2. SITE 146/149

The Shipboard Scientific Party[1]

Position:
146: 15°06.99′N, 69°22.67′W
146A: 15°06.99′N, 69°22.74′W
149: 15°06.25′N, 69°21.85′W.

Water Depth:
146: 3949 meters
146A: 3949 meters
149: 3972 meters.

Penetration:
146: 762 meters
146A: 105 meters
149: 390 meters.

Recovery:
146: 145.6 meters (19%)
146A: 4.6 meters (4.8%)
149: 239.9 meters (57%).

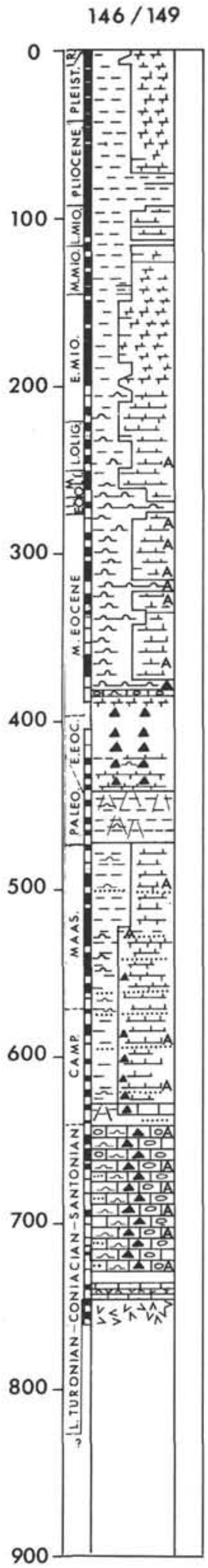
ABSTRACT

Sites 146 and 149 were drilled within 2 km of each other in the central Venezuelan Basin and are discussed as one site.

At Site 149 oozes and chalks of the Cenozoic were cored to 382 meters where hard limestones and cherts of Horizon A″ were encountered (406 m at Site 146). The Early (?) Eocene to early Early Miocene sediments are characterized by abundant Radiolaria.

At Site 146 sediments below Horizon A″ were cored to Horizon B″, identified as dolerite sills intruded into Coniacian limestones. Cherts and limestones of the Early (?) Eocene overlie noncalcareous Paleocene claystone. The Campanian and Maestrichtian pelagic marl and chalk contrast with the varied lithology of the Santonian which consists of silicified radiolarian limestone, with intercalated basaltic ash, carbonaceous layers, and radiolarian sands.

The upper contact of dolerite with the overlying sediment was not recovered, but the lower contact with an underlying limestone 0.5 meter thick showed a chill zone about 2 cm thick. The upper contact of the underlying sill was also not recovered.



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BACKGROUND

The central Venezuelan Basin was selected for the location of the drill site planned for the recovery of the oldest sediment in the Caribbean Sea. This basin lent itself to this particular objective because, despite the fact that it is surrounded by lands, islands, and ridges, terrigenous sediments are restricted to bathymetric depressions adjacent to sediment sources. As a result, the major part of the basin apart from the small abyssal plains in the deeper regions is blanketed with a uniform cover of acoustically transparent (pelagic) sediments, quite unlike the thick stratified (abyssal plain) sediments of the Colombian Basin west of the Beata Ridge.

The pelagic sediments are about 0.8 to 0.9 sec (reflection time) thick and are characterized by subbottom reflectors, Horizons A″ and B″ (Ewing et al., 1967, 1968, 1971; Edgar et al., 1971). Horizon A″ was identified as an early Eocene chert from examination of piston cores recovered from a fault escarpment on the eastern flank of the Beata Ridge (Talwani et al., 1966; Edgar, 1968). Drilling in the Venezuelan Basin on Leg 4 also recovered chert at the level of Horizon A″ and demonstrated the great areal extent of the chert layer.

Horizon B″ is a smooth reflector that is similar to sedimentary layers or igneous rock in certain parts of the Pacific (Horizon B′) and areas of the Atlantic near inactive continental margins (Horizon B′) but quite unlike the typical Atlantic acoustic basement or Layer 2. Seismic refraction studies indicated compressional wave velocities through the layer below B″ that range from 3.2 to 5.5 km/sec (Edgar et al., 1971). Rarely did the seismic reflection records show any reflections below B″ using standard oceanographic seismic techniques, but processed reflection data collected by Gulf Oil Company's *Gulfrex* (Eaton and Driver, 1969) clearly indicated layered structure below B″ in the central Venezuelan Basin.

Site 29 of Leg 4 (Bader, Gerard et al., 1970) was drilled near the central part of the Venezuelan Basin at a point at which the thickness above Horizon A″ was less than the maximum. The objectives of this site had been to obtain sedimentological information relevant to the history of the Caribbean and to recover an essentially complete Cretaceous and Tertiary biostratigraphic sequence. The drilling was terminated at Horizon A″, which was thought to correspond to unconsolidated radiolarian ooze overlying chert of middle Eocene age, after several unsuccessful attempts had been made to penetrate it. Continuous coring of the site provided a good stratigraphic section for post-Horizon A″ time, but a considerable interval (including the entire Oligocene) was missing, and a high degree of solution diminished the biostratigraphic value of the fossil assemblages recovered (Figure 1).

The unrealized objective of Site 29 of recovering Cretaceous or older pelagic sediments in the central Venezuelan Basin remained the prime scientific objective for Site 146. The thickness of sediment between Horizons A″ and B″ implies a middle Mesozoic age for the latter, if accumulation rates have been fairly uniform (Edgar et al., 1971). A further indication that older sediments may be found in the Venezuelan Basin is the widespread occurrence of Early Cretaceous and local Jurassic volcanic rocks found in the island-arc systems of the eastern Greater Antilles and Lesser Antilles, which imply the existence of crust of at least that age on the inside of the arcs.

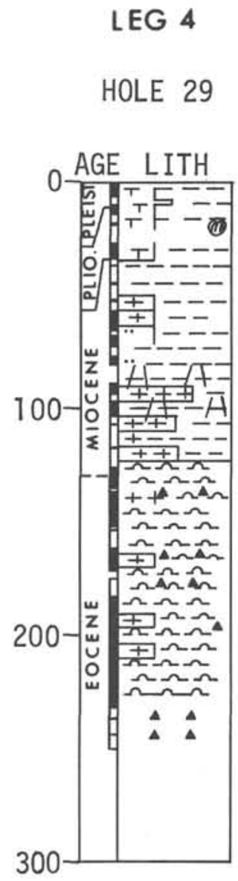

Figure 1. *Columnar section of Site 29, Leg 4, showing basic lithology recovered. Drilling was terminated in chert related to Horizon A″.*

Site 146/149 was located about 35 km north of Site 29 in shallower water (3949 m versus 4282 m) where the thickness of sediment above Horizon A″ was considerably thicker and, presumably, more calcareous and stratigraphically complete (Figures 2 and 3). The site was also in proximity to the *Gulfrex* seismic line that showed reflectors below Horizon B″. Two technological improvements available on Leg 15 which had not been available on Leg 4 were employed for deeper penetration. The first of these was an improved roller bit with tungsten carbide inserts for cutting through the chert and other brittle rocks. The other new capability was that of reentry, which had been tested previously but never used operationally. With this capability, a worn bit could be replaced and the drill string returned to the hole in order to continue drilling at the lowest depth reached by the first bit.

Previously obtained high quality seismic reflection records in the area (*Vema*-26 and *Gulfrex*, which had been the basis for Site 29) showed a uniform area of pelagic sedimentation and precluded the necessity for extensive site surveying by the *Glomar Challenger*. Figure 4 shows the

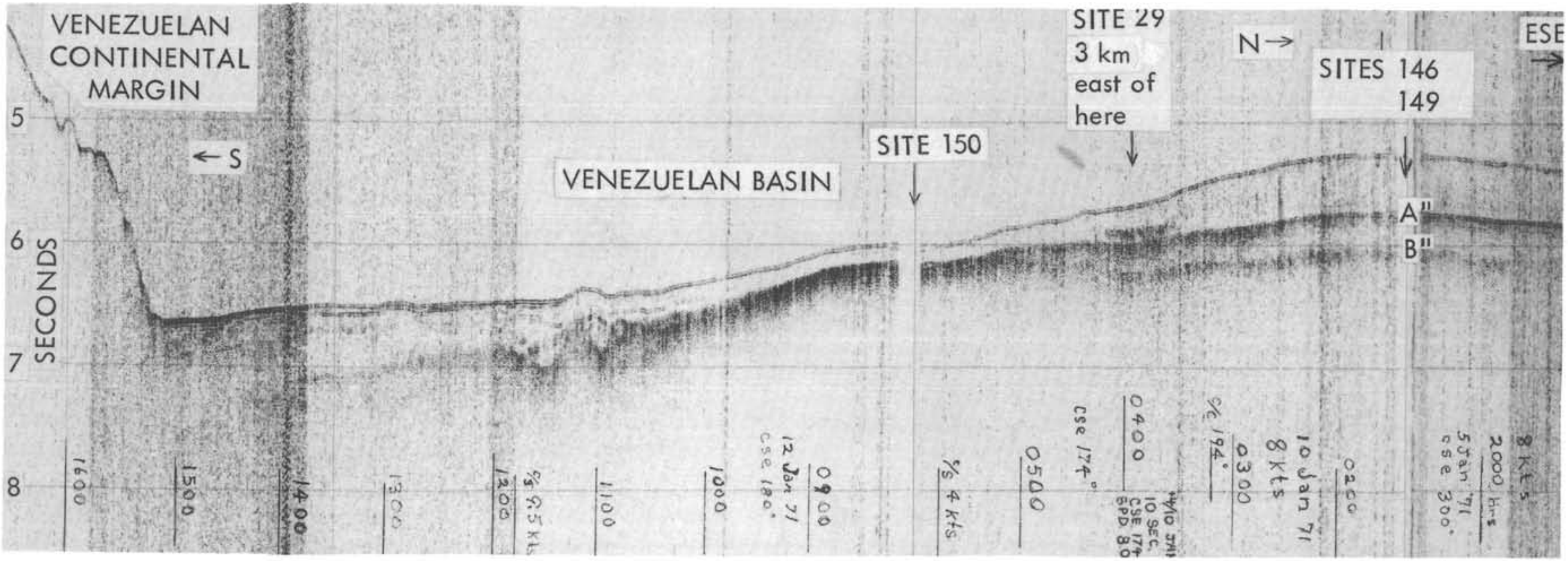

Figure 2. *Seismic reflection record made by* Glomar Challenger *from Site 146/149 to the Venezuelan continental margin and passing within 3 km of Site 29 and through Site 150. Pelagic sediment thickness at Site 146/149, typical for the Venezuelan Basin, then southward to a minimum at Site 150, then becoming thicker toward the abyssal plain at the foot of continental margin.*

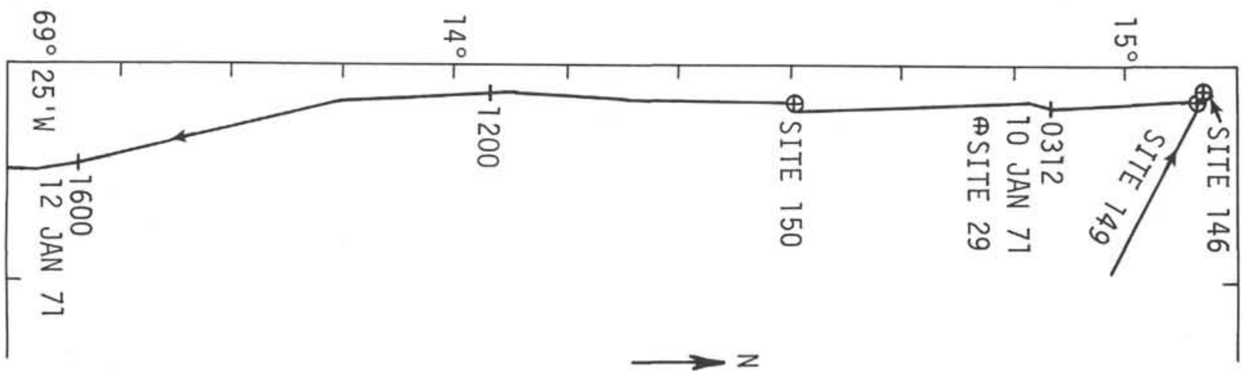

Figure 3. *Chart showing ship's track for reflection record in Figure 2.*

bathmetry in the area of Site 146/149 and Site 29, based on *Vema*-20 site survey (Bader, Gerard et al., 1970).

OBJECTIVES

Site 146/149 was the primary site on Leg 15, designed to recover a complete sequence of sediments from the Venezuelan Basin for lithologic and biostratigraphic studies and to determine the nature and age of Horizon B″. Penetration below Horizon B″ would have identified the nature and the age of sub-B″ layers that had been noted on the *Gulfrex* records.

OPERATIONS

The ship arrived on Site 146 (Figure 5) at about 0900 hours on 15 December. After dropping two beacons (the first had too weak a signal to be usable), the reentry cone was rigged and lowered over the port side in the manner that had proven successful during the reentry trials six months previously. However, after the cone had been lowered and filled with water (its large opening faced upwards), it was lifted momentarily out of the water by the roll of the ship in the 3 to 4 meter swell, broke its cable, and was lost. A second cone, this time oriented horizontally, was successfully launched at 1530 hours on 16 December and keelhauled into position amidships. Fifty meters of casing were lowered through the cone and secured to it. A 4-cone tungsten carbide bottom roller bit completed the bottom-hole assembly. The assembly was secured to a mechanical release mechanism in the cone (with the bit within the casing), the cone with its casing was freed from the ship, and the remainder of the drill string was made up in the conventional manner. When the casing reached the sea floor, it was washed into the soft upper sediments. With the cone on the sea floor, the release mechanism was actuated with a tool lowered on the sand line, the drill string was released from the cone, and drilling commenced on 17 December. Two spot cores were taken in the upper part of the section, at 96 and 254 meters, as drilling proceeded until the chert was encountered at 406 meters. Continuous coring began at the chert and continued to 701 meters through early Tertiary-late Cretaceous limestones, cherts, siliceous clays, and ash beds. Because the bit had reached 48-hours drilling time (nearly its total life expectancy), the decision was made, at 1000 hours on 21 December, to retrieve the drill string and change the bit rather than risk losing a cone from the bit in the hole. The drill string was reassembled and run down to the ocean floor by the afternoon of 22 December. An Edo rotating sonar transducer, which scans the ocean floor rather like a radar, was lowered into its position immediately beyond the opening of the bit. The ship was maneuvered to within 30 meters of the cone by tracking three sonar reflectors on the cone through the use of a cathode ray display on the bridge. An attempt was then made to position the drill string over the cone by moving it laterally with a jet of water pumped through the drill string and issuing through an opening near the bit. There was no detectable lateral movement and the decision was made to position the drill string by moving the entire ship. At 0658 hours on 22 December the bit was centered and the drill string lowered. Two successive cores (39 to 45 m and 96 to 100 m) were taken to confirm reentry, but the core barrels returned full of Pleistocene mud, indicating that the bit had missed the core and had started a new hole (146A). This core also showed no trace of the barite mud which had been pumped into the hole before withdrawal. With the realization that the reentry had failed, the drill string was withdrawn to the ship and the jetting device, which was believed to have interfered with water circulation, was removed. The drill string was reassembled and returned to the sea floor by 2100 hours on 24 December. The Edo transducer was lowered, returned for minor repairs, and lowered a second time. The second reentry attempt was successful at 0630 hours on 25 December. Drilling continued and the new bit cut an additional 61 meters of very hard sediments. Drilling terminated 16 meters into a dolerite sill, after penetration rates had slowed to 1 meter per hour. The drill string was withdrawn and the ship departed for Curacao at 1700 hours on 27 December to replace the reentry engineers with geochemists, who would be aboard for Sites 147, 148, and 149. On departure from Site 146 it was agreed that the vessel should return to the area with the geochemists to core the section overlying Horizon A″. Sites 147 and 148 were drilled before returning to complete the task (149).

Site 149 was approached in high seas during a four hour interval in which no acceptable satellite fix was obtained. By dead reckoning the site was located and later found to be within 1.5 km of Site 146 (Figure 6). Drilling commenced on 6 January and consisted of continuous coring down to the chert of Horizon A″. The uppermost six cores were taken with the extended core barrel and a smaller diameter liner. The remaining cores were cut with conventional core barrel. Drilling disturbance was moderate to severe and many of the cores contained large fractions of displaced, younger sediment. Two cores, 12 and 24, were cut while fresh water containing rhodamine dye was circulated to test the contamination of cores by drilling fluid. Parts of the cores were found to be completely saturated with dye when cut. Because many cores were stored for up to two days before cutting, the entrapped sea water and the ship's vibration turned these into a flocculent soup. Drilling was terminated late on 9 January and the ship was underway for Site 150 early on 10 January.

LITHOLOGY

The columnar section at Site 146/149 can be divided into seven major lithologic units. Two of these units are soft to semiconsolidated oozes that overlie Horizon A″; the remainder, lying below Horizon A″, are well consolidated to lithified.

The two ooze units are defined by the presence and absence of Radiolaria. The upper unit (0-198.5 m) is predominantly chalk and marl ooze and is divided into three subunits based on the carbonate content. The uppermost subunit (0-71.85 m) consists of foraminiferal nannoplankton chalk and marl ooze. Average carbonate decreases downward from approximately 50 down to 40 percent. Coarser fossil components are pteropods (upper 9 m only) and planktonic foraminifera, with minor micromollusks, echinoid spines, and benthonic foraminifera. Radiolaria occur very rarely near the top of the unit. Indeterminate black spots (hydrotroilite?) are conspicuous

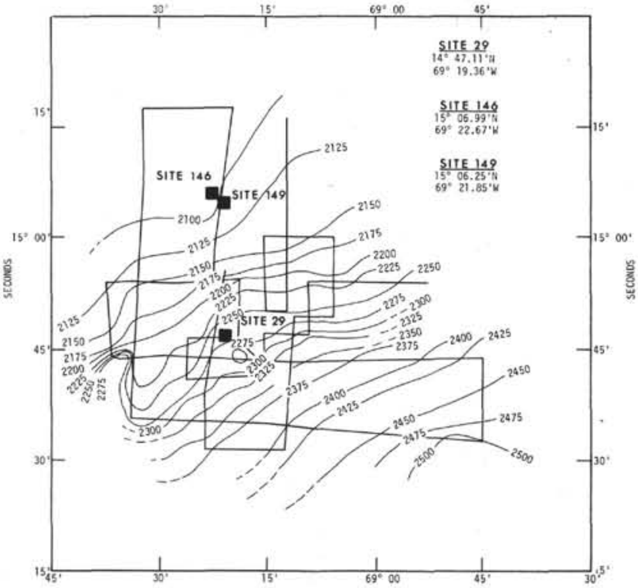

Figure 4. *Bathymetric chart of the region of Site 146/149 and Site 29 of Leg 4. Chart was prepared from a survey by the* Vema-26 *cruise. (Bader, Gerard et al., 1970).*

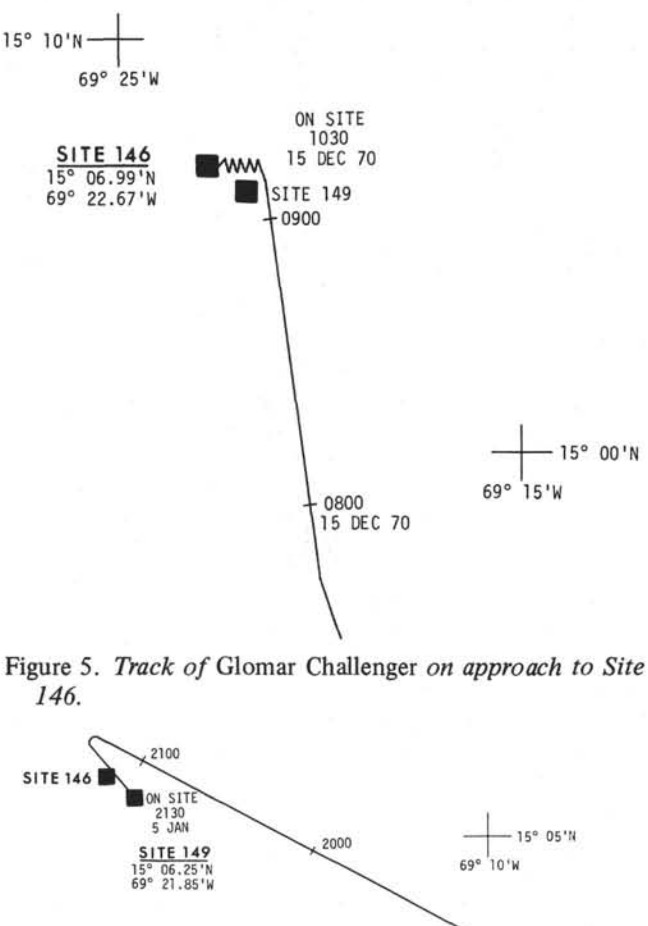

Figure 5. *Track of* Glomar Challenger *on approach to Site 146.*

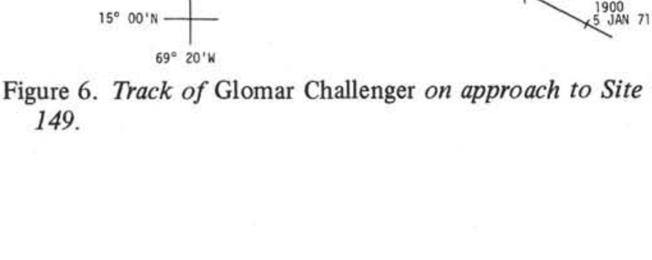

Figure 6. *Track of* Glomar Challenger *on approach to Site 149.*

in the lower part of the unit. Volcanic constituents, especially plagioclase and hornblende, are scarce but are found throughout.

A pelagic brown clay (71.85 to 96.45 m) underlies the uppermost subunit with a relatively abrupt upper contact. The clay has a negligible carbonate content, is brownish down to about 87 meters, and varicolored (gray, dark yellowish orange, and light brown) below this. Coarse constituents are limited to rare benthonic foraminifera, very rare and partly dissolved planktonic foraminifera, rare fish debris, and sparse volcanic minerals, especially plagioclase. Native copper was found in two places at about 75 and 85 meters; aggregation in the form of pellet-like shells and cylindrical tubes strongly suggests biological concentration of this element. Dolomite rhombs and anatase dipyramids (both a few microns in length) are persistent throughout this unit. Palygorskite and barite were found.

Below the clay subunit are interbedded clays, and calcareous clays and marl oozes (96.45-135.45 m). The top of this subunit is defined by the first occurrence (drilling) of carbonate below the clay subunit. The lower boundary is established at the first occurrence of chalk which coincides with the last occurrence of clay. The clay is mostly yellowish brown, firm, and contains K-feldspar and carbonate rhombs. The calcareous clays and marls are extensively mottled and contain plagioclase, apatite, and glauconite.

The lowermost subunit (135.45 to 198.50 m) of foraminiferal nannoplankton marl oozes and chalk oozes have been disturbed extensively by drilling which may, in part, be attributed to fresh water having been used for the drilling fluid during coring for the geochemical program. The carbonate content increases from the base of the overlying subunit to about 70 percent at 150 meters, then declines to about 50 percent at the base of the unit. The amount of carbonate fluctuates noticeably in units a fraction of a meter thick. Burrow mottling and black (iron-manganese?) spots are conspicuous in the marl layers. Planktonic foraminifera vary from strongly dissolved to well preserved, but in most instances show noticeable solution effects. Volcanic debris occurs throughout but increases downward, with plagioclase the most persistent element and glass and pumice appearing below 170 meters. The sediments of this unit are compacted to varying degrees but are nowhere lithified. Minor clinoptilolite was found by X-ray diffraction.

The first appearance of a siliceous fauna marks the top of Unit II, a semi-indurated calcareous radiolarian ooze and radiolarian nannoplankton chalk (198.50 to 382.50 m). The carbonate content of this unit fluctuates widely but, on the average, declines from about 70 percent at the top to about 40 percent near the base. Planktonic foraminifera are almost completely dissolved, but nannoplankton are common and generally well preserved. Volcanic constituents are abundant in this interval and ash beds (Figure 7) are conspicuous below 240 meters. Plagioclase is persistent and clino- and orthopyroxene, apatite, and red hornblende are found. Microtektites (this volume) were found in the core catcher of Core 31 (279 m). The unit can be subdivided into two subunits on the basis of sediment

Figure 7. *Radiolarian nannoplankton marl with distinct volcanic ash bed. Oligocene. (149-29-2, 113-125).*

components. The upper subunit (198.50 to 270.00 m) is a radiolarian-rich nannoplankton marl. The clay component decreases rapidly at the lower boundary and is essentially absent in the underlying subunit of radiolarian nannoplankton chalk. The only ash bed recovered above Horizon A″ at this site was found at about 250 meters (Figure 7). The first occurrence of chert is at 289 meters, which is 117 meters above the main chert layer comprising Horizon A″. Palygorskite was detected by x-ray diffraction in the three lowest cores.

The first occurrence of chert and limestone of Unit III was found at 382.50 meters at Site 149 but at 406 meters at Site 146. Consequently the exact depth of the contact between the second and third unit, which here identified with Horizon A″, is not clearly established. Volcanic clay is a minor component of this unit. Fresh glass and radiolaria are not found; cristobalite (replacements of radiolaria?), clinoptilotite, and montmorillonite comprise the clay units. Planktonic foraminifera are common in the chalk. Palygorskite was detected by x-ray diffraction at 422 meters. The lower boundary of the unit is defined by the presence of green siliceous claystone at 440.65 meters.

Beneath the chalk-chert sequence is a uniform, green siliceous claystone (449 to 477.25 m) which is markedly compacted, showing a conchoidal fracture and a tendency toward shaley fissility. This Unit (III) consists predominantly of cristobalite. Fossils are absent, except for cristobalite pseudomorphs after Radiolaria. Mottling is inconspicuous and flattened. X-ray diffraction showed rhodochrosite at 451 meters, palygorskite at 478 meters, and barite and clinoptilolite throughout.

The next lower major unit (V) is a varicolored nannoplankton chalk and marl sequence (477.25 to 630.30 m) that consists of interbedded neutral-colored chalks and varicolored (pinkish brown, brownish gray, etc.) marls. The average carbonate content increases downward from about 40 to about 80 percent. This unit is characterized by color contrasts and by the ubiquity of mottling and burrowing (Figure 8). Most of the burrows are subhorizontal, including horizontal chevron (*Zoophycos*) burrows, but many are vertical (*Teichichnus*), helicoid, or dendritic (*Chondrites*) in three dimensions. Interbedded sandy radiolarian layers, of possible local turbiditic origin, containing subordinate planktonic foraminifera, with sharp lower contacts and with or without grading, occur below 534 meters. In the marl layers radiolarians are absent and planktonic foraminifera present but badly preserved. Chert (Figure 9; Frontispiece) occurs at 557 meters (151 m below the main chert horizon). An occurrence of garnet (Donnelly and Melson, this volume), which may be authigenic, was noted at 517 meters. Lithification is moderate throughout this unit, increasing noticeably downward. The downward increase in carbonate distinguishes two subunits: brownish gray and olive gray marl (477.25 to 521.35 m), and a subunit of varicolored chalks (521.35 to 630.30 m) which is dominantly pinkish brown above, light gray in the middle, and pinkish gray below. Volcanic ash beds occur throughout this unit, but are more abundant downward. They contain a few volcanic crystals with exceptional beds that are rich in biotite, quartz, alkali feldspar, apatite, and zircon but are commonly almost pure montmorillonite. Barite is conspicuous throughout. Planktonic foraminifera are scarce and poorly preserved.

The next lower unit (VI) is radiolarian limestone (630.30 m to 721.00 m) which is characterized by a higher degree of lithification, more abundant cherts and ash layers, microfractures, and occurrences of pyrite. The carbonate content of this unit fluctuates widely between about 50 and 80 percent. The upper part is a fairly homogeneous, light gray limestone (630.30 to 692 m) and the lower part is a varicolored limestone with contrasting lithologies, including white radiolarian sands, very dark carbonaceous layers (Figure 10), and conspicuous ash layers. The organic-rich layers, restricted to the Turonian-Coniacian-Santonian, were analyzed for their organic carbon; the results are shown in Table 1. Sapropelite was defined by Olausson (1960) as a sediment containing more than 2.5 percent organic carbon; three of the samples analyzed classify as sapropelitic. Burrowing is conspicuous throughout (Figure 11), especially in the less carbonate-rich beds. X-ray diffraction shows minor barite, clinoptilolite, and palygorskite.

Immediately above the upper of two dolerites is a varied lithic subunit (721.00 to 738.30 m) differing from the overlying subunit in the presence of conspicuous graded beds of altered, greenish basaltic ash (Figure 12). The ash is interbedded with limestones and radiolarian sands (Figure 13), some graded like those in the above unit. Below this unit is an upper dolerite sill (738.30 to 739.63 m) whose upper contact was not recovered and whose lower contact is a chilled border about 2 cm thick. Below this dolerite is 0.5 meters of highly recrystallized limestone crowded with

Figure 8. *Nannoplankton chalk and marl showing a dark volcanic clay bed and pale chalk whose contrasting colors emphasize the extent of burrowing. Maestrichtian. (146-16-6, 9-35).*

Figure 9. *Radiolarian limestone showing sharp contact of replacement chert and limestone. Campanian. (146-28-3, 32-45).*

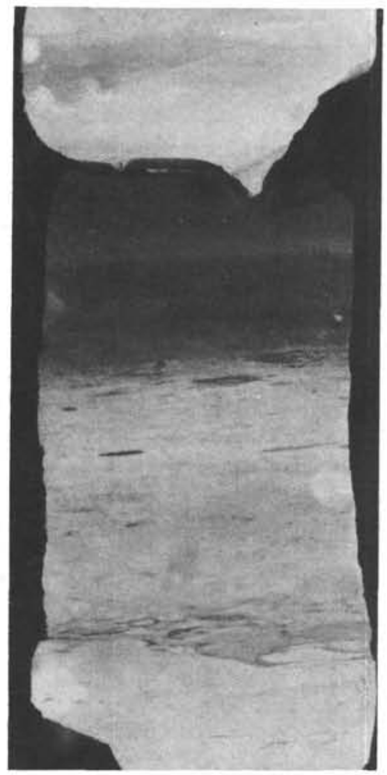

Figure 10. *Radiolarian limestone showing layer rich in organic carbon. Note flattened burrows. Turonian to Santonian. (146-38-1, 88-101).*

TABLE 1
Total Carbon, Organic Carbon, and $CaCO_3$ Per Cent for Samples Taken from Dark Carbonaceous Layer (Turonian to Santonian), Site 146

Sample	Total C (%)	Organic C (%)	$CaCO_3$ (%)
36R-2-87	8.1	2.5	48
36R-2-138	7.7	6.3	12
38R-1-106	14.5	11.2	28
39R-1-92	0.2	0.1	1

planktonic foraminifera. The limestone consists of calcite, a very well-crystallized montmorillonite, and some pyroxene (evidently metamorphic diopside).

The lower dolerite sill was penetrated from 740 to 762 meters; more than half of the drilled interval was recovered, but the upper contact was not. Grain size variations within the recovered material were minimal. The dolerite appears to be quite fresh and moderately fractured and only slightly veined.

PHYSICAL PROPERTIES

Wet-bulk Density, Water Content, and Porosity

Discussion

Wet-bulk density and porosity were measured by two methods aboard the *Glomar Challenger*: Gamma Ray Attenuation Porosity Evaluator (GRAPE) and individual sample volume-weight measurements (sample data are the enclosed dots on core and hole plots). Water content was determined by weight-weight relationships. These methods are described and discussed in Appendix I. In general, the data have a precision of ±5 per cent. The GRAPE data should be viewed with caution as it results from continuous diameter-scanning along the entire length of an unopened core which includes undisturbed sediment, disturbed sediment, and drilling slurries. The Appendix contains precautionary discussions concerning interpretation of these data and equations for diameter corrections for punch cores in the upper 45 meters of this site and for hard core samples which have a smaller diameter than the core liner.

Some stiff sediments or rocks are cored without plastic flowage of the sample and, since the drill bit has a smaller diameter than the core liner (2.60-in internal diameter), a space between the liner and the core results. The remaining space may be filled with a drilling slurry, highly disturbed sediment, or, in some cases, air. A problem arises here because a 2.60-inch diameter is assumed in the density calculation.

Where necessary the GRAPE data of Site 146 were adjusted (G.C.D. [GRAPE corrected diameter] data are the dotted density and porosity lines on the hole and core plots) for varying diameters of the core. Diameters are generally smaller than 2.60 inches by about 12% in cores recovered from 494 to 680 meters, 13 to 14% from 680 to 705 meters, respectively, 20% from 705 to 740 meters, and 14% from 740 to 760 meters.

Density adjustments for varying diameters in the data below 494 meters at Site 146 were made by observing the

Figure 11. *Burrowed limestone, with fish bone (lower center), recrystallized fossils, and flattened, highly organic burrows. Bar is 1 mm long. Turonian to Santonian. (146-36, CC).*

GRAPE data and determining the typical densities of the disturbed sediments or drilling slurries between the hard rock sample. The typical density was about 1.2 g/cc, but values ranged from 1.0 to 1.35 g/cc, except for air around the limestone and basalt cores at the bottom of Hole 146. However, this "slurry" density is for the most part an assumption, and the reader may wish to recalculate the data using other densities (the formula is in Chapter 13). Only maximum density trends and minimum porosity trends were recalculated (dotted lines in core and hole plots) as lesser densities and greater porosities are suspected of being drill-disturbed sediments, smaller diameters, or fractured rocks. These adjusted data are only approximations.

Results

In general, wet bulk densities irregularly increase (1.4 to 1.8 g/cc) then decrease (1.8 to 1.5 g/cc) between the surface and Horizon A″, while between Horizons A″ and B″, densities were about 2 g/cc (1.9 to 2.2 g/cc) with a slight decrease to 1.8 g/cc (1.8 to 2.3 g/cc) near Horizon B″. Horizons A″ and B″ were cored at 406 and 739 meters, respectively, at Site 146.

Wet bulk densities of the Tertiary calcareous ooze, marl, and clay above Horizon A″ irregularly increase from the surface value of 1.4 g/cc (76% porosity) to 1.6 g/cc (64%) at 10 meters, and then irregularly increase to approximately 1.8 g/cc (50%) at 200 meters. Below 200 meters, densities irregularly decrease to about 1.4 g/cc (68%) at 375 meters,

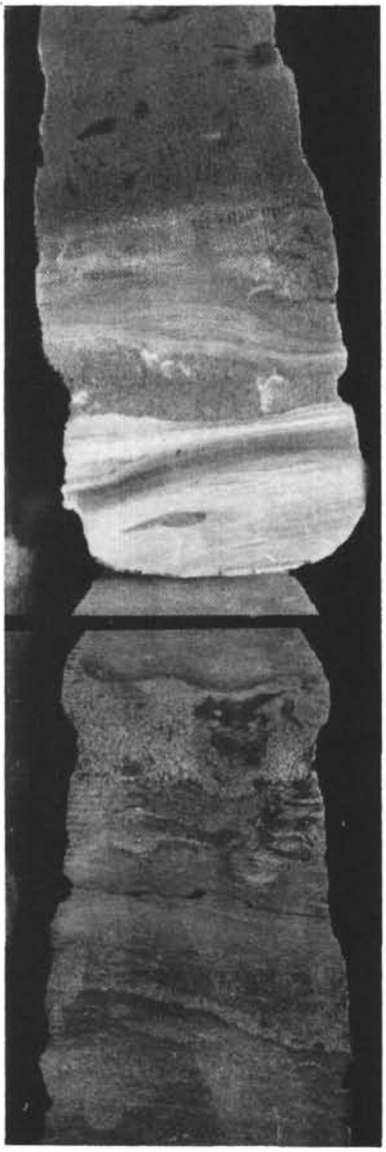

Figure 12. *Interbedded limestone, basaltic ash, and clay showing graded bedding, current scour, and flattened burrows. Turonian to Santonian. (146-39R-2, 65-84).*

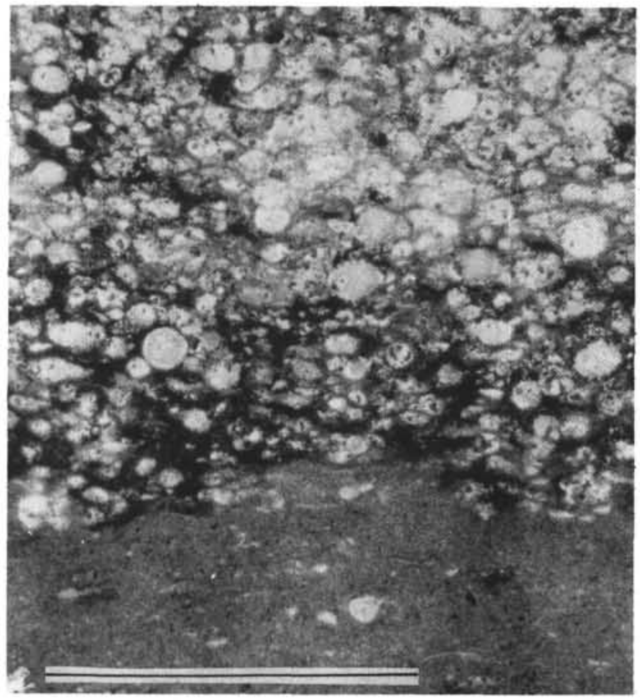

Figure 13. *Thin section showing radiolarian sand overlying clay with a sharply defined contact. No clear size grading is apparent in this section, but other radiolarian sands are graded. Bar is 1 mm long. Turonian to Santonian. (146-41R-1, 104-106).*

which corresponds with the occurrence of radiolarian ooze and radiolarian chalk. Also, below 362 meters, silicification and occurrences of chert become more common resulting in densities of about 2.1 g/cc.

Between Horizons A″ and B″ (406 to 739 m at Site 146), Cretaceous chalk, marl, and radiolarian limestone (and chert) have typical maximum densities of about 2 g/cc (40 to 20%) with a range from 1.9 to 2.3 g/cc (16%). Some chert nodules and layers have densities near 2.2 to 2.3 g/cc. The radiolarian limestone near Horizon B″ has a slightly lower density of 1.8 to 1.9 g/cc (range of 1.8 to 2.3 g/cc). The diabase which formed Horizon B″ has densities of 2.68 to 2.88 g/cc.

Porosity plots are slightly different from the density plots as the composition of the sediment or rock varies greatly. An example is opaline radiolarian tests, which are very light weight (2.2 g/cc) and have a very delicate, fine structure, versus the heavier calcite (2.7 g/cc) foraminifer tests or nannofossil plates. Therefore siliceous and calcareous sediments may weigh the same but have different porosities.

As a generality, porosity between the surface and Horizon A″ varies irregularly between 44 and 70%, decreasing then increasing with depth. Between Horizons A″ and B″ porosity varies irregularly (8 to 42%) but appears to decrease from about 36 to 22%. Some chert nodules and thin layers are hard and dense with essentially zero porosity.

In more detail, porosities in the Tertiary sediments above Horizon A″ decreased from 76 to 65% from zero to 10 meters depth and from 65% to 45 to 50% within 10 to 200 meters depth. These sediments are chalks and chalk ooze, marl and marl ooze, and clays. However, porosities in radiolarian-rich chalks and oozes from 200 to 375 meters increased from 50% to 65% respectively.

The Cretaceous sediments and rocks between Horizons A″ and B″ typically have a porosity of 36% between 495 and 577 meters. Below 577 meters, porosity irregularly varies (9 to 42%; 0% for chert nodules and layers), but generally decreases to about 22 to 32% at 660 meters depth, and then typically increases to 36% (with a low of 12%) at 720 meters. The porosity between Horizons A″ and B″ inversely correlates with the sound velocity (see section on Sound Velocity for Plot of Porosity).

Water contents varied irregularly between the surface and Horizon A″. They ranged from 53 to 28% at the surface. From 10 to 200 meters below the sea floor, water contents irregularly decrease from 42 to 30%, while from 200 to 300 meters they increase irregularly to about 50%. This increase appears to be related in part to the radiolarian content of the sediment. In general, sediments containing radiolarians have lower densities and higher porosities and water contents than comparable calcareous sediments.

Sound Velocity

Introduction

Velocities at which sound travels through sediment and rock core samples were measured by the Hamilton Frame technique, which is discussed in Appendix I. This method has a precision of ±1.1 percent.

These measurements were taken several days after the cores were split; however, the sediments were stored in sealed D-tubes containing wet towels and refrigerated (2-5°C) in a humid atmosphere to minimize moisture loss. If these sediments or rocks lost pore water, then their measured velocities would be significantly lower (10-20%) than velocities obtained from other seismic data; however, the data are in good agreement.

Only sediments and rocks which appeared to be physically undisturbed had velocity measurements made. These velocities were measured parallel to the bedding planes, unless otherwise noted in the tables, and are reported at laboratory pressures and temperatures (21.6 to 25.8°C; Table 2).

Results

Sound velocities measured at Site 146 range from 1.51 to 5.34 km/sec. Clay and chalk ooze in the upper part of the hole (98-103 m and 254-263 m) have typical velocities of 1.51 and 1.63 km/sec, respectively, while the lithified clays, chalks, marls, and radiolarian limestone in the lower part of the hole have typical velocities ranging from 1.95 to 2.95 km/sec. Velocities in reddish brown chert fragments range from 4.70 to 5.34 km/sec with an average of 5.09 km/sec. A diabase sample from a sill at 739 meters below the sea floor propagated sound at 4.86 km/sec.

Velocities were measured parallel and perpendicular to the bedding planes of Oligocene and Cretaceous samples. Oligocene, light gray radiolarian nannofossil chalk ooze recovered from 262 meters has velocities of 1.57 and 1.58 km/sec perpendicular and parallel to the bedding, respectively, while Maestrichtian light gray nannofossil chalk from 522 meters has velocities of 1.90 km/sec parallel to the bedding and 1.81 km/sec perpendicular to the bedding. These two spot checks are not sufficient data to draw any definite conclusions.

Discussion

Major lithologic sections were stratigraphically distinguished by their relative and uniform velocity differences. Average velocities were calculated for these sections, but velocities for the chert nodules (or layered fragments) were not averaged in these groupings as it is not known what thicknesses of the chert are in situ, and they might thus skew the average from the modal velocities (Figure 14). The sound velocity-stratigraphy is displayed in Table 3.

In general, velocity variations correlated with different lithologic sections as defined by the geologists, except in the bottom of the hole where velocities were controlled less by sediment type and more by cementation.

According to averaged core velocities, air-gun records, and drilling rates, the reflector Horizon A″ appears to be the hard rock (foraminiferal nannofossil chalk and chert) at 406 meters (at Site 146) below the sea floor and the reflector Horizon B″ is probably the diabase at 739 meters depth. It seems unusual that there were not other reflectors between Horizon A″ and Horizon B″, where varying velocities were recorded. It is possible that such zones would be reflectors with differing reflection frequencies, and it is also possible that these velocity changes in situ are in part gradational.

The sedimentary section above Horizon A″ (0-406 m at Site 146), calculated from the seismic reflection travel time and drilled depth, has an average velocity of 1.60 to 1.65 km/sec, which is in agreement with the meager laboratory sound velocity data in this section. From the laboratory sound velocity data the section between Horizons A″ and B″ has an average velocity of 2.44 km/sec (not including chert). This average velocity agrees with the average velocity of 2.47 km/sec (including chert) obtained from the seismic air-gun reflection times from Horizons A″ and B″ and their drilling depths.

The dolerite velocity of 4.86 km/sec is in good agreement with J. Ewing's (personal communication) sonobuoy data (Figure 14) and with previous refraction data. A summary of previous refraction and wide-angle reflection data is presented in Edgar et al (1971).

Considering the precision of all the data involved, it seems unusual that the data agree so well, and, therefore, the following discussion of their agreement and the following manipulation of data may not be warranted but is of interest.

If it is assumed that there is a 3- to 4-meter cumulative thickness of chert between Horizons A″ and B″, then the sample velocity data would theoretically match Edgar's air-gun-derived velocity for this section of 2.47 km/sec. In order to match Ewing's sonobuoy sound velocity average between A″ and B″ of 2.59 km/sec, which was taken 6 miles to the north (15°20′N, 69°50′W), the shipboard laboratory velocity data would have to include about a 15-meter section of chert, which does not seem probable at Site 146. Of course Ewing's geologic section may not be identical to the one at Site 146 (facies may change rapidly as suggested by Site 150), and factors such as temperature and pressure must be taken into consideration.

Negative temperature corrections would be significant in the high-porosity surficial sediments where the bottom water is about 4°C, but below here, the temperature would increase with depth. However, these negative corrections would be counterbalanced by positive corrections resulting from increasing pressure (and decrease in porosity), which is about 395 bars at the sea floor at Site 146 and 455 bars at Horizon A″.

In general one would expect in situ sound velocities to be higher because of pressure corrections. At Site 146, pressures at Horizons A″ and B″ would be about 455 and 530 bars, respectively (calculated from sample densities).

TABLE 2
Hamilton Frame Sonic Velocities, Site 146

Core	Section	Upper Interval[a] (cm)	Depth in Hole (m)	Velocity[b] (m/sec)	Temperature (°C)	Remarks
1	1	125.0	97.25	1511	24.8	Clay.
1	2	95.0	98.45	1527	24.8	Clay.
1	3	25.0	99.25	1482	25.4	Clay.
1	3	25.0	99.25	1467	25.8	Clay.
1	4	95.0	101.45	1501	24.8	Clay.
1	6	101.0	104.51	1539	24.9	Clay.
2	4	54.0	259.04	1623	23.8	Foram nanno chalk ooze, clay and rad.-rich.
2	4	85.0	259.35	1678	23.5	Foram nanno chalk ooze, clay and rad.-rich.
2	5	90.0	260.90	1574	23.5	Nanno chalk ooze, with radiolarians.
2	6	54.0	262.04	1577	23.5	Nanno chalk ooze, with radiolarians.
2	6	75.0	262.25	1563	24.7	Nanno chalk ooze, with radiolarians.
5	1	25.0	422.25	2140	24.5	Foram nanno chalk, clay-rich.
5	1	60.0	422.60	1702	24.5	Foram nanno chalk, clay-rich.
5	2	96.0	424.46	5216	25.5	Chert, brown.
5	1	96.0	424.46	5345	25.5	Chert, brown.
5	1	100.0	414.50	1928	25.5	Foram nanno chalk, clay-rich.
6	1	63.0	431.63	1928	25.1	Foram nanno chalk.
6	7	0.0	440.00	2025	24.1	Foram nanno chalk.
7	1	25.0	440.25	3198	24.3	Foram nanno chalk (light).
7	1	60.0	440.60	2477	25.3	Siliceous claystone (dark).
7	1	131.0	441.31	2697	24.3	Siliceous claystone.
8	1	96.0	449.96	2251	24.2	Siliceous claystone.
3	1	78.0	451.28	1927	24.2	Siliceous claystone.
9	1	64.0	458.64	2033	24.2	Siliceous claystone.
9	2	55.0	460.05	2225	24.2	Siliceous claystone.
10	2	76.0	469.26	1977	24.2	Siliceous claystone
11	1	107.0	477.07	2158	24.2	Siliceous claystone.
11	2	22.0	477.72	1768	23.5	Nanno marl.
11	2	75.0	478.25	1693	23.5	Nanno marl.
13	1	100.0	495.00	1869	23.5	Foram nanno marl, reddish gray.
13	2	18.0	495.68	1806	23.5	Foram nanno marl, gray, burrowed.
13	3	125.0	498.25	1808	22.8	Foram nanno marl, light gray.
13	4	20.0	498.70	1815	22.2	Foram nanno marl, gray.
13	4	90.0	499.40	1834	22.8	Foram nanno marl, reddish gray.
13	5	35.0	500.35	1832	22.2	Foram nanno marl, reddish gray.
14	1	110.0	504.10	2502	22.2	Foram nanno marl, gray.
14	2	38.0	504.88	1921	22.2	Foram nanno marl, light gray.
14	3	78.0	506.78	1961	22.2	Foram nanno marl, gray.
14	4	78.0	508.28	2045	22.2	Foram nanno marl, gray.
15	1	132.0	513.32	1998	22.2	Nanno marl, gray with light gray band.
15	2	9.0	513.59	2064	21.8	Nanno marl, light gray.
15	3	0.0	515.00	1957	21.8	Nanno marl, light gray.
15	4	8.0	516.58	2015	21.6	Nanno marl, light gray.
15	5	15.0	518.15	2027	21.6	Nanno marl, gray.
15	6	60.0	520.10	1831	21.8	Nanno marl, light gray.
16	1	119.0	522.19	1903	21.8	Foram nanno chalk, light gray.
16	1	119.0	522.19	1809	21.8	Foram nanno chalk, perpendicular to bedding.
16	2	120.0	523.70	1916	21.8	Foram nanno chalk, gray.
16	3	144.0	525.44	2116	21.8	Foram nanno chalk, light gray.
16	4	76.0	526.26	1515	22.1	Waxy volcanic clay, low density.
16	5	65.0	527.65	1969	22.1	Foram nanno marl, gray.
16	6	101.0	529.51	1931	22.1	Foram nanno marl, gray.
17	1	84.0	530.84	1935	22.1	Foram nanno marl, gray.
17	2	52.0	532.02	1967	22.1	Foram nanno marl, gray.
17	3	128.0	534.28	2047	22.1	Foram nanno marl, gray.
17	4	25.0	534.75	1980	22.0	Foram nanno chalk, gray, bedded.
17	4	33.0	534.83	2059	22.0	Foram nanno marl, bedded.
17	5	48.0	536.48	2138	22.0	Foram nanno marl.
17	6	14.0	537.64	1812	22.0	Volcanic clay.
17	6	36.0	537.86	2014	22.0	Foram nanno chalk, light gray.

TABLE 2 – *Continued*

Core	Section	Upper Interval[a] (cm)	Depth in Hole (m)	Velocity[b] (m/sec)	Temperature (°C)	Remarks
18	1	30.0	539.30	1922	22.0	Foram nanno chalk, light gray.
18	2	70.0	541.20	2008	22.1	Foram nanno marl.
18	3	100.0	543.0	2059	22.1	Foram nanno marl, dark gray (bedded).
18	3	147.0	543.47	2290	22.1	Nanno foram chalk, silty, light gray.
18	4	37.0	543.87	1963	22.1	Foram nanno marl, dark gray.
18	4	78.0	544.28	2136	22.1	Foram nanno chalk, light gray.
18	5	146.0	546.46	2012	25.2	Foram nanno chalk, gray.
18	6	66.0	547.16	2102	25.2	Foram nanno chalk, gray.
19	1	102.0	549.02	2702	25.2	Nanno foram chalk, sandy.
19	2	28.0	549.78	2720	25.2	Nanno foram chalk, sandy.
19	3	87.0	551.87	2381	25.2	Foram nanno chalk, gray.
19	4	101.0	553.51	2204	25.2	Foram nanno chalk, gray.
20	1	7.0	557.07	1924	25.4	Foram nanno chalk, white, No. 3.
20	2	82.0	559.32	2000	25.2	Foram nanno chalk, gray.
20	3	62.0	560.62	1847	25.2	Foram nanno chalk, top, gray.
20	3	62.0	560.62	2227	25.2	Foram nanno chalk, bottom, white.
22	1	72.0	575.72	1963	25.2	Foram nanno chalk.
23	1	16.0	584.16	2128	25.6	Nanno chalk.
23	2	5.0	585.55	2061	25.6	Nanno chalk.
23	2	45.0	585.95	1816	25.8	Nanno chalk.
23	2	58.0	586.08	2182		
23	2	96.0	586.46	1815	25.6	Clay, volcanic, waxy.
23	3	4.0	587.04	1720	25.6	Clay, volcanic, waxy.
23	3	60.0	587.60	2217	25.8	Nanno chalk.
23	3	108.0	588.08	5179	25.8	Chert, grayish red.
23	3	108.0	588.08	2970	25.8	Silicified nanno chalk, very pale red.
24	1	63.0	593.63	2308	25.8	Nanno marl.
24	1	140.0	594.40	5086	25.8	Chert, brown.
25	2	84.0	604.34	2540	25.8	Nanno marl; bedding.
26	1	121.0	612.21	2072	24.2	Nanno chalk, reddish gray.
26	2	68.0	613.18	2953	24.2	Nanno chalk, hard, reddish gray.
27	1	89.0	620.89	4727	24.2	Chert, grayish red, waxy luster, conchoidal.
27	1	92.0	620.92	3141	24.2	Nanno limestone, white between chert.
27	2	71.0	622.21	3101	24.2	Nanno limestone.
27	2	130.0	622.80	4698	24.3	Chert, red.
27	2	130.0	622.80	4672	24.2	Chert, red.
28	1	138.0	630.38	3719	24.2	Radiolarian limestone, partly silicified, near chert.
28	2	96.0	631.46	2681	22.4	Radiolarian limestone, partly silicified.
28	3	40.0	632.44	5092	22.0	Chert, brown.
28	3	114.0	633.14	3386	22.0	Radiolarian limestone; partly silicified.
29	1	118.0	639.18	2510	22.0	Radiolarian limestone; partly silicified.
30	2	58.0	649.08	2581	22.5	Radiolarian limestone; partly silicified.
30	3	65.0	650.65	2661	22.0	Radiolarian limestone; partly silicified.
30	4	89.0	652.39	2766	22.0	Radiolarian limestone; partly silicified.
31	1	118.0	657.18	5116	22.0	Chert, red.
31	2	44.0	657.94	2777	22.1	Foram radiolarian limestone, partly silicified.
31	3	77.0	659.77	2624	22.1	Foram radiolarian limestone, partly silicified.
31	4	0.0	660.50	2454		
31	4	104.0	661.54	3162	22.1	Foram radiolarian limestone, partly silicified.
32	1	83.0	665.83	2666	22.1	Radiolarian limestone.
32	2	148.0	667.98	3203	22.3	Radiolarian limestone.
33	1	130.0	675.30	3344	22.3	Radiolarian limestone.
34	1	75.0	683.75	2859	22.3	Radiolarian limestone.
35	1	95.0	692.95	3043	22.1	Radiolarian limestone.
35	1	136.0	693.36	3813	22.3	Radiolarian limestone.
35	2	62.0	694.12	3257	22.3	Radiolarian limestone.
36	2	130.0	703.80	2662	22.3	Foram radiolarian limestone.
38	1	86.0	714.86	2706	22.3	Radiolarian limestone.
39	1	88.0	719.88	3689	22.3	Volcanic ash.
39	1	88.0	719.88	3647	22.3	Volcanic ash.

TABLE 2 – *Continued*

Core	Section	Upper Interval[a] (cm)	Depth in Hole (m)	Velocity[b] (m/sec)	Temperature (°C)	Remarks
39	1	136.0	720.36	3049	22.3	Volcanic ash, banded.
39	2	112.0	721.62	2883	22.1	Volcanic ash.
41	1	105.0	738.05	3082	22.1	Foram limestone.
41	1	140.0	738.40	4859	22.1	Diabase.

[a]Upper limit of a 3-cm sample interval.

[b]Velocities were measured parallel to bedding unless noted otherwise.

[c]The few samples whose velocity was measured through the core liner and where a "D"-shaped lucite block was used to obtain liner thickness and travel time.

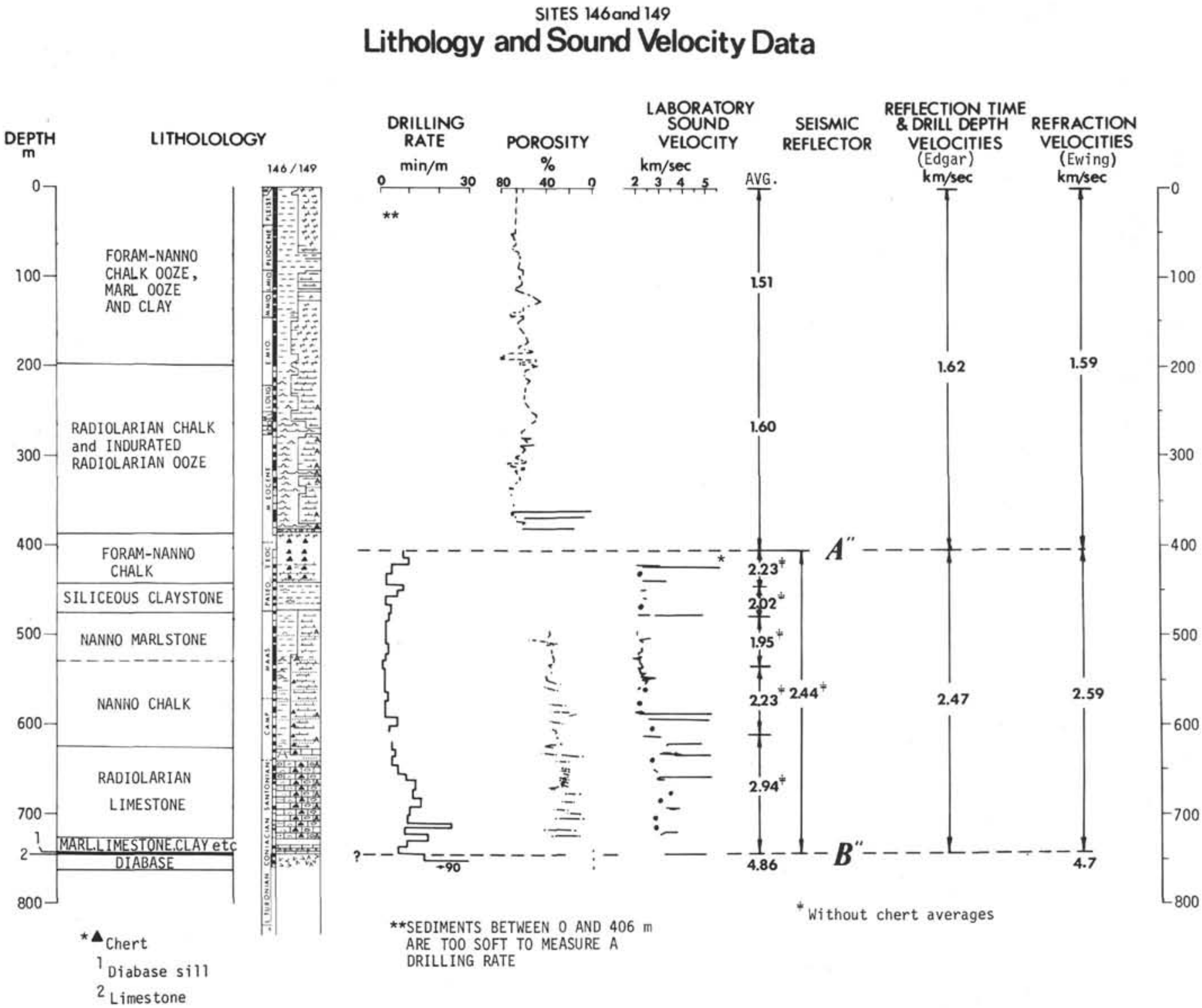

Figure 14. *Comparison of lithology with drilling rate, porosity, and sound velocity determined by the Hamilton Frame method onboard* Glomar Challenger *by calculation from drilling depth and reflection time and from sonobuoy velocities (J. Ewing, personal communication).*

TABLE 3
Major Lithologic Sections Stratigraphically Distinguished by their Velocity Characteristics

Avg. Vp[a] (km/sec)	Rock	Depth (m)
1.51	Unlithified clay	98-105
1.60	Chalk ooze	254-263
2.23	Foraminiferal nannofossil chalk	406-440
2.02	Green siliceous claystone	440-478
1.95	Nannofossil marl	478-529
2.23	Varicolored nannofossil chalk	529-612
2.94	Chalk, radiolarian limestone, variegated limestone, marlstone, and claystone	612-737
4.86	Diabase	737-738

[a]Without chert data.

Velocity changes versus pressure variations for many rocks, according to Press (1966) and Christensen (1970), are very sensitive to pressure changes from 1 to 500 bars. However, all dolerite samples listed by Press (1966, Table 9-2) suggest little change of sound velocity within these pressures. See the Schrieber and Fox chapter in this volume on rock velocities relative to pressure.

Other problems may arise, in comparing these differing types of sound velocity data, from acoustic anisotrophy in these rocks. Seismic reflection velocity records occur in a direction perpendicular to stratification, shipboard Hamilton Frame velocity measurements were predominately parallel to stratification and Ewing's are interval and refracted velocities.

Natural Gamma Radiation

Natural gamma ray emissions were counted for a period of 1.25 min at 7.62 cm (3 in) intervals along the core, with a counting precision of about ±100 counts. Sediment disturbance, porosity control, methods, and equipment are discussed in the Appendix.

Cores 1 through 6 at Site 149 were recovered in the extended core barrel which has a 2.25-inch internal diameter compared to the normal 2.60 inches. The volumetric difference per unit length between the two core sizes relative to the smaller core is 33.7%, therefore the natural gamma ray counts of 2.25-inch cores were increased by 33.7% so that they may be compared to the normal 2.60 inch data.

Natural gamma radiation at Sites 146 and 149 roughly corresponds to the different types of sediments or rocks, which range from Recent to Cretaceous and are from 0 to 760 meters below the sea floor. Gamma ray emissions range from 0 to 2100 counts/1.25 min period at 7.62-cm core intervals with typical high values for clays and marls, intermediate values for chalk, and the lower values for radiolarian-rich chalks, radiolarian-rich limestone, and radiolarian ooze. The diabase emitted the least radiation.

Pliocene-Miocene brown clays emitted natural gamma radiation ranging from 500 to 1900 counts with typical counts of about 1500, while Paleocene green siliceous claystone emitted 400 to 700 counts. Pleistocene-Miocene nannofossil and foraminiferal chalk and marl ooze ranged from about 500 to 1300 with typical counts of 900, Eocene radiolarian ooze ranged from 200 to 400, and Cretaceous radiolarian limestone from 100 to 400. In general, natural gamma ray emissions from mixtures of these sediment end members were related to their mixed proportions. The lowest counts of 100 are emitted from the diabase.

Penetrometer

Needle penetration tests were made at Sites 147 and 149 with a 1-mm diameter needle. Sediment disturbance, methods, and equipment are discussed in the Appendix. CP on the graph stands for complete penetration.

Penetration ranged from 26 mm to zero with penetration decreasing with increasing depth below the sea floor to 230 meters. Between 0 and 30 meters below the sediment surface, needle penetration in Pleistocene-Pliocene gray orange nannofossil chalk and marl ooze decreased from 17 to 9 mm with a range of 9 to 26 mm. Pleistocene-Pliocene gray nannofossil foraminifera marl ooze and foraminifera nannofossil marl recovered from 30 to 70 meters below the sea floor were typically penetrated 10 mm with a range of 6 to 15 mm, while penetrations were less in Pliocene-Miocene brown clay and marls from 70 to 110 meters, which have typical penetration values of about 3 mm (1.5 to 5 mm limits). From 110 meters to 140 meters, penetration was typically 2 to 3 mm with narrower limits (1 to 3 mm), while below 140 meters, in Oligocene and older sedimentary rock, penetration was usually within 0 to 3 mm regardless of lithology (chalks and marls, and radiolarian chalks).

BIOSTRATIGRAPHY

The uppermost lithologic unit recognized at Site 149 consists of foraminiferal nannoplankton chalk and marl ooze and is about 75 meters thick. The first core was taken mostly above the sea floor so that only the core catcher contained sediment. The sample contained abundant pteropods, planktonic foraminifera and calcareous nannofossils. The planktonic foraminifera belong to the *Globorotalia fimbriata* Subzone of the *Globorotalia truncatulinoides truncatulinoides* Zone and the calcareous nannoplankton belong to the *Emiliania huxleyi* Zone; the sample is Holocene. Core 2 (1-10 m below the sediment surface) sampled somewhat older, definitely Pleistocene sediments. The planktonic foraminifera of the upper two sections belong to the *Globigerina calida calida* Subzone of the *Globorotalia truncatulinoides truncatulinoides* Zone. Samples of the *Globigerina bermudezi* Subzone of the *Globorotalia truncatulinoides truncatulinoides* Zone, which lies between the *Globorotalia fimbriata* Subzone and the *Globigerina calida calida* Subzone and is considered to be latest Pleistocene, were not recovered. Calcareous nannoplankton assemblages from the top of Core 2 also suggest that the youngest Pleistocene was not samples. At this site the lowest occurrences of *Globigerina calida calida* and *Emiliania huxleyi* both lie in the lower part of Section 2 or the upper part of Section 3 of Core 2. The lower sections of Core 2 and all of the material in Cores 3, 4, and 5 belong to the *Globorotalia hessi* Subzone of the *Globorotalia truncatulinoides truncatulinoides* Zone according to the planktonic foraminifera or the *Gephyrocapsa oceanica* Zone using calcareous nannoplankton fossils. The highest occurrence of *Pseudoemiliania lacunosa* lies in the lower part of Section 2 or the upper part of Section 3 of Core 3, so that if the terminology of Gartner is used, only the upper two sections of Core 3 and lower four sections of Core 2 belong to the *Gephyrocapsa* Zone, lower sections and cores to the middle of Core 6 belonging to his *Pseudoemiliania* Zone. Very rare, well-preserved radiolarians are present in Core 2 but are not found in deeper samples from this unit.

The planktonic foraminiferal assemblages from Cores 6 to 11 are generally mixed, the sediments being disturbed by drilling; calcareous nannofossil assemblages from this same interval are also often mixed, but some small undisturbed pieces of the sediment yield normal assemblages in the expected stratigraphic order. Core 6 contains a highly condensed *Gephyrocapsa oceanica-Gephyrocapsa caribbeanica-Discoaster brouweri-Discoaster pentaradiatus* Zone sequence in less than 6 meters, probably a result of drilling disturbance. The highest occurrence of *Discoaster brouweri* has been used to determine the Pliocene-Pleistocene boundary between samples from Sections 3 and 4 of Core 6. Sections 1 to 5 of Core 7 are mixed in such a way as to suggest slumping of material from higher in the hole. Only the lowest section (6) of Core 7 contains an apparently indigenous assemblage, belonging to the *Discoaster pentaradiatus* Zone. Similarly, the first three sections of Core 8 contain mixed assemblages, but apparently indigenous assemblages of the *Discoaster surculus* Zone are present in Sections 4 and 6 of this core. In Core 9 it is possible to select undisturbed samples for calcareous nannofossils, particularly from the lowest section (6).

The interval from 75 to 138 meters (Cores 10-16) is represented by brown clay with some interbedded marl containing calcareous pelagic fossils. As noted above, the planktonic foraminiferal assemblages from Cores 10 and 11 appear to be mixed. In these cores the planktonic foraminifera are often damaged by solution effects. The calcareous nannoplankton assemblages have also been attacked and are particularly poor in the upper sections of Core 10. In Core 11 the *Reticulofenestra pseudoumbilica* and *Discoaster asymmetricus* zones are present in Sections 1 to 3 and 4 to 5 (to 115 cm) but the earlier Pliocene *Ceratolithus rugosus* and Early Pliocene-Late Miocene *Ceratalithus tricorniculatus* zones are missing, the lowest part of Section 5 (129 cm) belonging to the *Discoaster quinqueramus* Zone of the Late Miocene. Section 5 of Core 11 is marly brown clay, and it may be that the calcareous nannofossils representing the latest Miocene-early Pliocene have been completely dissolved. The assemblages which bracket the barren interval between 115 cm and 129 cm are not necessarily in situ, so it is possible that the real thickness of the Early Pliocene-Late Miocene might be greater than the apparent 14-cm interval observed in the core.

The planktonic foraminiferal assemblages throughout the remainder of this unit are moderately to severely damaged by solution. The *Globorotalia acostaensis* Zone of the Late Miocene and the *Globorotalia menardii, Globorotalia mayeri, Globorotalia fohsi lobata, Globorotalia fohsi fohsi,* and *Globorotalia fohsi peripheroronda* zones of the Middle Miocene are all recognizable in Cores 12 to 16. However, the *Globorotalia fohsi robusta* Zone, which should intervene between the *Globorotalia fohsi lobata* and *Globorotalia mayeri* zones in the Caribbean was not detectable. The calcareous nannofossil sequence of *Discoaster quinqueramus-Sphenolithus heteromorphus* zones is complete, so that the absence of the *Globorotalia fohsi robusta* Zone may be due to the lack of the defining species in the impoverished planktonic foraminiferal assemblages from the lower sections of Core 15.

The subjacent lithic unit recognized at Site 149 is foraminiferal nannoplankton chalk which extends from 138 to 195 meters (Cores 17-22). In cores 17 to 20 the planktonic foraminiferal assemblages are generally well preserved or only slightly to moderately affected by dissolution and represent the *Globorotalia fohsi peripheroronda* and *Praeorbulina glomerosa* of the Middle Miocene and *Globigerinatella insueta* Zone of the late Early Miocene. These cores contain calcareous nannoplankton assemblages belonging to the *Sphenolithus heteromorphus* and *Helicopontosphaera ampliaperta* zones. Preservation of calcareous fossils of both groups is notably poorer in Cores 21 and 22 through Section 6. The *Globigerinita stainforthi* and *Globigerinita dissimilis* zones (mid-early Miocene) are not distinguishable and are lumped together. The *Sphenolithus belemnos* Zone can be recognized in sediment at 94 to 96 cm in Section 2 of Core 21. The remainder of Core 21 and Core 22 through Section 6 belongs to the *Discoaster druggi* Zone. Core 22 contains very rare, poorly preserved fragments of radiolaria, inadequate for zonal assignment.

The fourth lithic unit recognized at Site 149 is an indurated calcareous radiolarian ooze and radiolarian nannoplankton chalk. The core catcher of Core 22 and all subjacent cores (through 43) recovered at Site 149 belong to this unit which extends from 195 meters to the bottom of the hole at 390 meters.

The core catcher of Core 22 and subjacent cores through Section 3 of Core 27 are grayish green radiolarian chalk. Planktonic foraminiferal assemblages are only slightly affected by solution in the higher part of this unit and become progressively more damaged toward the bottom of the unit. The boundary between the *Globigerinoides primordius* Zone (earliest Miocene) and *Globorotalia kugleri* Zone (latest Oligocene) is between Cores 25 and 26. In the case of the calcareous nannofossils, the base of the *Discoaster druggii* Zone lies between samples from Sections 3 and 4 of Core 23. Radiolarians are few to common in Cores 23 to 27 and somewhat dissolved. Core 23 belongs to the *Lychnocanoma elongata* Zone as do subjacent samples to the lower part of Core 26. The base of Core 26, all of Core 27, and part or all of Core 28 belong to the *Dorcadospyris ateuchus* Zone.

The sediment from Section 3 of Core 27 through Section 2 of Core 30 is a yellowish gray radiolarian chalk. Planktonic foraminifera are sparse and solution effects have reduced the assemblages to only a few resistant species. Material in Cores 27 and 28 is tentatively referred to the *Globorotalia kugleri* Zone and Cores 29 and 30 to the *Globorotalia opima opima* Zone. Calcareous nannoplankton assemblages in this interval are also affected by solution, but it is still possible to recognize the sequence *Triquetrorhabdulus carinatus* (Core 27, Section 3–Core 29, Section 1), *Sphenolithus ciperoensis* Zone (Core 29, Section 2), *Sphenolithus distentus* Zone (Core 29, Section 3), and *Sphenolithus predistentus* Zone (Core 30), although secondary species must be used to determine zone boundaries in the absence of the defining species. Nevertheless, this is good evidence that the Late and Middle Oligocene are represented by the sediments in this interval. The radiolarians are few to common and have been somewhat affected by dissolution. The base of the *Dorcadospyris ateuchus* Zone lies in the lower part of Core 28 or upper part of Core 29. The base of the *Theocyrtis tuberosa* Zone, which may approximate the Eocene-Oligocene boundary, lies between Cores 30 and 31.

Cores 31 to 34 (Section 3) consist of radiolarian chalk ooze. Planktonic foraminifera are virtually absent although debris is present, indicating that they have been removed through dissolution. Calcareous nannofossils are very sparse in Core 31, somewhat more diverse but still very poor assemblages occur in Cores 32 to 34. Samples from Core 34 are referable to the Middle Eocene *Discoaster saipanensis* Zone. The radiolarians in these cores are abundant and well preserved, but the assemblages in Cores 31 and 32 contain a high proportion of reworked specimens. As a consequence it is difficult to recognize the bases of the Late Eocene *Thyrsocyrtis bromia* and *Podocyrtis goethana* zones which must lie in these cores. The base of the late Middle Eocene *Podocyrtis chalara* Zone is probably in the lower part of Core 32, and subjacent cores belong to the *Podocyrtis mitra* Zone.

