9. SITE 30

The Shipboard Scientific Party[1]

SETTING AND PURPOSE

The main goal for Site 29, that of obtaining a complete biostratigraphic sequence of pelagic foraminifera and calcareous nannofossils in the upper Carib beds (sediments above Horizon A″), was not realized due to the paucity of carbonate in the post-Eocene sediments in the deeper parts of the Venezuelan Basin. For this reason a nearby site at a higher level, which would certainly have remained above the carbonate compensation depth since the Cretaceous, was required to fulfill the biostratigraphic goals.

This site lies on the Aves Ridge in an area which should correlate with the well-known stratigraphy of the nearby Barbados, Trinidad and Margarita sections. The Aves Ridge or Swell, with crestal depths about 500 fathoms, parallels the Lesser Antilles island arc and separates the Grenada Basin on the east from the Venezuelan Basin on the west. Reflection profiler records crossing the Ridge show the eastern and western flanks draped with sediments which are apparently continuous with those in the basins on both sides. On the Grenada Basin side, the sediments descending from the Ridge appear to be buried by turbidite sediments in some places. The sediments on the Ridge flanks resemble the Carib beds of the Venezuelan Basin, both in character and thickness. From geophysical measurements, the Aves Ridge is believed to represent a deformation of the crust by warping under stress of sea-floor spreading, accompanied by intrusive or near-surface volcanic activity suggested by magnetics studies of the area (Edgar, 1968). Geophysical studies suggest that the Aves Ridge appears to show a common positive gravity axis with the Dutch West Indies and may have been elevated in early Tertiary time (Ewing, Talwani and Ewing, 1965). Dredging results from depths of 1000 to 2000 meters from the western slopes of the Aves Ridge (Fox *et al.*, 1970) indicate that grantic rock having compressional wave velocities of about 6 km/sec underlies the Ridge, and probably corresponds to the 6.0-6.3 km/sec upper crustal layer of the Colombia and Venezuelan Basins. Dredge samples between 400 and 1400 meters along the Aves Ridge reveal Eocene and Miocene faunal assemblages, indicative of a carbonate-rich shelf depositional environment, while other samples contain late Miocene and Pliocene-Pleistocene material deposited in deep water.

A single profiler track crossing the Ridge was available to guide in the selection of a drilling site. This record was made aboard the *R/V Thomas Washington* in 1966, and was submitted by the late Dr. Harry Hess to the JOIDES Atlantic Advisory Panel just prior to the departure of Leg 4. The record shows relatively flat-lying beds on the eastern flank of the Ridge overlying a rough basement. The thickness of the upper "transparent" sediment layer is variable, but generally thicker (0.45 to 0.85 second) than that observed at the last site. Below this horizon, semi-transparent beds overlie a moderately rough "basement".

SITE SURVEY

The only survey operations at Site 30 were those carried out aboard the *Glomar Challenger.* The approach to the site (Figure 1) on the morning of March 16 along the track of the earlier profiler record (course 117°) revealed a profiler section similar to that of the *R/V Thomas Washington* (Figure 2A). An on-site profiler record was also made which revealed a section similar to that recorded in the underway corssing of the area. Figure 2B illustrates the profiler record obtained at this site. Problematical reflectors are seen between 0.40 and 0.60 second subbottom. The upper part of this zone would appear to correlate with the boundary between the soft calcareous clays of Pliocene age and the more indurated Miocene sediments sampled below 350 meters (1148 feet). A strong reflector at 0.85 second–700 to 800 meters (2297 to 2625 feet) below bottom–probably corresponds to the A″ Horizon.

DRILLING AND CORING OPERATIONS

At 0830 hours on March 16, after passing a few miles beyond the proposed site location and reaching the steep portion of the eastern slope of the Aves Ridge, the *Glomar Challenger* slowed to retrieve gear being

[1]Richard G. Bader, Institute of Marine and Atmospheric Sciences, University of Miami, Miami, Florida; Robert D. Gerard, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York; William E. Benson, National Science Foundation, Washington, D. C.; Hans M. Bolli, Swiss Federal Institute of Technology, Zurich, Switzerland, William W. Hay, Institute of Miami, Miami, Florida; W. Thomas Rothwell, Jr., Atlantic Richfield Company, Dallas, Texas; Michael H. Ruef, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; William R. Riedel, Scripps Institution of Oceanography, La Jolla, California; Fred L. Sayles, Woods Hole Oceanographic Institution, Woods Hole Massachusetts.

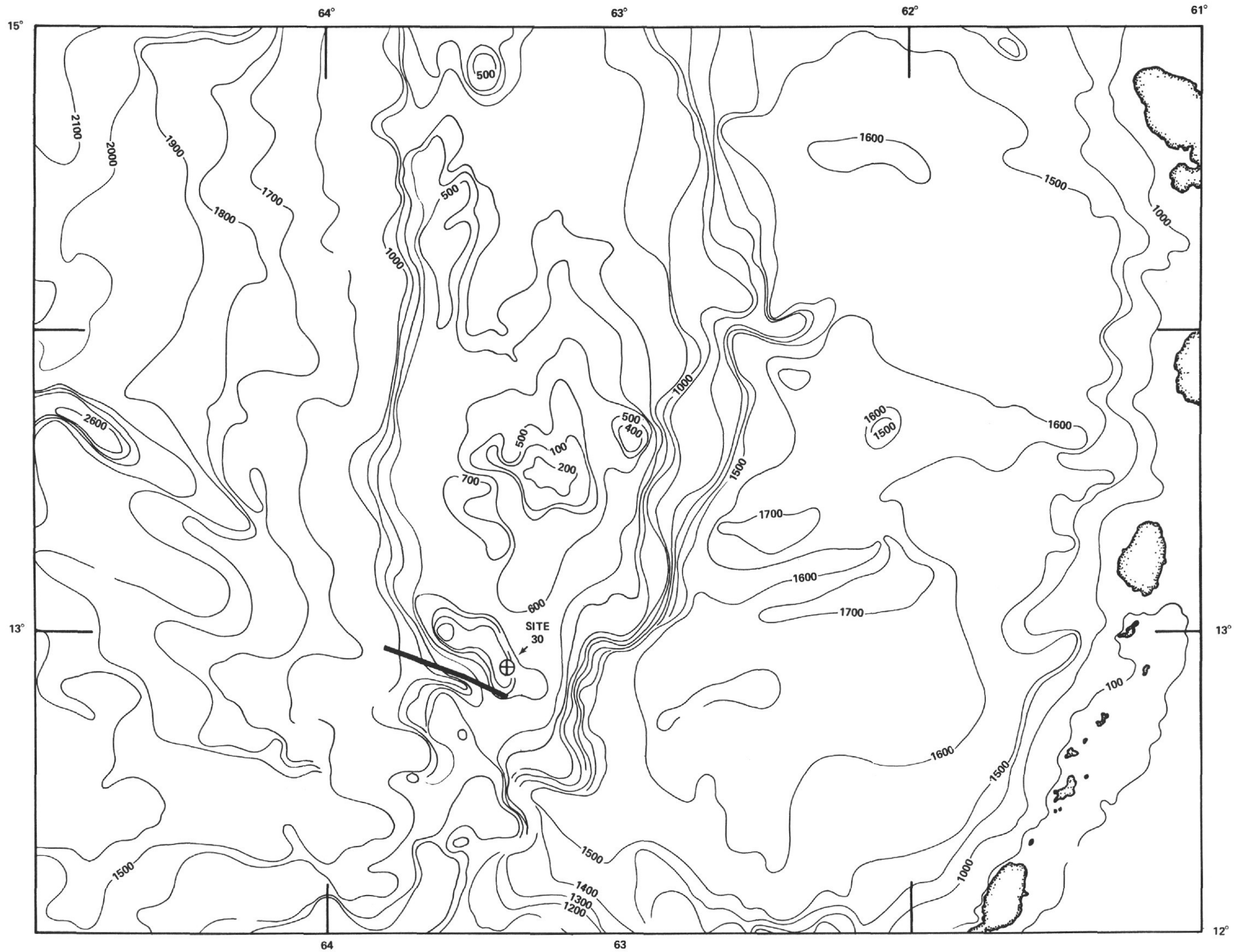

Figure 1. *Topographic contour chart of the Aves Ridge area showing the location of Site 30 and the location of a* Glomar Challenger *reflection profiler (see Figure 2) taken along the site approach track. Topography from U. S. Navy Hyrdographic Office Chart BC-0703N.*

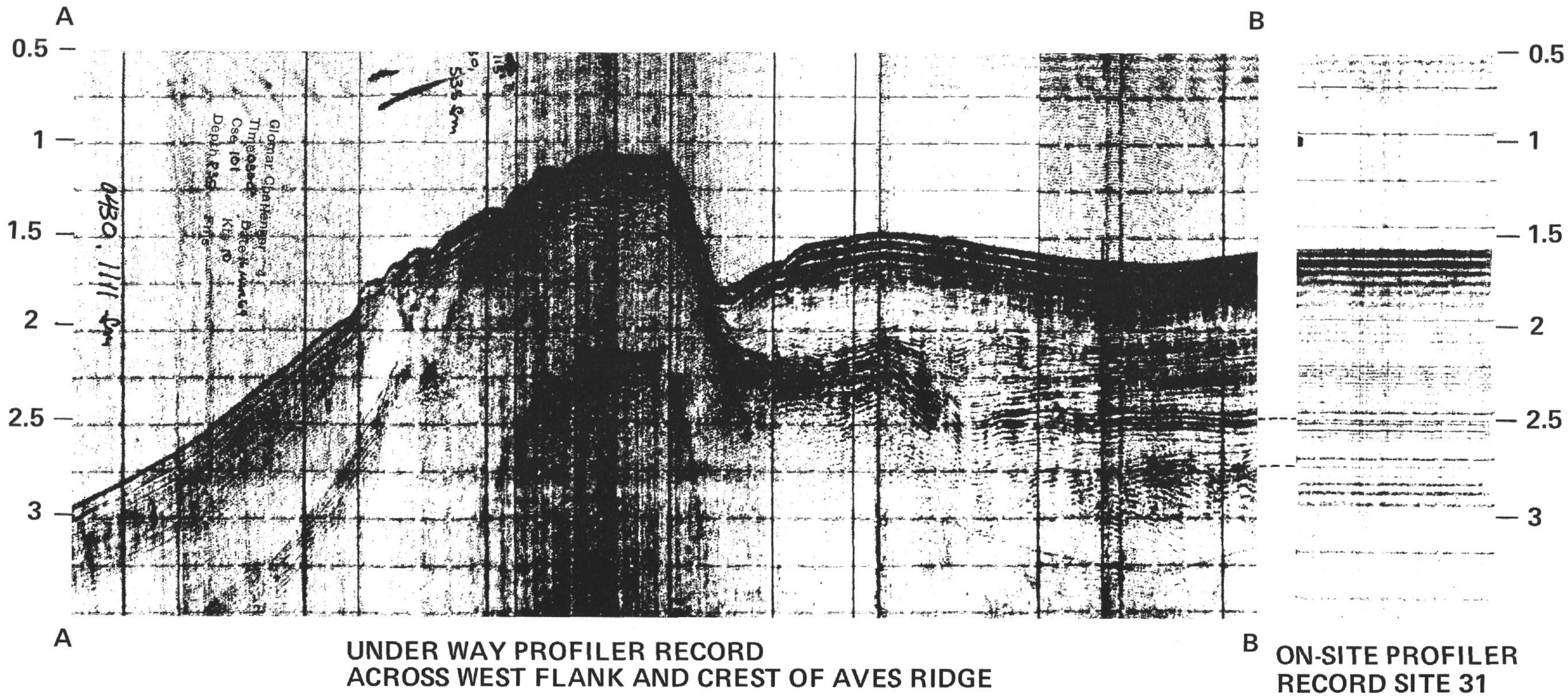

Figure 2A. *Reflection profiler record taken aboard* Glomar Challenger *while approaching Site 30 (left side of figure).*

Figure 2B. *On the right is a section of an on-site reflection profiler record at Site 30 showing subbottom reflectors which appear to coincide with the deep reflectors observed on the underway record.*

towed and then attempted to return to the selected location. Due to strong currents (2.5 to 3 knots) and a poor series of satellite navigator passes, it was noon before a suitable position was found.

At 1200 hours, two beacons (PCS and PPM) were dropped, but they soon went out, presumably due to entanglement of the two transducer cables. It was then necessary to move the ship in order to avoid interference should the first beacons come to life.

Accordingly, a new location was found in 662 fathoms (1211 meters; 3973 feet) using topography as a guide. A PPM beacon was dropped at 1400 hours, but the large amount of thrusting needed to hold position caused noise and "quenching" of the signal, which made for a marginal beacon. The PPM beacon was first thought to be unstable due to fading of the signal. Adjustment of the ship's heading and use of the thrusters improved the "quenching" problem, and the pipe was put down and spudded in at 1800 hours in 662 fathoms (1211 meters) of water. Continuing beacon signal problems accompanied the drilling at this site. The shallow depth (which limited the area of beacon signal at the surface) and the strong current, which probably extended to bottom and caused tilting of the buoyant transducer, contributed to the difficulties.

