4. SITE 292

The Shipboard Scientific Party[1]

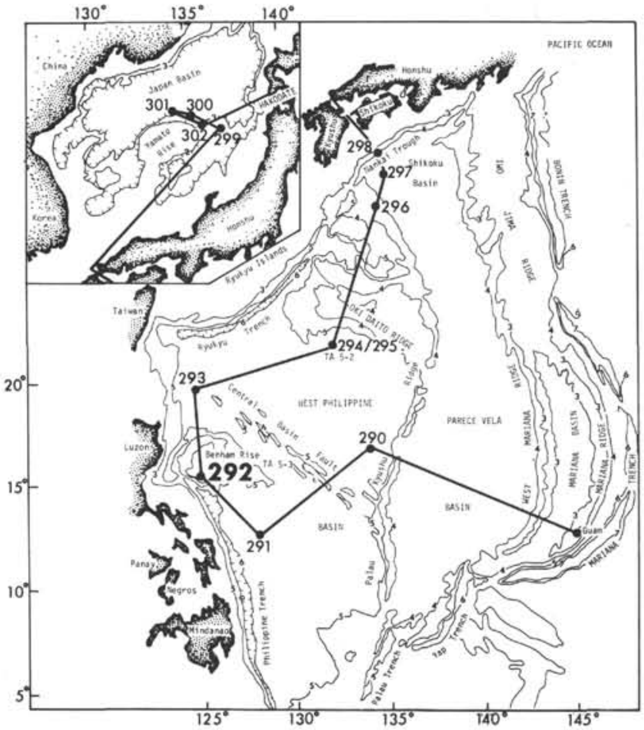

Figure 1. *Location map for Site 292 with approach and departure track of* Glomar Challenger. *From map: "Topography of North Pacific," T. E. Chase, H. W. Menard, and J. Mammerickx, Institute Marine Resources, Geol. Data Center, Scripps Institution of Oceanography, 1971. Contour depths in kilometers; scale 1:6,500,000.*

SITE DATA

Position: 15°49.11′N; 124°39.05′E

Water Depth (from sea level): 2943 corrected meters (echo sounding)

Bottom Felt At: 2937 meters (drill pipe)

Penetration: 443.5 meters

Number of Holes: 1

Number of Cores: 47

Total Length of Cored Section: 443.5 meters

Total Core Recovered: 242.7 meters

Percentage of Core Recovery: 55%

Oldest Sediment Cored:
Depth below sea floor: 367.5 meters
Nature: Nannofossil chalk-ooze
Age: late Eocene
Measured Velocity: 2.09-4.41 km/sec

Basement:
Depth below sea floor: 367.5-443.5 meters (drilled)
Inferred velocity to basement: 4.02 km/sec at top
Nature: Basalt

Principal Results: An excellent biostratigraphic reference section was penetrated on the southeastern flank of Benham Rise consisting of 154 meters of Pleistocene-late Oligocene nannofossil ooze, 71 meters of late to early Oligocene nannofossil ooze and chalk, and 142.5 meters of early Oligocene-late Eocene ooze, chalk, and minor chert underlain by basalt. Basalt was penetrated from 367.5 to 443.5 meters below the sea floor. A significant seismic reflector is correlated with a possible paleontologic hiatus at 101.5 meters marked by the apparent absence of planktonic foraminiferal Zones N11 through N6 apparently related to a period of intermittent erosion or nondeposition across the rise in early to mid Miocene time. Another hiatus is also indicated at 108.3 meters by the absence of the *Helicopontosphaera ampliaperta* Zone. Vugular basalt and displaced Eocene-Oligocene fossils indicate a history of subsidence for the rise after its formation in the mid to late Eocene.

BACKGROUND AND OBJECTIVES

Background

The Benham Rise represents a relatively small but significant midplate rise located immediately east of Luzon at the westernmost edge of the West Philippine Basin (Figures 1 and 2). The rise consists of an oblong, north-south-trending uplift averaging 2.5 to 3.0 km deep over its crest. The shallowest feature astride the rise crest is Benham Bank with a minimum depth of only 38 meters.

Earlier seismic profiles (Karig, 1973) together with *Glomar Challenger* profiles (Figures 3 and 4) clearly illustrate that Benham Rise is formed of north-south to north northeast-south southwest-trending basement highs with a central basement ridge reaching 2000 meters or less. These same profiles demonstrate that sediment-smoothed plateaus form the east and west

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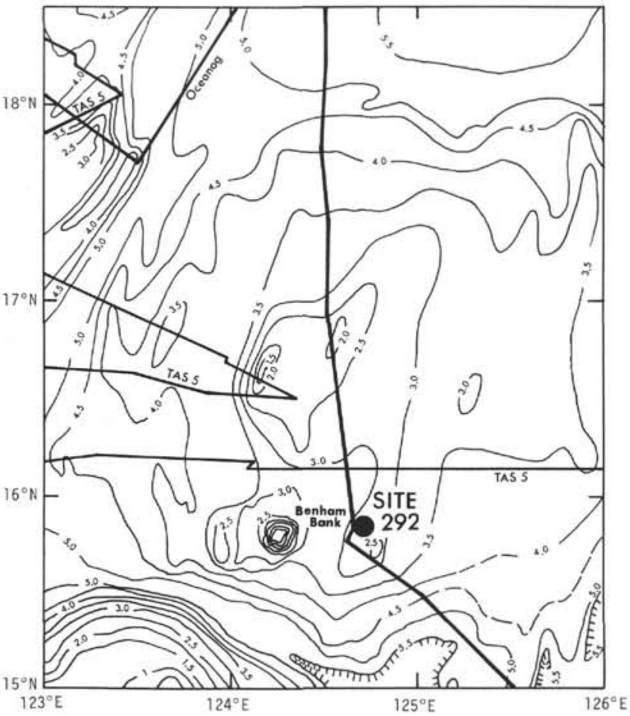

Figure 2. *Reconnaissance bathymetric chart of Benham Rises, modified from Karig (1973) with data from DSDP Leg 31, NOAA, and S.I.O. cruises. The reflection profile along the* Challenger *track is shown in Figure 3.*

flanks of the rise (Figure 3) with sediment thickness increasing from a normal 125-175 meter cover over the basin floor to more than 400 meters in some crestal areas. Moreover, a distinct break in the middle of the pelagic sediment column is clearly present in reflection profiles across the rise (Figures 3 and 4), representing a significant and ubiquitous unconformity.

Little was known regarding the origin of Benham Rise prior to drilling at Site 292. Nevertheless, it was clear that penetration of the rise crest offered a prime opportunity to obtain data bearing upon rise history and in the process to obtain a calcareous fossil-rich biostratigraphic reference section in the West Philippine Basin. The West Philippine Basin is an area notably deficient in fossil-rich debris due to its great depth and aggressive bottom water. The present position of Benham Rise near the eastern bight of Luzon and adjacent to the northern terminus of the Philippine Trench (Figure 1) has prompted speculation regarding possible genetic relationships between these features. Karig (1973) suggested that the rise might represent a crustal flexure related to the cessation of subduction along the east side of Luzon and may have experienced uplift during Oligocene and early Miocene time. Alternately, it was thought that it might represent a product of major volcanism occurring well after the formation of the Philippine Basin.

Objectives

Multiple goals were envisioned for drilling on Benham Rise. The location, elevation, topographic isolation, and assumed mid-Tertiary origin of the rise made it a prime target for recovery of a late Cenozoic calcareous fossil-rich sequence in an area bathed by a distal portion of the equatorial current system. *Glomar Challenger* seismic profiles confirmed the presence of a well-preserved pelagic record on this feature meeting the requirements of this first major objective. The second major objective was dating of rise formation by pinpointing the age and nature of the sediment-basement contact and reconstructing rise history with attendant implications for the tectonic evolution of the complex northwestern corner of the West Philippine Basin where it interacts with the Philippine Arc system. As a part of this program, it was decided a major effort would be made to penetrate a significant depth into the basement rocks hopefully recovering a meaningful suite of igneous material detailing the nature of early rise or prerise events. The sedimentary and igneous record ultimately obtained met both of the major objectives admirably well with the added bonus of a critical radiometric date obtained from well-preserved basement material (see McKee, this volume).

OPERATIONS

Drilling on the Benham Rise had both biostratigraphic and tectonic objectives. This region is very poorly known, with no surface cores and only several seismic profiles. The site was located on one of the plateaus along the east side of the rise where the sediment cover was typical, and drilling results could be extrapolated across the rise with seismic reflection profiles. The original site was located using a low-quality Alpine geophysical reflection profile, which was not accurately navigated. Proposed Site 292 was approached on a course of 313°T and at a reduced speed (8 knots). The sediments began to thicken up the rise flank as expected, but the bottom shallowed very irregularly at almost 2500 meters with little sign of the target plateau.

It had been predetermined that better conditions would lie northeast of the approach track. A course change was made to 043° and profiles indicated the bottom very soon smoothed onto the plateau. An adequate site, with 0.35 sec of sediment over a smooth opaque basement reflector, was located (Figures 2 and 3). After continuing a sufficient distance to insure that the bottom conditions around the site would not be anomalous, the course was reversed, speed decreased to 5 knots, and the beacon dropped at 1535, 26 June.

The drill string was lowered and the hole spudded in a soft nannofossil ooze. A continuous coring program was planned until a (probable) deep noncalcareous (brown clay) section was reached. However, the brown clay section did not occur, and the entire hole was continuously cored. Of the 47 cores cut, 39 were in nannofossil ooze, which markedly stiffened into chalk near 300 meters, and finally included chert lenses at 340 meters (Table 1). The acoustic basement represented the lower interbedded chalks and ooze. Basalt, reached at 370 meters, formed a deeper reflector partially hidden beneath the reflection series from the chalks.

The vesicular basalt in the first basement core (Core 40) quickly gave way to a denser plagioclase porphyritic basalt which showed very little change with depth. After cutting eight cores in basalt with a penetration rate of 5 m/hr (Figure 5), it was decided that drilling had proceeded far enough to show that the unit was not a thin flow. Also it was obvious that we could not penetrate far enough to define seismically resolved layers or to find possible sediment units below the thick basalt layer.

Before pulling out of the hole, an inclinometer survey indicated bottom-hole deviation from a vertical of 2°-3°. The site was departed at 2350, 30 June.

LITHOLOGY

Hole 292 penetrated 367.5 meters of nannofossil ooze and chalk into basalt. Good recoveries resulted in an exceptionally complete section of strata ranging in age from late Eocene to late Pleistocene or Holocene. The sediments, sedimentary rock, and basalt penetrated in Hole 292 are divided into two units (Table 2).

The sediments and sedimentary rock are placed in a single unit of uniform lithology, which is further divided into three subunits. The subdivision is based on the greater percentage of lithified ooze (chalk) in the lower two subunits, as shown in Figure 5. Unit 2, a tholeiitic basalt, was encountered in the next core (40) immediately below the last core containing chalk, but the actual contact was not recovered.

Unit 1

The ooze/chalk unit is rather uniform in lithology and consists of dominant nannofossils with varying amounts of foraminifera, volcanic glass, volcanic mafic minerals (mainly hornblende), radiolarians, and sponge spicules. Clay-sized material is presumably present in most specimens, but its proportion is difficult to estimate. Fine carbonate mud ("micarb") seen in some samples is probably derived from comminuted, and perhaps recrystallized, carbonate tests.

The only obvious changes in lithology are the presence of ash-rich layers in some portions (Figure 5) and the progressive change from plastic ooze to chalk with increasing depth. The proportion of chalk has been used as a basis for further lithological subdivision of this thick nannofossil ooze/chalk unit. However, this probably reflects the diagenetic history rather than any great difference in the original sediment.

Subunit 1A

The subunit is a nannofossil ooze with little or no lithification. It occurs from 0 to 154 meters. The color is medium yellow-brown, which becomes paler downwards (Core 2) to grayish-orange, pale grayish-orange, and very pale gray. Local ash-rich layers are pale to dark brown. The ooze was soupy to soft, but in some sections faint color variations enabled bedding to be distinguished.

Volcanic debris (brown and clear volcanic glass, plagioclase, amphibole, rare rock fragments) occurs in most samples, and is common at the following levels: 7-27 meters (Cores 2 and 3) and 92-93 meters (Core 11). Detrital material appears to be entirely absent, or represented only by minor pelagic clay. Zeolites rarely exceed 1%.

Subunit 1B

Subunit 1B is characterized by frequent, but subordinate bands of chalk, mostly 5-20 cm thick, occurring within soft plastic nannofossil ooze similar to Subunit 1A. Colors are similar to those of Subunit 1A, with pale grays predominating. Where color contrasts do occur (especially near ashy layers), intense bioturbation is present. Bioturbation can also be seen in the more indurated layers. Ash layers occur around 154 and 200 meters. The subunit is 71 meters thick.

Subunit 1C

In this subunit nannofossil chalk is predominant, with interbedded thin layers of plastic ooze. The lithology, colors, and composition are similar to those of Subunit 1B, except for the lowermost cores which are pinkish-gray. A thin (10 cm) ash-rich layer occurs at 312 meters (Core 34), and ash layers are common in the 329.5 to 351.5 meter interval (Cores 36 to 38).

Thin beds or nodules of light olive-gray and brownish silicified chalk occur from 351 meters to the base of the subunit, and are 10 cm or less in thickness. They appear to have formed by replacement of chalk by silica.

Unit 2

The basalt recovered consists of a sequence of exceptionally uniform intersertal to subophitic tholeiitic basalts. The cores contain for the most part, well-developed holocrystalline massive basalt. Veinlets commonly contain layers of marcasite or a greenish chloritic material, and sometimes calcite. A more altered appearance results from zones of vertical zoning through the basalt. There is no evidence of any discontinuities in the unit. Vesicles are found throughout the core; however, towards the top of the unit they are more abundant and filled with chlorite, zeolite, and calcite.

The presence of phenocrysts indicates a two-stage history for the basalt, although the similarity of mineralogy and chemistry between groundmass and phenocrysts suggests that the magma chamber supplying these basalts is at fairly shallow depths. Small individual units could be distinguished in the flow. A possible minimum thickness for this flow is 76 meters. This evidence is speculative since the nonrecovered intervals may contain important boundaries.

Basalt Petrography

The rock is typically composed of an interlocking network of lath-like plagioclase (40-400μ) and granular augite (200-400μ) with scattered skeletal crystals of an opaque phase. The interstitial areas between the larger subophitic crystals are composed of a very fine-grained (2-10μ) quench to feathery intergrowth of lath-like plagioclase and pyroxene granules. In the interstitial areas, long slender apatite needles are also found. Opaque phases occur as thin hollow acicular needles or a network. The interstitial areas are invariably highly altered to a brownish serpentinuous product, often with calcite. In certain core sections a slight greenish color is present resulting from greenish rather than brownish alteration products.

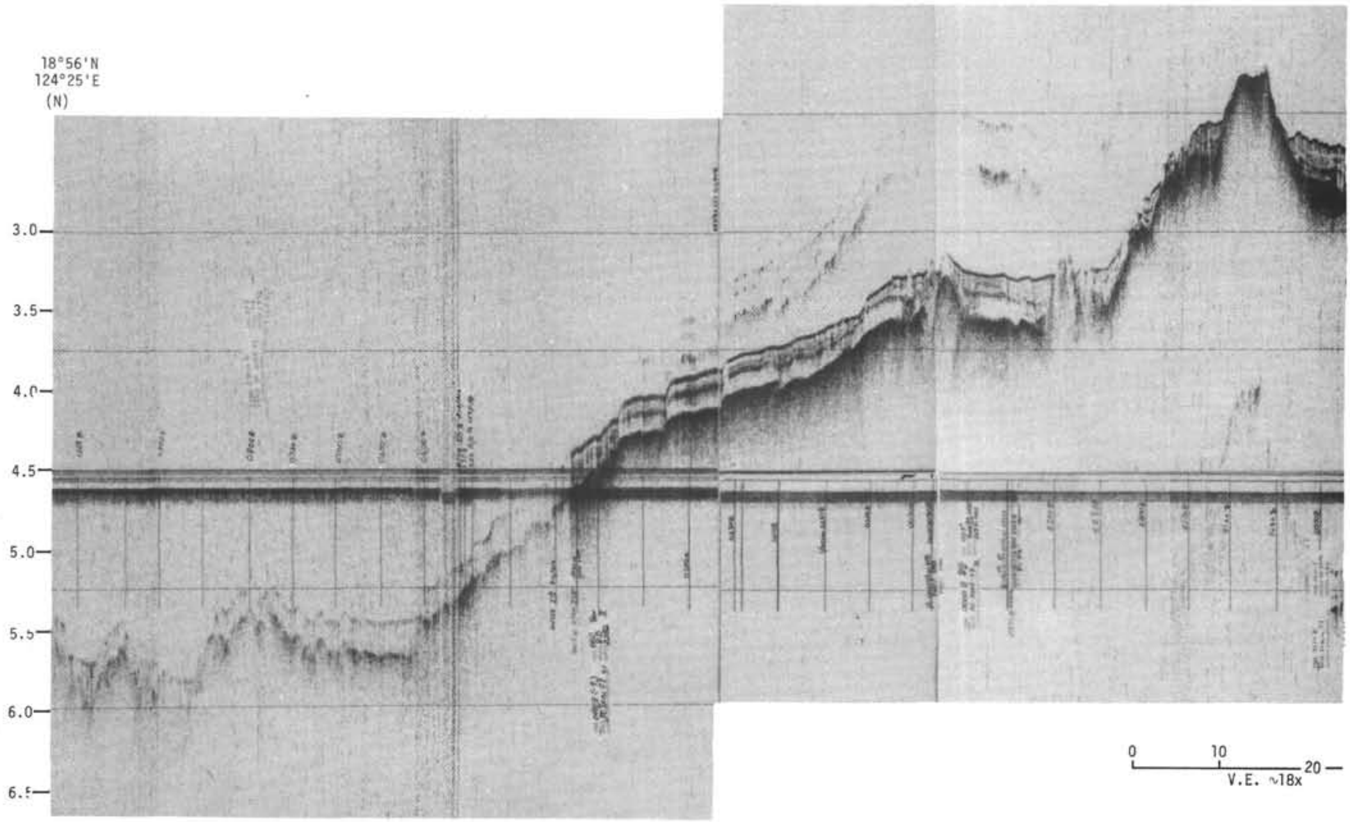

Figure 3. Challenger *seismic reflection profile over Benham Rise illustrating thickened late Eocene through Recent pelagic section and ubiquitous intermediate reflector shown in greater detail in Figure 4.*

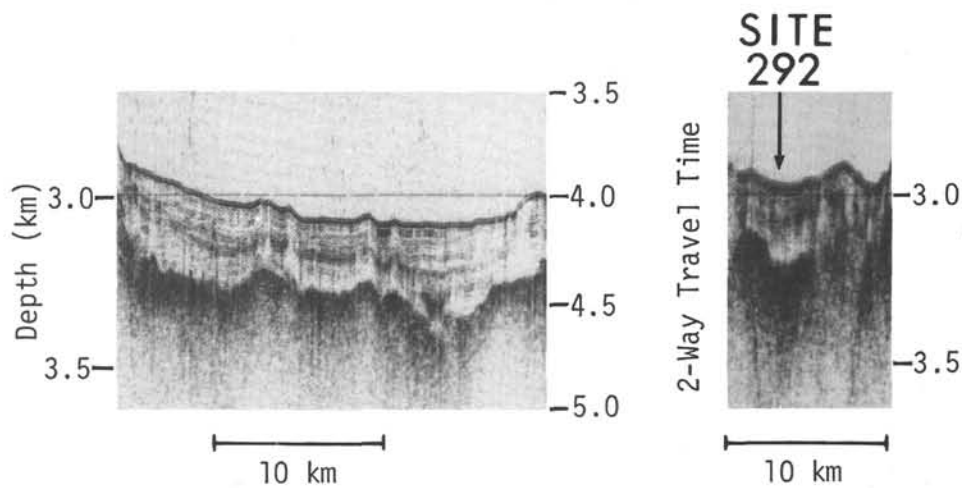

Figure 4. *Expanded reflection profiles near Site 292 illustrating the zone of early to mid Miocene disconformities near the middle of the sediment section.*

Phenocrysts of plagioclase ($400 \times 4000\mu$) are common (up to 5%) commonly associated with coarse pyroxene. The phenocryst plagioclase often contain small, silicate inclusions of pyroxene and opaque phases. The modal proportions are very uniform, with plagioclase ranging from 25% to 40%, pyroxene (15%-25%), opaques (5%-10%), and interstitial material (20%-55%). Pyroxene/plagioclase ratios are approximately 40:60. There appears to be no major discontinuities in modes or grain size throughout the core.

Plagioclase compositions vary from An_{48} to An_{20}, with the cores more calcic than the rims. Phenocrysts show a comparable range although their cores are more calcic (An_{52}), with zoning better defined, often with well-marked breaks of ghost crystals.

Lithologic Interpretations

The known history of the site area starts with extrusion of basalt, presumably in middle or late Eocene since it is overlain by late Eocene chalk. The vesicular nature

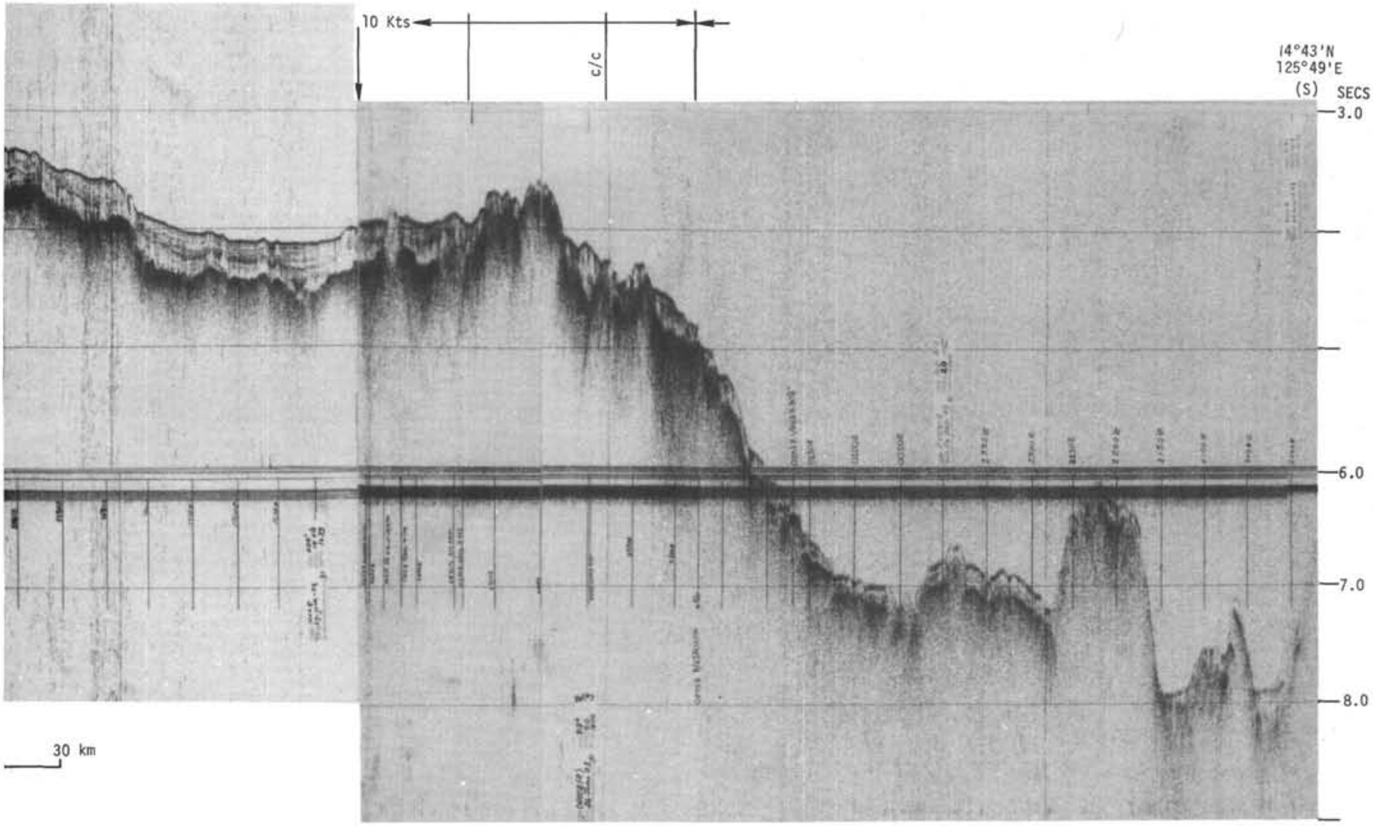

Figure 3. *(Continued).*

of the basalt indicates that it was extruded in shallow water, possibly in depths of 500 meters or less (see McKee, this volume).

After the basalt was extruded, almost continuous sedimentation of nannoplankton, with subordinate foraminifera, radiolarians, sponges, and tephra, continued until the Holocene. During this period the site area subsided to its present depth. Since the present sediment base is 437 meters below the sea floor, total subsidence has been about 2900 meters since the late Eocene. At no time was the area below the lysocline. The virtual absence of terrigenous detritus, and of shallow-water fossils such as corals or algae, indicates that there was no nearby land or coral reefs, or if such existed, that the site area was shielded from any supply of detritus.

Since a considerable area of the Benham Rise is at present shoaler than 2900 meters, a simple restoration of the late Eocene bathymetry by raising the region by 2900 meters would imply that a fairly extensive mountainous island, or archipelago, existed then. However, the absence of terrigenous material in Hole 292 argues against the existence of such a land area, in which case (if the shallow origin of the basalts is accepted) the parts of the Benham Rise shoaler than 2900 meters must have subsided less than the site area. Differential subsidence on this scale would imply faulting.

Rather regular, almost rhythmic interbedding of chalk and ooze in parts of Subunit 1B might suggest deposition by periodic slumping from nearby highs, and this could partly explain the high deposition rates during the Oligocene. However, examination of the deposit by smear slides does not show any obvious grading. Some of the ash beds show grading, as is to be expected.

Sedimentation rates show a high of 12 m/m.y. in the Oligocene to early early Eocene, and 8.5 m/m.y. in the late Miocene to Quaternary (Figure 6). These differences probably reflect differences in the rate of productivity.

PHYSICAL PROPERTIES

Physical property measurements on cores from Site 292 reveal minor changes with depth for the nannofossil ooze series and practically none for the upper half of the underlying nannofossil chalks. The lower half of the chalk with some extremely hard parts and silicified intercalations reveals higher bulk densities and sonic velocities, both with wide scattering. The basalt clearly has different values, although the silicified pieces in the nannofossil chalk can cause confusion in seismic interpretations, as they have comparable physical property values.

Bulk Density, Porosity, and Water Content

Except for the top two cores, little scattering exists in bulk-density values from Cores 3 through 14, all consisting of nannofossil ooze. This tendency can be observed in Figure 5, which also displays sonic velocity data.

Cores 15 through 24 contain a wider spread in bulk-density values than the upper portion. The mean, however, does not increase or decrease with depth. This indicates that at least the upper 90 meters of the nannofossil chalk has the same average degree of consolidation. Cores 30 through 39 display a wide scattering in bulk-density values, which corresponds to variations from chalk to locally silicified limestone.

TABLE 1
Coring Summary, Site 292

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)	Remarks[a]
1	0.0-6.5	6.5	5.7	88	Punch Core
2	6.5-16.0	9.5	4.0	42	
3	16.0-25.5	9.5	5.2	55	
4	25.5-35.0	9.5	7.3	77	
5	35.0-44.5	9.5	9.5	100	
6	44.5-54.0	9.5	8.4	88	
7	54.0-63.5	9.5	9.2	97	
8	63.5-73.0	9.5	9.3	98	
9	73.0-82.5	9.5	8.2	86	
10	82.5-92.0	9.5	2.1	22	
11	92.0-101.5	9.5	9.3	98	
12	101.5-111.0	9.5	6.4	67	
13	111.0-120.5	9.5	8.7	92	
14	120.5-130.0	9.5	8.7	92	
15	130.0-139.5	9.5	9.5	100	
16	139.5-149.0	9.5	9.5	100	
17	149.0-158.5	9.5	8.4	88	
18	158.5-168.0	9.5	9.5	100	
19	168.0-177.5	9.5	9.5	100	
20	177.5-187.0	9.5	1.8	18	
21	187.0-196.5	9.5	6.7	71	
22	196.5-206.0	9.5	3.3	35	
23	206.0-215.5	9.5	6.0	63	
24	215.5-225.0	9.5	3.1	33	
25	225.0-234.5	9.5	2.7	28	
26	234.5-244.0	9.5	2.4	25	
27	244.0-253.5	9.5	1.4	15	
28	253.5-263.0	9.5	0	0	
29	263.0-272.5	9.5	0.8	8	
30	272.5-282.0	9.5	2.3	24	
31	282.0-291.5	9.5	1.6	17	
32	291.5-301.0	9.5	1.3	14	
33	301.0-310.5	9.5	1.8	19	
34	310.5-320.0	9.5	3.0	32	
35	320.0-329.5	9.5	3.2	34	
36	329.5-339.0	9.5	7.5	79	
37	339.0-348.5	9.5	3.8	40	
38	348.5-358.0	9.5	2.5	26	
39	358.0-367.5	9.5	3.7	40	
40	367.5-377.0	9.5	1.4	15	
41	377.0-386.5	9.5	6.6	69	
42	386.5-396.0	9.5	6.6	69	
43	396.0-405.5	9.5	5.1	54	30 bbls mud
44	405.5-415.0	9.5	6.4	67	
45	415.0-424.5	9.5	4.2	44	
46	424.5-434.0	9.5	3.0	32	30 bbls mud
47	434.0-443.5	9.5	2.2	23	

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

Figure 5 displays to a certain degree the inverse relationship between bulk density and water content. The decrease in mean water content over the upper 110 meters is more pronounced than the increase in bulk density for that depth interval. Where the mean bulk density stays about constant (110-220 m), the water content shows the same tendency. However, less scattering is observed in the latter. The increase of the mean bulk density between 275 and 365 meters is not obviously correlative with a decrease in water content.

