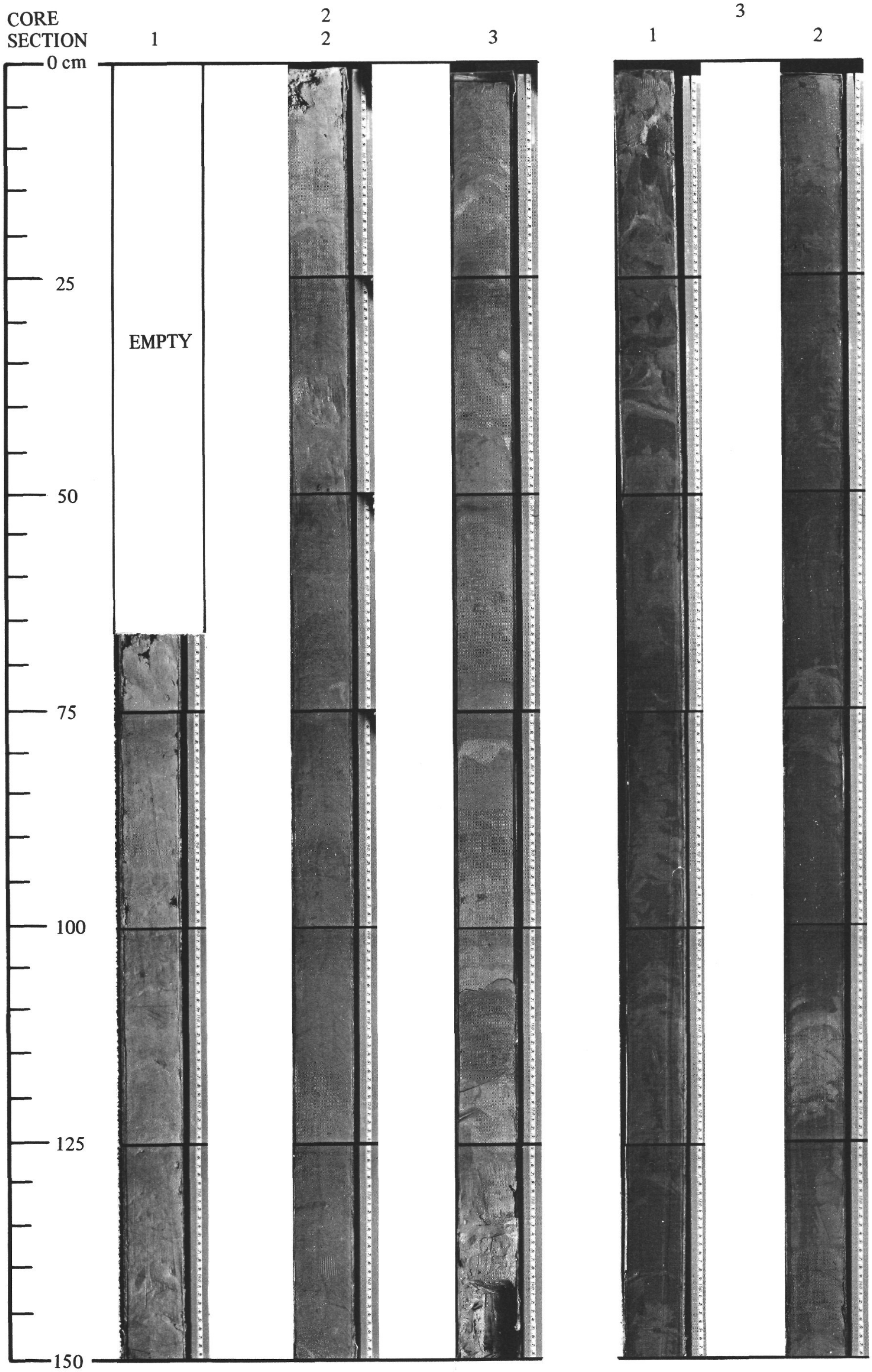


Plate 2. *Cores 2 and 3, Hole 27.*

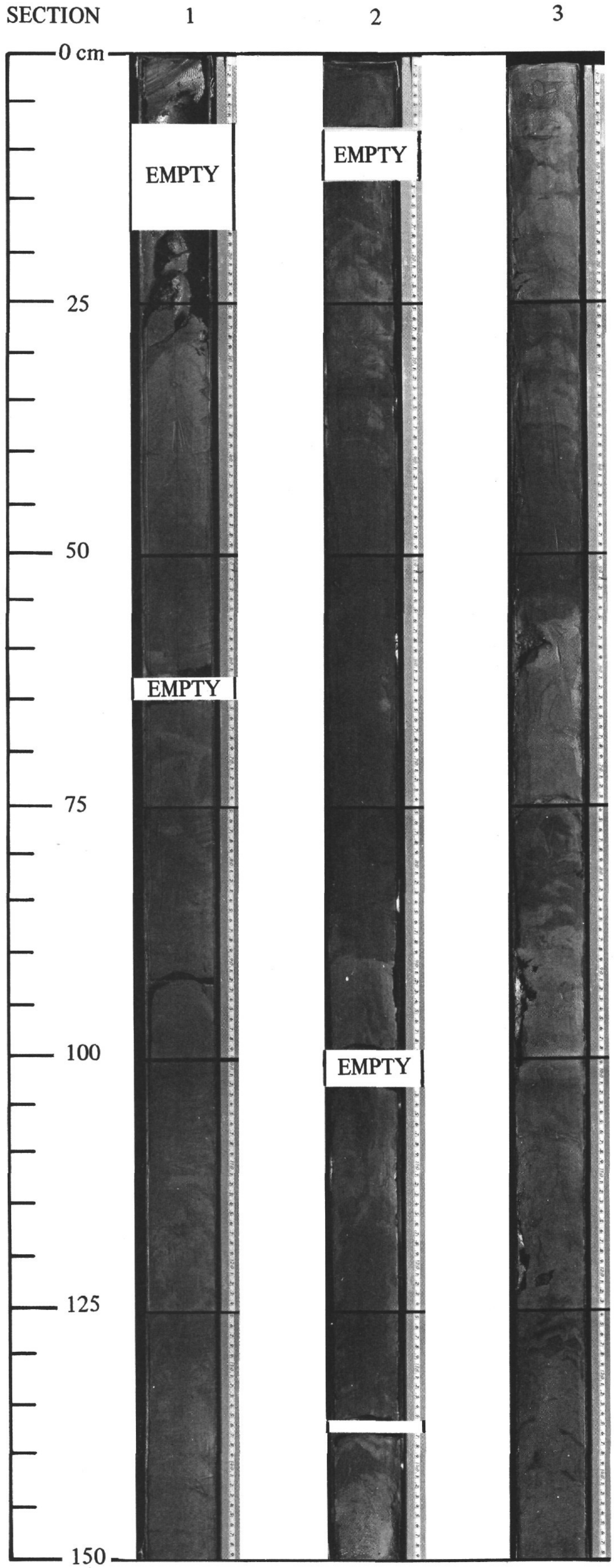


Plate 3. *Core 4, Hole 27.*

