7. SITE 296

The Shipboard Scientific Party[1]

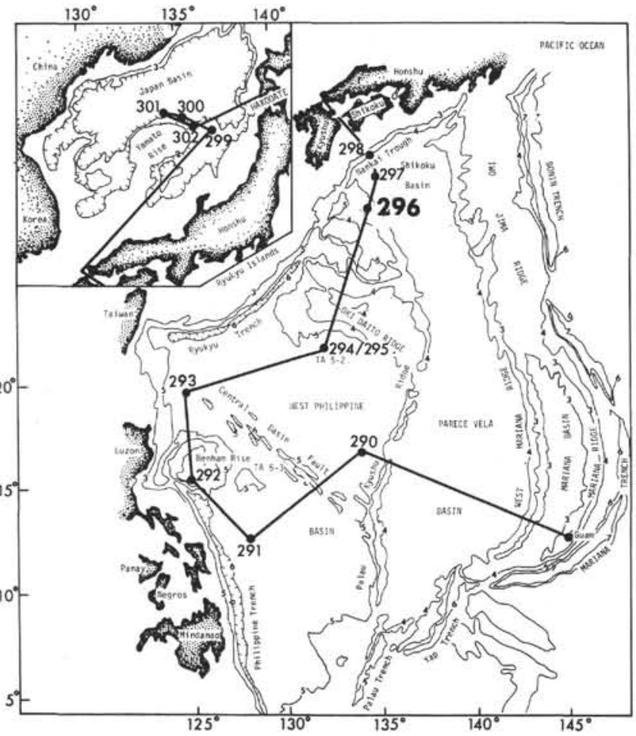

Figure 1. *Location of Site 296 and track of* Glomar Challenger. *From map: "Topography of North Pacific," T. E. Chase, H. W. Menard, and J. Mammerickx, Institute Marine Resources, Geol. Data Center, Scripps Institution of Oceanography, 1971. Contour depths in kilometers. Scale: 1:6,500,000.*

SITE DATA

Position: 29°20.41′N; 133°31.52′E.

Water Depth (from sea level): 2920 corrected meters (echo sounding)

Bottom Felt At: 2958 meters (drill pipe)

Penetration: 1087 meters

Number of Holes: 1

Number of Cores: 65

Total Length of Cored Section: 612 meters

Total Core Recovered: 312.1 meters

Percentage of Core Recovery: 51%

Oldest Sediment Cored:
Depth below sea floor: 1087 meters
Nature: Volcanic tuff and conglomerate
Age: Early Oligocene(?)
Measured velocity: 2.7 km/sec

Principal Results: Site 296 was drilled on a sediment-covered terrace high on the west flank of the Palau-Kyushu Ridge. The stratigraphic sequence consists of 453 meters of late Oligocene to Pleistocene ash-bearing, clay-rich, and clayey nannofossil oozes/chalks overlying more than 634 meters of early to late Oligocene volcaniclastics in which the hole bottomed (terminated). The clayey chalk-ooze interval provides an excellent biostratigraphic reference section and record of Neogene planktonic events beneath the Kuroshio Current. Displaced littoral foraminifera indicate that portions of the ridge were at or near sea level during the late Oligocene, whereas Neogene bathyal species document later subsidence of the ridge. The boundary between Oligocene volcaniclastics and younger chalks may coincide with rifting of the ridge after initial opening of the Parece Vela Basin in the late Oligocene.

BACKGROUND AND OBJECTIVES

Background

Site 296 is located on a northwest-west-trending structural bench or terrace near the northern terminus of the Palau-Kyushu Ridge adjacent to the Nankai Trough (Figures 1, 2). This major ridge has been most recently viewed as a remnant arc of Paleogene age (Karig, 1971; Uyeda and Ben-Avraham, 1972) which has undergone subsidence, perhaps beginning in the Oligocene in conjunction with rifting of the arc. Importantly, the Palau-Kyushu Ridge is rather broad at its northern terminus providing a topographically isolated platform for the accumulation of calcareous pelagic oozes above the calcium carbonate compensation depth (CCD), thus preserving a record of mid-Tertiary to Recent planktonic events in the overlying Kuroshio Current system.

Precruise study of LDGO *Vema*-21 reflection profiles revealed a suitable area displaying 500 to 700 meters (0.4-0.5 sec) of acoustically transparent sediment on the west side of the Palau-Kyushu Ridge which was confirmed by additional *Glomar Challenger* profiles (Figure

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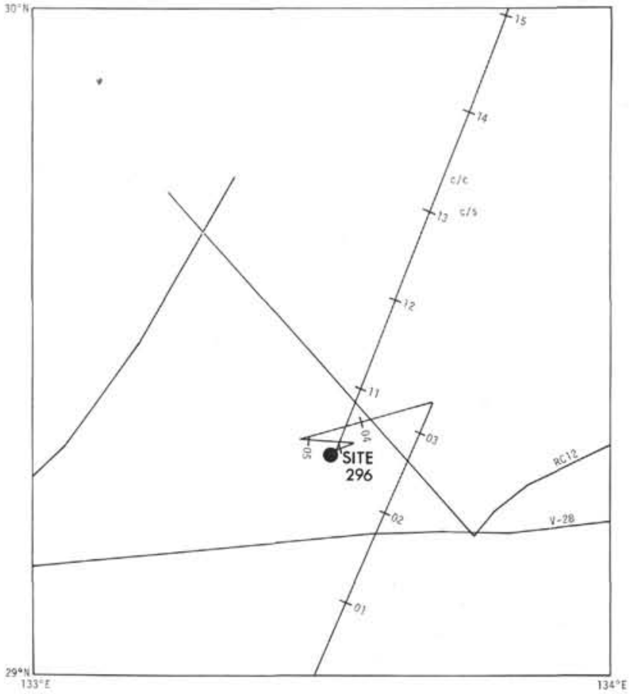

Figure 2. *Track of* Glomar Challenger *approaching and departing Site 296. Other well-navigated tracks, for which bathymetric and reflection data were available, are also shown.*

3); this area was ultimately selected as the site for Hole 296 (Figure 4). Thus, drilling at this position near the ridge terminus offered an equally attractive setting for recovery of data bearing on planktonic biostratigraphy of this mid-latitude area, as well as ridge history. Moreover, it was also thought that possible variations in the position of the convergence zone between the northward-moving warm Kuroshio Current and subarctic water of the Oyashio Current might have occurred in this region in response to major climatic fluctuations during the Neogene. If so, these variations might be expressed as stratigraphic variations in planktonic biofacies at Site 296.

Objectives

One of the major overall goals of Leg 31 was to obtain a series of biostratigraphic reference sections at sites traversing tropical through subarctic zoogeographic provinces extant in the marginal northwestern Pacific. The outstandingly complete Eocene through Pleistocene sequence recovered at Site 292 on Benham Rise formed the initial and wholly tropical biostratigraphic section within this series. The primary objective at Site 296 was the recovery of an equally valuable reference secion deposited beneath the subtropical transitional water mass of the Kuroshio Current, the major western boundary current in the Pacific Ocean. It was hoped that such a mid-latitude site would allow recovery of planktonic assemblages containing tropical, subtropical, and perhaps temperate species. The assemblages recovered would provide assistance in correlation of well-established tropical planktonic zonations with cooler water biofacies as well as detailing paleooceanographic trends.

The second major objective at Site 296 was centered on recovery of paleontologic and lithologic data which might aid in deciphering the age, origin, and history of the controversial Palau-Kyushu Ridge. It was anticipated that variations in occurrence and character of volcanic debris might prove especially helpful in this respect.

OPERATIONS

Site 296 had been planned primarily as a biostratigraphic hole with the additional objectives of exploring the possible subsidence, basement character, and volcanic activity on the Palau-Kyushu Ridge. Locating such a biostratigraphic hole was difficult because the area chosen had to be substantially shallower than the CCD, far enough north to produce a mid-latitude flora and fauna, and beneath sufficiently productive waters. The northern end of the Palau-Kyushu Ridge presented the only suitable site area. A favorable area was located on LDGO *Vema*-21 reflection profile, which showed about 500 meters of transparent sediment on a bench along the west side of the Palau-Kyushu Ridge. The constant thickness of the sediment on this bench suggested that the section consisted of pelagics, with little reworking. The track, headed directly from Site 295 toward the point on the *Vema* track which crossed this plateau. However, it was decided to survey the area briefly to insure that we were not adjacent to local topographic highs.

Presite Survey

The short survey began by reducing speed to 8.5 knots along a 020° track between sites and continuing until reaching the area of the basement core of the ridge. A second survey leg, along 255° contained data, that together with the *Vema* profile and our 020° survey, indicated that the plateau trended north-northwest. The data also revealed an adequate sediment pile between the major basement high and the edge of the plateau. After continuing 4 miles beyond the chosen site, the course was reversed, and a 16-kHz beacon was dropped. Because of a faulty signal from the beacon while descending to the bottom, the profiling gear was quickly restreamed, and a third pass made over the site. A 13.5-kHz beacon was dropped on this pass.

The water depth was 2920 meters, and the hole spudded in on 10 July with an initial punch core. Continuous coring, at a rate of about one core per hour (Figure 5), continued in nannofossil ooze to a depth of 472 meters (Table 1). At this depth the sediment changed gradually to coarse volcaniclastics, which formed acoustic basement. A decision was made to core and drill through the volcanics which were thought to be relatively thin because flows or very coarse material had not been encountered and the fossil content had remained high. However, after 700 meters of drilling with cores taken at an increasing spacing with depth (Table 1) and with the loss of fossil control, it was decided to abandon the site.

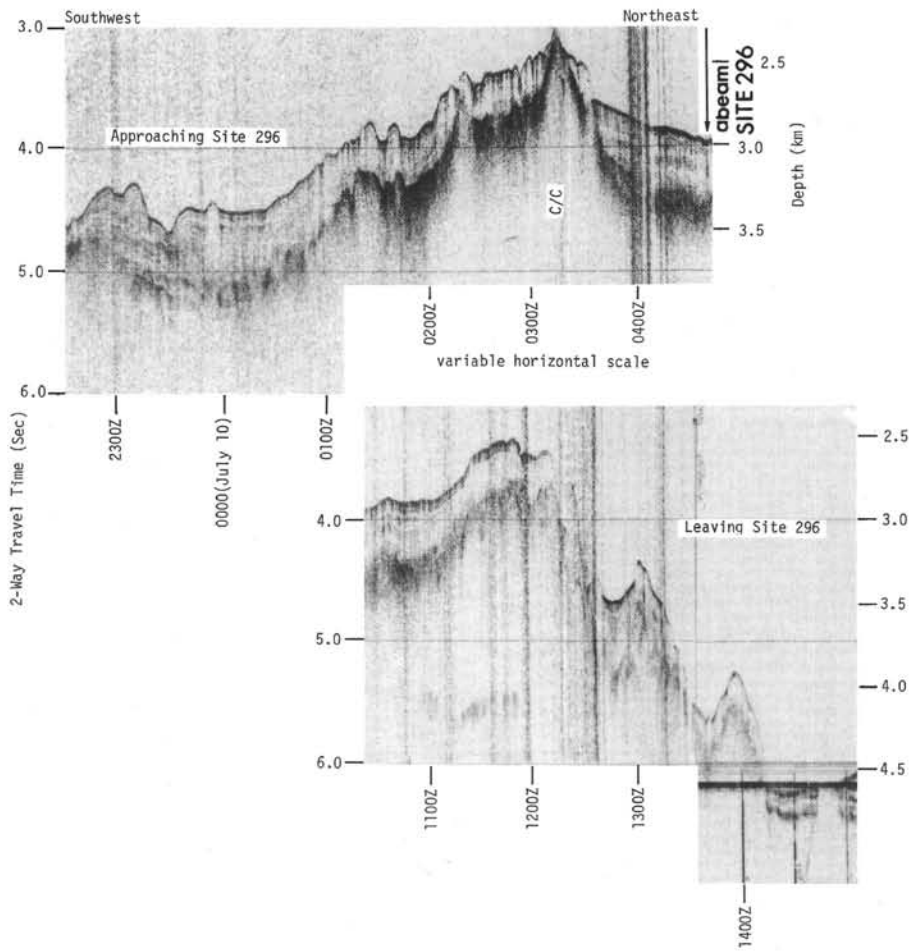

Figure 3. Glomar Challenger *seismic reflection profiles across the Palau-Kyushu Ridge near Site 296.*

The final, 65th, core was run in conjunction with an inclinometer test which showed the hole to be vertical. The pipe was pulled out of the hole at 1900 on 14 July.

Because there was insufficient current to run an onsite sonobuoy, a sonobuoy was dropped upon leaving the site. The ship left at low (2 knots) speed with one gun streamed. After completing a semicircle about 1 mile in diameter, the ship proceeded toward Site 297.

LITHOLOGY

Site 296 is located on a sediment-covered terrace on the western side of the Palau-Kyushu Ridge at a water depth of 2920 meters. The lithologic sequence is outlined in Table 2 and on Figure 5.

Unit 1

The unit is predominantly a 453-meter-thick clayey nannofossil ooze/nannofossil clay, but exhibits the following possible subunits: (A) The 0-44.5 meter interval (Cores 1 to 5) is a foraminifera-rich nannofossil clay, with occasional volcanic ash zones, ash-rich zones, or interbeds. The colors are grays and olive grays; (B) The 44.5-63.5 meter interval (Cores 6 and 7) is a foraminifera/clay-rich to clayey nannofossil ooze, with colors in grays, greenish-grays, and olive-grays; (C) This subunit is defined on the basis of a decrease in the foraminifera content and an increase in micarb. The basic lithology is a clay/micarb-rich nannofossil clay. It is found between 63.5 and 92.0 meters (Cores 8 to 10), with colors of green-gray, olive-gray, and gray; (D) Cores in the 92.0-206.0 meter interval contain a subunit, which is basically a clayey (clay-rich) nannofossil ooze and chalk. The lithification to chalk first becomes apparent in Core 15, Section 4 (134.5 m) and occurs in zones or interbeds with ooze thereafter. Local volcanic ash, ash-rich zones occur. The colors are predominantly light gray, and light olive-gray; (E) A color change to yellow-gray, grayish-orange, and yellow-brown occurs at 206 meters. The basic lithology (clayey nannofossil ooze/chalk) remains the same; however, radiolarians appear as a lithologic component, from 5% to a high of 20% in radiolarian-rich zones. Volcanic ash, ash-rich zones are common and become increasingly prevalent in Cores 28, 29, and 30 (253.5-282.0 m); (F) At 282 meters, lithification is dominant in the sediments. Although the upper 6.5 meters (Core 31) is a nannofossil-rich claystone, the dominant lithology is a grayish-orange to yellow-brown clayey (locally clay-rich) nannofossil chalk. Volcanic ash interbeds occur in Cores 35 and 36. The subunit is defined as occurring between 282 and 343.5 meters (Cores

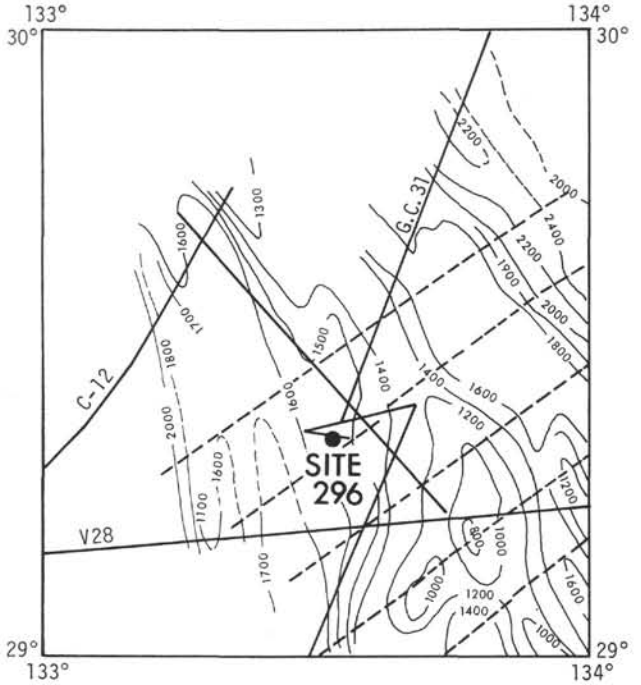

Figure 4. *Bathymetry in the vicinity of Site 296. The discontinuous and en-echelon nature of the basement ridge segments shows well. Dashed lines are bathymetric control from Bracey (1966, p. 11).*

31 to 37); (G) A noticeable color change from yellow-brown and pale orange to green-gray occurs at 343.5 meters in Core 37. The lithology in this core is a clay-rich nannofossil chalk; however, beginning in Core 38 (348.5 m) very significant amounts of volcanic ash, ashy chalk, clayey ash interbeds occur through Core 48 (445 m). There is a slight tendency to a decreasing ash influence in Cores 45 and 46. The X-ray analyses show significant amounts of augite (4.8%-25.3%) in the bulk, 2-20μm, and $<2\mu$m fraction in the interval 370.9 (Core 40) to 435.5 meters (Core 47).

In general, for Unit 1, bioturbation is most noticeable from 254 meters to 453 meters. The age is late Oligocene to late Pleistocene/Holocene.

Unit 2

Unit 2 begins at 453 meters and is a series of subunits of tuffs, lapilli tuffs, volcanic sandstones and siltstones, and occasional ash-rich/bearing nannofossil chalks.

Tuffs

The tuffs and lapilli tuffs contain lithic and crystal fragments that are essentially textural variants from adjacent volcanic sources. A major lithic type is a porphyritic pyroxene andesite, with phenocrysts of oscillation zoned plagioclase, hypersthene, augite, opaques, and occasionally hornblende in a pilotaxitic to hyalophitic or glassy matrix. The matrix consists of plagioclase microlites in a microgranular to glassy groundmass of pyroxene, with scattered specks of opaques. The size of the phenocrysts is essentially constant, whereas the groundmass grain size is highly variable.

1) Phenocrysts and clasts: The plagioclase phenocrysts usually show oscillatory zoning in the range from An_{45} to An_{52} and are full of tiny black specks of pyroxenes and opaques, which are often remelted to a brown glass. Augite is the predominant pyroxene, but hypersthene is often present. The hypersthene like the plagioclase may be inclusion filled, with the inclusions remelted to a brownish glass. In some cases the augite is replaced by hornblende. Along with euhedral opaque phenocrysts, the plagioclase and pyroxene often form large glomeroporphyritic aggregates, which themselves occur as lithic fragments in the tuff. Other abundant lithic fragments are vesicular basalt, pumice, spherulitic andesite, and brown glass. The distribution of the lithic fragments is such that the finer-grained volcanics such as the pumice, glass, and hyalopolitic-textured andesites predominate in the lower portions of the unit. Fragments with coarser-grained matrices are most abundant near the top of the unit. Still other clasts are the phenocryst phases of the andesites. These are predominantly plagioclase crystals, with associated augite, hypersthene, opaques, and hornblende. In general, the crystal fragments are more abundant in the finer-grained tuffs.

The clasts are generally angular to subangular, and poorly to moderately well sorted. Many of the tuffs are found as well-defined 3-meter-thick units, grading upward from lapilli tuffs to tuffs. In any graded unit, the sorting improves as the grain size becomes finer. Deeper in the section flattened clasts show a slight imbricate structure.

2) Matrix: The matrix of the tuff (from 10% to 20%) is composed primarily of palagonitized glass, which is often spherulitic. Near the top of the unit, the tuff has textures reminiscent of a welded tuff, or graywackes, where grain boundaries of the clasts often merge into that of the matrix. The palagonite matrix becomes more clayey and serpentinized with depth, so that deeper than Core 60, the matrix is essentially a clay-serpentine mixture. In addition, smaller fragments of lithics and minerals become more prevalent in the groundmass of the deeper cores. Small vugs in the matrix are often filled with acicular radiating crystals of zeolites. Calcareous nannofossils, shallow-water benthonic foraminifera, and micarb (algae) are found in the groundmass of Cores 53 and 56.

Volcanic Sandstones and Siltstones

A second sublithology present in Unit 2 are volcanic sandstones and siltstones. These are significant subunits starting at 750 meters. The sand/silt sized volcanic fragments are subrounded/subangular to angular, illustrate excellent graded units, poor to good sorting, and have excellent sedimentary structures including cut and fill, load casts, slumping, foreset bedding, and megaforeset bedding. The fragmental material is identical to that found in the tuffs.

Volcanic Ash-Rich/Bearing Nannofossil Chalks-Volcanic Ash

These occur as bearing (2%-10%), or rich (10%-25%) components in nannofossil chalks, or clay-rich nannofossil chalks. These sublithologies were present in Cores 52, 54, and 56. Characteristics of this sublithology

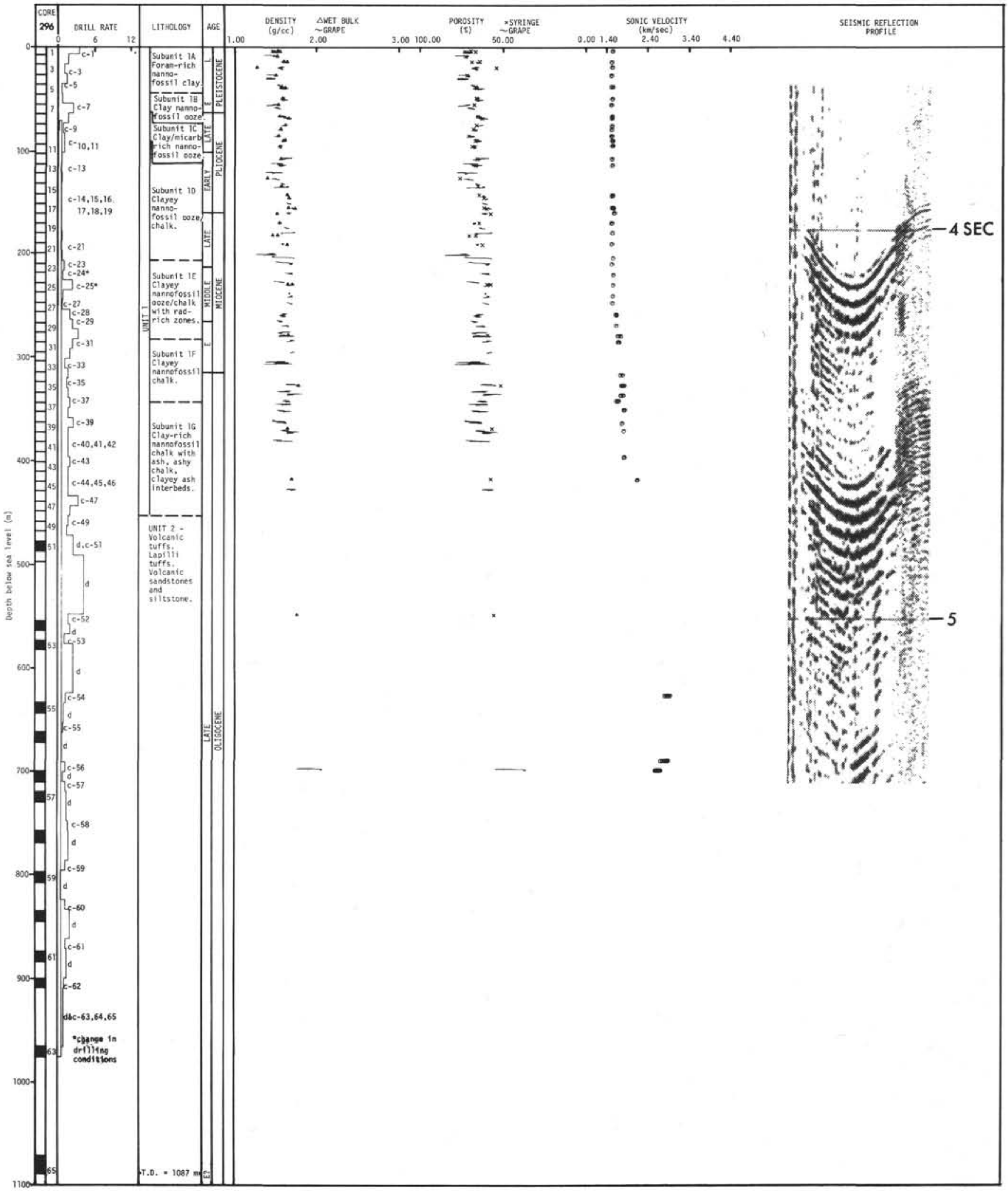

Figure 5. *Hole summary diagram, Site 296.*

TABLE 1
Coring Summary, Site 296

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)	Remarks[a]
1	0.0-6.5	6.5	5.9	91	Punch core
2	6.5-16.0	9.5	7.7	81	
3	16.0-25.5	9.5	5.9	62	
4	25.5-35.0	9.5	5.0	53	
5	35.0-44.5	9.5	5.5	59	
6	44.5-54.0	9.5	7.0	74	
7	54.0-63.5	9.5	4.3	47	
8	63.5-73.0	9.5	5.0	53	
9	73.0-82.5	9.5	9.5	100	
10	82.5-92.0	9.5	9.0	94	
11	92.0-101.5	9.5	5.1	54	
12	101.5-111.0	9.5	4.7	50	
13	111.0-120.5	9.5	5.2	55	
14	120.5-130.0	9.5	9.5	100	
15	130.0-139.5	9.5	5.5	58	
16	139.5-149.0	9.5	8.0	84	
17	149.0-158.5	9.5	7.0	74	
18	158.5-168.0	9.5	2.9	31	
19	168.0-177.5	9.5	8.5	89	
20	177.5-187.0	9.5	4.9	52	
21	187.0-196.5	9.5	8.6	91	
22	196.5-206.0	9.5	9.3	98	
23	206.0-215.5	9.5	3.4	36	
24	215.5-225.0	9.5	7.1	75	
25	225.0-234.5	9.5	5.5	58	
26	234.5-244.0	9.5	6.6	69	
27	244.0-253.5	9.5	3.1	34	
28	253.5-263.0	9.5	6.6	69	
29	263.0-272.5	9.5	8.8	94	
30	272.5-282.0	9.5	5.9	63	
31	282.0-291.5	9.5	7.1	75	
32	291.5-301.0	9.5	6.1	64	
33	301.0-310.5	9.5	5.2	55	
34	310.5-320.0	9.5	4.5	48	
35	320.0-329.5	9.5	7.3	77	
36	329.5-339.0	9.5	8.1	85	
37	339.0-348.5	9.5	6.1	64	
38	348.5-358.0	9.5	3.8	42	
39	358.0-367.5	9.5	5.2	55	
40	367.5-377.0	9.5	5.0	53	
41	377.0-386.5	9.5	3.1	33	
42	386.5-396.0	9.5	1.3	14	
43	396.0-405.5	9.5	1.1	12	
44	405.5-415.0	9.5	0.4	4	
45	415.0-424.5	9.5	3.4	36	
46	424.5-434.0	9.5	5.2	55	
47	434.0-443.5	9.5	0.3	3	30 bbls mud.
48	443.5-453.0	9.5	0.3	3	
49	453.0-462.5	9.5	0.4	4	
50	462.5-472.0	9.5	0.2	2	
Drill	472.0-481.5				
51	481.5-491.0	9.5	0.0	0.0	
Drill	491.0-548.0				50 bbls mud.
52	548.0-557.5	9.5	2.7	30.0	
Drill	557.5-567.0				
53	567.0-576.5	9.5	0.6	1.0	
Wash	576.5-624.0				50 bbls mud.
54	624.0-633.5	9.5	3.9	43.0	
Drill	633.5-652.5				
55	652.5-662.0	9.5	1.4	15.0	
Drill	662.0-690.5				
56	690.5-700.0	9.5	10.0[b]	100.0	
Drill	700.0-709.5				50 bbls mud.
57	709.5-719.0	9.5	4.5	47.0	
Drill	719.0-747.5				
58	747.5-757.0	9.5	4.4	46.0	
Drill	757.0-785.5				
59	785.5-795.0	9.5	1.2	13.0	

TABLE 1 – *Continued*

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)	Remarks[a]
Drill	795.0-823.5				50 bbls mud.
60	823.5-833.0	9.5	1.1	12.0	
Drill	833.0-861.5				
61	861.5-871.0	9.5	2.0	21.0	
Drill	871.0-899.5				
62	899.5-909.0	9.5	2.2	23.0	
Drill	909.0-966.0				50 bbls mud.
63	966.0-975.5	9.5	4.9	52.0	
Drill	975.5-1070.5				50 bbls mud.
64	1070.5-1080.0	9.5	5.1	53.0	
65	1080.0-1087.0	7.0	3.0	43.0	
Total	1087.0	612.0	312.1	51.0	

[a]See Figure 5 for graph of drilling rates.

[b]Extra 0.5 meter beyond core barrel.

TABLE 2
Unit Descriptions, Depths, Thicknesses, and Ages, Site 296

Unit	Descriptions	Depth (m)	Thickness (m)	Age
1A	Foraminifera-rich nannofossil clay	0-44.5	44.5	Early Pleistocene-Pleistocene/Holocene
1B	Foraminifera/clay-rich, (clayey) nannofossil ooze	44.5-63.5	19.0	Early Pleistocene
1C	Clay/micarb-rich nannofossil ooze	63.5-92.0	28.5	Late Pliocene-early Pleistocene
1D	Clayey nannofossil ooze/chalk	92.0-206.0	114.0	Late Miocene-Late Pliocene
1E	Clayey nannofossil ooze/chalk with radiolarians and radiolarian-rich zones	206.0-282.0	76.0	Early Miocene-late Miocene
1F	Clayey nannofossil chalk	282.0-343.5	61.5	Late Oligocene-early Miocene
1G	Clay-rich nannofossil chalk with extensive ash, ashy chalk and clayey ash interbeds	343.5-453.0	109.5	Late Oligocene
2	Volcanic tuffs, lapilli tuffs, volcanic sandstones/siltstones	453.0-1087.0	≅634	Early (?) to late Oligocene

included: lamination, thin bedding, sharp basal contacts, associated "fall" fragments, and bioturbation. Some of the ashy zones exhibited current traction features. The ash content varied from 7% to 30%.

Unit 2 is at least 65 meters thick, with an age of early(?) to late Oligocene. The early Oligocene date is based on marginal nannofossil floras which were recovered in Core 65 (1087 m).

Lithologic Interpretations

The geologic history of the Site 296 area is characterized by a dominant eruptive volcanic phase up through late Oligocene. This activity waned from late Oligocene to the Holocene, being replaced by pelagic nannofossil sedimentation.

The volcanogenic subunits of Unit 2 illustrate the combined effects of pyroclastic accumulation by settling through the water column, depositional characteristics associated with settling, and minor redistribution by gravity transfer and bottom current mechanisms.

1) The lapilli tuffs and tuffs, with their range of sorting from poor to moderate; the grading of the volcanic fragments (lapilli to tuff); the angular-subangular fragment shape; and in particular the glassy matrix are indicative of a near-direct accumulation from a volcanic eruptive process. Shallow-water foraminifera and algal

carbonate masses serve to indicate a shallow source for the pyroclastic products during certain eruptive periods. Graded bedding, imbricate structures, and current structures may emphasize sedimentary processes occurring during the initial accumulation, as well as transport over the bottom to deeper water. In general, there is increasing evidence of sedimentary structures toward the base of the unit.

Diagenetic changes associated with time and depth have imparted characteristics to these lapilli tuffs and tuffs. These changes include: consolidation, devitrification, hydration to palagonite, or hydration leading to diffuse fragment boundaries, and alteration of fragments to a clay-serpentine material. These characteristics are especially noticeable deeper in the cored section.

2) The angularity, grading, and composition of the volcanic ash, and its association with nannofossil chalks in Cores 52, 54, 56, and 57 support the idea that they are ash-fall accumulations which settled through the water column.

3) Volcanic sandstones and siltstones contain subrounded to subangular clasts and show moderate to good sorting and current structures. This evidence can be used to infer postdepositional redistribution by bottom currents or gravity transfer processes as single events or a concurrent interplay of volcanic settling and redistribution.

The thickness and age of the volcanic sediments in Unit 2 provide support for a rapid build-up (317 m/m.y.) of a volcanic pile. Factors such as oversteepening, liquification, or earthquakes could trigger a gravity transfer mechanism, and subsequent transfer processes on the sea floor. The lithologic variations throughout Unit 2 and the large- and small-scale graded units support periodicity of the eruptive and depositional processes in this area.

4) A rather significant waning of eruptive volcanic activity, and a decrease in sediment redistribution by bottom transfer processes is noted in Unit 1. A decrease in volcanic activity is noted upwards from Core 28, and the decrease becomes more evident toward the top of the unit.

Pelagic nannofossil sedimentation is quite apparent in Unit 1, showing occasional volcanic eruptive cycles throughout its 453-meter thickness. Trace amounts of detrital minerals (quartz, feldspar, and heavies), plus clay minerals (up to 25%), attest to contamination of the nannofossil ooze via settling in the water column or settling from a bottom turbid current or drift. Radiolarians are present in the upper portions of the cored interval, becoming absent with increasing depth, and reappearing again in Cores 22 to 38. They are generally absent thereafter. Foraminifera are also variable in their content, but occur down to Core 56 of Unit 2.

PHYSICAL PROPERTIES

Bulk Density, Porosity, and Water Content

In general, a minor increase in bulk density can be observed in a downward direction in this hole, and no significant difference can be seen between the nannofossil ooze, nannofossil chalk, and carbonate containing volcanic ash (Figure 5). Water content reveals the same irregular pattern, with a slight overall decrease in downward direction.

Vane Shear

The shear-strength measurements of the nannofossil ooze show a well-defined trend to 50 meters increasing rapidly over this interval. At greater depths, the data show more scatter and the rate of strengthening decreases. The scatter of measurements between 50 to 155 meters is partly due to drilling deformation, but also may be a function of periodic variation in natural consolidation/lithification observed at depths greater than 100 meters.

A comparison with the brown mud at Sites 294/295 shows, that for a given depth, the nannofossil ooze has a higher shear strength. Early incipient lithification and greater internal friction probably account for higher shear strengths of the nannofossil ooze. Additional discussion will be found in Bouma and Moore (this volume).

Sonic Velocities and Thermal Conductivities

Sonic velocities and thermal conductivities were both measured on the same core section. Syringe samples for water content were also collected at the same locations where thermal conductivities were measured, as long as the cores were soft enough. During the continuous coring, cores were brought up at about 1-hr intervals. This situation did not always allow thermal uniformity in the core to be attained, and most conductivity measurements were made 1.5 to 2.5 hr after cores were brought on deck. In a few cases, it was recognizable that the results were affected by thermal nonuniformity.

The results of sonic-velocity and thermal-conductivity measurements are tabulated in Tables 3 and 4, and summarized in Figures 5 and 6. Sonic velocity is almost constant in the upper 250 meters, while thermal conductivities increases slightly. At depths of about 260 and 410 meters, discontinuities are present in the trend of sonic velocities, while thermal-conductivity measurements show little change in trend at 260 meters. At the depth where sonic velocity became 1.8 km/sec, the sediment became too hard for thermal-conductivity measurements. A slightly slower velocity in vertical direction than in horizontal direction was suggested by a few measurements.

Thermal conductivities estimated from water content coincide well with the values by needle-probe method with few exceptions, suggesting that Ratcliffe's formula was applicable for deeply buried sediments.

Scattering in values is much larger for the thermal conductivities than for the sonic velocities, and this may partly be explained by a technical problem of sampling: sonic-velocity measurements were made on less-disturbed parts of sediments based on selection in a split core, while thermal-conductivity measurements were made at points apparently selected through the plastic liner before splitting, and it was normally impossible to

TABLE 3
Sonic-Velocity Measurements,
Site 296

Sample (Interval in cm)	Depth in Hole (m)	Velocity (km/sec)
1-3, 77	3.77	1.528
2-6, 50	14.50	1.506
3-3, 35	19.35	1.521
4-2, 52	27.52	1.499
4-2, 54	27.54	1.499
5-3, 55	38.55	1.517
6-4, 100	50.00	1.522
7-2, 44	55.94	1.501
8-3, 37	66.87	1.526
8-4, 37	68.37	1.513
8-4, 90	68.90	1.513
9-2, 111	75.61	1.511
9-5, 33	79.33	1.501
10-3, 43	85.93	1.501
10-6, 38	90.38	1.511
10-6, 42	90.42	1.530
11-3, 32	95.32	1.524
12-5, 74	108.24	1.506
12-5, 63	108.13	1.510
13-3, 35	114.35	1.517
13-3, 36	114.36	1.520
16-3, 63	143.13	1.517
16-3, 28	142.78	1.528
16-3, 36	142.86	1.523
17-5, 20	155.20	1.538
17-5, 78	155.78	1.556
17-5, 31	155.31	1.518
18-2, 36	160.36	1.570
19-2, 62	170.12	1.509
20-2, 52	179.52	1.522
21-3, 26	190.26	1.506
22-5, 115	203.65	1.533
23-3, 71	209.71	1.510
24-4, 20	220.20	2.545
25-4, 58	230.08	1.536
26-5, 0	240.50	1.529
27-3, 30	247.30	1.521
28-4, 60	258.60	1.608
28-4, 89	258.89	1.621
28-4, 110	259.10	1.620
29-5, 0	269.00	1.615
30-5, 64	279.14	1.655
30-5, 75	279.25	1.724
31-3, 30	285.30	1.672
34-5, 80	317.30	1.738
35-5, 147	327.47	1.762
35-5, 144	327.44	1.776
36-5, 148	336.98	1.778
36-5, 144	336.94	1.721
37-3, 38	342.38	1.645
38-2, 110	351.10	1.805
39-4, 132	363.82	1.749
40-3, 80	371.30	1.791
43-1, 63	396.63	1.800
45-3, 101	419.01	2.120
54-3, 62	627.62	2.875
54-3, 68	627.68	2.809
55-1, 137	653.87	4.634
56-1, 29	699.79	2.627
56-7, 28	699.78	2.625
56-1, 2	690.52	2.785
56-1, 2	690.55	2.816

identify the degree of deformation exactly. Consequently, it is conceivable that the real values of the thermal conductivities may be always slightly higher than the measured ones.

GEOCHEMICAL MEASUREMENTS

Alkalinity, *p*H, and salinity measurements are summarized in Table 5.

Alkalinity

The average alkalinity for Hole 296 is 2.20 meq/kg. Six of the values are higher than the surface seawater reference value of 2.35 meq/kg, and they are found in Cores 1 to 25. Two cores (Core 40, Section 1, and Core 45, Section 2) show very significant low values of 0.59 and 0.78 meq/kg, respectively. Both cores are from Unit 1, Subunit 1G, a clay-rich nannofossil chalk, with extensive ash, ashy chalk, and clayey ash interbeds.

pH

The average *p*H values obtained by both punch-in and flow-through methods were all below that of the seawater reference at the site (8.17 to 8.19). The seven punch-in *p*H values averaged 7.24, while the 12 flow-through values averaged 7.65. The most noticeable change in *p*H values is that shown by the flow-through values of Cores 40 and 45. These two values exceed 8.4. The two high *p*H values correspond to the two very low alkalinity values (0.59 and 0.78) reported. These cores of Unit 1, Subunit 1G contained substantial volcanic ash interbeds and volcanic components in the biogenous sediments.

Salinity

Twelve salinity measurements at Site 296 averaged 35.6‰. A fairly definite increase in salinity with depth is noticed, except for some variability in Cores 40, 45, and 52. All 12 values and their average were above the overlying seawater reference value of 34.4‰.

PALEONTOLOGIC SUMMARY

Introduction

The thick and unusually complete sedimentary section penetrated at Site 296 ranges in age from Pleistocene to late Oligocene and may include basal sediments as old as early Oligocene. Nannofossils and planktonic foraminifera occur quite abundantly throughout most of the sequence, whereas radiolarians, when present, occur rather intermittently. The state of preservation for all groups ranges from poor to good, with a general decrease in quality downward in the hole.

