4. SITE 14

The Shipboard Scientific Party[1]

SURVEY DATA AND SITE BACKGROUND

At the time of arrival of *Glomar Challenger* at this site (2210 hours, 20 December, 1968), *R/V Vema* had partially surveyed the area with all of the standard geophysical techniques. A recognizable negative magnetic anomaly strip adjacent and to the west of Magnetic Anomaly 13 was chosen for the site, following the recommendations of the JOIDES Atlantic Panel.

The topography near the selected site is undulating with an amplitude of 40 to 200 meters (131 to 656 feet) (Figure 2). Figure 3 shows the sediment thickness to vary between about 0 and 0.15 second acoustic travel time between the bottom and the rough basement reflector, with the thickest accumulations occurring over the basement valleys.

The exact site (latitude 28° 19.89'S, longitude 20° 56.46'W) is located over the upper flank of a small hill where the sediment thickness gives about 0.13 second reflection time. This hill is coincident with the center of a negative magnetic anomaly of about 250 gammas amplitude in the E-W direction, relative to the positive peaks on each side (Figure 1). The magnetic anomaly has a width of 10 to 15 kilometers. The depth on the site was measured as 4346 meters (13,255 feet) corrected (2307 fathoms, uncorrected).

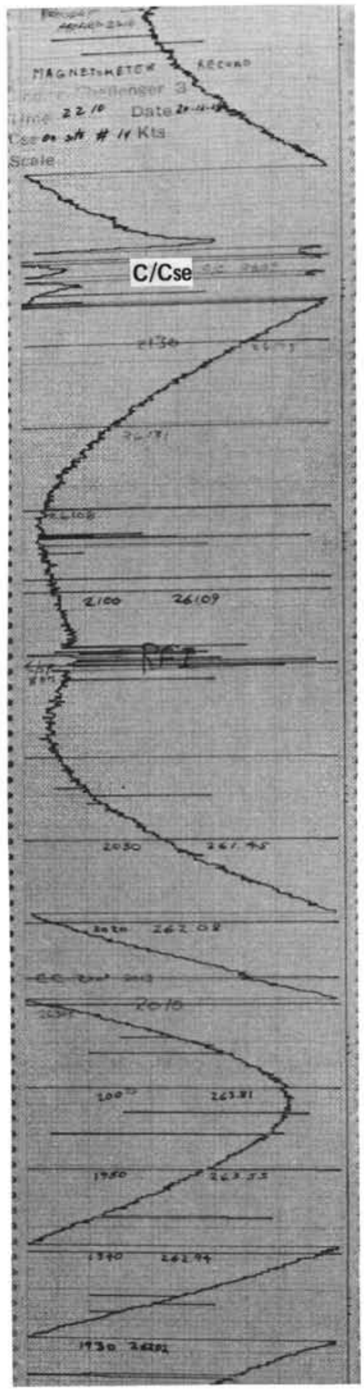

Figure 1. *Magnetometer record in the vicinity of Site 14.*

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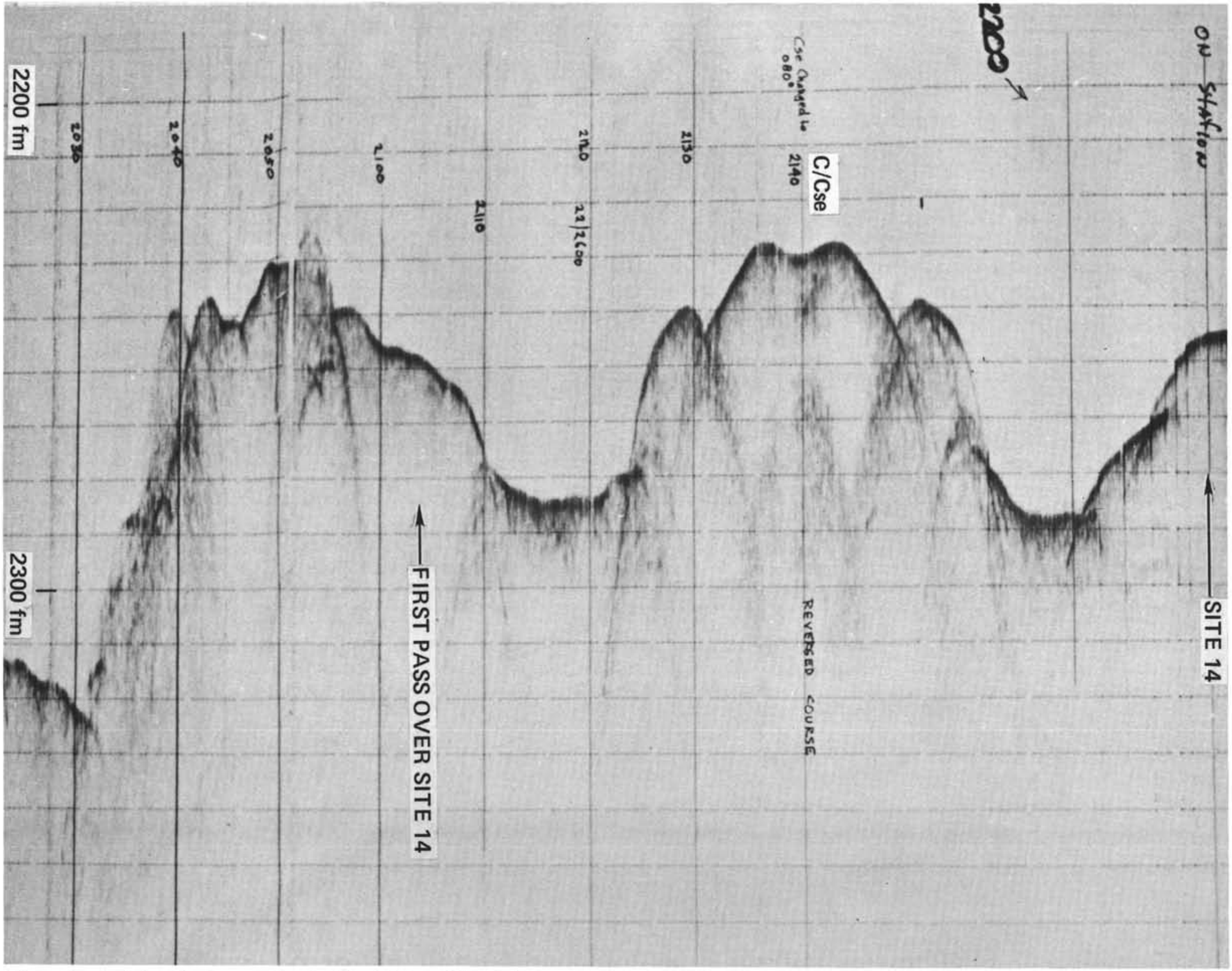


Figure 2. *Precision depth recording in the vicinity of Site 14.*

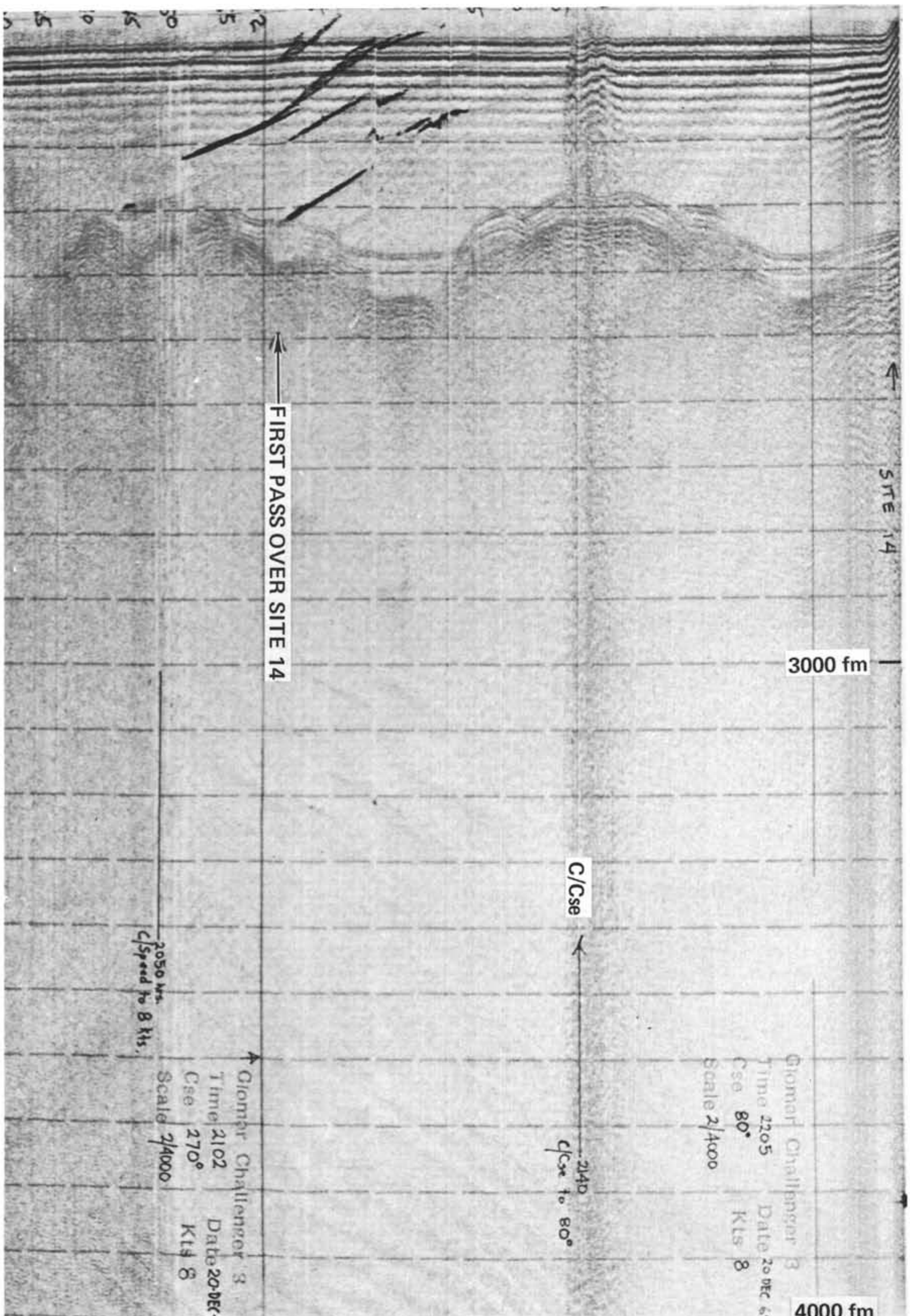


Figure 3. *Continuous seismic profiler record in the vicinity of Site 14.*

OPERATIONS

Positioning

The beacon was dropped over the side at Site 14 at 2230 hours on 20 December. A 20 to 25 knot wind made positioning difficult in the automatic mode; and, for the first 36 hours, positioning was handled semi-automatically. Toward the end of the day on the 22nd, the wind abated sufficiently to shift to automatic control. No special difficulties were experienced in keeping position on Site 14.

Drilling

Only two drilling breaks at Site 14 appeared to be significant. The first of these occurred at a depth of 53 meters (174 feet), when a reduction in the drilling rate from about 18 to 5 m/hr was noted. A core collected at this depth showed fragments of calcite throughout. The drilling record indicates this break may have represented calcite layers for a thickness of 1.5 meters (5 feet).

A second major break in drilling rate took place at 107 meters (351 feet). A core showed this to be the upper surface of the basalt basement. At this depth, the rate of penetration changed from about 18 to less than 2 m/hr. After drilling in the basalt for 1.5 meters (5 feet), penetration was reduced to zero during the succeeding 2 hours. The core was pulled and the hole abandoned at this point.

No unusual problems were encountered during drilling.

Coring

A list of the cores collected, times of arrival on deck, interval cored and length of cores is shown in Table 1. Nominally, a 9-meter core was brought aboard every three hours.

Only 3 meters (10 feet) were recovered from the first surface core (14-1); hence, a second surface core was retrieved (14-1A). In removing Core 14-4 from the barrel, it was discovered that the plastic core liner was broken. This made removal of the core from the barrel difficult and resulted in an extremely disturbed core. Similarly, the liner of Core 14-9 was broken and the core was disturbed during extrusion—particularly the upper 2 meters (7 feet) of the core.

The recovery of 1 meter (3 feet) of broken basalt from a 1.5-meter (5-foot) core attempt is attributed to a break in the core latching mechanism, which allowed the core barrel to rotate with the drilling pipe.

PALEONTOLOGY

Lower Miocene, Upper Oligocene, Lower Oligocene and Upper Eocene sediments were recovered in nine out of the ten barrels cored in Hole 14. In Core 10 from 107 to 108 meters (351 to 354 feet) basalt was recovered. Coring was discontinuous in the upper 52 meters (170 feet) (Cores 1 through 4) of the hole and continuous below that depth into the basalt (Cores 5 through 10). The only major stratigraphic boundary cored was the Eocene/Oligocene boundary

TABLE 1
Summary of Coring

Core No.	Date/Time	Interval Cored (m below sea floor)	Core Retrieved (m)	Remarks
14-1	12-21-68 1300	0-9	3.0	Incomplete recovery.
14-1A	1600	0-9	9.0	
14-2	1900	12-21	9.0	
14-3	2230	33-42	9.0	
14-4	12-22-68 0230	52-61	3.7	Disturbed.
14-5	0530	61-71	9.0	
14-6	0800	71-80	9.0	
14-7	0945	80-89	9.0	
14-8	1130	89-98	9.0	
14-9	1430	98-107	8.5	Disturbed.
14-10	2030	107-108	0.9	
	Total		79.1	87 per cent recovery.

in Core 9. In addition, two stage boundaries, Aquitanian/Burdigalian of the Miocene and Rupelian/Chattian of the Oligocene epoch were cored.

One of the purposes of drilling at this site was to test the hypothesis of sea-floor spreading and the interpretation of linear magnetic anomalies. This hole was drilled on a negative magnetic anomaly just west of Magnetic Anomaly 13 of Heirtzler *et al.* (1968), which has a suggested age of 38 million years. Examination of "marble" and limestone which are intercalated with the basement basalt revealed no microfossils. The sediments immediately overlying the basalt contain the foraminiferal species, *Cribrohantkenia inflata* (Howe), which became extinct in a late Eocene time and probably represents the *Globorotalia cerro-azulensis* Zone of Bolli, 1966. Berggren (1969) suggests an age of 39 million years B.P. for the level of extinction of this species (Chapter 2, Figure 3). The calcareous nannoplankton flora probably represents the *Helicopontosphaera reticulata* Zone of Bramlette and Wilcoxon, 1967. Thus, the 39 million years date derived from the paleontological evidence is in close agreement with the age predicted by the study of magnetic anomalies.

Another purpose in drilling this hole was to study the flora and fauna at approximately 30° South latitude to ascertain whether they are tropical or temperate. The floras and faunas found throughout the section are typical of those found in tropical areas. Absences of various species of both calcareous nannoplankton and planktonic foraminifera are interpreted to be the result of solution.

The sediments in Cores 1 through 9 consist predominantly of the plates of calcareous nannoplankton with minor amounts of planktonic foraminifera tests. Variations from lithologic unit to lithologic unit are discussed in the section on Stratigraphy.

The Aquitanian/Burdigalian boundary of the Lower Miocene as defined by the JOIDES Paleontology and Biostratigraphy Panel, which places the boundary at the top of the *Globigerinita stainforthi* (= *Catapsydrax stainforthi*) planktonic foraminiferal Zone of Bolli (1957c), occurs in Section 1 of Core 1A, 0 to 9 meters (0 to 29 feet), between the samples from 0 to 2 centimeters and 145 to 147 centimeters depth. The former sample comprises species characteristic of the *Globigerinatella insueta/Globigerinoides bisphericus* Zone of Blow (1959), such as, *Globorotalia praesitula* Blow and *Globigerinoides sicanus* de Stefani (= *G. bisphericus* Todd). The latter sample is characterized by the concomitant occurrence of *Globigerinita dissimilis* (Cushman and Bermudez) and *G. stainforthi* (Bolli, Loeblich and Tappan) and is correlative with the *G. stainforthi* Zone. The sample from 0 to 2 centimeters depth contains the calcareous nannoplankton *Sphenolithus belemnos* Bramlette and Wilcoxon, *Discoaster deflandrei, D. challengeri, D. druggi,* and *Cyclococcolithus neogammation* Bramlette and Wilcoxon and represents the *Sphenolithus belemnos* calcareous nannoplankton zone of Bramlette and Wilcoxon (1967).

