10. SITE 20

The Shipboard Scientific Party[1]

SURVEY DATA AND SITE BACKGROUND

Prior to arrival on this site, the only survey data available was from the *Vema-20* crossing of the area. The recommended site location was over a relatively smooth valley in the bottom topography at about 4750 meters (15,580 feet) depth (uncorrected), about 10 kilometers wide E-W between peaks (or ridges) on either side. Sediment thickness was unknown. The center of the valley is near the peak of a wide (40 to 50 kilometers) positive magnetic anomaly, identified as Magnetic Anomaly 30 in the hypothesized geomagnetic time scale with an age of 72 million years.

The *Glomar Challenger* carried out a preliminary survey before setting up for drilling. The topography appeared to be lineated generally N-S, although the ridge bordering the western side of the valley is either discontinuous or is an isolated peak. The detailed topography in the valley (Figure 1) consists of small hills up to 200 meters (656 feet) in amplitude, with a relatively smooth, N-S lineated region a few kilometers wide near the base of the eastern ridge at a consistent depth of about 5014 meters (16,446 feet), corrected (4850 meters, uncorrected). The detailed shape of the magnetic high appears to be locally controlled, perhaps by topography.

The eastern slope is fairly uniform, reaching a height of 500 to 600 meters (1600 to 1968 feet) above the valley floor. The site (28° 31,57'S, 26° 50.58'W) was chosen near the upper part of this slope where the sediment cover appears fairly continuous and uniform. Depth on the site is 4447 meters (14,586 feet), corrected, to 4484 meters (14,707 feet), corrected, with the uncertainty caused by several diffuse bottom reflections over this range. Exact sediment thickness at the site is undetermined from the air-gun records. However, diffuse reflected energy from the air-gun was recorded from about 0.15 to 0.25 second later than the bottom return over the region of the site.

OPERATIONS

Positioning

The ship was stopped at 0625 hours on 9 January, 1969, and the beacon was dropped over the side. Since two sets of batteries for the beacon were found to be dead while preparing the beacon for dropping, the availability of working beacons became a critical factor for the remainder of the leg. While the beacon was sinking, the PCS pinger stopped operating leaving us with no backup pinger at this site. Further, it was noted that the beacon had a considerable horizontal motion, as it was sinking. One-hundred and sixty rpm on the port main shaft was required to keep abreast of the motion of the beacon. A combination of this large motion at depth plus a strong surface current indicated that it would be difficult to drop a second PCS pinger alongside the first beacon.

Wind at this site varied from 15 to 30 knots from the NNW. There were times when the wind exceeded this figure considerably, especially during squalls in connection with the passage of a cold front. Surface currents were estimated at 1 knot from the north. A large stationary storm to the south gave rise to long period swells from the south. The combination of these factors made position keeping more difficult than was ordinary, and caused onerous rolling and pitching motions that perceptably affected the drilling operations. The ship had to be placed in semi-automatic control about 25 per cent of the time while on site.

At about 2300 hours on 11 January, it was decided to move the ship about 300 meters (984 feet) to the west to select better bottom conditions for drilling. An offset of 150 meters (492 feet) to the north and 240 meters (787 feet) to the west was placed in the computer, and the ship moved to the new location (20A, 20B and 20C). An average of all satellite fixes at these two locations showed agreement with the position relative to the offset within 30 meters (98 feet). This close agreement gives added confidence to the satellite navigation.

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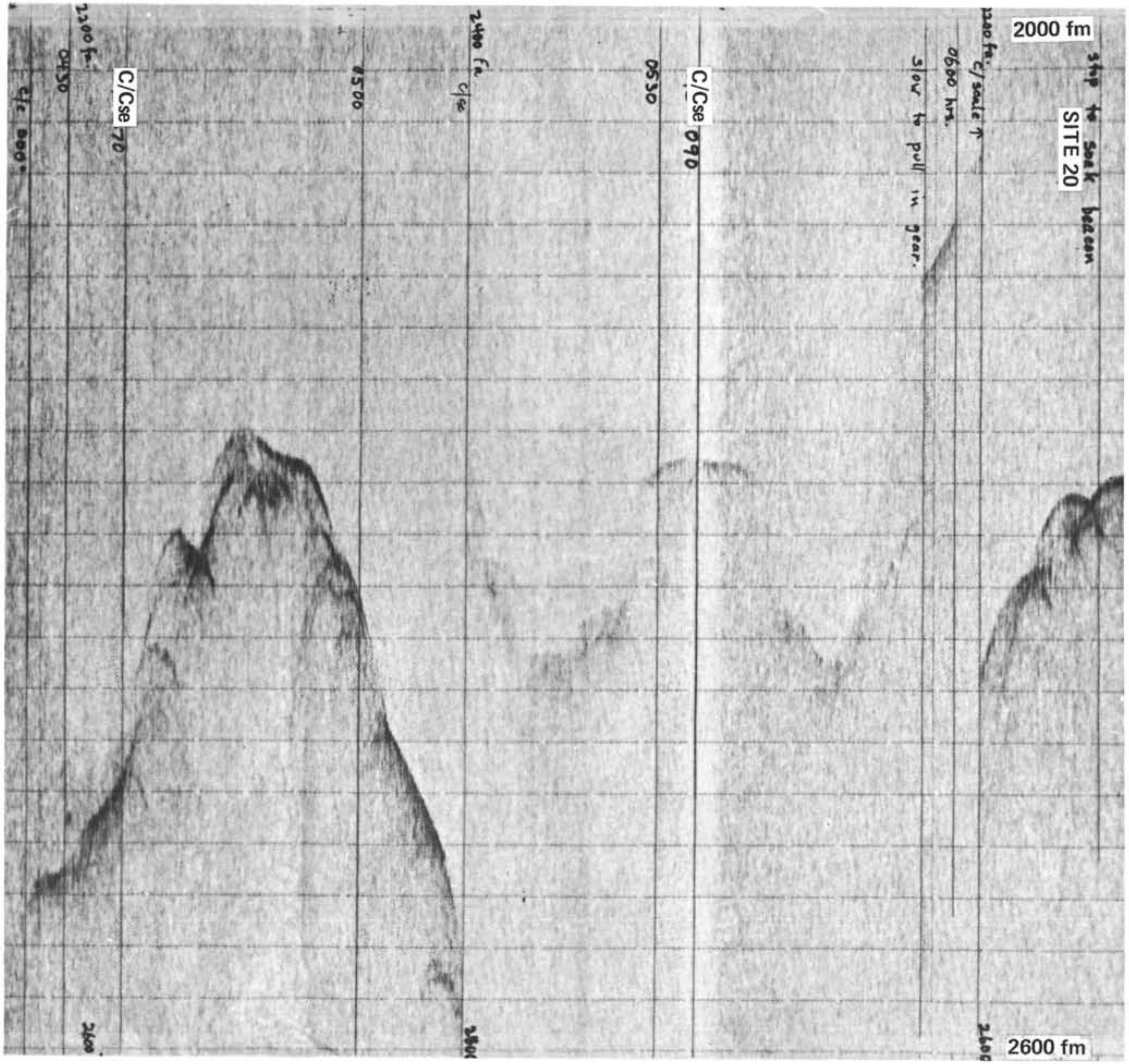


Figure 1. *Precision depth recording in the vicinity of Site 20.*

Drilling

A 10 centimeter piece of basalt was found lodged in the bottom of the core barrel on retrieval of the first core. This prevented collecting any sediment. Two more attempts to core showed that the drill string apparently had pieces of basalt stuck in it. It is assumed that these had fallen out of the core barrel and were from the last core cut in basalt which was at Site 19. It was necessary to pull the drill string aboard to clear it of debris. This task required 24 hours.

Next, Hole 20-1 was cored which started at the sea floor in soft sediments and bottomed in manganese pebbles at 6 meters (20 feet). At this point it was decided to move the ship to the west to find more favorable bottom conditions. Three holes (20A, 20B and 20C) were drilled at the new location. The first of these encountered basalt at about 60 meters (197 feet) depth. Hole 20B was drilled in order to pick up sediments missed on the earlier attempt. While retrieving the second core (20B-2), the drill string parted leaving a core barrel, bit, bumper sub and two drill collars in the hole. This necessitated the retrieval of the remainder of the drill string before continuing, which required an additional 24 hours. Failure was attributed to fatigue caused by the high torque used to core the basalt.

Hole 20C was drilled without any difficulties. The only drilling breaks observed in these holes were when the bit encountered basalt at the bottom of Holes 20A and 20C.

Coring

Four separate holes were cored at this site and a total of 73.9 meters (242 feet) of sample was collected with a recovery rate of 82.6 per cent. A summary of the cores collected at Site 20 is presented in Table 1.

The first hole (Hole 20) hit an area of shallow sediments and bottomed in manganese pebbles. At this time the hole was shifted to the west in search of better sediments. Hole 20A was cored at four nearly evenly spaced intervals with a core at both the top and bottom. Relatively poor recovery (43 per cent) was experienced in this hole. Next, Hole 20B filled in the gaps of the previous hole. The last hole (Hole 20C) was successful in filling in the gaps of the earlier holes and provided a recovery of virtually 100 per cent of the entire section from the sea floor to the basement.

TABLE 1
Summary of Coring at Site 20

Core No.	Date/Time		Interval Cored (m below sea floor)	Core Retrieved (m)	Remarks
20-1	1-11-69	2300	0-6.4	6.1	Bottomed in manganese pebbles.
20A-1	1-12-69	0330	0-4.5	0.3	New position.
20A-2		0600	15.5-24.7	9.0	–
20A-3		0800	34.7-43.7	0.6	–
20A-4		1100	62.2-64.6	0.9	Chalk and basalt.
20B-1	1-12-69	1430	6.4-15.5	9.0	–
20B-2		1600	-	-	Drill string parted.
20C-1	1-13-69	1515	0-8.5	8.5	–
20C-2		1715	25.6-34.7	9.0	–
20C-3		1900	36.9-46.0	9.0	–
20C-4		2055	46.9-56.1	6.1	–
20C-5		2300	57.0-66.1	9.0	–
20C-6	1-14-69	0200	67.1-72.2	6.4	Basalt chips recovered from bit.
	Totals		90.7	73.9	

PALEONTOLOGY

Four holes were drilled at Site 20: 20, 20A, 20B and 20C. The stratigraphic relationships of these holes are shown in Figure 2. A mixed stratigraphic sequence with basalt fragments and manganese nodules was obtained from the one barrel cored in Hole 20. Pleistocene, Pliocene, Eocene and Upper Cretaceous microfossil assemblages were recognized in various samples from this core. Pleistocene, Upper Oligocene and Lower Oligocene sediments were recovered from three out of the four cores in Hole 20A. Maestrichtian (Upper Cretaceous) sediments were found intercalated with basalt in Core 4 of Hole 20A. Coring was discontinuous from the sea bottom to 64.6 meters (212 feet). Upper Oligocene sediments were recovered from the one core from Hole 20B. Pleistocene, Upper Pliocene, Upper Oligocene, Lower Oligocene, Upper Eocene, Middle Eocene, Lower Eocene, Upper Paleocene, Lower Paleocene and Maestrichtian sediments were recovered from the six cores at Hole 20C. Only one core was taken between the sea bottom and 25.6 meters (84 feet), and below that depth coring was practically continuous down to 67.2 meters (220 feet).

Six stratigraphic boundaries were cored at Site 20; however, only three appear to represent continuous sequences. These include the Upper Paleocene/Lower Eocene, the Lower Oligocene/Upper Oligocene and the Pliocene/Pleistocene boundaries. The Upper Paleocene/Lower Eocene boundary occurs in Core 5 of Hole 20C. The Lower Oligocene/Upper Oligocene boundary is found between Section 6 and the core catcher sample in Core 2 of Hole 20A. The Pliocene/Pleistocene boundary is present in Core 1 of Hole 20C. The other three boundaries: the Cretaceous/Tertiary, the Middle Eocene/Upper Eocene and the Lower Eocene/Middle Eocene occur in Cores 5 and 6 of Hole 20C and in Core 3 of Hole 20C, respectively. Time limitations aboard the ship and the soupy nature of many of the sediments cored resulted in many of the cores not being slabbed and sampled in detail for geologic and paleontologic studies.

One of the purposes in drilling these holes was to test the hypothesis of sea-floor spreading and the interpretation of linear magnetic anomalies. The site was located on a positive anomaly associated with Magnetic Anomaly 30, and had a suggested age of from 70 to 72 million years based on the work of Heirtzler *et al.* (1968). The oldest sediments above the basalt are Late Maestrichtian in age and represent the *Abathomphalus mayaroensis* Zone of Bolli (1966). Likewise, the calcareous nannoplankton found in sediments immediately above the basalt and intercalated with the basalt indicate an upper Maestrichtian age. Chapter 2, Figure 1 indicates an equivalent radiometric age of approximately 67 million years for these

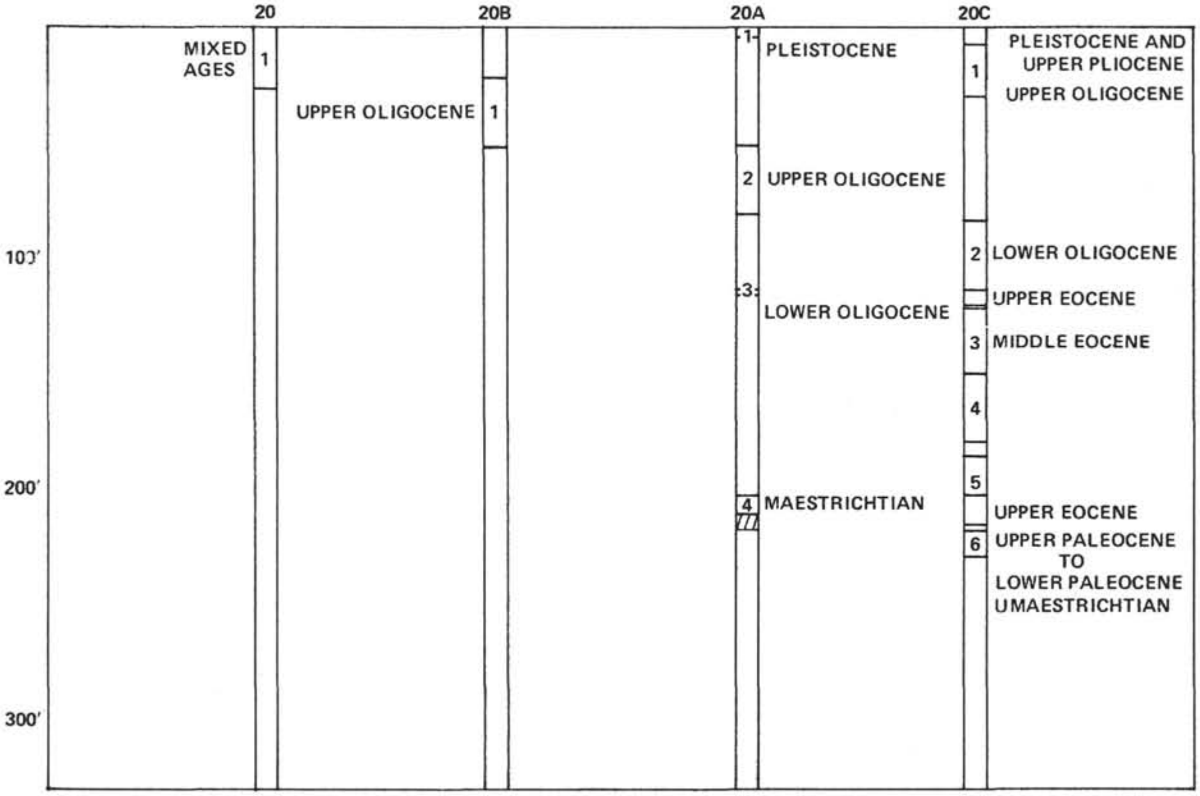


Figure 2. *Stratigraphic relationships between Holes 20, 20A, 20B and 20C.*

sediments. This is in close agreement with the minimum age of 70 million years suggested by the interpretation of the magnetic anomalies.

Another purpose in drilling this hole was to study any floral or faunal changes which may take place at 30° South Latitude. The Pliocene-Pleistocene fauna is not typical of tropical areas, though those in the older sediments are more typical. All of the calcareous nannoplankton are similar to those reported from tropical areas.

The sediments from most of the cores in Holes 20A, 20B and 20C consist predominantly of the plates of calcareous nannoplankton with minor amounts of tests of planktonic foraminifera, except for Core 1 of Hole 20 and the uppermost part of Core 1 of Hole 20C where zeolitic clays predominate. In Core 1 of Hole 20A, in Core 1 of Hole 20B and in Cores 2, 3, 4 and 5 of Hole 20C most of the planktonic foraminiferal tests are broken and show evidence of solution. Variations in lithology from unit to unit are discussed in the section on Stratigraphy.

In Hole 20, Core 1, from 0 to 6.4 meters (0 to 21 feet), contains mixed stratigraphic section. In addition to the sediments, manganese nodules and basalt fragments are present. This core is badly disturbed and contains floras ranging in age from Late Cretaceous to Pleistocene. Many samples were examined for the calcareous nannoplankton. Some samples contained either Upper Cretaceous, Eocene, Pliocene or Pleistocene floras; others contained mixtures of these. The planktonic foraminifera present are Recent in age and include: *Globorotalia inflata, G. truncatulinoides, G. menardii* and *Globigerinoides ruber.*

The sediments in Core 1, from 0 to 4.5 meters (0 to 15 feet), of Hole 20A are Pleistocene in age based on the planktonic foraminifera and calcareous nannoplankton. The fauna present consists of: *Globorotalia truncatulinoides, G. inflata, G. tumida,* left coiling *G. menardii, Pulleniatina obliquiloculata* and *Globoquadrina dutertrei* (d'Orbigny). The characteristic calcareous nannoplankton species are: *Gephyrocapsa oceanica, Cyclococcolithus leptoporus, Ceratolithus cristatus* and *Helicopontosphaera kamptneri.*

Core 2, from 15.5 to 24.7 meters (51 to 82 feet), of Hole 20A contains the Lower Oligocene/Upper Oligocene boundary based on the planktonic foraminifera. The samples from Sections 1 to 6 are Late Oligocene (Chattian) in age and the core catcher sample is Early Oligocene (Lattorfian-Rupelian) in age. Thus, the boundary is placed between the lowest sample in Section 6 and the top of the core catcher. The planktonic foraminifera above the boundary consist of *Globorotaloides suteri, Globorotalia opima nana, G. postcretacea, Globigerinita dissimilis* and *G. unicava.* The planktonic fauna is poor consisting of very few species; most of the tests are broken and show the effects of solution. This fauna is very questionably assigned to the *Globigerina ampliapertura* Zone of Blow (1969). The fauna below the boundary is better preserved and is correlated with the *Globigerina sellii/Pseudohastigerina barbadiensis* Zone of Banner and Blow (1965). The top of this zone is marked by the first appearance of *Pseudohastigerina micra.* Other forms in this sample are *Chiloguembelina cubensis, Globigerina ciperoensis* and *G. sellii,* in addition to the species occurring above the boundary. The flora represents the *Sphenolithus predistentus* Zone of Bramlette and Wilcoxon (1967), and it is characterized by: *Coccolithus bisectus, Sphenolithus predistentus, S. pseudoradians, S. distentus, Discoaster deflandrei, D. tani* s.l., *Cyclococcolithus neogammation* and *Helicopontosphaera compacta.* The core catcher sample contains fragments of the previously mentioned *Braarudosphaera rosa* Chalk. This chalk is older than those found at Sites 14, 17, 19 and 22.

Core 3, from 34.7 to 43.7 meters (114 to 143 feet), of Hole 20A is interpreted to be Early Oligocene (Lattorfian-Rupelian, undifferentiated) in age based on the planktonic foraminifera and calcareous nannoplankton from the core catcher sample even though reworked species of both groups are present. The planktonic fauna which is interpreted to be *in situ* consists of: *Globigerina sellii, G. tapuriensis, Globoquadrina venezuelana, Globorotalia opima nana, Globorotaloides suteri* and *Globigerinita unicava.* Reworked Upper Cretaceous (Maestrichtian), Upper Paleocene (Thanetian) and Lower Eocene (Ypresian) planktonic foraminifera species are also present. The *in situ* fauna is interpreted to represent the *Globigerina tapuriensis* Zone of Blow (1969). The flora interpreted to be *in situ* consists of: *Coccolithus bisectus, Cyclococcolithus neogammation, C. lusitanicus, Reticulofenestra umbilica, Sphenolithus pseudoradians, S. predistentus* and *Isthmolithus recurvus* which represent the *Helicopontosphaera reticulata* Zone of Bramlette and Wilcoxon (1967). Reworked Eocene calcareous nannoplankton are also present. In addition, fragments of the *Braarudosphaera rosa* Chalk mentioned in the preceding paragraph are present.