With a few minor exceptions, it can be said that the laboratory-derived bulk-density values are always lower than the GRAPE analog readings. Part of the differences can be due to drift in the GRAPE, but most differences must be sought in the syringe/chunk method which collects too small a sample, which may not be representative for a larger part of a core or even a section.

Vane Shear

The bottom of Core 1, Section 6 had a bearing strength of 839.8 g/cm², and the top of Core 7, Section 6, 956.9 g/cm². A more detailed discussion of vane-shear results is found in Moore and Bouma (this volume).

Sonic Velocity

Several sonic-velocity measurements were made, most of them parallel to bedding direction with the half core still in the plastic liner. A limited number of measurements was also made perpendicular to the bedding direction on pieces removed from the liner. Where silicified "concretions" occurred in the lower part of the nannofossil chalk, a few samples were cut into a plan-parallel slice for sonic-velocity measurements. Tabulated results are given in Table 3 and displayed in Figure 5.

Figure 5 reveals that the upper 140 meters consisting of nannofossil ooze are very homogeneous in sonic velocity. The velocities vary little (1.49-1.58 km/sec), which can be considered to be within the error of measurements. Although it should be expected that an increase occurs with depth, this is not obvious in Figure 5, indicating that this type of sediment does not consolidate easily. The highest values were obtained from more indurated segments measured in a direction perpendicular to the bedding.

The nannofossil chalk to a depth of 300 meters has a slightly higher sonic velocity (about 0.1 km/sec) than the ooze. It is also characterized by a wider scattering of values. Again it can be seen that the harder parts have the highest velocities, especially for Cores 20 and 21.

Below 300 meters a sudden increase in velocity is seen. The sediment becomes rather hard and contains silicified inclusions. This variation in hardness is reflected in the scattered bulk-density values and explains the wide range in sonic velocities. Measurements from Cores 35, 38, and 39 include "high" velocities of hard chalks. A measurement on a consolidated nannofossil ooze-rich volcanic ash in Core 36 gives a velocity comparable to the hard chalks. One measurement in a silicified chalk (4.41 km/sec) indicates that these inclusions contain sonic-velocity characteristics that are comparable to basalt. It is very likely that horizons of this type of material will produce seismic reflections that easily become confused with the basement surface.

An experiment to study possible anisotropy in sonic velocity was made on Core 35, Section 2. The velocity in the direction parallel to the bedding was slightly higher (about 6%) than that in the direction perpendicular to the bedding. Though the difference might be within the order of magnitude of the technical error, the comparatively small values of the standard deviation for repeated measurements may indicate that sonic anisotropy actually exists in this type of slightly laminated sediment.

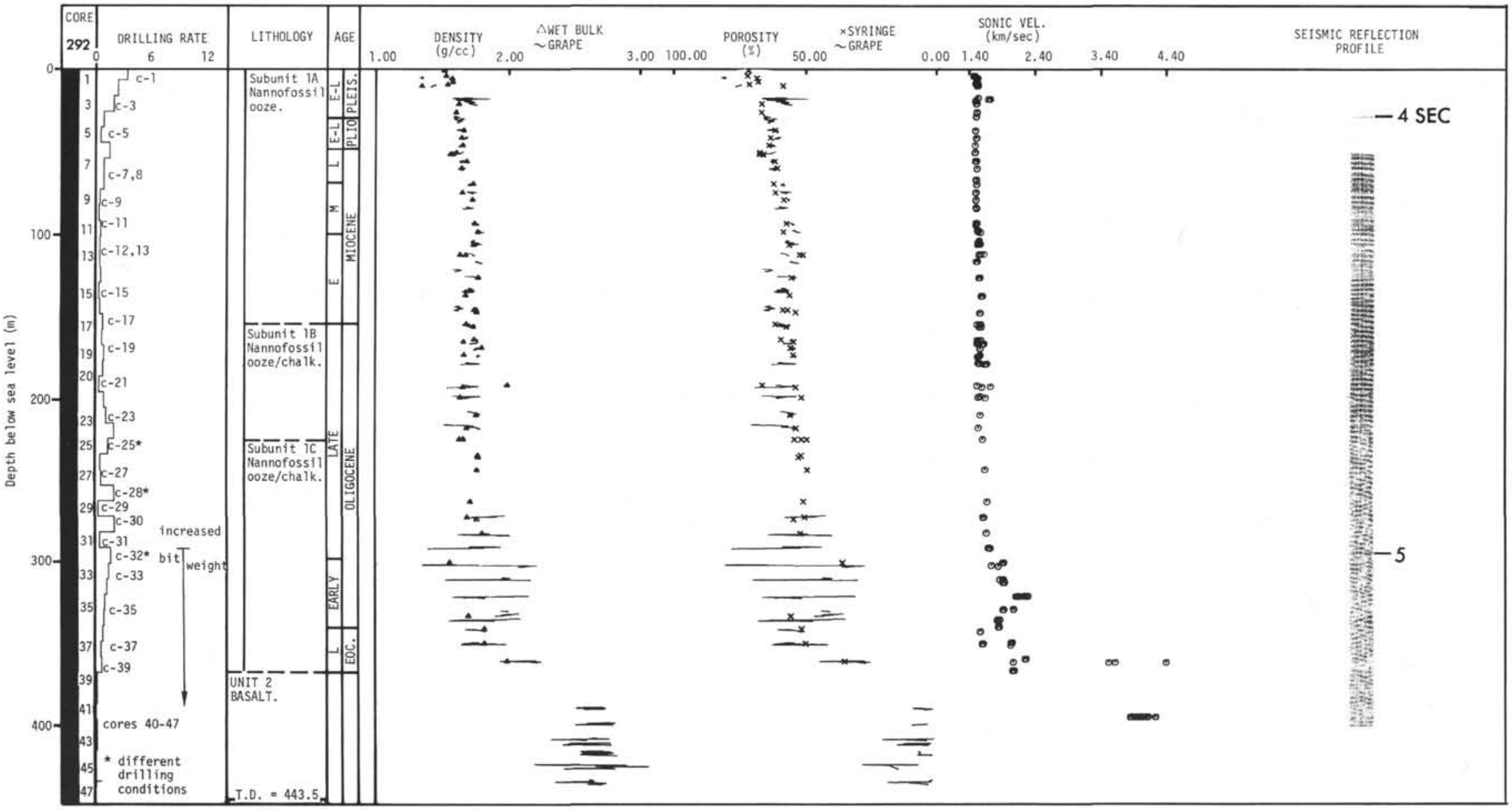

Figure 5. *Hole summary diagram, Site 292.*

TABLE 2
Unit Descriptions, Depths, Thicknesses, and Ages, Site 292

	Unit and Descriptions	Depth (m)	Thickness (m)	Age
1	Nannofossil ooze and chalk	0-367.5 (Total)	367.5	Late Eocene-late Pleistocene (Holocene)
	1A Nannofossil ooze		154	Late Oligocene-late Pleistocene (Holocene)
	1B Nannofossil ooze with interbedded nannofossil chalk		71	Late Oligocene
	1C Nannofossil chalk with minor interbedded ooze, and cherty concretions		142.5	Late Eocene-late Oligocene
2	Basalt, subophitic tholeiitic	367.5-443.5	+76(?)	?

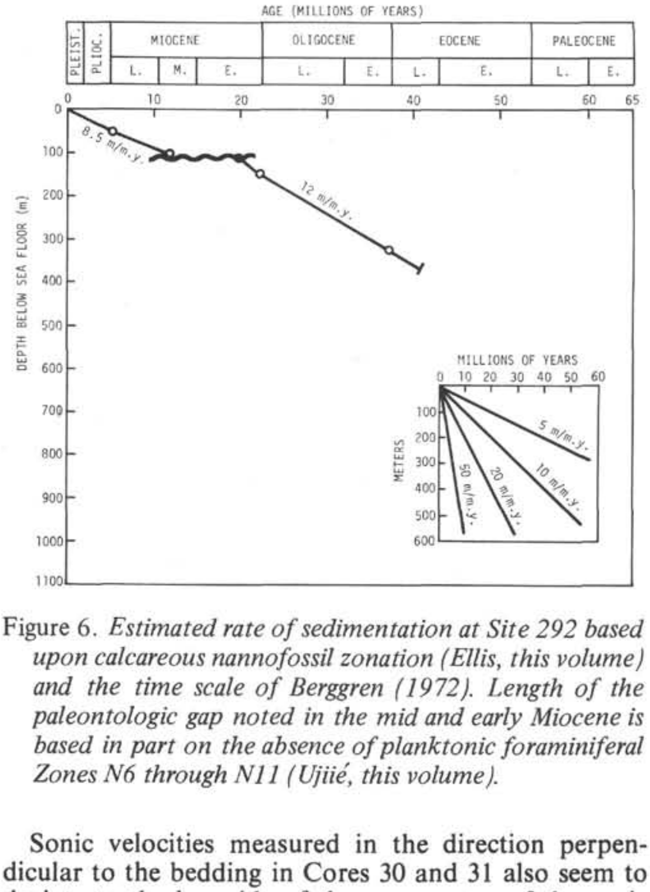

Figure 6. *Estimated rate of sedimentation at Site 292 based upon calcareous nannofossil zonation (Ellis, this volume) and the time scale of Berggren (1972). Length of the paleontologic gap noted in the mid and early Miocene is based in part on the absence of planktonic foraminiferal Zones N6 through N11 (Ujiié, this volume).*

Sonic velocities measured in the direction perpendicular to the bedding in Cores 30 and 31 also seem to deviate to the low side of the mean curve of the sonic velocity-depth relationship.

GEOCHEMICAL MEASUREMENTS

Alkalinity, *p*H, and salinity measurements are summarized in Table 4.

Alkalinity

The average alkalinity of the eight samples from Site 292 is 1.27 meq/kg. Seven of these values and the average are all below the surface seawater reference value of 2.20. The highest value (2.25) is found in Core 2, Section 2, 9.5 meters below the sea floor. A rather sharp drop in values occurs between Cores 21 and 26 (1.56 to 0.88, respectively). Core 21 from Unit 1 Subunit 1B is a nannofossil ooze with interbedded chalk, while Core 26 from Subunit 1C is nannofossil chalk with minor interbedded ooze.

pH

*p*H values were all below that of the seawater reference at the site (8.25 to 8.29). The punch-in *p*H averaged 7.37 (5 samples), while the flow-through values average 7.39 (8 samples). The *p*H values do not show any particular trends with depth.

Salinity

Eight salinity measurements averaged 35.9‰. Four values were higher than the overlying seawater reference value of 35.2‰, while the remaining four values (Cores 2, 6, 11, and 16) equaled the seawater value. Those samples with the higher values came from units consisting of nannofossil chalk rather than nannofossil ooze (Cores 21, 26, 31, and 36).

PALEONTOLOGIC SUMMARY

Introduction

The thick and nearly complete sedimentary section encountered at Site 292 ranges in age from Holocene/Pleistocene to late Eocene and represents a potential biostratigraphic reference section for the western edge of the equatorial Pacific. The Oligocene interval, in particular, deserves further study and may well constitute one of the most complete equatorial records of this epoch currently available. Age and zonal determinations were made with the use of calcareous nannofossils and planktonic foraminifera in Holocene/Pleistocene, Pliocene, and Miocene sediments, whereas calcareous fossils together with radiolarians were used in subdividing the Oligocene and late Eocene portions of the sequence. Diatoms and silicoflagellates were not observed in any of the samples examined.

TABLE 3
Sonic-Velocity Measurements, Site 292

Sample (Interval in cm)	Hole Depth (m)	Sonic Velocity (km/sec)	Remarks
1-3, 118	4.2	1.49	Nannofossil ooze
1-4, 109	5.6	1.54	Nannofossil ooze
2-1, 130	7.8	1.53	Nannofossil ooze
2-2, 97	9.0	1.53	Nannofossil ooze
2-3, 81	10.3	1.54	Nannofossil ooze upper 100 cm
3-2, 23	17.7	1.55	Nannofossil ooze
3-2, 89	18.4	1.72	Silty foraminifera ooze
3-3, 56	19.6	1.51	Nannofossil ooze
3-4, 66	21.1	1.53	Nannofossil ooze
4-1, 99	26.5	1.53	Nannofossil ooze
4-3, 60	29.1	1.53	Nannofossil ooze
5-2, 88	37.7	1.51	Nannofossil ooze
5-5, 50	42.2	1.53	Nannofossil ooze
6-2, 55	46.6	1.51	Nannofossil ooze
6-5, 51	51.0	1.51	Nannofossil ooze
7-2, 42	56.1	1.52	Nannofossil ooze
7-5, 56	60.7	1.53	Nannofossil ooze
8-3, 65	67.4	1.52	Nannofossil ooze
8-5, 53	70.3	1.53	Nannofossil ooze
9-2, 87	75.4	1.52	Nannofossil ooze
9-5, 86	79.9	1.52	Nannofossil ooze
10-2,	84.5	1.52	Nannofossil ooze; average value
11-2,	94.5	1.53	Nannofossil ooze; average value
11-5,	98.5	1.56	Nannofossil ooze; average value
12-3,	104.9	1.56	Nannofossil ooze; average value
12-4,	106.6	1.57	Nannofossil ooze; average value
13-2, 56	113.1	1.62	Indurated part
13-2, 67	113.2	1.57	Nannofossil ooze
13-5, 40	117.4	1.54	Nannofossil ooze
14-5, 76	127.3	1.58	Nannofossil ooze
15-6, 41	138.4	1.62	Indurated part only
16-6, 139	148.8	1.58	Nannofossil chalk
17-5, 67	155.7	1.57	Nannofossil chalk
17-6, 76	157.4	1.59	Nannofossil chalk
18-5, 45	165.3	1.59	Representation of hard fragments
18-5, 45	165.3	1.54	Soft part
18-6	166.0	1.63	Average value
18-6	166.0	1.54	Average value
19-2	170.6	1.59	Nannofossil chalk; average value
19-5	175.5	1.56	Nannofossil chalk; average value
20-2, 30	179.3	1.57	Average for normal soft part
20-2, 60	179.6	1.67	Average for hard fragmental part
20-2, 90	179.9	1.55	Average for normal soft part
21-5, 29	193.3	1.55	Average for normal soft part
21-5, 119	194.2	1.68	Average for hard fragmental part
22-3, 45	199.9	1.59	Hardness of this section is extremely nonuniform
22-3, 90	200.4	1.56	Hardness of this section is extremely nonuniform
22-3, 135	200.8	1.67	Hardness of this section is extremely nonuniform
23-4, 77	211.3	1.59	Nannofossil chalk
24-3, 62	219.1	1.56	Nannofossil chalk
25-1, 103	226.0	1.63	Nannofossil chalk
27-1, 65	244.6	1.66	Nannofossil chalk
29-1, 100	264.0	1.69	Nannofossil chalk
30-1, 102	273.5	1.64	In direction perpendicular to bedding
30-1, 110	283.1	1.67	In direction perpendicular to bedding
32-1,	292.2	1.72	Nannofossil chalk; average value
33-1, 20	301.2	1.93	Nannofossil chalk
34-1, 95	311.4	1.93	Nannofossil chalk
34-2, 127	313.3	1.94	
35-2, 15	321.6	2.28 ±0.02	Very hard chalk
35-2, 19	321.7	2.15 ±0.02	In direction perpendicular to bedding

TABLE 3 – *Continued*

Sample (Interval in cm)	Hole Depth (m)	Sonic Velocity (km/sec)	Remarks
36-1, 17	329.7	2.09	Consolidated volcanic ash
36-1, 33	329.8	1.93	Hard chalk
36-5, 58	336.1	1.86	Hard chalk
37-1, 128	340.3	1.87	Hard chalk
37-3, 120	343.2	1.58	Soft chalk
38-1, 147	350.0	2.06	Hard chalk
38-2, 55	350.5	1.62	Soft chalk
38-2, 147	351.5	2.01	Hard chalk
39-2, 26	359.8	2.27	Micarb chalk
39-3, 90	361.9	2.85	Hard chalk
39-3, 105	362.0	4.41	Silicified chert-like chalk
39, CC	367.0	2.09	
42, CC	395.5	4.02 ±0.08	Basalt

TABLE 4
Summary of Shipboard Geochemical Data, Site 292

Sample (Interval in cm)	Depth Below Sea Floor (m)	*p*H Punch-in	*p*H Flow through	Alkalinity (meq/kg)	Salinity (°/₀₀)	Lithologic Unit
Surface seawater reference		8.25	8.29	2.20	35.2	
2-2, 144-150	9.5	7.39	7.35	2.25	35.2	Unit 1 (Subunit 1A)
6-6, 0-6	52.0	7.51	7.44	1.37	35.2	
11-5, 144-150	99.5	7.59	7.50	1.27	35.2	
16-5, 144-150	147.0	7.26	7.45	1.37	35.2	
21-4, 144-150	193.0	7.12	7.30	1.56	35.5	Unit 1 (Subunit 1B)
26-1, 144-150	236.0	–	7.34	0.88	36.8	Unit 1 (Subunit 1C)
31-1, 144-150	283.5	–	7.45	0.68	36.8	
36-3, 142-150	334.0	–	7.32	0.78	37.7	
Average		7.37	7.39	1.27	35.95	

A virtually continuous Holocene/Pleistocene through Pliocene section is present in Cores 1 through 6 (0-50 m) with the Miocene/Pliocene boundary placed between Core 6, Sections 1-3 (45.5-49.0 m) on the basis of calcareous nannofossils and planktonic foraminifera following the zonations of Bukry (1973b) and Blow (1969).

The Miocene is represented in Cores 7 through possibly Core 19 with a significant disconformity present within Cores 11 and 12. Middle to early Miocene planktonic foraminiferal Zones N6 through N11 are missing between Cores 11 and 12 (101.5 m), representing an interval of 5 to 6 m.y. according to the scale of Berggren and Van Couvering (1973). Moreover, the calcareous nannofossil *Helicopontosphaera ampliaperta* Zone is missing within Core 12 indicating a gap of as much as 3 m.y. following the zonal scheme of Bukry (1973a).

The exceptionally thick and complete Oligocene section is represented between Cores 17 to 36 (149-330.9 m), with discrepancies in positioning of the Miocene/Oligocene and Oligocene/Eocene boundaries affecting the total amount of section assigned to this epoch. Calcareous nannoplankton zonation places the Miocene/Oligocene boundary between Sample 16, CC and Core 17, Section 1 (126-127 m). Alternately, planktonic foraminiferal zonation places this boundary between Cores 18 and 19 (169 m) while radiolarians suggest it is within Core 18. The controversial boundary between the late and early Oligocene differs widely at Site 292 depending upon the fossil group utilized. Foraminiferal and radiolarian zonations place the early Oligocene/late Eocene boundary between Cores 34 and 35 (329.5 m) based upon the extinction level of *Cribrohankinina inflata* and the radiolarian zonation of Riedel and Sanfilippo (1971). Calcareous nannofossil zonation places this boundary between Core 36, Sections 1 and 2 (331 m) based upon the zonal scheme of Bukry (1973a). These various discrepancies appear to reflect a matter of boundary definitions as all three fossil groups occur in equivalent time zones.[2]

Significantly, displaced shallow-water fossils (ostracodes in Core 39; echinoid spines in Core 36; the nannofossil *Braarudosphaera* in Cores 31, 33, and 34) were recovered from late Eocene and Oligocene samples, suggesting portions of the Benham Rise were within wave base during its early history.

[2]Epoch and subepoch boundaries appearing on core log summaries for Site 292 were arbitrarily placed solely on the basis of calcareous nannofossil zonation for ease of definition.

Preservation of calcareous microfossils is good to excellent throughout the entire sedimentary section in contrast to radiolarians which are present only in Cores 16 through 38 (149-358 m).

Calcareous Nannofossils

Abundant and diverse nannofossil assemblages were recovered from throughout the entire sedimentary section. In most cases they are quite well preserved. A complete listing of the nannofossil recovery by sample and zonal assignments is presented by Ellis (this volume).

The Holocene/Pleistocene and Pleistocene *Emiliania huxleyi*, *Gephyrocapsa oceanica*, and *G. caribbeanica* zones and subzones, can be recognized in Cores 1 through 3, Section 1. The *Emiliania annula* Subzone was not identified. All of the Pliocene subzones except the *Discoaster pentaradiatus* Subzone were observed in samples from Core 3, Section 1 through Core 6, Section 2. Only the late Miocene *Triquetrorhabdulus rugosus* and the *Ceratolithus primus* subzones were recognized in Core 6, Section 3 through Core 8, whereas all the middle Miocene subzones are present in samples from Core 9 through Core 12, Section 5. The *Helicopontosphaera ampliaperta* Zone is absent, but the remaining early Miocene subzones are present in samples from Cores 12 through 16. All of the Oligocene zones and subzones are presented in Core 17 through Core 36, Section 1, except the *Coccolithus subdistichus* Zone, which was not recognized. Samples from Core 36, Section 2 through Core 39, contain nannofossils typical of the late Eocene *Discoaster barbadiensis* Zone.

The Miocene-Oligocene boundary, as established with nannofossils, is based on the last occurrence of *Cyclicargolithus abisectus* and occurs between Samples 16, CC, and 17-1, 126-127 cm. The Oligocene-Eocene boundary is recognized by the last occurrence of *Discoaster saipanensis* which occurs in Sample 36-2, 78-79 cm; the last occurrence of *Discoaster barbadiensis* in Sample 36, CC provides supplementary evidence.

Foraminifera

Site 292 provides a continuous sequence of planktonic foraminiferal faunas from the Pleistocene/Holocene to the late Eocene. A distinct biostratigraphic gap occurs between Cores 11 and 12 (101.5 m) according to foraminiferal zonation and indicates parts of the early middle Miocene and early Miocene (Zones N11 to N5) are missing. This gap in foraminiferal zones appears to correspond to an unconformity in the seismic reflection record for this site. Another hiatus may be expected in Core 6 (44.5-54.0 m), or between Cores 6 and 9, judging from an extraordinary relationship between the presumed time duration and the measured core length of this interval. A short and continuous sequence between Core 6, Sections 2 and 6 appears to represent all of Zones N17 and N16 encompassing about 6 m.y., according to the time scale of Berggren (1972), if the base of Zone N16 could be defined by the initial appearance of *Globorotalia* (*Turborotalia*) *acostaensis* in Core 6, Section 6. However, this latter species appears initially at Site 292 with only rare abundance and without any ancestral taxon which should normally be recovered from underlying cores. Thus, the abrupt and rare first occurrence of *Globorotalia* (*T.*) *acostaensis* at Site 292 may represent an ecological invasion of this species from elsewhere at a point in time later than its true first evolutionary appearance normally used to mark the base of Zone N16. In turn, this suggests an additional possible hiatus may be present at some horizon between Cores 6 through 9 (44.5-82.5 m), although seismic records at this site do not reveal any obvious breaks within this interval.

It should be noted that the rate of sedimentation increases abruptly below the interrupted sequence encompassing Zones N11 through N5 (Figure 6). The lower portion at Site 292 constitutes an Oligocene sequence of extraordinarily great thickness, and detailed biostratigraphic work on these sediments may result in this sequence becoming a standard biostratigraphic reference section. In fact, current work indicates that the stratigraphic ranges of many "Oligocene" species at Site 292 are different from those reported in the standardized sections of Banner and Blow (*in* Eames et al., 1962) and Blow (1969), and that their taxonomy may also need revision once specimens from Site 292 have been compared with the appropriate holotypes.

Radiolarians and Silicoflagellates

No radiolarians were recovered from Cores 1 through 15, and sediments retained in Sample 16, CC (149 m) contain only rare, poorly preserved specimens. Samples from Core 17 (149-158.5 m) and Core 18, Section 1 (158.5-160 m) are assigned to the *Calocycletta virginis* Zone. Samples from Core 18, Section 3 (163 m) to Core 24 (225 m) are thought to encompass the *Lychnocanoma elongata* and *Dorcadospyris atenchus* zones of Riedel and Sanfilippo (1971), but the absence of guide species makes subdivision impossible.The *Theocyrtis tuberosa* Zone is recognized between Cores 25 to 34 (225-320 m), and the *Thyrsocyrtis bromia* Zone from Core 35 through Core 38, Section 2 (348.5-358.5 m). Radiolarians are completely absent in the remaining sections of Core 38, as well as in Core 39, where sediments are more lithified and several chert layers are present.

No silicoflagellate specimens were observed.

SUMMARY AND INTERPRETATIONS

Summary

Continuous coring at Site 292 revealed that the sedimentary blanket covering the southeastern flank of Benham Rise consists of 367.5 meters of Pleistocene through late Eocene calcareous oozes and chalks representing a superb record of planktonic productivity over the rise during the past 37 m.y. Basalt basement was encountered from 367.5 to 443.5 meters; however, the actual sediment-basalt contact was not recovered.

Distinct lithologic breaks are absent in the sedimentary sequence, as it represents one long series of nannofossil oozes that have been lithified into chalk at depth. Consequently, all of these sediments were placed in Unit 1 with three subunits defined by increasing proportion of chalk; subtle lithologic boundaries within the ooze-chalk column thus represent diagenetic events rather than distinct changes in the nature of sedimentation. Subunit 1A (0-152 m) represents an unconsolidated nannofossil ooze of Pleistocene through early Miocene age containing varying amounts of volcanic debris. Subunit 1B (152-223 m) is marked by alternating bands of chalk and soft nannofossil ooze and is Oligocene in age. Subunit 1C (223-367.5 m) is characterized by a high proportion of chalk with only scattered horizons of plastic nannofossil ooze. Ash-rich layers, siliceous nodules, and displaced shallow-water microfossils are also present in lower portions of this subunit. Interestingly, occurrence of siliceous nodules is coincident with the disappearance of radiolarians in Cores 38 and 39 (348.5-367.5 m) implying dissolution and mobilization of the hydrous silica forming the tests of these protists.

One of the most significant rewards of drilling at Site 292 was the recovery of a near-continuous Pleistocene through late Eocene calcareous biostratigraphic record preserved in the ooze-chalk sequence of Unit 1. Abundant and well-preserved calcareous nannofossils and planktonic foraminifera are present throughout the entire sedimentary column attesting to deposition of this sequence above the lysocline during the late Eocene to Recent interval. Curiously, radiolarians are absent in the upper portion of the column (Cores 1 through 15), but appear in varying abundance in Oligocene and Eocene sediments. It is also important to note that several middle and early Miocene planktonic foraminiferal and nannofossil zones are missing at the base of Core 11 and in Core 12 denoting a significant disconformity representing an apparent gap of 5 to 6 m.y. This paleontologic gap correlates well with a diffuse reflector at 0.14 sec on the *Glomar Challenger* seismic profiles which can in turn be traced across the entire rise. In all likelihood, this represents a middle to early Miocene interval of erosion or nondeposition.

Unit 2 (367.5-443.5 m) consists of uniform interstitial to subophitic tholeiitic basalts based upon study of the 35.5 meters of this rock recovered. No direct evidence for individual flow units was found, but the presence of phenocrysts indicates a two-stage history for the basalt. Two significant radiometric dates were obtained by whole rock K-Ar analysis of basalt sampled in Core 45 (417.4 m) and in Core 47 (436.2 m) yielding ages of 38.2 ±1 m.y. and 37.1 ±1 m.y., respectively (McKee, this volume). Limits of analytical uncertainty yield a maximum-minimum age range of 39.2 to 36.1 m.y. for these samples, indicating it is late Eocene in age according to the time scale of Berggren (1972). This age is consistent with the late Eocene fossil age determined for chalks immediately overlying the basalt at Site 292, and indicates deposition above the calcium carbonate compensation depth begins almost immediately after formation of the basalt. No evidence of a baked contact was encountered and an extensive basalt sequence is assumed. The size and nature of vesicules in the basalt indicate it was extruded at a water depth of 500 meters or less.

Interpretation

The definitive late Eocene basement age obtained, along with the evidence of shallow-water extrusion of basalts and Eocene-Oligocene shallow-water microfossils, indicates that the Benham Rise must have formed as a small midplate rise during mid to late Eocene time. General motion of the Philippine plate dictates that the rise first appeared southeast of its present location relative to the Asian plate and ultimately moved northwest toward a Cretaceous-Oligocene (?) trench represented by ophiolitic rocks and melanges in the Sierra Madre Range of eastern Luzon (Irving, 1952). Moreover, the shallow-water basalts and displaced shallow-water microfossils also suggest that portions of the rise hovered at an elevation much shallower than its present mean depth allowing downslope transport of debris onto the flanking plateaus and providing a suitable platform for the continuous accumulation of carbonate-rich biogenous oozes. A lack of displaced microfossils in post-Early Oligocene sediments points to subsidence of the rise-crest as it traveled westward.

A major unconformity between the uplifted and intensely folded Cretaceous-Oligocene trench complex exposed on Luzon and overlying early Miocene shallow water limestones (Irving, 1952; Bandy, 1963) implies cessation of subduction in the Luzon Trench during the late Oligocene-early Miocene interval with subsequent uplift of the subduction complex prior to deposition of the wide-spread orbitoid limestone unit. It is tempting to correlate this major event with a possible collision of the Benham Rise with the dying Luzon Trench in the late Oligocene-early Miocene. The proposed collision might well have triggered cessation of subduction in the trench, and at the same time caused uplift of the Benham Rise to a depth where vigorous midwater currents caused erosion or prevented continuous deposition of pelagic debris during early to mid Miocene. This would have created the apparent widespread zone of multiple disconformities detected in the 101.5 to 111.0 meter interval at Site 292. This particular scenario would have the rise again subside to its present depth during mid to late Miocene time in concert with subsidence of the sea floor and basin formation immediately west of the rise (Bandy, 1963). In any event, explanations of the apparent early to mid Miocene disconformities must account for a "one time" event in the history of the rise which would appear to rule out long-term climatically induced bottom currents. The currents, if present in the mid Miocene, should also be operating today under an even more vigorous climatic gradient. No evidence of significant post-mid Miocene discontinuities was found.