Age and zonal determinations at Site 296 were made with the use of calcareous nannofossils, planktonic foraminifera, radiolarians, silicoflagellates, and diatoms in Pleistocene sediments. Only planktonic foraminifera and calcareous nannofossils were utilized in Pliocene sediments. These two groups together with radiolarians were utilized in the Miocene and late Oligocene portion

TABLE 4
Thermal Conductivities Measured at Site 296

Sample (Interval in cm)	Hole Depth (m)	Thermal Conductivity in 10^{-3} cal/cm sec°C		
		Needle Probe	Average	From Water Content
1-3, 35	3	1.75		
1-3, 70	4	2.03	1.90	2.08 ±0.11
1-3, 105	4	1.93		
2-2,			2.12	
2-2, 110	9	2.12		2.01 ±0.11
6-6, 40	14	2.38	2.47	2.19 ±0.12
6-6, 110	15	2.57		
3-3, 40	19	2.25	2.15	
3-3, 110	20	2.05		2.17 ±0.12
4-2, 40	27	1.92	1.97	2.02 ±0.11
4-2, 110	28	2.01		
5-3, 40	38	2.13	2.04	2.17 ±0.12
5-3, 105	39	2.00		
6-4, 40	49	1.89	2.00	2.19 ±0.13
6-4, 110	50	2.10		
7-2, 40	56	2.07	2.22	2.13 ±0.12
7-2, 110	57	2.47		
8-3, 40	67	2.17	2.13	2.19 ±0.13
8-3, 110	68	2.09		
8-4, 40	68	1.88	2.09	
8-4, 110	69	2.30		2.33 ±0.14
9-2, 40	75	2.25	2.22	
9-2, 110	76	2.18		2.22 ±0.13
9-5, 40	79	1.95	2.04	2.14 ±0.12
9-5, 110	80	2.12		
10-3, 40	86	2.09	2.09	2.06 ±0.11
10-3, 110	87	2.08		
10-6, 40	90	2.32	2.29	2.19 ±0.12
10-6, 110	91	2.26		
11-3, 40	95	2.02	2.07	
11-3, 110	96	2.12		2.11 ±0.12
12-5, 75	108	2.24	2.22	2.19 ±0.12
12-5, 120	108	2.28		
14-5, 40	127	2.15	2.25	1.86 ±0.10
14-5, 110	128	2.35		
16-3, 40	143	2.28	2.28	2.29 ±0.13
16-3, 110	144	2.28		
16-5, 40	146	2.08	2.23	2.36 ±0.14
16-5, 110	147	2.38		
18-2, 40	160	2.44	2.28	
18-2, 110	161	2.11		2.34 ±0.13
19-2, 40	170	2.13		
19-2, 110	171	2.07	2.10	
20-2, 40	179	2.58	2.40	
20-2, 120	180	2.22		
21-3, 40	190	2.21	2.08	
21-3, 110	191	1.94		2.32 ±0.13
25-4, 40	230	2.52	2.32	
25-4, 120	231	2.12		
26-5, 40	241	2.38	2.19	
26-5, 120	242	1.99		
28-4, 40	258	2.45	2.03	(Hard part)
28-4, 120	259	1.61		(Soft part)
30-5, 60	279	2.17	2.18	
30-5, 110	280	2.19		
31-2, 24	284	2.45	2.24	
31-2, 104	285	2.03		
32-3, 30	295	2.59	2.57	
32-3, 120	296	2.55		
33-4, 60	306	1.64	2.06	
33-4, 104	307	2.47		
35-5, 25	326	2.52	2.65	
35-5, 110	327	2.77		
36-5, 34	336	2.91	2.85	
36-5, 115	337	2.79		
37-3, 32	342	2.50	2.49	
37-3, 114	343	2.47		
38-3, 33	352	2.85	2.52	
38-3, 121	353	2.18		

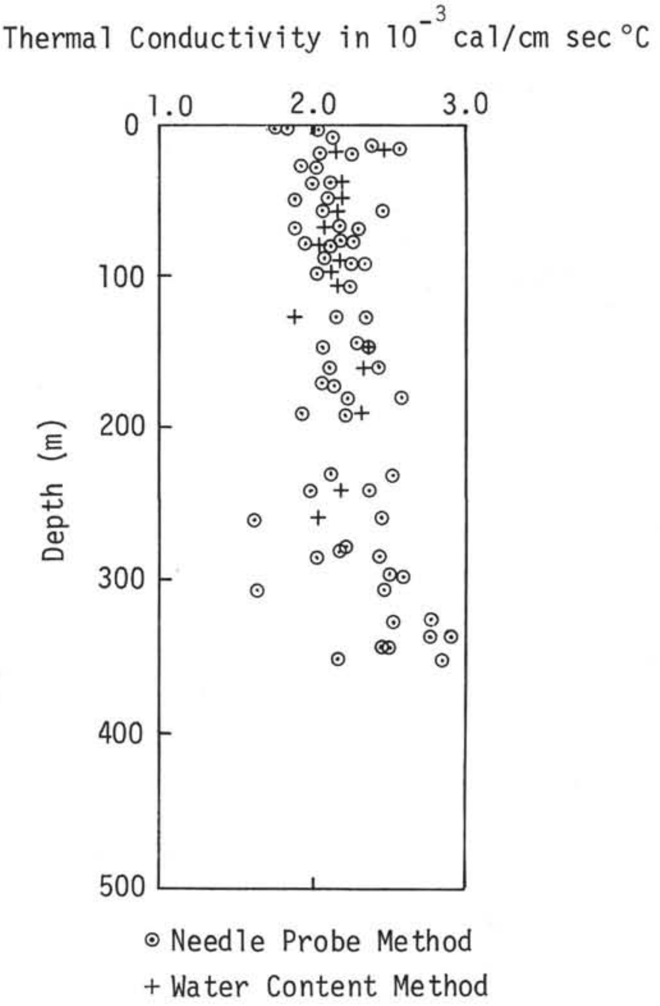

Figure 6. *Thermal-conductivity results, Site 296.*

of the sequence. Calcareous nannofossils of possible early Oligocene age are present in the basal portion of the section.

Both planktonic foraminiferal and calcareous nannofossil evidence places the Pliocene-Pleistocene boundary between Cores 7 and 8 (63.5 m), based upon the zonal schemes of Blow (1969) and Bukry (1973b). Virtually all of the Pliocene nannofossil and foraminiferal zones are recognized in Cores 8 through 17 (63.5-158.5 m). The Miocene/Pliocene boundary is placed between Cores 17 and 18 (158.5 m) on the basis of calcareous nannofossils, or alternately, between Cores 16 and 17 (149.0 m) on the basis of planktonic foraminiferal zones recognized by Ujiié and Oki (in press). If the zonal correlations of Berggren and Van Couvering (1973) are utilized in interpreting nannofossil and planktonic foraminiferal ranges at Site 296, then placement of the Miocene/Pliocene boundary utilizing these two groups would coincide at the base of Core 17 (158.5 m).

The Miocene sequence is marked by the apparent absence of several nannofossil, planktonic foraminiferal, and radiolarian zones. This suggests that significant intervals of erosion or nondeposition occurred on this portion of the Palau-Kyushu Ridge during this epoch. For example, two calcareous nannofossil subzones are missing between Cores 17 and 18 (158.5 m), with one subzone missing in Core 23, and another absent between Cores 27 and 28 (253.5 m). The absence of these various subzones represents gaps of 1 to 4 m.y., following the zonal scheme of Bukry (1973b). Furthermore, four planktonic foraminiferal zones (N10 through N13) are missing within Core 26 (234.5-244.0 m), and at least one radiolarian zone is absent within the Core 26 through 28 interval.

Despite the apparent loss of several microfossil zones within Miocene sediments at Site 296, calcareous nannofossil and planktonic foraminiferal evidence places the late Miocene/middle Miocene boundary within Core 23 (approximately 209 m), and the middle Miocene/early Miocene boundary within, or at the base of Core 28 (263 m).

Differences in definition cause the controversial Miocene/Oligocene boundary to be placed between Cores 33 and 34 (310.5 m) on the basis of calcareous nannofossil zonation, and within Core 36 (334 m) on the basis of planktonic foraminiferal zonation. A thick late

TABLE 5
Summary of Shipboard Geochemical Data, Site 296

Sample (Interval in cm)	Depth Below Sea Floor (m)	pH		Alkalinity (meq/kg)	Salinity (°/°°)	Lithologic Units
		Punch-in	Flow-through			
Surface seawater reference		8.17	8.19	2.35	34.4	
1-3, 144-150	4.5	7.31	7.58	3.23	34.9	Unit 1, Subunit 1A
2-5, 144-150	14.0	7.31	7.37	3.32	34.9	
5-3, 144-150	39.5	7.35	7.55	2.93	35.2	
10-5, 144-150	90.0	7.24	7.57	2.35	34.4	Unit 1, Subunit 1C
15-3, 144-150	134.5	7.14	7.36	3.03	34.4	Unit 1, Subunit 1D
20-3, 140-150	182.0	7.32	7.35	2.74	34.6	
25-3, 144-150	229.5	7.02	7.24	2.83	35.2	Unit 1, Subunit 1E
30-4, 144-150	278.5	–	7.35	1.96	35.2	
35-5, 144-150	327.5	–	7.39	1.37	36.6	Unit 1, Subunit 1F
40-1, 143-150	369.0	–	8.42	0.59	36.3	Unit 1, Subunit 1G
45-2, 144-150	418.0	–	8.44	0.78	38.2	
52-1, 144-150	549.5	–	8.16	1.27	37.4	Unit 2
Average		7.24	7.65	2.20	35.6	

Oligocene sequence is present in Cores 34 through 63 (310.5-975.5 m). Cores 64 and 65 (1070.5-1087 m) contain only a few rare, and relatively long-ranging nannofossils whose maximum age cannot be older than early Oligocene. This is based on the exceedingly high sedimentation rates represented by the thick volcaniclastic sequence at Site 296. However, the actual age range of the species identified is mid-early Eocene to early Oligocene. Possible reworking of some of these forms cannot be ruled out since the specimens are poorly preserved. In any event, the basal sediments at Site 296 are most probably late Oligocene in age and no older than early Oligocene.

Finally, it is important to note that a few specimens of larger benthonic foraminifera (*Lepidocyclina* sp.), displaced from a littoral environment, occur in Cores 55 and 56 (662.0-693.5 m) and clearly indicate that portions of the Palau-Kyushu Ridge were at or near sea level during the late Oligocene.

Calcareous Nannofossils

Abundant, diverse, well-preserved nannofossil assemblages were recovered from throughout the Neogene part of the section. There is a marked decrease in the species diversity and state of preservation in the Oligocene assemblages. Fourteen of the 17 zones established by Bukry (1973b) were recognized in samples from the Holocene to Oligocene interval of the Cenozoic.

Floods of the very small coccolith, *Emiliania huxleyi*, were observed in samples from Cores 1 through 3, Section 1, which clearly places these samples in the Holocene-late Pleistocene *E. huxleyi* Zone.

A complete sequence of Pleistocene nannofossil zones can be recognized in Core 3, Section 1 through Core 7. The *Gephyrocapsa oceanica* Zone, and the *G. caribbeanica* and *Emiliania annula* subzones are readily identified. Core 8 marks the first occurrence of discoasters; consequently, this appearance is interpreted as indicating the top of the Pliocene.

A normal progression of Pliocene and late and middle Miocene zones can be recognized in Cores 8 through 28, except for the early Pliocene *Ceratolithus acutus* Subzone, the late Miocene *Triquetrorhabdulus rugosus* and *Discoaster bellus* Subzones, and the middle Miocene *Coccolithus miopelagicus* Subzone. These subzones should be present in the intervals between Cores 17 and 18, Core 23, Sections 2 and 3, and Cores 27 and 28, respectively. According to Bukry (1973a), 0.9 m.y. is represented by the *Ceratolithus acutus* and *Triquetrorhabdulus rugosus* subzones, nearly 4 m.y. is represented by the *Discoaster bellus* Subzone, and 0.6 m.y. is represented by the *Coccolithus miopelagicus* Subzone. The absence of these various subzones may reflect a hiatus in the sedimentary record, or it may indicate that zone-defining species were just not recognized.

There is a normal sequence of foraminiferal zones representing continuity through the interval, with the missing nannofossil zones described above. Similarly, a break in the continuity of foraminiferal and radiolarian zones within Core 26 occurs within the nannofossil *Discoaster kugleri* Subzone of the *Discoaster exilis* Zone, and no interruption in the nannofossil sequence is apparent. This clearly demonstrates that while the three fossil groups are in general agreement with regard to age determinations, some specific differences need to be resolved.

Cores 34 through 63 represent a thick, fine to coarse, clastic sediment interval. A normal progression of the three late Oligocene nannofossil zones (*Cyclicargolithus abisectus* Subzone of the *Triquetrorhabdulus carinatus* Zone, *Sphenolithus ciperoensis* Zone, and *S. distentus* Zone) was recognized in these cores. The sphenolith index species for the latter two zones are unusually small and occur sparsely in these samples, and their recognition requires rather extreme microscopic techniques. The boundary between the *S. ciperoensis* Zone and the *S. distentus* Zone cannot be clearly defined. If a specimen of *S. ciperoensis* in the sample from Core 56 is correctly identified, then the boundary must be between Cores 56 and 57. However, if the first occurrence of *S. ciperoensis* is in reality in Core 52, then the boundary lies between Cores 52 and 53. Consequently, until this problem can be resolved, the interval represented by Cores 53 through 56 is designated a transitional interval.

Cores 64 and 65 contain only a few specimens of the nannofossil species *Helicopontosphaera compacta, Dictyococcites bisectus,* and possibly *Cyclococcolithina formosa.* These species have reported occurrences ranging from the middle early Eocene to the early Oligocene. While they may not be very age definitive, they may provide some indication of the possible minimum and maximum ages for these samples. If the identification of *C. formosa* in Core 65 is correct, and if they are not reworked specimens, then the sample can be no younger than early Oligocene.

Foraminifera

A nearly continuous biostratigraphic succession was observed from the lower Pleistocene (lower N22 Zone) to the upper Oligocene (lower N21 Zone) at Site 296, except for the absence of the N13 to N10 zones in the lower middle Miocene, between Core 26, Section 5 and Sample 26, CC. It is interesting that the hiatus correlates roughly with a similar gap in the fossil record observed at Site 292. A hiatus at this same time has also been recognized in many of the sedimentary basins on the Pacific coast of the Japanese Islands. Therefore, this hiatus may be regional in nature and not due to local events.

Zone P21 of the late Oligocene is represented by faunas in samples of a layer of more than 731 meters (Cores 38 through 64) thick, providing evidence of a truly rapid rate of sedimentation.

Some larger benthonic foraminifera, including *Lepidocyclina (Eulepidina)* cf. *formosa* and probably others, are scattered throughout Core 56, Section 2 and Sample 56-1, 137 cm. The subgenus *Eulepidina* ranges from Aquitanian to middle Oligocene; consequently, this age agrees with that determined by the planktonic foraminifera. A displaced fauna, consisting of four species of small benthonic foraminifera that are characteristic of shallow water, and a fragment of coral were found in Sample 55, CC.

Radiolarians and Silicoflagellates

Radiolarians occur in the samples from Site 296 in the topmost (Cores 1 and 2) and in the middle part of the section (Cores 21 to 47), but they are virtually absent from Cores 45 to 65. It was also noticed that, although Site 296 is located beneath the track of the warm-water Kuroshio Current, several age-diagnostic index forms are absent, and ranges of others are different from those reported from lower latitude areas.

A well-preserved Pleistocene assemblage is present in Core 1 as would be expected in surface sediments of a modern warm-water region, but abundance is sharply decreased in Core 2. Radiolarians are completely absent from Cores 3 through 23, except for occasional rare specimens of collosphaerids, found in Cores 21 and 24.

The *Ommatartus antepenultimus* Zone is recognized in sediments of Core 25 and in part of Core 26. Radiolarians are rare in Core 27. Sections 2 and 4 of Core 28 belong to the *Cannartus laticonus* Zone of Moore (1971). Sediments equivalent to the *Cannartus pettersoni* Zone are apparently missing from this site despite continuous coring. Sample 28, CC to Core 30, Section 4 belong to the *Calocycletta costala* Zone; the interval from Sample 30, CC to at least Core 33, Section 2 is assigned to the *Calocycletta virginis* Zone. Sediments within Core 33, Section 4 to Core 44, Section 1 contain only marginal abundances of radiolarians as well as the absence of guide species making age assignment difficult. Radiolarians are absent from Core 45 to the base of Site 296 (Core 65).

A few specimens of the silicoflagellate *Dictyocha fibula* and its variety, *D. f.* var. *aculeata*, were observed in Core 1 representing the initial recognition of silicoflagellates on Leg 31.

Diatoms

Core 1 contains the Quaternary species *Coscinodiscus excentricus, C. lineatus, C. nodulifer, C. radiatus, Nitzschia marina, Pseudoeunotia doliolus, Rhizosolenia bergonii,* and *Roperia tesselata.* These specimens occur in frequent abundance and are moderately well preserved and represent tropical species.

Preservation of diatoms in Core 2 is poor, but a few specimens were recovered which belong to the species *Rhizosolenia bergonii, Thalassionema nitzschioides,* and *Thalassiothrix longissima.* None of these are age diagnostic.

The sample from Core 3 contains only a few fragments of *Thalassionema nitzschioides* and *Thalassiothrix longissima.* No additional diatoms were found in samples from Cores 4 through 65.

SUMMARY AND INTERPRETATIONS

Summary

Hole 296 was spudded in a water depth of 2920 meters on a structural bench about 30 km west of the crest of the Palau-Kyushu Ridge (Figures 2, 3, and 4) initially penetrating an acoustically transparent layer composed of pelagic oozes. Drilling ultimately penetrated a total of 1087 meters into an entirely sedimentary section representing two major depositional phases in the Holocene through late Oligocene history of the rise.

Continuous coring was maintained to a depth of 472 meters due to biostratigraphic objectives revealing that this portion of the Palau-Kyushu Ridge is capped by a 453-meter-thick Holocene/Pleistocene through late Oligocene sequence of nannofossil oozes and chalks containing variable amounts of volcanic debris. These sediments were placed in Unit 1 and further subdivided into seven secondary units based upon degree of lithification, variable percentage of foraminifera, and abundance of volcanic ejecta. Chalks initially appear at 134.5 meters (Core 15), with complete lithification to chalk at 282 meters (Core 31). Abundant planktonic foraminifera and calcareous nannofossils occur throughout Unit 1; however, radiolarians are found only sporadically with diatoms and silicoflagellates restricted to Pleistocene sediments. Unfortunately, the apparent absence of several foraminiferal, nannofossil, and radiolarian zones mars the continuity of the Miocene portion of this section with paleontologic gaps present in the Core 17 through 28 sequence representing an estimated stratigraphic loss of 1 to 4 m.y. Although these gaps interrupt the biostratigraphic continuum present in this section, they alternately provide evidence of an early mid Miocene period of active erosion or nondeposition on the rise.

Volcanic ash and evidence of bioturbation increase in the lower portion of Unit 1, with distinct ash interbeds beginning at 348.5 meters (Core 38) forming a transitional zone with underlying Unit 2 which is predominantly composed of volcaniclastic material. In fact, continuous coring was halted at 472 meters in this latter series of late Oligocene volcanic ashes, lapilli tuffs, and volcanic sandstones due to poor core recovery. The boundary between the ooze-chalk sequence of Unit 1 and underlying Unit 2 was placed at 453 meters. This lithologic transition apparently correlates with the reverberant acoustic "basement" noted in continuous reflection profiles and a sonobuoy record at Site 296 (Figures 3 and 5). These same records suggest that volcaniclastic Unit 2 fills troughs between buried highs of the ridge and onlaps older basement ridge flanks.

Interval coring within Unit 2 penetrated a strikingly thick (634 m) series of coarse volcaniclastics to a depth of 1087 meters at which point the hole was abandoned due to loss of fossil control and the prospect of many more meters of similar sediment before any underlying lithology might be reached. The major lithic type within the tuffs and lapilli tuffs of Unit 2 is porphyritic andesite with a matrix composed primarily of palagonitized glass. Volcanic sands, sandstones, and siltstones increase in abundance from 750 meters to 1087 meters and display well-preserved sedimentary structures including cross bedding, cut-and-fill, graded bedding, and load casts. The structures attest to vigorous redistribution of this material by bottom currents in association with slumping and mass movement on the Oligocene ridge slope (see Bouma, this volume); enclosing tuffs and lapilli tuffs exhibit sorting and structures indicative of near-direct accumulation from a volcanic eruptive process. Additional evidence of the displaced nature of these deposits is provided by the occurrence of littoral and neritic species of benthonic foraminifera (including the larger tropical foraminifer *Lepidocyclina*) along with algal debris in Cores 55 and 56. In fact, many of the individual beds within Unit 2 are marked by sharp basal contacts and in all likelihood represent single instantaneous events associated with volcanic eruptions, ash falls, and mass movement downslope with attendant erosion of underlying material resulting in a depositional rate exceeding 140 m/m.y.

Somewhat surprisingly, calcareous nannofossil and planktonic foraminifera are generally present in low abundance throughout Unit 2 and indicate that the bulk of the volcaniclastic sequence can be placed within a portion of the late Oligocene correlative with planktonic foraminiferal Zone P21 of Blow (1969) and the *Sphenolithus distentus* Zone of Bukry (1973b) emphasizing the rapid deposition of this unit. However, fossils are sparse in the basal part of the unit with a meager nannofossil flora indicative of an early Oligocene age.

Interpretation

The primary biostratigraphic objective was most certainly fulfilled by recovery of the continuously cored sequence of Pleistocene through late Oligocene nannofossil oozes and chalks assigned to Unit 1. These sediments contain an excellent calcareous paleontologic record of planktonic evolution and productivity within the mid-Kuroshio Current system for the past 26-27 m.y., complementing the equivalent equatorial record obtained at Site 292. Estimated rates of deposition within the latest Oligocene through late Miocene portion of the chalk-ooze sequence average about 9 m/m.y., whereas Plio-Pleistocene oozes accumulated at an estimated rate of 32 m/m.y. (Figure 7), signifying accelerated productivity and overturn within the Kuroshio surface water coincident with the onset of climatic deterioration in the late Neogene. Variations in species abundance (Ujiié, this volume) also appear to represent responses to latitudinal shifts of critical isotherms in the marginal northwestern Pacific with subtropical (transitional) and tropical species alternately dominant during portions of the Miocene, Pliocene, and Pleistocene. However, the present study does not suggest that the major Oyashio-Kuroshio convergence zone migrated as far south as Site 296 (latitude 29°N) even during the most severe periods of Quaternary refrigeration.

Unfortunately, the age of the Palau-Kyushu Ridge and its probable pre-Oligocene history were not clarified by the results from Site 296. The basement core of the ridge, which apparently underlies the volcaniclastics could consist of earlier volcanics, deformed sediments, or even a metamorphic-plutonic complex, and of an age as possibly as old as Cretaceous. The late Eocene volcaniclastic apron west of the Palau-Kyushu Ridge, drilled at Site 290, and mixed Eocene volcanics and sediments on Palau afford a firm minimum age further south, but there is no well-defined apron west of Site 296, and the assumption that the Palau-Kyushu Ridge has a similar history along its entire length is hazardous. A Cretaceous origin would now hang on the very

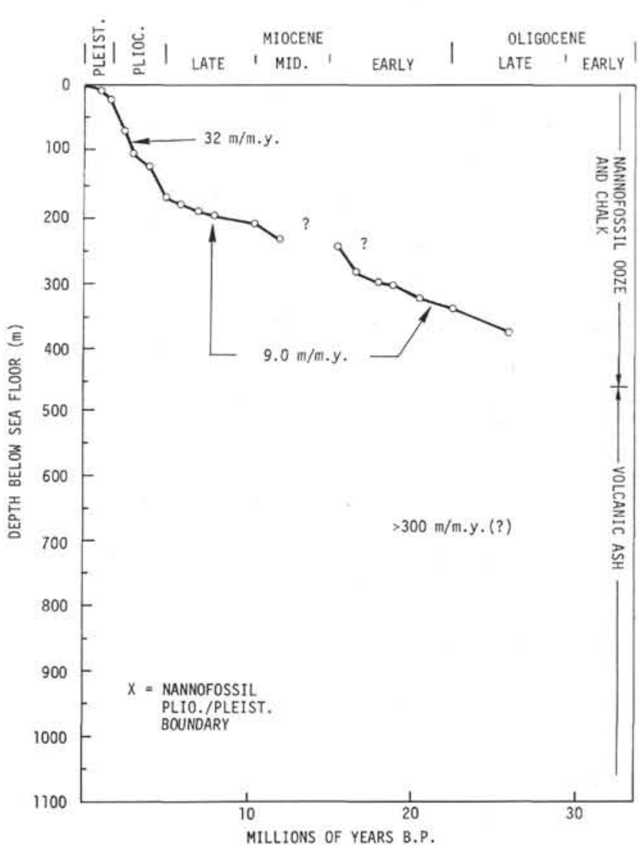

Figure 7. *Sedimentation rates–Site 296. Based on correlations of planktonic foraminiferal zonation with time scale of Berggren (1972).*

speculative assumption that the several reworked late Cretaceous planktonic foraminifera in Hole 290 were derived from the Palau-Kyushu Ridge.

If, for the moment, the Palau-Kyushu Ridge is considered to have a similar history along its length, then it witnessed two Tertiary volcanic pulses which were related to island arc tectonism. The first peaked in the late middle Eocene to late Eocene time and formed the major apron west of the ridge. The second, of late (?) early Oligocene to late Oligocene age, probably did not greatly enlarge the apron. An eastward thinning of the post Eocene (Site 290) pelagic brown clay which covers the distal part of the apron from 120 meters to less than 60 meters adjacent to the ridge (unpublished *Antipode* 4, 14 reflection and 3.5-kHz profiles), indicates that the influx of volcanic material to the head of the apron ceased only 20-30 m.y. ago.

Although volcanism along the Palau-Kyushu Ridge ceased by the end of the Oligocene as marked by the boundary between Unit 1 and Unit 2 in Hole 296, it continued in the Shikoku and Parece Vela basins to the east, and constitutes a prominent volcanic sequence on Guam, Yap, and other segments of the eastern arc systems. The cutoff of volcanism along the Palau-Kyushu Ridge thus corresponds well with the beginning of volcanism on the next ridge east and with the probable extensional development of both the Shikoku and Parece Vela basins. The most coherent integration of present information would support the idea that until the late Oligocene, the Palau-Kyushu Ridge was part of a frontal arc and contained the volcanic chain with attendant rapid deposition of volcaniclastics at rates as high as 140 m/m.y. on the ridge and ridge flanks. Near the Oligocene-Miocene boundary, the Parece Vela and Shikoku basins were formed by crustal extension within the part of the frontal arc near the volcanic chain. Within a short time, the volcanic chain, which stays with the active frontal arc, had left the Palau-Kyushu Ridge and became reestablished along the new frontal arc. As the Shikoku Basin opened to the east, the steep rifted eastern flank of the Palau-Kyushu Ridge developed (Figures 3 and 4) and with increasing width of the basin, the source moved further from the ridge. The coarse volcaniclastics were succeeded by wind and waterborne ash deposition which declined to a low level by the end of the Oligocene (Donnelly, this volume).

These abandoned ridges, or remnant arcs (Karig, 1972) seem to subside after rifting together with the cooling basins to either side. The displaced larger late Oligocene benthonic foraminifera present in Unit 2 provide clear evidence that portions of the ridge were at or near sea level and harbored a tropical reef biota at that time. Moreover, initial accumulation of nannofossil oozes (Unit 2) suggests major subsidence of the ridge occurred during this same interval allowing deposition of dominantly biogenic debris beneath the then through the flowing Kuroshio Current. Prior to this event the Kuroshio Current may well have been deflected eastward by the arc-ridge complex or perhaps split into an eastern and western fork. Further study is needed to sort out these various possibilities of reorganization of surface flow.

The presence of lower bathyal benthonic foraminifera throughout the late Oligocene-Pleistocene chalk-ooze unit at Site 296 also points to major subsidence during the post-rifting phase of ridge history. However, submergence of all portions of the ridge to depths in excess of 150 meters may not have occurred until the late Pleistocene judging from the continual presence of displaced shallow-water benthonic foraminiferal species throughout most of this sequence.

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APPENDIX A
Summary of X-Ray, Grain Size, and Carbon-Carbonate Results, Site 296

Section	Sample Depth Below Sea Floor (m)	Lithology	Age	Bulk Sample Major Constituent			2-20μm Fraction Major Constituent			<2μm Fraction Major Constituent			Grain Size			Classification	Carbon Carbonate			Comments
				1	2	3	1	2	3	1	2	3	Sand (%)	Silt (%)	Clay (%)		Total (%)	Organic (%)	$CaCO_3$ (%)	
296-1-2	2.5	Unit 1 Gray, olive-gray foraminifera-rich 1A Nannofossil clay with volcanic ash zones	E. Pleist. -late Pleist- Holocene	Calc.	Quar.	Mica	Quar.	Plag.	Mica	Mica	Quar.	Plag.					3.4	0.4	25	
296-1-3	4.2												32.9	53.5	13.6	Sandy Silt				
296-2-6	14.2			Calc.	Quar.	Mica	Quar.	Plag.	Mica	Mica	Quar.	Mont.					5.4	0.3	43	
296-3-1	16.4												10.7	54.3	35.0	Clayey Silt				
296-3-3	19.0-19.2			Calc.	Quar.	Mica	Quar.	Mica	Plag.	Mont.	Quar.	Mica					5.7	0.1	47	
296-3-4	20.5																3.7	0.3	28	
296-5-4	39.8																6.0	0.1	49	
296-5-4	40.3																3.3	0.3	25	
296-6-4	50.0	1B Gray, foraminifera/ clay-rich-clayey nannofossil ooze	Early Pleistocene														6.9	0.1	57	
296-6-5	51.3																4.4	0.3	35	
296-8-4	68.5	1C Green, olive-gray clay-rich nannofossil ooze	Late Pliocene to early Pleistocene										0.6	33.6	65.7	Silty Clay	3.4	0.4	25	
296-8-4	69.1												0.6	21.7	77.7	Clay	6.8	0.1	56	
296-9-4	78.9			Calc.	Quar.	Mica	Quar.	Mica	Plag.	Mica	Quar.	Mont.								
296-10-1	83.9																5.9	0.1	48	
296-10-5	89.2																6.4	0.1	52	
296-12-4	107.0																7.1	0.1	58	
296-13-2	113.5																7.5	0.1	61	
296-14-4	125.8																6.6	0.1	54	
296-15-3	133.3												58.5	25.5	15.9	Silty Sand				
296-15-3	134.0																5.7	0.1	47	
296-16-4	144.8																9.5	0.1	79	
296-17-4	154.5																8.2	0.1	68	
296-19-2	170.3	1D Clay-rich nannofossil ooze and chalk with radiolarian/ clay-rich nannofossil chalks	Late miocene -late Pliocene	Calc.	Mica.	Quar.	Quar.	Mica	Plag.	Mica	Mont.	Quar.					6.8	0.1	56	
296-20-3	181.9																8.5	0.1	70	
296-21-2	189.4																6.8	0.1	56	
296-22-2	198.8			Calc.	Quar.	Mica	Quar.	Mica	Plag.	Mica	Quar.	Mont.					8.0	0.1	66	
296-23-2	208.7			Calc.	Quar.	Mica	Quar.	Plag.	Mica	Quar.	Mont.	Mica					6.4	0.1	53	Kaol. in <2μm (5.4%)
296-24-4	220.5																7.9	0.1	65	
296-25-3	228.8																6.0	0.0	50	
296-26-4	239.7			Calc.	Quar.	Mica	Quar.	Plag.	Mica	Quar.	Mica.	Mont.					5.2	0.0	43	Kaol. in <2μm (2.2%)
296-28-5	260.1																7.2	0.0	60	
296-30-4	277.4-277.7			Calc.	Mica	Quar.	Quar.	Plag.	Mica	Mont.	Quar.	Mica	2.0	50.6	47.4	Clayey Silt	7.4	0.0	61	
296-31-5	288.1-288.2			Calc.	Plag.	Mica	Plag.	Quar.	Mica	Mont.	Quar.	Mica	4.3	49.3	46.4	Clayey Silt	3.5	0.0	28	Kaol. in <2μm (3.1%)
296-34-1	311.5			Calc.	Quar.	Mica	Quar.	Plag.	Mica	Mont.	Quar.	Mica					7.5	0.1	62	Kaol. in <2μm (2.1%)
296-35-1	321.0																7.9	0.1	66	Augi. in 2-20μm (7.5%)
296-36-2	331.9			Calc.	Plag.	Mont.	Plag.	Quar.	Mica	Mont.	Quar.	Plag.					9.1	0.0	76	Kaol. in <2μm (2.6%)
296-38-2	350.8	1E Greenish-gray clayey, clay-rich nannofossil chalks with volcanic ash interbeds	Early Miocene to late Miocene														3.0	0.0	25	
296-39-2	360.2																8.5	0.0	71	
296-40-3	370.9			Plag.	Mont.	Augi.	Plag.	Augi.	Quar.	Mont.	Plag.	Augi.	0.2	65.3	34.4	Clayey Silt				Clin. in <2μm (2.6%)
296-40-3	371.0*			Plag.	Augi.	Calc.	Plag.	Augi.	Chlo.	Plag.	Mont.	Augi.	86.6	7.9	5.4	Sand				
296-40-4	372.2-372.7			Plag.	Augi.	Calc.	Plag.	Augi.	Quar.	Mont.	Plag.	Chlo.	19.4	64.8	15.8	Sandy Silt	7.5	0.0	62	Augi. in <2μm (8.8%)
296-40-4	373.5			Calc.	Plag.	Augi.	Plag.	Augi.	Quar.	Plag.	Mont.	Augi.	72.4	17.5	10.1	Silty Sand	0.3	0.0	2	
296-41-1	377.1			Plag.	Augi.	Mont.	Plag.	Augi.	Quar.	Plag.	Mont.	Augi.								
296-41-2	378.7			Plag.	Mont.	Calc.	Plag.	Mont.	Augi.	Mont.	Plag.	Augi.	0.4	74.9	24.7	Clayey Silt				Augi. in bulk (6.6%)
296-41-2	379.3-379.4			Plag.	Augi.	Mont.	Plag.	Augi.	Quar.	Plag.	Mont.	Augi.	53.7	36.7	9.6	Silty Sand	7.5	0.1	62	
296-41-3	380.3			Plag.	Mont.	Augi.	Plag.	Augi.	Quar.	Plag.	Mont.	Quar.								
296-42-1	387.0-387.2			Plag.	Augi.	Mont.	Plag.	Augi.	Quar.	Plag.	Augi	Quar.	28.0	55.1	16.9	Sandy Silt	6.5	0.0	54	
296-43-1	397.2			Plag.	Calc.	Augi.	Plag.	Augi.	Quar.	Mont.	Plag.	Augi.	73.4	20.0	6.5	Silty Sand				Clin. in <2μm (1.8%)
296-45-1	415.7																3.4	0.0	28	
296-46-4	429.6																7.7	0.0	64	
296-47-1	435.5			Calc.	Plag.	Mont.	Plag.	Quar.	–	Mont.	Plag.	Quar.	16.1	73.5	10.5	Sandy Silt				
296-52-1	548.7	Unit 2 Volcanic tuffs sand-stones, siltstones with ash-rich nannofossil chalks	Early to late Oligocene (?)														6.2	0.0	51	
296-52-1	549.3			Plag.	Calc.	Augi.	Plag.	Augi.	Quar.	Plag.	Augi.	Mont.	1.0	77.6	21.4	Silt				
296-54-1	624.8																0.8	0.0	6	
296-54-3	628.2												52.9	26.8	20.3	Sand-silt-clay				
296-55-1	653.5												57.6	20.3	22.0	Sand-silt-clay				

Note: Complete results of X-ray Site 296 will be found in Part V, Appendix I. X-ray mineralogical legend on Appendix A, Chapter 2.

Site 296 Hole Core 1 Cored Interval: 0.0-6.5 m

AGE: LATE PLEISTOCENE/HOLOCENE

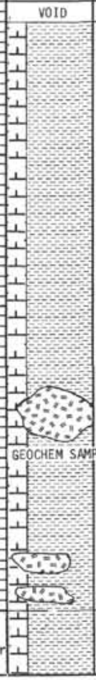
ZONE: N23; Pseudoeunotia doliolus (D); Emiliana huxleyi

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO. DIATOMS): Ag, Fg, Fm (Section 1); Fm, Fm (Section 3); Am (Section 4); Ag, Ag, Cm, Fm (Core Catcher)

SECTION: 1, 2, 3, 4, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY: VOID; GEOCHEM SAMPLE



LITHO. SAMPLE: *43, *100, *80, *120, *95, *130, *CC

Colors: 10YR; 5YR 4/1 with 10YR 4/2; 10YR 4/2; 5YR 4/1; N6; 5Y 4/1; 5YR 4/1 with N6 and N4; 5YR 4/1

LITHOLOGIC DESCRIPTION

Unit 1 - Dominant color olive gray (5Y 4/1) with 10-20 cm beds of dark yellow brown (10YR 4/2); moderate drilling deformation; color mottling common especially with gray colors, medium light (N6), medium dark (N4).

NANNOFOSSIL-RICH CLAY
Smears: 2-43, 2-100, 3-80, CC

Texture	Composition
70-85% Clay	63-68% Clay minerals
5-20% Silt	15-20% Nannofossils
10% Sand	5- 7% Foraminifera
	4- 5% Volcanic glass
	1- 2% Feldspar
	1- 2% Heavy minerals
	5% Quartz
	Tr% Diatoms
	Tr% Sponge spicules
	Tr% Fe-oxides
	Tr% Radiolarians

VOLCANIC ASH (Minor Lith)
Smears: 3-120, 4-95, 4-130

Texture	Composition
55% Silt	76-81% Volcanic glass
35% Sand	10-20% Clay minerals
10% Clay	5-10% Feldspar
	2% Quartz
	2% Heavy minerals
	Tr% Nannofossils

Grain Size 3-117 (Ash bed)
32.9, 53.5, 13.6

Carbon Carbonate 2-100
3.4, 0.4, 25

X-ray 2-101 (Bulk)
46.1% Calc
22.3% Quar
17.5% Mica
10.9% Plag
3.1% Chlo

Explanatory notes in chapter 1

Site 296 Hole Core 2 Cored Interval: 6.5-16.0 m

AGE: LATE PLEISTOCENE/HOLOCENE

ZONE: N22; Emiliania huxleyi; Pseudoeunotia doliolus (D)

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO. DIATOMS): Ag, Rm (Section 2); Rp (Section 4); Ag (Section 6); Ag, Ag, Rm, Rp (Core Catcher)

SECTION: 1, 2, 3, 4, 5, 6, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY: VOID; GEOCHEM SAMPLE

LITHO. SAMPLE: *120, *135, *23, *CC

Colors: 5Y 4/2; 5Y 6/1 with N6; N6; N4; N6; N2; N4; N2; N6; 5GY 6/1; N6; 5GY 6/1

LITHOLOGIC DESCRIPTION

Generally intensely disturbed (breccia) with areas of moderate drilling deformation; colors vary from olive gray (5Y 4/1), to light olive gray (5Y 6/1) with medium light gray (N6) plus grayish black (N2); color streaking or mottling common and greenish gray (5GY 6/1) concentrations noted.

