9. SITE 238

The Shipboard Scientific Party[1]

SITE DATA

Date Occupied: 16 June 1972

Date Departed: 21 June 1972

Time on Site: 111 hours

Position:
Latitude: 11°09.21′S
Longitude: 70°31.56′E

Water Depth: 2832 corrected meters (echo sounding)

Bottom Felt At: 2844.5 meters (drill pipe)

Penetration: 586.5 meters

Holes Drilled: 1

Number of Cores: 64

Total Length of Cored Section: 586.5 meters

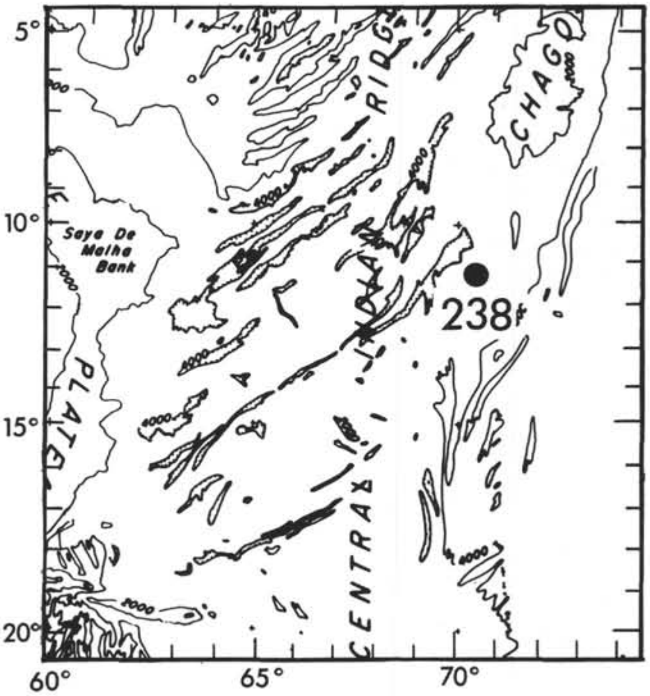
Total Core Recovered: 424.5 meters

Acoustic Basement:
Depth: 506 meters
Nature: Basalt
Inferred vertical velocity to basement: 1.95 km/sec

Age of Oldest Sediment: Lower Oligocene

Basement: Lower Oligocene

Principal Results: The site is very near the northeast end of the Argo Fracture Zone and the adjacent southern end of the Chagos-Laccadive Plateau. The fracture zone is a transform fault dating from early Tertiary, so the site was intended to penetrate the entire column well into basement in order to establish and date microcontinent breakup. The single penetration was cored continuously until basement was encountered at 506 meters, and thereafter continuously to the hole bottom at 586.5 meters. There was a penetration of 80.5 meters into porphyritic flow basalts basement with 40.6 meter recovery. There are some limestone inclusions containing brecciated glass in the basement well below the uppermost flow. Overlying sediment is a uniform white foram-bearing nanno ooze, occurring from 0-348.0 meters. Tan-brown nanno ooze occupies the next 114 meters. From 462 to 506 meters, layered iron-stained oxidized mottled oozes occur. Complete section is Quaternary to lower Oligocene: Pleistocene 0-38 meters; Pliocene 38-139 meters; Miocene 139-405 meters; and Oligocene 405 meters to base of sediment.



BACKGROUND AND OBJECTIVES

Direct evidence for a pre-Miocene unity of the Chagos region with, perhaps, Nazareth Bank of the present Mascarene Plateau is lacking, but magnetic patterns of the Central Indian Ridge and supposed transform fault interpretations are extremely suggestive (Fisher et al., 1971). Notions as to timing, direction of motion, and gross igneous lithology could be verified by drilling to basement at two presumably matched localities at the extremes of a moderately well-mapped cross-fracture that traverses the seismically active Central Indian Ridge. Shortage of time precluded the drilling of paired holes for a definitive test, but proposed site 24-10, south of Chagos, was a high-priority location. It was believed that a hole there stood a good chance of reaching basement below contorted basal sediment layers that may reflect tectonic adjustments following the rifting. Additionally, a supportable age for basement in the Chagos region relative to the Laccadive area (there early Paleocene or older from Site 219 on Leg 23) would foster acceptance of one of two currently held constructions; (1) volcanism building the plateau has migrated north along a leaky, open but long since

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supplanted transform fault or (2) volcanism "moved south" with time as the present Chagos-Laccadive Ridge passed northward over a mantle "hot spot" or plume.

Two east-west traverses by R/V *Argo* in mid-1968 revealed the presence of thick flat-lying sediments constrained between—or even overflowing—strongly reflecting basement ridges or lips on the southern end of the Chagos-Laccadive Ridge, about 400 km south-southwest of Diego Garcia Atoll. Early in 1971, a detailed bathymetric seismic reflection magnetic site survey was made by R/V *Melville* (ANTIPODE Expedition); Figure 1 (modified to include *Glomar Challenger* 1972 lines) is based primarily on those results. It was learned that proposed site 24-10 lies on the intersection of the Chagos-Laccadive Ridge and the northeast end of Argo Fracture Zone, a transform fault crossing the Central Indian Ridge. Profiles normal to the transform fault system's trend successively farther from the active mid-ocean ridge crest, show increasingly thick sediment sections within the cross-fracture. Proposed site 24-10, at the extremity, should yield the thickest or, at least, the oldest sediments that may date the sundering of the Chagos-Laccadive Ridge from the Mascarene Plateau. Surface topography at the side is not overly much lineated in a northeast-southwest direction, but that trend is clearly shown in the basement ridge-trough system.

The ANTIPODE airgun records reveal a simple picture of faintly stratified sediment over well-defined basement with bedding lapping basement at a large angle. A northeast-trending trough is centered at about 11°10'S, 70°31'E and shows a maximum sediment thickness of 0.55 sec on four intersecting profiles. The basal 0.15-0.20 sec of the column shows more obvious, and more contorted, layering. The lowest and oldest sediments may contain pebbles or fragments of coarse-grained mafic or ultramafic rocks of the lower crust such as the lherzolites and gabbros today exposed on the walls of the transform faults near the

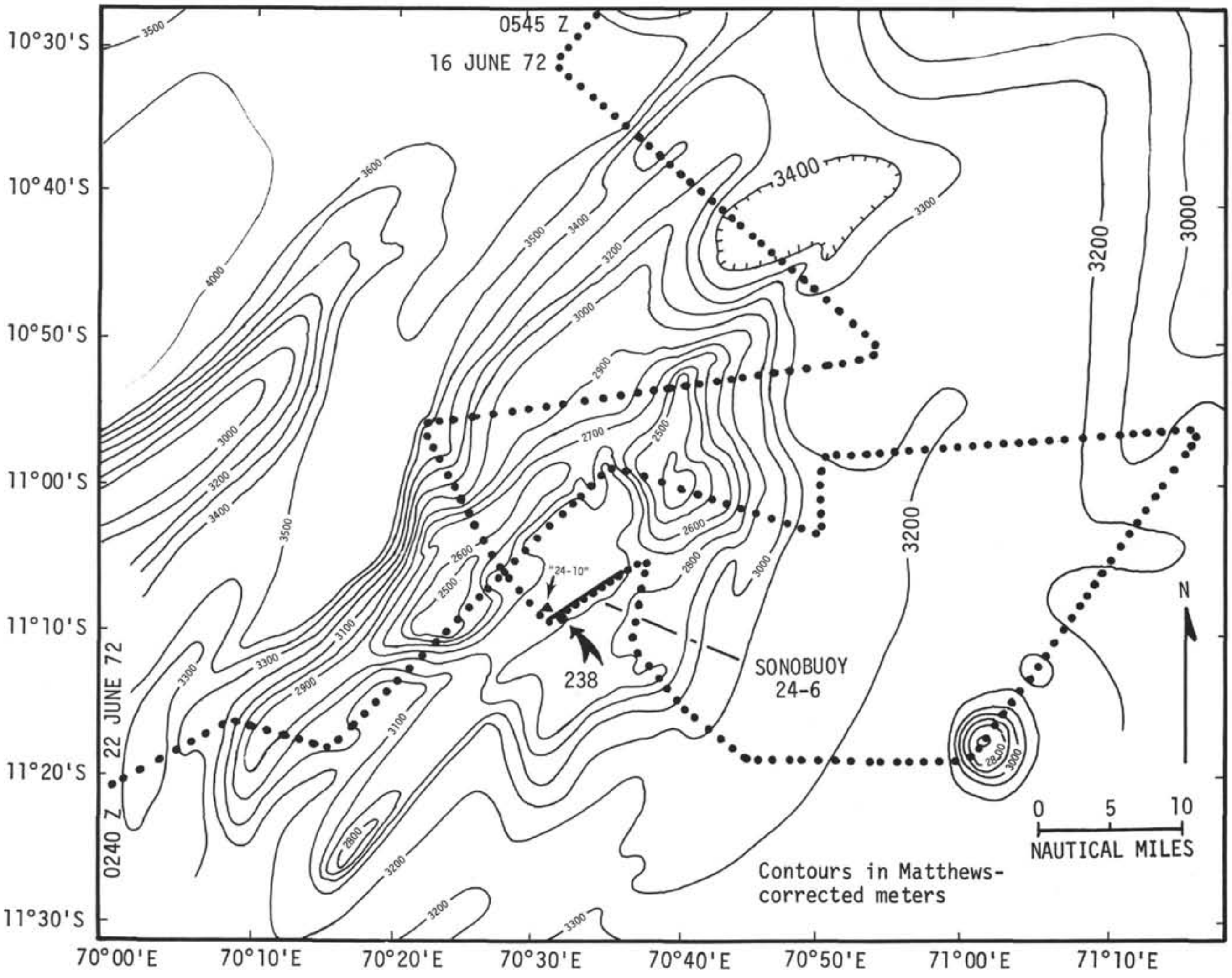

Figure 1. *Location of Site 238, proposed site 24-10, and sonobuoy 24-6. Dotted line is track of* Glomar Challenger. *Contours are in Matthews-corrected meters.*

seismically active crests (Engel and Fisher, 1969). Magnetic stripe correlation ages for the site 24-10 region do not exist, but the basal sediments may be early Miocene, and the extensive deep reflectors are not so likely to be due to chert. A piston core yielded calcareous ooze with no siliceous microfossils and a foram age at bottom of mixed middle Miocene-Quaternary. Bottom photographs show a mottled, tracked, pockmarked but fairly firm surface.

The objectives for drilling Site 238 (proposed site 24-10) were:

1) To penetrate the sediment column, coring as continuously as possible, and recover a definitive basement sample from the south end of Chagos-Laccadive Plateau.

2) To date, by fossils, both shallower horizontally bedded layers and deeper, rather contorted, sediment layers. Coarse fragments from the latter beds might reveal gross igneous lithology of the shallower plateau regions nearby that now are coralline encrusted and capped; they also may have slumped from faulted flank exposures that now are inundated by sediments.

3) If former unity was found to be true, to establish the time of sundering of the Chagos region from the vicinity of Saya de Malha-Nazareth Bank.

4) To help establish whether volcanism building the ridge foundation moved north to south or south to north in Tertiary time.

OPERATIONS

Near-Site Activities

Following a brief unscheduled call at Diego Garcia to disembark a seriously ill member of the drilling group, *Glomar Challenger* moved south-southwesterly along a zig-zag track on the southernmost portion of the Chagos-Laccadive Ridge. This track was employed to examine the sedimentary layering overlying basement in the region north of 11°S, the northern limit of the site 24-10 survey conducted by R/V *Melville*. Since no further survey was required within the latter region, this proposed site was approached directly on a southeasterly course. *Glomar Challenger* was slowed to six knots for better profiling, a drilling locality was selected, the ship was headed north at 4 kn and the beacon and a lighted spar buoy were dropped. Seismic streamers and magnetometer were retrieved and *Glomar Challenger* returned south to the beacon. It lay in a water depth (by echo sounder) of 2832 meters (corrected) at a point 1.2 nmi southeast of site 24-10 (Figure 2).

At the close of the drilling operations, *Glomar Challenger* ran west-southwest at 4 kn, streaming and testing gear, then came about to an east-northeasterly course paralleling the topographic grain of the basement. As noted earlier, surface lineation had seemed less pronounced than basement lineation at this site. Subsequent exploration bore out this conclusion; accumulating sediments have spilled out over the hard rock margins of the transform fault, blurring its trend. Sonobuoy run 24-6 was made along the canoe-shaped feature, ending as basement approached the sea floor to the northeast. The following eighteen hours were employed in airgun-magnetic-topographic profiling to better delineate the intersection of the transform fault pattern of the spreading Central Indian Ridge with the non-seismic Chagos-Laccadive structure and Site 238's exact setting in the system.

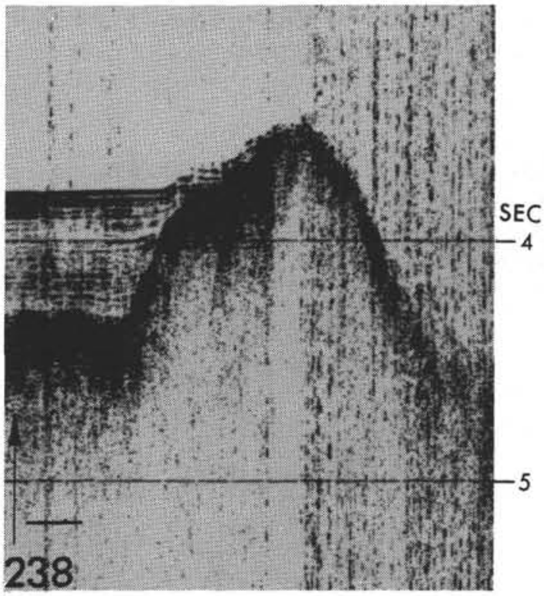

Figure 2. *On-site profile, Site 238. Site location is indicated by arrow.*

Site 238 lies very near the northeastern extremity (earliest portion) of the cross-fracture. North of 11°00'S, the cross-fracture could not be seen either in exposed or basement topography. Lines run north and east of 10°56'S, 70°40'E show the characteristic nearly homogeneous 0.3-0.45 sec acoustically transparent sediment over strongly reflecting basement that extends north at least as far as Diego Garcia. Here any fault scarp bounding the plateau would occur at about 70°50'E but might be obscured by volcanic flows following rupture. Leaving the site environs near 11°20'S, 70°00'E, *Glomar Challenger* proceeded southwest along the axis of Argo Fracture Zone (Fisher et al., 1971) heading directly for Mauritius.

Drilling Program

Bottom was established at 2844.5 meters by drill pipe measurements. The hole was continuously cored from the mud line to a total depth of 3431 meters (Table 1). The first 350 meters was nanno ooze, and the core recovery was 86 percent. Brown nanno ooze and chalk was cored from 350 to 506 meters. Core 54, at 3350.5 meters, had some basalt fragments in the bottom. The rate of penetration changed from a minute per meter to 16 minutes per meter at 3350.5 meters. Site conditions were good; however, while coring basement, it became necessary to flush the hole with 10 to 20 barrels of mud for each 9.5 meters cored. Some minor sloughing did occur, probably caused by a wind and swell condition that cause the ship to have rolls of from 4° to 10° and a pitch of 3°

Site 238 was a very good one for obtaining the deepest penetration into basement. There was no chert, limestone, or sand to fall in from above and stick the drill string. At 3431 meters, after coring a record depth of 80.5 meters into basement and recovering 40.6 meters of core, the hole was abandoned because of a locked bit.

A total of 586.5 meters had been cored and 424.5 meters recovered for a 72.3 percent recovery.

LITHOLOGIC SUMMARY

Hole 238 was continuously cored from the sediment surface to basement at 506.0 meters and then a further 80.5 meters into basalt. The sediment sequence can be divided into three sedimentary units; basalt basement with intercalated baked sediments constitutes a fourth unit. The units are listed in Table 2.

TABLE 2
Lithologic Units–Site 238

Depth Below Sea Floor (m)	Unit	Lithology	Thickness (m)	Cores
	1	Nanno ooze to foram-rich nanno ooze	291	1-31
291.0				
	2	Nanno ooze to foram-bearing nanno ooze	180.5	32-50
471.5				
	3	Nanno chalk with intercalated horizons of volcanic ash and zeolites	34.5	51-54
506.0				
	4	Basalt with intercalated horizons of recrystallized chalk	80.5	55-64
586.5				

Unit 1 (0.0-291.0 m; Cores 1-31)

This unit consists of nanno ooze to foraminifer-rich nanno ooze. In the upper 3 meters, the sediments are oxidized and are very pale orange in color. However, below this depth, the redox potential drops, and the color changes to a very light gray. Throughout this latter part of the unit, the sediments are very uniform both in color and composition. Colors range from white through bluish white to very light gray, with bluish gray wisps, streaks, and darker mottles and patches in medium and dark gray. Some of the latter are pyritic. Lithified foraminiferal chalk fragments occur at several levels in Unit 1. However, it is not known whether these represent separate layers or one layer which became fragmented and redistributed down the hole as a result of the coring process (McManus et al., 1970). The principal biogenic constituents of Unit 1 are calcareous nannofossils, which vary in abundance from 60 to 90 percent. Foraminifera are the next most abundant, ranging from 0 to 25 percent and constituting almost 100 percent of the coarse fraction. Siliceous microfossils generally constitute less than 10 percent of the sediment but reach 20 percent at one horizon in Core 1. Nonbiogenous components are rare. Quartz, feldspar, micas, and heavy minerals are virtually absent. Zeolites and volcanic glass appear in minor quantities at a few horizons, palagonite and Fe oxides not at all, and pyrite in concentrations of up to 4 percent in some of the darker mottles and streaks. Dolomite rhombs occur in small amounts near the center of the unit. The upper cores are very soupy and disturbed, but the disturbance lessens as the degree of lithification increases downwards.

Unit 2 (291.0-471.5 m; Cores 32-50)

Unit 2 consists of nanno ooze to foram-bearing nanno ooze. It is distinguished from Unit 1, principally by its lower foraminifera content and higher content of amorphous iron oxides. The latter give the sediments their predominant colors, which vary from very pale orange to grayish orange at the top of the section to light and moderate browns toward the base. Also, toward the base of this unit, color banding becomes common. Bands and layers in shades of orange and brown occur. As in Unit 1, calcareous nannofossils dominate the biogenic constituents, whereas foraminifers are reduced in abundance relative to Unit 1 and vary between 0 and 10 percent. Siliceous microfossils are also reduced in abundance relative to Unit 1 (1-3%). Nonbiogenic constituents are rare except for zeolites and Fe oxides, which increase in abundance towards the base of the unit. Pyrite is absent from this unit other than in the upper portion, indicating, together with the presence of Fe oxides, sediment accumulation under oxidizing conditions. The sediments are semilithified, becoming more compact downwards.

Unit 3 (471.5-506.0 m; Cores 51-54)

Unit 3 consists predominantly of semilithified nanno chalk with intercalated horizons of volcanic debris and zeolite sands. Color variation are many, principally in various shades of orange and brown, although pinks, greens, and yellows also make an appearance. The top of the unit (471.5-481.0 m) consists of a light brown nanno ooze with layers in moderate brown and pale orange. This grades down into nanno oozes containing layers of volcanic ash and zeolite sands. Iron oxide staining is common throughout, and some of the layers contain appreciable concentrations of amorphous Fe oxide globules mixed with the calcareous components. Nannofossils are again the dominant biogenous component, with foraminifera varying between 0 and 10 percent. Nonbiogenous constituents are more common than in the upper two units; quartz, feldspar, and mica are present in concentrations of up to 10 percent and clay minerals up to 80 percent in several thin horizons. The outstanding constituents of this unit are volcanic ashes and zeolites. Each attains high concentrations (30% maximum for zeolites and 75% maximum for volcanic ash). Coarse fractions consist principally of foraminifera, but manganese micronodules, fragments of limestone, palagonite, and volcanic glass are all common.

Unit 4 (506.0-586.5 m; Cores 55-64)

This unit consists of basalt with intercalated horizons of recrystallized chalk. The basalts are the subject of Appendix A to this chapter.

Conclusions

The principal preliminary conclusions that can be drawn from this hole are as follows:

1) The sea floor at this site was always above the $CaCO_3$ compensation depth and under an area of relatively high carbonate productivity.

TABLE 1
Coring Summary – Site 238

Core	Date (June 1972)	Time	Depth Below Sea Floor (m)	Depth From Drill Floor (m)	Cored (m)	Recovered (m)	Recovered (%)
1	17	0606	0-9.5	2844.5-2854.0	9.5	9.3	98
2	17	0656	9.5-19.0	2854.0-2863.5	9.5	9.0	95
3	17	0744	19.0-28.5	2863.5-2873.0	9.5	9.4	99
4	17	0833	28.5-38.0	2873.0-2882.5	9.5	9.3	98
5	17	0917	38.0-44.0	2882.5-2888.5	6.0	5.2	87
6	17	1005	44.0-53.5	2888.5-2898.0	9.5	6.0	63
7	17	1051	53.5-63.0	2898.0-2907.5	9.5	9.0	95
8	17	1141	63.0-72.5	2907.5-2917.0	9.5	3.6	38
9	17	1232	72.5-82.0	2917.0-2926.5	9.5	2.3	24
10	17	1333	82.0-91.5	2926.5-2936.0	9.5	9.1	96
11	17	1430	91.5-101.0	2936.0-2945.5	9.5	9.3	98
12	17	1520	101.0-110.5	2945.6-2955.0	9.5	8.8	92
13	17	1620	110.5-120.0	2955.0-2964.5	9.5	7.0	73.5
14	17	1718	120.0-129.5	2964.5-2974.0	9.5	7.2	76
15	17	1816	129.5-139.0	2974.0-2983.5	9.5	9.5	100
16	17	1913	139.0-148.5	2983.5-2993.0	9.5	9.2	97
17	17	2012	148.5-158.0	2993.0-3002.5	9.5	9.0	95
18	17	2111	158.0-167.5	3002.5-3012.0	9.5	8.7	91
19	17	2222	167.5-177.0	3012.0-3021.5	9.5	9.1	96
20	17	2320	177.0-186.5	3021.5-3031.0	9.5	9.5	100
21	18	0022	186.5-196.0	3031.0-3040.5	9.5	9.2	97
22	18	0121	196.0-205.5	3040.5-3050.0	9.5	9.2	97
23	18	0221	205.5-215.0	3050.0-3059.5	9.5	9.0	95
24	18	0319	215.0-224.5	3059.5-3069.0	9.5	9.3	98
25	18	0412	224.5-234.0	3069.0-3078.5	9.5	9.5	100
26	18	0517	234.0-243.5	3078.5-3088.0	9.5	2.2	23
27	18	0616	243.5-253.0	3088.0-3097.5	9.5	8.0	84
28	18	0718	253.0-262.5	3097.5-3107.0	9.5	9.2	97
29	18	0825	262.5-272.0	3107.0-3116.5	9.5	9.4	99
30	18	0922	272.0-281.5	3116.5-3126.0	9.5	8.0	84
31	18	1019	281.5-291.0	3126.0-3135.5	9.5	0	0
32	18	1123	291.0-300.5	3135.5-3145.0	9.5	9.3	98
33	18	1224	300.5-310.0	3145.0-3154.5	9.5	1.6	17
34	18	1324	310.0-319.5	3154.5-3164.0	9.5	7.5	80
35	18	1435	319.5-329.0	3164.0-3173.5	9.5	8.5	89
36	18	1539	329.0-338.5	3173.5-3183.0	9.5	9.2	97
37	18	1643	338.5-348.0	3183.0-3192.5	9.5	9.5	100
38	18	1808	348.0-357.5	3192.5-3202.0	9.5	8.2	86
39	18	1912	357.5-367.0	3202.0-3211.5	9.5	8.0	84
40	18	2012	367.0-376.5	3211.5-3221.0	9.5	2.6	28
41	18	2115	376.5-386.0	3221.0-3230.5	9.5	7.9	83
42	18	2217	386.0-395.5	3230.5-3240.0	9.5	5.7	60
43	18	2324	395.5-405.0	3240.0-3249.5	9.5	9.0	95
44	19	0039	405.0-414.5	3249.5-3259.0	9.5	9.2	97
45	19	0148	414.5-424.0	3259.0-3268.5	9.5	3.0	31
46	19	0250	424.0-433.5	3268.5-3278.0	9.5	4.5	48
47	19	0352	433.5-443.0	3278.0-3287.5	9.5	5.5	58
48	19	0446	443.0-452.5	3287.5-3297.0	9.5	4.3	45
49	19	0546	452.5-462.0	3297.0-3306.5	9.5	3.2	33
50	19	0658	462.0-471.5	3306.5-3316.0	9.5	5.5	58
51	19	0757	471.5-481.0	3316.5-3325.0	9.5	5.0	53
52	19	0900	481.0-490.5	3325.5-3335.0	9.5	6.7	70
53	19	1000	490.5-500.0	3335.0-3344.5	9.5	6.2	65
54	19	1056	500.0-506.0	3344.5-3350.5	6.0	1.3	22
55	19	1430	506.0-515.5	3350.5-3360.0	9.5	4.2	44
56	19	1916	515.5-525.0	3360.0-3369.5	9.5	4.5	48
57	19	2249	525.0-531.5	3369.5-3376.0	6.5	3.5	54
58	20	0337	531.5-539.0	3376.0-3383.5	7.5	6.5	87
59	20	0753	539.0-547.5	3383.5-3392.0	8.5	5.6	66
60	20	1149	547.5-556.5	3392.0-3401.0	9.0	4.6	51
61	20	1540	556-566.0	3401.0-3410.5	9.5	5.7	61
62	20	2010	566.0-574.5	3410.5-3419.0	8.5	3.2	38
63	20	2326	574.5-580.5	3419.0-3425.0	6.0	0.2	4
64	21	0302	580.5-586.5	3425.0-3431.0	6.0	2.3	38

2) Sedimentation rates were probably high during the deposition of Unit 1 but lower during that of Unit 2, as evidenced by the increasing concentration of Fe oxides down the section (see section on sedimentation rates).

3) The incidence of material of volcanic origin in Unit 3 points to the influence of continuing volcanism in this area after the final extrusion of the basement basalts.

BIOSTRATIGRAPHIC SUMMARY

Introduction

The sedimentary sequence continuously cored at Site 238 represents an apparently uninterrupted sequence from early Oligocene to Quaternary. Throughout the section, the sediments are nanno oozes and nanno chalks which contain abundant, diverse, and well to moderately preserved calcareous plankton. Radiolarians are common to abundant and moderately to well preserved in Cores 1 to 39 (middle Miocene to Quaternary) and absent below Core 39.

Fossil zonation and age assignments are summarized on the site summary form at the end of this chapter. The Pliocene/Pleistocene boundary cannot be determined with certainty because of the presence of displaced lower Pliocene sediments underlying the Pleistocene. This boundary, however, was placed at 30 meters in Core 4, Section 1 just above the displaced sediments, at the top of the *Pterocanium prismatum* Zone. The Pleistocene marker *Globorotalia truncatulinoides* does not extend below this level. Some discrepancies were found between nannofossil and foraminiferal zonations in defining the early/middle Miocene and Oligocene/Miocene boundaries. The early/middle Miocene boundary was placed at 362 meters, within Core 39, on the basis of nannofossil data, somewhat lower than is indicated by the foraminferal zonation. The Oligocene/Miocene boundary was drawn on the basis of nannofossil zonation at 405 meters, between Cores 43 and 44; the foraminiferal zonation, however, indicates that the boundary should be placed lower in the section, between Core 47, Section 1 and Core 47, Section 3.

Sediments above basement are of late early Oligocene age (approximately 30 to 34 m.y. B.P.). Sediments included in the basalt are strongly recrystallized and did not yield datable fossils.

Reworking of older material was commonly found in Pleistocene, upper Pliocene, and upper Miocene sediments.

Calcareous Nannoplankton

Core 1 contains common small placoliths, probably *Emiliania huxleyi* and *Gephyrocapsa oceanica.* It is tentatively assigned to the *Emiliania huxleyi* Zone. Core 2 belongs to the *Gephyrocapsa oceanica* Zone and contains assemblages including *Gephyrocapsa oceanica* and *Ceratolithus cristatus.* Core 3 recovered the *Pseudoemiliania lacunosa* Zone with *Pseudoemiliania lacunosa, Crenalithus doronicoides,* and *Ceratolithus cristatus.* Between Cores 4 and 11, the upper Pliocene and the uppermost part of the lower Pliocene are repeated. Whether this is due to reworking or slumping is difficult to determine. Core 4, Section 1 belongs to the *Discoaster pentaradiatus* Zone and yields assemblages including *Discoaster pentaradiatus, D. surculus,* and *D. brouweri,* together with reworked Miocene discoasters like *Discoaster neohamatus* and *D. divaricatus.* Core 4, Section 6 recovered the *Discoaster tamalis* Zone with *Discoaster tamalis, D. pentaradiatus, D. surculus, D. asymmetricus, D. variabilis,* and *D. brouweri.* Core 5, Section 2 recovered the *Reticulofenestra pseudoumbilica* Zone with *Reticulofenestra pseudoumbilica* and *S. abies.* Core 5, Section 4, and Core 6, belong to the late Pliocene *Cyclococcolithina macintyrei* Zone with *Discoaster brouweri* and *Cyclococcolithina macintyrei.* Cores 7 and 8 yield assemblages typical of the *Discoaster pentaradiatus* Zone, and Cores 9 and 10 are assigned to the *Discoaster tamalis* Zone. Core 11 recovered the *Reticulofenestra pseudoumbilica* Zone. Cores 12 and 13 belong to the *Ceratolithus rugosus* Zone and contain assemblages including *Ceratolithus rugosus, C. tricorniculatus,* and *C. primus. Ceratolithus rugosus* is replaced by *C. acutus* in Cores 14 and 15, which are thus assigned to the earliest Pliocene *Ceratolithus acutus* Zone. The Miocene/Pliocene boundary, based on nannofossils, lies between Cores 15 and 16. Cores 16 to 20 contain *Discoaster quinqueramus, D. berggrenii,* and *Ceratolithus primus* and therefore belong to the late Miocene *Ceratolithus primus* Zone. Cores 21 through 23 recovered the *Discoaster berggrenii* Zone with *Discoaster quinqueramus, D. berggrenii,* and *D. surculus.* Rare specimens of *Discoaster* sp. cf. *D. neorectus* and common *D. neohamatus* in Core 24 indicate the presence of the *D. neohamatus* Zone. Cores 25 through 28 belong to the *Discoaster bellus* Zone with assemblages including *Discoaster neohamatus, D. calcaris,* and *D. bellus.* Cores 29 and 30 are assigned to the middle Miocene *Discoaster hamatus* Zone based on assemblages with common *Disocaster hamatus, D. neohamatus,* and *D. calcaris.* Part of the middle Miocene (*Catinaster coalitus, Discoaster kugleri,* and *D. exilis* zones) was not found and might be absent or condensed. Cores 32 through 39 recovered the *Sphenolithus heteromorphus* Zone with assemblages including *Sphenolithus heteromorphus, Discoaster exilis, D. deflandrei,* and *Coccolithus eopelagicus.* Cores 40 and 41 recovered the *Helicopontosphaera ampliaperta* Zone, lacking the marker species, but with an otherwise characteristic assemblage including *Sphenolithus heteromorphus, S. belemnos,* and common *Discoaster deflandrei.* Core 42 recovered the *Discoaster druggii* Zone with *Triquetrorhabdulus carinatus* and *Discoaster druggii.* Core 43 belongs to the *Triquetrorhabdulus carinatus* Zone with *Triquetrorhabdulus carinatus* and some reworked Oligocene forms like *Reticulofenestra bisecta* and *Sphenolithus ciperoensis.* The Oligocene/Miocene boundary, based on nannofossils, lies between Cores 43 and 44. Cores 44 through 49 belong to the late Oligocene *Reticulofenestra abisecta* Zone with assemblages including *Triquetrorhabdulus carinatus, Reticulofenestra abisecta,* and *Braarudosphaera bigelowii* (in the lower part only). Cores 50 and 51 are assigned to the *Sphenolithus ciperoensis* Zone based on assemblages including *Sphenolithus ciperoensis, Reticulofenestra bisecta,* and *Braarudosphaera bigelowii.* Cores 52 and 53 recovered the *Sphenolithus distentus* Zone with *Sphenolithus distentus,* rare *S. ciperoensis,* and *Reticulofenestra abisecta.* Core 54 belongs to the early Oligocene *Sphenolithus predistentus* Zone with *Sphenolithus predistentus, S. distentus,* and *S. pseudoradians.*

Preservation: Assemblages in the upper part of the section down to the upper Pliocene are well preserved. Most of the Pliocene, the upper Miocene, and the uppermost middle Miocene assemblages show slight etching and overgrowth. The lower part of the middle Miocene, the lower Miocene, and the Oligocene assemblages display slight etching and moderate overgrowth. Braarudosphaerids occur in the Oligocene.

Foraminifera

Abundance and Preservation

Planktonic foraminifera are the dominant component of the coarse sediment fraction (>63μ) in the upper 471 meters (Cores 1 to 50; Units 1 and 2). The coarse sediment fraction below this level to just above the basalt (Cores 51 to 54; Unit 3) yielded abundant foraminifera together with common fragments of colorless volcanic glass, sideromelane, and palagonite, and rare manganese micronodules.

Planktonic foraminifera are diversified and well to moderately preserved throughout the upper 281 meters (Cores 1 to 30; Unit 1) although in some horizons they show a high degree of fragmentation. Below this level, planktonic foraminifera are moderately to well preserved and less diversified but with a lower degree of fragmentation. They are often small in size.

Planktonic Foraminiferal Zonation

Core 1, Section 1 penetrated Quaternary sediments (N.23-N.22) containing *Globorotalia truncatulinoides*. Pink colored *Globigerina rubescens* and *Globigerinoides ruber* are rare to common in Core 1, Section 1 to Core 2, Section 3 and were not found below this interval. Abundant reworked early Pliocene foraminifera (N.19) occur in the upper part of Core 1. The N.22/N.21 zonal boundary is drawn in Core 4, Section 1 at the lowest occurrence of *Globorotalia truncatulinoides*, although this level may not represent the initial evolutionary appearance of the species. The transition from *Globorotalia tosaensis* to *G. truncatulinoides* was not observed at Site 238 because of the presence of reworked lower Pliocene sediments directly below the Pleistocene.

Core 4, Section 2 to Core 7, Section 1 contain an early Pliocene (N.19) assemblage characterized by common *Globoquadrina altispira altispira* and *Sphaeroidinellopsis* spp. The interval from Core 7, Section 2 to Core 10, Section 5 yielded typical late Pliocene (N.21) faunas containing common *Globorotalia limbata, Globigerinoides quadrilobatus fistulosus, Turborotalia humerosa,* and *Globigerina decoraperta*, as well as rare *Globorotalia tosaensis.* The N.21/N.20-N.19 limit lies in Core 9, Section 1 at the lowest appearance of *G. tosaensis* and highest common occurrence of *Sphaeroidinellopsis* spp. The N.18/N.17 limit which marks the late middle Miocene boundary, is in Core 15, Section 5 at the base of the range of *Globorotalia tumida.* Zones N.16 and N.15 were not identified, but may be represented by the condensed interval of Core 31, which was not recovered. The Miocene/Pliocene boundary could not be defined because of the presence of a reworked fauna older than N.14 reworked into N.17 (?) sediments between Cores 26 and 30. A similar mixed fauna was observed between lowermost upper Miocene and uppermost middle Miocene sediments at Sites 236 and 237.

Core 32 is assigned to Zone N.14 on the basis of the cooccurrence of *Globigerina nepenthes* and *Turborotalia siakensis*, and Cores 33, 34, and 35, which contain *Sphaeroidinellopsis dehiscens* and members of the *Globorotalia fohsi* lineage, to Zone N.13. Zone N.12 and N.11 were not identified. Core 36 is assigned to N.10 based on the co-occurrence of *Globorotalia peripheroacuta* and *Globorotalia archaeomenardii.* Core 37, which contains common *Globigerinoides sicanus* and rare *Praeorbulina* spp. and *Orbulina* spp. is placed within the interval of the Zone N.8 and N.9. However, the limit between the two latter zones, which defines the early/middle Miocene boundary, was not delineated because of the overlapping within Core 37 of *Orbulina universa* and *Praeorbulina glomerosa curva.* Cores 38 to 41 are assigned to Zone N.8, and the lower limit of this zone is marked by the lowest occurrence of *Globigerinoides sicanus* in Core 41, Section 6. Zones N.7 and N.6 were not recognized, and the highest occurrence of *Globigerinoides quadrilobatus primordius,* a species known to become extinct elsewhere within N.5 occurs, in the upper part of Core 42. Cores 42 and 43, which contain *Globigerinoides quadrilobatus primordius, Globoquadrina dehiscens,* and *Globoquadrina dehiscens praedehiscens,* were assigned to Zone N.5; the N.5/N.4 boundary was placed between Cores 43 and 44, above the highest occurrence of *Turborotalia kugleri* in the upper part of Core 44. The interval from Core 44 to Core 47, Section 1 was assigned to Zone N.4, and the Oligocene/Miocene boundary (N.4/P.22) appears to lie between Core 47, Section 1 and Core 47, Section 3 at the lowest occurrence of *Globigerinoides quadrilobatus primordius.* Cores 48 to 53 represent upper Oligocene zones (P.22 to P.20) and contain a minute fauna of species difficult to identify with the exception of the large form *Globoquadrina tripartita.* The presence of rare *Pseudohastigerina barbadoensis* suggest an age of late early Oligocene (P.19) for Core 54, Section 1 above the basement.

Benthic Foraminifera

Throughout the section, benthic foraminifera are rare. They constitute less than 1 percent of the total foraminiferal population and are indicative of a lower bathyal environment.

Radiolarians

Radiolarians are few to abundant, moderately to well preserved in samples for 238-1-1 through 238-24-1 and not consistently so common and well preserved in sampled from 238-24-6 through 238-39-2. In samples from 238-39-6 through 238-54-1 radiolarians are absent except for rare, moderately well preserved specimens in 238-53-2.

The upper limit of the *Pterocanium prismatium* Zone appears to lie between 238-3-6 and 238-4-1 though the lower evolutionary limit of *Theocorythium trachelium* appears to be considerably below that level. The lower limit of the *Pterocanium prismatium* Zone is between Core 8, Section 2 and Core 9, Section 1, the lower limit of the *Spongaster pentas* Zone between Core 13, Section 1 and Core 13, Section 5, the lower limit of the *Stichocorys peregrina* Zone between Core 20, Section 6 and Core 21, Section 1, the lower limit of the *Ommatartus penultimus* Zone cannot be determined, the lower limit of the *Ommatartus antepenultimus* Zone is between Core 29, Section 1 and Core 30, Section 2, the lower limit of the *Cannartus petterssoni* Zone cannot be determined, the lower limit of the *Dorcadospyris alata* Zone is approximately in Core 38, Section 6 (uncertain because of poor preservation), and the lower limit of the *Calocycletta costata* Zone is below Core 39, Section 2.

SEDIMENT ACCUMULATION RATES

Average accumulation rates at Site 238 were calculated as follows:

Series	Thickness (m)	Average Sedimentation Rate (m/m.y.)
Pleistocene	38.0	21.1
Upper Pliocene	53.5	44.6
Lower Pliocene	47.5	23.8
Upper Miocene	131.0	21.8
Middle Miocene	92.0	30.7
Lower Miocene	43.0	5.0
Upper Oligocene	95.5	12.7

Sediment accumulation rates are high throughout post-early Miocene time, averaging 25.9 m/m.y. These sediments consist almost entirely of foram-rich nanno ooze and this high accumulation rate points to considerable organic productivity in the water overlying the site during post early Miocene times. The high late Pliocene value results from the influx of displaced lower Pliocene sediments at this time.

Sediment accumulation rates are lower in pre-middle Miocene times, averaging 8.7 m/m.y. This lower rate is reflected in the higher concentration of amorphous iron oxides in these sediments than higher in the section. One can assume a fairly constant rate of precipitation of these oxides from seawater (other than near basement) and thus their abundance in the sediment is a function of their degreee of dilution by other materials.

Within the lowermost four sediment cores, the sedimentation rates probably vary quite considerably. The intervals concerned are too small to be reflected in the faunal analyses, bands are as thin as 1 cm, but analogy with the East Pacific Rise (Bender et al., in press) suggests that horizons rich in volcanic detritus and Fe oxides immediately overlying basement are deposited rapidly and that the intervening nanno chalks are deposited more slowly.

PHYSICAL PROPERTIES

Bulk Density and Porosity

The bulk density and porosity of the nanno oozes in Units 1 and 2 (0 to 471.5 m) increase from 1.64 to 1.98 g/cm^3 and decrease from 63.5 to 43.1 percent, respectively, from near 30 meters to 470 meters below the sediment/water interface (Figure 3). Because of the high degree of sediment disturbance, no bulk density or porosity values were obtained for the upper 30 meters of sediment nor for the 34.5 meters of nanno chalk in Unit 3 (471.5 to 506.0 m).

Hard "consolidated" chunks of the nanno ooze were obtained in cores from 200 to 505 meters. Section 3 of Core 36 visually substantiates the author's previous interpretation of similarly "consolidated" chunks of nanno chalk ooze at Site 237. In Section 3 of Core 36, the hard "consolidated" chunks have horizontal bedding, whereas the interlying soft sediments have vertical "flow in" structure. For this reason, all physical property measurements of Cores 22 through 54 were made on the hard "consolidated" chunks of nanno chalk. However, for the cores preceeding Core 22, it is impossible to evaluate the degree of disturbance due to lack of visual, horizontal, or vertical structure. Thus, physical property values for Cores 2 through 21 are presented with a note of caution because of possible core disturbance. The data of this site may serve to emphasize one important facet of the physical properties measurements, i.e., these values should never be measured at predetermined intervals or core sections; rather, the investigator should choose his measurement sites only after examining all sections of each core.

Bulk densities of the basement rocks were obtained by the GRAPE device on block samples approximately 1.5 cm × 1.5 cm × 2.5 cm. Bulk densities of the basalt samples measured in the vertical direction (long axis) range from 2.87 to 3.01 g/cm^3 and those measured in the horizontal direction range from 2.78 to 3.03 g/cm^3. A sample of metamorphic sediment (marble) from Core 60 has a vertical bulk density of 2.70 g/cm^3 and a horizontal bulk density of 2.74 g/cm^3 (Table 3).

Sonic Velocity

The sonic velocity for the nanno ooze of Unit 1 (0 to 291 m) increases from 1.49 km/sec near the top of the unit to 1.67 km/sec near the base. Unit 2 (291-471.5 m) consists of a more "consolidated" nanno ooze, having higher velocities ranging from 1.60 to 1.84 km/sec. The nanno chalk (with intercalated horizons of volcanic ash and zeolites) of Unit 3 has velocities ranging from 1.75 to 2.29 km/sec.

The nanno ooze and nanno chalk of Units 2 and 3 have minor velocity anisotropism in the vertical and horizontal directions. This suggests that the calcite plates of the predominant nannofossils have no preferred orientation in the sediment.

No major reflectors are readily identifiable by physical property measurements of the 506 meters of nanno ooze and nanno chalk. The author believes that this thickness is characterized in situ by uniformly increasing density and velocity depth and a decreasing porosity with depth.

The major velocity change occurs at 506 meters (Unit 4) where basaltic basement is encountered. Twenty-one samples of apparently fresh (see Appendix A) basalt and marble have vertical velocities ranging from 5.12 to 6.16 km/sec and horizontal velocities ranging from 5.09 to 6.20 km/sec (Table 3).

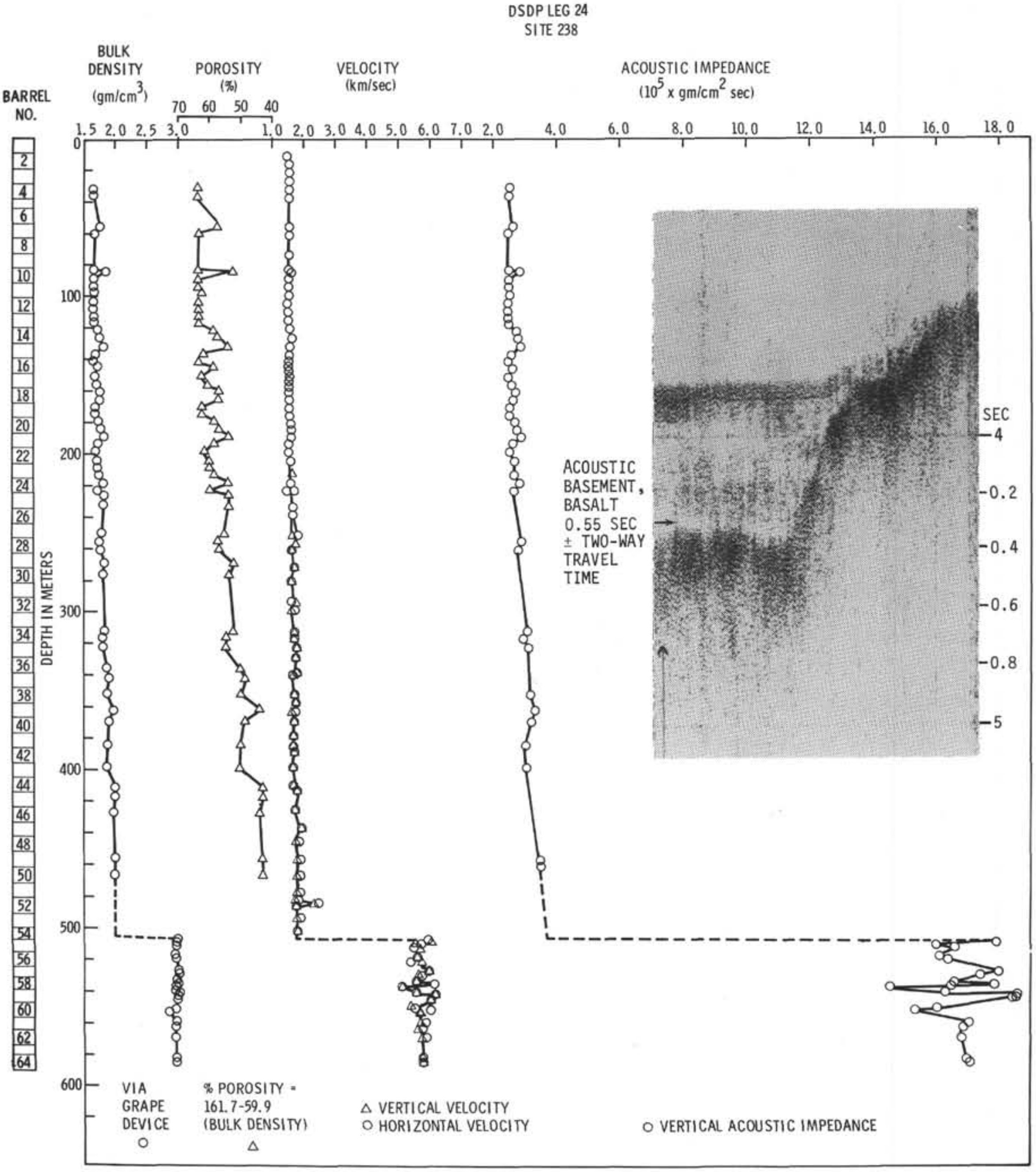

Figure 3. *Physical properties, Site 238.*

A maximum one-way travel time for acoustic energy travelling from the sediment/water interface to the basaltic basement can be calculated as follows:

Interval Depth Below Sea Floor (m)	Average Velocity (km/sec)	Travel Time (sec)
0–200	1.53	0.131
200–300	1.60	0.062
300–506	1.70	0.121
		0.314

Thus, maximum one-way travel time at Site 238 for the basement reflection should be 0.314 sec.

The relationship of bulk density to velocity for the 20 various basalt samples and one marble sample from Unit 4 is presented in Figure 4. The data suggest a linear relationship and least square analysis defines bulk density as:

$$\text{Bulk Density } (\text{g/cm}^3) = 2.137 \text{ g/cm}^3 + \left(0.140 \sim \frac{\text{g} \cdot \text{sec}}{\text{cm}^3 \cdot \text{km}}\right) \sim (\text{Velocity (km/sec)}).$$

Acoustic Impedance

The acoustic impedance varies between 2.44 and 3.47 × 10^5 g/cm^2 sec in Units 1, 2, and 3 (the nanno oozes and

TABLE 3
Bulk Density of Basalt – Site 238

Sample[a]	Bulk Density (g/cm^3) Vertical	Bulk Density (g/cm^3) Horizontal	Velocity (km/sec) Vertical	Velocity (km/sec) Horizontal	Rock Description
55-1 (5)	2.96	2.98	6.02	5.98	Basalt (microdolerite)
55-2 (3)	2.93	2.93	5.46	5.74	Basalt
55-3 (11)	2.92	2.92	5.65	5.58	Basalt (vesicular)
56-1 (2)	2.87	2.90	5.58	5.57	Basalt (vesicular)
56-3 (18)	2.94	2.91	5.60	5.56	Basalt
57-2 (1)	3.01	3.02	5.97	5.98	Basalt (olivine-bearing)
57-3 (7)	2.93	3.20 (?)	5.68	5.76	Basalt
58-2 (4)	2.97	2.95	5.60	5.60	Basalt
58-3 (2)	2.98	3.00	5.96	6.08	Basalt
58-4 (8)	2.90	2.78	5.12	5.09	Basalt
59-1 (3)	2.92	2.92	5.57	5.57	Basalt
59-2 (4)	3.01	3.03	6.16	6.20	Basalt (fresh microdolerite)
59-3 (2)	3.01	3.02	6.13	6.12	Basalt (olivine-bearing)
59-4 (6)	2.99	3.00	6.12	6.03	Basalt (fresh microdolerite)
60-2 (1)	2.95	2.92	5.46	5.56	Basalt
60-3 (7)	2.70	2.74	5.64	6.04	Metamorphic sediment (marble)
61-2 (15)	2.96	2.95	5.76	5.82	Basalt
61-4 (13)	2.93	2.96	5.71	5.76	Basalt
62-2 (9)	2.93	2.92	5.75	5.80	Basalt
64-1 (10)	2.94	2.95	5.77	5.73	Basalt (chloritized)
64-2 (9)	2.94	2.95	5.79	5.80	Basalt

[a] Numbers in parentheses are the sequence of rock samples in the section.

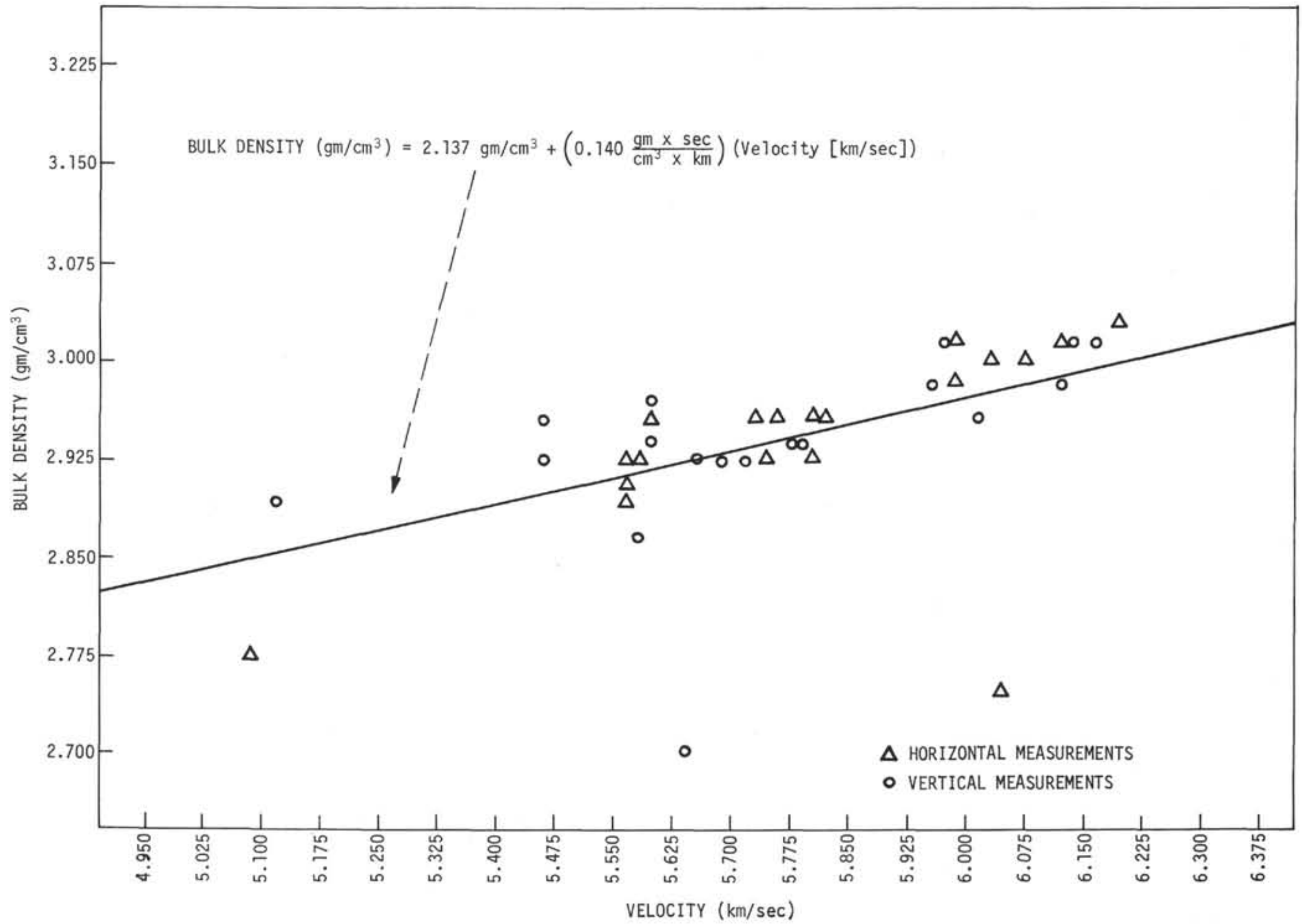

Figure 4. *Relationship of bulk density to velocity for various basalt samples and a marble sample from lithologic Unit 4, Site 238.*

nanno chalk) in the upper 506 meters of sediment. The only major reflector observed on the acoustic impedance profile is Unit 4 (basaltic basement). The basalt has an average velocity of approximately 5.8 km/sec and an average bulk density of about 2.94 g/cm^3. Thus, the acoustic impedance is about 17.0 × 10^5 g/cm^2 sec or about 5.0 times that of the overlying sediment layers.

The previously calculated travel time for the basement reflection (0.314 sec one-way or 0.628 sec two-way travel time) agrees reasonably with the ±0.55 sec two-way travel time determined on the seismic reflection profile in Figure 3.

INTERSTITIAL WATER CHEMISTRY

Interstitial water chemistry, *p*H, and alkalinity data are presented in Table 4 and Figure 5, for pore waters expressed from sediments cored at Site 238. Water content data are presented in Table 5.

Salinity: Surface seawater has a measured salinity of 35.5°/oo compared with a published bottom water salinity of 34.7°/oo (Wyrtki, 1971). Pore water salinities are all in the range 35.3 ±0.7°/oo, with no general trend being displayed.

***p*H and Alkalinity**: *p*H values are in the range 7.25 ±0.2, with a weak trend displayed toward lower values with increasing depth. Punch-in and flow-through electrode data agree fairly well, with the former most commonly giving slightly higher values, suggestive of CO_2 degassing during measurement.

Alkalinity values throughout the calcite dominated sediments of Units 1 and 2 are all in the range of 3.2-4.1, except for a single value at 356 meters (not readily explainable – may possibly represent $CaCO_3$ contamination of the sample). The two values in Unit 3, which contains much volcanic glass and zeolite, are between 2.5 and 3.0 meq/kg.

TABLE 4
Interstitial Water Chemistry – Site 238

Depth Below Sea Floor (m)	Salinity (°/oo)	*p*H[a]	Alkalinity (meq/kg)
18	35.2	7.31 (7.33)	3.36
37	35.8	7.21 (7.33)	3.23
62	35.2	7.41 (7.32)	3.48
90	36.0	7.35 (7.36)	3.75
117	35.5	7.35 (7.27)	3.75
146	34.9	7.34 (7.32)	4.03
174	34.9	7.32(7.29)	3.48
204	34.9	7.30 (7.32)	3.55
231	34.6	7.18 (7.41)	3.62
261	34.9	7.15 (7.25)	3.69
299	34.6	7.09 (7.32)	4.03
328	34.9	7.28 (7.33)	4.03
356	34.9	7.14 (7.31)	5.22
385	34.9	7.16 (7.21)	3.89
413	35.8	7.32 (7.30)	3.89
439	35.8	7.33	3.27
489	35.5	7.22	2.92
497	35.8	7.17	2.64
Surface seawater	35.5	8.27 (8.20)	2.51

[a] *p*H values in parentheses are corrected (See Explanatory Notes, Chapter 1).

Water Content: At the top of the cored section, water content of the sediments is close to 45 percent by weight, decreasing with depth to about 25%.

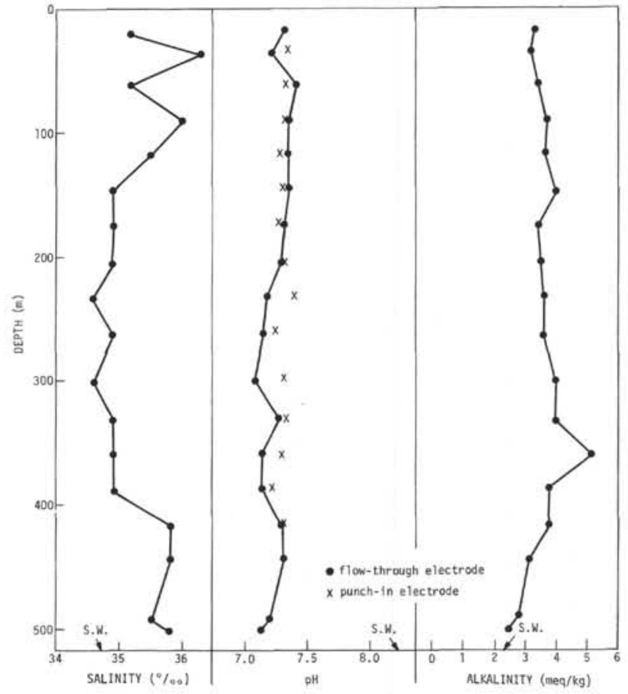

Figure 5. *Interstitial pore water salinity,* pH, *and alkalinity.*

CORRELATION OF SEISMIC PROFILES AND LITHOLOGIES

The onsite reflection profile shows a sediment sequence ponded or trapped by ridges of basement material, which the surface sediments either onlap or cover in different places. The site selected is over a minor basement rise at the base of the sediments, where the material immediately above is conformable to it. The total section is between 0.52 and 0.55 sec thick; site survey (R/V *Melville*) and onsite records differ in their presentation of the sediment section, in large part due to the difference in seismic systems. *Melville* records suggest a layered sequence, the upper 0.4 sec relatively flat lying, and beneath these a distinctive reflecting horizon conformable to the small basement rise. The acoustic basement at the base of the sediments, and the prominent basement ridges to either side, are continuous. The *Glomar Challenger* profile differs in detail (Figure 6), the neatly layered sequence does not appear, the majority of the section being acoustically transparent with a reflection sequence at 0.35-0.4 sec, in agreement with *Melville* data.

Correlation of acoustic reflectors with lithologic units is straightforward for acoustic and basaltic basement. There is no obvious lithologic change to be correlated with the reflection sequence A, (Figure 6). The cored sediments are nanno ooze to about 470 meters with measured velocities not compatible with an interpretation of Unit 3 (the intercalated nanno chalk complex) as the particular reflecting agent. The difference between Units 1 and 2 is that the second is lower in foraminifera content and higher in

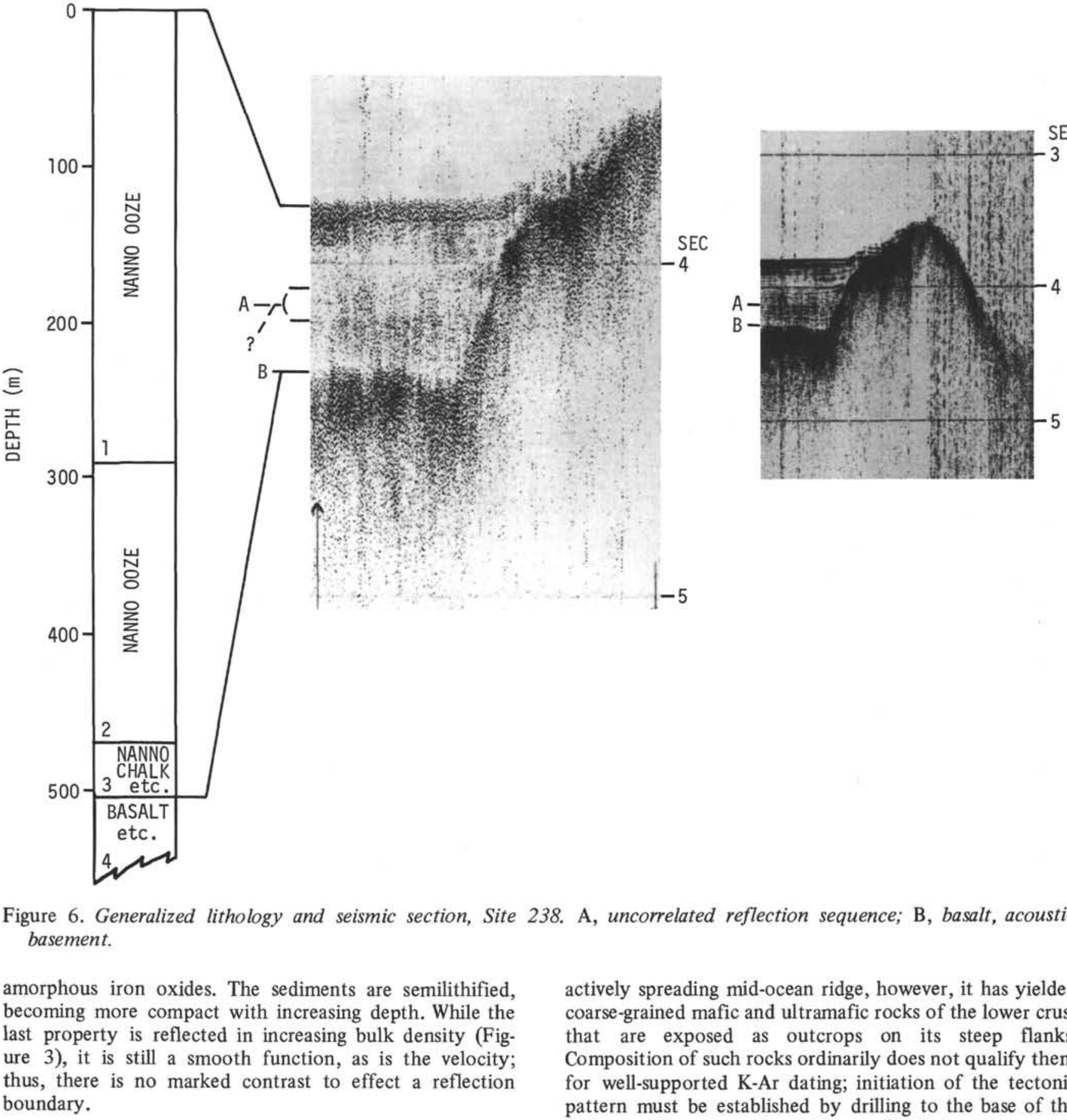

Figure 6. *Generalized lithology and seismic section, Site 238.* A, *uncorrelated reflection sequence;* B, *basalt, acoustic basement.*

amorphous iron oxides. The sediments are semilithified, becoming more compact with increasing depth. While the last property is reflected in increasing bulk density (Figure 3), it is still a smooth function, as is the velocity; thus, there is no marked contrast to effect a reflection boundary.

