4. SITE 213

The Shipboard Scientific Party[1]

ABSTRACT

The stratigraphic column at Site 213 is 154 meters in thickness and contains four stratigraphic units with gradational contacts. These units comprise an uppermost radiolarian-diatom ooze of Quaternary to middle Miocene age, a nonfossiliferous zeolitic brown clay, a nannofossil ooze of lower Eocene to upper Paleocene age, and a basal iron-manganese oxide sediment overlying weathered pillow basalt. Stratigraphic evidence is consistent with a gradual deepening of the oceanic crustal plate since its formation. The nonfossiliferous brown clay interval midway down the hole may represent normal deep-basin sedimentation subsequent to the plate sinking below the carbonate compensation level. The uppermost radiolarian diatom ooze suggests the onset of high productivity, with only the siliceous component being preserved below the carbonate compensation level and may reflect northward migration of the site into the equatorial productive zone. The oldest sediment age of 55 to 57 m.y. places an upper limit on the age of the beginning of magnetic anomaly 26.

SITE DATA

Date Occupied:
213: 4 Feb 72 (1800)
213A: 6 Feb 72 (1800)

Date Departed:
213: 6 Feb 72 (1800)
213A: 6 Feb 72 (1520)

Time on Site:
213: 48 hours
213A: 21 hours 20 minutes

Position:
lat 10°12.71′S
long 93°53.77′E

Water Depth (to rig floor):
5609 meters (Echo sounding)
5611 meters (Drill pipe)

Penetration:
213: 172.5 meters
213A: 130.5 meters

Number of Holes: 2

Number of Cores:
213: 19
213A: 3

Total Length of Cored Section:
213: 172.5 meters
213A: 24.5 meters

Total Core Recovered:
213: 145.5 meters
213A: 24.5 meters

Acoustic Basement:
Depth: 154.0 meters
Nature: Basalt

Age of Oldest Sediment: Upper Paleocene

Basement: Basalt

BACKGROUND AND OBJECTIVES

The major piece of information governing the selection of all three sites in the Wharton Basin was the identification by Sclater and Fisher (in preparation) of lineated east-west trending magnetic anomalies to the east of the Ninetyeast Ridge. On the basis of this identification these authors suggested that the Wharton Basin was formed from an east-west spreading center which is either against the Java Trench or has descended down the trench after the cessation of spreading. The general topography of the basin is accounted for by having large north-south trending fracture zones offsetting the spreading axis progressively northwards to the east of the Ninetyeast Ridge. This

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interpretation of the age and tectonics of the basin is totally dependent on the correct identification of the anomalies east of the Ninetyeast Ridge as 23 through 33 getting older to the south.

Initially it was planned to drill close to anomaly 27 in a site surveyed during Scripps Institution of Oceanography Cruise ANTIPODE XII. However, the sediment in the area was too thin, and the site was moved further north to an alternate site at 10°00'S, 93°57'E. This site is located in the middle of a slight trough south of a 500-meter ridge which stops the distal Nicobar Fan sediments on the eastern side of the Ninetyeast ridge from penetrating further south (Figure 1). The ANTIPODE XII airgun record was of poor quality, but was good enough to show that the trough consists of a series of small basins 3 to 5 kilometers long covered with flat-lying sediments of 0.1 to 0.2 sec thickness. The incoming and outgoing airgun records (Chapter 10) are typical of the area.

The principal objective of the site was to date the age of basement and to help identify the magnetic anomalies. A secondary objective was to obtain a stratigraphic and biostratigraphic sequence east of the Ninetyeast Ridge. The data from this site are to be compared with sections recovered from sites on and to the west of the ridge. If the tectonic history as illustrated by the magnetics is correct, then before the Eocene the oceanic crust on either side of the ridge moved in opposite directions, and this difference in motion may be reflected in the biostratigraphic, biogeographic, and paleomagnetic record.

OPERATIONS

Site 213 was approached in a northward direction along the seismic reflection profile of ANTIPODE XII. Sediments in the area occur in what appear to be isolated basins, a few kilometers in cross-section, within basement. The site was selected in what appears to be a typical basin, containing 0.1 to 0.15 sec of acoustically transparent sediment overlying a strong irregular basement reflector.

Due to the small size of the basin, the acoustic beacon and a spar buoy were dropped underway at 5 knots, after which the seismic gear and magnetometer were secured in the normal way and the Challenger reversed course back to the site. In order to drill in the deepest portion of the basin, the drilling vessel was offset 1500 ft to the north of the beacon. The chosen site is situated in 5611 meters of water (drill pipe to rig floor) at 10°12.75'S, 93°53.77'E. The site was occupied on 4 Feb 72 at 1800 hours.

Soft siliceous oozes, red clays, and stiff chalks of Site 213 presented no drilling difficulties. The Smith 10, 1/8-inch bit from Site 212 was rerun. Basalt was reached at a sediment depth of 154 meters and was drilled for 18.5 meters with a recovery of 45.4%. The hole was terminated at a total depth of 172.5 meters. A total of 145.5 meters of sediment and basalt was recovered, giving an overall recovery of 84% (Table 1).

A second hole, 213A, was subsequently drilled offset approximately 40 ft from the first. This hole was designed to test the mechanical latching and electronic operation of the temperature probe. Three mechanically successful lowerings were made of the downhole instrument package, and temperature data were successfully gathered on the last two. Three cores were taken from Hole 213A. A total of 24.5 meters of sediment was cored with 100% recovery (Table 2). Discussion of the heat flow results is given in Chapter 14.

LITHOLOGIC SUMMARY

The total sediment section of about 150 meters was continuously cored and ranged in age from Quaternary to late Paleocene. About 8 meters of weathered basalt were also recovered from a penetration of 18 meters. The cored sequences have been divided into five lithologic units (Figure 2) as follows:

Unit	Depth Below Sea Floor (m)	Lithology	Age	Cores
1	0 to 75	Rad-diatom ooze with varying clay	Quaternary upper Miocene	1-8
2	~70.5 to 135	Zeolitic clay grading towards nanno-bearing manganese iron-oxide-rich dlay	Middle Miocene	8-15
3	~135 to 147	Nanno ooze	Early Eocene late Paleocene	15,16
4	~147 to 152	Iron-oxide-manganese facies	?	16
5	~154 to 172	Weathered basalt	?	17-19

Unit 1 – Radiolarian-Diatom Ooze (Cores 1-8)

Unit 1 consists of reddish yellow radiolarian-diatom ooze. The diatoms and Radiolaria make up 50% to 75% and 12% to 40%, respectively, of the unit. The minor constituent is mainly a clay fraction averaging 7%. However, the clay content increases considerably near the top (35%) and bottom (70%) of this unit. Among the other minor constituents, iron-oxide minerals associated with manganese micronodules are concentrated in thin layers and laminae in the middle portion of the unit (Cores 3 and 6). Here the iron-oxide minerals are minute crystals with an oolitic shape, reddish yellow color, with high relief and often associated with purple red hematitic material. Volcanic ash of probably rhyolitic composition is also scattered throughout the unit with major concentrations (about 25%) and pumice being noted in Core 2 (upper Pliocene) and in Core 5 (late lower Pliocene).

Unit 2–Zeolitic Clay, Mn Iron-Rich at Base (Cores 8-15)

Unit 2 consists of zeolitic, brown clay. Well-crystallized phillipsite is the main type of zeolite found. The zeolite content varies from 1% to 7% in Cores 8, 9, and 13 and is higher elsewhere in the unit reaching a maximum of 20% in Cores 11 and 12. Iron-oxide minerals and manganese micronodules are concentrated in the lower part (Cores 12 through 15) of the unit where they make up about 15% of the sediment. One concentration of volcanic ash of rhyolitic composition was noted at the top of this unit. The base of Unit 2 grades into Unit 3 and consists of interbedded nannofossil ooze and clay, the latter containing

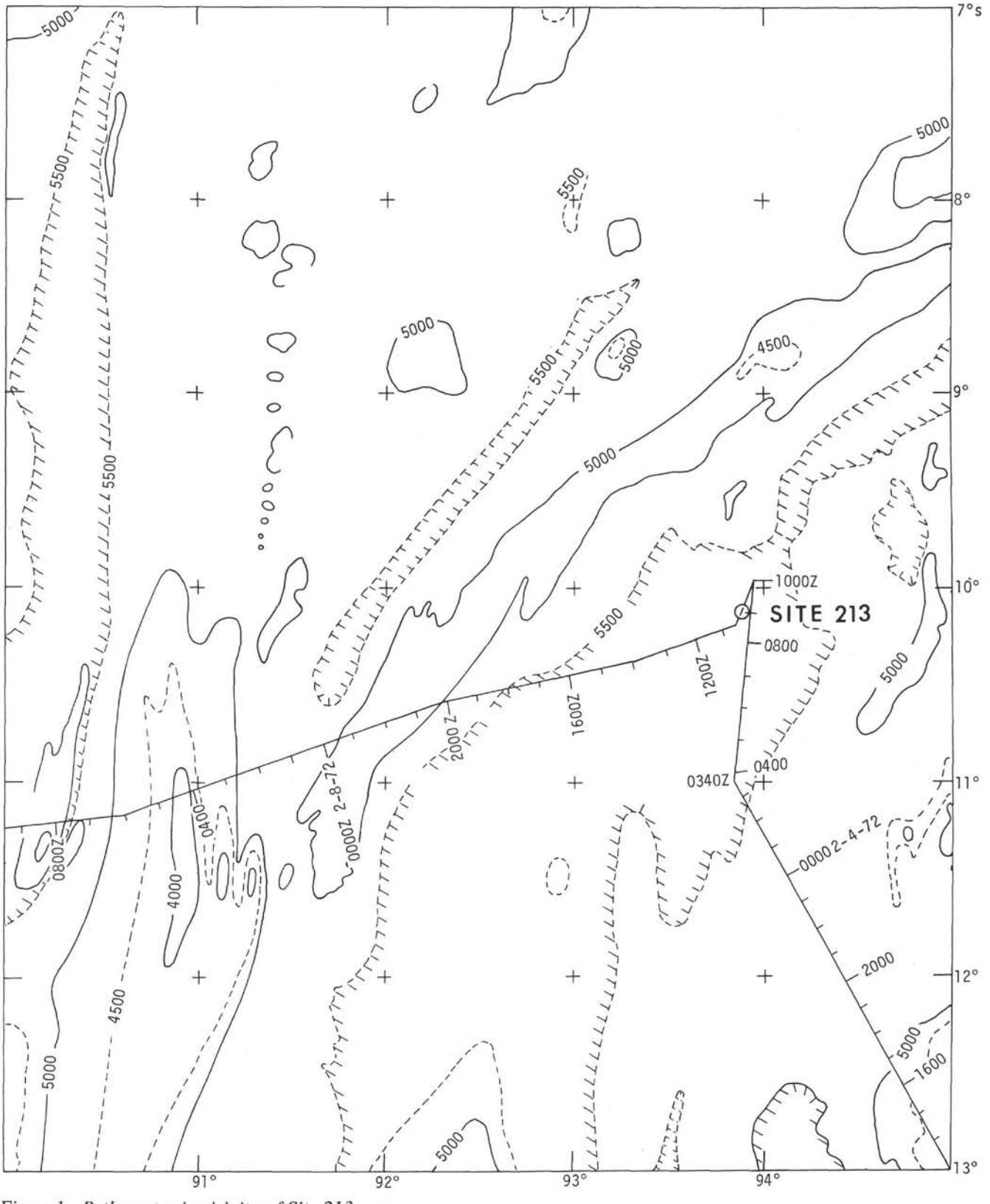

Figure 1. *Bathymetry in vicinity of Site 213.*

TABLE 1
Coring Summary, Hole 213

Core	Date (Feb)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Length Cored (m)	Recovered (m)	Recovery (%)
1	5	0805	5611.0-5620.0	0-9.0	9	6.8	76
2	5	1203	5620.0-5629.5	9.0-18.5	9.5	7.3	77
3	5	1335	5629.5-5639.0	18.5-28.0	9.5	9.5	100
4	5	1558	5639.0-5648.5	28.0-37.5	9.5	8.5	94
5	5	1635	5648 5-5658.0	37.5-47.0	9.5	9.5	100
6	5	1800	5658.0-5667.5	47.0-56.5	9.5	9.5	100
7	5	1930	5667.5-5677.0	56.5-66.0	9.5	9.5	100
8	5	2105	5677.0-5686.5	66.0-75.5	9.5	9.5	100
9	5	2230	5686.5-5696.0	75.5-85.0	9.5	9.5	100
10	6	0005	5696.0-5705.5	85.0-94.5	9.5	9.5	100
11	6	0140	5705.5-5715.0	94.5-104.0	9.5	8.0	84
12	6	0305	5715.0-5724.5	104.0-113.5	9.5	8.0	63
13	6	0440	5724.5-5734.0	113.5-123.0	9.5	9.5	100
14	6	0610	5734.0-5743.5	123.0-132.5	9.5	9.5	100
15	6	0730	5743.5-5753.0	132.5-142.0	9.5	9.5	100
16	6	0905	5753.0-5762.5	142.0-151.5	9.5	5.3	56
17	6	1145	5762.5-5770.5	151.5-159.5	8.0	3.4	50
18	6	1505	5770.5-5774.0	159.5-163.0	3.5	3.3	94
19	6	1800	5774.0-5783.5	163.0-172.5	9.5	1.9	20
Total					172.5	147.5	84

Note: Echo sounding depth (to drill floor) = 5609 meters; drill pipe length to bottom = 5611 meters.

TABLE 2
Coring Summary, Hole 213

Core	Date (Feb)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
1	6	2200	5648.5-5656.0	37.5-47.0	7.5	7.5	100
2	7	0130	5724.5-5733.0	113.5-122.0	8.5	8.5	100
3	7	0440	5743.5-5752.0	132.5-141.0	8.5	8.5	100
Totals					24.5	24.5	100

Note: Echo sounding depth (to drill floor) = 5609 meters; drill pipe length to bottom = 5611 meters.

less iron-oxide-manganese constituents than above and no zeolite.

Unit 3–Nannofossil Ooze (Cores 15, 16)

Unit 3 is defined as the sediment section consisting only of pure nannofossil ooze (≤10% clay only). The minor constituents are authigenic carbonate (3%) and foraminifera (2%). Iron-oxide-manganese minerals only occur in trace amounts.

Unit 4–Iron-Oxide-Manganese Facies (Core 16)

This unit comprising the lower part of Core 16 consists entirely of iron-oxide-manganese facies. The iron-oxide material is made up of oolitic-like crystals (geothite?) associated with red scales of hematitic and less crystalline masses of limonitic material. Micronodules and aggregates of manganese were also seen. The only other mineral occurring in significant amounts in this facies is palygorskite (detected by X-ray diffraction).

Unit 5–Basalt (Cores 17-19)

Unit 5 consists of a succession of at least 11 basaltic flows. Each flow is a pillow-lava with chilled margins. Within each flow three different zones are identified: (1) a glassy palagonatized margin, (2) a weathered porphyritic basaltic zone, and (3) a more crystalline and less weathered basaltic zone. A thin film of manganese was noticed in some fragments near the top of Unit 5. The general mineralogy consists of plagioclase, clinopyroxene, palagonite, iron-oxide minerals, calcite, silica aggregate, and a dark mesostasis. The texture varies from variolitic to subophitic.

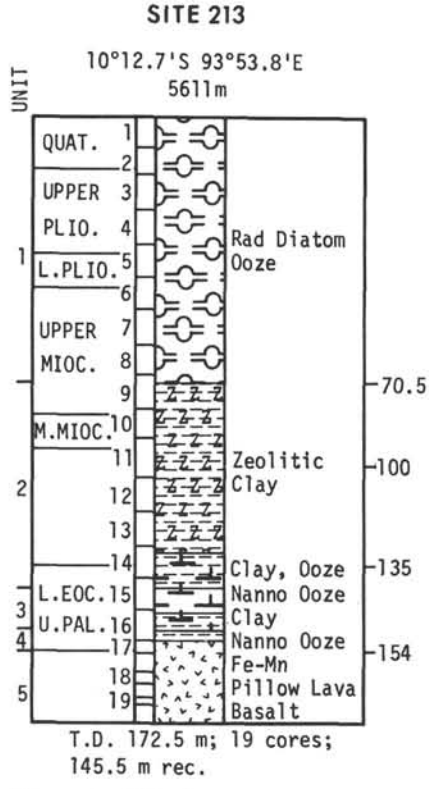

Figure 2. *Lithologic units at Site 213.*

CHEMICAL PROPERTIES

Ten samples were collected from the 16 cores which contained sediments. Two contiguous 10-cm minicores were taken from the top of the selected core section in all cases excepting Samples 213-2-5 and 213-16-4 when only one was removed. Samples were held at 4°C until processing. One minicore was used for resistivity measurements, then removed from the liner, scraped to remove contamination, and loaded into the squeezer. Sufficient time was allowed for the sediment to reach ambient room temperature before extraction of the pore fluids. The other minicore was used for punch-in pH measurements, then preserved for shore-laboratory studies. Complete shipboard results are given in Table 3.

