3. SITE 232

The Shipboard Scientific Party[1]

SITE DATA

Date Occupied: 10 May 1972

Date Departed: 13 May 1972

Time on Site: 73 hours, 30 minutes

Position:
Hole 232: lat 14°28.93′N, long 51°54.87′E
Hole 232A: lat 14°28.96′N, long 51°54.86′E

Water Depth:
Hole 232: 1743 corrected meters (echo sounding)
Hole 232A: 1726 corrected meters (echo sounding)

Bottom Felt At:
Hole 232: 1757.5 meters (drill pipe)
Hole 232A: 1753.0 meters (drill pipe)

Penetration: 434 meters

Holes Drilled: 2

Number of Cores: 49

Total Length of Cored Section: 434 meters

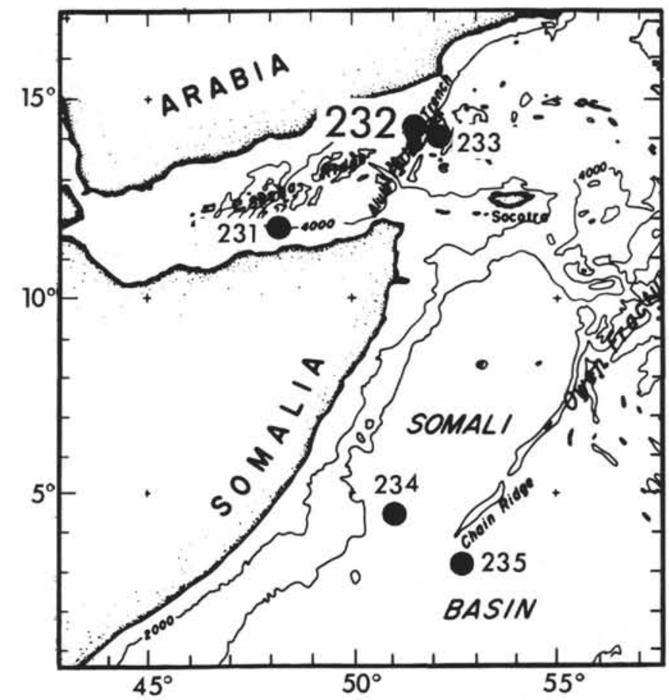
Total Core Recovered: 252 meters

Acoustic Basement:
Hole 232: Not reached; hole closed out
Hole 232A: Depth: 396.5 meters
Nature: sandstone
Inferred vertical velocity to basement: 1.88 km/sec

Age of Oldest Sediment: Upper Miocene

Basement: Probably Miocene

Principal Results: Holes 232 and 232A are located on the lip of the western flank of the Alula Fartak Trench, a north-northeast-south-southwest trending feature at the eastern entrance to the Gulf of Aden. Holes 232 and 232A can be considered to be essentially at the same location; 232A is 275 feet removed from 232 (upslope NW). The section was cored continuously from the sediment surface to acoustic basement, and beyond. The cored section was overlapped in the depth interval between 159 and 169 meters, when the ship was moved and a new hole drilled. The two cored sections are thus reported as one composite. Continuous drilling and coring penetrated to 434 meters with 125.5 meters of core recovered. The section consists of sediments appearing as semicontinuous reflectors and semi-acoustically transparent material above a weak acoustic basement. Acoustic basement, drilled from 396.5 to 421 meters, overlies sediments drilled to 434 meters. The upper section contains four units; in order they are: 301.5 meters of nanno ooze with some quartzose and volcanic sand layers; 9.5 meters of lithified, laminated siltstone; 9.5 meters of lithified quartzose sandstone; and 76 meters of nanno ooze. Acoustic basement is composed of lithified quartzose sandstone 24.5 meters thick which is upper Miocene in age. The sediment sequence below acoustic basement is nanno ooze. Biostratigraphically, the section consists of: Pleistocene 0-78.5 meters; upper Pliocene 78.5-143.5 meters; lower Pliocene 143.5-273.0 meters; upper Miocene 273.0 meters to base of sediment. The nanno ooze below acoustic basement is also upper Miocene.



BACKGROUND AND OBJECTIVES

Sites 232 and 233 are located on the west and east margins, respectively, of the Alula-Fartak Trench, a feature explored extensively by R.R.S. *Discovery* in 1967 (Laughton and Tramontini, 1969). They were selected to provide comparative information as to basement composition on either side of this fault that reflects both vertical

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and strike-slip motion. Seismic reflection profiles indicate that the sediment section close to the trench on the west side should be thicker than the one on the east and that a basement horst appears to have dammed sediments probably derived from Arabia. The age surmised for the acoustic basement at the base of the section, possibly Layer 2, is 10 m.y. The sediment column should yield information on the subsidence or elevation, early history, and evolution of the Arabian continental margin. These data should be comparable to those expected from the upper portion of Site 231, whose terrigenous sediments are derived from Somalia. The companion Site 233, near the east edge of the trench, lies close to the rift axis of East Sheba Ridge and may reveal a hiatus in spreading prior to anomaly 3 (5 m.y.B.P.) time. It may reflect chiefly pelagic sedimentation over a prominent flattish reflecting horizon similar to that of the basement at Site 231 in Half Degree Square, but the lower section may include terrigenous sediments, helping to date the trench's development.

Although it was not originally planned to continuously core these two sites, the wealth of lithologic and biostratigraphic information obtained at Site 231 indicated that Site 232, at least, should be so cored, and also, probably, Site 233. This would accomplish one of the primary objectives of Leg 24: to study in detail, and to contrast, the stratigraphy of the three Gulf of Aden sites for evidences of tectonic and sedimentary processes in a newly-developed ocean.

OPERATIONS

Near-Site Activities

Sites 232 and 233, respectively, just west and east of the Alula-Fartak Trench, have been considered a linked pair throughout the planning and site selection, and *Glomar Challenger* made preliminary surveys for both before stopping to drill either. The exploration pattern consisted primarily of three sections across the trench to determine basement depth and probable character near the rims; these profiles were joined by short segments parallel to the trench to establish layering locally along the feature. The basement horst mentioned by Laughton and Tramontini (1969) was sought for Site 232. Seismic refraction profiles (6215, 6218, and 6219, Laughton and Tramontini, 1969) and summaries of dredging stations (Ramsay and Funnell, 1969) influenced the survey. Site 232 was chosen 6.8 nmi east-northeast of proposed site 24-2 (Figures 1a and b), a spar buoy was dropped, *Glomar Challenger* doubled back to retrieve hydrophones and magnetometer, and the beacon was dropped in a water depth of 1743 meters (corrected) as determined by the echo sounder.

Drilling Program

As at Site 231, the soft sediments were drilled with no pump pressure and minimal weight on the bit, and higher pumping rates were utilized.

On some of the previous legs there has been some concern about crooked holes. Since the drill bit is always rotated to the right and in many areas the hole is drilled in a spiral, the most severe case of a sudden change in angle or direction will result in a "dog leg." A severe bend area will cause the drill string to stick or the BHA to break at a connection. To study this problem, an Eastman survey unit was installed in the sinker bars. On Core 14, the survey unit was installed in the sinker bars and a downhole picture was made at the bit. Hole deviation was 6 1/4° off vertical. At 173.5 meters, another survey was taken (on Core 19). When the core barrel was almost at the surface, the instrument case parted and the core barrel fell to the bottom of the drill string. The drill pipe was pulled out to retrieve the core barrel and instrument.

Since the upper portion of Hole 232A had already been cored and determined to be free of hydrocarbon, the initial 159 meters were drilled. The hole was then cored to a total depth of 434 meters (Table 1).

LITHOLOGIC SUMMARY

Hole 232 was continuously cored from the sediment surface to a depth of 173.5 meters; Hole 232A, 275 feet to the northwest, was continuously cored from 159 to 434 meters, providing an overlap of 14.5 meters in the coring. The cored section comprises six lithologic units as shown in Table 2 and the Site Summary.

Unit 1 (0.0-301.5 m; Cores 1-19, 1A-15A)

Unit consists of a somewhat monotonous sequence of olive-gray to dusky yellow-green, nanno ooze with occasional thin (1-5 cm) quartzose sand layers, some of which are pyritiferous. Occasional sand filled burrows are present. Thin, gray, volcanic ash layers occur at 164 and 165 meters.

Unit 2 (301.5-311.0 m; Core 16A)

Unit is medium and dark gray, laminated, calcite cemented quartz siltstone with fine sandstone interlayers. It is extremely well lithified, was only retrieved in the core catcher, and its real thickness is uncertain.

Unit 3 (311.0-320.5 m; Core 17A)

Unit is medium light gray, calcite cemented, quartzose sandstone, with calcareous fossils. It is extremely well lithified, was only retrieved in the core catcher, and its real thickness is uncertain.

Unit 4 (320.5-396.5 m; Cores 18A-25A)

Unit is olive-gray to dusky yellow-green, nanno ooze with occasional thin quartzose sand layers.

Unit 5 (396.5-421.5 m; Cores 26A-28A)

Unit is medium light gray, calcite cemented, quartzose sandstone and is extremely well lithified.

Unit 6 (421.5-434.0 m; Cores 29A-30A)

Unit is olive gray nanno ooze.

Lithified Sediment: Sandstones

Core 16, core catcher: The rock is composed of fine-grained sandstone with thin interlayers of contorted clay material. The cement consists of carbonate. The sandstone is composed of 90-95 percent quartz and 5-10 percent of the following minerals: plagioclase (albite?), amphibole, biotite, and muscovite. Individual grains of

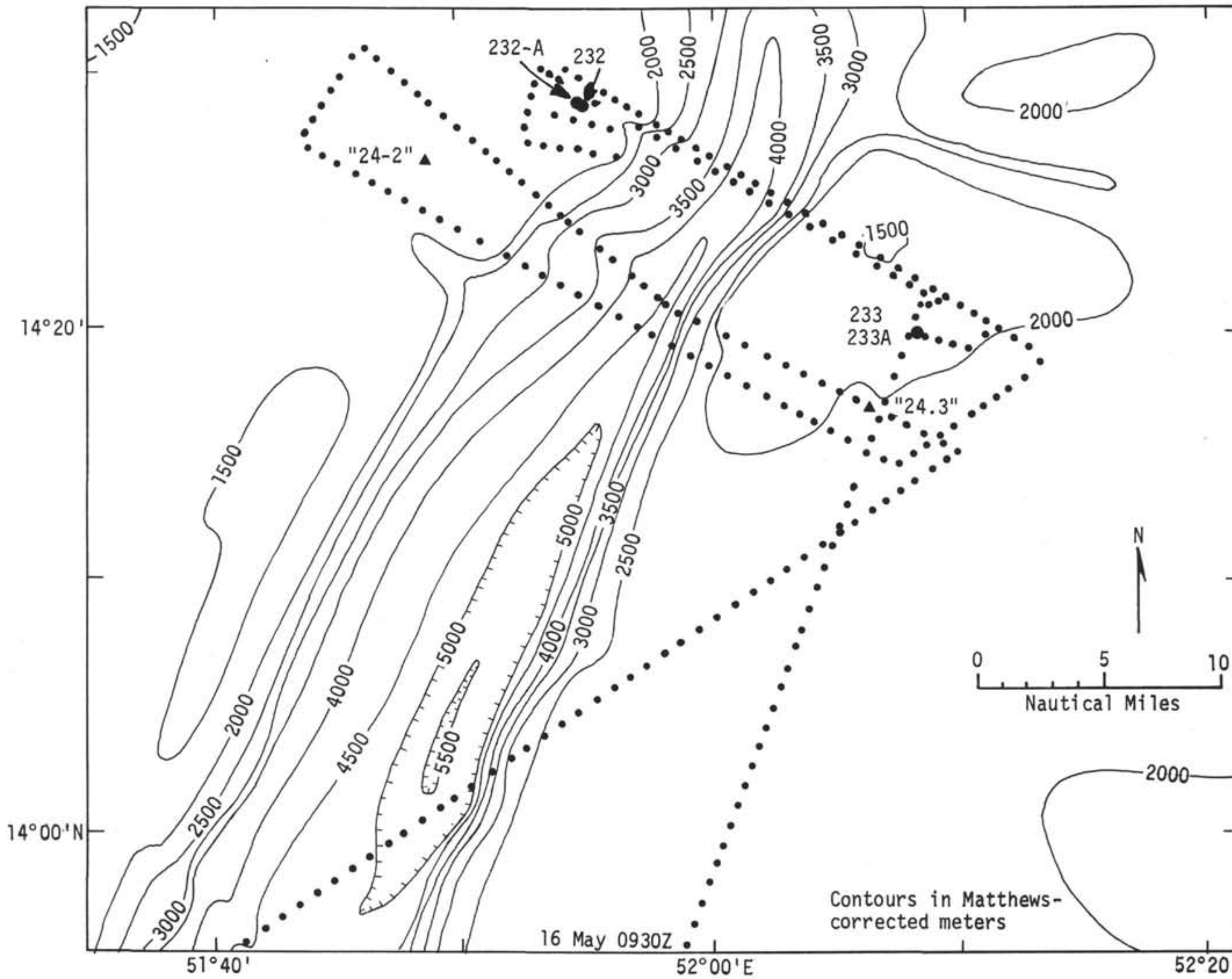

Figure 1a. *Location of the DSDP Sites 232, 233 and position of proposed site 24-2 at the Alula-Fartak Trench. Dotted line shows track.*

sphene and zircon are present. The grains are angular and average 0.01-0.05 mm in diameter.