Core 34, Section 3, through Core 43 (301-390 m) are radiolarian chalk and ooze. Planktonic foraminifera are virtually absent. Calcareous nannofossil assemblages have also been strongly attacked by solution, but it appears possible to recognize the *Discoaster tani nodifer* Zone in Cores 35 and 36, the *Chiphragmalithus alatus* Zone in Cores 37 to 39, and the *Discoaster sublodoensis* Zone in Cores 40 to 41; all belong to the Middle Eocene. No calcareous nannofossils were encountered in Cores 42 and 43. The Radiolaria are abundant and well preserved. The base of the *Podocyrtis mitra* Zone is between the bottom of Core 36 and the lower part of Core 37. The base of the *Podocyrtis ampla* Zone is between Cores 38 and 39. The base of the *Thyrsocyrtis triacantha* Zone is between Cores 42 and 43, and Core 43 belongs to the *Theocampe mongolfieri* Zone. All of the radiolarian zones are considered to belong to the Middle Eocene.

Two spot cores were taken in post-Eocene sediments at Site 146. In the first core taken at 96 to 105 cm, Sections 1 through 6 were devoid of foraminifera and Radiolaria, but contain fish debris and a poor calcareous nannofossil assemblage of the *Discoaster quinqueramus* Zone (Late Miocene). The core catcher sample from Core 1 contains rich planktonic foraminiferal and calcareous nannofossil assemblages belonging to the Late Miocene *Neogloboquadrina dutertrei* and *Discoaster quinqueramus* zones respectively. Correlation by depth of this core with Site 149 would suggest that this level should belong to the *Globorotalia acostaensis* Zone, and the sediment sampled may represent material slumped from slightly higher in the hole.

Core 2 was taken between 254 and 263 meters below the sediment surface. The upper four sections contain rich planktonic foraminiferal assemblages assigned to the Early Miocene *Globigerinoides primoridius* Zone. Calcareous nannofossils are also abundant in these sections and belong to the *Discoaster druggi* Zone. Sections 5 and 6 are devoid of planktonic foraminifera but contain thick-walled benthonic foraminifera and rich calcareous nannofossil assemblages of the early Miocene, part of the *Triquetrorhabdulus carinatus* Zone. Radiolarians are abundant and moderately well preserved. Those from the upper half of the core belong in the *Lychnocanoma elongata* Zone and those from the lower part in the *Dorcadospyris ateuchus* Zone, but, because the core is disturbed, the transition between these zones cannot be investigated in detail. Correlation by depth with Site 149 indicates that this material may be slumped from a level some 40 meters higher.

Continuous coring at Site 146 was initiated at a depth of 406 meters. Cores 3 to 8 belong to a lithified foraminiferal nannoplankton chalk with chert which extends from 382 to 441 meters below the sediment surface. Cores 3 and 4 yielded mostly chert fragments with no foraminifera or calcareous nannoplankton. Radiolarians are rare to common, moderately well to poorly preserved. Core 4 evidently belongs in the *Buryella clinata* Zone. Cores 5 to 7 contain some levels with planktonic foraminiferal assemblages adequate for dating, although all have been affected to some degree by dissolution. All of these assemblages are assigned to the new *Globorotalia edgari* Zone of earliest Eocene age. Calcareous nannofossil assemblages from rock fragments in the upper part of Core 5 belong to the *Discoaster diastypus* Zone; those from deeper levels in Core 5 and from Cores 6 and 7 belong to the *Discoaster multiradiatus* Zone. A meager assemblage from the top of Core 8 may belong to either the *Heliothius riedeli* or *Discoaster gemmeus* Zone (Paleocene). Radiolaria are as above, moderately well to poorly preserved, some being partially dissolved, thus silicified, and others perhaps zeolitized. An assemblage from Core 7 belongs to the *Bekoma bidarfensis* Zone.

A monotonous green siliceous clay was found in Cores 9, 10, and the upper part of 11. (441-477 m). Foraminifera and calcareous nannofossils are absent, and the Radiolaria belong to that part of the Paleocene left unzoned in the Leg 10 Initial Report.

A calcareous layer at 128 to 138 cm in Section 1 of Core 11 contains planktonic foraminifera belonging to three distinct assemblages occurring in different lenses. These assemblages belong to the *Globorotalia pseudobulloides* and the *Globigerina eugubina* zones of the earliest Paleocene, and a *Globotruncana* Zone of the Late Cretaceous. No calcareous nannoplankton were found in this material, but there are many small calcite crystals which may indicate complete recrystallization of the nannofossils. Cretaceous calcareous nannofossils appear immediately below this layer and the Cretaceous-Tertiary boundary is indicated at 138 cm in Section 1 of Core 11. The highest assemblage at 140 cm is extremely poor, but 3 cm below, specimens become more abundant. Moderately good diverse assemblages of Late Cretaceous forms appear in Section 2 of Core 11.

The radiolarians in Core 11 (476 to approximately 480 m) have what is commonly regarded as a "Cretaceous aspect," but they might equally well be early Paleocene since no well-dated assemblages of that age are known.

The sequence from 477 to 630 meters (Cores 12-27) is a varicolored nannoplankton chalk and marl. Planktonic foraminifera are abundant and the assemblages diverse, although almost all have been strongly damaged by dissolution. Core 12 did not recover any material for analysis. Core 13 belongs to the *Abathomphalus mayaroensis* Zone, Core 14 and the top of Core 15 to the *Globotruncana contusa* Zone, the remainder of Core 15 and subjacent material to near the base of Core 18 to the *Globotruncana gansseri* Zone, and the base of Core 18 through the base of Core 21 to the *Globotruncana "tricarinata"* Zone, all assigned to the Maestrichtian. Calcareous nannofossil assemblages in this interval are moderately well to poorly preserved and all show dissolution effects. Species diversity is generally low and it is impossible to establish a fine zonation. Core 22 contains relatively well-preserved planktonic foraminifera of the *Globotruncana calcarata* Zone (Late Campanian). Cores 23 to 27 contain progressively more corroded planktonic foraminifera belonging to the *Globotruncana elevata* Zone (Early Campanian). In this same interval the diversity of calcareous nannofossil assemblages decreases markedly.

From 630 to 738 meters the sequence consists of radiolarian limestone. Planktonic foraminifera are strongly affected by dissolution and the diversity of assemblages is considerably reduced. Nevertheless, it is possible to recognize the *Globotruncana concavata carinata* Zone (Cores 34-38), indicating the Santonian. The basal calcareous sediments (Cores 39-41) contain the assemblage of the *Globotruncana schneegansi* Zone of Late Turonian. Calcareous nannofossil assemblages in this unit tend to be very poor.

Practically all samples from Cores 12 to 41 (from 485 to approximately 740 m) contain rare, moderately well-preserved (partially dissolved) radiolarians representing a small number of taxa. Many samples (particularly those from sandy layers) from cores below Core 14 contain, in addition, common to abundant, poorly preserved (usually silicified) radiolarians representing large numbers of taxa. These results, together with the fact that an orderly sequence of foraminiferal faunas is found in the cores, suggest that the sparse, better preserved radiolarians are autochthonous, and that the floods of poorly preserved specimens were introduced by some mechanism such as turbidity currents, which carried material not significantly older than that being deposited at this site. This explanation requires a pattern of paleoecological conditions such that the water column at this site was inhabited by a restricted radiolarian assemblage, while at the presumably not-far-distant source of the transported component, a much more diverse fauna flourished.

CONCLUSIONS

Cores recovered from Site 146/149 give a record of apparently uninterrupted sedimentation for the last 80 m.y. Although total recovery was about 50 per cent, only 2 out of 86 core barrels were completely empty. Thus, this site affords an exceptionally fine opportunity for studying a long record of sedimentary history in the Caribbean area.

As a result of the coring and measurement of sound velocities and densities of the rocks of this site, we feel that we can identify Horizons A″ and B″ with a high degree of confidence. Horizon A″ correlates with the chalk/limestone and chert interface separating lithic units 2 and 3. Horizon B″ is identified here with the upper dolerite sill (B″ was found to be basalt or dolerite in sediments of approximately the same age at four other sites of Leg 15). The latter conclusion is of extreme importance: the nearly ubiquitous distribution of Horizon B″ in the Venezuelan Basin and its occurrence in much of the Colombian Basin implies a wide areal extent to this igneous episode.

The earliest lithic unit is extremely varied and shows striking contrasts between successive layers. Although dominantly a radiolarian limestone, there are, especially near the base, intercalated basaltic ash beds, carbonaceous layers, and radiolarian sands. Glauconite and pyrite are present. This diversity in lithologies implies strongly that the topography of the sea floor was irregular, with high and low areas in juxtaposition. The reduced, organic-rich sediment, the relatively high phosphorous contents (Donnelly, Mineralogy and Chemistry of Noncalcareous Sediments, this volume), and the presence of glauconite and pyrite all suggest sedimentation on a bottom with limited water circulation. The intercalations of radiolarian sands indicate incursions of detritus from nearby topographic highs (see Biostratigraphic Summary); the sorting (with or without grading), sharp bottom contacts, and the relatively well-preserved Radiolaria and planktonic foraminifera in a sedimentary environment below the lysocline all indicate that these beds represent rapidly transported sediment from topographic high areas within the basin.

The lower radiolarian limestones pass upward into Campanian-Maestrichtian chalks and marls and younger chalks, oozes, marls, and clays. The gradual disappearance of the intercalated radiolarian sands and the blurring together of lithologies results from the gradual subduing of sea floor topography through sedimentation. The entire post-Cretaceous section is characterized by the near absence of juxtaposed contrasting lithologies, except that ash beds are recognizable as late as Oligocene at Site 149.

The entire post-Santonian section represents nearly constant pelagic sedimentation, with a variable volcanic admixture, under conditions dominated by changing patterns in productivity of calcareous and siliceous organisms and by the relative movement of the depth of calcium carbonate compensation above and below the sea bottom at the site. Thus, the Paleocene and Late Miocene-Early Pliocene intervals are marked by complete solution of calcareous fossils. During most of the remaining times, the site was at about the level of the depth of calcium carbonate compensation, and the planktonic foraminifera were more or less dissolved. During brief intervals the planktonic foraminifera escaped solution. A significant accumulation of siliceous fossils is seen from the late Cretaceous through the late Eocene, reaching a maximum during the latter unit of time and later falling to a low level through the remainder of the Cenozoic Era.

The history of volcanic activity shown by the sediments at Site 146/149 is a complete and interesting one (discussed more fully in Donnelly, Circum-Caribbean Explosive Volcanic Activity . . . , this volume). The basaltic episode at the base of the section actually consisted of several eruptions, represented by basaltic ash layers at Site 146 in Cores 39 and 41. The volcanic clays which form impressively thick layers in the later Cretaceous section (many are several cm thick) are of special interest. Several contain minerals typical of subalkalic, highly explosive eruptions of the continental margins (quartz, biotite, alkali feldspar, apatite, and zircon), but most consist of glass which has completely devitrified to montmorillonite. If these ashes are of continental origin, their thickness at relatively great distances from possible sources is remarkable; igneous activity of that age is found only in the Greater Antilles and, to a limited extent, along the Venezuelan coast. However, similar ashes outcrop in Puerto Rico, Jamaica, Curacao, and Bonaire. The possibility that they may represent eruptions from within the basin cannot be completely dismissed; similar volcanic materials are known from the east and southeastern Pacific.

After a diminution of volcanic activity during the late Maestrichtian-Paleocene, there was a sharp renewal of activity in the middle Eocene. This material is entirely pumice of a calc-alkaline origin, and the probable source was the Lesser Antilles. This activity diminished to a minimum during the middle Miocene but apparently was renewed in the late Pliocene to Recent (Site 148).

The occurrence of chert at Horizon A″ provides some valuable insights into the origin of chert layers of this age in many parts of the ocean. The analysis of Donnelly and Nalli (this volume) shows that the present non-chert silica component is not exceptionally great at the level of the main cherts, but was much greater at a higher level at which fresh opaline radiolarian and fresh glass shards were found. The chert represents a recrystallization, or lithification, of opal and volcanic glass, and its coincidence with chalks (in which calcitic fossil debris is recrystallized to sparry calcite) indicates that the problem of chert formation is one of the post-deposition chemical environment, not the rate of supply of silica to the sea floor.

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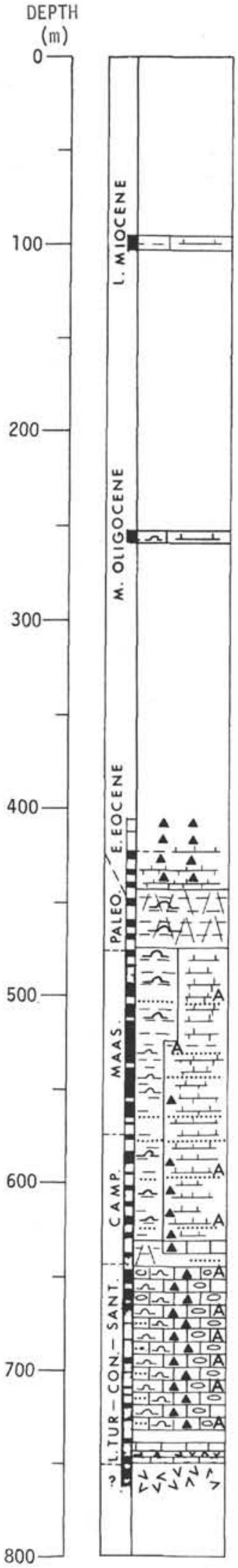
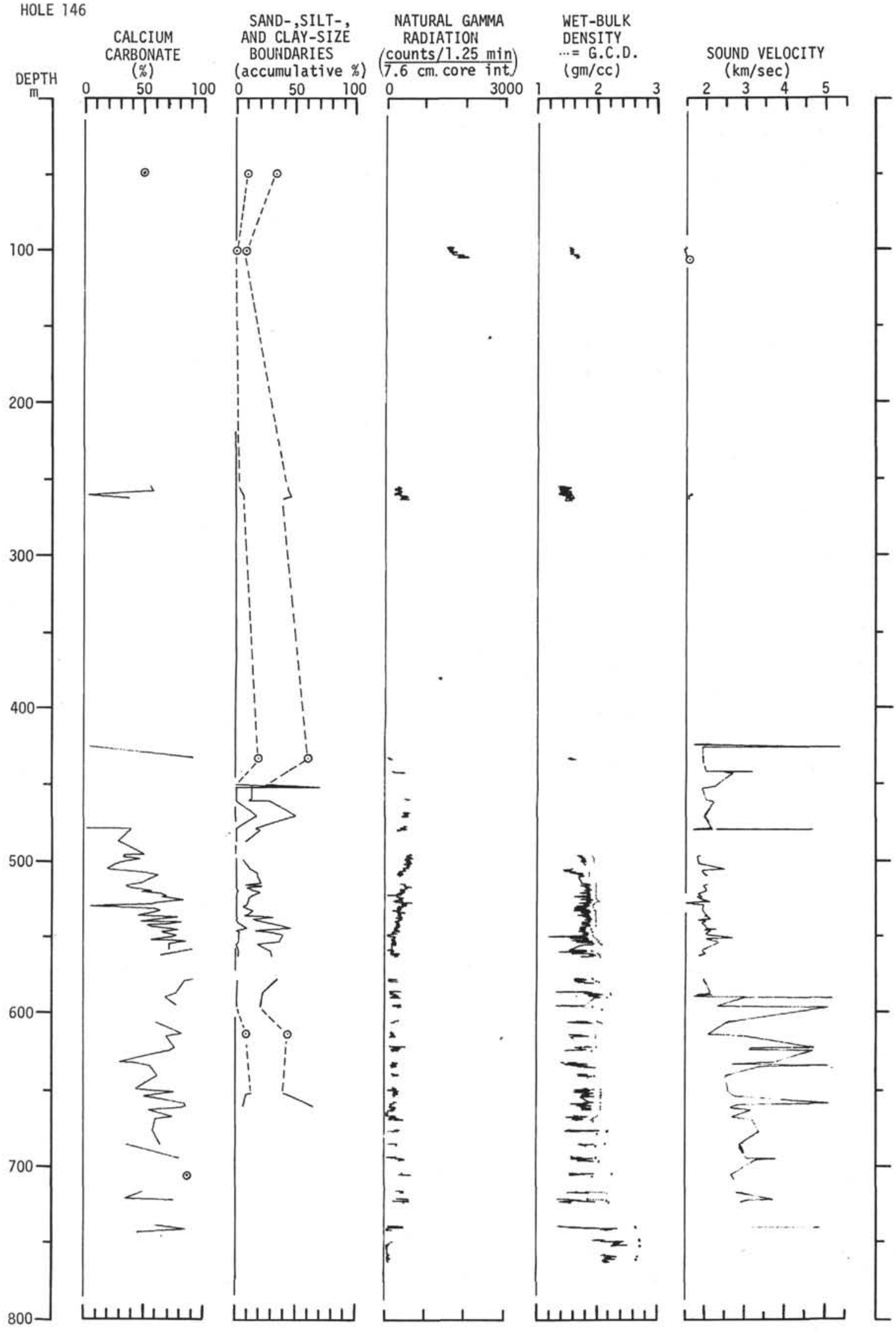
HOLE 146

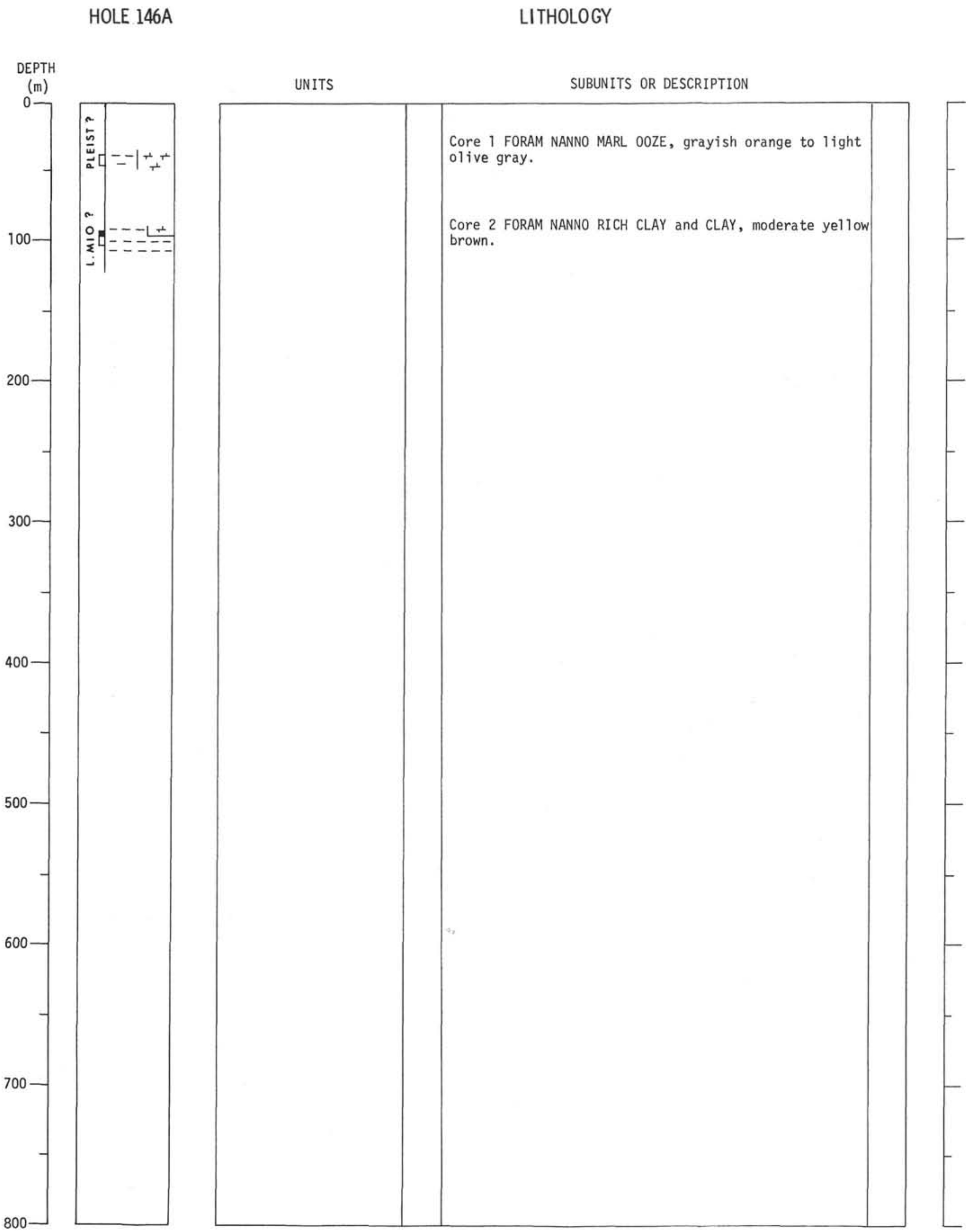
LITHOLOGY

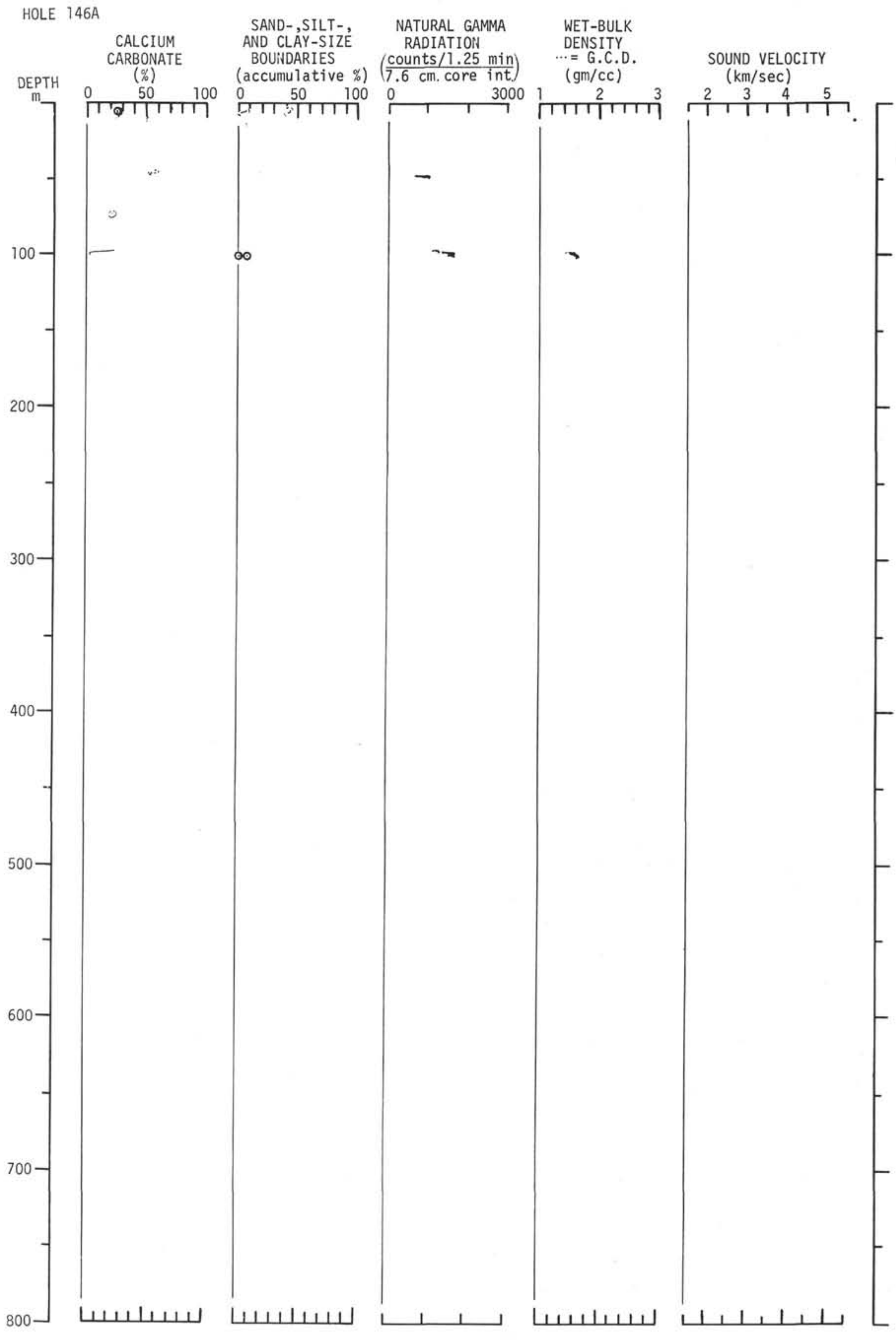


UNITS	SUBUNITS OR DESCRIPTION
	Core 1 CLAY and nannoplankton foraminiferal rich CLAY, brown.
	Core 2 NANNOFOSSIL MARL, yellow gray
UNIT III† (406* to 440.65 m) FORAM NANNO CHALK and CHERT	FORAM NANNO CHALK, light olive gray CHERT, olive gray
UNIT IV (440.65 to 477.25 m) SILICEOUS CLAYSTONE	SILICEOUS CLAYSTONE, greenish gray, homogeneous, subconcoidal fracture.
UNIT V (477.25 to 630.30 m) VARICOLORED NANNO MARL and NANNO CHALK, and CHERT	Subunit a. (477.25 to 521.35 m) NANNO MARL, brownish gray and olive gray; ash and sandstone layers; some forams in lower part.
	Subunit b. (521.35 to 630.30 m) Clay rich NANNO CHALK, varicolored; forams present in upper part (521 to 560 m) and radiolarian sandstone interbeds are frequent. Lower most part is predominately pinkish gray with increasing ash layers and chert. Increasing hardness with depth.
UNIT VI (630.30 to 738.30 m) RADIOLARIAN LIMESTONE	Subunit a. (630.30 to 721.00 m) RADIOLARIAN LIMESTONE, gray (630 to 692 m) and varicolored (692 to 721 m). Abundant chert and ash layers. Occurrence of dark carbonaceous layers and increasing microfractures with depth.
	Subunit b. (721.00 to 738.30 m) LIMESTONE, MARLSTONE, CLAYSTONE, variegated.
UNIT VII (738.30 to 762 m T.D.) DIABASE and LIMESTONE	Subunit a. (738.30 to 739.63 m) DIABASE SILL, upper. Subunit b. (739.63 to 740.00 m) FORAM LIMESTONE slightly metamorphosed. Subunit c. (740.00 to 762.00 m T.D.) DIABASE, lower.

†See Site 149 for Lithologic Unit I through V. *Slightly higher in Site 149.


HOLE 146
DEPTH m
CALCIUM CARBONATE (%)
0 50 100
SAND-,SILT-, AND CLAY-SIZE BOUNDARIES (accumulative %)
0 50 100
NATURAL GAMMA RADIATION (counts/1.25 min / 7.6 cm. core int.)
0 3000
WET-BULK DENSITY ···= G.C.D. (gm/cc)
1 2 3
SOUND VELOCITY (km/sec)
2 3 4 5
100
200
300
400
500
600
700
800

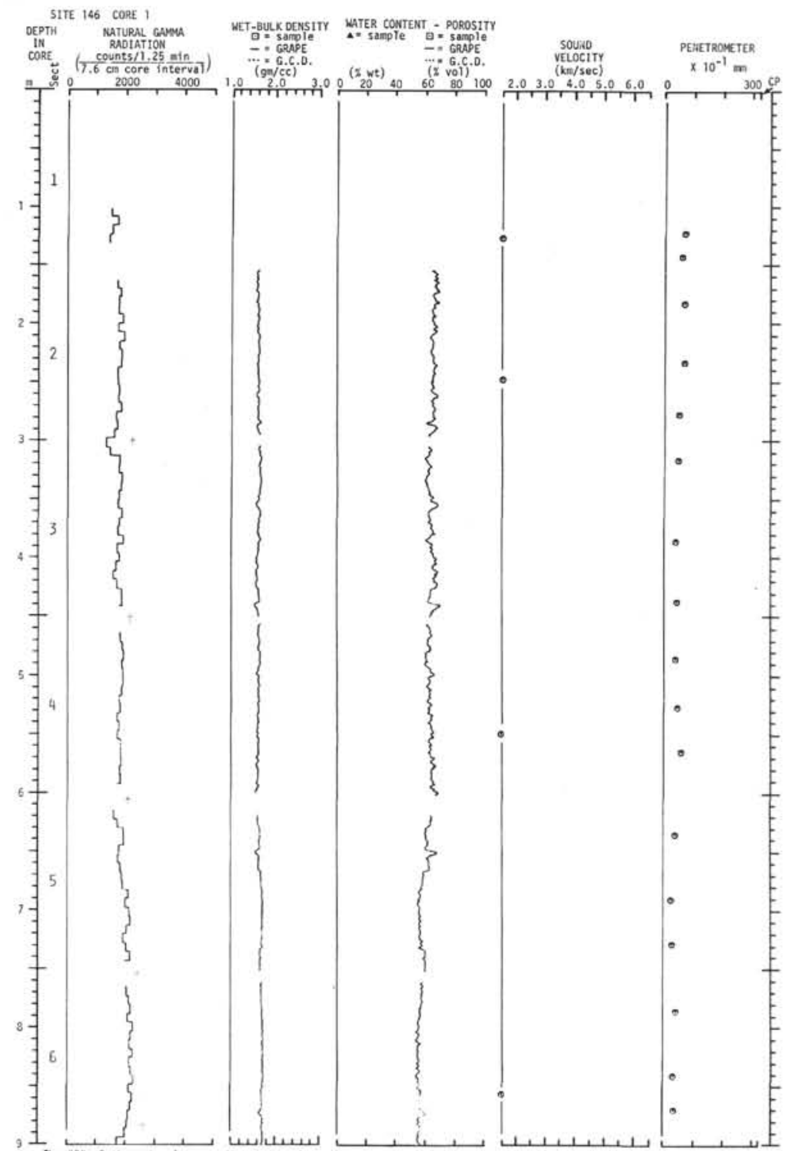

HOLE 146A
LITHOLOGY
DEPTH (m)
0
100
200
300
400
500
600
700
800
PLEIST ?
L. MIO ?
UNITS
SUBUNITS OR DESCRIPTION
Core 1 FORAM NANNO MARL OOZE, grayish orange to light olive gray.
Core 2 FORAM NANNO RICH CLAY and CLAY, moderate yellow brown.


HOLE 146A
DEPTH m
CALCIUM CARBONATE (%)
0 50 100
SAND-,SILT-, AND CLAY-SIZE BOUNDARIES (accumulative %)
0 50 100
NATURAL GAMMA RADIATION (counts/1.25 min / 7.6 cm. core int.)
0 3000
WET-BULK DENSITY ···= G.C.D. (gm/cc)
1 2 3
SOUND VELOCITY (km/sec)
2 3 4 5
100
200
300
400
500
600
700
800

SITE 146 HOLE CORE 1 CORED INTERVAL (m) 96-105

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
?	?	?		1	0.5, 1.0	VOID		f			
				2	0.5, 1.0			n, f, n	CLAY; predominantly pale yellowish brown (10YR6/2) to dark yellowish brown (10YR4/4) with irregular shade changes due to mottling and secondary disturbances from drilling. Sparse plagioclase and hornblende. Section 1 is mixed with light olive gray (5Y5/2) and contains displaced nannoplankton. Remainder of core is barren except for core catcher which is rich in planktonic foraminifers, quartz, chlorite, and kaolinite.		
				3	0.5, 1.0			n, n			Ch. 13 III
				4	0.5, 1.0			f, n, n			
				5	0.5, 1.0			n, f, n			
				6	0.5, 1.0			n, n, f	Section 6 less disturbed		
LATE MIOCENE	Globoquadrina dutertrei	Discoaster quinqueramus		CORE CATCHER				F A W / R O / N A W			

·For explanation of symbols, see Chapter 1

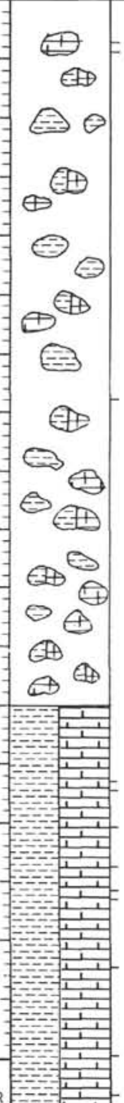


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1347. This background was subtracted from the data.

SITE 146 HOLE CORE 2 CORED INTERVAL (m) 254-263

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHO SAMPLE	PALEO SAMPLE (ABUNDANCE, PRESERVATION)
EARLY MIOCENE	Globigerinoides primordius	Discoaster druggi	Lychnocanoma elongata	1	0.5, 1.0		F F W; R A M
				2	0.0, 0.5, 1.0		R A M; N C W
				3	0.0, 0.5, 1.0		F F W; N C W
				4	0.0, 0.5, 1.0		R A M; F F W; f; R A M; N A W; N C W; R A M
		Triquetrorhabdulus carinatus	Dorcadospyris ateuchus	5	0.0, 0.5, 1.0		R A M; N A W; f; R A M; N A W
				6	0.0, 0.5, 1.0		R A M; N A W; R A G; f; R A M; N A W
				CORE CATCHER			R A M; f

LITHOLOGY



LITHOLOGIC DESCRIPTION[1]

FORAMINIFERAL NANNOPLANKTON MARL AND CHALK; essentially broken lumps in a soupy to watery matrix. Lumps reflecting compositional variation, vary from yellowish gray (5Y8/1) to greenish gray (5GY7/1) with some grayish orange (10YR7/4).

Phillipsite in Section 2.

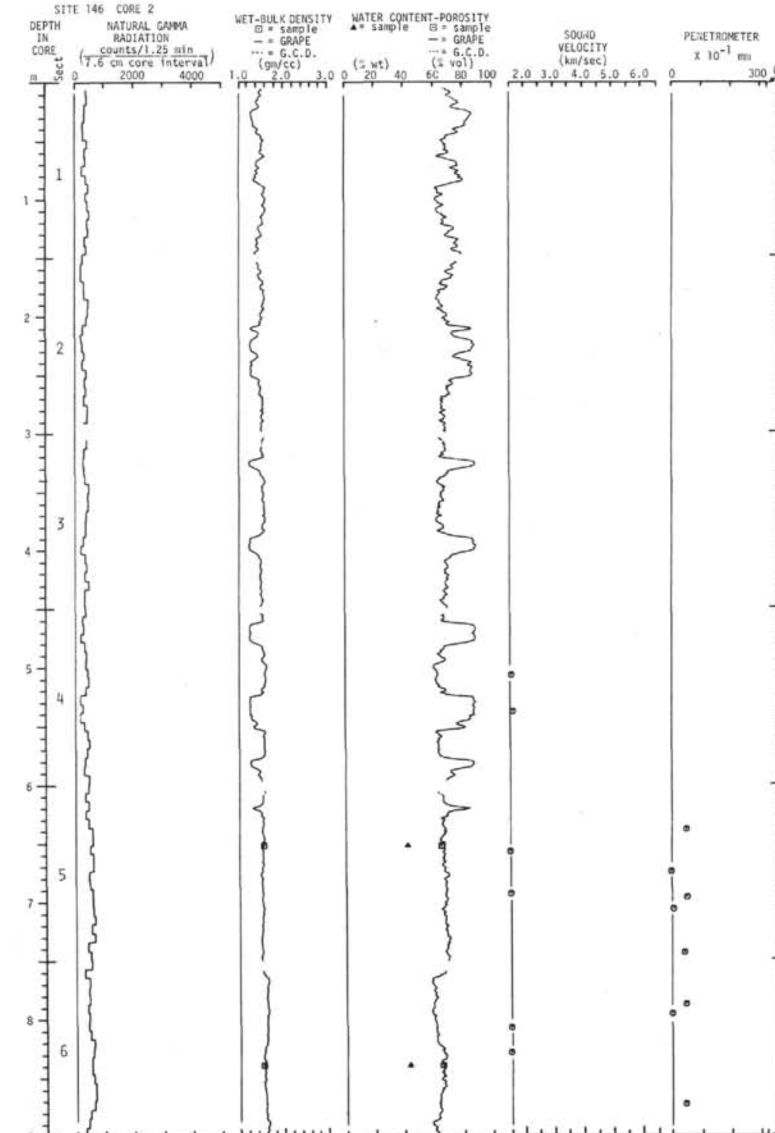
RADIOLARIA-RICH NANNOPLANKTON MARL; light gray (5Y7/1) to light olive gray (5Y6/1). Sediment is quite homogenous despite faint burrow mottling enhanced with minor volcanic shards. Sparse plagioclase. Indurated layers, apparently richer in light volcanic shards, appear at several intervals with increasing thickness toward bottom of the core.

Conspicuous burrow mottling associated with volcanics (5GY6/1) Indurated

$CaCO_3$ (%) — SAND-SILT-CLAY (accumulative %) 0 50 100

DEFORMATION: CH. 13 III AND V

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1315. This background was subtracted from the data.

SITE 146 HOLE CORE 3 CORED INTERVAL (m) 406-413

AGE	ZONE			SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
	FORAM	NANNO	RAD								
				CORE CATCHER				R F M	Only two fragments were recovered from the core catcher: CHERT; dark gray (5Y4/1) with conchoidal fracture and a potential grayish green (5G5/2) alteration rim. CHERT; dark olive gray (5Y3/2) covered on one side with a thin (0.5 cm) layer of very pale green (10G8/2) chert. In thin section, cherts contain bands of lighter colored, somewhat calcareous materials. These bands resemble, in their shape and mutual relationship, the mottled and bioturbated areas of the adjoining limestone. Mainly parallel, well-preserved to recrystallized radiolarians are present. In one case, chalcedony has been observed. Microcrystalline quartz fills chambers. Abundant "ghosts" of radiolarians and some probably benthonic foraminifer occurs. Dark cherts contain irregular patches of probably argillaceous material. Matrix is mainly microcrystalline cristobalite. Lighter areas contain some scattered barite crystals.		

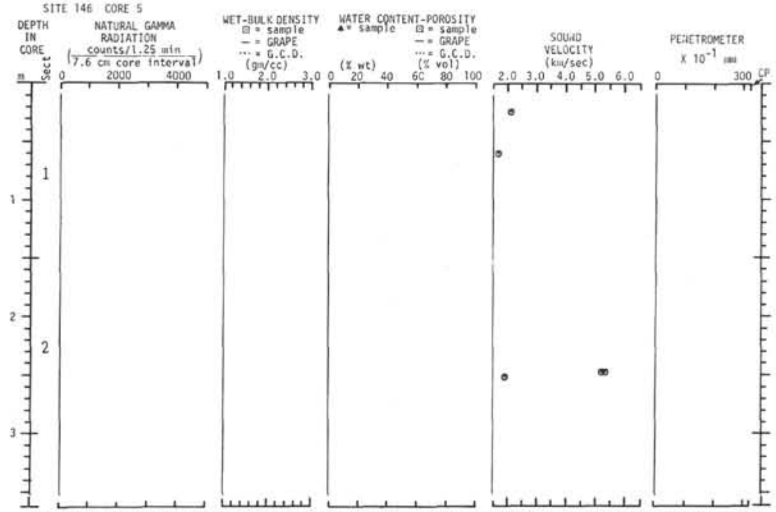
SITE 146 HOLE CORE 4 CORED INTERVAL (m) 413-422

AGE	ZONE			SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
	FORAM	NANNO	RAD								
	UNZONED			CORE CATCHER				R C M	Six fragments of CHERT were collected from the core catcher. They vary from olive gray (5Y4/2) to very pale green (10G8/2) and greenish gray (5G6/1). Some have a laminated structure; conchoidal fracture. The lowest fragment has sand-sized white grains at the bottom. In addition, X-ray identified palygorskite. These samples show varying degrees of lithification.		

[1]For explanation of symbols, see Chapter 1

SITE 146 HOLE CORE 5 CORED INTERVAL (m) 422-431

AGE	FORAM	NANNO	RAD	SECTION	LITHOLOGY	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	DEFORMATION
EARLY EOCENE / LATE PALEOCENE	Globorotalia edgari	Discoaster multiradiatus	?	1	VOID	R C P; N R P; N C M	Loose pebble-sized fragments consisting of: 1) FORAMINIFERAL NANNOPLANKTON CHALK; white (N9) to light gray (N7). 2) CHERT; stringers in chalk are up to 2 cm thick and have transitional boundaries; olive gray (5Y6/1) to brown (5YR4/4). 3) ALTERED ASH; gray (N6 to N7) with streaks of light greenish gray (5G8/1) to moderate brown (5YR4/4) and brownish gray (5YR4/1) variegated structure likely due to burrow mottling. Sparse plagioclase, quartz common clinoptilolite in green and gray facies	VERY BROKEN
				2		N F P; N C M; N F P; N C M; R R P	FORAMINIFERAL NANNOPLANKTON CHALK; white (N9), crumbly, very compacted, with interbedded CHERT, moderate brown (5YR4/4) to pale yellowish brown (10YR6/2) and dark reddish brown (5YR3/4), broken into fragments. Chalk becomes partially silicified near chert contact.	
				CORE CATCHER				

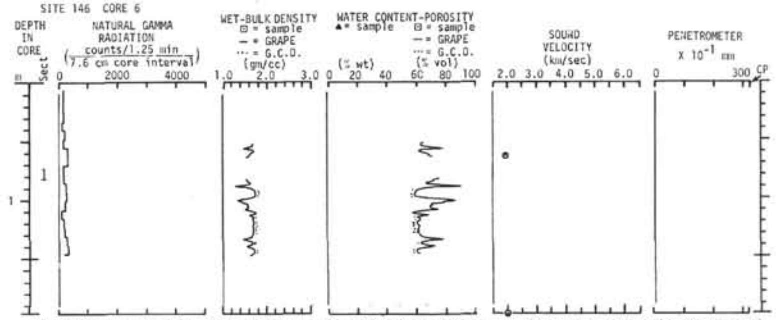


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1315. This background was subtracted from the data.

SITE 146 HOLE CORE 6 CORED INTERVAL (m) 431-440

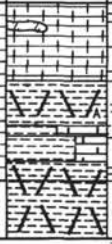
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]		CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE PALEOCENE EARLY EOCENE	Globorotalia edgari	Discoaster multiradiatus	?	1	0.5 1.0	VOID		N R P R F M	Sparse clinoptilolite, fish debris Sandy textured zone Chert fragments (5YR3/4)	FORAMINIFERAL NANNOPLANKTON CHALK; very light gray (N8) with two fragments of reddish brown (5YR3/4) chert stringers. Sediment very compacted, but easily broken. Sandy textured, loose zone of radiolarian molds appears interbedded in consolidated sediment.		
				CORE CATCHER						Core catcher has fragments of CHALK and CHERT similar to Section 1. Chert shows transitional change to chalk. Some chert fragments are grayish brown (10YR5/3) to light gray (N7).		

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1327. This background was subtracted from the data.

SITE 146 HOLE CORE 7 CORED INTERVAL (m) 440-449

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE PALEOCENE / EARLY EOCENE	Globorotalia edgari	Discoaster multiradiatus	Bekoma bidarfensis	1	0.5, 1.0			R C M R C G N A W	Zone particularly rich in forams		
				CORE CATCHER							

FORAMINIFERAL NANNOPLANKTON CHALK; very light gray (N8), indurated, with a sharp basal contact on volcanic clay.

Alternating zones of silicified VOLCANIC CLAYSTONE and NANNOPLANKTON MARL varying from greenish gray (5GY7/1) to light brownish gray (5YR6/1). Conspicuous graded bed occurs below contact with overlying highly calcareous zone. Faint burrow mottling occurs at scattered levels. Cristobalite throughout.

In general, sparse plagioclase, clinoptilolite, and quartz are present and in Section 1 (60 cm), silicified foraminfers are common. X-ray data show dominant cristobalite.

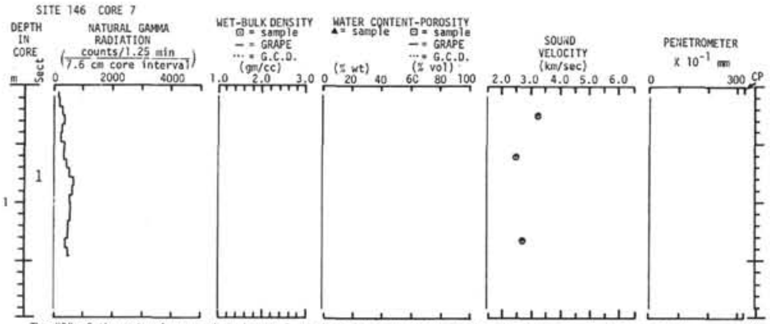
X-ray diffraction results at 145-146 cm.

Amorphous scattering	62%
Quartz	4%
Cristobalite	92%
Plagioclase	3%
Montmorillonite	1%

In Section 1 (145-147 cm) SPICULITIC-RADIOLARIAN CHERT, slightly calcareous, with abundant sponge spicules and well-preserved radiolarians. The chambers are empty or filled by cristobalite. Bioturbated. Detrital quartz.

SILICEOUS VOLCANIC CLAYSTONE greenish gray (5GY7/1).

[1] For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1327. This background was subtracted from the data.

SITE 146 HOLE CORE 8 CORED INTERVAL (m) 449-458

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE PALEOCENE		Discoaster gemmeus	?	1	0.5 / 1.0			N F P / N R P / R R P			
				2	0.0 / 0.5 / 1.0		A	n R R P			
				CORE CATCHER							

SILICIFIED VOLCANIC CLAYSTONE; greenish gray (5G6/1), hard, lithified, friable to massive, blocky to subconchoidal, developing shaly cleavage. Faint burrow mottling, very flattened, occurs throughout. Cristobalite, volcanic glass, and plagioclase throughout; Spare clinoptilolite and pyrite. X-ray diffraction shows dominant cristobalite and minor barites in Section 2. Trace rhodochrosite. Highly framented.

X-ray diffraction results:

Section 1 - 3 cm

Amorphous scattering	63%
Calcite	29%
Quartz	7%
Cristobalite	55%
Plagioclase	4%
Clinoptilolite	1%
Barite	3%

Section 1 - 26 cm

Amorphous scattering	60%
Quartz	4%
Cristobalite	86%
K-feldspar	1%
Plagioclase	2%
Montmorillonite	3%
Barite	2%

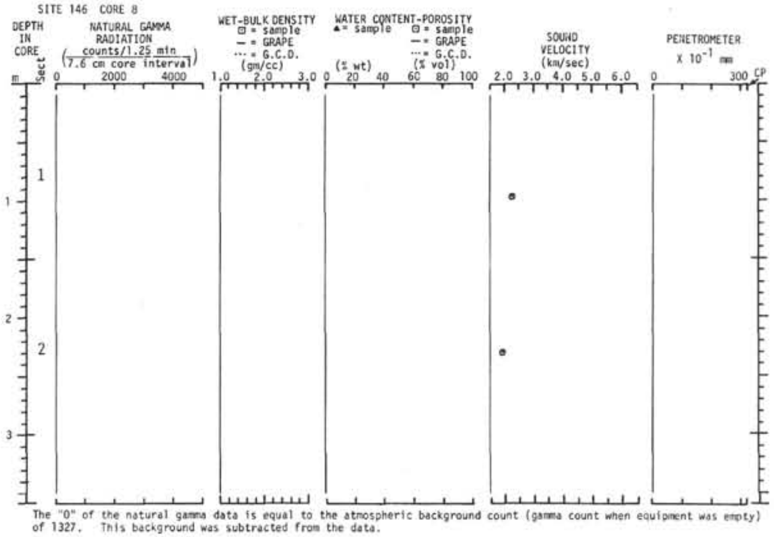
Section 2 - 41 cm

Amorphous scattering	66%
Quartz	4%
Cristobalite	85%
Plagioclase	5%
Montmorillonite	4%
Barite	2%

Section 2 - 58 cm

Amorphous scattering	59%
Quartz	55%
Plagioclase	14%
Montmorillonite	24%
Clinoptilolite	2%
Barite	5%

[1]For explanation of symbols, see Chapter 1

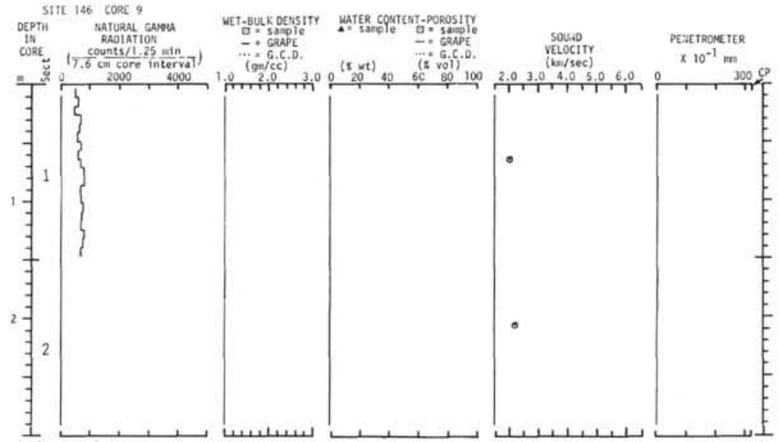


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1327. This background was subtracted from the data.

SITE 146 HOLE CORE 9 CORED INTERVAL (m) 458-467

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION*	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
				1	0.5, 1.0			R F M; n R R P	Oval lense pale greenish gray (5BG7/2). SILICEOUS CLAYSTONE, greenish gray (5GY6/1), blocky, hard, subconchoidal fracture. Sediment apparently homogeneous except for faint flattened burrow mottling at scattered intervals. Scattered cristobalite. X-ray data show K-feldspar.		
			?	2	0.0, 0.5, 1.0			R R P; n; R C P; R O	0.5 cm greenish gray (5BG7/2) lamina with irregular basal contact.		
				CORE CATCHER					Irregular blotches yellowish gray (5Y8/1)		

*For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1327. This background was subtracted from the data.

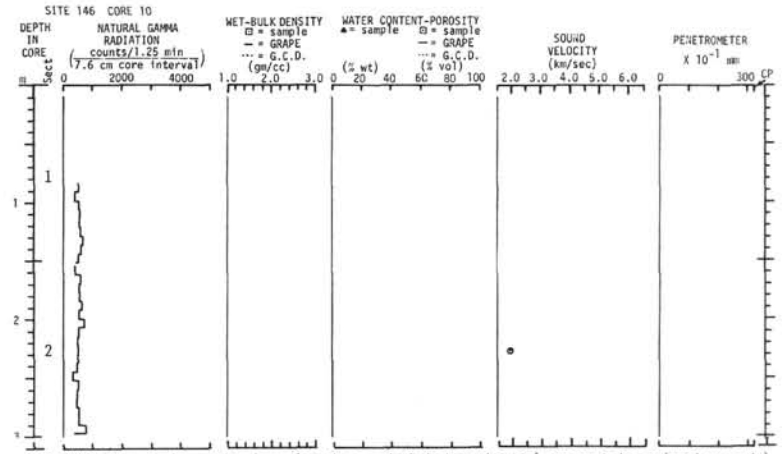
SITE 146 HOLE CORE 10 CORED INTERVAL (m) 467-476

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
				1	0.5, 1.0	VOID		R C P n	(5G6/1) (5G6/1) SILICEOUS CLAYSTONE; greenish gray (5GY6/1) to olive gray (5Y5/1) with lighter greenish gray (5G6/1) blotches at scattered intervals. Faint flattened burrow mottling. Sediment is hard and blocky, with subconchoidal fracture. Dominant cristobalite and sparse calcite rhombs and fish debris. Ash contains plagioclase and quartz.		
				2	0.0, 0.5, 1.0			R C M; R A M n; R C M	(5G6/1)		
				CORE CATCHER					quartz		

In core catcher:

SiO_2 75.2%	Al_2O_3 8.2%	TiO_2 0.35%	Fe_2O_3 3.4%
MgO 2.2%	CaO 1.3%	Na_2O 1.65%	K_2O 0.9%
MnO 0.06%	P_2O_5 0.42%	Ba 270 ppm	
Sr 270 ppm	Cu 90 ppm		

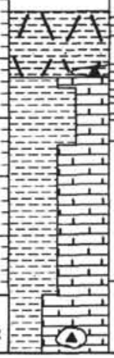
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1327. This background was subtracted from the data.

SITE 146 HOLE CORE 11 CORED INTERVAL (m) 476-485

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
EARLY PALEOCENE				1	0.5 / 1.0	VOID		R F P / n n n n	Chert Stringer		
? LATE CRETACEOUS	Gr. pseudobulloides or ? Globogerina eugubina			2	0.5 / 1.0			N R P / N R P / N R P / N R M / N R P / N R P	Olive gray (5G7/2) Nanno Marl; (10YR6/2) (5YR8/1) (5G8/1)		
				CORE CATCHER							



SILICEOUS CLAYSTONE; grayish brown (10YR5/2) to moderate brown (5YR5/4) with slightly lighter blotches due to flattened burrow mottling. Chert stringer appears at bottom. Sediment hard and broken, with cristobalite, quartz, biotite, plagioclase, barite, and fish debris. X-ray shows polygorskite.

INTERBEDDED NANNOPLANKTON MARL AND CLAY; pinkish gray (5Y6/2) to moderate brown (5YR4/4) to pale yellowish brown (10YR6/2). Horizontal burrow mottling associated with color changes, light greenish gray (5G8/1) to pinkish gray (5YR8/1), occurs throughout. The clays are characteristically the darker zones and the marls the lighter - gradational contacts. X-ray shows K-feldspar and polygorskite. Sediment well consolidated and very broken. Upper boundary sharp, with a marlstone separated by a thin claystone layer.

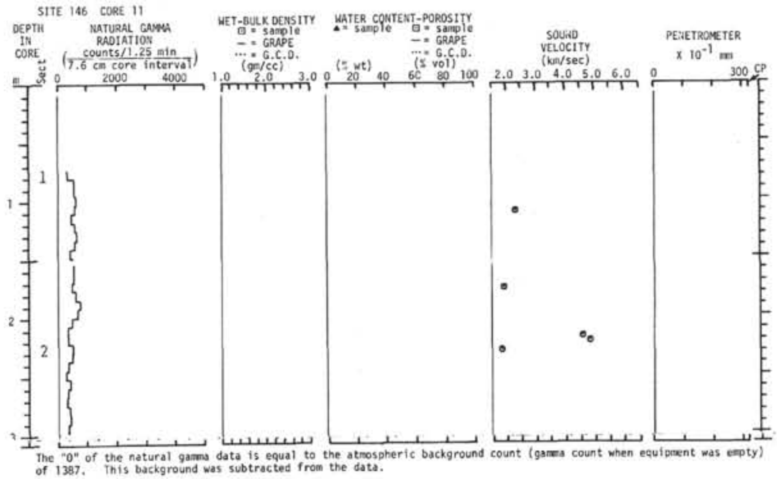
X-ray diffraction results:

Section 1	63-64cm	113-114cm
Amorphous scattering	62%	55%
Quartz	8%	69%
Cristobalite	76%	--
Plagioclase	6%	--
Palygorskite	--	12%
Montmorillonite	6%	6%
Clinoptilolite	2%	9%
Barite	2%	5%

In thin section the banding is seen to be the result of argillaceous and pyrite-rich biomicrite alternating with sparse highly calcareous biomicrite. Matrix partly silicified.

NANNOPLANKTON CHALK (5YR8/1) and RADIOLARIAN CHERT; up to 150μ plagioclase.

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1387. This background was subtracted from the data.

SITE 146 HOLE CORE 12 CORED INTERVAL (m) 485-494

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
? LATE CRETACEOUS				1	0.5 1.0	VOID		R R P	A few pieces of NANNOPLANKTON MARL AND CHALK light brownish gray (5YR6/1), hard and compacted. Lighter colored mottling due to fine burrowing occurs throughout. Some radiolarians and foraminifers, more conspicuous in the upper pieces. Minor biotite, quartz, and carbonate pellets. X-ray diffraction results, 126-127 cm Amorphous scattering 46% Calcite 72% Quartz 26% K-feldspar 2%		
				CORE CATCHER							

[1]For explanation of symbols, see Chapter 1

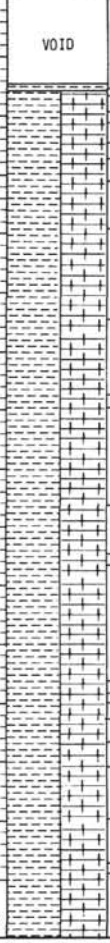
SITE 146 HOLE CORE 13 CORED INTERVAL (m) 494-503

AGE: MAASTRICHTIAN

ZONE — FORAM: *Abathomphalus mayaroensis*; NANNO: *Lithraphidites quadratus*; RAD: —

SECTION	METERS	PALEO SAMPLE ABUNDANCE PRESERVATION	
1	0.5		VOID
1		R O / R R M / N F P	apatite
1	1.0	N R P	(5YR6/1)
2	0.0–0.5	R R M / N F M	(5BG7/2)
2	1.0	N R P	(5B7/1)
3	0.0–0.5	N F M / R R M	
3	1.0	N F M	(5B7/1)
4	0.0–0.5	N C M / R R M	
4	1.0	N R P	Common chlorite
5	0.0	N C M	Bioturbated ash
5	0.5		(5G8/1)
5	1.0	R R M / N F M	(5G8/1)
CORE CATCHER		R R M	

LITHOLOGY



LITHOLOGIC DESCRIPTION[1]

VOLCANIC CLAY about 0.5 cm thick, with sharp basal contact on marl.

NANNOPLANKTON MARL AND CALCAREOUS CLAY; predominantly light brownish gray (5YR6/1) and brownish gray (5YR4/1) respectively. The darker zones are characteristically the claystone which are gradational with lighter marl zones. Abundant burrow mottling in various shades of brown to olive gray (5Y5/1), pale blue green (5BG7/2), and bluish gray (5B7/1) causes horizontal to subhorizontal banding and a marbled structure throughout. Sediment is well consolidated, but darker; less calcareous zones are much softer.

X-ray diffraction results:

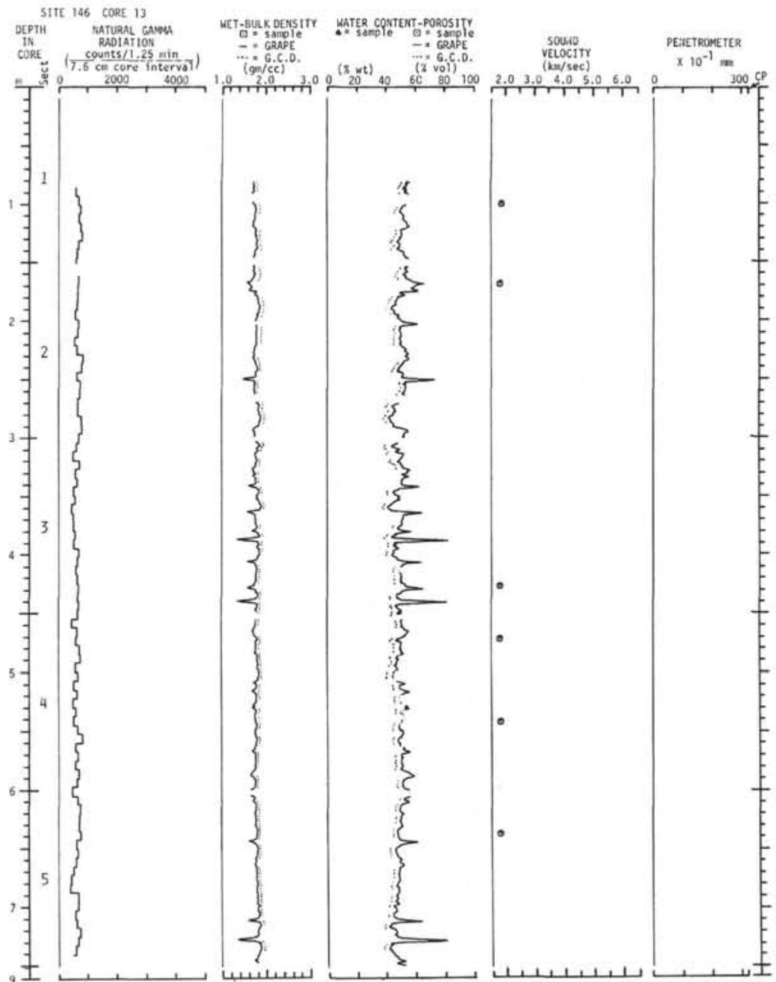
	Section 3 45-46 cm	Section 5 1-2 cm	Section 5 142-143 cm
Amorphous Scattering	51%	66%	44%
Calcite	72%	14%	77%
Quartz	18%	8%	20%
K-feldspar	3%	10%	--
Kaolinite	--	1%	--
Montmorillonite	5%	66%	2%

Abundant to dominant quartz and montmorillonite, trace biotite, carbonate rhombs, apatite, and sparse fish debris. In addition, X-ray results show K-feldspar and hematite.

CaCO₃ (%) — — — SAND-SILT-CLAY (accumulative %) 0 50 100

DEFORMATION

[1]For explanation of symbols, see Chapter 1



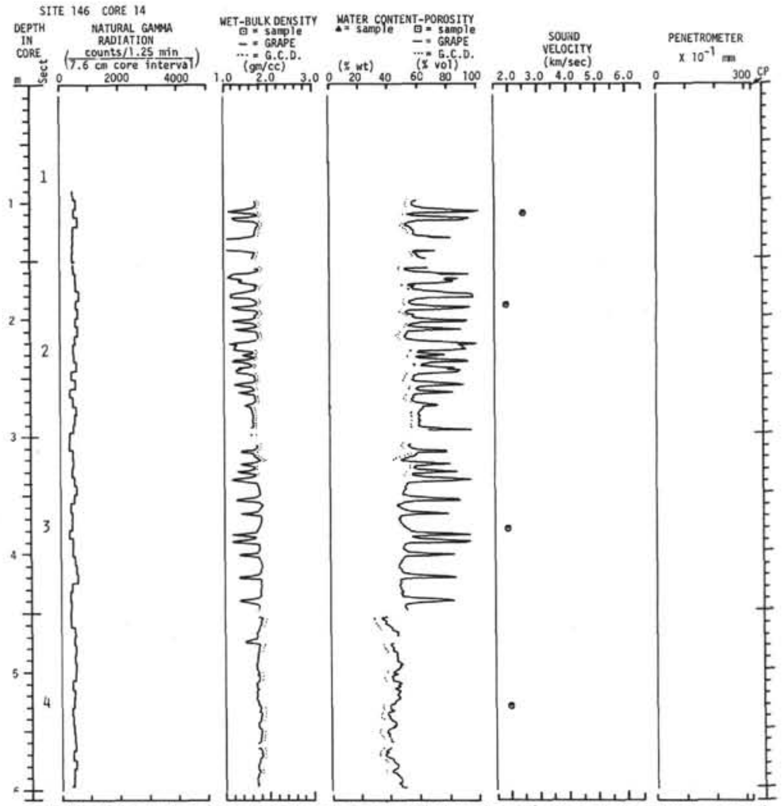
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1373. This background was subtracted from the data.

SITE 146 HOLE CORE 14 CORED INTERVAL (m) 503-512

AGE	ZONE (FORAM / NANNO / RAD)	SECTION	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]
MAASTRICHTIAN	Globotruncana contusa	1 (0.5–1.0 m: VOID)	N F M; N F M	Interbedded FORAMINIFERAL NANNOPLANKTON MARL and CALCAREOUS CLAY; light olive gray (5Y6/1) to olive gray (5Y4/1) with abundant horizontal varicolored burrow mottling, mainly brownish gray (5YR4/1) and greenish gray (5G6/1) with devitrified glass fragments throughout. Color shades are gradational as are variations in carbonate content. Dark brown areas are characteristic of high clay content. Minor clinoptilolite. Traces of biotite, chlorite, apatite, plagioclase, and quartz. Sparse fish debris. In addition, X-ray shows K-feldspar, barite, and hematite.
		2	N R P; R R M; N R P	
		3	N R P; R R M; N F P	
		4	R R M; N F M; R R M	SILICEOUS CLAY-ASH, (5YR4/1), with plagioclase, biotite, chlorite, and apatite. Sandy layers particularly rich in corroded radiolarian molds.
		CORE CATCHER		

Other column headings: METERS, LITHOLOGY, LITHO SAMPLE, CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100, DEFORMATION

[1]For explanation of symbols, see Chapter 1



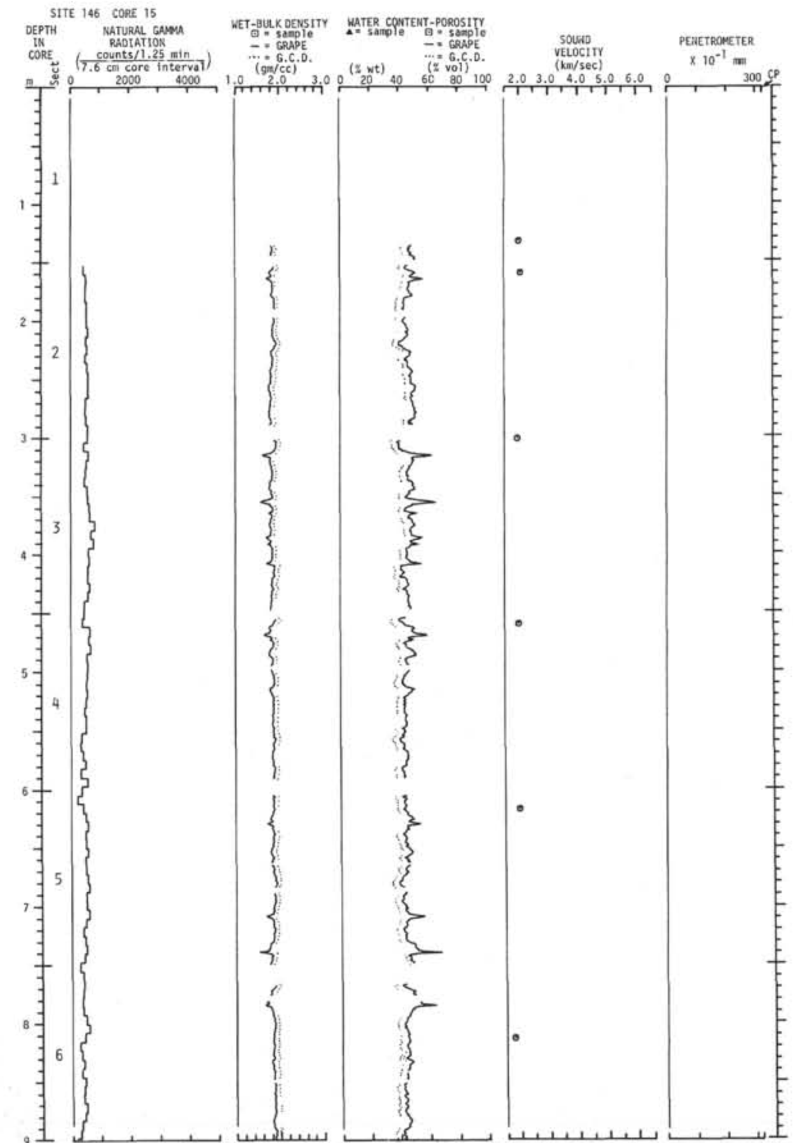
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1403. This background was subtracted from the data.

SITE 146 HOLE CORE 15 CORED INTERVAL (m) 512-521

AGE	ZONE: FORAM	SECTION	METERS	LITHOLOGY	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]
MAASTRICHTIAN	Globotruncana contusa	1	0.5–1.0	VOID		NANNOPLANKTON MARL; predominantly light olive gray (5Y6/1) to light gray (N7), with gradationally intercalated zones from pinkish gray (5YR7/1) to olive gray (5Y5/1). The darker zones typically have higher clay content. Burrow mottling, mostly horizontal, common throughout; usually darker than the surrounding sediment. Mottling is variable in shape and size; horizontal chevron-like burrows appear in bottom of Section 6. Interlayering of darker zones fades away toward lower sections.
		2	0.0–1.0		N P M; R R M; R R M; N F P	
	Globotruncana gansseri	3	0.0–1.0		N F M; R R M	
		4	0.0–1.0		N R P; N R P; N R P	
		5	0.0–1.0		R C P/M; N F M	Minor quartz, biotite, plagioclase and apatite. Garnet (?spessartite) in Section 4, 10 cm. Sparse fish debris.
		6	0.0–1.0		N F M; N C M; N C M; R R P	In addition, X-ray shows K-feldspar, barite, carbonate rhombs. Horizontal chevron-like burrows. Fossiliferous micrite with rare benthonic foraminifers and radiolarians and abundant volcanic fragments.
		CORE CATCHER				

CaCO₃ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100; DEFORMATION

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1403. This background was subtracted from the data.

SITE 146 HOLE CORE 16 CORED INTERVAL (m) 521-530

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MAASTRICHTIAN	Globotruncana gansseri	?		1	0.5, 1.0	VOID		N F P	MCND		
								R C P/M	Volcanic clay apatite (5YR3/1)		
				2	0.0, 0.5, 1.0			N F P	MCND		
								N C P			
				3	0.0, 0.5, 1.0			N C P / R R P	Volcanic Clay (5B6/1)		
				4	0.0, 0.5, 1.0			N F P			
								N C P			
								R R P	7 cm thick volcanic clay (5Y5/1)		
				5	0.0, 0.5, 1.0			N F P			
								N F P			
				6	0.0, 0.5, 1.0			R R M / N F P	Volcanic clay (5YR2/1)		
								R O	Volcanic clays (5GY6/1) and (N5)		
								N F P / R O / N F P			
				CORE CATCHER							

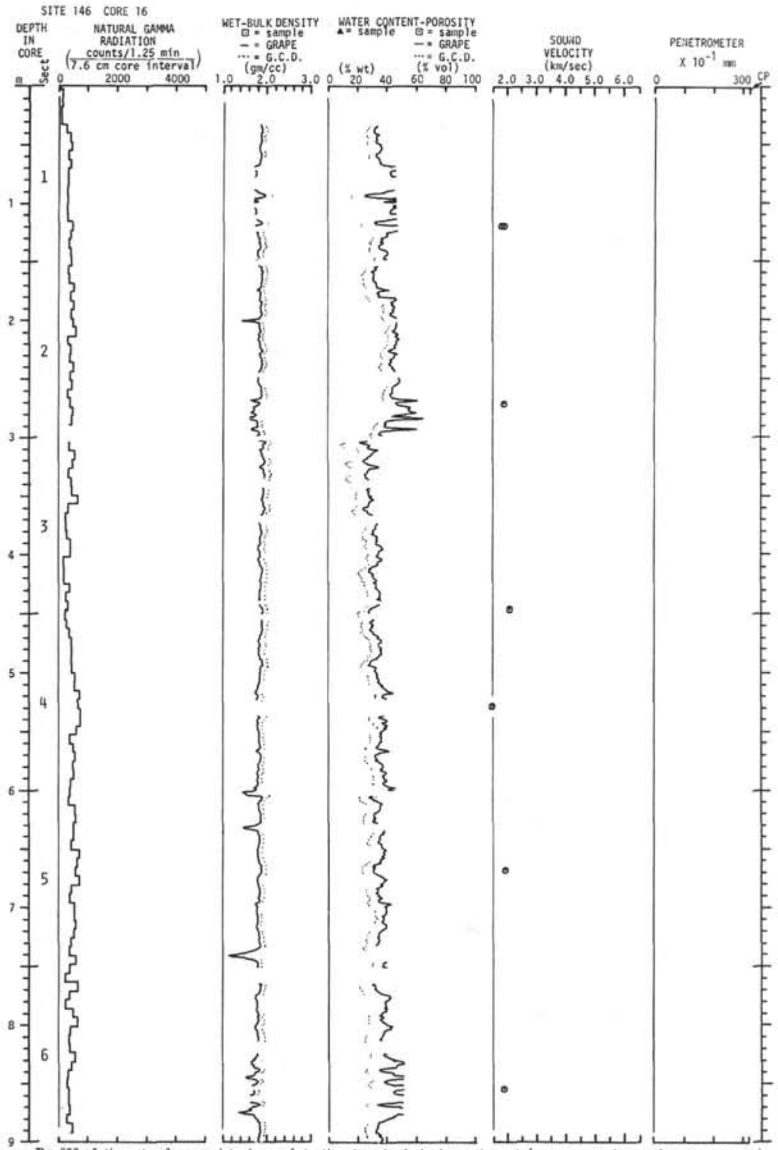
Interbedded FORAMINIFERAL NANNOPLANKTON CHALK AND MARL, very light gray (N7) to light olive gray (5Y6/1) and light brownish gray (5YR6/1) respectively. Darker zones are characteristically marly and are gradational with the lighter chalky zones. Sparse quartz, plagioclase and biotite. Widespread fish debris, apatite, and clinoptilite. Minor carbonate rhombs. In addition, X-ray shows K-feldspar and barite. Several volcanic clay layers occur. They vary in thickness and color from dark brownish gray (5YR3/1) to medium bluish gray (5B6/1) olive gray (5Y5/1) and darker shades. Burrow mottling abundant throughout, particularly conspicuous in and nearby volcanic clay layers when darker sediments are filling in burrows. Sandy zone rich in radiolarian molds occurs in lower part of Section 1. The volcanic clay at 80 cm in Section 4 has common alkaline feldspar, minor clinoptilolite, subspherical quartz, plagioclase, biotite, and zircon.

