5. SITE 214

The Shipboard Scientific Party[1]

ABSTRACT

Site 214 is situated on the crest of Ninetyeast Ridge in a water depth of 1655 meters. The 490-meter-thick stratigraphic column comprises several distinct stratigraphic units which were deposited in environments ranging from pelagic to shallow water and subaerial. Uppermost of these is a thick pelagic foraminiferal-nannofossil ooze, glauconitic at its base, which ranges in age from upper Pleistocene to lower Eocene. This grades down into a glauconitic carbonate silt of lower Eocene to Paleocene age which is underlain by pyritic lagoonal sediments and a complex of lignitic and volcanoclastic sediments and tuffs interbedded with differentiated igneous flows. A coarse amygdalar basalt occurs below a depth of 490 meters, possibly representing the basement of Ninetyeast Ridge. The stratigraphy of this site is in accord with subsidence of the area at or above sea level during Paleocene and possibly older times to its present depth.

SITE DATA

Date Occupied: 8 Feb 72 (2315)

Date Departed: 12 Feb 72 (0103)

Time on Site: 73 hours 48 minutes

Position:
lat 11°20.21′S
long 88°43.08′E

Water Depth (to rig floor):
1671 meters (Echo sounding)
1665 meters (Drill pipe)

Penetration: 500 meters

Number of Holes: 1

Number of Cores: 54

Total Length of Cored Section: 494.5 meters

Total Core Recovered: 346.0 meters

Acoustic Basement:
Depth: 490 meters
Nature: Vesicular basalt

Age of Oldest Sediment: Paleocene

Basement: Vesicular basalt

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BACKGROUND AND OBJECTIVES

Prominent and distinctive east-west trending magnetic anomalies have been identified on either side of the Ninetyeast Ridge (McKenzie and Sclater, 1971; Sclater and Fisher, in press). These anomalies have been identified as 23 through 32, spreading in opposite directions. The oceanic crust on the east of the ridge gets older to the north, while on the west the age increases to the south. Thus, the Ninetyeast Ridge and the Chagos-Laccadive Ridge to the west which marks a similar offset in the magnetics (McKenzie and Sclater, 1971) are the features left behind when India moved north during the Late Cretaceous and early Tertiary relative to a fixed Antarctica/Australia. In the middle Eocene (anomaly 21), Australia started to separate from Antarctica. The ridge between the triple junction, marking the junction of the central Indian Ridge and southeast and southwest branches, and the Tasman Fracture Zone became a long continuous feature, and motion on the Ninetyeast Ridge terminated. Australia and India became part of the same plate, and the spreading direction started to change from north-south to northeast-southwest. McKenzie and Sclater (1971) postulated that this change in spreading direction caused compression along the line of weakness—the long north-south fracture zone—and the Ninetyeast Ridge was formed by uplift of the oceanic crust. The Ninetyeast Ridge has a basically north-south grain south of 12°S and an en-echelon nature north of this point. It is possible that the differences reflect the different tectonic process active in the ridge at the time of compression. The ridge to the north, being just a fracture zone and not an active transform fault, was offset in an en-echelon fashion, whereas the portion to the south, being part of the recently active transform fault, was formed by major outbursts of volcanic material.

Cretaceous and Eocene calcareous material has been dredged from the sides of the Ninetyeast Ridge, and calcareous cores of Eocene through present have been recovered from the crest. From this evidence is it presumed that the ridge has been above the carbonate compensation level since the Cretaceous. Thus sites on the ridge present a unique chance to obtain the complete calcareous biostratigraphic records for the post-Cretaceous sediments

Site 214 was chosen on an elevated region at the crest of the Ninetyeast Ridge on the last section of the predominantly north-south grain before the ridge turns into a series of en-echelon north northeast-south southwest trending short ridges (Figure 1). In this region the ridge is thinner than to the south and has a roughly bell-like shape. However, it is not quite symmetrical having a steeper eastern slope. The *Conrad 14* Site Survey (Figure 2) shows transparent sediment on top of stratified sediments with a smooth strong reflector at 0.2 sec with a strong probably basement reflector at 0.45 sec. Surface sediments consist of a coarse foraminiferal sand. An Eocene core was obtained not far from this site on Ninetyeast Ridge and may give the age of the smooth hard reflector. The seismic reflection record from the *Challenger* going towards and leaving the site are typical of the ridge in this area (Chapter 10).

The objectives of this site were to attain a continuous calcareous biostratigraphic section from above the carbonate composition depth in the Indian Ocean and to determine the basement age and method of formation and petrology of the Ninetyeast Ridge.

OPERATIONS

Site 214 was approached in a westerly direction along the seismic reflection profile of *Conrad 14*. The site is situated on the crest of the Ninetyeast Ridge, in an area where sediment thickness is about 0.5 sec over acoustic basement.

A spar buoy was dropped over the proposed drilling site, after which the seismic gear and magnetometer were secured, and the *Challenger* reversed course to the buoy. The beacon was dropped in a water depth of 1665 meters. The coring summary is given in Table 1.

The uppermost 330 meters of the hole was drilled in unconsolidated to semiconsolidated foraminiferal-nannofossil ooze. A minor amount of hole caving was experienced in the uppermost few meters due to the loose foraminiferal sand. Hole conditions improved after Barrels 2 and 3, and drilling progressed through 53 meters of glauconitic chalk and 62 meters of lagoonal sediments and lignites to a basalt flow at a sediment depth of 445 meters. The basalt, 27 meters in thickness, was penetrated without mishap, after which 16 meters of semi-indurated volcanoclastic material was drilled overlying coarse amygdaloidal basalt. The lower basalt was penetrated for 12 meters before drilling was stopped. Flowage of sand-sized material from the layer between the basalts caused some hole problems. Fifty barrels of mud were pumped into the hole for stabilization, with successful results.

The bit used was a Smith 94 CJS, 4-cone type.

LITHOLOGIC SUMMARY

Hole 214 was continuously cored to a total depth of 500 meters. Pleistocene to Eocene calcareous biogenous ooze, 323 meters thick, overlies a Paleocene glauconitic silty calcarenite and a complex of presumably older Paleocene lignite and volcanogenic sediments which are intruded by a basaltic sill. Five lithologic units are recognized as shown in Figure 3 and below.

Unit	Depth Below Sea Floor (m)	Lithology	Age	Cores
1b	0 to 162	Foram-nanno ooze	Pleistocene to upper mid-Miocene	1-17
1b	162 to 219	Foram-rich nanno ooze	Mid-early Miocene	18-23
1c	219 to 323	Nanno ooze	Late Oligocene to Early Eocene	24-34
1d	323 to 333	Glauconitic foram-rich ooze and chalk	Early Eocene to Paleocene	35-36
2a	333 to 366	Glauconitic carbonate silt and sand with some shells	Paleocene	36-39
2b	366 to 390	Glauconitic shelly carbonate silt and limestone with volcanic components	Paleocene	40-41
3	390 to 490	Lignite, volcanic clay, tuff, and lapilli tuff interlayered with Unit 4	?	42-53
4	440 to 468	Intermediate differentiated rocks	?	48-51
5	490 to 500	Basalt, coarse grained, vesicular and amygdalar	?	53-54

Unit 1–Nannofossil Ooze (Cores 1-34)

All but a small part of Unit 1 is made up of calcareous nannofossils with variable amounts of foraminifera. Parts of subunit 1a contain as much as 50% of foraminifera, subunit 1b < 20%, subunit 1c < 10%, and subunit 1d < 13%. The other constituents are in trace quantities only and include radiolarians, diatoms, sponge spicules, and volcanic glass near the surface (0-66 meters) and a mottle of volcanic glass fragments at 263 meters. Except for subunit 1d, the entire unit is uniform in appearance, being a soft white (N9) to very pale orange (10YR8/2) ooze, and the only structures are color bands, streaks, and mottles. The top 95 cm are fairly regularly banded, either white (N9) and yellowish gray (5Y7/2), or dusky yellow green (5GY5/2) and grayish yellow green (5GY7/2). These bands probably reflect climatic effects. Subunit 1a and the top 30 cm of subunit 1b give off H_2S.

Subunit 1d is transitional to Unit 2 and includes pale yellow glauconite (<3%), some of it altered to limonite, and parts of it are lightly indurated to chalk.

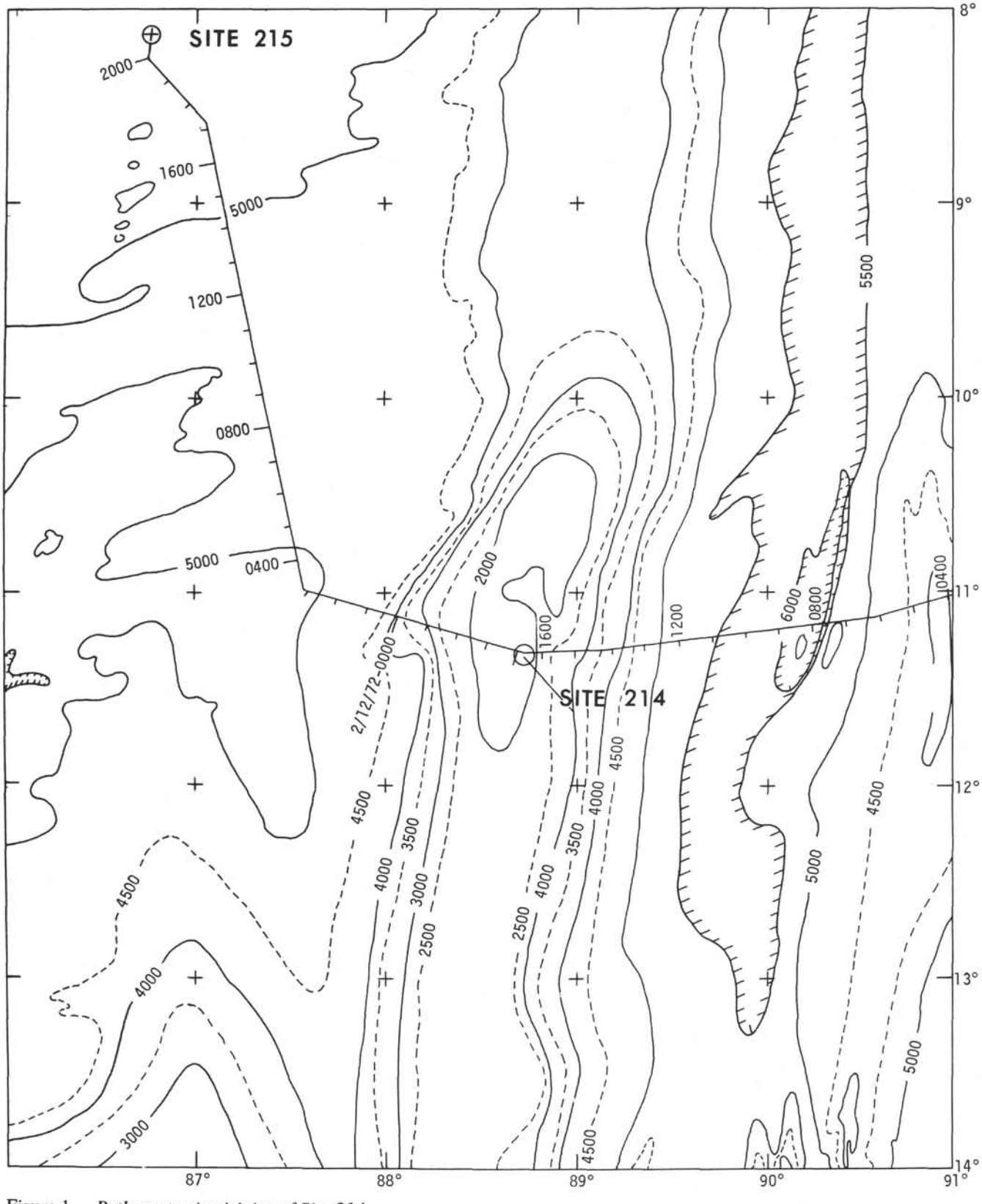


Figure 1. *Bathymetry in vicinity of Site 214.*

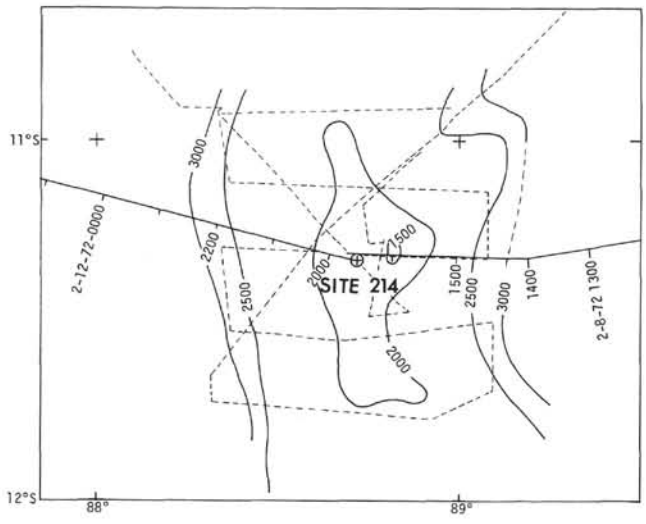


Figure 2. *Presite survey and form lines for Site 214.*

Unit 2–Glauconitic Carbonate Silt and Sand With Some Volcanic Components (Cores 36-41)

Unit 2 is an unconsolidated grayish olive green (5GY3/2) glauconitic carbonate silt and sand with gastropods and bivalves which in subunit 2b additionally contains abundant reworked volcanic components. The chief constituent is calcite, in grains <0.5 mm across, some of them identifiable as various fossils, including foraminifera and echinoderms, others as micrite pellets, but most grains are unidentifiable. Other constituents include glauconite, volcanic (basaltic) glass, fragments of volcanic rocks, feldspar, apatite, pyrite, and various amounts of calcareous nannofossils and siliceous fossils. The only structures are poorly developed bedding and imbricated bivalves. Near the base of Unit 2 is a 10-cm-thick bed of white recrystallized limestone.

Unit 3 – Lignite, Volcanic Clay, Tuff, and Lapilli Tuff (Cores 42-53)

Unit 3 is made up of an interbedded sequence of lignite and volcanoclastic material mainly pyritic volcanic clay, tuff, and lapilli tuff that overlies coarse-grained amygdalar and vesicular basalt, interpreted as basement. The sediments are interlayered with two bodies of fine-grained basalt, interpreted as differentiated rocks. The lignite is greenish gray, brown, or black, and impurities include sand-sized and larger grains of clay aggregates and pyrite. The thickest recovered lignite interval was 80 cm. Clay aggregates ranging in size up to 4 mm constitute most of the tuff; many of them stained with hematite and other iron oxides. Other constituents include variable amounts of pyrite, feldspar, volcanic glass, some of it identifiable as devitrified basaltic glass, chlorite, and apatite. The lapilli tuff is made up of clayey or glassy lapilli (>4 mm), in which relict feldspar laths are visible in a predominantly siliceous matrix. Three indurated beds (20-23 cm in thickness) of volcanic conglomerate occur in the volcanoclastic sequence. They consist of rounded volcanic rock granules and pebbles cemented by sparite. A crystal tuff bed was seen in Core 43. The volcanic clay consists mainly of montmorillonite and/or beidellite and K-feldspar (see X-ray results).

Unit 4–Intermediate Differentiated Rocks (Cores 48-51).

Unit 4 consists of a differentiated flow within volcanoclastic sediments (Figure 2).

This flow consists of fine-grained moderately fresh intermediate differentiated rocks (about 3 meters of recovery). The top and the bottom of this unit, where in direct contact with volcanoclastic material, show chilled margins with a decrease in the size of the minerals and an increase of glassy groundmass. The general textural feature is trachytic, with plagioclase laths being arranged in a parallel manner within a matrix containing few pyroxene granules, iron ore, and fresh light brown glass.

Unit 5–Basaltic Rocks (Cores 53, 54).

Unit 5 consists of partially weathered basaltic rocks. These basaltic rocks are subdivided into three categories according to their fabric: (1) vesicular bbasalt, (2) amygdalar basalt, and (3) crystalline basalt, which alternate with one another.

1) The vesicular basalt is fine grained and has a dark mesostasis made up of dark glass and iron-oxide aggregates. The size of the vesicles varies between 1 and 10 mm in diameter, and they comprise about 10% to 15% of the bulk rock.

2) The amygdalar basalts are medium-grained hypocrystalline rocks containing clinopyroxene, chlorite, phenocrysts, and microphenocrysts of plagioclase, iron ore, and small amounts of dark mesostasis. The amygdales are filled with calcite.

3) The crystalline basalts are coarse grained, holocrystalline, and porphyritic. Plagioclase phenocrysts are set in a subophitic matrix of plagioclase and clinopyroxene.

Preliminary Interpretation

Unit 1: Except for their variable proportions of foraminifera and calcareous nannofossils and their subtle color banding, Subunits 1a to 1c are uniform and from sedimentological evidence alone were deposited presumably in uniformly deep water above the carbonate compensation level similar to the present depth of 1665 meters. The appearance of glauconite in Subunit 1d probably indicates shallowing to a few hundred meters. The glauconite seems to be weathered, as shown by its pale amber color, and much of it is replaced by limonite, so the possibility that it is detrital (and not authigenic) must be entertained. Whatever the case may be, from its grain size alone the glauconite indicates deposition in shallower water.

Unit 2: Further shallowing is indicated by deposition of the carbonate silts and sands with large shells in Unit 2. The appearance of grains of feldspar, volcanic glass, and volcanic rock fragments reflects a volcanic provenance.

Unit 3: Sediments here lack marine fossils, and the only biogenous component is lignite which contains abundant terrestrial palynomorphs (Chapter 24). This unit is dominated by volcanoclastic material which was mostly deposited subaerially, but the three thin indurated volcanic conglomerates were water lain (Chapter 39).

Unit 4: The glassy margins and the freshness of the intermediated type of rocks of this unit indicate that they are sills.

TABLE 1
Coring Summary, Site 214

Core	Date (Feb)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
1	9	0705	1665.0-1674.5	0-9.5	9.5	9.5	100
2	9	0800	1674.5-1684.0	9.5-19.0	9.5	6.8	72
3	9	0900	1684.0-1693.5	19.0-28.5	9.5	9.5	100
4	9	0945	1693.5-1703.0	28.5-38.0	9.5	9.5	100
5	9	1030	1703.0-1712.5	38.0-47.5	9.5	9.5	100
6	9	1105	1712.5-1722.0	47.5-57.0	9.5	6.0	63
7	9	1145	1722.0-1731.5	57.0-66.5	9.5	9.5	100
8	9	1230	1731.5-1741.0	66.5-76.0	9.5	8.2	85
9	9	1315	1741.0-1750.5	76.0-85.5	9.5	9.5	100
10	9	1400	1750.5-1760.0	85.5-95.0	9.5	9.5	100
11	9	1445	1760.0-1769.5	95.0-104.5	9.5	9.5	100
12	9	1512	1769.5-1779.0	104.5-114.0	9.5	7.5	79
13	9	1600	1779.0-1788.5	114.0-123.5	9.5	8.3	87
14	9	1645	1788.5-1798.0	123.5-133.0	9.5	9.5	100
15	9	1805	1798.0-1806.5	133.0-141.5	8.5	8.5	100[a]
16	9	1850	1808.0-1817.5	143.0-152.5	9.5	9.5	100
17	9	1935	1817.5-1827.0	152.5-162.0	9.5	9.5	100
18	9	2045	1827.0-1835.5	162.0-170.5	8.5	7.5	100[a]
19	9	2130	1836.5-1846.0	171.5-181.0	9.5	8.6	90
20	9	2215	1846.0-1855.5	181.0-190.5	9.5	9.5	100
21	9	2330	1855.5-1864.0	190.5-199.0	8.5	7.0	82[a]
22	10	0020	1865.0-1874.5	200.0-209.5	9.5	9.5	100
23	10	0105	1874.5-1884.0	209.5-219.0	9.5	9.5	100
24	10	0200	1884.0-1893.5	219.0-228.5	9.5	9.0	95
25	10	0320	1893.5-1902.0	228.5-237.0	8.5	2.0	25[a]
26	10	0410	1903.0-1912.5	238.0-247.5	9.5	8.7	90
27	10	0510	1912.5-1922.0	247.5-257.0	9.5	9.5	100
28	10	0635	1922.0-1931.5	257.0-266.5	9.5	9.0	95
29	10	0755	1931.5-1940.0	266.5-276.0	8.5	8.5	100[a]
30	10	0843	1941.0-1950.5	276.0-285.5	9.5	9.3	98
31	10	0935	1950.5-1960.0	285.5-295.0	9.5	9.3	98
32	10	1035	1960.0-1969.5	295.0-304.5	9.5	9.3	98
33	10	1125	1969.5-1979.0	304.5-314.0	9.5	9.4	99
34	10	1215	1979.0-1988.5	314.0-323.5	9.5	9.2	97
35	10	1310	1988.5-1998.0	323.5-333.0	9.5	6.0	63
36	10	1405	1998.0-2007.5	333.0-342.5	9.5	4.7	49
37	10	1500	2007.5-2017.0	342.5-352.0	9.5	3.0	32
38	10	1540	2017.0-2026.5	352.0-361.5	9.5	5.0	53
39	10	1630	2026.5-2036.0	361.5-371.0	9.5	3.7	39
40	10	1725	2036.0-2045.5	371.0-380.5	9.5	3.8	40
41	10	1900	2045.5-2055.0	380.5-390.0	9.5	3.2	34
42	10	2000	2055.0-2058.0	390.0-399.5	3.0	0.8	26
43	10	2105	2058.0-2067.5	399.5-402.0	9.5	CC	1
44	10	2220	2067.5-2077.0	402.5-412.0	9.5	1.5	20
45	10	2330	2077.0-2086.5	412.0-421.5	9.5	1.0	12

TABLE 1 – *Continued*

Core	Date (Feb)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
46	11	0055	2086.5-2096.0	421.5-431.0	9.5	3.8	40
47	11	0205	2096.0-2105.5	431.0-440.5	9.5	1.1	13
48	11	0405	2105.5-2113.0	440.5-448.0	7.5	3.0	45
49	11	0745	2113.0-2122.5	448.0-457.5	9.5	1.9	20
50	11	1000	2122.5-2132.0	457.5-467.0	9.5	0.5	5
51	11	1145	2132.0-2141.5	467.0-476.5	9.5	0.8	8
52	11	1315	2141.5-2151.0	476.5-486.0	9.5	0.4	4
53	11	1545	2151.0-2155.5	486.0-490.5	4.5	2.6	57
54	11	1840	2155.5-2165.0	490.5-500.0	9.5	4.0	42
Totals					494.5	345.0	70

Note: Echo sounding depth (to drill floor) = 1671 meters; drill pipe length to bottom = 1665 meters.

[a]Heat-flow run.

Unit 5: The coarse grain, the amygdalar and vesicular structures, and the weathering of this basalt indicate that it is made up of flows; the absence of pillow structure suggests that the flows were deposited on land or in shallow water.

CHEMICAL PROPERTIES

Twenty samples were collected for the interstitial water and inorganic geochemistry shipboard measurements program from the 54 cores recovered at this site. A total of 12 pairs of contiguous minicores was collected from the calcareous sediments. Samples were taken from odd-numbered cores between Cores 1 and 11 approximately every 20 meters to a depth of ~100 meters. Thereafter, pairs of minicores were removed from every fourth core through Core 31, 290 meters (approximately 40-meter intervals). A single 10-cm sample was taken from Core 35 which proved to be the bottom of the carbonate layer. Eight samples representing other lithologic units were collected from Cores 36 through 52 which was the last core containing sufficient sediment to sample (486 meters). Insofar as was practical, a single 10-cm minicore was removed; otherwise core-catcher samples were taken. It was possible to make resistivity measurements on 18 of these samples. The results are summarized in Table 2.

BIOSTRATIGRAPHIC SUMMARY

General

Good assemblages of Radiolaria, calcareous nannofossils, and foraminifera occur together in the Holocene to middle Miocene interval. It is noteworthy that Radiolaria disappear downsection at about the same level biostratigraphically in Sites 213 and 214. Foraminifera and nannofossils, variable in preservation, occur on down into the lower Eocene where firm dates are obtained almost to the Paleocene/Eocene boundary. This carbonate ooze section is believed to be essentially continuous, variations in the quality of material notwithstanding. Poor returns of nannofossils and planktonic foraminifera indicate a Paleocene age for the basal marine section in which oceanic influence was restricted, as in a lagoonal or shallow shelf environment.

Sediment accumulation rates are variable, and the interval of slower accumulation matches well with the interval in which preservation of planktonic foraminifera is poor.

Foraminifera

Diverse and well-preserved assemblages were found in Cores 1 to 10 (Quaternary to Pliocene). Upper to middle Miocene assemblages (Cores 11 to 20) show increasing signs of chemical corrosion. Lower Miocene to upper Eocene assemblages (Cores 21 to 26) are recovered easily from the soft sediment, but the quality of preservation reaches a low over this interval: diversity is reduced, tests are badly fragmented and often recrystallized or overgrown with calcite, and robust *Globigerina* and *Globoquadrina* dominate. A striking increase in specimen numbers and in quality of preservation begins within the middle Eocene (Core 29) and continues into the lower Eocene (Core 34). Preservation falls off again (for different reasons) with the change to coarser, glauconitic carbonate in Core 35 (lowest two Eocene Zones). It is poor in the Paleocene assemblages down to the pyritic siltstone in Core 41.

At this stage of the investigation there is little evidence to suggest that the pelagic lower Eocene to Quaternary section is other than "low latitude" throughout; that is, absences can be ascribed to preservation. For example, the indications of "extratropical" faunas found (displaced) at Site 212 are not found here, while the sharply restricted late stages of the *Globorotalia fohsi* lineage are. The distinctive and short-ranging *Truncorotaloides (Morozovella) caucasica* occurs in noteworthy abundance in Core 33; this species does not figure in the detailed zonations of Trinidad or the Appennines, but occurs in

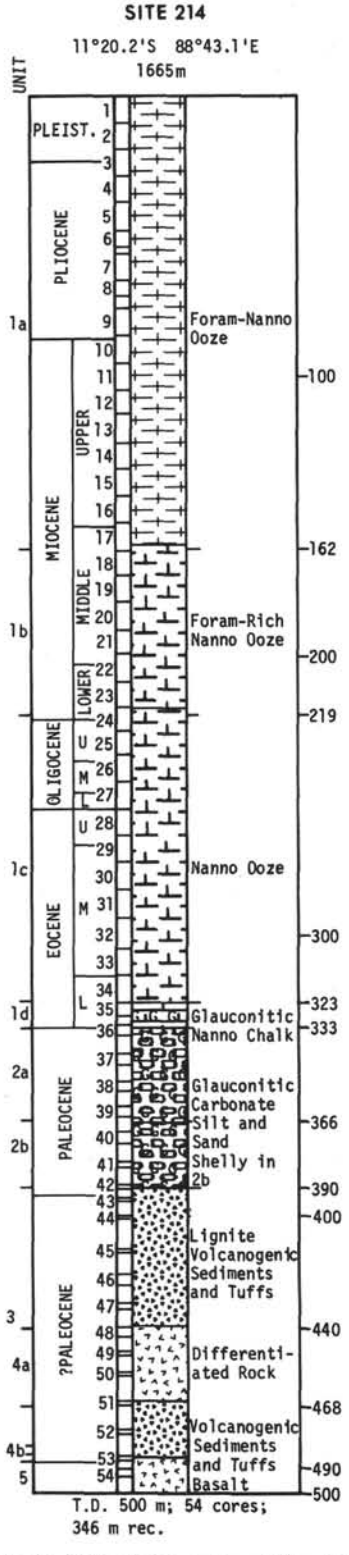


Figure 3. *Lithologic units at Site 214.*

New Zealand–facts which are not explained clearly but which require something more than a simplistic climatic interpretation,

The lowest material determinable biostratigraphically was found in Cores 37 and 38, where rare, poor specimens of *Planorotalites chapmani* suggest an age in the vicinity of

TABLE 2
Shipboard Chemistry Results

Core, Section, Interval (cm)	pH (flow-through)	pH (punch-in)	Water (%)	Porosity (%)	Density (gm/cc)
1-4, 143	–	–	43.82	–	–
1-5, 130	7.54	7.30	–	–	–
3-1, 27	–	–	45.36	–	–
3-3, 70	–	–	41.07	72	1.63
3-5, 0	7.40	7.17	47	–	–
4-2, 70	–	–	44	–	–
5-4, 80	–	–	43	–	–
5-6, 0	7.17	7.14	43	64	1.48
6-1, 96	–	–	41	68	1.65
6-3, 58	–	–	42	67	1.59
7-3, 57	–	–	45	71	1.56
7-5, 0	7.32	7.10	44	72	1.63
8-3, 51	–	–	40	70	1.73
9-1, 117	–	–	44	72	1.62
9-3, 118	–	–	39	62	1.59
9-5, 0	7.14	7.10	48	75	1.57
10-2, 113	–	–	41	66	1.59
11-5, 0	7.16	7.06	42	69	1.64
13-3, 96	–	–	35	57	1.63
15-2, 108	–	–	36	64	1.77
15-3, 0	7.14	7.04	43	72	1.67
16-1, 72	–	–	42	66	1.60
17-3, 98	–	–	32	56	1.75
18-3, 116	–	–	39	66	1.71
19-5, 0	7.16	7.02	37	64	1.74
19-5, 88	–	–	36	63	1.73
21-5, 55	–	–	28	52	1.86
22-5, 36	–	–	34	62	1.85
23-2, 95	–	–	31	53	1.73
23-5, 0	7.44	7.04	32	60	1.87
27-5, 0[a]	7.13	7.03	24	49	2.03
28-5, 83[a]	–	–	28	55	1.96
29-6, 128[a]	–	–	30	58	1.92
31-5, 0[a]	7.22	7.05	–	–	–
35-3, 99[a]	–	–	26	49	1.88
35-5, 0[a]	7.32	7.31	–	–	–
36-4, 0	–	–	31	–	–
37-2, 0	–	–	32	–	–
39-3, 0	–	–	28	–	–
41-CC	–	–	–	–	–
41-3, 0	–	–	25	–	–
42-CC	–	–	–	–	–
46-3, 0	–	–	–	–	–
52–CC	–	–	–	–	–

[a]The water tended to rise in sediments on standing. The results, therefore, may be high.