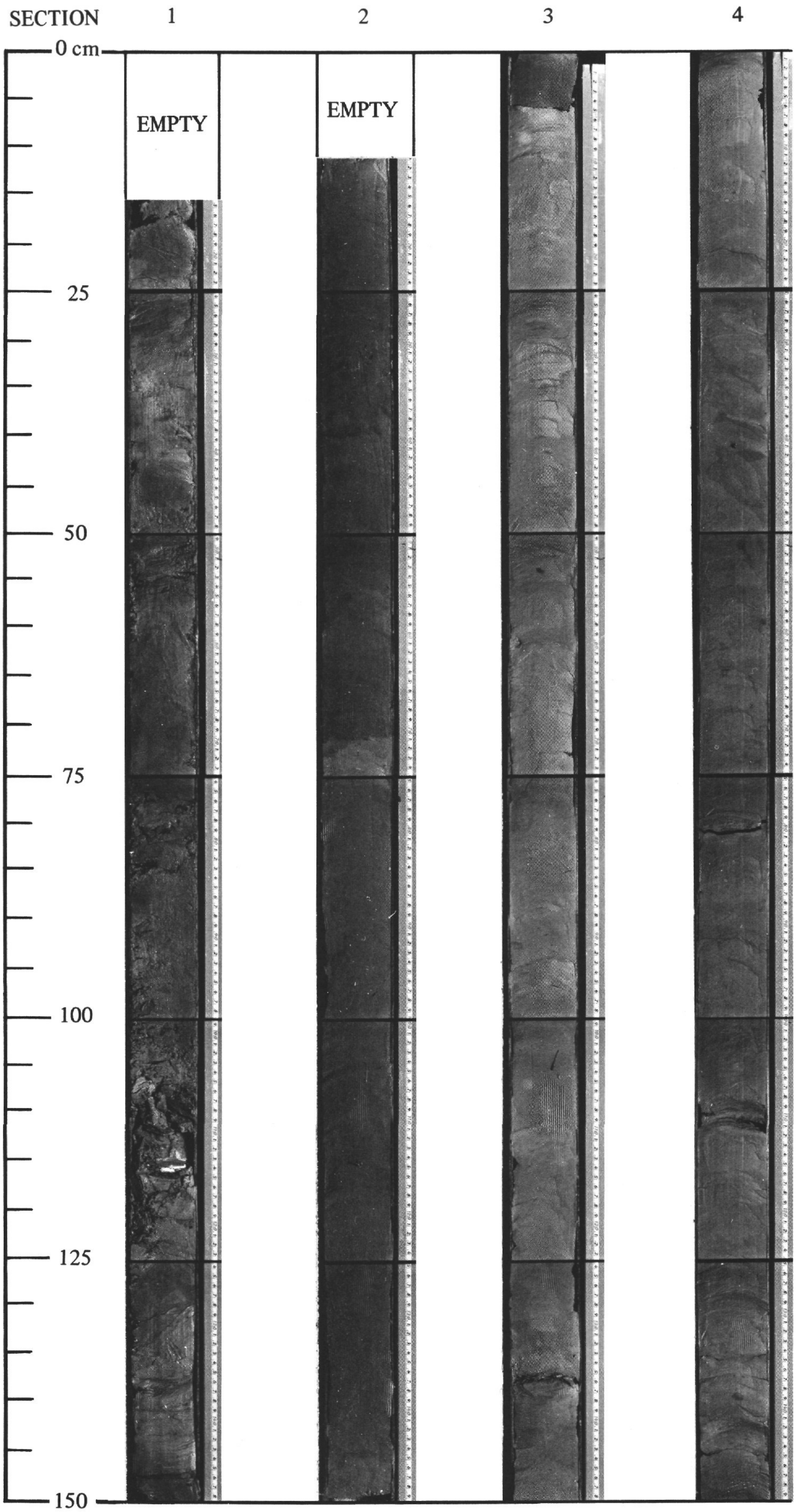


Plate 4. *Core 5, Hole 27.*

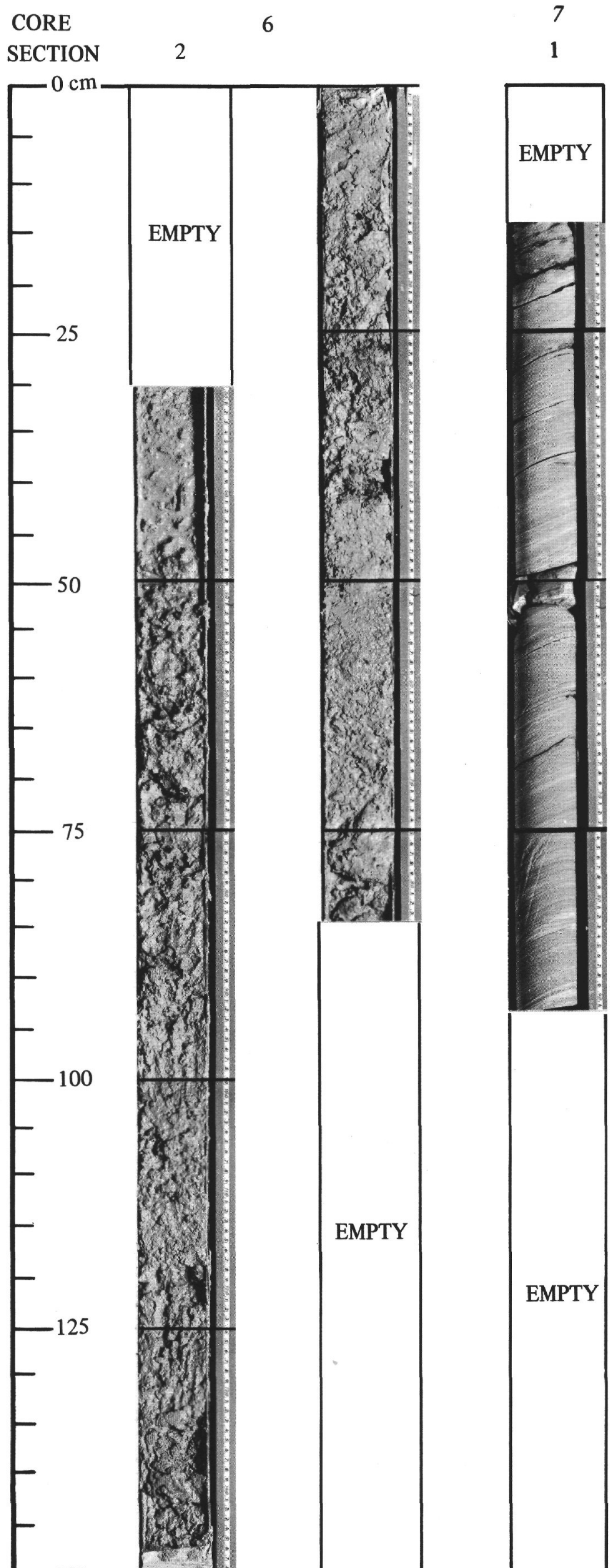


Plate 5. *Cores 6 and 7, Hole 27.*

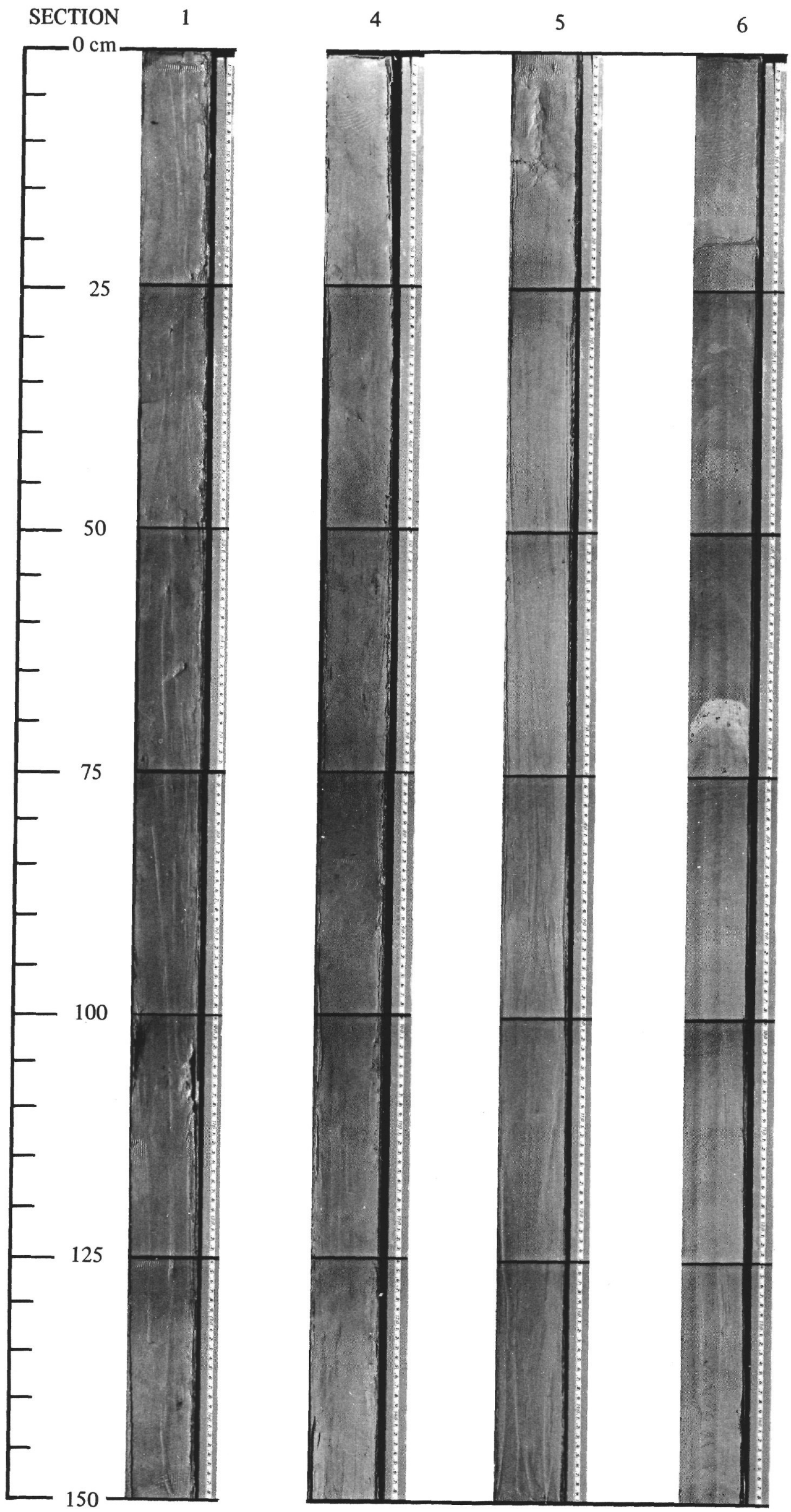