Core 4, from 62.2 to 64 meters (204 to 210 feet) of Hole 20A contains basalt intercalated with chalk. Although, no planktonic foraminifera were found in the chalk, it did contain some calcareous nannoplankton which are of late Maestrichtian (uppermost Upper Cretaceous) age. A few of the diagnostic forms are *Arkhangelskiella cymbiformis, Micula decussata* and *Tetralithus murus.*

In Hole 20B, the sediments in Core 1, from 6.4 to 15.5 meters (21 to 51 feet), are Late Oligocene

(Chattian) in age, based on the calcareous nannoplankton which is correlated with the planktonic foraminiferal zone. The core contains two zones of Bramlette and Wilcoxon (1967), namely: the *Sphenolithus predistentus* and *Sphenolithus distentus* Zones. The contact is placed in Section 6 between samples from 100 to 102 centimeters and from 100 to 102 centimeters in Section 5. The flora above the contact consists of *Coccolithus bisectus, Sphenolithus predistentus, S. distentus, Cyclococcolithus neogammation* and *Discoaster deflandrei.* The flora below is marked by the first appearance of *Discoaster tani* s.l. and *Sphenolithus pseudoradians,* in association with the previously mentioned forms. Most of the planktonic foraminiferal tests are broken and show the effects of solution in all the samples studied. The fauna is poor and cannot be assigned to any zone. Species present are *Globorotaloides suteri* and *Globorotalia postcretacea.*

In Hole 20C, Core 1, from 0 to 8.5 meters (0 to 28 feet), contains a thin veneer of Upper Pliocene (Astian-Piacenzian, undifferentiated) and Pleistocene sediments overlying sediments that are Late Oligocene (Chattian) in age. The Pliocene/Pleistocene boundary is placed between samples from 0 to 2 centimeters and from 60 to 62 centimeters in Section 1, and it is based on the calcareous nannoplankton. The planktonic foraminifera above and below the boundary are similar–consisting of forms, such as: *Globorotalia inflata, G. truncatulinoides, G. hirsuta* and *Pulleniatina obliqueloculata.* However, the calcareous nannoplankton show a marked change in this interval. Above the boundary the flora consists of *Gephyrocapsa oceanica, Helicopontosphaera kamptneri, Cyclococcolithus leptoporus* and *Ceratolithus cristatus;* below are found *Discoaster brouweri, D. pentaradiatus, D. surculus* and *D. challengeri,* associated with these forms. The contact between the Oligocene and Pliocene is placed between Sections 1 and 2, and is based on the planktonic foraminifera and calcareous nannoplankton. The fauna in Section 2 represents the *Globigerina ciperoensis* Zone of Bolli (1957c), and the fauna from Section 3 represents the *Globorotalia opima opima* Zone of Bolli (1957c). Most of the planktonic foraminiferal tests are broken and show the effects of solution. In fact, some samples contain only benthonic foraminiferal species. The fauna above the contact between the two zones consists of *Globigerina sellii, Globorotalia opima nana, Globigerinita dissimilis, G. unicava* and *Globorotaloides suteri.* The first appearance of *Globorotalia opima opima* is observed in the sample from 76 to 78 centimeters in Section 3. The flora in Section 2 and below probably represents the *Sphenolithus ciperoensis* Zone of Bramlette and Wilcoxon (1967), and consists of *Coccolithus bisectus, C.* aff. *bisectus, Cyclococcolithus neogammation* and *Discoaster deflandrei.*

The sediments in Core 2, from 25.6 to 34.7 meters (84 to 114 feet), of Hole 20C are Early Oligocene (Lattorfian-Rupelian, undifferentiated) in age based on the planktonic foraminifera and calcareous nannoplankton. The fauna is correlative with the *Globigerina sellii/Pseudohastigerina barbadiensis* Zone of Blow (1969) in Sections 1 through 5. The fauna consists of *Globigerina sellii, G. yeguaensis, Pseudohastigerina micra* and *Globorotaloides suteri.* The fauna in the sample from Section 6 and the core catcher contains *Globigerina tapuriensis, G. angiporoides* and *G. gortanii* which indicates a correlation with the *Globigerina tapuriensis* Zone of Blow (1969). The flora represents the *Helicopontosphaera reticulata* Zone of Bramlette and Wilcoxon (1967), and consists of *Reticulofenestra umbilica, Sphenolithus pseudoradians, S. predistentus, Isthmolithus recurvus, Cyclococcolithus neogammation, C. lusitanicus, Coccolithus bisectus* and *Discoaster tani* s.l.

In Core 3, from 36.9 to 46 meters (121 to 151 feet), the Middle Eocene (Lutetian)–Upper Eocene (Bartonian) boundary is probably present, based on the observed relationship of the calcareous nannoplankton and planktonic foraminifera. The nannoplankton flora indicates that three zones are present, namely: the *Isthmolithus recurvus* Zone of Late Eocene age of Hay in Hay *et al.* (1967), in the upper part of Section 1; the *Discoaster tani nodifera* Zone of Middle to Late Eocene age of Hay in Hay *et al.* (1967), in the lower part of Section 1 and the upper part of Section 2; and, the *Chiphragmalithus quadratus* Zone of Middle Eocene age of Hay in Hay *et al.* (1967), in the remainder of the core. The flora of the youngest zone contains: *Isthmolithus recurvus, Discoaster tani* s.l., *D. barbadiensis, D. saipanensis, Coccolithus bisectus, Cyclococcolithus lusitanicus* and *Reticulofenestra umbilica.* The next zone lacks *Isthmolithus recurvus* and marks the first appearance of *Chiasmolithus grandis.* The flora of the oldest zone is characterized by the absence of *Discoaster tani nodifera* and the first appearance of *Chiphragmalithus quadratus.* The flora in the sample from Section 6 consists of: *Chiphragmalithus quadratus, Chiasmolithus grandis, Campylosphaera dela, Sphenolithus furcatolithoides, Cyclococcolithus lusitanicus, Discoaster barbadiensis* and *D. saipanensis.* Although broken planktonic foraminifera and effects of solution are found, most of the samples studied contained well-preserved, rich faunas. The alternation of poorly preserved and well preserved faunas makes it difficult to establish a definite zonal assignment, except for the core catcher sample, which represents the *Globigerapsis kugleri* Zone of Bolli (1957b). The fauna in this sample includes: *Globigerapsis index, Globigerinatheka barri, Globigerina senni, G. frontosa, Acarinina pseudotopilensis, A. rotundimarginata, A. coalingaensis* (Cushman and Hanna) and *Truncorotaloides rohri,* Bronnimann and Bermudez. The rest of the core is assigned to a Middle Eocene age.

The sediments in Core 4, from 46.9 to 56.1 meters (154 to 184 feet), of Hole 20C are Middle Eocene (Lutetian) in age based on the planktonic foraminifera and calcareous nannoplankton. They are assigned to the *Globigerapsis kugleri* Zone of Bolli (1957b), and the *Chiphragmalithus quadratus* Zone of Hay (1967). These sediments have floras and faunas similar to those discussed for the lower part of Core 3. Most of the planktonic foraminiferal tests in the samples studied are broken and show the effects of solution.

Core 5, from 57 to 66.1 meters (187 to 217 feet), of Hole 20C contains sediments of three ages: Late Paleocene (Thanetian), Early Eocene (Ypresian) and Middle Eocene (Lutetian). Although the boundary between the Upper Paleocene/Lower Eocene appears to represent a continuous sequence, the boundary between the Lower and Middle Eocene suggests the presence of a stratigraphic hiatus in which several planktonic foraminiferal and calcareous nannoplankton zones may be missing. The missing planktonic foraminiferal zones are the *Globorotalia aragonensis* Zone of Early Eocene age and the *Hantkenina aragonensis* Zone of Middle Eocene age. The missing calcareous nannoplankton zones include: the *Marthasterites tribrachiatus* Zone of Bramlette and Sullivan (1961) of Early Eocene age and the *Discoaster lodoensis* Zone of Hay and Mohler in Hay *et al.* (1967), of Early Eocene age.

The planktonic foraminiferal zones of Bolli (1957b) present here are: the *Globigerapsis kugleri* Zone of Middle Eocene age in Section 1 and the *Globorotalia formosa formosa* Zone of Early Eocene age in Section 4; the *Globorotalia rex (=G. subbotinae)* Zone of Early Eocene age in Section 5; and, the *Globorotalia velascoensis* Zone of Late Paleocene age in the lower part of Section 6 and the core catcher. In Sections 1 and 2 most of the planktonic foraminiferal tests are broken and show the effects of solution. Forms present in this part of the section are: *Globigerina senni, Globorotalia quetra* Bolli, *G. lehneri* Cushman and Jarvis, *Acarinina densa* and *A. rotundimarginata* Subbotina. The first appearance of *Globigerina soldadoensis, G. soldadoensis angulosa, Globorotalia aragonensis* and *G. formosa formosa* takes place in the upper part of Section 4.

The calcareous nannoplankton zones present are: the *Chiphragmalithus quadratus* Zone of Middle Eocene age of Hay (1967), in Sections 1 and 2; the *Discoaster sublodoensis* Zone of Middle Eocene age of Hay in Hay *et al.*, (1967), in Section 3 and the upper part of Section 4; the *Discoaster diastypus* Zone of Early Eocene age of Hay (1964), in Section 5 and the upper part of Section 6; and, the *Discoaster multiradiatus* Zone of Late Paleocene age of Bramlette and Sullivan (1961), in the lower part of Section 6 and the core catcher. The flora of the youngest zone consists of *Chiphragmalithus quadratus, Chiasmolithus grandis, C. gigas, Sphenolithus radians* and *Campylosphaera dela.* The first appearance of *Discoaster sublodoensis* Bramlette and Sullivan occurs in Section 3 indicating the *Discoaster sublodoensis* Zone. A marked floral change takes place in the middle of Section 4 with the first appearance of *Marthasterites tribrachiatus* Bramlette and Sullivan, *Discoaster diastypus* Bramlette and Sullivan, *D. lodoensis* Bramlette and Riedel, *Chiasmolithus consuetus* (Bramlette and Sullivan), and *Coccolithus cavus* Hay and Mohler, which are characteristic of the *Discoaster diastypus* Zone. Likewise, another marked floral change takes place in the middle of Section 6 with the first appearance of *Discoaster multiradiatus* Bramlette and Riedel, *Heliorthus concinnus* (Martini), and *Toweius eminens* (Bramlette and Sullivan) in the lower part. This flora indicates its correlation with the *Discoaster multiradiatus* Zone.

In Core 6 of Hole 20C, the sediments range in age from Late Cretaceous (Maestrichtian) to Early Paleocene (Danian). The authors draw the Cretaceous/Tertiary boundary between the Maestrichtian and Danian Stages where a marked change in the fossil planktonic biota takes place in many different part of the world (Bramlette, 1965). The Cretaceous/Tertiary boundary is placed in Section 5; however, the boundary is complicated by the occurrence of a 14-centimeter thick layer of Maestrichtian sediments in the lower part of Section 4 between 110 and 124 centimeters depth (see Section Sheet). The boundary and all of its complications will be discussed in the subsequent paragraphs.

Sections 1 and 2 represent the *Globorotalia velascoensis* Zone of Bolli (1957a) and the *Discoaster multiradiatus* Zone of Bramlette and Sullivan (1961). The fauna is characterized by *Globorotalia velascoensis, G. aequa, G. marginodentata, G. acuta, G. convexa, G. imitata* and *Globigerina soldadoensis.* The flora consists of *Discoaster multiradiatus, Coccolithus cavus, Chiasmolithus consuetus, Toweius eminens, Fasciculithus tympaniformis* Hay and Mohler and *Heliorthus concinnus.*

The lower part of Section 3 and the uppermost part of Section 4 represent the *Globorotalia pseudomenardii* Zone of Bolli (1957a). The middle represents the *Globorotalia pusilla pusilla* Zone of Bolli. The first appearance of *Globorotalia pseudobulloides* and *Globigerina triloculinoides* is in the sample from 78 to 80 centimeters. Between 110 and 124 centimeters, a detached layer of Late Cretaceous (Maestrichtian) age occurs. This layer contains a fauna typical of the *Abathomphalus mayaroensis* Zone of Bolli (1966). Forms found in this layer include: *Abathomphalus mayaroensis, Globotruncana stuarti, G. citae, G. contusa, G. stuartiformis* and *G. aegyptica.* The fauna below this layer again belongs to the *Globorotalia pusilla pusilla* Zone. The flora shows a similar sequence: the upper part represents the *Discoaster multiradiatus* Zone; the middle the *Fasciculithus tympaniformis* Zone of Hay and Mohler in Hay *et al.* (1967); a layer of upper Maestrichtian between 110 and 124 centimeters; and a return to the Paleocene with the *Cruciplacolithus tenuis* Zone of Mohler and Hay in Hay *et al.* (1967), below the Cretaceous layer. The flora of the *Discoaster multiradiatus* Zone is similar to that reported for the lowermost part of Core 5. The flora of the *Fasciculithus tympaniformis* Zone is characterized by the occurrence of the nominal species associated with many of the species mentioned for the *Cruciplacolithus tenuis* Zone which contains: *Cruciplacolithus tenuis, Coccolithus cavus, Ericsonia subpertusa* and *Zygodiscus sigmoides* Bramlette and Sullivan. The Maestrichtian layer contains *Arkhangelskiella cymbiformis, Tetralithus murus, Lithraphidites quadratus* Bramlette and Martini, and *Micula decussata.* The occurrence of this detached layer may be the result of slumping during the *G. pusilla pusilla* Zone time. Geomagnetic polarity measurements (see Chapter 21) of sediments in Sections 4 and 5 indicate that only this detached Maestrichtian layer is normally magnetized, while the Paleocene sediments in contact with this layer and the Maestrichtian sediments of the equivalent zone age in Section 5 all show reversed magnetic polarity. This magnetic evidence appears to suggest that during the *G. pusilla pusilla* Zone time of late Paleocene a layer of Maestrichtian sediments was removed from the site of the original deposition and overturned during transport to the present drilling site.

In Section 5, the sequence appears to be more normal with the lowermost Danian overlying the uppermost Maestrichtian, but it is not, as will be described below. The Cretaceous/Tertiary boundary is placed about 14 centimeters from the top of the core based on the planktonic foraminifera and the calcareous nannoplankton. There is no sharp lithological change at the boundary (Figure 19). The planktonic foraminifera just above the boundary (from 12 to 13 centimeters in Section 5) consist of *Globorotalia compressa* (Plummer), *G. pseudobulloides, Globorotalia trinidadensis* Bolli = *Globorotalia praecursoria* (Morozova), *Globigerina eugubina* Luterbacher and Silva (identification confirmed by Luterbacher), *Globigerina daubjergensis* Bronnimann and *G. triloculinoides.* This assemblage appears to be a mixture of species characteristic of the three planktonic foraminiferal zones established by Luterbacher and Silva (1964) in the lowest Paleocene section of the Central Apennines, Italy. These zones are the *Globorotalia trinidadensis, Globorotalia pseudobulloides/Globigerina daubjergensis* and *Globigerina eugubina* Zones in descending order. The samples examined above the boundary contain some Upper Cretaceous planktonic foraminifera which are interpreted as reworked. Below the boundary, the fauna consists of *Abathomphalus mayaroensis* (Bolli), *Globotruncana contusa, G. gagnebini, G. stuarti, Globotruncanella citae, Rugoglobigerina rugosa* (Plummer) and *Planoglobulina multicamerata* de Klasz. Some of the samples from this interval contain younger Early Paleocene planktonic foraminifera and calcareous nannoplankton. This occurrence together with the mixing of Early Paleocene planktonic foraminifera indicates that this boundary is not continuous, but is badly disturbed.

The calcareous nannoplankton above the boundary represent the *Cruciplacolithus tenuis* Zone of Hay and Mohler in Hay *et al.* (1967), consisting of *Coccolithus cavus, Cruciplacolithus tenuis, Ericsonia subpertusa* and *Markalius astroporus.* However, in the sample from 12 to 13 centimeters *Fasciculithus tympaniformis,* which is typical of the younger *Fasciculithus tympaniformis* Zone, is found in abundance which indicates mixing above the boundary. The flora below the boundary is typical of the Upper Maestrichtian consisting of *Lithraphidites quadratus, Arkhangelskiella cymbiformis, Tetralithus murus* and *Micula decussata.*

STRATIGRAPHY

Of the four holes drilled at Site 20, only one core was recovered from the original hole. This core includes a mixture of nannofossil oozes, foraminiferal nannofossil oozes, manganese nodules, basalt chips and sediments ranging in age from Holocene to Late Cretaceous. An unsolved mystery is a piece of basalt perched on top of the core, with a firm Upper Cretaceous nannofossil chalk ooze adhered to the basalt. This is believed to be a piece of basalt left in the core barrel from the previous hole.

Three further holes (Holes 20A, 20B and 20C) were drilled and a normal oceanic sedimentary sequence was penetrated. This sequence could be divided into seven lithologic units, of which five constitute formations:

3-20A-1-1	Local Unit	Brown foraminiferal marl ooze, with manganese nodules.
3-20C-1-1	Local Unit	Nannofossil marl ooze.
3-20C-1-2	Discovery Clay	Red clays and nannofossil chalk oozes.
3-20C-1-4	Endeavor Ooze	Nannofossil marl oozes and clays.
3-20A-2-1	Fram Ooze	Nannofossil chalk oozes.
3-20C-3-1	Gazelle Ooze	Zeolitic marl oozes and clays.
3-20C-5-1	Hirondelle Ooze	Nannofossil chalk oozes, foraminiferal at base.

The Pleistocene Unit 3-20A-1-1 has a variable lithology. The sediments cored from Hole 20A consist of abundant manganese nodules, a shark tooth and some interstitial yellowish-brown clays. Yet at about the same location, but from Hole 20C, the unit is made of 0.4 meter (1 foot) of thick yellowish-brown foraminiferal nannofossil clays, which contain practically no manganese nodules.

The Pliocene Unit 20C-1-1 consists of light yellowish-brown nannofossil marl oozes, and dark brown nannofossil clays. Nannofossils and clay minerals constitute the bulk of the sediments. Hematitic material is common, 8 to 15 per cent. Zeolite (2 to 5 per cent) is also present. Foraminifera are, however, very rare.

These Pliocene-Pleistocene sediments, with a 1.5-meter (5-foot) total thickness, represent the thin veneer of Late Cenozoic sediments at this site, and could be correlated to the Unit 19-1-1 at Site 19 and to the Pliocene veneer at Site 14. The authors have chosen to refer to those thin patches of surface veneers in regions below 4500 meters (14,760 feet) as local units.

The Unit 3-20C-1-2 consists mainly of interbedded red clays and zeolite clays. Zeolite content is less than 5 per cent in red clays, but it may constitute half of the sediment bulk in zeolite clays. Hematitic material varies from about 10 per cent in zeolite clays to 20 per cent in red clays. This unit could be dated by the presence of a few nannofossil chalk and marl oozes as Upper Oligocene (in part, at least), and could be recognized as the Discovery Clay at Site 20.

The Upper Oligocene Unit 3-20C-1-4 includes interbeds of light yellowish-brown, yellowish-brown, and dark brown nannofossil marl oozes and clays. A few nannofossil, marly-chalk ooze intercalations are present (for example, 3-20B-1-5). This unit was apparently deposited near the carbonate compensation depth; the carbonate-content is variable, ranging from 21 to 76 per cent in the samples analyzed. Nannofossils and clays are the main constitutents. Zeolite, traces to 5 per cent, and hematitic material, 2 to 8 per cent, are also present. Foraminifera are very rare (sand-size fraction, average 0.5 per cent). The lithologic characters of this unit serve clearly to identify it as the Endeavor Ooze.

Included in the Endeavor Ooze here, as in Site 19, is the *Braarudosphaera* Chalk Subunit (3-20B-1-4 Subunit). However, the chalk marker here consists of multiple laminations of white crystalline chalk, indicatint recurrence of conditions for the blooming of *Braarudosphaera rosa.* Lithologically the chalk is indistinguishable from those encountered at previous sites, except that some dolomite has been identified by X-ray analysis. This subunit marks the same transition from the *Globigerina ampliapertura* Zone to *Globorotalia opima opima* Zone, serving thus as an excellent time-stratigraphic marker.

Unit 3-20A-2-1, mainly of the Lower Oligocene, is the homogeneous, very pale brown nannofossil chalk ooze, which is typical of the Fram Ooze. Some pink nannofossil chalk oozes are present as interbeds. A few interbeds should be classified as a marl ooze on the basis of their low calcium carbonate content (for example, 55 per cent in 3-20C-2-3, 29-30 centimeters). Foraminifera are very rare, and the sand-size fraction is less than 1 per cent in all samples analyzed. This unit has been correlated with the Fram Ooze, even though it is recognized that the terrigenous content here is considerably higher (almost 30 per cent) as compared to the Fram Ooze at Site 17 (only 15 per cent).

The Eocene Unit 3-20C-3-1 consists of nannofossil marl oozes and clays in various shades of brown. This unit may also be deposited near the carbonate-compensation depth, as the calcium carbonate content oscillates between 16 and 52 per cent. Zeolite is commonly present, with one zeolite rich layer in 3-20C-4-3 (at 51 meters; 167 feet, BOB), and so is the hematitic material. Foraminifera content is very low (sand fraction less than 0.5 per cent). The correlation of this unit posed some problem. The authors were first inclined to correlate it with the Grampus Ooze on account of the dark colors, which are not uncommon in the latter. However, they found the trend of color variation disconcerting: the color shades became invariably darker with depth in the Grampus Ooze, but Unit 3-20C-3-1 showed almost a reverse trend. Also, by using the critical criterion of the presence of foraminifera and its increase with depth–a criterion that defines the Grampus Ooze–the Unit 3-20C-3-1 would be ruled out as a correlative. Consequently, they were led to erect a new formation to characterize the dark brown zeolitic marl oozes and clays, similar to the Endeavor Ooze in lithology, but which are found below the Fram Ooze. The correlative of this unit here, as mentioned previously, is present at the adjacent site as the Unit 3-19-5-3. Together they constitute the Gazelle Formation, which has been identified, so far, only from the area on the western lower flank of Mid-Atlantic Ridge.

The basal Unit 3-20C-5-1, ranging from Late Cretaceous to Middle Eocene in age, consists of very pale brown-pink and pink nannofossil chalk oozes. An increase was noted in the recrystallization of nannofossils in older sediments, so that almost half of the calcium carbonate clay-and silt-size particles in Cretaceous oozes could no longer be positively identified as nannofossils. The pink Cretaceous oozes also contain pale olive mottling. In smear slides, the mottled material includes a considerable number of euhedral

TABLE 2
Stratigraphy Site 20

Age	Cored Interval (m)	Formation Name	Probable Interval (m)	Probable Thickness (m)	Description
Pleistocene	0-0.4	Local unit 3-20A-1-1	0-0.4	0.4	Yellowish-brown nannofossil clays, with local patches of manganese nodules.
Pliocene	0.4-1.5	Local unit 3-20C-1-1	0.4-1.5	1.1	Light yellow brown nannofossil marl oozes, and dark brown nannofossil clays, hematitic, zeolitic, but no foraminifera.
Upper Oligocene	1.5-5.0	Discovery Clay 3-20C-1-2	1.5-5.0	3.5	Interbedded dark brown zeolite clays, red clays and yellow brown marl oozes.Two to 40 per cent zeolites, 30 to 80 per cent clay, 0 to 75 per cent nannofossil.
Upper Oligocene	5-9 (6.4-15.5)	Endeavor Ooze 3-20C-1-4 with *Braarudosphaera* Chalk in 20B-1-4 and 5	5.0-15.5	10.5	Dark brown to light yellow brown marl ooze. Five to 35 per cent clay, 5 per cent zeolites. *Braarudosphaera rosa* here makes up five beds of chalk - pure white, friable - each bed about 5 centimeters thick, and about 10 to 15 centimeters apart.
Lower Oligocene	(15.5-24.7) 25.6-34.7	Fram Ooze 3-20A-2-1	15.5-34.7	19.2	Very pale brown nannofossil chalk ooze - very homogeneous.
Upper to Middle Eocene	34.7-43.7 36.9-56.1	Gazelle Ooze 3-20C-3-1	34.7-56.5	21.8	Brown nannofossil marl oozes and clays, hematitic, zeolitic, and very rare foraminifera.
Middle Eocene to Upper Cretaceous	57.0-72.2	Hirondelle Ooze 3-20C-5-1	56.5-72.2	15.7	Very pale brown and pink nannofossil chalk oozes. Up to 50 per cent recrystallized calcareous matrix. Contains dolomite rhombs, and rhodochrosite.
?	72.2	Basement 3-20A-4-1	?	?	Pillow breccia with glass and marble fragments. Weathered basalt with glassy chill margins.

rhombs of dolomite and/or rhodochrosite. This basal unit is sufficiently different from the Grampus Ooze, to establish a new formation. Also a good correlation can be made with the Paleocene-Maestrichtian Unit 3-21-2-1 on the Rio Grande Rise. The authors have chosen, therefore, to erect a new formation (Hirondelle) to designate the basal unit at Site 20. They note, however, that the Hirondelle Ooze here has the same characteristic increase of foraminifera as the Grampus Ooze. The foraminifera content is less than 0.5 per cent in the upper part, but it is more than 5 per cent just above the basement in Unit 3-20C-5-1.

