9. SITE 154

Shipboard Scientific Party[1]

Position:
154: 11°05.11'N; 80°22.75'W
154A: 11°05.07'N; 80°22.82'W.

Water Depth: 3,338 meters.

Penetration:
154: 278 meters
154A: 127 meters.

Recovery:
154: 66 meters (50%)
154A: 130.6 meters (77%).

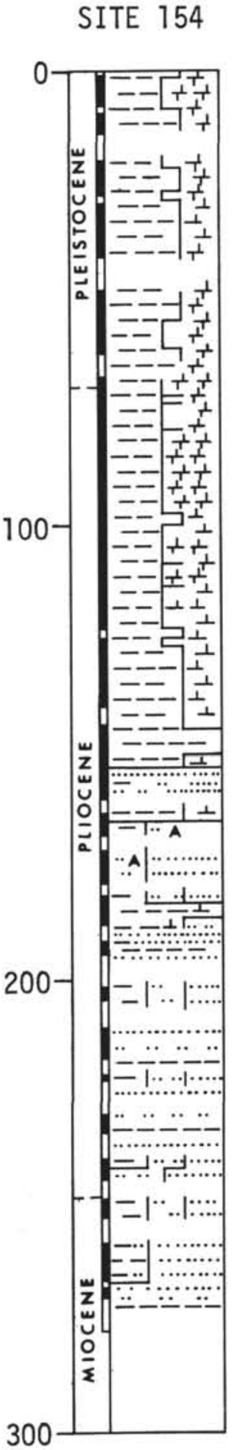
ABSTRACT

A reflector at 0.2 sec reflection time below the crest of the ridge can be traced beneath the terrigenous sediments of the surrounding basin. The cores indicate that this reflector is associated with the abrupt transition from Middle Pliocene and younger pelagic sediments to underlying Pliocene and Miocene terrigenous sands. This transition marks the time of elevation of a ridge above the level of the surrounding ocean floor. The lower terrigenous unit is derived dominantly from calc-alkaline volcanic centers in southern Central America. The upper pelagic unit of marl and calcareous clay contains sediment probably derived from Colombia.

BACKGROUND

The Colombian Basin, unlike the Venezuelan Basin is covered by a thick layer of acoustically stratified sediments. These overlie acoustically transparent sediments in the northern part of the basin, but in the south where the stratified sediment is apparently thicker, the acoustic nature of the underlying sediment has not yet been reported.

Seismic refraction profiles shot in the southern Colombian Basin (Ewing et al., 1960) indicate less than 2 km of 2.0 km/sec (unconsolidated) sediment overlying a layer of 4.6 km/sec rock. Along the continental margin of Colombia, 2.1 and 3.5 km/sec sediment and sedimentary rock increase in thickness to about 6 km. Underlying the 4.6 km/sec layer are two crustal layers, 6.0 and 7.0 km/sec layers. One mantle velocity of 8.2 km/sec was recorded.



In the southwestern part of the basin, about 200 km north of Panama, a topographic high was found by Lamont-Doherty Geological Observatory's vessel *Robert D. Conrad* (Figure 1) and was discussed by Edgar et al. (1971).

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It was of interest because it is capped by acoustically transparent sediments, apparently inaccessible to turbidites, and offered about the only opportunity to core pelagic sediments in the predominantly terrigenous regime of the Colombian Basin. One strong reflector can be seen on the profiler records at about 0.2 sec reflection time in the acoustically transparent sediments that can be traced beneath the stratified sediments of the surrounding area. Note that where there is a change in slope of the ocean floor, there is a corresponding change in facies from stratified sediment in the basin to accoustically transparent sediment on the ridge. Lamont's *Vema* made a site survey over the area before *Glomar Challenger* arrived on site and established that the feature is a north-south trending ridge, probably a fault block, with a steep west-facing escarpment (see site survey, Appendix). Figure 2 is a profiler record made by the *Glomar Challenger* on her approach to the site. The track for all these profiler records is shown in Figure 3.

OBJECTIVES

From the profiler record (Figure 2) it was clear that old pelagic sediments could be recovered at much shallower depths below the ocean floor at this site than if the site had been located in the stratified sediments covering the rest of the Colombian Basin. Old sediments recovered here would provide the only control in the southwestern Caribbean, a critical area in the later history of this region. Although the emergence of the isthmus in the Middle Pliocene has been well documented from the studies of mammal migration (recent references, Whitmore and Stewart, 1965; Hallam, 1972) and micropaleontology (Kaneps, 1970), a study of the detailed biostratigraphy and volcanic history at a site adjacent to the isthmus would be a valuable goal. The volcanic history could be compared to that found at Site 148 on the Aves Ridge.

OPERATIONS

The *Glomar Challenger* approached the site from the east, at 1600 hours on 29 January, crossed the ridge, and then doubled back to drop a beacon and begin drilling operations. The first hole was spot cored to 164 meters and continuously cored to 277 meters. The presence of hydrocarbons, the abundance of coarse sand, and the discovery of a very high sedimentation rate all forced the decision to abandon the hole. An offset hole, 154A, was cored continuously from the surface to 172 meters in order to obtain a complete core recovery from this site. The hole was abandoned at 0830 hours on 1 February and the ship departed immediately for Cristobal, Panama.

LITHOLOGY

The sediments at Site 154 are broadly divisible into an upper pelagic sequence (marl ooze and clay) and a lower volcanic-terrigenous sequence (sands, silts, and clays). The boundary between the two units is in the earliest Pliocene.

The upper pelagic sequence is further divisible by variations in the carbonate content into a calcareous clay and marl ooze (0-72 m), a nannoplankton marl ooze (72-127 m), and a calcareous clay (127-153 m). The calcareous clay-marl ooze unit is generally homogeneous and medium bluish gray with the upper ten meters light olive gray and with several light olive brown zones. The major sedimentary components are nannofossils, foraminifera, and clay, with variable pyrite. Beds of higher carbonate content within this subunit are conspicuously richer in foraminifera. Volcanic constituents are rare except in disturbed pockets of ash, which is dominantly pumice with minor plagioclase and hornblende. Additionally, these components along with minor phillipsite, clino-, and orthopyroxene were found dispersed throughout the entire upper sequence. A special correlation problem concerns the occurrence of pockets at Site 154, Core 1 (depth 52-61 m) of a coarse volcanic sand which occurs nowhere else in the upper sequence, but which is abundant in the lower sequence. This sand, which has conspicuous pyroxenes, red hornblende, and minor quartz and alkali feldspar, as well as plagioclase and green hornblende, appears to have been reworked from the older sequence, very possibly as a local turbidite.

Below the upper subunit occurs a light bluish gray to medium bluish gray nannoplankton marl ooze (72-127 m) which differs from the uppermost subunit by its slightly higher carbonate content and which is not so obviously correlated with the higher content of foraminifera. Pyrite is more conspicuous in this interval and volcanic constituents are relatively rare. Dolomite crystals are rare but widespread.

The lowermost subunit is a medium bluish gray calcareous clay (127-153 m) which is mottled and shows sulfide staining. The coarse fraction (foraminifera and pyrite) constitutes less than 1 per cent and carbonate decreases downward through the unit from 20 to 5 per cent. Pyrite and dolomite are locally conspicuous.

Beneath the pelagic unit is a strongly contrasting terrigenous sandy unit (153-280 m) which consists of interbedded volcanic sands, silts, and clays. The upper contact of this unit is sharp; in Hole 154 it occurred in an interval of 5 cm at a depth of 167 m. In Hole 154A the contact itself was not recovered but occurred at about 153 meters. The sediments are predominantly dark olive gray to greenish black volcanic silts and olive black volcanic sands. A few rounded clasts evidently representing downhole contamination were found.

Sedimentary structures are rarely preserved; most striking are sharp contacts between medium coarse sands and overlying fine sands or silty clays. Several sand contacts are apparently erosional. Size-graded bedding with the finer fraction forming the upper part was identified in only three sections: 154-3-3, 154-4-1, and 154-5-3. Extensive drilling disturbance has probably obscured almost all of the sedimentary structure and probably other occurrences of size grading.

The dominant constituents of the sands are volcanic minerals: clinopyroxene, orthopyroxene, and plagioclase are abundant; red and green hornblende common; and alkali feldspar, quartz, biotite, apatite, and zircon are rare. Phillipsite is a conspicuous authigenic mineral. Clinoptilolite has been found in X-ray diffraction (C. Fan et al., X-ray Mineralogy ..., this volume). Authigenic K-feldspar was identified optically in one sample and detected by x-ray diffraction in several others. Glass and rock fragments (pumice or porphyritic andesite) are locally common.

Biogenic detritus is common and includes foraminifera (including shallow-water benthonics), wood (Figure 4), mollusk shell fragments, and leaves. Many of the indurated zones display burrowing.

PHYSICAL PROPERTIES

Wet-bulk Density, Water Content, and Porosity

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 (the sample data are the enclosed dots in the hole and core plots). Water content was determined by weight-weight relationships. In general, these data have a precision of about ±5 percent. Methods, errors, corrections, assumptions, disturbed sediment, and interpretation precautions are discussed in Appendix I.

Core 1 of Site 154 was recovered using a 2.25-inch internal diameter extended core barrel rather than the normal 2.60-inch internal diameter core barrel. Correction for this anomalous diameter was calculated by the following formula:

$$\text{corrected density} = A + A\frac{(2.60\text{-}2.25)}{2.25}$$

$$= 1.155\,A$$

where, A = apparent GRAPE density

In general the sediments at Site 154 are highly disturbed and therefore do not represent in situ conditions; however, the data is important as it serves as a control for the natural gamma data. The individual sample data, however, are probably more representative of undisturbed conditions than the GRAPE data; therefore, the sample data are discussed below.

Results

The individual density samples suggested that the Pleistocene-Pliocene foraminifer nannofossil calcareous clays and marls from 50 to 150 meters have densities of 1.50 to 1.67 g/cc (67 to 56% porosity) with 1.60 to 1.67 g/cc being typical (60 to 56% porosity). A single sample from the volcanic sandstone had a high density of 1.80 g/cc (35% porosity).

Water contents from the Pleistocene-Pliocene nannofossil foraminiferal calcareous clays and marls were between 34 and 46 percent with 34 to 41 percent being typical. The Pliocene volcanic sand had a water content of 20 percent.

Sound Velocity

Sound velocities through sediment and rock samples were measured by the Hamilton Frame technique, which is discussed in Appendix I. This method has a precision within ±1.1 percent.

Sonic velocity was measured only on sediments and rocks which appeared to be physically undisturbed. These velocities were measured parallel to the bedding planes unless otherwise noted in Table 1 and were measured at laboratory pressures and temperatures (27.2 and 28.5°C).

Results

The cores, other than the Pliocene-Miocene volcanic sandstone, siltstone, and claystone, are highly disturbed; therefore, their velocities were not measured. Velocities through the volcanic sandstone and sandy siltstone from 140 to 260 meters were 1.74 to 1.91 km/sec. A limestone fragment, however, in Core 4 has a sonic velocity of 4.19 km/sec.

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. Methods, equipment, error, porosity correction, and sediment disturbance are discussed in Appendix I. The following data are not corrected for varying porosities, and the sediments are highly disturbed.

Core 1 of Hole 154 was recovered in the extended core barrel which had a 2.25-inch internal diameter compared to the normal 2.60 inches. The volumetric difference between the two core sizes, per unit length, relative to the smaller core is 33.7%; therefore, the natural gamma counts of the 2.25-inch cores were increased by 33.7%.

Pleistocene and Pliocene (volcanic detritus in some cores) foraminiferal nannofossil clacareous clay and marl and Miocene volcanic sands, silts, and clays emitted gamma counts from 300 to 1400 per 1.25 min, along each 7.62 cm interval. There did not appear to be an overall systematic variation of natural gamma radiation with major sediment types (other than porosity) or with age or depth.

Penetrometer

Needle penetration tests were conducted at Site 154 with a 1-mm diameter needle. The methods, equipment, and sediment disturbance are discussed in the Appendix.

Penetration tests were performed on cores between 100 and 200 meters below the sea floor, where penetration decreased with increasing depth until it was nil at 200 meters depths. Pliocene foraminifer nannofossil marl ooze, from 108 to 117 meters, was penetrated 2 to 6 mm, while Pliocene volcanic silt and sand from 173 to 182 meters and volcanic clay and volcanic calcareous clay from 182 to 192 meters were penetrated 5 to 6 mm and 1 to 3 mm, respectively. Penetration was nil in Pliocene volcanic sandy silt at a depth of 192 to 202 meters.

BIOSTRATIGRAPHY

Of two major lithic units recognized at this site, only the upper series of calcareous clays and marl oozes contains abundant planktonic fossils useful for biostratigraphy. This pelagic sequence extends from the surface to a depth of 153 meters and was continuously cored in Hole 154A where it extends into the top of Core 17. The following discussion utilizes the numbers of cores from Hole 154A, which contains abundant planktonic foraminifera and calcareous nannofossils but is devoid of radiolaria. The Holocene and youngest Pleistocene were not sampled. *Globorotalia tumida flexuosa* was not found in a sample from Section 1 of Core 1 immediately below the sediment surface, and the uppermost material may be younger than the *Globigerina calida calida* Subzone of the *Globorotalia truncatulinoides truncatulinoides* Zone. That the top of the core may be a condensed section of young Pleistocene is

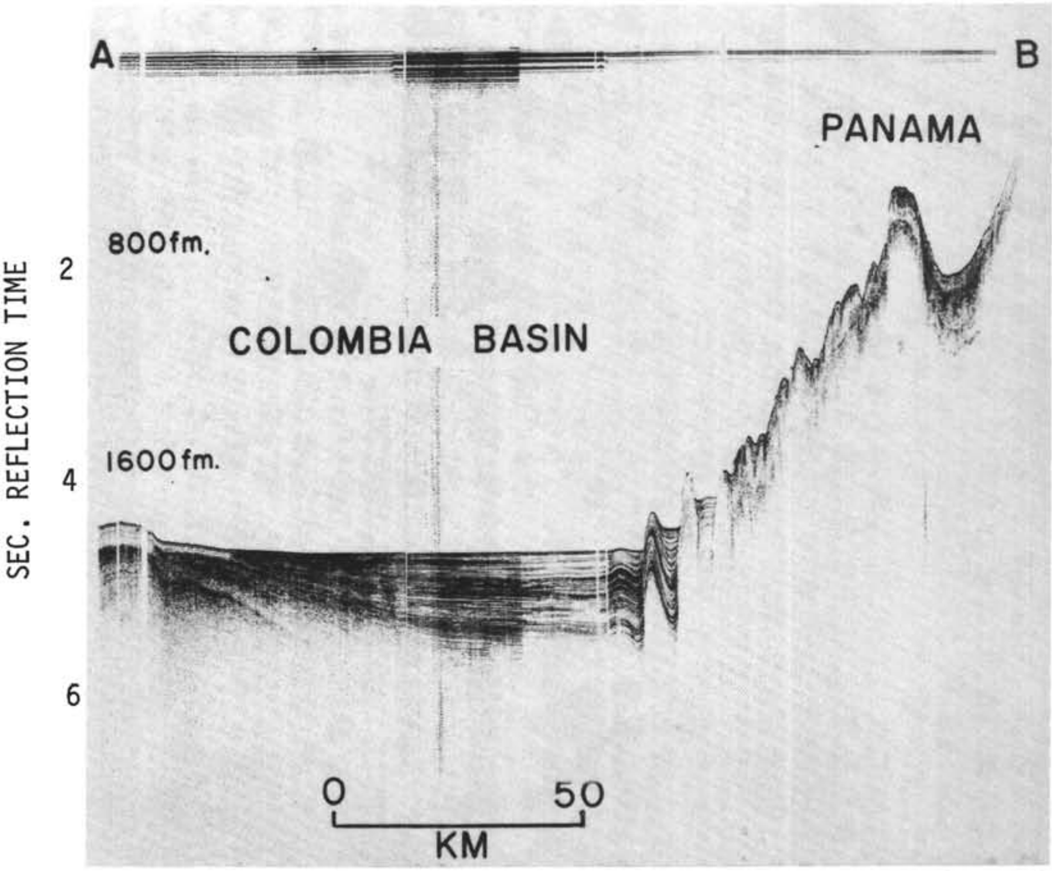

Figure 1. *Profiler record made by Lamont's Robert D. Conrad extending from area of Site 154 on the left to Panama on the right. Note facies change from stratified to pelagic sediments associated with change in topography. Folding and the foot of the continental slope is apparently active at present. (Edgar* et al., *1971).*

further indicated by the highest occurrences of *Gephyrocapsa kamptneri* and *Gephyrocapsa sinuosa* in Section 2 of Core 1. The lowest occurrence of *Emiliania huxleyi* lies between samples from Section 2 and 3 of Core 1, so that Sections 1 and 2 are assigned to the *Emiliania huxleyi* Zone. Core 1 below Section 1 definitely belongs to the *Globigerina calida calida* Subzone.

Cores 2 to 7 belong to the *Globorotalia hessi* Subzone, the lowest occurrence of *Globorotalia hessi* marking the base of this zone. The lowest occurrence of *Gephyrocapsa oceanica* at this site lies within Section 6 of Core 4, so that most of Cores 4 and 1 and all of Cores 2 and 3 belong to the *Gephyrocapsa oceanica* Zone. It should be noted that at Sites 148 and 151, the lowest occurrence of *Gephyrocapsa oceanica* and *Globorotalia hessi* nearly coincide, the nannoplankton species appearing a few meters below the planktonic foraminifer at Site 148 and the two events being within an unsampled interval of less than 2 meters. At Site 154 these two events do not coincide but are separated by about 30 meters. This may indicate that hiatuses are present at Sites 148 and 151, that very rapid sedimentation occurred at Site 154 during this time, or that the species invaded the Colombian Basin at different times, *Gephyrocapsa oceanica* lagging behind *Globorotalia hessi.*

The lowest occurrence of *Globorotalia truncatulinoides truncatulinoides* lies between samples from the upper parts of Sections 3 and 4 of Core 8, and Sections 1, 2, and most of 3 of this core are assigned to the basal Pleistocene *Globorotalia crassaformis viola* Subzone of the *Globorotalia truncatulinoides truncatulinoides* Zone. The highest occurrence of *Discoaster brouweri* lies in the middle of Section 3, the interval above this to the middle of Section 6 of Core 4 being referred to the "*Gephyrocapsa caribbeanica*" Zone.

The highest occurrence of *Globorotalia miocenica* lies between Cores 9 and 10, so that Sections 4, 5, and 6 of Core 8 and all of Core 9 belong to the Late Pliocene *Globorotalia truncatulinoides* cf. *tosaensis* Zone. Core 10 belongs to the *Globorotalia exilis* Subzone of the *Globorotalia miocenica* Zone. The base of the *Discoaster brouweri* Zone, marked by the highest occurrence of *Discoaster pentaradiatus,* lies between samples from Sections 4 and 5 of Core 10. The highest occurrence of *Discoaster pentaradiatus* within the *Globorotalia exilis* Subzone was also noted at Site 148.

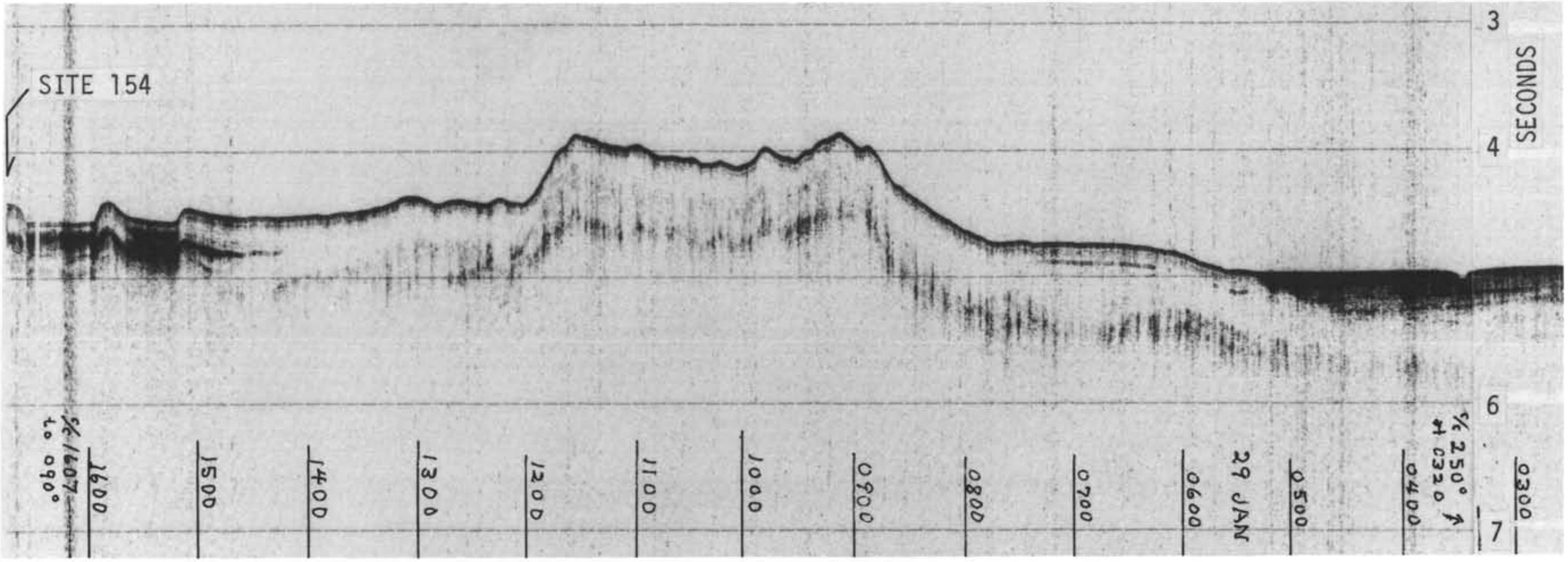

Figure 2. *Profiler record made by* Glomar Challenger *on approach to Site 154. Fault origin of the small rise is evident. Broad rise has been high for a longer time than fault block that was drilled as evidenced by termination of terrigenous Pliocene sediments (reflector at 0.3 sec) on to the rise.*

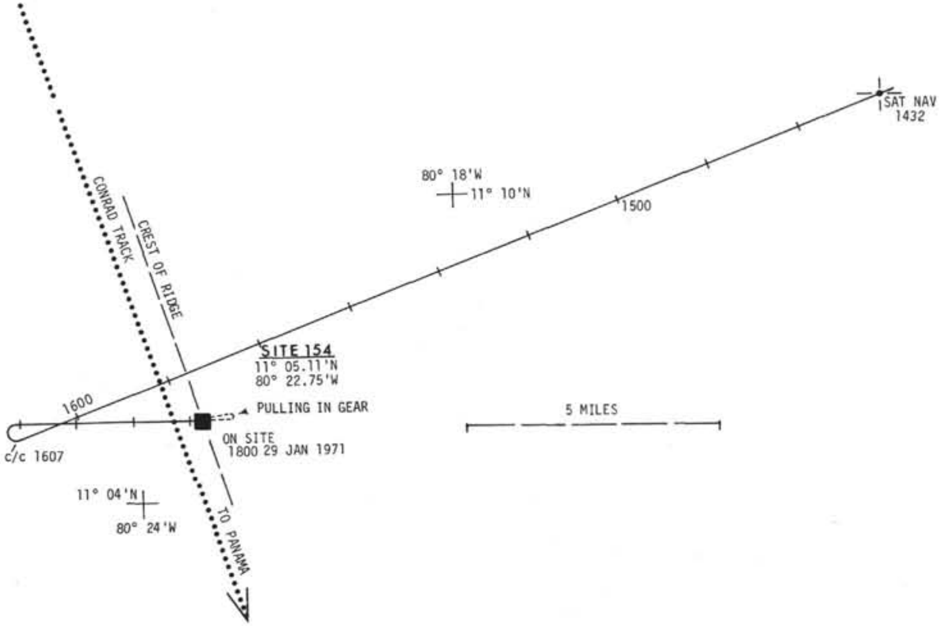

Figure 3. *Track of Robert D. Conrad and* Glomar Challenger *for profiler records shown in Figures 1 and 2.*

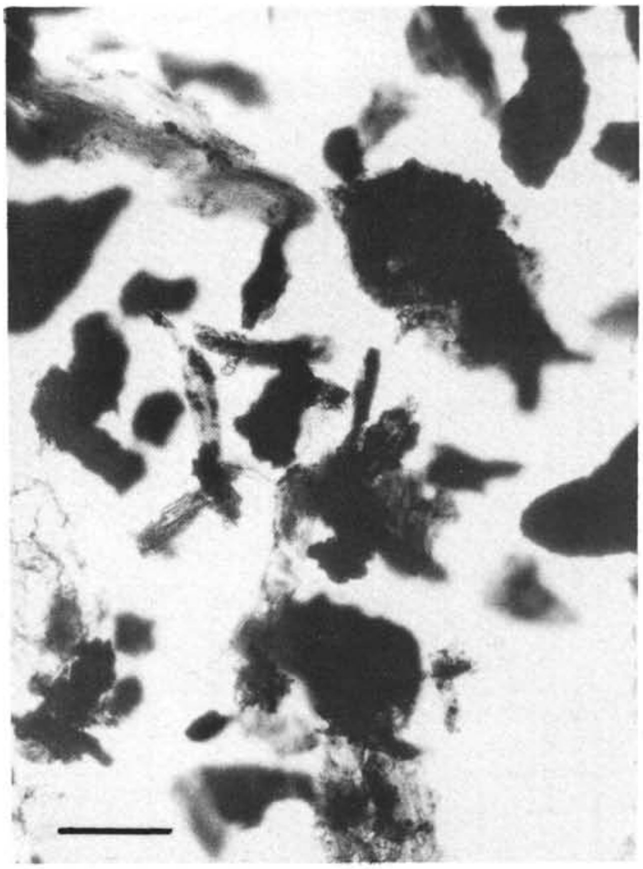

Figure 4. *Photomicrograph of smear slide of turbidite and sand showing wood fragments, Miocene. Bar is 100 microns long (154/14,CC).*

The highest occurrence of *Globorotalia margaritae evoluta* is between samples from Sections 3 and 4 of Core 12, so that all of Core 11 and the upper part of Core 12 belong to the *Globigerinoides trilobus fistulosus* Subzone of the *Globorotalia miocenica* Zone. The highest occurrence of *Discoaster surculus*, which marks the base of the *Discoaster pentaradiatus* Zone, is difficult to fix with precision because calcareous nannoplankton assemblages begin to show dissolution effects below Core 11 and diversity correspondingly decreases. The limit between the *Discoaster pentaradiatus* and *Discoaster surculus* zones is better defined in Core 2 from Site 154 and must lie in the lower part of Core 12 in Hole 154A. This limit falls within the *Globorotalia trilobus fistulosus* Zone, as at Site 148.

The lower part of the pelagic sequence in Hole 154A belongs to the *Globorotalia margaritae* Zone. The two subunits, *Globorotalia margaritae evoluta* Subzone and *Globorotalia margaritae margaritae* Subzone are recognizable, the limit between them lying between samples from Sections 1 and 2 of Core 14. The distinctive calcareous nannofossil *Reticulofenestra pseudoumbilica* is present in samples below Section 2 of Core 15, defining the top of the *Reticulofenestra pseudoumbilica* Zone.

Spot cores in the pelagic sedimentary section of Hole 154 correlate with the continuously cored Hole 154A as follows: Core 1, which by its depth should lie in the *"Gephyrocapsa caribbeanica"* Zone contains an assemblage of the *Geophyrocapsa oceanica* Zone throughout, which leads to the suspicion that all of the material sampled may have slumped from higher in the hole. Core 2 contains the *Discoaster pentaradiatus-Discoaster surculus* Zone transition and correlates exactly by depth with the same interval in Cores 12 and 13 of Hole 154A. According to its depth, Core 3 of Hole 154 should have sampled only volcanic sediments. However, it contains pelagic sediments of the *Globorotalia margaritae margaritae* Subzone and the *Discoaster surculus* Subzone. On the basis of detailed analysis of the planktonic foraminifera (see Bolli and Premoli Silva, this volume) it appears that this material has slumped from approximately the level of Core 15 of Hole 154A. Core 5 of Hole 154 also contained some apparently slumped material mixed with older volcanics.

The lower part of the section cored continuously at Hole 154 (Cores 3-14, 164-277 m) consists largely of volcanic sediments. Planktonic foraminifera of the *Globorotalia margaritae* Zone (Early Pliocene) are rare but occur in samples from Cores 3, 5, 7, 8, 9, 10, and 11. Poor assemblages from Cores 12 and Section 1 of Core 14 may belong to either the *Globorotalia margaritae* Zone or to the Late Miocene *Globorotalia acostaensis* Zone. The catcher sample from Core 14 contains but a single species, *Globorotalia acostaensis*, and is referred to the *Globorotalia acostaensis* Zone. A few calcareous nannofossils also occur, the most significant being *Ceratolithus tricorniculatus* in Section 2 of Core 11, indicating an early Pliocene or latest Miocene age.

CONCLUSIONS

The lithic transition in the Early Pliocene from a sandy terrigenous sequence to a pelagic sequence at Site 154 reflects a topographic transition from a position on a basin floor to one elevated above this floor where it is inaccessible to downslope sediment movement and turbidity flows. This relative uplift is probably the result of tectonic activity. The transition correlates with the depth of the strong reflector at 0.2 sec reflection time. The age of inception of folding of basinal turbidites (Figure) on the Caribbean side of the Panamanian isthmus is not independently known, but the paleontology of Site 154 suggests an earliest Pliocene age at this locality. The detritus of the lower unit is clearly terrigenous both in composition and size. The provenance is less certain, but the abundance and coarseness of calc-alkaline volcanic constituents suggests Panama and Costa Rica (where, according to Terry, 1956, vulcanism has been widespread since late Eocene) rather than Colombia. The transition at Site 154 is nearly correlative with an episode of widespread folding and uplift on the isthmus which Terry (1956) places within the middle Miocene.

The carbonate content of the upper pelagic unit undergoes a steady increase upward from 155 to about 100 meters and then decreases very slightly and irregularly to the present. The carbonate increase to 100 meters (which is in the *Discoaster pentaradiatus* Zone, late Pliocene) is strikingly coincident with the evidence from vertebrate paleontology for the final emergence of the isthmian land bridge: the first South American ground sloths appeared in

TABLE 1
Hamilton Frame Sonic Velocities, Site 154

Core	Section	Upper Interval[a] (cm)	Depth in Hole (m)	Velocity[b] (m/sec)	Temperature (°C)	Remarks
Hole 154						
4	1	132.0	174.32	4190	27.2	Limestone fragment.
5	6	51.0	190.01	1741	28.5	Sandstone, volcanic.
5	6	71.0	190.21	1827	28.5	Sandstone, volcanic.
14	1	78.0	268.78	1908	28.4	Sandy siltstone, volcanic.
Hole 154A						
17	6	80.0	161.30	1728	29.2	Silty clay, volcanic, semilithified.
17	6	80.0	161.30	1714	29.2	Silty clay, volcanic, semilithified.

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

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

Florida in middle Pliocene times and glyptodonts in late Pliocene, while North American carnivores, ungulates, and mice suddenly appear in South America at this time. The raising of the isthmian land bridge may be reflected in the inferred tectonic uplift of Site 154 in earliest Pliocene and the increase in carbonate content in the lower part of the pelagic sequence. The increase in carbonate could be explained by an increase in local productivity related to a change in surface ocean current regime, a change in the lysocline depth, also related to current changes, or a change in the amount of diluting near-bottom clay as the ridge is raised above a persistent quasi-nepheloid layer which may accompany the abundant turbidites covering the floor of the Colombian Basin. Our inability to date with sufficient accuracy the zonal boundaries within the upper unit prevents us from determining whether there was an increase or decrease in total sedimentation throughout this interval, and the selection among the three alternatives is not certain.

The lower terrigenous sequence bears a resemblance to the highly organic sediments of the Cariaco Basin (Site 147) in the high organic matter content and the cooccurrence of dolomite and gypsum. Although reduced carbon values are variable, about one-fourth at Site 154 are greater than 1 per cent and one sample contains 5.9 per cent. Dolomite has been found in the terrigenous sequence as a prominent constituent in a smear slide (Sample 154-10-2, 99); x-ray analysis also revealed dolomite in Core 13. Dolomite is also present in minor amounts in the calcareous clay subunit of the upper, pelagic sequence (Cores 10 through 16 of Hole 154A). Gypsum was found in the upper part of the lower terrigenous sequence (Sample 154-4-3, 13-14.5) and interpreted as grains in a turbidite. The abundance of pyrite in both sequences is also noteworthy.

Quartz and plagioclase are both common constituents in the upper and lower sequences. Plagioclase is conspicuous in smear slides and is evidently the principal volcanic component of the lower terrigenous sequence. Quartz is only rarely identifiable in this sequence; apparently the bulk of the quartz is a fine-grained, dispersed terrigenous component in both sequences. The ratio of quartz to plagioclase (as determined by x-ray diffraction, Fan et al., X-ray Mineralogy . . ., this volume) changes abruptly at the contact between the two units. In the lower sequence it averages 0.7±0.5 and in the upper 2.4±0.6, the change reflects a contrast in provenance: the lower sequence is dominantly derived from calc-alkaline volcanic centers (high plagioclase, low quartz) in southern Central America, while the upper sequence is probably derived from a sedimentary-metamorphic provenance (high quartz, low plagioclase) of the Magdalena River in Colombia. One occurrence of gibbsite (x-ray diffraction of Core 14, Hole 154A) supports this view.

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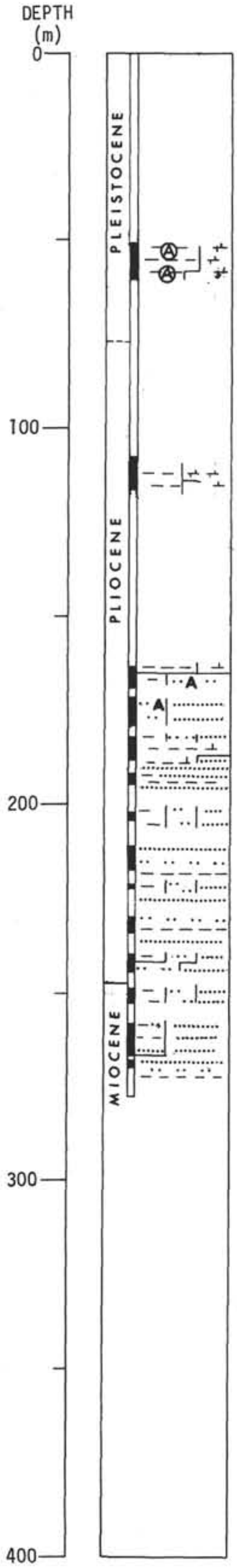
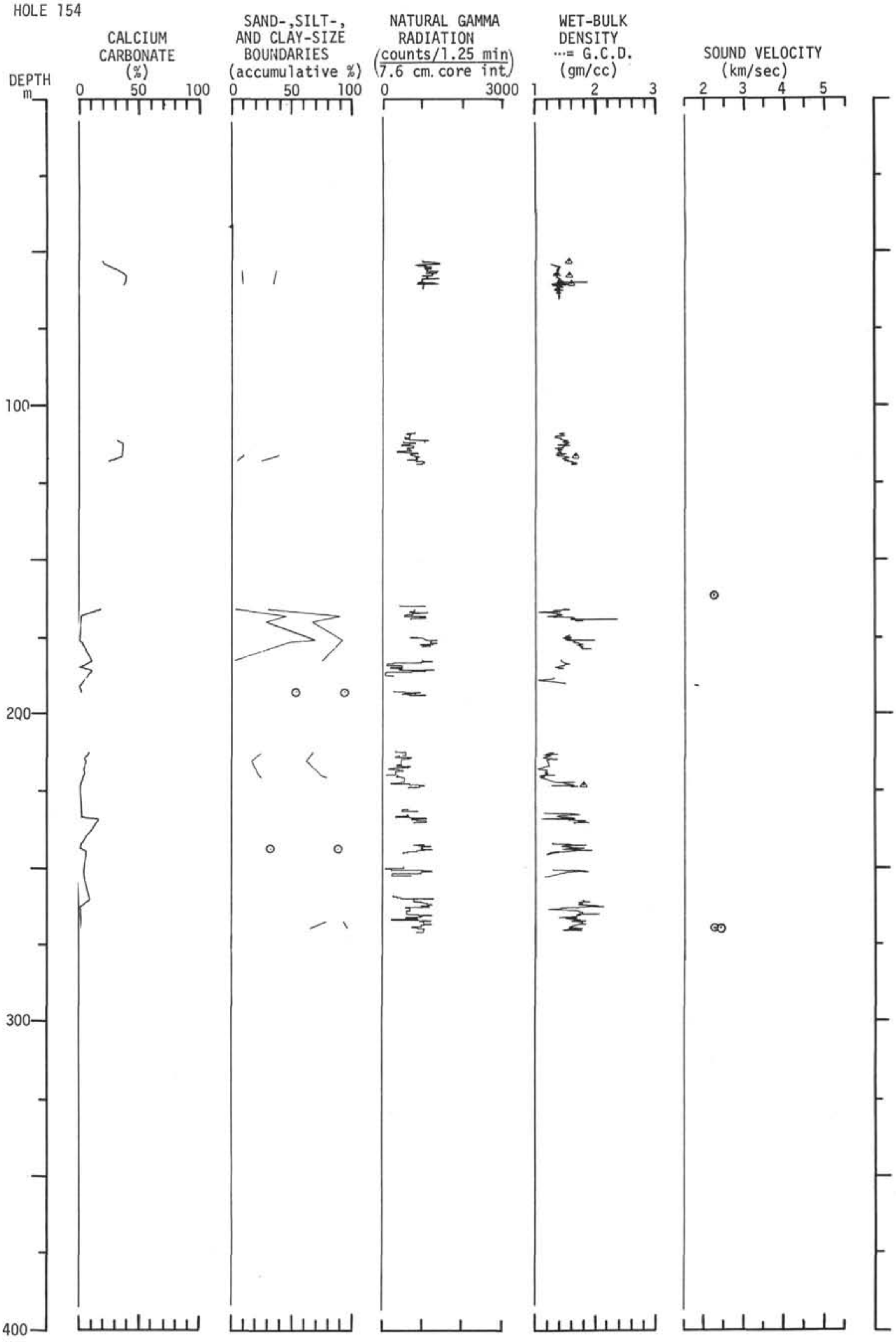
HOLE 154

LITHOLOGY



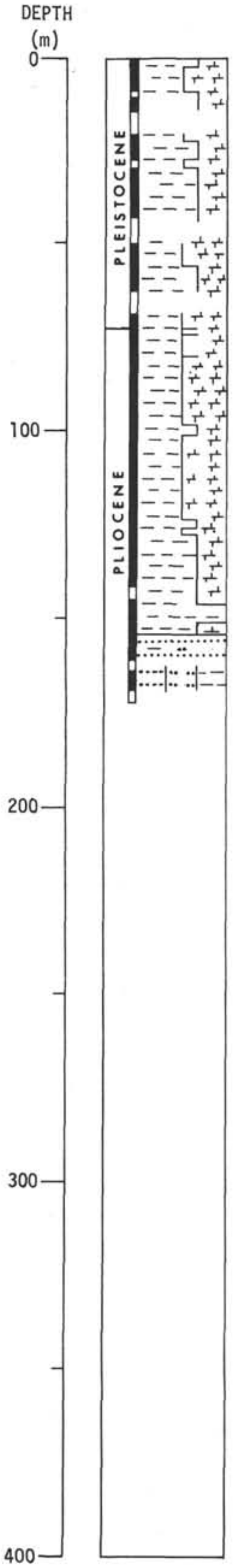
UNITS	SUBUNITS OR DESCRIPTION
UNIT 1 (0-277 m) FORAM-NANNO and NANNO MARLS, and CALCAREOUS-RICH CLAYS	Core 1 VOLCANIC CALCAREOUS CLAY interbedded with FORAMINIFERAL NANNOPLANKTON MARL OOZE, bluish gray and dark greenish gray. Core 2 FORAMINIFERAL NANNOPLANKTON MARL OOZE and CALCAREOUS CLAY light to medium bluish gray. NANNOPLANKTON CALCAREOUS CLAY, *medium bluish gray; lower contact at 167.17* m.
UNIT II (167.17* to 277 m T.D.) VOLCANIC SANDS, SILTS, and CLAYS	(167.17* to 277 m T.D.) VOLCANIC SANDS, SILTS, and CLAYS, olive black, some size graded bedding (coarser lower contact). Occasional carbonaceous matter. (211 to 215 m) and wood fragments (240 to 243 m).