Volcanic ash, in discrete layers as well as a more uniformly distributed minor constituent, is found throughout the stratigraphic column in Hole 292. A detailed study of volcanic debris at Site 292 by Donnelly (this volume) documents that peaks in volcanic activity occurred near the Oligocene-Miocene boundary, during the late Miocene, with maximum activity occurring in Pleistocene-Recent time. A moderate level of volcanic activity occurred throughout late Eocene-Oligocene time in concert with activity along the Palau-Kyushu Ridge. The Pleistocene-Recent concentration of volcanic debris at Site 292 likely reflects volcanism associated with the Luzon arc system during this time.

The 200 to 500 meter thick blanket of late Eocene through Pleistocene pelagic chalks and oozes covering the Benham Rise represents a record of continuous but variable productivity over this feature generated independently of its tectonic history. These deposits are a result of both local and ocean-wide variations in surface circulation, most especially variations in the vigor of vertical circulation. Divergence and overtopping of the Benham Rise by midwater currents in all likelihood aided overturn of otherwise nutrient-poor surface waters, whereas its position at the distal end of the north equatorial current has allowed the local water column to be continuously tuned to major climatically induced variations of Pacific circulation and equatorial productivity. In light of these relationships, it is instructive to note that the estimated rates of sedimentation over the rise during late Eocene through early Miocene and the late Miocene through Pleistocene are high (12 m/m.y. and 8.5 m/m.y., respectively; Figure 6). The Oligocene figure exceeds the assumed "normal" rate of deposition for calcareous oozes (Winterer, 1973), denoting an unusually high rate of planktonic productivity in this area during this period.

The two intervals of maximum productivity and pelagic deposition on the Benham Rise in the Oligocene and late Neogene correspond to periods of intense polar refrigeration, steep pole-to-equator climatic gradients, and resulting vigorous surface circulation (Ingle, 1967; Heath, 1969; Margolis and Kennett, 1971; Kennett and Watkins, 1974). The relatively great thickness of the Oligocene oozes at Site 292 is especially impressive and offers solid evidence of an equatorial response to the severity and length of Oligocene refrigeration now well established in the Southern Ocean (Shackleton and Kennett, in press). Productivity in the Oligocene interval was perhaps also aided by intrusion of cold circum-Antarctic surface water into the mid latitudes of the Pacific basin due to the migrating Australia-Antarctica barrier (Kennett et al., 1973, 1974). In contrast, portions of the early and mid Miocene are now widely recognized as a period of climatic amelioration in the Pacific (Addicott, 1969), poleward migration of warm isotherms, and sluggish circulation with a resulting lower rate of productivity.

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APPENDIX A
Summary of X-Ray, Grain Size, and Carbon-Carbonate Results, Site 292

Section	Sample Depth Below Sea Floor (m)	Lithology	Age	Bulk Sample (C) Major Constituent 1	2	3	2-20μm Fraction (c)(d) Major Constituent 1	2	3	<2μm Fraction (c) Major Constituent 1	2	3	Grain Size Sand (%)	Silt (%)	Clay (%)	Classification	Carbon Carbonate Total (%)	Organic (%)	$CaCO_3$ (%)	Comments
292-1-1	0.7	Subunit 1A Nannofossil ooze	Late Oligocene to late Pleistocene (Holocene)														2.1	0.2	16	
292-1-2	2.4			Calc.	Plag.	Quar.	Plag.	Quar.	Augi.	Mont.	Mica	Plag.	7.2	68.1	24.7	Clayey silt				Amph. (3.8%) in bulk; Clin. in bulk (1.3%), 2-20μm (1.9%); <2μm (3.0%)
292-1-4	5.6																3.2	0.1	26	
292-2-1	7.8																2.5	0.1	19	
292-2-2	8.9			Calc.	Plag.	Quar.	Plag.	Quar.	Mica	Mont.	Quar.	Plag.								Amph. (4.5%), Augi (9.3%) in 2-20μm
292-3-1	17.4			Calc.	Plag.	Quar.	Plag.	Quar.	Mica	Mont.	Plag.	Quar.					4.0	0.1	32	Amph. (4.1%) in 2-20μm, Augi. (7.5%) in 2-20μm
292-3-2	18.3-18.4			Calc.	Plag.	Mont.	Plag.	Augi.	Quar.	Mont.	Plag.	Quar.					11.3	0.0	94	Augi. in bulk (8.9%), Amph. (2.3%) in 2-20μm, Augi. (7.9%) in <2μm
292-3-3	19.0												6.7	43.2	50.1	Silty clay				
292-4-4	30.6			Calc.	Plag.	Quar.	Plag.	Quar.	Mica	Mont.	Plag.	Quar.					6.3	0.1	52	Amph. (1.5%) in bulk, in 2-20μm (6.5%) Clin. (3.5%) in <2μ; Anal. (1.1%) in 2-2μm
292-4-4	31.5																7.6	0.1	63	
292-5-6	43.4			Calc.	Plag.	Quar.	Plag.	Quar.	Mont.	Mont.	Plag.	Quar.					8.3	0.1	68	Clin. (2.6%), Anal. (0.9%) and Amph. (6.4%) in 2-20μm
292-7-4	59.4																9.0	0.1	75	
292-8-5	70.1																9.9	0.1	82	
292-9-5	79.8																8.2	0.1	68	
292-11-2	94.3																7.2	0.1	59	
292-12-2	104.1																10.1	0.1	84	
292-12-4	107.3																9.2	0.1	76	
292-13-3	114.8																9.5	0.1	79	
292-13-5	117.2			Calc.	Mont.	Plag.	Mont.	Plag.	K-Fe	Mont.	Quar.	–								
292-14-5	127.3																8.6	0.1	71	
292-15-6	137.9																9.6	0.1	79	
292-16-3	143.4			Calc.	Plag.	Mont.	Plag.	Amph.	Mont.	Mont.	Plag.	Clin.								Amph. (5.9%), Clin. (0.9%) in Bulk
292-16-6	148.3																9.7	0.1	80	
292-17-4	154.4																9.7	0.1	80	
292-17-5	156.2	Subunit 1B Nannofossil ooze with interbedded chalk	Late Oligocene										23.0	63.9	13.1	Sandy silt				
292-18-5	165.2																10.2	0.0	85	
292-19-5	174.5			Calc.	Plag.	Quar.	Plag.	Augi.	Quar.	Mont.	Plag.	Augi.								Amph. in 2-20μm (1.9%) Hema. in <2μm (3.9%)
292-22-2	199.2																10.7	0.1	89	
292-22-3	200.0												20.6	47.6	31.8	Sand-silt-clay				
292-23-1	206.2												5.9	58.7	35.4	Clayey silt				
292-23-4	211.3																9.3	0.1	77	
292-24-3	219.2	Subunit 1C Nannofossil chalk with interbedded ooze and cherty concretions	Late Eogene to late Oligocene														10.3	0.1	85	
292-25-1	226.1																9.7	0.1	81	
292-26-2	237.1																10.1	0.1	88	
292-27-1	244.9																11.0	0.1	91	
292-29-1	264.0																11.1	0.1	92	
292-30-1	273.5																11.1	0.1	92	
292-31-2	284.1																8.5	0.1	70	
292-33-2	303.2																10.8	0.1	90	
292-34-2	313.4																10.6	0.1	88	
292-35-2	322.8			Calc.	Plag.	Mont.	Plag.	Augi.	Quar.	Mont.	Plag.	Quar.					9.8	0.1	81	
292-36-4	334.5																9.0	0.1	74	
292-37-2	341.7																10.0	0.1	83	
292-37 3	343.2			Plag.	Calc.	Quar.	Plag.	Augi.	Quar.	Mont.	Plag.	Augi.	17.1	64.2	18.7	Clayey Silt				Augi. in bulk (4.7%)
292-38-2	350.5																5.1	0.0	42	
292-39-3	361.5			Calc.	–	–	Clin.	Plag.	Mont.	Mont.	Plag.	Clin.					11.1	0.0	92	

Note: Complete results of X-ray, Site 292, will be found in Part V, Appendix I. X-ray mineralogical legend in Appendix A, Chapter 2.

[a]Two plagioclases were combined for samples 292-13-5, 16-3, 19-5, and 37-3

[b]U-1 peaks at 9.46Å, 4.16Å, and 2.705Å – recorded for Samples 292-4-4, (Present) and 5-6 (Trace).

Site 292 Hole Core 1 Cored Interval: 0.0-6.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE-HOLOCENE	Emiliania huxleyi		Ag			1	0.5, 1.0	VOID		170, 107	
			Ag			2				100	
LATE PLEISTOCENE	N23 Gephyrocapsa oceanica		Ag			3				50, 85	
			Ag			4				110	
		Ag	Ag	B		Core Catcher				CC	

UNIT 1

Intense to moderate deformation; moderate yellowish brown (10YR 5/4) throughout except for gray (N3, N4, N5) ash layers; vague streaking of colors; some dusky brown (5YR 2/2), and dark yellowish brown (10YR 4/2).

CLAY/GLASS-RICH NANNOFOSSIL OOZE
Smears: 1-70, 2-100, 3-85

Texture	Composition
60-68% Silt	53-55% Nannofossils
25-30% Clay	20% Clay minerals
7-10% Sand	15% Volcanic glass
	2- 4% Feldspar
	2% Heavy minerals
	1- 4% Foraminifera
	1- 2% Sponge spicules
	Tr% Radiolarians

10YR 5/4

5YR 2/2

CLAY-RICH NANNOFOSSIL OOZE
(or NANNOFOSSIL OOZE)
Smears: 3-50, 4-110

Texture	Composition
90% Clay	69% Nannofossils
10% Silt	15% Clay minerals
	7% Foraminifera
	5% Volcanic glass
	2% Opaques
	1% Feldspar
	1% Heavy minerals

10YR 5/4

NANNOFOSSIL-RICH VOLCANIC ASH (Minor Lith)
Smear: 1-107

Texture	Composition
90% Silt	33% Volcanic glass
10% Clay	17% Nannofossils
	17% Feldspar
	17% Heavy minerals
	8% Foraminifera
	8% Radiolarians

10YR 4/2

10YR 5/4

Grain Size 2-94
7.2, 68.1, 24.7

Carbon Carbonate 1-70
2.1, 0.2, 16

Carbon Carbonate 4-110
3.2, 0.1, 26

X-ray 2-92 (Bulk)
39.1% Calc
21.7% Plag
15.1% Quar
9.7% Mica
7.5% Mont
3.8% Amph
1.9% Chlo
1.3% Clin

10YR 5/4 CC: Foraminifera-rich nannofossil ooze (Minor Lith)

Explanatory notes in chapter 1

Site 292 Hole Core 2 Cored Interval: 6.5-16.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE	N23		Ag			1	0.5, 1.0	VOID		90	
			Ag			2		GEOCHEM SAMPLE		65, 74, 100	
	N22 Gephyrocapsa oceanica		Ag			3				78	
		Ag	Ag	B		Core Catcher				CC	

Grayish orange (10YR 7/4); stiff but intensely deformed; darkening in ash-rich layers; no apparent bedding.

FORAM-RICH NANNOFOSSIL OOZE
Smear: 1-90

Texture	Composition
85% Clay	79% Nannofossils
15% Silt	11% Foraminifera
	3% Volcanic glass
	2% Heavy minerals
	3% Feldspar
	2% Clay minerals

10YR 7/4

Volcanic detritus increases to 10% near middle of Section 2; detritals of volcanic glass, amphibole and plagioclase - 20%.

CLAY/FORAMINIFERA-RICH NANNOFOSSIL OOZE
Smears: 2-65, 2-74, 3-78

Texture	Composition
75% Clay	50% Nannofossils
25% Silt	15% Foraminifera
	15% Clay minerals
	10% Feldspar
	5% Volcanic glass
	5% Heavy minerals

NANNOFOSSIL/CLAY-RICH ASH (Minor Lith)
Smears: 2-100, CC

Texture	Composition
70% Clay	50% Volcanic glass
20% Silt	15% Nannofossils
10% Sand	10% Feldspar
	10% Clay minerals
	5% Heavy minerals
	5% Radiolarians
	5% Foraminifera
	Tr% Sponge spicules

Carbon Carbonate 1-129
2.5, 0.1, 19

X-ray 2-89 (Bulk)
32.8% Calc
31.0% Plag
14.4% Quar
12.8% Mica
6.2% Mont
2.9% Chlo

Explanatory notes in chapter 1

Site 292 Hole Core 3 Cored Interval: 16.0-25.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE	N22 Gephyrocapsa caribbeanica Subzone		Ag			1	0.5, 1.0	VOID		*114	10YR 7/4	
LATE PLIOCENE	Cyclococcolithina macintyrei Subzone		Cg			2				*4, *49, *79, *87, *123	10YR 2/2, 10YR 6/2, 10YR 2/2, 5YR 8/1, 10YR 5/4	
			Ag			3				*75	10YR 7/4	
	N21 Discoaster tamalis Subzone		Ag			4				*2, *75, *133		
		Ag	Ag	B		Core Catcher				*CC		

Grayish orange (10YR 7/4); moderate to intense drilling deformation - soft; color variations pale yellow brown (10YR 6/2) to moderate yellow brown (10YR 5/4) to dusky yellow brown (10YR 2/2) and pink gray (5YR 8/1).

CLAY/FORAMINIFERA-RICH NANNOFOSSIL OOZE
Smears: 1-114, 3-75

Texture	Composition
85% Clay	66% Nannofossils
15% Silt	17% Foraminifera
	13% Clay minerals
	2% Volcanic glass
	1% Heavy minerals
	1% Feldspar

CLAY-RICH MICARB OOZE
Smears: 2-49, 2-123, 4-2

Texture	Composition
70% Clay	68% Micarb
20% Sand	20% Clay minerals
10% Silt	9% Foraminifera
	2% Heavy minerals
	1% Feldspar

Lithology is locally nannofossil and foraminifera-rich; Smear 2-87 is a micarb-foraminifera ooze.

Other lithologies for core include: clay-rich nannofossil ooze (4-75); micarb-nannofossil-rich clay (4-133); foraminifera-nannofossil rich ash (2-79); nannofossil ooze (CC) and volcanic ash (2-4).

Grain Size 3-3
6.7, 43.2, 50.1

Carbon Carbonate 1-140
4.0, 0.1, 32

Carbon Carbonate 2-86
11.3, 0.0, 94

X-ray 1-140	X-ray 2-80 (Bulk)
66.8% Calc	46.4% Calc
14.1% Plag	29.7% Plag
7.4% Quar	8.9% Augi
4.5% Mont	5.3% Mont
4.3% Mica	4.8% Quar
2.8% Chlo	3.5% Mica
	1.5% Chlo

Explanatory notes in chapter 1

Site 292 Hole Core 4 Cored Interval: 25.5-35.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE PLIOCENE	N21 Discoaster tamalis Subzone		Ag			1	0.5, 1.0	VOID				
			Ag			2				*91, *92		
			Ag			3					10YR 7/4	
			Ag			4				*60	10YR 8/2	
EARLY PLIOCENE	N19 Discoaster asymmetricus Subzone		Ag			5		GEOCHEM SAMPLE			10YR 7/4	
		Ag	Ag	B		Core Catcher				*CC	10YR 7/4	

Core generally grayish orange (10YR 7/4) in color and intensely deformed throughout - color variations are minor; noticeable in Section 4.

NANNOFOSSIL OOZE
Smears: 2-91, 2-92, 4-60

Texture	Composition
85-100% Clay	76-85% Nannofossils
15% Silt	7-10% Clay minerals
	3-8% Foraminifera
	2% Volcanic glass
	1% Opaques
	1% Feldspar

Locally foraminifera-bearing (2-92) and clay-bearing (CC) and clay-rich.

Carbon Carbonate 4-57
6.3, 0.1, 52

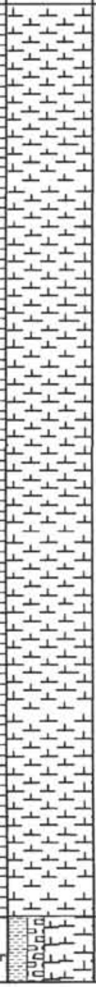
Carbon Carbonate 4-145
7.6, 0.1, 63

X-ray 4-59 (Bulk)
82.6% Calc
6.0% Plag
4.4% Quar
2.0% Mont
1.8% Mica
1.7% Chlo
1.5% Amph

Explanatory notes in chapter 1

Site 292 Hole Core 5 Cored Interval: 35.0-44.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	N19 D. asymmetricus Subzone		Ag			1	0.5, 1.0					
	Sphenolithus neoabies Subzone		Ag			2				*75		
	Ceratolithus rugosus Subzone		Ag			3					10YR 7/4	
			Ag			4				*75		
			Am			5					10YR 7/4 to 10YR 8/2	
			Am			6				*75		
		Ag	Ag	B		Core Catcher				*CC	10YR 7/4	



Color grayish orange (10YR 7/4); intense deformation; colors are consistent through core except in Section 5, where slight color change to pale gray orange brown (10YR 8/2) occurs.

NANNOFOSSIL OOZE
Smears: 2-75, 4-75, 6-75

Texture	Composition
100% Clay	84-90% Nannofossils
	5- 8% Clay minerals
	2- 3% Opaques
	2% Foraminifera
	1% Feldspar
	Tr- 2% Heavy minerals

CLAY/MICARB-RICH/NANNOFOSSIL OOZE
Smear: CC

Texture	Composition
80% Clay	60% Nannofossils
20% Silt	20% Clay minerals
	11% Micarb
	7% Foraminifera
	1% Heavy minerals

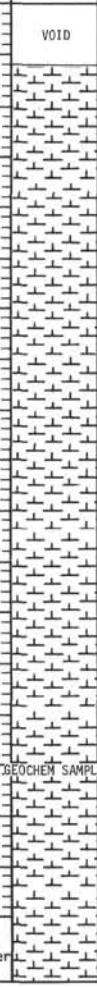
Carbon Carbonate 6-88
8.3, 0.1, 68

X-ray 6-82 (Bulk)
95.1% Calc
2.9% Plag
1.4% Quar
0.7% Chlo

Explanatory notes in chapter 1

Site 292 Hole Core 6 Cored Interval: 44.5-54.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	N19 Ceratolithus actus Subzone	Ag	Am			1	0.5, 1.0	VOID				
	N18		Ag			2						
LATE MIOCENE	N17 Triquetrorhabdulus rugosus Subzone	Ag	Ag			3				*99	10YR 7/4	
		Ag	Ag			4						
	N17 Ceratolithus primus Subzone	Ag	Ag			5		GEOCHEM SAMPLE				
	N16	Ag	Ag			6						
	N15	Ag	Ag	B		Core Catcher				*CC	10YR 7/4	



Firm with moderate to intense drilling deformation; colors are grayish orange (10Y 7/4) color to very pale orange (10YR 8/2); very consistent core

NANNOFOSSIL OOZE
Smears: 3-99, CC

Texture	Composition
95% Clay	87-95% Nannofossils
5% Silt	3% Clay minerals
	2% Micarb
	Tr- 2% Feldspar
	0- 9% Foraminifera
	0- 1% Volcanic glass

Explanatory notes in chapter 1

Site 292 Hole Core 7 Cored Interval: 54.0-63.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	N15 Ceratolithus primus Subzone		Ag			1	0.5 1.0				Entire core moderately deformed; consistent pale orange color (10YR 8/2).
			Am			2					
						3					10YR 8/2
			Am			4				*90	
						5					
			Ag			6				*97	
		Ag	Ag	B		Core Catcher				*CC	10YR 8/2

NANNOFOSSIL OOZE
Smears: 4-90, CC

Texture	Composition
97% Clay	88% Nannofossils
2- 3% Silt	10% Clay minerals
	1% Heavy minerals
	1% Feldspar

ASH-RICH NANNO OOZE
Smear: 6-97

Texture	Composition
70% Clay	70% Nannofossils
30% Silt	10% Zeolite
	10% Volcanic glass
	5% Clay minerals
	3% Feldspar
	2% Heavy minerals

Carbon Carbonate 4-90
9.0, 0.1, 75

Explanatory notes in chapter 1

Site 292 Hole Core 8 Cored Interval: 63.5-73.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	N15 Ceratolithus primus Subzone					1	0.5 1.0				Core slightly deformed and stiff; color-pale orange yellow (10YR 7/3) throughout.
			Ag			2					
						3				*90	10YR 7/3
			Ag			4					
						5					
			Am			6					
		Ag	Ag	B		Core Catcher				*CC	10YR 8/2

NANNOFOSSIL OOZE
Smear: 3-90

Texture	Composition
96% Clay	82% Nannofossils
4% Silt	10% Clay minerals
	5% Micarb
	2% Heavy minerals
	1% Zeolite

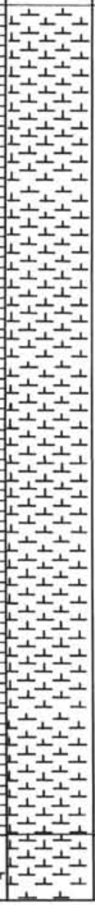
Core catcher is micarb-rich with 26% micarb and 70% nannofossils.

Carbon Carbonate 5-56
9.9, 0.1, 82

Explanatory notes in chapter 1

Site 292 Hole Core 9 Cored Interval: 73.0-82.5 m

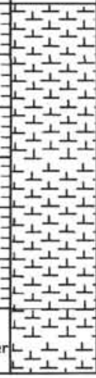
AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	N15		Ag			1	0.5, 1.0	VOID				Deformation slight, and core is firm; color very pale orange (10YR 8/2) throughout.
			Ag			2						NANNOFOSSIL OOZE Smears: 5-75, CC Texture: 97% Clay, 3% Silt Composition: 88-93% Nannofossils; 5- 7% Clay minerals; 1% Volcanic glass; 1% Heavy minerals; 0- 3% Zeolite; 0- 2% Micarb; 0- 2% Foraminifera Locally clay-rich. Carbon Carbonate 5-75 8.2, 0.1, 68
						3					10YR 8/2	
	N14 Discoaster hamatus		Ag			4						
						5				*75		
			Ag			6						
		Ag	Ag	B		Core Catcher				*CC	10YR 8/2	



Explanatory notes in chapter 1

Site 292 Hole Core 10 Cored Interval: 82.5-92.0 m

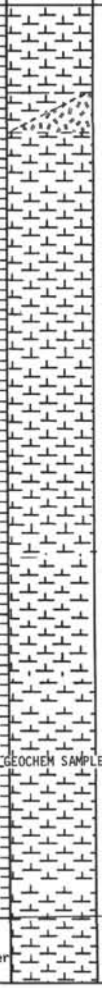
AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	N14 Gatinaster coalitus / Discoaster kugleri Subzone		Ag			1	0.5, 1.0			*130	10YR 7/4	Slight drilling deformation-firm; color gray orange (10YR 7/4) with slight color changes to gray orange (10YR 7/3) NANNOFOSSIL OOZE Smears: 1-130, 2-145, CC Texture: 96-100% Clay, 0- 4% Silt Composition: 85-92% Nannofossils; 7-10% Clay minerals; 2- 3% Foraminifera; 1- 5% Micarb; 1% Zeolite; 0- 2% Heavy minerals
	N13		Ag			2				*145	10Y 7/3	
		Ag	Ag	B		Core Catcher				*CC	10YR 7/4	



Explanatory notes in chapter 1

Site 292 Hole Core 11 Cored Interval: 92.0-101.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	COLOR
MIDDLE MIOCENE	N12, Coccolithus miopelagicus Subzone	Ag	Ap			1	10YR 6/2
			Ap			2	
		Ag	Ap			3	
			Am			4	10YR 7/4
		Ag	Ap			5	
	N12, Sphenolithus heteromorphus	Ag	Ap			6	
		Ag	Ag	B		Core Catcher	10YR 7/4



Lithology samples: Section 1: 95, 122; Section 2: 75. METERS: 0.5, 1.0.

LITHOLOGIC DESCRIPTION

Slight deformation; color gray orange (10YR 7/4) except ash beds; burrow mottling and vague, thick (10-14 cm) bedding which is alternation of homogeneous and burrow-mottled beds

NANNOFOSSIL OOZE
Smear: 2-75

Texture	Composition
100% Clay	76% Nannofossils
	10% Clay minerals
	10% Foraminifera
	2% Micarb
	1% Zeolite (Clinoptilolite)
	1% Volcanic glass

VOLCANIC ASH (Minor Lith)
Smear: 1-122

Texture	Composition
87% Clay	82% Clay, Volcanic ash
10% Silt	10% Quartz, Feldspar
3% Sand	5% Heavy minerals
	2% Micarb
	1% Nannofossils

NANNOFOSSIL ASH (Minor Lith)
Smear: 1-95

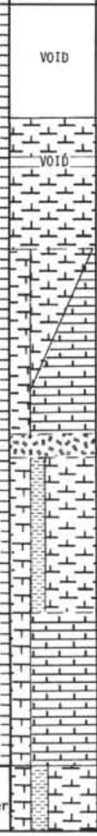
Texture	Composition
89% Clay	50% Clay, Volcanic ash
10% Silt	38% Nannofossils
1% Sand	4% Quartz, Feldspar
	3% Zeolite
	2% Heavy minerals
	2% Foraminifera
	1% Micarb

Carbon Carbonate 2-75
7.2, 0.1, 59

Explanatory notes in chapter 1

Site 292 Hole Core 12 Cored Interval: 101.5-111.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	COLOR
EARLY MIOCENE (FORAM)	N5	Ag	Ap			1	
			Ap			2	
MIDDLE MIOCENE	Sphenolithus heteromorphus	Ag	Am			3	10YR 7/3
			Am			4	10YR 6/2, 10YR 8/2
EARLY MIOCENE	N4, Sphenolithus belemnos		Am			5	10YR 7/4, 10YR 7/3
		Ag	Ag	B		Core Catcher	10YR 7/3



Lithology samples: Section 2: 110; Section 4: 30. METERS: 0.5, 1.0.

LITHOLOGIC DESCRIPTION

Slight deformed-stiff; color pale gray orange (10YR 7/4) with some pale yellow brown (10YR 6/2) and very pale orange (10YR 8/2); some vague bedding (7-11 cm thick) and slight color mottling; semilithification to chalk increases with depth.

FORAMINIFERA-RICH NANNOFOSSIL OOZE
Smear: 2-110

Texture	Composition
90% Clay	79% Nannofossils
10% Silt	12% Foraminifera
	9% Clay mineral
	Tr% Volcanic glass

Volcanic ash beds at 35-40 cm (Section 2) and 120-150 cm (Section 3).

CLAY AND FORAMINIFERA-RICH NANNOFOSSIL OOZE
Smear: 4-30

Texture	Composition
90% Clay	69% Nannofossil
10% Silt	15% Clay minerals
	15% Foraminifera
	1% Quartz, Feldspar
	Tr% Zeolite

Carbon Carbonate 2-110
10.1, 0.1, 84

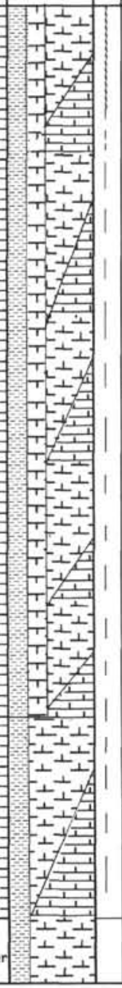
Carbon Carbonate 4-130
9.2, 0.1, 76

Explanatory notes in chapter 1

Site 292 Hole Core 13 Cored Interval: 111.0-120.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHO. SAMPLE	
EARLY MIOCENE	N5 / Sphenolithus belemnos		Am			1	0.5, 1.0		
						2			10YR 7/3
			Am			3		*75	
			Am			4			10YR 7/3 and 10YR 8/2
			Ap, Am			5			10YR 7/3; 10YR 8/2
	N4 / Discoaster druggii Subzone		Am			6		*17	10YR 7/3
		Ag	Am	B		Core Catcher			10YR 7/3

LITHOLOGY / DEFORMATION



LITHOLOGIC DESCRIPTION

Soupy in higher sections to slight drilling deformation lower in core; color pale gray orange (10YR 7/3); alternation of hard-soft layers; hard beds ≈3-6 cm thick, soft beds (10-15 cm thick); mottling noticed.

CLAY/FORAMINIFERA-RICH NANNOFOSSIL OOZE
Smear: 3-75

Composition
73% Nannofossils
15% Clay minerals
12% Foraminifera

CLAY-RICH NANNOFOSSIL OOZE
Smear: 6-17

Texture
90% Clay
8% Silt
2% Sand

Composition
66% Foraminifera
20% Clay minerals
5% Foraminifera
2% Opaques
2% Feldspar
1% Heavy minerals
1% Volcanic glass

Carbon Carbonate 3-75
9.5, 0.1, 79

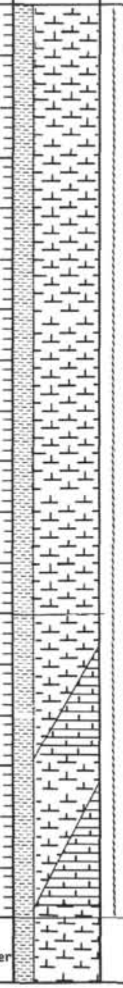
X-ray 5-16 (Bulk)
81.1% Calc
9.7% Mont
3.4% Plag
2.5% Mica
2.3% K-Fe
1.1% Quar

Explanatory notes in chapter 1

Site 292 Hole Core 14 Cored Interval: 120.5-130.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHO. SAMPLE	
EARLY MIOCENE	Discoaster druggii Subzone		Am			1	0.5, 1.0		
			Ap			2			
	Discoaster deflandrei Subzone		Am			3			
						4			10YR 7/3
	N4		Ap			5		*75	
	D. deflandrei Subzone					6			
		Ag	Am	B		Core Catcher			10YR 7/3

LITHOLOGY / DEFORMATION



LITHOLOGIC DESCRIPTION

First 4 sections "soupy" with drilling breccia; colors (pale) yellow gray orange (10YR 7/3) and (10YR 8/2); mottling noted; alternation of indurated beds in Section 5 very noticeable but contacts are indistinct, faint bedding noticeable by colors and dark streaking occurs in Section 6.

