3. SITE 212

The Shipboard Scientific Party[1]

ABSTRACT

Site 212 was drilled in a water depth of 6243 meters in a small basin of partly ponded sediments in the deepest portion of the Wharton Basin. Sediment penetration was 521 meters. Four calcareous ooze to chalk units, from a few meters to 250 meters in thickness, dominate the stratigraphic section and range in age from Pliocene to Upper Cretaceous. Each calcareous unit, with the exception of the late Neogene, one which incorporates a minor hiatus, is of essentially uniform age throughout and contains residual and in part current-sorted fossil assemblages. Three nonfossiliferous zeolitic brown clays, averaging 30 meters thick, separate the calcareous units. The lowermost brown clay lies directly over a metabasalt which is intercalated with small quantities of recrystallized carbonate. Observations suggest that the brown clays represent normal deep-basin oceanic sedimentation below the carbonate compensation level. The chalk units, on the other hand, are postulated to be exotic to the area and to have been transported to the basin by slumping or bottom current activity from areas of nearby higher elevation. Age of oldest datable sediment at the site, 34 meters above basalt, is Upper Cretaceous. Age of the recrystallized carbonate in contact with the basalt is unknown; however, the extrapolated age of sediment immediately above basalt ranges between extremes of 85 to 110 m.y., depending upon the sedimentation rate chosen for the brown clay. The basal sediment is unlikely to be older than Cretaceous and most probably is close to the Early/Late Cretaceous boundary.

SITE DATA

Date Occupied: 27 Jan 72 (0113)

Date Departed: 1 Feb 72 (1645)

Time on Site: 123 1/2 hours

Position:
Lat 19°11.34′S
Long 99°17.84′E

Water Depth (to rig floor):
6240 meters (Echo sounding)
6243 meters (Drill pipe)

Penetration: 521 meters

Number of Holes: 1

Number of Cores: 39

Total Length of Cored Section: 366 meters

Total Core Recovered: 174.3 meters

Acoustic Basement:
Depth: 516 meters
Nature: Spilitized basalt

Age of Oldest Sediment: Upper Cretaceous

Basement: Spilitized basalt

BACKGROUND AND OBJECTIVES

After drilling Site 211 and obtaining early to middle Campanian sediments at the base of the section we decided to drop the alternate site to the north and to head due south to the deepest part of the Wharton Basin. In the oceans there is a strong correlation between increasing depth and increasing age of the crust. The purposes of Site 212 are to check the tectonic history of the basin mentioned in the Introduction and to date the oldest ocean crust in the Wharton Basin. We chose the deepest portion of the basin for Site 212 on the principle that the deepest crust is also the oldest.

The initial site at 19°11′S and 99°18′E was selected from a R/V *Robert Conrad* 9 airgun profile between Colombo and Freemantle. The profile showed a thick

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section of greater than 0.4 to 0.5 sec of sediments in a flat basin, of water 6240 meters deep. This basin is at the southern end of a general drop in topography from 5800 meters at 10°S, 100°E to 6250 meters at 19°30'S, 98°E with rough relief. It is in a zone where the magnetic anomalies are of low amplitude and is also 500 km to the southeast of what was thought to be anomaly sequence 31 through 33. On this evidence it was thought that the age of basement would be close to 90 m.y.

A generalized contour chart of the area of the site (Figure 1) shows that it is located in a flat basin some 40 km long and 20-30 km wide. It is also close, but to the east of the southern extension of a pronounced north-south topographic high which may mark an old north-south fracture zone. The oceanic crust to the east of the high is some 200 meters deeper. Thus, the oceanic crust on which Site 212 was situated may be slightly older than the crust on which the magnetic anomalies to the north and west are found. However, the age difference is probably no more than 10 m.y. A detailed chart of the area of the site has not been shown as there was no preliminary site survey. However, the prominent features in the incoming and outgoing airgun records can easily be seen on the generalized contour chart (Figure 1 from Carpenter and Ewing, in press). These records are very similar to those of the R/V *Robert Conrad.* They show that the site was selected in a basin with at least two prominent reflectors within the sediment and no very obvious acoustic or hard rock basement. Some 0.1 sec of stratified sediments overlie a thin transparent layer which in turn overlies alternating layers of stratified and transparent sediment. Hard rock basement was estimated at between 450 and 520 meters.

The principal objective at this site was to date basement. It was expected that the sediment would be predominantly brown clay. A secondary objective was to sample this sediment extensively for paleomagnetism and to use the measurements to determine possible paleolatitudinal shifts in this portion of the oceanic crust.

OPERATIONS

Site 212 was approached along a course of 164° in order to run in on a seismic profile collected by R/V *Robert Conrad.* The site was selected in a deep basin containing ponded sediments, approximately 40 nautical miles in extent along the seismic line of *Conrad 9.* A spar buoy was dropped overboard at the chosen site and the seismic gear secured, after which a Williamson Turn was made to approach the drilling locality. The beacon was dropped in a water depth of 6243 meters. This represents the deepest site occupied by *Glomar Challenger* to date.

Coring was planned on the basis of one core every 20 to 30 meters to within 100 meters of basement, with continuous coring of basal sediments to basement. The bit used was a Smith 93 CJS. A total of 39 cores was ultimately recovered with an overall recovery of 47.6% (Table 1).

No drilling or coring difficulties were encountered at this site, despite the fact that the longest drill string (6764 meters) to be suspended from a floating drilling vessel was employed. Hole condition in the stiff brown clays and nannofossil chalks, as well as the weather, were ideal for deep drilling. Spilitized basaltic basement was reached at a sediment depth of 516 meters and was cored for 5 meters to give 4.05 meter recovery.

LITHOLOGIC SUMMARY

Introduction

The sedimentary section penetrated at Site 212 is 516 meters thick; 366 meters were cored with a recovery of 174 meters. The sediments range in age from mid-Pliocene at the surface to Late Cretaceous (?) 34 meters above basalt. Basalt was encountered between 516 and 521 meters, at which depth the hole was terminated.

Nine lithologic units (Figure 2) are distinguished at this site as follows:

Unit	Depth Below Sea Floor (m)	Lithology	Age	Cores
1	0 to ~30	Interbedded nanno ooze and brown clay	Mixed Pliocene with some late Miocene	1-2
2	~30 to 166	Nanno ooze	Mixed late Miocene with some Middle Miocene	3-10
3	166 to 288.5	Nanno ooze and chalk	Early middle Miocene	10-14
4	288.5 to 318.5	Brown zeolitic claystone	?	15-18
5	318.5 to 402.5	Nanno chalk	Mid-Eocene	18-27
6	402.5 to 430.5	Brown zeolitic claystone	?	27-29
7	430.5 to 482.0	Nanno chalk	Late Cretaceous	29-35
8	482.0-516.0	Brown zeolitic claystone	?	35-38
9	516-521	Metabasalt with limestone inclusions		39

Description

Unit I-Interbedded Nannofossil Ooze and Brown Clay (Cores 1, 2)

An interbedded sequence of foraminifera-bearing nannofossil oozes and brown clays constitutes Unit 1. About 90% to 95% of the grayish orange oozes consist of calcareous nannofossils; foraminifera generally constitute less than 5% and decrease in abundance toward the base of the section. The brown clays contain a few percentage of nannofossils but consist principally of clay minerals and iron-oxide-rich clay aggregates. Pockets containing up to 75% of volcanic glass occur in the clay at a depth of 10 meters. Between 12.5 and 14.5 meters (Core 2), clay and ooze alternate in beds only 5 to 10 cm in thickness. Generally, the ooze over clay contacts are sharp, whereas clay over ooze contacts are gradational and characterized by lithologic mottling.

The lower boundary of this unit was picked arbitrarily at a depth midway between Cores 2 and 3—a vertical distance of 23 meters.

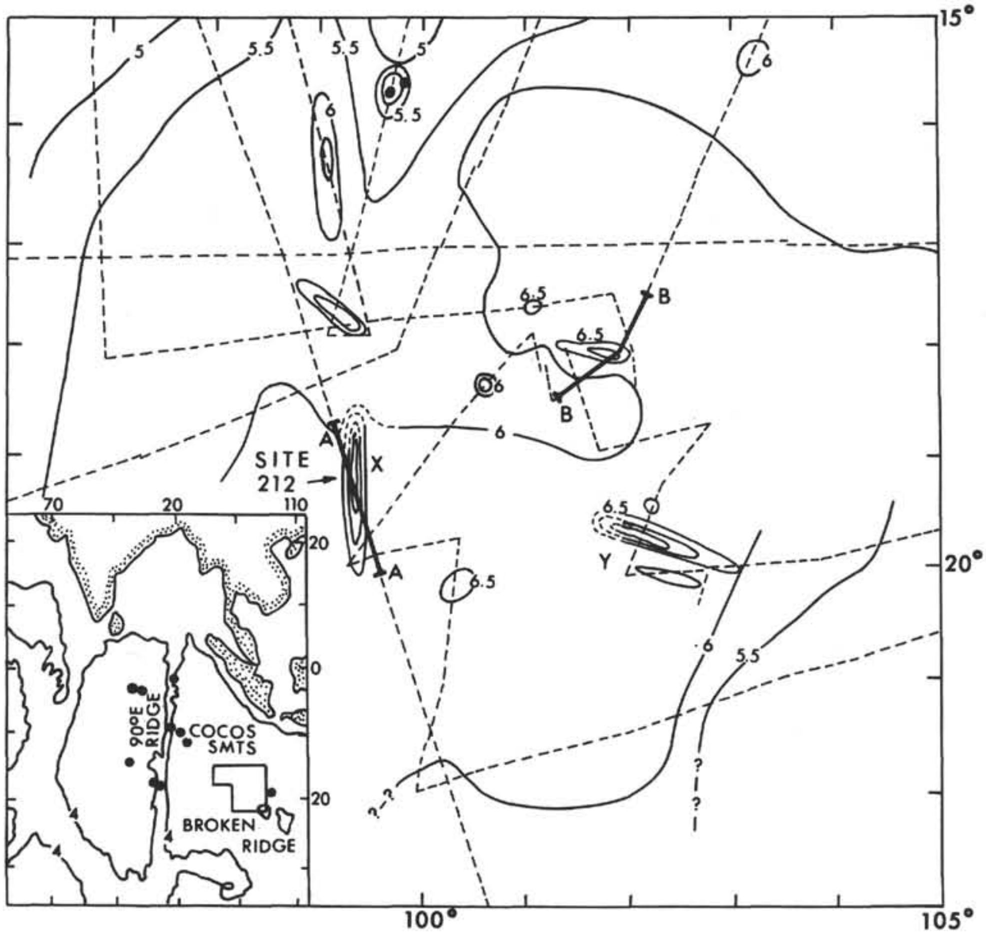

Figure 1. *Location of Site 212.*

Units 2, 3—Nannofossil Ooze and Chalk with Minor Brown Clay (Cores 3-15)

The difference between Units 2 and 3 is defined by age on the basis of the nannoplankton floras (see later), their lithologies being essentially similar. Unit 2 consists of fine-grained nannofossil ooze, but Unit 3 is mostly chalk becoming lithified at a depth of about 220 meters. The color changes gradually from very pale orange at the top to yellowish gray below, this trend being accompanied by an increase in clay content from 2% to 3% near the top to 25% to 20% in the lower part (confirmed by $CaCO_3$ analysis). Generally whole and fragmental foraminifera constitute only 1% to 2% of the total sediment; however, three zones of relative foraminifera enrichment are evident: between 60 and 70 meters where foraminifera range from 2% to 8%, between 250 and 262 meters, and between 288 and 288.2 meters where foraminifera make up about 40% to 50%, thus constituting nannofossil-foraminifera chalk. The foraminifera-rich zones contain less clay, and in the lower, more prominent zones, coarse silt-sized feldspar, rock fragments, and heavy minerals are present. All foraminifera-rich zones are laminated; however, lamination is best developed in Core 13 (250.0-259.5 meters) where the variety of sedimentary structures present include: (1) Well-developed horizontal lamination (alternating light and dark layers); (2) Rare cross-lamination; (3) Contorted lamination, some of which appears as small-scale flute or load casts. The lowermost nannofossil-foraminifera chalk immediately overlying Unit 3, appears graded and contains fragments of green claystone along with a trace of glauconite (Core 15).

Units 4, 6, 8—Brown Zeolitic Claystone (Cores 15-18, 27-29, 35-38)

Although these zeolitic claystone units vary from one another in detail, the number of lithologic similarities justifies considering them together. Each unit is on the order of 30 meters thick and encased either between chalk layers or, in the case of Unit 8, between chalk and basalt. The prevailing colors are moderate brown, dusky brown, or dusky yellowish brown. These colors often occur mottled together or as alternating bands, though in each case a part of the unit is uniformly dark brown and apparently manganese rich. Near the top of each unit occurs a layer of greenish to bluish gray claystone ranging from 5 to 30 cm in thickness. In Units 4 and 8 this layer occurs at the contact with the overlying chalk; in Unit 6 it is separated from the chalk by 40 cm of brown claystone.

TABLE 1
Coring Summary, Site 212

Core	Date (Jan/ Feb)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Length Cored (m)	Recovered (m)	Recovery (%)
1	28	0305	6243.0 6252.5	0-9.5	9.5	9.5	100
2	28	0515	6252.5-6262.0	9.5-18.0	9.5	7.5	80
3	28	0735	6284.0-6293.5	41.0-50.5	9.5	0.8	8
4	28	0940	6293.5-6303.0	50.5-60.0	9.5	1.5	17
5	28	1155	6303.0-6312.5	60.0-69.5	9.5	1.9	20
6	28	1400	6331.5-6341.0	88.5-98.0	9.5	0.2	2
7	28	1550	6350.5-6360.0	107.5-117.0	9.5	1.5	17
8	28	1805	6369.5-6379.0	126.5-136.0	9.5	5.5	60
9	28	2015	6379.0-6388.5	136.0-145.5	9.5	0.7	7
10	28	2245	6407.5-6417.0	164.5-174.0	9.5	9.0	100
11	29	0150	6436.0-6445.5	193.0-202.5	9.5	4.6	48
12	29	0505	6464.5-6474.0	221.5-231.0	9.5	6.5	67
13	29	0755	6493.0-6502.5	250.0-259.5	9.5	4.7	50
14	29	1015	6512.0-6521.5	269.0-278.5	9.5	8.0	84
15	29	1315	6531.0-6540.5	288.0-297.5	9.5	4.1	45
16	29	1530	6540.5-6550.0	297.5-307.0	9.5	2.7	33
17	29	1730	6550.0-6559.5	307.5-316.5	9.5	0.5	6
18	29	1935	6559.5-6569.0	316.5-326.0	9.5	3.6	40
19	29	2130	6569.0-6578.5	326.0-335.5	9.5	1.9	20
20	29	2335	6578.5-6588.0	335.5-345.0	9.5	0.9	9
21	30	0145	6588.0-6597.5	345.0-354.5	9.5	6.0	63
22	30	0340	6597.5-6607.0	354.5-364.0	9.5	4.7	49
23	30	0550	6607.0-6616.5	364.0-373.5	9.5	6.7	70
24	30	0845	6616.5-6626.0	373.5-383.0	9.5	0.5	5
25	30	1040	6626.0-6635.5	383.0-392.5	9.5	9.5	100
26	30	1230	6635.5-6645.0	392.5-402.0	9.5	9.5	100
27	30	1420	6645.0-6654.5	402.0-411.5	9.5	6.2	65
28	30	1615	6654.5-6664.0	411.5-421.0	9.5	4.5	50
29	30	2030	6664.0-6673.5	421.0-430.5	9.5	1.6	20
30	30	2315	6673.5-6683.0	430.5-440.0	9.5	3.4	37
31	31	0145	6683.0-6692.5	440.0-449.5	9.5	8.6	90
32	31	0425	6692.5-6702.0	449.5-459.0	9.5	9.2	97
33	31	0710	6702.0-6711.5	459.0-468.5	9.5	9.2	97
34	31	1015	6711.5-6721.0	468.5-478.0	9.5	3.3	34
35	31	1200	6721.0-6730.5	478.0-387.5	9.5	6.7	70
36	31	1515	6703.5-6740.0	487 5-497.0	9.5	1.0	10
37	31	1750	6740.0-6749.5	497.0-506.5	9.5	1.4	16
38	31	2030	6749.5-6759.0	506.5-516.0	9.5	2.1	23
39	1 Feb.	0040	6759.0-6764.0	516.0-521.0	5.0	4.0	80
Total					366.0	173.7	47.6

Note: Echo sounding depth (to drill floor) = 6240 meters;
drill pipe length to bottom = 6243 meters.

Compositionally these units range from zeolite-bearing iron-oxide-rich claystone to clay zeolitites (>50% zeolite). Other persistent constituents, usually in concentrations of less than 5%, include: opaques (Mn micronodules), volcanic glass, and a significant fraction of very fine ($<4\mu$) iron-oxide spherules (probably goethite) and equally fine, high relief, nonopaque grains of heavy minerals. The content of zeolite and the degree of crystalinity generally increase with depth within each unit; however, these are not uniform trends.

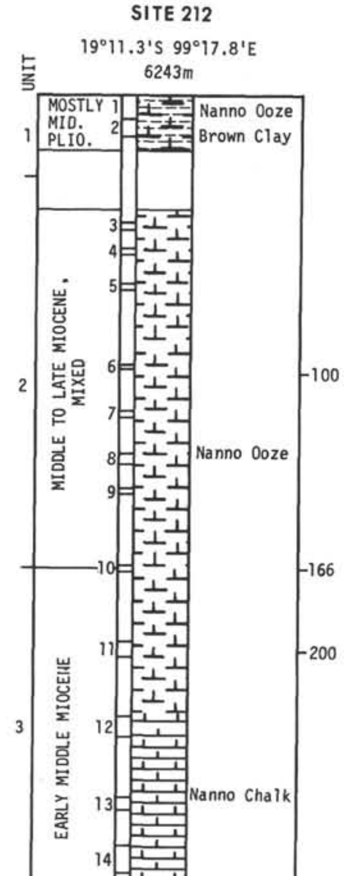

Figure 2. *Lithologic units at Site 212.*

One prominent feature which differentiates the claystones of Units 6 and 8 from Unit 4 is the occurrence of thin bands (<10 cm) of pale olive claystone surrounded by "halos" of reddish brown, iron-oxide-enriched claystones. These are best developed in Core 28 (see core photos and core summary log).

Unit 5—Nannofossil Chalk (Cores 18-27)

Fairly uniform nannofossil chalk comprises the bulk of Unit 5. From examination of smear slides onboard the ship, the $CaCO_3$ content was estimated at more than 90%, but the $CaCO_3$ analyses show it to be closer to 80%. The unit ranges in color from white near the top to light gray or pinkish gray at the base. A trace of siliceous microfossils (rads, sponge spicules, and diatoms) is evident in the upper chalk. The siliceous component increases to a maximum of about 12% at a depth of 347 meters (Core 21) and tails off again to trace amounts in the lower part of the unit. Micarb (see Explanatory Notes, Chapter 1) ranges between 1% and 5%, and a trace (<1%) of glauconite persists throughout the unit.

A green, zeolite-rich claystone bed (20 cm thick) occurs in Core 23. Immediately above and below this bed, the chalk is conspicuously laminated and contains fragments of green claystone.

Unit 7—Nannofossil Chalk (Cores 29-35)

Clay-bearing to essentially pure (>95% nannofossils) nannofossil chalk constitutes the bulk of Unit 7. This unit varies in color from grayish orange pink in the upper 13 to 14 meters to light olive gray with abundant mottles of greenish gray in the lower part. Volcanic glass and manganese micronodules comprise a significant admixture to the nannofossils in the upper 2 to 3 meters of the unit. Small whole foraminifera and foraminiferal fragments gradually increase from about 1% to 2% in the upper section to a maximum of 30% in the lower 3 meters, thus yielding a gross textural grading to the unit. This increase is accompanied by color banding (lamination?) and the presence of fragments of green claystone similar to that immediately underlying this unit. Micarb and recrystallized foraminifera increase from a few percent in the upper section to 10% near the base.