X-ray diffraction results.

	Section 1 123.2-123.3 cm	Section 3 37.5-40 cm
Amorphous Scattering	49%	54%
Calcite	11%	2%
Quartz	1%	2%
K-feldspar	3%	--
Montmorillonite	85%	97%

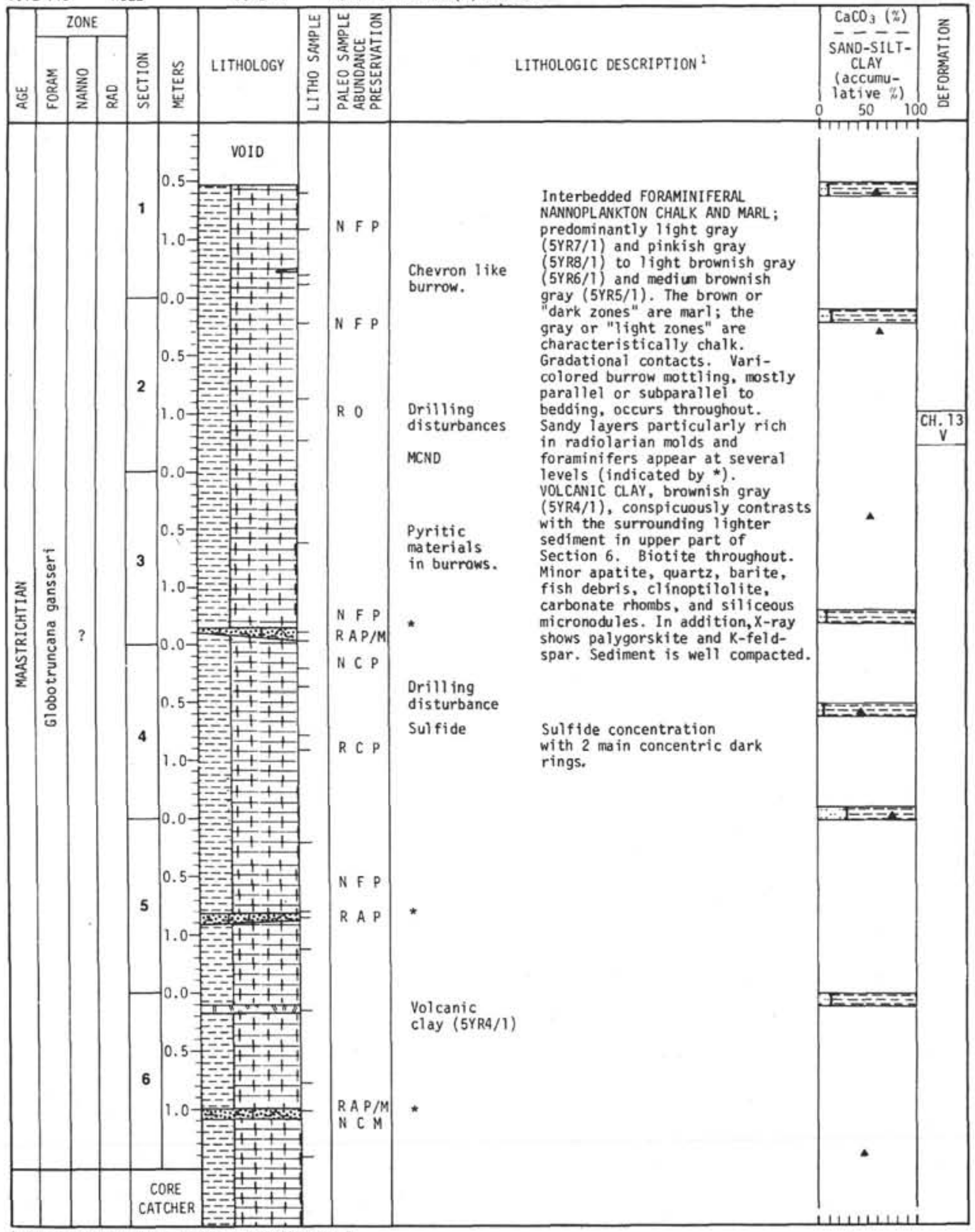
MCND=micronodules

[1]For explanation of symbols, see Chapter 1

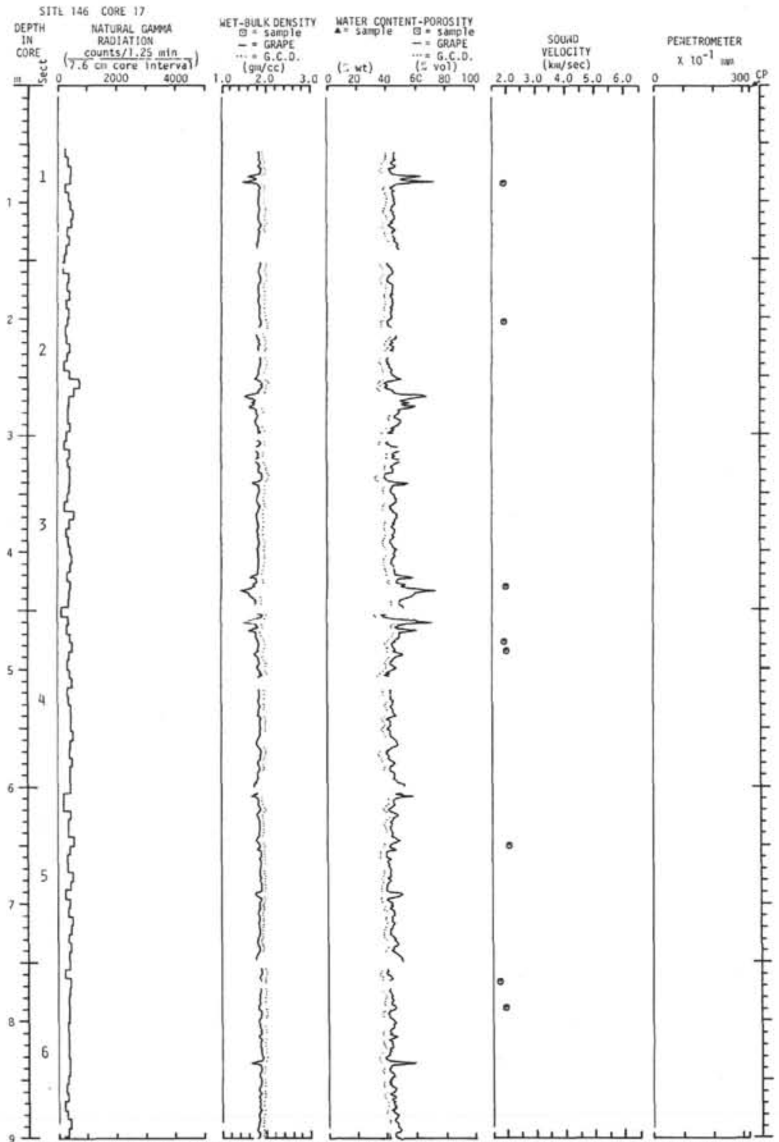


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1411. This background was subtracted from the data.

SITE 146 HOLE CORE 17 CORED INTERVAL (m) 530-539

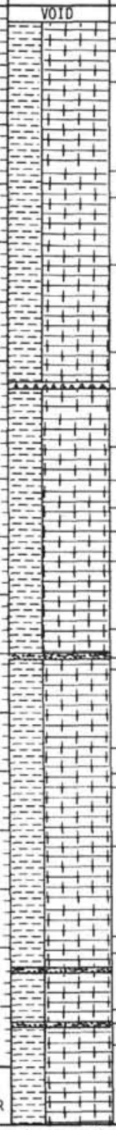


¹For explanation of symbols, see Chapter 1

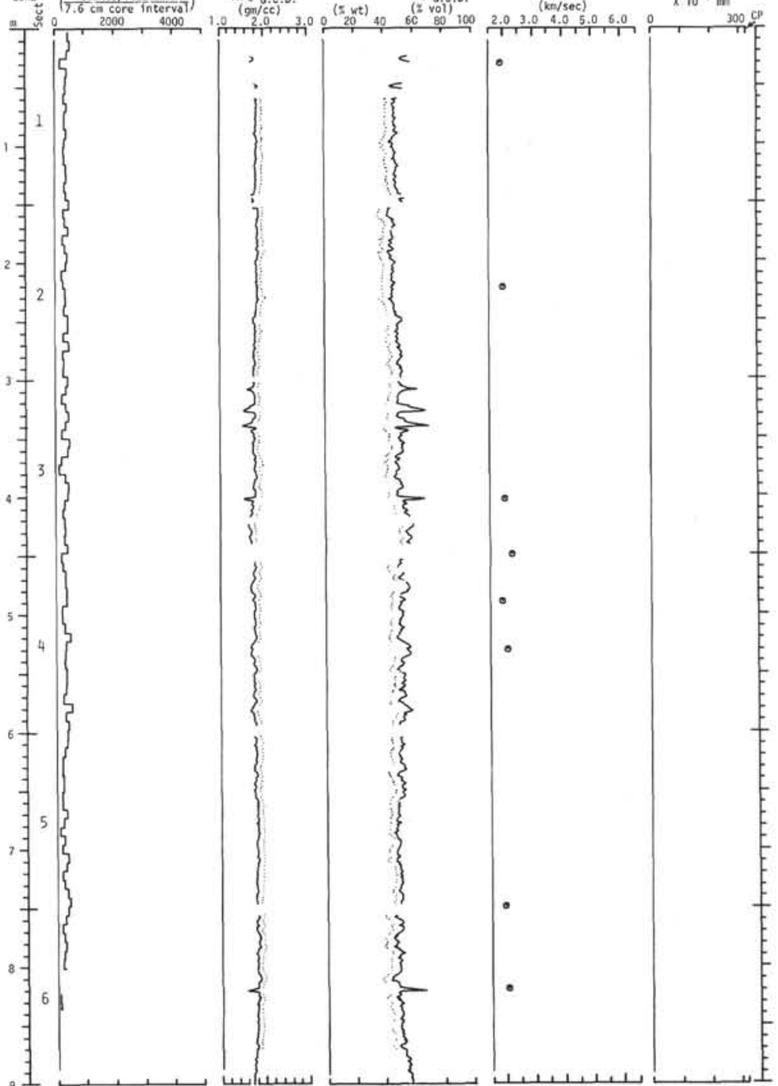


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1406. This background was subtracted from the data.

SITE 146 HOLE CORE 18 CORED INTERVAL (m) 539-548

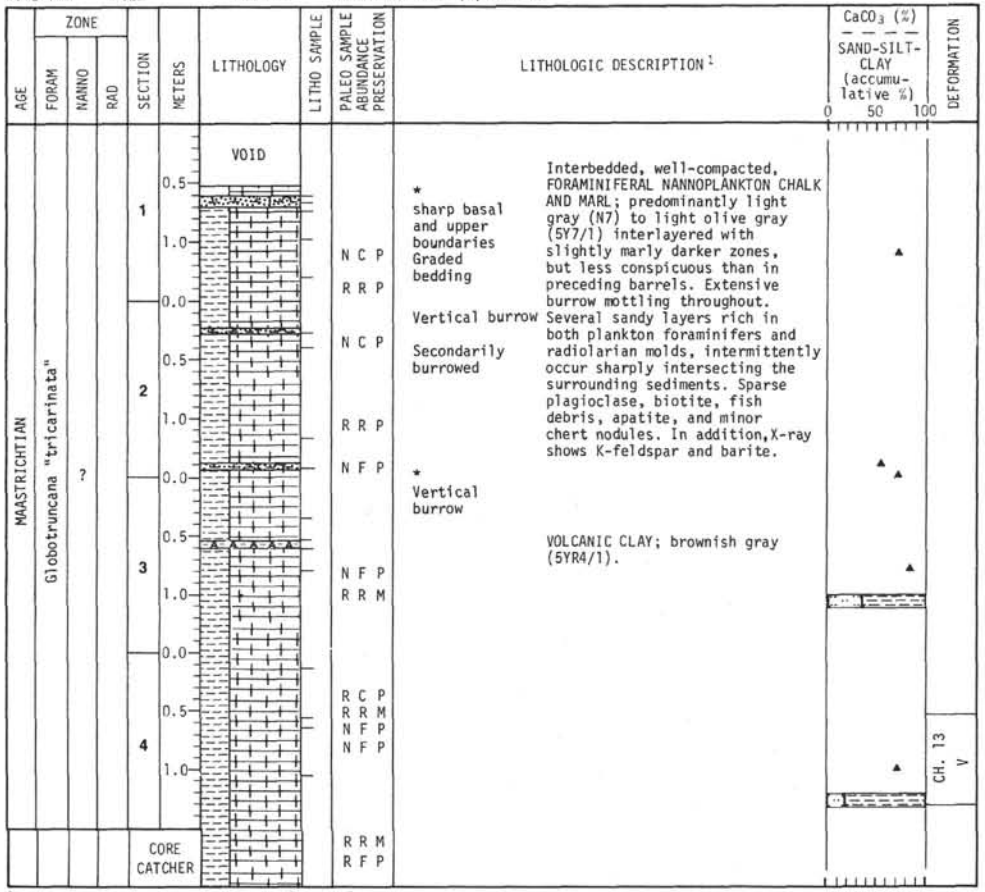
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MAASTRICHTIAN	Globotruncana gansseri	?		1	VOID; 0.5; 1.0			N C M; N F P; R O	Interbedded FORAMINIFERAL, NANNOPLANKTON CHALK and MARL; light brownish gray (5YR6/1) with intermittant minor darker marly zones particularly evident in Section 3 and 4. Extensive burrow mottling somewhat blurs the gradational change between the zones. The darker zones are characteristically marl while the lighter zones are characteristically chalks. Traces of apatite, chlorite, and biotite. Widespread fish debris. Chert micronodules and carbonate rhombs throughout. In addition, X-ray shows barite. Some layers are particularly rich in radiolarian molds and richer in well-preserved planktonic foraminifers than the surrounding sediment. Occasionally large elliptical burrows are filled with the same radiolarian-rich sediment comprising the sandy layers (indicated by *). Volcanic clay layer occurs in Section 3. Sediment well compacted.		
				2	0.0; 0.5; 1.0			N F P; R R P; N F P			
				3	0.0; 0.5; 1.0			R R P/M; N C P	Volcanic clay sharp basal contact, burrowed, blurred upper contact.		
				4	0.0; 0.5; 1.0			N F P; R R P	Sandy layer		
	Globotruncana "tricarinata"			5	0.0; 0.5; 1.0			R F P; N C P	*		
				6	0.0; 0.5; 1.0			R R P/M; N F P	Trace chlorite; Sandy layer; Trace biotite; Mica?; Sandy layer		
				CORE CATCHER							

[1]For explanation of symbols, see Chapter 1

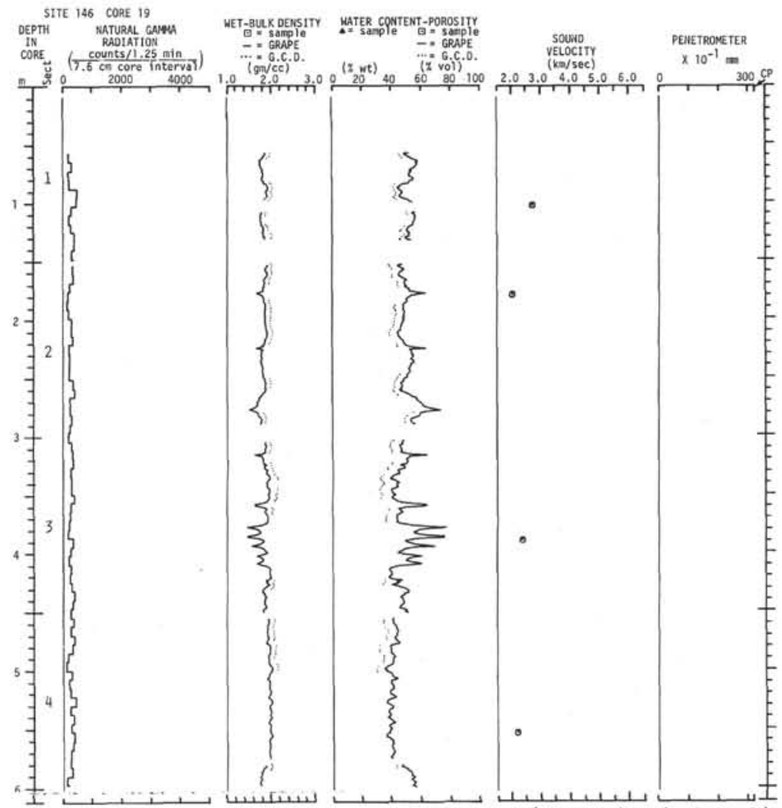


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1405. This background was subtracted from the data.

SITE 146 HOLE CORE 19 CORED INTERVAL (m) 548-557



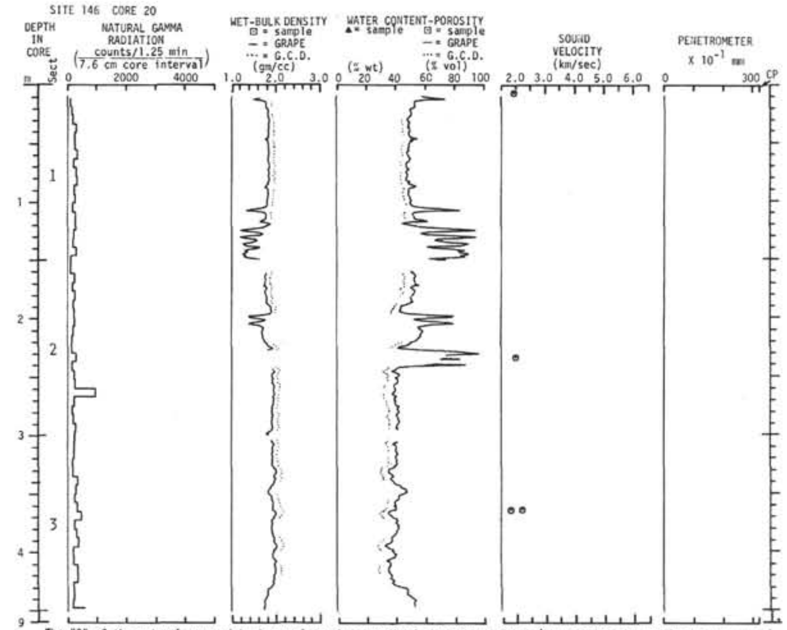
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1405. This background was subtracted from the data.

SITE 146 HOLE CORE 20 CORED INTERVAL (m) 557-566

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MAASTRICHTIAN	Globotruncana "tricarinata"	?		1	0.5, 1.0			N C P; R C P	FORAMINIFERAL NANNOPLANKTON CHALK; light gray (N7) to very light gray (N8) with minor interbedded light brownish gray (5YR6/1) zones of greater clay content. Extensive burrow mottling throughout. Very compact, but crumbly especially in light gray zones. Trace amounts of biotite, apatite, barite, plagioclase, mica, quartz, and widespread fish debris. Chert micronodules and carbonate rhombs throughout. Chert fragment grayish orange (5YR7/2) with light brown (5YR6/4) nucleus is at top section 1.		
				2	0.0, 0.5, 1.0			N F P; R R P; R R P/M	Sandy layer with predominance of foraminifers and with graded bedding. Zone with abnormally high gamma count contains mainly devitrified volcanic glass with few crystals of plagioclase and biotite.	▲	
				3	0.0, 0.5, 1.0			N F P; R R M		▲	
				CORE CATCHER							



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1415. This background was subtracted from the data.

SITE 146 HOLE CORE 21 CORED INTERVAL (m) 566-575

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
*	**			CORE CATCHER					No recovery. Core catcher consists of FORAMINIFERAL NANNOPLANKTON CHALK, light gray (N7), crumbly and fragmented.	-	

[1]For explanation of symbols, see Chapter 1

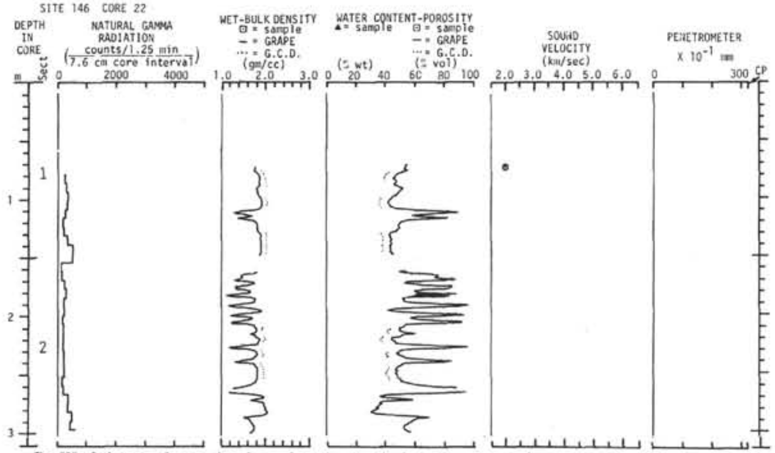
* MAASTRICHTIAN

** Globotruncana "tricarinata"

SITE 146 HOLE CORE 22 CORED INTERVAL (m) 575-584

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) — SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
CAMPANIAN	Globotruncana calcarata	?		1	0.5 1.0	VOID		R C P R R M R F P	FORAMINIFERAL NANNOPLANKTON CHALK; predominantly yellowish gray (5Y8/1) to light gray (N7), becoming light olive gray (5Y5/1) to light brownish gray (5YR7/1) in zones which are also softer than the surrounding sediments. The darker zones are typically more clayey. Extensive burrowing. Sparse fish debris, barite and apatite. Minor chert micronodules and carbonate rhombs throughout. In addition, X-ray diffraction shows palygorskite. Grayish pink (5R8/2) CHERT fragment occurs in darker, more clayey zone, lower part Section 2. Sandy layer rich in radiolarian molds in top part Section 2. Sediment very compact.		
				2	0.0 0.5 1.0			N F P R R M N C M N F P R R M			
				CORE CATCHER							

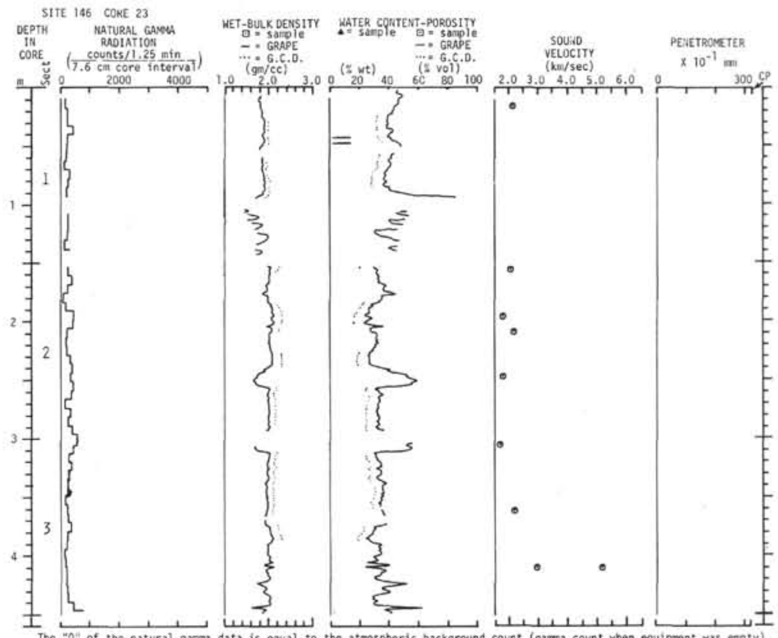
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1448. This background was subtracted from the data.

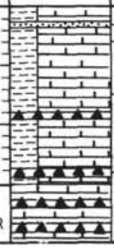
SITE 146 HOLE CORE 23 CORED INTERVAL (m) 584-593

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
CAMPANIAN	Globotruncana elevata	?		1	0.5, 1.0			R R M; N C M	NANNOPLANKTON CHALK; light olive gray (5Y7/1) becoming gradationally pale yellowish brown (10YR7/2) with higher clay content in intermittent zones. Sparse plagioclase, alkali feldspar, aptite, and barite. Widespread biotite, fish debris, and carbonate rhombs. In addition, X-rays shows palygorskite. Two *VOLCANIC CLAY layers medium gray (N5) and medium dark gray (N4) occur in sharp contrast to the surrounding lighter sediment in Sections 2 and 3. Ash silt on CHERT fragments, very pale red (10R7/2) to grayish red (10R4/2) is interbedded in Section 3 with apparent sharp contacts. Burrow mottling abundant throughout.	▲	
				2	0.0, 0.5, 1.0			N C M; R R M	*(N4); *(N5)		
				3	0.0, 0.5, 1.0			R C P; R R M; N F P	(10R7/2) to (10R4/2). Upper boundary blurred by burrowing. Contains devitrified glass fragments, biotite, apatite, and plagioclase. Sharp lower contact within narrow zone of diffusion into underlying chalk.	▲	
				CORE CATCHER					Broken fragments of cherts.		

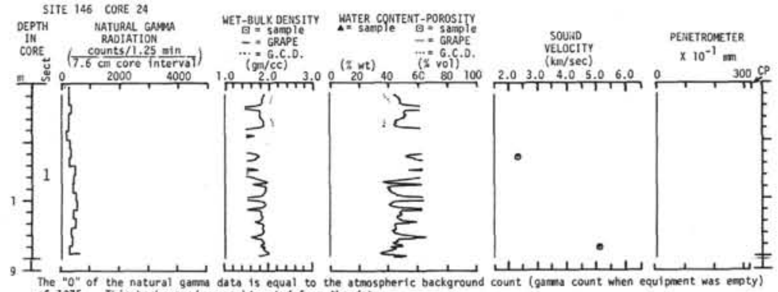


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1448. This background was subtracted from the data.

SITE 146 HOLE CORE 24 CORED INTERVAL (m) 593-602

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION*	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
CAMPANIAN	Globotruncana elevata	?		1	0.5 1.0			N C P R C P R R M	(5YR4/1) (5YR4/1) and (5Y4/1) (5R6/2) NANNOPLANKTON CHALK; light olive gray (5Y6/1) to pinkish gray (5YR7/1) (marly zones). Extensively burrow mottled throughout. Sandy layers consisting mostly of silicified radiolarian molds and chert fragments occur interbedded in upper and lower parts respectively. Lowermost cherts show irregular color banding and may be filling in burrows. Light colored chert is slightly calcareous. Minor quartz, fish debris, barite, chert micronodules, and carbonate rhombs throughout. In addition, X-ray diffraction shows K-feldspar.		
				CORE CATCHER							

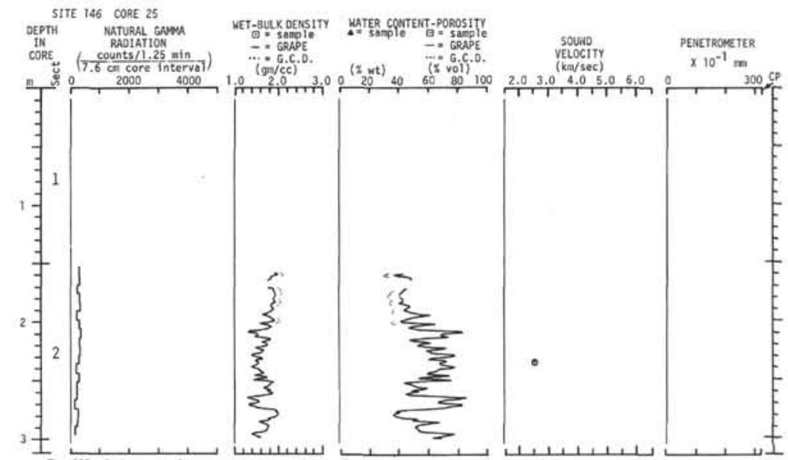
*For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1375. This background was subtracted from the data.

SITE 146 HOLE CORE 25 CORED INTERVAL (m) 602-611

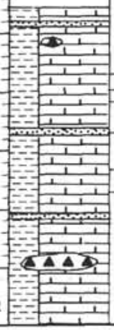
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) – SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE CRETACEOUS		?		1	0.5 1.0				Section 1: Very soupy mixture of *CHERT* cuttings and *CHALK*, totally disturbed.		CH. 13 I
				2	0.0 0.5 1.0			R C P R R M N F P R R M	(5GY8/1) (5GY8/1) (5GY8/1) Volcanic clay (5YR2/1) (5GY8/1) NANNOPLANKTON CHALK; predominantly light brownish gray (5YR6/1) to pinkish gray (5YR7/1). The darker (brownish) layers are characteristically marly. Minor fish debris, apatite, chert, and barite micronodules. Carbonate rhombs throughout. In addition, X-ray shows K-feldspar. Extensive burrow mottling throughout, and occasionally associated with contrasting hue change into light greenish gray (5GY8/1). Thin lamina of brownish black (5YR2/1) volcanic clay is partly blurred by mottling. Semi-indurated.	▲	
				CORE CATCHER							



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1365. This background was subtracted from the data.

SITE 146 HOLE CORE 26 CORED INTERVAL (m) 611-620

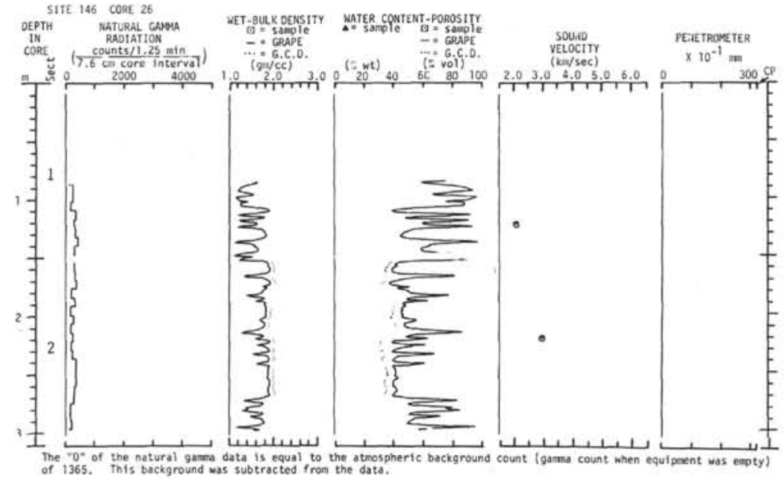
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) / SAND-SILT-CLAY (accumulative %)	DEFORMATION
CAMPANIAN	Globotruncana elevata	?		1	0.5 1.0	VOID		N C P R R M N F P	* (5YR7/1)		
				2	0.0 0.5 1.0			N C P R C P N F P R F G	* *		
				CORE CATCHER							



NANNOPLANKTON CHALK; predominantly light greenish gray (5GY7/1) and light brownish gray (5YR6/1) with alternating zones of varying shades into pale red (10R6/2) and grayish orange pink (5YR7/2). Color changes are gradational and rhythmic. The darker (brownish) layers are typically marly. Sparse barite, widespread chert micronodules and carbonate rhombs. In addition, X-ray shows palygorskite and hematite.

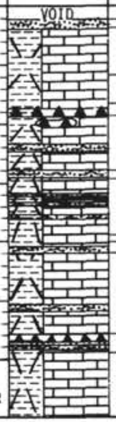
*Several sandy-textured layers rich in radiolarian molds occur intermittently intercalated in chalk. Some present sharp hue change, whereas others are of identical color relative to surrounding. Burrow mottling abundant throughout. Chert micronodules abundant in upper part. Semi-indurated.

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1365. This background was subtracted from the data.

SITE 146 HOLE CORE 27 CORED INTERVAL (m) 620-629

AGE	FORAM	NANNO	RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE CRETACEOUS		?		1, 2, CORE CATCHER	0.5, 1.0, 0.0, 0.5, 1.0			R C P R R M R R M R C P R R M N F P R C P N C P R R M N F P R A P/M	(5R4/2) (5R6/2)		

Sandy layer with veinlets of pyrite and calcite.
LIMESTONE; pinkish gray (5YR8/1) to light brownish gray (5YR6/1) marly zones are gradationally interbedded. Subhorizontal burrow mottling abundant throughout. Sparse biotite, barite, and apatite. Carbonate rhombs and micronodules throughout. X-ray diffraction also shows palygorskite. CHERT, grayish red (5R4/2) to pale red (5R6/2), and several sandy-textured layers rich in radiolarian molds appear intermittently at several levels. Chert micronodules throughout.

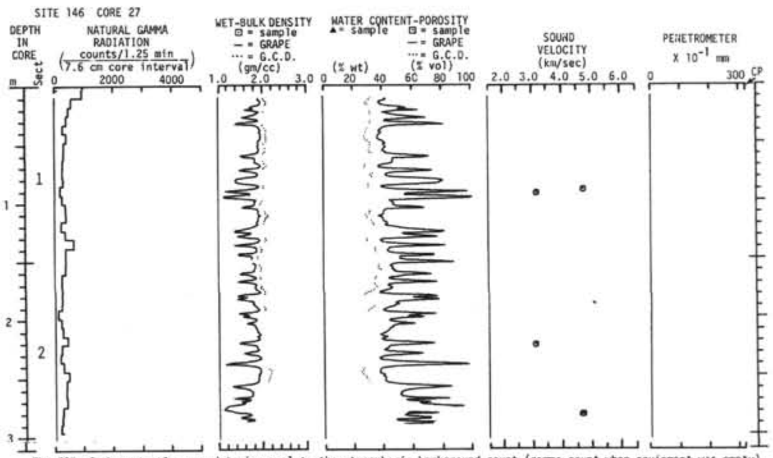
Laminated, bioturbated ARGILLACEOUS LIMESTONE with rare planktonic foraminifers mainly micritic and pelletoidal (feacal?), with radiolarians and fish debris. Rare, partly calcified feldspar.

Core catcher:

	light	dark
SiO_2	63.0%	55.4%
Al_2O_3	3.9%	5.1%
TiO_2	0.1%	0.45%
Fe_2O_3	0.9%	1.5%
MgO	1.9%	0.7%
CaO	16.4%	17.9%
Na_2O	0.7%	1.1%
K_2O	0.7%	0.75%
MnO	0.08%	0.06%
P_2O_5	0.09%	0.17%
Ba	2700 ppm	2800 ppm
Sr	240 ppm	600 ppm
Cu	20 ppm	70 ppm

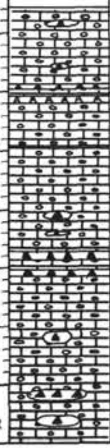
For explanation of symbols, see page

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1378. This background was subtracted from the data.

SITE 146 HOLE CORE 28 CORED INTERVAL (m) 629-638

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) — SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE CRETACEOUS		?		1	0.5, 1.0	VOID					
				2	0.0, 0.5, 1.0			R C P; R R M; N R P; R C P	Chert (10R4/2); Chert (5Y4/1); *Volcanic clay (N4); Thin volcanic clay (N4)	▲ ▲	
				3	0.0, 0.5, 1.0			N R P; R C P; R R M; N R P	10R4/2; 10R4/2; 10Y4/2	▲	
				CORE CATCHER				R F M			

RADIOLARIAN LIMESTONE; partly silicified, light olive gray (5Y7/1) with slightly darker zones. Gradationally interbedded and characteristically having higher clay content. Burrow mottling common, occasionally associated with pyritic streaks. Sparry calcite and macrocrystalline pyrite are found in microfracture-like feature in Section 3 (10-18 cm). CHERT layers and lenses; olive gray (5Y4/1) and mostly grayish red (10R4/2) occur in several intervals, particularly in Section 3. In peels, chert shows gradual transition toward partly silicified radiolarian limestone, and intensive silicification in burrows. Silicification front is irregular and about 1 mm wide. "Ghosts" of radiolarians and foraminifers are present in cherts, the former better preserved toward the limestone as the calcite content increases. Limestone can be classified as sparse to packed radiolarian biomicrite. Radiolaria often calcified. Laminations are due to varying clay content and subparallel orientation of the microfossils. Abundant silicified replacement veins. In general, sparse barite and chert micronodules.

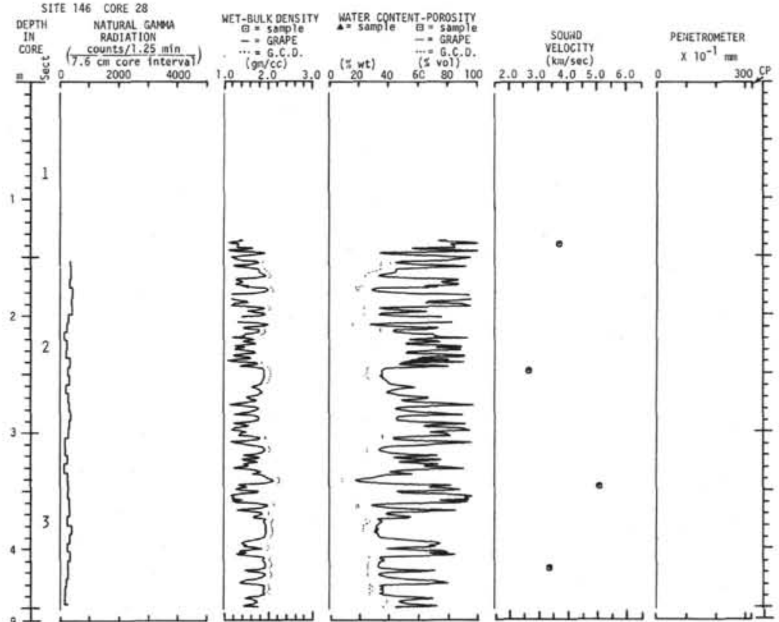
*VOLCANIC CLAY; contains alkali feldspar, plagioclase, biotite, apatite, conspicuous zircon, hornblende, barite, and glass devitrified to montmorillonite.

ASH, on bedding plane, contains plagioclase, biotite, chlorite, and apatite.

Calcareous radiolarian chert, with calcified radiolaria.

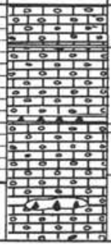
For explanation of symbols, see page

[1]For explanation of symbols, see Chapter 1

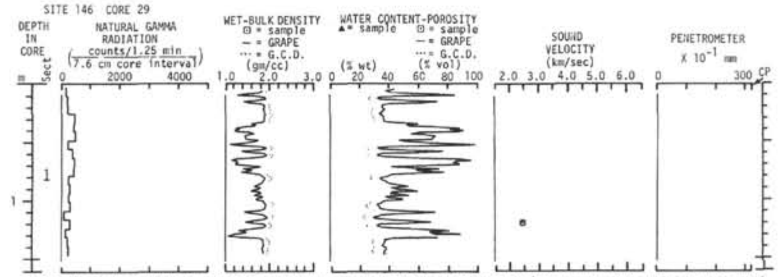


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1372. This background was subtracted from the data.

SITE 146 HOLE CORE 29 CORED INTERVAL (m) 638-647

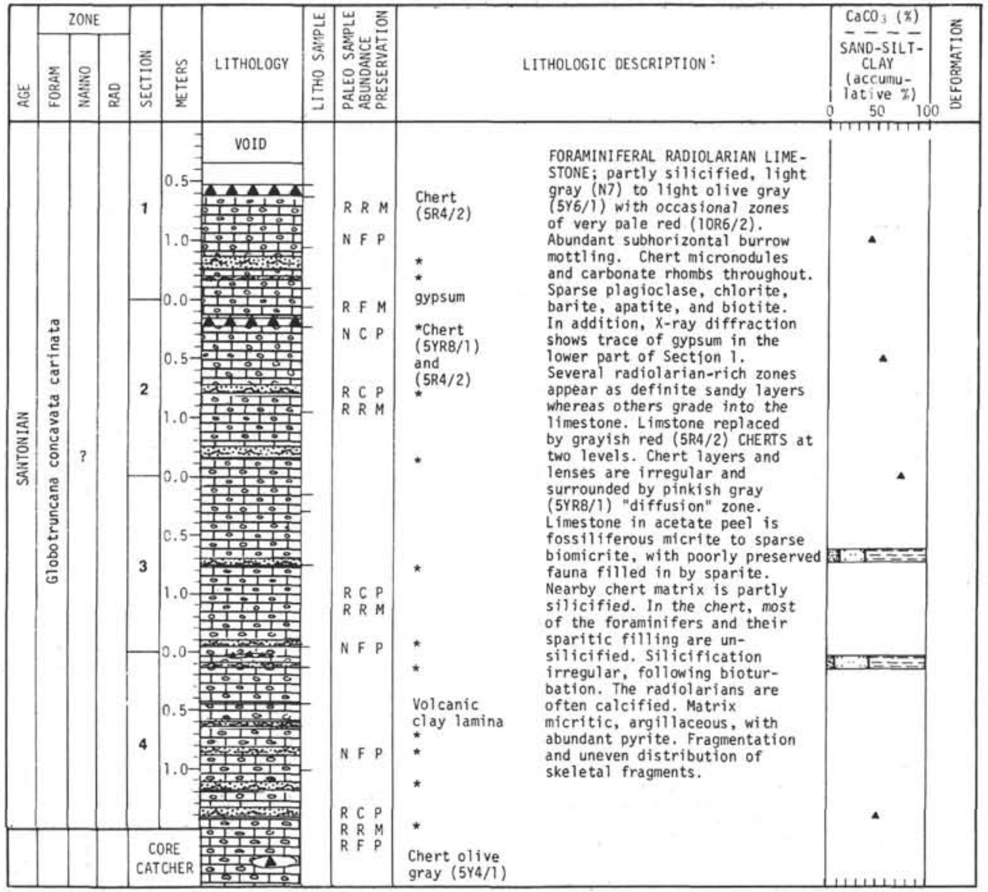
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE CRETACEOUS		?		1	0.5 1.0			N F P R C P R R M	Volcanic clay *(5YR3/1) Chert (5R6/2) RADIOLARIAN LIMESTONE; light olive gray (5Y7/1) becoming darker by zones. Extensive burrow mottling throughout, some burrows with minor pyritic streaks. Chert micronodules and carbonate rhombs throughout. In addition, X-ray diffraction shows K-feldspar. VOLCANIC CLAY, dark brownish gray (5YR3/1), and CHERT, pale red (5R6/2), are randomly intercalated in limestone, which also presents some sandy textured zones with no definite boundaries. *VOLCANIC CLAY, contains alkali feldspar, plagioclase, chlorite, biotite, apatite, clinoptilolite, zircon, and devitrified glass.	▲	
				CORE CATCHER				R F P/M			

[1]For explanation of symbols, see Chapter 1



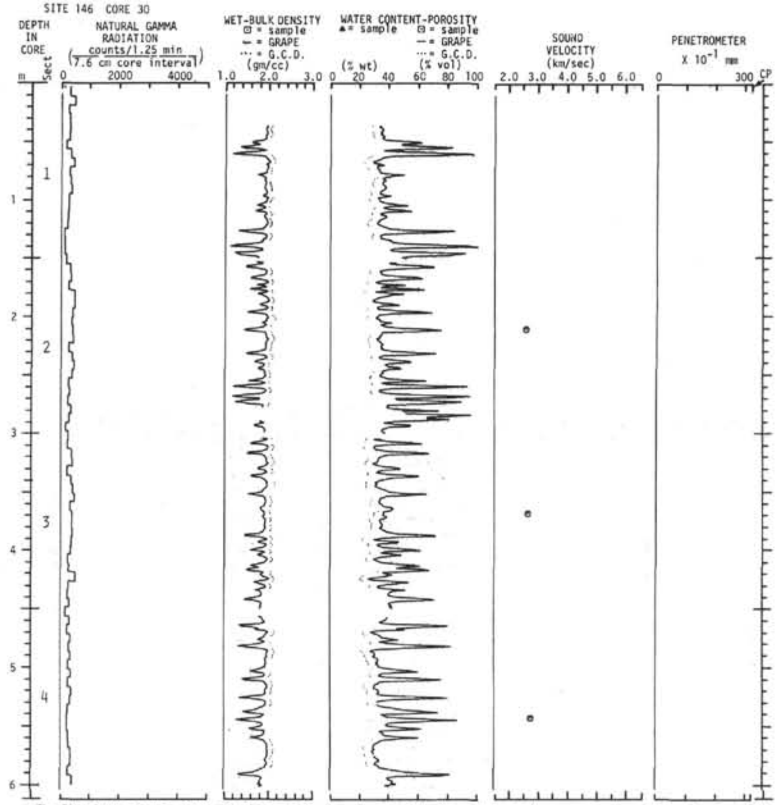
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1372. This background was subtracted from the data.

SITE 146 HOLE CORE 30 CORED INTERVAL (m) 647-656



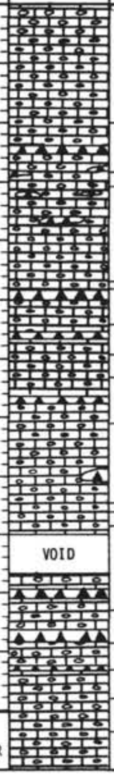
FORAMINIFERAL RADIOLARIAN LIMESTONE; partly silicified, light gray (N7) to light olive gray (5Y6/1) with occasional zones of very pale red (10R6/2). Abundant subhorizontal burrow mottling. Chert micronodules and carbonate rhombs throughout. Sparse plagioclase, chlorite, barite, apatite, and biotite. In addition, X-ray diffraction shows trace of gypsum in the lower part of Section 1. Several radiolarian-rich zones appear as definite sandy layers whereas others grade into the limestone. Limstone replaced by grayish red (5R4/2) CHERTS at two levels. Chert layers and lenses are irregular and surrounded by pinkish gray (5YR8/1) "diffusion" zone. Limestone in acetate peel is fossiliferous micrite to sparse biomicrite, with poorly preserved fauna filled in by sparite. Nearby chert matrix is partly silicified. In the chert, most of the foraminifers and their sparitic filling are unsilicified. Silicification irregular, following bioturbation. The radiolarians are often calcified. Matrix micritic, argillaceous, with abundant pyrite. Fragmentation and uneven distribution of skeletal fragments.

*For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1367. This background was subtracted from the data.

SITE 146 HOLE CORE 31 CORED INTERVAL (m) 656-665

AGE	FORAM	NANNO	RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %)	DEFORMATION
LATE CRETACEOUS		?		1	0.5, 1.0			R C P; N F P			
				2	0.0, 0.5, 1.0			R C P; R R M; N F P			
				3	0.0, 0.5, 1.0			R C P; R R M; N R P			
				4	0.0 (VOID), 0.5, 1.0			N R P; R A P; R R M			
				CORE CATCHER				R AP/M			

FORAMINIFERAL RADIOLARIAN LIMESTONE; silicified, very light gray (N8) and light olive gray (5Y6/1). Extensive burrow mottling throughout, becoming zonally dark greenish gray (5GY6/1) and contains disseminated pyrite. Sparse plagioclase chlorite, apatite, and altered volcanic glass. Chert micro-nodules and carbonate rhombs throughout. Crystals of authigenic K-feldspar in Section 2, 120 cm. In addition, X-ray diffraction shows palygorskite. CHERT layers and lenses, predominantly grayish red (5R5/2) to (10R4/2) and light olive gray (5Y7/1), occur at irregular intervals throughout and consist of a matrix of microcrystalline quartz mosaic with coarser quartz and chalcedony as chamber filling. Sandy layers rich in radiolarian molds are very abundant but mostly with undefined boundaries.

Limestone is a sparse biomicrite with poor to well preserved planktonic foraminifers, few benthonics and *Inoceramus* prism. Fossils are aligned parallel to bedding. Sandy zones consist of packed biomicrite with abundant radiolarians; matrix is more argillaceous than that of the limestone.

* Convolute color lamination

Faunal remains are partly filled by sparite or by well-recrystallized quartz.

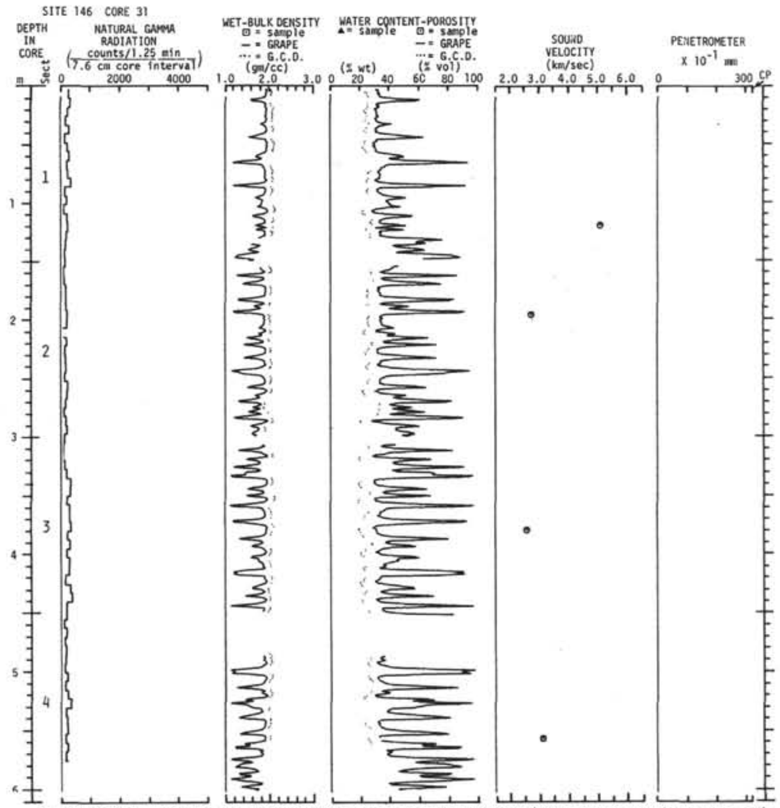
X-ray diffraction results:

	Section 2, 3-5 cm
Amorphous scattering	27%
Calcite	89%
Quartz	11%

*Area contains quartz, plagioclase, alkali, feldspar, apatite.

Limestone (N8): Thin section shows abundant radiolarians replaced by calcite, scattered fish debris.

[1]For explanation of symbols, see Chapter 1



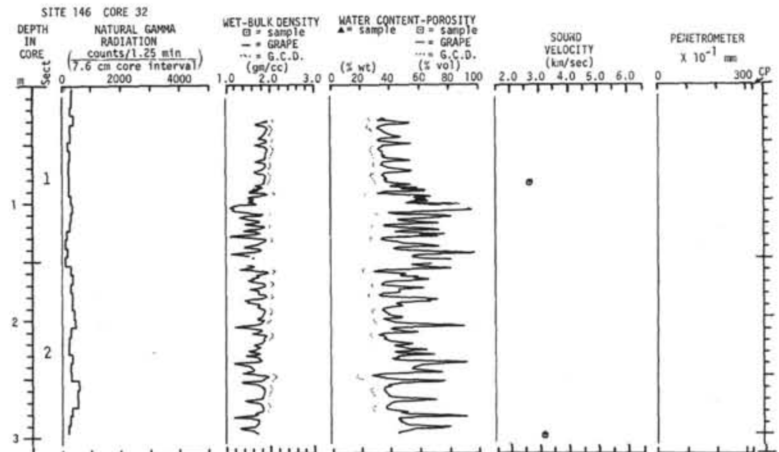
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1390. This background was subtracted from the data.

SITE 146 HOLE CORE 32 CORED INTERVAL (m) 665-674

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
SANTONIAN	Globotruncana concavata carinata	?		1	0.5 – 1.0			R F P R R M N F P	RADIOLARIAN LIMESTONE; light gray (N7) to light olive gray (5Y6/1) with several intercalated olive gray (5Y4/1) to dark greenish gray (5GY4/1) zones. Alternative colors partly associated with flattened, sub-horizontal burrow mottling throughout. Sandy textured zones abundant but become less conspicuous than in overlying bands due to intermixing with surrounding sediments by burrowing and redeposition. Grayish red (10R4/2) and (5R4/2) CHERT fragments and lenses and a VOLCANIC CLAY lamina occur interbedded in the limestone. In peel, limestone is a sparse to packed biomicrite with nannofossils, foraminifers, and radiolarians. Fauna often badly preserved and filled in with sparite. Overall faunal orientation parallel to bedding. Limestone-chert boundary may be sharp although the adjacent limestone contains patches of chert. Sparse plagioclase, alkali feldspars, chlorite, and chert micronodules. Carbonate rhombs throughout. In addition, X-ray diffraction shows palygorskite and barite.	▲	
				2	0.0 – 0.5 – 1.0			R C P R R M N R P		▲	
				CORE CATCHER				R F M	Few fragments (N8) — Sparse biomicrite with benthonic and planktonic foraminifers and calcified radiolarians, with fish scales.		

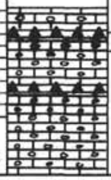
For explanation of symbols, see page

[1]For explanation of symbols, see Chapter 1

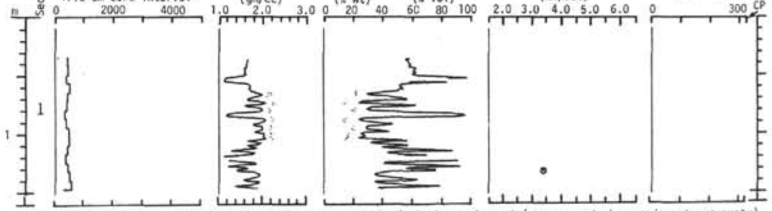


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1334. This background was subtracted from the data.

SITE 146 HOLE CORE 33 CORED INTERVAL (m) 674-683

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) — SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
SANTONIAN	*Globotruncana concavata carinata*	?		1	0.5 1.0	VOID 		R R P N R P	Horizontal calcitic lenses Microfracture with sparite few fragments (5Y6/1) RADIOLARIAN LIMESTONE; predominantly light olive gray (5Y7/1) to (5Y6/1) with abundant interlayered dark greenish gray (5GY4/1) zones, some associated with flattened burrow mottling. Radiolarian-rich, sandy-textured zones with undefined boundaries appear at several levels. Common carbonate rhombs. Trace of chlorite and chert micronodules.	▲	
				CORE CATCHER							

SITE 146 CORE 33



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1342.' This background was subtracted from the data.

SITE 146 HOLE CORE 34 CORED INTERVAL (m) 683-692

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]		CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
CONIACIAN/SANTONIAN	Globotruncana concavata concavata	?		1	0.5 1.0	VOID		N R P R R M	Lithified volcanic clay Slight graded bedding Chlorite Gypsum	RADIOLARIAN LIMESTONE; very light gray (N8) to medium light gray (N6) with laminations in darker shades and dark greenish gray (5GY4/1). CHERT, brownish gray (5YR4/1), is transitional into sandy zones as in previous core. At 51-52: radiolarian limestone fossils calcified. Scattered fish debris. Large barite crystals in burrows. Chemical analysis, Section 1, 51-56 cm.	▲ ▲	
				CORE CATCHER		VOID						

SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO
55.3%	14.9%	0.9%	7.0%	5.9%

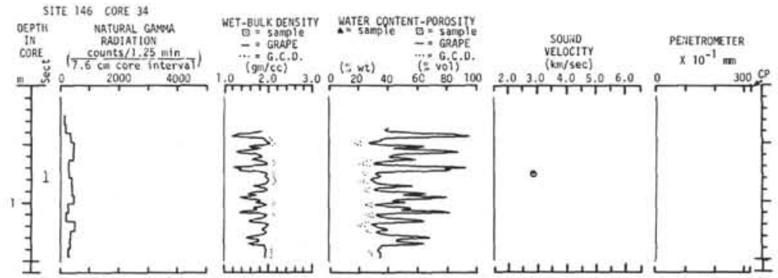
CaO	Na_2O	K_2O	MnO	P_2O_5
7.4%	2.35%	1.65%	0.02%	0.13%

Ba	Sr	Cu
750ppm	250ppm	90ppm

No C/C available

Trace chlorite.
Trace of gypsum at 103 cm.
In addition, X-ray diffraction shows palygorskite.

[1]For explanation of symbols, see Chapter 1

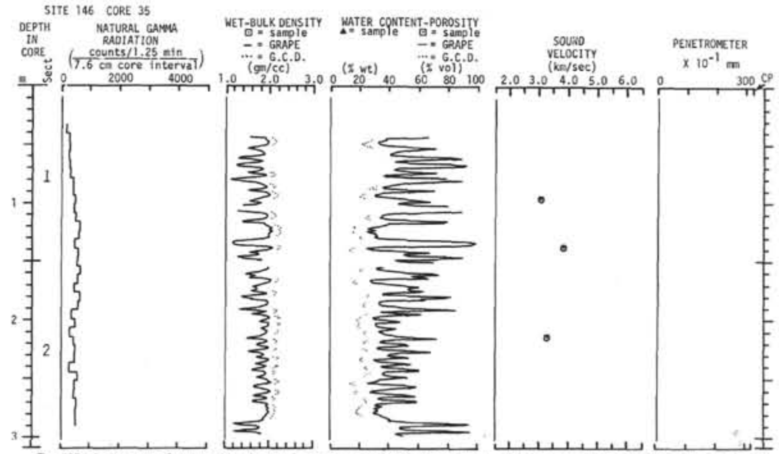


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1369. This background was subtracted from the data.

SITE 146 HOLE CORE 35 CORED INTERVAL (m) 692-701

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION		LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
CONIACIAN/SANTONIAN	Globotruncana concavata concavata	?		1	0.5 / 1.0	VOID		N R P R R P/M		RADIOLARIAN LIMESTONE; light olive gray (5Y5/1) interlayered with dark olive gray (5Y3/1) and dark greenish gray (5GY4/1) associated with burrow mottling. In addition, some blackish red (5R2/2) volcanic-rich layers occur in sharp contrast at several levels in Section 2. Sandy-textured zones present, but blurred. CHERT; brownish gray (5YR4/1) and medium gray (N5) present in both sections. Boundaries between limestone and cherts are sharp in hand specimen, but gradual under microscope. Sparite seems to fill some of the radiolarian cavities. Limestone is sparse to packed biomicrite with mainly calcified radiolarians and very rare benthic foraminifers. Slightly argillaceous lenses and laminae unevenly distributed. Representative thin section from Section 2, 136-139 cm contains abundant foraminifers with fish debris, pyrite, diffuse organic matter, glauconite, and plagioclase. Bioturbated.	▲	
				2	0.0 / 0.5 / 1.0			N R P R C P R R M	(5R2/2) (5R2/2) N5 (5R2/2)	In general, sparse plagioclase, hornblende, biotite, and fish debris. Minor chert micronodules and carbonate rhombs throughout.		
				CORE CATCHER				R A P	fragments (5Y5/1)	Microfossils aligned parallel. Partly silicified, with concentration of clays at silicification front.		

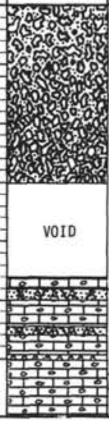
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1349. This background was subtracted from the data.

SITE 146 HOLE CORE 36R CORED INTERVAL (m) 701-710

Columns: AGE | ZONE (FORAM, NANNO, RAD) | SECTION | METERS | LITHOLOGY | LITHO SAMPLE | PALEO SAMPLE ABUNDANCE PRESERVATION | LITHOLOGIC DESCRIPTION[1] | $CaCO_3$ (%) SAND-SILT-CLAY (accumulative %) 0 50 100 | DEFORMATION



Section 1 (0.5, 1.0); Section 2 (0.0, 0.5, 1.0); CORE CATCHER

Age: * ; Foram: * *

Paleo samples: R F M; R R P; R R M

Deformation: V

←high organic * carbon 2.5%

←high organic carbon 6.3%

FORAMINIFERAL RADIOLARIAN LIMESTONE; light gray (N7) with slightly brownish to greenish gray (5GY6/1) interlayered zones, some associated with burrow mottling. Three olive black (5Y2/1) predominantly detrital volcanic and carbon-rich layers have sharp boundary with the limestone. Limestone partly silicified, sparse to packed foraminiferal radiolarian biomicrite with rare benthonic foraminifers, calcified radiolarians and echinoid fragments. Faunal remains are filled with sparite often drusy. Rhombohedral spar crystals disseminated in the matrix. *Microfracture filled with coarse sparite and transected by finer microfracture filled with microspar.

RADIOLARIAN LAMINATED LIMESTONE, with benthonic foraminifers and calcified and recrystallized radiolarians, with fish debris, echinoderm fragments, glauconite pellets, plagioclase and barite. Some microfossils filled by opaque material.
Washed >38μ fraction of core catcher: altered volcanic detritus, pyritic aggregates, radiolarian molds, and fish bone fragments.

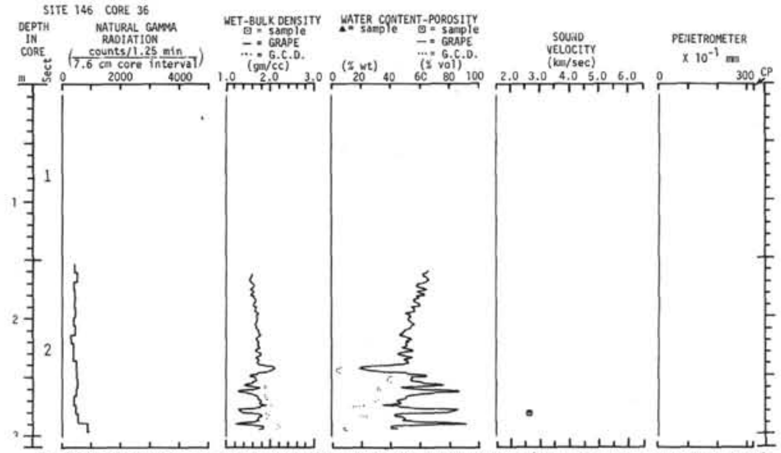
Fragments (N7) and (5Y6/1) — In addition, X-ray diffraction shows K-feldspar, palygorskite, clinoptilolite, barite, and pyrite.

[1]For explanation of symbols, see Chapter 1

Core 37R: No recovery; Cored Interval (m) 710-714.

* CONIACIAN/SANTONIAN

* * Globotruncana concavata concavata



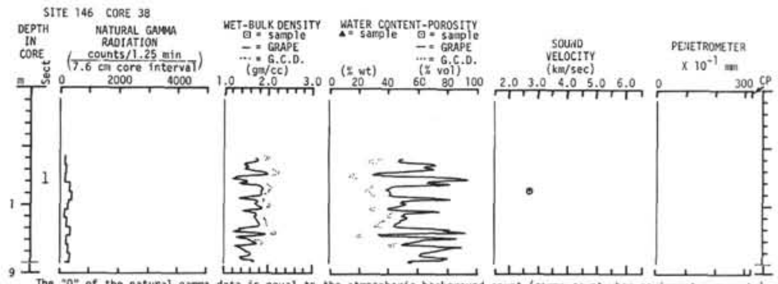
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1341. This background was subtracted from the data.

SITE 146 HOLE CORE 38R CORED INTERVAL (m) 714-719

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]		CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
CONIACIAN/SANTONIAN	Globotruncana concavata concavata	?		1	0.5 / 1.0	VOID		R C P R R M N F P R R M	layer rich in organic carbon 11.2% (5Y3/1) Microfracture filled with Sparite	CORE 37R: No recovery. RADIOLARIAN LIMESTONE; predominantly light gray (N7) to greenish gray (5GY6/1) with interbedded olive black (5Y3/1) zones rich in detrital volcanics (plagioclase, hornblende, biotite), radiolarian molds, organic carbon, and clay. Flattened burrow mottling often gives a finely laminated structure due to color changes. Limestone in microscopic study is a sparse foraminiferal radiolarian biomicrite, with minor amount of mollusc shell and echinoid fragments. Forams are filled with microspar and sparite. Radiolarians are usually calcified. Skeletal fragments and volcanic grains oriented parallel to bedding. Pyrite disseminated throughout, often concentrated in lenses. Sparse hornblende and biotite. Chert micronodules and carbonate rhombs throughout. X-ray diffraction also shows K-feldspar, trace gypsum, and pyrite.	▲	
	*			CORE CATCHER					fragments (N7) and (5GY6/1)	RADIOLARIAN LIMESTONE, with rare foraminifers and fish debris. Secondary dendritic opaque material.		

* Globotruncana concavata concavata

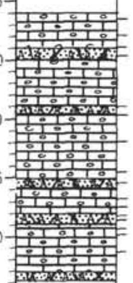
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1341. This background was subtracted from the data.

SITE 146 HOLE CORE 39R CORED INTERVAL (m) 719-728

AGE	FORAM	NANNO	RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION*	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
TURONIAN/CONIACIAN	Globotruncana schneegansi			1	0.5, 1.0	VOID		n; R C P	(5Y2/1) (5Y2/1)		
				2	0.0, 0.5, 1.0			R F M n	(5Y2/1) (5Y2/1) graded (5Y2/1) Microfractures		
				CORE CATCHER							



*For explanation of symbols, see Chapter 1

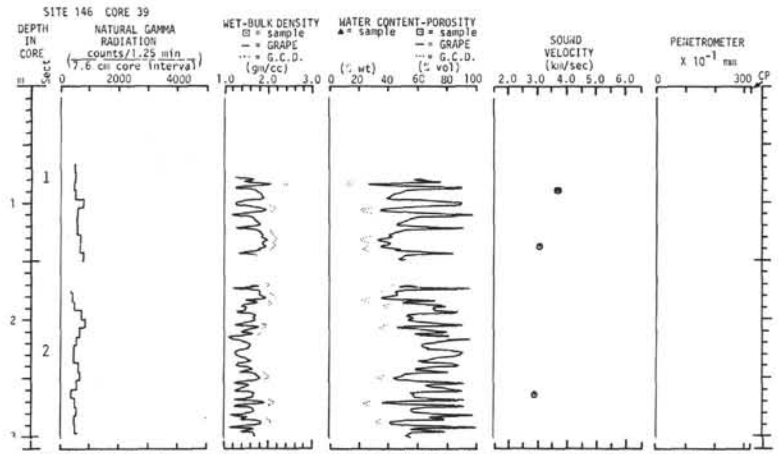
FORAMINIFERAL RADIOLARIAN and ARGILLACEOUS LIMESTONE and BASALTIC ASH; light gray (N7) to greenish gray (5GY6/1) with abundant interbedded olive black (5Y2/1) ash beds becoming particularly abundant in Section 2. These ash layers occur as rhythmic, size-graded, medium to fine grained sequences somewhat disturbed by burrowing. Calcitic veins cutting the bedding plane nearly vertically occur at several levels.

Limestone is a sparse to packed biomicrite with predominantly planktonic foraminifers and calcified radiolarians. Filling is mainly microsparite and sparite. Matrix partly silicified or microsparic, with some biogenic fragments, carbonaceous material, and carbonate rhombs. More argillaceous and pyritic filling of burrows. Interpenetration and clay bending around fossils.

X-ray diffraction results:

	Section 1 145-148cm	Section 2 46-47cm	Section 2 91-93cm
Amorphous scattering	35%	48%	--
Calcite	66%	59%	2%
Quartz	30%	23%	2%
K-feldspar	4%	--	7%
Plagioclase	--	6%	9%
Mica	--	8%	3%
Montmorillonite	--	3%	77%

Basaltic ash layers consist of 200μ, graded, altered palagonite grains with holocrystalline basaltic fragments, some augite, and plagioclase. The green layers are a fine grained equivalent, with a very similar chemical composition. Sparse apatite. X-ray results: dominant mica, minor montmorillonite, some clinoptilolite, K-feldspar, barite, and pyrite.



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1341. This background was subtracted from the data.

SITE 146 HOLE CORE 40R CORED INTERVAL (m) 728-737

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
				CORE CATCHER				R R M	LIMESTONE; medium dark gray (N4) with irregular lighter shades of gray to light brownish gray (5YR5/1) with finely sublaminated structure due to flattened burrow mottling.		

[1]For explanation of symbols, see Chapter 1

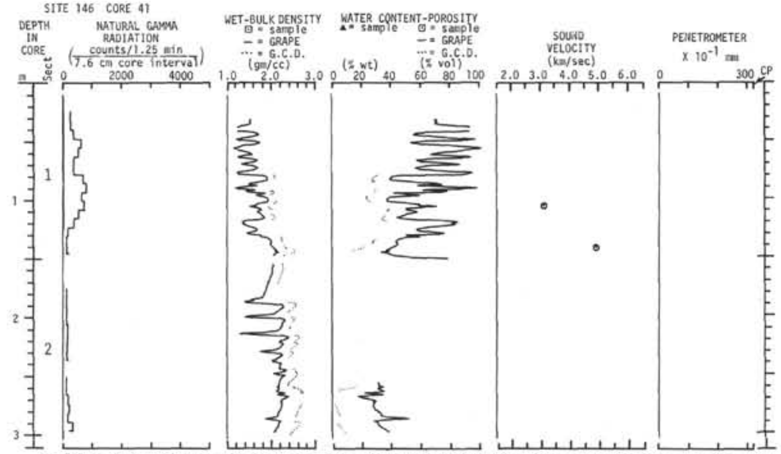
SITE 146 HOLE CORE 41R CORED INTERVAL (m) 737-746

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]		CaCO3 (%) SAND-SILT-CLAY (accumulative %)	DEFORMATION
TURONIAN/CONIACIAN	Globotruncana schneegansi	?		1	0.5, 1.0	VOID		R O R R M N R P	Sandy texture zone apatite Thin, very disturbed Argillaceous layers	FORAMINIFERAL LIMESTONE; variegated, alternating light gray (N7), greenish gray (5GY5/1) to dark olive gray (5Y5/1) and dusky yellowish brown (10YR5/2). Dark zones are very argillaceous, soft, with shaley cleavage, and crumbly. Limestone is a packed foraminiferal biomicrite, with most of the foram chambers empty, but a few are filled with sparite. Matrix is mainly micrite with areas of microspar development, pyrite, plagioclase, and chlorite, and spare apatite. Actual contact with dolerite below was not recovered intact(?).		
				2	0.0, 0.5, 1.0			R O	(N2) (5YR6/1)	DOLERITE SILL; grayish black (N2), medium-grained, grading to fine-grained in the lower contact zone. Subhorizontal and oblique fractures occur throughout, mainly filled with calcite. Grain size about 0.3 mm relatively uniform, fine grained toward base. Actual contact with limestone below was not recovered intact.		
				CORE CATCHER						SLIGHTLY METAMORPHOSED FORAMINIFERAL LIMESTONE; light brownish gray (5YR6/1) with greenish gray streaks associated with flattened burrowing. In thin section, limestone is a packed foraminiferal biomicrite with rare radiolarians, mollusc fragments, and fish debris. Matrix micritic, locally recrystallized into microspar. Well-crystallized montmorillonite.		

X-ray diffraction results:

	Section 1 52cm	Section 1 126cm	Section 2 120-124cm
Amorphous scattering	39%	30%	28%
Calcite	46%	80%	80%
Quartz	36%	3%	1%
K-feldspar	3%	--	--
Mica	9%	--	--
Montmorillonite	7%	18%	19%

[1]For explanation of symbols, see Chapter 1

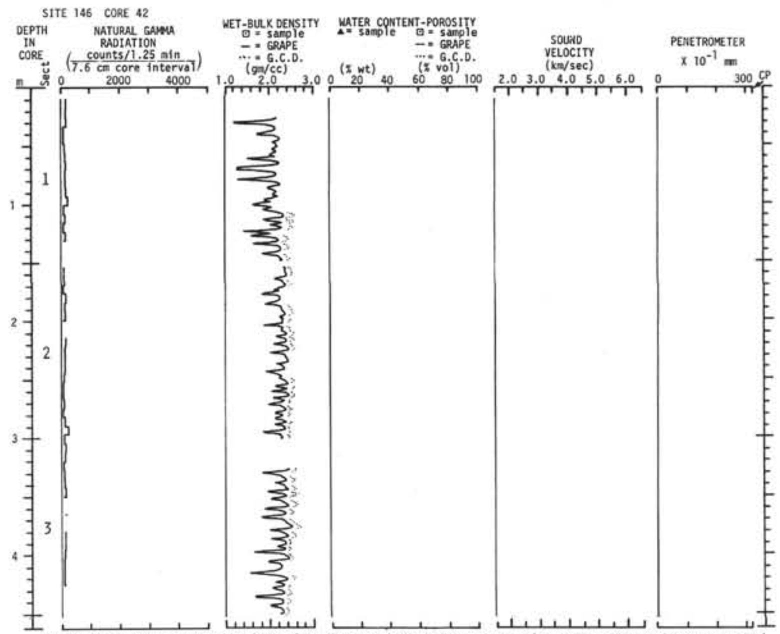


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1401. This background was subtracted from the data.