FORAMINIFERA-RICH, NANNOFOSSIL CLAY
Smears: 3-120, 3-135, 6-23, CC

Texture	Composition
50% Clay	41-56% Clay minerals
30% Silt	29-34% Nannofossils
20% Sand	10-15% Foraminifera
	5% Quartz
	3% Feldspar
	1% Heavy minerals
	1% Radiolarians
	1% Sponge spicules
	Tr- 2% Volcanic glass
	Tr- 3% Micarb

Carbon Carbonate 6-22
5.4, 0.3, 43

X-ray 6-20 (Bulk)
64.4% Calc
13.1% Quar
12.8% Mica
6.8% Plag
1.6% Chlo
1.3% Mont

Explanatory notes in chapter 1

Site 296 Hole Core 3 Cored Interval: 16.0-25.5 m

AGE: LATE PLEISTOCENE

ZONE: N22 Gephyrocapsa oceanica | Emiliania huxleyi

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO. DIATOMS): Ag, B; B; Ag; Ag; Ag- Ag- B Rp (Core Catcher)

SECTION: 1, 2, 3, 4, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY:

LITHO. SAMPLE: * 21, *25, *33, 48, *; * 130; * 25; * 55; * 25; * CC

Colors: 5Y 4/1; N5; 5Y 4/1; N7 to N6; 5G 6/1 with N6, N5 N4; 5R 2/2; 5G 6/1; N6; 5Y 6/1; 5Y 4/1; N5; 5G 6/1; N4 and N6

LITHOLOGIC DESCRIPTION

Intense deformation - stiff; color variations olive gray (5Y 4/1) with light gray (N7) and medium light gray (N6); ash blebs are grayish black (N2), and greenish gray (5G 6/1).

FORAMINIFERA-RICH NANNOFOSSIL CLAY
Smears: 1-25, 3-25, 3-55, 4-25, CC

Texture	Composition
45-60% Silt	40-53% Clay minerals
25-30% Clay	37-40% Nannofossils
15-25% Sand	7-10% Foraminifera
	5% Volcanic glass
	2- 5% Micarb
	2- 5% Quartz, feldspar
	Tr% Radiolarians
	Tr% Sponge spicules
	Tr% Heavy minerals

Locally foraminifera-bearing - smear 3-55 and higher clay - smear 4-25.

ASH/CLAY-RICH NANNOFOSSIL OOZE (Minor Lith)
Smears: 1-21, 1-33, 1-48

Texture	Composition
50-55% Silt	44-55% Nannofossils
35-40% Clay	15-20% Volcanic glass
5-15% Sand	10-20% Clay minerals
	5-15% Foraminifera
	5- 7% Micarb
	1% Quartz
	1% Feldspar
	1% Heavy minerals
	1% Diatoms
	Tr- 7% Radiolarians
	Tr- 2% Sponge spicules

NANNOFOSSIL-RICH VOLCANIC ASH (Minor Lith)
Smear: 2-130

Texture	Composition
40% Sand	60% Volcanic glass
40% Clay	25% Nannofossils
20% Silt	10% Foraminifera
	5% Micarb

Grain Size 1-37
10.7, 54.3, 35.0

Carbon Carbonate 3-55
5.7, 0.1, 47

Carbon Carbonate 4-25
3.7, 0.3, 28

X-ray 3-18 (Bulk)
72.5% Calc
9.3% Quar
7.0% Mica
4.8% Mont
4.6% Plag
1.8% Chlo

Explanatory notes in Chapter 1

Site 296 Hole Core 4 Cored Interval: 25.5-35.0 m

AGE: LATE PLEISTOCENE

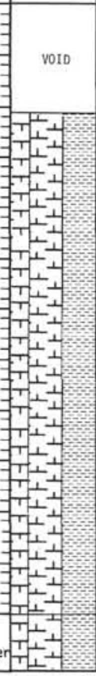
ZONE: N22 Gephyrocapsa oceanica

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO. DIATOMS): Am B; Am; Ag Ag B Rp (Core Catcher)

SECTION: 1, 2, 3, 4, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY:



LITHO. SAMPLE: CC

Colors: 5Y 6/1 with N5-N4; 5GY 6/1 and N5

LITHOLOGIC DESCRIPTION

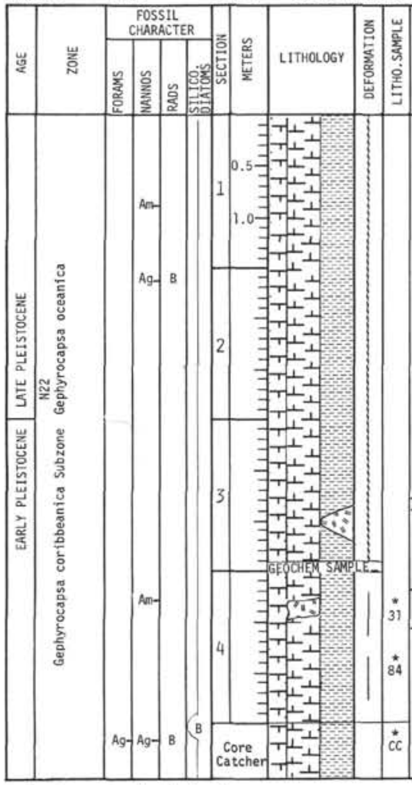
Very intense deformation and breccia in Sections 1, 2, 3, becoming firmer in 4-6; colors in grays - medium (N5); medium dark (N4), with light olive gray (5Y 6/1).

FORAMINIFERA-RICH NANNOFOSSIL CLAY
Smear: 4-CC

Texture	Composition
65% Clay	41% Clay minerals
25% Silt	40% Nannofossils
10% Sand	15% Foraminifera
	2% Feldspar
	1% Quartz
	1% Heavy minerals

Explanatory notes in chapter 1

Site 296 Hole Core 5 Cored Interval: 35.0-44.5 m



LITHOLOGIC DESCRIPTION

Intense deformation - very disturbed; mottled colors of greenish gray (5GY 6/1) with medium gray (N5), and medium dark gray (N6); occasional dark gray streaks (N3); mottling extreme.

5GY 6/1 ↓ 5Y 4/1 ↓ N5

FORAMINIFERA-RICH NANNOFOSSIL CLAY
Smears: 4-31, 4-84, CC

Texture	Composition
90% Clay	39-50% Clay minerals
10% Silt	35-40% Nannofossils
	10-15% Foraminifera
	2- 7% Micarb
	1- 3% Quartz, feldspar, heavy minerals
	2% Volcanic glass
	1% Radiolarians

Locally nannofossil-rich 4-84.

Carbon Carbonate 4-31
6.0, 0.1, 49

Carbon Carbonate 4-84
3.3, 0.3, 25

5GY 6/1 with N5

5G 6/1

5Y 4/1 with N5

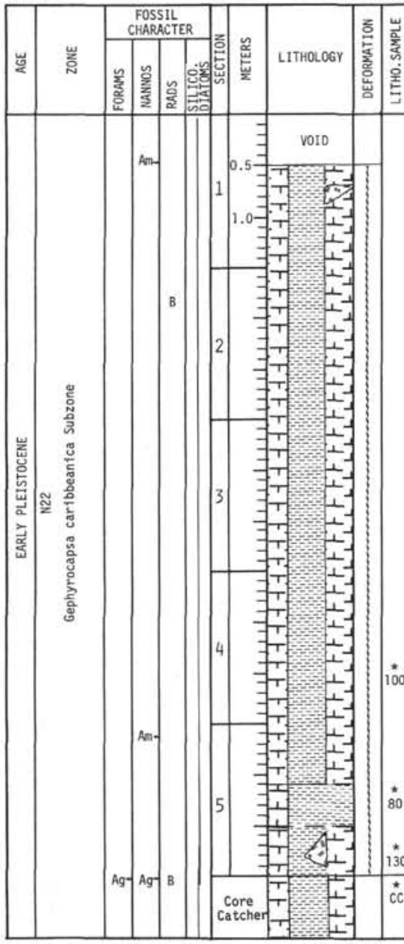
5GY 6/1 with N5

5Y 4/1 with N5

N6

Explanatory notes in chapter 1

Site 296 Hole Core 6 Cored Interval: 44.5-54.0 m



LITHOLOGIC DESCRIPTION

Colors are light with greenish gray (5GY 6/1) and medium gray (N5), to dark-olive gray (5Y 4/1) with medium gray (N5); extreme mottling due to intense drilling deformation.

5G 6/1

5GY 6/1 with N5

5Y 4/1 with N5

FORAMINIFERA-RICH CLAYEY NANNOFOSSIL OOZE
Smears: 4-100, CC

Texture	Composition
55-60% Clay	45-50% Nannofossils
30% Silt	26-41% Clay minerals
10-15% Sand	10-15% Foraminifera
	2- 7% Micarb
	1% Feldspar
	Tr- 1% Volcanic glass
	Tr% Sponge spicules

56y 6/1 with N5

NANNOFOSSIL RICH CLAY (*Minor Lith*)
Smear: 5-80

Texture	Composition
95% Clay	65% Clay minerals
5% Silt	25% Nannofossils
	5% Foraminifera
	3% Micarb
	1% Quartz
	1% Feldspar
	Tr% Volcanic glass

5GY 6/1

5Y 4/1 with N5

5GY 6/1

5Y 4/1 with N5

VOLCANIC ASH (Minor Lith)
Smear: 5-130

Texture	Composition
55% Sand	83% Volcanic glass
30% Silt	10% Nannofossils
15% Clay	3% Feldspar
	2% Heavy minerals
	1% Quartz
	1% Foraminifera

5GY 6/1 with N5

Carbon Carbonate 4-100
6.9, 0.1, 57

Carbon Carbonate 5-80
4.4, 0.3, 35

5Y 4/1 with N5

5Y 4/1 to 5GY 6/1 with N5

5Y 4/1 to 5GY 6/1

Explanatory notes in chapter 1

Site 296 Hole Core 7 Cored Interval: 54.0-63.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE	N22 Emiliania annula Subzone/Gephyrocapsa caribbeanica Subzone					1	0.5, 1.0	VOID			Intense deformation to near-breccia; extreme mottling and mixing of colors; greenish gray (5GY 6/1) and olive gray (5Y 4/1), with gray (N6, N4).
			Am-	B		2					5GY 6/1 with N6
						3		VOID			
						4		VOID			5GY 6/1 and 5Y 4/4 with N4
			Am-								
		Ag-	Ag-	B		Core Catcher				* CC	5GY 6/1

FORAMINIFERA/CLAY-RICH NANNOFOSSIL OOZE

CLAY-RICH NANNOFOSSIL OOZE (Minor Lith)
Smear: CC

Texture	Composition
85% Clay	69% Nannofossils
15% Silt	20% Clay minerals
	7% Foraminifera
	2% Micarb
	1% Quartz
	1% Heavy minerals
	Tr% Volcanic glass

Explanatory notes in chapter 1

Site 296 Hole Core 8 Cored Interval: 63.5-73.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	N22 Cyclococcolithina macintyrei Subzone					1	0.5, 1.0	VOID			Very intense drilling deformation leading to extreme vertical streaking of greenish gray (5GY 6/1) with medium light gray (N6) = light and medium to medium dark gray (N5-N4) = dark; deformation less intense, lower in core.
			Ag-	B		2					↑ mixed colors ↓
			Ag-			3					
			Cm-	B							5GY 6/1 with N5 and N4
	D. pentaradiatus Subzone		Ag- Am-	B		4				* 50	5GY 6/1 with N6 / 5GY 6/1 with N5 and N4
			Am-							* 110	5GY 6/1 with N6
	N21	Ag-	Ag-	B		Core Catcher				* CC	5GY 6/1

MICARB/CLAY-RICH NANNOFOSSIL OOZE
Smears: 4-50, CC

Texture	Composition
62-69% Clay	45-50% Nannofossils
30-35% Silt	17-25% Clay minerals
1- 3% Sand	10-15% Micarb
	3- 7% Foraminifera
	1% Detritals, feldspar
	Tr% Volcanic glass

MICARB/NANNOFOSSIL-RICH CLAY (Minor Lith)
Smear: 4-110

Texture	Composition
73-79% Clay	66% Clay minerals
20-25% Silt	20% Nannofossils
1- 2% Sand	10% Micarb
	3% Foraminifera
	1% Feldspar
	Tr% Volcanic glass

Grain Size 4-51
0.6, 33.6, 65.7

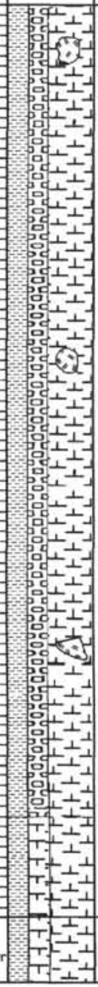
Grain Size 4-107
0.6, 21.7, 77.7

Carbon Carbonate 4-50
6.8, 0.1, 56

Carbon Carbonate 4-111
3.4, 0.4, 25

Explanatory notes in chapter 1

Site 296 Hole Core 9 Cored Interval: 73.0-82.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	N21 Discoaster pentaradiatus Subzone		Am			1	0.5, 1.0				5Y 4/1, N6, and N5
			Am	B		2					5GY 6/1, N6, and N5 (dominant)
			Am			3					
			Am			4				* 11; * 145	5Y 4/1 with N6 and N5
			Cm			5					5GY 6/1 with N6 and N5; 5Y 4/1 with N6 and N5
			Cm			6				* 145	5GY 6/1 with N6 and N5
		Ag	Ag	B		Core Catcher				* CC	5GY 6/1 with N6 and N5

Very intense drilling deformation with extreme color mixing; light = green gray (5GY 6/1) with N6 and N5 - dark = olive gray (5Y 4/1) with N6 and N5.

CLAY/MICARB-RICH NANNOFOSSIL OOZE
Smears: 4-11, 4-145

Texture	Composition
57% Clay	67% Nannofossils
40% Silt	15% Clay minerals
3% Sand	10% Micarb
	5% Foraminifera
	5% Feldspar
	5% Quartz
	2% Volcanic glass

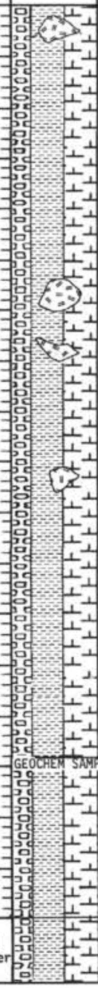
CLAY/FORAMINIFERA-RICH NANNOFOSSIL OOZE
Smears: 6-145, CC

Texture	Composition
68% Clay	66-68% Nannofossils
25% Silt	15-20% Clay minerals
7% Sand	10% Foraminifera
	3- 7% Micarb
	1% Feldspar
	Tr- 1% Volcanic glass
	Tr% Diatoms
	Tr% Detritals

X-ray 4-144 (Bulk)
63.7% Calc
15.0% Quar
12.7% Mica
6.3% Plag
2.3% Chlo

Explanatory notes in chapter 1

Site 296 Hole Core 10 Cored Interval: 82.5-92.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	N21 Discoaster pentaradiatus Subzone		Cm			1	0.5, 1.0			* 135	5GY 6/1 with N5 and N6
						2					
						3					
			Am			4					
			Am			5		GEOCHEM SAMPLE		* 75	
	Discoaster tamalis Subzone		AG			6					
		Ag	Ag	B		Core Catcher				* CC	5GY 6/1 with N5 and N6

Intense drilling deformation with less color streaking as in former cores: colors greenish gray (5GY 6/1) with (N5), (N6) grays.

MICARB-RICH CLAYEY NANNOFOSSIL OOZE
Smears: 1-135, 5-75, CC

Texture	Composition
63-65% Clay	40-44% Nannofossils
30% Silt	31-43% Clay minerals
5- 7% Sand	10-15% Micarb
	5- 7% Foraminifera
	1% Feldspar
	Tr- 2% Volcanic glass
	Tr- 1% Heavy minerals

May locally be foraminifera-rich.

Carbon Carbonate 1-135
5.9, 0.1, 48

Carbon Carbonate 5-72
6.4, 0.1, 52

Explanatory notes in chapter 1

Site 296 Hole Core 11 Cored Interval: 92.0-101.5 m

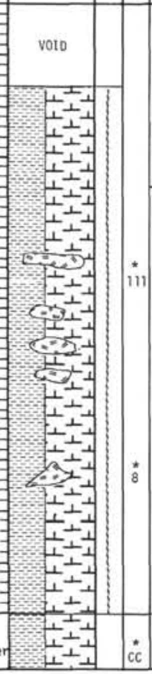
AGE: LATE PLIOCENE

ZONE: N21, Discoaster tamalis Subzone

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Section 2: Ag- B; Section 4: Ag-; Core Catcher: Ag- Ag- B

SECTION: 1, 2, 3, 4, Core Catcher

METERS: 0.5, 1.0



LITHO. SAMPLE: * 111 (Section 2); * 8 (Section 4); * CC (Core Catcher)

LITHOLOGIC DESCRIPTION

Intense drilling deformation; mixing of colors - light-greenish gray (5GY 6/1) with N6, dark-olive gray (5Y 4/1) with (N5).

5Y 4/1 with N5

CLAYEY NANNOFOSSIL OOZE
Smear: CC

Texture	Composition
50% Clay	42% Nannofossils
40% Silt	35% Clay minerals
10% Sand	10% Micarb
	7% Volcanic glass
	5% Foraminifera
	Tr% Feldspar
	Tr% Heavy minerals

5GY 6/1 with N6

NANNOFOSSIL VOLCANIC ASH (Minor Lith)
Smear: 2-111

Texture	Composition
50% Silt	40% Volcanic glass
35% Sand	39% Nannofossils
15% Clay	15% Clay minerals
	2% Feldspar
	2% Foraminifera
	1% Heavy minerals
	1% Micarb

VOLCANIC ASH (Minor Lith)
Smear: 4-08

Texture	Composition
70% Silt	69% Volcanic glass
20% Sand	20% Feldspar
10% Clay	10% Clay minerals
	1% Heavy minerals

5GY 6/1 and N6

Explanatory notes in chapter 1

Site 296 Hole Core 12 Cored Interval: 101.5-111.0 m

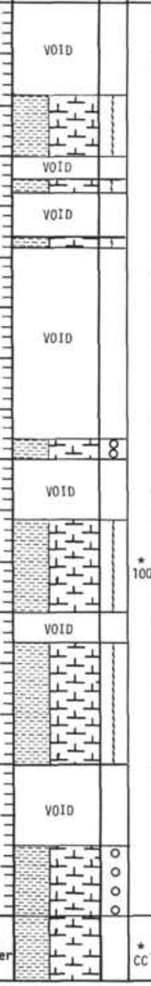
AGE: EARLY PLIOCENE

ZONE: N21, Discoaster asymmetricus Subzone

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Section 1: Cm- B; Section 4: Am-; Section 5: Cm-; Core Catcher: Ag- Ag- B

SECTION: 1, 2, 3, 4, 5, 6, Core Catcher

METERS: 0.5, 1.0



LITHO. SAMPLE: * 100 (Section 4); * CC (Core Catcher)

LITHOLOGIC DESCRIPTION

5GY 6/1 (Section 1)
5GY 6/1 (Section 2)
5GY 6/1 (Section 2)
5GY 6/1 (Section 3)
5GY 6/1 (Section 4)
5GY 6/1 (Section 5)
5GY 6/1 (Section 6)
5GY 6/1 (Core Catcher)

Intense deformation to breccia; color dominant in greenish grays (5GY 6/1).

CLAYEY NANNOFOSSIL OOZE
Smears: 4-100, CC

Texture	Composition
100% Clay	55% Nannofossils
	38% Clay minerals
	5% Foraminifera
	1% Feldspar
	1% Micarb

Some areas are clay-rich.

Carbon Carbonate 4-100
7.1, 0.1, 58

Explanatory notes in chapter 1

Site 296 Hole Core 13 Cored Interval: 111.0-120.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	N19 Discoaster asymmetricus Subzone			B		1	0.5, 1.0	VOID		* 100		Intense drilling deformation; color light gray (N7) with greenish gray (5GY 6/1) mixed. CLAYEY NANNOFOSSIL OOZE Smear: 1-100 Texture: 100% Clay Composition: 65% Nannofossils, 31% Clay minerals, 2% Micarb, 2% Foraminifera Carbon Carbonate 2-100 7.5, 0.1, 61
						2					N7 5GY 6/1	
			Fm			3					N7	
						4		VOID				
		Aq	Aq	B		Core Catcher					5GY 6/1 N7	

Explanatory notes in chapter 1

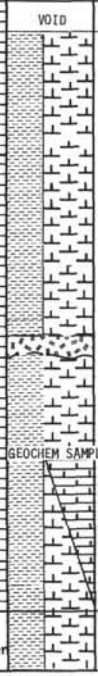
Site 296 Hole Core 14 Cored Interval: 120.5-130.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	N19 Discoaster asymmetricus Subzone					1	0.5, 1.0				5GY 6/1	Intense deformation to breccia; color dominant greenish gray (5GY 6/1) to light gray (N7) at base. CLAYEY NANNOFOSSIL OOZE Smears: 4-75, CC Texture: 100% Clay Composition: 50% Nannofossils, 44-47% Clay minerals, 2- 5% Foraminifera, 1% Micarb Carbon Carbonate 4-75 6.6, 0.1, 54
				B		2		VOID				
						3						
			Cm			4				* 75	5GY 6/1	
						5						
						6					5GY 6/1 with N7	
		Ag	Ag	B		Core Catcher				* CC	5GY 6/1	

Explanatory notes in chapter 1

Site 296 Hole Core 15 Cored Interval: 130.0-139.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE N19	Discoaster asymmetricus Subzone		Am-			1	0.5, 1.0	VOID				
			Am-			2					5Y 6/1	
						3		GEOCHEM SAMPLE		* 30, * 100		
	S. neoabies Subzone		Am-			4					N7	
		Ag-	Am-	B		Core Catcher				* CC	5GY 6/1	



Intense drilling deformation; colors light olive gray (5Y 6/1) and greenish gray (5GY 6/1); deformation becomes slight in Section 3; lithification noted in Section 4 in zones.

CLAYEY NANNOFOSSIL OOZE
Smears: 3-100, CC

Texture	Composition
100% Clay	45-47% Nannofossils
	42-47% Clay minerals
	5% Volcanic glass
	1- 3% Foraminifera
	2% Quartz
	1% Micarb

Locally chalk in Section 4.

VOLCANIC ASH (Minor Lith)
Smear: 3-30

Texture	Composition
60% Sand	80% Volcanic glass
25% Silt	15% Feldspar
15% Clay	5% Clay minerals

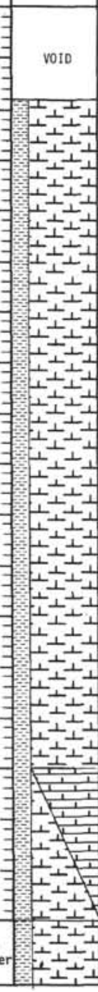
Grain Size 3-27 (Ash bed)
58.5, 25.5, 15.9

Carbon Carbonate 3-100
5.7, 0.1, 47

Explanatory notes in chapter 1

Site 296 Hole Core 16 Cored Interval: 139.5-149.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE N19	S. neoabies Subzone		Ag-			1	0.5, 1.0	VOID				
	Ceratolithus rugosus Subzone		Ag-			2						
			Ag-	B		3					N7	
						4				* 75		
						5						
						6						
		Ag-	Ag	B		Core Catcher				* CC	N7	



Deformation breccia (Section 1) to moderate drilling deformation; color light gray (N7); lithified zones in Section 6 (4-5 cm thick).

CLAY-RICH NANNOFOSSIL OOZE
Smears: 4-75, CC

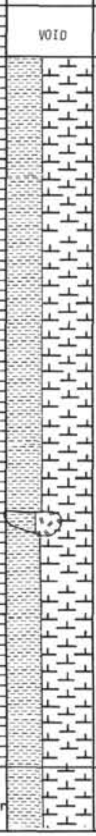
Texture	Composition
100% Clay	75-80% Nannofossils
	20-21% Clay minerals
	2- 3% Foraminifera
	1- 2% Micarb
	1% Volcanic glass

Carbon Carbonate 4-75
9.5, 0.1, 79

Explanatory notes in chapter 1

Site 296 Hole Core 17 Cored Interval: 149.0-158.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	N19 Ceratolithus rugosus Subzone					1	0.5 / 1.0	VOID			N8	Moderate drilling deformation - firm; color dominant light (N7) to very light gray (N8); areas of intense deformation appear down-core - leading to vertical streaking of colors.
			Ag	B		2						
						3						
						4				* 50, * 100	N7	
						5						
		Ag	Ag	B		Core Catcher					N7	



CLAYEY NANNOFOSSIL OOZE
Smear: 4-100

Texture	Composition
91% Clay	65% Nannofossils
9% Silt	30% Clay minerals
	3% Foraminifera
	2% Feldspar
	1% Micarb

CLAYEY VOLCANIC ASH (Minor Lith)
Smear: 4-50

Texture	Composition
40% Sand	45% Volcanic glass
30% Silt	30% Clay minerals
30% Clay	11% Nannofossils
	10% Feldspar
	3% Heavy minerals
	1% Foraminifera

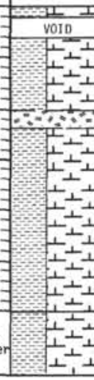
May be nannofossil-rich.

Carbon Carbonate 4-100
8.2, 0.1, 68

Explanatory notes in chapter 1

Site 296 Hole Core 18 Cored Interval: 158.5-168.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE MIOCENE	N17/N18 Ceratolithus primus Subzone		Cg	B		1	0.5 / 1.0	VOID		* 80	N8, 5Y 6/1	Deformation slight to moderate; dominant color very light gray (N8), with areas of light olive gray (5Y 6/1); (N2) grayish black in burrow areas burrowing noticeable in all sections especially in chalky areas; ash bed is graded.
						2				* 27	N2, 5Y 6/1	
		Ag	Ag	B		Core Catcher					N7 and 5Y 6/1	



CLAYEY NANNOFOSSIL OOZE
Smear: 1-80

Texture	Composition
100% Clay	73% Nannofossils
	25% Clay minerals
	2% Foraminifera

PYRITITE (from worm burrow) (minor)
Smear: 2-27

	Composition
	80% Pyrite
	20% Nannofossils

Explanatory notes in chapter 1

Site 296 Hole Core 19 Cored Interval: 168.0-177.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	N17 Ceratolithus primus Subzone		Ag-			1	0.5, 1.0	VOID			
						2					
			Ag-	B		3				* 80	5Y 6/1
			Ag-			4					
	Discoaster berggrenii Subzone		Cm-			5					
			Ag-			6					
		Ag-	Ag-	B		Core Catcher					N7

Color light olive gray (5Y 6/1) with darkening in burrow zones; moderate drilling deformation with "chalky" zones 30-50 cm apart and with intense burrow mottling.

CLAYEY NANNOFOSSIL OOZE (Chalk)
Smear: 3-80

Texture	Composition
80% Clay	50% Nannofossils
20% Silt	39% Clay minerals
	5% Volcanic glass
	5% Quartz
	1% Foraminifera

Carbon Carbonate 2-82
6.8, 0.1, 56

X-ray 2-80 (Bulk)
82.0% Calc
7.5% Mica
7.2% Quar
3.3% Plag

Explanatory notes in chapter 1

Site 296 Hole Core 20 Cored Interval: 177.5-187.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	N17 Discoaster berggrenii Subzone					1	0.5, 1.0	VOID			
				B		2		VOID			
						3		VOID; GEOCHEM SAMPLE		135 *	N8
						4					
		Ag-	Am-	B		Core Catcher					N7

Color dominant very light gray (N8); intense to moderate drilling deformation.

CLAYEY NANNOFOSSIL OOZE
Smear: 3-135

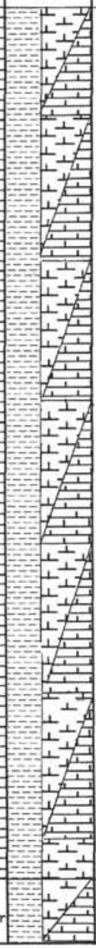
Texture	Composition
100% Clay	69% Nannofossils
	30% Clay minerals
	1% Foraminifera

Carbon Carbonate 3-135
8.5, 0.1, 70

Explanatory notes in chapter 1

Site 296 Hole Core 21 Cored Interval: 187.0-196.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE MIOCENE	N17; Discoaster berggrenii Subzone		Ag	B, Rp		1	0.5, 1.0	VOID			N8	Slight deformation; color dominant very light gray (N8); "chalky" zones every 20-30 cm, about 10 cm thick (periodic); mottling (5Y 6/1) in chalky zones.
						2				* 85		
						3					5Y 6/1	
						4						
						5						
						6						
		Ag	Am	Rm		Core Catcher					5Y 6/1	



CLAYEY NANNO OOZE (Chalk)
Smear: 2-85

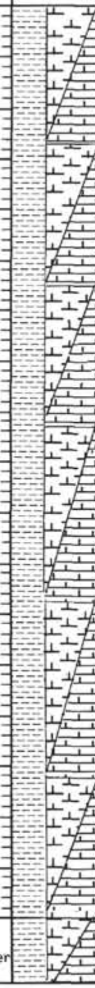
Texture	Composition
100% Clay	55% Nannofossils
	43% Clay minerals
	1% Pyrite
	1% Foraminifera

Carbon Carbonate 2-85
6.8, 0.1, 56

Explanatory notes in chapter 1

Site 296 Hole Core 22 Cored Interval: 196.5-206.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE MIOCENE	N16 / N15; Discoaster berggrenii Subzone			Rp		1	0.5, 1.0					Drilling breccia through Section 4; slight deformation in Sections 5, 6; "chalk" zones (10 cm thick) at 20-40 cm intervals; dominant color light olive gray (5Y 6/1).
						2				* 80		
			Ag			3					5Y 6/1	
				B		4						
			Cg			5						
	D. neorectus Subzone		Ag			6						
		Ag	Ag	B		Core Catcher					5Y 6/1	



CLAYEY NANNOFOSSIL OOZE (Chalk)
Smear: 2-80

Texture	Composition
100% Clay	62% Nannofossils
	28% Clay minerals
	5% Quartz
	2% Micarb
	2% Feldspar
	1% Foraminifera

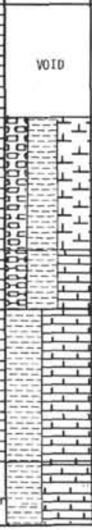
Carbon Carbonate 2-80
8.0, 0.1, 66

X-ray 2-81 (Bulk)
87.7% Calc
5.4% Quar
4.7% Mica
2.2% Plag

Explanatory notes in chapter 1

Site 296 Hole Core 23 Cored Interval: 206.0-215.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	N15 Discoaster neorectus Subzone?					1	0.5, 1.0	VOID			
			Ag-	B, B		2				*123	5Y 7/2
MIDDLE MIOCENE	Discoaster hamatus		Ag-	B		3				*14	
		Ag-	Ag-	Rm		Core Catcher				* CC	



Intense drilling deformation; color dominant yellowish gray (5Y 7/2); moderate-slight deformation with chalk layers in lower half *Section 1 and Section 2.

MICARB-RICH CLAYEY NANNOFOSSIL OOZE (Chalk)
Smear: 2-123

Texture	Composition
95% Clay	25% Clay minerals
5% Silt	50% Nannofossils
0- 5% Sand	15% Micarb
	5% Quartz
	2% Feldspar
	1% Foraminifera
	Tr% Heavy minerals

CLAYEY NANNOFOSSIL CHALK
Smears: 3-14, CC

Texture	Composition
80% Clay	60% Nannofossils
15% Silt	30-35% Clay minerals
5% Sand	3- 5% Foraminifera
	3% Micarb
	Tr% Feldspar
	Tr% Volcanic glass

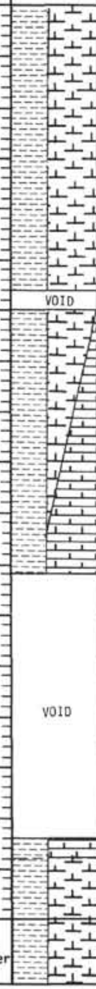
Carbon Carbonate 2-123
6.4, 0.1, 53

X-ray 2-123 (Bulk)
80.7% Calc
7.9% Quar
7.1% Mica
4.3% Plag

Explanatory notes in chapter 1

Site 296 Hole Core 24 Cored Interval: 215.5-225.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	N15 Discoaster hamatus					1	0.5, 1.0				
				Rm		2		VOID			5Y 7/2
						3				*75	
				Rm		4				*50	
						5		VOID			
				Fm		6					5Y 7/2
		Ag-	Ag-	Rm		Core Catcher				CC	



Color yellow gray (5Y 7/2); drilling breccia in Sections 1, 2, 6 to moderate deformation - slight in Section 4; chalk zones in Sections 3 and 4.

CLAYEY NANNOFOSSIL OOZE (Chalk)
Smears: 3-75, 4-50, CC

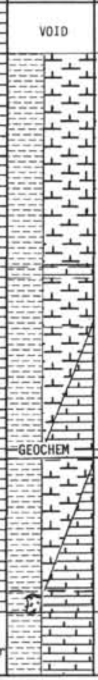
Texture	Composition
90% Clay	63-71% Nannofossils
10% Silt	20-30% Clay minerals
	3- 7% Micarb
	1% Foraminifera
	Tr% Feldspar

Carbon Carbonate 4-50
7.9, 0.1, 65

Explanatory notes in chapter 1

Site 296 Hole Core 25 Cored Interval: 225.0-234.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	N14 Catinaster coalitus Ommatartus antepenaltimus (R)		Am-			1	0.5, 1.0	VOID				
			Ag-	Cg		2					10YR 7/4	
			Ag-			3				* 75		
			Am-	Rg		4		GEOCHEM		* 95, * 115, * 145	10YR 5/4	
	D. kugleri Subzone	Ag-	Ag-	Cg		Core Catcher				* CC	5Y 6/4	



Drilling breccia to moderately deformed; color dominant grayish orange (10YR 7/4) to medium yellow brown (10YR 5/4); chalk zones in Sections 3, 4.

CLAYEY NANNOFOSSIL OOZE (Chalk)
Smears: 3-75, 4-95, CC

Texture	Composition
85% Clay	40-45% Nannofossils
10% Silt	40-45% Clay minerals
5% Sand	5% Foraminifera
	2- 3% Micarb
	1- 2% Radiolarians
	1- 2% Heavy minerals
	1% Quartz
	Tr- 1% Volcanic glass

CLAY-RICH NANNOFOSSIL ASH (Minor Lith)
Smear: 4-115

Texture	Composition
40% Sand	38% Volcanic glass
40% Silt	30% Nannofossils
20% Clay	15% Clay minerals
	7% Feldspar
	5% Micarb
	3% Quartz
	2% Heavy minerals

RADIOLARIAN/CLAY-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 4-145

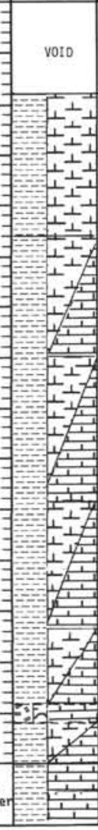
Texture	Composition
80% Clay	56% Nannofossils
15% Silt	20% Clay minerals
5% Sand	15% Radiolarians
	3% Micarb
	2% Feldspar
	2% Heavy minerals
	1% Quartz
	1% Foraminifera

Carbon Carbonate 3-75
6.0, 0.0, 50

Explanatory notes in chapter 1

Site 296 Hole Core 26 Cored Interval: 234.5-244.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	Ommatartus antepenaltimus (R)					1	0.5, 1.0	VOID				
			Cm-	Cg		2					10YR 5/4	
	N14 Discoaster kugleri Subzone					3				* 75	10YR 7/4	
				Fm		4					10YR 5/4	
			Rp-			5				* 103		
		Ag-	Ag-	Cg		Core Catcher				* CC	5Y 7/2	



Drilling breccia - moderate-slight drilling deformation down-core; colors grayish orange (10YR 7/4), with medium dark gray (N4), and moderate yellow brown (10YR 5/4); colors streaked in many cores.

CLAYEY NANNOFOSSIL OOZE (Chalk)
Smears: 3-75, CC

Texture	Composition
100% Clay	40-45% Nannofossils
	25-30% Clay minerals
	3-10% Micarb
	5% Quartz
	2- 5% Radiolarians
	2% Foraminifera
	2% Heavy minerals
	1% Feldspar
	1% Volcanic glass

RADIOLARIAN/ASH-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 5-103

Texture	Composition
65% Clay	56% Nannofossils
20% Silt	20% Volcanic glass
15% Sand	15% Radiolarians
	3% Heavy minerals
	2% Micarb
	1% Quartz
	1% Feldspar
	1% Foraminifera
	Tr% Glauconite

Carbon Carbonate 4-73
5.2, 0.0, 43

X-ray 4-74 (Bulk)
73.7% Calc
10.1% Quar
7.6% Mica
7.0% Plag
1.5% Mont

Explanatory notes in chapter 1

Site 296 Hole Core 27 Cored Interval: 244.0-253.5 m

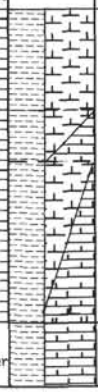
AGE: MIDDLE MIOCENE

ZONE: N13; Discoaster kugleri Subzone

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Rm; Fm-; Fm-; Ag- Ag- Rp-

SECTION / METERS: 1 (0.5, 1.0), 2, 3, Core Catcher

LITHOLOGY: VOID



DEFORMATION / LITHO. SAMPLE: * 90; * 90; * CC

5Y 7/2

5Y 7/2 ↕ 5Y 6/1

5Y 7/2

LITHOLOGIC DESCRIPTION

Drilling breccia to slight disturbance; chalky interbeds; color yellow gray (5Y 7/2) with other grays and light olive gray (5Y 6/1).

CLAYEY NANNOFOSSIL OOZE (Chalk)
Smears: 2-90, 3-90, CC

Texture	Composition
100% Clay	60-65% Nannofossils
	30-35% Clay minerals
	3% Radiolarians
	1- 2% Micarb
	Tr- 2% Volcanic glass
	1% Detrital
	1% Foraminifera

Explanatory notes in chapter 1

Site 296 Hole Core 28 Cored Interval: 253.5-263.0 m

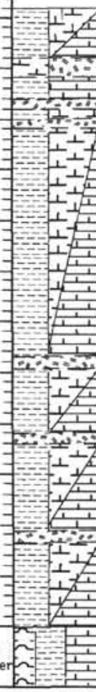
AGE: MIDDLE MIOCENE

ZONE: N9; N8; Sphenolithus heteromorphus; Cannartus laticonus (R)

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Ag-; Ag; Ag-; Ag; Am-; Ag- Ag- Cm

SECTION / METERS: 1 (0.5, 1.0), 2, 3, 4, 5, Core Catcher

LITHOLOGY: VOID



DEFORMATION / LITHO. SAMPLE: * 125; * 56; 82; * 55; * CC

10YR 7/4

N6

N6

N6

10YR 5/4

10YR 7/4

10YR 5/4

N6

10YR 7/4

10YR 7/4

LITHOLOGIC DESCRIPTION

Stiff chalk-ooze; moderate drilling deformation; color grayish orange (10YR 7/4), moderate yellow brown (10YR 5/4); ash layers, burrows; dark colors are common.

CLAY-RICH NANNOFOSSIL OOZE (Chalk)
Smears: 1-125, 5-55

Texture	Composition
95% Clay	50-55% Nannofossils
5% Silt	30-40% Clay minerals
	5- 7% Radiolarians
	2- 5% Micarb
	1- 2% Foraminifera
	1% Volcanic glass
	Tr% Feldspar

Smear CC is radiolarian-rich.