CLAY-RICH NANNOFOSSIL OOZE
Smear: 5-75

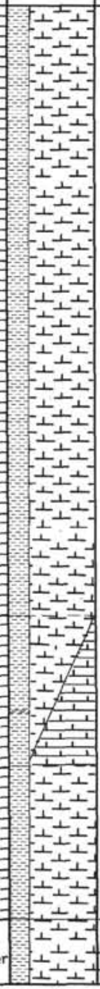
Composition
73% Nannofossils
20% Clay Minerals
6% Foraminifera
1% Zeolite

Carbon Carbonate 5-75
8.6, 0.1, 71

Explanatory notes in chapter 1

Site 292 Hole Core 15 Cored Interval: 130.0-139.5 m

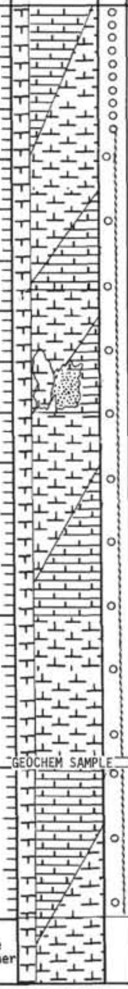
AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY MIOCENE	N4 Discoaster deflandrei Subzone		Cp			1	0.5, 1.0					Very soupy; pale yellow orange color (10YR 7/3) with some pale yellow brown (10YR 6/2); some local induration; mottling occurs throughout core.
						2						CLAY-RICH NANNOFOSSIL OOZE Smears: 6-45, 6-124 Texture: 100% Clay Composition: 74-76% Nannofossils; 16-19% Clay minerals; 7% Foraminifera; Tr% Zeolite Carbon Carbonate 6-44 9.6, 0.1, 79
			Ap			3					10YR 7/3	
						4						
						5					10YR 6/2	
			Ap			6				*45, *124	10YR 7/3	
		Ag	Am	B		Core Catcher					10YR 8/2	



Explanatory notes in chapter 1

Site 292 Hole Core 16 Cored Interval: 139.5-149.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY MIOCENE	N4 Discoaster deflandrei Subzone			B		1	0.5, 1.0					White-pale orange (10YR 8/2) with darker areas pale yellow brown (10YR 6/2); drilling breccia dominant; some burrowing and alternation of semilithified beds.
			Am			2					10YR 8/2	FORAMINIFERA-RICH NANNOFOSSIL OOZE Smear: CC Composition: 73% Nannofossils; 18% Foraminifera; 9% Clay minerals; Tr% Zeolite NANNOFOSSIL DETRITAL SILTY SAND (Minor Lith) Smear: 3-84 Texture: 60% Sand; 30% Silt; 10% Clay Composition: 47% Nannofossils; 25% Heavy minerals; 12% Feldspar; 6% Foraminifera; 5% Clay minerals; 4% Opaques; 1% Sponge spicules
				B		3				*84	10YR 6/2	Heavy minerals mainly green hornblende. Carbon Carbonate 6-134 9.7, 0.1, 80 X-ray 3-85 (Bulk) 74.8% Calc 12.5% Plag 5.9% Amph 1.1% Mica 0.9% Clin 0.5% Quar
			Ap			4						
				B		5		GEOCHEM SAMPLE			10YR 8/2	
			Cp	B		6						
		Ag	Ag	Rp		Core Catcher				*CC	10YR 8/2	



Explanatory notes in chapter 1

Site 292 Hole Core 17 Cored Interval: 149.0-158.5 m

AGE: LATE OLIGOCENE

ZONE: N4; Cyclicargolithus abisectus Subzone; Calocycletta virginis (D)

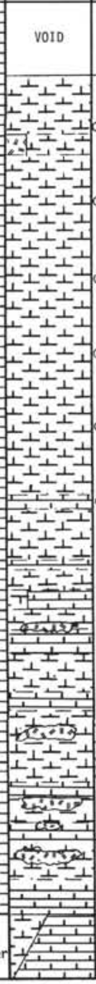
FOSSIL CHARACTER

	FORAMS	NANNOS	RADS	OTHERS
Section 1		Ap	Ag	
Section 3		Ap	Ag	
Section 5		Ap	Cg	
Core Catcher	Ag	Ag	Cm	

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

METERS: 0.5, 1.0

LITHOLOGY



LITHO. SAMPLE: *150 (Section 1); *94, *142 (Section 4); *118 (Section 5)

LITHOLOGIC DESCRIPTION

10YR 8/2
10YR 4/2
10YR 8/2
Subunit A
Subunit B
10YR 4/2
10YR 8/2
10YR 4/2
10YR 4/2
10YR 4/2
10YR 8/2

Soupy/drilling breccia; colors are very pale orange (10YR 8/2); alternating indurated-non-indurated beds; some dark gray brown (10YR 4/2) coloration for ash beds.

FORAMINIFER-RICH NANNOFOSSIL OOZE (CHALK)
Smear: 4-142

Texture	Composition
80% Clay	60% Nannofossils
20% Silt	24% Foraminifera
	10% Clay minerals
	2% Feldspar
	2% Sponge spicules
	1% Volcanic glass
	1% Heavies

Locally (4-94) foraminifer-bearing.

ASH-RICH NANNOFOSSIL OOZE (Minor Lith)
Smear: 1-150

Texture	Composition
75% Clay	70% Nannofossils
25% Silt	15% Volcanic glass
	10% Foraminifera
	4% Feldspar
	1% Heavy minerals

VOLCANIC ASH (Minor Lith)
Smear: 5-118

Texture	Composition
64% Silt	85% Volcanic glass
23% Sand	7% Feldspar
13% Clay	4% Nannofossils
	3% Heavy minerals
	1% Foraminifera

Grain Size 5-117
23.0, 63.9, 13.1

Carbon Carbonate 4-93
9.7, 0.1, 80

Explanatory notes in chapter 1

Site 292 Hole Core 18 Cored Interval: 158.5-168.0 m

AGE: LATE OLIGOCENE

ZONE: N4; Cyclicargolithus abisectus Subzone; Sphenolithus ciperoensis; Calocycletta virginis (R); Dorcadospyris atenchus - Lychnocanoma elongata (R)

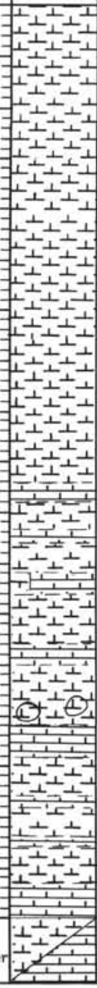
FOSSIL CHARACTER

	FORAMS	NANNOS	RADS	OTHERS
Section 1		Ap	Ag	
Section 3		Am	Ag	
Section 5		Am	Ag	
Core Catcher	Ag	Ag	Ag	

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

METERS: 0.5, 1.0

LITHOLOGY



LITHO. SAMPLE: *112, *126 (Section 4); *80 (Section 5); *CC

LITHOLOGIC DESCRIPTION

10YR 8/2
and
10YR 6/2
10YR 8/2
10YR 8/2

Soft, soupy, drilling breccia; very pale orange (10YR 8/2) mottled with pale yellow brown (10YR 6/2); - few small ash beds; slight - moderate drilling deformation lower in core; interbedded chalk and ooze.

NANNOFOSSIL OOZE AND CHALK
Smear: 4-112
FORAMINIFER-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 4-126

Texture	Composition
50% Clay	89% Nannofossils
50% Sand	10% Foraminifera
	Tr% Sponge spicules
	Tr% Feldspar
	Tr% Mica

Smear 4-126 has 50% of slide composed of cemented aggregates of nannofossils - foraminifera to sand size - graded unit base?

FE-RICH NANNOFOSSIL OOZE (Minor Lith)
Smear: 5-80

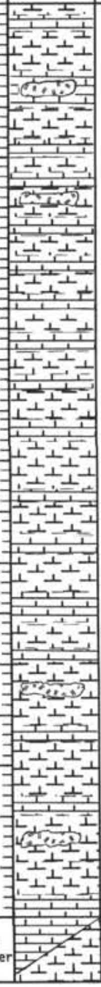
Composition
76% Nannofossils
10% Clay minerals
10% Fe-oxides
3% Foraminifera
1% Heavy minerals
Tr% Sponge spicules
Tr% Zeolite

Carbon Carbonate 5-70
10.2, 0.0, 85

Explanatory notes in chapter 1

Site 292 Hole Core 19 Cored Interval: 168.0-177.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	N4 / P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanoma elongata (R)		Ap	Ag		1	0.5, 1.0				10YR 4/2; 10YR 8/2	
						2				*37	10YR 4/2	
			Ap	Ag		3					10YR 8/2	
						4				*69		
			Ap	Ag		5					10YR 4/2	
						6				*74	10YR 4/2	
		Ag	Ag	Rm		Core Catcher				*CC	10YR 8/2	



Soft with interbedded chalk; very pale orange color (10YR 8/2): slight deformation; some dark ash layers (10YR 4/2).

NANNOFOSSIL OOZE AND CHALK (locally CLAY-RICH NANNOFOSSIL OOZE AND CHALK)
Smears: 4-69, CC

Texture	Composition
98% Clay	73-86% Nannofossils
2% Silt	10-15% Clay minerals
	5-10% Foraminifera
	1% Heavy minerals
	1% Feldspar

CLAY-RICH NANNOFOSSIL ASH (Minor Lith)
Smear: 2-37

Texture	Composition
60% Silt	30% Nannofossils
40% Clay	30% Volcanic glass
	15% Feldspar
	15% Clay minerals
	5% Heavy minerals
	5% Foraminifera

VOLCANIC ASH (Minor Lith)
Smear: 6-74

Texture	Composition
80% Silt	60% Volcanic glass
20% Clay	15% Heavy minerals
	10% Feldspar
	5% Clay minerals
	5% Foraminifera
	5% Nannofossils

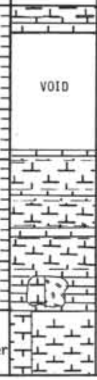
Carbon Carbonate 5-49
8.7, 0.0, 72

X-ray 5-49 (Bulk)
92.1% Calc
7.4% Plag
0.5% Quar

Explanatory notes in chapter 1

Site 292 Hole Core 20 Cored Interval: 177.5-187.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanoma elongata (R)					1	0.5, 1.0	VOID				
			Ap			2				*122	10YR 8/2; 10YR 4/2	
		Ag	Ag	Ag	Ag	Core Catcher				*CC	10YR 8/2	



Very pale orange (10YR 8/2); core is soft and firm with indurated and non-indurated beds throughout.

NANNOFOSSIL OOZE AND CHALK

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

Texture	Composition
90% Clay	80% Nannofossils
10% Silt	15% Foraminifera
	2% Zeolite
	2% Clay minerals

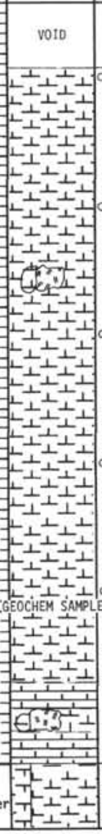
NANNOFOSSIL VOLCANIC ASH (Minor Lith)
Smear: 2-122

Texture	Composition
50% Silt	49% Nannofossils
50% Clay	45% Volcanic glass
	5% Feldspar
	1% Foraminifera

Explanatory notes in chapter 1

Site 292 Hole Core 21 Cored Interval: 187.0-196.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	
LATE OLIGOCENE	P22; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanoma elongata (R)		Ap	Ag		1	0.5, 1.0	VOID			
											10YR 8/2
				Ag		2				*118	10YR 4/2
						3					
						4		GEOCHEM SAMPLE			10YR 8/2
	P21		Ap	Ag		5				*107	10YR 4/2
		Ag	Ag	Am		Core Catcher				*CC	10YR 8/2



LITHOLOGIC DESCRIPTION

Soupy to moderately deformed; very pale orange (10YR 8/2); few ash-rich areas in core (10YR 4/2).

NANNOFOSSIL OOZE
Smear: 5-107

Texture	Composition
95% Clay	92% Nannofossils
5% Silt	5% Foraminifera
	2% Clay minerals
	1% Feldspar

NANNOFOSSIL VOLCANIC ASH (Minor Lith)
Smear: 2-118

Texture	Composition
60% Silt	45% Volcanic glass
40% Clay	35% Nannofossils
	10% Feldspar
	5% Heavy minerals
	5% Foraminifera

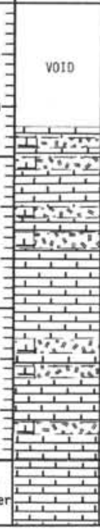
FORAMINIFERA-RICH NANNOFOSSIL OOZE (Minor Lith)
Smear: CC

Composition
75% Nannofossils
25% Foraminifera

Explanatory notes in chapter 1

Site 292 Hole Core 22 Cored Interval: 196.5-206.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	
LATE OLIGOCENE	P21; Sphenolithus ciperoensis; Dorcadospyris atenchus - Lychnocanoma elongata (R)					1	0.5, 1.0	VOID		*135	10YR 4/2
			Am	Ag		2				*3	10YR 4/2
										*56	10YR 4/2
						3				*31	10YR 4/2
										*53	
										*124	10YR 4/2
										*133	10YR 8/2
		Ag	Ag	Cg		Core Catcher				*CC	10YR 8/2



LITHOLOGIC DESCRIPTION

Very pale orange (10YR 8/2) chalk with occasional dark gray brown ash beds (10YR 4/2) and occasional color mottling; core is stiff with slight deformation.

NANNOFOSSIL CHALK
Smears: 3-53, 3-133, CC

Texture	Composition
48% Silt	82% Nannofossils
32% Clay	10% Clay minerals
20% Sand	8% Foraminifera

Locally clay, foraminifera-bearing, sponge spicule-rich (3-53).

NANNOFOSSIL-RICH VOLCANIC ASH (Minor Lith)
Smears: 1-135, 2-3, 2-56, 3-31, 3-124

Texture	Composition
80% Silt	70% Volcanic glass
20% Clay	14% Nannofossils
	9% Feldspar
	3% Foraminifera
	1% Heavy minerals

Grain Size 3-53
20.6, 47.6, 31.8

Carbon Carbonate 2-116
10.7, 0.1, 89

Explanatory notes in chapter 1

Site 292 Hole Core 23 Cored Interval: 206.0-215.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21 Sphenolithus ciperoensis Dorcadospyris atenchus - Lychnocanoma elongata (R)		Am	Ag		1	0.5 1.0			*22	5Y 4/1 5Y 7/1	Core is stiff with slight deformation; color variations of medium-light-green gray (5Y 7/1) with ash beds being olive gray (5Y 4/1) to pinkish gray (5YR 8/1); alternating hard-soft layers.
						2				*89	5Y 7/1	
			Ap	Am		3					5YR 7/1	
						4				*75	5YR 8/1	
		Ag	Amg	Cg		Core Catcher				*CC	5YR 8/1	

NANNOFOSSIL OOZE AND CHALK

FORAMINIFERA-RICH NANNOFOSSIL OOZE/CHALK (Minor Lith)
Smears: 2-89, 4-75, CC

Texture	Composition
90-100% Clay	67-72% Nannofossils
10% Sand	15-20% Foraminifera
	8- 9% Clay Minerals
	2% Micarb
	1% Quartz, feldspar

NANNOFOSSIL-RICH VOLCANIC ASH (Minor Lith)
Smear: 1-22

Texture	Composition
59% Silt	71% Devitrified glass
35% Clay	15% Quartz, feldspar
6% Sand	10% Nannofossils
	3% Heavy minerals
	1% Zeolite

Grain Size 1-21
5.9, 58.7, 35.4

Carbon Carbonate 4-75
9.3, 0.1, 77

Explanatory notes in chapter 1

Site 292 Hole Core 24 Cored Interval: 215.5-225.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21 Sphenolithus ciperoensis Dorcadospyris atenchus - Lychnocanoma elongata (R)					1	0.5 1.0	VOID				Chalk with minor ooze; color (N8)-very light gray color to olive gray zones (5Y 4/1); burrowing; ash layers (5GY 6/1).
			Ap	Ag		2					5Y 4/1 5Y 6/1 N8	
			Ap			3				*68	5GY 6/1 N8	
		Ag	Ag	Ag		Core Catcher				*CC	N8	

FORAMINIFERA-RICH NANNOFOSSIL OOZE/CHALK
Smear: 3-68, CC

Texture	Composition
100% Clay	77-80% Nannofossils
	12-20% Foraminifera
	9% Clay minerals
	1- 2% Sponge spicules
	Tr% Radiolarians

Carbon Carbonate 3-67
10.3, 0.1, 85

Explanatory notes in chapter 1

Site 292 Hole Core 25 Cored Interval: 225.0-234.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P21 Sphenolithus ciperoensis Dorcadospyris atenchus - Lychnocanoma elongata (R)		Am	Ag		1	0.5 1.0			*110	Subunit C	Generally an indurated chalk; colors alternate - very light gray (N8) to white (N9); slight drilling deformation; burrows present.
	P20 Sphenolithus distentus Dorcadospyris					2		VOID			N8 and N9	
	Theocyrtis tuberosa (R)	Ag	Ag	Fm		Core Catcher		VOID			N8 to N9	

FORAMINIFERA-RICH NANNOFOSSIL CHALK
Smear: 1-110

Texture	Composition
90% Clay	78% Nannofossils
10% Silt	10% Clay minerals
	10% Foraminifera
	2% Sponge spicules

Carbon Carbonate 1-110
9.7, 0.1, 81

Explanatory notes in chapter 1

Site 292 Hole Core 26 Cored Interval: 234.5-244.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P20 Sphenolithus distentus Theocyrtis tuberosa (R)		Ap	Cg		1	0.5 1.0	VOID				Core indurated with slight deformation; light gray (N8) to white (N9); indistinct burrows.
			Ap			2		GEOCHEM SAMPLE		*106	N8-N9	NANNOFOSSIL CHALK Smear: 2-106 Texture: 100% Clay Composition: 76% Nannofossils, 9% Clay minerals, 8% Foraminifera, 5% Micarb, 2% Sponge spicules Carbon Carbonate 2-106 10.6, 0.1, 88
		Ag	Am	Ag		Core Catcher					N8-N9	

Explanatory notes in chapter 1

Site 292 Hole Core 27 Cored Interval: 244.0-253.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P20 Sphenolithus distentus Theocyrtis tuberosa (R)		Cp	Ag		1	0.5 1.0	VOID		*87	N8 to N9 +	Very light gray (N8) to white (N9); very uniform core with slight deformation; vague burrowing. NANNOFOSSIL CHALK Smear: 1-87 Texture: 100% Clay Composition: 76% Nannofossils, 9% Foraminifera, 9% Clay minerals, 5% Micarb, 1% Sponge spicules, Tr% Palagonite Carbon Carbonate 1-87 11.0, 0.1, 91
		Ag	Am	Ag		Core Catcher						

Explanatory notes in chapter 1

Site 292 Hole Core 28 Cored Interval: 253.5-263.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P19 Sphenolithus distentus T. tuberosa (R)	Ag	Am	Cg		Core Catcher				*CC	N8	Very light gray (N8) chalk; core catcher only. FORAMINIFERA-RICH NANNOFOSSIL CHALK Smear: CC Texture: 100% Clay Composition: 75% Nannofossils, 12% Foraminifera, 8% Clay minerals, 3% Micarb, 1% Radiolarians, 1% Sponge spicules, Tr% Zeolite Zeolite is Clinoptilolite.

Explanatory notes in chapter 1

Site 292 Hole Core 29 Cored Interval: 263.0-272.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P19 Sphenolithus distentus T. tuberosa (R)		Am	Ag		1	0.5 1.0	VOID			N8-N9	Slight deformation; very light gray (N8) to white (N9); fragmented and burrows are present. NANNOFOSSIL CHALK Smear: CC Texture: 100% Clay Composition: 73% Nannofossils, 9% Foraminifera, 9% Micarb, 8% Clay minerals, 1% Zeolite, 1% Sponge spicules Zeolite is Clinoptilolite. Carbon Carbonate 1-104 11.1, 0.1, 92
		Ag	Am	Ag		Core Catcher				*CC		

Explanatory notes in chapter 1

Site 292 Hole Core 30 Cored Interval: 272.5-282.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P19 / P18 Sphenolithus distentus Theocyrtis tuberosa (R)		Am	Cg		1	0.5, 1.0	VOID		*102		
						2		VOID			N8-N9	
		Ag	Am	Ag		Core Catcher					N8-N9	

Slight deformation; color very light gray (N8) to white (N9); chalk with brown black (5YR 2/1) streaks; burrows; also olive black (5Y 2/1) streaks.

NANNOFOSSIL CHALK
Smear: 1-102

Texture	Composition
100% Clay	75% Nannofossils
	9% Clay minerals
	7% Foraminifera
	6% Micarb
	2% Sponge spicules
	1% Zeolite
	Tr% Radiolarians

Carbon Carbonate 1-101
11.1, 0.1, 92

Explanatory notes in chapter 1

Site 292 Hole Core 31 Cored Interval: 282.0-291.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	P18 Sphenolithus distentus Theocyrtis tuberosa (R)					1	0.5, 1.0	VOID				
			Am	Ag		2		GEOCHEM SAMPLE		*28, *57	N8-N9	
		Ag	Ag	Cg		Core Catcher				*CC		

Chalk; light gray (N8) to white (N9); slight deformation; burrowing common with dark colors; fragmental at base of Section 2.

CLAY-RICH NANNOFOSSIL CHALK
Smears: 2-57, CC

Texture	Composition
100% Clay	65-71% Nannofossils
	6-8% Clay minerals
	10-12% Foraminifera
	1% Radiolarians
	0-5% Sponge spicules
	0-3% Volcanic glass
	0-1% Heavy minerals

May be locally foraminifera-rich.

MICARB-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 2-28

Texture	Composition
100% Clay	78% Nannofossils
	20% Micarb
	2% Radiolarians
	Tr% Volcanic glass
	Tr% Feldspar

Carbon Carbonate 2-56
8.5, 0.1, 70

Explanatory notes in chapter 1

Site 292 Hole Core 32 Cored Interval: 291.5-301.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE OLIGOCENE	Sphenolithus distentus			Cg		1	0.5, 1.0	VOID				
EARLY OLIGOCENE	P18 Sphenolithus predistentus Theocyrtis tuberosa (R)		Ap								N8	
		Ag	Ag	Cm		Core Catcher					N8	

Very light gray (N8); slight deformation, indistinct burrowing, 5 mm diameter.

NANNOFOSSIL CHALK
Smear: CC

Composition
95% Nannofossils
5% Foraminifera

Explanatory notes in chapter 1

Site 292 Hole Core 33 Cored Interval: 301.0-310.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	P18 Sphenolithus predistentus Theocyrtis tuberosa (R)					1	0.5, 1.0	VOID			N8	
			Rp	Cm		2				*65, *121	N8, 5Y 8/1	
		Ag	Ag	Fm		Core Catcher					N8	

Chalk, slight deformation; very light gray (N8) to white (N9); burrows are irregular; some pink gray color (5YR 8/1) in Section 2; fragmental in Section 2 with some soft-ooze areas.

NANNOFOSSIL CHALK
Smears: 2-65, 2-121

Texture	Composition
100% Clay	80-90% Nannofossils
	10% Clay minerals
	5% Foraminifera
	4- 8% Sponge spicules
	1- 3% Volcanic glass
	1% Radiolarians
	1% Feldspar
	1% Heavy minerals

Carbon Carbonate 2-66
10.8, 0.1, 90

Explanatory notes in chapter 1

Site 292 Hole Core 34 Cored Interval: 310.5-320.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	Sphenolithus predistentus; Theocyrtis tuberosa (R); P18	Ag	Am, Ag	Fm, Fm		1, 2, Core Catcher	0.5, 1.0			*2, *140, *CC	N8, 5YR 4/2, N8	see below

Very light gray (N8); hard and firm; slight-moderate deformation; some breccia in Section 1 with soft ooze; faint bedding-burrows.

CLAY-RICH NANNOFOSSIL CHALK
Smear: 2-140

Texture	Composition
99% Clay	92% Nannofossils
1% Silt	6% Clay minerals
	2% Sponge spicules

CLAY-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 2-2

Texture	Composition
80% Clay	67% Nannofossils
20% Silt	20% Clay minerals
	10% Palagonite
	1% Volcanic glass
	1% Heavy minerals
	1% Feldspar

MICARB-RICH NANNOFOSSIL CHALK
Smear: CC

Texture	Composition
90% Clay	75% Nannofossils
10% Silt	15% Micarb
	10% Clay Minerals
	Tr% Foraminifera
	Tr% Feldspar

Carbon Carbonate 2-140
10.6, 0.1, 88

Explanatory notes in chapter 1

Site 292 Hole Core 35 Cored Interval: 320.0-329.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE; LATE EOCENE (FORAM, RAD)	Cyclococcolithina formosa Subzone; P17; P16	Ag	Am, Am, Ap	Cm, Ag, Cm		1, 2, 3, Core Catcher	0.5, 1.0	VOID, VOID, VOID		*106	5YR 4/2, 5YR 8/1 ↓ N8, 5YR 8/1 N8	see below

Pinkish gray (5YR 8/1) with very light gray (N8); very mottled due to bioturbation; slight drilling deformation.

CLAY-RICH NANNOFOSSIL CHALK
Smear: 2-106

Texture	Composition
85% Clay	83% Nannofossils
15% Silt	10% Clay minerals
	3% Volcanic glass
	2% Feldspar
	1% Heavy minerals
	1% Sponge spicules

Carbon Carbonate 2-129
9.8, 0.1, 81

X-ray 2-125 (Bulk)
93.9% Calc
4.4% Plag
1.3% Mont
0.4% Quar

Explanatory notes in chapter 1

Site 292 Hole Core 36 Cored Interval: 329.5-339.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE; LATE EOCENE	Cyclococcolithina formosa Subzone; Discoaster barbadiensis; P16; D. barbadiensis; Theocyrtis bromia (R)	Ag	Ap, Ap, Ap, Am	Ag, Ag, Ag, Ag		1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	GEOCHEM SAMPLE		*16, *117, *78, *CC	N4, N8, N4, N8 to 5YR 8/1, N8 ↕ N7, 5YR 8/1, N4, 5YR 8/1	see below

Very light gray (N8) chalk to medium dark gray (N4) in the ash layers; slight to no deformation; mottled and bioturbation throughout including ash; some tendency to a pinkish gray color in the chalk (5YR 8/1).

NANNOFOSSIL CHALK
(May be locally sponge spicule-rich [CC]).

VOLCANIC ASH (Minor Lith)
Smears: 1-16, 2-117

Texture	Composition
85% Silt	60% Volcanic glass
15% Clay	10-15% Nannofossils
	9-15% Feldspar
	5-20% Heavy minerals
	1- 5% Foraminifera

CLAY BEARING/RICH RADIOLARIAN-RICH NANNOFOSSIL CHALK (Minor Lith)
Smear: 5-78

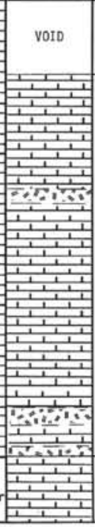
Texture	Composition
80% Clay	62% Nannofossils
20% Silt	20% Radiolarians
	15% Clay minerals
	3% Sponge spicules
	1% Feldspar

Carbon Carbonate 4-45
9.0, 0.1, 74

Explanatory notes in chapter 1

Site 292 Hole Core 37 Cored Interval: 339.0-348.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
LATE EOCENE	Discoaster barbadiensis; Theocyrtis bromia (R); P16	Ag-	Am-; Am-; Am-	Ag; Ag; Cm-		1; 2; 3; Core Catcher	0.5; 1.0	VOID		*121	N8; 5YR 5/2; N8; 5YR 5/2; 5YR 5/2; N8	Generally very light gray (N8) with darker areas of light brown gray (5YR 6/1) layers; slight drilling deformation and bioturbated.



Generally very light gray (N8) with darker areas of light brown gray (5YR 6/1) layers; slight drilling deformation and bioturbated.

NANNOFOSSIL CHALK
Smear: 2-121

Texture	Composition
100% Clay	72% Nannofossils
	9% Clay minerals
	9% Foraminifera
	6% Micarb
	3% Sponge spicules
	1% Radiolarians

Grain Size 3-122
17.1, 64.2, 18.7

Carbon Carbonate 2-121
10.0, 0.1, 83

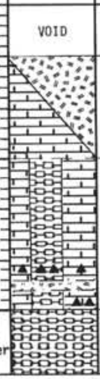
X-ray 3-122 (Bulk)
56.4% Plag
17.9% Calc
11.8% Quar
9.3% Mont
4.7% Augi

Explanatory notes in chapter 1

Site 292 Hole Core 38 Cored Interval: 348.5-358.0 m

AGE: LATE EOCENE; ZONE: Discoaster barbadiensis; P16
FOSSIL CHARACTER: Cg; Ap- Rf; Ap- Ag- B
SECTION: 1; 2; Core Catcher — METERS: 0.5; 1.0 — LITHOLOGY: VOID — LITHO. SAMPLE: *54; *TS

N8 and 5GY 6/1; N7-N8; 5Y 6/1; 5YR 4/1; N7; N8



Slight deformation; generally very light gray (N8) to greenish gray (5GY 6/1) layers; irregular-sharp contacts; wedge-shaped interbeds; moderate mottling some light olive gray (5Y 6/1) chert; interbedded volcanic-rich nannofossil chalk; nannofossil-bearing volcanic ash; volcanic-bearing nannofossil chalk (5-150 cm) Section 1.