SUMMARY, CONCLUSIONS, AND SPECULATIONS

Site 238 (11°09.2′ S, 70°31.6′ E) is located at the extreme northeast end of Argo Fracture Zone, within a transform fault cleft that trends athwart the seismically active and spreading Central Indian Ridge. Argo Fracture Zone extends from just south of Chagos Archipelago, at the south end of Chagos-Laccadive Ridge, for at least 1450 km, nearly in a straight line, to the vicinity of Cargados Carajos Bank, north of Mauritius. Over part of its length, at either end, it is a buried trough with basement lips or "levees" containing a thick section of stratified biogenous sediment and volcanic debris. Near its crossing of the actively spreading mid-ocean ridge, however, it has yielded coarse-grained mafic and ultramafic rocks of the lower crust that are exposed as outcrops on its steep flanks. Composition of such rocks ordinarily does not qualify them for well-supported K-Ar dating; initiation of the tectonic pattern must be established by drilling to the base of the oldest sediment conformably confined by the coarse fracture.

Hence, Site 238 was drilled and cored continuously to, and well into, volcanic basement. Water depth at the site was 2832 meters (corrected). A single penetration was made to encounter basement at 506 meters and to penetrate 80.5 meters into the basalt before wear forced termination of drilling. The total length of cored section was 586.5 meters; total core recovered was 424.5 meters. Of this latter figure, the basal 40.6 meters was basalt. The oldest sediments, conformable to the basalts, were lower Oligocene in age, about 30-34 m.y.

Three sedimentary lithologic units were distinguished, basement basalt constitutes the fourth member. The

TABLE 5
Water Content of Sediments – Site 238

Core, Section, Top of Interval (cm)	Water (%)	Core, Section, Top of Interval (cm)	Water (%)
1-5, 75	45.95	19-3, 126	42.12
2-3, 85	38.33	19-4, 65	43.25
2-5, 135	44.57	19-5, 105	41.42
3-2, 63	45.55	19-6, 85	37.12
3-5, 106	47.21	20-2, 50	37.24
4-2, 130	46.16	20-3, 34	36.72
4-3, 70	44.92	20-4, 108	36.32
4-4, 110	44.64	20-5, 25	34.25
4-5, 24	46.72	20-6, 70	42.75
4-5, 80	45.69	21-2, 42	34.09
7-2, 25	46.69	21-3, 100	34.34
7-2, 100	39.40	21-4, 51	38.80
7-2, 116	39.49	21-5, 100	37.22
7-3, 85	43.55	22-2, 80	37.80
7-4, 62	43.53	22-4, 68	37.50
7-5, 108	42.05	22-5, 98	37.15
7-5, 132	46.05	22-5, 109	40.53
9-1, 120	46.58	23-5, 15	38.96
10-2,36	45.26	24-2, 74	34.15
10-2,96	45.14	24-5, 0	39.04
10-3, 104	45.87	24-5, 90	37.50
10-4, 100	44.56	25-6, 116	35.35
10-5, 86	45.44	26-2, 100	37.72
11-2, 112	45.09	27-2, 116	36.66
11-3, 76	45.46	27-5, 42	35.88
11-3, 114	47.02	28-2, 147	37.59
11-4, 86	45.27	28-5, 65	36.89
11-5, 78	43.68	29-6, 69	33.11
12-2, 66	46.58	30-6, 131	36.00
12-3,82	44.13	32-2, 59	35.40
12-4,102	45.11	32-4, 2	34.52
12-5, 86	44.00	34-2, 76	32.40
13-2, 60	43.08	34-4, 51	32.56
13-2, 114	43.08	35-2, 136	32.94
13-3, 114	44.01	35-2, 130	33.92
13-4, 62	44.00	35-6, 94	32.02
14-1, 100	38.04	36-1, 112	32.01
14-2, 75	38.63	36-6, 146	30.36
14-4, 90	36.82	37-1, 14	34.24
15-2, 50	35.66	38-3, 128	32.45
15-2, 117	37.46	38-6, 140	33.16
15-3, 20	40.21	39-3, 112	31.13
15.3,100	27.48	40-2, 63	32.12
15-4, 94	39.28	41-1,129	28.82
15-5, 74	39.27	41-5, 133	30.63
15-6, 80	42.75	42-1,40	30.46
16-1, 100	40.12	42-4, 102	25.81
16-2, 68	44.01	43-2, 112	28.56
16-3, 115	36.23	44-6, 45	27.34
16-4, 90	37.31	45-1, 112	28.08
16-5, 25	35.69	46-1, 137	31.39
16-5, 100	38.53	47-3, 68	11.96
16-6, 80	40.50	48-2. 112	23.73
17-2, 115	40.70	49-3, 1	22.11
17-3, 70	39.17	50-3,76	20.99
17-4, 120	40.52	50-4, 128	21.16
17-5, 90	39.59	51-2, 13	25.39
17-6, 80	40.26	51-4, 70	21.37
18-2, 35	36.96	52-1, 59	23.88
18-2, 115	40.72	52-3, 2	36.78
18-3, 80	39.72	52-3, 13	25.25
18-4, 65	39.22	53-2, 6	41.65
18-5, 46	38.89	53-4, 67	23.96
19-2, 54	40.30	54-1, 128	23.91

sediments down to 471.5 meters are nanno oozes, the two units being distinguished from one another largely by decreased foraminiferal content and increased evidence of oxidation downward. The thick shallowest unit, Neogene in age, is uniform white to bluish white to light gray in color, with streaks of pyrite, all indicative of reducing conditions. The deeper unit, lower in foraminiferal content and higher in amorphous iron oxides, ranges in color from pale or grayish orange at the top to light or moderate brown at the base, the color being due to an increase in oxides of iron. The lowest sedimentary unit, 34.5 meters thick and conformable to the basement, is multicolored in shades of orange, brown, and green. It contains intercalated horizons of volcanic debris and zeolite sands, which locally attain high concentrations. Quartz, mica, and feldspars occur in concentration of 2-10 percent, and clays up to 80 percent in thin horizons. In addition to foraminifera, coarse fractions include manganese micronodules, fragments of limestone, palagonite, and volcanic glass. Such coarse material would have been deposited in a trough then extending between the igneous lips, the facing scarps of the transform fault. From the sedimentary lithology, one might conclude that this area always lay above the calcium carbonate compensation depth, was in a highly productive region, that iron oxides increasing in proportion with depth downward implies an increase in sedimentation rate with time, and finally, that the incidence of volcanic material in the lowest sedimentary unit shows that the after-effects of volcanism persisted long after the final extrusion of basement basalts, in fact, until the site had migrated away from the spreading center.

The igneous basement is composed of dense dark gray, nearly unaltered basalt flows. Selvages of glass occur at pillow edges and seams, and the lower igneous section contains inclusions of metamorphosed sediments with relics of foraminifers and radiolarians. Vesicles are common in the granular basalts. Petrographically, the basement at Site 238 is a very uniform tholeiite, some with minor olivine. Notable in these basalts is their saturation by volatile components; vesicles and cavities are encrusted with calcite-zeolite material. The structure commonly is microdoleritic, with irregularly oriented needles of labradorite and interstitial augite, or, occasionally, orthopyroxene. The olivine-bearing basalts have typical intersertal structure with 30-40 percent of palagonitized or chloritized glass and aggregations of plagioclase microlites with small grains of olivine. Alteration of the rocks is minor, with some chloritization and palagonitization. The basalts from Site 238 are normal tholeiites, very similar to those at Site 231 in the Gulf of Aden; both instances, the upper part of the basement consists of multiple flows.

The sediment section cored at Site 238 represents an apparently uninterrupted sequence from Quaternary to early Oligocene. The sediments are nanno oozes with abundant and well preserved calcareous plankton. Radiolarians are common and well preserved in the lower Miocene to Recent strata but are rare to absent below. Calcareous sediments present as inclusions in the basalts are recrystallized and did not yield datable fossils. Reworking of older material is found in Quaternary and upper Pliocene strata. Sedimentation rates are high for the post early

Miocene times, averaging 25.9 m/m.y.; this indicates considerable productivity in overlying waters during post early Miocene time. Sedimentation rates are lower in Oligocene through early Miocene times averaging 8.7 m/m.y.; amorphous iron oxides are less diluted in this unit. Sedimentation rates within the lowest four cores probably vary considerably, with rapid deposition of volcanic debris and iron oxides and slow deposition of the intervening nanno chalks.

Except for the upper 30 and lower 34.5 meters of the section, where the sediments are very disturbed and no measurements were made, measured bulk density and porosity values increased from 1.64 to 1.98 g/cm^3 and decreased from 63.5 to 43.1 percent, respectively. Physical property measurements for the majority of these cores were made on the hard "consolidated" chunks within the generally soft sediments. Sonic velocity (P_V) for these nanno chalks increases from 1.49 km/sec to 2.29 km/sec, with overlap within the lithologic units. There is a lack of significant velocity anisotropy in the vertical and horizontal values of about 5.1 to 6.2 km/sec. From the measurements on the nanno oozes, the maximum travel time (one way to basement) should be 0.314 sec. The only major reflector detected on the acoustic impedance profile is basaltic basement, which has an impedance of 15.7×10^5 g/cm^2, 4.5 times that of the overlying sediment layers.

Correlation of seismic profiles with lithology at this site seems rather reasonable with the main sedimentary reflector at 0.4 sec (two-way time) being correlated with the top of the basal sediments of Oligocene age and the overlying nanno ooze being acoustically transparent. Taking the basalt as the obvious acoustic basement yields an average velocity-to-basement of either 1.85 or 1.95 km/sec, depending on whether acoustic basement lies at 0.52 or 0.55 sec (two-way time). Both of these values are higher than those measured on sediment specimens from the section.

Site 238, at the extreme northeast end of Argo Fracture Zone and not, as it turned out, incontrovertibly on the south end of the Chagos-Laccadive Plateau, fulfilled in part the objectives set forth for it. Through its unexpectecly great basement penetration, it provides abundant information on the mineralogy, physical condition, alteration processes, structure, and eruptive history of volcanic rock emplaced in a tectonic lineation. Now, fresh igneous rock of early middle Tertiary age, possibly suitable for K-Ar dating, is in hand. Magnetic property measurements, too, are indicated. Fine structure and textural differences in selvages, flows, and pillows can be determined.

The Site 238 column may become a standard paleontological section for moderately low southern latitudes. Shallower layers ponded within the transform fault zone, as shown by seismic records, can be dated and traced laterally to elucidate questions of time of motion, provenance, and slumping of hard rock fragments from cliffs now inundated. Studies to date have not revealed significant quantities of the hoped-for-tracers, coarse-grained mafic and ultramafic debris in these reflecting zones. The data of supposed sundering of the Chagos-Diego Garcia region from Cargados Carajos-Nazareth Bank has been moved earlier to, perhaps, lower Oligocene time, about 30 m.y. ago. This calls for reexamination of magnetic lineations between Anomaly 5 and the end of the transform-faulted blocks. Since Site 238 was obviously not on the aseismic plateau, nature of basement there, and its age relative to the Laccadive region, was not determined.

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APPENDIX A

PRELIMINARY OBSERVATIONS ON THE IGNEOUS ROCKS SAMPLED AT SITE 238

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At Site 238, drilling encountered basalt, here acoustic basement, at a depth of 506 meters below the sea floor. Since weather, water depth, drilling and bit conditions seemed favorable, penetration and continuous sample recovery was continued until bit failure occurred at 80.5 meters of basement penetration. In that 80.5 meters, 40.6 meters of volcanic rock, basaltic glass, and minor sediment inclusions were recovered, and the specimens revealed details of structure in deep submarine flows or pillows. Glassy horizons, fracture patterns, and occurrence of inclusions are indicated on the visual core description.

Megascopic Description

The rocks obtained in Site 238 are dense, dark gray nearly fresh basalt; the principal evidences of alteration are narrow zone of oxidation bordering fractures.

There are 92 thin seams or selvages of fresh black glass, 1-2 cm thick, associated with zones of minor fracturing. Distribution of horizons of fracturing or glassy layers is not constant down the hole; such zones are especially common in Core 55, Section 2, Core 57, Section 2, Core 58, Section 1, Core 60, Section 3, Core 60, Section 4, Core 62, Section 2, and Core 64, Section 2. Near the glassy selvages, there are commonly vesicles and cavities in the granular basalt.

The 40.6 meters recovered contains 17 inclusions of metamorphosed sediments, often with relics of foraminifera and radiolarians. These commonly are associated with glassy zones, and may, in large part, be accumulations that trickled down into cracks when the lower volcanic material was exposed and then were sealed by later flows, or they may have been incorporated in the manner suggested for inclusions at Site 231. Cores 57 and 60 contain several inclusions, but even the lowermost section, 238-64-2, contains veins or inclusions of "fine-grained, little-metamorphosed carbonate sediments."

Preliminary Petrographic Description

Thirty thin-sections were made of basalts and glasses at Site 238. The basement here at the northeast end of Argo Fracture Zone, close to the south end of the Chagos-Laccadive Ridge, is a typical tholeiite, very uniform in composition. Some of the basalts contain rare phenocrysts of plagioclase, and olivine is locally present (238-57-2, No. 1, 238-59-3, No. 2, 238-59-3, No. 3/1, 238-60-2, No. 1).

One notable characteristic of these basalts is their saturation by volatile components. Specimens containing many vesicles and cavities occur just below the glassy zone at the upper surface of the lava flow (Figure 7, after 238-59-3, No. 3); such vesicles and cavities are encrusted with calcite-zeolite material. Some fragments show vesicles distributed throughout the piece; these, having microdiabasic (microdoleritic) texture and round, empty vesicles, probably come from the central parts of pillows.

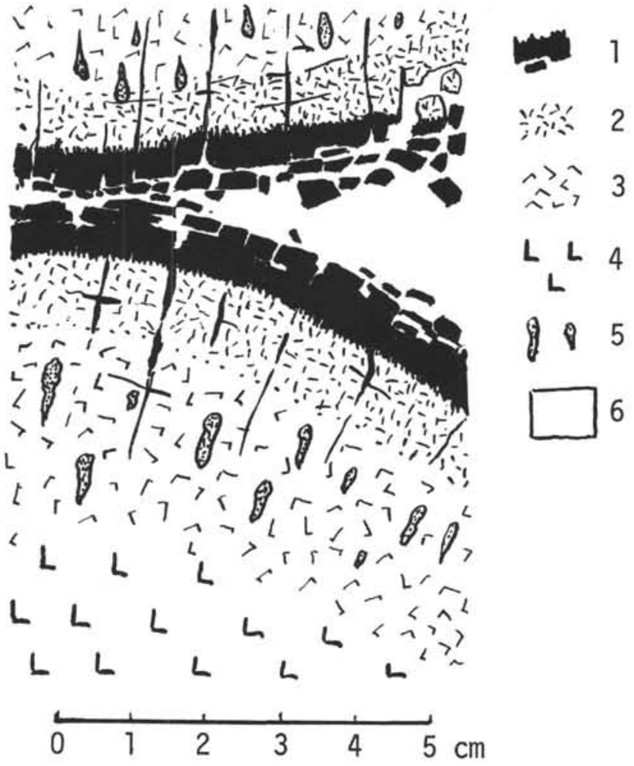


Figure 7. *Schematic drawing of transitional zone between two lava flows, based on 238-59-3, no. 3:* (1) *glassy surface,* (2) *zone where crystals appear,* (3) *basalt with intersertal texture,* (4) *basalt with microdiabasic (microdoleritic) texture,* (5) *vesicles filled by calcite, and* (6) *metamorphosed sediments.*

The texture of the granular basalts is commonly microdiabasic, with little (less than 5%) or no chloritized glass. The microdiabase consists of randomly oriented needles of labradorite, An$_{50\text{-}55}$ 0.5 to 0.7 mm in length, and interstitial augite, extinction $c \Lambda Z \approx 50^\circ$ (Figure 8). Interstitial orthopyroxene, as identified by parallel extinction, is occasionally in evidence (238-55-1, no. 5, 238-58-4, no. 8, 238-59-2, no. 4). The microdiabases gradually become finer grained toward the surface of the flow; two examples of transitional textures are shown in Figure 9a, b.

Some of the basalt horizons contain phenocrysts of labradorite, An$_{55\text{-}60}$, up to 2 to 3 mm in length. In one instance, there is accretion of labradorite and augite in phenocrysts (Figure 10; 238-56-2, No. 9).

The olivine-bearing basalts display typical intersertal texture and contain 30-40 percent palagonitized or chloritized glass (Figure 11). These rocks do not contain

Figure 8. *Microdiabasic texture in basalt: 238-59-4, no. 6 (without analyzer).*

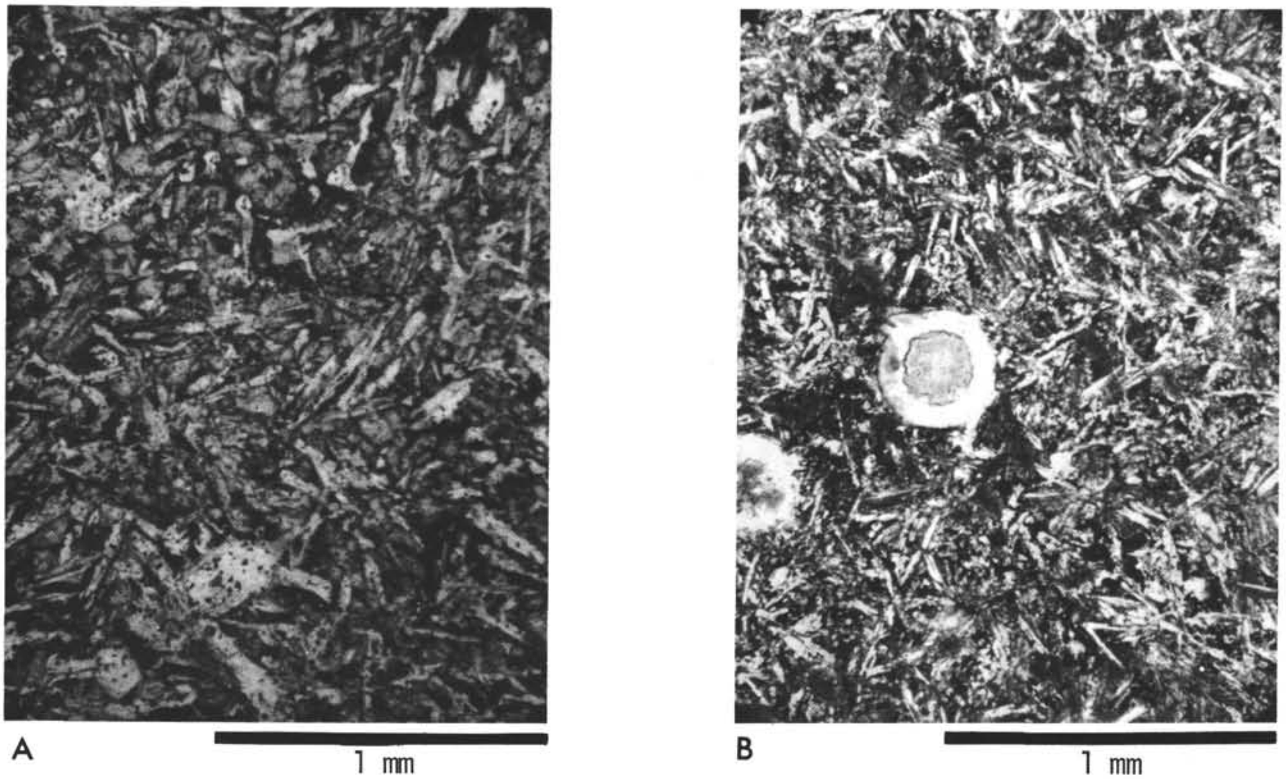


Figure 9. *Decreasing grain size in microdiabases:* (a) *238-55-3, no. 11;* (b) *238-56-2, no. 9 (both without analyzer).* Note: *in both cases the concentration of glass is no more than 5 percent.*

well-developed phenocrysts, but there are small accretions of plagioclase microlites associated with small olivine grains (Figure 12).

Basalts, believed to be basement at Site 238, are only slightly altered. The process here consists of chloritization and palagonization, and the formation of iron hydroxides along the margins of fractures.

Weakly carbonatized plagioclase phenocrysts occur in transitional zones, with abundant calcite-filled vesicles. Some thin fractures in the granular basalt are encrusted with calcite-chlorite-zeolite material, but chiefly calcite. Occasionally thin sparry calcite veins merge with the metamorphosed sediments cementing glassy breccias.

Figure 10. *Aggregation of labradorite and augite in phenocrysts: 238-56-2, no. 9 (without analyzer).*

Conclusions

The basement basalts from Site 238, 2500 km south of the tip of India, are very similar in composition to those from Site 231, within the Gulf of Aden; both are normal oceanic tholeiites. The rocks show little or no crystallization differentiation. Olivine-bearing basalts at Site 238 must have a bulk composition very similar to the predominating microdiabasic basalts.

Locally, the presence of microdiabasic texture and the near absence of glass is accompanied by saturation by volatile components; crystal development is facilitated by enrichment of volatiles.

Structurally, the numerous layers with glassy seams and horizons, fractures, veins, and inclusions of variously metamorphosed sediments suggest that the upper portion of this volcanic basement consists of several superposed flows.

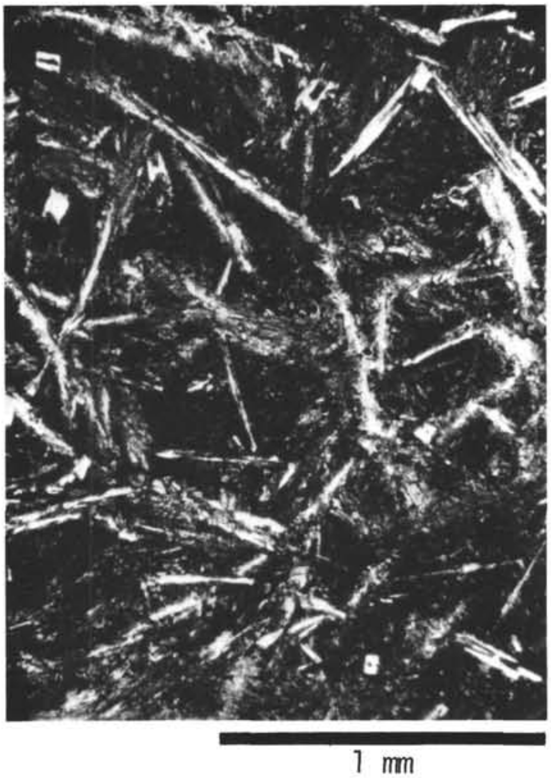
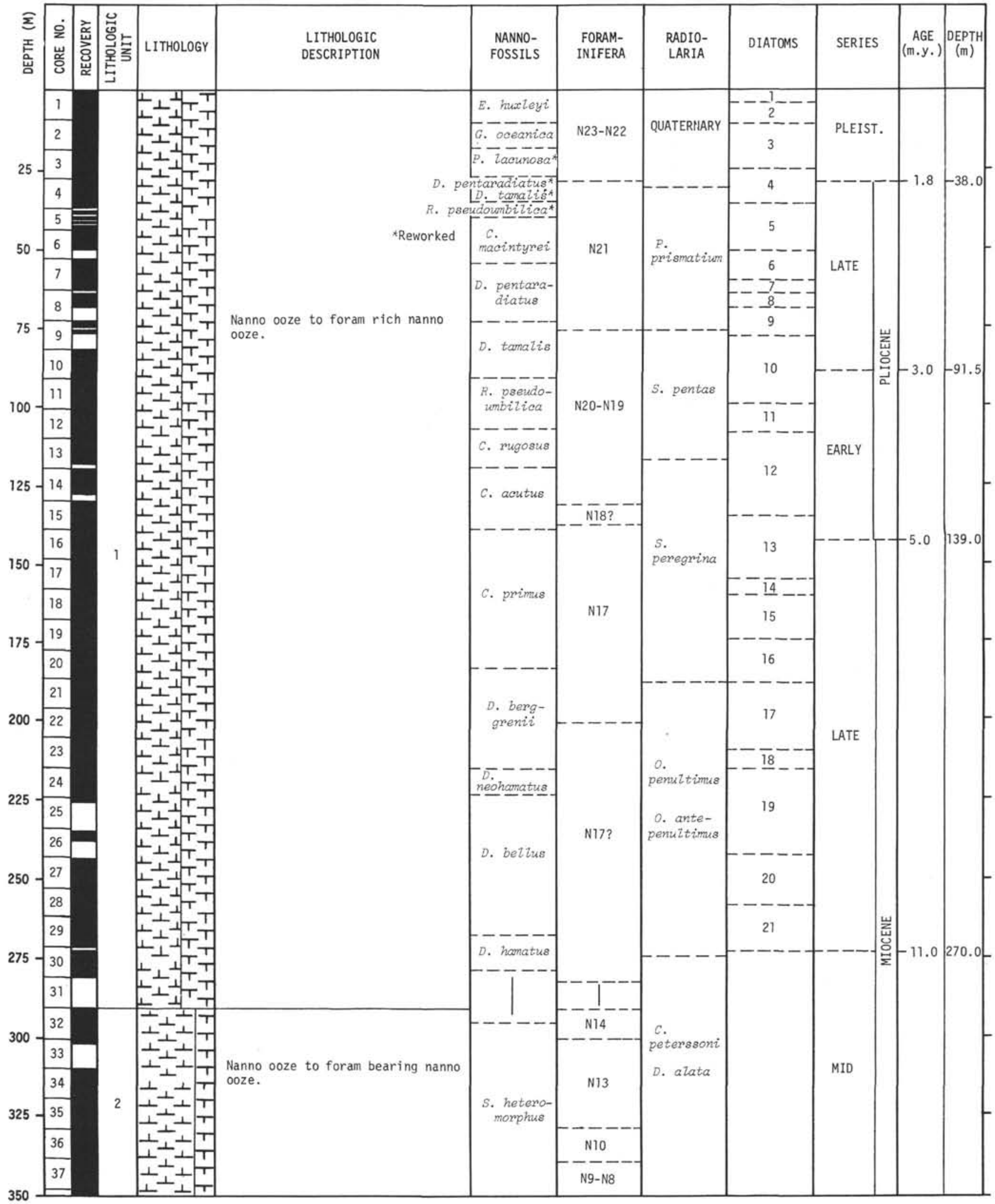
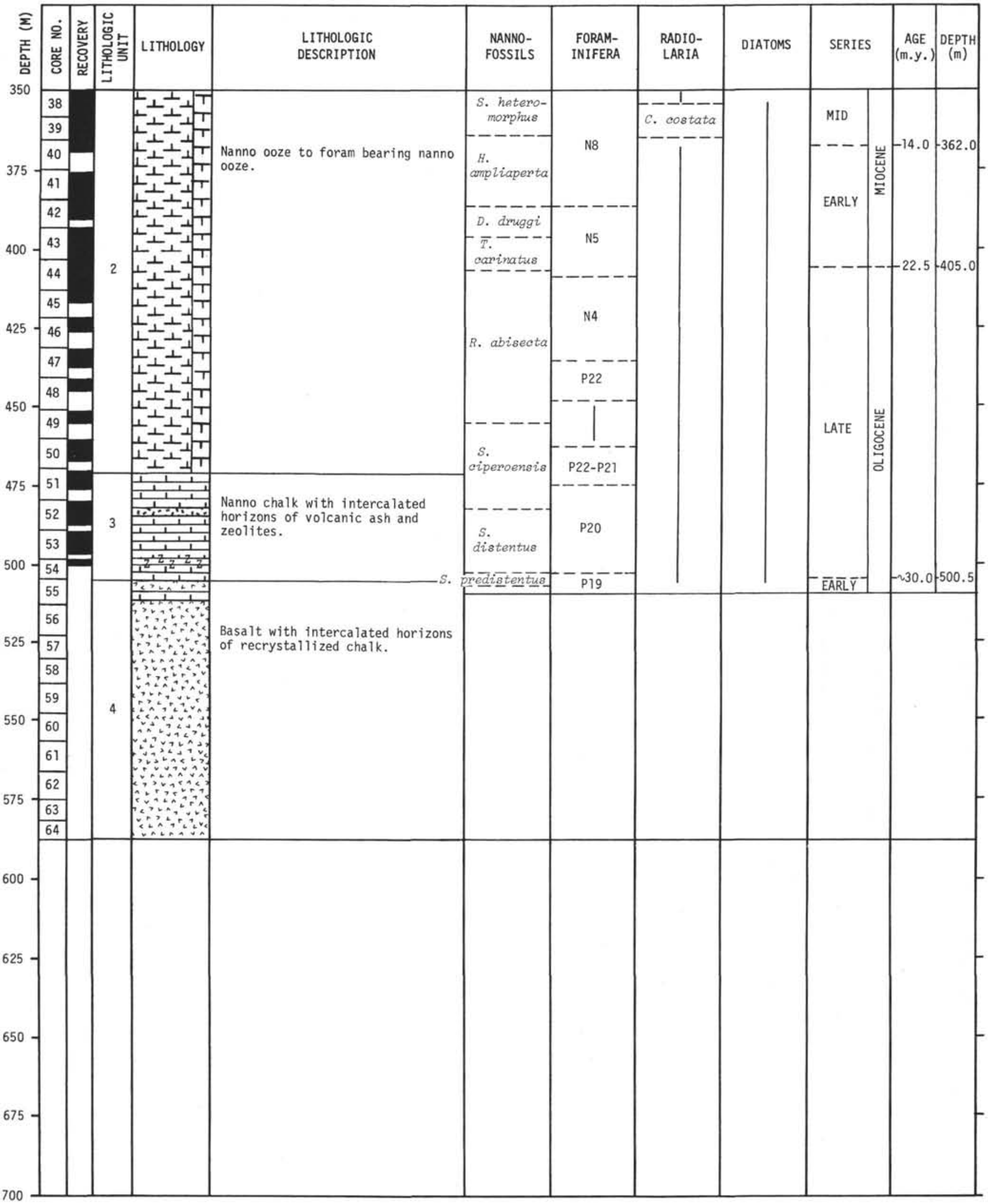


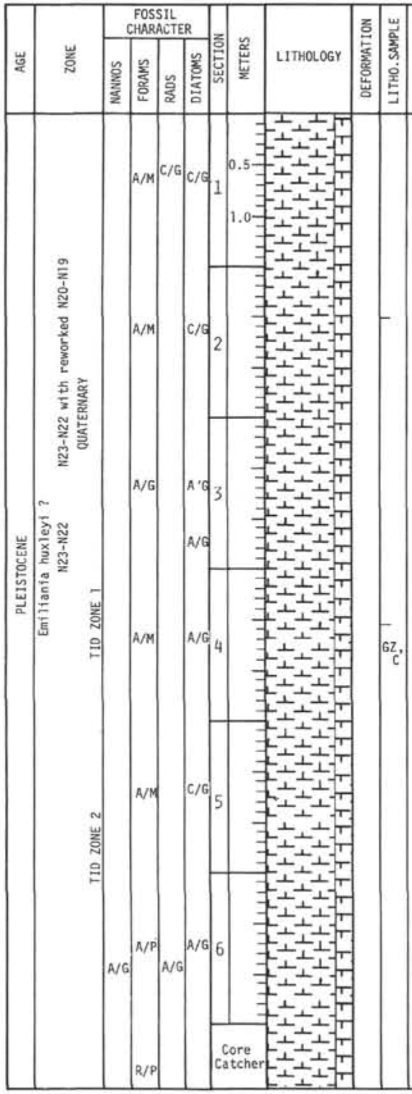
Figure 11. *Intersertal texture in olivine basalt, with a concentration of glass of about 30-40 percent: 238-57-2, no. 1 (without analyzer).*

Figure 12. *Aggregation of microlites, labradorite, and olivine in olivine basalt: 238-57-2, no. 1 (without analyzer).*


DEPTH (M)
CORE NO.
RECOVERY
LITHOLOGIC UNIT
LITHOLOGY
LITHOLOGIC DESCRIPTION
NANNO-FOSSILS
FORAM-INIFERA
RADIO-LARIA
DIATOMS
SERIES
AGE (m.y.)
DEPTH (m)
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
1
2
Nanno ooze to foram rich nanno ooze.
Nanno ooze to foram bearing nanno ooze.
*Reworked
E. huxleyi
G. oceanica
P. lacunosa*
D. pentaradiatus*
D. tamalis*
R. pseudoumbilica*
C. macintyrei
D. pentara-diatus
D. tamalis
R. pseudo-umbilica
C. rugosus
C. acutus
C. primus
D. berg-grenii
D. neohamatus
D. bellus
D. hamatus
S. hetero-morphus
N23-N22
N21
N20-N19
N18?
N17
N17?
N14
N13
N10
N9-N8
QUATERNARY
P. prismatium
S. pentas
S. peregrina
O. penultimus
O. ante-penultimus
C. petersson
D. alata
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
PLEIST.
LATE
EARLY
LATE
MID
PLIOCENE
MIOCENE
1.8
3.0
5.0
11.0
38.0
91.5
139.0
270.0


DEPTH (M)
CORE NO.
RECOVERY
LITHOLOGIC UNIT
LITHOLOGY
LITHOLOGIC DESCRIPTION
NANNO-FOSSILS
FORAM-INIFERA
RADIO-LARIA
DIATOMS
SERIES
AGE (m.y.)
DEPTH (m)
350
375
400
425
450
475
500
525
550
575
600
625
650
675
700
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
2
3
4
Nanno ooze to foram bearing nanno ooze.
Nanno chalk with intercalated horizons of volcanic ash and zeolites.
Basalt with intercalated horizons of recrystallized chalk.
S. hetero-morphus
H. ampliaperta
D. druggi
T. carinatus
R. abisecta
S. ciperoensis
S. distentus
S. predistentus
N8
N5
N4
P22
P22-P21
P20
P19
C. costata
MID
EARLY
LATE
EARLY
MIOCENE
OLIGOCENE
14.0
22.5
~30.0
362.0
405.0
500.5

Site 238 Hole Core 1 Cored Interval: 0.0-9.5 m



LITHOLOGIC DESCRIPTION

FORAM RICH NANNO OOZE
Very pale orange (10YR8/2). Soupy sediment.

Smear 1-2-50

Sand	20%	Nannos	80%
Silt	30%	Forams	20%
Clay	50%		

Color changing to very light gray (N8) at 1-3-115.

Smear 1-4-50

Sand	20%	Nannos	60%
Silt	30%	Forams	20%
Clay	50%	Rads	10-20%

$CaCO_3$ 91%

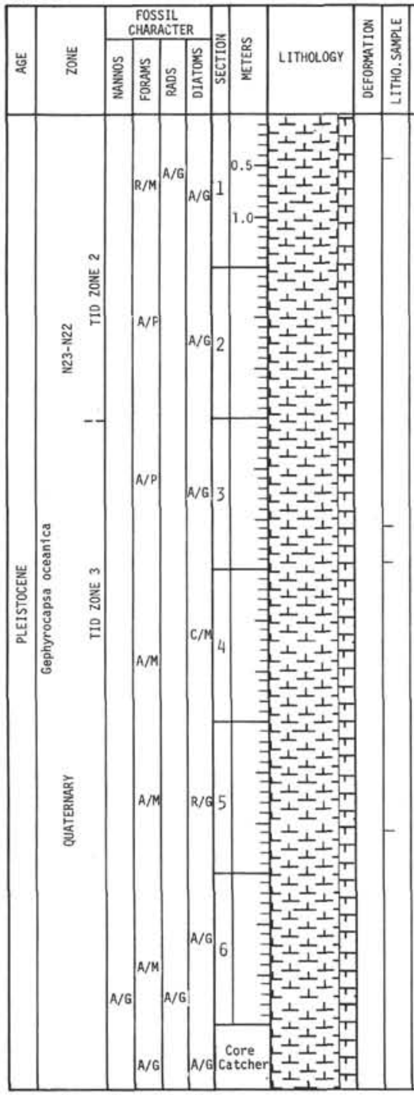
Grain Size

Sand	27%
Silt	32%
Clay	42%

Very light bluish gray (5B7/1) streaks. Color changing to bluish white (5B9/1) at 1-6-0.

Explanatory notes in chapter 1

Site 238 Hole Core 2 Cored Interval: 9.5-19.0 m



LITHOLOGIC DESCRIPTION

FORAM RICH NANNO OOZE
Very light gray (N8). Medium gray (N5) layer at 2-1-40. Sediment soupy.

Smear 2-1-39

Sand	10%	Nannos	85%
Silt	30%	Forams	10%
Clay	60%	Rads	1- 2%

Medium light gray (N6) mottles.

Color changing to bluish white (5B9/1). Dark gray (N3) layer at 2-3-100.

Smear 2-3-100

Sand	20%	Nannos	70%	Pyrite	5-10%
Silt	30%	Forams	20%		
Clay	50%				

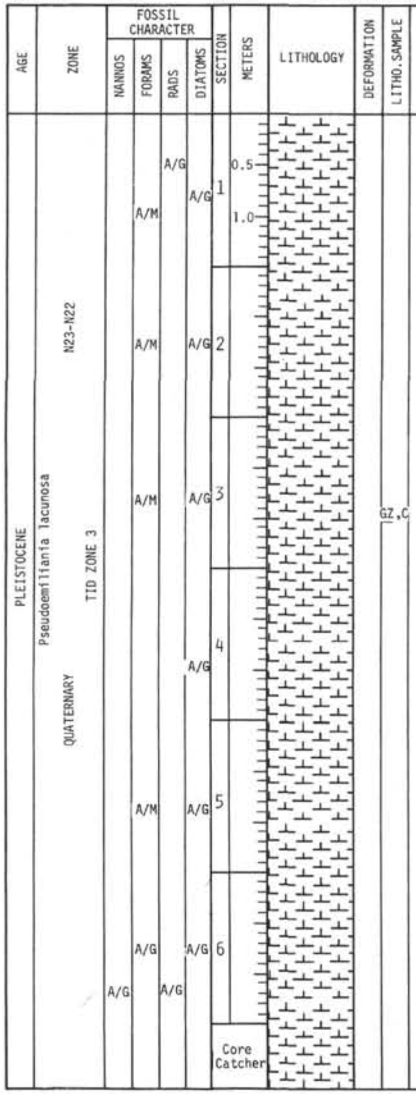
Fragment of FORAM CHALK containing almost 100% sand sized forams.

Smear 2-5-100

Sand	20%	Nannos	75%
Silt	30%	Forams	20%
Clay	50%	Rads	1- 2%FP
		Diatoms	1%

Explanatory notes in chapter 1

Site 238 Hole Core 3 Cored Interval: 19.0-28.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Very light gray (N8).

Many mottles and streaks, medium bluish gray (5B5/1) at 3-2-90.

Color change to white (N9).

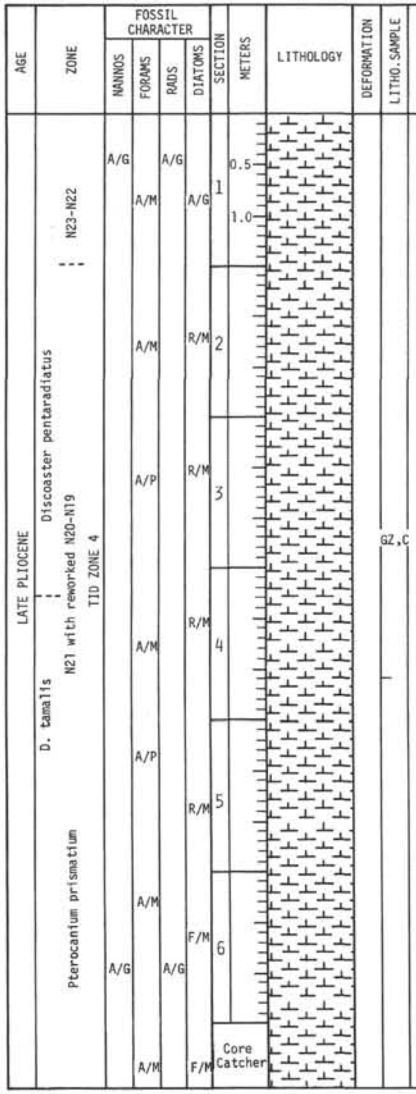
Smear 3-3-100

Sand	23%	Nannos	90%	Micarb	1%
Silt	30%	Forams	1- 5%	$CaCO_3$	91%
Clay	47%	Rads	1- 2%		
		Sponge Spic.	1%		
		Silicoflag.	1%		

Color change to white (N9) to very light gray (N8).

Explanatory notes in chapter 1

Site 238 Hole Core 4 Cored Interval: 28.5-38.0 m



LITHOLOGIC DESCRIPTION

FORAM RICH NANNO OOZE
Bluish white (5B9/1) with medium light gray (N6) layers.

Color change to homogenous white (N9).

Smear 4-4-100

Sand	10%	Nannos	90%
Silt	30%	Forams	5-10%
Clay	60%	Rads	1%FP

$CaCO_3$ 86%

Color change to bluish white (5B9/1) at 4-5-0.

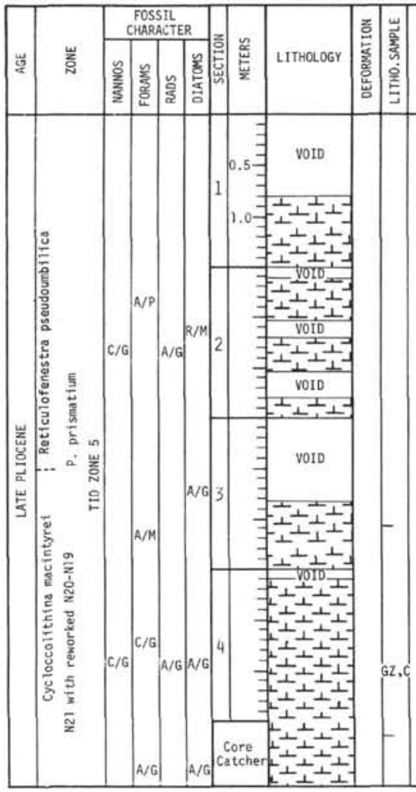
Color change to white (N9) at 4-6-0.

Smear 4-CC

Sand	5%	Nannos	90%
Silt	30%	Forams	10%
Clay	65%	Rads	1- 2%

Explanatory notes in chapter 1

Site 238 Hole Core 5 Cored Interval: 38.0-44.0 m



LITHOLOGIC DESCRIPTION

FORAM RICH
NANNO OOZE
Medium gray (N6) changing to bluish white (5B9/1) at 5-1-107. Soupy sediment.

Smear 5-3-100

Sand	10-20%	Nannos	80%
Silt	30%	Forams	10%
Clay	50%	Silicoflag.	2- 3%
		Diatoms	1- 2%
		Rads	1- 2%FP
		Sponge Spic.	1- 2%

Grain Size

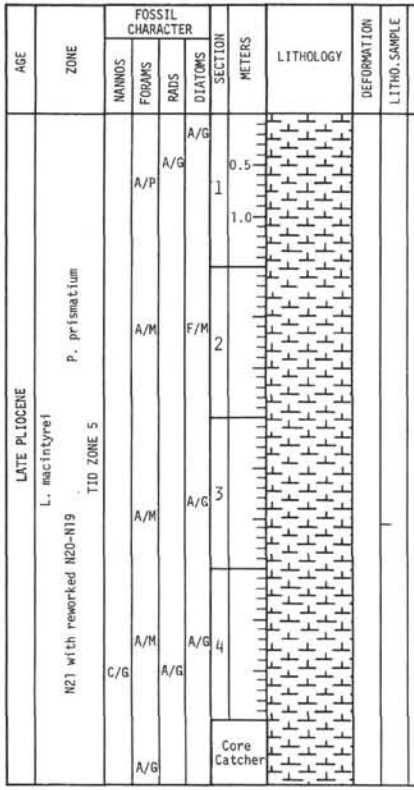
Sand	33%
Silt	27%
Clay	40%

Smear 5-CC

Sand	5%	Nannos	90%	
Silt	30%	Forams	2- 5%	
Clay	65%	Diatoms	1- 2%	$CaCO_3$ 92%
		Rads	1- 2%	

Explanatory notes in chapter 1

Site 238 Hole Core 6 Cored Interval: 44.0-53.5 m



LITHOLOGIC DESCRIPTION

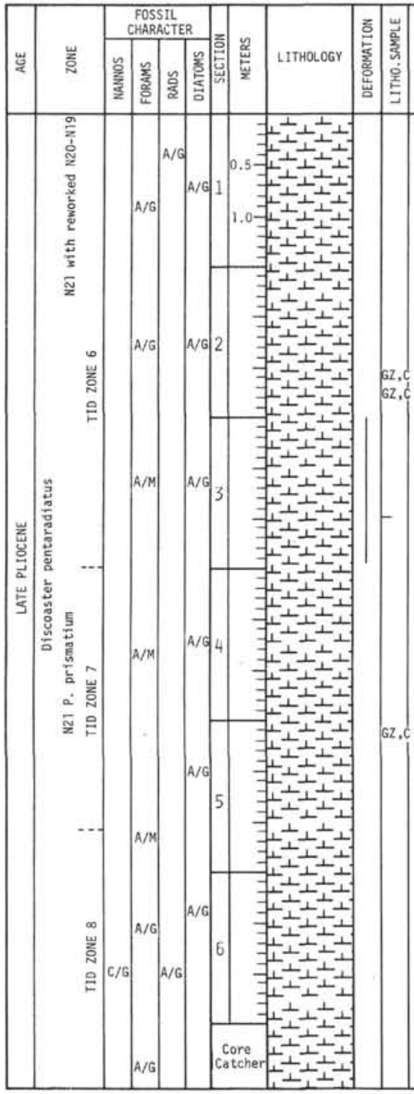
NANNO OOZE
Very light gray (N8). Few burrows in darker gray shades.

Smear 6-3-100

Sand	10-20%	Nannos	80-90%	Feldspar	<1%
Silt	30%	Forams	10%		
Clay	50%	Rads	2- 5%FP		
		Diatoms	1%FP		
		Sponge Spic.	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 7 Cored Interval: 53.5-63.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
In various shades of bluish white (5B5/1) to light bluish gray (5B7/1). Intensively layered in 7-1. Piece of FORAM CHALK at 7-1-20.

Slightly darker layers.

Grain Size 7-2-110 cm

Sand	2%
Silt	32%
Clay	66%

$CaCO_3$ 94%

Smear 7-3-90

Sand	10-20%	Nannos	85%
Silt	30%	Forams	10%
Clay	50%	Rads	5%
		Diatoms	1- 2%
		Sponge Spic.	1%

Grain Size 7-2-119 cm

Sand	1%
Silt	37%
Clay	62%

$CaCO_3$ 93%

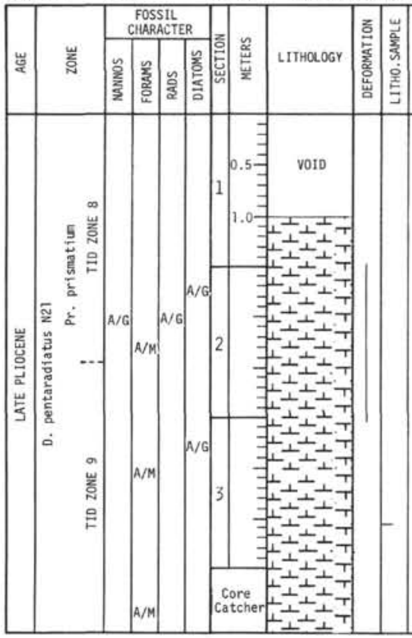
Grain Size 7-5-10 cm

Sand	20%
Silt	32%
Clay	48%

$CaCO_3$ 7-5-12 cm 92%

Explanatory notes in chapter 1

Site 238 Hole Core 8 Cored Interval: 63.0-72.5 m



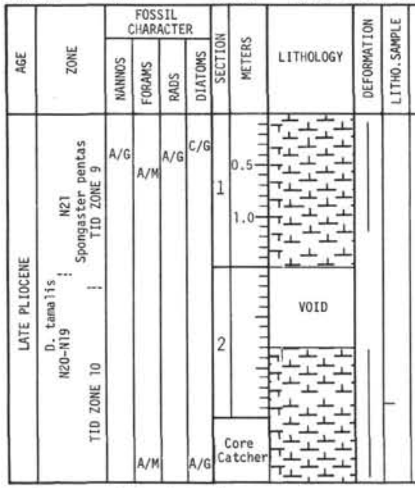
LITHOLOGIC DESCRIPTION

FORAM RICH NANNO OOZE
Bluish white (5B9/1)

Smear 8-3-100

Sand	10-20%	Nannos	80%
Silt	30%	Forams	10-15%
Clay	50%	Rads	5%
		Diatoms	1- 2%
		Sponge Spic.	1%

Site 238 Hole Core 9 Cored Interval: 72.5-82.0 m



LITHOLOGIC DESCRIPTION

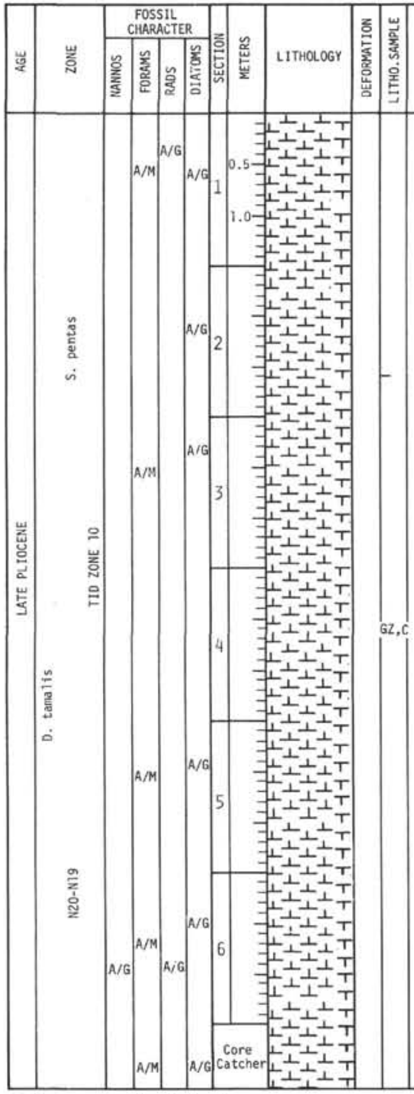
FORAM RICH NANNO OOZE
Bluish white (5Y9/1). Piece of FORAM LIMESTONE at 9-1-75.

Smear 9-2-130

Sand	10-20%	Nannos	80%
Silt	30%	Forams	15%
Clay	50%	Rads	2%
		Diatoms	1%
		Sponge Spic.	1%

Explanatory notes in chapter 1

Site 238 Hole Core.10 Cored Interval: 82.0-91.5 m



LITHOLOGIC DESCRIPTION

FORAM RICH NANNO OOZE
Bluish white (5B9/1)

FORAM LIMESTONE fragments at 10-2-73, 10-2-77, 10-2-120, 10-2-140, 11-3-145.

Smear 10-2-100

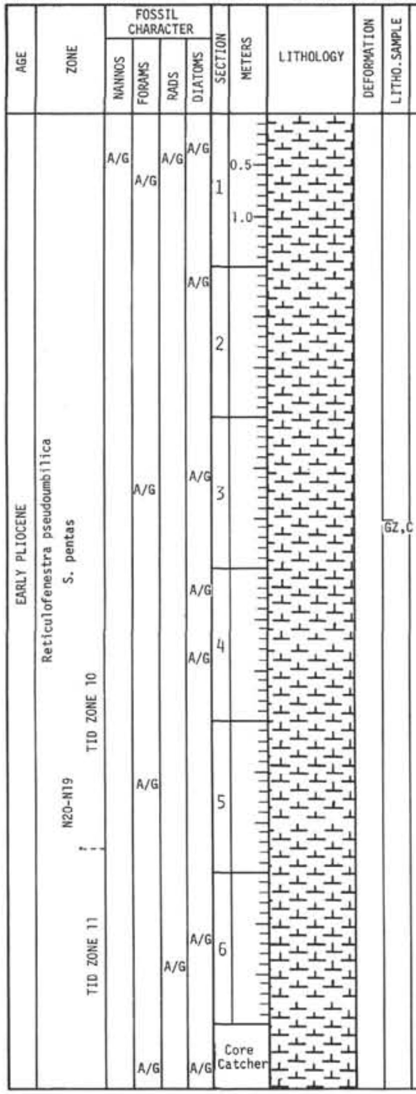
Sand	10-20%	Nannos	80%
Silt	30%	Forams	15%
Clay	50%	Diatoms	1%
		Rads	1%
		Sponge Spic.	1%

Grain Size
Sand 19%
Silt 39%
Clay 43%

$CaCO_3$ 93%

Explanatory notes in chapter 1

Site 238 Hole Core 11 Cored Interval: 91.5-101.0 m



LITHOLOGIC DESCRIPTION

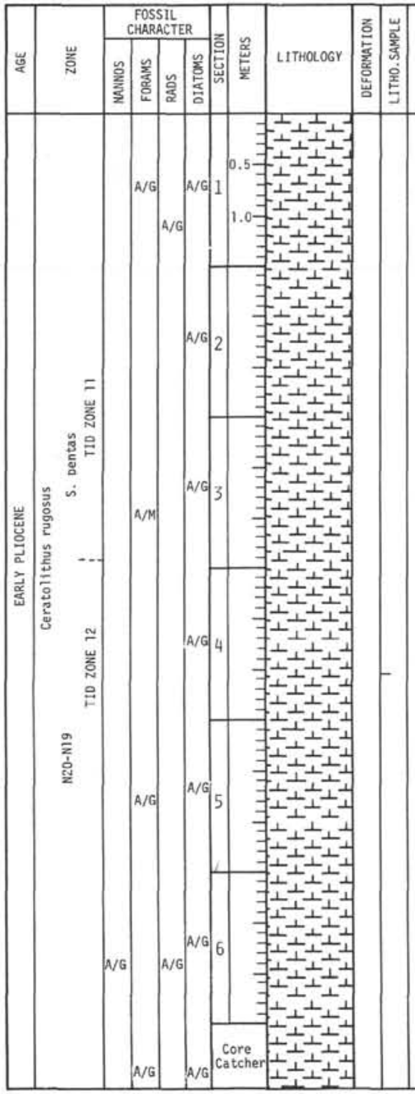
FORAM RICH NANNO OOZE
Bluish white (5B9/1) with medium bluish gray (5B5/1) layering at 11-1-10 to 30.

Smear 11-3-100

Sand	9%	Nannos	80%	Volc. Glass	1%
Silt	40%	Forams	10%		
Clay	52%	Rads	1- 5%FP-FM		
		Diatoms	1%		
		Sponge Spic.	1%		
		$CaCO_3$	86%		

Explanatory notes in chapter 1

Site 238 Hole Core 12 Cored Interval:101.0-110.5 m



LITHOLOGIC DESCRIPTION

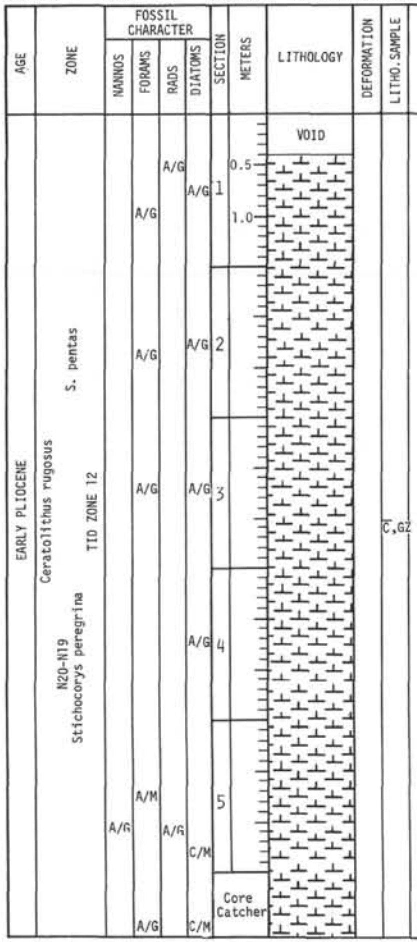
NANNO OOZE
Light bluish gray (5B7/1) changing to bluish white (5B9/1) at 12-1-135.

Smear 12-4-100

Sand	5-10%	Nannos	85%
Silt	30%	Forams	5-10%
Clay	60%	Diatoms	1%
		Rads	1%
		Silicoflag.	1%

Explanatory notes in chapter 1

Site 238 Hole Core 13 Cored Interval:110.5-120.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Bluish white (5B9/1).

Smear 13-3-100

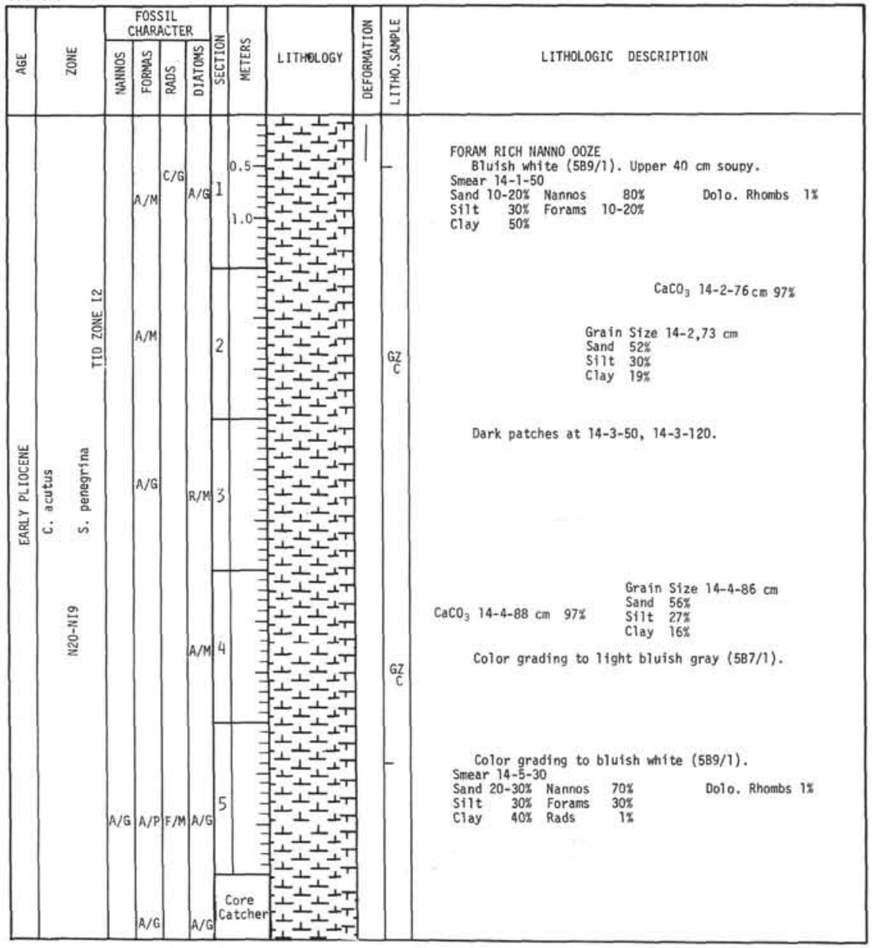
Sand	5%	Nannos	85%
Silt	40%	Forams	5-10%
Clay	55%	Rads	1- 2%
		Diatoms	1%
		Sponge Spic.	1%
		Silicoflag.	1%

$CaCO_3$ 87%

Color change to white (N9).

Explanatory notes in chapter 1

Site 238 Hole Core 14 Cored Interval: 120.0-129.5 m



FORAM RICH NANNO OOZE
Bluish white (5B9/1). Upper 40 cm soupy.
Smear 14-1-50

Sand 10-20%	Nannos	80%	Dolo. Rhombs	1%
Silt 30%	Forams	10-20%		
Clay 50%				

$CaCO_3$ 14-2-76 cm 97%

Grain Size 14-2,73 cm
Sand 52%
Silt 30%
Clay 19%

Dark patches at 14-3-50, 14-3-120.