The Hirondelle Ooze may include several obscure unconformitires here, as some faunal and floral zones are not represented in the continuously cored samples. The Cretaceous-Tertiary contact is included in this unit. As mentioned previously, this contact has been cored twice, probably because of the submarine slumping of a Cretaceous block into a Paleocene sea (see Paleontology Section).

Basalt basement was reached in at least two of the four holes (Holes 20A and 20C); the origin of the basalt sample from Hole 20 is unknown. Some 0.4 meter (1 foot) of basalt core was retrieved from Hole 20A. The basalt is a pillow breccia and, thus, definitely an extrusive. Fragments of black glass and aphanitic basalt, now weathered, are mixed in a marble matrix.

The two holes at Site 20 which reached basement show a difference in total thickness of 5 meters (16 feet), or some 8 per cent. This variation is remarkable, considering that the ship always was contrived to remain stationary during the drilling.

The formational boundaries were drawn with the help of the correlation of cores from the three holes that penetrated the normal section, and on the basis of data presented below:

Base of Pleistocene Local Unit	At 0.4 meter (Hole 20C)	Lithological and floral changes described in text.
Base of Pliocene Local Unit	At 1.5 meters (Hole 20C)	Same as above.
Base of Discovery Clay	At 5.0 meters (Hole 20C)	Base of the lowest layer noncalcareous red clay.
Base of Endeavor Ooze	At 15.5 meters	Midpoint in uncored interval.
Base of Fram Ooze	At 35.0 meters (Hole 20C)	Lithological change described in text.
Base of Gazelle Ooze	At 56.5 meters (Hole 20C)	Lithological change described in text.
Base of Hirondelle Ooze	At 72.2 meters (Hole 20C)	Basement.

The sedimentation rates are estimated as follows:

Pleistocene Local Unit	0.1 m/2 m.y.,	or	0.02 cm/t.y.
Pliocene Local Unit	1.1 m/4 m.y.,	or	0.03 cm/t.y.
Discovery Clay	3.5 m/22 m.y.,	or	0.02 cm/t.y.
Endeavor Ooze	10.5 m/6 m.y.,	or	0.15 cm/t.y.
Fram Ooze	19.2 m/4.5 m.y.,	or	0.4 cm/t.y.
Gazelle Ooze	21.4 m/10 m.y.,	or	0.2 cm/t.y.
Hirondelle Ooze	15.7 m/18 m.y.,	or	0.1 cm/t.y.

The rates for all formations here are slower, as compared to their correlatives at other sites on the Mid-Atlantic Ridge; but, the trend that calcareous chalk oozes were deposited at a rate some 10-times faster than the red clays is also shown here. The average sedimentation rate for the Hirondelle Ooze here is unusually low, because of the several obscure unconformities within this formation as suggested by paleontological studies.

The stratigraphy at this site is shown in Table 2. The cited cored intervals, probable formational intervals and probable formation thicknesses refer to those intervals from Hole 20C. Cored intervals in the other holes are also given, but these are in parentheses.

PHYSICAL PROPERTIES

Natural Gamma Radiation

At Site 20 natural gamma radiation extended from zero to 2100 counts/1.25 min/7.6-centimeter intervals, averaging about 800 counts (Figures 3A & 4A and 7A-17A). Natural gamma radiation core averages exhibit a rough, direct variation with porosity and, to a lesser extent, an inverse variation to wet-bulk density and sound velocity. For the most part, natural gamma radiation varied unsystematically with depth. The higher average, natural radiation from the cores was emitted from sediments with a clay-zeolite content in the Discovery Clay, Endeavor Ooze and Gazelle Ooze. The pale nanno-chalk oozes of almost pure calcareous nannoplankton (Fram and Hirondelle Oozes) had the lower radiation counts.

Porosity, Wet-Bulk Density, and Water Content

Porosities, wet-bulk densities, and water contents ranged from 36 per cent to 82 (?) per cent, 1.30 (?) to 2.05 g/cc, and 27 per cent to 48 per cent, respectively, with averages of 60 per cent, 1.63 g/cc, and 35 per cent at Site 20 (Figures 3A & 4A and 7A-17A). In general, porosities irregularly decreased with depth and, of, course, varied inversely with wet-bulk densities. This irregular decrease appears to be controlled by lithology at the Discovery Clay and Gazelle Ooze have greater porosities than the adjacent formations. These higher porosities are in part related to the greater amount of clay-size material. The lowest porosity of 36 per cent occurred in the compact and partly recrystallized Cretaceous Hirondelle Ooze. As usual, porosity is roughly inversely related to sound velocity. The crude direct correlation of porosity to natural radiation may be secondary as clay mineral types, which contain radionuclides, usually form the finer-grained fraction of the sediment, and unconsolidated fine-grained sediments normally have a higher porosity.

Sediment Sound Velocity

Sediment sound velocities ranged from 1.48 to 1.63 km/sec, with an average of 1.52 km/sec at Site 20 (Figures 3A & 4A and 7A-17A). Sound velocity, in general, irregularly increased with depth through the Discovery Clay, Endeavor Ooze and Fram Ooze; and it decreased in the Gazelle Ooze, and increased again in the Hirondelle Ooze. Sound velocity appears to be directly related to wet-bulk density and inversely related to porosity. See the section on wet-bulk density and porosity for a discussion of their relationships.

Penetrometer

Penetration of the penetrometer needle ranged from complete penetration to 30×10^{-1} millimeters in sediments from Site 20 (Figures 3A & 4A and 7A-17A). The values which did not completely penetrate the core had a norm of 134×10^{-1} millimeters. These values irregularly decreased with depth, but they do not necessarily represent *in situ* values as the cores were somewhat disturbed.

Thermal Conductivity

Thermal conductivity values had about the same range as determined for site 19, about 2.0 to 3.2×10^{-3} cal/°C cm sec. However, vertical gradients of thermal conductivity were larger at this site, probably reflecting the more rapid variations in sediment type with depth. Values increased over the whole range between the surface and 30 m. and then dropped back to about a value of 2.1×10^{-3} cal/°C cm sec at a depth of 40 m. From 30 m. to 70 m. the increase was similar as for the upper part of the hole, reaching a maximum of about 3.0×10^{-3} cal/°C cm sec in the bottom of the hole.

Interstitial Water Salinity

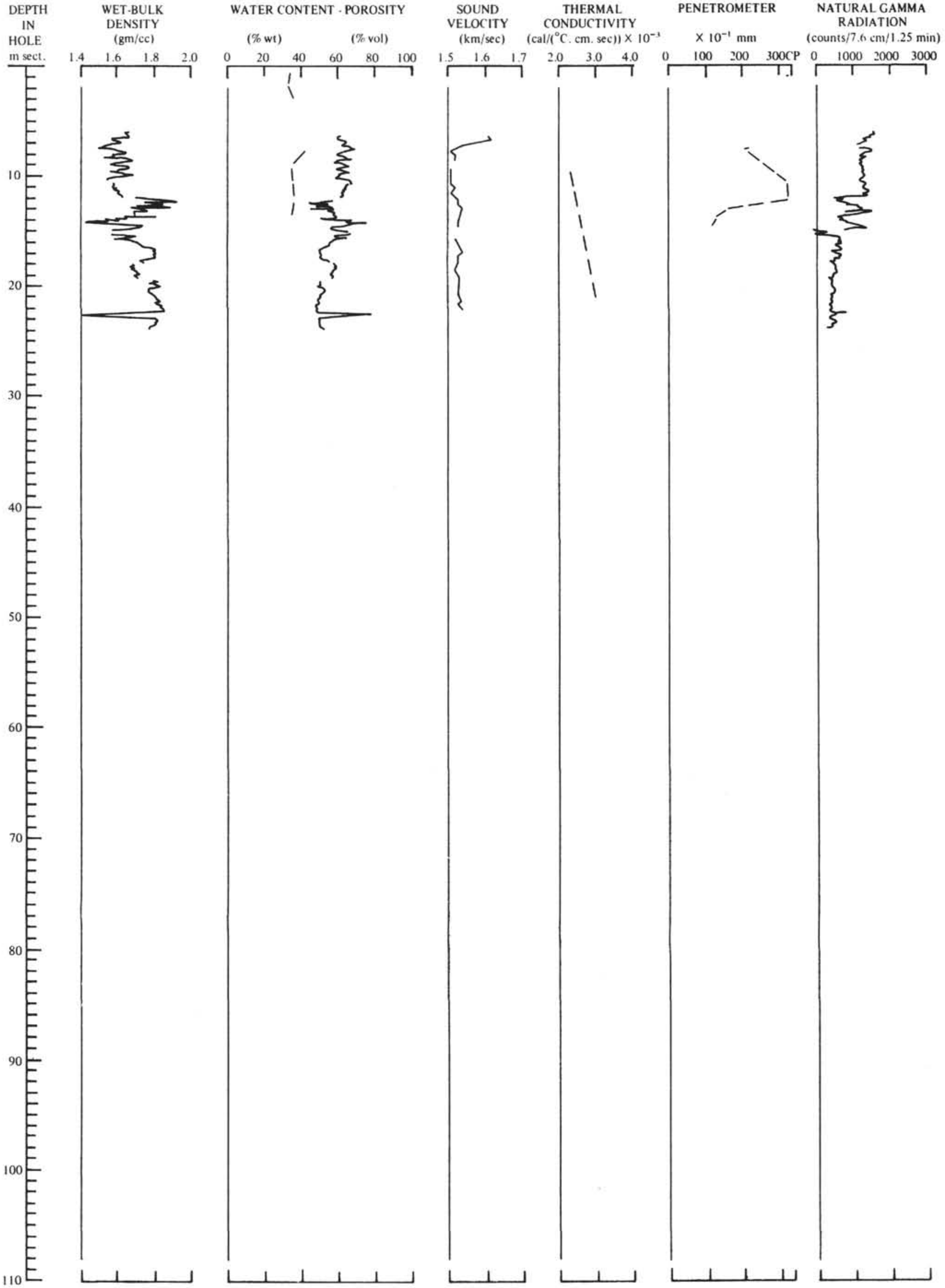
At Site 20C two interstitial salinity water samples were collected; one from lower Oligocene Endeavor Ooze and the other from Eocene Gazelle Ooze. Their respective salinities were 35.5 and 34.7 ppt, and their respective depths below the sediment surface were 7 and 38 meters (23 and 125 feet).

THE CORES RECOVERED FROM SITE 20

The following pages present a graphic summary of the results of drilling and coring at Site 20.

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 20. 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 3A. *Summary of the Physical Properties of the cores recovered from Holes 20A and 20B.*

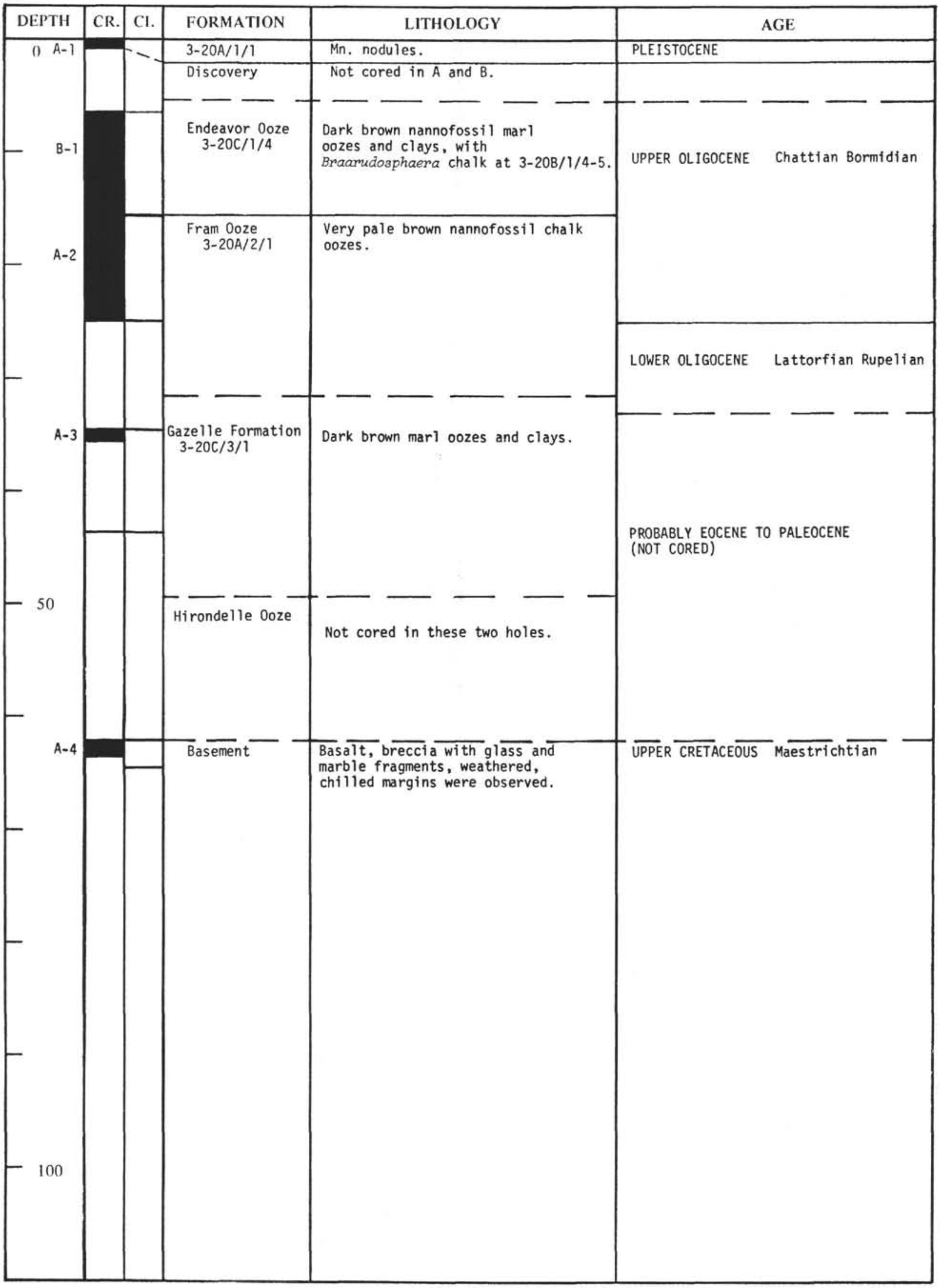
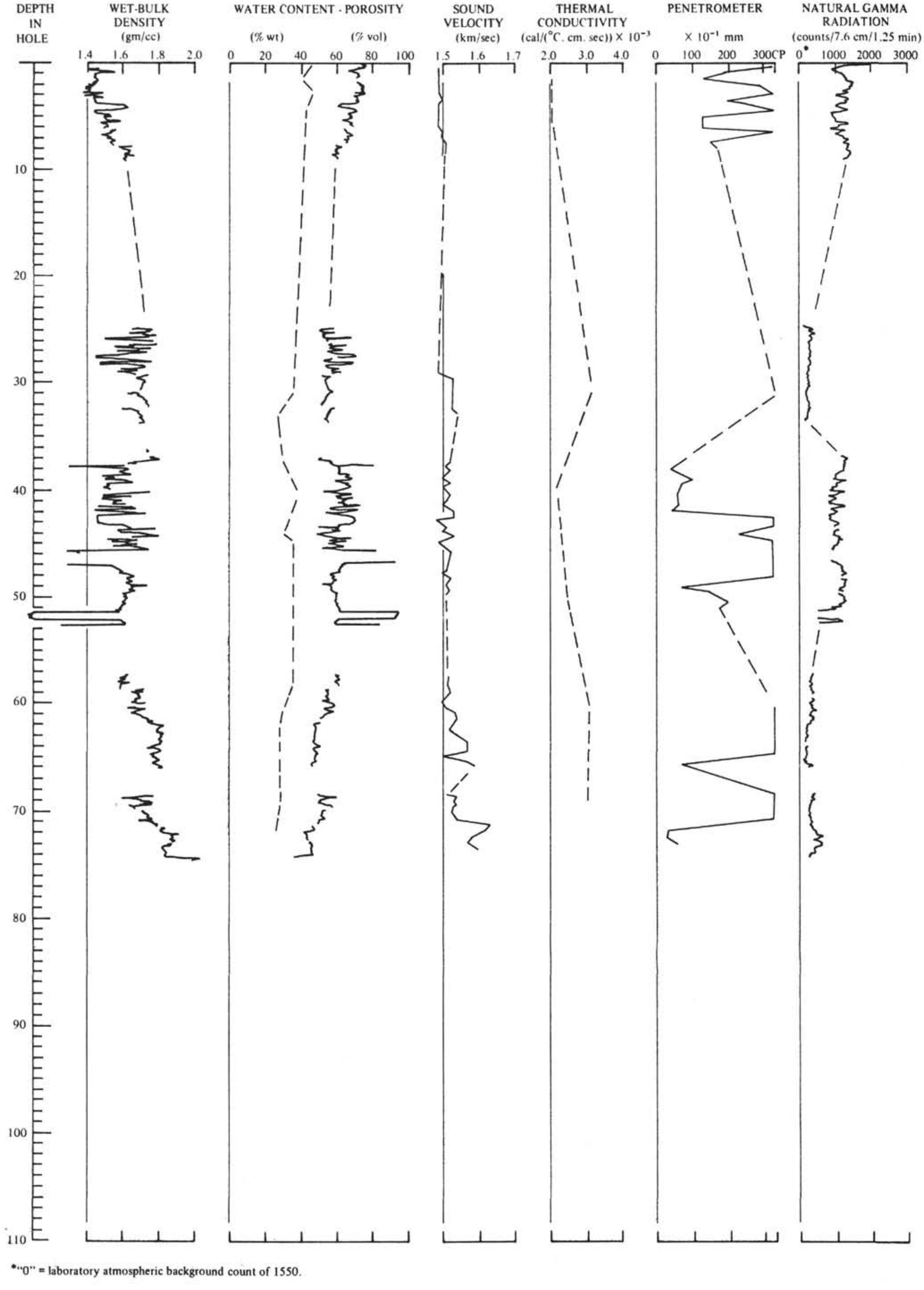


Figure 3B. *Summary of the cores from Holes 20A and 20B. (Depth in meters below sea bed; C.R. = core recovered; C.I. = cored interval.)*



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

Figure 4A. *Summary of the Physical Properties of the cores recovered from Hole 20C.*

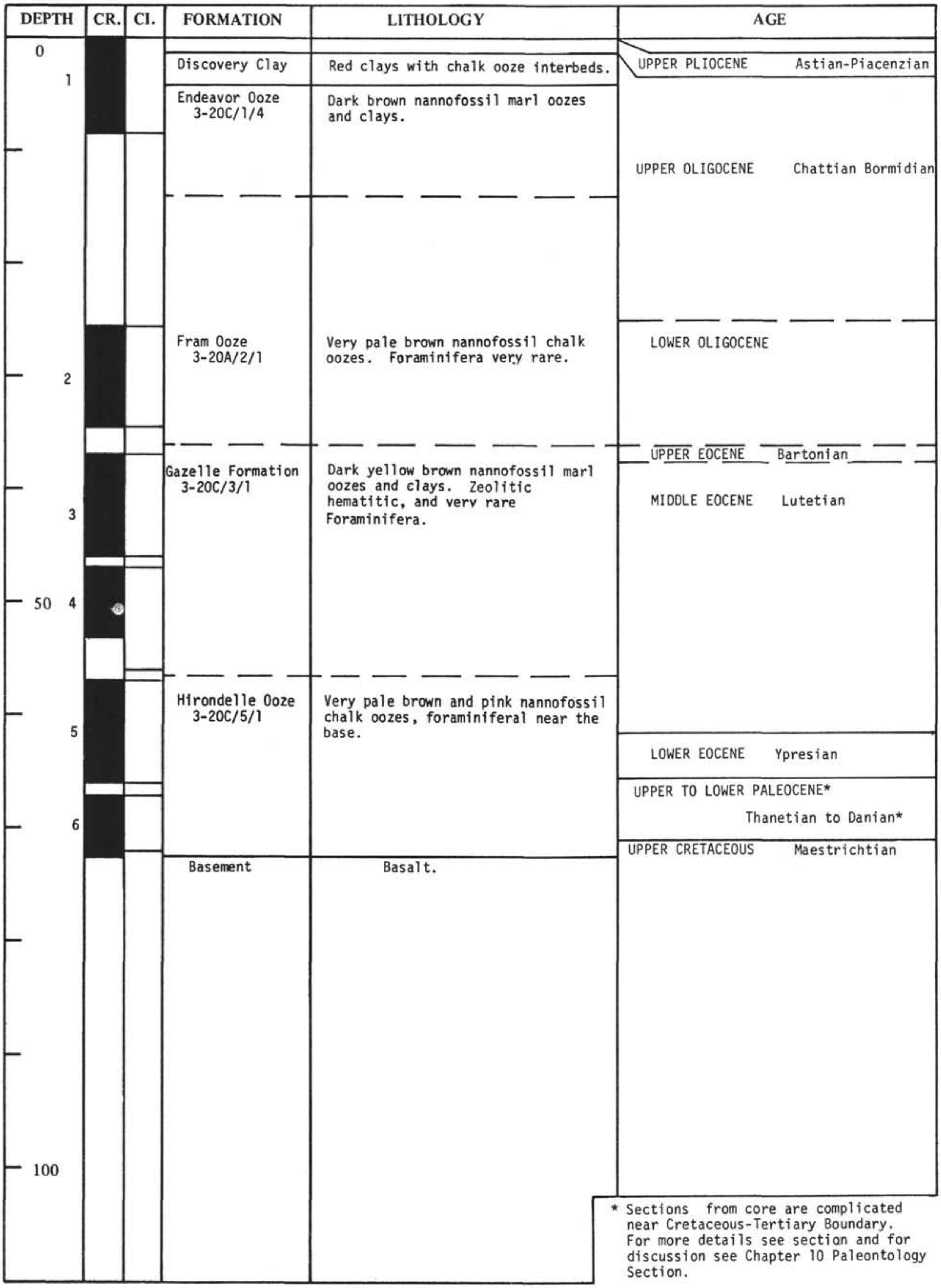


Figure 4B. *Summary of the cores from Hole 20C. (Depth in meters below sea bed; C.R. = core recovered; C.I. = cored interval.)*