Coring and drilling progressed alternately to a depth of 430 meters (1411 feet) (see Table 1). Core recovery amounted to 45 per cent of the 133 meters (436 feet) attempted. The plan was to sample all of the Miocene section, log the hole, and then redrill to further sample in the upper Pliocene and Pleistocene layers. However, at 1815 hours on March 17, the beacon signal had become too marginal for safe operations, and the drilling at this site was terminated. The drill string was clear of the bottom at 1914 hours, and all tools were laid down by 2245. The ship was under way for the next site by 2300 hours.

LITHOLOGIC SUMMARY

For detailed lithology and paleontology see Hole Summaries. (See pages 226-241).

After drilling through the surficial sediments, coring was started at a depth of 165 feet (50.3 meters) in the sediment (Core 1, from 165 to 195 feet–50.3 to 59.4 meters. Core 2, from 196 to 225 feet–59.4 to 68.6). The sediments recovered are green-gray calcareous clays, and the cores are very fluid, with some sections essentially liquid. There are a few layers of fine foraminiferal ooze, but these cores are highly disturbed by the coring process. The calcareous nannoplankton and planktonic foraminifera indicate a Late Pleistocene age.

Cores 3 and 4 were drilled between 353 and 413 feet (107.6 and 125.9 meters) beneath the sea floor, and recovered green-gray soft silty calcareous clays. The calcareous plankton date these sediments as Middle-Early Pliestocene.

TABLE 1
Cores Recovered from Hole 30
(Using a Tungsten Carbide Bit)

Core	Drill String (m)	Penetration (m)	Core Recovered (m)
1	1271-1280	50-59	7.0
2	1280-1289	59-69	5.2
3	1328-1337	108-117	5.2
4	1337-1347	117-126	1.8
5	1385-1394	164-174	3.0
6	1394-1399	174-178	4.6
7	1481-1490	260-269	1.5
8	1539-1548	318-327	1.8
9	1586-1596	366-375	3.7
10	1596-1605	375-384	3.0
11	1605-1614	384-393	7.6
12	1614-1623	393-402	4.6
13	1623-1628	402-407	3.0
14	1628-1633	407-412	1.5
15	1633-1642	412-421	7.0
16	1642-1651	421-430	1.2
		Total	61.7

Cores 5 and 6 were drilled between 539 and 585 feet (164 and 178.3 meters) beneath the sea floor, and recovered slightly more indurated green-gray silty clays, again of Early Pleistocene age.

Core 7 was drilled between 853 and 883 feet (260.0 and 269.1 meters) beneath the sea floor, and contains similar but slightly more compact sediment of Late Pliocene age.

Core 8, drilled between 1043 and 1073 feet (317.9 and 327.1 meters) beneath the sea floor, again contains green-gray silty clay of Late Pliocene age.

Cores 9 through 16, representing the sediment between 1200 and 1411 feet (365.8 and 430.1 meters) beneath the sea floor, contain gray siltstones with up to 20 per cent clay content. There are small amounts of volcanic ash in the fine sand fraction of these sediments, and

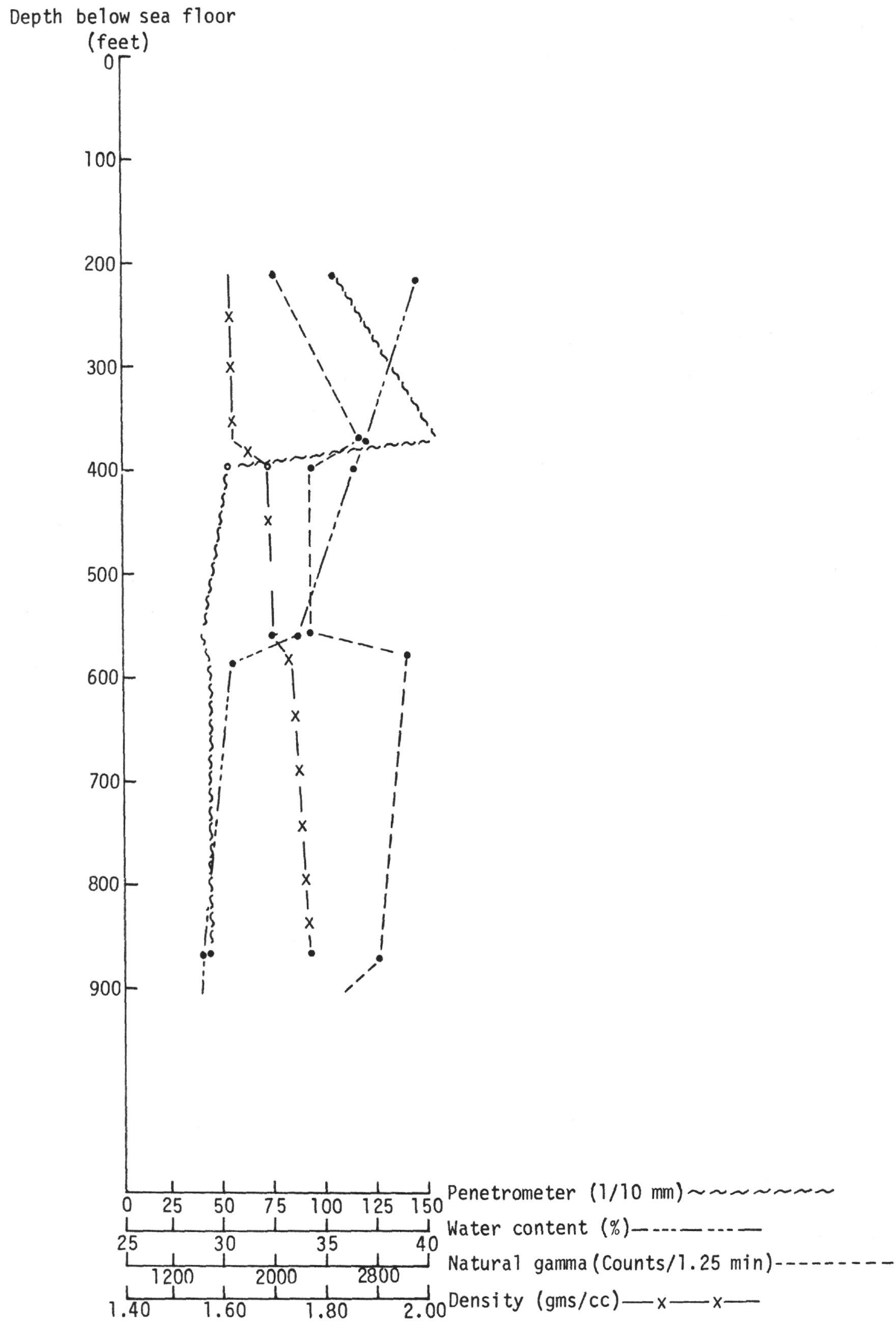

Figure 3. *Summary of physical properties, Site 30.*

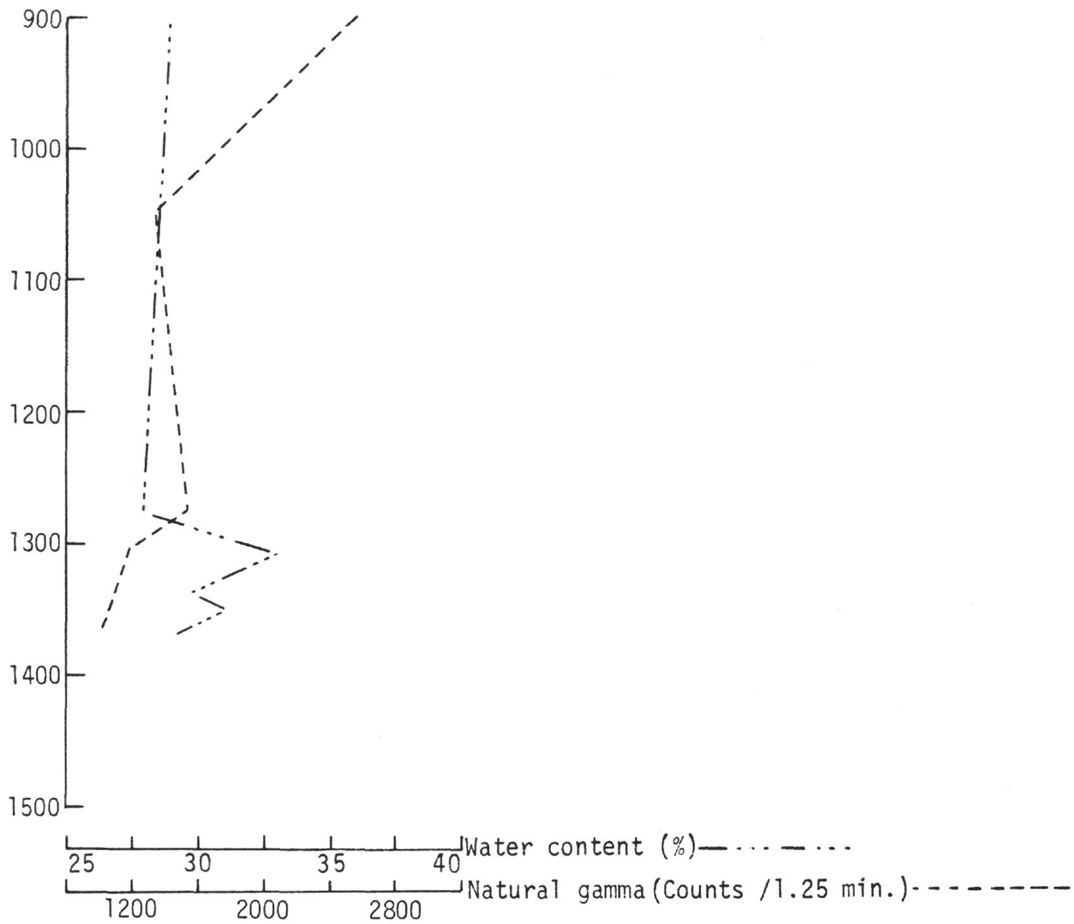

Figure 3. *(Continued)*

TABLE 2
Thermal Conductivity Data

Hole	Core	Section	Sample Depth Below Bottom (feet)	Sample Depth Below Bottom (meters)	Lithology	Thermal Conductivity X 10^{-3} cal/°C/cm/sec
30	1	2	165-195	50.3-59.4	Greenish calcareous clayey ooze.	2.12
30	2	3	195-225	59.4-68.6	Soft greenish clay.	3.09
30	3	3	353-383	107.6-116.7	Gray clay.	2.47
30	4	2	383-412	116.7-125.6		2.52
30	5	1	539-570	164.3-173.7	Firm, dense, olive-gray foraminiferal clay.	2.65
30	6	2	570-585	173.7-178.3	Gray clay.	2.87
30	7	1	853-883	260.0-269.1	Very firm, green-gray claystone.	2.79

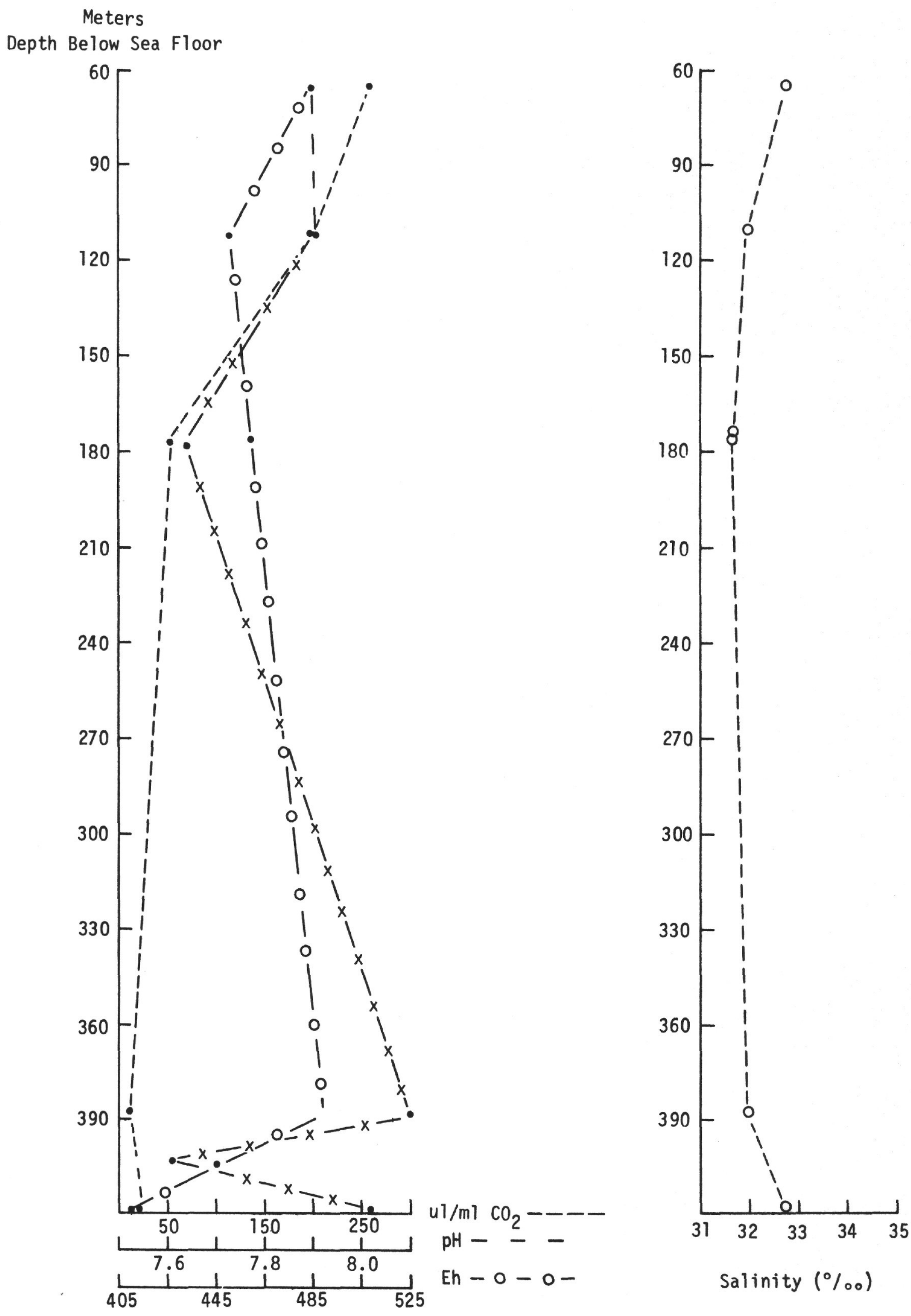

Figure 4. *Summary of chemical properties, Site 30.*

unaltered feldspars are present along with finely disseminated glauconite grains. Many of these cores show extensive mottling produced by burrowing organisims; some of the markings are quite distinctive. Mudballs and indistinct crossbedding suggest the presence of currents during deposition. Ripple marks may be present. Occasional small mollusc shell fragments occur at some levels. Some core sections contain as much as 10 per cent volcanic ignimbrites or grade into a clayey, calcareous, fine sandstone constructed essentially of the tests of planktonic foraminifera. The glauconite is most common in Core 16, where it constitutes about 25 per cent of the sediment.