56 to 58+ m.y. (upper Paleocene), and in Core 41, where benthonics are of Paleocene age; a single benthonic specimen in Core 52 could be too. This material is characterized by sponge spicules, poor foraminifera preservation, small specimen size, low diversity, and high but varying dominance (cibicidids, ostracodes, and buliminids dominate at different horizons). The foraminiferal evidence agrees with the lithological in suggesting a shallow environment into which planktonic organisms were washed. The lack of agglutinated benthonics may indicate negatively that the water was not significantly below normal salinity. There is no foraminiferal biostratigraphic evidence to oppose the concept of more or less continuous deepening from a Paleocene "lagoonal" or shelf facies, through lower Eocene shelf glauconite-carbonates, into lower Eocene deep-water ooze.

Nannofossils

Calcareous nannofossils were recovered in the sediments of Cores 1 through 41 at Site 214. The sediments range in age from late Pleistocene Holocene (*Emiliania huxleyi* Zone) at the top of Core 1 to the mid-Paleocene (*Heliolithus kleinpelli* Zone) at the top of Core 37, and possibly as old as the *Cyclococcolithina robusta* Zone in Core 41. The Pliocene-Pleistocene boundary is within section 2, Core 3, and the Miocene-Pliocene boundary is between Cores 9 and 10, or possibly in Section 1 of Core 10. The base of the Miocene is within Core 23, but it is difficult to determine this boundary precisely on the basis of calcareous nannofossils, as no unequivocal index species are present. The base of the Oligocene is more clearly determinable on the highest occurrence of *Discoaster barbadiensis* in Core 27, Section 6. The base of the Eocene again cannot be clearly determined as it is within a greatly attenuated section within Core 35, Sections 1 and 2, which contains parts of the early Eocene and late Paleocene interval. A more or less continuous record was recovered from the Holocene to the early Eocene (*Discoaster lodoensis* Zone) in Core 35. The record is considered continuous, although not all nannofossil zones of any one scheme are represented. This may be owing entirely, however, to the absence of certain provincial index species in this region. In addition, the middle Miocene discoasters are excessively calcified as are also many early and middle Eocene nannofossils. The early Oligocene seems somewhat compressed possibly as a result of loss during coring.

The late Miocene to Holocene nannofossil assemblage has, in general, an oceanic aspect, but backward from the late Miocene progressively stronger hemipelagic influences are present. The nonoceanic species *Zygrhablithus bjugatus crassus* is present throughout the Eocene-Oligocene interval, and in the early Eocene assemblages pentaliths are abundantly present. Much of the lower Eocene and upper Paleocene may not be present, and the interval below the top of Core 37 can be dated only as mid-to-late Paleocene because of the meager assemblage.

Radiolaria

Radiolaria at Site 214 are common to abundant and well preserved within Cores 1 through 20 (0 to 190.5 meters), which range in age from Quaternary to middle Miocene. In the lower part of this interval (Cores 17 through 20) the radiolarian assemblages show strong effects of corrosion; species are only moderately preserved. Below Core 20 no identifiable Radiolaria were encountered, although trace amounts of siliceous debris are present in some samples.

The following radiolarian zonal boundaries can be recognized within the cores at Site 214:

The base of the Quaternary lies between Samples 214-2, CC and 214-3-2, 70-72 cm. The base of the *Pterocanium prismatium* Zone lies between Samples 214-5-1, 70-72 cm and 214-5-3, 66-68 cm. The base of the *Spongaster pentas* Zone lies between Samples 214-9-6, 70-72 cm and 214-9, CC. The base of the *Stichocorys peregrina* Zone lies between Samples 214-13-3, 70-72 cm and 214-13-5, 70-72 cm. The base of the *Ommatartus penultimus* Zone lies between samples 214-14, CC and 214-15-2, 70-72 cm. The base of the *Ommatartus antepenultimus* Zone lies between Samples 214-16, CC and 214-17-1, 70-72 cm. The base of the *Cannartus petterssoni* Zone lies between Samples 214-18-2, 70-72 cm and 214-18-3, 70-72 cm. The base of the *Dorcadospyris alata* Zone occurs in the nonsiliceous interval, probably not far below Sample 214-20, CC.

All radiolarian assemblages appear to contain contemporaneous species, with no indication of reworking of species from older sediment.

CORRELATION OF REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

Site 214 is on the crest of the Ninetyeast Ridge. The airgun seismic reflection profile of the area shows a sediment column approximately 0.5 sec in thickness and thickening westward, overlying the ridge basement.

Details of the reflection profile (Figure 4) suggest an upper draped sediment unit about 0.28 sec in thickness. This upper unit incorporates a zone of reflectors (1) at a depth of 0.13 sec which are concordant with surface topography. A stronger series of reflectors (2) appears at 0.28 sec, marking the upper level of possible ponding of the sediments against higher basement to the east. A coherent strong reflector (4) occurs at 0.47 sec, and the upper portion of a zone that wedges out appears at 0.40 sec.

The only obvious correlation with the stratigraphic column (Figure 4) is the upper surface of the fine-grained basalt flow and the upper surface of the carbonate sand. Though not obvious to the stratigraphic column, Reflector 1 corresponds to a level about 100 meters deep, Reflector 2 probably correlates with a level about 242 meters, and Reflector 3 at 356 meters to satisfy the constraints of interval velocities.

Depths of reflectors and interval velocities are as follows:

Reflector	2-Way Time (sec)	Depth (m)	Interval Velocity (km/sec)	
0	0	0	1.55	1.9
1	0.13	100	1.90	
2	0.28	242	1.90	
3	0.40	356	2.40	
4	0.47	440		

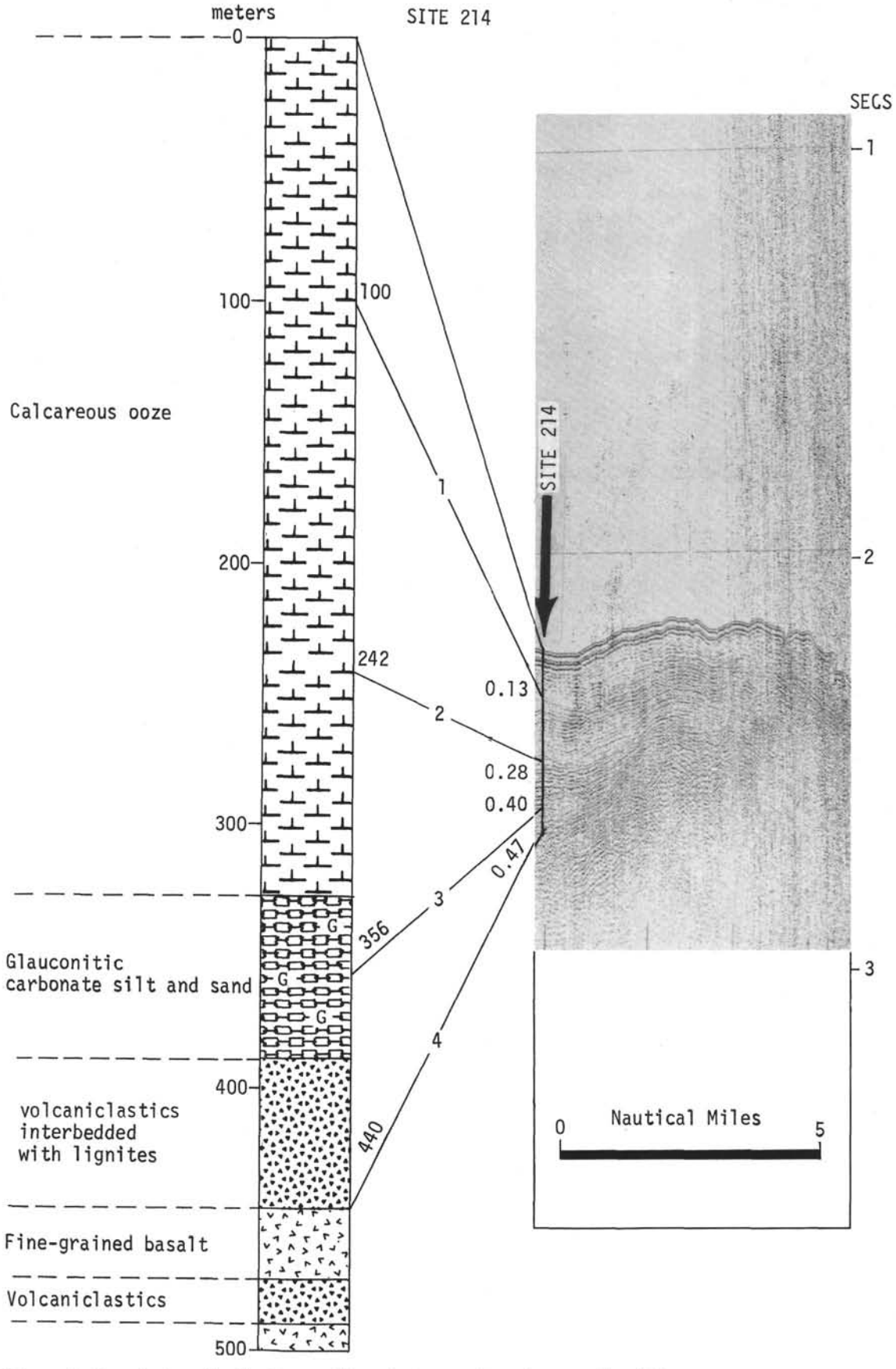


Figure 4. *Correlation of reflection profile and stratigraphic column at Site 214.*

SUMMARY AND CONCLUSIONS

Site 214 is situated on the crest of Ninetyeast Ridge in a water depth of 1655 meters. The airgun seismic reflection profile of the area shows an upper draped sedimentary unit, about 0.28 sec in thickness, overlying a series of reflectors that show evidence of ponding against acoustic basement. The site was chosen in a location which would enable sampling of the deepest of the ponded layers.

The section is composed of several distinct stratigraphic units ranging from subaerial and shallow water to pelagic. The lowermost unit below a depth of 490 meters consists of a series of highly vesicular, and nonvesicular basalts compositionally similar to basalts of oceanic volcanic islands. These basalts are overlain by tuffs which are succeeded by differentiated igneous rocks. The volcanics from Site 214 are similar to the mildly tholeiitic series of St. Paul and New Amsterdam islands' rocks. Above this level occurs a complex of lignites and volcanoclastic sediments which are overlain in turn by a Paleocene shallow shelf and open shelf sequence of glauconitic shelly carbonate silt and sand. The uppermost unit at Site 214 consists of 330 meters of foraminiferal-nannofossil ooze of early Eocene to Quaternary age which contains glauconite at its base.

The igneous, sedimentary and paleontological evidence indicates that Ninetyeast Ridge was once an emergent chain of volcanic islands which sank below sea level in Paleocene times at Site 214. A short history of shallow-shelf and open-shelf conditions was followed in the early Eocene by a deepening to oceanic depths as suggested by the upward disappearance of glauconite and transition of the sediment to a pelagic calcareous ooze. Oceanic pelagic sedimentation has persisted in the area to the present. Biostratigraphic and lithologic observations place possible constrictions on the paleolatitude of Site 214 during the Paleocene. The site at present is located at 11° south of the equator and lies well within the zone of reef-building coral. No fragments of reef coral were found in the cored shelf sediments, suggesting that during Paleocene times the area was at a higher latitude than at present. Palynological evidence (Chapter 24) is in accord with this suggestion.

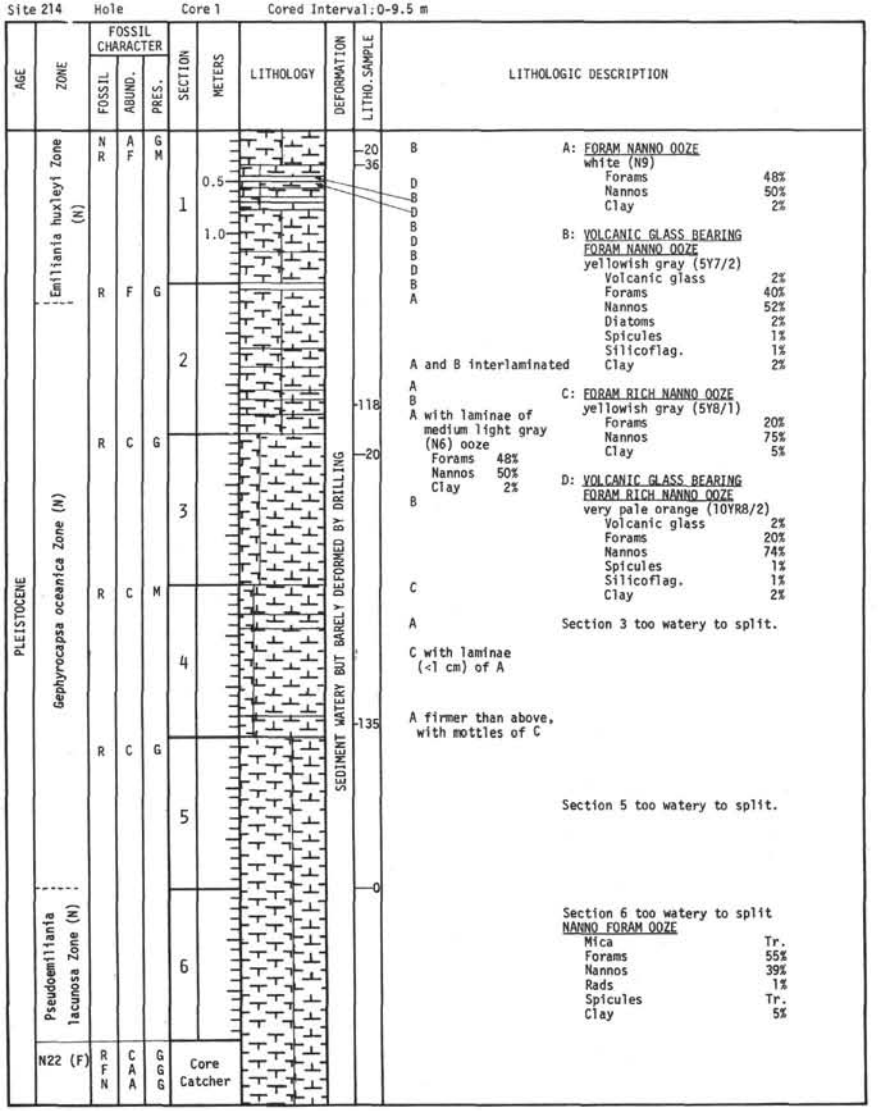
The evidence presented for slow sinking of the Ninetyeast Ridge since the Paleocene would argue strongly against the McKenzie and Sclater (1971) compressional hypothesis for the origin of the ridge. In this hypothesis, the ridge would have been elevated in the middle Eocene and not the Paleocene as observed in the earliest sediment record.

REFERENCES

McKenzie, D. P. and Sclater, J. G., 1971. The evolution of the Indian Ocean since the Late Cretaceous; Geophys. J. Roy. Astro. Soc., v. 25, p. 437-528.

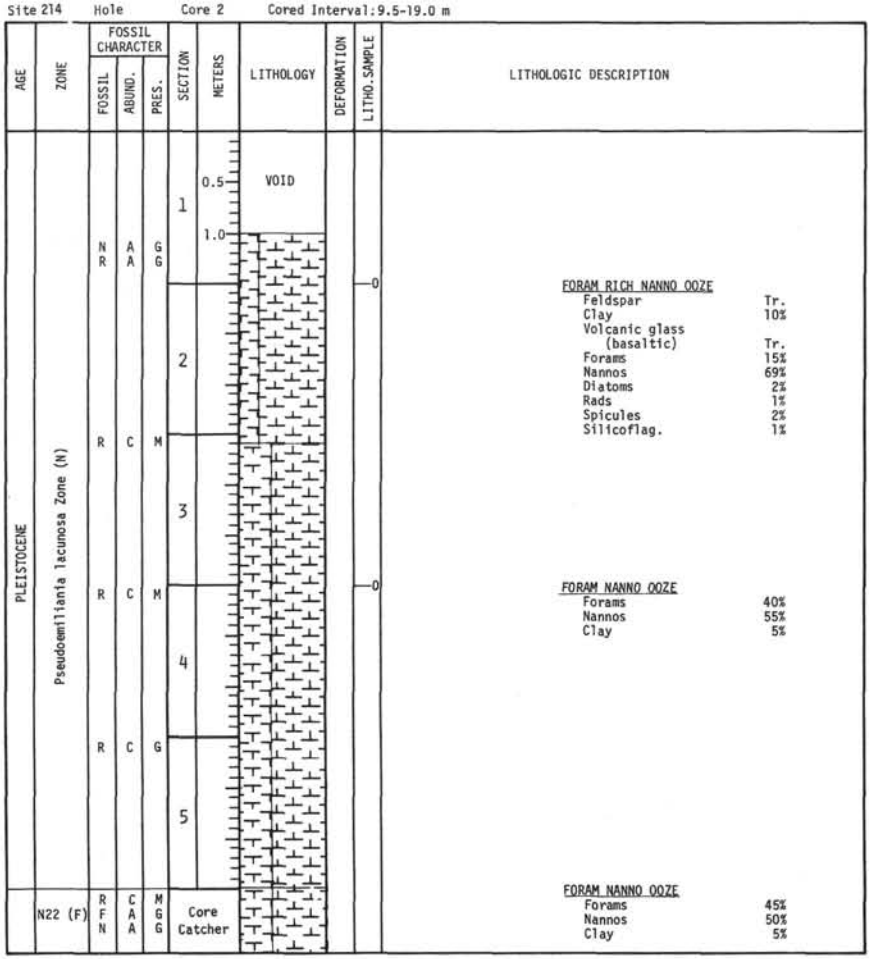
Sclater, J. G. and Fisher, R. L., in preparation. The evolution of the East Central Indian Ocean with emphasis on tectonic setting of Ninetyeast Ridge.

Site 214 Hole Core 1 Cored Interval: 0-9.5 m



Explanatory notes in Chapter 1

Site 214 Hole Core 2 Cored Interval: 9.5-19.0 m



Explanatory notes in Chapter 1

Site 214 Hole Core 3 Cored Interval: 19.0-28.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE / PLIOCENE	Pseudoemiliania lacunosa Zone (N) / Discoaster brouweri Zone (N) / Pterocanium prismatium Zone (R)	N	A	F	1	0.5–1.0		C	A B A B A	FORAM NANNO OOZE A: dominantly white (N9) with laminae (<1 cm) of B: yellowish gray (5Y8/1) and microlaminae (~1 mm) of C: medium bluish gray (5B5/1)
								C	mottles of B	
								C	B B	
		N	A	F	2			C	VOID A B	
								C	A	FORAM NANNO OOZE Forams 45% Nannos 50% Clay 5%
		R	C	G				C	C A	
									B	FORAM NANNO OOZE Volcanic glass (basaltic) Tr. Forams 45% Nannos 50% Clay 5%
		N	A	G					A	
					3				B A B	
		R	C	M					A	
					4			BARELY DEFORMED	B A B A	FORAM NANNO OOZE Mica Tr. Forams 45% Nannos 50% Spicules Tr. Clay 5%
		R	C	G					A and B mixed by deformation	
					5				GEO CHEM SAMPLE B A B	
									A and B mixed by deformation	
		R	C	G	6				A and B inter-laminated A B	
									A in the few laminae of B	
	N21 (F)	R F N	C A A	G G G	Core Catcher				A hard	X-ray at 19.30 m Calc 100 X-ray at 23.40 m Calc 100

Explanatory notes in Chapter 1

Site 214 Hole Core 4 Cored Interval: 28.5-38.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Discoaster brouweri Zone (N)	N R	A C	F G	1	0.5–1.0				
		N	A	F	2				A E	A: FORAM NANNO OOZE white (N9)
									1 cm piece of pumice A	D: LAMINAE of dusky yellow green (5GY5/2)
		R	C	G					D A	E: FORAM NANNO OOZE laminae of grayish yellow green (5GY7/2) Forams 45% Nannos 50% Clay 5%
									E	
		R	C	G	3				A pumice fragment	Volcanic glass Tr. Forams 30% Nannos 65% Clay 5%
					4				C (as in core 3)	
	Discoaster surculus Zone (N) / Pterocanium prismatium (R)	R	C	M	5				A	
		N	A	F	6				dark gray and light green mottles	
	N21 (F)	R F N	C A A	M G G	Core Catcher					NB: gives off H_2S

Explanatory notes in Chapter 1

Site 214 Hole Core 5 Cored Interval: 38.0-47.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Discoaster surculus Zone (N) / Spongaster pentas (R)	N	A	F	1	0.5–1.0		VERY WATERY, POSSIBLY DEFORMED	80	A: FORAM NANNO OOZE white (N9) with rare mottles Mica Tr. Forams 35% Nannos 60% Clay 5% B: FORAM NANNO OOZE Forams 40% Nannos 55% Clay 5%
		R	C	M	2					Section 2 too watery to split. A
		R	C	G	3			SLIGHTLY DEFORMED	36 100	A with a tinge of blue (bluish white 5B9/1) B A FORAM NANNO OOZE Forams 40% Nannos 55% Clay 5% Rads Tr. Spicules Tr.
		R	F	M	4			POSSIBLY DEFORMED		A with mottles of darker material
					5					Section 5 too watery to split.
					6			POSSIBLY DEFORMED		A with mottles
	N20 (F)	R F N	C A A	M G F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 6 Cored Interval: 47.5-57.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Discoaster surculus Zone (N)	N	A	P	1	0.5–1.0			7	gray green gray gray and green gray green gray VOID green gray green gray gray green gray green gray green gray gray and green gray vague mottles FORAM NANNO OOZE white with green and gray laminae repeated at intervals of every 30 to 50 cm. Forams 45% Nannos 50% Clay 5% Spicules Tr. FORAM NANNO OOZE Forams 40% Nannos 55% Clay 5% FORAM NANNO OOZE Forams 40% Nannos 55% Clay 5%
		R	C	M	2				17 70	
	Spongaster pentas Zone (R)	N	A	P	3					
	Reticulofenestra pseudoumbilica Zone (N)	R	F	M	4					
	N19 (F)	R F N	C A A	G G F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 7 Cored Interval: 57.0-66.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Reticulofenestra pseudoumbilica Zone (N) / Spongaster pentas Zone (R)	N	A	G	1	0.5 – 1.0				VOID FORAM NANNO OOZE white with gray and green mottles
		R	F	M	2		VOID			green gray green
		R	C	M	3		VOID			green gray green pure white
					4					dark gray green green
					5		GEO CHEM SAMPLE			
		R	C	M	6				80	dark gray FORAM NANNO OOZE Forams 40% Nannos 55% Clay 5% Diatoms Tr. Rads Tr. Spicules Tr.
	N19 (F)	R F N	C A A	G G G	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 8 Cored Interval: 66.5-76.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Reticulofenestra pseudoumbilica Zone (N) / Spongaster pentas Zone (R)	N	A	G	1	0.5 – 1.0				Section 1 too watery to be split.
		R	F	M	2			DEFORMED, PROB. CAVINGS		
					3			SLIGHTLY DEFORMED	90	FORAM NANNO OOZE white with rare laminae and mottles Forams 45% Nannos 50% Clay 5%
		R	F	M	4					as above
	N19 (F)	R F N	C A A	G G G	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 9 Cored Interval: 76.0-85.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Ceratolithus rugosus Zone (N) / Spongaster pentas Zone (R)	N	A	G						FORAM NANNO OOZE white with laminae as indicated Forams 45% Nannos 50% Clay 5%
		R	C	G	1	0.5 1.0				gray and green
							VOID			gray
					2					
							VOID			
		R	C	G	3					
										gray green gray green
		R	C	G	4					
										→GEO CHEM SAMPLE
		R	C	G	5					locally lightly indurated
									31	lightly indurated Forams 30% Nannos 65% Clay 5% Rads Tr. Spicules Tr.
		R	A	G	6				110	green mottled with pale red purple (5RP6/2) Volcanic glass Tr. Forams 40% Nannos 55% Clay 5% Rads Tr.
	N19 (F)	R F N	C A A	G G G	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 10 Cored Interval: 85.5-95.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Ceratolithus tricorniculatus Zone (N) / Stichocorys peregrina Zone (R) / Discoaster quinqueramus Zone (N)	N	A	G						FORAM NANNO OOZE white
		R	C	G	1	0.5 1.0				
		R	C	G	2				80	Forams 45% Nannos 50% Clay 5% purple gray green
		R	C	G	3					
		N	A	F						green
		R	C	G	4					lightly indurated
					5					gray mottles gray
										gray
					6					
										gray
	N19 (F)	R F N	C A A	G G F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole 11 Core Cored Interval: 95.0-104.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Discoaster quinqueramus Zone (N) Stichocorys peregrina Zone (R)	N	A	G	1	0.5 – 1.0		SLIGHTLY DEFORMED		FORAM NANNO OOZE white without color bands. Lightly indurated layers becoming harder and more frequent.
									110 cm	Forams 40% Nannos 55% Clay 5%
		R	C	G	2					Forams 55% Nannos 40% Clay 5%
										Some color bands (pale gray blue 5PB7/2)
		R	C	G	3					
										pure white
		R	C	G	4					blue gray bands
							GEO CHEM SAMPLE			
					5					blue gray
										blue gray
		R	C	M	6					blue gray
	N17 (F)	R F N	C A A	G F G	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 12 Cored Interval: 104.5-114.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Discoaster quinqueramus Zone (N) Stichocorys peregrina Zone (R)	N R	A C	F M	1	0.5 – 1.0		WATERY, DEFORMED		NANNO OOZE white
					2					Section 2 too watery to split.
					3				90	Forams 40% Nannos 55% Clay 5%
		R	C	G	4					Section 4 too watery to split.
										gray
	N17 (F)	R F N	C A A	G F G	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 13 Cored Interval: 114.0-123.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Discoaster quinqueramus Zone (N) / Stichocorys peregrina Zone (R)	N	A	F	1	0.5, 1.0				Section 1 not split: 0- 78 cm void 78-150 cm ooze FORAM NANNO OOZE white
		N	A	F	2					
		N	A	F	3			WATERY	-100	very pale gray Forams 40% Nannos 55% Clay 5%
		R	C	G						
	Discoaster neohamatus Zone (N) / Ommatartus penultimus Zone (R)				4					Section 4 not opened.
		N	A	F	5					purple gray mottles
		R	C	G						purple gray mottles
		R	C	G	6					
	N17 (F)	R F N	C A A	G F F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 14 Cored Interval: 123.5-133.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Discoaster neohamatus Zone (N) / Ommatartus Penultimus Zone (R)	N	A	F	1	0.5, 1.0		SLIGHT		FORAM NANNO OOZE white
					2					Section 2 not opened.
					3				-100	Forams 40% Nannos 55% Clay 5%
					4					
		R	A	G	5					gray purple mottles
							VOID			purple gray mottles
					6					
	N17 (F)	R F N	A A A	G F F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 15 Cored Interval: 133.0-141.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Discoaster neohamatus Zone (N) Ommatartus antepenultimus Zone (R)				1	0.5				FORAM NANNO OOZE white (5B9/1) mottled very light gray (N8)
						1.0	VOID			
		N	A	F	2					
		R	C	G			GEO CHEM SAMPLE		50	Forams 25% Nannos 70% Clay 5% Rads Tr. Spicules Tr.
		R	C	G	3					
					4					Section 4 not opened.
										no mottling
		R	C	G	5				50	Forams 40% Nannos 55% Clay 5% Rads Tr.
	? N16 (F)	R F N	C A A	G F F	6 Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 16 Cored Interval: 143.0-152.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Discoaster neohamatus Zone (N) Ommatartus antepenultimus Zone (R)	N	A	F	1	0.5				FORAM NANNO OOZE white with rare short intervals of lightly indurated material.
						1.0				
		R	F	M	2					
					3				100	Forams 45% Nannos 50% Clay 5%
					4					Section 4 not opened.
					5		VOID			
					6					
	N15-16 (F)	R F N	C A A	G F F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 17 Cored Interval: 152.5-162.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	Discoaster neohamatus Zone (N)	N	A	F						FORAM NANNO OOZE white
		R	C	G	1	0.5 1.0				
	Discoaster hamatus Zone (N) Cannartus petterssoni Zone (R)	R	F	M	2					
		R	F	M	3				132	FORAM NANNO CHALK Forams 45% Nannos 50% Clay 5%
					4					Section 4 not opened.
	Catinaster coalitus Zone (N) Cannartus petterssoni Zone (R)	R	F	M	5					
					6					
	N14 (F)	R F N	F A A	M F P	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 18 Cored Interval: 162.0-170.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	Cannartus petterssoni Zone (R)	N	A	F						FORAM RICH NANNO OOZE white
		R	C	M	1	0.5 1.0			100	Forams 15% Nannos 80% Clay 5%
		R	C	M	2					
	Catinaster coalitus Zone (N) Dorcadospyris alata Zone (R)	R	C	M	3					
					4					Section 4 not opened.
		R	R	P	5					
	? N13 (F)	R F N	F C A	M F F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 19 Cored Interval: 171.5-181.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	Discoaster exilis Zone (N) Dorcadospyris alata Zone (R)	N	A	P	1	0.5 1.0				FORAM RICH NANNO OOZE white
					2					
		R	C	M	3					lightly indurated intervals 5 cm thick every 10 cm
					4					
					5				-100	Forams 20% Nannos 75% Clay 5%
	N12 (F)	R F N	F C A	M F P	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 20 Cored Interval: 181.0-190.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	Discoaster exilis Zone (N) Dorcadospyris alata Zone (R)	R	F	M	1	0.5 1.0				FORAM RICH NANNO OOZE white
					2				-120	Forams 15% Nannos 82% Clay 3%
					3					
					4					
					5					
					6					Last core with H_2S odor.
	N12 (F)	R F N	C A A	M P P	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 21 Cored Interval: 190.5-199.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)				1	0.5				Not opened.
						1.0				
					2				-80	FORAM RICH NANNO OOZE Forams 15% Nannos 82% Clay 3%
					3					Not opened.
					4					
					5					
	? N6-7 (F)	R	-	P	Core Catcher					
		F	C	P						
		N	A	P						