Plate 6. *Core 1, Hole 27A.*

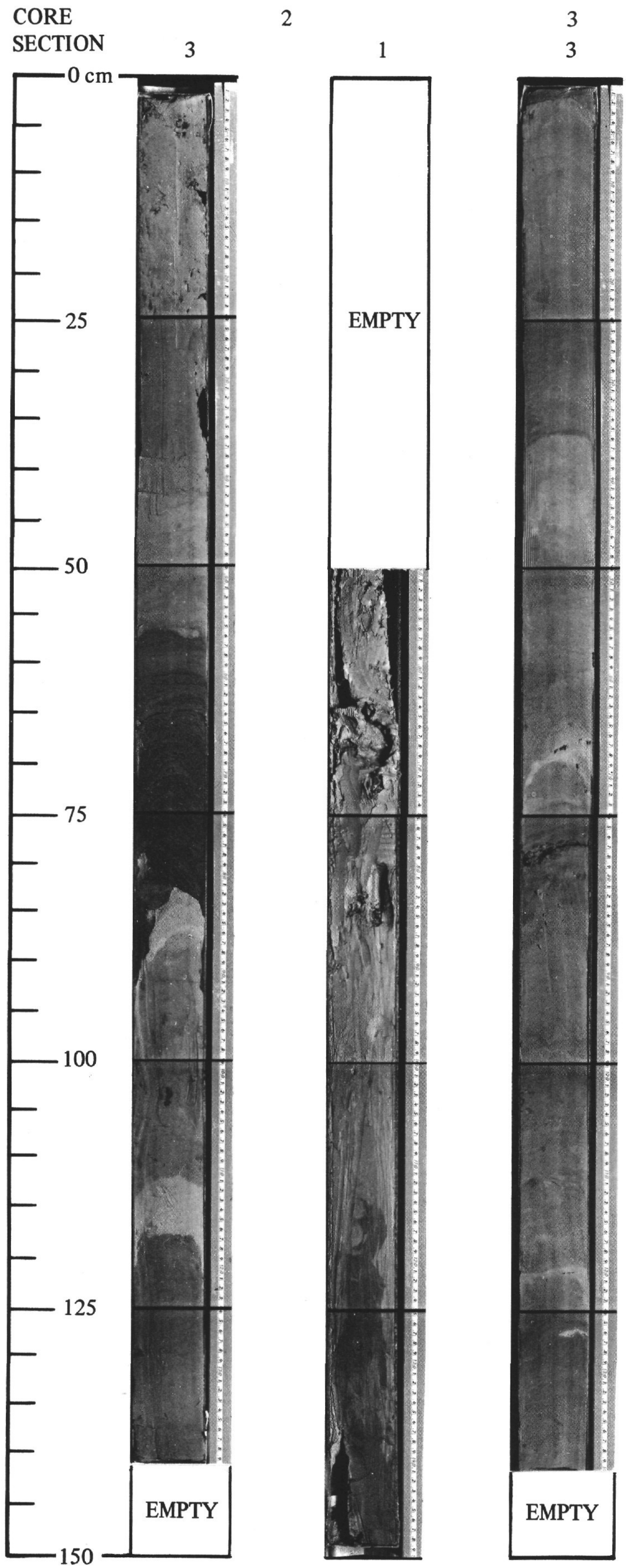


Plate 7. *Cores 2 and 3, Hole 27A.*

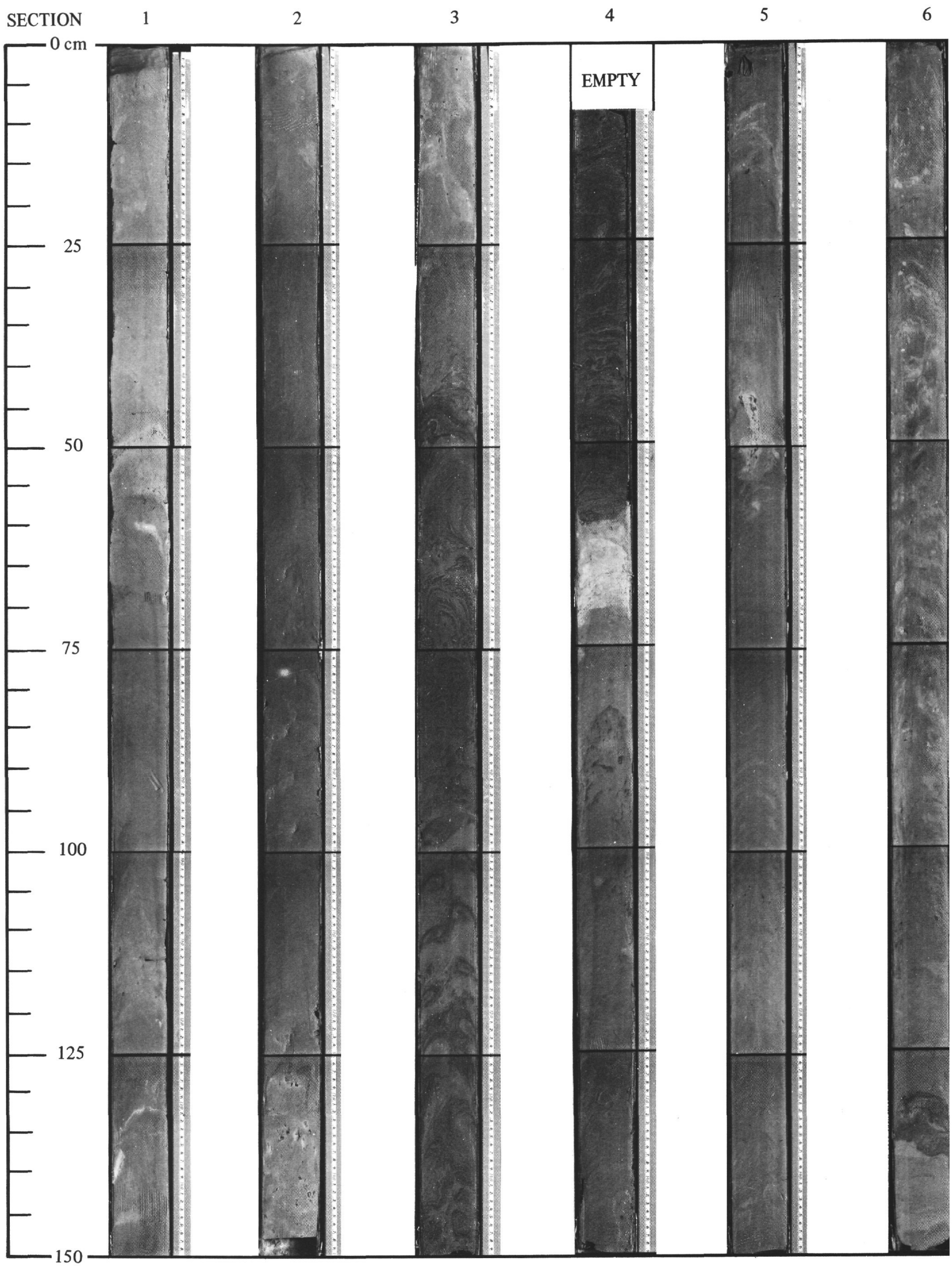


Plate 8. *Core 4, Hole 27A.*