AGE	STAGE	DEPTH (METERS)	SECTION NO.	LITHOLOGY	SAMPLE INTERVAL	LITHOLOGY	DIAGNOSTIC FOSSILS
		1	1			Mixed slump sediments basalt fragments brown clay white chalk fragments manganese nodules basaltic glass.	This core is badly disturbed and contains floras ranging in age from Upper Cretaceous to Pleistocene. Floras are Upper Cretaceous, Eocene, Pliocene, and Pleistocene in age. These floras occur separately at times; at other times they are thoroughly mixed. Planktonic foraminifera are Holocene in age. they are *Globorotalia inflata*, *G. menardii*, *G. truncatulinoides*, and *Globigerinoides ruber*.
		2	2	OPENED			
		3 4	3	NOT			
		5	4	CORE			
		6 7	5				
		8	6				

Figure 5. *Core 1, Hole 20.*

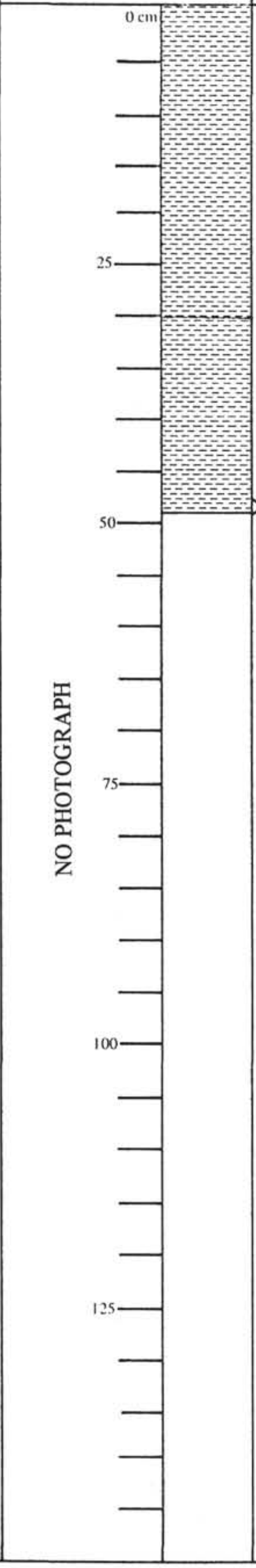
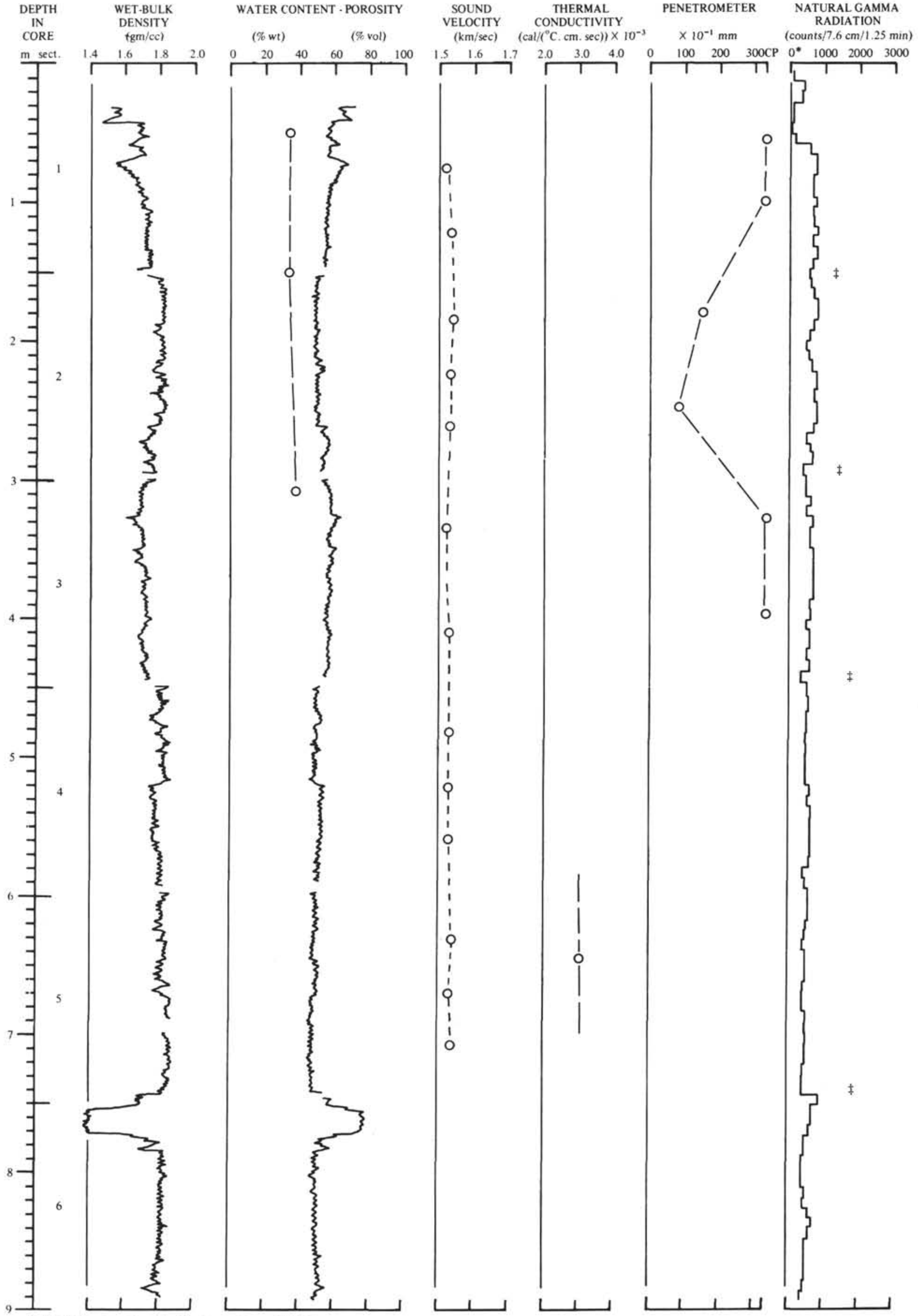
AGE	STAGE	LITHOLOGY	SAMP. INT.	LITHOLOGY	DIAGNOSTIC FOSSILS
PLEISTOCENE			FN	DISCOVERY CLAY Yellow brown clay - (10YR 4/4); 10% nanno, 5% foram, in fine pelitic matrix.	Core catcher: Planktonic foraminifera: *Globorotalia truncatulinoides*, *G. inflata*, *G. menardii* (L), *G. tumida*, *Pulleniatina obliquiloculata*, *Globoquadrina dutertrei*. Calcareous nannoplankton: *Gephyrocapsa oceanica*, *Cyclococcolithus leptoporus*, *Ceratolithus cristatus*, *Helicopontosphaera kamptneri*, *Scyphosphaera* sp.

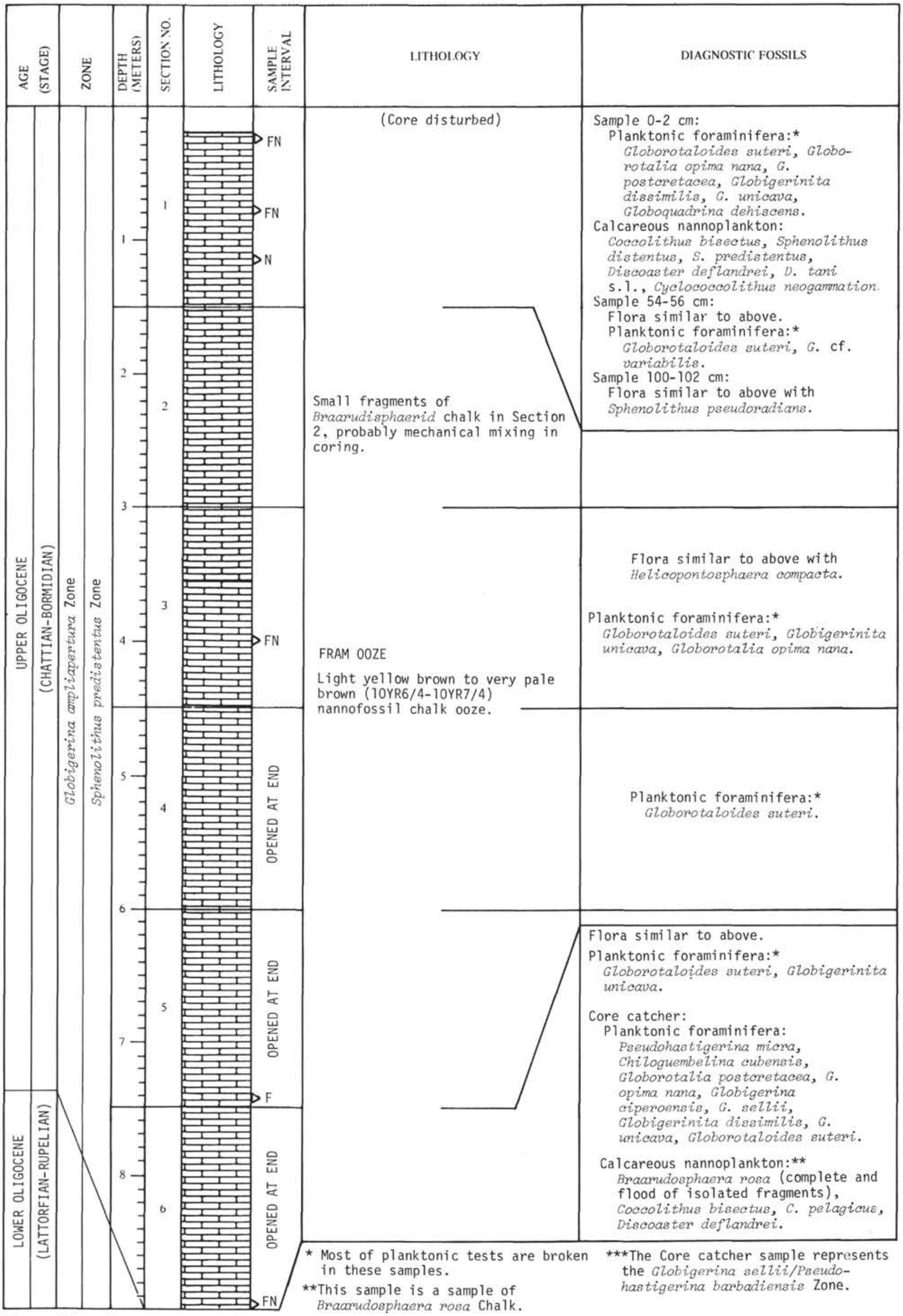
Figure 6. *Core 1, Hole 20A.*



* "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 7A. *Physical properties of Core 2, Hole 20A.*



(Core disturbed)

Small fragments of *Braarudisphaerid* chalk in Section 2, probably mechanical mixing in coring.

FRAM OOZE

Light yellow brown to very pale brown (10YR6/4-10YR7/4) nannofossil chalk ooze.

Sample 0-2 cm:
Planktonic foraminifera:*
Globorotaloides suteri, Globorotalia opima nana, G. postcretacea, Globigerinita dissimilis, G. unicava, Globoquadrina dehiscens.
Calcareous nannoplankton:
Coccolithus bisectus, Sphenolithus distentus, S. predistentus, Discoaster deflandrei, D. tani s.l., *Cyclococcolithus neogammation.*
Sample 54-56 cm:
Flora similar to above.
Planktonic foraminifera:*
Globorotaloides suteri, G. cf. *variabilis.*
Sample 100-102 cm:
Flora similar to above with *Sphenolithus pseudoradians.*

Flora similar to above with *Helicopontosphaera compacta.*

Planktonic foraminifera:*
Globorotaloides suteri, Globigerinita unicava, Globorotalia opima nana.

Planktonic foraminifera:*
Globorotaloides suteri.

Flora similar to above.
Planktonic foraminifera:*
Globorotaloides suteri, Globigerinita unicava.

Core catcher:
Planktonic foraminifera:
Pseudohastigerina micra, Chiloguembelina cubensis, Globorotalia postcretacea, G. opima nana, Globigerina ciperoensis, G. sellii, Globigerinita dissimilis, G. unicava, Globorotaloides suteri.

Calcareous nannoplankton:**
Braarudosphaera rosa (complete and flood of isolated fragments), *Coccolithus bisectus, C. pelagicus, Discoaster deflandrei.*

* Most of planktonic tests are broken in these samples.

**This sample is a sample of *Braarudosphaera rosa* Chalk.

***The Core catcher sample represents the *Globigerina sellii/Pseudohastigerina barbadiensis* Zone.

Figure 7B. *Core 2, Hole 20A.*

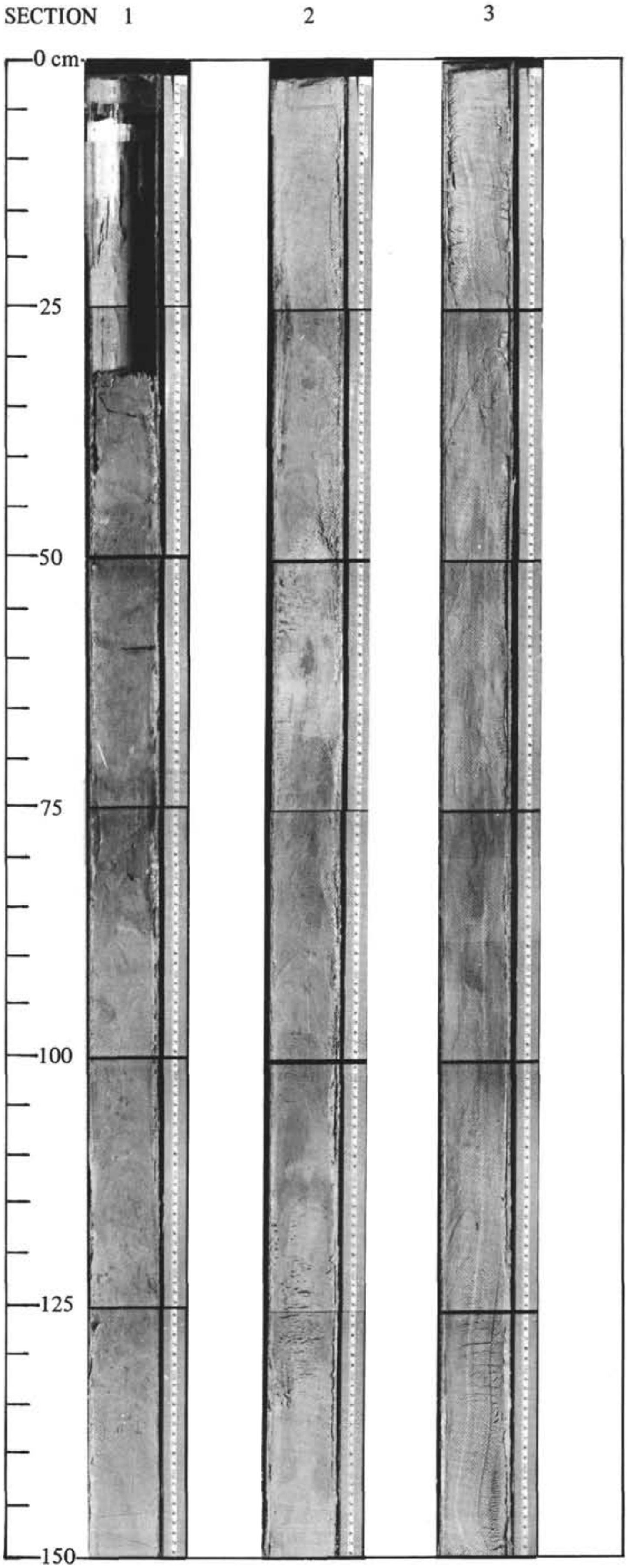
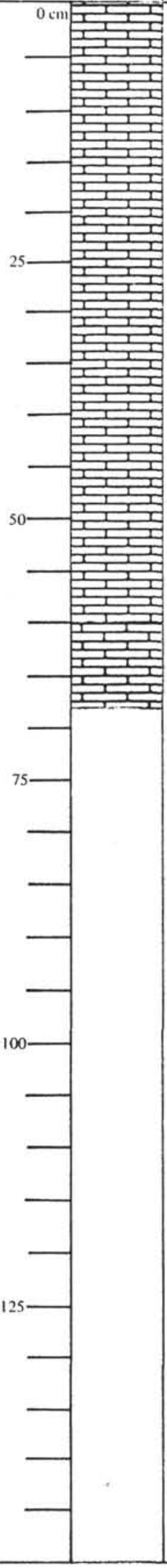


Plate 1. *Core 2, Hole 20A.*

AGE (STAGE)	ZONE		LITHOLOGY	SAMP. INT.	LITHOLOGY	DIAGNOSTIC FOSSILS
LOWER OLIGOCENE (LATTORFIAN-RUPELIAN)	*Globigerina tapuriensis* Zone	*Helicopontosphaera reticulata* Zone	NO PHOTOGRAPH 		GRAMPUS OOZE Dark brown nannofossil chalk ooze. 1-3% zeolite	Core catcher: Planktonic foraminifera:* *Globigerina sellii, G. tapuriensis, Globoquadrina venezuelana, Globorotalia opima nana, Globorotaloides suteri, Globigerinita unicava.* Calcareous nannoplankton:** *Coccolithus bisectus, Cyclococcolithus lusitanicus, C. neogammation, Reticulofenestra umbilica, Sphenolithus pseudoradians, S. predistentus, Isthmolithus recurvus, Discoaster deflandrei, D. tani* (s.l.). Calcareous nannoplankton:*** *Braarudosphaera rosa* (complete and flood of isolated fragments), *Coccolithus pelagicus, C. eopelagicus, Discoaster deflandrei.*

* This sample contains reworked lower Middle Eocene (Lutetian), Upper Paleocene (Thanetian), and Upper Cretaceous (Maestrichtian) planktonic foraminifera.

**This sample contains reworked Eocene (Lutetian). calcareous nannoplankton.

***This sample is a sample of *Braarudosphaera rosa* Chalk.

Figure 8. *Core 3, Hole 20A.*

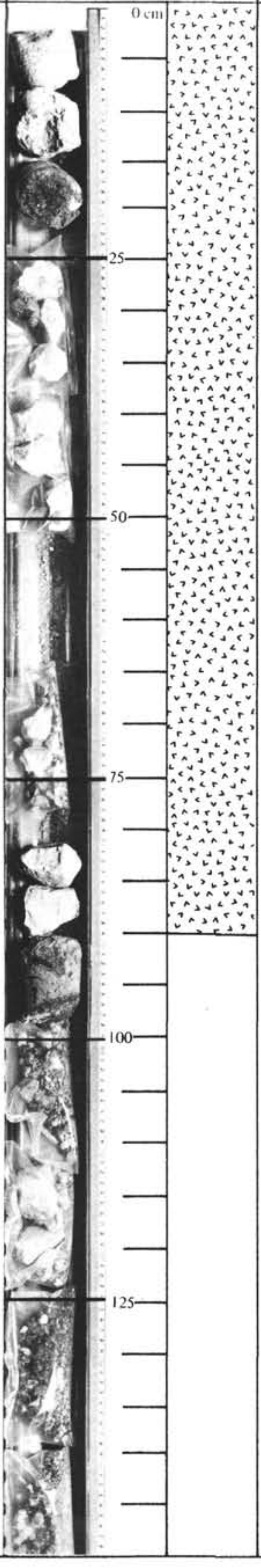
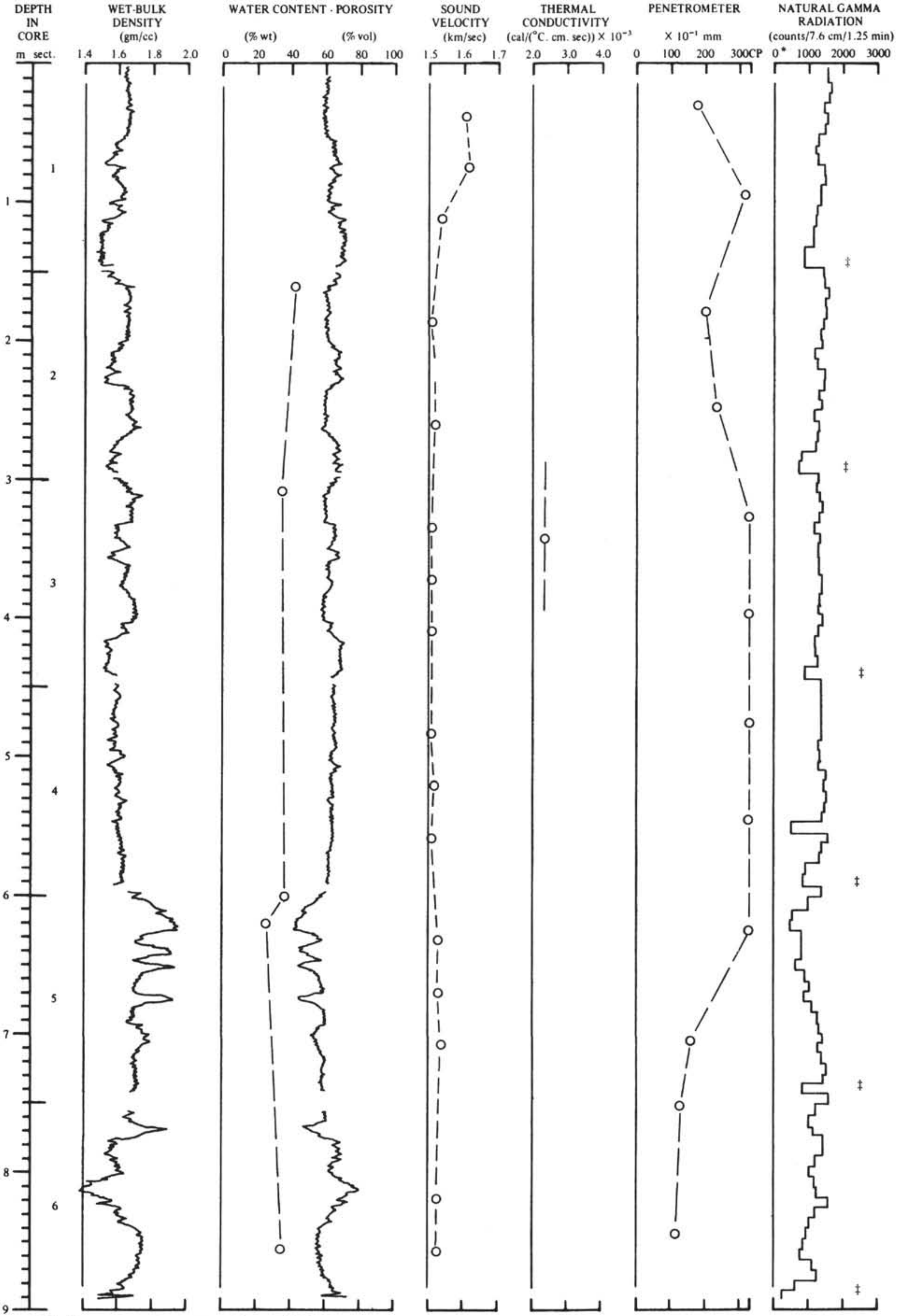
AGE	STAGE	LITHOLOGY	SAMP. INT.	LITHOLOGY	DIAGNOSTIC FOSSILS
UPPER CRETACEOUS	MAESTRICHTIAN			Basement. Breccia with glass and marble fragments in marble matrix; Weathered basalt with glassy chilled margins in contact with underlying marble.	Chalk intercalated with basalt. Calcareous nannoplankton: *Arkhangelskiella cymbiformis, Micula decussata, Tetralithus murus.*

