7. SITE 160

The Shipboard Scientific Party[1]

SYNOPSIS

Area: West flank East Pacific Rise between Clarion and Clipperton fracture zones

Date Occupied: 5-7 March, 1971

Position:
Lat. 11°42.27′N
Long. 130°52.81′W

Water Depth: 4940 meters (corrected)

Penetration: 114 meters

Number of Holes: 1

Number of Cores: 14

Core Recovery: 95.8 meters

Acoustic Basement:
Depth: 0.135 second
Nature: Basalt
Inferred velocity in the sedimentary section: 1610 m/sec

Age of Oldest Sediment: Early Oligocene

The site was continuously cored to yield the following sequence of deposits:

0-27 meters – Brown zeolitic clay with abundant ferromanganese micronodules and ferruginous aggregates; barren except for upper 3 meters.
Age: If no hiatuses exist, Quaternary to early Miocene.

27-108 meters – Nannofossil chalk ooze; radiolarians are present throughout but foraminifers are poorly preserved and restricted to 36 to 108 meters. A disconformity may exist near 43 meters (Oligocene-Miocene boundary).
Age: Early Miocene to early Oligocene.

108-109 meters – Dark brown calcareous clay rich in ferruginous aggregates. Severely disturbed and contaminated.
Age: Early Oligocene.

109-114 meters – Extrusive basalt.

The upper interval, assuming that no hiatuses are present, has a sedimentation rate of about 1.5 m/m.y. The underlying ooze has a rate of 5 m/m.y., which is low for a calcareous sediment, suggesting that it was laid down mainly between the lysocline and the calcite compensation depth. The basal sediment is from the *Globigerina ampliapertura* (foraminiferal), *Helicopontosphaera reticulata* (nannofossil) and *Theocyrtis tuberosa* (radiolarian) zones, giving an estimated age of 34 to 36 m.y.

REGIONAL SETTING AND OBJECTIVES

DSDP 160 forms part of a series of sites in the eastern equatorial Pacific on the west flank of the East Pacific Rise (Figure 1). Earlier legs of the Deep Sea Drilling Project, in particular Legs 5 and 9, have reported sediments rich in oxides of iron and perhaps other transition metals just above basement in the eastern Pacific (McManus et al., 1970; Hays et al., 1972). These occurrences roughly define a broad zone on the west flank of the rise. Sites DSDP 159 and DSDP 160 lie on this trend and were selected by the Pacific Site Selection Panel to test the extent of such deposits. The nature of the metalliferous sediments has been described in a general way by von der Borch and Rex (1970). Sediments containing relatively large quantities of iron, manganese, and trace metals, somewhat similar to those reported by von der Borch and Rex, have also been found on the crest of the East Pacific Rise (Boström and Peterson, 1966, 1969; Boström et al., 1969). By analogy, the iron-rich deposits of the DSDP holes have been considered the products of hydrothermal activity on the ridge crest which have subsequently been transported downflank by sea floor spreading and buried under younger sediments. The number of sites from which such deposits have been reported is far larger than can be ascribed to accidental penetration of highly localized formations, thus lending credence to the rise-crest origin.

The site, like DSDP 159, is located on the northern edge of the equatorial zone of high biological productivity. The axis of this zone, beneath the equator, coincides with a thick lens of calcareous sediments (Figure 1) which extends across the eastern Pacific. This lens, which was extensively drilled on Legs 7, 8, and 9, contains a record of migrating, expanding, and contracting equatorial biogenous sedimentation during the Cenozoic. Data obtained on a meridional profile at 140°W (Tracey et al., 1971) show that with increasing age the zone of maximum calcareous deposition shifts gradually northward, and also that the width and rate of sedimentation within the zone have varied through the Cenozoic. DSDP 160 and associated sites were selected to further delineate the Cenozoic history of equatorial sedimentation in this part of the world and its dependence on tectonic, oceanographic, and climatic variations.

The site is located on the middle flank of the East Pacific Rise about 3,000 km west of the present rise crest and 1,000 km west of DSDP 159. The data from DSDP 159 and earlier paleontological studies of surface cores (Burckle et al., 1967; Riedel, 1967) indicate that during most of the Cenozoic, the sea floor was spreading at the high rate of approximately 8 cm/yr parallel to the Clarion and Clipperton fracture zones, which define the structural block in which the sites are located. Sclater and Bell (1971) have suggested that during this period the spreading axis was located at the Mathematicians Seamounts and that it

---

[1] Tjeerd H. van Andel and G. Ross Heath, Oregon State University, Corvallis, Oregon; Richard H. Bennett, N.O.A.A., Miami, Florida; David Bukry, U. S. Geological Survey, La Jolla, California; Santiago Charleston, Instituto Mexicano del Petroleo, Mexico City; David S. Cronan, University of Ottawa, Ottawa, Canada; Menno G. Dinkelman, Oregon State University, Corvallis, Oregon; Ansis Kaneps, Scripps Institution of Oceanography, La Jolla, California; Kelvin S. Rodolfo, University of Illinois, Chicago, Illinois; Robert S. Yeats, Ohio University, Athens, Ohio.

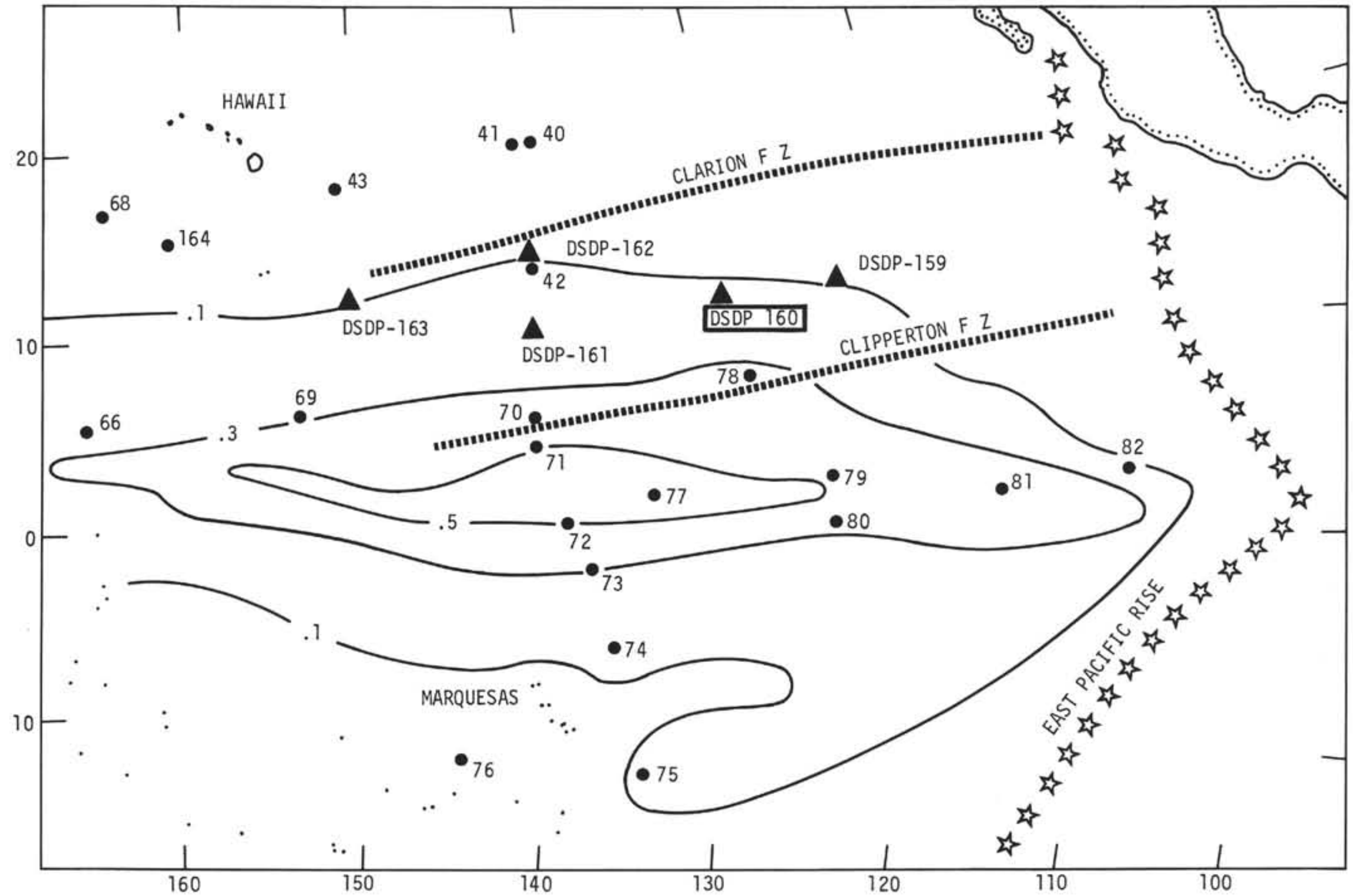


Figure 1. *Location of Leg 16 sites (large triangles) in the eastern equatorial Pacific on the west flank of the East Pacific Rise. Small dots are sites from Legs 5, 8, 9, and 17. Contours indicate sediment thickness above acoustic basement in seconds (approximately equivalent to 800 meters).*

jumped to its present position in the late Miocene. This jump was accompanied by a change in direction and a reduction in the rate of spreading (Heirtzler, 1968).

TOPOGRAPHIC AND GEOLOGICAL SETTING

The relief of the middle flank of the East Pacific Rise is very subdued, with a regional slope of approximately 1 in 500. Superimposed on this slope is a rather complex local basement relief which consists of a stepped series of level or tilted surface, each only a few kilometers wide and separated from its neighbors by steeper slopes and maximum differences in elevation of 100 meters or so. The basement surface and sea floor are generally parallel. The small-scale relief appears to result from normal downflank faulting of the basement (Figure 3). Clusters of small seamounts, rising a few hundred meters above the surrounding terrain, appear infrequently. The largest fault blocks are 10 to 20 km long in an east-west direction and of unknown length parallel to the regional strike. Detailed surveys made elsewhere on the flank of the East Pacific Rise (Luyendyk, 1970) suggest that the structure is probably rather strongly lineated perpendicular to the strike of the major fracture zones.

The site itself is located in a downfaulted block, approximately 5 km wide, between two upfaulted basement ridges each less than 2 km wide, (Figure 2 and 3). Two parallel crossings by the drilling vessel show very similar profiles and suggest a northerly trend of the structure. There are no basement outcrops in the vicinity of the site and the area is covered with a uniform sediment blanket varying in thickness from 0.15 to 0.20 sec. The cover is regional; basement appears to crop out only on very steep slopes, on rare, high, upfaulted blocks, and on seamounts. The records are inadequate to determine whether the faulting predates or postdates sedimentation, although the two appear to be at least in part synchronous.

DSDP 160 was placed in a different location from the one proposed by the Pacific Site Selection Panel. The panel had chosen two alternatives each located at a substantial distance from the direct line between sites DSDP 159 and DSDP 161, and each based on a single seismic reflection profile. Since all data, including those obtained during the Leg 16 traverse, indicated little variation in sediment cover over the region, the final location of DSDP 160 was arbitrarily selected at the appropriate distance from the rise crest on the most economic track. Given the uniformity of

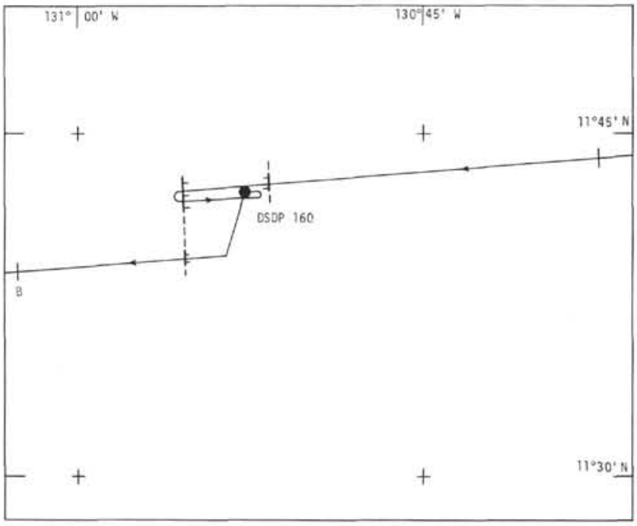


Figure 2. *Site location map: A-160 and 160-B are locations of profiles of Figure 3. Approximate positions of boundary faults of drilled trough shown.*

the sediment blanket and the very small scale of the relief observed, an extensive site survey appeared unnecessary, and the location was determined after a double pass across the target area (Figure 2).

The acoustic section at the site is uniform and highly transparent, containing only a few weak and rather discontinuous reflectors. The most prominent of these occurs very near the surface, and appears and disappears irregularly along the profile. The entire section is uniform in thickness and shows no consistent evidence of thickening in the valleys or thinning on slopes and hill crests, thus suggesting that local displacement of sediments is minor. Several small faults are present and are marked by basement displacement of the order of 0.05 sec and surface relief of 10 to 20 meters. The basement reflector is somewhat discontinuous because of the presence of the small, rather closely spaced faults, and its upper surface is not very sharply defined. The acoustic profile at the drill site is summarized in Table 1.

OPERATIONS

The vessel arrived in the site area near noon on March 5 and the beacon was dropped at 1445 hours. The hole was

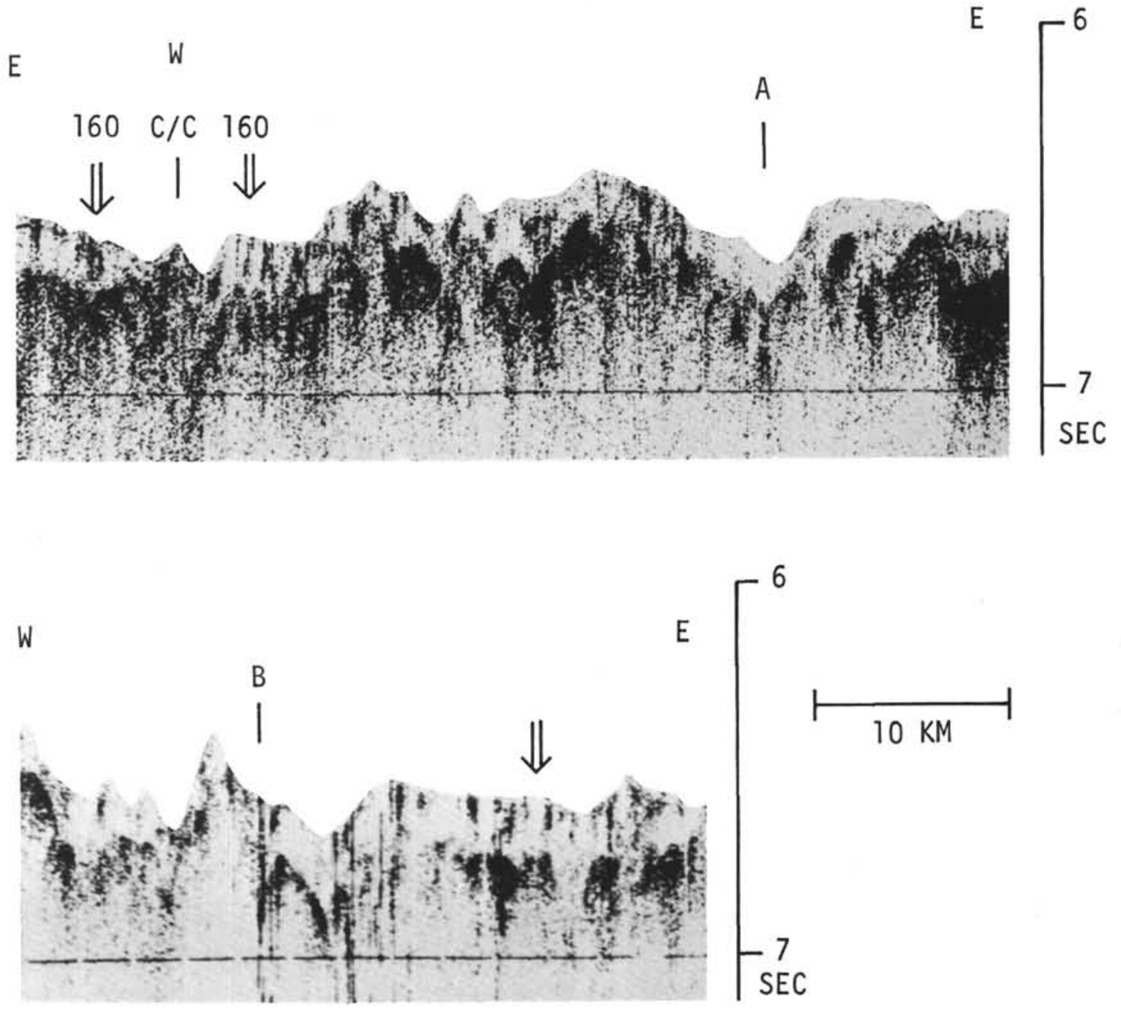


Figure 3. *Acoustic reflection profiles in vicinity of DSDP 160. Depths in seconds of two-way travel time. Locations are shown on Figure 2. Horizontal scale is approximate.*

TABLE 1
Comparison of Acoustic Section and Drill Data, DSDP 160

Reflectors	Depth (sec)	Drilling Results	Velocity (m/sec)
Base of upper transparent zone	0.035	27 m top chalk ooze	1540
Top of acoustic basement	0.135	109 m top basalt	1610

TABLE 2
Coring Summary, DSDP 160

Core	Depth Below Sea Level (m)	Depth Below Sea Floor (m)	Cored (cm)	Recovered	
				(cm)	(%)
1	4940-4949	0-9	900	540	60.0
2	4949-4958	9-18	900	680	75.6
3	4958-4967	18-27	900	850	94.4
4	4967-4976	27-36	900	670	74.4
5	4976-4985	36-45	900	850	94.4
6	4985-4994	45-54	900	870	96.7
7	4994-5003	54-63	900	780	86.7
8	5003-5012	63-72	900	710	78.9
9	5012-5021	72-81	900	890	98.9
10	5021-5030	81-90	900	870	96.7
11	5030-5039	90-99	900	880	97.8
12	5039-5048	99-108	900	895	99.4
13	5048-5049	108-109	100	87	87.0
14	5049-5054	109-114	500	5	1.0

cored continuously, using a new 10 1/8″ Smith regular 4-cone button bit. Drilling was uneventful except for positioning problems resulting from 20 to 25 kt winds and 8 to 12 feet seas from variable directions. Low recovery of basalt despite six meters of penetration into basement was attributed to pounding of the bit. The vessel left the site area on March 7, after completing a seismic reflection pass across the beacon. A summary of coring operations is given in Table 2.

LITHOLOGY

The sediments at DSDP 160 can be divided into three units (Figure 4), two of which dominate the section, overlying basalt at the base of the hole. Unlike DSDP 159 (chapter 6, this volume), each unit consists of a single lithologic type.

Unit 160-1 – Zeolitic clay, predominantly moderate brown, with abundant manganese micronodules and common radiolarians; (0-27 m).

Unit 160-2 – Nannofossil chalk ooze, grayish orange to very pale orange (27-108 m).

Unit 160-3 – Basal brown ferruginous clay (108-109 m).

Unit 160-4 – Basalt.