FORAMINIFERA-RICH NANNOFOSSIL MICARB CHALK
Smear: 2-54

Texture	Composition
80% Clay	40% Micarb
20% Silt	28% Nannofossils
	12% Foraminifera
	9% Clay minerals
	8% Sponge spicules
	2% Volcanic glass
	1% Radiolarians

CC-Thin Section: Foraminifera with a micarb matrix: Chalcedony 10-20%; Foraminifera 7%; Clay minerals 9%; Nannofossils 2%; Micarb matrix 70%

Foraminifera are pseudomorphed and filled with chalcedony.

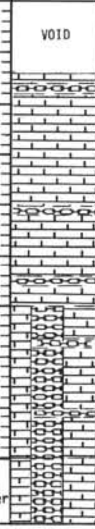
Carbon Carbonate 2-54
5.1, 0.0, 42

Explanatory notes in chapter 1

Site 292 Hole Core 39 Cored Interval: 358.0-367.5 m

AGE: LATE EOCENE; ZONE: P15; Discoaster barbadiensis; P16
FOSSIL CHARACTER: Am-; Ap-; Ag- Ag- B
SECTION: 1; 2; 3; Core Catcher — METERS: 0.5; 1.0 — LITHOLOGY: VOID — LITHO. SAMPLE: TS *67; *50

5YR 4/4 to 5YR 3/4; 5YR 7/2; 5YR 7/2



Slight drilling deformation; grayish orange pink (5YR 7/2) indistinct burrows; chert layers moderate brown (5YR 4/4) to dark moderate brown (5YR 3/4); thin bedding.

FORAMINIFERA-RICH MICARB NANNOFOSSIL CHALK
Smear: 3-50

Composition
40% Nannofossils
39% Micarb
12% Foraminifera
9% Clay minerals

Thin Section: Chalcedony 10-20%, clay minerals and micarb matrix; foraminifera are pseudomorphed.

Carbon Carbonate 3-50
11.1, 0.0, 92

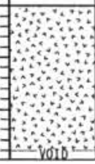
X-ray 3-50 (Bulk)
100% Calc

Explanatory notes in chapter 1

Site 292 Hole Core 40 Cored Interval: 367.5-377.0 m

SECTION: 1 — METERS: 0.5; 1.0 — LITHOLOGY: VOID — LITHO. SAMPLE: *TS

N2



BASALT
Grayish black (N2); Vesicular infillings of zeolite, green clay and marcasite; calcite veins.

Thin Section 1-6: Intersertal; lath-like plagioclase and granular pyroxene within intersertal matrix.

Intersertal matrix: fine-grained intergrowth of plagioclase, pyroxene and opaques; has extensive alteration.

Composition
45% Matrix
30% Plagioclase (AN_{48-30})
20% Pyroxene
5% Opaques

Explanatory notes in chapter 1

Site 292 Hole Core 41 Cored Interval: 377.0-386.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5, 1.0	VOID		TS * 86		
						2				TS * 37		
						3				TS * 46		
						4				TS * 59	N2	
						5				TS * 40		
						Core Catcher						

BASALT
Greenish black (N2); vesicular.

Thin Section 1-86:
Intersertal basalt with tabular phenocrysts of plagioclase; granular pyroxene in fine intersertal matrix. Matrix: fine grained quench crystals of pyroxene, plagioclase, apatite with alteration to brown chlorite, sericite.

Composition
45% Matrix
35% Plagioclase
15% Pyroxene
5% Opaques

Thin Sections 2-37; 3-46:
As in 1-86, matrix intersertal to supophitic; skeletal opaque phases.

Composition
32-35% Plagioclase (AN_{46})
30-40% Matrix
20-25% Pyroxene
8-10% Opaques

Thin Section 4-59:
Subophitic-intersertal; groundmass of felted plagioclase microlites, skeletal opaques, and glass; all with alteration.

Composition
40% Intersertal matrix
30% Plagioclase (AN_{48-30})
22% Pyroxene
8% Opaques

Thin Section 5-40:
Subophitic, plagioclase phenocrysts (AN_{52-24}); matrix is altered.

Composition
35% Intersertal matrix
30% Plagioclase (AN_{46-30})
25% Pyroxene
10% Opaques

Explanatory notes in chapter 1

Site 292 Hole Core 42 Cored Interval: 386.5-396.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5, 1.0	VOID		TS * 111		
						2				TS * 67		
						3				TS * 72	N2	
						4				TS * 86		
						5				TS * 29		
						Core Catcher						

BASALT

Thin Section 1-111 - Intersertal basalt:

Composition
40% Plagioclase (AN_{42-35})
30% Intersertal matrix
22% Pyroxene
8% Opaques

Thin Section 2-67 - Subophitic basalt:
One complex phenocryst with plagioclase/pyroxene.

Composition
40% Plagioclase
32% Pyroxene
20% Intersertal matrix
8% Opaques

Thin Section 3-72 - Intersertal basalt:
Coarse grained; zoning in feldspars - long acicular ilmenite crystals.

Composition
40% Plagioclase (AN_{24-40})
30% Matrix
23% Pyroxene
7% Opaques

Thin Section 4-86 - Intersertal basalt:

Composition
35% Matrix
30% Plagioclase (AN_{40-30})
25% Pyroxene
10% Opaques

Thin Section 5-29 - Intersertal basalt:
Few large complex phenocrysts with highly zoned plagioclase and pyroxene.

Composition
35% Plagioclase (AN_{50-20})
35% Matrix
20% Pyroxene
10% Opaque

Explanatory notes in chapter 1

Site 292 Hole Core 43 Cored Interval: 396.0-405.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5 / 1.0	VOID		TS * 139		
						2				TS * 111		
						3				TS * 45	N2	
						4				TS * 40		
						Core Catcher				TS * CC		

BASALT

Thin Sections 1-139, 2-111, 4-40 - Intersertal basalt:

Composition
35-45% Interstitial
25-35% Plagioclase (AN_{40-25})
19-22% Pyroxene
6-10% Opaques

Thin Section 3-45 - Intersertal basalt:
Large plagioclase (AN_{42-25}) phenocryst

Composition
35% Plagioclase
35% Interstitial
24% Pyroxene
6% Opaque

Thin Section CC - Intersertal to subophitic basalt:

Composition
40% Interstitial
30% Plagioclase (AN_{40-20})
20% Pyroxene
10% Opaques

Explanatory notes in chapter 1

Site 292 Hole Core 44 Cored Interval: 405.5-415.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5 / 1.0	VOID		TS * 133		
						2				TS * 69	N2	
						3				TS * 107	N2	
						4				TS * 48		
						5				TS * 69	N2	
						Core Catcher				TS * CC	N2	

BASALT
Color grayish black (N2), pyrite veinlets (100-130 cm - Section 2). Some vesicules in Section 5.

Thin Section 5-69 - Subophitic basalt

Thin Sections 1-133, 2-69, 3-107, 4-48, CC - Intersertal basalt

Explanatory notes in chapter 1

Site 292 Hole Core 45 Cored Interval: 415.0-424.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
						1	0.5, 1.0			TS * 109	
						2				TS * 48	N2
						3					
						Core Catcher					N2

BASALT
Color grayish black (N2).

Thin Sections 1-109, 2-48 - Intersertal basalt:
Intersertal basalt; some matrix less altered than rest (Section 2); some with complex phenocrysts of pyroxene and plagioclase.

Explanatory notes in chapter 1

Site 292 Hole Core 46 Cored Interval: 424.5-434.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
						1	0.5, 1.0			TS * 120
						2				TS * 64 * 72
						Core Catcher				TS * CC

LITHOLOGIC DESCRIPTION

BASALT
Grayish black (N2) in unaltered areas to greenish black (5GY 2/1) in altered zones; some vertical weathering zones.

Thin Section 1-120 - Subophitic basalt

Thin Section 2-64 - Intersertal to Subophitic basalt

Thin Section 2-72 - Intersertal basalt:
Intersertal basalt - large complex phenocrysts of plagioclase-pyroxene. Intersertal areas altered to green serpentine-like mineral; CO_3 present; some fresh plagioclase.

Composition
50% Interstitial
26% Plagioclase (AN_{42-30})
18% Pyroxene
6% Opaques

Thin Section CC - Subophitic basalt:
Vertical veinlets of alteration in interstitial areas.

Explanatory notes in chapter 1

Site 292 Hole Core 47 Cored Interval: 434.0-443.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
						1	0.5, 1.0			TS * 51	
						2				TS * 73	N5
						Core Catcher					N5

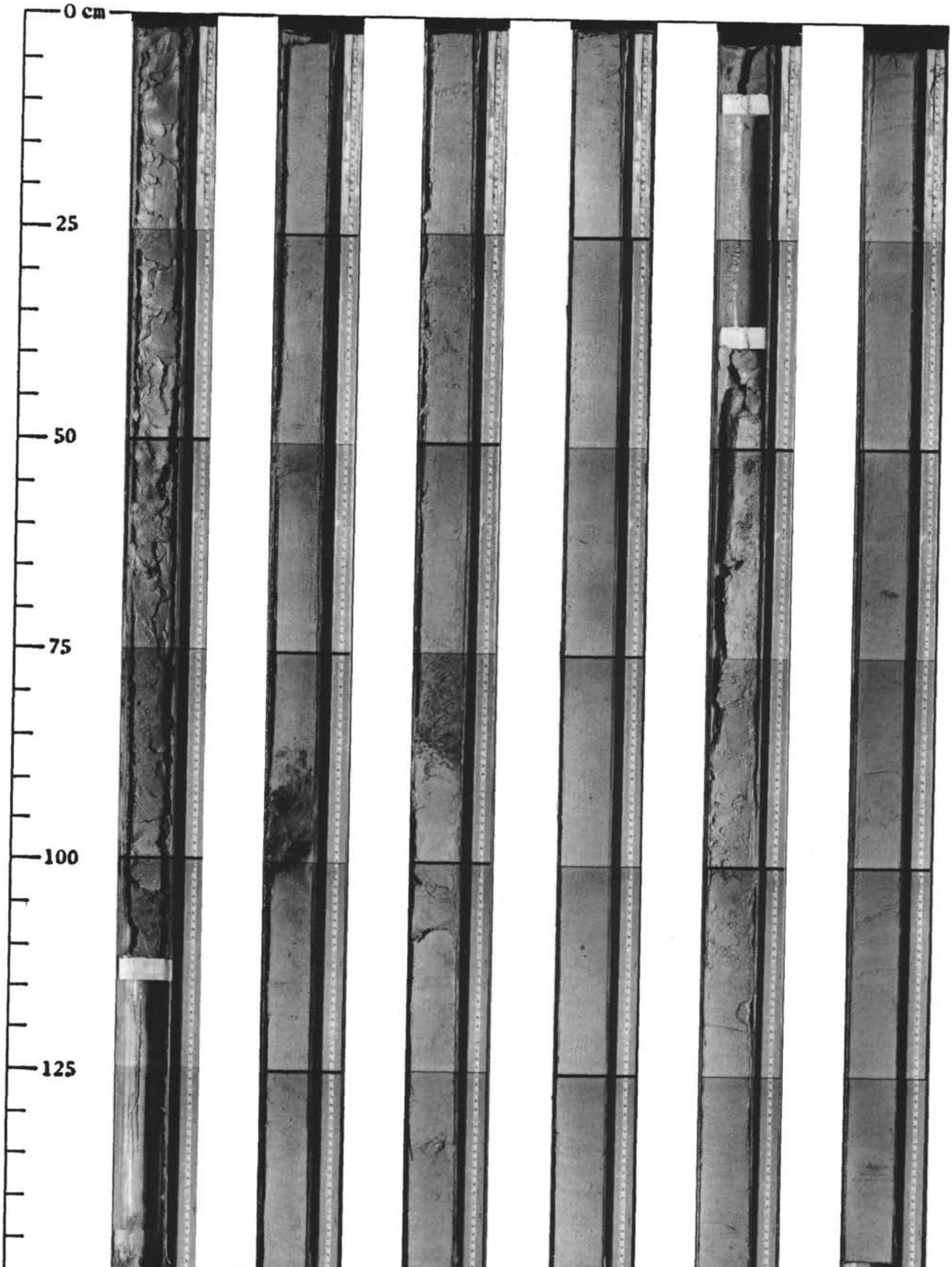
BASALT (N5)

Thin Section 1-51 - Intersertal basalt:
Intersertal basalt with pyroxene plagioclase phenocrysts.

Thin Section 2-73 - Intersertal to Subophitic basalt:
Intersertal to Subophitic basalt; pyroxene and plagioclase phenocrysts.

Composition
38% Plagioclase
25% Pyroxene
25% Interstitial
12% Opaques

Explanatory notes in chapter 1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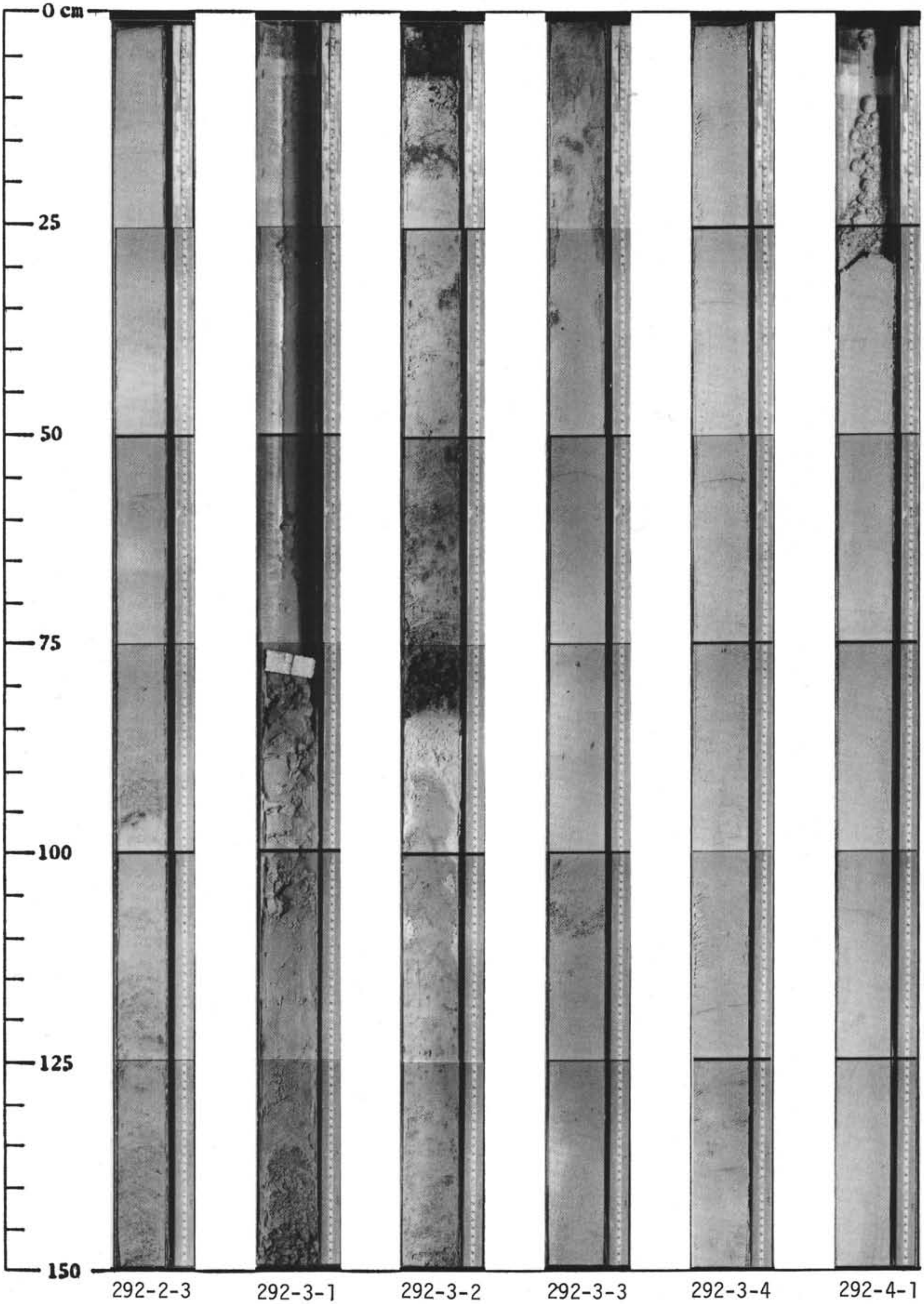
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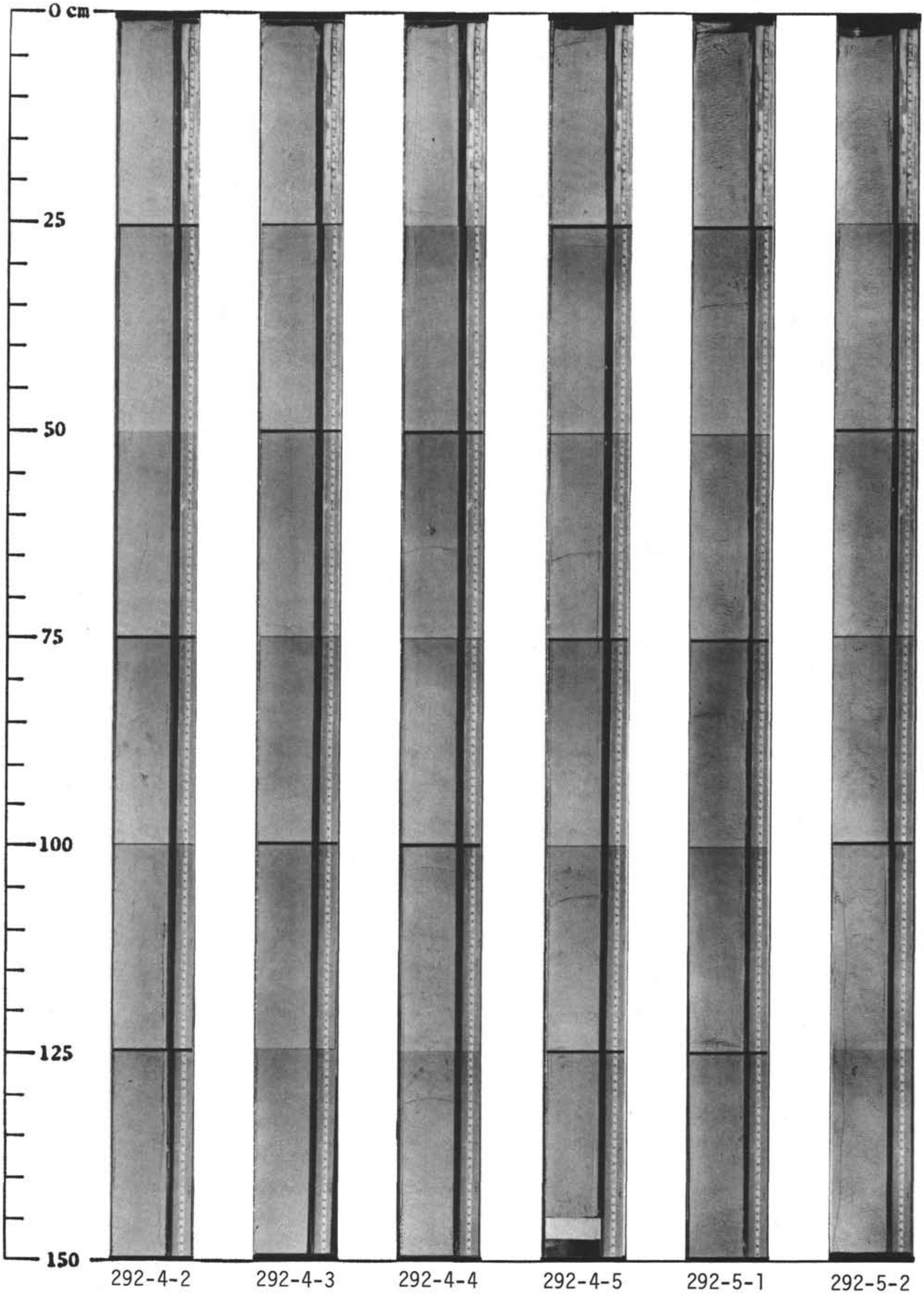
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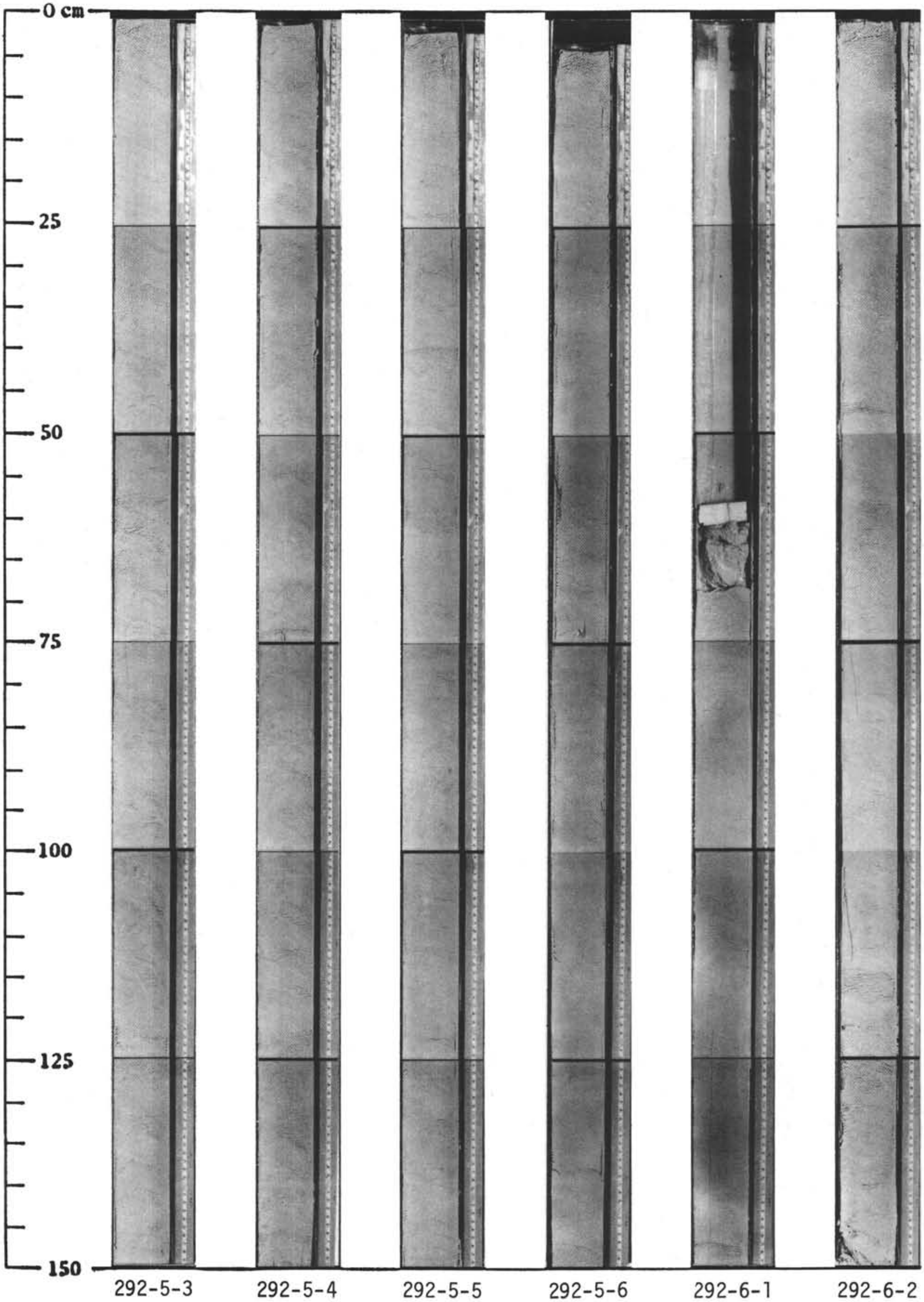
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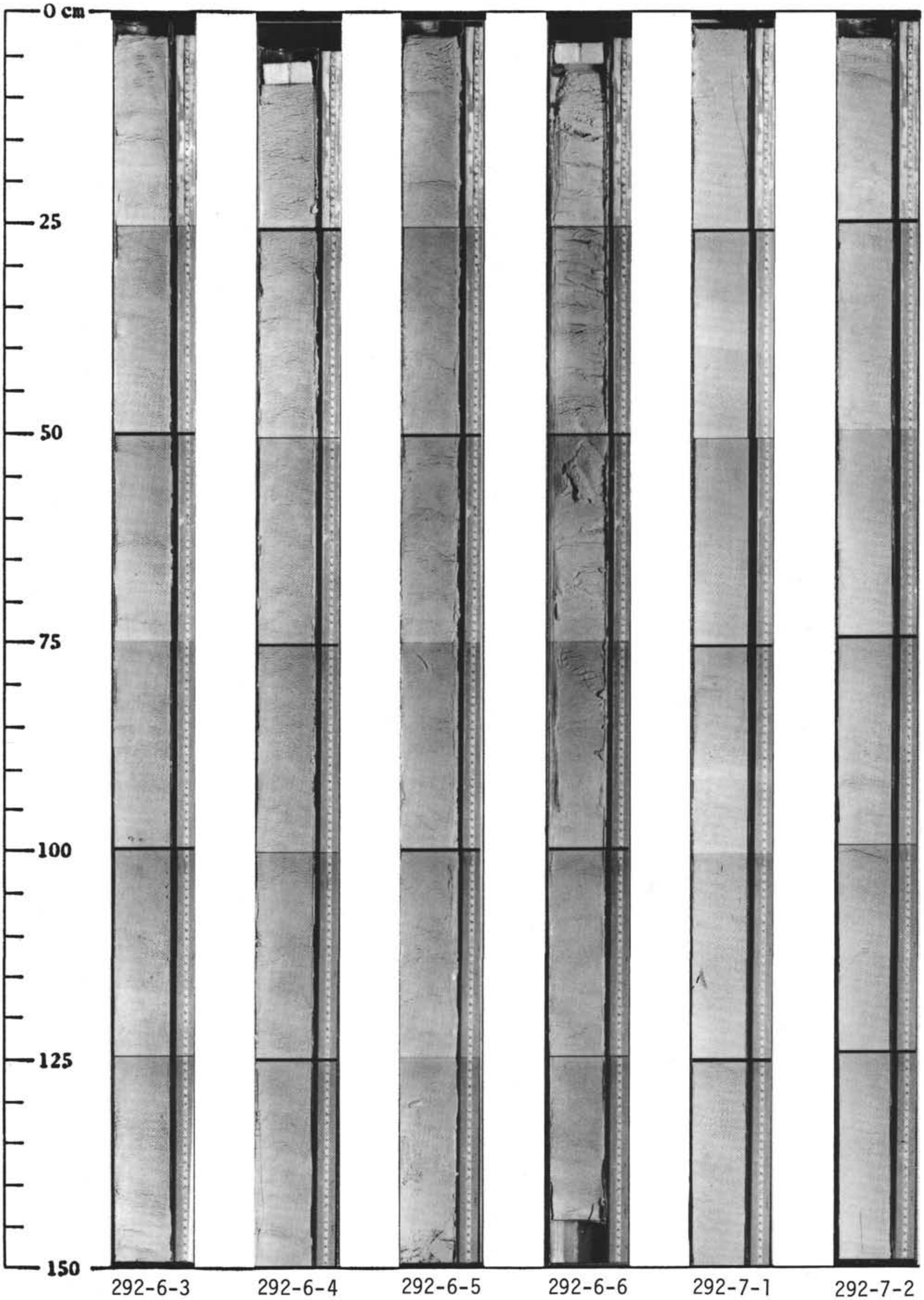
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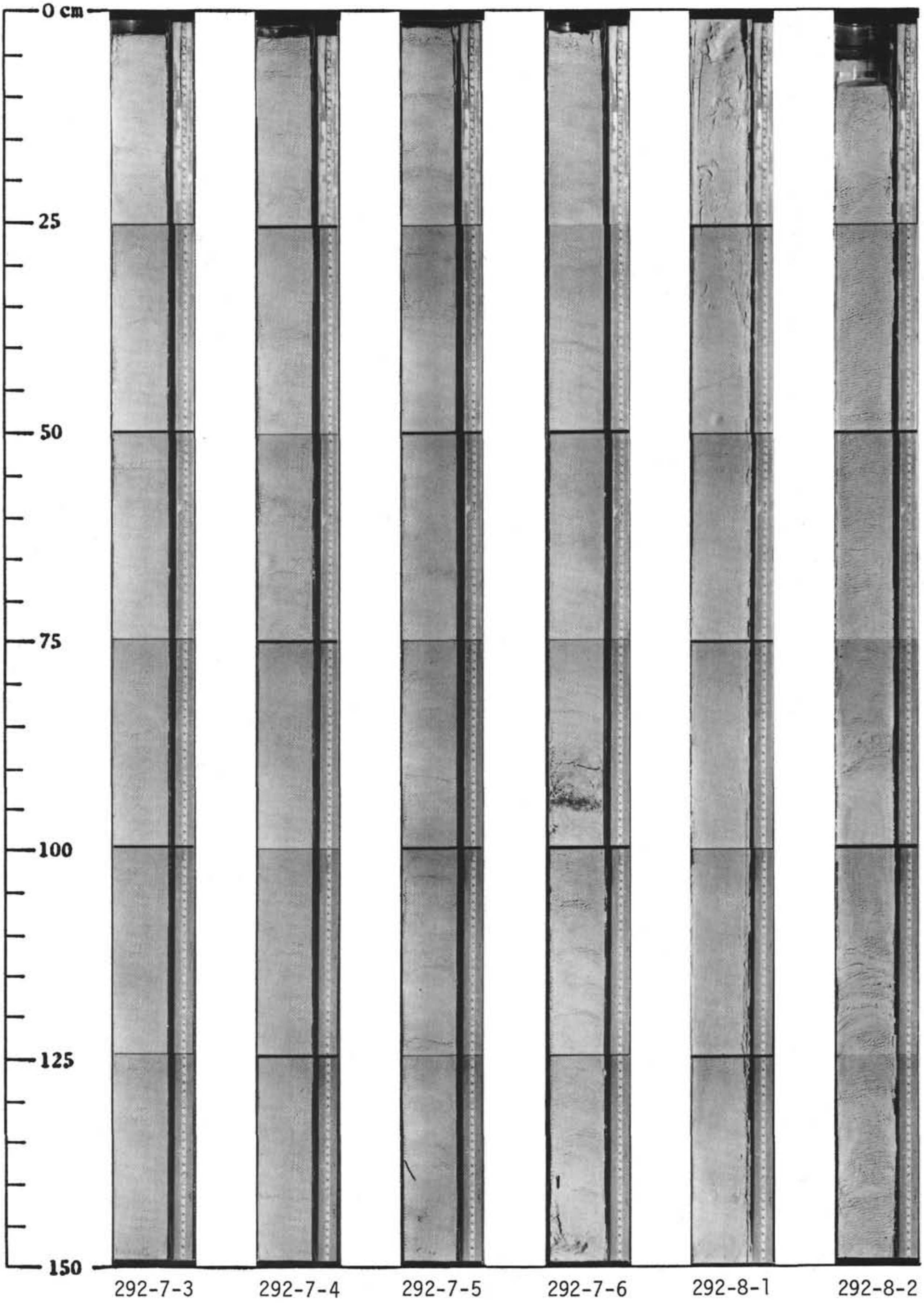
292-7-1
292-7-2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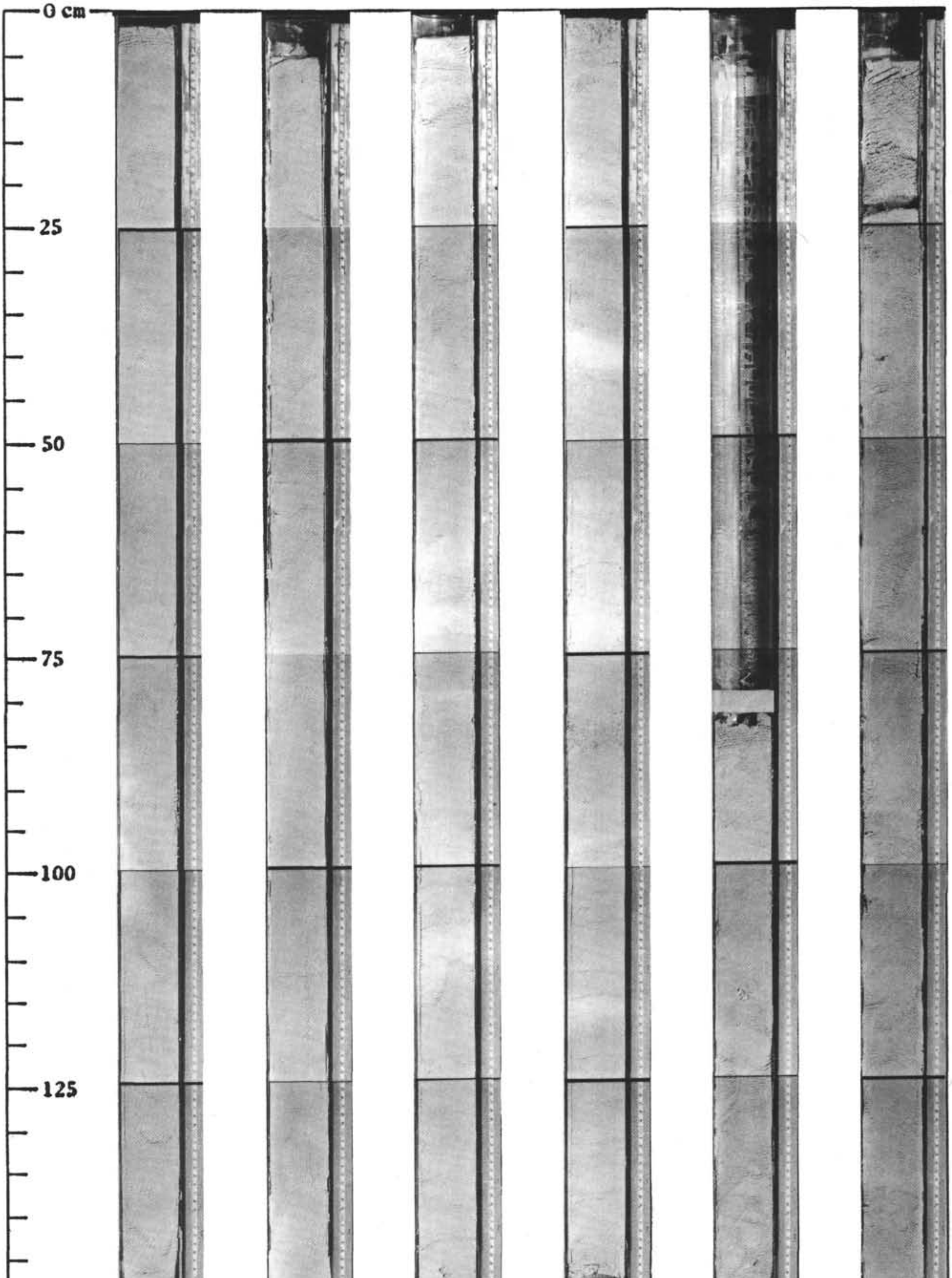
292-7-6
292-8-1
292-8-2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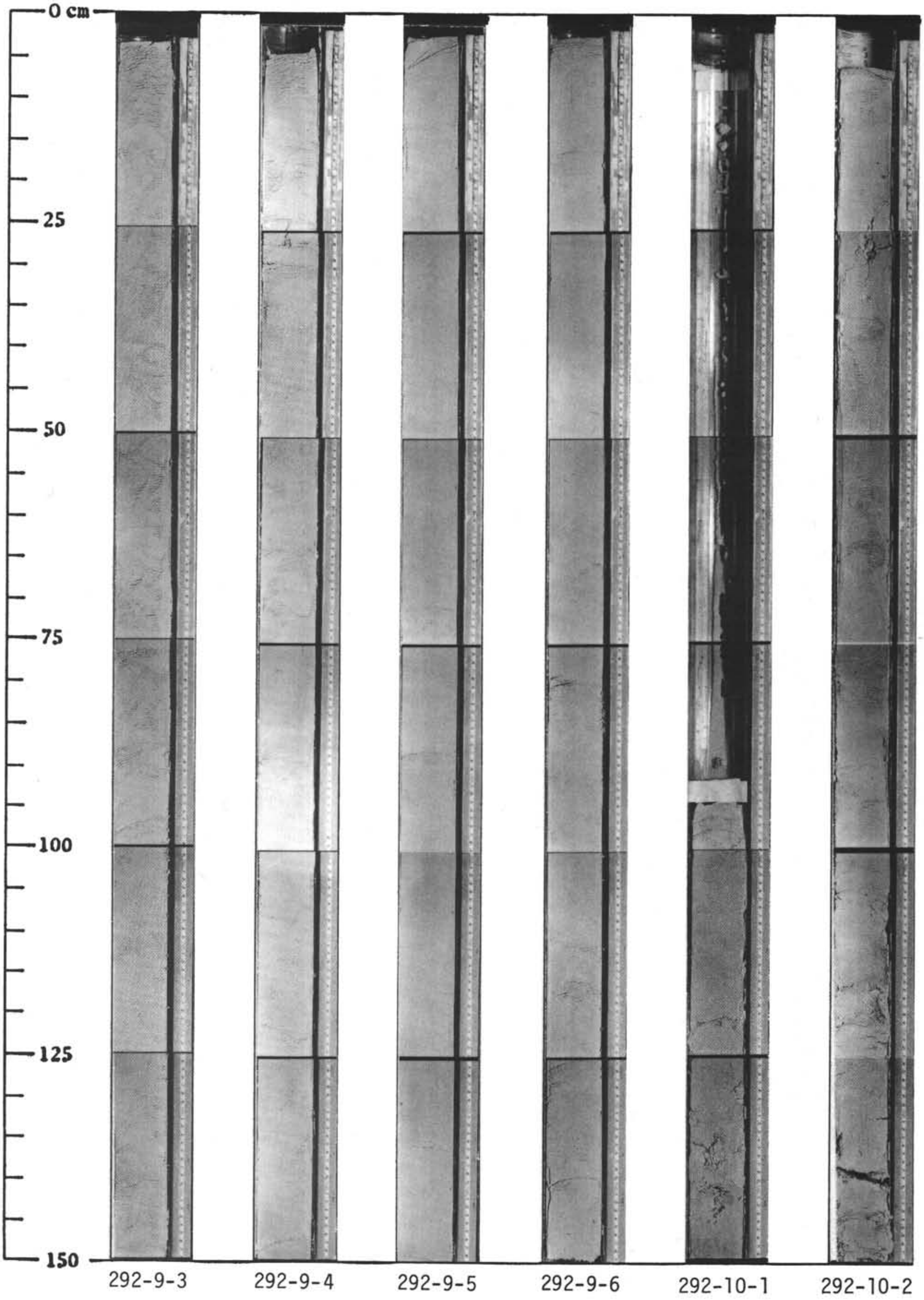
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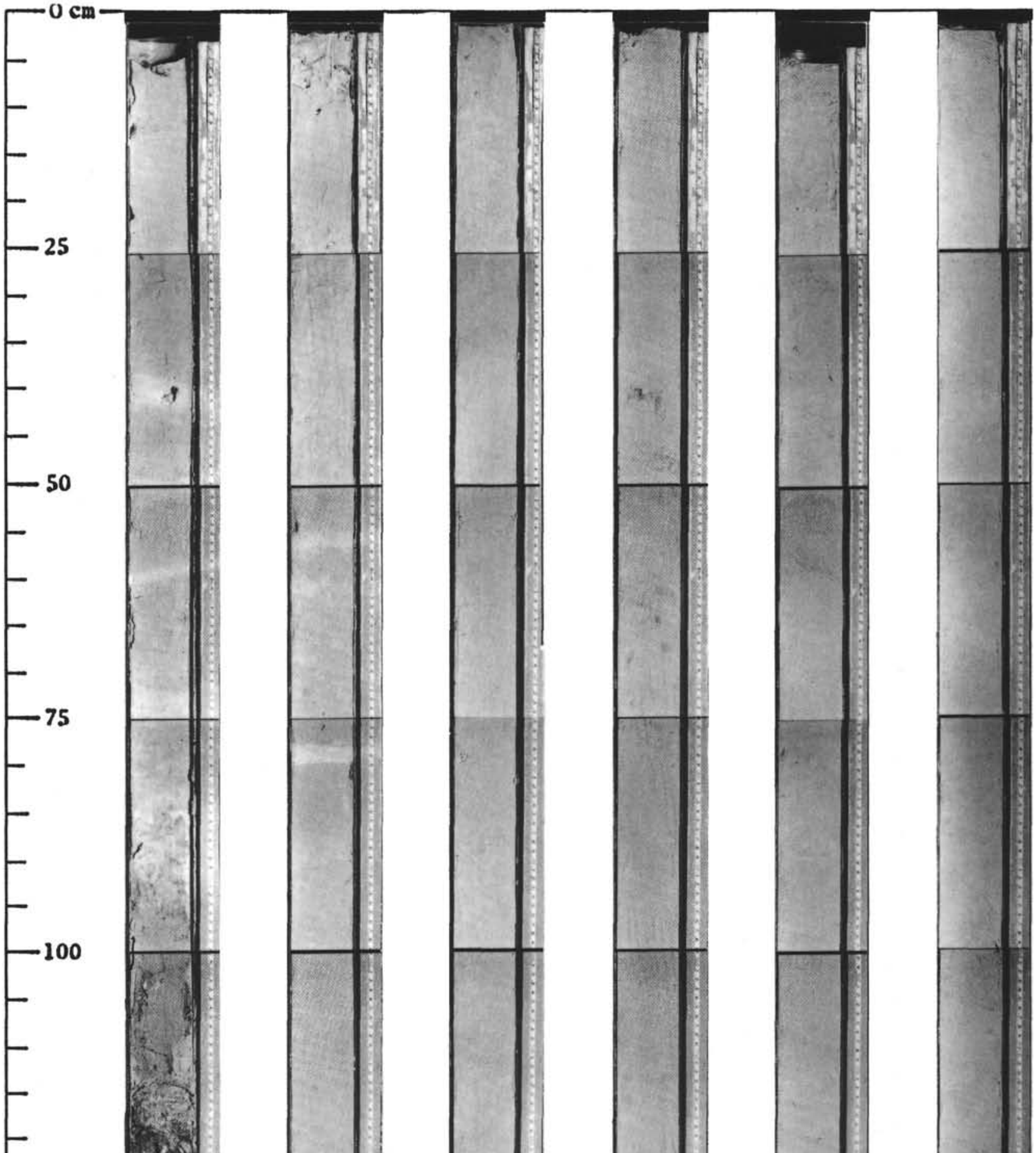
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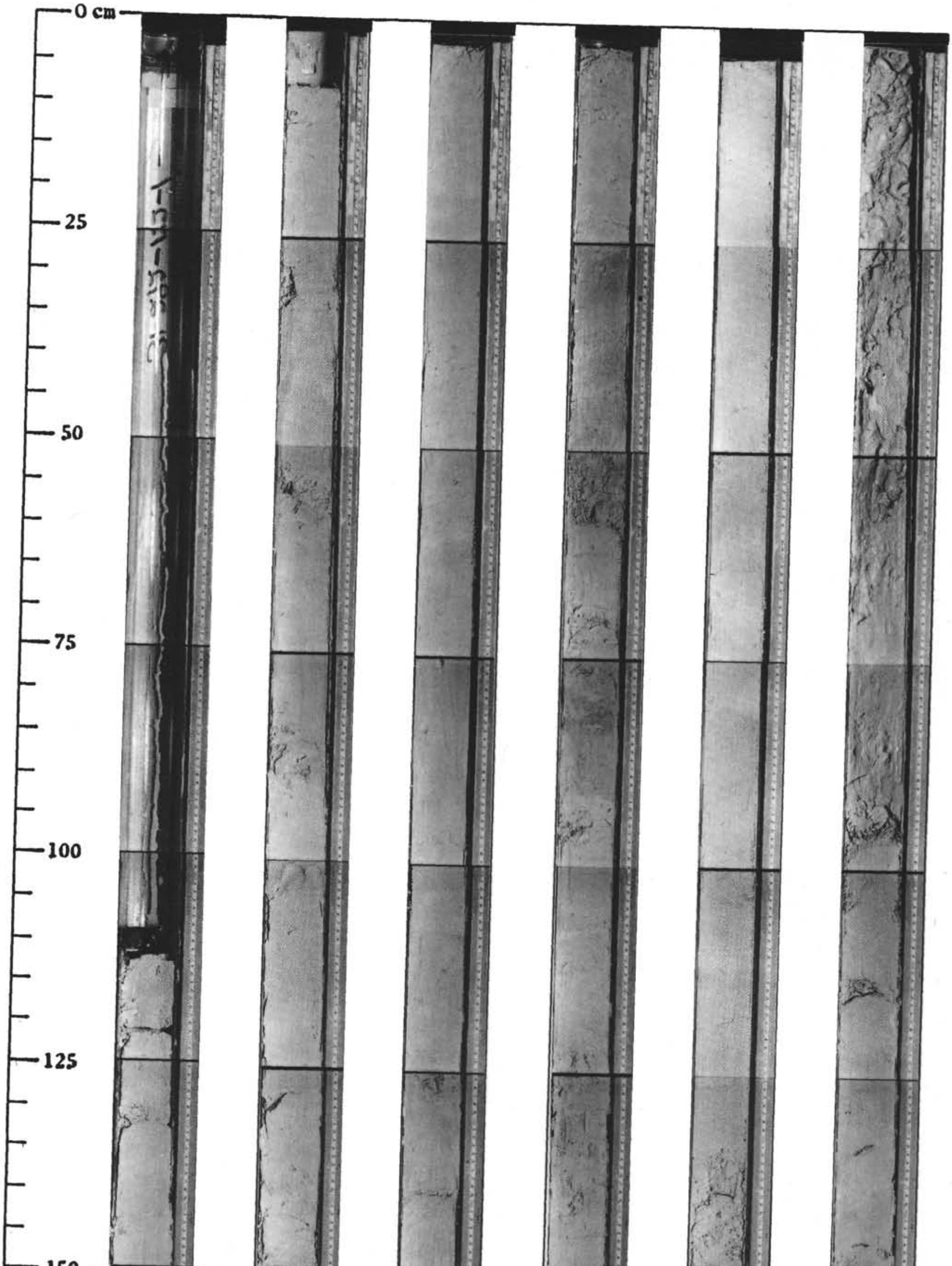