NANNOFOSSIL-RICH VOLCANIC ASH (Minor Lith)
Smear: 2-56

Texture	Composition
70% Sand	70% Volcanic glass
15% Silt	20% Nannofossils
15% Clay	5% Feldspar
	3% Quartz
	1% Heavy minerals
	1% Radiolarians

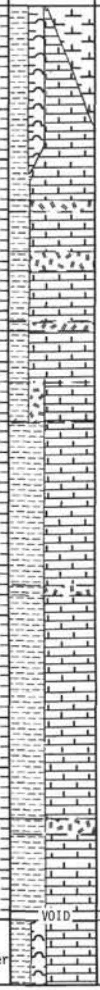
Ash at 2-82 has clay mineral content of 15% and radiolarian content of 15%.

Carbon Carbonate 5-55
7.2, 0.0, 60

Explanatory notes in chapter 1

Site 296 Hole Core 29 Cored Interval: 263.0-272.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIOCENE	N8; Cannartus laticonus (R); Helicopontosphaera ampliaperta; Calocycletta costata (R)	AG	Ag-, Ag-, AG-	Ag, Ag, Ag, Cm		1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0	VOID		1-75, 2-20, 3-75, 4-90, 6-75, CC	10YR 7/4; N6; N6; 10YR 7/4; N6; N6; 10YR 7/4



Chalk breccia; moderate-intense deformation; color mainly (10YR 7/4) grayish orange; burrows common; scattered pumice fragments.

CLAYEY NANNOFOSSIL OOZE (Chalk)
Smears: 4-90, 6-75

Texture	Composition
85% Clay	55-60% Nannofossils
15% Silt	25-30% Clay minerals
	5- 7% Foraminifera
	3- 7% Radiolarians
	3- 5% Micarb
	1% Quartz
	Tr% Volcanic glass

RADIOLARIAN/CLAY-RICH NANNOFOSSIL OOZE (Chalk)
Smears: 1-75, 4-90, CC

Texture	Composition
85% Clay	45-66% Nannofossils
15% Silt	20% Clay minerals
	10-20% Radiolarians
	2-10% Foraminifera
	2- 5% Micarb
	Tr% Feldspar

NANNOFOSSIL/CLAY-RICH VOLCANIC ASH (Minor Lith)
Smear: 3-20

Texture	Composition
40% Clay	43% Volcanic glass
30% Silt	71% Nannofossils
30% Sand	20% Clay minerals
	7% Radiolarians
	6% Feldspar
	3% Heavy minerals
	1% Quartz

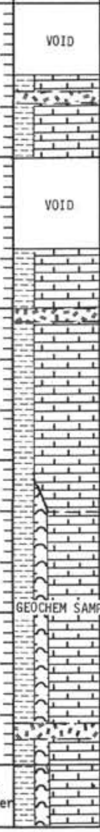
CLAY/ASH-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 3-75

Texture	Composition
80% Clay	61% Nannofossils
10% Silt	15% Clay minerals
10% Sand	5% Radiolarians
	2% Micarb
	1% Foraminifera
	1% Heavy minerals
	Tr% Feldspar

Explanatory notes in chapter 1

Site 296 Hole Core 30 Cored Interval: 272.5-282.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIOCENE	N8; N7; Helicopontosphaera ampliaperta; Calocycletta costata (R)	Ag-	Ag-, Am-	Ag, Ag, Cm		1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	VOID; VOID; GEOCHEM SAMPLE		4-40, 4-75, CC	N6; 10YR 7/4; N6; 10YR 7/4; 10YR 7/4 with N4; N6; 10YR 7/4



Chalk with unconsolidated ooze; slight deformation; color grayish orange (10YR 7/4); some darkening; burrowing, pumice fragments.

RADIOLARIAN*/CLAY-RICH NANNOFOSSIL OOZE (Chalk)
Smears: 4-40, 4-75, CC

Texture	Composition
50% Silt	55% Nannofossils
47% Clay	20% Radiolarians
3% Sand	15% Clay minerals
	5% Micarb
	2% Volcanic glass
	2% Foraminifera
	1% Feldspar

*Radiolarian-rich at 4-75 and CC.

Grain Size 4-38
2.0, 50.6, 47.4

Carbon Carbonate 4-73
7.4, 0.1, 61

X-ray 4-74 (Bulk)
91.6% Calc
3.0% Mica
2.9% Quar
1.4% Plag
1.1% Mont

Explanatory notes in chapter 1

Site 296 Hole Core 31 Cored Interval: 282.0-291.5 m

AGE: EARLY MIOCENE

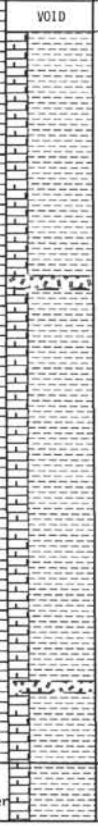
ZONE: N7 / N6; Sphenolithus belemnos/Helicopontosphaera ampliaperta; Calocycletta virginis (R)

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO. DIATOMS):
- Section 1: Am
- Section 2: Cm (rads)
- Section 3: Am
- Section 4: Cm (rads); Am
- Section 5: Am
- Core Catcher: Ag- Am- Fg-

SECTION: 1, 2, 3, 4, 5, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY: VOID



LITHO. SAMPLE: * 80 (Section 1); 80 * (Section 4); * 16 (Section 5); * CC

10YR 7/4

N4

10YR 7/4

N4

10YR 7/4

LITHOLOGIC DESCRIPTION

Colors grayish orange (10YR 7/4); intense deformation to a chalk breccia with slight deformation; pumice fragments, burrows common.

NANNOFOSSIL RICH CLAYSTONE
Smears: 1-80, 4-80, 5-16, CC

Texture	Composition
50% Silt	58-65% Clay minerals
45% Clay	50-60% Nannofossils
5% Sand	5% Foraminifera
	5% Radiolarians
	5% Quartz
	3- 5% Micarb
	2- 5% Volcanic glass
	3% Sponge spicules
	Tr- 1% Feldspar

Radiolarian, foraminifera-bearing; locally volcanic ash-bearing.

Grain Size 5-15
4.3, 49.3, 46.4

Carbon Carbonate 5-15
3.5, 0.0, 28

X-ray 5-15 (Bulk)
75.8% Calc
9.0% Plag
6.3% Mica
6.2% Quar
2.8% Mont

Explanatory notes in chapter 1

Site 296 Hole Core 32 Cored Interval: 291.5-301.0 m

AGE: EARLY MIOCENE

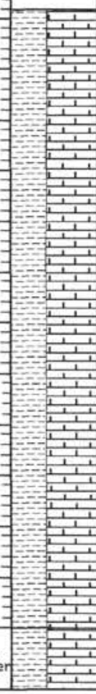
ZONE: N6; Discoaster druggii Subzone/Sphenolithus belemnos; Calocycletta virginis (R)

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO. DIATOMS):
- Section 2: Am; Fm
- Section 3: Am
- Section 4: Rp; Cm
- Section 5: Am
- Core Catcher: Ag- Am- Rp

SECTION: 1, 2, 3, 4, 5, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY: VOID



LITHO. SAMPLE: * 120 (Section 2); * CC

10YR 7/4

10YR 7/4

LITHOLOGIC DESCRIPTION

Color grayish orange (10YR 7/4); chalk breccia and slight deformation; burrow mottling common.

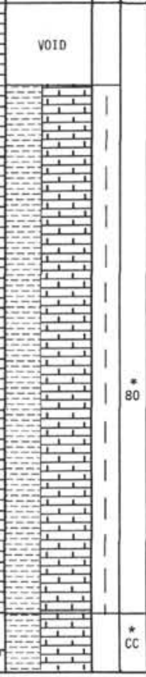
CLAYEY NANNOFOSSIL CHALK
Smears: 2-120, CC

Texture	Composition
100% Clay	70-75% Nannofossils
	20% Clay minerals
	1- 2% Micarb
	1% Volcanic glass
	1% Foraminifera
	Tr- 2% Radiolarians
	Tr% Sponge spicules

Explanatory notes in chapter 1

Site 296 Hole Core 33 Cored Interval: 301.0-310.5 m

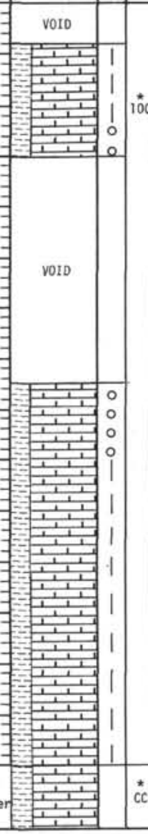
AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY MIOCENE	N6 Discoaster deflandrei Subzone / Discoaster druggi Subzone Dorcadospyris atenchus - Lychnocanoma elongata (R)		Cm			1	0.5 1.0	VOID			Colors grayish orange (10YR 7/4) to moderate yellow brown (10YR 5/4); slight deformation; moderate to intense burrow mottling throughout. CLAYEY NANNOFOSSIL CHALK Smears: 3-80, CC Texture: 100% Clay Composition: 58% Nannofossils; 40% Clay minerals; 1% Micarb; 1% Foraminifera; Tr% Sponge spicules; Tr% Volcanic glass
			Am	Rp		2					10YR 7/4 ↕ 10YR 5/4
						3				* 80	
			Cm	Rp		4					
		Ag	Am	Rp		Core Catcher				* CC	10YR 7/4



Explanatory notes in chapter 1

Site 296 Hole Core 34 Cored Interval: 310.5-320.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	N5/6 Cyclicargolithus abisectus Subzone Dorcadospyris atenchus - Lychnocanoma elongata (R)		Cm			1	0.5 1.0	VOID		* 100	Color grayish orange (10YR 7/4): chert breccia with slight deformation; intense burrows; some dark yellow brown (10YR 4/2) and yellow brown (10YR 5/2) colors. CLAY-RICH NANNOFOSSIL CHALK Smear: 1-100, CC Texture: 100% Clay Composition: 60-70% Nannofossils; 15-25% Clay minerals; 4- 5% Volcanic glass; 3% Quartz; Tr- 3% Radiolarians; 2% Feldspar; Tr% Sponge spicules; Tr% Heavy minerals Carbon Carbonate 1-100 7.5, 0.1, 62 X-ray 1-100 (Bulk) 90.5% Calc 3.4% Quar 2.4% Mica 2.2% Plag 1.5% Mont
						2		VOID			
						3					
			Cm	Fm		4					10YR 7/4
			Am			5					
		Ag	Am	Rp		Core Catcher				* CC	10YR 7/4



Explanatory notes in chapter 1

Site 296 Hole Core 35 Cored Interval: 320.0-329.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	N4; Cyclicargolithus abisectus Subzone; Dorcadospyris atenchus - Lychnocanoma elongata (R)					1	0.5, 1.0	VOID		* 100	10YR 7/4; N4
						2		VOID			
				Fm		3					10YR 7/2
			Cm-			4					
				Rp		5		GEOCHEM SAMPLE			
						6					N4; N4; 10R 7/4
		Ag-	Am-	Rm-		Core Catcher				* CC	10YR 7/2

Color grayish orange (10YR 7/4) to yellowish brown (10YR 7/2); moderate to intense burrowing; slight deformation.

CLAYEY NANNOFOSSIL CHALK
Smears: 1-100, CC

Texture	Composition
100% Clay	60-65% Nannofossils
	28-30% Clay minerals
	2- 5% Volcanic glass
	2% Micarb
	Tr- 5% Radiolarians
	Tr% Foraminifera
	Tr% Sponge spicules

Carbon Carbonate 1-100
7.9, 0.1, 66

Explanatory notes in chapter 1

Site 296 Hole Core 36 Cored Interval: 329.5-339.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	N4; P22; Cyclicargolithus abisectus Subzone; Dorcadospyris atenchus - Lychnocanoma elongata (R)					1	0.5, 1.0	VOID			
				Rp		2				* 90	10YR 8/2
						3				* 87	5Y 4/1
			Am-	Fp		4					10YR 8/2 → 10YR 7/4
						5					
				Rp		6					
		Ag	Am-	Cm		Core Catcher				* CC	10YR 8/2

Color very pale orange (10YR 8/2); slight deformation; extensive burrows, some with pyrite; ash beds - olive gray (5Y 4/1).

CLAY-RICH NANNOFOSSIL CHALK
Smears: 2-90, CC

Texture	Composition
100% Clay	69-75% Nannofossils
	20-25% Clay minerals
	1- 2% Volcanic glass
	1% Micarb
	1% Foraminifera
	Tr- 3% Radiolarians
	Tr% Sponge spicules

NANNOFOSSIL-RICH CLAYEY VOLCANIC ASH (Minor Lith)
Smear: 3-87

Texture	Composition
40% Silt	40% Volcanic glass
30% Sand	30% Clay minerals
30% Clay	20% Nannofossils
	10% Feldspar

Carbon Carbonate 2-90
9.1, 0.0, 76

X-ray 2-90 (Bulk)
92.7% Calc
2.3% Mica
1.9% Plag
1.7% Mont
1.5% Quar

Explanatory notes in chapter 1

Site 296 Hole Core 37 Cored Interval: 339.0-348.5 m

AGE: LATE OLIGOCENE

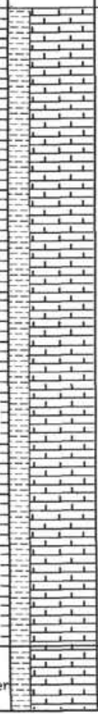
ZONE: P22; Cyclicargolithus abisectus Subzone; Dorcadospyris atenchus - Lychnocanoma elongata (R)

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Rp (Section 2); Am- Cm (Section 4); Ag- Am- Rm (Core Catcher)

SECTION: 1, 2, 3, 4, 5, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY: VOID (Section 1, upper part)



LITHO. SAMPLE: * 140 (Section 1); * 80 (Section 2)

10YR 6/2

10YR 8/2

--color change

5GY 6/1

5GY 6/1

LITHOLOGIC DESCRIPTION

Color: pale yellow brown (10YR 6/2) - very pale orange (10YR 8/2); slight deformation; extensive burrows; natural slickensides in Section 2; color green gray (5GY 6/1) in Sections 4 and 5.

CLAY-RICH NANNOFOSSIL CHALK
Smears: 1-140, 2-80

Texture	Composition
100% Clay	76% Nannofossils
	20% Clay minerals
	1- 2% Volcanic glass
	1% Opaques
	Tr% Radiolarians
	Tr% Sponge spicules

Explanatory notes in chapter 1

Site 296 Hole Core 38 Cored Interval: 348.5-358.0 m

AGE: LATE OLIGOCENE

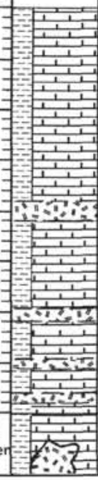
ZONE: P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanoma elongata (R)

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Cm- (Section 1); Fm (Section 2); Ag- Am- Rp (Core Catcher)

SECTION: 1, 2, 3, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY: VOID (Section 1, upper part)



LITHO. SAMPLE: * 70 (Section 2); * 100 (Section 3)

N8

5Y 6/1

N7

5Y 6/1

N7

N7

5Y 6/1

LITHOLOGIC DESCRIPTION

Generally very light gray (N8) to light gray (N7); slightly deformed; very bioturbated and slickensides noted; color darkens in Section 3 to light olive gray (5Y 6/1).

CLAY-RICH NANNOFOSSIL CHALK
Smear: 2-70

Texture	Composition
95% Clay	72% Nannofossils
5% Silt	20% Clay minerals
	4% Foraminifera
	2% Heavy minerals
	1% Volcanic glass
	1% Radiolarians

VOLCANIC ASH (Minor Lith)
Smear: 3-100

Texture	Composition
50% Silt	74% Volcanic glass
25% Sand	15% Feldspar
25% Clay	10% Heavy minerals
	1% Nannofossils

Carbon Carbonate 2-80
3.0, 0.0, 25

Explanatory notes in chapter 1

Site 296 Hole Core 39 Cored Interval: 358.0-367.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22; Sphenolithus ciperoensis; Lychnocanoma bipes (R) Dorcadospyris atenchus - Lychnocanoma elongata (R)	Ag	Am (sec. 3), Am (CC)	Fm (sec. 2), Rp (CC)		1, 2, 3, 4, Core Catcher	0.5, 1.0	VOID		*140, *65, *CC	5GY 6/1 with N2; 5Y 2/1 (CC)

Colors - greenish gray (5GY 6/1) to grayish black (N2) in ash-rich zones; intense burrowing; slight deformation; ash beds have sharp lower contact and vague upper contact, average 5-10 cm thick, every 30 cm. Burrows only at top of ash beds.

CLAY-RICH NANNOFOSSIL CHALK
Smear: 2-65

Texture	Composition
93% Clay	70% Nannofossils
7% Silt	20% Clay minerals
	5% Micarb
	3% Foraminifera
	1% Feldspar
	1% Volcanic glass

VOLCANIC ASH (Minor Lith)
Smear: 1-140

Texture	Composition
70% Sand	64% Volcanic glass
30% Silt	20% Feldspar
	10% Nannofossils
	6% Heavy minerals

ASHY NANNOFOSSIL CHALK (Minor Lith)
Smear: CC

Texture	Composition
65% Clay	56% Nannofossils
25% Silt	25% Volcanic glass
10% Sand	15% Heavy minerals
	3% Feldspar
	1% Foraminifera
	Tr% Radiolarians
	Tr% Sponge spicules

Carbon Carbonate 2-65
8.5, 0.0, 71

Explanatory notes in chapter 1

Site 296 Hole Core 40 Cored Interval: 367.5-377.0

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCEN	P22; Sphenolithus ciperoensis; Lychnocanoma bipes (R) Dorcadospyris atenchus - Lychnocanoma elongata (R)	Ag	Am	Rm (sec. 2), Rm (CC)		1, 2, 3, 4, Core Catcher	0.5, 1.0	VOID; GEOCHEM SAMPLE		*16, *65	5GY 6/1 with N3; 5GY 4/1

Interbedded ash dark gray (N3) and chalk greenish gray (5GY 6/1); ash beds have sharp bases; graded, burrows at top; slight deformation for core.

CLAYEY NANNOFOSSIL CHALK
Smear: 4-65

Texture	Composition
100% Clay	60% Nannofossils
	30% Clay minerals
	3% Micarb
	3% Foraminifera
	3% Volcanic glass
	Tr% Sponge spicules

CLAYEY VOLCANIC ASH
Smear: 4-16

Texture	Composition
64.8% Silt	30% Volcanic glass
19.4% Sand	30% Feldspar
15.8% Clay	15% Clay minerals
	10% Heavy minerals
	10% Quartz
	5% Nannofossils

Grain Size 3-44
0.2, 65.3, 34.4

Grain Size 3-53
86.6, 7.9, 5.4

Grain Size 4-16
19.4, 64.8, 15.8

Grain Size 4-145 (Ash bed)
72.4, 17.5, 10.1

Carbon Carbonate 4-65
7.5, 0.0, 62

X-ray 3-44 (Bulk)	X-ray 3-53 (Bulk)
50.2% Plag	58.1% Plag
21.9% Mont	20.7% Augi
11.3% Augi	14.1% Calc
9.2% Calc	4.9% Quar
4.1% Mica	2.2% Mont
3.3% Quar	

X-ray 4-16 (Bulk)	X-ray 4-145 (Bulk)
56.3% Plag	45.7% Calc
13.4% Mont	36.1% Plag
12.5% Augi	11.1% Augi
12.5% Quar	5.1% Mont
3.9% Calc	2.1% Quar
1.3% Chlo	

Explanatory notes in chapter 1

Site 296 Hole Core 41 Cored Interval: 377.0-386.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanoma elongata (R); Lychnocanoma bipes (R)	Ag-	Am-	Rm, Rm-		1, 2, 3, Core Catcher	0.5, 1.0	VOID		* 24, * 78	5GY 6/1 with N2, N3, N6

Interbedded ash gray black (N2) and chalk greenish gray (5GY 6/1); slight deformation; ash beds graded, bioturbated at top; grading is from very coarse sand to clay size; burrows in chalk.

VOLCANIC ASH
Smear: 2-24

Texture	Composition
75% Silt	40% Glass lithics
25% Clay	25% Feldspar
	20% Clay minerals
	13% Nannofossils
	2% Heavy minerals

May be considered clay mineral-rich.

CLAYEY NANNOFOSSIL CHALK
Smear: 2-78

Texture	Composition
100% Clay	60% Nannofossils
	36% Clay minerals
	1% Foraminifera
	1% Micarb
	1% Opaques
	Tr% Feldspar
	Tr% Volcanic glass

Grain Size 2-24 (Ash)
0.4, 74.9, 24.7

Grain Size 2-93 (Ash)
53.7, 36.7, 9.6

Carbon Carbonate 1-12
0.3, 0.0, 2

Carbon Carbonate 2-77
7.5, 0.1, 62

X-ray 1-12 (Bulk)	X-ray 2-24 (Bulk)
63.8% Plag	39.4% Plag
16.4% Augi	25.0% Mont
9.4% Mont	21.9% Calc
5.3% Calc	6.6% Augi
5.1% Quar	5.3% Quar
	1.8% Chlo

X-ray 2-93 (Bulk)	X-ray 3-28 (Bulk)
66.4% Plag	60.9% Plag
17.4% Augi	20.0% Mont
7.4% Mont	14.1% Augi
4.6% Quar	5.0% Quar
4.2% Calc	

Explanatory notes in chapter 1

Site 296 Hole Core 42 Cored Interval: 386.5-396.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanamo elongata (R)	Ag-	Am-	Rm, B		1, Core Catcher	0.5, 1.0	VOID		* 65	5GY 4/1 with N2

Deformation slight; interbedded chalk-light gray (N7) and ash-grayish black (N2); ash graded, bioturbated at top, sharp lower contacts, 10 cm+ thick.

CLAYEY NANNOFOSSIL CHALK
Smear: 1-65

Texture	Composition
93% Clay	50% Nannofossils
7% Silt	39% Clay minerals
	5% Micarb
	2% Feldspar
	2% Radiolarians
	1% Volcanic glass
	1% Foraminifera

Grain Size 1-50
28.0, 55.1, 16.9

Carbon Carbonate 1-65
6.5, 0.0, 54

X-ray 1-50 (Bulk)
48.9% Plag
19.9% Augi
16.4% Calc
11.0% Mont
3.7% Quar

Explanatory notes in chapter 1

Site 296 Hole Core 43 Cored Interval: 396.0-405.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanamo elongata (R)		Am-	Rp, B		1, Core Catcher	0.5, 1.0	VOID			N7/N2

Light gray (N7) chalk interbedded with gray black (N2) ash; 50:50; ash bioturbated at top, with vague contact, graded beds, and sharp basal contacts; slight deformation.

CLAY-RICH NANNOFOSSIL CHALK
interbedded with
VOLCANIC ASH

Grain Size 1-123
73.4, 20.0, 6.5

X-ray 1-123 (Bulk)
49.4% Plag
25.4% Calc
16.1% Augi
5.3% Mont
3.8% Quar

Explanatory notes in chapter 1

Site 296 Hole Core 44 Cored Interval: 405.5-415.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis Dorcadospyris atenchus - Lychnocanoma elongata (R)	Ag	Am	Fp, Rm		1	0.5, 1.0	VOID			Color light gray medium (N6) to grayish black (N2). CLAY-RICH NANNOFOSSIL CHALK interbedded with VOLCANIC ASH. N6/N2
						Core Catcher					

Explanatory notes in chapter 1

Site 296 Hole Core 45 Cored Interval: 415.0-424.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis					1	0.5, 1.0			* 45	N6
						2		VOID			
				B		3		GEOCHEM SAMPLE			N6
		Ag	Am	Rp		Core Catcher					5GY 4/1

Slight drilling deformation; medium light gray (N6) throughout core; and even-colored; less ash-chalk bedding.

CLAY-RICH NANNOFOSSIL CHALK
Smear: 1-45

Texture	Composition
70% Silt	54% Nannofossils
30% Clay	15% Clay minerals
	10% Feldspar
	8% Heavy minerals
	8% Volcanic glass
	5% Micarb
	Tr% Foraminifera
	Tr% Sponge spicules

Locally ash-rich.

Carbon Carbonate 1-71 (Ash layer)
3.4, 0.0, 28

Explanatory notes in chapter 1

Site 296 Hole Core 46 Cored Interval: 424.5-434.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis			Rp		1	0.5, 1.0				5Y 4/1
						2		VOID			5Y 4/1
				Rm		3					--color change; 5GY 6/1
						4				* 55	
		Ag	Am	Rm		Core Catcher					5GY 6/1

Slight deformation; dominant colors, olive gray (5Y 4/1) and greenish gray (5GY 6/1); ash-rich nannofossil chalk occurs locally in Section 2; ash fragments sand size; moderate to intense burrowing.

CLAYEY NANNOFOSSIL CHALK
Smear: 4-55

Texture	Composition
80% Clay	50% Nannofossils
20% Silt	38% Clay minerals
	5% Micarb
	2% Foraminifera
	1% Feldspar
	1% Heavy minerals
	1% Volcanic glass
	1% Opaques
	1% Radiolarians
	Tr% Sponge spicules

Locally ash-rich in Section 2.

Carbon Carbonate 4-55
7.7, 0.0, 64

Explanatory notes in chapter 1

Site 296 Hole Core 47 Cored Interval: 434.0-443.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis	Ag-	Am-	B Rp-		1	0.5 1.0	VOID		*N6	5Y 4/1 5GY 6/1
						Core Catcher					

Colors: olive gray (5Y 4/1) - ash; greenish gray (5GY 6/1) - chalk, interbedded; ash unit graded.

CLAY NANNOFOSSIL-RICH VOLCANIC ASH
Smear: 1-146

Texture	Composition
74% Silt	43% Volcanic glass
16% Sand	25% Nannofossils
10% Clay	25% Clay minerals
	5% Quartz
	1% Heavy minerals
	1% Foraminifera

CLAYEY NANNOFOSSIL CHALK

Grain Size 1-146
16.1, 73.5, 10.5

X-ray 1-146 (Bulk)
48.7% Calc
43.5% Plag
4.1% Mont
3.7% Quar

Explanatory notes in chapter 1

Site 296 Hole Core 48 Cored Interval: 443.5-453.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis		Fm-	B B		1	0.5 1.0	VOID		*130	N5 with N1
						Core Catcher		VOID			

Medium light gray (N5) with black (N1); sandy unit (ashy) at base of Section 1 = boundary to Unit 2.

CLAY/ASH-RICH NANNOFOSSIL CHALK
Smear: 1-130

Texture	Composition
55% Clay	53% Nannofossils
30% Silt	20% Clay minerals
15% Sand	15% Glass, lithics
	5% Micarb
	3% Heavy minerals
	2% Feldspar
	2% Opaques

Explanatory notes in chapter 1

Site 296 Hole Core 49 Cored Interval: 453.0-462.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis		Cm			1	0.5 1.0	VOID			N2
						Core Catcher		VOID			

Unit 2 - (Lapilli) Tuff, black (N2), friable; clasts consist of pumice fragments, glass, mineral fragments, red pumice; subrounded-angular outlines; sandy matrix of glass; Lapilli sizes for fragments with some ash-sizes.

Explanatory notes in chapter 1

Site 296 Hole Core 50 Cored Interval: 462.5-472.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
				B		1	0.5 1.0	VOID			N2
						Core Catcher		VOID			

Black (N2), (Lapilli) Tuff, friable, fragments consist of pumice, glass, and minerals; sub-angular to angular, with sizes from very-fine sand to granules; some associated ASH-RICH NANNOFOSSIL CHALK.

Explanatory notes in chapter 1

Site 296 Hole Core 51 Cored Interval: 481.5-491.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22 Sphenolithus ciperoensis		Rm	B		Core Catcher					N2

LAPILLI TUFF recovered in core catcher only; similar to Cores 49-50.

Explanatory notes in chapter 1

Site 296 Hole Core 52 Cored Interval: 548.0-557.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21/22 Sphenolithus ciperoensis		Am			1	0.5 1.0	VOID; GEOCHEM SAMPLE		* 55 * 71 * 91	N1 N3 + N7; 5GY 2/1 with N1, N3-N7
						2					
		Ag	Am	B		Core Catcher					

Colors: black (N1), grays (N7-N3) and greenish black (5GY 2/1); areas with excellent laminae bedding; some with sharp basal contacts; pumice fragments with fall characteristics; extensive bioturbation and current (traction) features.

NANNOFOSSIL/CLAY-RICH VOLCANIC ASH
Smear: 1-91

Texture	Composition
45% Clay	40% glass, devit. clay
35% Silt	20% Nannofossils
20% Sand	20% Clay minerals
	10% Feldspar
	5% Micarb
	3% Heavy minerals
	1% Foraminifera

CLAY/ASH-RICH NANNOFOSSIL CHALK
Smear: 1-55

Texture	Composition
75% Clay	65% Nannofossils
20% Silt	15% Clay minerals
5% Sand	10% Volcanic glass
	4% Micarb
	3% Foraminifera
	2% Feldspar
	1% Heavy minerals

CLAY-RICH NANNOFOSSIL CHALK
Smear: 1-71

Texture	Composition
90% Clay	60% Nannofossils
10% Silt	25% Clay minerals
	5% Volcanic glass
	5% Micarb
	3% Foraminifera
	1% Feldspar
	1% Heavy minerals
	1% Radiolarians
	1% Sponge spicules

Grain Size 1-127
1.0, 77.6, 21.4

Carbon Carbonate 1-72
6.2, 0.0, 51

X-ray 1-127 (Bulk)
57.4% Plag
23.9% Calc
12.9% Augi
3.5% Quar
2.3% Mont

Explanatory notes in chapter 1

Site 296 Hole Core 53 Cored Interval: 567.0-576.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21/22 Sphenolithus ciperoensis or S. distentus					1	0.5 1.0	VOID		* TS	N1-N5
			Rp	B		Core Catcher		VOID			

(Lapilli) Tuff
Fragments consist of pumice, mineral grains, glass, volcanic lithics and carbonate fragments; size is sand to granule, angular and subangular with faint grading noted; colors: black with lighter gray (N5) fragments.

Thin Section: 1-143
Fragments: clinopyroxene; plagioclase (An_{52}) volcanic flow and tuff fragments and foraminifera fragments; size: average 2-3 mm; maximum = 1 cm (10 mm).

Matrix: 10-15% = fine glass and fractured crystals; closed framework.

Explanatory notes in chapter 1

Site 296 Hole Core 54 Cored Interval: 624.0-633.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21/22 Sphenolithus ciperoensis or S. distentus					1	0.5 1.0	VOID; GEOCHEM SAMPLE		* 83 * TS * TS	N4 N5
						2				* TS * TS	N2
						3				* TS	
			Rm	B		Core Catcher					

(Lapilli) Tuff and (Ash) Tuff
Silt to granule sizes; particles > matrix; volcanogenic clasts/matrix; subangular with graded beds in all sections.

Thin Sections: 1-132, 1-135, 2-1, 2-35, 2-98, 3-22.
Composition (General)
Clasts: Glass with phenocrysts (5%)
Pumice fragments (40%)
Porphyritic basalts (5%)
Microtrachyte (Tr%)
Plagioclase (20%)
Pyroxenes (5%)
Oxides (2%)
Amphiboles (Tr%)
Carbonate (Tr%)
Matrix: Glass (altered), brown devitrified, palagonitized.

NANNOFOSSIL-BEARING/CLAY-RICH VOLCANIC ASH
Smear: 1-83

Texture	Composition
45% Silt	62% Volcanic glass
30% Clay	25% Clay minerals
25% Sand	5% Nannofossils
	5% Feldspar
	3% Heavy minerals

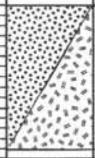
bioturbated, laminations

Grain Size 3-115
52.9, 26.8, 20.3

Carbon Carbonate 1-82
0.8, 0.0, 6

Explanatory notes in chapter 1

Site 296 Hole Core 55 Cored Interval: 652.5-662.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21 Sphenolithus ciperoensis or S. distentus		Rm-	B		1	0.5, 1.0			* TS, * TS	N2; N4
						Core Catcher		VOID			

(Lapilli) Tuff
Ash-Lapilli size, subangular-angular shapes; graded beds (0-110 cm); particles > matrix; plagioclase, amphibole phenocrysts in felted glassy matrix (altered).
Two large clasts are hornblende andesites and pyroxene andesites (see description below).

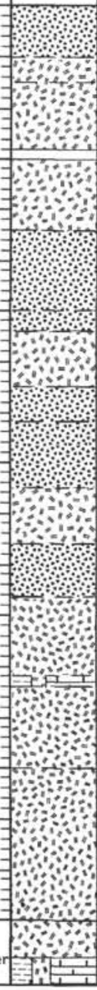
Thin Section: 1-114
Plagioclase (35), amphibole, pyroxene (5) and euhedral oxide (10), phenocrysts in a fine grained matrix of microtrachytic feldspars and glass (now devitried and altered) (Hornblende andesite).

Thin Section: 1-135
Plagioclase (35) and pyroxene (5), phenocrysts; euhedral oxides (10) in fine grained matrix of microtrachyte feldspars (pyroxene andesite).

Grain Size 1-99
57.6, 20.3, 22.0

Explanatory notes in chapter 1

Site 296 Hole Core 56 Cored Interval: 690.5-700.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21 Sphenolithus ciperoensis or S. distentus					1	0.5, 1.0			* TS, * TS, * TS	N2
						2				* TS	
						3				* TS, * TS, * TS	
						4				* TS	N2; 5G 2/1
			Rp-			5					N6; N2
						6				* TS	5G 2/1
			Cp-	B		Core Catcher				* CC	5G 2/1; N5

(Lapilli) Tuffs - (Ash) Tuffs
Colors: greenish black (5G 2/1) and gray (N2); angular to subangular fragments with poor sorting in lapilli zones, good in ash zones; graded beds in all sections; sizes 0.5-2 mm for ash, 0.1 to 1.5 cm for lapilli; sharp contacts at fine/coarse graded beds.

Units
Section 1: 0-74, graded, poor sorting, angular fragments, lapilli tuff; (74-144), angular, poor sorting, ash tuff.
Section 2: 0-150, as in lower of Section 1 - lapilli tuff.
Section 3: 0-22, graded ash-lapilli coarse base of Section 2; 22-73, new unit, well sorted ash tuff; 73-150, ash+lapilli, poor sorted, angular.
Section 4: 0-88, as 73-150 in Section 3; 88-124, lapilli tuff, poor sorting, angular; 124-150, ash tuff well sorted, top of unit in Section 5 - 0-68.
Section 5: 0-68, ash tuff; 68-73, nanno chalk, 73-150, fair sorted ash tuff.
Section 6: well sorted ash tuff.

Thin Sections: 1-67, 1-79, 1-141, 2-46, 2-136, 3-20, 3-29, 4-97, 6-10
Composition (General)
Fragments: Volcanogenic (15%) including:
glass
porphyritic basalt
vesicular basalt
glassy basalt
pumice
Mineral fragments (30%) including:
plagioclase
pyroxene
oxides
amphiboles
Foraminifera and carbonate
Matrix: brown glass - devitrified and palagonitized (55%).

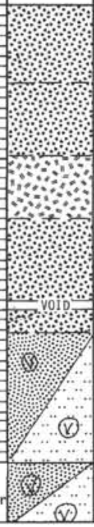
Many fragments with diffuse boundaries with matrix.

ASH CLAY-RICH NANNOFOSSIL CHALK
Smear: CC

Texture	Composition
65% Silt	36% Nannofossils
35% Clay	25% Volcanic glass
	25% Clay minerals
	10% Feldspar
	3% Micarb
	1% Foraminifera

Explanatory notes in chapter 1

Site 296 Hole Core 57 Cored Interval: 709.5-719.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus distentus		Cp-	B		1, 2, 3, Core Catcher	0.5, 1.0	 (VOID in Section 2)		* 55 (Section 3); * CC	N2, N3, N2, N4

(Lapilli) Tuff - (Ash) Tuff
Section 1: 0-77 cm, grayish black (N2) subround-subangular clasts; clasts > matrix with grain to grain contact; clasts are volcanic plus some carbonate and foraminifera; 1 m - 1.5 mm average sizes up to 10 mm = lapilli.

Sections 1-2: 77-150 cm to 60 cm of Section 2, dark gray (N3) volcanic fragments; lighter color due to less clast % and lighter color matrix; clast size increase to maximum = 10 mm; 1 mm - 10 mm = range of sizes.

Sections 2-3: 60 cm Section 2 to 25 cm Section 3, similar to Section 1, 0-77 cm.

VOLCANIC SILTSTONES/SANDSTONES
Sharp contact at 25 cm with volcanic sandstone - siltstones. Unit at → (25 cm to 150 cm); medium dark gray (N4) and exhibits grading

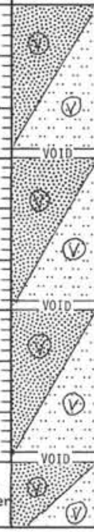
coarse
↑
fine / coarse — sharp with calcite stringer
↑
F / coarse — sharp
↑
fine — sharp
coarse (fine-very fine sand)

Smear: 3-55, CC

Composition
65-74% Volcanic glass
15% Feldspar
10-15% Clay minerals
5% Heavy minerals
1% Nannofossils

Explanatory notes in chapter 1

Site 296 Hole Core 58 Cored Interval: 747.5-757.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus distentus		Ap-	B		1, 2, 3, Core Catcher	0.5, 1.0	 (VOID at base of Sections 1, 2, 3)		* TS (Section 2); * TS (Section 3)	N3 → N5; N3-N5

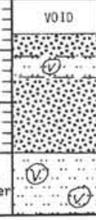
VOLCANIC SANDSTONE/SILTSTONE
Dark gray (N3) to medium gray (N5); bedding is of dark and medium colors: bedding thickness 0.5-1.0 cm to ±9 cm in Sections 2-3; some irregular thicknesses. Volcanogenic fragments subangular to subrounded; graded units apparent throughout.

coarse (N3) / fine (N5) — sharp
↑
coarse (N3) / fine (N5) — sharp — 0.2 mm→1 mm coarseness increases
↑
coarse (N3)

Thin Sections: 2-32, 3-16, sand of plagioclase fragments (30), pyroxene (5), amphiboles (5), and opaques (5) in silt-clay size matrix (20) of palagonite clay, silt-size volcanic materials and clay minerals.

Explanatory notes in chapter 1

Site 296 Hole Core 59 Cored Interval: 785.5-795.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus distentus		Rp-	B		1, Core Catcher	0.5, 1.0	 (VOID at top)		*TS, *TS	N6-N3; 5GY 6/1, N7, N6; N4-N3

(Lapilli) Tuff
35-55 cm: salt-pepper volcanic tuff; medium light gray (N6) to dark gray (N3); subround - white (medium light gray) pumice fragments in dark ash matrix; sizes - 3-5 mm average - to 20 mm = lapilli.

Volcanic Siltstone
55-78 cm: greenish gray (5G 6/1), light gray (N7); medium light gray (N6); extremely fine aphanitic ash with 0.2-0.5 mm white pumice fragment layers.

Lapilli Tuff
78-150 cm: dark gray (N4) - medium dark gray colors; subangular to angular - close packed; darker colors show size increase to 2-3 mm average to 15 mm maximum.

Volcanic Silstone
Thin Sections: 1-60, 1-67, silt size fragments of glass (fresh), amphiboles; plagioclase, lithic frags; angular shapes, well sorted; few large lithic frags. Clay minerals (15%).