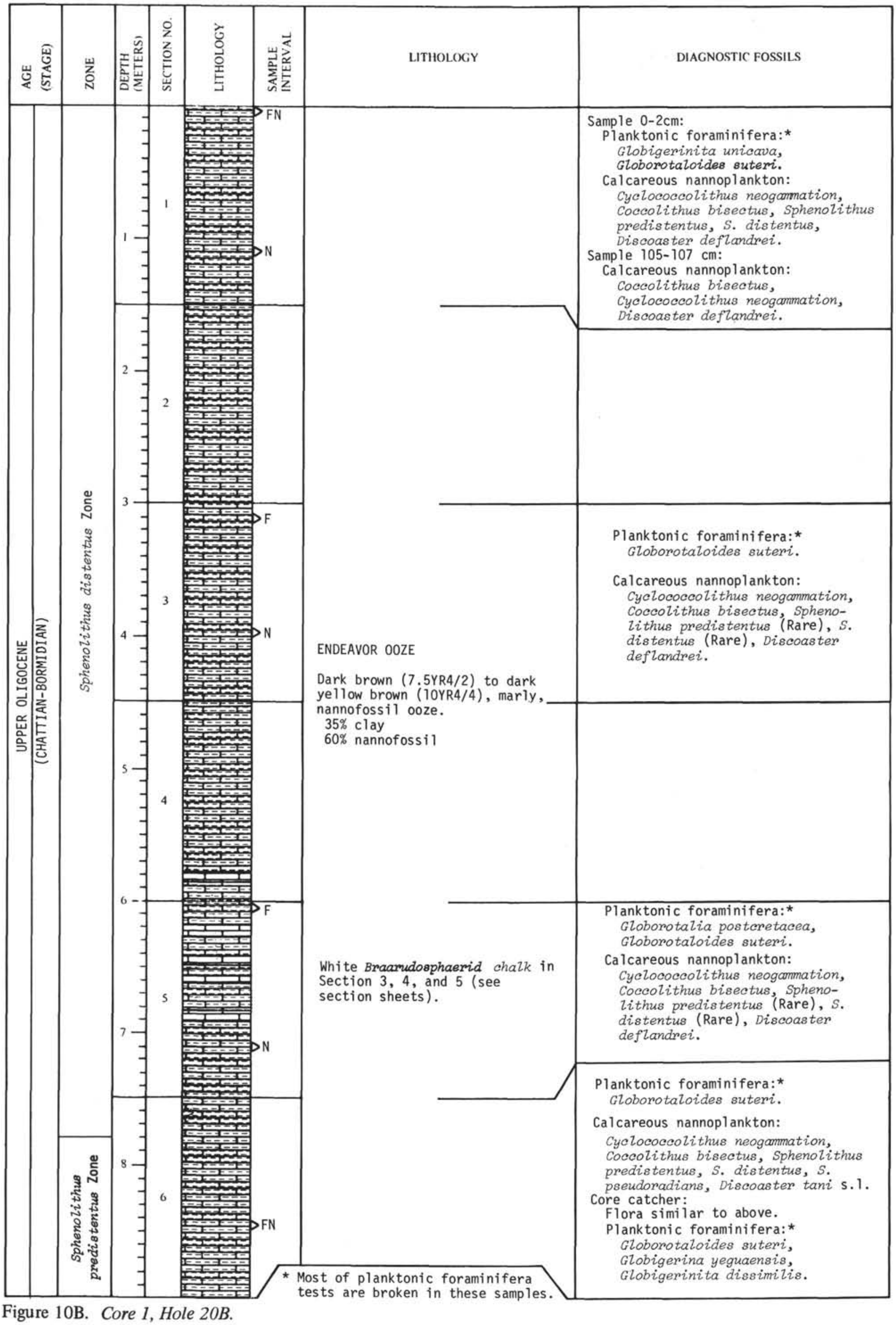
Figure 9. *Core 4, Hole 20A.*



* "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 10A. *Physical Properties of Core 1, Hole 20B.*



ENDEAVOR OOZE

Dark brown (7.5YR4/2) to dark yellow brown (10YR4/4), marly, nannofossil ooze.
35% clay
60% nannofossil

White ***Braarudosphaerid*** *chalk* in Section 3, 4, and 5 (see section sheets).

* Most of planktonic foraminifera tests are broken in these samples.

Sample 0-2cm:
Planktonic foraminifera:*
Globigerinita unicava, ***Globorotaloides suteri.***
Calcareous nannoplankton:
Cyclococcolithus neogammation, *Coccolithus bisectus*, *Sphenolithus predistentus*, *S. distentus*, *Discoaster deflandrei.*
Sample 105-107 cm:
Calcareous nannoplankton:
Coccolithus bisectus, *Cyclococcolithus neogammation*, *Discoaster deflandrei.*

Planktonic foraminifera:*
Globorotaloides suteri.

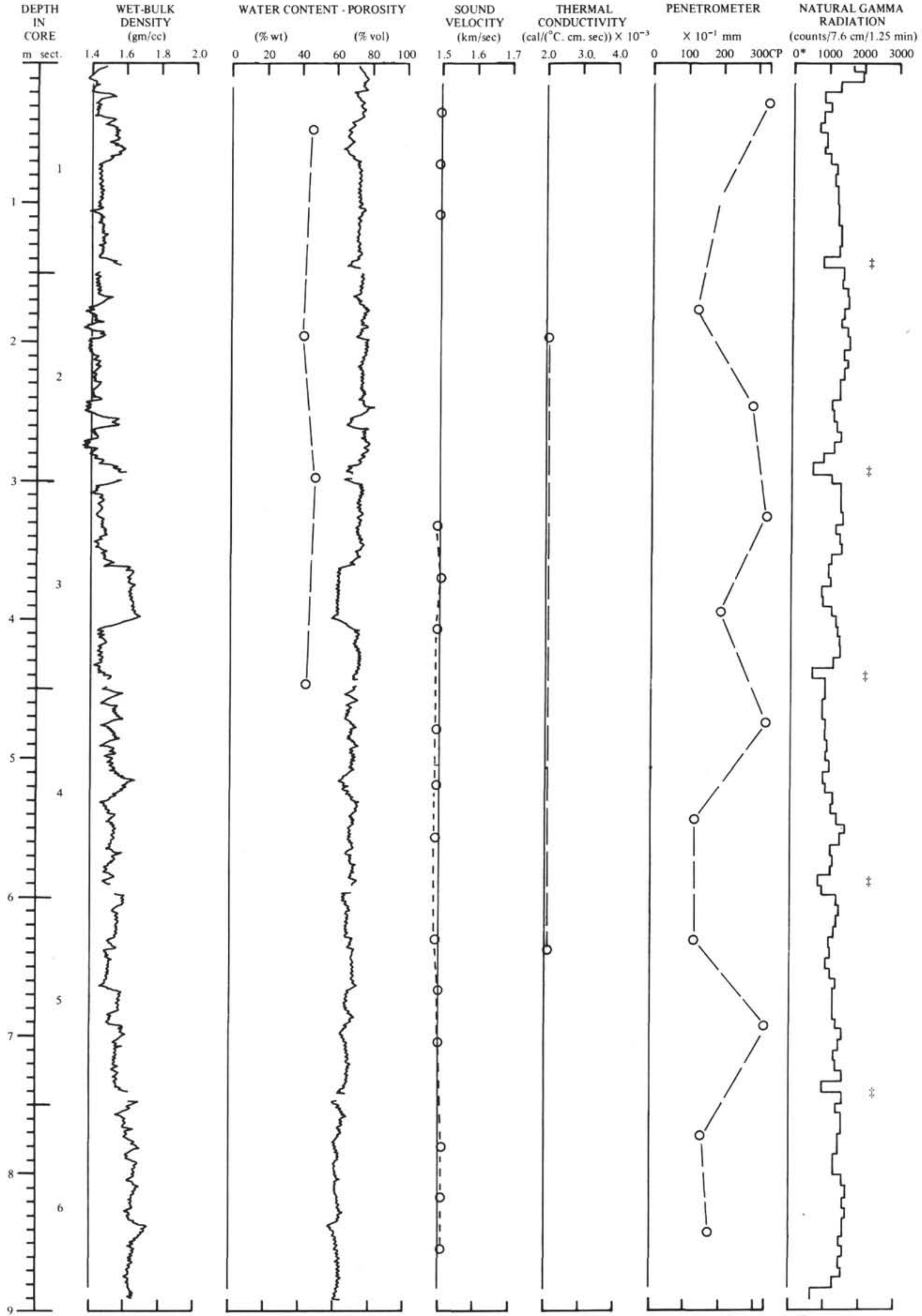
Calcareous nannoplankton:
Cyclococcolithus neogammation, *Coccolithus bisectus*, *Sphenolithus predistentus* (Rare), *S. distentus* (Rare), *Discoaster deflandrei.*

Planktonic foraminifera:*
Globorotalia postcretacea, *Globorotaloides suteri.*
Calcareous nannoplankton:
Cyclococcolithus neogammation, *Coccolithus bisectus*, *Sphenolithus predistentus* (Rare), *S. distentus* (Rare), *Discoaster deflandrei.*

Planktonic foraminifera:*
Globorotaloides suteri.

Calcareous nannoplankton:
Cyclococcolithus neogammation, *Coccolithus bisectus*, *Sphenolithus predistentus*, *S. distentus*, *S. pseudoradians*, *Discoaster tani* s.l.
Core catcher:
Flora similar to above.
Planktonic foraminifera:*
Globorotaloides suteri, *Globigerina yeguaensis*, *Globigerinita dissimilis.*

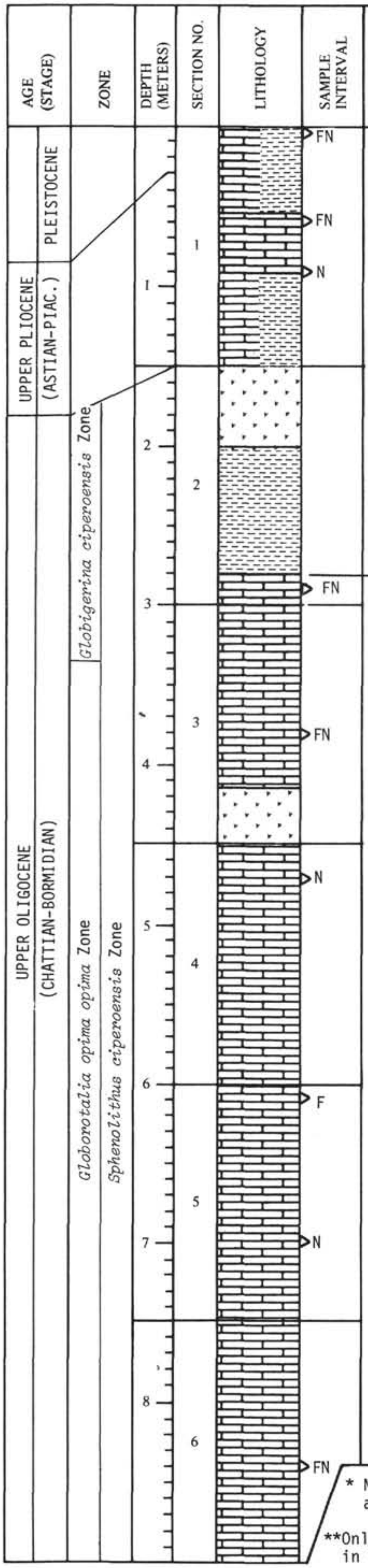
Figure 10B. *Core 1, Hole 20B.*



* "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 11A. *Physical properties of Core 1, Hole 20C.*



LITHOLOGY

DISCOVERY CLAY

Dark brown to light yellow brown (7.5YR3/2-10YR6/4) nannofossil, marl ooze.
30-75% nannofossil

Zeolite clay

Red clay

ENDEAVOR OOZE

Very pale brown (10YR7/4) to light yellow brown (10YR6/4) nannofossil chalk ooze.

Brown (10YR4/3) zeolite clay

Light yellow brown to brown, marly nannofossil chalk ooze.

DIAGNOSTIC FOSSILS

For flora and fauna descriptions see section sheet.

Planktonic foraminifera:
Globigerina sellii, Globorotaliu opima nana, Globigerinita dissimilis, G. unicava, Globorotalioides suteri.
Calcareous nannoplankton:
Coccolithus bisectus, C. aff. *bisectus, Cyclococcolithus neogammation, Discoaster deflandrei.*

Flora similar to above.
Planktonic foraminifera:*
Globorotalia opima opima, G. opima nana, Globorotaloides suteri, Globigerinita dissimilis.

Flora similar to above.

Flora similar to above.
Planktonic foraminifera:*
Globigerinita dissimilis, Globorotaloides suteri, Globorotalia opima nana.

Flora similar to above.**
Core catcher:
Flora similar to above.****
Planktonic foraminifera:***
Globigerinita dissimilis, Globorotaloides suteri, Globorotalia opima nana.

* Most of planktonic foraminifera tests are broken in these samples.

