5. SITE 26

The Shipboard Scientific Party[1]

SETTING AND PURPOSE

The crest of the Mid-Atlantic Ridge between 15°N and 5°S is offset to the east nearly 4000 kilometers through a series of fracture zones. One of the most prominent of these is the Vema Fracture Zone, a narrow east-west trending trough which cuts through the Mid-Atlantic Ridge at latitude 11°N. This feature was first described and named by Heezen *et al.* (1964), based upon surveys by ships of Lamont-Doherty Geological Observatory. It has also been surveyed by ships of Woods Hole Oceanographic Institution and of Scripps Institution of Oceanography (van Andel *et al.,* 1967).

Heezen *et al.* (1964) pointed out the seismically active nature of that portion of the Vema Fracture Zone (some 300 kilometers) between the displaced Mid-Atlantic Ridge crests. These Ridge displacements, which result from sea floor spreading, have been explained by Wilson (1965) as transform faults. Sykes (1967, 1968) has studied the shallow focus earthquakes in the fracture zones of the central Atlantic, and found the transform faults to be characterized by a predominance of right-lateral strike-slip motion on steeply dipping planes that strike east-west.

Gerard *et al.* (1962) reported a heat flow value of 2.6×10^{-6} cal/cm^2/sec in the floor of the valley near 41°W. This measurement taken near the eastern axis of the displaced Ridge crest, is typical of the high heat flows associated with mid-ocean ridges.

Figure 1, from Heezen and Tharp (1961), shows the location and nature of the major fracture zones of the central Atlantic. One striking feature of the fracture zones in this area is the extent to which they have been penetrated by the sedimentary fill of the adjacent Demerara Abyssal Plain on the west. The figure also shows the relationship between the Amazon Cone, building northeastward, and the Vema Fracture Zone, widening westward.

Both Heezen *et al.* and van Andel *et al.* discuss possible sources for the thick sediments (greater than 0.9 second reflection time) in the trough, suggesting that they might be: 1) local materials derived from the steep slopes of the surrounding ridge, or 2) turbidites of continental origin entering from the area of the Demerara Abyssal Plain to the east. Van Andel *et al.* conclude that "whatever its origin, a sediment thickness of approximately one kilometer represents, at this distance from the continent and in this water depth, a very long time interval, probably in excess of several tens of millions of years" (van Andel *et al.,* 1967, p. 349).

Heezen *et al.* consider the fracture zone valley to be a continuous feature passing through the Ridge and creating a deep channel for the passage of Antarctic Bottom Water from the western to the eastern Atlantic Basins. Van Andel *et al.* suggest that the trough is pinched off or blocked somewhere to the east of the area which they studied. Since the area as far east as 38°50′W longitude was surveyed by the earlier workers and revealed the presence of Antarctic Bottom Water and ripple marks on the ocean bottom, as well as winnowed near-surface sediments, it seems that the through-channel interpretation has more factual support. Coring the thick sediments of the valley floor was expected to obtain evidence of geological development of the zone over a long period, leading to information on the spreading history of the Ridge, transform faulting, and sedimentary processes.

SITE SURVEY

Because the region was relatively well known from previous studies with regard to the most favorable location for the site, no pre-site survey was conducted by the *R/V Vema.* Instead, *Vema* used the time to move on to the area of Site 27, where a greater need for survey data existed. Figure 2 based on earlier *R/V Vema* surveys shows the topography of the Vema Fracture Zone. The only survey accomplished at this location was that carried out by the *Glomar Challenger* in crossing the Vema Fracture Zone on its approach to Site 26. The reflection profile record obtained on a south-to-north crossing was of poor quality, but indicated a depth of

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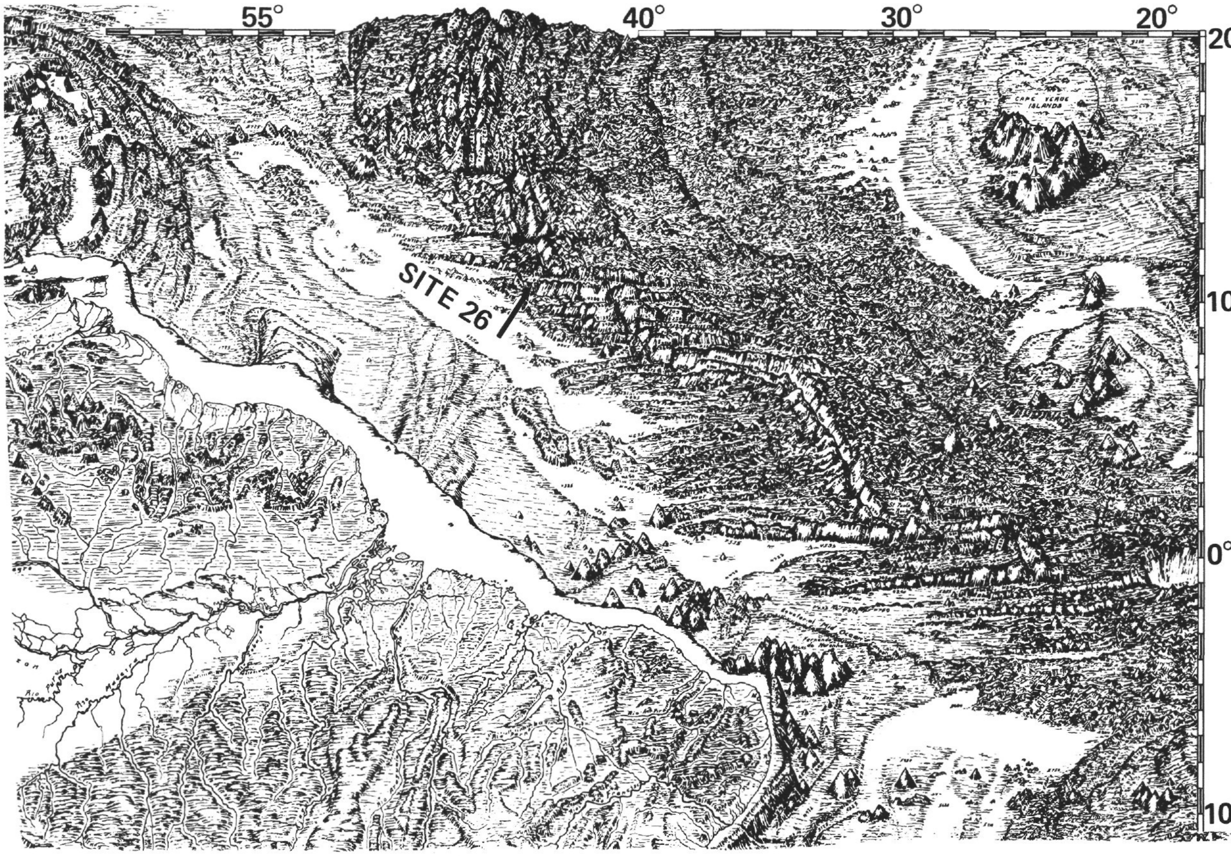

Figure 1. *Portion of Physiographic Diagram of the South Atlantic (Heezen and Tharp 1961) showing the location of Site 26.*

approximately one kilometer of sedimentary fill above basement rock in the narrow trough between the steep north and south walls of the fracture zone. Figure 3, from van Andel *et al.* (1967), is a reflection profile record along transect A-B (Figure 2), showing the nature of the sedimentary fill near the drilling site.