Explanatory notes in Chapter 1

Site 214 Hole Core 22 Cored Interval: 200.0-209.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIOCENE	? S. heteromorphus Zone (N)				1	0.5			-80	FORAM RICH NANNO OOZE white Forams (all <100μ) 15% Nannos 82% Clay 3%
						1.0				
					2				-100	Color change to white (N9). Forams 15% Nannos 82% Clay 3%
					3				-30 -66 -90	Forams 15% Nannos 82% Clay 3% FORAM RICH NANNO OOZE pinkish gray (5YR8/1) Forams 15% Nannos 82% Clay 3% brownish gray (5YR4/1) stains white
	Sphenolithus belemnos Zone (N)				4					Not opened.
					5					brownish gray mottles
					6				-120	Forams 15% Nannos 82% Clay 3%
	N5 (F)	R	-	P	Core Catcher					
		F	C	P						
		N	A	P						

Explanatory notes in Chapter 1

Site 214 Hole Core 23 Cored Interval: 209.5-219.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIOCENE	Sphenolithus belemnos Zone (N) / Triquetrorhabdulus carinatuy Zone (N)	N4 (F)	R F N	- C A	P P	1	0.5				Section 1 not split.
							1.0				FORAM RICH NANNO OOZE uniform pinkish gray (5YR8/1)
						2				75	brown with white flecks white mottles, bordered by brown Forams 15% Nannos 82% Clay 3%
						3					brown mottles
						4					Section 4 not opened.
						5	GEO CHEM SAMPLE				brown laminae
						6				90	Forams 15% Nannos 82% Clay 3%
						Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 24 Cored Interval: 219.0-228.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus ciperoensis Zone (N)	N3 (F)	R F N	- C A	P F	1	0.5				Section 1 not opened.
							1.0				FORAM BEARING NANNO OOZE pinkish gray (5YR8/1)
						2			50		white mottles Forams 5% Nannos 92% Clay 3%
						3					Sections 3 to 6 not opened.
						4					
						5					
						6					
						Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 25 Cored Interval: 228.5-237.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus ciperoensis Zone (N)				1	0.5				
						1.0				
					2					
					3		VOID			
					4					
					5					Not opened (too wet)
					6				—0	FORAM RICH NANNO OOZE Forams 10% Nannos 87% Clay 3%
		R	-	F	Core Catcher					
		N	A							

Explanatory notes in Chapter 1

Site 214 Hole Core 26 Cored Interval: 238.0-247.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MID OLIGOCENE	Sphenolithus distentus Zone (N)				1	0.5				Too wet to open.
						1.0				
		N	A	F	2					
					3				—0	FORAM BEARING NANNO OOZE Opaques Tr. Forams 8% Nannos 89% Clay 3%
					4					
					5					
	Cyclococcolithina formosa Zone (N)	N	A	F	6				—0	Forams 1% Nannos 96% Clay 3%
		R	C	P	Core Catcher					
		F	A	F						

Explanatory notes in Chapter 1

Site 214 Hole Core 27 Cored Interval: 247.5-257.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	Cyclococcolithina formosa Zone (N) / Globigerina tapuriensis Zone (F)	N F	A C	F P	1	0.5 / 1.0				Too wet to open.
					2					
		F	C	P	3				0	NANNO OOZE Heavy minerals (goethite) Tr. Forams 2% Nannos 95% Clay 3%
					4					
		R	C	P	5					
					6					
	P16 (F)	R F N	- C A	P F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 28 Cored Interval: 257.0-266.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE EOCENE	Discoaster barbadiensis Zone (N) / Globigerapsis mexacana to Cribrohantkenina inflata Zones (P15 to P16) (F)				1	0.5 / 1.0				Section 1 too wet to open.
		N F	A C	F P	2		VOID			Section 2 too wet to open.
		F	C	P	3		WHITE			NANNO OOZE Dominantly pinkish gray (5YR8/1) into vague bands of other colors, as indicated.
					4		VOID			Section 4 too wet to open.
		F	C	P	5				12 75 115	as in Section 3 NANNO RICH IRON OXIDE VOLCANIC GLASS ASH Feldspar 5% Iron oxide 30% Volcanic glass (basaltic) 50% Nannos 15% VOLCANIC GLASS ASH FORAM BEARING NANNO OOZE Forams 5% Nannos 92% Clay 3% NANNO OOZE Forams 2% Nannos 95% Clay 3%
		F	C	P	6					
		R F N	- C A	P F	Core Catcher					

mottle of brown ash
WHITE
WHITE
mainly white
white mottle
white
white
brown

Explanatory notes in Chapter 1

Site 214 Hole Core 29 Cored Interval: 266.5-276 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	Chiasmolithus grandis Zone (N) Truncorotaloides rohri (P14) (F)	N	A	F	1	0.5				NANNO OOZE pinkish gray (5YR8/1)
		F	C	P		1.0				Sections 1 to 4 too wet to open.
					2					
		F	C	P	3					
					4					
		F	A	P			VOID			
					5		VOID			
	Orbulinoides beckmanni (P13) (F)	F	A	F	6					white FORAM RICH NANNO OOZE
									96	
		R	-	F	Core Catcher					
		F	A	F						

Explanatory notes in Chapter 1

Site 214 Hole Core 30 Cored Interval: 276.0-285.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	Chiasmolithus grandis Zone (N) Morozovella lehneri Zone (P12) (F)	F	C	F	1	0.5				NANNO OOZE pinkish gray
						1.0				white
		F	C	F	2					
		F	C	F	3					
		F	C	F	4					
		F	C	P	5				50	NANNO OOZE Forams 2% Nannos 95% Clay 3%
		F	C	F	6					NANNO OOZE very pale orange (10YR8/2) Forams 1% Nannos 96% Clay 3%
		R	-	F	Core Catcher				147	
		F	C	F						

Explanatory notes in Chapter 1

Site 214 Hole Core 31 Cored Interval: 285.5-295.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	Chiasmolithus grandis Zone (N) Morozovella lehneri Zone (P12) (F)				1	0.5 1.0				NANNO OOZE very pale orange (10YR8/2) with mottles of white, brown, and dark gray
					2		VOID			
					3				-121	white white white, with gray borders (smear slide) NANNO OOZE Forams 10% Nannos 87% Clay 3%
	Nannotetrina alta Zone (N) Globigerinatheka kugleri Zone (P11) (F)				4					white
					5		GEO CHEM SAMPLE			white white white white
					6				-90	NANNO OOZE Forams 5% Nannos 92% Clay 3% white
		R F N	- C A	F F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 32 Cored Interval: 295.0-304.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	Nannotetrina alta Zone (N) Globigerinatheka kugleri Zone (P11) (F)	F	A	F	1	0.5 1.0				Section 1 too wet to open. NANNO OOZE very pale orange (10YR8/2)
		F	A	F	2					
		F	R	P	3					
		F N F	A A A	F F F	4					
		F	A	F	5					
	Hantkenina aragonensis Zone (P10) or Globigerinatheka kugleri Zone (P11) (F)	F	A	F	6				-135	Nannos 79-84% Sparry calcite 10-15% Forams 3% Clay 3% Opaques Tr.
		R F N	- C A	F F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 33 Cored Interval: 304.5-314.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY EOCENE	Discoaster sublodoensis Zone (N) Acarinina densa Zone (P9) (F)				1	0.5 1.0			-87	NANNO OOZE very pale orange (10YR8/2) Forams 3% Nannos 94% Clay 3%
					2					
					3					
					4					
					5				-80	NANNO OOZE Forams 5% Nannos 92% Clay 3%
					6					
		R F	- A	F	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 34 Cored Interval: 314.0-323.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY EOCENE	Discoaster lodoensis Zone (N) Acarinina densa Zone (P9) (F)	F	A	F	1	0.5 1.0			-105	FORAM RICH NANNO OOZE very light gray (N8) with shorter intervals of white (N9) Forams 10% Nannos 87% Clay 3%
		F	A	F	2					
		F	A	F	3					creamy white, moderately firm
		N F	A A	P F	4					
	Morozovella formosa Zone (P7) to M. aragonensis Zone (P6)	F	A	F	5				-103	FORAM RICH NANNO OOZE Feldspar Tr. Forams 20% Nannos 77% Clay 3%
		F	A	F	6					
		R F N	- A C	F P	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 35 Cored Interval: 323.5-333.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY EOCENE	Morozovella subbotinae/Pseudohastigerina wilcoxensis Zone (P6b) (F); Discoaster lodoensis Zone (N)	F	A	F	1	0.5		WATERY		FORAM RICH NANNO OOZE very light gray (N8) chalk ooze
						1.0			-130	
		F	A	F	2					GLAUCONITE-BEARING FORAM RICH NANNO CHALK cream and white, speckled with green ooze chalk ooze chalk ooze chalk Glauconite 2% Forams 13% Nannos 80% Clay 5%
		N F	A A	P F	3		VOID		-70	FORAM BEARING NANNO OOZE Glauconite 1% Forams 9% Nannos 85% Clay 5% ooze chalk ooze chalk ooze chalk ooze chalk ooze grayish yellow (5Y8/4) ooze and chalk
		N	A	P	4				-90	GLAUCONITE BEARING NANNO CHALK pale pink (5RP8/2) chalk with spots of glauconite Glauconite 3% Forams 5% Nannos 82% Clay 10%
		F	C	P						
		R N	- C R	P P	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 36 Cored Interval: 333.0-342.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
?	Hellolithus kleinpelli Zone (N)				1	0.5	VOID			
						1.0		WATERY	2	
		N	R	P					10	
									18	
?					2				40	pale olive 10Y6/2 speckled grayish green 5G5/2 GLAUCONITIC CARBONATE SAND grayish green 10GY5/2 Glauc. 25% Forams and other Shell fragments 20% Carbonate silt (few nannos only) 30% Clay 15% Feldspar, Opaques 10% GLAUCONITE BEARING CARBONATE SILT dusky yellow 5Y6/4 Glauc. 5% Carbonate silt 75% Nannos 2% Clay 18% Feldspar, Apatite Tr.
					3					shells, including brachipod shell clay bivalves SILTY SHELL RICH GLAUCONITE SAND speckled yellowish gray 5Y7/2 Glauc. 55-65% Forams and other Shell fragments 20% Silt and Clay size inc. Carbonate material, Heavy mins., and Clay 15-25% mins. SAND FRACTION Glauc. 72% Apatite 3% Augite 1% Calcite 7% Forams 9% Mica Tr. Opaque 4% Unidentified 3% Other shells 1%
LATE PALEOCENE		N	A	P	4					Section 4 not opened.
					Core Catcher					X-ray at 334.60 m Plag 40, Mont 39, Apat 21 X-ray at 336.50 m Calc 55, Plag 12, Mica 4, Mont 6, Clin 22

Explanatory notes in Chapter 1

Site 214 Hole Core 37 Cored Interval: 342.5-352.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PALEOCENE	Fasciculithus tympaniformis Zone (N)				1	0.5, 1.0			85	GLAUCONITE BEARING CARBONATE SILTY SAND crudely laminated grayish green 5G5/2 Forams and other shell(?) fragments 48% Glauc. 3% Feldspar 1% Heavy mins., FeO, Opaques 1% Sponge spic. 2% Diatoms Tr. Auth. carb. Tr. Carbonate silt 45%
					2					Section 2 not opened. X-ray at 345.20 m Calc 88, Plag 8, Mont 3, Pyri 1
	*	R F N	- R A	P P	Core Catcher					

* Planorotalites pseudomenardii Zone (P4) (F)

Site 214 Hole Core 38 Cored Interval: 352.0-361.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PALEOCENE	Cyclococcolithina robusta Zone (N)	N	R	P	1	0.5, 1.0	VOID			GLAUCONITE BEARING CARBONATE SILTY SAND grayish green 10GY5/2 crudely layered Forams and other Shell fragments 42% Glauc. 2% Spicules 3% Diatoms 2% Opaques 3% Volc. glass 1% Feldspar 1% Carbonate silt 44% Nannos 2%
					2				70	
					3				0	X-ray at 356.50 m Calc 76, Plag 13, Mont 9, Pyri 2
					4				0	
	*	R F N	- R R	P P	Core Catcher					

Explanatory notes in Chapter 1 * Planorotalites pseudomenardii Zone (P4) (F)

Site 214 Hole Core 39 Cored Interval: 361.5-371.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PALEOCENE	Cyclococcolithina robusta Zone (N)				1	0.5, 1.0		*	100	*WATERY GLAUCONITE BEARING CARBONATE SILTY SAND grayish olive green 5GY3/2 with white (fossil) and black flecks, and grayish yellow green 5GY7/2 interbeds of mud Forams and other Shell fragments 50% Spicules 5% Glauc. 2% Feldspar 1% Volc. glass 1% Opaques (pyrite and FeO?) 2% Heavies Tr. Diatom fragments 1% Carbonate silt 37% Nannos 1%
					2					
					3					shells
		R N	- R	P	Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 40 Cored Interval: 371.0-380.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PALEOCENE	Cyclococcolithina robusta Zone (N)				1	0.5	VOID			
						1.0		HARD	-100	GLAUCONITE BEARING CARBONATE SANDY SILT AND SILTSTONE grayish olive green 5GY3/2 with laminae of gastropods and bivalves
								SOFT		
					2					Section 2 not split.
										GLAUCONITE BEARING VOLCANIC LIMESTONE Section 3, Thin Section, 135 cm dark green Limey clay matrix 55% Grains including: 45% subrounded volc. frags.- with laths or chloritized subhedral feldspar phenocrysts scattered opaques-some secondary in fossils-pyrite?
					3			SOFT		gastropods
								HARD		gastropods rads diatoms sponge spic. glauconite also veins of calcite present
		R N	- R	P	Core Catcher					gastropods

X-ray at 372.10 m Calc 26, Arag 12, Quar 1, Plag 40, Mont 15, Pyri 6

Explanatory notes in Chapter 1

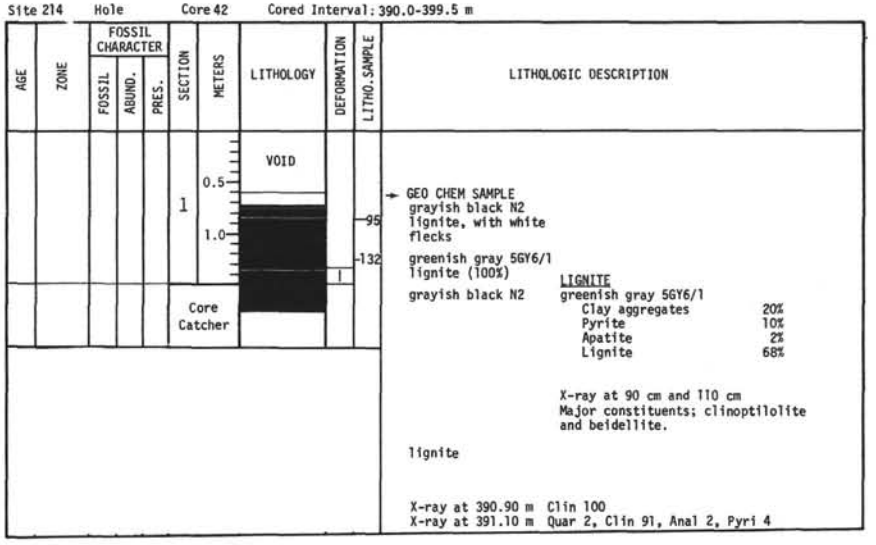
Site 214 Hole Core 41 Cored Interval: 380.5-390.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PALEOCENE	Cyclococcolithina robusta Zone (N)				1	0.5				Section 1 not opened.
						1.0				
					2				-120	hard VOLCANIC CLAY CARBONATE SILT grayish olive green 5GY3/2 with pyrite Clay aggregates 30% Opaques (pyrite?) 15% Feldspar 5% soft Glauconite 2% Carbonate silt 45% Forams 1% Nannos 2%
										→ GEO CHEM SAMPLE
					3				-50	gastropods white recrystallized limestone
									-140	VOLCANIC SILTY CLAY grayish green Feldspar 5% Pyrite 15% Clay aggregates 40% Volc. glass 1% Glauc. 1% Carbonate silt 33% Forams 1% Nannos 2%
		R F N	- R R	P P	Core Catcher					Thin Section at Section 3, 49 cm. GLAUCONITE-BEARING VOLCANIC SAND RICH LIMESTONE Matrix-recryst. calcite mosaic 90% Rest: Feldspar, chloritized volc. (?) rock frags., glauconite, fossil ghosts, pyrite

X-ray at 384.50 m Calc 12, Quar 1, Plag 39, Mont 21, Pyri 27
X-ray at 384.80 m Calc 7, Plag 31, Mont 38, Pyri 24

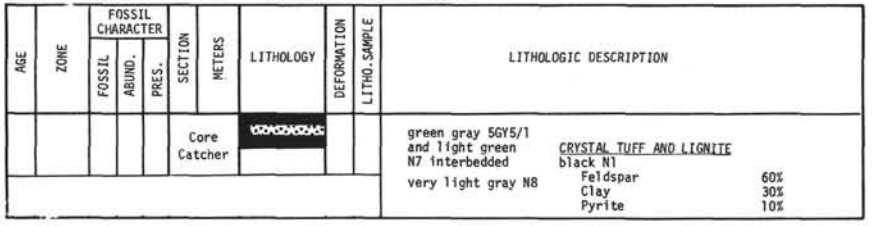
Explanatory notes in Chapter 1

Site 214 Hole Core 42 Cored Interval: 390.0-399.5 m



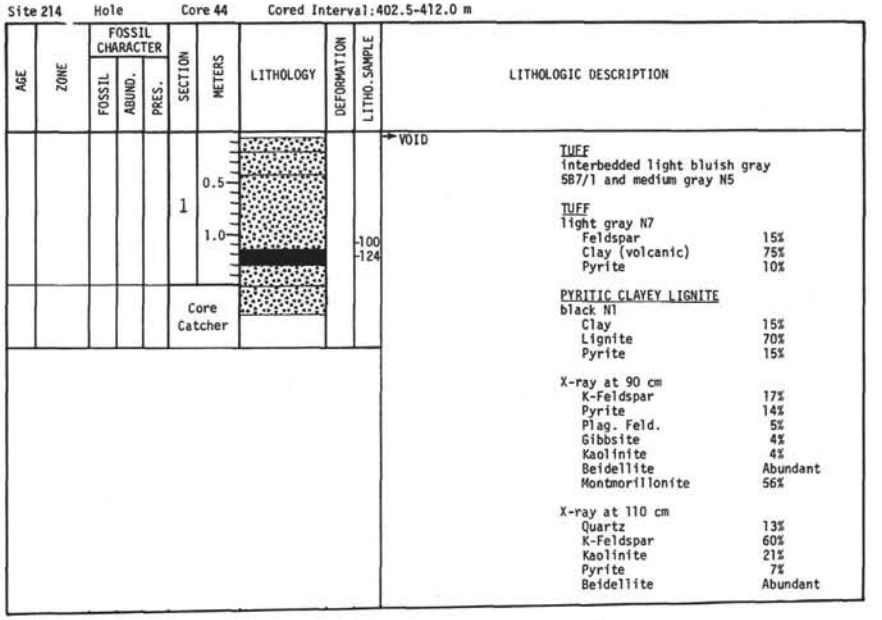
Explanatory notes in Chapter 1

Site 214 Hole Core 43 Cored Interval: 393.0-402.0 m

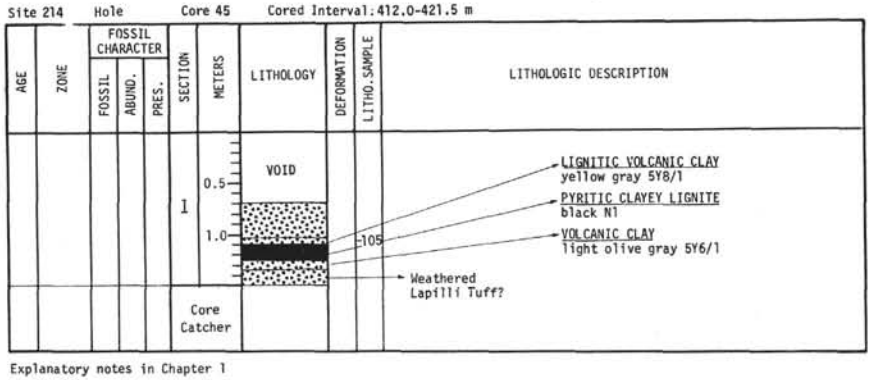


Explanatory notes in Chapter 1

Site 214 Hole Core 44 Cored Interval: 402.5-412.0 m



Site 214 Hole Core 45 Cored Interval: 412.0-421.5 m



Explanatory notes in Chapter 1

Site 214 Hole Core 46 Cored Interval: 421.5-431.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	VOID			
					2					
					3					
					Core Catcher					

WEATHERED VOLCANIC CLAY and LAPILLI TUFF WITH LIGNITE

- light brownish gray 5YR6/1 CLAY — Feldspar 10%; Clay aggregates, Fe stained 90%
- pale blue green 5BG7/2 CLAY
- pinkish gray 5YR8/1 CLAY
- interbedded purple and gray CLAY, with LAPILLI
- brownish gray 5YR4/1 (flecked with white) CLAY interlayered with dark gray N4 CLAY — Feldspar 5%; Fe oxides 5%; Clay 90%
- dark gray CLAY
- clay flake LAPILLI, flakes pinkish gray 5YR8/1 — Feldspar 40%; Fe stained clay 60%
- black LIGNITE
- clay flake LAPILLI
- interbedded LIGNITE and CLAY
- CLAYEY LAPILLI TUFF — Feldspar 2%; Clay 98%
- dark greenish gray 5G4/1 CLAY
- medium light gray N6, clasts dark
- greenish gray 5GY4/1 CLAYEY LAPILLI TUFF; lapilli of chloritic clay — Feldspar 2%; Fe stained clay 46%; not stained clay 32%; Chlorite 20%
- as above, but harder, grayish green 5G5/2, with grayish yellow green 5GY7/2 LAPILLI
- black LIGNITE interbedded with greenish gray 5GY6/1 CLAYEY LAPILLI TUFF
- black and brown LIGNITE

Thin Section, Section 2, 44-48 cm. Relict lava fragments-subrounded to subangular closely packed with siliceous cement in parts.

Thin Section, Section 2, 84-91 cm. Lapilli are all lava fragments-many strongly altered to pale gray clay or dark brown volcanic glassy fragments - all retain feldspar lath ghosts sim. silica cement to thin section at 44 cm.

X-ray at 423.30 m Quar 10, Feld 53, Mont 34, Pyri 2
X-ray at 424.40 m Quar 4, Feld 16, Mont 65, Pyri 15

Explanatory notes in Chapter 1

Site 214 Hole Core 47 Cored Interval: 431.0-440.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	VOID			Weathered LAPILLI TUFF and LIGNITE matrix dark greenish gray 5G4/1, with white and dark clasts lignite as above LIGNITE as above
					Core Catcher					VOLCANIC CLAYSTONE

Site 214 Hole Core 48 Cored Interval: 440.5-448.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0				GLASSY BASALT medium dark gray N4 fine-grained
					2					medium-grained BASALT vesicular and amygdalar BASALT fine-grained BASALT, medium dark gray N4, similar to 48/1.
					Core Catcher					medium dark gray N4 BASALT

Site 214 Hole Core 49 Cored Interval: 448.0-457.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	VOID			fine grained BASALT medium dark gray N4, very similar to Core 48 Section 1. BASALT
					Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 50 Cored Interval: 457.5-467.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5	VOID			
						1.0				very fine grained BASALT, medium dark gray N4
					Core Catcher					very fined grained BASALT

Site 214 Hole Core 51 Cored Interval: 467.0-476.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5	VOID			
						1.0			67	fine grained BASALT veins of calcite in chilled glassy margin contact at 117 cm olive gray 5Y4/1 VOLCANIC CLAY, consists of brown glass, partly divitrified
					Core Catcher					olive gray LAPILLI TUFF

Explanatory notes in Chapter 1

Site 214 Hole Core 52 Cored Interval: 476.5-486.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5	VOID			
						1.0			115	
									145	
one specimen no age		F	R	P	Core Catcher					

Collection (order not known) of LIGNITE and WEATHERED LAPILLI TUFF (grayish blue green 5BG5/2).