Core 17, core catcher and Core 27, Section 1: Both samples are medium-grained sandstone with carbonate cement. The proportion of quartz is approximately 95 percent. Plagioclase, microcline, biotite, and amphibole make up 5 percent of these rocks. Amphibole, sphene, zircon, magnetite, and monazite were found as minor constituents.

The mineral grains are angular and range from 0.2 to 0.5 mm in maximum size. Small rounded fragments of fossiliferous limestone, fragments of shells, and fragments of basalt with microdoleritic structure also occur.

Conclusions

1. Units 1, 4, and 5, which comprise the major part of the section, are rather uniform, nannoplankton-rich, hemipelagic muds. This uniformity suggests near-constant water depth and stable conditions of pelagic carbonate production and detrital sediment input.

2. The fairly abundant silt-sized quartz, biotite, calcite, and other detrital grains dispersed throughout the hemipelagic muds are probably of eolian origin.

3. The two acid volcanic ash layers at 164 and 165 meters in Unit 1 may correlate with similar layers occurring at 170, 180, 188.5, and 203 meters at Site 231.

4. The very well lithified siltstone and quartz sandstone of Units 2, 3, and 5 exhibit characteristics suggestive of a shallow-water environment of deposition. Their degree of lithification also distinguishes them from the unlithified hemipelagic sediments. Structural emplacement as fault or slide blocks may have occurred.

BIOSTRATIGRAPHIC SUMMARY

Introduction

The 434 meters of sediments continuously cored at Site 232 represent an apparently uninterrupted sequence from Quaternary to late Miocene. The lower 37 meters of the

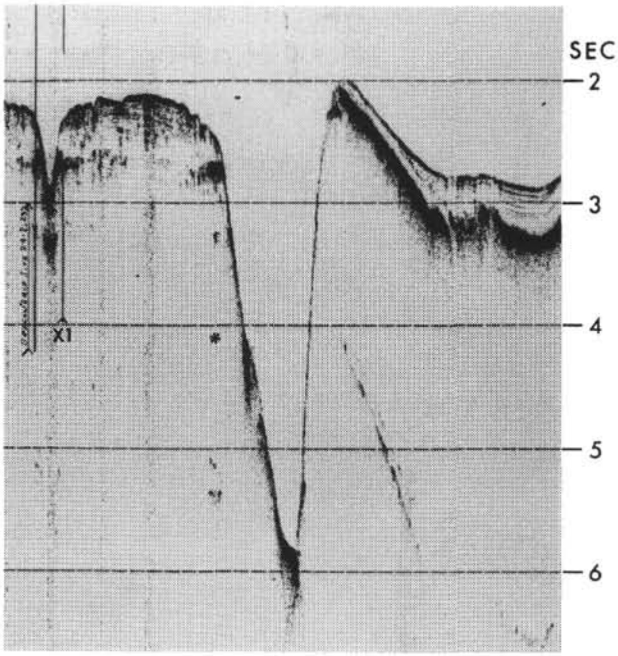

Figure 1b. *Site 232, west-east section, Alula Fartak Trench. *Same location on west rim of trench, 3 views; X1 is course reverse to come on site and made over edge of trench.*

section could not be dated because of poor recovery and lack of datable fossils, however, the bottom of the hole, at 434 meters, is judged to be approximately 6.7 m.y. old (upper part of the late Miocene) on the basis of sedimentation rate estimates.

Calcareous nannofossils are abundant and well preserved throughout the recovered section. Foraminifera are common and well to moderately preserved in the upper 40 meters and become less common and poorly preserved below this interval. Radiolarians are common and moderately to well preserved in the upper 254 meters and between 330 and 358.5 meters and are absent in the remainder of the section.

The sequences of nannofossil, foraminiferal, and radiolarian zones are summarized in the graphic site summary at the end of this chapter. On the basis of nannofossil data, as at Site 231, the Pliocene/Pleistocene boundary was placed at 78.5 meters, between Cores 9 and 10, although both foraminiferal and radiolarian zonations indicate a higher position for the boundary.

Calcareous Nannoplankton

Nannoplankton assemblages are rich and diversified, and reworked forms occur throughout a larger part of the section.

Cores 1 to 5 are assigned to the *Gephyrocapsa oceanica* Zone. They contain common *Gephyrocapsa oceanica, G. caribbeanica, Umbilicosphaera sibogae*, and *Pontosphaera discopora. Pseudoemiliania lacunosa* is present in the lower part of this zone (Cores 3 to 5). The *Gephyrocapsa caribbeanica* Zone with *Gephyrocapsa caribbeanica, Crenalithus doronicoides*, and *Coccolithus pelagicus* occurs in Cores 6 and 7. This high range of *Coccolithus pelagicus* in fairly large numbers, and being thus probably not reworked, is unusual and suggests cool water. The *Pseudoemiliania lacunosa* Zone was recovered in Cores 8 and 9 with an assemblage including *Pseudoemiliania lacunosa* and *Crenalithus doronicoides.* The Pliocene/Pleistocene boundary based on nannofossils lies between Cores 9 and 10. Core 10 belongs to the *Cyclococcolithina macintyrei* Zone and contains *Cyclococcolithina macintyrei, Discoaster brouweri*, and rare specimens of the Eocene *Discoaster barbadiensis.* The *Discoaster pentaradiatus* Zone is present in Cores 11 through 14 with *Discoaster brouweri, D. pentaradiatus, D. surculus*, and *Ceratolithus rugosus.* The *Discoaster tamalis* Zone was recovered in Cores 15 and 16. The *Reticulofenestra pseudoumbilica* is quite thick and includes Cores 17 to 19 and 1A to 3A. There might be some overlap between the two holes so that this interval seems thicker than it is. Assemblages contain common *Reticulofenestra pseudoumbilica, Sphenolithus abies*, and *Ceratolithus rugosus.* The *Ceratolithus rugosus* Zone, with both *Ceratolithus rugosus* and *C. tricorniculatus* present, was found in Core 9A and the *Ceratolithus acutus* Zone, with *C. acutus* and *C. tricorniculatus*, in Cores 10A and 11A. Reworked Miocene discoasters occur in Cores 8A, 10A, and 11A. The Pliocene/Miocene boundary based on calcareous nannofossil lies between Core 11A and 13A. The *Ceratolithus tricorniculatus* Zone of late Miocene age was recovered in Cores 13A through 19A. Assemblages include *Ceratolithus tricorniculatus, C. primus*, and *Triquetrorhabdulus rugosus.* The assemblages above and below the indurated siltstone and sandstone bed are almost identical. Cores 20A through 26A belong to the *Ceratolithus primus* Zone with an assemblage including *Ceratolithus primus, Discoaster quinqueramus, D. berggrenii*, and *D. intercalaris.*

Preservation: The state of preservation is similar to that at Site 231. Slight etching of coccoliths, leading to serrate margins, was observed. Since the present water depth is quite shallow, the high organic content in the sediment must be responsible for this etching. *Pontosphaera* is present in many samples throughout the entire section; *Scyphosphaera* occurs only rarely in the upper Miocene.

Foraminifera

Abundance and Preservation

Well-preserved to moderately preserved foraminifera are the dominant component of the coarse fraction (>63μ) in the upper 40 meters of the section (Cores 1 to 5). Below 40 meters, foraminifera are less abundant and are moderately to poorly preserved while radiolarians and terrigenous components, small subangular quartz grains and mica flakes, become common. No foraminifera could be extracted from the lithified quartzose sandstones (lithologic Units 3 and 5) and only two benthic foraminifers, neither identifiable, were observed in thin sections from these units.

Planktonic foraminifera dominate the foraminiferal assemblages in Cores 1 through 5 in which they commonly comprise more than 90 percent of the total foraminiferal

TABLE 1
Coring Summary – Site 232

Core	Date (May 1972)	Time	Depth Below Sea Floor (m)	Depth From Drill Floor (m)	Cored (m)	Recovered (m)	Recovered (%)
Hole 232							
1	11	0131	0-2.5	1757.5-1760.0	2.5	2.4	96
2	11	0226	2.5-12.0	1760.0-1769.5	9.5	8.5+	89
3	11	0321	12.0-21.5	1769.5-1779.1	9.5	8.4+	92
4	11	0418	21.5-31.0	1779.0-1788.5	9.5	8.2+	87
5	11	0513	31.0-40.5	1788.5-1798.0	9.5	9.5	100
6	11	0611	40.5-50.0	1798.0-1807.5	9.5	5.8	61
7	11	0653	50.0-59.5	1807.5-1817.0	9.5	4.8+	50
8	11	0746	59.5-69.0	1817.0-1826.5	9.5	6.9+	72
9	11	0838	69.0-78.5	1826.5-1836.0	9.5	6.4+	68
10	11	0919	78.5-88.0	1836.0-1845.5	9.5	2.5	26
11	11	1011	88.0-97.5	1845.5-1855.0	9.5	6.5	68
12	11	1108	97.5-107.0	1855.0-1864.5	9.5	6.4	67
13	11	1214	107.0-116.5	1864.5-1874.0	9.5	1.2	12
14	11	1338	116.5-126.0	1874.0-1883.5	9.5	7.3+	77
15	11	1438	126.0-135.5	1883.5-1893.0	9.5	7.9	83
16	11	1537	135.5-145.0	1893.0-1902.5	9.5	7.5	79
17	11	1643	145.0-154.5	1902.5-1912.0	9.5	9.5	100
18	11	1753	154.5-164.0	1912.0-1921.5	9.5	8.7	91
19	11	1911	164.0-173.5	1921.5-1931.0	9.5	8.0	84
Hole 232A							
1	12	1037	159.0-168.5	1912.0-1921.5	9.5	8.2	86
2	12	1127	168.5-178.0	1921.5-1931.0	9.5	9.4	99
3	12	1235	178.0-187.5	1931.0-1940.5	9.5	8.6+	90
4	12	1342	187.5-197.0	1940.5-1950.0	9.5	8.2	86
5	12	1500	197.0-206.5	1950.0-1959.5	9.5	6.0	63
6	12	1544	206.5-216.0	1959.5-1969.0	9.5	9.0	95
7	12	1627	216.0-225.5	1969.0-1978.5	9.5	9.4	99
8	12	1710	225.5-235.0	1978.5-1988.0	9.5	9.0	95
9	12	1801	235.0-244.5	1988.0-1997.5	9.5	9.5	100
10	12	1854	244.5-254.0	1997.5-2007.0	9.5	8.8+	93
11	12	2004	254.0-263.5	2007.0-2016.5	9.5	1.4	15
12	12	2112	263.5-273.0	2016.5-2026.0	9.5	2.1	22
13	12	2222	273.0-282.5	2026.0-2035.5	9.5	0.7	7
14	12	2313	282.5-292.0	2035.5-2045.0	9.5	1.5	16
15	13	0019	292.0-301.5	2045.0-2054.5	9.5	1.7	18
16	13	0126	301.5-311.0	2054.5-2064.0	9.5	CC	X
17	13	0225	311.0-320.5	2064.0-2073.5	9.5	CC	X
18	13	0320	320.5-330.0	2073.5-2083.0	9.5	6.1	64
19	13	0422	330.0-339.5	2083.0-2092.5	9.5	2.7	28
20	13	0520	339.5-349.0	2092.5-2102.0	9.5	1.3	13
21	13	0628	349.0-358.5	2102.0-2111.5	9.5	7.9	83
22	13	0747	358.5-368.0	2111.5-2121.0	9.5	3.8	40
23	13	0836	368.0-377.5	2121.0-2130.5	9.5	7.4	78
24	13	0927	377.5-387.0	2130.5-2140.0	9.5	0.9	9
25	13	1023	387.0-396.5	2140.0-2149.5	9.5	0.1	1
26	13	1126	396.5-402.5	2149.5-2155.5	6.0	0.6	11
27	13	1238	402.5-412.0	2155.5-2165.0	9.5	0.3	
28	13	1344	412.0-421.5	2165.0-2174.5	9.5	0.1	
29	13	1511	421.5-431.0	2174.5-2184.0	9.5	0.5	
30	13		431.0-434.0	2184.0-2187.0			

population. In Cores 6 to 1A they make up only 30 to 50 percent of the foraminiferal assemblages, whereas in this interval benthics are dominant. In the lower part of the section, below Core 1A, planktonic foraminifera constitute 50 to 80 percent of the faunas. The downward decrease in relative abundance of planktonic foraminifera, which are less resistant to solution than benthics, appears to be related to calcium carbonate solution. This is also evidenced by the poorer preservation of planktonic foraminifera, which present a significant degree of fragmentation, and a higher relative proportion of radiolarians below Core 5.