**Only benthonic foraminifera are present in this sample.

***This sample contains Quaternary planktonic foraminifera contaminants from uphole.

****This sample contians Pliocene floral contaminants from uphole.

Figure 11B. *Core 1, Hole 20C.*

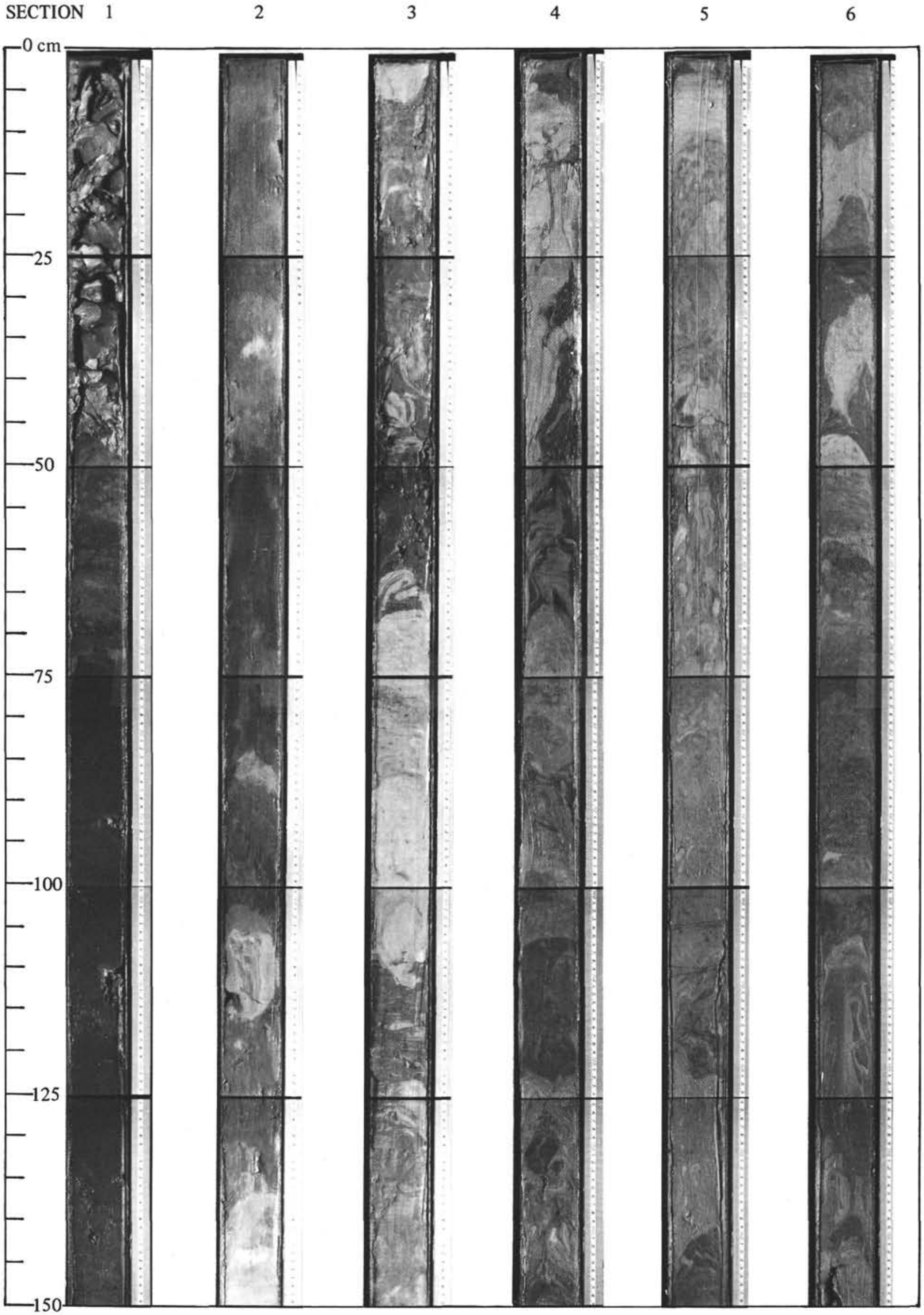


Plate 2. *Core 1, Hole 20C.*

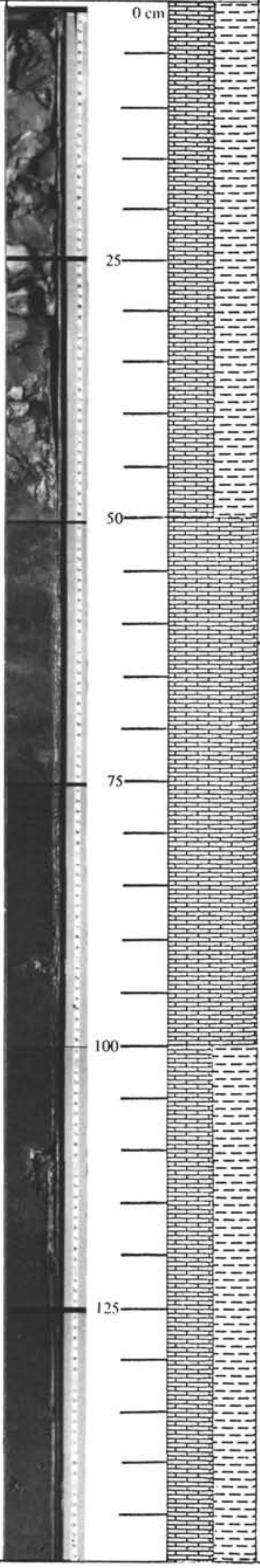
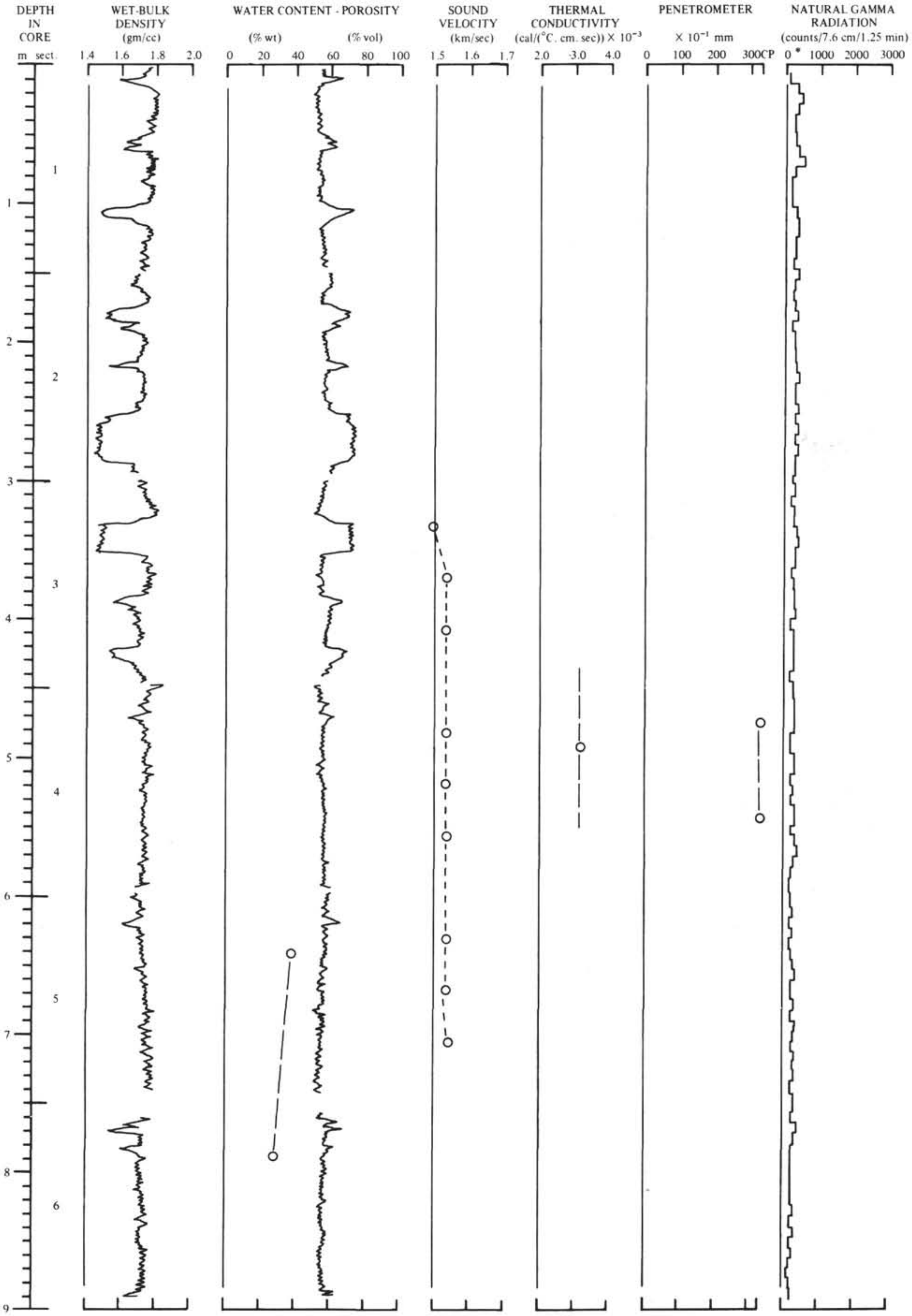
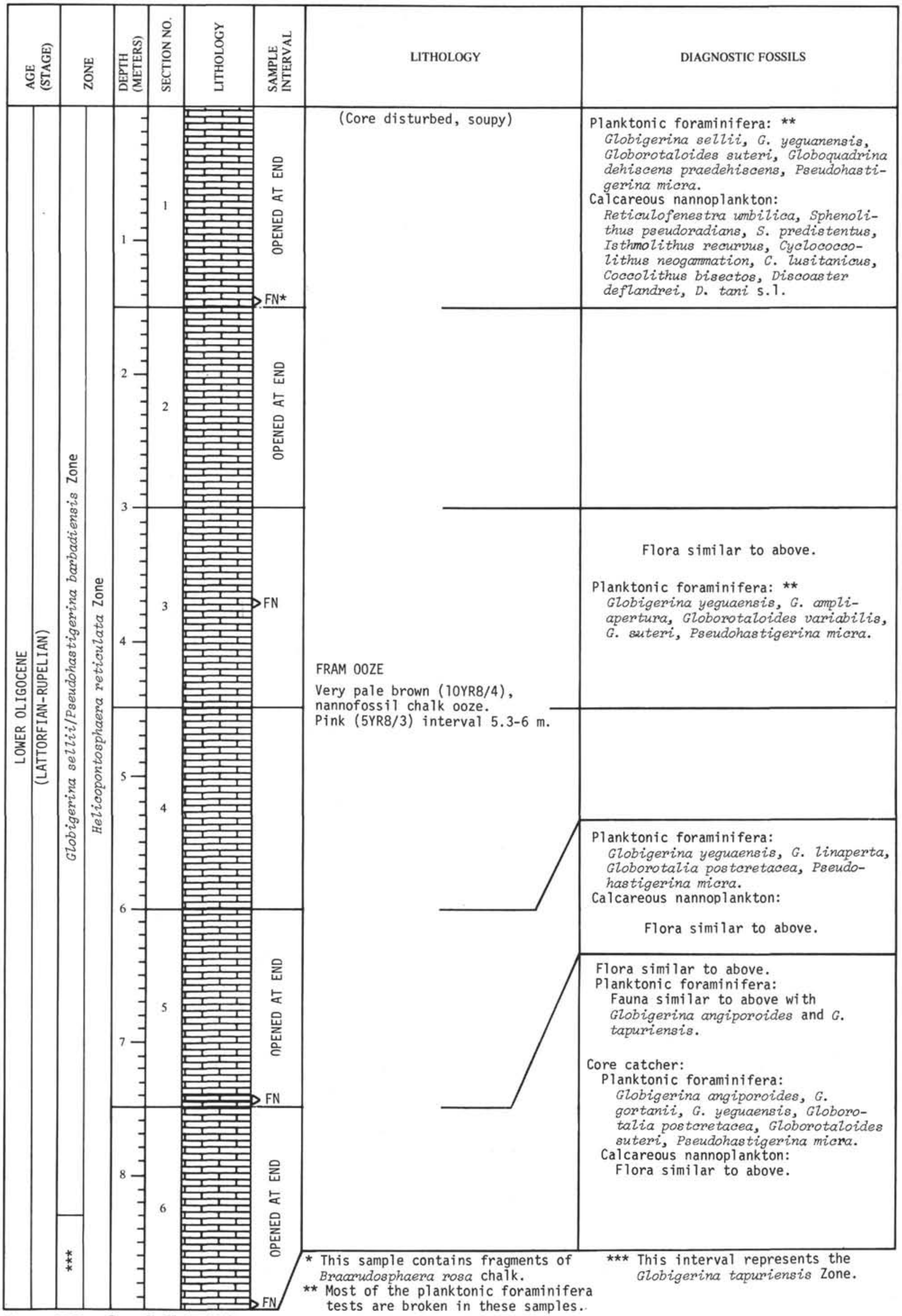
AGE	STAGE	LITHOLOGY	SAMP. INT.	LITHOLOGY	DIAGNOSTIC FOSSILS
PLEISTOCENE			>FN 0-2	Fm. DISCOVERY CLAY Core disturbed. Dark brown (7.5YR3/2), marl ooze. 30% nannofossil 55% clay minerals 5% zeolite 5% hematite 5% foram	Sample 0-2 cm: Planktonic foraminifera: *Orbulina universa, Globorotalia truncatulinoides, G. inflata, G. hirsuta, Pulleniatina obliquiloculata, Globigerinoides conglobatus.* Calcareous nannoplankton: *Gephyrocapsa oceanica, Helicopontosphaera kamptneri, Cyclococcolithus leptoporus, Ceratolithus cristatus.*
UPPER PLIOCENE	ASTIAN-PIACENZIAN		>FN 60-62	Light yellow brown (10YR6/4), nannofossil marl ooze. 75% nannofossil 20% clay 5% zeolite and hematite	Sample 60-62 cm: Planktonic foraminifera: *Globorotalia inflata, Globigerinoides conglobatus, Globigerina conglomerata.* Calcareous nannoplankton: *Discoaster brouweri, D. pentaradiatus, D. surculus, Ceratolithus cristatus, Cyclococcolithus leptoporus.*
			> N 80-82		Sample 80-82 cm: Flora similar to above with *Discoaster challengeri.*
				Dark brown (7.5YR3/2), marl ooze. Same as first zone.	

Figure 12. *Summary of Section 1, Core 1, Hole 20C.*



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

Figure 13A. *Physical propertise of Core 2, Hole 20C.*



(Core disturbed, soupy)

FRAM OOZE

Very pale brown (10YR8/4), nannofossil chalk ooze.
Pink (5YR8/3) interval 5.3-6 m.

Planktonic foraminifera: **
Globigerina sellii, *G. yeguanensis*, *Globorotaloides suteri*, *Globoquadrina dehiscens praedehiscens*, *Pseudohastigerina micra*.
Calcareous nannoplankton:
Reticulofenestra umbilica, *Sphenolithus pseudoradians*, *S. predistentus*, *Isthmolithus recurvus*, *Cyclococcolithus neogammation*, *C. lusitanicus*, *Coccolithus bisectos*, *Discoaster deflandrei*, *D. tani* s.l.

Flora similar to above.

Planktonic foraminifera: **
Globigerina yeguaensis, *G. ampliapertura*, *Globorotaloides variabilis*, *G. suteri*, *Pseudohastigerina micra*.

Planktonic foraminifera:
Globigerina yeguaensis, *G. linaperta*, *Globorotalia postcretacea*, *Pseudohastigerina micra*.
Calcareous nannoplankton:
Flora similar to above.

Flora similar to above.
Planktonic foraminifera:
Fauna similar to above with *Globigerina angiporoides* and *G. tapuriensis*.

Core catcher:
Planktonic foraminifera:
Globigerina angiporoides, *G. gortanii*, *G. yeguaensis*, *Globorotalia postcretacea*, *Globorotaloides suteri*, *Pseudohastigerina micra*.
Calcareous nannoplankton:
Flora similar to above.

* This sample contains fragments of *Braarudosphaera rosa* chalk.
** Most of the planktonic foraminifera tests are broken in these samples.

*** This interval represents the *Globigerina tapuriensis* Zone.

Figure 13B. *Core 2, Hole 20C.*

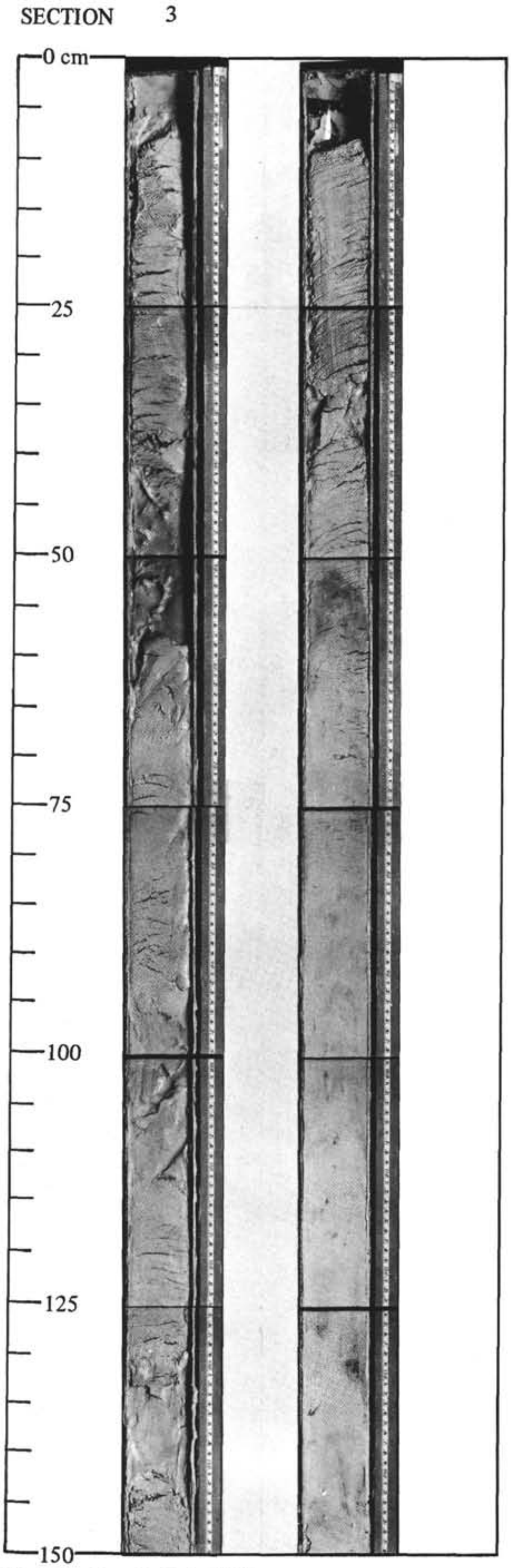


Plate 3. *Core 2, Hole 20C.*

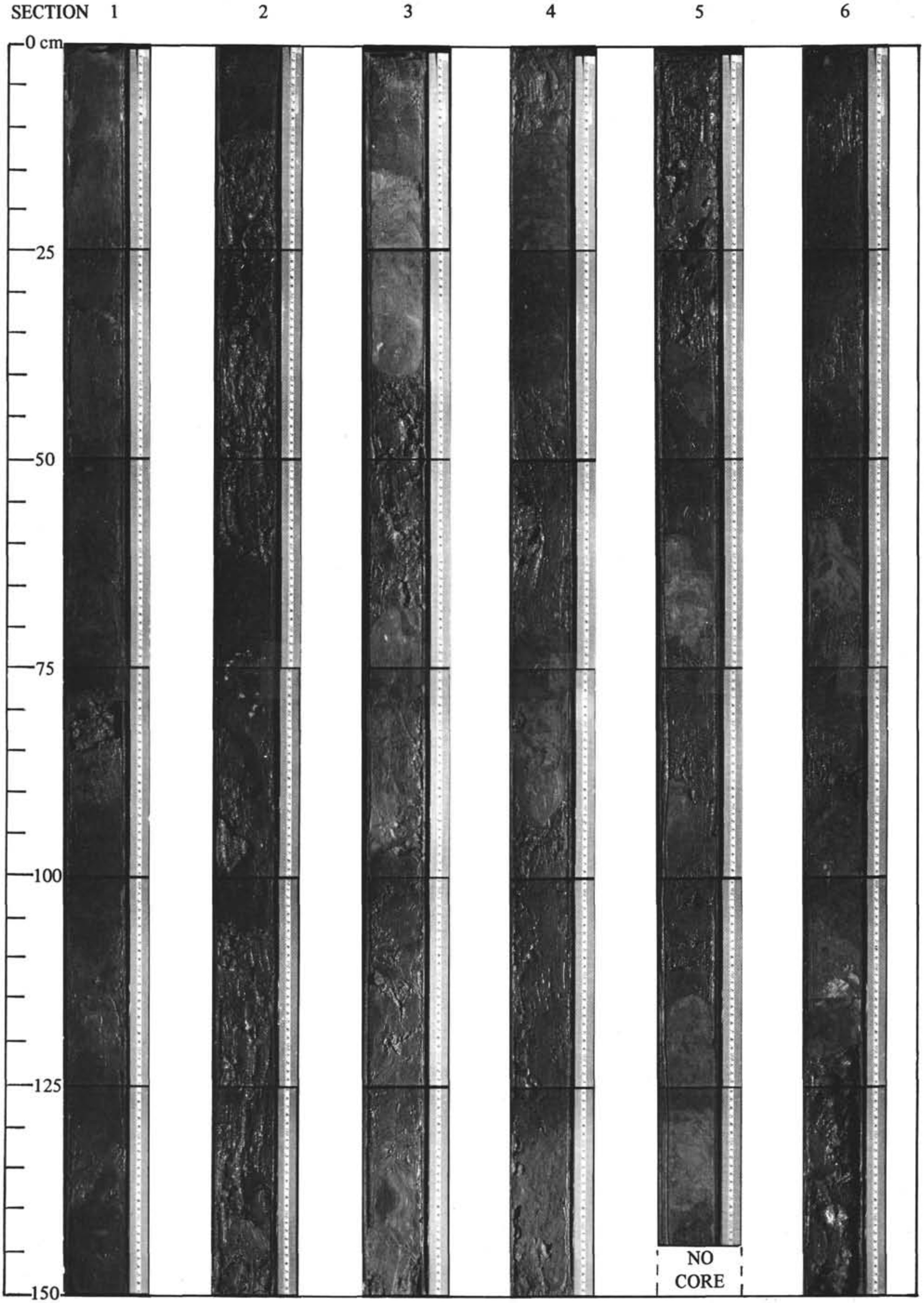
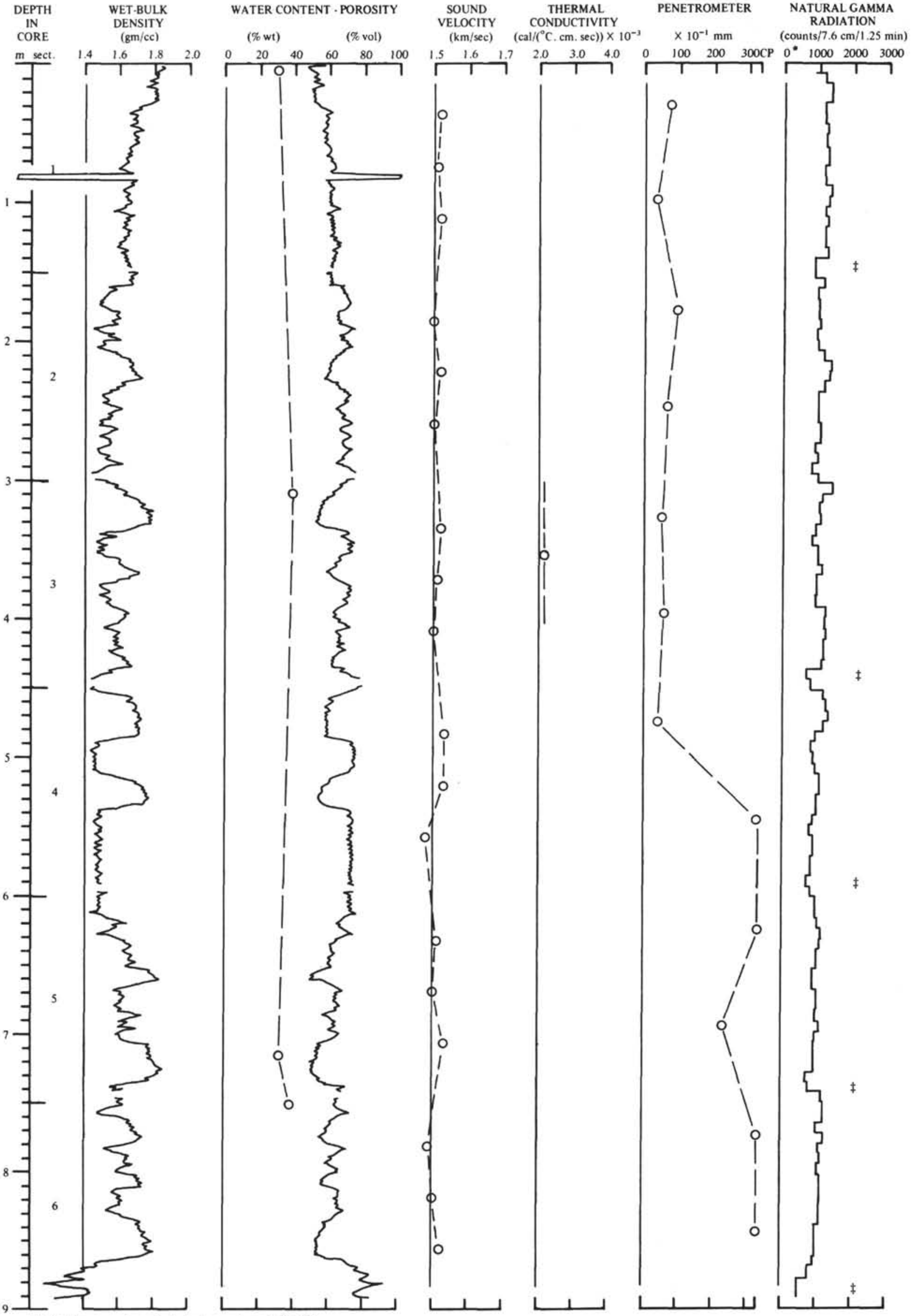


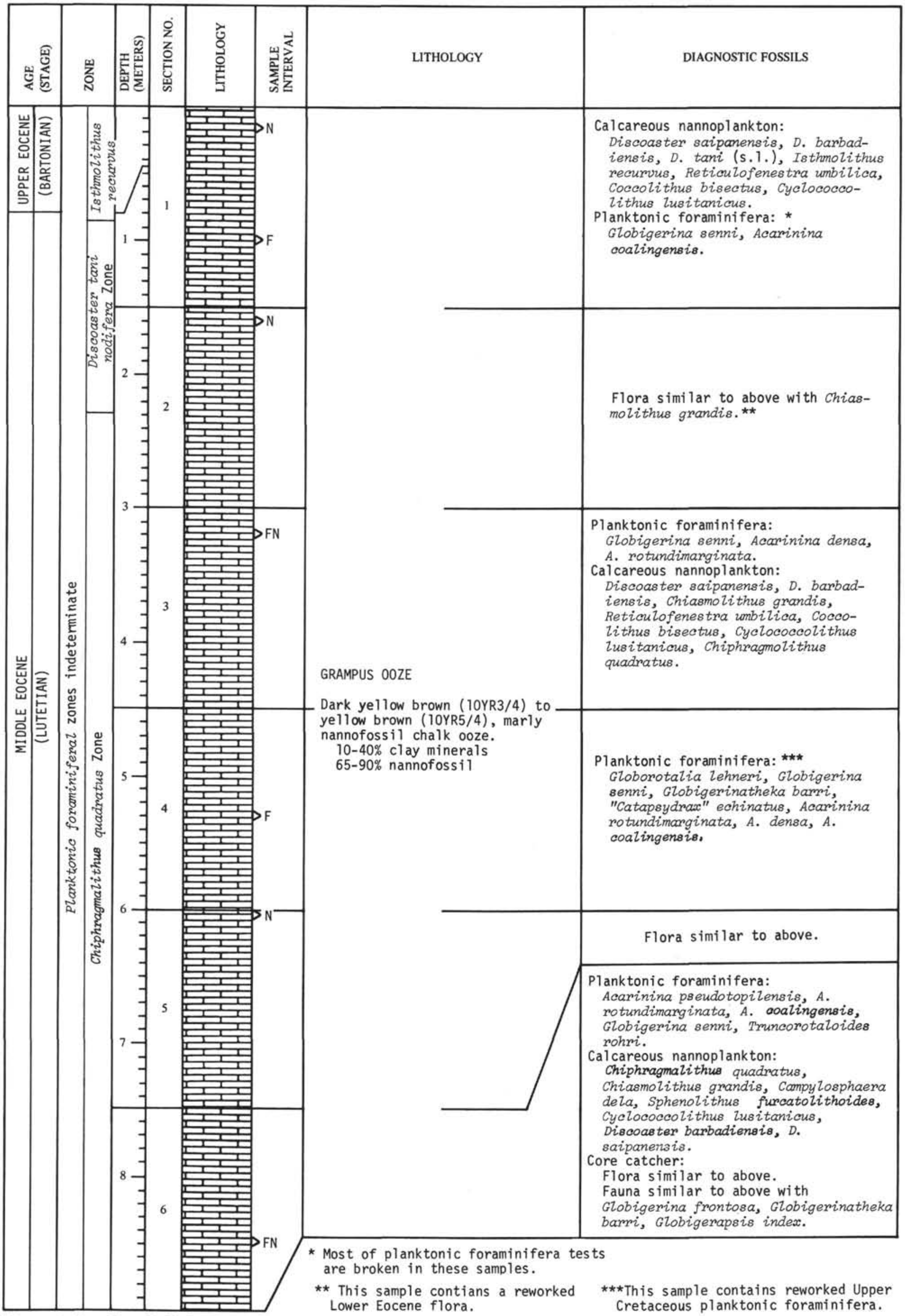
Plate 4. *Core 3, Hole 20C.*



* "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 14A. *Physical propertise of Core 3, Hole 20C.*



GRAMPUS OOZE

Dark yellow brown (10YR3/4) to yellow brown (10YR5/4), marly nannofossil chalk ooze.
10-40% clay minerals
65-90% nannofossil

Calcareous nannoplankton:
Discoaster saipanensis, D. barbadiensis, D. tani (s.l.), *Isthmolithus recurvus, Reticulofenestra umbilica, Coccolithus bisectus, Cyclococcolithus lusitanicus.*
Planktonic foraminifera: *
Globigerina senni, Acarinina coalingensis.