BASALT debris: aggregates of

Iron oxide and brown glass	83%
Feldspar	5%
Chlorite	10%
Remainder	2%

CHLORITIC CLAY:

Fe stained clay	45%
Clay, clear	45%
Chlorite	10%

X-ray at 130 cm

Montomorillonite	63%
K-Feldspar	23%
Beidellite	Present
Quartz	3%
Siderite	5%
Calcite	6%

Thin Section 120-123 cm.
Variety igneous rock fragments and lignite.
- lavas - lath textures
- glassy lavas with spherulitic and perlitic cracks
- feldspar crystals

143-145 cm
most fragments glassy
lavas with perlitic textures

VOLCANIC SILTY CLAY

X-ray at 477.80 m Calc 6, Side 5, Quar 3, Feld 23, Mont 63

Explanatory notes in Chapter 1

Site 214 Hole Core 53 Cored Interval: 486.0-490.5 m

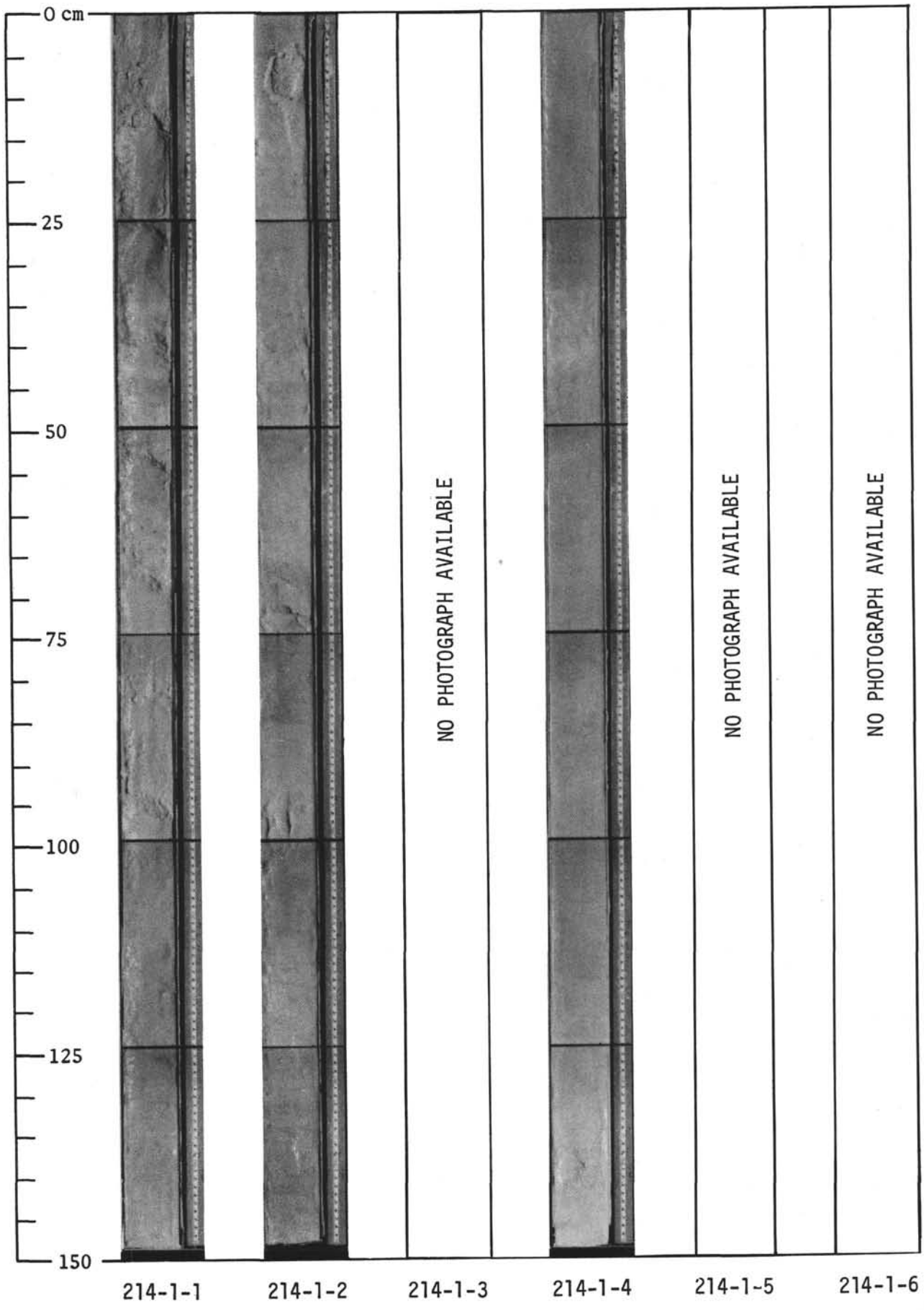
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5				greenish gray 5GY6/1 LAPILLI TUFF, hard
										chilled margin of fine grained GLASSY BASALT, dark gray N3
						1.0				coarser grained
					2		VOID			
										loose pieces of basalt, probably chilled margin
										dusky blue green 5BG3/2 basalt debris — Devitrified glass, Chlorite, Feldspar, Clay
										cuttings, including chunks of basalt
										Thin Section, Section 2, 50-54 cm: glassy lava fragments-perlitic, vesicular, etc.
										basalt: chloritic amygdaloidal glassy lava, cavities lined with zeolite in vugs
					Core Catcher					

Explanatory notes in Chapter 1

Site 214 Hole Core 54 Cored Interval: 490.5-500.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
							VOID			
					1	0.5				amygdalar BASALT, very coarse grained, dark greenish gray 5GY5/1; amygdales ~1-10 m, filled with calcite. Contact at point of disappearance of anygdalar
						1.0				very coarse grained basalt, dark greenish gray 5GY5/1: clinopyroxene, plagioclase, chlorite, iron ore
					2					
					3					vesicular BASALT, vesicles 3-9 mm in diameter
										amygdalar BASALT, amygdales 3-6 mm
										vesicular BASALT, vesicles 2-9 mm
										amygdalar BASALT, amygdales 1-5 mm
										coarse grained BASALT, dark greenish gray 5GY5/1, similar to Core 54, Sections 1 and 2.
										vesicular BASALT, vesicles 1-5 mm
					Core Catcher					amygdalar basalt