These deeper strata are somewhat indurated, and were usually split with a saw. Calcareous plankton are generally abundant, but the preservation of the nannofossils is often poor. Cores 9 through 16 represent the Middle and late Early Miocene.

PHYSICAL AND CHEMICAL PROPERTIES

The natural gamma radiation from the sediment at Site 30 varies widely. In the clays and silty clays of the upper portions of the hole (to 269 meters) relatively high values ranging from 2000 to 3100 counts/1.25 min. were measured. The fluctuations are doubtless due to the wide range of both clay and organic content (40 to 80 per cent and 0.2 to 0.7 per cent, respectively). The lithologic change from clays to indurated sandy siltstones is reflected in the natural gamma values; values on the order of 2800 counts decrease to 1200-1500 counts, the latter being the characteristic range of the indurated sediments (see Figure 3). These relatively low values are due to the high silt and sand content (55 to 80 per cent) of these sediments.

Densities for the unconsolidated sediment range from 1.50 to 1.82 gm/cc. There are no accurate density data for the indurated material. No syringe samples could be collected; fracturing and the use of an undersized bit negated the bulk density and GRAPE measurements. There is little difference in water content between the clays and indurated sediment of Cores 9 through 16 indicating that cementation was far from complete. The only abrupt water content change occurs between Cores 5 and 6 (174 meters). There is considerable fluctuation in water content at the bottom of the hole (see Figure 3) which contrasts sharply with the constancy of values for most of the samples.

Sonic velocities in the clay sediment show wide fluctuation (1500 to 1600 m/sec) and only very weak correlation with depth. Readings from the indurated sediment were only rarely obtained, and these were in error due to the undersized diameter of the core. A corrected value for the highest velocity measured is approximately 2000 m/sec.

The total carbonate content of the sediment from Cores 1 through 10 (ranges from 1 to 25 per cent with alternating horizons of relatively low carbonate (1 to 10 per cent) and somewhat higher carbonate (10 to 25 per cent). The carbonate content of Cores 11 through 16 (384 to 430 meters) ranges from 48 to 68 per cent. It is in this section of the hole that the pattern of constant water content alters to a widely fluctuating pattern. The organic carbon content of the sediments is high compared to that found at most of the previous sites, ranging from 0.2 to 0.7 per cent with most values being 0.5 (±0.1) per cent.

Six interstitial water samples were processed at Site 30. Salinities deviate markedly from those found at most of the previous sites, ranging from 31.6 to 32.7 per mil. These values are similar to those found at Site 26; the organic carbon content of these sediments is several times greater than that usually found as was the case at Site 26.

Total dissolved carbon dioxide ranges from approximately one-sixth that of surface sea water (10 μl/ml) to more than four times that of surface sea water (260 μl/ml). (See Figure 4.) There is an overall decrease in total dissolved carbon dioxide with depth. As found previously, there is no correlation between carbon dioxide and *p*H. The latter ranges from 7.61 to 8.10, showing no definite trend with depth. Eh ranges from +410 to 490 millivolts, showing little consistent trend with depth.

Seven thermal conductivity measurements were taken (Cores 1 through 7); the values range from 2.12 to 3.09 X 10^{-3} cal/°C/cm/sec (see Table 2). There is considerable scatter, but there is a discernible increase in conductivity with depth. This appears to correlate directly with density and inversely with water content.

REFERENCES

Edgar, N. T., 1968. "Seismic Refraction and Reflection in the Caribbean Sea." (Ph.D. thesis, Columbia University, New York).

Ewing, J., Talwani, M. and Ewing, M., 1965. Sediment distribution in the Caribbean Sea. *4th Caribbean Geological Conf. Trinidad,* 317.

Fox, P. J., Schreiber, E. and Heezen, B. C. (in press). Igneous rocks and tertiary sediments from the Aves Ridge. *Geol. Soc. Am. Spec. Paper.* 1970.

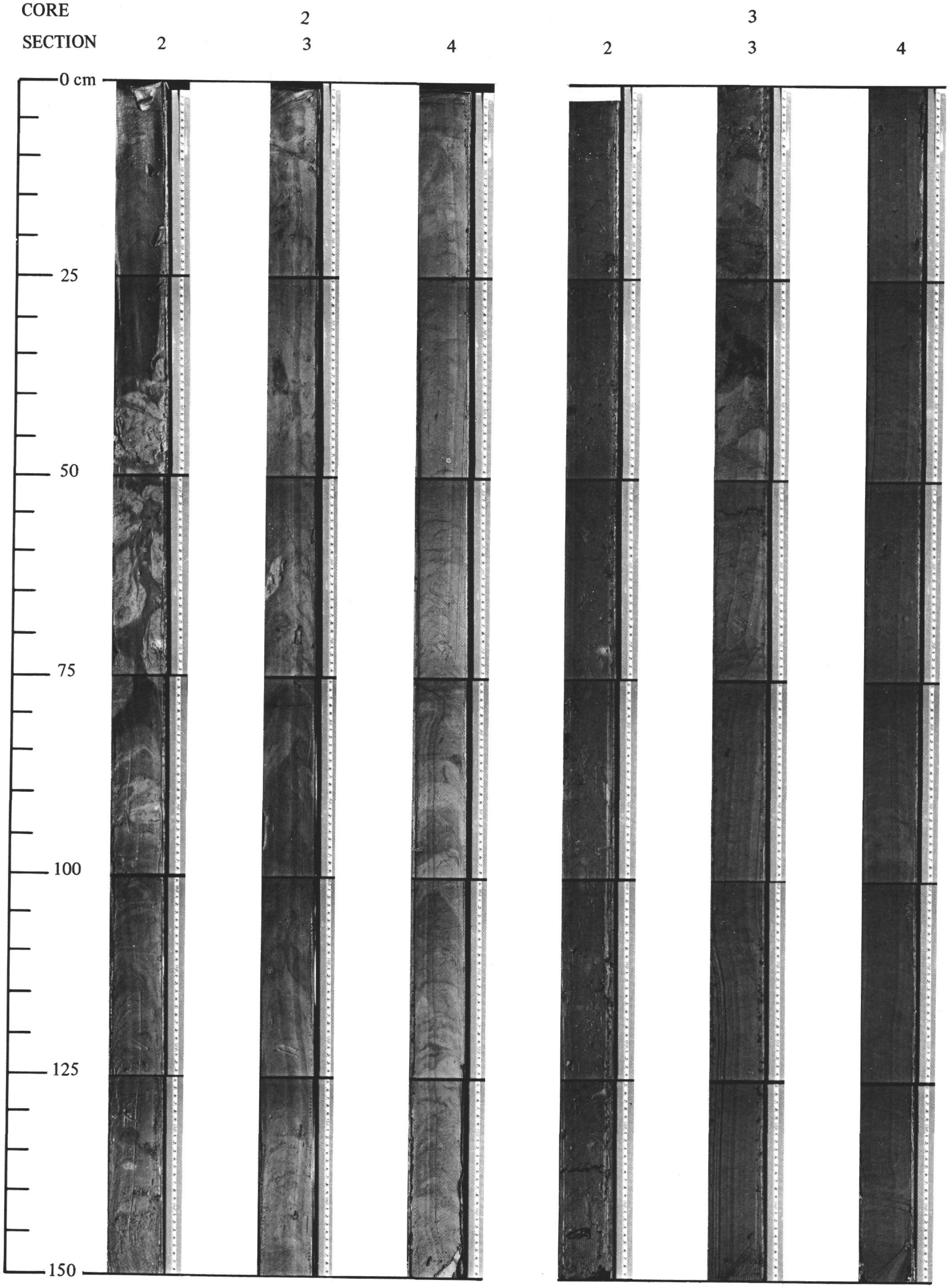

Plate 1. *Cores 2 and 3, Hole 30.*

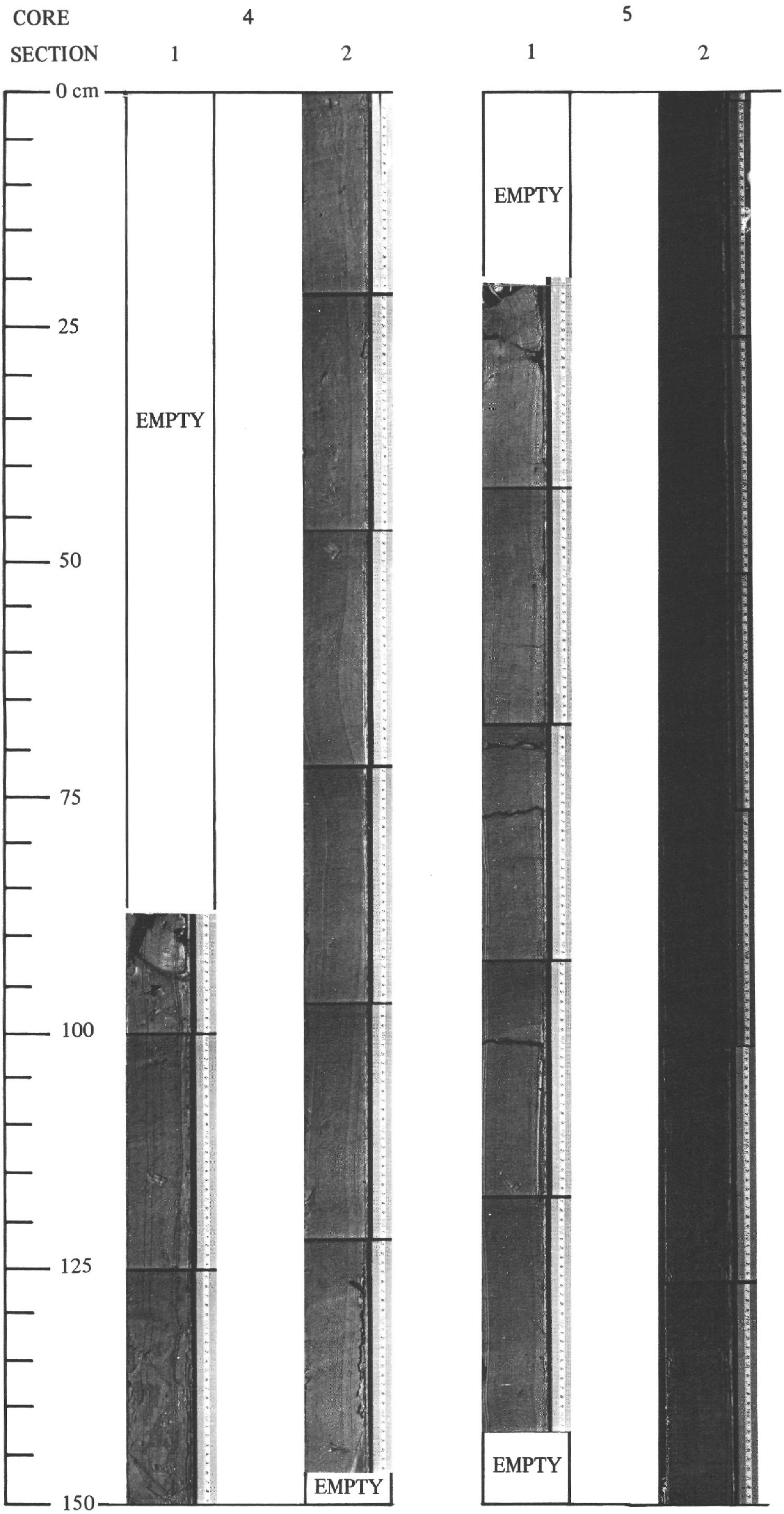

Plate 2. *Cores 4 and 5,* Hole 30.