Flora similar to above with *Chiasmolithus grandis.* **

Planktonic foraminifera:
Globigerina senni, Acarinina densa, A. rotundimarginata.
Calcareous nannoplankton:
Discoaster saipanensis, D. barbadiensis, Chiasmolithus grandis, Reticulofenestra umbilica, Coccolithus bisectus, Cyclococcolithus lusitanicus, Chiphragmolithus quadratus.

Planktonic foraminifera: ***
Globorotalia lehneri, Globigerina senni, Globigerinatheka barri, "Catapsydrax" echinatus, Acarinina rotundimarginata, A. densa, A. coalingensis.

Flora similar to above.

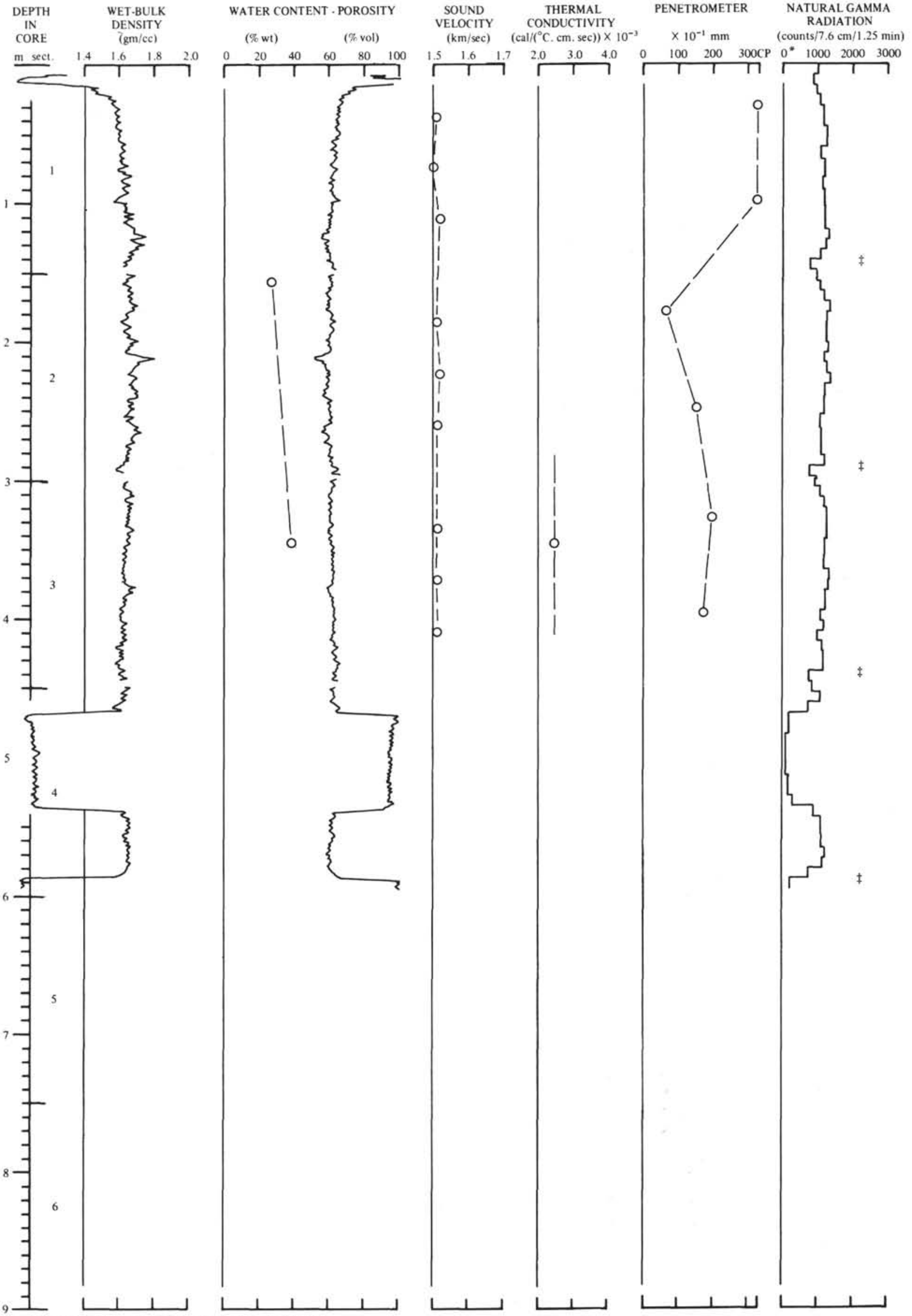
Planktonic foraminifera:
Acarinina pseudotopilensis, A. rotundimarginata, A. coalingensis, Globigerina senni, Truncorotaloides rohri.
Calcareous nannoplankton:
Chiphragmalithus quadratus, Chiasmolithus grandis, Campylosphaera dela, Sphenolithus furcatolithoides, Cyclococcolithus lusitanicus, Discoaster barbadiensis, D. saipanensis.
Core catcher:
Flora similar to above.
Fauna similar to above with *Globigerina frontosa, Globigerinatheka barri, Globigerapsis index.*

* Most of planktonic foraminifera tests are broken in these samples.

** This sample contians a reworked Lower Eocene flora.

***This sample contains reworked Upper Cretaceous planktonic foraminifera.

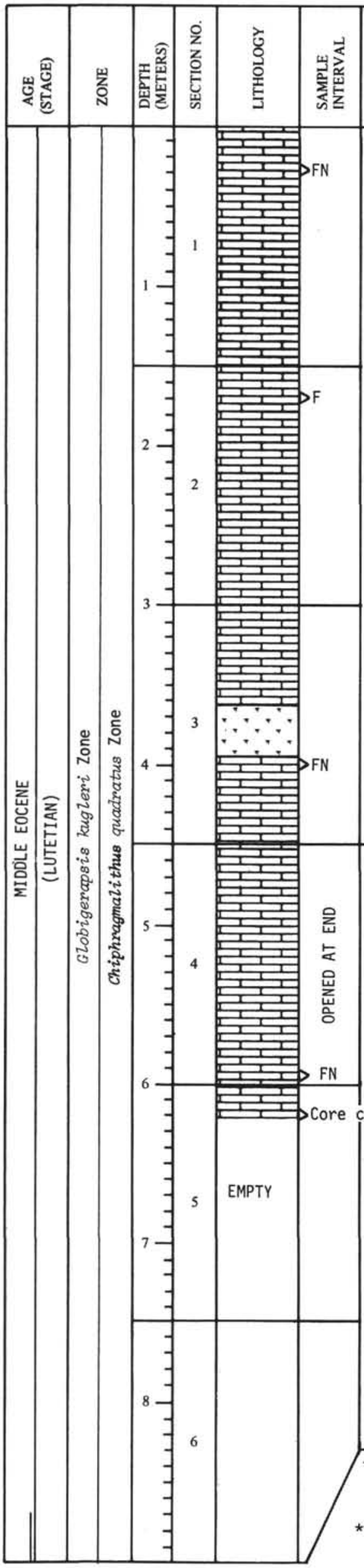
Figure 14B. *Core 3, Hole 20C,*



* "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 15A. *Physical properties of Core 4, Hole 20C.*



LITHOLOGY

GRAMPUS OOZE

Dark brown to light yellow brown (10YR3/4-6/4), marly, nannofossil chalk ooze.
10-40% clay
65-90% nannofossil

Dark brown zeolite clay zone

DIAGNOSTIC FOSSILS

Planktonic foraminifera: *
Globigerina senni, Acarinina densa, Globigerapsis index.
Calcareous nannoplankton: **
Sphenolithus furcatolithoides, Cyclococcolithus lusitanicus, Discoaster saipanensis, D. barbadiensis, Reticulofenestra umbilica, Chiasmolithus grandis.

Planktonic foraminifera: *
Globigerina senni.

Flora similar to above with ***Chiphragmalithus** quadratus.***

Planktonic foraminifera: *
Acarinina rotundimarginata, Globigerina senni.

Flora similar to above. **
Planktonic foraminifera: *
Globorotalia aragonensis, G. lehneri, Globigerina senni, G. frontosa, Acarinina pseudotopilensis, A. rotundimarginata, A. ***coalingensis.***
Core catcher:
  Planktonic foraminifera:
    Acarinina densa, A. ***coalingensis.*** *Globorotalia spinulosa, Truncorotaloides topilensis, Globigerina senni, Globigerapsis index.*
  Calcareous nannoplankton:
    Chiphragmalithus *quadratus, Cyclococcolithus lusitanicus, Sphenolithus furcatolithoides, Campylosphaera dela, Discoaster barbadiensis, D. saipanensis.*
  Calcareous nannoplankton: ***
    Chiasmolithus grandis, C. gigas, Campylosphaera dela, Discoaster barbadiensis.

* Most of the planktonic foraminifera tests are broken in these samples.

** Flora apparently contaminated by species from uphole.

*** Sample of chalk apparently from this horizon, but it does not consist of isolated fragments of *Braarudosphaera.*

Figure 15B. *Core 4, Hole 20C.*

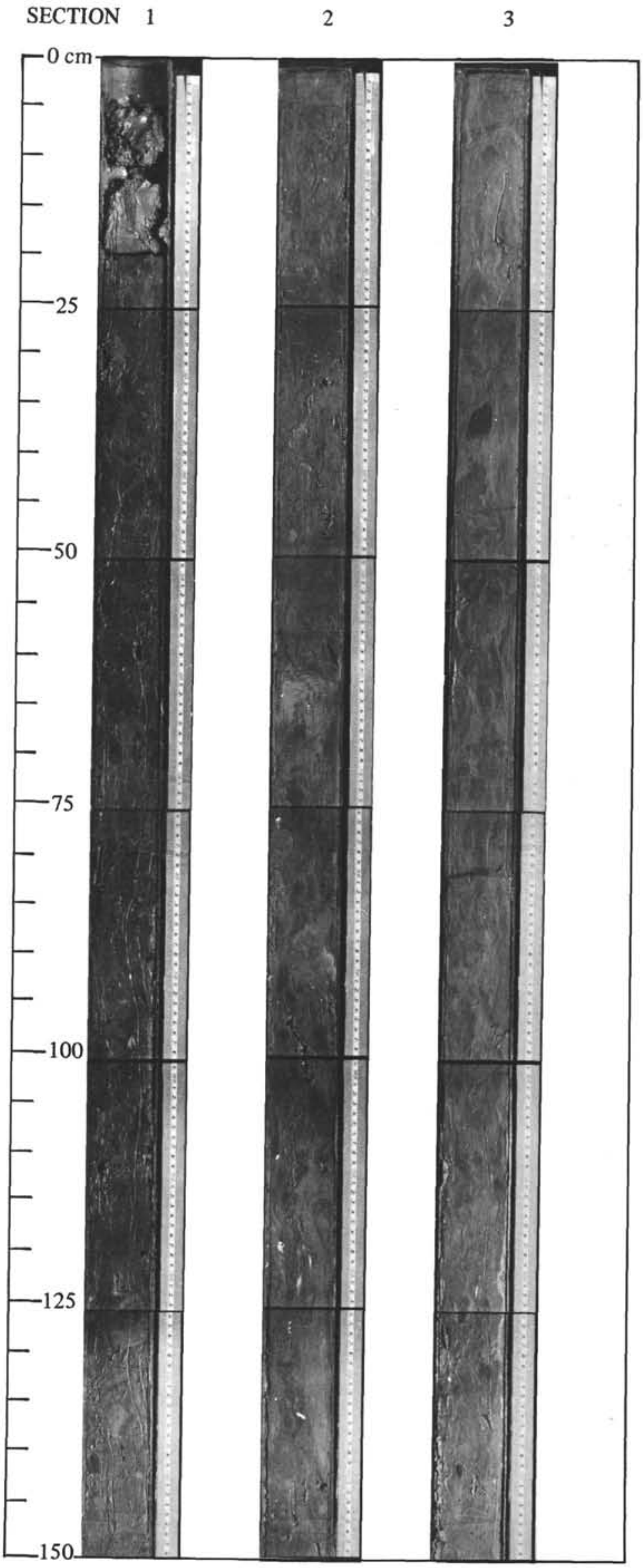


Plate 5. *Core 4, Hole 20C.*

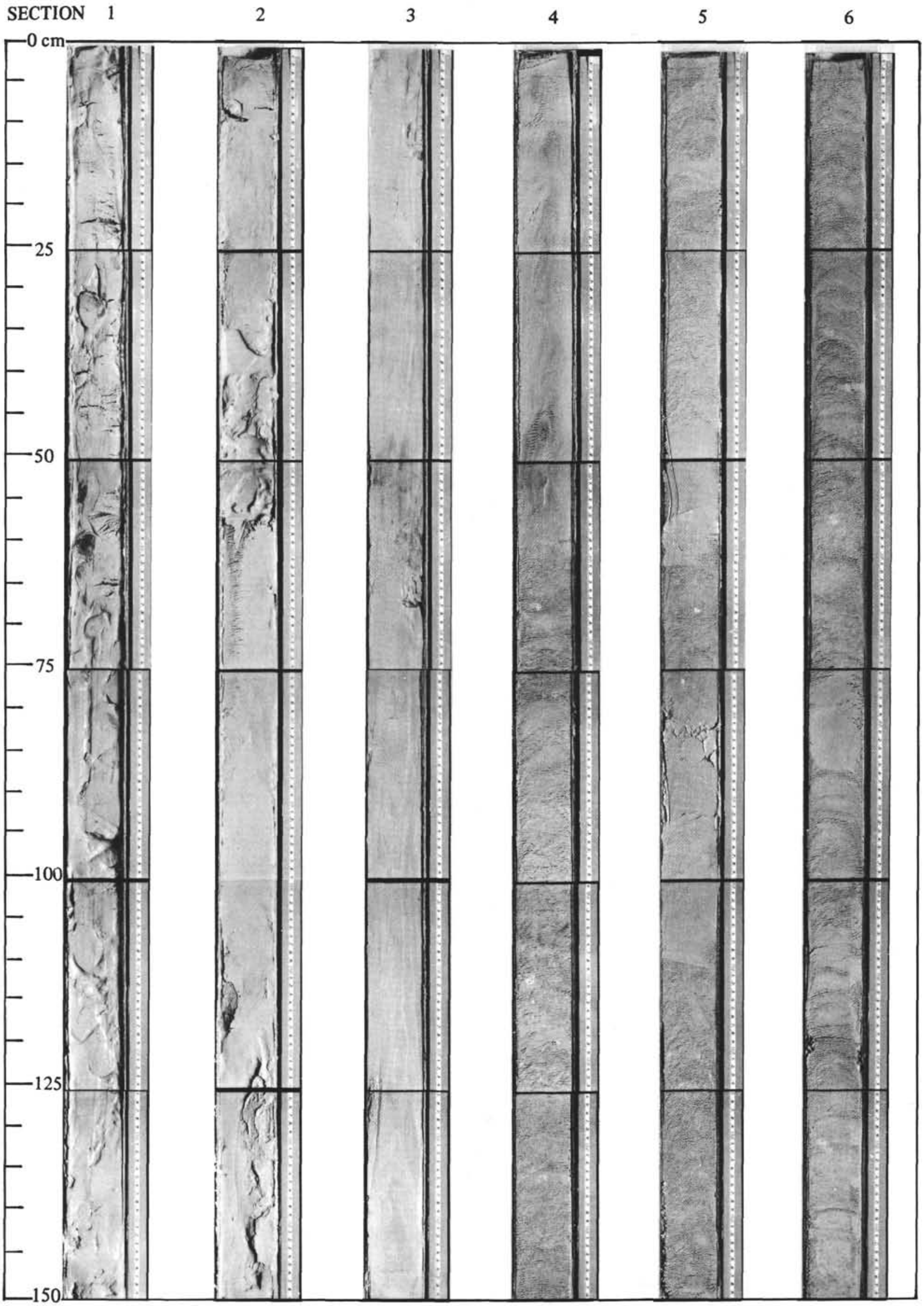
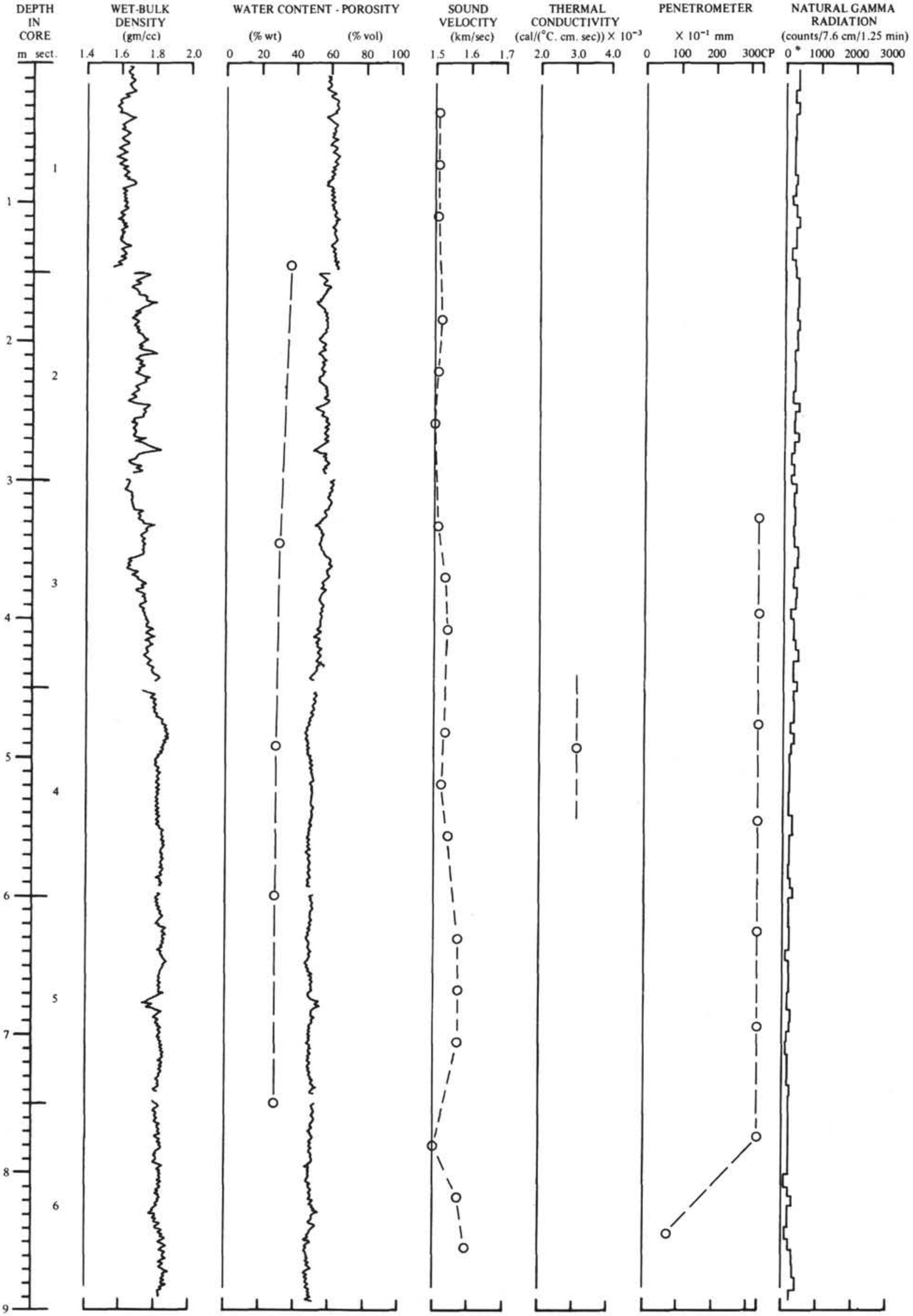
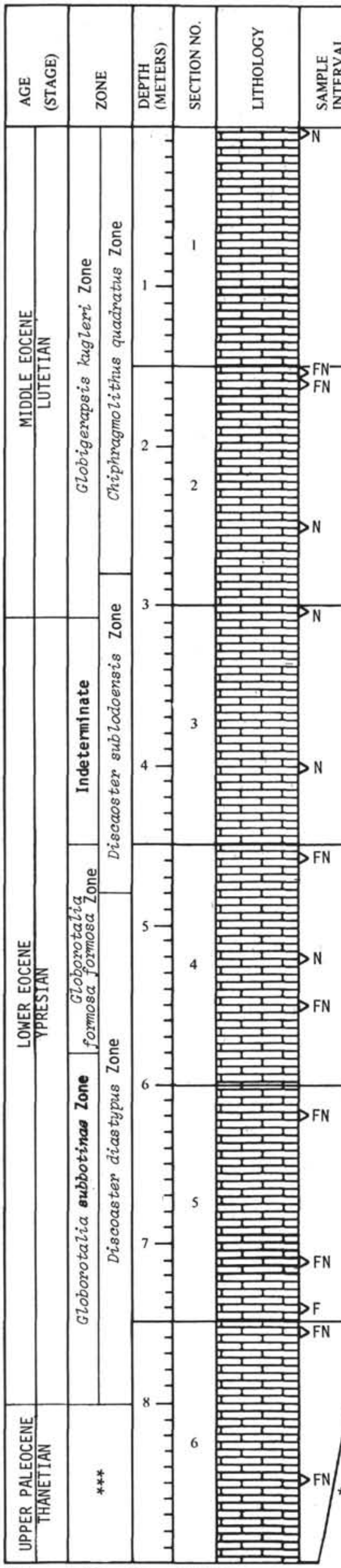


Plate 6. *Core 5, Hole 20C.*



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

Figure 16A. *Physical properties of Core 5, Hole 20C.*



LITHOLOGY

(Core disturbed)

HIRONDELLE OOZE

Light yellow brown (10YR6/4) to very pale brown (10YR7/4), nannofossil chalk ooze.

* Most of the planktonic foraminifera tests are broken in this sample.