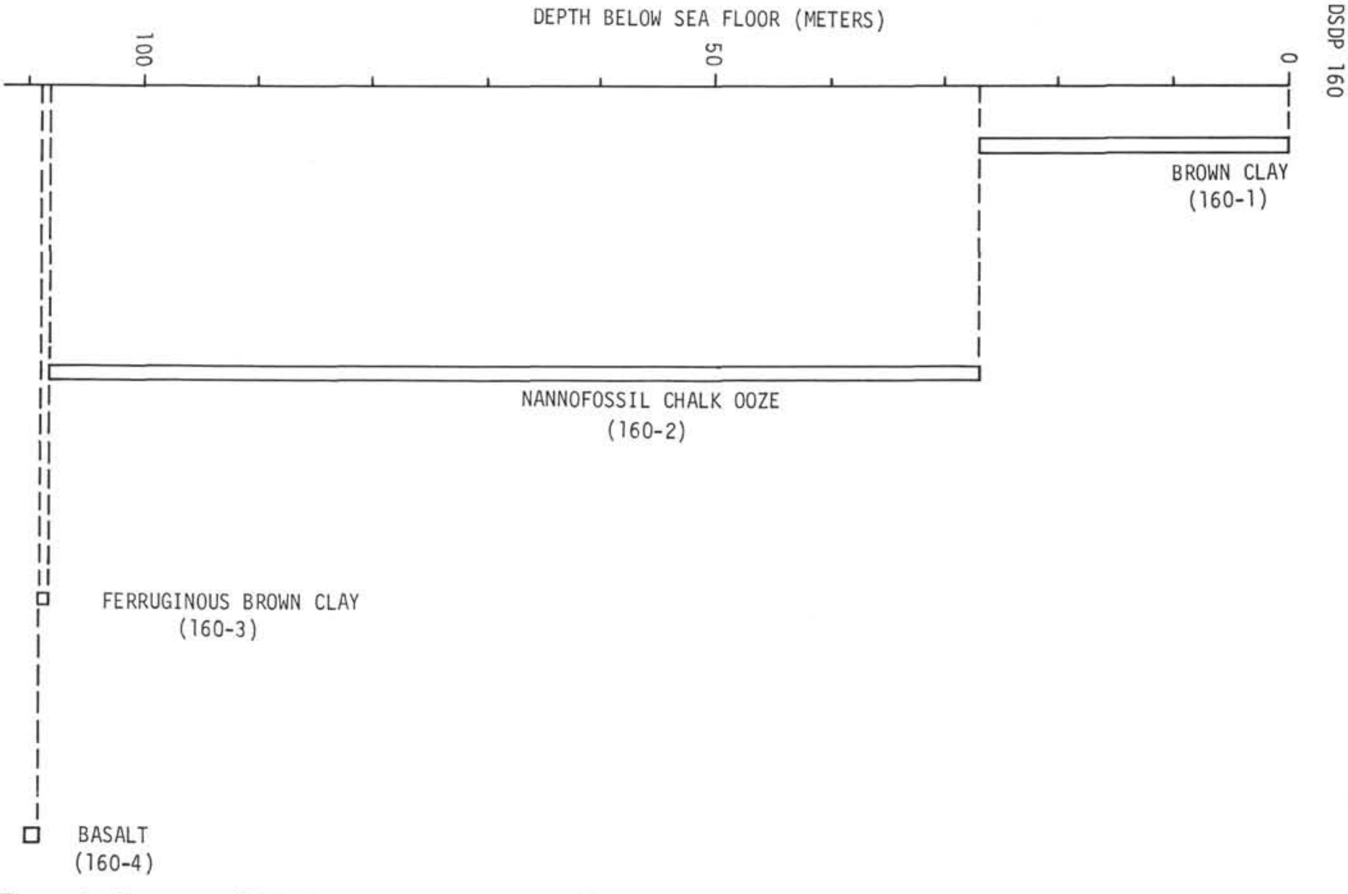


Figure 4. *Sequence of lithologic types at DSDP 160. For explanation, see text.*

Unit 160-1 (0-27 m)

The unit consists of a zeolitic clay with streaks, bands, patches, and mottles of dusky brown, grayish orange, and moderate yellow brown clays in a moderate brown matrix. The clay is severely disturbed by the coring process. Radiolarians are present in this unit, varying from abundant between 0 and 3 meters to very rare between 9 and 19 meters. Diatoms are also present, as well as diagenetic minerals including manganese nodules, micronodules, dark yellowish brown isotropic ferruginous aggregates, and zeolites. The manganese nodules occur near the top of Cores 1, 2, and 3, and are roughly spherical in shape, ranging in size from 2 to 4 cm. The sediment coating then contains Quaternary radiolarians, suggesting that they have caved from the surface. Manganese micronodules vary from common to abundant throughout the unit and are most concentrated in the darkest sections. The ferruginous aggregates cluster in some zones of abundant micronodules between 18 and 27 meters, and are similar to the aggregates noted in the upper part of DSDP 159.

Unit 160-2 (27-108 m)

Unit 160-1 changes abruptly to Unit 160-2 at 27 meters; the contact was not recovered although discoasters make an appearance in the core catcher sample of Core 3. The upper part of 160-2 consists of grayish orange nannofossil chalk ooze with abundant discoasters and common to abundant radiolarians. Micronodules are common and diatoms are present together with sponge spicules. The sediments are moderately to severely disturbed and show various mottles, patches and streaks of moderate yellowish brown and pale yellowish brown intermixed with the predominant grayish orange.

Near 44 to 46 meters, the dominant color changes to very pale orange, but mottles of grayish orange, similar to the overlying sediment, persist. Radiolarians and micronodules remain common. With increasing depth, the very pale orange oozes become increasingly abundant although darker hues still persist in the form of mottles, streaks, and patches. Below 45 meters, foraminifers are present in small numbers while radiolarians remain common. Micronodules are present throughout but become more common in small diffuse yellowish brown patches which appear near 53 meters. Some very pure calcareous material appears as white streaks.

Between 63 and 99 meters, the sediments consist of almost uniform very pale orange nannofossil chalk ooze, containing foraminifers, radiolarians, and micronodules in various concentrations together with white streaks and mottles. These contain fewer micronodules and radiolarians than does the bulk of the sediment. An increased degree of consolidation is evident in this section.

Near 99 meters, there is a slight change in color from very pale orange to grayish yellow. The grayish yellow persists down to 108 meters; the sediments in this interval show minor mottling in very pale orange and contain micronodules, radiolarians, foraminifers and silicoflagellates in variable concentrations.

Unit 160-3 (108-109 m)

Due to poor recovery this unit is ill-defined. Core 13 contains fragments of the overlying chalk resulting from caving as well as basalt cuttings in a moderate yellowish brown matrix of clay. Much of the clay is slurried, but at 50 cm above the bottom of Core 13, a piece of brown, ferruginous material is well preserved. This fragment contains a flood of dark yellow brown amorphous aggregates which appear to be the equivalent of the ferruginous deposits found elsewhere just above basement (Cronan, this vol., chapter 18).

Unit 160-4 (Below 109 m)

Basement was recovered only as a few fragments of a fine-grained basalt containing phenocrysts and phenocryst clusters of laboradorite and augite in a groundmass of very fine-grained material rich in magnetite and devitrified glass. The textures in the phenocryst clusters are generally diabasic. Plagioclase zoning is limited to slight normal zoning on the rims. The pyroxene is low-2V augite, occurring as variolitic clusters and individual euhedral grains. Iddingsite and chlorophaeite aggregates are probably pseudomorphs after olivine. Amygdules, 100 to 200 microns in diameter, are filled with devitrified very fine-grained basalt, green spherulitic serpentine, or iddingsite. In the groundmass, opaque minerals occur as oriented chains of octahedra. Despite the alteration of the ground-mass and olivine, the plagioclase and pyroxene are relatively fresh. The glassiness of the basalt and the absence of evidence for metasomatism and metamorphism of the overlying sediment suggest that it is extrusive.

GEOCHEMISTRY

Interstitial water samples and shipboard operations for DSDP 160 are listed in Table 3.

TABLE 3
Interstitial Water Samples and Shipboard Observations, DSDP 160

Core	Section	Sampled Interval (cm)	pH	Eh (mv)	Lab. Temp. (°C)	Salinity (%)	Squeeze Pressure (psi)
1	2	0-9	7.31	170	25.7	34.7	508
2	4	0-9	7.39	168	25.8	34.1	1015
3	6	0-9	7.48	164	26.0	34.7	1015
4	5	0-9	7.48	167	26.0	35.2	1015
5	6	0-8	7.53	160	26.0	35.2	1015
6	5	0-9	7.45	163	25.9	35.2	1015
7	6	0-6	7.55	162	26.0	35.2	2030
8	2	0-7	7.49	167	26.1	35.2	2436
9	4	0-6	7.49	167	25.8	35.2	2436
10	6	0-5	7.50	164	26.3	35.2	2030
11	6	0-6	7.53	160	26.2	35.2	2436
12	6	0-6	7.47	159	26.3	35.2	1015

BIOSTRATIGRAPHY

A mid-Tertiary, early Oligocene to early Miocene, section with some superficial Quaternary was recovered at DSDP 160.

Foraminifera are absent from Cores 1 through 5 and have undergone extensive dissolution throughout the remainder of the section. Best preservation was found in Cores 7 through 9 where, in addition to solution-resistant forms such as *Globorotalia opima, Catapsydrax* spp., and *Globigerina prasaepis*, other species such as *Globigerina* *galairsi, G. gortanii, G. sellii*, occur. *Globorotalia opima* is especially abundant from the bottom of the section upward through Core 7. Its dominance in the assemblages no doubt results from its thick-walled, solution-resistant test. The zones recognized include the *Globigerina ampliapertura* Zone, *Globorotalia opima* Zone, and the *Globigerina ciperoensis* Zone.

Nannofossils are absent from Cores 1 through 3, but are abundant in the calcareous sediments of Cores 4 through 13. Preservation is moderate to poor. Deposition under tropical conditions is indicated by an abundance of *Discoaster* and *Sphenolithus.*

Radiolarians are present throughout the section except for the lower part of Core 2 and the upper part of Core 3. Their abundance increases with depth in the hole.

In Core 1, radiolarians are rare and poorly preserved. the presence of *Collosphaera tuberosa* in Sections 1 and 2 indicates upper Pleistocene, and of *Amphirhopalum ypsilon* in Section 3, middle Pleistocene, in the uppermost 5 meters of the hole. Sections 3, 4, and 5 of Core 2 contain the lower Miocene *Calocycletta virginis* Zone, which lies disconformably on the Upper Oligocene *Lychocanoma bipes* Zone. Below 42 meters in the hole (in Section 4 of Core 5) all the Oligocene zones down to and including the *Theocyrtis tuberosa* Zone are present.

PHYSICAL PROPERTIES

Sediment disturbance was apparent throughout much of the cored section. Consequently, the GRAPE data can be only considered as an approximation. A number of subsamples were collected for laboratory measurement of physical properties from the least disturbed sections. Shear strength measurements consist of a limited number of vane shear and Swedish Fall Cone penetrometer tests made on carefully selected intervals of the core.

Bulk Density

Although GRAPE bulk density (average values per section) is highly variable throughout the stratigraphic column, three general zones are delineated by these data. Within the zone of zeolitic clay (0 to 27 meters), bulk densities of less than 1.30 g/cc and as low as 1.23 g/cc, predominate. Densities of 1.34 to 1.47 g/cc delineate the nannofossil chalk ooze zone extending from 27 meters to about 54 meters. A significant increase in bulk density with depth from 1.56 to 1.71 g/cc occurs in the nannofossil chalk ooze below 54 meters.

The lowest laboratory-measured bulk densities, 1.27 to 1.33 g/cc, are found in the upper 30 meters with an increase from 1.40 to 1.51 g/cc from 30 to 53 meters. Below this depth, the highest bulk densities, 1.61 to 1.85 g/cc, are found in the nannofossil chalk ooze. An exceptionally low density of 1.55 g/cc at a depth of 108 meters is probably due to an abundance of Radiolaria in the chalk ooze.

Porosity

GRAPE porosities of 75 to 87 per cent occur in the upper 27 meters, but decrease to 74 to 82 per cent from 27 to 54 meters. Lower porosities of 60 to 69 per cent are found below 54 meters. Laboratory porosities of 82 to 89 per cent are characteristic of the upper 30 meters of zeolitic clay whereas the upper chalk ooze displays values ranging from 68 to 76 per cent in the interval of 30 to 53 meters. Low laboratory porosities of 51 to 66 per cent occur in the nannofossil chalk ooze below 53 meters.

Water Content

Water content is highly variable throughout the entire section at DSDP 160. The highest water contents of 67 to 75 per cent are associated with the zeolitic clay. A decrease in water content, with values ranging from 40 to 64 per cent, is found in the transitional zone of nannofossil chalk ooze (30 to 53 meters). Low values of 28 to 40 per cent occur below 53 meters with the exception of a water content of 42 per cent which corresponds to the interval of low bulk density at 108 meters.

Grain Density

Grain density averages 2.72 g/cc for the entire sedimentary sequence with values ranging from 2.58 to 2.84 g/cc. The lowest and highest values are found in the nannofossil chalk ooze and zeolitic clay respectively. A relative abundance of Radiolaria in the nannofossil chalk ooze may account for the low average grain density observed at a depth of 52 meters. The high density may be due to the presence of ferromanganese micronodules which were found in the zeolitic clay in close proximity to the sample collected at a depth of 20 meters.

Sonic Velocity

Numerous sonic velocities were measured at selected intervals and repeated in a number of cases in order to determine the reproducibility and variability in the test itself (see Physical Properties Evaluation, this volume). A relatively high degree of velocity variation was observed throughout the sedimentary sequence. Velocities average 1.48 km/sec and range from 1.40 to 1.53 km/sec. Overall, velocities increased slightly with depth. Acoustic measurements of the basalt was not possible due to insufficient sample recovery.

Natural Gamma Radiation

Natural gamma radiation activity (average value per section) was highest in the high porosity zeolitic clay which correlates with a similar lithology and degree of activity at DSDP 159. Below 30 meters, the activity was considerably lower in the calcareous sediments than in the overlying clay. This activity relationship with depth is similar to that observed in the calcareous section at DSDP 159.

Shear Strength

Vane shear and Swedish Fall Cone penetrometer tests were made on a limited number of selected sections owing to the degree of sample disturbance. Vane shear strengths of 49 to 63 g/cm^2 and fall cone measurements averaging 91 g/cm^2 were found for the zeolitic clay at a depth of 3 to 4 meters. Fall cone measurements average 249 g/cm^2 in the nannofossil chalk ooze at 38 meters and range from 245 to 346 g/cm^2 in the chalk ooze section from 74 to 81 meters.

A vane shear strength of 123 g/cm^2 was recorded in the chalk ooze at a depth of 81 meters. The highest fall cone values (328 and 767 g/cm^2) occur in the nannofossil chalk ooze at 83 and 107 meters respectively.

SUMMARY AND DISCUSSION

The single hole drilled at DSDP 160 penetrated 109 meters of pelagic sediment before entering basalt basement. From 0 to 27 meters, the sediment is brown zeolitic clay containing ferromanganese nodules and fine, ferruginous-looking aggregates. Large manganese nodules in the interval are probably due to caving from the surface. The brown clay, like its equivalent in DSDP 159, is characterized by high natural gamma activity compared to the underlying ooze. It also has a high GRAPE porosity of over 80 per cent. The clay sequence represents deposition during the Quaternary, Pliocene, and most of the Miocene. Only the upper 3 meters can be dated paleontologically with some confidence, but if the sequence is assumed to be complete, the sedimentation rate is about 1.5 m/m.y. yrs for the past 18 m.y.

From 27 to 108 meters, the sediment is a grayish orange to very pale orange nannofossil chalk ooze, locally grading to marl ooze. Radiolarians are present throughout, but foraminifers are restricted to the interval 36 to 108 meters and are poorly preserved. The sediment was apparently laid down between the lysocline and the calcite compensation depth, a conclusion supported by the low sedimentation rate of 5 m/m.y. yrs from 18 to 34 m.y.

The absence of the *Dictyococcites abisectus* Subzone points to a disconformity at about 43 meters (Oligocene-Miocene boundary). Below this level, sedimentation appears to have been continuous throughout the Oligocene. The sediment becomes more indurated with depth and the GRAPE porosity decreases from about 75 to 60 per cent between 27 and 50 meters, but then remains fairly constant to basement.

Just above basement, from 108 to 109 meters, the core is severely disturbed with cavings from above and cuttings from the underlying basalt, contaminating the dark brown calcareous clay, rich in ferruginous micro-aggregates, that represents the basal "amorphous iron-oxide" facies mentioned in the DSDP 159 summary (see also Cronan, this vol., chapter 18).

Sonic velocities measured in the sedimentary section show little variation. In general, they increase from about 1.56 km/sec to 1.62 km/sec between 0 and 108 meters. Since duplicate determinations show differences of as much as 0.1 km/sec, fine detail is difficult to extract (cf. Chapter 12, this volume). The average measured velocity of 1.6 km/sec, uncorrected for temperature or pressure, is in reasonable agreement with the value obtained from the seismic profiler records.

Basement, encountered at 109 meters, is a fine-grained extrusive basalt, containing labradorite and augite microphenocrysts and magnetite grains in an altered groundmass that was probably once glass.

REFERENCES

Boström, K. and Peterson, M.N.A., 1966. Precipitates from hydrothermal exhalations on the East Pacific Rise. Econ. Geol. **61**, 1258.

_______, 1969. The origin of aluminum-poor ferromanganoan sediments in areas of high heat flow on the East Pacific Rise. Marine Geol. **7**, 427.

Boström. K., Peterson, M.N.A., Joensuu, O. and Fisher, D.E., 1969. Aluminum-poor sediments on active oceanic ridges. J. Geophys. Res. **74**, 3261.

Burckle, L.H., Ewing, J.I., Saito, T. and Leyden, R., 1967. Tertiary sediment from the East Pacific Rise. Science. **157**, 537.

Hays, J.D. et al., 1972. Initial Reports of the Deep Sea Drilling Project, Volume IX. Washington (U.S. Government Printing Office).

Heirtzler, J.R., 1968. Sea floor spreading. Sci. Am. **219**, 60.

Luyendyk, B.R., 1970. Origin and history of abyssal hills in the northeast Pacific Ocean. Bull. Geol. Soc. Am 81 (8), 2237.

McManus, D.A., Burns, R.E. et al., 1970. Initial Reports of the Deep Sea Drilling Project, Volume V. Washington (U. S. Government Printing Office).

Riedel, W.R., 1967. Radiolarian evidence consistent with spreading of the Pacific floor. Science. **157**, 540.

Sclater, J.G., Anderson, R.N. and Bell, M.L., 1971. Elevation of ridges and evolution of the central eastern Pacific. J. Geophys. Res. **76**, 7888.

Tracey, J.I., Jr., Sutton, G.H. et al., 1971. Initial Reports of the Deep Sea Drilling Project, Volume VIII. Washington (U. S. Government Printing Office).

von der Borch, C. C. and Rex, R. W., 1970. Amorphous iron-oxide precipitates in sediments cored during Leg 5, Deep Sea Drilling Project. *In* McManus, D. A., Burns, R. E. et al., 1970. Initial Reports of the Deep Sea Drilling Project, Volume V. Washington (U.S. Government Printing Office).