Grain Size 14-4-86 cm
Sand 56%
Silt 27%
Clay 16%

$CaCO_3$ 14-4-88 cm 97%

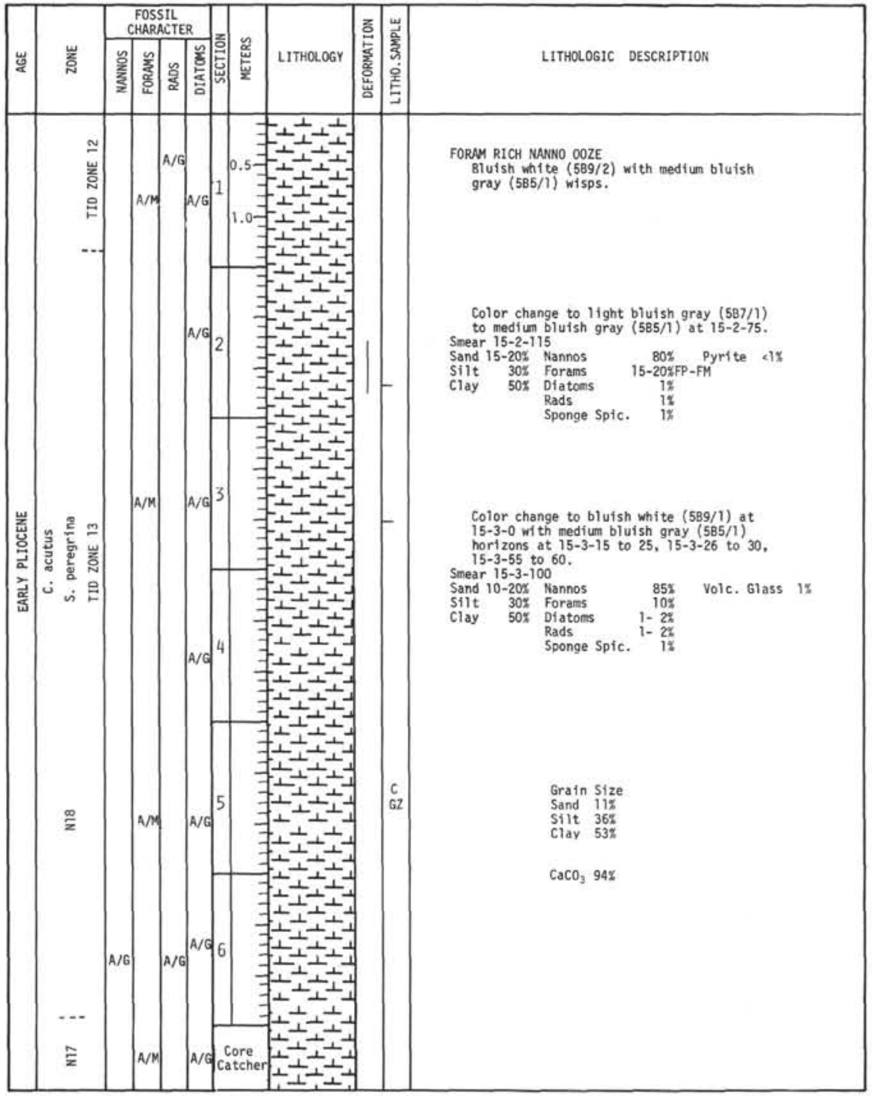
Color grading to light bluish gray (5B7/1).

Color grading to bluish white (5B9/1).
Smear 14-5-30

Sand 20-30%	Nannos	70%	Dolo. Rhombs	1%
Silt 30%	Forams	30%		
Clay 40%	Rads	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 15 Cored Interval: 129.5-139.0 m



FORAM RICH NANNO OOZE
Bluish white (5B9/2) with medium bluish gray (5B5/1) wisps.

Color change to light bluish gray (5B7/1) to medium bluish gray (5B5/1) at 15-2-75.
Smear 15-2-115

Sand 15-20%	Nannos	80%	Pyrite	<1%
Silt 30%	Forams	15-20%FP-FM		
Clay 50%	Diatoms	1%		
	Rads	1%		
	Sponge Spic.	1%		

Color change to bluish white (5B9/1) at 15-3-0 with medium bluish gray (5B5/1) horizons at 15-3-15 to 25, 15-3-26 to 30, 15-3-55 to 60.
Smear 15-3-100

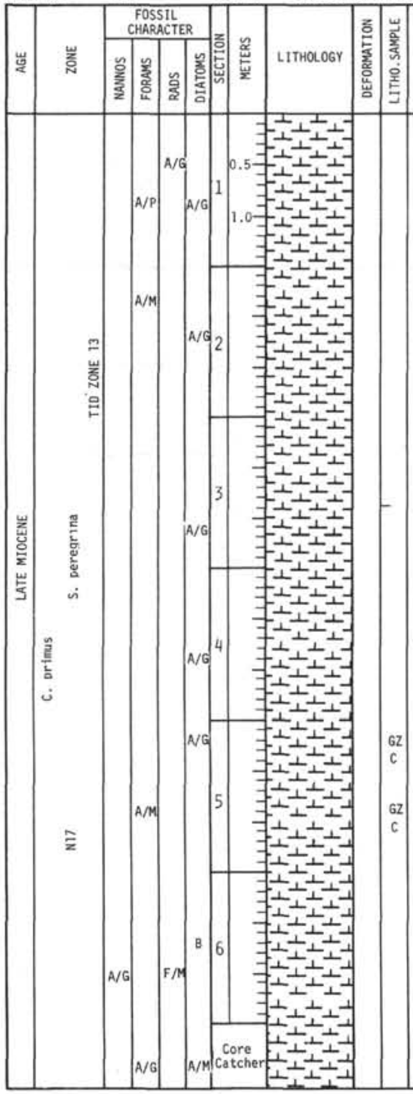
Sand 10-20%	Nannos	85%	Volc. Glass	1%
Silt 30%	Forams	10%		
Clay 50%	Diatoms	1- 2%		
	Rads	1- 2%		
	Sponge Spic.	1%		

Grain Size
Sand 11%
Silt 36%
Clay 53%

$CaCO_3$ 94%

Explanatory notes in chapter 1

Site 238 Hole Core 16 Cored Interval:139.0-148.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Bluish white (5B9/1)

Smear 16-3-82

Sand	10%	Nannos	90%	Volc. Glass	1%
Silt	30%	Forams	1- 5%	Pyrite	1%
Clay	60%	Rads	1- 3%FP		
		Sponge Spic.	1%		

Light bluish gray (5B7/1) layer at 16-5-30 and 16-6-135 to 142.

Grain Size 16-5-25

Sand	0%
Silt	35%
Clay	65%

$CaCO_3$ 16-5-25 94%

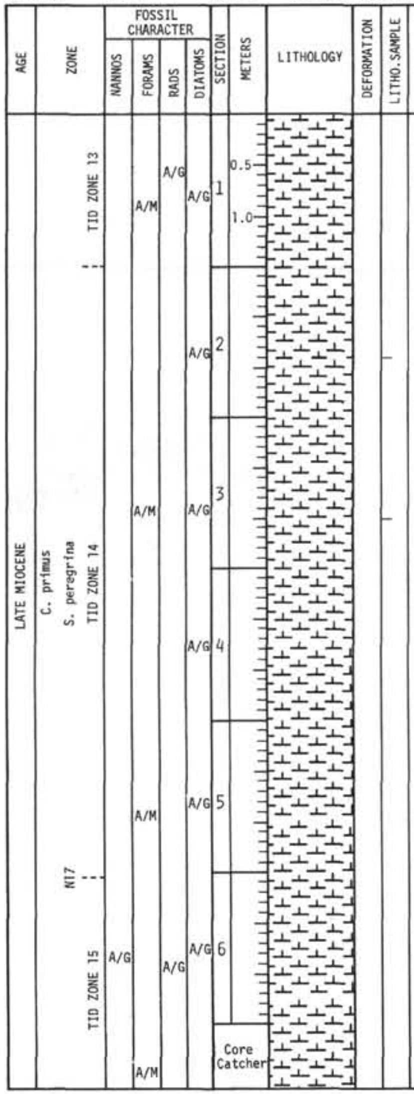
Grain Size 16-5-100 cm

Sand	32%
Silt	44%
Clay	25%

$CaCO_3$ 16-5-100 cm 96%

Explanatory notes in chapter 1

Site 238 Hole Core 17 Cored Interval:148.5-158.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Bluish white (5B9/1) with medium bluish gray (5B5/1) mottles.

Smear 17-2-84

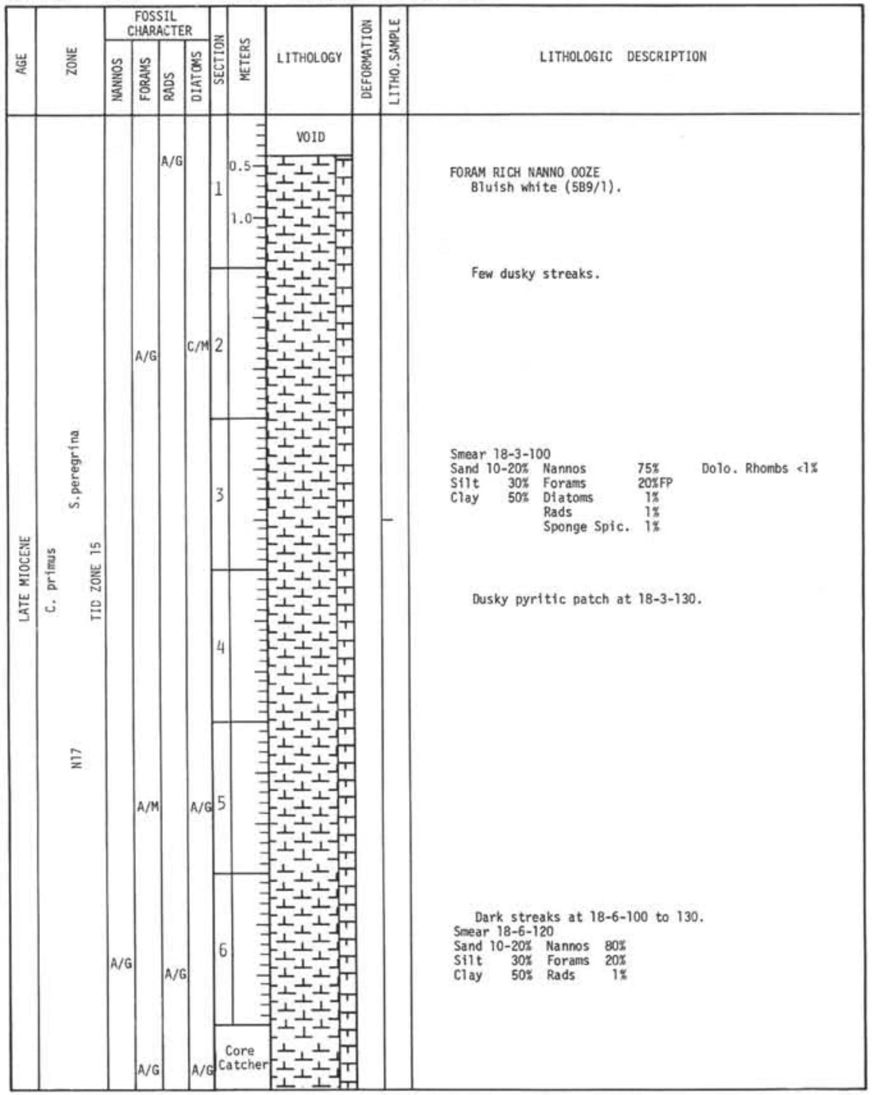
Sand	2- 5%	Nannos	90%	Pyrite	1%
Silt	30%	Forams	1- 2%		
Clay	65%	Diatoms	1- 2%		
		Rads	1%		
		Sponge Spic.	1%		
		Silicoflag.	1%		

Smear 17-3-100

Sand	5-10%	Nannos	90%	Heavy Min.	1%
Silt	30%	Forams	5%		
Clay	60%	Diatoms	2%		
		Rads	2%		
		Sponge Spic.	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 18 Cored Interval: 158.0-167.5 m



FORAM RICH NANNO OOZE
Bluish white (5B9/1).

Few dusky streaks.

Smear 18-3-100

Sand	10-20%	Nannos	75%	Dolo. Rhombs <1%
Silt	30%	Forams	20%FP	
Clay	50%	Diatoms	1%	
		Rads	1%	
		Sponge Spic.	1%	

Dusky pyritic patch at 18-3-130.

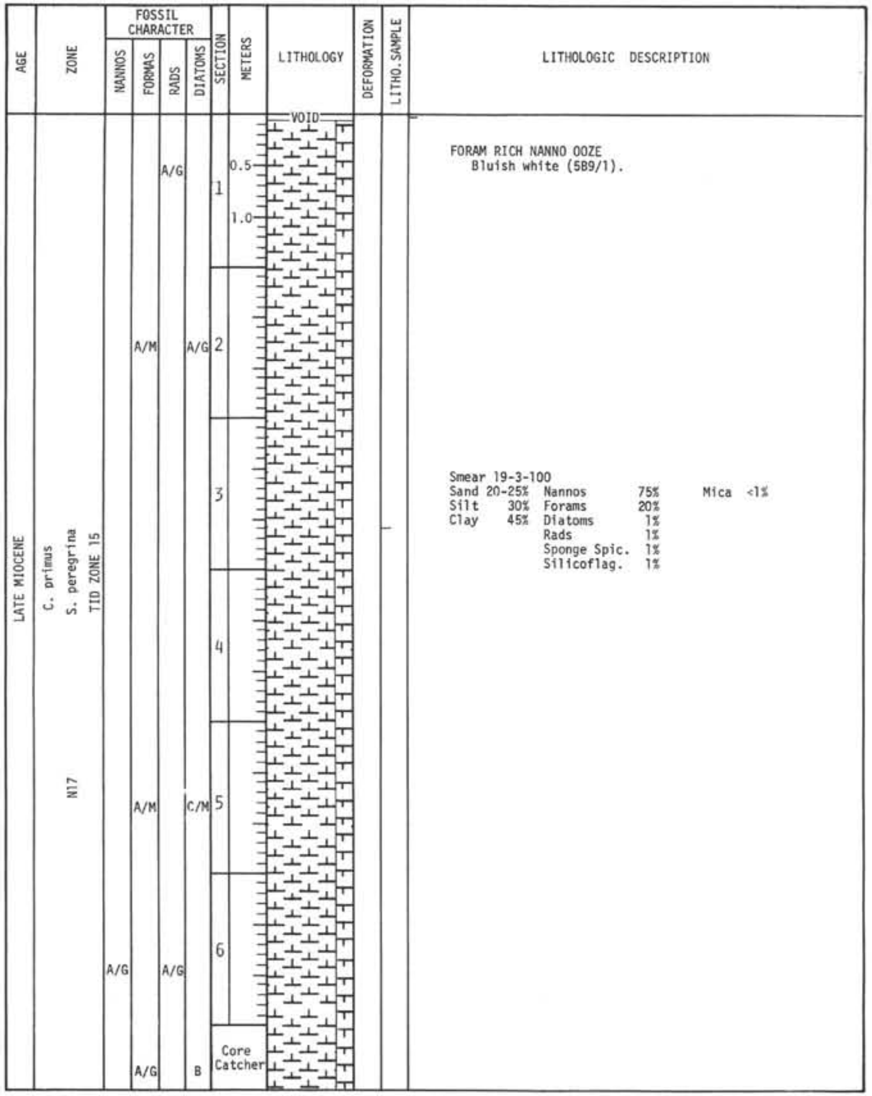
Dark streaks at 18-6-100 to 130.

Smear 18-6-120

Sand	10-20%	Nannos	80%
Silt	30%	Forams	20%
Clay	50%	Rads	1%

Explanatory notes in chapter 1

Site 238 Hole Core 19 Cored Interval: 167.5-177.0 m



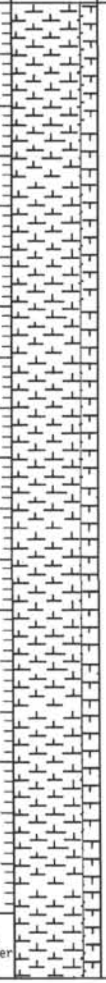
FORAM RICH NANNO OOZE
Bluish white (5B9/1).

Smear 19-3-100

Sand	20-25%	Nannos	75%	Mica <1%
Silt	30%	Forams	20%	
Clay	45%	Diatoms	1%	
		Rads	1%	
		Sponge Spic.	1%	
		Silicoflag.	1%	

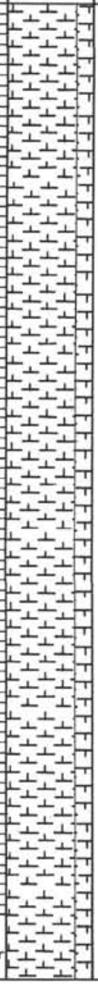
Explanatory notes in chapter 1

Site 238 Hole Core 20 Cored Interval: 177.0-186.5 m

AGE	ZONE	FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
		NANNOS	FORMAS	RADS	DIATOMS						
LATE MIOCENE	C.PRIMUS S.PEREGRINA TID ZONE16			A/G		1	0.5 1.0				FORAM RICH NANNO OOZE Bluish white (5B9/1)
			A/G		R/M	2					
						3					Smear 20-3-100 Sand 20-25% Nannos 70% Silt 30% Forams 25% Clay 45% Diatoms 1% Rads 1% Sponge Spic. 1%
						4					
	N17		A/G		R/M	5					
		A/G		C/M		6					
			A/M		F/M	Core Catcher					

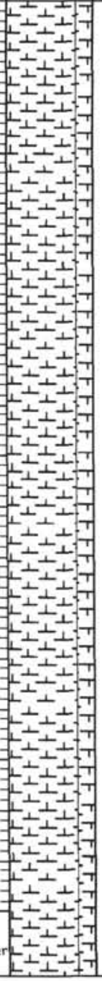
Explanatory notes in chapter 1

Site 238 Hole Core 21 Cored Interval: 186.5-196.0 m

AGE	ZONE	FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
		NANNOS	FORAMS	RADS	DIATOMS						
LATE MIOCENE	D. bergreni Ommatartus penultimus and O. antepenaltimus TID ZONE I7			F/G		1	0.5 1.0				FORAM RICH NANNO OOZE Bluish white (5B9/1).
			A/M		A/G	2					
						3					
						4					
			A/M		B	5					
	N17	A/G		A/G		6					Dark wisp.
			A/M		A/G	Core Catcher					

Explanatory notes in chapter 1

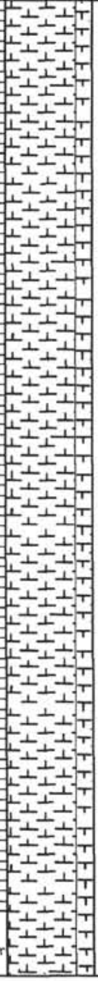
Site 238 Hole Core 22 Cored Interval: 196.0-205.5 m



AGE	ZONE	FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		NANNOS	FORAMS	RADS	DIATOMS						
LATE MIOCENE	D. berggreni N17? TID 18 N17 O. penultimus and O. antepenultimus TID 17			A/G		1	0.5 1.0				FORAM RICH NANNO OOZE Bluish white (5B9/1).
			A/M		A/G	2					Medium bluish gray (5B5/1) horizon at 22-3-20 to 25. Smear 22-3-22 Sand 25% Nannos 80% Silt 25% Forams 20% Clay 50% Rads 1%FP
						3					Smear 22-3-100 Sand 25% Nannos 70% Silt 30% Forams 25% Clay 45% Diatoms 1% Rads 1% Sponge Spic. 1% Fish Debris <1%
						4					
			A/G		A/G	5					
		A/G		A/G		6					
			A/G		A/G	Core Catcher					

Explanatory notes in chapter 1

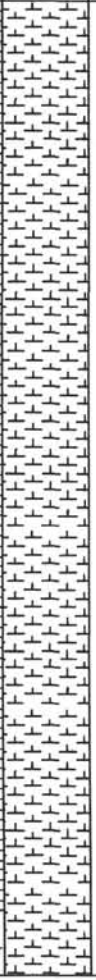
Site 238 Hole Core 23 Cored Interval: 205.5-215.0 m



AGE	ZONE	FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		NANNOS	FORAMS	RADS	DIATOMS						
LATE MIOCENE	D. berggreni N17? O. penultimus and O. antepenultimus TID 18			A/G		1	0.5 1.0				FORAM RICH NANNO OOZE Bluish white (5B9/1).
			A/M		C/G	2					
						3					Smear 23-3-100 Sand 15-20% Nannos 80% Silt 30% Forams 15% Clay 50% Diatoms 1% Rads 1% Sponge Spic. 1% Silicoflag. 1%
						4					
			A/M		B	5					
		A/G		A/G		6					
			A/G		C/M	Core Catcher					

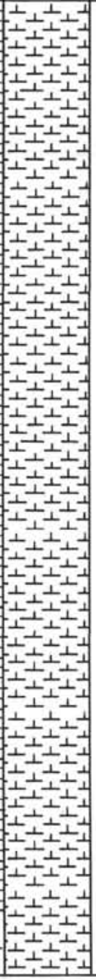
Explanatory notes in chapter 1

Site 238 Hole Core 24 Cored Interval: 215.0-224.0 m

AGE	ZONE	FOSSIL CHARACTER NANNOS	FOSSIL CHARACTER FORAMS	FOSSIL CHARACTER RADS	FOSSIL CHARACTER DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	D. neohamatus O. penultimus and O. antepenultimus TID 19 N17?			F/M		1	0.5 1.0				FORAM RICH NANNO OOZE Bluish white (5B9/1).
			A/G		B	2					
						3				–	Smear 24-3-100 Sand 5-10% Nannos 85% Silt 30% Forams 10% Clay 60% Diatoms 1% Sponge Spic. 1%
			A/M			4					Color change to white (N9).
					B	5					
		A/G		R/M		6					
			A/M		B	Core Catcher					

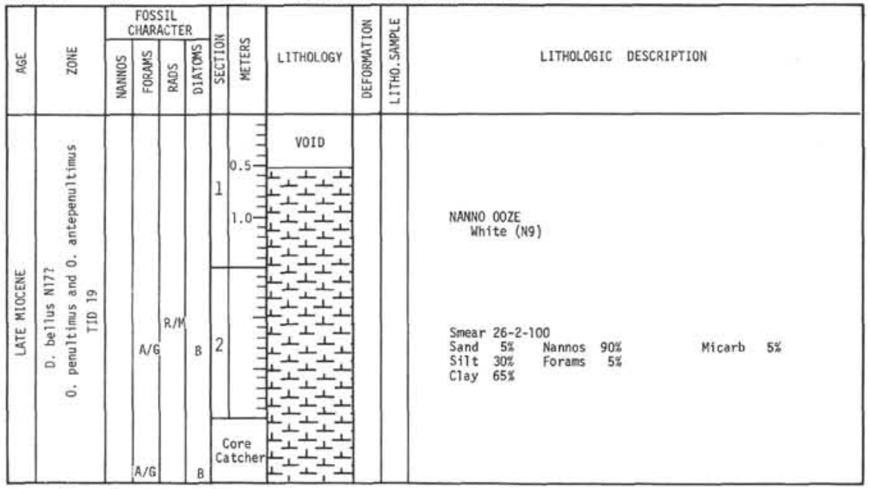
Explanatory notes in chapter 1

Site 238 Hole Core 25 Cored Interval: 224.5-234.0 m

AGE	ZONE	FOSSIL CHARACTER NANNOS	FOSSIL CHARACTER FORAMS	FOSSIL CHARACTER RADS	FOSSIL CHARACTER DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	TID I9 NI7? D.BELLUS O. penultimus and U. antepenultimus			R/M		1	0.5 1.0				NANNO OOZE White (N9). Becoming increasingly stiff.
			A/M		B	2					
						3				–	Smear 25-3-100 Sand 5-10% Nannos 90% Silt 30% Forams 5-10% Clay 60% Sponge Spic. 1%
						4					Semi-lithified at 25-4-30 to 35.
			A/G		B	5					
		A/G		R/M		6					
			A/M		B	Core Catcher					

Explanatory notes in chapter 1

Site 238 Hole Core 26 Cored Interval: 234.0-243.5 m

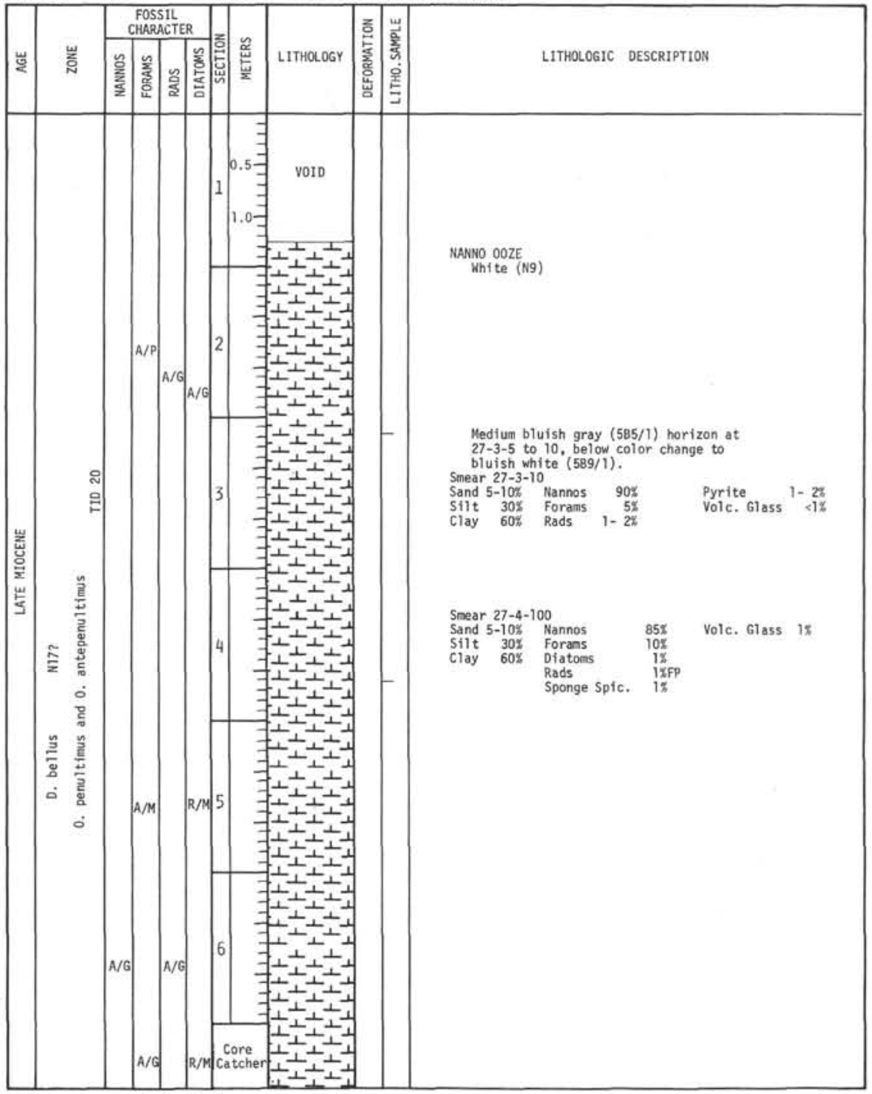


NANNO OOZE
White (N9)

Smear 26-2-100
Sand 5% Nannos 90% Micarb 5%
Silt 30% Forams 5%
Clay 65%

Explanatory notes in chapter 1

Site 238 Hole Core 27 Cored Interval: 243.5-253.0 m



NANNO OOZE
White (N9)

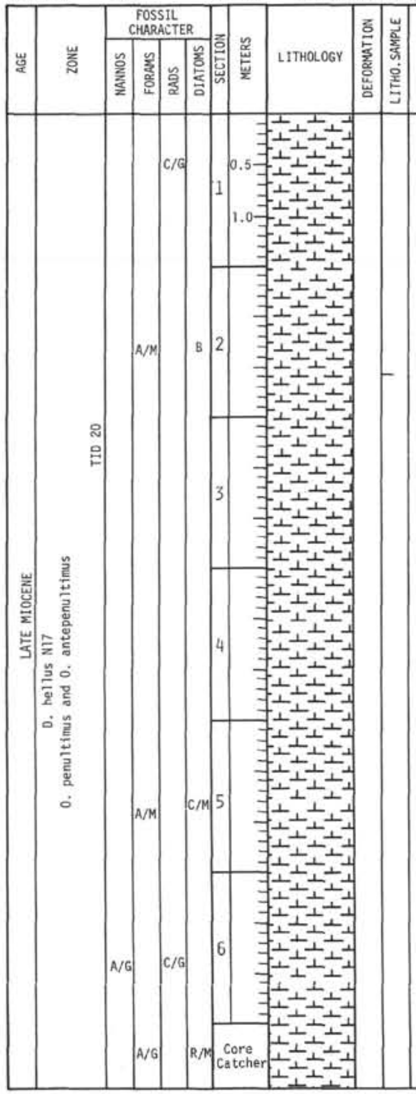
Medium bluish gray (5B5/1) horizon at 27-3-5 to 10, below color change to bluish white (5B9/1).

Smear 27-3-10
Sand 5-10% Nannos 90% Pyrite 1- 2%
Silt 30% Forams 5% Volc. Glass <1%
Clay 60% Rads 1- 2%

Smear 27-4-100
Sand 5-10% Nannos 85% Volc. Glass 1%
Silt 30% Forams 10%
Clay 60% Diatoms 1%
Rads 1%FP
Sponge Spic. 1%

Explanatory notes in chapter 1

Site 238 Hole Core 28 Cored Interval: 253.0-262.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Bluish white (5B9/1).

Color changing to white (N9).

Smear 28-2-100

Sand	5-10%	Nannos	85%	Micarb	5%
Silt	30%	Forams	5-10%	Quartz	1%
Clay	60%	Sponge Spic.	1%		
		Silicoflag.	<1%		

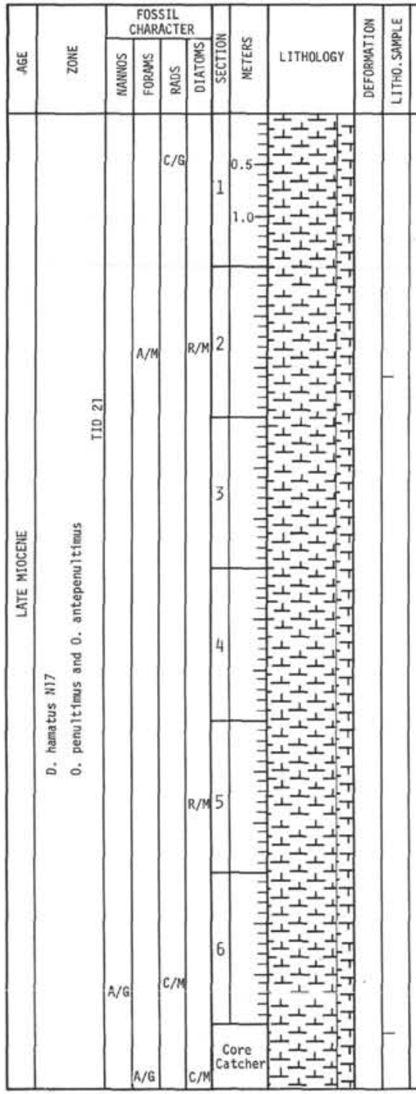
Medium bluish gray (5B5/1) streaks.

Color change to bluish white (5B9/1).

Some greenish layers in 28-5.

Explanatory notes in chapter 1

Site 238 Hole Core 29 Cored Interval: 262.5-272.0 m



LITHOLOGIC DESCRIPTION

FORAM RICH NANNO OOZE
Bluish white (5B9/1).

Smear 29-2-100

Sand	20-25%	Nannos	75%	Micarb	5%
Silt	30%	Forams	20%		
Clay	45%	Rads	1%		
		Sponge Spic.	1%		

Color changing to white (N9).

Smear 29-CC

Sand	30%	Nannos	70%
Silt	30%	Forams	25%
Clay	40%	Diatoms	1%
		Rads	1%
		Sponge Spic.	1%

Explanatory notes in chapter 1

Site 238 Hole Core 30 Cored Interval: 272.0-281.5 m

AGE	ZONE	FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FORAMS	NANNOS	RADS	DIATOMS						
MIDDLE MIOCENE	D. hamatus Cannartus petterssoni and Dorcadospyris alata TID 22					1	0.5 1.0	VOID			NANNO OOZE White (N9).
			A/M	C/G	R/M	2					Smear 30-2-100 Sand 5-10% Nannos 85% Silt 30% Forams 10% Clay 60% Rads 1% Sponge Spic. 1%
			A/G		R/M	3					
			A/G		R/M	4					
			A/M		R/M	5					
		A/G	A/G	F/G	R/M	6					
			A/G		R/M	Core Catcher					

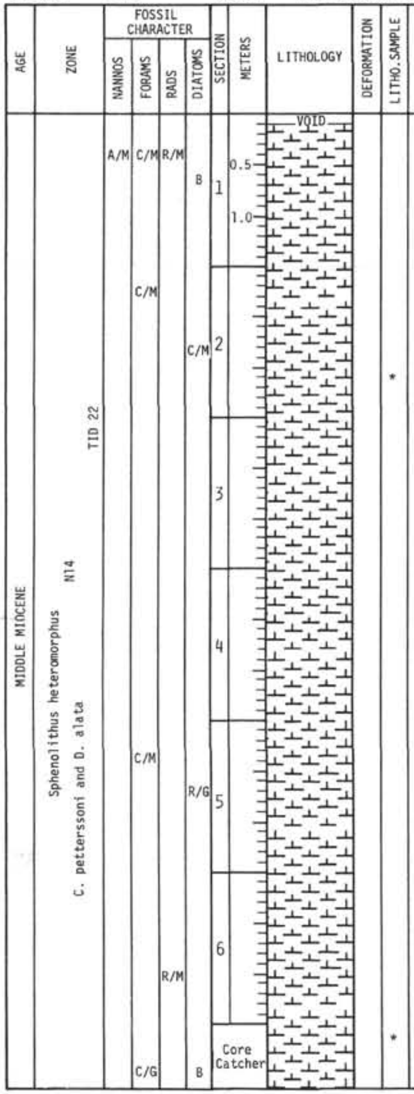
Explanatory notes in chapter 1

Site 238 Hole Core 31 Cored Interval: 281.5-291.0 m

AGE	ZONE	FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		NANNOS	FORAMS	RADS	DIATOMS						
M. MIOCENE						Core Catcher				–	NANNO OOZE White (N9) and small fragment of FORAM LIMESTONE Smear 31-CC Sand 5% Nannos 90% Micarb 5% Silt 30% Forams 1- 3% Pyrite 1% Clay 65% Sponge Spic. 1%

Explanatory notes in chapter 1

Site 238 Hole Core 32 Cored Interval: 291.0-300.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Very pale orange (10YR8/2).

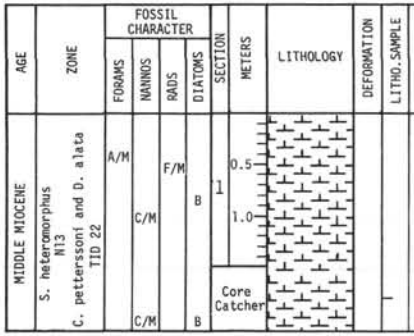
Smear 32-2-100
Sand 1- 3% Nannos 90% Micarb 1%
Silt 25% Forams 1- 3%
Clay 70% Sponge Spic. 1%

Grayish orange (10YR7/4) layer at 32-4-60 to 135.

Smear 32-CC
Sand 5% Nannos 90% Micarb 5%
Silt 35% Forams 5%
Clay 60% Sponge Spic. 1%

Explanatory notes in chapter 1

Site 238 Hole Core 33 Cored Interval: 300.5-310.0 m

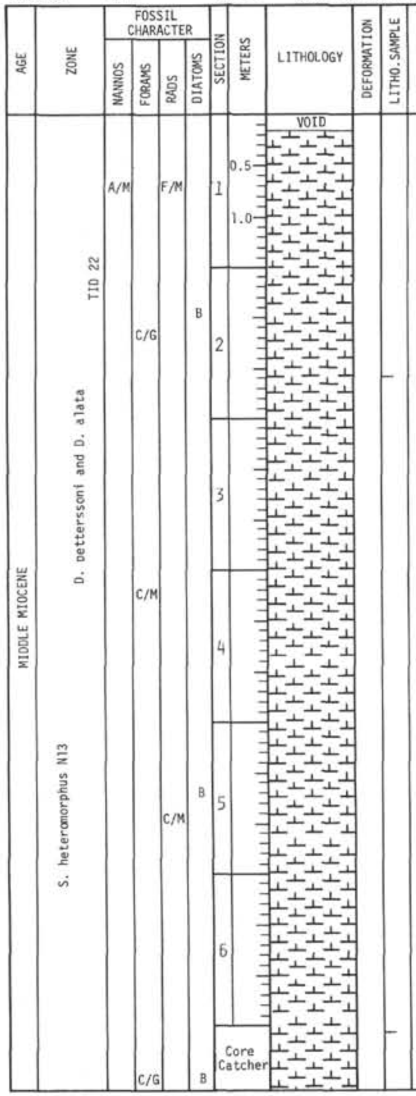


LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish orange (10YR7/4) changing to very pale orange (10YR8/2) at 33-1-90.
Smear 32-CC
Sand 1- 3% Nannos 90% Micarb 5%
Silt 25% Forams 1- 2%
Clay 70% Sponge Spic. <1%

Explanatory notes in chapter 1

Site 238 Hole Core 34 Cored Interval: 310.0-319.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Very pale orange (10YR7/4)

Smear 34-2-100

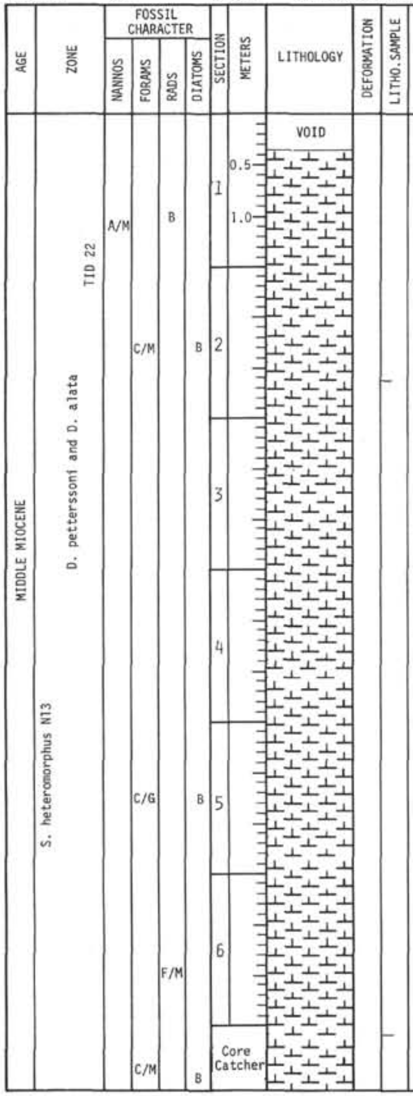
Sand	1- 2%	Nannos	90%	Micarb	5%
Silt	25%	Forams	1- 2%		
Clay	75%				

Smear 34-CC

Sand	1- 3%	Nannos	90%	Micarb	5%
Silt	30%	Forams	1- 2%		
Clay	65%	Sponge Spic.	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 35 Cored Interval: 319.5-329.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Moderate orange pink (5YR8/4). Soupy sediment.

Smear 35-2-100

Sand	1- 5%	Nannos	90%	Micarb	5%
Silt	30%	Forams	2- 3%FP-FM		
Clay	65%	Sponge Spic.	1%		
		Fish Debris	1%		

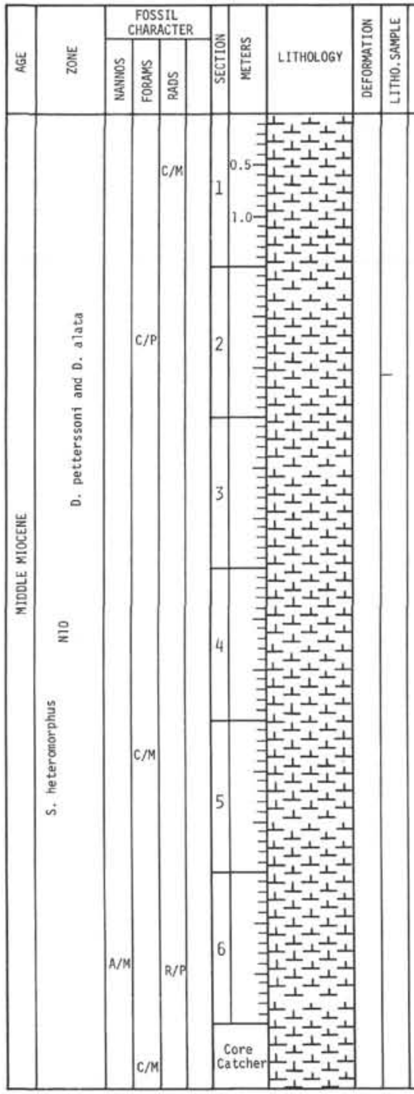
Color change to very pale orange (10YR8/2) at 35-3-30.

Smear 35-CC

Sand	1- 3%	Nannos	90%	Micarb	5%
Silt	30%	Forams	1- 3%FP		
Clay	70%	Sponge Spic.	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 36 Cored Interval: 329.0-338.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE

Very pale orange (10YR8/2) changing to grayish orange (10YR7/4) at 36-1-70, to moderate orange pink (5YR8/4) at 36-1-100, and to grayish orange (10YR7/4) at 36-2-90.

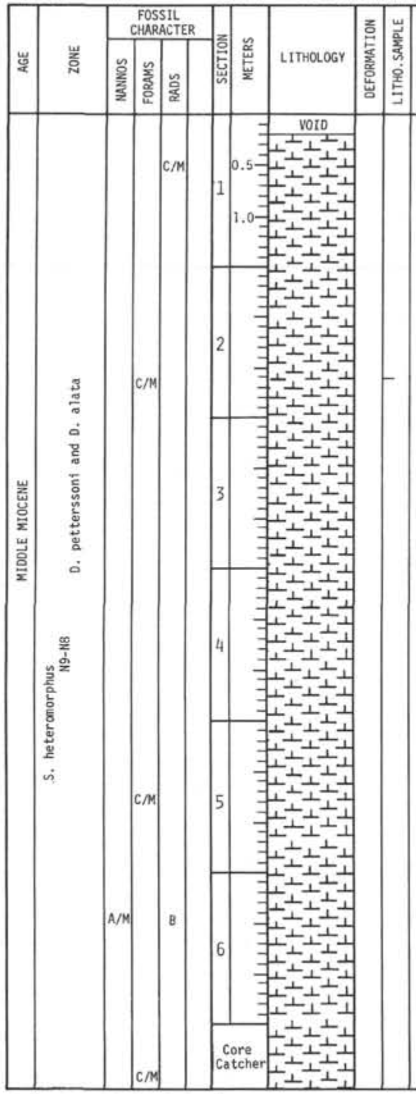
Smear 36-2-100

Sand	5%	Nannos	90%	Micarb	5%
Silt	25%	Forams	5%		
Clay	70%	Sponge Spic.	1%		
		Fish	1%		

Color change to very pale orange (10YR8/2) at 36-5-20.

Explanatory notes in chapter 1

Site 238 Hole Core 37 Cored Interval: 338.5-348.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE

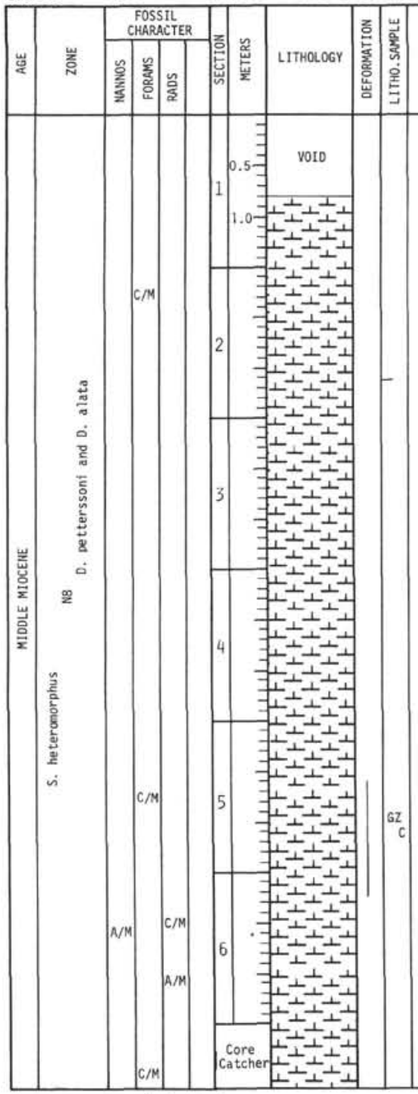
Grayish orange (10YR7/4). Very pale orange (10YR8/2) horizon at 37-2-115 to 37-3-40.

Smear 37-2-100

Sand	1- 3%	Nannos	90%	Micarb	5%
Silt	27%	Forams	1- 3%	Volc. Glass	<1%
Clay	70%	Sponge Spic.	<1%		

Explanatory notes in chapter 1

Site 238 Hole Core 38 Cored Interval: 348.0-357.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish orange (10YR7/4) with a moderate yellowish brown (10YR5/4) horizon at 38-1-117 to 140.

Smear 38-2-100

Sand	1- 2%	Nannos	90%	Micarb	5%
Silt	25%	Forams	1- 2%	Fe-oxide	<1%
Clay	73%	Sponge Spic.	1%		

Distorted streaks of very pale orange (10YR8/2).

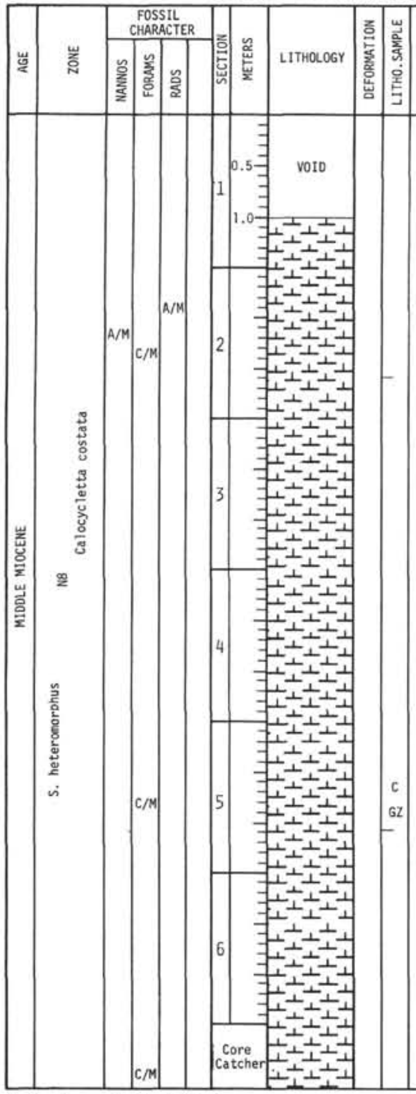
Grain Size

Sand	8%
Silt	53%
Clay	39%

$CaCO_3$ 94%

Explanatory notes in chapter 1

Site 238 Hole Core 39 Cored Interval: 357.5-367.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish orange (10YR7/4).

Smear 39-2-100

Sand	1%	Nannos	95%	Volc. Glass	<1%
Silt	25%	Rads	<1%FP	Fe-oxide	<1%
Clay	75%	Sponge Spic.	<1%		

Gradational color change to pale yellowish brown (10YR6/2).

Smear 39-5-100

Sand	10-15%	Nannos	75%	Micarb	10%
Silt	25-35%	Forams	10%	Fe-oxide	1%
Clay	55%	Sponge Spic.	1%	Volc. Glass	<1%

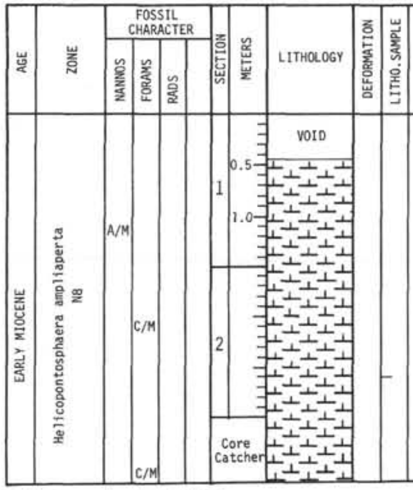
Grain Size

Sand	6%
Silt	57%
Clay	37%

$CaCO_3$ 89%

Explanatory notes in chapter 1

Site 238 Hole Core 40 Cored Interval: 367.0-376.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Pale yellowish brown (10YR6/2)

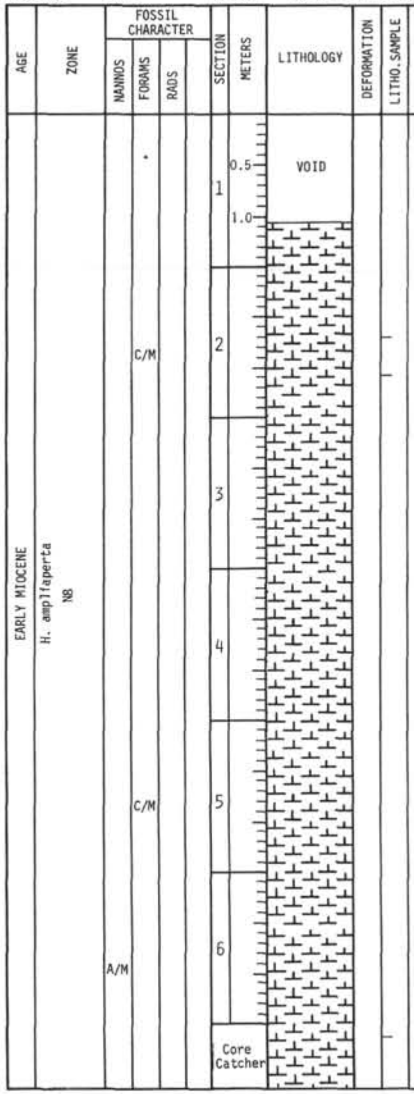
Very pale orange (10YR8/2) layer at 40-2-60.

Smear 40-2-100

Sand	5-10%	Nannos	90%	Micarb	5%
Silt	30%	Forams	5%	Fe-oxide	<1%
Clay	60%				

Explanatory notes in chapter 1

Site 238 Hole Core 41 Cored Interval: 376.5-386.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Light brown (5YR6/4)
Dusky brown (5YR2/2) band at 41-2-68.

Smear 41-2-69

Sand	5-10%	Nannos	50%	Needles of unknown origin (zeolite?)	20%
Silt	30%	Forams	10%FM	Micarb	10%
Clay	60%			Fe-oxide	1- 2%
				Zeolite	1%

Very pale orange (5YR6/4) horizon at 41-2-70.

Smear 41-2-100

Sand	1- 5%	Nannos	95%	Micarb	2%
Silt	25%	Forams	1- 3%		
Clay	70%				

Color changing to grayish orange (10YR7/4) at 41-4-0.

Color changing to light brown (5YR6/4).

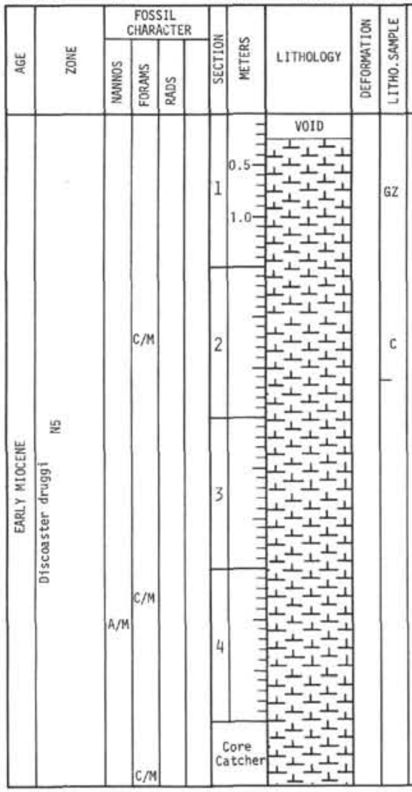
Very pale orange (10YR8/2) layers at 41-6-82, 41-6-90, 41-6-97.

Smear 41-CC

Sand	5%	Nannos	95%	Fe-oxide	<1%
Silt	25%	Forams	1- 2%FP		
Clay	70%	Sponge Spic.	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 42 Cored Interval: 386.0-395.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE

Light brown (5YR6/4). Very pale orange (10YR8/2) at 42-1-35 to 40.

Grain Size
Sand 5%
Silt 60%
Clay 36%

Smear 42-2-100

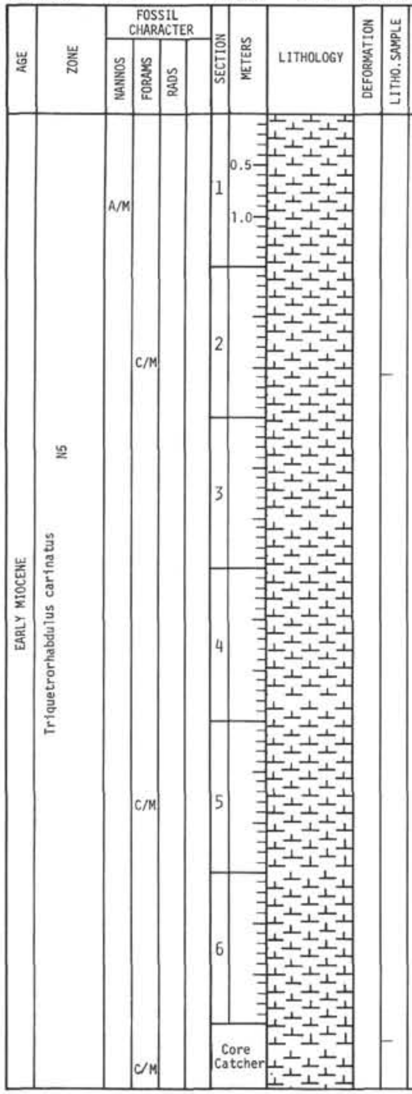
Sand	5%	Nannos	90%	Fe-oxide	1- 2%
Silt	25%	Forams	5%	Zeolite	<1%
Clay	70%				

$CaCO_3$ 90%

Grayish yellow (5Y8/4) at 42-4-7 to 20.

Explanatory notes in chapter 1

Site 238 Hole Core 43 Cored Interval: 395.5-405.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE

Light brown (5YR6/4)

Smear 43-2-100

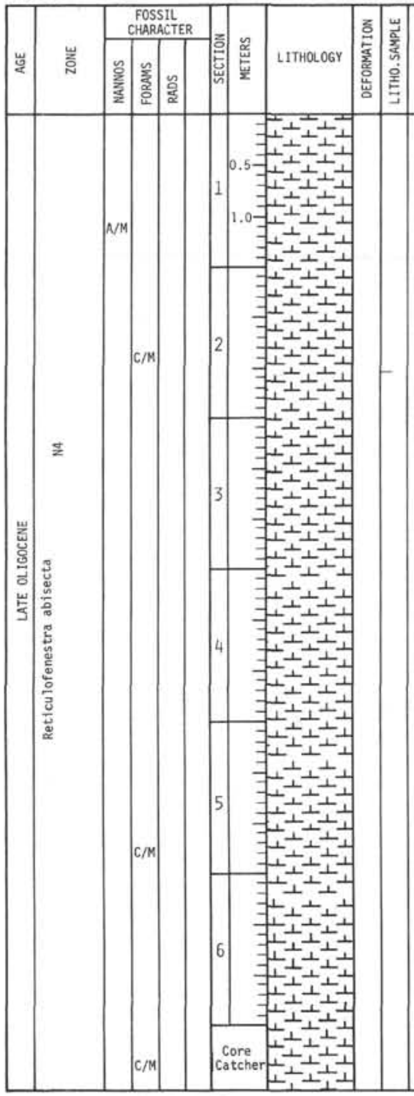
Sand	10-20%	Nannos	85%	Micarb	5%
Silt	20%	Forams	10%	Zeolite	1%
Clay	60%				

Smear 43-CC

Sand	5-10%	Nannos	80%	Micarb	10%
Silt	20%	Forams	5%	Zeolite	1%
Clay	70%	Sponge Spic.	1%		

Explanatory notes in chapter 1

Site 238 Hole Core 44 Cored Interval: 405.0-414.5 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish orange (10YR7/4), very pale orange (10YR8/2) at 44-2-0 to 44-3-40.

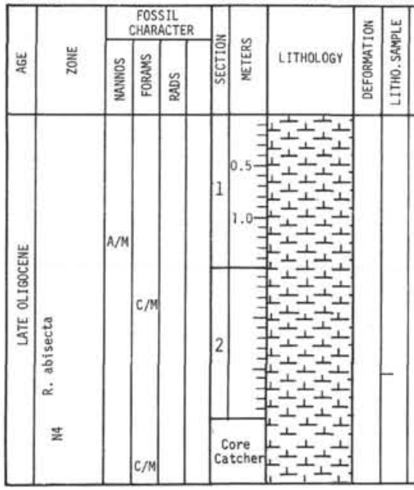
Smear 44-2-100

Sand	10-20%	Nannos	70-80%	Micarb	10%
Silt	30%	Forams	10%	Volc. Glass	1%
Clay	50%			Fe-oxide	1%
				Zeolite	1%

Very pale orange (10YR8/2) horizon at 44-5-125 to 150.

Explanatory notes in chapter 1

Site 238 Hole Core 45 Cored Interval: 414.5-424.0 m



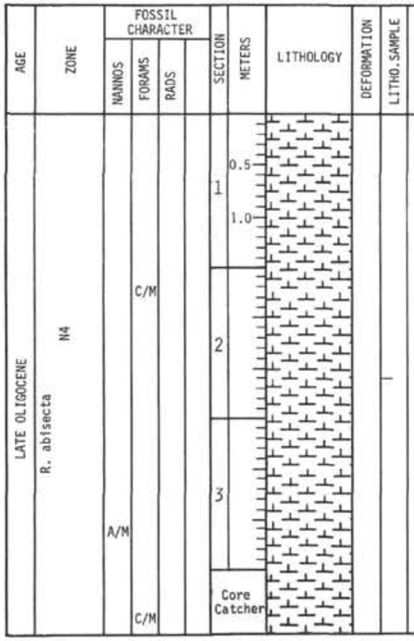
LITHOLOGIC DESCRIPTION

NANNO OOZE
Light brown (5YR6/4).

Smear 45-2-100

Sand	1- 3%	Nannos	90%	Micarb	5%
Silt	27%	Forams	1- 2%		
Clay	70%				

Site 238 Hole Core 46 Cored Interval: 424.0-433.5 m



LITHOLOGIC DESCRIPTION

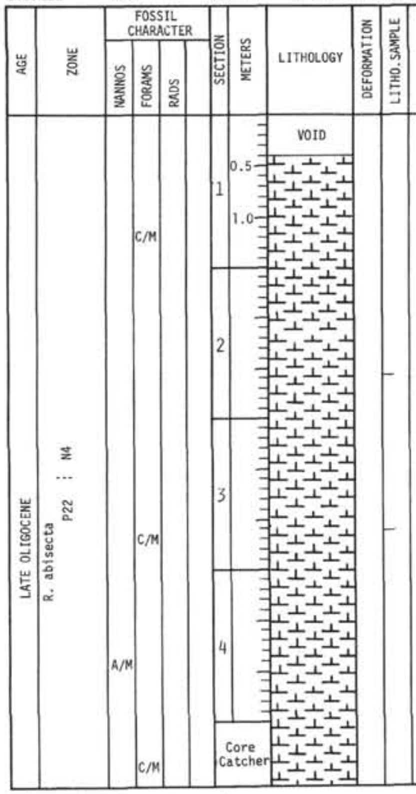
NANNO OOZE
Light brown (5YR6/4).

Smear 46-2-100

Sand	1- 4%	Nannos	90%	Micarb	2- 5%
Silt	26%	Forams	2- 3%	Fe-oxide	1%
Clay	70%				

Explanatory notes in chapter 1

Site 238 Hole Core 47 Cored Interval: 433.5-443.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Light brown (5YR6/4), changing to very pale orange (10YR8/2) at 47-1-100, to grayish orange (10YR7/4) at 47-2-0.

Smear 47-2-100

Sand	1- 2%	Nannos	95%	Micarb	1- 2%
Silt	28%	Forams	1%	Zeolite	1- 2%
Clay	70%				

Very pale orange (10YR8/2) layer at 47-3-40 to 45.

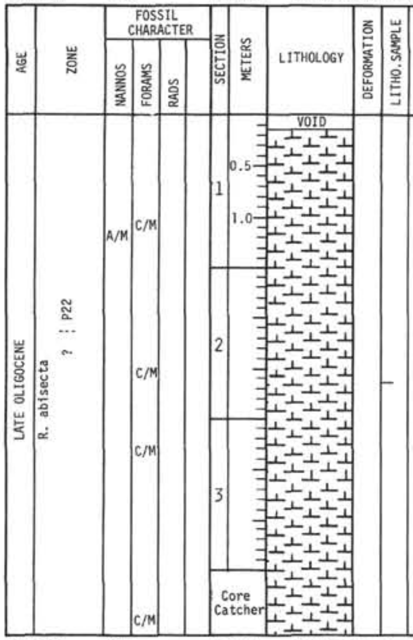
Finely banded darker layer at 47-3-107

Smear 47-3-107

Sand	1- 2%	Nannos	90%	Micarb	5%
Silt	20%	Forams	1- 2%	Zeolite	1%
Clay	75%			Dolo. Rhombs	<1%

Explanatory notes in chapter 1

Site 238 Hole Core 48 Cored Interval: 443.0-452.5 m



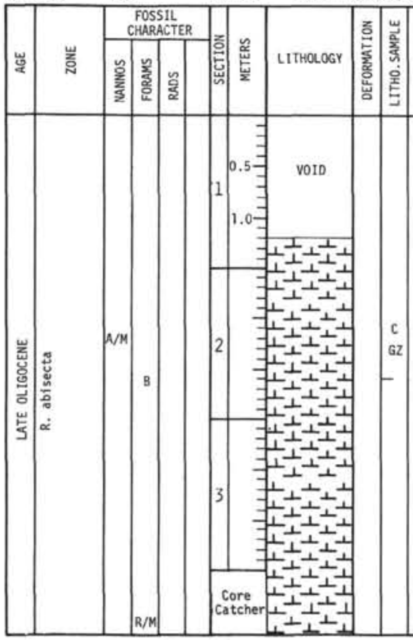
LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish orange (10YR7/4) grading to light brown (5YR6/4) at 48-2-10.