Explanatory notes in Chapter 1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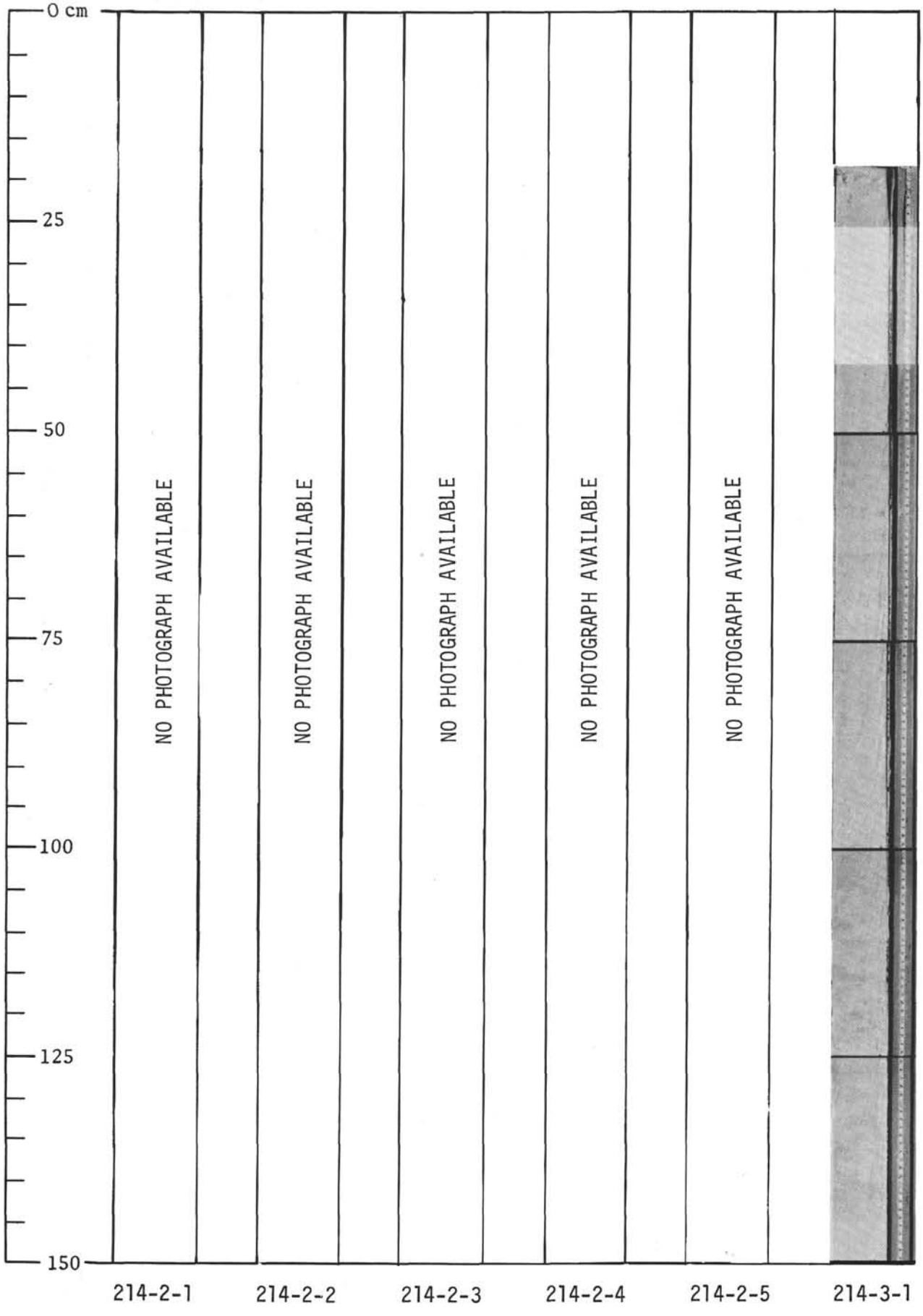
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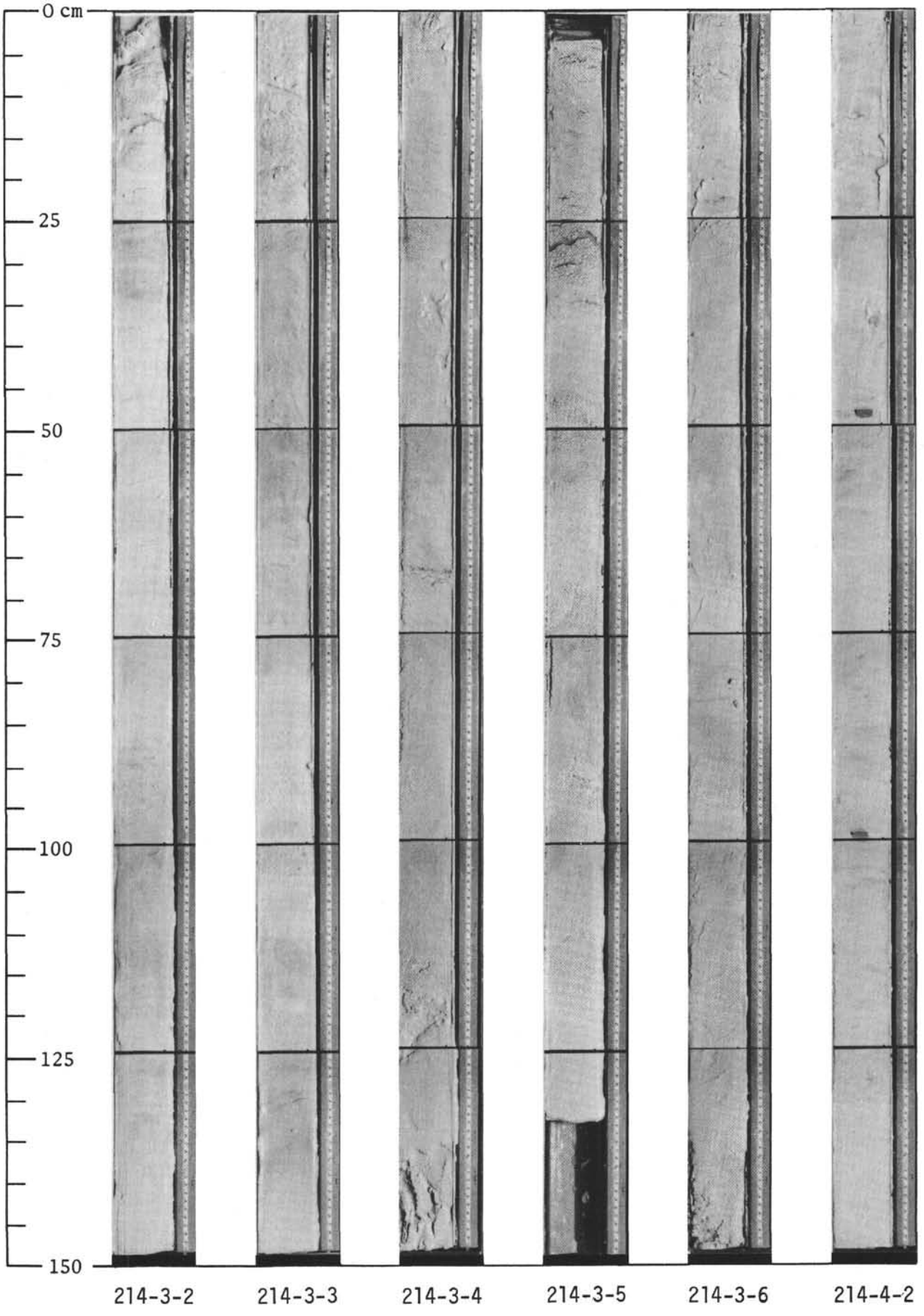
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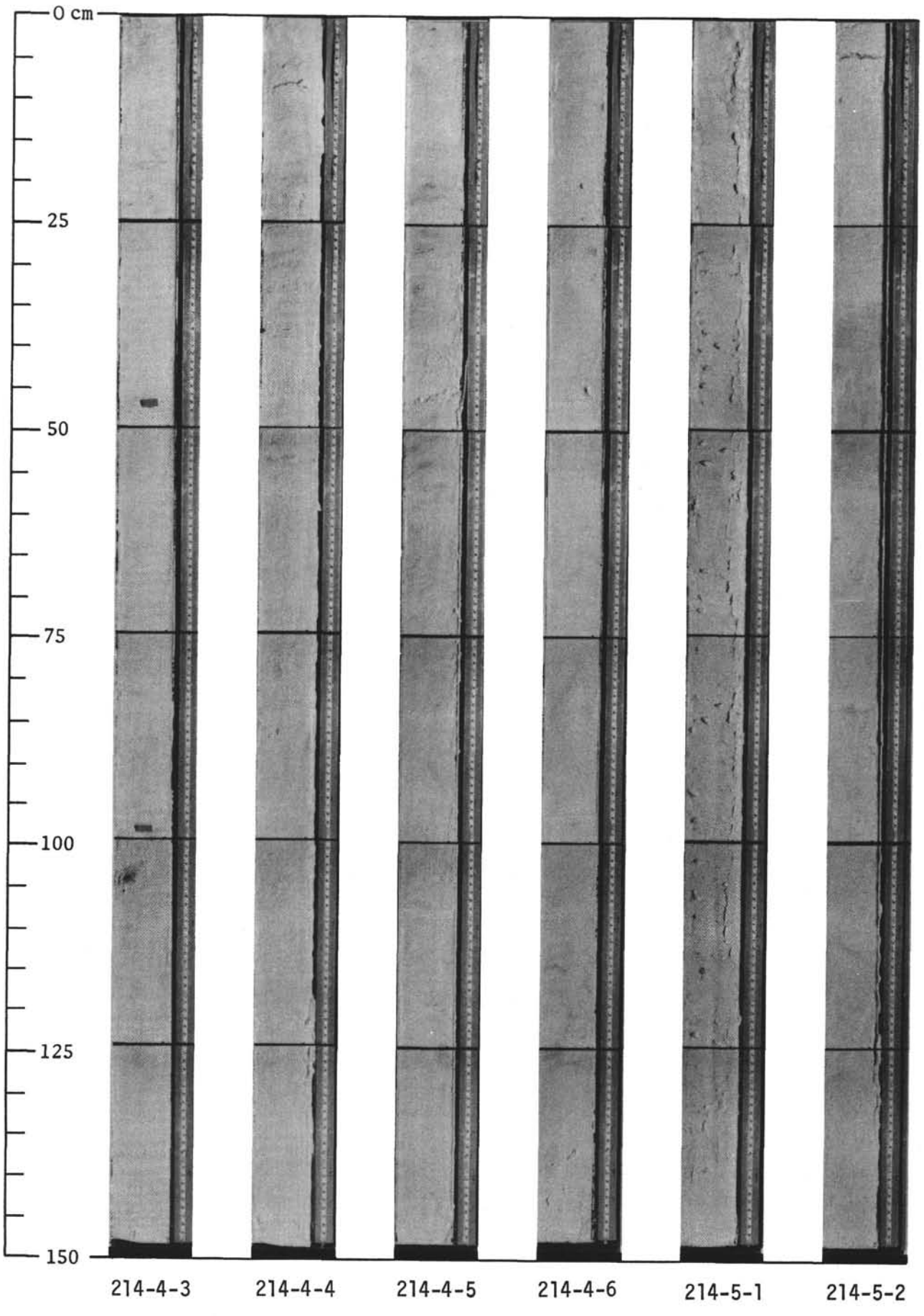
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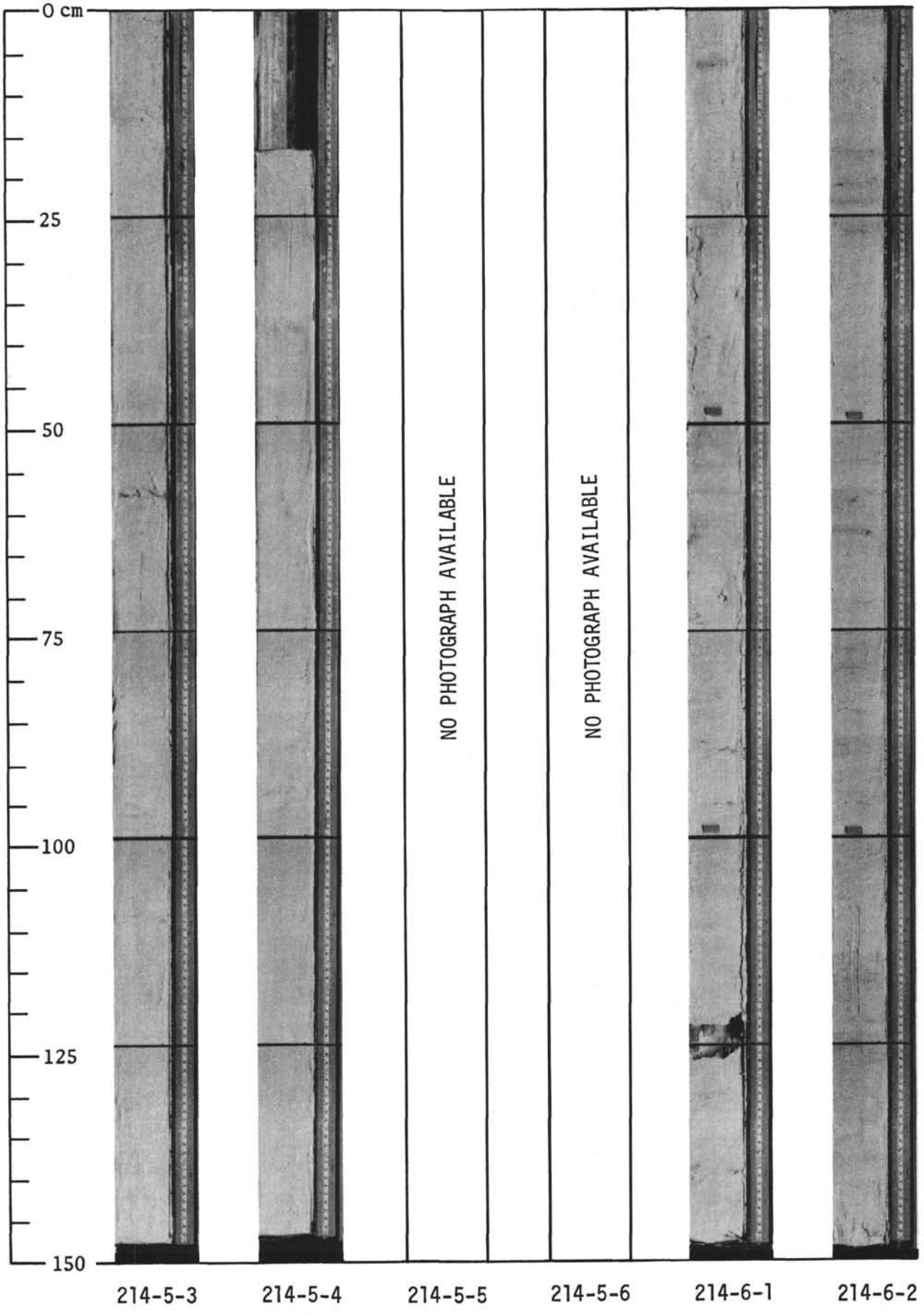
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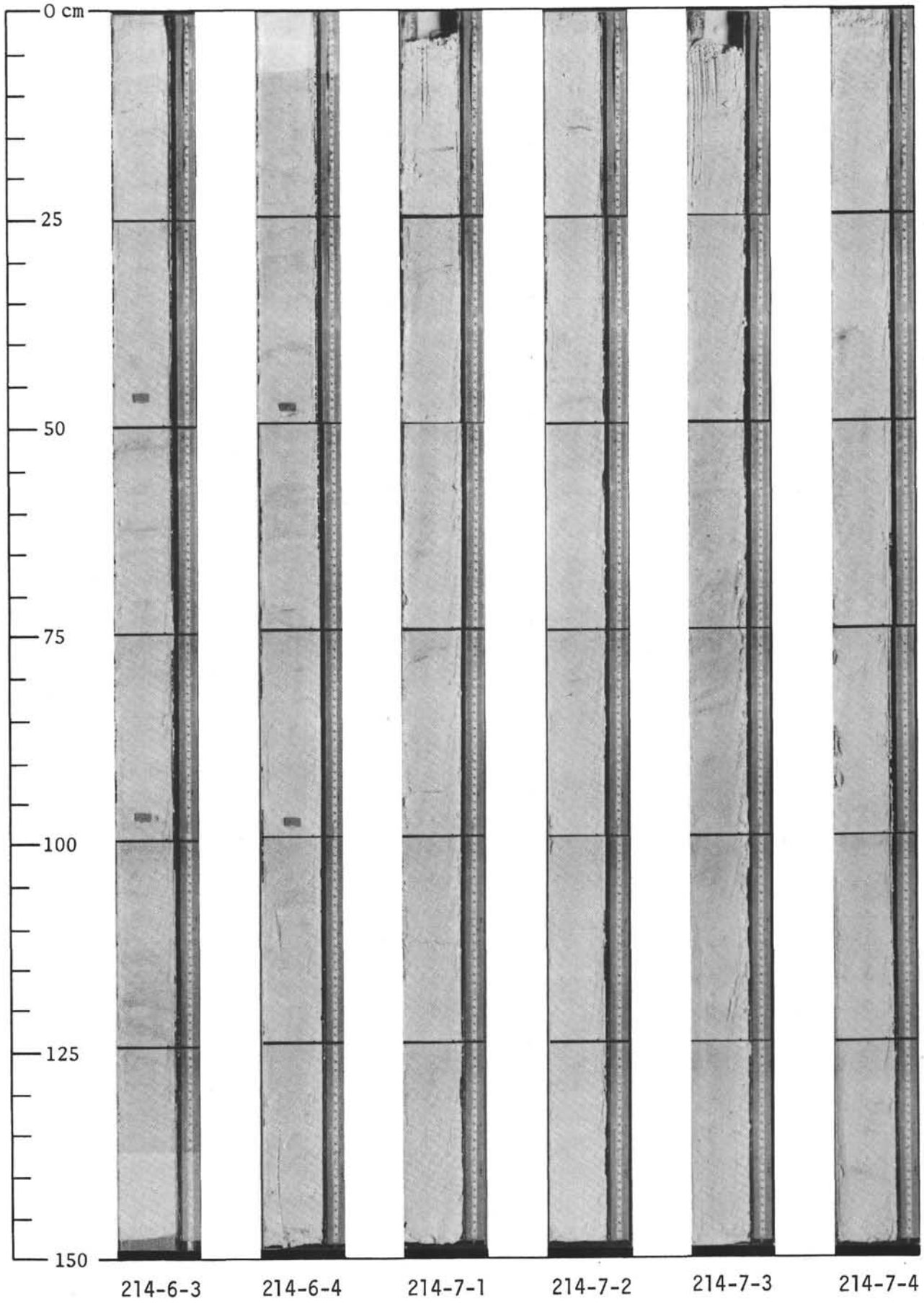
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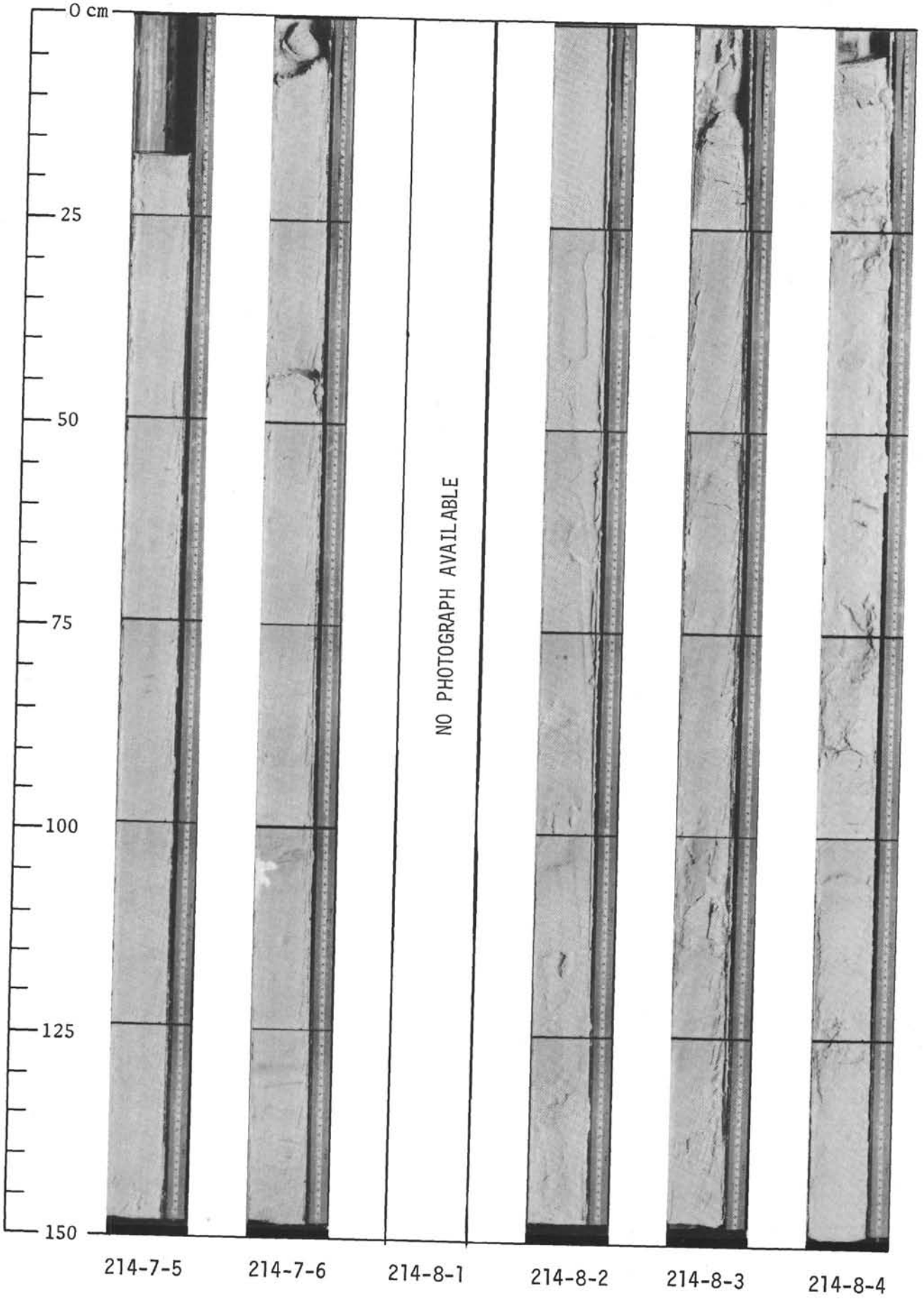
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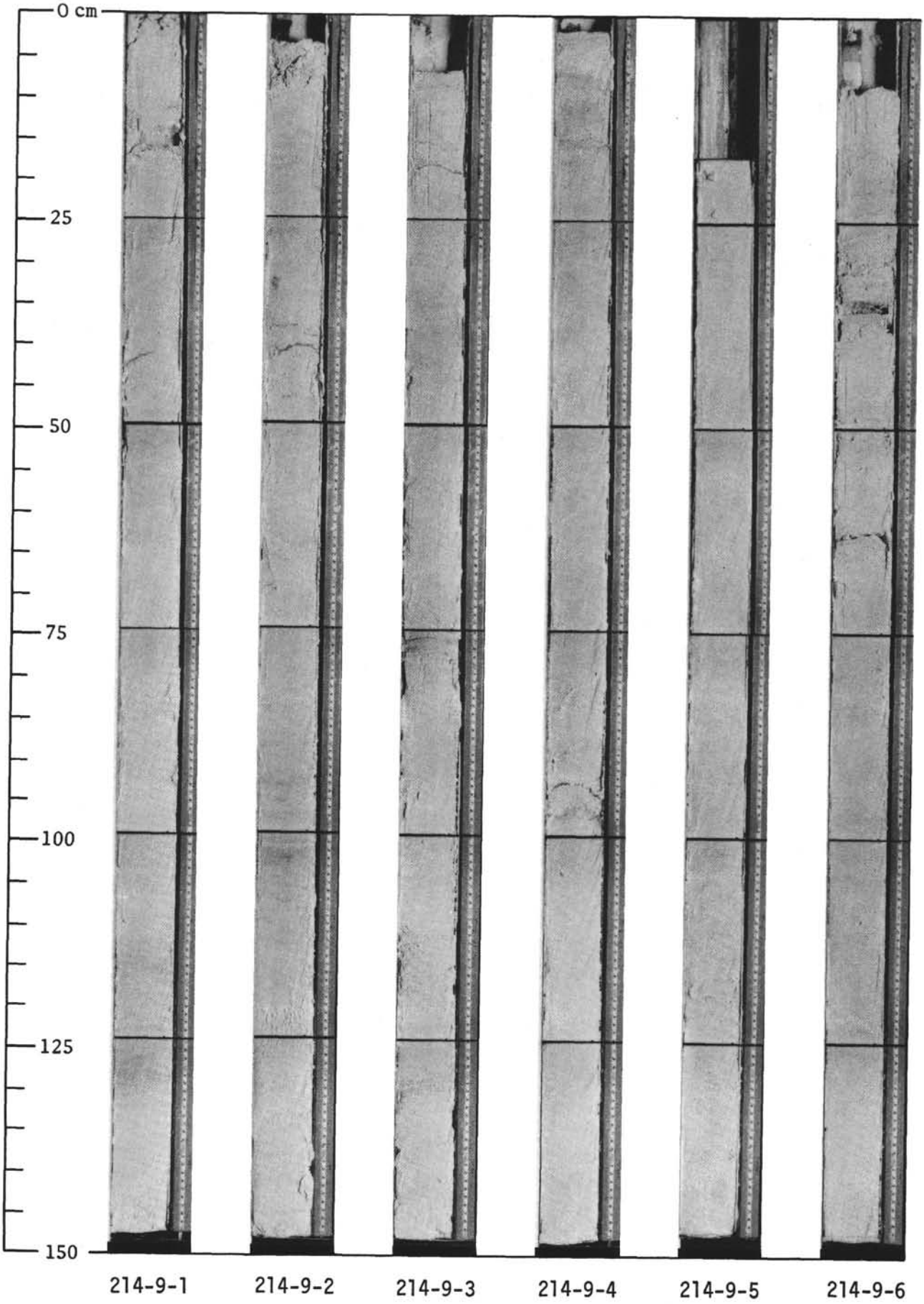
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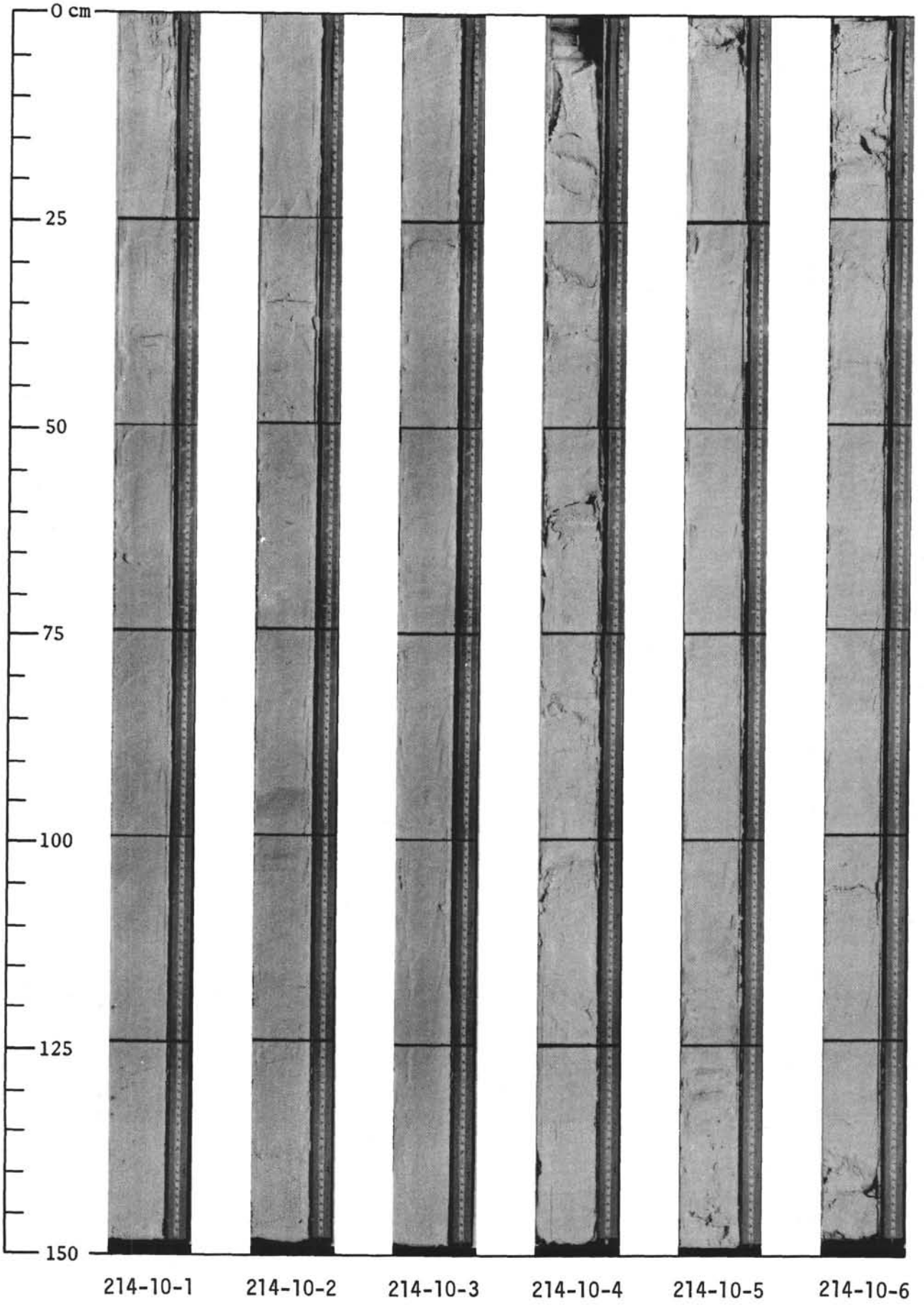
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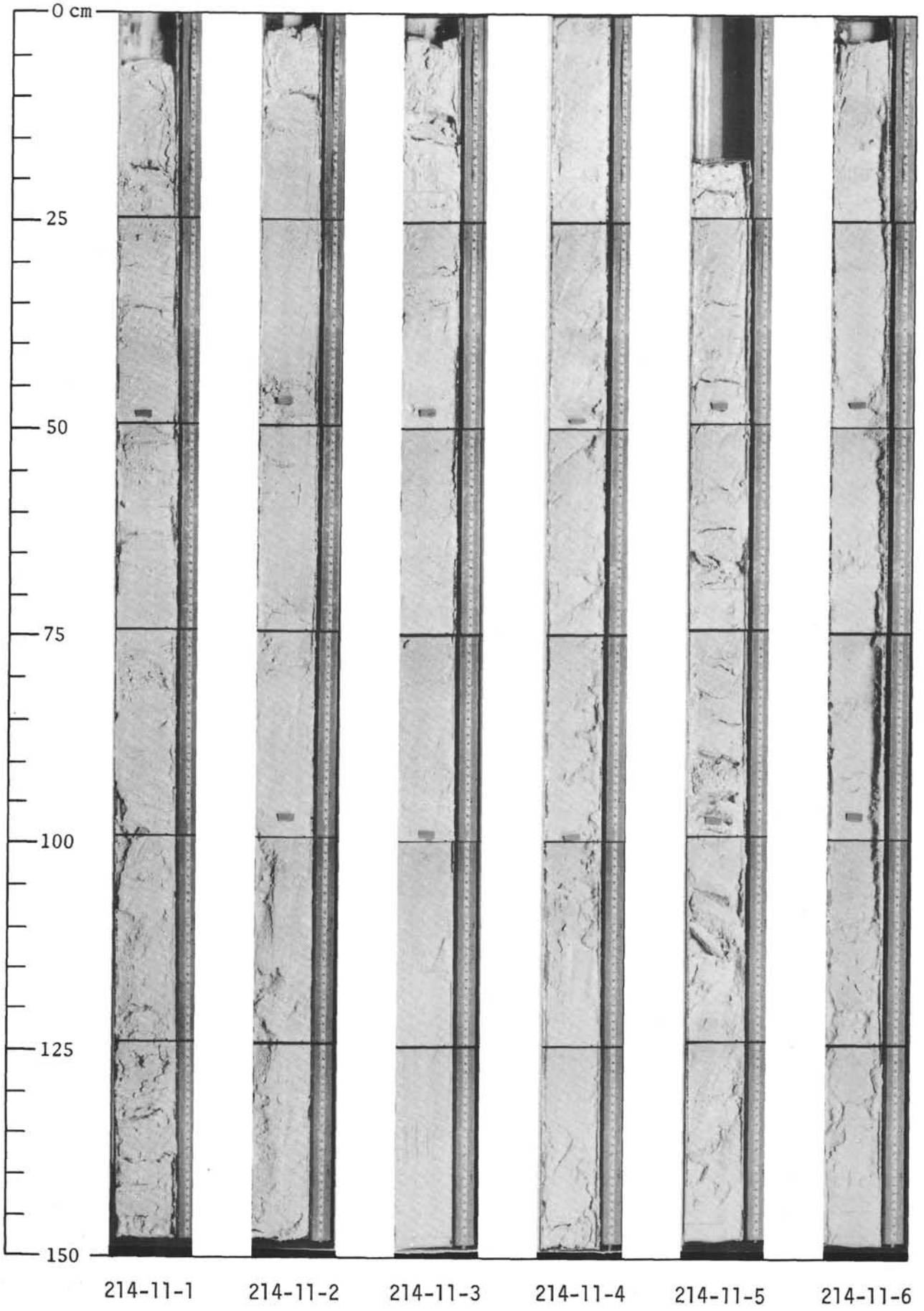