*This contact in hole 154A was at 153 m.


HOLE 154
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

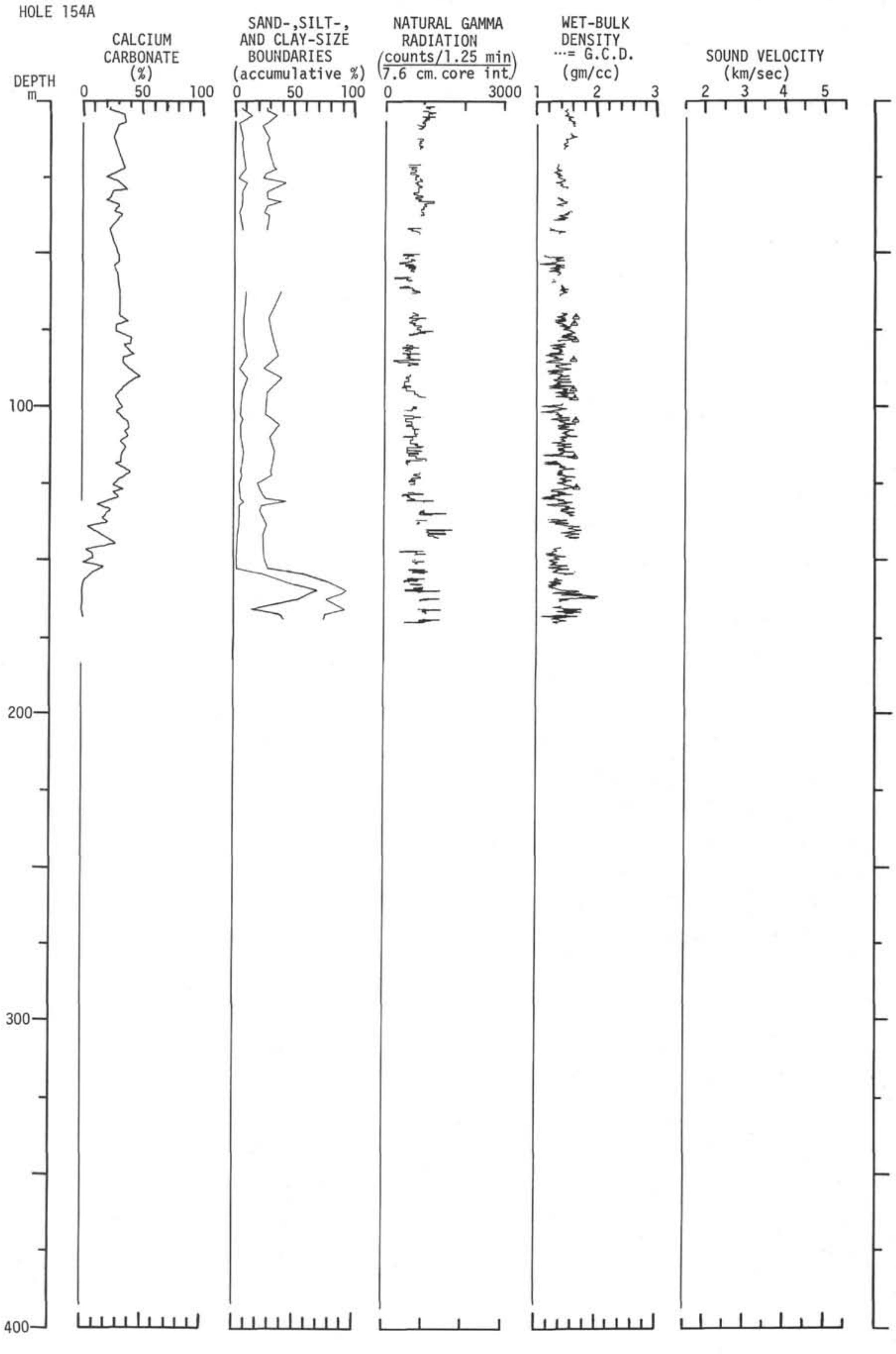
HOLE 154A

LITHOLOGY

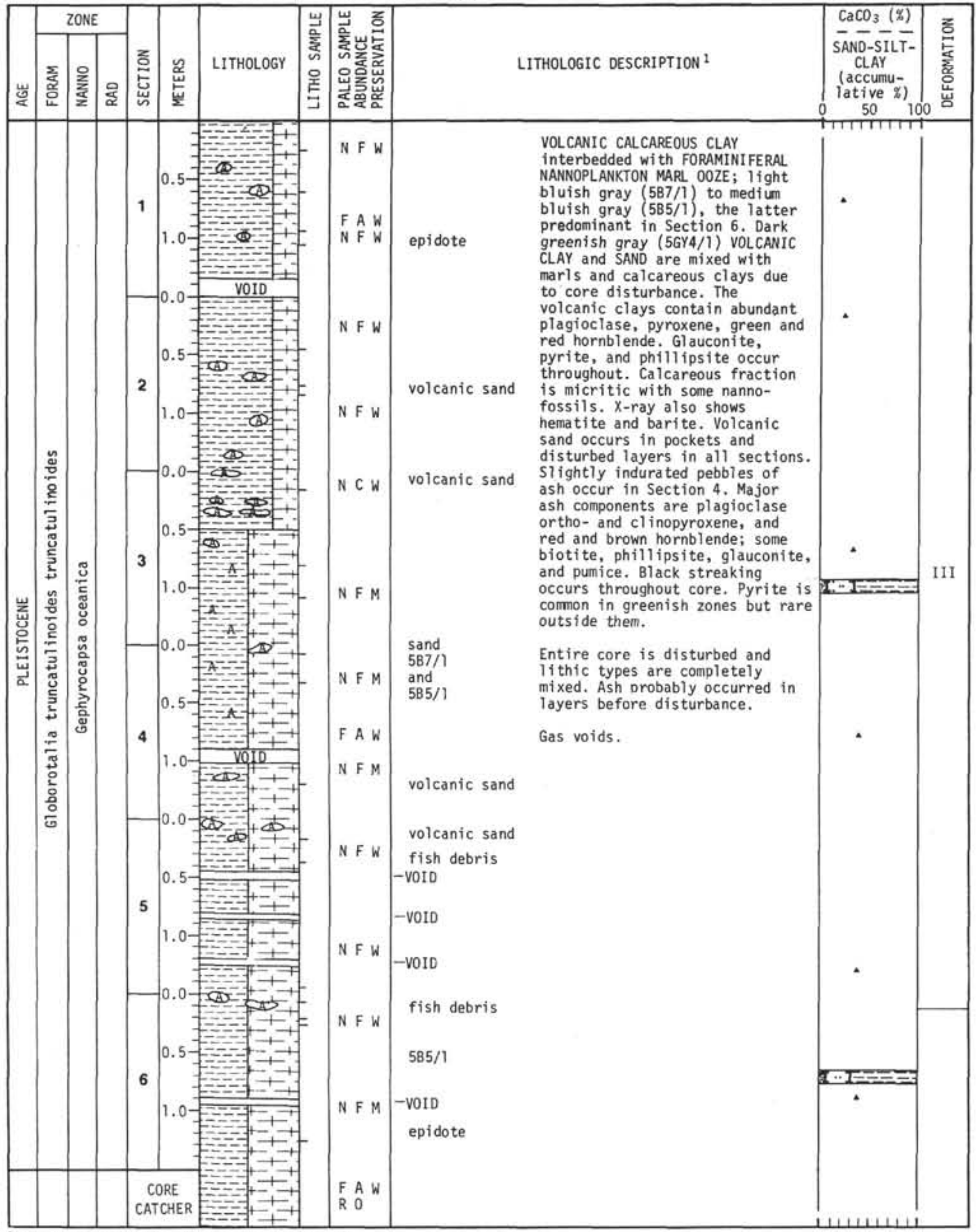


UNITS	SUBUNITS OR DESCRIPTION
UNIT I (0 to 153*m) FORAM NANNO and NANNO MARLS and CALCAREOUS RICH CLAYS	Subunit a. (0-72 m) FORAM NANNO RICH CLAY with interbedded FORAM NANNO MARL OOZE; light olive gray to medium light gray. Some volcanic ash layers between 34 and 60 meters, in addition to pumice fragments.
	Subunit b. (72 to 127 m) FORAM NANNO MARL OOZE with interbedded FORAM NANNO RICH CLAY; medium gray, light bluish gray to greenish gray.
	Subunit c. (127 to 153 m) NANNO RICH CLAY, light bluish gray to greenish gray; 5 meters of clay near the lower contact.
UNIT II (153 to 172 m T.D.) VOLCANIC SANDS, SILTS and CLAYS	(153 to 172 m T.D.) VOLCANIC SANDS, SILTS, and CLAYS; interbedded, olive black; some size graded bedding (coarser lower contacts).

*167.17 m at hole 154.


HOLE 154A
DEPTH m
100
200
300
400
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

SITE 154 HOLE CORE 1 CORED INTERVAL (m) 52-61



LITHOLOGIC DESCRIPTION[1]

VOLCANIC CALCAREOUS CLAY interbedded with FORAMINIFERAL NANNOPLANKTON MARL OOZE; light bluish gray (5B7/1) to medium bluish gray (5B5/1), the latter predominant in Section 6. Dark *greenish gray* (5GY4/1) VOLCANIC CLAY and SAND are mixed with marls and calcareous clays due to core disturbance. The volcanic clays contain abundant plagioclase, pyroxene, green and red hornblende. Glauconite, pyrite, and phillipsite occur throughout. Calcareous fraction is micritic with some nannofossils. X-ray also shows hematite and barite. Volcanic sand occurs in pockets and disturbed layers in all sections. Slightly indurated pebbles of ash occur in Section 4. Major ash components are plagioclase ortho- and clinopyroxene, and red and brown hornblende; some biotite, phillipsite, glauconite, and pumice. Black streaking occurs throughout core. Pyrite is common in greenish zones but rare outside *them*.

Entire core is disturbed and lithic types are completely mixed. Ash probably occurred in layers before disturbance.

Gas voids.

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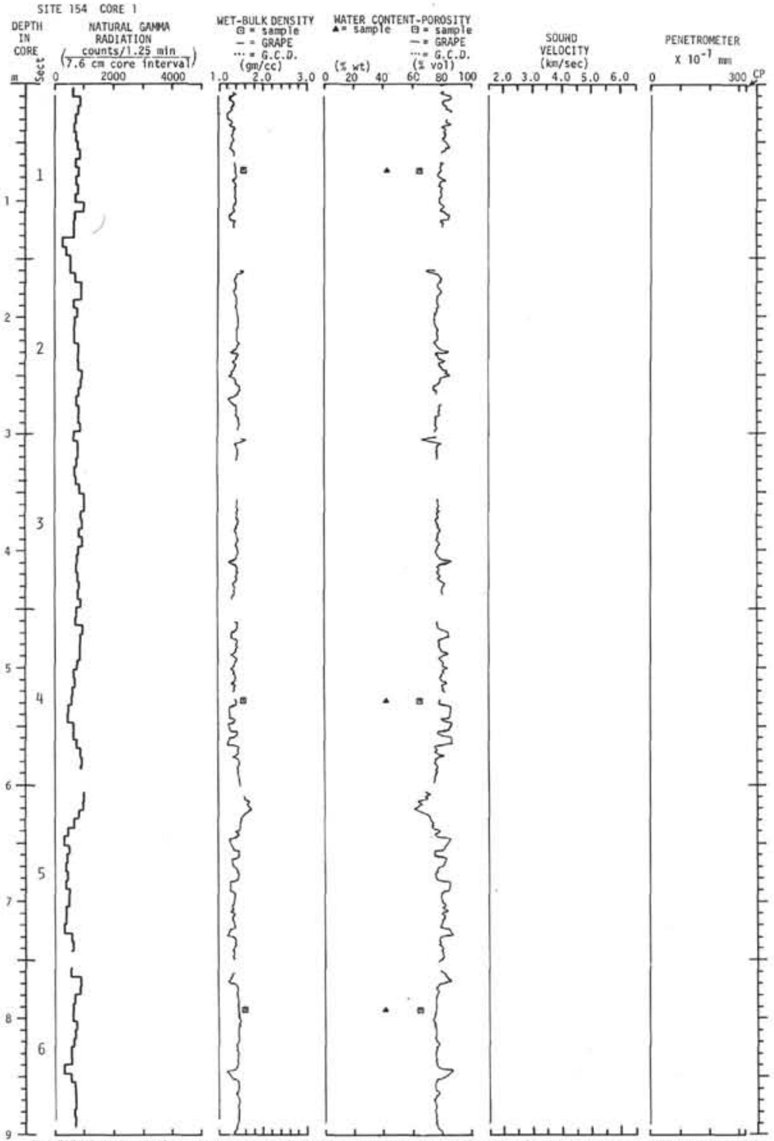
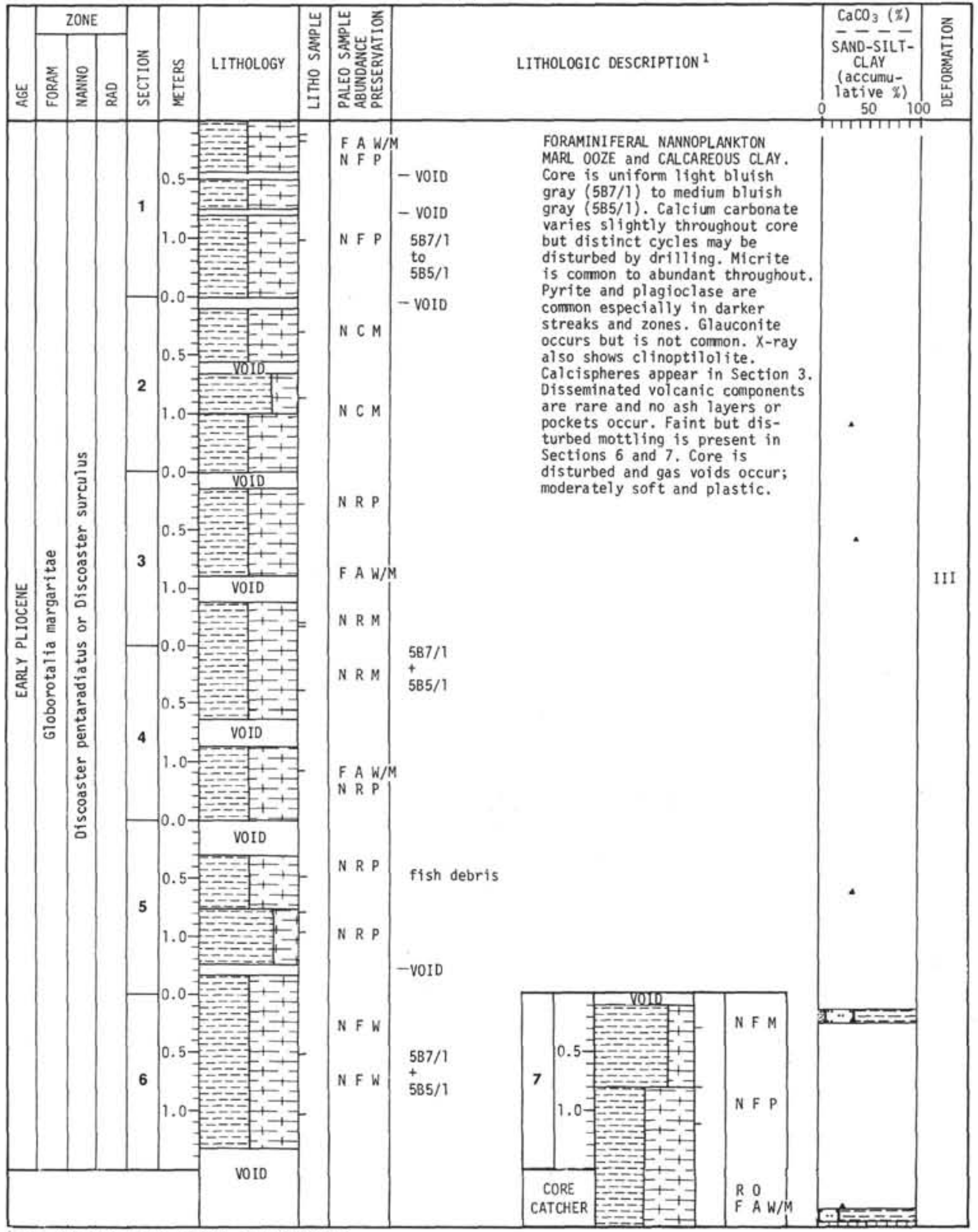
[1] For explanation of symbols, see Chapter 1



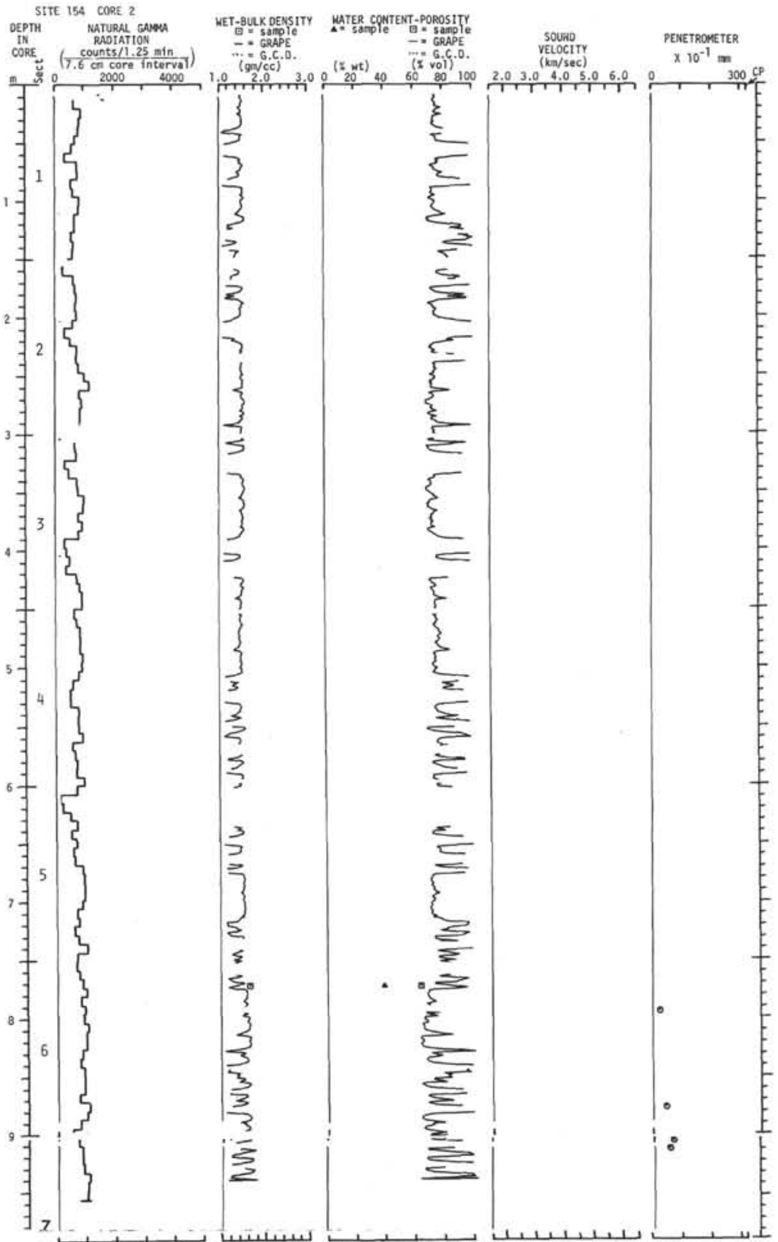
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1362. This background was subtracted from the data.

SITE 154 HOLE CORE 2 CORED INTERVAL (m) 108-117



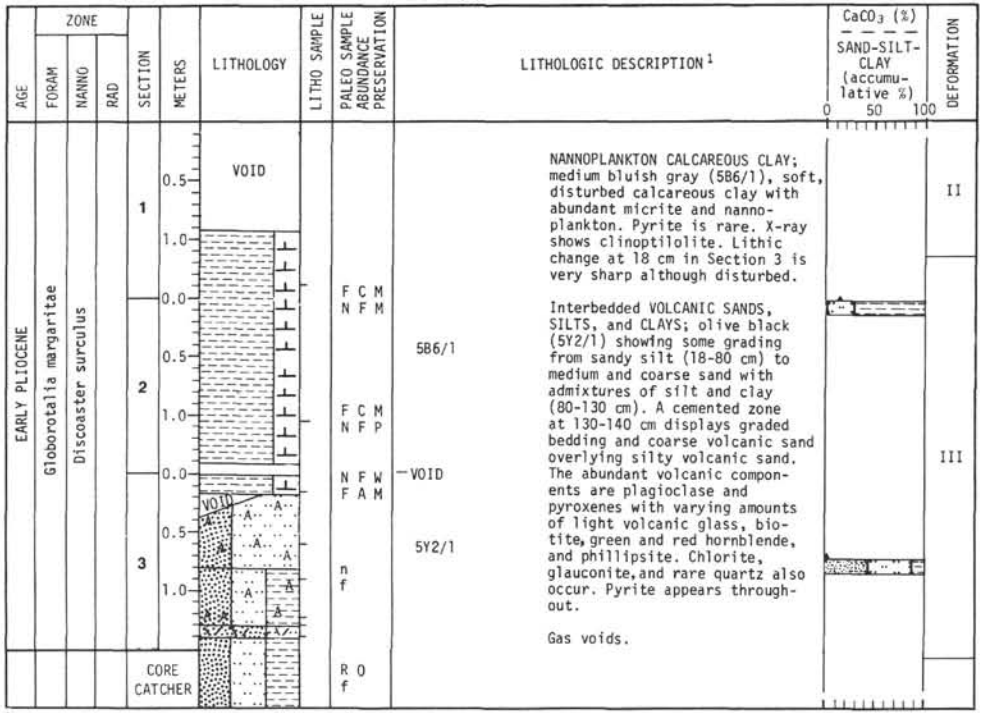
FORAMINIFERAL NANNOPLANKTON MARL OOZE and CALCAREOUS CLAY. Core is uniform light bluish gray (5B7/1) to medium bluish gray (5B5/1). Calcium carbonate varies slightly throughout core but distinct cycles may be disturbed by drilling. Micrite is common to abundant throughout. Pyrite and plagioclase are common especially in darker streaks and zones. Glauconite occurs but is not common. X-ray also shows clinoptilolite. Calcispheres appear in Section 3. Disseminated volcanic components are rare and no ash layers or pockets occur. Faint but disturbed mottling is present in Sections 6 and 7. Core is disturbed and gas voids occur; moderately soft and plastic.

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 1381. This background was subtracted from the data.

SITE 154 HOLE CORE 3 CORED INTERVAL (m) 164-173

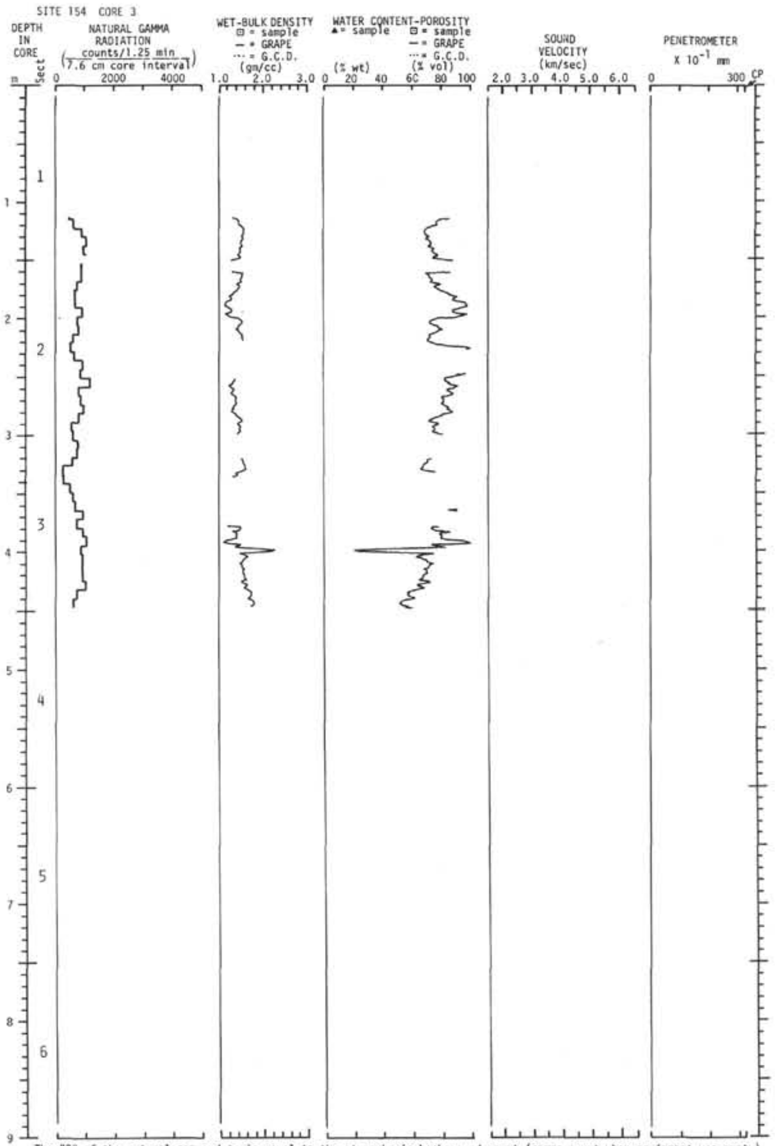


NANNOPLANKTON CALCAREOUS CLAY; medium bluish gray (5B6/1), soft, disturbed calcareous clay with abundant micrite and nannoplankton. Pyrite is rare. X-ray shows clinoptilolite. Lithic change at 18 cm in Section 3 is very sharp although disturbed.

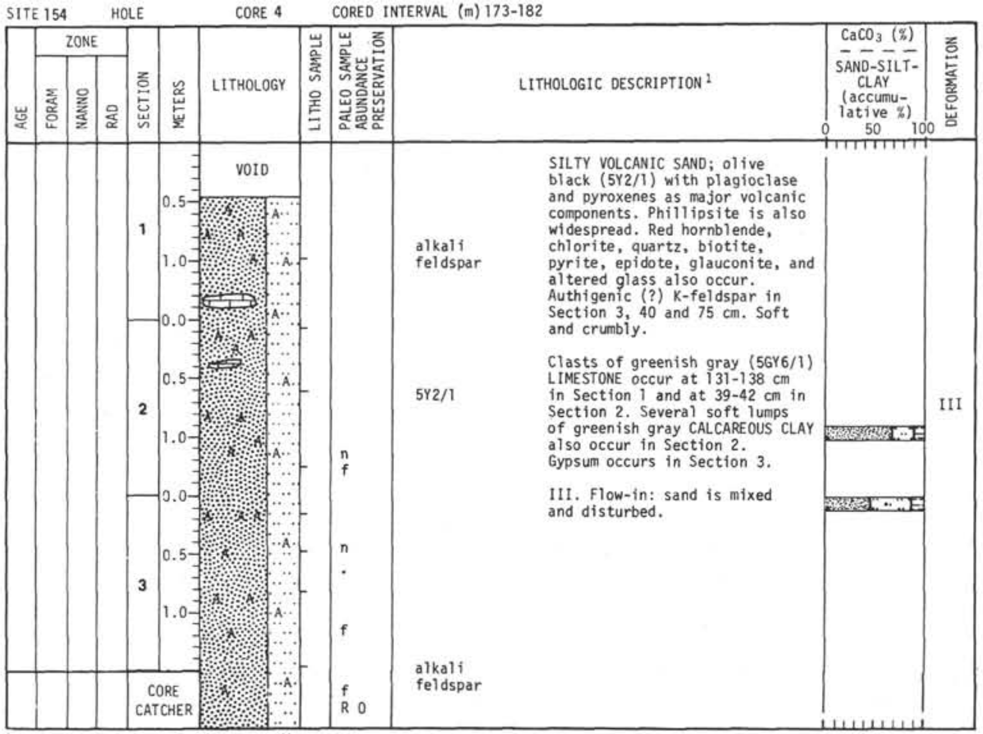
Interbedded VOLCANIC SANDS, SILTS, and CLAYS; olive black (5Y2/1) showing some grading from sandy silt (18-80 cm) to medium and coarse sand with admixtures of silt and clay (80-130 cm). A cemented zone at 130-140 cm displays graded bedding and coarse volcanic sand overlying silty volcanic sand. The abundant volcanic components are plagioclase and pyroxenes with varying amounts of light volcanic glass, biotite, green and red hornblende, and phillipsite. Chlorite, glauconite, and rare quartz also occur. Pyrite appears throughout.

Gas voids.

[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 1430. This background was subtracted from the data.

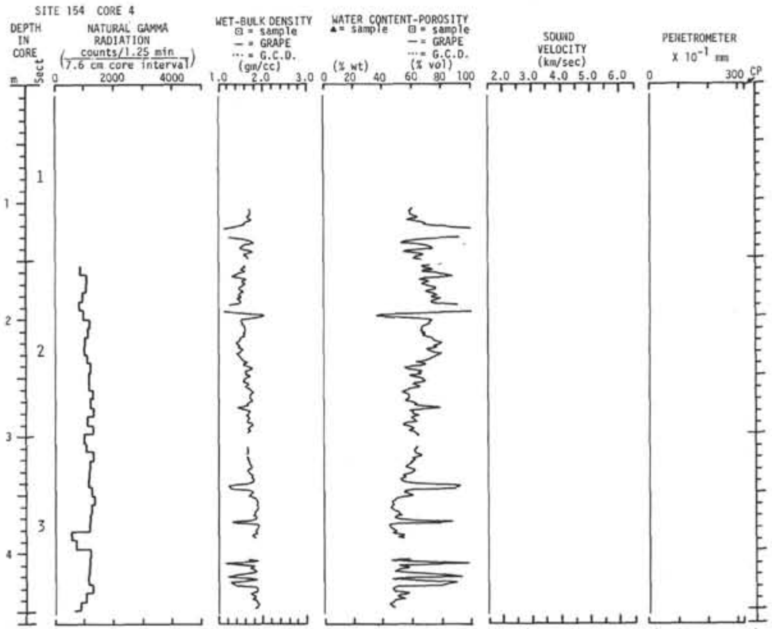


SILTY VOLCANIC SAND; olive black (5Y2/1) with plagioclase and pyroxenes as major volcanic components. Phillipsite is also widespread. Red hornblende, chlorite, quartz, biotite, pyrite, epidote, glauconite, and altered glass also occur. Authigenic (?) K-feldspar in Section 3, 40 and 75 cm. Soft and crumbly.

Clasts of greenish gray (5GY6/1) LIMESTONE occur at 131-138 cm in Section 1 and at 39-42 cm in Section 2. Several soft lumps of greenish gray CALCAREOUS CLAY also occur in Section 2. Gypsum occurs in Section 3.

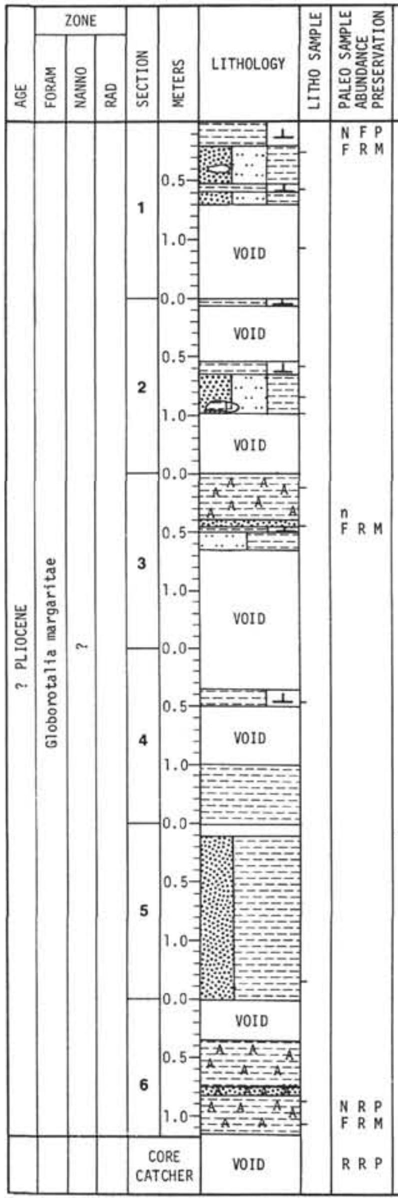
III. Flow-in: sand is mixed and disturbed.

[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 1430. This background was subtracted from the data.

SITE 154 HOLE CORE 5 CORED INTERVAL (m) 182-192



LITHOLOGIC DESCRIPTION[1]

5GY5/1
5Y2/1 apatite
fish debris
5GY3/1
5Y2/1
apatite
5Y2/1
5Y7/2
fish debris
zircon
mollusc shells
5GY3/1
— VOID
5Y2/1
5Y2/1

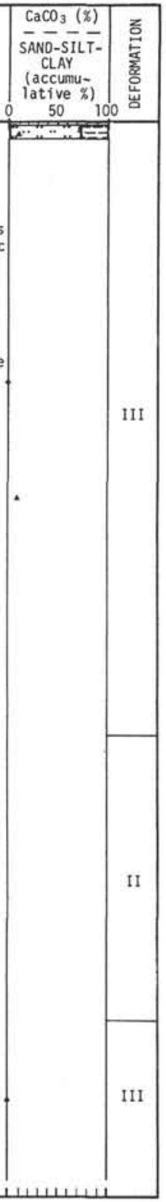
VOLCANIC CLAY and VOLCANIC CALCAREOUS CLAY interbedded with VOLCANIC SANDS and SILTS. Volcanic clays are predominantly dark olive gray (5Y3/1) to olive black (5Y2/1). Compactness varies due to core disturbance. Volcanic components other than clay are rare as is glauconite. Volcanic calcareous clays are medium greenish gray (5GY5/1) to dark greenish gray (5GY3/1). Carbonate content is due to nannoplankton and micrite. Phillipsite and volcanic components compose the remaining sediment. X-ray also shows clinoptilolite. Some zones are slightly indurated and display burrows. Volcanic sands and silts are composed predominantly of plagioclase and pyroxenes with varying amounts of hornblende, alkali feldspar, glauconite, light glass, and quartz. Phillipsite is also abundant. Pumice is found in Section 2. Sand-clay contacts in Section 6 are distorted but sharp.

Wood fragments occur in a cemented sand-silt at 40 cm in Section 1.

A CALCAREOUS SAND occurs in Section 3 (40-45 cm). The subrounded components include mollusc fragments, planktonic foraminifers, and other biogenous debris. The upper and lower contacts are quite sharp but disturbed by coring.

Gas voids.

III. Flow-in: Sand and clay between indurated zones disturbed.



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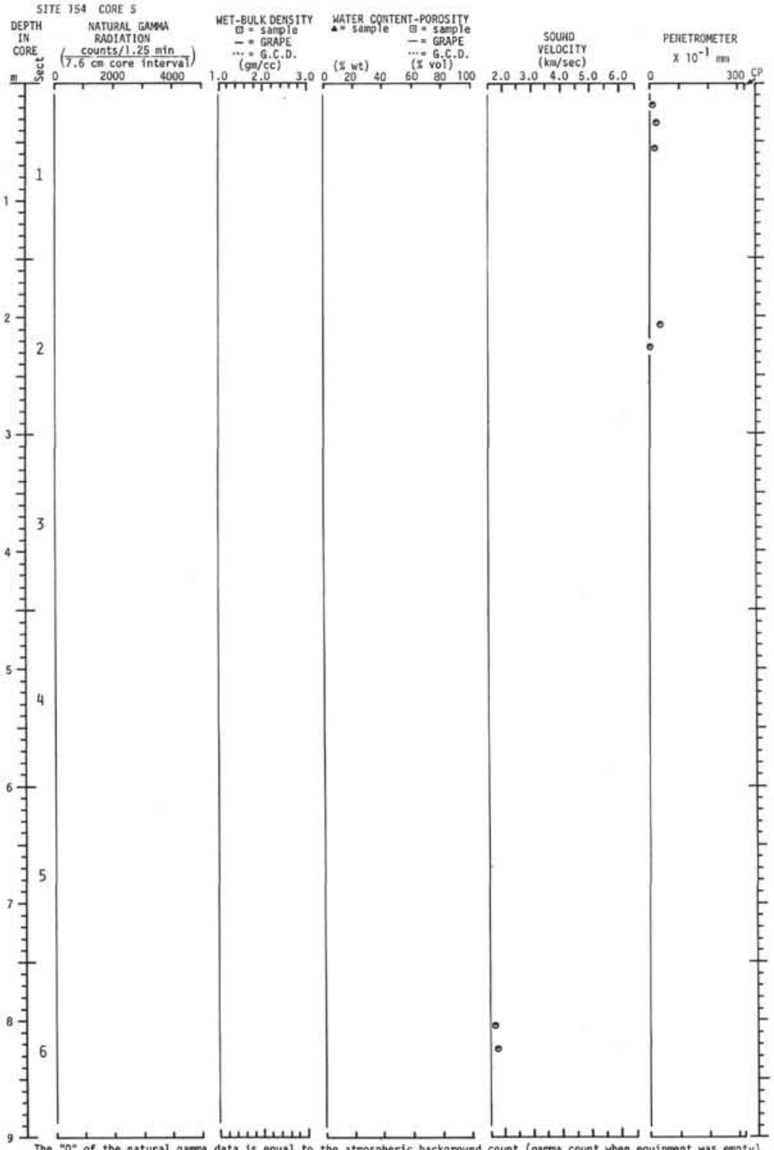
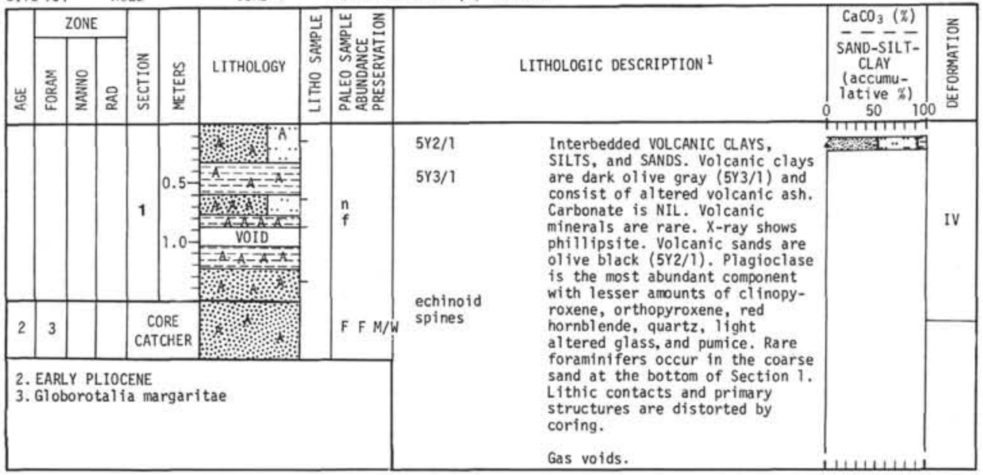
[1] For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1430. This background was subtracted from the data.

SITE 154 HOLE CORE 6 CORED INTERVAL (m) 192-202



5Y2/1

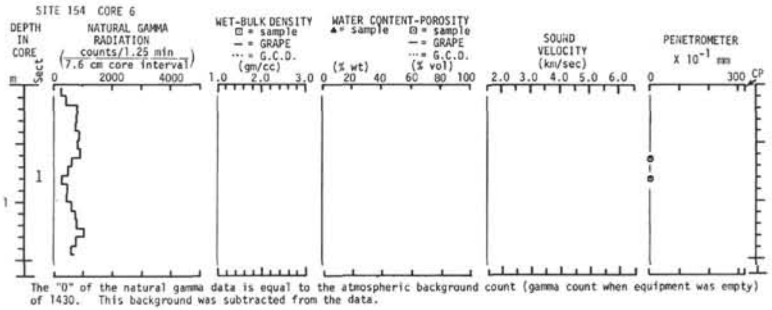
5Y3/1

echinoid spines

Interbedded VOLCANIC CLAYS, SILTS, and SANDS. Volcanic clays are dark olive gray (5Y3/1) and consist of altered volcanic ash. Carbonate is NIL. Volcanic minerals are rare. X-ray shows phillipsite. Volcanic sands are olive black (5Y2/1). Plagioclase is the most abundant component with lesser amounts of clinopyroxene, orthopyroxene, red hornblende, quartz, light altered glass, and pumice. Rare foraminifers occur in the coarse sand at the bottom of Section 1. Lithic contacts and primary structures are distorted by coring.