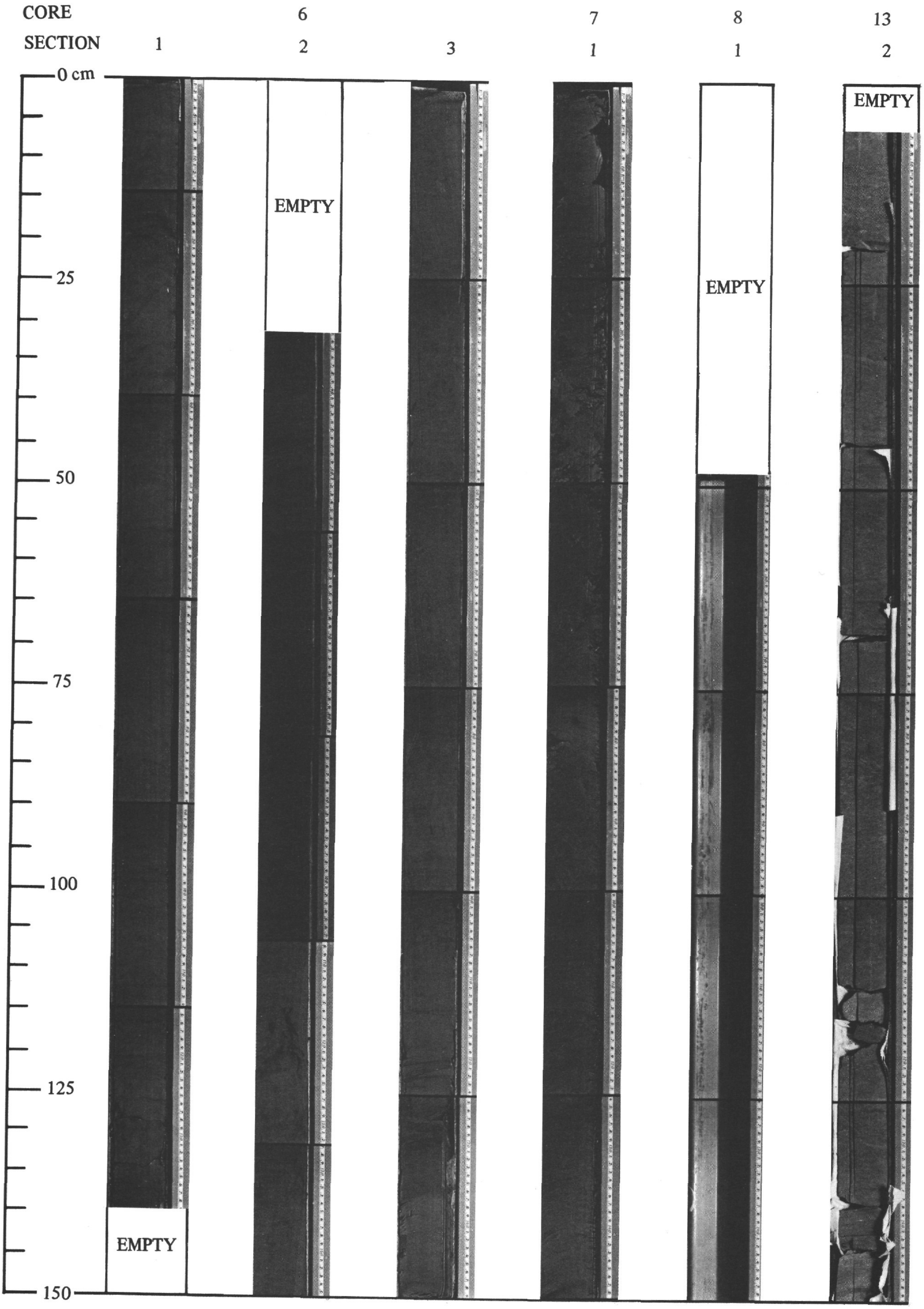

Plate 3. *Cores 6, 7, 8 and 13, Hole 30.*

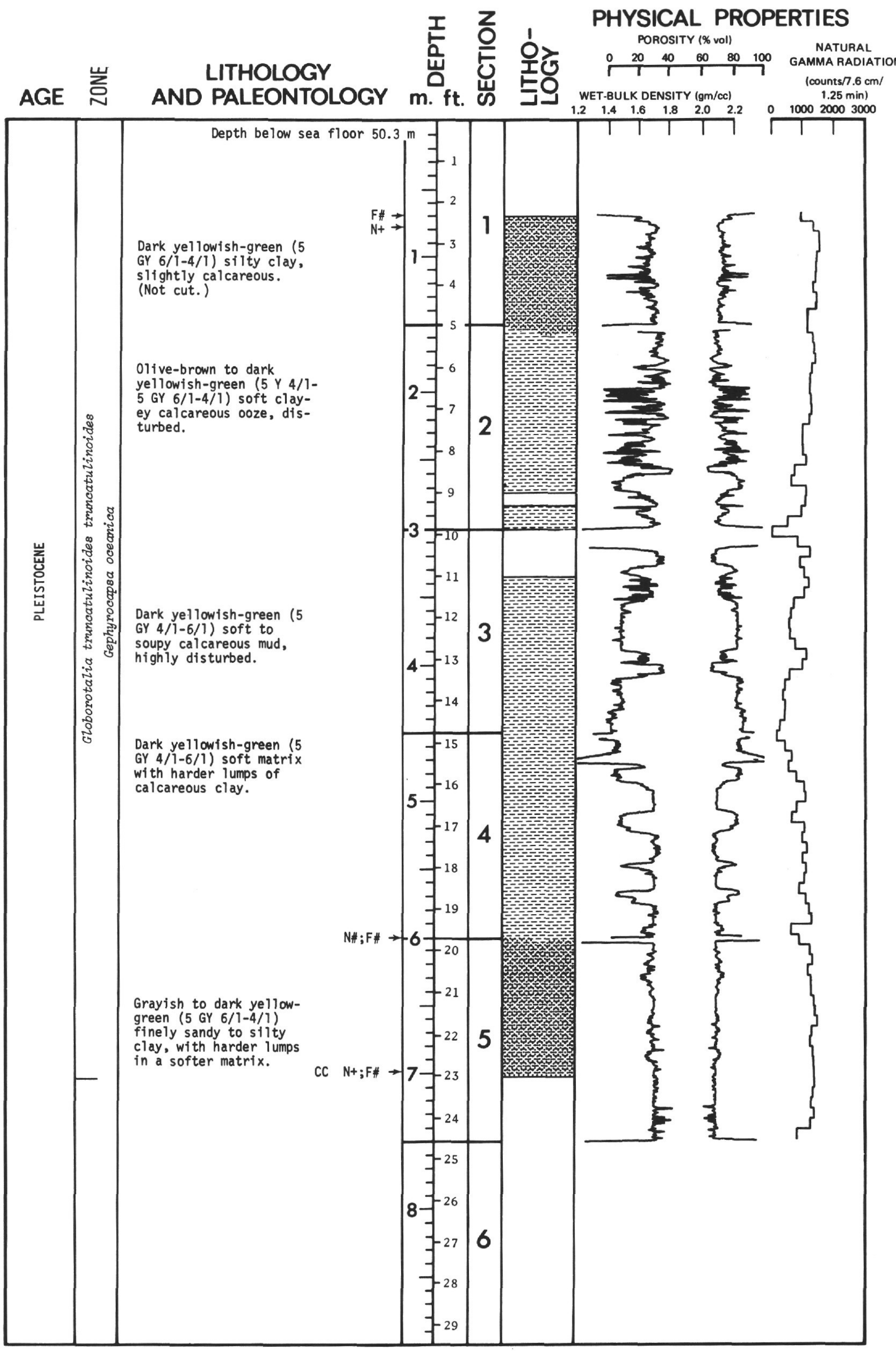

Figure 5. *Core 1, Hole 30.*

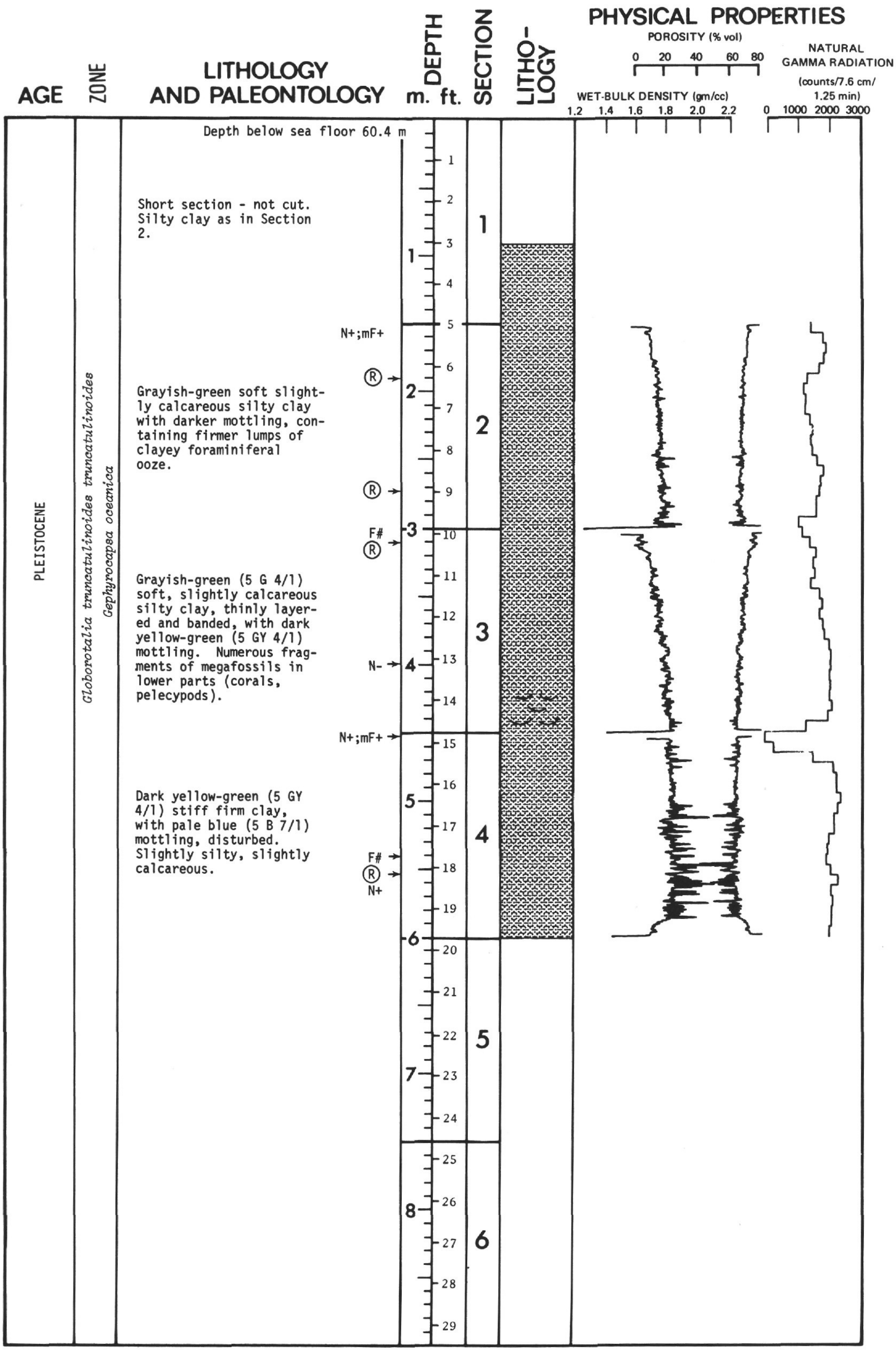

Figure 6. *Core 2, Hole 30.*

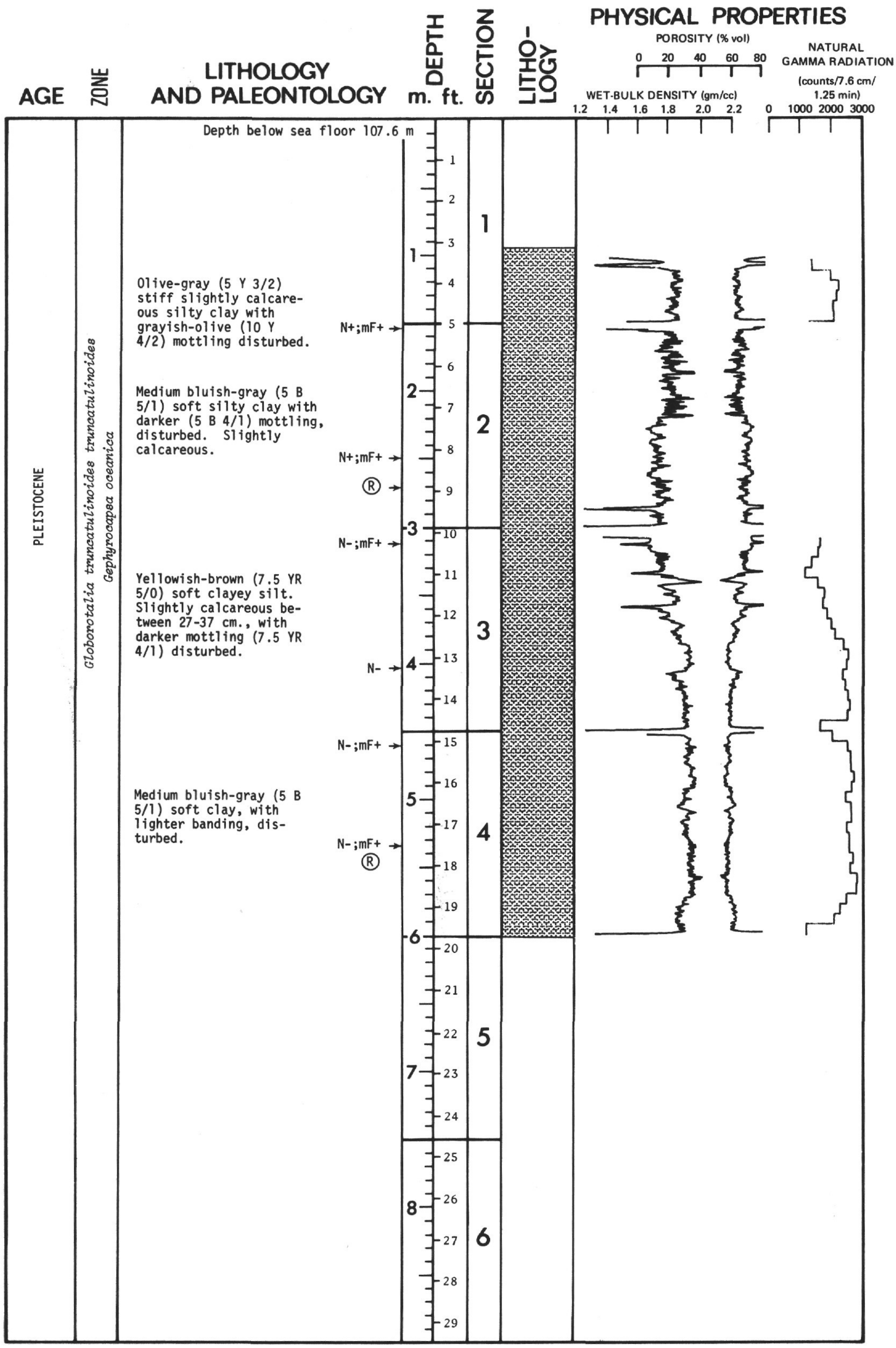