SITE 146 HOLE CORE 42R CORED INTERVAL (m) 746-755 m

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION [1]	CaCO₃ (%) ---- SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
				1	0.5, 1.0	VOID			DOLERITE; grayish black (N2) with subvertical fractures, some filled with calcitic materials. Conspicuously finer grained (about 0.1 mm) than in barrel 41, very uniform.		
				2	0.0, 0.5, 1.0						
				3	0.0, 0.5, 1.0	VOID			Vertical fracture filled with calcitic material. DOLERITE		
				CORE CATCHER							

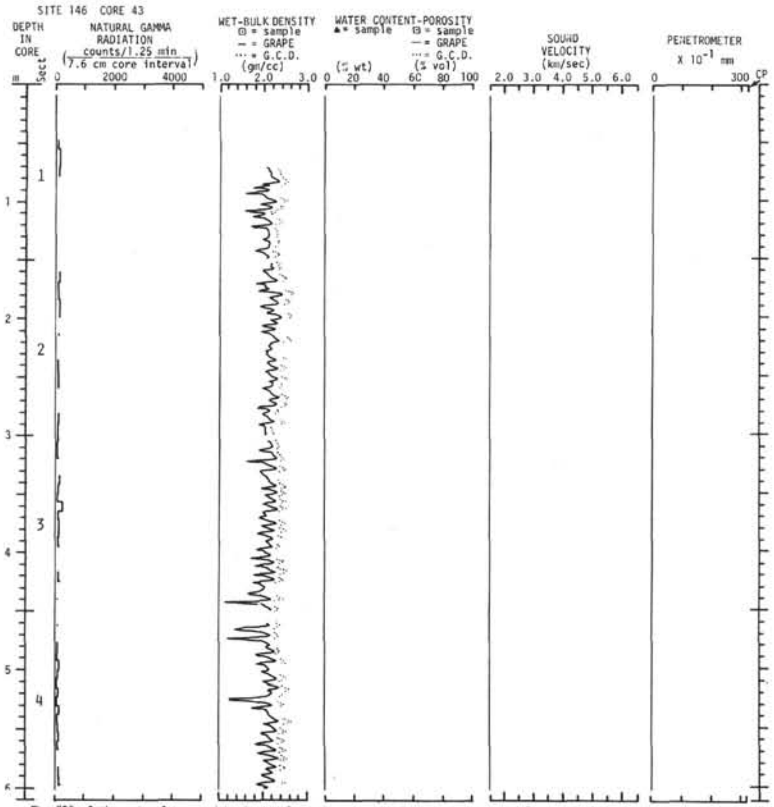
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1376. This background was subtracted from the data.

SITE 146 HOLE CORE 43R CORED INTERVAL (m) 755-760

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
				1	0.5, 1.0	VOID			DOLERITE; grayish black (N2) with minor calcitic veining, fine grained, uniform.		
				2	0.0, 0.5, 1.0						
				3	0.0, 0.5, 1.0						
				4	0.0, 0.5, 1.0						
				CORE CATCHER							

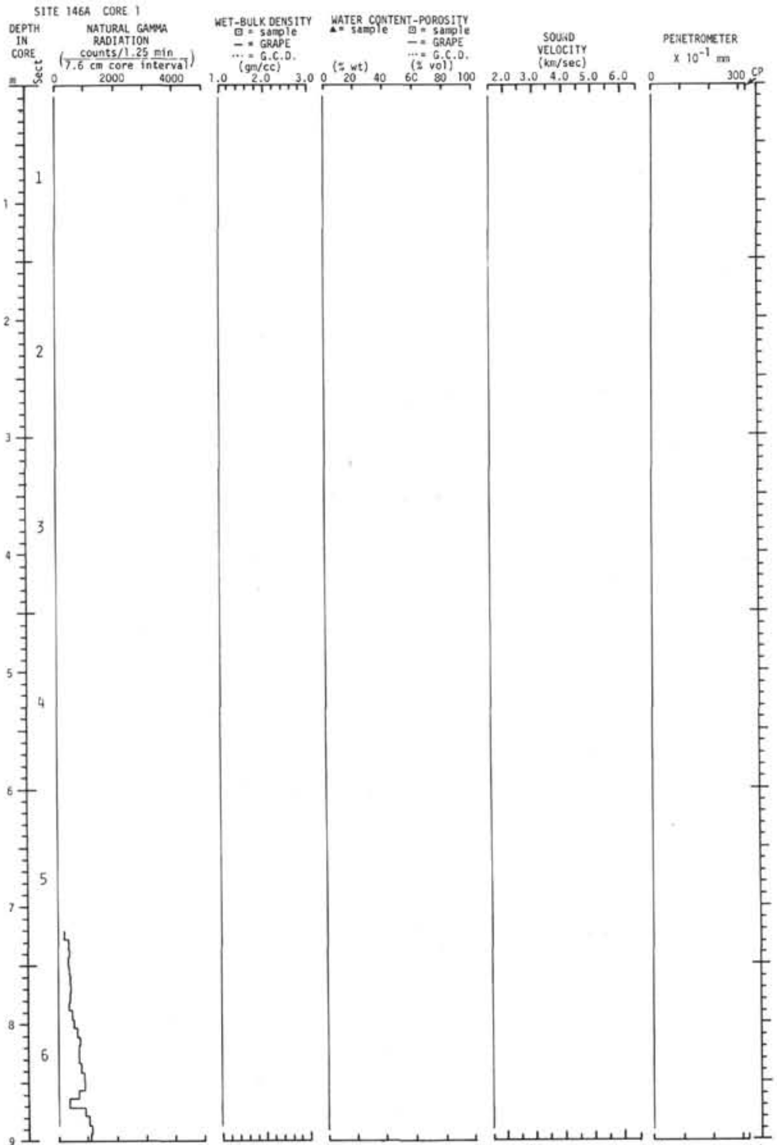


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1376. This background was subtracted from the data.

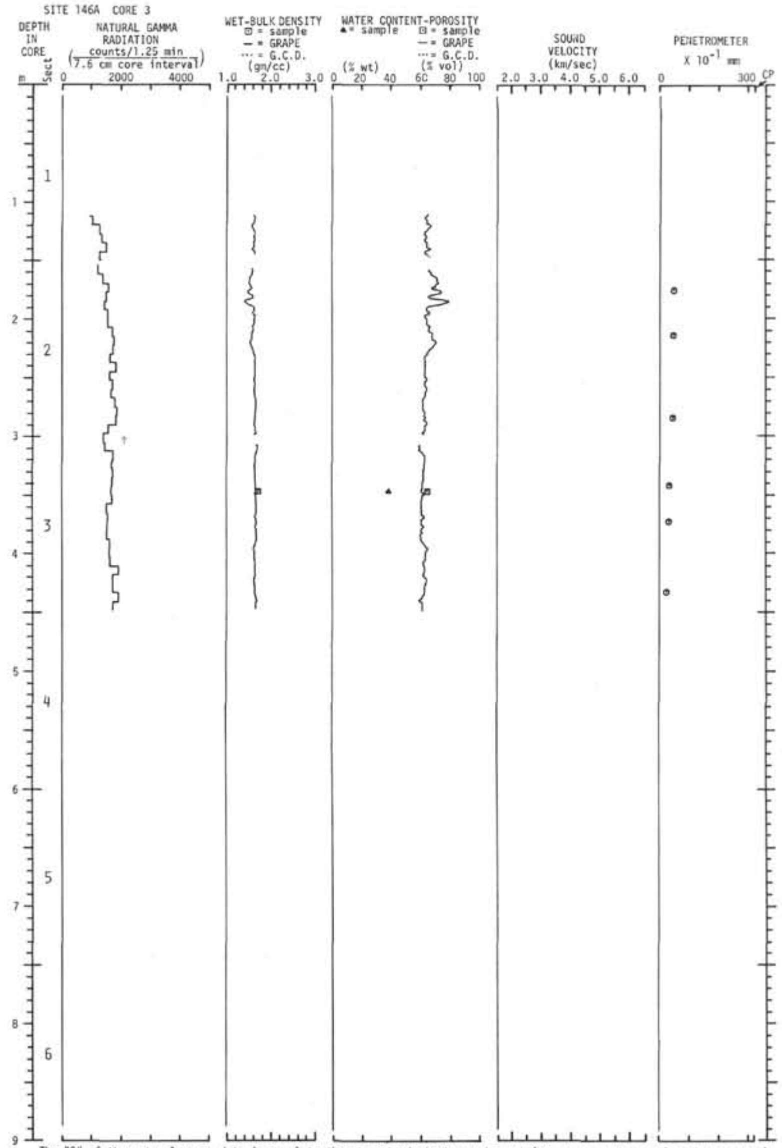
SITE 146 HOLE CORE 44R CORED INTERVAL (m) 760-762

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
				CORE CATCHER					DOLERITE, grayish black (N2).		

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1376. This background was subtracted from the data.



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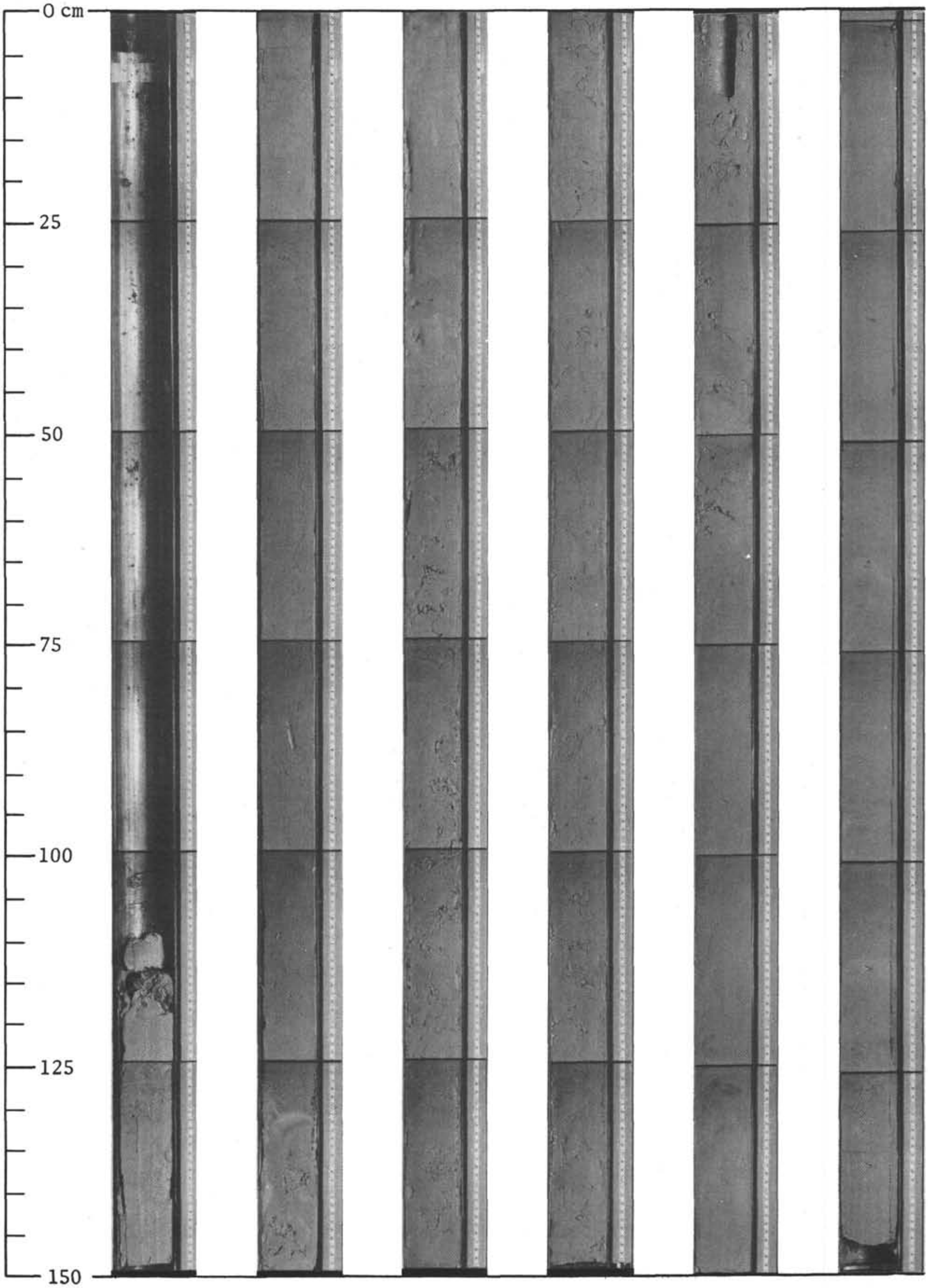
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125
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146-1-2
146-1-3
146-1-4
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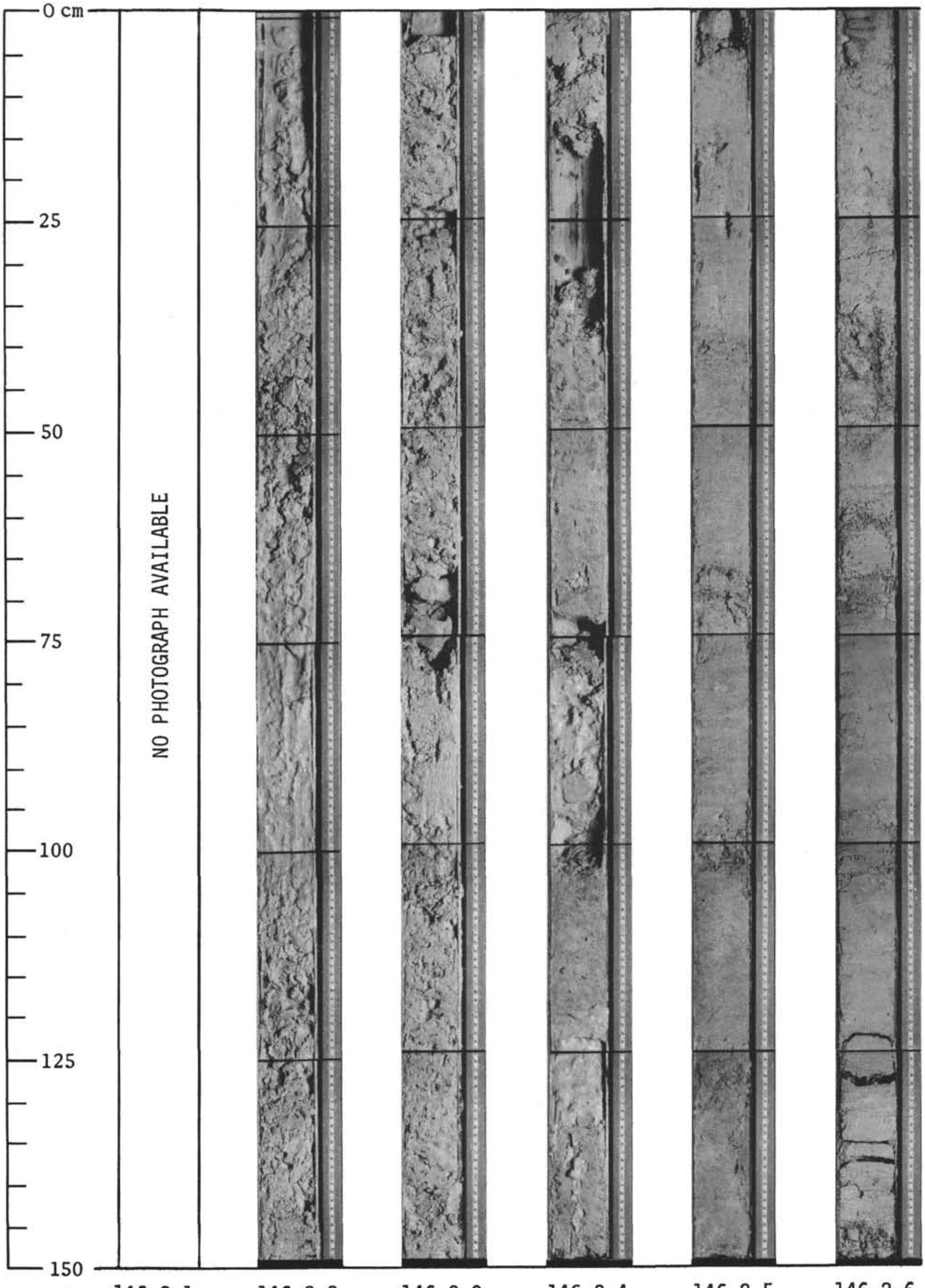
146-1-6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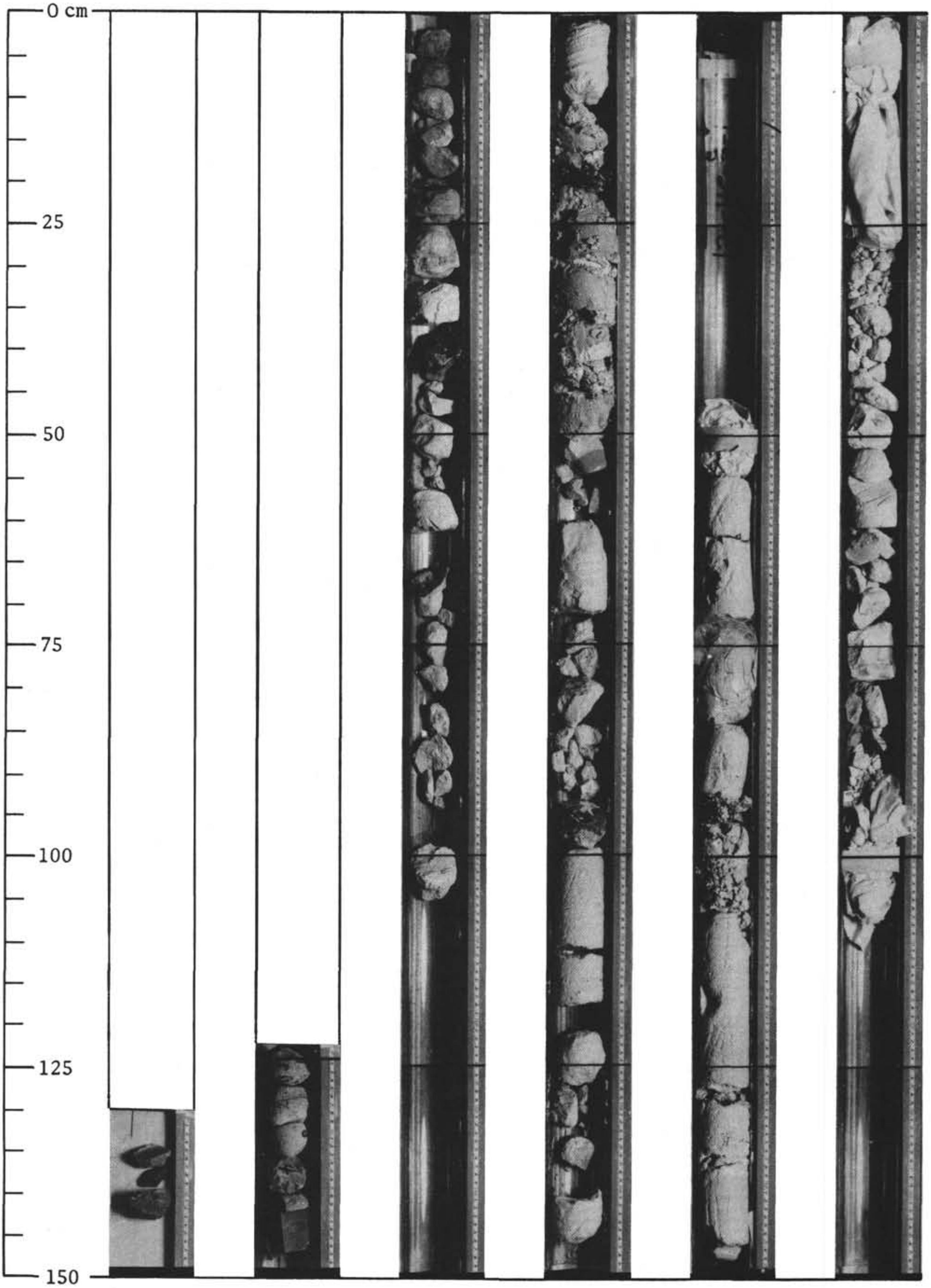
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146-4CC
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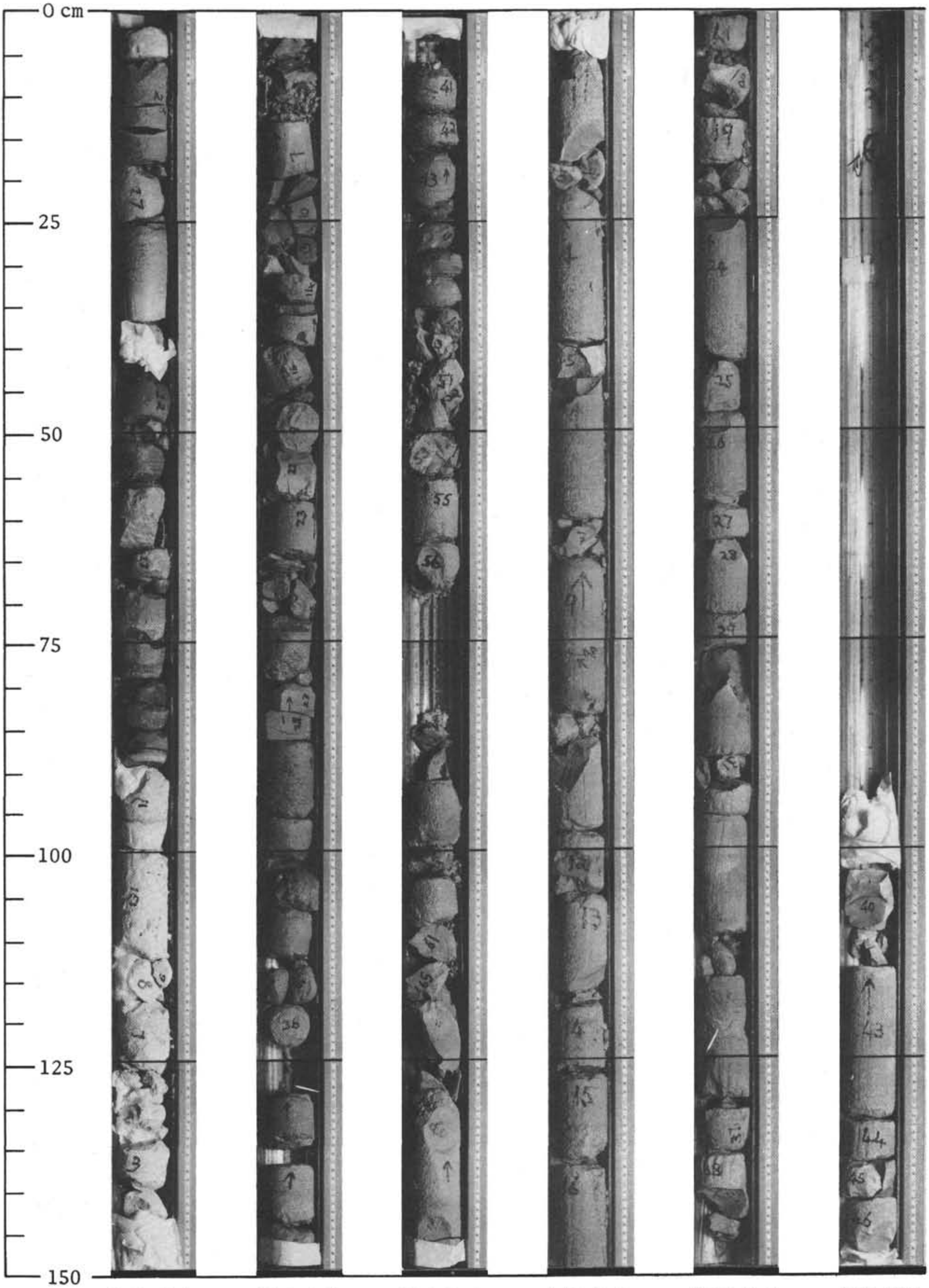
146-5-2
146-6-1
146-6CC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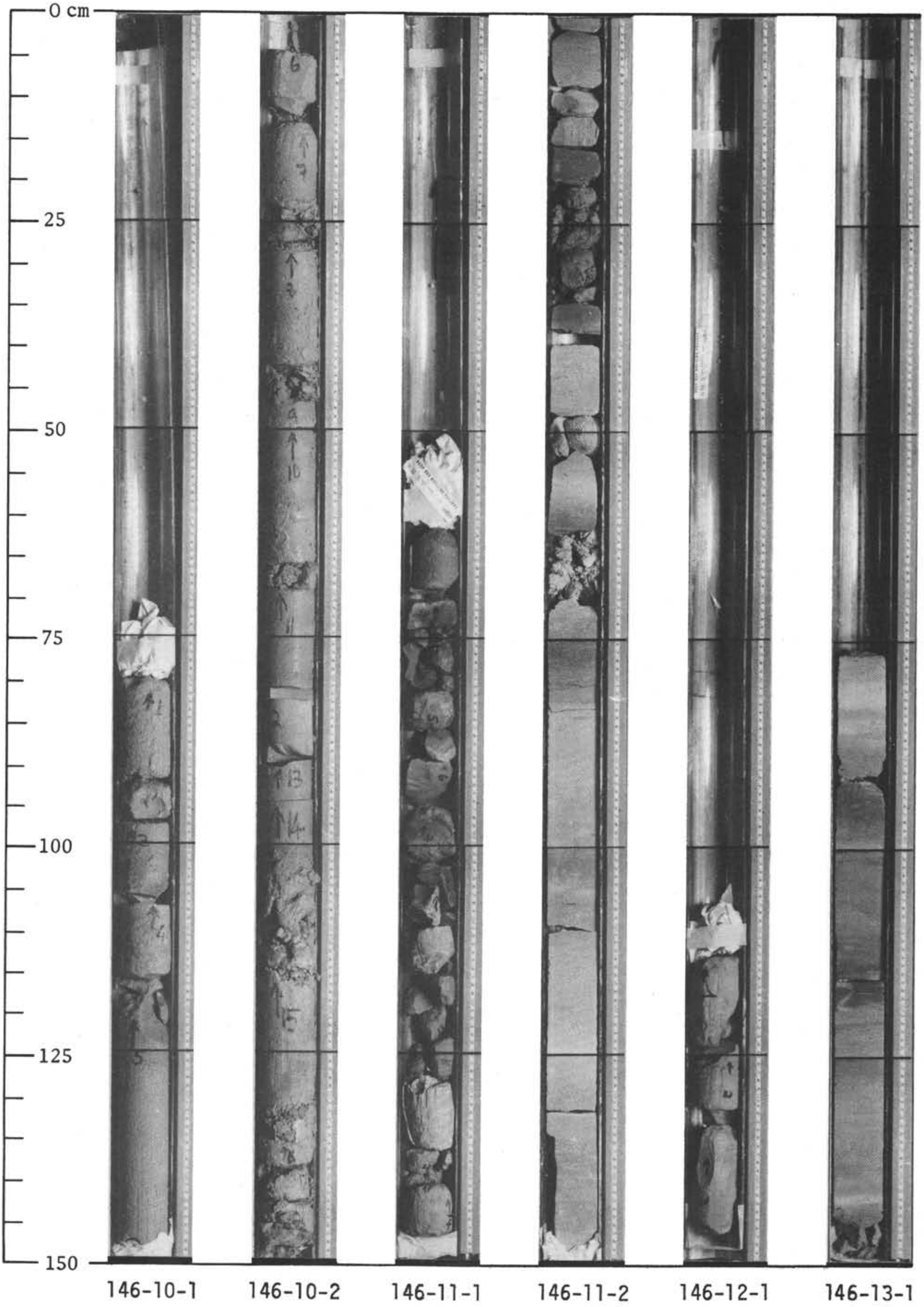
146-8-1
146-8-2
146-9-1
146-9-2
146-9CC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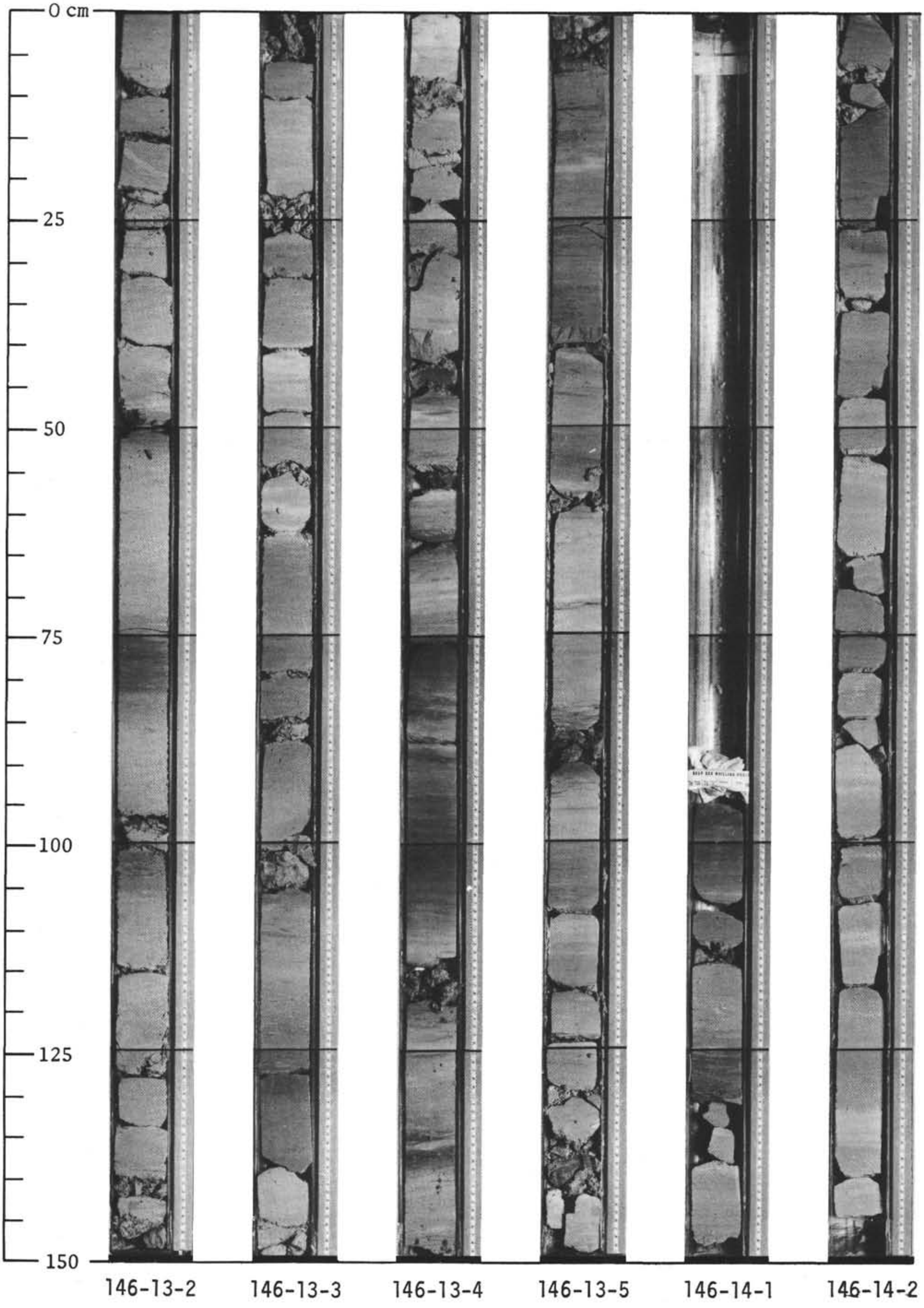
146-11-2
146-12-1
146-13-1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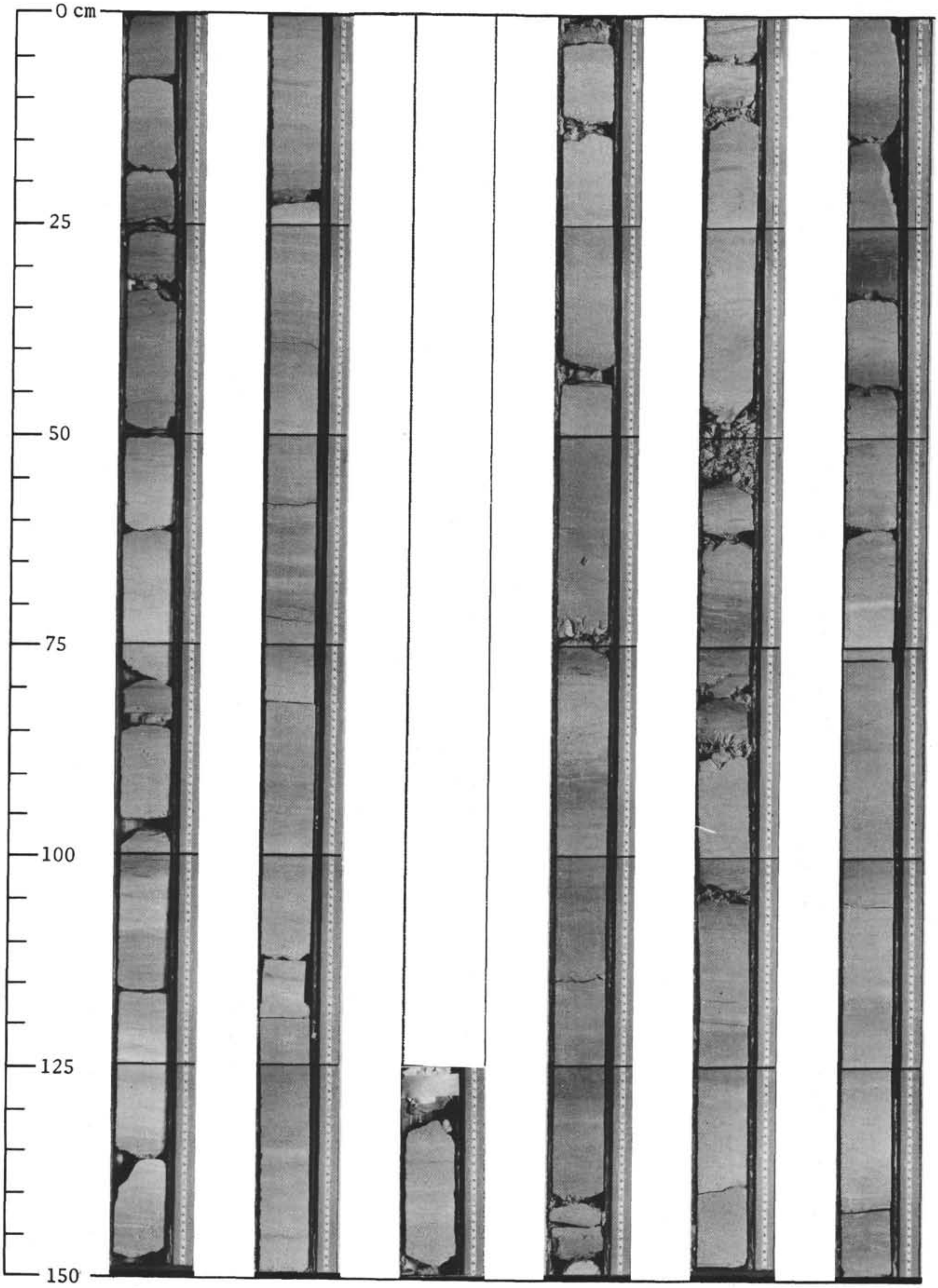
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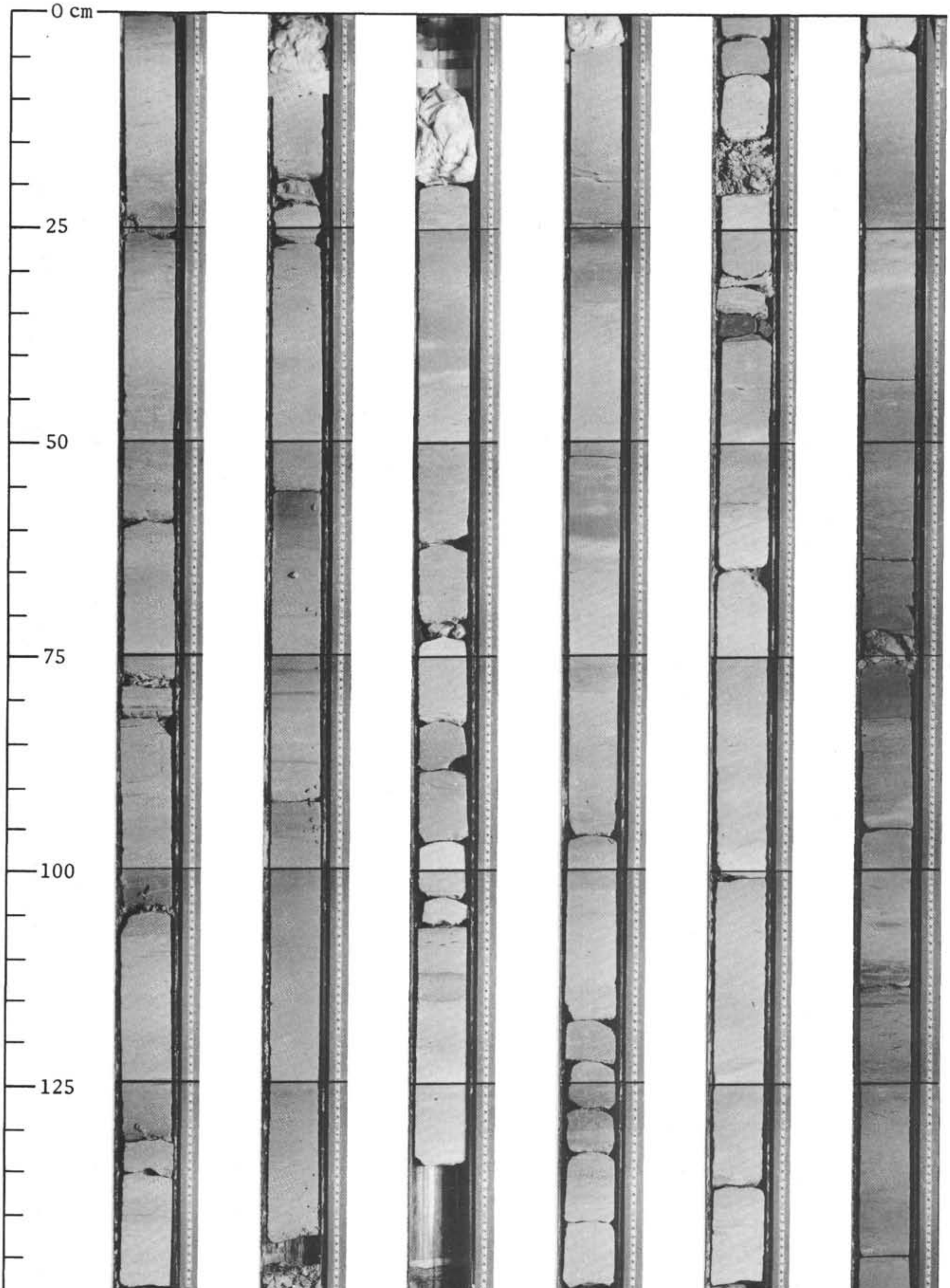
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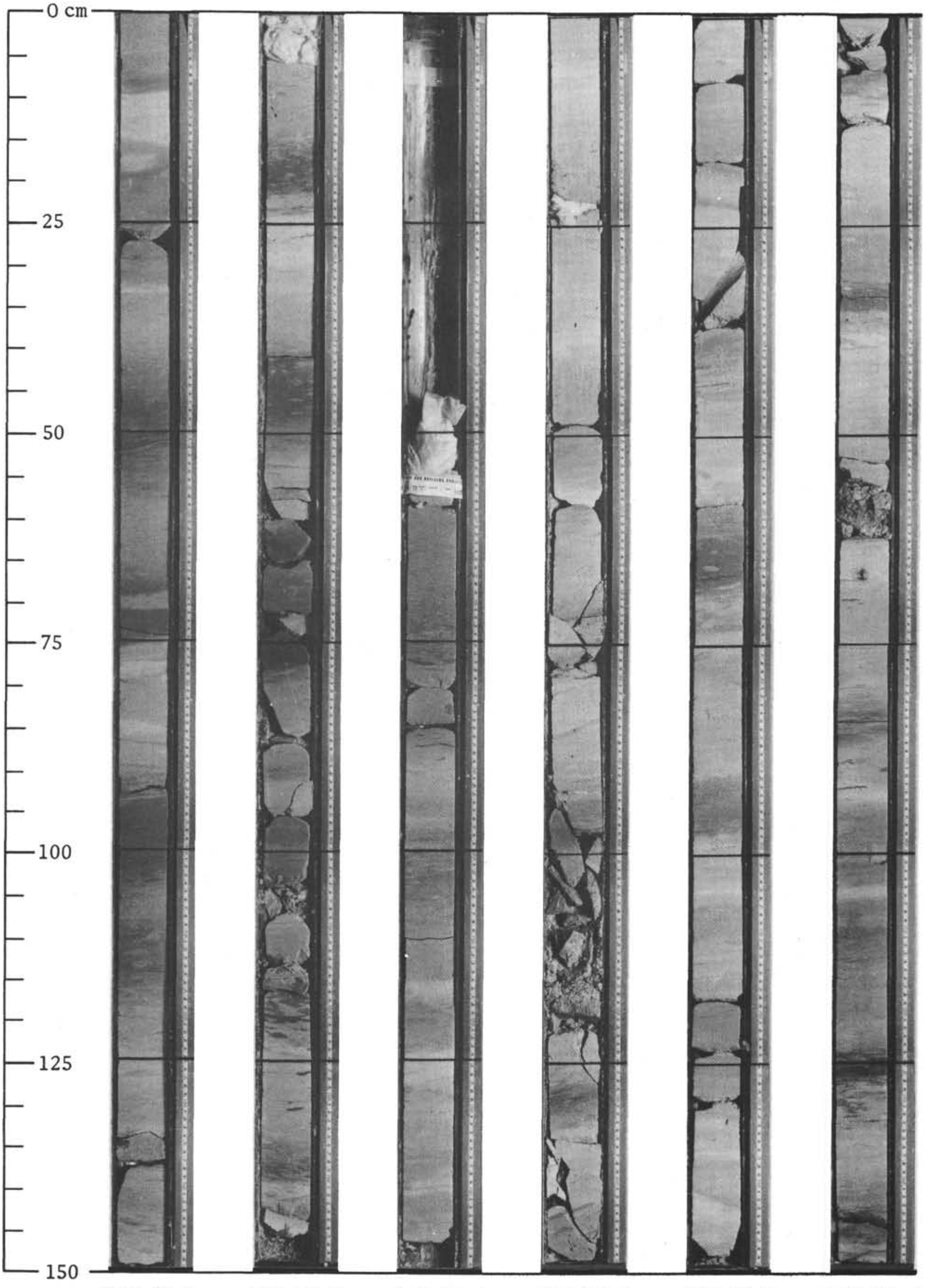
146-16-4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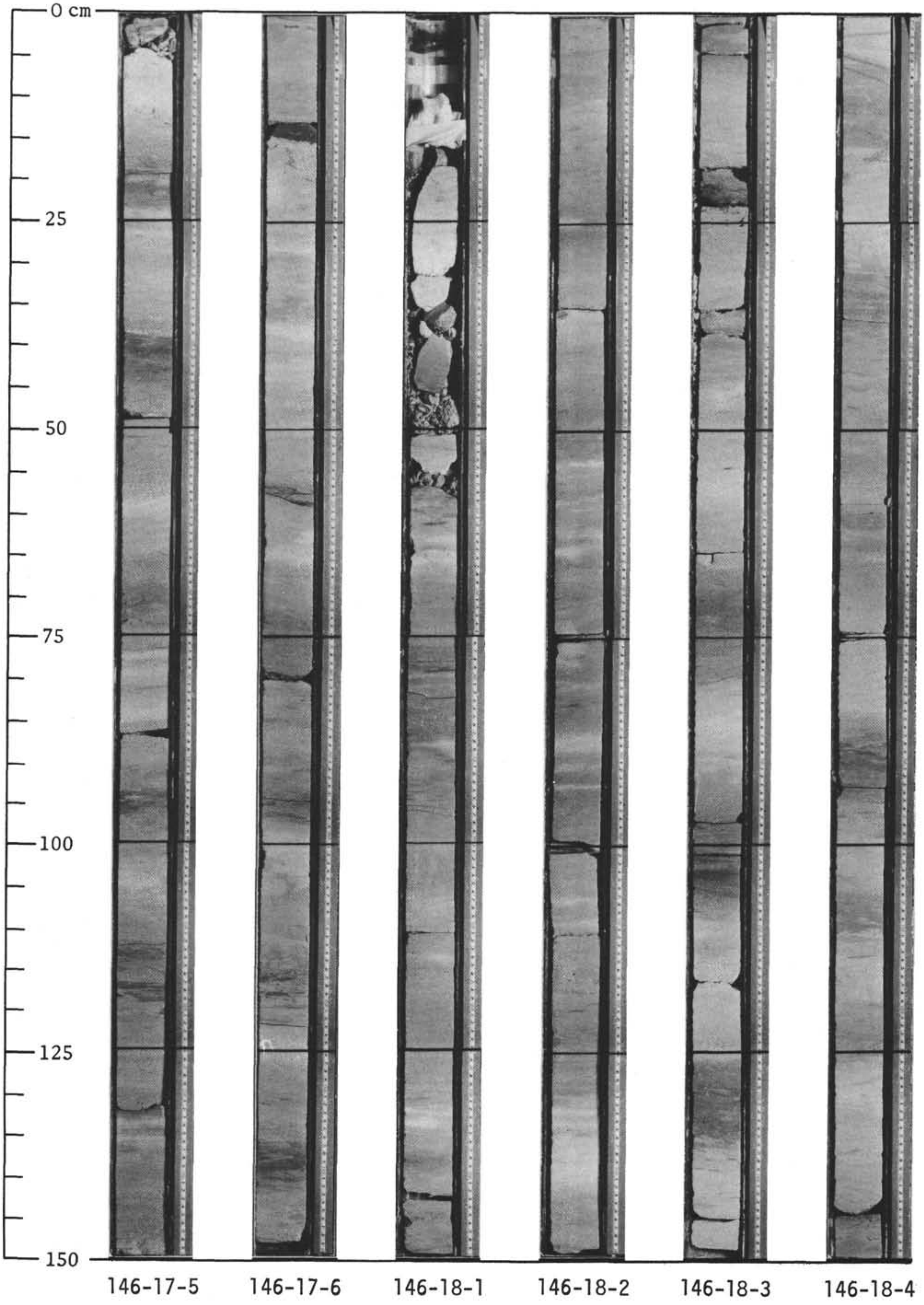
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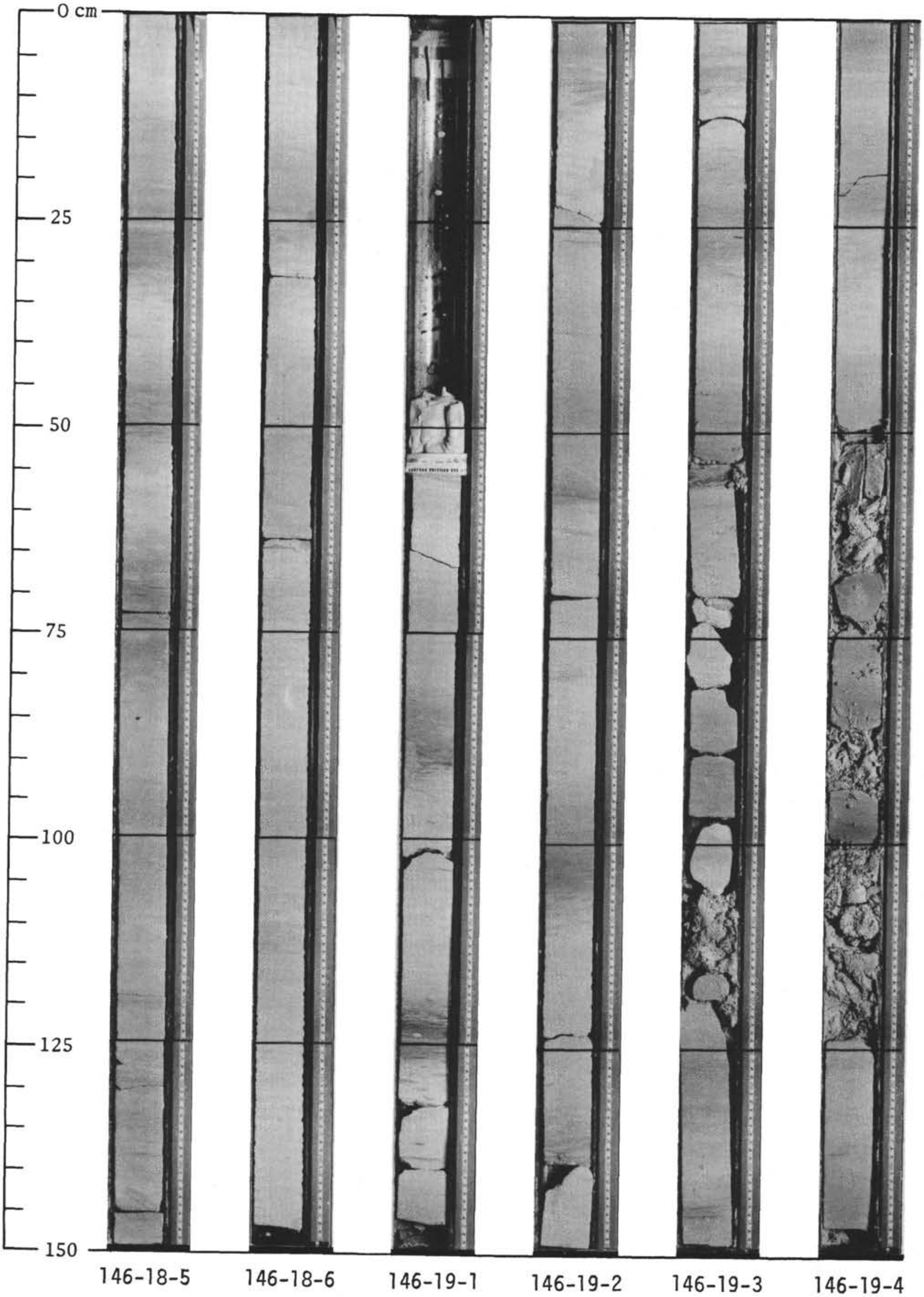
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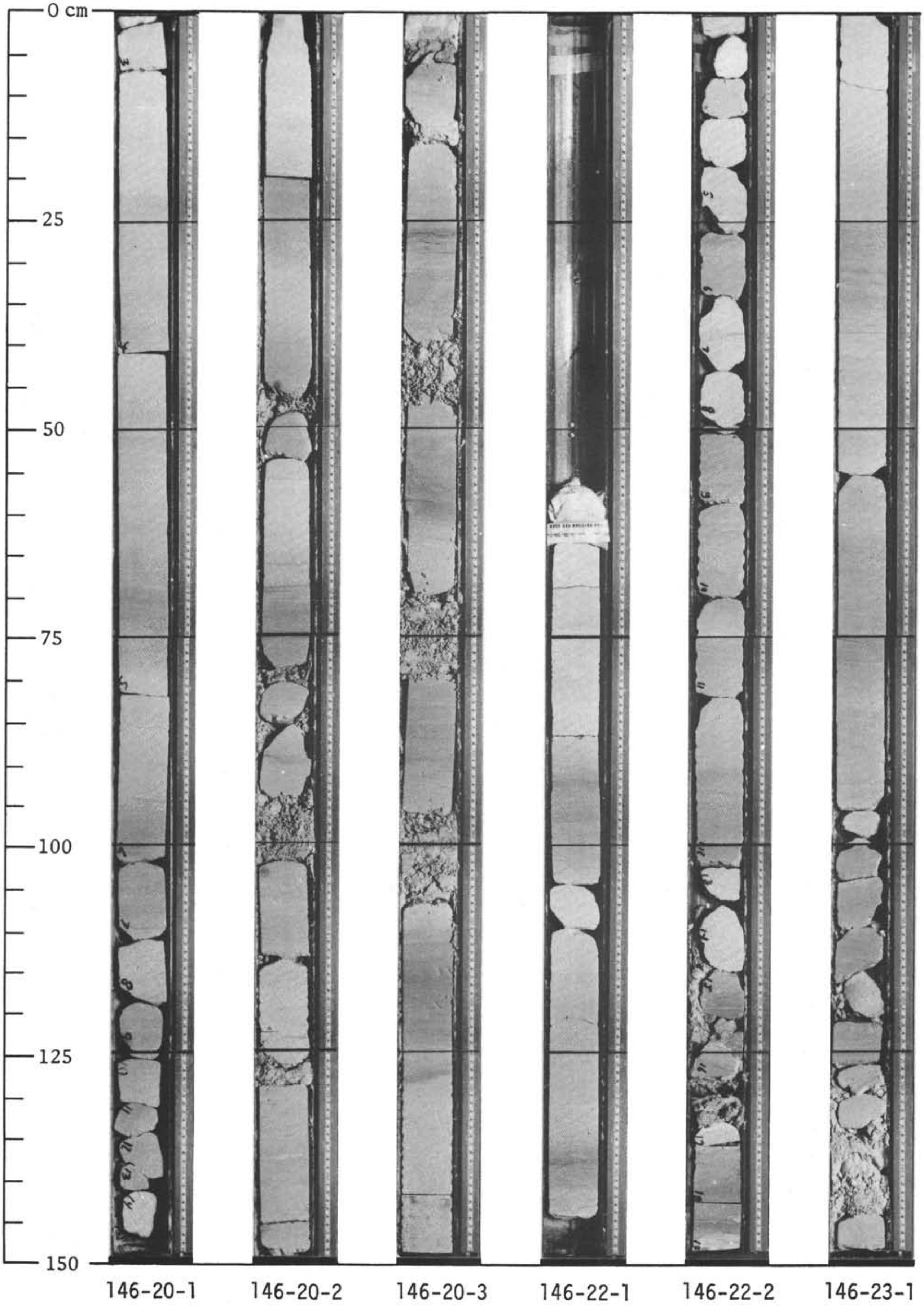
146-19-4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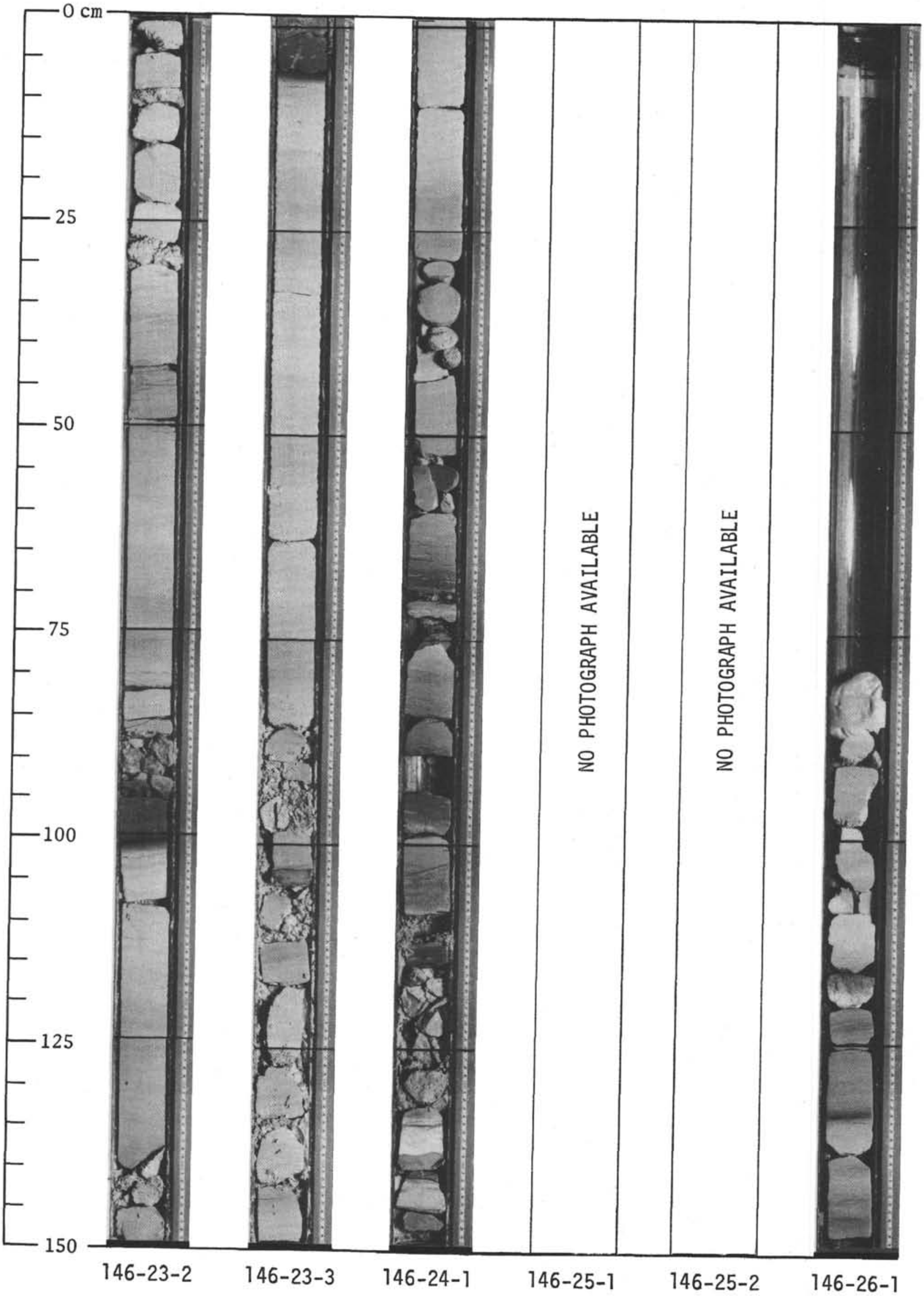
146-22-2
146-23-1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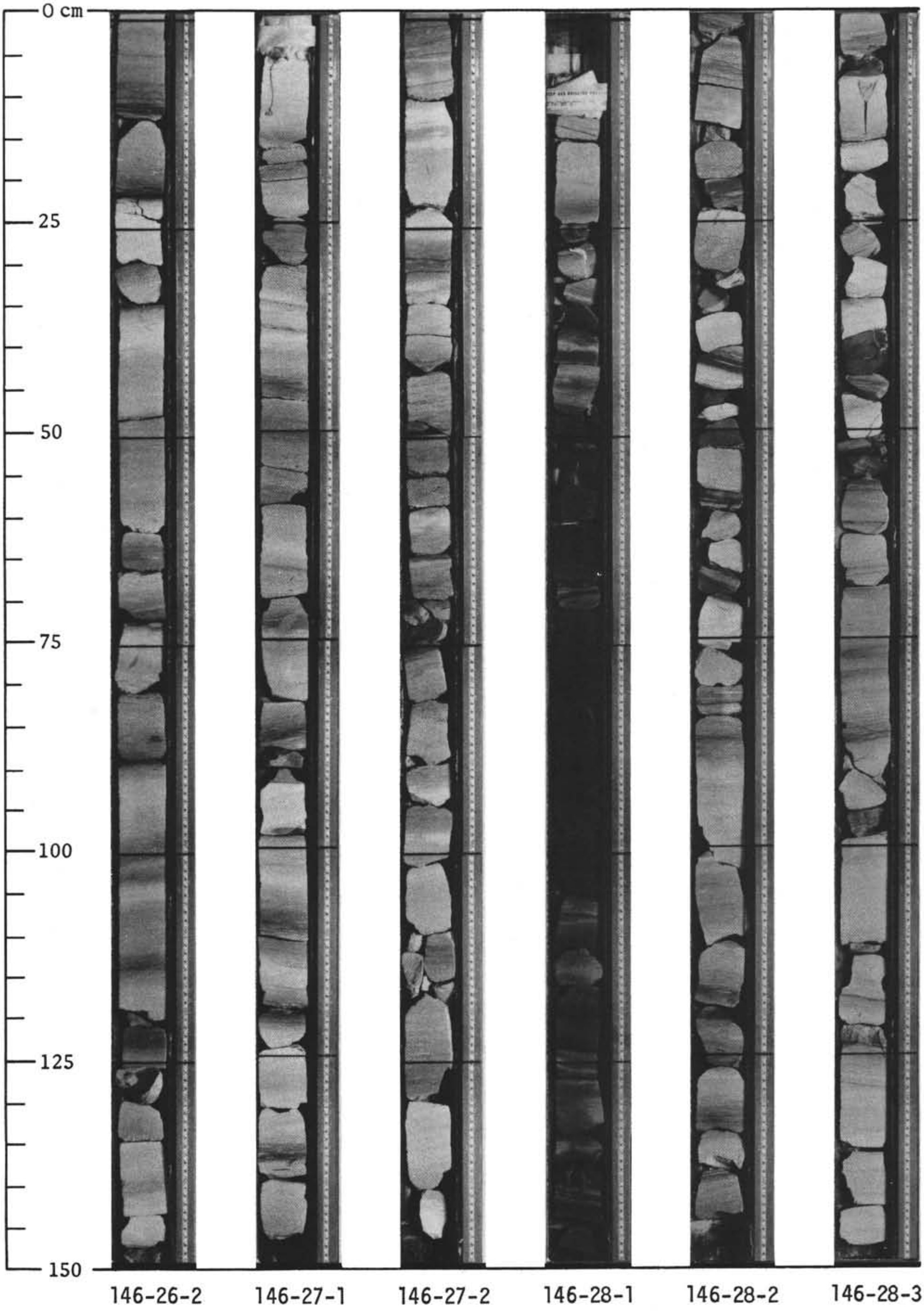
146-25-2
146-26-1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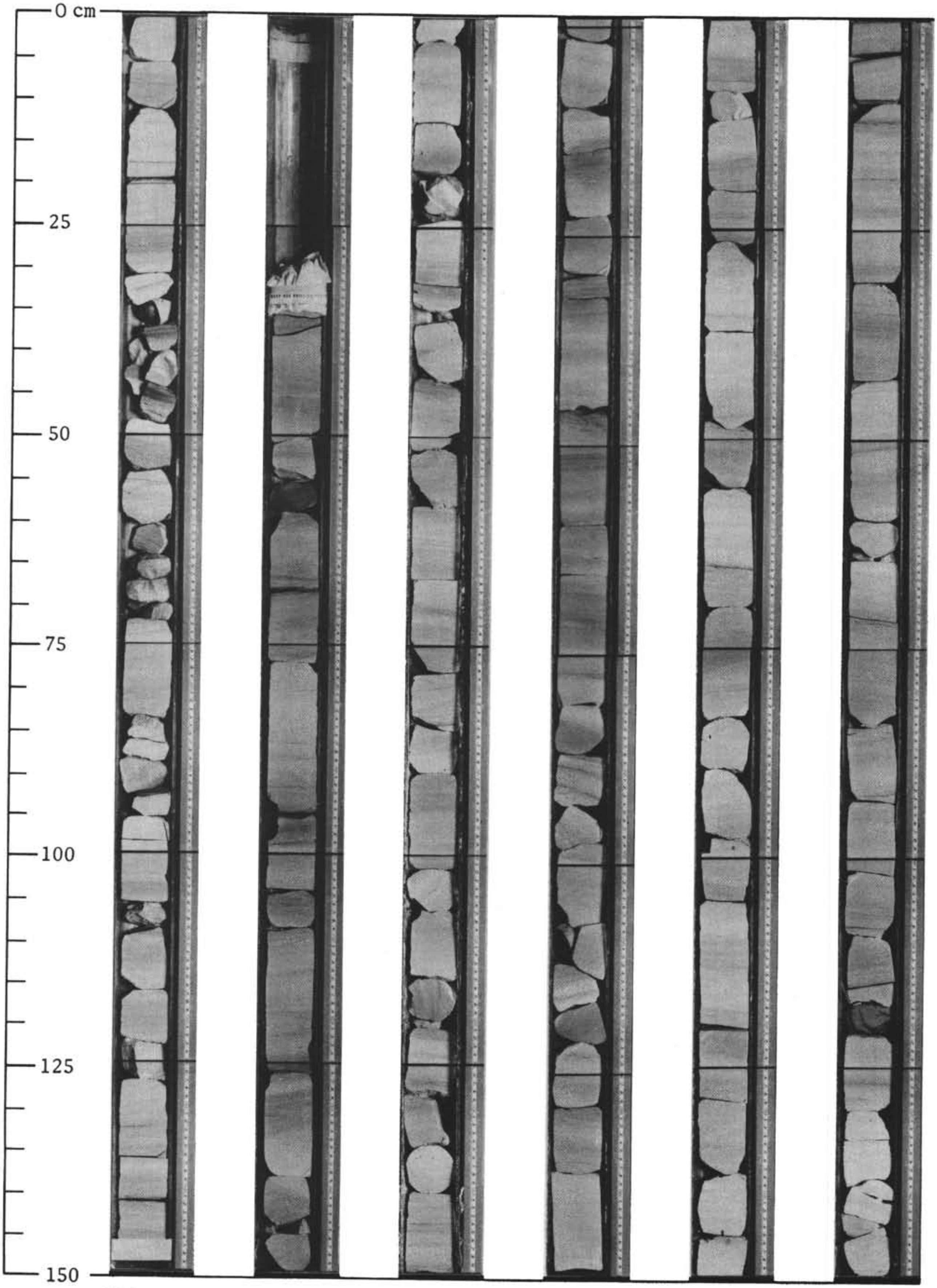
146-28-1
146-28-2
146-28-3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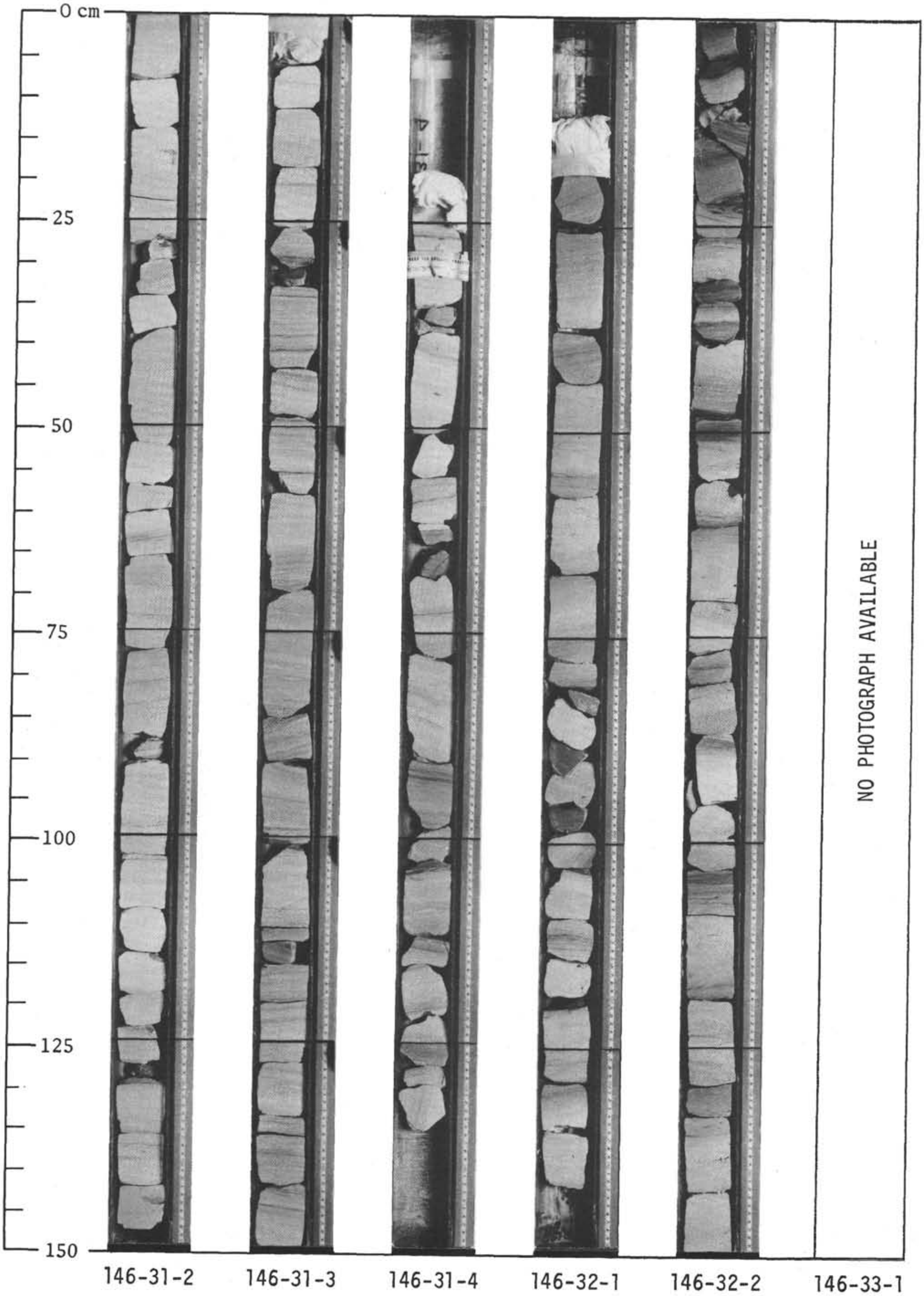
146-31-1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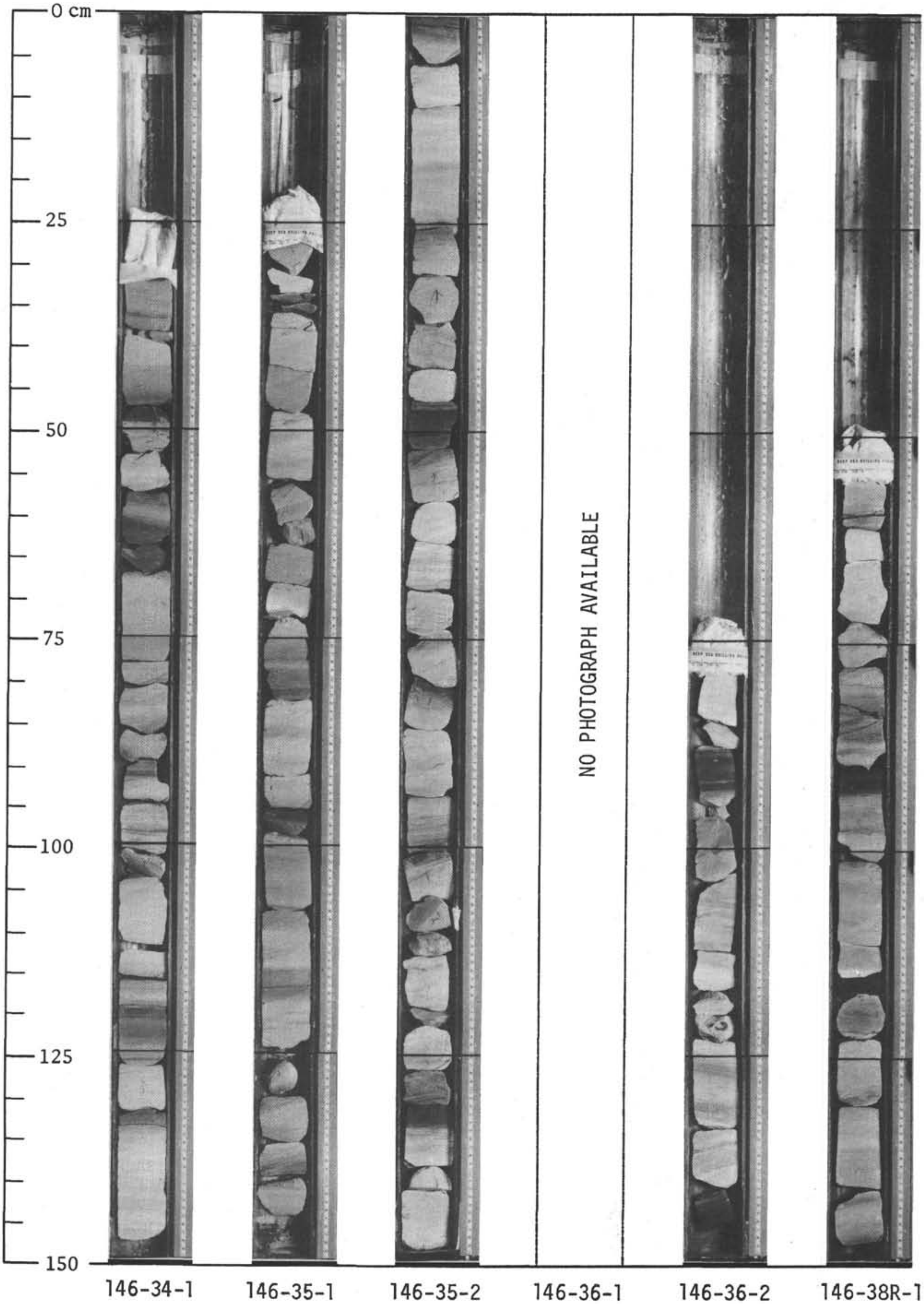
146-32-2
146-33-1