Unit 9—Basalt with Recrystallized Limestone (Core 39)

Unit 9 consists of partially weathered, altered basalt with altered drilled margins of chlorite bearing basaltic glass (<10 cm thick).

The inner part of the metabasalt is phaneritic containing phenocrysts and microphenocrysts of partially altered plagioclase set into a medium coarse-grained matrix having intersertal texture. The interstices between the altered plagioclase laths are filled with chlorite, pyroxene granules, dark brown mesostasis, and calcite. Chlorite, calcite, pumpellyite, and occasional epidote are often included in both the plagioclase microphenocryts and the matrix plagioclase.

The metabasalt changes its textural features near the basaltic glassy zone becoming phaneritic with a finer-grained and more cryptocrystalline matrix. This finer-grained metabasalt zone is also more weathered and grades into a chloritized glassy zone.

The chloritized glassy zone consists of palagonite, brown glass, and chloritic aggregates and smectite. At least seven different chilled margins with gradual grain-size and textural variations were noticed within the recovered core.

These variations suggest the occurrence of pillowed structure. Trapped between the pillow lavas there are some limestone fragments consisting almost entirely of recrystallized calcite and very little plagioclase. In places near the contact of the rock unit, angular fragments of chloritized glass and fragments of crystalline metabasalt are incorporated in the carbonate rocks. Traces of fossils were noticed. The content of trapped limestone material decreases with depth in the core.

Discussion

The most conspicuous problem in interpretation of the sedimentary section at this site pertains to the reason (or reasons) for alternation of calcium-carbonate-rich and noncalcareous sediments. At least two plausible interpretations are obvious: (1) the calcium carbonate compensation depth has fluctuated repeatedly relative to the bottom depth at this site; and (2) the site has remained continuously below the $CaCO_3$ compensation depth, but carbonate sediments were flushed in rapidly from shallower water on several occasions and thus preserved.

Several features of the recovered sediments which bear on this problem and seem to favor the second interpretation include the following:

1) The similarity of the claystone units at various levels within the section.

2) Presence of occasional coarser foraminifera-rich layers which grade upward into finer nannofossil chalks. Relatively coarse terrigenous material accompanies the foraminifera-rich layers in at least one case.

3) Lamination and cross-lamination in the foraminifera-rich zones indicative of substantial bottom current activity.

4) In all cases where chalk is observed overlying claystone the contact is sharp. In contrast, in two observable cases, clay over chalk contacts are diffuse and gradational, arguing for gradual return from somewhat catastrophic carbonate depositing intervals to more quiescent clay accumulation. Concentration of manganese and clay in the upper part of the Cretaceous chalk suggests a gradual slowing of carbonate deposition, though the actual contact with overlying clay was not observed.

5) Incorporation of claystone clasts in the chalks immediately above the contact zones.

6) Persistent (though minute) fraction of glauconite throughout the chalk of Lithologic Unit 4 and in the lower foraminifera nannofossil chalk of Lithologic Unit 2.

7) Small-scale interbedding of brown clay and ooze which is incompatible with a slowly fluctuating process such as a change in compensation depth.

CHEMICAL PROPERTIES

Twenty-three cores were sampled at this site, and a list of the results obtained is given in Table 2. Insofar as was practical, minicores or generous portions from the core-catcher material were taken from every core when spot coring and from alternate cores when continuously coring. Principal lithologic units were sampled whenever they occurred.

All samples were warmed to ambient room temperature prior to making punch-in pH and resistivity measurements. Punch-in pH measurements were made on only three samples at the top of the hole owing to the stiffness of the clays and impenetrability of the chalks. Direct readings of resistivity was attempted on all of the minicores and some

TABLE 2
Shipboard Chemistry Results

Core, Section, Interval (cm)	pH	Water (%)	Porosity (%)	Density (gm/cc)
2-1, 42	–	38	64	1.68
2-1, 110	–	57	80	1.40
2-3, 0	6.9	58	86	1.48
2-3, 109	–	53	79	1.50
5, CC	7.4	–	–	–
8-3, 0	–	31	59	1.87
8-3, 2	–	27	48	1.77
9-1, 110	–	29	56	1.89
10-1, 30	–	25	–	–
10-4, 100	–	26	–	–
10-5, 0	7.4	25	49	1.95
10-6, 100	–	26	45	1.71
11-1, 144	–	15	29	1.91
11-3, 0	6.9	25	–	–
11-4, 143	–	23	–	–
12-1, 141	–	22	–	–
12-4, 0	6.9	23	–	–
13-2, 7	–	32	(darker material)	
13-2, 15	–	29	(lighter material)	
13-3, 0	6.9	32	–	–
14-5, 0	6.8	21	–	–
15-2, 11	–	35	54	1.58
15-3, 0	7.0	41	–	–
16-1, 150	–	31	–	–
16-2, 0	6.9	32	–	–
18-2, 81	–	32	38	1.19
18-3, 140	7.2	–	–	–
20, CC	6.7	27	–	–
20-1, 126	–	27	–	–
21-3, 0	6.9	25	–	–
22-2, 139	–	26	–	–
22-3, 0	6.8	25	–	–
23-1, 83	–	25	–	–
23-3, 0	6.9	–	–	–
25-5, 0	6.7	15	–	–
27-4, 16	–	31	53	1.72
27-5, 0	7.0	30	–	–
28-1, 34	–	28	–	–
29, CC	6.7	16	–	–
29-1, 64	–	29	52	1.80
31-1, 102	–	17	–	–
31-5, 0	7.0	–	–	–
33-2, 68	–	10	–	–
33-3, 0	6.5	13	–	–
35-2, 0	6.8	14	–	–
36-1, 108	–	26	–	–
36-6, 46	–	–	–	–
37, CC	6.8	–	–	–
37-1, 43	–	27	–	–
38-2, 32	–	31	–	–

large pieces taken from the core catcher. This procedure was successful on the hard sediments only when it was possible to drill holes for inserting the electrodes without causing the material to break into pieces.

Samples from the top of the hole were squeezed to obtain pore fluids as soon as practical after warming to room temperature. Later, chalk samples were held for increasingly longer periods before squeezing was started owing to the difficulty in getting pore water out of these drier and harder sediments. All the chalks were squeezed in the 4.25-cm Manheim squeezer, and multiple squeezings were necessary in all cases. The driest material encountered was in Sample 18-3, 140-150 cm, which was squeezed in six portions and yielded only 6.8 ml of pore fluid. In nearly all instances, pore water recovered from an individual portion of sediment represented the amount which could be extracted in a maximum of 10 min of applying pressure. In most instances a total of 10 to 12 ml of interstitial water was obtained.

The pH values of the pore water measured with the flow-through electrode reach a maximum of 7.41 in the Core 10 sample (~170 meters) and a minimum of 6.54 in Core 31 (~460 meters). Between Cores 11 (193 meters) and 37 (506 meters) the pH averages out to 6.86 with the most notable departures occurring in Cores 18 and 31. The somewhat regular alternation of plus and minus deviations from the average, a "sawtooth" effect, seen in this profile may be partly attributable to sample handling, particularly the necessity for multiple squeezings and prolonged squeezing time.

Pore water salinities, estimated with a Goldberg refractometer, show only small departures from ocean water values and are more or less randomly scattered between 34.4 °/oo and 36.3 °/oo.

BIOSTRATIGRAPHIC SUMMARY

General

The sediments recovered at Site 212 yielded calcareous as well as siliceous fossils in some parts of the section. Planktonic foraminifera were recovered in Cores 1 through 15, but for the most part these are small forms ill suited for biostratigraphy. Useful Miocene assemblages were recovered in Cores 6, 7, 10, 11, 13, and 15. Below Core 15 no foraminifera were recovered down to Core 29, except for some few small planktonics in Core 23, which, however, are not useful. Cores 29 through 36 yielded a rich assemblage of very small specimens, including unusually large numbers of heterohelicids.

Coccoliths and associated calcareous nannofossils are present in profusion where the sediment is calcareous. They are, for the most part, useful for dating the sediments, although in several instances only broad age assignments are possible. A marked lack of species diversity is apparent from Core 10 on down, and this also coincides with poor preservation and fragmentation of most of the nannofossils. It is inferred that solution has removed all but the most resistant species from the assemblage, and that which remains may be termed properly a residual thanatocoenose.

Radiolaria are sparsely represented in Cores 1 and 3 and indicate a late Neogene age, in agreement with the calcareous fossils with which they occur. A broader assemblage is present in Cores 19 through 23 and indicates an early middle Eocene age. As the associated nannofossils indicate a slightly younger age, it is likely that the Radiolaria have been redeposited.

Foraminifera

Cores 1 to 4 inclusive contain numerous minute globigerinids and globorotaliids; these are abundant in Core 5 together with fragments of larger tests. Cores 6 to 12 are the same, although some useful larger specimens were recovered from Cores 6, 7, 10, and 11. The occurrence of abundant tiny planktonics over this interval would seem to indicate rather consistent size fractionation during some process of redeposition. There are also some indications of mixing: species expected to have nonoverlapping ranges are found together.

Globorotalia conomiozea in Cores 6 and 7 indicate a high upper Miocene age (N.17 or higher), although the species seem to occur also (more rarely) in Cores 10 and 11. *G. siakensis* and *G.* cf. *peripheroronda* are evidence for a mixing-in from older assemblages. Core 13 is different from the others as it contains a foraminiferal sand; again, mixing is suggested by the association of Oligocene species (*Globorotalia opima, Globigerina prasaepis*) with middle Miocene (*Globigerina nepenthes*; N.14 or younger).

The dominant globorotaliids are *Globorotalia conomiozea* (in the upper Miocene) and *G. miozea* with its variant *conoidea.* These forms are well known in New Zealand and this, together with the virtual absence of typical tropical globorotaliids and other genera, suggests that the middle and upper Miocene feeding the section at Site 212 was "extratropical" in character, i.e., closer in its appearance to assemblages from New Zealand and southern Australia, and unlike the Miocene known from lower latitudes.

Core 15 contains a poor fauna which seems probably to be in situ. Single specimens of a few species indicate a lower Miocene age.

Cores 29 (lower calcareous part) to 35 contain a very distinctive foraminiferal assemblage characterized by: (1) minute size, all passing through the 100-mesh sieve (150μ); (2) abundance of planktonics, some calcareous benthonics; (3) no biostratigraphic change through the section; (4) seemingly no juvenile *Globotruncana* or other forms characterizing assemblages from warmer water masses; and (5) a distinctly greater proportion of biserial tests of heterohelicids than would be expected in a "normal open marine" planktonic foraminiferal assemblage.

As in the Miocene, the restricted size range indicates mechanical fractionation during redeposition. However, no mixing of different faunas is discerned (the common forms are long ranging). The apparent absence of *Globotruncana* suggests perhaps that the original deep-water assemblage was extratropical. Selective solution would explain neither the taxonomic bias nor the size bias. The abundance of heterohelicids is unexplained; Pessagno (1969) has suggested that they might indeed be less common in abyssal pelagic deposits, but the evidence of Douglas (1971) does not support this.

The agglutinated assemblage in Core 36 is of deep-water origin. It is quite different in overall character from the assemblage in the Upper Cretaceous at Site 211.

A specimen in a thin section from Core 39 (Section 1, 143 cm) is of a calcareous-perforate foraminifera, quite possibly a buliminid. A Cretaceous (rather than Jurassic) age is quite likely.

Nannofossils

Calcareous ooze or chalk rich in nannofossils constitutes the bulk of the sediment recovered at Site 212. The age of the calcareous sediments ranges from late Neogene to Late Cretaceous, the latter being separated from basement by several meters of red clay.

On the basis of calcareous nannofossils, the section penetrated at this site can be divided into several distinct units. Three of these units are brown clay devoid of nannofossils; five units are calcareous ooze or chalk. The lowermost unit consists of basalt and recrystallized limestone without identifiable fossils. From top to bottom the eight upper units have the following position and age relationships.

Unit 1 (Cores 1 and 2): mixed Pliocene calcareous ooze interbedded with brown clay in Core 2 and containing some late Miocene and mid-Tertiary contaminants.

Unit 2 (Core 3 to Core 10, Section 2): mixed late Miocene calcareous ooze with some middle Miocene and mid-Tertiary contaminants.

Unit 3 (Core 10, Section 2 through Core 15, Section 1): early middle Miocene chalk (*Sphenolithus heteromorphus* Zone) with sparse but consistent Eocene-Oligocene contaminants. No significant age difference seems discernible from the top to the bottom of this thick chalk. The span is 17 to 15 m.y.

Unit 4 (Core 15, Section 1 through Core 18, Section 2): brown clay barren of nannofossils.

Unit 5 (Core 18, Section 3 through Core 27, Section 1): middle Eocene chalk. The age of this chalk is within the time interval of the earliest occurrence of *Reticulofenestra umbilica* about 47 m.y. and the last occurrence of *Chiasmolithus grandis* about 43 m.y.

Unit 6 (Core 27, Section 1 through Core 29): brown clay barren of nannofossils.

Unit 7 (Core 30, CC through Core 35): Upper Cretaceous chalk. This last unit is an enigma as to precise age. It consists almost exclusively of long-ranging Upper Cretaceous species which indicate Santonian or younger age. Sporadically throughout this unit *Nephrolithus frequens* is encountered, however, and this species indicates a late Maastrichtian age.

Unit 8 (Core 36 through Core 38): brown clay barren of nannofossils.

Units 1 and 2 contain moderately diverse oceanic assemblages of nannofossils with about the normal number of species present and the specimens, for the most part, are well preserved. The mixed nature of the nannofossil assemblages in these two units suggests that both were redeposited probably from a turbidity current.

The Unit 3 assemblage is dominated by one species, *Cyclicargolithus floridanus*, and much of the calcareous material consists of unidentifiable fragments of coccoliths and other nannofossils. The marker species *Sphenolithus heteromorphus*, though rare, is consistently found in this chalk. In addition, several Eocene-Oligocene species are found throughout Unit 3, indicating that some transport and redeposition occurred in the region at this time.

Units 5 and 7 are in overall aspect similar to Unit 3 in that the assemblages are dominated by a relatively small number of species, and much of the calcareous material consists of fragmented nannofossils. This paucity of species in these last two units is even more notable as the intervals they represent (middle Eocene and Upper Cretaceous, respectively) elsewhere yield some of the most diverse assemblages known. It seems reasonable, therefore, that many species have been removed through selective solution, and only the more resistant have been preserved. Units 5 and 7 differ from Unit 3 in one significant aspect: they contain no older redeposited species.

It is also noteworthy that although Units 1, 2, 3, 5, and 7 consist of substantial thicknesses of chalk and calcareous ooze, they represent relatively short periods of time. The total time represented by calcareous sediment is perhaps not more than 15 m.y., although the section cored ranged over a 70-m.y. interval.

Radiolaria

At Site 212 poorly preserved Radiolaria are present in the core-catcher samples of Cores 1 and 3. Radiolaria are absent between the bottom of Core 4 and Core 19, Section 2. Moderately preserved to well-preserved Radiolaria of middle Eocene age are present between the bottom of Core 19 and Core 23, Section 3. Radiolaria are absent in the interval between Core 23, Section 5 and the volcanic rock encountered at the bottom of the hole.

The sediment in Cores 1 and 3 contains poorly preserved fragments of Radiolaria, including *Ommatartus tetrathalamus, Euchitonia elegans, Lithopera bacca,* and *Theocorythium trachelium.* A late Miocene to Pliocene age is assigned on the basis of the nannofossil assemblages present in these cores.

A portion of the middle Eocene chalk unit, between the bottom of Core 19 and Core 23, Section 3, contains a well-preserved assemblage of diatoms and radiolarians. The radiolarian assemblage includes common specimens of *Lophocyrtis biaurita* and rare to common occurrences of *Phormocyrtis striata striata, Theocotyle cryptocephala cryptocephala, Lamptonium fabaeforme fabaeforme*, and *Lychnocanoma babylonis. Theocampe mongolfieri* is present in trace amounts, whereas the form which is believed to be its precursor (*Theocampe amphora*) is much more common. The age of the radiolarian assemblage in these cores appears to be lowermost middle Eocene, probably near the base of the *Theocampe mongolfieri* Zone. However, the nannofossil assemblages within this part of the core suggest a slightly younger age, probably upper middle Eocene (see section on nannofossils).

CORRELATION OF REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

The seismic reflection profile over Site 212 (Figure 3) shows an upper acoustically transparent zone about 0.16 sec in thickness, largely obscured by the bubble pulse. This

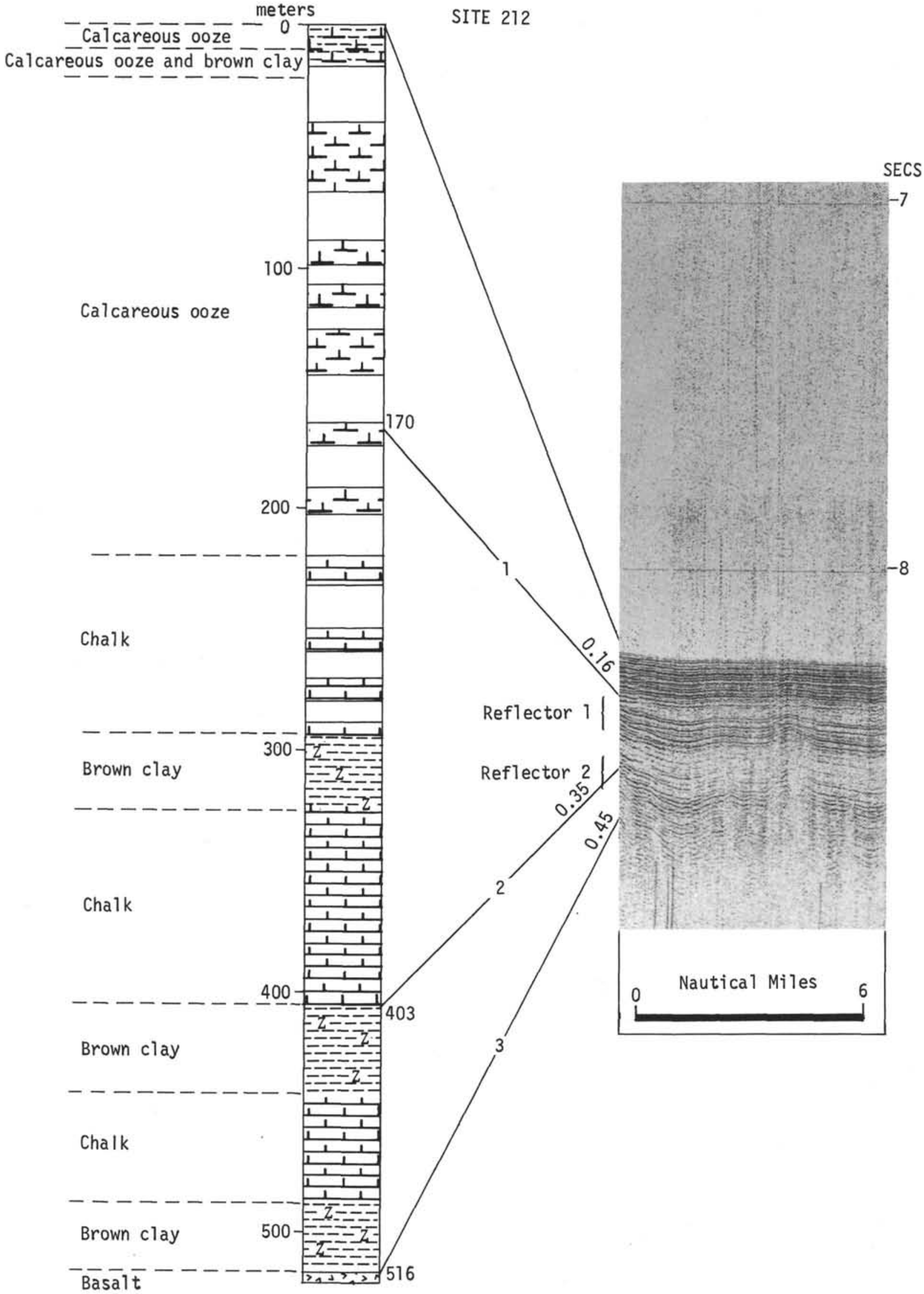

Figure 3. *Correlation of reflection profile and stratigraphic column at Site 212.*

is underlain by a well-defined zone of reflections 0.08 sec in thickness which is herein termed Reflector 1. Below Reflector 1 lies Reflector 2, at 0.35 sec. Acoustic basement at this site is difficult to define on the seismic profile. However, by extrapolation a highly irregular zone below the lowest coherent reflectors suggests seismic basement to be at a depth of about 0.45 sec.