Figure 7. *Core 3, Hole 30.*

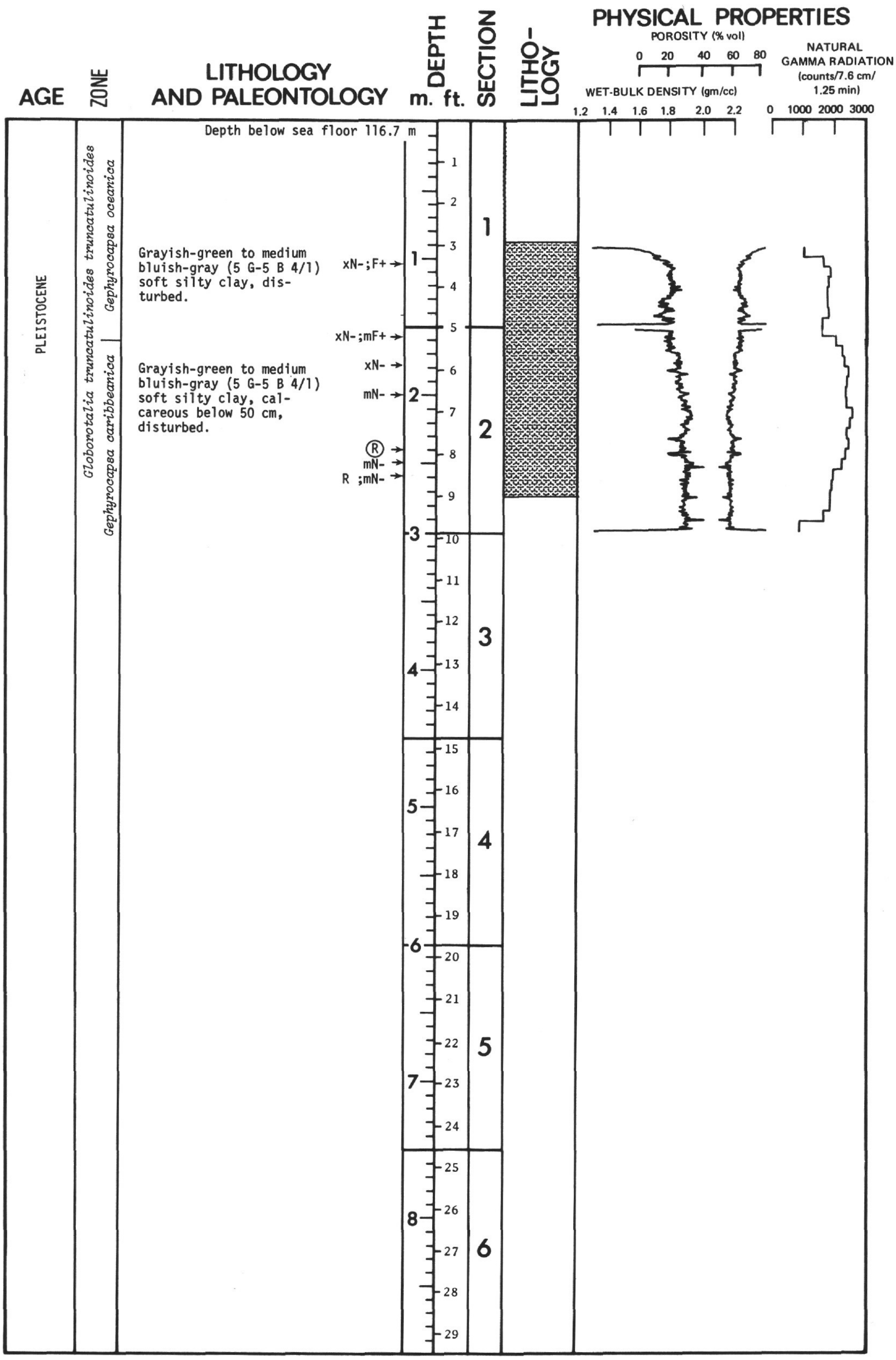

Figure 8. *Core 4, Hole 30.*

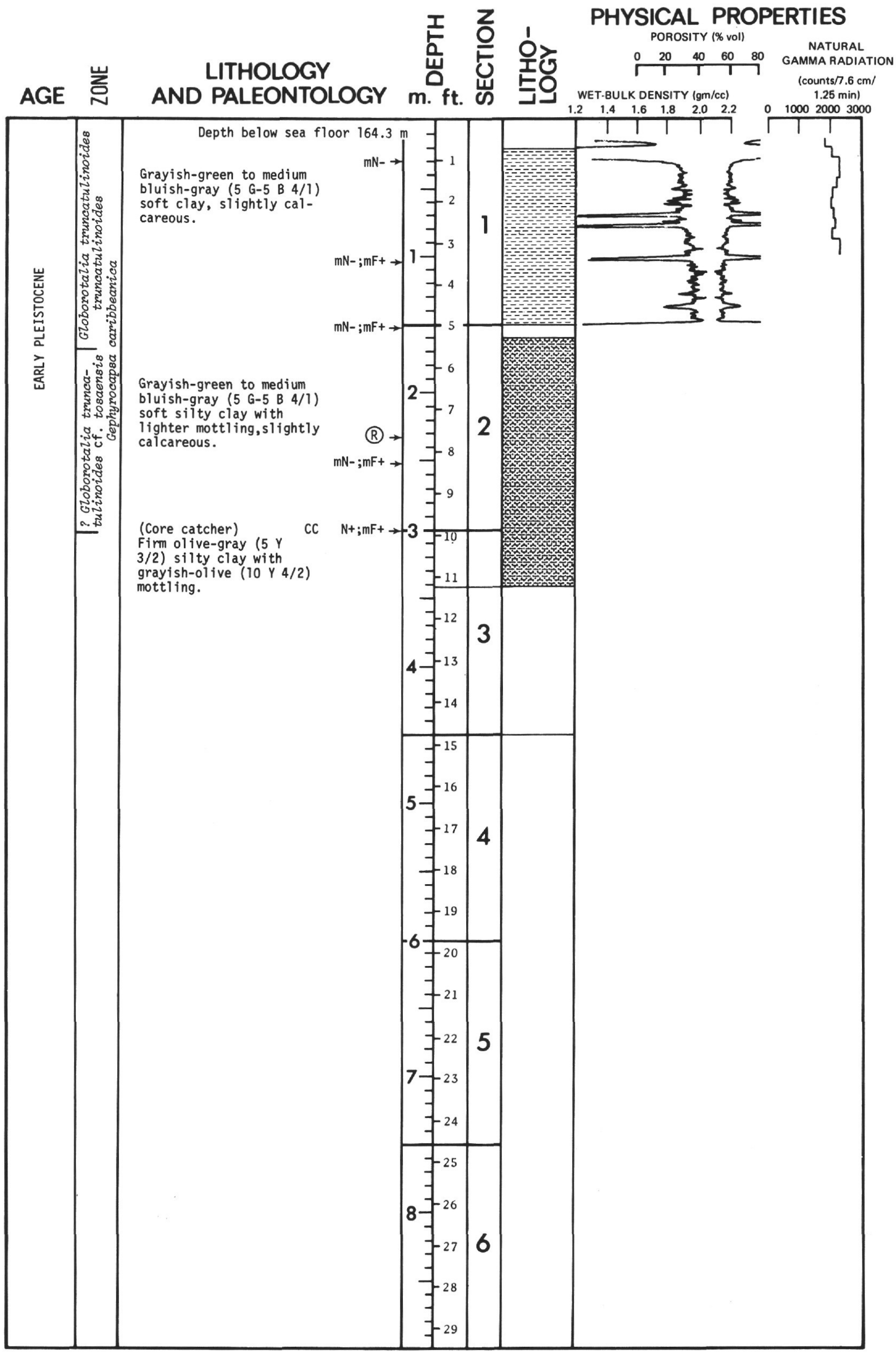

Figure 9. *Core 5, Hole 30.*

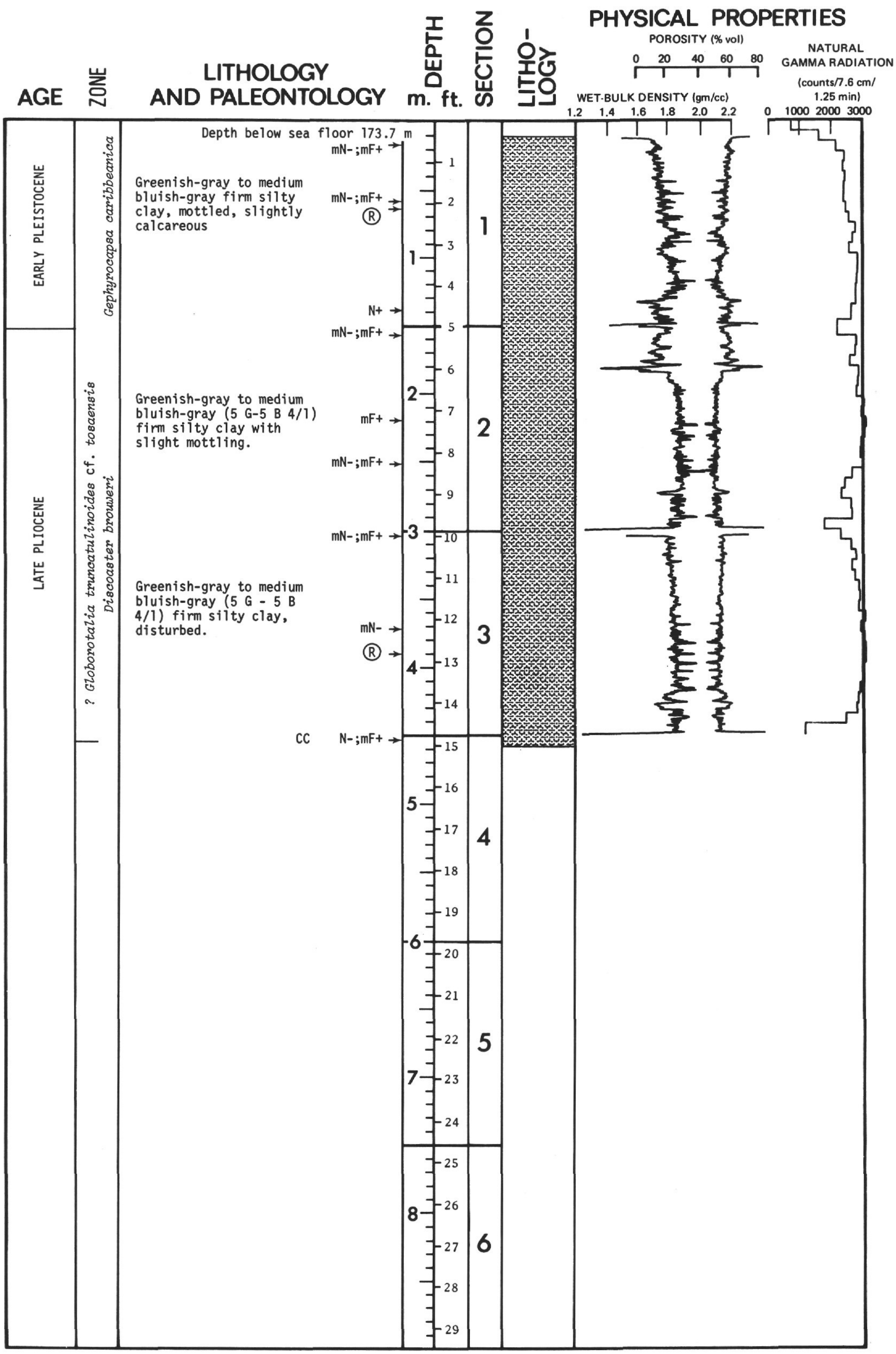