TABLE 3
Shipboard Chemistry Results

Core, Section, Interval (cm)	pH (flow-through)	pH (punch-in)	Water (%)	Porosity (%)	Density (gm/cc)
1-0	7.29	7.16	70	86	1.23
1-1,69	–	–	71	90	1.26
1-1,140	–	–	73	91	1.25
1-3,20	–	–	71	90	1.27
1-4,40	–	–	72	90	1.24
2-3,102	–	–	68	88	1.29
2-5,0	6.92	7.15	68	90	1.32
2-5,120	–	–	71	91	1.29
3-3,130	–	–	69	93	1.34
3-5,0	7.29	7.12	70	90	1.28
4-1,71	–	–	59	79	1.33
4-5,55	–	–	69	89	1.29
5-1,65	–	–	61	83	1.35
5-5,0	6.97	6.94	62	86	1.39
6-3,70	–	–	67	90	1.34
6-6,50	–	–	67	87	1.34
7-5,0	7.11	6.80	69	91	1.31
8-3,14	–	–	67	88	1.31
8-6,14	–	–	67	88	1.30
9-6,0	7.09	6.92	63	87	1.37
9-6,85	–	–	66	89	1.34
10-3,75	–	–	65	87	1.34
11-3,30	–	–	56	76	1.35
11-5,0	7.04	too stiff	54	79	1.46
13-6,0	7.16	too stiff	54	82	1.53
14-2,77	–	–	53	80	1.50
14-6,90	–	–	35	62	1.76
15-5,102	–	–	33	56	1.72
15-6,0	7.30	7.52	31	56	1.82
16-4,0	7.29	7.49	29	55	1.88
16-4,34	–	–	31	58	1.85
16-4,140	–	–	52	71	1.36

BIOSTRATIGRAPHIC SUMMARY

General

Site 213 was cored continuously from the sea floor to the acoustic basement, which was encountered at a depth of approximately 152 meters. The sequence can conveniently be divided into three lithologic units. Transitions between these major units occur over intervals of several meters.

The upper unit (Cores 1 through 8) is a siliceous ooze with abundant diatoms and common radiolarians. Diatoms are in greatest abundance near the top of the unit and decrease in abundance downward. This unit contains an apparently uninterrupted sequence from the Recent into the late Miocene. At the lower part of the unit (Cores 9 and 10) the radiolarian specimens become increasingly more corroded. Below Core 10 radiolarians are absent entirely.

Underlying the siliceous ooze is an unfossiliferous zeolitic clay, which represents much of the depositional history of the area (from early Eocene to middle Miocene).

The lowermost unit consists of interbedded nannofossil ooze and iron-rich clay of early Eocene and late Paleocene age. Approximately 5 to 10 meters of unfossiliferous clay overlies the acoustic basement. There is one recognizable unconformity within the cores obtained; the *Cannartus petterssoni* (radiolarian) Zone (within the middle Miocene) may be missing.

Foraminifera

Cores 4 to 6 contain sporadic deep-water benthonic assemblages. Single specimens of *Morozovella* aff. *spinulosa*, *Acarinina* aff. *primitiva*, *"Globorotalia"* aff. *pseudomayeri*, and one fragment of *Globigerapsis* or *"Globigerinoides" higginsi* are sufficient to indicate a middle Eocene age for the clays of the Core 11 CC to Core 13 CC interval.

There is a downward increase in total assemblage in Core 14 from fish teeth and agglutinated benthonics (Sections 1, 2) through very rare planktonics (Sections 3, 4) and calcareous benthonics (Sections 5 and upper part of 6) to a planktonic assemblage (lower part of Sections 6 and CC). In the latter, specimens are corroded, fragmented, and recrystallized.

This planktonic assemblage is richer in specimens and more diverse in Core 15 (Sections 1 to 3) where the *"Globorotalia" formosa* Zone (P.7) is recognizable.

There is a change within Core 15, Section 4: a distinctly different, better preserved and even richer assemblage from Section 5 to CC is identified as the *Morozovella subbotinae/Pseudohastigerina wilcoxensis* Subzone (P.6b).

There is another change between Sections 15, CC and 16-1. Core 16 contains a rich, excellently preserved assemblage with abundant *Morozovella velascoensis* and very few of the *M. subbotinae/gracilis/marginodentata/pasionensis* group, in both respects being in sharp contrast with Core 15. Core 16 is identified as the *Morozovella velascoensis* Zone (P.5) and, on negative evidence, is assigned to the upper part of that zone. Core 16, CC contains a mixed Paleocene and Eocene assemblage due to contamination.

The limits of this three-part calcareous section are estimated to be approximately 51 and 55 m.y.

Material removed ultrasonically from the surface of the top four pieces of basalt in Core 17 yielded small benthonics and small planktonics in two distinct preservations. All of the planktonics could be downhole contaminants; if they were in situ, they would give a maximum age of 57 to 58 m.y.

Nannofossils

Calcareous nannofossils of early Tertiary age were recovered in Cores 14, 15, and 16. In addition, nannofossils were also recovered from the surfaces of basalt fragments near the top of Core 17. The highest occurrence of nannofossils is in Core 14, Section 5, which contains a sparse assemblage consisting primarily of *Discoaster lodoensis* and *Tribrachiatus orthostylus.* The cooccurrence of these two species indicates an early Eocene age *(Tribrachiatus orthostylus* Zone = ~52 m.y.) for this interval. This same assemblage, with progressively more species added, continues to Core 15, Section 4. *Discoaster lodoensis* is not present below this level, but *Tribrachiatus orthostylus* and *Discoaster diastypus* cooccur as far as the bottom of Core 15. The interval from the middle of Section 6, Core 14 to the bottom of Core 15 is assignable to the early Eocene as well (*Discoaster diastypus* Zone of Bukry, 1971).

All of Core 16 is assignable to the late Paleocene *Discoaster multiradiatus* Zone. The core-catcher sample for Core 16 is contaminated as it contains a mixture of late Paleocene and early Eocene elements.

One additional age assignment can be made—and that is for the calcareous material scraped from basalt fragments from near the top of Core 17. The assemblage from this material contains, among others, *Cyclococcolithina robusta* and *Sphenolithus anarrhopus* with few asteroliths of the *Discoaster ornatus* type. Only one specimen of *Discoaster multiradiatus* was encountered, and this is probably a contaminant. Only a relative age assignment can be made for this sample. It is slightly, but distinctly, older than the oldest material recovered in Core 16. The nannofossil assemblage has an oceanic aspect with normal diversity except at the top and bottom of the calcareous interval, where the number of species is much reduced and the remaining specimens show strong evidence of solution/corrosion.

Radiolaria

Radiolaria ranging in age from Quaternary to middle Miocene are present in Cores 1 through 10 at Site 213. In Cores 1 through 8 Radiolaria are common and well preserved. In Cores 9 and 10 Radiolaria are increasingly more corroded downward, and the orosphaerids and collosphaerids are the predominant forms present.

The following faunal boundaries can be recognized within the siliceous ooze section of the cores:

The base of the Quaternary is between Samples 213-2-3, 100-102 cm and 213-2-4, 90-92 cm. The base of the *Pterocanium prismatium* Zone is between Samples 213-3, CC and 213-4-2, 105-107 cm. The base of the *Spongaster pentas* Zone is between Samples 213-7-4, 60-62 cm and 213-7, CC. The base of the *Stichocorys peregrina* Zone is between Samples 213-8-6, 100-102 cm and 213-8, CC. The *Ommatartus penultimus* Zone is represented at Sample 213-8, CC. Material between Samples 213-9-1, 140-142 cm and 213-9-6, 73-75 cm is within the *Ommatartus antepenultimus* Zone. The material in Sample 213-9, CC lies within the lower *Cannartus petterssoni* Zone or upper *Dorcadospyris alata* Zone. Radiolaria are absent below Sample 213-10-1, 70-72 cm.

CORRELATION OF REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

Sediment cover in the region of Site 213 is sparse, with sediment mainly occurring in small "basins" a few miles in length within rugged basin topography. The actual drill site was chosen in a typical basin which contains a maximum of 0.14 to 0.16 sec of sediment over basement.

The seismic profile of the site (Figure 3) shows the sediment to be acoustically highly transparent throughout the entire section. Acoustic basement is topographically rough, and from the figure it is apparent that the drill site was chosen in a basement "valley" over which about 0.16 sec of sediment occurs.

The only positive correlation possible in this area is that of acoustic basement, depth 0.16 sec, and basalt, at a drilled depth of 154 meters. This correlation gives an interval velocity to the sediment of 1.9 km/sec. From the stratigraphic column it is evident that the acoustically transparent sediment corresponds with monotonous massively bedded units of siliceous ooze, zeolitic brown clay, and stiff calcareous ooze.

Depths of reflectors and interval velocities are as follows.

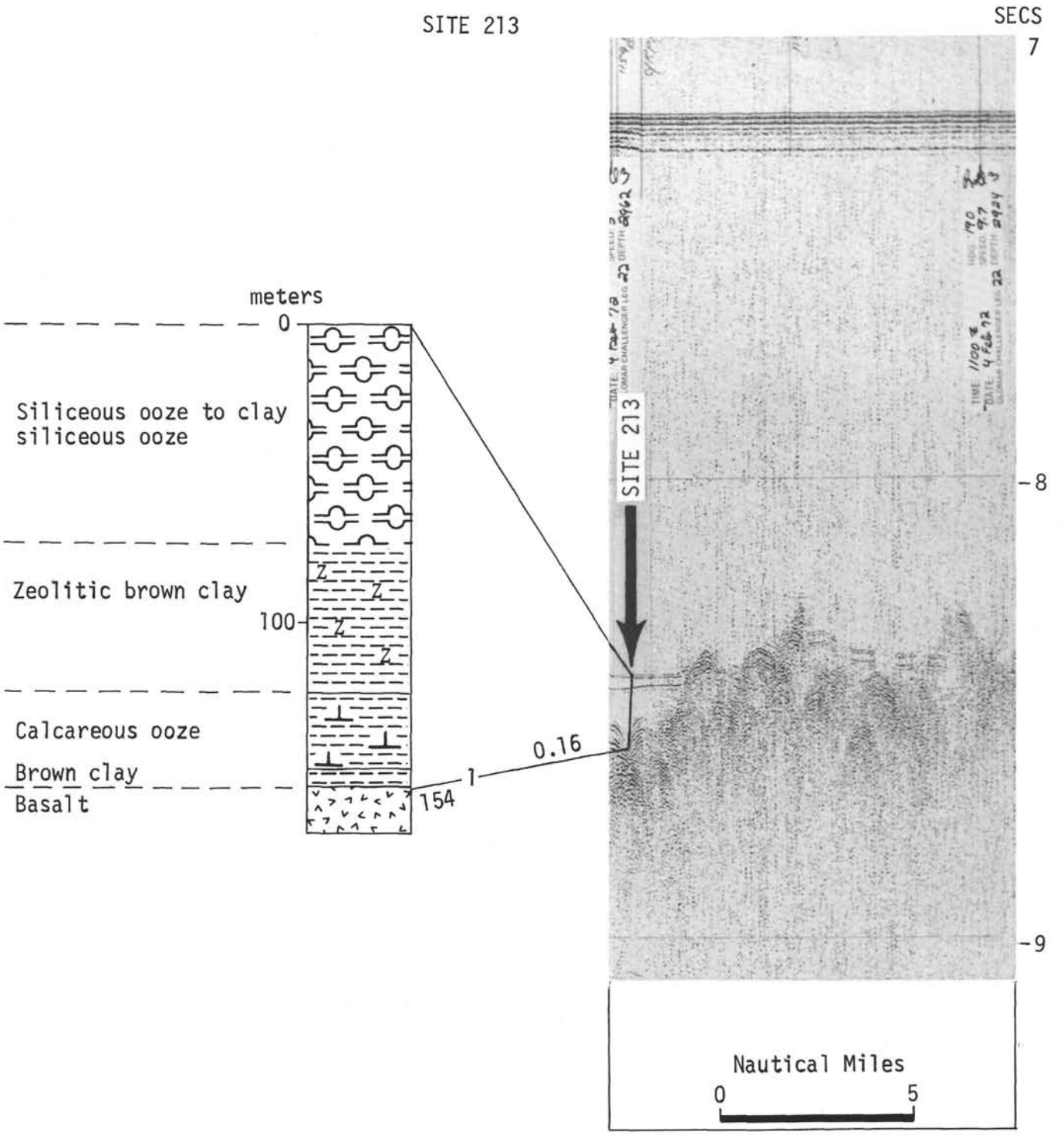

Figure 3. *Correlation of reflection profile and stratigraphic column at Site 213.*

Reflector	2-Way Time (sec)	Depth (m)	Interval Velocity (km/sec)
0	0	9	1.9
1	0.16	154	

SUMMARY AND CONCLUSIONS

Site 213 was chosen at a point approximately 500 km east of the Ninetyeast Ridge. It was drilled close to the beginning of anomaly 26 identified by Sclater and Fisher (in preparation).

The site was drilled in a small basin approximately 6 miles in length which contains a maximum of 0.14 sec of acoustically transparent, apparently ponded sediment. Water depth is 5601 meters. The site typifies the region, so far as can be deduced from the seismic profile. To the north and south the basement is rugged and includes several similar basins.

The basal unit is a weathered pillow-basalt with distinct mid-Indian Ocean ridge affinities. Approximately 2.5 meters of section, possibly calcareous ooze, is missing from just above the basalt, but upper Paleocene calcareous ooze adheres to the uppermost basalt fragments. Above the zone of missing basal sediment lies an iron-oxide-rich clay which is overlain by and partly interbedded with a calcareous nannofossil ooze unit of late Paleocene to early Eocene age. The main unit at this site is a zeolitic clay and the upper lithologic unit is a Quarternary to upper Miocene radiolarian-diatom ooze.

Foraminiferal and nannofossil assemblages in the calcareous section near the bottom of the hole have a low latitude oceanic aspect. Towards the top of the calcareous unit where it grades into overlying red clay, a residual flora and fauna composed only of the most resistant forms is present, indicating the onset of dissolution.

At the time of the formation of oceanic crust at Site 213, the area was situated above the regional carbonate compensation depth as a sea-floor spreading center and remained so until early Eocene as evidenced by accumulation of biogenic carbonates. The ridge then slowly subsided below the carbonate compensation level during spreading, resulting in a gradual diminution of the carbonate supply to the sea floor. The resulting lack of diluting biogenous material would then favor the accumulation of nonfossiliferous zeolitic brown clay facies. During late Miocene, the plate moved northwards into equatorial high productivity regions so that brown clay sediments became swamped with biogenous material. Because the plate has subsided below the carbonate compensation depth, noncalcareous radiolarian diatom ooze began to accumulate and has persisted to the present.

The weathered basalts below the sediments are similar in composition to those from the active mid-Indian Ocean ridges. The presumed basement contact was continuously cored, and nannofossils were recovered in Core 17 adhering to the basalt which gave an age of 55 to 57 m.y. Foraminifera were recovered to the bottom of Core 16 and were located in the P.6a (54 m.y.) Zone of Berggren (1971). However, material removed ultrasonically from the basalt in Core 17 gave a maximum downward age of Zone P.4 or 57 to 58 m.y. The magnetic anomaly identification is clear and is the beginning of 26 giving a magnetic age from Heirtzler et al. (1968) of 64 m.y. This is 6 to 7 m.y. more than the oldest sediment, and together with the results from Legs 3 and 5, is evidence that the magnetic and biostratigraphic scales are significantly different. As a result, a special chapter (Chapter 13) has been devoted in this report to the correlation between the two time scales.