The delineation of the boundary between *G. stainforthi* and the subjacent *G. dissimilis* Zone is rather difficult in this area owing to the absence of *Globigerinatella insueta* Cushman and Stainforth, the first appearance of which delineates the boundary. For this stratigraphic interval, Bramlette and Wilcoxon (1967) indicated that typical *Sphenolithus belemnos* is common only in the *S. belemnos* Zone but small specimens occur in the stratigraphically lower *Triquetrorhabdulus carinatus* Zone of Bramlette and Wilcoxon (*op. cit.*). A similar morphological change of *S. belemnos* is noticed in Section 3 of Core 1A between samples 5 to 7 centimeters and 100 to 102 centimeters depth, with typical specimens of this taxon occurring commonly in the shallower depth. Thus, the upper limit of *Triquetrorhabdulus carinatus* Zone is placed between these two samples based on this floral change.

The upper boundary of the *Globorotalia kugleri* Zone of Bolli (1957c) is clearly defined in Section 4 of Core 1A with the first appearance of this zonal marker in a sample from 125 to 127 centimeters depth. Other important planktonic species present in this sample are: *Globigerina woodi connecta* Jenkins, *Globigerinoides primordius* Blow and *Globoquadrina rohri* Bolli. A marked calcareous nannoplankton floral change is also noticed in this section between samples from 25 to 27 centimeters and 125 to 127 centimeters depth. The absence of *Discoaster druggi, D. challengeri* and *Sphenolithus belemnos?* and the first appearance of *Coccolithus* aff. *bisectus* (Hay, Mohler and Wade) in a sample from 125 to 127 centimeters depth suggests its correlation with the lower part of the *Triquetrorhabdulus carinatus* Zone. Rare specimens of the uppermost Cretaceous (upper Maestrichtian) planktonic foraminifera, such as, *Racemiguembelina fructicosa* (Egger), *Globotruncanella havanensis*, and *Globotruncana mariei* Banner and Blow are found in the sample interval from 25 to 27 centimeters of Section 4, Core 1A. This is interpreted as contamination of the core barrel from Cretaceous samples taken and left behind by the preceding DSDP leg. A similar incident of finding leftover Cretaceous sediments in core barrels occurred during the operation at Site 15.

Core 2 from 12 to 21 meters (39 to 69 feet) represents the lower part of the *Globorotalia kugleri* Zone of Bolli (1957) and is assigned to the Chattian Stage of the upper Oligocene based on the absence of *Globigerinoides primordius* Blow. This definition of the uppermost Oligocene is adopted from the DSDP

Paleontology Manual. The planktonic foraminiferal fauna from this interval is characterized by *Globorotalia kugleri* Bolli, *G. opima continuosa* Blow, *G. opima nana* Bolli, *Globoquadrina praedehiscens* Banner and Blow, *G. venezuelana* (Hedberg), *Globigerina praebulloides* Blow and *G. woodi* Jenkins. The calcareous nannoplankton flora consists of *Cyclococcolithus neogammation, Coccolithus bisectus* (Hay, Mohler and Wade), *C.* aff. *bisectus* and *Discoaster deflandrei.*

The Chattian Stage of the Upper Oligocene is also found in Core 3, from 33 to 42 meters (108 to 141 feet); however, here it is represented by the *Globorotalia opima opima* and *Globigerina ciperoensis* Zones of Bolli (1957c). The boundary between these two zones occurs between the sample at 100 to 102 centimeters in Section 1 and the sample from 100 to 102 centimeters of Section 2. The former sample is characterized by: *Globigerinita dissimilis, G. unicava* (Bolli, Loeblich and Tappan), *Globoquadrina rohri, Globigerina sellii* (Borsetti), *G. yeguaensis* Weinzierl and Applin, *Globorotalia opima nana* and *G. postcretacea* (Myatiluk); the latter by the first appearance of *Globorotalia opima opima* Bolli, *Globigerina angulisuturalis* Bolli and *G. corpulenta* Subbotina among others. All samples studied from the core contain a calcareous nannoplankton flora consisting of *Coccolithus bisectus, C.* aff. *bisectus, Discoaster deflandrei* and *Sphenolithus ciperoensis* Bramlette and Wilcoxon which are typical of the *Sphenolithus ciperoensis* Zone of Bramlette and Wilcoxon (1967).

The planktonic foraminifera designate Core 4, from 52 to 61 meters (170 to 200 feet), as being in the *Globigerina ampliapertura* Zone of Blow (1969). This zone represents the lower part of the Chattian as defined by the JOIDES Paleontology and Biostratigraphy Panel. Recognition of this zone is based on the first appearance (= extinction) of *Chiloguembelina cubensis* (Palmer) and *Globigerina ampliapertura* Bolli. Approximately at the same horizon, *Globigerina angulisuturalis* makes its first evolutionary appearance. The calcareous nannoplankton indicate that the sample from 13 to 15 centimeters in Section 1 belongs to the *Sphenolithus distentus* Zone of Bramlette and Wilcoxon (1967) and the sample from 50 to 52 centimeters of the same section, as well as the rest of the core, belong to the *Sphenolithus predistentus* Zone of Bramlette and Wilcoxon (1967). The former sample is characterized by *Sphenolithus distentus* Bramlette and Wilcoxon, *S. predistentus* Bramlette and Wilcoxon, *Coccolithus bisectus* and *Discoaster deflandrei;* the latter contains, besides the forms previously mentioned, *Sphenolithus pseudoradians* Bramlette and Wilcoxon and *Discoaster tani* s.l.

Disseminated throughout Core 4 are white chalk fragments which consist almost exclusively of isolated fragments of *Braarudosphaera rosa* Levin and Joeger with some complete specimens and rare *Coccolithus pelagicus* (Wallich). This chalk had probably occurred as thin layers in the sediments but became fragmented and mixed in the core barrel during the drilling. Hereafter, occurrences of chalk which are rich in fragments of *Braarudosphaera rosa* will be referred to as the *Braarudosphaera rosa* Chalk. This chalk is also found in Sites 17, 19, 20 and 22.

Core 5 from 61 to 71 meters (200 to 233 feet), Core 6 from 71 to 80 meters (233 to 262 feet) and most of Core 7 from 80 to 89 meters (262 to 291 feet) are assigned to the *Globigerina ampliapertura* Zone of the Upper Oligocene (Chattian). All of these cores, except, probably, for the core catcher sample from Core 7, represent the *Sphenolithus predistentus* Zone of Bramlette and Wilcoxon (1967). In Section 5 of Core 7 between samples from 50 to 52 centimeters and from 100 to 102 centimeters lies the Rupelian/Chattian boundary as defined by the JOIDES Biostratigraphy Panel. This is marked by the first appearance (= extinction) of *Pseudohastigerina micra* (Cole) in the sample from 100 to 102 centimeters, and also corresponds to the boundary between the *Globigerina selli/Pseudohastigerina barbadiensis* Zone of Blow (1969) and the overlying *Globigerina ampliapertura* Zone.

The occurrence of *Reticulofenestra umbilica* (Levin) in the core catcher sample of Core 7 suggests that this sample probably belongs to the *Helicopontosphaera reticulata* Zone of Bramlette and Wilcoxon (1967). The floras and faunas indicative of the Lattorfian/Rupelian age of the early Oligocene continue into Core 8 and most of Core 9. The upper three sections of Core 8 are roughly correlated with the *Globigerina sellii/Pseudohastigerina barbadiensis* Zone of Blow (1969) and the sample from 148 to 150 centimeters in Section 6 as well as most of Core 9 to the *Globigerina tapuriensis* Zone of Blow (1969). The boundary between these two zones occurs somewhere in the lower three sections of Core 8. The calcareous nannoplankton in Cores 8 and 9 represent the *Helicopontosphaera reticulata* Zone of Bramlette and Wilcoxon (1967). The flora is characterized by *Reticulofenestra umbilica, Sphenolithus predistentus, S. pseudoradians, Coccolithus bisectus, Discoaster tani* s.l., *Cyclococcolithus neogammation, C. lusitanicus* and *Isthmolithus recurvus* Deflandre.

The boundary between the Upper Eocene (Bartonian) and the Lower Oligocene (Lattorfian/Rupelian) is placed in Section 6 of Core 9 between 100 to 102 centimeters and 145 to 147 centimeters depth, where extinction of two diagnostic planktonic foraminiferal species *Globorotalia cerro-azulensis* and *Hantkenina* sp. take place. The core catcher sample of Core 9 contains abundant *Cribrohantkenina inflata* (Howe).

The associated calcareous nannoplankton floras show no change across the boundary and consist of *Coccolithus bisectus, Cyclococcolithus neogammation, C. lusitanicus, Reticulofenestra umbilica, Sphenolithus pseudoradians, Isthmolithus recurvus,* and *Discoaster tani* s.l. Subsequent to the extinction horizon of *Cribrohantkenina inflata,* but still within the Upper Eocene, Blow (1969) has proposed the *Globigerina gortanii gortanii/Globorotalia (Turborotalia) centralis* Zone which represents his uppermost Eocene. As both *G. gortanii* and *G. centralis* are absent from the Eocene/Oligocene sediments at this site, direct application of his zonation is not possible. However, Blow (1969) states that *G. cerro-azulensis* is still present much less frequently in his uppermost Eocene zone. In the bottom of Core 9, between the extinction of *Cribrohantkenina inflata* and the first evolutionary appearance of *G. tapuriensis,* there is an interval less than 50 centimeters thick characterized by *G. cerro-azulensis.* No lithologic change or nannoplankton floral change is observed within this interval. Therefore, if the *G. gortanii gortanii/G. centralis* Zone is applied here, it should be a very thin one. Bolli (1966), on the other hand, has proposed the *G. cerro-azulensis* Zone for the uppermost Eocene, the top of which corresponds to the extinction horizon of the zonal marker. For the sediments cored from the South Atlantic, it appears that the Bolli sequence, at least from the Lower Oligocene down to Upper Eocene, is the most applicable, and it is used here as a basis for comparison with nannoplankton floras (Chapter 2, Figure 1).

Samples from the "marble" and calcite veins occurring in the basalt recovered from Core 10 were examined for microfossils but no fossils were found.

STRATIGRAPHY

Site 14 represents the first drilling in the sedimentary province of the Mid-Atlantic Ridge. Correlation of lithologic units between holes in this province has permitted the recognition of several formations (Chapter 2). The names assigned to these formations are used throughout this section, with the unit designation and description from the hole.

Three formations were encountered above the basement; they are in descending order:

3-14-1-1	Endeavor Ooze	Zeolitic nannofossil marly chalk oozes, marl oozes and clay.
3-14-2-1	Fram Ooze	Nannofossil chalk oozes with *Braarudosphaera* Chalk member (3-14-4-1, Subunit).
3-14-6-1	Grampus Ooze	Dark nannofossil chalk oozes and marly chalk oozes.

The surface at Site 14 may be covered by a thin veneer of Pliocene chalk ooze, which occurs as a contaminator at the bottom of 3-14-2. The Unit 3-14-1-1, representing the Lower Miocene Endeavor Ooze here, consists of very pale brown nannofossil chalk oozes, yellowish to dark brown zeolitic nannofossil marl oozes and clays. The Endeavor Ooze of the Mid-Atlantic Ridge is distinguished from the underlying Fram Ooze by the presence of relatively large amounts of the non-carbonate constituents, ranging from 30 to 70 per cent here. At Site 14 the zeolite content is noticeably high (5 to 25 per cent), especially in the marl oozes and red clays. Clay minerals are present in varying amounts. Foraminifera are practically absent, however. The oozes are laminated in part, but the structures have been disturbed during the coring.

The Fram Ooze of the Mid-Atlantic Ridge is a nannofossil chalk ooze, characterized by its very uniform lithology, its very pale brown color, and its very small content of planktonic foraminifera. It is represented here by the Unit 3-14-2-1 in its typical development. The smear-slides showed that the sediments include few recognizable foraminifera tests, except at several thin intervals (for example, 5 per cent foraminifera in 3-14-3-6, 26 to 28 centimeters). The relatively high percentage (4.7 to 7 per cent) of sand-size particles found in the upperpart of the unit are mainly carbonate fragments which may represent partially dissolved foraminifera tests. The main part of the Unit 3-14-3-5 includes 1 per cent or less sand-size particles. Except for the white *Braarudosphaera* Chalk, the homogeneity of the 62-meter thick unit is impressive. A very pale brown chalk ooze is found section after section, with only a slight pinkish white mottling, and one or two yellowish-brown intercalations (for example, 3-14-3-6, 26 to 28 centimeters), to break the monotony.

The *Braarudosphaera* Chalk is a crystalline white chalk ooze, consisting almost exclusively of pentelets of the nannofossil *Braarudosphaera rosa.* A few unbroken skeletons are present to permit specific identification. Drilling breaks suggest the presence of a 1.5-meter (5-foot) thick interval of hard chalk layers at a depth of 53 to 54.5 meters BOB. This 3-14-4-1 chalk member proves to be a widespread Oligocene marker bed in the South Atlantic, for which the name *Braarudosphaera* Chalk Marker is suggested.

The Grampus Ooze consists of an assemblage of foraminiferal nannofossil chalk oozes on the Mid-Atlantic Ridge, which are darker and commonly contain more identifiable foraminifera tests than the Fram Ooze. This formation here is represented by the Unit 3-14-6-1. The oozes change from light yellow brown at the top gradually to dark brown at the bottom of the unit, as the hematitic impurities increase from about 2 per cent to more than 15 per cent. The percentage of identifiable foraminifera ranges from 2 to 8 per cent.

TABLE 2
Stratigraphy Site 14

Age	Cored Interval (m)	Formation Name	Probable Interval (m)	Probable Thickness (m)	Description
Lower Miocene	0-9	Endeavor Ooze 3-14-1-1	0-9	9	Interbeds of very pale brown nannofossil chalk ooze and yellow brown zeolitic marl ooze. Zeolites 5 to 25 per cent (higher in a few darker bands).
Upper Oligocene	12-21 33-42 52-71	Fram Ooze 3-14-2-1 (*Braarudosphaera* Chalk in 4-1)	9-71	62	Very pale brown nannofossil chalk ooze–very uniform. 0 to 4 per cent foraminifera, opaques very rare. 3-14-4-1 Subunit consists exclusively of fragments of the nannofossil *Braarudosphaera rosa*. This chalk is consolidated, friable, and bright white in color.
Upper Oligocene to Upper Eocene	71-107	Grampus Ooze 3-14-6-1	71-107	36	Interbeds of yellow brown and dark yellow brown marly nannofossil chalk oozes. Upper contact is transitional to very pale brown chalk ooze. Hematite and opaque content increases down section from 2 to 15 per cent. Foraminifera content 2 to 8 per cent.
?	107-108	Basalt 3-14-10-1			White crystalline marbles in contact with basalt. Basalt has thin (5 mm) chill margin (horizontal) at contact. Weathered yellow brown basalt grades down into dark gray basalt, cut by veins of calcite.

Core 3-14-10 sampled about 1 meter of the "basement" reflector. The core consists of marbles and basalts. Coarse-grained white, and fine-grained red-purple marbles occur at the top of the core. Thin laminae of basaltic glass are intrusive into cracks in the marble, and enclose cavities with euhedral calcitic fillings. The glass has caused discoloration and coarsening in the adjacent marble.

The top of the main basalt sections is marked by a horizontal layer of black basaltic glass 5-millimeters thick. This grades downward into weathered, yellow-brown cryptocrystalline basalt. In turn, this grades—in about 10 centimeters—into a relatively fresh, dark greenish-gray aphanitic basalt. The basalt is traversed by calcite veins, and may represent a sill, intrusive beneath a layer of sediments.

Hole 14 was cored almost continuously, with only 25 meters of the 108-meter hole not being sampled. The contact between the Endeavor and Fram Oozes falls within a 3-meter uncored interval (9 to 12 meters BOB.). The contact between the Fram and Grampus Oozes was represented by a transitional change, and was thus placed arbitrarily at the top of first light yellow-brown ooze below the main very pale brown ooze section at 71 meters BOB. The contact between the Grampus Ooze and basalt is sharply defined at 107 meters b.o.b.

The rate of sedimentation since early Miocene is practically nil; there might in fact have been removal of sediments by solution. The depositional rate of the Endeavor Ooze at Site 14 is about 10 meters in more than 5 million years, or about 0.2 cm/t.y. The Fram Ooze, 60 meters thick, was deposited in about 6 million years, or at a rate of 1.0 cm/t.y. The Grampus Ooze, 36 meters, was laid down in about 8 million years, or 0.45 cm/t.y.