Figure 10. *Core 6, Hole 30.*

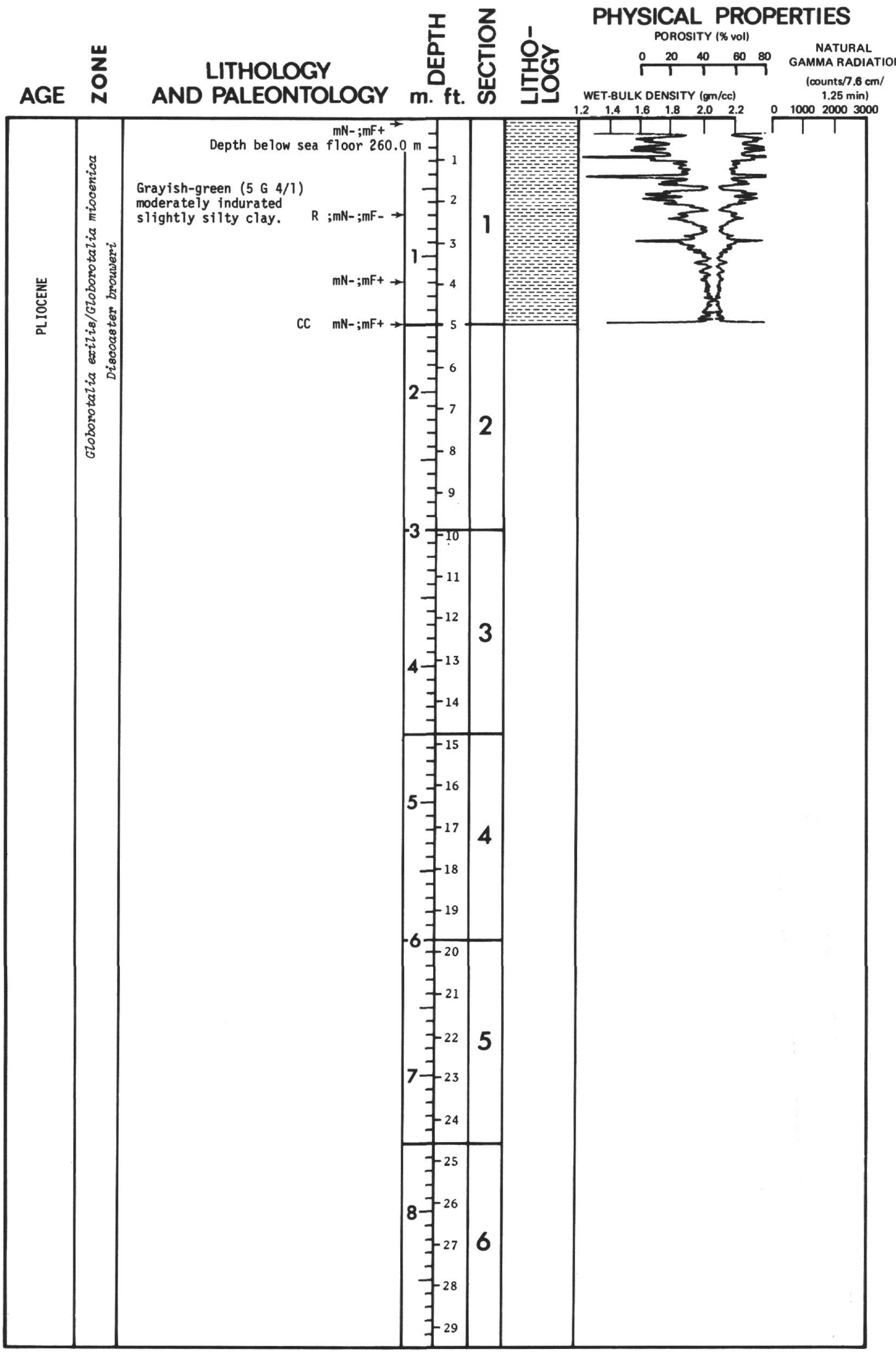

Figure 11. *Core 7, Hole 30.*

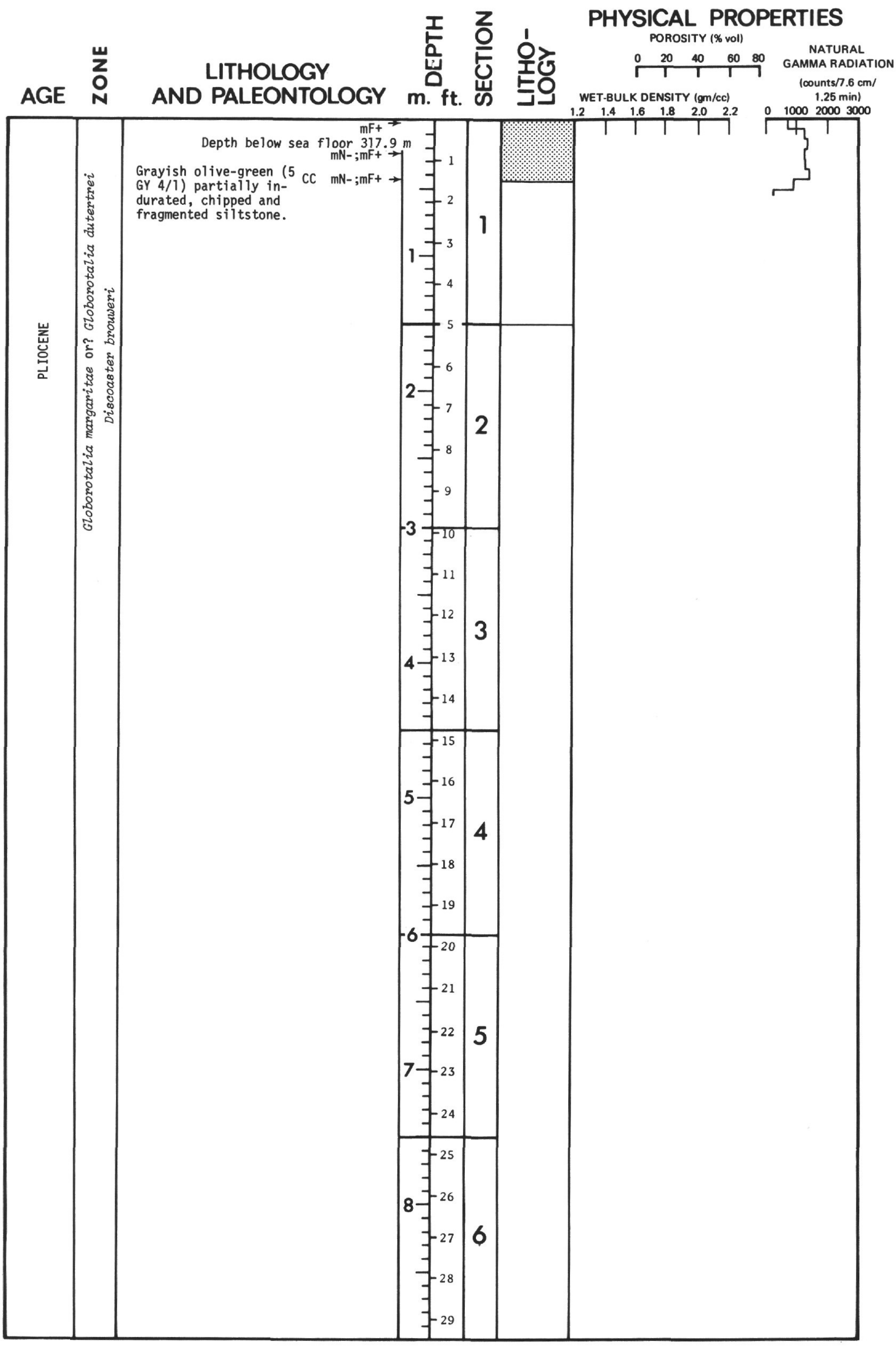

Figure 12. *Core 2, Hole 30.*

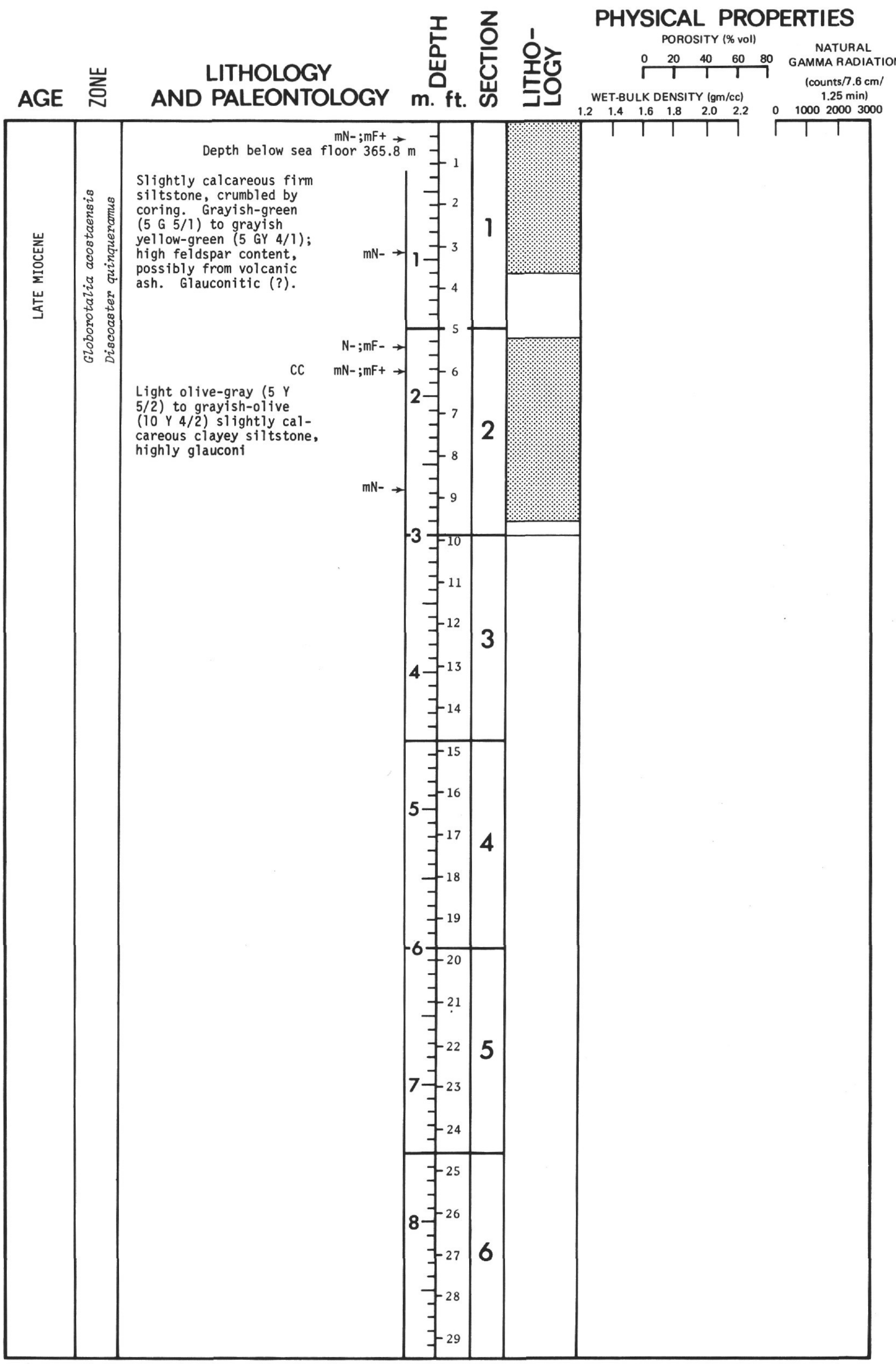

Figure 13. *Core 9, Hole 30.*