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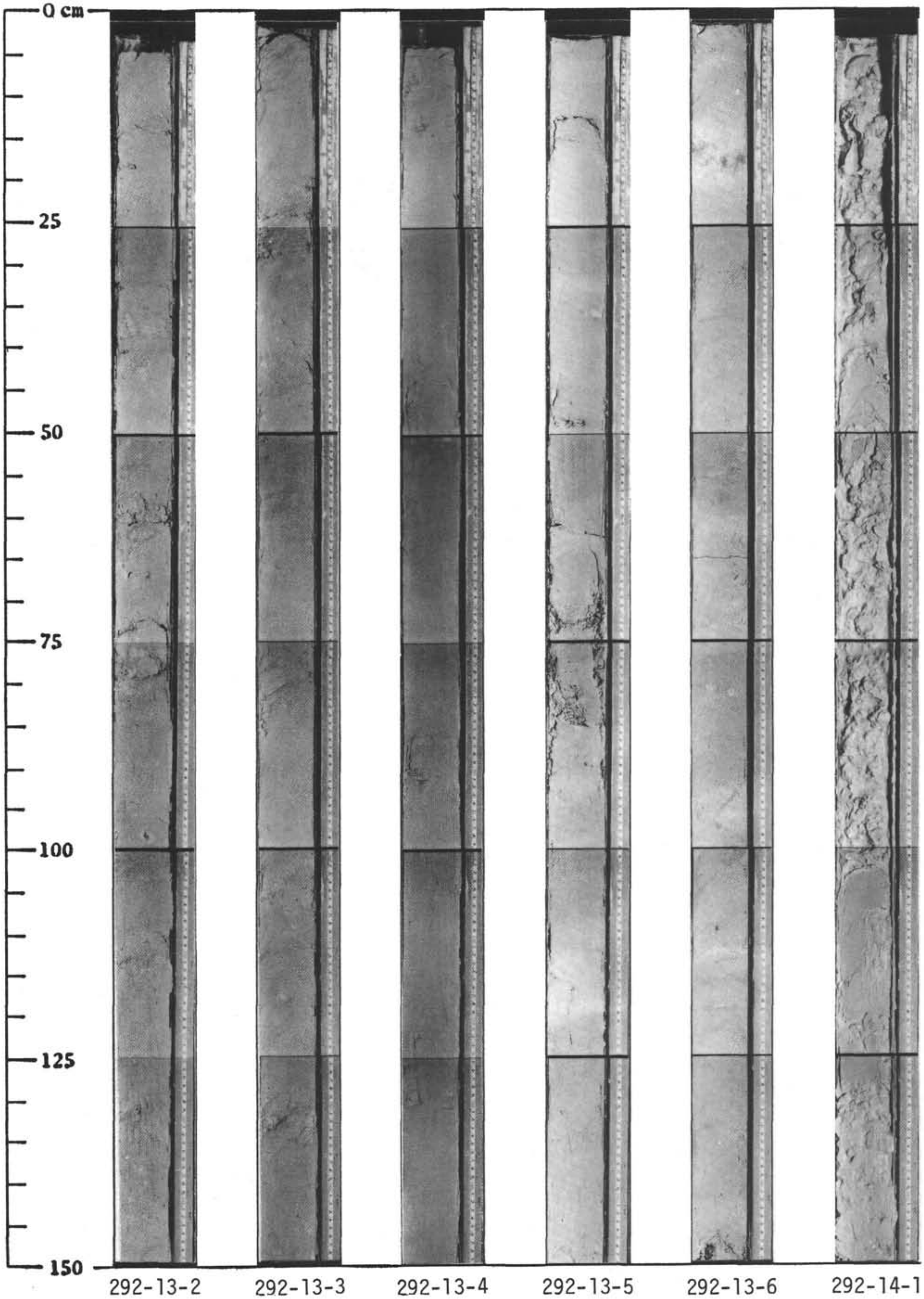
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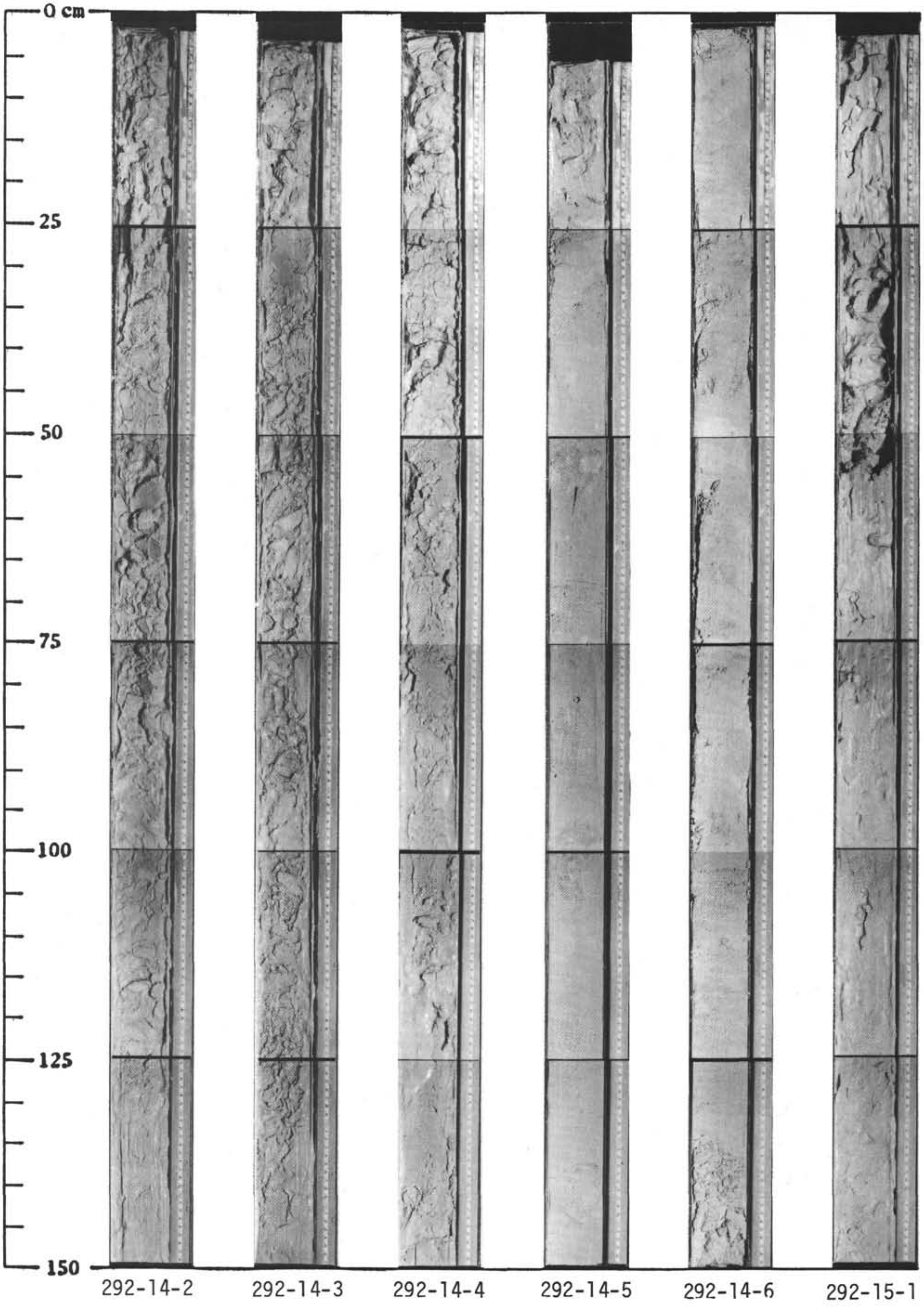
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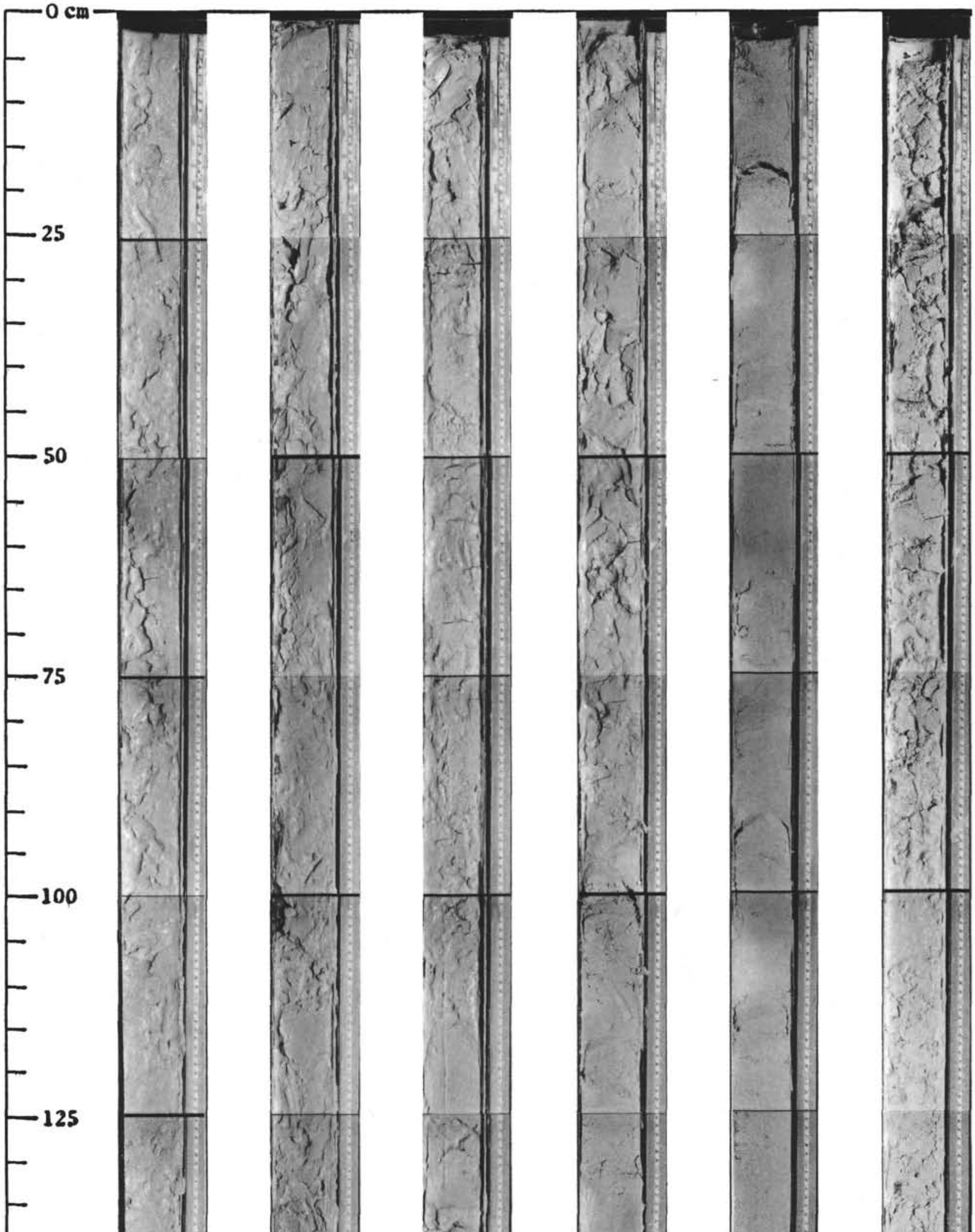
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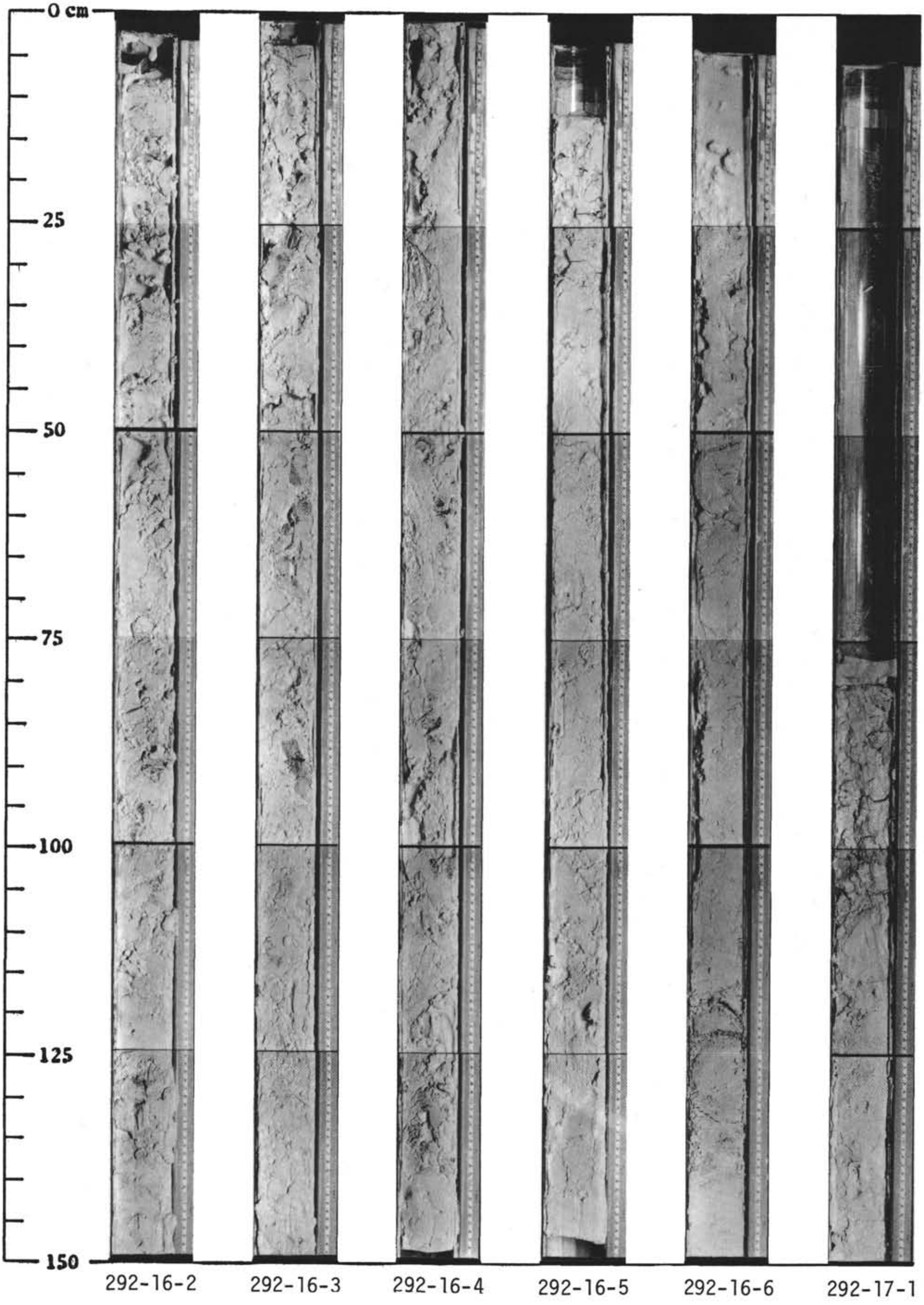
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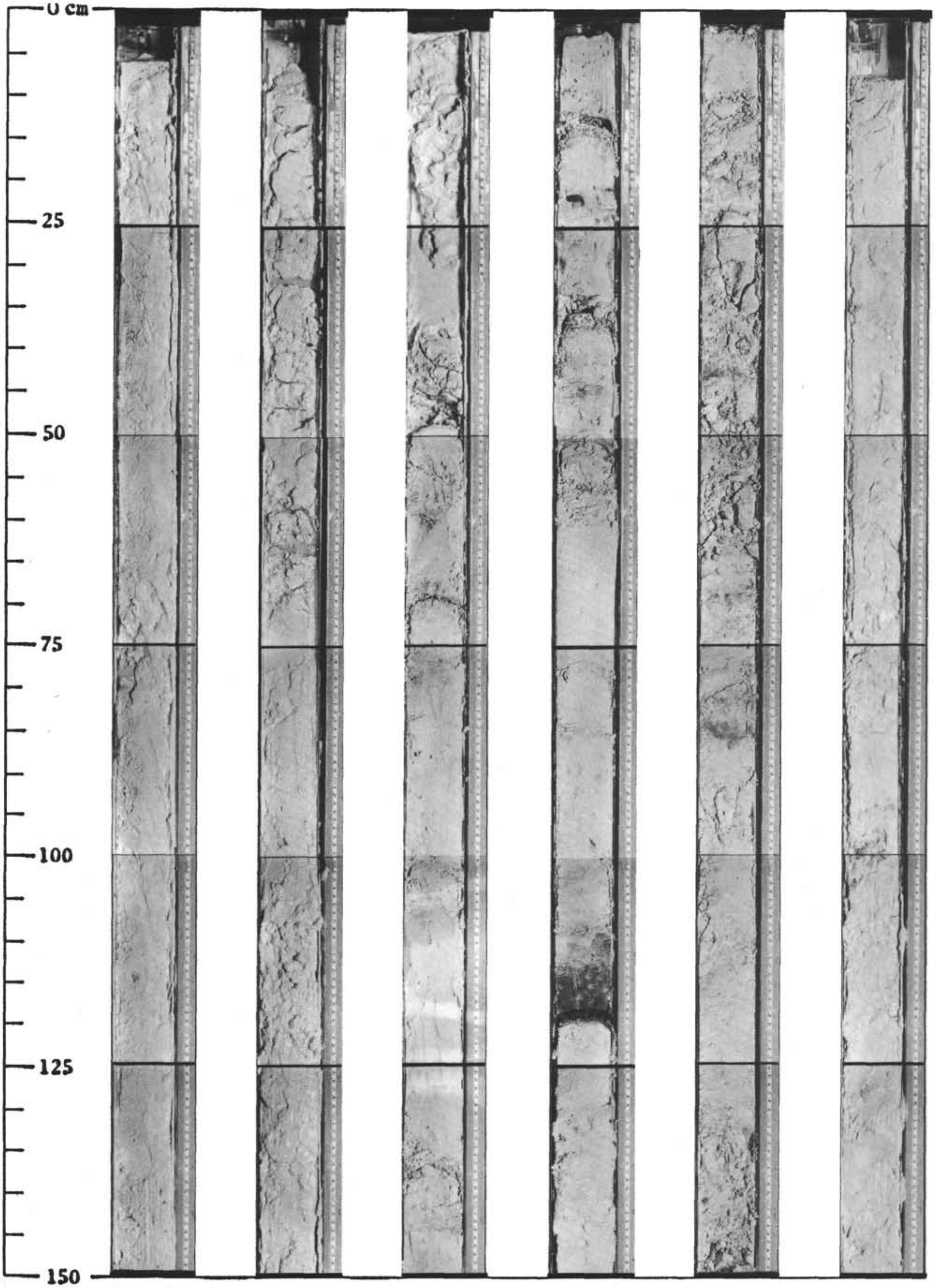