The age, lithology, and probable interval of the Units at Site 14 are summarized in Table 2.

PHYSICAL PROPERTIES

Natural Gamma Radiation

At Site 14 natural radiation counts ranged from 50 to 1300 with an average of about 300 counts/1.25 minutes/7.6-centimeter core segment. In general, radiation decreased irregularly from a core average of 750 to 150 with depth (Figures 4A and 5A-13A). It also had an apparent inverse correlation to sound velocity and wet-bulk density, and an apparent direct correlation to porosity. However, these correlations have very little certainty. Natural radiation in the top core, 14-1A in the Endeavor Ooze, ranged from 450 to 1300 counts with an average of about 750. The comparison of gross lithologies and natural radiation, based on core averages, relates these high radiation counts to the zeolite or clay content of this core. Another possibility is that radioactive elements, such as, U^{234}, etc., may be present which have completed a significant portion of their half life between the Miocene Cores 1A and 2 (3 to 4 million years). Any exponential decay of radiation may be obscured by the source of the radioactive isotope not being constant, differing sedimentation rates, or differing amounts of the minerals holding these elements. However, specific isotopes have not been confirmed by overt evidence, and the Endeavor Ooze, which is at the surface at this site, also has high radiation at other sites where it is of a different age and well below the surface. Below Core 1A, in the Fram Ooze and Grampus Ooze, the counts range from 50 to 400 with an average of about 250 counts. These low counts correlate with the foraminiferal-nannoplankton chalk oozes, which do not contain abundant zeolites or clay minerals.

Site 14 data do not support the broad gamma-count sediment composition correlations described at Site 13. The low counts attributed to radiolarian oozes at Site 13 were also obtained from calcareous nannoplankton-foraminiferal oozes at Site 14. Also, a gamma radiation count of 1000 does not appear to delineate the presence of zeolites and clays as it did at Site 13. At Site 14 the delineation of clays and zeolites occurred at about 500 counts. These differences between sediments at Sites 13 and 14 could be attributed to the sites being in different sedimentation provinces, as the formations do not appear to be correlatable. However, a more detailed comparison of the lithology within each section is necessary to be certain that these gamma count correlations are significant.

Porosity, Wet-Bulk Density, and Water Content

Porosities and wet-bulk densities at Site 14 ranged from 42 per cent to about 75 (?) per cent, and 1.5 g/cc (?) to 2.0 g/cc, with approximate averages of 52 per cent and 1.85 g/cc (Figures 4A and 5A-13A). Water contents were within 29 to 44 per cent, averaging 47 per cent. Unusually high porosities and low densities are suspected to be artifacts. In general, wet-bulk densities increased and porosities decreased with increasing depth, suggesting some sediment compaction, but probably to a greater extent due to differing lithologies of the formations. Porosities correlated inversely to sound velocity and directly with the gamma radiation. The gamma radiation may be the result of the clay-zeolite content, which usually comprises fine-grained sediments, that, when unconsolidated, have greater porosities than coarse-grained sediments. Densities correlate inversely to porosity. These data may approximate *in situ* values, but the cores were disturbed in many instances.

Sediment Sound Velocity

Sediment sound velocities, at laboratory conditions, extended from 1.49 to 1.58 km/sec with a mean of about 1.53 km/sec (Figures 4A and 5A-13A). In general, sound velocities at Site 14 increased with depth. The average core sound velocity was lowest (1.50 km/sec) in the Endeavor Ooze, the highest values (1.55 km/sec) occurred in the Fram Ooze, and intermediate averages were measured in the Grampus Ooze. These sediment cores were somewhat disturbed, and even after *in situ* temperature-pressure corrections are made, these velocities may not accurately represent *in situ* sediment velocity.

Sound velocities were inversely correlated to porosity and to the natural radiation, and they varied directly to wet-bulk density. The zeolites and clays, which give high radiation counts, are probably finer-grained sediments with higher porosities, thus possibly causing the lower velocities.

Penetrometer

Except for a few sections, the Site 14 penetrometer measurements penetrated to the core liner.

Thermal Conductivity

At Site 14, thermal conductivity averages for each core varied from about 2.3 to 3.3 $\times$ 10^{-3} cal/°C cm sec over the hole depth, with little systematic change with depth (Figures 4A and 5A-13A). In contrast to the apparent direct correlation with natural gamma radiation at Site 13, thermal conductivity at this site showed an inverse or lack of correlation with this variable. On the other hand, thermal conductivity generally varied directly with bulk density and sound velocity, and inversely with porosity, as might be expected.

Interstitial Water Salinity

Interstitial salinity samples were not collected at Site 14.

REFERENCES

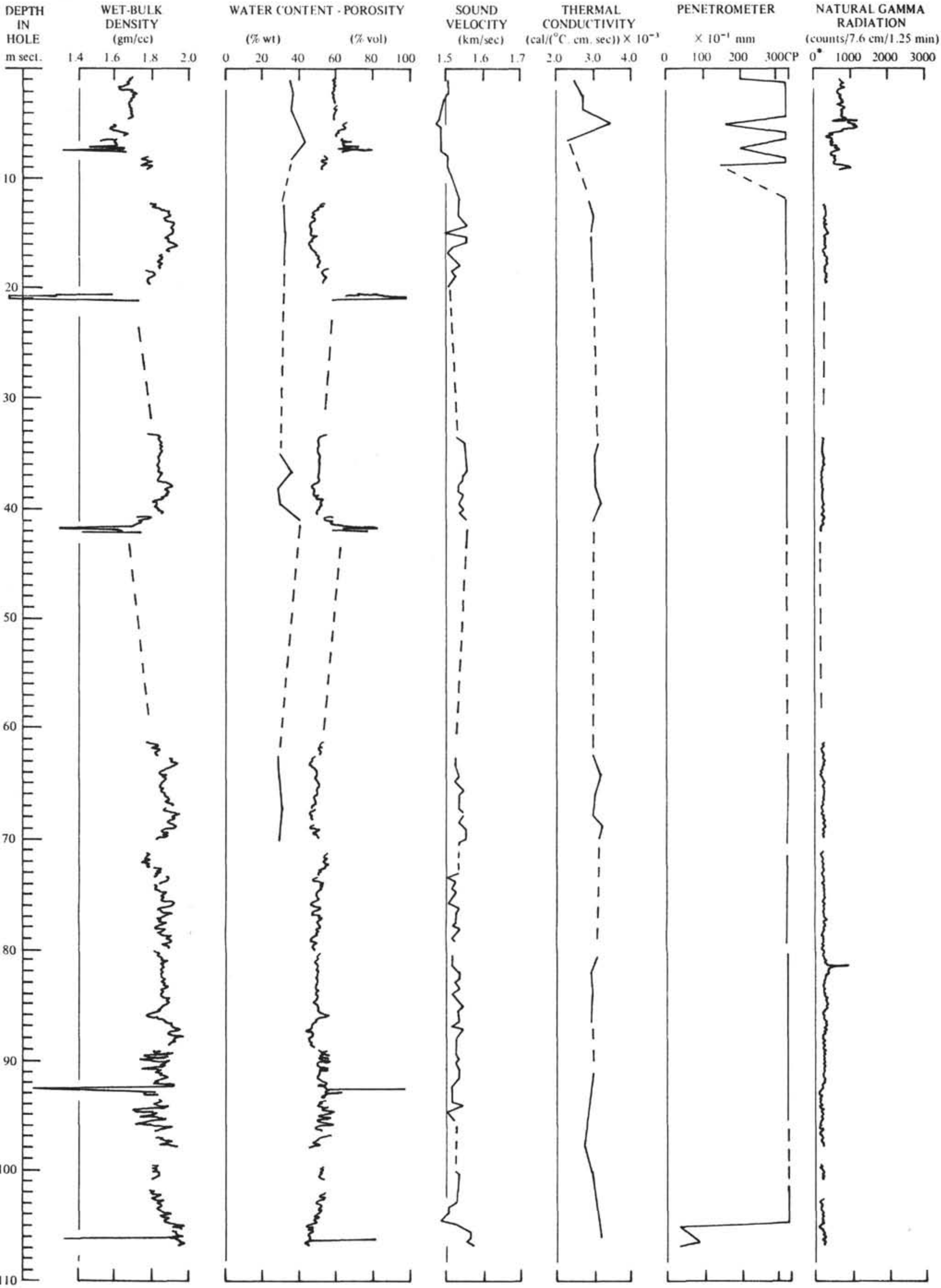
See consolidated list at the end of Chapter 13.

THE CORES RECOVERED FROM SITE 14

The following pages present a graphic summary of the results of drilling and coring at Site 14.

The first illustrations show a summary of the physical properties of the cores, the positions of the cores and cored intervals and some notes on the lithology and ages of the cores recovered from the holes.

Following this summary are more detailed displays of the individual cores recovered from Site 14. These two-page displays show the physical properties of the cores, the age assignments made on the basis of paleontology, a graphic representation of the lithology of the cores, some notes on the lithology, and notes regarding the diagnostic fossil species present. Symbols have been used for graphic display of lithology to give a general impression only, rather than a detailed representation, and these are supplemented by the lithology notes. For this reason, a detailed key has not been prepared. Interspersed among the core descriptions are photographs of the cores, where photographs are available. In general, every attempt has been made to locate photographs of the cores adjacent to, or as close as practicable to, the relevant Core Summaries. Where sections of core are of special interest, detailed Section Summaries are inserted.

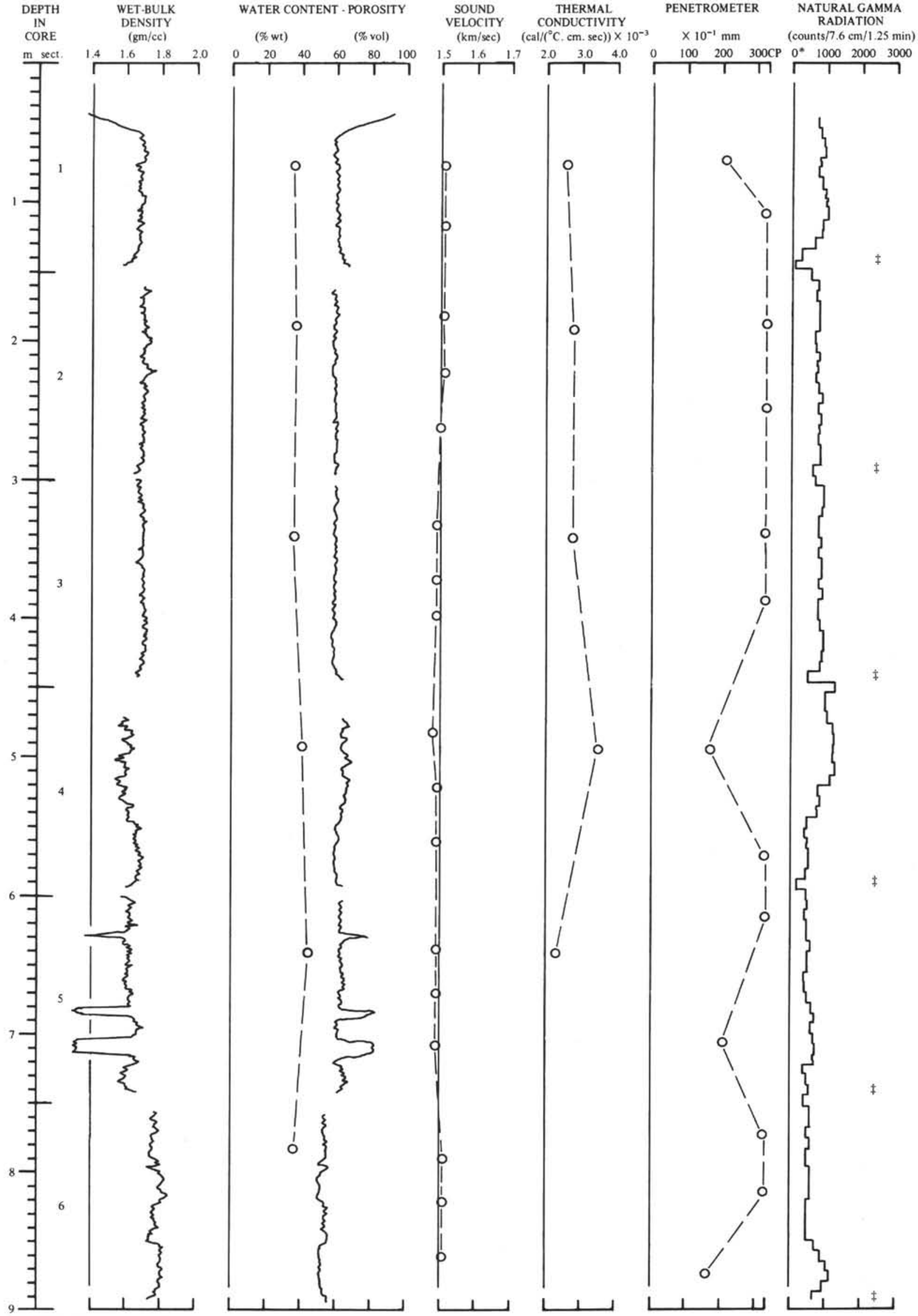


*"0" = laboratory atmospheric background count of 1550.

Figure 4A. *Summary of the physical properties of the cores recovered from Hole 14.*

DEPTH	CR.	CI.	FORMATION	LITHOLOGY	AGE
0	1A		Endeavor Ooze 3-14/1/1	Very pale brown nannofossil chalk oozes and yellow brown zeolitic marl oozes.	LOWER MIOCENE Aquitanian Budigalian (see core sheet for boundary)
	2		Fram Ooze 3-14/2/1	Very pale brown nannofossil chalk oozes, very uniform, rare foraminifera.	
	3			Same as above.	UPPER OLIGOCENE Chattian Bormidian
50	4		*Braarudosphaera* Marker (3-14/4/1)	The Marker bed consists exclusively of the nannofossil *B. rosa*. A white, friable chalk rock in very pale brown oozes, 1.5m. thick.	
	5			Very pale brown nannofossil chalk oozes.	
	6		Grampus Ooze 3-14/6/1	Yellow brown to dark brown marly chalk oozes, consisting mainly of nannofossils. Foraminifera content 2-8%, increasing with depth. Color darkens with depth also, due to increasing hematitic impurities.	
	7				
	8				LOWER OLIGOCENE Lattorfian Rupelian
100	9				
	10		Basement 3-14/10/1	Basalt	UPPER EOCENE Bartonian

Figure 4B. *Summary of the cores recovered from Hole 14. (Depth in meters below sea bed; C.R. = core recovered, C.I. = cored interval.)*



* "0" = laboratory-atmospheric background count of 1550.

‡ Radiation counts at the ends of 1.5 m sections are low because the volume of sediment being scanned is reduced.