An overall view of the seismic record suggests that all layers above Reflector 1 are essentially horizontally disposed, while the upper surface of Reflector 1 and all layers below appear to be draped over the rough basement topography possibly due to sediment compaction.

Although no definite conclusions are possible, the most likely correlation between the stratigraphic column and airgun seismic reflection profile is illustrated in Figure 3. The whole zone down to the top of Reflector 2 may correspond with the Pliocene to middle Eocene nannofossil ooze, nannofossil chalk, and clay. This unit, 403 meters thick, is represented by 0.35-sec two-way travel time on the seismic profile, giving it an interval velocity of 2.3 km/sec. Lithological variations within this zone, apart from the clay interbeds, are extremely small. Reflector 1 possibly correlates with a bed of stiff clay, and Reflector 2 with the top of a bed of clay at 403 meters.

Below Reflector 2 no definite correlations can be made down to acoustic basement at about 0.45 sec. The thickness of 113 meters of sediment between the zone correlated with Reflector 2 and basaltic basement in the column, corresponding to 0.10-sec two-way time on the seismic record, gives an interval velocity of 2.3 km/sec for the lower sedimentary unit, a velocity which agrees with the observed semi-indurated nature of these sediments.

Depths of reflectors and interval velocities are as follows:

Reflector	2-Way Time (sec)	Depth (m)	Interval Velocity (km/sec)	
0	0	0		
1	0.16	170	2.1	
2	0.35	403	2.5	2.3
3	0.45	516	2.3	

SUMMARY AND CONCLUSIONS

Site 212 is situated in the deepest portion of the Wharton Basin in a water depth of 6233 meters. The site locality lies within a sedimentary basin about 35 km in length in an area of rough outcropping basement near the southern termination of the approximately north-south trending Investigator Fracture Zone (Sclater and Fisher, in preparation). The region on either side of the fracture is a magnetically quiet zone coinciding with the Wharton Basin. The seismic reflection profile over the site made by *Glomar Challenger* (see Chapter 10) suggests ponding of uppermost sediments in the basin and compaction draping of deeper and older sediments over basement topography.

The deepest lithologic unit cored, which may represent oceanic basement, consists of a succession of altered and weathered pillow lavas termed metabasalts. These have apparently suffered hydrothermal alteration, possibly due to the proximity of the Investigator Fracture Zone mentioned above. Minor intercalcations of recrystallized carbonate between pillows represent older sediments trapped during the emplacement of the basalts. These rocks have all the characteristics of weathered mid-Indian Ocean Ridge basalts.

The sedimentary column overlying the metabasalt contains seven lithostratigraphic units comprising four calcareous oozes grading to chalks, 30 to 250 meters thick, alternating with three zeolitic brown clay units averaging 30 meters in thickness, the lowermost of which lies directly on the metabasalt.

Ages of the calcareous units have been determined paleontologically as early-late Pliocene to late Miocene, early middle Miocene, middle Eocene, and Maastrichtian. Sedimentological and biostratigraphic evidence (this chapter and Chapter 39) implies an exotic source for the calcareous units and suggest the sediments were emplaced by a combination of turbidite and nepheloid layer transport.

Historic periods of significant carbonate accumulation which were related to concomitant and episodic lowering of the carbonate compensation depth are documented in the oceans (Chapters 39 and 41). Each lowering was associated with carbonate accumulation on highs. The exotic chalk units at Site 212, which are postulated to have been transported to the locality are tentatively correlated with these episodes.

Estimate of Basement Age

The lithology of Site 212 consists of four sections of brown clay separated by three sections of nannofossil ooze grading to nannofossil chalk. The fourth brown clay section lies directly above basement which is metabasalt containing minor interbedded crystallized calcareous sediments. Unfortunately, there are no fossils in the brown clay and no datable fossils in the crystallized calcareous sediment, thus an exact age cannot be given to the basement-sediment contact. However, a rough estimate can be made if the sedimentation rate of the bottom brown clay can be determined.

The lithology of the site appears to represent continuous slow deposition of brown clay sediment interrupted by short pulses of much more rapidly deposited calcareous units. If the brown clay sedimentation rate is assumed uniform to a first approximation, then the age of the top and bottom of each clay section is given by the youngest age of the calcareous sediment immediately above and below. From such ages an average sedimentation rate of 0.7 to 1.6 m/m.y. can be computed for the two clay sections. The general uniformity of rates for the two sections and the similarity to rates in the Pacific support the assumption of a uniform rate of brown clay sedimentation. As the lowermost brown clay section differs little from those above it, the sedimentation rate can be used to estimate an age for the brown clay metabasalt contact. Assuming a 65 to 72 m.y. age span for the Maastrichtian and a thickness of 34 meters for the basal brown clay section, the contact age ranges from 85 to 110 m.y. with a mean value of close to 100 m.y., assuming an average sedimentation rate of 1 m/m.y. Thus the best age estimate lies close to the Early/Late Cretaceous boundary.

Site 212 is located at the southern extremity of the Investigator Fracture Zone. As it is not obvious on which side of this north-south trending fracture the site is located, it cannot be used quantitatively to aid tectonic reconstructions. On the other hand, this site does show (a) that the age of the oceanic crust in the central Wharton Basin increases to the south and (b) the central Wharton Basin is no older than Cretaceous.

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Pessagno, E. A., 1969. Mesozoic planktonic foraminifera and Radiolaria Leg I, Deep Sea Drilling Project. In Ewing, M. et al. Initial Reports of the Deep Sea Drilling Project, Volume I: Washington (U. S. Government Printing Office), p. 607-621.

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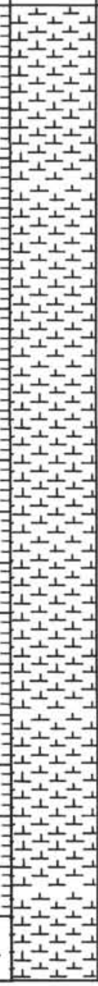
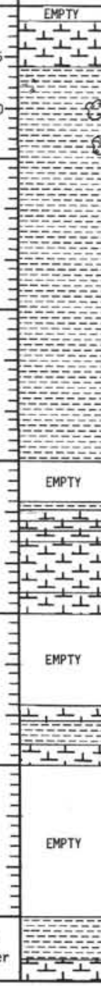
Site 212 Hole Core 1 Cored Interval: 0-9.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	Mixed assemblage	N	A	G	1	0.5 1.0			-30 100 -0	
					2				-0	
					3				- 0	NANNO OOZE grayish orange (10YR7/4) general composition: Nannofossils 80-85% Forams 4- 8% Volcanic ash 1- 2% Iron-clay aggregates 1- 2% Zeolites Tr.
					4				-0	soupy and disturbed
					5					
					6					
		F N R	R R +	P F P	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 2 Cored Interval: 9.5-18.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	Mixed assemblage	N	A	G	1	0.5 1.0			-39 -74 -90 110 145	ash pockets NANNO OOZE grayish orange (10YR7/4) faint laminations of enriched iron oxide Volcanic glass 75% Undiff. clay 20% Other volcanogenic minerals, chiefly feldspar and horn-blende 5%
					2				100	IRON OXIDE BEARING CLAY moderate brown (5YR3/4) with mottles of grayish orange (10YR7/4). Contains pockets of rhyolitic ash and from 2-5% silt. General composition: Clay 88-96% Iron oxide aggregates 2-10% Zeolite 1%
					3				100	
LATE MIOCENE		N	A	G	4				42 45 142	gradational Interbedded: CLAY, moderate brown (5YR3/4) NANNO OOZE, grayish orange (10YR7/4) Contacts between beds generally sharp with exception of two indicated which show gradual transition from ooze upward into clay. General composition: CLAY LAYERS Clay 92% Nannos 4% Iron oxide and aggregates 4%
		N	A	G	5				100 112	gradational NANNO OOZE LAYERS Nannos 77-99% Clay 1-20% Forams 0- 3% both lithologies contain up to 15% terrigenous(?) silt - chiefly feldspar
					6					X-ray at 10.70 m Quar 35, Feld 5, Plag 7, Kaol 21, Mica 21, Mont 11
		F N R	R A -	P G	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 3 Cored Interval: 41.0-50.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage				1	0.5, 1.0			136	NANNO OOZE VERY PALE ORANGE (10YR8/2) faint lamination - 110-120 cm, 130-140 cm Composition: Nannos 96% Clay 3% Mica 1% Core contains abundant rust from drill string!
		F N R	R A R	P G M	Core Catcher					

Site 212 Hole Core 4 Cored Interval: 50.5-60.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage	N	A	G	1	0.5, 1.0			20 93 117 125	Core is highly disturbed and contains jumbled mixture of various lithologies. Principal lithology: NANNO SILT grayish orange (10YR7/4) Composition: Nannos 92% Clay 7% Forams 1% Feldspar Tr. Minor lithologies in order of decreasing abundance include: 1) CLAY grayish brown 5YR3/2 2) SILTY CLAY moderate yellowish brown (10YR5/4) 3) NANNO SILT bluish white (5B9/1) lithologies 1) and 3) above
		F N R	R A -	P G	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 5 Cored Interval: 60.0-69.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage	N	A	G	1	0.5, 1.0			21 25	NANNO OOZE very pale orange (10YR8/2) Composition: Nannos 92-93% Forams 2- 8% Volcanic glass Tr. Zeolite Tr. many of forams are fragmented Subtle lamination at scale of 2-3 mm; reflects differences in foram content.
		R N F	- A C	G F	Core Catcher					

Site 212 Hole Core 6 Cored Interval: 88.5-98.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage	R N F	- A C	G F	Core Catcher					NANNO OOZE

Site 212 Hole Core 7 Cored Interval: 107.5-117.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage				1	0.5, 1.0			40	5Y7/2 N9 NANNO OOZE yellowish gray above to white below Composition: Nannos 93-94% Clay 5% Forams 1- 2% Iron oxide Tr.
		R N F	- A R	G F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 8 Cored Interval: 126.5-136.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage	N	A	G	1	0.5, 1.0			-30, 140	5Y8/4 CLAY, grayish brown (5YR3/2); probably cavings 5Y7/2 NANNO OOZE grayish yellow above to yellowish gray below Composition: Nannos 88-94%, Clay 5-10%, Forams 1- 2%, Iron oxide 0- 1%
					2					5Y8/4
					3				102	faint lamination - 10-20 cm Section 3 scale of ~1 cm.
		R N F	- A C	G F	Core Catcher					

Site 212 Hole Core 9 Cored Interval: 136.0-145.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage	N	A	G	1	0.5, 1.0	EMPTY CAVINGS		140	NANNO OOZE very pale orange (10YR8/2) very faint lamination and subtle mottling. Composition: Nannos 90%, Clay 5%, Forams 2%, Volcanic glass 1%, Micronodules 1%, Zeolite and pyrite Tr.
		R N F	- A R	G F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 10 Cored Interval: 164.5-174.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mixed assemblage	N	A	G	1	0.5, 1.0	EMPTY		-25, -60	5Y6/4 Intermixed (disturbed) NANNO OOZE and IRON OXIDE RICH CLAY, dusky brown (5YR2/2) mottles of 5YR7/2
EARLY MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)				2					
					3				134	mottles of 5Y8/4 NANNO OOZE dusky yellow (5Y6/4) with zones of color mottling. Composition: Nannos 82-94%, Clay 5-10%, Forams 1%, Iron oxide 0- 2% General increase in clay downward, very stiff
					4					X-ray at 172.80 m Calc 99, Quar 1
					5				82	
					6		EMPTY EMPTY			
		F N R	C A -	F F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 11 Cored Interval: 193.0-202.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)	N	A	F	1	0.5 1.0	EMPTY		145	
					2					CLAY RICH NANNO OOZE dusky yellow (5Y6/4) with occasional mottles of grayish yellow (5Y8/4) Composition: Nannos 67-80% Clay 18-30% Forams 1% Iron oxide 1% Pyrite Tr. Subtle lithologic (?) mottling.
					3				130	
					4					
		R N F	- A C	F F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 12 Cored Interval: 221.5-231.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)	N	A	F	1	0.5 1.0	EMPTY		145	
					2					
					3				90	CLAY RICH NANNO CHALK dusky yellow (5Y6/4) with spots and irregular mottles of grayish yellow (5Y8/4) Semilithified. Composition: Nannos 82% Clay 15% Forams 2% Iron oxide 1% Zeolite Tr.
					4					X-ray at 228.90 m Calc 98, Quar 1, Mica 1
					5					
		R N F	- A C	F F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 13 Cored Interval: 250.0-259.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)	N	A	F	1	0.5 – 1.0	EMPTY			
					2				-76 -81	cross lamination
					3					contorted lamination
					4				-75 144	contorted lamination
		R N F	- A A	F F	Core Catcher					

NANNO RICH MICARB FORAM CHALK
very pale orange (10YR8/2) and moderate olive brown (5Y4/4) interlaminated.
General composition:

Nannos	20-30%
Micarb	30-40%
Forams	30-40%
Clay	0- 7%
Others (heavy minerals, volcanic glass, feldspar, rock fragments)	<2%

Very well laminated - alternating light and dark laminae generally less than 1 mm thick. Dark and light laminae are variably grouped to produce alternating light and dark sections to the core which range from 1/2 to 10 cm in thickness.
Other structures include:
1) cross lamination
2) contorted lamination - including small 'flame' structure

Explanatory notes in Chapter 1

Site 212 Hole Core 14 Cored Interval: 269.0-278.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)	N	A	F	1	0.5 – 1.0	EMPTY			
					2				-90	
					3					
					4					
					5					
					6					
		N R	A -	F	Core Catcher					

CLAY RICH NANNO CHALK
grayish orange (10YR7/4)
Composition:

Nannos	80%
Clay	19%
Micronodules	1%

Explanatory notes in Chapter 1

Site 212 Hole Core 15 Cored Interval: 288.0-297.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIDDLE MIOCENE	Sphenolithus heteromorphus Zone (N)	N	A	F	1	0.5, 1.0	EMPTY; a, b, a, b; G		40, 62, 65, 68, 128	
					2					
					3					
		F R	R -	P	Core Catcher					

Interbedded:
a) CLAY RICH NANNO CHALK (as above)
b) NANNO FORAM SANDSTONE bluish white (5B9/1) well laminated; possibly graded in lower part. Contains fragments of underlying greenish clay, and trace of glauconite

sharp contact

CONTACT ZONE:

NANNO FORAM CHALK

sharp, irregular contact 1 cm

grayish blue green CLAYSTONE (5BG5/2) 5 cm

moderate brown iron oxide rich clay (5YR4/4)

Clays contain abundance of very fine, high relief minerals indicative of authigenic mineralization.

ZEOLITE IRON OXIDE RICH CLAY
dusky brown (5YR2/2)
highly manganiferous
Composition:

Clay	73%
Iron oxide micronodules	10%
Clay-iron oxide aggregates	5%
Zeolites	10%
Mn micronodules	1%
Feldspar	Tr.

X-ray at 289.10 m Quar 28, Feld 19, Plag 9, Kaol 9, Mica 25, Chlo 1, Mont 8

Site 212 Hole Core 16 Cored Interval: 297.5-307.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5, 1.0	EMPTY		80	
					2					
		R	-		Core Catcher					

IRON OXIDE RICH ZEOLITE CLAYSTONE
dusky brown (5YR2/2)
Composition:

Clay	45%
Zeolite	40%
Iron oxide	14%
Mn micronodules	1%

Iron oxide occurs as stain in clay aggregates and as very fine micronodules.

decrease zeolite
increase iron oxide

X-ray at 297.50 m Quar 29, Feld 12, Plag 5, Kaol 18, Mica 17, Mont 18

Explanatory notes in Chapter 1

Site 212 Hole Core 17 Cored Interval: 307.5-316.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5, 1.0	EMPTY			
		R	-		Core Catcher					

ZEOLITE BEARING IRON OXIDE RICH CLAY
dusky brown (5YR2/2)

Site 212 Hole Core 18 Cored Interval: 316.5-326.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIDDLE EOCENE	Chiasmolithus grandis Zone (N)				1	0.5, 1.0			90	
					2		Z Z Z		67, 2	
		R	-		3				85	
		N R	A -	F	Core Catcher					

ZEOLITE BEARING IRON OXIDE RICH CLAYSTONE
dusky brown (5YR2/2) with mottles of moderate brown (5YR4/4)
Composition:

	top	bottom
Clay	83%	44%
Zeolite	2%	50%
Fe-clay aggregates	10%	5%
Fe micronodules	3%	0%
Mn micronodules	2%	1%

increase zeolite
decrease clay
lighten color

CLAY ZEOLITITE
dark yellowish brown (10YR4/2) with mottles of moderate brown (5YR4/4).
Zeolite more coarsely crystalline than above.