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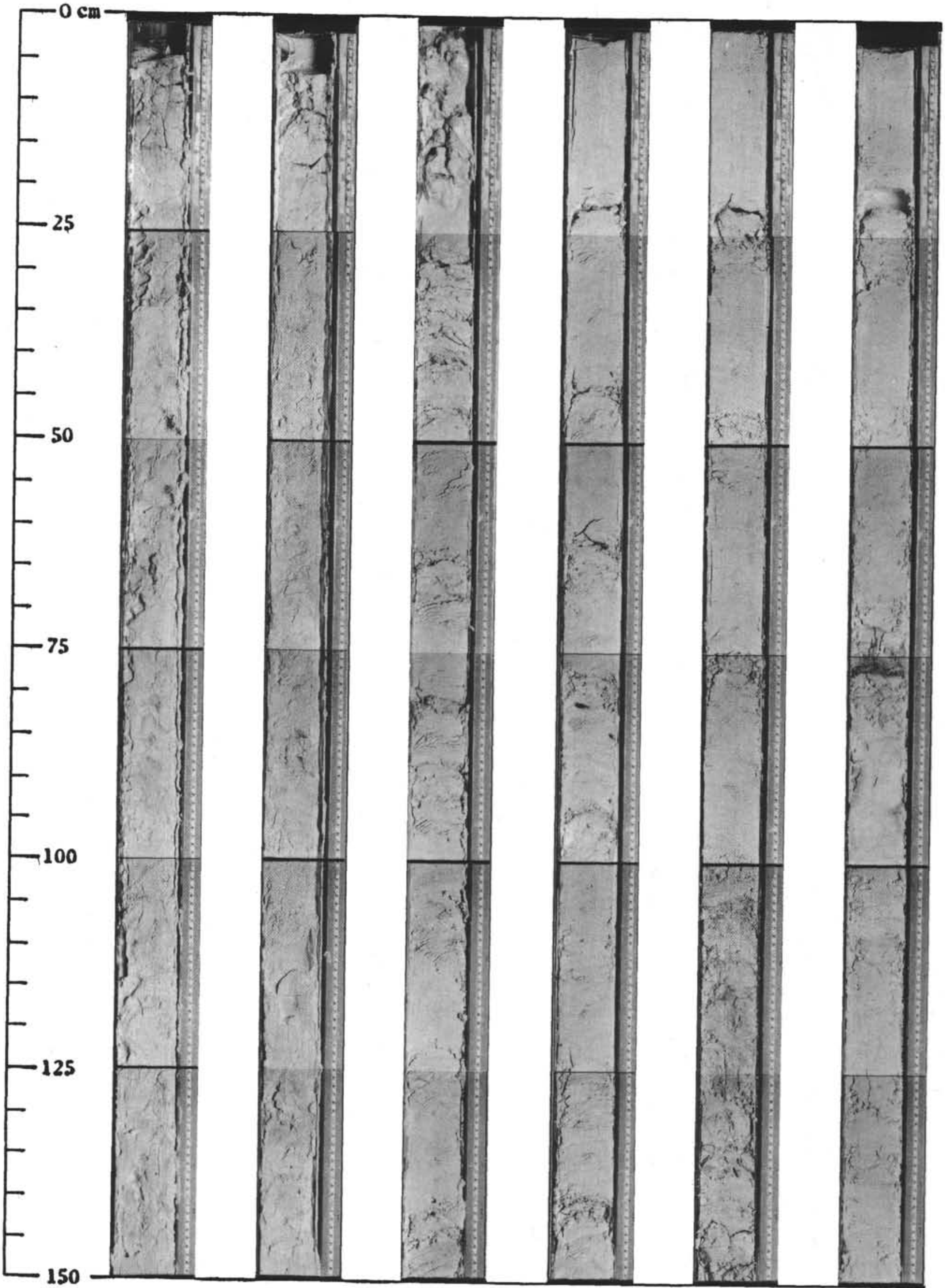
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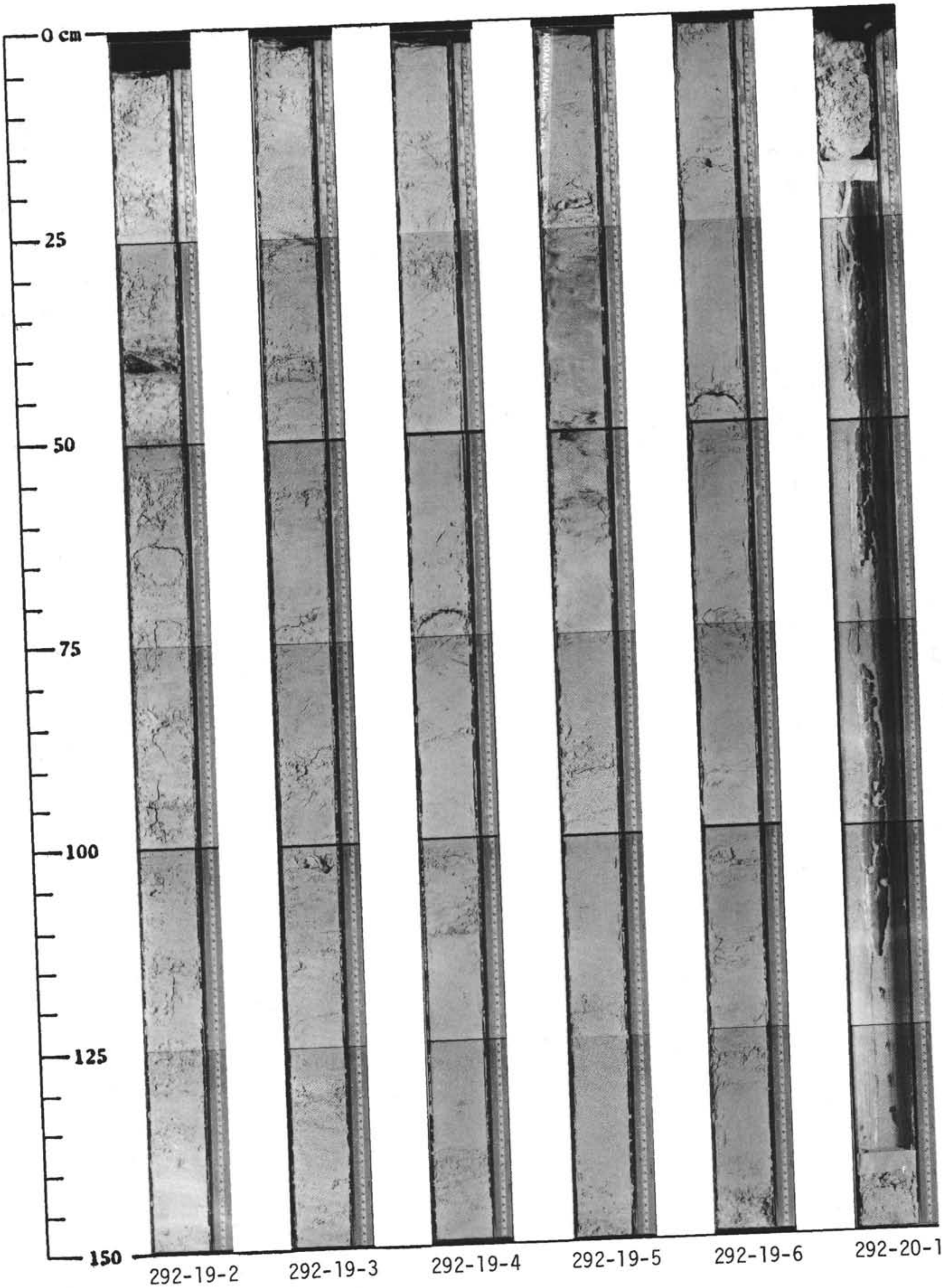
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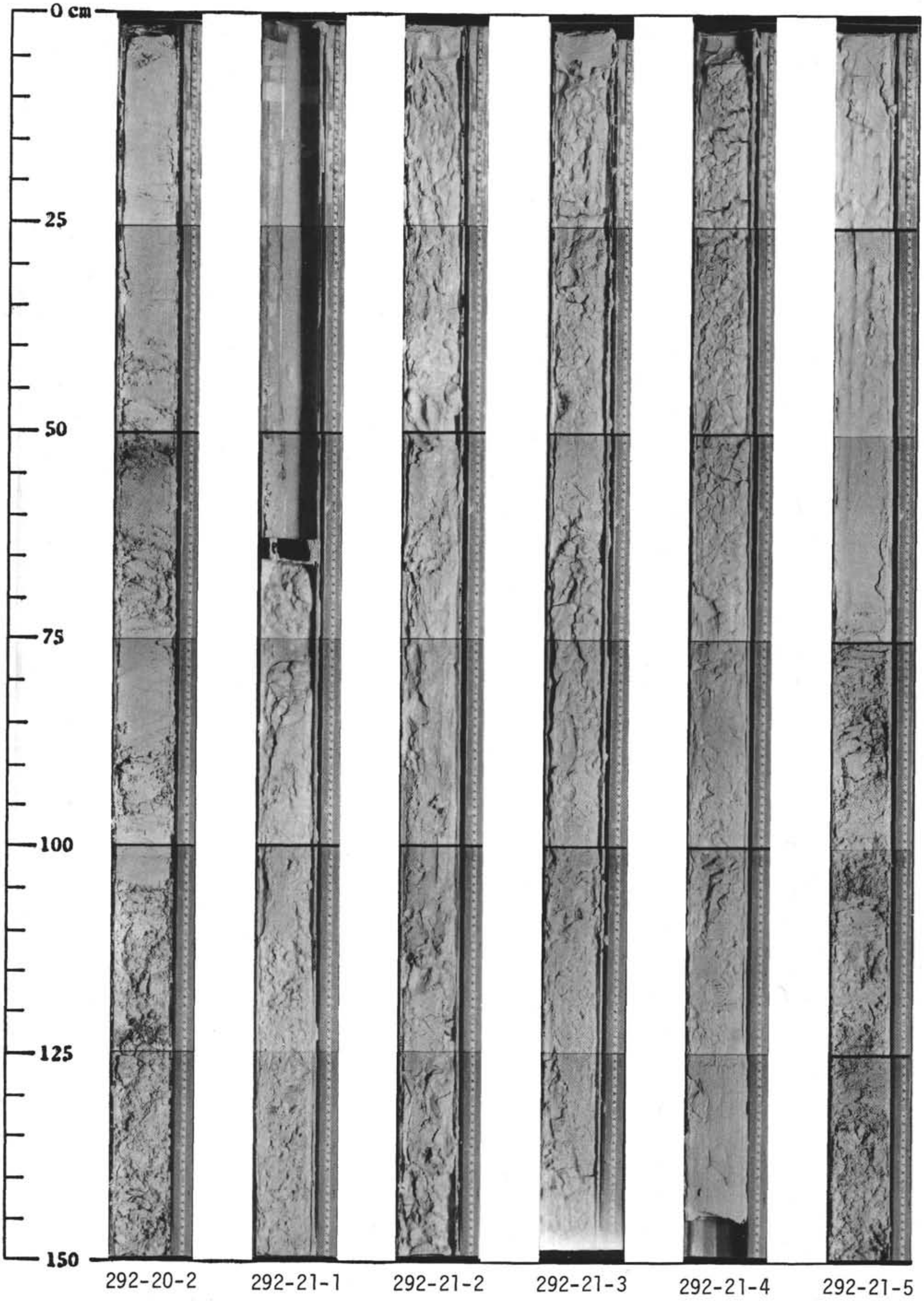
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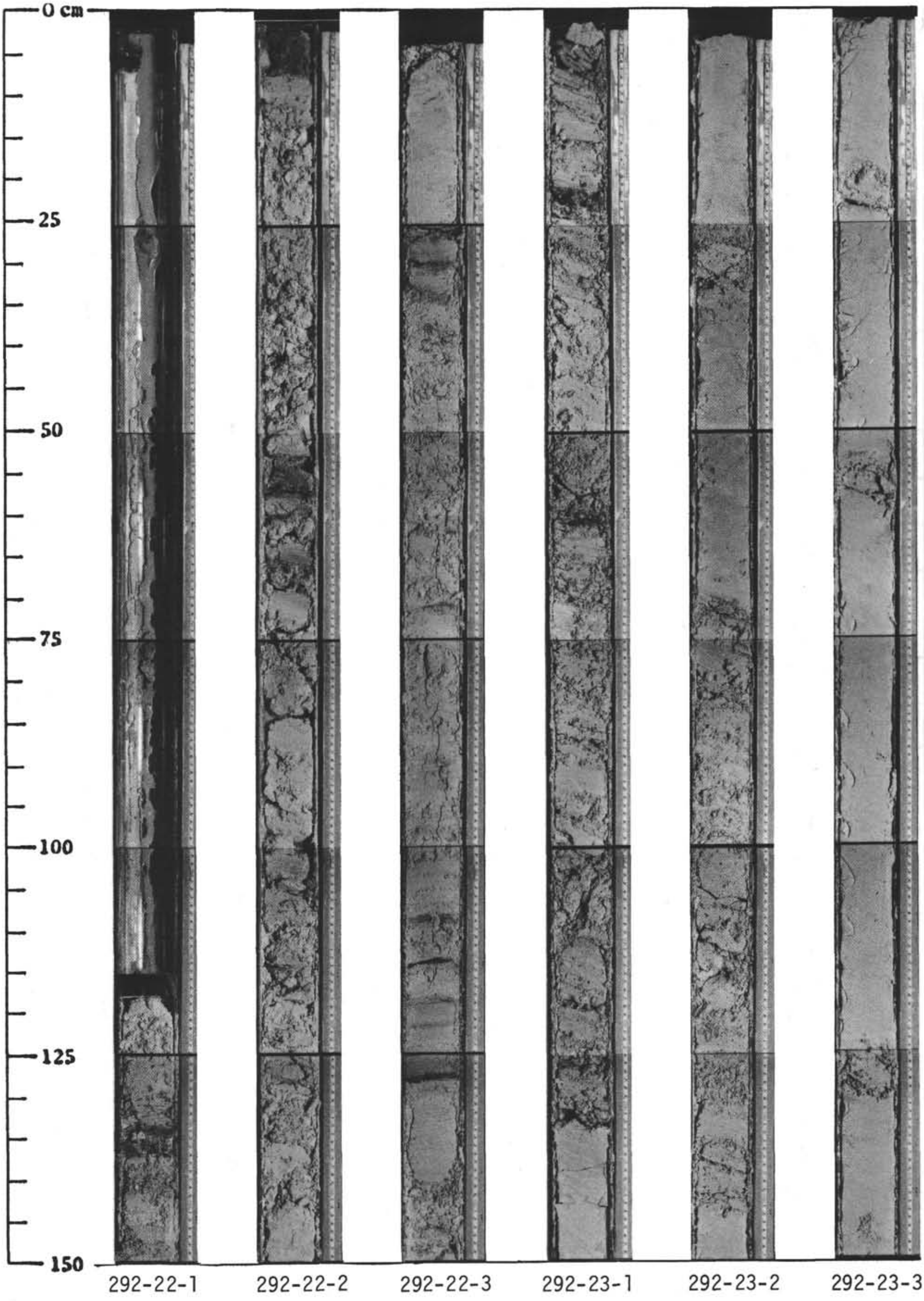
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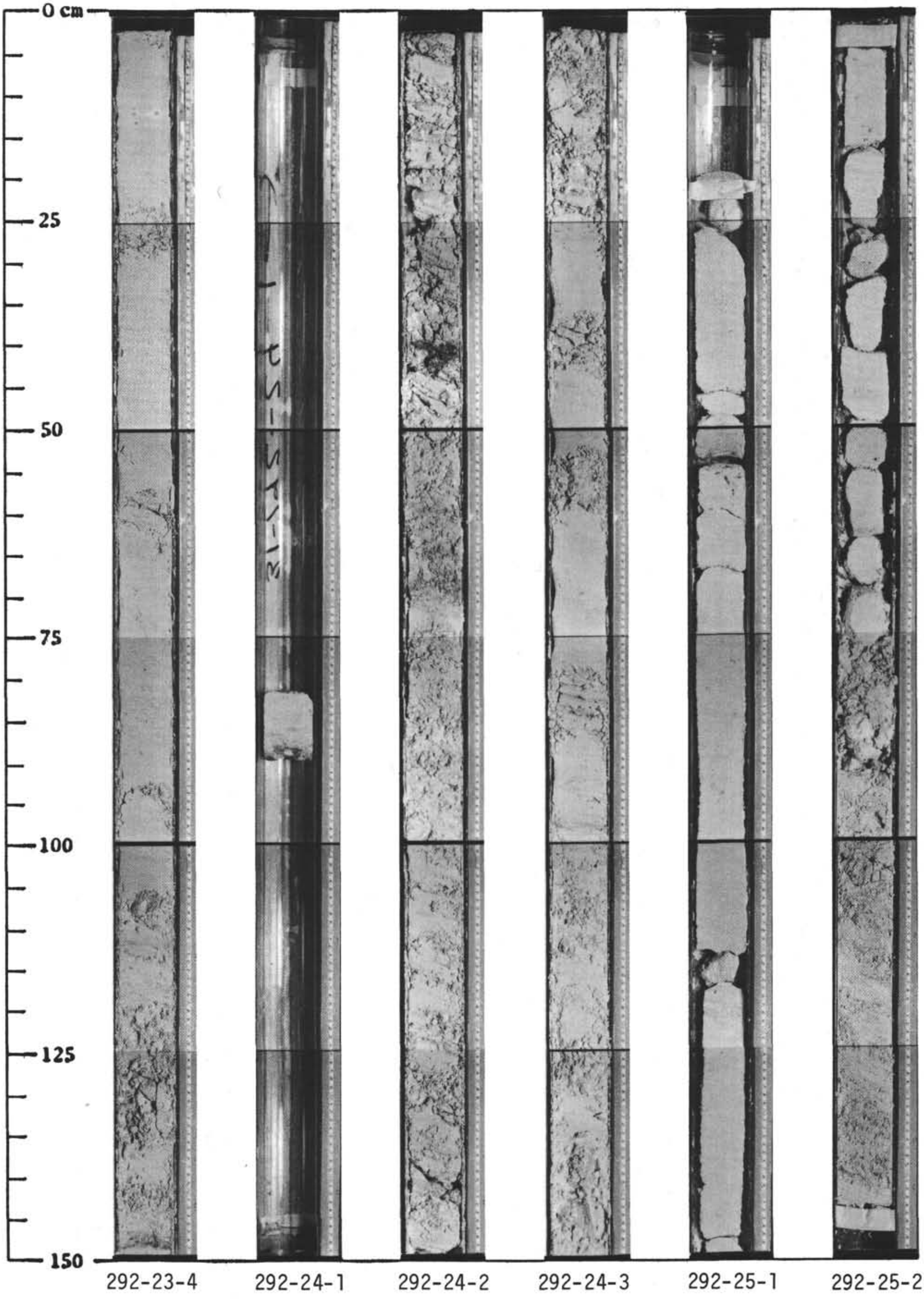
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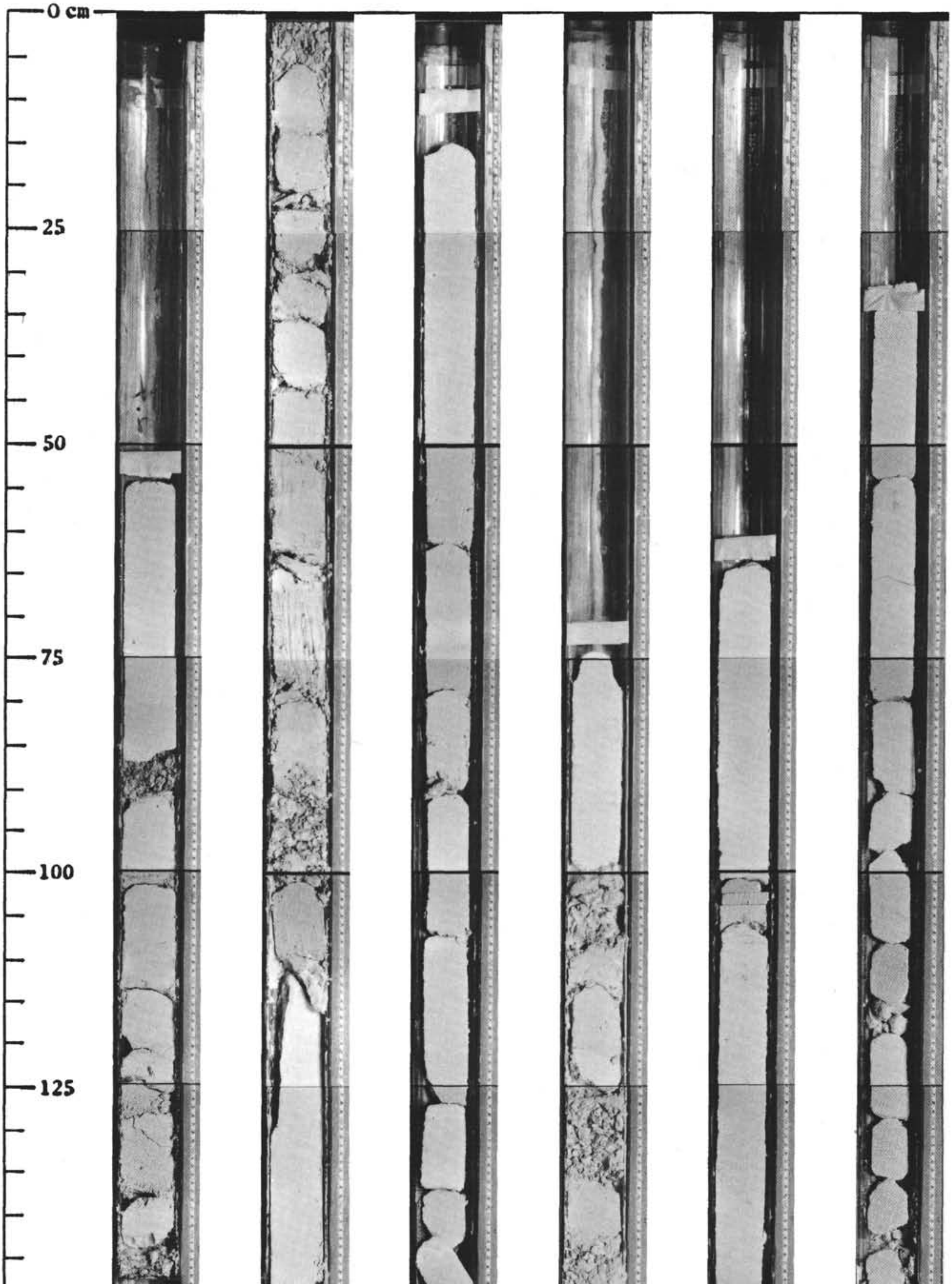
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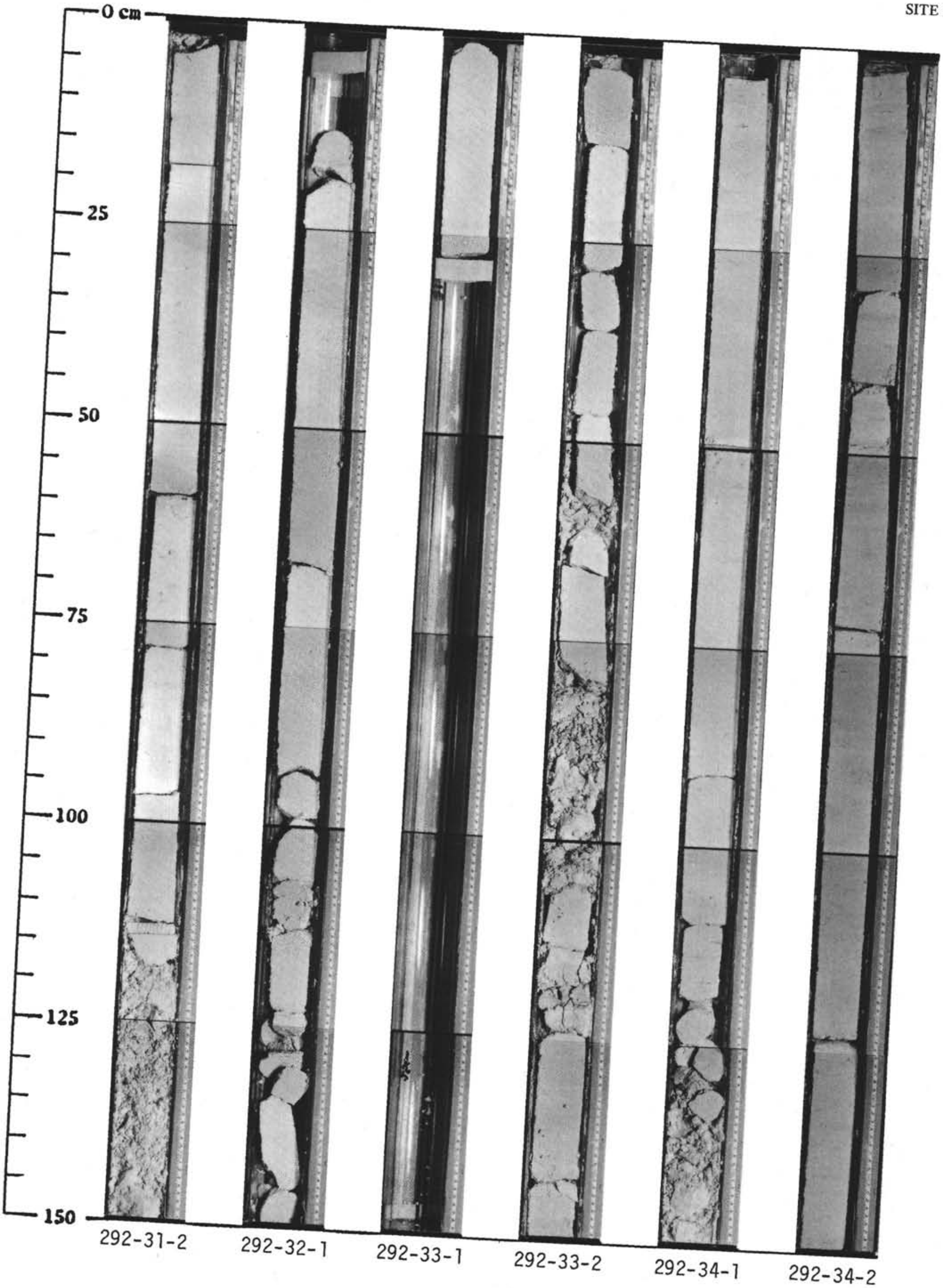
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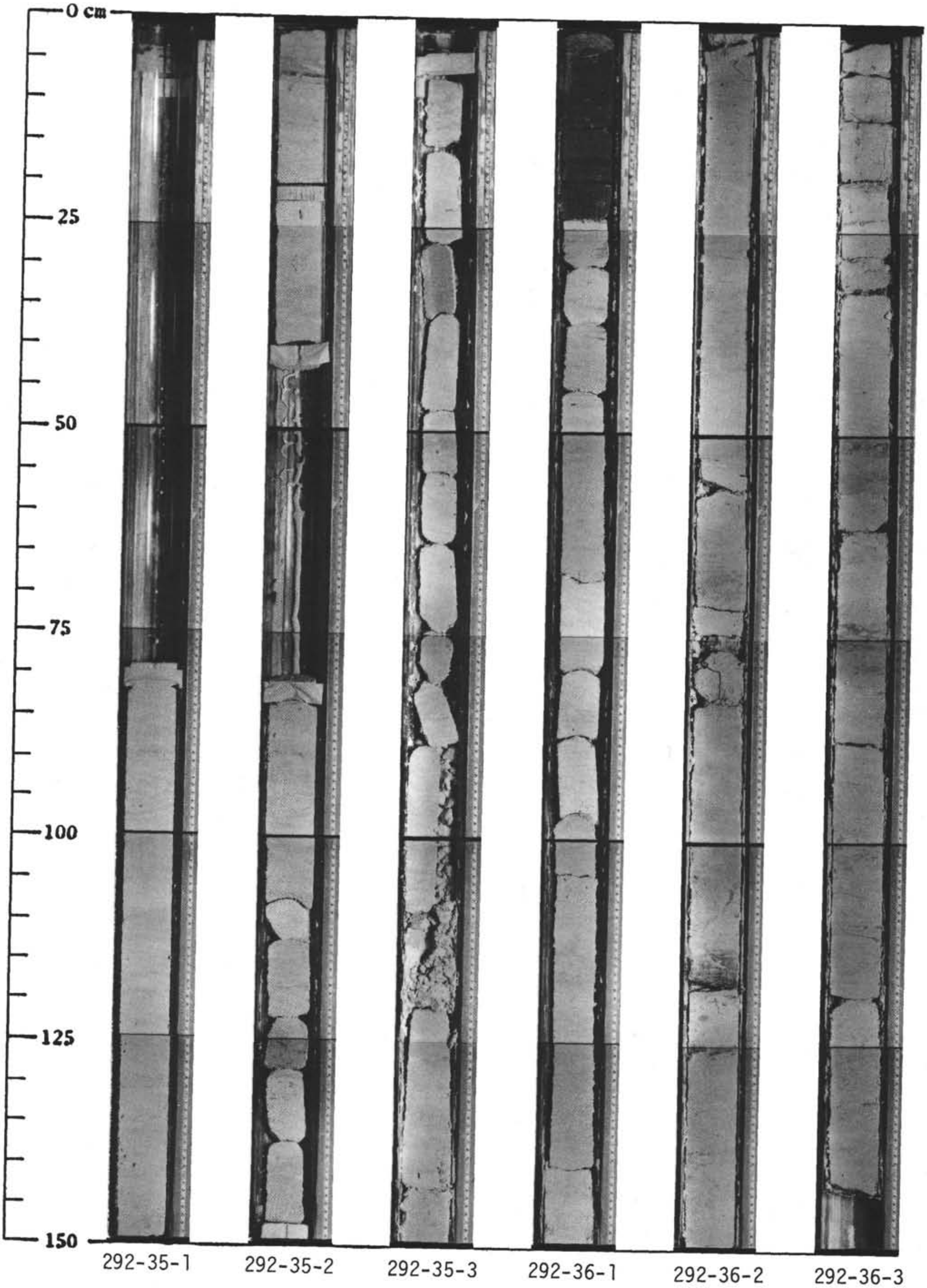