The *Glomar Challenger* approached the site on course 360°, crossing the steep south wall of the Vema Fracture Zone at 1230 hours on 14 February. The flat floor of the trough at 2826 fathoms extended for about five miles, until reaching the abrupt north wall. Near the south side of the flat-floored valley a sharp peak or spur, rising some 100 fathoms, was crossed. The presence of this feature and its deep subsurface extension required that the northern side of the trough be favored in order to drill to the deepest level. After crossing the north scarp, the air gun, hydrophones and magnetometer were hauled in; and, the ship returned to a position which showed the optimum drilling conditions on the initial crossing. An air-gun profiler record taken at this site after the ship had come on position shows a possible basement reflector at 1.05 seconds (two-way travel time), indicating a sediment thickness of about one kilometer (assuming a sound velocity of 1.8 to 1.9).

DRILLING AND CORING OPERATIONS

The *D/V Glomar Challenger* reached the position of Site 26 and dropped a PPM beacon at 1455 hours on February 14, 1969. The location was later determined by satellite fixes and celestial navigation to be 10° 53.55′N latitude by 44° 02.57′W longitude. This location is about 1.7 miles south of the north wall of the Vema Fracture Zone valley.

About twelve minutes after dropping the beacon—while it was free-falling to the bottom (having reached about

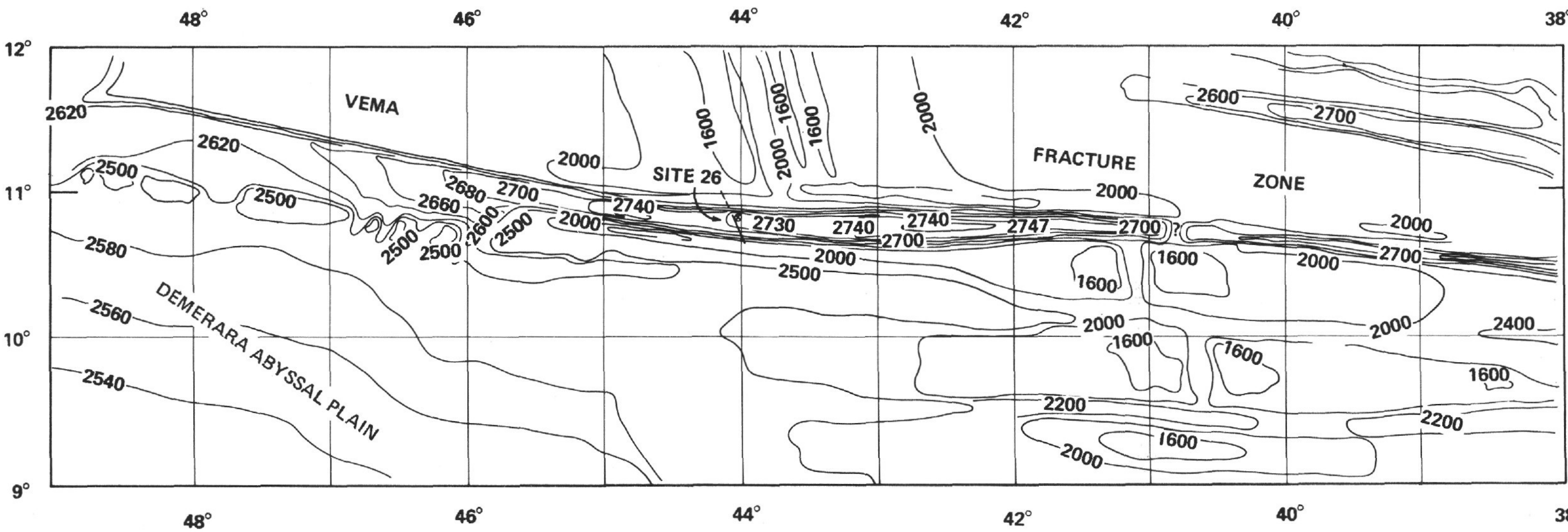

Figure 2. *Topographic chart of the Vema Fracture Zone showing the location of Site 26. Line A-B shows the location of the reflection profiler transect shown in Figure 3. Contours are in fathoms.*

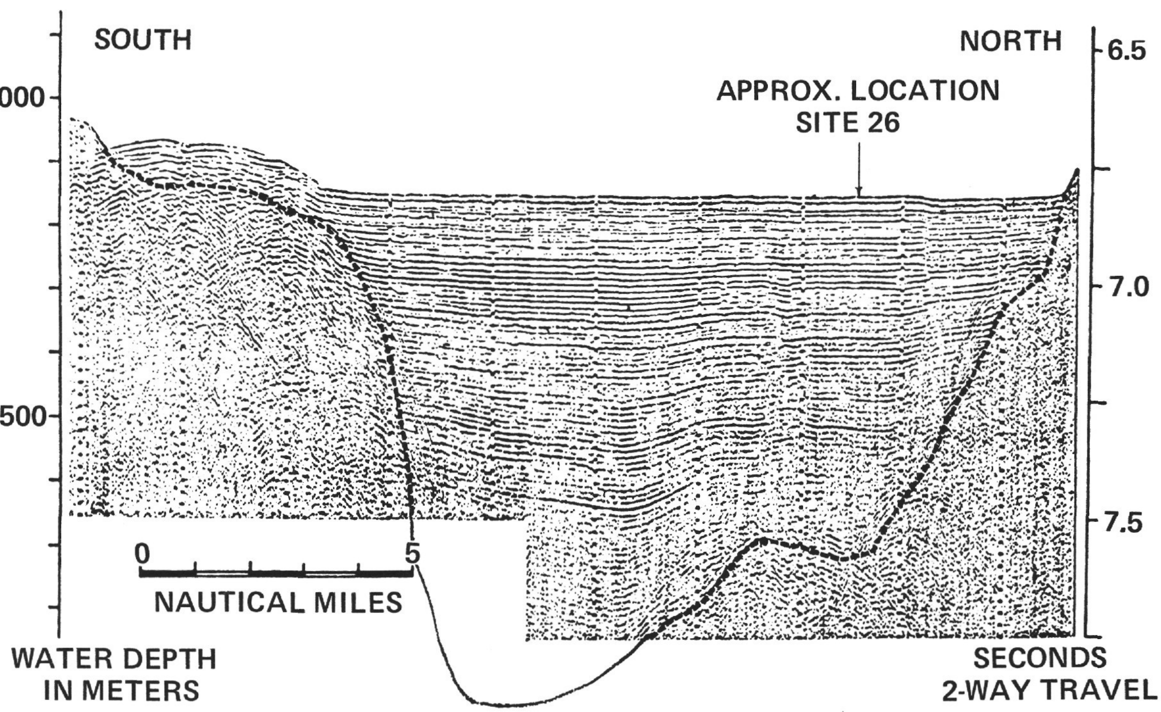

Figure 3. *Reflection profile section A-B (see Figure 2) across the Vema Fracture Zone (from van Andel* et al. *1967). The maximum thickness of sediment fill across this section is about 1 kilometer.*

1200 fathoms)—the signal changed abruptly, producing an envelope shape only marginally acceptable to the computer. For emergency purposes, a PCS beacon was dropped (from the position over the PPM beacon), and landed an estimated 1000 feet (328 meters) eastward of the ship's position.