CLAY BEARING NANNO CHALK
white (N9) to very pale orange (10YR8/4)
some dark lamination and ripples

X-ray at 319.70 m Quar 8, Feld 6, Plag 3, Kaol 2, Mica 6, Mont 6, Paly 16, Clin 44, Phil 8

Explanatory notes in Chapter 1

Site 212 Hole Core 19 Cored Interval: 326.0-335.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIDDLE EOCENE	Chiasmolithus grandis Zone (N) Theocampe mongolfieri Zone (R)				1	0.5 1.0	EMPTY			
		R	-							
		N	A	F	2				30	CLAY BEARING NANNO CHALK white (N9), homogeneous Composition: Nannos 94% Clay 5% Spicules 1% Other (glauconite, micarb, Radiolaria) Tr.
		R	-							
		N R	A R	F M	Core Catcher					

Site 212 Hole Core 20 Cored Interval: 335.5-345.0 m

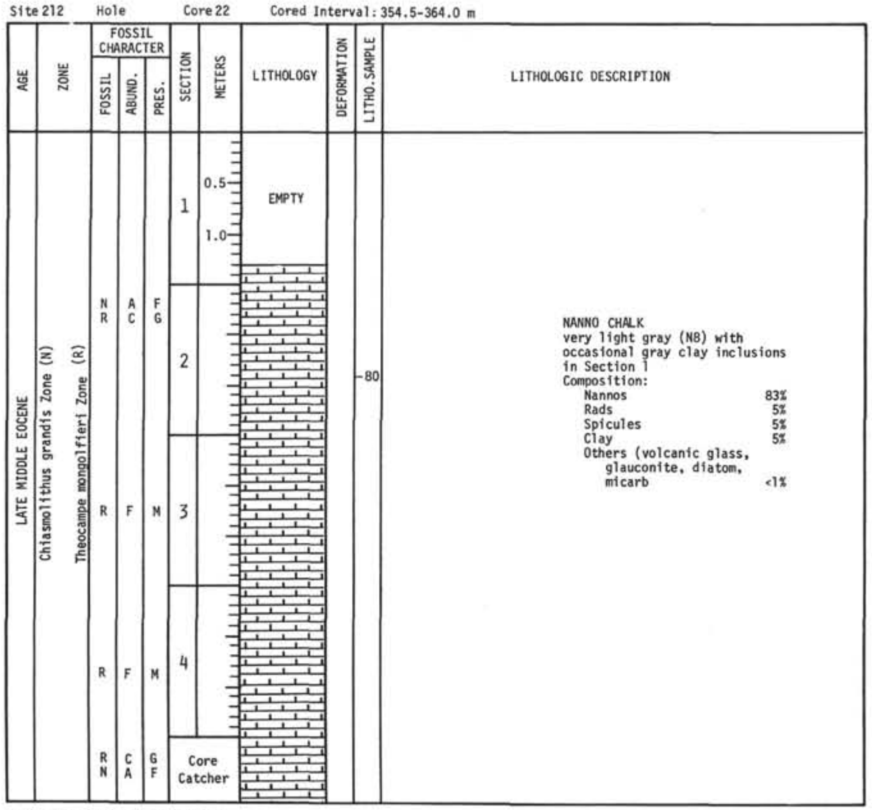
AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIDDLE EOCENE	Chiasmolithus grandis Zone (N) Theocampe mongolfieri Zone (R)				1	0.5 1.0	EMPTY			
		N R	A F	F M						NANNO CHALK white (N9), homogeneous as core 19
		N R	A C	F G	Core Catcher					

Explanatory notes in Chapter 1

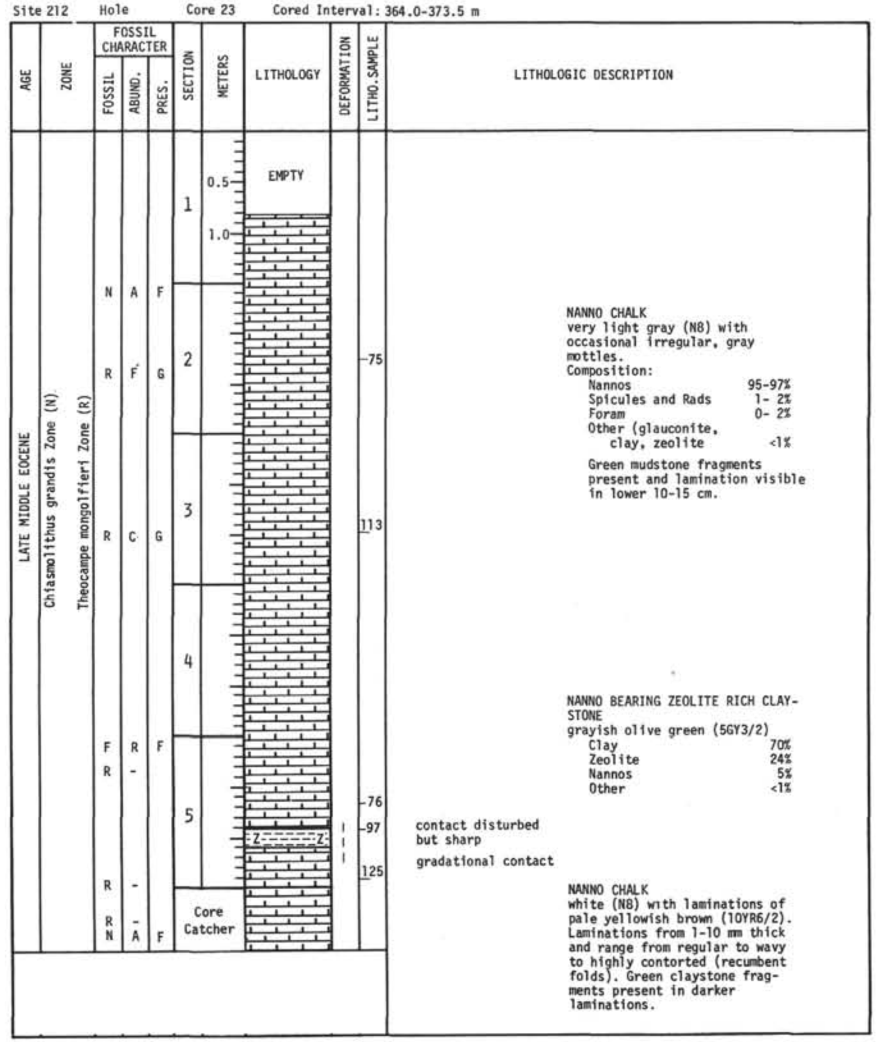
Site 212 Hole Core 21 Cored Interval: 345.0-354.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIDDLE EOCENE	Chiasmolithus grandis Zone (N) Theocampe mongolfieri Zone (R)	N	A	F	1	0.5 1.0				
		R	R	P						
		R	F	M	2				138	NANNO CHALK white (N9) Composition: Nannos 83% Rads 5% Spicules 5% Diatoms 2% Clay 5% pale green laminations and spots richer in clay
		R	C	G	3					
		R	F	G	4				90	
		R N	C A	G F	Core Catcher					

Explanatory notes in Chapter 1



Explanatory notes in Chapter 1



Explanatory notes in Chapter 1

Site 212 Hole Core 24 Cored Interval: 373.5-383.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIDDLE EOCENE	Chiasmolithus grandis Zone (N)				1	0.5	EMPTY			
						1.0				NANNO CHALK yellowish gray (5Y8/1)
		N R	A -	F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 25 Cored Interval: 383.0-392.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIDDLE EOCENE	Chiasmolithus grandis Zone (N)				1	0.5 1.0			100	
					2					NANNO CHALK very light gray (N8) to pinkish gray (5YR8/1) with mottles of light greenish gray (5GY5/1) scattered throughout Composition: Nannos >95% Clay <5% Other (micarb, glauconite, foraminifera, Radiolaria, spicules) <2%
					3					
					4				100	
					5					
					6					
		N R	A -	F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 26 Cored Interval: 392.5-402.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	LITHO. SAMPLE
LATE MIDDLE EOCENE	*Chiasmolithus grandis* Zone (N)				1	
					2	65
					3	110
					4	
					5	
					6	110
		R N	- A	F	Core Catcher	

METERS: 0.5, 1.0

LITHOLOGY

DEFORMATION

LITHOLOGIC DESCRIPTION

diagonal fracture coated with greenish CLAY RICH NANNO CHALK

Nannos	70%
Clay	10%
Micarb	15%
Opaques	5%

Slickensides is apparent.

NANNO CHALK
very light gray (N8) to pinkish gray (5YR8/1).
Composition:

Nannos	>95%
Clay	<5%
Micarb	2%
Others (glauconite, foraminifera)	<1%

increasing degree of recrystallization (authigenic carbonate)

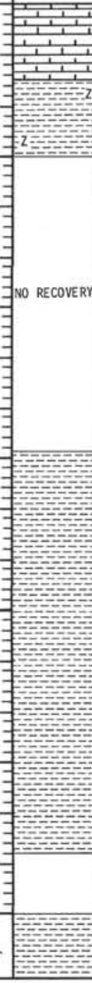
Explanatory notes in Chapter 1

Site 212 Hole Core 27 Cored Interval: 402.0-411.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	LITHO. SAMPLE
	Chiasmolithus grandis Zone (N)				1	90, 122, 130, 134
					2	
					3	
					4	
					5	90
					6	58, 59
		R	-		Core Catcher	

METERS: 0.5, 1.0

LITHOLOGY



DEFORMATION

LITHOLOGIC DESCRIPTION

NANNO CHALK
bluish white (5B9/1)

sharp contact

NANNO ZEOLITE BEARING CLAYSTONE
moderate brown (5YR4/4)
Composition:

Clay and clay aggregates	87%
Nannos	5%
Zeolite	5%
Other (opaques, glass, high relief minerals)	3%

"reduced zone"-
color varies from dark greenish gray 5G5/1 to medium bluish gray (5B4/1) to greenish black (center) (5GY2/1)
Composition:

Clay and clay aggregates	88%
Zeolite	7%
Volcanic glass	2%
Other (opaques, high relief minerals)	3%

uniform moderate brown (5YR4/4)

IRON OXIDE RICH "MINERALIZED" CLAYSTONE
variegated color - moderate brown (5YR4/4) and dusky yellowish brown (10YR4/2). Small "flecks" of black scattered through.
Composition:

Clay	68%
Iron oxide-clay aggregates	5%
Iron spherules	2%
Opaques	5%
Zeolite	5%
Other (mainly very fine, high relief, non-opaque minerals)	15%

"reduced" band with hematite halos - see core 28 for description

X-ray at 403.00 m Quar 16, Feld 10, Plag 3, Kaol 20, Mica 20, Mont 31
X-ray at 403.30 m Calc 3, Quar 18, Feld 14, Plag 6, Kaol 18, Mica 14, Mont 27
X-ray at 406.60 m Quar 18, Feld 11, Plag 3, Kaol 22, Mica 12, Mont 33

Explanatory notes in Chapter 1

Site 212 Hole Core 28 Cored Interval: 411.5-421.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5, 1.0				diffuse boundaries. Color bands marking 'chemical alteration'. Generally characterized as follows: dark reddish brown (10R3/4); pale olive (10Y6/2); pale reddish brown (10R5/4)
					2					Bleached (olive) zones contain more ash and zeolite, less iron oxide and high relief minerals than encasing clays. Reddish zones are slightly enriched in iron oxides.
					3					ZEOLITE IRON OXIDE BEARING CLAYSTONE dark yellowish brown (10YR4/2) with abundant mottles and irregular "laminae" of 1) grayish black (N2) 2) light brown (5YR5/6) Contains also color bands of chemical alteration as shown above. Composition: Clay 87%; Iron rich clay aggregates 5%; Zeolite 4%; Other (opaque, iron micronodules, high relief - non-opaque minerals 4%
					4					
					5		EMPTY			X-ray at 411.70 m Quar 14, Feld 14, Plag 5, Kaol 20, Mica 19, Chlo 10, Mont 8, Paly 9
					6					
		R	-		Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 29 Cored Interval: 421.0-430.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE CRETACEOUS	Nephrolithus frequens Zone (N)	N	A	P	1	0.5, 1.0	EMPTY		100	color band as core 28. Zero section (31 cm) - clay as below. NANNO SILTSTONE moderate orange pink (5YR6/4). ZEOLITE IRON OXIDE RICH CLAYSTONE dark yellowish brown (10YR4/2) with mottles and irregular streaks of pale reddish brown (10YR5/4) and grayish black (N2). Manganese micronodules scattered throughout. Composition: Clay 74%; Zeolite 12%; Iron rich clay aggregates 10%; Other (opaques, glass, authigenic carbonate, high relief non-opaque) 4%
		F R N	C - A	F P	Core Catcher					X-ray at 421.30 m Quar 12, Feld 14, Plag 5, Kaol 28, Mica 23, Chlo 11, Mont 6

Site 212 Hole Core 30 Cored Interval: 430.5-440.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE CRETACEOUS	Nephrolithus frequens Zone				1	0.5, 1.0	EMPTY; EMPTY			CLAY RICH NANNO CHALK pale yellowish brown (10YR6/2) with elliptical "concretions" of grayish orange pink (5YR7/2) Composition: Nannos 89%; Clay 10%; Foram 1%; Authigenic calcite Tr.
					2				20	irregular color banding and interlamination of pale yellowish brown and gray orange pink
					3				82	NANNO CHALK gray orange pink (5YR7/2) speckled with black manganese micronodules Composition: Nannos 85%; Volcanic glass 10%; Opaques (Mn) 4%; Foram 1%
		R N F	- A C	P F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 31 Cored Interval: 440-449.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE CRETACEOUS	Nephrolithus frequens Zone (N)				1	0.5 1.0			80	NANNO CHALK grayish orange pink (5YR7/2) with occasional elliptical areas of very light gray (N8) Composition: Nannos 92-93%, Clay ~5%, Forams 1- 2%, Micarb 1- 2%
					2					
					3					variegated gray orange pink and yellowish gray
					4				85	gradual change from grayish orange pink to yellowish gray (5Y8/1)
		N	A	P	5					
		N F	A C	P F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 32 Cored Interval: 449.5-459 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE CRETACEOUS	Nephrolithus frequens Zone (N)				1	0.5 1.0				
					2				113	NANNO CHALK light olive gray (5Y6/1) with mottles of greenish gray (5GY6/1) Composition: Nannos 91%, Clay ~5%, Micarb 3%, Foram 1%
					3					X-ray at 457.50 m Calc 97, Quar 1, Mont 2
					4					
					5				114	
					6					
		R N F	- A C	P F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 33 Cored Interval: 459.0-465.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE CRETACEOUS	Nephrolithus frequens Zone (N)				1	0.5 1.0				
					2				100	NANNO CHALK light olive gray (5Y6/1) with occasional mottles of greenish gray (5G6/1) which appear as holes around dark spots. Composition: Nannos 95% Clay ~2% Micarb 1- 2% Volcanic glass 1% Forams Tr.
					3					
					4					
					5				100	
		R	-		6					
		N F	A C	P F	Core Catcher				100	

Explanatory notes in Chapter 1

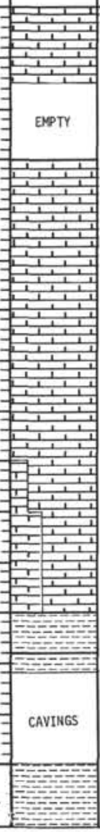
Site 212 Hole Core 34 Cored Interval: 468.5-478.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE CRETACEOUS	Nephrolithus frequens Zone (N)				1	0.5 1.0				NANNO CHALK light olive gray (5Y6/1) with mottles of light greenish gray (5GY8/1) as holes around dark spots. Composition as above.
					2					
					3				104 140	Irregular laminae of pale yellow brown (10YR6/2) in chalk of light olive gray. Softer than above and richer in clay and volcanic glass. Composition: Nannos 87% Clay 5% Volcanic glass 3% Forams 2% Micarb 2% Opaques 1%
		N F	A C	P F	Core Catcher					

Explanatory notes in Chapter 1

Site 212 Hole Core 35 Cored Interval: 478.0-487.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE CRETACEOUS	*Nephrolithus frequens* Zone (N)				1	0.5, 1.0	EMPTY		
					2				
					3				90
					4				140
		N	A	P	5		CAVINGS		15, 50
		F, R	C, -		Core Catcher				



LITHOLOGIC DESCRIPTION

NANNO CHALK

X-ray at 481.80 m Calc 92, Quar 1, Feld 1, Plag 1, Mica 2, Mont 2
X-ray at 483.30 m Calc 94, Quar 1, Feld 1, Mica 2, Mont 2
X-ray at 484.10 m Quar 13, Feld 11, Plag 6, Kaol 3, Mica 13, Chlo 1, Mont 43, Paly 9
X-ray at 484.40 m Quar 17, Feld 16, Plag 6, Kaol 5, Mica 8, Chlo 1, Mont 22, Paly 21, Hema 3

NANNO CHALK
light olive gray (5Y6/1) with abundant mottles of greenish gray (5GY5/1) and light greenish gray (5G8/1)
Composition:

Nannos	81%
Micarb	10%
Forams	8%
Volcanic glass	1%

greenish gray 5GY6/1

increasing foram content; coarsening texture

color banded (1 cm bands) greenish gray with light olive gray (5Y6/1)

greenish gray with white mottles

green mudstone fragments in lower 70 cm of chalk

FORAM NANNO CHALK

Nannos	55%
Forams	30%
Micarb	10%
Clay	3%
Volcanic glass	2%

CLAYSTONE, grayish green (5G5/2)

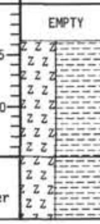
IRON OXIDE RICH CLAYSTONE
dark reddish brown (10YR3/4)
Composition:

Clay	61%
Iron rich clay aggregates	30%
Zeolite	5%
Other (Fe micronodules, high relief non-opaque)	4%

Explanatory notes in Chapter 1

Site 212 Hole Core 36 Cored Interval: 487.5-497.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
					1	0.5, 1.0	EMPTY		54
		F, R	R, -	F	Core Catcher				



LITHOLOGIC DESCRIPTION

ZEOLITE CLAYSTONE
moderate reddish brown (10R4/6)
Composition:

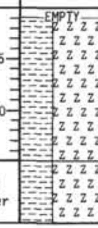
Clay	50%
Zeolite	40%
Fe rich clay aggregates	2%
Volcanic glass	2%
Other (very fine high relief minerals, opaques, feldspar	6%

Zeolites very poorly crystallized.

X-ray at 488.60 m Quar 24, Feld 16, Plag 8, Kaol 3, Mica 13, Chlo 2, Mont 9, Paly 26

Site 212 Hole Core 37 Cored Interval: 497.0-506.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
					1	0.5, 1.0	EMPTY		92, 98
		R	-		Core Catcher				



LITHOLOGIC DESCRIPTION

uniform 5YR4/4

5YR4/4 banded at 1-8 cm scale with 10YR2/2

CLAY RICH ZEOLITITE
color varies from moderate brown to dusky yellowish brown
General composition:

Zeolite	60-70%
Clay	20-30%
Opaques	1- 3%
Fe micronodules	1- 4%
Others (very fine high relief non-opaque, silt sized feldspar	<2%

Zeolites - well crystallized laths averaging 12-15 m in length.

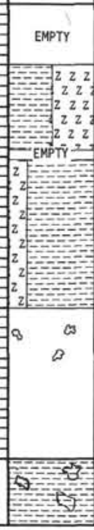
Light colored layers contain less opaques and Fe micronodules than dark layers.

X-ray at 497.30 m Quar 23, Feld 14, Plag 2, Mica 8, Mont 5, Paly 48

Explanatory notes in Chapter 1

Site 212 Hole Core 38 Cored Interval: 506.5-516.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	EMPTY EMPTY		112	alternating 5YR5/6 and 5YR3/2 occasional greenish mottle — CLAY ZEOLITITE light brown to grayish brown
					2				10 12 52	grayish green (10GY5/2) to yellow green (5GY7/4) — decrease zeolite; increase iron oxide
					3					IRON OXIDE RICH ZEOLITE CLAYSTONE grayish brown
					Core Catcher					basaltic rock fragments



IRON OXIDE RICH ZEOLITE CLAYSTONE
grayish brown
Composition:

Clay	55%
Iron oxide clay aggregates	20%
Zeolites	17%
Fe micronodules	4%
Opaques	2%
Authigenic carbonate	2%

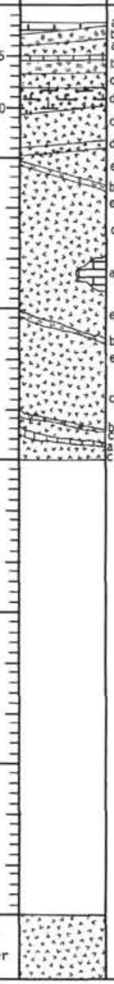
X-ray at 507.20 m Quar 13, Mica 5, Mont 11, Paly 52, Clin 19
X-ray at 508.20 m Quar 19, Feld 34, Mica 12, Paly 36

basaltic rock fragments

Explanatory notes in Chapter 1

Site 212 Hole Core 39 Cored Interval: 516-521 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	1 Flow				1	0.5 1.0				Thin section at 63 cm.
	2 Flow				2					Thin section 143 cm. Thin section 149 cm. (Basaltic glass)
	3 Flow				3					(Basaltic glass) (Basaltic glass) (Limestone)
					4					
					5					
					6					
					Core Catcher					



(a) very light gray (N8) LIMESTONE

Calcite	95%
Plagioclase	<5%

(b) CHLORITE BEARING BASALTIC GLASS greenish black (5GY2/1)

Palagonite	40%
Glass	50%
Chlorite	10%

(c) MEDIUM GRAINED SPILITIZED BASALT medium dark greenish gray (5GY5/1). Hypocrystalline medium grained and weathered basalt. Microphenocrysts of partially albitized plagioclase are set into an intersertal matrix of plagioclase (probably albitized). Pyroxene granules, dark brown mesosrasis (iron oxide granules and brown glass), chlorite and cryptocrystalline material occur between the interstices of the plagioclase laths. The plagioclase microphenocrysts and the plagioclase from the matrix often show inclusion of chlorite, calcite and rare epidote.