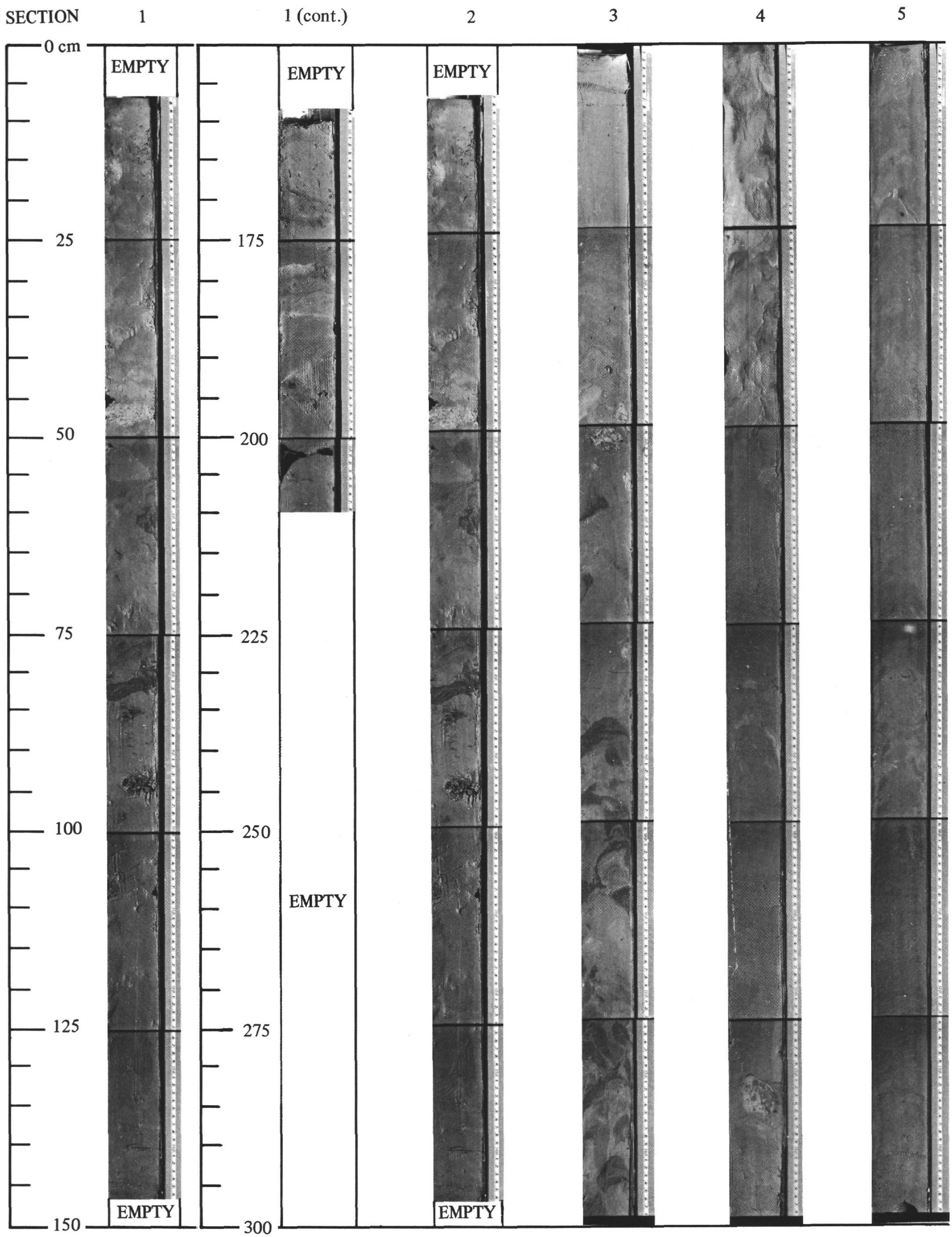


Plate 9. *Core 5, Hole 27A.*

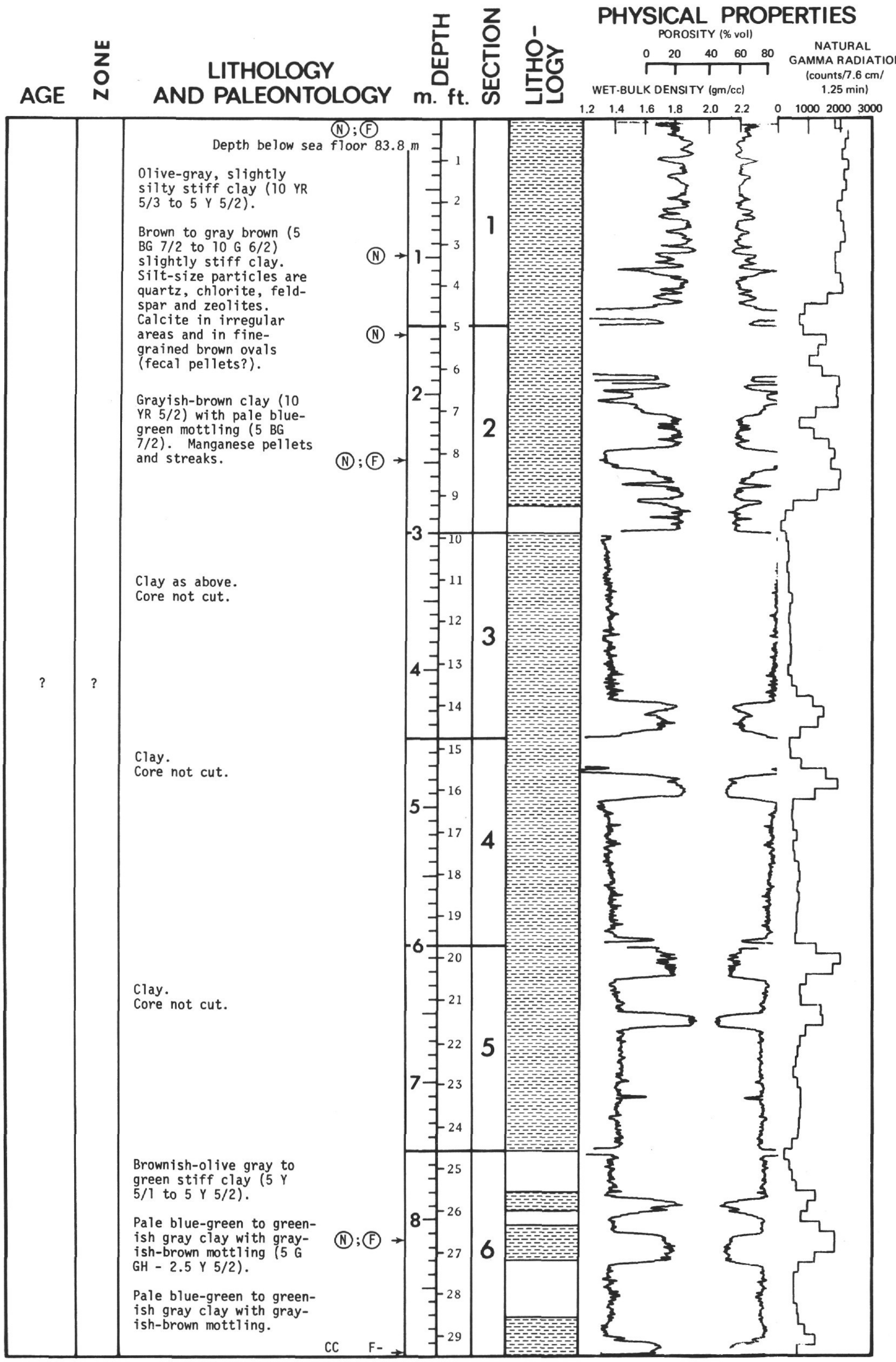
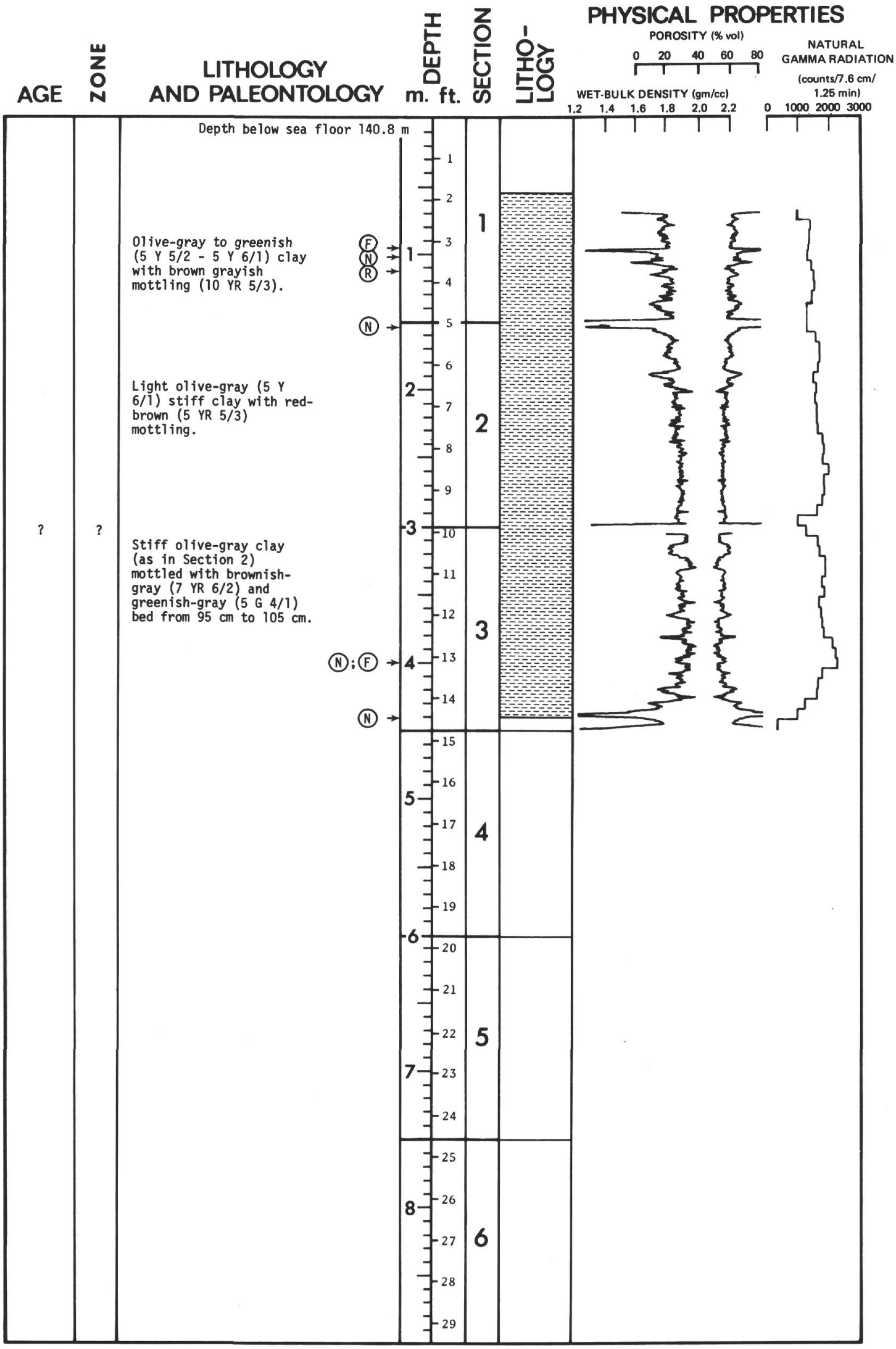