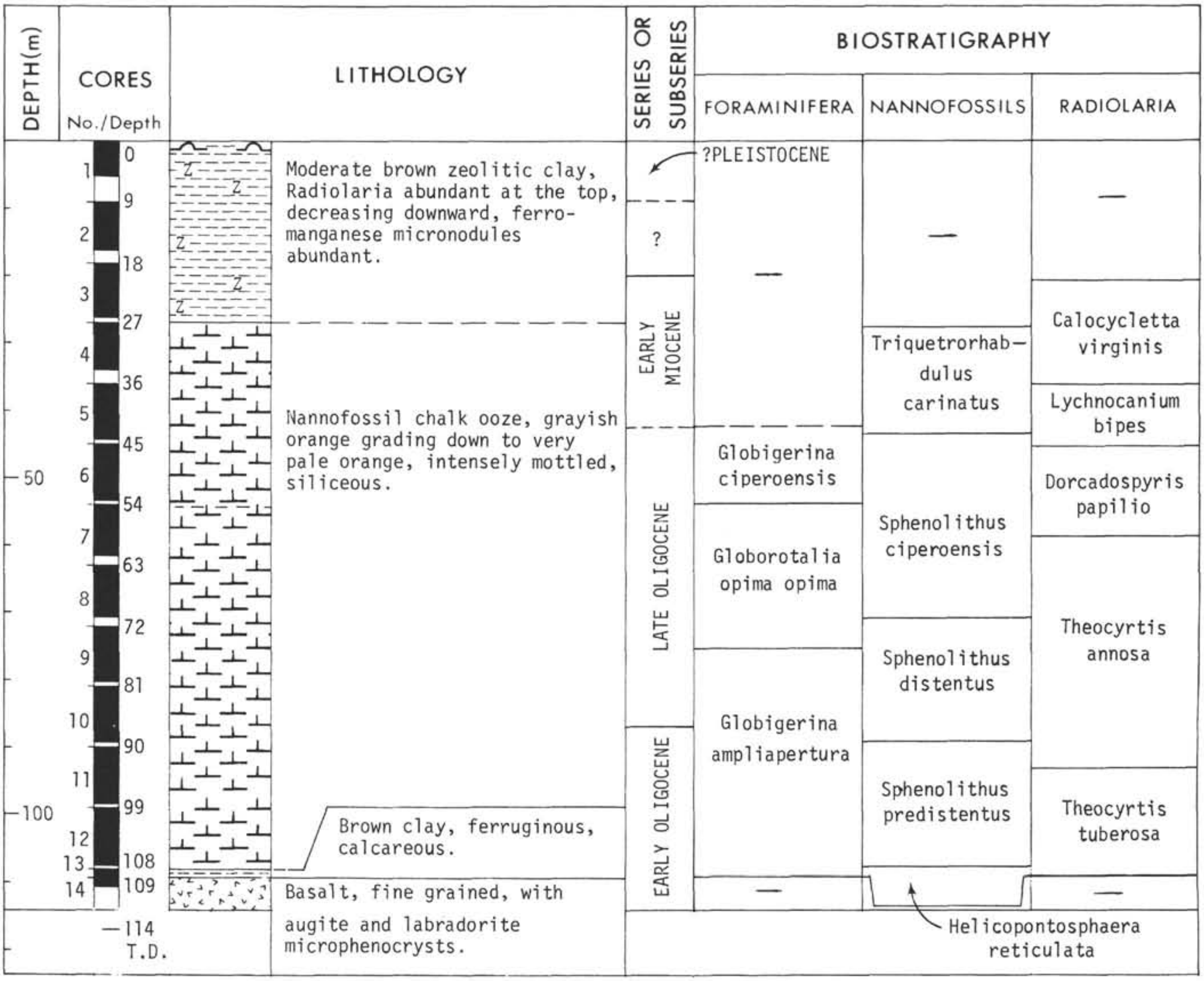
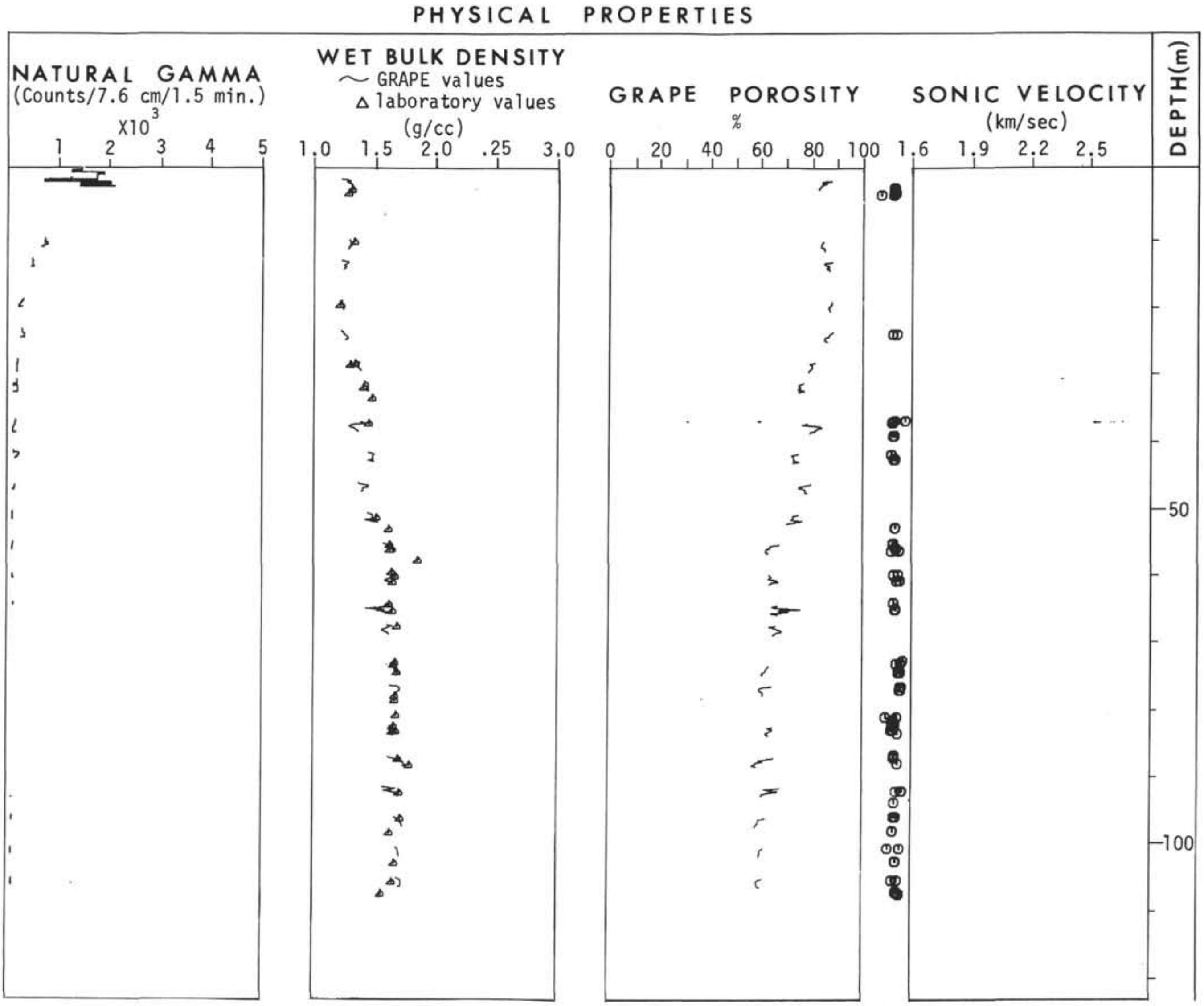
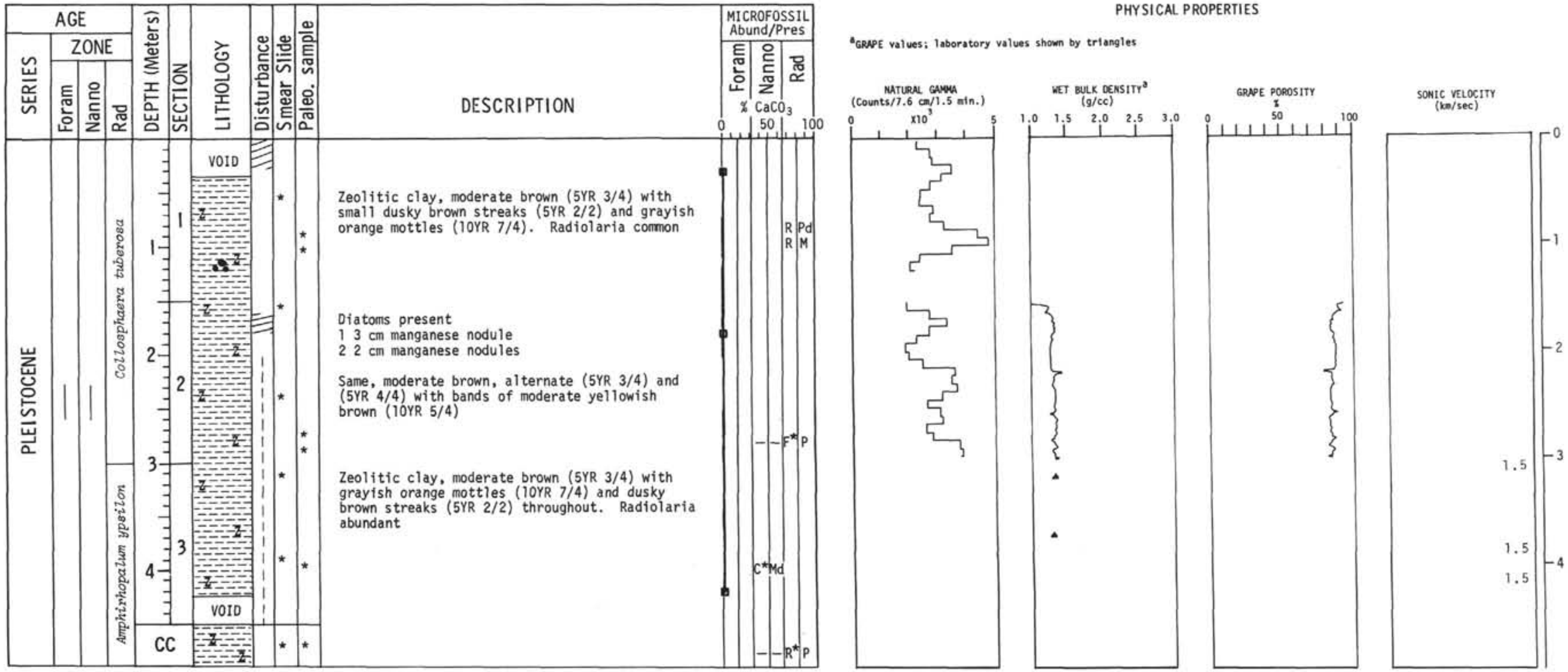


Figure 5. *DSDP 160, graphic hole summary. Vertical scale 1 cm = 10 m (1:1000).*


PHYSICAL PROPERTIES
NATURAL GAMMA
(Counts/7.6 cm/1.5 min.)
X10^3
1
2
3
4
5
WET BULK DENSITY
GRAPE values
laboratory values
(g/cc)
1.0
1.5
2.0
.25
3.0
GRAPE POROSITY
%
0
20
40
60
80
100
SONIC VELOCITY
(km/sec)
1.6
1.9
2.2
2.5
DEPTH(m)
50
100

SITE: 160 HOLE: CORE: 1 Cored Interval: 0-9 m



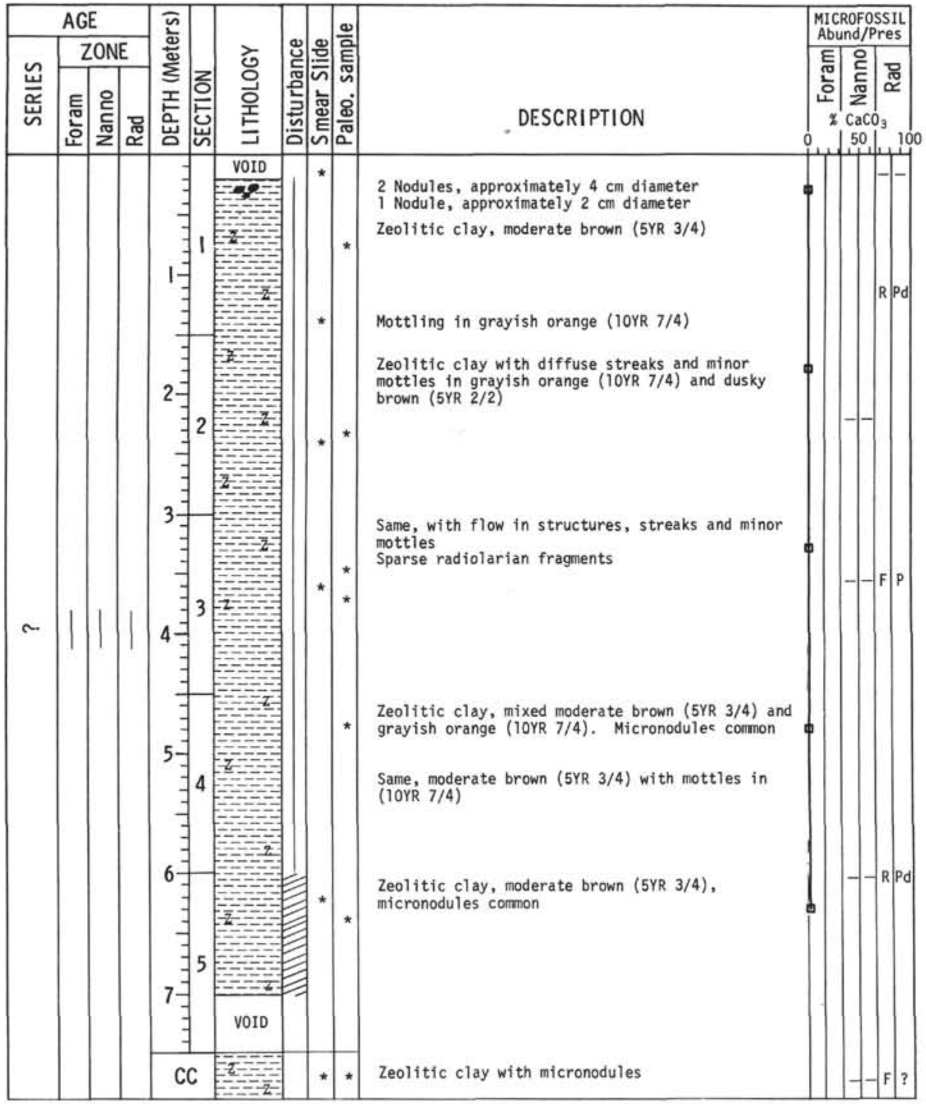
Zeolitic clay, moderate brown (5YR 3/4) with small dusky brown streaks (5YR 2/2) and grayish orange mottles (10YR 7/4). Radiolaria common

Diatoms present
1 3 cm manganese nodule
2 2 cm manganese nodules

Same, moderate brown, alternate (5YR 3/4) and (5YR 4/4) with bands of moderate yellowish brown (10YR 5/4)

Zeolitic clay, moderate brown (5YR 3/4) with grayish orange mottles (10YR 7/4) and dusky brown streaks (5YR 2/2) throughout. Radiolaria abundant

SITE: 160 HOLE: CORE: 2 Cored Interval: 9-18 m



2 Nodules, approximately 4 cm diameter
1 Nodule, approximately 2 cm diameter

Zeolitic clay, moderate brown (5YR 3/4)

Mottling in grayish orange (10YR 7/4)

Zeolitic clay with diffuse streaks and minor mottles in grayish orange (10YR 7/4) and dusky brown (5YR 2/2)

Same, with flow in structures, streaks and minor mottles
Sparse radiolarian fragments

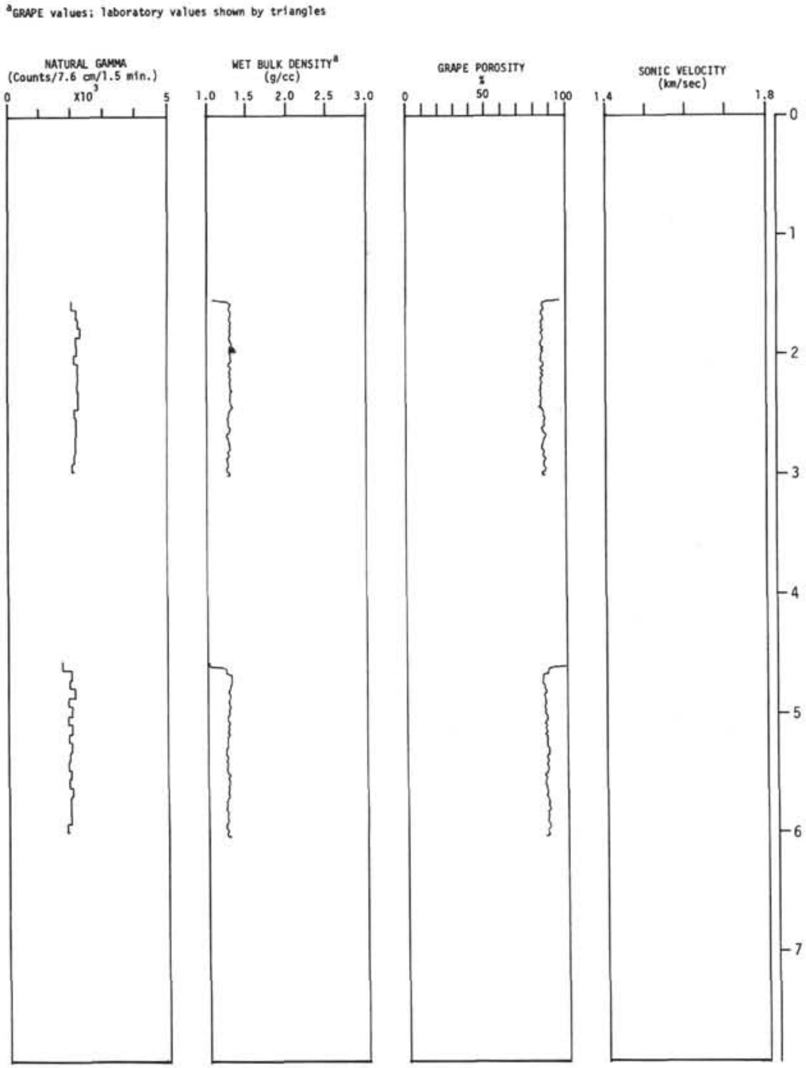
Zeolitic clay, mixed moderate brown (5YR 3/4) and grayish orange (10YR 7/4). Micronodules common

Same, moderate brown (5YR 3/4) with mottles in (10YR 7/4)

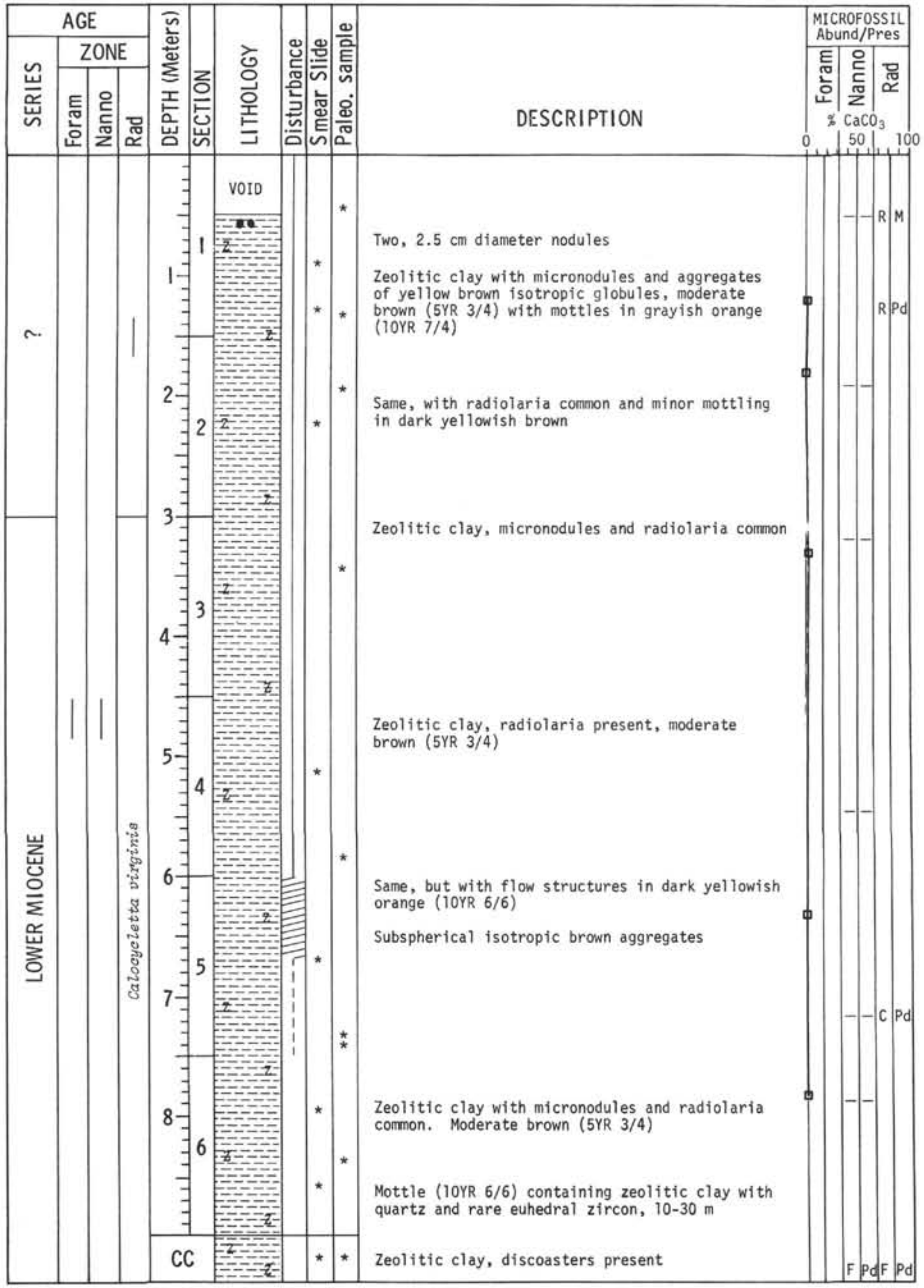
Zeolitic clay, moderate brown (5YR 3/4), micronodules common

Zeolitic clay with micronodules

PHYSICAL PROPERTIES



SITE: 160 HOLE: CORE: 3 Cored Interval: 18-27 m



Two, 2.5 cm diameter nodules

Zeolitic clay with micronodules and aggregates of yellow brown isotropic globules, moderate brown (5YR 3/4) with mottles in grayish orange (10YR 7/4)

Same, with radiolaria common and minor mottling in dark yellowish brown

Zeolitic clay, micronodules and radiolaria common

Zeolitic clay, radiolaria present, moderate brown (5YR 3/4)

Same, but with flow structures in dark yellowish orange (10YR 6/6)