Benthic foraminiferal assemblages are mainly characteristic of a bathyal environment throughout the section.

Planktonic Foraminiferal Zonation

The interval from Core 1 to Core 5, Section 4, is assigned to the Quaternary (Zones N.23-N.22) based on the common presence of *Globorotalia truncatulinoides*. As at

TABLE 2
Lithologic Units – Site 232

Depth Below Sea Floor (m)	Unit	Lithology	Thickness (m)	Cores
	1	Nanno ooze with occasional sandy layers	301.5	1-19 1A-15A
301.5				
	2	Quartz siltstone	9.5	16A
311.0				
	3	Quartz siltstone	9.5	17A
320.5				
	4	Nanno ooze with occasional sandy layers	760	18A-25A
396.5				
	5	Quartz sandstone	250	26A-28A
421.5				
	6	Nanno ooze	12.5	29A-30A
434.0				

Site 231, specimens of pink *Globigerina rubescens* occur commonly in the upper part of the section (Core 1 and Core 2, Section 4) and were not found in lower levels. The N.22/N.21 boundary was placed, as at Site 231, at the base of the common occurrence of *G. truncatulinoides,* in Core 5, Section 4. However, rare specimens of this species were found below this level, between Cores 7 and 11. It is not easy to determine whether this presence is due to downhole contamination or if the initial evolutionary appearance of *G. truncatulinoides* occurs lower in the section. Only rare occurrences of *Globorotalia tosaensis,* the direct ancestor of *G. truncatulinoides,* were found in the interval between Core 6, Section 2 and 12, CC, and the transition between the two species could not be observed. As at Site 231, the base of the common occurrence of *G. truncatulinoides* coincides with the lowest appearance of *Globigerina tenella;* however, none of the two species, *Globigerinoides obliquus* s.l. and *Globigerinoides quadrilobatus fistulosus,* were found near this level.

A horizon with dextrally coiled *Globorotalia tumida tumida* was observed in Core 6, Section 2, and the presence of *Globoquadrina* sp. A (a new species to be described) was found in Core 9, Section 2, at the same level as the highest occurrence of *Globorotalia limbata.* This succession of events in the upper part of Zone N.21 correlates with the same events at Site 231. The N.21/N.20-N.19 boundary is not conclusively determined due to the rarity of the index species, *G. tosaensis.* It is, however, tentatively placed at the highest occurrence of *Sphaeroidinellopsis,* between Cores 15 and 16, a level slightly below the top of *Globoquadrina altispira* s.s.

A horizon, including common *Globorotalia tumida flexuosa,* located in the lower part of Core 19 and in Core 2A and Core 3A, Section 2 allows the correlation between Holes 232 and 232A. Core 19 corresponds to Core 2A, a correlation in agreement with the sub-bottom depths of these cores. Very rare occurrences of *Globorotalia margaritae* (a species known to become extinct elsewhere within N.19) were observed in Core 4A, Section 4. The base of Zone N.19 cannot be conclusively determined because the index marker, *Sphaeroidinella dehiscens,* first appears higher in this section than its known evolutionary appearance, as reported elsewhere. The N.19/N.18 boundary was tentatively placed at the highest occurrence of forms referable to *Globorotalia tumida plesiotumida*, between Cores 9A and 10A.

The N.18/N.17 boundary was not identified because forms intermediate between *G. tumida tumida* and *G. tumida plesiotumida* were commonly found throughout the interval between Core 10A, Section 1 and Core 23A, Section 2. Specimens attributable to *G. tumida tumida* occur as low in the section as Core 23A, Section 2, but this level is probably too low for the base of Zone N.18 as it lies below the lowest occurrence of *Pulleniatina* spp. and is lower than the Miocene/Pliocene boundary defined by nannofossils and radiolarian zonations.

Radiolarians

Radiolarians are generally few to abundant and moderately to well preserved in all samples examined from Hole 232 and the top ten cores of Hole 232A. Below this level they are absent, with the exception of few to abundant, moderately to well-preserved specimens in Cores 19A-21A.

The base of the Quaternary is uncertain, apparently lying between 232-4-6 and 232-8-3. The entire *Pterocanium prismatium* Zone is apparently included within this uncertain interval. All samples from 232-8-3 through 232A-6-1 are within the *Spongaster pentas* Zone, and those from 232A-7-1 through 232A-21-2 are in the *Stichocorys peregrina* Zone.

SEDIMENT ACCUMULATION RATES

Average accumulation rates were calculated as follows:

Series	Thickness (m)	Average Accumulation Rate (m/m.y.)
Pleistocene	78.5	43.6
Upper Pliocene	65.0	54.2
Lower Pliocene	129.5	64.8
Upper part of upper Miocene	150.0	88.6

The lower part of the sedimentary sequence (lower part of Lithologic Unit 4 and Units 5 and 6) could not be dated. However, two fossil events occurring in Unit 4 allow an estimate to be made of the accumulation rate for the lower sediments. The highest occurrence of *Discoaster quinqueramus* (at the *Ceratolithus primus/Ceratolithus tricorniculatus* zonal boundary) lies at 340 meters (Core 20A, Section 1) and the highest occurrence of *Ommatartus antepenultimus* (in the lower *Stichocorys peregrina* Zone) lies at 33.6 meters (Core 19A, Section 1). These floral and faunal events have been calibrated with paleomagnetic reversal stratigraphy and have both been dated at approximately 5.7 m.y. in magnetic epoch 5 (Gartner, 1973; Theyer and Hammond, in press). The good agreement between the position of these two fossil events in this section permits an age assignment of 5.7 m.y. for the sediments at about 335 meters, and implies that the sedimentary sequence between 273 and 335 meters accumulated over a time interval of approximately 0.7 m.y. Assuming a constant accumulation rate for sediments in the lower part of the section, an age of approximately 6.7 m.y. (late late Miocene) is estimated for the bottom of the hole.

There is a gradual decrease in the average accumulation rate throughout the section from 88.6 m/m.y. in the late Miocene to 43.6 m/m.y. in the Pleistocene. The average accumulation rate for Pleistocene and Pliocene sediments is 54.6 m/m.y. (a value comparable to the average rate of 43.7 m/m.y. for the entire sequence Pleistocene to middle Miocene at Site 231) while the uppermost Miocene rate is almost twice as high.

The sediments are fairly uniform throughout the entire sequence, except for a few thin sand layers and the siltstone and sandstone of Units 2, 3, and 5. The average input of terrigenous (about 20 percent) and pelagic (about 80 percent) material remains constant throughout the Quaternary and Pliocene. In the upper Miocene part of the section, percentages of terrigenous material (mainly quartz and heavy minerals) increase slightly to about 25 percent.

The siltstone and sandstone of Units 2, 3, and 5 in the late Miocene may have been emplaced by slumping and thus may be fault or slide blocks. However, the succession of fossil events in the lower part of Unit 1 and in Unit 4 do not reflect repetitions in the series.

PHYSICAL PROPERTIES

Bulk Density and Porosity

The bulk density and porosity of the 377.5 meters of nanno ooze in lithologic Units 1 and 4 are rather uniform with slight variations occurring in the interval from 25 to 90 meters (Figure 2). The upper 90 meters of nanno ooze has an associated bulk density of approximately 1.88 ±0.1 g/cm^3 and a corresponding porosity of approximately 49.0 ±6.0 percent. The bulk density values are higher and the porosity values lower than in a similar depth interval at Site 231. Although this cannot be fully explained at this time, an interesting parallel may be drawn between the two sites. That is, the general trends of bulk density and porosity at Site 231 for the interval from 30 to 70 meters appear to correspond to those in the interval from 20 to 90 meters at Site 232. The base of both zones lies close to the Pleistocene/Pliocene contact defined by paleontological data. Thus, these physical parameters suggest that similar sedimentary environments were present during Pleistocene time at both Sites 231 and 232.

The bulk density and corresponding porosity remain at a rather uniform 1.83 g/cm^3 and 52 percent, respectively, throughout the remaining nanno ooze. A quartzose sandstone sample from Unit 5 has a bulk density of 2.74 g/cm^3, as measured by the GRAPE device. Bulk densities and porosities of rock samples from Units 2 and 3 were not determined.

Sonic Velocity

The velocity profile of the nanno ooze shows a smooth increase from 1.52 km/sec near the surface to 1.80 km/sec just above the lithified quartzose sandstone of Unit 5 (Figure 2). The interval from 25 to 90 meters appears to correspond to Unit 2 of Site 231 and contains three zones of velocity increases of approximately 1.0 km/sec.

The major velocity change occurs at 320 meters (Unit 3, lithified quartzose sandstone), and at 410 meters (Unit 5, lithified quartzose sandstone). A sample of the laminated lithified siltstone of Unit 2 was not available for velocity determination. The lithified quartzose sandstone of Unit 3 has a vertical velocity of 4.78 km/sec; that from Unit 5 has a vertical velocity of 4.57 km/sec and a horizontal velocity of 5.34 km/sec (Table 3). The interpolated thickness of combined Units 2 and 3 (lithified siltstone and quartzose sandstone) is 19 meters, whereas the thickness of the lithified quartzose sandstone of Unit 5 is 25 meters. Both of these high velocity lithified layers are potential reflectors.

A maximum one-way travel time for seismic energy traveling from the sediment/water interface to these two potential reflectors can be calculated as follows:

Depth Interval (m)	Average Velocity (km/sec)	Travel Time (sec)
0-25	1.53	0.016
25-80	1.58	0.035
80-160	1.56	0.051
160-250	1.60	0.056
250-301	1.65	0.031
301-320	4.78	0.004
320-396	1.75	0.043
		0.236

Thus, maximum one-way travel time is 0.189 sec to the lithified siltstone and quartzose sandstone at 301 meters and 0.236 sec to the lithified quartzose sandstone at 396 meters.

Acoustic Impedance

The acoustic impedance profile is smooth throughout the 377.5 meters of nanno ooze, increasing from 2.8 × 10^5 g/cm^2 sec near the surface to 3.25 × 10^5 g/cm^2 directly above the lithified quartzose sandstone of Unit 5. Interruptions in the acoustic impedance profile are observed along the interval from 25-90 meters.

Two major reflectors were observed: (1) the combination of Units 2 and 3 at 301 to 320 meters, and (2) Unit 5 at 396 to 421 meters. The lithified quartzose sandstone at 396 to 421 meters has a velocity of 4.57 km/sec and a bulk density of 2.74 g/cm^3. Thus, the acoustic impedance is about 12.5 × 10^5 g/cm^2 or about four times that of the overlying nanno ooze sediment layer. The lithified siltstone and quartzose sandstone at 301 to 320 meters should have a comparable (although somewhat less) acoustic impedance.

It is interesting to speculate as to which lithified layer causes the reflection at about 0.25 seconds two-way travel time on the seismic profile (Figure 3). The previously calculated two-way travel times are 0.378 seconds for the siltstone and sandstone at 301 meters and 0.472 seconds for the sandstone at 396 meters. Both of these travel times differ significantly from the 0.25 seconds on the seismic profile, although the siltstone and sandstone at 301 meters