0 cm
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75
100
125
150
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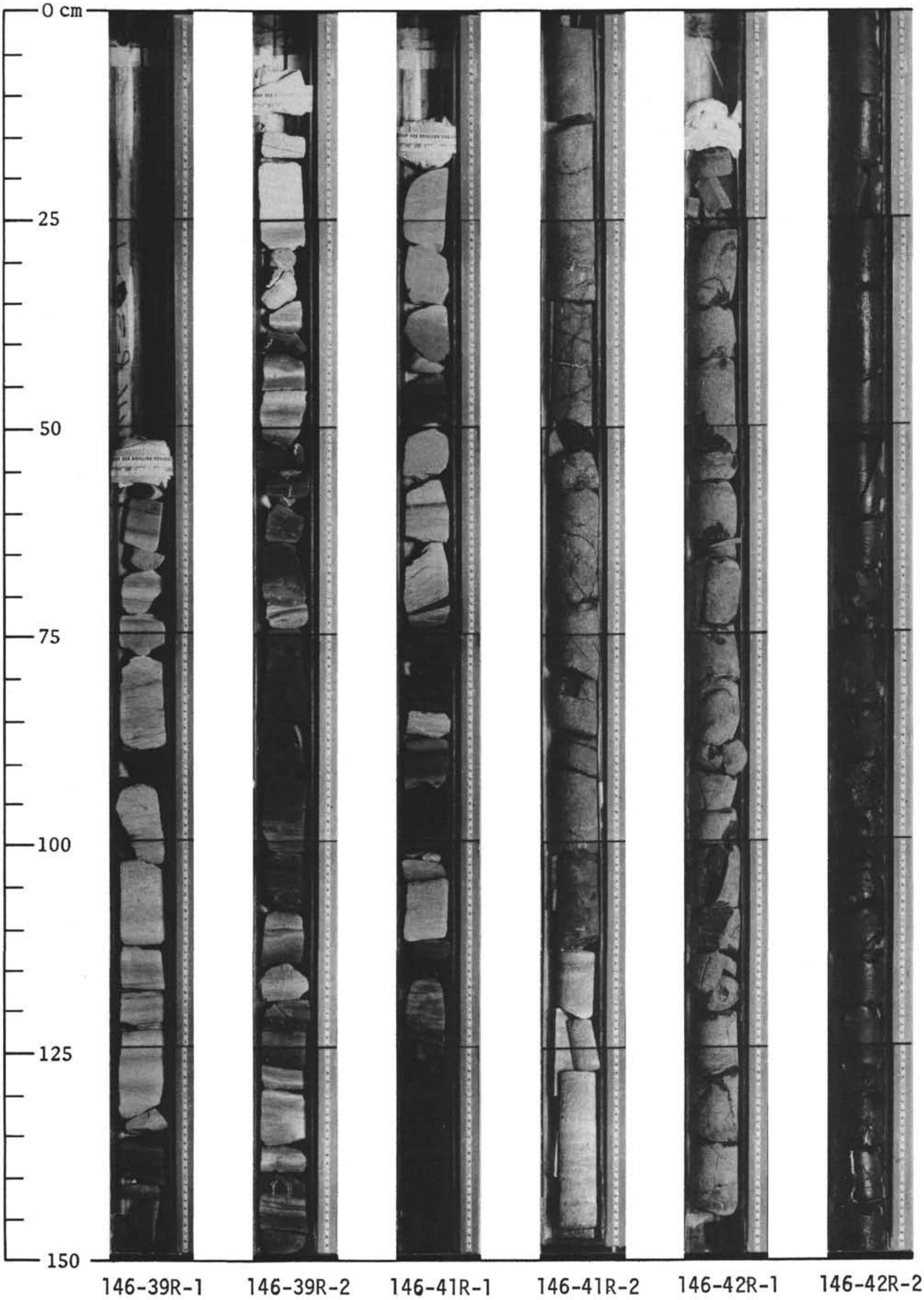
146-35-1
146-35-2
146-36-1
146-36-2
146-38R-1


0 cm
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100
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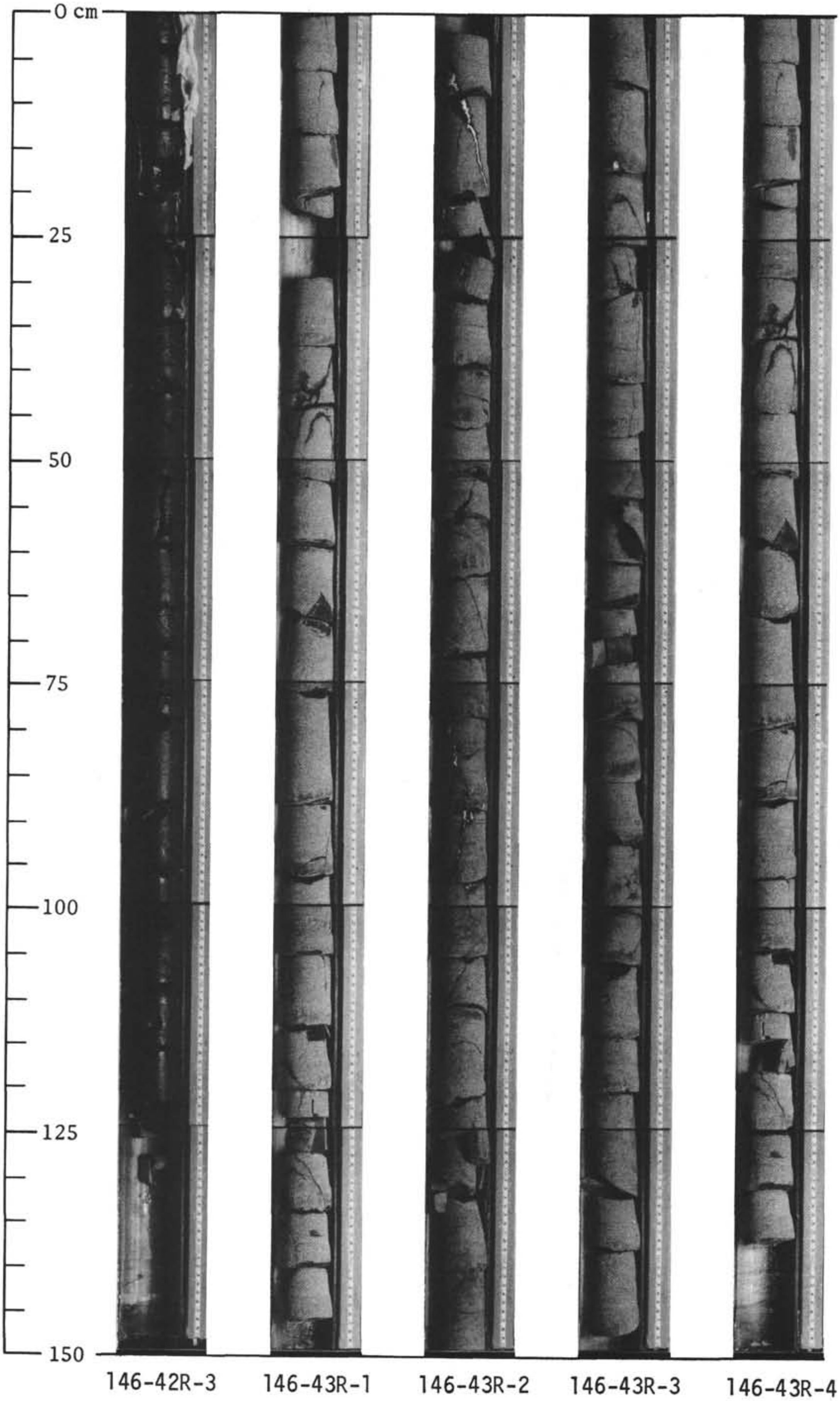
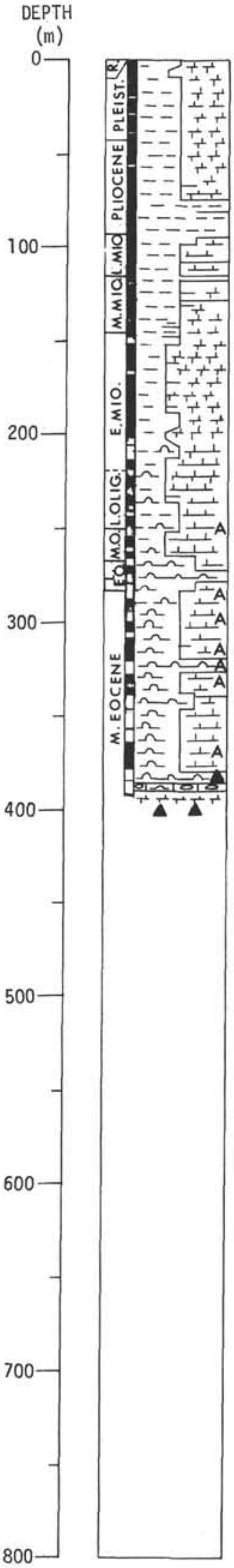
146-39R-2
146-41R-1
146-41R-2
146-42R-1
146-42R-2


0 cm
25
50
75
100
125
150
146-42R-3
146-43R-1
146-43R-2
146-43R-3
146-43R-4

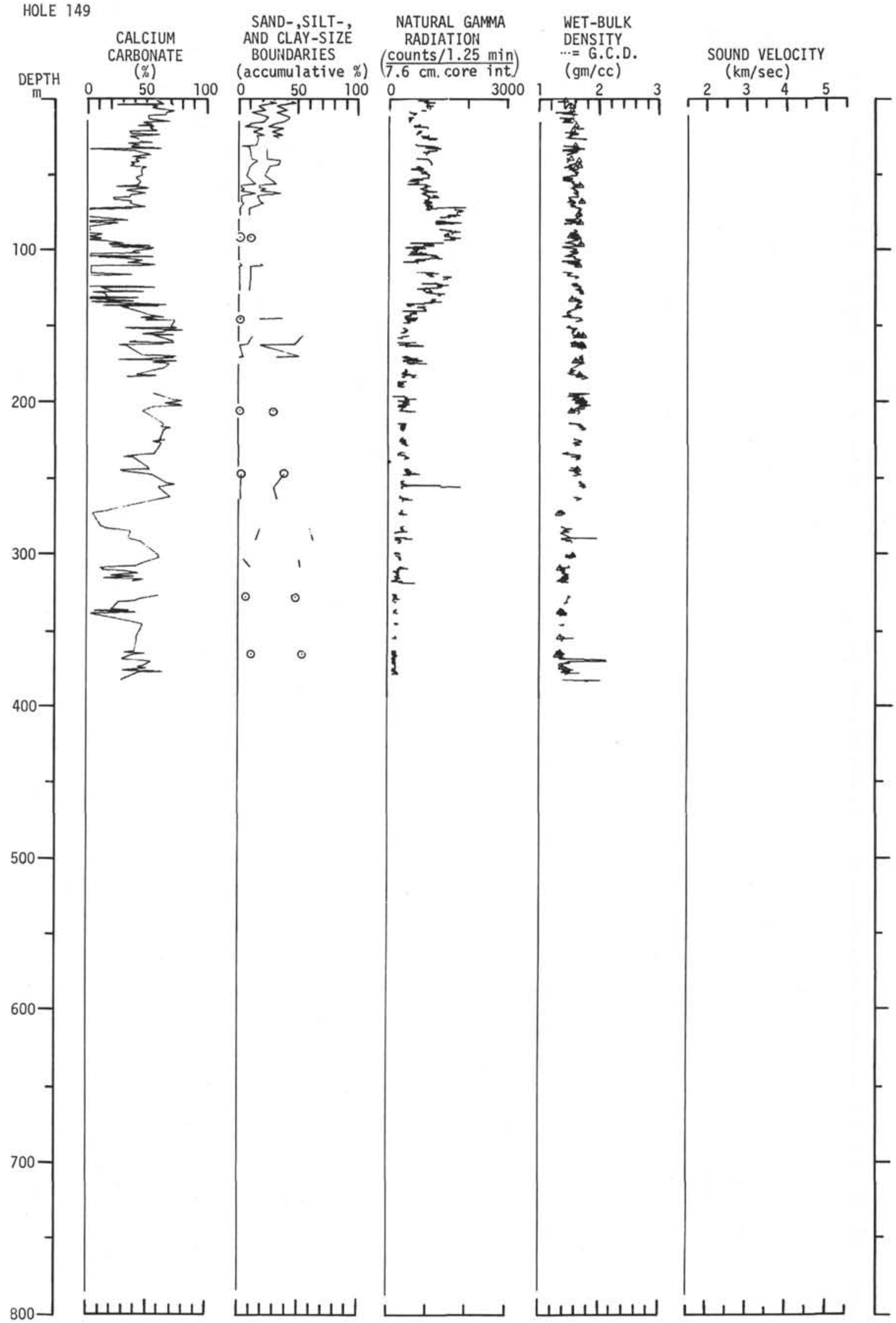
SITE 149

LITHOLOGY



UNITS	SUBUNITS OR DESCRIPTION
UNIT I (0 to 198.50 m) FORAM NANNO CHALK OOZE, FORAM NANNO MARL OOZE, and CLAY	Subunit a. (0 to 71.85 m) FORAM NANNO CHALK and MARL OOZE, grayish orange (0 to 30 m) and light olive gray. Pteropods present in upper 9 m.
	Subunit b. (71.85 to 96.45 m) ZEOLITIC CLAY, brown
	Subunit c. (96.45 to 135.45 m) FORAM NANNO MARL OOZE, bluish gray, dark yellowish orange, and light brown.
	Subunit d. (135.45 to 198.50 m) FORAM NANNO CHALK OOZE and FORAM NANNO MARL OOZE, yellowish gray and grayish orange.
UNIT II (198.50 to 382.50 m) RADIOLARIAN NANNO CHALK, RADIOLARIAN RICH NANNO CHALK, and semi-indurated RADIOLARIAN OOZE	Subunit a. (198.50 to 270.00 m) RADIOLARIAN rich NANNO MARL; minor radiolarian rich nanno chalk; greenish gray and yellowish gray.
	Subunit b. (270.00 to 382.50 m) RADIOLARIAN NANNO CHALK, light olive gray and greenish gray with interbeds of semi-indurated radiolarian ooze, and frequent ash layers.
UNIT III (382.50 to 390 m? T.D.). FORAM NANNO CHALK, and CHERT	FORAM NANNO CHALK, light olive gray. CHERT, olive gray.

*The upper boundary was cored at 406 m at Site 146.

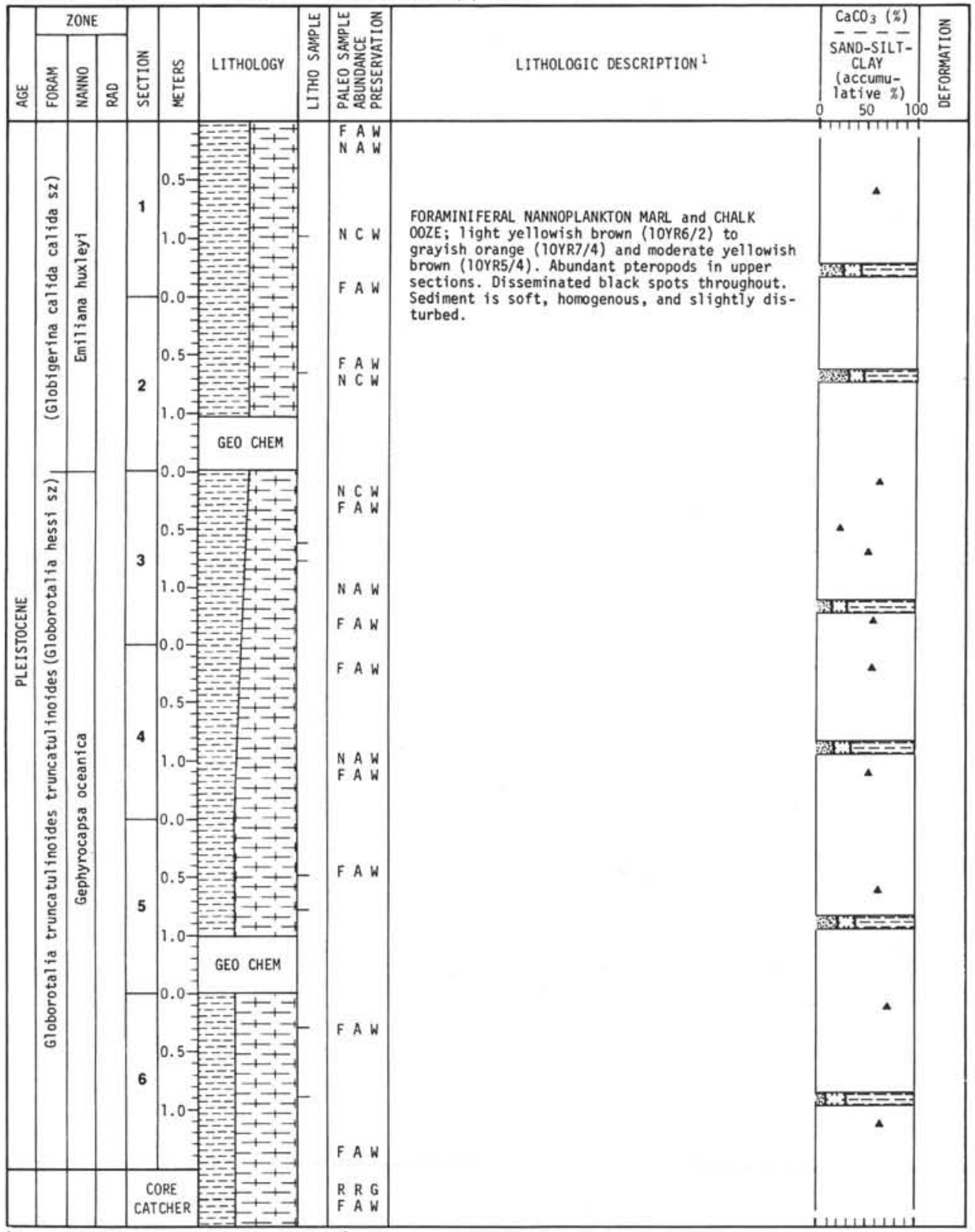

HOLE 149
DEPTH m
CALCIUM CARBONATE (%)
0 50 100
SAND-,SILT-, AND CLAY-SIZE BOUNDARIES (accumulative %)
0 50 100
NATURAL GAMMA RADIATION (counts/1.25 min / 7.6 cm. core int.)
0 3000
WET-BULK DENSITY ···= G.C.D. (gm/cc)
1 2 3
SOUND VELOCITY (km/sec)
2 3 4 5
100
200
300
400
500
600
700
800

SITE 149 HOLE CORE 1 CORED INTERVAL (m) 0-1

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
RECENT	*Globorotalia fimbriata*	*Emiliana huxleyi*		CORE CATCHER				F A W	FORAMINIFERAL CHALK OOZE with abundant pteropods.		

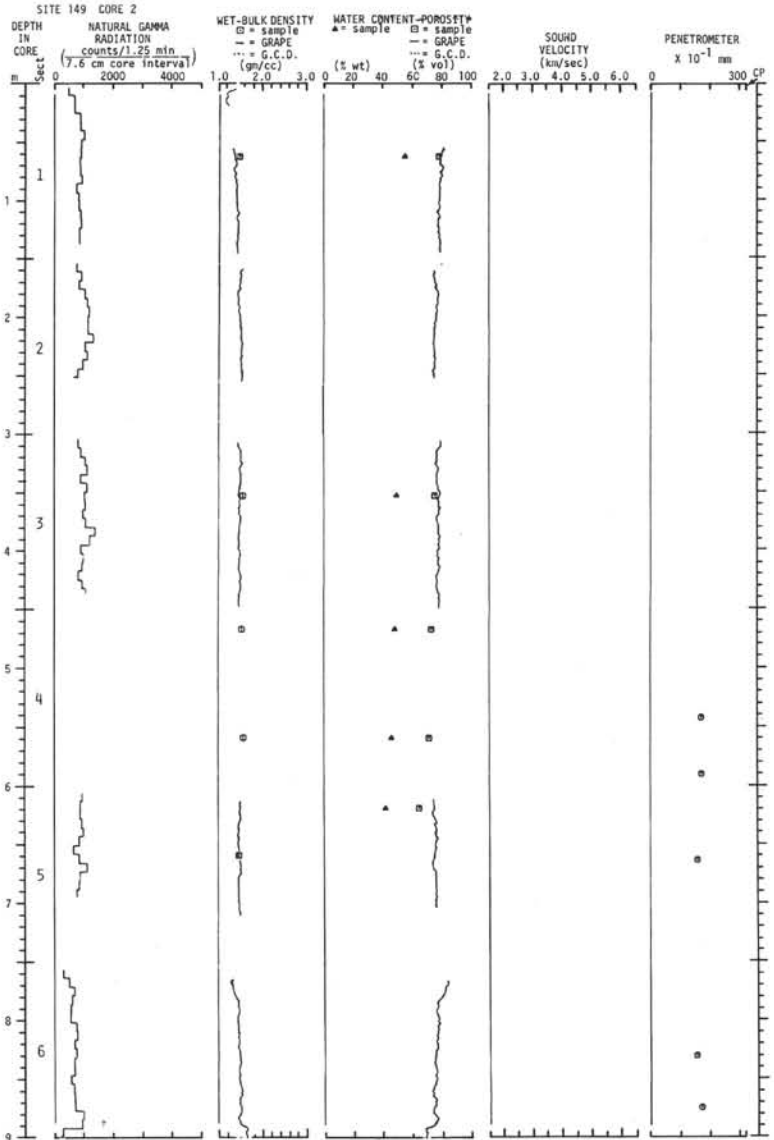
[1]For explanation of symbols, see Chapter 1

SITE 149 HOLE CORE 2 CORED INTERVAL (m) 1-10



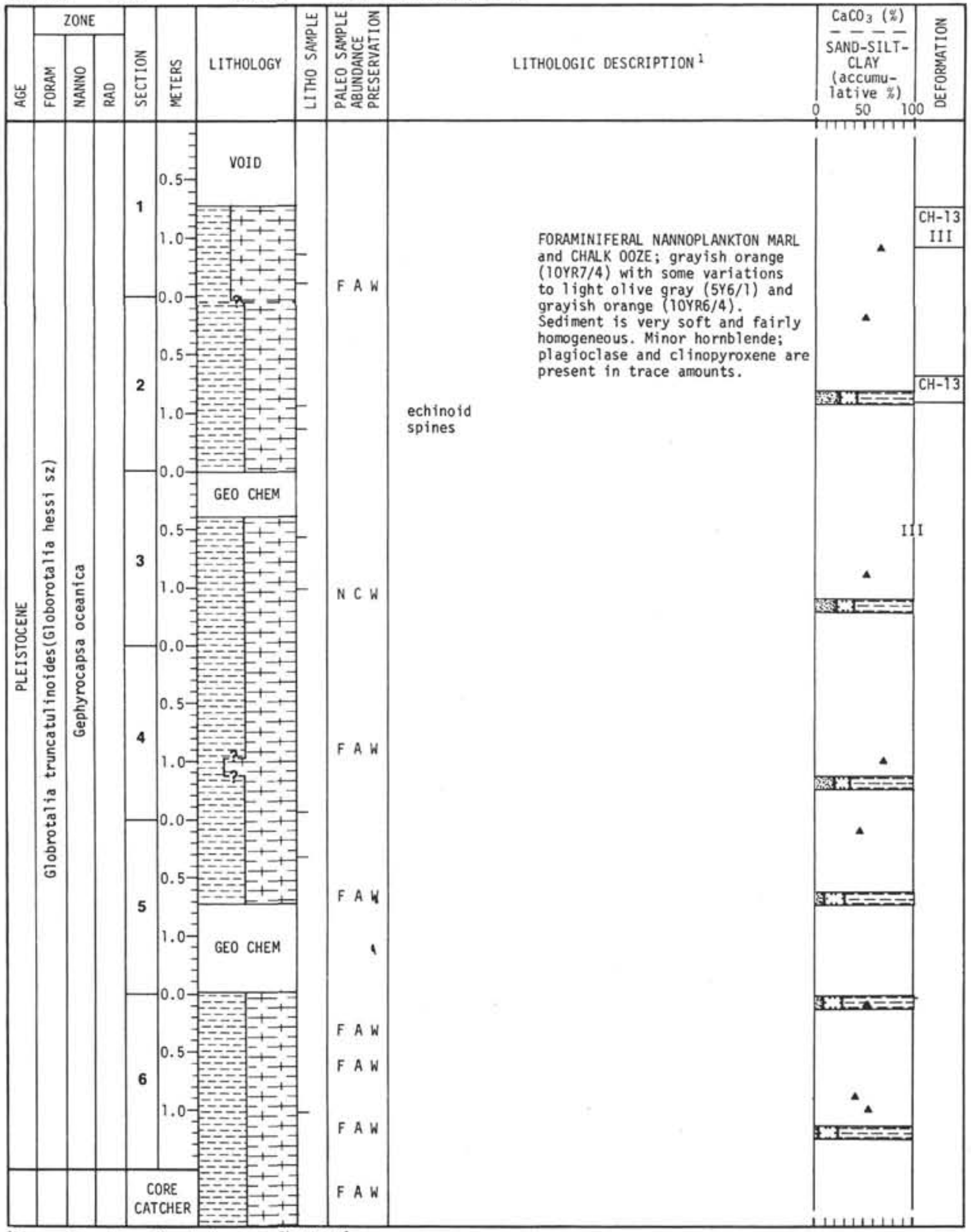
FORAMINIFERAL NANNOPLANKTON MARL and CHALK OOZE; light yellowish brown (10YR6/2) to grayish orange (10YR7/4) and moderate yellowish brown (10YR5/4). Abundant pteropods in upper sections. Disseminated black spots throughout. Sediment is soft, homogenous, and slightly disturbed.

[1]For explanation of symbols, see Chapter 1



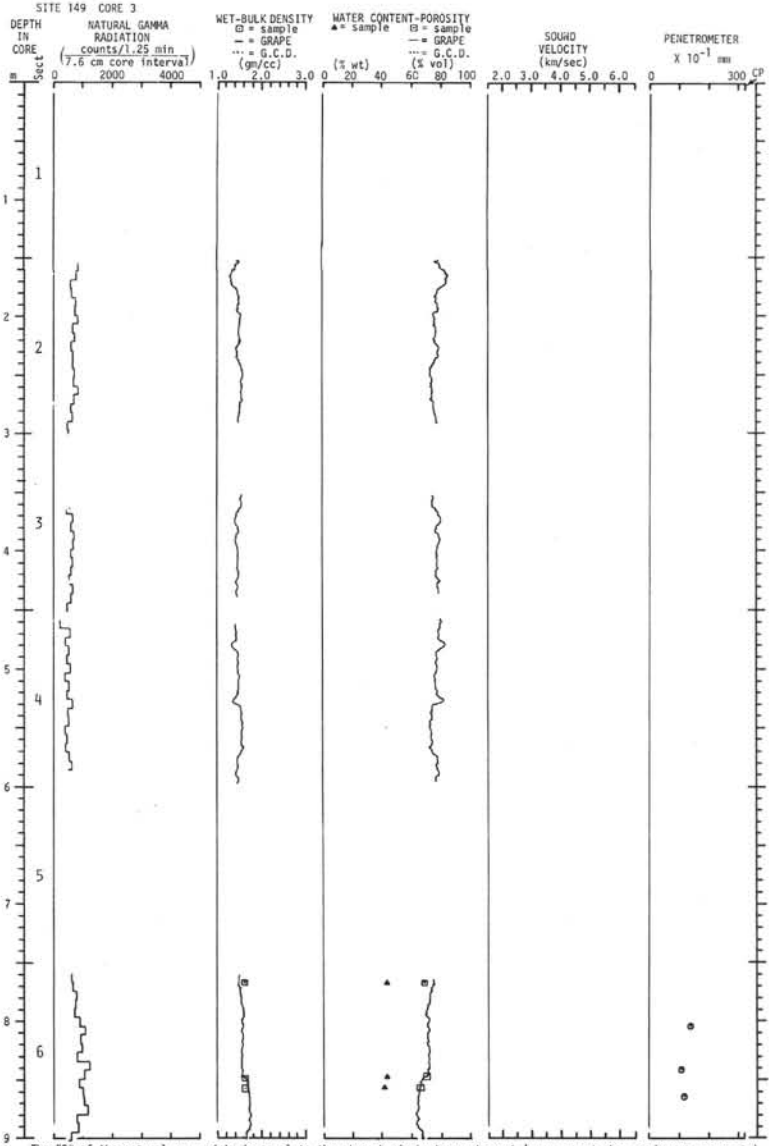
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1386. This background was subtracted from the data.

SITE 149 HOLE CORE 3 CORED INTERVAL (m) 10-19



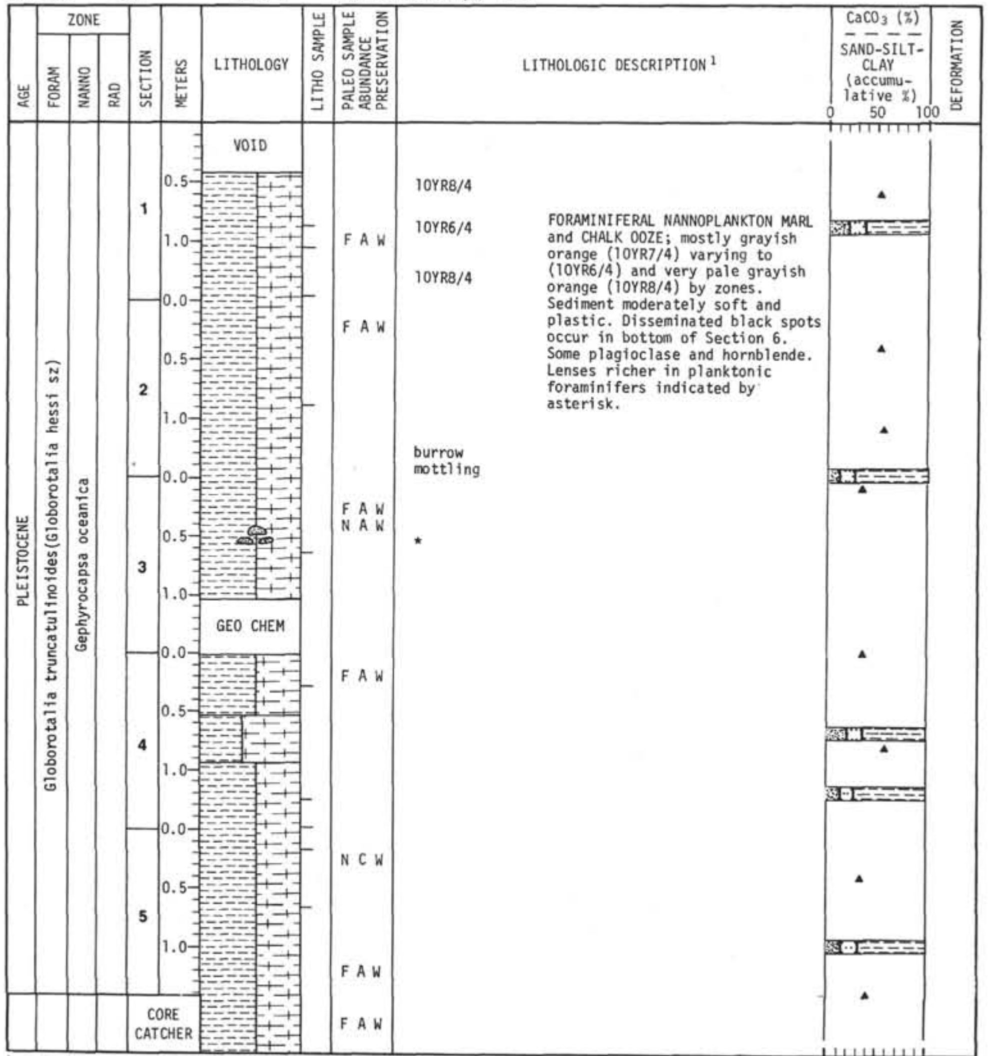
FORAMINIFERAL NANNOPLANKTON MARL and CHALK OOZE; grayish orange (10YR7/4) with some variations to light olive gray (5Y6/1) and grayish orange (10YR6/4). Sediment is very soft and fairly homogeneous. Minor hornblende; plagioclase and clinopyroxene are present in trace amounts.

[1]For explanation of symbols, see Chapter 1

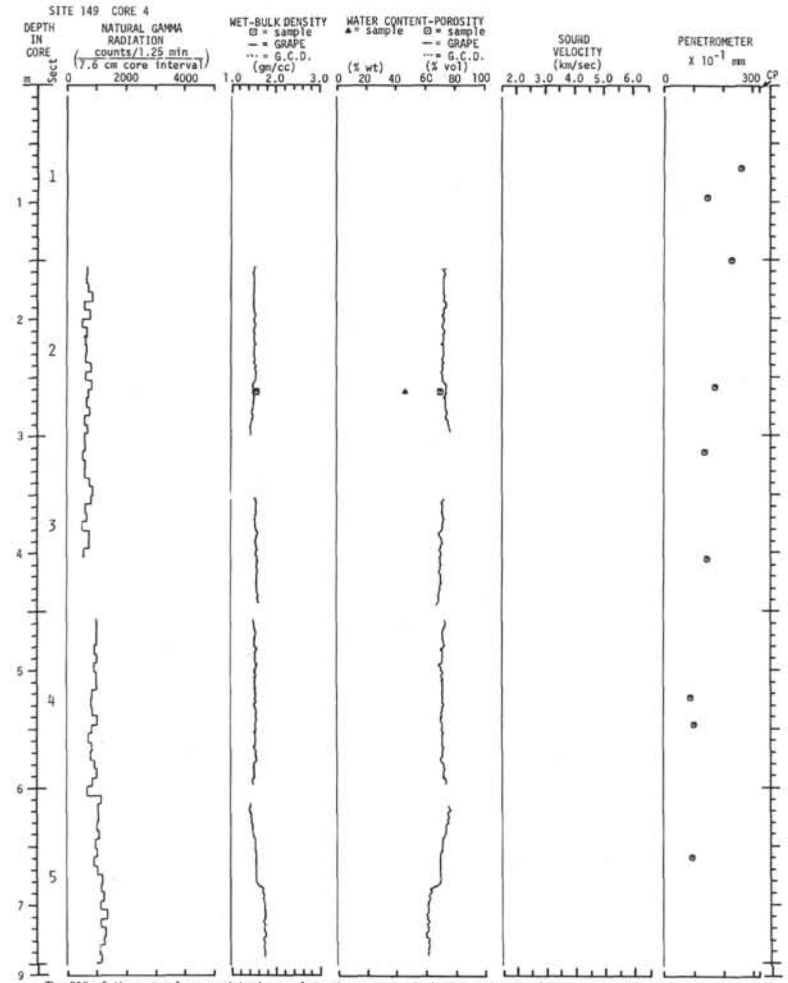


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1394. This background was subtracted from the data.

SITE 149 HOLE CORE 4 CORED INTERVAL (m) 19-28

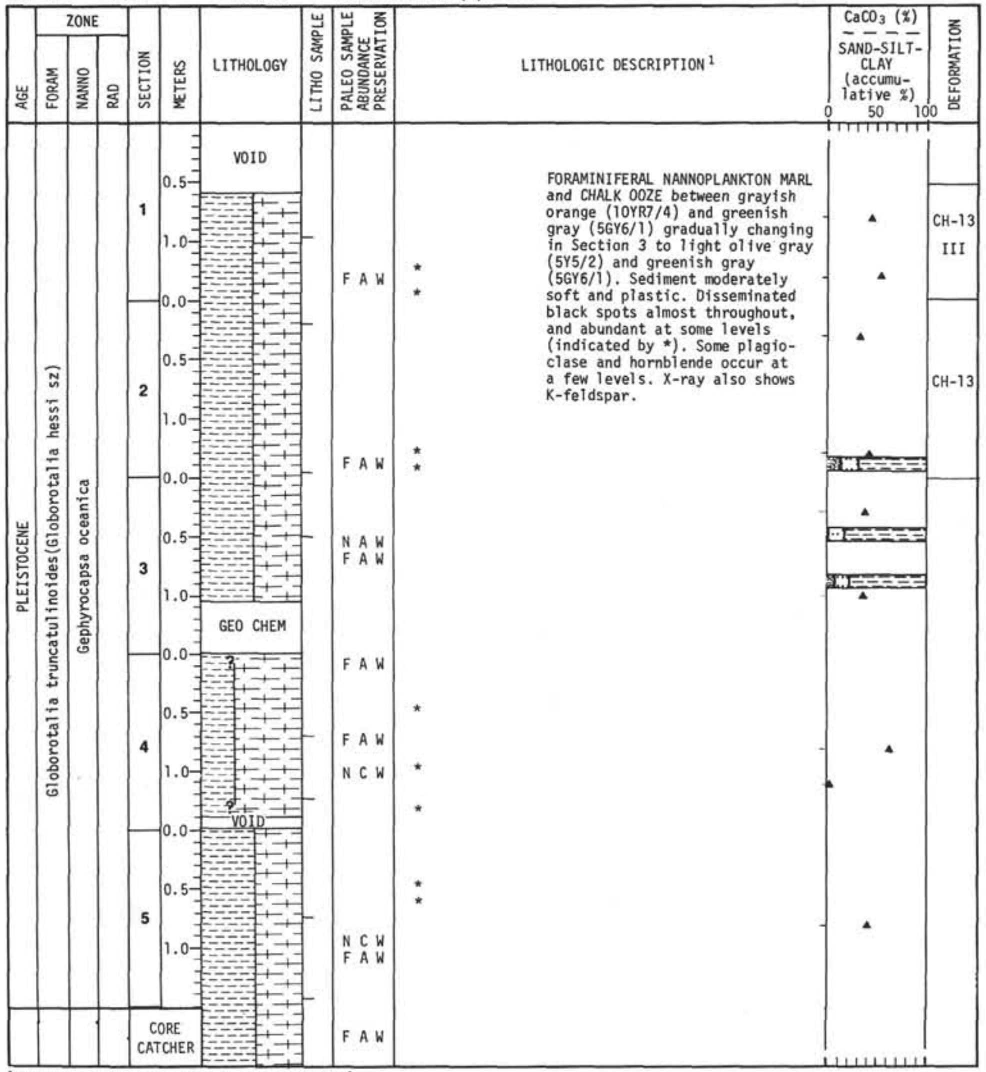


[1]For explanation of symbols, see Chapter 1

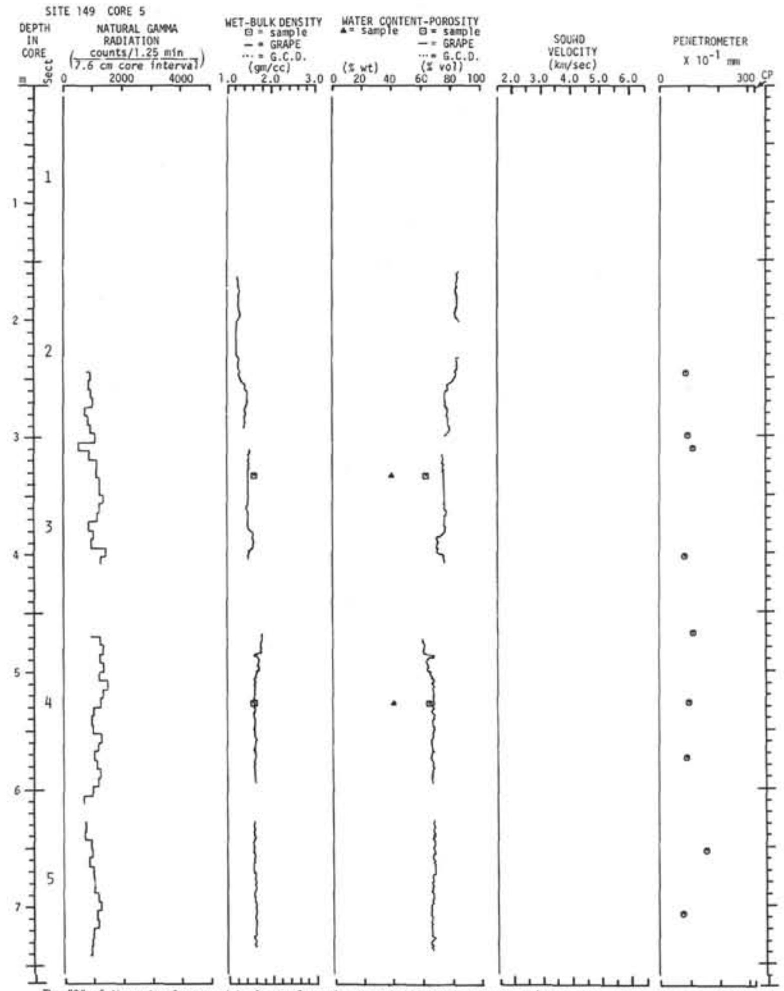


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1394. This background was subtracted from the data.

SITE 149 HOLE CORE 5 CORED INTERVAL (m) 28-37



[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1378. This background was subtracted from the data.

SITE 149 HOLE CORE 6 CORED INTERVAL (m) 37-46

AGE	FORAM	NANNO	SECTION	LITHOLOGY	PALEO SAMPLE ABUNDANCE PRESERVATION	DEFORMATION
PLEISTOCENE	MIXED Globorotalia truncatulinoides cf. tosaensis to Neogloboquadrina dutertrei	Gephyrocapsa oceanica	1	VOID		CH-13
			2		F A W; N C W; N C W	CH-13 VI
LATE PLIOCENE		Gephyrocapsa caribbeanica	3	dusky blue	F A W; N C W; F A W	CH-13 III
		Discoaster pentaradius	4	GEO CHEM	F A W; N C W	
			5		N C W; F A W; N C W	CH-13 V
			6		N C W; N C W; F A W	CH-13 III
			CORE CATCHER		F A W	

Columns: AGE; ZONE (FORAM, NANNO, RAD); SECTION; METERS; LITHOLOGY; LITHO SAMPLE; PALEO SAMPLE ABUNDANCE PRESERVATION; LITHOLOGIC DESCRIPTION[1]; $CaCO_3$ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100; DEFORMATION

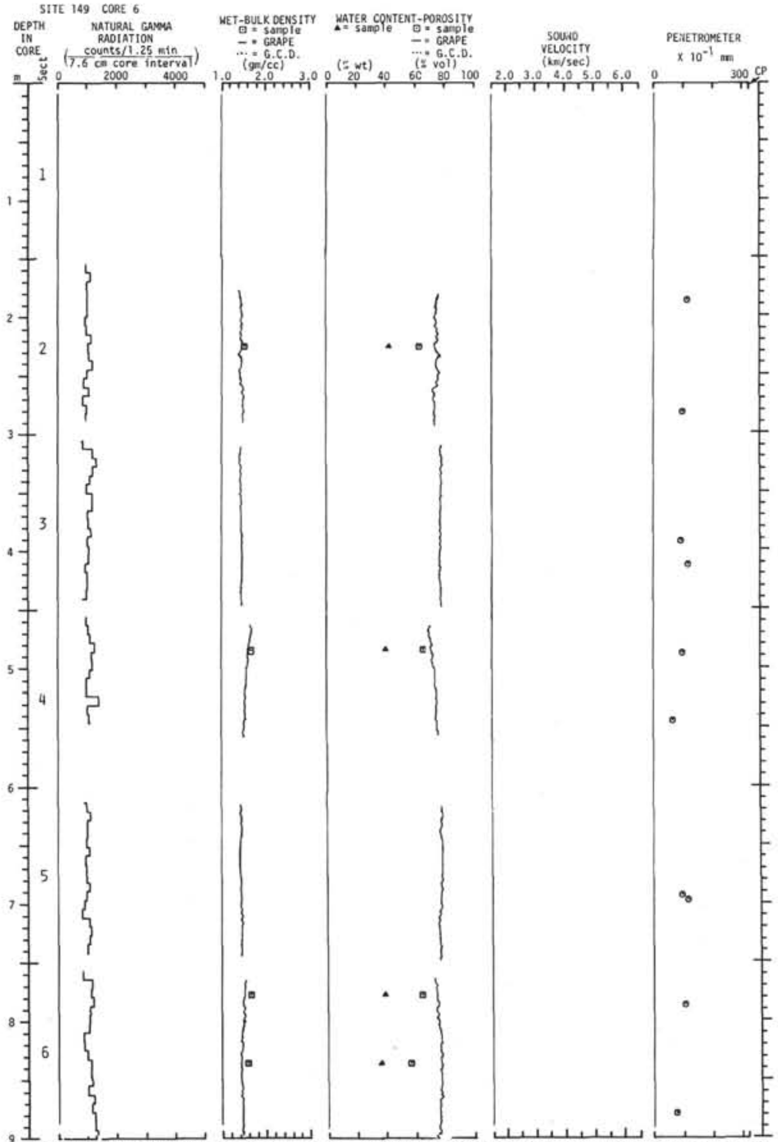
LITHOLOGIC DESCRIPTION[1]

FORAMINIFERAL NANNOPLANKTON MARL OOZE; light olive gray (5Y6/2) to greenish gray (5GY6/1) with intermittent dusky blue (5PB3/2) layering throughout. Some plagioclase and hornblende. X-ray also shows K-feldspar. Sediment moderately firm and plastic. Foraminiferal-rich layer indicated by "+". Black, 1-2 cm diameter pods of sulfide minerals at 90 and 140 cm in Section 6.

VI. Mixed assemblages: the section appears superficially undisturbed as it has good horizontal banding but the fauna and flora indicate mixing with younger material.

Dusky yellow (5Y6/4) blotches of oxidized hydrotroilite.

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1391. This background was subtracted from the data.

SITE 149 HOLE CORE 7 CORED INTERVAL (m) 46-56

AGE	FORAM ZONE	NANNO ZONE	SECTION	LITHOLOGY	PALEO SAMPLE ABUNDANCE PRESERVATION	DEFORMATION
PLEISTOCENE	MIXED Globorotalia truncatulinoides cf. to Neogloboquadrina dutertrei	MIXED Gephyrocapsa caribbeanica and Discoaster brouweri	1		F A W, N C W	
				VOID		
			2		F A W, N C W	
				GEO CHEM		CH-13 III VI
			3		N C W; F A W, N C W	
			4	VOID		
			5		N C W, F A W; N C W	
MID PLIOCENE		Discoaster pentaradiatus	6	VOID	F A W; F A W, N C W	
			CORE CATCHER		F A W	

LITHOLOGIC DESCRIPTION[1]

FORAMINIFERAL NANNOPLANKTON MARL OOZE; light olive gray (5Y6/2) and (5Y6/1). Dark material diffused throughout. X-ray shows K-feldspar. Sediment soft, plastic and badly disturbed. Washed coarse fraction in Section 5 consists mainly of planktonic foraminifers, some filled by dark material. Very rare benthonic foraminifers, ostracods, and ecthinoderm spines.

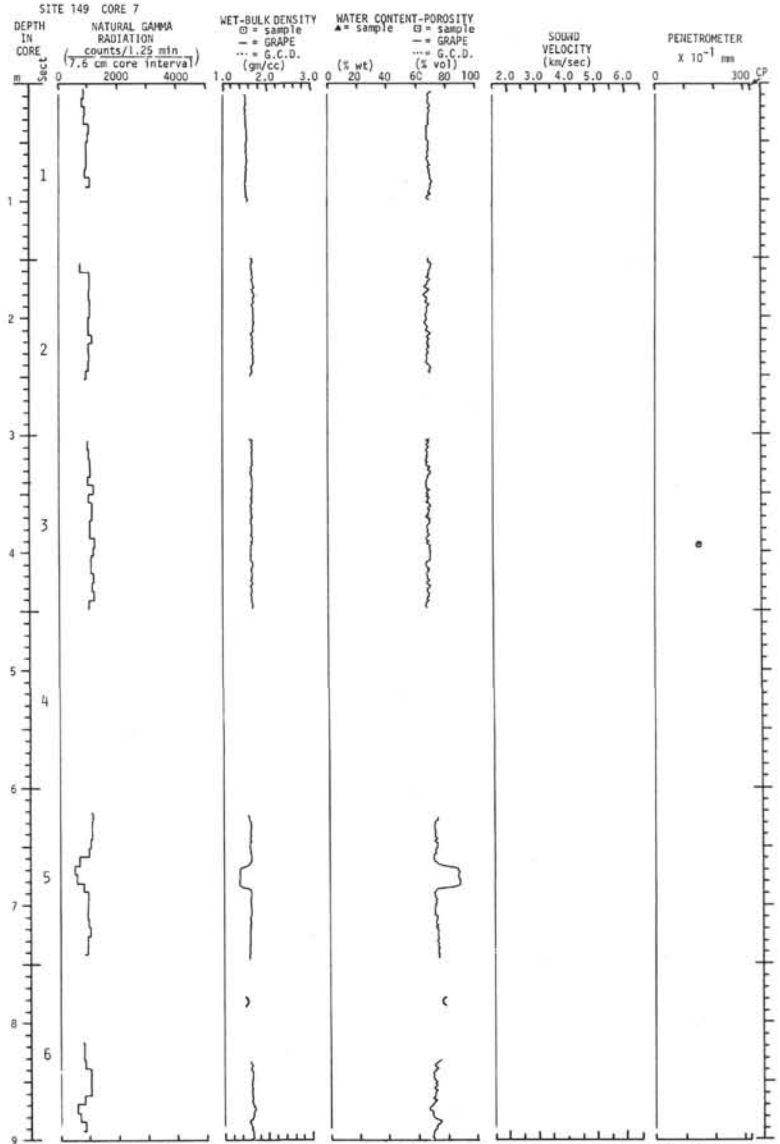
III. Flow-in: highly disturbed throughout.

VI. Mixed assemblages: collapsed material from the upper part of the hole.

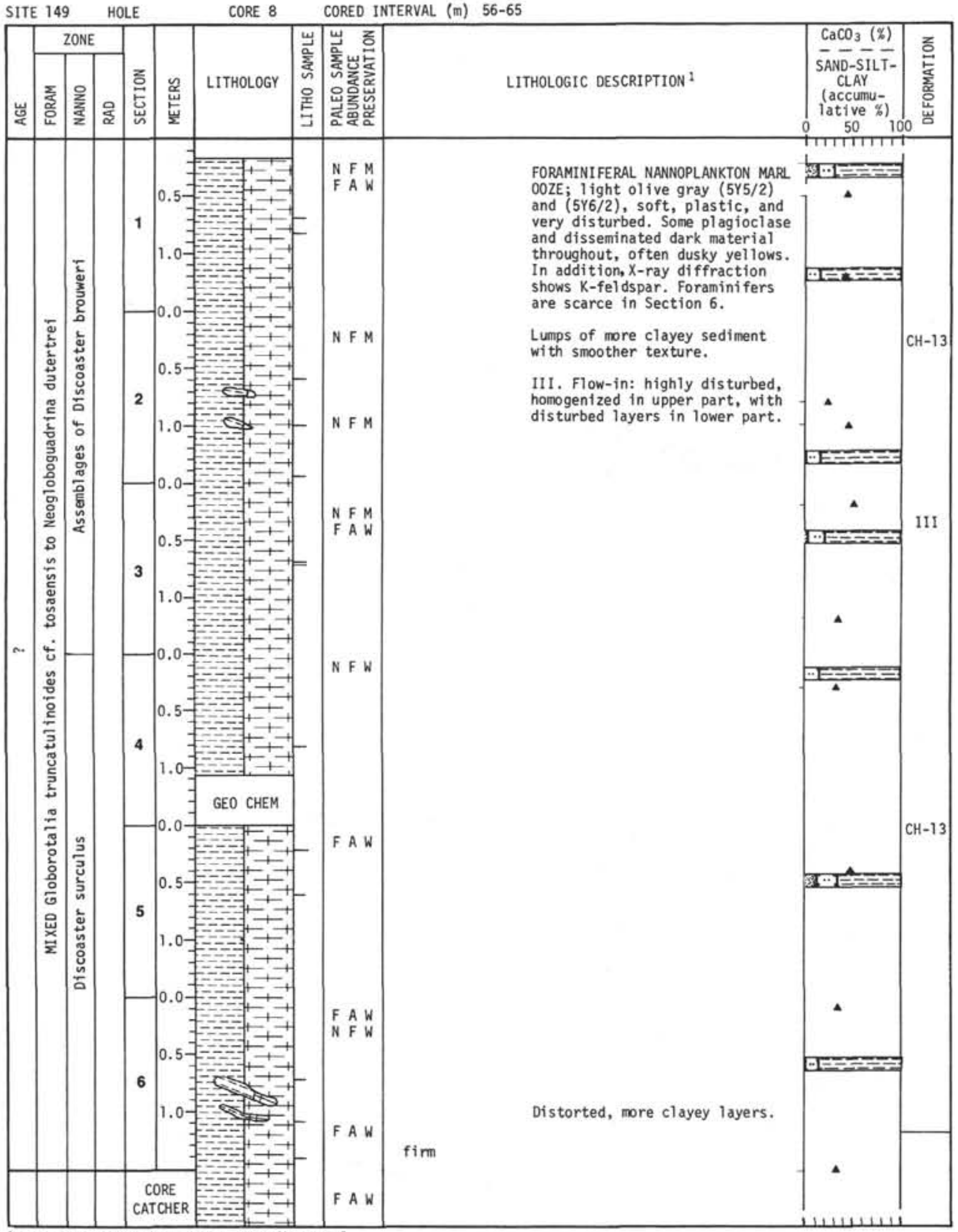
Section 5: sparse green and red hornblende

CaCO₃ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100

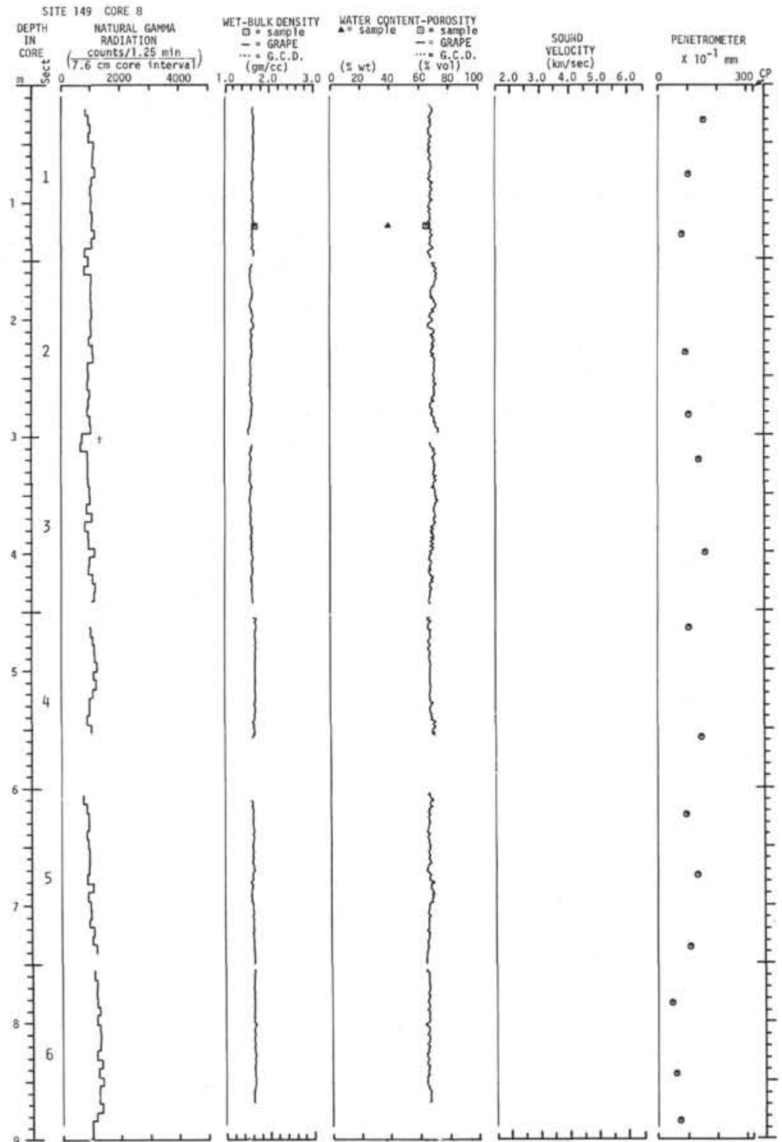
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1388. This background was subtracted from the data.



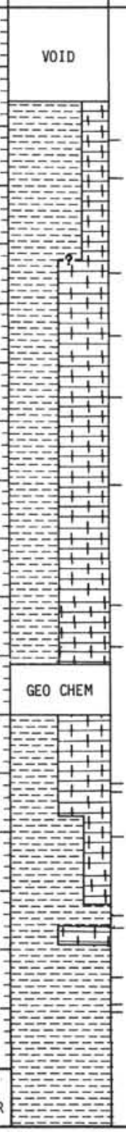
¹For explanation of symbols, see Chapter 1



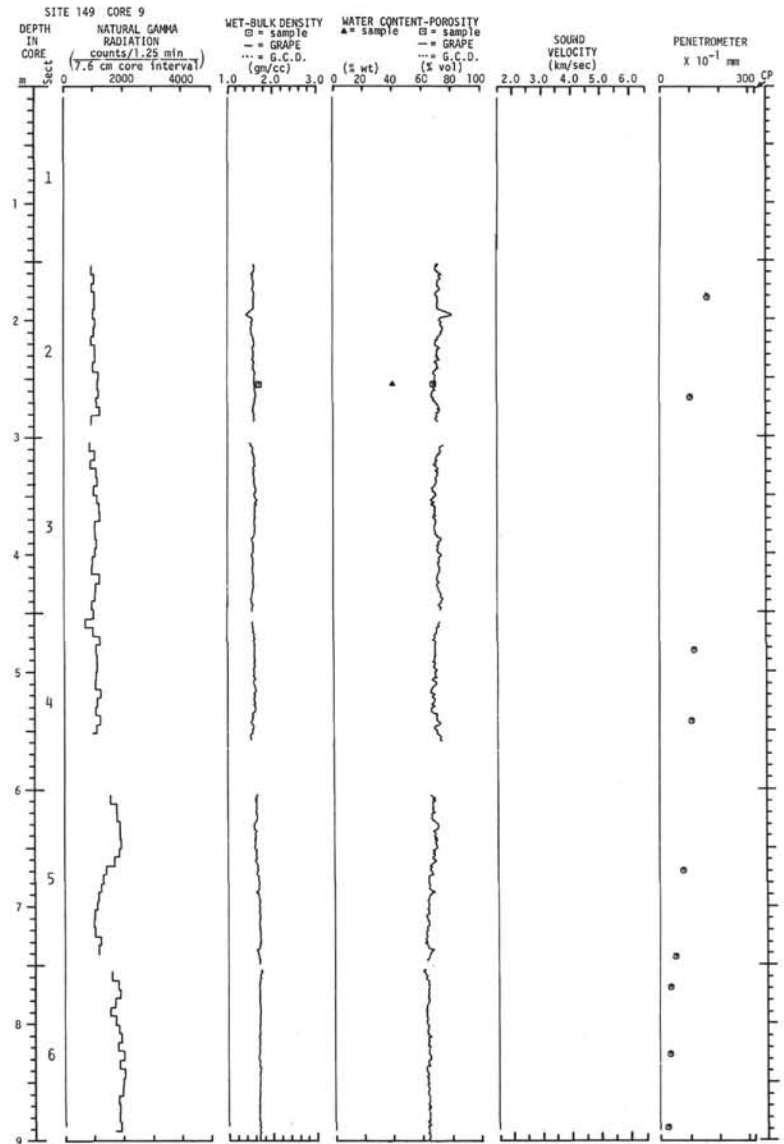
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1423. This background was subtracted from the data.

SITE 149 HOLE CORE 9 CORED INTERVAL (m) 65-75

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %)	DEFORMATION
	MIXED *Globorotalia truncatulinoides* cf. *tosaensis* to *Neogloboquadrina dutertrei*	*Discoaster surculus*		1	0.5, 1.0	VOID			FORAMINIFERAL NANNOPLANKTON MARL and FORAMINIFERAL NANNOPLANKTON CLAY; light olive gray (5Y6/1) to (5Y6/2) and greenish gray (5GY6/1). Rare dark specks. Sediment is soft and plastic; badly disturbed by drilling.		
				2	0.0, 0.5, 1.0			N F M; F A W; N F W; F A W			CH-13 III
				3	0.0, 0.5, 1.0						
				4	0.0, 0.5, 1.0	GEO CHEM					
				5	0.0, 0.5, 1.0			F A W; F A W	INTERBEDDED FORAMINIFERAL NANNOPLANKTON MARL and CALCAREOUS CLAY; light yellowish brown (10YR5/4) and olive gray (5Y5/1). Conspicuous burrow mottling at zone boundaries. Sparse nannofossils in clay.		
				6	0.0, 0.5, 1.0			F C M; N F W; N R P; N C W; F A M; F C M; N R P; F F M; N R P	CLAY; moderate yellowish brown (10YR5/4), firm, and plastic. Scattered grayish olive mottling.		
				CORE CATCHER				F C M	X-ray shows K-feldspar throughout core and pyrite in Section 6.		



[1]For explanation of symbols, see Chapter 1

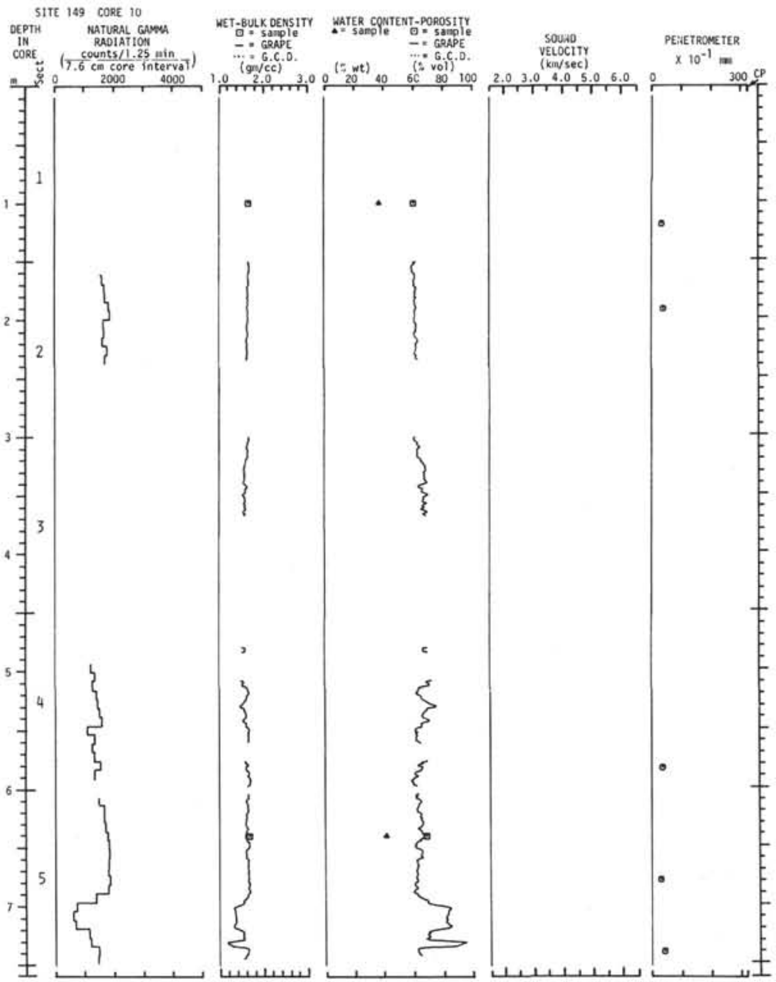


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1391. This background was subtracted from the data.

SITE 149 HOLE CORE 10 CORED INTERVAL (m) 75-84

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION [1]	$CaCO_3$ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
	MIXED Globorotalia truncatulinoides cf. tosaensis to Neogloboquadrina dutertrei	Discoaster surculus		1	0.5 1.0	VOID		F C M	CLAY; moderate yellowish brown (10YR5/4); firm and plastic. Rare anatase and carbonate rhombs with a high refractive index appear throughout the core. Washed out sample of disturbed clay from Section 1 contains rare copper and quartz phenocrysts. In addition, X-ray shows K-feldspar and palygorskite. VI. Mixed assemblages: highly disturbed throughout. Probably a result of caving in.		CH-13 VI
				2	0.0 0.5 1.0	GEO CHEM		N F W F A M			
				3	0.0 0.5 1.0	VOID					
				4	0.0 0.5 1.0			F A M	Highly disturbed calcareous lumps with younger foraminifers from higher in the hole.		
				5	0.0 0.5 1.0			N R P F A M	Highly disturbed calcareous zone with younger foraminifers.		
				CORE CATCHER				F F M	The sieved sand fracture contains rare copper, quartz, plagioclase, apatite, clinopyroxene, orthopyroxene, biotite, hornblende, analase, and rutile.		

·For explanation of symbols, see Chapter 1

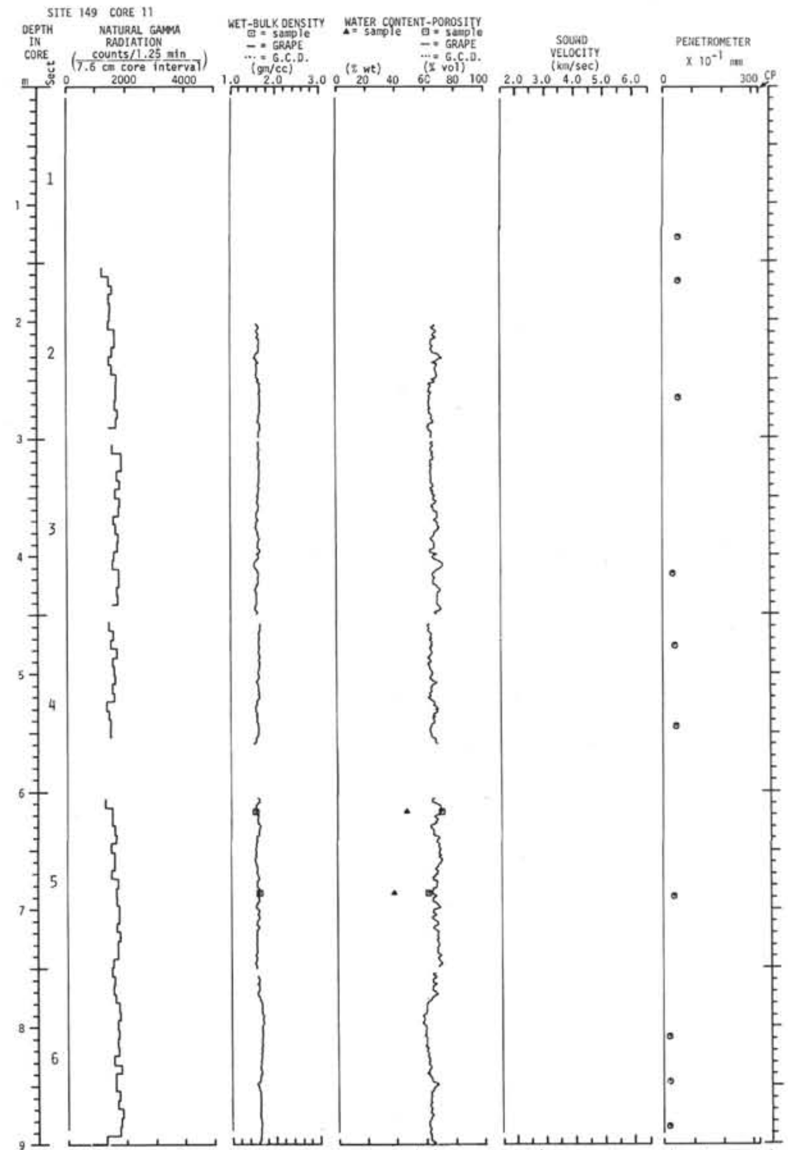


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1418. This background was subtracted from the data.

SITE 149 HOLE CORE 11 CORED INTERVAL (m) 84-93

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %)	DEFORMATION
	MIXED Globorotalia truncatulinoides cf. tosaensis to Neogloboquadrina dutertrei	Reticulofenestra pseudoumbilica		1	0.5	VOID		N F M	CLAY; moderate yellowish brown (10YR5/4) with disturbed patches of greenish gray (5GY6/1), moderate yellowish brown (10YR5/2), and orange pink (5YR5/4). Drilling disturbances largely account for the color changes. Two nannofossil zones are missing at the lower part of Section 5. Possibly only Section 6 is relatively undisturbed. Faint burrow mottling. Sediment is firm and plastic. Manganese speckling in Section 6; rare dolomite rhombs throughout. In addition, X-ray shows K-feldspar.		
				2				N R P; f; N C W	5YR5/4; 5YR5/4; 5YR5/4		
				3				N F W	small spot at 29 cm: plagioclase, clino-pyroxene, hornblende, biotite, phillipsite, apatite, and light glass.		CH-13 III
		Discoaster asymmetricus		4		GEO CHEM		N F M; F A M			
				5				N F W; N F M; N F M; F C M; N R P			
		Discoaster quinqueramus ?		6				n; f	10YR4/4; 5GY6/1 laminae. The sieved sand fraction yielded plagioclase, clino-pyroxene, and quartz.		
				CORE CATCHER				f			

[1]For explanation of symbols, see Chapter 1

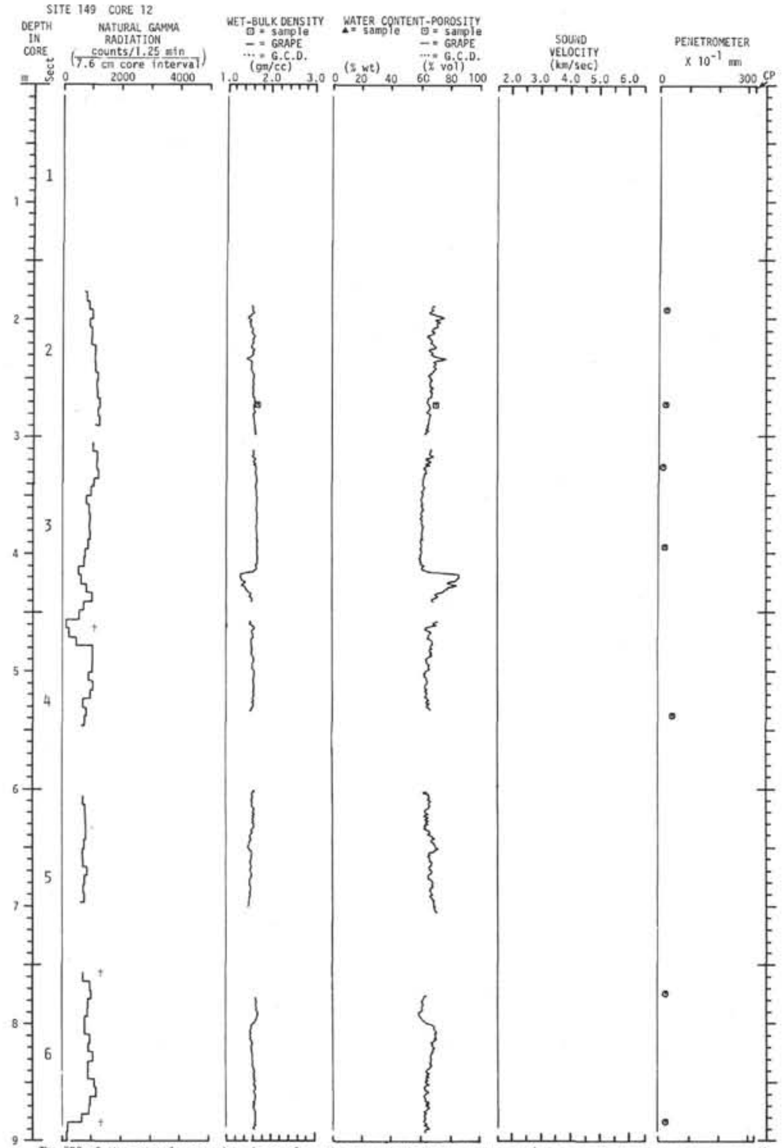


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1418. This background was subtracted from the data.

SITE 149 HOLE CORE 12 CORED INTERVAL (m) 93-102

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) SAND-SILT-CLAY (accumulative %)	DEFORMATION
LATE MIOCENE	Globorotalia acostaensis	Discoaster quinqueramus		1	0.5, 1.0	VOID			CALCAREOUS CLAY and CLAY; grayish orange (10YR7/4) to yellowish gray (5Y7/2). Rare nannofossils. Trace of carbonate rhombs (high refractive index). Faint burrow mottling. Sediment firm and plastic; highly disturbed by drilling. VII. Flocculent soap: intermixed with Rhodamine dye (pink).		CH-13 VII
				2	0.0, 0.5, 1.0	VOID		F R P / N C W	faint burrows		
				3	0.0, 0.5, 1.0			F A P	5YR5/6 layer. Interbedded CALCAREOUS CLAY and NANNOPLANKTON MARL; grayish orange (10YR6/4) to very pale grayish orange (10YR8/4); firm and plastic. Scattered small scale burrow mottling somewhat blurred by drilling disturbances. Disseminated fine, dark material at some levels. Sparse calcite rhombs. In addition, X-ray shows plagioclase and K-feldspar.		CH-13 III / CH-13 VII
				4	0.0, 0.5, 1.0	VOID		F A M	III. Flow-in: highly disturbed; secondarily colored by Rhodamine dye (pink).		CH-13 III
				5	0.0, 0.5, 1.0	VOID		F A M			CH-13
				6	0.0, 0.5, 1.0			F A M / N C W	Sharp contact with change to yellowish gray (5Y7/2); sediment very compact.		
				CORE CATCHER				F A M			

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1425. This background was subtracted from the data.