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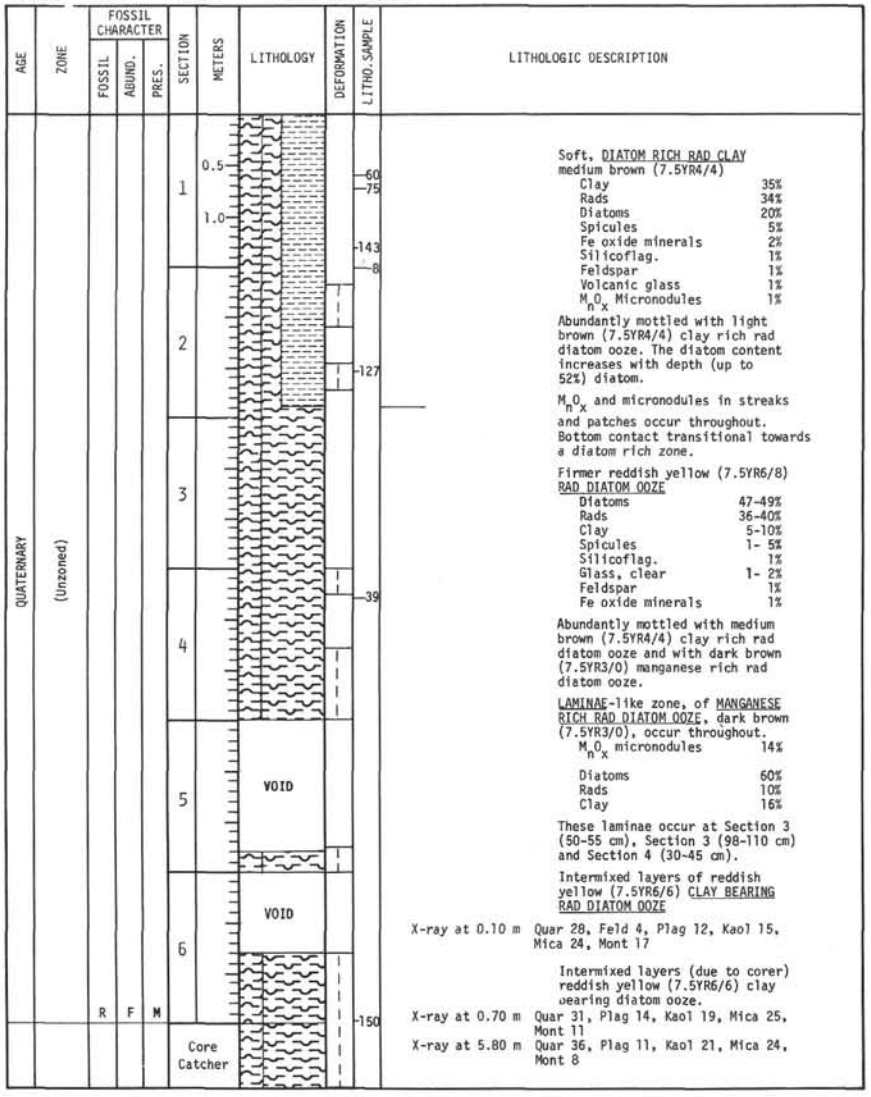
Site 213 Hole Core 1 Cored Interval: 0-9 m



Soft, DIATOM RICH RAD CLAY
medium brown (7.5YR4/4)

Clay	35%
Rads	34%
Diatoms	20%
Spicules	5%
Fe oxide minerals	2%
Silicoflag.	1%
Feldspar	1%
Volcanic glass	1%
M_nO_x Micronodules	1%

Abundantly mottled with light brown (7.5YR4/4) clay rich rad diatom ooze. The diatom content increases with depth (up to 52%) diatom.

M_nO_x and micronodules in streaks and patches occur throughout. Bottom contact transitional towards a diatom rich zone.

Firmer reddish yellow (7.5YR6/8) RAD DIATOM OOZE

Diatoms	47-49%
Rads	36-40%
Clay	5-10%
Spicules	1- 5%
Silicoflag.	1%
Glass, clear	1- 2%
Feldspar	1%
Fe oxide minerals	1%

Abundantly mottled with medium brown (7.5YR4/4) clay rich rad diatom ooze and with dark brown (7.5YR3/0) manganese rich rad diatom ooze.

LAMINAE-like zone, of MANGANESE RICH RAD DIATOM OOZE, dark brown (7.5YR3/0), occur throughout.

M_nO_x micronodules	14%
Diatoms	60%
Rads	10%
Clay	16%

These laminae occur at Section 3 (50-55 cm), Section 3 (98-110 cm) and Section 4 (30-45 cm).

Intermixed layers of reddish yellow (7.5YR6/6) CLAY BEARING RAD DIATOM OOZE

X-ray at 0.10 m Quar 28, Feld 4, Plag 12, Kaol 15, Mica 24, Mont 17

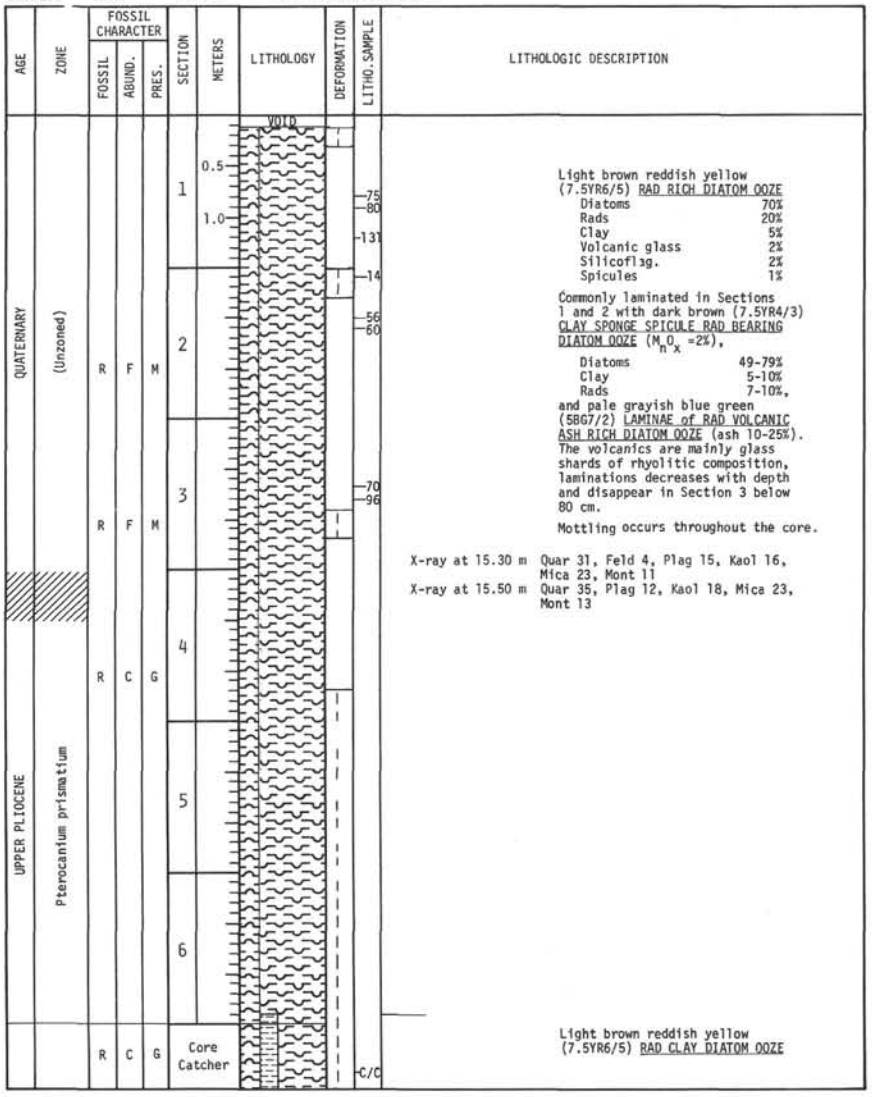
Intermixed layers (due to corer) reddish yellow (7.5YR6/6) clay bearing diatom ooze.

X-ray at 0.70 m Quar 31, Plag 14, Kaol 19, Mica 25, Mont 11

X-ray at 5.80 m Quar 36, Plag 11, Kaol 21, Mica 24, Mont 8

Explanatory notes in Chapter 1

Site 213 Hole Core 2 Cored Interval: 9-18.5 m



Light brown reddish yellow (7.5YR6/5) RAD RICH DIATOM OOZE

Diatoms	70%
Rads	20%
Clay	5%
Volcanic glass	2%
Silicoflag.	2%
Spicules	1%

Commonly laminated in Sections 1 and 2 with dark brown (7.5YR4/3) CLAY SPONGE SPICULE RAD BEARING DIATOM OOZE (M_nO_x =2%),

Diatoms	49-79%
Clay	5-10%
Rads	7-10%,

and pale grayish blue green (5BG7/2) LAMINAE of RAD VOLCANIC ASH RICH DIATOM OOZE (ash 10-25%). The volcanics are mainly glass shards of rhyolitic composition, laminations decreases with depth and disappear in Section 3 below 80 cm.

Mottling occurs throughout the core.

X-ray at 15.30 m Quar 31, Feld 4, Plag 15, Kaol 16, Mica 23, Mont 11

X-ray at 15.50 m Quar 35, Plag 12, Kaol 18, Mica 23, Mont 13

Light brown reddish yellow (7.5YR6/5) RAD CLAY DIATOM OOZE

Explanatory notes in Chapter 1

Site 213 Hole Core 3 Cored Interval:18.5-28 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	Pterocanium prismatium	R	C	G	1	0.5	Fe-Mn		4	
							Fe-Mn		7.5YR5/2	Reddish yellow (7.5YR7/5) RAD RICH DIATOM OOZE. Diatoms 65-75%; Rads 12-25%; Clay 5-10%; Spicules 1- 5%; Silicoflag. <1%. Interlayered with mottled zones of medium brown (7.5YR5/2) manganese Fe-oxide bearing rad rich diatom ooze (Fe-oxide minerals 3% M_nO_x <5%).
						1.0	Fe-Mn		7.5YR5/2	
					2		Fe-Mn		7.5YR5/2	
									120	
					3					Volcanic ash increase in Section 3 (volcanic 3%) in the reddish yellow clay bearing rad rich diatom ooze.
					4		VOID			
									pumice	
										X-ray at 26.10 m Quar 26, Plag 8, Kaol 19, Mica 30, Mont 17
					5					
							Fe-Mn		7.5YR5/2	
					6		VOID			
							Fe-Mn		23	
							Fe-Mn		37	Laminated zone of manganese iron enrichment very dark brown (7.5YR2.5/2) Section 6 (10-30 cm). Clay rad rich diatom ooze: Clay 20%; Diatoms 46%; Rads 25%; Silicoflag. 5%; Spicules 1%; Glass 2%; M_nO_x 2%.
		R	F	G	Core Catcher				C/C	

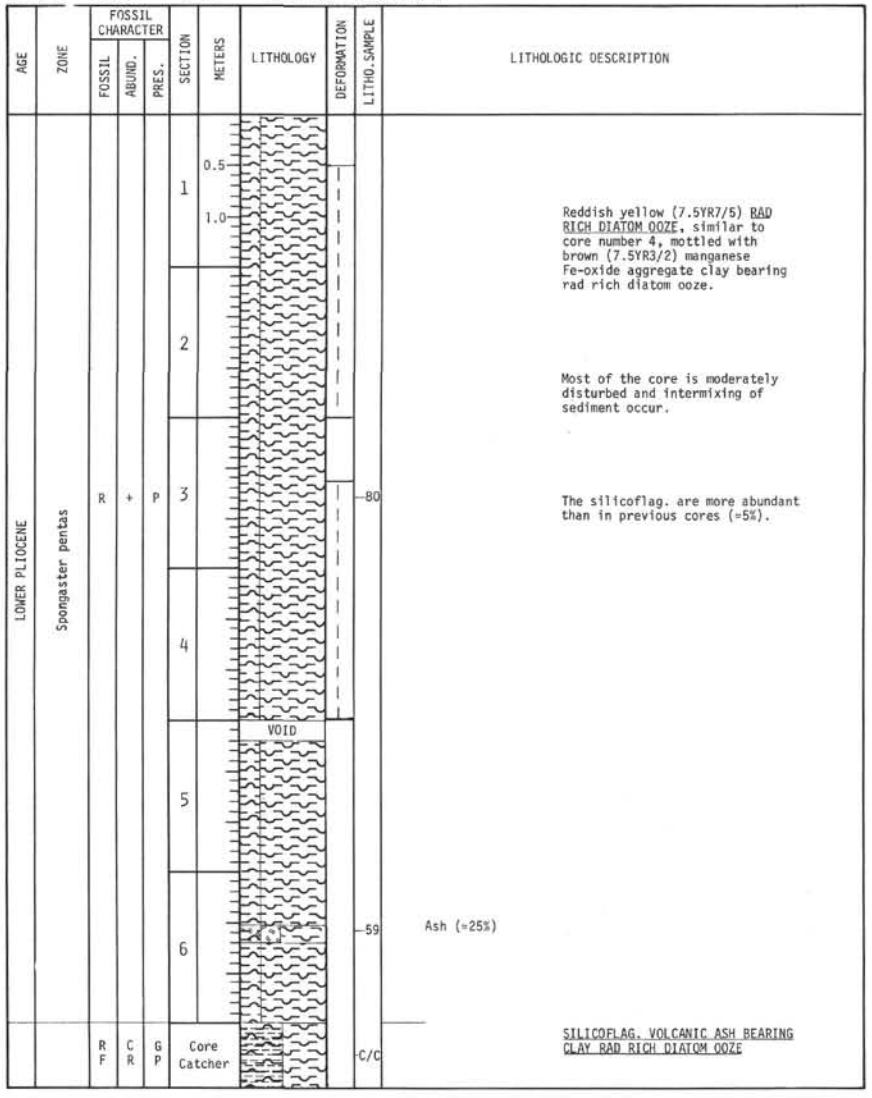
Explanatory notes in Chapter 1

Site 213 Hole Core 4 Cored Interval:28-37.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	Pterocanium prismatium				1		VOID			
									40	
						0.5	Fe-Mn		7.5YR3/2	Reddish yellow (7.5YR8/5) RAD RICH DIATOM OOZE. Diatoms 75%; Rads 16%; Clay 2- 3%; Glass 1%; M_nO_x 2%; Spicules 1%; Silicoflag. 1%.
									70	
							Fe-Mn		≈5%	
						1.0			73	
									7.5YR3/2	Interlayered with dark brown (7.5YR3/2) manganese Fe-oxide mineral bearing rad rich diatom ooze.
					2		VOID			
		R	C	M						
					3					Below Section 3 the core is badly disturbed and intermixing of reddish yellow and dark brown sediment similar to the above sections occur.
		R	F	M						
	Spongaster pentas				4					
		R	C	G						
					5					
					6					
		R F	C R	G P	Core Catcher					

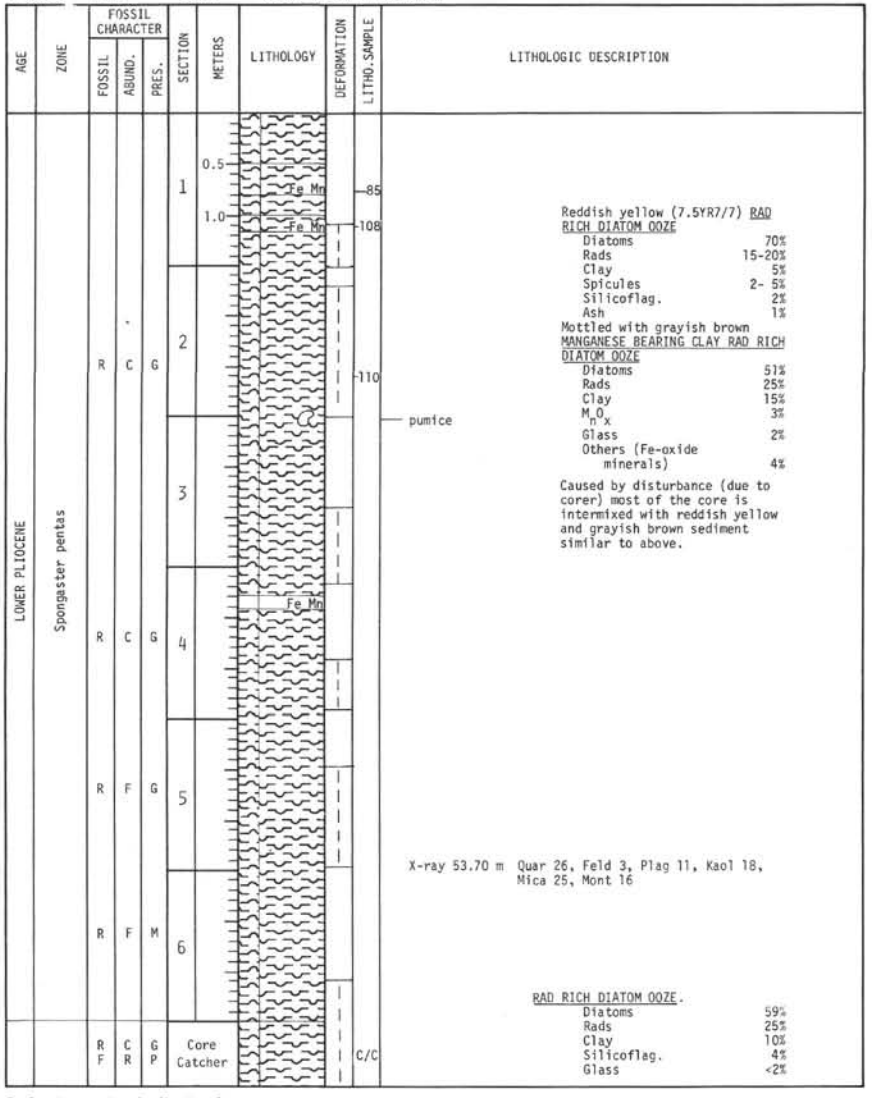
Explanatory notes in Chapter 1

Site 213 Hole Core 5 Cored Interval: 37.5-47 m



Explanatory notes in Chapter 1

Site 213 Hole Core 6 Cored Interval: 47-56.5 m



Explanatory notes in Chapter 1

Site 213 Hole Core 7 Cored Interval: 56.5-66 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE	Spongaster pentas	R	C	G	1	0.5, 1.0			29	pumice (at 5 cm)
					2				70	
					3				43	pumice at 40-65 cm
	Stichocorys peregrina	R	C	G	4					
					5					
					6				120	
		R	C	G	Core Catcher				C/C	

Reddish yellow (7.5YR7/7) CLAY RAD RICH DIATOM OOZE.