Figure 6. *Core 1, Hole 27.*



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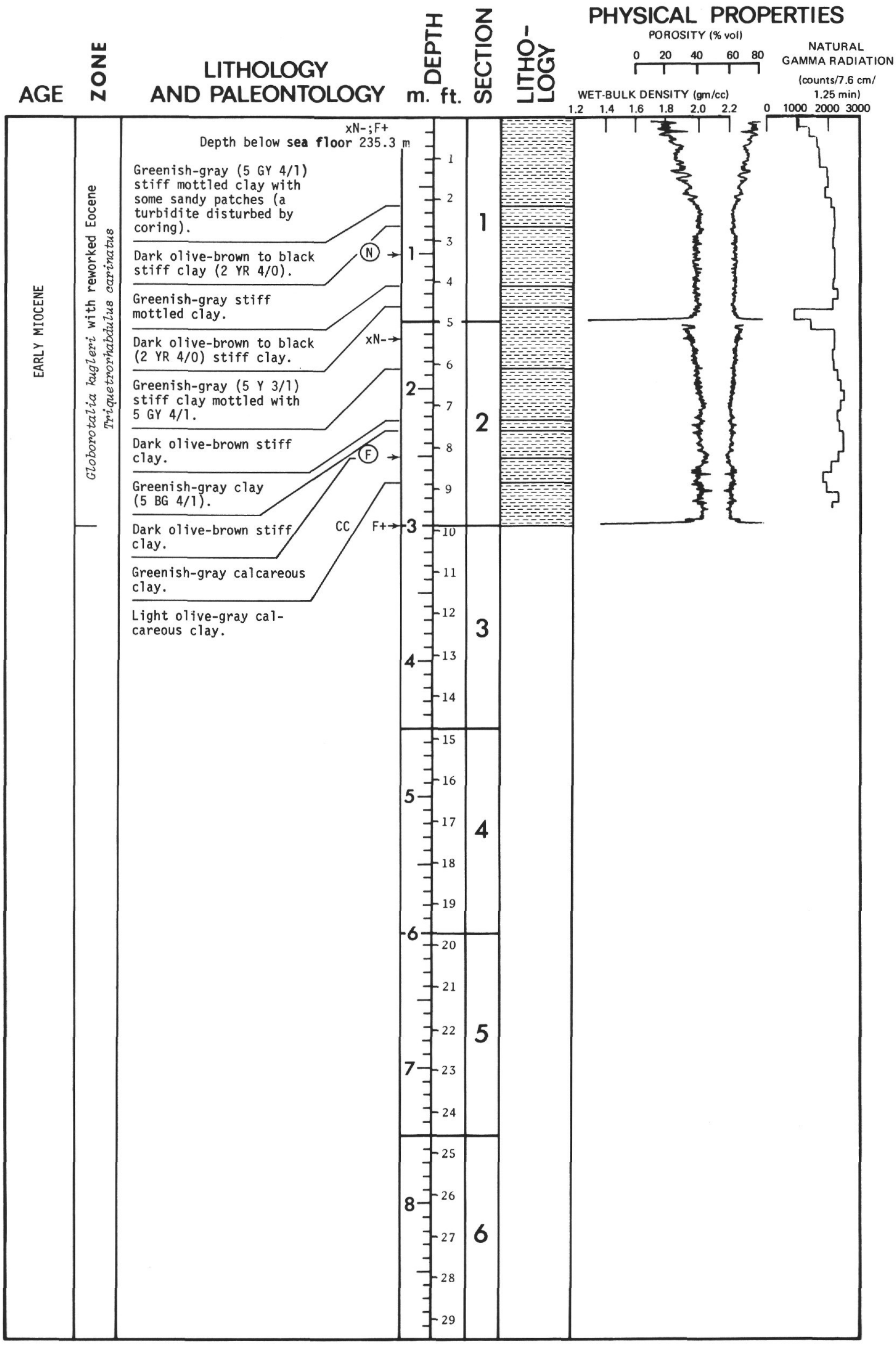