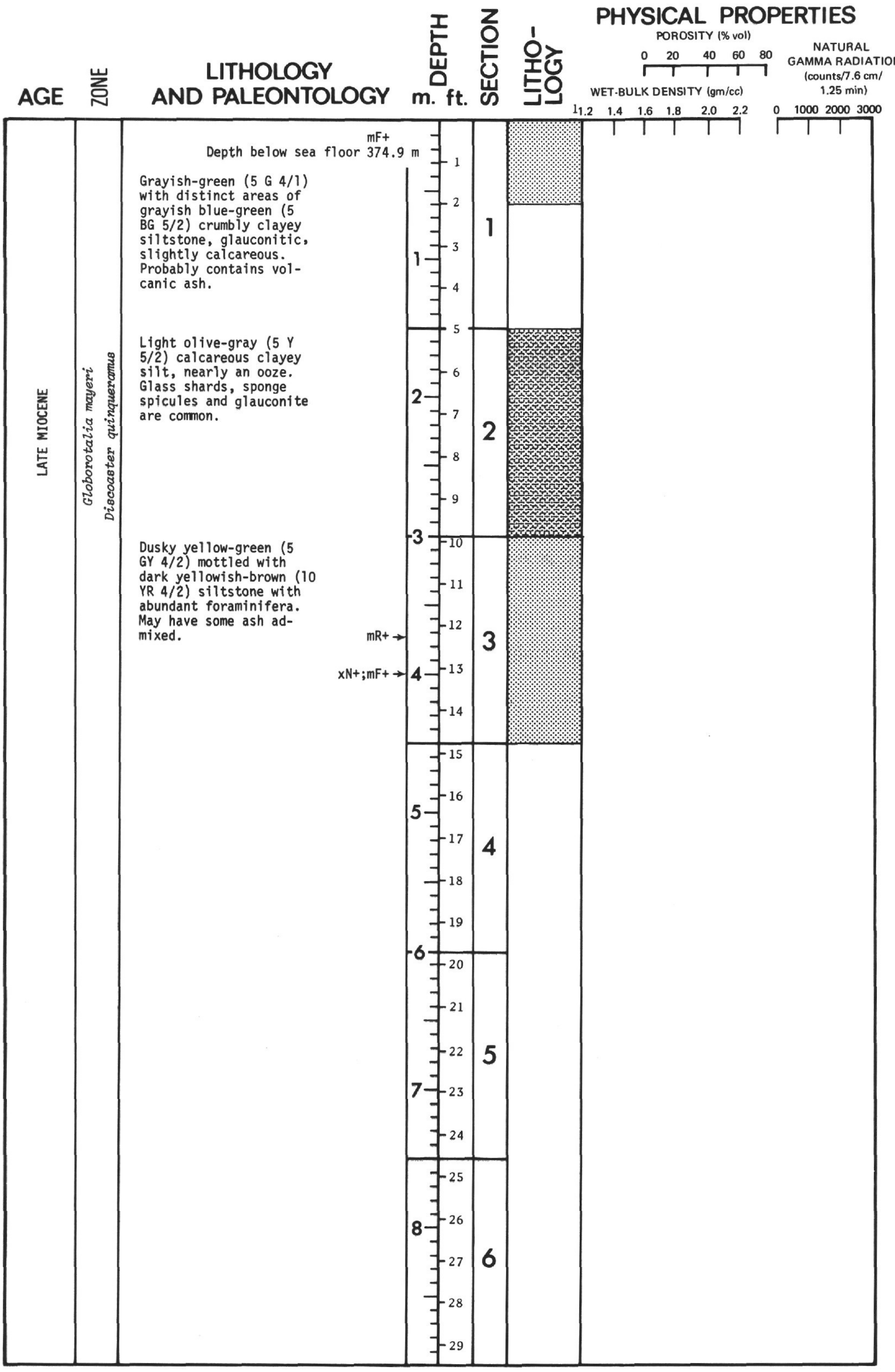

Figure 14. *Core 10, Hole 30.*

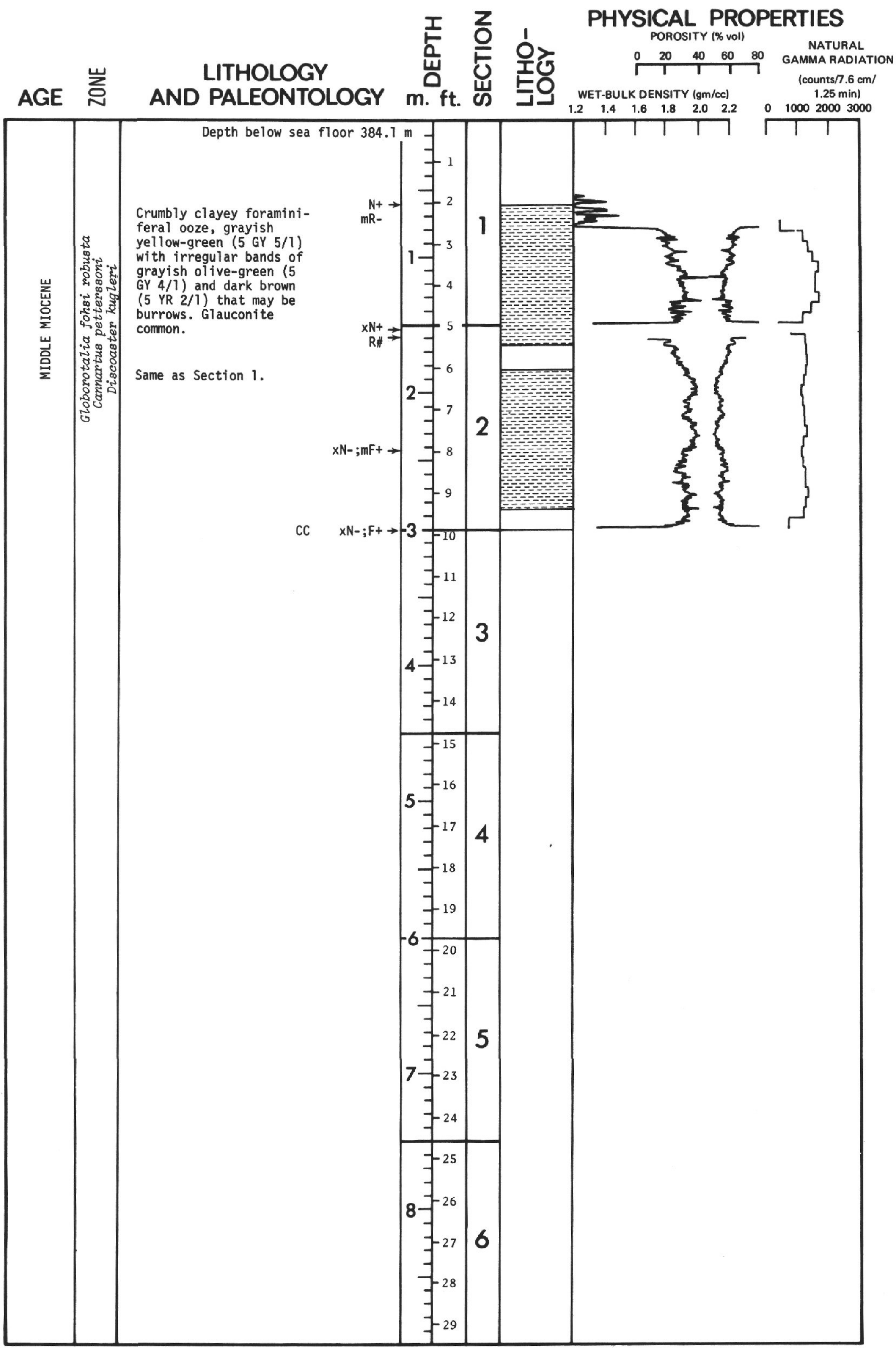

Figure 15. *Core 11, Hole 30.*

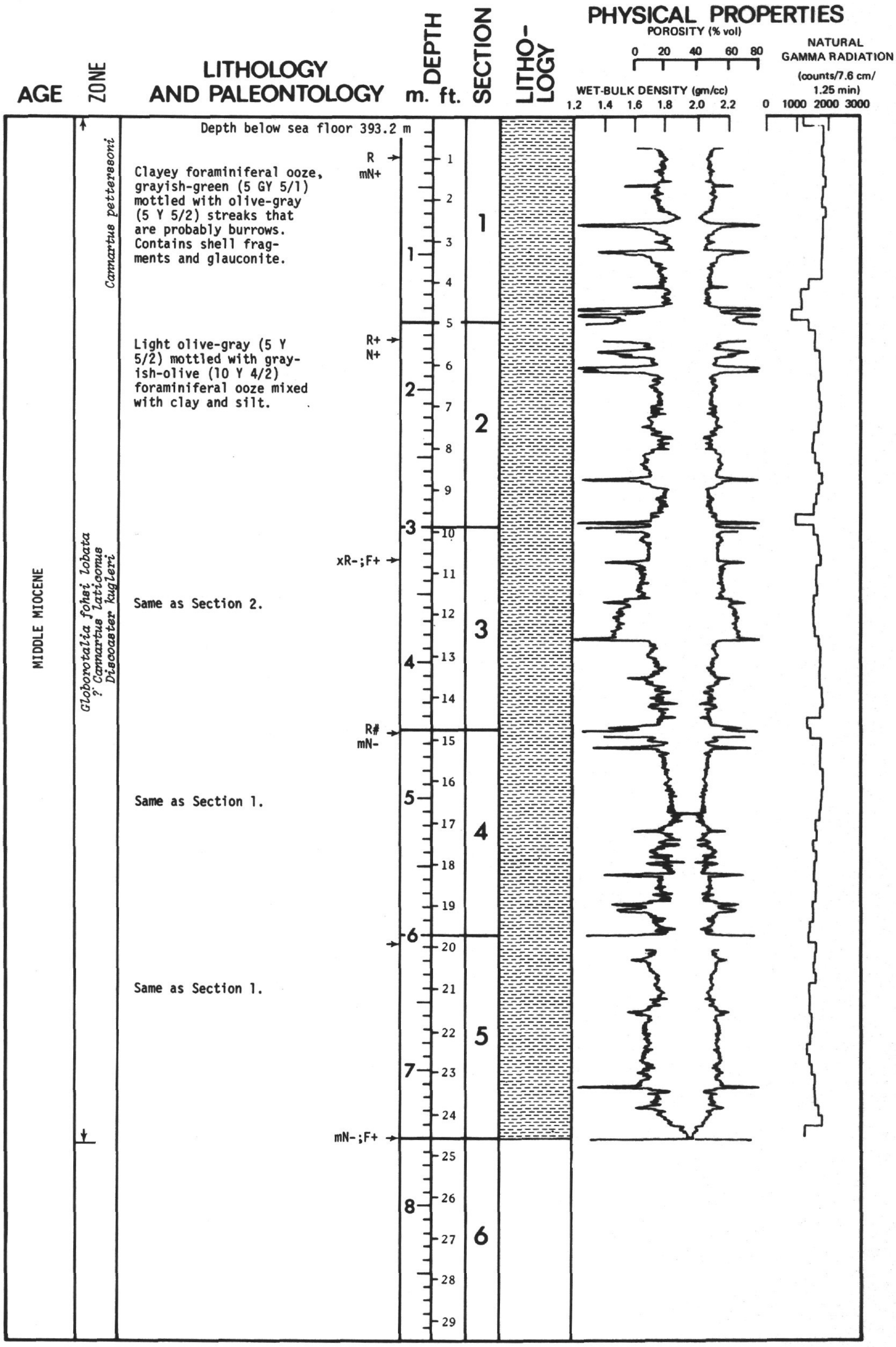

Figure 16. *Core 12, Hole 30.*

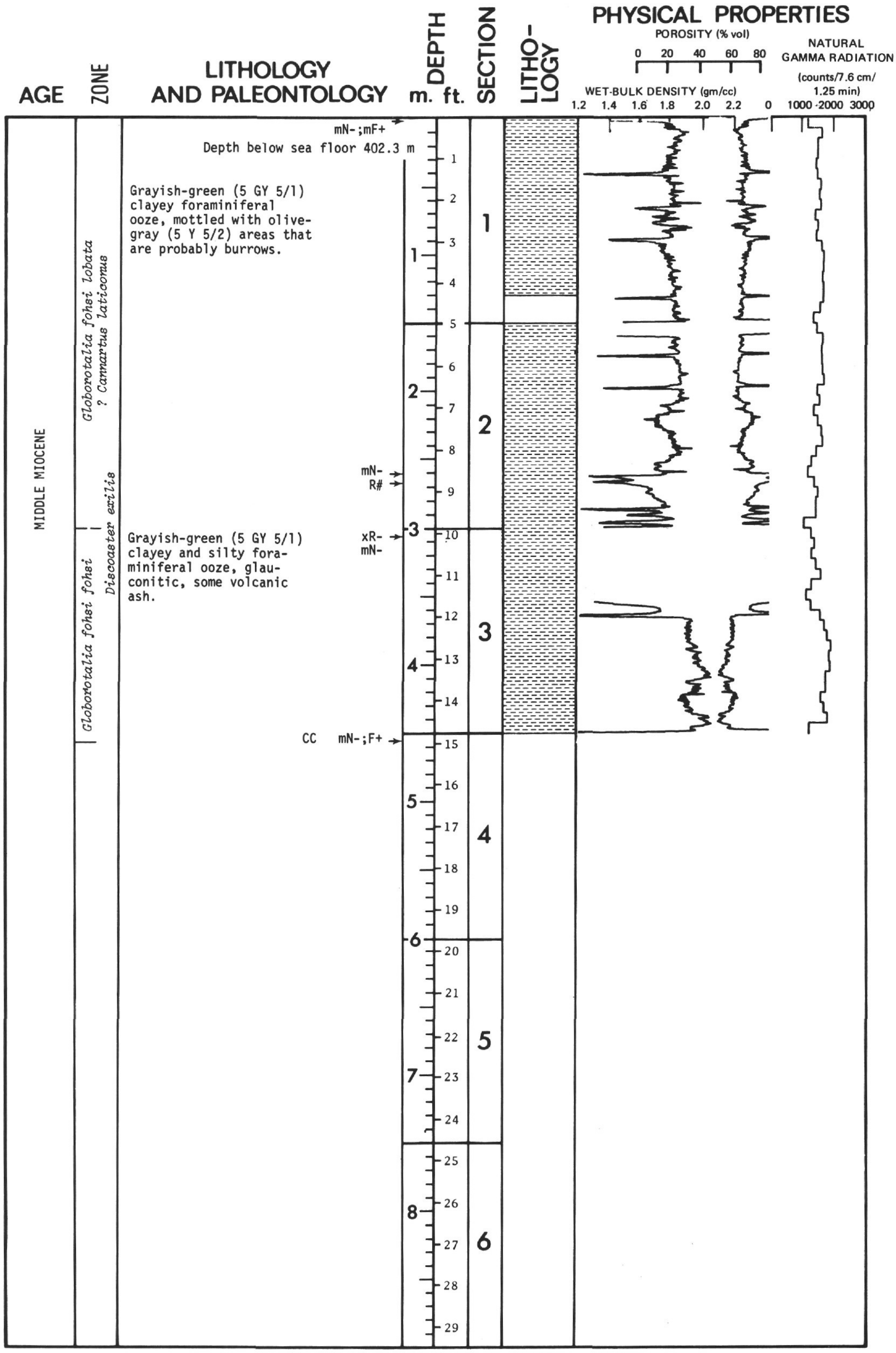