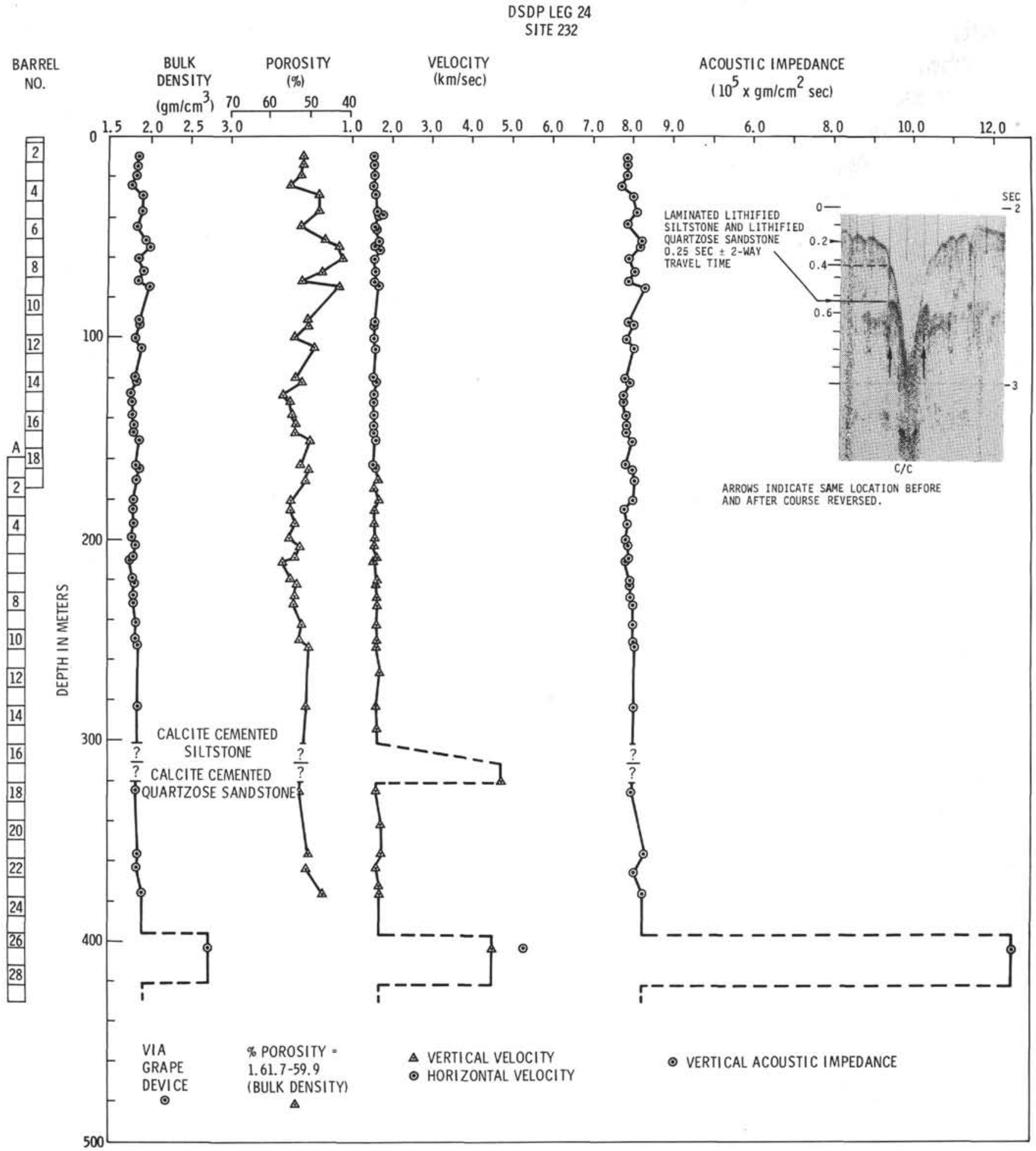

Figure 2. *Physical properties, Site 232.*

TABLE 3
Bulk Density of Sandstone – Site 232

Sample	Bulk Density (gm/cm^3)		Velocity (km/sec)		Rock Description
	Vertical	Horizontal	Vertical	Horizontal	
17–1, CC			4.78		Lithified quartzose sandstone
27–1(3)[a]	2.74	2.73	4.57	5.34	Lithified quartzose sandstone

[a]Sequence number of the sandstone piece in the section.

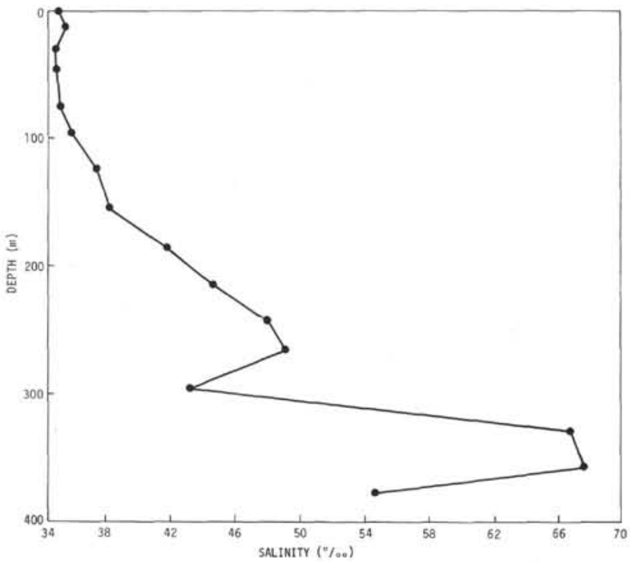

Figure 3. *Interstitial pore water salinities, Site 232.*

is most likely the acoustic basement. However, if the actual location of Site 232 on the seismic profile is slightly "off," the travel time should be increased to 0.37± seconds which corresponds readily with the travel time to the siltstone and sandstone at 301 meters. Thus, it is interpreted that the seismic reflection at 0.25 seconds is caused by the combined lithified siltstone and quartzose sandstone layer at 301 to 320 meters.

INTERSTITIAL WATER CHEMISTRY

Depth below the sediment-water interface, salinity, *p*H, and alkalinity data are recorded in Table 4 for pore waters squeezed from core samples at Site 232. Data on water content, porosity, and bulk density are listed in Table 5.

Salinity: Bottom sea water salinity at this site is 35.0 °/oo (Wyrtki, op. cit.). Salinity distribution with depth is shown in Figure 3. An initial decrease in salinity down to a depth of 46 meters is followed by a fairly rapid increase to a maximum value of 67.7 °/oo. The decrease seen in the deepest sample may be due to seawater contamination during drilling. The salinity trend is too large to be caused by minor changes in ion ratios, such as addition of Ca^{++}, and thus could perhaps indicate the presence of evaporites at greater depth.

***p*H and Alkalinity**: *p*H measurements in Table 4 were made with a flow-through electrode; values in parentheses were made with a punch-in electrode. The trends are grossly similar to those found at Site 231; the *p*H decreases steadily with depth from 7.5 to 7.0 and the alkalinity, after

TABLE 4
Interstitial Water Chemistry – Site 232

Depth Below Sea Floor (m)	Salinity (°/oo)	pH[a]	Alkalinity (meq/kg)
Surface Seawater	36.3		
Hole 232			
11	35.5	7.46 (7.21)	6.54
30	34.9	7.34 (7.23)	6.64
46	34.9	7.36	7.85
76	35.2	7.31 (7.16)	5.22
95	35.8	7.33 (7.06)	5.68
123	37.4	7.27 (7.06)	6.12
155	38.2[b]	7.16 (6.92)	5.64
Hole 232A			
186	41.8	7.11 (6.82)	4.98
215	44.6	7.00	4.31
243	47.0	7.02	4.28
265	49.2	7.30	2.74
295	43.2	7.50	2.09
327	66.8	6.83	1.14
357	67.7	6.90	0.89
386	54.7[b]	7.06	0.88

[a]Measurements with a flow-through electrode; values in parentheses were made with a punch-in electrode. *p*H numbers in parentheses are corrected (see Chapter 1 Explanatory Notes.)

[b]Contaminated?

an initial increase, decreases to values well below that of surface seawater (Figure 4).

Water Content, Porosity, and Bulk Density: These data comprise Table 5. The water content, except for Core 1 samples, is significantly lower than at Site 231, but little trend is obvious. Porosity values are mostly in the range 50-70 percent and bulk densities 1.8-2.0 g/cm^3.

CORRELATION OF REFLECTION PROFILES AND LITHOLOGIES

Profiler records of four crossings of the Alula-Fartak Trench between 14°20′ and 14°25′N show changes in the detailed structure of the two sides from one small area to another. The major differences, however, are seen in the two ridges bordering the west and east sides. Reflection sequences show dissimilar surface features, sedimentary regions, and acoustic basement character. This is not surprising when we consider the so-called trench in its role as transform fault, its east and west margins under the respective influences of the Arabian and Somalian environ-

TABLE 5
Water Content, Porosity, and Bulk Density – Site 232

Core, Section, Top of Interval (cm)	Water (%)	Porosity (%)	Density (g/cm^3)
Hole 232			
1-1, 101	44.08	69.55	1.5778
1-2, 86	36.63	64.50	1.7608
1-2, 128	32.08	57.84	1.8029
2-3, 68	29.79	54.94	1.8442
2-3, 94	32.03	58.94	1.8401
2-3, 135	29.66	54.18	1.8267
2-5, 80	31.28	56.63	1.8104
2-5, 130	35.68	60.10	1.6844
3-2, 110	29.31	55.36	1.8887
3-5, 104	31.64	57.21	1.8081
4-2, 136	36.87	66.13	1.7935
4-5, 90	25.54	49.87	1.9526
5-3, 102	32.16	62.48	1.9427
5-5, 20	24.12	.	.
5-6, 68	29.80	55.77	1.8714
5-6, 88	20.20	42.52	2.1049
6-3, 134	30.09	56.65	1.8826
6-4, 30	30.14	57.00	1.8911
6-4, 107	21.38	37.03	1.7319
7-2, 124	26.83	52.51	1.9571
7-3, 122	25.81	51.82	2.0077
7-4, 20	28.10	49.42	1.7587
8-2, 140	36.08	65.72	1.8215
8-5, 105	29.23	57.88	1.9801
8-5, 118	26.56	61.64	2.3207
8-5, 132	27.58	52.68	1.9100
9-2, 107	28.18	55.58	1.9723
9-4, 112	27.93	54.57	1.9538
9-4, 136	20.66	39.15	1.8949
11-3, 70	25.59	46.83	1.8300
11-4, 97	23.07	41.52	1.7997
11-4, 105	24.86	46.74	1.8801
12-2, 68	23.72	47.00	1.9814
12-2, 123	22.36	42.56	1.9033
12-5, 82	32.96	62.64	1.9004
12-5, 132	25.27	48.04	1.9010
14-3, 120	29.06	53.00	1.8238
14-4, 128	25.80	48.70	1.8875
15-2, 122	29.06	53.67	1.8468
15-4, 123	31.51	56.61	1.7965
16-2, 106	28.49	56.00	1.9656
16-5, 75	28.07	55.38	1.9729
17-5, 118	25.76	51.77	2.0097
18-2, 96	31.41	62.83	2.0003
Hole 232A			
1-3, 112	28.33	55.25	1.9502
1-4, 100	30.93	58.75	1.8994
2-2, 147	30.34		
2-4, 61	34.22		
3-2, 66	29.99	56.29	1.8769
3-5, 75	32.07	56.96	1.7761
4-2, 100	30.19	57.82	1.9152
4-3, 101	29.67	56.97	1.9201
5-2, 52	30.77	58.70	1.9077
5-4, 87	31.60		
6-2, 35	30.52		
6-3, 98	30.53		
7-3, 115	30.96		
7-4, 51	29.82		
8-2, 120	32.99		

TABLE 5 – *Continued*

Core, Section, Top of Interval (cm)	Water (%)	Porosity (%)	Density (g/cm^3)
Hole 232A – *continued*			
8-4, 38	30.29		
9-5, 106	32.86		
10-6, 72	27.39		
12-2, 110	23.21		
14-1, 45	27.47		
15-2, 123	26.61		
18-3, 66	26.39		
18-4, 6	28.34		
19-2, 100	32.24		
20-1, 130	26.29		
21-5, 82	25.08		
22-3, 37	8.60		
23-3, 109	23.34		
23-5, 105	22.83		
24-1, 80	24.50		

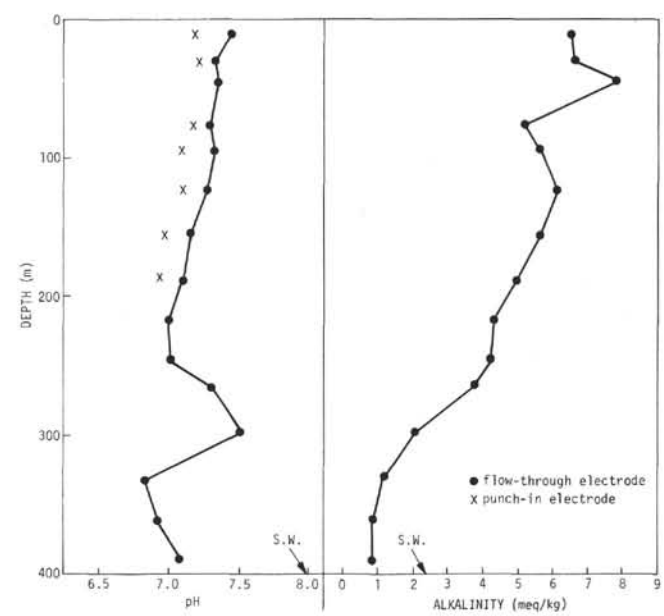

Figure 4. p*H and alkalinity of interstitial pore waters, Site 232.*

ments and activity. The deeper structures also support this picture, as Laughton and Tramontini (1969) have shown.