Figure 8. *Core 3, Hole 27.*

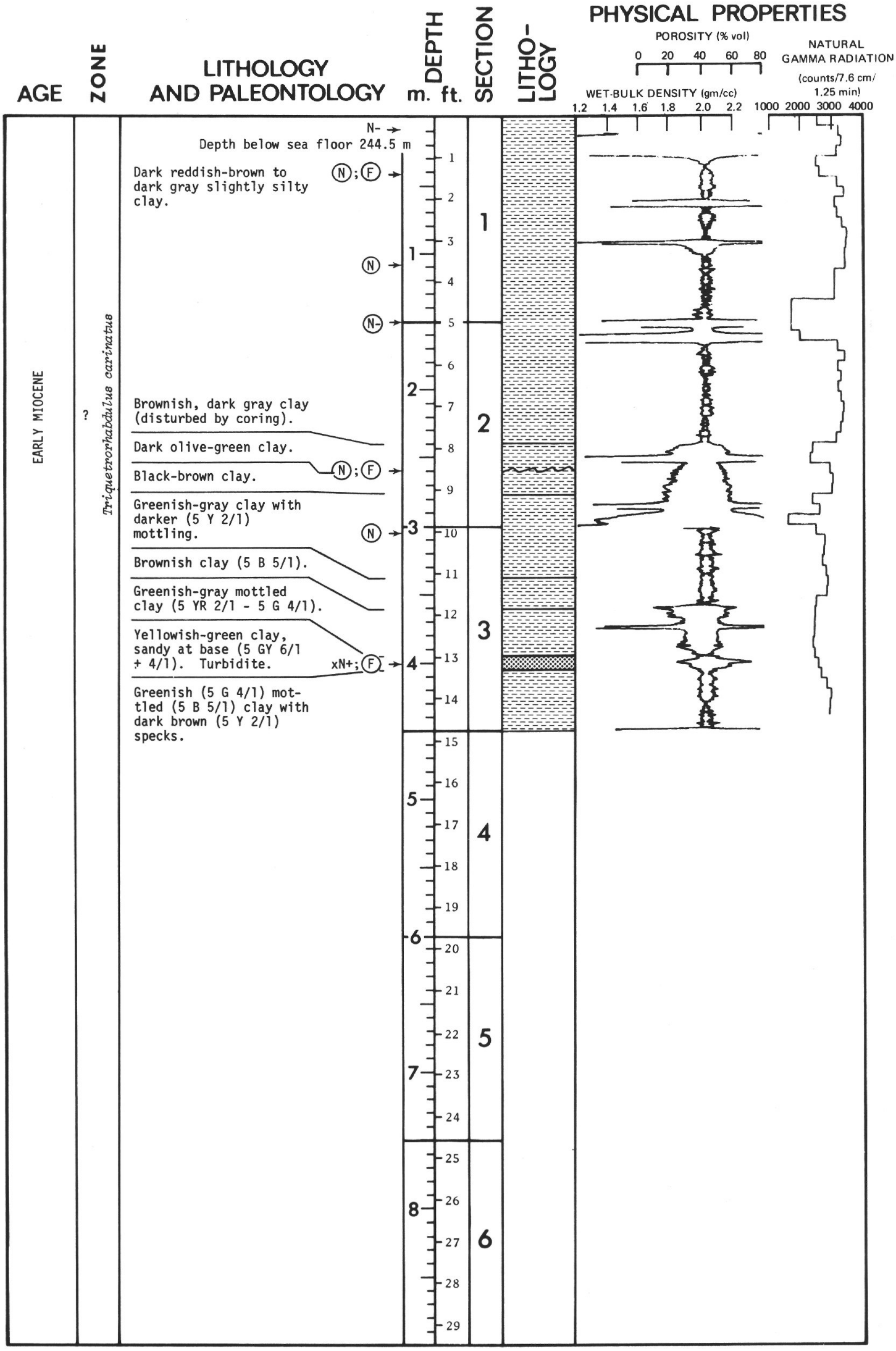


Figure 9. *Core 4, Hole 27.*

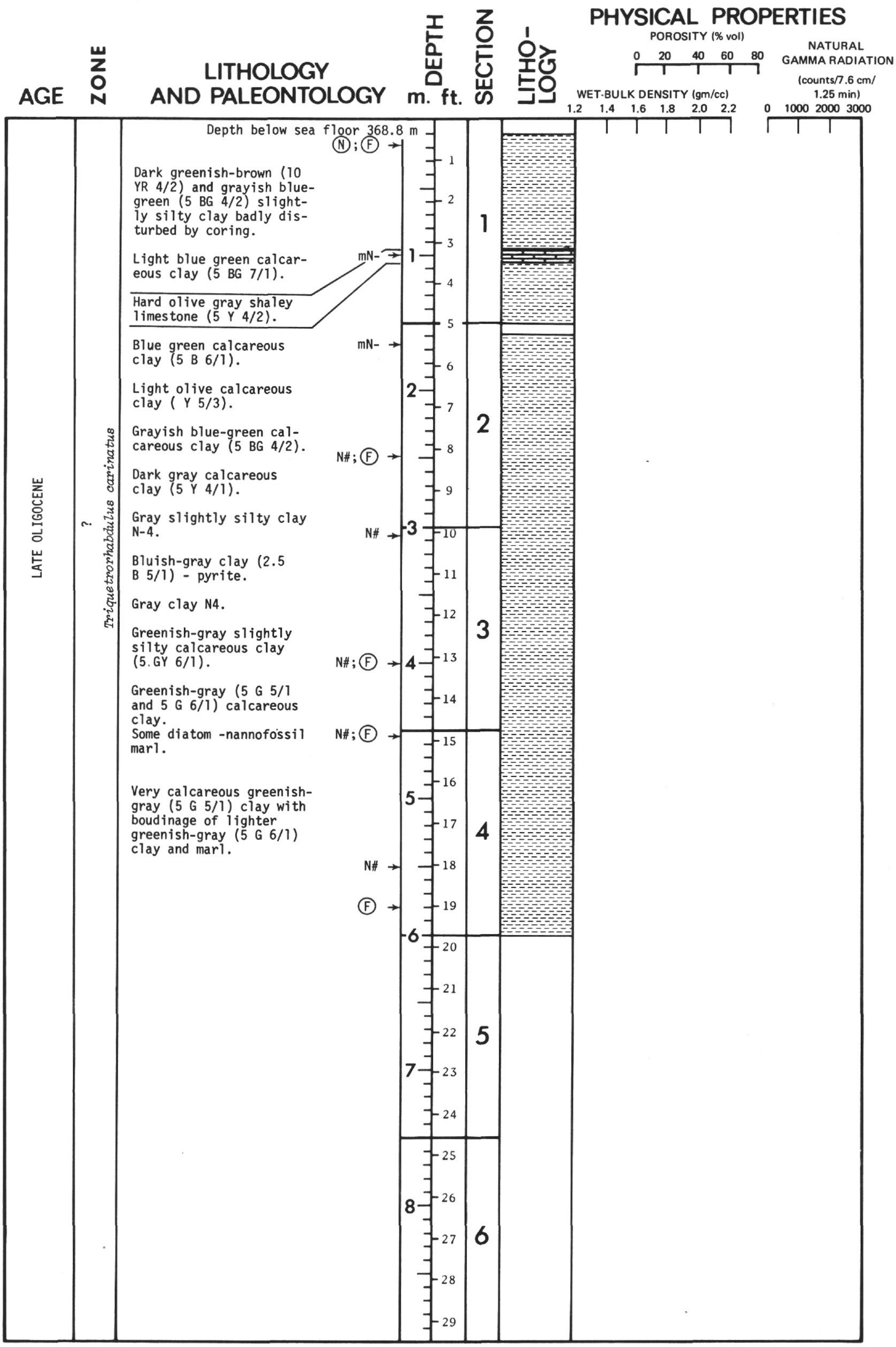


Figure 10. *Core 5, Hole 27.*

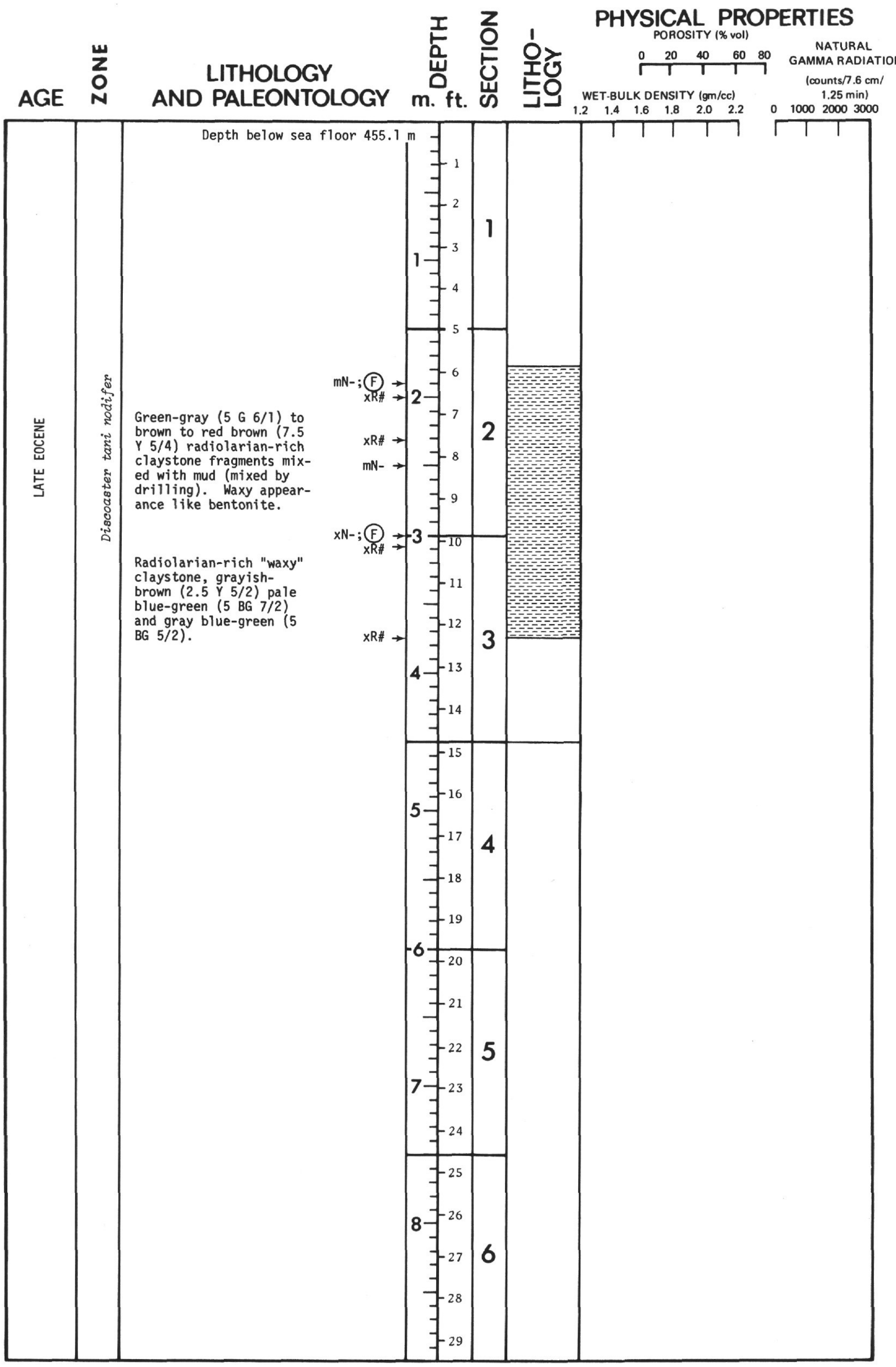
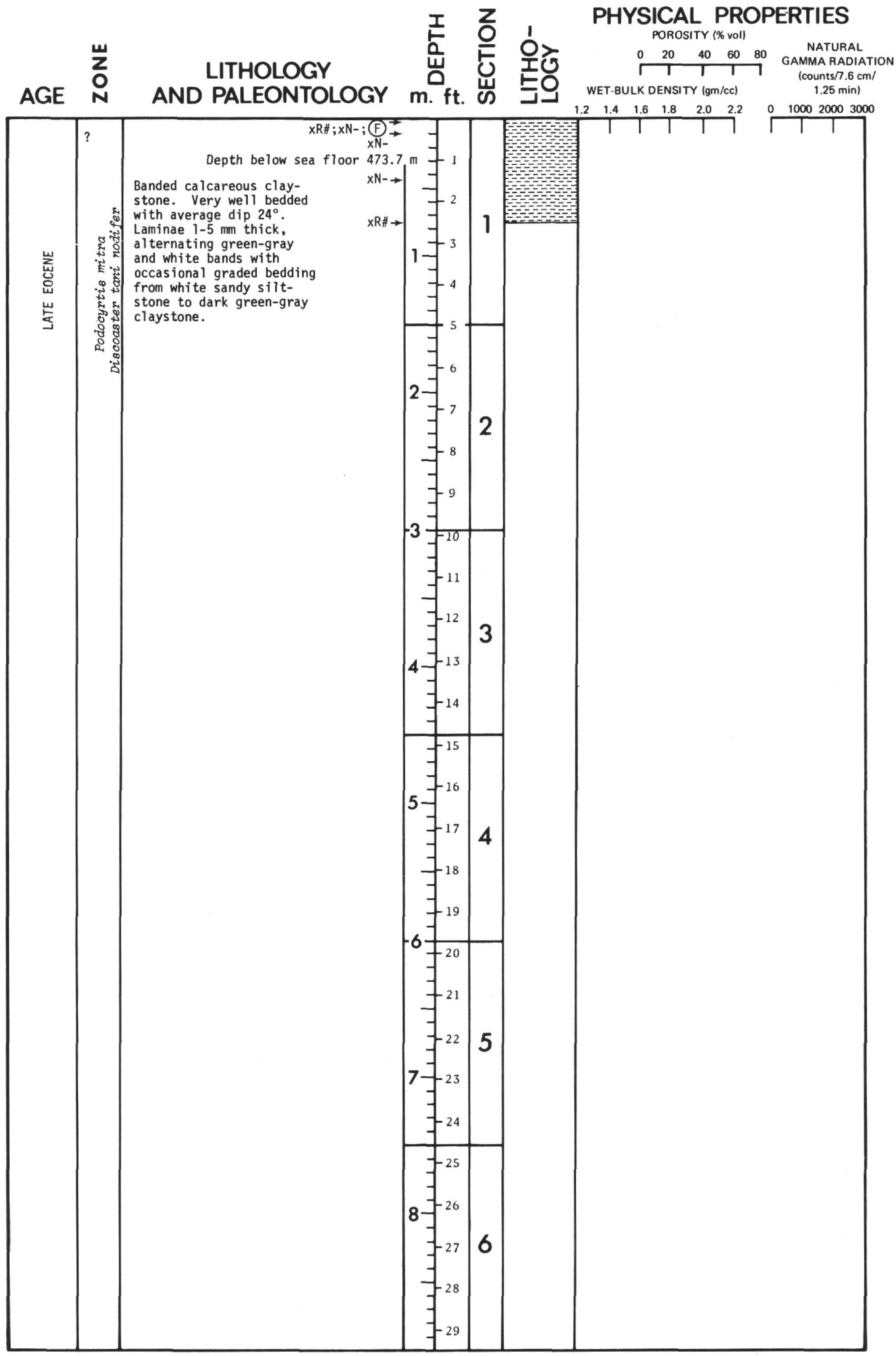