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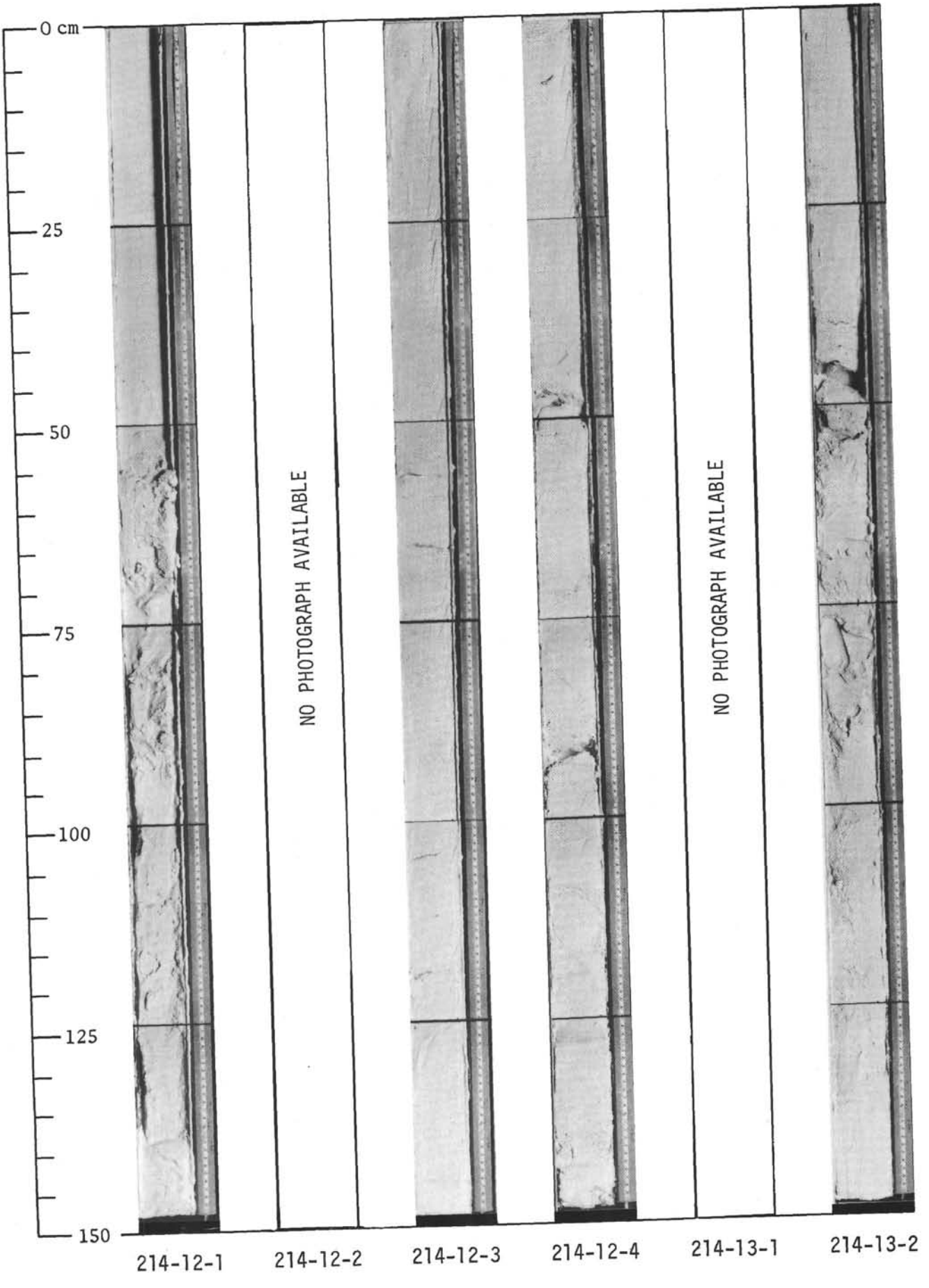
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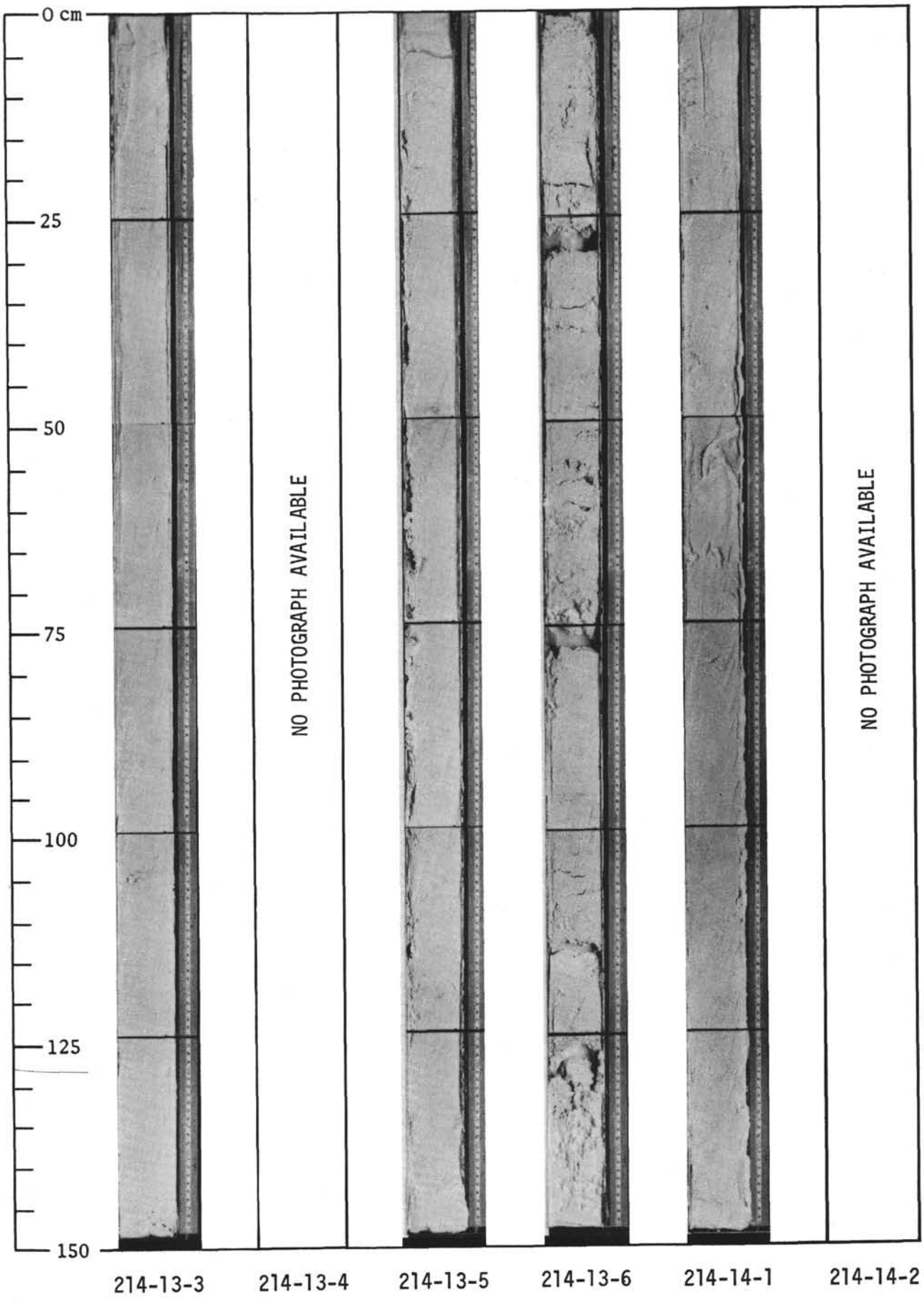
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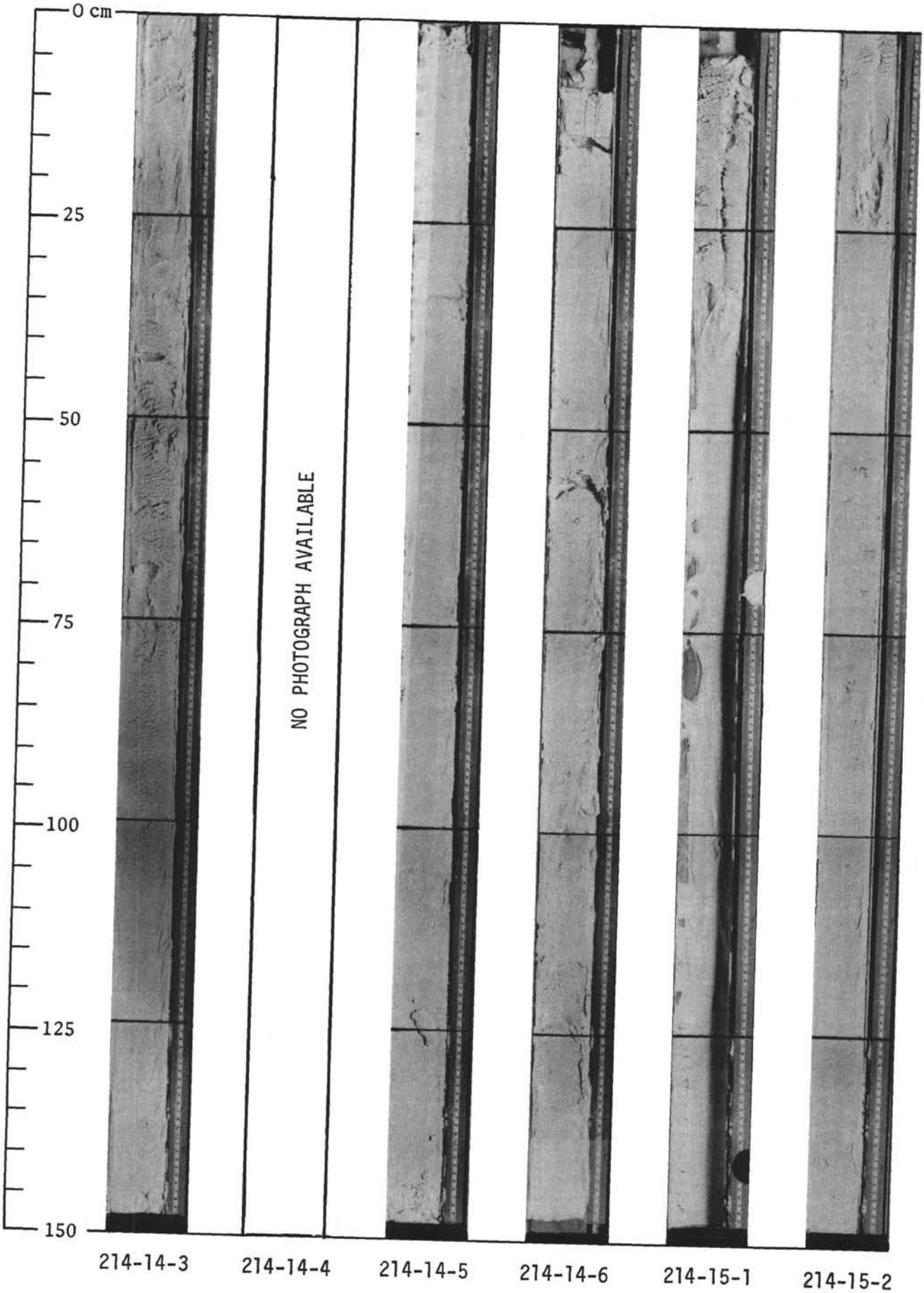
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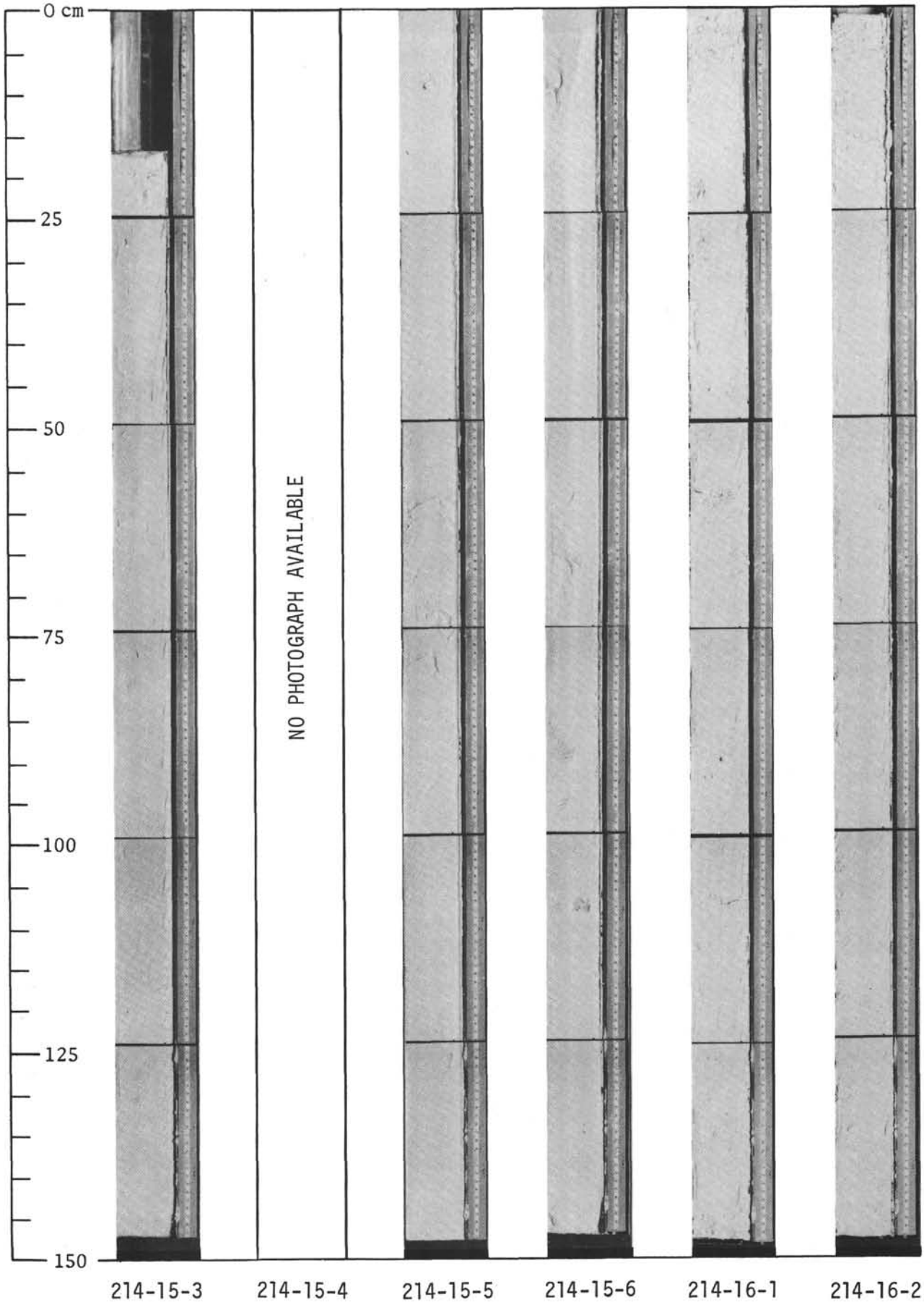
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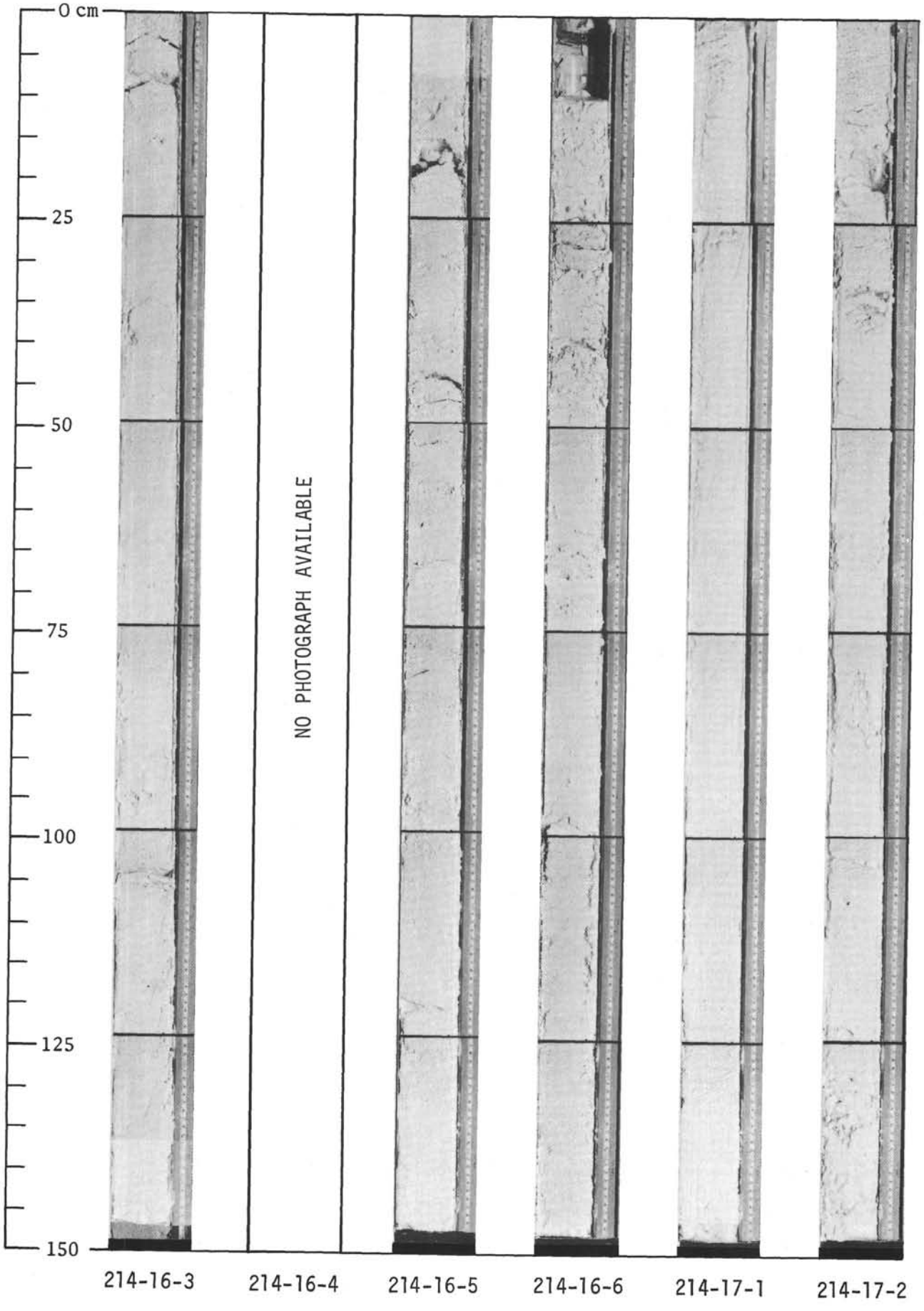
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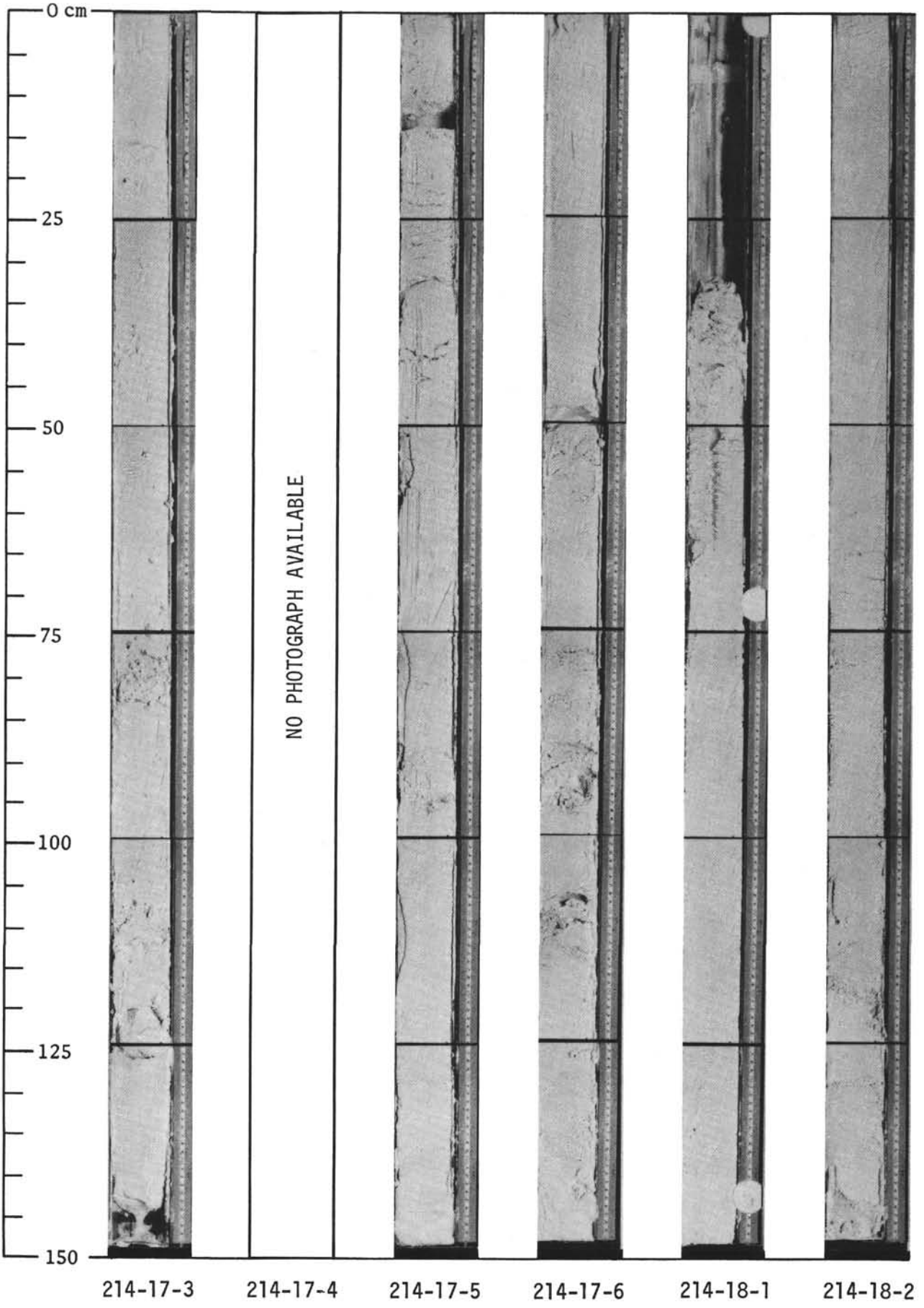
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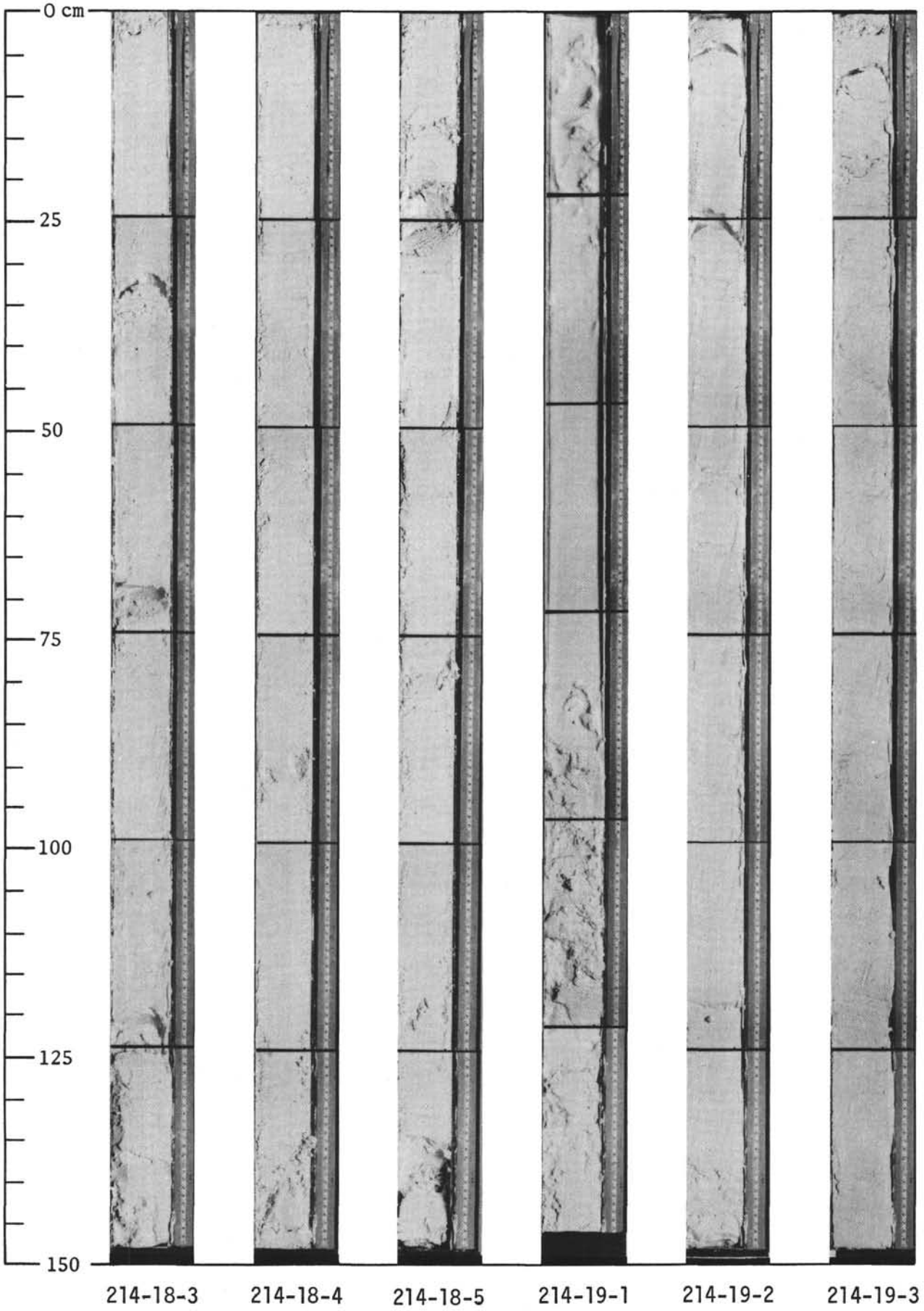
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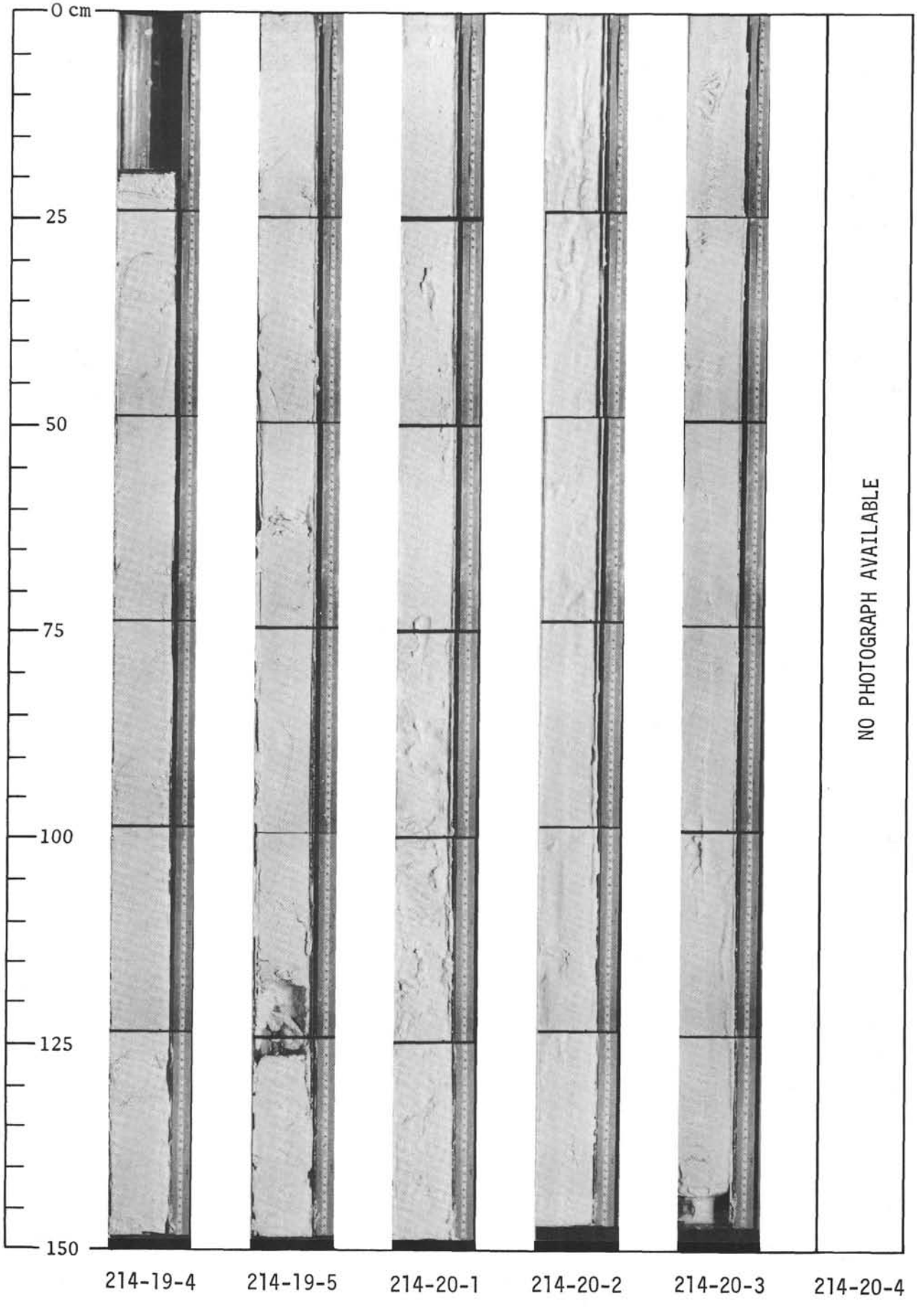
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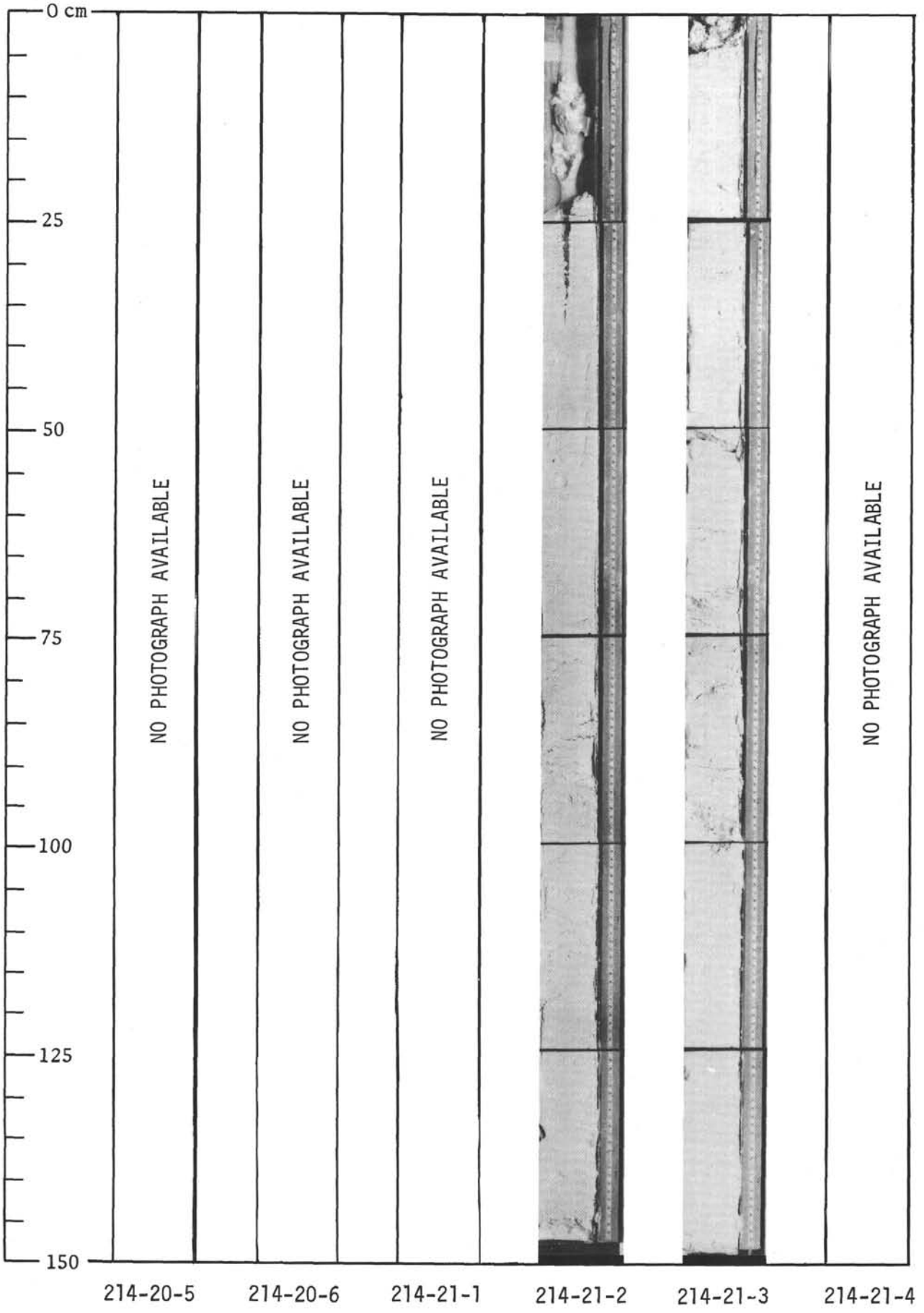
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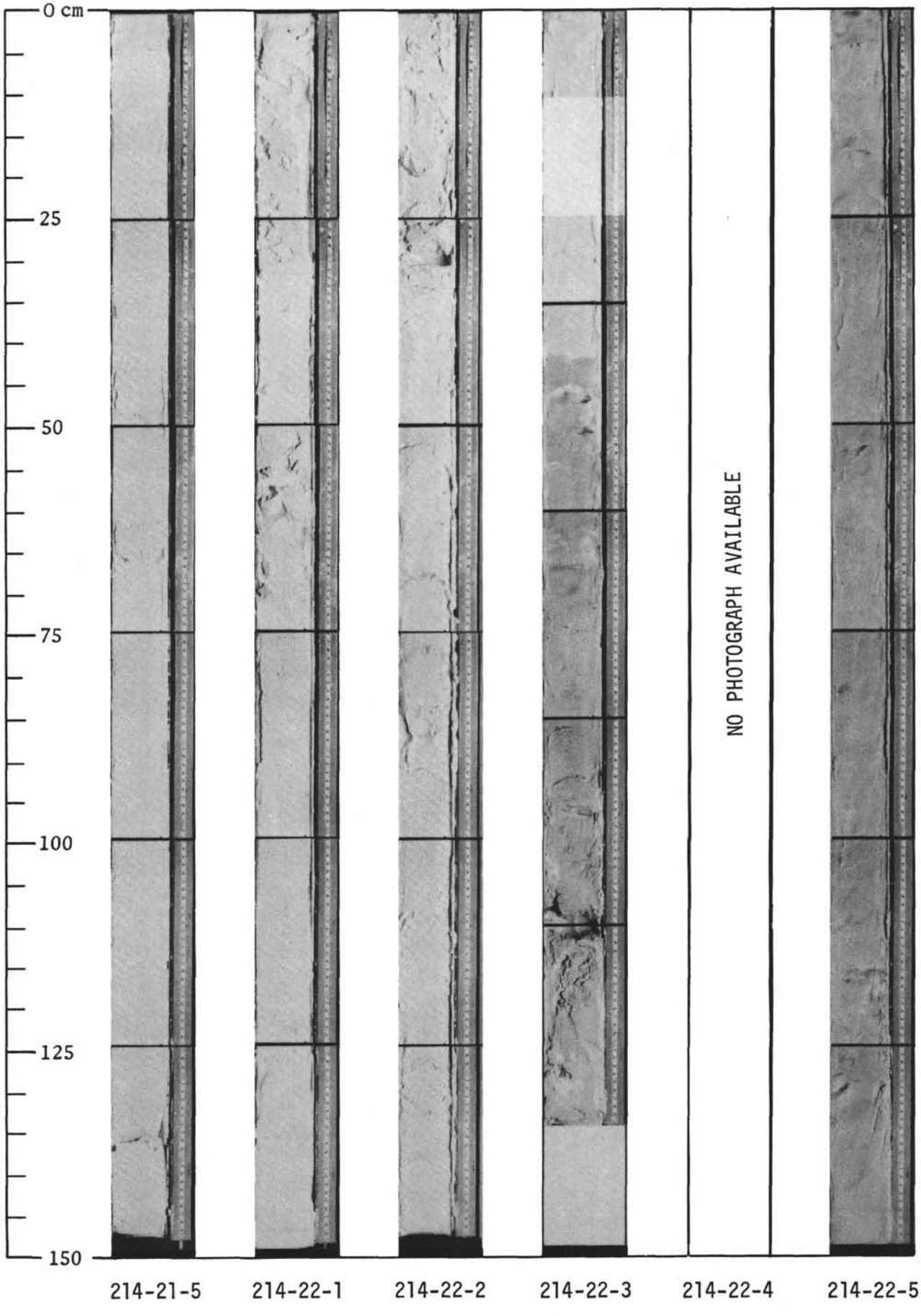