** The sample from 66 cm is a chalk, but it does not consist of isolated fragments of *Braarudosphaera*.

DIAGNOSTIC FOSSILS

Sample 0-2 cm:
Calcareous nannoplankton:
Chiphragmolithus quadratus, Chiasmolithus grandis, C. gigas, Sphenolithus radians, Campylosphaera delus.
Sample 148-150 cm:
Flora similar to above with *Discoaster lodoensis.*
Planktonic foraminifera:
Globigerina senni, G. frontosa, Globorotalia quetra, Acarinina densa, A. rotundimarginata.

Flora similar to above.

Planktonic foraminifera: *
Globigerina senni, Globorotalia lehneri, Acarinina densa, A. rotundimarginata.

Flora similar to above with *Discoaster sublodoensis.*

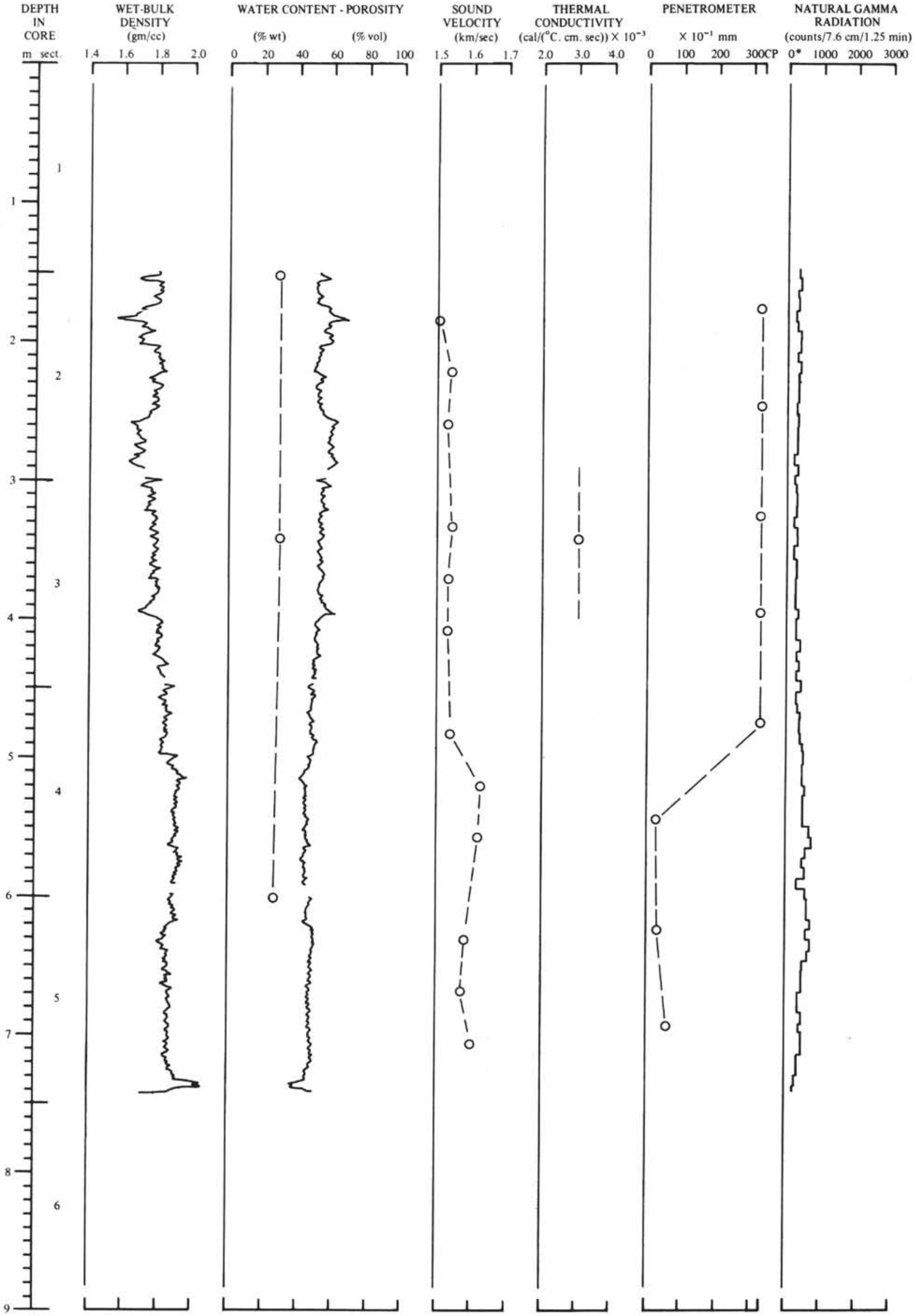
Sample 8-10 cm:
Planktonic foraminifera:
Globigerina soldadoensis angulosa, G. senni, G. linaperta, Globorotalia aragonensis, G. formosa formosa, Acarinina pseudotopilensis, A. esnaensis, A. coalingaensis.
Calcareous nannoplankton:
Discoaster sublodoensis, D. ***lodoensis, Campylosphaera dela*** *Sphenolithus radians, Chiasmolithus grandis.*
Samples 66 cm and 100-102 cm: **
Calcareous nannoplankton:
Marthasterites tribrachiatus, Discoaster sublodoensis, D. lodoensis, D. diastypus, Sphenolithus radians, Coccolithus cavus, Chiasmolithus consuetus.
Sample 100-102 cm:
Fauna similar to above. First appearance of *Globorotalia formosa gracilis.*

Flora similar to above.
Fauna similar to above with *Globorotalia wilcoxensis.*

Sample 10-12 cm:
Flora and fauna similar to above.
Sample 100-102 cm:
Planktonic foraminifera:
Fauna similar to above. First appearance of *Globorotalia velascoensis.*
Calcareous nannoplankton:
Discoaster multiradiatus, D. diastypus, Coccolithus cavus, Chiasmolithus consuetus, Heliorthus concinnus, Toweius eminens.
Core catcher:
Flora similar to above.

*** This interval represents the *Globorotalia velascoensis* Zone and the *Discoaster multiradiatus* Zone.

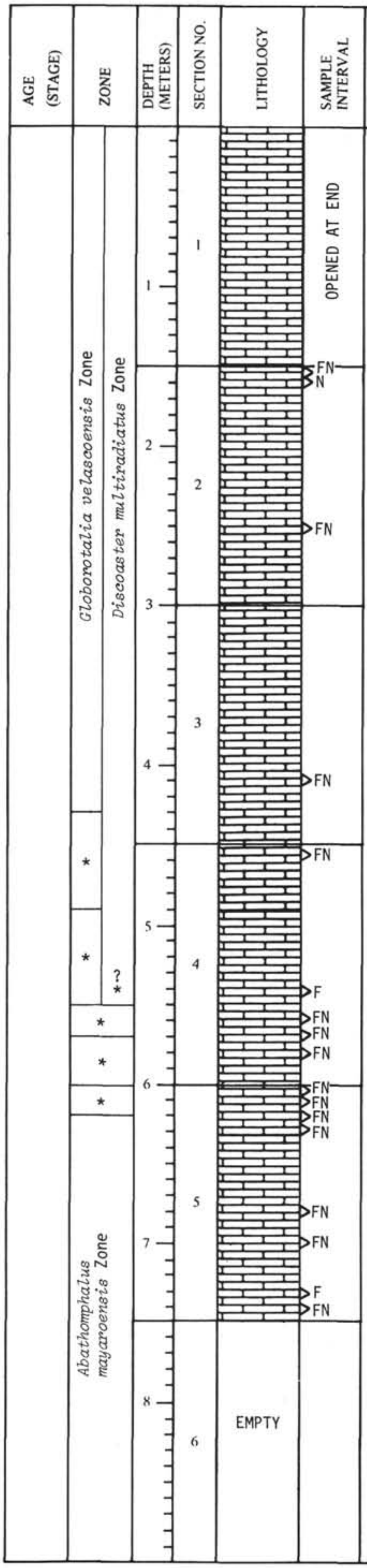
Figure 16B. *Core 5, Hole 20C.*



* "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 17A. *Physical properties of Core 6, Hole 20C.*



LITHOLOGY	DIAGNOSTIC FOSSILS
(Core disturbed)	Planktonic foraminifera: *Globorotalia velacoensis, G. aequa, G. marginodentata, G. acuta, G. mckannai, G. convexa, G. imitata, Globigerina soldadoensis.* Calcareous nannoplankton: *Discoaster multiradiatus, Coccolithus, cavus, Chiasmolithus consuetus, Toweius eminens, Fasciculithus tympaniformis, Heliorthus concinnus.*
	Flora and fauna similar to above.
HIRONDELLE OOZE Very pale brown (10YR7/4) to yellow brown, nannofossil chalk ooze. Dolomitic (5%) interval 1.03-1.06 m. and dolomitic inclusion (100%) at 8.89 m. with pink interval in Section 4 & 5.	Flora similar to above. Fauna similar to above. First appearance of *Globorotalia pseudomenardii.*
	For flora and fauna descriptions see section sheets.
	For flora and fauna descriptions see section sheets.

* For identifications of zones see appropriate section sheet.

Figure 17B. *Core 6, Hole 20C.*

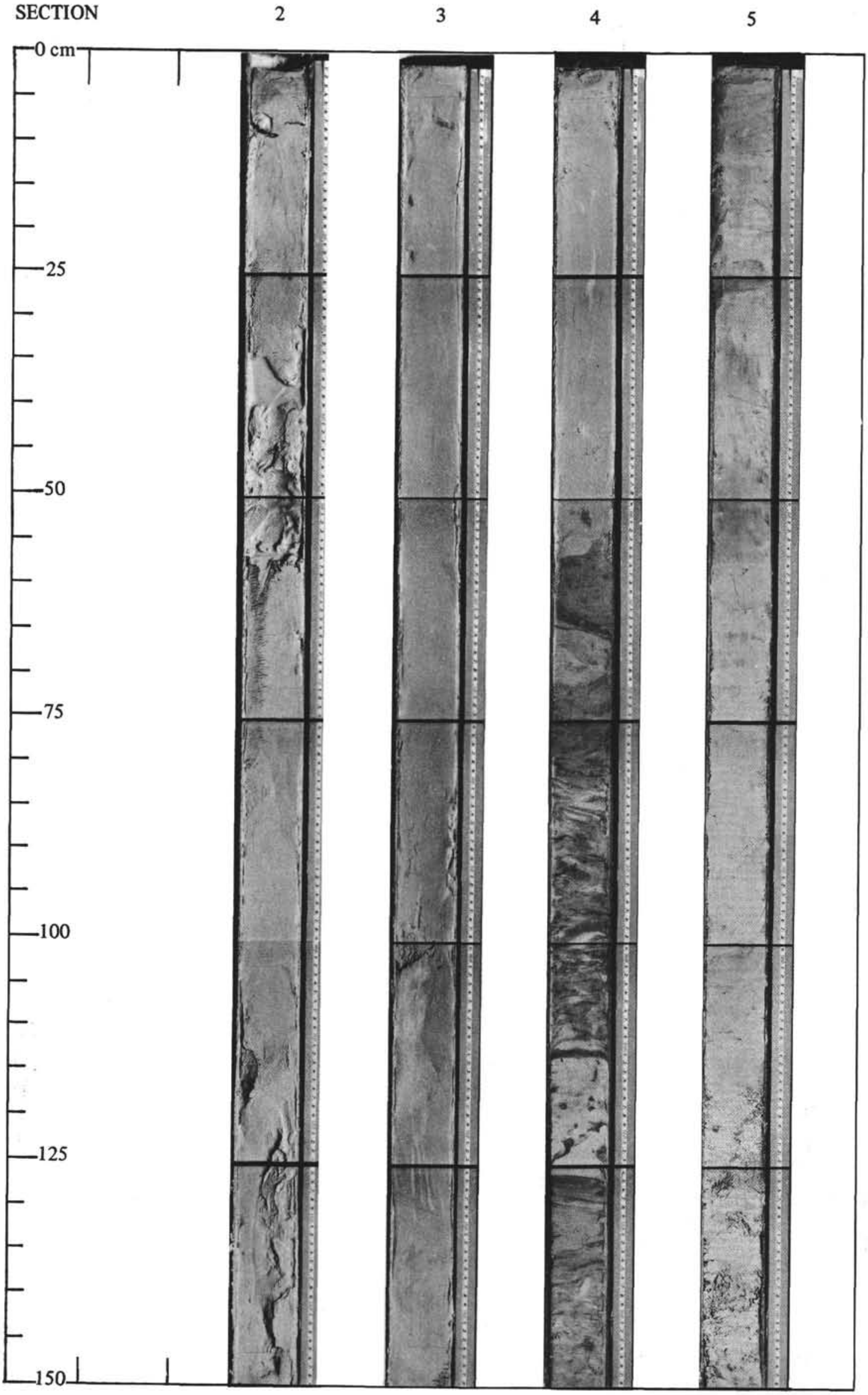
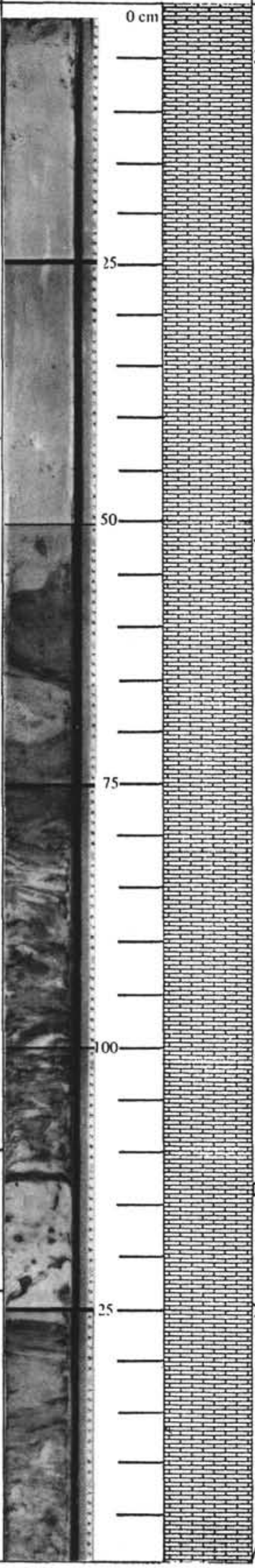


Plate 7. *Core 6, Hole 20C.*

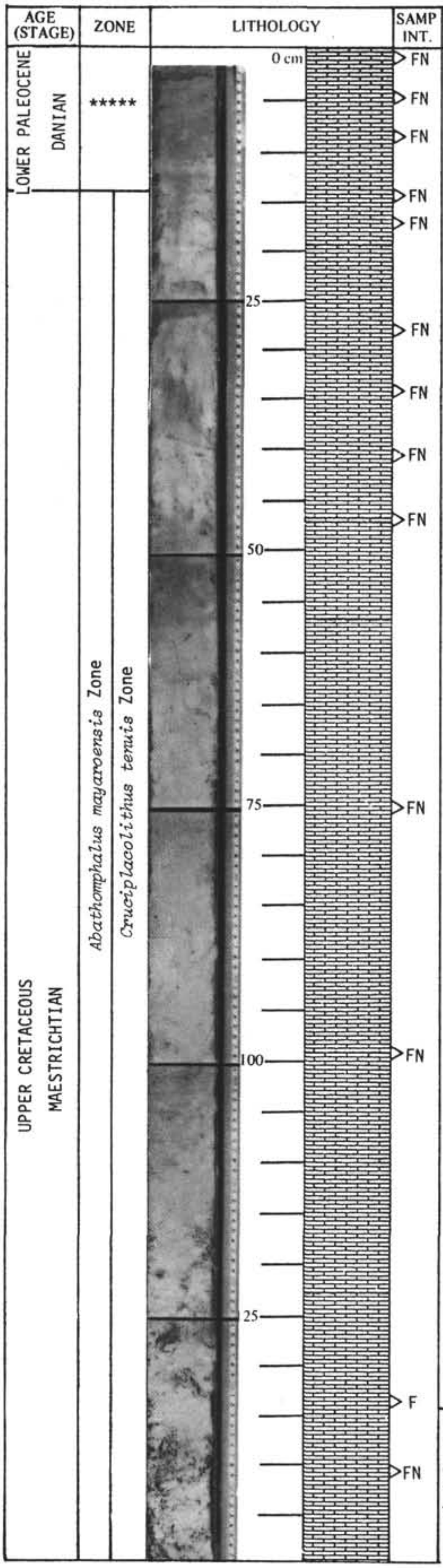
AGE (STAGE)	ZONE		LITHOLOGY	SAMP. INT.	LITHOLOGY	DIAGNOSTIC FOSSILS
	Globorotalia pseudomenardii Zone	*Discoaster multiradiatus* Zone		> FN	Fm. HIRONDELLE OOZE Very pale brown (10YR7/4), disturbed nannofossil chalk ooze.	Sample 5-7 cm: Planktonic foraminifera: *Globorotalia pusilla pusilla, G. pusilla laevigata, G. angulata, G. angulata abundocamerata, G. aequa, G. acuta, G. chapmanni, G. velascoensis, G. pseudomenardii.* Calcareous nannoplankton: *Discoaster multiradiatus, Coccolithus cavus, Toweius eminens, Fascioulithus tympaniformis, Zygodiscus concinnus.*
	Globorotalia pusilla pusilla Zone	*Fasciculithus tympaniformis* Zone		> F	Yellow brown (10YR5.5/5) nannofossil chalk ooze recrystallized. 20% clay and carb.	
						Sample 78-80 cm: Planktonic foraminifera:* *Globorotalia pusilla pusilla, G. pusilla laevigata, G. compressa, G. pseudobulloides, G. inconstans, G. conicotruncata, G. acuta, Globigerina triloculinoides.*
					Mottled (10YR7/4 and 5YR7/3) very pale brown and pink nannofossil chalk with traces of dolomite rhombs.	
				> FN		Sample 100-102 cm: Planktonic foraminifera:* *Globorotalia uncinata, G. compressa, G. chapmanni, G. imitata, G. conicotruncata, G. ehrenbergi, G. angulata, Globigerina daubjergensis, G. triloculinoides.* Calcareous nannoplankton:** *Coccolithus cavus, Cruciplacolithus tenuis, Ericsonia subpertusa, Zygodiscus simplex, Fasciculithus tympaniformis.*
UPPER CRETACEOUS MAESTRICHTIAN	***			> FN	Pink (5YR7/3) mottled very pale brown and light brown (10YR7/4 and 5YR6/4) nannofossil chalk with dolomite.	Sample 112-114 cm: Planktonic foraminifera: *Abathomphalus mayaroensis, Globotruncana stuarti, G. citae, G. contusa G. stuartiformis, G. aegyptica.* Calcareous nannoplankton: *Arkhangelskiella cymbiformis, Tetralithus murus, Lithraphridites quadratus, Micula decussata.*
	Globorotalia pusilla pusilla	*Cruciplacolithus tenuis*		> FN	Brown yellow (10YR6/6) nannofossil chalk ooze.	Sample 125-126 cm: Flora and fauna similar to 100-102 cm.*

* These samples contain reworked? Upper Cretacerous (Maestrichtian) planktonic foraminifera.

** This sample contains reworked? Upper Cretaceous (Maestrichtian) calcareous nannoplankton.

***This interval represents the *Abathomphalus mayaroensis* Zone and contains Upper Cretaceous (Maestrichtian) calcareous nannoplankton.

Figure 18. *Summary of Section 4, Core 6, Hole 20C.*



LITHOLOGY

Yellow brown (10YR5/4) nannofossil chalk ooze.

Pink (7.5YR8/4) recrystallized nannofossil chalk ooze.

Light yellow brown (10YR6/4) nannofossil chalk ooze.

Very pale brown (10YR7/4) nannofossil chalk ooze.
20% clay

Pink to white (7.5YR8/2), recrystallized nannofossil chalk ooze.
50% nannofossil
50% clay and carb.
Olive (5Y5/4) mottles compare
100% dolomite.

DIAGNOSTIC FOSSILS

Sample 0-2 cm:
Planktonic foraminifera:*
Globorotalia pseudobulloides, *G. praecursoria*, *G. compressa*, *Globigerina triloculinoides*, *G. daubjergensis*.
Calcareous nannoplankton:
Coccolithus cavus, *Cruciplacolithus tenuis*, *Ericosonia subpertusa*, *Markalius astroporus*, *Zygodiscus simplex*.

Sample 6-7 cm:
Fauna similar to above.
Planktonic foraminifera:*
Globorotalia pseudobulloides, *G. compressa*, *G. inaequispira*, *G.*

Sample 8-10 cm:
Flora similar to above.
Planktonic foraminifera:*
Globorotalia compressa, *G. trinidadensis*, *G. pseudobulloides*, *G. inconstans*, *Globigerina daubjergensis*, *G. triloculinoides*.

Sample 12-13 cm:
Flora similar to above.
Planktonic foraminifera:**
Globigerina daubjergensis, *G. triloculinoides*, *Globorotalia compressa*, *G. pseudobulloides*, *G. trinidadensis*, *Globigerina eugubina*.

Sample 15-16 cm:
Planktonic foraminifera:***
Abathomphalus mayaroensis, *Globotruncana stuarti*, *G. stuartiformis*, *G. gagnebini*.
Calcareous nannoplankton:
Arkhangelskiella cymbiformis, *Lithraphidites quadratus*, *Tetralithus murus*, *Micula decussata*.

Sample 25-26 cm:
Flora and fauna similar to above.***

Sample 30-32 cm:
Flora and fauna similar to above.

Sample 40-42 cm:
Flora and fauna similar to above.

Sample 75-77 cm:
Flora and fauna similar to above.

Sample 100-102 cm:
Flora and fauna similar to above without *Abathomphalus mayaroensis*.

Sample 138-140 cm:
Fauna similar to above.

Sample 140-142 cm:
Flora and fauna similar to above.

Core catcher:
Flora similar to above.
Planktonic foraminifera:****
Globotruncana contusa, *G. stuartiformis*, *Pseudotextularia elegans*, *Rugoglobigerina rugosa*.

* These samples contain reworked? Upper Cretaceous (Maestrichtian) planktonic foraminifera. **This sample contains Upper Paleocene planktonic foraminifera contaminants from uphole and Upper Cretaceous planktonic foraminifera.
*** These samples contain Lower Paleocene planktonic foraminifera.
****This sample consists largely of unfossiliferous baked sediment, palagonite, manganese nodules, and fragments of marble. *****Includes species representative of three planktonic foraminiferal zones of Luterbacher and Silva (1964); namely in descending order, the *Globorotalia trinidadensis*, *Globorotalia pseudobulloides*/*Globigerina daubjergensis*, and *Globigerina eugubina* Zones.

Figure 19. *Summary of Section 5, Core 6, Hole 20C.*