Figure 5A. *Physical properties of Core 1A, Hole 14.*

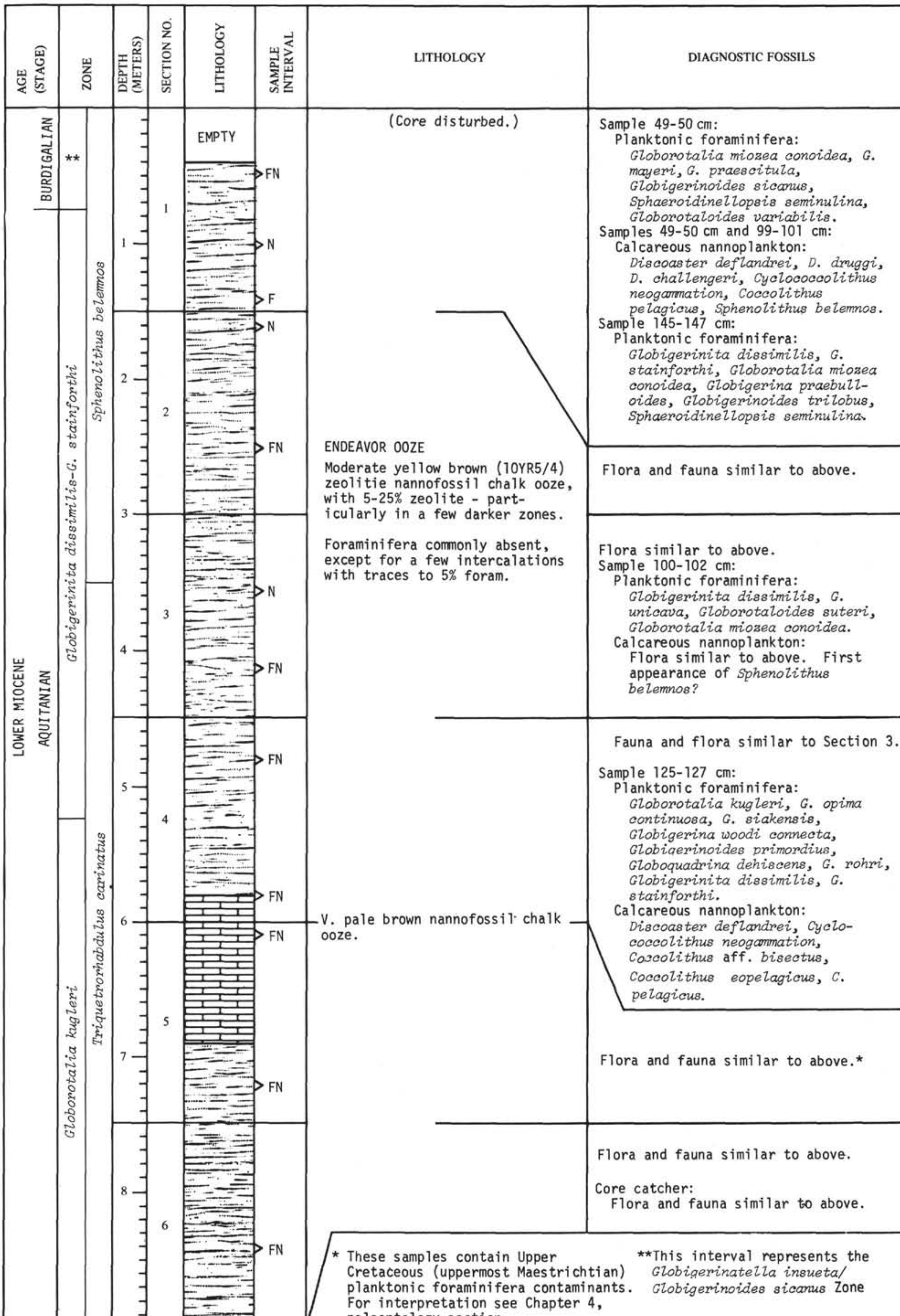


Figure 5B. *Core 1A, Hole 14.*

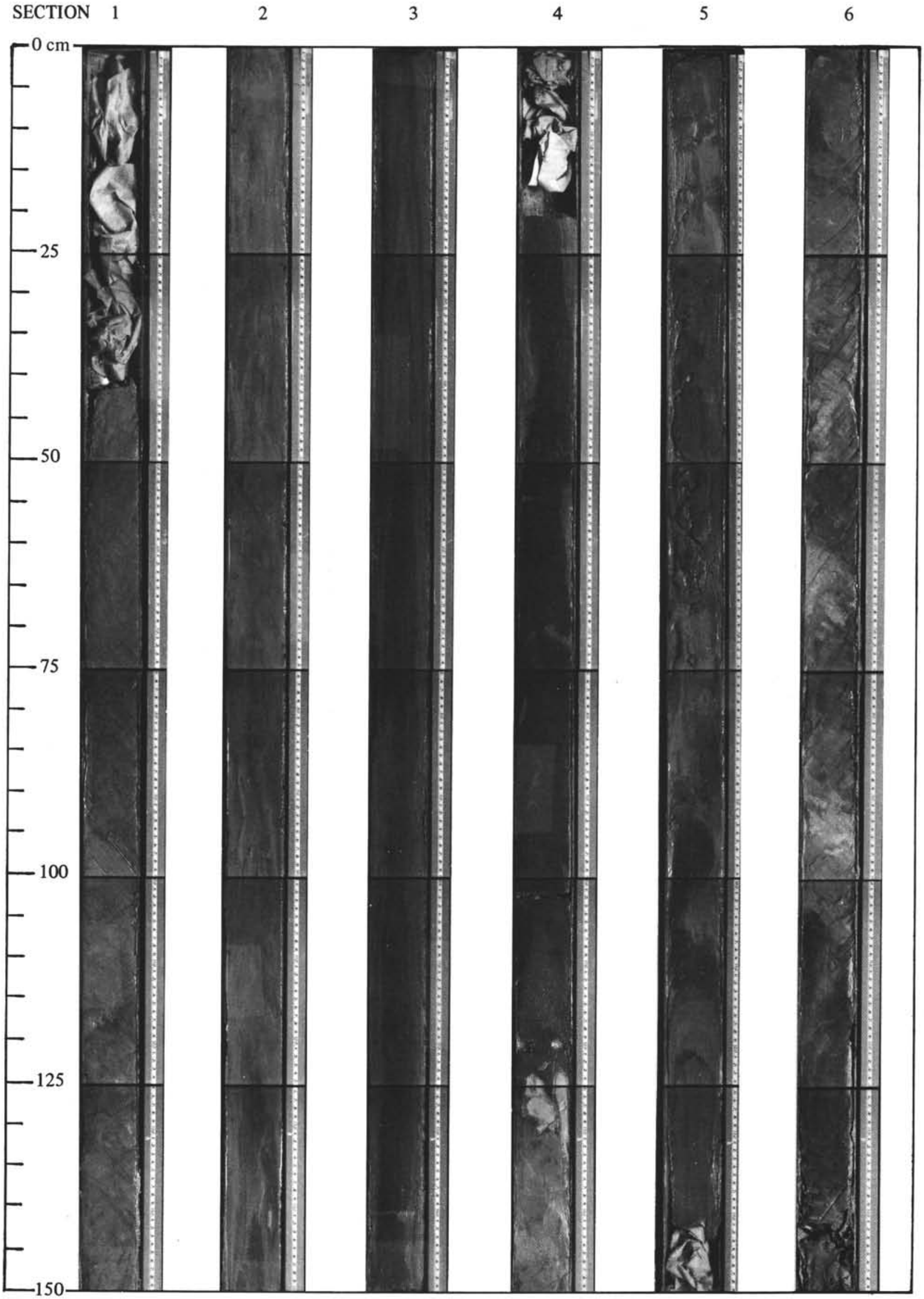


Plate 1. *Core 1A, Hole 14.*

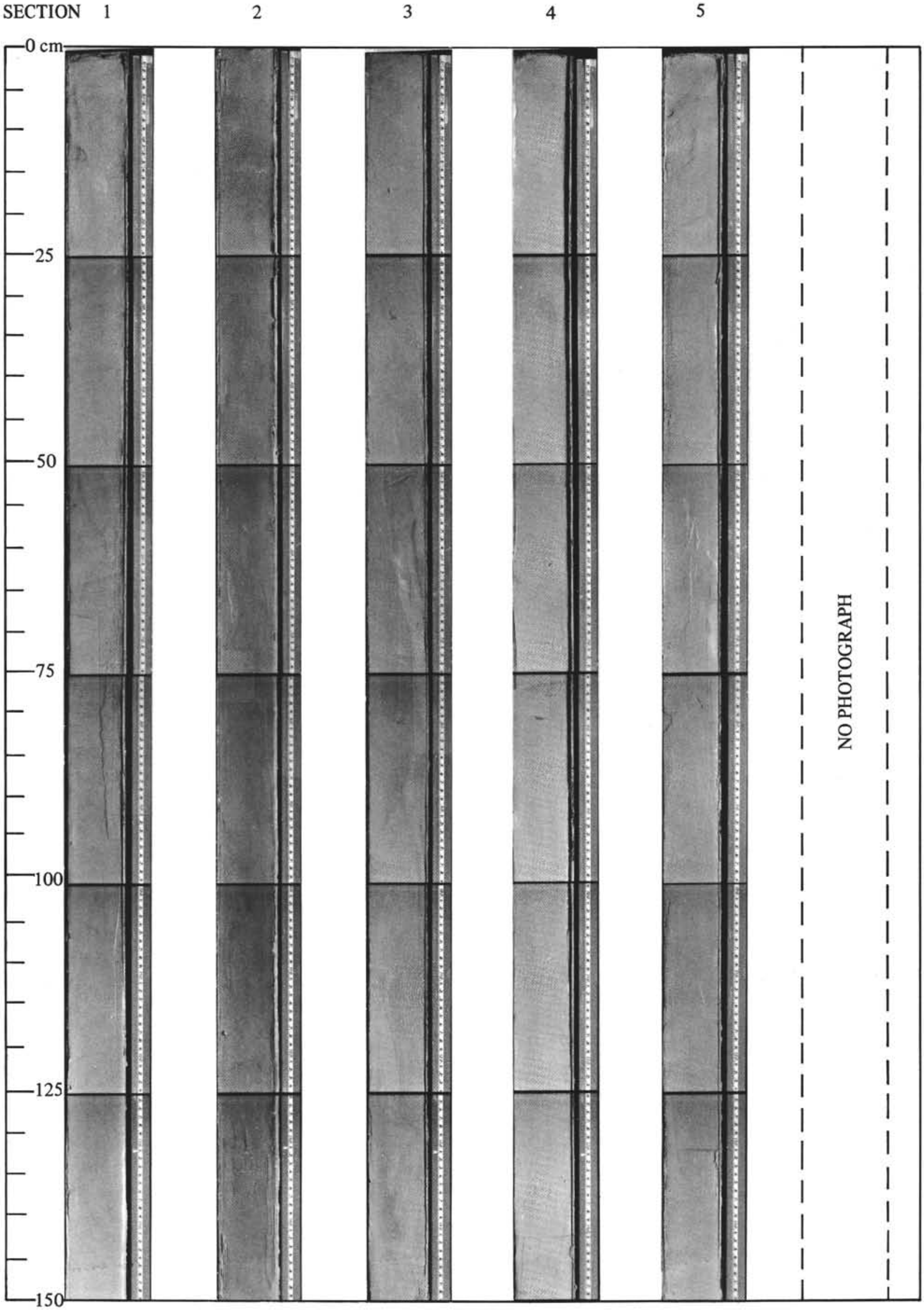
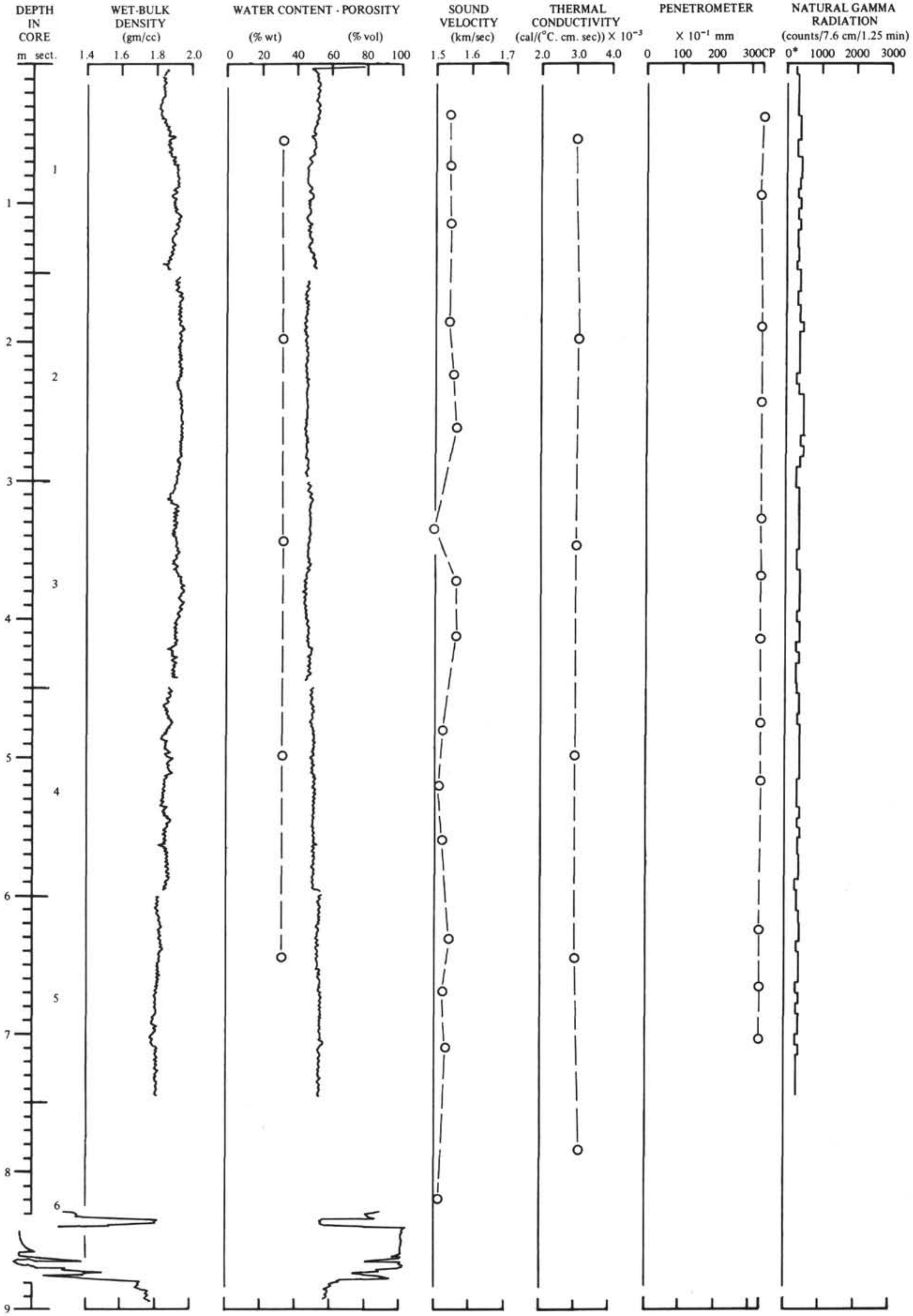


Plate 2. *Core 2, Hole 14.*

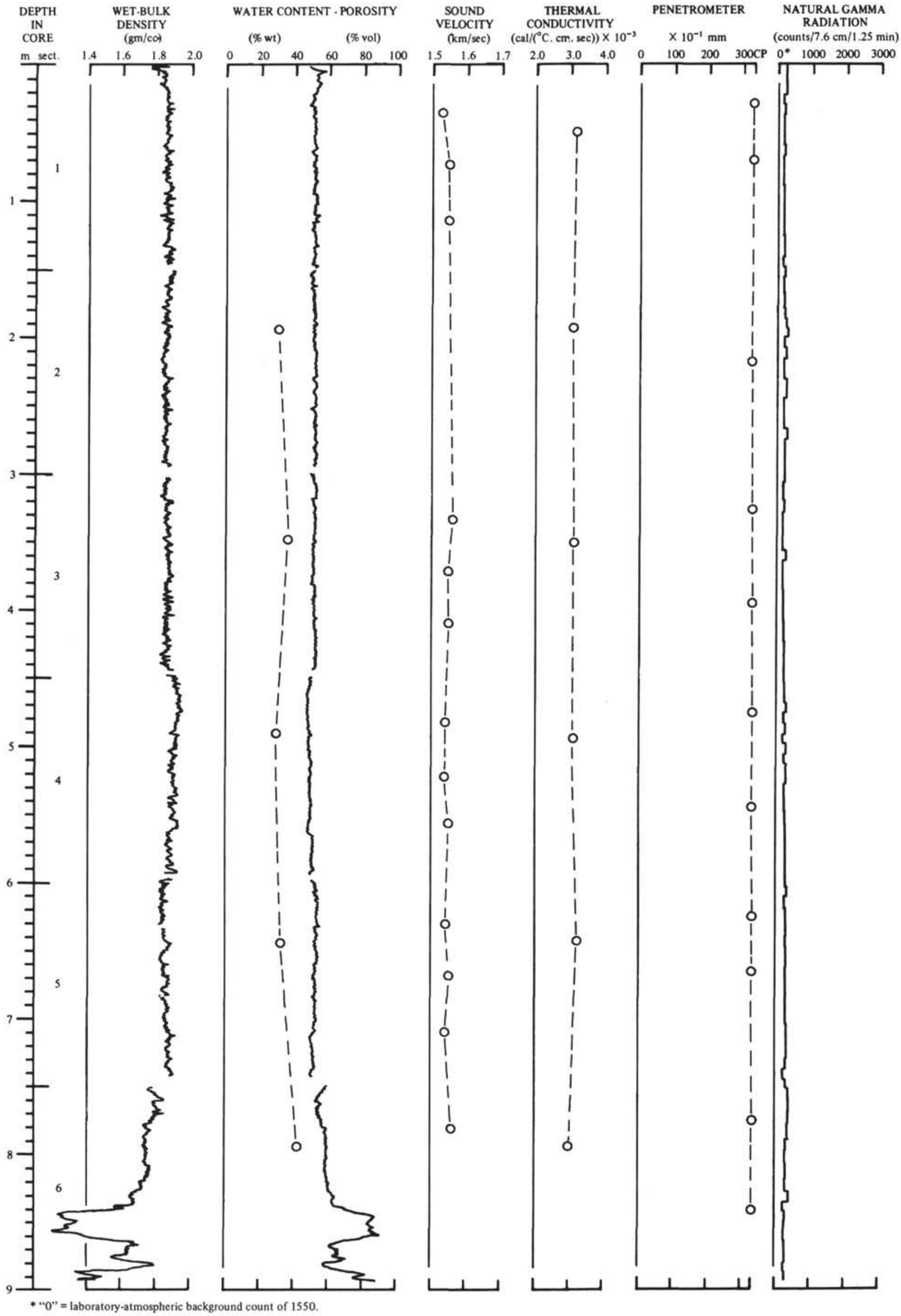


* "0" = laboratory-atmospheric background count of 1550.