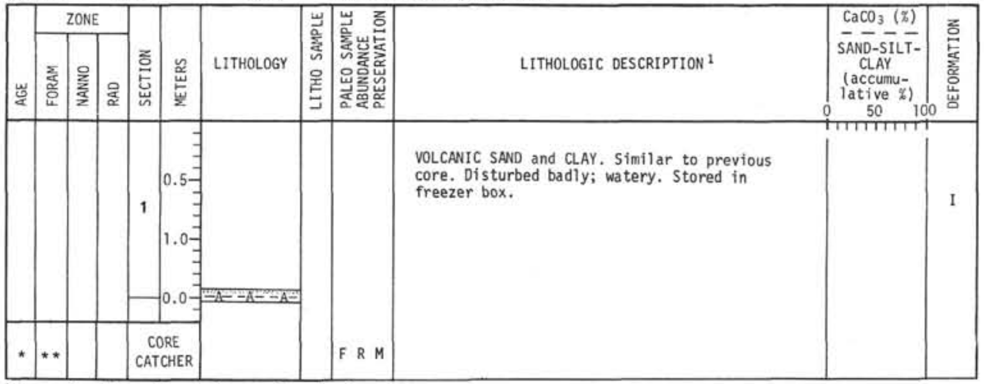
Gas voids.

2. EARLY PLIOCENE
3. Globorotalia margaritae



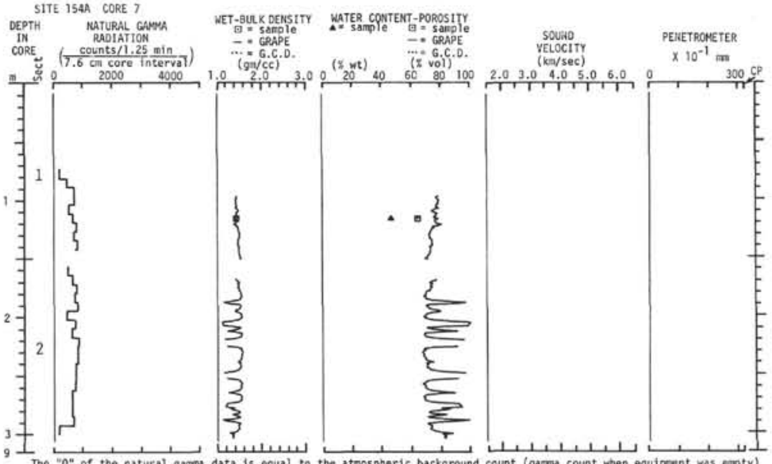
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1430. This background was subtracted from the data.

SITE 154 HOLE CORE 7 CORED INTERVAL (m) 202-211



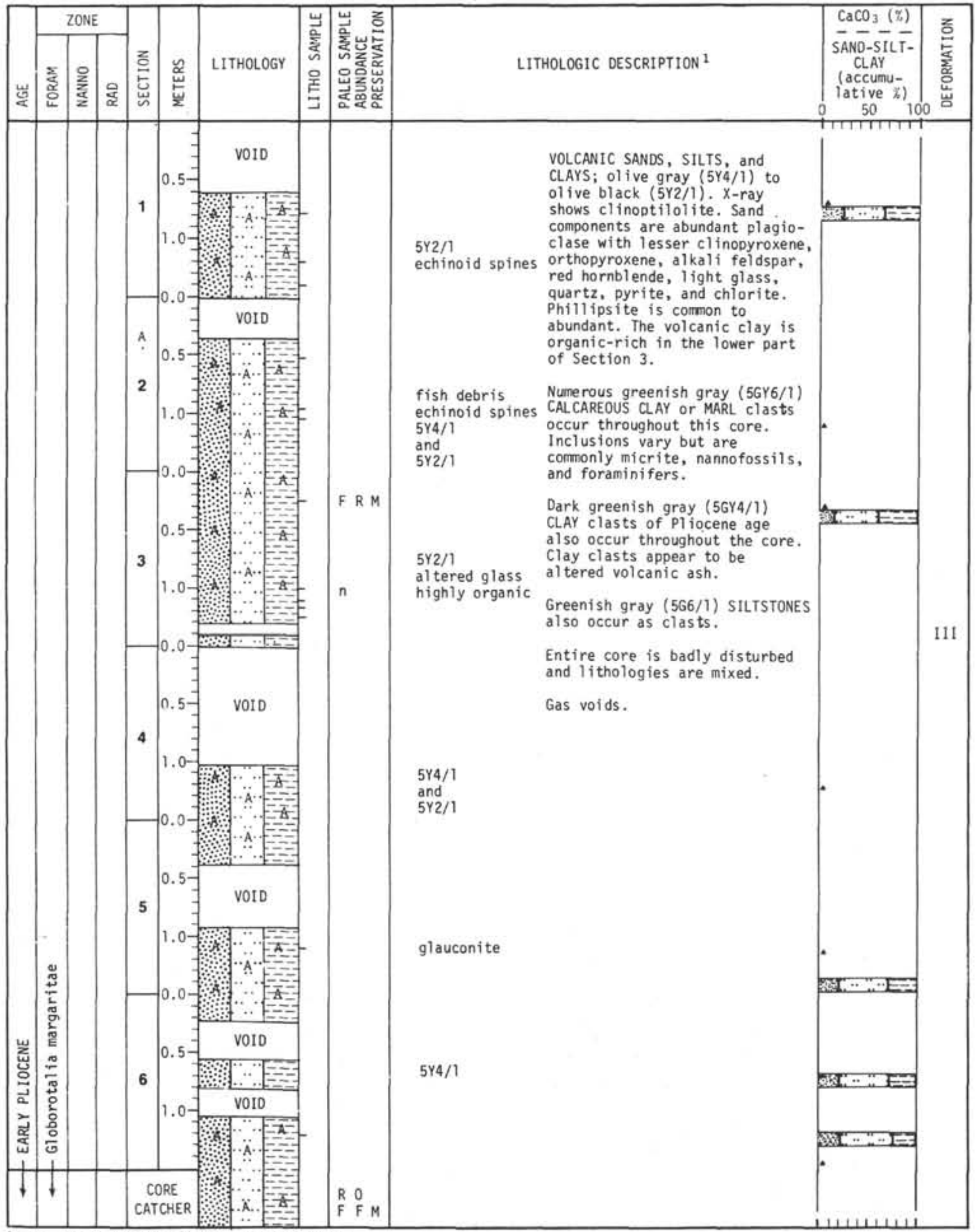
VOLCANIC SAND and CLAY. Similar to previous core. Disturbed badly; watery. Stored in freezer box.

¹For explanation of symbols, see Chapter 1
* EARLY PLIOCENE
** Globorotalia margaritae



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1437. This background was subtracted from the data.

SITE 154 HOLE CORE 8 CORED INTERVAL (m) 211-221



VOLCANIC SANDS, SILTS, and CLAYS; olive gray (5Y4/1) to olive black (5Y2/1). X-ray shows clinoptilolite. Sand components are abundant plagioclase with lesser clinopyroxene, orthopyroxene, alkali feldspar, red hornblende, light glass, quartz, pyrite, and chlorite. Phillipsite is common to abundant. The volcanic clay is organic-rich in the lower part of Section 3.

Numerous greenish gray (5GY6/1) CALCAREOUS CLAY or MARL clasts occur throughout this core. Inclusions vary but are commonly micrite, nannofossils, and foraminifers.

Dark greenish gray (5GY4/1) CLAY clasts of Pliocene age also occur throughout the core. Clay clasts appear to be altered volcanic ash.

Greenish gray (5G6/1) SILTSTONES also occur as clasts.

Entire core is badly disturbed and lithologies are mixed.

Gas voids.

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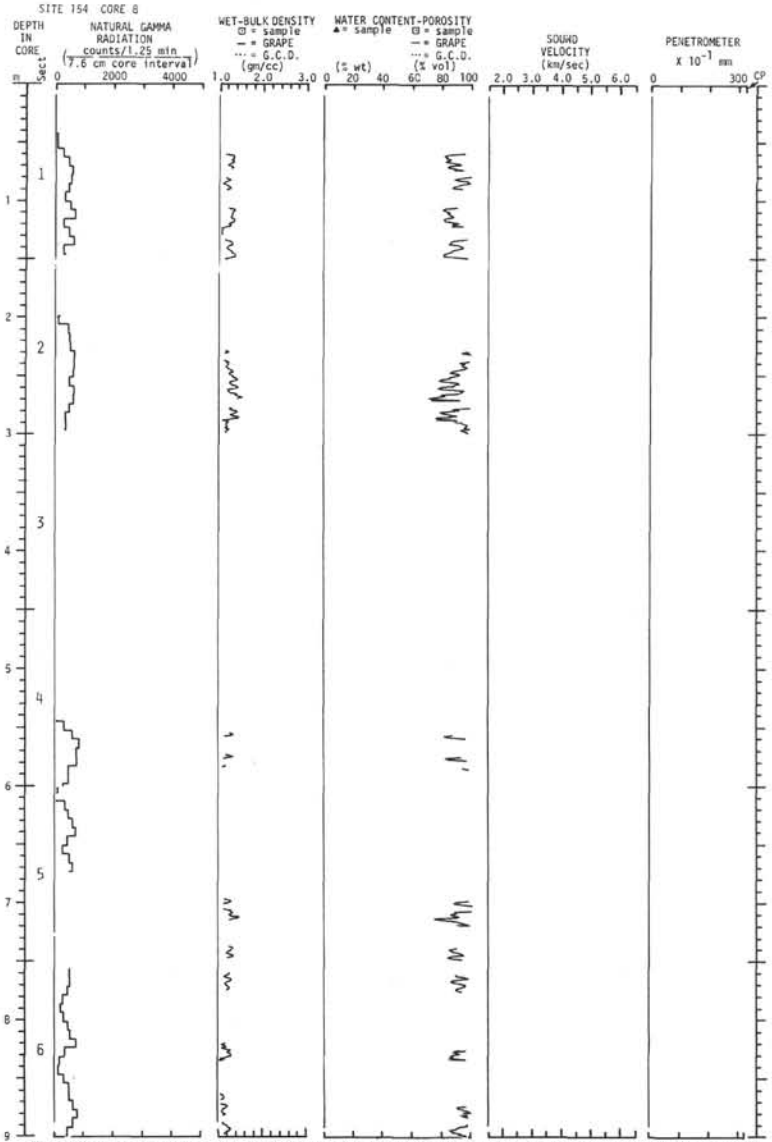
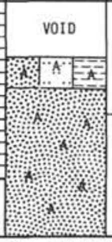
[1] For explanation of symbols, see Chapter 1

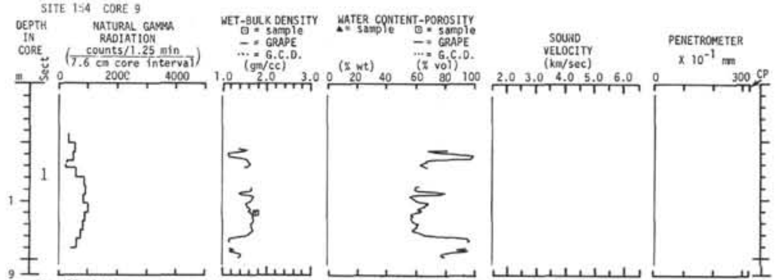


The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1402. This background was subtracted from the data.

SITE 154 HOLE CORE 9 CORED INTERVAL (m) 221-230

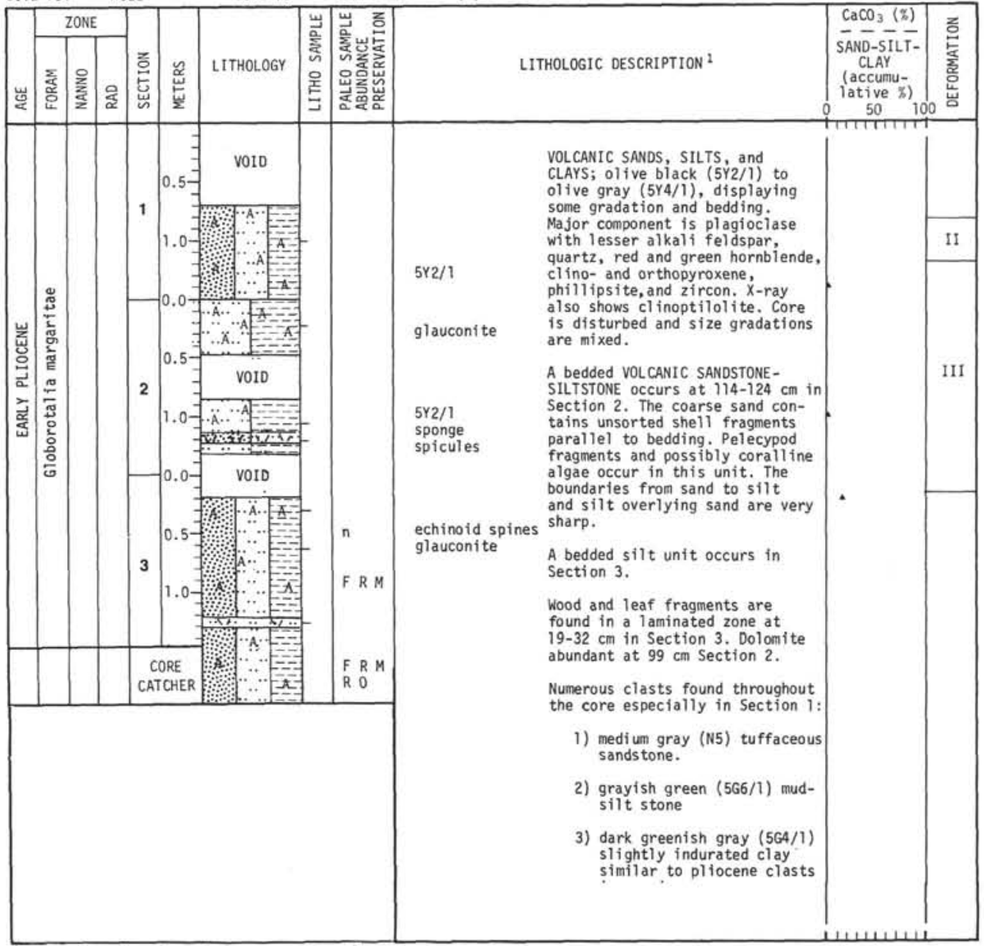
AGE	ZONE			SECTION	METERS	LITHOLOGY	LITHO SAMPLE	PALEO SAMPLE ABUNDANCE PRESERVATION	LITHOLOGIC DESCRIPTION[1]	CaCO3 (%) — SAND-SILT-CLAY (accumulative %) 0 50 100	DEFORMATION
	FORAM	NANNO	RAD								
EARLY PLIOCENE	Globorotalia margaritae			1	0.5 1.0	VOID 		n F R M	VOLCANIC SAND, SILT, and CLAY; olive black (5Y2/1), grading to predominantely volcanic sand. Section is homogeneous, noncalcareous, and disturbed. Plagioclase is the major volcanic component with clinopyroxene, orthopyroxene, slightly altered light glass, and quartz in lesser abundance. Sponge spicules. X-ray also shows clinoptilolite and phillipsite. A grayish green (5G6/1) slightly calcareous mudstone clast occurs at 68-74 cm.		II III
				CORE CATCHER				f R O			

[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.

SITE 154 HOLE CORE 10 CORED INTERVAL (m) 230-240



5Y2/1

glauconite

5Y2/1
sponge
spicules

echinoid spines
glauconite

VOLCANIC SANDS, SILTS, and CLAYS; olive black (5Y2/1) to olive gray (5Y4/1), displaying some gradation and bedding. Major component is plagioclase with lesser alkali feldspar, quartz, red and green hornblende, clino- and orthopyroxene, phillipsite, and zircon. X-ray also shows clinoptilolite. Core is disturbed and size gradations are mixed.

A bedded VOLCANIC SANDSTONE-SILTSTONE occurs at 114-124 cm in Section 2. The coarse sand contains unsorted shell fragments parallel to bedding. Pelecypod fragments and possibly coralline algae occur in this unit. The boundaries from sand to silt and silt overlying sand are very sharp.

A bedded silt unit occurs in Section 3.

Wood and leaf fragments are found in a laminated zone at 19-32 cm in Section 3. Dolomite abundant at 99 cm Section 2.

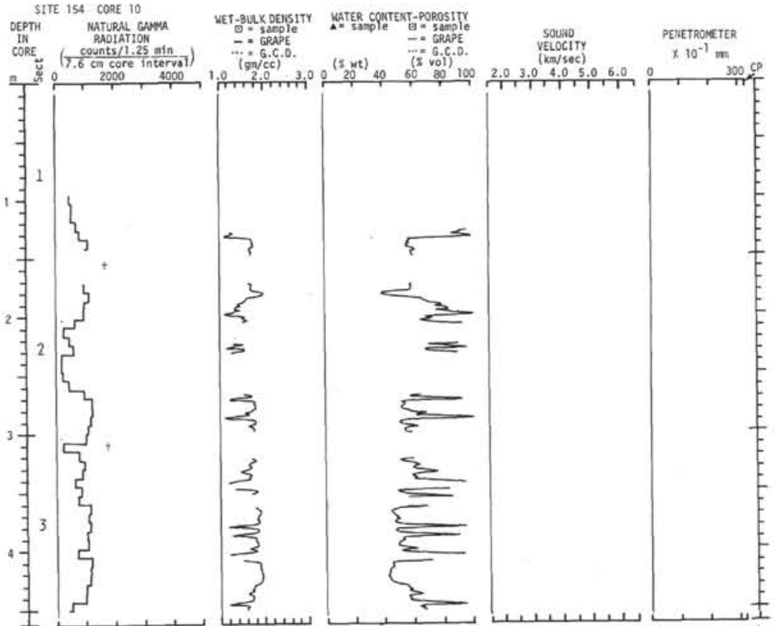
Numerous clasts found throughout the core especially in Section 1:

1) medium gray (N5) tuffaceous sandstone.

2) grayish green (5G6/1) mud-silt stone

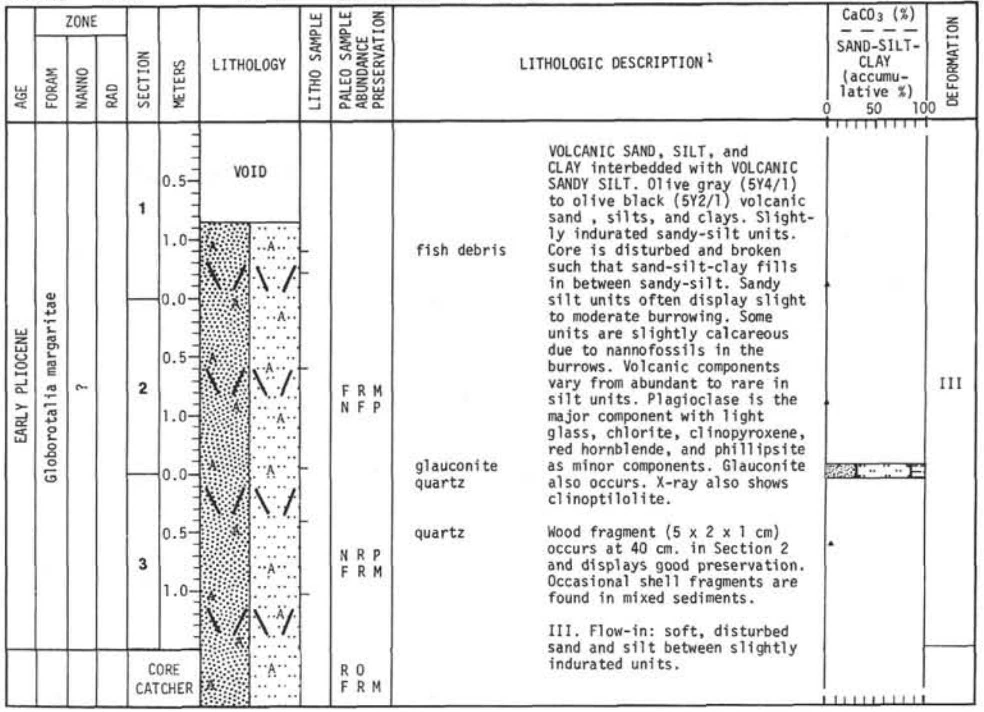
3) dark greenish gray (5G4/1) slightly indurated clay similar to pliocene clasts

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 154 HOLE CORE 11 CORED INTERVAL (m) 240-249



fish debris

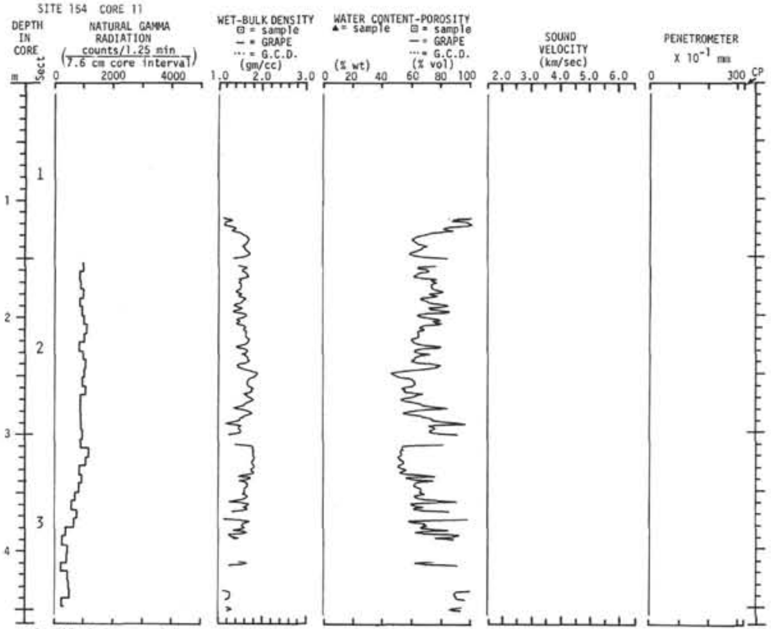
glauconite
quartz

quartz

VOLCANIC SAND, SILT, and CLAY interbedded with VOLCANIC SANDY SILT. Olive gray (5Y4/1) to olive black (5Y2/1) volcanic sand , silts, and clays. Slightly indurated sandy-silt units. Core is disturbed and broken such that sand-silt-clay fills in between sandy-silt. Sandy silt units often display slight to moderate burrowing. Some units are slightly calcareous due to nannofossils in the burrows. Volcanic components vary from abundant to rare in silt units. Plagioclase is the major component with light glass, chlorite, clinopyroxene, red hornblende, and phillipsite as minor components. Glauconite also occurs. X-ray also shows clinoptilolite.

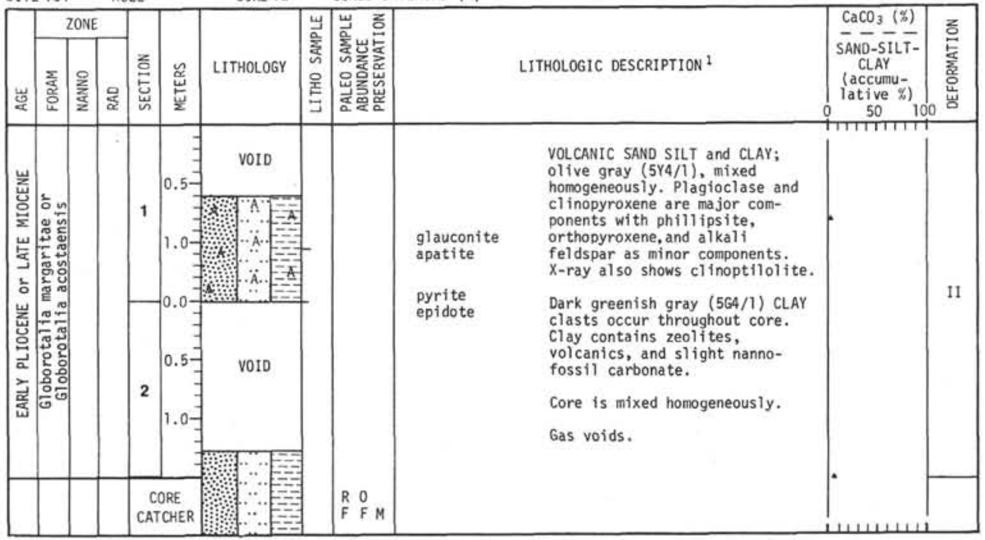
Wood fragment (5 x 2 x 1 cm) occurs at 40 cm. in Section 2 and displays good preservation. Occasional shell fragments are found in mixed sediments.

III. Flow-in: soft, disturbed sand and silt between slightly indurated units.



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 154 HOLE CORE 12 CORED INTERVAL (m) 249-258



glauconite
apatite

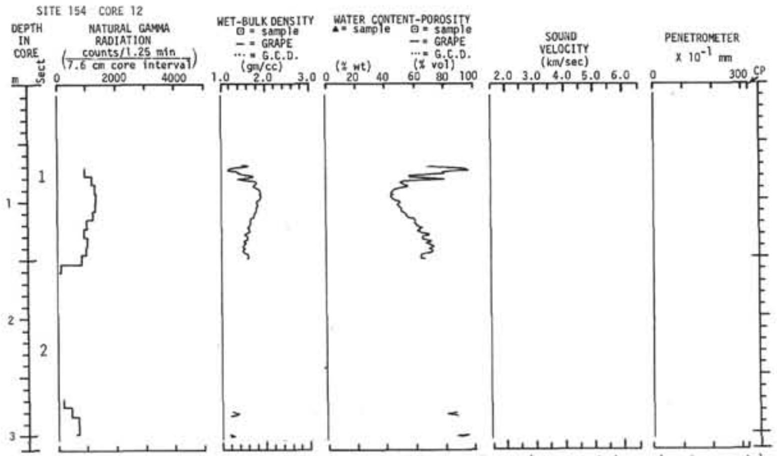
pyrite
epidote

VOLCANIC SAND SILT and CLAY; olive gray (5Y4/1), mixed homogeneously. Plagioclase and clinopyroxene are major components with phillipsite, orthopyroxene, and alkali feldspar as minor components. X-ray also shows clinoptilolite.

Dark greenish gray (5G4/1) CLAY clasts occur throughout core. Clay contains zeolites, volcanics, and slight nannofossil carbonate.

Core is mixed homogeneously.

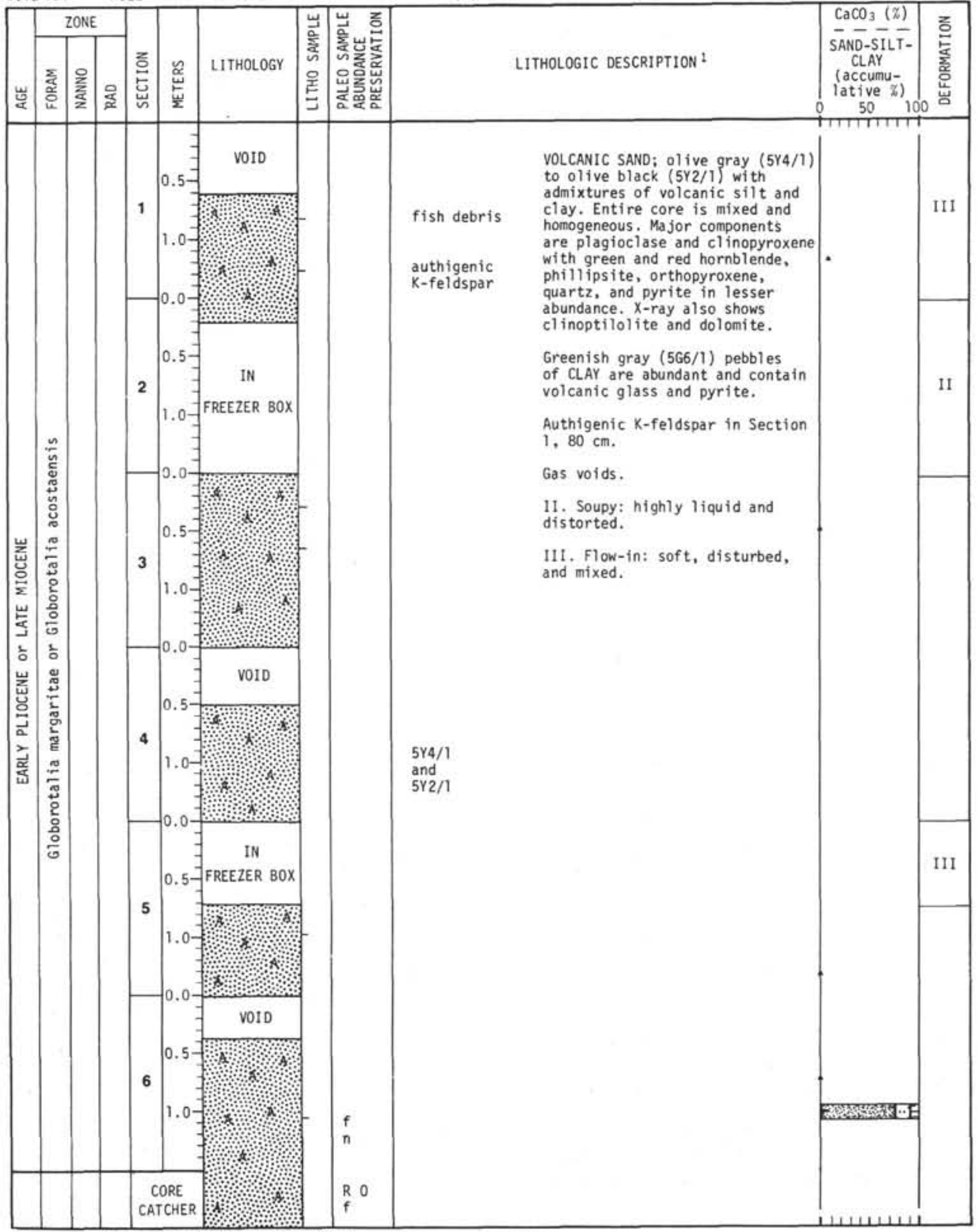
Gas voids.



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.

¹For explanation of symbols, see Chapter 1

SITE 154 HOLE CORE 13 CORED INTERVAL (m) 258-268



VOLCANIC SAND; olive gray (5Y4/1) to olive black (5Y2/1) with admixtures of volcanic silt and clay. Entire core is mixed and homogeneous. Major components are plagioclase and clinopyroxene with green and red hornblende, phillipsite, orthopyroxene, quartz, and pyrite in lesser abundance. X-ray also shows clinoptilolite and dolomite.

Greenish gray (5G6/1) pebbles of CLAY are abundant and contain volcanic glass and pyrite.

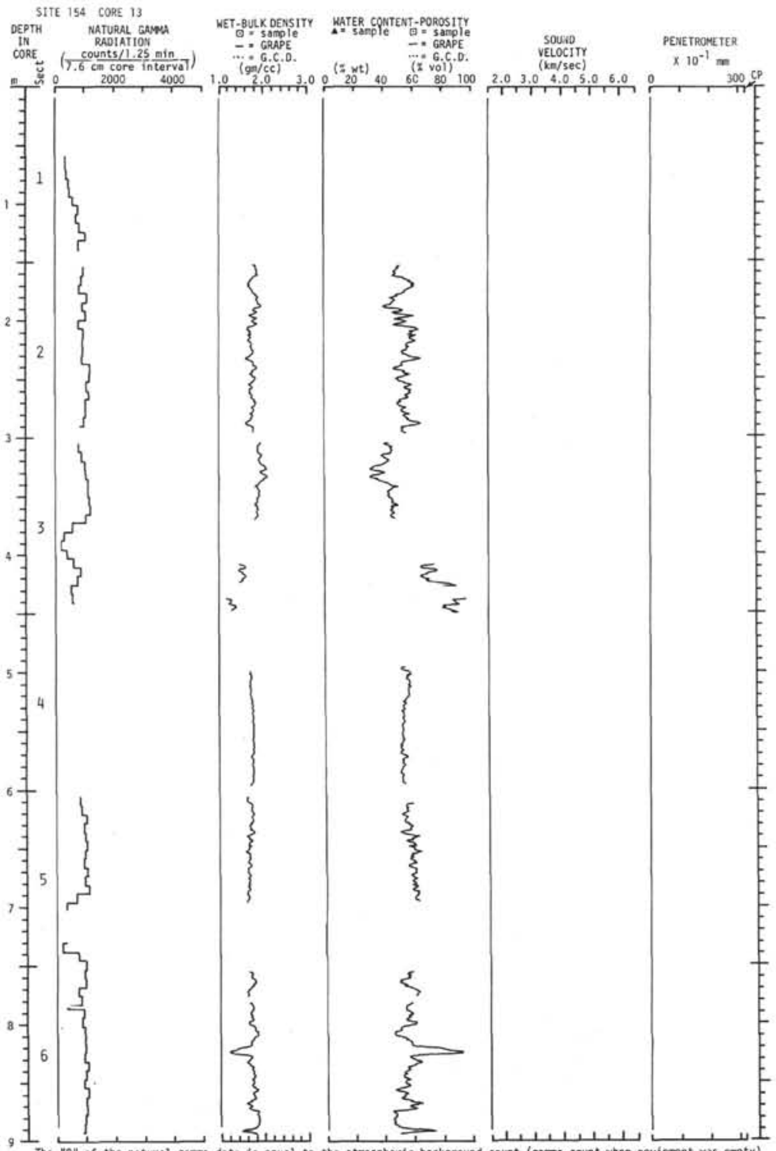
Authigenic K-feldspar in Section 1, 80 cm.

Gas voids.

II. Soupy: highly liquid and distorted.

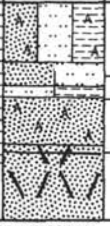
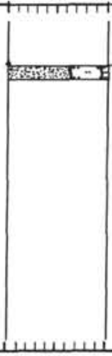
III. Flow-in: soft, disturbed, and mixed.

¹For explanation of symbols, see Chapter 1



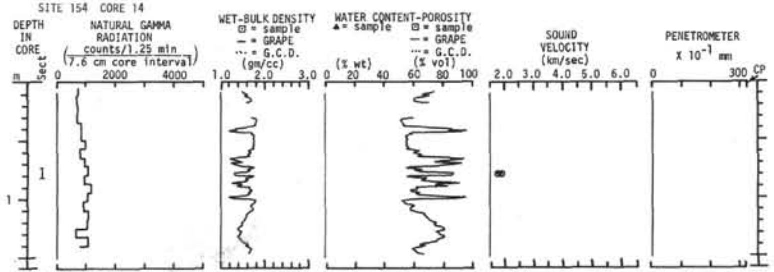
The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1400. This background was subtracted from the data.

SITE 154 HOLE CORE 14 CORED INTERVAL (m) 268-277

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
2	3	?		1	0.5 1.0			F R M N R P	5Y2/1 5GY2/1 echinoid spines glauconite Interbedded VOLCANIC SAND, SILT, and CLAY; olive black (5Y2/1) volcanic sands and greenish black (5GY2/1) volcanic silts and clays. Major volcanic component is plagioclase with lesser clinopyroxene, orthopyroxene, quartz, biotite, red hornblende, and alkali feldspar. Phillipsite is also abundant. X-ray also shows clinoptilolite. A zone of well-compacted CLAY occurs at 70-81 cm. A partially cemented SAND with a few altered plant fragments occurs between 123 + 130 cm. III. Flow-in: soft and disturbed except in compacted zones.		II III
				CORE CATCHER				f R O			

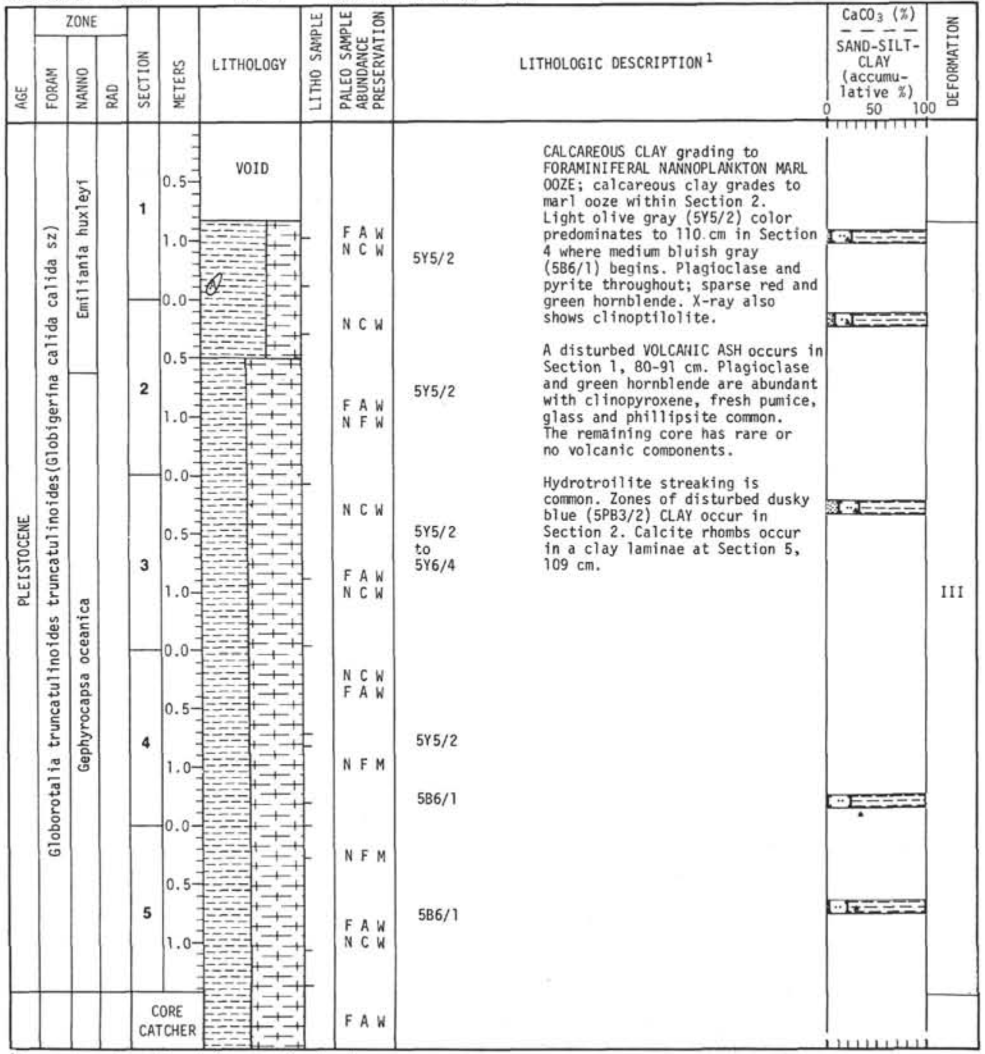
2. EARLY PLIOCENE or LATE MIOCENE
3. Globorotalia margaritae or Globorotalia acostaensis

[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 154 A HOLE CORE 1 CORED INTERVAL (m) 1-10

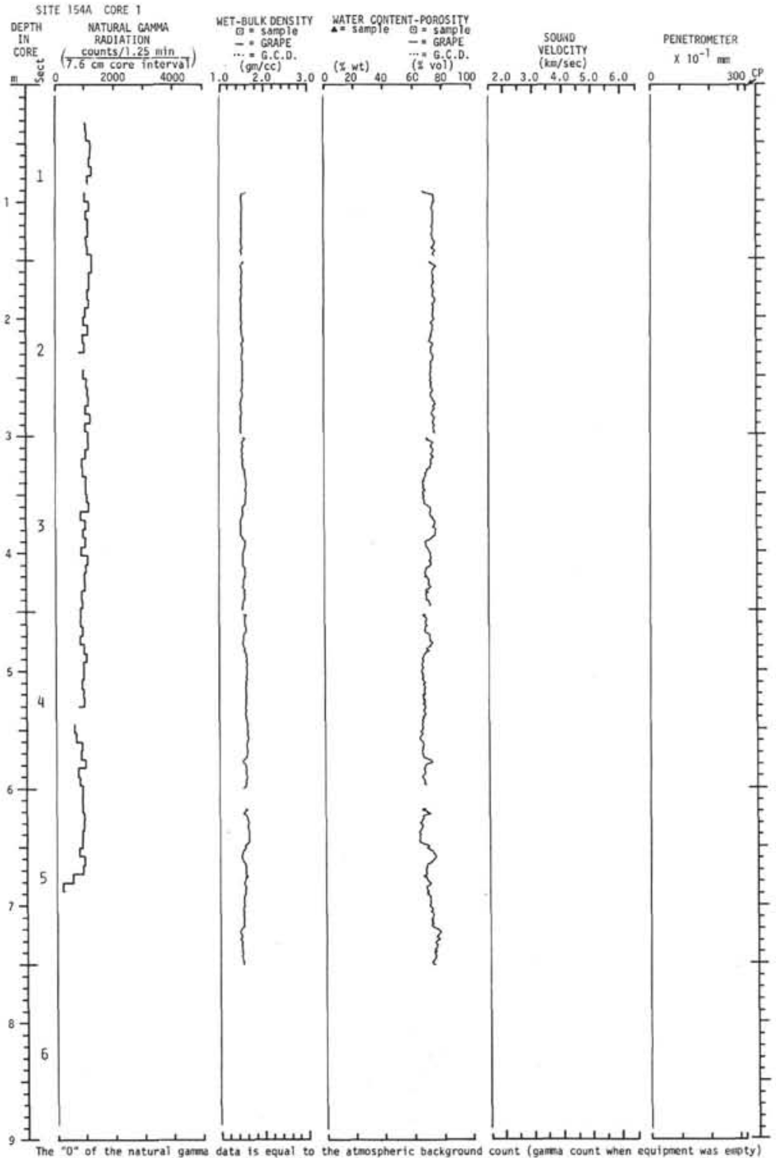


CALCAREOUS CLAY grading to FORAMINIFERAL NANNOPLANKTON MARL OOZE; calcareous clay grades to marl ooze within Section 2. Light olive gray (5Y5/2) color predominates to 110 cm in Section 4 where medium bluish gray (5B6/1) begins. Plagioclase and pyrite throughout; sparse red and green hornblende. X-ray also shows clinoptilolite.