Figure 11. *Core 6, Hole 27.*



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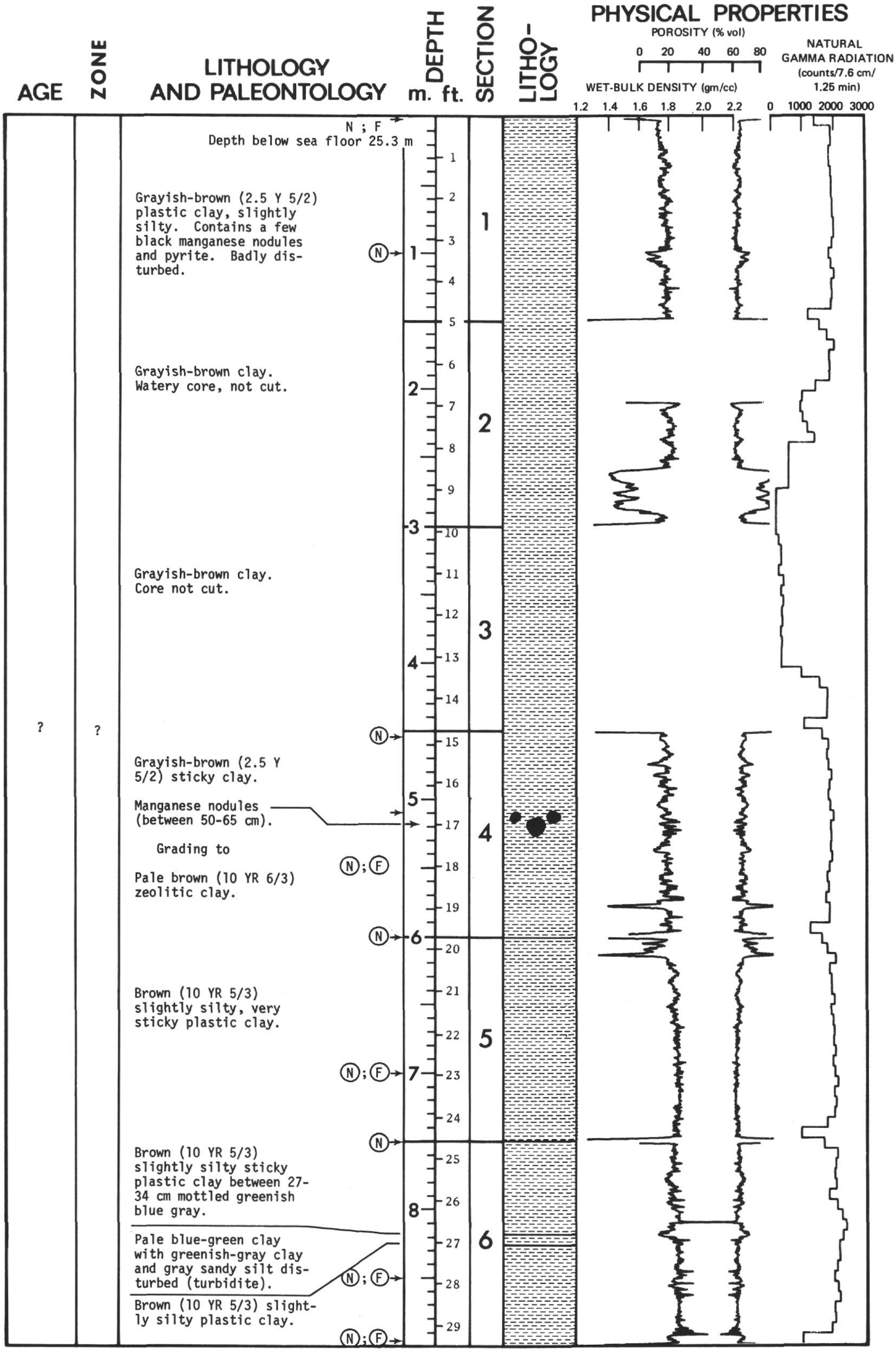