SITE 149 HOLE CORE 13 CORED INTERVAL (m) 102-112

AGE: LATE MIOCENE

ZONE:
- FORAM: *Globorotalia acostaensis*
- NANNO: Assemblage of *Discoaster quinqueramus*; *Discoaster namatus*

SECTION	PALEO SAMPLE (ABUNDANCE, PRESERVATION)
1	f
2	N R P; N C W
3	N C W; F A M
4	N C W
5	F C P
6	F A M; N C W
CORE CATCHER	

LITHOLOGIC DESCRIPTION[1]

CLAY; mainly moderate yellowish brown (10YR5/4) with disturbed MARL layers and lenses, pale grayish orange (10YR8/4). Sediment is firm and plastic. Traces of carbonate rhombs. X-ray shows K-feldspar throughout.

Interbedded FORAMINIFERAL NANNOPLANKTON MARL and CALCAREOUS CLAY; yellowish gray (5Y7/2) to olive gray (5Y6/2) and yellowish brown (10YR5/4). Traces of carbonate rhombs. Distorted light brown (5YR5/6) lamina occurs in Section 4 and some burrow-like mottling in Section 5. Sediment firm and plastic.

III. Flow-in: intermittent layers of high disturbance.

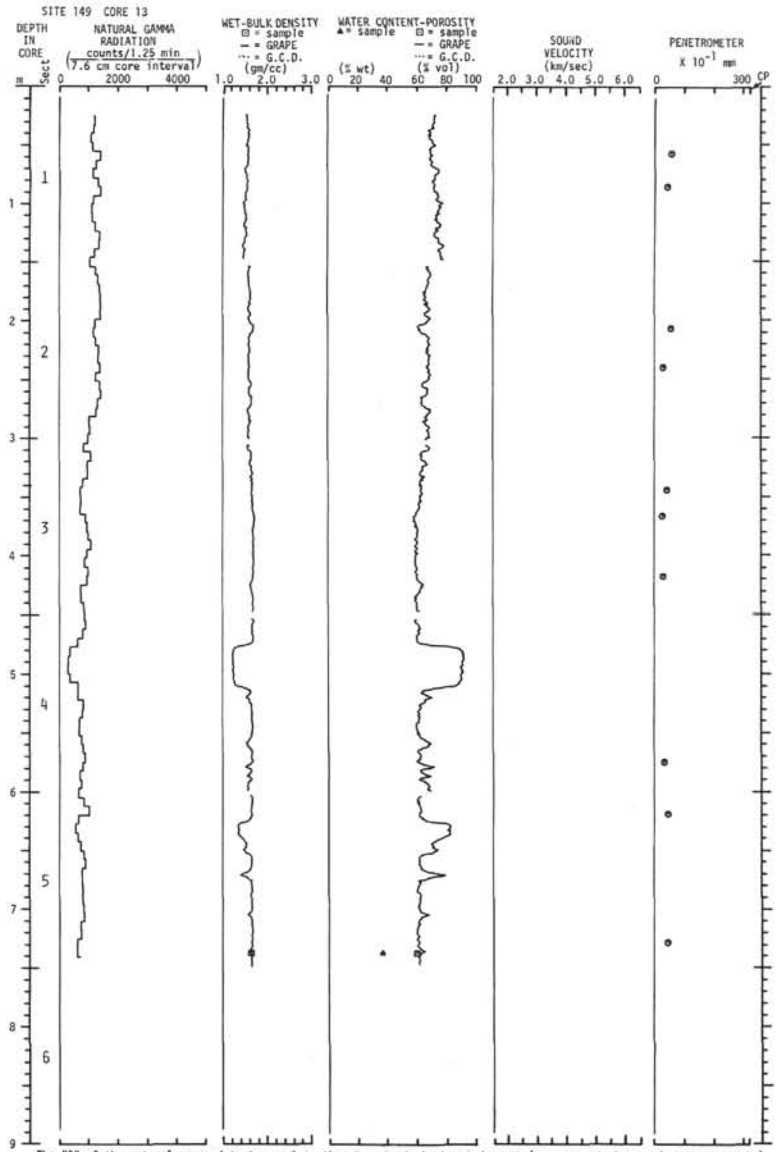
(5YR5/6)

sharp contact

CLAY; moderate yellowish brown (10YR5/4); very firm and plastic. Traces of plagioclase and carbonate rhombs.

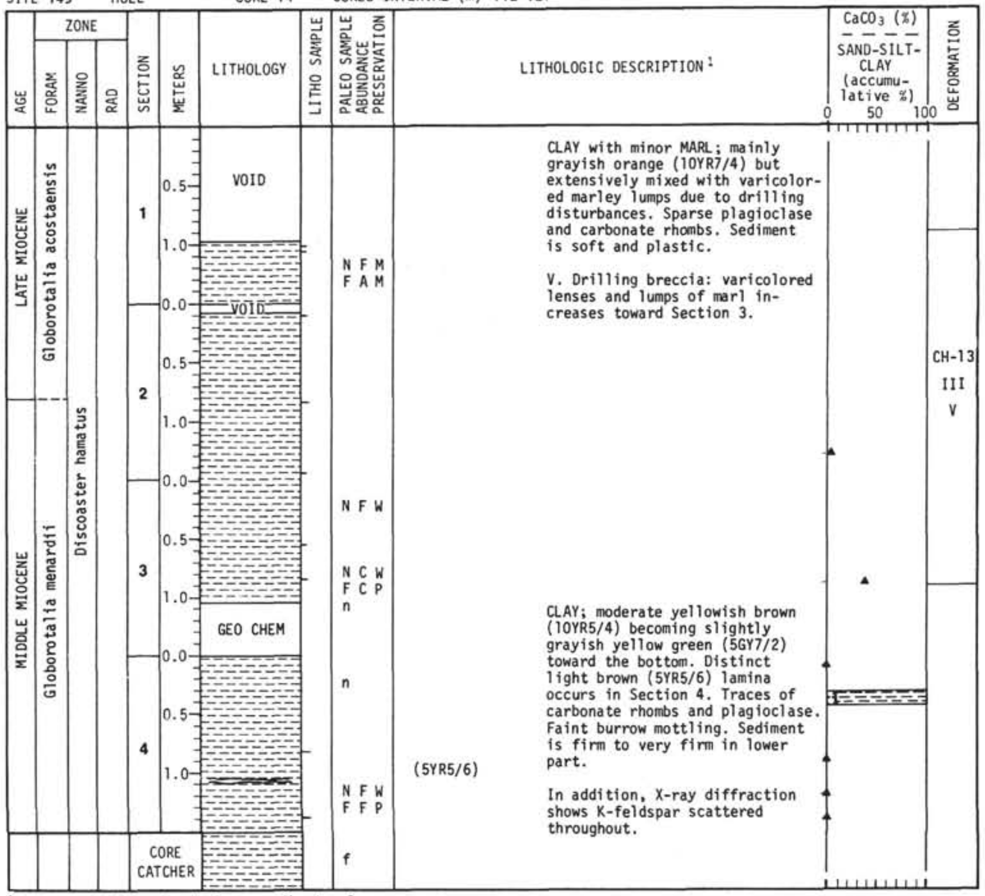
DEFORMATION: CH-13 III; CH-13 III

[1]For explanation of symbols, see Chapter 1

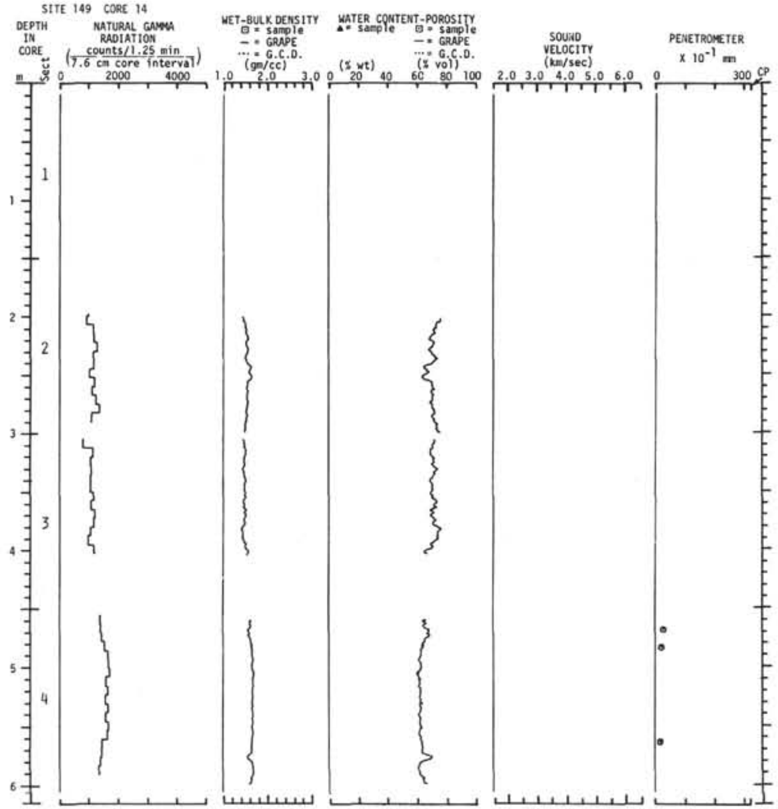


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1408. This background was subtracted from the data.

SITE 149 HOLE CORE 14 CORED INTERVAL (m) 112-121



[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1414. This background was subtracted from the data.

SITE 149 HOLE CORE 15 CORED INTERVAL (m) 121-130

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) / SAND-SILT-CLAY (accumulative %)	DEFORMATION
MIDDLE MIOCENE	Globorotalia menardii	Catinaster coalitus		1	0.5, 1.0			F R P; N R P; n	Disseminated dark material; 5YR5/6 lamina		CH-13 VI
	Globorotalia mayeri	Catinaster coalitus		2	0.5, 1.0			n; N C M; F F P			
	Globorotalia mayeri / Globorotalia kugleri	Discoaster kugleri		3	0.5, 1.0			N C W; F C P; N C W	* ; *		
	Globorotalia fohsi lobata	Discoaster kugleri		4	0.5, 1.0			N F W; N C W; F F P			
	Globorotalia fohsi fohsi			5	0.5, 1.0			f; F C P			
				CORE CATCHER				F R P			

NANNOPLANKTON MARL; grayish orange (10YR8/4) to (10YR5/4), very disturbed.

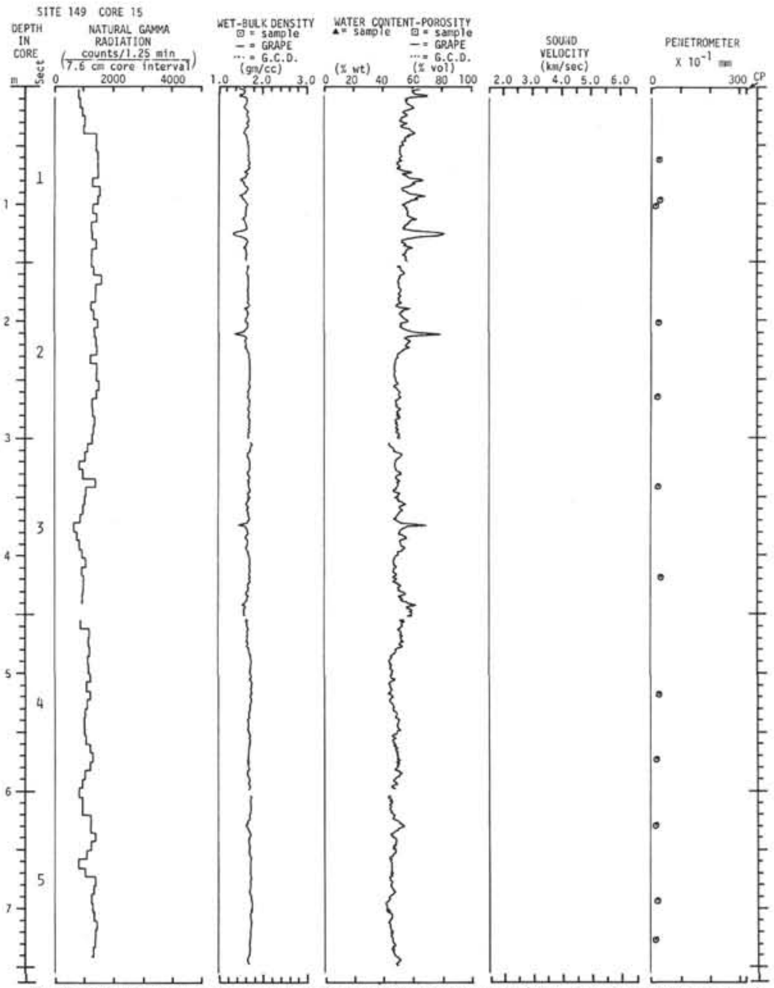
CLAY; moderate yellowish brown (10YR5/4); firm and plastic. Slight mottling.

VI. Mixed assemblage: nannofossils indicate collapse from higher up in the hole.

Interbedded NANNOPLANKTON MARL and CALCAREOUS CLAY; grayish orange (10YR8/4) and (10YR7/4) to light olive gray (5Y6/1). Traces of carbonate rhombs, plagioclase, apatite, and glauconite. Extensive burrow mottling throughout. Somewhat blurs primary layered structure.

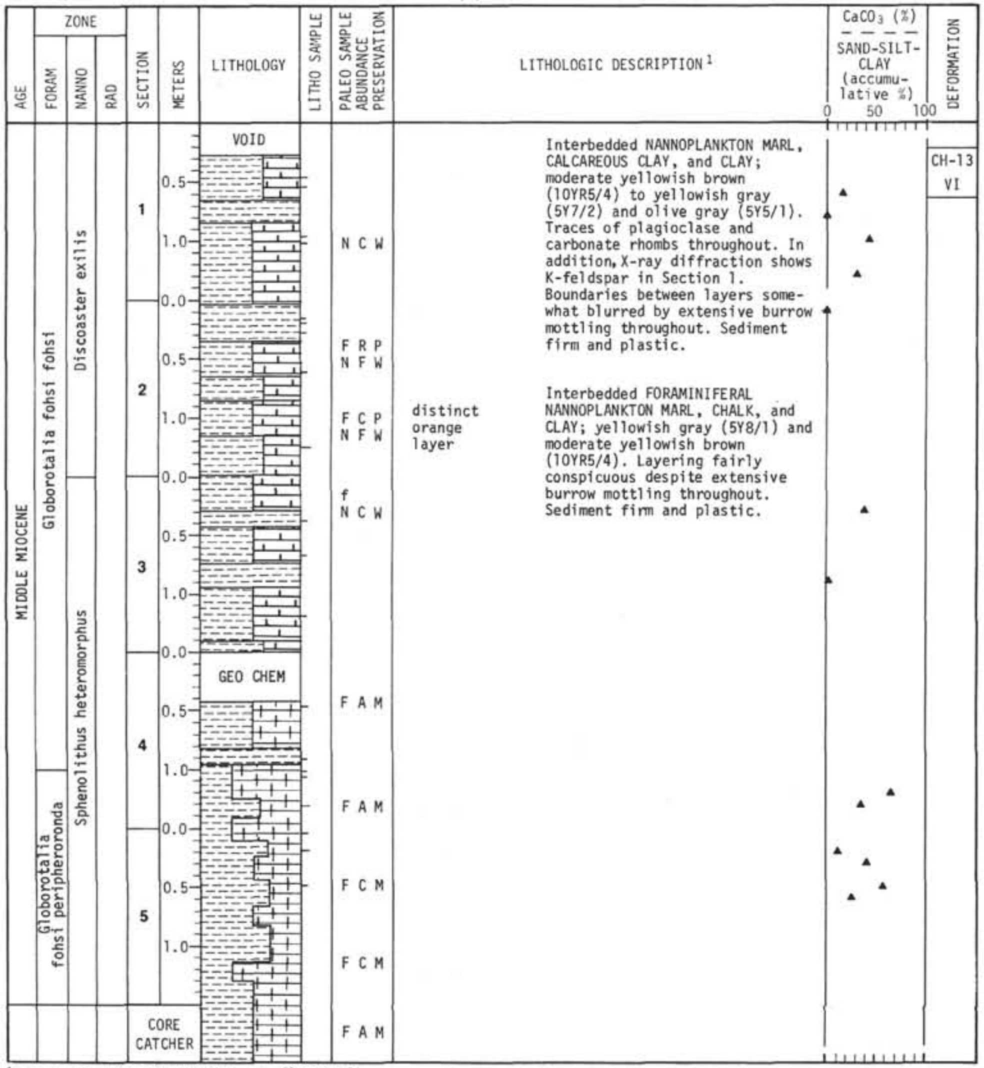
Lenses of plagioclase, glauconite, and apatite are indicated by asterisks.

[1]For explanation of symbols, see Chapter 1

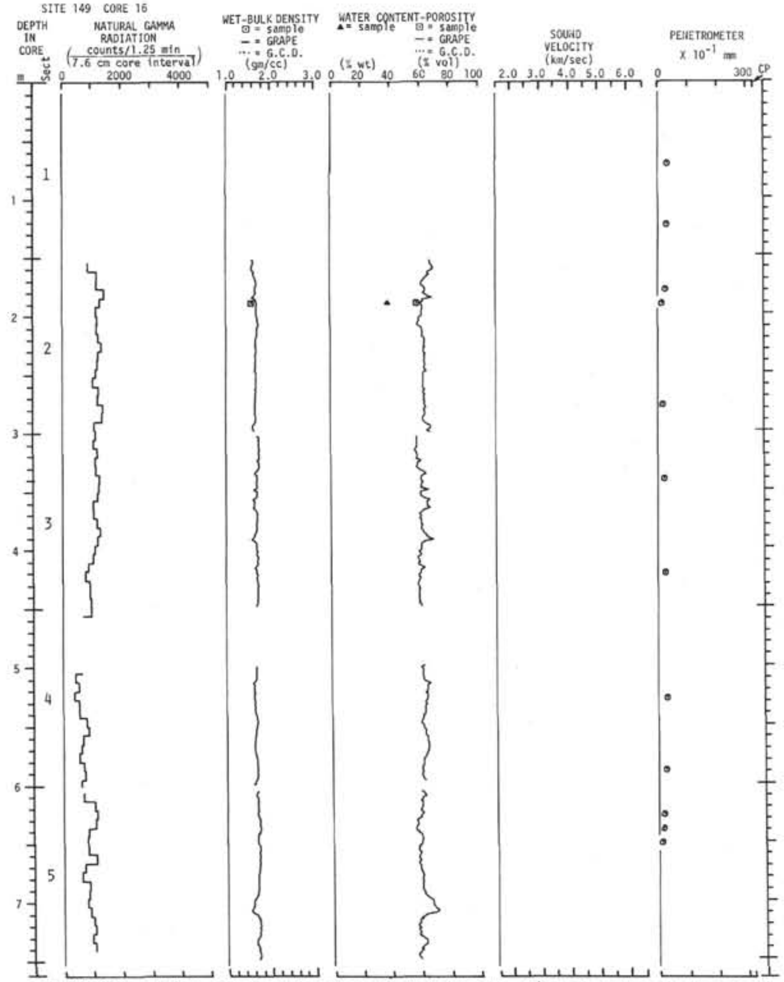


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1413. This background was subtracted from the data.

SITE 149 HOLE CORE 16 CORED INTERVAL (m) 130-139



[1]For explanation of symbols, see Chapter 1

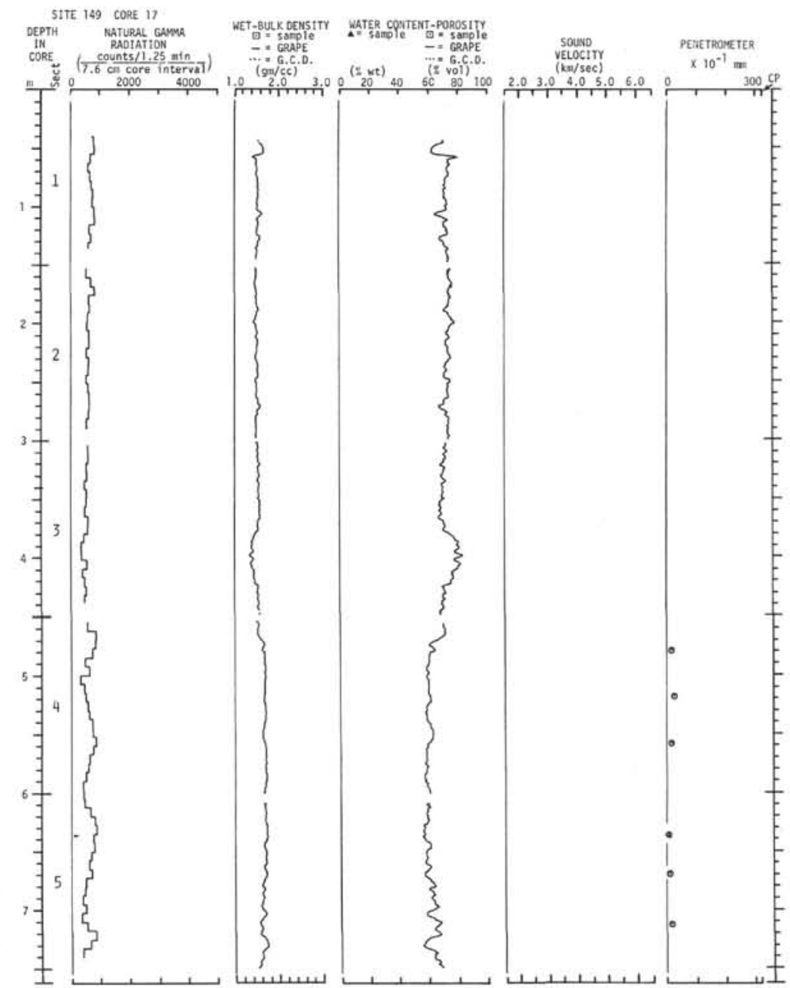


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1442. This background was subtracted from the data.

SITE 149 HOLE CORE 17 CORED INTERVAL (m) 139-149

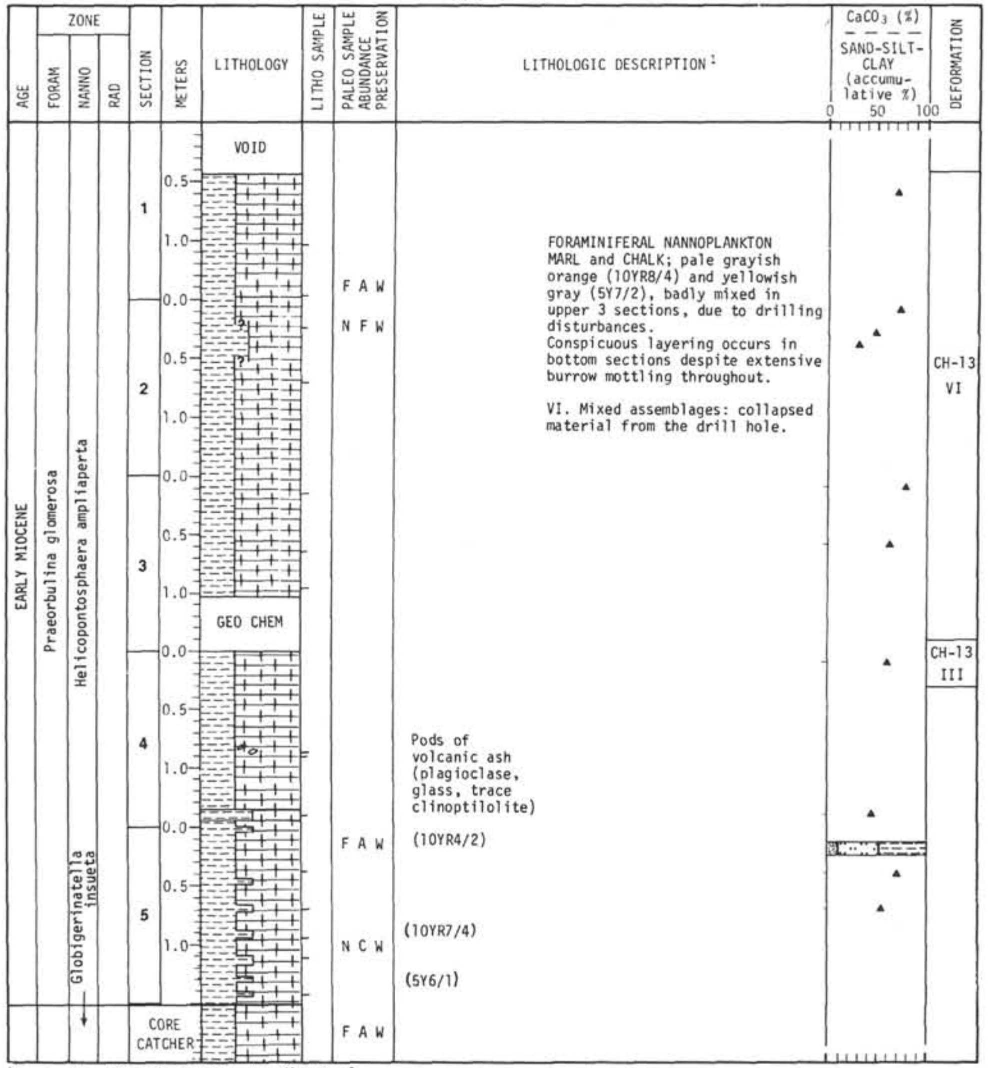
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE MIOCENE	Globorotalia fohsi peripheronda	Sphenolithus heteromorphus		1	0.5, 1.0	VOID		F F P	trace carbonate rhombs. Variegated NANNOPLANKTON MARL; light olive gray (5Y6/1), grayish orange (10YR7/4) to moderate yellowish brown (10YR5/4) and yellowish gray (5Y7/2). Totally disturbed. VI. Mixed assemblage: collapsed material.		CH-13 VI
				2	0.0, 0.5, 1.0						
				3	0.0, 0.5, 1.0			F C M			
				4	0.0, 0.5, 1.0			F A M; N C W; F C M	Interbedded FORAMINIFERAL NANNOPLANKTON MARL and CHALK; very pale orange (10YR8/2) to grayish orange (10YR7/4), light olive gray (5Y6/1) and pale yellowish brown (10YR6/4). Extensive burrow mottling throughout. Sediment firm and plastic.		
EARLY MIOCENE	Praeorbulina glomerosa			5	0.0, 0.5, 1.0			F A M; N C W	Common plagioclase, quartz		
				CORE CATCHER				F A M			

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1373. This background was subtracted from the data.

SITE 149 HOLE CORE 18 CORED INTERVAL (m) 149-158



FORAMINIFERAL NANNOPLANKTON MARL and CHALK; pale grayish orange (10YR8/4) and yellowish gray (5Y7/2), badly mixed in upper 3 sections, due to drilling disturbances.
Conspicuous layering occurs in bottom sections despite extensive burrow mottling throughout.

VI. Mixed assemblages: collapsed material from the drill hole.

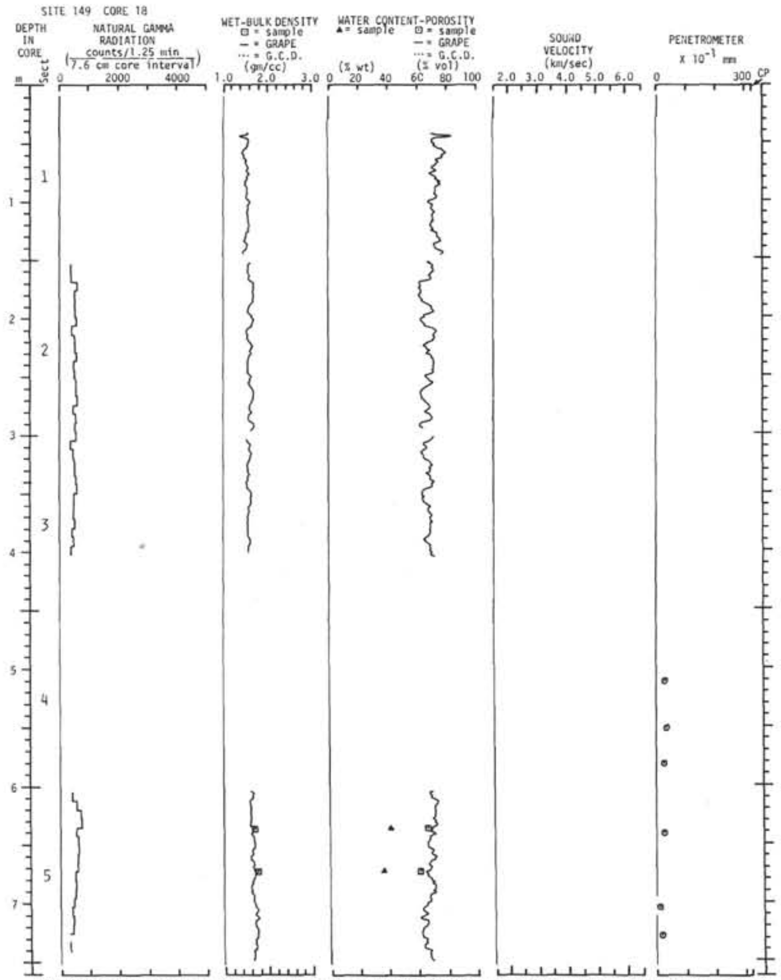
Pods of volcanic ash (plagioclase, glass, trace clinoptilolite)

(10YR4/2)

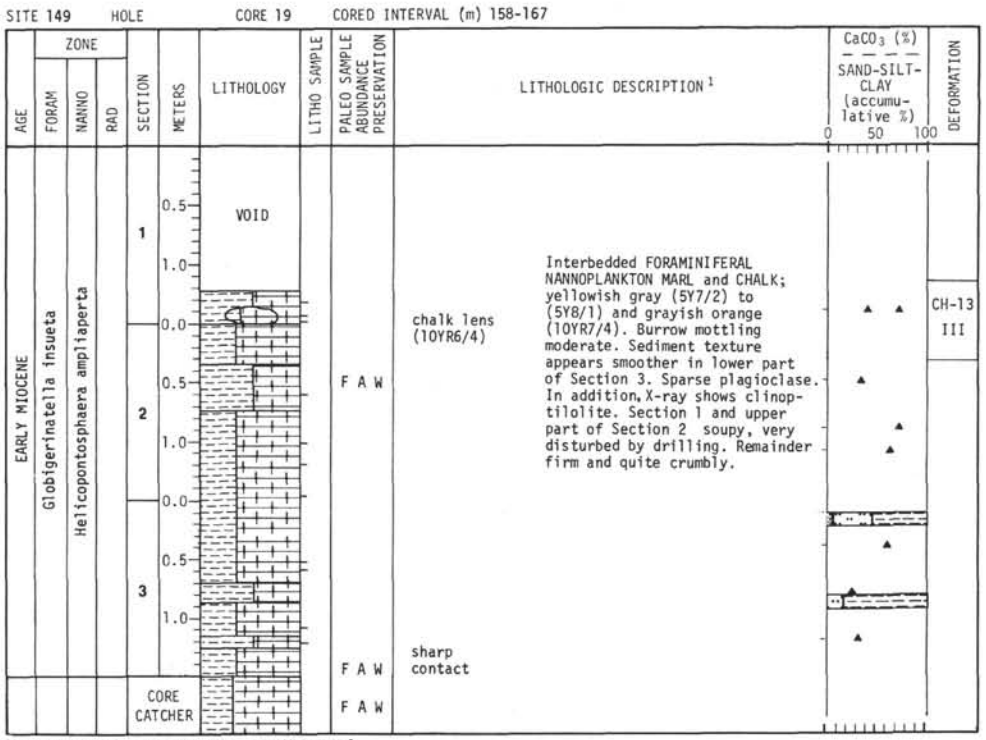
(10YR7/4)

(5Y6/1)

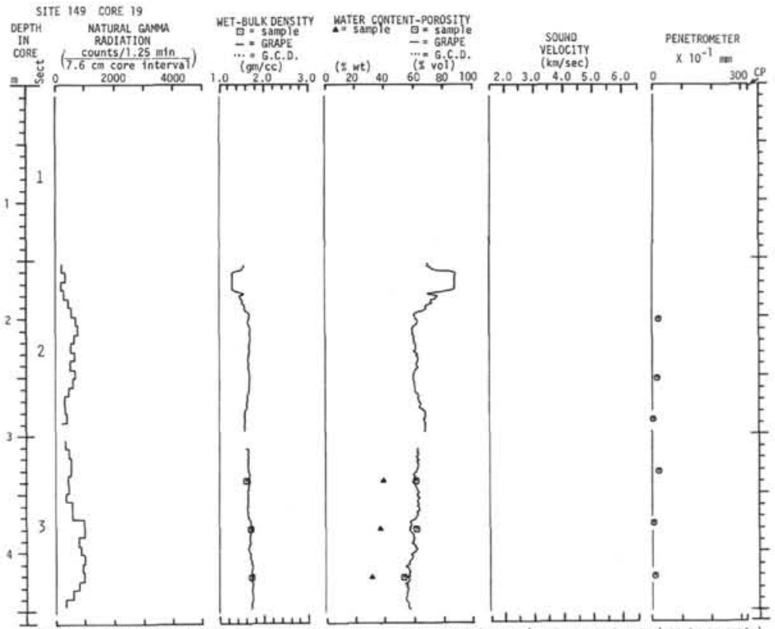
¹For explanation of symbols, see Chapter 1



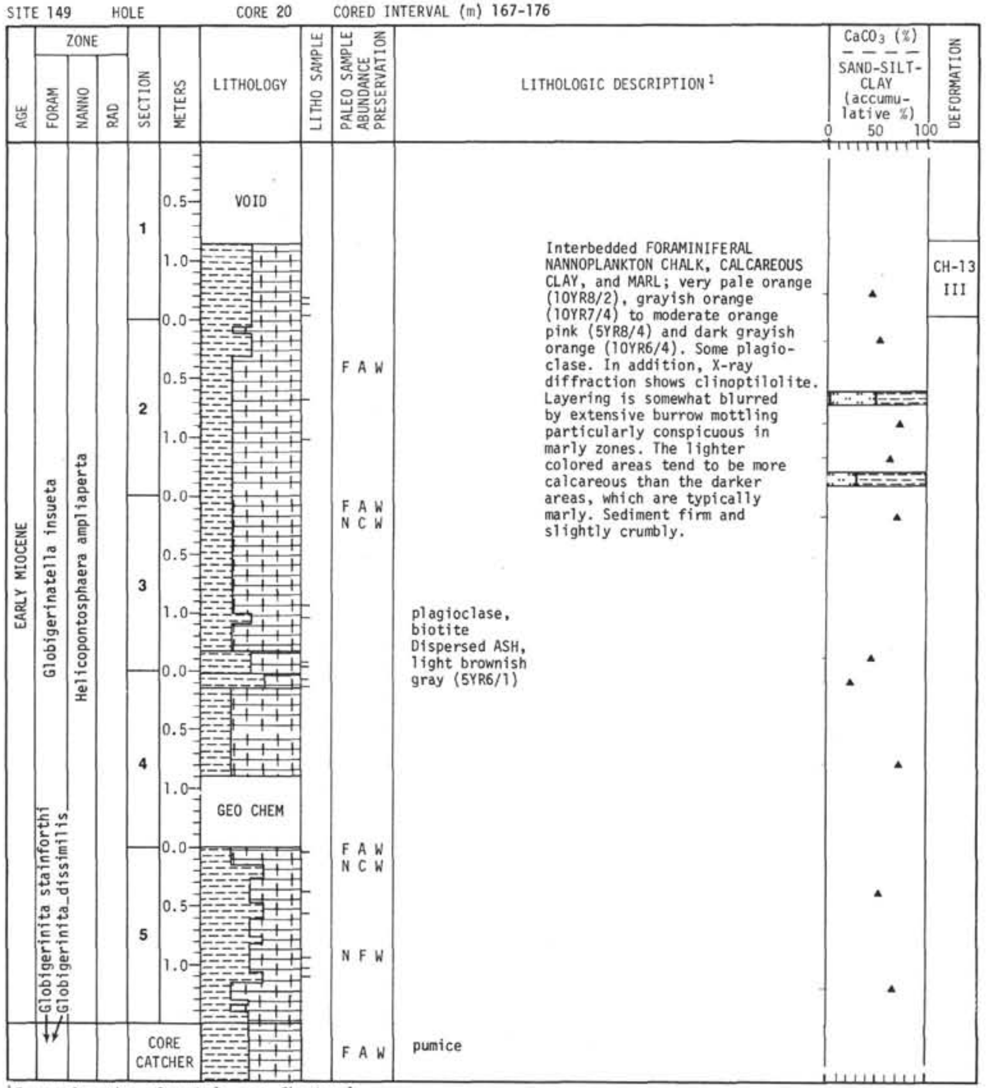
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1406. This background was subtracted from the data.



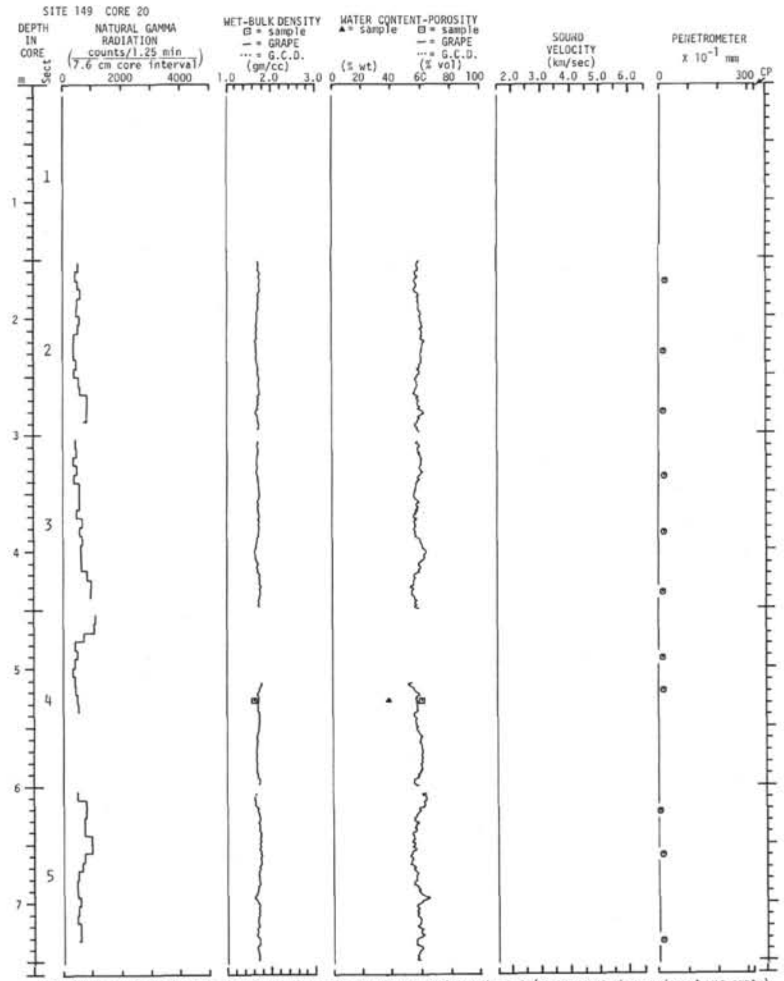
[1]For explanation of symbols, see Chapter 1



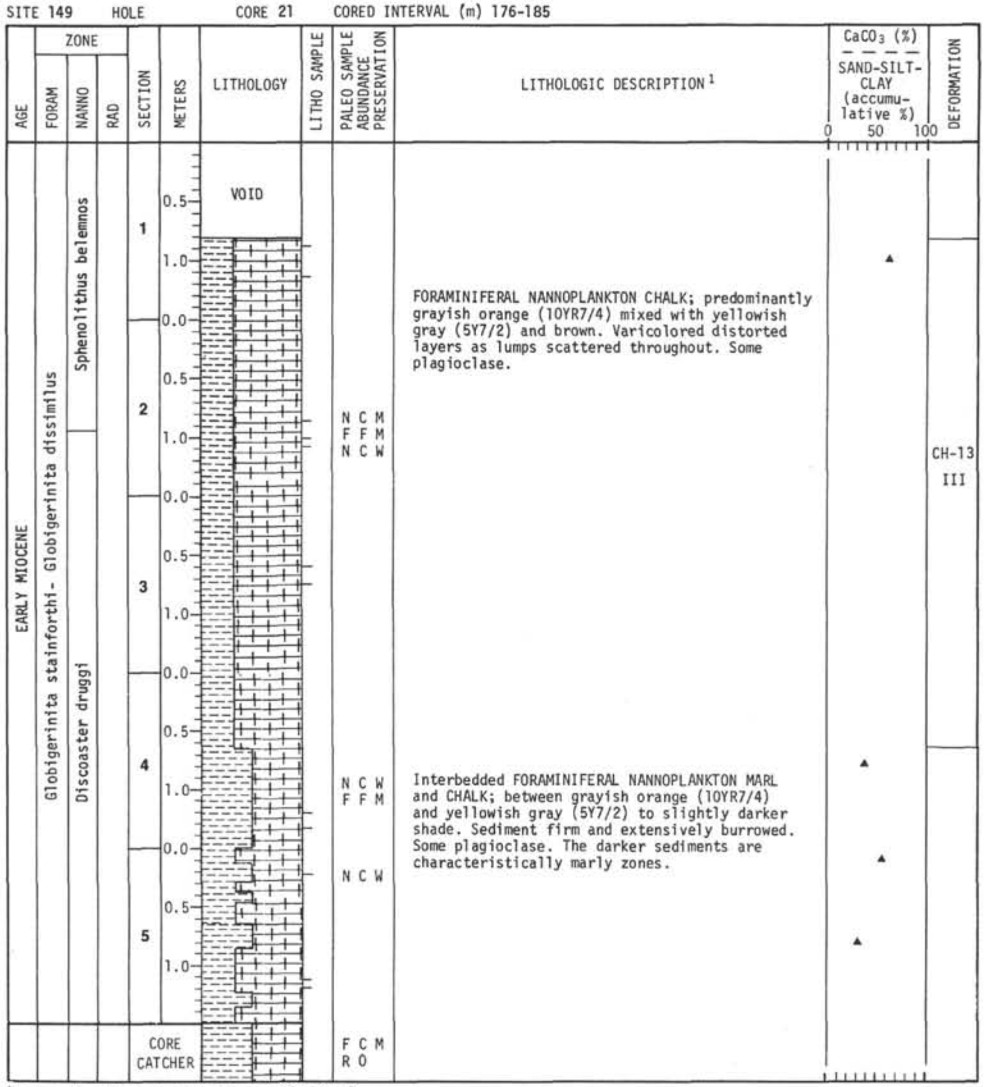
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1406. This background was subtracted from the data.



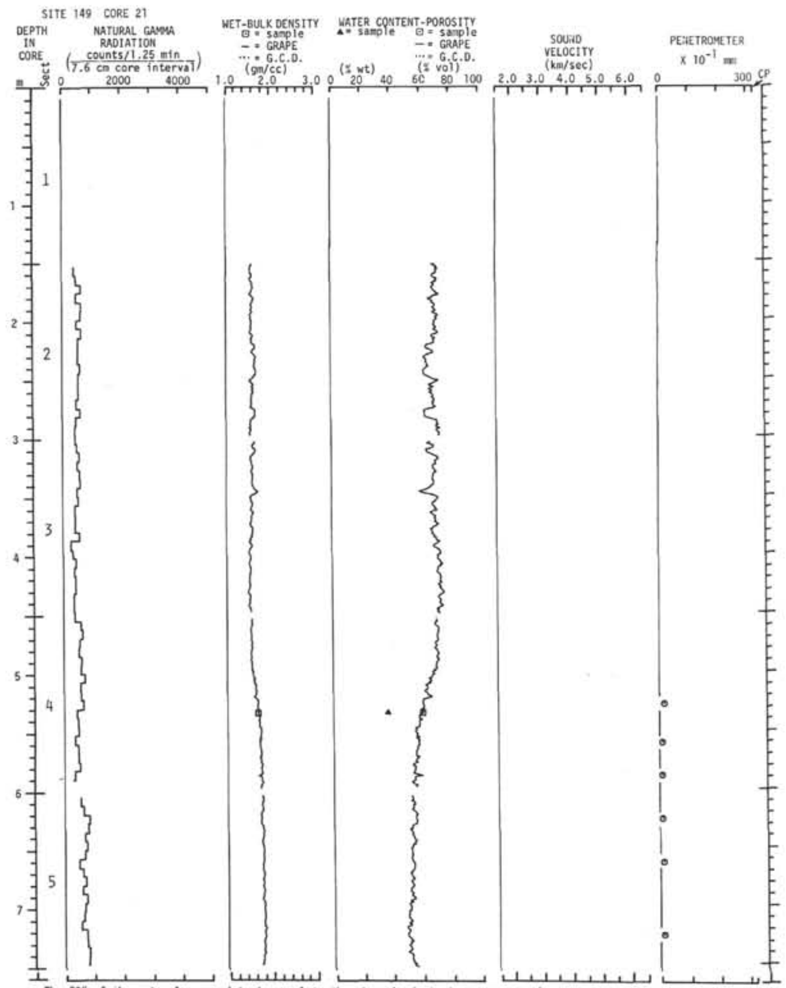
¹For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1380. This background was subtracted from the data.



[1]For explanation of symbols, see Chapter 1

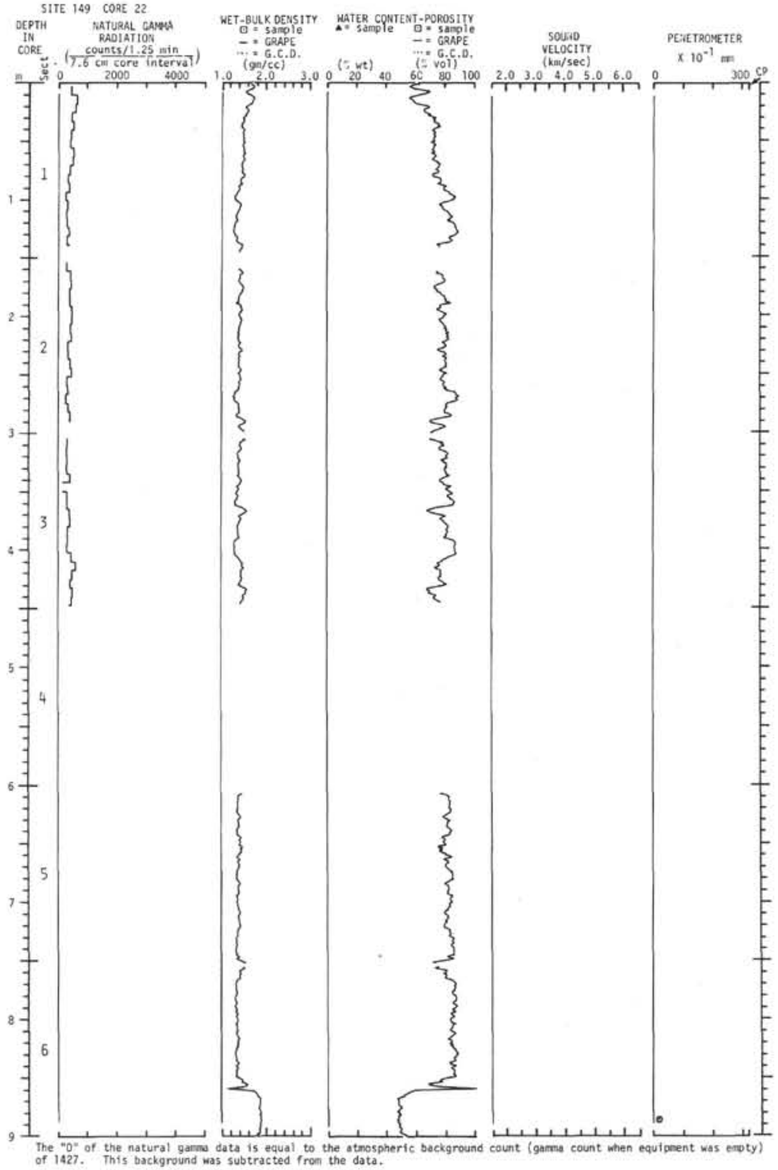


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1412. This background was subtracted from the data.

SITE 149 HOLE CORE 22 CORED INTERVAL (m) 185-195

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
EARLY MIOCENE	Globerinita stainforthi-Globerinita dissimilus	?		1	0.5 1.0	VOID; IN FREEZER BOX			FORAMINIFERAL NANNOPLANKTON MARL; grayish orange (10YR7/4), lower part of Section 6 is pale grayish orange (10YR8/4) to light olive gray (5Y7/1) in lowermost part. Light greenish gray blotches appear to be the result of bioturbation. Sparse plagioclase. Sediment highly disturbed. I. Watery: stored in a freezer box or unopened.		CH-13 II; CH-13 I
				2	0.0 0.5 1.0	VOID					CH-13 I; CH-13 III
				3	0.0 0.5 1.0	NOT OPENED					CH-13 I
				4	0.0 0.5 1.0	VOID					CH-13 III
				5	0.0 0.5 1.0	NOT OPENED					CH-13 I
	Globigerinoides primordius	Discoaster druggi		6	0.0 0.5 1.0	IN FREEZER BOX		F R P N C W	Disturbed top. Sparse radiolarians in layer at 96-103 cm of Section 6. In general, traces of radiolarians in Section 6.	▲	
				CORE CATCHER				R R P F A M			

[1]For explanation of symbols, see Chapter 1

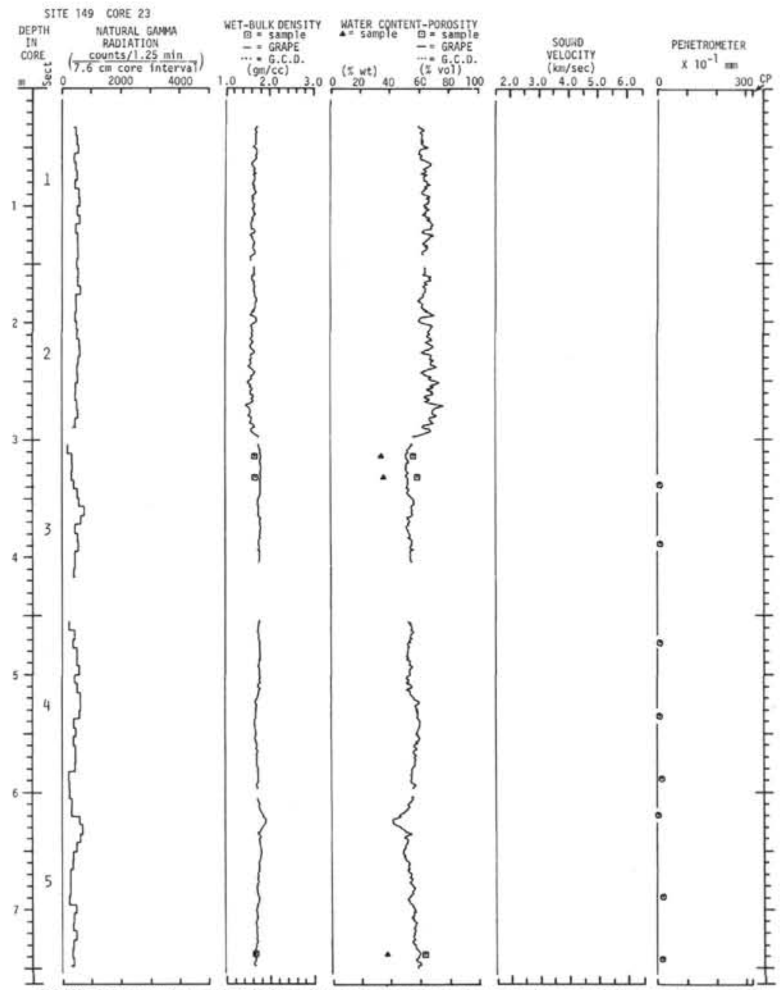


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1427. This background was subtracted from the data.

SITE 149 HOLE CORE 23 CORED INTERVAL (m) 175-204

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
EARLY MIOCENE	Globigerinoides primordius	Discoaster druggi	Lychnocanium bipes	1	0.5, 1.0	VOID			FORAMINIFERAL NANNOPLANKTON CHALK; predominantly grayish orange (10YR7/4) with mixed light greenish gray (5GY8/1) and moderate orange pink (6YR8/4). Color mixed due to extreme drilling disturbance. Traces of radiolarians and plagioclase. IV. Fragmentation highly disturbed, with firm lumps of plastic sediment.		CH-13 IV
				2	0.0, 0.5, 1.0						
				3	0.0, 0.5, 1.0	GEO CHEM		F A M, N C W, R F P, N C W	Interbedded FORAMINIFERAL NANNOPLANKTON CHALK and RADIOLARIA-RICH NANNOPLANKTON CHALK and MARL; light olive gray (5Y7/1) and light greenish gray (5GY8/1). Traces of plagioclase and sponge spicules. Faint burrow mottling throughout. Sediment is compact yet crumbly.		
		Triquetrorhabdulus carinatus		4	0.0, 0.5, 1.0			N C W, F A M			
				5	0.0, 0.5, 1.0			N F W			
				CORE CATCHER				F A M, R F M			

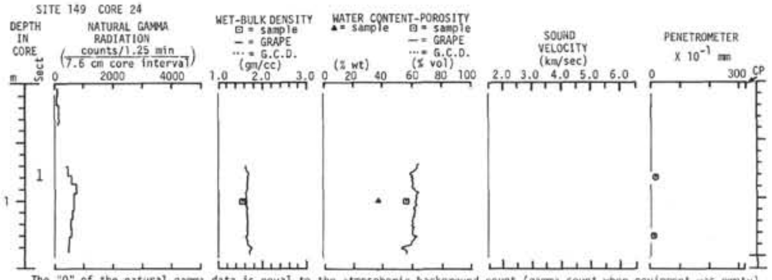
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1427. This background was subtracted from the data.

SITE 149 HOLE CORE 24 CORED INTERVAL (m) 204-213

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
EARLY MIOCENE	Globigerinoides primordius	Triquetrorhabdulus carinatus	Lychnocanium bipes	1	0.5, 1.0	VOID		R F M F R M R F M	RADIOLARIA-RICH FORAMINIFERAL NANNOPLANKTON MARL; grayish yellow green (5GY7/2), compact. Faint scattered burrow mottling. Sparse apatite.		
				CORE CATCHER				F A M R C M			

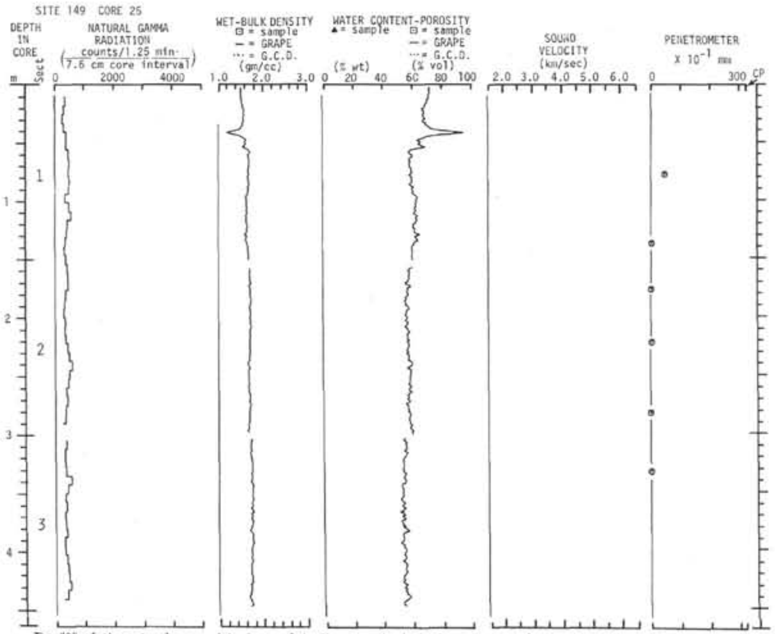


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1402. This background was subtracted from the data.

SITE 149 HOLE CORE 25 CORED INTERVAL (m) 213-223

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
EARLY MIOCENE	Globigerinoides primordius	Triquetrorhabdulus carinatus	Lychnocanoma elongata	1	0.5, 1.0	VOID		F F M R C M	RADIOLARIA-RICH FORAMINIFERAL NANNOPLANKTON CHALK; grayish yellow green (5GY7/2) to very pale grayish yellow green (5GY8/2). Trace plagioclase. Sediment very compact. Faint burrow mottling at scattered levels.		CH-13 III
				2	0.0, 0.5, 1.0			R C M f N C W R C M			
				3	0.0, 0.5, 1.0			R C M N C W			
				CORE CATCHER				F A M R C M			

[1] For explanation of symbols, see Chapter 1

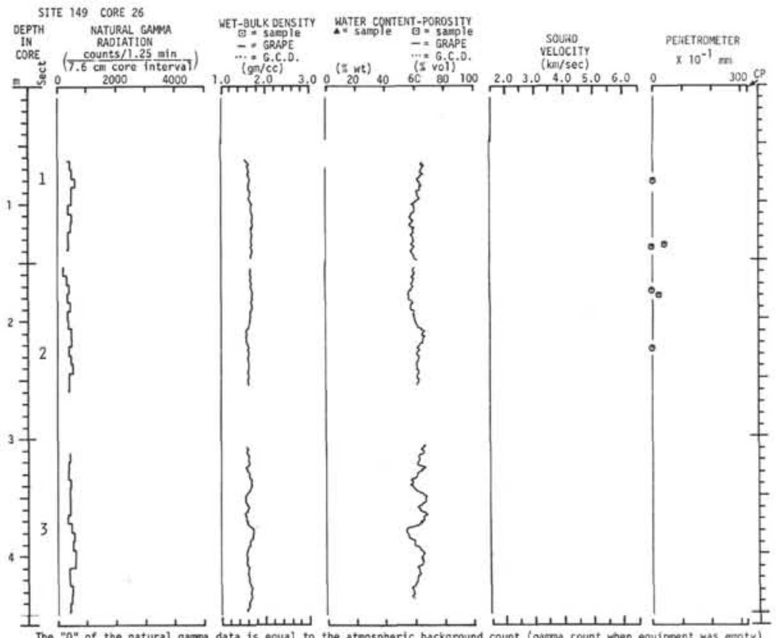


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1402. This background was subtracted from the data.

SITE 149 HOLE CORE 26 CORED INTERVAL (m) 223-232

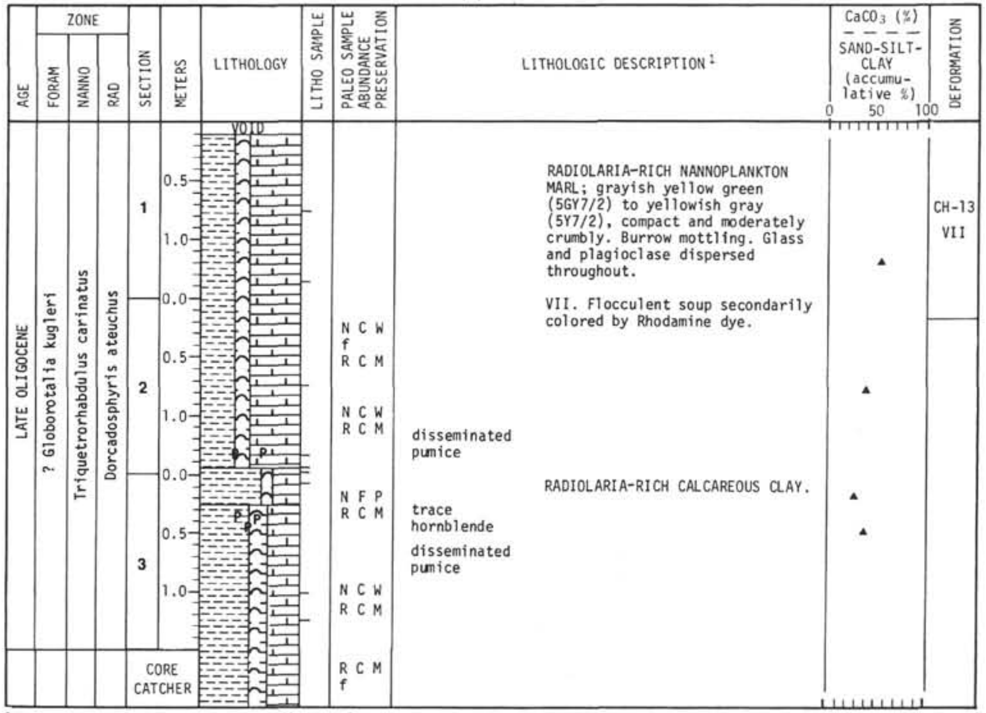
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) — SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE OLIGOCENE	*Globorotalia kugleri*	*Triquetrorhabdulus carinatus*	*Lychnocanoma elongata*	1	0.5, 1.0	VOID		R C M F R P	RADIOLARIA-RICH NANNOPLANKTON MARL and CHALK; grayish yellow green (5GY7/2) to moderate grayish yellow green (5GY6/2) and light olive gray (5Y7/1). Scattered, faint burrow mottling, light greenish gray (5GY8/1). Some plagioclase and light volcanic glass. Sediment firm and quite crumbly.		
				2	0.0, 0.5, 1.0	GEO CHEM		R C M R C M N F W			
				3	0.0, 0.5, 1.0			F R P R F M N C W R F M	Disseminated pumice		
				CORE CATCHER				R C M F R P			

[1]For explanation of symbols, see Chapter 1

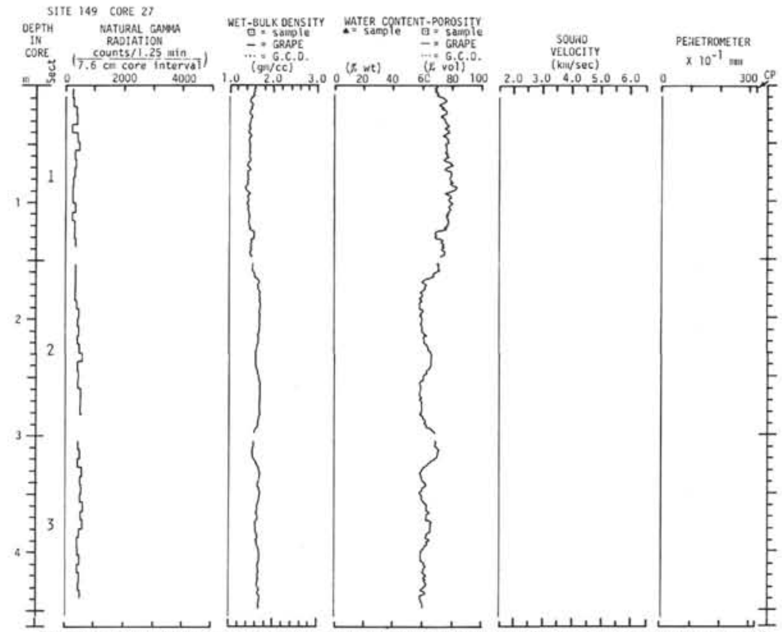


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1402. This background was subtracted from the data.

SITE 149 HOLE CORE 27 CORED INTERVAL (m) 232-241



¹For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1456. This background was subtracted from the data.

SITE 149 HOLE CORE 28 CORED INTERVAL (m) 241-251

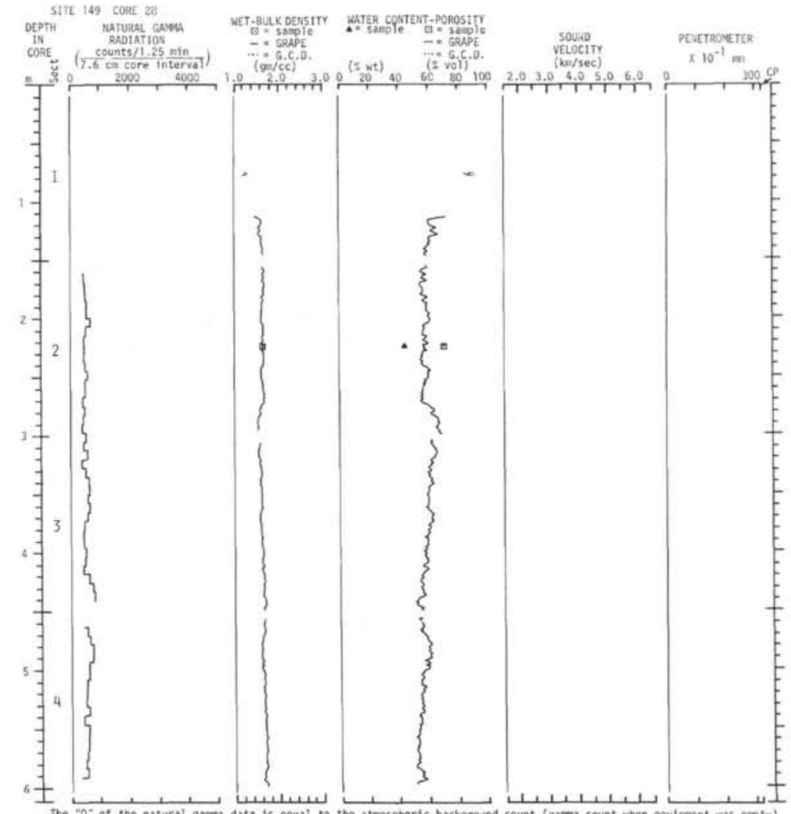
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) — SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE OLIGOCENE	Globorotalia kugleri	Triquetrorhabdulus carinatus	Dorcadospyris ateuchus	1	0.5, 1.0	VOID		N C P; R C M	RADIOLARIA-RICH NANNOPLANKTON MARL; between yellowish gray (5Y7/2) and dusky yellow (5Y6/4) to grayish orange (10YR7/4) toward bottom. Sediment very firm and crumbly. Burrow mottling throughout. Dispersed plagioclase and glass shards throughout; sparse apatite and quartz. Disseminated ASH lumps indicated by asterisks.		
				2	0.0, 0.5, 1.0		* ; *	N C W; F R P; R C M; N C W; R C M			
				3	0.0, 0.5, 1.0			N C W; R C M; N F P; f; R C M	ASH layer; medium brownish gray (5YR5/1). The lower contact is quite sharp, and the upper contact is gradational, apparently the result of burrowing.		
				4	0.0, 0.5, 1.0			N C P; R C M; N C W; R C M	Abundant ASH; grayish blue to medium brownish gray, highly bioturbated.		
				CORE CATCHER				F R P; R C M			

X-ray diffraction results:

Section 3, 128-130 cm:

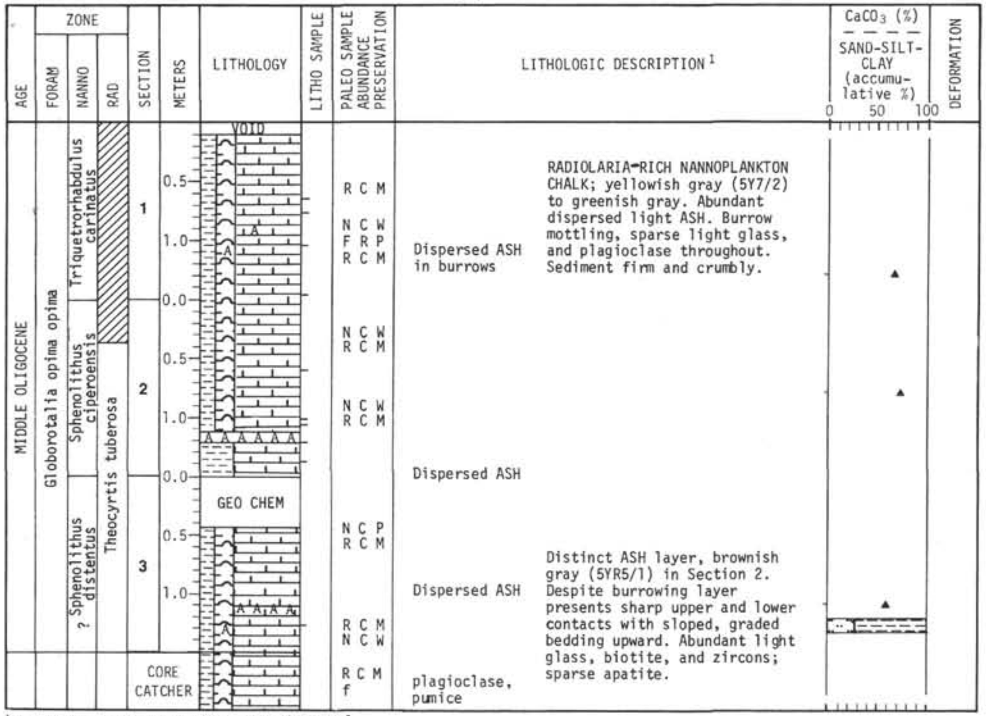
Amorohous scattering	77%
Calcite	82%
Quartz	6%
Plagioclase	8%
Kaolinite	1%
Montmorillonite	3%

[1]For explanation of symbols, see Chapter 1

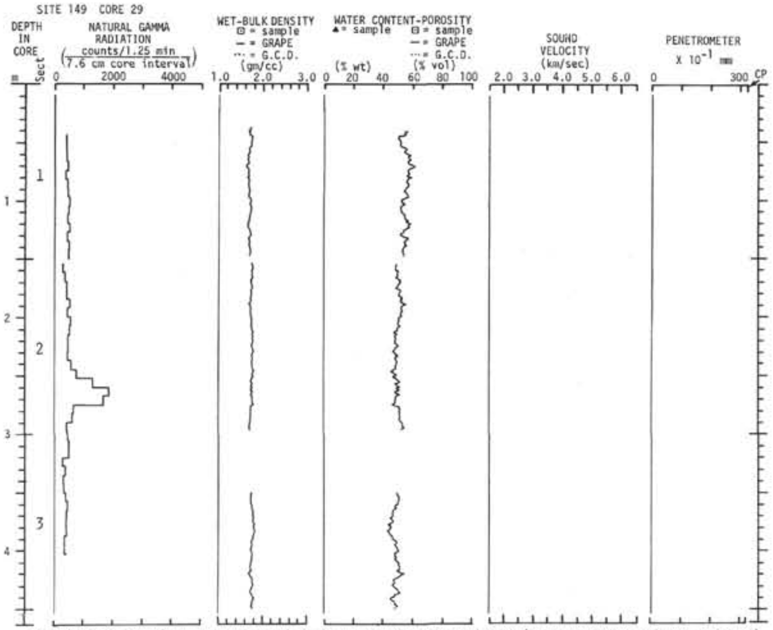


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1456. This background was subtracted from the data.

SITE 149 HOLE CORE 29 CORED INTERVAL (m) 251-260



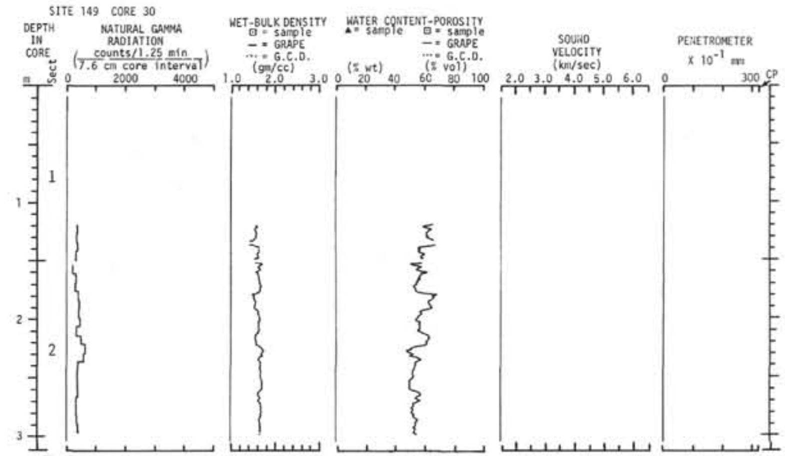
[1] For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1404. This background was subtracted from the data.