Figure 6A. *Physical Properties of Core 2, Hole 14.*

AGE (STAGE)	ZONE	DEPTH (METERS)	SECTION NO.	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
UPPER OLIGOCENE (CHATTIAN-BORMIDIAN)	*Globorotalia kugleri.* Probably *Sphenolithus ciperoensis*	1	1	FN, N	FRAM OOZE Very pale brown nannofossil chalk oozes. 0-3% forams.	Planktonic foraminifera: *Globorotalia kugleri, G. opima continuousa, Globigerinita dissimilis. Globoquadrina praedehiscens, G. venezuelana, Globigerina praebulloides, G. woodi.* Calcareous nannoplankton: *Cyclococcolithus neogammation, Coccolithus biscetus, C.* aff. *bisectus, C. pelagicus, C. eopelagicus, Discoaster deflandrei.*
		2	2	N, N		Flora similar to above.
		3, 4	3	N, FN		Flora similar to above. Planktonic foraminifera: *Globigerina sellii, G. praebulloides, Globorotalia kugleri, G. opima nana, Globoquadrina praedehiscens, G. rohri, Globigerinita dissimilis.*
		5	4	N, N		Flora similar to above.
		6, 7	5	FN, N		Flora and fauna similar to above.
		8	6	NOT OPENED		Core catcher: Flora and Fauna similar to above.

Figure 6B: *Core 2, Hole 14.*



* "0" = laboratory-atmospheric background count of 1550.

Figure 7A. *Physical Properties of Core 3, Hole 14.*

AGE (STAGE)	ZONE	DEPTH (METERS)	SECTION NO.	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
UPPER OLIGOCENE CHATTIAN-BORMIDIAN	*Globigerina ciperoensis* *Sphenolithus ciperoensis*	0–1.5	1	N FN	FRAM OOZE Very pale brown nannofossil chalk ooze, 0-4% forams present.	Sample 10-12 cm: Calcareous nannoplankton: *Cyclococcolithus neogammation, Coccolithus bisectus, C.* aff. *bisectus, C. pelagicus, C. eopelagicus, Discoaster deflandrei, Sphenolithus ciperoensis.* Sample 100-102 cm: Planktonic foraminifera: *Globigerinita dissimilis, G. unicava, Globoquadrina rohri, Globigerina sellii, G. yeguaensis, Globorotalia opima nana, G. postcretacea.*
	Globigerina ciperoensis / *Globorotalia opima opima*	1.5–3	2	N FN		Flora similar to above. Planktonic foraminifera: First appearance of *Globorotalia opima opima, Globigerina angulisuturalis, G. corpulenta.*
	Globorotalia opima opima *Sphenolithus ciperoensis*	3–4.5	3	FN N		Flora and fauna similar to above.
		4.5–6	4	N N		Flora similar to above.
		6–7.5	5	N FN		Flora and fauna similar to above.
		7.5–9	6	N N		Flora similar to above. Core Catcher: Flora and fauna similar to above

Figure 7B. *Core 3, Hole 14.*

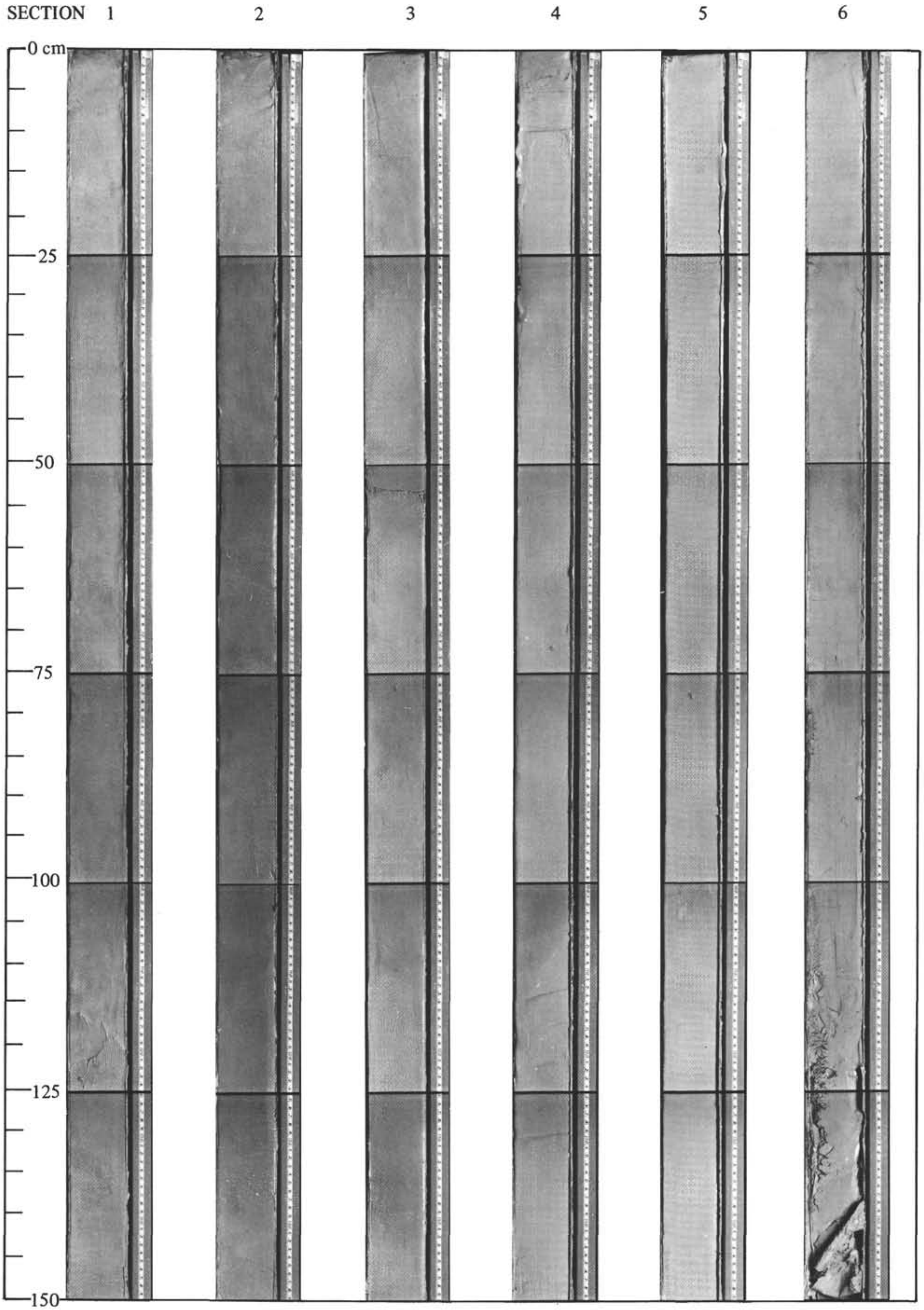


Plate 3. *Core 3, Hole 14.*

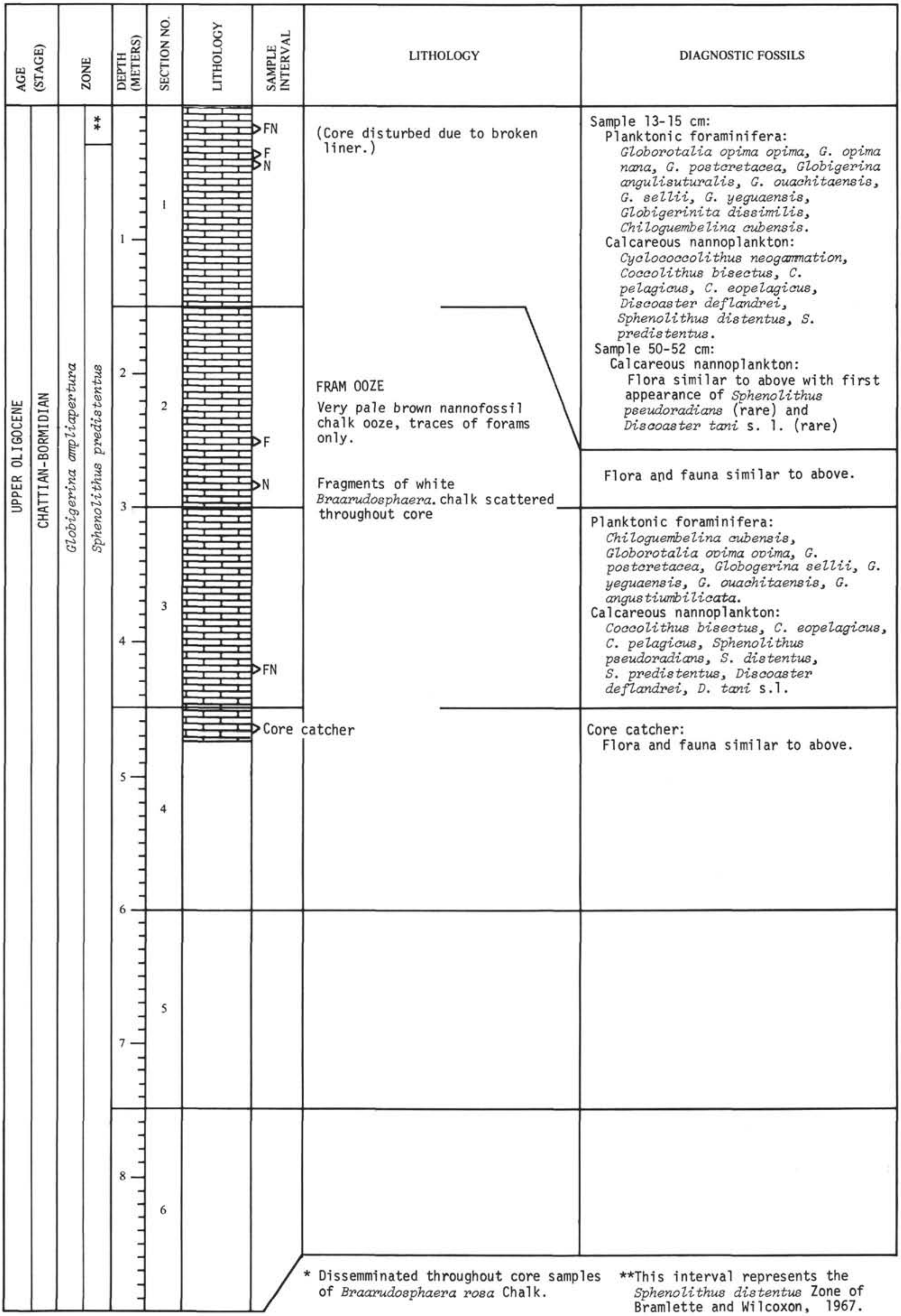
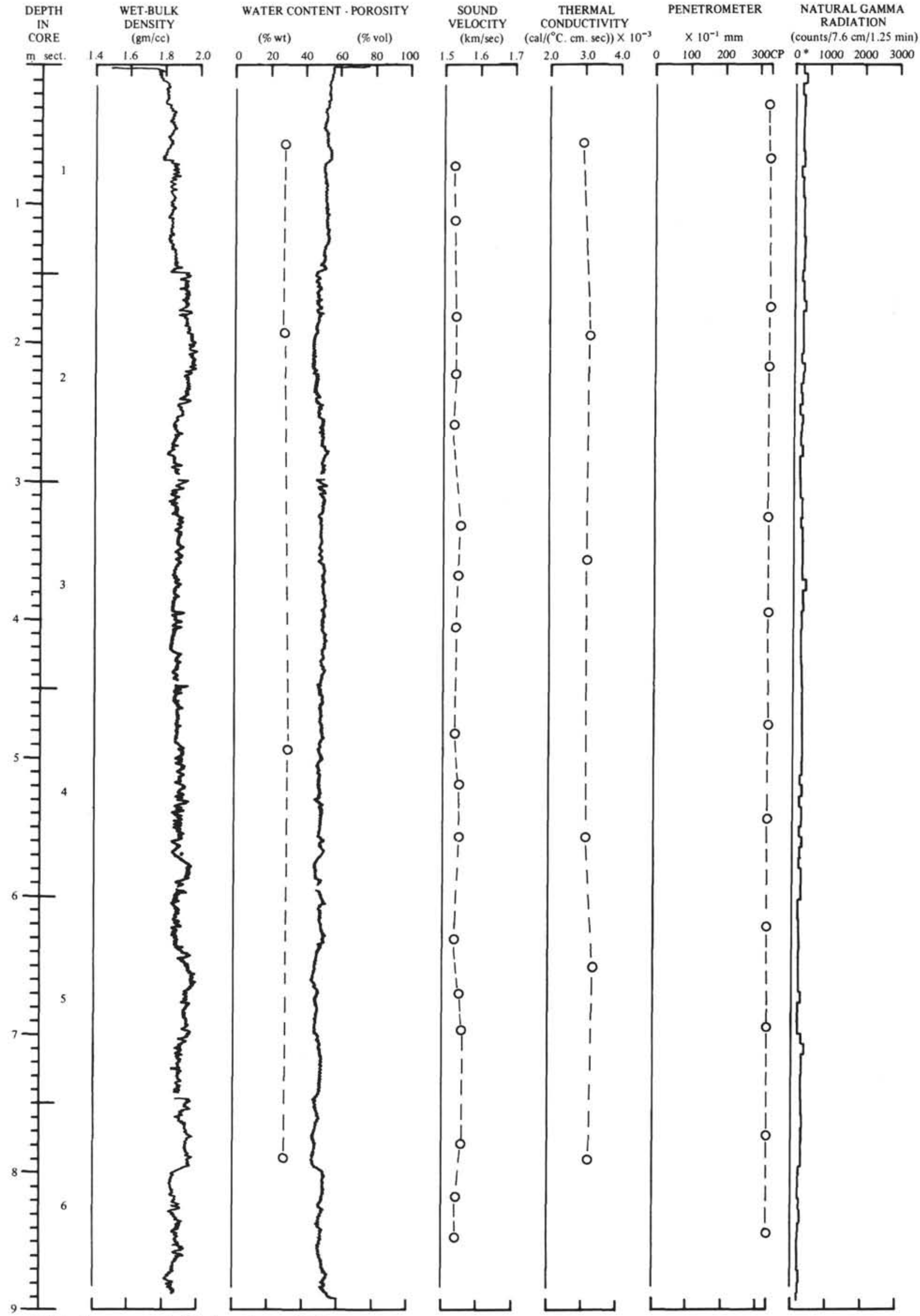


Figure 8. *Core 4, Hole 14. (No physical properties, data or photographs.)*



* "0" = laboratory-atmospheric background count of 1550.