Plagioclase matrix	47%
Plag. Microphenocryst	10%
Chlorite	15%
Mesostasis	10%
Calcite	7%
Pyroxene	6%
Epidote	<1%
Palagonite	1%
Iron oxide	3%

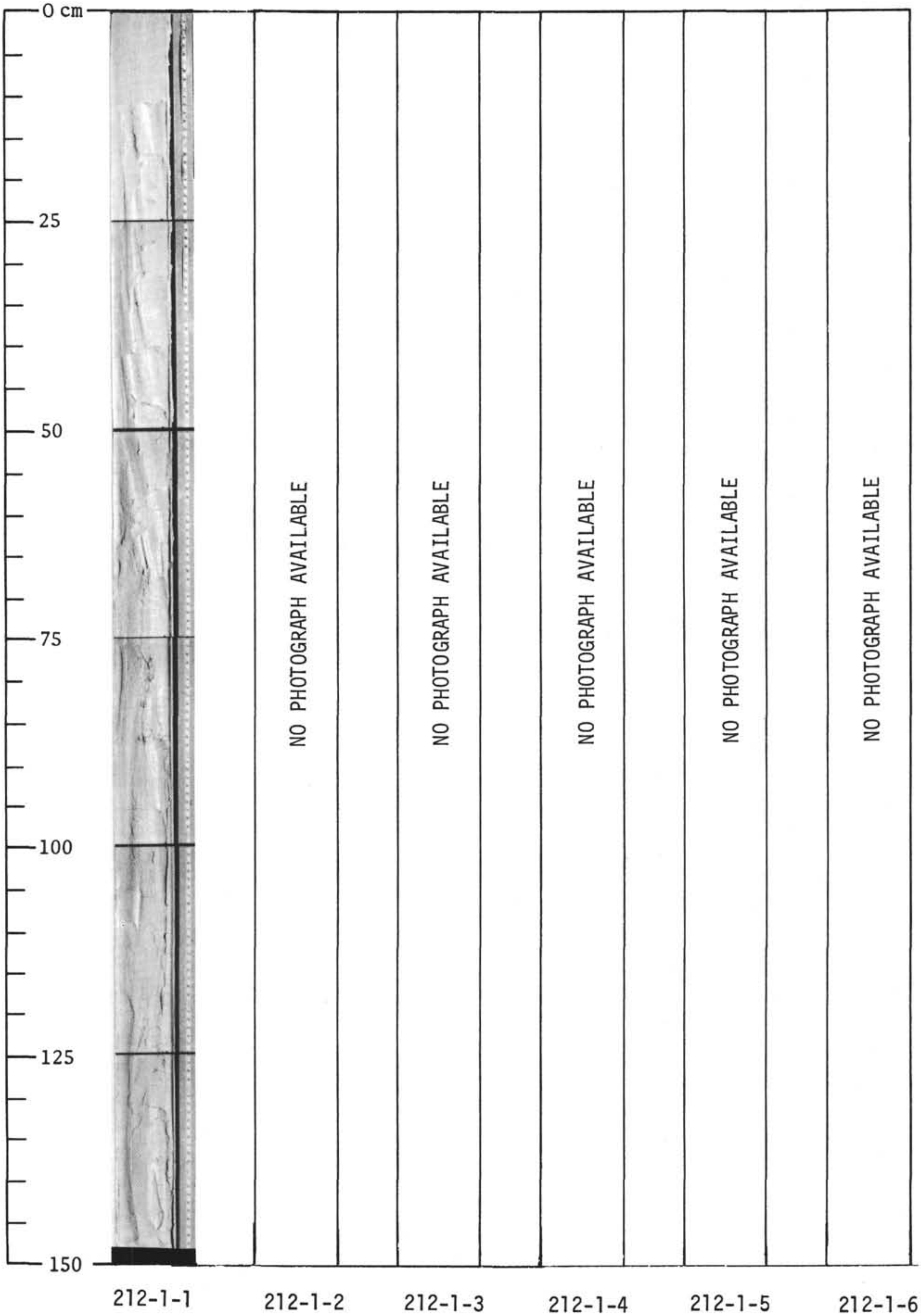
(d) VOLCANIC BRECCIA fragments of basaltic glass in calcitic cement one foram was found within the carbonate cement.

Calcite	75%
Spilitized basalt fragment	15%
Basaltic glass	10%

(e) FINE GRAINED SPILITIZED BASALT medium olive gray (5Y5/1). This zone often grades into a glassy margin and consists of porphyritic weathered rock. Phenocrysts and microphenocrysts of olivine outlined crystals and partially albitized plagioclase are set in a variolitic and partially crystalline matrix.

Plag. microlite	40%
Plag. micropheno.	5%
Plag. phenocryst	2%
Mesostasis	39%
Olivine outlined crystals	6%
Chlorite	3%
Calcite	2%
Cristobalite	2%
Volcanic glass	1%