The spud-in was made at 0900 hours on February 15 in 5168 meters (16964 feet, 2826 fathoms), and an attempt was made to take a surface core. The overshot became stuck while attempting to recover the core barrel, and after further attempts the sand line parted. The drill string was tripped back to the surface by midnight, only to find that the bottom hole assembly had broken on spudding, and the core barrel and three drill collars had been lost.

The drill string was started down again, reaching bottom at 1405 hours on February 16. The intervals drilled and the cores recovered at Site 26 are listed in Table 1. The first two cores, from the interval 96 to 114 meters (315 to 373 feet) in Late Pleistocene clay and turbidites, recovered an average of 30 per cent. Alternate coring and drilling followed. In attempting to retrieve a core in the 477 to 483-meter interval, the wire line parted. The drill string was again tripped, this time to about 1829 meters (6000 feet) below the drilling floor, at which time (1200 hours, February 18) the broken wire line was hauled out and the inner core barrel recovered. This core barrel, sent down without the usual plastic liner, showed 100 per cent recovery in hard clay and sand-silt turbidites. The core was extruded by the rod-piston method with considerable distortion. However, since the unlined core barrel seems to be a superior method of coring hard clay material, an improved piston extruding rod and sample tray holder were built for future use.

The drill string was sent down for Hole 26A and spudded in at 1630 hours on February 18. Drilling continued

TABLE 1
Core Recovered from Hole 26
(Using a Tungsten Carbide Bit)

Core	Drill String (m)	Penetration (m)	Core Recovered (m)
1	5186-5195	0-9	0

Cores Recovered from Hole 26A
(Using a Tungsten Carbide Bit)

Core	Drill String (m)	Penetration (m)	Core Recovered (m)
1	5282-5291	96-105	3.4
2	5291-5300	105-114	2.0
3	5415-5424	229-238	1.8
4	5587-5596	401-410	0.3
5	5663-5669	447-483	6.1
		Total	13.6

down to 610 meters (2000 feet) below bottom, reaching that level by noon on February 19. Attempts to core at this level were thwarted by an inability to recover the center bit used in drilling. The drill string again was tripped to the surface, and the tools laid down on deck at 0500 hours on February 20. It was then discovered that the outer barrel and one drill collar had been lost, probably twisted off while drilling the last 30.5 meters (100 feet). A sample of hard clay was taken from the inside junction of the broken bumper sub; this is assumed to be from the "hard layer" reached at about the time of twist-off. Also, a dense gray sticky clay was sampled from outside the lower sections of drill pipe at the junctions of the drill pipe and the rubber pipe protectors. The ship was underway for Site 27 at 0600 hours on February 20.

LITHOLOGIC SUMMARY

For detailed lithology and paleontology see Hole Summaries. (See pages 87-91).

The entire section penetrated in Hole 26 is of Quaternary age. Coring started at 315 feet (96.0 meters) below the floor of the ocean in beds of Late Pleistocene age, and stopped at 1586 feet (483.4 meters) in Upper Middle Pleistocene. The total sequence appears to consist of turbidity deposits. Medium to dark gray and olive-gray, slightly silty to very silty clays are interbedded with stringers of fine-to-medium and occasionally coarse sands. Some of the beds are clearly graded, silty sand at the bottom, grading to silty clay and, finally, clay at the top. Other sand beds have sharp contacts both at top and bottom. In one thin semi-indurated sand layer, at 1345 feet (410 meters), foreset and bottomset beds 1 to 2 millimeters thick occurred.

The clays range from nearly silt-free to very silty; most are slightly calcareous and have nanno-planktonic fossils. The silt content is largely fine-grained detrital quartz with small amounts of feldspar and micas. Glauconite and manganese pellets are present, but not abundant. Much of the dark color seems to be from organic matter.

The sand beds range from less than 1 centimeter to about 10 centimeters in thickness, and are fine-to medium-grained. Some coarse-grained samples were recovered from core catcher samples. The suite of detrital minerals is extensive. Quartz of several types is predominant; these types include clear, clear with hematite veinlets, clear with rutile, rose quartz, and minor amounts of milky and smokey quartz. The grains are angular to very well-rounded with little or no frosting. Muscovite is abundant; biotite and chlorite are common. Specular hematite is common in some of the coarser beds, especially those with large amounts of organic materials. Angular calcite and chalcedony are fairly common. The following heavy minerals are noted: pyroxene (probably augite), hornblende, zircon, tourmaline, apatite, beryl, barite or gypsum, monazite, jadeite? and corundum?. A small number of grains are fragments of schist. It is noteworthy that, except for one questionable grain of olivine, none of the sediments seem to be derived from the adjacent scarps of the fracture zone. The hematitic quartz, rose quartz, beryl and corundum suggest an Amazon provenance.

Material of organic origin is present in all sand beds. In some the organic fraction consists largely of foraminifera; but in others, especially those with coarser grain size, the foraminifera are eclipsed by large volumes of organic "trash". This material is mostly plant remains, well-preserved, in which the structure is clearly visible and which is combustible when dry. Also present are pieces of woody plant material, seed pods and some amber. Some of the wood, especially from the deeper beds, has been replaced by pyrite, and limonite or hematite. Several small crustacean legs were seen.

A twist-off at the top of the core barrel assembly prevented coring in Hole 26A, but it was drilled to about 2000 feet (609.6 meters) below the sea floor, some 400 feet (121.9 meters) deeper than Hole 26. Sandy mud up to one-half inch thick coated some of the lower part of the drill string. As it is lighter in color and since it contains pebbles of sandstone not found in the cores from Hole 26, the authors presume that it was picked up somewhere between 1600 and 2000 feet (487.7 and