A disturbed VOLCANIC ASH occurs in Section 1, 80-91 cm. Plagioclase and green hornblende are abundant with clinopyroxene, fresh pumice, glass and phillipsite common. The remaining core has rare or no volcanic components.

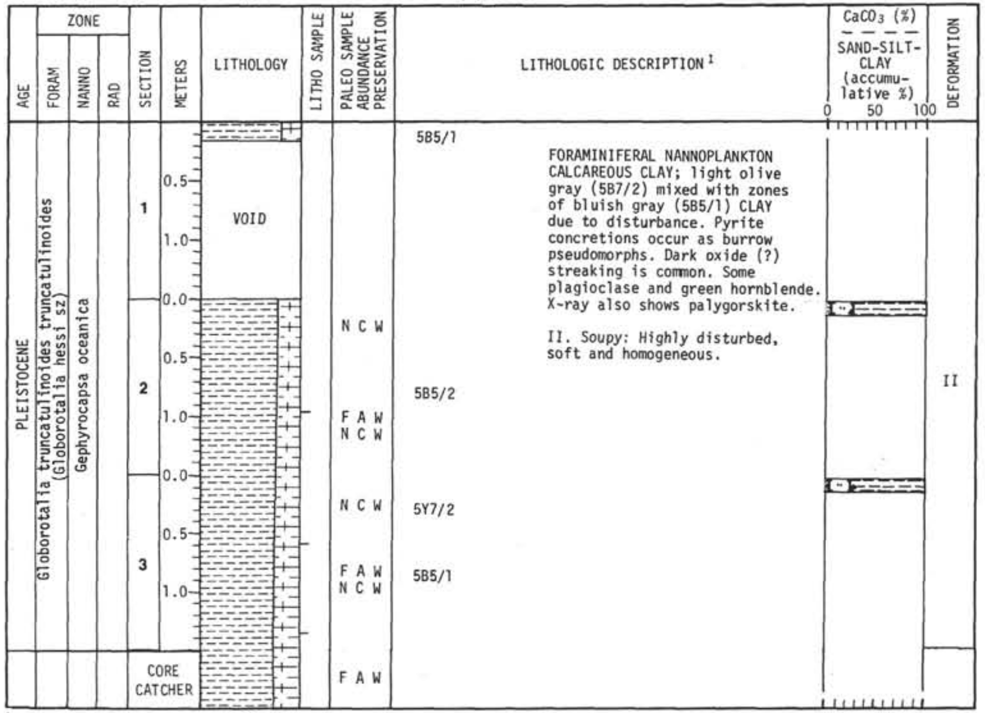
Hydrotroilite streaking is common. Zones of disturbed dusky blue (5PB3/2) CLAY occur in Section 2. Calcite rhombs occur in a clay laminae at Section 5, 109 cm.

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 1393. This background was subtracted from the data.

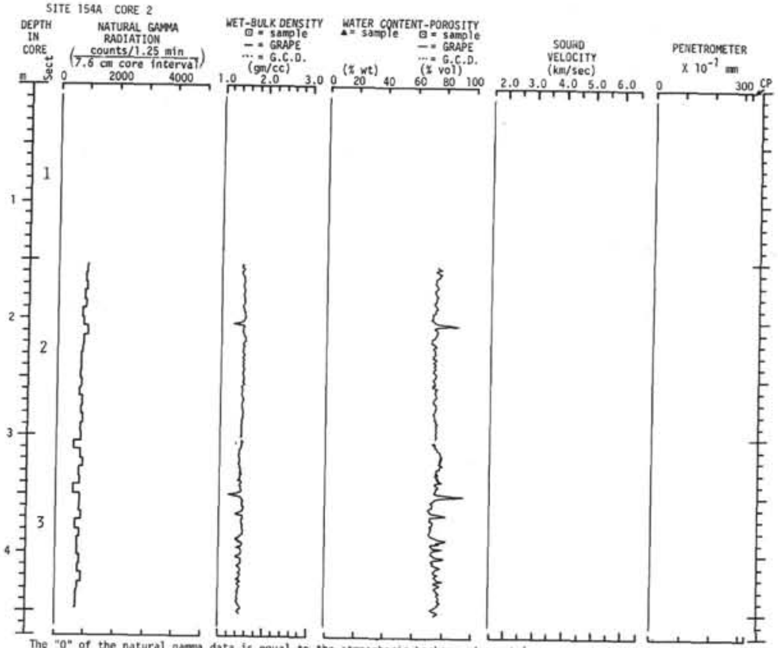
SITE 154 A HOLE CORE 2 CORED INTERVAL (m) 10-20



FORAMINIFERAL NANNOPLANKTON CALCAREOUS CLAY; light olive gray (5B7/2) mixed with zones of bluish gray (5B5/1) CLAY due to disturbance. Pyrite concretions occur as burrow pseudomorphs. Dark oxide (?) streaking is common. Some plagioclase and green hornblende. X-ray also shows palygorskite.

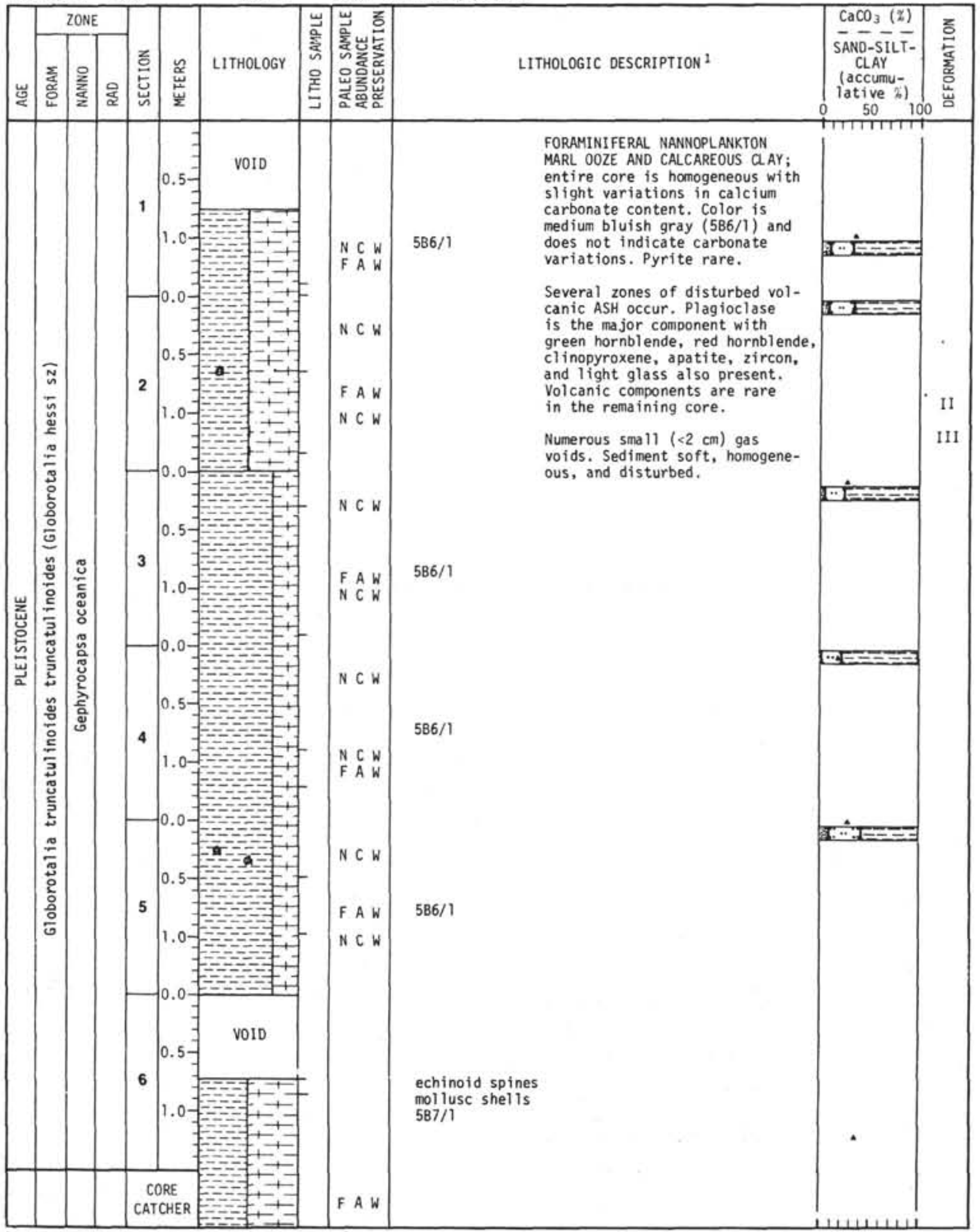
II. *Soupy: Highly disturbed,* soft and homogeneous.

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 1412. This background was subtracted from the data.

SITE 154 A HOLE CORE 3 CORED INTERVAL (m) 20-29

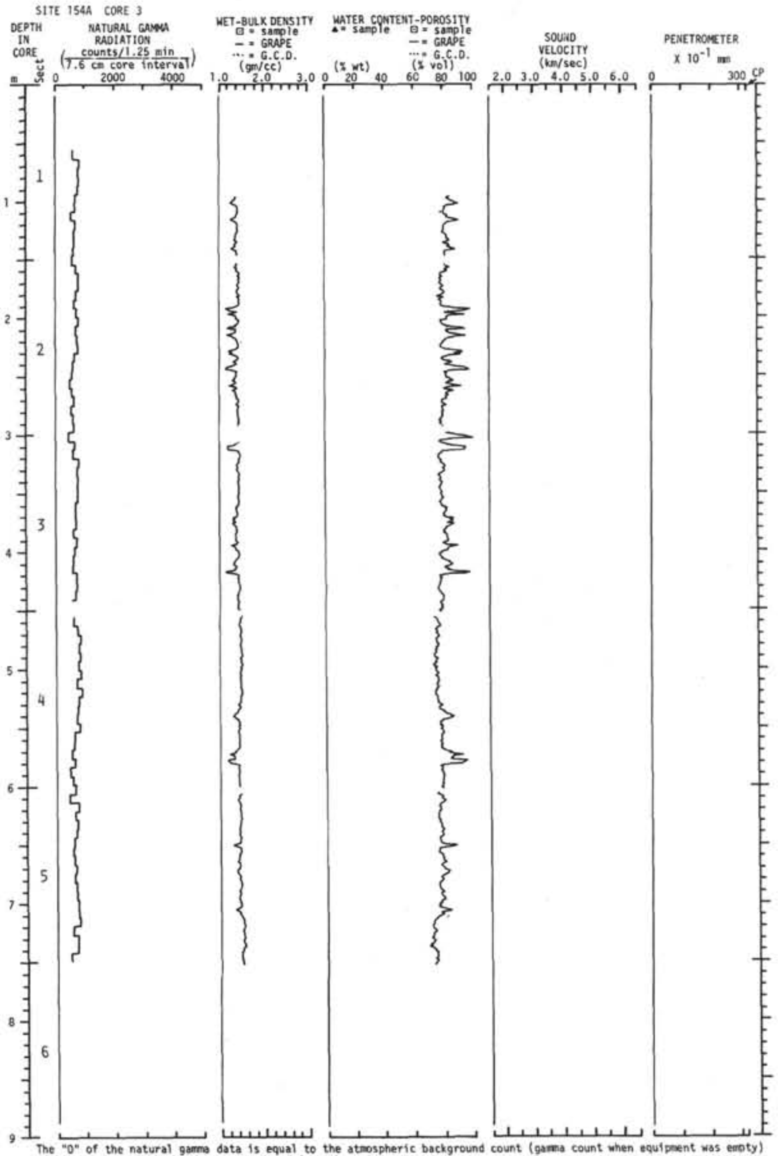


FORAMINIFERAL NANNOPLANKTON MARL OOZE AND CALCAREOUS CLAY; entire core is homogeneous with slight variations in calcium carbonate content. Color is medium bluish gray (5B6/1) and does not indicate carbonate variations. Pyrite rare.

Several zones of disturbed volcanic ASH occur. Plagioclase is the major component with green hornblende, red hornblende, clinopyroxene, apatite, zircon, and light glass also present. Volcanic components are rare in the remaining core.

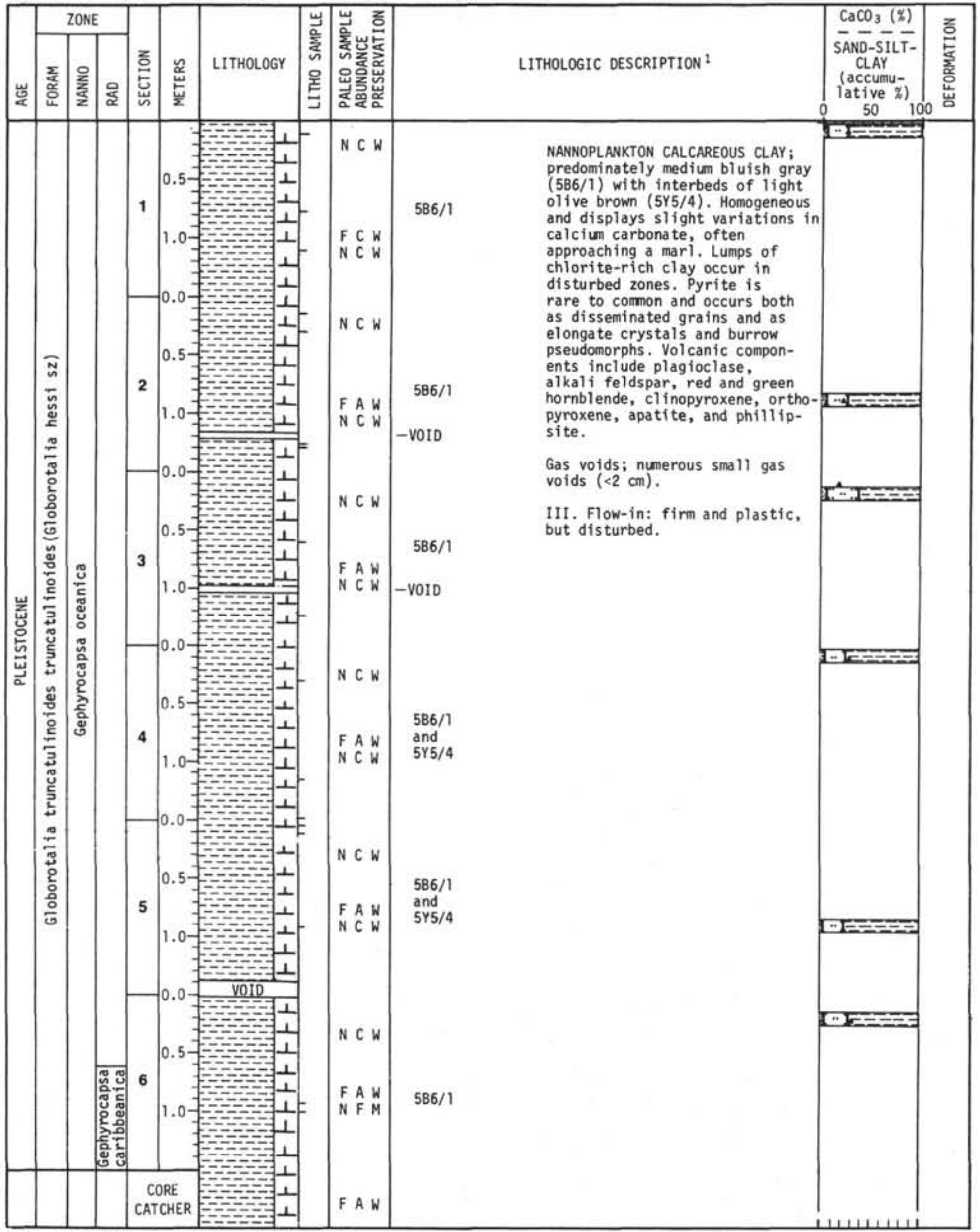
Numerous small (<2 cm) gas voids. Sediment soft, homogeneous, and disturbed.

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 1419. This background was subtracted from the data.

SITE 154 A HOLE CORE 4 CORED INTERVAL (m) 29-39.0

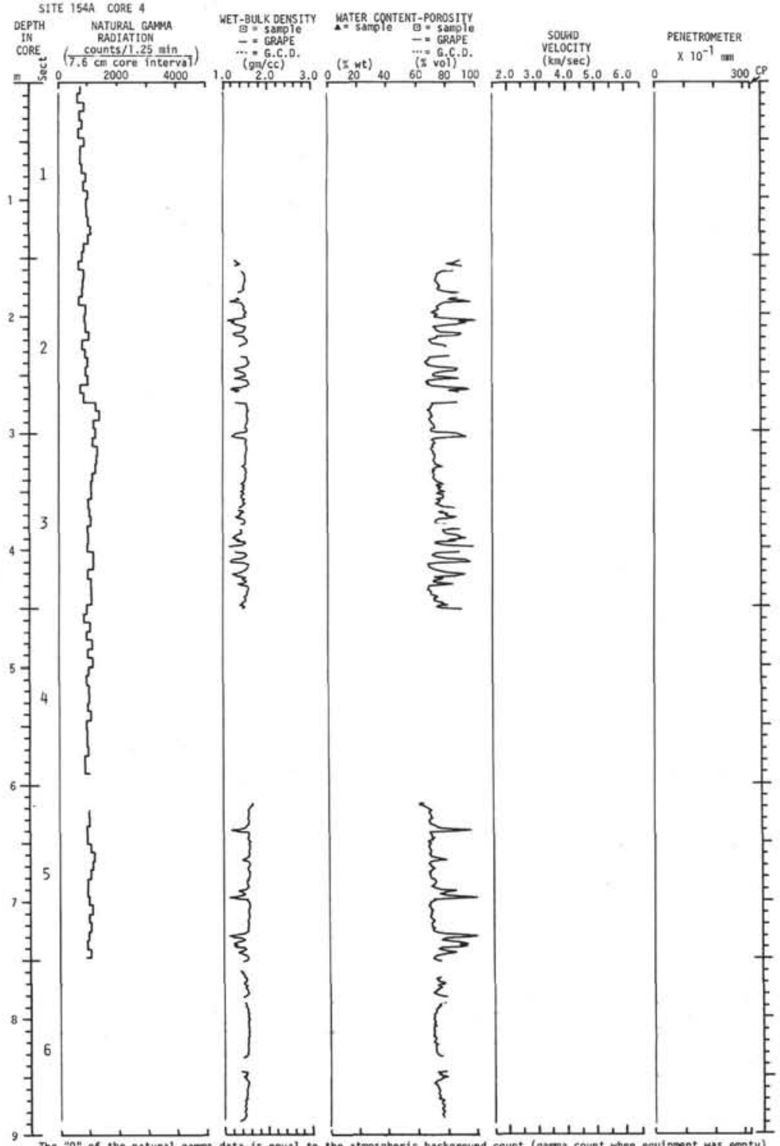


NANNOPLANKTON CALCAREOUS CLAY; predominately medium bluish gray (5B6/1) with interbeds of light olive brown (5Y5/4). Homogeneous and displays slight variations in calcium carbonate, often approaching a marl. Lumps of chlorite-rich clay occur in disturbed zones. Pyrite is rare to common and occurs both as disseminated grains and as elongate crystals and burrow pseudomorphs. Volcanic components include plagioclase, alkali feldspar, red and green hornblende, clinopyroxene, orthopyroxene, apatite, and phillipsite.

Gas voids; numerous small gas voids (<2 cm).

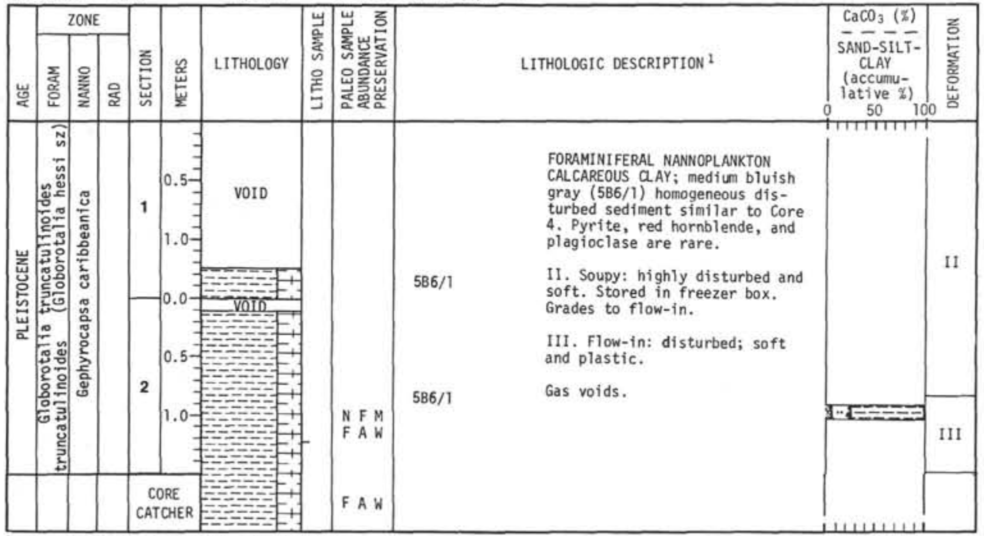
III. Flow-in: firm and plastic, but disturbed.

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 1431. This background was subtracted from the data.

SITE 154 A HOLE CORE 5 CORED INTERVAL (m) 39-49



FORAMINIFERAL NANNOPLANKTON CALCAREOUS CLAY; medium bluish gray (5B6/1) homogeneous disturbed sediment similar to Core 4. Pyrite, red hornblende, and plagioclase are rare.

II. Soupy: highly disturbed and soft. Stored in freezer box. Grades to flow-in.

III. Flow-in: disturbed; soft and plastic.

Gas voids.

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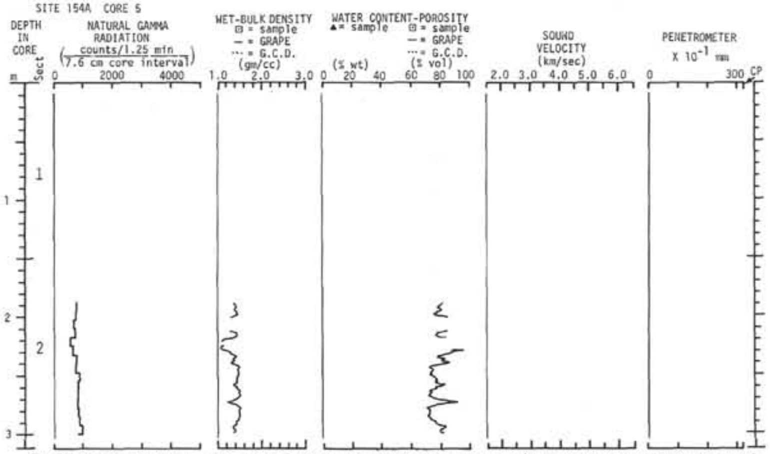
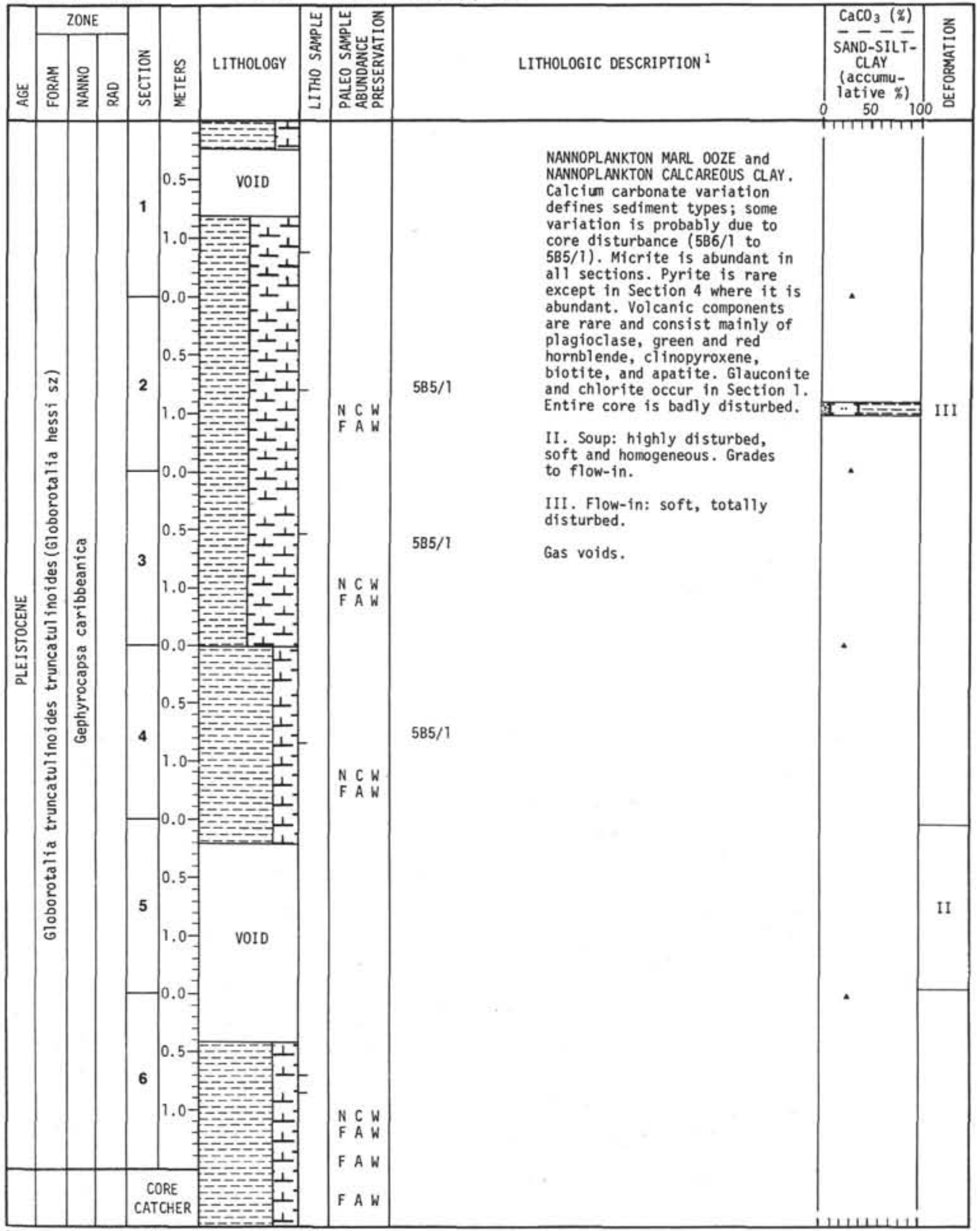
¹For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1419. This background was subtracted from the data.

SITE 154 A HOLE CORE 6 CORED INTERVAL (m) 49-59



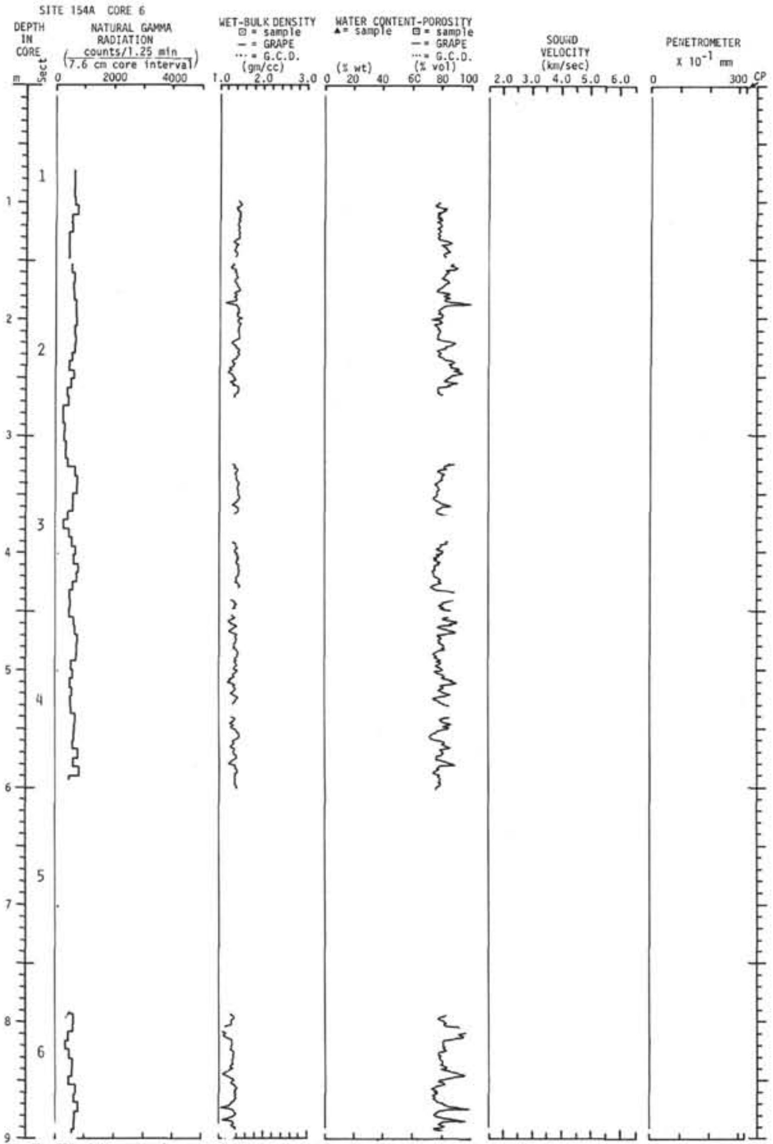
NANNOPLANKTON MARL OOZE and NANNOPLANKTON CALCAREOUS CLAY. Calcium carbonate variation defines sediment types; some variation is probably due to core disturbance (5B6/1 to 5B5/1). Micrite is abundant in all sections. Pyrite is rare except in Section 4 where it is abundant. Volcanic components are rare and consist mainly of plagioclase, green and red hornblende, clinopyroxene, biotite, and apatite. Glauconite and chlorite occur in Section 1. Entire core is badly disturbed.

II. Soup: highly disturbed, soft and homogeneous. Grades to flow-in.

III. Flow-in: soft, totally disturbed.

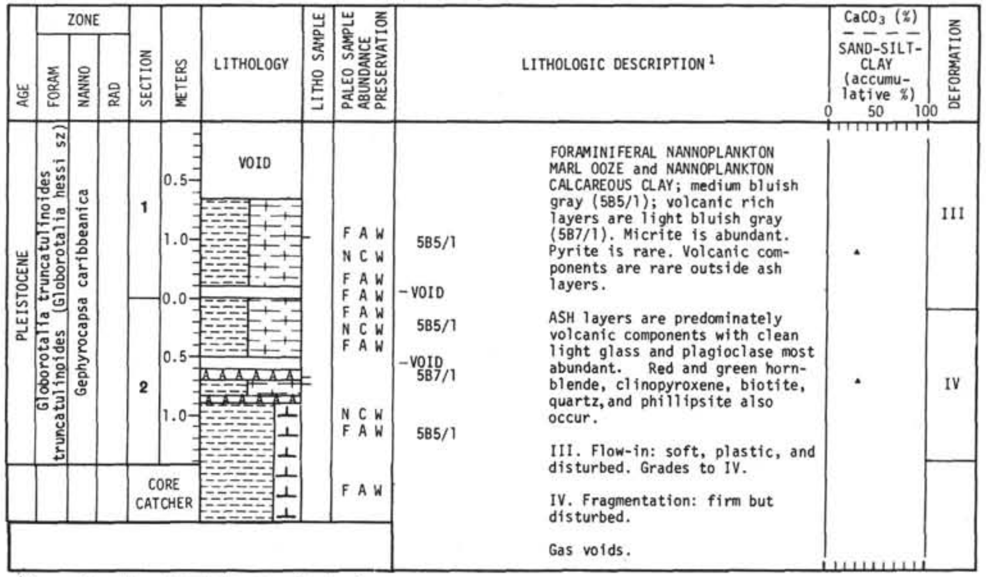
Gas voids.

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 1407. This background was subtracted from the data.

SITE 154 A HOLE CORE 7 CORED INTERVAL (m) 59-68



FORAMINIFERAL NANNOPLANKTON MARL OOZE and NANNOPLANKTON CALCAREOUS CLAY; medium bluish gray (5B5/1); volcanic rich layers are light bluish gray (5B7/1). Micrite is abundant. Pyrite is rare. Volcanic components are rare outside ash layers.

ASH layers are predominately volcanic components with clean light glass and plagioclase most abundant. Red and green hornblende, clinopyroxene, biotite, quartz, and phillipsite also occur.

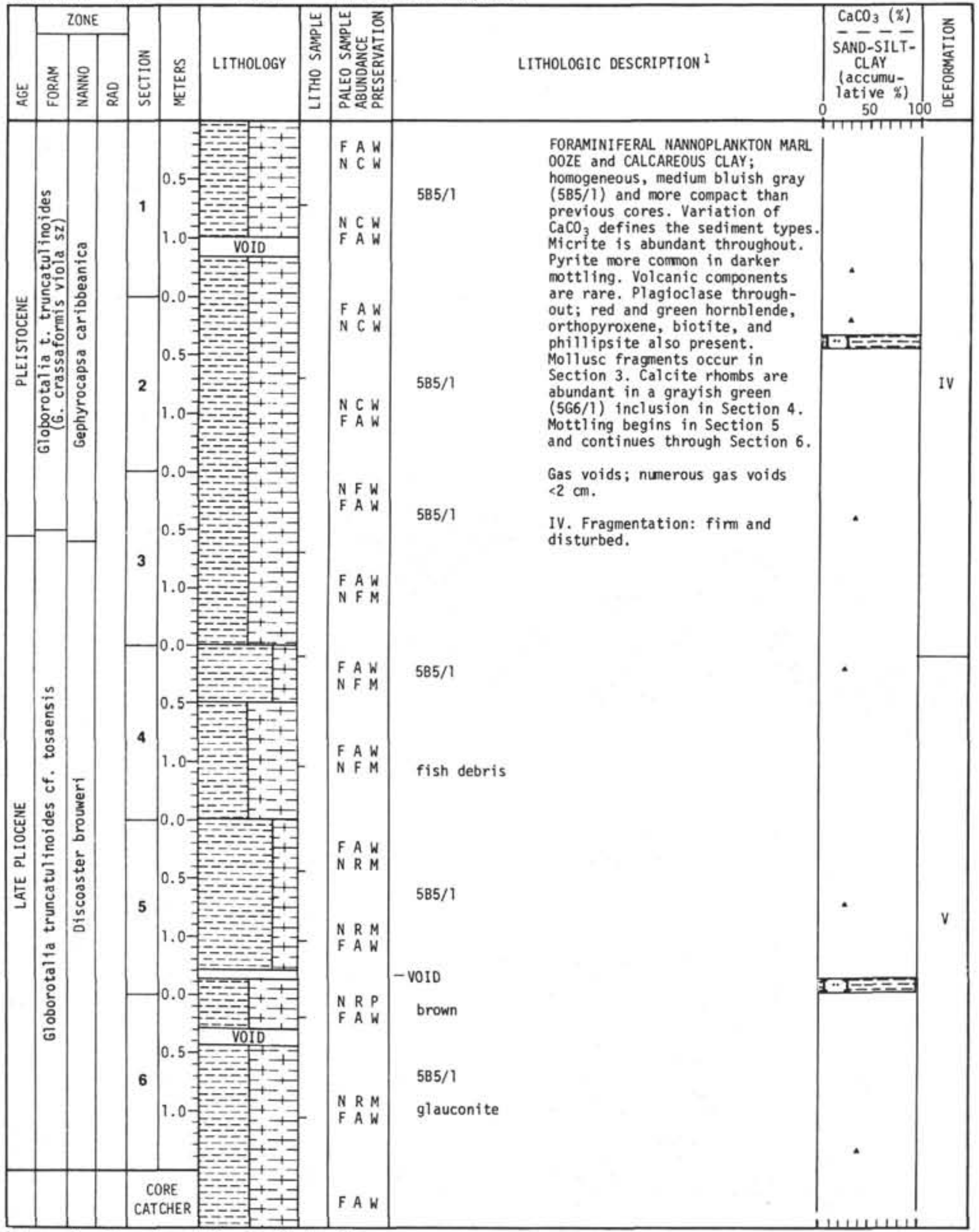
III. Flow-in: soft, plastic, and disturbed. Grades to IV.

IV. Fragmentation: firm but disturbed.

Gas voids.