Smear 48-2-100

Sand	5%	Nannos	90%	Micarb	1- 2%
Silt	25%	Forams	2- 3%	Zeolite	1- 2%
Clay	70%			Volc. Glass	1%

Site 238 Hole Core 49 Cored Interval: 452.5-462.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Light brown (5YR6/4).

Smear 49-2-100

Sand	1%	Nannos	95%	Micarb	2%
Silt	24%	Forams	1%	Fe-oxide	1%
Clay	75%				

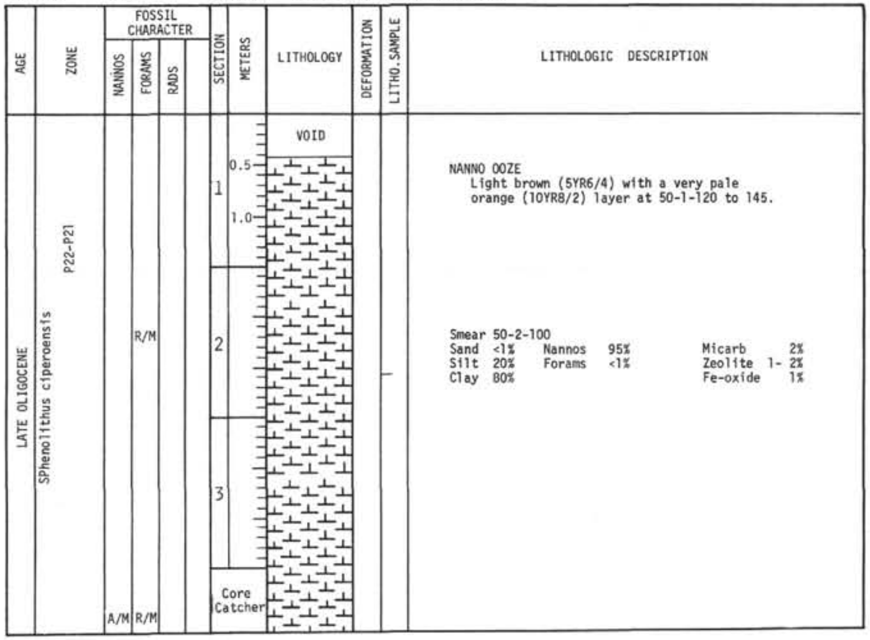
Grain Size

Sand	0%
Silt	55%
Clay	45%

$CaCO_3$ 92%

Explanatory notes in chapter 1

Site 238 Hole Core 50 Cored Interval: 462.0-471.5 m



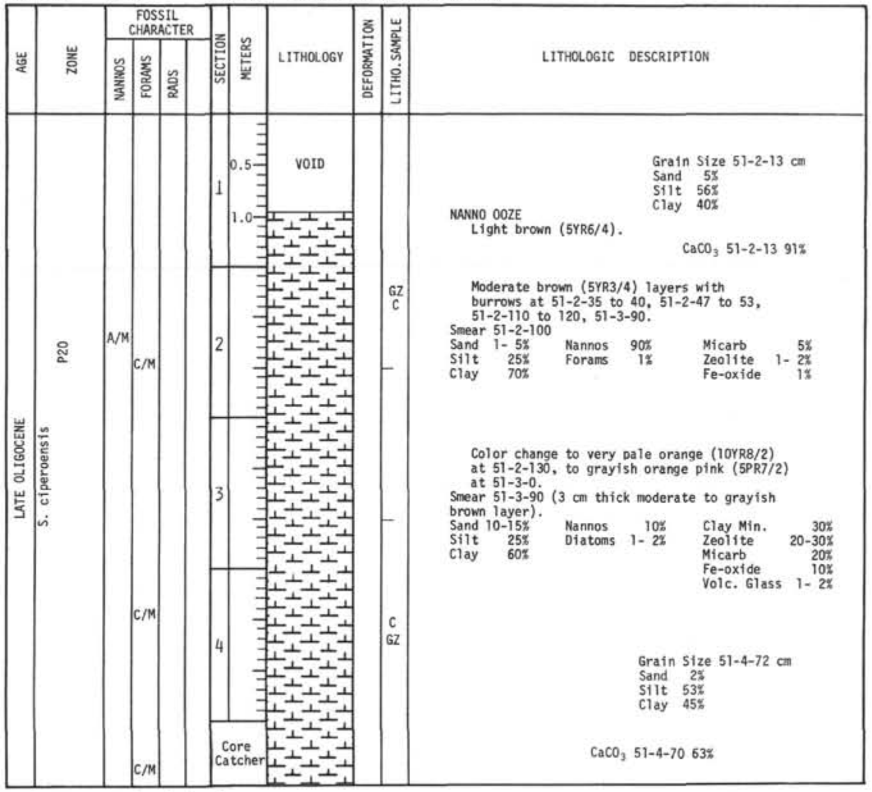
NANNO OOZE
Light brown (5YR6/4) with a very pale orange (10YR8/2) layer at 50-1-120 to 145.

Smear 50-2-100

Sand	<1%	Nannos	95%	Micarb	2%
Silt	20%	Forams	<1%	Zeolite	1- 2%
Clay	80%			Fe-oxide	1%

Explanatory notes in chapter 1

Site 238 Hole Core 51 Cored Interval: 471.5-481.0 m



Grain Size 51-2-13 cm
Sand 5%
Silt 56%
Clay 40%

NANNO OOZE
Light brown (5YR6/4).

$CaCO_3$ 51-2-13 91%

Moderate brown (5YR3/4) layers with burrows at 51-2-35 to 40, 51-2-47 to 53, 51-2-110 to 120, 51-3-90.

Smear 51-2-100

Sand	1- 5%	Nannos	90%	Micarb	5%
Silt	25%	Forams	1%	Zeolite	1- 2%
Clay	70%			Fe-oxide	1%

Color change to very pale orange (10YR8/2) at 51-2-130, to grayish orange pink (5PR7/2) at 51-3-0.

Smear 51-3-90 (3 cm thick moderate to grayish brown layer).

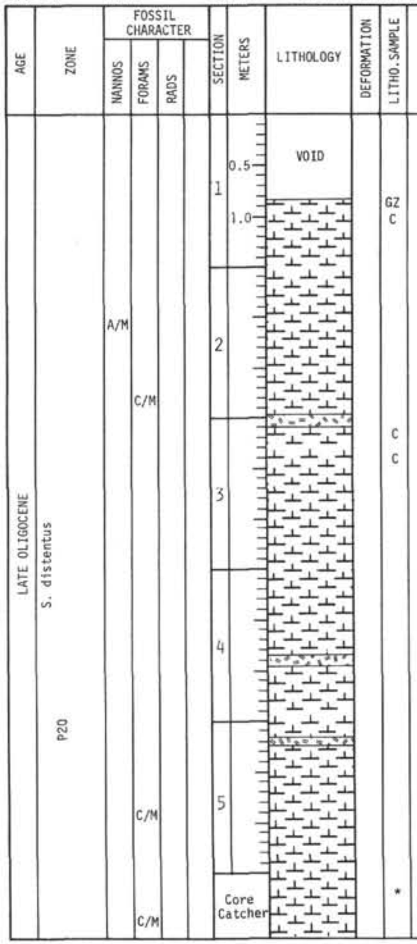
Sand	10-15%	Nannos	10%	Clay Min.	30%
Silt	25%	Diatoms	1- 2%	Zeolite	20-30%
Clay	60%			Micarb	20%
				Fe-oxide	10%
				Volc. Glass	1- 2%

Grain Size 51-4-72 cm
Sand 2%
Silt 53%
Clay 45%

$CaCO_3$ 51-4-70 63%

Explanatory notes in chapter 1

Site 238 Hole Core 52 Cored Interval: 481.0-490.5 m



LITHOLOGIC DESCRIPTION

$CaCO_3$ 89%

Grain Size
Sand 5%
Silt 63%
Clay 33%

NANNO OOZE
Very pale orange (10YR8/2) to pinkish gray (5YR8/1) hues

and

VOLCANIC ASHES
Dark yellowish brown (10YR4/2).

$CaCO_3$ 52-3-2 cm 1%

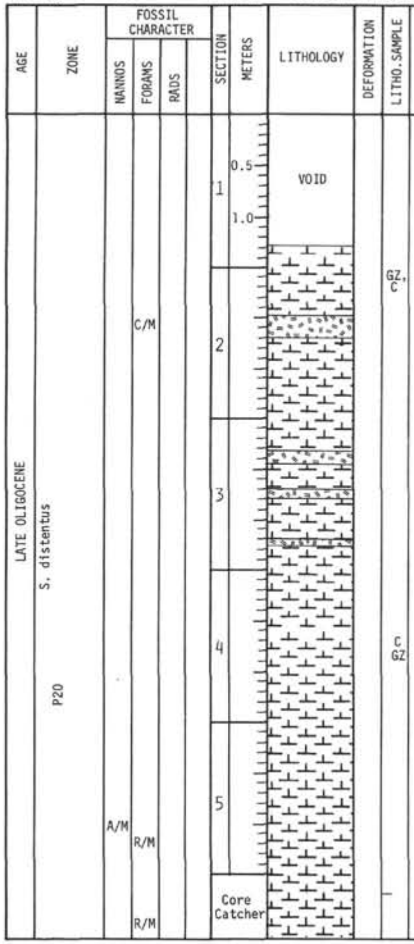
$CaCO_3$ 52-3-13 cm 73%

Smear 52-cc

Sand	1- 2%	Nannos	90%	Micarb	5%
Silt	25%	Forams	1- 2%	Fe-oxide	1%
Clay	72%			Zeolite	1%

Explanatory notes in chapter 1

Site 238 Hole Core 53 Cored Interval: 490.5-500.0 m



LITHOLOGIC DESCRIPTION

Grain Size 53-2-6 cm
Sand 1%
Silt 62%
Clay 37%

NANNO OOZE
Grayish orange (10YR7/4) $CaCO_3$ 69%

and

VOLCANIC ASH horizons in various shades of brown and gray and thin bands of iron oxides.

$CaCO_3$ 81%

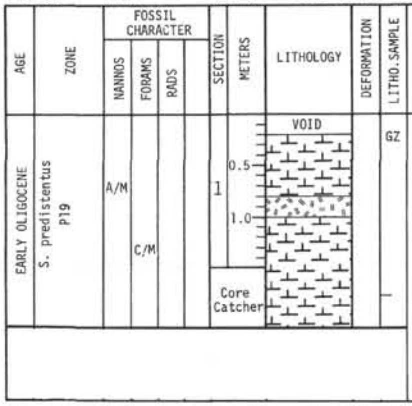
Grain Size 53-4-97 cm
Sand 1%
Silt 64%
Clay 35%

Smear 53-CC

Sand	1- 3%	Nannos	90-95%	Micarb	1- 3%
Silt	27%	Forams	1- 2%	Fe-oxide	1%
Clay	70%			Volc. Glass	<1%

Explanatory notes in chapter 1

Site 238 Hole Core 54 Cored Interval: 500.0-506.0 m



LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish orange (10YR7/4) changing to pale yellowish brown (10YR6/2) at 54-1-70 and very pale orange (10YR8/2) at the base

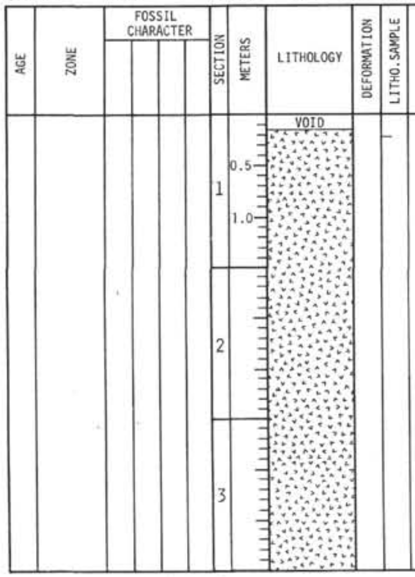
and
VOLCANIC ASH very pale orange (10YR8/2) to light olive brown (5Y5/6) at 54-1-80-100.

Grain Size 54-1-23 cm
Sand 1%
Silt 66%
Clay 33%

Smear 54-CC

Sand	5%	Nannos	50%	Micarb	30-40%
Silt	25%	Forams	1%	Zeolite	5%
Clay	70%			Fe-oxide	1- 2%
				Volc. Glass	1%

Site 238 Hole Core 55 Cored Interval: 506.0-515.5 m



LITHOLOGIC DESCRIPTION

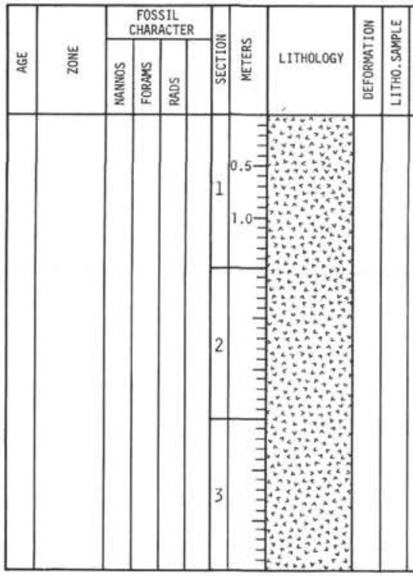
BASALT
Dark gray (N3) to greenish yellow with layers of glass and recrystallized NANNO CHALK.

Smear 55-1-15 (top basalt)

Sand	20%	Nannos	60%	Clay Min.	10%
Silt	20%	Forams	15%	Fe-oxide	10%
Clay	60%	Rads	1%	Palagonite	1%

Explanatory notes in chapter 1

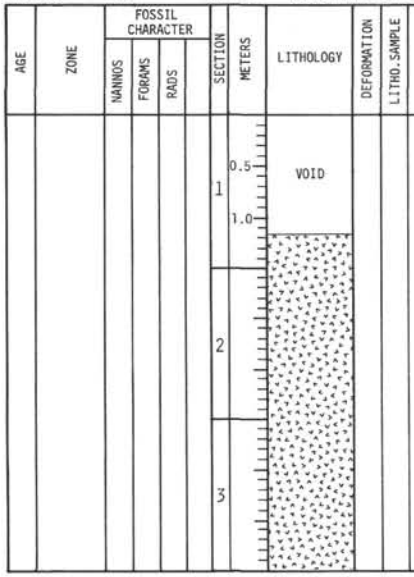
Site 238 Hole Core 56 Cored Interval: 515.5-525.0 m



LITHOLOGIC DESCRIPTION

BASALT
Dark gray (N3), massive with glassy layers and calcite filled fractures.

Site 238 Hole Core 57 Cored Interval: 525.0-531.5 m

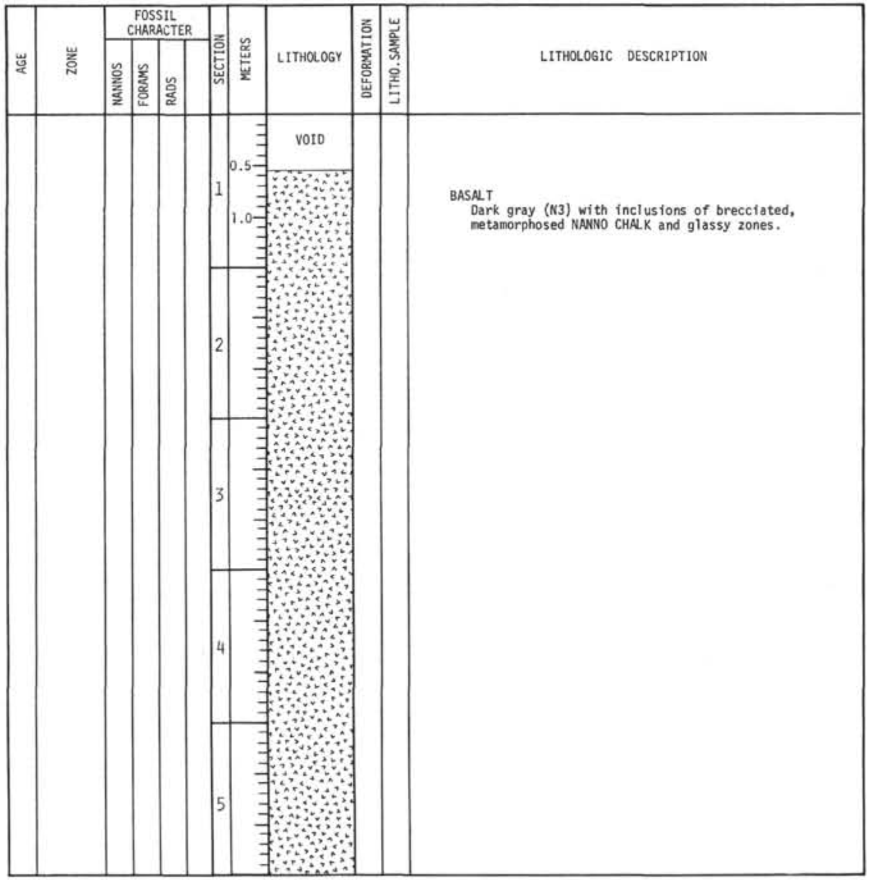


LITHOLOGIC DESCRIPTION

BASALT
Dark gray (N3), massive, with glassy layers adjacent to zones of metamorphosed NANNO CHALK.

Explanatory notes in chapter 1

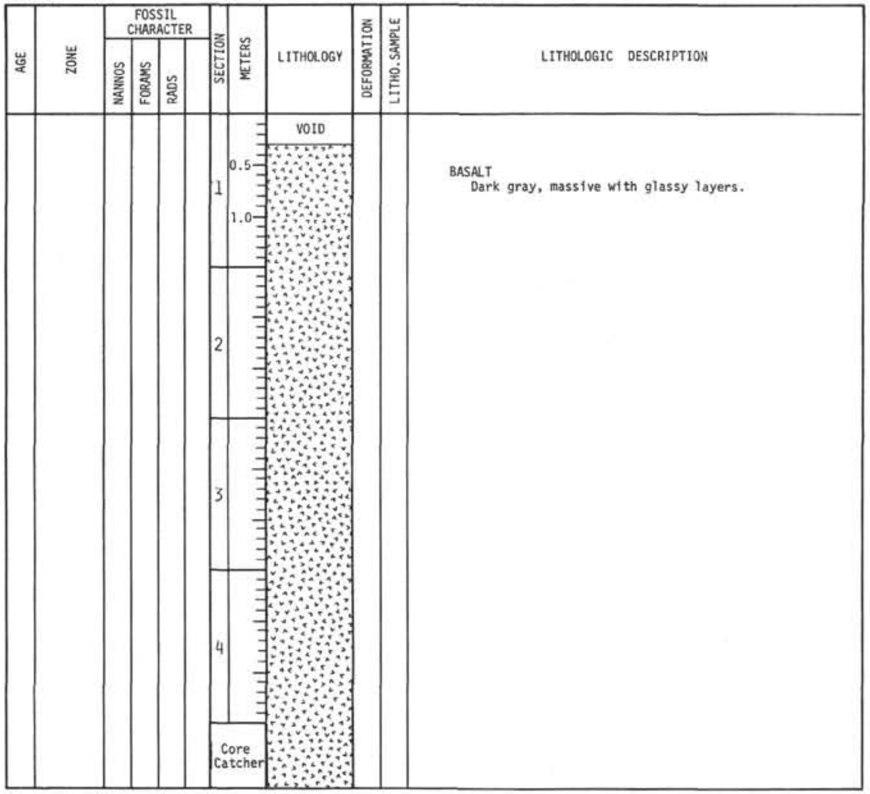
Site 238 Hole Core 58 Cored Interval: 531.5-539.0 m



BASALT
Dark gray (N3) with inclusions of brecciated, metamorphosed NANNO CHALK and glassy zones.

Explanatory notes in chapter 1

Site 238 Hole Core 59 Cored Interval: 539.0-547.5 m

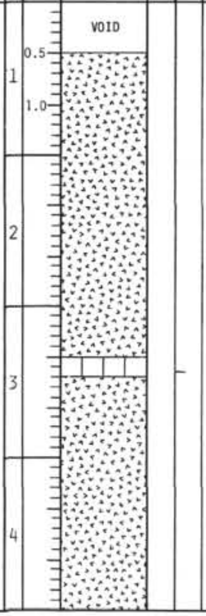


BASALT
Dark gray, massive with glassy layers.

Explanatory notes in chapter 1

Site 238 Hole Core 60 Cored Interval:547.6-556.5 m

AGE	ZONE	FOSSIL CHARACTER NANNOS	FOSSIL CHARACTER FORAMS	FOSSIL CHARACTER RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION



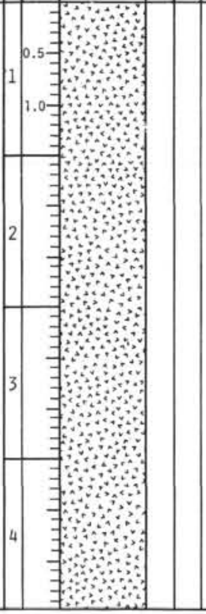
BASALT
Dark gray, massive with some glassy layers.
Some veins filled with calcite.

Smear 60-3-65
Partially recrystallized calcite.

Explanatory notes in chapter 1

Site 238 Hole Core 61 Cored Interval:556.5-566.0 m

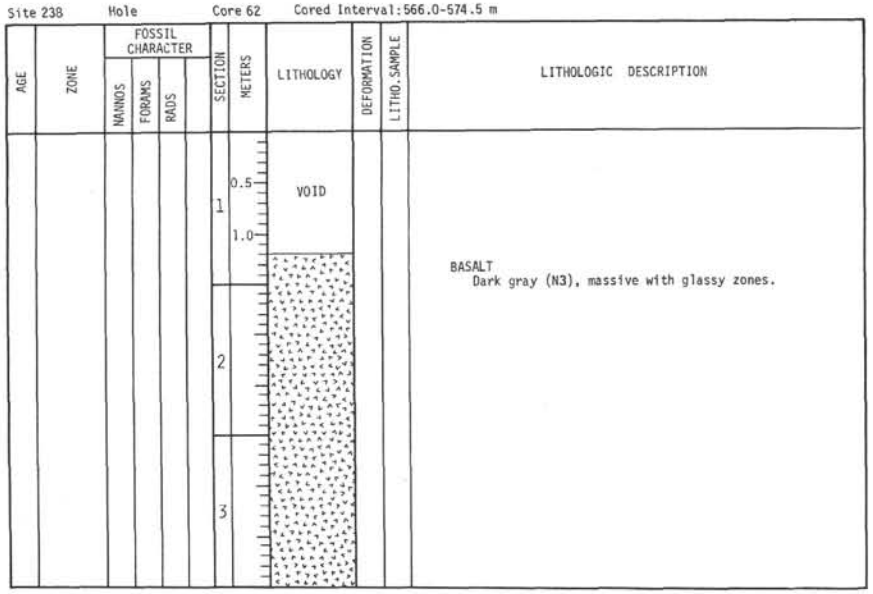
AGE	ZONE	FOSSIL CHARACTER NANNOS	FOSSIL CHARACTER FORAMS	FOSSIL CHARACTER RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION



BASALT
Dark gray (N3), massive with glassy layers.

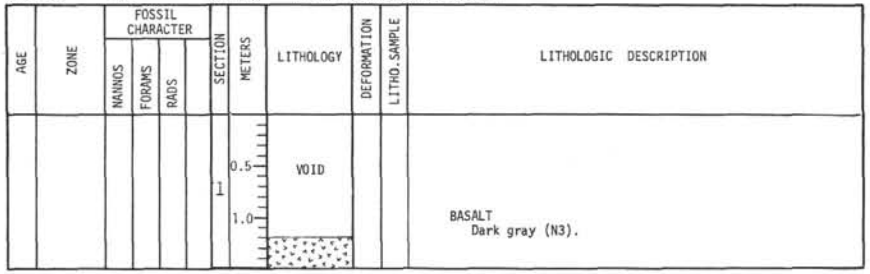
Explanatory notes in chapter 1

Site 238 Hole Core 62 Cored Interval: 566.0-574.5 m



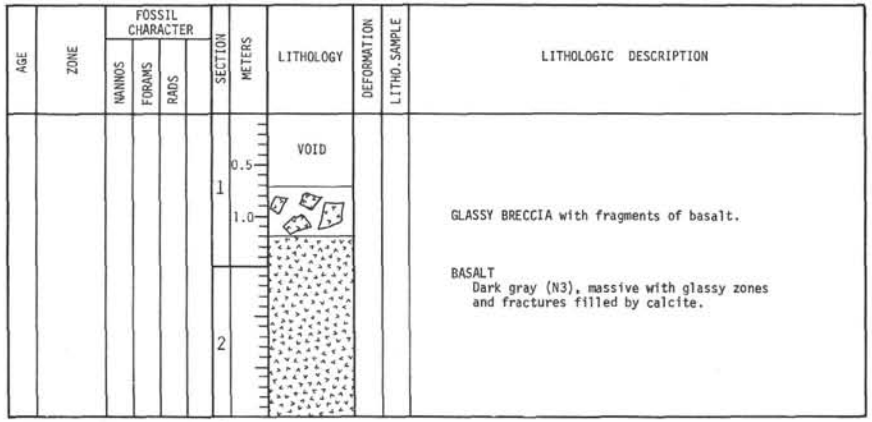
BASALT
Dark gray (N3), massive with glassy zones.

Site 238 Hole Core 63 Cored Interval: 574.5-580.5 m



BASALT
Dark gray (N3).

Site 238 Hole Core 64 Cored Interval: 580.5-586.5 m



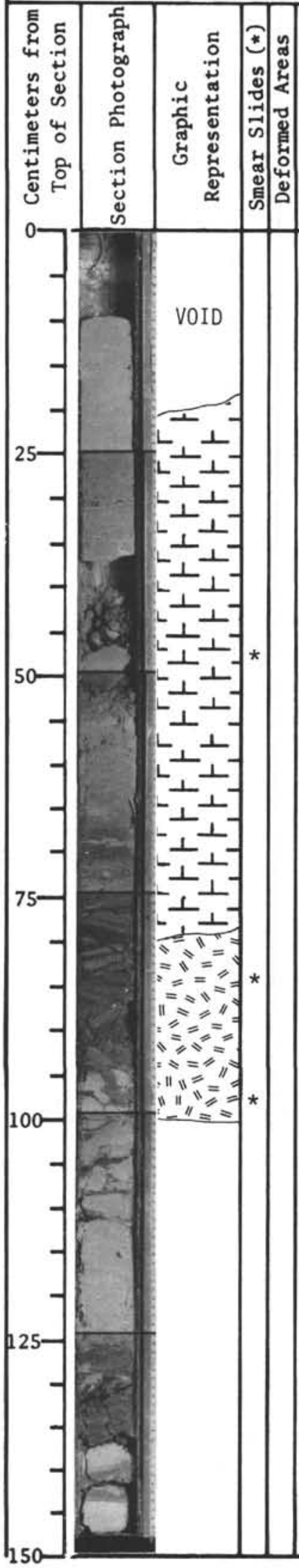
GLASSY BRECCIA with fragments of basalt.

BASALT
Dark gray (N3), massive with glassy zones and fractures filled by calcite.

Explanatory notes in chapter 1

DETAILED CORE DESCRIPTIONS

Site 238 Core 54 Section 1



Description

NANNO OOZE
Grayish orange (10YR 7/4) with streaks of moderate yellowish brown. Finely banded zone at 54-1-40 to 50 with very pale orange (10YR 8/2), pale yellowish brown (10YR 6/2), dark yellowish brown (10YR 6/2), grayish orange (10YR 7/4) and dusky yellowish brown (10YR 2/2) horizons. Similar fine banded zones at 54-1-65 to 80 and 54-1-130 to 150.

Smear 54-1-48

Sand	10%
Silt	20%
Clay	70%
Nannos	85%
Forams	5%
Clay Min.	5%
Fe-oxide	3%
Heavy Min.	2%
Quartz	1%

VOLCANIC ASH
Light olive brown (5Y 5/6) with lumps of light olive gray (5Y 5/2).

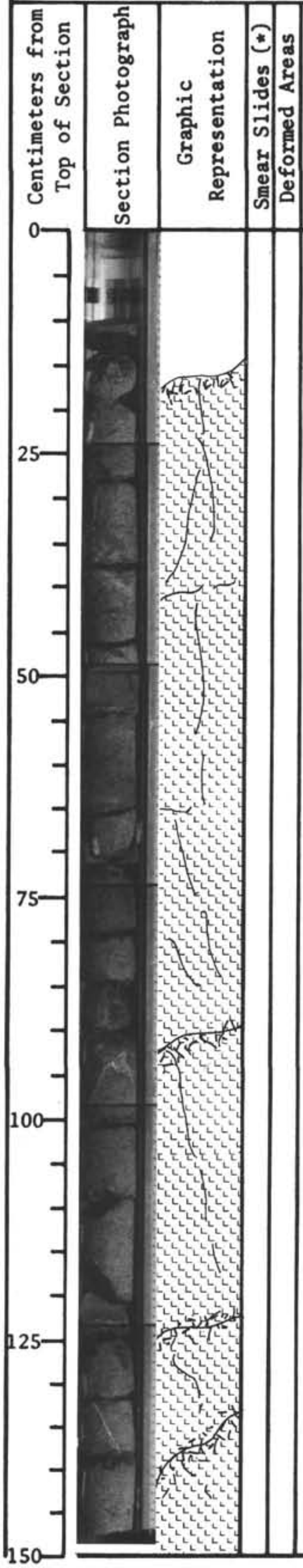
Smear 54-1-84

Sand	50%
Silt	40%
Clay	10%
Forams	10%
Zeolite	50%
Fe-oxide	10%
Clay Min.	10%
Plagioclase	5%
Quartz	3%
Feldspar	3%
Heavy Min.	1%

Smear 54-1-98

Sand	30%
Silt	30%
Clay	40%
Nannos	5%
Forams	2%
Volc. Glass	40%
Clay Min.	30%
Fe-oxide	8-10%
Feldspar	3%
Palagonite	3%
Quartz	2%

Site 238 Core 55 Section 1



Description

G

Dark-gray to greenish-yellow rather fresh micro-doleritic basalt, with rare small phenocrysts of plagioclase. Augite abundant in groundmass. Round vesicles and thin (1-3 mm) fractures filled with carbonate. (The greenish-yellow areas may be oxidized or otherwise weathered.)

G

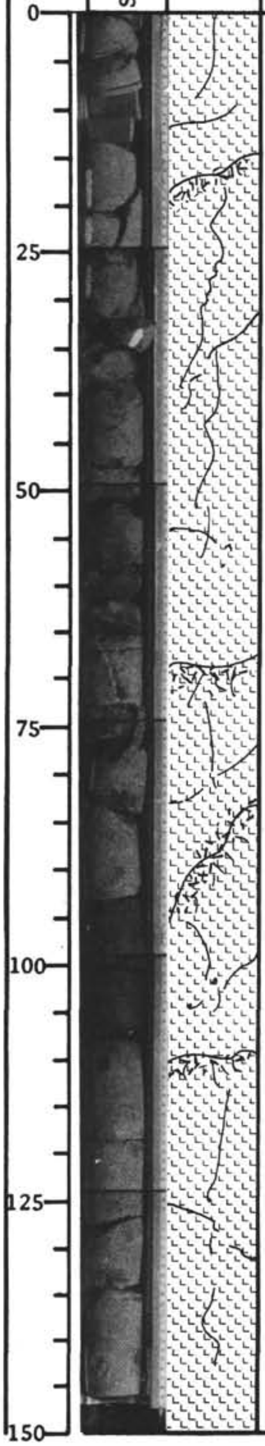
G Habit massive, with four thin near-horizontal glassy zones (marked "G").

The glass is paglagonitized, and associated with veins and filled vesicles of calcite, and inclusions (or filled cracks) of slightly altered carbonate microfossils.

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 55 **Section** 2

Centimeters from Top of Section	Section Photograph	Graphic Representation	Smear Slides (*)	Deformed Areas	Description



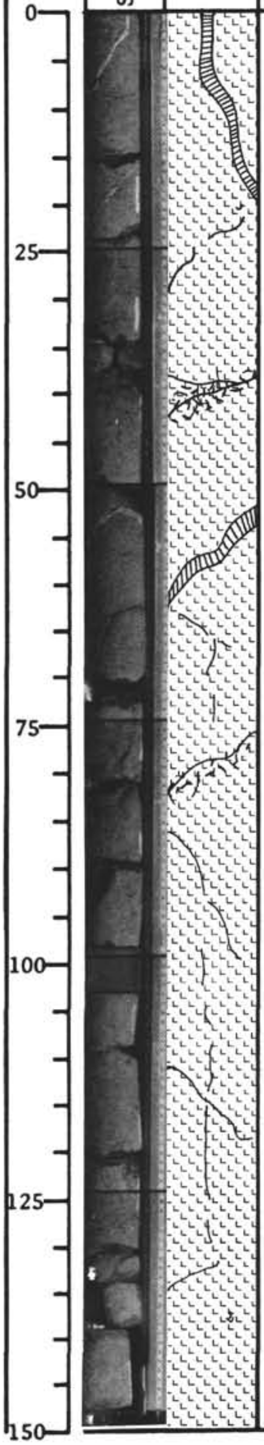
G

G Greenish-gray (somewhat weathered?) massive micro-doleritic basalt, with four thin glassy layers ("G"). Basalts moderately fractured, with 1-2 mm cracks nearly vertical and incrusted with calcite. Round vesicles abundant,
G and filled.

G

Site 238 **Core** 55 **Section** 3

Centimeters from Top of Section	Section Photograph	Graphic Representation	Smear Slides (*)	Deformed Areas	Description



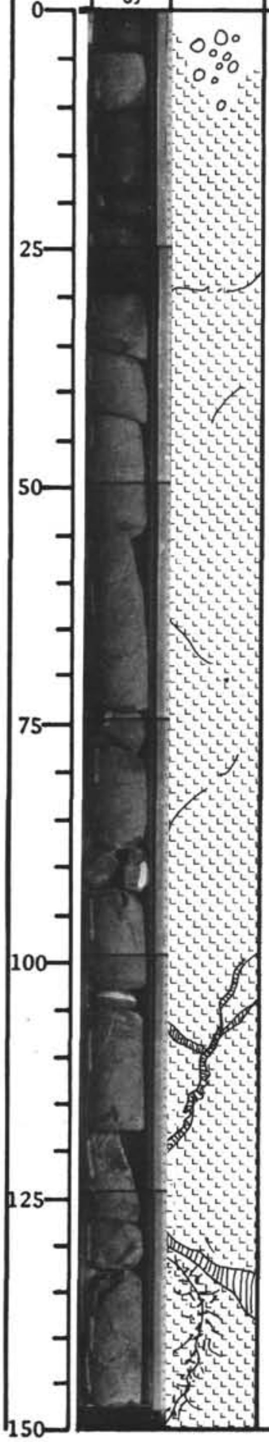
Greenish-gray to dark-gray massive, highly vesicular, little-fractured micro-doleritic basalt. Augite common, rather fresh. Two veins of carbonate, 3-6 mm wide, in upper part of section probably are metamorphosed calcareous sediments. Large round vesicles,
G some filled with calcite; most show rims only or are empty. Two glassy horizons ("G").

G

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 56
Section 1

Centimeters from Top of Section	Section Photograph	Graphic Representation	Smear Slides (*)	Deformed Areas	Description



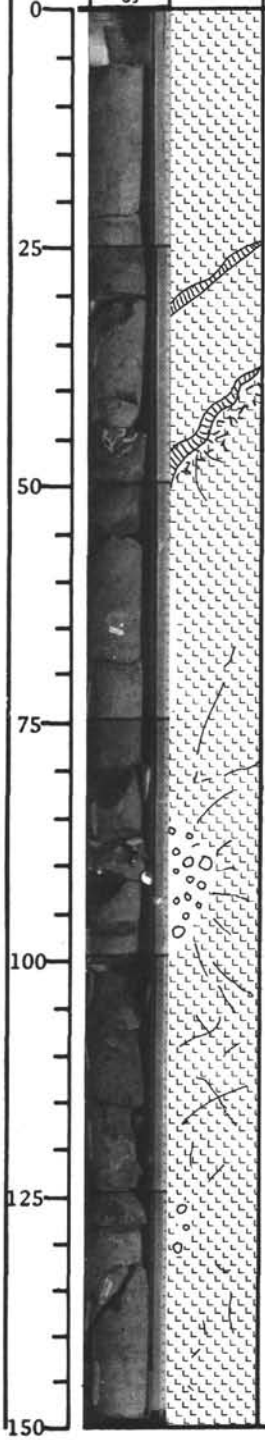
Porous, highly-vesicular zone, with vesicles up to 5 mm in diameter. (Probably central portion of a lava flow.)

Dark-gray, massive, rather fresh microdoleritic basalt; augite abundant. Phenocrysts rare. Large round vesicles, empty or partially to wholly filled by carbonate-chlorite.

G Glassy zone; fractures filled with calcite aggregates.

Site 238 **Core** 56
Section 2

Centimeters from Top of Section	Section Photograph	Graphic Representation	Smear Slides (*)	Deformed Areas	Description

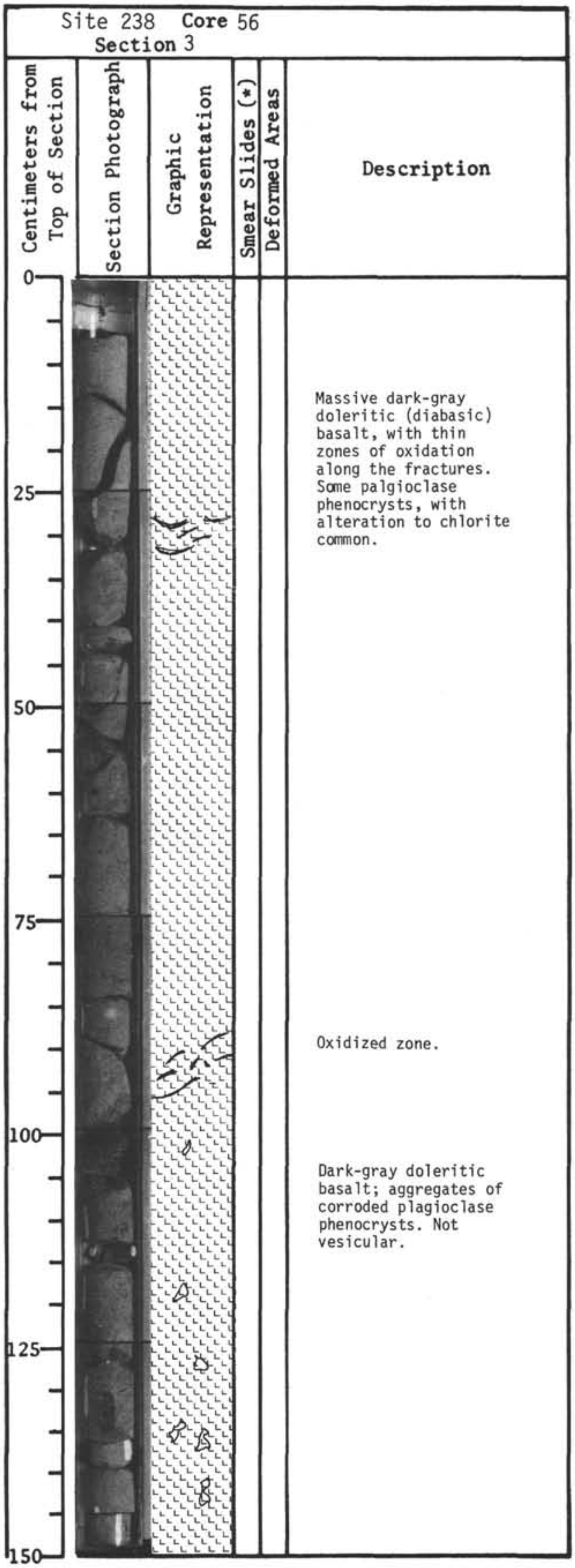


Dark-gray massive basalt.

G Palagonitized and devitrifying-basaltic glass; round vesicles and small irregular vugs and cavities filled or lined with calcite. Fresh phenocrysts of plagioclase, rarely augite.

Massive very fine-grained basalt, altered; occasional aggregates of plagioclase-augite phenocrysts. Some extremely vesicular horizons, with small round vesicles filled with zeolites; iron compounds give brown hue to groundmass and vesicles.

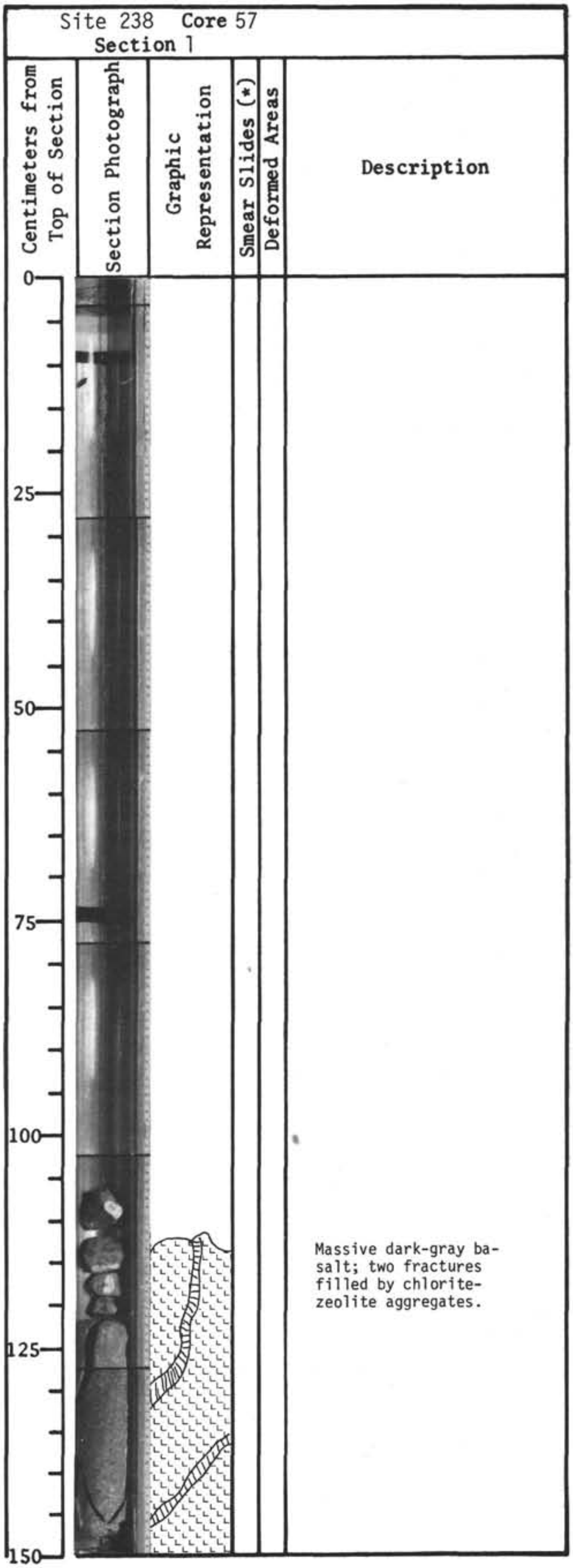
DETAILED CORE DESCRIPTIONS



Massive dark-gray doleritic (diabasic) basalt, with thin zones of oxidation along the fractures. Some palgioclase phenocrysts, with alteration to chlorite common.

Oxidized zone.

Dark-gray doleritic basalt; aggregates of corroded plagioclase phenocrysts. Not vesicular.

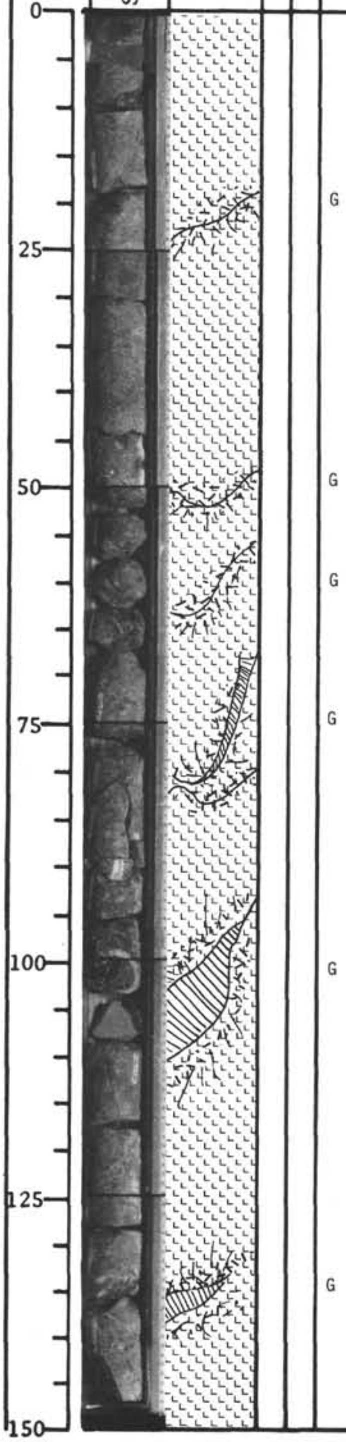


Massive dark-gray basalt; two fractures filled by chlorite-zeolite aggregates.

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 57
Section 2

Centimeters from Top of Section | Section Photograph | Graphic Representation | Smear Slides (*) | Deformed Areas | **Description**

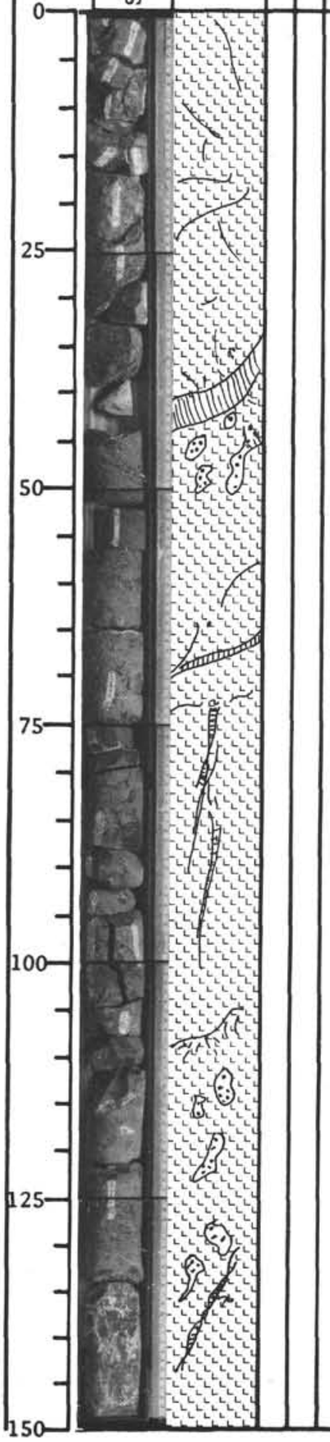


Dark-gray massive basalt, nonvesicular. Intersertal texture, with rare small phenocrysts of plagioclase and of fresh olivine.

Several glassy layers ("G") associated with veins or inclusions of metamorphosed sediments.

Site 238 **Core** 57
Section 3

Centimeters from Top of Section | Section Photograph | Graphic Representation | Smear Slides (*) | Deformed Areas | **Description**



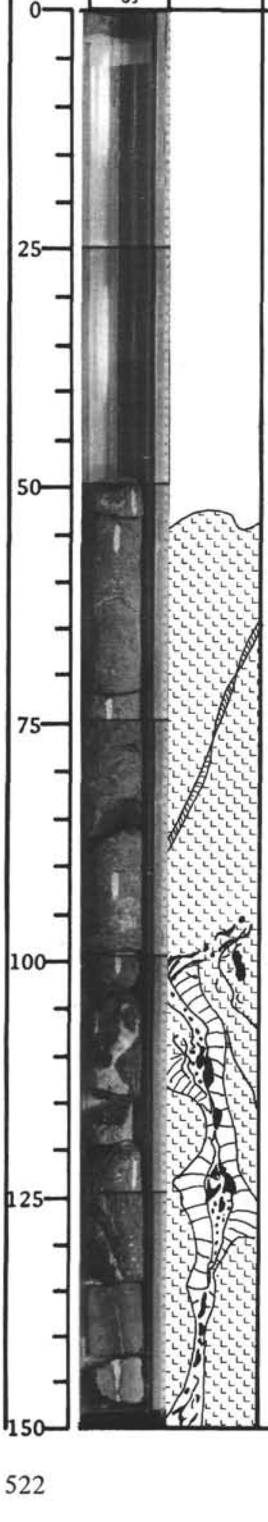
Dominantly dark-gray massive basalt. Two glassy layers overlying horizons of cavities filled with calcite-chlorite and associated with lenses or inclusions of partially-recrystallized microfossil assemblages and carbonate sediment.

Basalt is micro-doleritic with altered grains, plagioclase partially chloritized, with augite and dusty opaques. Not vesicular.

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 58
Section 1

Centimeters from Top of Section | **Section Photograph** | **Graphic Representation** | **Smear Slides (*)** | **Deformed Areas** | **Description**

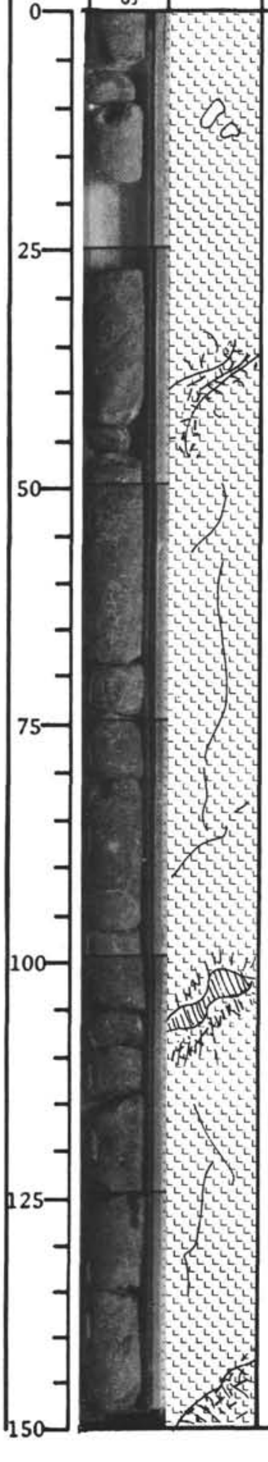


Dark-gray massive basalt.

Zone of brecciated glass and inclusions of metamorphosed sediments oriented almost vertically (filled crack?).

Site 238 **Core** 58
Section 2

Centimeters from Top of Section | **Section Photograph** | **Graphic Representation** | **Smear Slides (*)** | **Deformed Areas** | **Description**



G Massive dark-gray, rather altered dolerite. Augite in groundmass, with irregular phenocrysts of plagioclase and rare altered olivine phenocrysts. Very slightly vesicular. Three glassy horizons ("G").

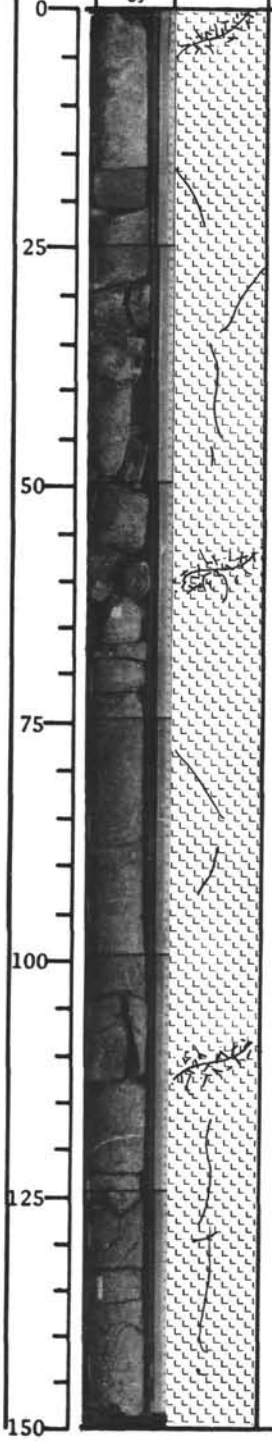
G

G

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 58
Section 3

Centimeters from Top of Section | Section Photograph | Graphic Representation | Smear Slides (*) | Deformed Areas | **Description**



G

Dark-gray, massive, micro-dolerite: plagioclase and partially altered augite, with zones of glass and glassy rims on cavities, locally iron-stained. Not markedly porphyritic.

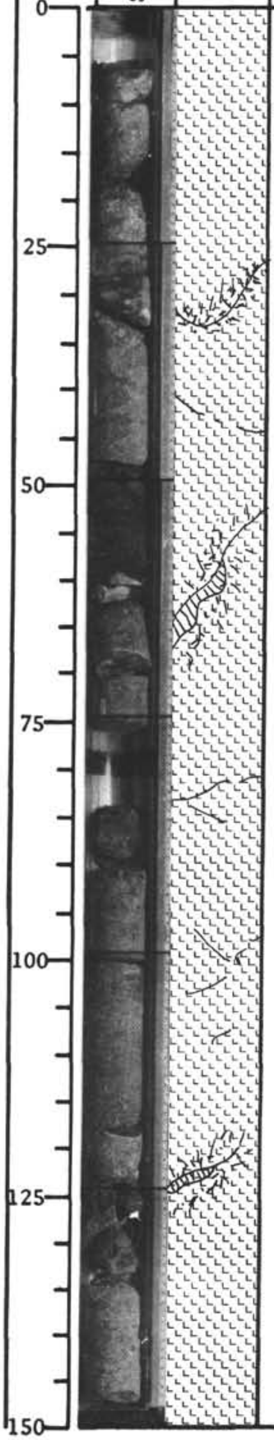
G

Three glassy horizons ("G").

G

Site 238 **Core** 58
Section 4

Centimeters from Top of Section | Section Photograph | Graphic Representation | Smear Slides (*) | Deformed Areas | **Description**



Dark-gray massive basalt, with three glassy zones ("G") and narrow fractures filled with calcite.

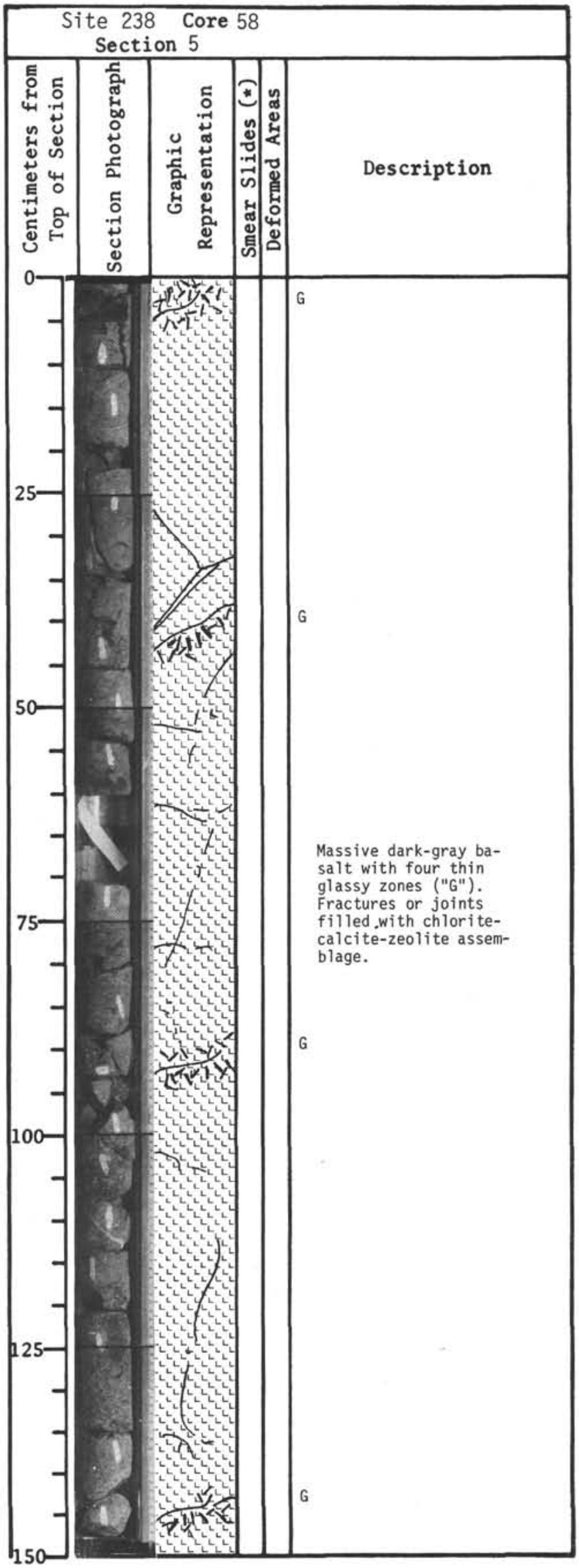
G

G Inclusions of metamorphosed carbonate sediments and partially-recrystallized microfossils between glassy selvages.

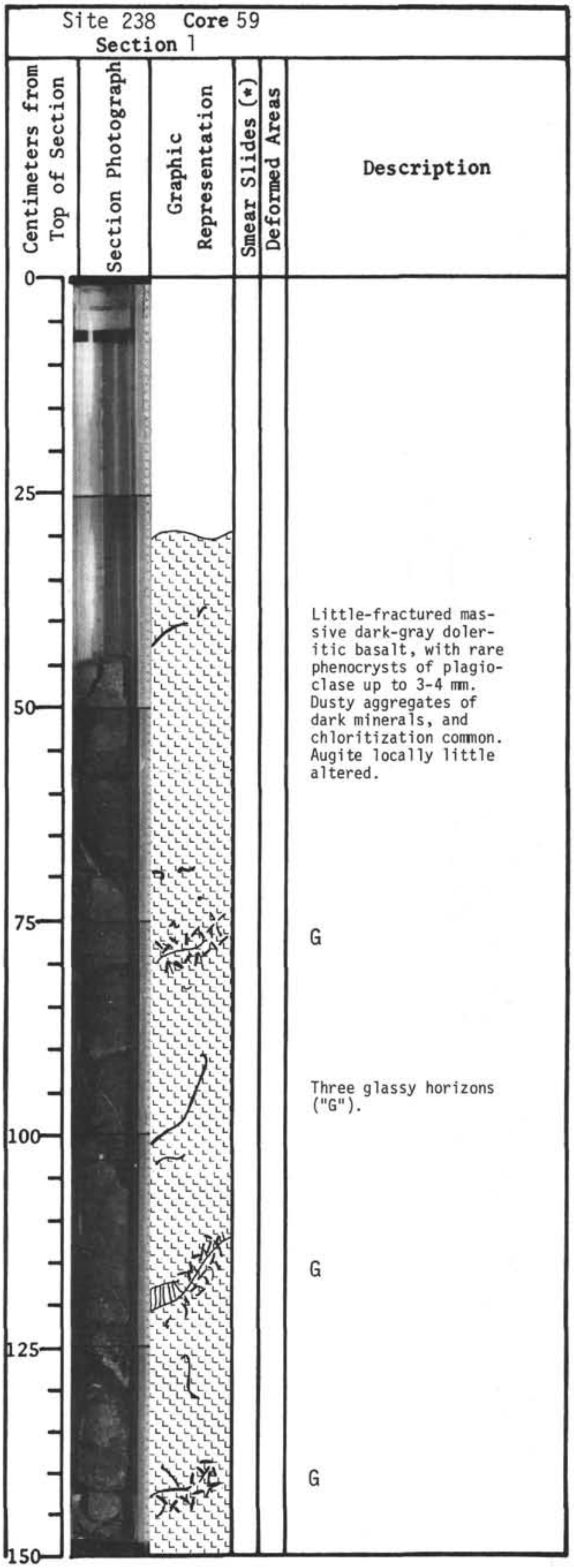
Massive, slightly porphyritic (plagioclase) dark-gray micro-dolerite (micro-diabase). Moderately fresh augite and very minor orthopyroxene in groundmass.

G

DETAILED CORE DESCRIPTIONS



Massive dark-gray basalt with four thin glassy zones ("G"). Fractures or joints filled with chlorite-calcite-zeolite assemblage.

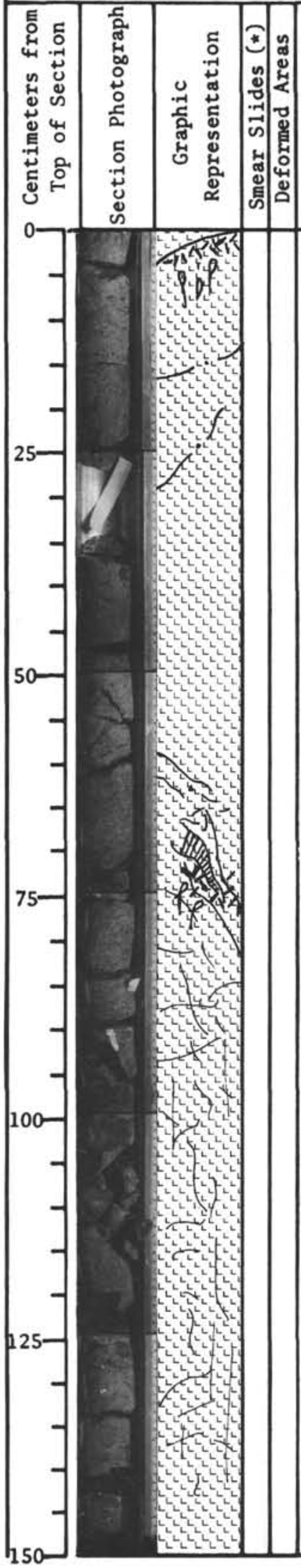


Little-fractured massive dark-gray doleritic basalt, with rare phenocrysts of plagioclase up to 3-4 mm. Dusty aggregates of dark minerals, and chloritization common. Augite locally little altered.