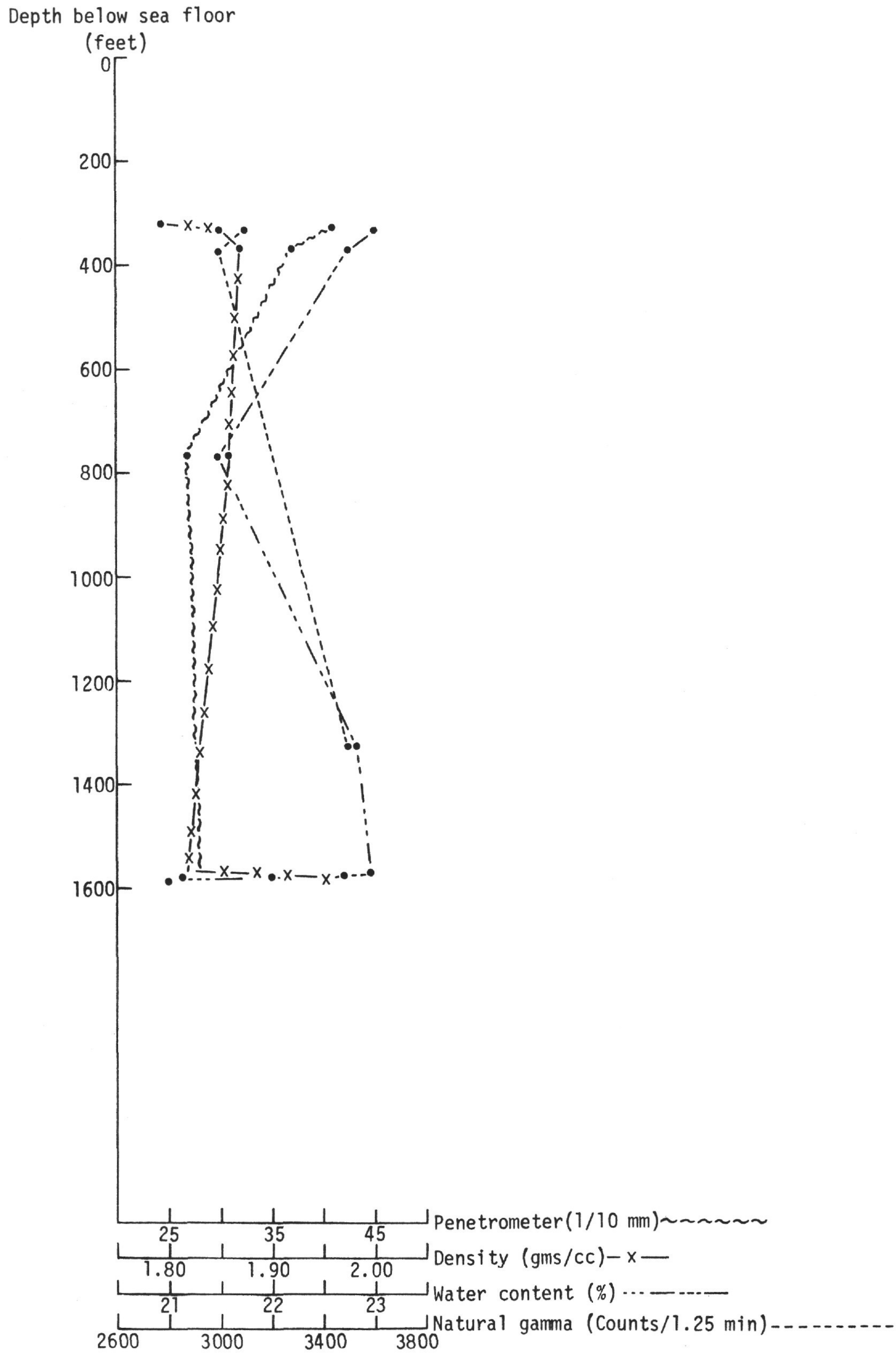

Figure 4. *Summary of physical properties, Site 26.*

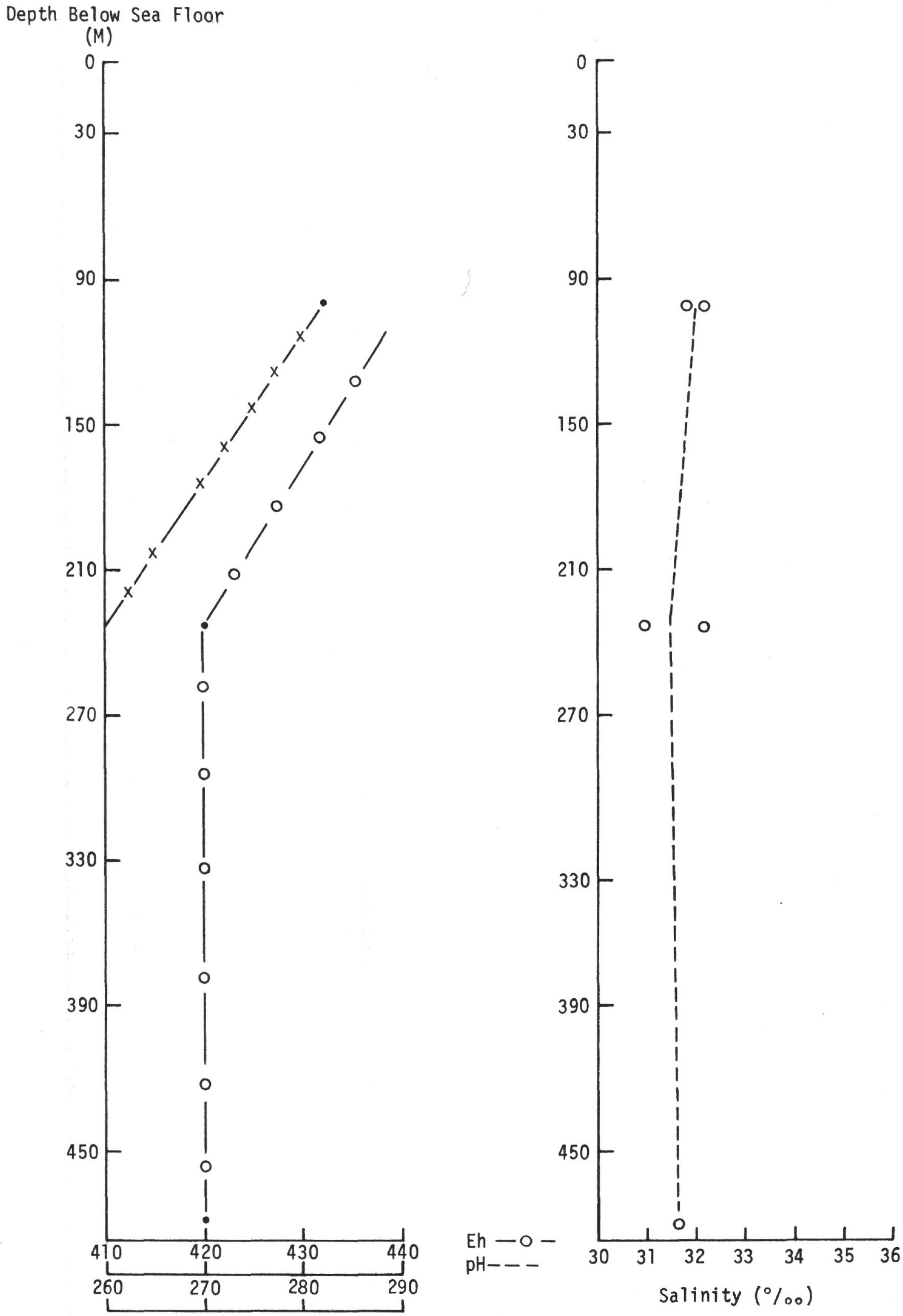

Figure 5. *Summary of chemical properties, Site 26.*

609.6 meters). The coarser fractions contain a mineral suite and organic remains identical to those found in the sand beds of Hole 26, the only different material being the pebbles and one small (1 millimeter long) gold nugget. The pebbles are micaceous siltstone and sandstone, light-gray, pink and orange-red in color. A few of the larger sandstone pebbles contain Pleistocene foraminifera. The pebbles might be fragments of lithified beds, rounded by the drilling, but they are quite abundant, very well-rounded and of various sizes down to that of coarse sand. More likely they are derived from erosion of Pleistocene beds of the Amazon delta on the continental shelf. The erosion may have been submarine turbidity currents or may have been by streams during a glacial stage when sea level was lowered.

PHYSICAL AND CHEMICAL PROPERTIES

The sediments cored at Site 26 are clays interbedded with turbidite sands. The natural gamma-radiation from these sediments is unusually high, particularly so for sediment containing such a high proportion of silt and sand (gamma values range from 3100 to 3400 counts/1.25 min.). These values are considerably higher than any found previously on Leg 4 for pure clays (25 to 35 per cent higher). The mineralogy differs noticeably from that found at previous sites, particularly in the quantity and variety of translucent heavy minerals. This is a possible source of the high gamma-radiation, but it does not seem very likely. The organic content of these sediments is commonly four to five times greater than that found in sediments from other sites. Uranium and thorium are commonly associated with organic debris; this seems the most likely source for the unusually high gamma-radiation levels found at this site.