Diatoms	51-56%
Rads	20-25%
Clay	15%
M_nO_x	2%
Silicoflag.	2%
Spicules	1%
Fe-oxide minerals	2%
Feldspar	1%
Glass	1- 3%

Mottled with light olive brown (2.5Y5/4) ASH BEARING CLAY RAD RICH DIATOM OOZE. Small patches enriched in manganese aggregates scattered throughout the core. A small pocket of white VOLCANIC ASH occur in Section 3 at 70 cm.

Medium dark brown (7.5YR4/2) RAD RICH CLAY

Clay	73%
Diatoms	5%
Spicules	7%
Glass	3%
Silicoflag.	1%
Rads	11%

Explanatory notes in Chapter 1

Site 213 Hole Core 8 Cored Interval: 66-75.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE	Stichocorys peregrina	R	C	G	1	0.5, 1.0				pumice
					2					
					3				45 50	
					4					
		R	C	G	5					
		R	C	G	6					
		R	C	G						
	O. penultimus	R	F	G	Core Catcher				C/C	

Medium dark brown (7.5YR4/2) SPONGE SPICULE DIATOM RAD RICH CLAY

Clay	67%
Diatoms	10%
Rads	10%
Spicules	10%
Silicoflag.	1%
Glass	2%
Zeolite	Tr.

Intermixed (due to coring disturbance) with reddish yellow (7.5YR6/6) rad rich diatom ooze similar to Core number 7.

This medium dark brown layer grades into a darker brown layer. The contact appears to be gradational.

Dark brown (7.5YR3/2) CLAY

Clay	92%
Rads	3%
Spicules	2%
Glass	1%
Zeolite	1%
M_nO_x	1%

Black streaks of manganese aggregates occur throughout Section 4.

A pinkish white pocket of rhyolitic ash

X-ray at 69.10 m Quar 29, Plag 10, Kaol 19, Mica 16, Mont 26

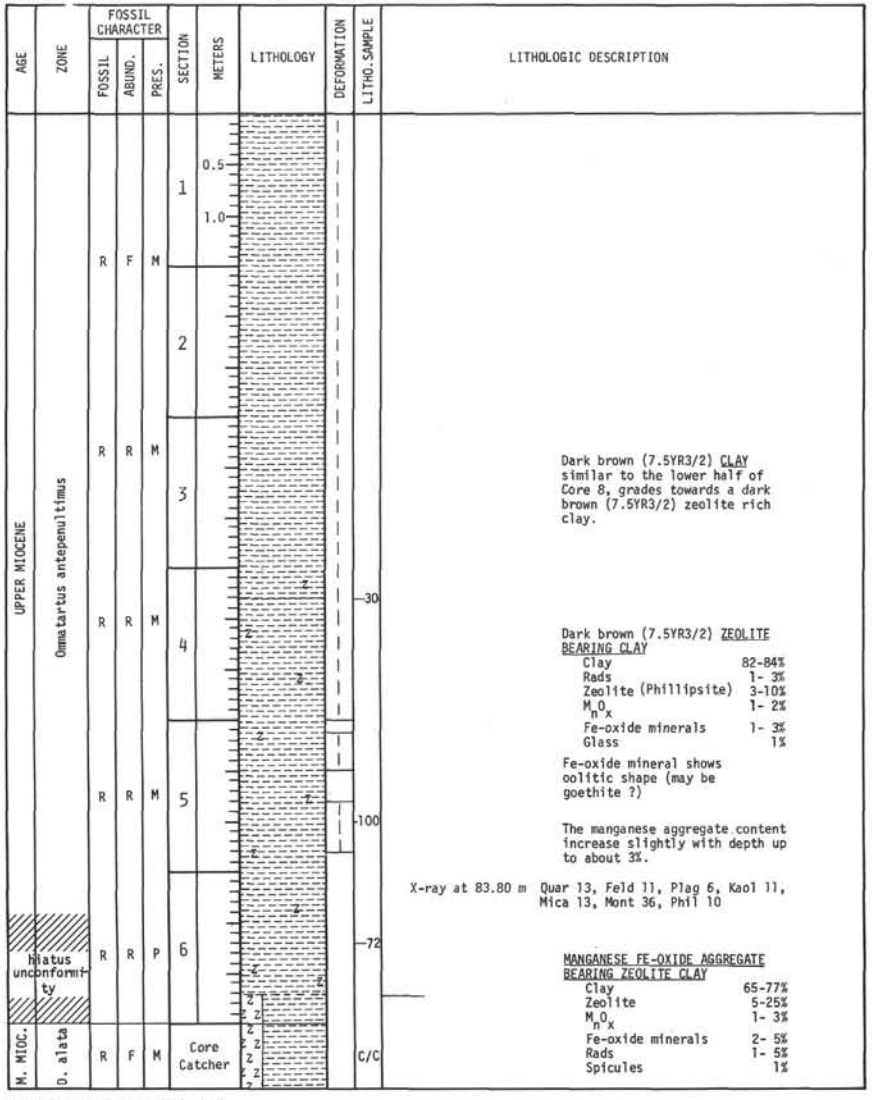
X-ray at 74.90 m Quar 15, Feld 3, Plag 7, Kaol 11, Mica 14, Mont 50

CLAY

Clay	87%
Rads	10%
Spicules	2%
Zeolite	1%

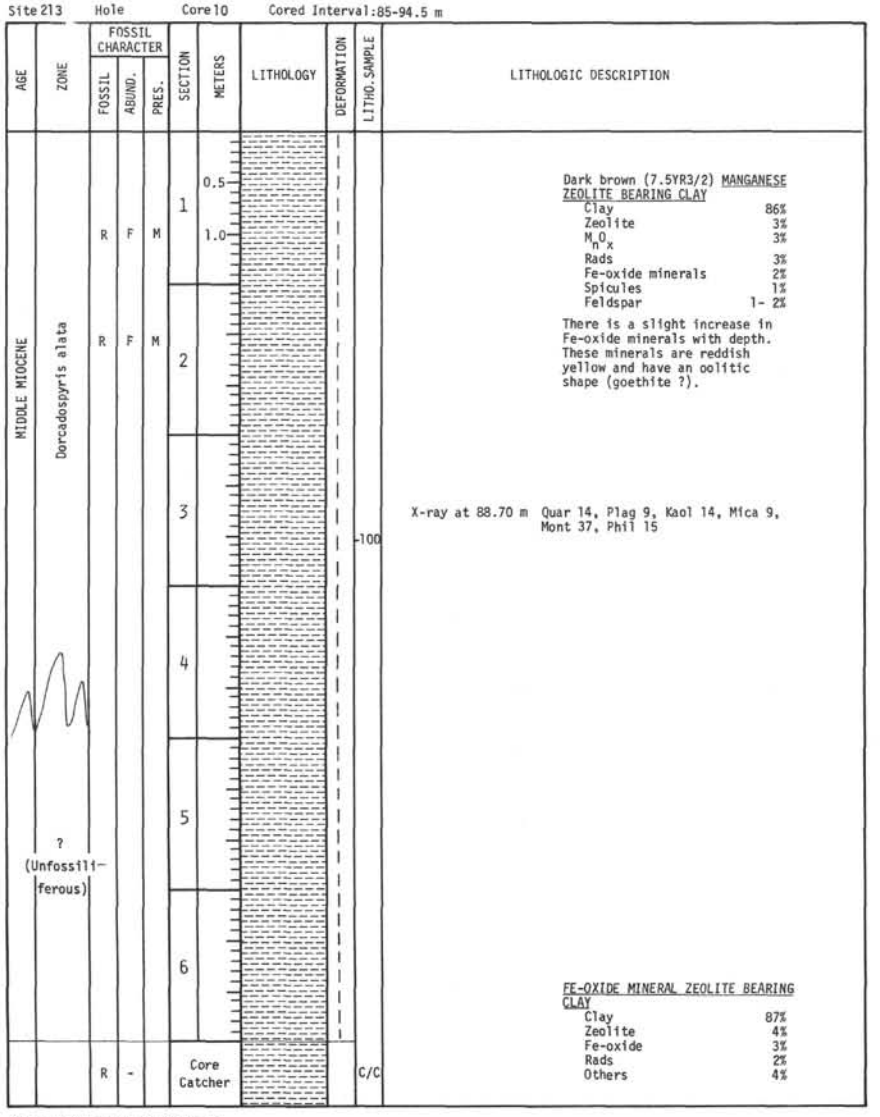
Explanatory notes in Chapter 1

Site 213 Hole Core 9 Cored Interval:75.5-85 m



Explanatory notes in Chapter 1

Site 213 Hole Core 10 Cored Interval:85-94.5 m



Explanatory notes in Chapter 1

Site 213 Hole Core 11 Cored Interval: 94.5-104 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	very rare foraminifera not zoned	R F	- R	P	1	0.5	VOID			
						1.0				
					1					Dusky yellow brown (10YR2/2) MANGANESE BEARING ZEOLITE RICH CLAY
										Clay 67-79%
										Zeolite 15-25%
										M_nO_x aggregates 3- 6%
										Fe-oxide minerals 2%
										Feldspar 1%
					2				144	
										The content of zeolite seems to be constant throughout the core.
					3					
					4					X-ray at 99.70 m Quar 9, Feld 5, Plag 6, Kaol 4, Mica 7, Mont 15, Paly 14, Phil 38, Amph 1
					5					
					6				100	
					Core Catcher				C/C	Zeolite rich clay Clay

Explanatory notes in Chapter 1

Site 213 Hole Core 12 Cored Interval: 104-113.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5	VOID			
						1.0				
					1					Dusky brown (5YR2/2) MANGANESE BEARING FE-OXIDE MINERAL and ZEOLITE RICH CLAY
										Clay 59%
										Zeolite 20%
										Fe-oxide mineral (goethite ?) 15%
										Feldspar <1%
										M_nO_x <10%
					2					
							VOID			
? Unfossiliferous					3					
					4					
					5					
					6				115	
										Manganese bearing Fe-oxide mineral and zeolite rich clay
										Clay 52%
										Zeolite 20%
										M_nO_x <10%
										Fe-oxide minerals 15%
										Others 3%
		R	-		Core Catcher				C/C	

Explanatory notes in Chapter 1

Site 213 Hole Core 13 Cored Interval: 113.5-123 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	? Unfossiliferous very rare foraminifera not zoned	R F	- R	M	1 2 3 4 5 6 Core Catcher	0.5 1.0	Fe		134 130 160	Dusky brown (5YR2/2) MANGANESE FE-OXIDE MINERALS and ZEOLITE RICH CLAY Clay 73-84% Zeolite 3-10% Fe-oxide minerals (goethite ?) 13-20% Glass Tr. The iron oxide minerals are reddish yellow, with high relief, opaque and oolitic shaped (goethite ?). The main type of zeolite is philipsite. The zeolite content decreases with depth in the core. In Section 6 there is only about 3-4% zeolite. X-ray 117.20 m Quar 10, Feld 10, Mica 7, Mont 5, Paly 20, Phil 47

Explanatory notes in Chapter 1

Site 213 Hole Core 14 Cored Interval: 123-132.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY EOCENE	Morozovella formosa Zone (P7) (F) Discoaster lodoensis Zone (N)	F F F F N F N F	R R R A R A C	M M M P M F M	1 2 3 4 5 6 Core Catcher	0.5 1.0	Fe		110 100 25 146	Light brown (5YR5/6) FE-OXIDE MINERAL RICH CLAY Clay 70% Fe-oxide minerals 30% Nanno Tr. Transitional contact. Moderate brown (5YR3/4) MANGANESE BEARING FE-OXIDE MINERAL RICH CLAY Clay 78% Fe-oxide 15% M_nO_x 3% Nanno 3% Rads 1% Interbedded with moderate yellowish brown (10YR5/4) CLAY RICH NANNO OOZE and becoming less clayey with depth. Nanno 70-85% Clay 10-25% Rads 1% Fe-oxide <2% M_nO_x <2% Calcite 1- 3% Moderate yellowish brown (10YR5/4) CLAY BEARING NANNO OOZE X-ray at 125.20 m Quar 13, Feld 25, Kaol 1, Mica 13, Chlo 2, Mont 10, Paly 35

Explanatory notes in Chapter 1

Site 213 Hole Core 15 Cored Interval: 132.5-142 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY EOCENE	Tribrachiatus orthostylus Zone (N) / Morozovella subbotinae/ Pseudohastigerina wilcoxensis Zone (P6b) (F)	F	C	P	1	0.5	Fe			Moderate brown (5YR3/4) NANNO MANGANESE BEARING FE-OXIDE MINERAL RICH CLAY similar to Core number 14.
						1.0				
	Discoaster lodoensis Zone (N) / Morozovella formosa Zone (P7) (F)	N F	A C	F P						In Section 2 this sediment is intermixed (due to coring process) with moderate yellowish brown (10YR5/4) clay bearing nanno ooze.
					2		Fe			
		F	F	M						
					3		Fe		60	Yellow (2.5Y7/4) CLAY BEARING NANNO OOZE Nanno 85% Clay 10% Rads 1% Foram 1% Calcite 3%
		F	A	M						
		F F	A C	G M						Interbedded with moderate brown (5YR3/4) nanno bearing Fe-oxide mineral rich clay similar to Core number 14. Burrow mottled.
		N	A	F	4		Fe			
							Fe			
		F	C	M						
		F	A	M	5					
		F F	A A	M E						
		F	A	E	6					
		F N	A A	E F					110	Yellow (2.5Y7/6) NANNO OOZE Nanno 98% Foram 2% Auth. carb. 3% Clay 10% Fe-oxide mineral, Manganese and glass occur in traces.
		R F	- A	E	Core Catcher					

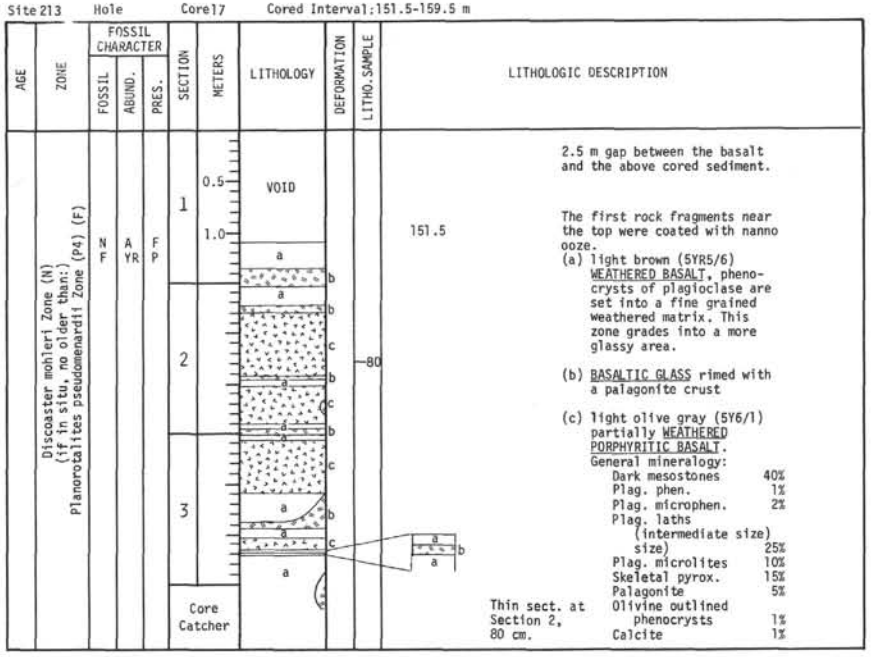
Explanatory notes in Chapter 1

Site 213 Hole Core 16 Cored Interval: 142-151.5 m

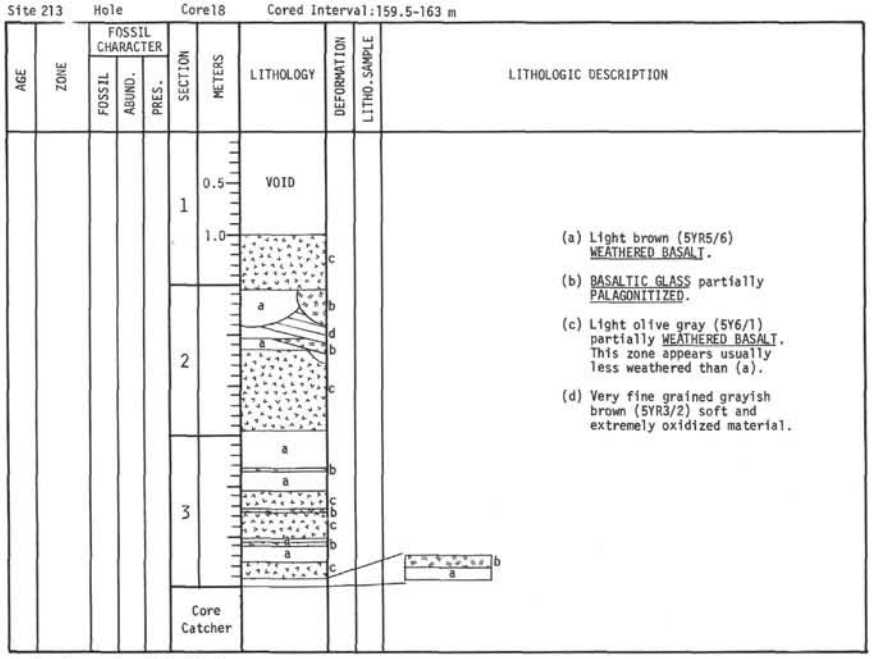
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PALEOCENE	Discoaster multiradiatus Zone (N) / Morozovella velascoensis Zone (P5) (F)				1	0.5	VOID			Yellow (2.5Y7/6) NANNO OOZE Similar to Core number 15 and homogeneous down to Section 4.
		F N	A A	E F		1.0				
		F N	A A	E F	2					
		N F	A A	E F	3					
		N F	A A	E E	4		Fe		90	Transitional bottom contact due to the increase in clay and iron oxide material.
							Fe		140	
					5		Fe			Grayish brown (5YR3/2) CLAY RICH IRON OXIDE SEDIMENT Clay 9-18% Iron ore 80-85% Nanno 1- 3% Auth. carb. 0- 2%
							Fe			X-ray at 144.60 m Calc 100 X-ray at 147.90 m Calc 12, Quar 11, Feld 15, Kaol 4, Mont 3, Paly 54
					6		Fe			
							Fe			Grayish brown (5YR3/2) CLAY BEARING IRON OXIDE SEDIMENT Limonitic aggregates and manganese comprise about 40%, oolitic Fe-oxide 45%, clay 9%, and nanno 3%.
		R N	- C	F	Core Catcher		Fe		C/C	