Explanatory notes in chapter 1

Site 296 Hole Core 60 Cored Interval: 823.5-833.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
						1	0.5, 1.0	VOID		N3; N2 N3; N4 ↕ 5G 6/1	(Lapilli) Tuff - (Ash) Tuff Section 1: 0-106 cm, continuation of Core 59. Section 1: 78-150 cm, dark gray (N3) to grayish black; angular, to subangular and poorly sorted; sizes - 0.2 - 15 mm (average 2-3 mm): grain to grain contacts with clasts > matrix. 106-150: medium dark gray (N4); better sorted; large % greenish gray (5G 6/1) fragments; subround; clasts > matrix with size. Average ≡ 1 mm to 10 mm - ash to lapilli. Coarse at 150 → finer at 106 cm (Section 1).
				B		Core Catcher					

Explanatory notes in chapter 1

Site 296 Hole Core 61 Cored Interval: 861.5-871.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
						1	0.5, 1.0	VOID		N7 N2	(Ash) Tuff Sections 1-2: 62 cm, light gray (N7) and grayish black (N2) which continues into Section 2 to 62 cm; pumice fragments, glass, lithic fragments, scoria, mineral fragments in an altered glass matrix; poor sorting; sizes (1-2 mm average); subangular-angular.
						2				N7 ↓ N2; N6	Section 2: 62-120 cm, VOLCANIC SILTSTONE, medium light gray (N6) with some dark gray (N3) areas; bedding, flow structures including load costs; cut and fill, slump, pebble drop structures. 120-150 cm: same as 0-62 cm and continues to 100 cm Section 3.
						3				N7 ↓ N2; N6 N3 N4	Section 3: 0-62 cm: same as Tuff (Lapilli) (N7-N2) 100-120 cm: Volcanic Siltstone - ripple marks 120-134 cm: Tuff (Lapilli) (N7-N2) 134-140 cm: Tuff (Lapilli) dark (N3) 140-150 cm: Volcanic Siltstone
				B		Core Catcher				N7-N2	

Explanatory notes in chapter 1

Site 296 Hole Core 62 Cored Interval: 899.5-909.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
						1	0.5, 1.0	VOID		N2	Lapilli Tuff - (Ash) Tuff - Volcanic Silt/ Sandstones, grayish black (N2) - medium gray (N5); poor sorting with altered glass matrix of a light color; contacts of grains poor; a few large fragments are pumices, scorias. Graded Units: Section 1 - 74-150 cm Section 2 - 0-100 cm 100-120 cm = Vol. silt/sandstone 120-134 cm 134-139 cm 139-150 cm = Vol. siltstone
						2				↓ N5	
				B		Core Catcher				N2 ↓ N5	

Explanatory notes in chapter 1

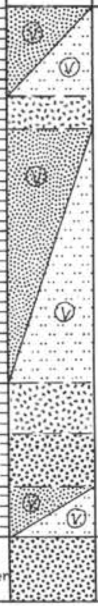
Site 296 Hole Core 63 Cored Interval: 966.0-975.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus distentus					1	0.5, 1.0	VOID		* TS	(Lapilli) Tuff - (Ash) Tuff Section 1 (130 cm) to Section 4 (105 cm): medium gray (N5) to dark gray (N3); subround-subangular volcanic clasts in devitrified altered glass; clasts > matrix; poorly sorted (0.5-30 mm), Average ≡2 mm. Volcanic clasts: pumice, lithics, mineral, glass fragments; some grading and imbrication. Section 4: 105-133 cm, greenish gray (5G 6/1) and medium dark gray (N4); fine grained version of above (Average 1-2 mm); better sorting. Section 4: 133-150 cm, sharp contact with above; medium dark gray (N4) and dark gray (N3). Thin Sections: 1-118: Volcanic Siltstone, fragments: pumice (40), fresh glass (10), porphyritic basalt (5), plagioclase (10), pyroxene (5), opaques (2). Matrix: glass and small pumice fragments (28) and fine clay minerals. 4-130: (Lapilli) Tuff, fragments of pumice (25), porphyritic basalt (5), variolitic basalt (10), serpentinzed fragments (2), plagioclase (25), pyroxenes and oxides (3) in devitrified to palagonitized matrix (30).
						2				N5 ↓ N3	
						3					
						4				* TS; N4-N3	
		Cp	Ap	B		Core Catcher				N5-N3	

Explanatory notes in chapter 1

Site 296 Hole Core 64 Cored Interval: 1070.5-1080.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE						1	0.5, 1.0	VOID		* TS		VOLCANIC SILTSTONES/SANDSTONES
						2				TS * TS, TS *, TS * TS *		
						3				TS *, TS *	N4, N5 5G 6/1	
						4				* TS * TS *		
		Ap	Rp	B		Core Catcher					5G 6/1	



VOLCANIC SILTSTONES/SANDSTONES

Colors: medium gray (N5) with medium dark gray (N4) and greenish gray (5G 6/1), moderate to good grading and subgrading; contacts of coarse to fine units are sharp - distinct; clasts generally > matrix, sub-angular to angular, well sorted, silt/sand sizes to 15 mm.

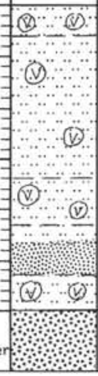
Thin Sections: 1-98, 2-15, 2-91, 2-145, 3-44, 3-136, 4-108, 4-144
General Composition
Fragments (40-80%), volcanogenic including pumice,glass, glassy-microcrystalline basalts, plagioclase, pyroxenes; epidote glomeroporphyritic aggregates. Matrix: mixed clay mineral and serpentine material.

(Lapilli-Ash) Tuff
Thin Sections: 2-20, 4-83, CC
Fragments of porphyritic basalt (5-25), glassy basalt (1-15), pumice (10-20); minerals: plagioclase (10-25), pyroxenes (5-10), opaques (5). Matrix: palagonitized basalt - some glass - glassy basalt altered to serpentine; devitrified.

Explanatory notes in chapter 1

Site 296 Hole Core 65 Cored Interval: 1080.0-1087.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE(?)						1	0.5, 1.0			* TS	N3 5GY 2/1	VOLCANIC SILTSTONE
						2				*TS *TS *TS	5GY 2/1	
			Rp	B		Core Catcher						



VOLCANIC SILTSTONE
Section 1: 0-29 cm, 0.1-0.3 mm clasts volcanic in fine grained grayish black matrix (N3) angular-subangular; poorly sorted.
29-150 cm: silty sand down grading to coarser grains (0.1-0.2 mm) in greenish black matrix.

Section 2: 0-18 cm, continuation of above.
18-67 cm: single graded unit - silty sand unit.
18-33 cm thick: coarsens to base.
67-117 cm: single graded unit with clasts (0.1-0.4 cm); of volcanic fragments, angular and poorly sorted, some subangular; green gray matrix (5GY 2/1).
117-150 cm: as above.

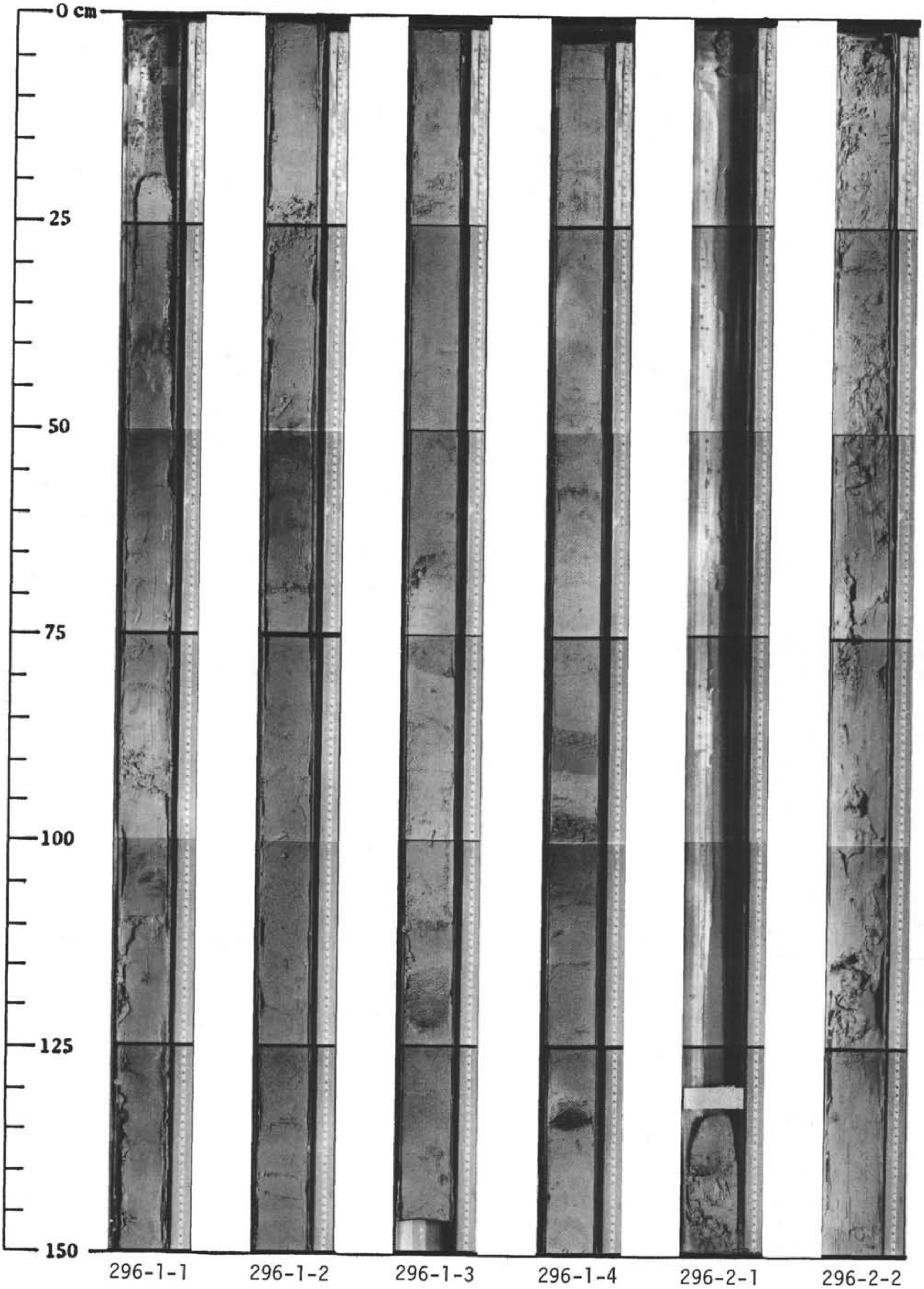
Thin Section: 1-16, fragments of vesicular basalt, glassy basalt, spherulitic basalts, plagioclase, pyroxene; all poorly sorted, angular, in fine-grained clay, palagonite and serpentine matrix - siltstone.

Thin Section: 2-107, some clast composition as 1-16; (75%) matrix of palagonitized and serpentinized basalt plus clay minerals (25) - siltstone.

Thin Section: 2-113, fragments as above - in coarse unit = poor sorting, angular; fragments (45) - matrix (53) fine fraction is angular-subangular, well-sorted sandstone.

Thin Section: 2-150, fragments, angular, moderately well-sorted (30%) in matrix of fine grained palagonite, clay minerals, nannos, fossils, mineral fragments and zeolites (70%) - siltstone.

Explanatory notes in chapter 1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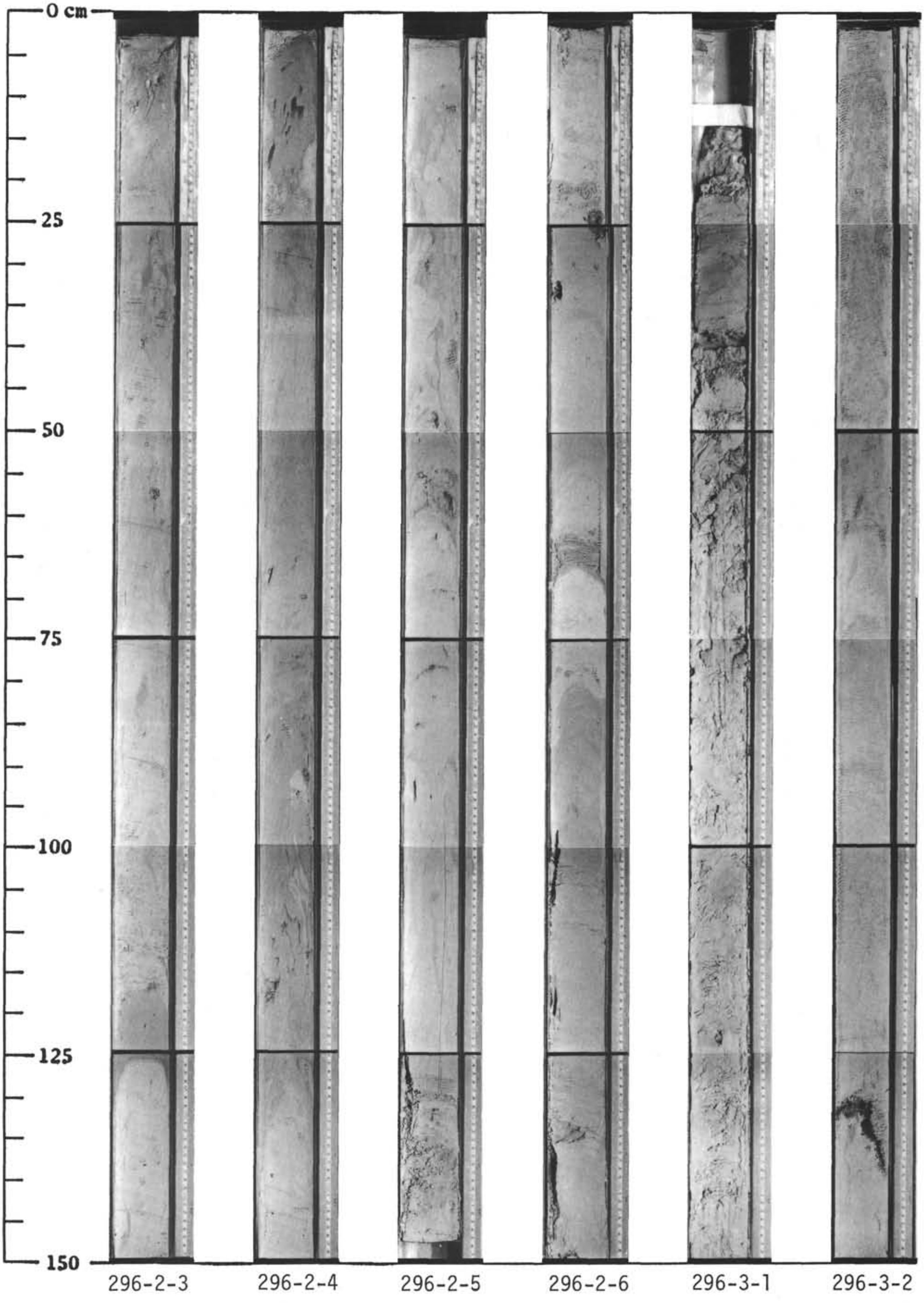
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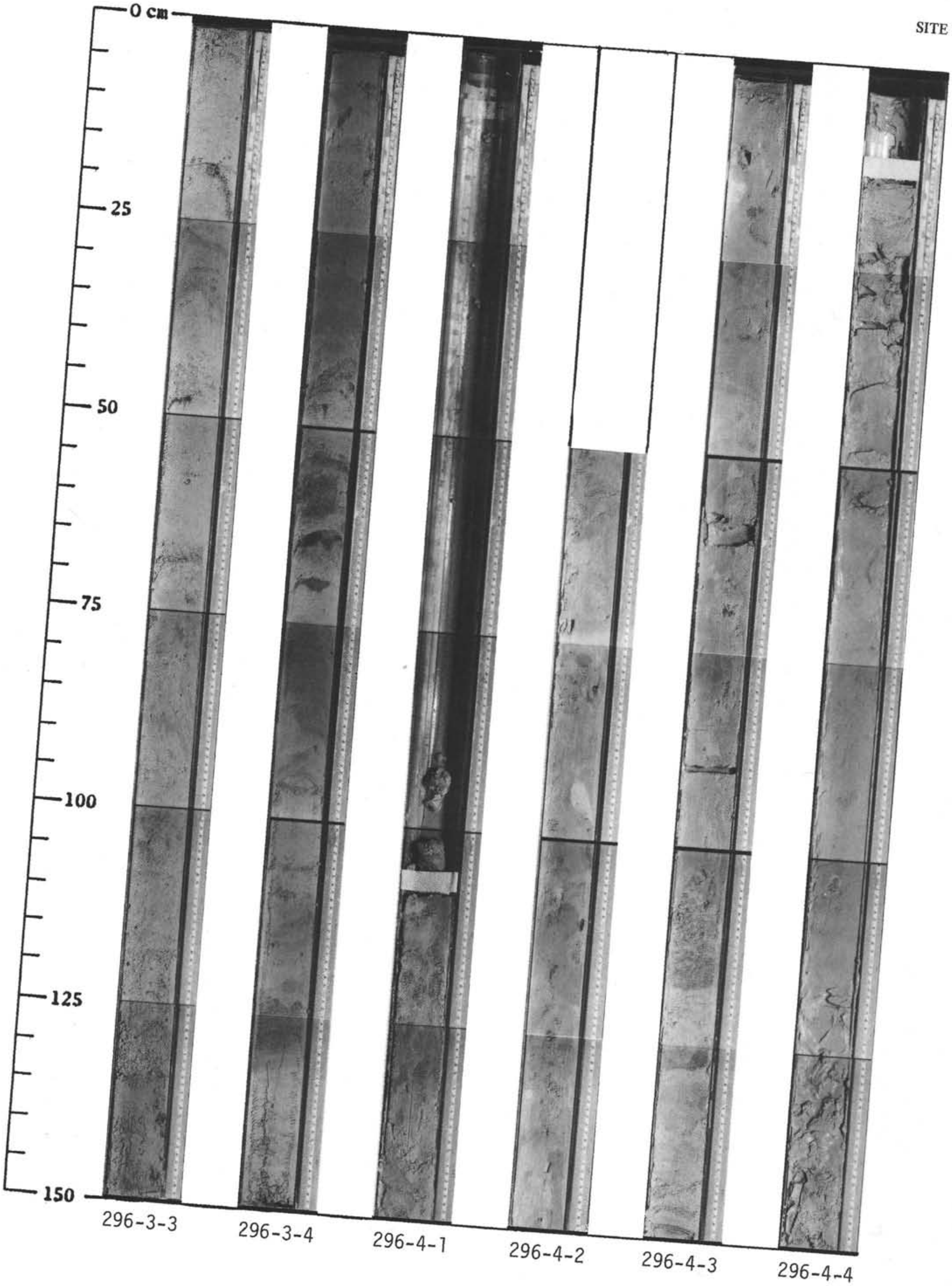
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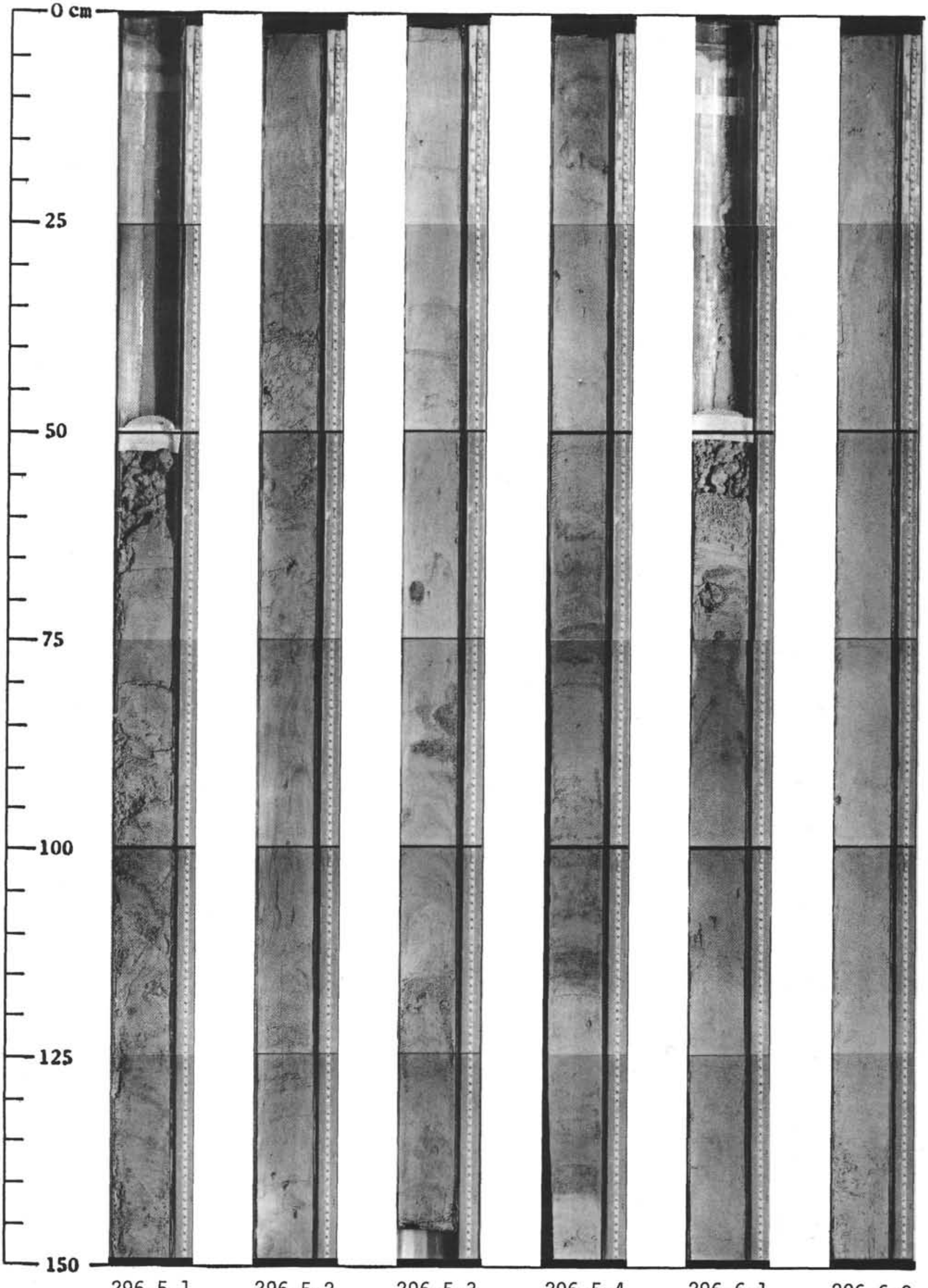
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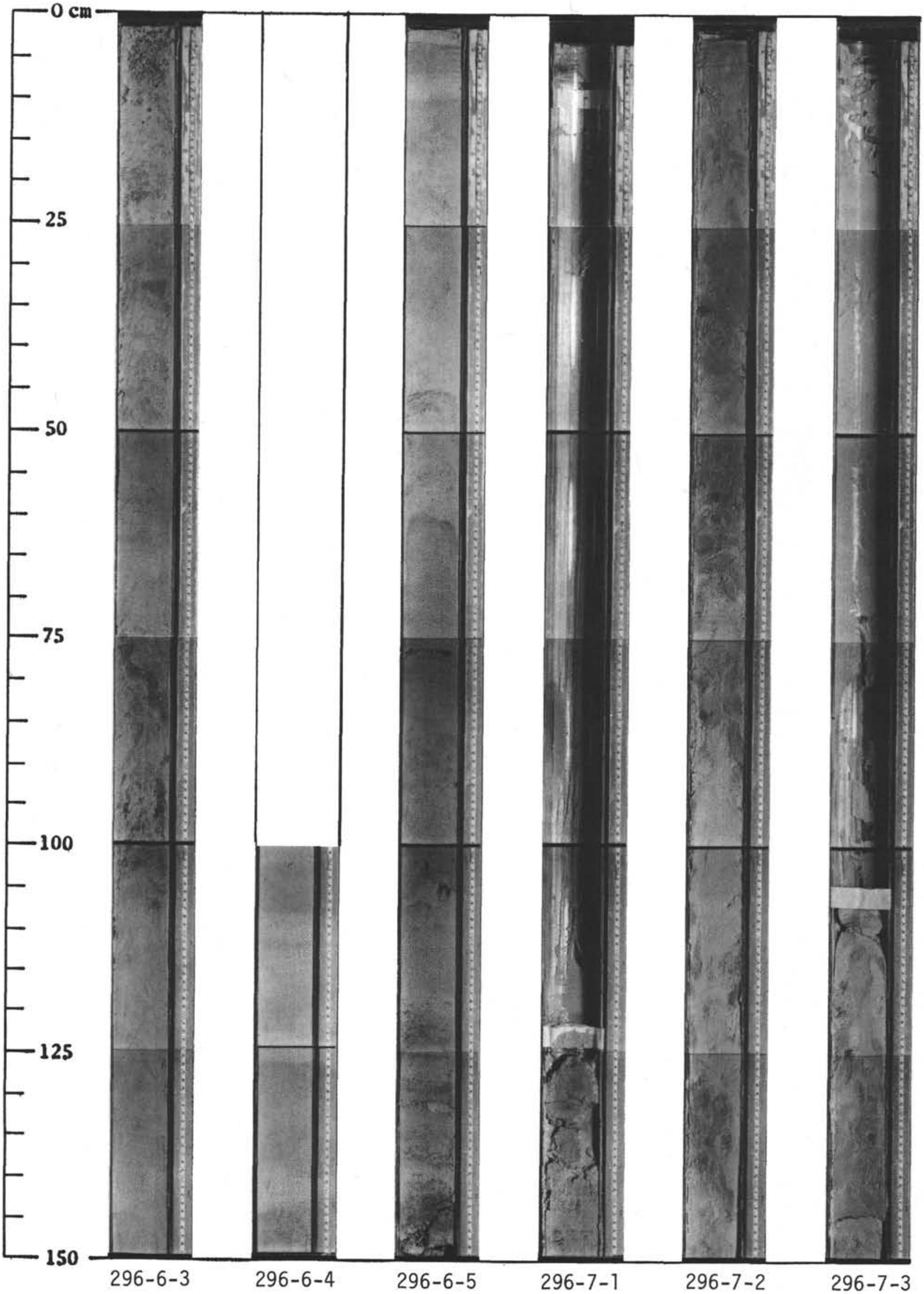
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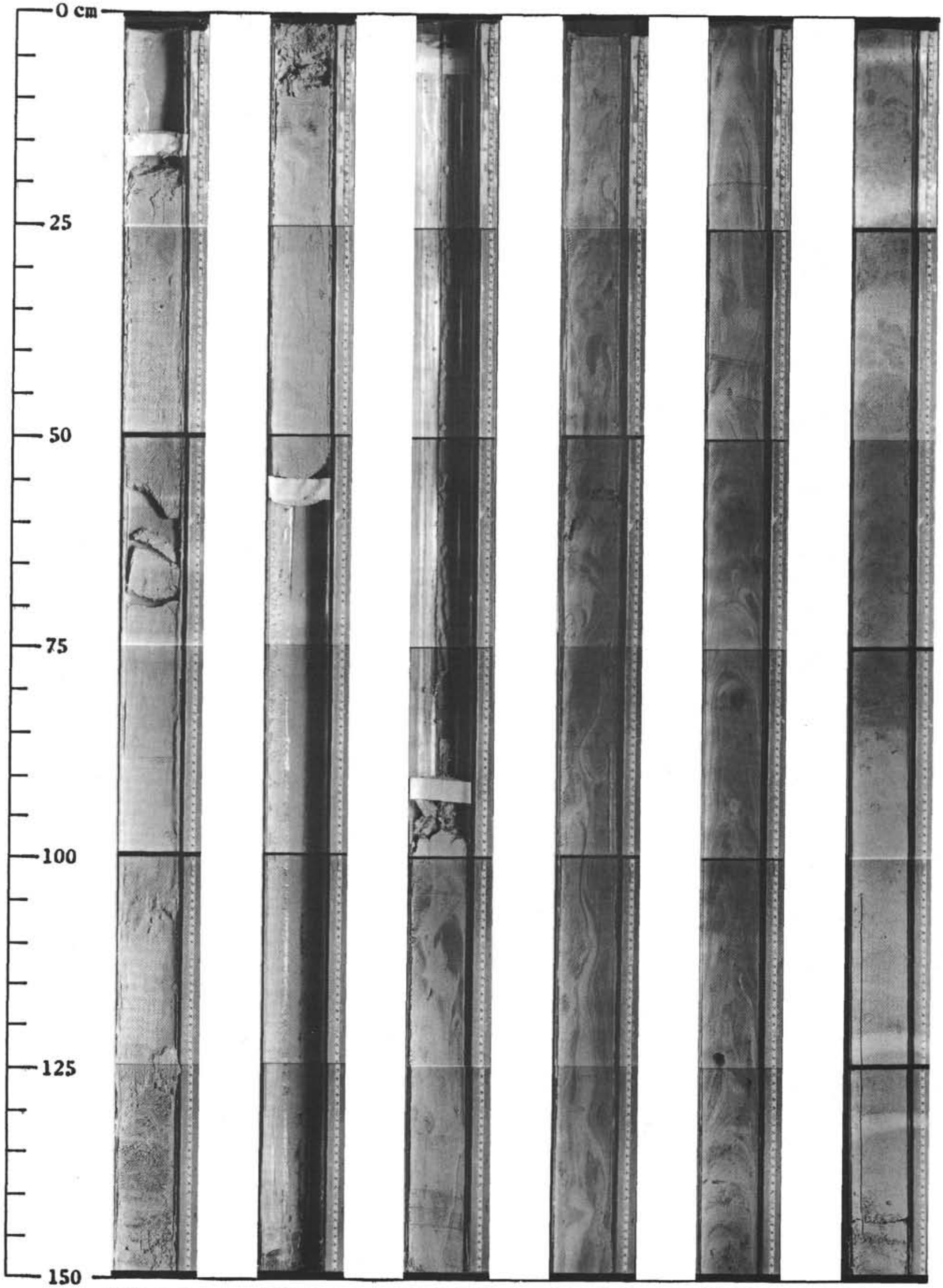