Subspherical isotropic brown aggregates

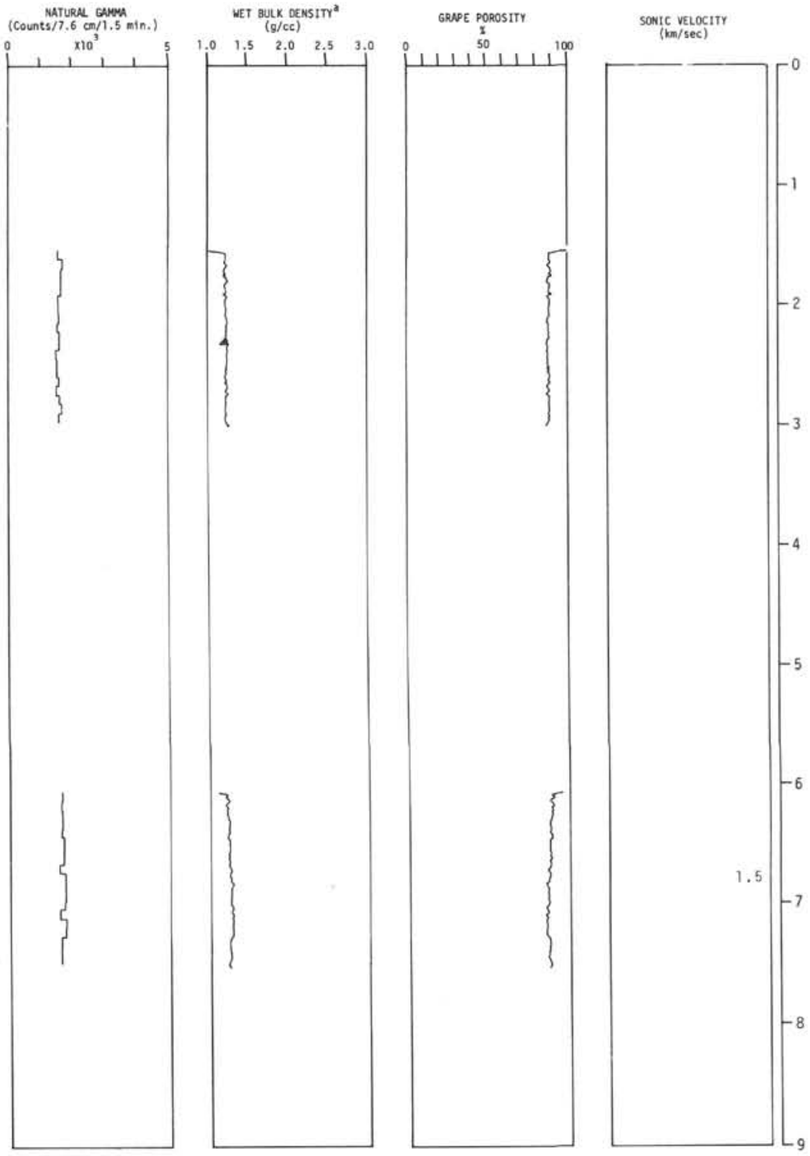
Zeolitic clay with micronodules and radiolaria common. Moderate brown (5YR 3/4)

Mottle (10YR 6/6) containing zeolitic clay with quartz and rare euhedral zircon, 10-30 m

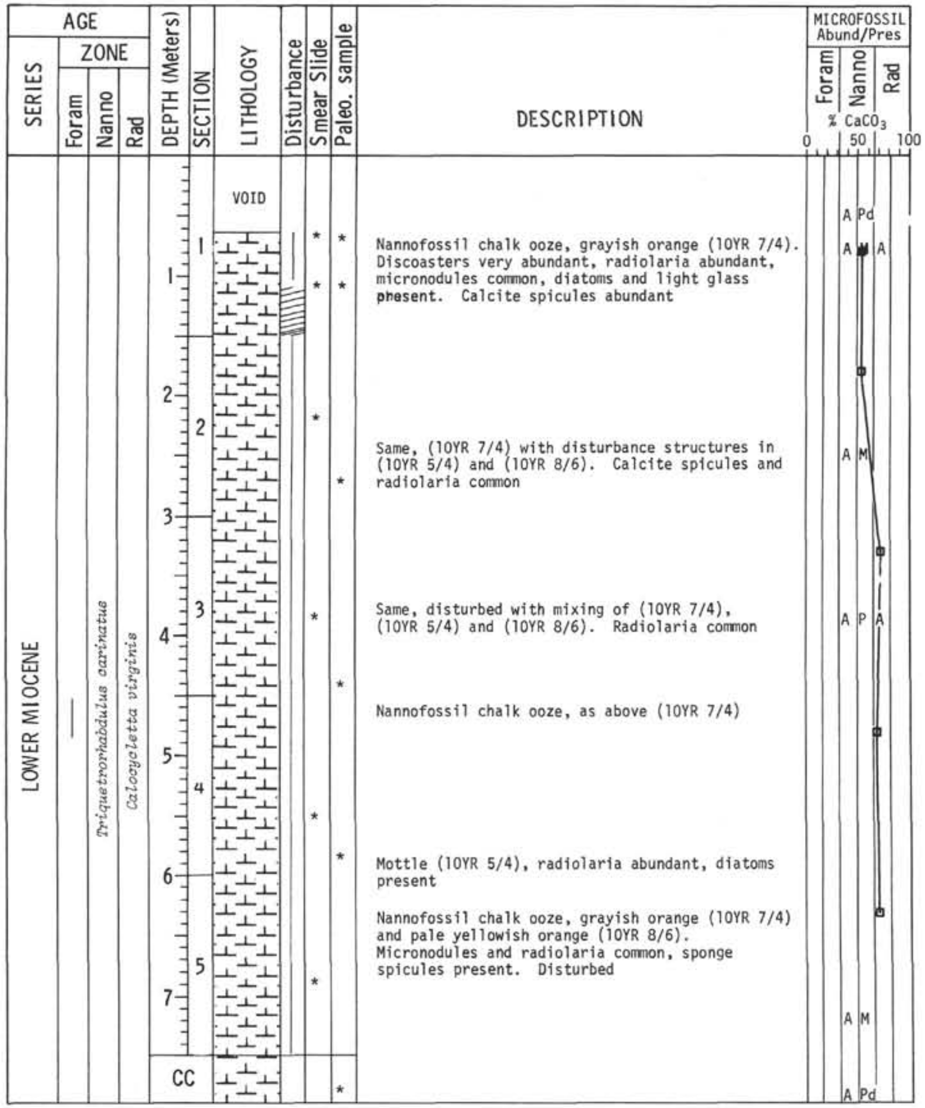
Zeolitic clay, discoasters present

PHYSICAL PROPERTIES

aGRAPE values; laboratory values shown by triangles



SITE: 160 HOLE: CORE: 4 Cored Interval: 27-36 m



Nannofossil chalk ooze, grayish orange (10YR 7/4). Discoasters very abundant, radiolaria abundant, micronodules common, diatoms and light glass phesent. Calcite spicules abundant

Same, (10YR 7/4) with disturbance structures in (10YR 5/4) and (10YR 8/6). Calcite spicules and radiolaria common

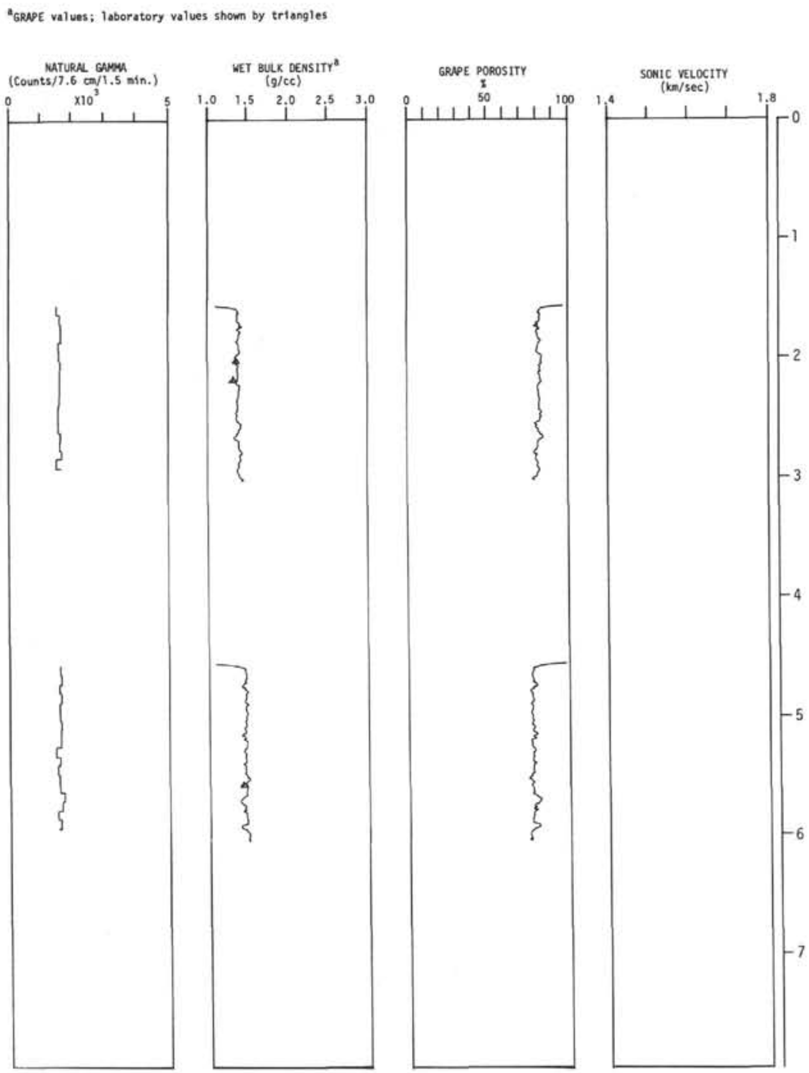
Same, disturbed with mixing of (10YR 7/4), (10YR 5/4) and (10YR 8/6). Radiolaria common

Nannofossil chalk ooze, as above (10YR 7/4)

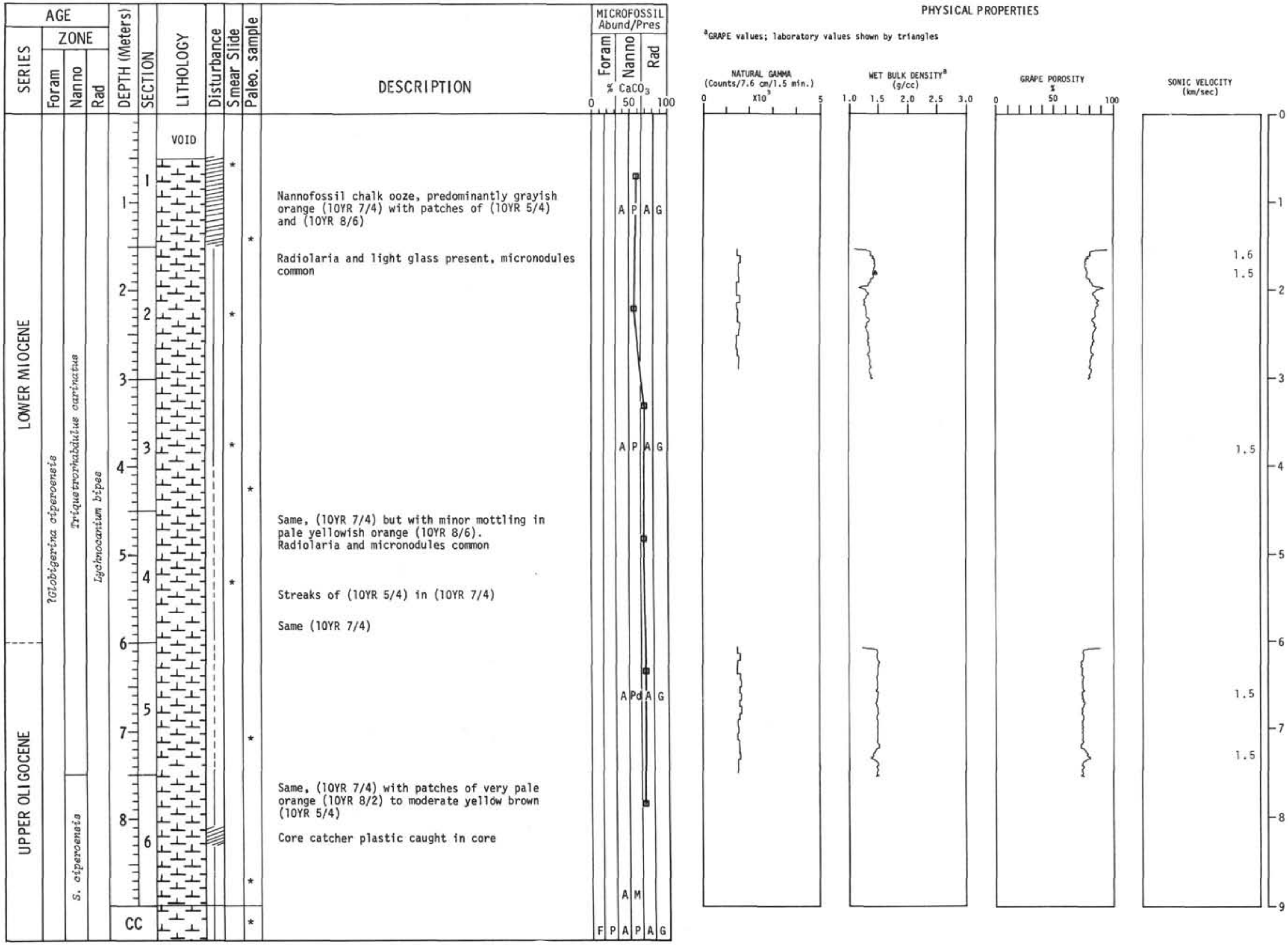
Mottle (10YR 5/4), radiolaria abundant, diatoms present

Nannofossil chalk ooze, grayish orange (10YR 7/4) and pale yellowish orange (10YR 8/6). Micronodules and radiolaria common, sponge spicules present. Disturbed

PHYSICAL PROPERTIES



SITE: 160 HOLE: CORE: 5 Cored Interval: 36-45 m



Nannofossil chalk ooze, predominantly grayish orange (10YR 7/4) with patches of (10YR 5/4) and (10YR 8/6)

Radiolaria and light glass present, micronodules common

Same, (10YR 7/4) but with minor mottling in pale yellowish orange (10YR 8/6). Radiolaria and micronodules common

Streaks of (10YR 5/4) in (10YR 7/4)

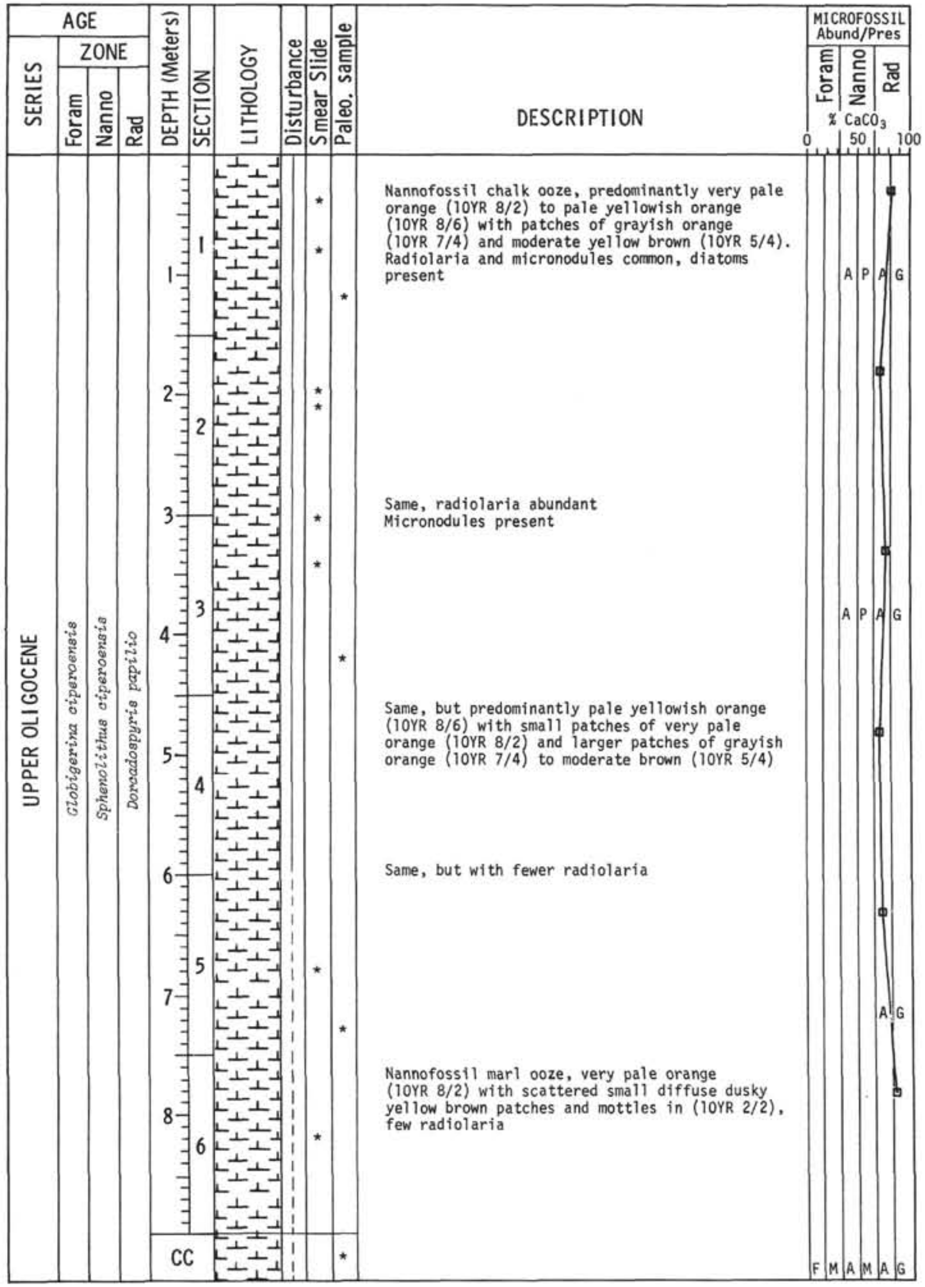
Same (10YR 7/4)

Same, (10YR 7/4) with patches of very pale orange (10YR 8/2) to moderate yellow brown (10YR 5/4)

Core catcher plastic caught in core

^{a}GRAPE values; laboratory values shown by triangles

SITE: 160 HOLE: CORE: 6 Cored Interval: 45-54 m



Nannofossil chalk ooze, predominantly very pale orange (10YR 8/2) to pale yellowish orange (10YR 8/6) with patches of grayish orange (10YR 7/4) and moderate yellow brown (10YR 5/4). Radiolaria and micronodules common, diatoms present

Same, radiolaria abundant Micronodules present

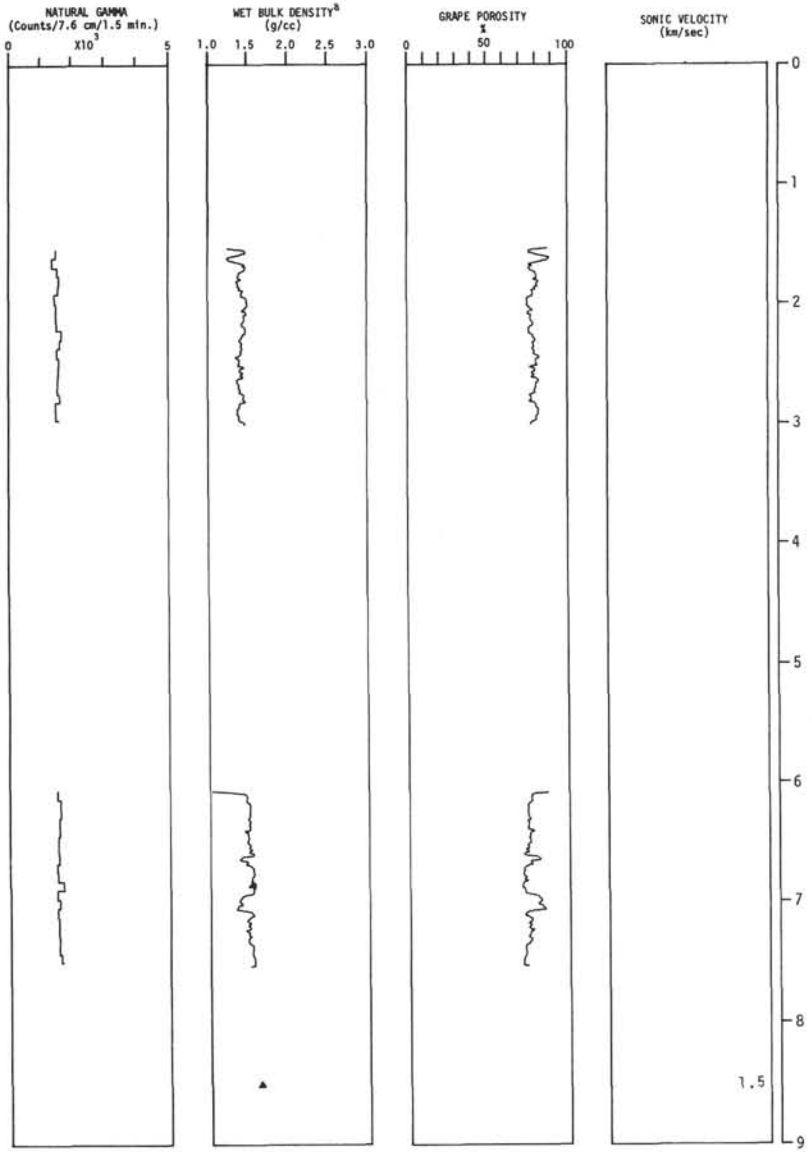
Same, but predominantly pale yellowish orange (10YR 8/6) with small patches of very pale orange (10YR 8/2) and larger patches of grayish orange (10YR 7/4) to moderate brown (10YR 5/4)