Explanatory notes in Chapter 1

Site 213 Hole Core 17 Cored Interval: 151.5-159.5 m

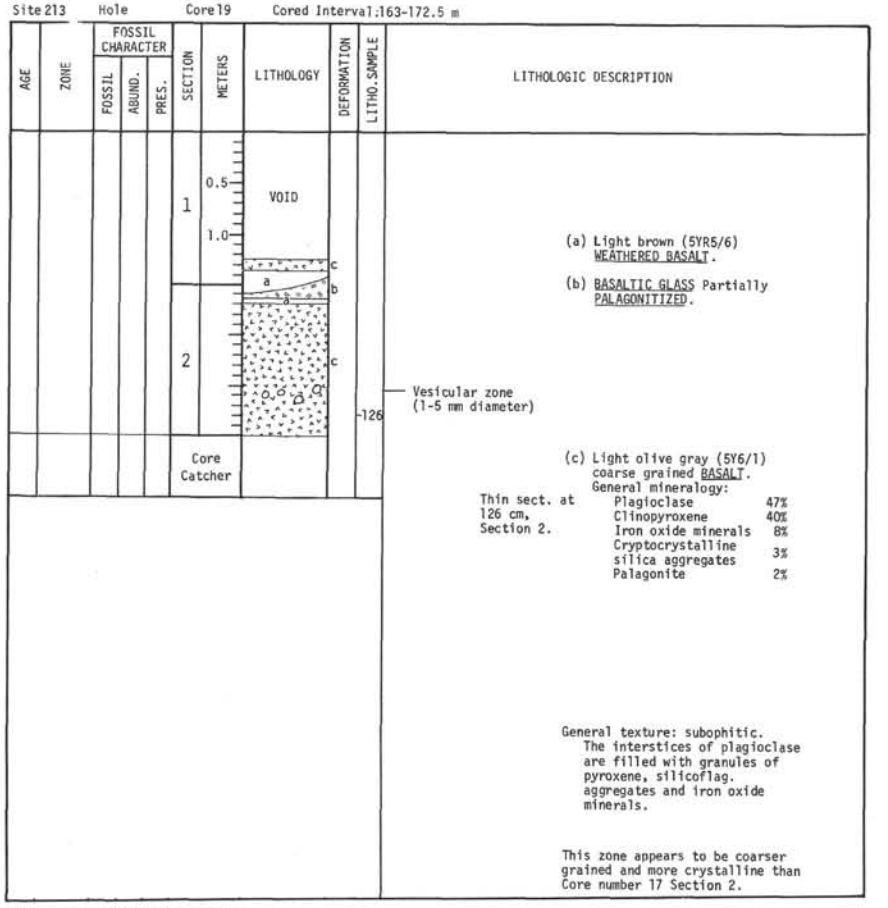


Site 213 Hole Core 18 Cored Interval: 159.5-163 m

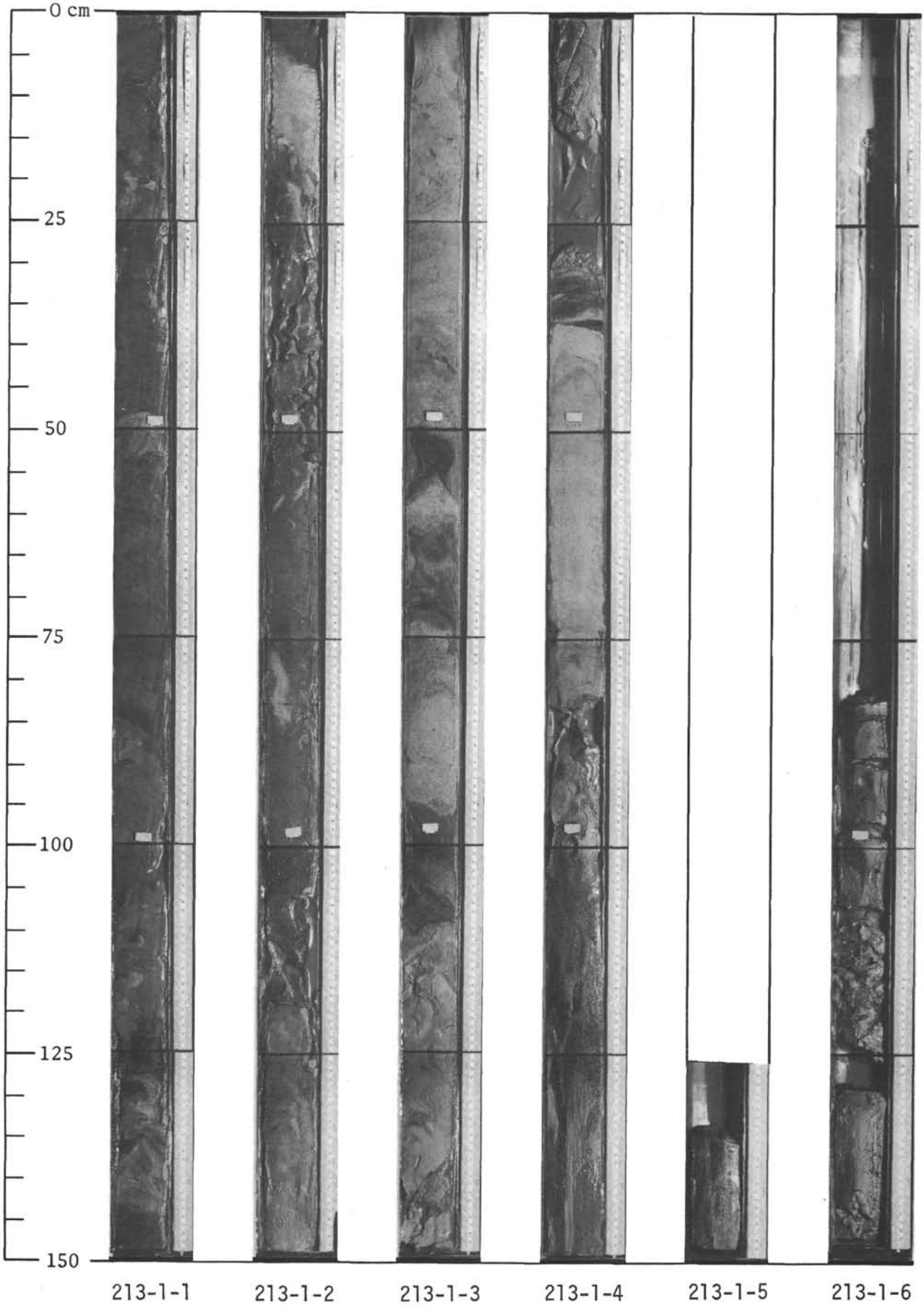


Explanatory notes in Chapter 1

Site 213 Hole Core 19 Cored Interval: 163-172.5 m



Explanatory notes in Chapter 1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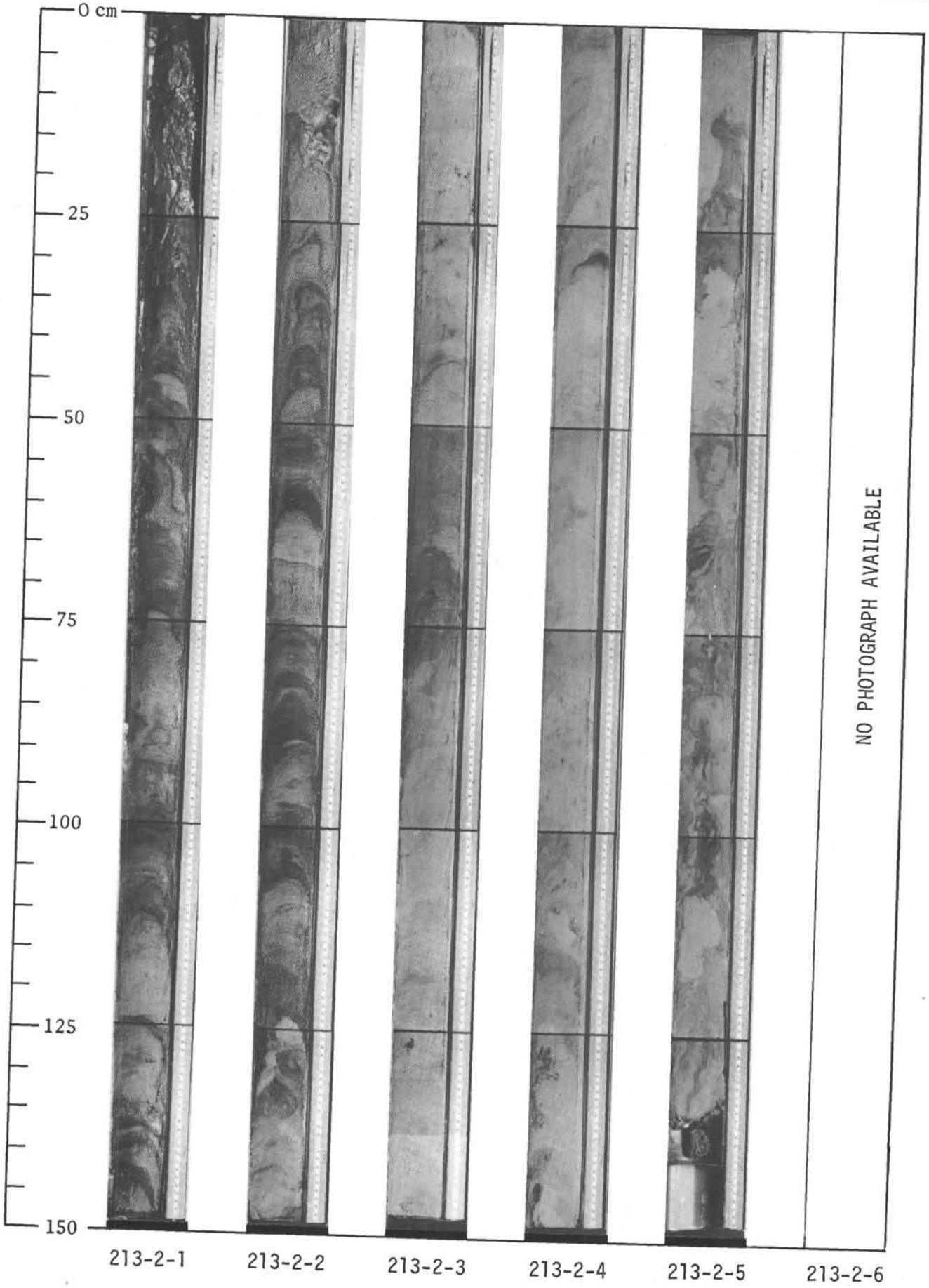
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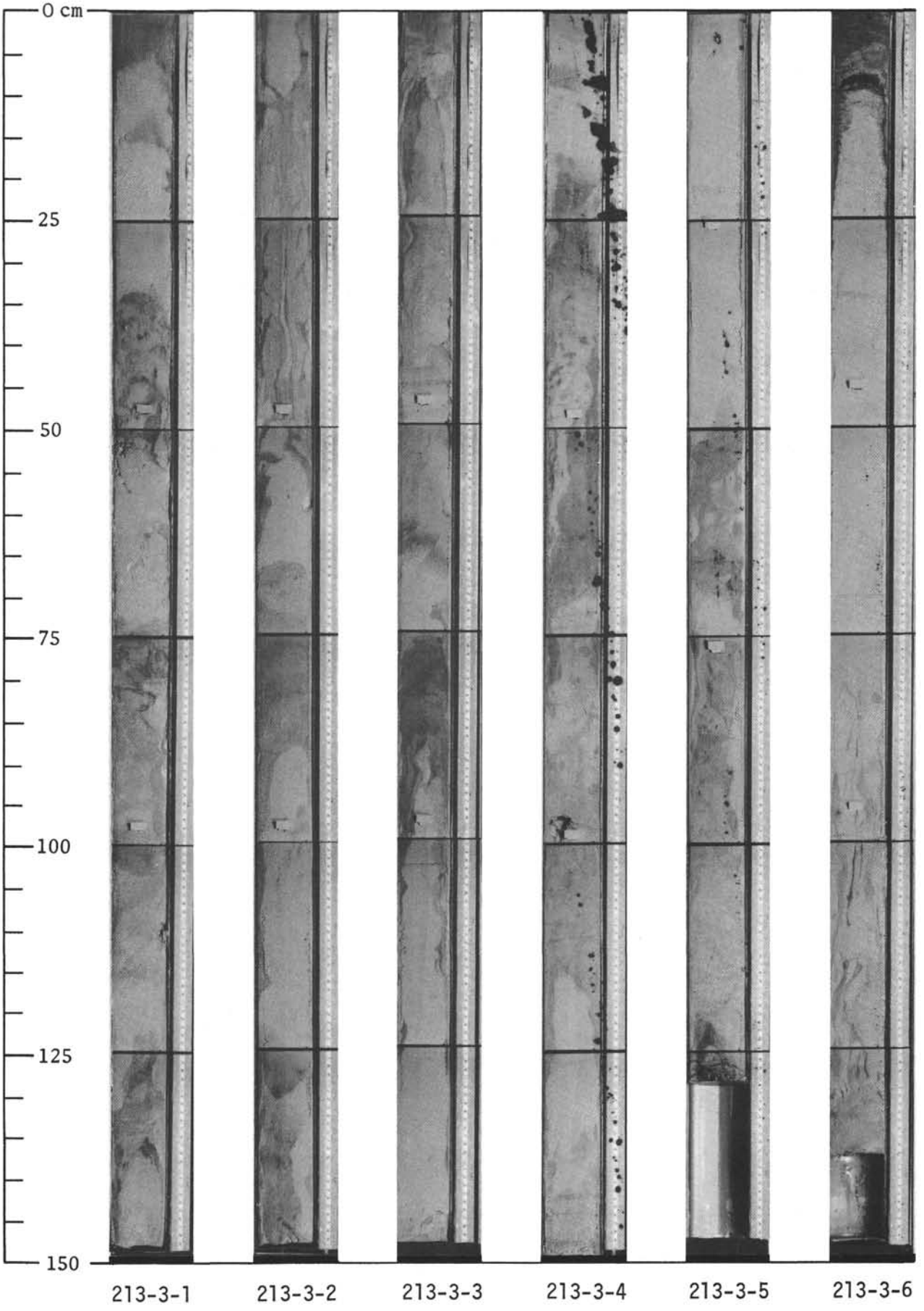