Explanatory notes in Chapter 1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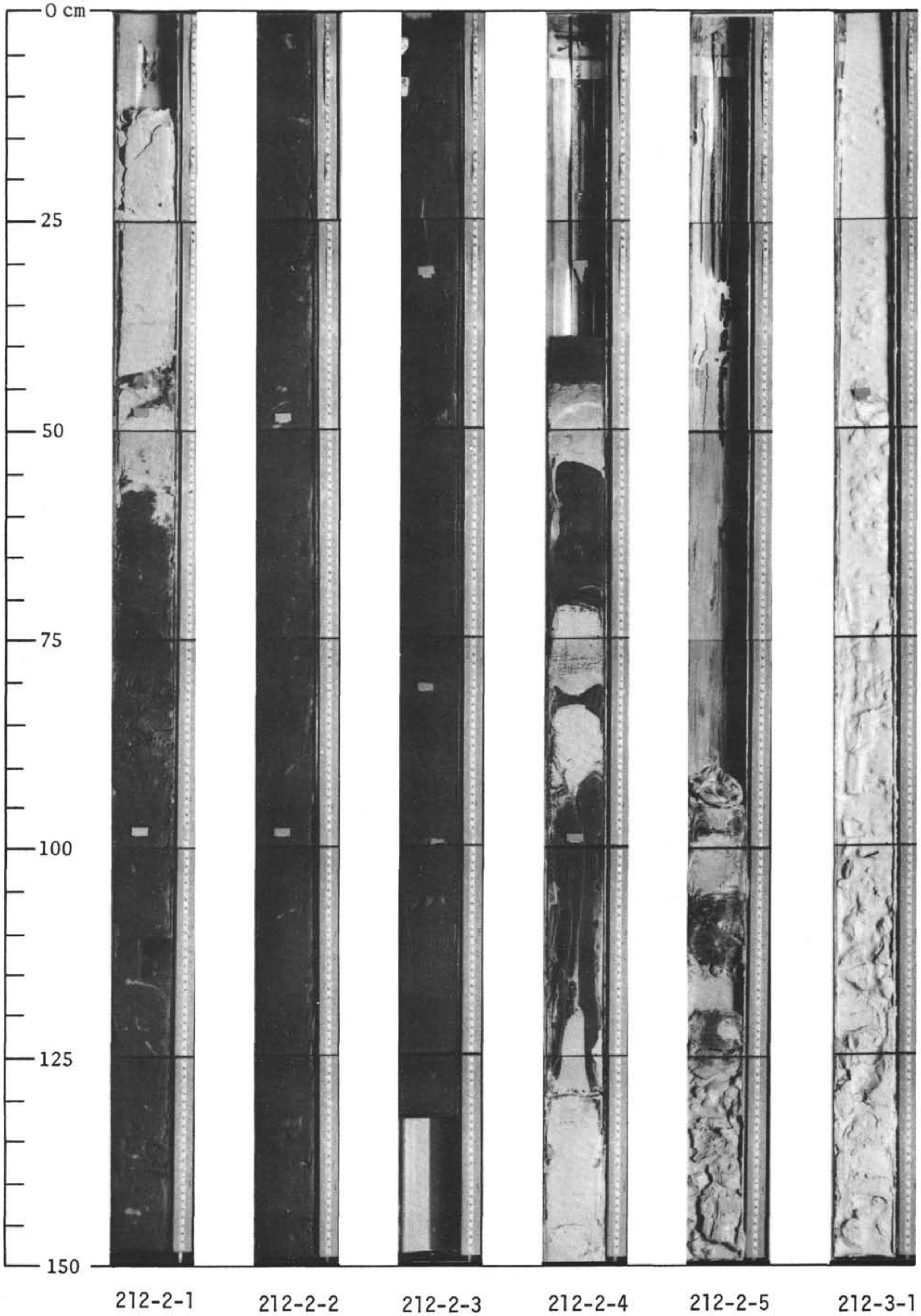
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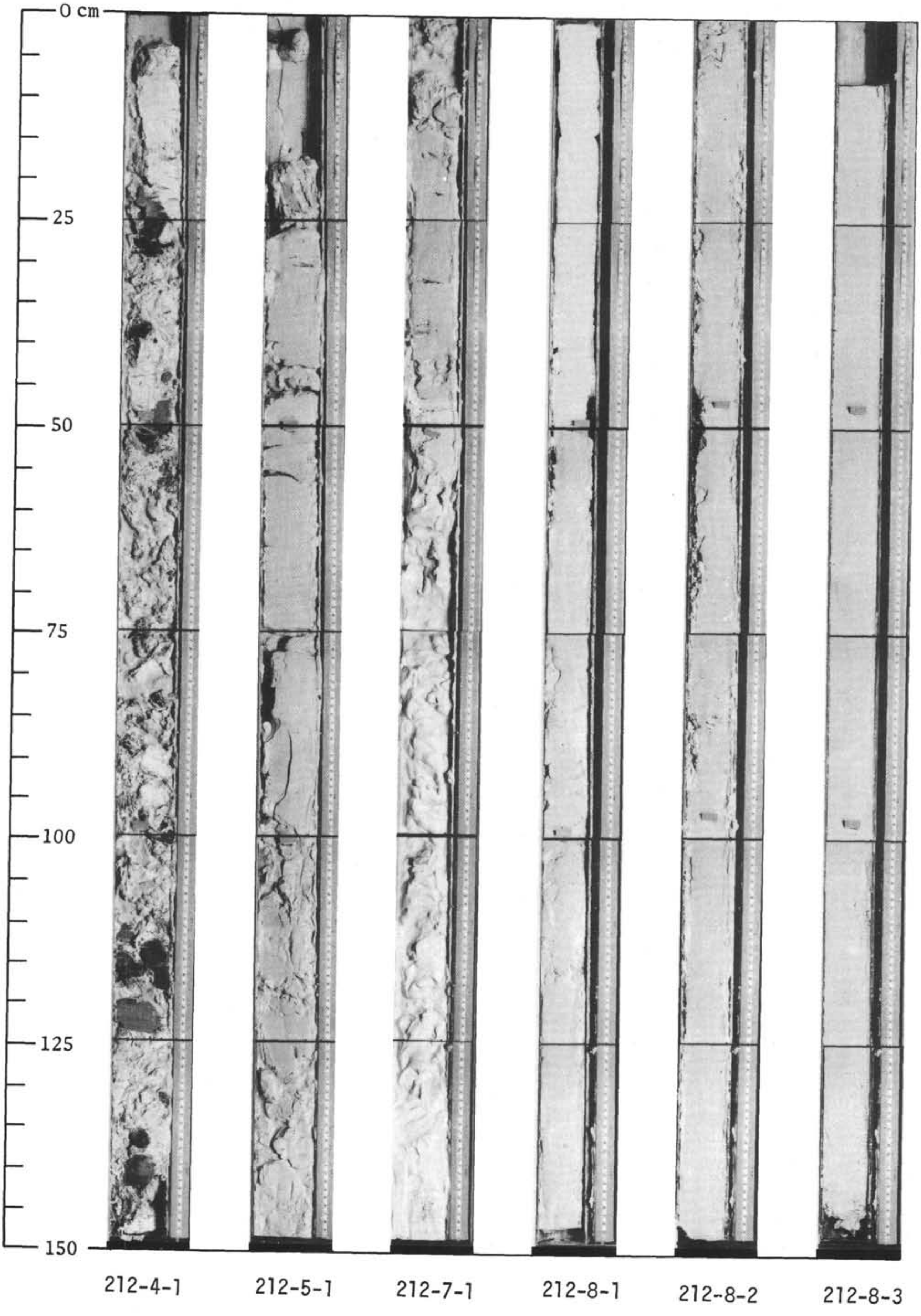
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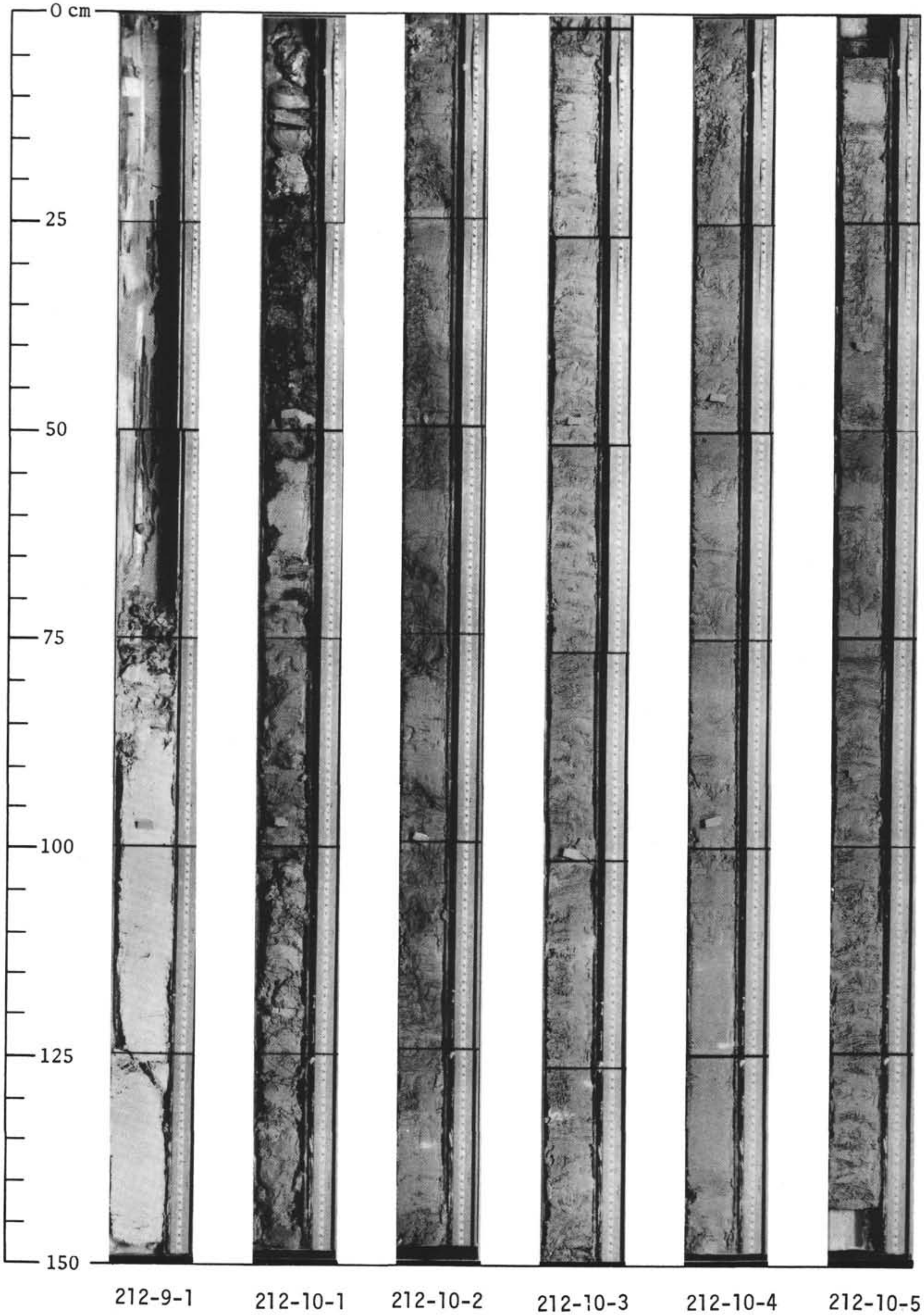
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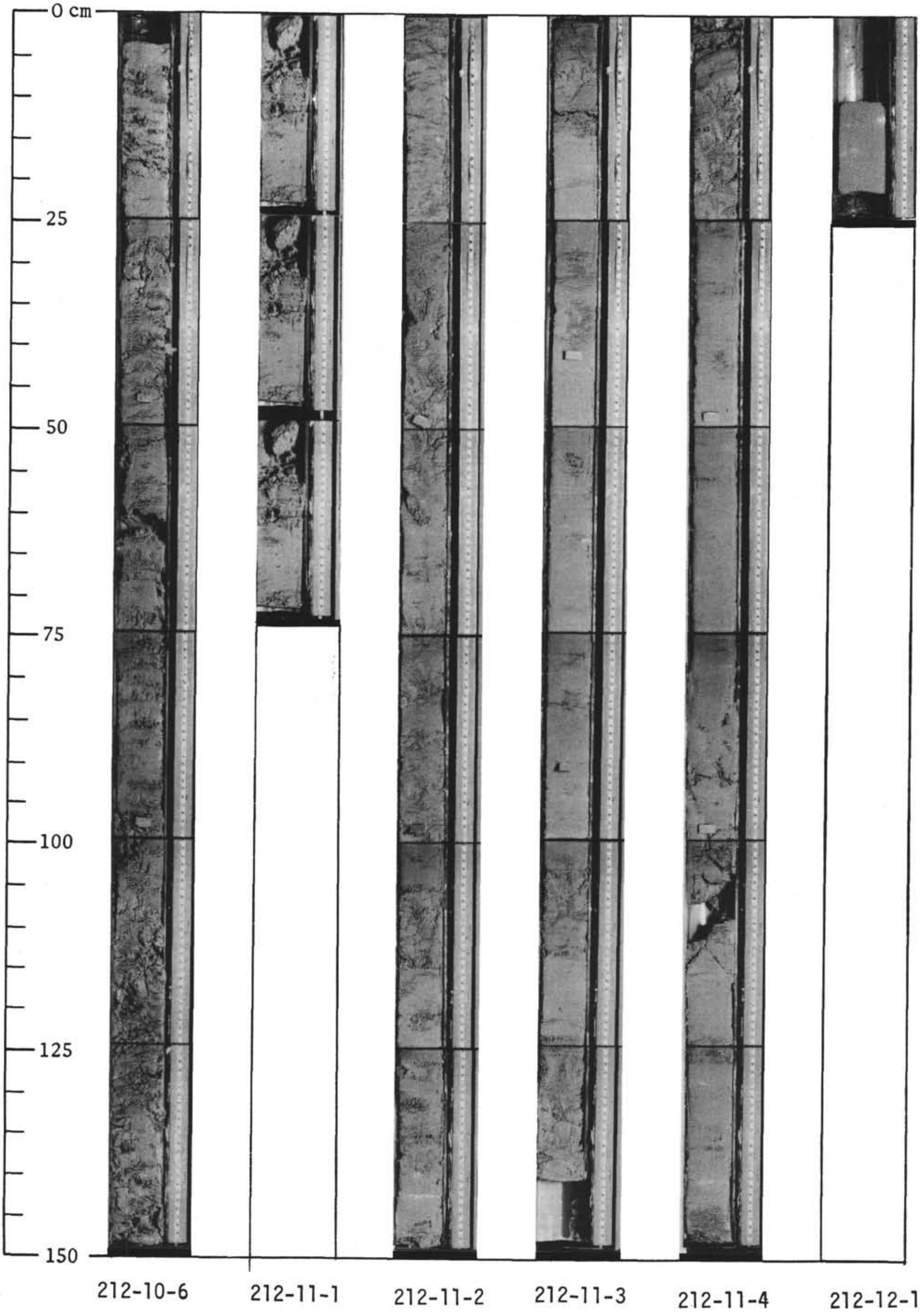
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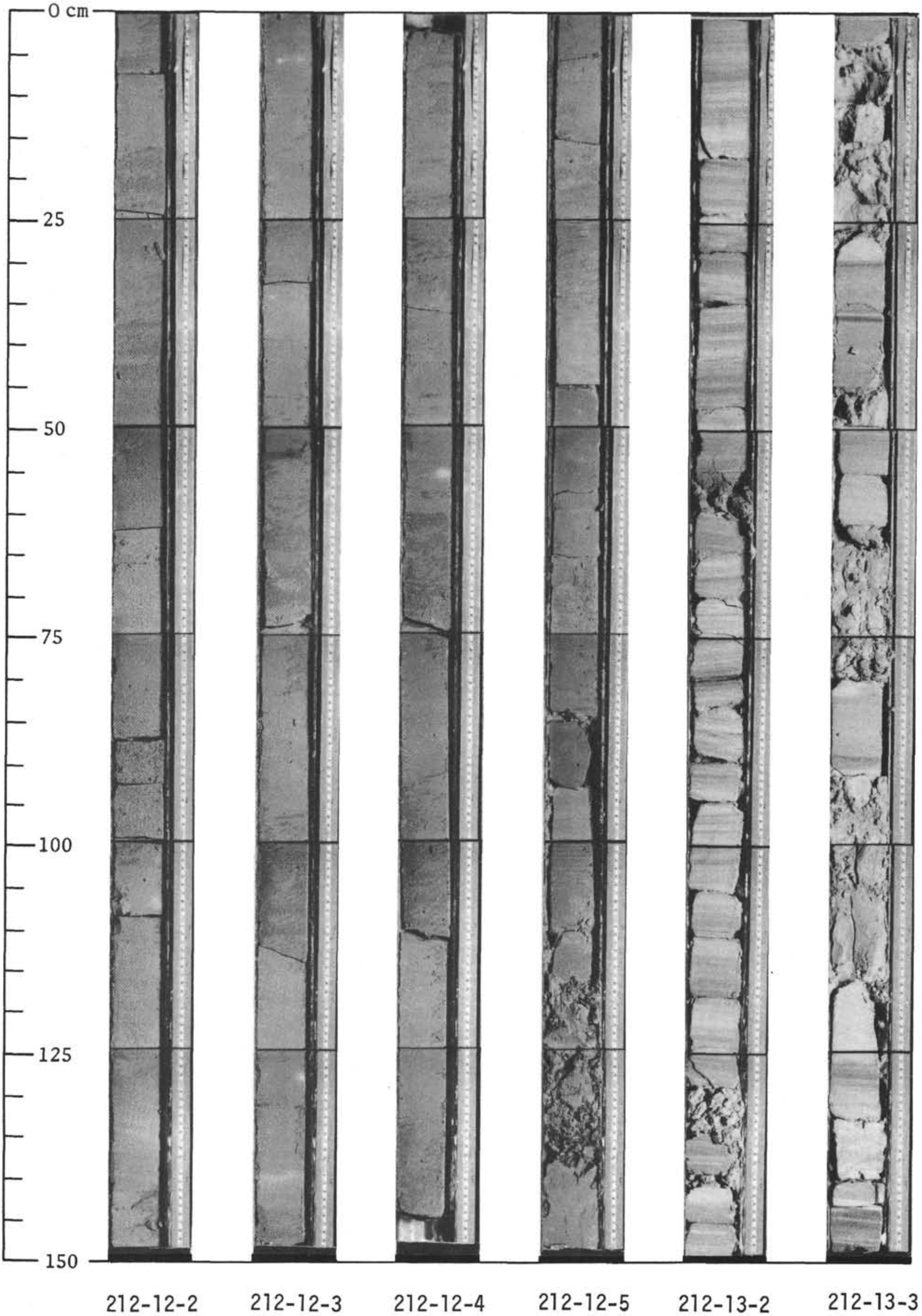
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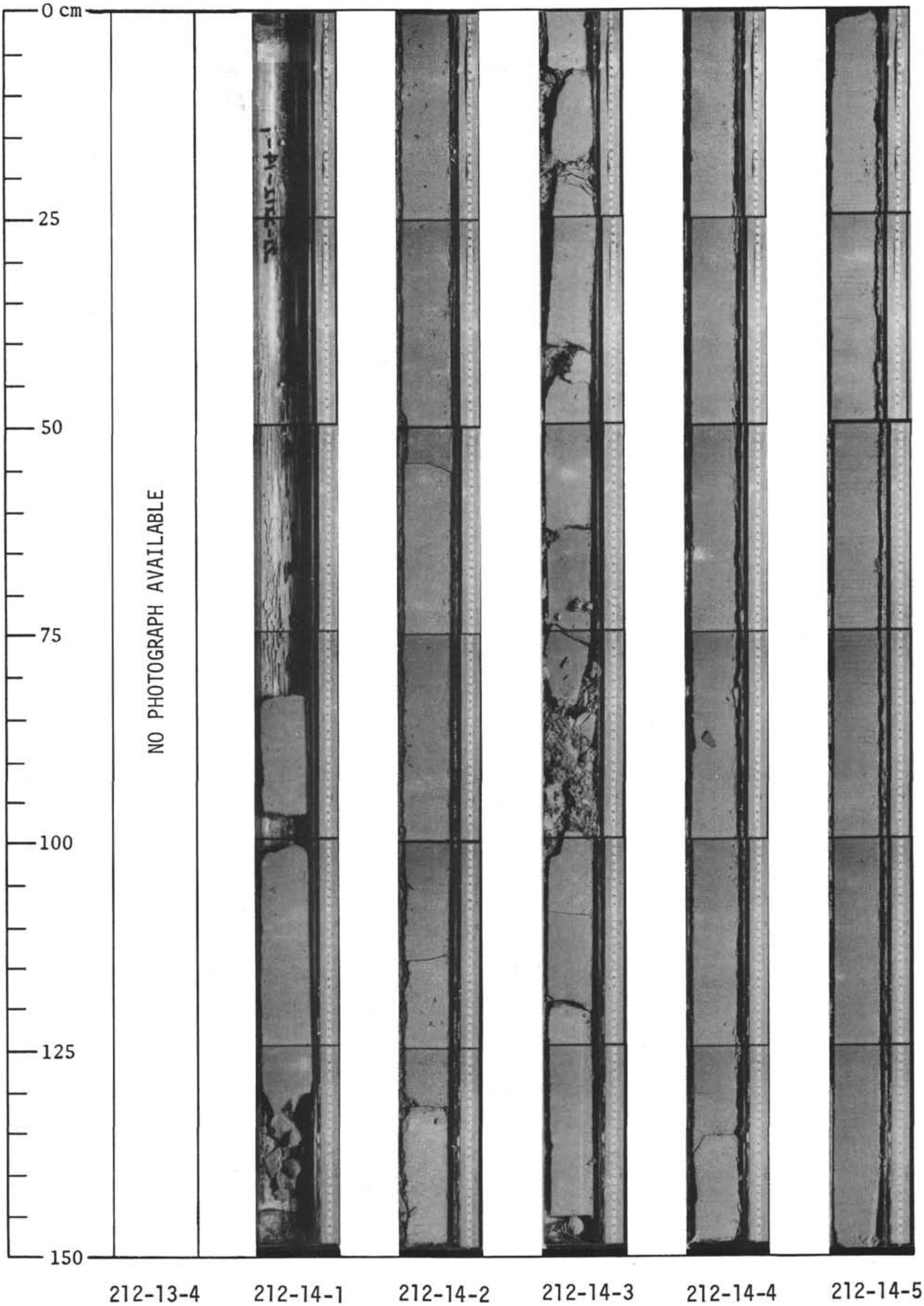
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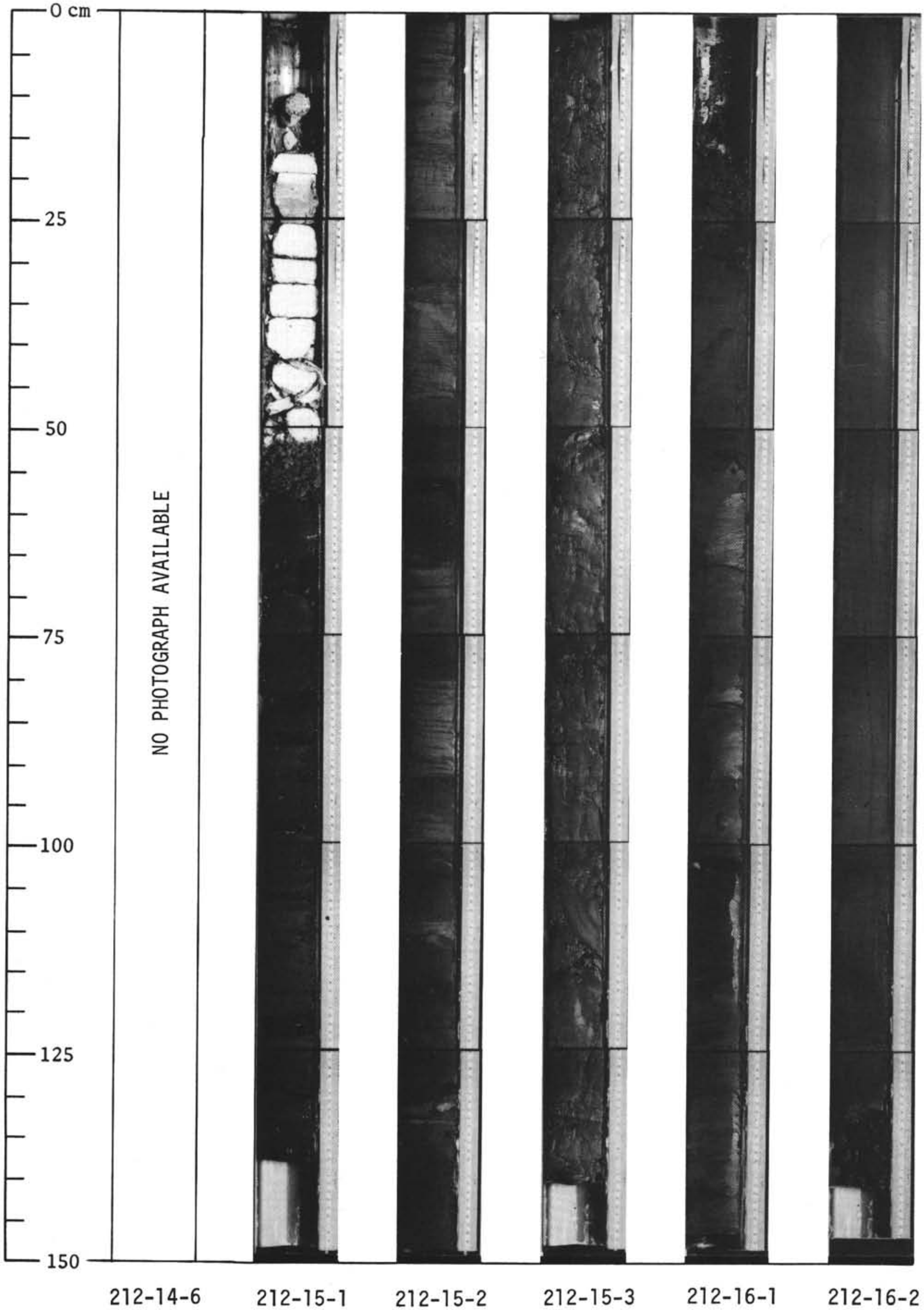
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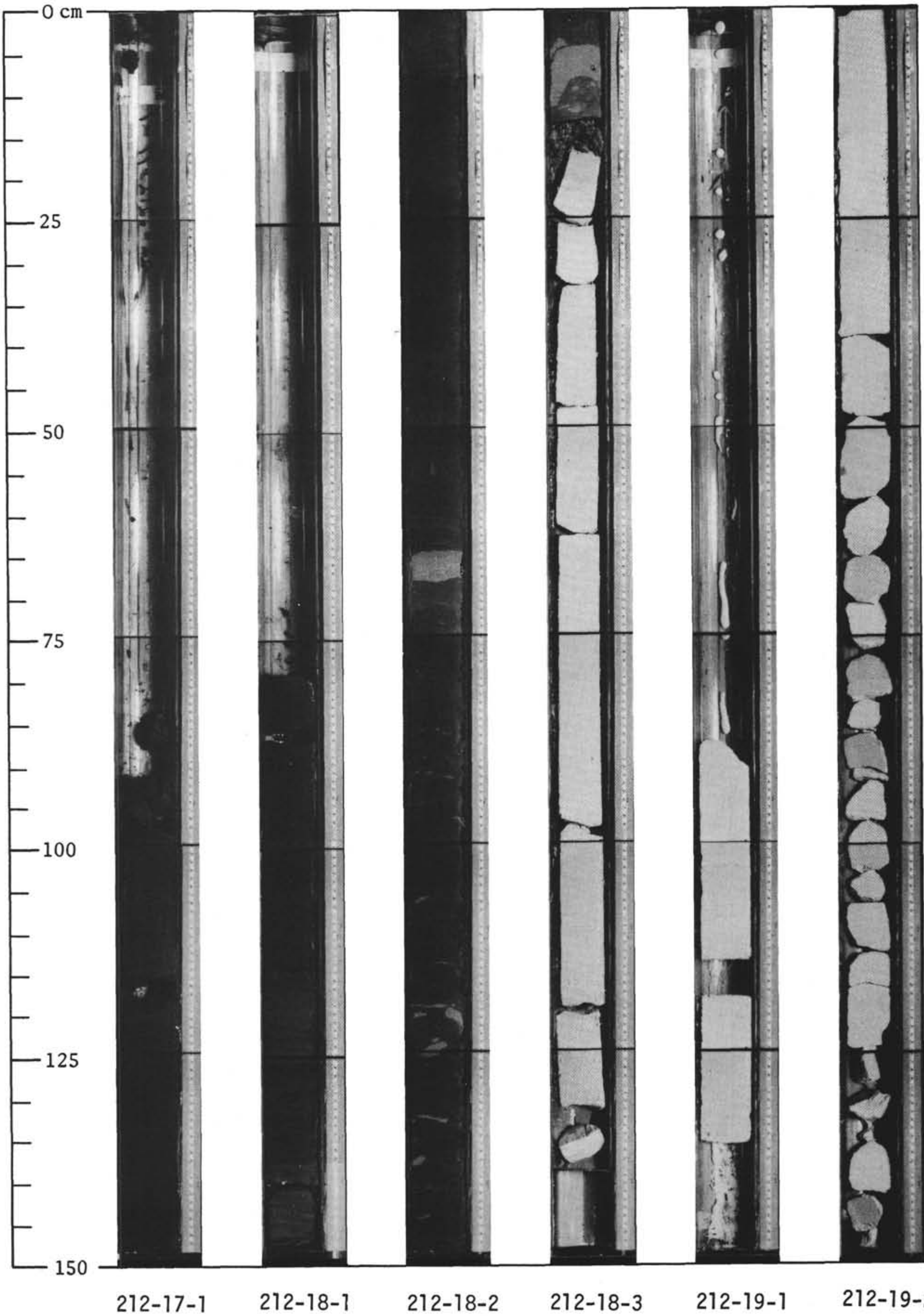
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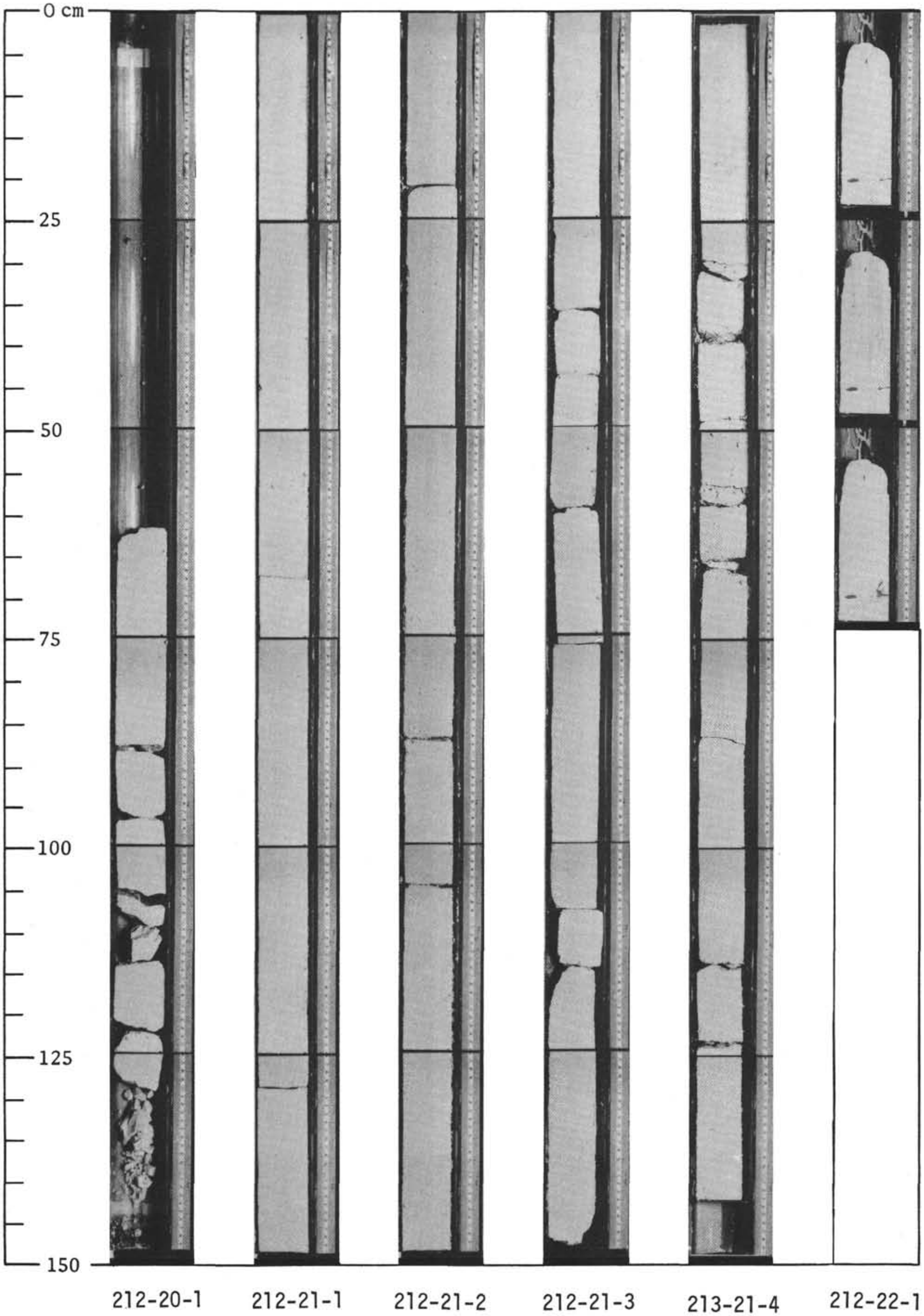