Figure 9A. *Physical Properties of Core 5, Hole 14.*

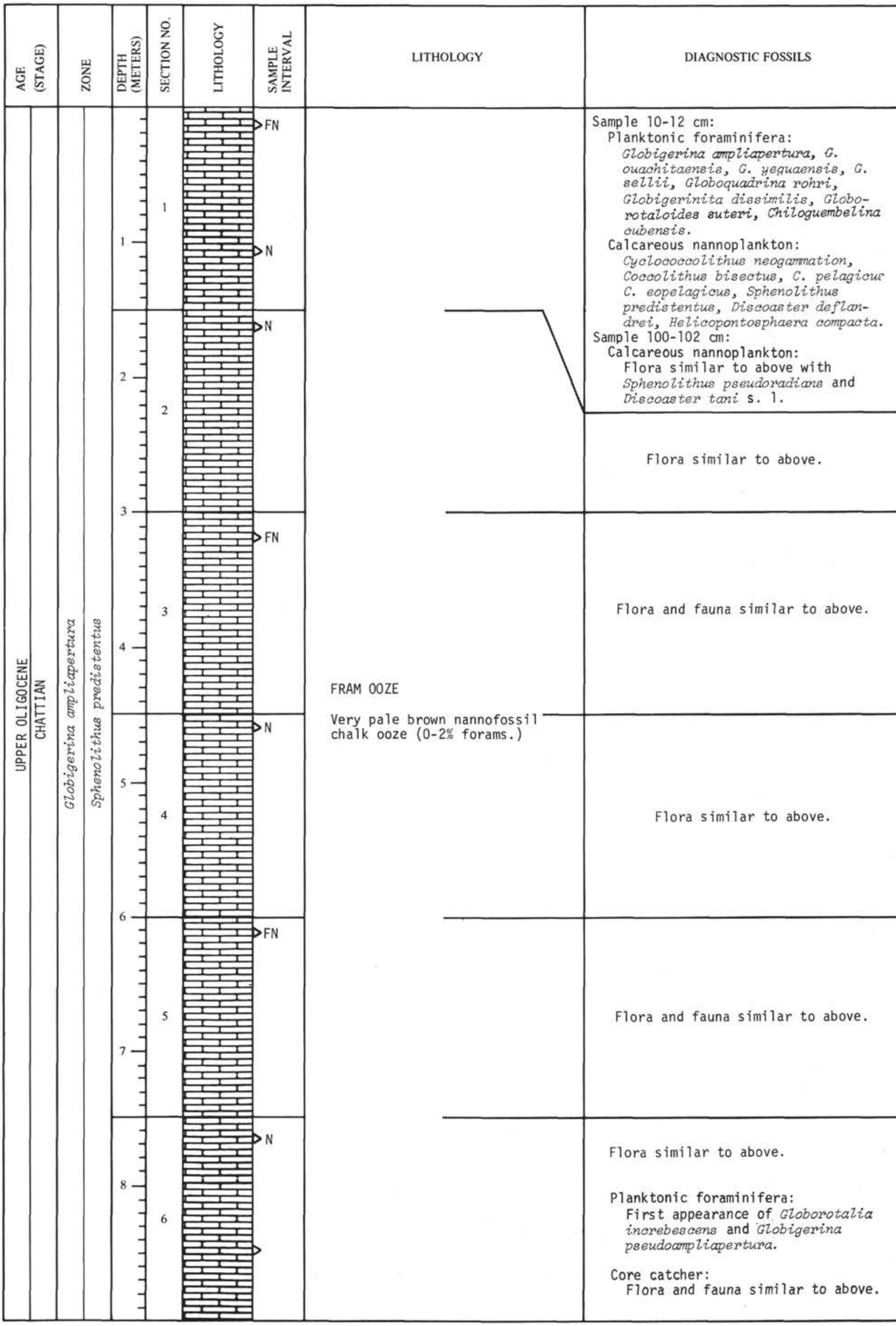


Figure 9B. *Core 5, Hole 14.*

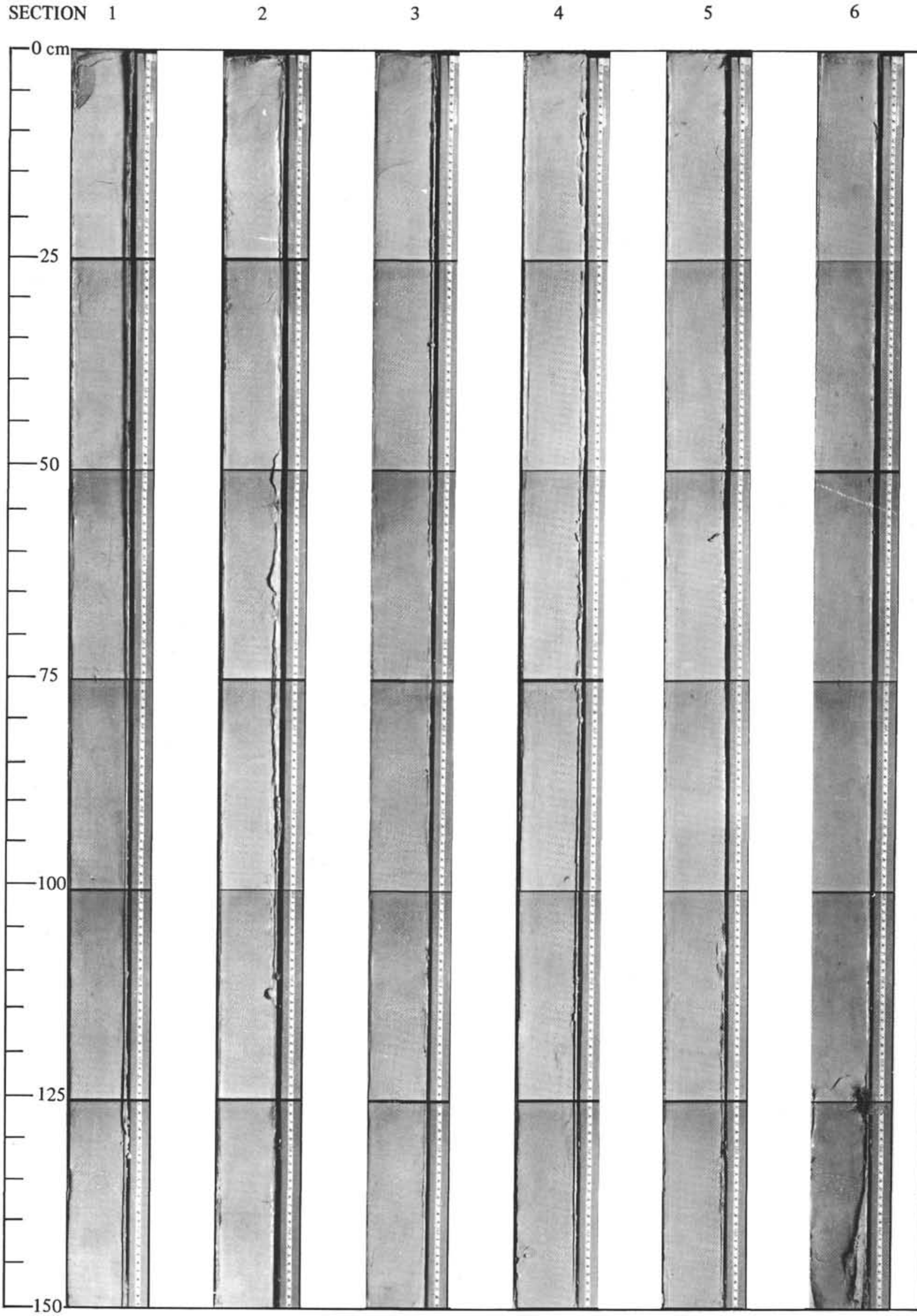


Plate 4. *Core 5, Hole 14.*

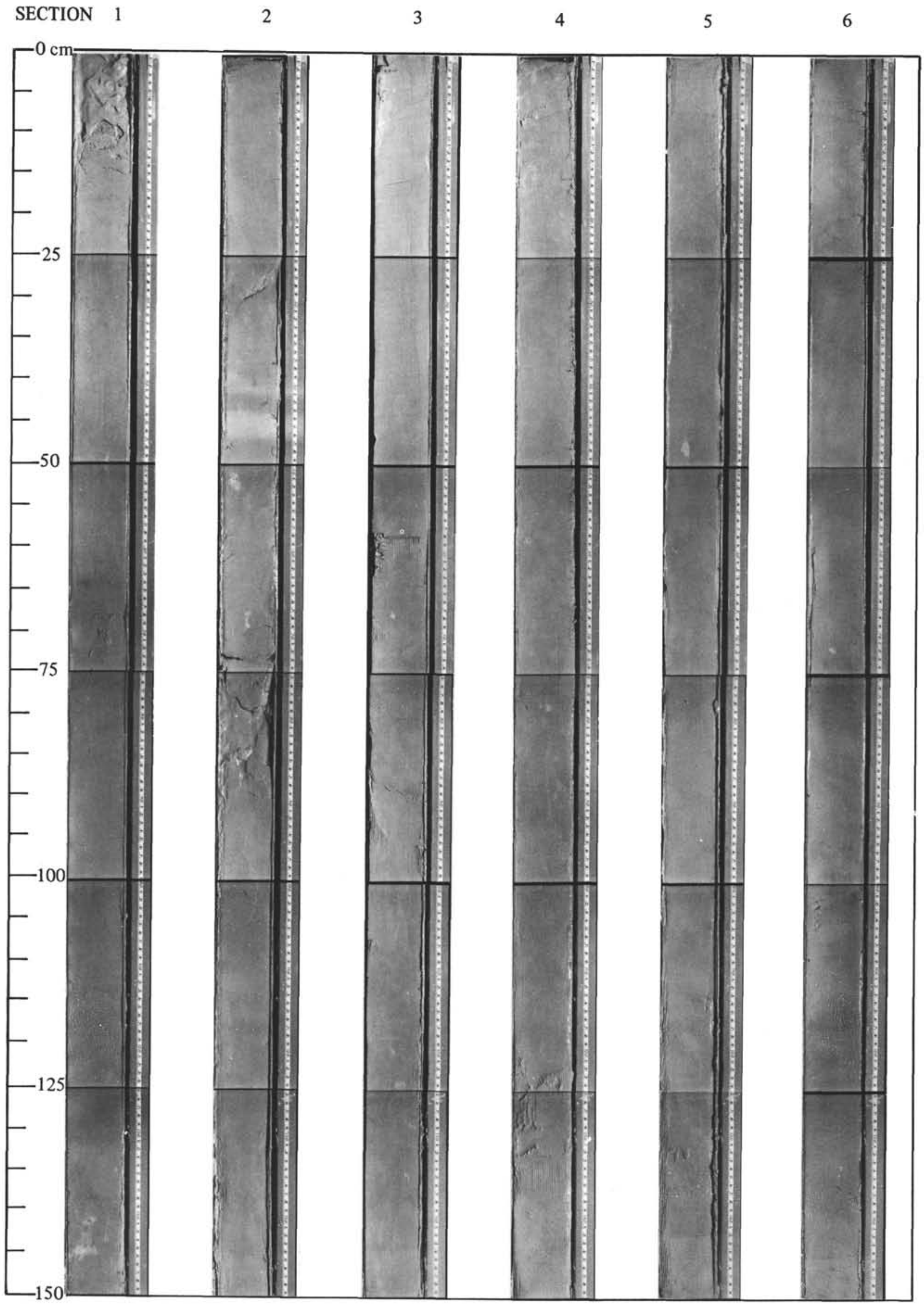
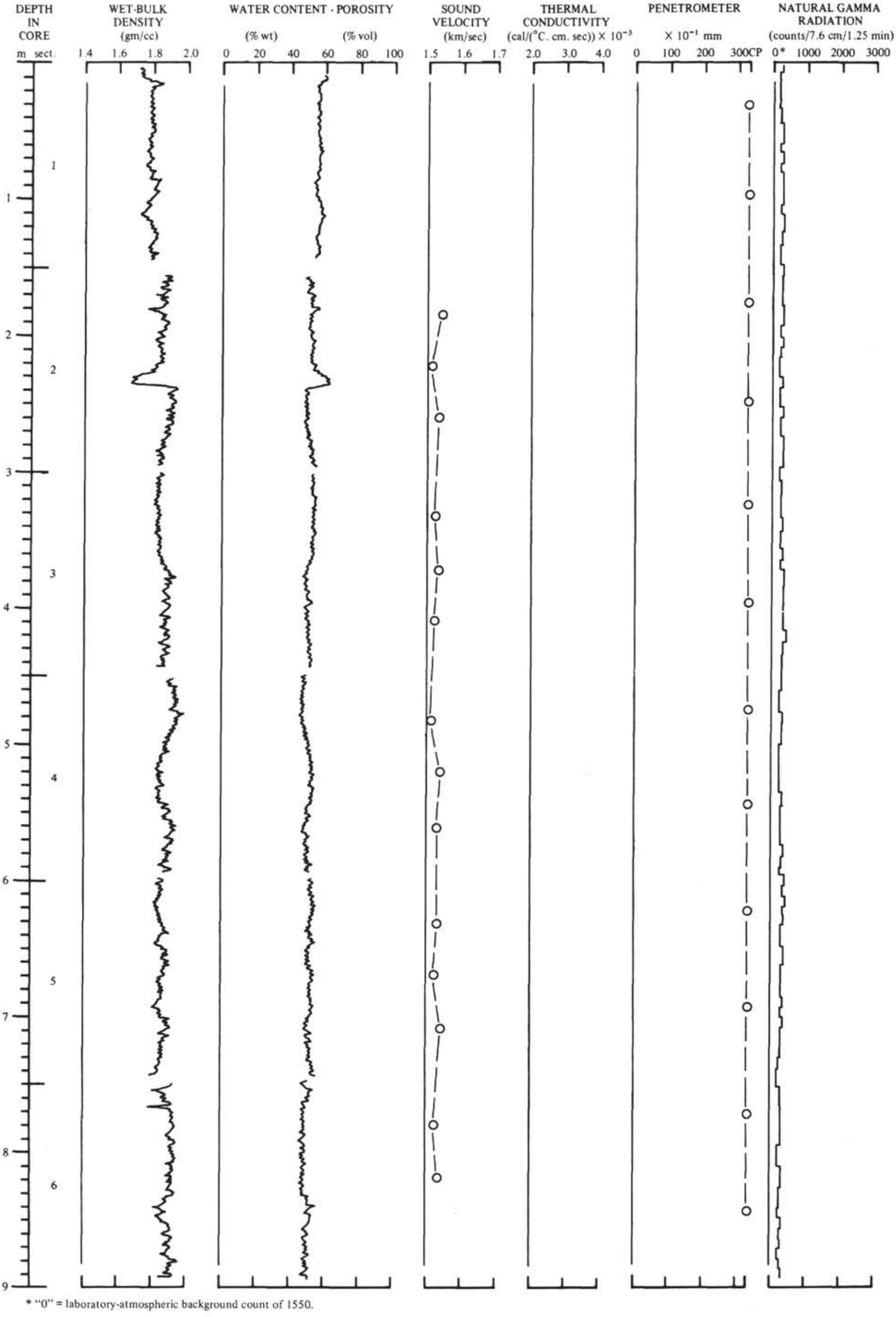


Plate 5. *Core 6, Hole 14.*



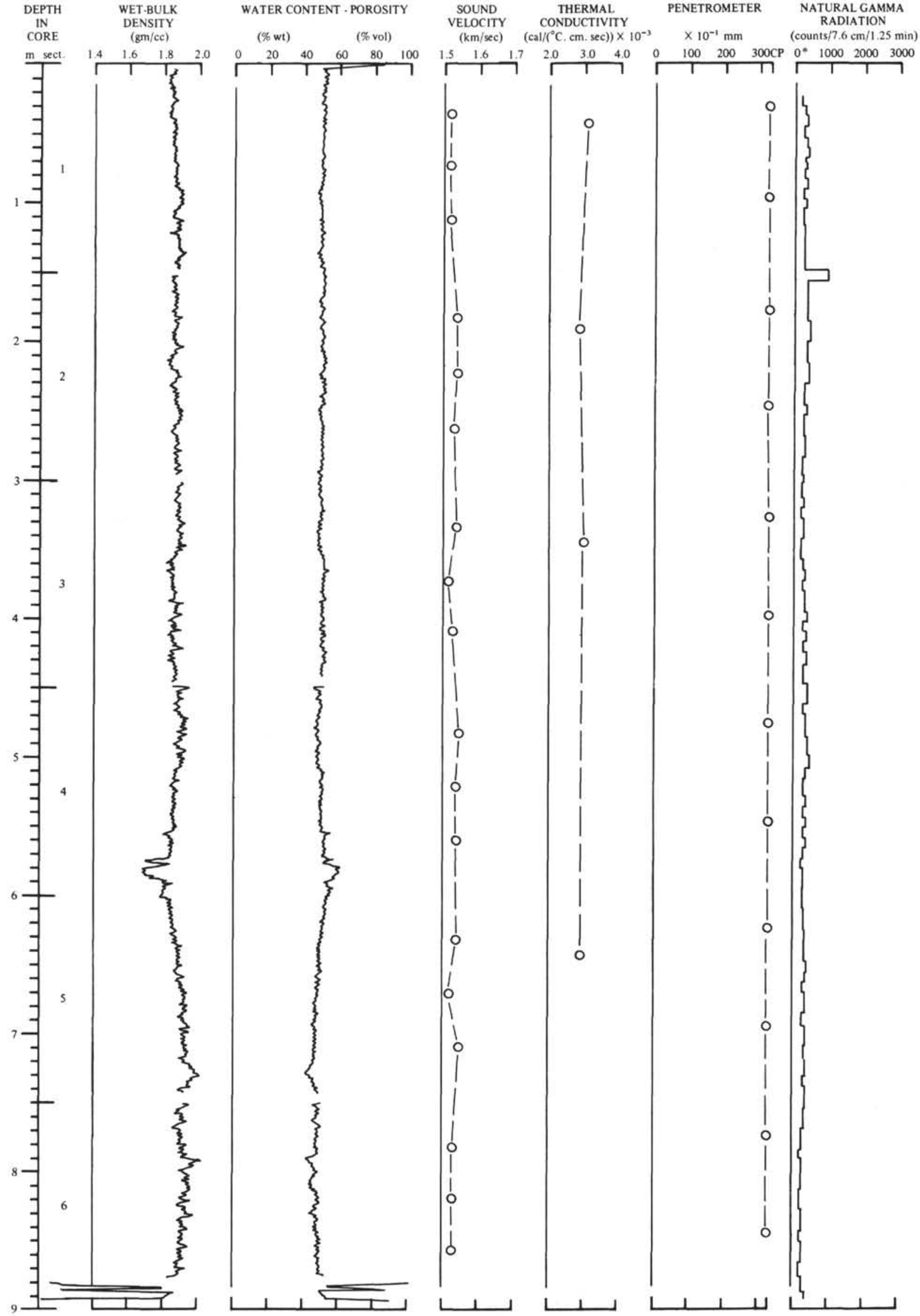
* "0" = laboratory-atmospheric background count of 1550.