[1] For explanation of symbols, see Chapter 1

SITE 154 A HOLE CORE 8 CORED INTERVAL (m) 68-78

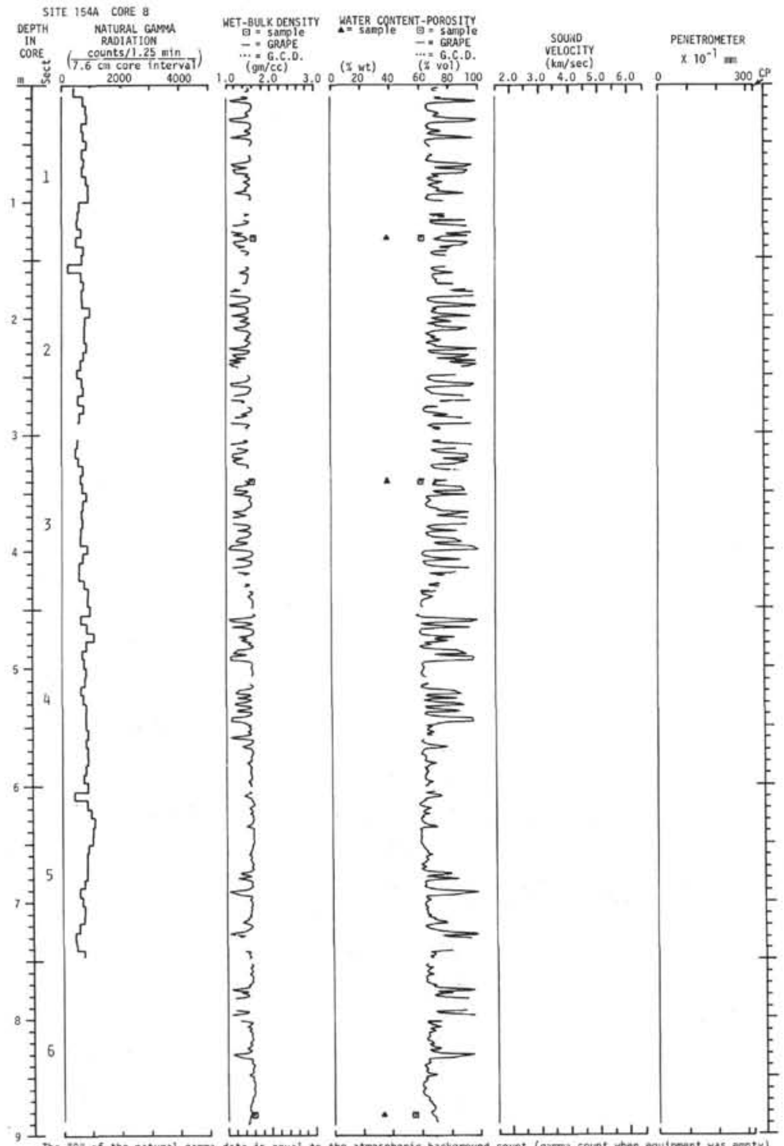


FORAMINIFERAL NANNOPLANKTON MARL OOZE and CALCAREOUS CLAY; homogeneous, medium bluish gray (5B5/1) and more compact than previous cores. Variation of $CaCO_3$ defines the sediment types. Micrite is abundant throughout. Pyrite more common in darker mottling. Volcanic components are rare. Plagioclase throughout; red and green hornblende, orthopyroxene, biotite, and phillipsite also present. Mollusc fragments occur in Section 3. Calcite rhombs are abundant in a grayish green (5G6/1) inclusion in Section 4. Mottling begins in Section 5 and continues through Section 6.

Gas voids; numerous gas voids <2 cm.

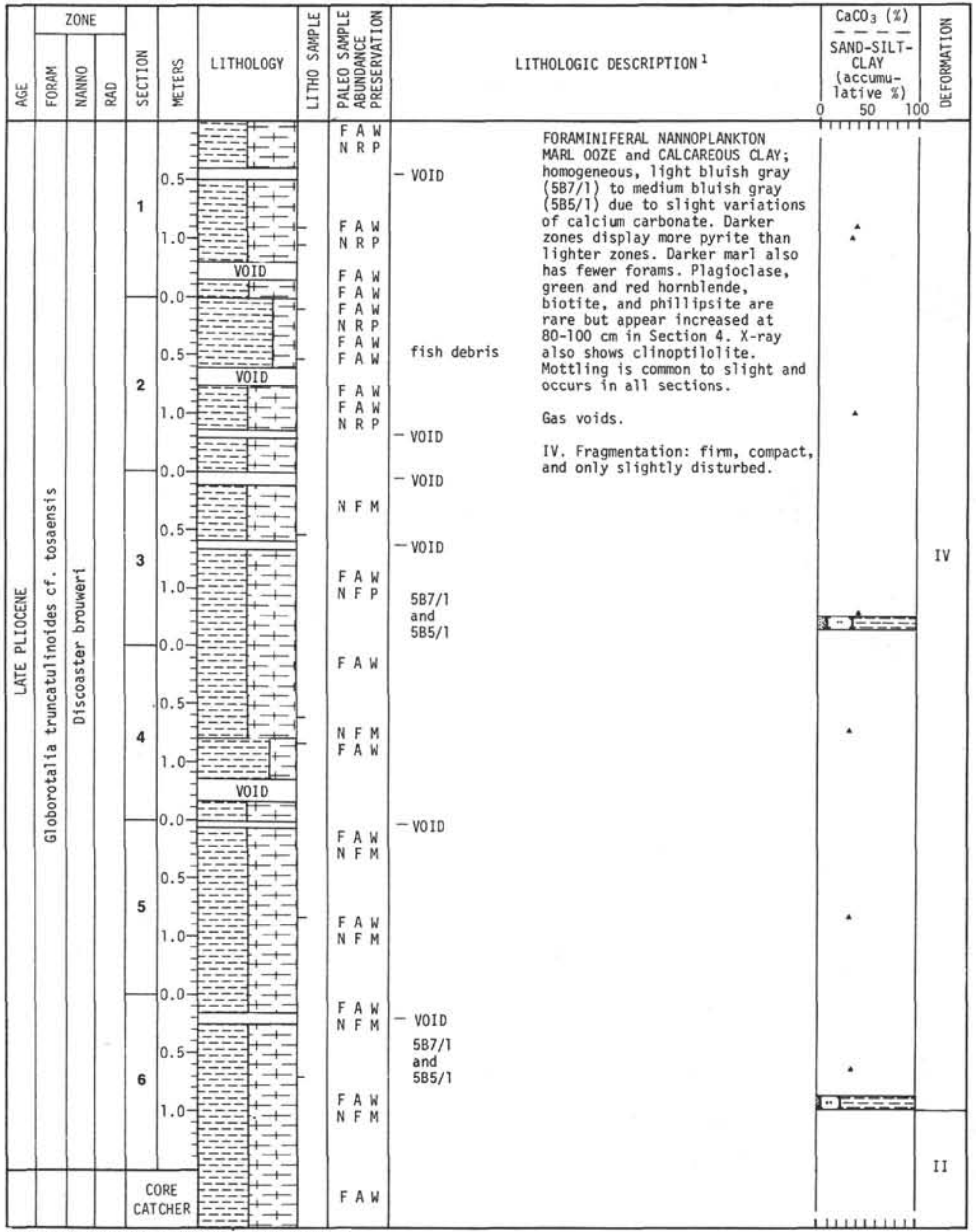
IV. Fragmentation: firm and disturbed.

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 1416. This background was subtracted from the data.

SITE 154 A HOLE CORE 9 CORED INTERVAL (m) 78-87

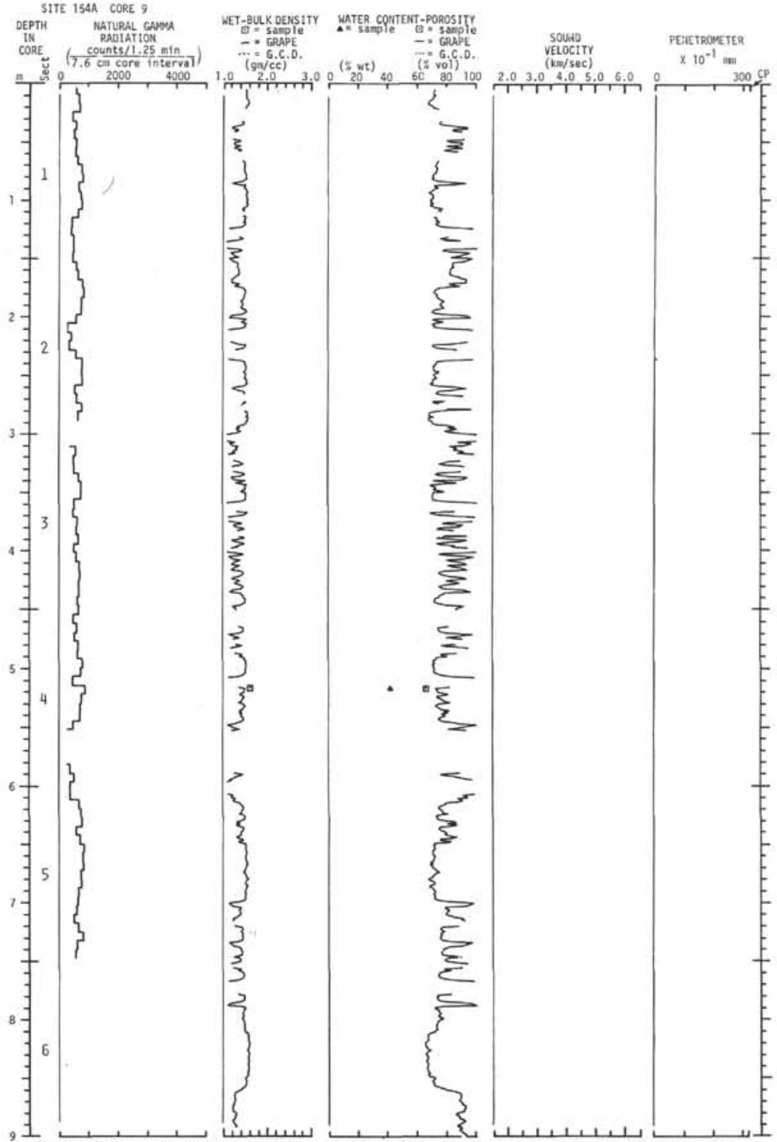


FORAMINIFERAL NANNOPLANKTON MARL OOZE and CALCAREOUS CLAY; homogeneous, light bluish gray (5B7/1) to medium bluish gray (5B5/1) due to slight variations of calcium carbonate. Darker zones display more pyrite than lighter zones. Darker marl also has fewer forams. Plagioclase, green and red hornblende, biotite, and phillipsite are rare but appear increased at 80-100 cm in Section 4. X-ray also shows clinoptilolite. Mottling is common to slight and occurs in all sections.

Gas voids.

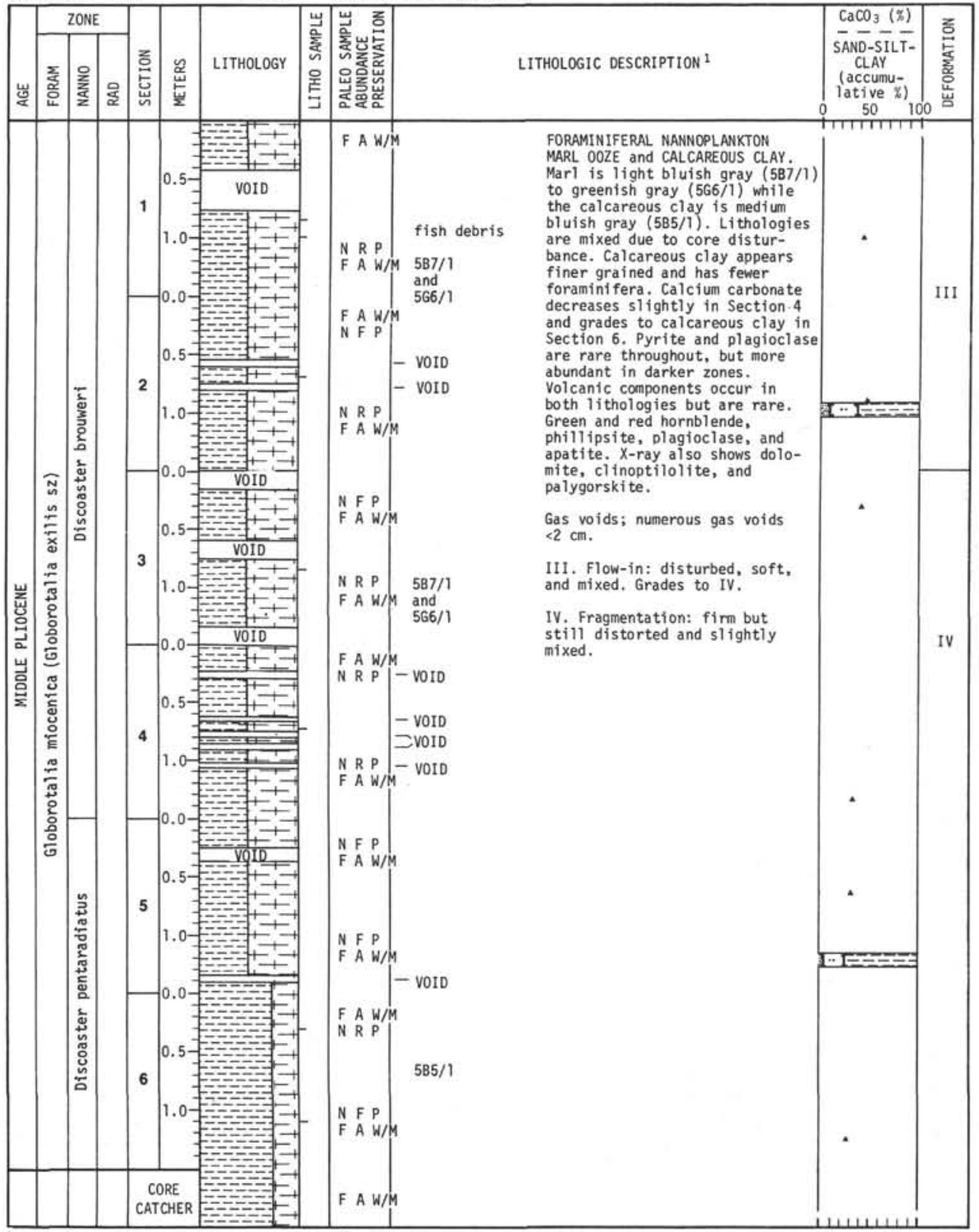
IV. Fragmentation: firm, compact, and only slightly disturbed.

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 1458. This background was subtracted from the data.

SITE 154 A HOLE CORE 10 CORED INTERVAL (m) 87-97



FORAMINIFERAL NANNOPLANKTON MARL OOZE and CALCAREOUS CLAY. Marl is light bluish gray (5B7/1) to greenish gray (5G6/1) while the calcareous clay is medium bluish gray (5B5/1). Lithologies are mixed due to core disturbance. Calcareous clay appears finer grained and has fewer foraminifera. Calcium carbonate decreases slightly in Section 4 and grades to calcareous clay in Section 6. Pyrite and plagioclase are rare throughout, but more abundant in darker zones. Volcanic components occur in both lithologies but are rare. Green and red hornblende, phillipsite, plagioclase, and apatite. X-ray also shows dolomite, clinoptilolite, and palygorskite.

Gas voids; numerous gas voids <2 cm.

III. Flow-in: disturbed, soft, and mixed. Grades to IV.

IV. Fragmentation: firm but still distorted and slightly mixed.

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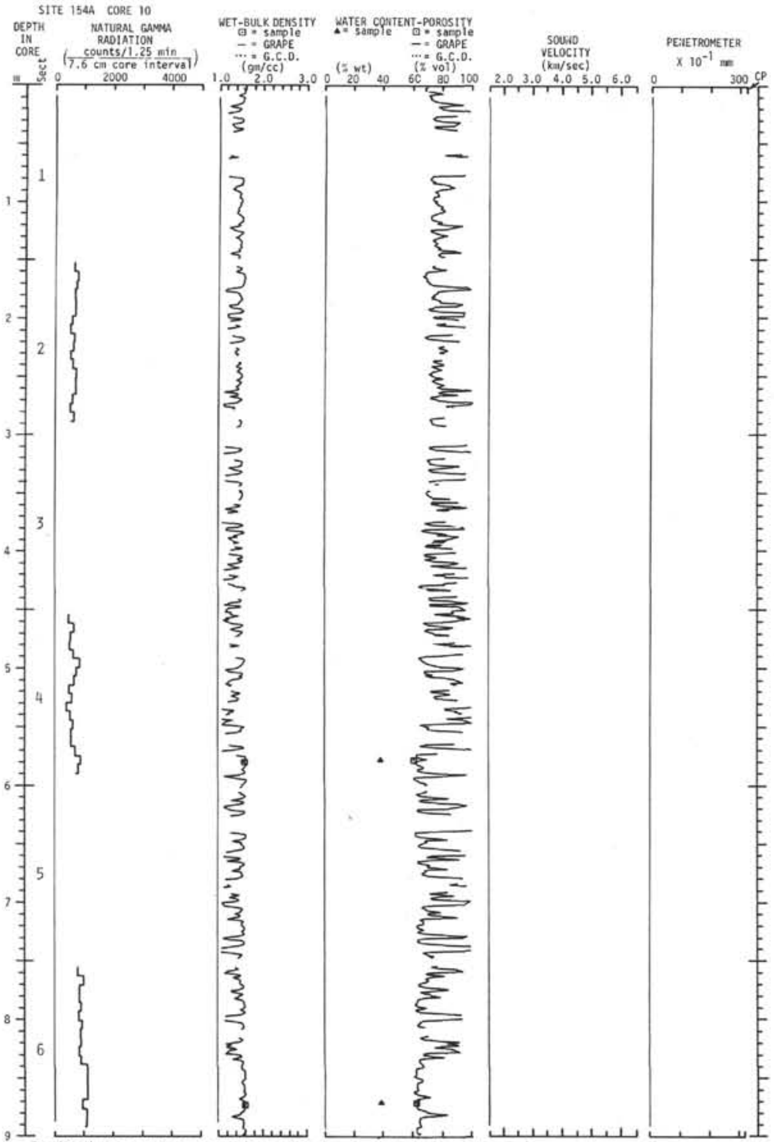
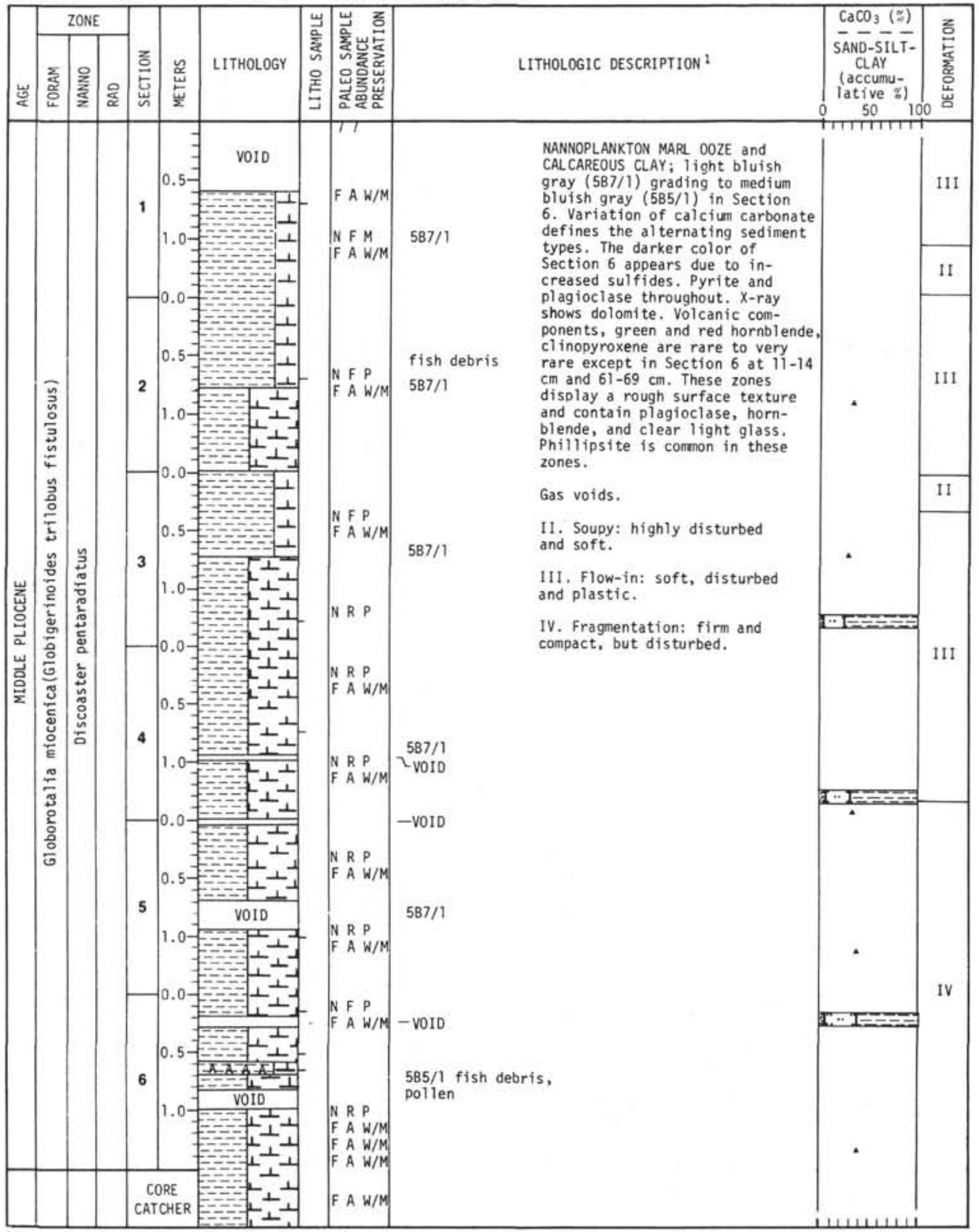
[1] For explanation of symbols, see Chapter 1



The "0" of the natural gamma data is equal to the atmospheric background count (gamma count when equipment was empty) of 1450. This background was subtracted from the data.

SITE 154 A HOLE CORE 11 CORED INTERVAL (m) 97-106



NANNOPLANKTON MARL OOZE and CALCAREOUS CLAY; light bluish gray (5B7/1) grading to medium bluish gray (5B5/1) in Section 6. Variation of calcium carbonate defines the alternating sediment types. The darker color of Section 6 appears due to increased sulfides. Pyrite and plagioclase throughout. X-ray shows dolomite. Volcanic components, green and red hornblende, clinopyroxene are rare to very rare except in Section 6 at 11-14 cm and 61-69 cm. These zones display a rough surface texture and contain plagioclase, hornblende, and clear light glass. Phillipsite is common in these zones.

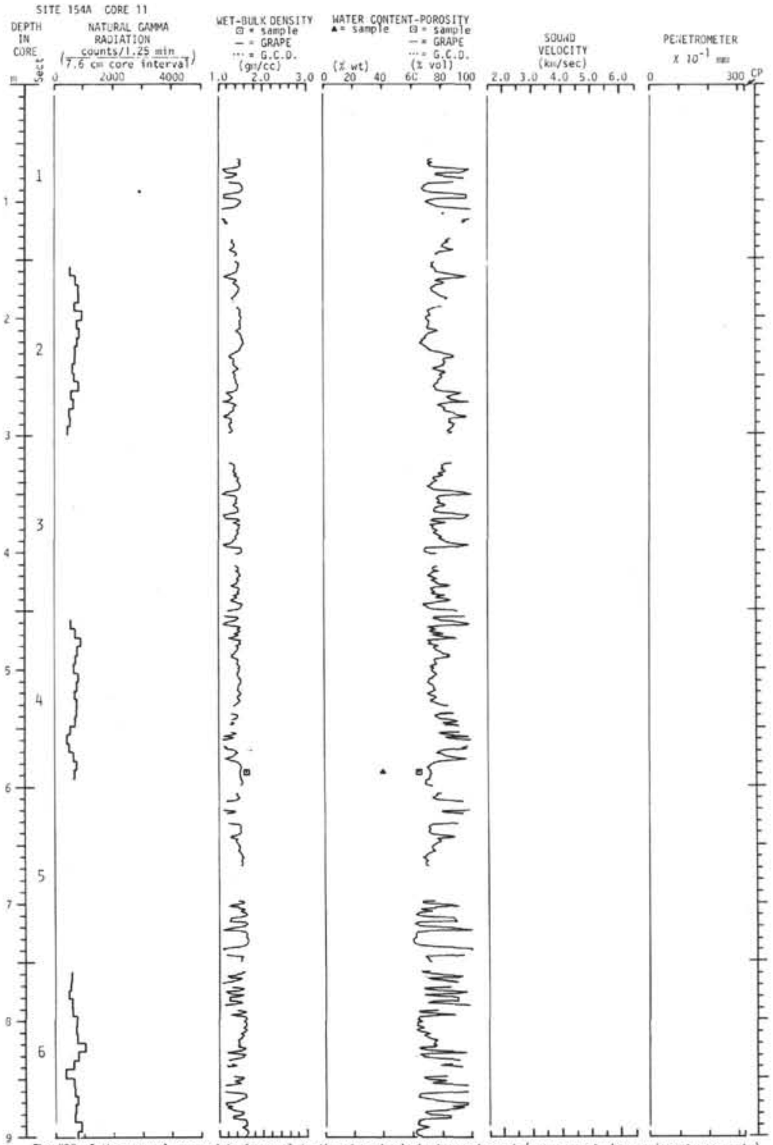
Gas voids.

II. Soupy: highly disturbed and soft.

III. Flow-in: soft, disturbed and plastic.

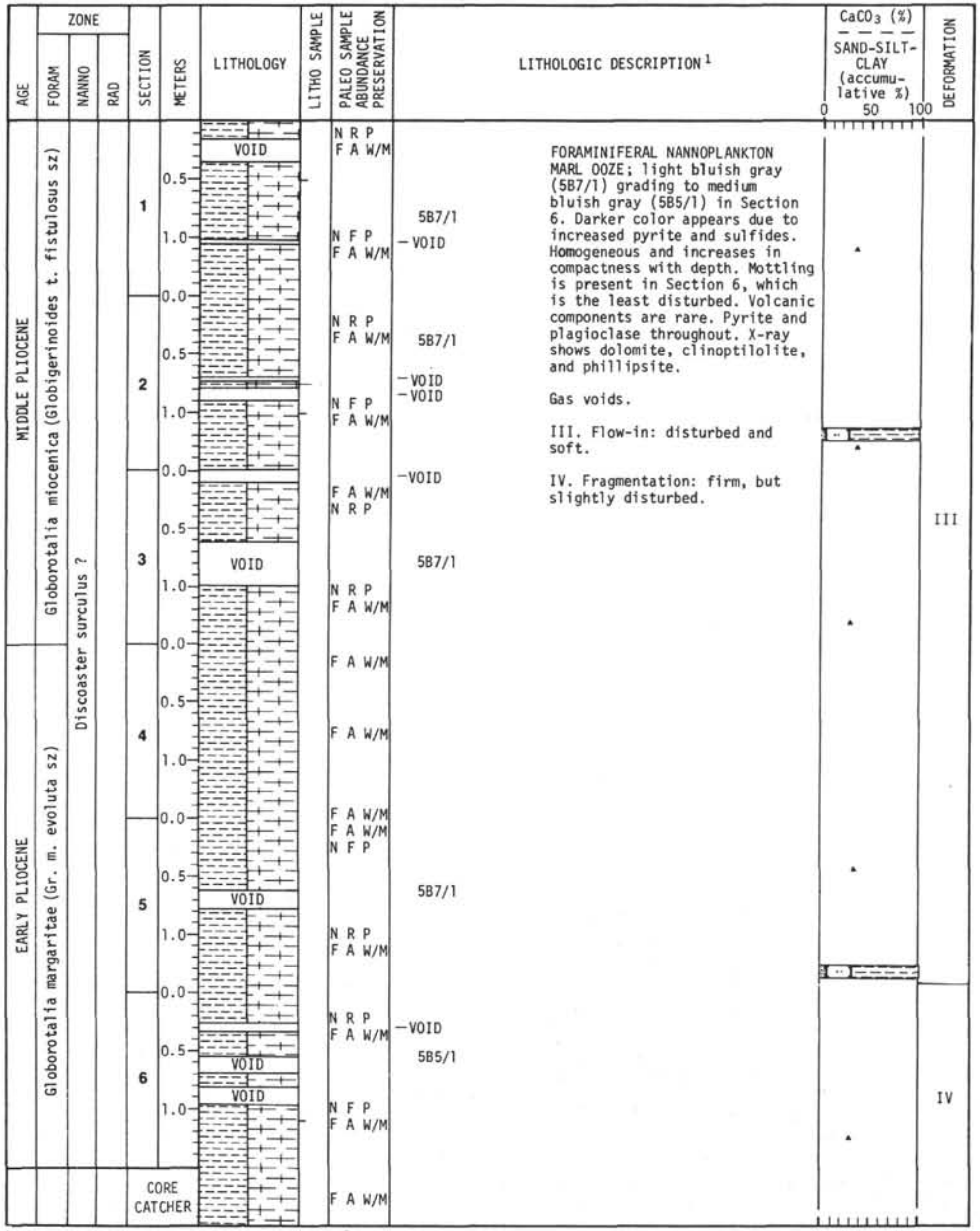
IV. Fragmentation: firm and compact, but disturbed.

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 1450. This background was subtracted from the data.

SITE 154 A HOLE CORE 12 CORED INTERVAL (m) 106-116



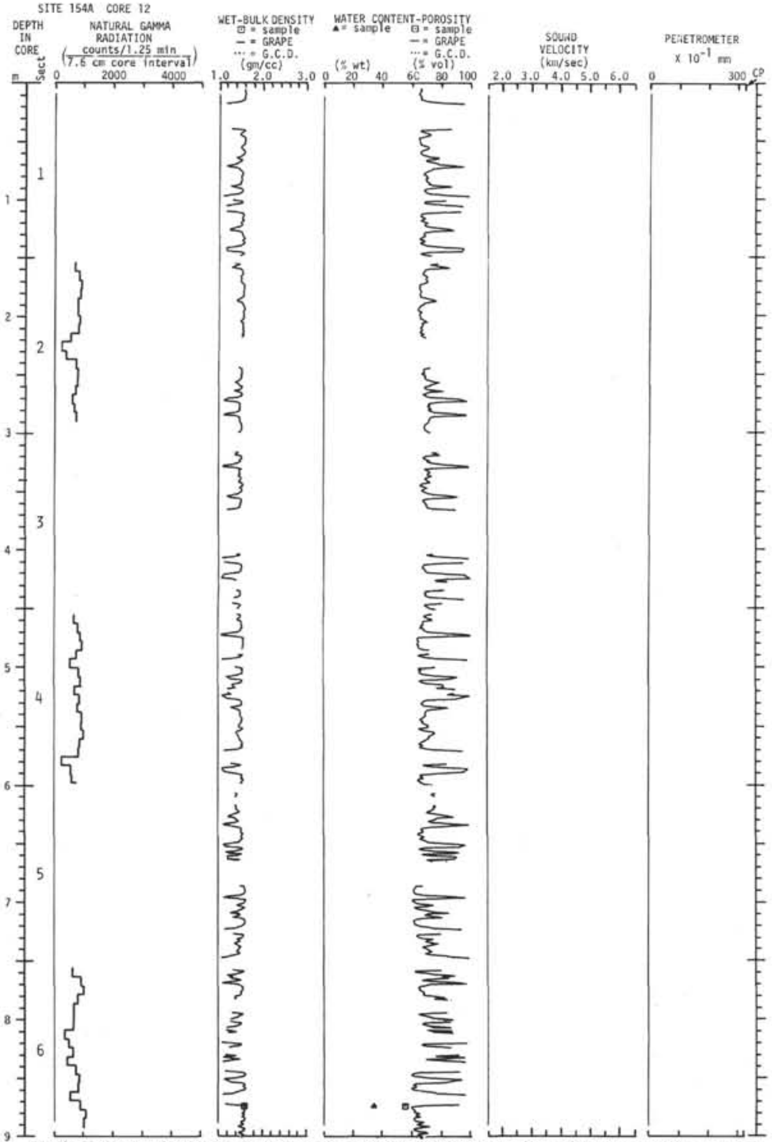
FORAMINIFERAL NANNOPLANKTON MARL OOZE; light bluish gray (5B7/1) grading to medium bluish gray (5B5/1) in Section 6. Darker color appears due to increased pyrite and sulfides. Homogeneous and increases in compactness with depth. Mottling is present in Section 6, which is the least disturbed. Volcanic components are rare. Pyrite and plagioclase throughout. X-ray shows dolomite, clinoptilolite, and phillipsite.

Gas voids.

III. Flow-in: disturbed and soft.

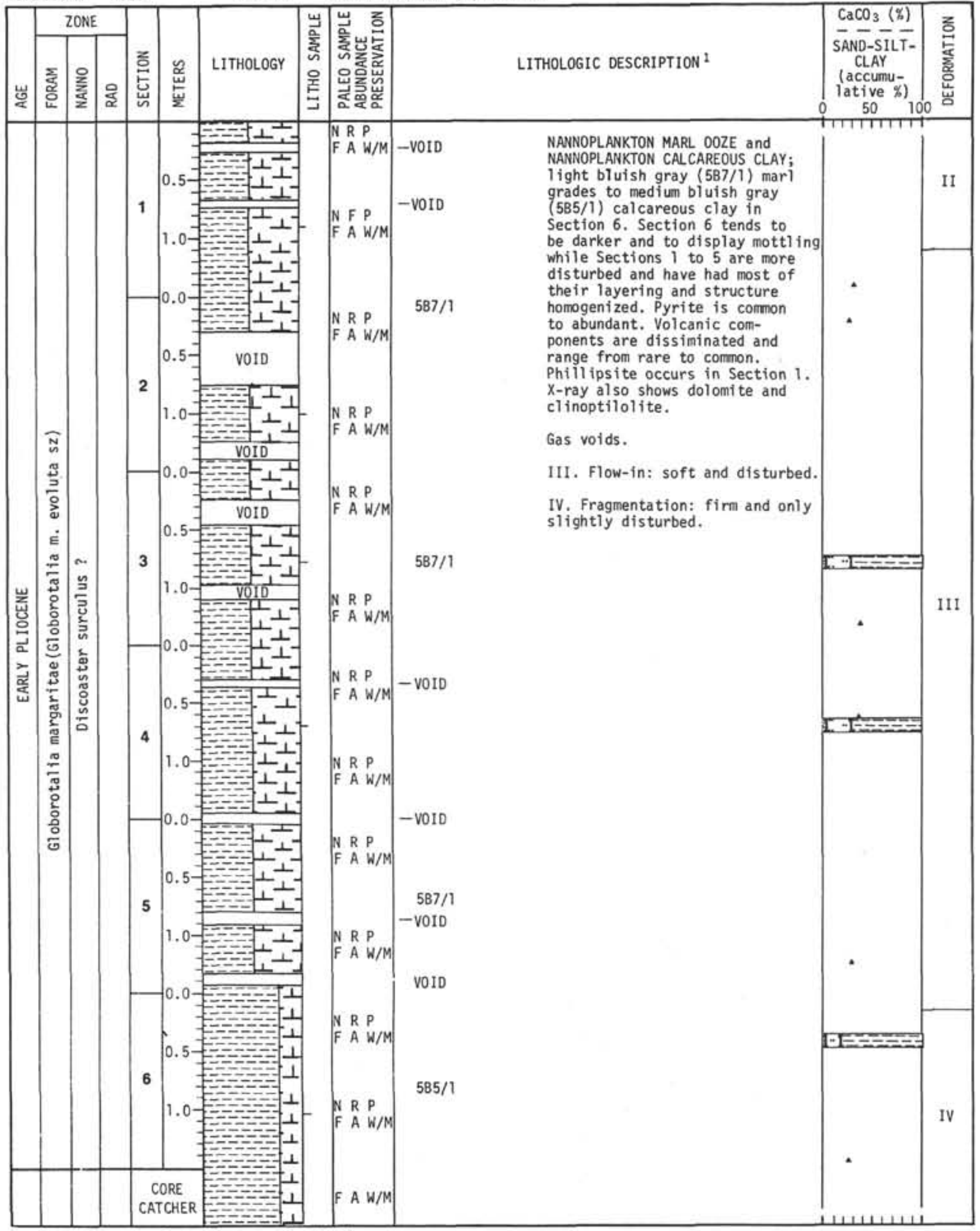
IV. Fragmentation: firm, but slightly disturbed.

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 1450. This background was subtracted from the data.

SITE 154 A HOLE CORE 13 CORED INTERVAL (m) 116-175



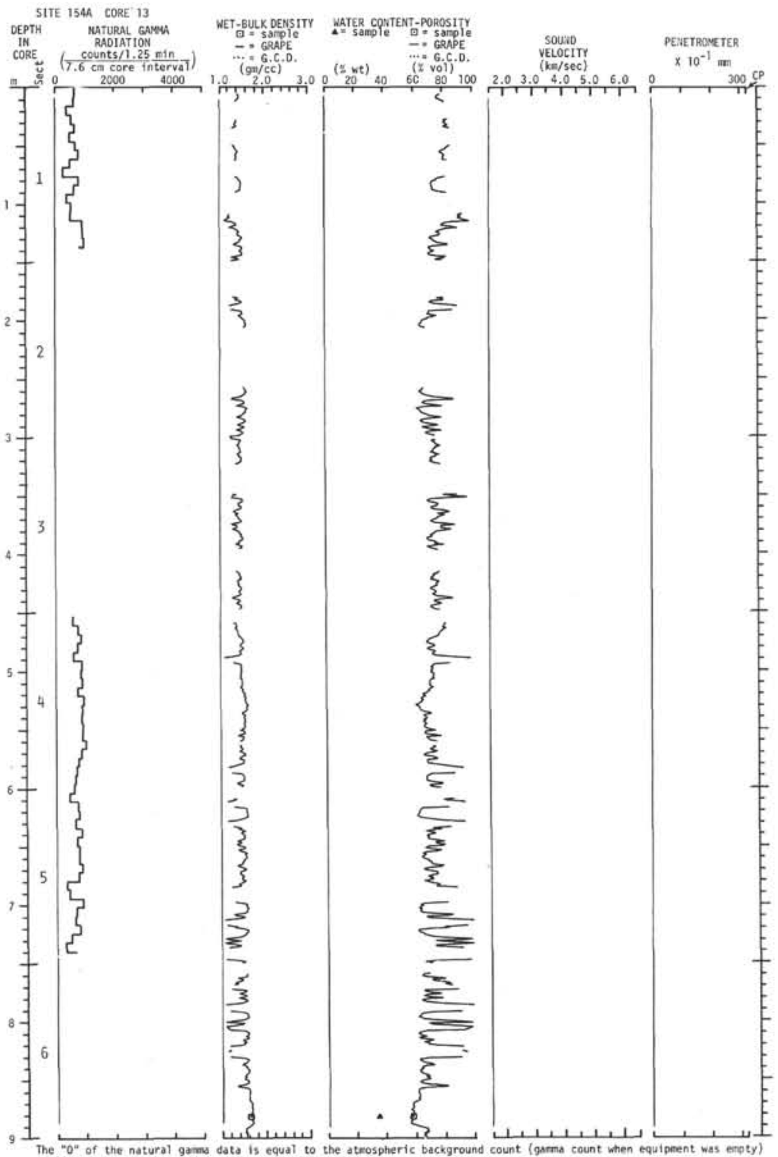
NANNOPLANKTON MARL OOZE and NANNOPLANKTON CALCAREOUS CLAY; light bluish gray (5B7/1) marl grades to medium bluish gray (5B5/1) calcareous clay in Section 6. Section 6 tends to be darker and to display mottling while Sections 1 to 5 are more disturbed and have had most of their layering and structure homogenized. Pyrite is common to abundant. Volcanic components are dissiminated and range from rare to common. Phillipsite occurs in Section 1. X-ray also shows dolomite and clinoptilolite.

Gas voids.