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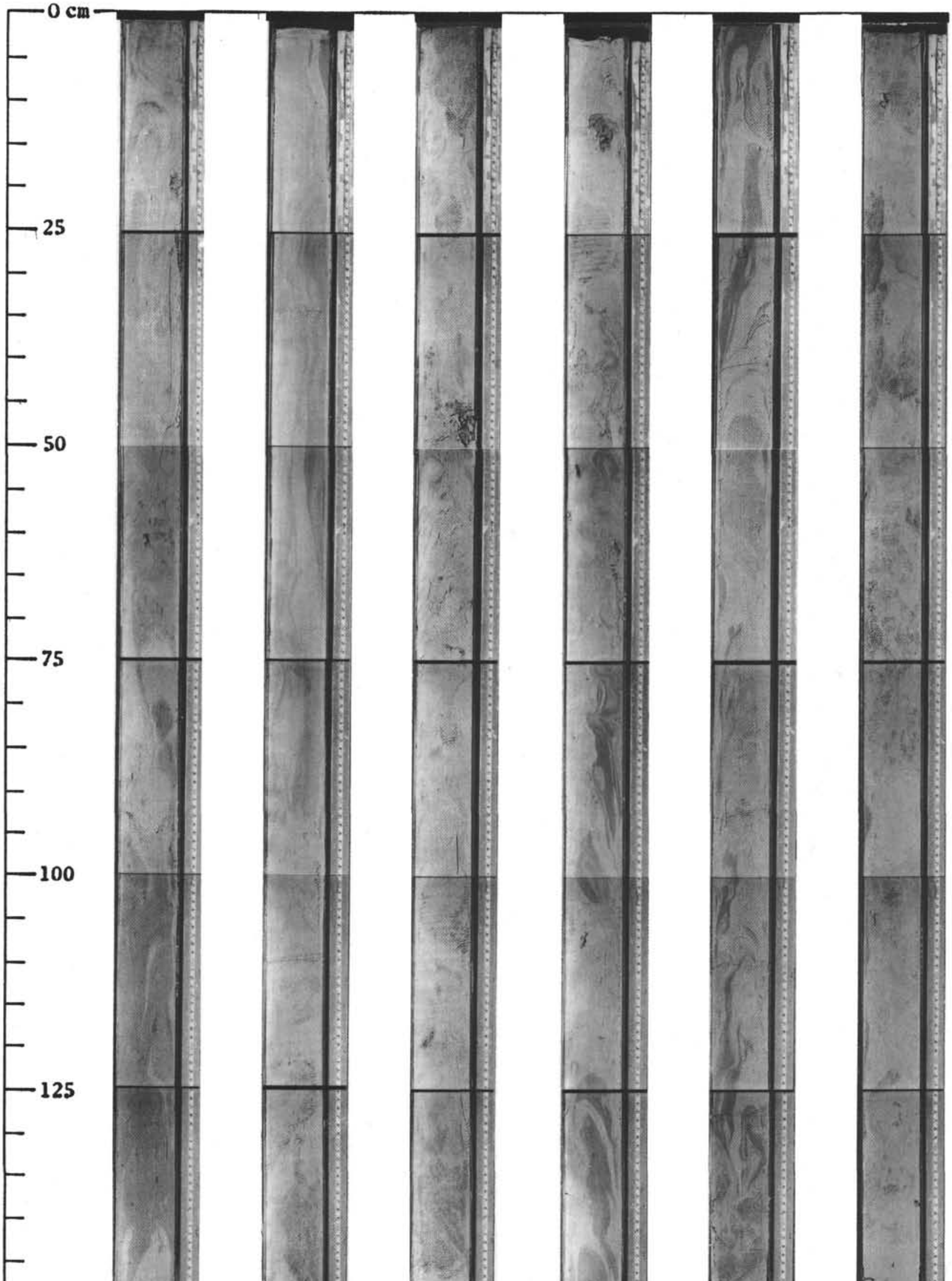
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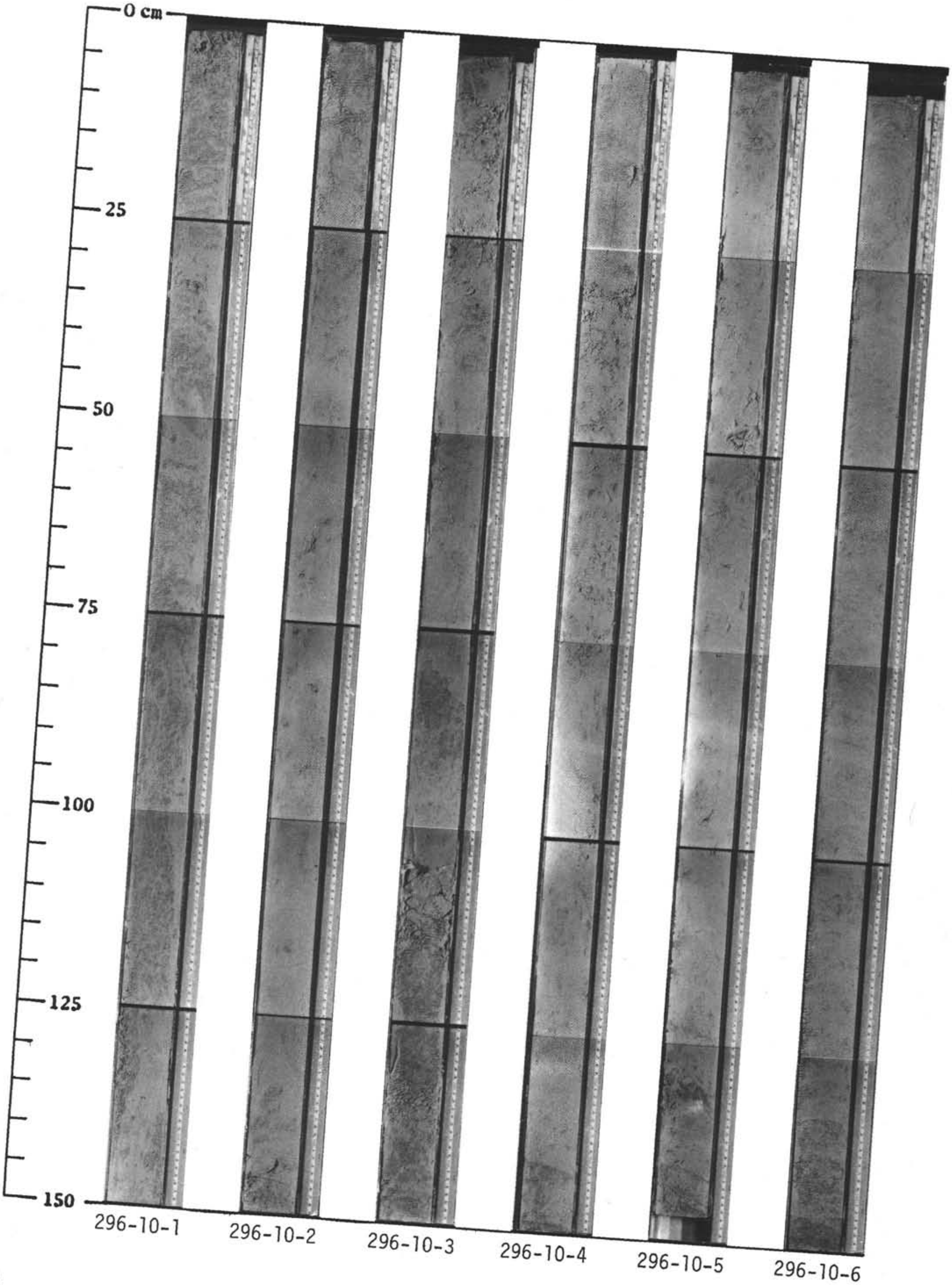
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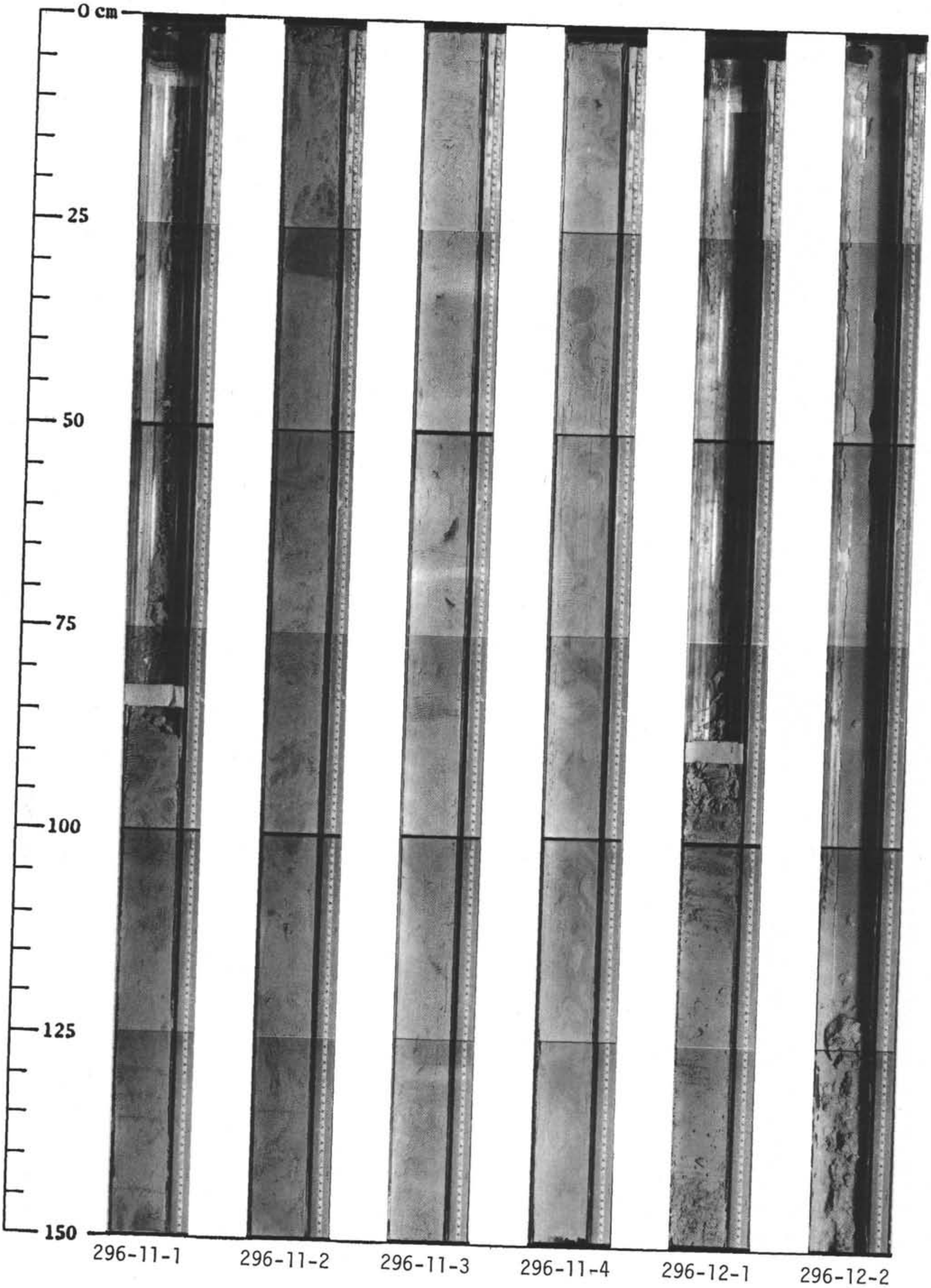
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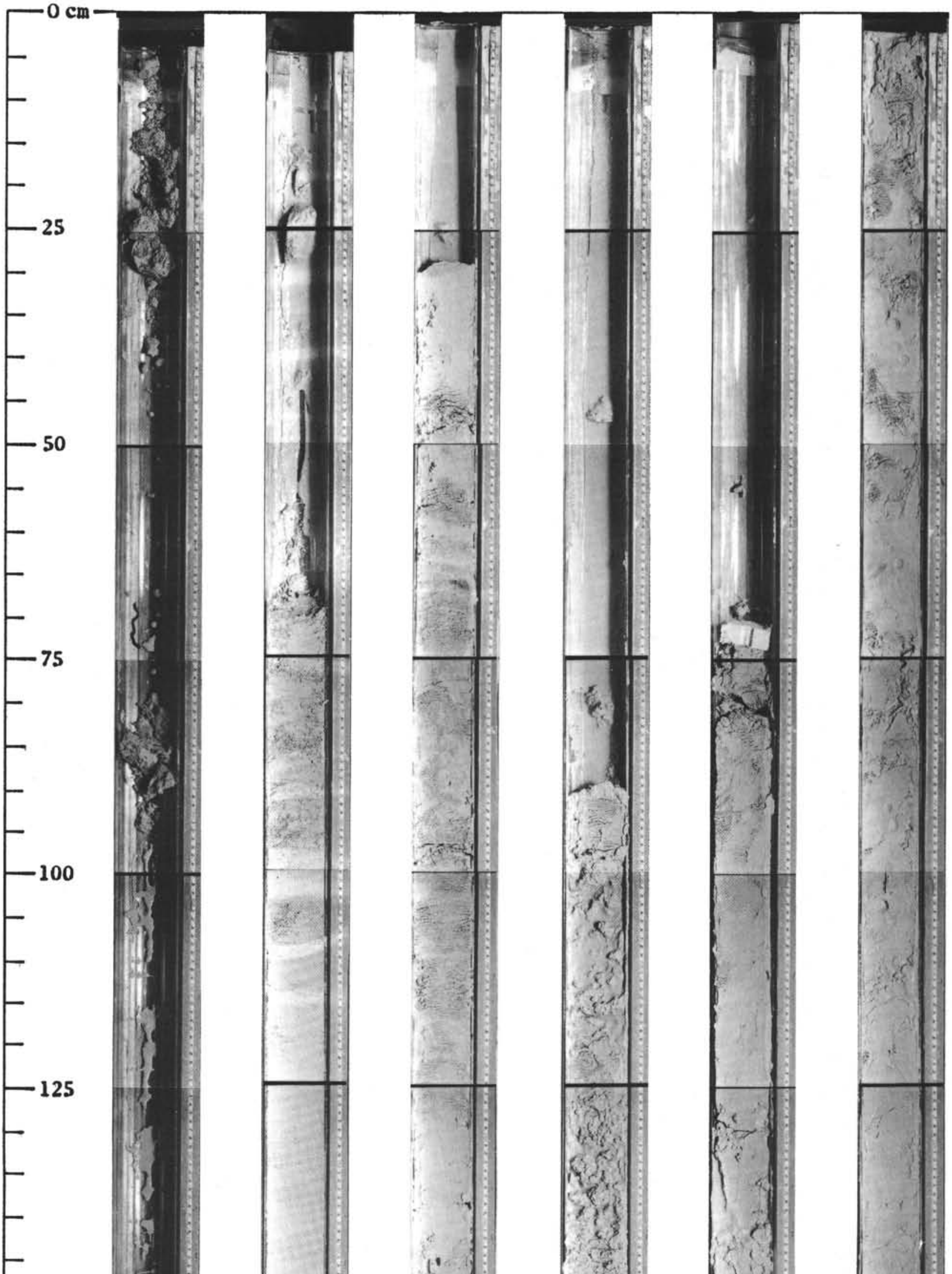
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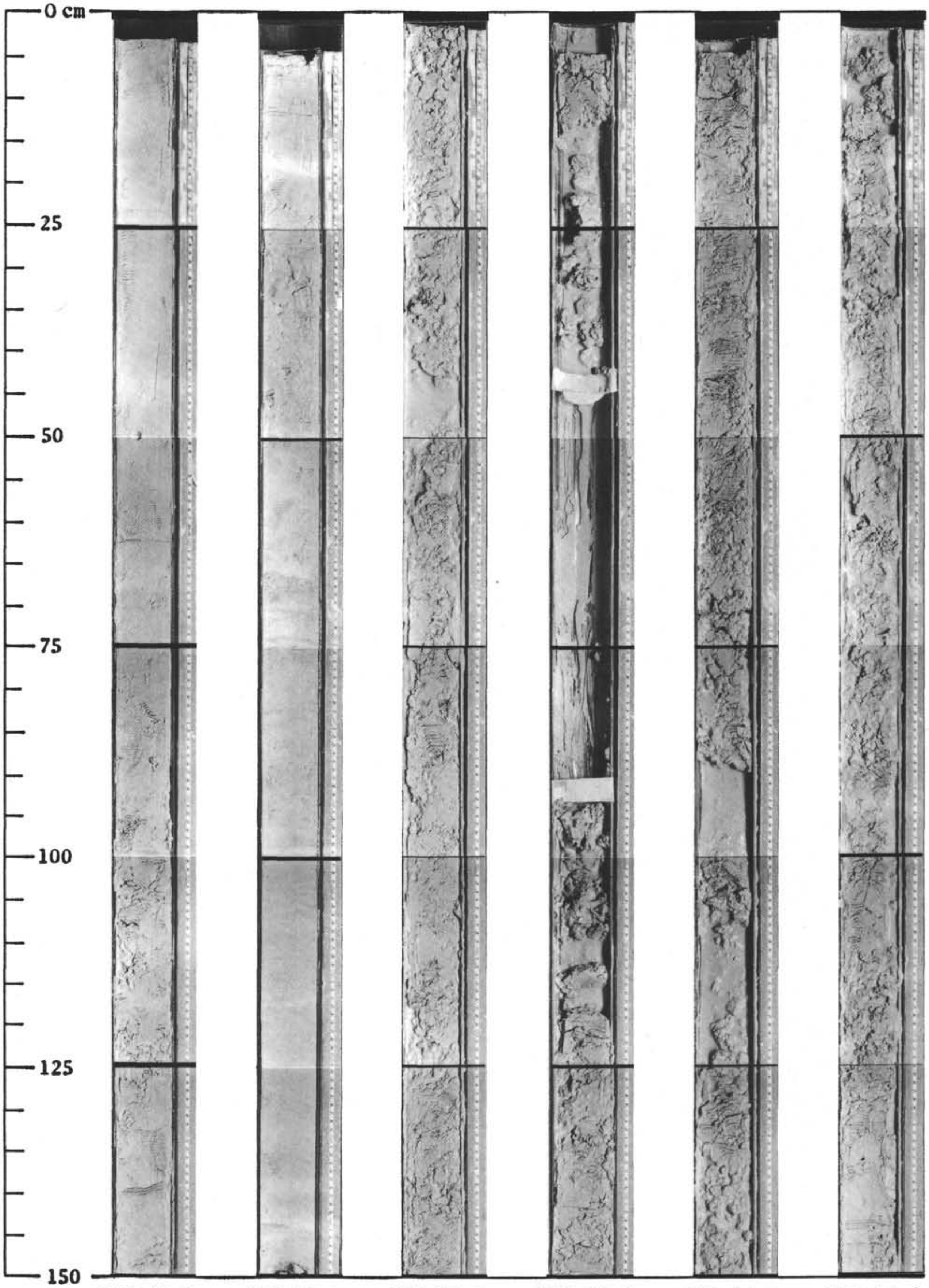
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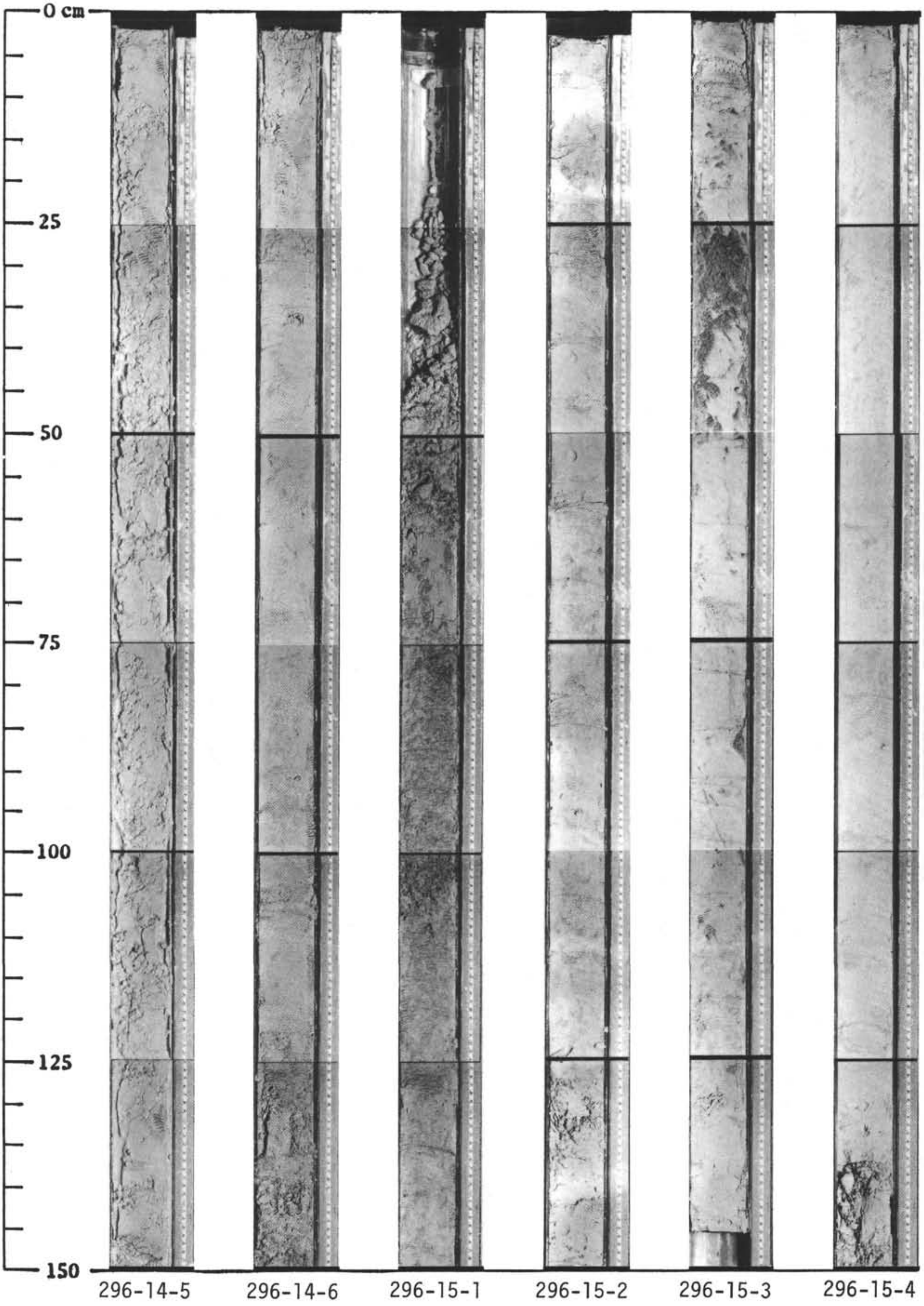
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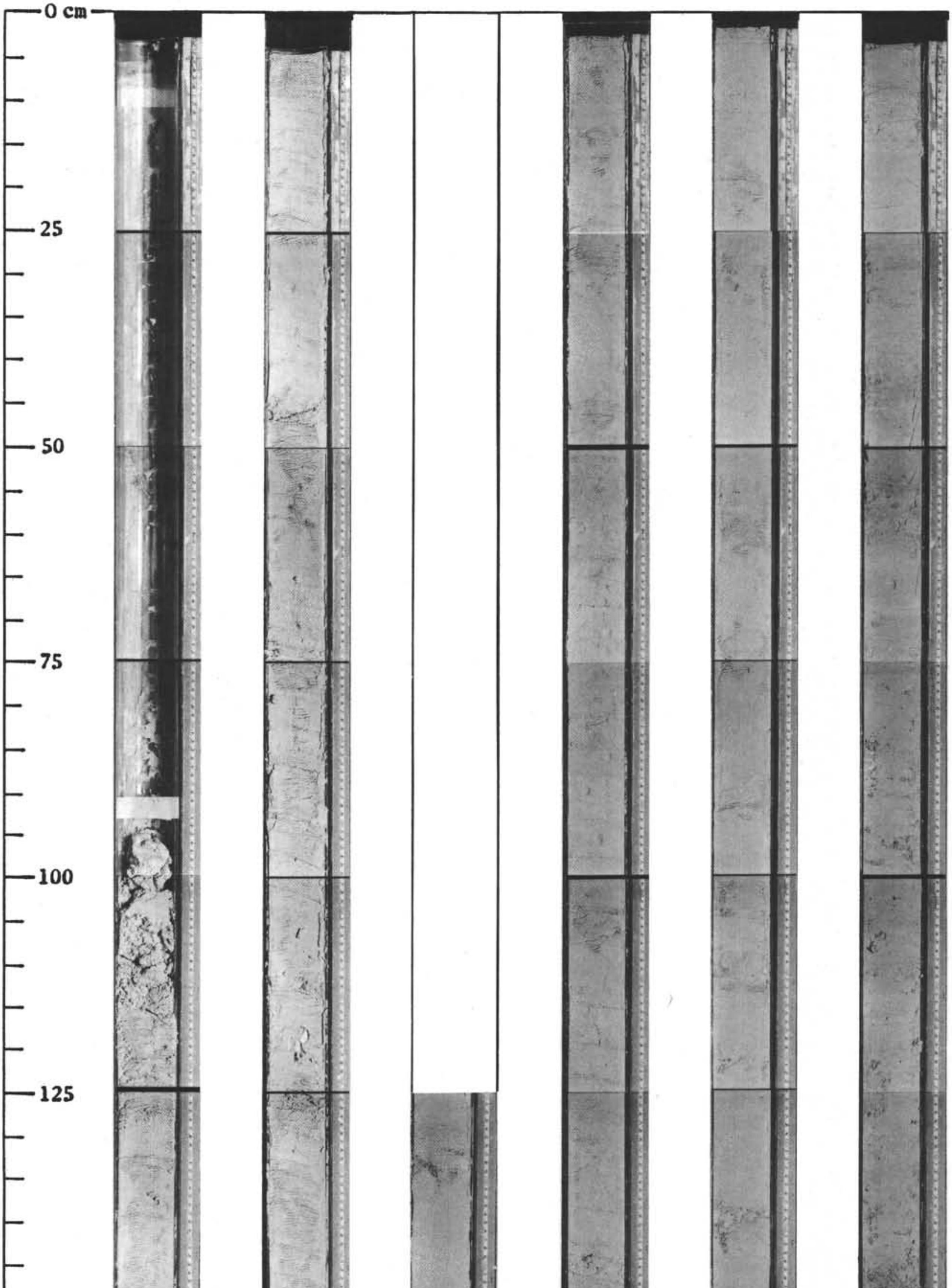
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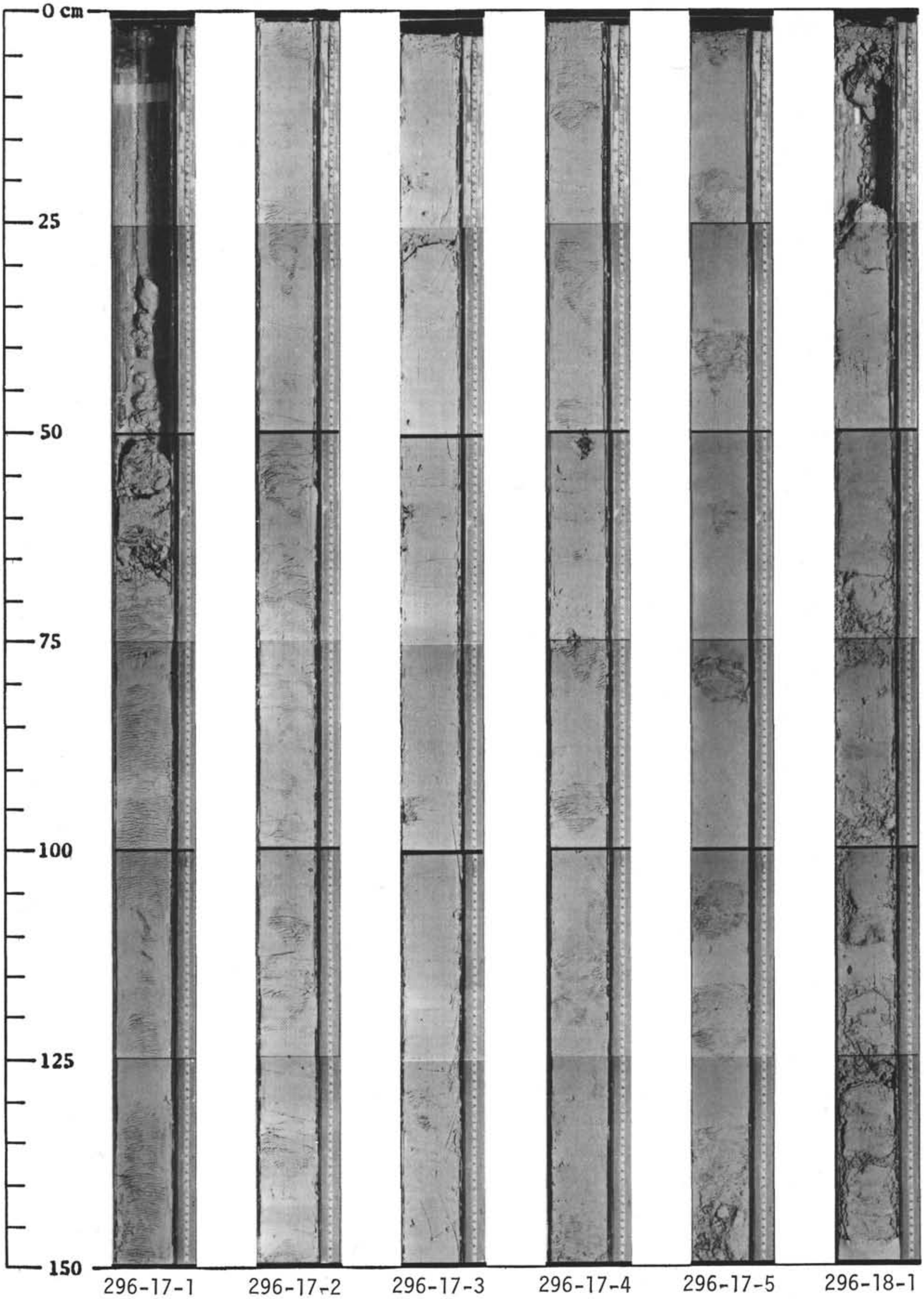
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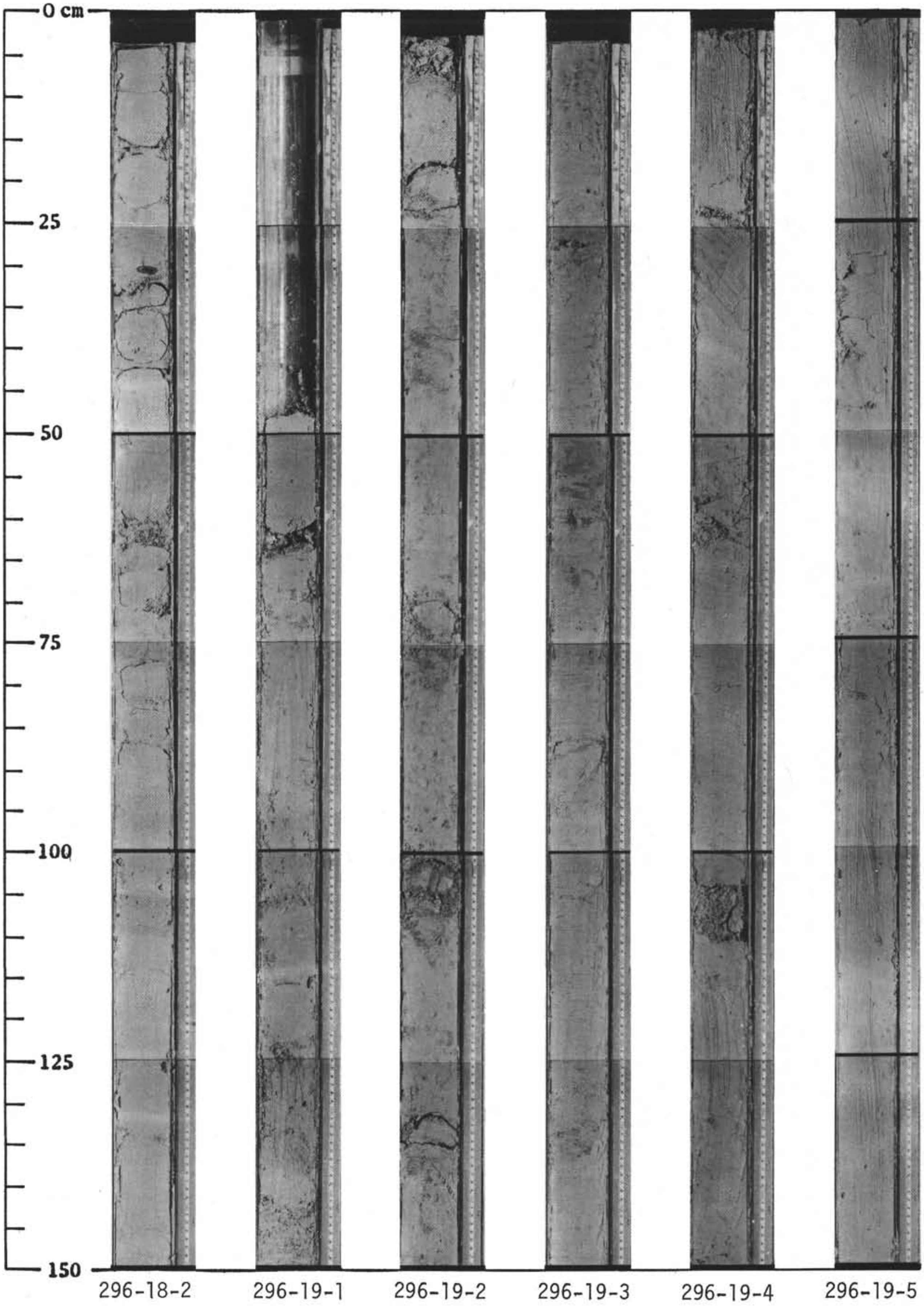
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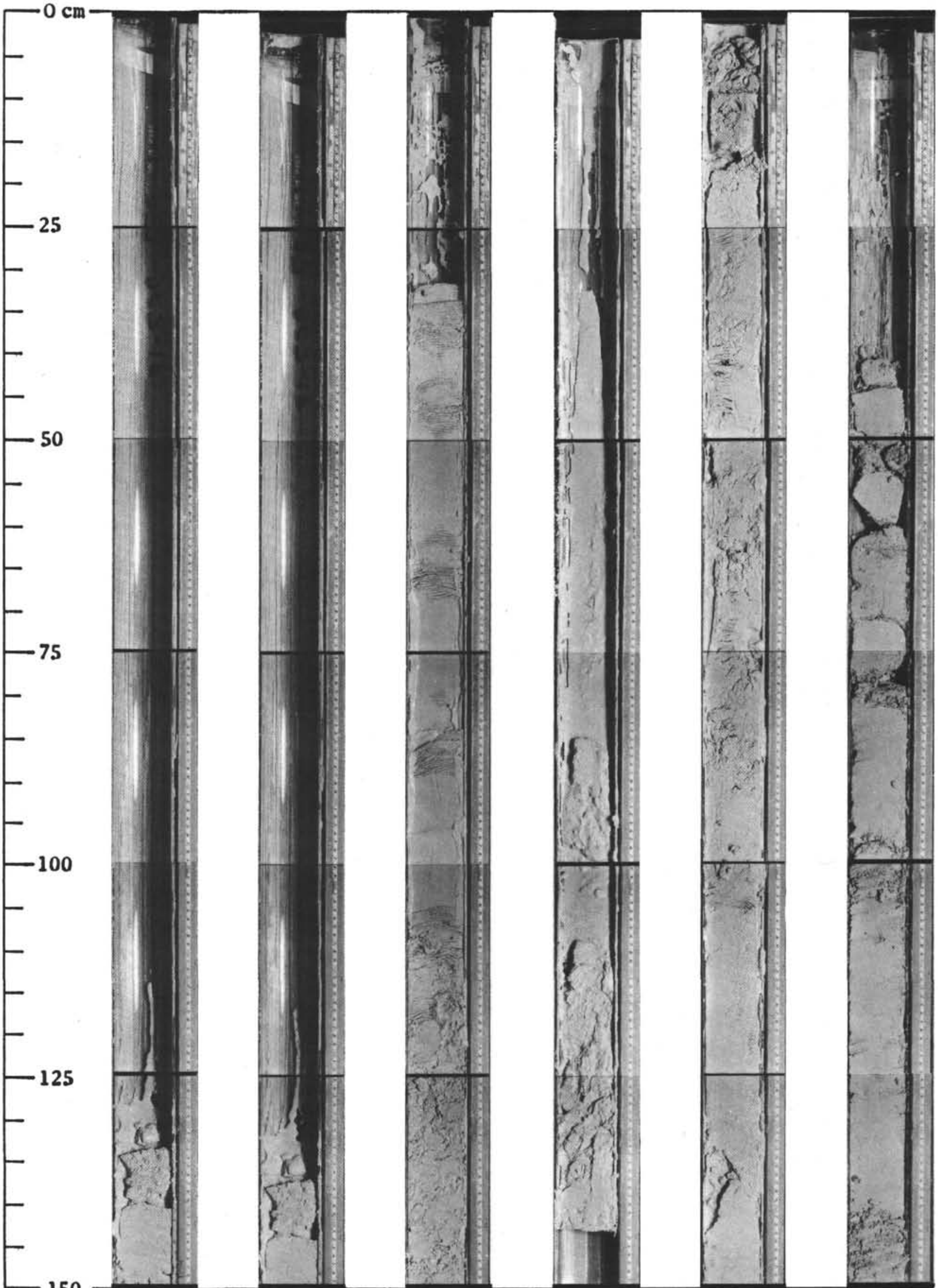
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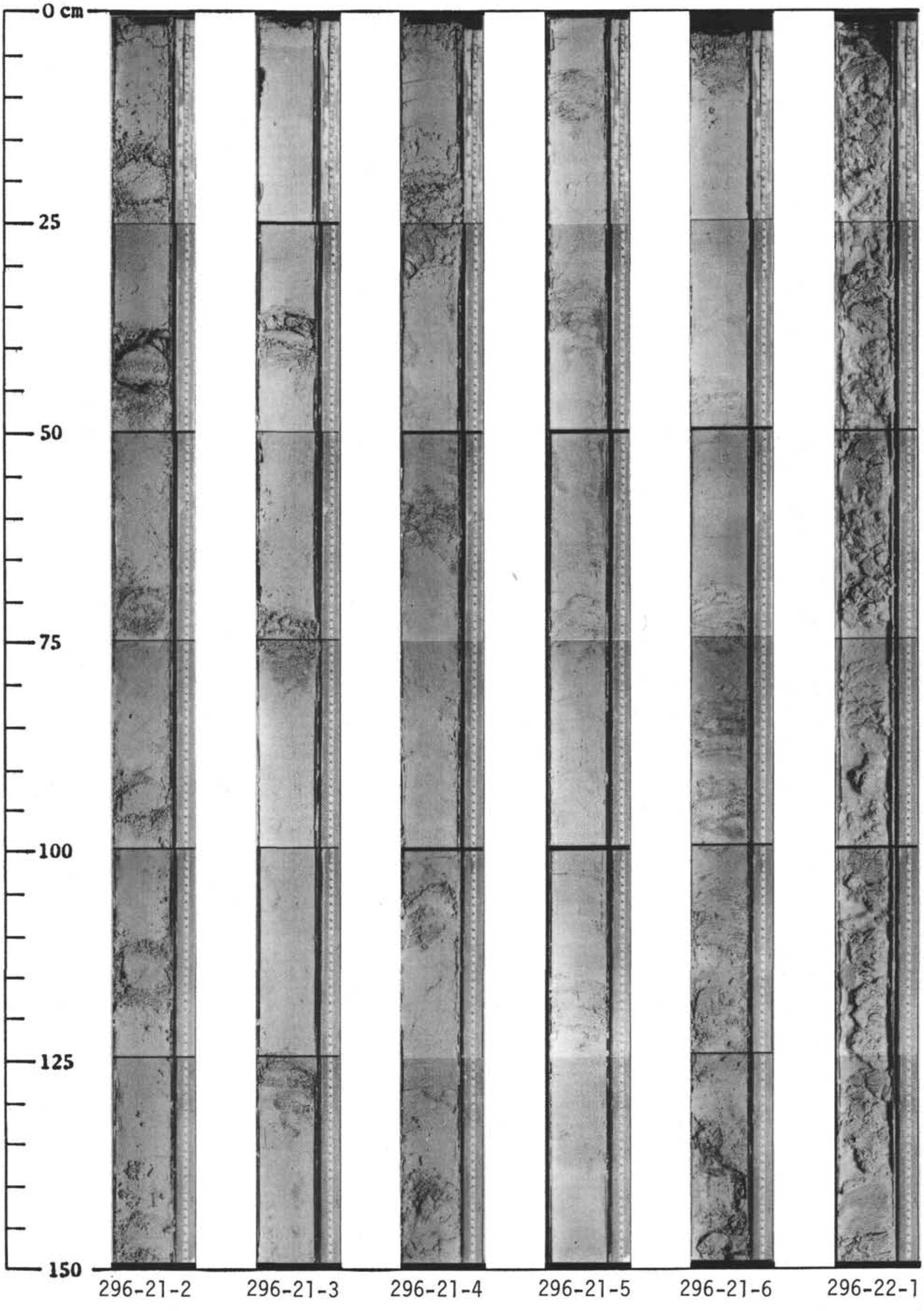
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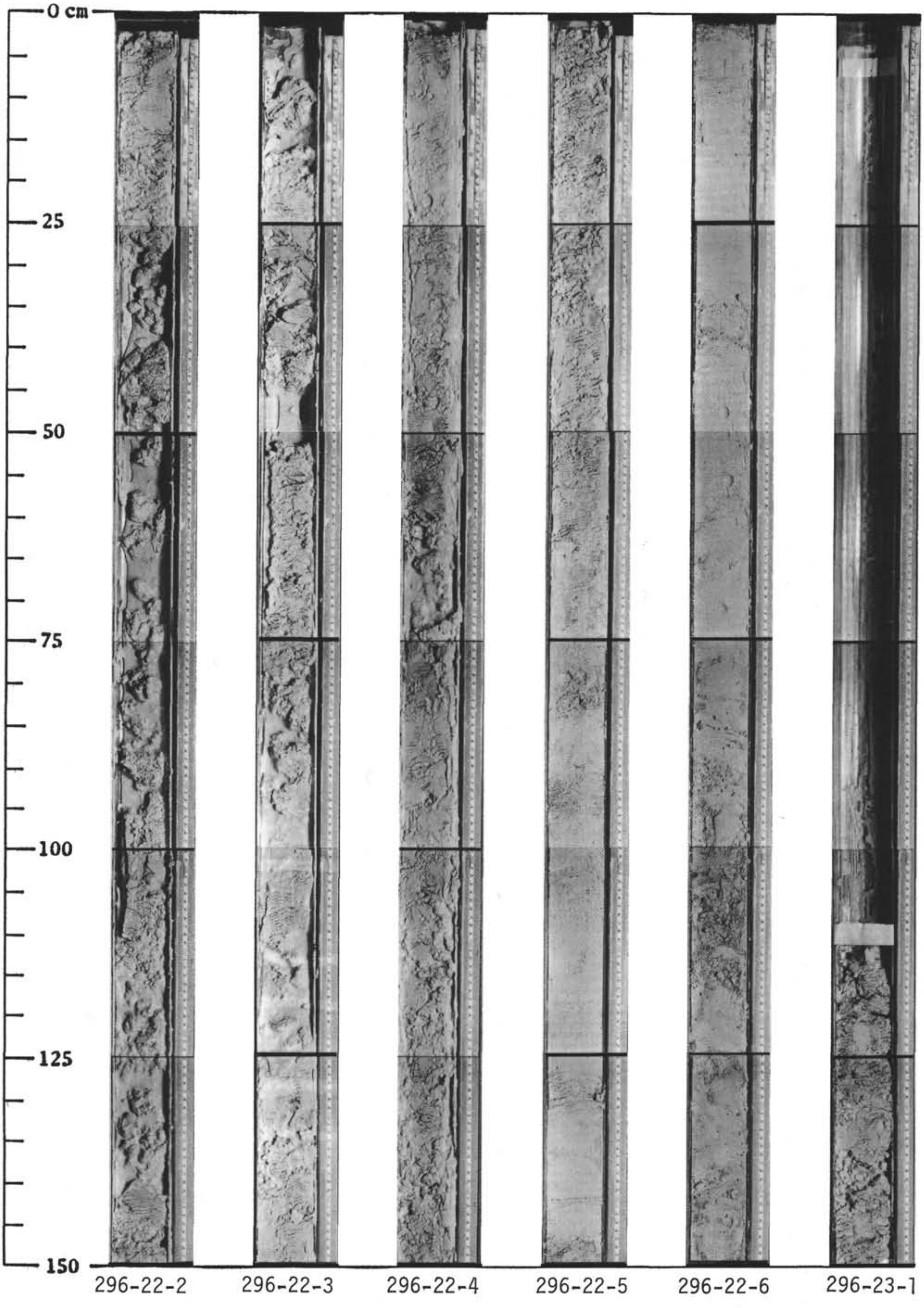
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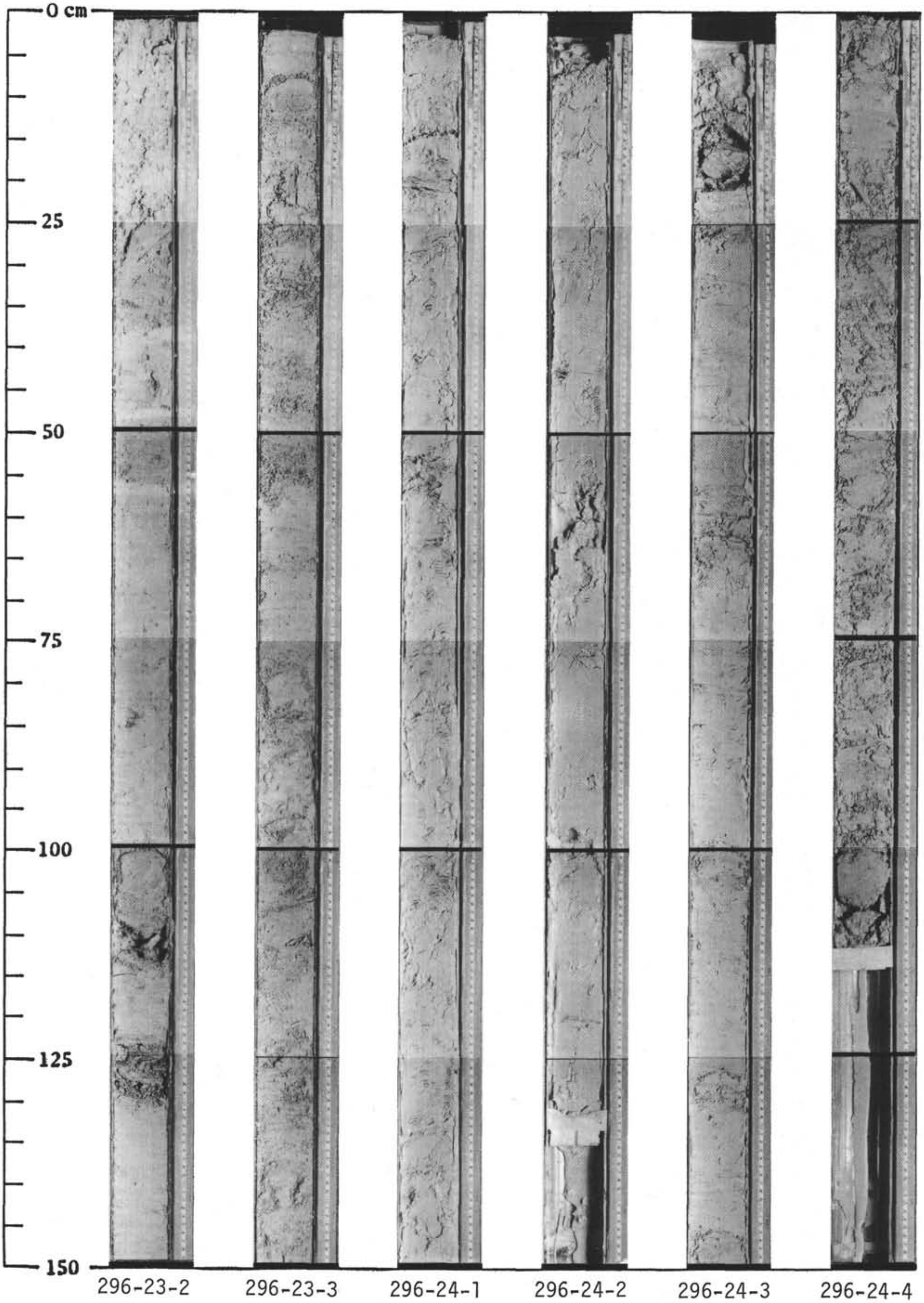
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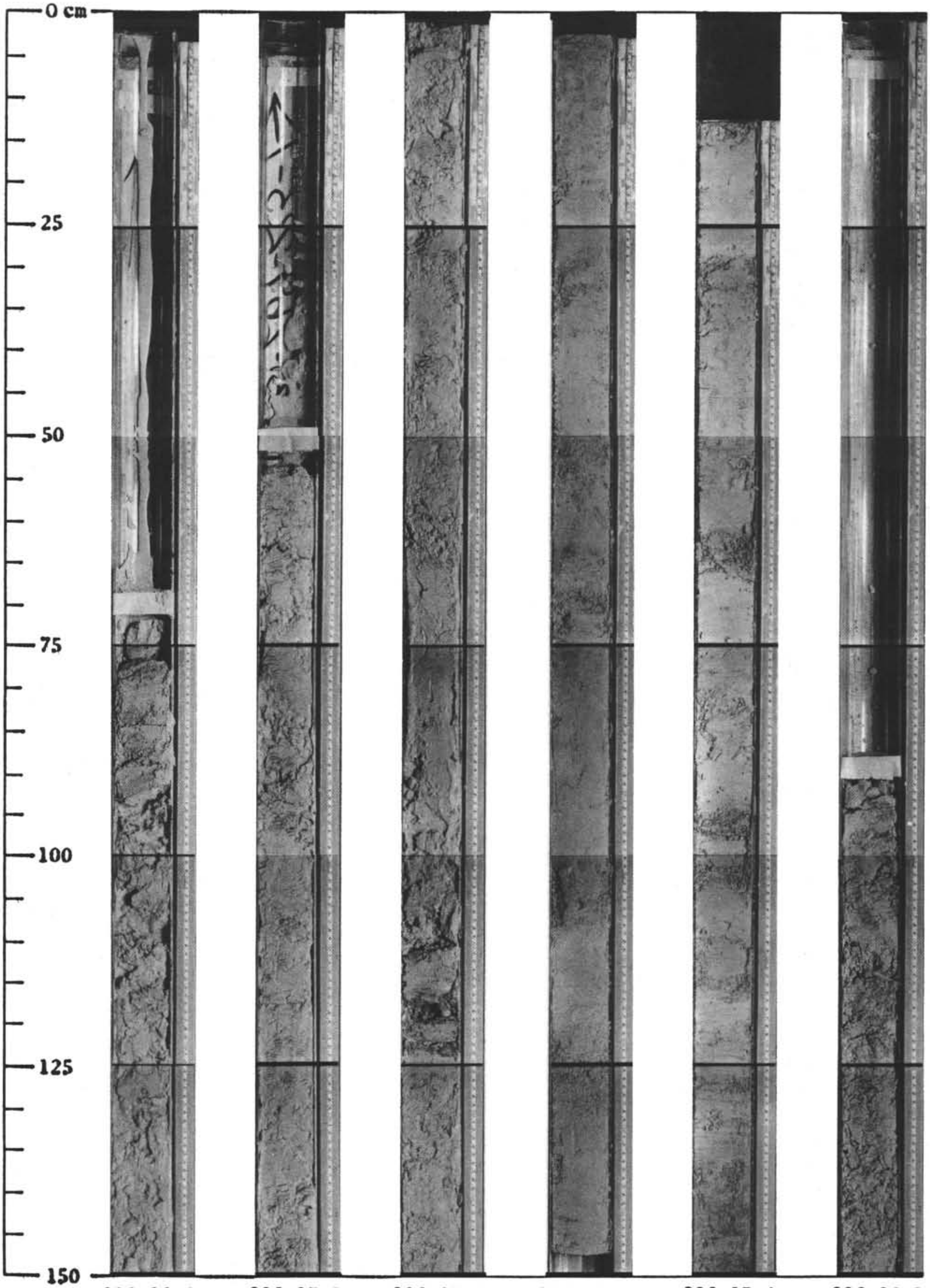
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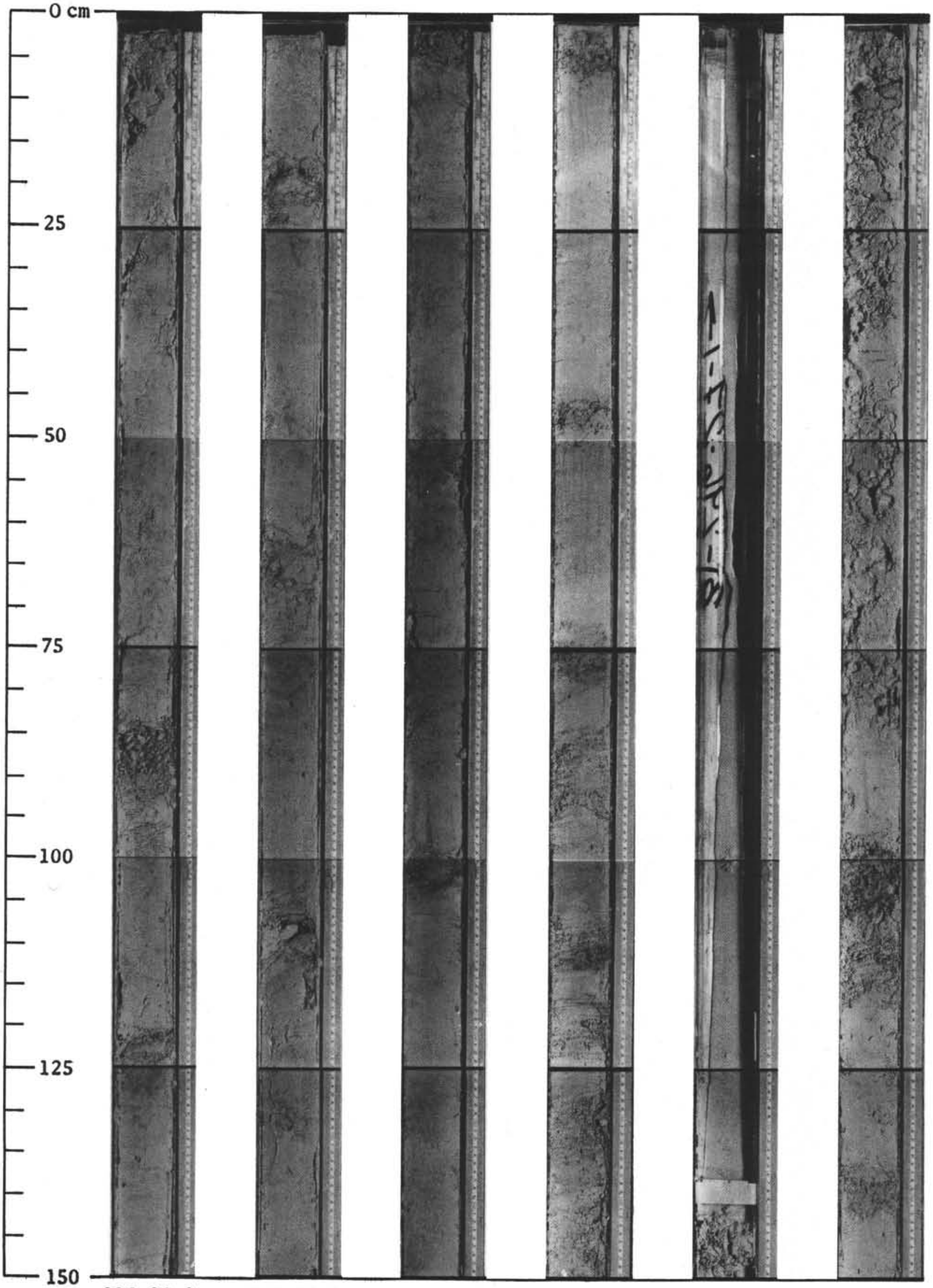