Three glassy horizons ("G").

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 59
Section 2



Description

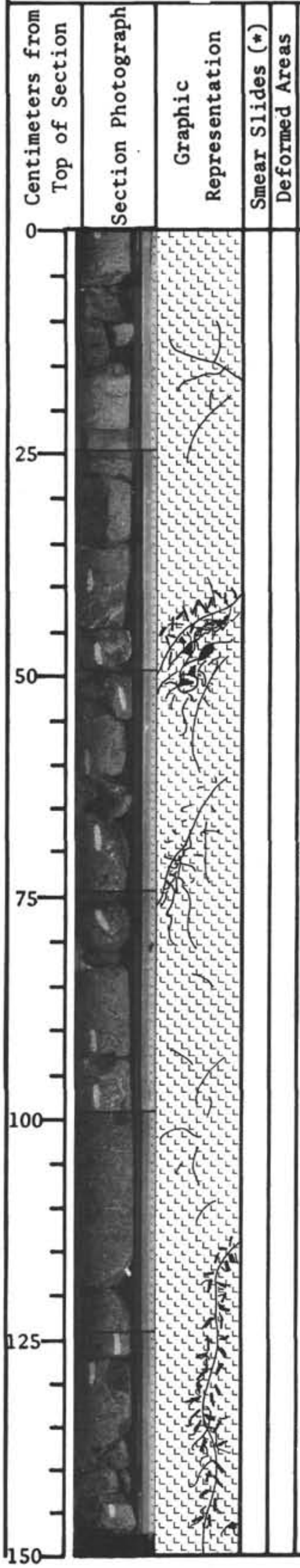
G Glass.

Massive dark-gray doleritic basalt. Intersertal texture. Some olivine. Dusty aggregates of opaques. Coarse plagioclase aggregates rather than individual phenocrysts.

G Glassy selvages bordering fine-grained metamorphosed carbonate sediment with few recognizable microfossils. Iron-stained.

Fractured basalt.

Site 238 **Core** 59
Section 3



Description

Dark-gray dolerite (diabase) showing flow structure in plagioclase needle alignment. Fibrous to acicular augite common in groundmass. Small phenocrysts of plagioclase and fresh olivine. Not vesicular.

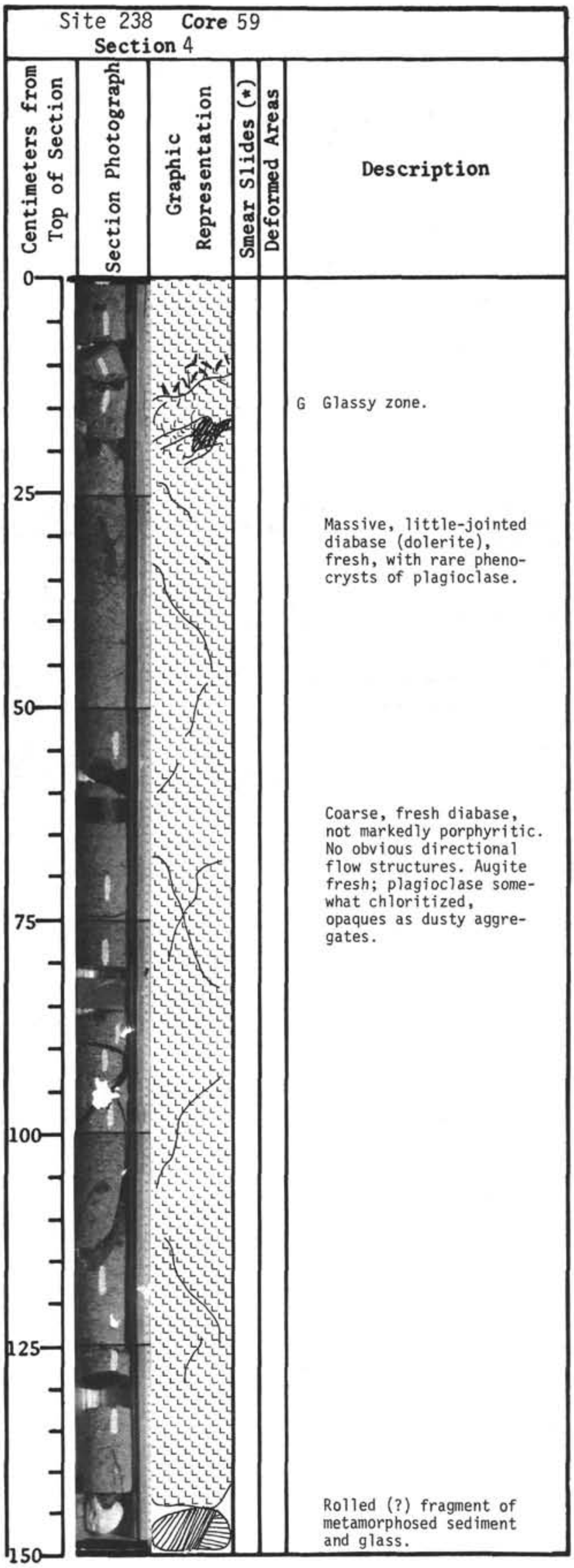
GB Three horizons of brecciated glass, with dip increasing with depth in section ("GB").

Upper portion of breccia horizon is very fresh to palagonitized basaltic glass with rare small plagioclase and olivine phenocrysts, and cracks filled with calcite. The mid-portio- is stained glass and small

GB plagioclase needles, with calcite filling cavities and cracks in large grains of plagioclase. The lower part of the zone is similar to the middle, with needles showing flow and less calcite present. Rather altered.

GB

DETAILED CORE DESCRIPTIONS

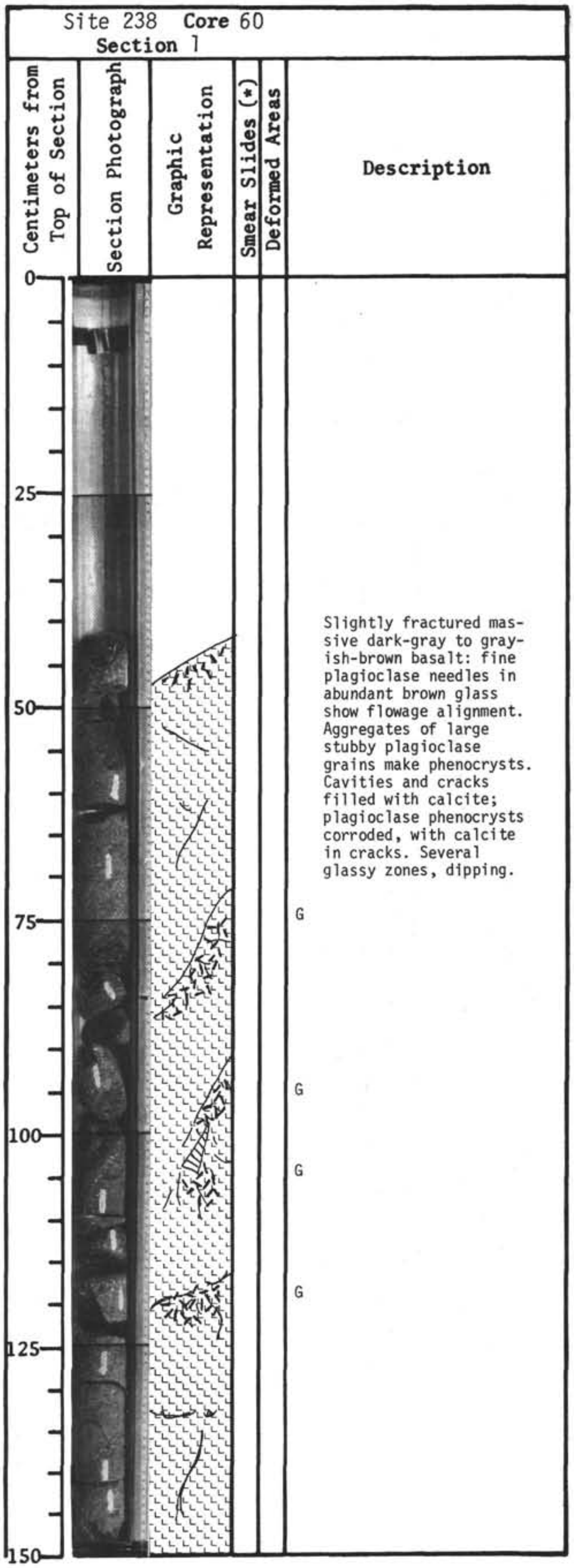


G Glassy zone.

Massive, little-jointed diabase (dolerite), fresh, with rare phenocrysts of plagioclase.

Coarse, fresh diabase, not markedly porphyritic. No obvious directional flow structures. Augite fresh; plagioclase somewhat chloritized, opaques as dusty aggregates.

Rolled (?) fragment of metamorphosed sediment and glass.

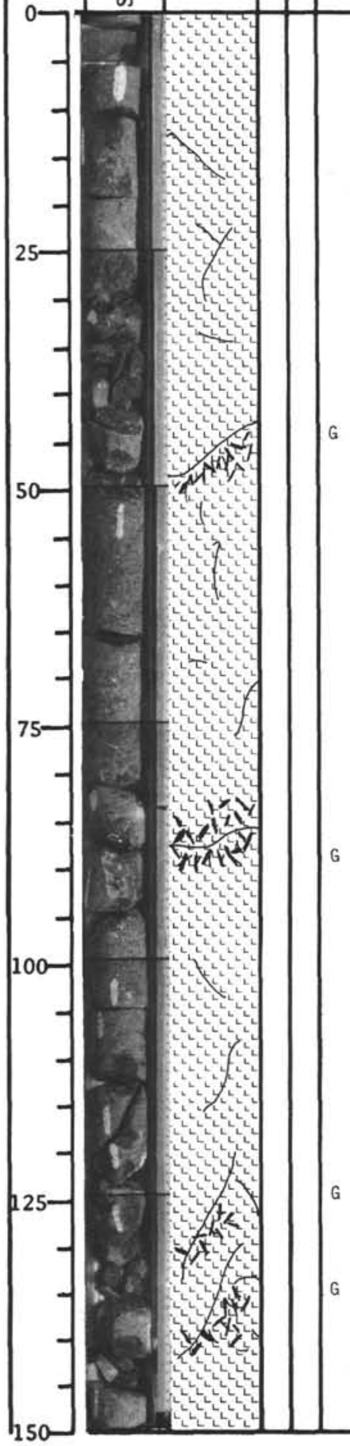


Slightly fractured massive dark-gray to grayish-brown basalt: fine plagioclase needles in abundant brown glass show flowage alignment. Aggregates of large stubby plagioclase grains make phenocrysts. Cavities and cracks filled with calcite; plagioclase phenocrysts corroded, with calcite in cracks. Several glassy zones, dipping.

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 60
Section 2

Centimeters from Top of Section | **Section Photograph** | **Graphic Representation** | **Smear Slides (*)** | **Deformed Areas** | **Description**

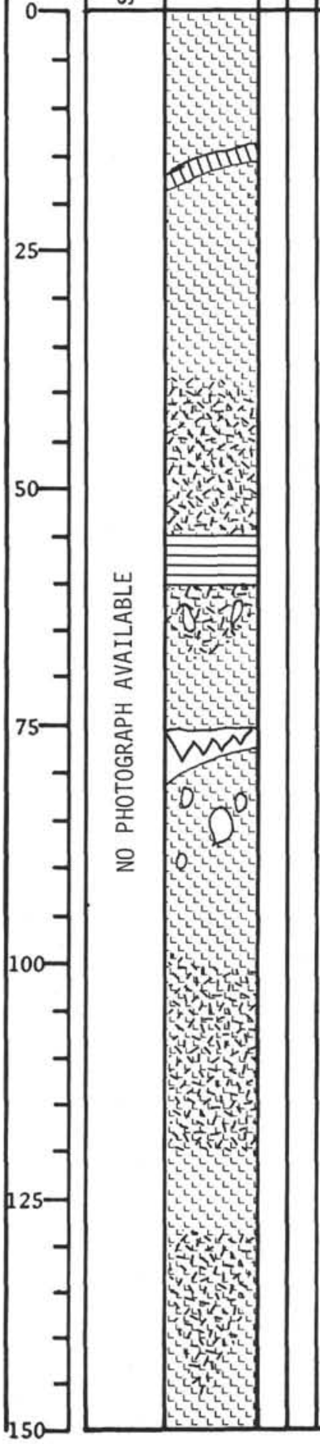


Dark-gray, slightly fractured, fairly fresh diabase with augite common and some olivine. Aggregates of stubby anhedral plagioclase make phenocrysts. Rare vesicles with fine-grained rims, empty.

Glassy zones ("G").

Site 238 **Core** 60
Section 3

Centimeters from Top of Section | **Section Photograph** | **Graphic Representation** | **Smear Slides (*)** | **Deformed Areas** | **Description**



NO PHOTOGRAPH AVAILABLE

The massive basalt with fractures, filled by calcite. One of fractures is enriched by yellow material (sulfur?).

G

Sediments (marble).

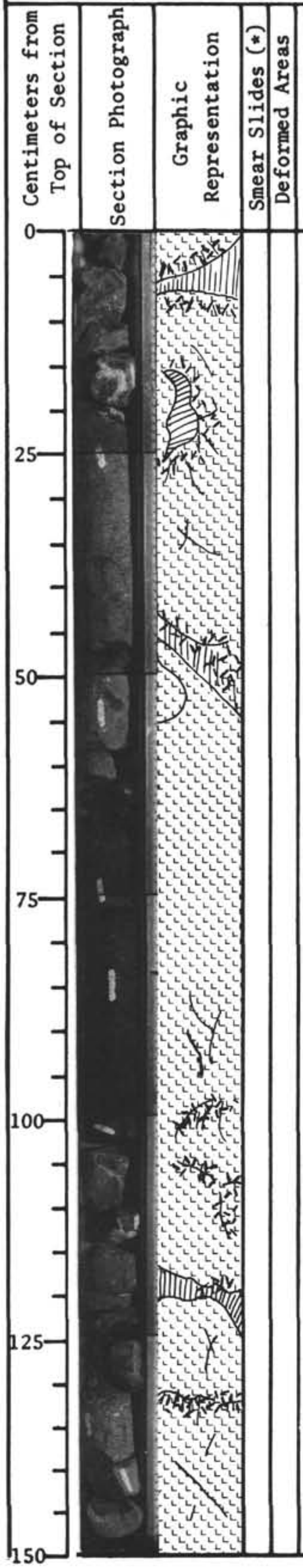
(sulfur?)

There is one inclusion of metamorphosed sediments with layering. (Marble).

G

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 60
Section 4

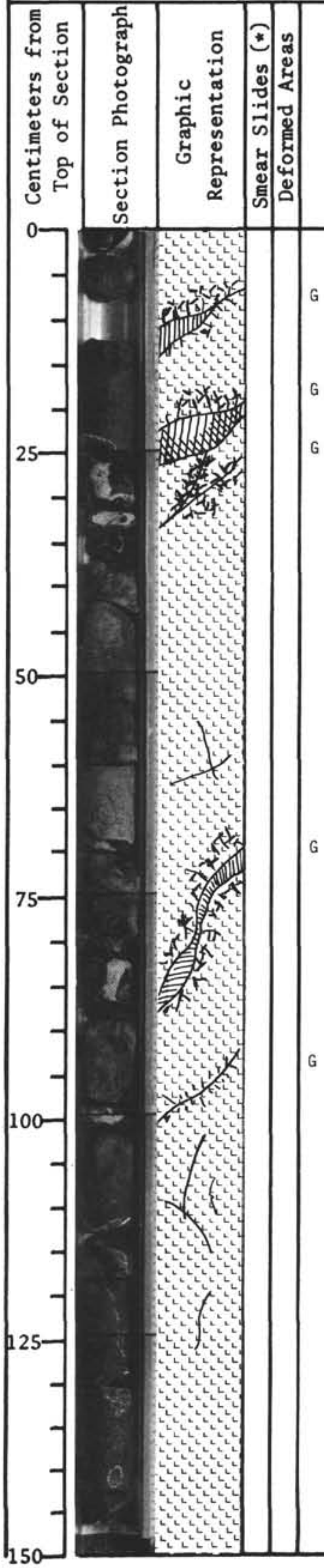


Description

Massive dark-gray basalt, with plagioclase as individual phenocrysts.

Six glassy zones ("G") are associated with metamorphosed sediments and calcite.

Site 238 **Core** 61
Section 1



Description

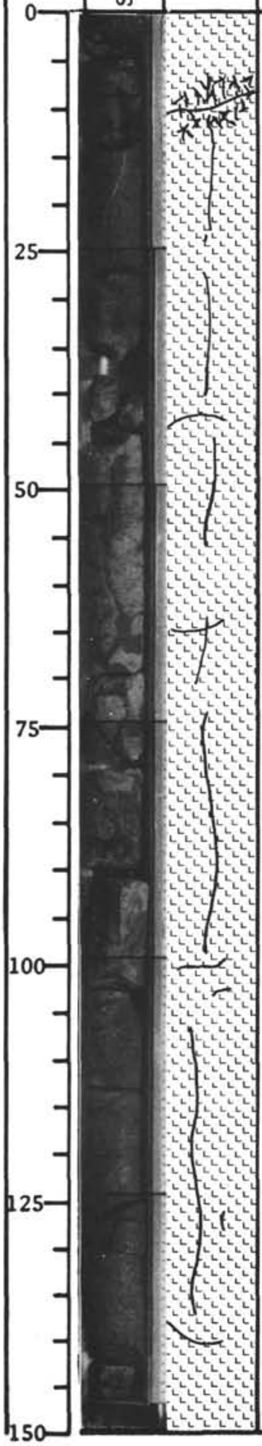
Extremely fine-grained carbonate: metamorphosed sediment with no obvious microfossils still evident. Cavities and seams filled with palagonitized glass.

Massive dark-gray basalt, locally fractured. Glassy zones ("G") and selvages associated with inclusions and crack fillings of fine-grained metamorphosed carbonate sediments.

DETAILED CORE DESCRIPTIONS

Site 238 Core 61
Section 2

Centimeters from Top of Section	Section Photograph	Graphic Representation	Smear Slides (*)	Deformed Areas	Description



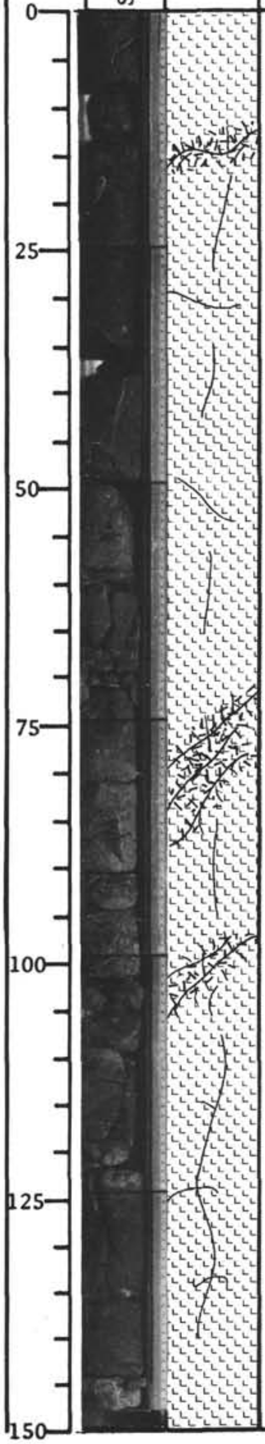
G

Relatively unfractured massive dark-gray basalt, with rare phenocrysts of plagioclase; one glassy layer in the upper part of the section.

Somewhat altered, equigranular, medium-grained basalt, with rare small phenocrysts of fresh plagioclase, augite abundant and olivine occasionally present in groundmass. Round vesicles, filled with fine-grained chlorite(?) and with dusty aggregates of opaques, locally in pockets or at rim.

Site 238 Core 61
Section 3

Centimeters from Top of Section	Section Photograph	Graphic Representation	Smear Slides (*)	Deformed Areas	Description



G

Dark-gray micro-doleritic basalt, locally fractured. Plagioclase partially chloritized, with phenocrysts corroded. Anhedral augite common to abundant in groundmass; fairly fresh. No flow structure.

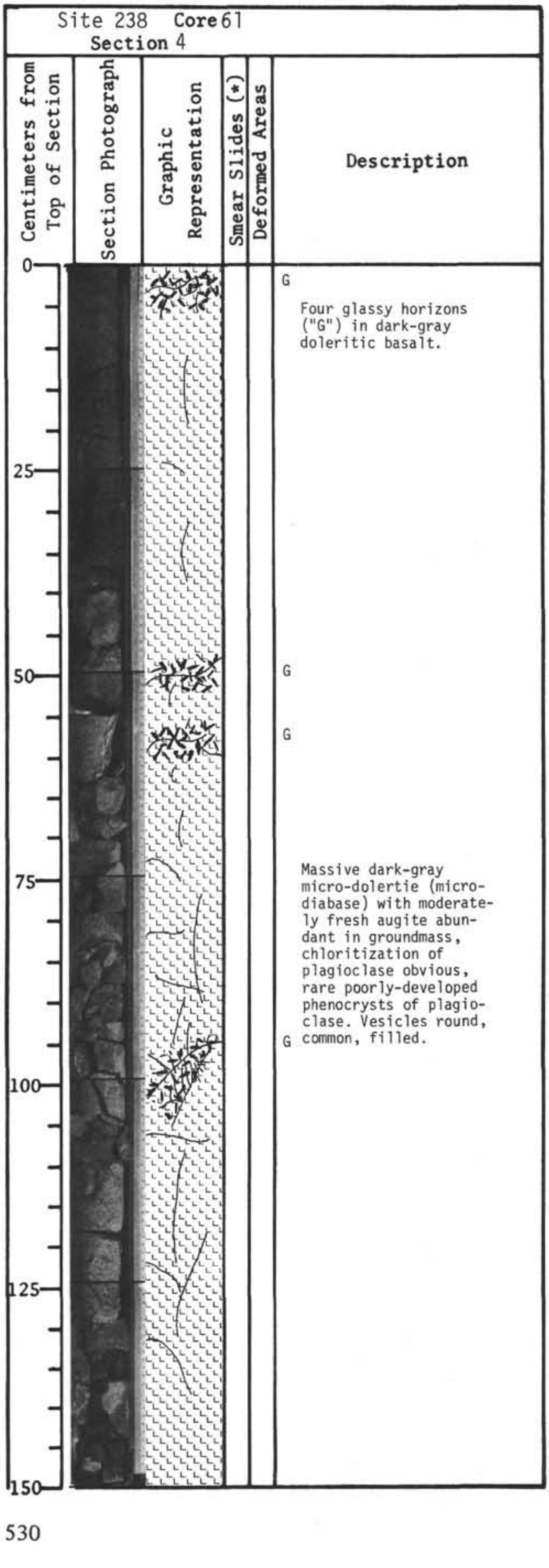
G

G Three major glassy horizons ("G").

G

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 61
Section 4



G

Four glassy horizons ("G") in dark-gray doleritic basalt.

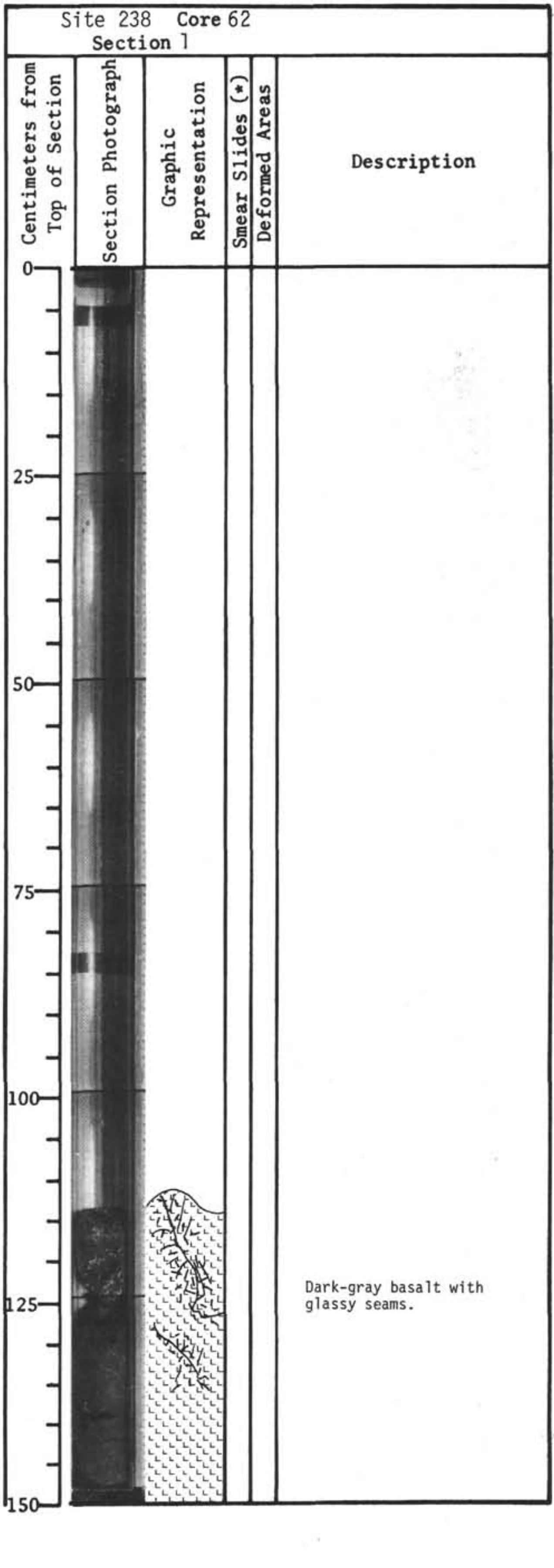
G

G

Massive dark-gray micro-dolertie (micro-diabase) with moderately fresh augite abundant in groundmass, chloritization of plagioclase obvious, rare poorly-developed phenocrysts of plagioclase. Vesicles round, common, filled.

G

Site 238 **Core** 62
Section 1

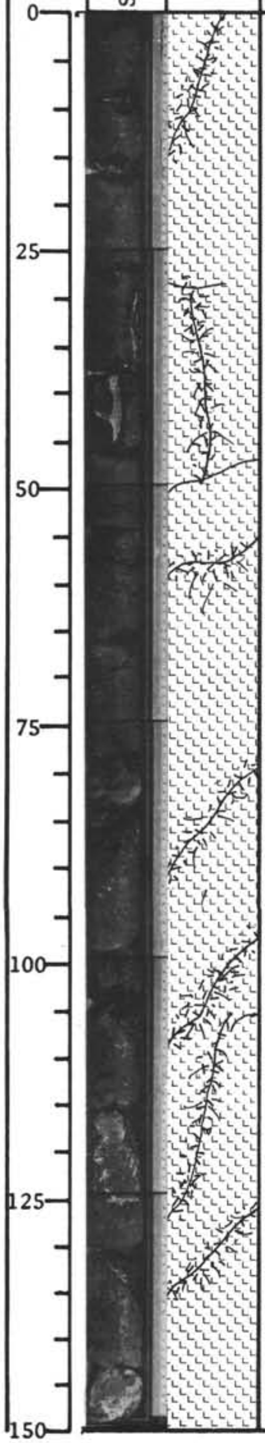


Dark-gray basalt with glassy seams.

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 62
Section 2

Centimeters from Top of Section | **Section Photograph** | **Graphic Representation** | **Smear Slides (*)** | **Deformed Areas** | **Description**



G

Dark-gray medium-grained basalt segmented by numerous glassy seams, of various orientation.

G

G

Dark-gray micro-dolerite, with rare subhedral phenocrysts of plagioclase. Augite abundant, altered in varying degree. Chloritization common in G groundmass; chlorite fills irregular small cavities and rare round cavities.

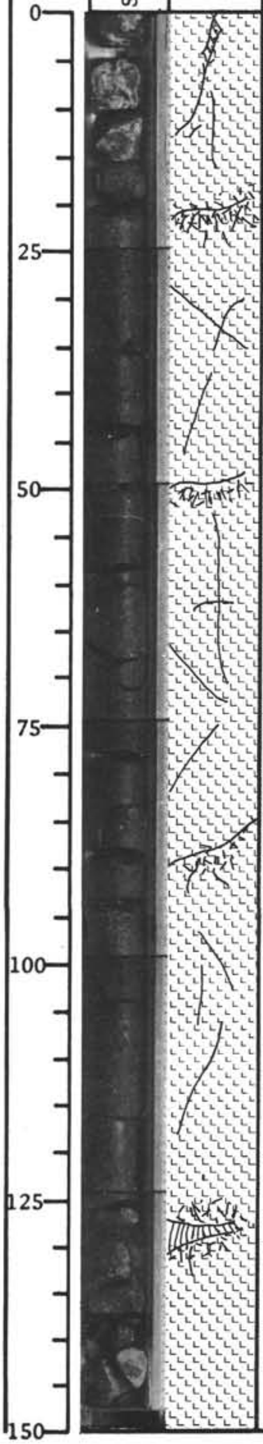
G

G

G

Site 238 **Core** 62
Section 3

Centimeters from Top of Section | **Section Photograph** | **Graphic Representation** | **Smear Slides (*)** | **Deformed Areas** | **Description**



G Five glassy horizons ("G") in this section.

G

G

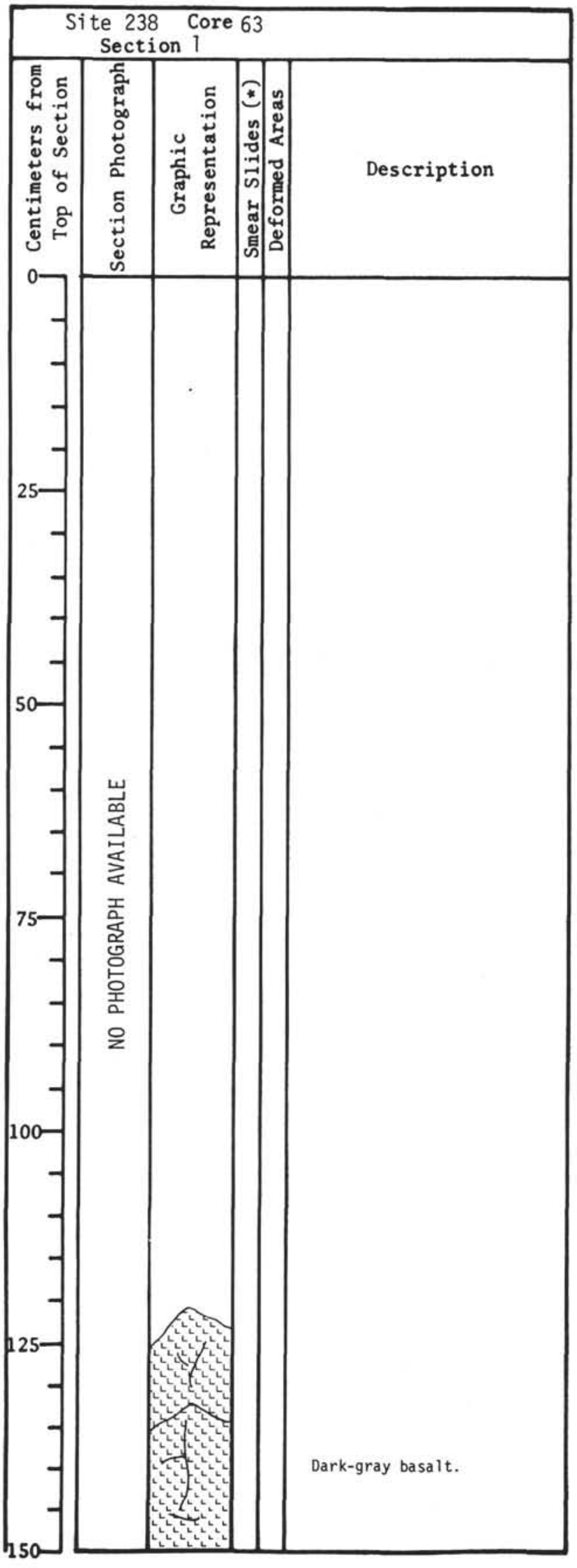
Dark-gray massive micro-dolerite (micro-diabase) fresh augite and minor olivine; chloritization of plagioclase and aggregates of opaques. Fresh subhedral plagioclase phenocrysts. Round to irregular vesicles filled with chlorite.

G

G

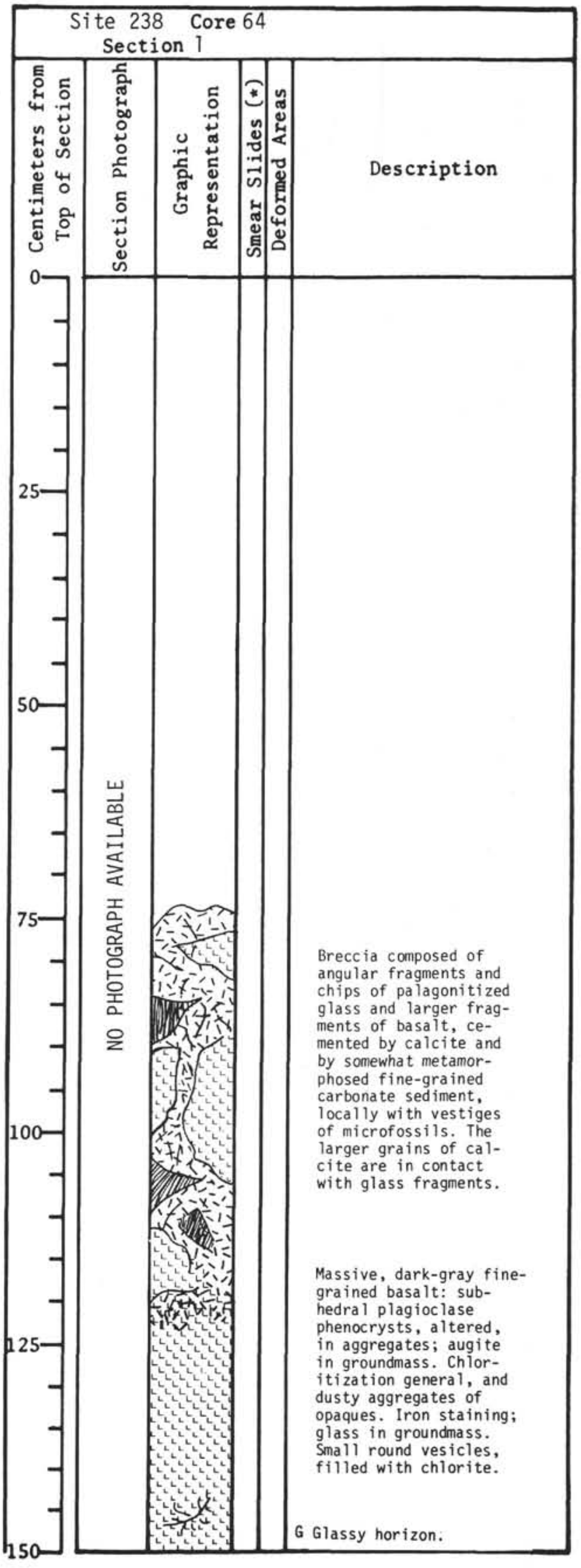
DETAILED CORE DESCRIPTIONS

Site 238 **Core** 63
Section 1



Dark-gray basalt.

Site 238 **Core** 64
Section 1



Breccia composed of angular fragments and chips of palagonitized glass and larger fragments of basalt, cemented by calcite and by somewhat metamorphosed fine-grained carbonate sediment, locally with vestiges of microfossils. The larger grains of calcite are in contact with glass fragments.

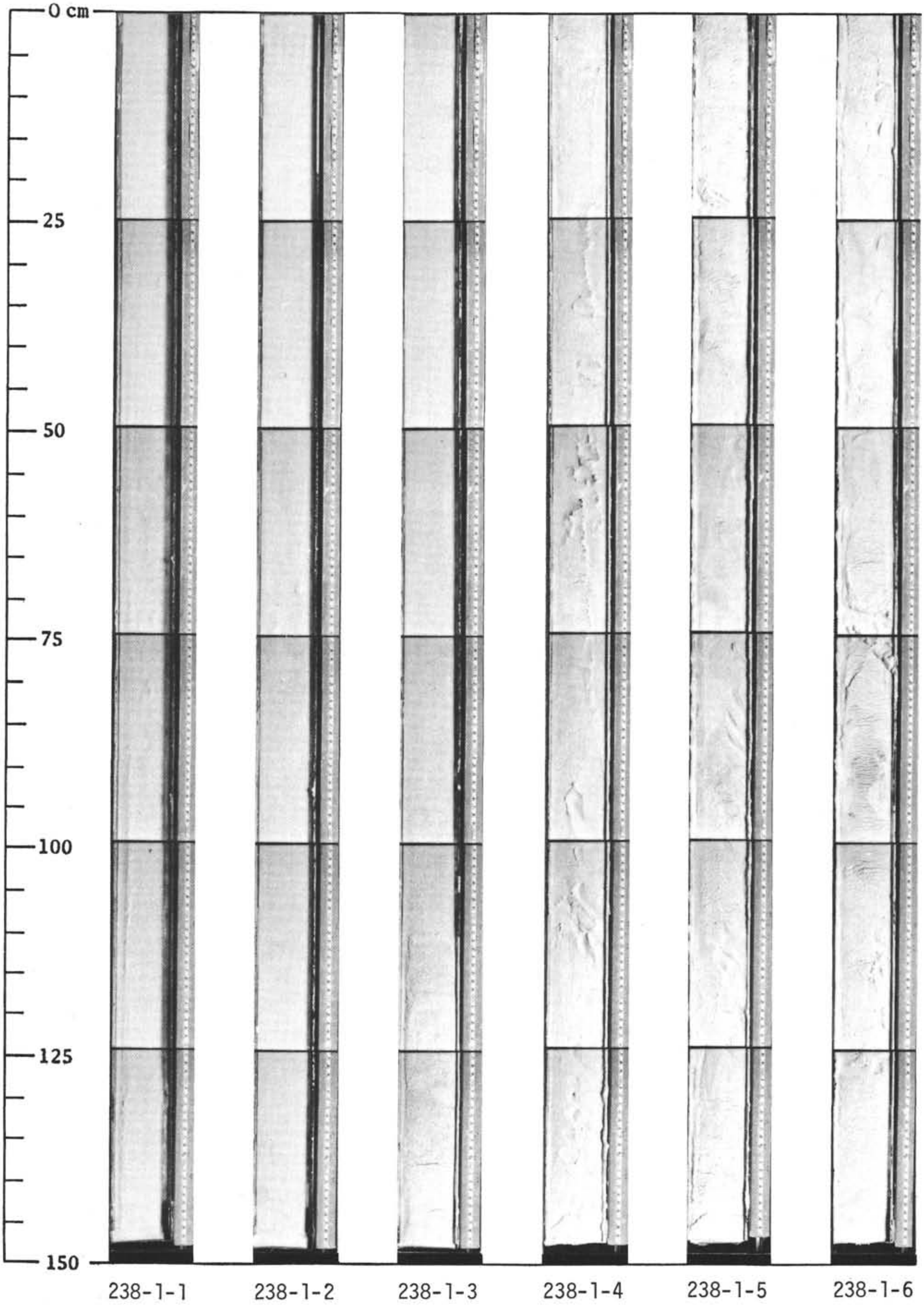
Massive, dark-gray fine-grained basalt: subhedral plagioclase phenocrysts, altered, in aggregates; augite in groundmass. Chloritization general, and dusty aggregates of opaques. Iron staining; glass in groundmass. Small round vesicles, filled with chlorite.

G Glassy horizon.

DETAILED CORE DESCRIPTIONS

Site 238 **Core** 64
Section 2

Centimeters from Top of Section	**Section Photograph**	**Graphic Representation**	**Smear Slides (*)**	**Deformed Areas**	**Description**
0	NO PHOTOGRAPH AVAILABLE				Dark gray massive basalt, fractured, with rare phenocrysts of plagioclase. There is considerable alteration, with chloritization general, corrosion of aggregates of plagioclase forming phenocrysts, augite in groundmass altered. Irregular cavities filled with calcite; small round vesicles, empty, with rims of chlorite or calcite or filled with chlorite. Glassy drifts in groundmass.
25					G
50					G
75					There are four zones of breccia, (here "G"), at steep angles to the horizontal. Angular fragments of basaltic glass, with rounded plagioclase phenocrysts and with palagonitized rims, are cemented by coarsely and irregularly crystallized calcite in veins or by fine-grained, little-metamorphosed carbonate sediments that appear to be inclusions. G
100					
125					G
150					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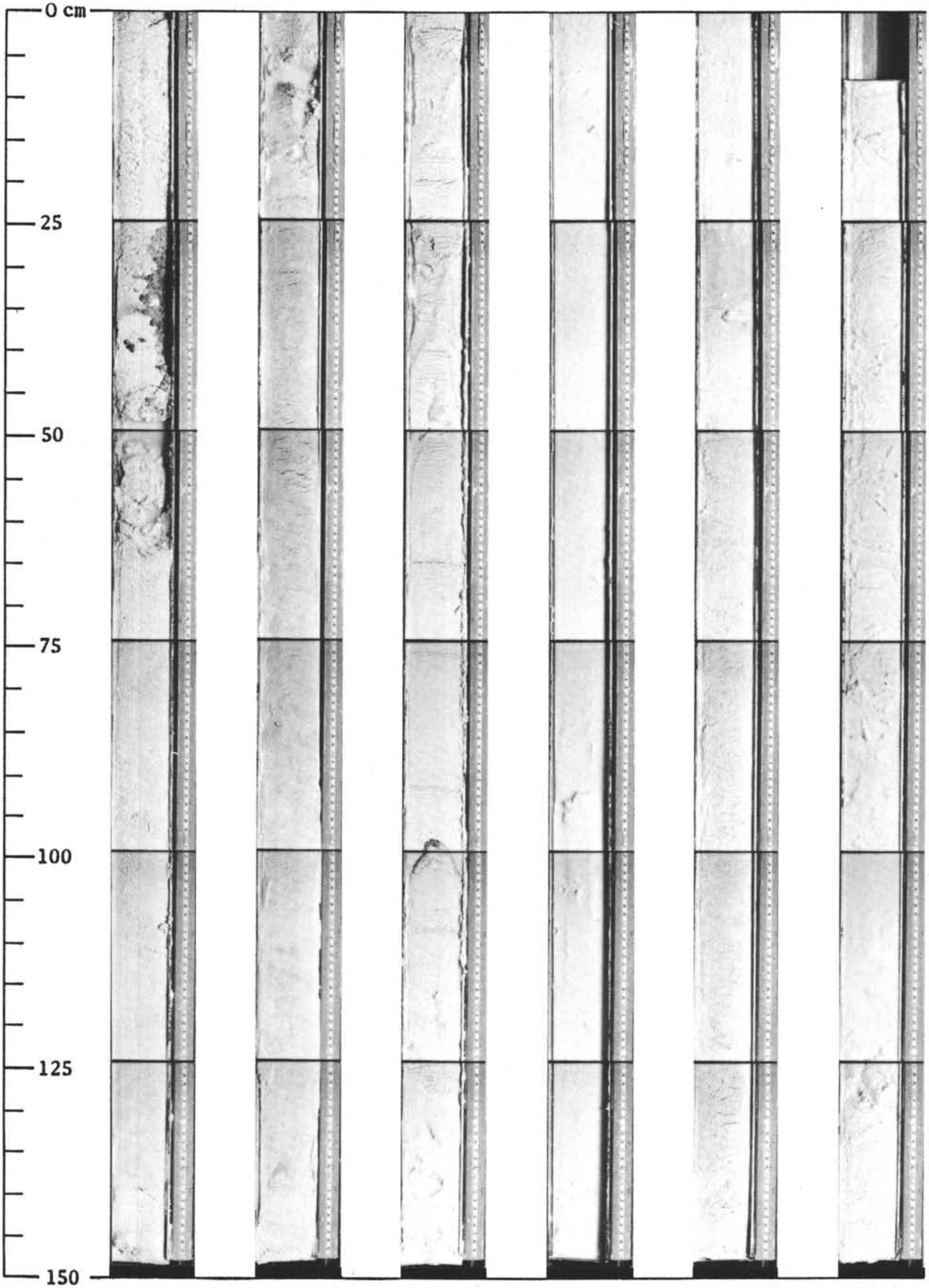
238-1-6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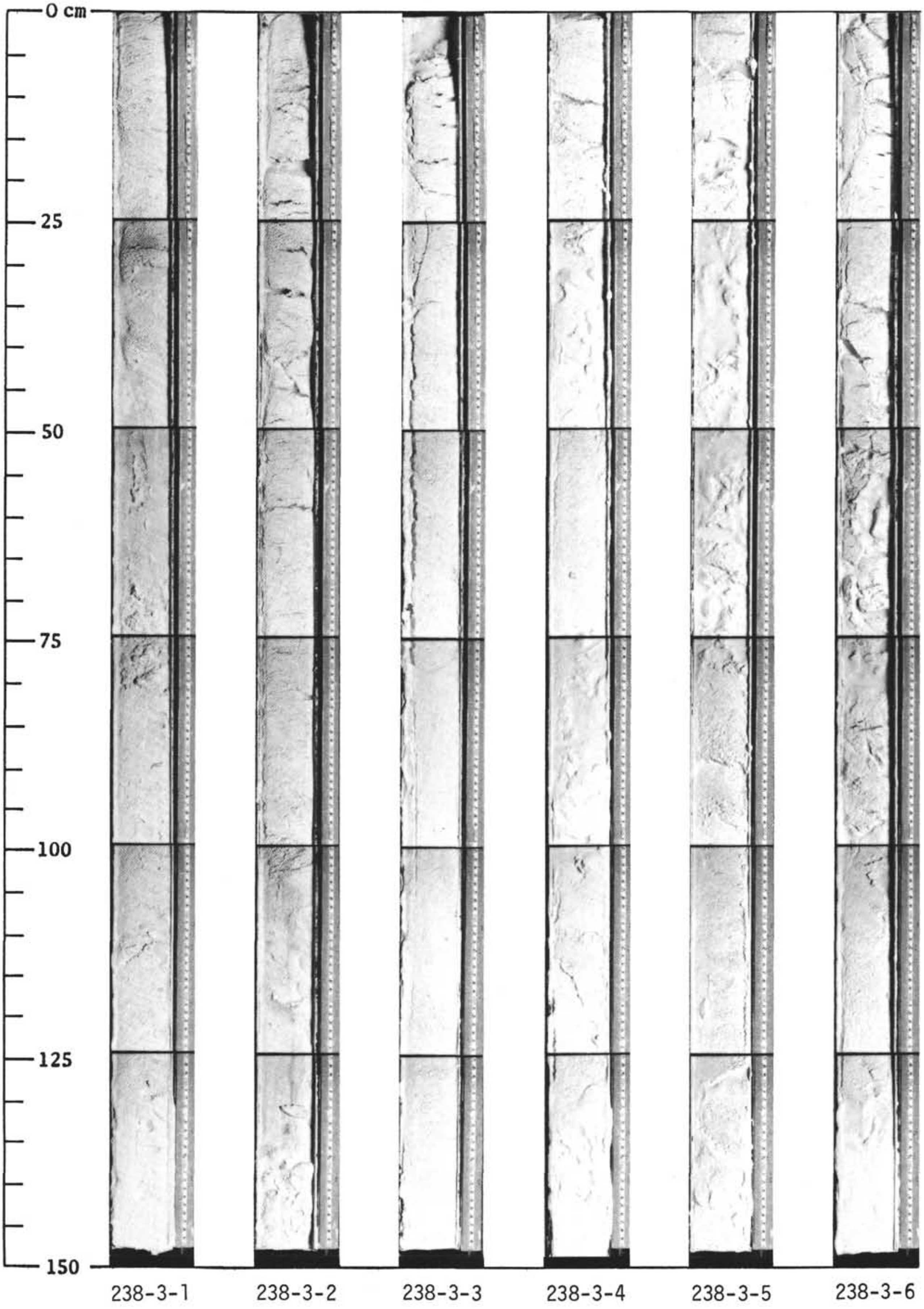