Figure 10A. *Physical properties of Core 6, Hole 14.*

AGE	STAGE	ZONE		SECTION NO.	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
UPPER OLIGOCENE	CHATTIAN	*Globigerina ampliapertura*	*Sphenolithus predistentus*	1	NF		Planktonic foraminifera: *Globigerina angiporoides, G. ampliapertura, G. pseudoampliapertura, G. ouachitaensis, G. yeguaensis, G. sellii, Chiloguembelina cubensis, Globorotalia postcretacea.* Calcareous nannoplankton: *Cyclococcolithus neogammation, Coccolithus bisectus, C. pelagicus, C. eopelagicus, Sphenolithus predistentus, S. pseudoradians, Discoaster tani* s.l.
				2	N		Flora similar to above.
				3	FN	GRAMPUS OOZE Very pale brown (10YR7/4) nannofossil chalk ooze 1-5% opaques 1-8% foram 1-5% clay	Flora and fauna similar to above Planktonic foraminifera: First appearance *Globigerina gortanii.*
				4	FN	Opaque and clay content increase down core; color darkens Lt. yellow brown (10YR6/4)	Flora and fauna similar to above.
				5	N		Flora similar to above.
				6	FN FN	Mod. Yellow brown (10YR5/4)	Flora and fauna similar to above. Core catcher: Flora and fauna similar to above.

DEPTH (METERS): 1, 2, 3, 4, 5, 6, 7, 8

Figure 10B. *Core 6, Hole 14.*



* "0" = laboratory-atmospheric background count of 1550.

Figure 11A. *Physical Properties of Core 7, Hole 14.*

AGE	STAGE	ZONE		DEPTH (METERS)	SECTION NO.	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
UPPER OLIGOCENE	CHATTIAN	*Globigerina ampliapertura*	*Sphenolithus predistentus*	1	1	FN	GRAMPUS OOZE Mod. yellow brown (10YR5/4) to brown (10YR4/5/3) nannofossil chalk ooze 1-2% foram 2-5% clay min. } increasing to 2-8% hematite } bottom	Sample 10-12 cm: Planktonic foraminifera: *Globigerina gortanii, G. sellii, G. ouachitaensis, G. ampliapertura, Globorotalia opima nana, Chiloguembelina cubensis.* Calcareous nannoplankton: *Cyclococcolithus neogammation, Coccolithus bisectus, C. pelagicus, C. eopelagicus, Sphenolithus predistentus, S. pseudoradians, Discoaster tani* s.l., *Helicopontosphaera compacta.*
				2	2	N		Flora similar to above.
				3, 4	3	N		Flora similar to above.
				5	4	N, F		Flora and fauna similar to above.
		?		6	5	N, F, FN		Flora and fauna similar to above. Sample 100-102 cm: Planktonic foraminifera: Fauna similar to above. First appearance of *Pseudohastigerina micra.*
LOWER OLIGOCENE	LATTORFIAN-RUPELIAN	*Globigerina selli/Pseudohastigerina barbadiensis*	*	7, 8	6	FN, N		Flora and fauna similar to above. Core catcher: Flora similar to above. First appearance of *Reticulofenestra umbilica.* Fauna similar to above.

* The core catcher sample probably represents the *Helicopontosphaera reticulata* Zone.

Figure 11B. *Core 7, Hole 14.*

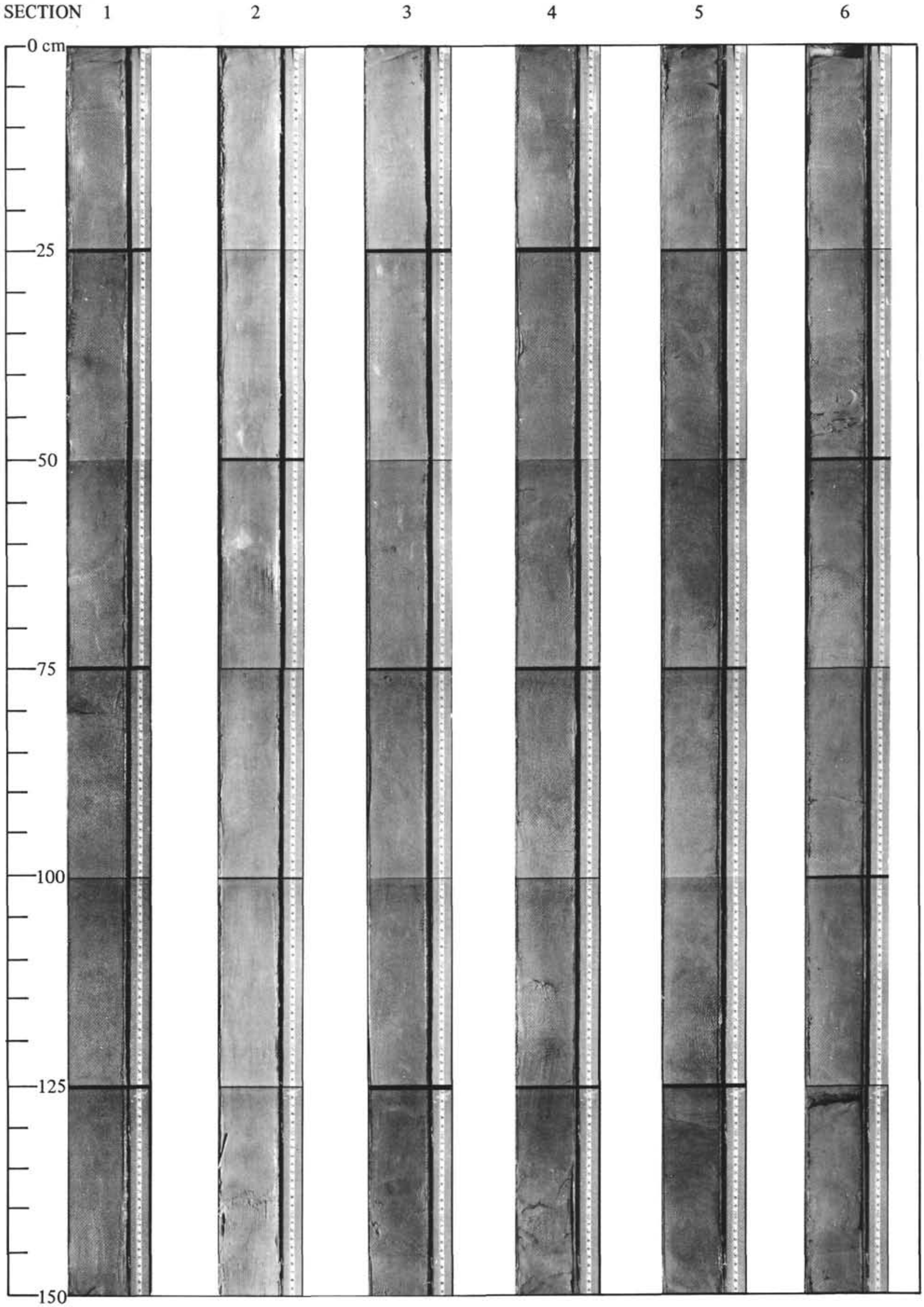


Plate 6. *Core 7, Hole 14.*

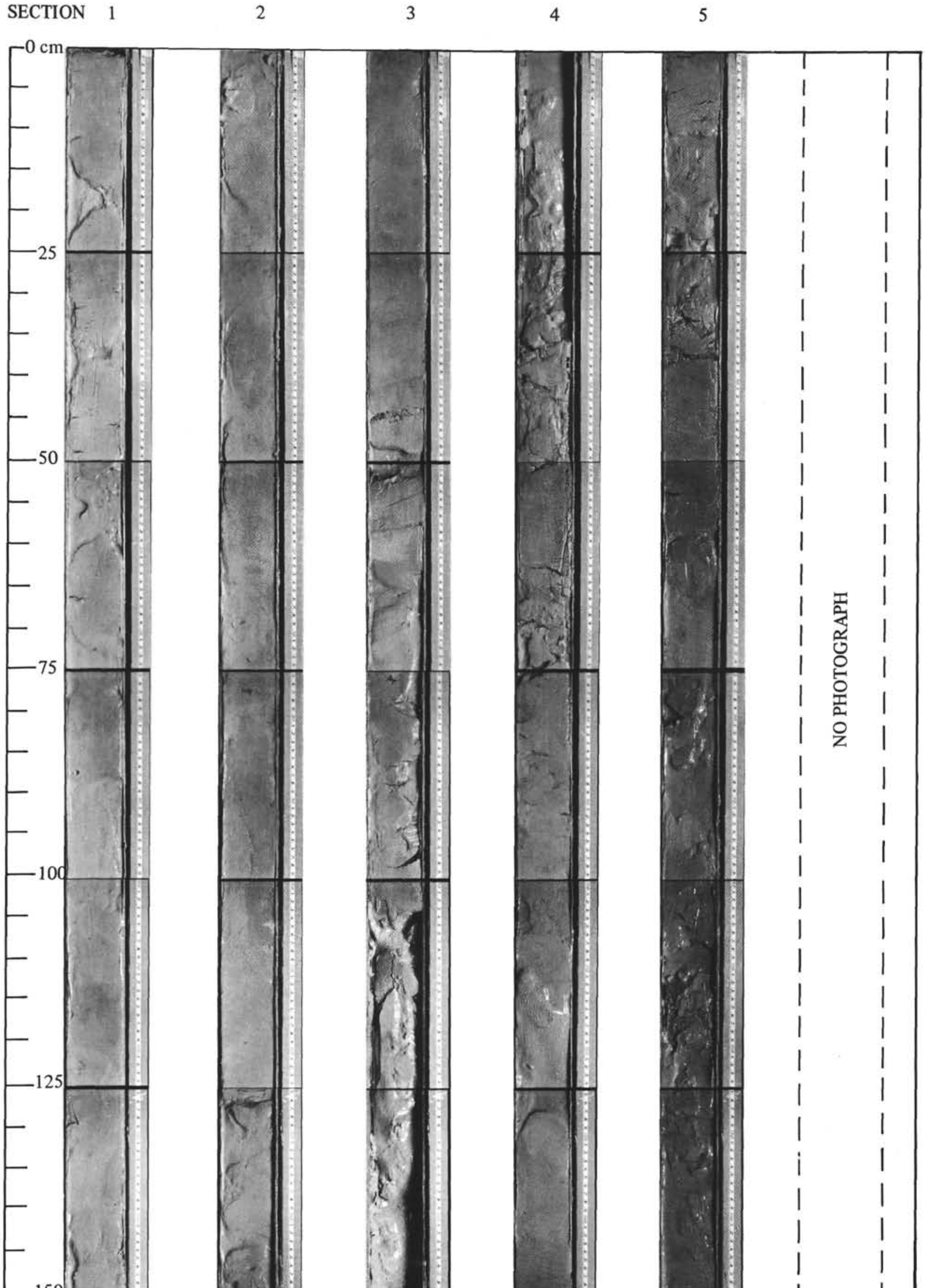
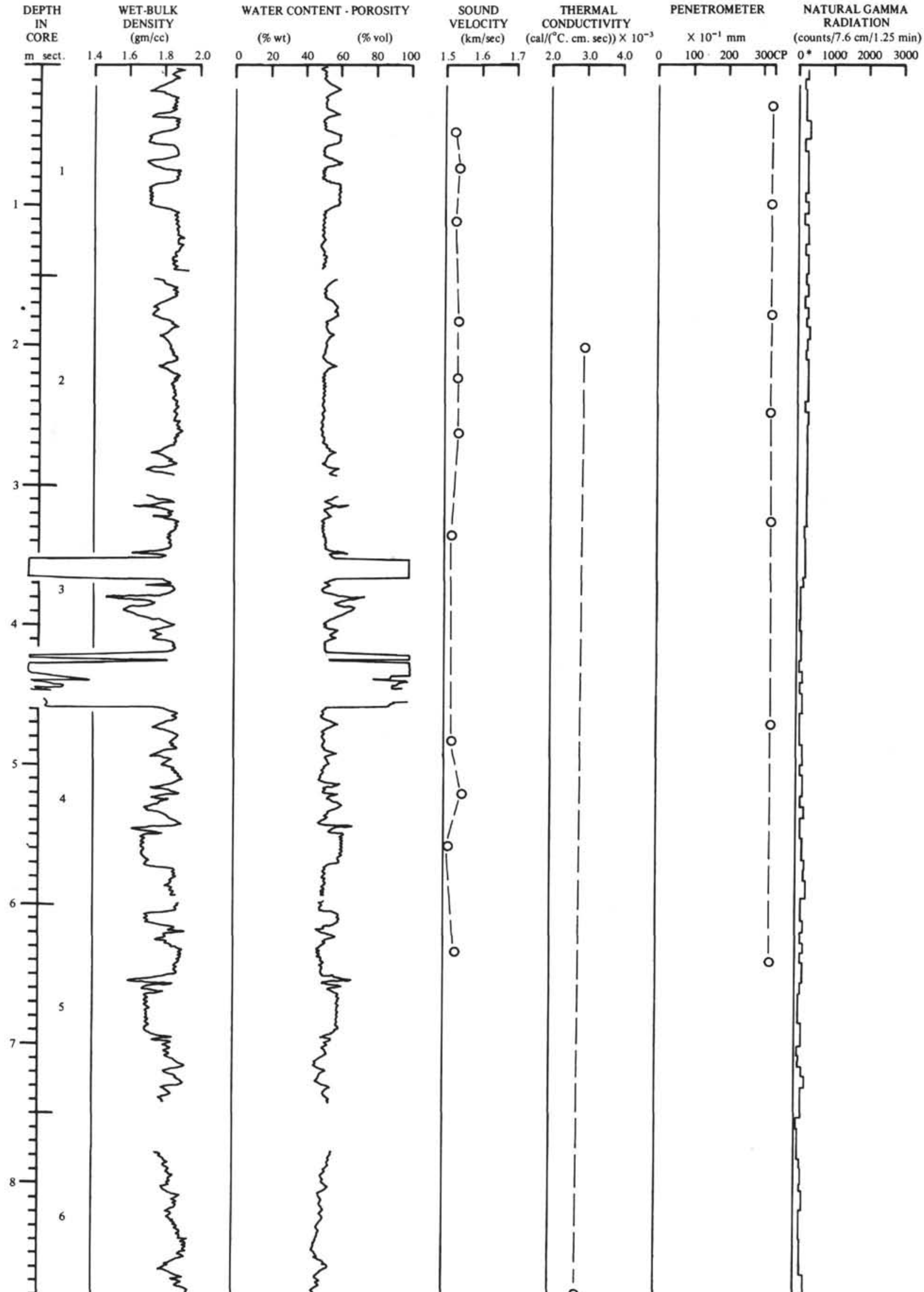