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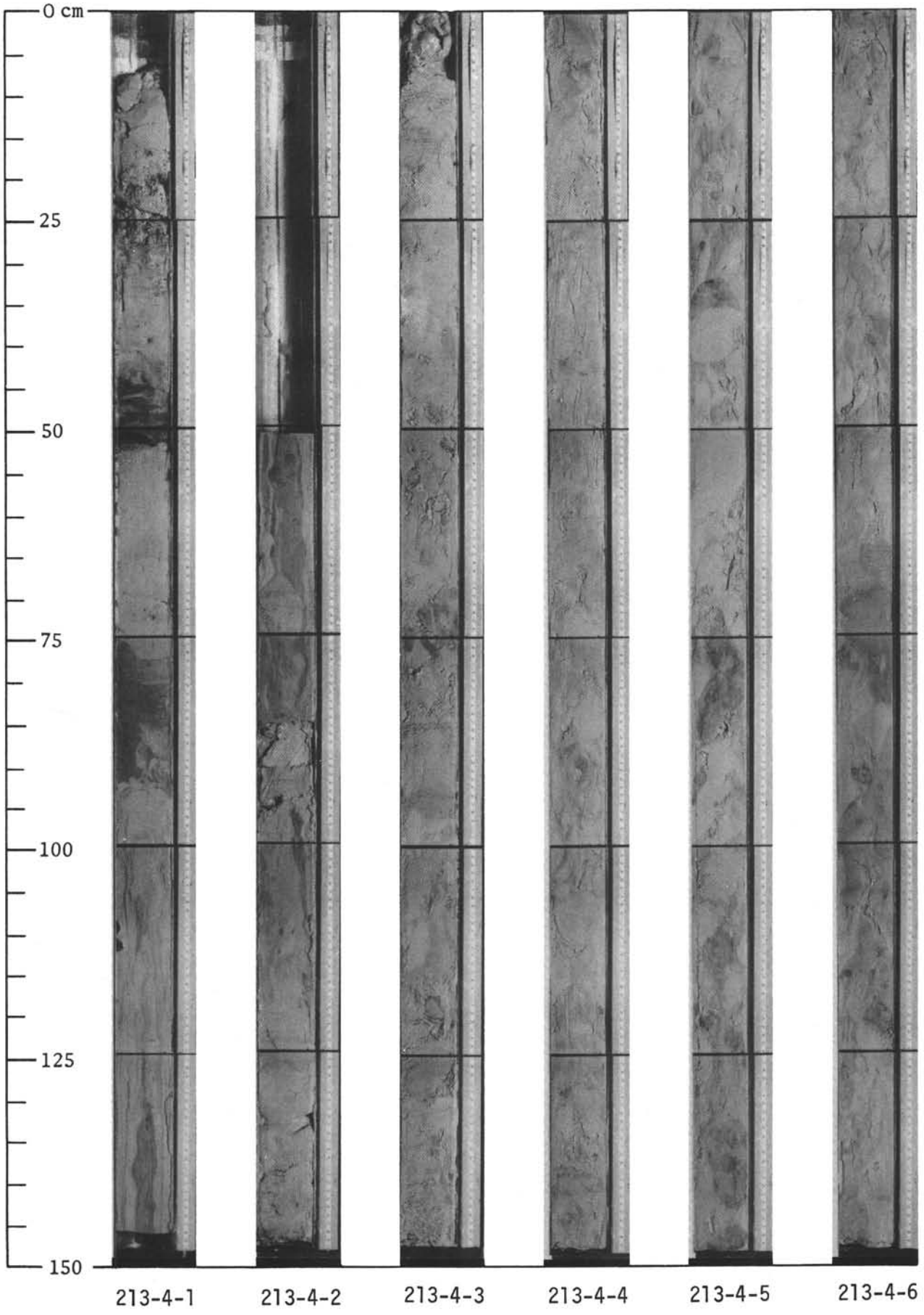
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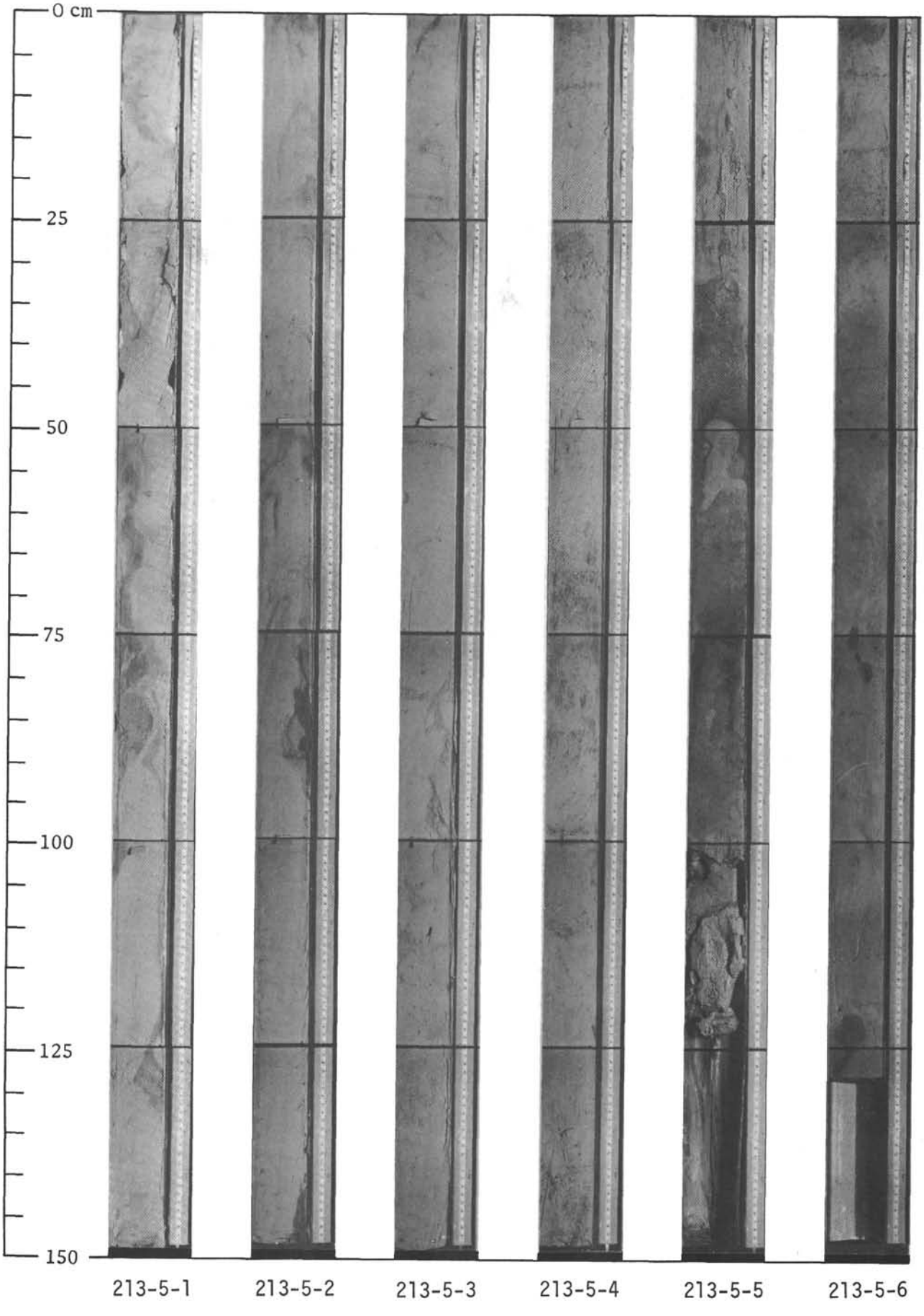
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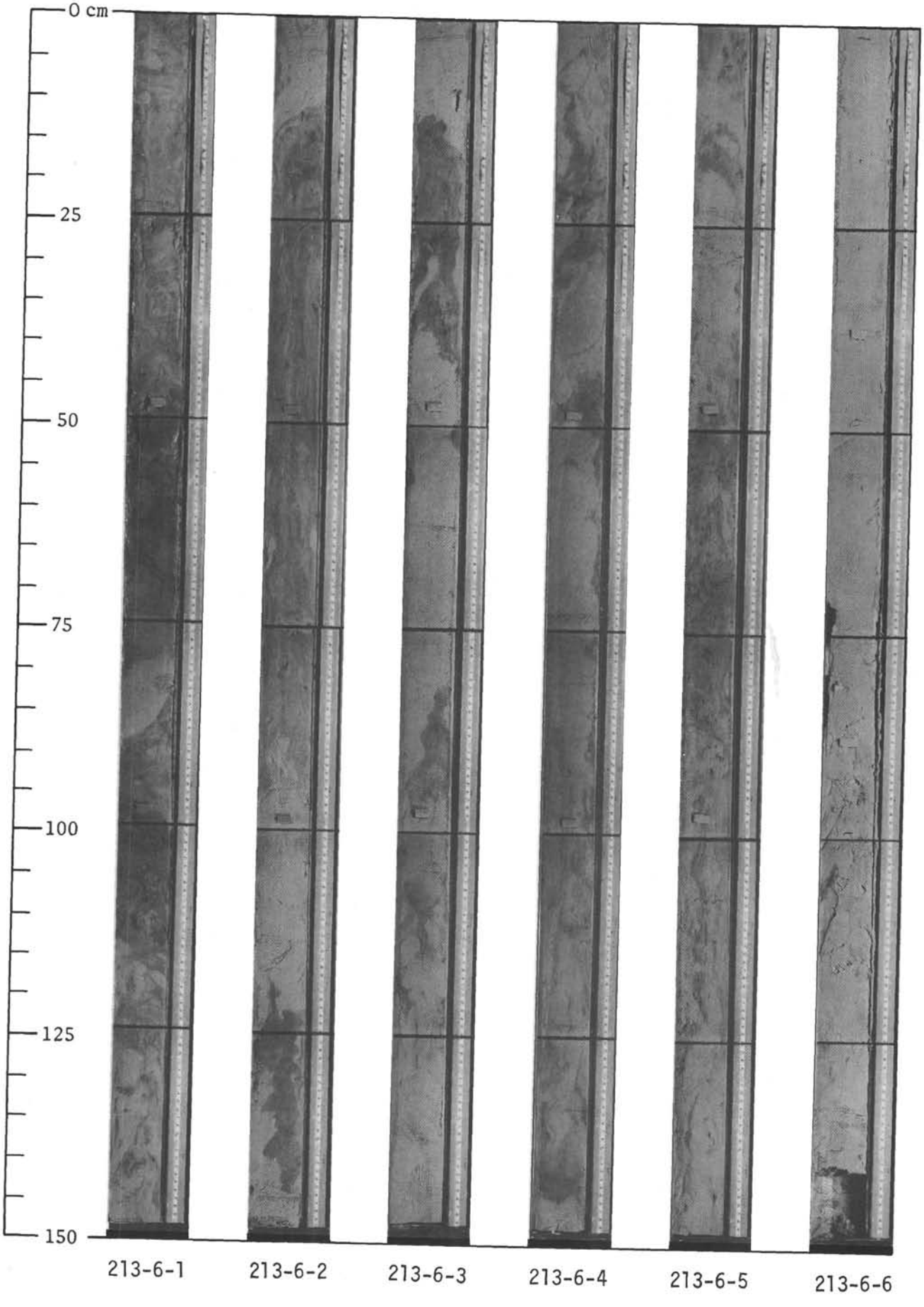
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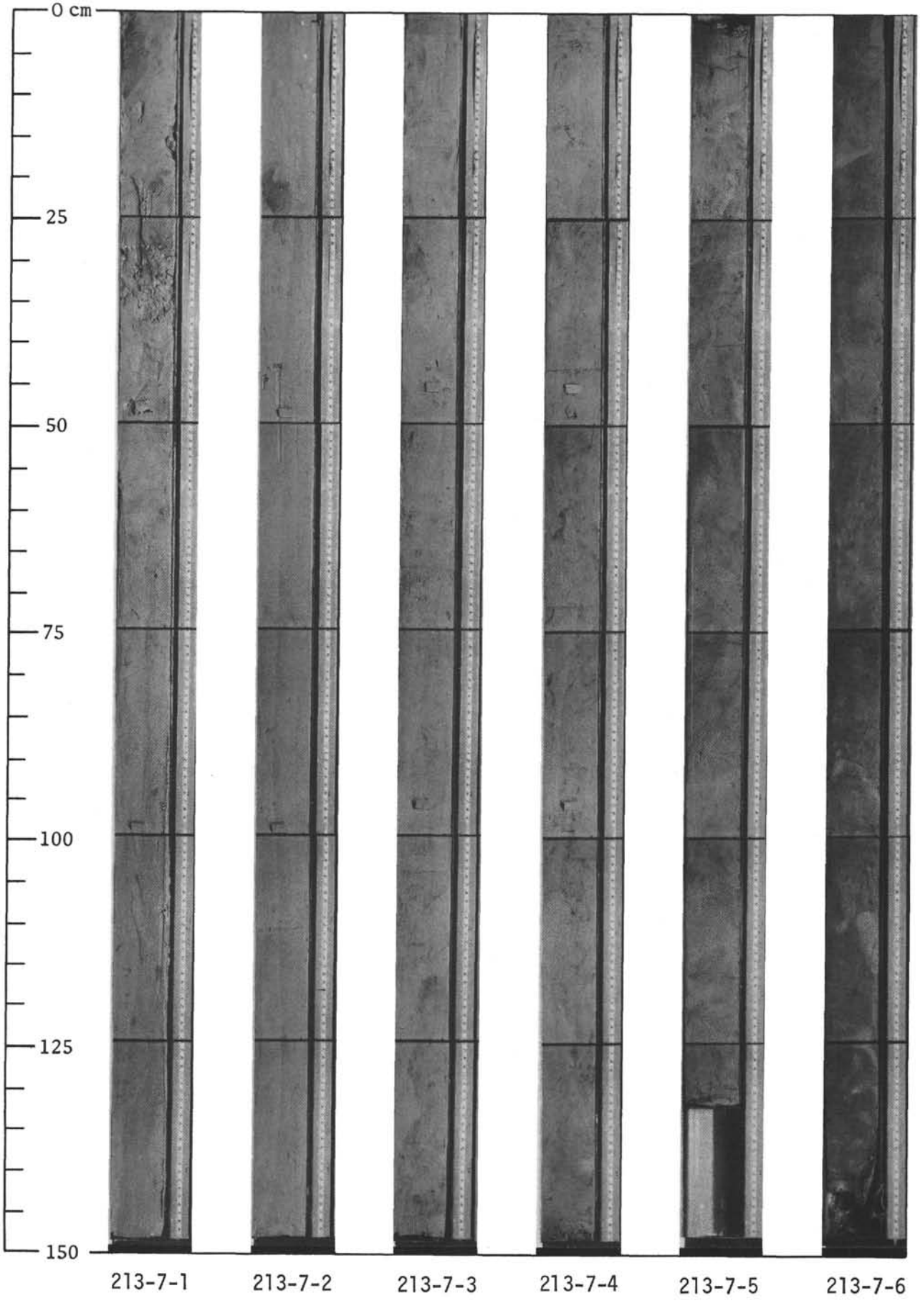
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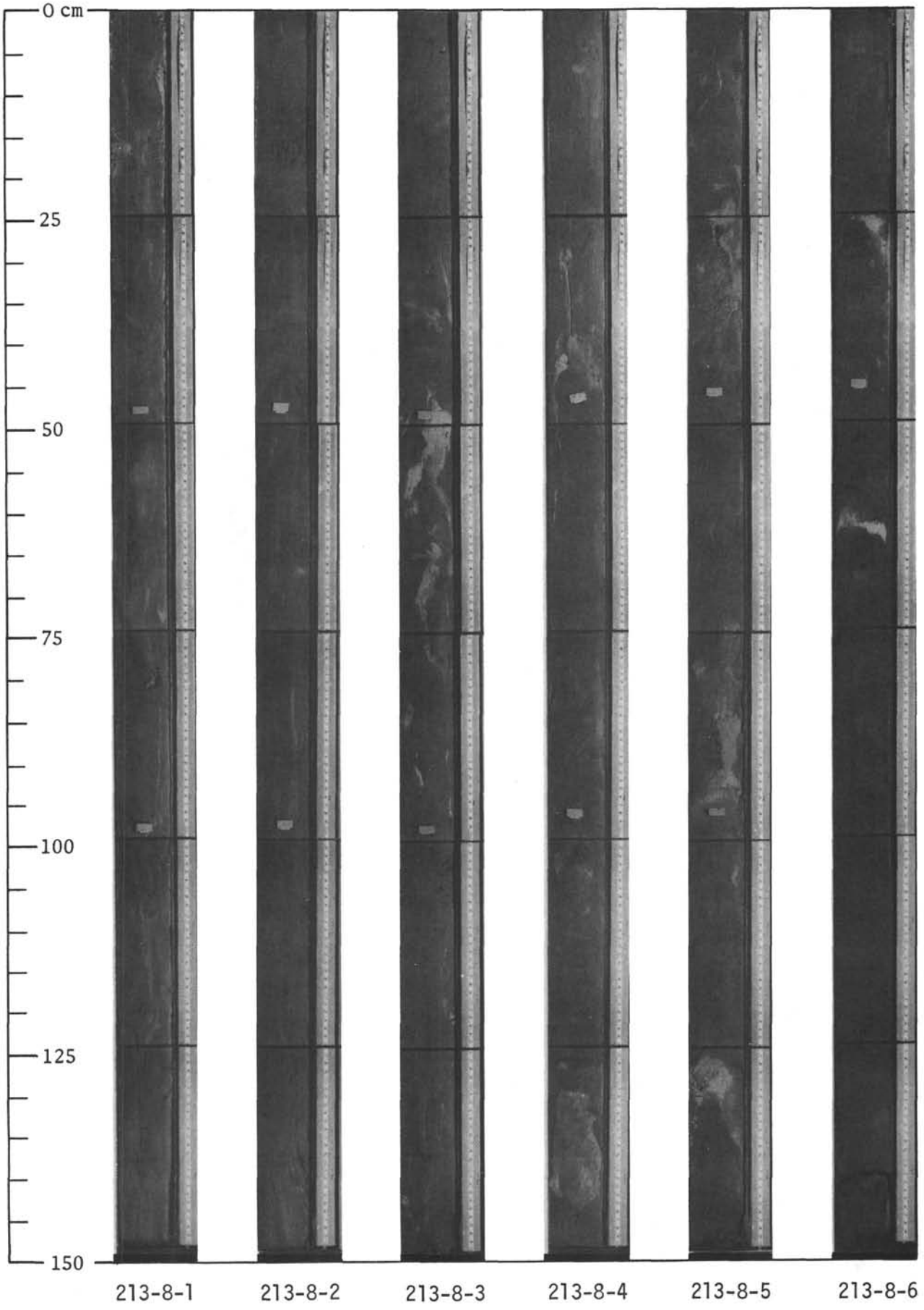