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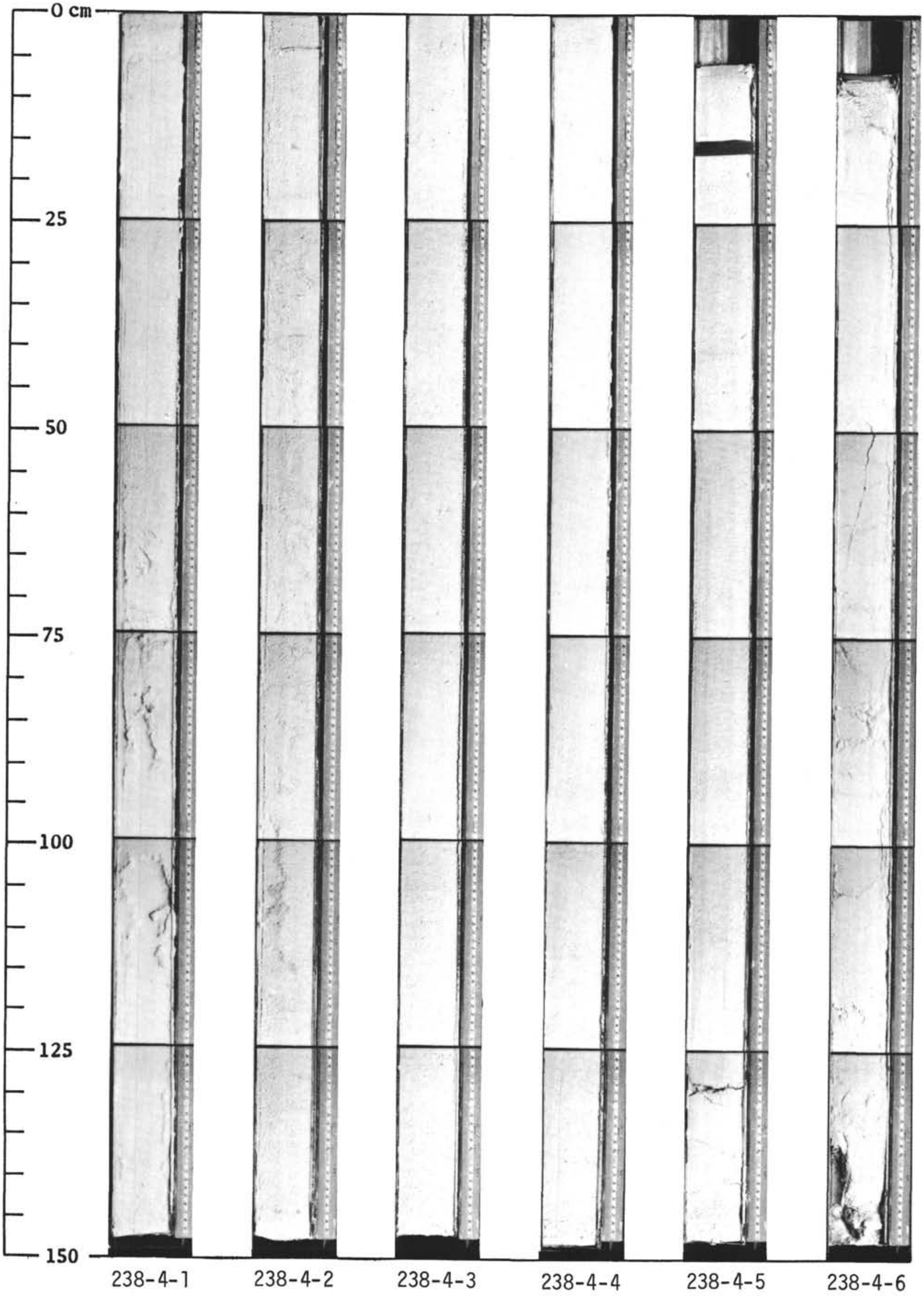
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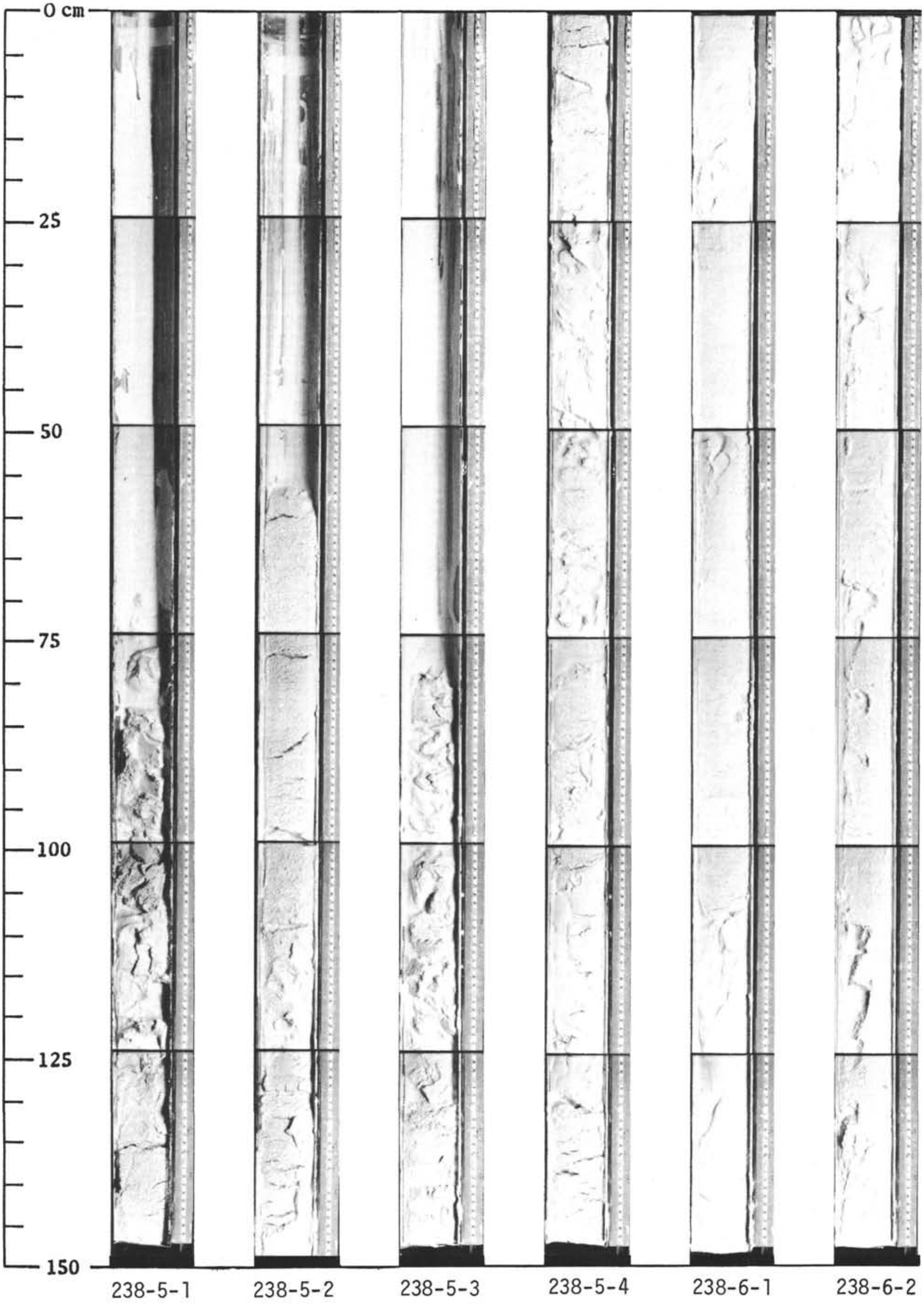
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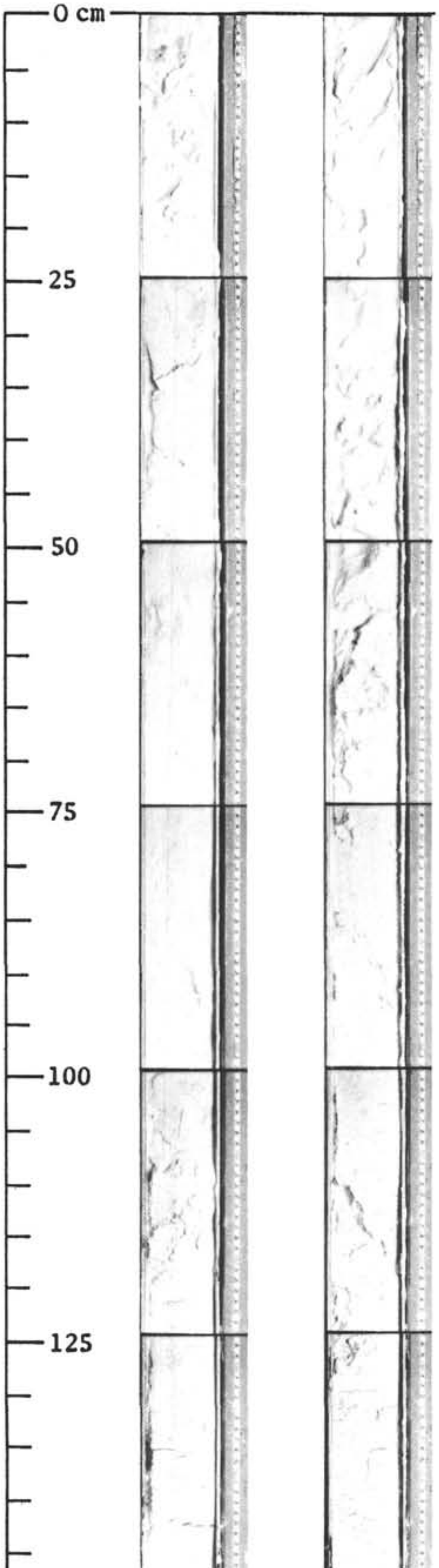
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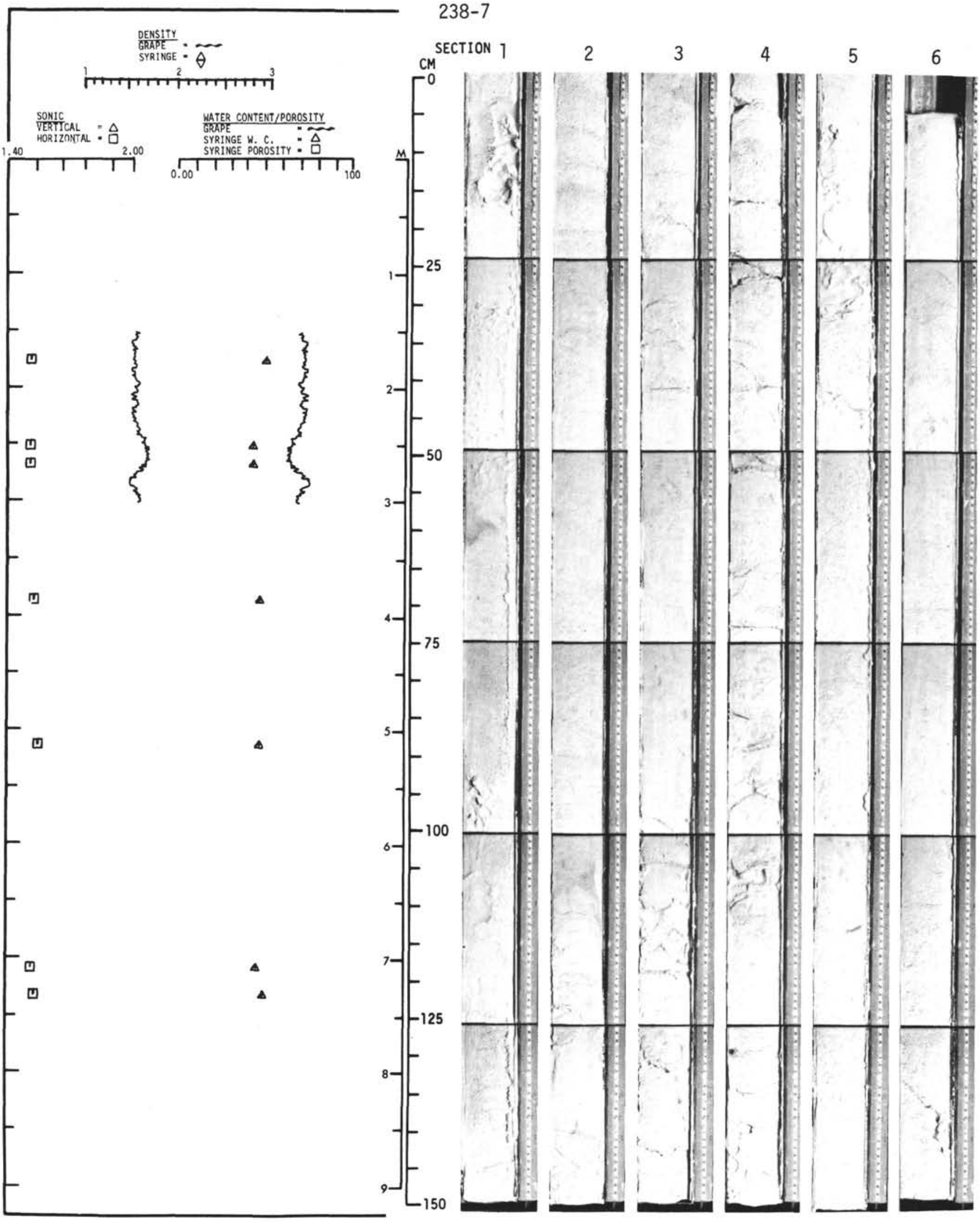
238-7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2.00
WATER CONTENT/POROSITY
GRAPE = 〰
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
100
M
CM
SECTION 1
2
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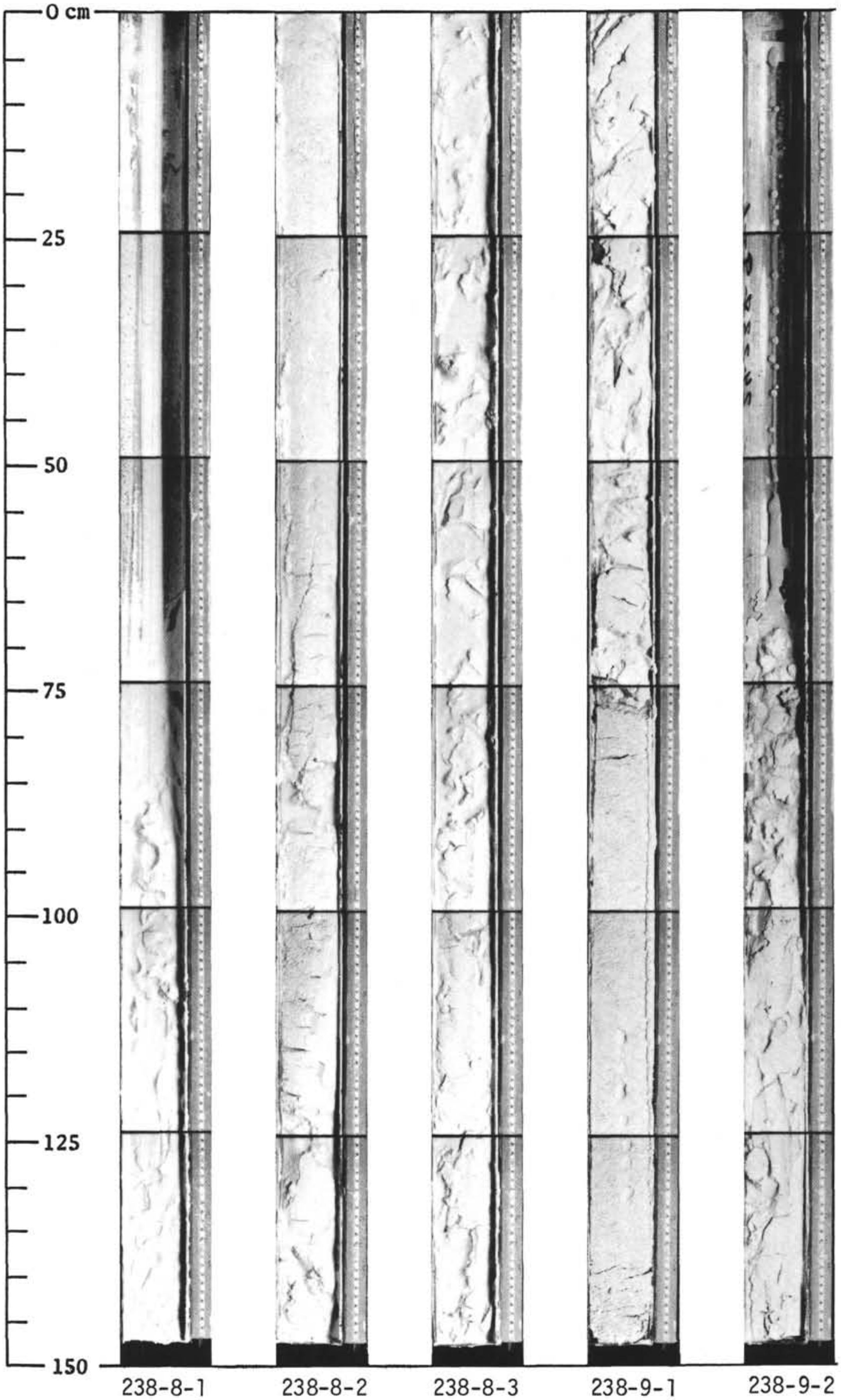
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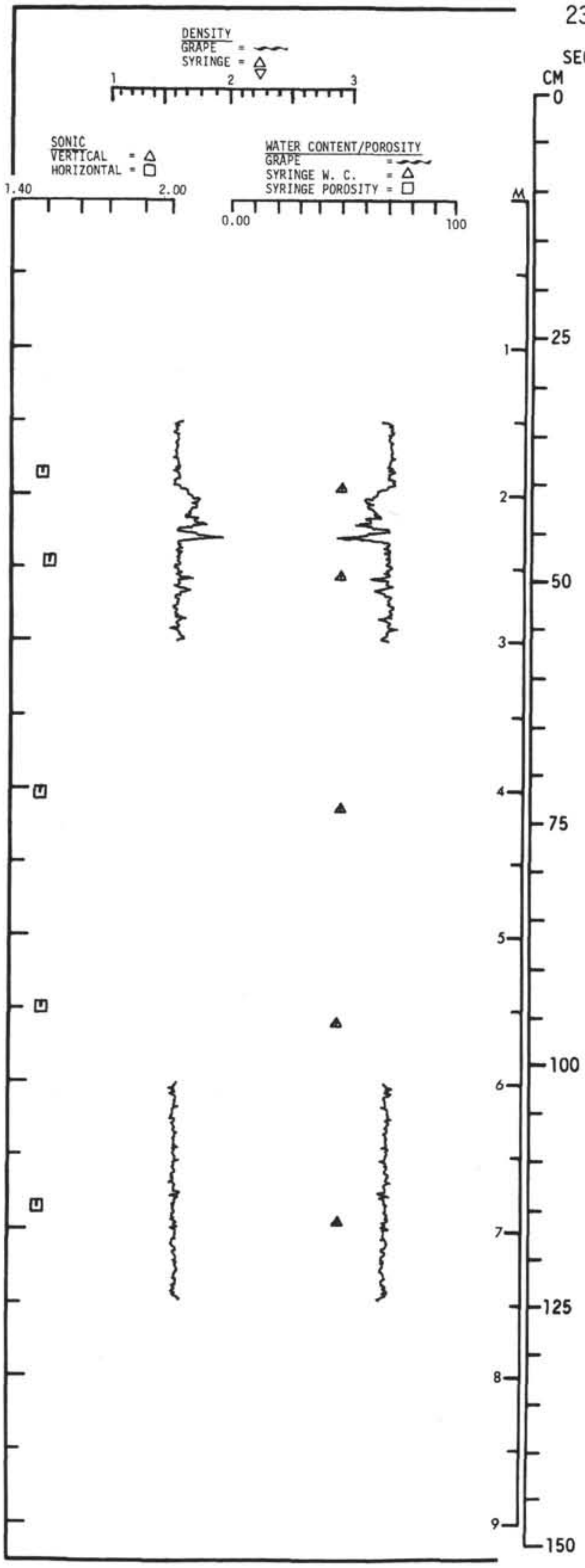
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WATER CONTENT/POROSITY
GRAPE = 〰
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SYRINGE POROSITY = □
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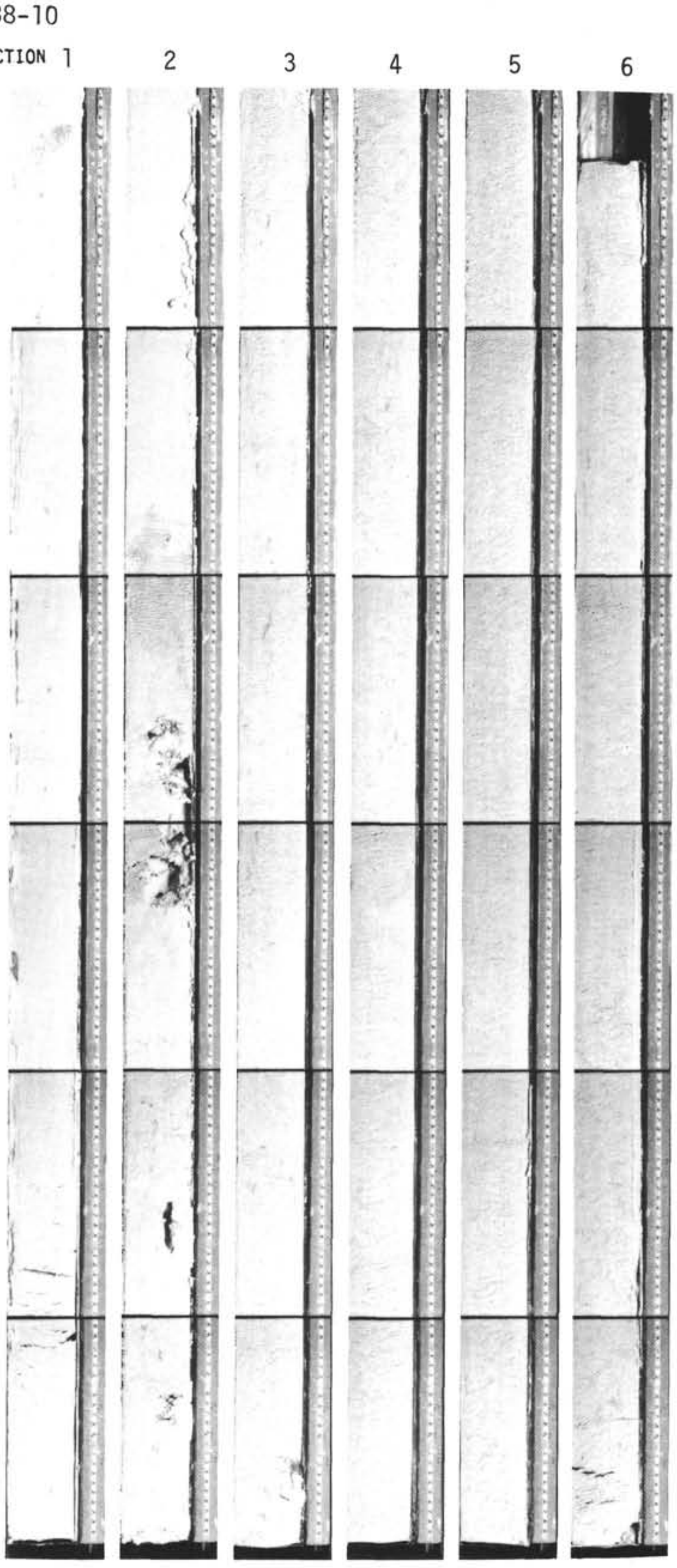
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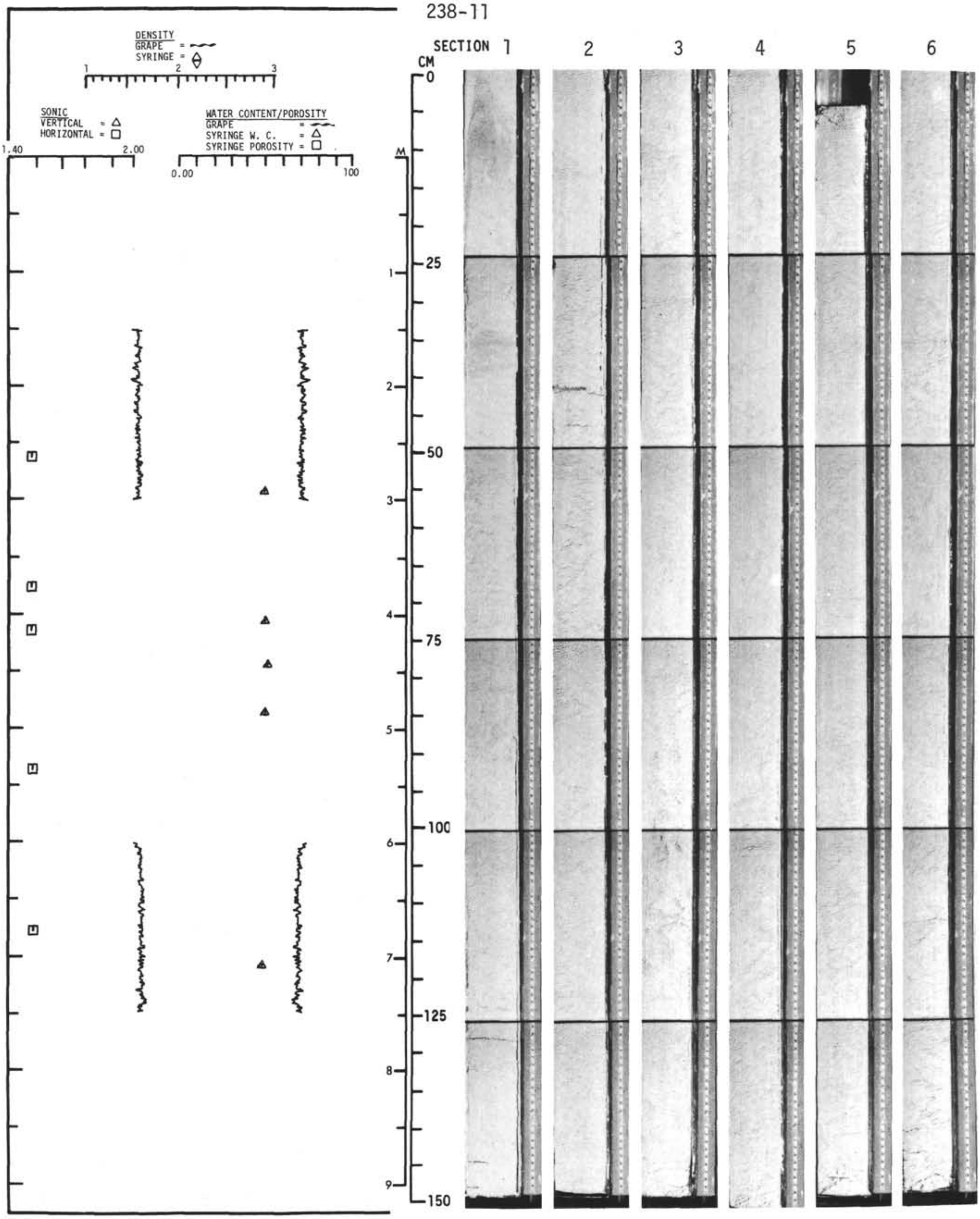
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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100
M
1
2
3
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SECTION 1
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CM
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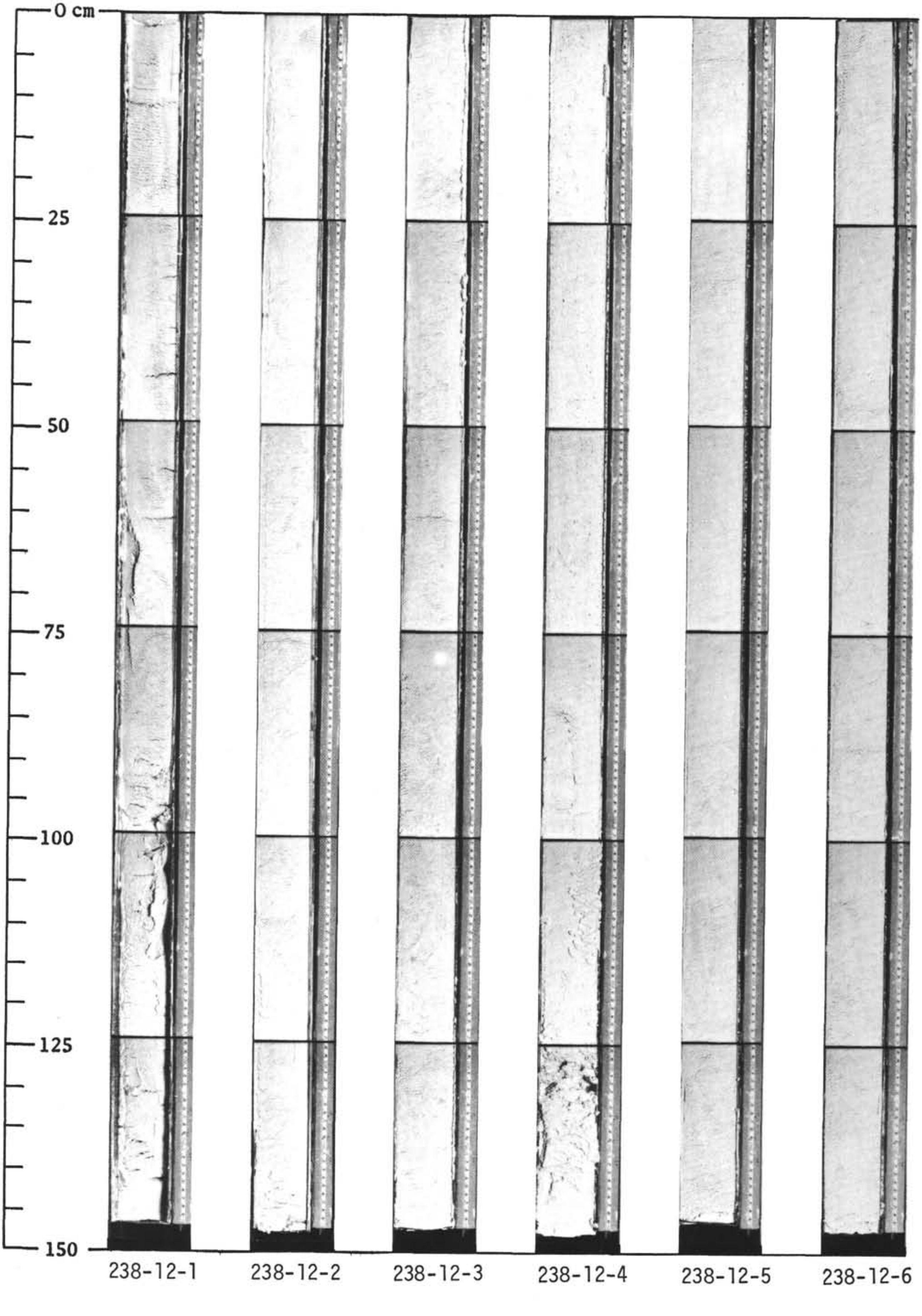
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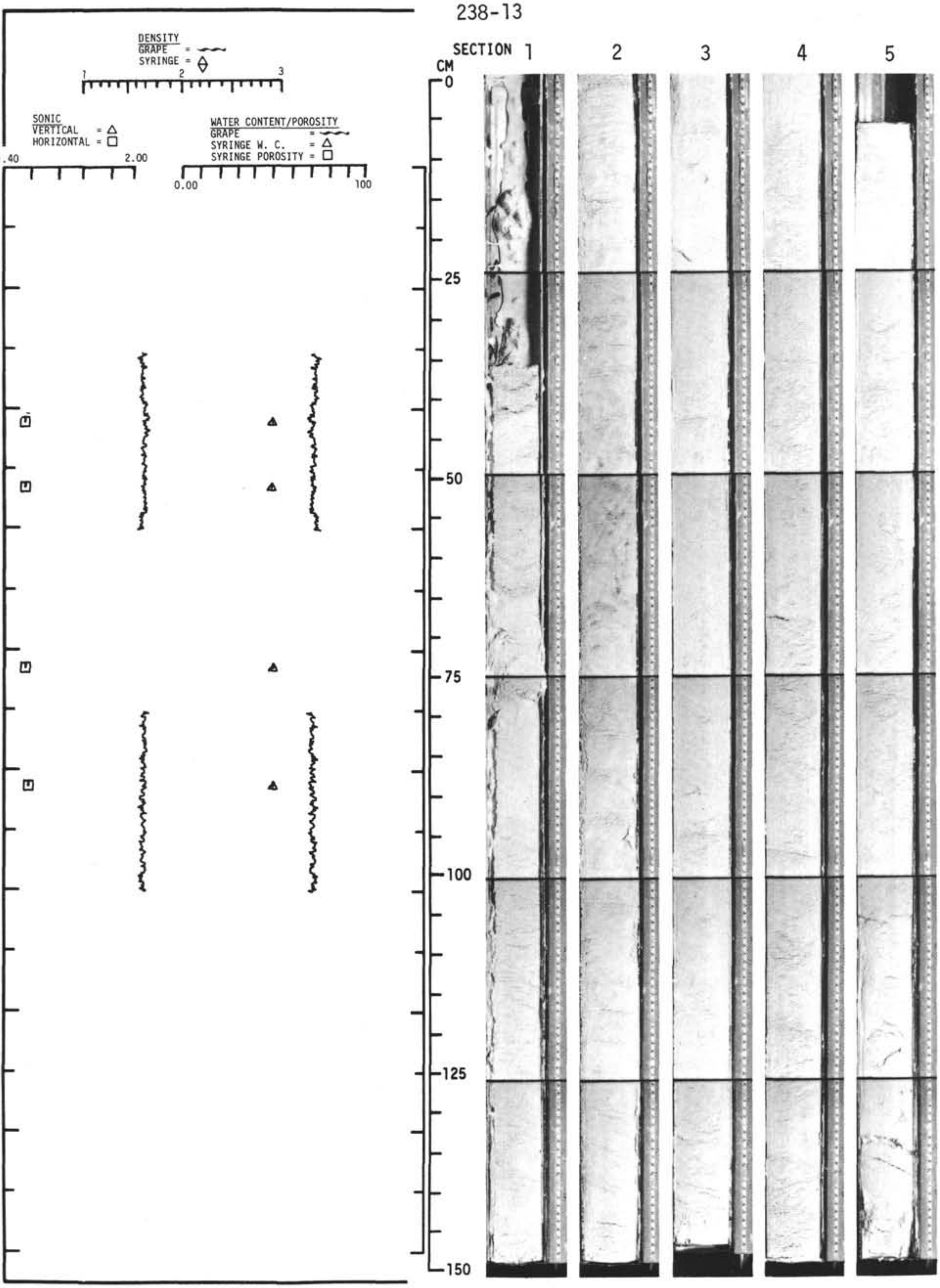
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SECTION 1 2 3 4 5
CM
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2
3
SONIC
VERTICAL = △
HORIZONTAL = □
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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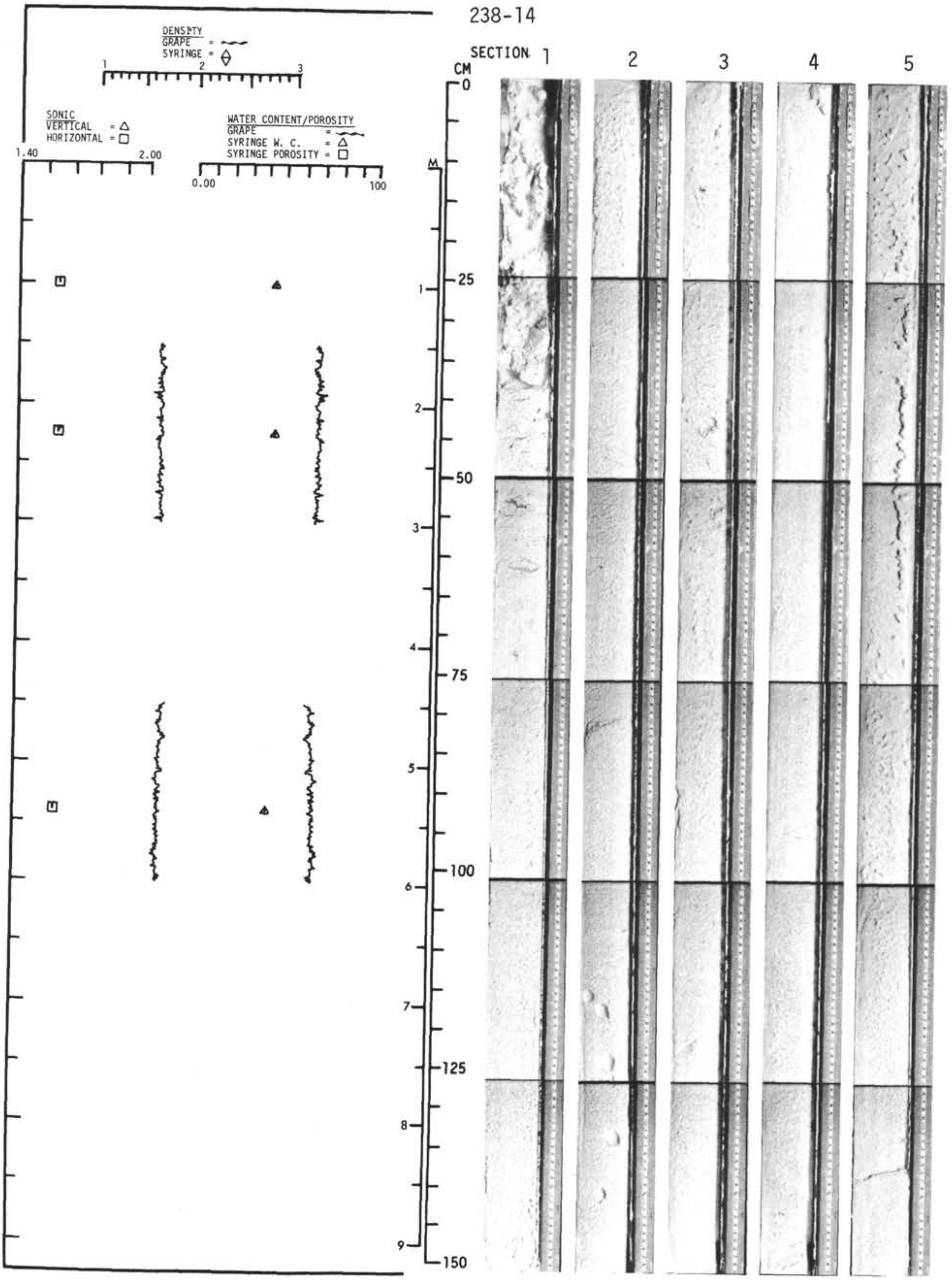
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WATER CONTENT/POROSITY
GRAPE = 〰
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
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M
1
2
3
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CM
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238-14
SECTION 1
2
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4
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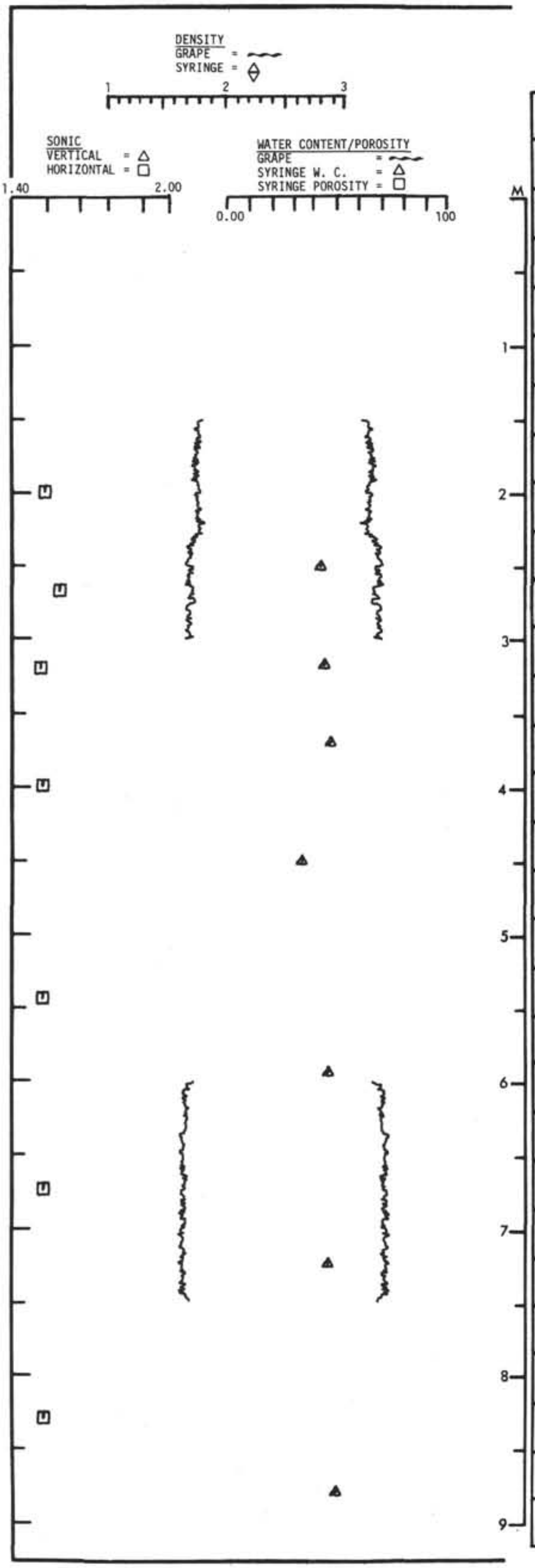
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HORIZONTAL = □
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2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
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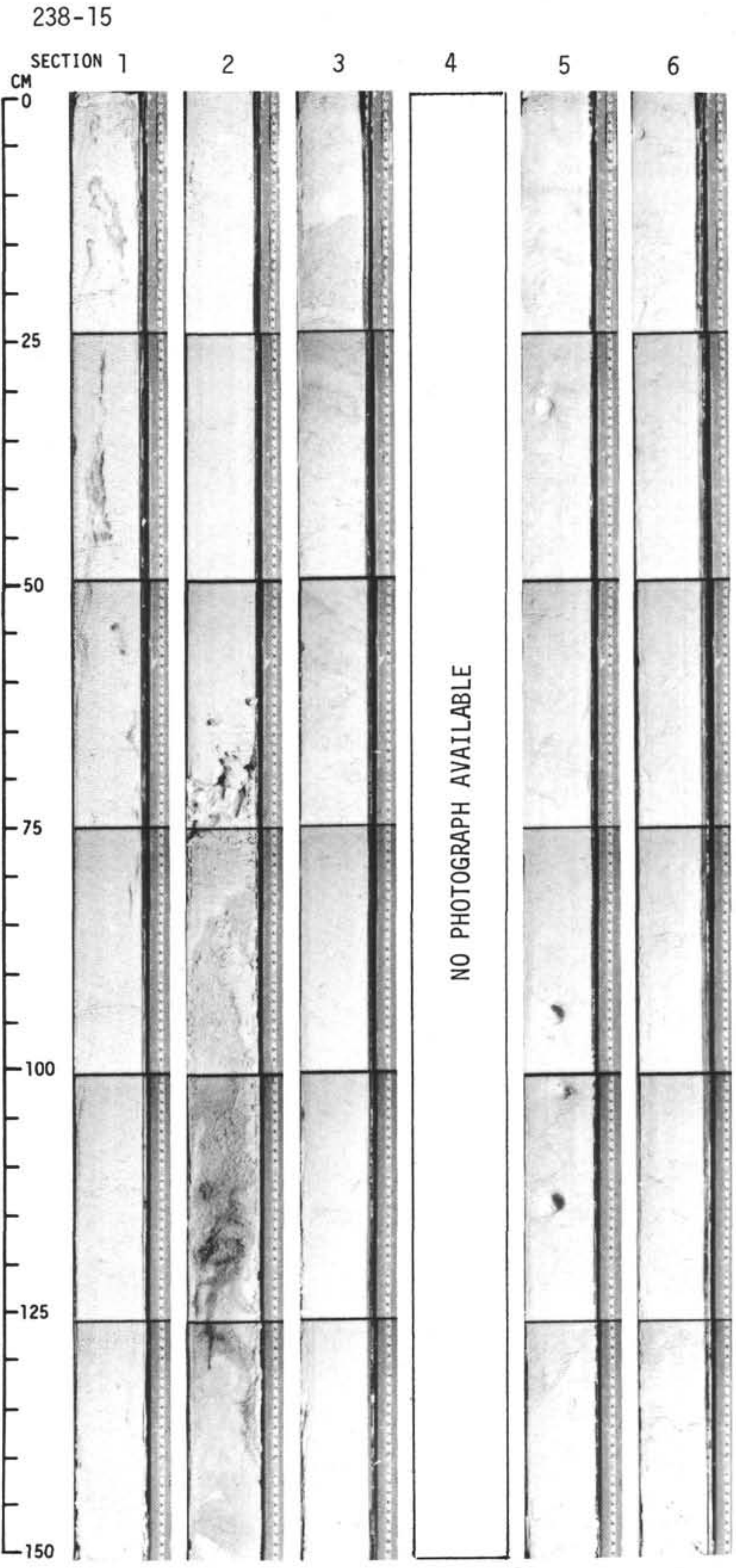
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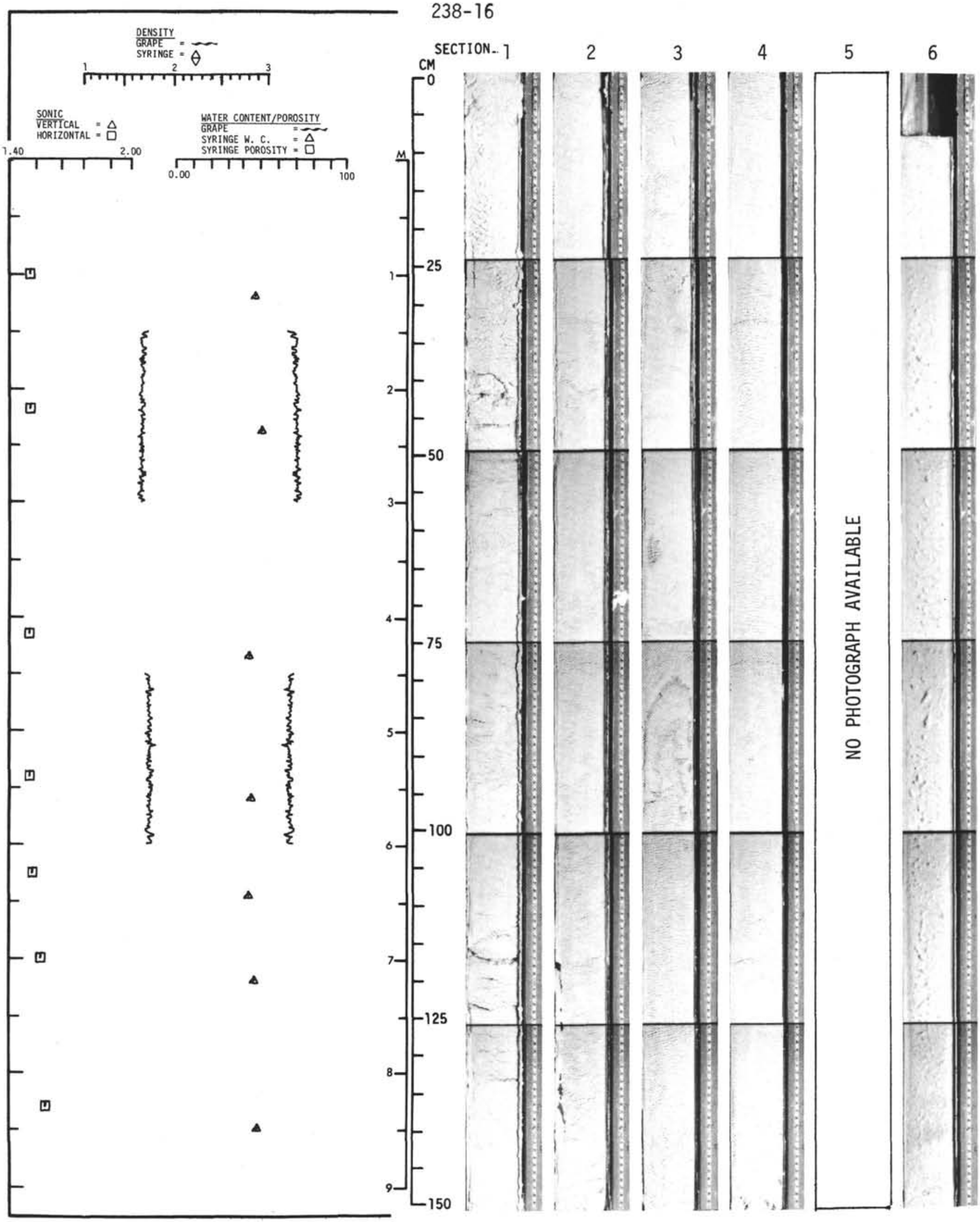
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
100
M
1
2
3
4
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SECTION
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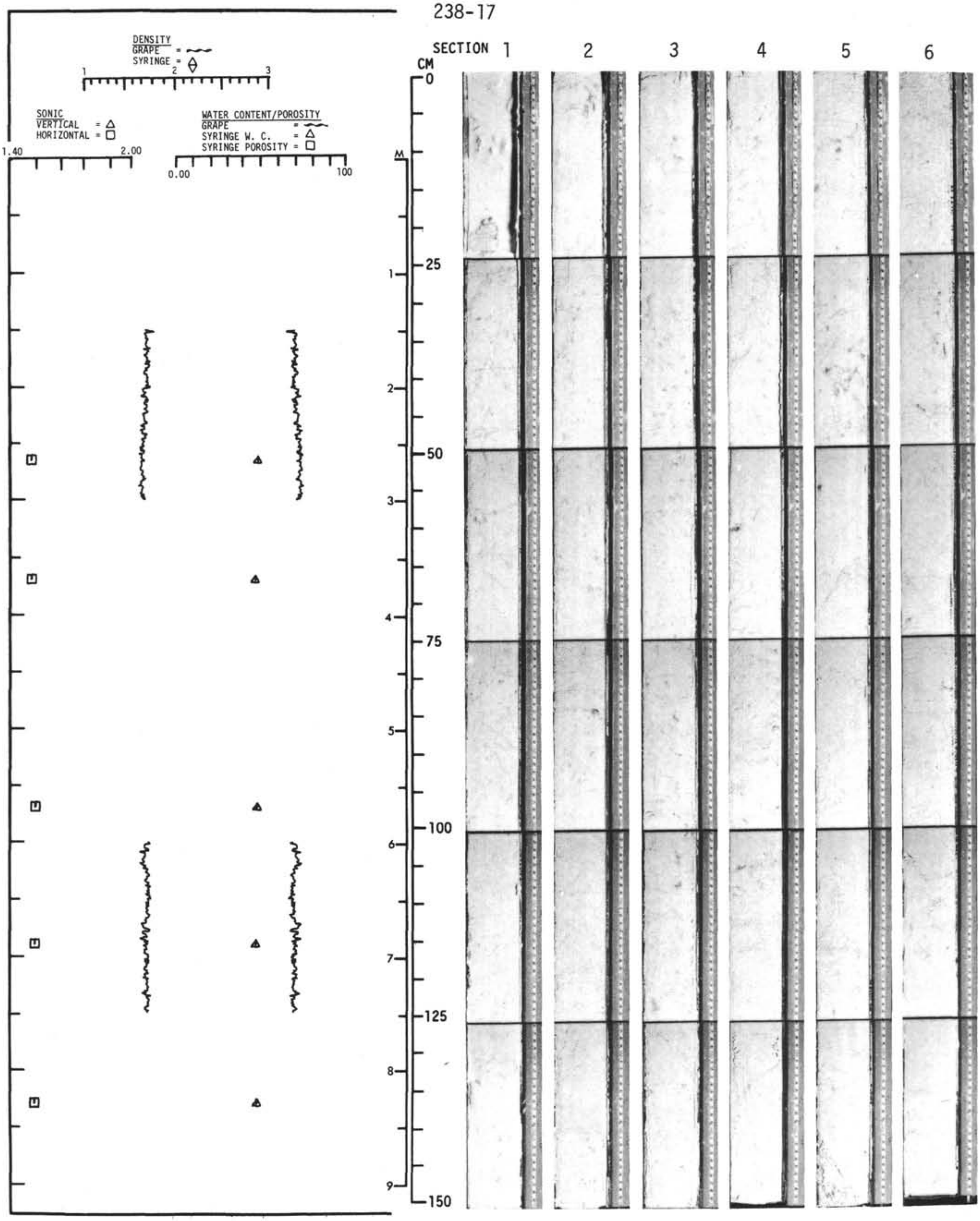
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WATER CONTENT/POROSITY
GRAPE = 〰
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M
1 2 3 4 5 6 7 8 9
CM
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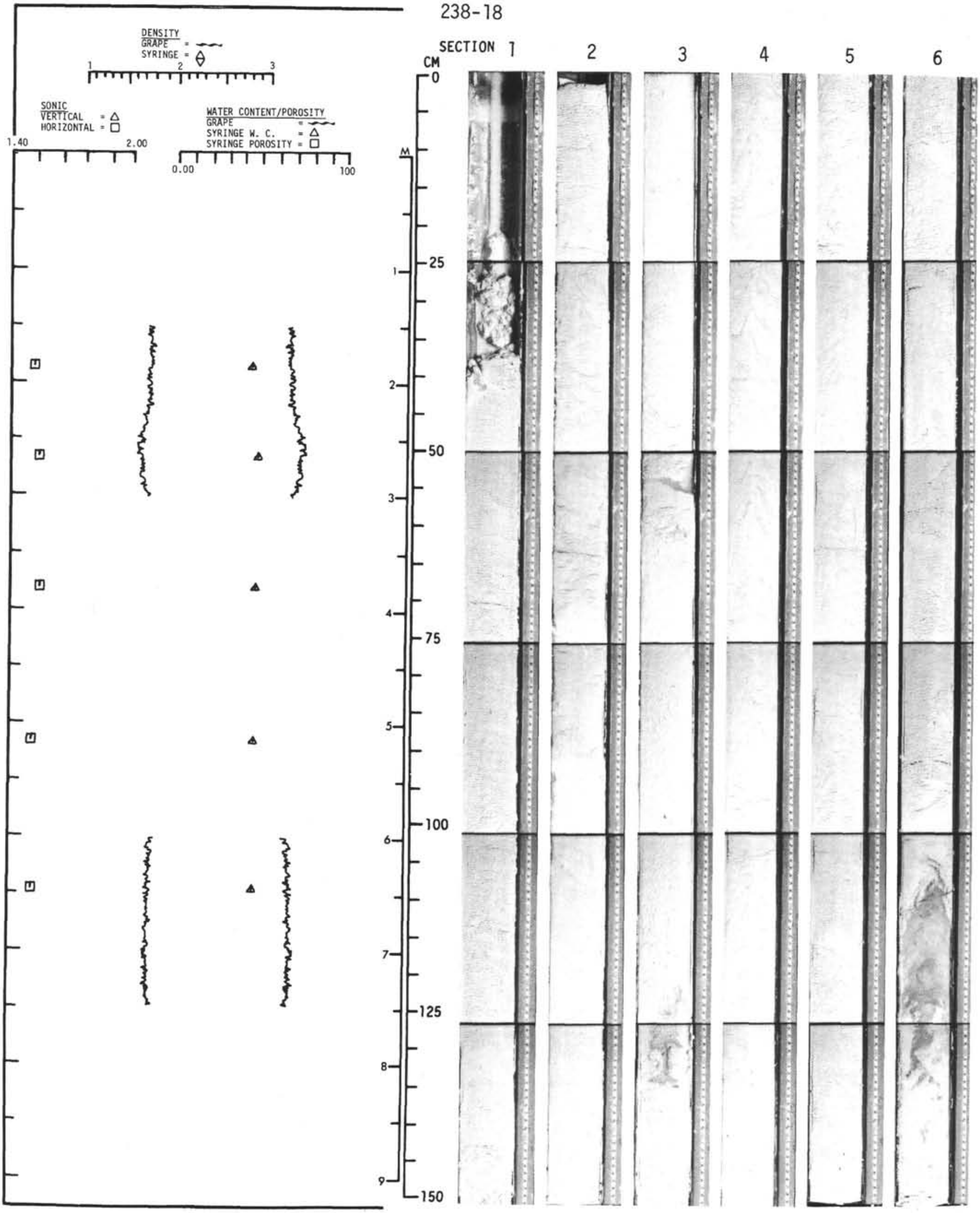
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SONIC
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2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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CM
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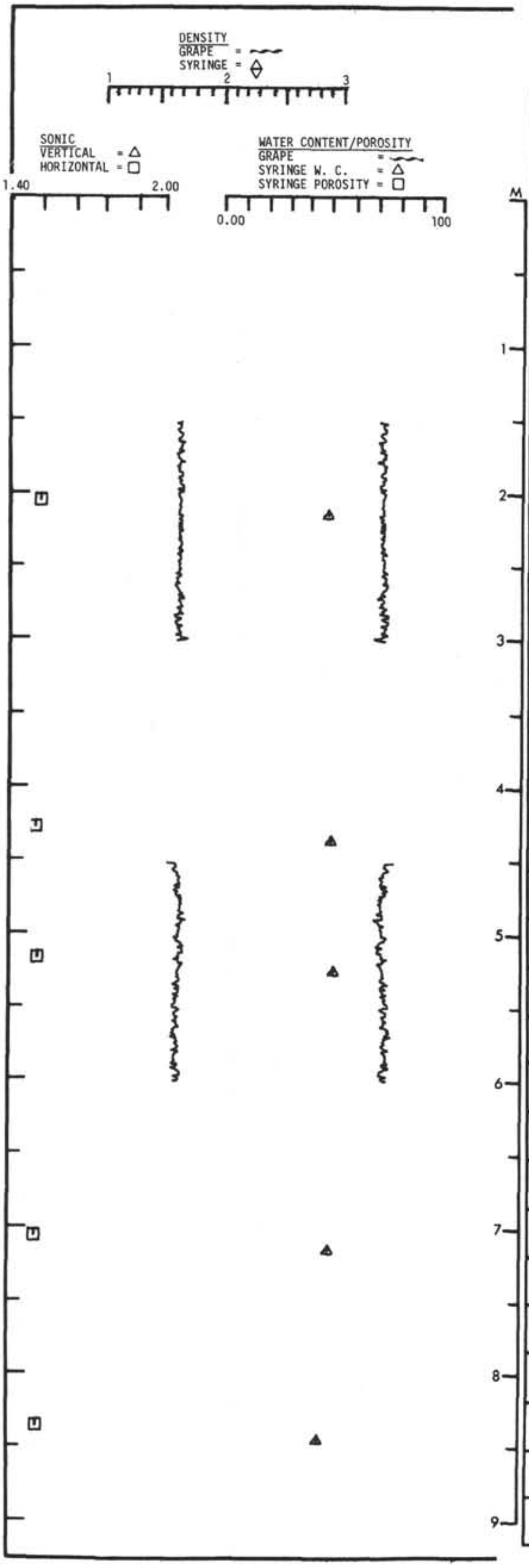
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
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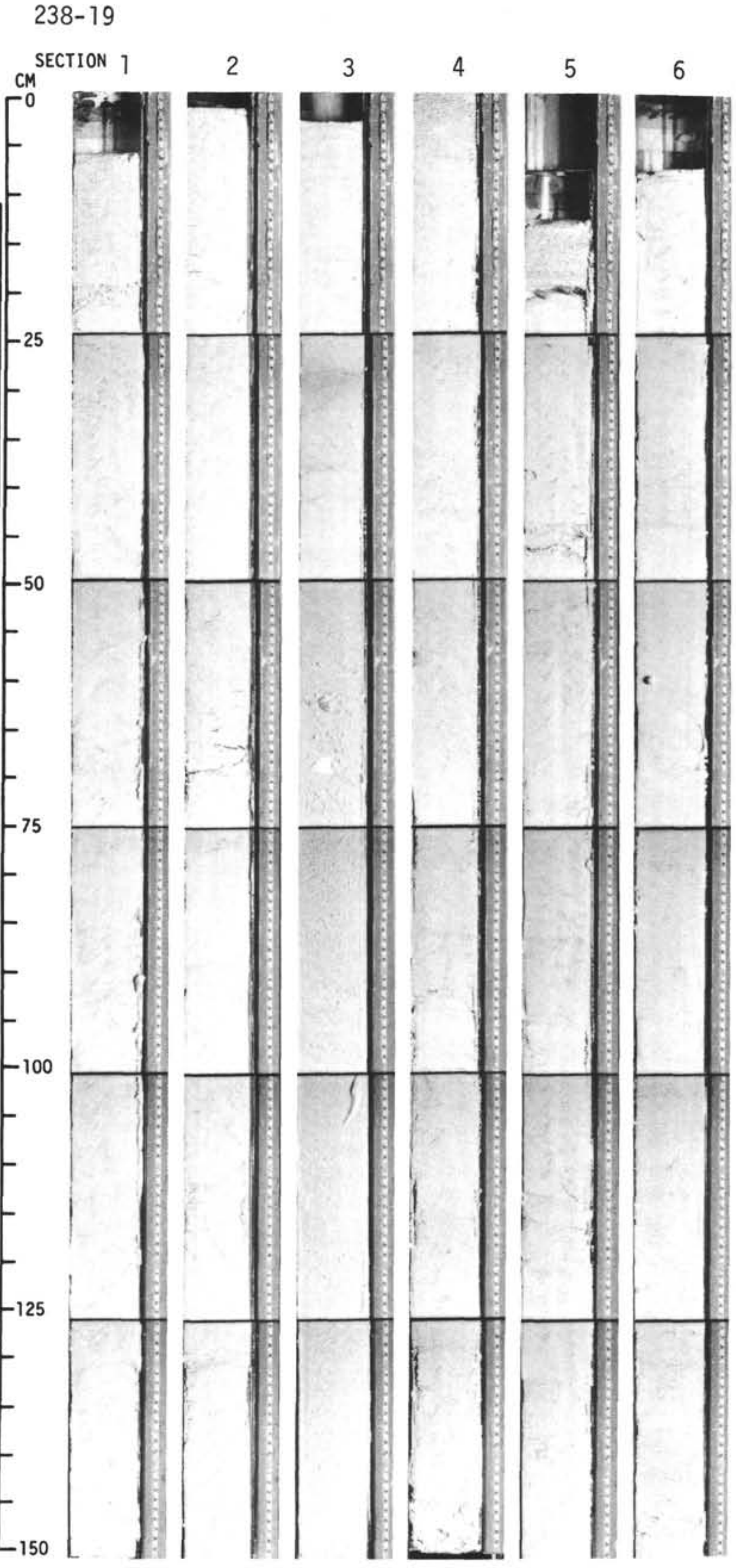
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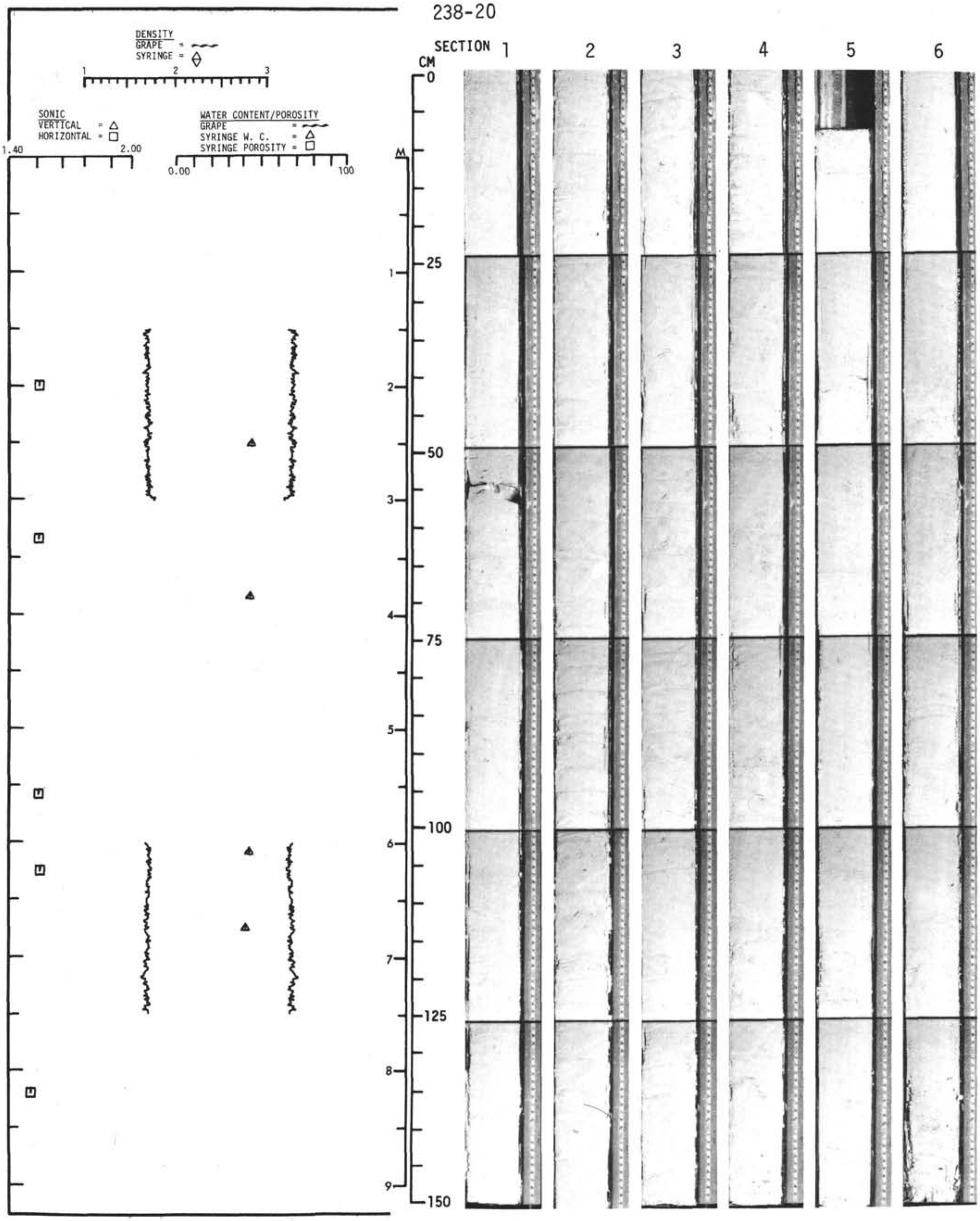
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8
9
DENSITY
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SYRINGE = ◊
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SONIC
VERTICAL = △
HORIZONTAL = □
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WATER CONTENT/POROSITY
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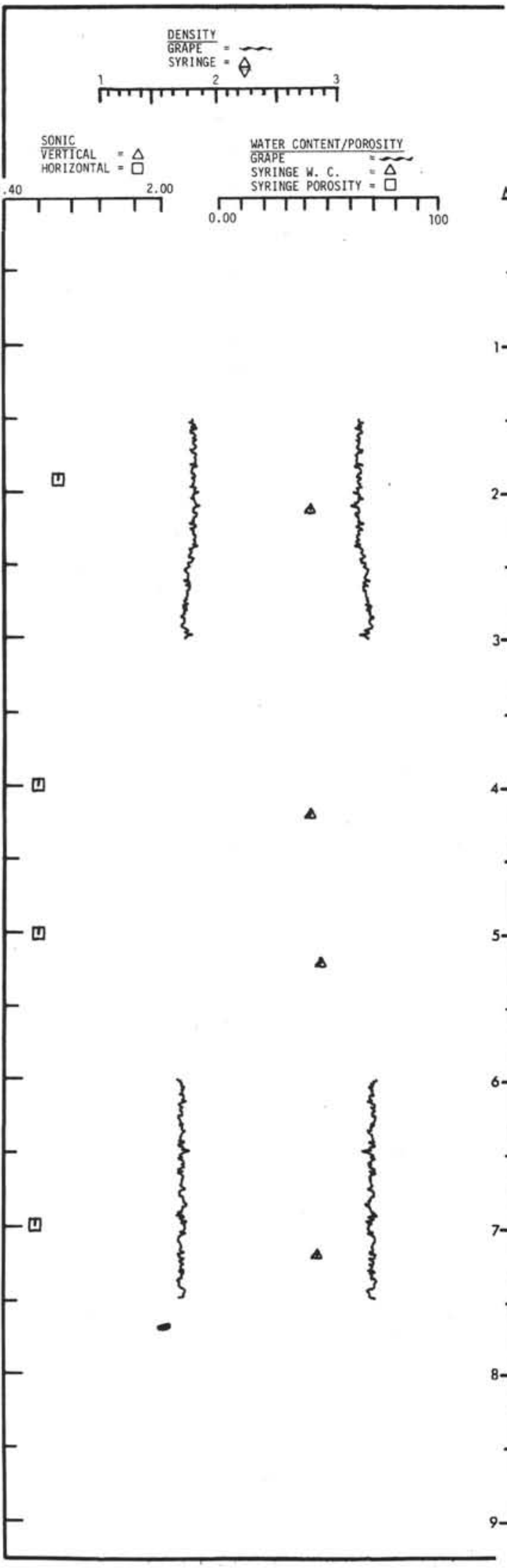
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HORIZONTAL = □
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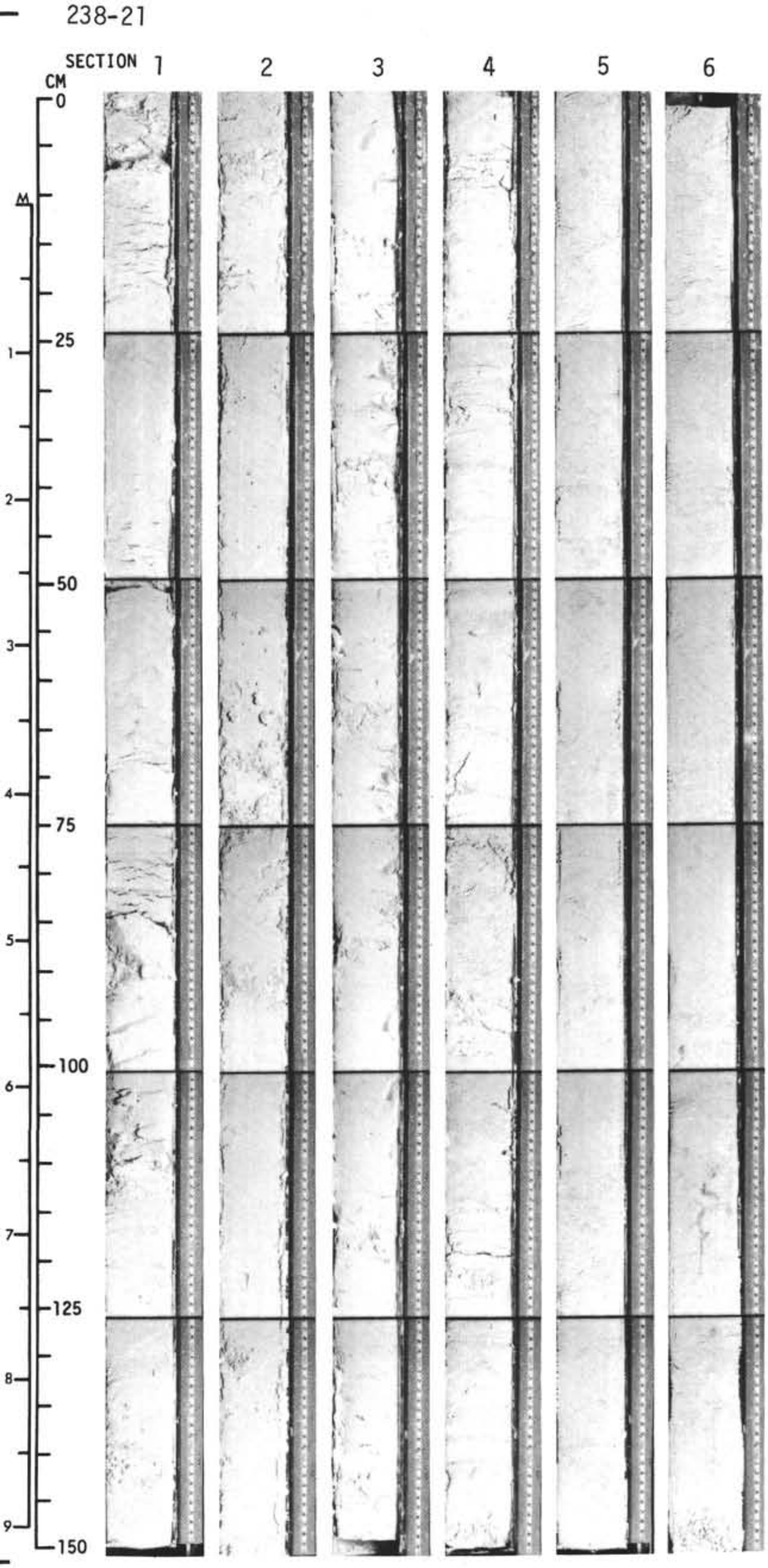
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SECTION
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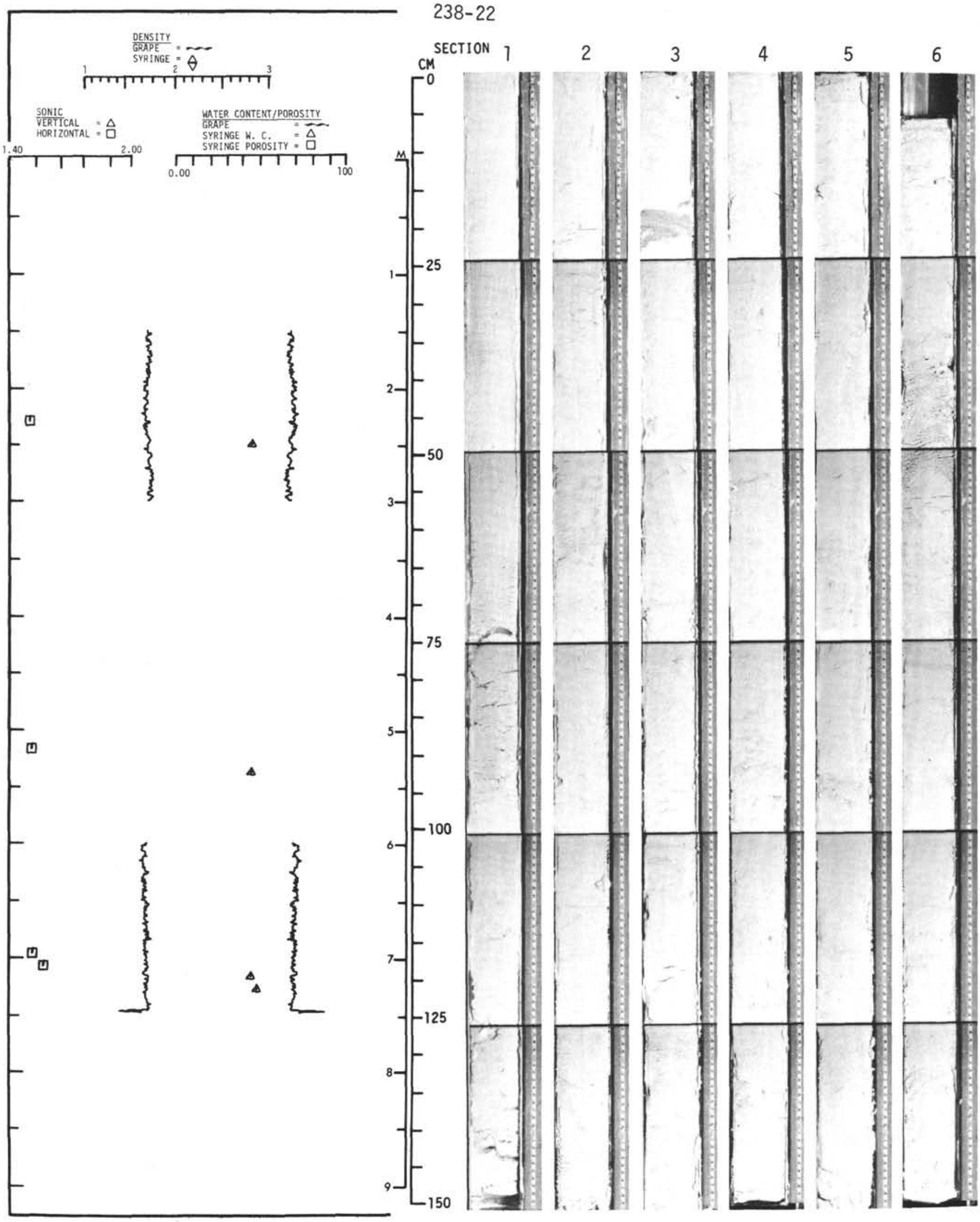
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M
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SECTION 1 2 3 4 5 6
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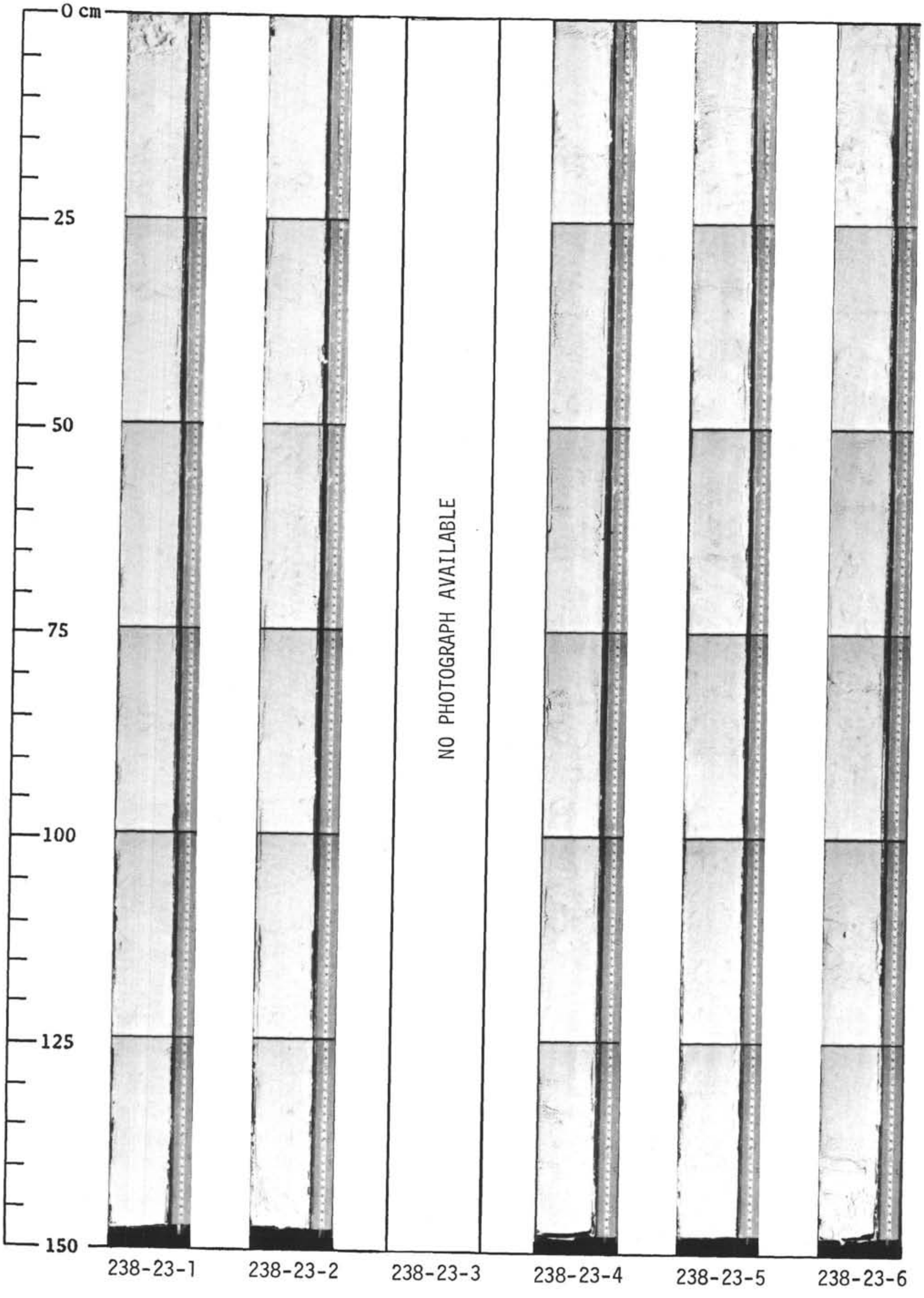
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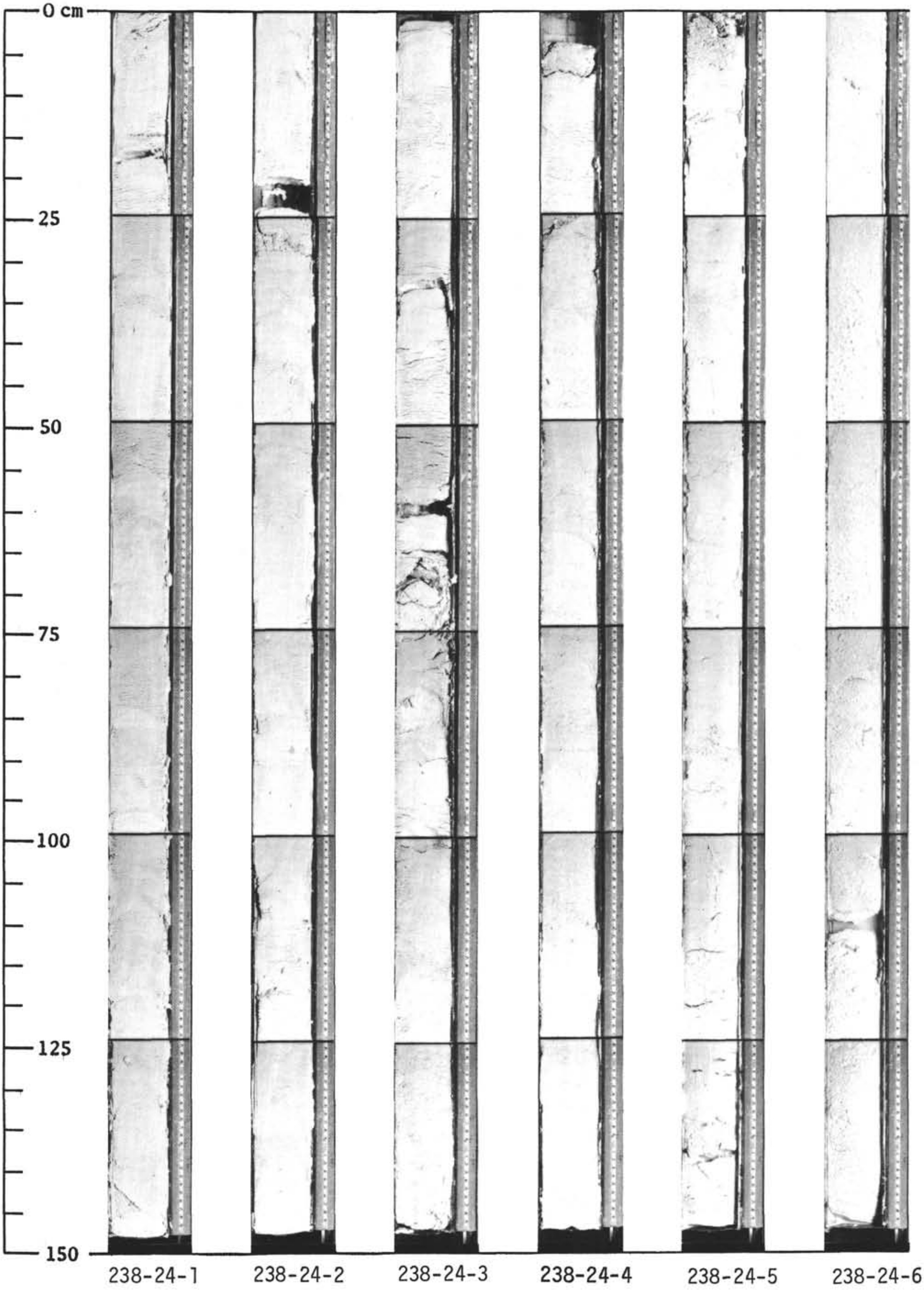
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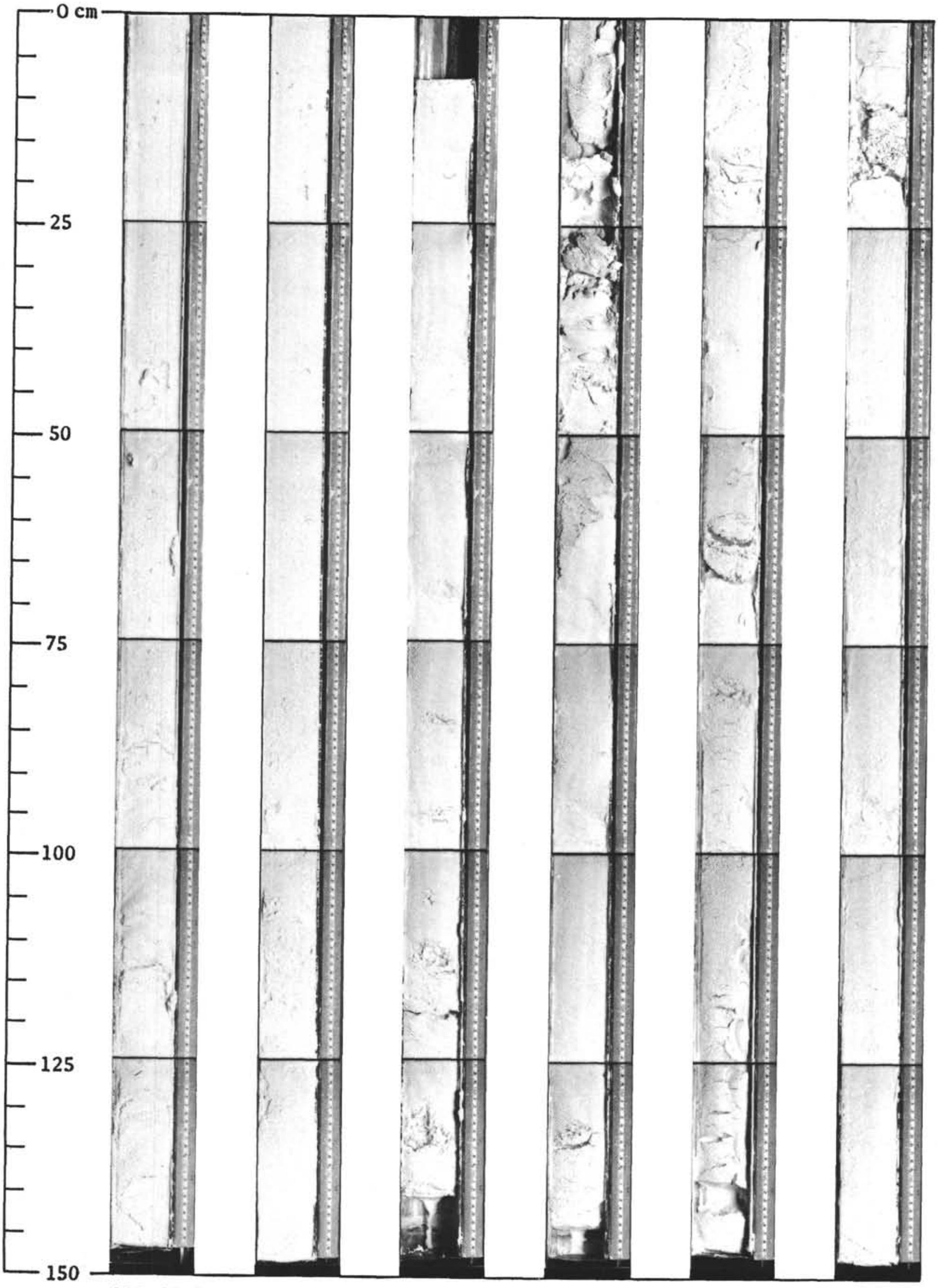
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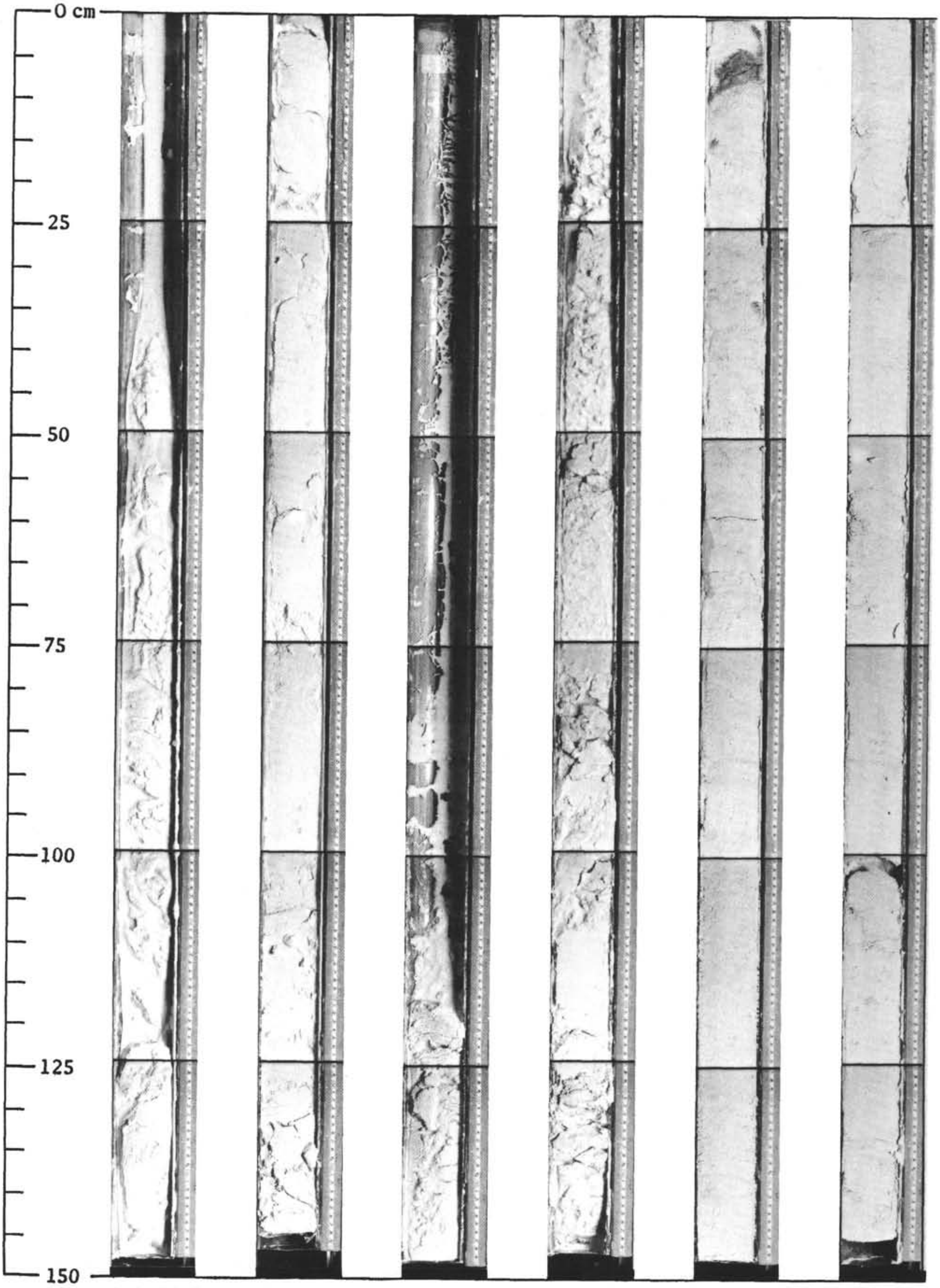
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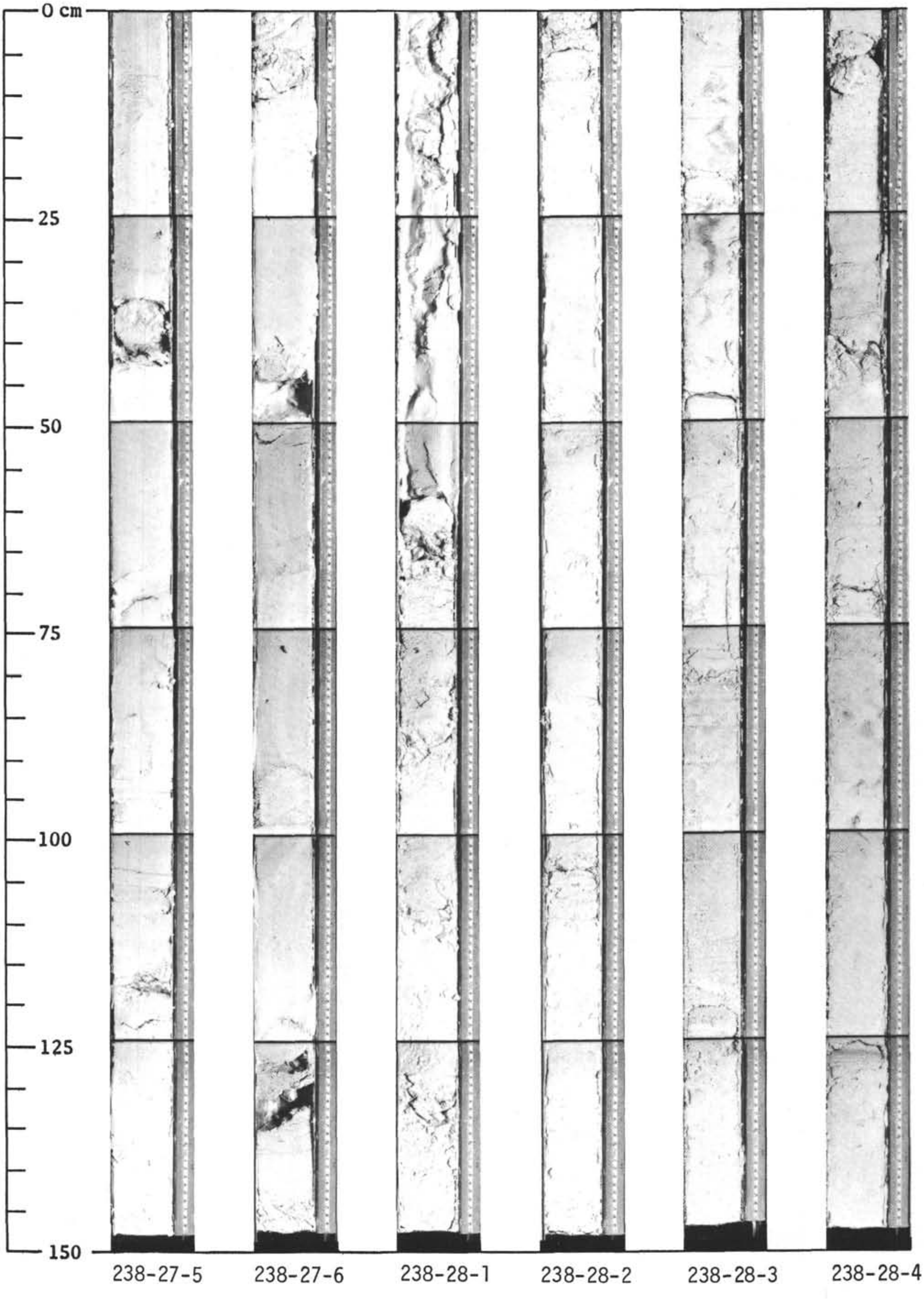
238-27-4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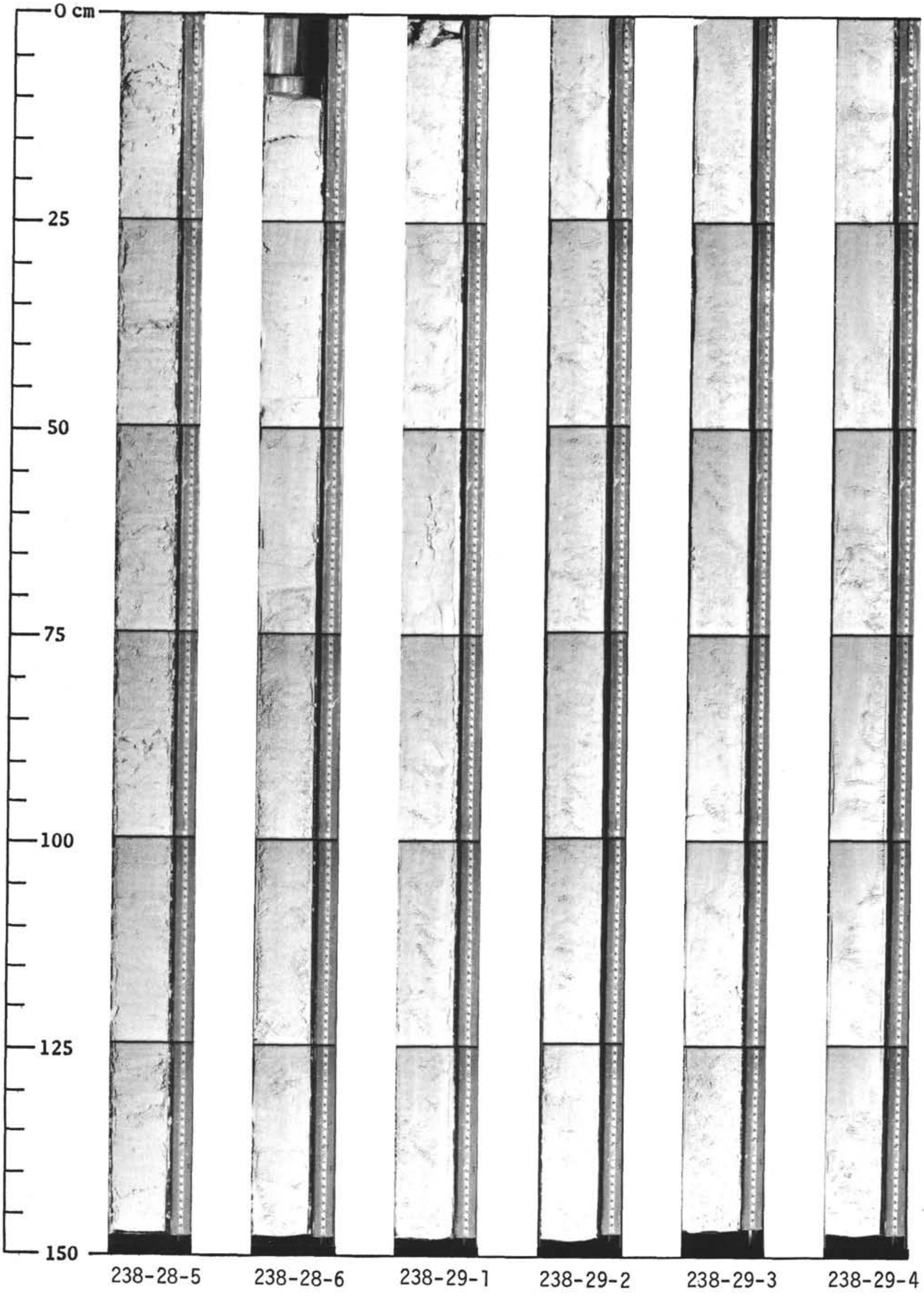
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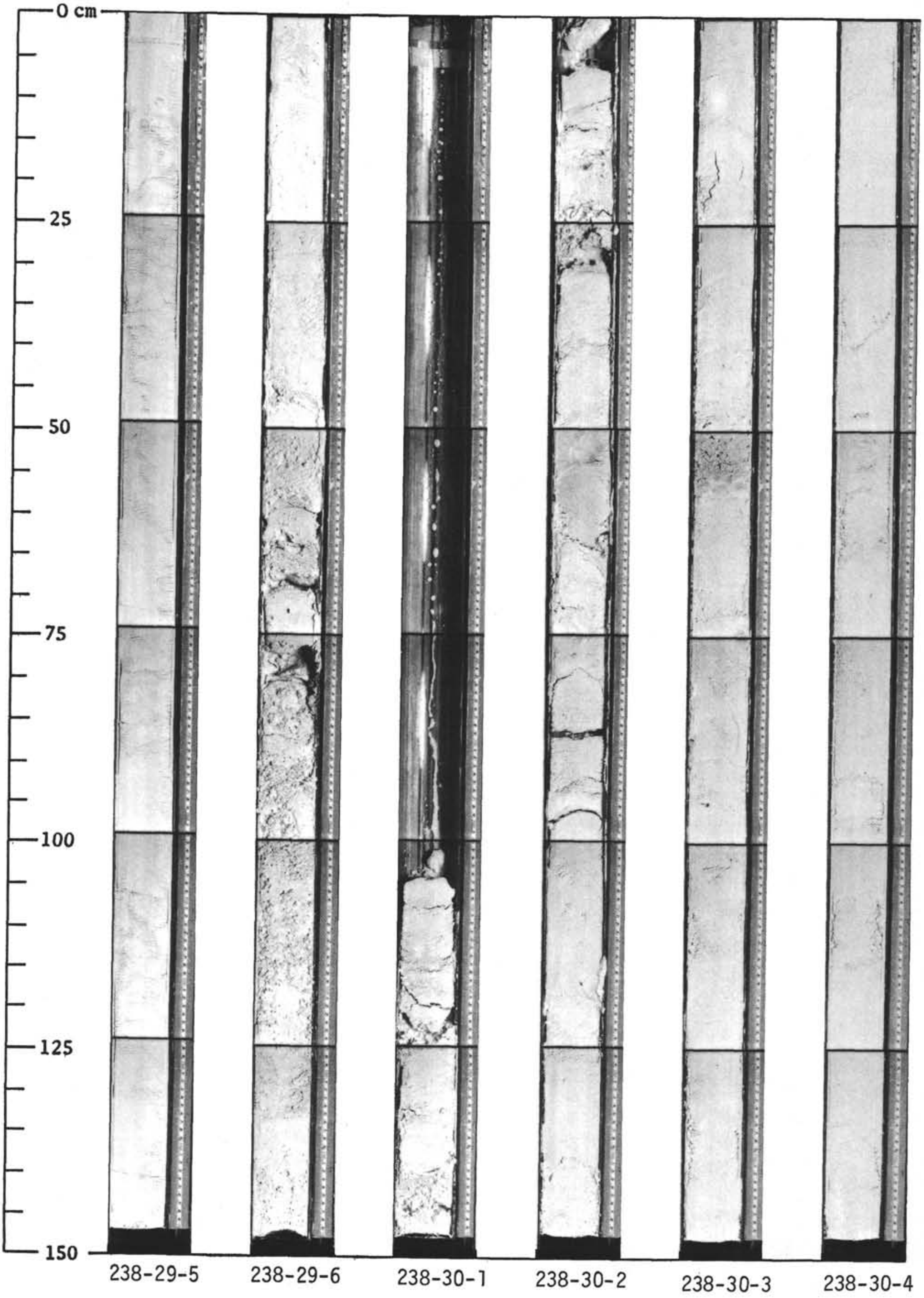
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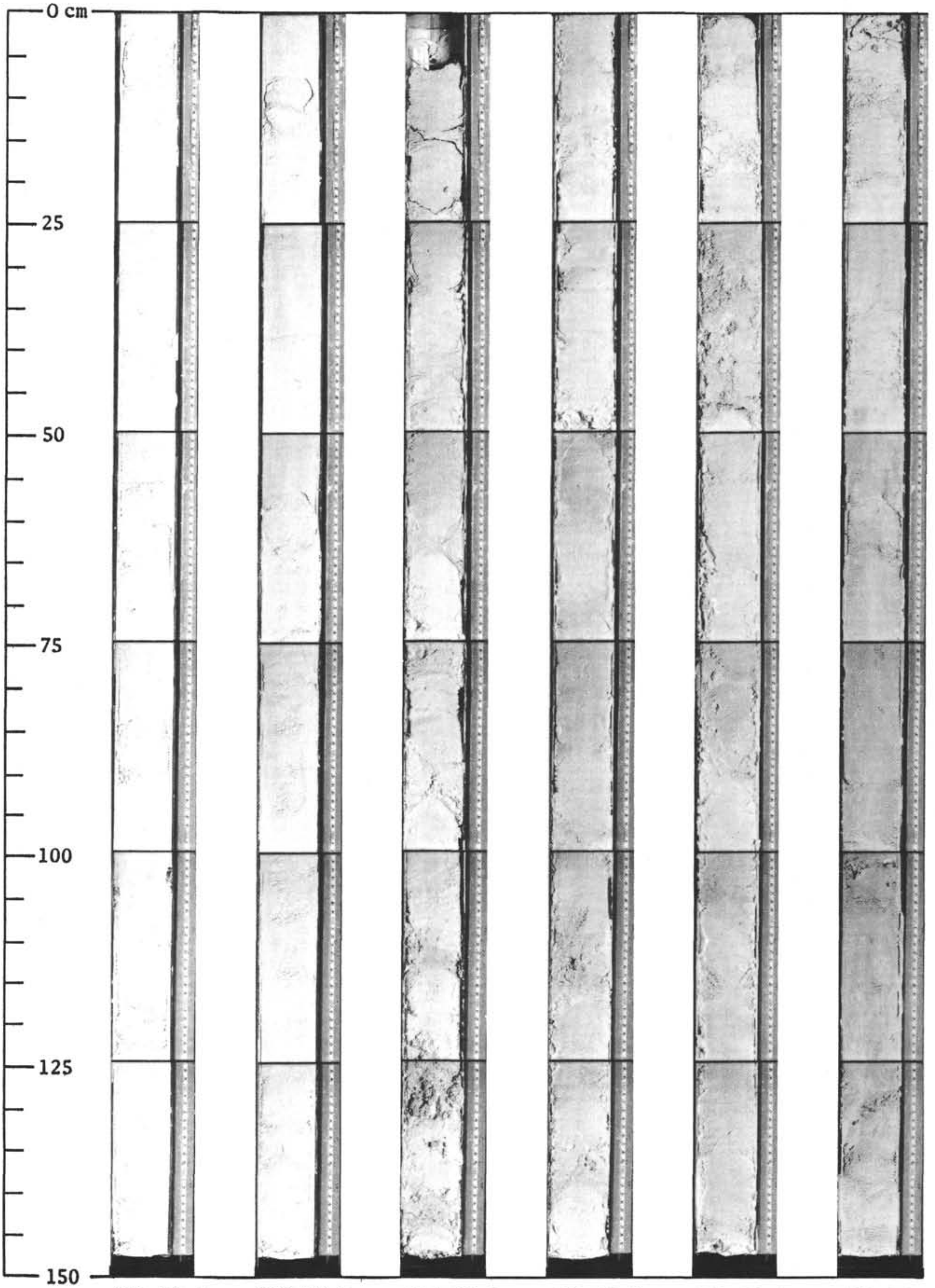
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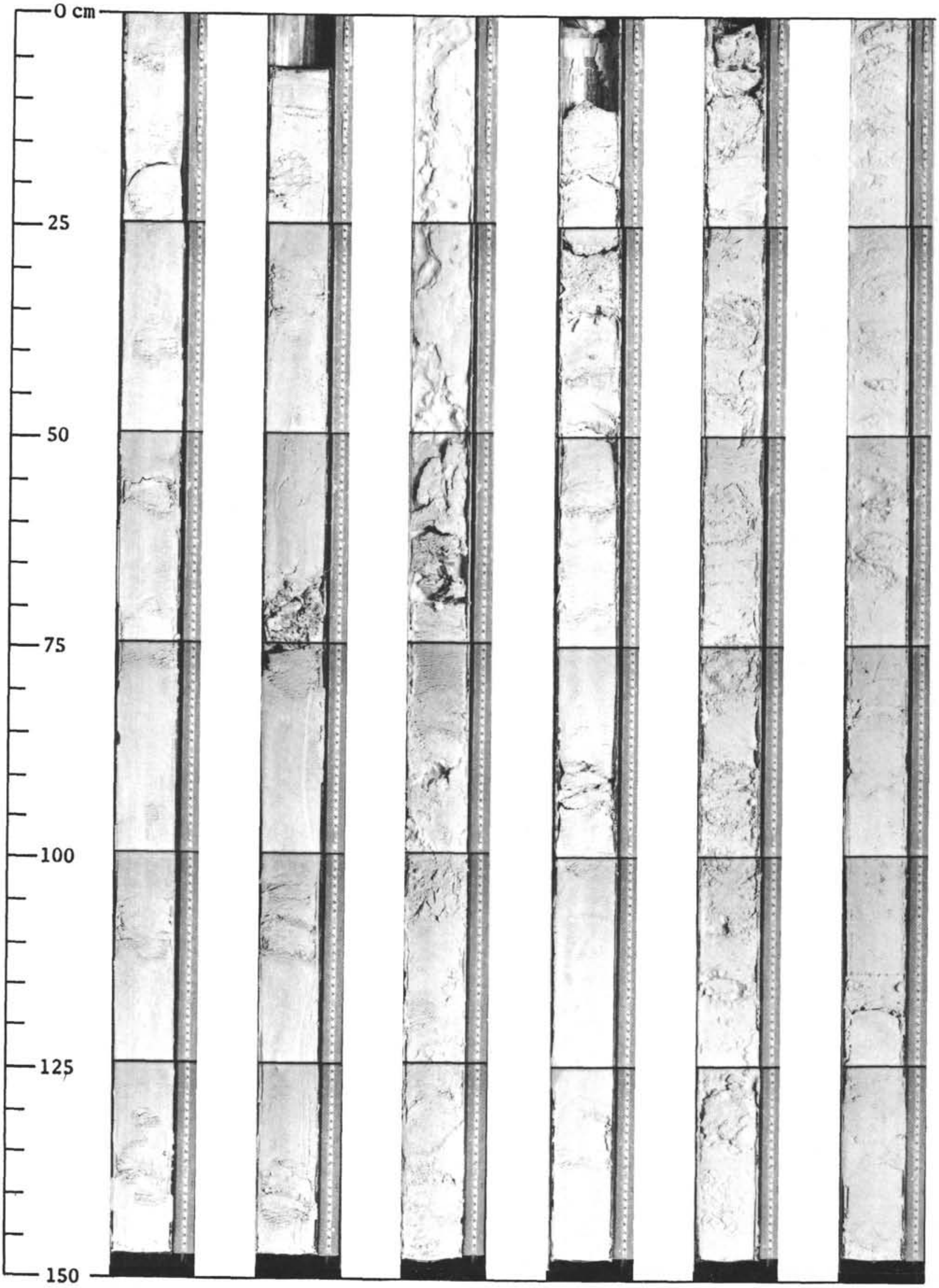