Same, but with fewer radiolaria

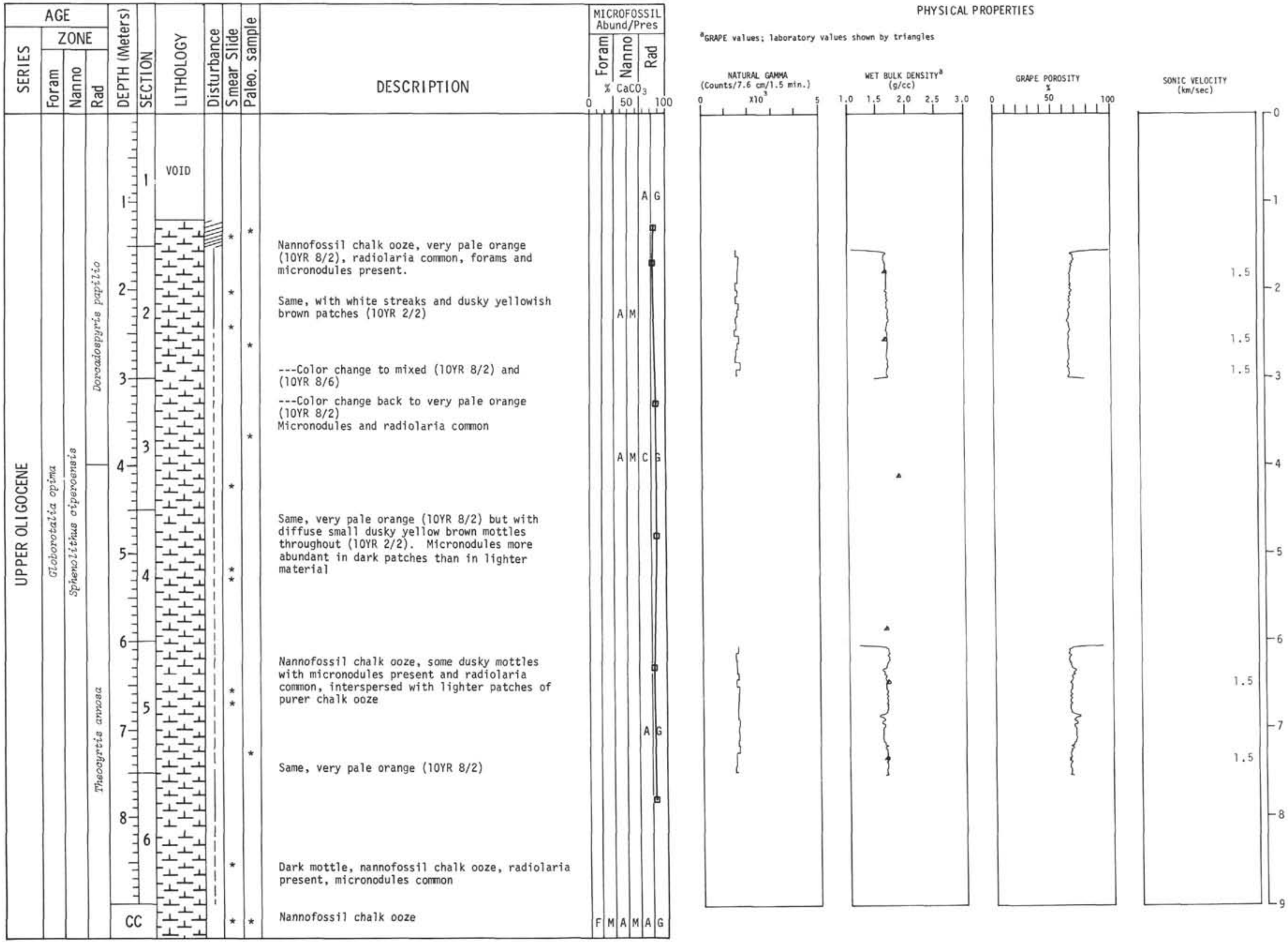
Nannofossil marl ooze, very pale orange (10YR 8/2) with scattered small diffuse dusky yellow brown patches and mottles in (10YR 2/2), few radiolaria

PHYSICAL PROPERTIES

ᵃGRAPE values; laboratory values shown by triangles



SITE: 160 HOLE: CORE: 7 Cored Interval: 54-63 m



aGRAPE values; laboratory values shown by triangles

Nannofossil chalk ooze, very pale orange (10YR 8/2), radiolaria common, forams and micronodules present.

Same, with white streaks and dusky yellowish brown patches (10YR 2/2)

---Color change to mixed (10YR 8/2) and (10YR 8/6)

---Color change back to very pale orange (10YR 8/2)
Micronodules and radiolaria common

Same, very pale orange (10YR 8/2) but with diffuse small dusky yellow brown mottles throughout (10YR 2/2). Micronodules more abundant in dark patches than in lighter material

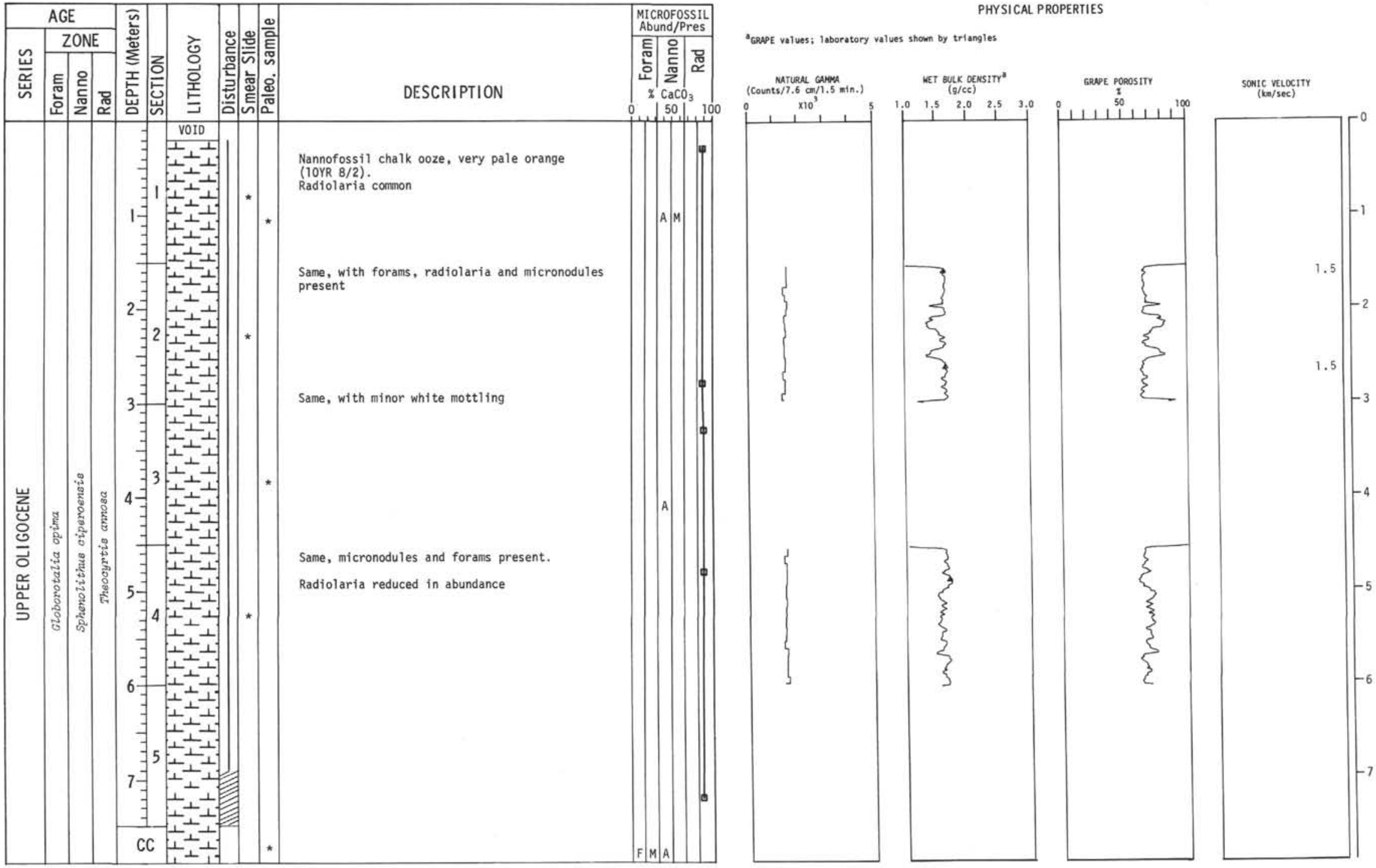
Nannofossil chalk ooze, some dusky mottles with micronodules present and radiolaria common, interspersed with lighter patches of purer chalk ooze

Same, very pale orange (10YR 8/2)

Dark mottle, nannofossil chalk ooze, radiolaria present, micronodules common

Nannofossil chalk ooze

SITE: 160 HOLE: CORE: 8 Cored Interval: 63-72 m



Nannofossil chalk ooze, very pale orange (10YR 8/2).
Radiolaria common

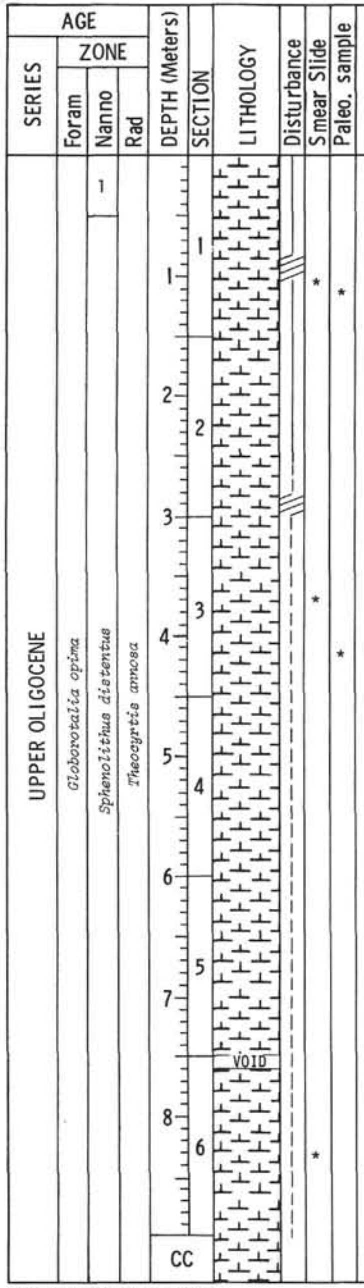
Same, with forams, radiolaria and micronodules present

Same, with minor white mottling

Same, micronodules and forams present.

Radiolaria reduced in abundance

SITE: 160 HOLE: CORE: 9 Cored Interval:



DESCRIPTION

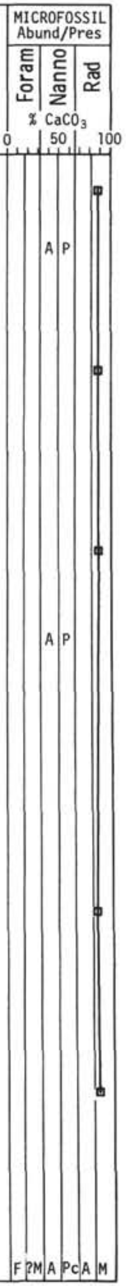
Nannofossil chalk ooze, very pale orange (10YR 8/2). Whitish mottles throughout section. Mottles contain fewer micronodules and radiolaria than does the remainder of the core

Same, but with mottles increasing in concentration towards the base of the section. Mottles have a diffuse dark outer margin

Same, but mottles rare in upper portion of section becoming more abundant lower down. Micronodules and forams common, radiolaria present

Same, but with fewer mottles

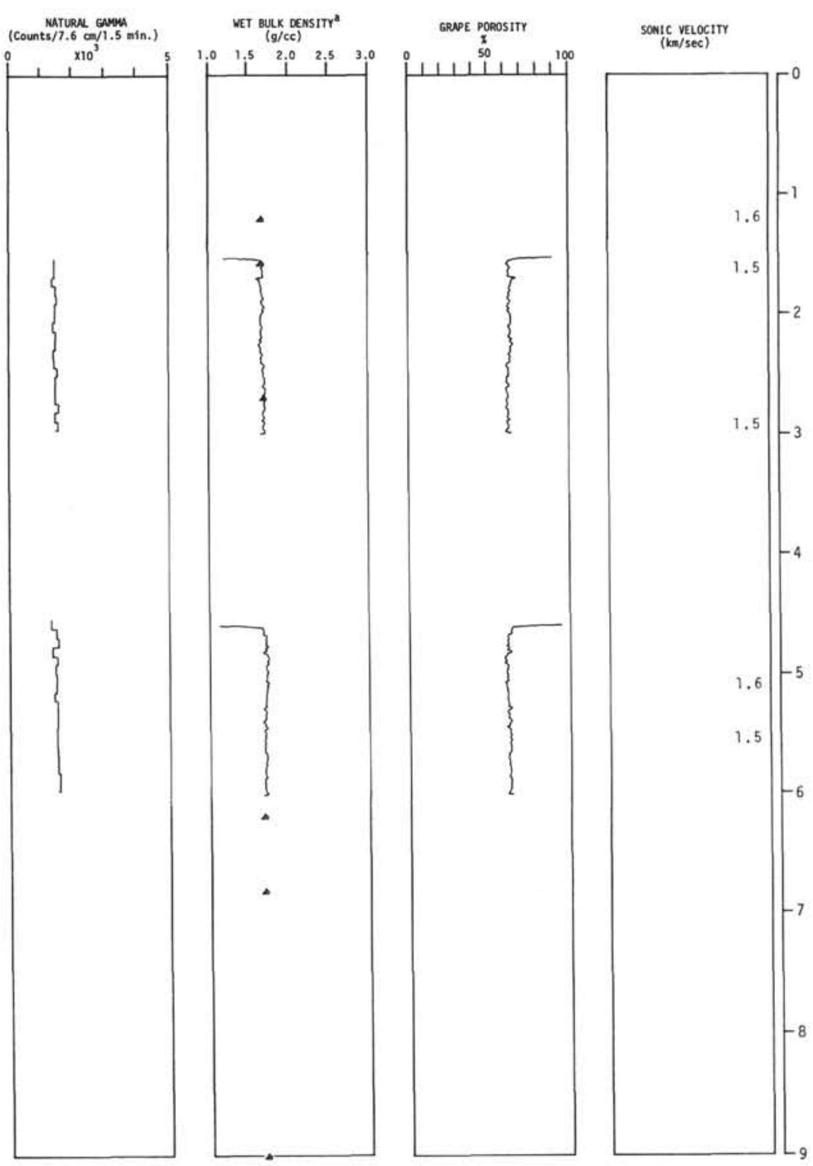
Same, radiolaria and micronodules common



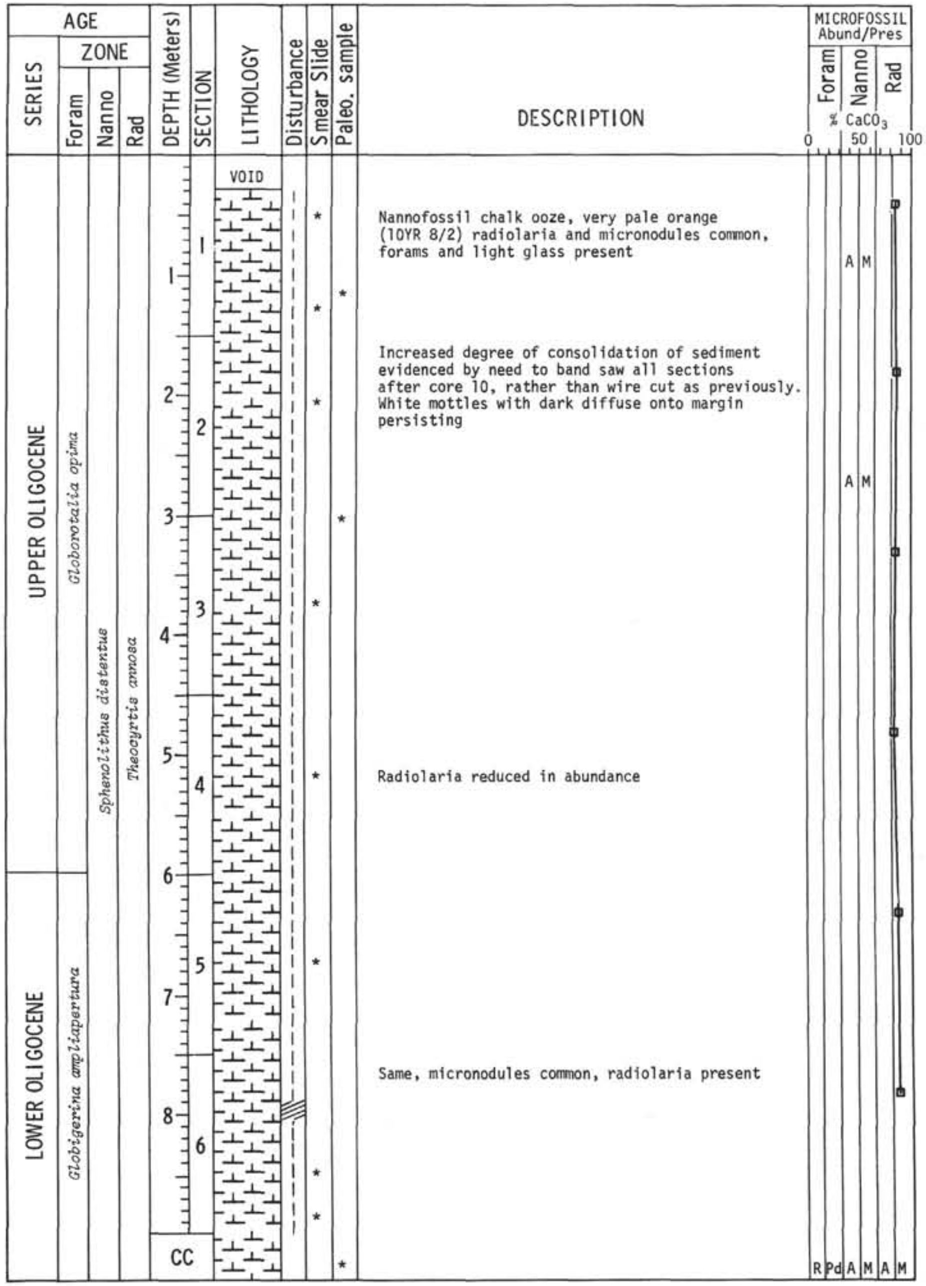
1 *Sphenolithus ciperoensis*

PHYSICAL PROPERTIES

aGRAPE values; laboratory values shown by triangles



SITE: 160 HOLE: CORE: 10 Cored Interval: 81-90 m

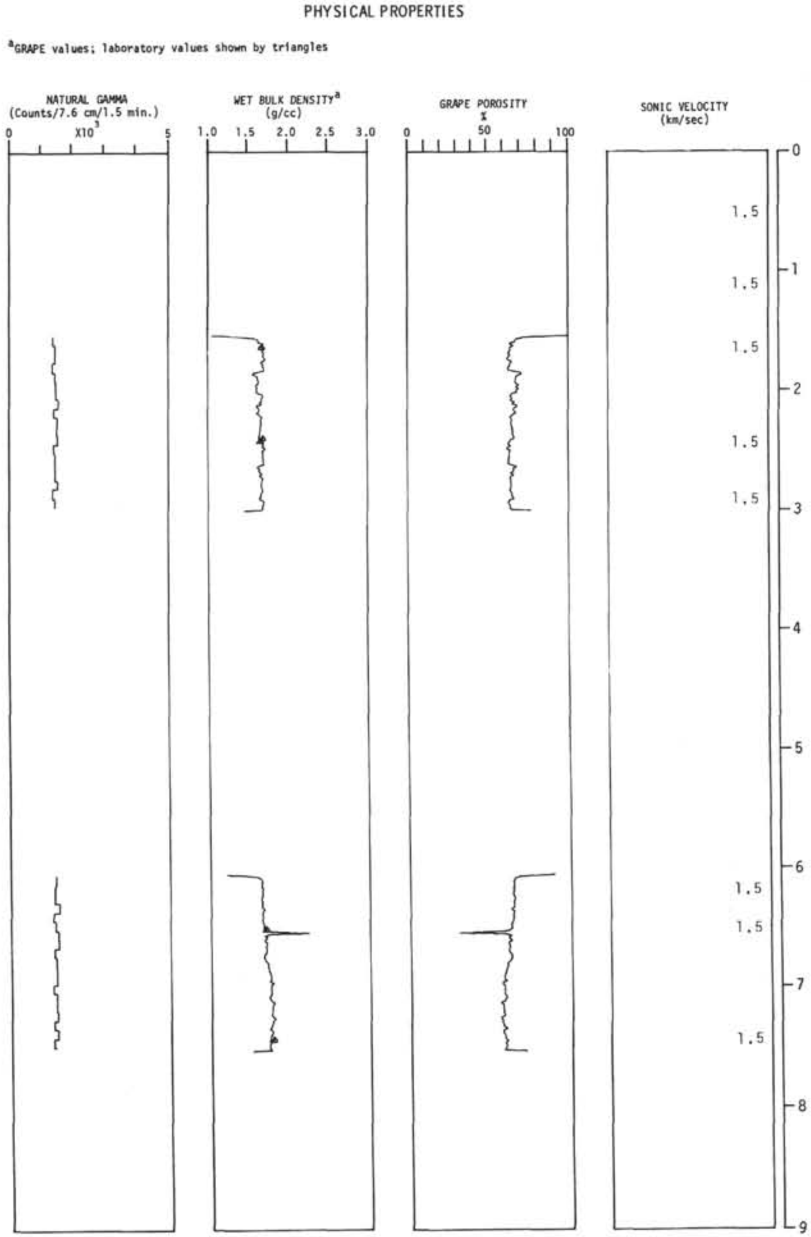


Nannofossil chalk ooze, very pale orange (10YR 8/2) radiolaria and micronodules common, forams and light glass present