On the back slope of the western boundary ridge, refraction evidence (ibid, Profile 6218) indicates that a relatively thick (1.5 km) sedimentary section overlies Layer 2 basement material (5.3 km/sec). The onsite reflection information may not penetrate to this basement (Figure 5). It shows an acoustically semitransparent layer above a poorly reflecting acoustic basement lying at a depth of about 0.25 sec. The uppermost interval of semitransparent material possibly contains thinly layered sediments that conform to the general trend of the acoustic basement surface at the base of the entire sequence. In addition, the sediment surface shows evidence either of deformation,

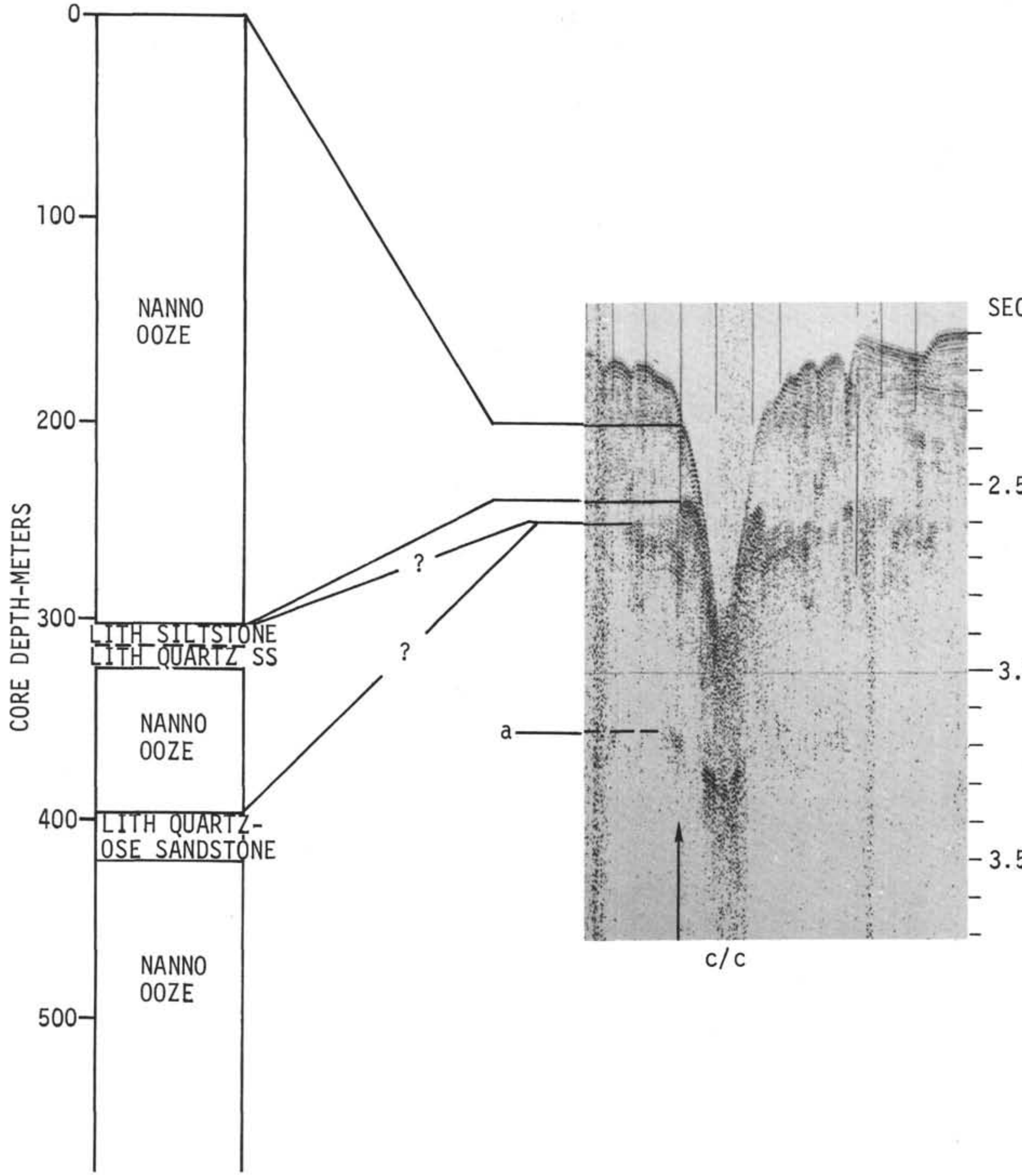

Figure 5. *Generalized lithology and seismic section; core length in meters, seismic section in seconds of two-way travel time. Arrows indicate site; "a", possible deep reflector;* c/c, *course reverse over edge of trench. What appears to be two sides are in fact almost the same location.*

perhaps compressional, and/or of incision in a direction subparallel to the axis of the trench.

The correlation of lithology and seismic reflections (Figure 5) identifies the nanno ooze as the acoustically transparent sequence; there are no discrete units within this sequence that may be correlated with the possible reflecting horizons within the upper section. The acoustic basement appears to be lithified quartzose sandstone interbedded with nanno ooze. As in Site 231, there are really only two very different lithologies, nanno ooze and lithified siltstone-quartz sandstone complexes. On these nonambiguous data, the seismic-lithologic correlation can be said to be good.

Some interesting speculation occurs in considering the significance of the lithologic-seismic picture here and in the underway record from the previous site.

The reflection profile between Site 231 in Half-Degree Square and the western margin of the Alula-Fartak Trench shows a continuous reflector, acoustic basement, that in both Site 231 and the Sheba Ridge region is Layer 2-type basement. This reflector appears continuous with the shallow acoustic basement complex of the western edge of the trench, the lithified material, siltstone-quartzose sandstone, interbedded with nanno ooze.

One question raised: where does the transition between basalt and lithified sediments occur or, what is the extent of the latter material geographically and vertically? There is no obvious answer to the question of lateral coverage, but some estimate of thickness can be made. Based on refraction and dredge information reported by Laughton and Tramontini (1969) and Ramsay and Funnell (1969), respectively, there is basalt beneath the lithified material. As shown on the reflection profile, there is a faint possibility of a reflector at 3.2 sec depth (0.85 sec deep in the section, Figure 5). A calculation made using a measured velocity for the lithified material (section on Physical Properties) and the depth difference from the seismic record gives about 1.4 km of 4.57 km/sec material beneath the 300 meters of nanno ooze cored, a total of 1.7 km. This is not in too bad agreement with the 1.5 km on Station 6218 (Laughton and Tramontini, 1969) and is at least an allowable speculation.

SUMMARY, CONCLUSIONS, AND SPECULATIONS

Holes 232 and 232A are located near the western lip of The Alula-Fartak Trench, a north-northeast-south-southwest trending feature at the eastern entrance to the Gulf of Aden. At Hole 232, water depth (from drill pipe) is 1758 meters and at Hole 232A, 275 feet to the northwest, water depth is 1753 meters. The section was cored continuously to 434 meters (from sediment-water interface) to acoustic basement and beyond into more soft sediments. Recovery totaled 252 meters.

Six lithologic units were found (Figure 2). Unit 1, from 0-302 meters, is a monotonous sequence of olive-gray to dusky yellow-green, nanno oozes with occasional thin quartzose sand layers. Two acid volcanic sand layers occur at 164 and 165 meters. Unit 2, known only from a single core catcher sample, is a medium and dark gray, well-lithified, laminated, calcite cemented siltstone with thin sandstone interlayers. Unit 3, similarly known only from a single core catcher sample, is a medium light gray, well-lithified, calcite cemented, medium-grained, quartzose sandstone, containing a few fragments of calcareous megafossils. Unit 4, from 321-397 meters, comprises olive-gray to dusky-yellow-green nanno ooze with occasional thin quartzose sand layers. Unit 5, from 397-422 meters, is similar to Unit 3, being a medium light gray, well-lithified, calcite cemented quartzose sandstone. Unit 6, from 422-434 meters, comprises olive gray nanno ooze.

The sediments of Units 1, 4, and 6 are rather uniform nannoplankton-rich hemipelagic muds, suggestive of very constant conditions of water depth, pelagic carbonate production, and detrital sediment input. The fairly abundant silt-sized detrital grains dispersed throughout the hemipelagic muds are probably of eolian origin. The two acid volcanic sand layers of Unit 1 may correlate with similar layers in the Pliocene section of Site 231. The siltstone and sandstones of Units 2, 3, and 5 exhibit characteristics suggestive of shallow-water deposition and seem sedimentologically exotic in this otherwise hemipelagic sequence. Their diagenetic grade or degree of lithification also signal their alien nature. Emplacement of these rocks as fault or slide blocks, derived from the Arabian continental margin to the northwest, is suggested.

Calcareous nannofossils are abundant and well preserved throughout the cored section. Foraminifers are common and well preserved in the upper 40 meters and become less common and poorly preserved in the remainder of the section. Radiolarians are common and well preserved in the intervals of 0-254 meters and 330-358.5 meters, but are rare to absent between 254 and 330 meters and below 358.5 meters. Fossil zonations and stratigraphic boundaries are summarized in Figure 1. Average sediment accumulation rates are 54.6 m/m.y. for the Pleistocene/Pliocene, and 88.6 m/m.y. for the late Miocene. Data from Site 231 and from the Pleistocene/Pliocene of Site 232 suggest that the hemipelagic nanno ooze lithofacies accumulates at rates of 38-65 m/m.y. The high upper Miocene nanno ooze accumulation rate at this site (86.6 m/m.y.) may indicate that slumping took place during the interval 5-6.7 × m.y. ago. The siltstone and sandstones of Units 2, 3, and 5 were presumably emplaced during this/these slumping episode(s) as exotic slide blocks.

Physical property measurements of bulk density, porosity, and sonic velocity are summarized in Figure 3. The variability in all parameters in the upper part of the section is related to the occurrence of more sandy layers within the nanno oozes of Unit 1. Major discontinuities coincide with the hard and dense rocks of Units 2, 3, and 5. Reflection data show an acoustically semitransparent layer to lie above a poorly reflecting acoustic basement, the latter lying at a depth of 0.25 second (2-way travel time). Shipboard-determined sediment velocities enable a synthetic seismic section to be constructed which closely agrees with refraction data and lithologic units. The acoustically transparent layer comprises the nanno oozes of Unit 1. Acoustic basement lies at the interface of Units 1 and 2.

Interstitial pore water salinities show an initial slight decrease down to 46 meters, followed by a fairly rapid increase to a maximum value of 68 ‰ at 350 meters. This salinity trend could possibly be indicative of evaporites at greater depths.

It was hoped that drilling at Site 232 would provide information relating to the oceanic basement age, the uplift and subsidence history of the Alula-Fartak Trench transform fault, and the relationship of the latter to the geological history of the Arabian continental margin. Basaltic basement was not reached and so the question of the age and nature of the ocean floor at this site remains unanswered. Concerning the uplift and subsidence history of the Alula-Fartak Trench, we have little definitive to offer; the slumping episode 5-6 × 10^6 yr ago presumably marks one or more tectonic events, but their vertical and or horizontal motions are not known. The rate of sedimentation and homogeneity of the sediments accumulated subsequent to this event suggest later motions to have been of a more insidious nature. Our findings enable us to add little or nothing to previous notions concerning the geological history of the Arabian continental margin. The hemipelagic sediments accumulated at this site are dominated by biogenic debris, the terrigenous fraction being rather minor. Thus the sediment input into the northern Gulf of Aden from the extensive Wadi Hadramaut drainage system has been relatively small or has all been trapped in nearshore environments.