III. Flow-in: soft and disturbed.

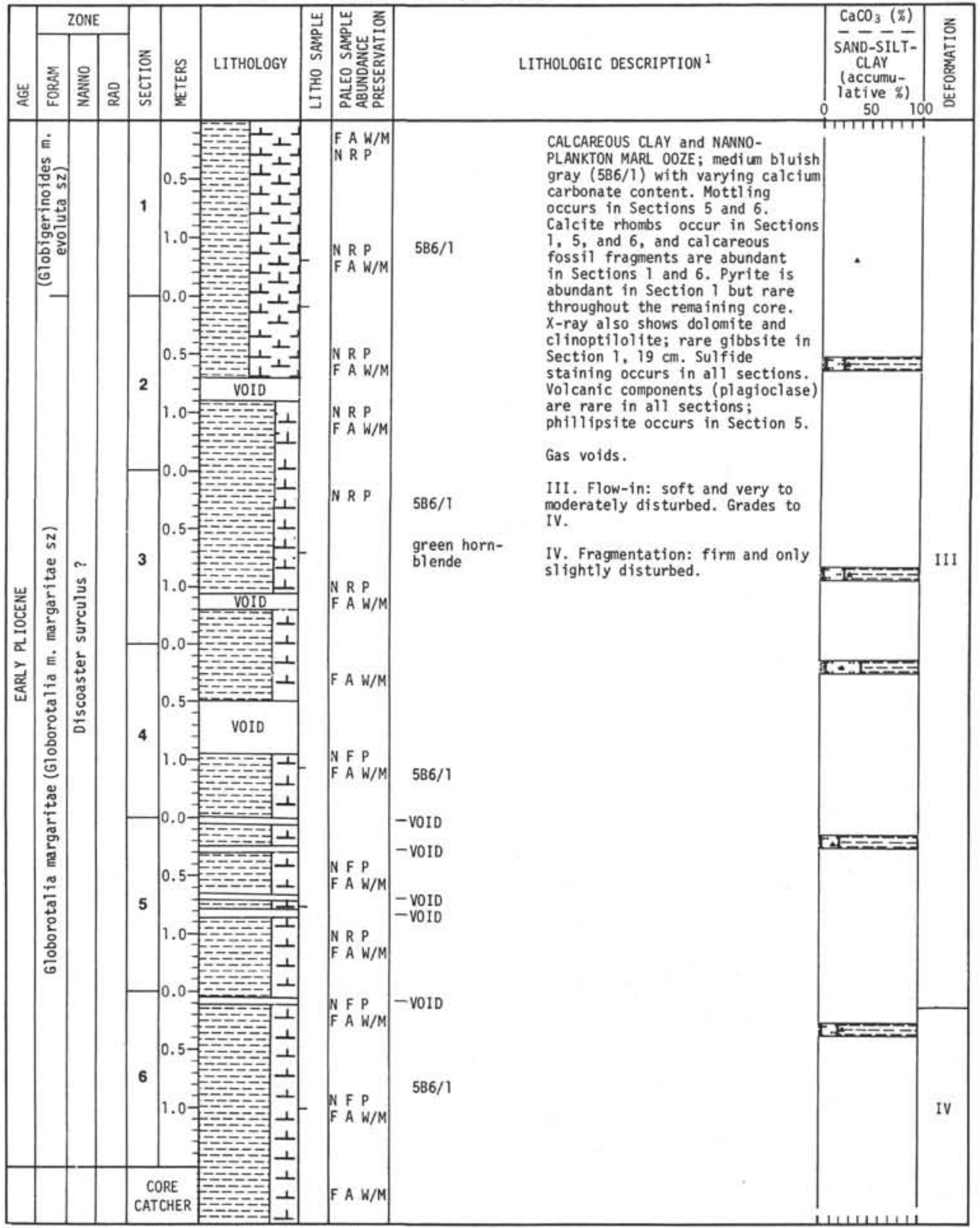
IV. Fragmentation: firm and only slightly disturbed.

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 1450. This background was subtracted from the data.

SITE 154 A HOLE CORE 14 CORED INTERVAL (m) 125-134



CALCAREOUS CLAY and NANNOPLANKTON MARL OOZE; medium bluish gray (5B6/1) with varying calcium carbonate content. Mottling occurs in Sections 5 and 6. Calcite rhombs occur in Sections 1, 5, and 6, and calcareous fossil fragments are abundant in Sections 1 and 6. Pyrite is abundant in Section 1 but rare throughout the remaining core. X-ray also shows dolomite and clinoptilolite; rare gibbsite in Section 1, 19 cm. Sulfide staining occurs in all sections. Volcanic components (plagioclase) are rare in all sections; phillipsite occurs in Section 5.

Gas voids.

III. Flow-in: soft and very to moderately disturbed. Grades to IV.

IV. Fragmentation: firm and only slightly disturbed.

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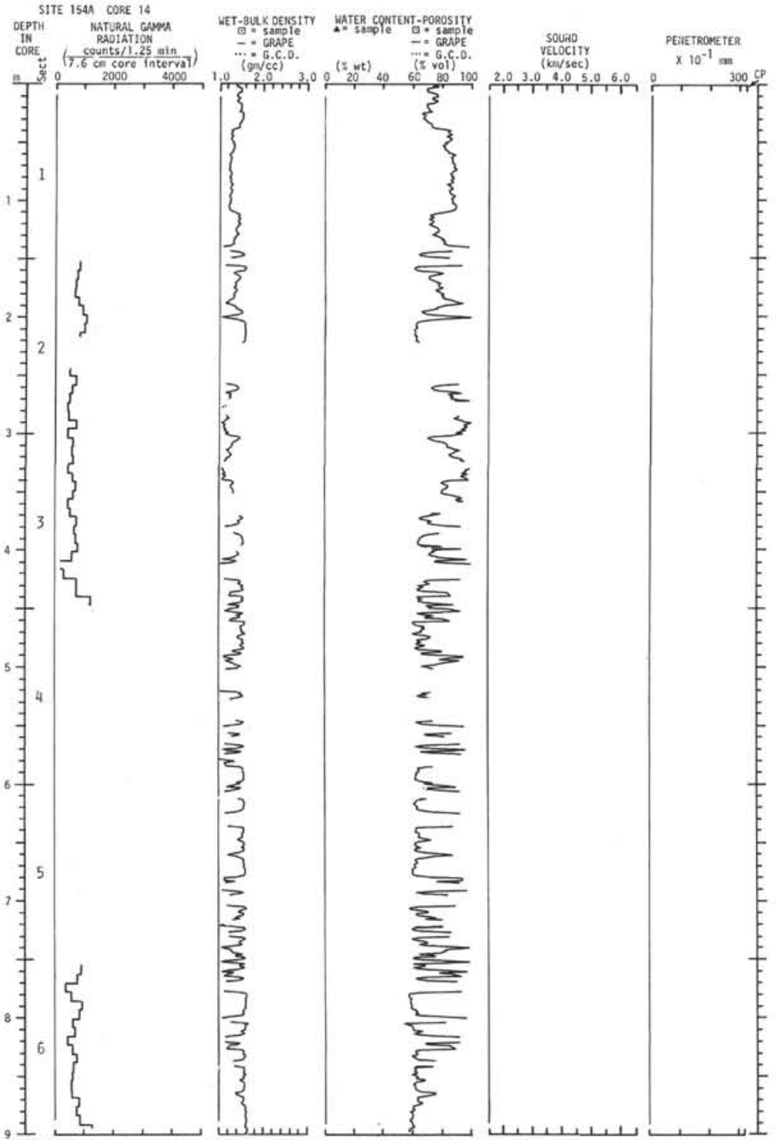
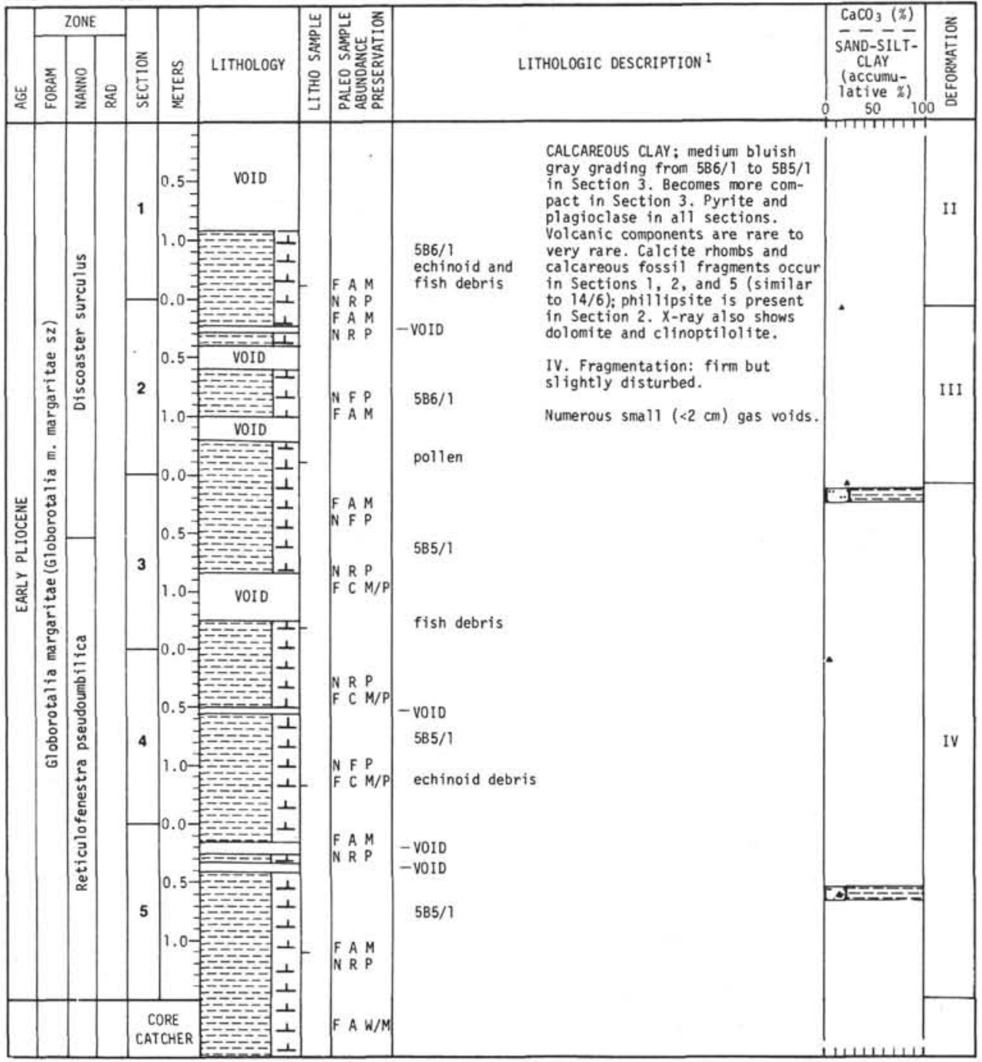
[1] For explanation of symbols, see Chapter 1



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 154 A HOLE CORE 15 CORED INTERVAL (m) 134-144



CALCAREOUS CLAY; medium bluish gray grading from 5B6/1 to 5B5/1 in Section 3. Becomes more compact in Section 3. Pyrite and plagioclase in all sections. Volcanic components are rare to very rare. Calcite rhombs and calcareous fossil fragments occur in Sections 1, 2, and 5 (similar to 14/6); phillipsite is present in Section 2. X-ray also shows dolomite and clinoptilolite.

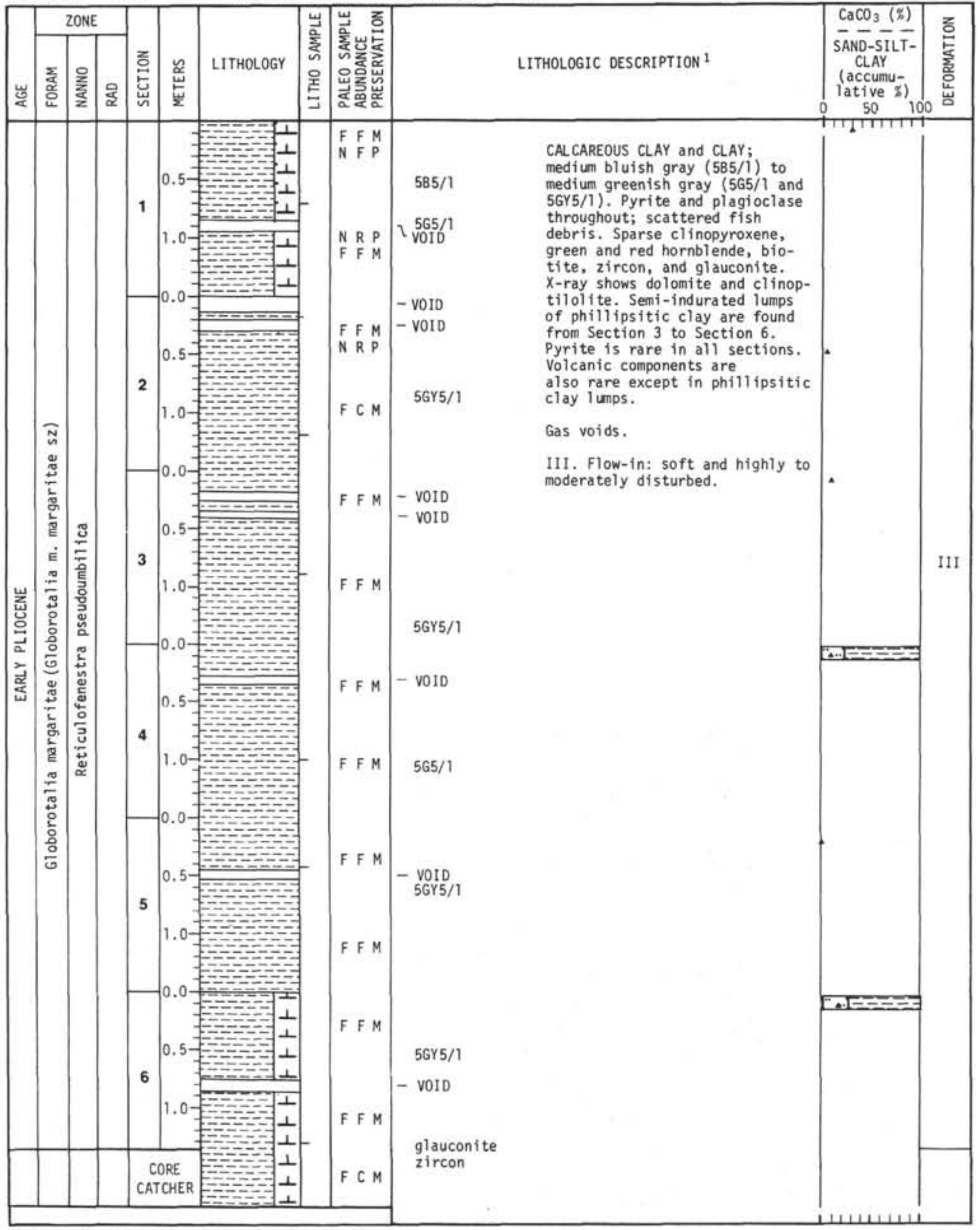
IV. Fragmentation: firm but slightly disturbed.

Numerous small (<2 cm) gas voids.

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 1428. This background was subtracted from the data.

SITE 154 A HOLE CORE 16 CORED INTERVAL (m) 144-153

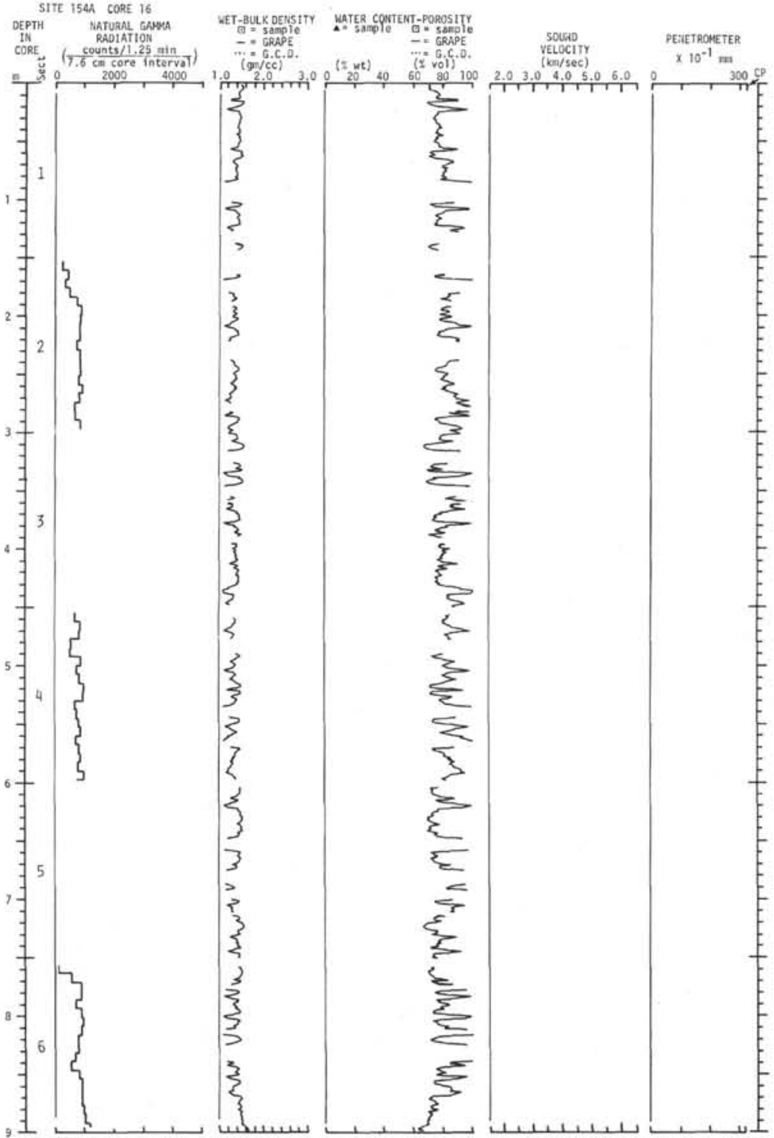


CALCAREOUS CLAY and CLAY; medium bluish gray (5B5/1) to medium greenish gray (5G5/1 and 5GY5/1). Pyrite and plagioclase throughout; scattered fish debris. Sparse clinopyroxene, green and red hornblende, biotite, zircon, and glauconite. X-ray shows dolomite and clinoptilolite. Semi-indurated lumps of phillipsitic clay are found from Section 3 to Section 6. Pyrite is rare in all sections. Volcanic components are also rare except in phillipsitic clay lumps.

Gas voids.

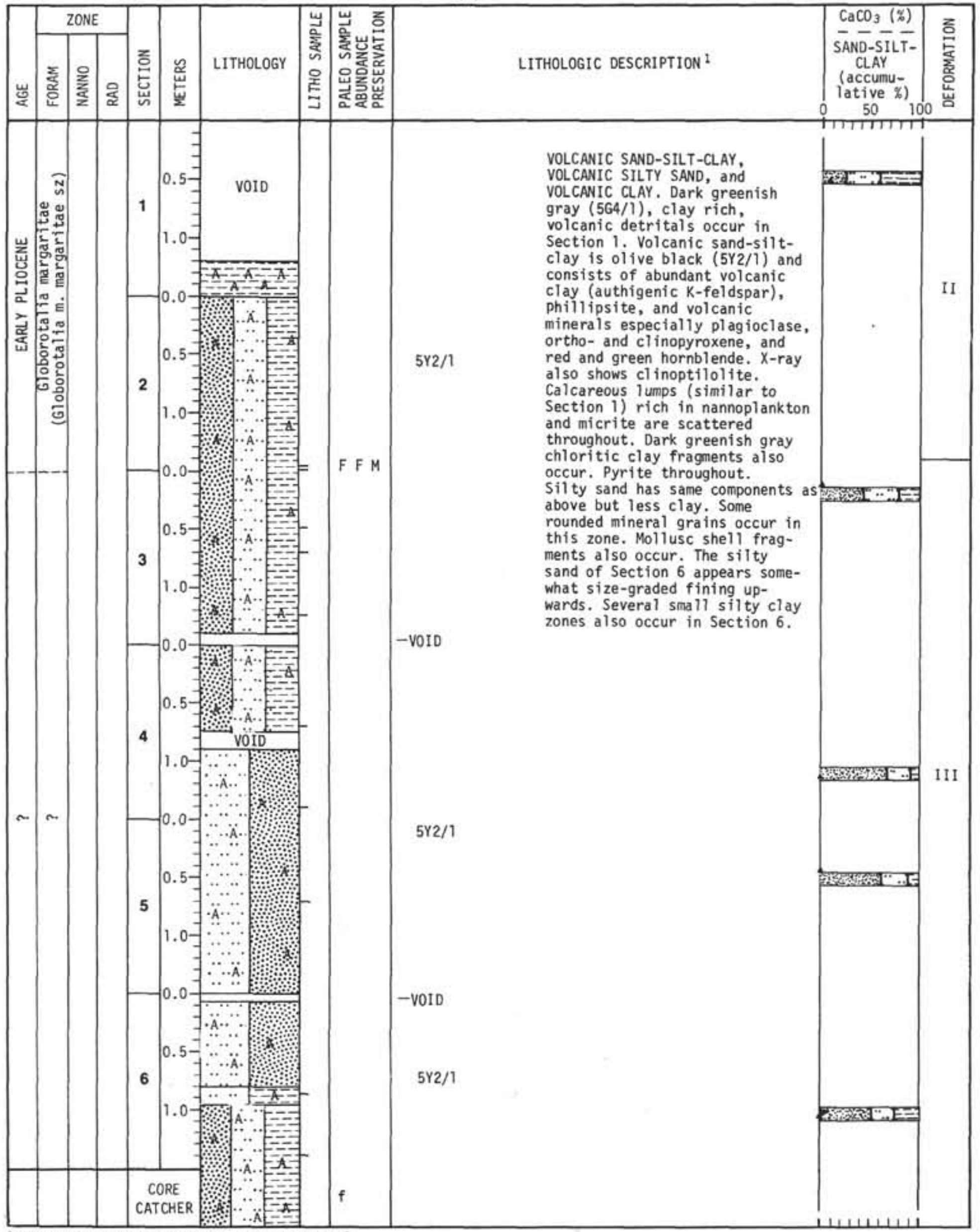
III. Flow-in: soft and highly to moderately disturbed.

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 1402. This background was subtracted from the data.

SITE 154 A HOLE CORE 17 CORED INTERVAL (m) 153-163



VOLCANIC SAND-SILT-CLAY, VOLCANIC SILTY SAND, and VOLCANIC CLAY. Dark greenish gray (5G4/1), clay rich, volcanic detritals occur in Section 1. Volcanic sand-silt-clay is olive black (5Y2/1) and consists of abundant volcanic clay (authigenic K-feldspar), phillipsite, and volcanic minerals especially plagioclase, ortho- and clinopyroxene, and red and green hornblende. X-ray also shows clinoptilolite. Calcareous lumps (similar to Section 1) rich in nannoplankton and micrite are scattered throughout. Dark greenish gray chloritic clay fragments also occur. Pyrite throughout. Silty sand has same components as above but less clay. Some rounded mineral grains occur in this zone. Mollusc shell fragments also occur. The silty sand of Section 6 appears somewhat size-graded fining upwards. Several small silty clay zones also occur in Section 6.

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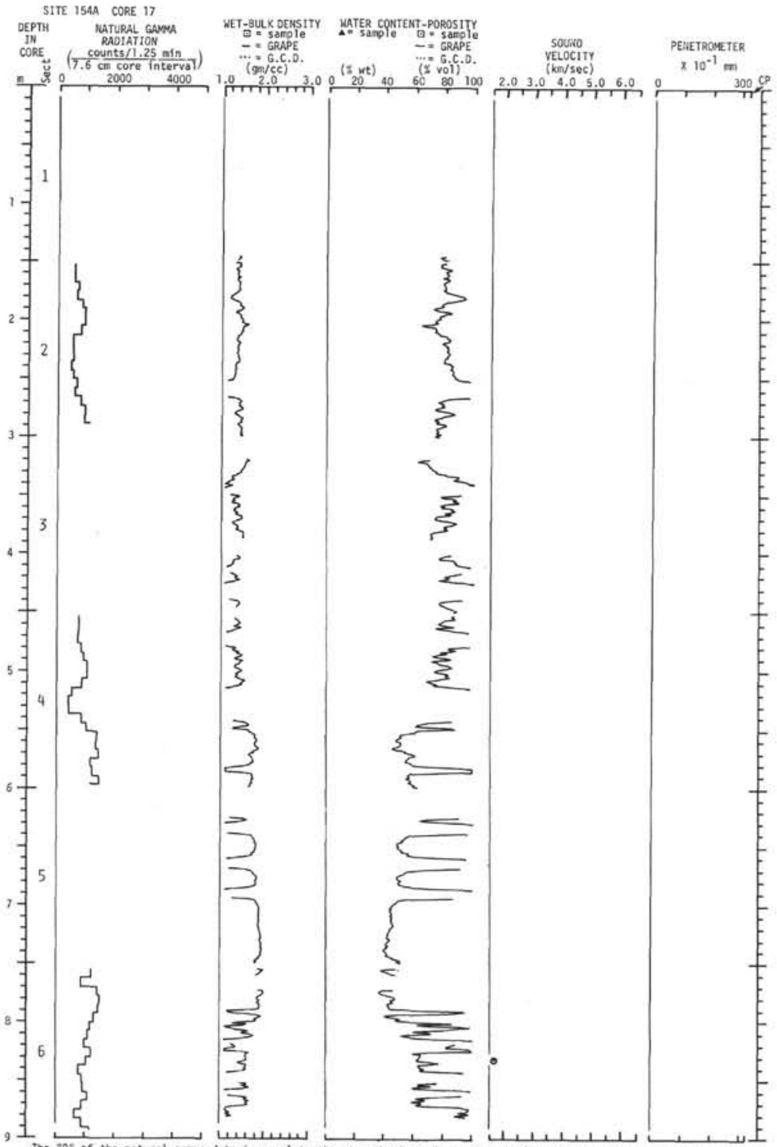
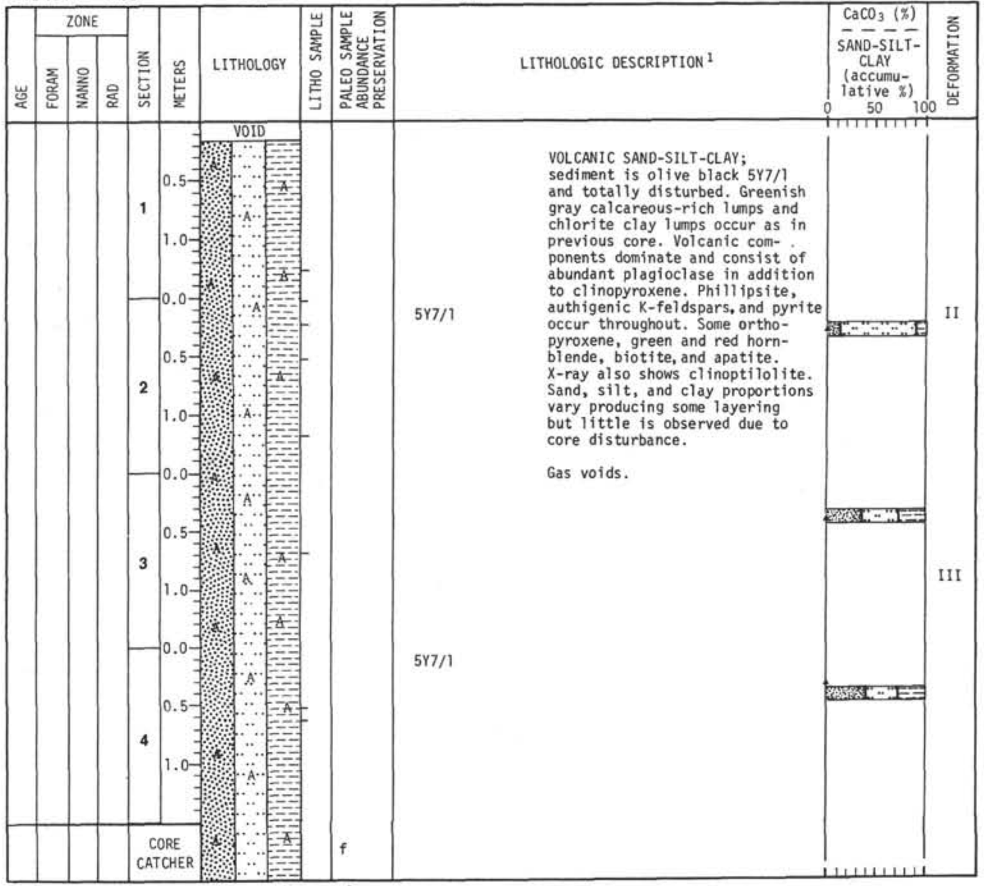
¹For explanation of symbols, see Chapter 1



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

SITE 154 A HOLE CORE 18 CORED INTERVAL (m) 163-172



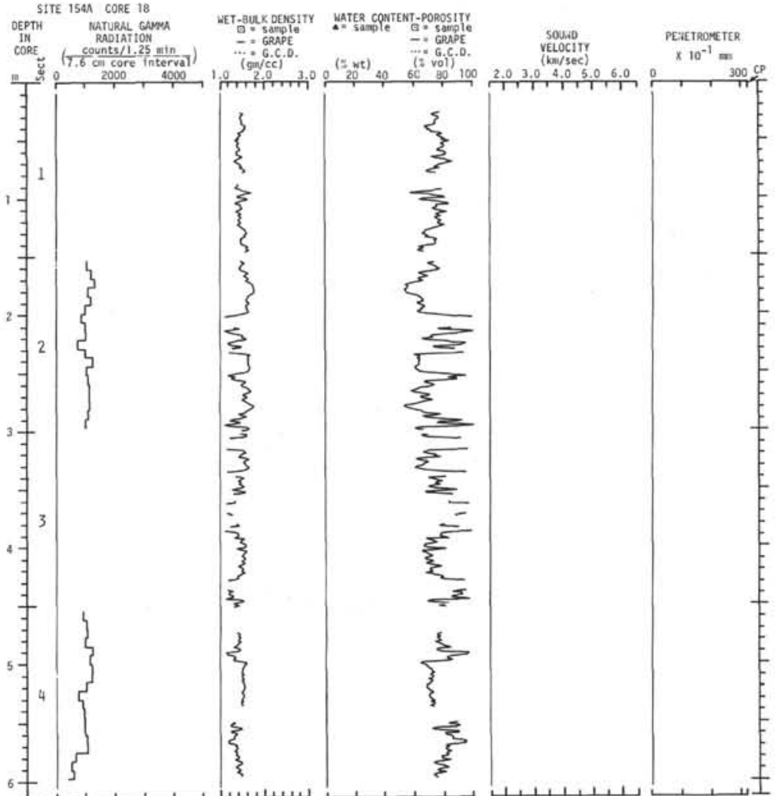
5Y7/1

VOLCANIC SAND-SILT-CLAY; sediment is olive black 5Y7/1 and totally disturbed. Greenish gray calcareous-rich lumps and chlorite clay lumps occur as in previous core. Volcanic components dominate and consist of abundant plagioclase in addition to clinopyroxene. Phillipsite, authigenic K-feldspars, and pyrite occur throughout. Some orthopyroxene, green and red hornblende, biotite, and apatite. X-ray also shows clinoptilolite. Sand, silt, and clay proportions vary producing some layering but little is observed due to core disturbance.

Gas voids.