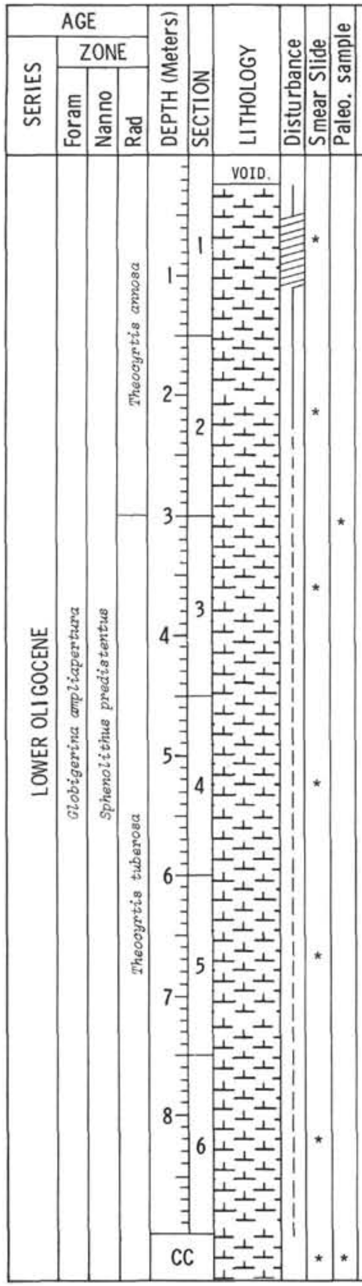
Increased degree of consolidation of sediment evidenced by need to band saw all sections after core 10, rather than wire cut as previously. White mottles with dark diffuse onto margin persisting

Radiolaria reduced in abundance

Same, micronodules common, radiolaria present



SITE: 160 HOLE: CORE: 11 Cored Interval: 90-99 m



DESCRIPTION

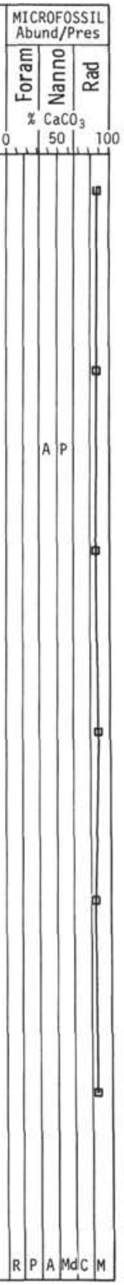
Nannofossil chalk ooze, very pale orange (10YR 8/2). Sparse White mottles, forams common, radiolaria and micronodules present
Well consolidated

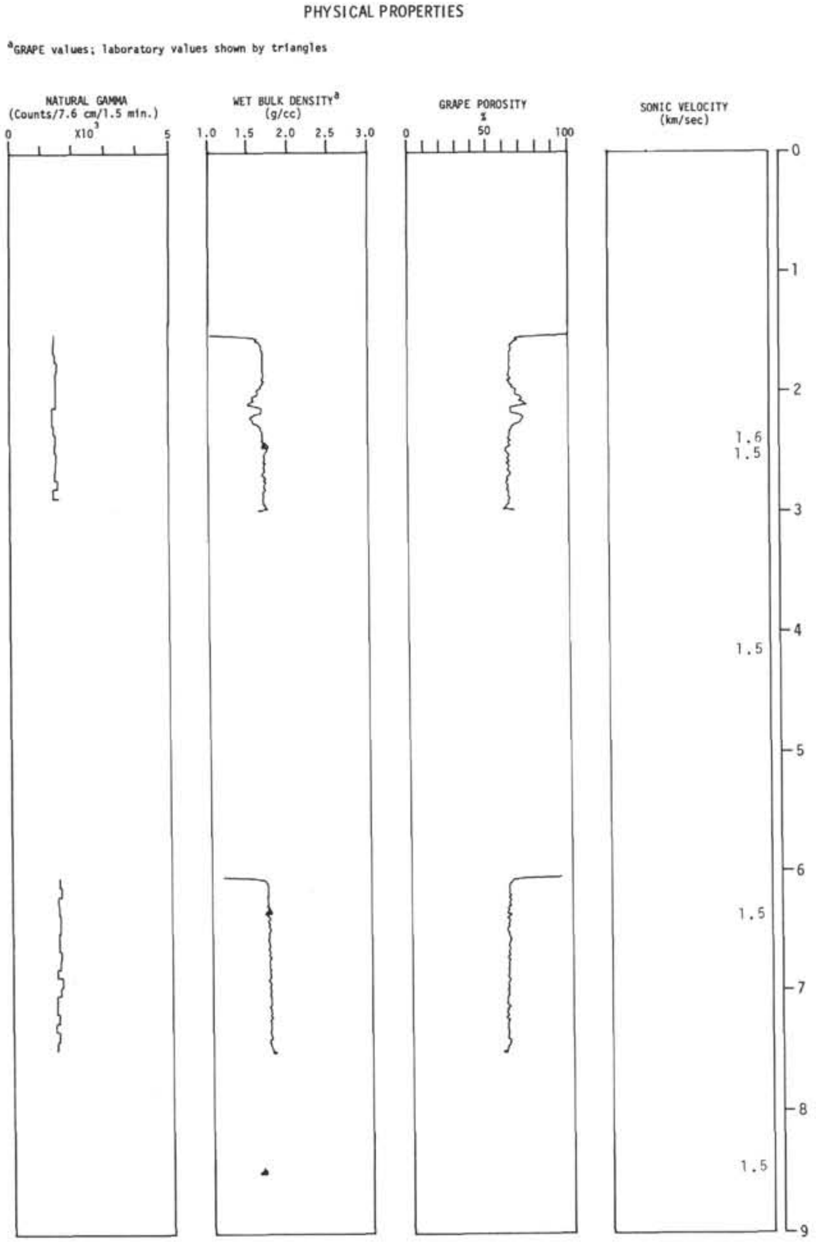
Same, whitish mottles at 20, 42, 121, 130 cm with smaller diffuse whitish patches throughout. Radiolaria and micronodules common, forams present

Same, minor mottles throughout, forams and radiolaria present

Radiolaria present in small concentrations

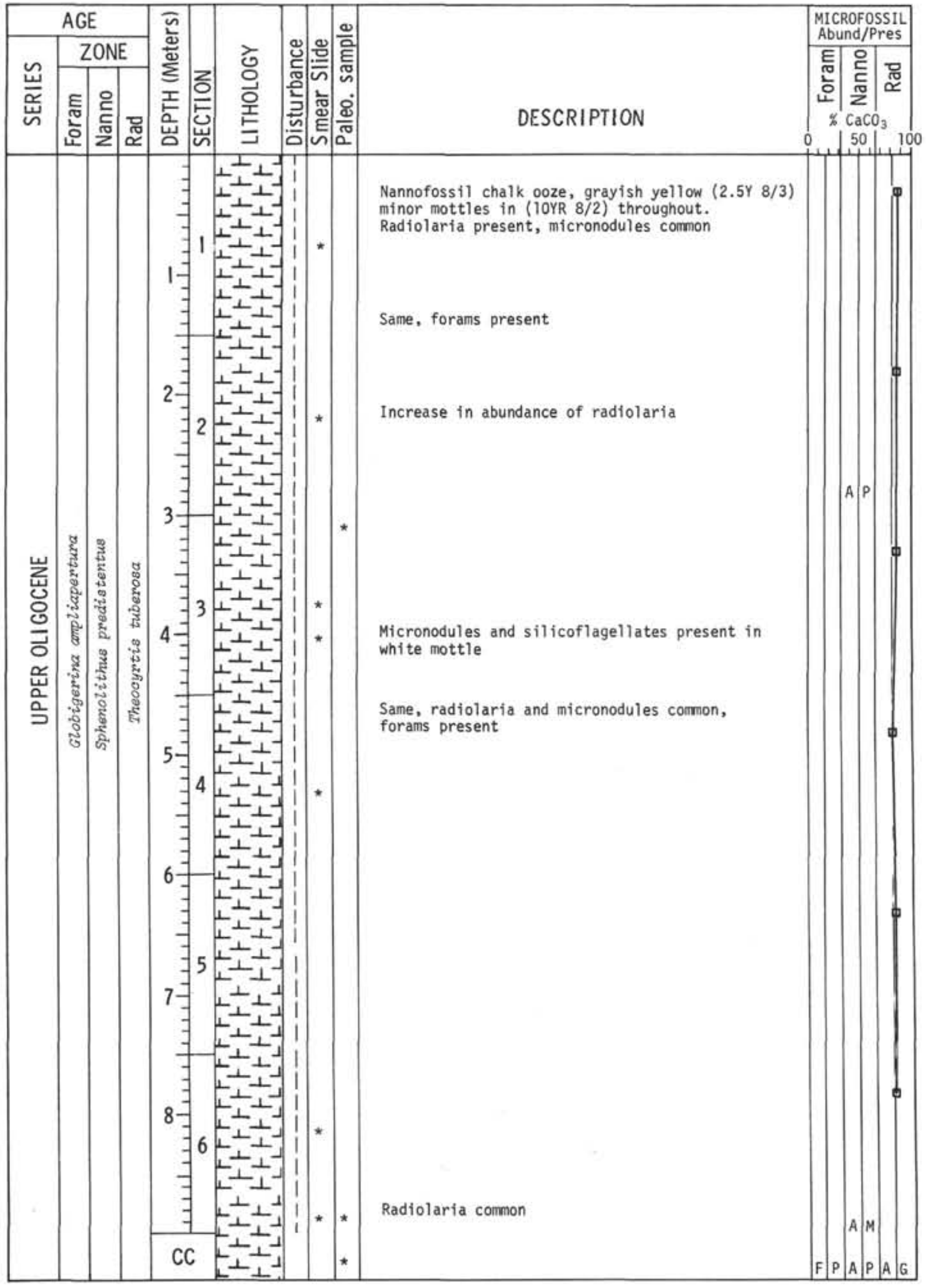
Same with whitish mottles at 40, 91, 125, 130, 132, 138 and 151 cm. Radiolaria and forams present, micronodules common





ᵃGRAPE values; laboratory values shown by triangles

SITE: 160 HOLE: CORE: 12 Cored Interval: 99-108 m



Nannofossil chalk ooze, grayish yellow (2.5Y 8/3) minor mottles in (10YR 8/2) throughout. Radiolaria present, micronodules common

Same, forams present

Increase in abundance of radiolaria

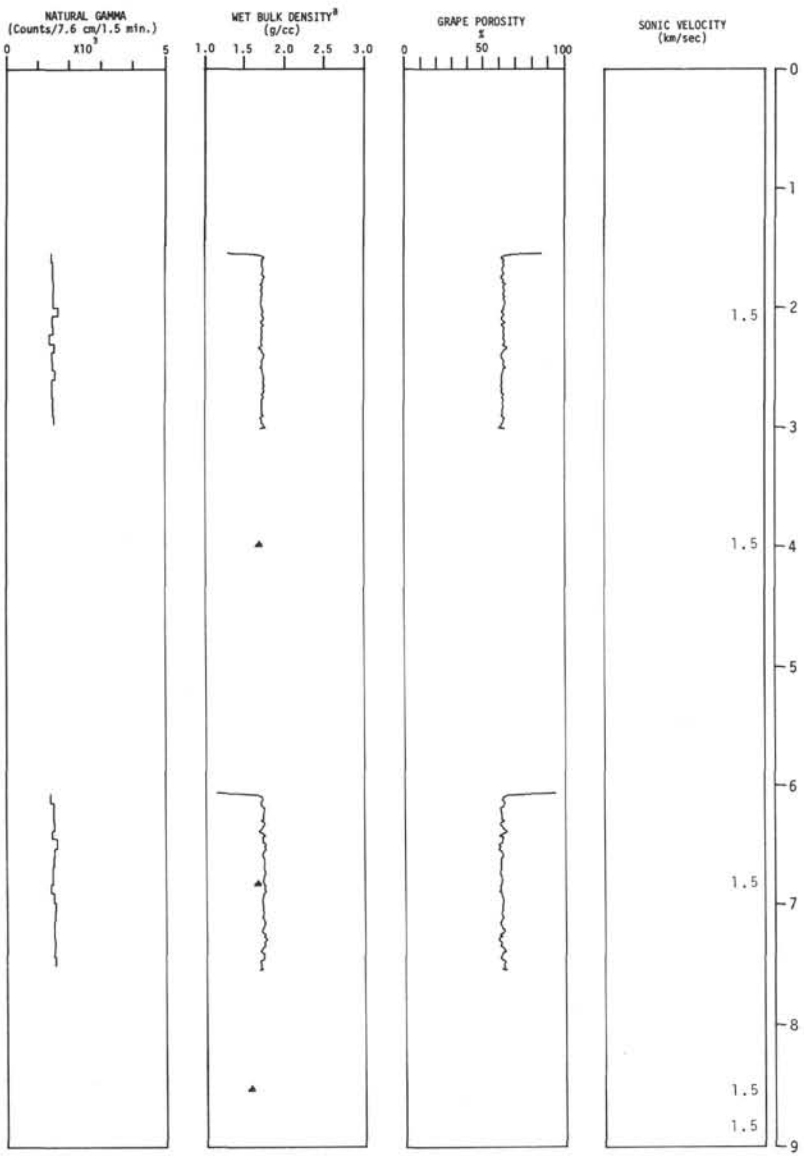
Micronodules and silicoflagellates present in white mottle

Same, radiolaria and micronodules common, forams present

Radiolaria common

PHYSICAL PROPERTIES

[a]GRAPE values; laboratory values shown by triangles



SITE: 160 HOLE: CORE: 13 Cored Interval: 108-109 m

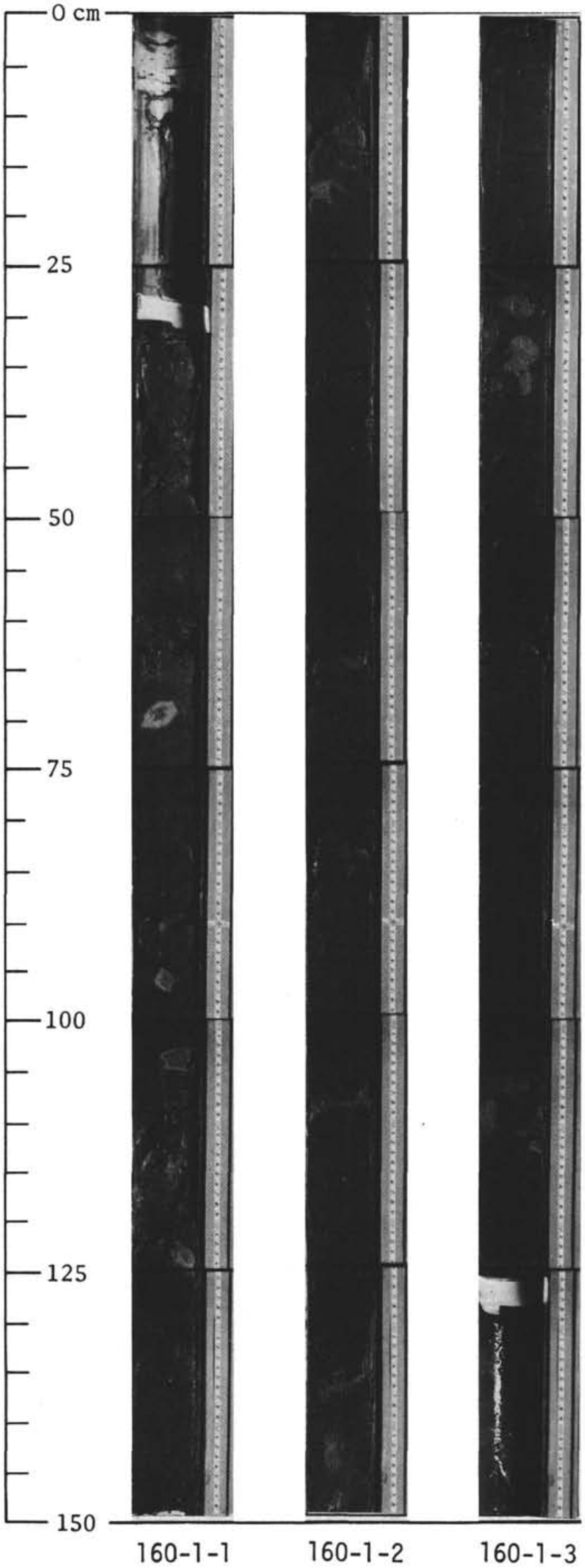
AGE				DEPTH (Meters)	SECTION	LITHOLOGY	Disturbance	Smear Slide	Paleo. sample	DESCRIPTION	MICROFOSSIL Abund/Pres					
SERIES	ZONE										Foram		Nanno		Rad	
	Foram	Nanno	Rad													
LOWER OLIGOCENE	*G. ampliapertura*	*Helicopontosphaera reticulata*	*Theocyrtis tuberosa*	1	1	VOID										
								*		Slurried basalt and chalk fragments in mud						
								*	*	Moderate yellowish brown (10YR 5/4). Dark brown isotropic aggregates present in clay			A	P		
					CC			*	*	Red marl with basalt and mud, micronodules abundant			A A	P M	C	M