SITE 149 HOLE CORE 30 CORED INTERVAL (m) 260-270

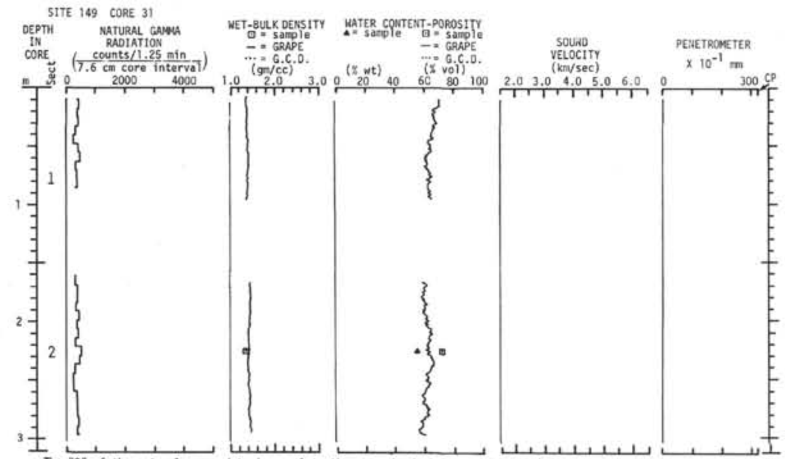
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE OLIGOCENE	Globorotalia opima opima	Sphenolithus predistentus	Theocyrtis tuberosa	1	0.5, 1.0	VOID		R C G N C M F R P R C M	RADIOLARIA-RICH NANNOPLANKTON CHALK; yellowish gray (5Y7/2), semi-indurated, and crumbly. Scattered faint burrow mottling. Plagioclase and glass dispersed throughout.		
				2	0.0, 0.5, 1.0			R C M N C M R C M	Dispersed ASH in burrows		
				CORE CATCHER				F R P R C M			



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1404. This background was subtracted from the data.

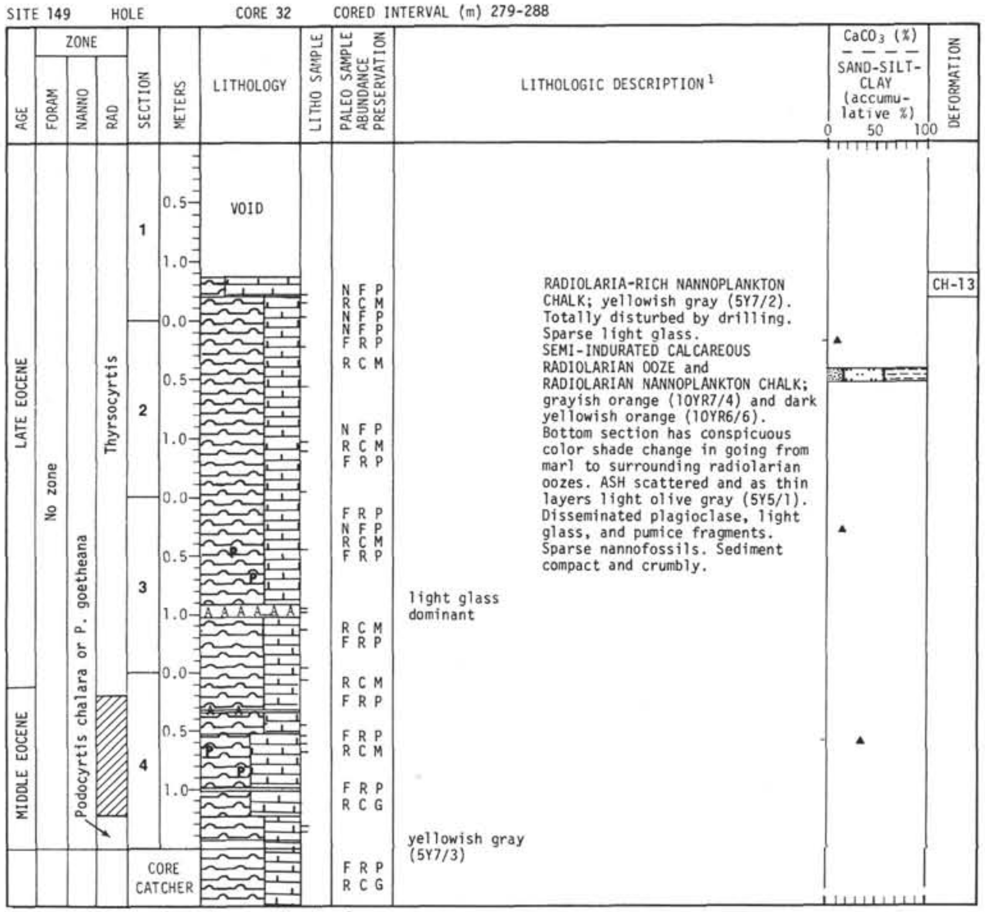
SITE 149 HOLE CORE 31 CORED INTERVAL (m) 270-279

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
LATE EOCENE	No zone			1	0.5, 1.0	GEO CHEM		R C M N R P F R P R C M F R P	Disseminated pumice pebbles up to 1.5 cm. SEMI-INDURATED CALCAREOUS-RICH RADIOLARIAN OOZE; grayish orange (10YR7/4) to dark yellowish orange (10YR6/6). Sediment quite crumbly. Sparse plagioclase and light glass throughout.		
				2	0.0, 0.5, 1.0			F R P R C M N R P N F P R C M F R P	red hornblende, orthopyroxene		
				CORE CATCHER				R C M F R P	Washed residue includes plagioclase, orthopyroxene, clinopyroxene, microtektites, and pumice.		

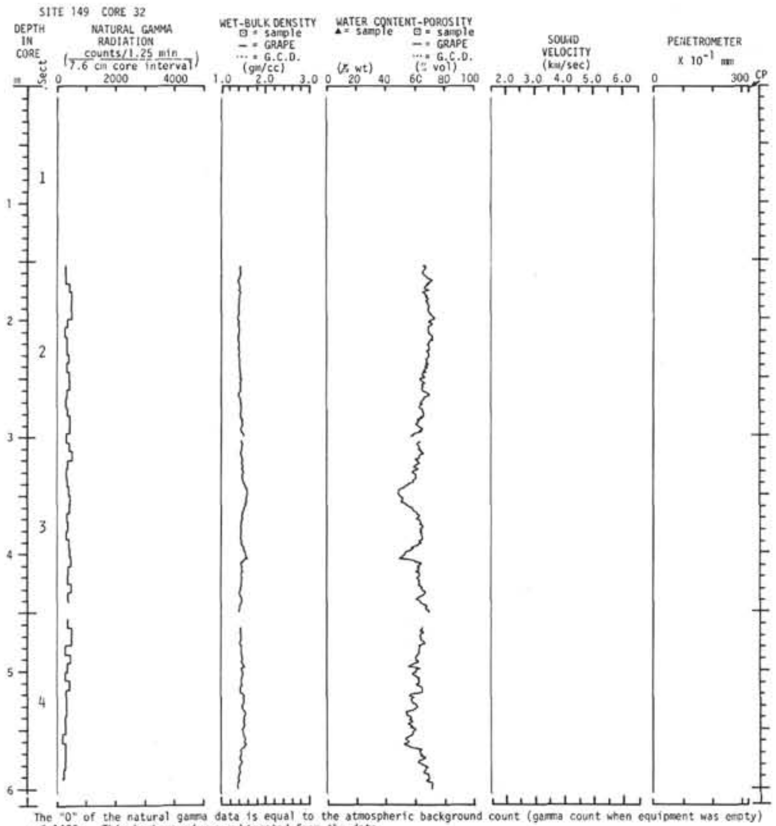


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1404. This background was subtracted from the data.

[1]For explanation of symbols, see Chapter 1



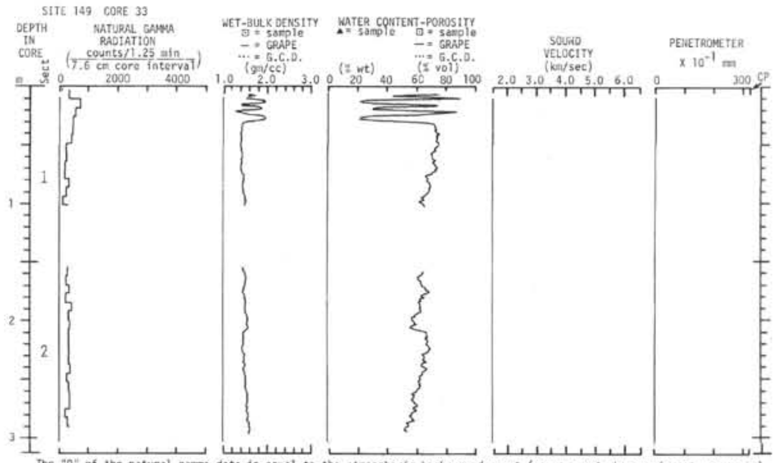
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1400. This background was subtracted from the data.

SITE 149 HOLE CORE 33 CORED INTERVAL (m) 288-298

AGE	FORAM	NANNO	RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	Discoaster saipanensis	Podocyrtis mitra	1	0.5, 1.0	GEO CHEM		R A G; F F P; R A G; N F M	abundant light glass. CHERT; predominantly light olive gray (5Y5/2) to moderate yellowish brown (10YR5/4) with light brown (5YR5/0) blotches and grayish green streaks (10G4/2) associated with micro-fractures.		CH-13 IV
				2	0.0, 0.5, 1.0			N F M; F F P; N F M; R A G	RADIOLARIA-RICH NANNOPLANKTON MARL; grayish orange (10YR7/4) to dark yellowish orange (10YR6/6), compacted, and crumbly. Disseminated pumice fragments between chert and blurred ASH layer at 52-56 cm of Section 2. Minor burrow mottling and plagioclase throughout.		
				CORE CATCHER				F F P; R A G			

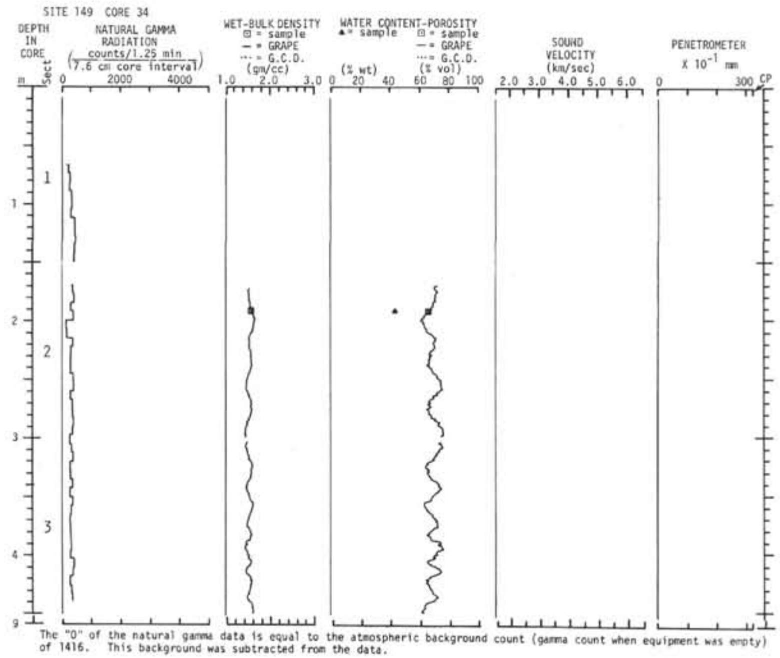


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1400. This background was subtracted from the data.

SITE 149 HOLE CORE 34 CORED INTERVAL (m) 298-307

AGE	FORAM	NANNO	RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	Discoaster saipanensis	Podocyrtis mitra	1	0.5, 1.0	VOID		N F M; F F P			
				2	0.0, 0.5, 1.0			R A G; N F M; F F P; N F P; F F P	common clino-pyroxene. RADIOLARIA NANNOPLANKTON CHALK; grayish orange (10YR8/4) to (10YR7/4). Pumice fragments and disseminated black blotches particularly conspicuous from the bottom of Section 1 to top of Section 3. Plagioclase and light glass are dispersed throughout.		
				3	0.0, 0.5, 1.0	VOID		N F M; R A G; N F M; F F P; R A G; N F M; F F P			
				CORE CATCHER				F F P; R A G			-

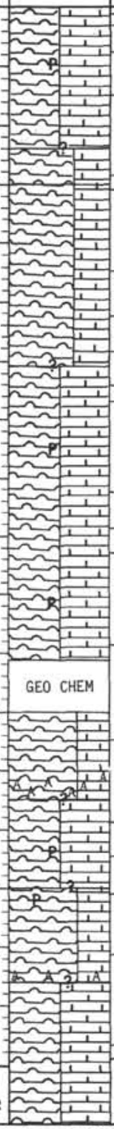
[1] For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1416. This background was subtracted from the data.

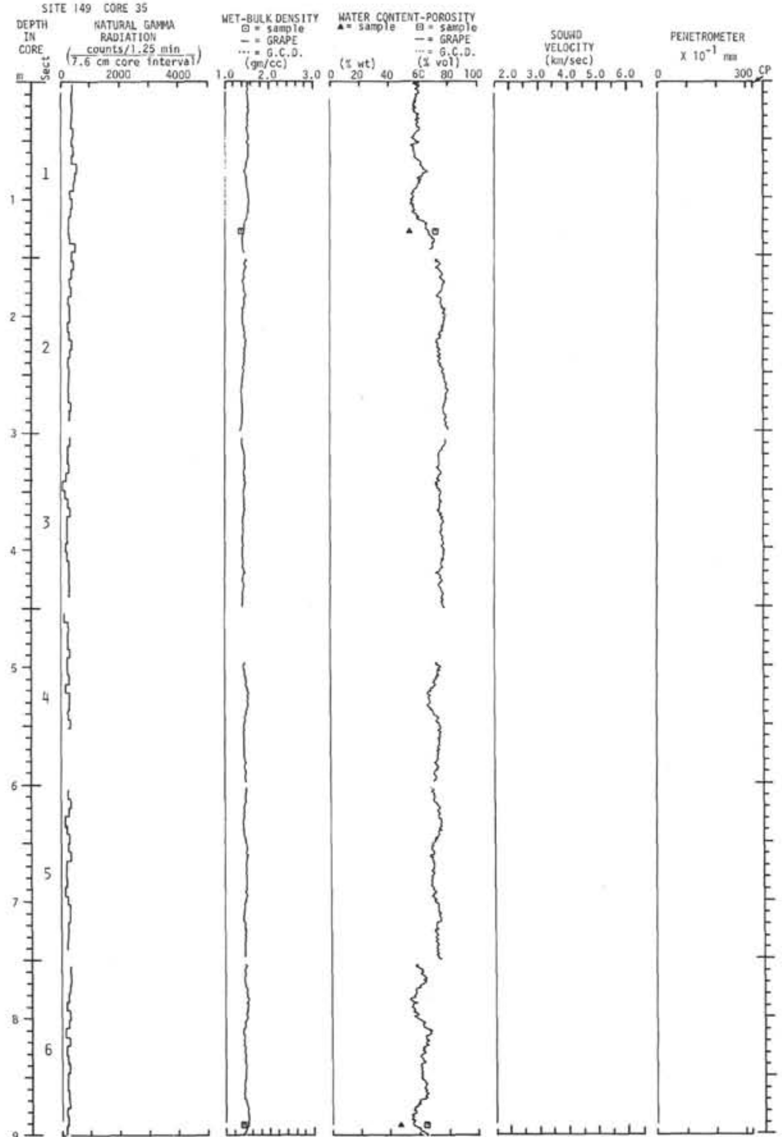
SITE 149 HOLE CORE 35 CORED INTERVAL (m) 307-316

AGE	FORAM	NANNO	RAD	SECTION	METERS	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]
MIDDLE EOCENE	No zone	Discoaster tani nodifer	Podocyrtis mitra	1	0.5, 1.0	N F M R A G F F P F F P	Interbedded RADIOLARIA NANNO-PLANKTON CHALK and SEMI-INDURATED CALCAREOUS-RICH RADIOLARIAN OOZE; yellowish gray (5Y7/2) to (5Y8/2). Burrow mottling and disseminated pumice fragments. Some plagio-clase and sparse light volcanic glass. Radiolaria coated with calcite appear below Section 2. Sediment quite crumbly.
				2	0.0, 0.5, 1.0	N F M R A G F F P R A G N F M N F P R A G	
				3	0.0, 0.5, 1.0	F F P N F P N F M F F P R A G	
				4	0.0, 0.5, 1.0	N F M F F P	
						GEO CHEM	
				5	0.0, 0.5, 1.0	N F M F F P N F M R A G	Dispersed ASH
				6	0.0, 0.5, 1.0	N F M F F P N R P R A G	Dispersed ASH
				CORE CATCHER		R A G	



CaCO3 (%) / SAND-SILT-CLAY (accumulative %): 0 50 100

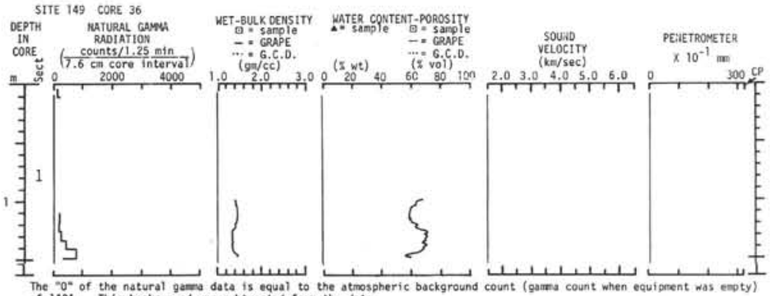
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1425. This background was subtracted from the data.

SITE 149 HOLE CORE 36 CORED INTERVAL (m) 316-325

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	? Discoaster tani nodifer	Podocyrtis mitra	1	0.5, 1.0	VOID		R A G F F P N R P R A G	sparse light glass RADIOLARIA NANNOPLANKTON CHALK and SEMI-INDURATED RADIOLARIAN OOZE; yellowish gray (5Y8/2) and light olive gray (5Y6/2) respectively. Abundant volcanic ASH; light brownish gray (5YR6/1) below 136 cm. Some plagioclase and sparse light glass throughout. Radiolaria coated with calcite.	▲	
				CORE CATCHER				R A G			

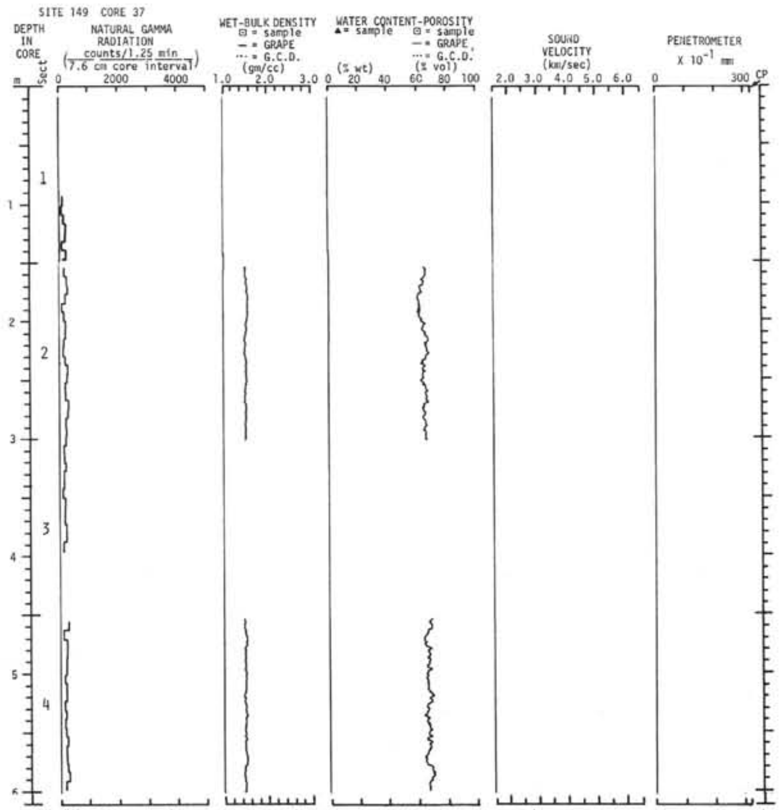


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1434. This background was subtracted from the data.

SITE 149 HOLE CORE 37 CORED INTERVAL (m) 325-334

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	Chiphragmalithus alatus	Podocyrtis ampla	1	0.5, 1.0	VOID		R A G N F M F F P	RADIOLARIA NANNOPLANKTON CHALK; very pale orange (10YR8/2), very compact and crumbly. Trace plagioclase. Radiolaria coated with calcite.	▲	
				2	0.0, 0.5, 1.0			F F P N F M R A G F F P N F M	pumice fragment	▲	
				3	0.0, 0.5, 1.0	GEO CHEM		N F M F F P R A G N F M		▲	
				4	0.0, 0.5, 1.0			N R P F F P R A G F F P	Dispersed ASH	▲ ▲	
				CORE CATCHER				F F P R A G			

[1]For explanation of symbols, see Chapter 1

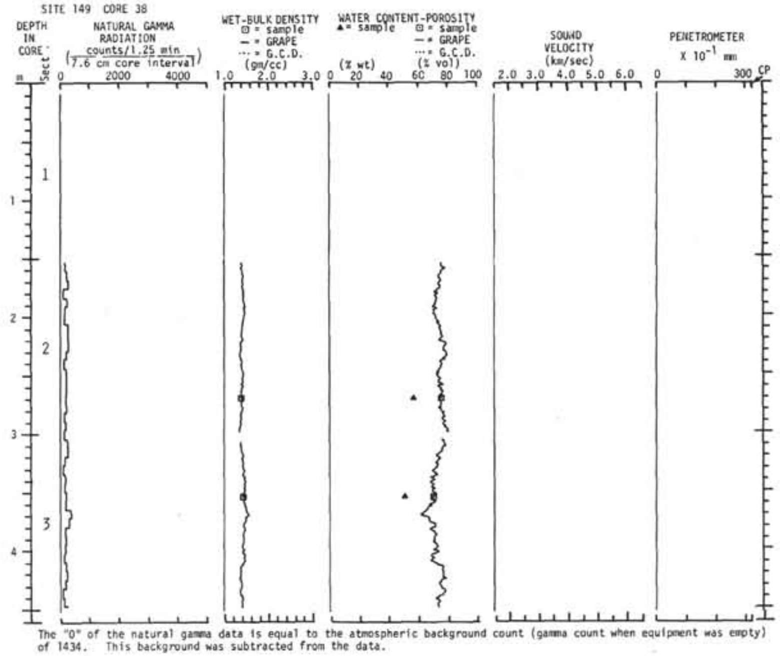


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1434. This background was subtracted from the data.

SITE 149 HOLE CORE 38 CORED INTERVAL (m) 334-344

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	*Chiphragmalithus alatus*	*Podocyrtis ampla*	1	0.5, 1.0	VOID			Interbedded RADIOLARIA NANNO-PLANKTON CHALK and CALCAREOUS-RICH RADIOLARIAN OOZE; yellowish gray (5Y7/2) to light olive gray (5Y6/2). Sediment firm yet crumbly. Burrow mottling throughout, but particularly conspicuous in darker radiolarian ooze zones. Scattered pumice fragments. Trace plagioclase, light volcanic glass. Radiolarians coated with calcite. ASH layer light brownish gray (5YR5/1). Contacts are disturbed by burrowing.		CH-13 V
				2	0.0, 0.5, 1.0			R A G; N C M; F F P; N F P; F F P	trace fish debris		
				3	0.0, 0.5, 1.0			N F P; F F P; R A G; N F P; F F P; R A G	fish debris; pumice		
				CORE CATCHER				R A G			

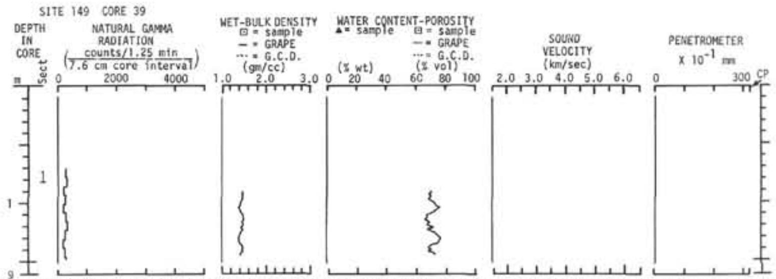
[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1434. This background was subtracted from the data.

SITE 149 HOLE CORE 39 CORED INTERVAL (m) 344-353

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	Chiphragmalithus alatus	Thyrsocyrtis triacantha	1	0.5 1.0	VOID		R A G N F M F F P	pumice fragments RADIOLARIA NANNOPLANKTON CHALK; yellowish gray (5Y8/1), compact, and crumbly.	▲	
				CORE CATCHER				F F P R A G			

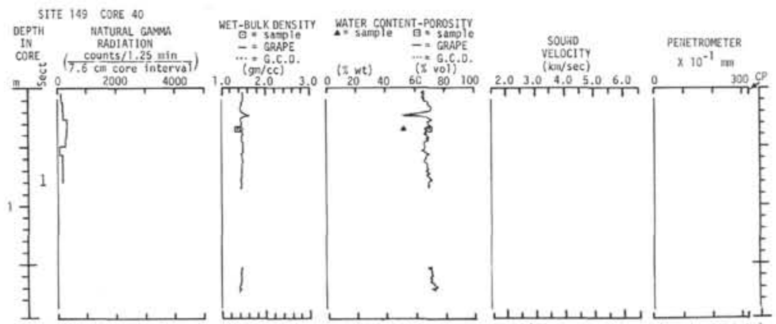


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1455. This background was subtracted from the data.

SITE 149 HOLE CORE 40 CORED INTERVAL (m) 353-362

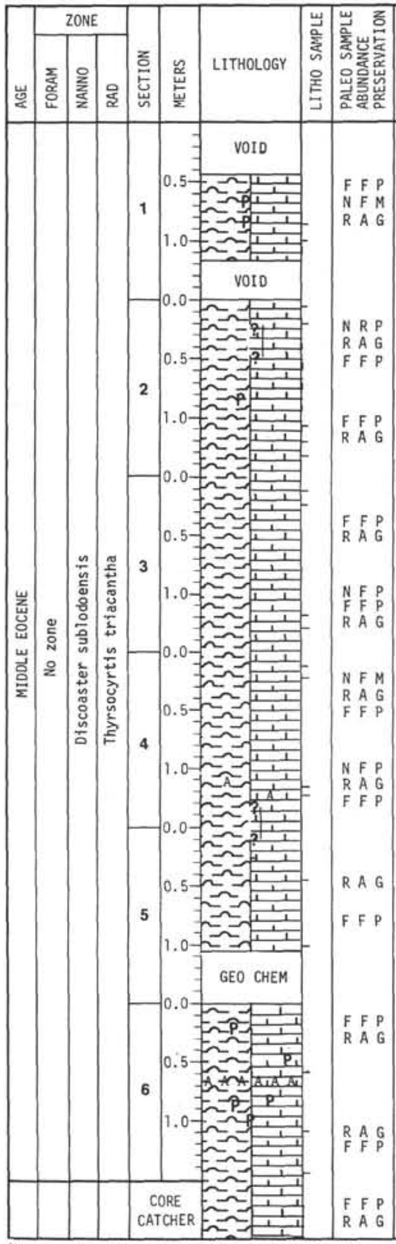
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	? Discoaster Sublodoensis	Thyrsocyrtis triacantha	1	0.5 1.0 0.0	GEOCHEM VOID		R A G N F P F F P R A G N F M F F P	trace fish debris RADIOLARIA NANNOPLANKTON CHALK; yellowish gray (5Y7/2); semi-lithified and more friable zones interbedded in upper 20 cm of Section 1.	▲ ▲	
				CORE CATCHER				F F P R A G			

[1]For explanation of symbols, see Chapter 1



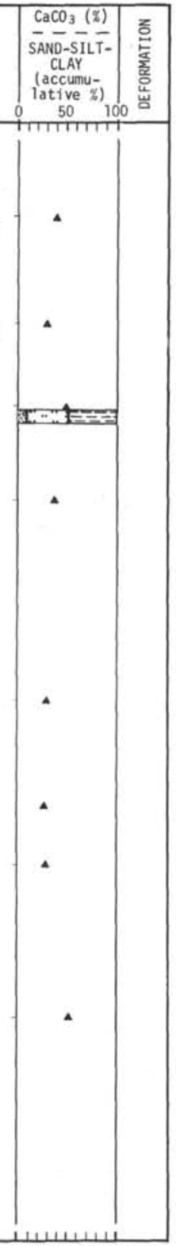
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1455. This background was subtracted from the data.

SITE 149 HOLE CORE 41 CORED INTERVAL (m) 362-371

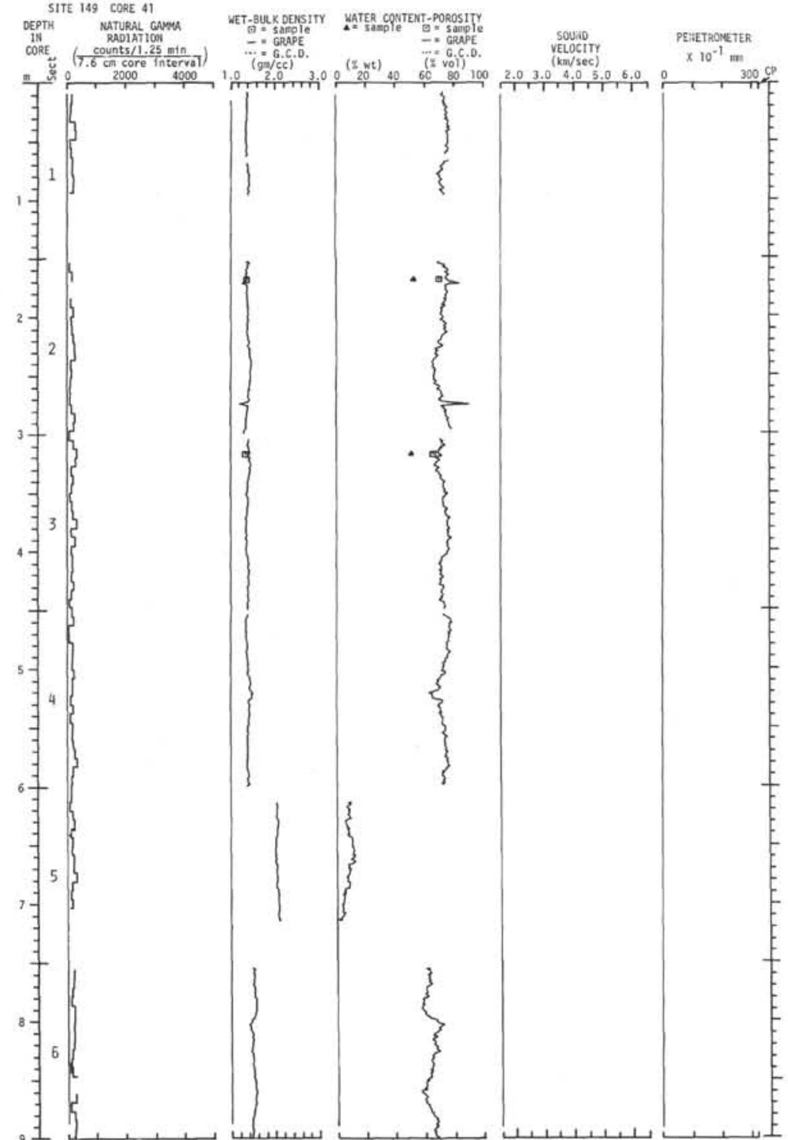


LITHOLOGIC DESCRIPTION[1]

Interbedded SEMI-INDURATED CALCAREOUS-RICH RADIOLARIAN OOZE and RADIOLARIA NANNOPLANKTON CHALK; pale yellowish gray (5Y8/2) to very pale grayish orange (10YR8/4) and grayish orange (10YR7/4). Sparse plagioclase, light volcanic glass, apatite, diatoms, and fish debris. In addition, X-ray diffraction shows palygorskite. Radiolarians coated with calcite. Sediment quite crumbly with some semi-lithified and more friable zones. Pumice scattered at several levels above volcanic ash of Section 6. Faint burrow mottling.



[1]For explanation of symbols, see Chapter 1

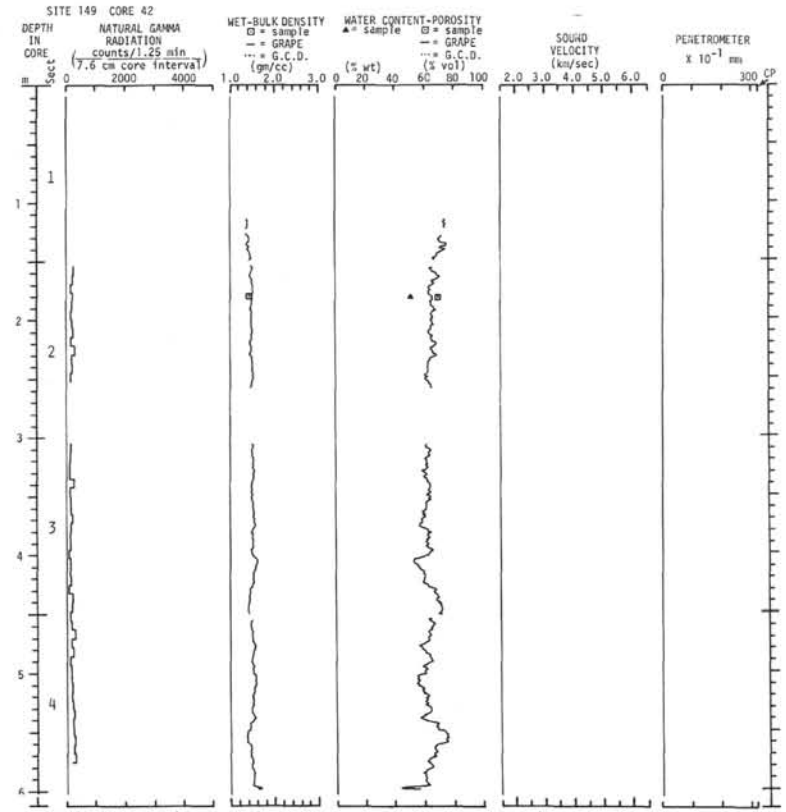


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1455. This background was subtracted from the data.

SITE 149 HOLE CORE 42 CORED INTERVAL (m) 371-381

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	$CaCO_3$ (%) - - - - SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
MIDDLE EOCENE	No zone	? Discoaster Lodoensis	Thyrsocyrtis triacantha	1	0.5, 1.0	VOID			DRILLING SAND of broken fragments caused by drilling.		CH-13 V
				2	0.0, 0.5, 1.0	GEOCHEM		R A G, F F P, F F P, R A G	Interbedded INDURATED RADIOLARIA NANNOPLANKTON CHALK; yellowish gray (5Y8/1) to grayish orange (10YR7/2), crumbly. Some plagioclase, and sparse light volcanic glass and diatoms. In addition, X-ray shows palygorskite. Few pumice fragments in Section 3.		
				3	0.0, 0.5, 1.0	P		R A G, F F P, F F P	sparse fish debris		
				4	0.0, 0.5, 1.0	P, A		F F P, R A G	ASH layer disturbed by burrowing. sharp basal contact. CALCAREOUS-RICH RADIOLARIAN OOZE; carbonate increases downward. CHERT pebble;		
				CORE CATCHER				R A G, F F P	between light brownish gray (5YR6/1) and light olive gray (5Y6/1).		

[1]For explanation of symbols, see Chapter 1

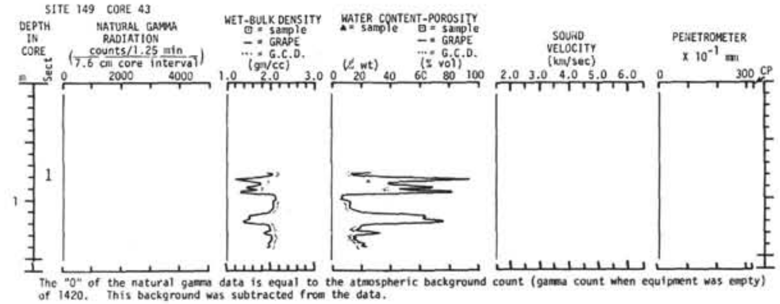


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1420. This background was subtracted from the data.

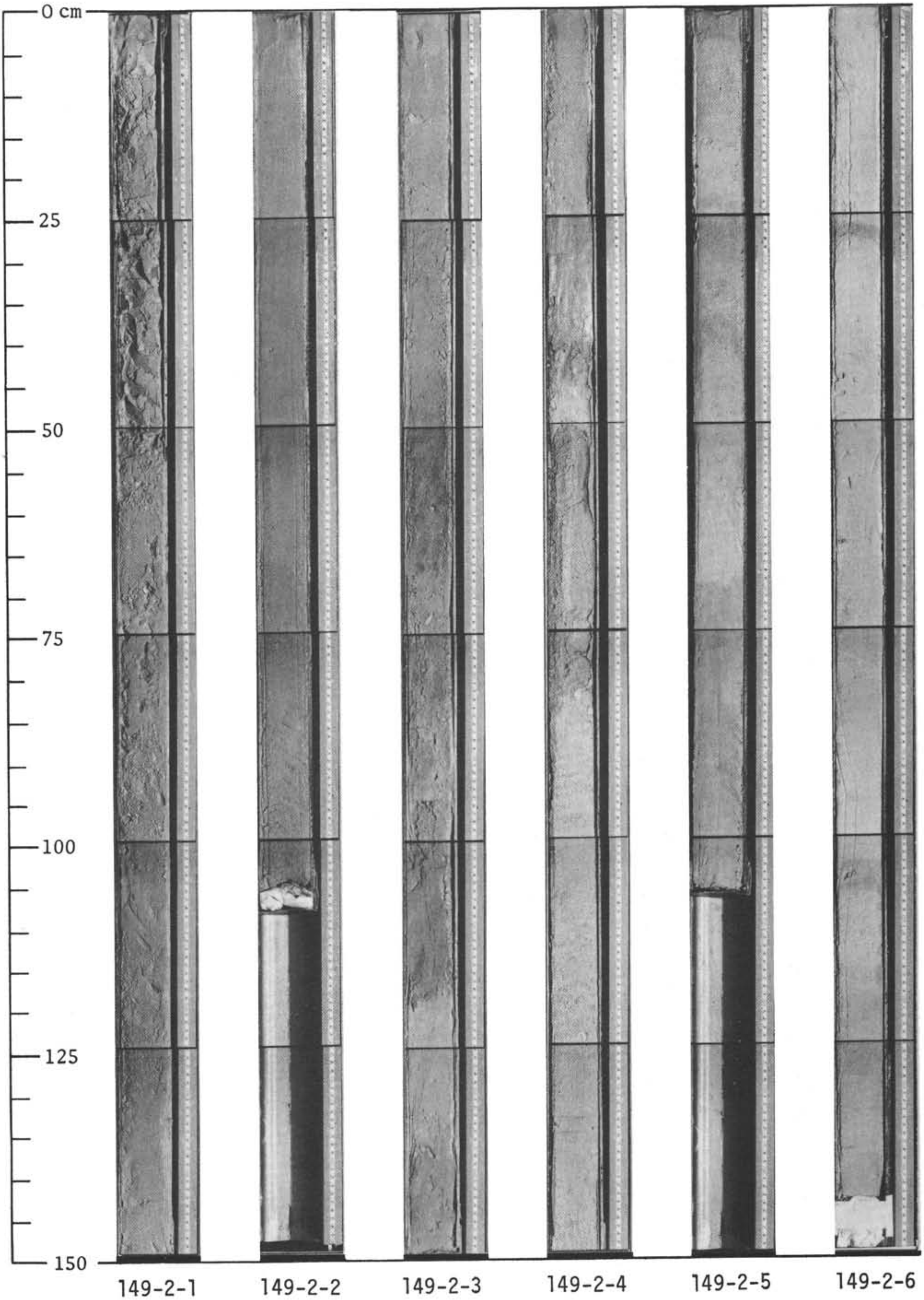
SITE 149 HOLE CORE 43 CORED INTERVAL (m) 381-390

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO₃ (%) / SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
			Theocampe mongolfieri	1	0.5, 1.0	VOID		R F M R C M	SILICIFIED RADIOLARIAN LIMESTONE; varicolored yellowish gray (5Y8/1) to light brownish gray (5YR6/1) extensively burrowed and fragmented. Basal contact sharp. "Ghosts" of radiolaria and foraminifers filled by microquartz and chalcedony. Soft CHALK layer rich in planktonic foraminifers. CHERT; varicolored, predominantly olive gray (5Y4/1) with abundant streaks of green, dusky purple, and grayish orange shades associated with burrowing. Almost packed biomicrite with well-preserved to totally replaced radiolaria and rare foraminifers. Chalcedony filling. Irregular silicification. X-ray shows palygorskite.	▲	CH-13 IV
				CORE CATCHER							

[1]For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1420. This background was subtracted from the data.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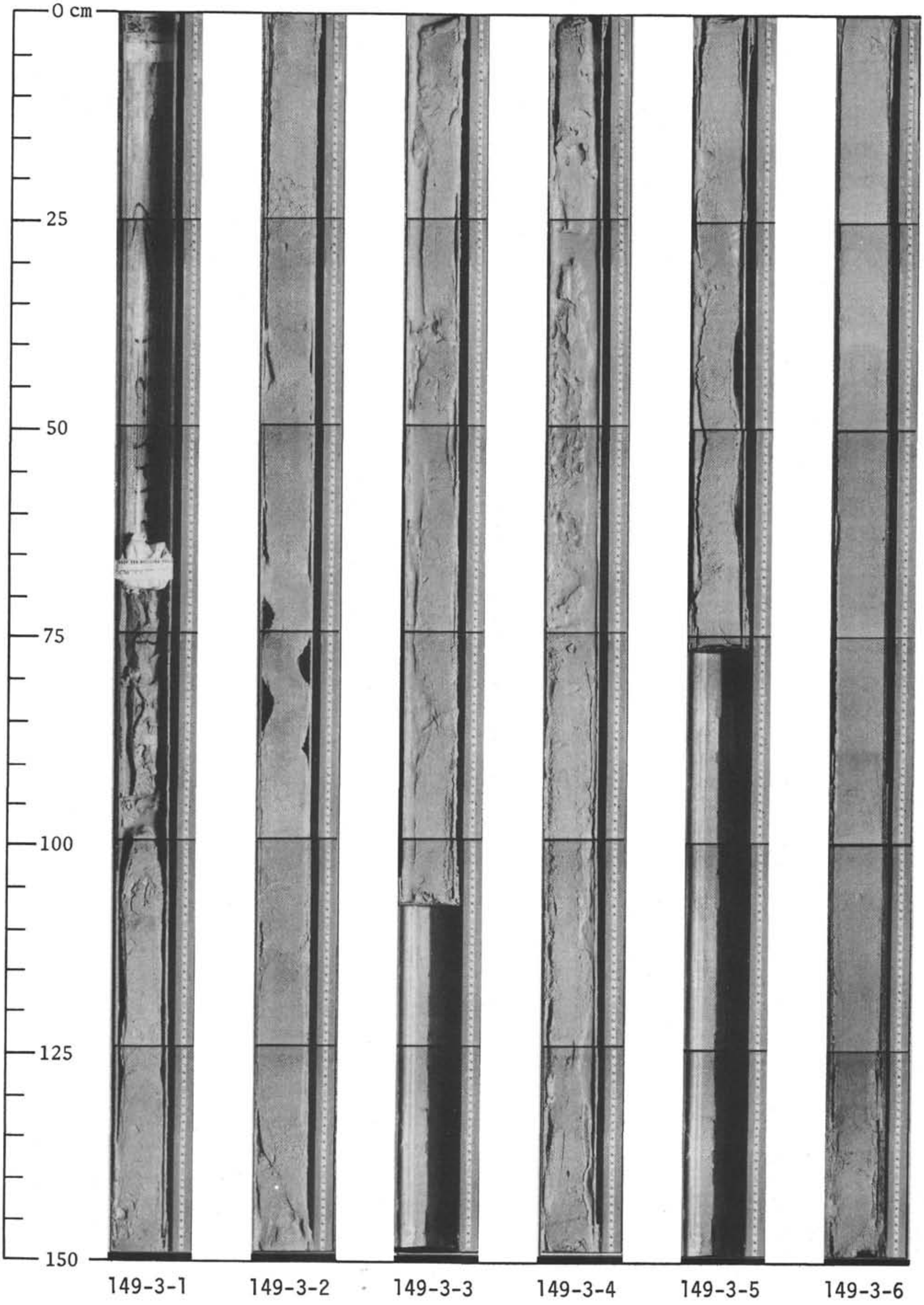
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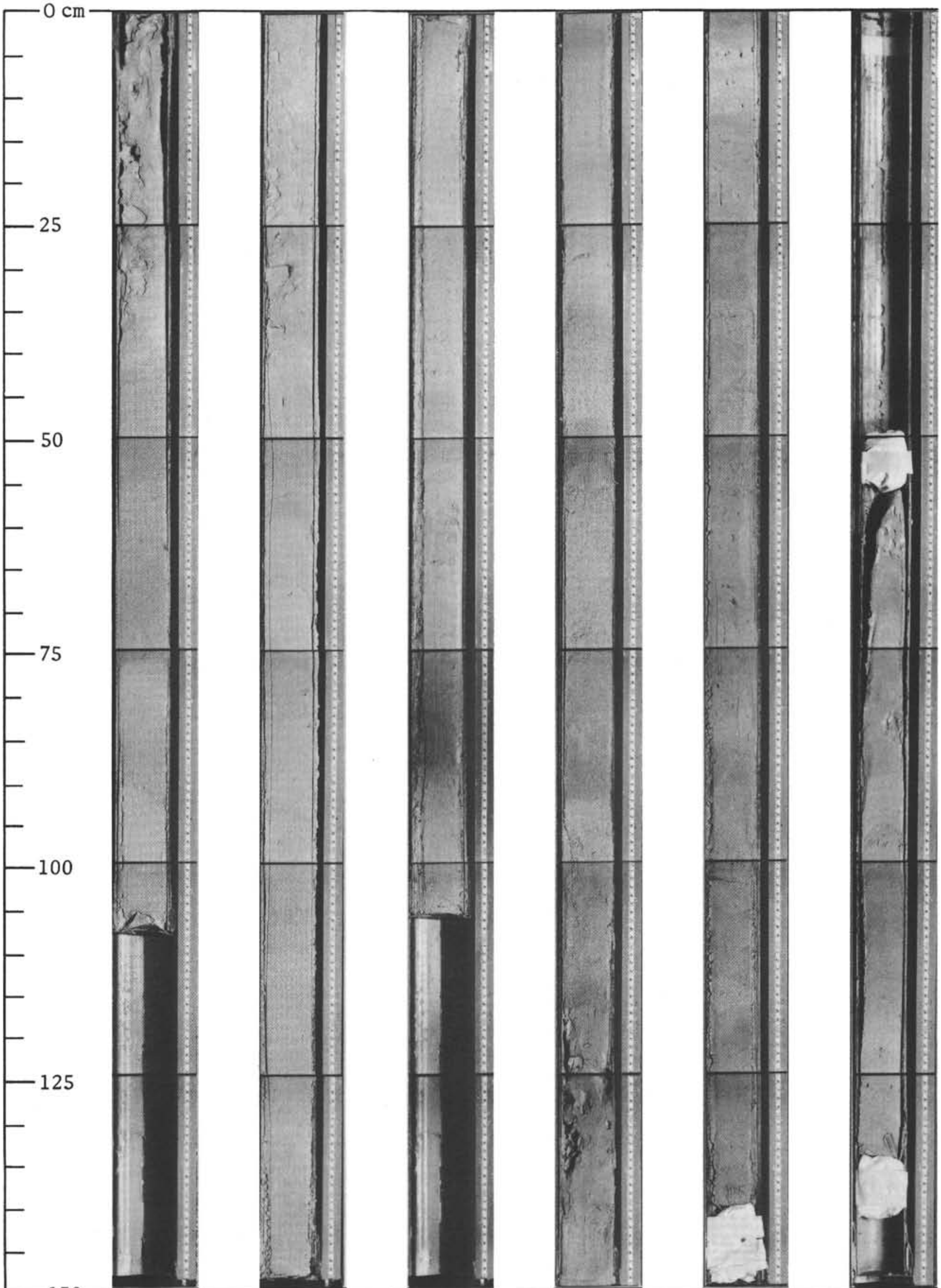
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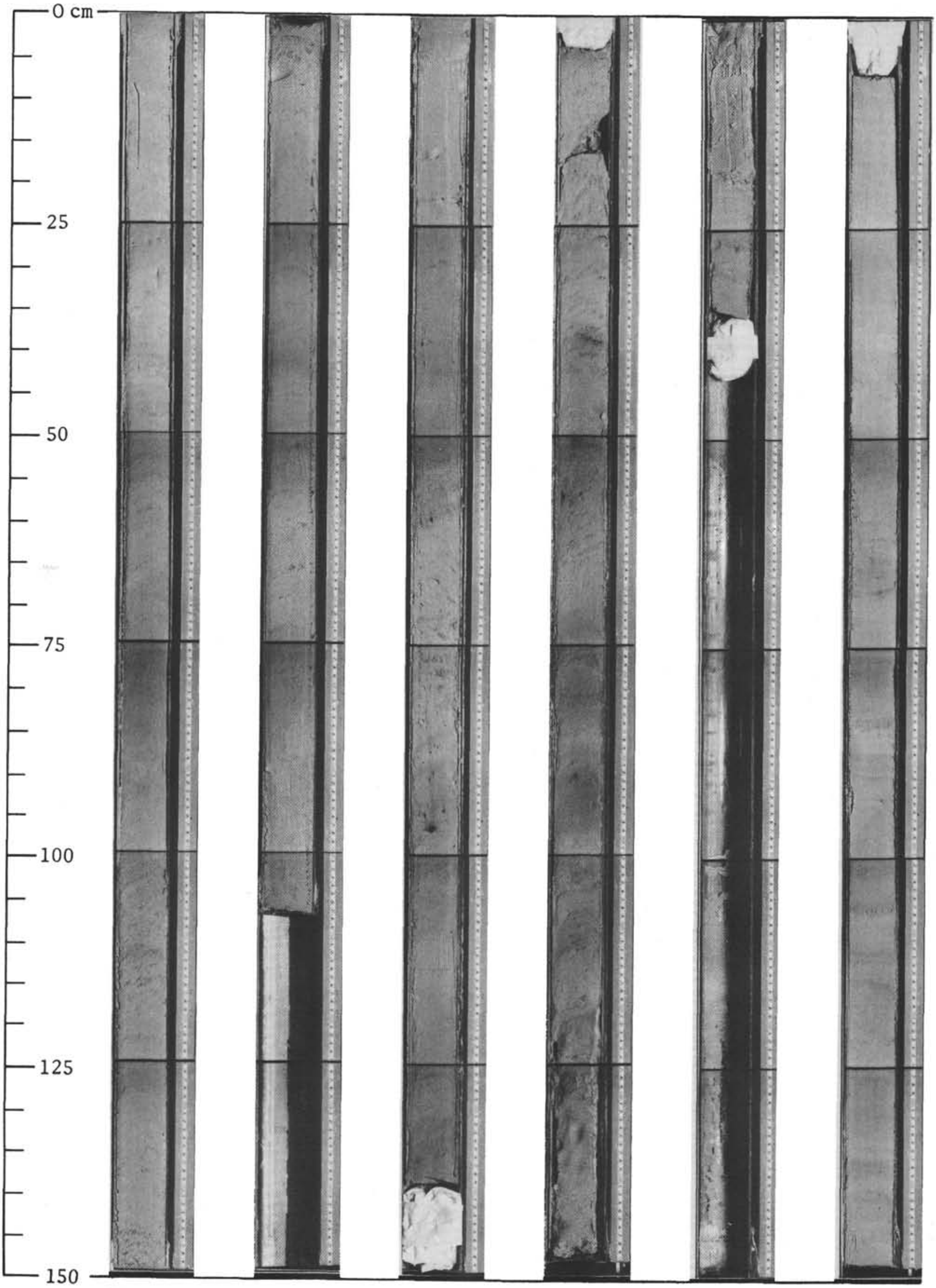
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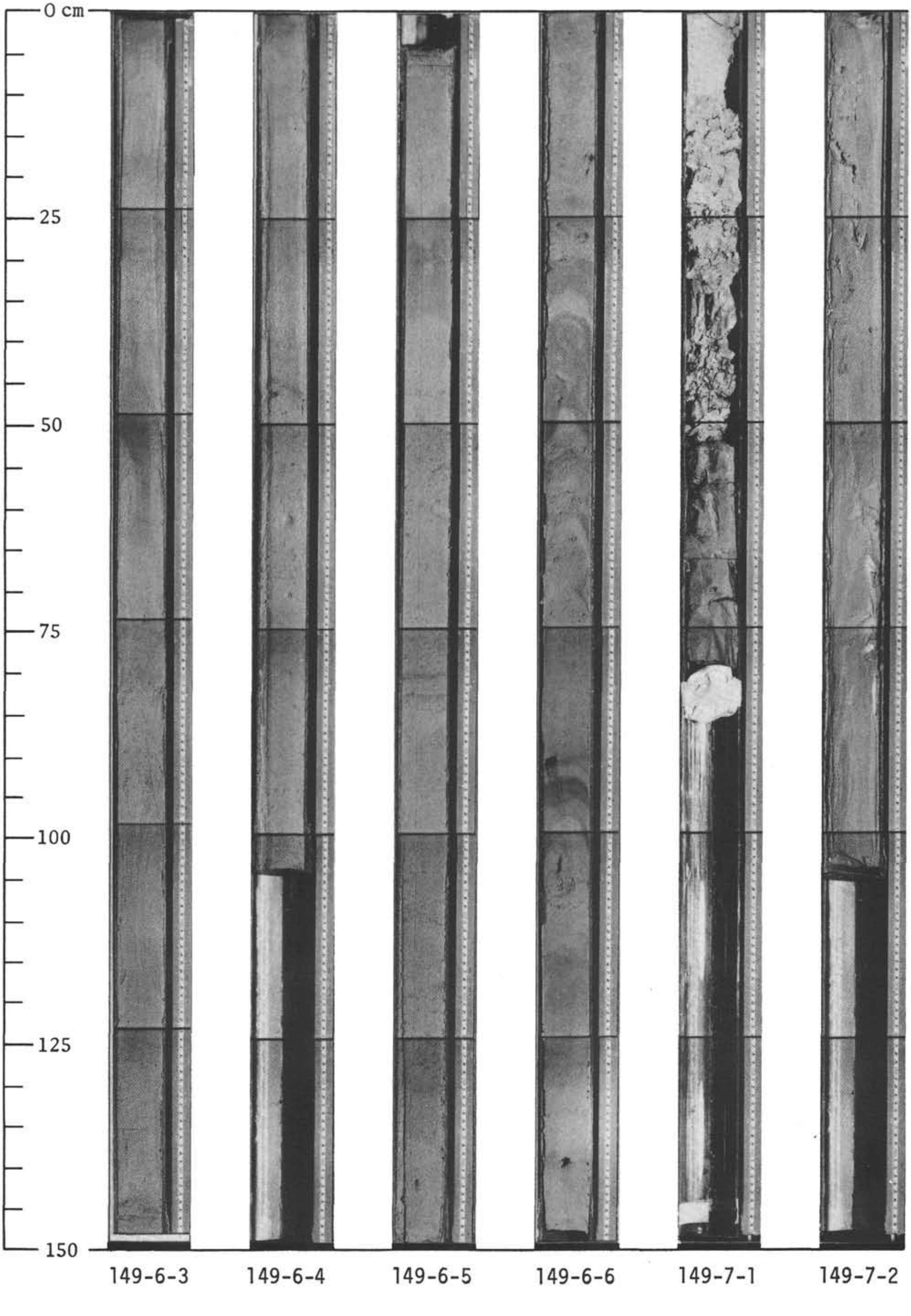
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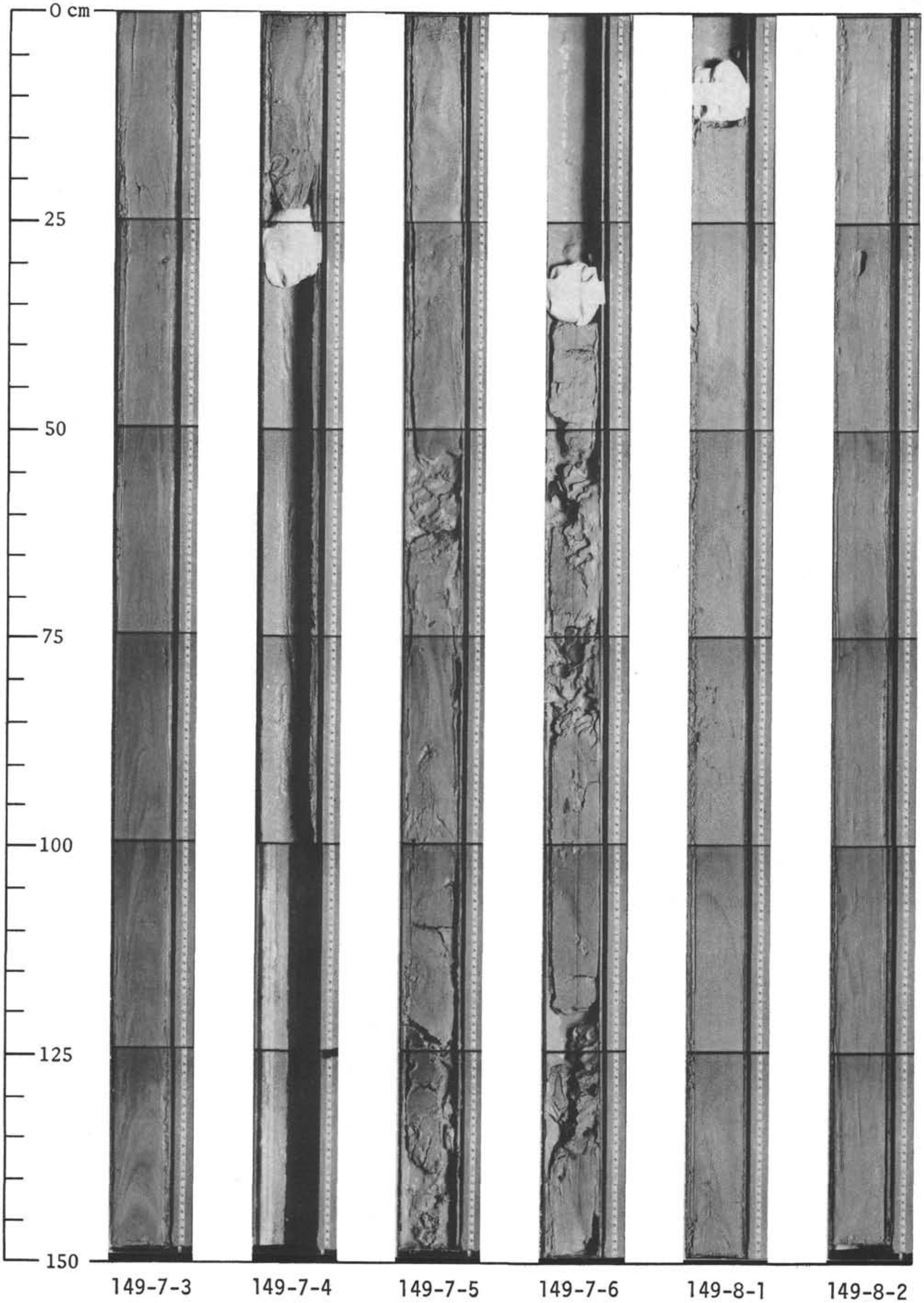

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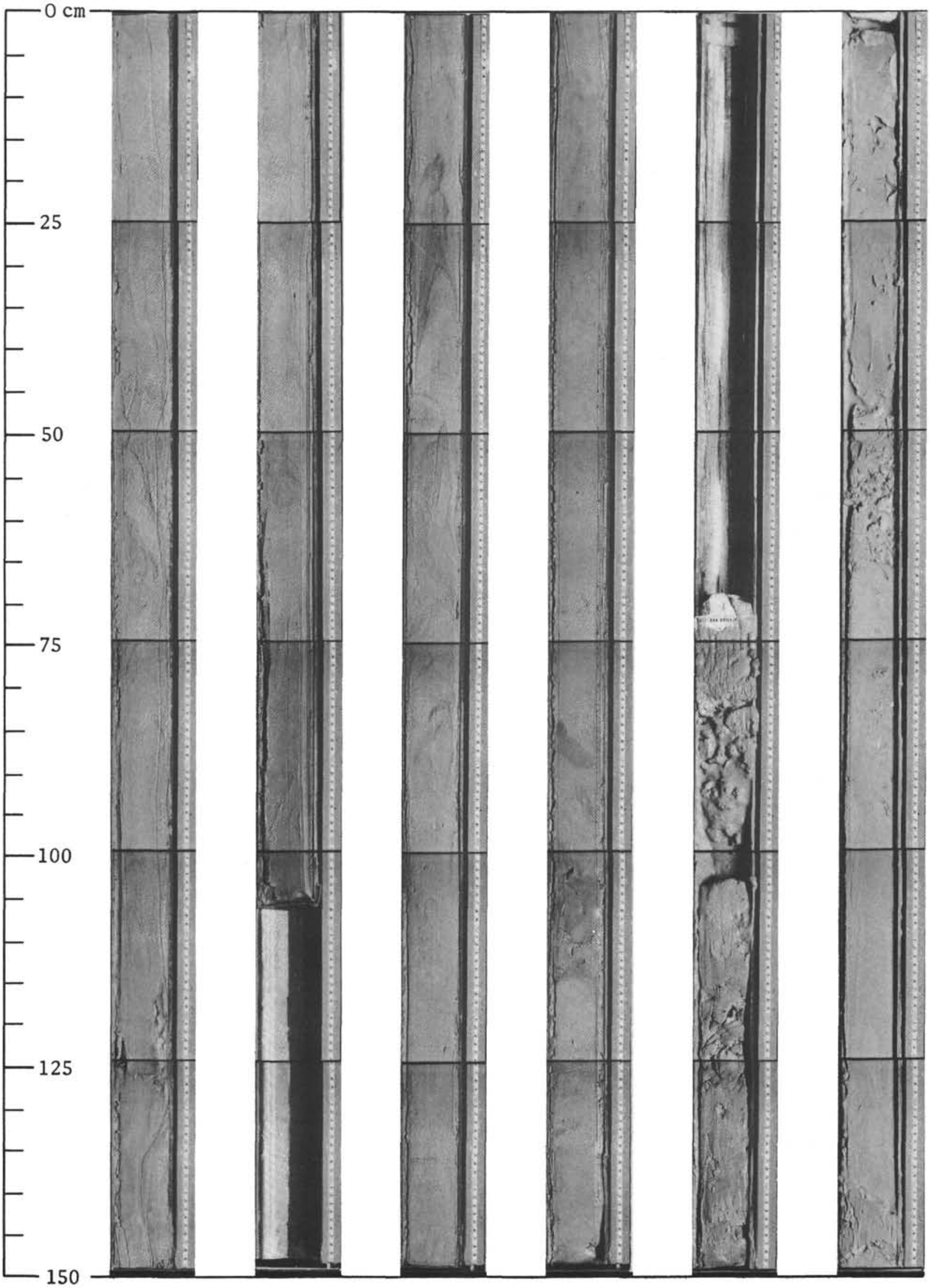
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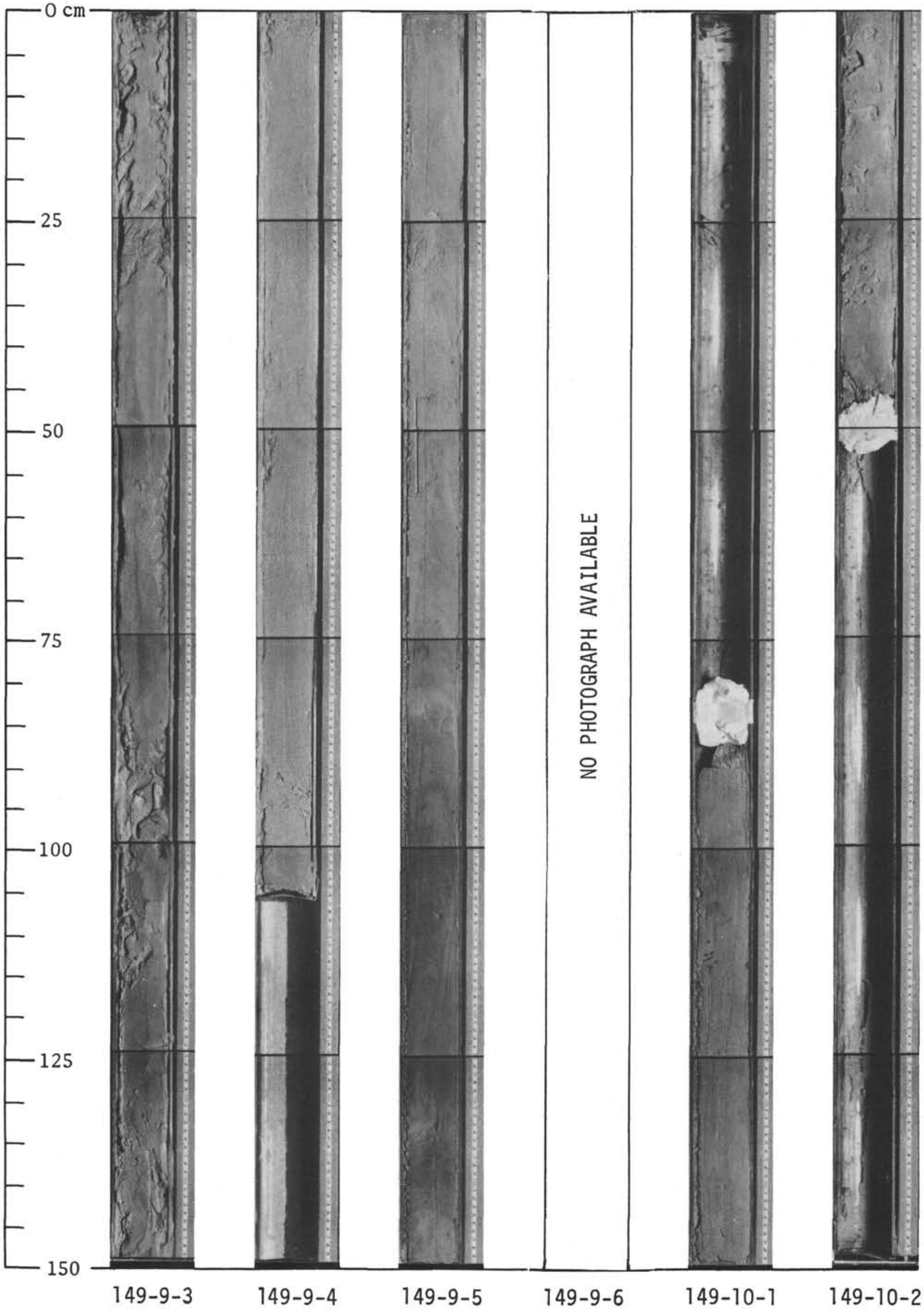
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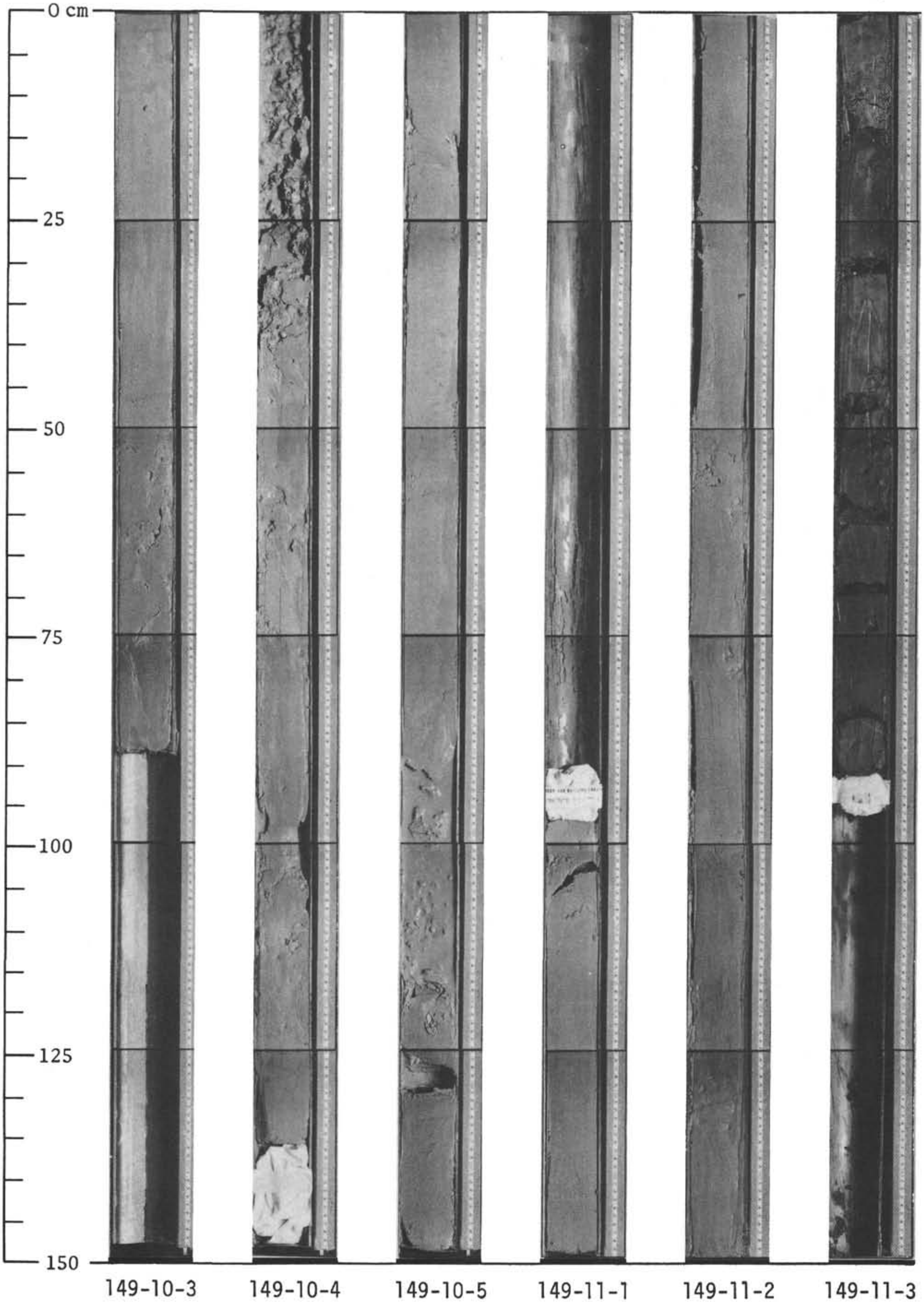
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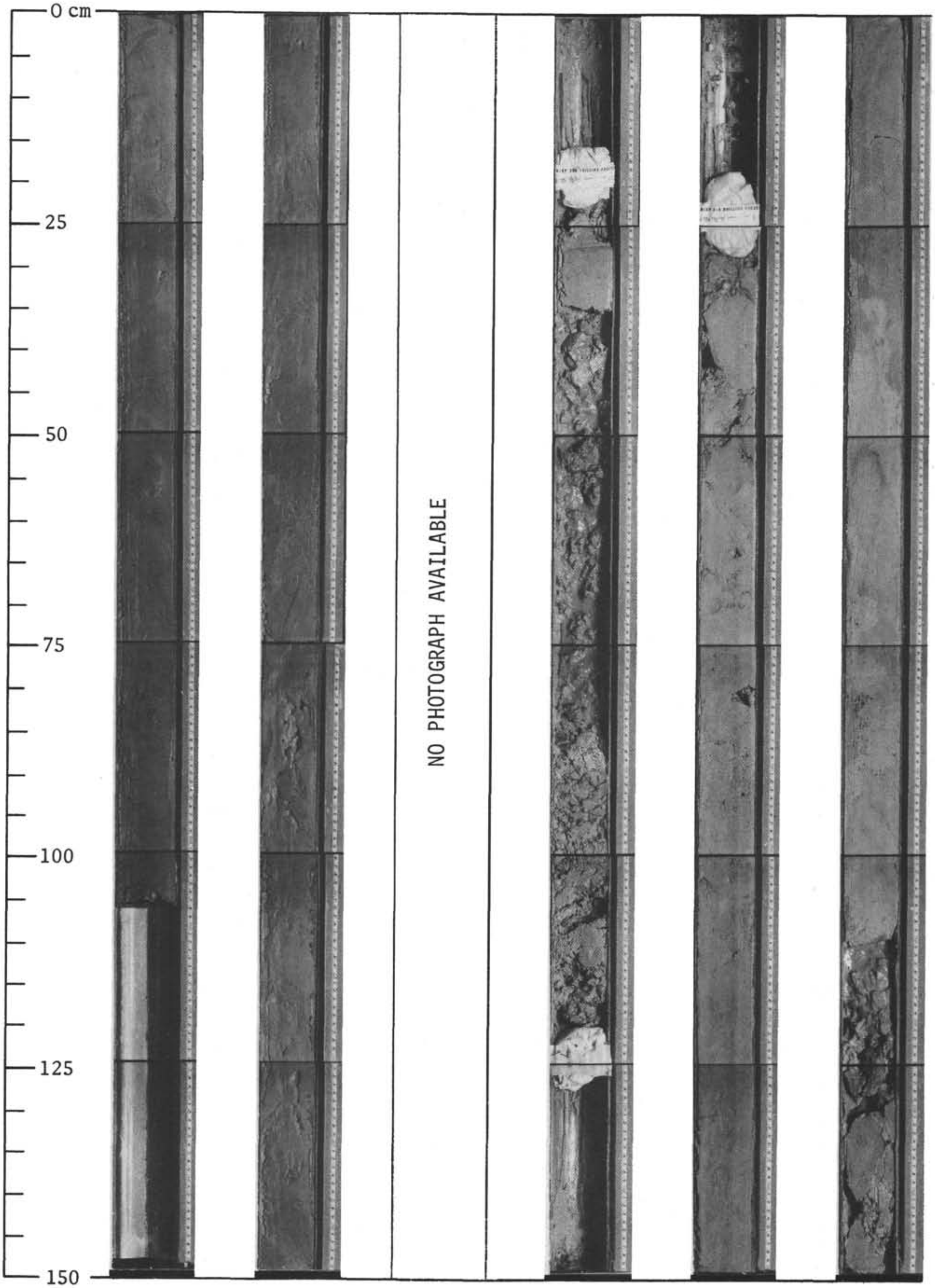