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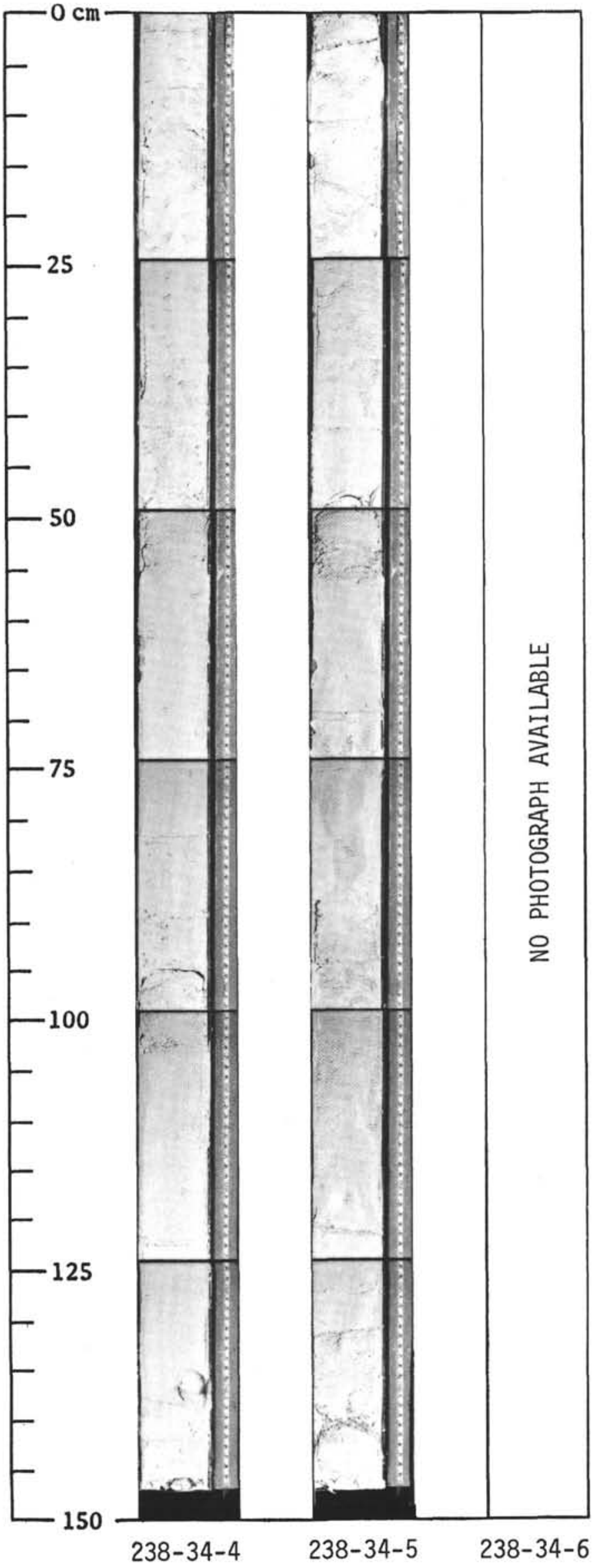
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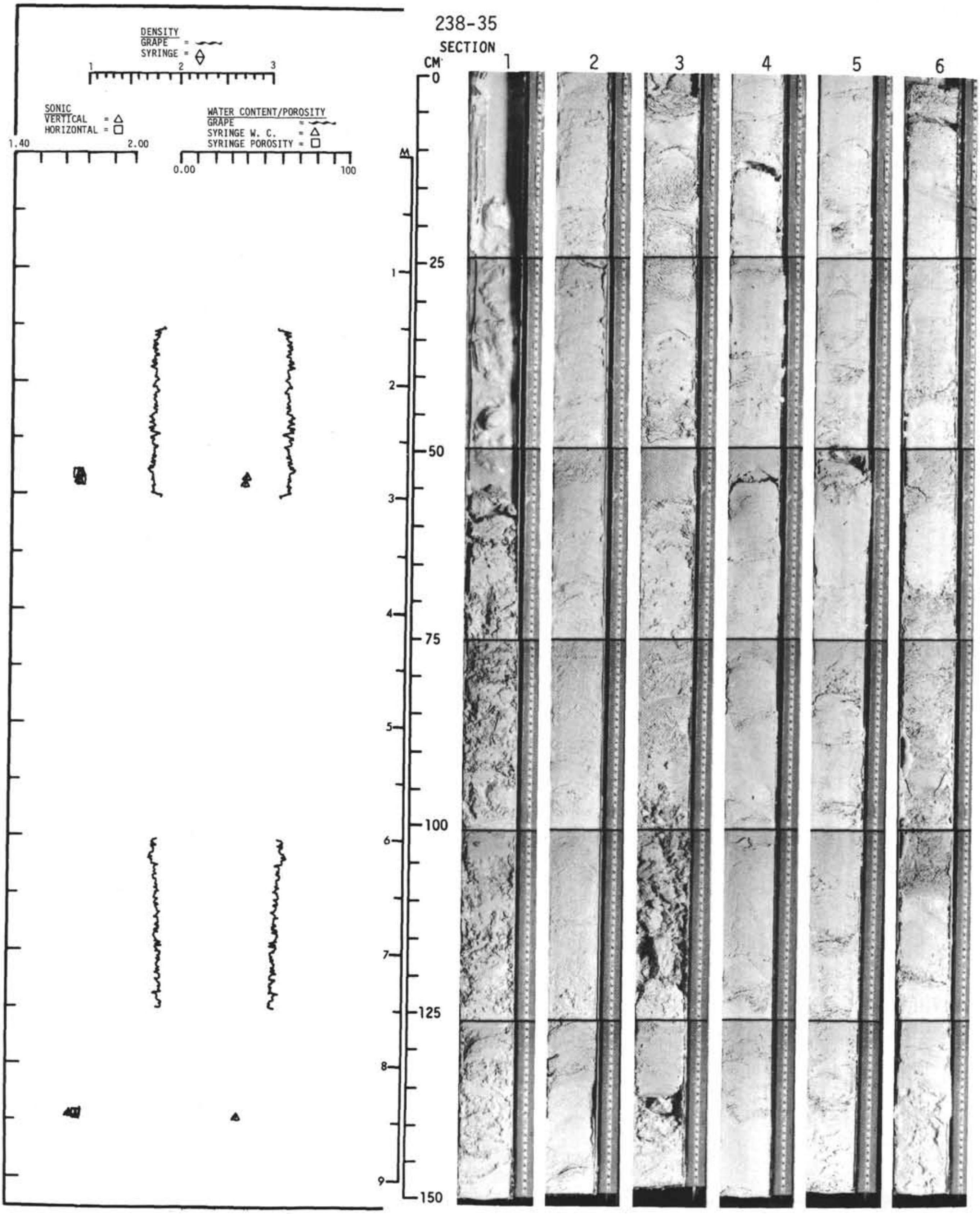
238-34-6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SONIC
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HORIZONTAL = □
1.40
2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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100
M
1
2
3
4
5
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238-35
SECTION
CM
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125
150
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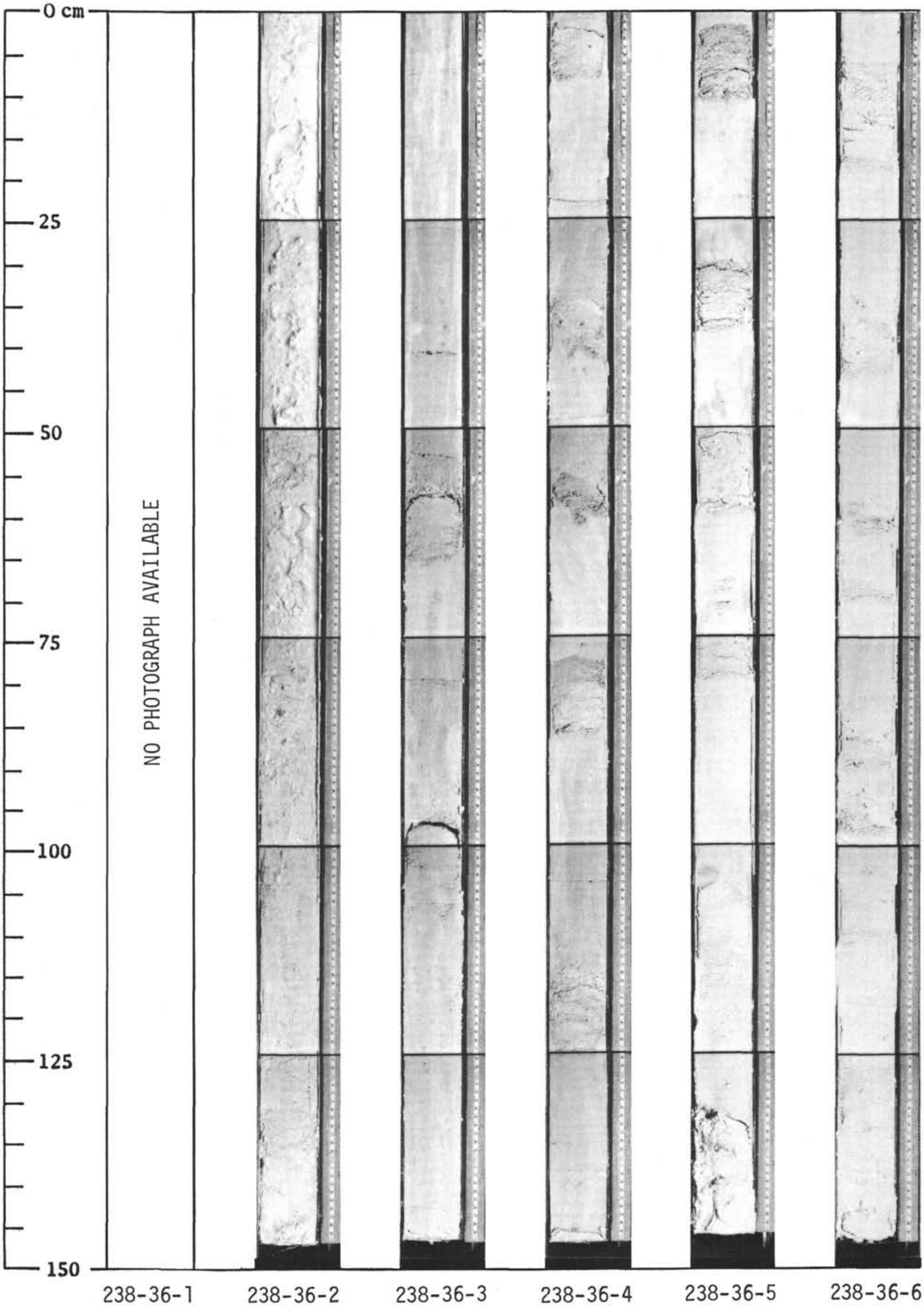
3
4
5
6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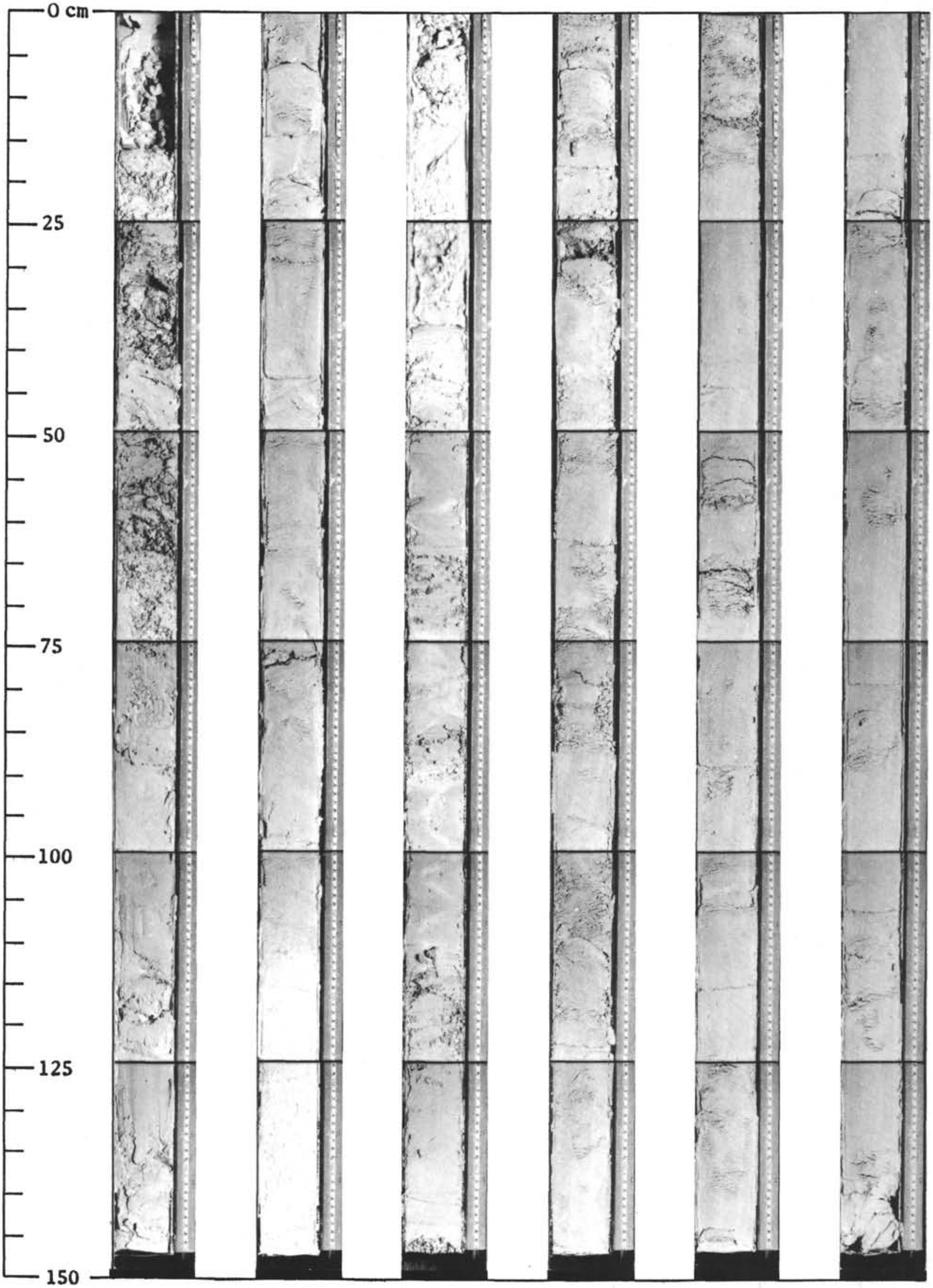
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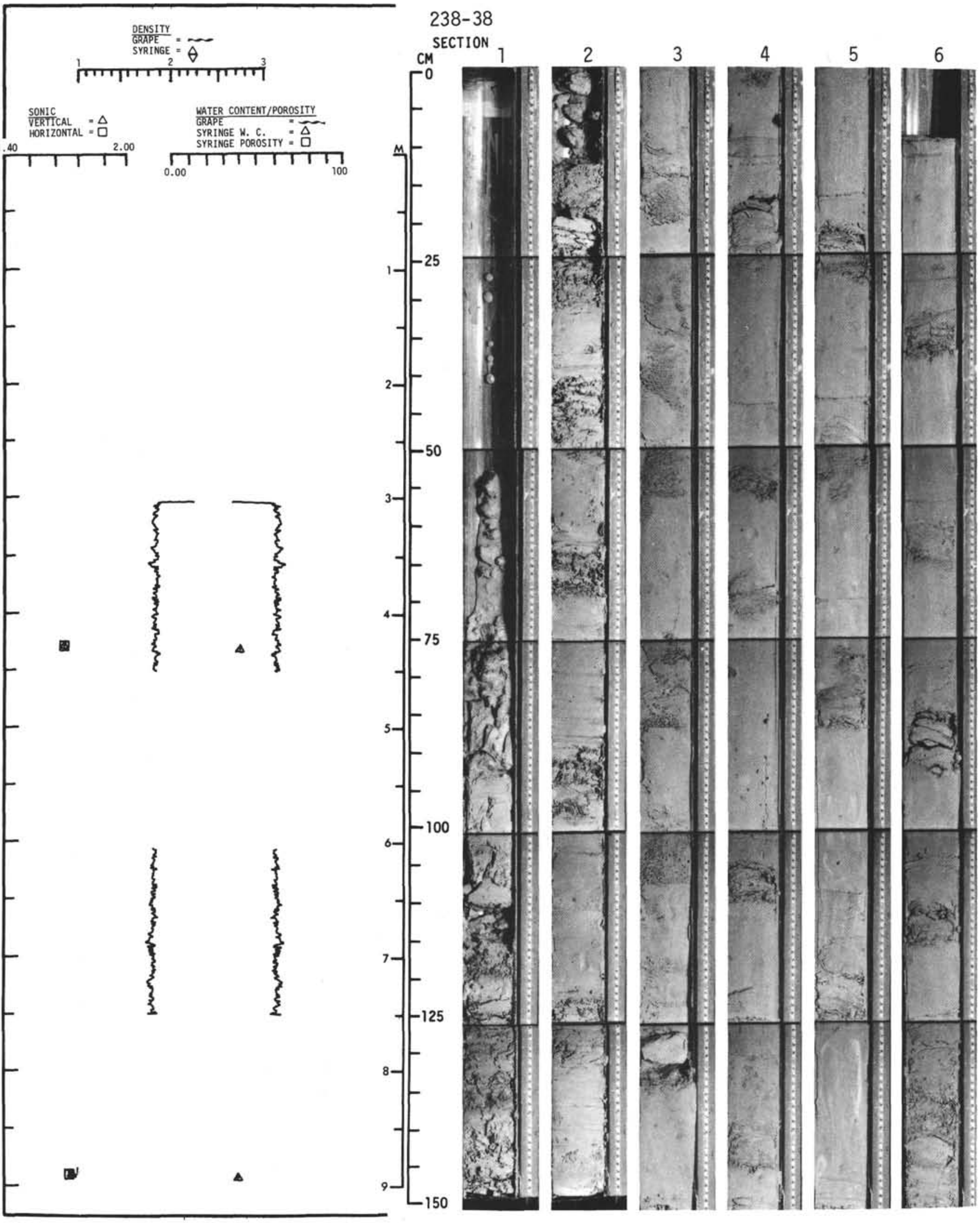
238-37-6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SONIC
VERTICAL =
HORIZONTAL =
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2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. =
SYRINGE POROSITY =
0.00
100
M
1
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4
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6
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8
9
238-38
SECTION
CM
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75
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125
150
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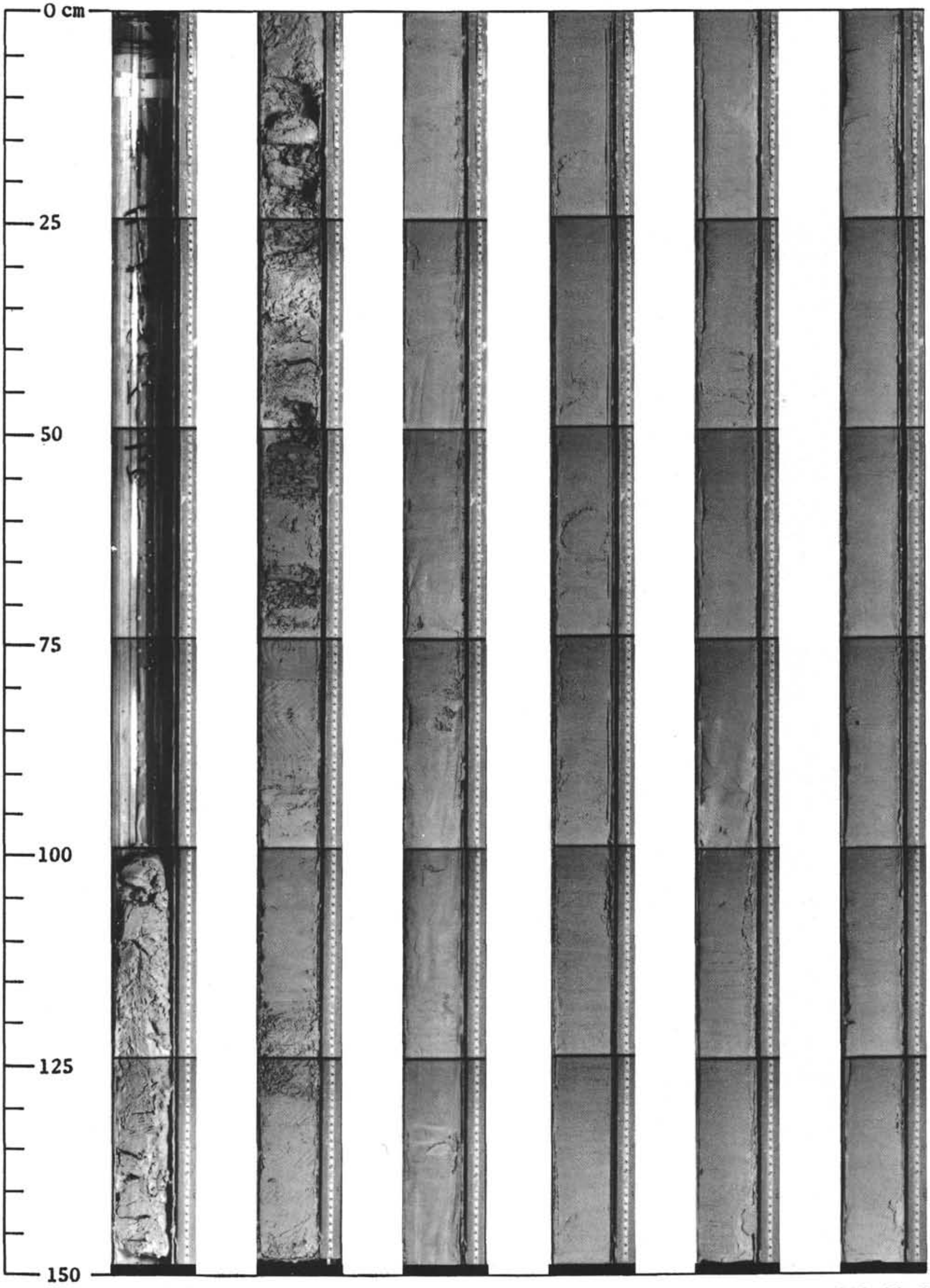
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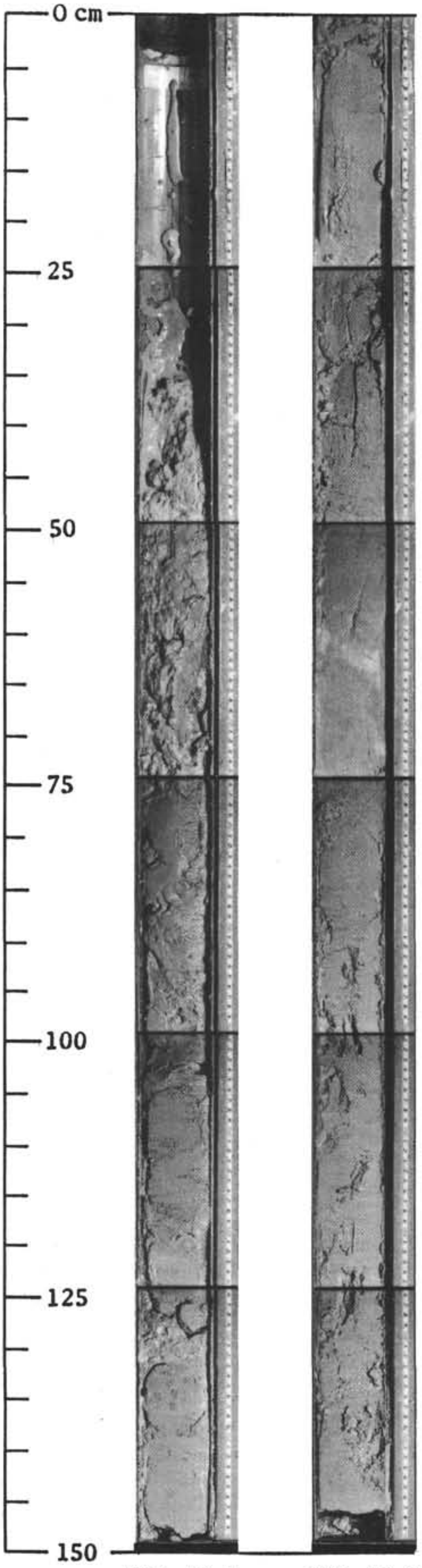
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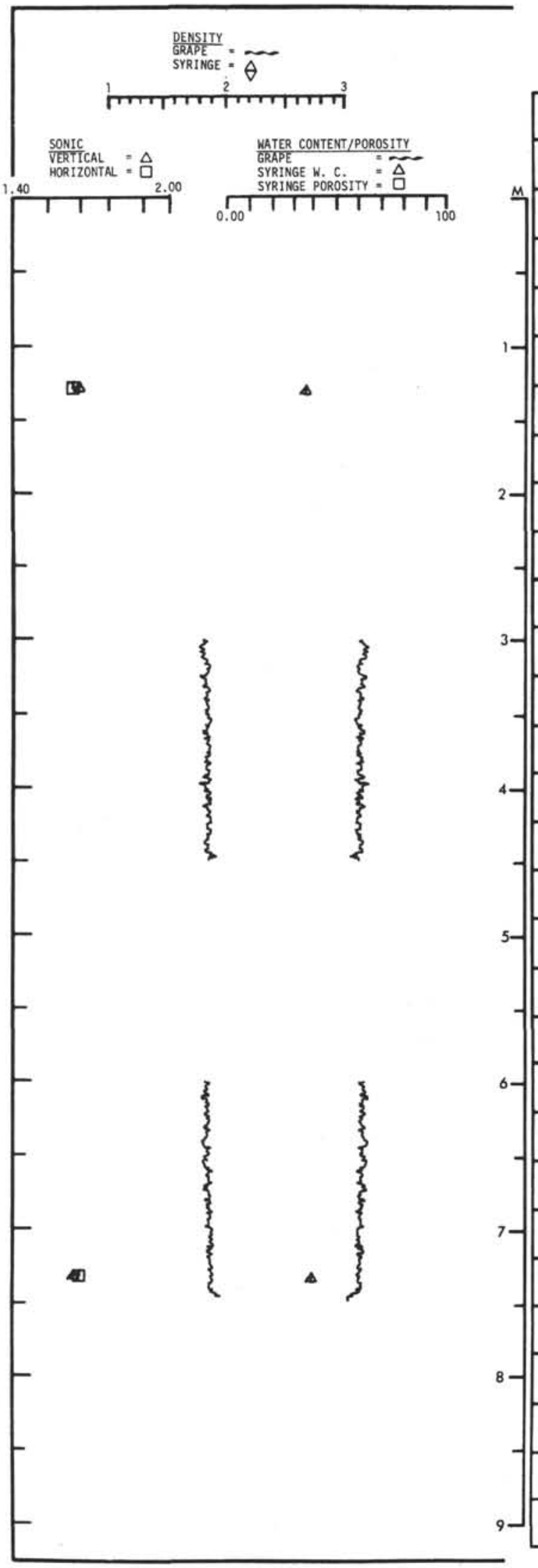
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
100
M
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2
3
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6
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8
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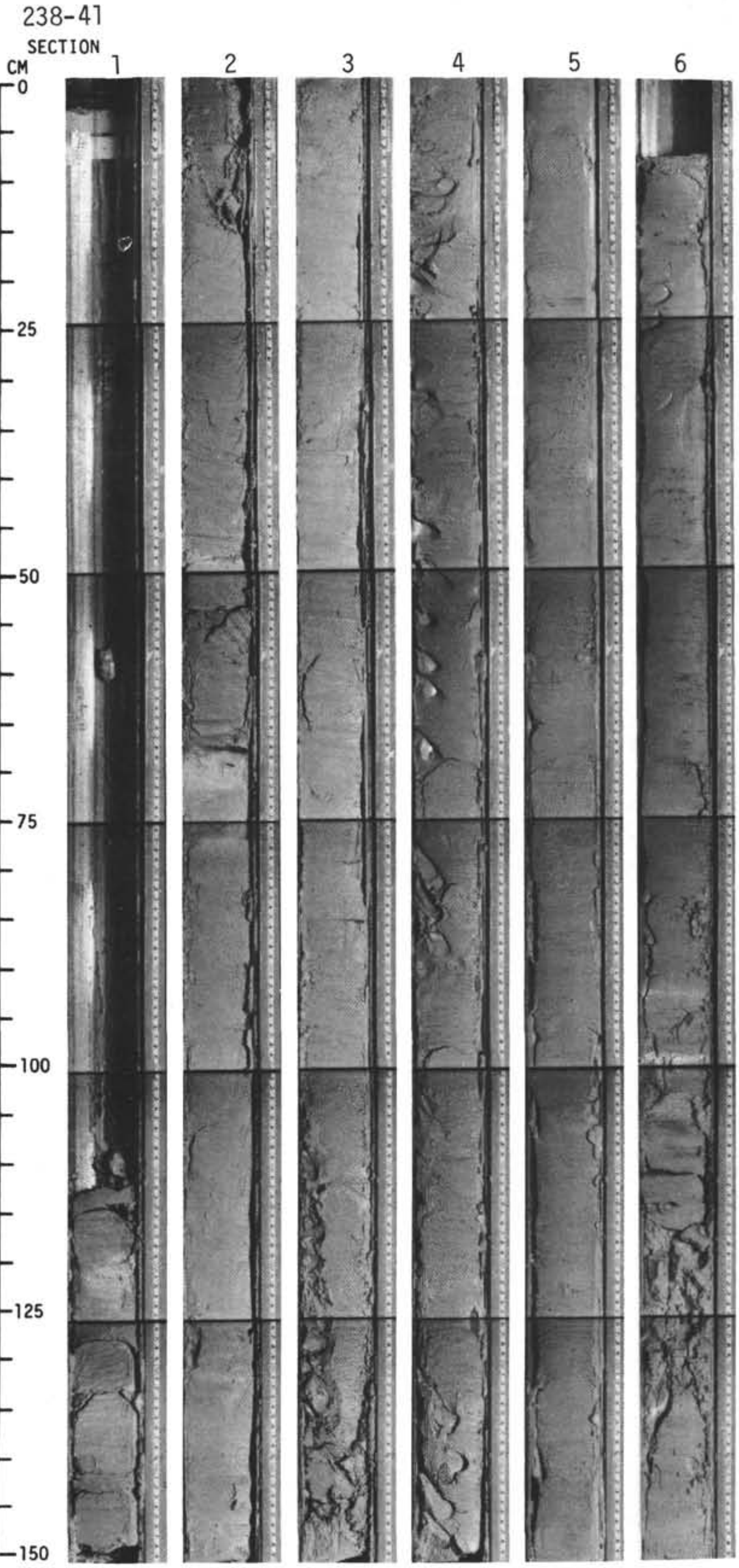
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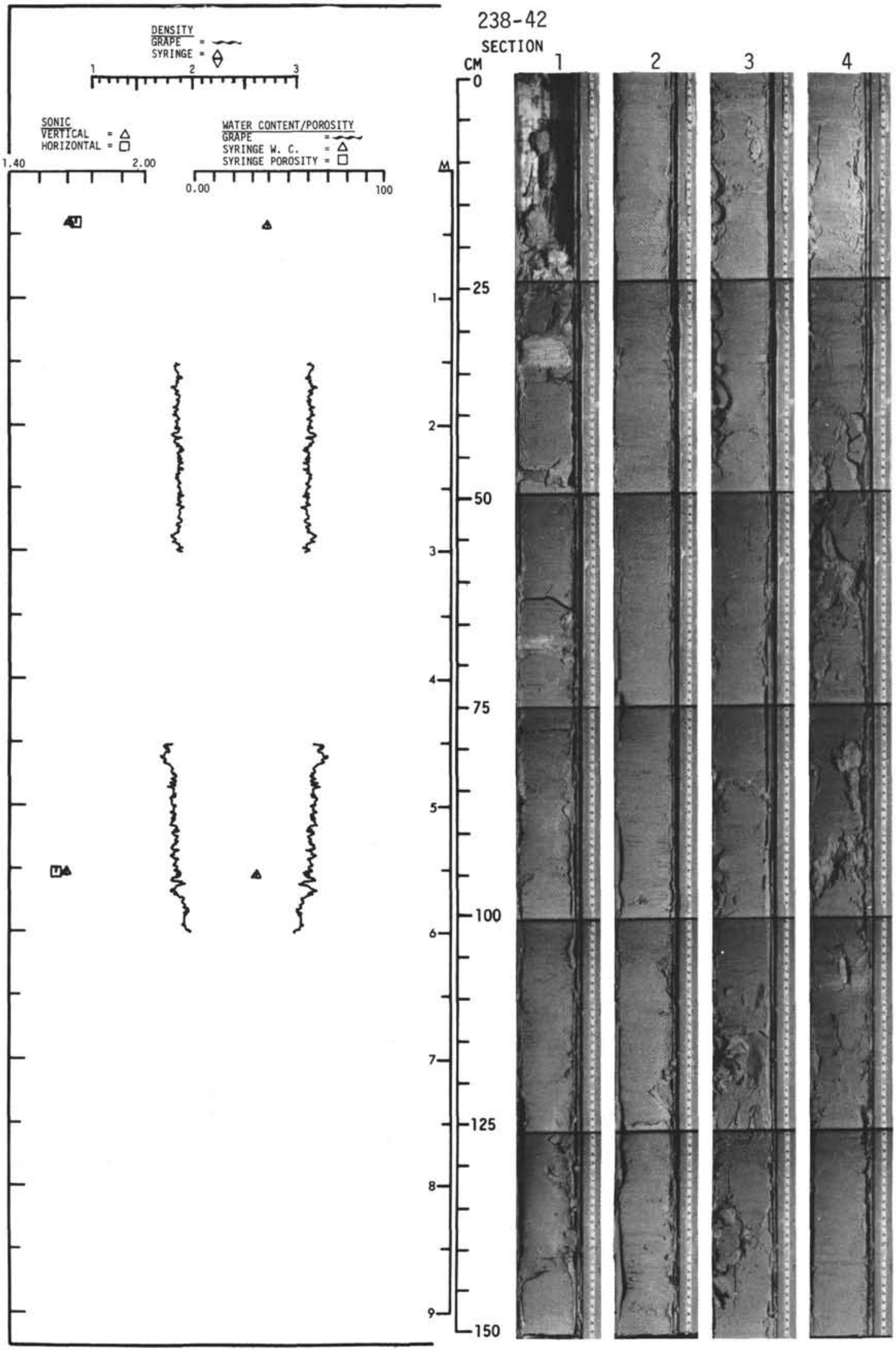
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2.00
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GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
100
M
1
2
3
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6
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9
CM
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238-42
SECTION
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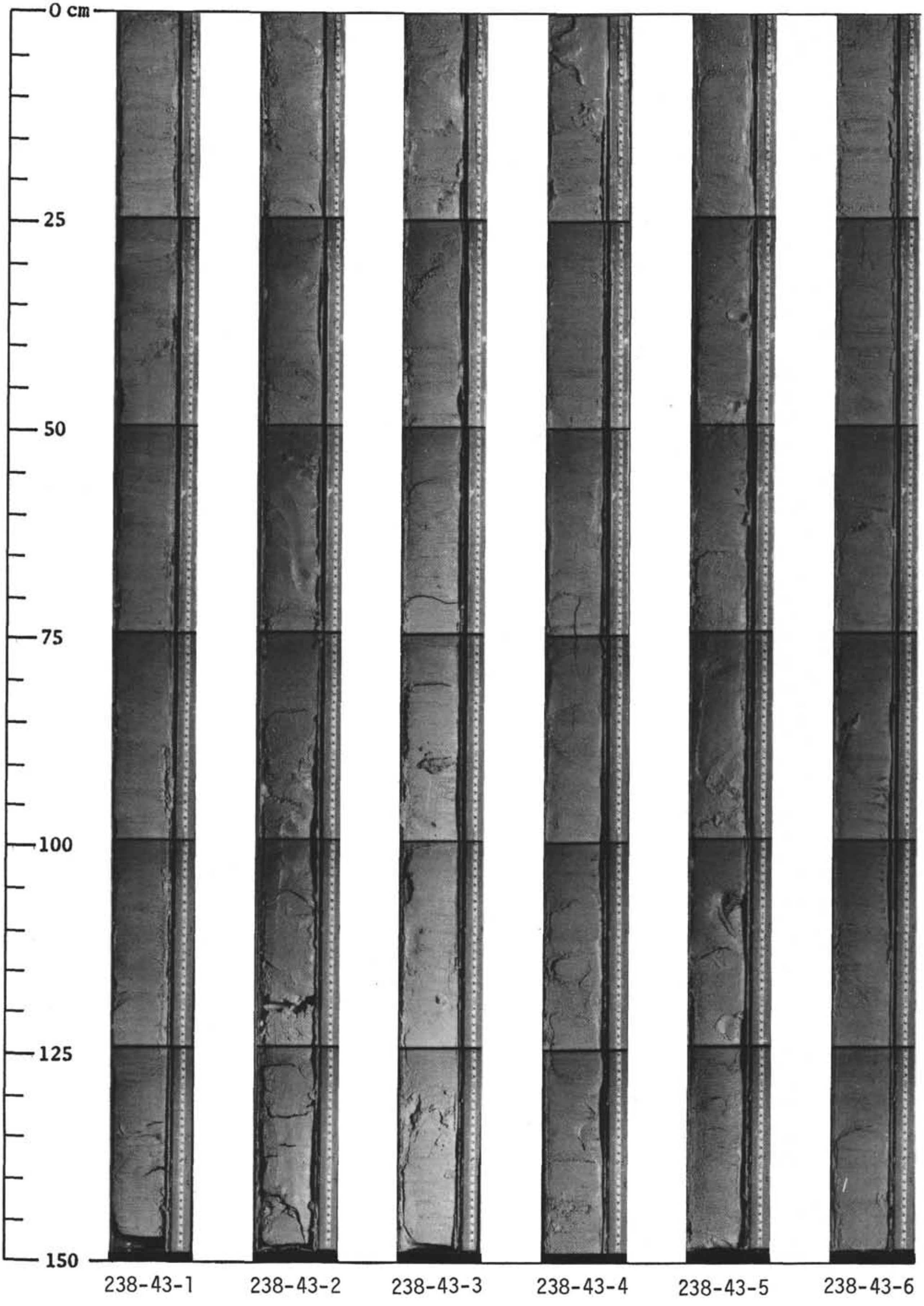
3
4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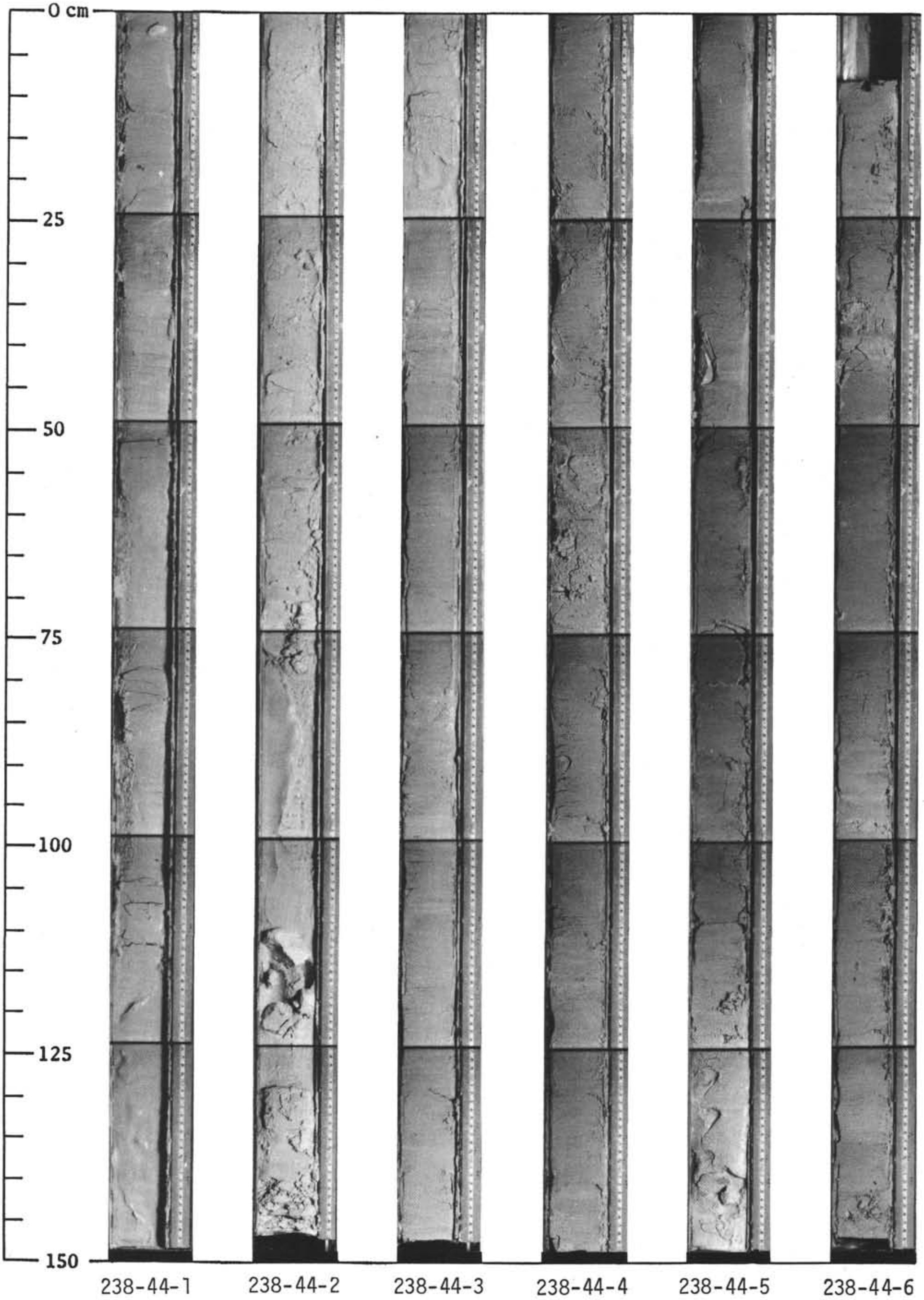
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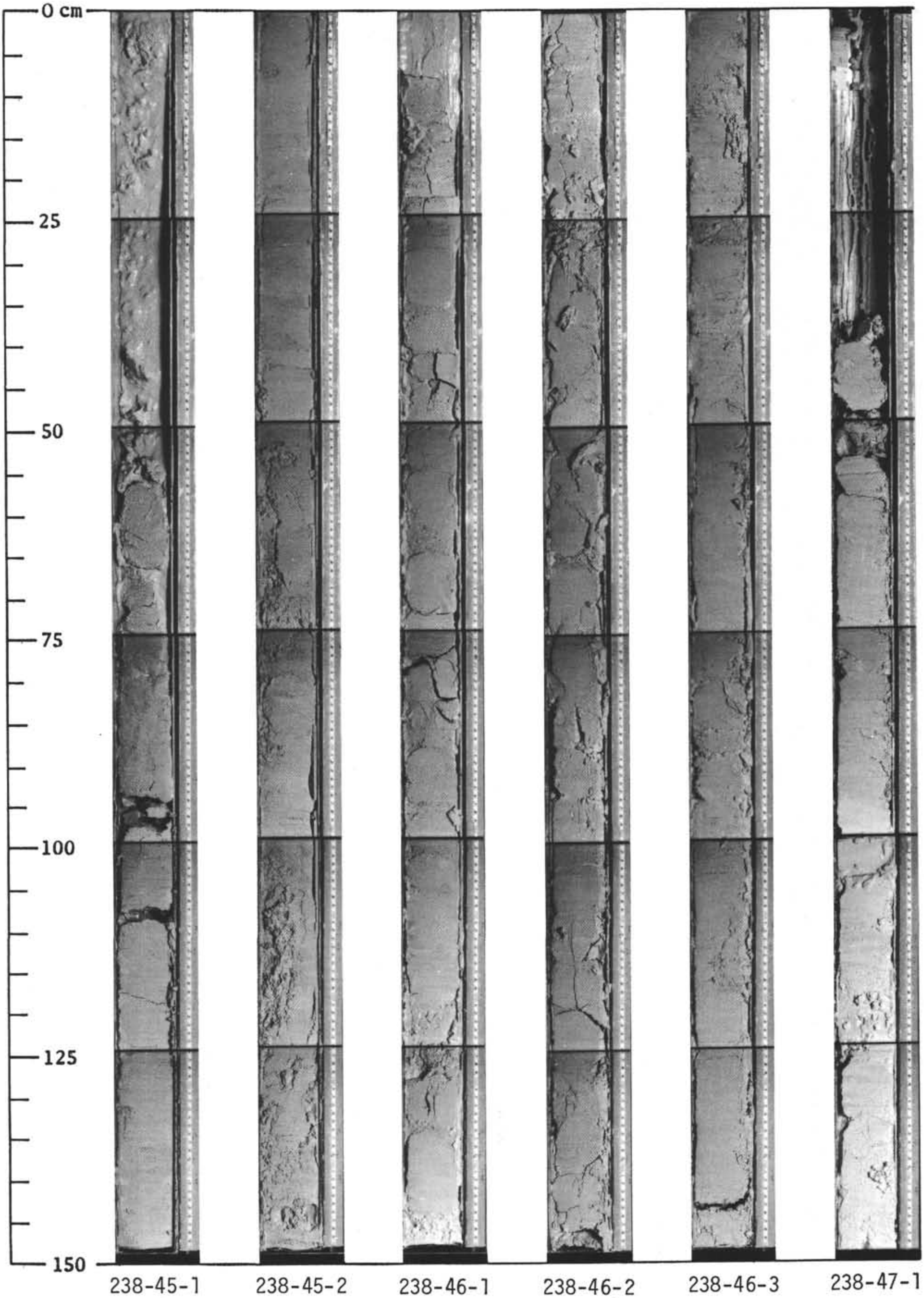
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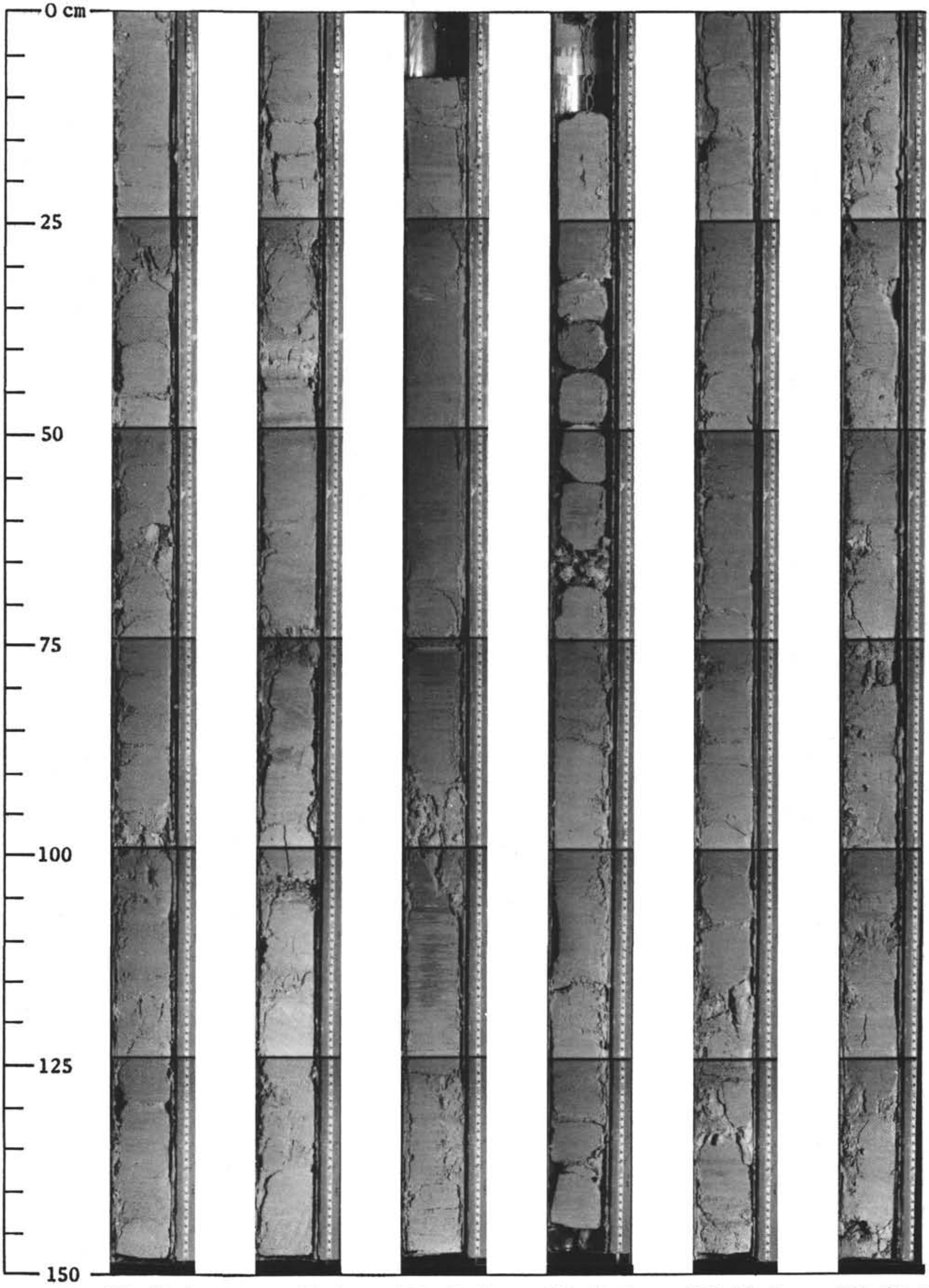
238-46-3
238-47-1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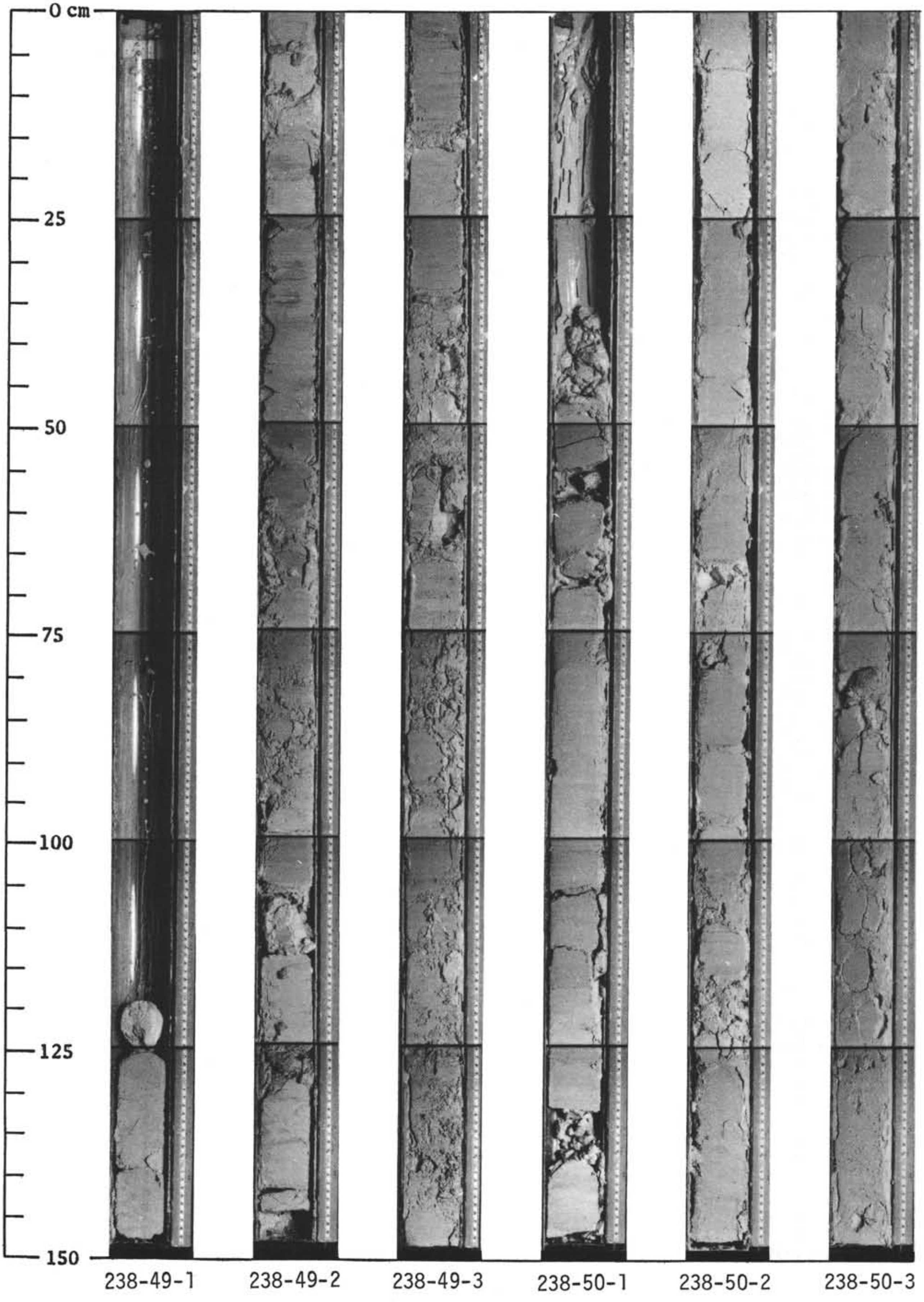
238-48-2
238-48-3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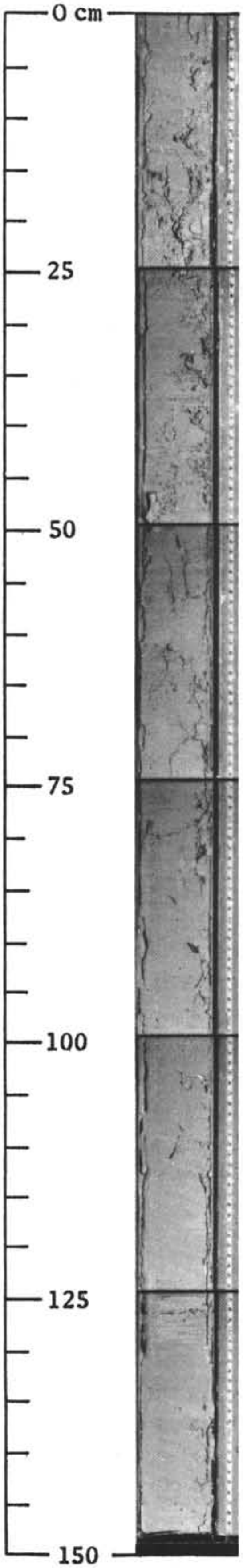
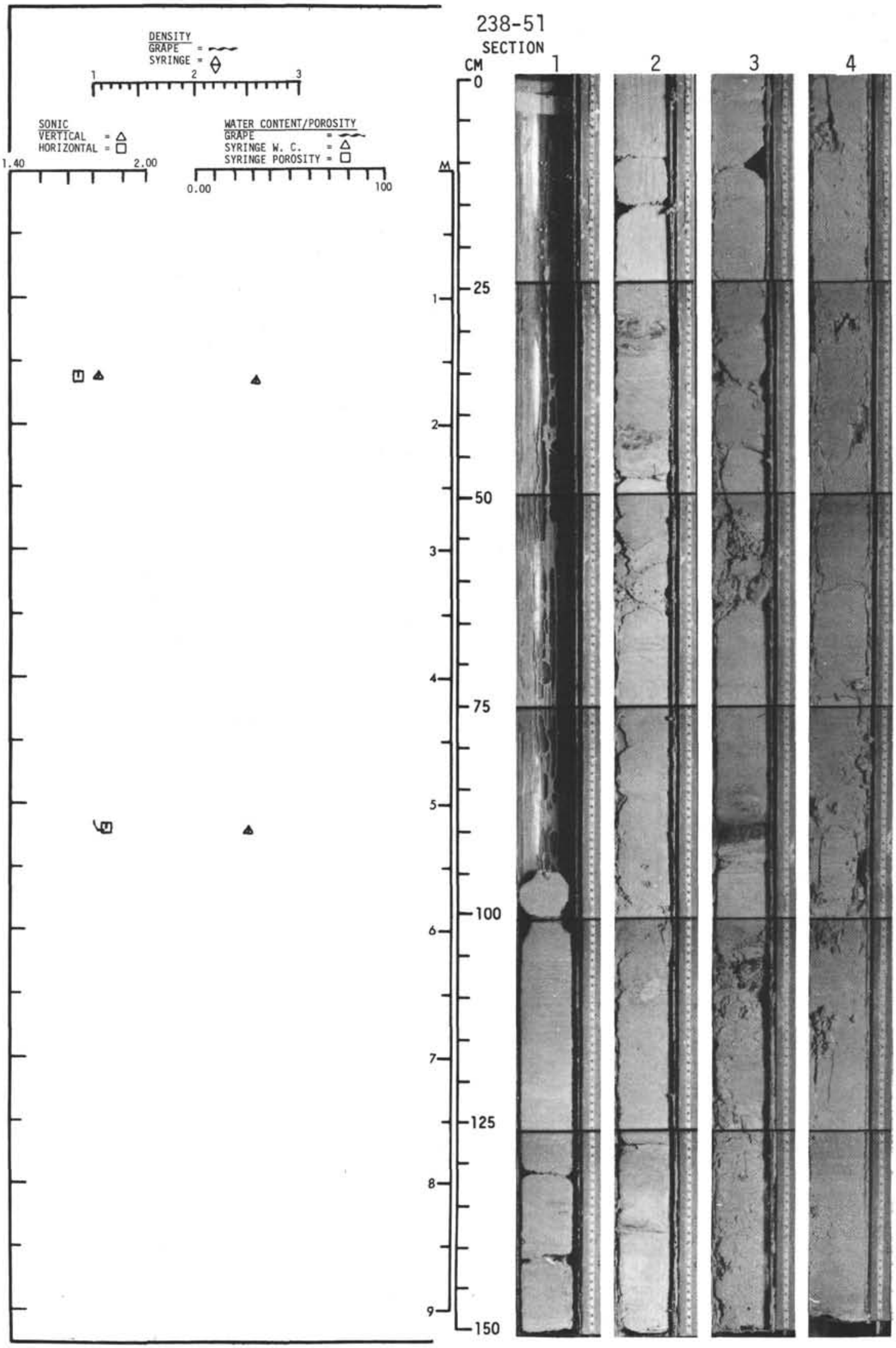
238-50-3