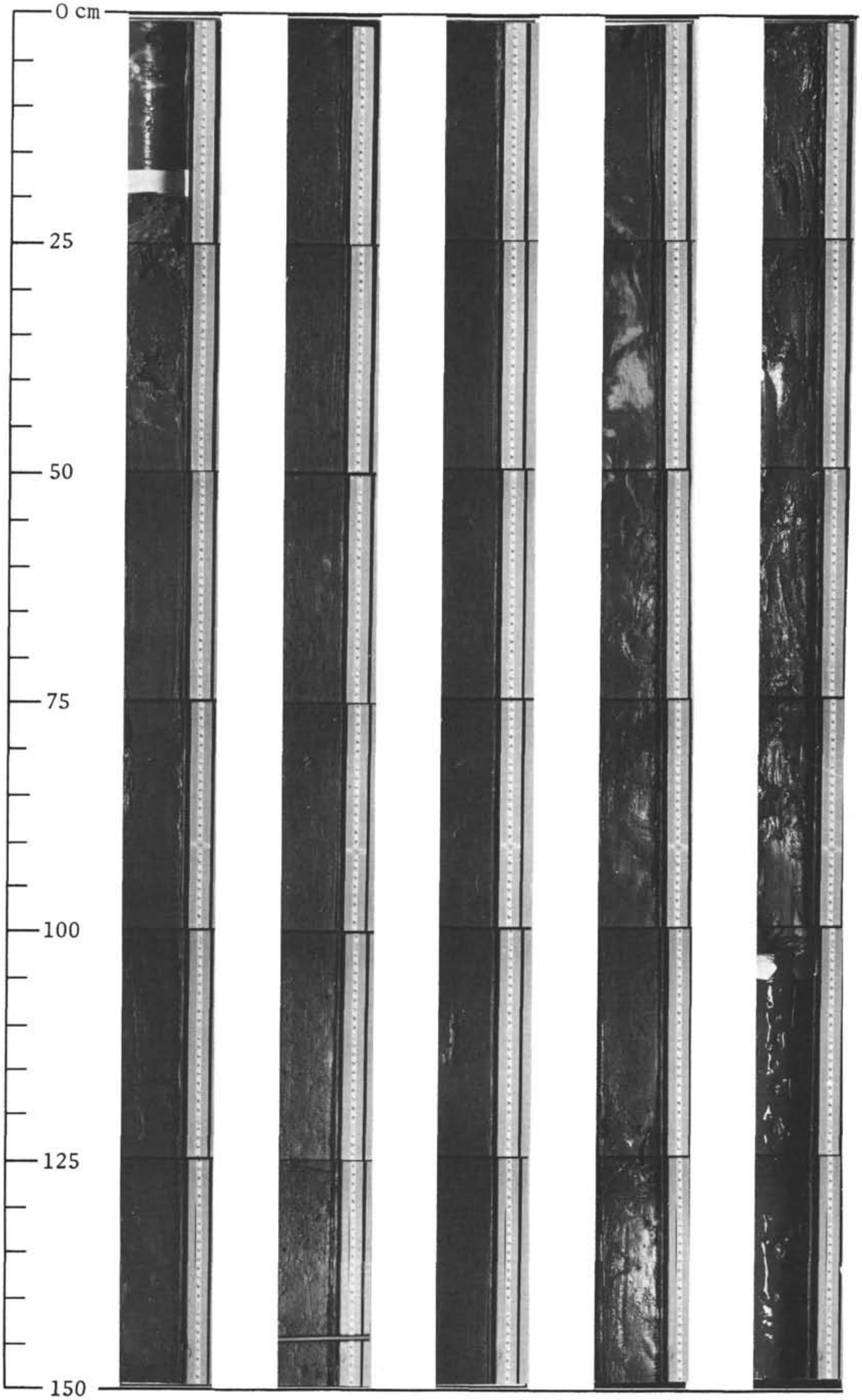
% CaCO$_3$ 0 50 100

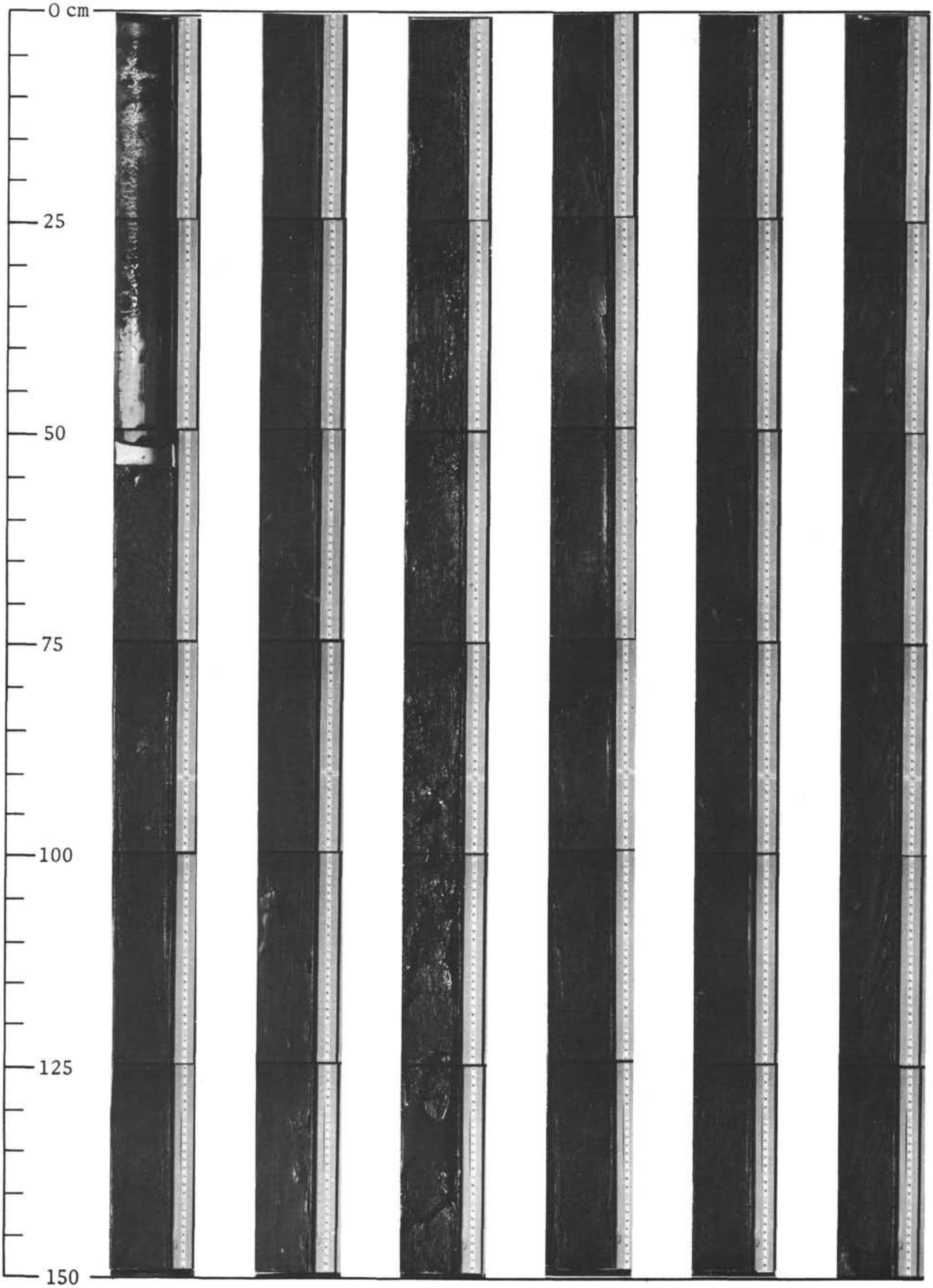
SITE: 160 HOLE: CORE: 14 Cored Interval: 109-114 m

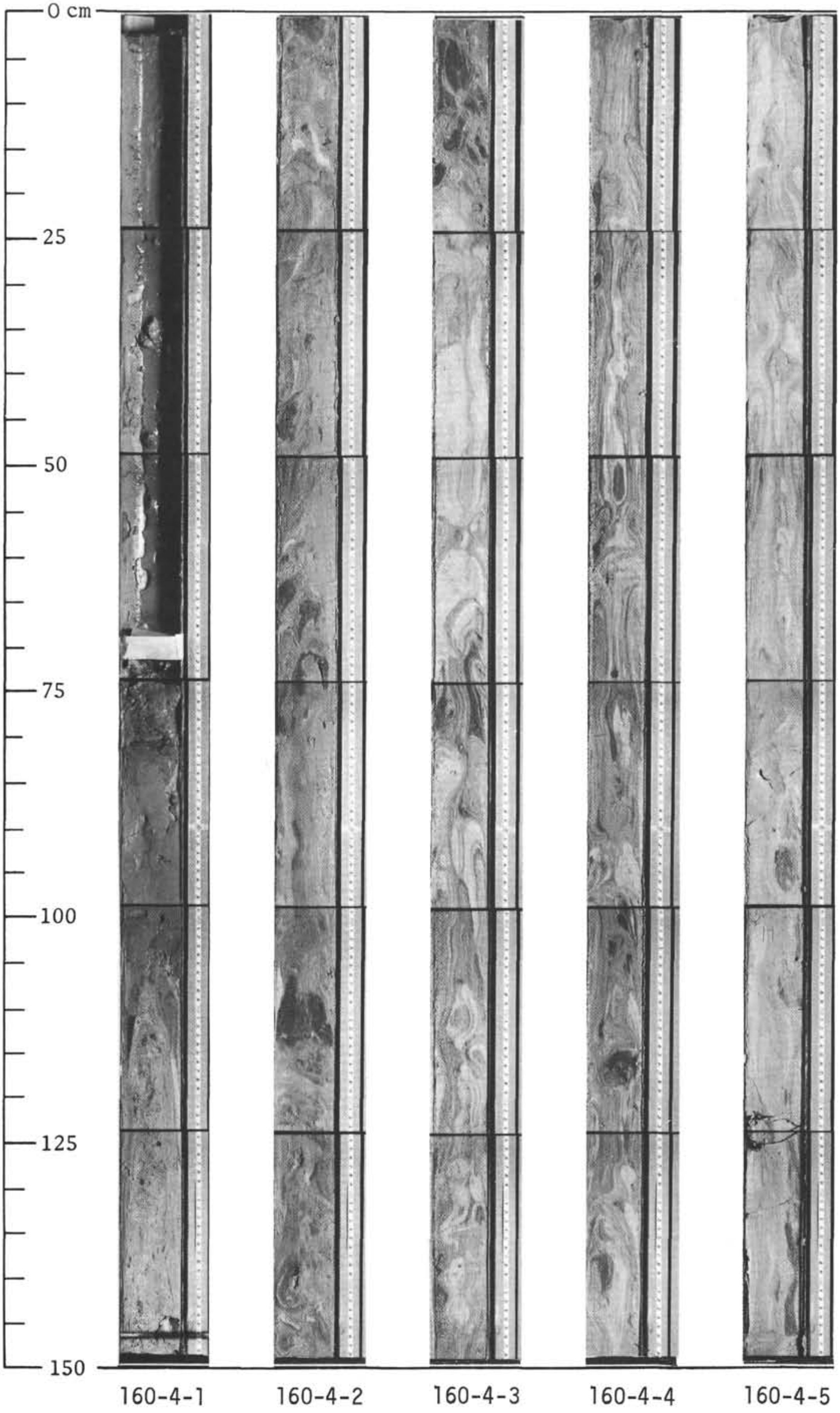
AGE				DEPTH (Meters)	SECTION	LITHOLOGY	Disturbance	Smear Slide	Paleo. sample	DESCRIPTION	MICROFOSSIL Abund/Pres					
SERIES	ZONE										Foram		Nanno		Rad	
	Foram	Nanno	Rad													
					CC					Basalt						