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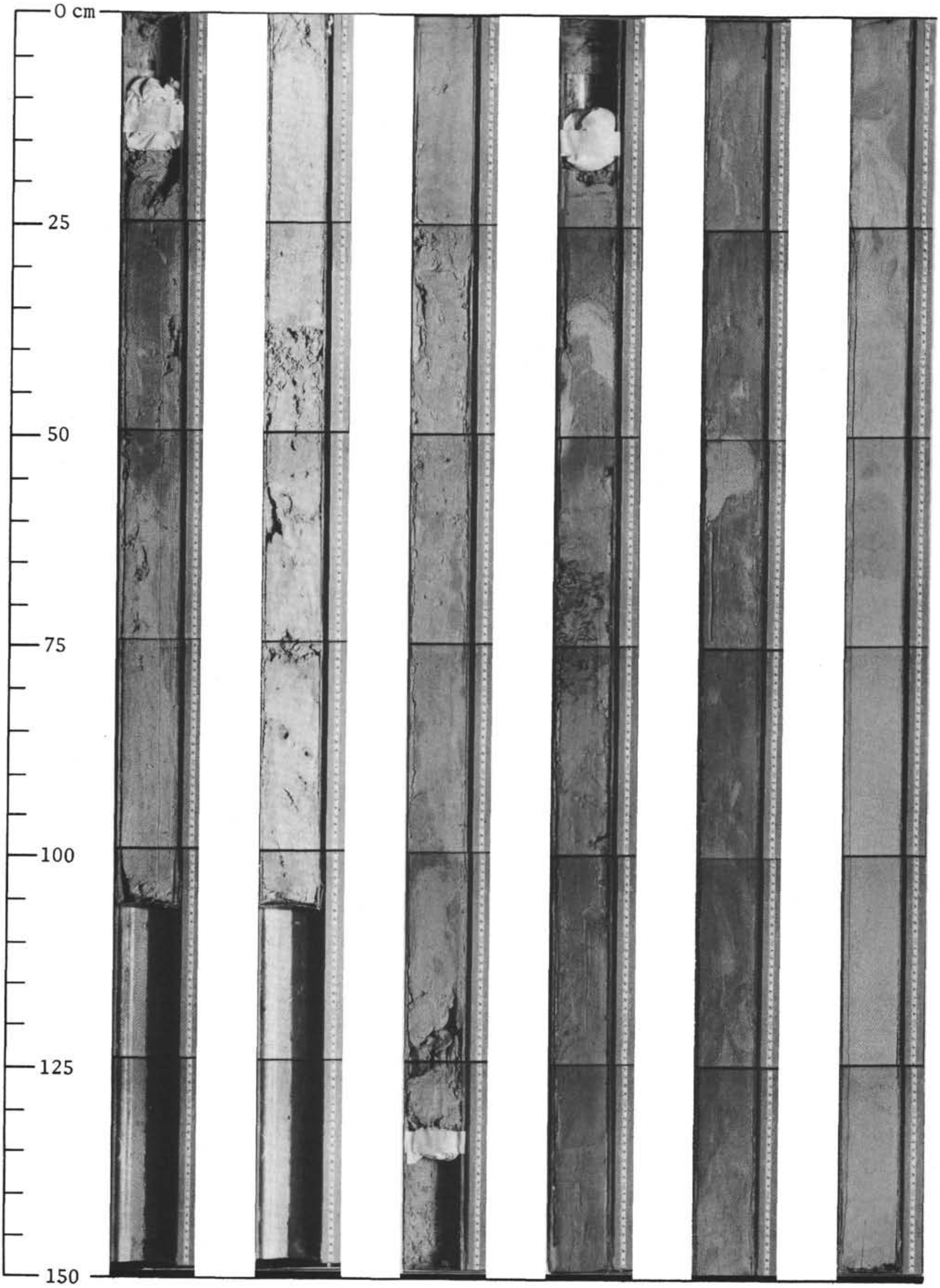
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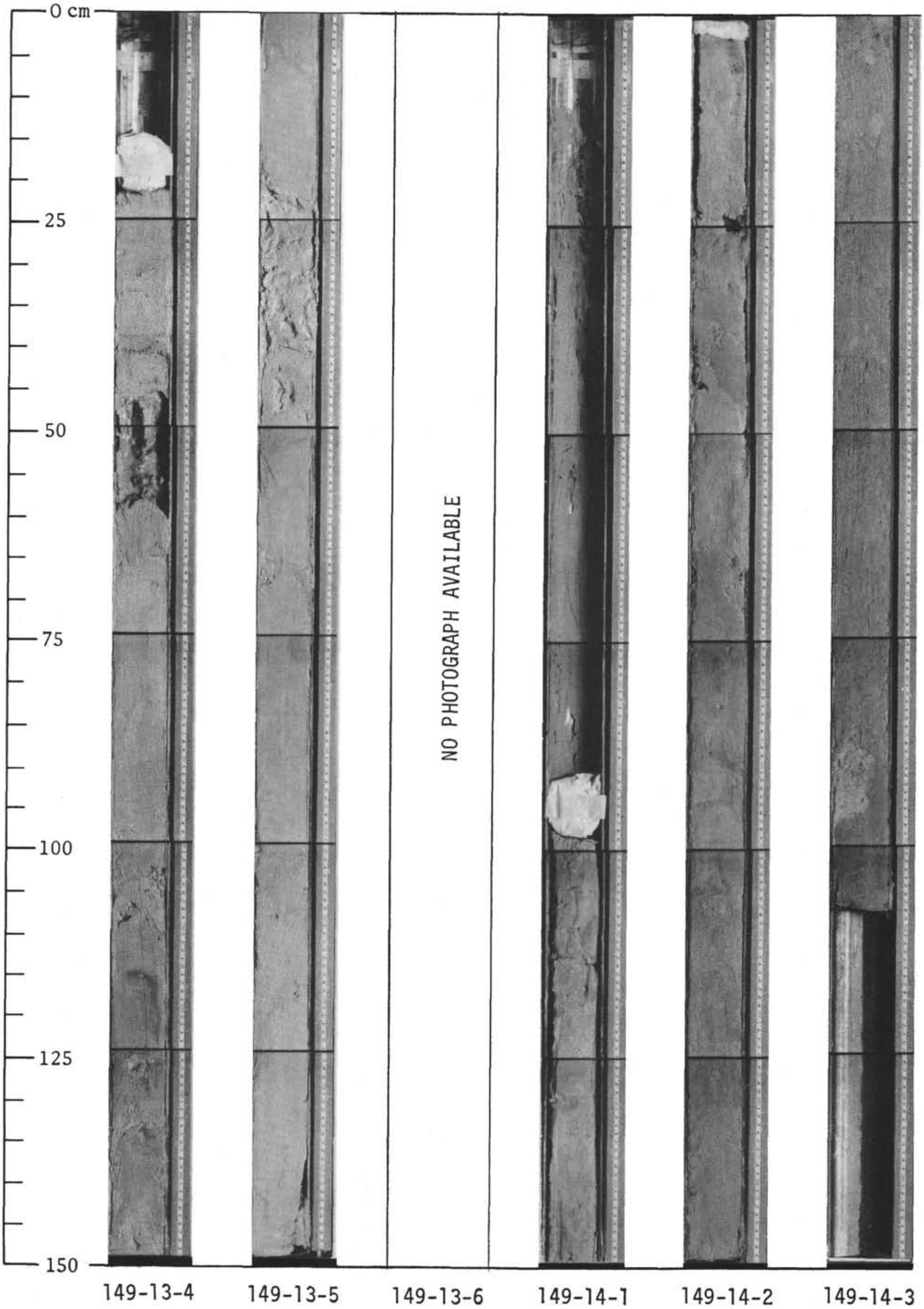
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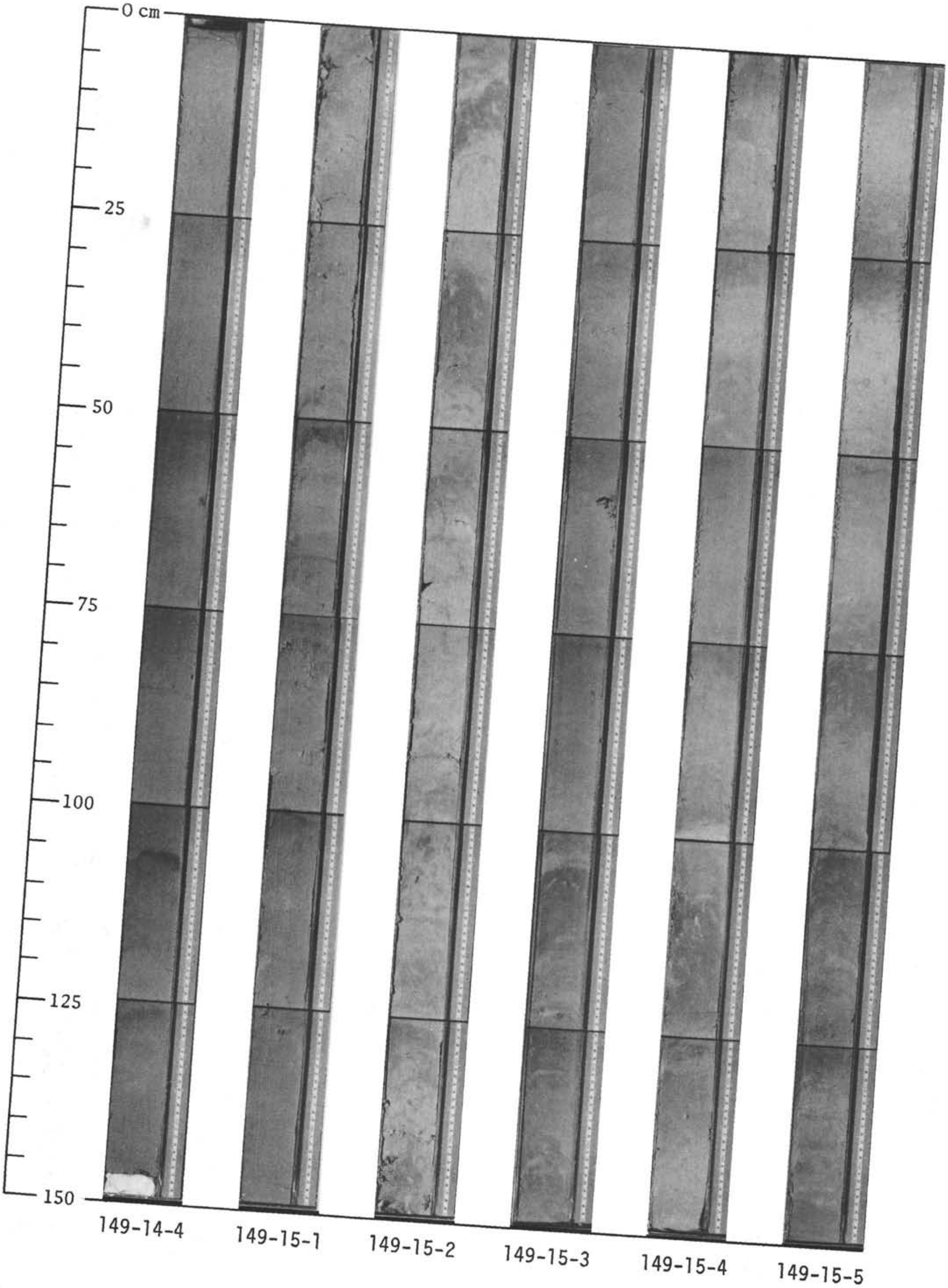
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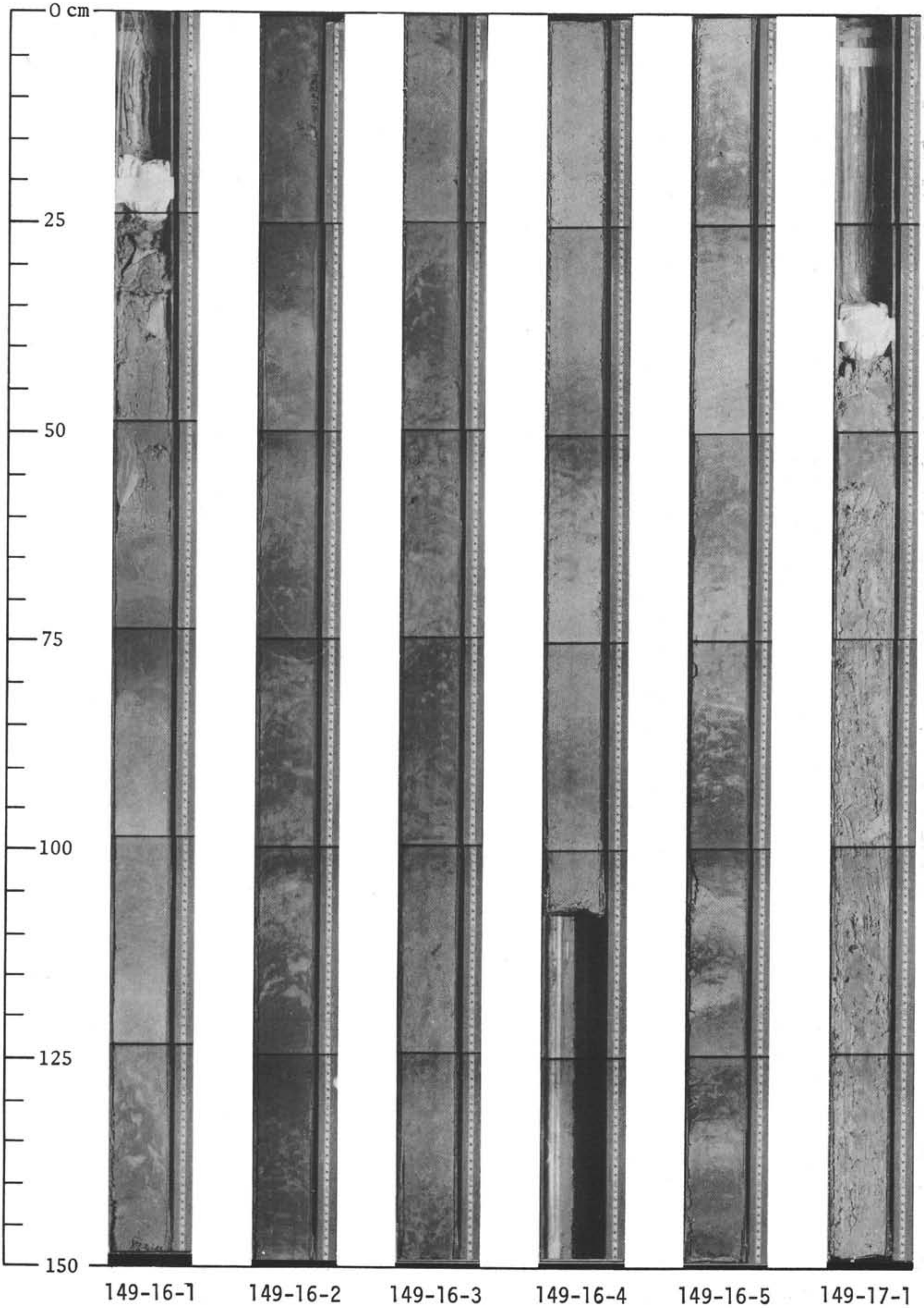
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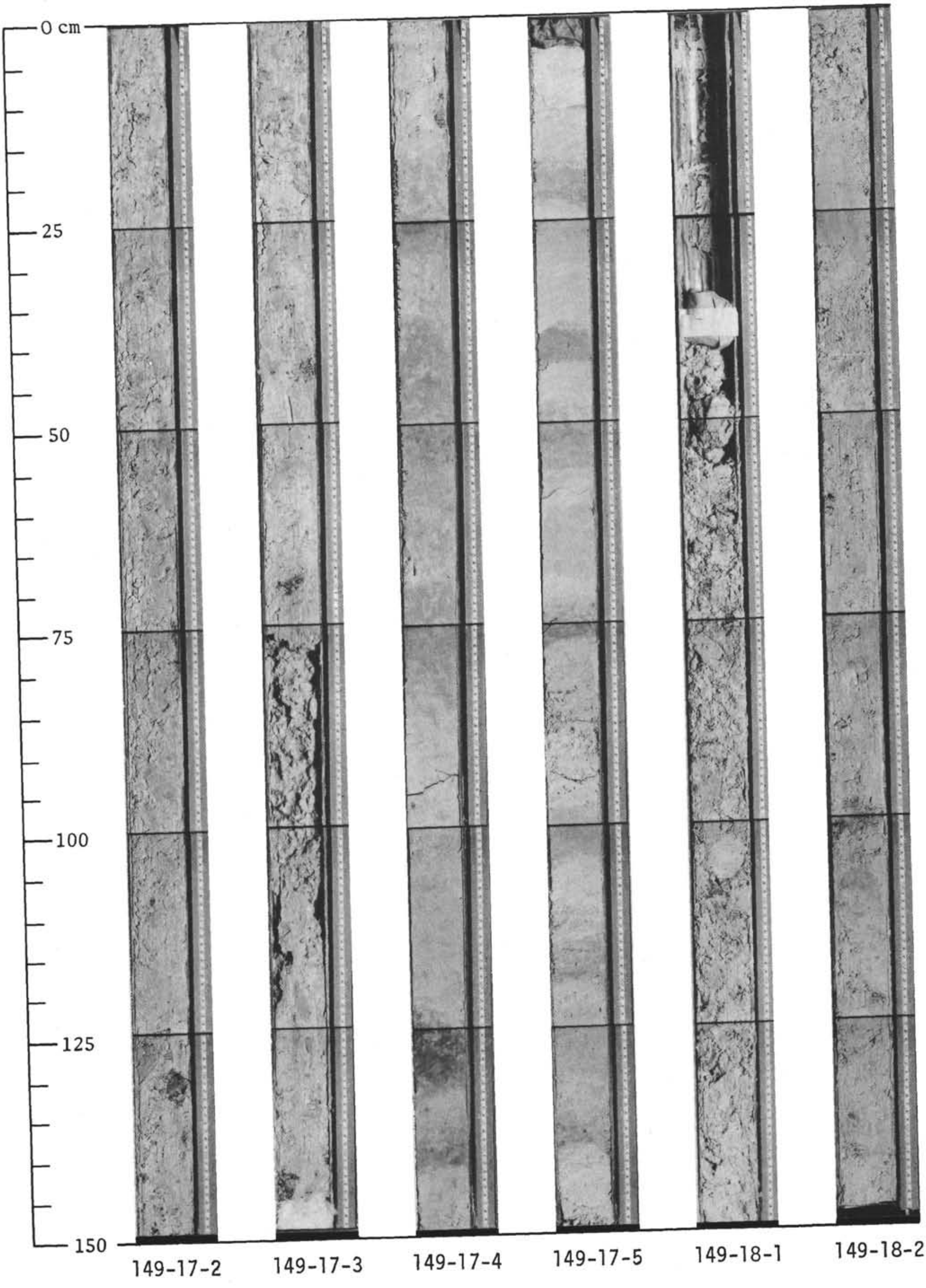
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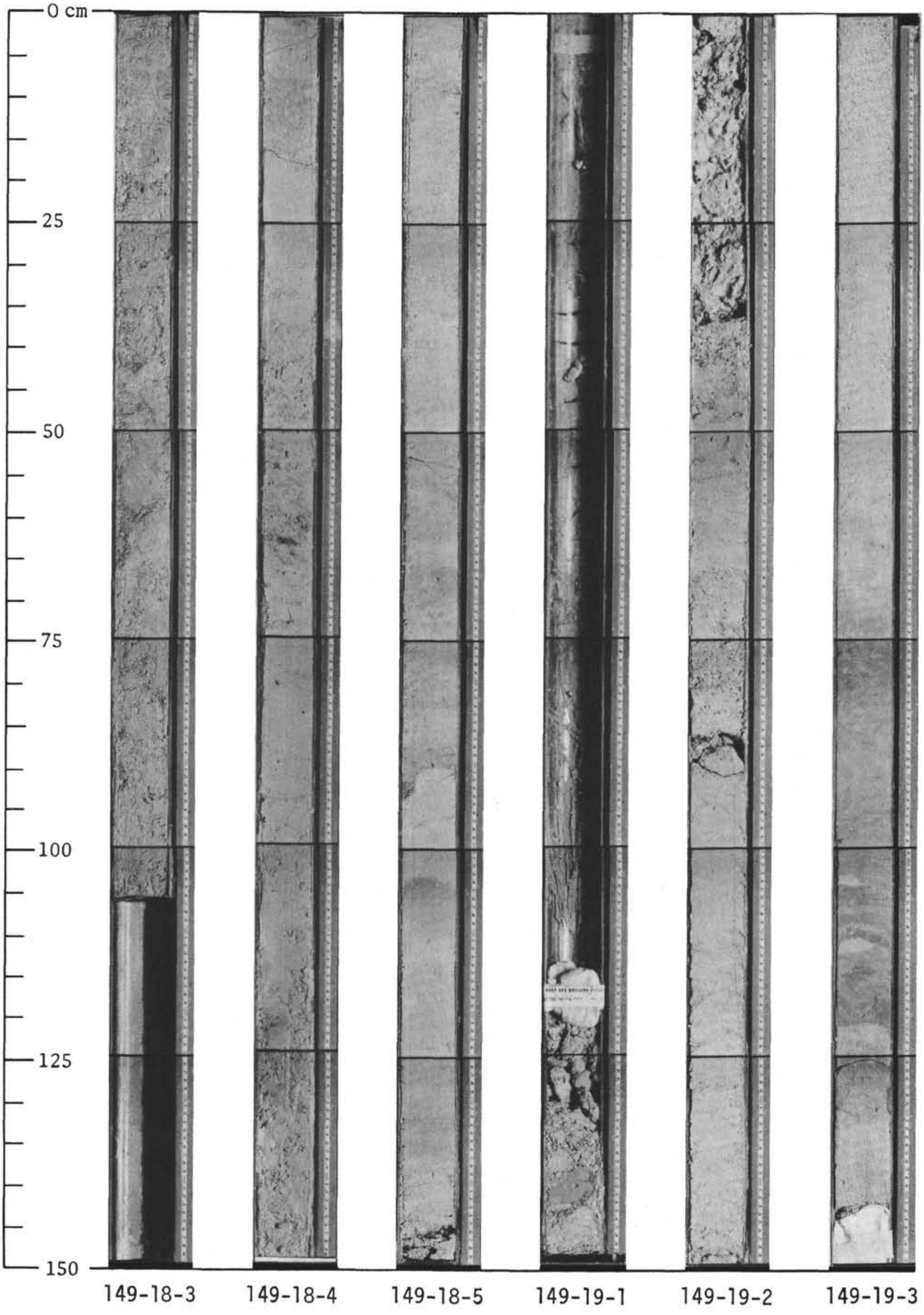
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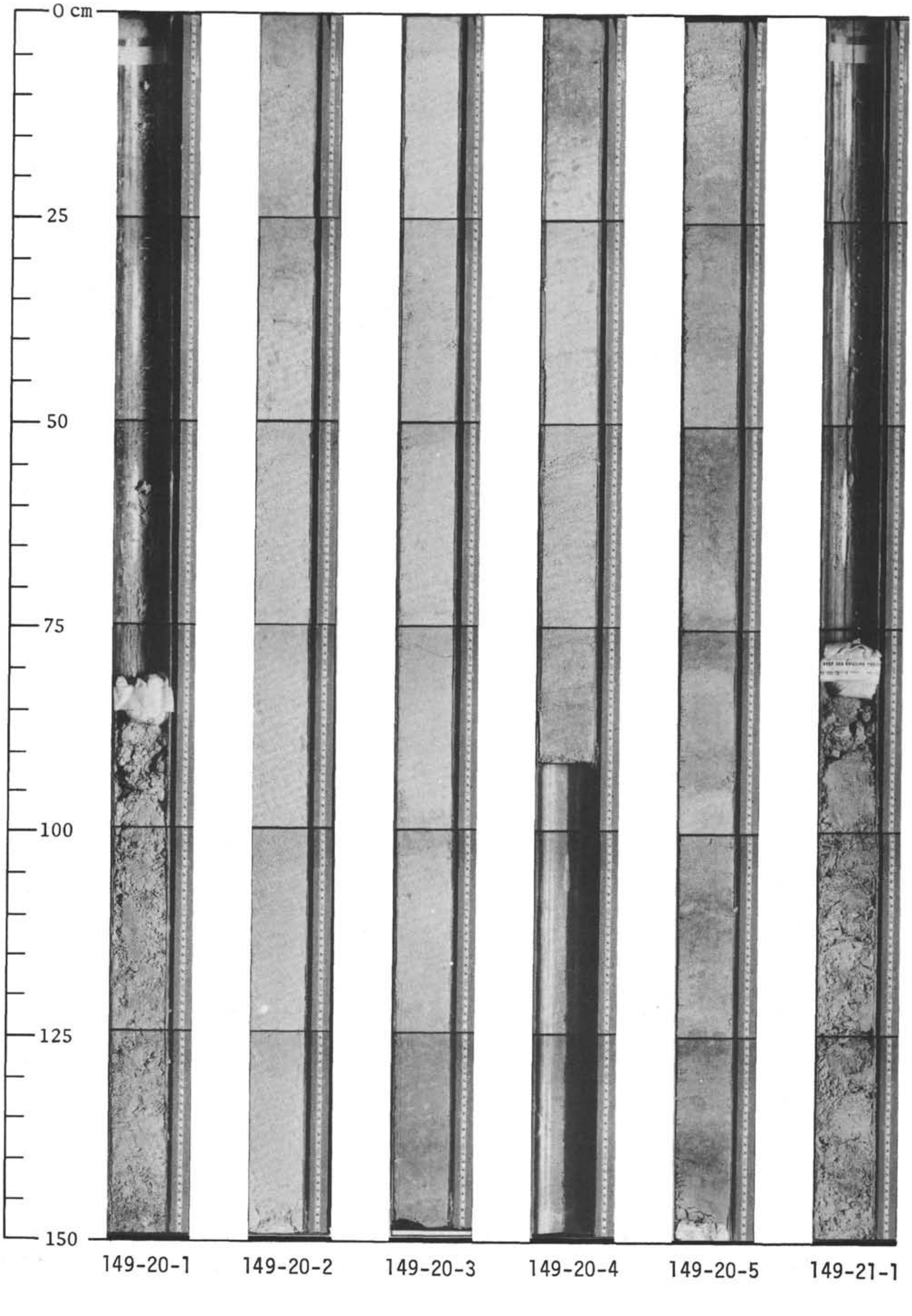
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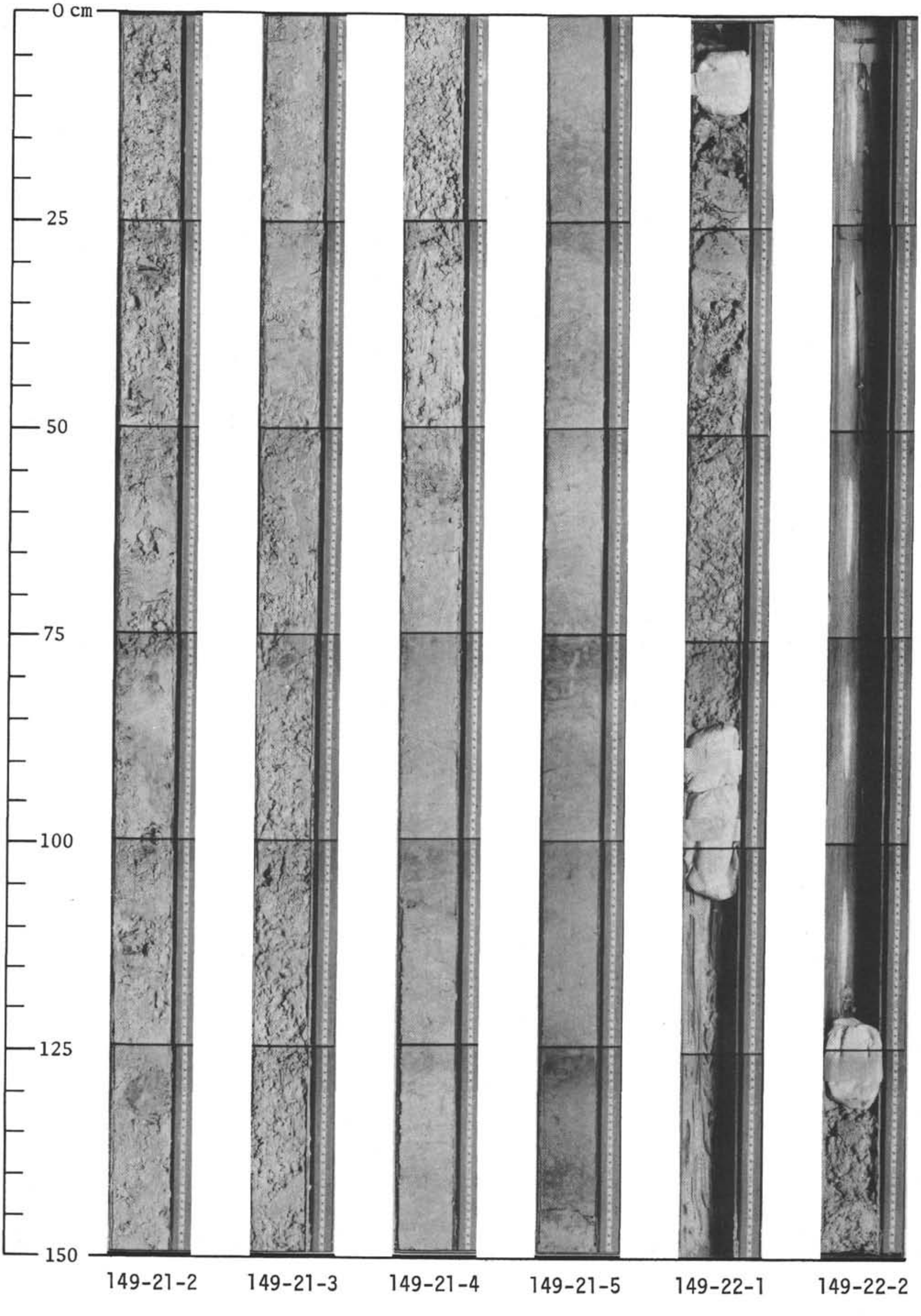
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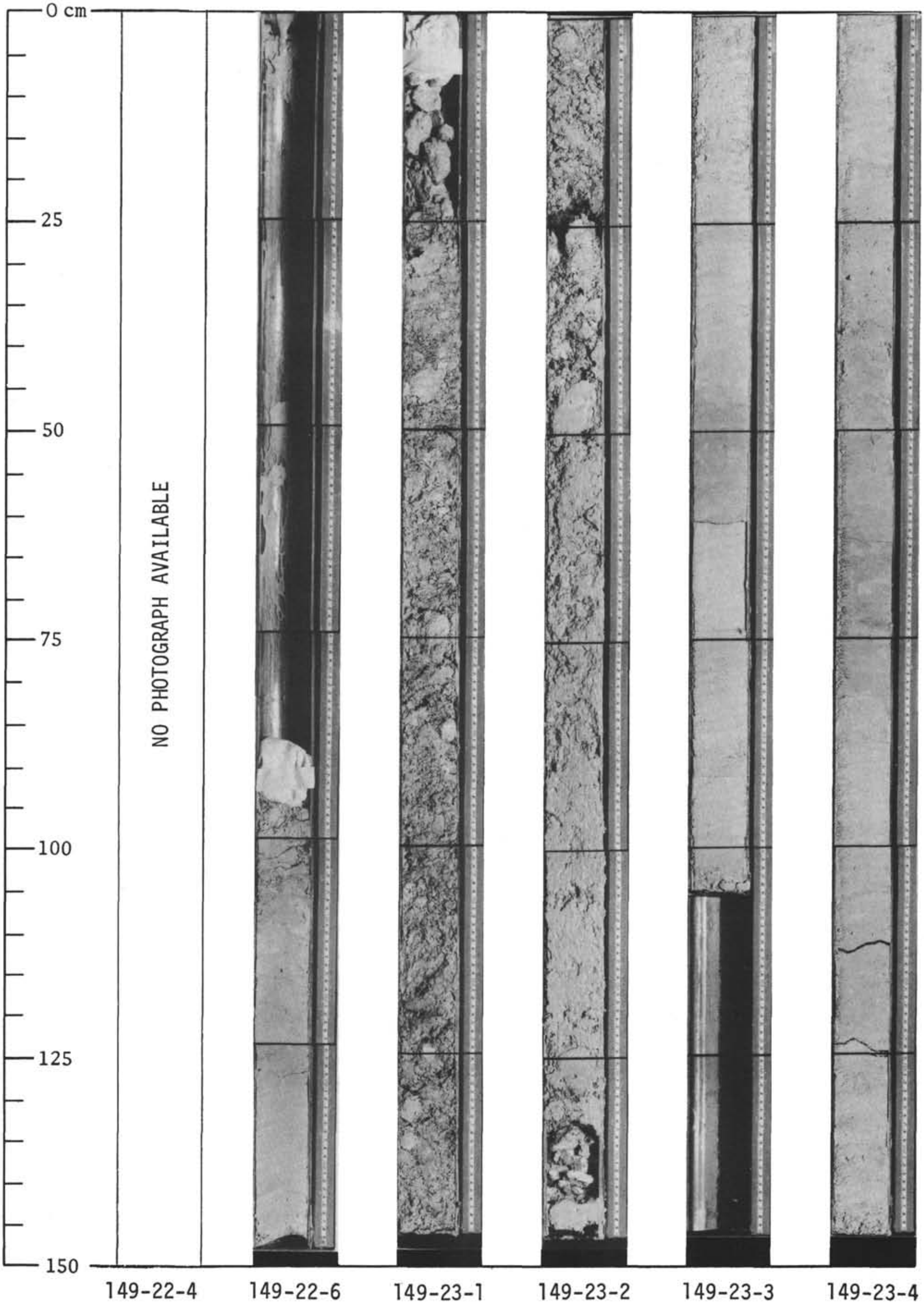
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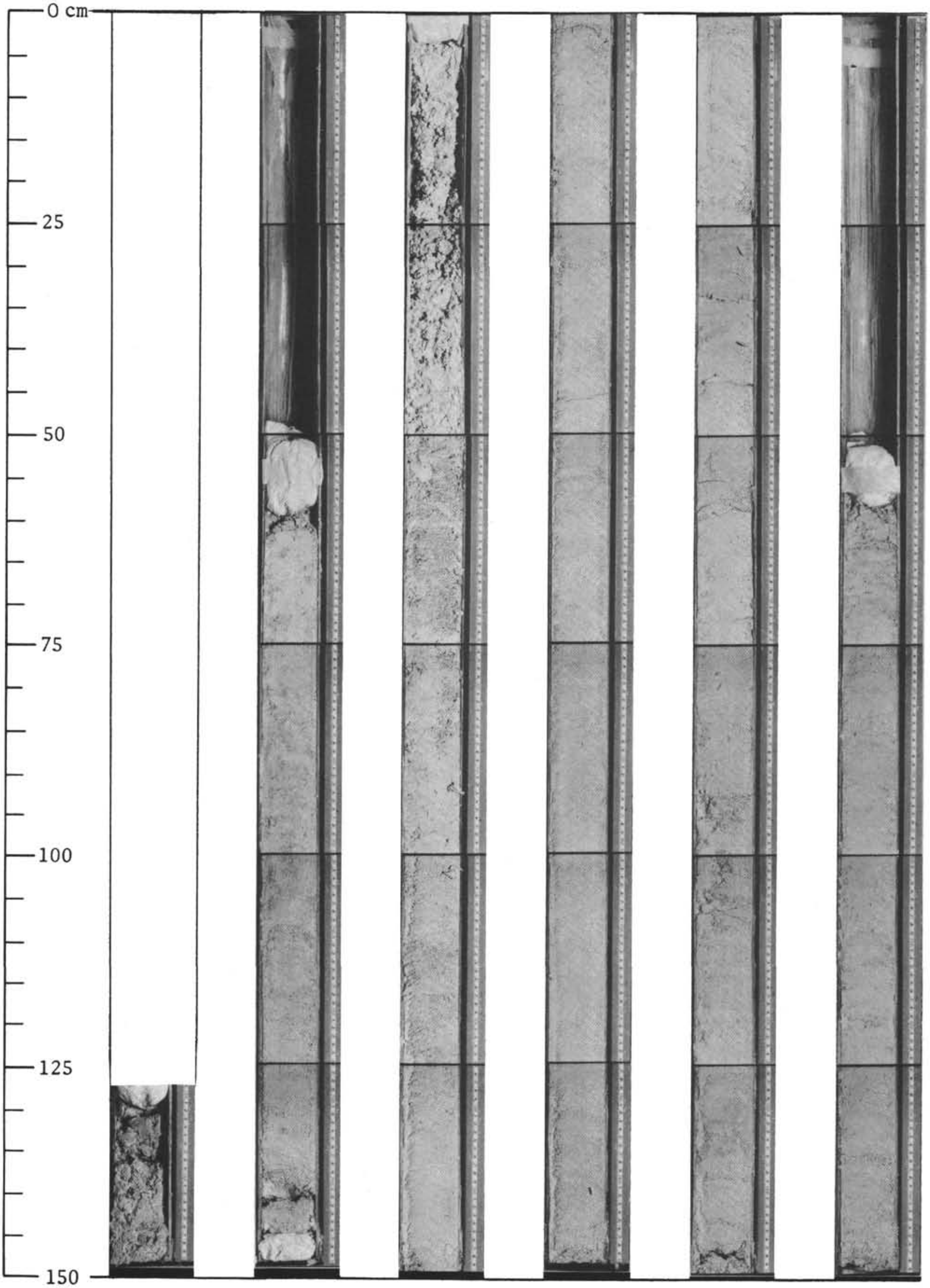
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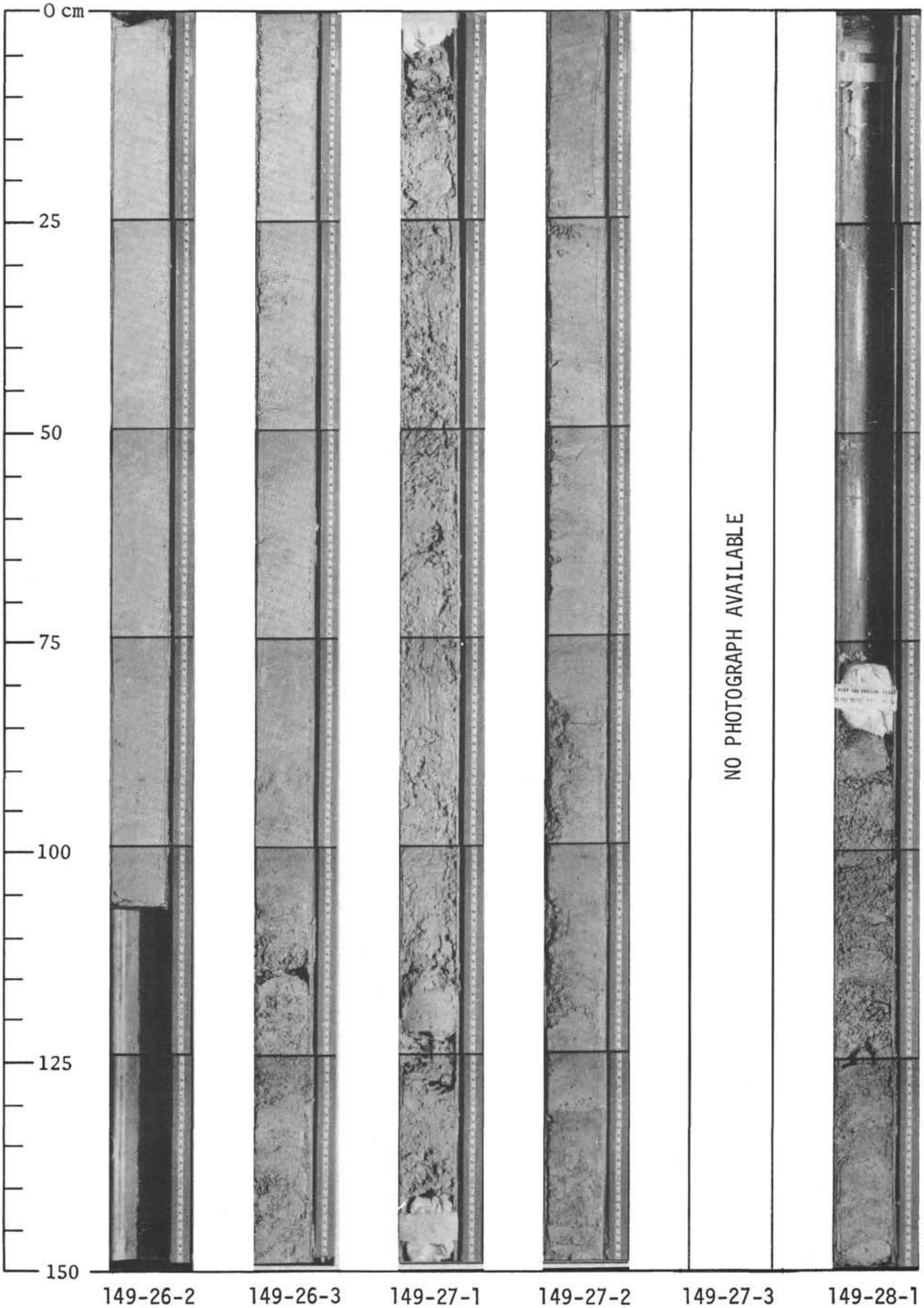
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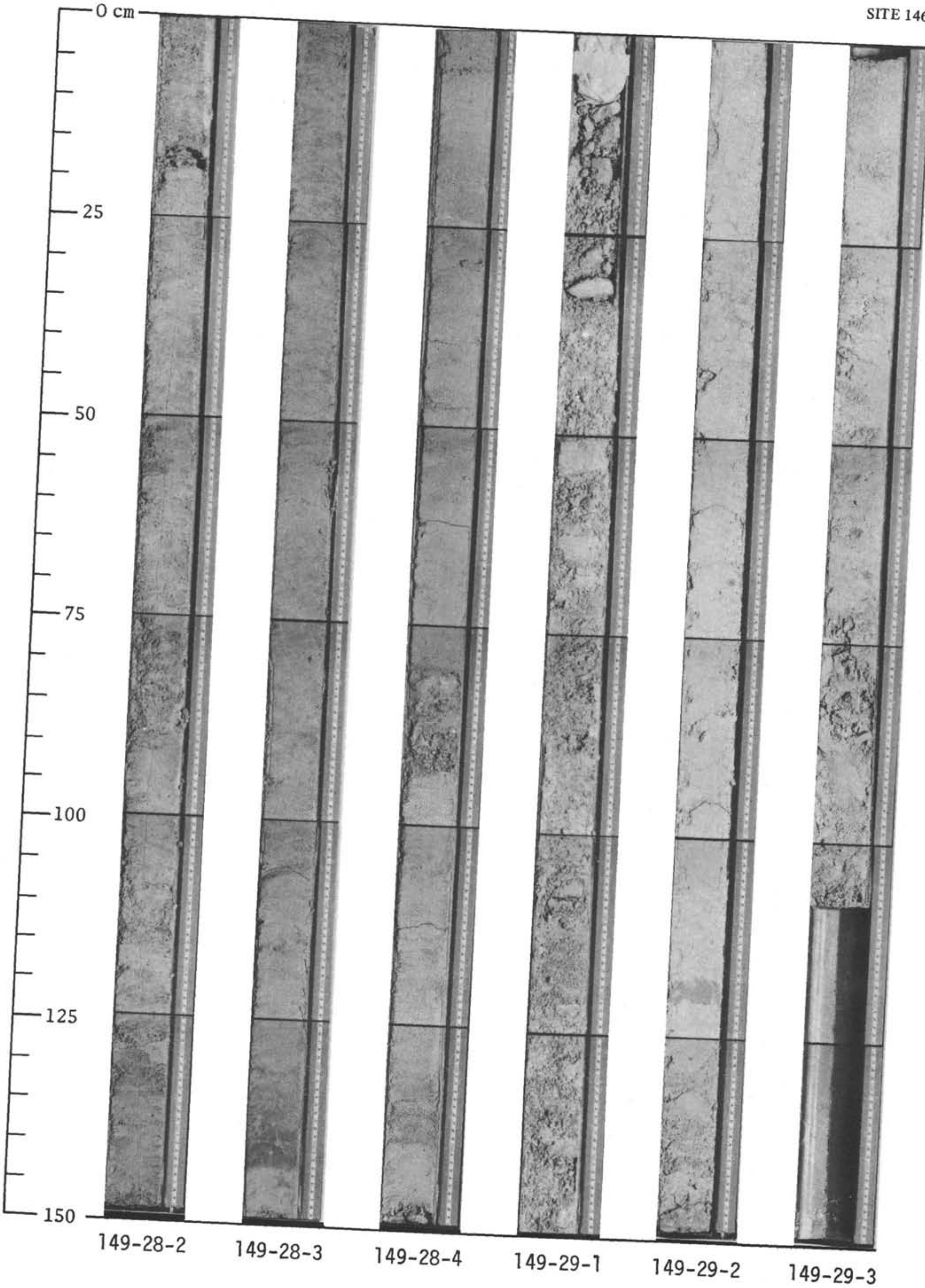
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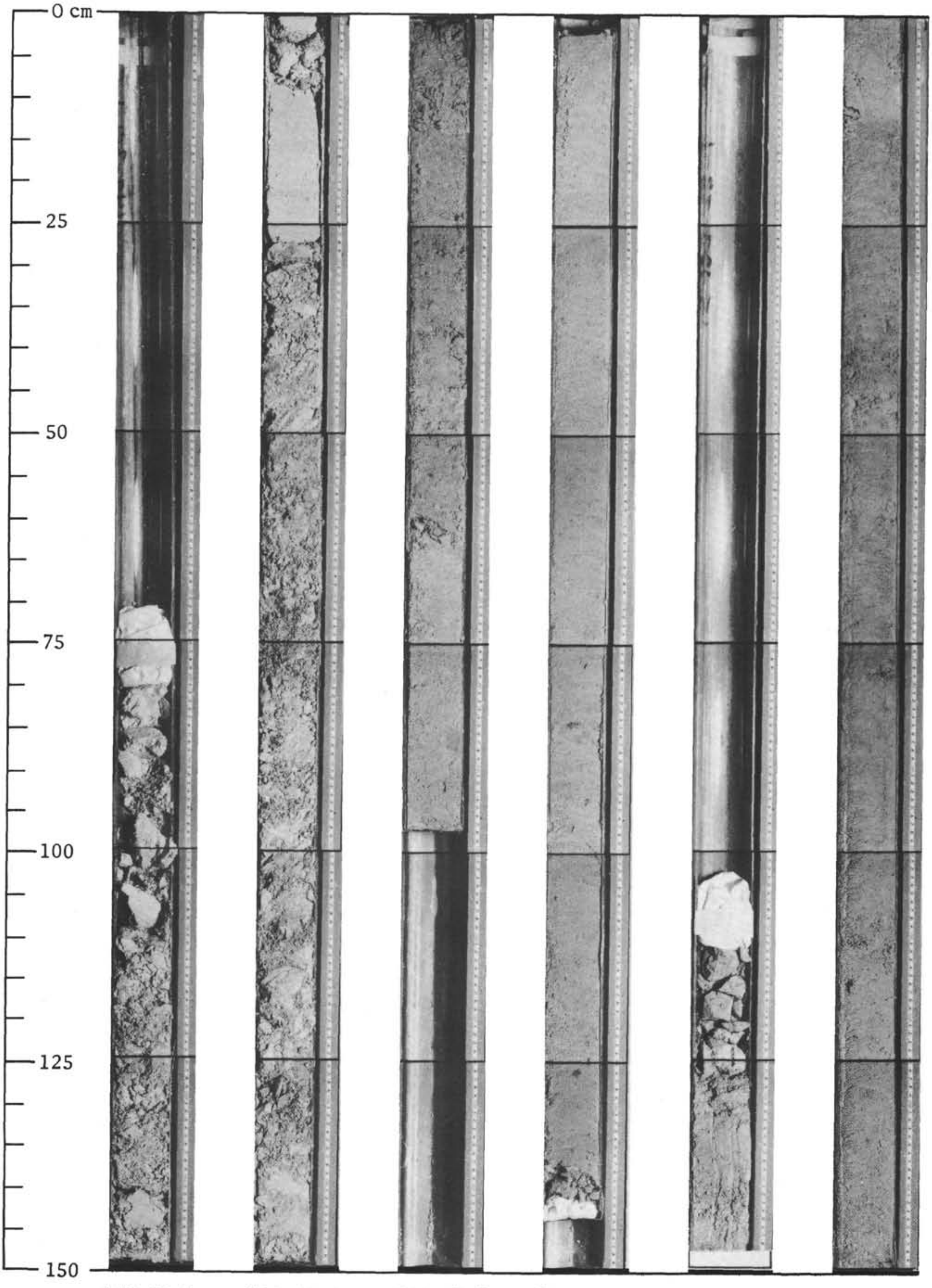
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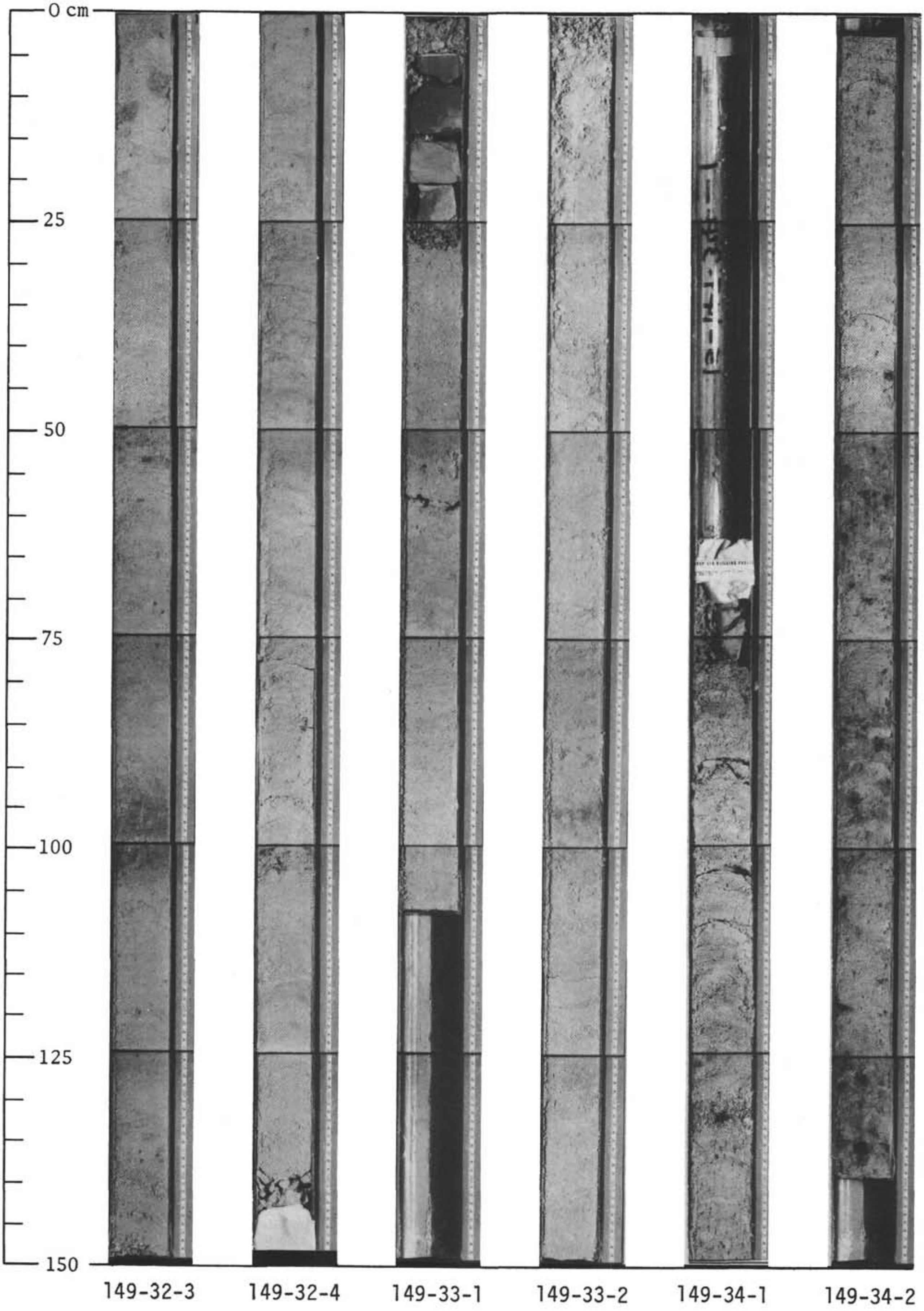
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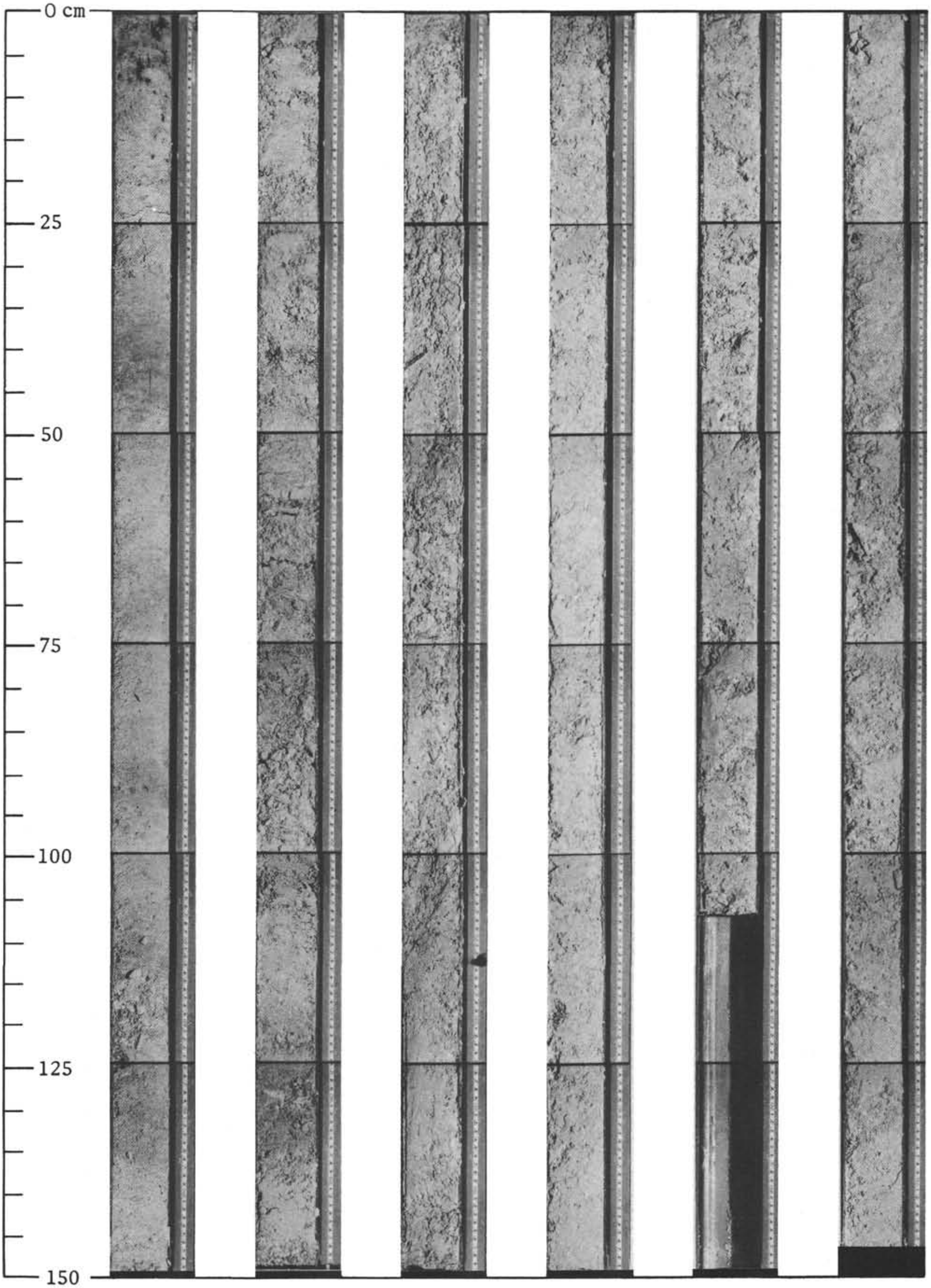
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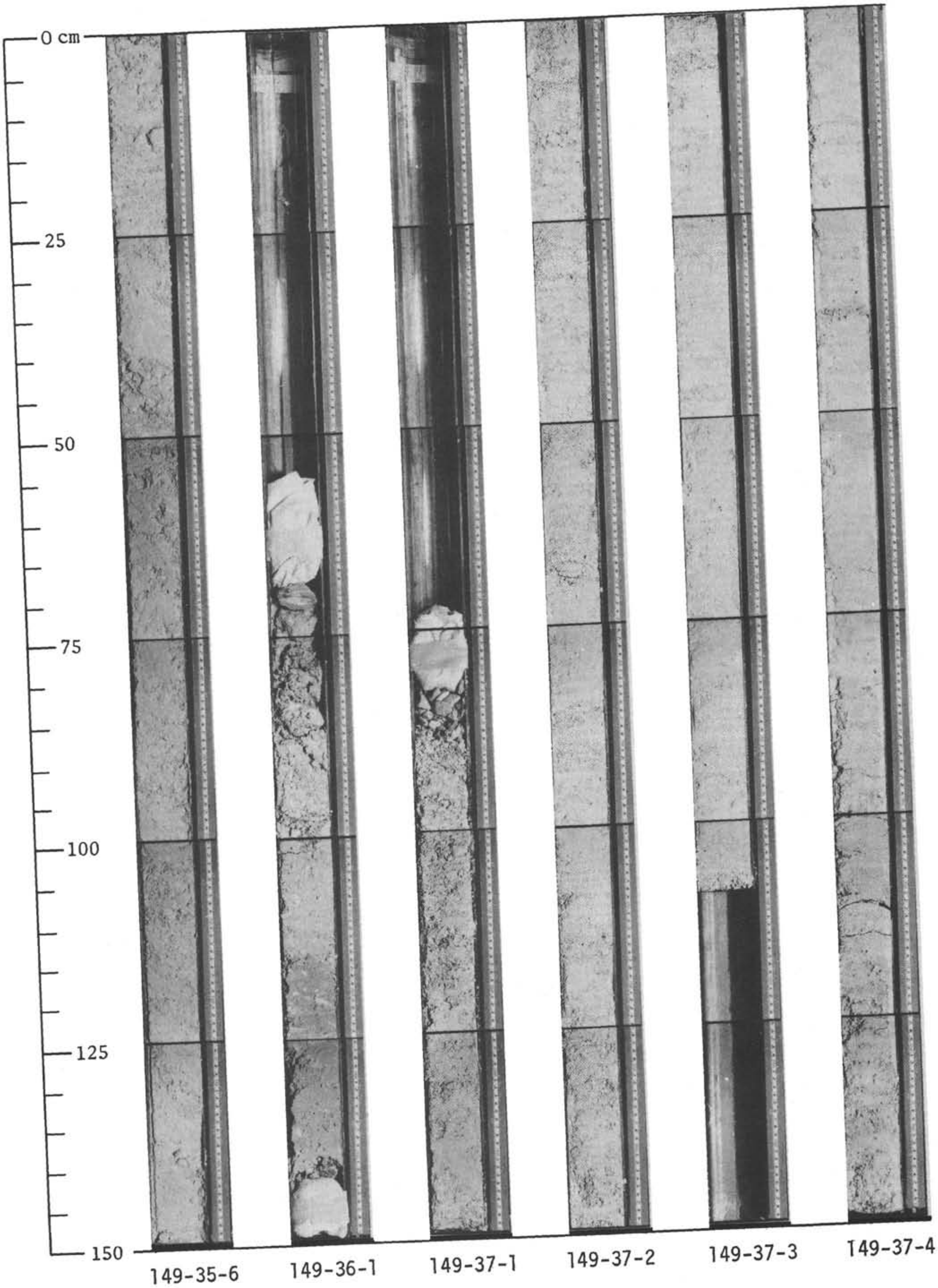
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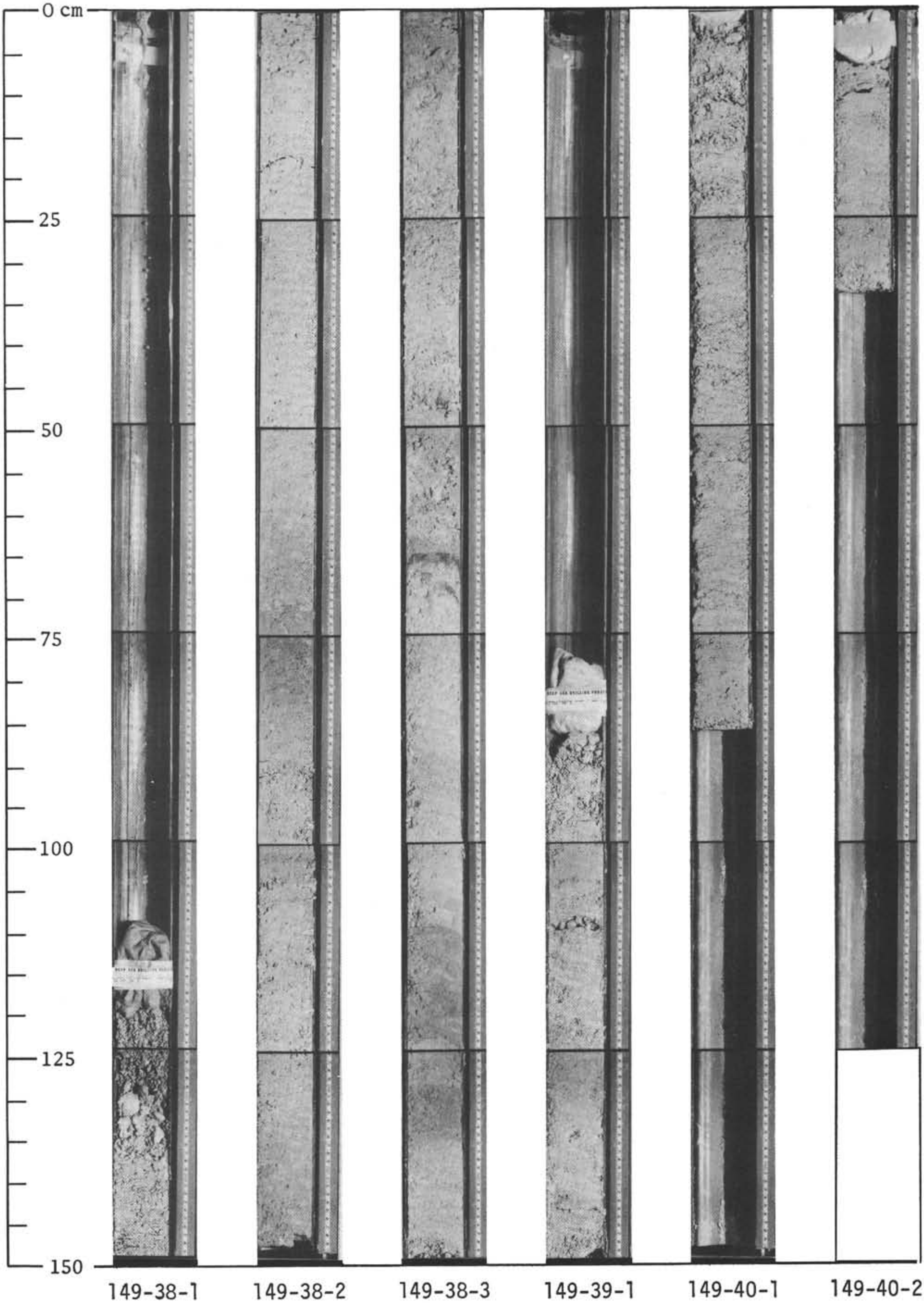
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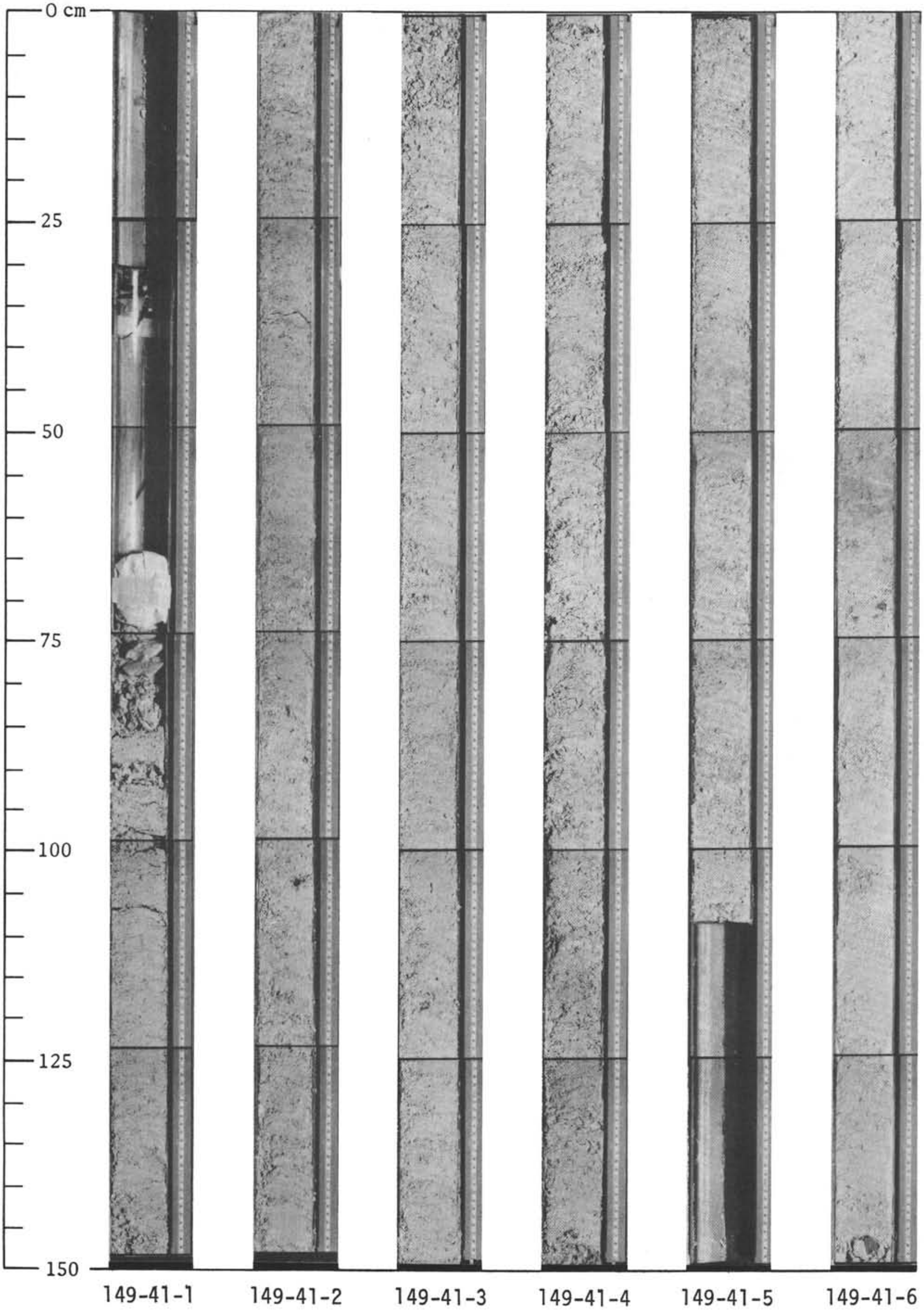
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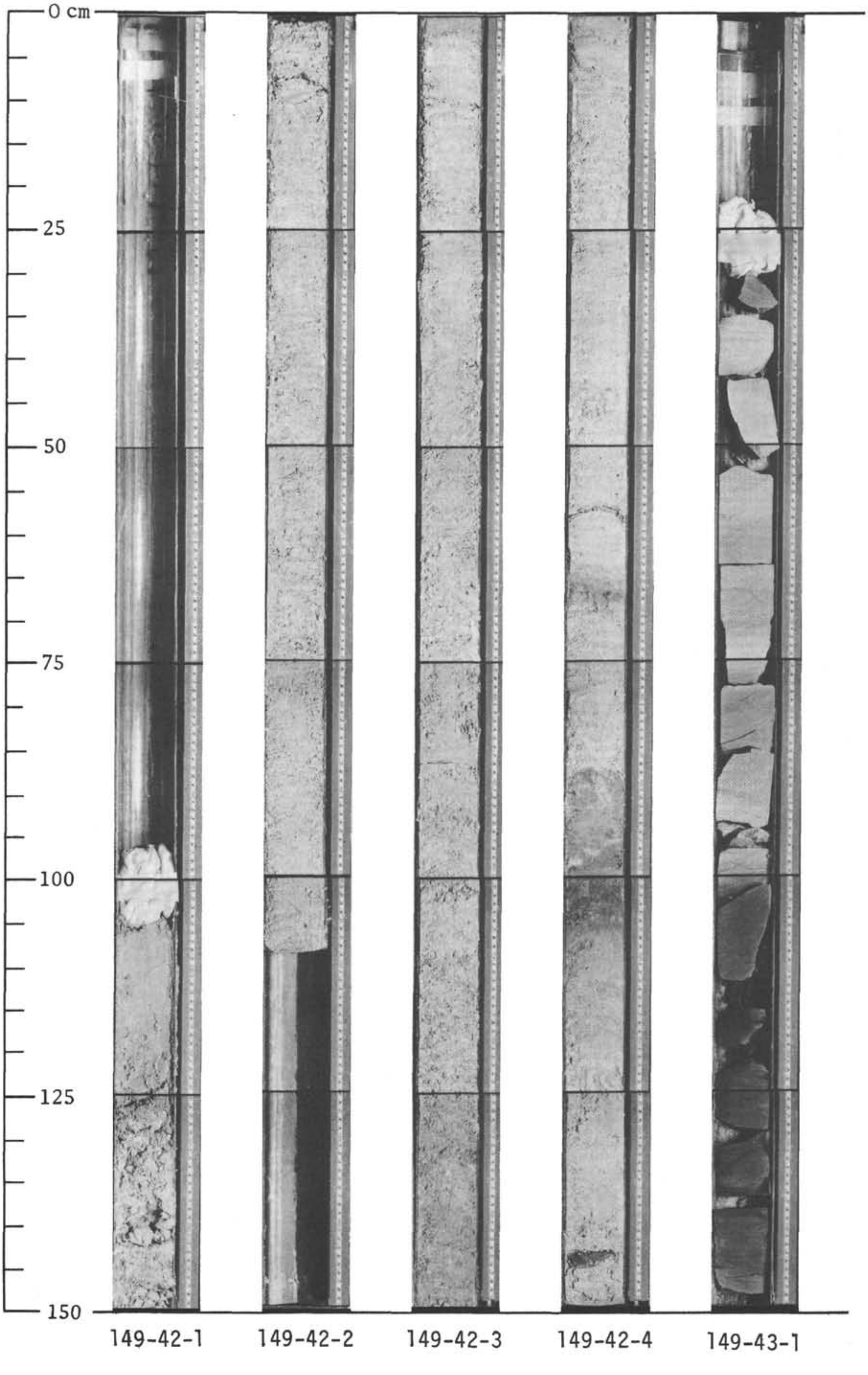
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