Densities range from 1.78 to 1.97; water contents range from 30.3 to 20.9 per cent; and porosities range from 52.5 to 39.3 per cent (see Figure 4). The large drop in water content at the bottom of the hole is probably an artifact introduced by contamination of Section 5-1; the same is probably true for Section 4-1. This will, of course, be reflected in the density calculations. The density measurements of 1.95 and 1.97 gm/cc and the water contents of 21 to 22 per cent at the bottom of the hole ought to be taken as representative of the sediment from these depths. Sonic velocities range from 1520 to 1686 m/sec, and increase as density increases.

The carbonate content of the sediment averages only 2.0 per cent, which is consistent with the proposed turbidite origin of the deposits. The organic carbon content ranges from 0.4 to 0.7 per cent, averaging 0.5 per cent.

The interstitial solutions from Site 26 differ markedly from those found at previously drilled sites. All of the pore solutions are characterized by salinities well below surface sea water and they range from 31.1 to 31.9 per cent (see Figure 5). Three possible explanations suggest themselves. The area is active geologically and the introduction of "juvenile" water is a possibility; however, it does not seem very probable. The low salinities may represent paleosalinities, but this seems still less likely as they are too low (on the basis of volumetric calculations) to be produced during glacial minima, and as there is no indication of such salinities from other published data. A more probable source is the oxidation of some of the organic matter to produce water. Such a reaction would require the production of carbon dioxide as well; unfortunately, no sampling for gas analysis was done (see Site 30 report). Three *p*H measurements were made (7.82, 7.60, 7.80; see Figure 5). These values are similar to those values found at previous sites; this belies a high carbon dioxide content although, as can be seen in the *p*H-carbon dioxide data from Sites 27 through 30, there is often no obvious correlation between *p*H and carbon dioxide. Eh values for these solutions fall in the range 420 to 440 millivolts (Figure 5), which is somewhat lower than usually found.

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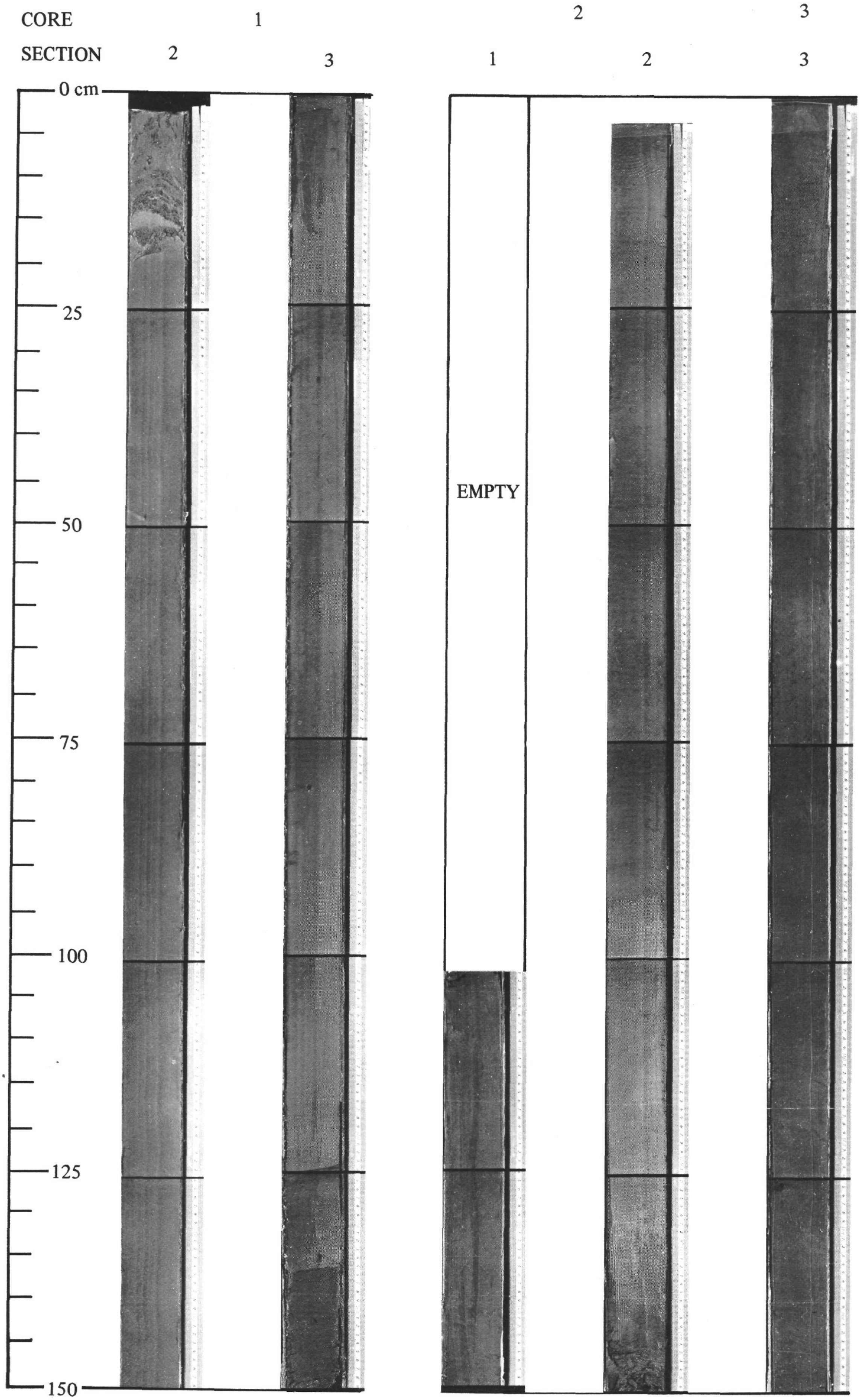