238-50-4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3
SONIC
VERTICAL = △
HORIZONTAL = □
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2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
100
M
1
2
3
4
5
6
7
8
9
238-51
SECTION
CM
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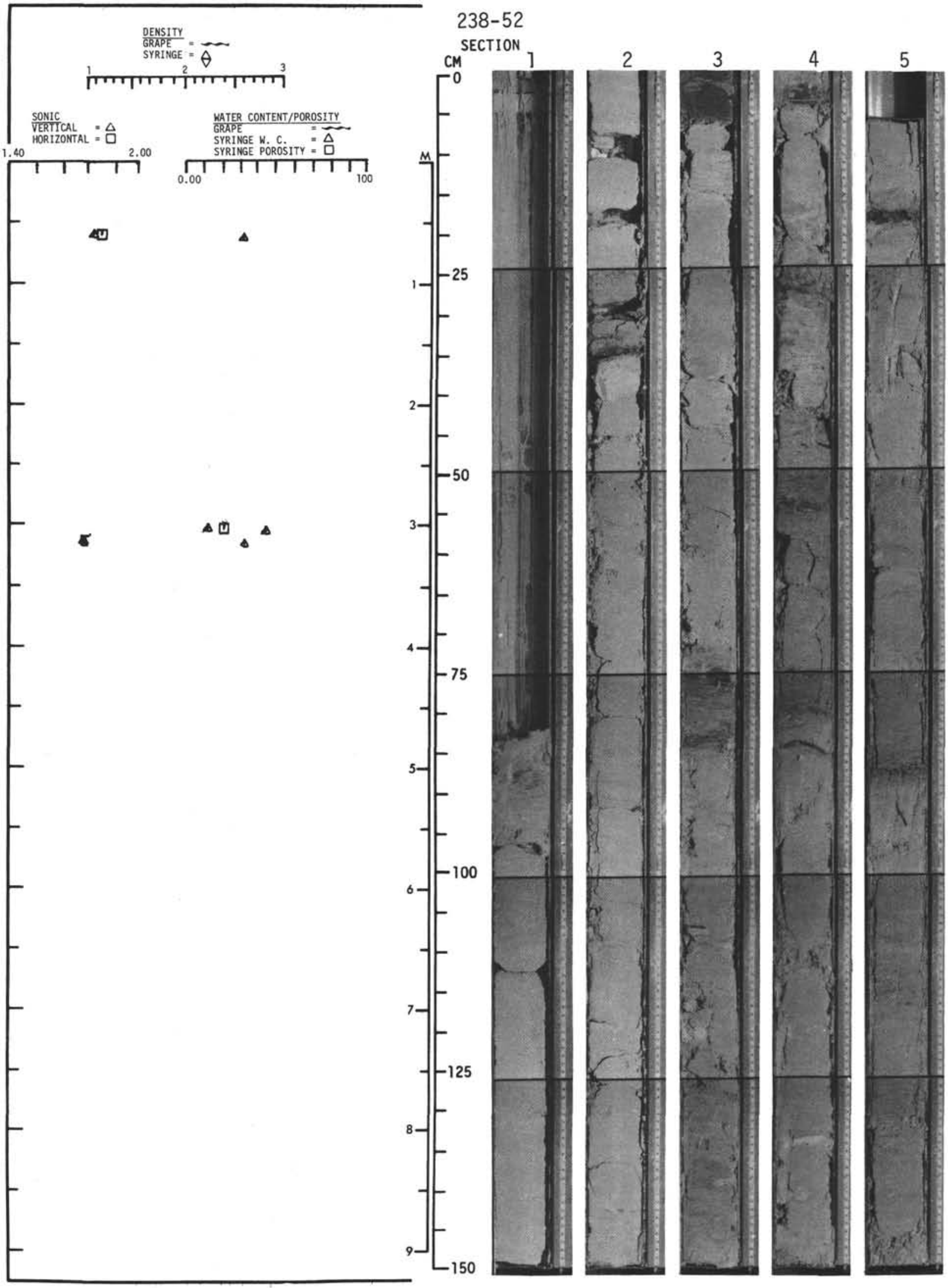
75
100
125
150
1
2
3
4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SONIC
VERTICAL = △
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2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
0.00
100
M
1
2
3
4
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238-52
SECTION
CM
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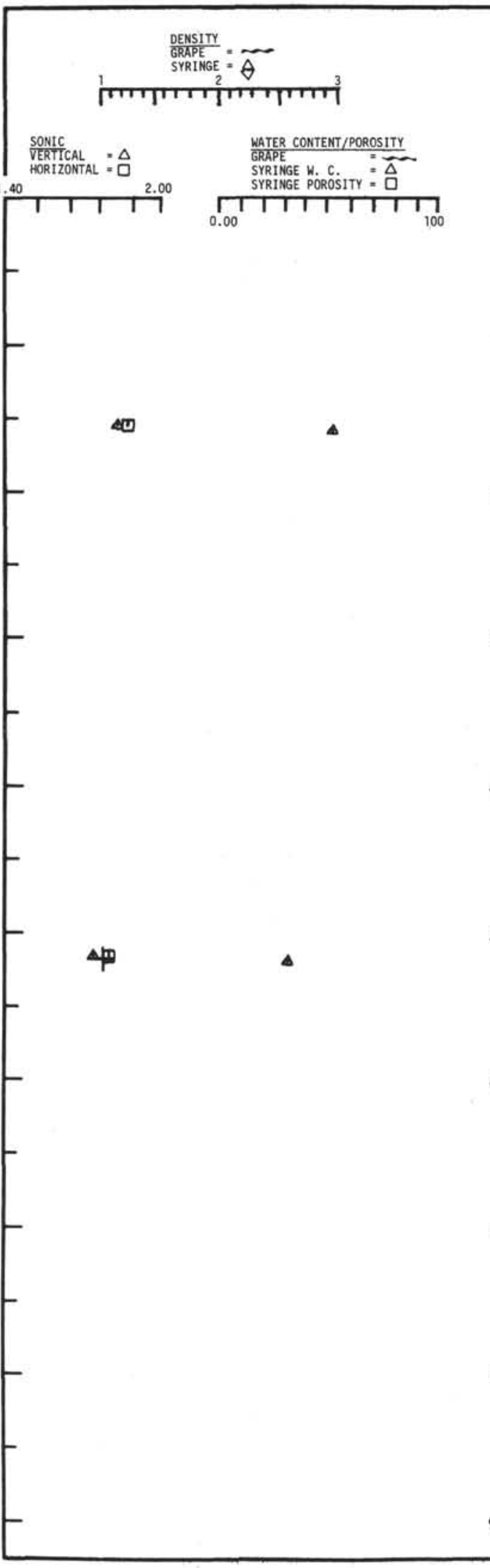
125
150
1
2
3
4
5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SONIC
VERTICAL = △
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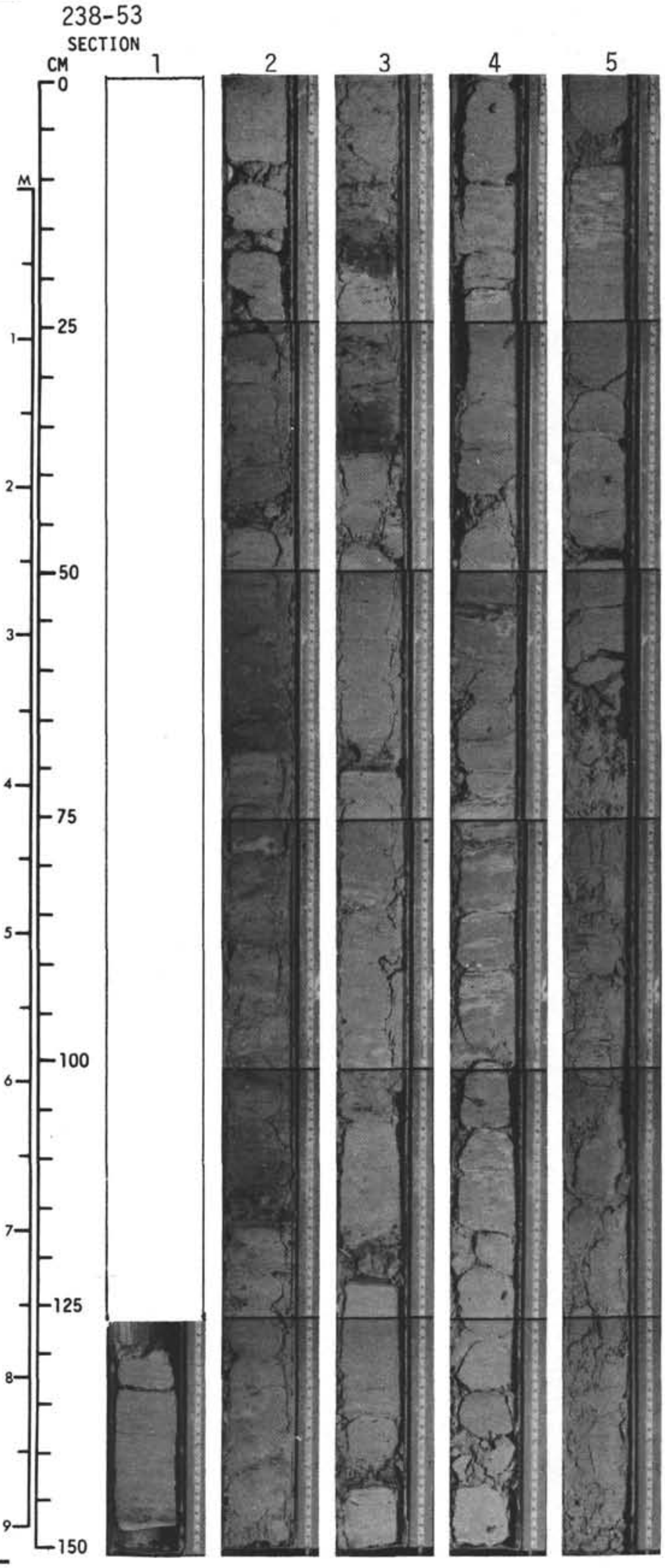
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SECTION
CM
M
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8
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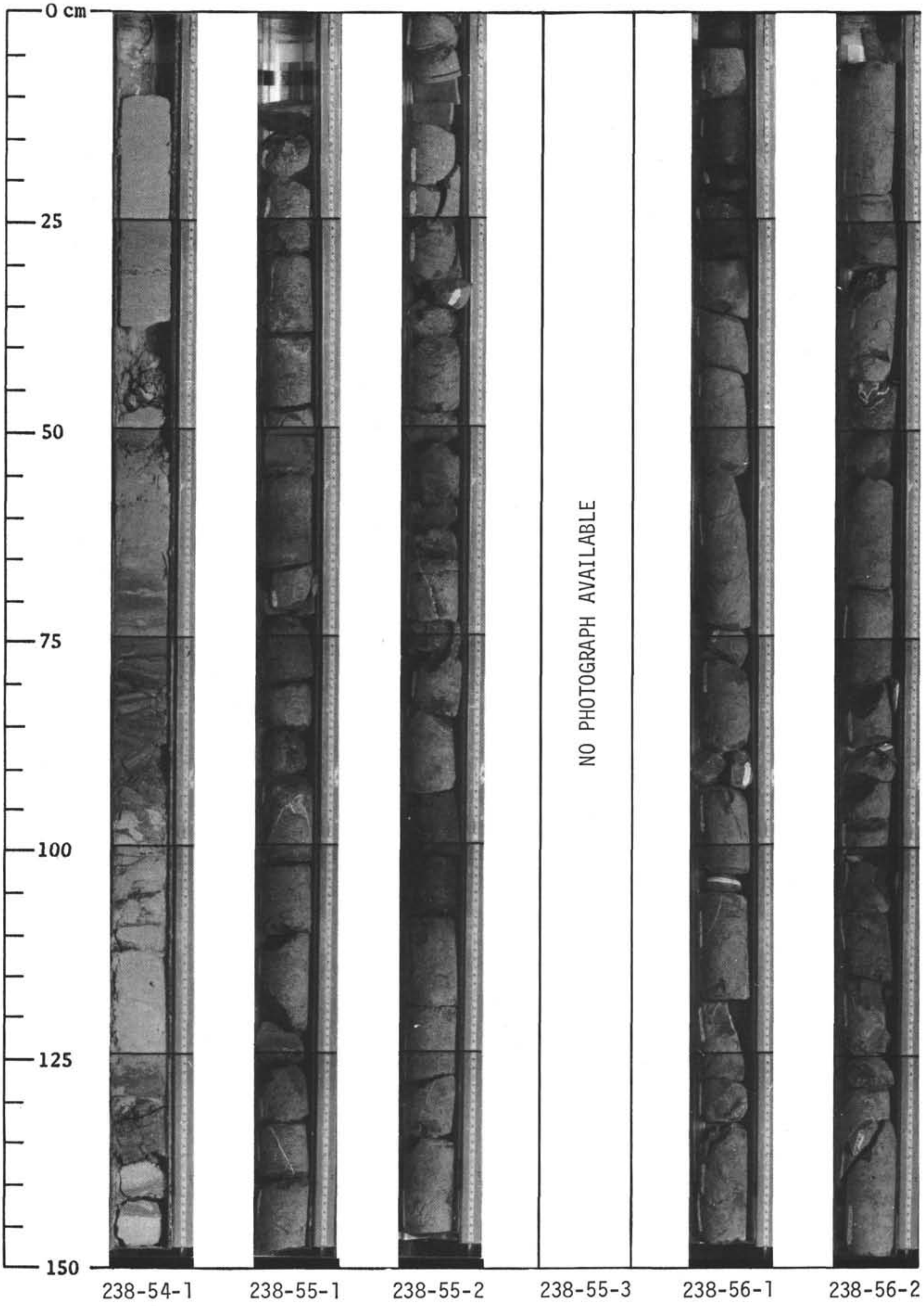
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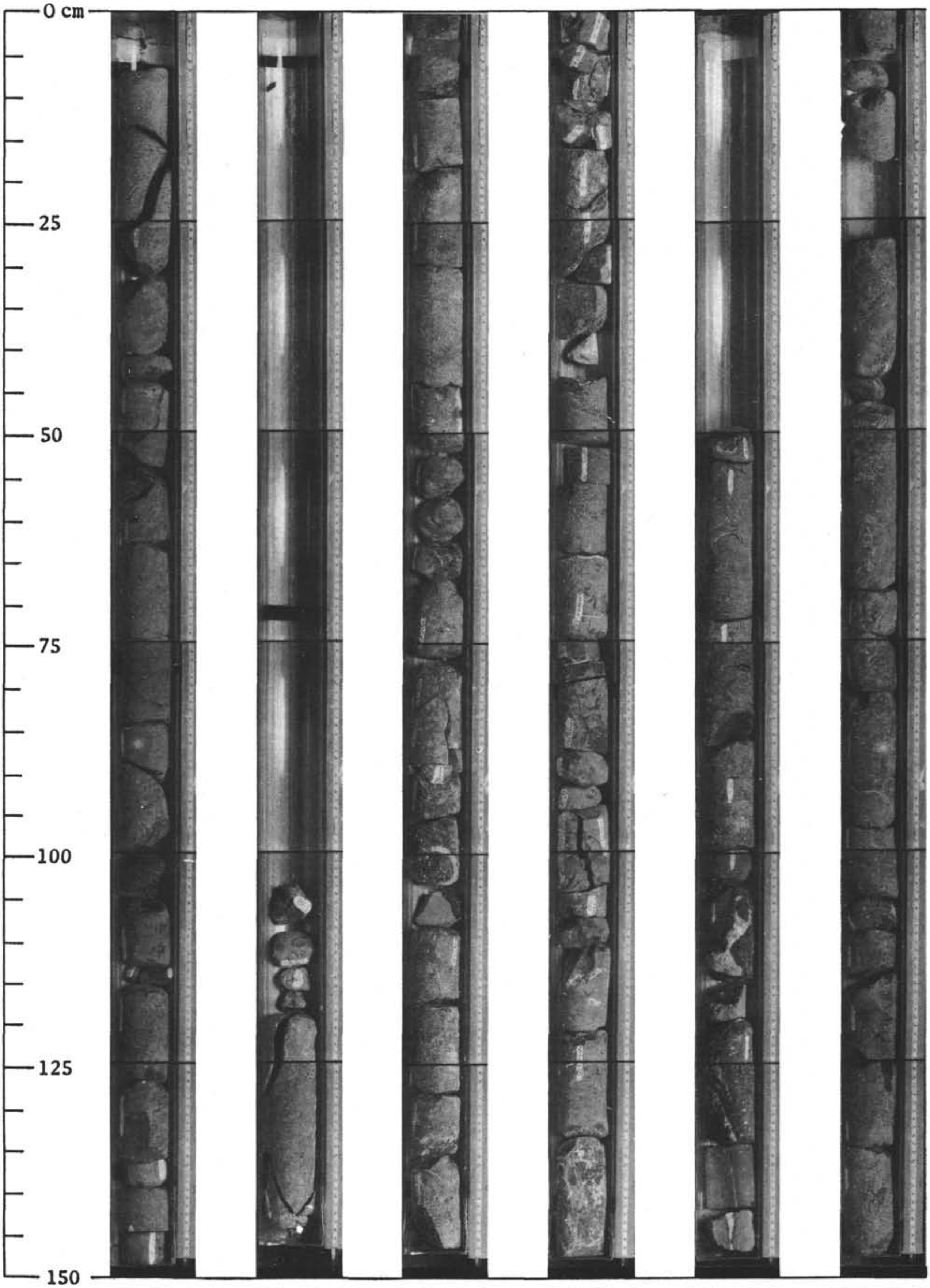
238-55-2
238-55-3
238-56-1
238-56-2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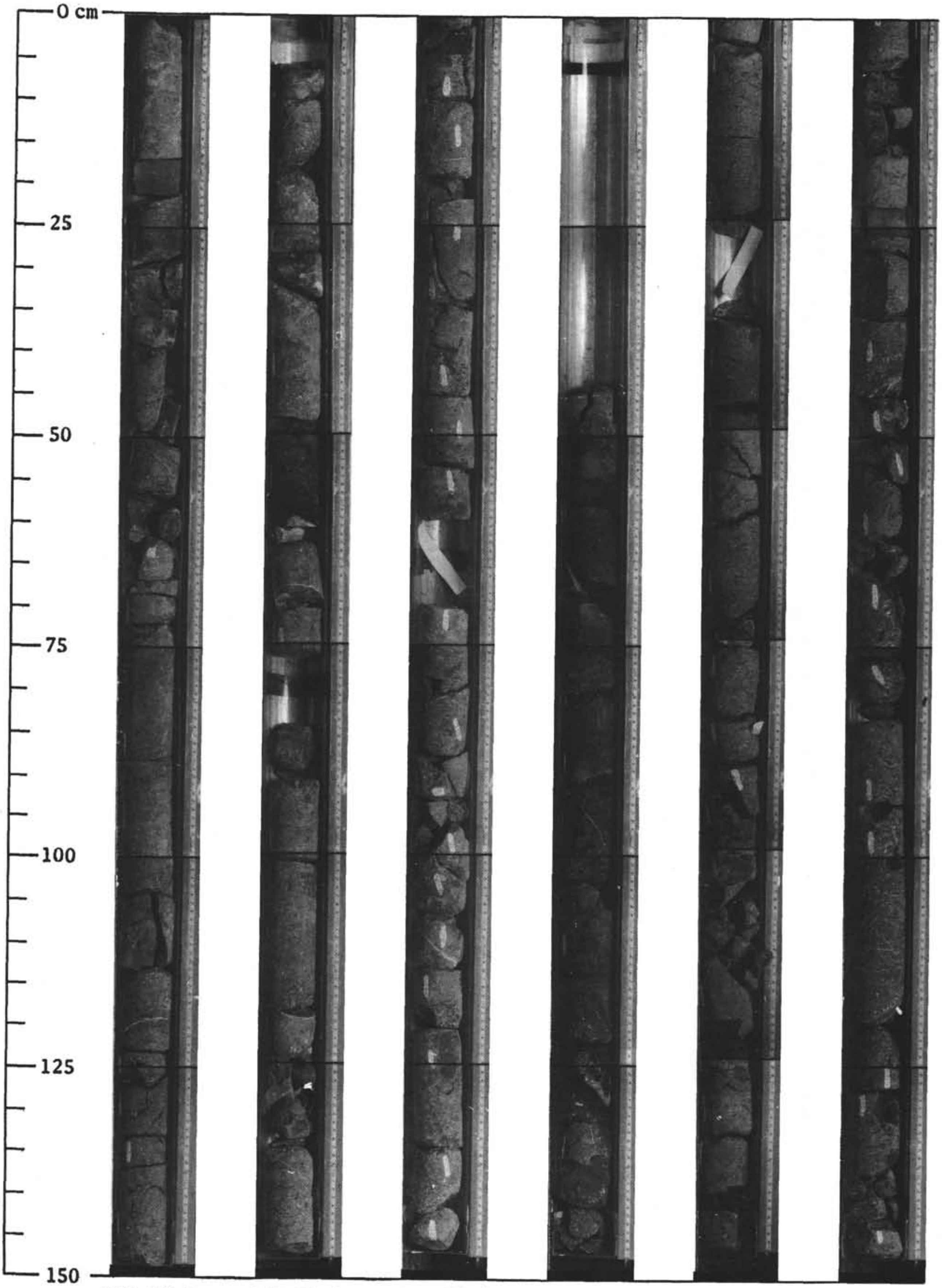
238-57-3
238-58-1
238-58-2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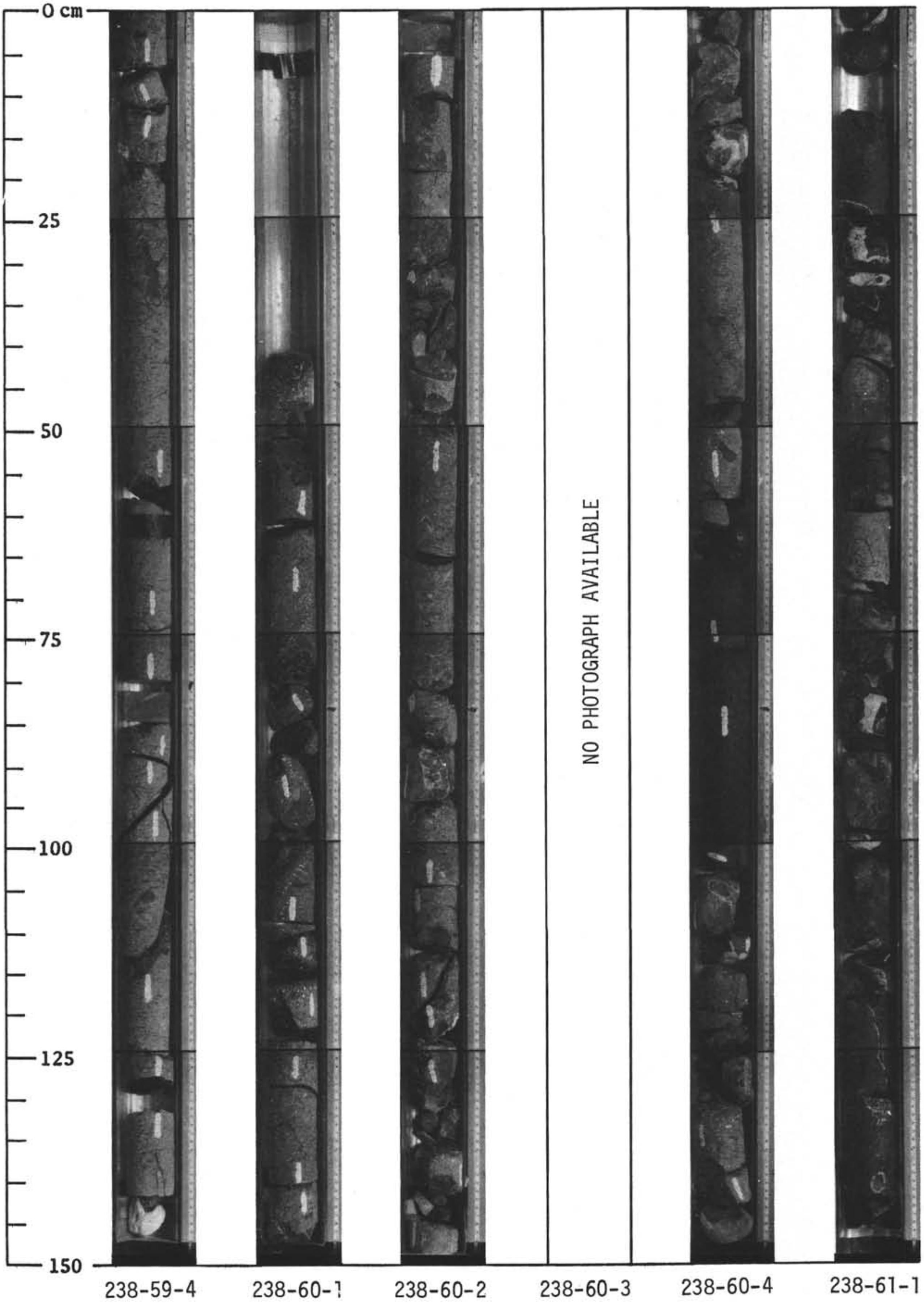
238-59-1
239-59-2
239-59-3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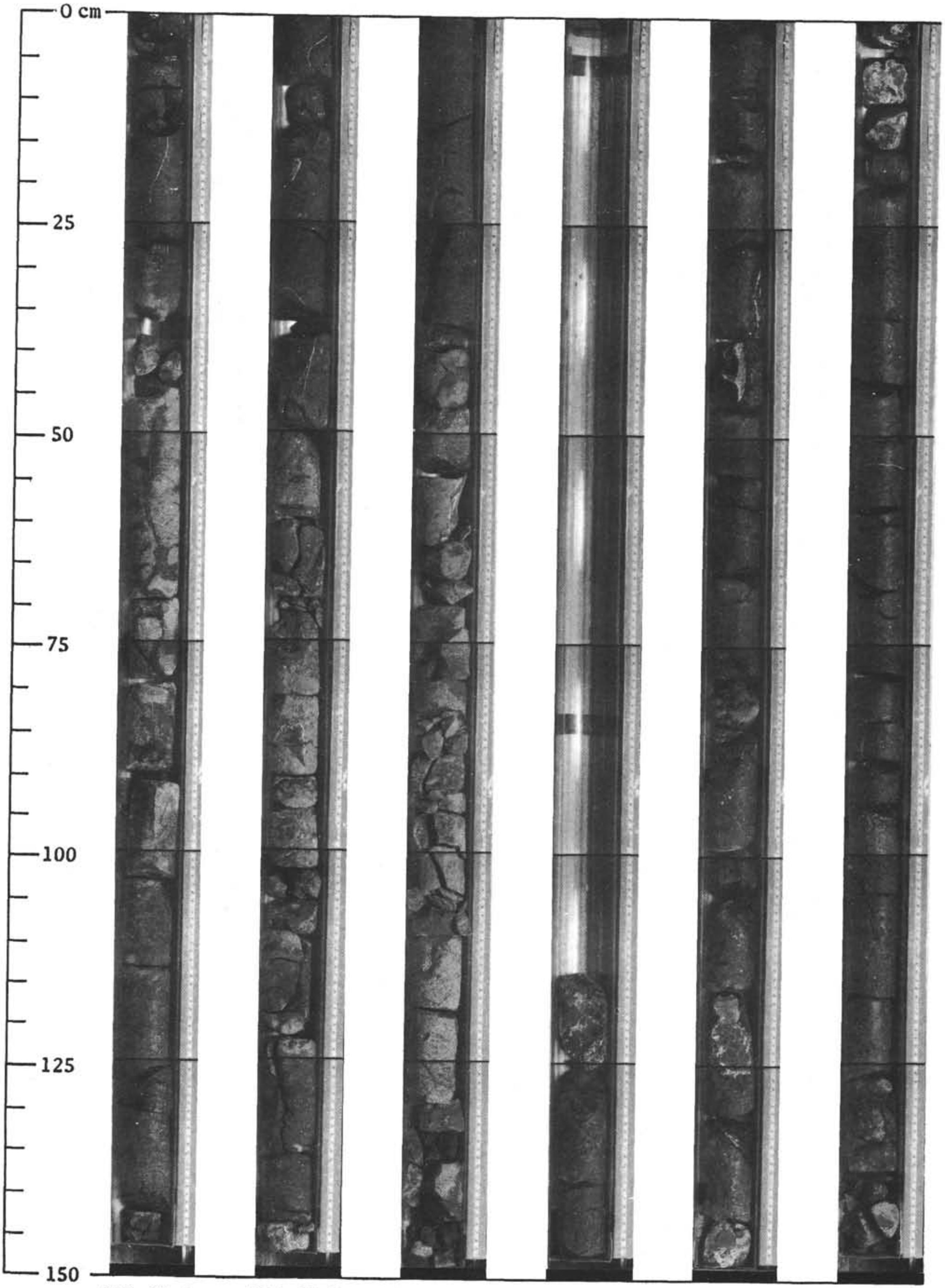
238-61-1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125
150
238-61-2
238-61-3
238-61-4
238-62-1
238-62-2
238-62-3

0 cm
25
50
75
100
125
150

NO PHOTOGRAPH AVAILABLE

238-63-1

NO PHOTOGRAPH AVAILABLE

238-64-1

NO PHOTOGRAPH AVAILABLE

238-64-2