Figure 17. *Core 13, Hole 30.*

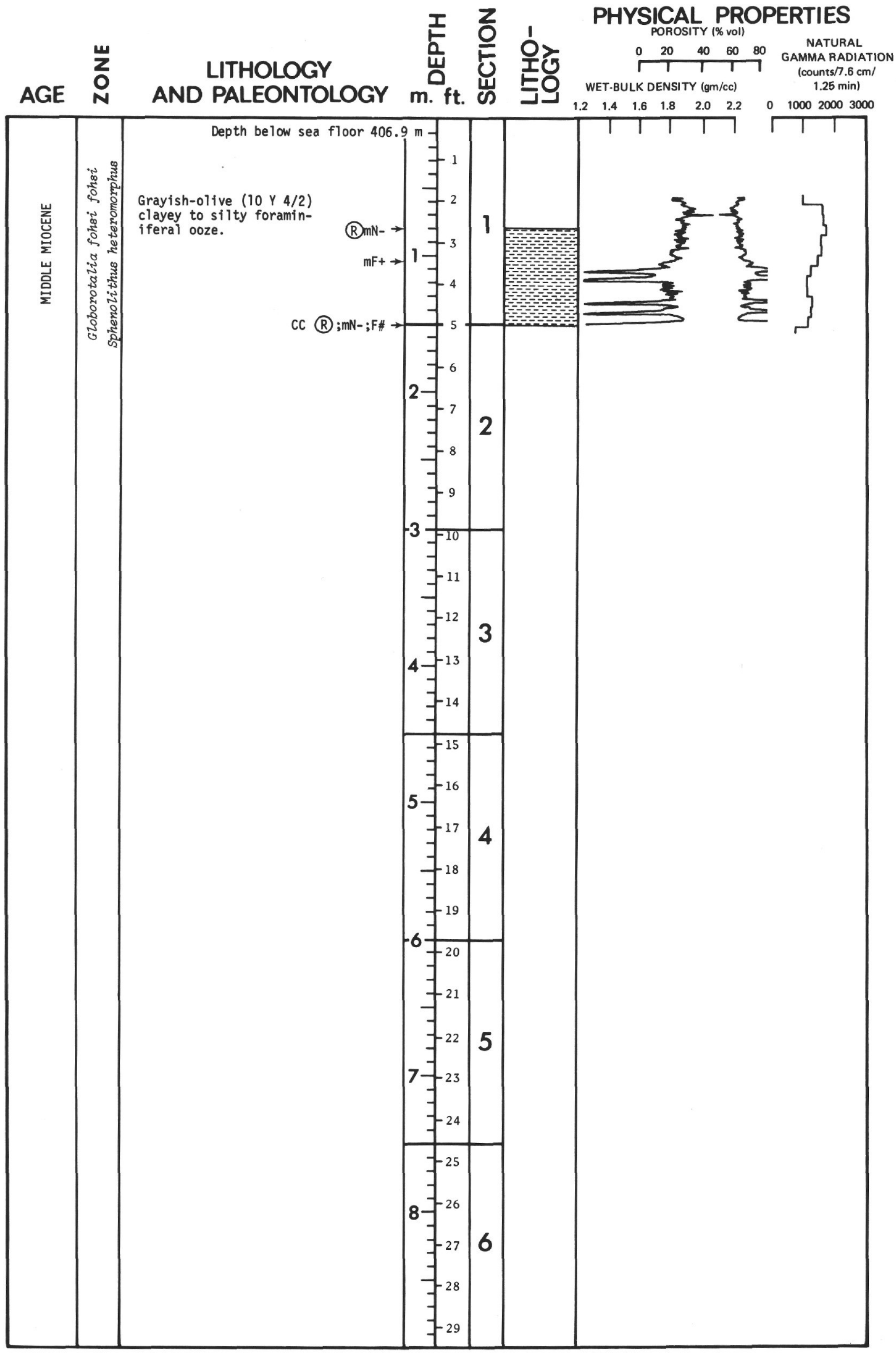

Figure 18. *Core 14, Hole 30.*

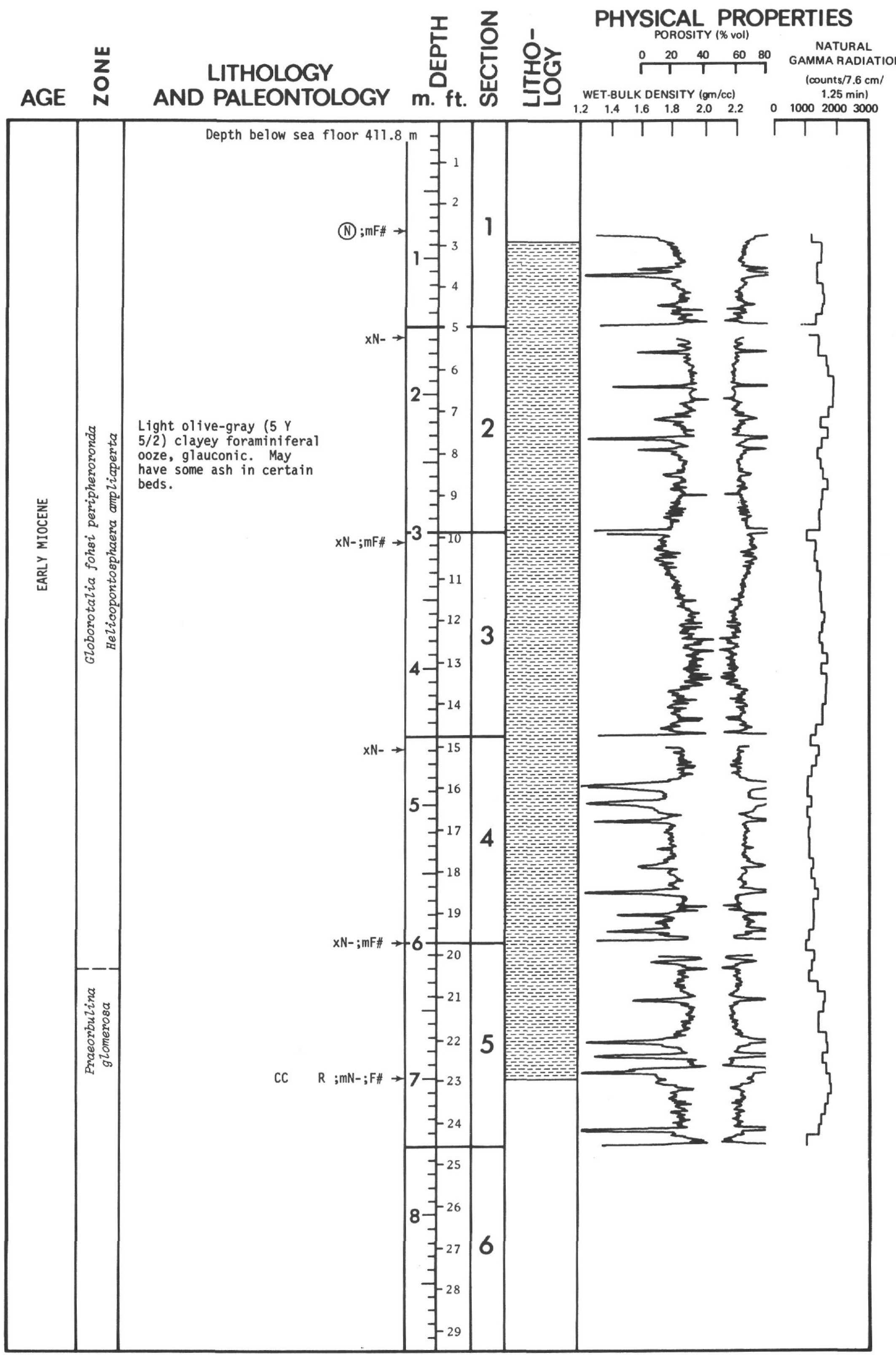

Figure 19. *Core 15, Hole 30.*

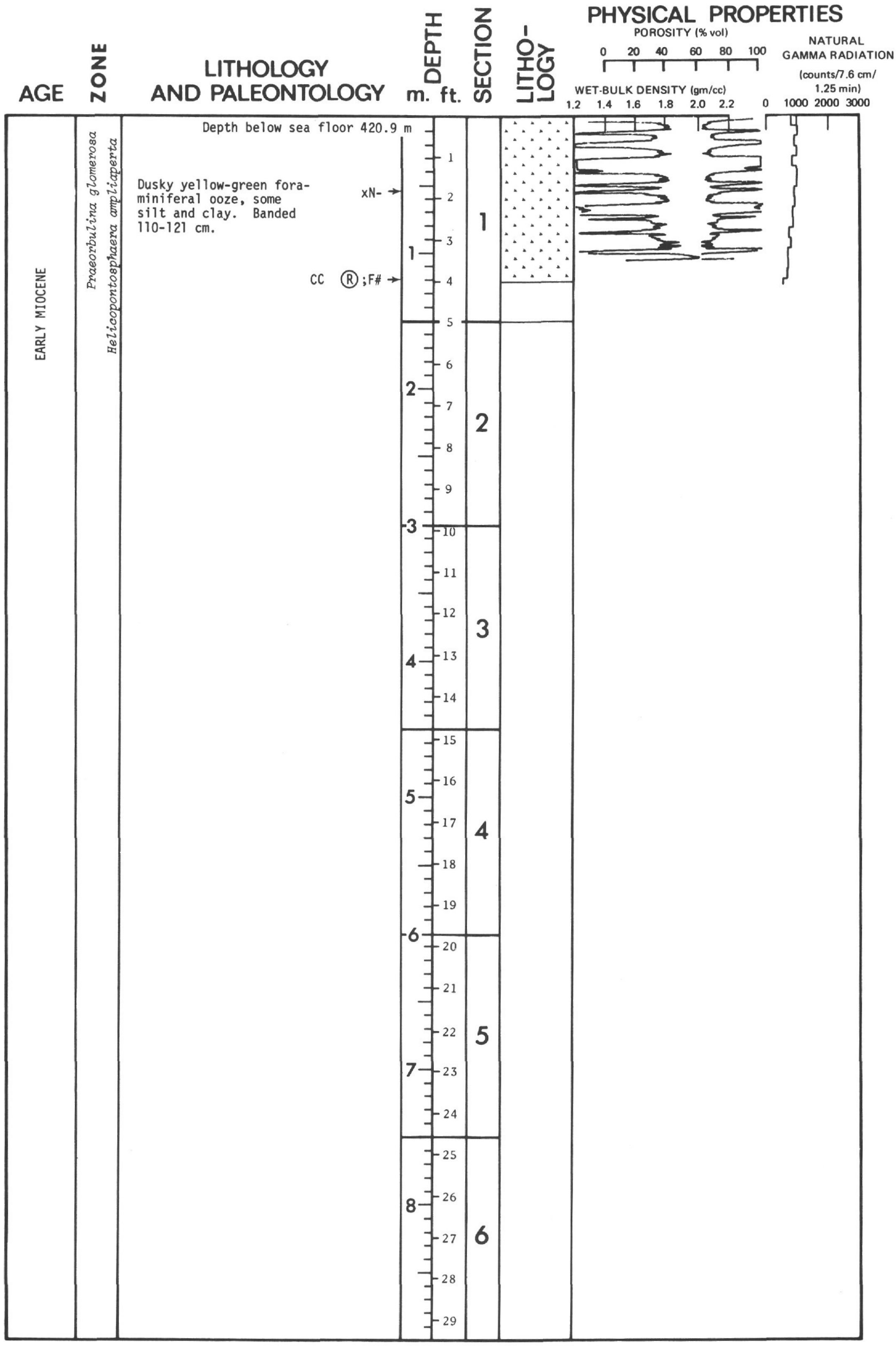

Figure 20. *Core 16, Hole 30.*