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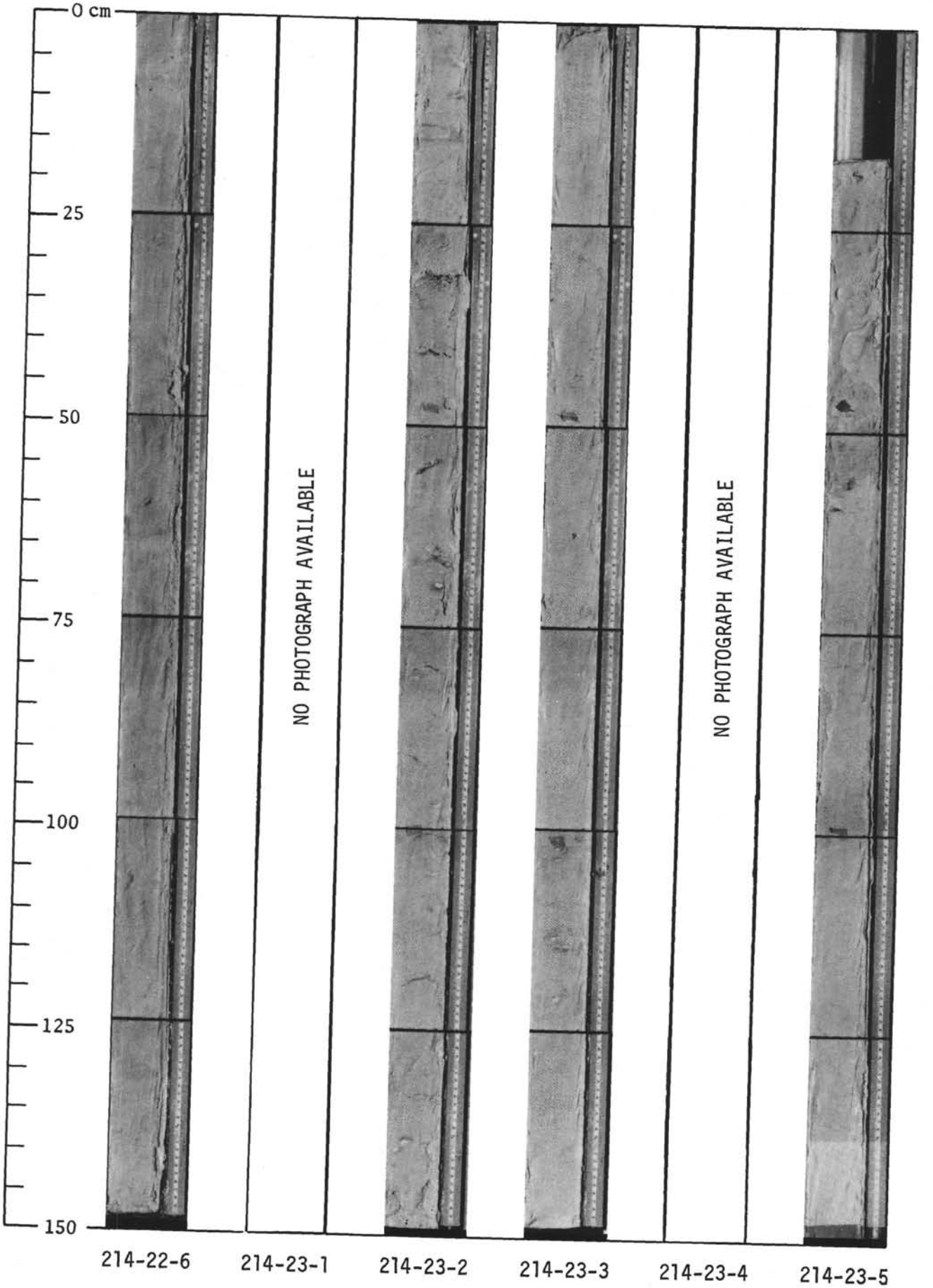
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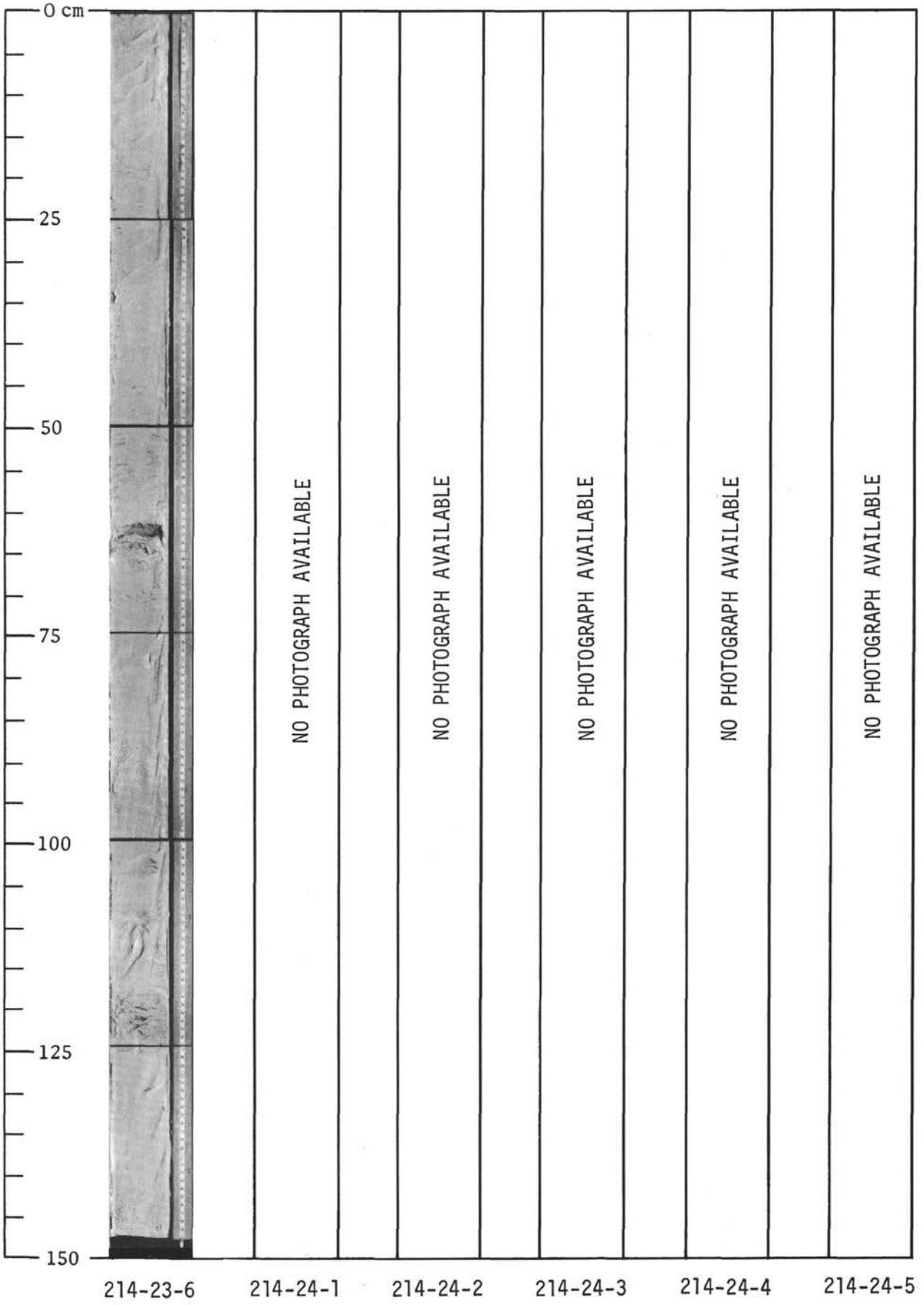
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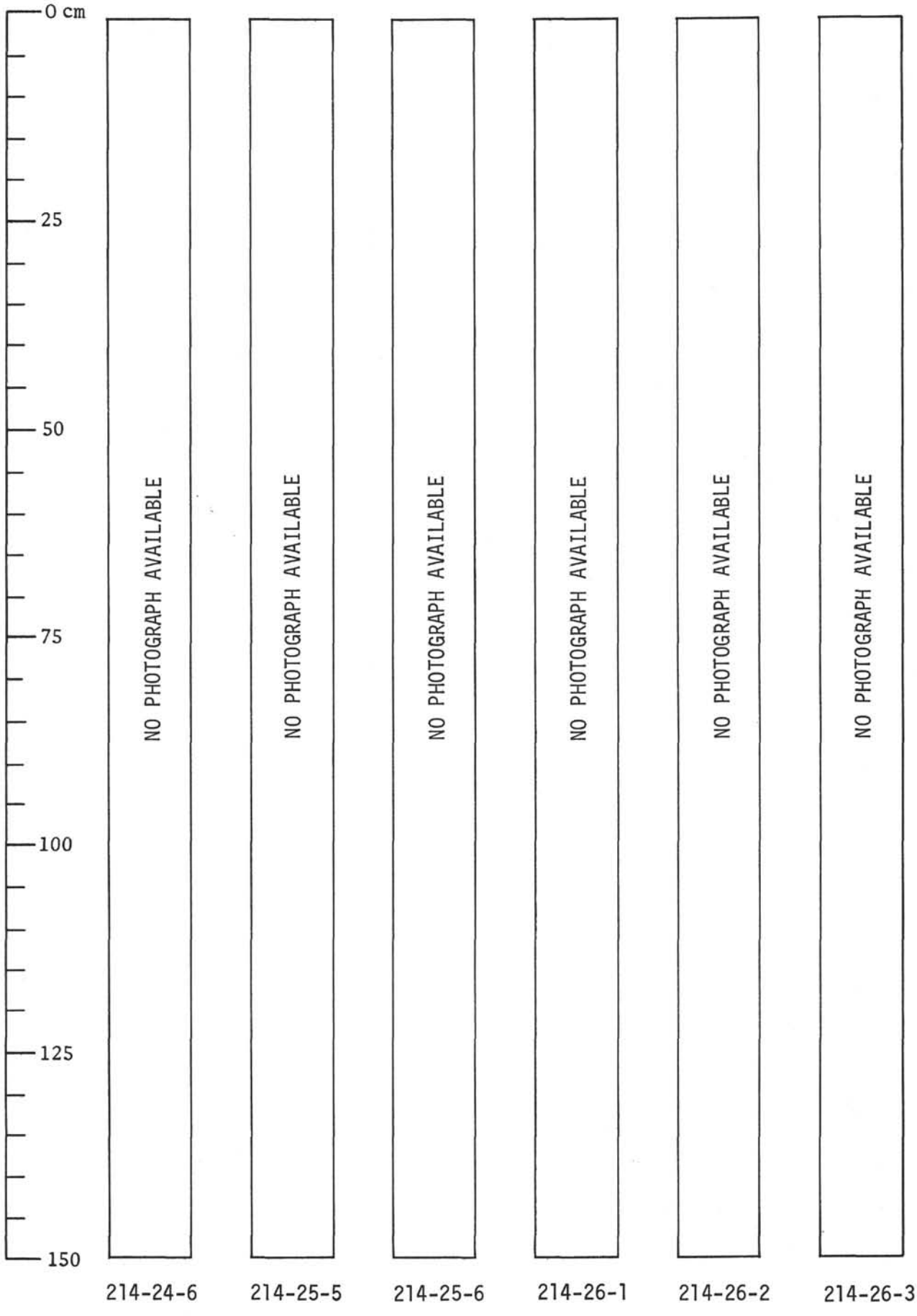
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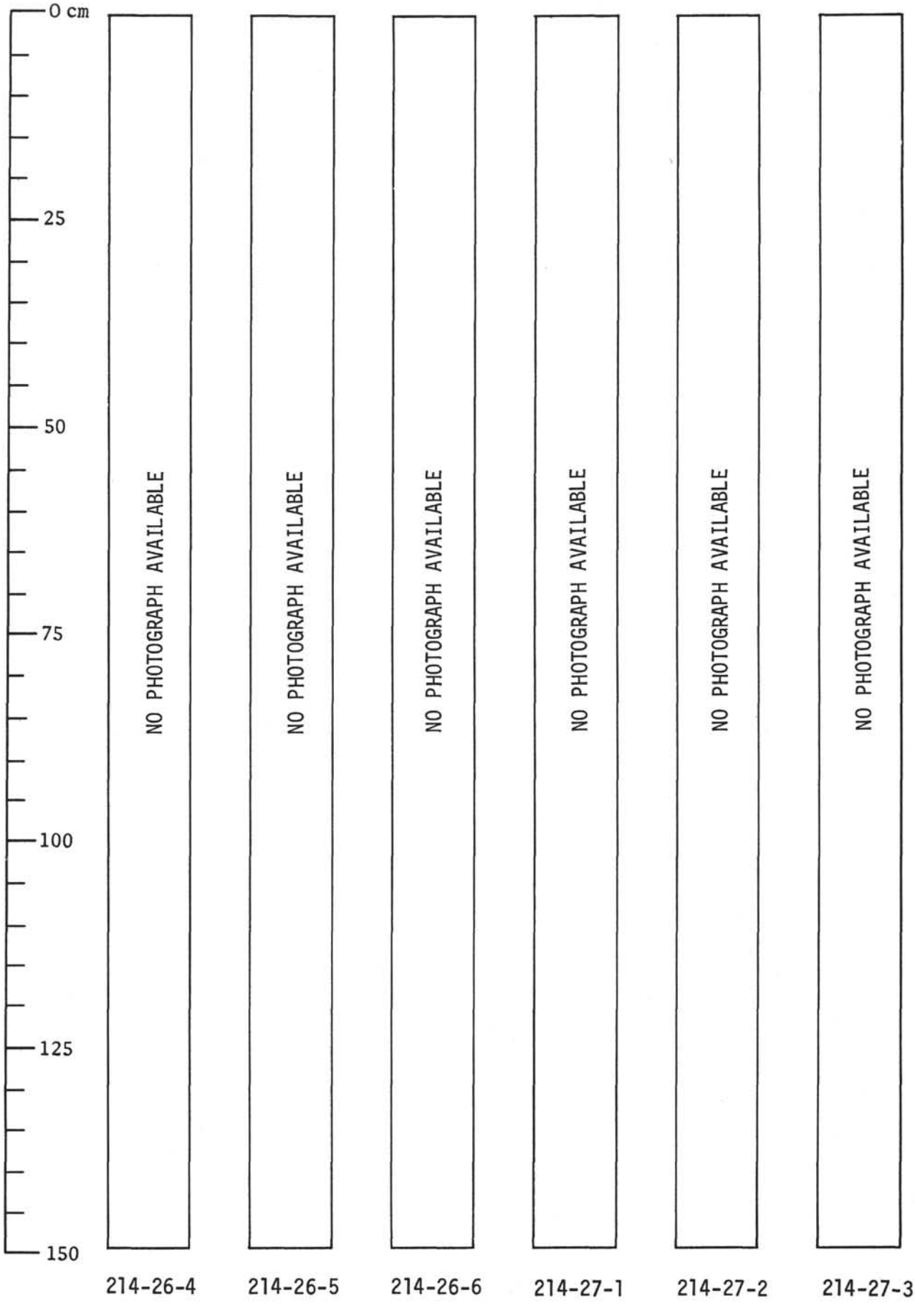
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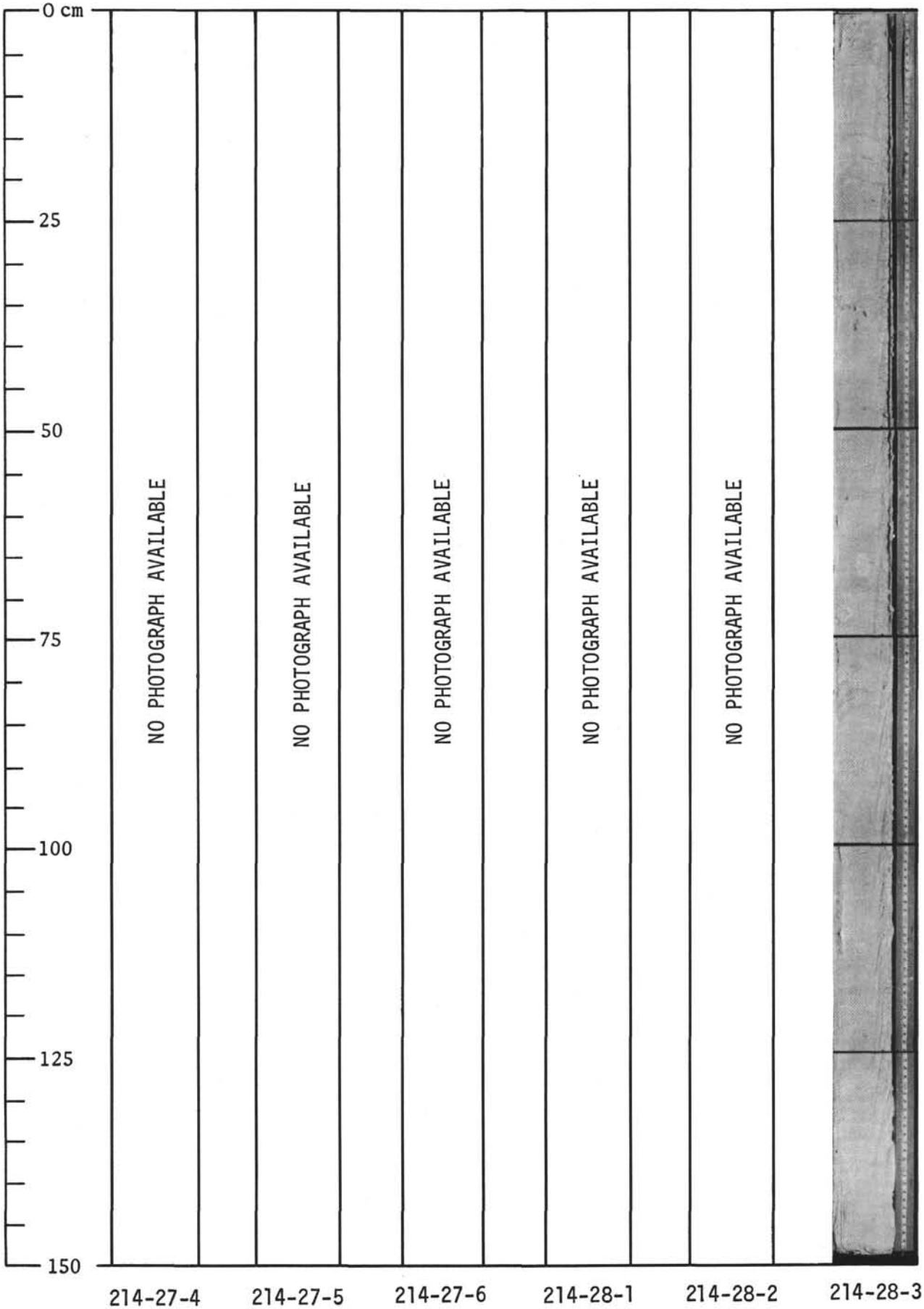
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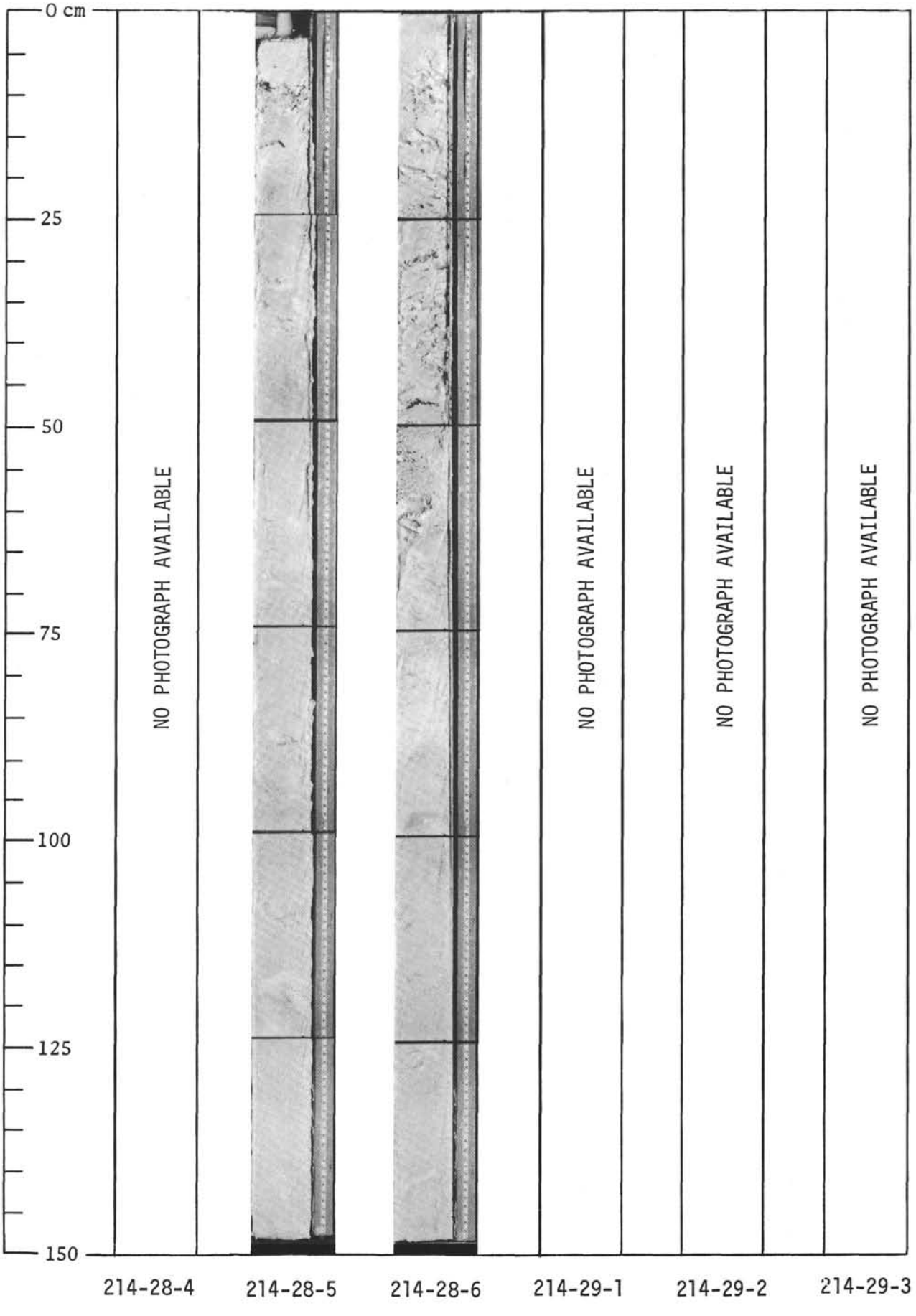
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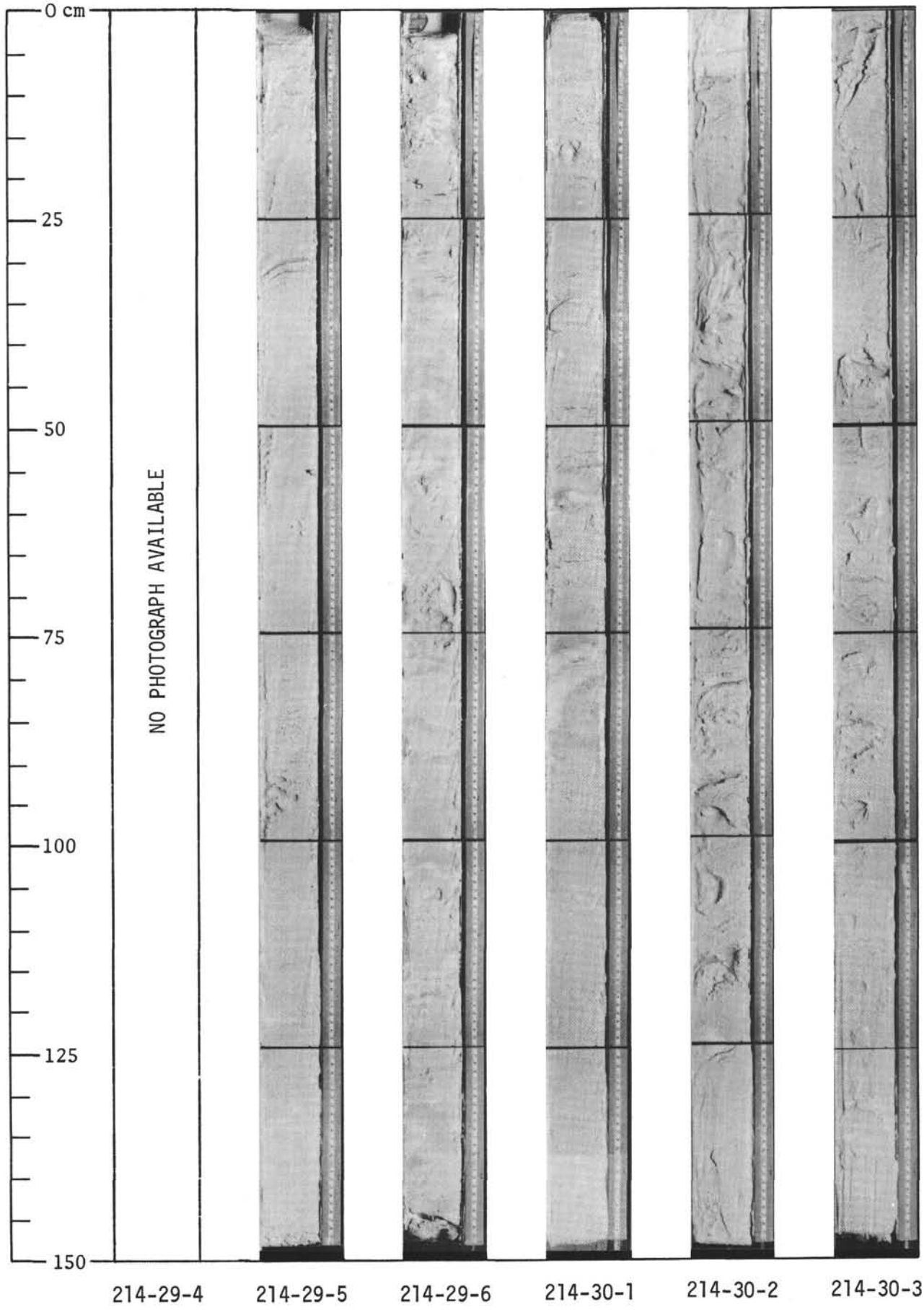
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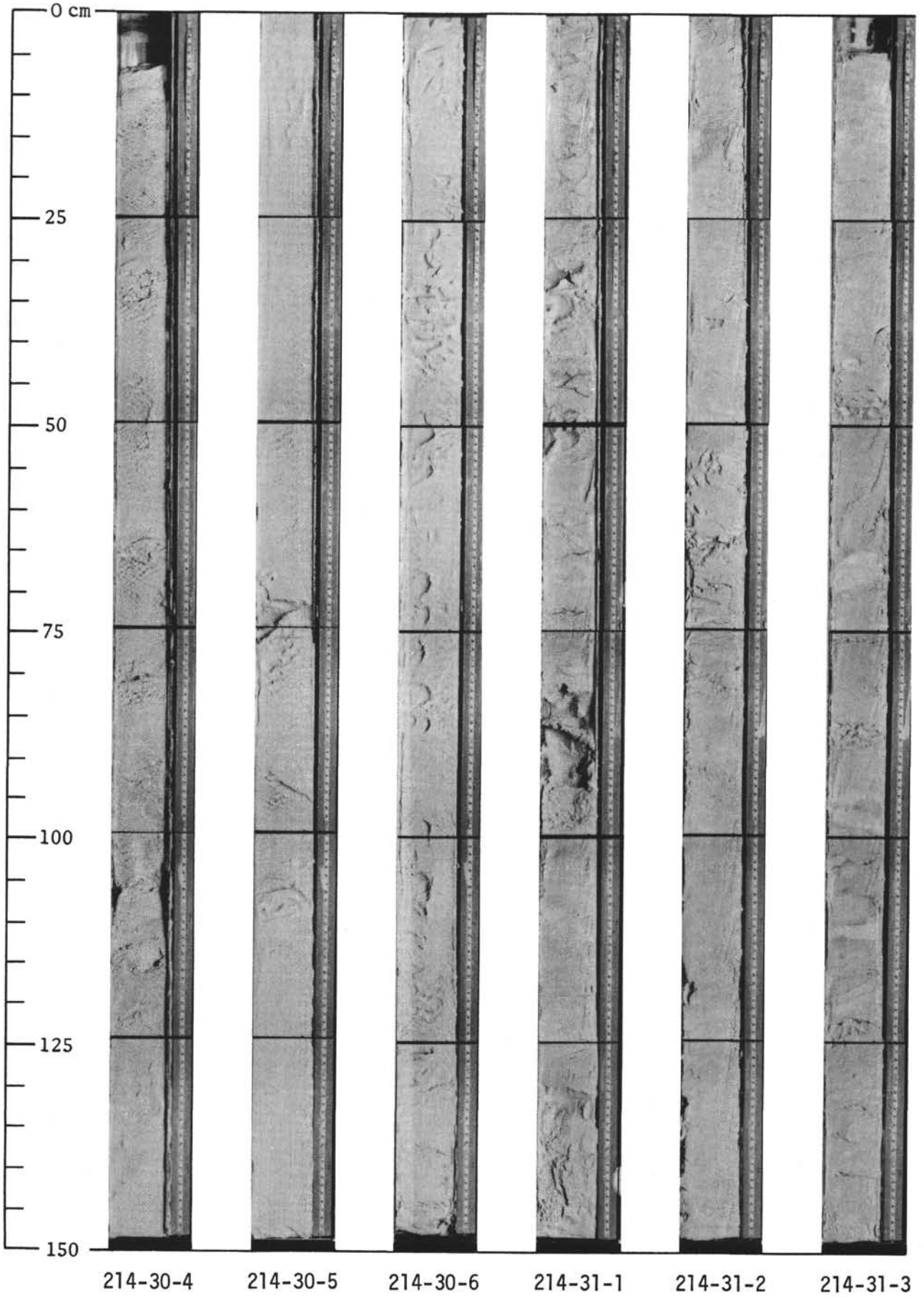
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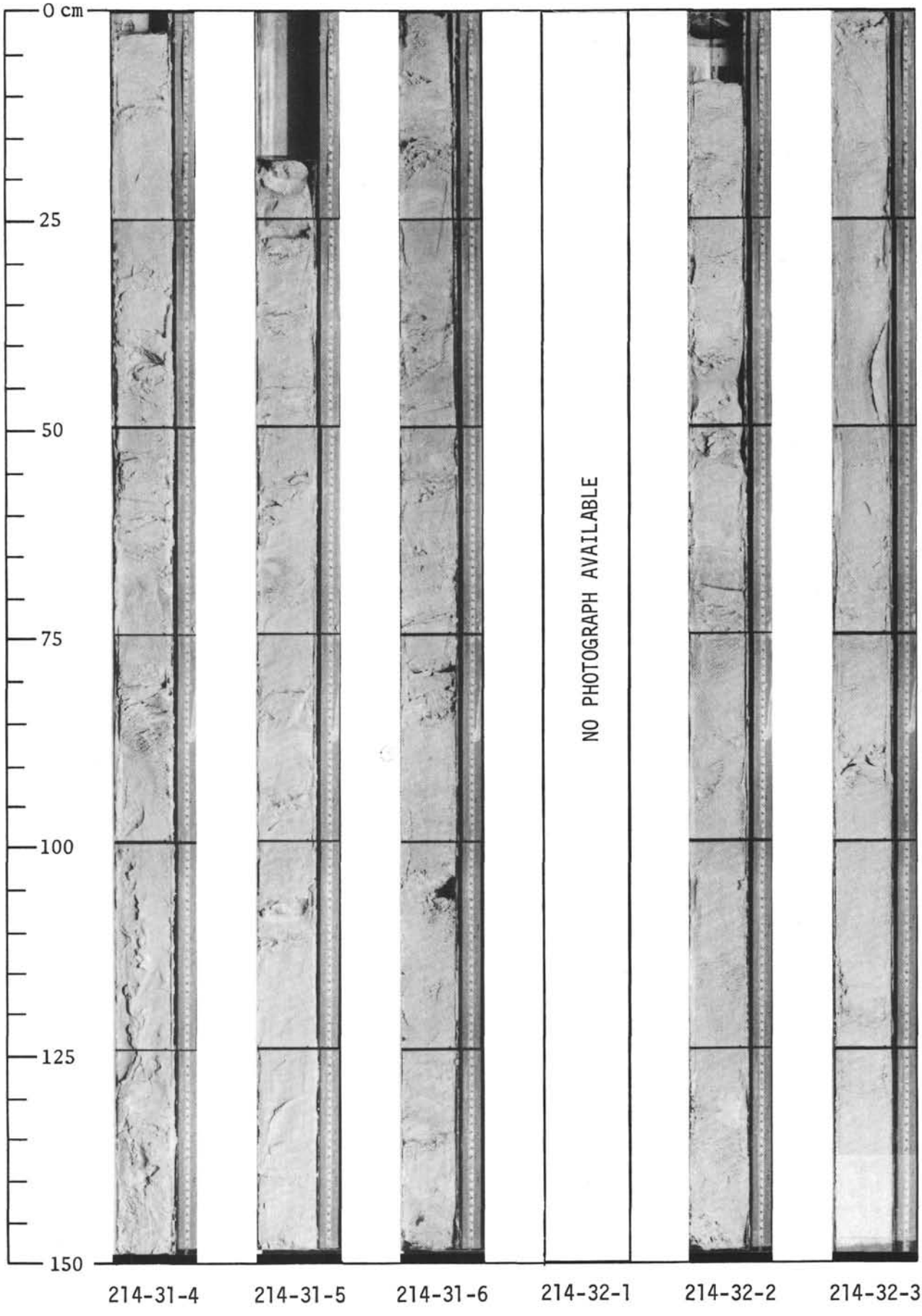
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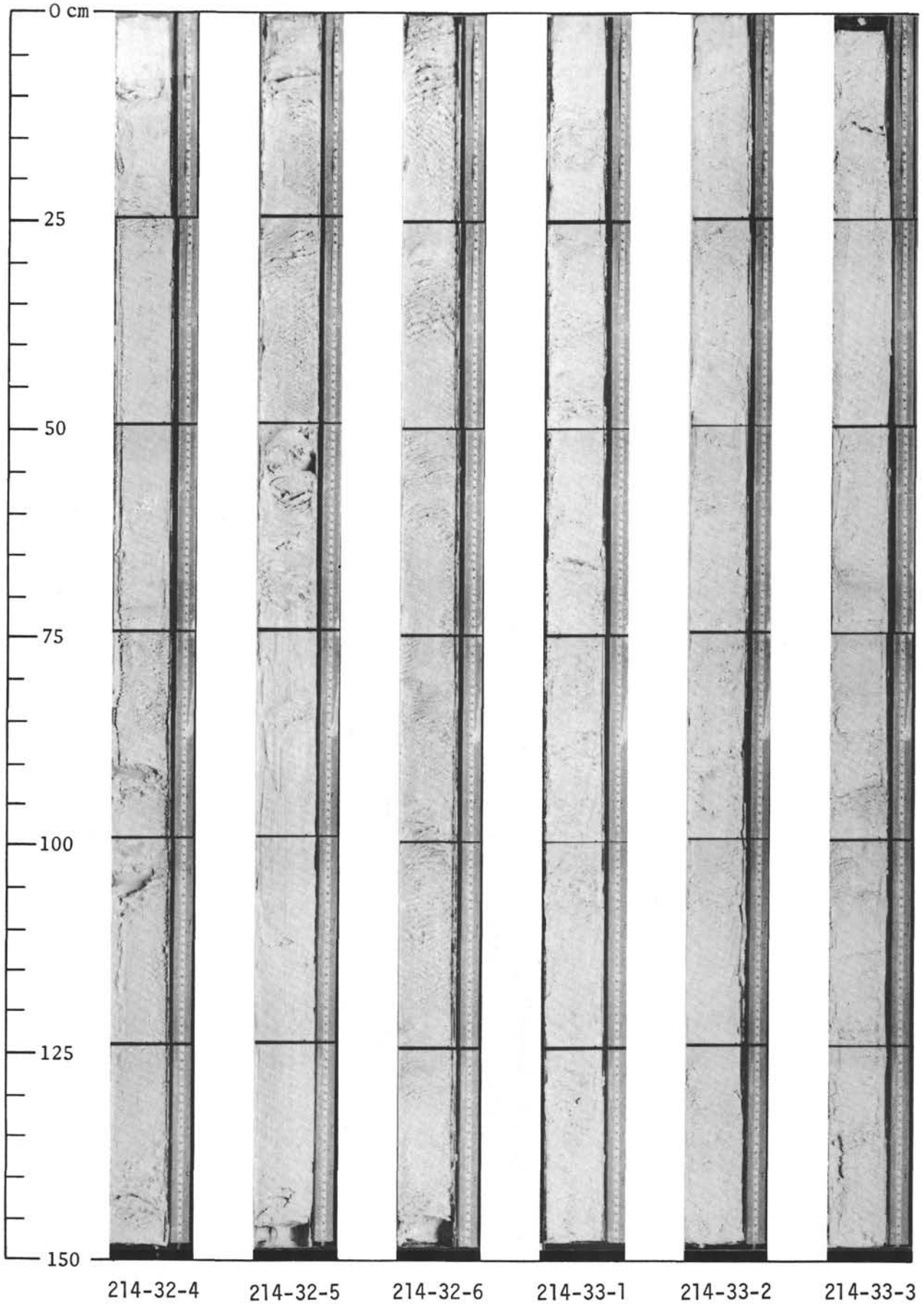