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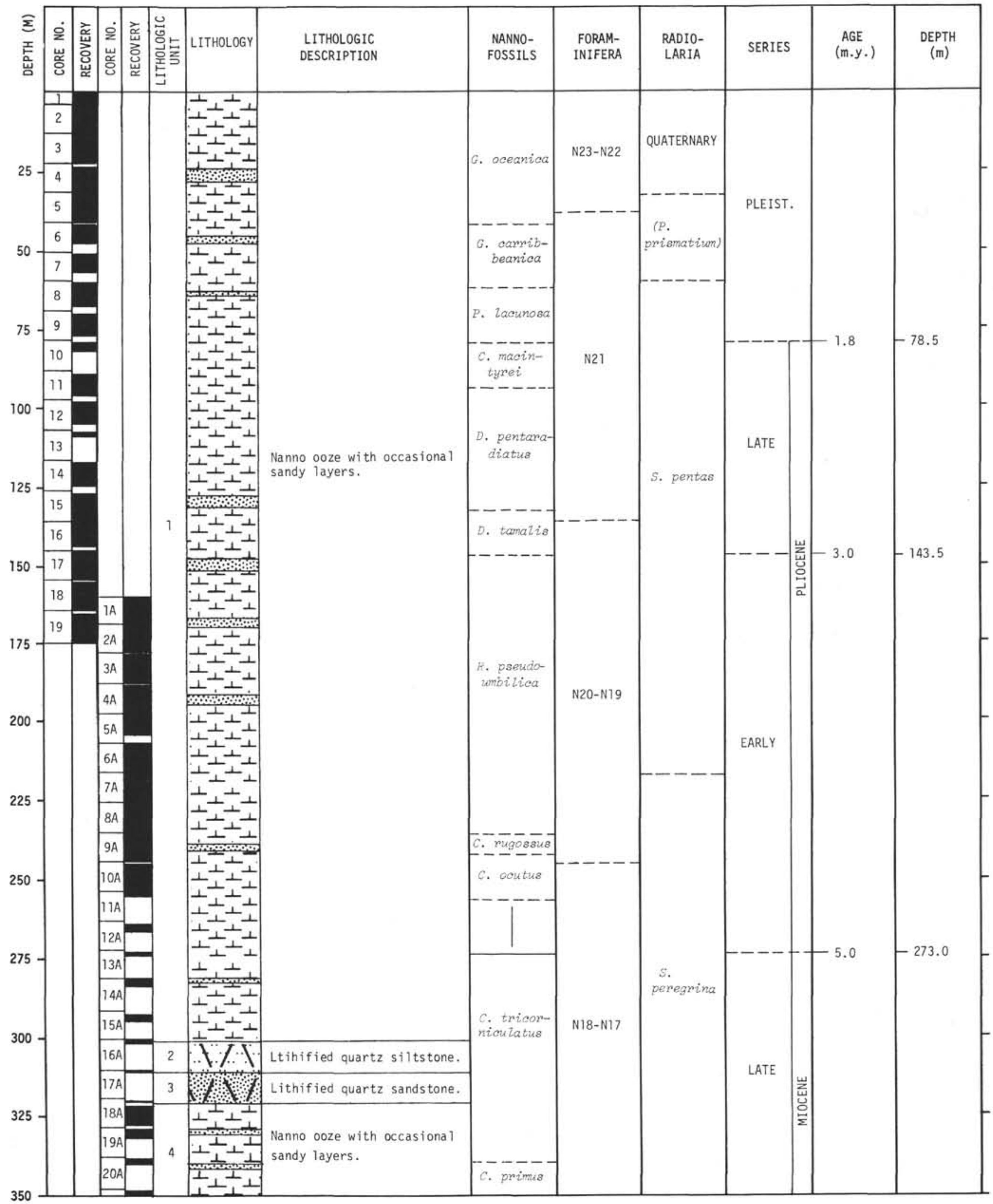
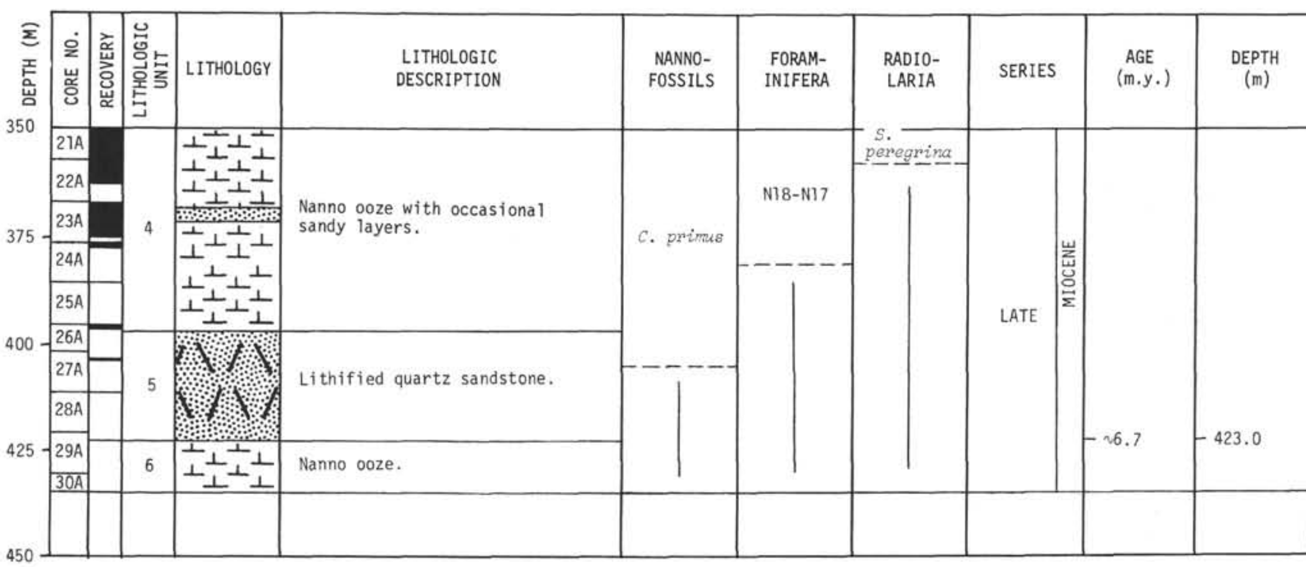
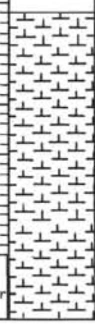

DEPTH (M)
CORE NO.
RECOVERY
CORE NO.
RECOVERY
LITHOLOGIC UNIT
LITHOLOGY
LITHOLOGIC DESCRIPTION
NANNO-FOSSILS
FORAM-INIFERA
RADIO-LARIA
SERIES
AGE (m.y.)
DEPTH (m)
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
1A
2A
3A
4A
5A
6A
7A
8A
9A
10A
11A
12A
13A
14A
15A
16A
17A
18A
19A
20A
1
2
3
4
Nanno ooze with occasional sandy layers.
Ltihified quartz siltstone.
Lithified quartz sandstone.
Nanno ooze with occasional sandy layers.
G. oceanica
G. carribbeanica
P. lacunosa
C. macintyrei
D. pentaradiatus
D. tamalis
R. pseudoumbilica
C. rugossus
C. acutus
C. tricorniculatus
C. primus
N23-N22
N21
N20-N19
N18-N17
QUATERNARY
(P. prismatium)
S. pentas
S. peregrina
PLEIST.
LATE
EARLY
LATE
PLIOCENE
MIOCENE
1.8
3.0
5.0
78.5
143.5
273.0


DEPTH (M)
CORE NO.
RECOVERY
LITHOLOGIC UNIT
LITHOLOGY
LITHOLOGIC DESCRIPTION
NANNO-FOSSILS
FORAM-INIFERA
RADIO-LARIA
SERIES
AGE (m.y.)
DEPTH (m)
350
375
400
425
450
21A
22A
23A
24A
25A
26A
27A
28A
29A
30A
4
5
6
Nanno ooze with occasional sandy layers.
Lithified quartz sandstone.
Nanno ooze.
C. primus
N18-N17
S. peregrina
LATE
MIOCENE
~6.7
423.0

Site 232 Hole Core 1 Cored Interval: 0.0-2.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	Gephyrocapsa oceanica N23-N22	QUATERNARY	C/G	A/M, A/G, A/G	R/M	1, 2, Core Catcher	0.5, 1.0	VOID		C, GZ, CC	see below



NANNO OOZE
Light olive gray (5Y5/2)
Smear 1-1-100

Sand 5%	Nannos	75%	Quartz 2%
Silt 10%	Forams	15%	
Clay 85%	Fish Debris	2%	

Minor color changes (20 to 40 cm thick zones) to pale olive (10Y6/2)

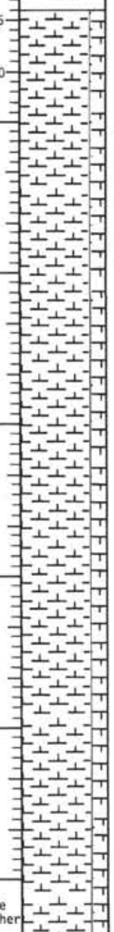
$CaCO_3$ 62%

Grain Size
Sand 19%
Silt 57%
Clay 24%

Explanatory notes in chapter 1

Site 232 Hole Core 2 Cored Interval: 2.5-12.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	Gephyrocapsa oceanica N23-N22	QUATERNARY	C/G	A/M, A/G, A/G	R/M	1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0	VOID			see below



FORAM RICH NANNO OOZE
Light olive gray (5Y5/2) grading to pale olive (10Y6/2)
Smear 2-1-110

Sand 5%	Nannos	75%	Quartz	5%
Silt 15%	Forams	10%	Volc. Glass	1%
Clay 80%	Fish Debris	1%	Pyrite	1%

Smear 2-2-116 (from pyritic streak)

Sand 5%	Nannos	50%	Pyrite	25-30%
Silt 10%	Forams	5%	Quartz	2%
Clay 85%	Fish Debris	2%		

Frequently color changes to grayish yellow green (5GY7/2) and light olive gray (5Y5/2). Pyritic streaks and mottles 2-2-30, 2-2-75, 2-3-50, 2-4-20, 2-6-90 and 2-6-130.

Smear 2-3-80

Sand 5%	Nannos	85%	Quartz	2- 5%
Silt 10%	Forams	5%	Feldspar	2- 5%
Clay 85%	Fish Debris	2%		

Explanatory notes in chapter 1

Site 232 Hole Core 3 Cored Interval: 12.0-21.5 m

AGE: PLEISTOCENE

ZONE: *Gephyrocapsa oceanica* / N23-N22 / QUATERNARY

FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
NANNOS	FORAMS	RADS					
			1	0.5, 1.0			
	A/M		2				
			3				
	R/M		4				
			5				
C/G		R/M	6				
	A/M		Core Catcher				

LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish olive (10Y4/2) grading to pale olive (10Y6/2) at 3-2-70, dusky yellow green (5GY5/2) at 3-3-0, pale olive (10Y6/2) at 3-3-110, dusky yellow green (5GY5/2) at 3-4-0.

Smear 3-2-80

Sand	5%	Nannos	80-85%	Quartz	2%
Silt	10%	Forams	2- 5%	Volc. Glass	1%
Clay	85%	Fish Debris	1%		

Pyritiferous mottles and streakes scattered throughout.

Scattered slight color changes from light olive gray (5Y5/2) to pale olive (10Y6/2).

Explanatory notes in chapter 1

Site 232 Hole Core 4 Cored Interval: 21.5-31.0 m

AGE: PLEISTOCENE

ZONE: *Gephyrocapsa oceanica* / N23-N22 / QUATERNARY

FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
NANNOS	FORAMS	RADS					
			1	0.5, 1.0	VOID		
	R/M		2				
			3				
	A/G		4				
			5				C GZ
C/G		C/M	6				
	A/G		Core Catcher				

LITHOLOGIC DESCRIPTION

NANNO OOZE
Grayish olive (10Y4/2)
Smear 4-1-90

Sand	5%	Nannos	85%	Quartz	1- 2%
Silt	35%	Forams	1- 5%	Feldspar	1%
Clay	60%	Fish Debris	1- 2%	Volc. Glass	1%
				Pyrite	1%

Color grading to dusky yellow green (5GY5/2) at 4-2-50 and back to pale olive (10Y6/2) at 4-4-15.

Scattered dark mottles; bigger ones at 4-4-74, 4-5-25, 4-5-80, 4-5-105.

Smear 4-4-74 (taken in dark mottle)

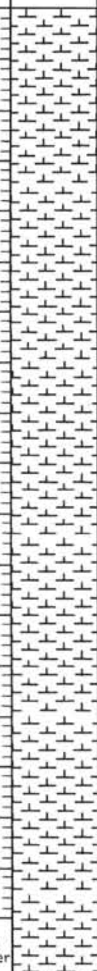
Sand	10%	Nannos	40-50%	Pyrite	15-20%
Silt	15%	Forams	15-20%	Volc. Glass	2- 5%
Clay	75%	Fish Debris	1%		

Color change to dusky yellow green (5GY5/2) at 4-5-40 with pale olive (10Y6/2) zones.
$CaCO_3$ 35%
Grain Size
Sand 9%
Silt 75%
Clay 16%

Explanatory notes in chapter 1

Site 232 Hole Core 5 Cored Interval: 31.0-40.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	QUATERNARY; Gephyrocapsa oceanica N23-N22; Pterocanium prismatium	C/G	A/M; A/P	C/M	1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0			GZ C; C	see below



NANNO OOZE
Dusky yellow green (5GY5/2) with pale olive (10Y6/2) zones at 5-2-80, 5-3-130, 5-4-110.

Smear 5-2-80

Sand 5%	Nannos 80-90%	Quartz 1- 2%
Silt 10%	Forams 5-10%	Pyrite 1%
Clay 85%	Fish Debris 1%	

Scattered pyritiferous dark mottles concentrated at 5-5-30, 5-5-73, 5-5-105 and 5-5-150.

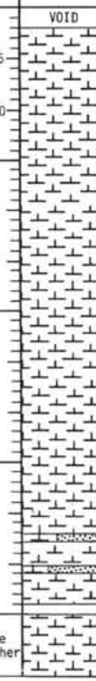
Dark mottled layers at 5-6-50, 5-6-90, 5-6-115.

Grain Size	Grain Size
Sand 3%	Sand 6%
Silt 54%	Silt 81%
Clay 43%	Clay 14%
$CaCO_3$ 50%	$CaCO_3$ 31%

Explanatory notes in chapter 1

Site 232 Hole Core 6 Cored Interval: 40.5-50.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	G. caribbeanica oceanica G. oceanica N21; Pterocanium prismatium	C/G	A/P; C/P	F/M	1, 2, 3, 4, Core Catcher	0.5, 1.0	VOID			see below



NANNO OOZE
Dusky yellow green (5GY5/2)

Dark mottled layers at 6-1-30, 6-1-130 to 6-2-50.

Color grading between pale olive (10Y6/2) and dusky yellow green (5GY5/2).

Some dark mottles.

Sandy layers (5-10 cm thick) at 6-4-75, 6-4-105, 6-4-145.