Plate 1. *Cores 1, 2 and 3, Hole 26.*

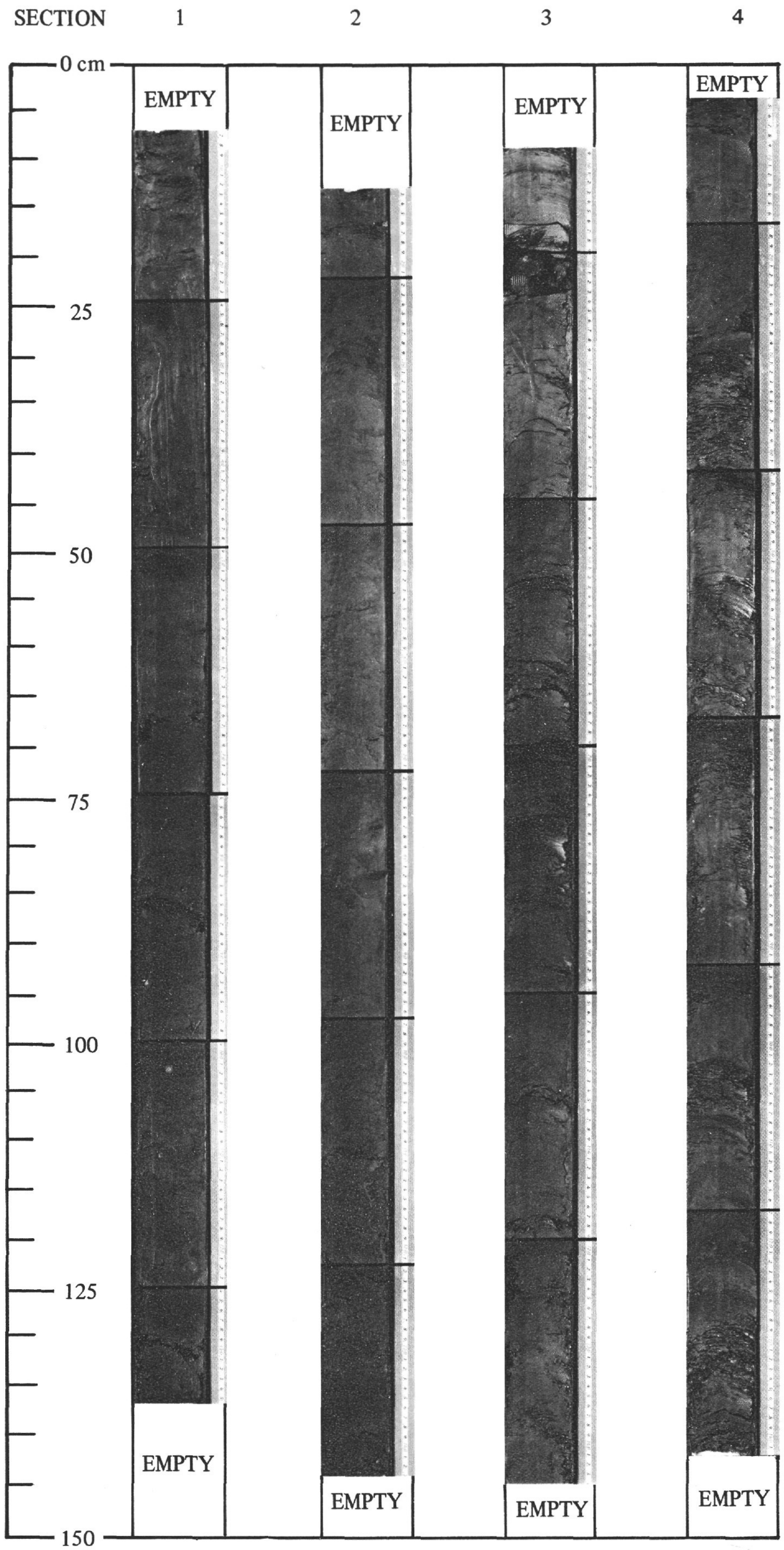

Plate 2. *Core 5, Hole 26.*

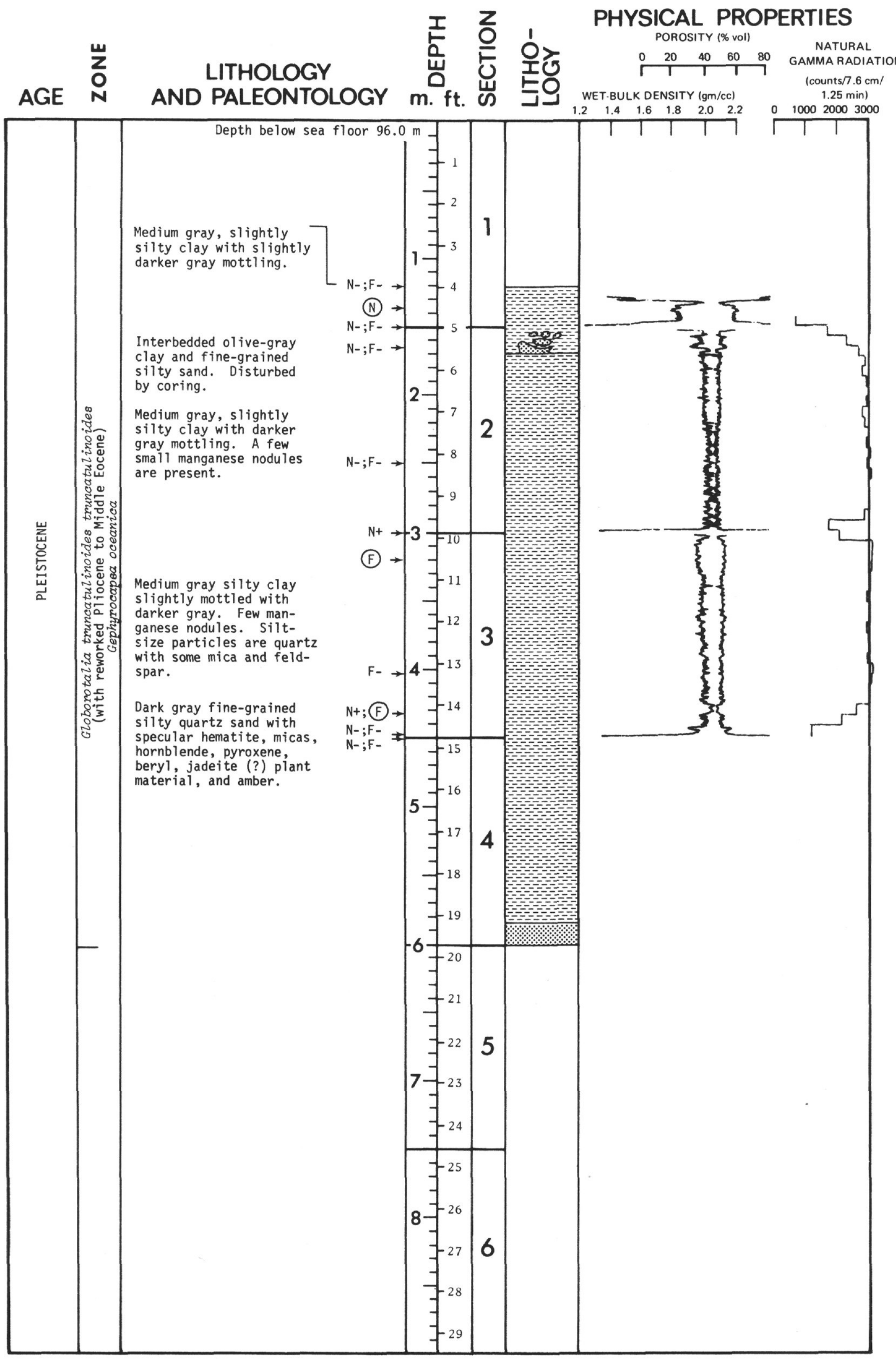