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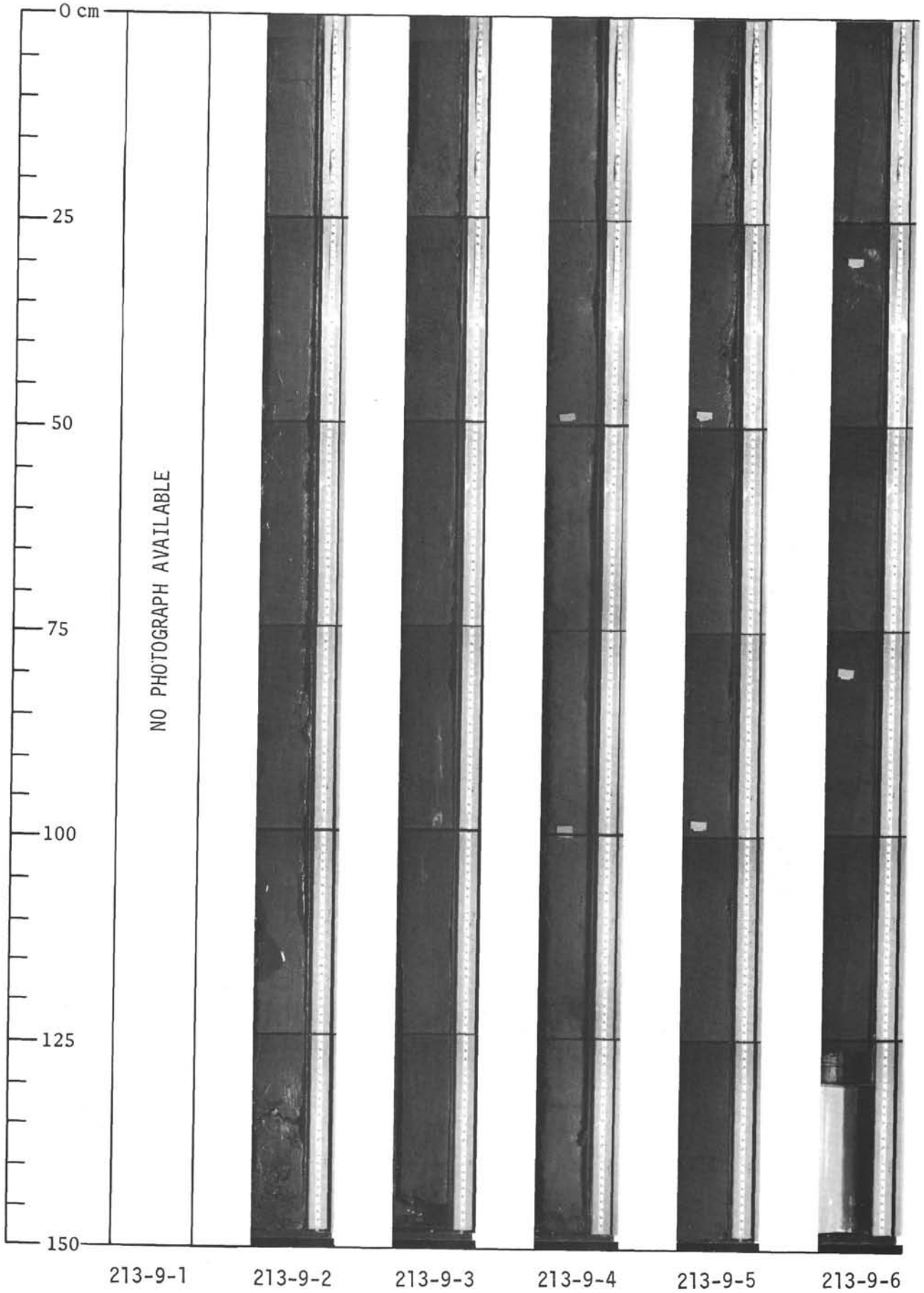
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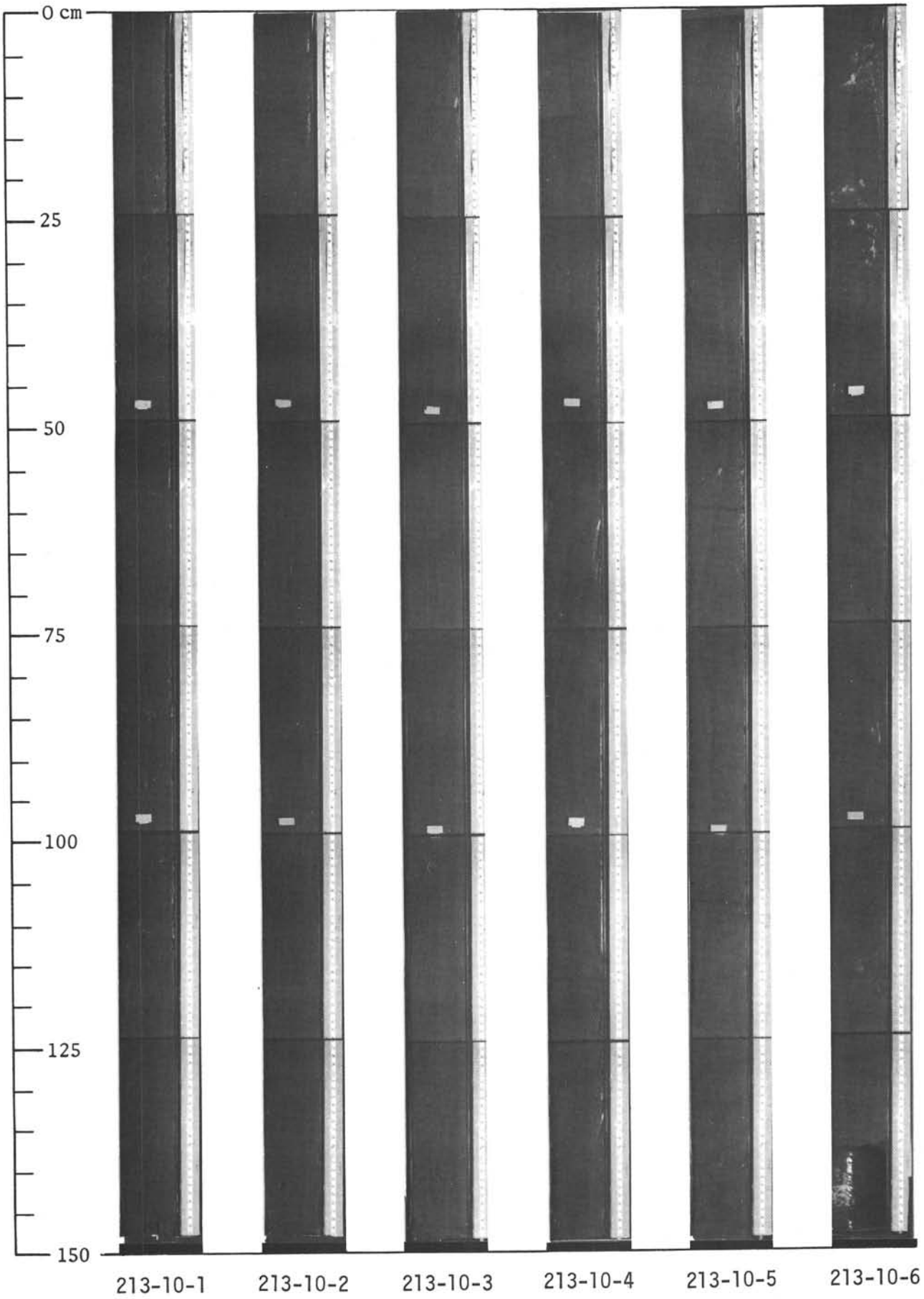
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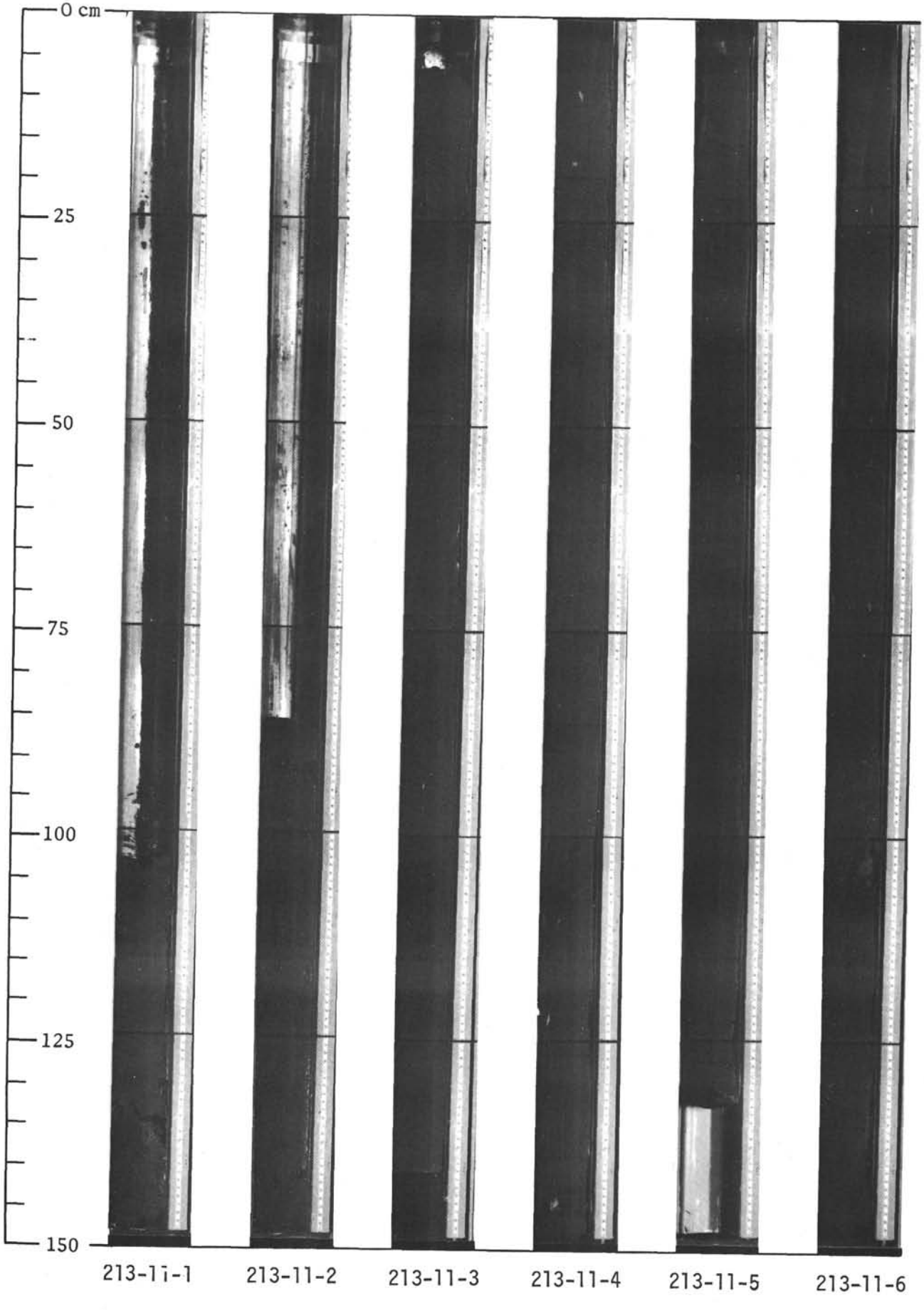
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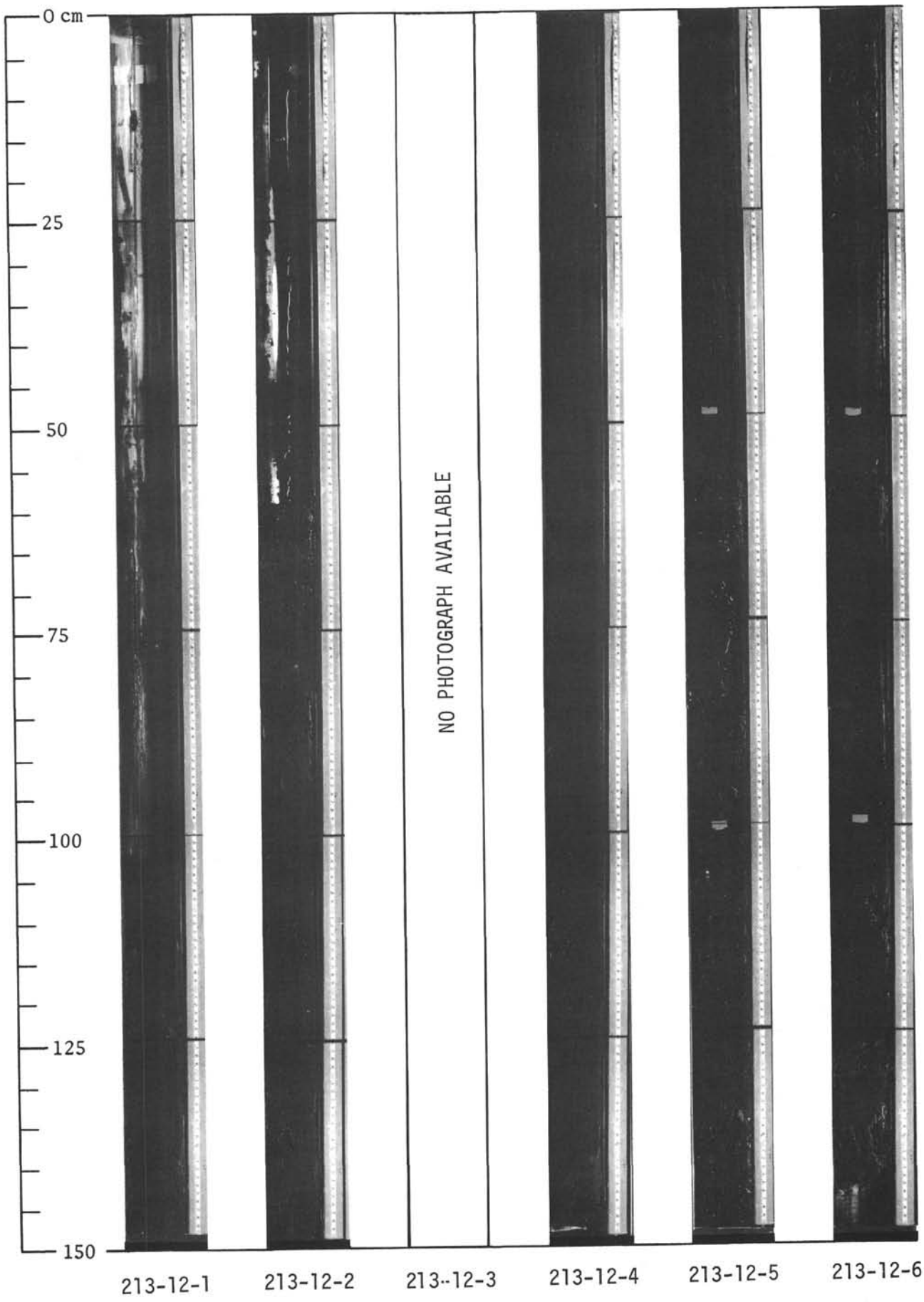
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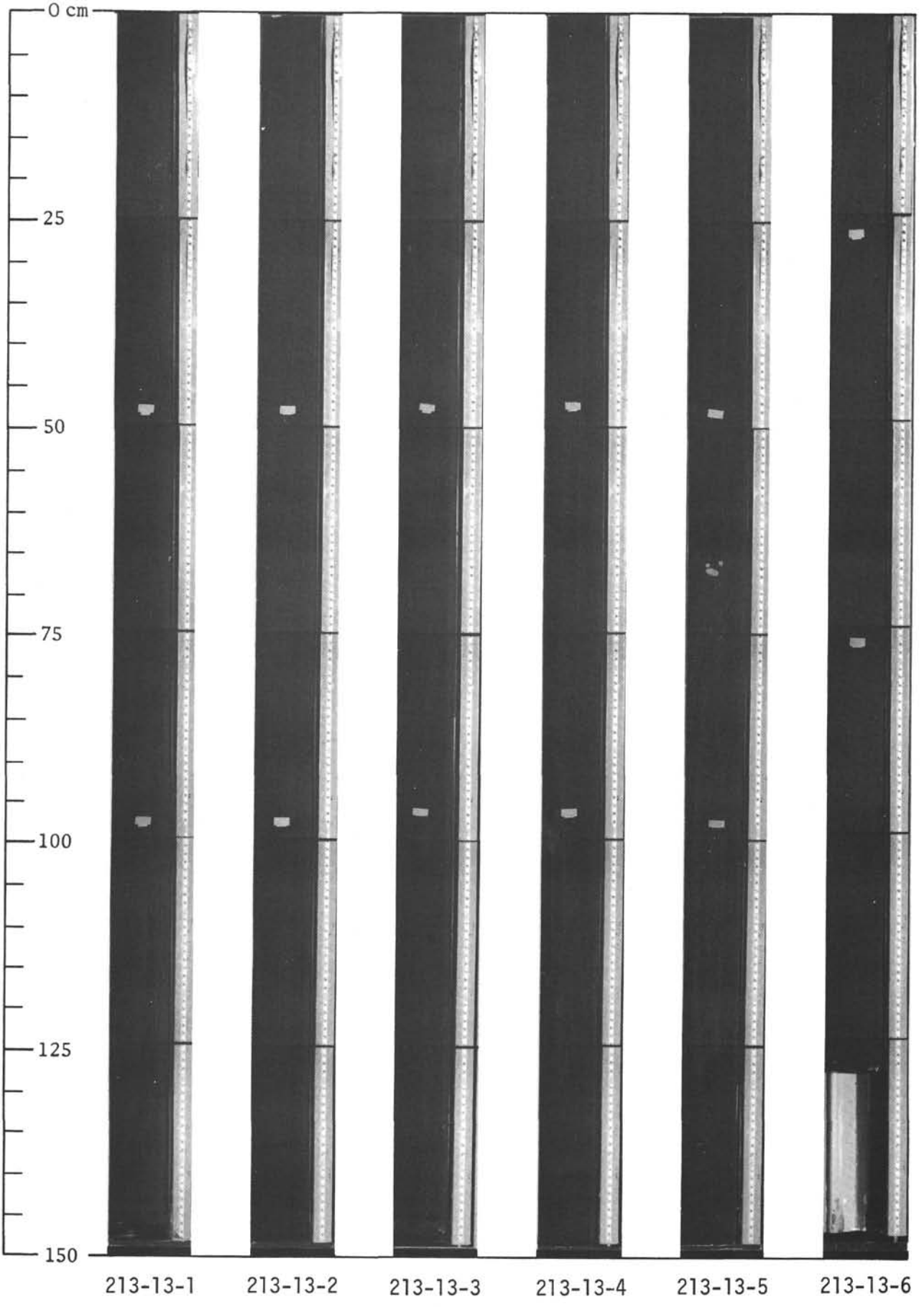