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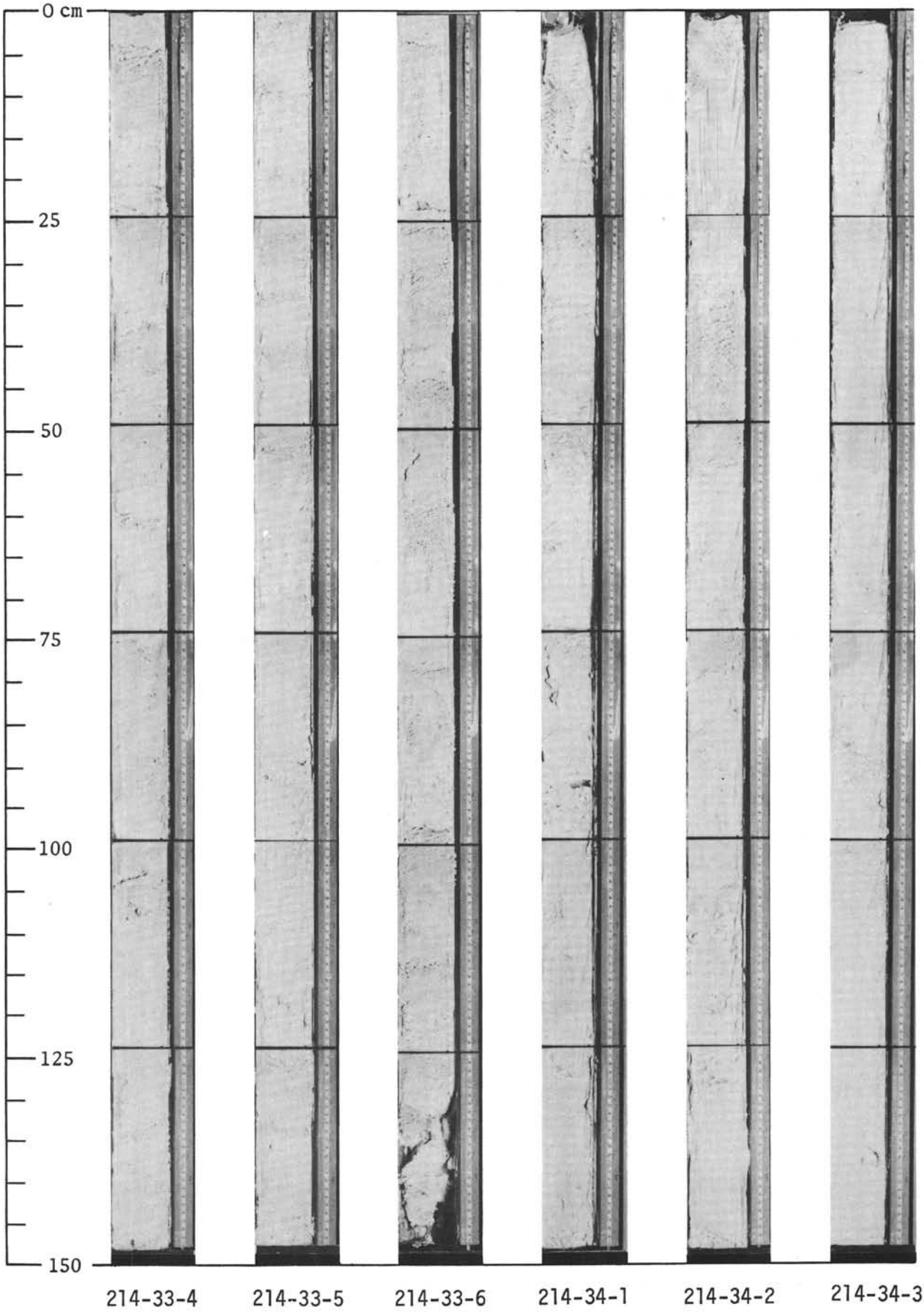
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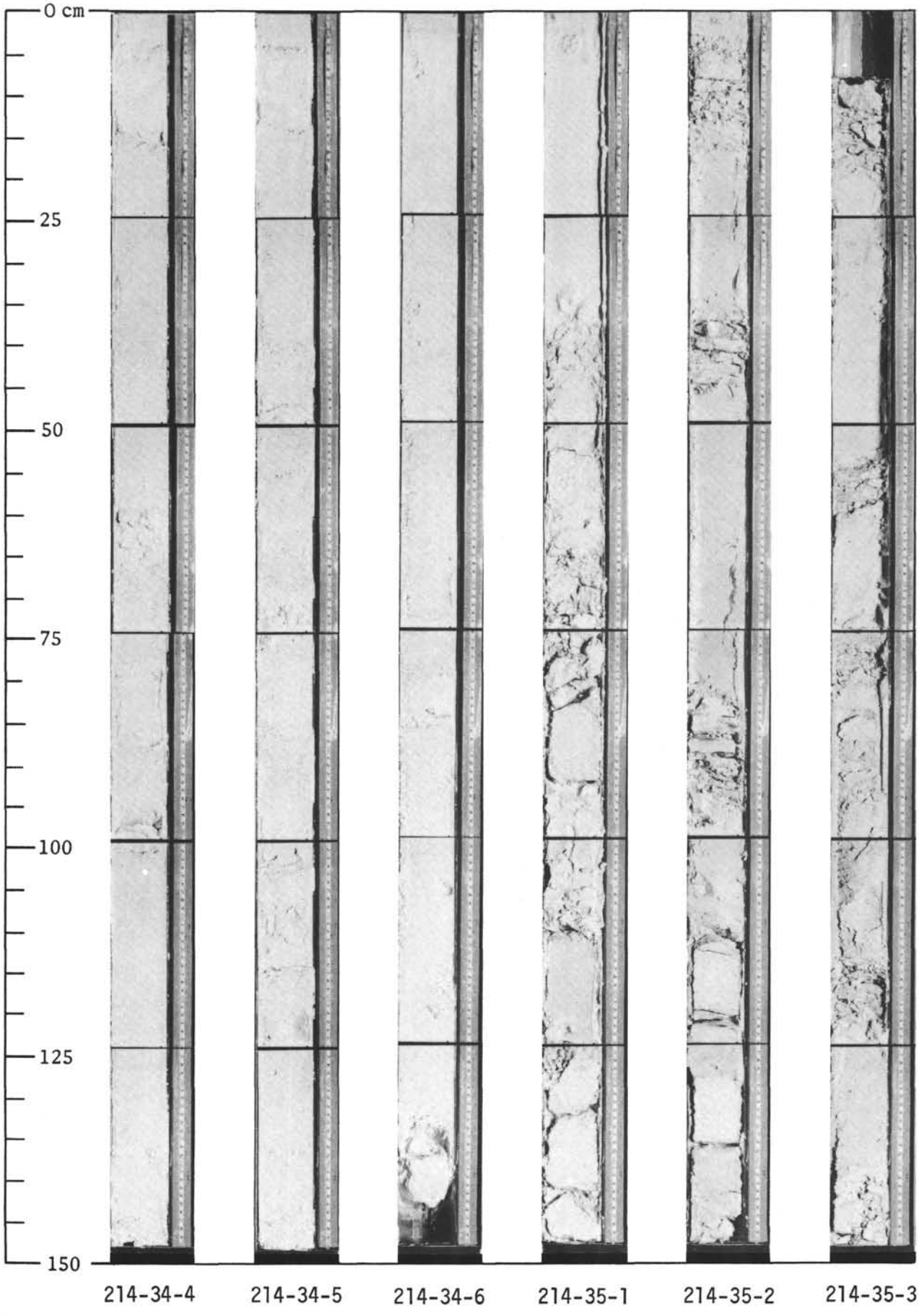
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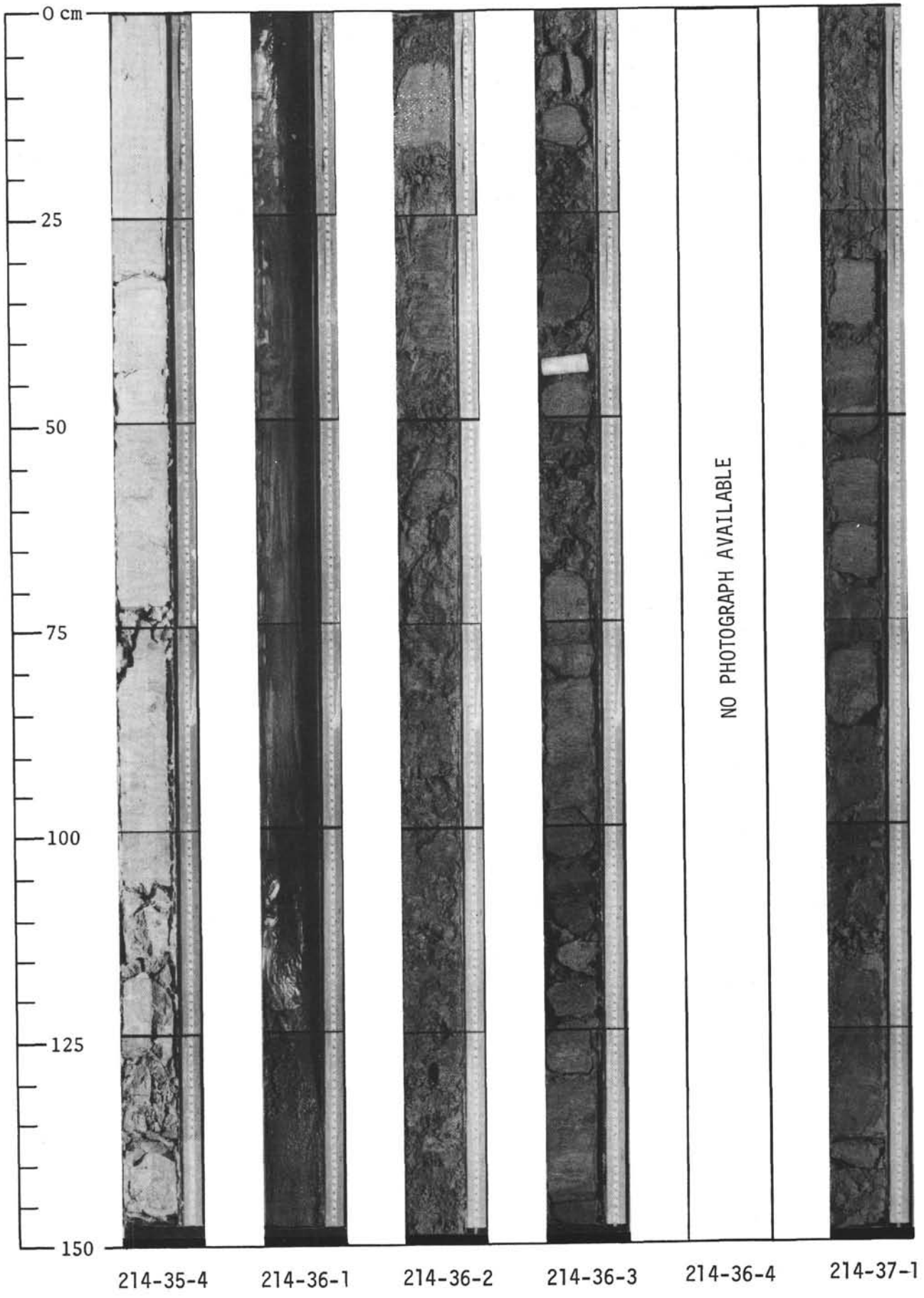
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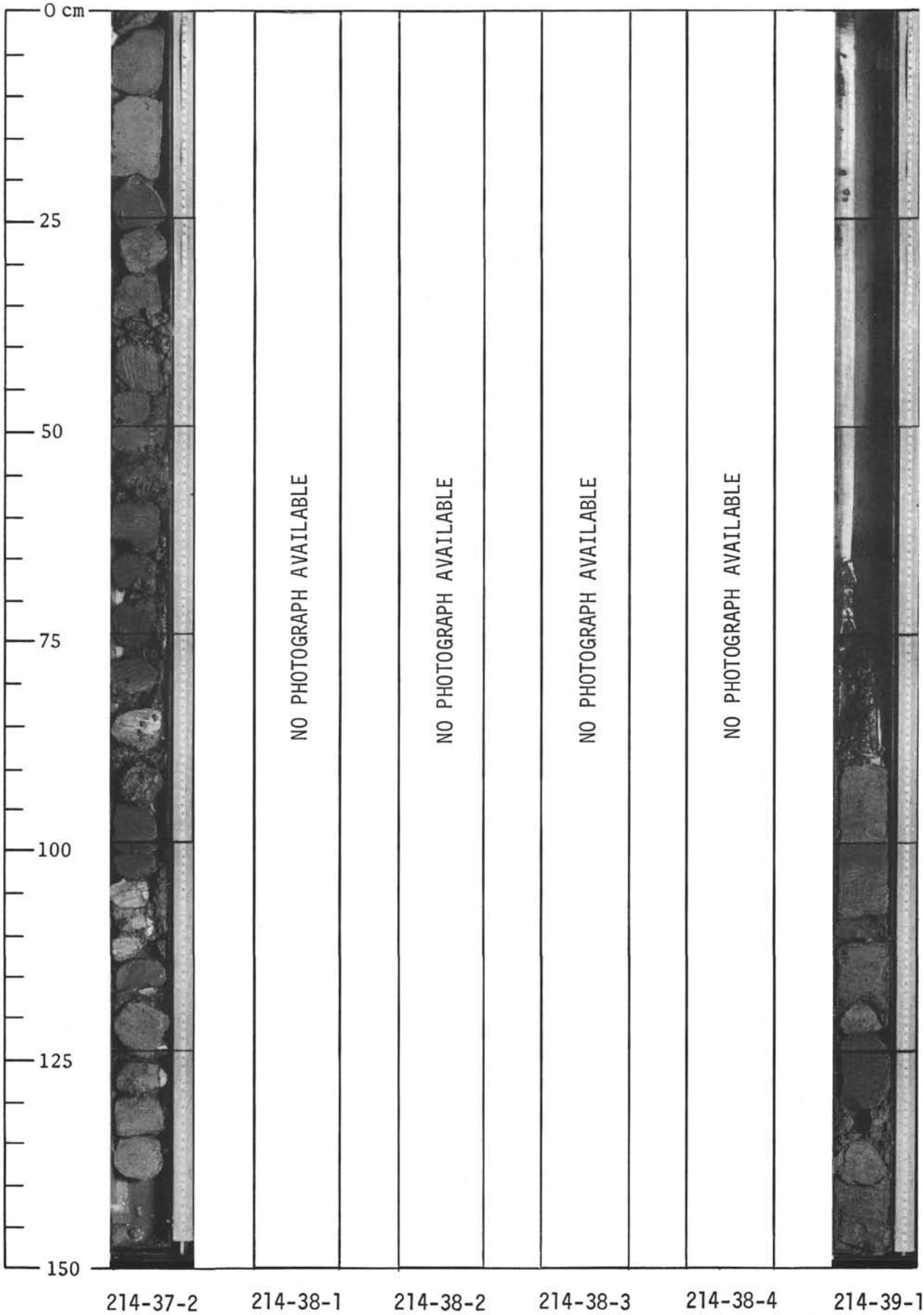
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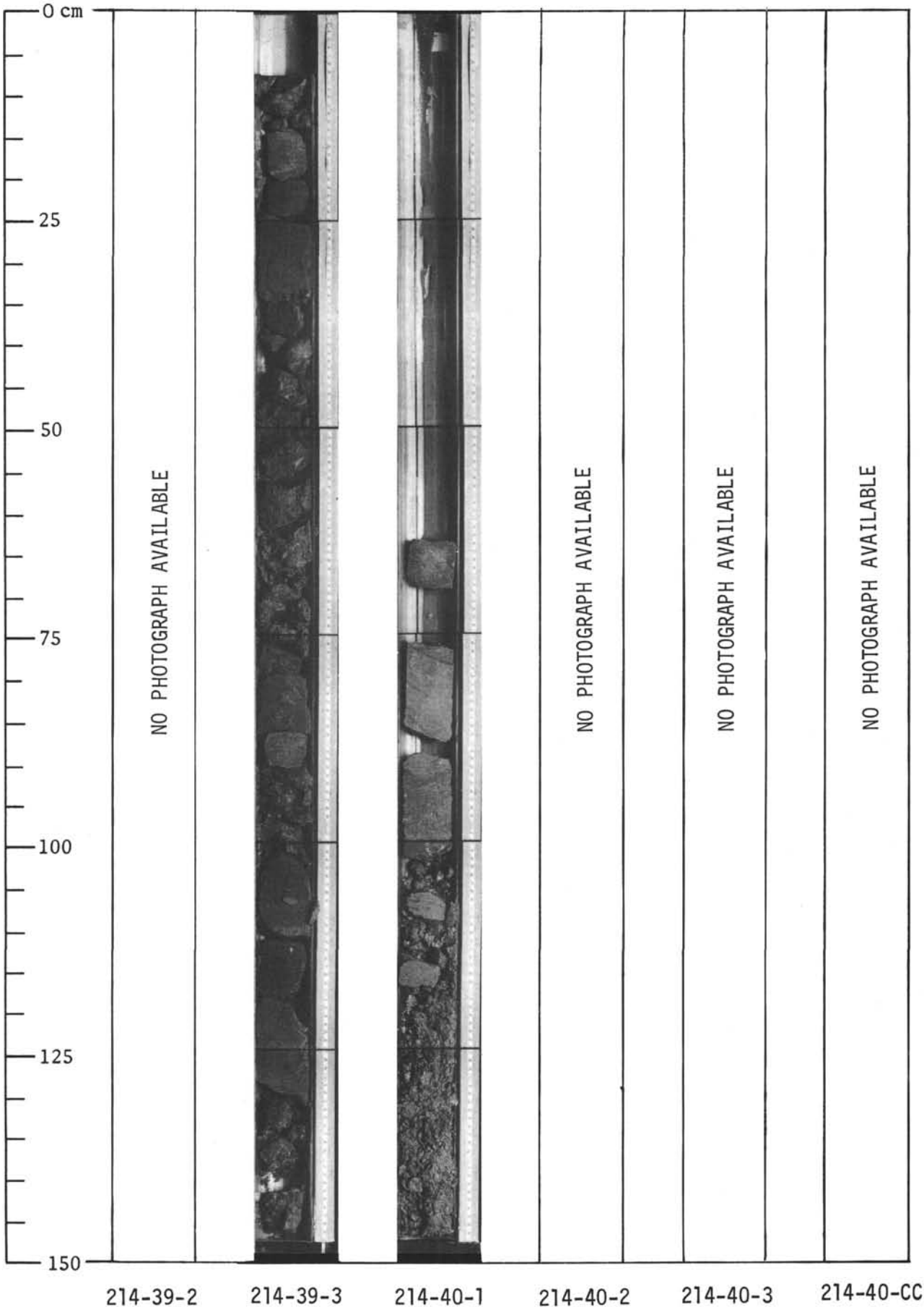
214-39-1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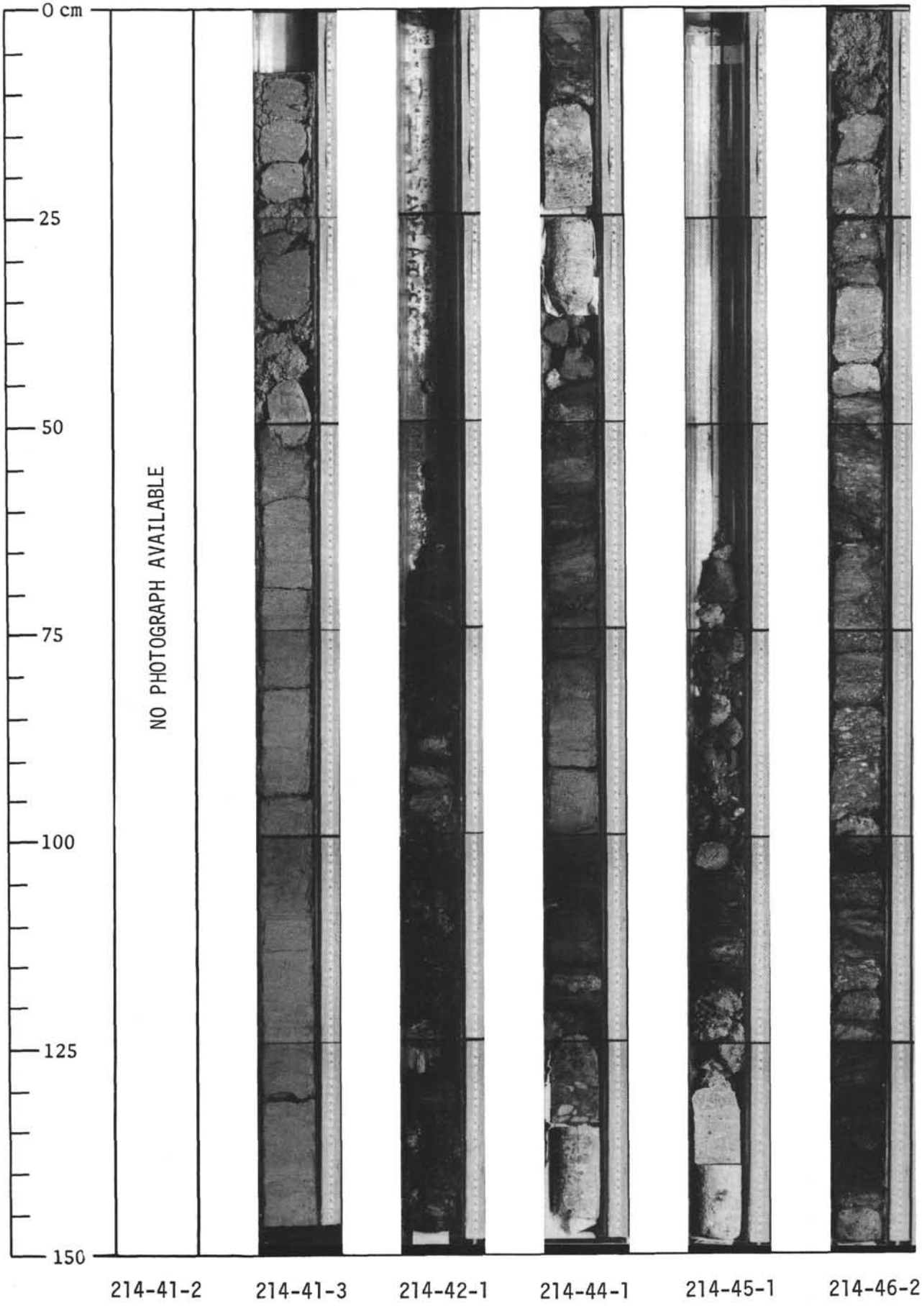
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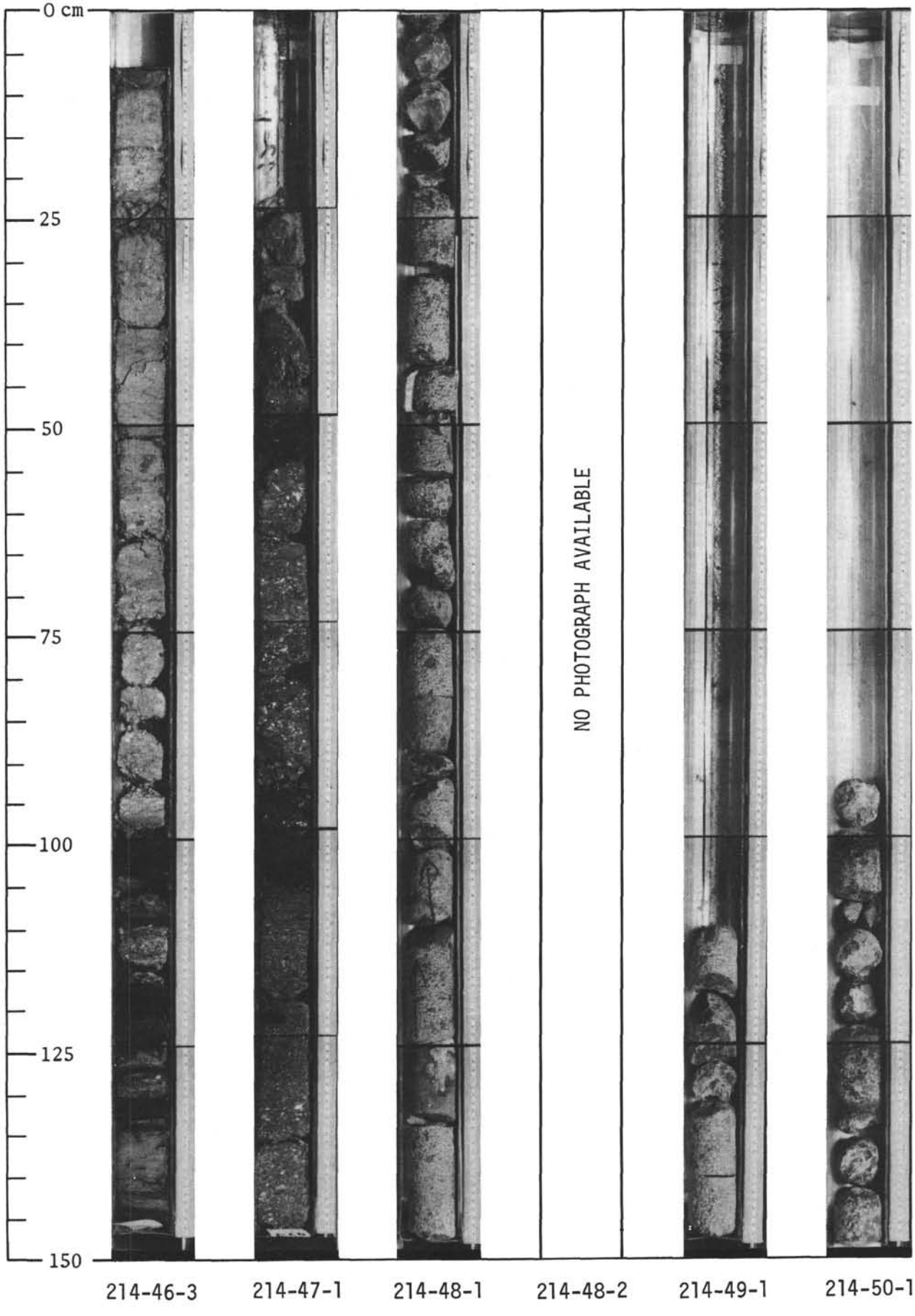
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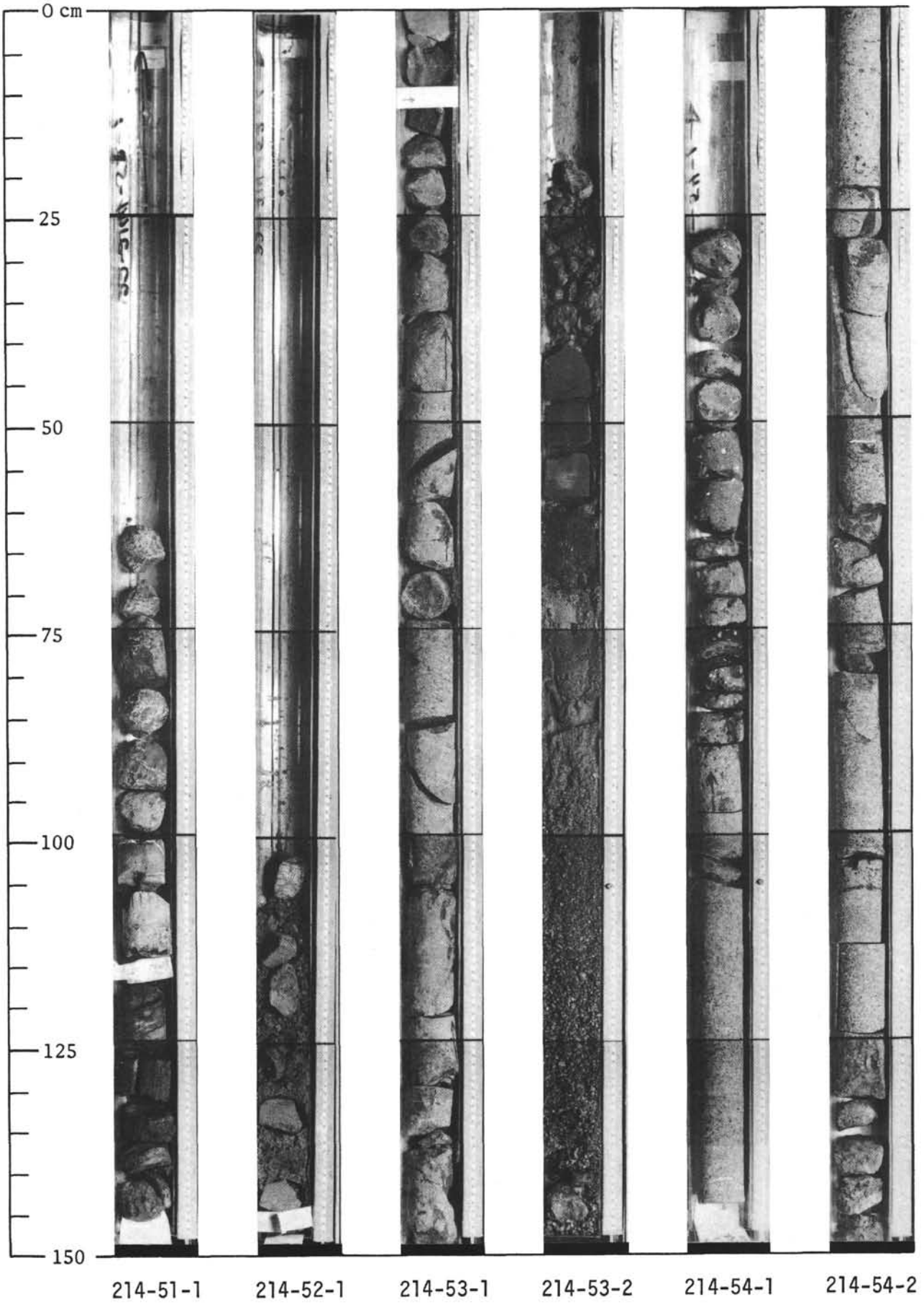
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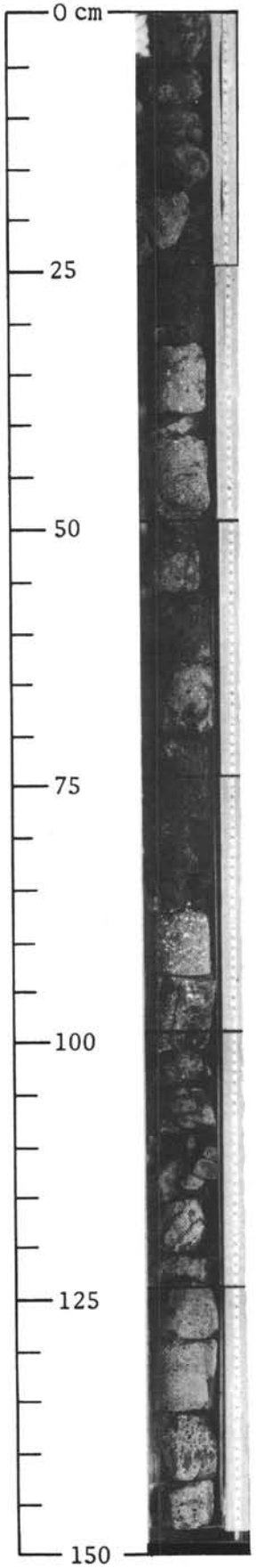

214-54-3