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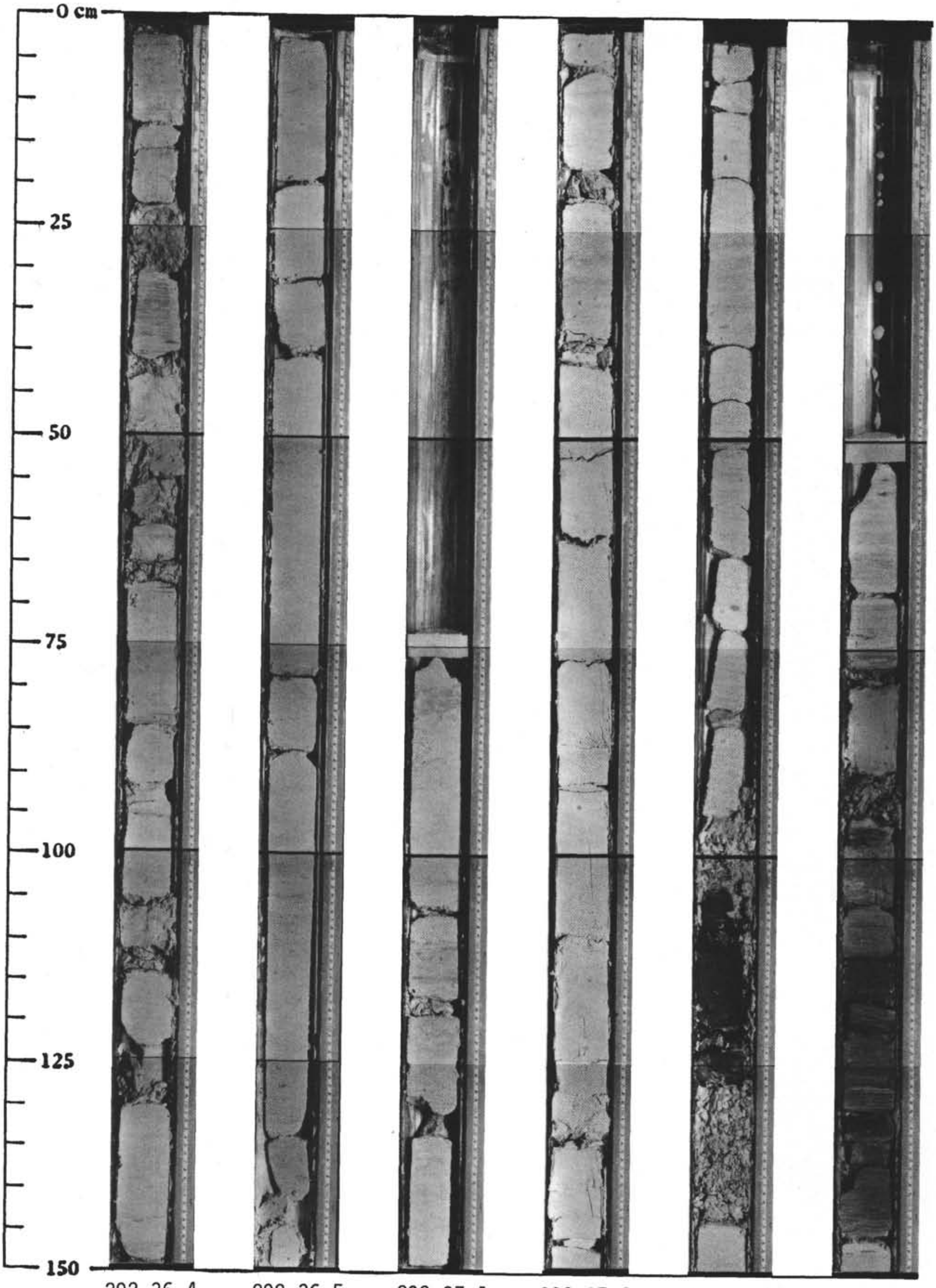
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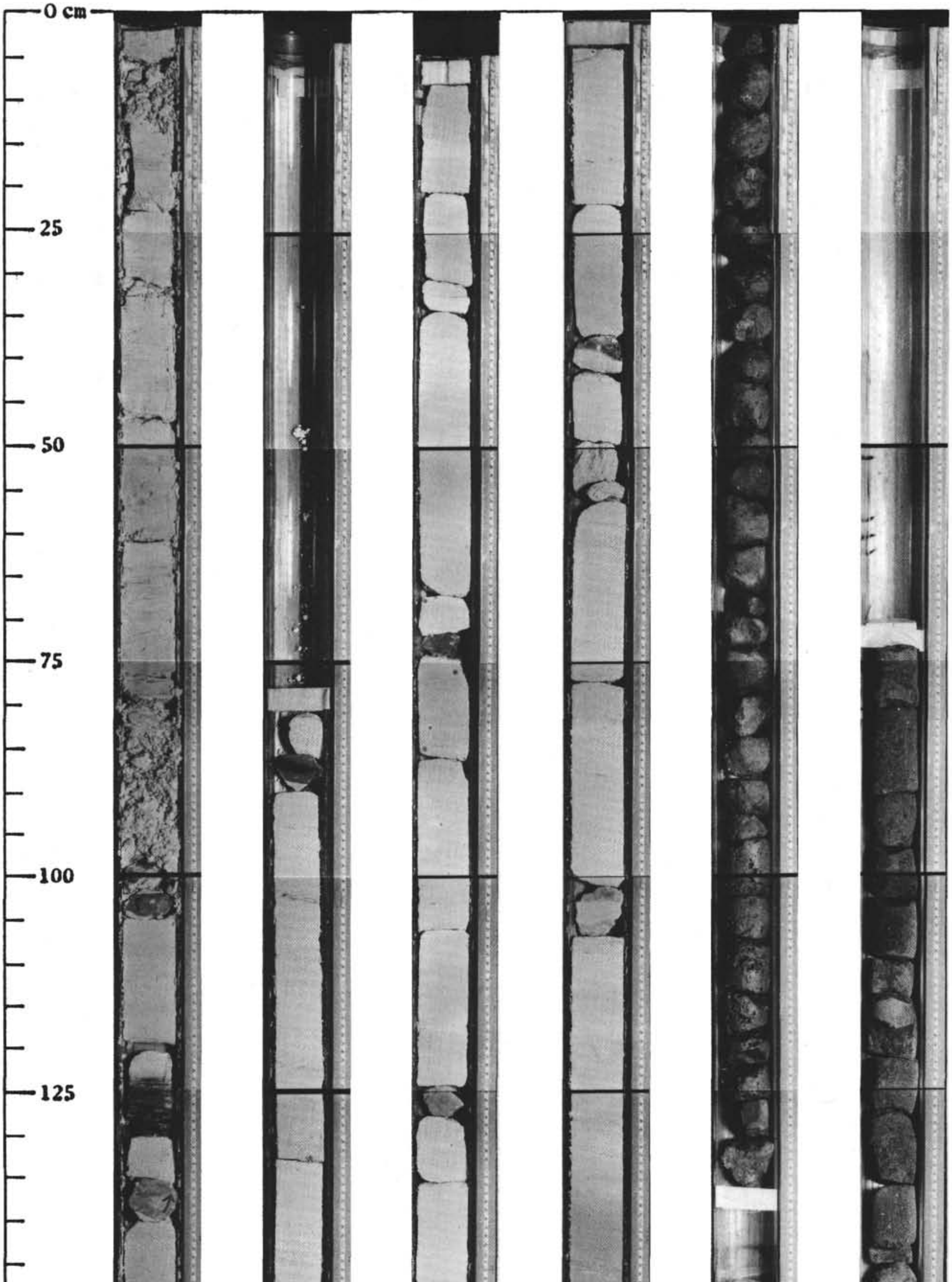
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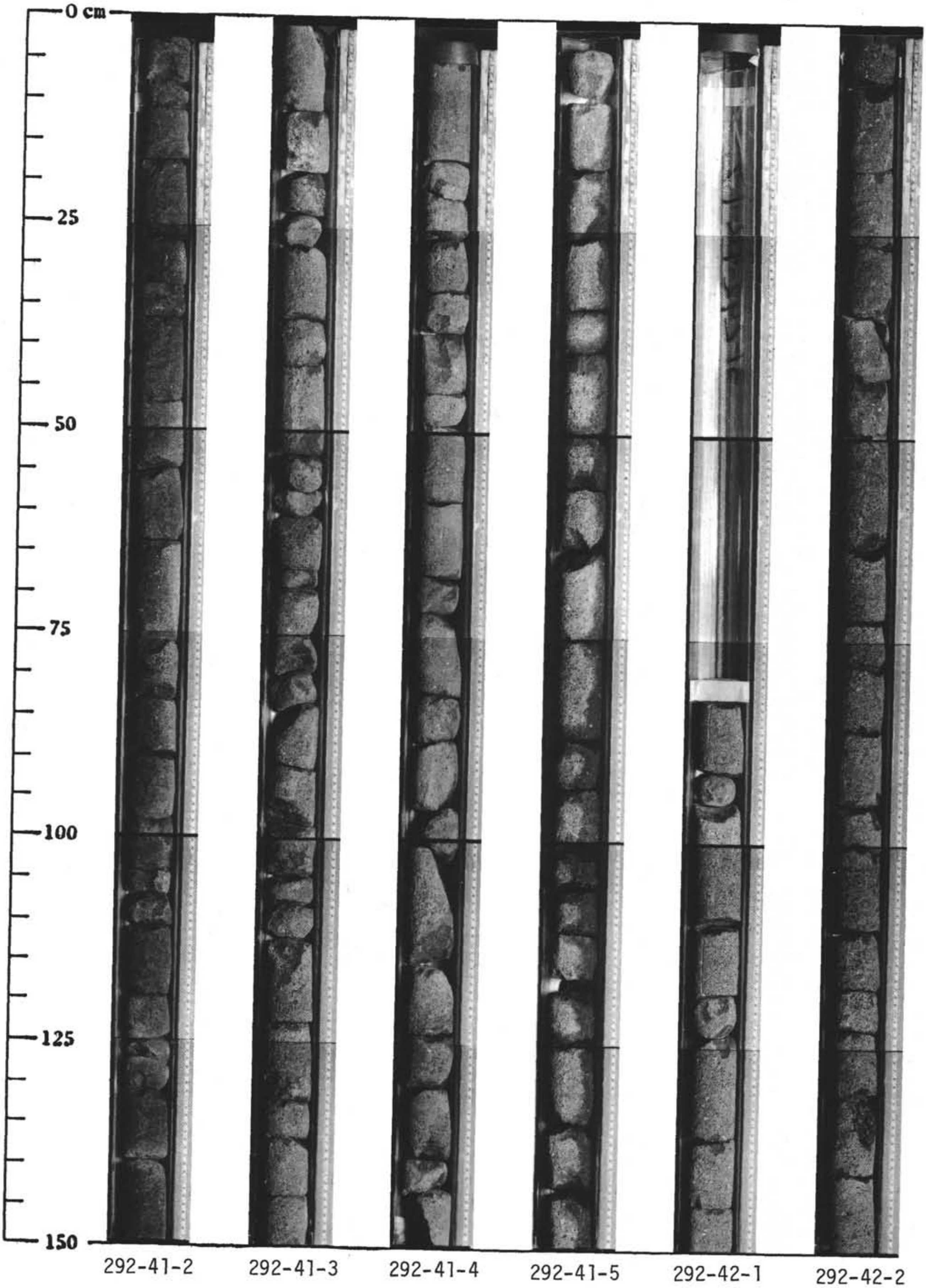
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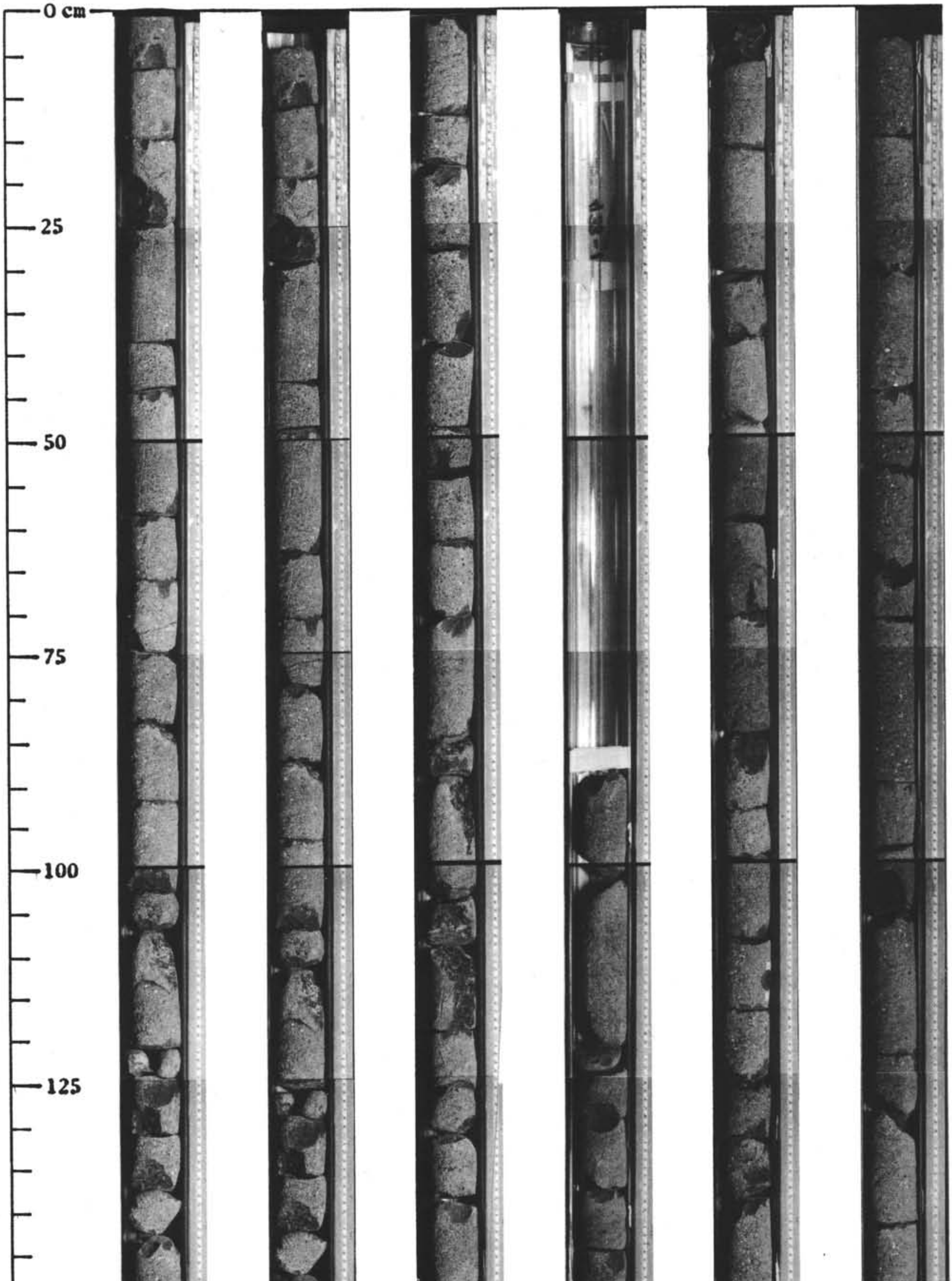
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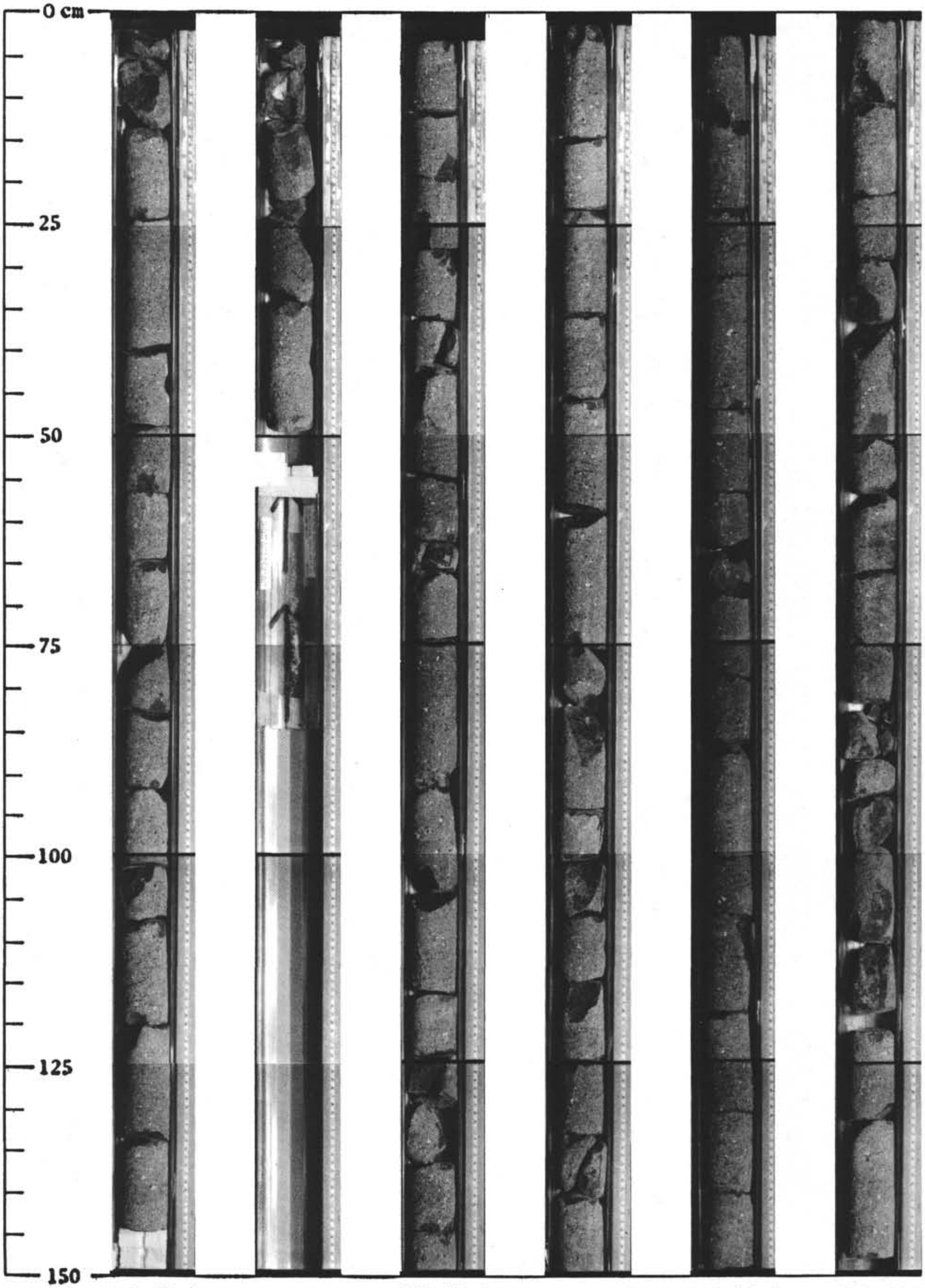
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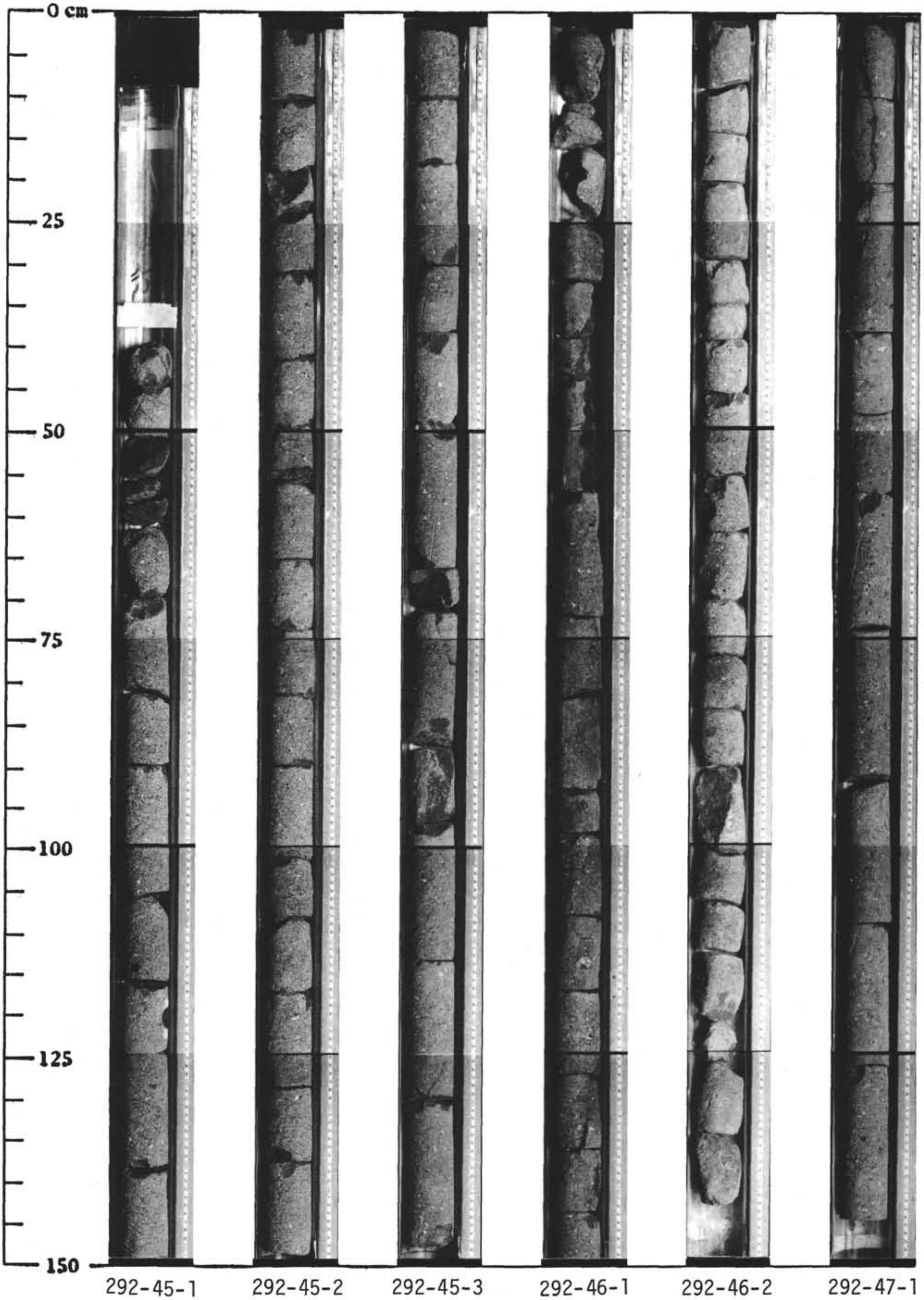
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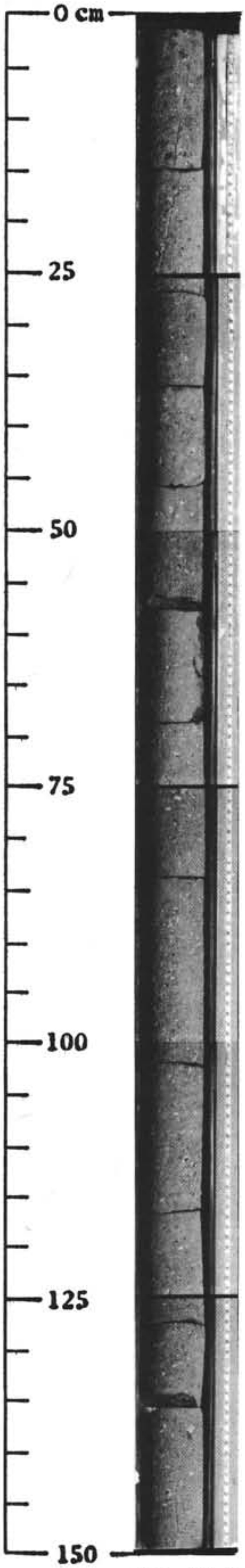

292-47-2