Figure 6. *Core 1, Hole 26.*

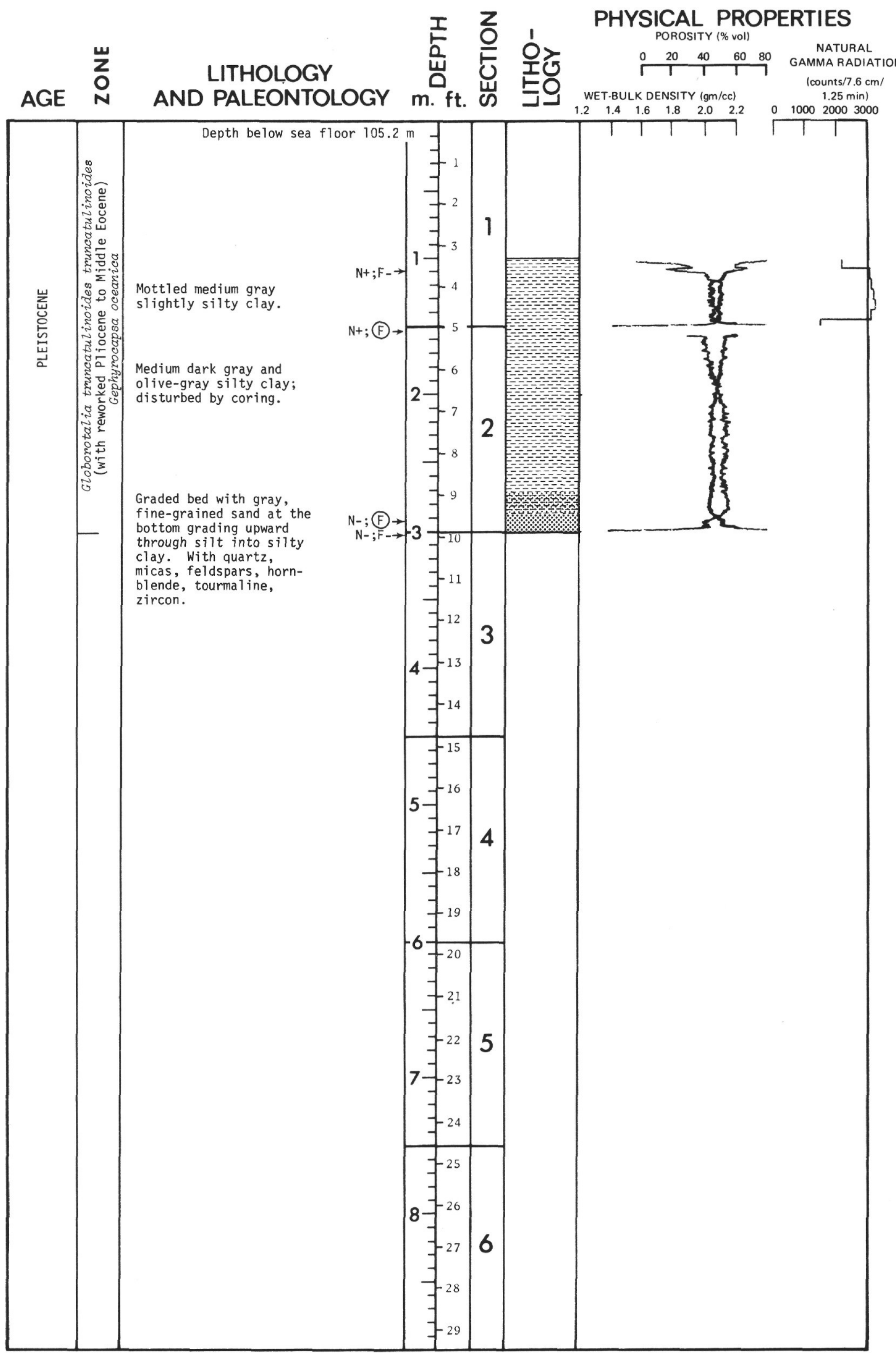

Figure 7. *Core 2, Hole 26.*

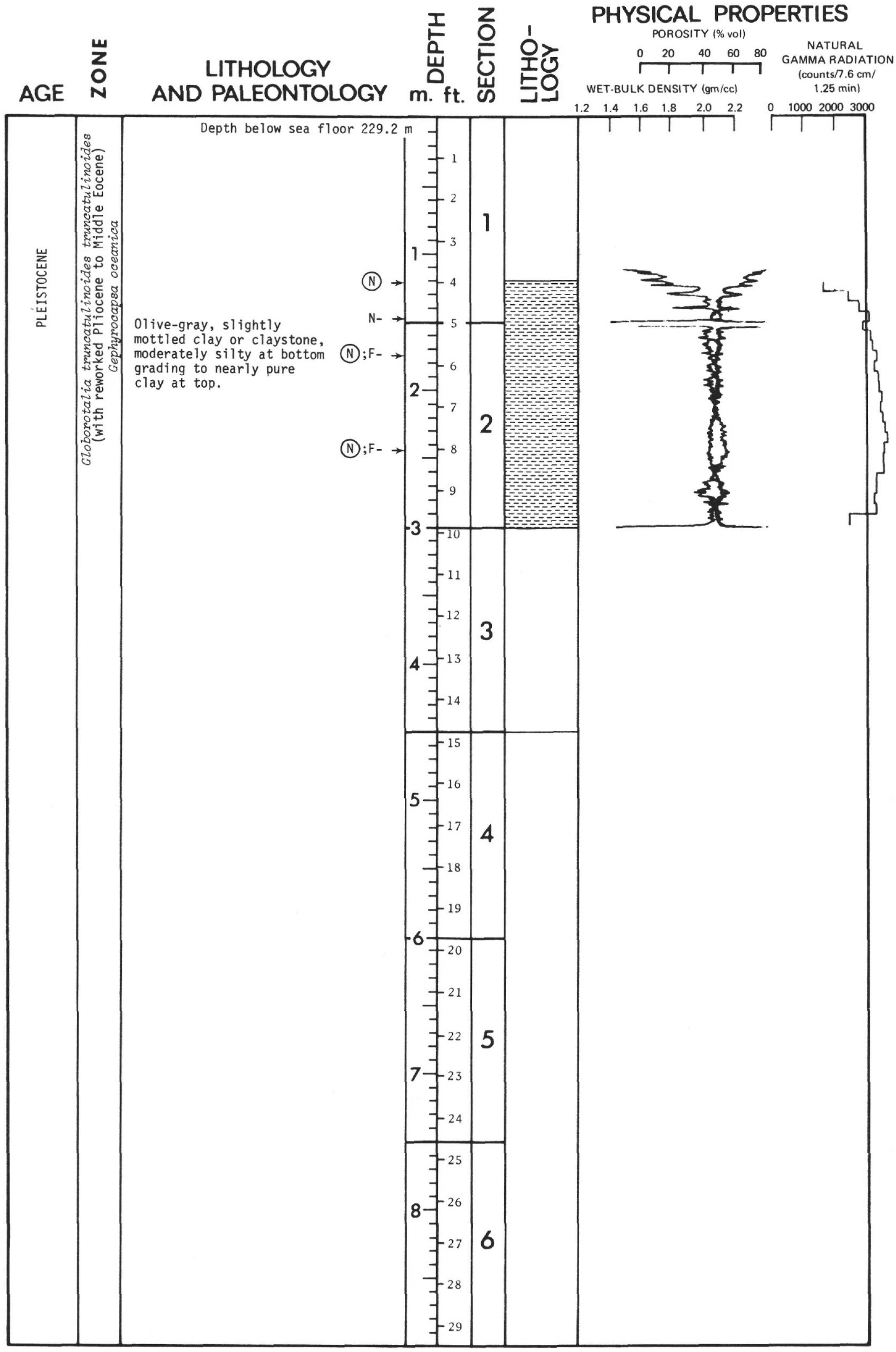

Figure 8. *Core 3, Hole 26.*