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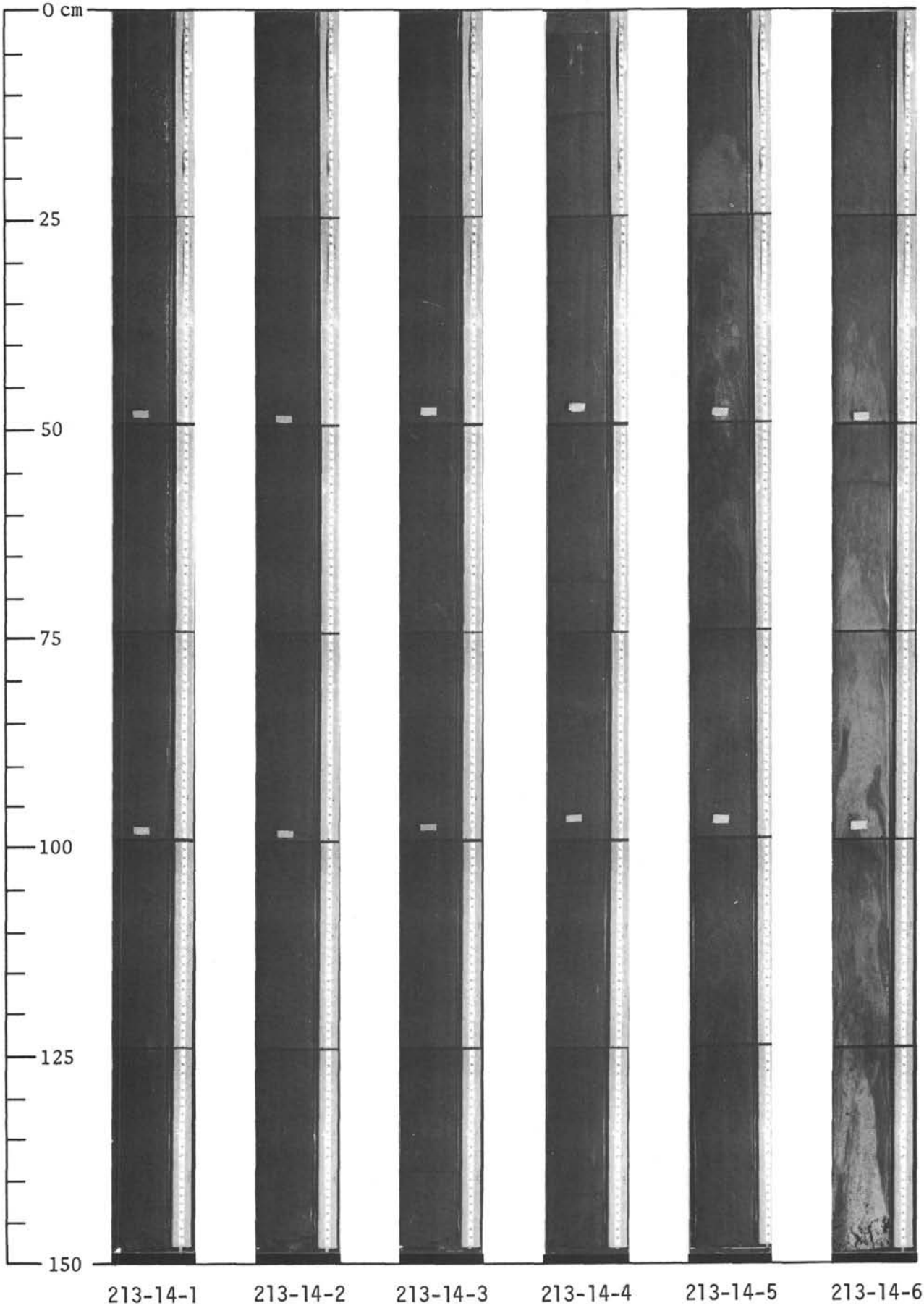
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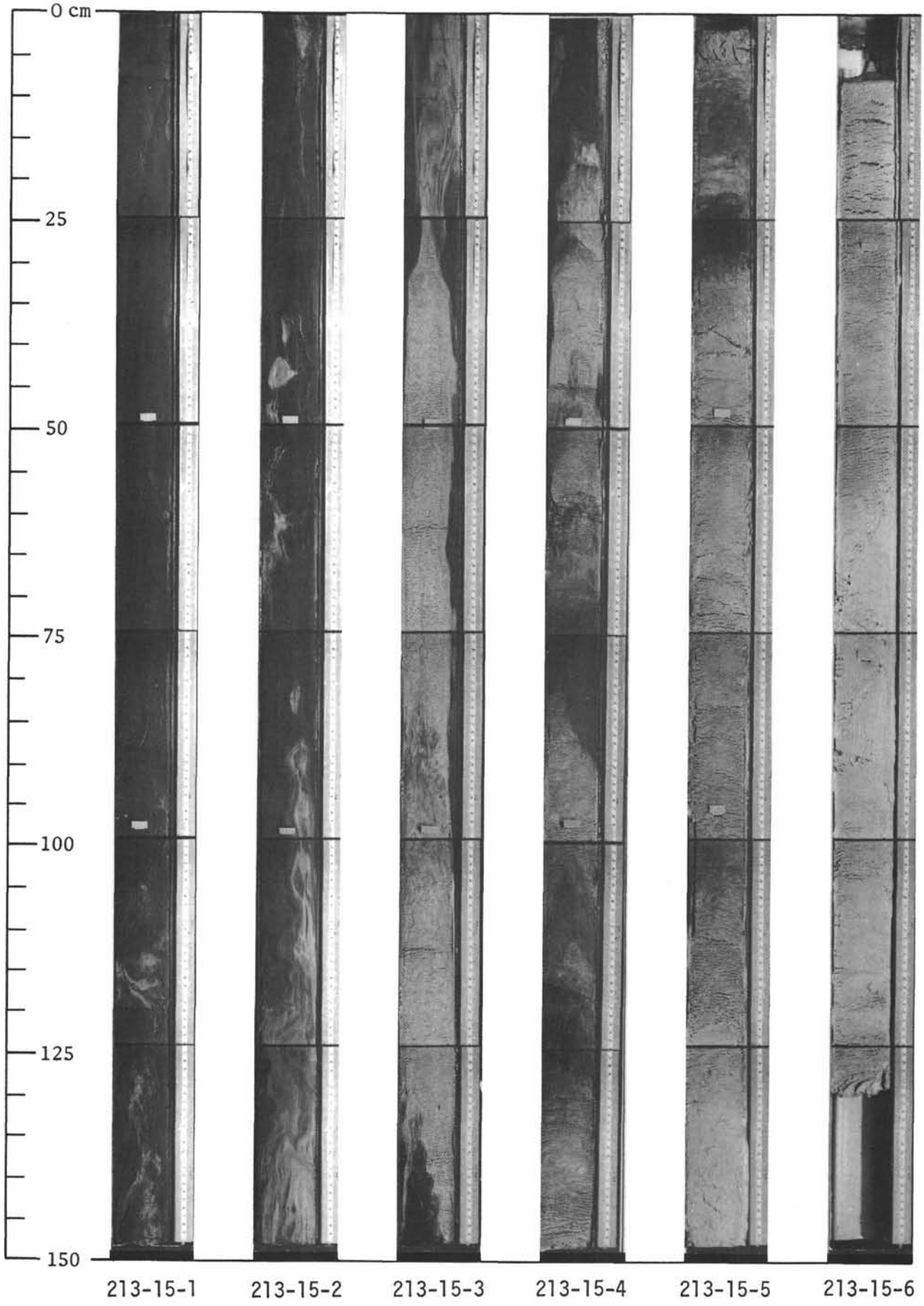
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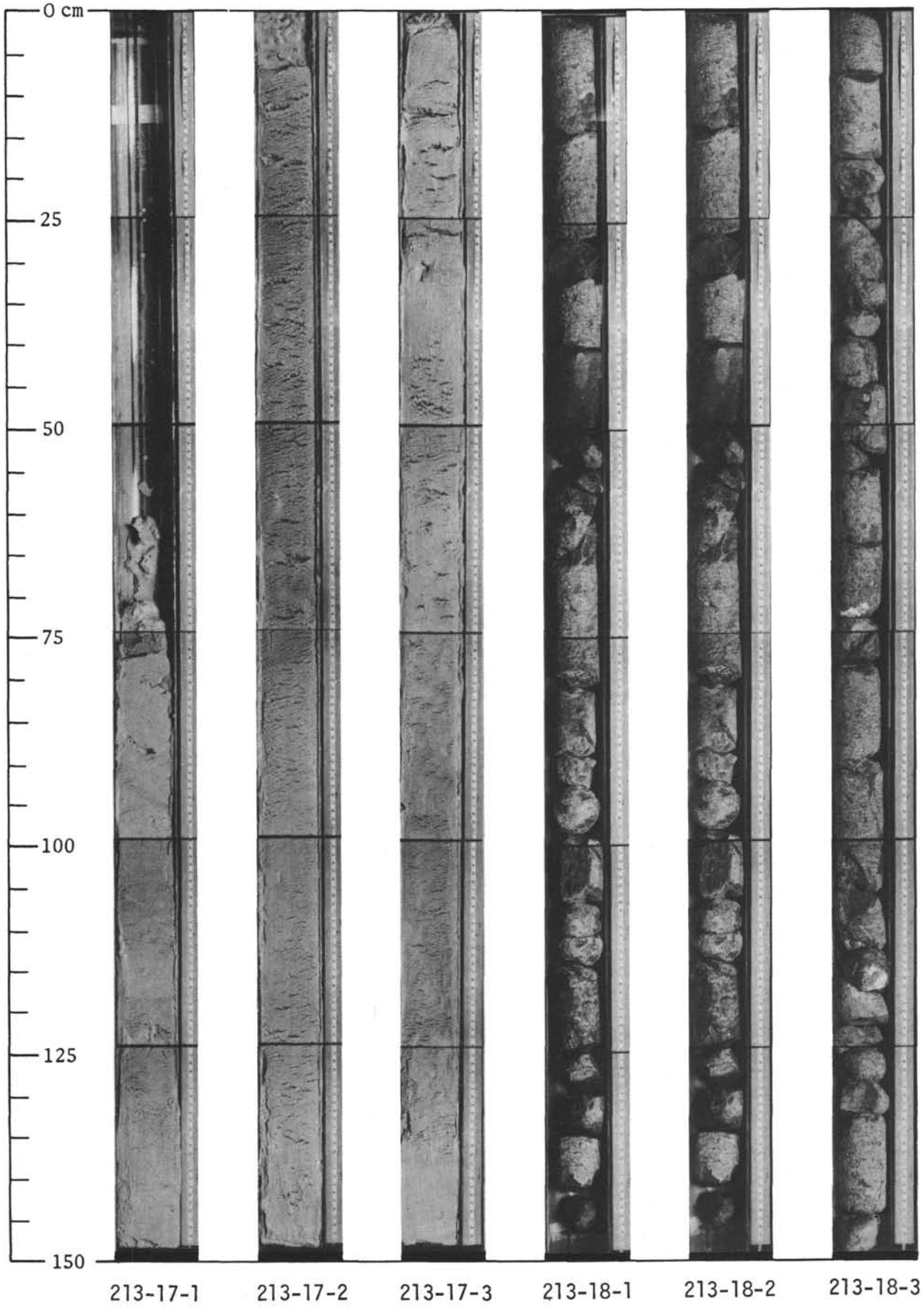
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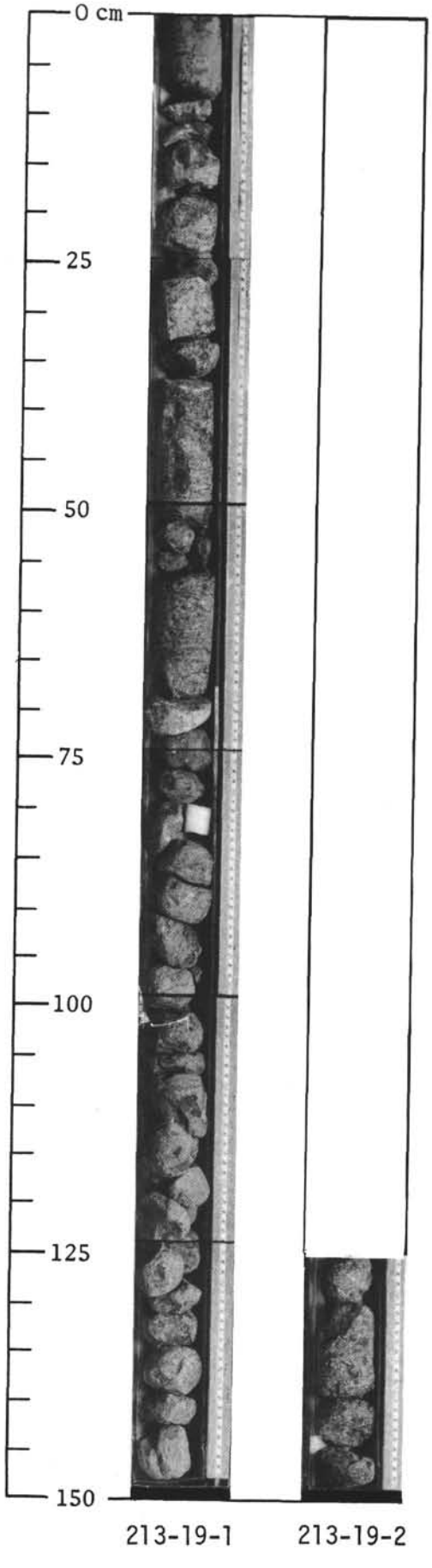
213-17-1
213-17-2
213-17-3
213-18-1
213-18-2
213-18-3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213-19-1
213-19-2