Plate 7. *Core 8, Hole 14.*

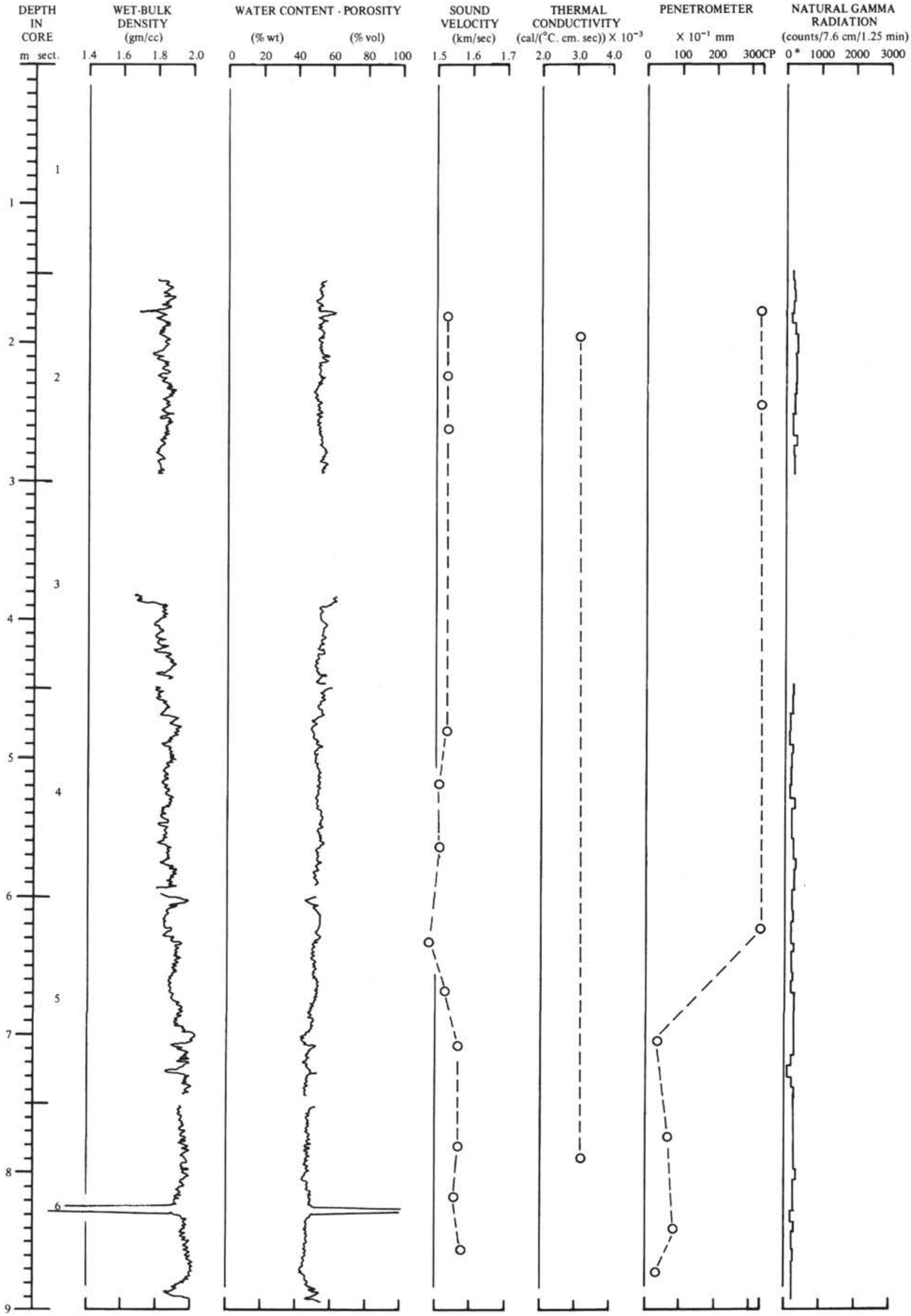


* "0" = laboratory-atmospheric background count of 1550.

Figure 12A. *Physical Properties of Core 8, Hole 14.*

AGE (STAGE)	ZONE	DEPTH (METERS)	SECTION NO.	LITHOLOGY	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
LOWER OLIGOCENE LATTORFIAN - RUPELIAN	*Globigerina sellii / Pseudohastigerina barbadiensis* *Helicopontosphaera reticulata*	0–1.5	1		FN	GRAMPUS OOZE Dk. brown. (10YR4/3) to dk. yellow brown (10YR3/4), nannofossil chalk ooze. 2-5% foram 10-15% opaques	Planktonic foraminifera: *Pseudohastigerina micra, Chiloguembelina cubensis, Globorotalia postcretacea, G. increbescens, Globorotaloides suteri, Globigerina yeguaensis, G. ampliapertura, G. corpulenta, G. gortanii.* Calcareous nannoplankton: *Coccolithus bisectus, C. eopelagicus, C. pelagicus, Sphenolithus predistentus, S. pseudoradians, Cyclococcolithus neogammation, Reticulofenestra umbilica, Discoaster tani* s.l.
		1.5–3	2		N		Flora similar to above.
		3–4.5	3		FN		Flora similar to above with *Cyclococcolithus lusitanicus.* Fauna similar to above.
		4.5–6	4		N		Flora similar to above.
		6–7.5	5		N		Flora similar to above.
	Globigerina tapuriensis	7.5–9	6		OPENED AT END FN		Fauna similar to above with *Globigerina linaperta, G. pseudoampliapertura,* and *G. tapuriensis.* Core catcher: Flora similar to above with *Isthmolithus recurvus.* Fauna similar to above with *Globigerina pseudovenezuelana.*

Figure 12B. *Core 8, Hole 14.*



* "0" = laboratory-atmospheric background count of 1550.

Figure 13A. *Physical properties of Core 9, Hole 14.*

AGE	(STAGE)	ZONE		DEPTH (METERS)	SECTION NO.	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
LOWER OLIGOCENE	LATTORFIAN - RUPELIAN	*Globigerina tapuriensis*	*Helicopontosphaera reticulata*	0–1.5	1	NOT OPENED	GRAMPUS OOZE Dark brown (10YR3/3) to brown (10YR5/3) calcareous, nannofossil chalk ooze. 2% foram 8-15% opaques (hematite)	
				1.5–3	2	N FN		Calcareous nannoplankton: *Coccolithus bisectus, C. pelagicus, C. eopelagicus, Cyclococcolithus neogammation, C. lusitanicus, Reticulofenestra umbilica, Sphenolithus pseudoradians, S. predistentus, Isthmolithus recurvus, Discoaster tani* s.l. Planktonic foraminifera: *Globigerina linaperta, G. pseudoampliapertura, G. ampliapertura, G. corpulenta, Chiloguembelina cubensis, Pseudohastigerina micra.*
				3–4.5	3	OPENED AT END N		Flora similar to above.
				4.5–6	4	N		Flora similar to above.
				6–7.5	5	FN N		Flora and fauna similar to above.
			?	7.5–8.2	6	N		For flora and fauna descriptions see section sheet.
UPPER EOCENE	BARTONIAN	*		8.2–9		FN FN		

* The *Globorotalia cerroazulensis* Zone.

Figure 13B. *Core 9, Hole 14.*

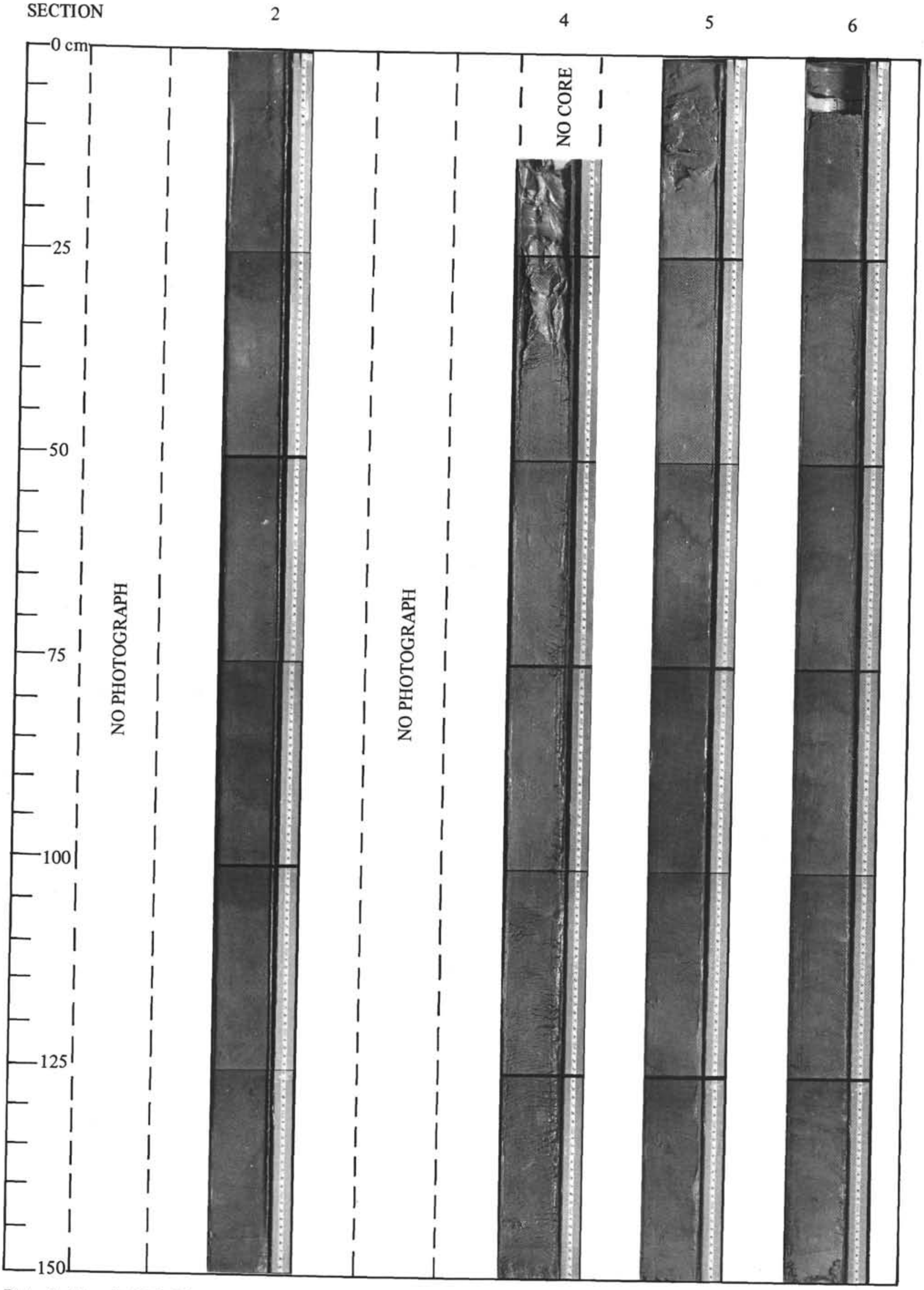


Plate 8. *Core 9, Hole 14.*

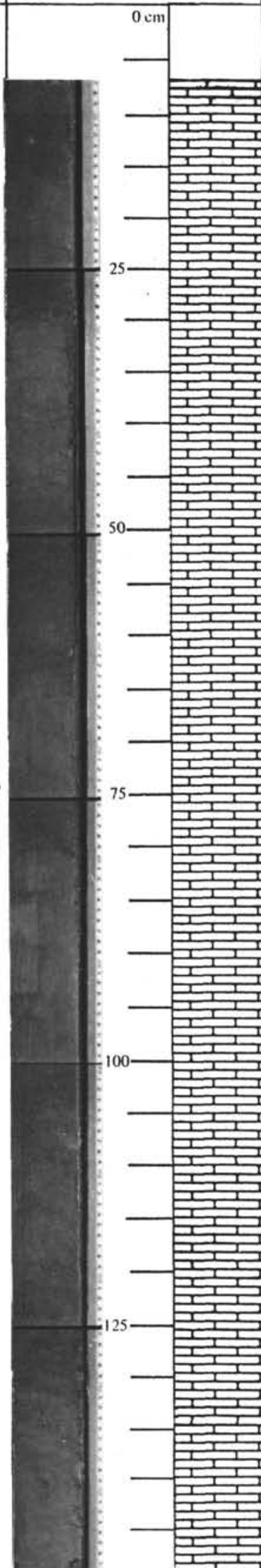
AGE (STAGE)	ZONE	LITHOLOGY	SAMP. INT.	LITHOLOGY	DIAGNOSTIC FOSSILS
LOWER OLIGOCENE LATTORFIAN-RUPELIAN	*Globigerina tapuriensis* Zone *Helicosphaera reticulata* Zone		N	Fm. GRAMPUS OOZE Calcareous nannofossil chalk ooze. 2% foram 8-15% opaques Colors: 10YR3/3-10YR5/3 Dark brown to brown, interbedded with gradational contacts. 0-60 cm. 10YR predominate 60-150 cm. 10YR5/3 predominate	Sample 15-17 cm: Calcareous nannoplankton: *Coccolithus bisectus, Cyclococcolithus neogammation, C. lusitanicus, Reticulofenestra umbilica, Sphenolithus pseudoradians, Isthmolithus recurvus, Discoaster tani* s.l.
UPPER EOCENE BARTONIAN	*Globorotalia cerroazulensis*		FN FN		Sample 100-102 cm: Flora similar to above. Planktonic foraminifera: *Globigerina linaperta, G. pseudoampliapertura, G. corpulenta, Chiloguembelina cubensis, Pseudohastigerina micra.* Sample 145-146 cm: Flora similar to above. Planktonic foraminifera: *Globorotalia cerroazulensis, Globigerina sellii, G. tapuriensis, Hantkenina* sp. Core catcher: Flora similar to above. Planktonic foraminifera: *Globorotalia cerroazulensis, Globigerina angiporoides, G. tapuriensis, G. linaperta, Hantkenina suprasuturalis, H. primitiva, H. alabamaensis, Cribrohantkenina inflata, Pseudohastigerina micra.*

Figure 14. *Summary of Section 6, Core 9, Hole 14.*

AGE (STAGE)	ZONE	DEPTH (METERS)	SECTION NO.	LITHOLOGY	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
		1	1	EMPTY		White and pale red purple fine crystaline marble with rhombohedral cavity fillings. Thin laminae of basaltic glass intrusive into cracks in the marble, causing discoloration, and coarser crystals in the adjacent marble. 5mm of black basaltic glass grades into weathered mod. yellow-brown cryptocrystalline basalt (horizontal contact).	
		2	2	EMPTY		Basalt grades to relatively fresh, dark greenish gray, fine grained basalt, with calcite veins.	
		3, 4	3				
		5, 6	4				
		7	5				
		8	6				

Figure 15. *Core 10, Hole 14.*

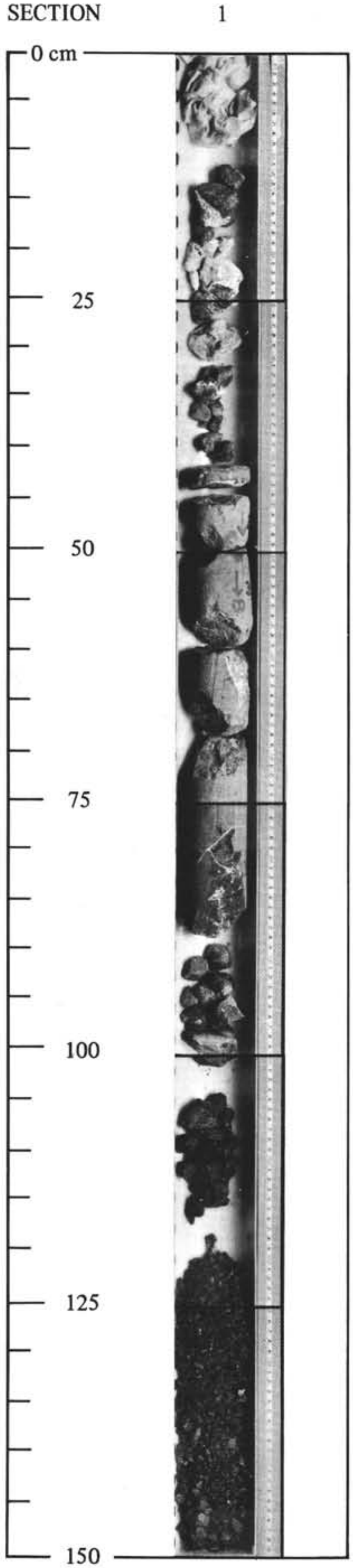


Plate 9. *Core 10, Hole 14.*