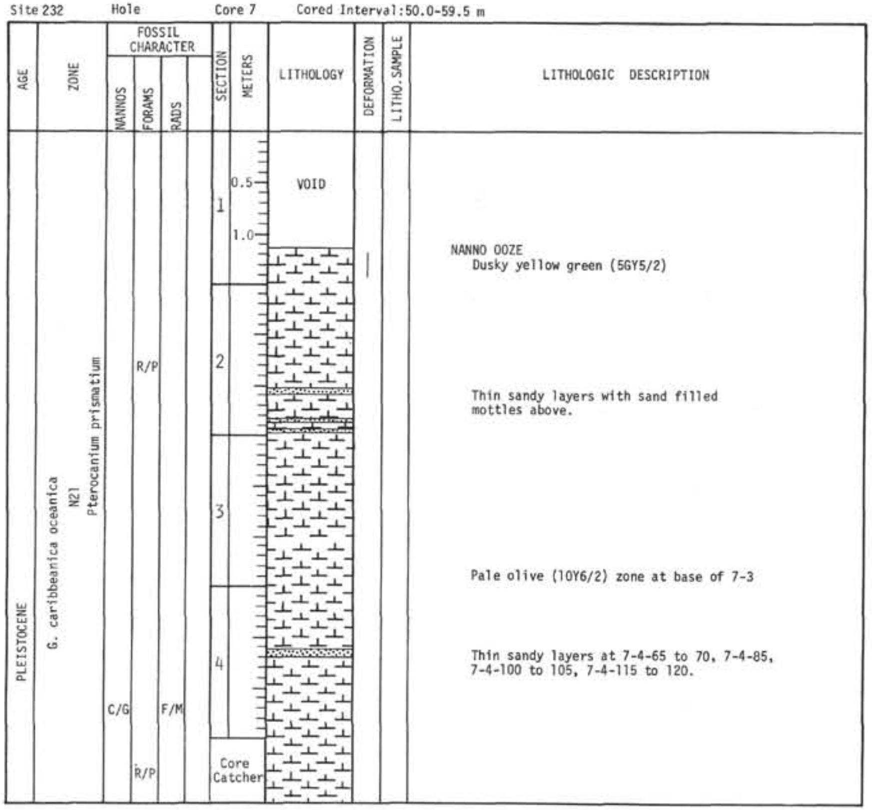
Smear 6-4-76

Sand 40%	Nannos 30-40%	Quartz 30-40%
Silt 20%	Forams 2- 5%	Feldspar 10%
Clay 40%		Mica 5%
		Volc. Glass 5%

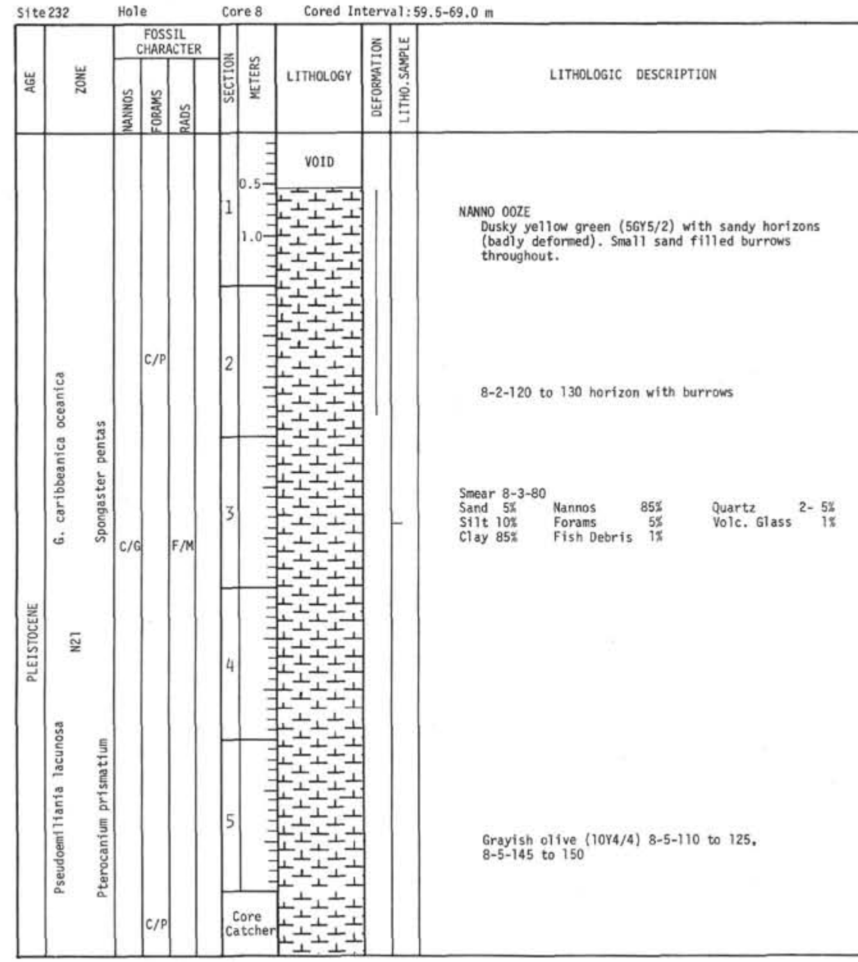
Smear 6-4-105

Sand 60%	Nannos 30%	Quartz 50-60%
Silt 10%	Fish Debris 2%	Feldspar 5%
Clay 30%		Pyrite 5%
		Mica 2%

Explanatory notes in chapter 1



Explanatory notes in chapter 1



Explanatory notes in chapter 1

Site 232 Hole Core 9 Cored Interval: 69.0-78.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	P. lacunosa; N21; Spongaster pentas	C/G	A/G; C/P	C/M	1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2) with some sand filled burrows Sandy layers at 9-4-135, 9-4-147, 9-5-55 to 65 and 9-5-100 Smear 9-5-60 Sand 30% Nannos 50-60% Quartz 30-40% Silt 15% Fish Debris 1- 2% Clay 55%

Explanatory notes in chapter 1

Site 232 Hole Core 10 Cored Interval: 78.5-88.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	Cyclococcolithina macintyrei; P. lacunosa; N21; Spongaster pentas	C/G	C/P; C/M	C/M	1, 2, Core Catcher	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2), few burrows. Sandy layers at 10-1-90, 10-1-105, 10-1-125, 10-2-145 Color change to pale olive (10Y6/2) at 10-2-65 and back to dusky yellow green at 10-2-145.

Explanatory notes in chapter 1

Site 232 Hole Core 11 Cored Interval: 88.0-97.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	Discoaster pentaradiates; C. macintyrei; N21; Spongaster pentas	C/G	C/P, C/M	C/M	1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	VOID			

NANNO OOZE
Dusky yellow green (5GY5/2)

Smear 10-2-80

Sand	5%	Nannos	80%	Quartz	5%
Silt	10%	Forams	2- 5%	Volc. Glass	1- 2%
Clay	85%	Rads	1- 2%	Dolo. Rhombs	1%

Few dark burrows

Explanatory notes in chapter 1

Site 232 Hole Core 12 Cored Interval: 97.5-107.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	D. pentaradiatus; N21; Spongaster pentas	C/G	R/P, R/P	C/M	1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	VOID			

NANNO OOZE
Dusky yellow green (5GY5/2) with thin sand layers at 12-1-115 to 120, 12-2-120 to 130, 12-4-50, 12-4-90, 12-4-58, 12-4-120.

Smear 12-2-128 (sand layer)

Sand	60%	Nannos	20%	Quartz	60%
Silt	10%	Forams	5-10%	Heavy Min.	5%
Clay	30%	Fish Debris	1- 2%	Feldspar	2- 5%

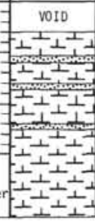
Some sand filled burrows

Some sand filled burrows

Explanatory notes in chapter 1

Site 232 Hole Core 13 Cored Interval: 107.0-116.5 m

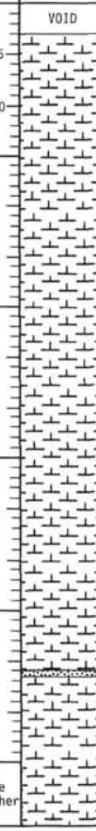
AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	D. pentaradiatus N21 Spongaster pentas	C/G	R/P R/P	C/M	1 Core Catcher	0.5 1.0	VOID		GZ C	NANNO OOZE Dusky yellow green (5GY5/2) with thin sand layers at 13-1-40, 13-1-55, 13-1-80, 13-1-120 Smear 13-1-85 Sand 25% Nannos 60-70% Quartz 10-15% Silt 10% Forams 5-10% Heavy Min. 5-10% Clay 65% Fish Debris 1- 2% $CaCO_3$ 22% Grain Size Sand 8% Silt 72% Clay 20%



Explanatory notes in chapter 1

Site 232 Hole Core 14 Cored Interval: 116.5-126.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	D. pentaradiatus N21 Spongaster pentas	C/G	C/P C/P	C/M	1 2 3 4 5 Core Catcher	0.5 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2) Smear 14-2-135 Sand 15% Nannos 70-80% Quartz 5-10% Silt 5% Rads 1- 2% Heavy Min. 2- 5% Clay 80% Sand layer 14-5-60 to 66 Smear 14-5-60 Sand 60% Nannos 20-30% Quartz 40-50% Silt 15% Heavy Min. 15-20% Clay 25%



Explanatory notes in chapter 1

Site 232 Hole Core 15 Cored Interval: 126.0-135.5 m

AGE	ZONE	NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	D. pentaradiatus N21; Spongaster pentas; D. tamalis	C/G	C/P; C/P	A/M	1	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2)
					2					
					3					Some small sand filled burrows
					4					
					5					
					6					Pale olive (10Y6/2) zone 15-6-10 to 15
					Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole Core 16 Cored Interval: 135.5-145.0 m

AGE	ZONE	NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLIOCENE	D. tamalis N20-N19; Spongaster pentas	C/G	R/P; C/P	C/M	1	0.5, 1.0				NANNO OOZE Dusky yellow green (5GY5/2)
					2					Some sand filled burrows
					3					Smear 16-3-80 Sand 10% Silt 5% Clay 85% Nannos 70-80% Forams 5-10% Fish Debris 2% Rads 1- 2% Quartz 3- 5%
					4					Color change to pale olive (10Y6/2) at 16-4-40
					5					
					Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole Core 17 Cored Interval: 145.0-154.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	D. tamalis; Reticulofenestra pseudoumbilica; N20-N19; Spongaster pentas	C/G	C/P; C/P (core catcher)	A/M	1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0				

NANNO OOZE
Dusky yellow green (5GY5/2) with thin sand layers at 17-1-100, 17-1-130; some sand filled burrows throughout.

Smear 17-3-80

Sand	10%	Nannos	80-90%	Quartz	2%
Silt	5%	Forams	2- 5%	Dolo. Rhombs	1%
Clay	85%	Rads	2- 5%		
		Fish Debris	2- 3%		

Smear 17-6-150

Sand	20%	Nannos	60-70%	Quartz	15-20%
Silt	10%	Forams	2- 5%	Feldspar	2- 5%
Clay	70%			Pyrite	1- 3%
				Heavy Min.	2%

Explanatory notes in chapter 1

Site 232 Hole Core 18 Cored Interval: 154.5-164.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica; N20-N19; Spongaster pentas	C/G	C/P; C/P (core catcher)	A/G	1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0	VOID		GZ C	

NANNO OOZE
Pale olive (10Y6/2) grading to dusky yellow green (5GY5/2) at 18-1-100

Smear 18-2-90

Sand	10%	Nannos	80-90%	Quartz	2-5%
Silt	5%	Forams	2- 5%		
Clay	85%	Fish Debris	1- 2%		

$CaCO_3$ 46%

Grain Size
Sand 1%
Silt 47%
Clay 52%

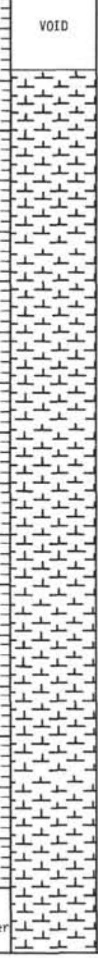
Smear 18-5-80

Sand	5%	Nannos	70-80%	Quartz	2- 5%
Silt	10%	Forams	10-15%	Heavy Min.	1- 2%
Clay	85%	Plant Debris	1- 2%		

Explanatory notes in chapter 1

Site 232 Hole Core 19 Cored Interval: 164.0-173.5 m

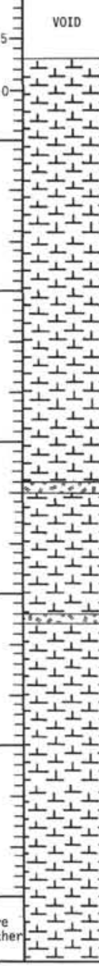
AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica; N20-N19; Spongaster pentas				1	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2)
			R/P		2					
					3				—	Smear 19-3-80 Sand 5% Nannos 80-90% Quartz 1- 2% Silt 25% Forams 3- 5% Dolo. Rhombs 1% Clay 70% Diatoms 1- 2% Fish Debris 1- 2%
			C/P		4					
					5					
		C/G		A/G	6					Pale olive (10Y6/2) zone 19-6-90 to 140
			C/P		Core Catcher					