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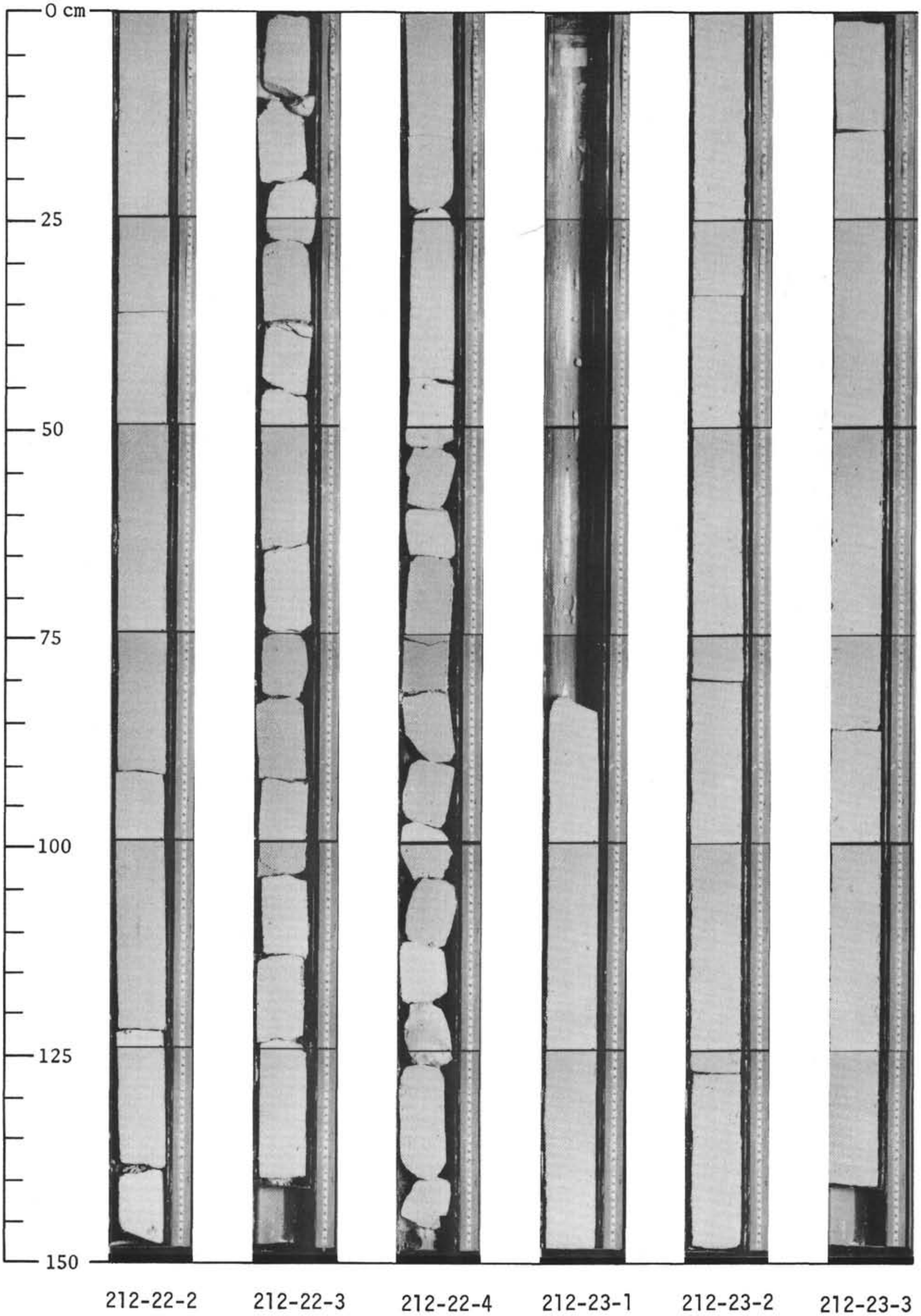
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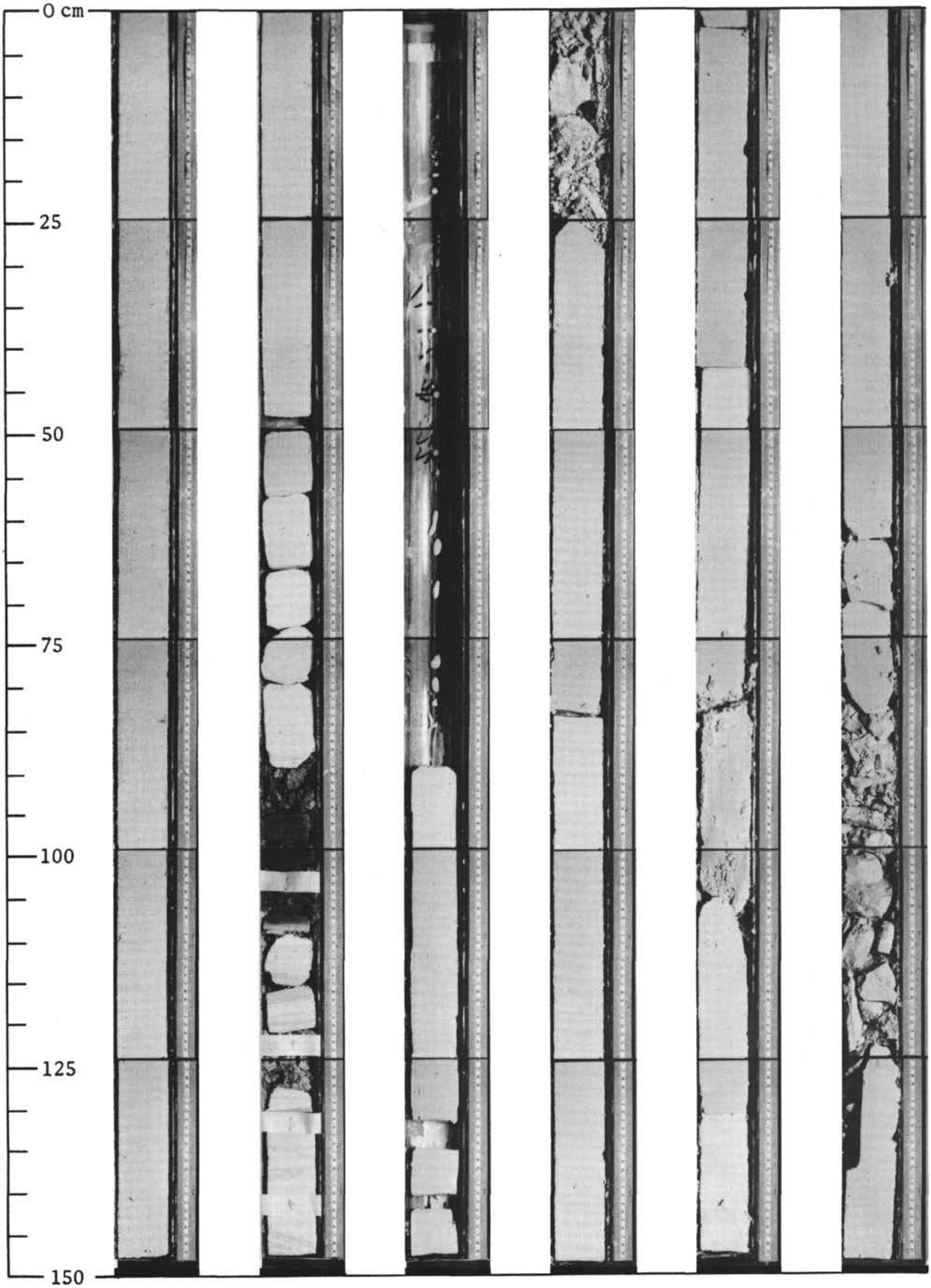
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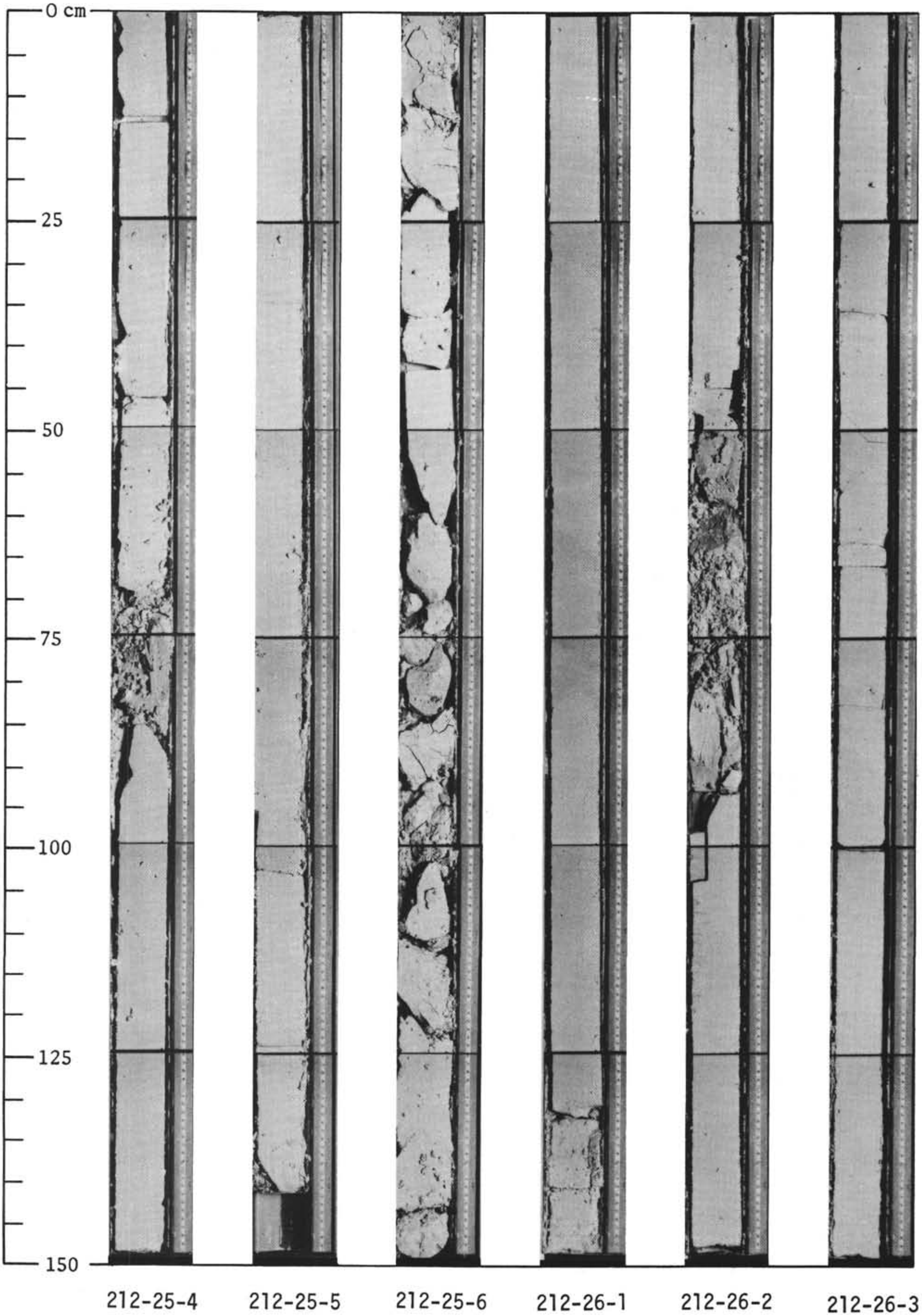
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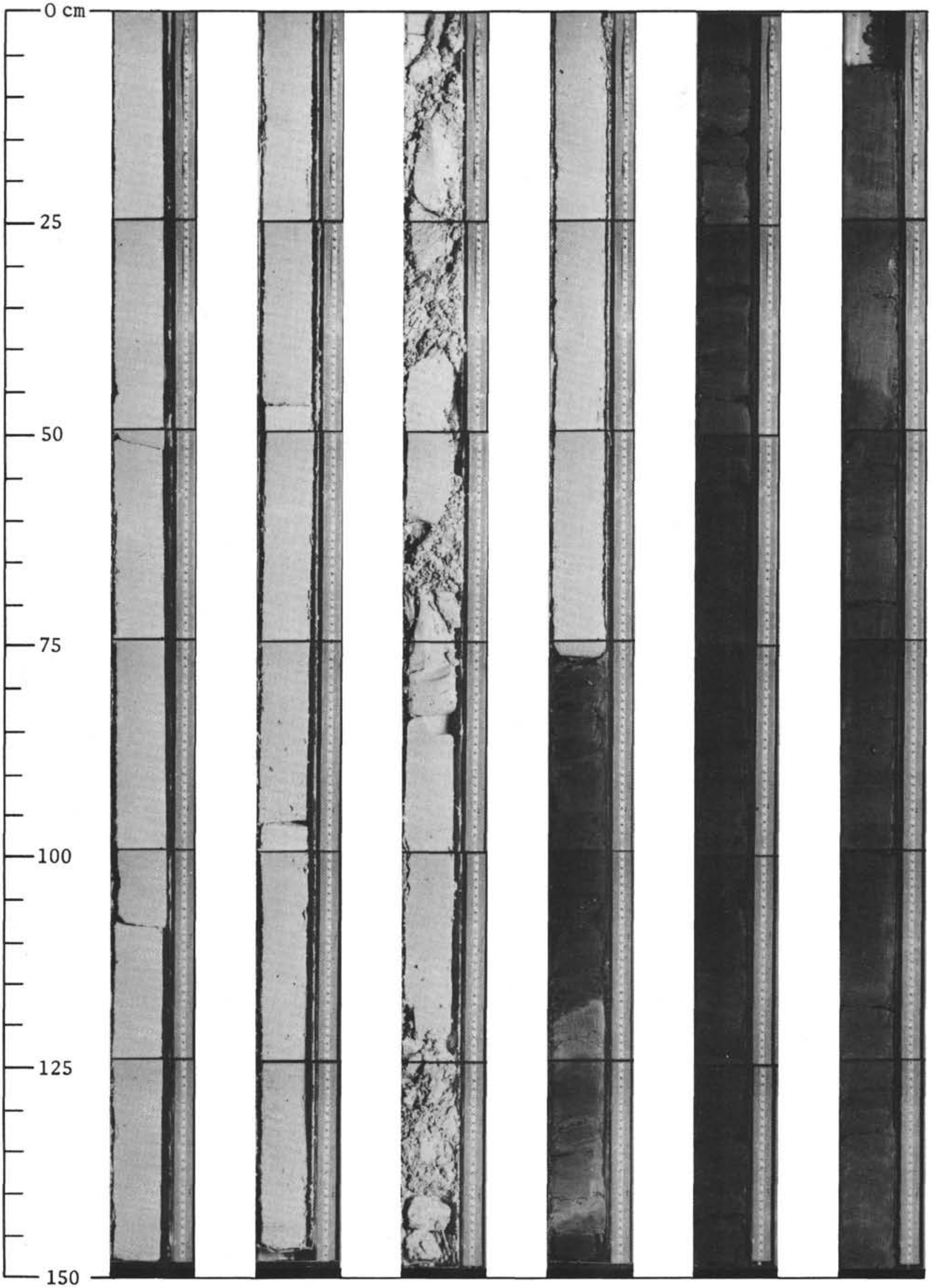
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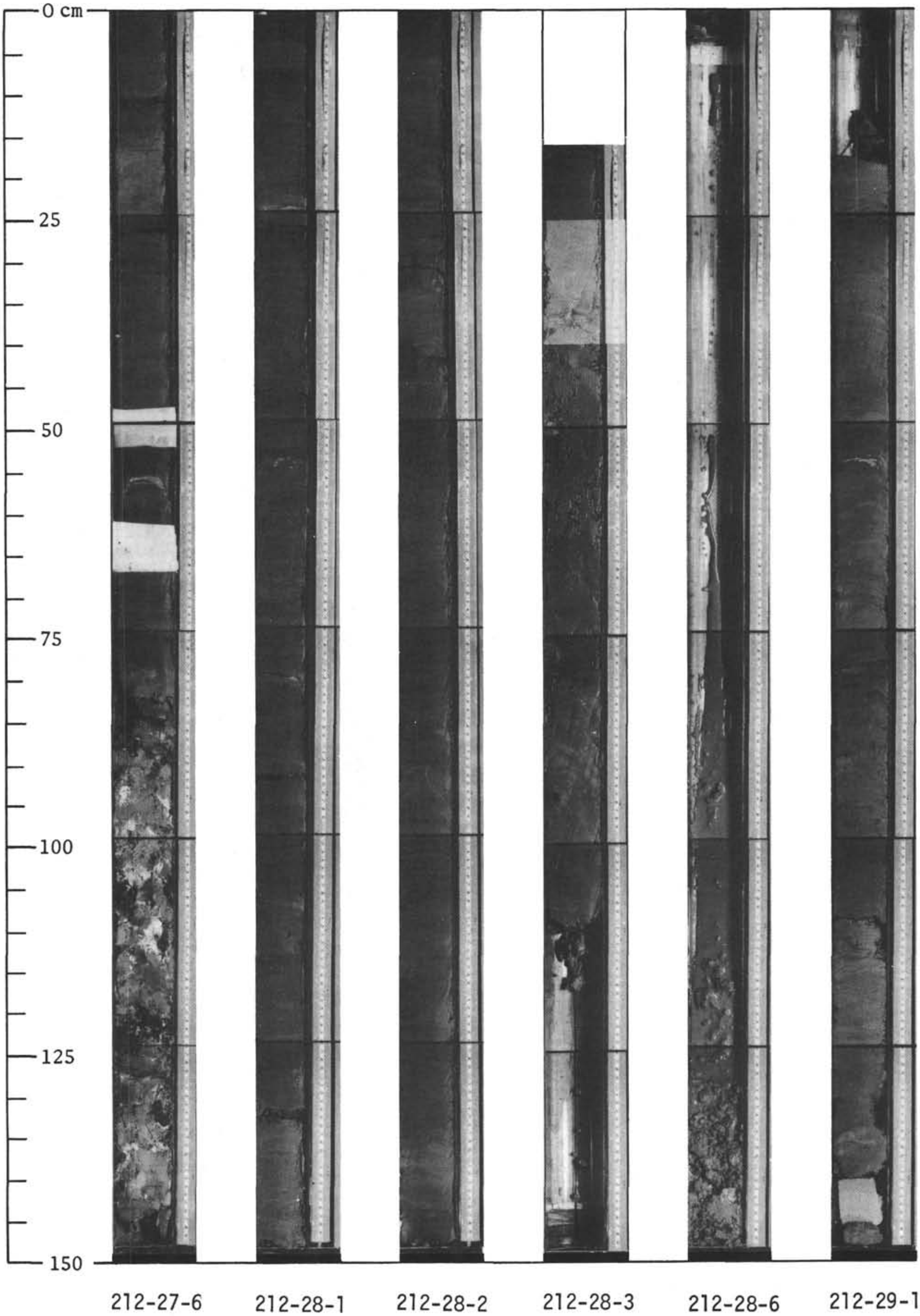
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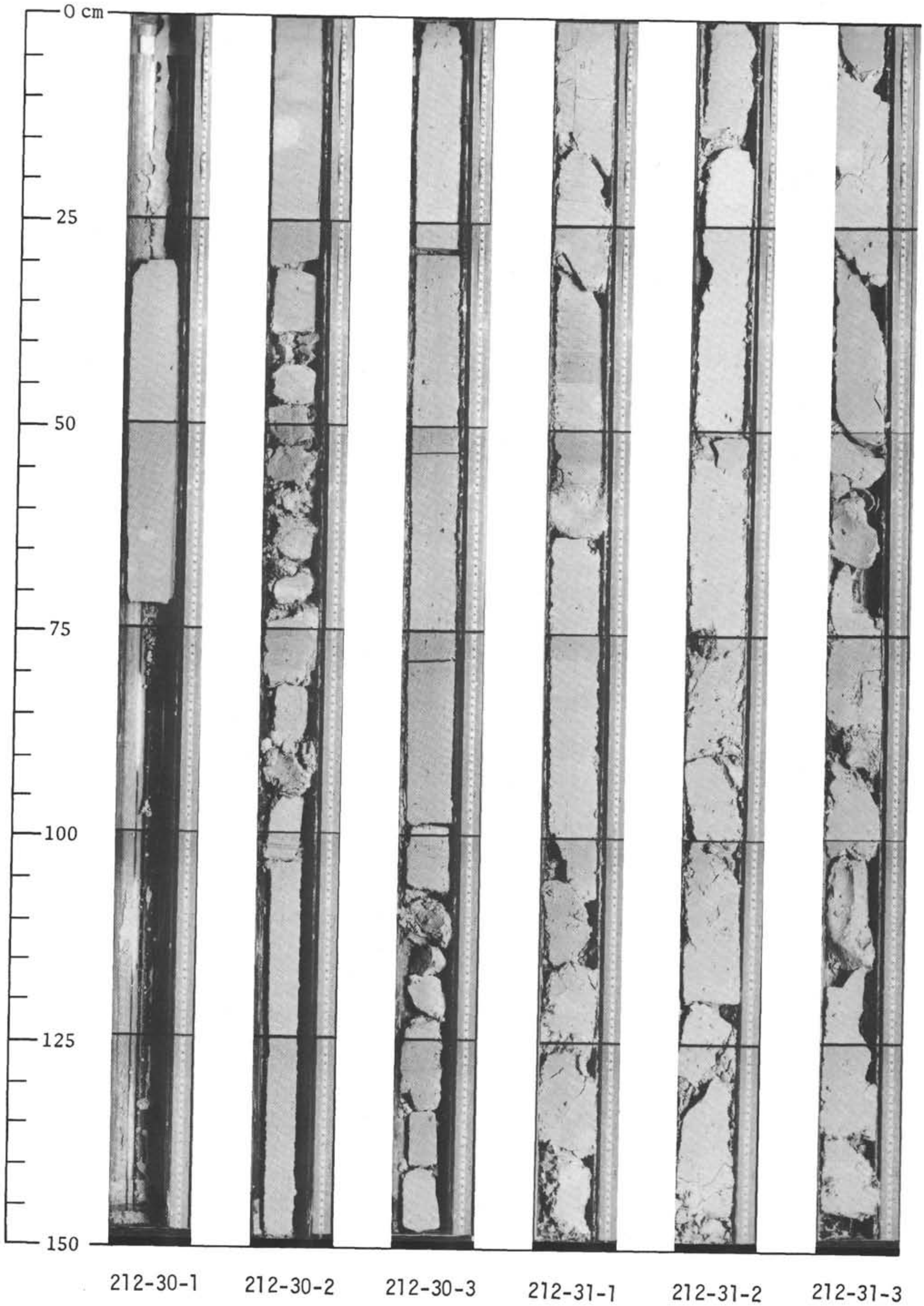
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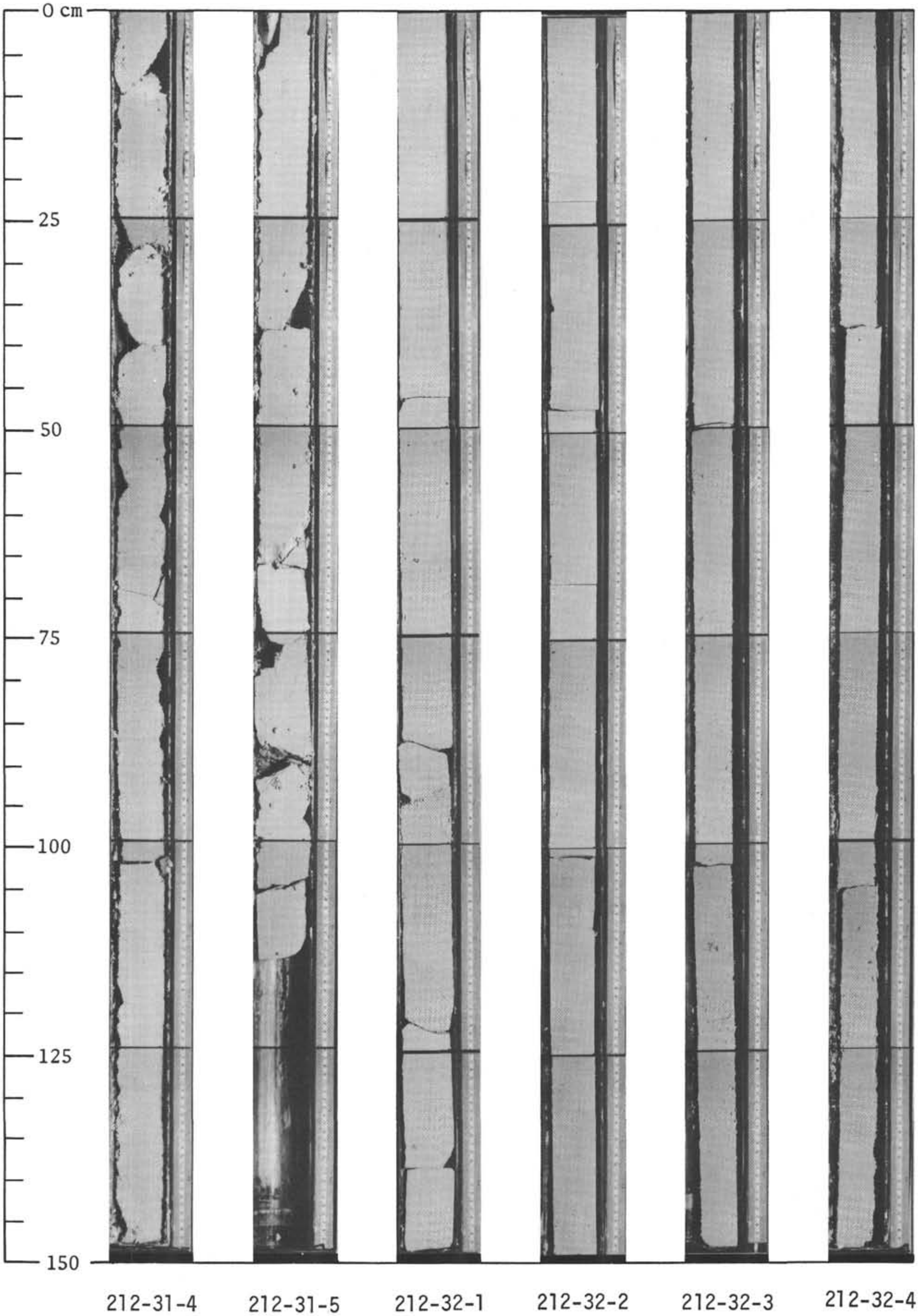
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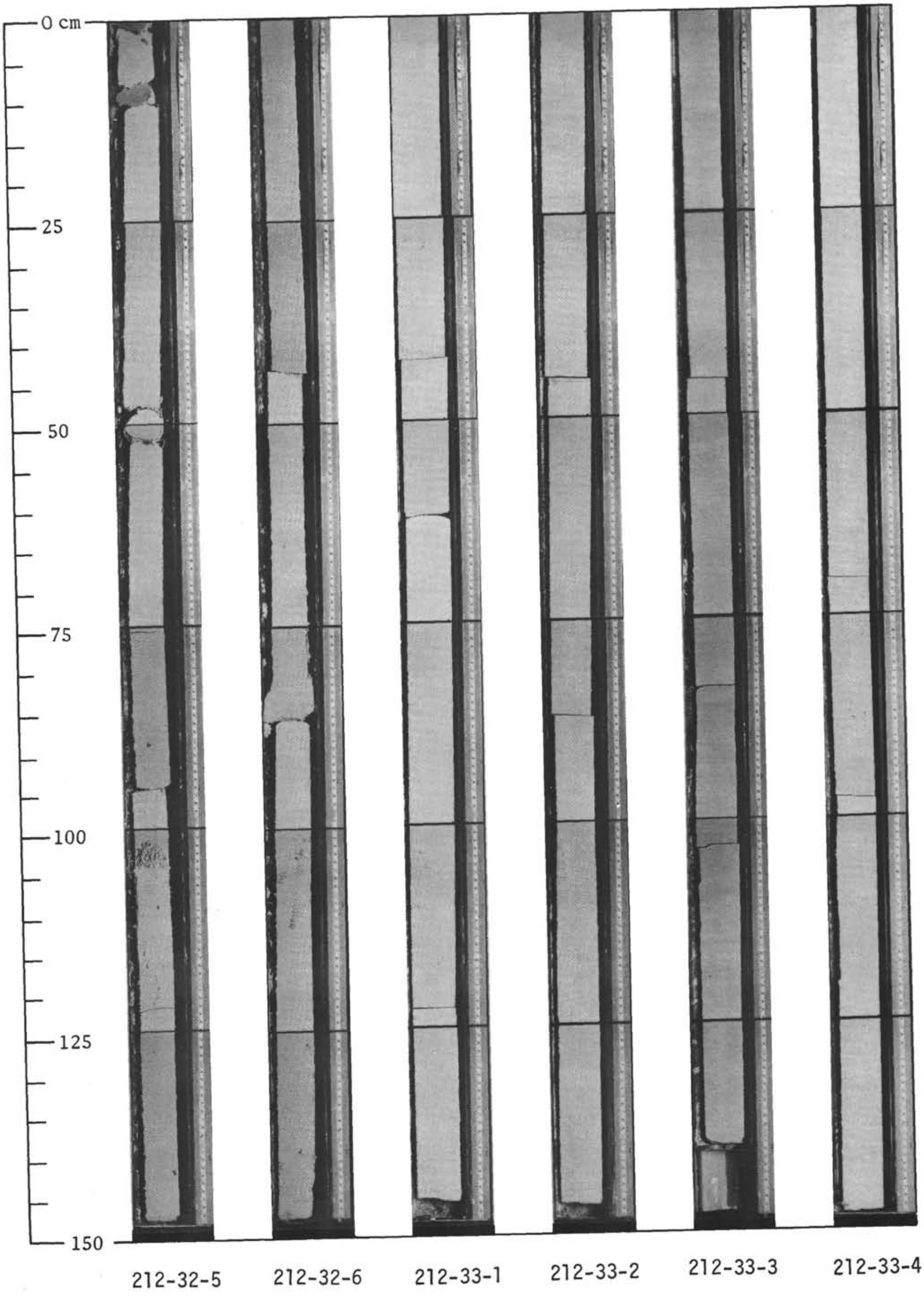
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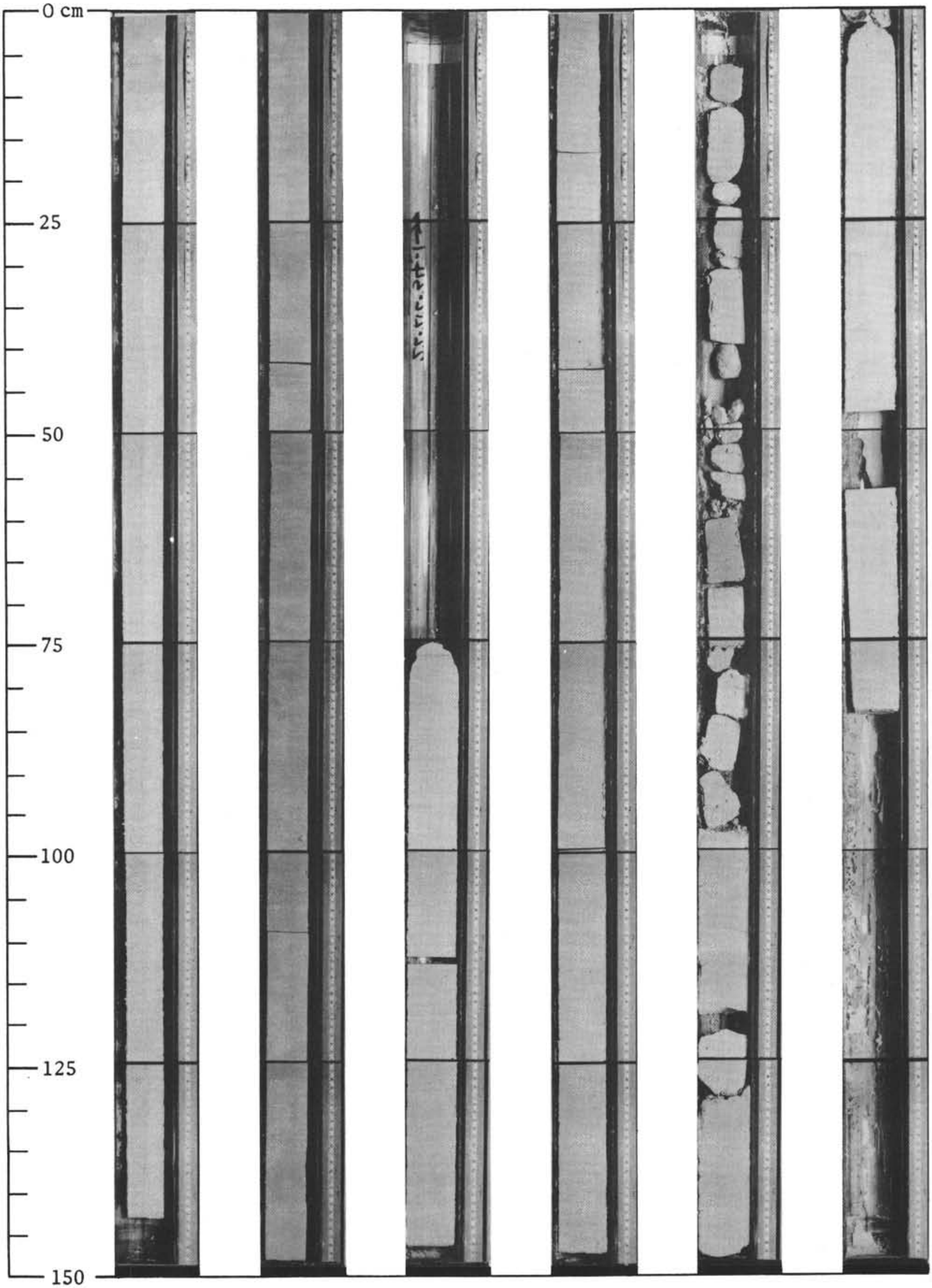