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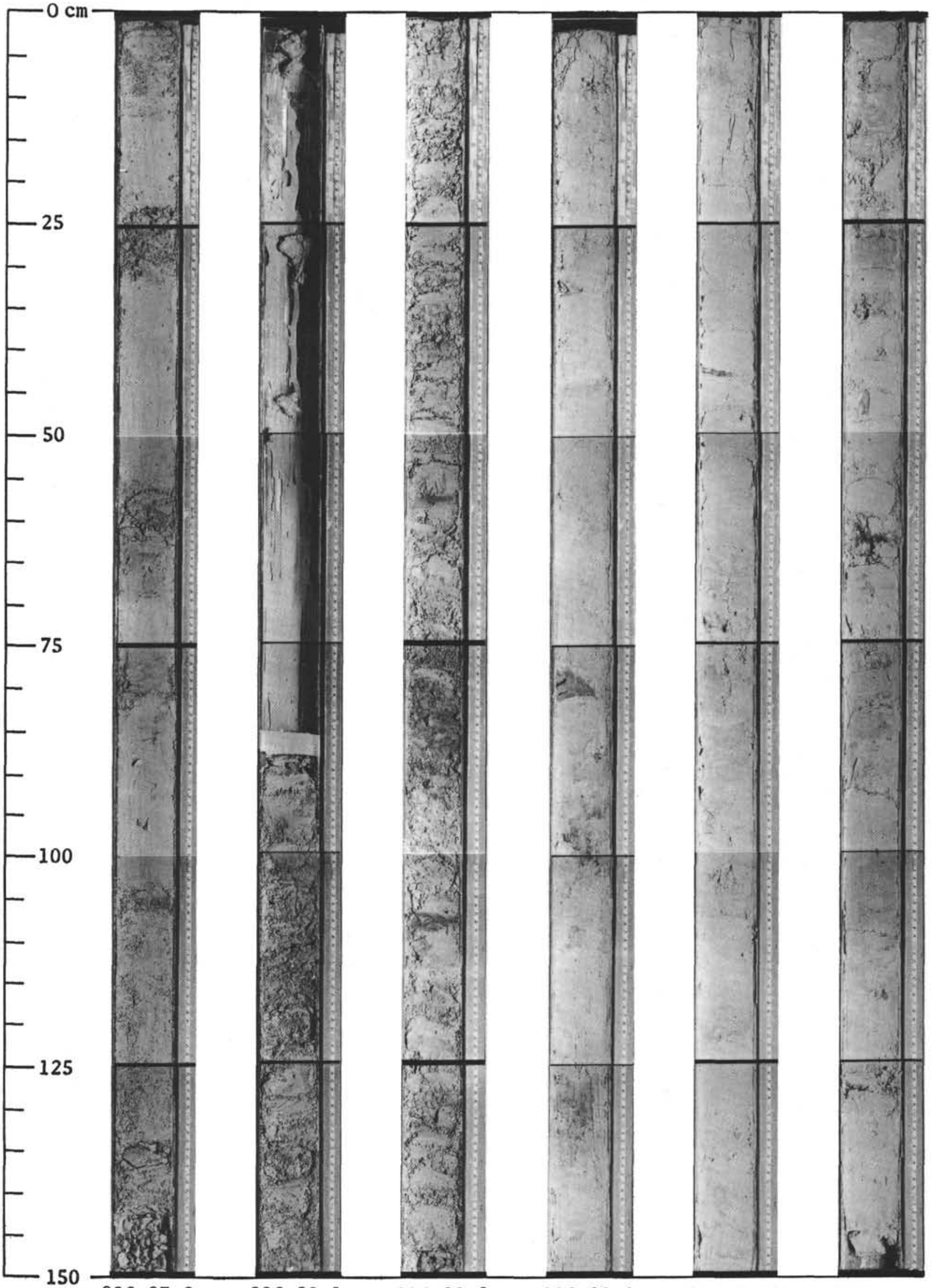
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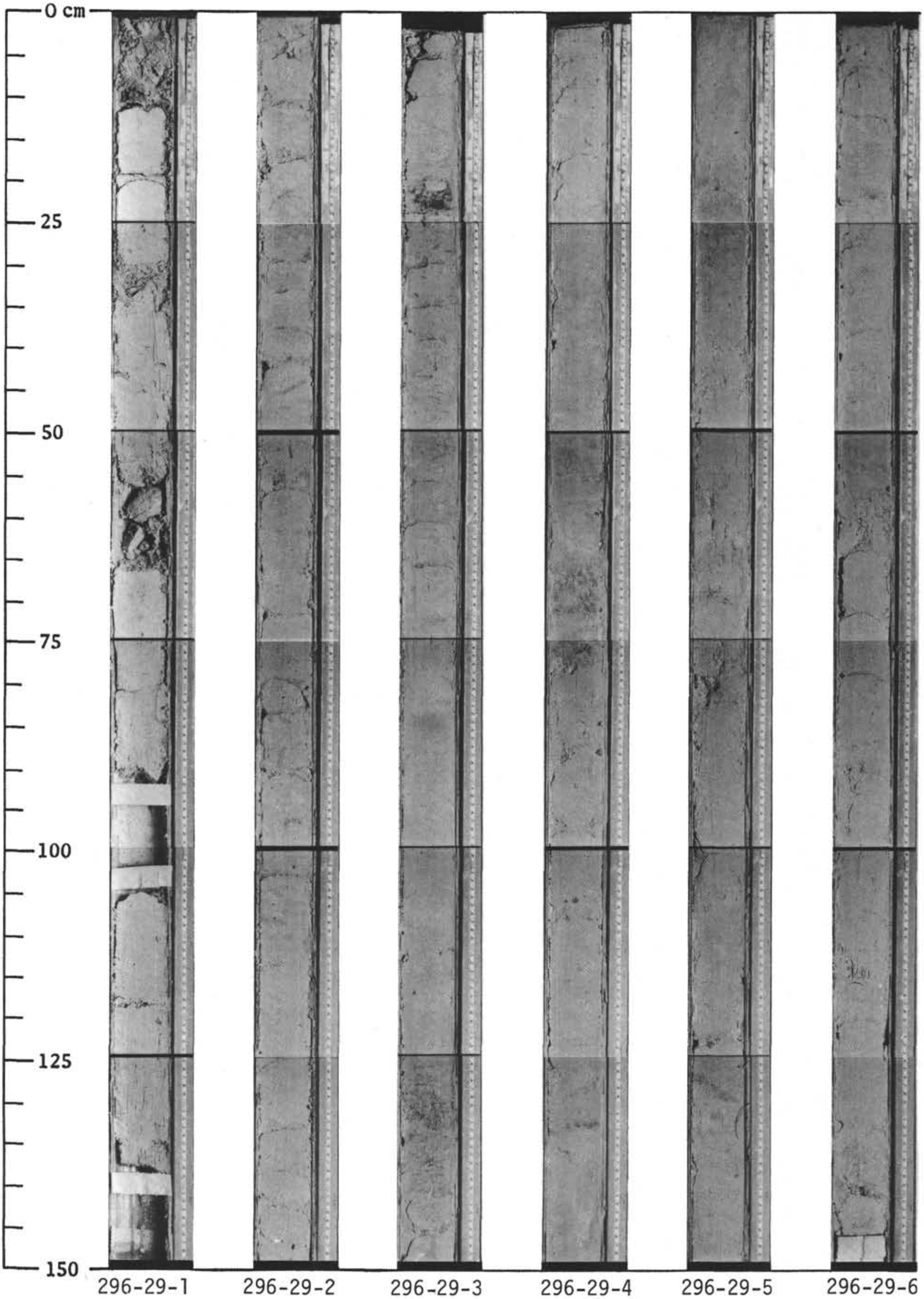
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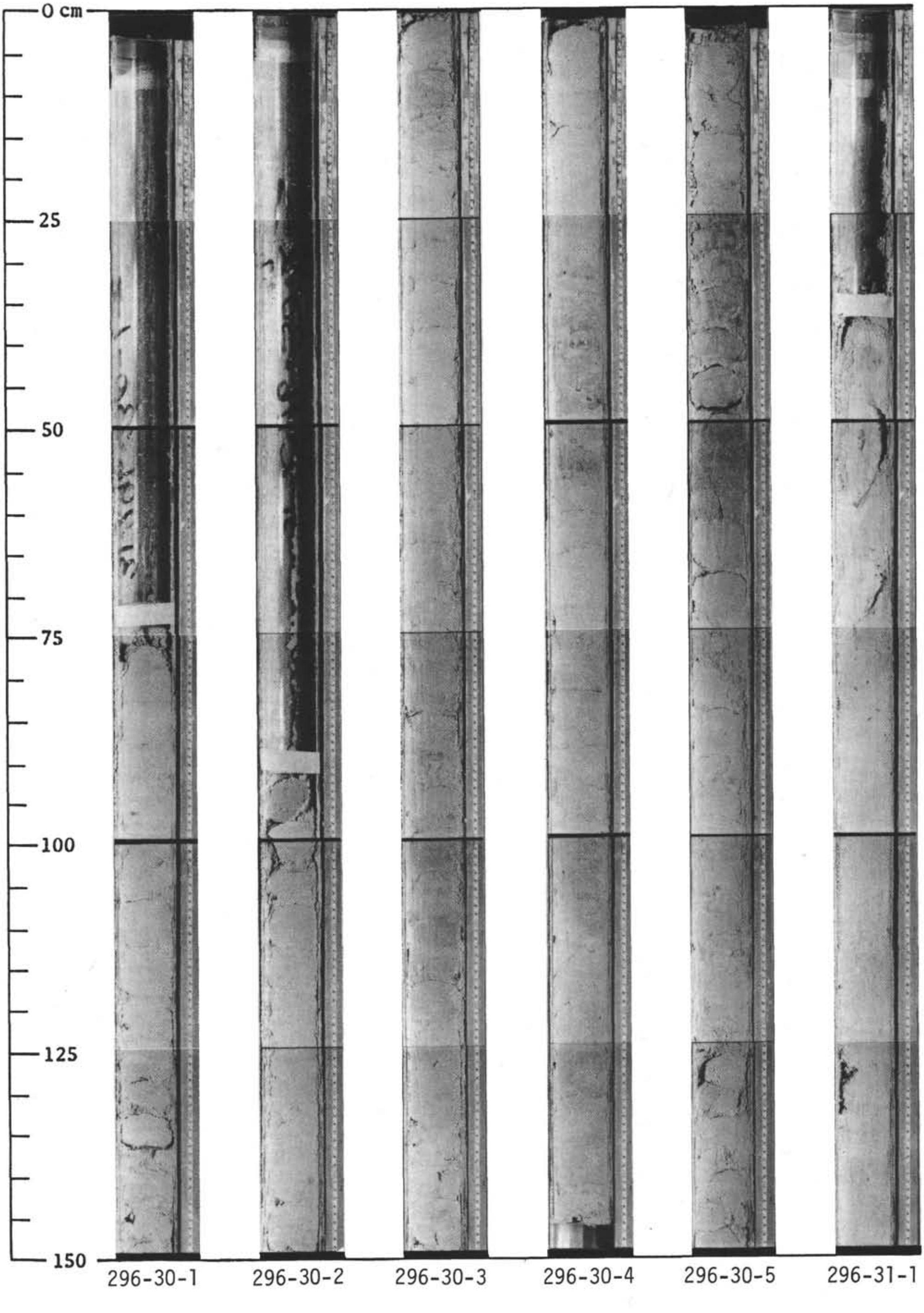
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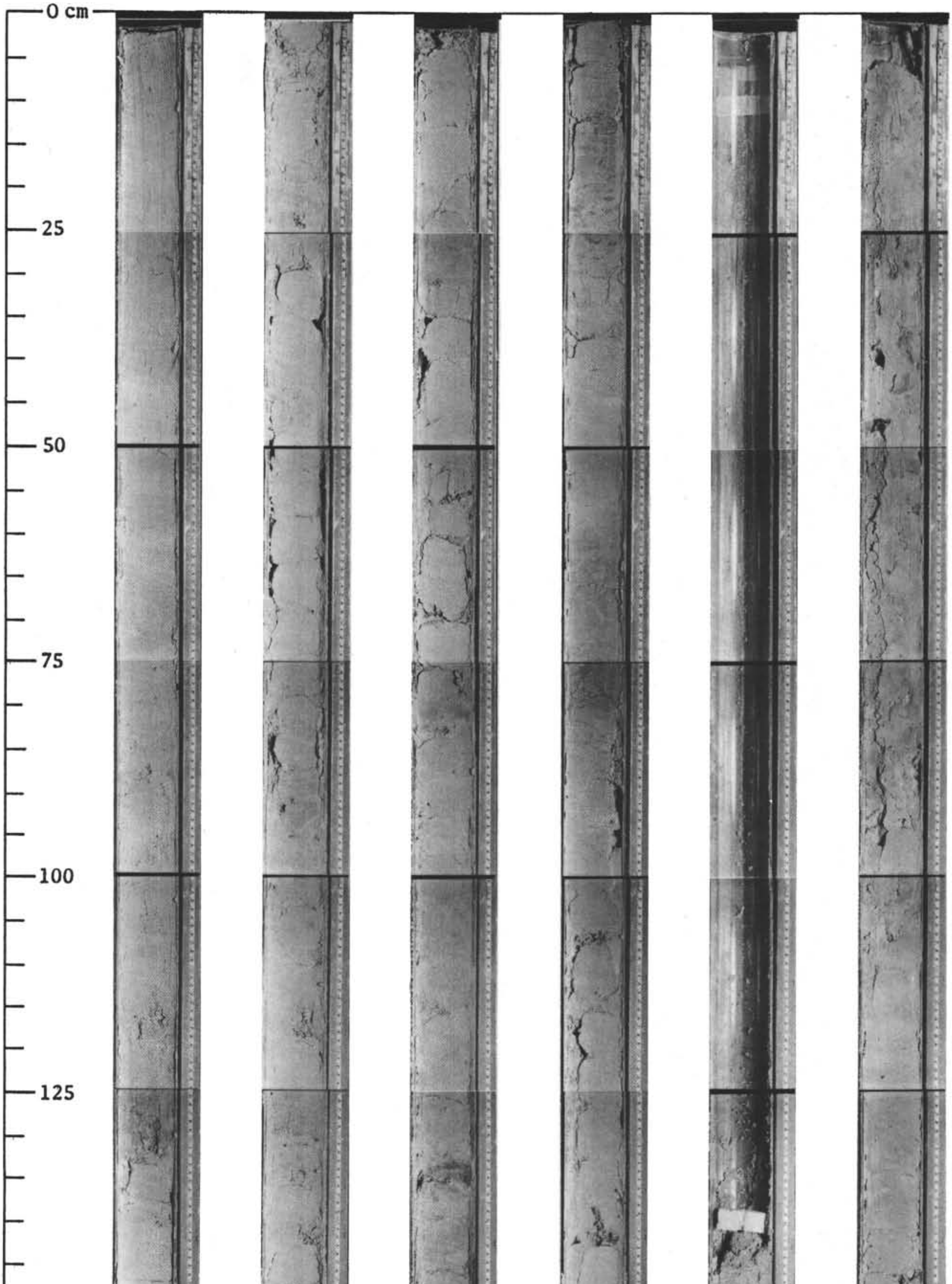
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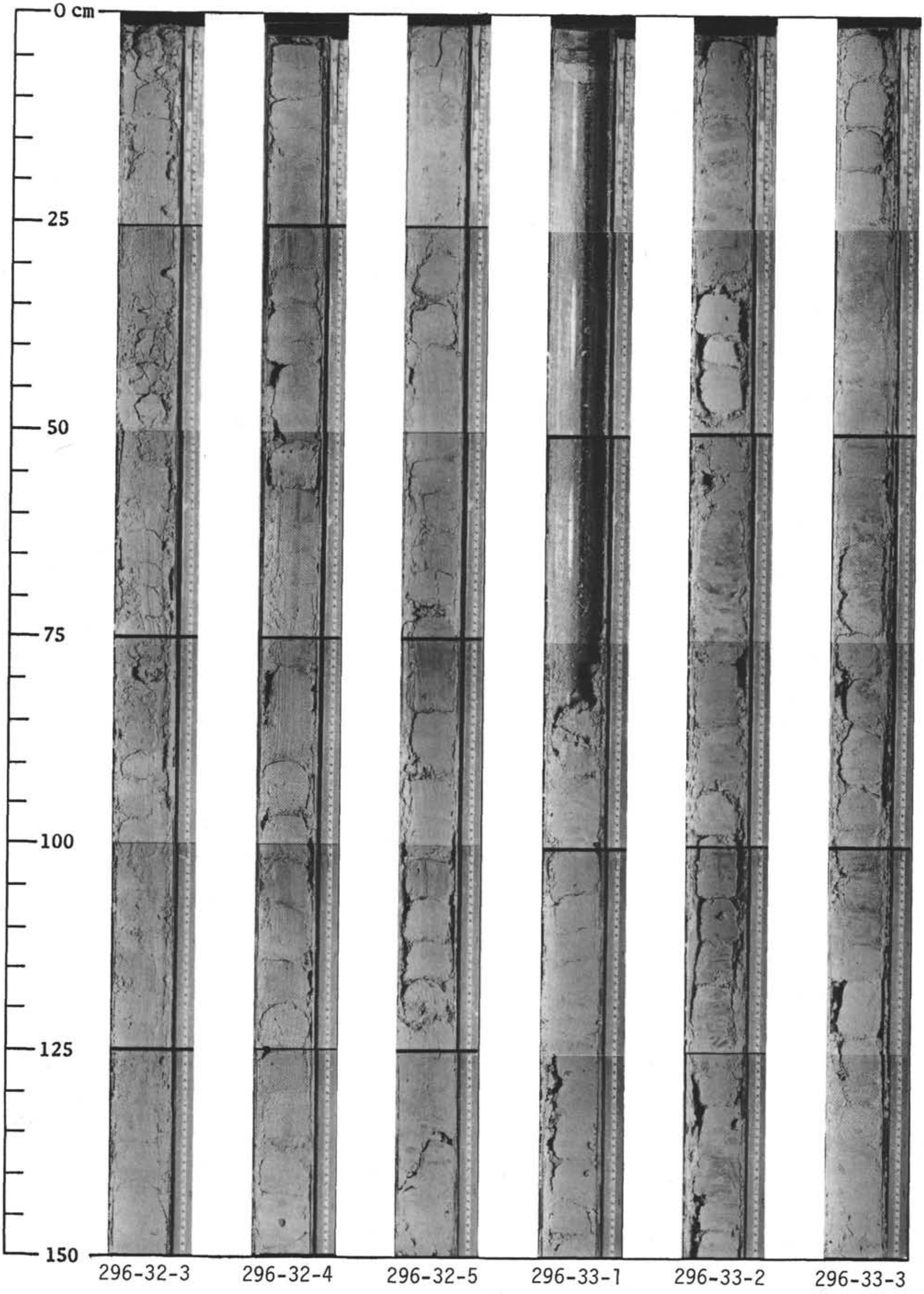
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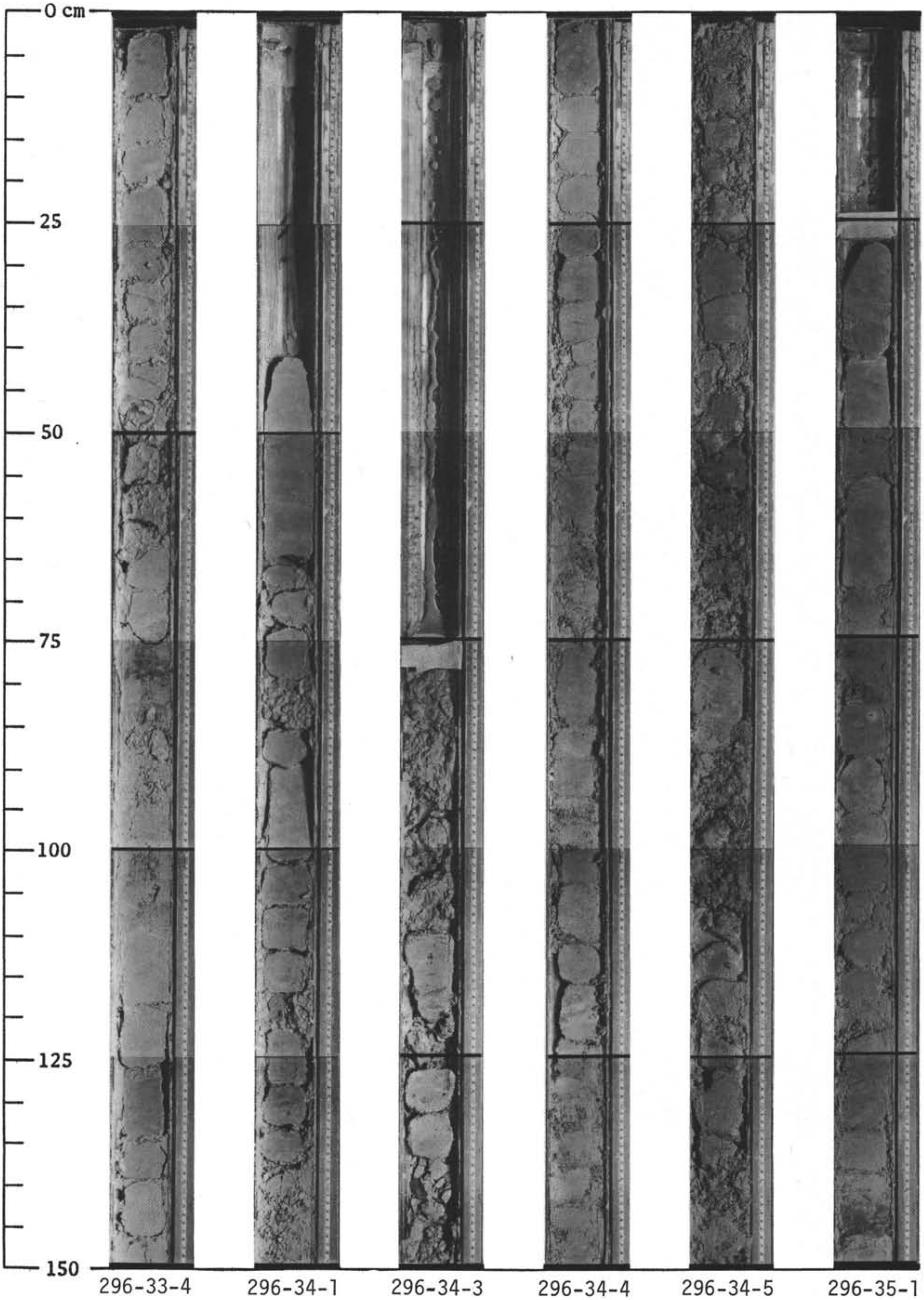
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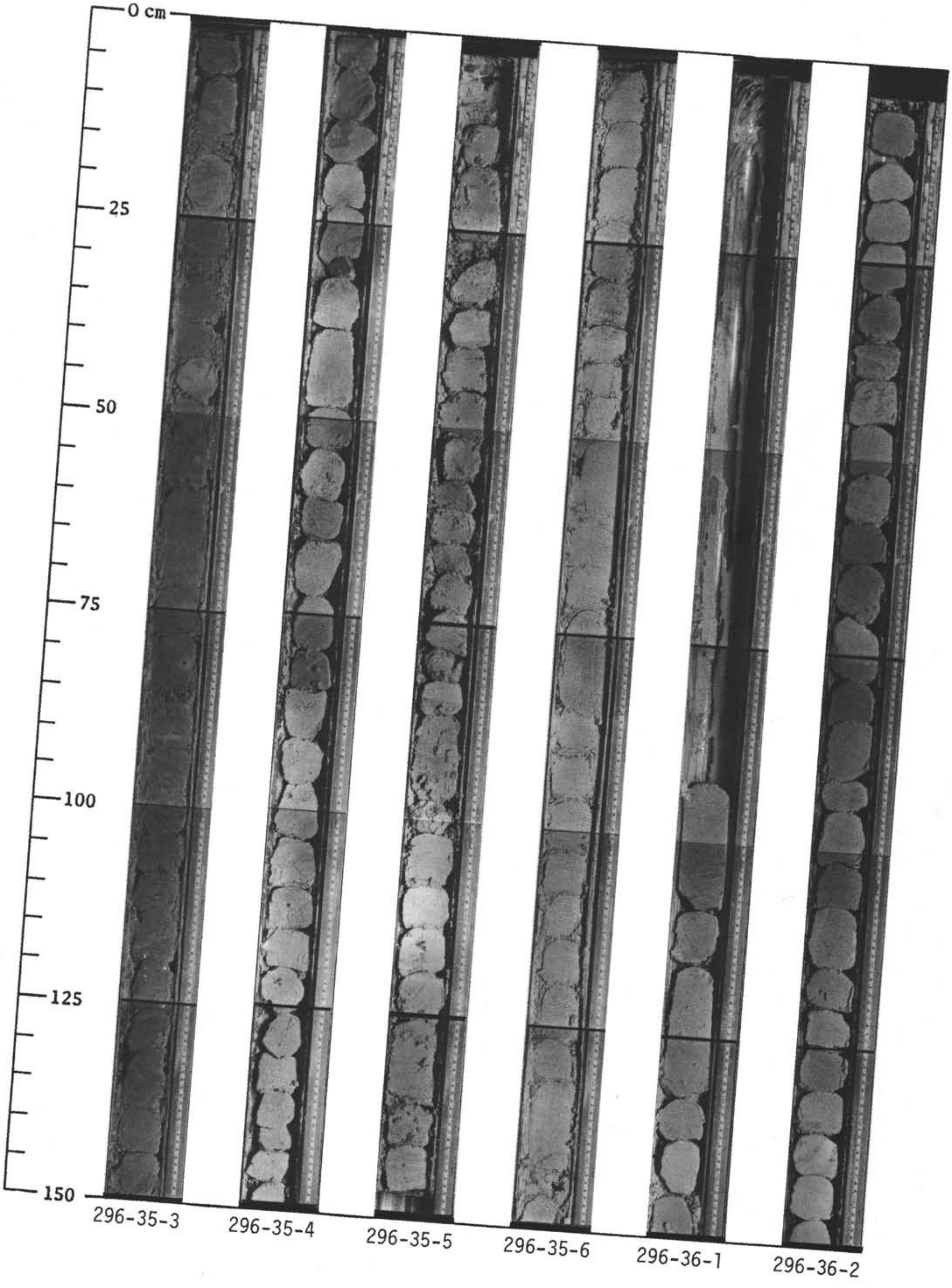
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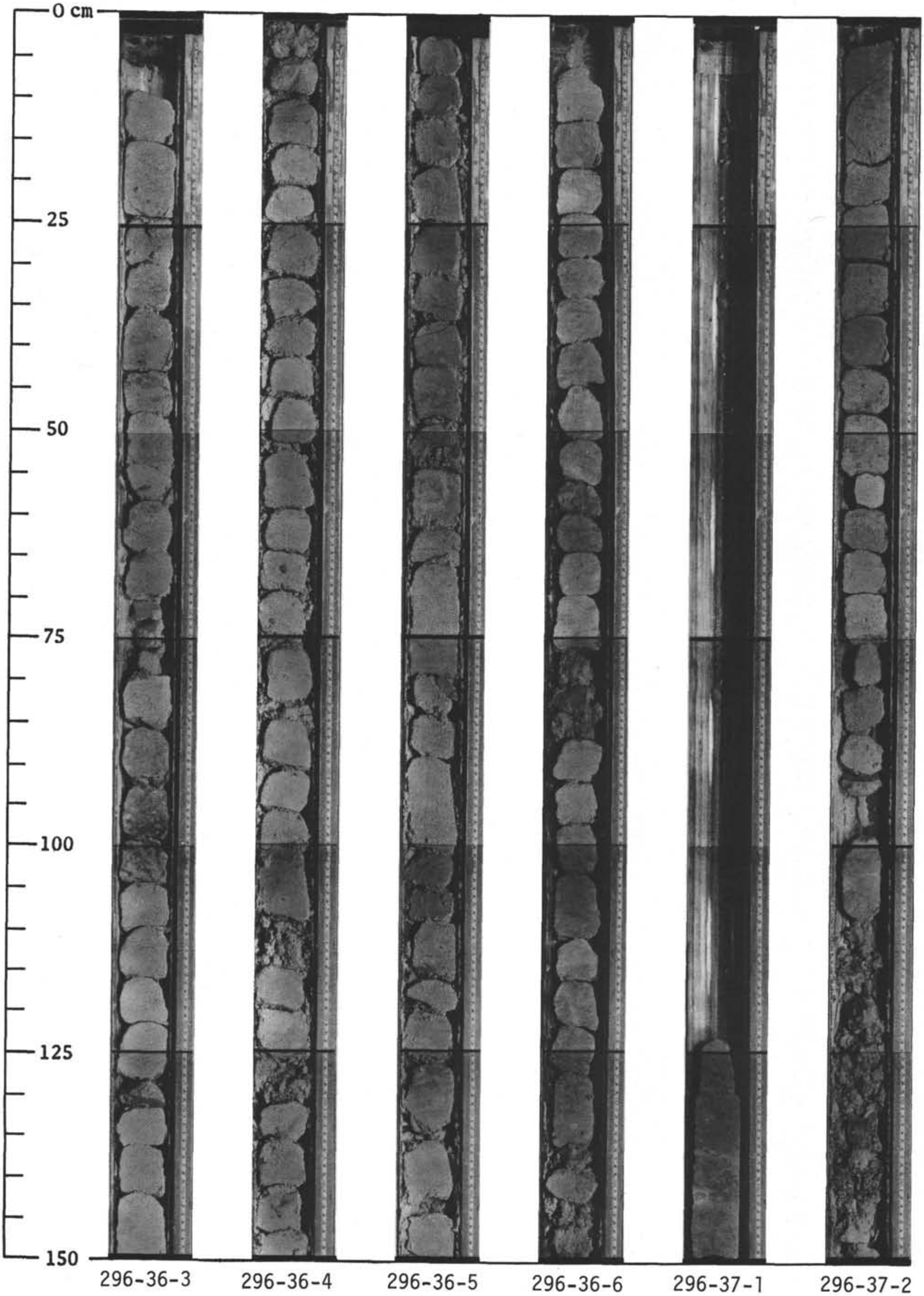
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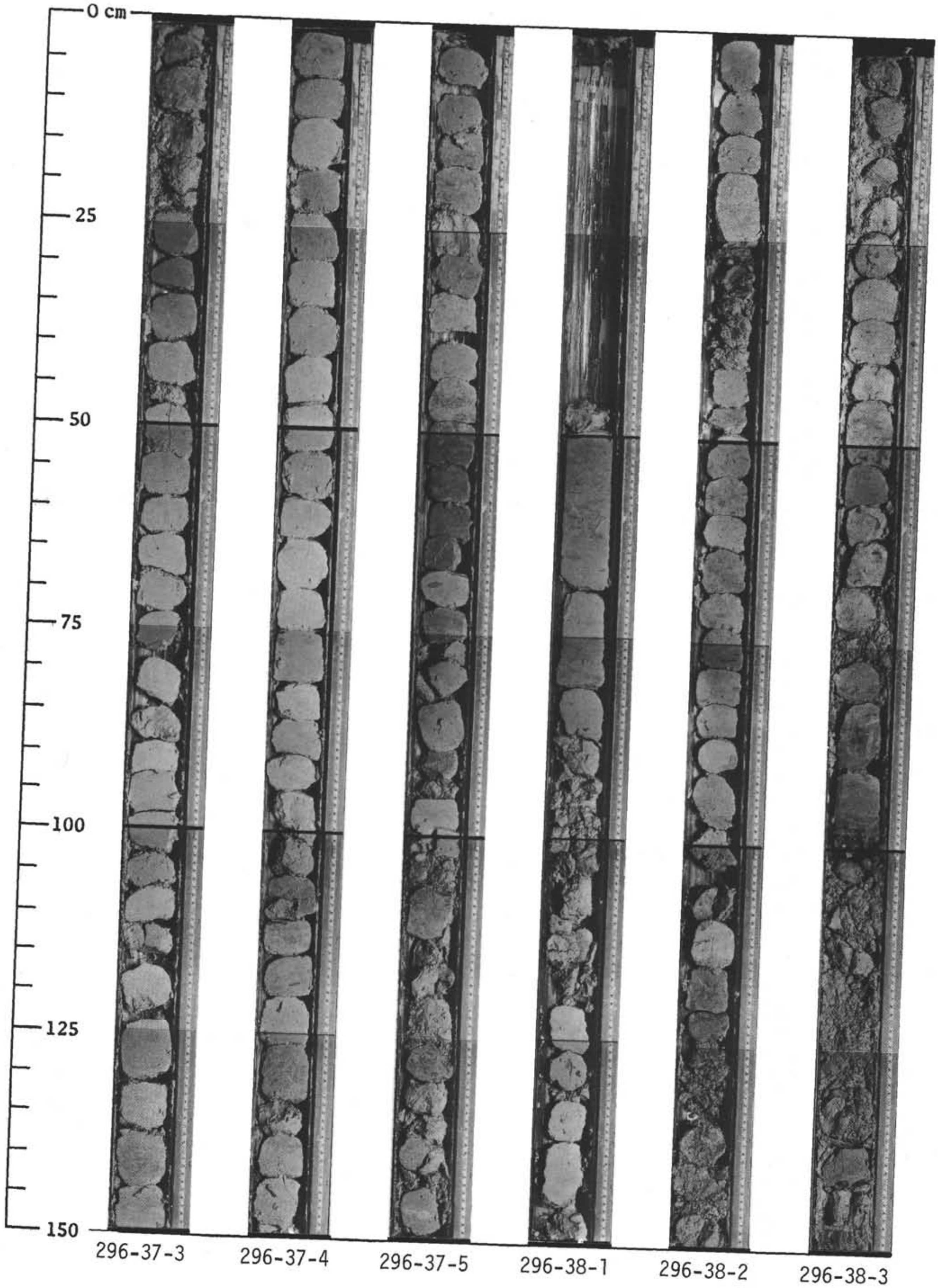
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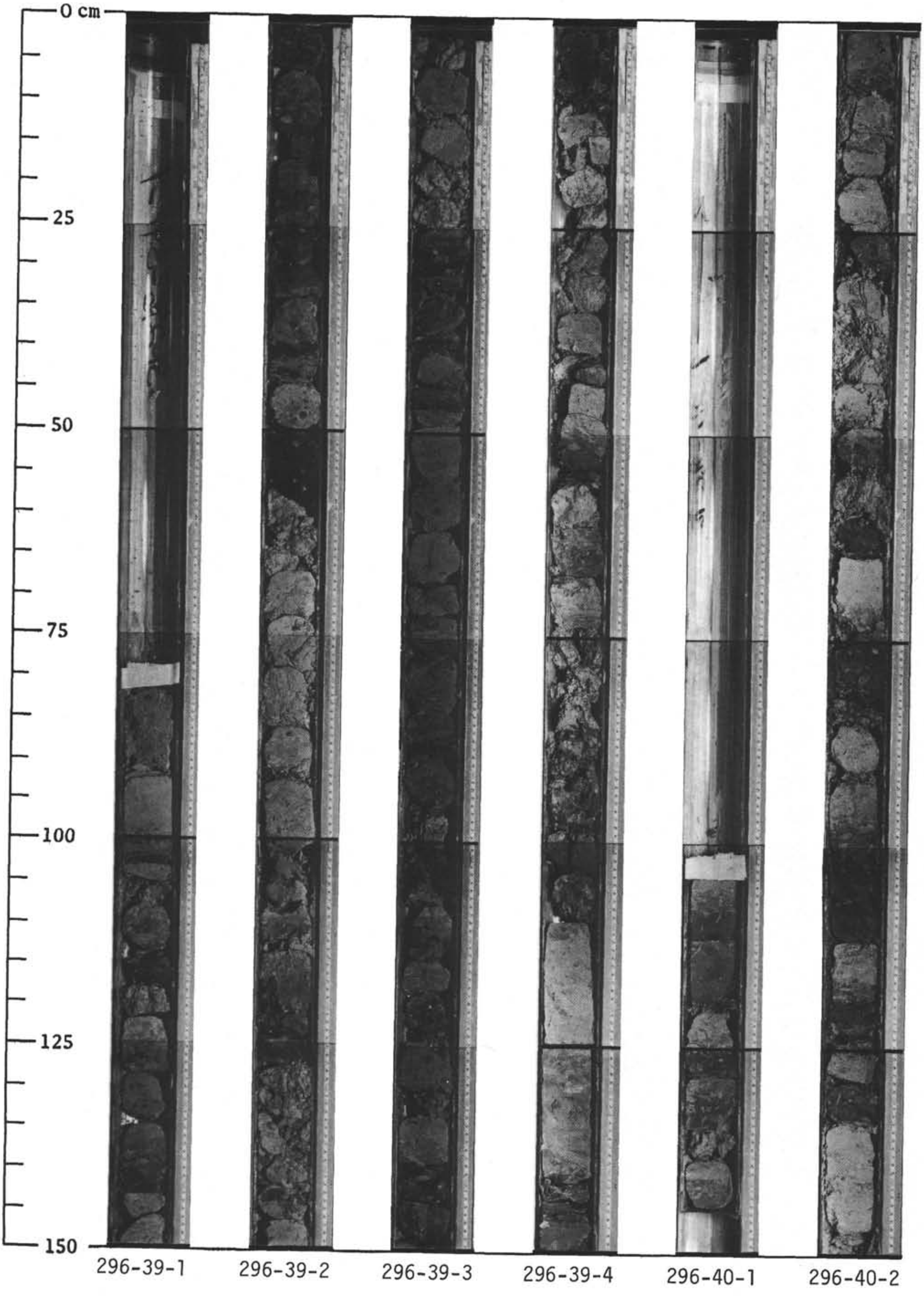