Figure 13. *Core 1, Hole 27A.*

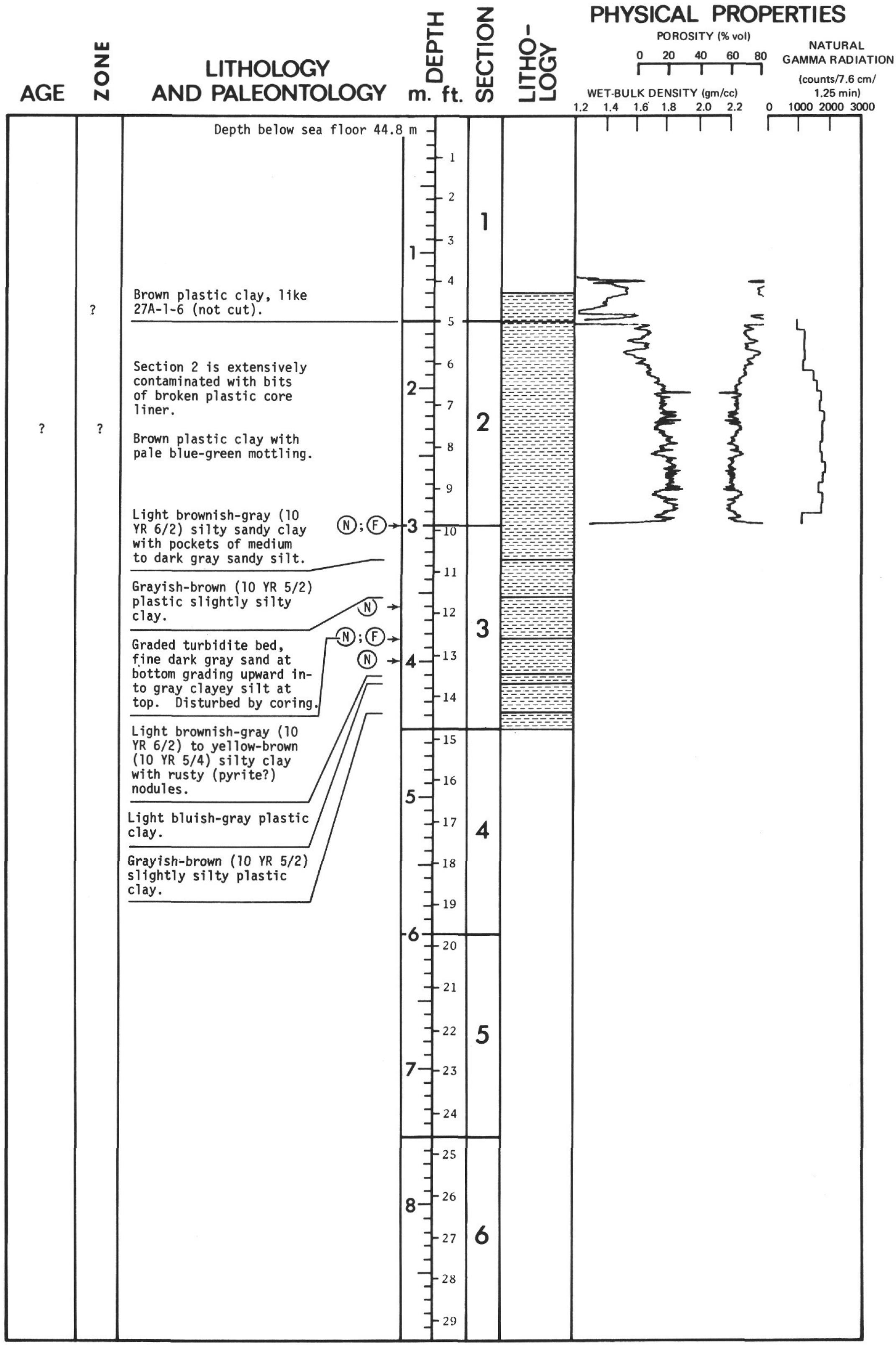

Figure 14. *Core 2, Hole 27A.*

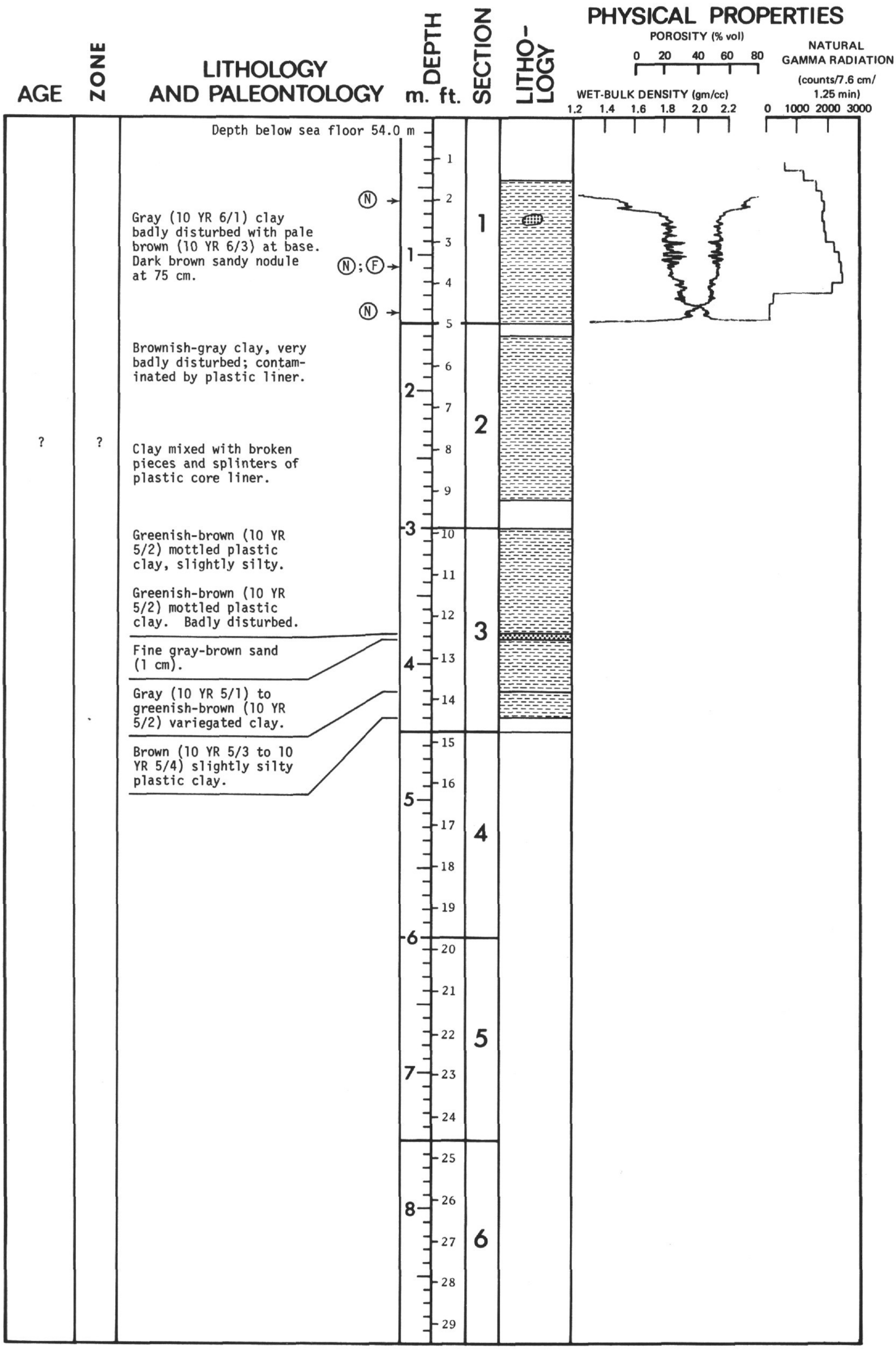

Figure 15. *Core 3, Hole 27A.*

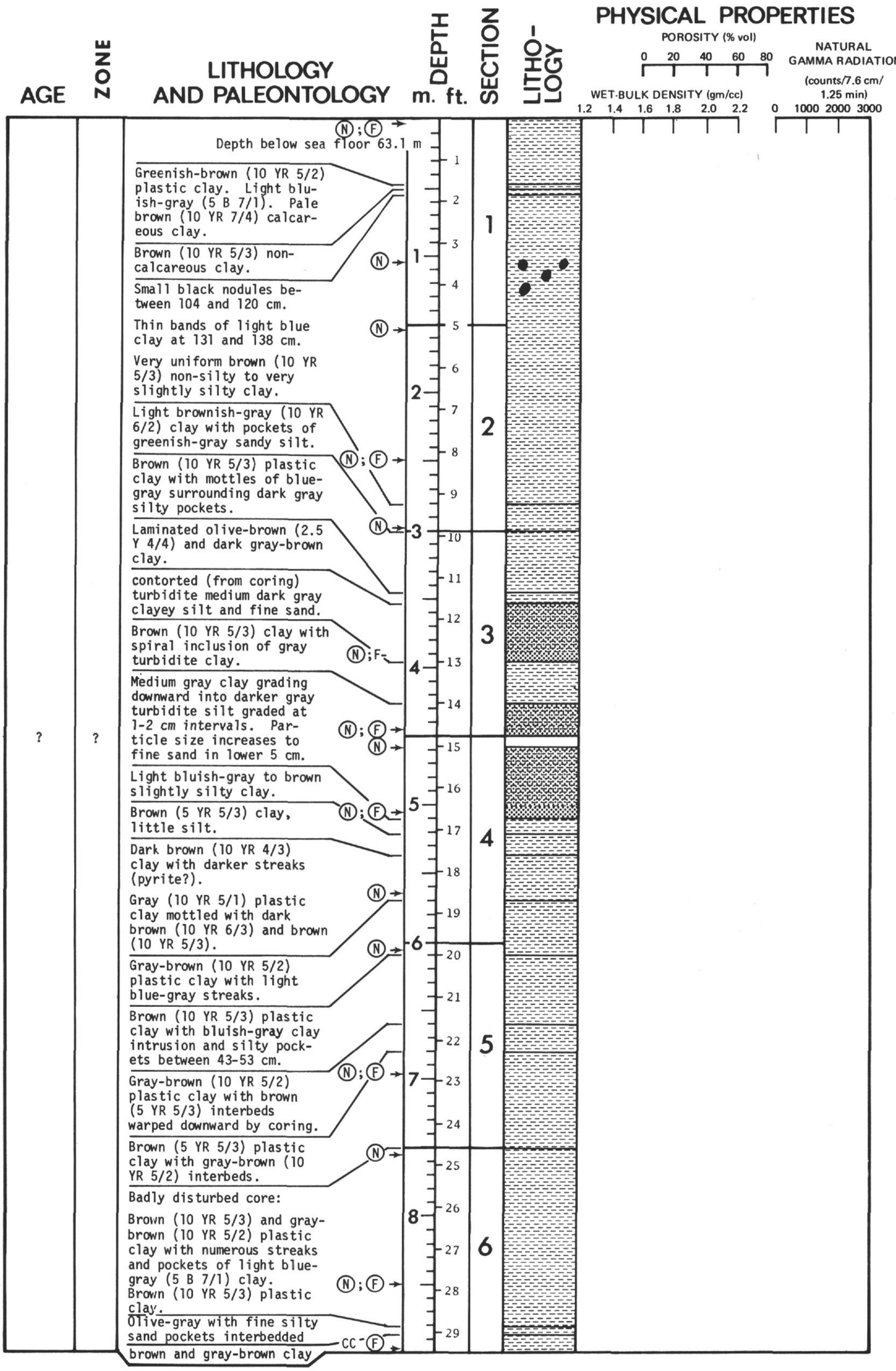

Figure 16. *Core 4, Hole 27A.*

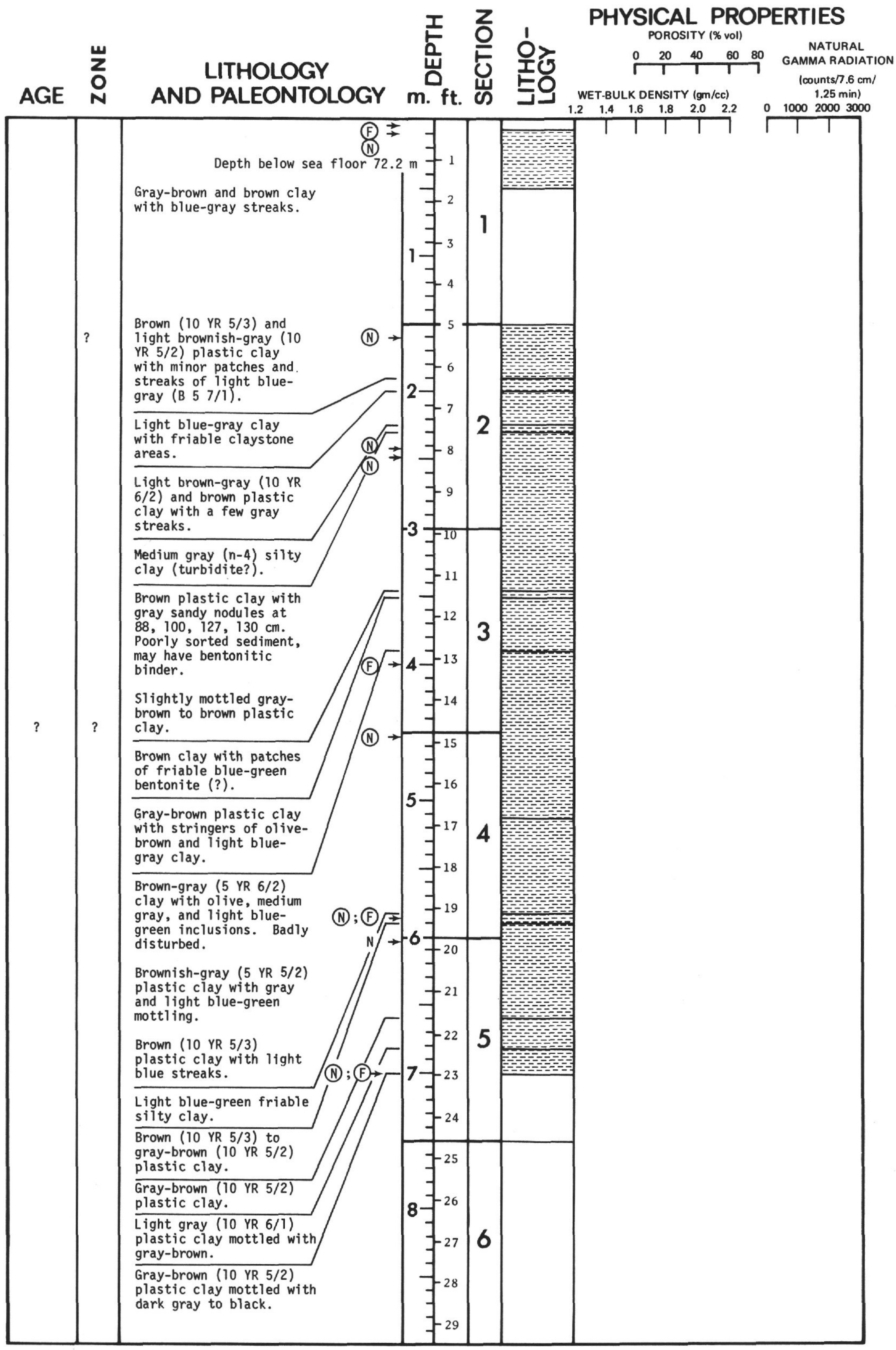

Figure 17. *Core 5, Hole 27A.*