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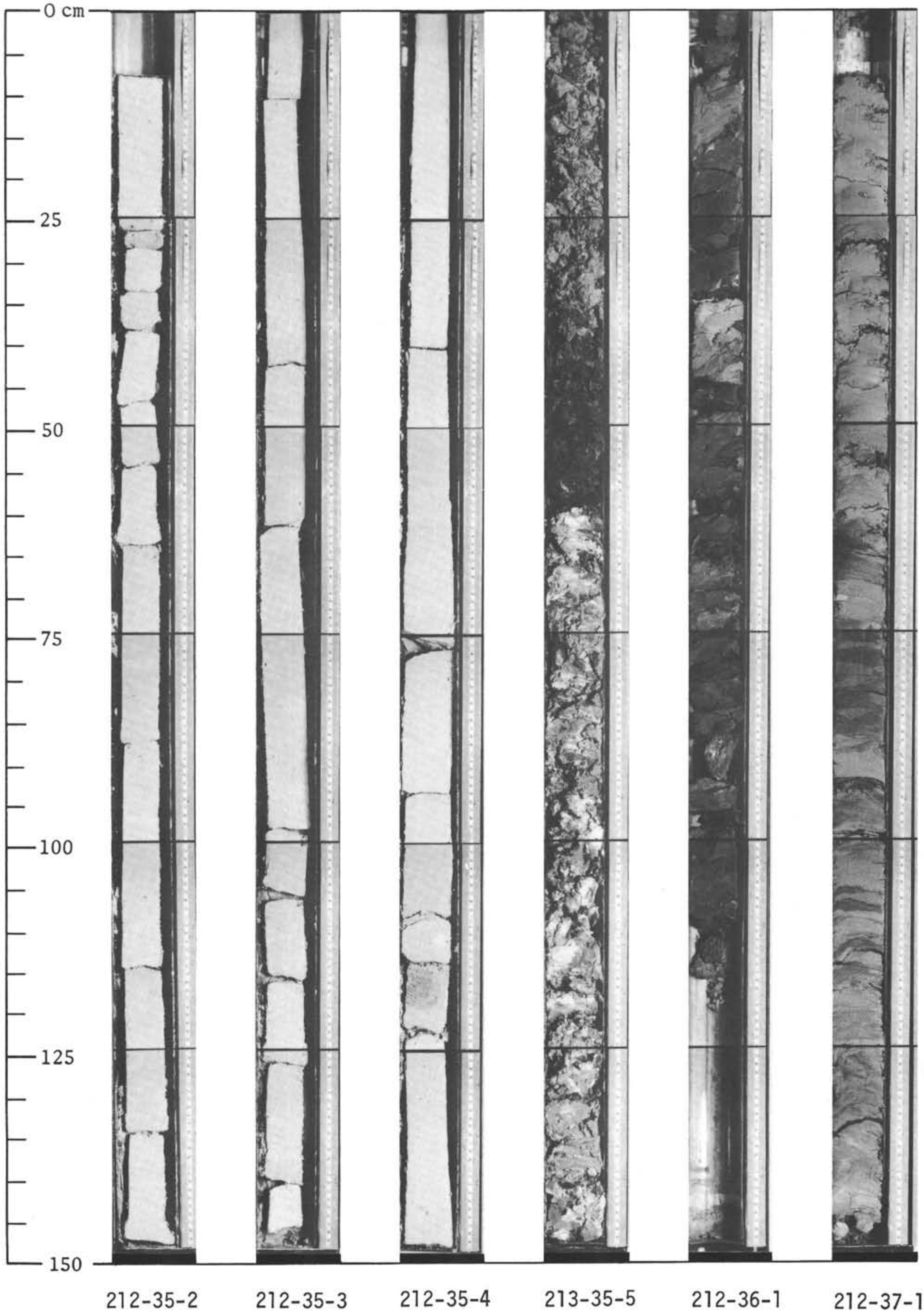
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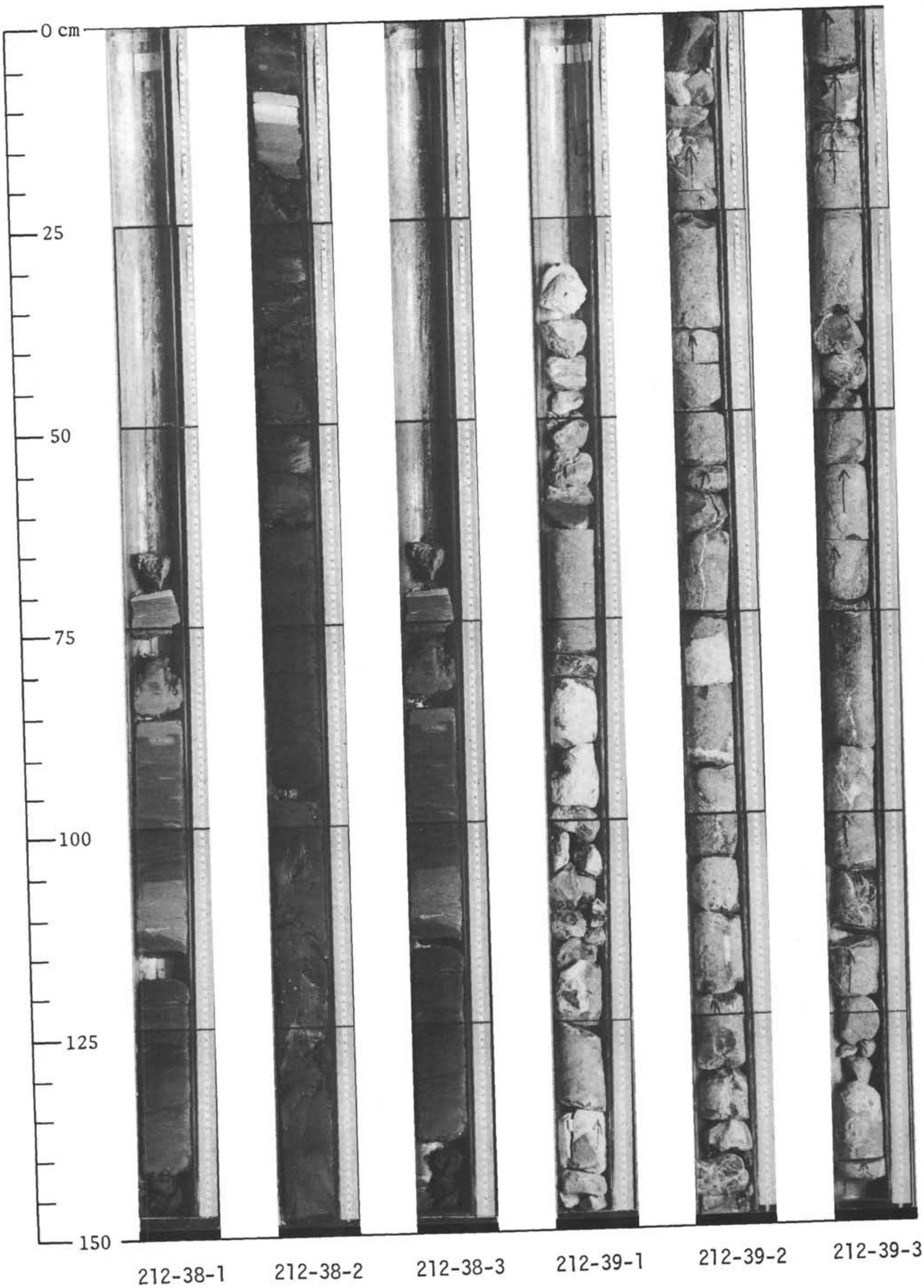
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212-38-3
212-39-1
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