5Y7/1

¹For explanation of symbols, see Chapter 1



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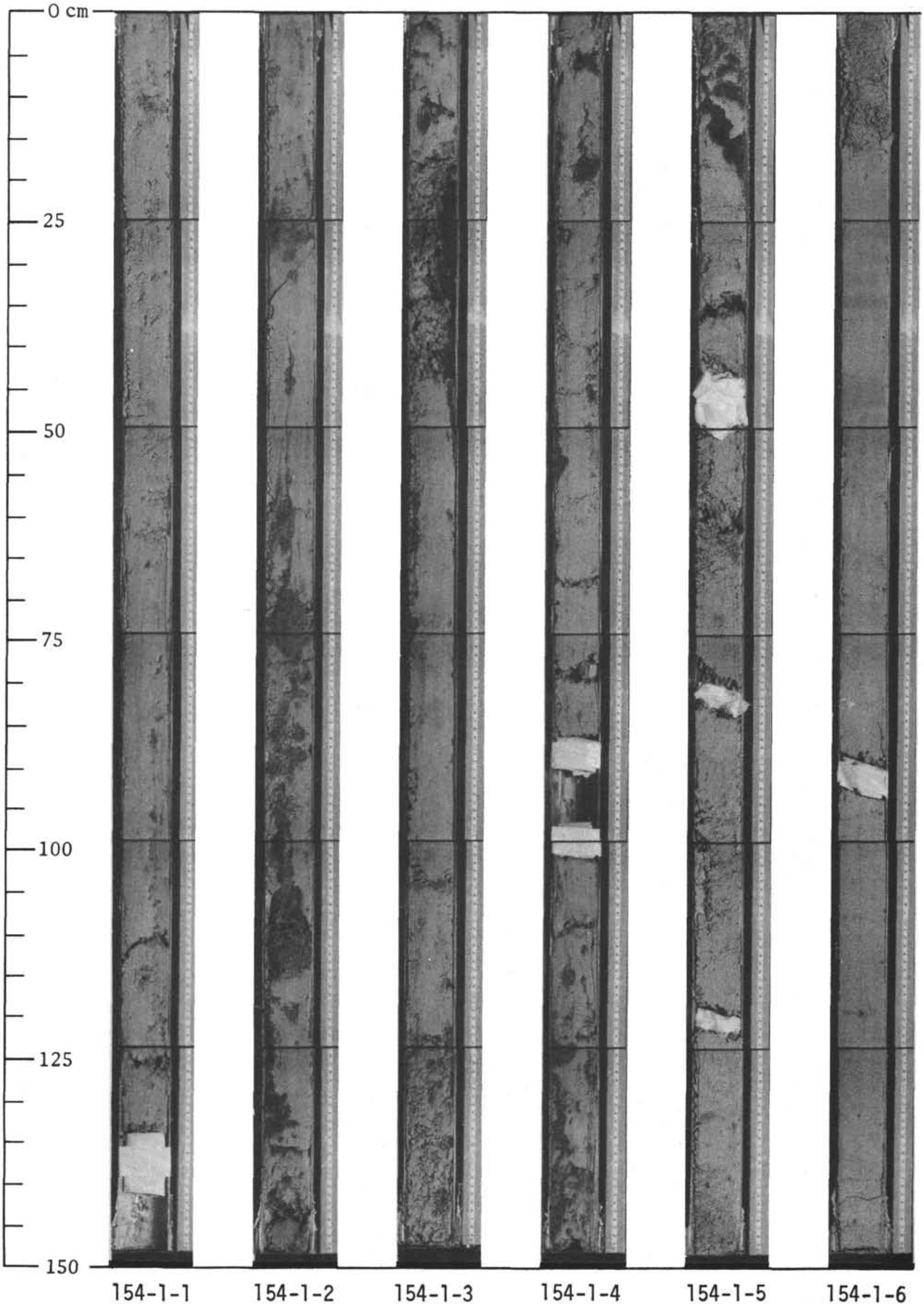
0 cm
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50
75
100
125
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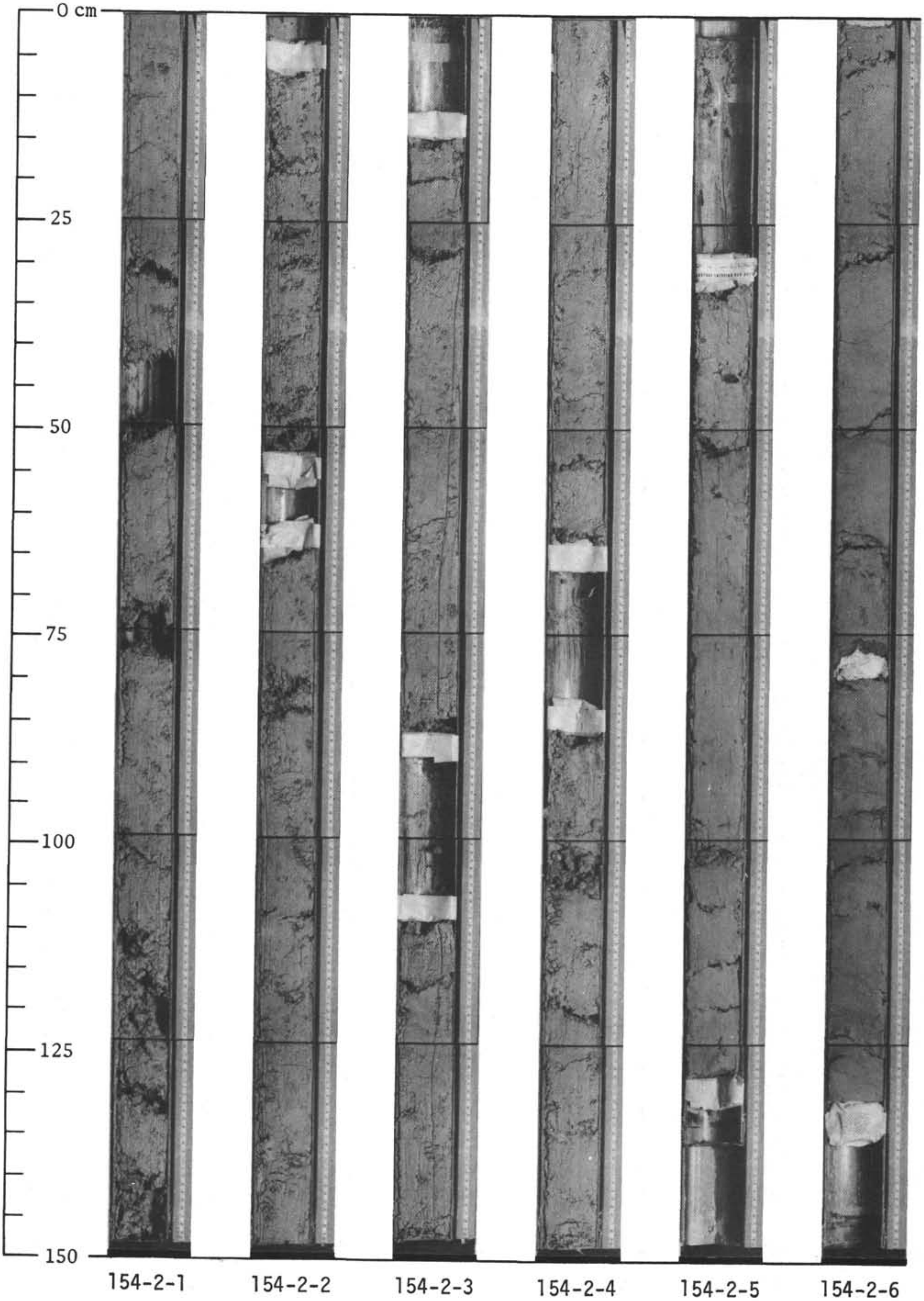
154-1-2
154-1-3
154-1-4
154-1-5
154-1-6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50
75
100
125
150
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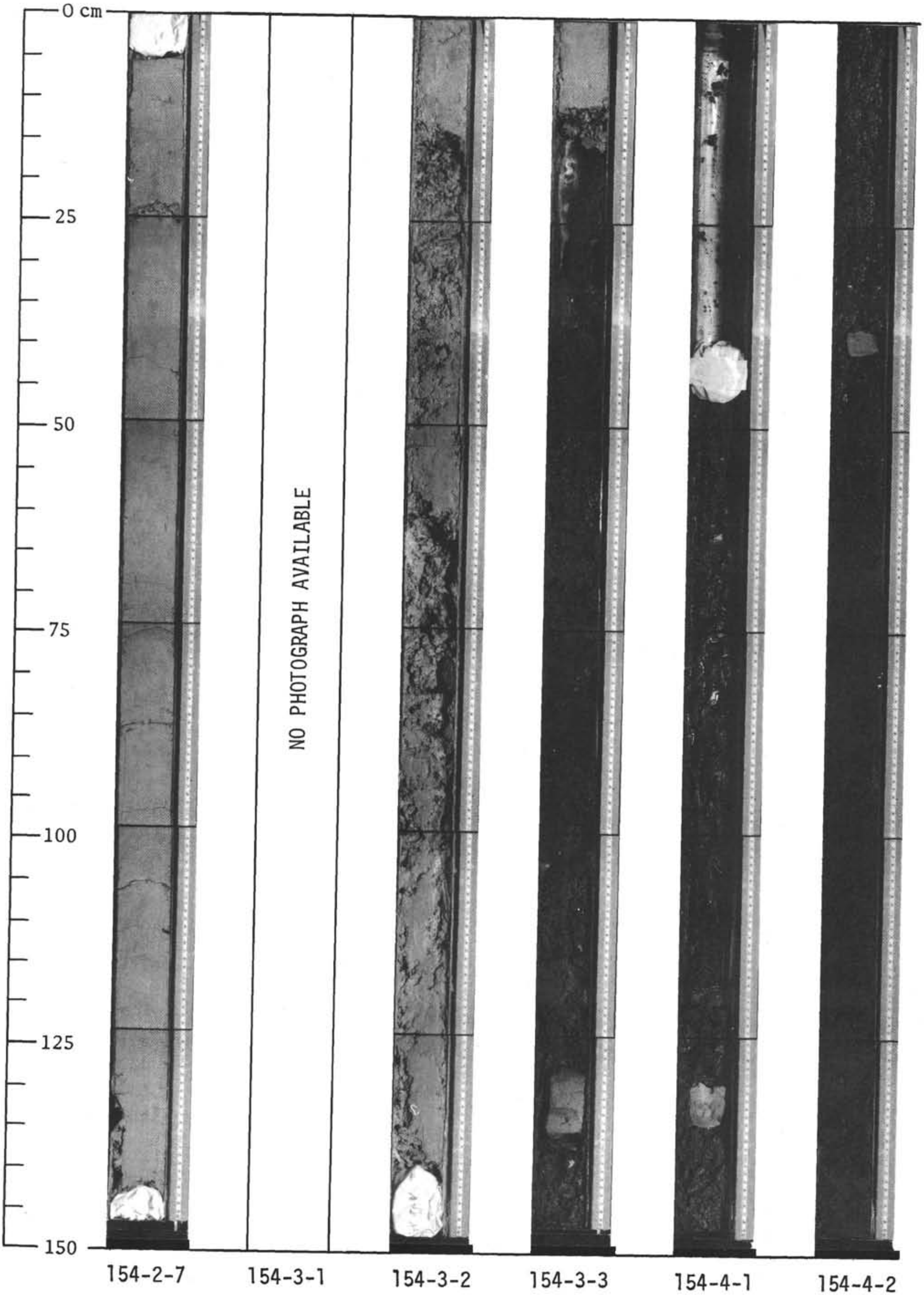
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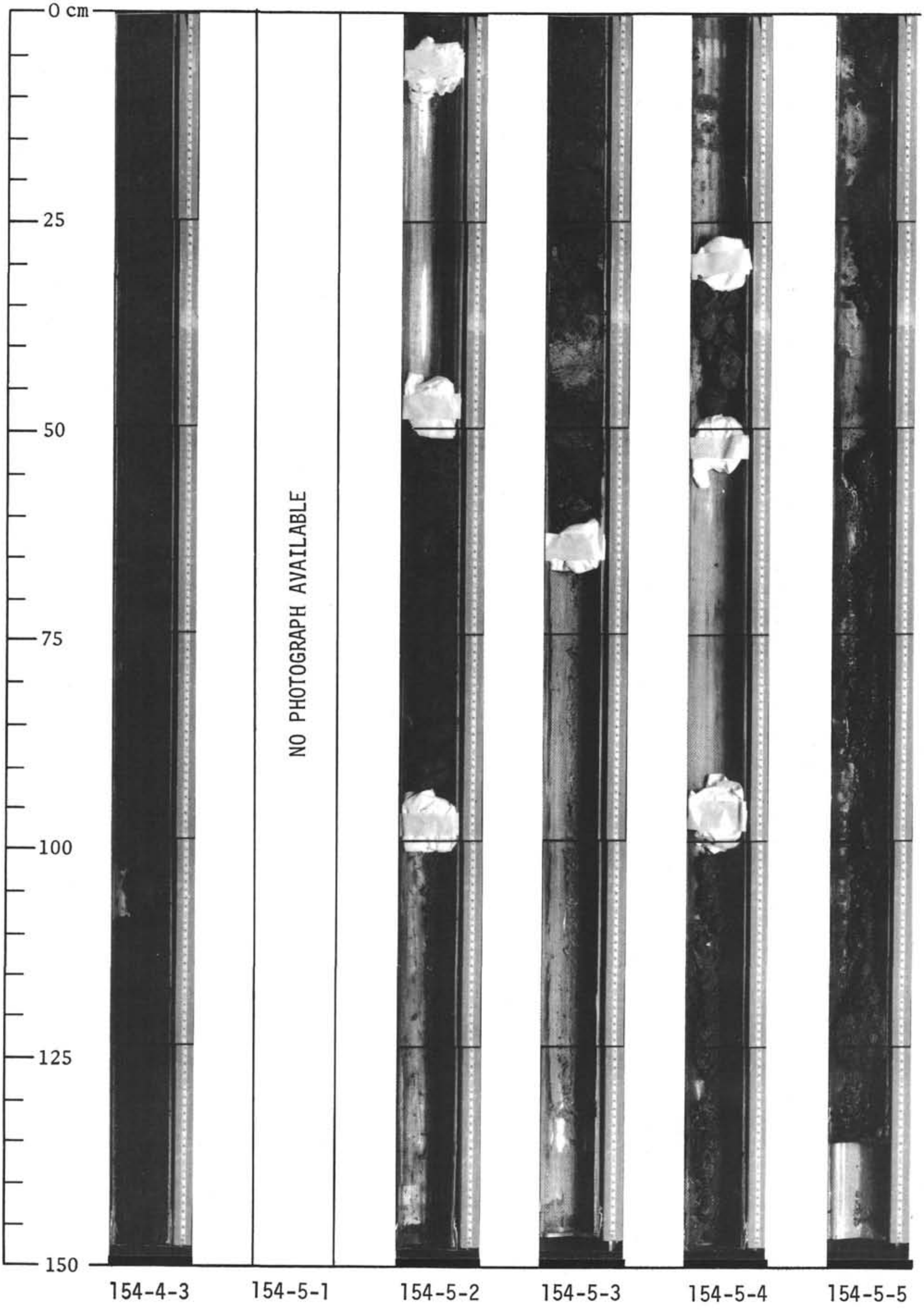
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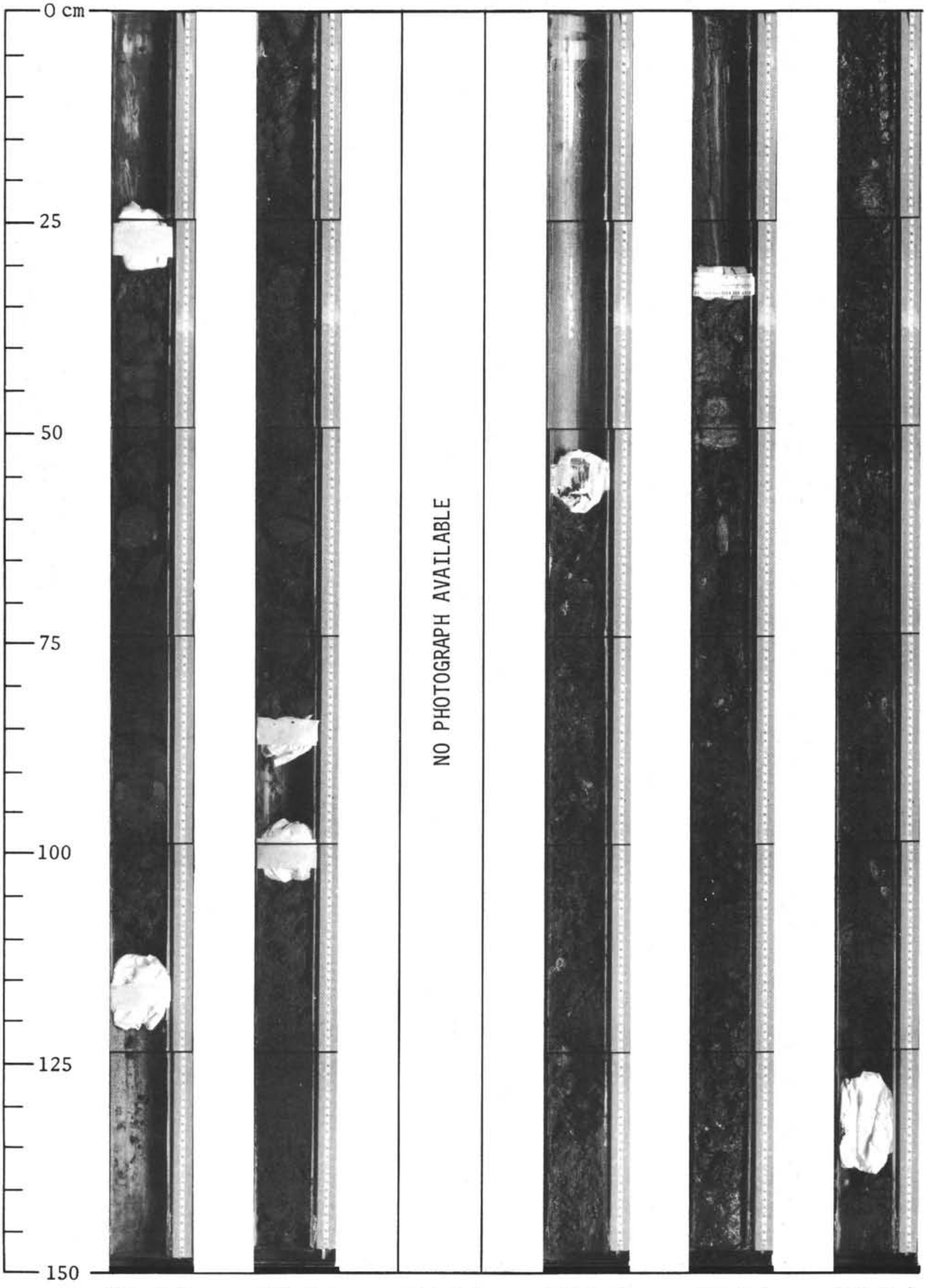
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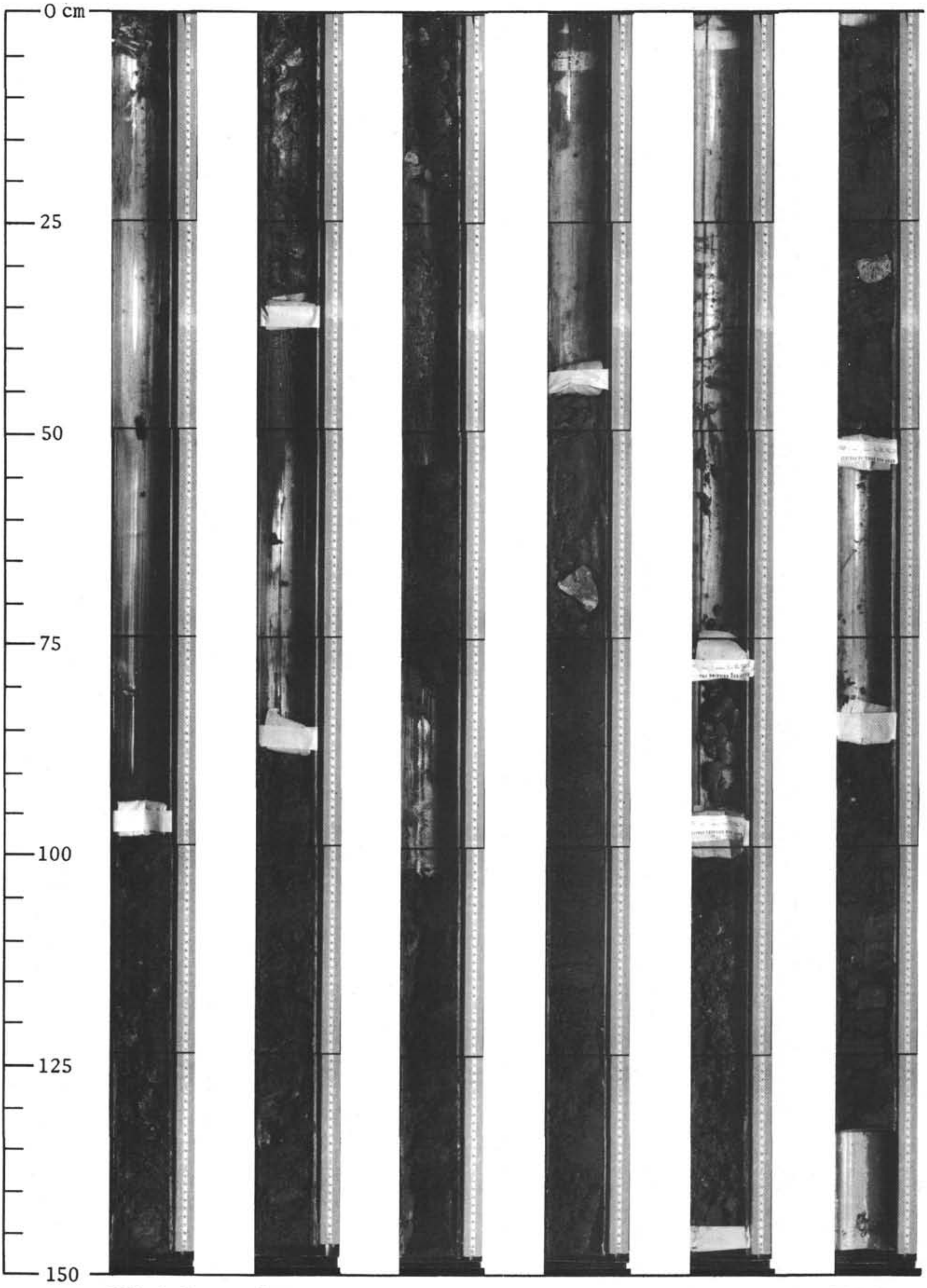
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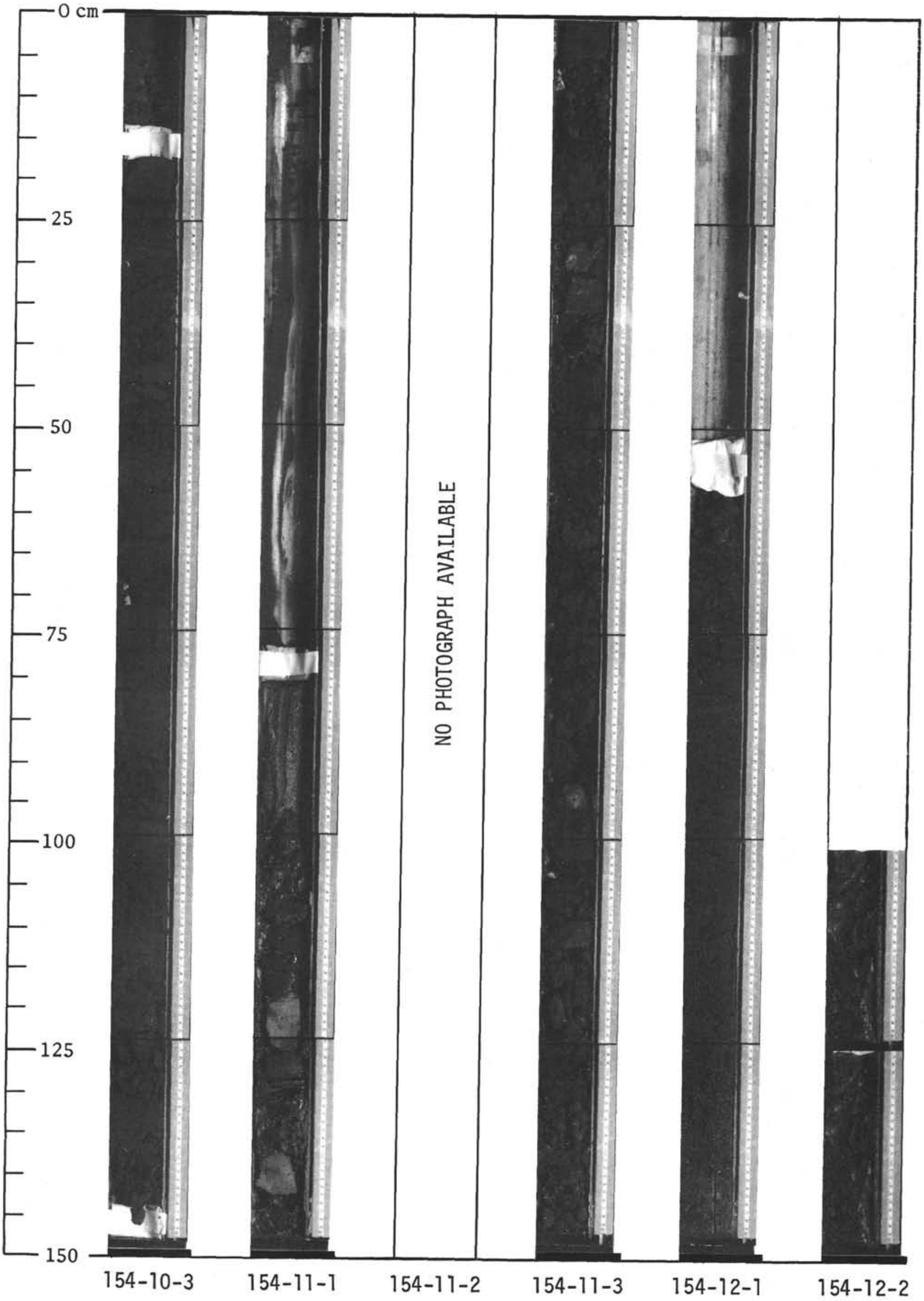
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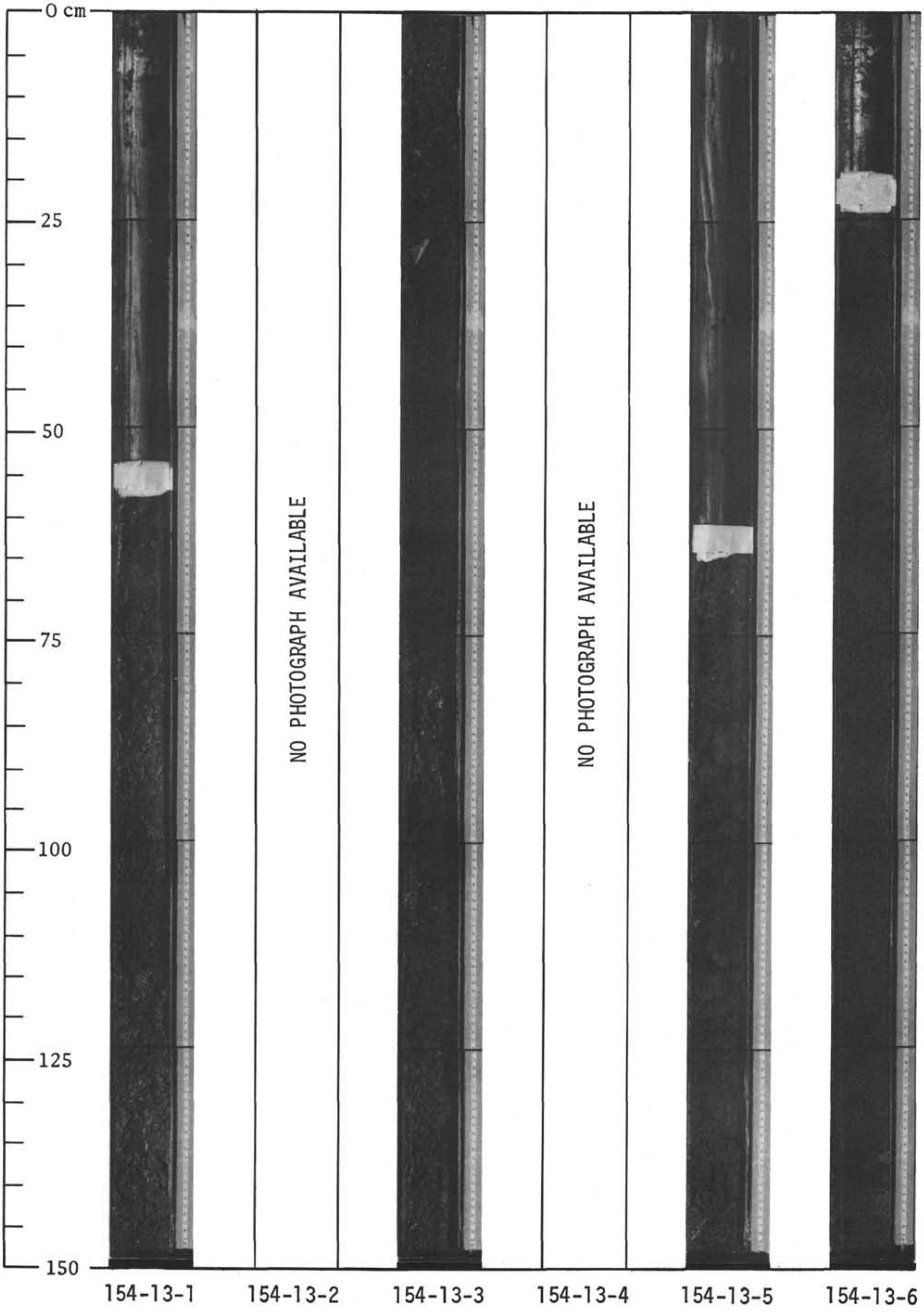
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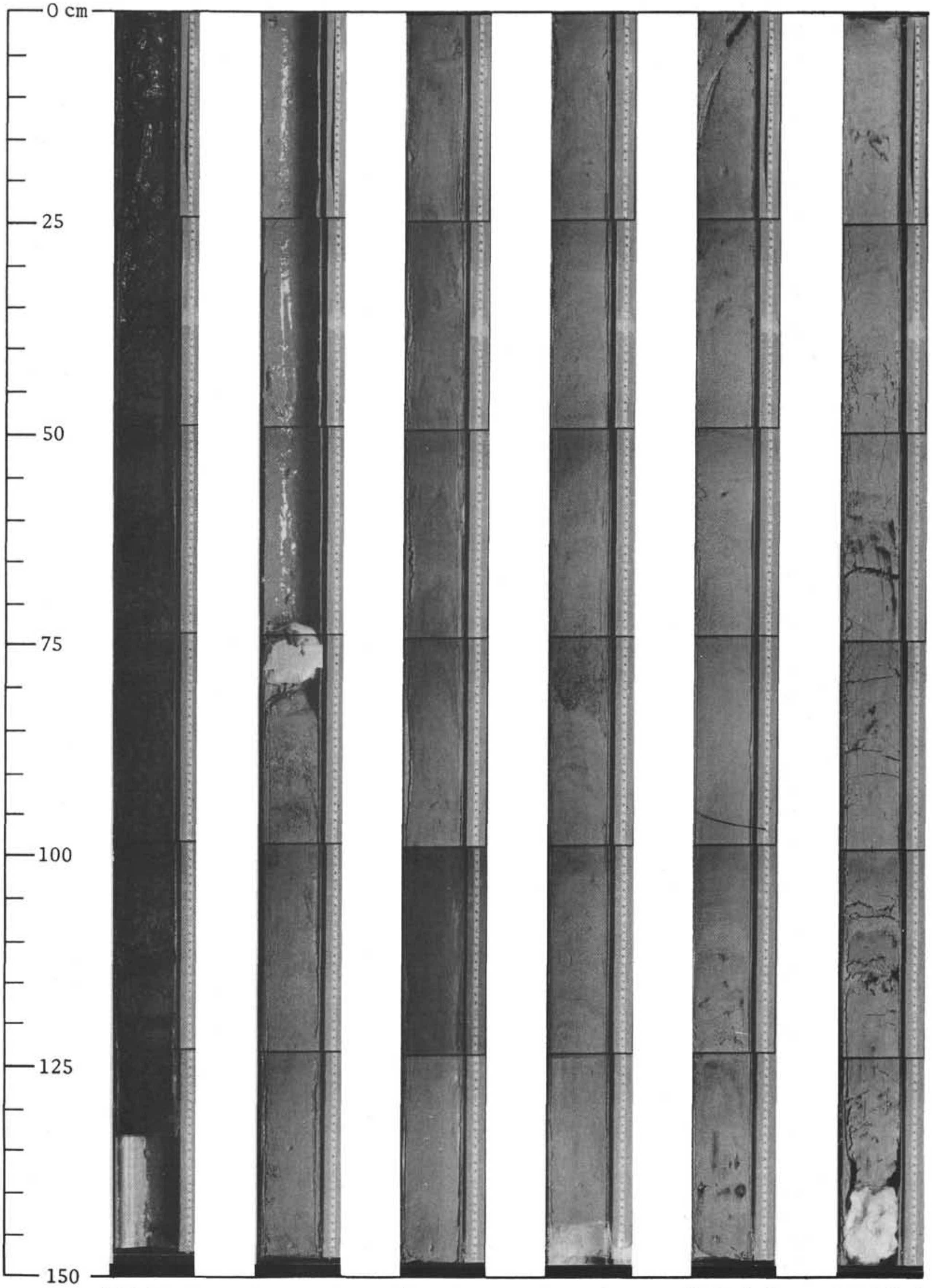
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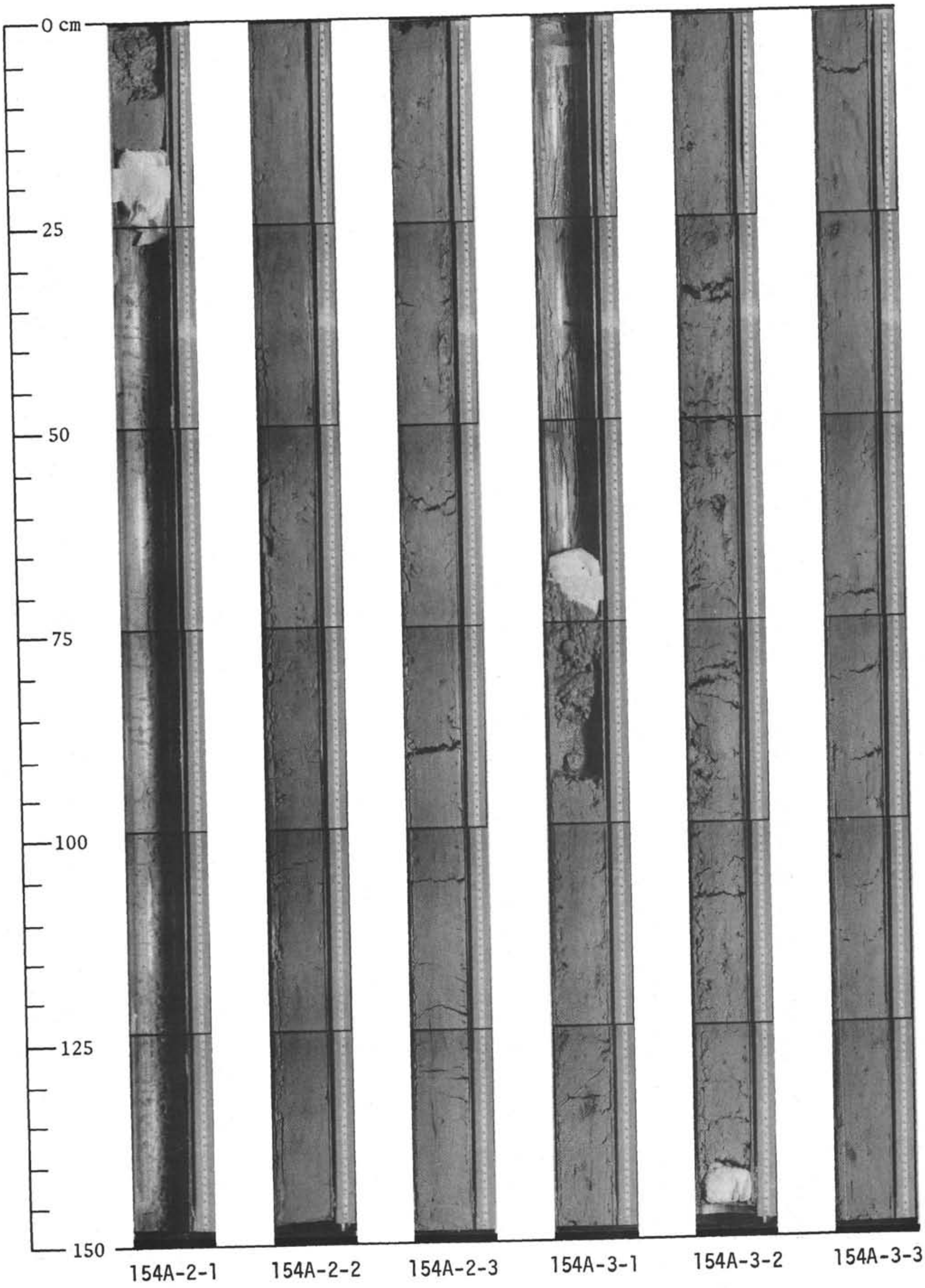
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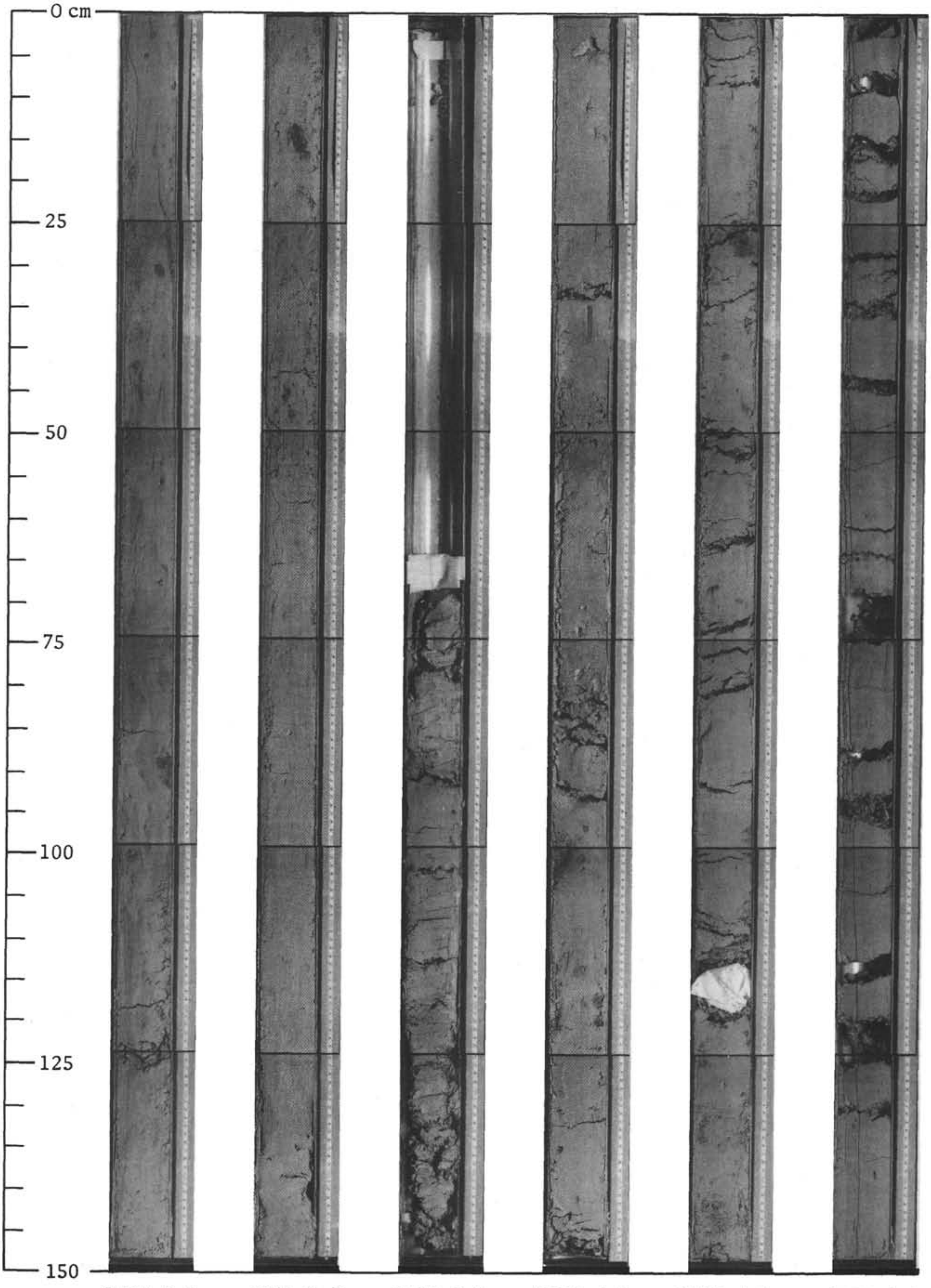