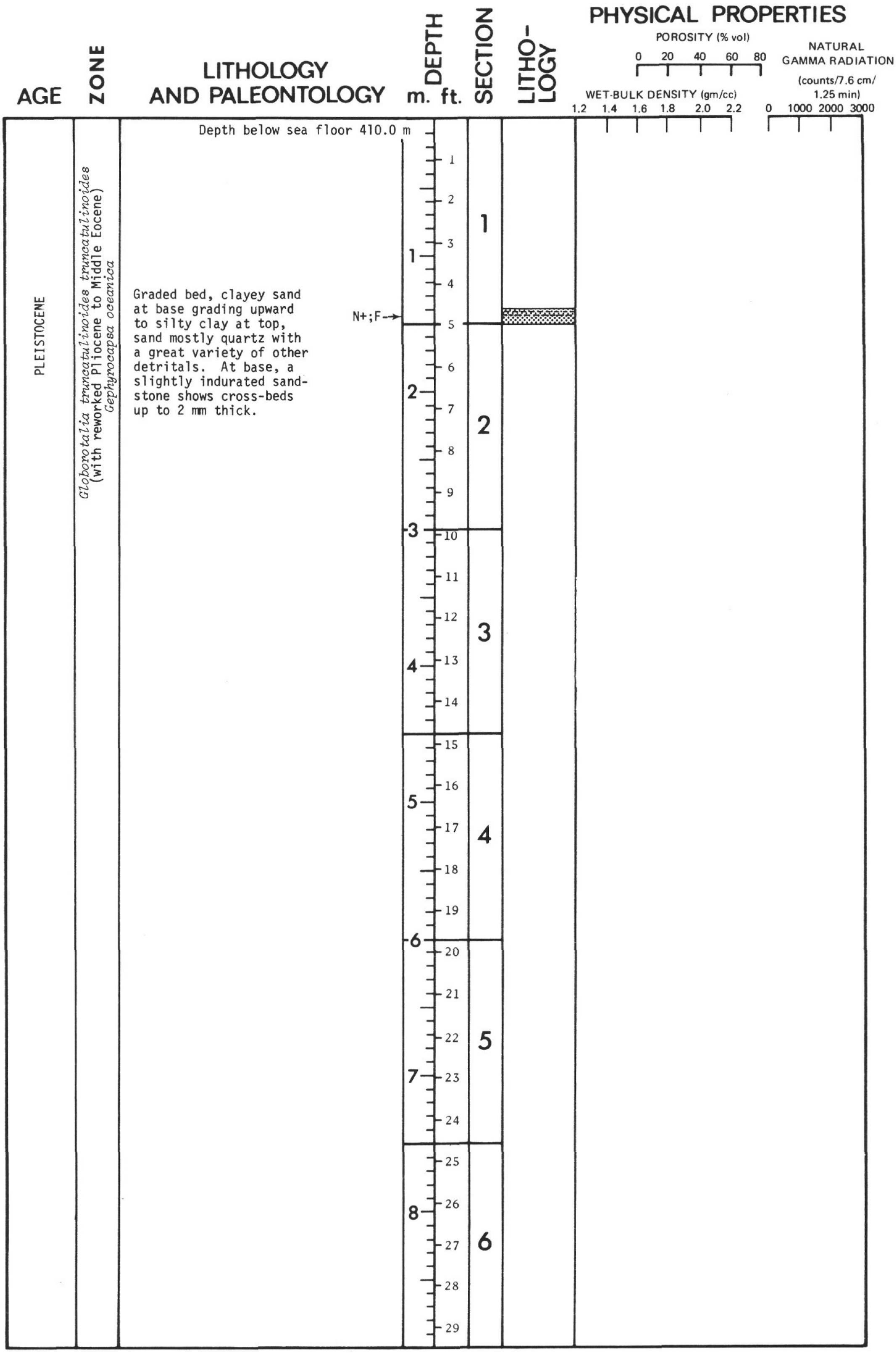

Figure 9. *Core 4, Hole 26.*

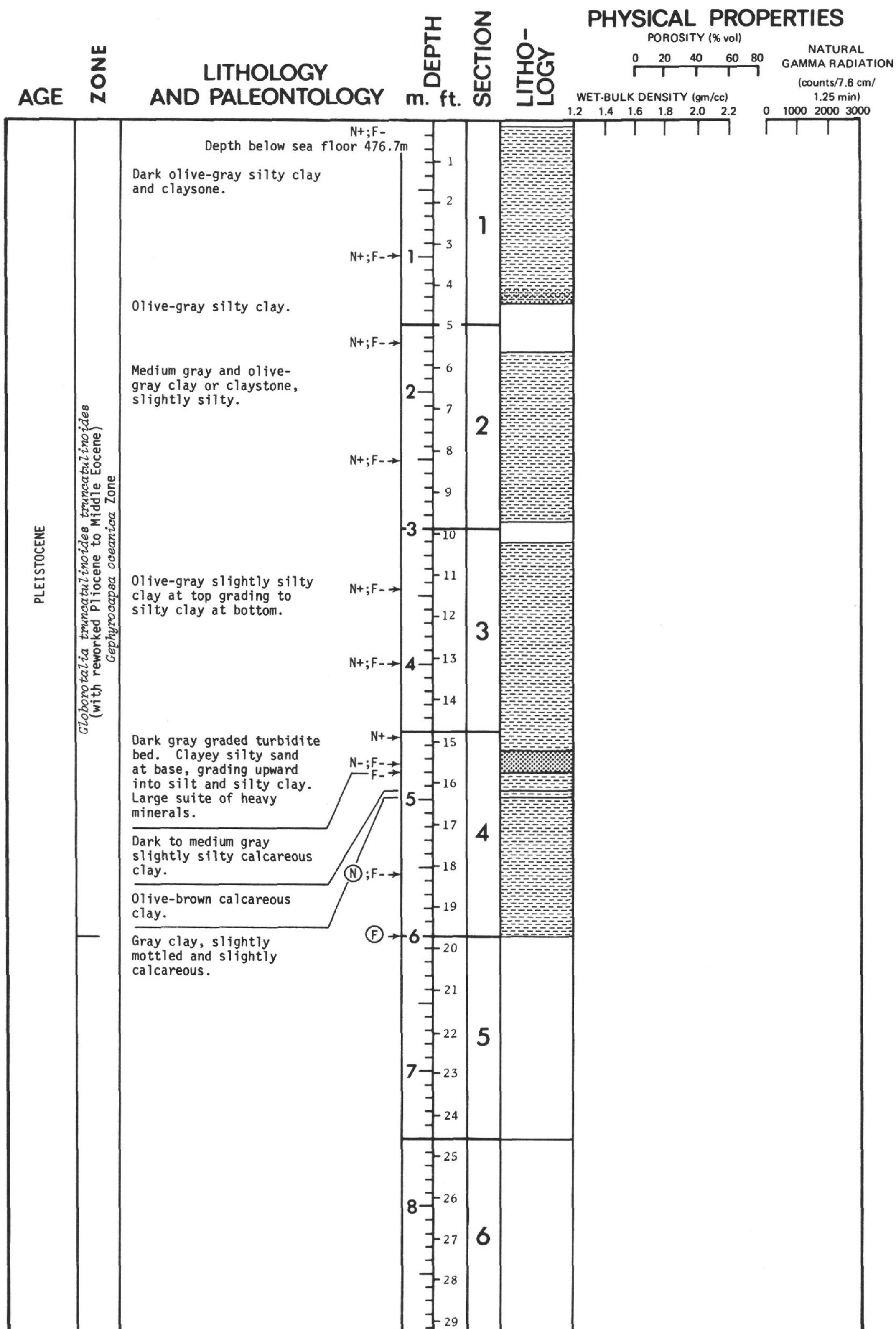

Figure 10. *Core 5, Hole 26.*