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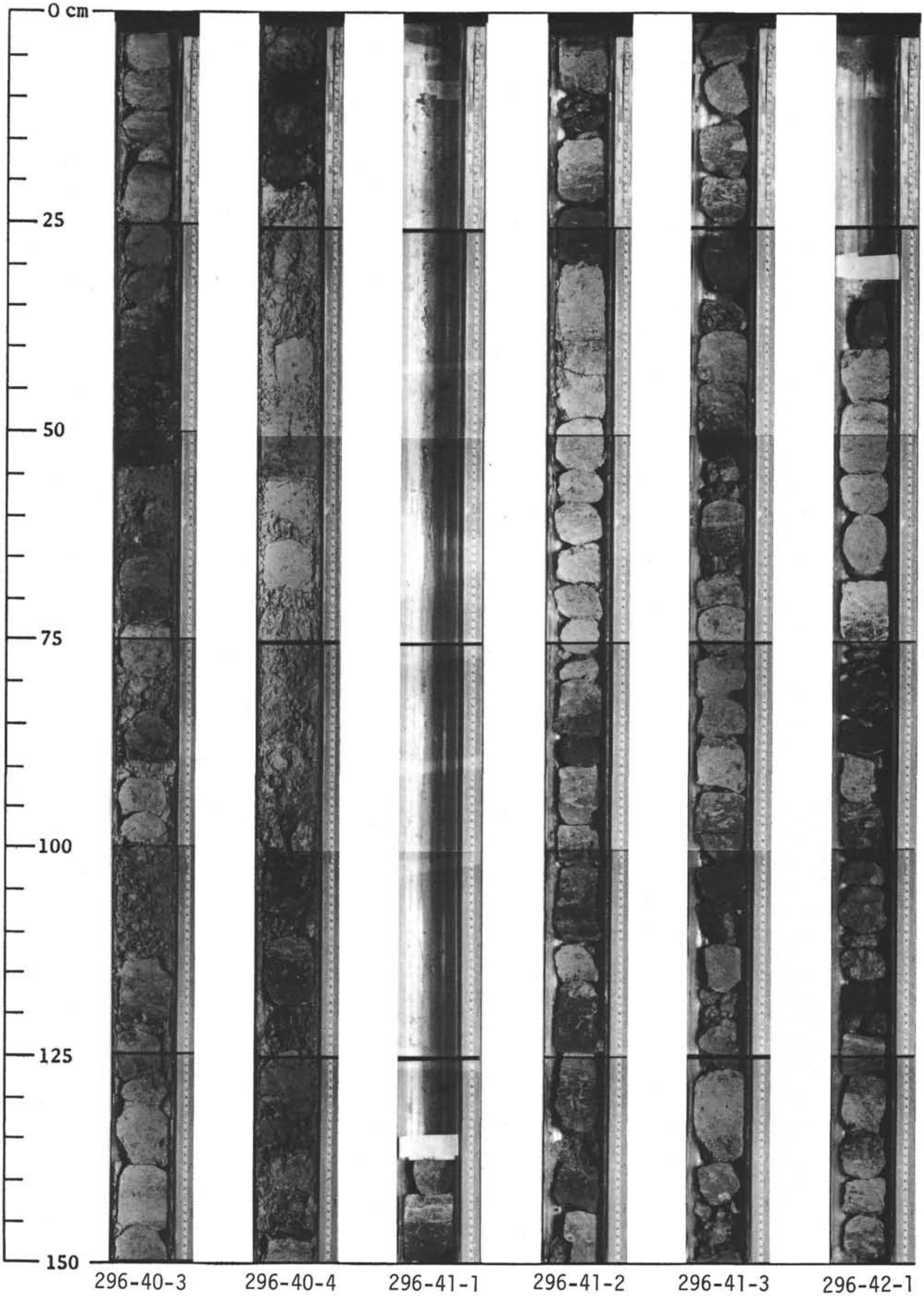
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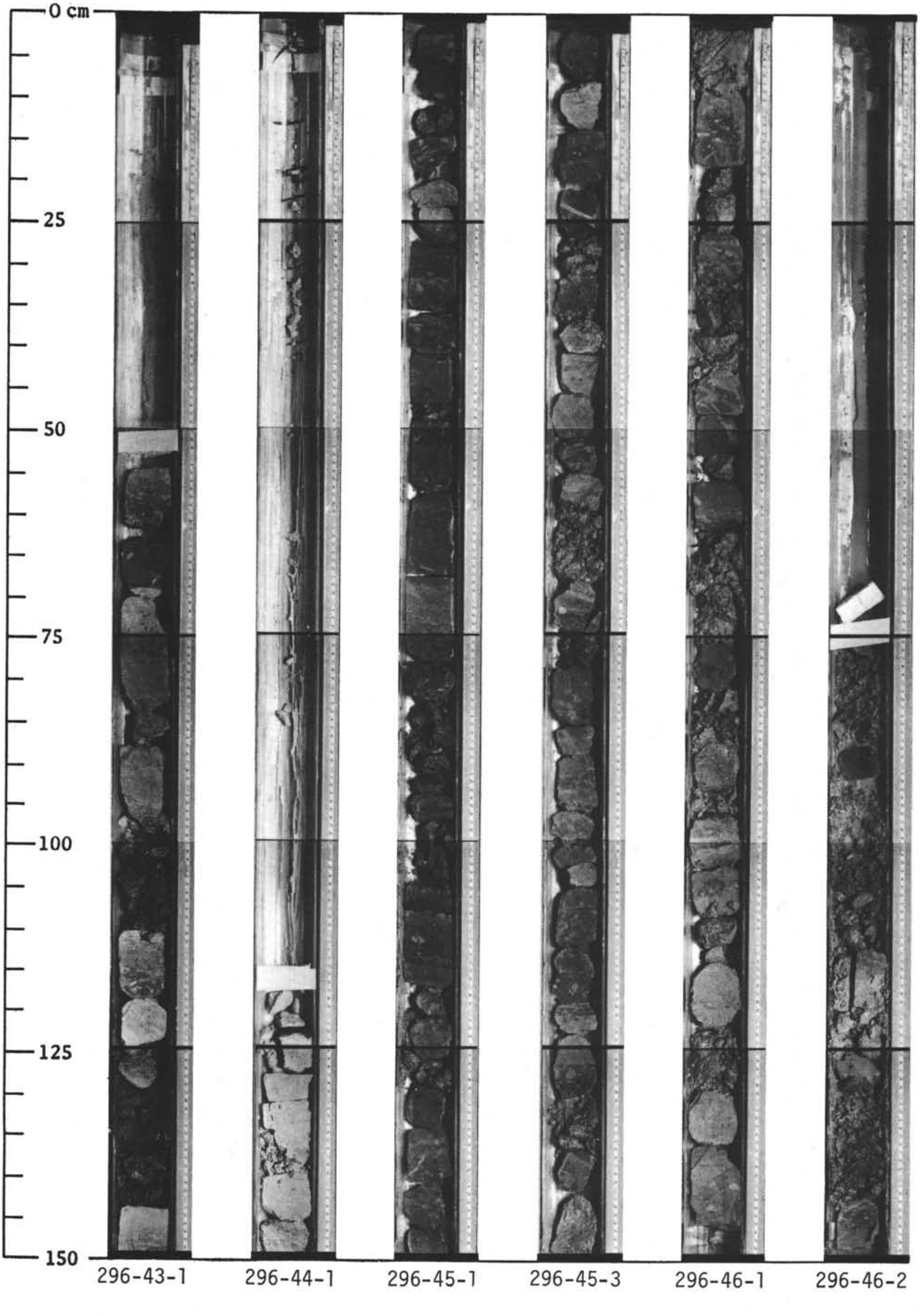
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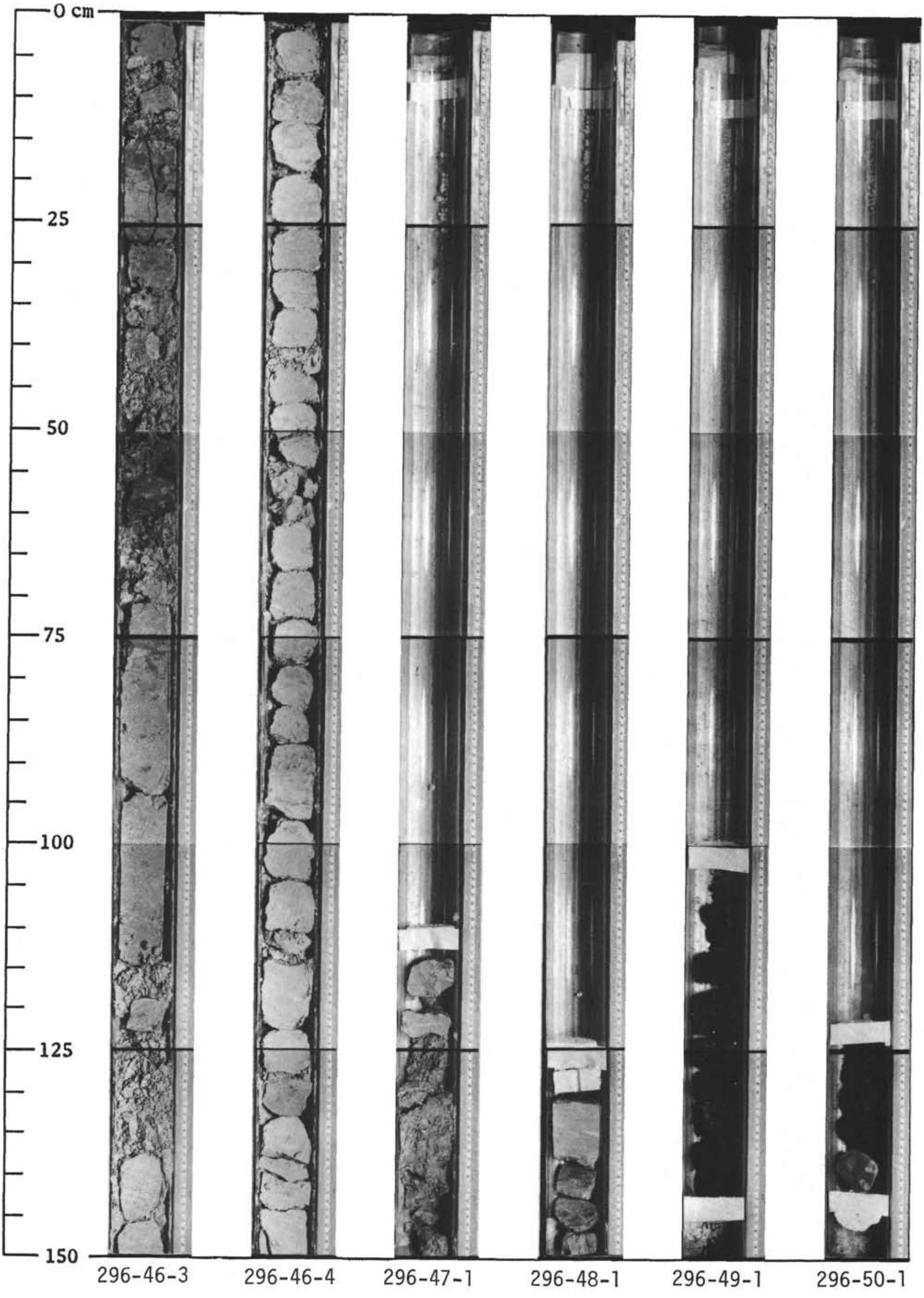
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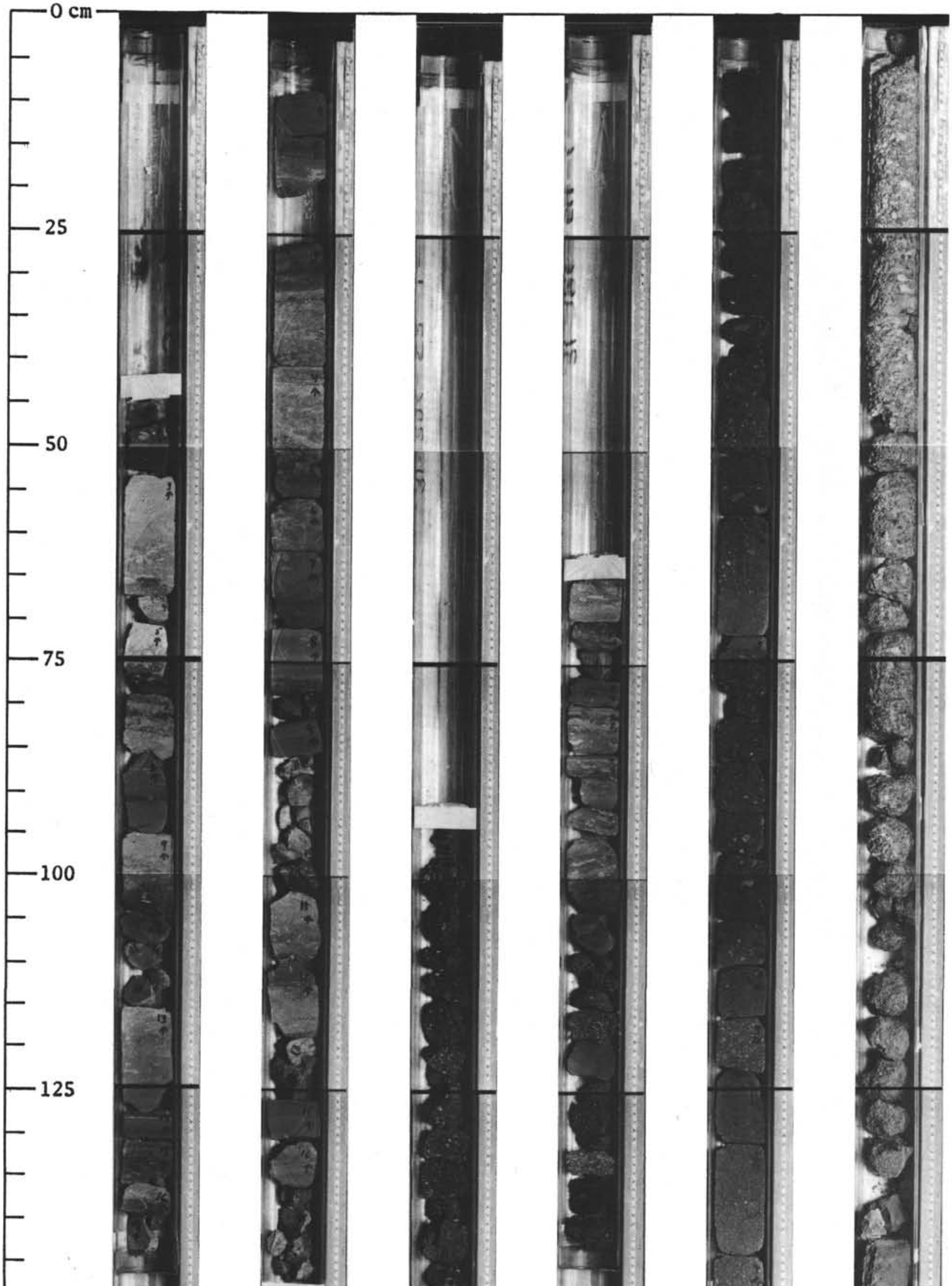
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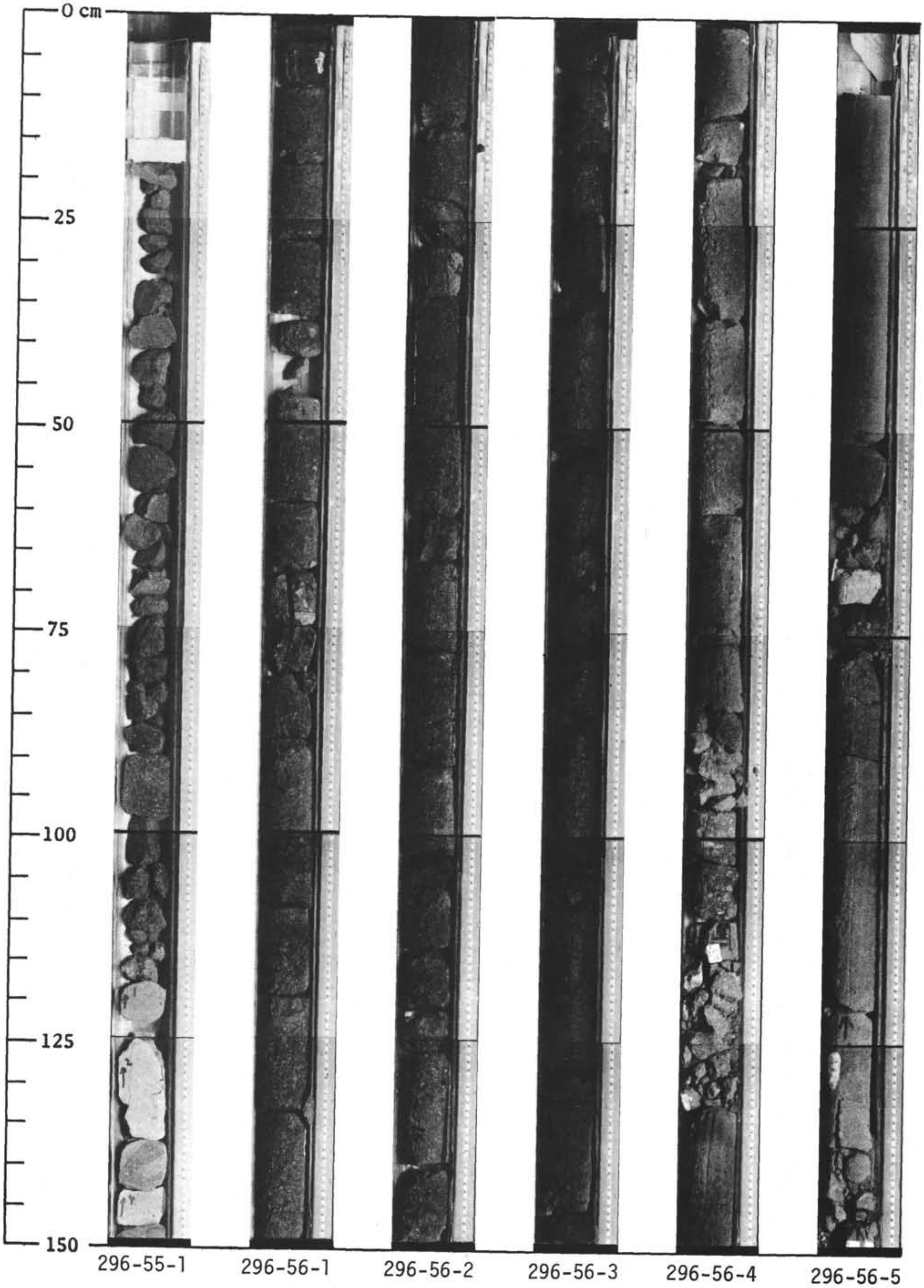
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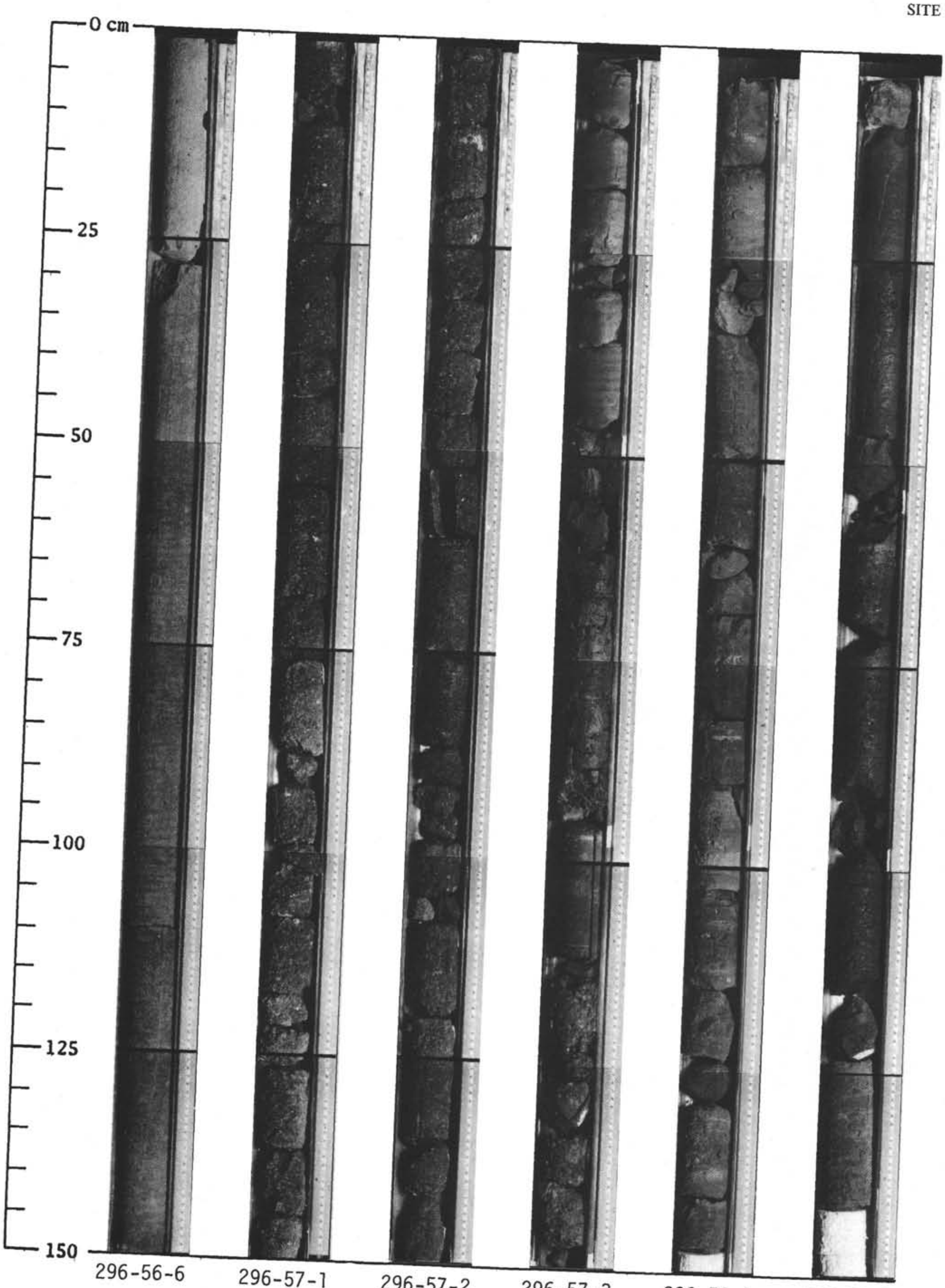
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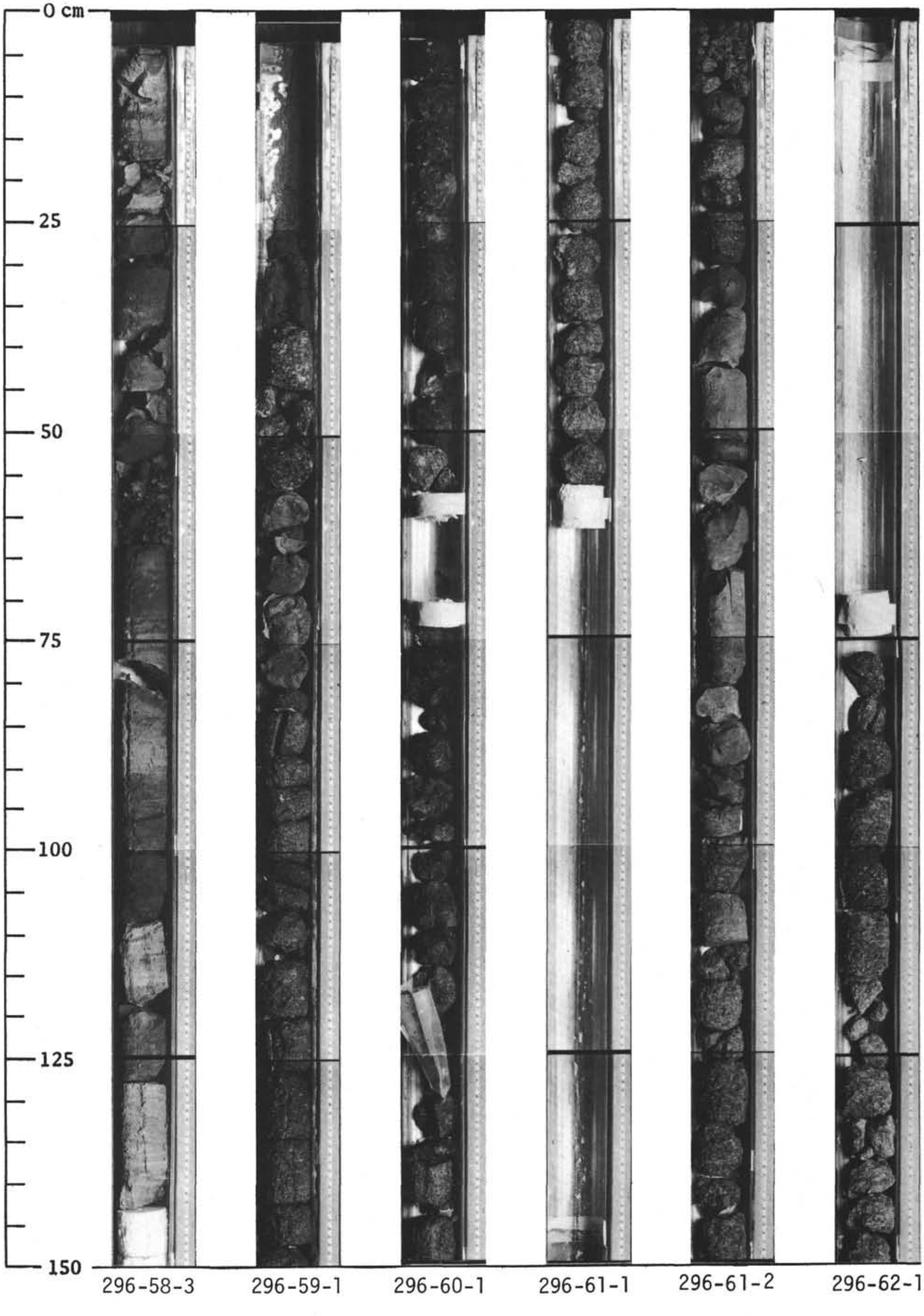
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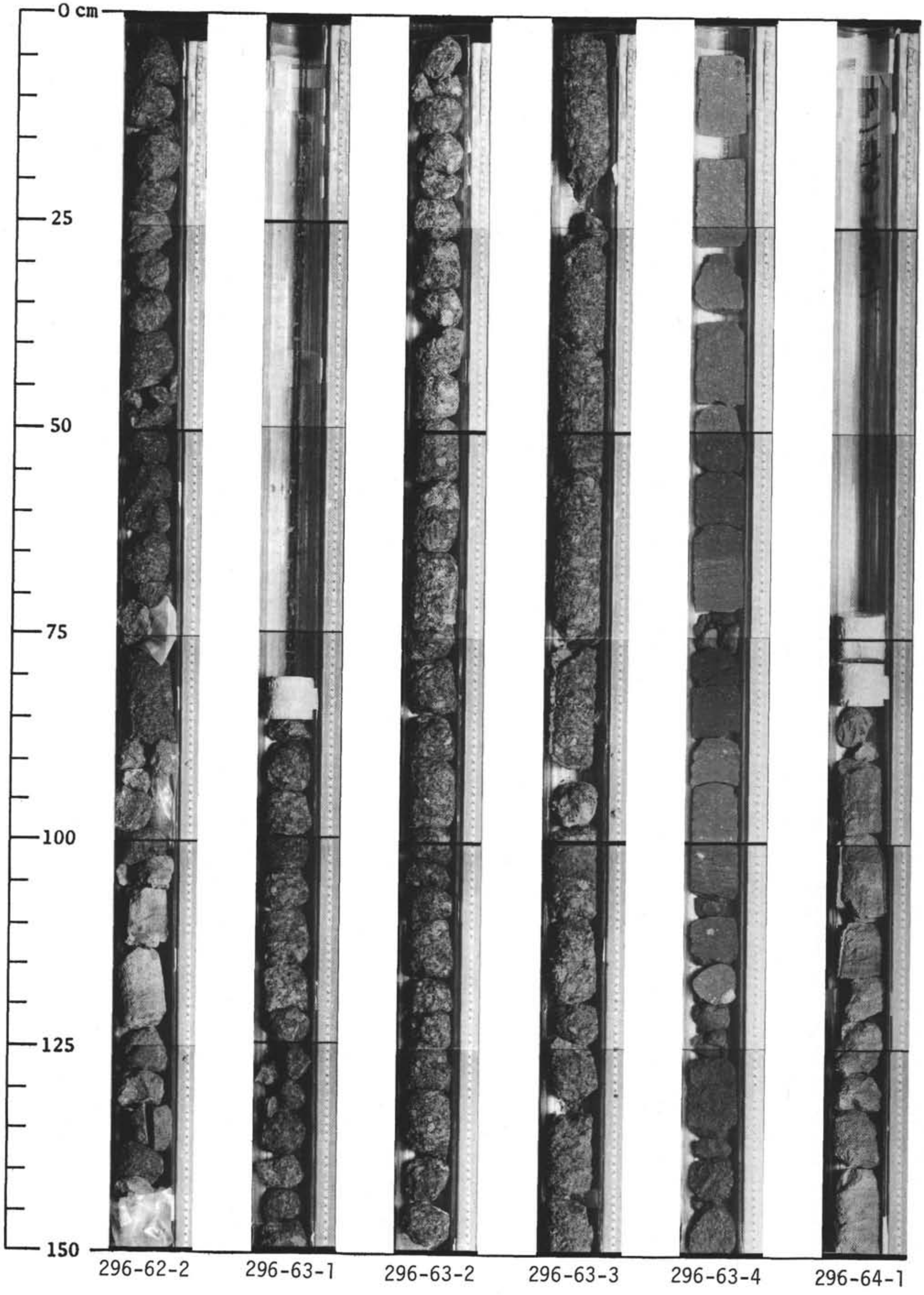
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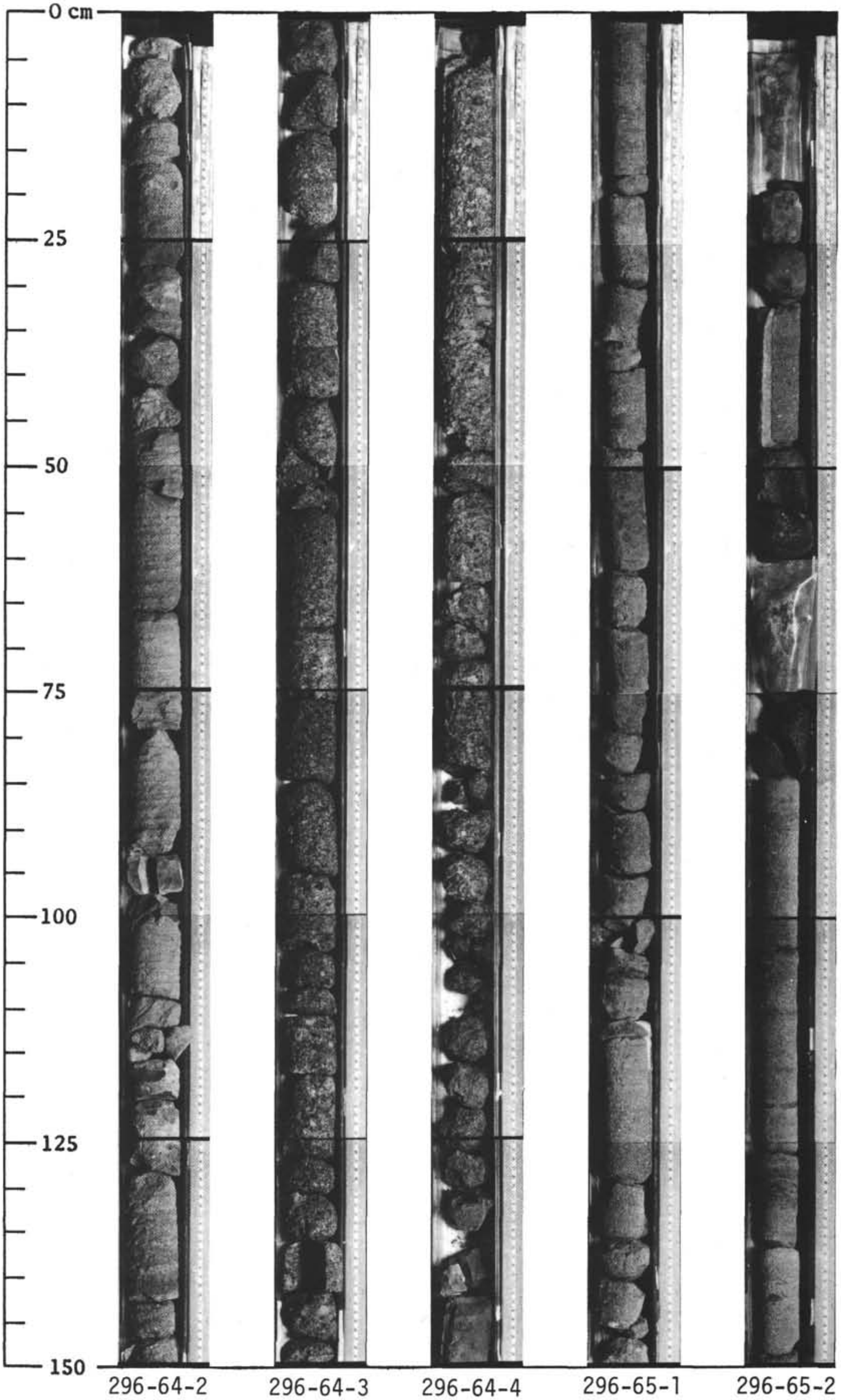
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