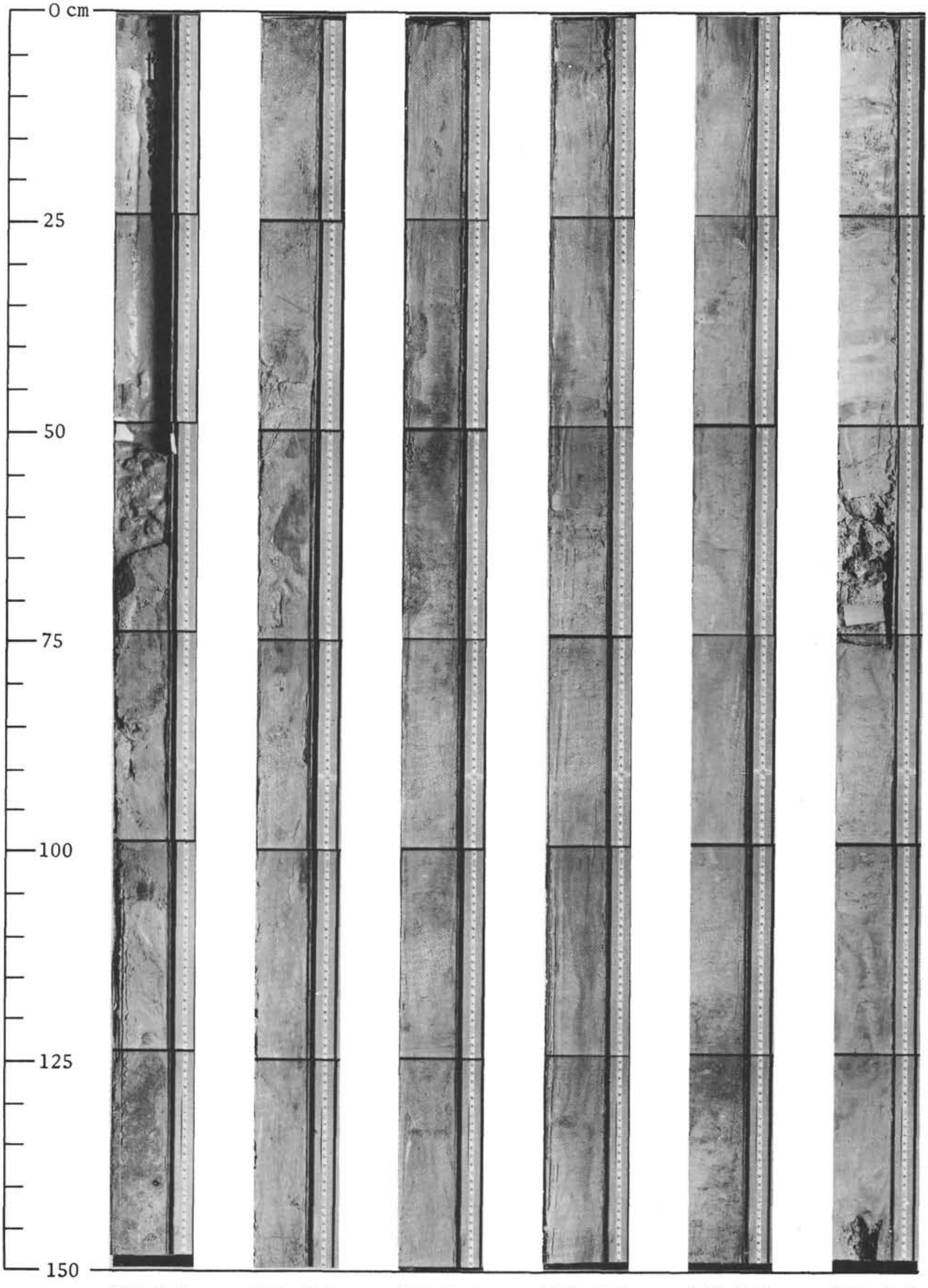
% CaCO$_3$ 0 50 100

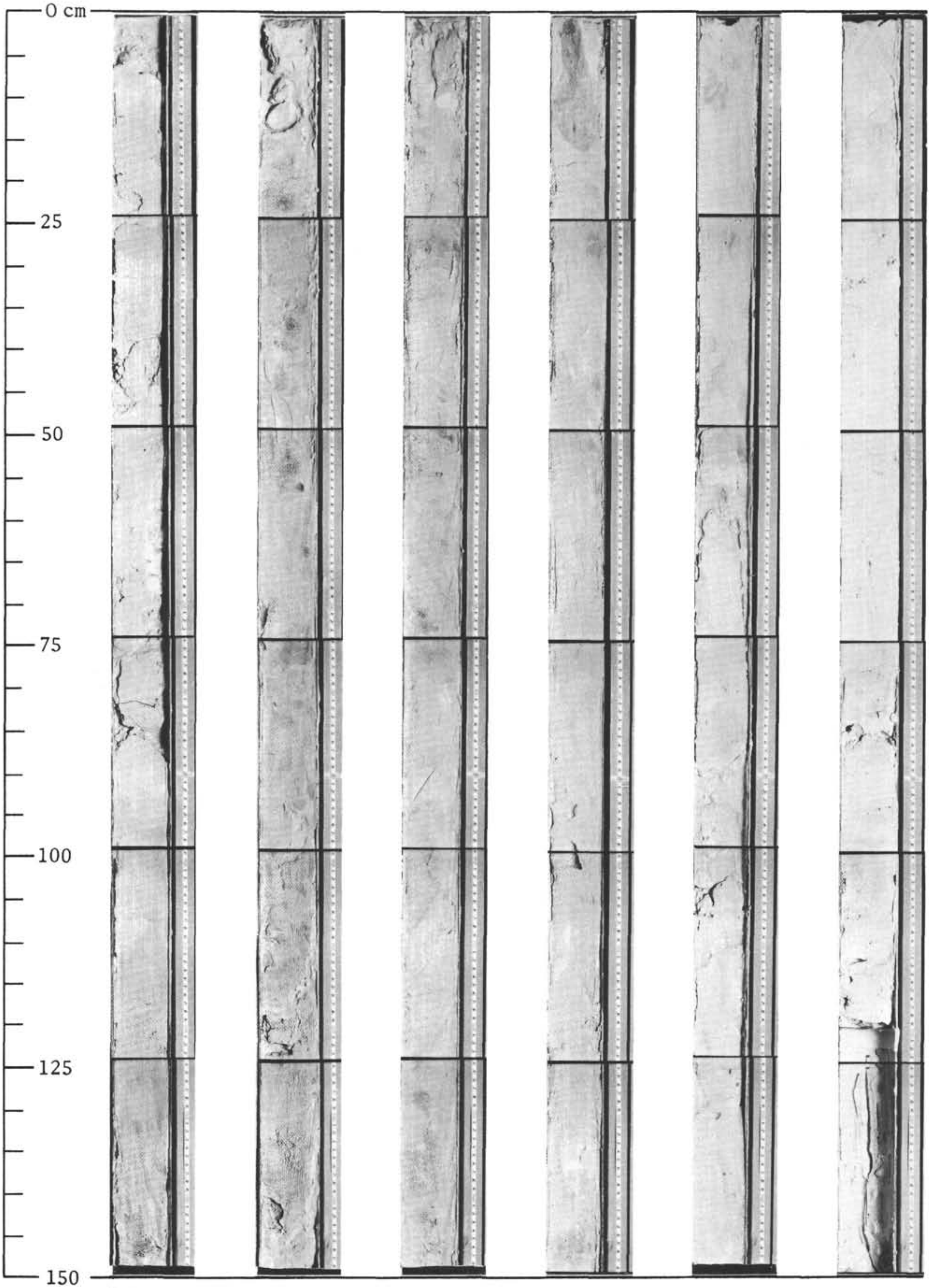

0 cm
25
50
75
100
125
150
160-1-1
160-1-2
160-1-3

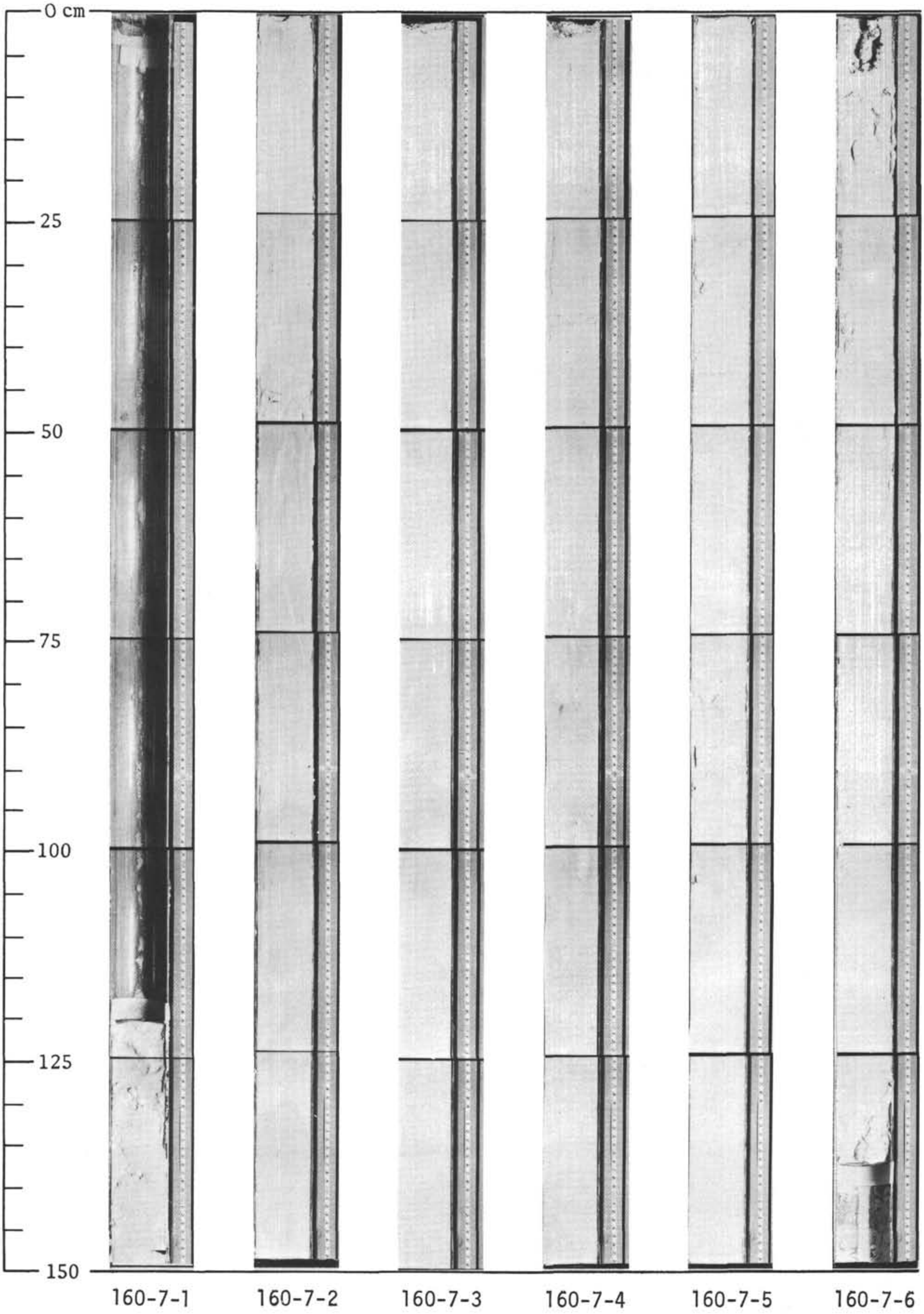

0 cm
25
50
75
100
125
150
160-2-1
160-2-2
160-2-3
160-2-4
160-2-5

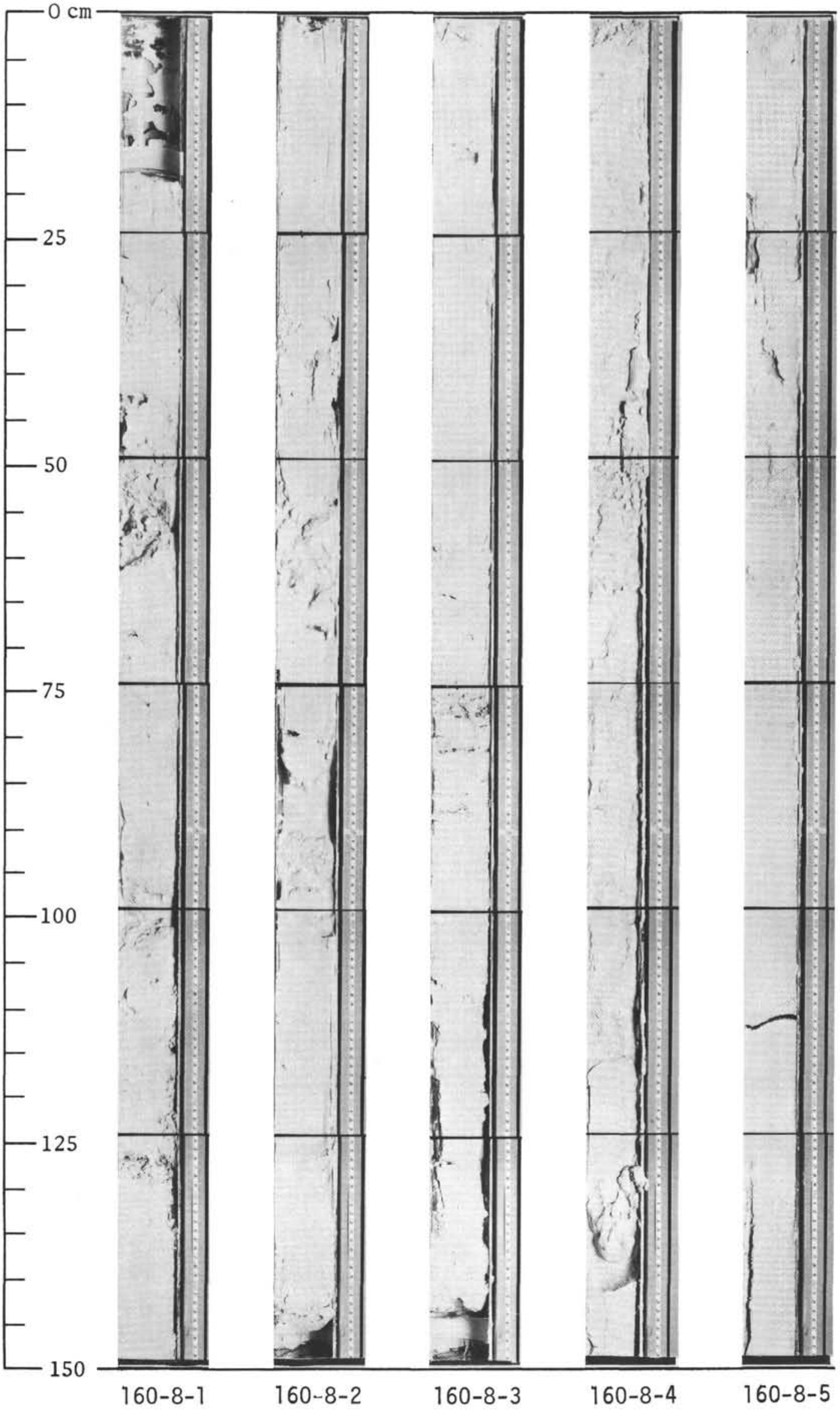

0 cm
25
50
75
100
125
150
160-3-1
160-3-2
160-3-3
160-3-4
160-3-5
160-3-6

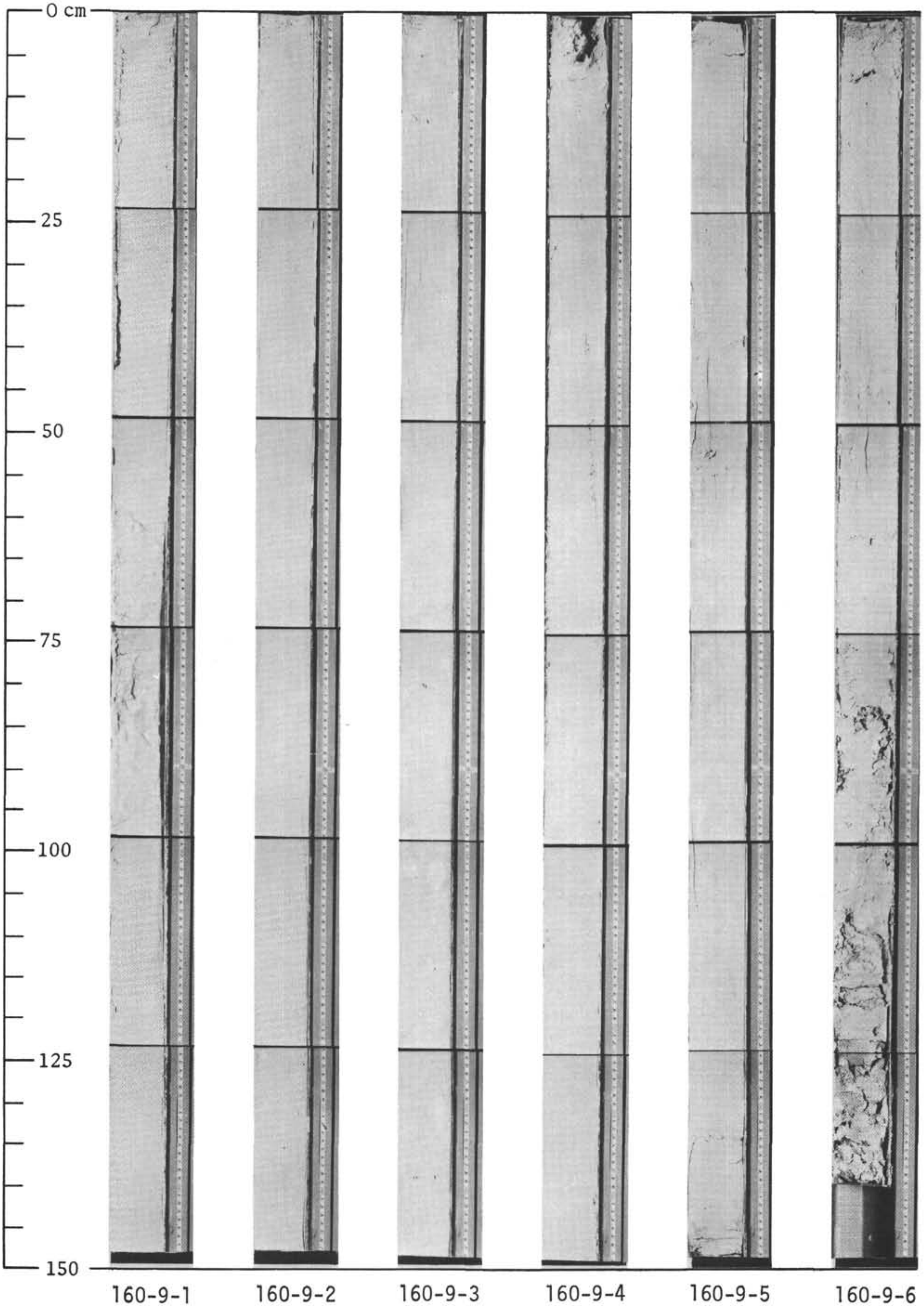

0 cm
25
50
75
100
125
150
160-4-1
160-4-2
160-4-3
160-4-4
160-4-5

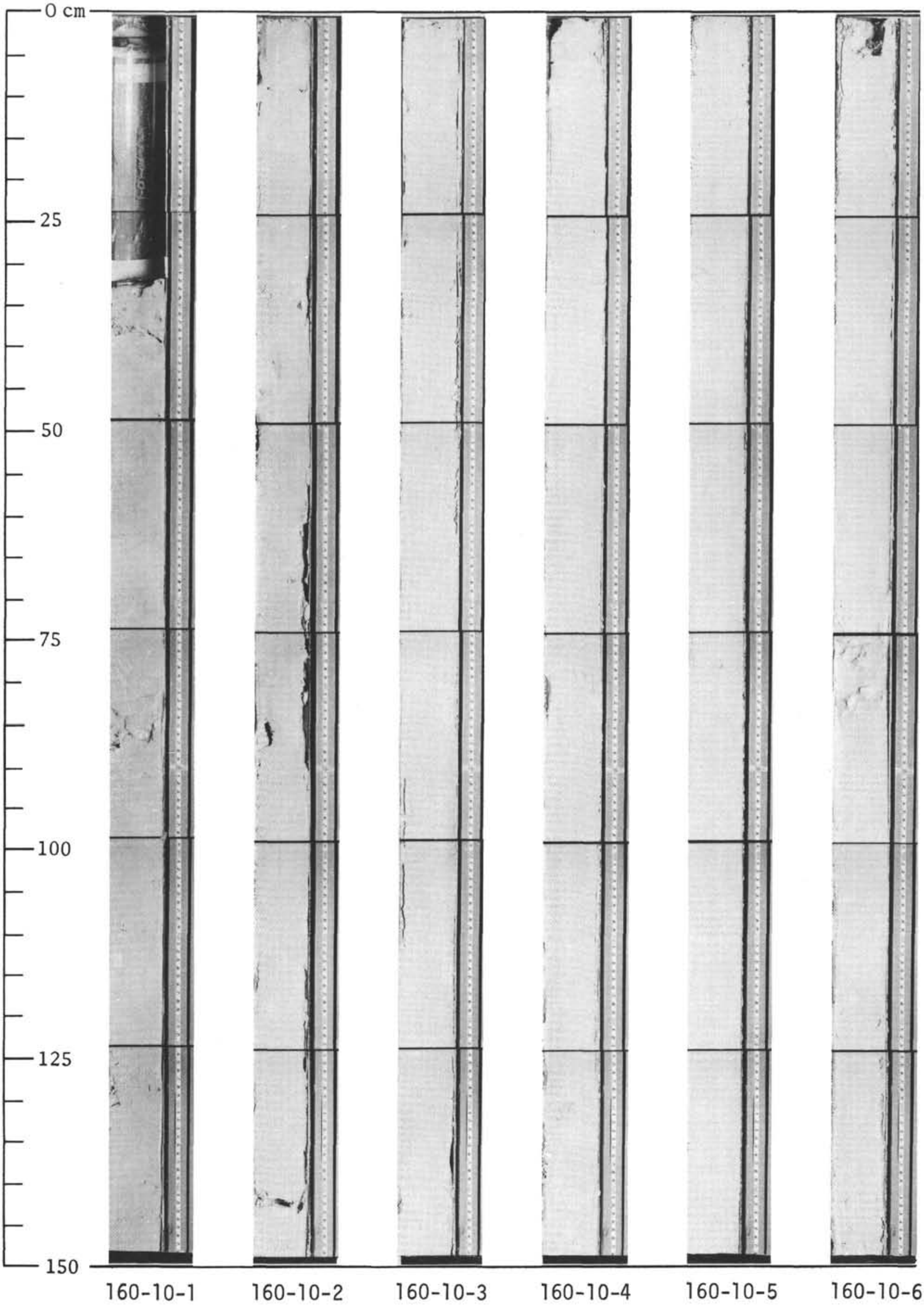

0 cm
25
50
75
100
125
150
160-5-1
160-5-2
160-5-3
160-5-4
160-5-5
160-5-6

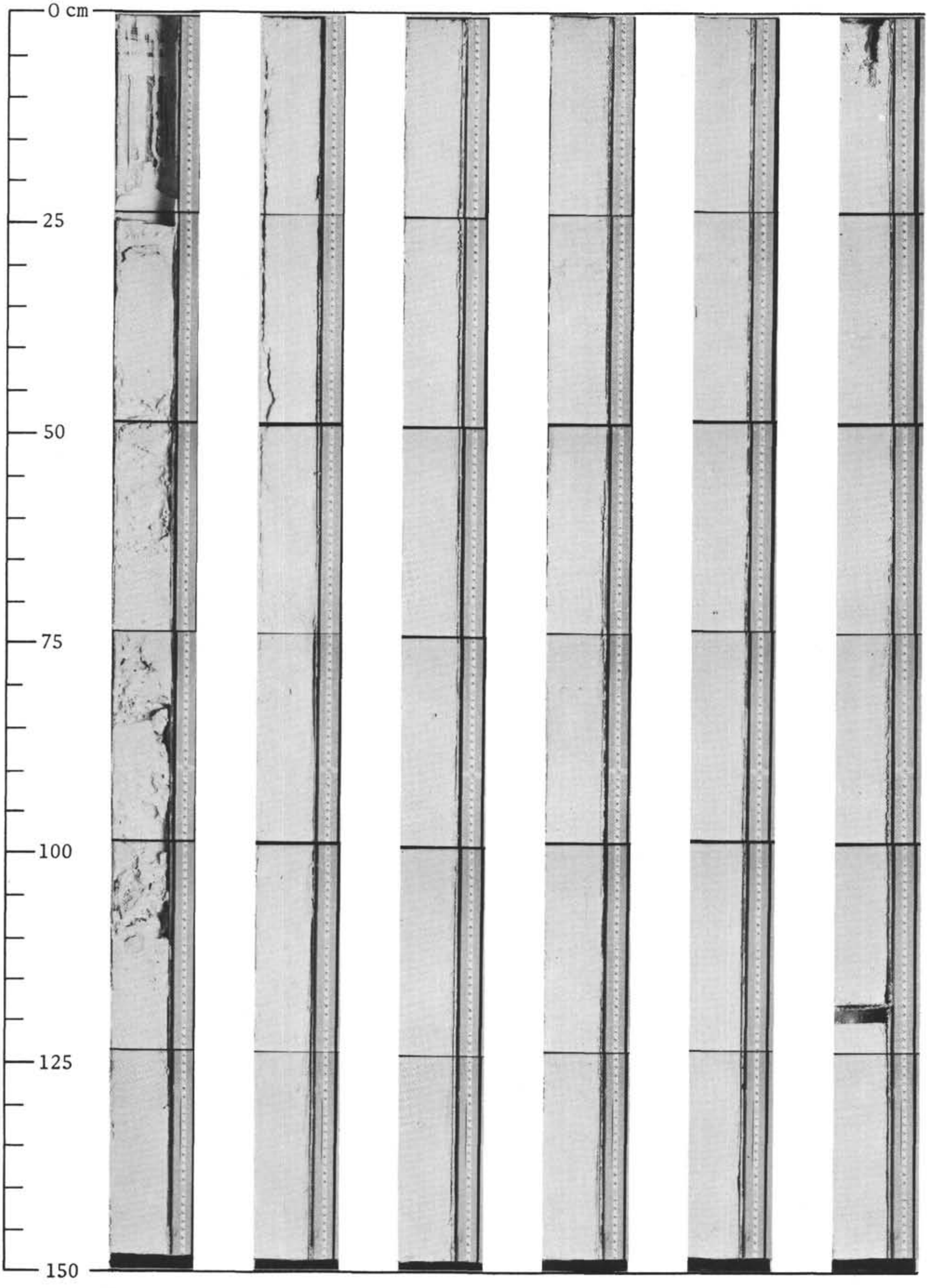

0 cm
25
50
75
100
125
150
160-6-1
160-6-2
160-6-3
160-6-4
160-6-5
160-6-6

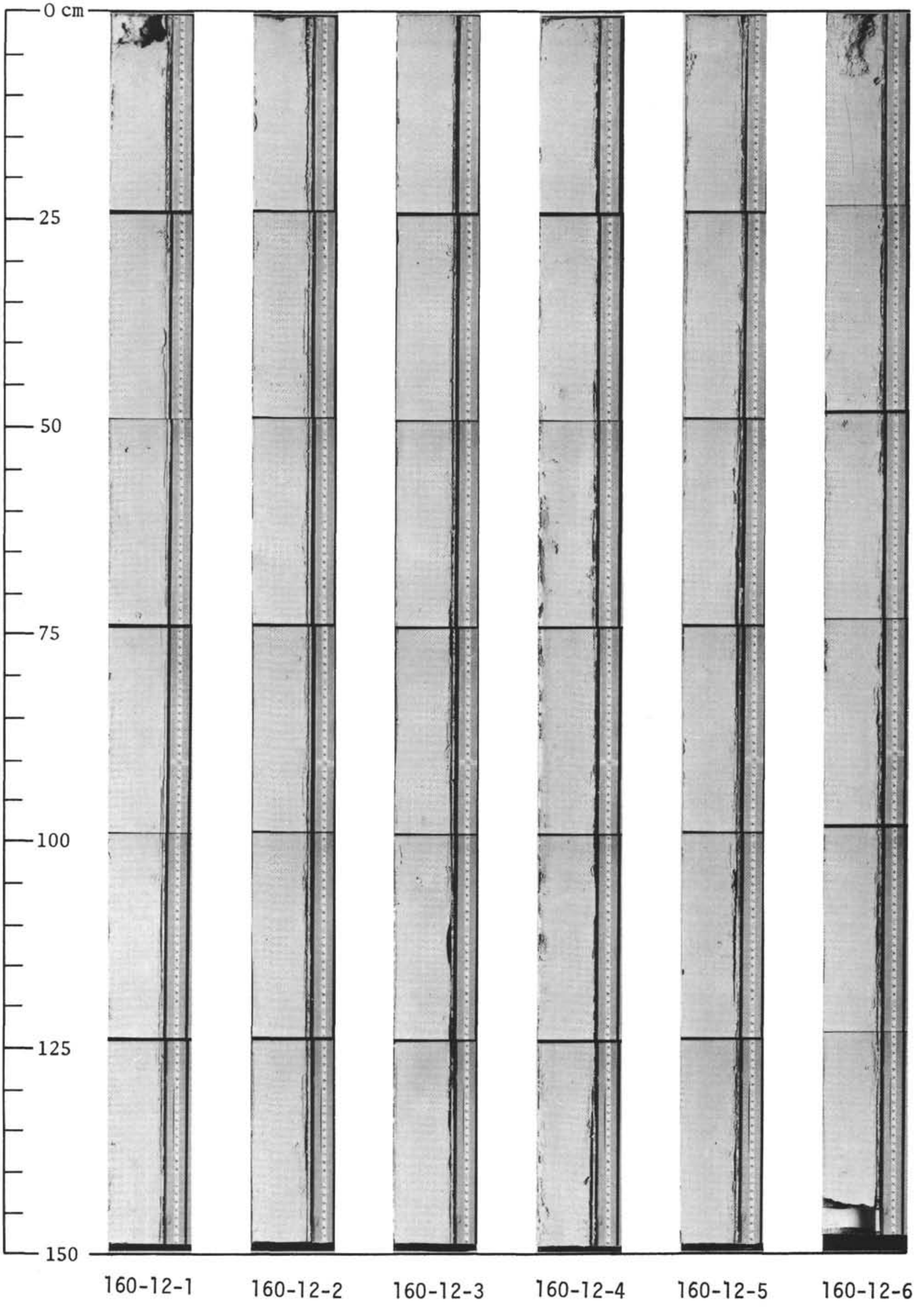

0 cm
25
50
75
100
125
150
160-7-1
160-7-2
160-7-3
160-7-4
160-7-5
160-7-6

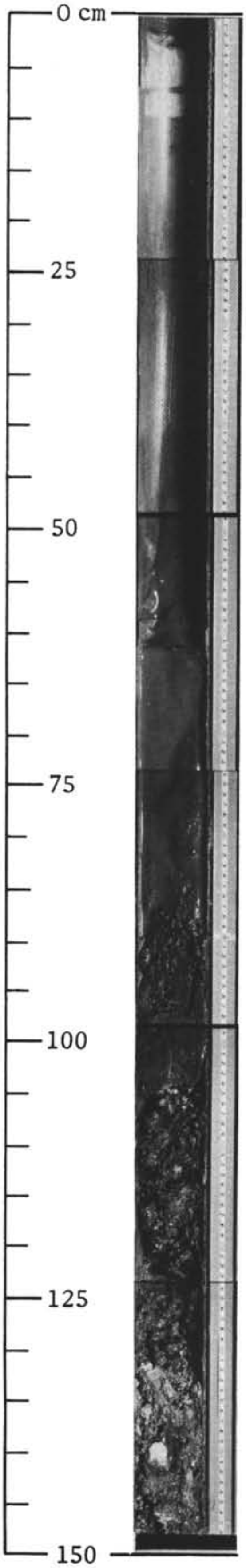

0 cm
25
50
75
100
125
150
160-8-1
160-8-2
160-8-3
160-8-4
160-8-5


0 cm
25
50
75
100
125
150
160-9-1
160-9-2
160-9-3
160-9-4
160-9-5
160-9-6


0 cm
25
50
75
100
125
150
160-10-1
160-10-2
160-10-3
160-10-4
160-10-5
160-10-6


0 cm
25
50
75
100
125
150
160-11-1
160-11-2
160-11-3
160-11-4
160-11-5
160-11-6


0 cm
25
50
75
100
125
150
160-12-1
160-12-2
160-12-3
160-12-4
160-12-5
160-12-6



160-13-1