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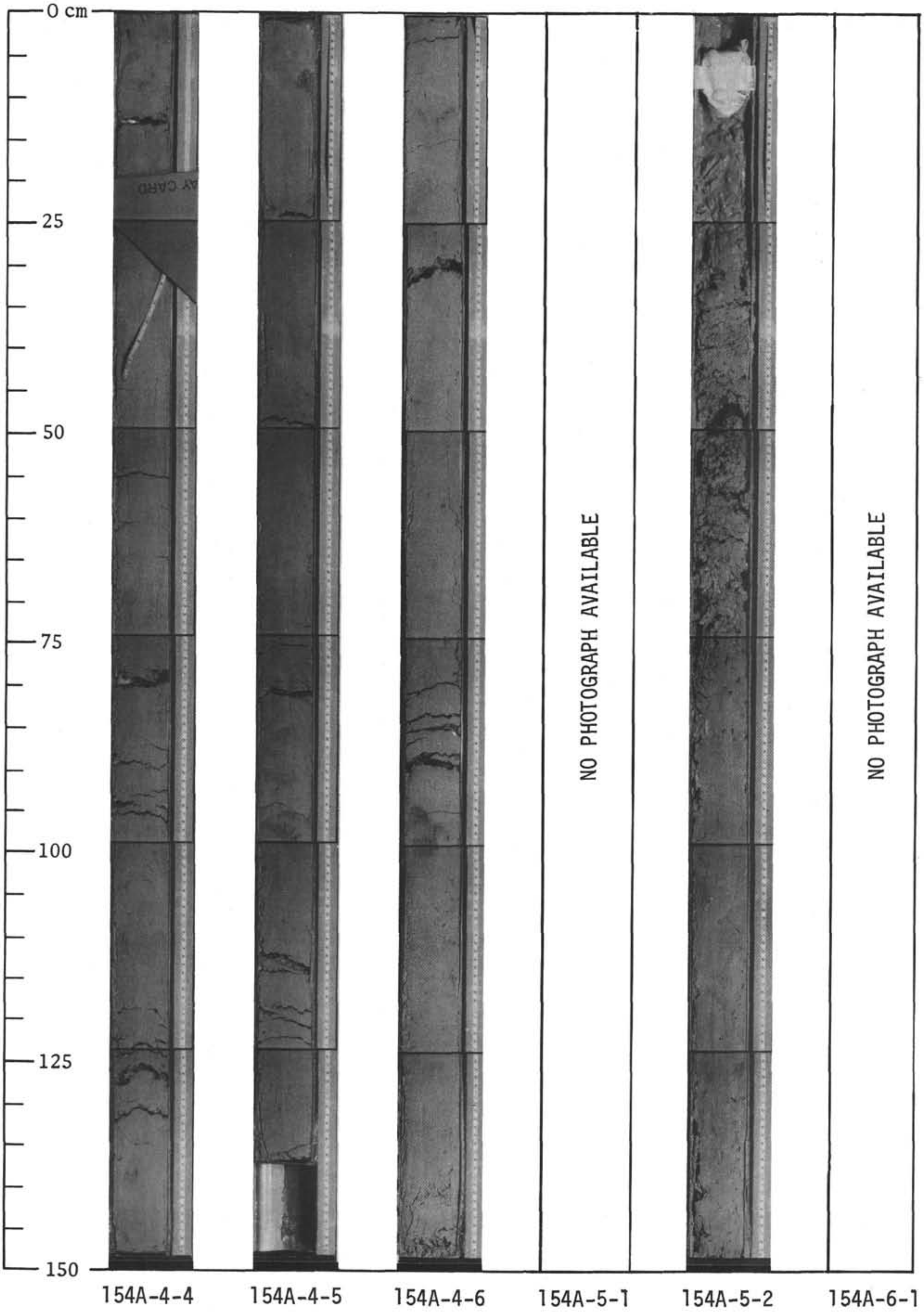
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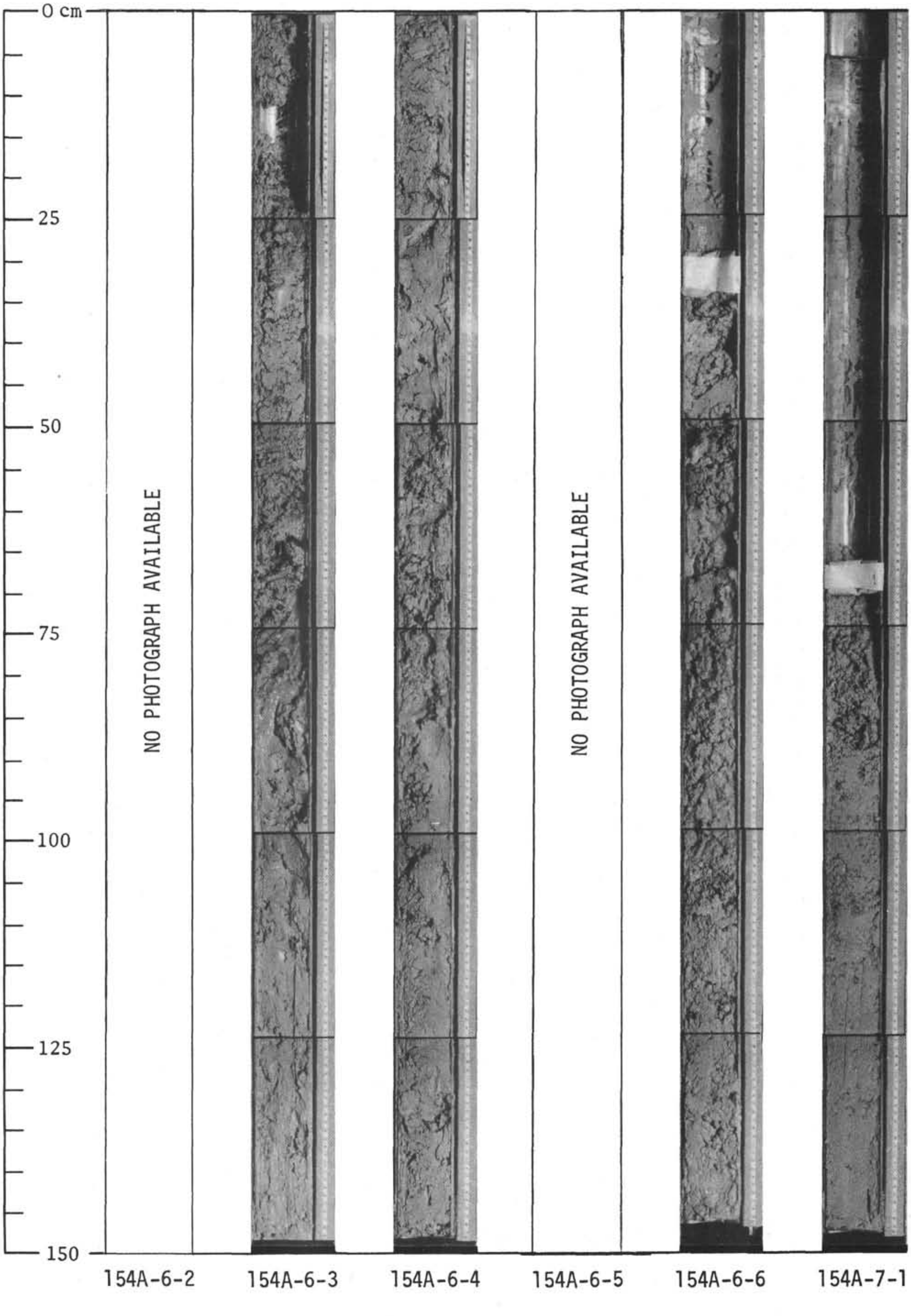
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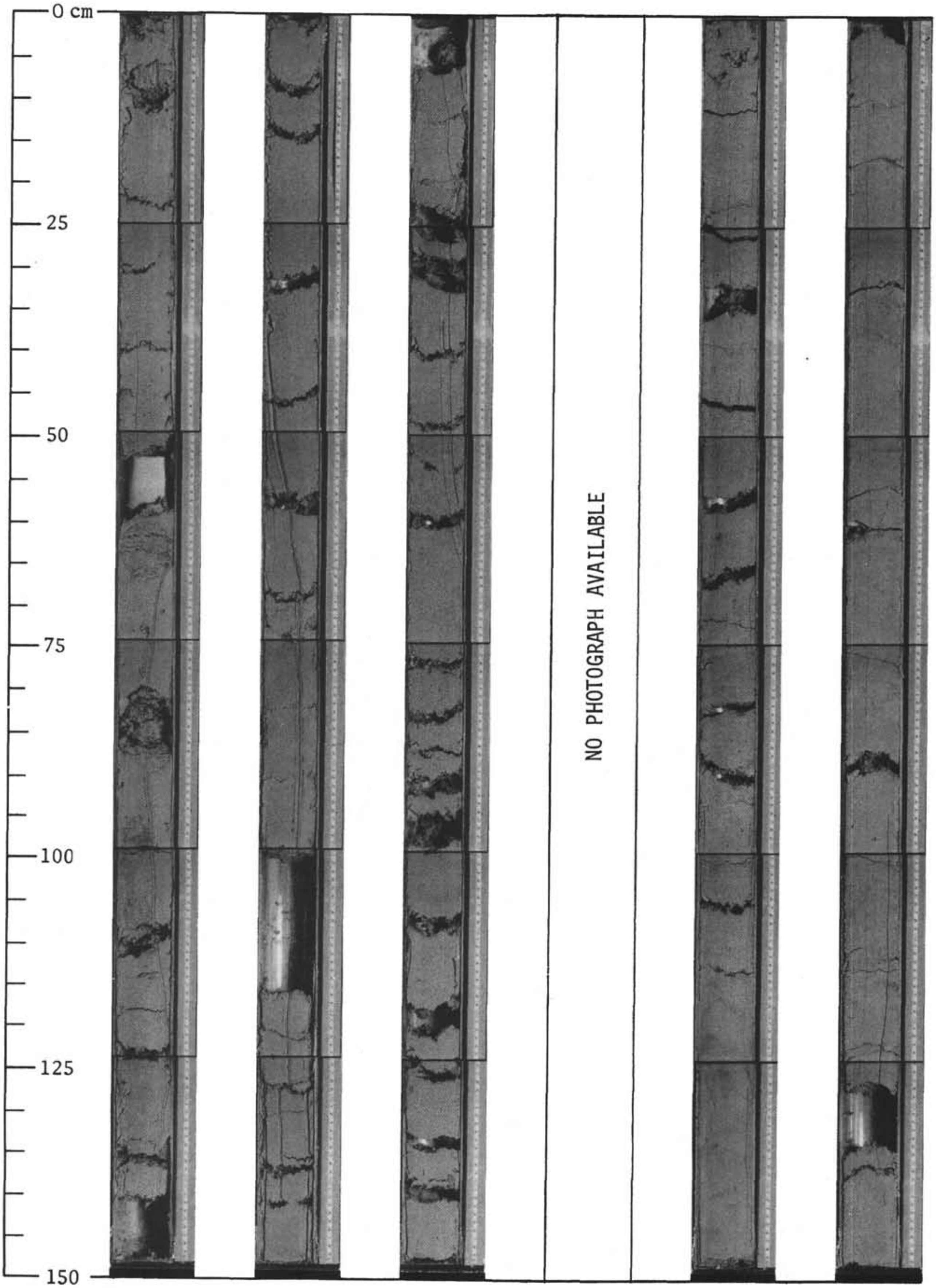
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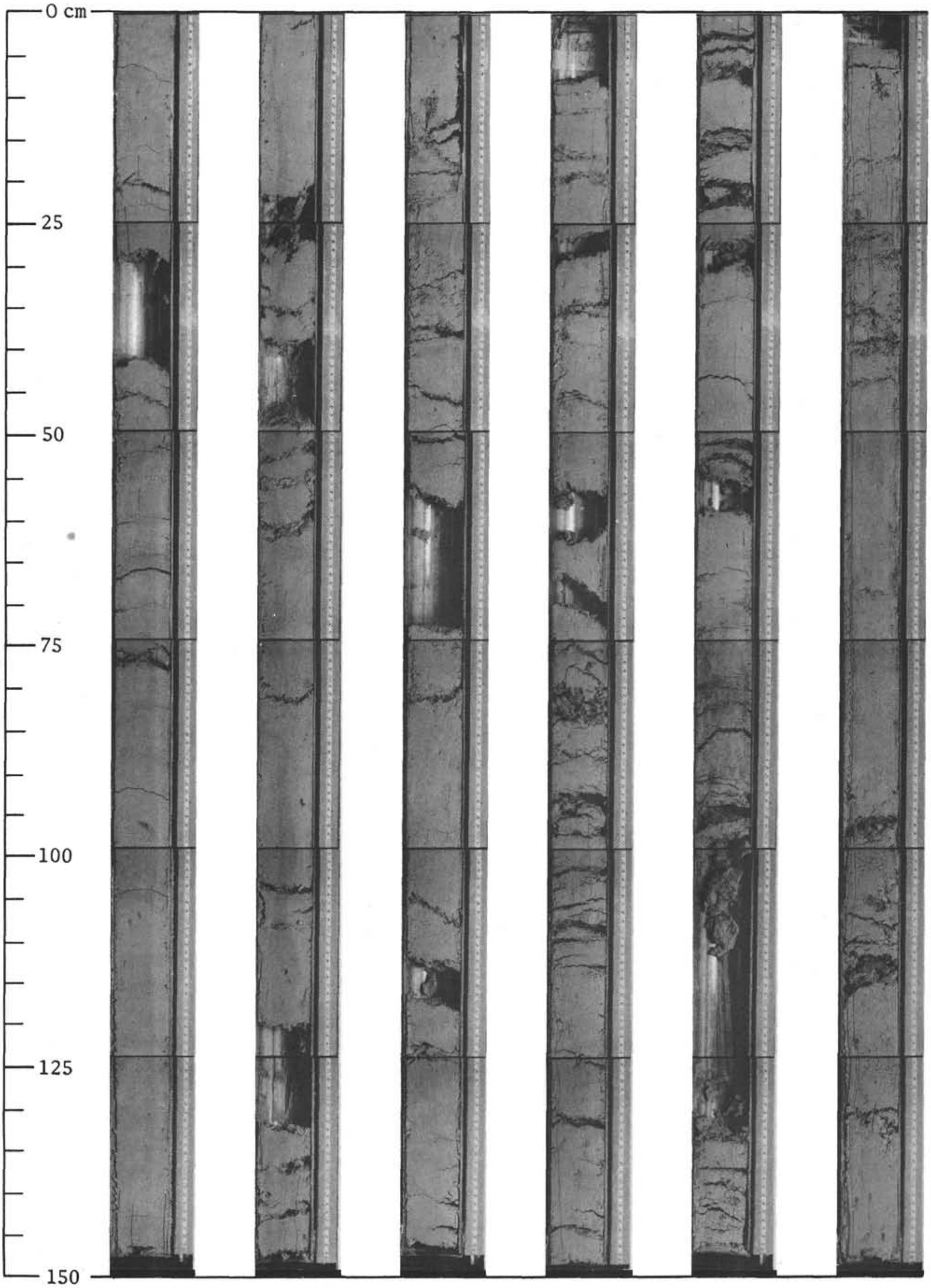
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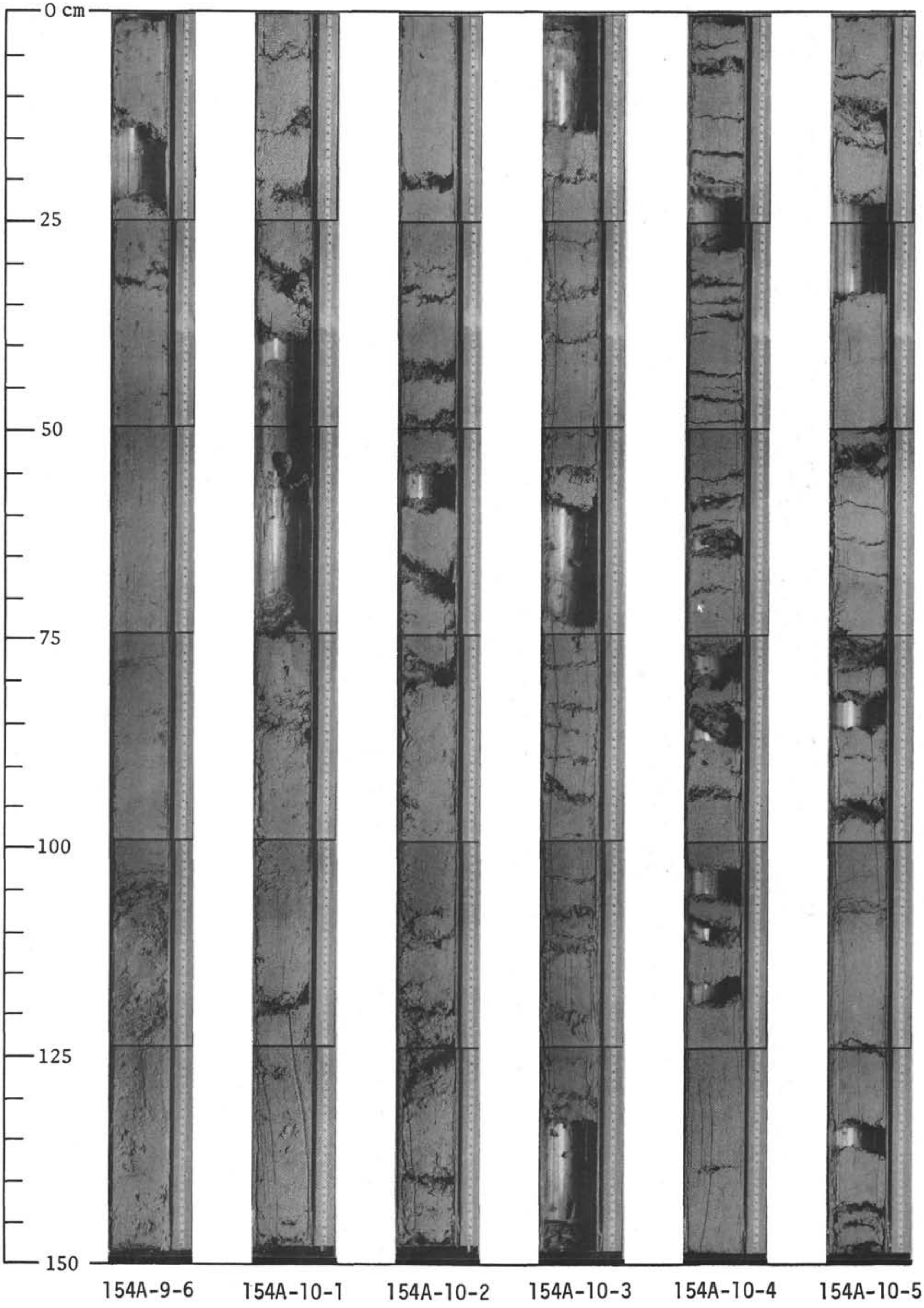
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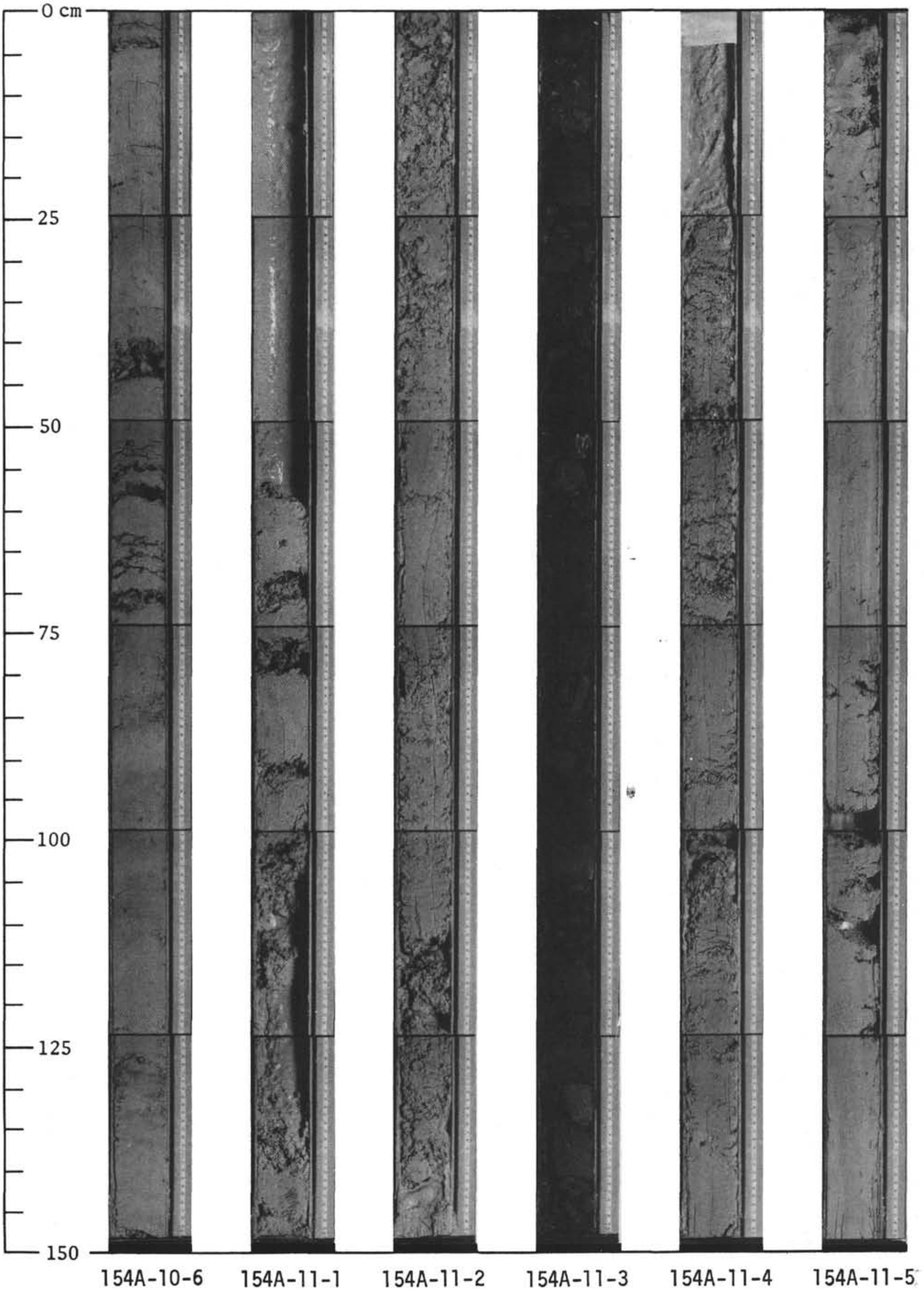
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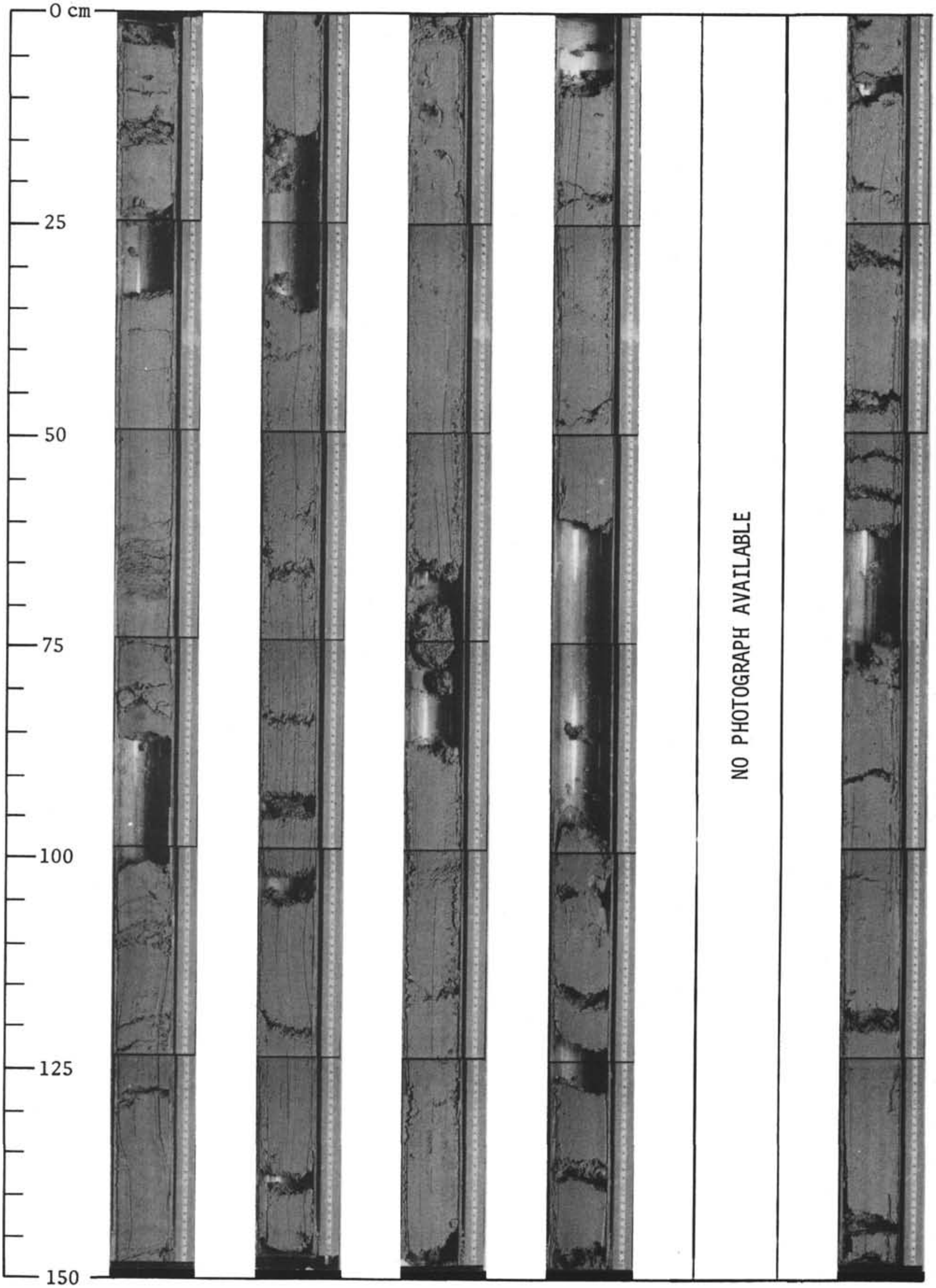
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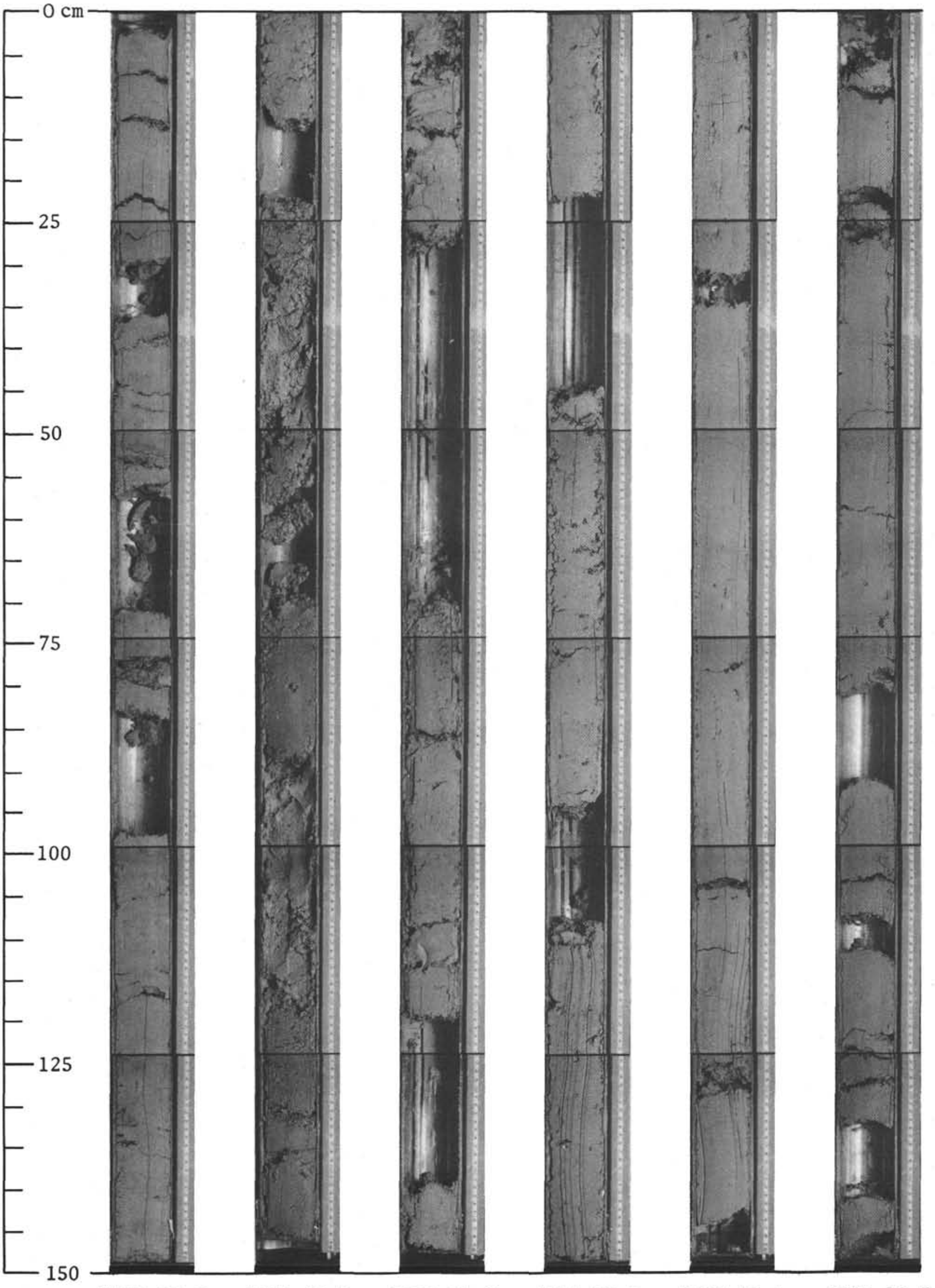
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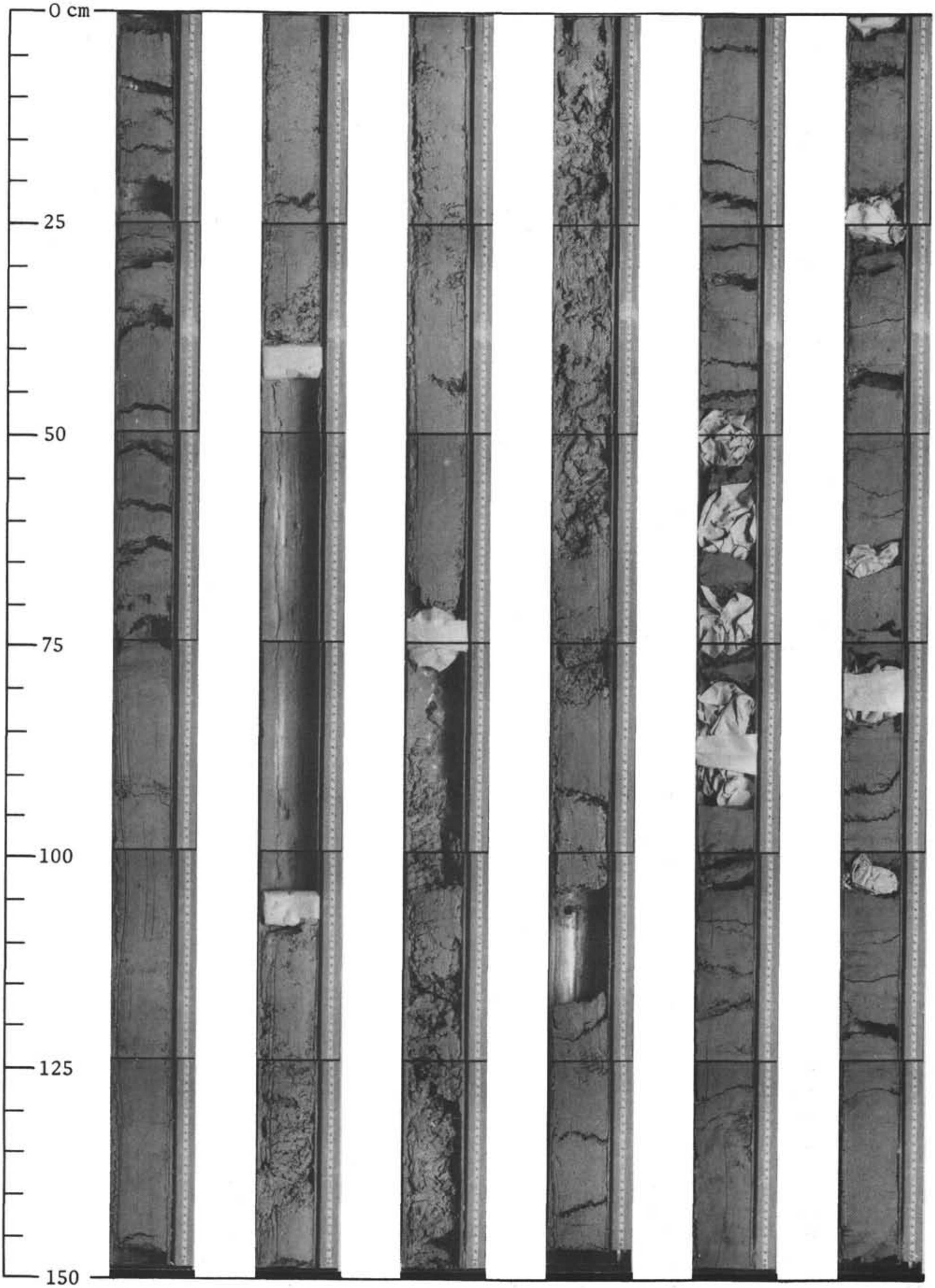
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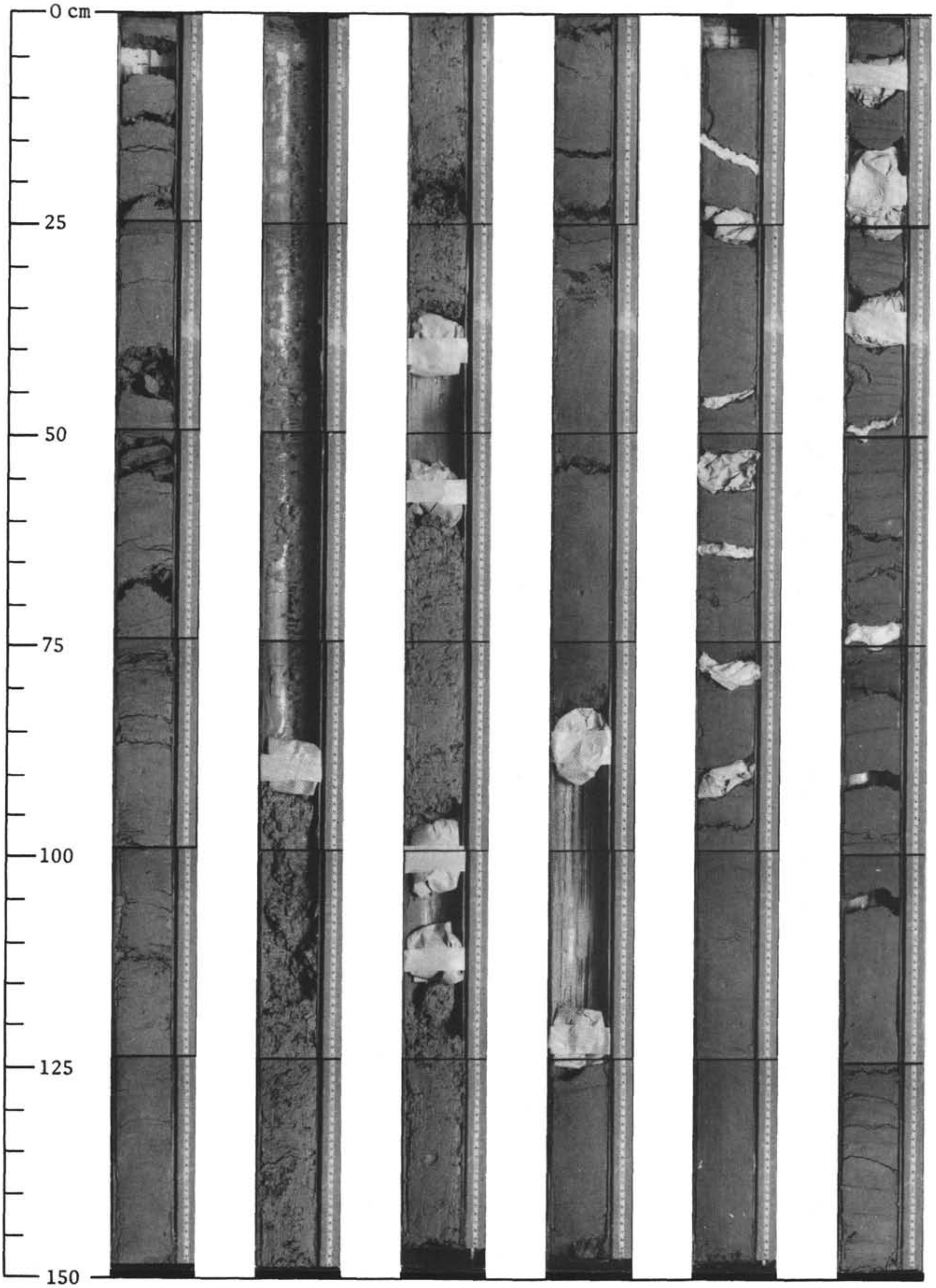
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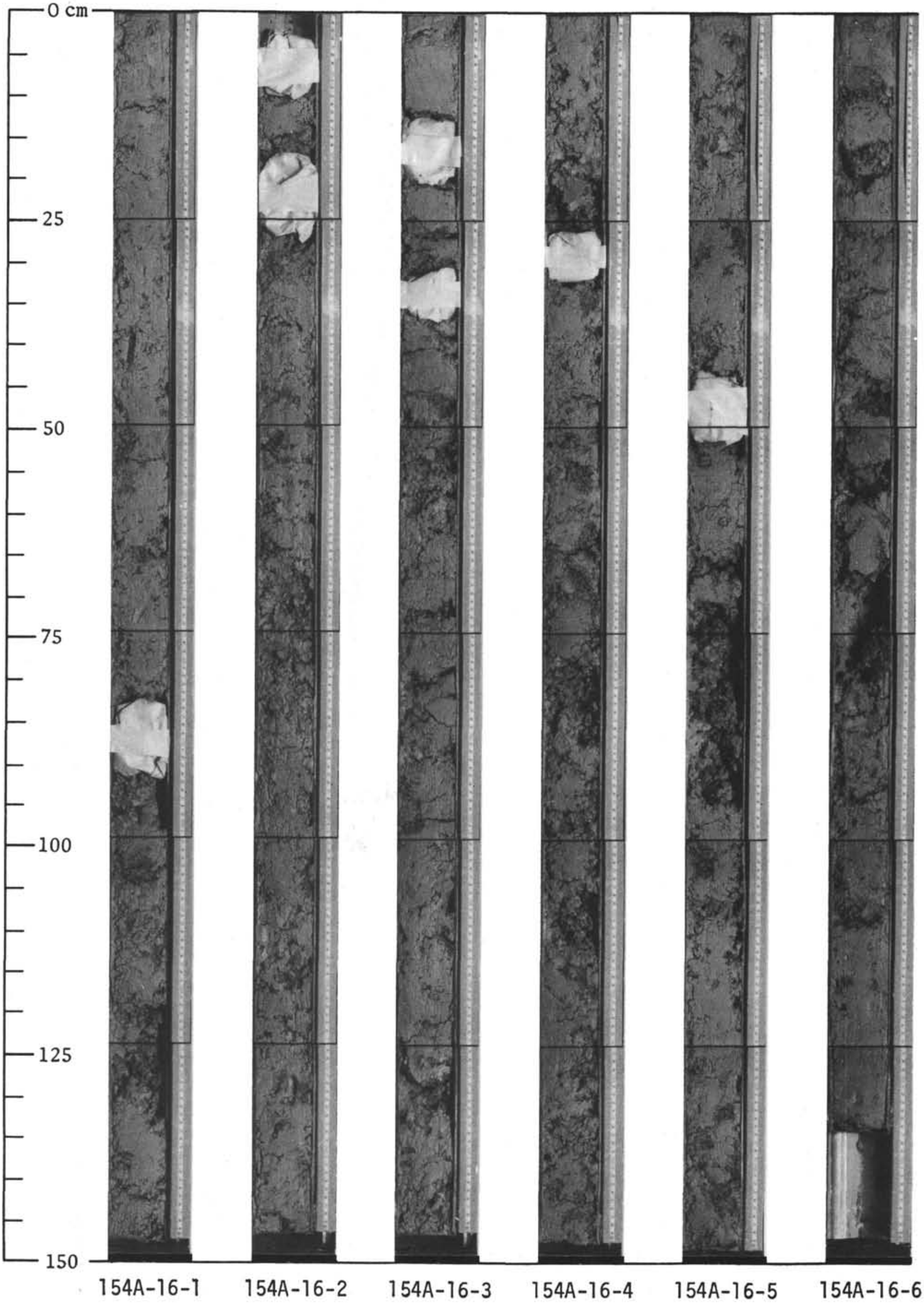
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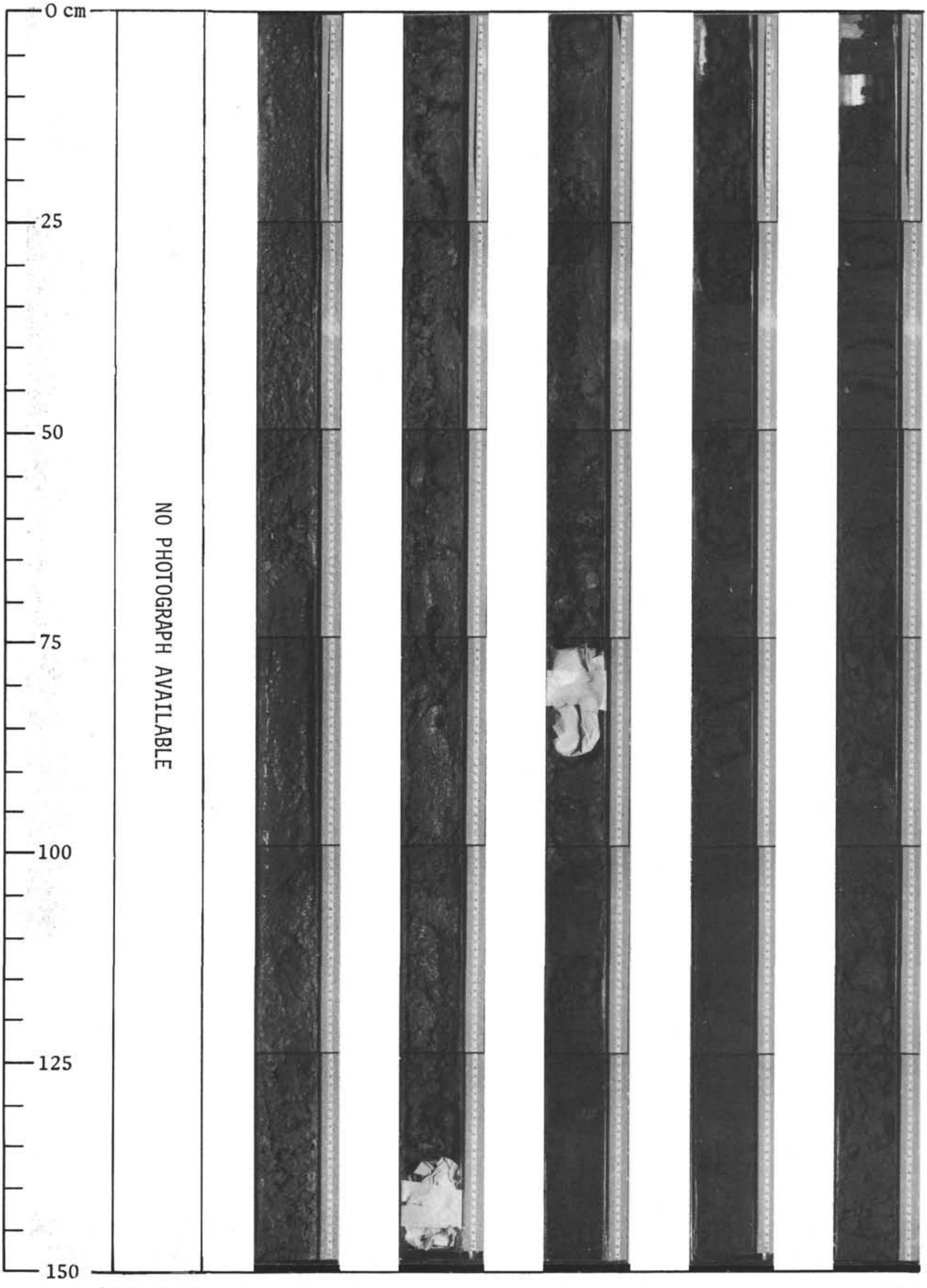
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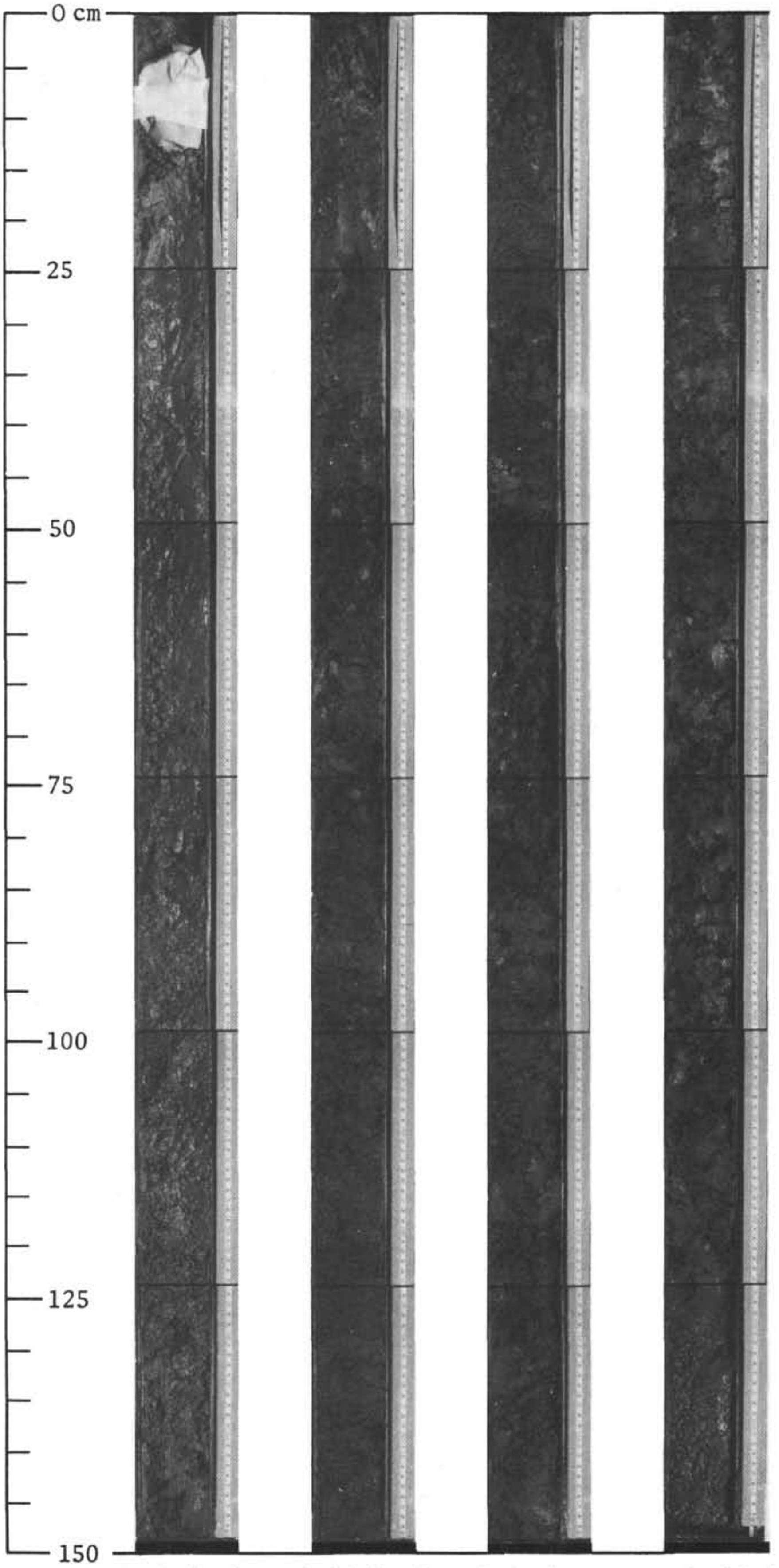

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