Explanatory notes in chapter 1

Site 232 Hole A Core 1 Cored Interval: 159.0-168.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica; N20-N19; Spongaster pentas	C/G		C/M	1	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2)
			C/P		2				—	Smear 1-2-80 Sand 5% Nannos 80-90% Quartz 1- 2% Silt 10% Forams 2- 5% Clay 80% Fish Debris 1- 2%
			C/P		3					
			R/P		4				GZ —	VOLCANIC ASH 1-4-40 to 50 Smear 1-4-40 (Volcanic Ash) Sand 75% Nannos 5-10% Volc. Glass 80-90% Silt 15% Fish Debris 1% Quartz 2- 5% Clay 10%
			R/P		5					VOLCANIC ASH 1-5-24 to 27 Smear 1-5-25 (Volcanic Ash) Sand 50% Nannos 25-30% Volc. Glass 50-60% Silt 15% Forams 2- 5% Quartz 5-10% Clay 35% Heavy Min. 1- 2% Grain Size Sand 9% Silt 67% Clay 24%
			C/P		6					
			C/P		Core Catcher					



Explanatory notes in chapter 1

Site 232 Hole A Core 2 Cored Interval: 168.5-178.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica N20-N19	Spongaster pentas	C/G		C/M	1	0.5, 1.0				NANNO OOZE Dusky yellow green (5GY5/2)
				C/P		2					
						3				–	Smear 2-3-80 Sand 5% Nannos 80-90% Quartz 2- 5% Silt 10% Rads 2- 5% Dolo. Rhombs 1% Clay 85%
				C/M		4					
						5					
						6					
				C/P		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 3 Cored Interval: 178.0-187.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica N20-N19	Spongaster pentas	C/G		A/G	1	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2)
				C/P		2					
						3				–	Smear 3-3-80 Sand 5% Nannos 80-90% Quartz 2- 5% Silt 10% Diatoms 2- 5% Pyrite 1% Clay 85% Rads 2- 5% Dolo. Rhombs 1% Fish Debris 1- 2%
				R/P		4					
						5					
						6					
				C/P		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 4 Cored Interval: 187.5-197.0 m

AGE	ZONE			FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica	N20-N19	Spongaster pentas	C/G	R/P, R/M, C/P	A/G	1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0	VOID; nanno ooze		C	NANNO OOZE Dusky yellow green (5GY5/2) Smear 4-2-90 Sand 5% Nannos 80-90% Quartz 1- 3% Silt 10% Forams 1- 2% Pyrite 1% Clay 85% Rads 1- 2% Fish Debris 1- 2% Diatoms 1% Smear 4-3-100 Sand 15% Nannos 60-70% Quartz 2- 5% Silt 10% Forams 5-10% Pyrite 1- 3% Clay 75% Rads 2- 5% Diatoms 1- 2% $CaCO_3$ 5% Pale olive (10Y6/2) zone 4-5-0 to 110

Explanatory notes in chapter 1

Site 232 Hole A Core 5 Cored Interval: 197.0-206.5 m

AGE	ZONE			FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica	N20-N19	Spongaster pentas	C/G	C/M, C/P, C/M	A/G	1, 2, 3, 4, Core Catcher	0.5, 1.0	VOID; nanno ooze			NANNO OOZE Dusky yellow green (5GY5/2) Color changing to pale olive (10Y6/2) at 5-2-120 Smear 5-3-80 Sand 5% Nannos 80-90% Quartz 1- 2% Silt 10% Forams 2- 5% Pyrite 1- 2% Clay 85% Diatoms 1- 2% Color change to dusky yellow green (5GY5/2) at 5-4-100

Explanatory notes in chapter 1

Site 232 Hole A Core 6 Cored Interval: 206.5-216.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica	N20-N19 / Spongaster pentas	C/G		A/G	1	0.5, 1.0				— VOID NANNO OOZE Dusky yellow green (5GY5/2)
				C/P		2				—	Smear 6-2-80 Sand 5% Nannos 80-90% Quartz 1- 2% Silt 10% Forams 2- 5% Clay 85% Fish Debris 1- 2%
						3					Color change to pale olive (10Y6/2) at 6-4-10
				R/P		4				—	Smear 6-4-30 Sand 5% Nannos 75-80% Quartz 2- 5% Silt 10% Rads 3- 5% Clay 85% Diatoms 1- 3%
						5				—	Dusky yellow green (5GY5/2) zone 6-5-30 to 75 Smear 6-5-75 Sand 10% Nannos 65-75% Quartz 5-10% Silt 10% Forams 2- 5% Heavy Min. 1% Clay 80% Rads 1- 3%
						6					Color change to dusky yellow green (5GY5/2)
				R/P		Core Catcher					

Explanatory notes in chapter 1

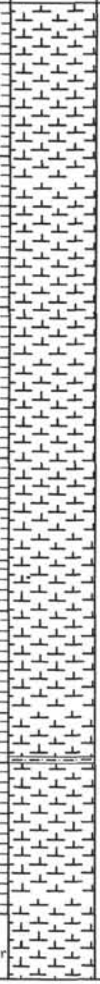
Site 232 Hole A Core 7 Cored Interval: 216.0-225.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	R. pseudoumbilica	N20-N19 / Stichocorys peregrina	C/G		C/M	1	0.5, 1.0			—	NANNO OOZE Dusky yellow green (5GY5/2) with pale olive (10Y6/2) zones 7-1-0 to 45, 7-1-100 to 7-2-70 Sandy layers at 7-1-72 to 77, 7-2-90, 7-2-100, 7-2-115, 7-5-90 and 7-5-115 Smear 7-1-72 Sand 40% Nannos 50-60% Quartz 25-30% Silt 20% Fish Debris 1- 2% Heavy Min. 3- 5% Clay 40% Mica 2%
				R/M		2			GZ C		Some sand filled burrows throughout.
						3					$CaCO_3$ 19% Grain Size Sand 13% Silt 71% Clay 16%
				R/P		4					
						5				—	Smear 7-5-92 Sand 30% Nannos 50-60% Quartz 15-20% Silt 20% Forams 1- 3% Heavy Min. 5-10% Clay 50% Fish Debris 1- 2%
						6					
				R/P		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 8 Cored Interval: 225.5-235.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	*R. pseudoumbilica*; N20-N19; *Stichocorys peregrina*	C/G	C/M, C/P, C/P	A/G	1 (0.5, 1.0), 2, 3, 4, 5, 6, Core Catcher					



NANNO OOZE
Dusky yellow green (5GY5/2)

Some sand filled burrows at 8-4-105 and 8-6-5

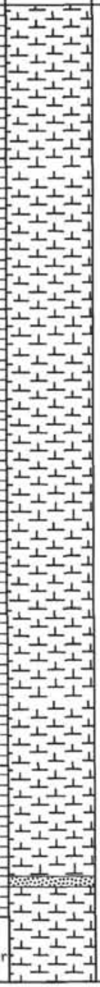
Thin sandy layer at 8-5-150
Smear 8-5-150

Sand	30%	Nannos	60-70%	Quartz	15-20%
Silt	20%	Forams	2- 5%	Heavy Min.	3- 5%
Clay	50%				

Explanatory notes in chapter 1

Site 232 Hole A Core 9 Cored Interval: 235.0-244.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	*Ceratolithus rugosus*; N20-N19; *Stichocorys peregrina*	C/G	C/P, C/P, C/P	A/G	1 (0.5, 1.0), 2, 3, 4, 5, 6, Core Catcher				C, GZ	



NANNO OOZE
Dusky yellow green (5GY5/2)

Olive gray (5Y3/2) zones 9-4-35 to 55, 9-4-95 to 110, 9-5-70 to 9-6-60.

Smear 9-5-120

Sand	10%	Nannos	70-80%	Pyrite	5-10%
Silt	20%	Rads	1- 3%	Volc. Glass	2- 5%
Clay	70%	Fish Debris	1- 2%	Quartz	1- 3%

$CaCO_3$ 28%

Grain Size
Sand 1%
Silt 49%
Clay 50%

Sand layer 9-6-110 to 119
Smear 9-6-118

Sand	50%	Nannos	30-40%	Quartz	40-50%
Silt	20%	Forams	2- 5%	Heavy Min.	10-15%
Clay	30%	Rads	1- 2%	Dolo. Rhombs	2%

Explanatory notes in chapter 1

Site 232 Hole A Core 10 Cored Interval: 244.5-254.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	C. acutus	N18-N17 Stichocorys peregrina	C/G		A/G	1	0.5, 1.0				NANNO OOZE Dusky yellow green (5GY5/2) with grayish olive (10Y4/2) zones at 10-2-0 to 70, 10-3-70 to 120, 10-4-70 to 120.
				C/P		2					
						3					
				C/P		4					
						5				—	Grayish olive green (5GY3/2) at 10-5-80 to 150. Smear 10-5-130 Sand 5% Nannos 80-90% Pyrite 2- 5% Silt 15% Forams 2- 5% Quartz 1% Clay 80% Fish Debris 1- 2%
						6					
				C/P		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 11 Cored Interval: 254.0-263.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	C. acutus N18-N17	Stichocorys peregrina	C/G	R/P	R/M	1	0.5, 1.0			—	NANNO OOZE Dusky yellow green (5GY5/2) with many thin sandy layers 11-1-65 to 150. Smear 11-1-117 (sandy layer) Sand 20% Nannos 75-85% Quartz 5-10% Silt 10% Fish Debris 1- 2% Heavy Min. 5% Clay 70% Pyrite 5%
				C/M		Core Catcher					

Site 232 Hole A Core 12 Cored Interval: 263.5-273.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	N18-N17	Stichocorys peregrina				1	0.5, 1.0	VOID			NANNO OOZE Olive gray (5Y3/2) with thin pyritized sandy layers at 12-2-30, 12-2-50, 12-2-75. 12-2-105, 12-2-120
				R/P		2				—	Smear 12-2-84 Sand 5% Nannos 70-80% Pyrite 5-10% Silt 10% Forams 5% Quartz 3- 5% Clay 85% Fish Debris 1- 2%
				R/P		Core Catcher					

Site 232 Hole A Core 13 Cored Interval: 273.0-282.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	C. tricorniculatus N18-N17	Stichocorys peregrina	R/G	B	N	1	0.5, 1.0	VOID		—	NANNO OOZE Dusky brown (5YR2/2) with thin sandy layer at 13-1-110 and sand filled burrows. Smear 13-1-100 Sand 5% Nannos 70-80% Pyrite 5-10% Silt 10% Forams 2% Quartz 3- 5% Clay 85% Heavy Min. 2%
				R/M		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 14 Cored Interval: 282.5-292.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE MIOCENE	C. tricorniculatus N18-N17	Stichocorys peregrina	R/G	R/P	N	1	0.5, 1.0			C,GZ
				R/P		Core Catcher				

LITHOLOGIC DESCRIPTION

NANNO OOZE
Dusky brown (5YR2/2) with many thin sandy layers at 14-1-20, 14-1-50, 14-1-70, 14-1-80, 14-1-110 to 120, 14-1-130, 14-1-145

Smear 14-1-118 (sand layer)

Sand 80%	Nannos	5%	Quartz	70-80%
Silt 15%	Forams	5%	Heavy Min.	3- 5%
Clay 5%	Grain Size		Mica	2%
$CaCO_3$ 18%	Sand	19%	Dolo. Rhombs	1%
	Silt	57%		
	Clay	24%		

Site 232 Hole A Core 15 Cored Interval: 292.0-301.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE MIOCENE	C. tricorniculatus N18-N17	Stichocorys peregrina				1	0.5, 1.0	VOID		
			R/G	R/P	N	2				
				R/P		Core Catcher				

LITHOLOGIC DESCRIPTION

NANNO OOZE
Dusky brown (5YR2/2) with many thin sandy layers showing ripple marks and lamination (sand layers sometimes medium gray [N5] to dark gray [N3]) at 15-2-20, 15-2-25, 15-2-35, 15-2-60, 15-2-70, 15-2-90, 15-2-100, 15-2-120, 15-2-130, 15-2-140

Smear 15-2-58

Sand 80%	Nannos	5%	Quartz	70-80%
Silt 15%	Forams	5%	Heavy Min.	5%
Clay 5%	Fish Debris	1- 2%	Feldspar	2%

Site 232 Hole A Core 16 Cored Interval: 301.5-311.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE MIOCENE	C. tricorniculatus N18-N17	S. peregrina				Core Catcher				

LITHOLOGIC DESCRIPTION

QUARTZ SANDSTONE
Medium gray (N5) and dark gray (N3) with thin laminae of finer material.

Explanatory notes in chapter 1

Site 232 Hole A Core 17 Cored Interval: 311.0-320.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE MIOCENE	C. tricorniculatus N18-N17	S. peregrina				Core Catcher				

LITHOLOGIC DESCRIPTION

QUARTZ SANDSTONE
Greenish gray (5GY6/1) with shell debris; laminated.

Site 232 Hole A Core 18 Cored Interval: 320.5-330.0 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE MIOCENE	C. tricorniculatus	N18-N17 S. peregrina				1	0.5, 1.0	VOID		
			C/G	R/M	N	2				—
						3				—
				R/M		4				
						5				
				R/M		Core Catcher				

LITHOLOGIC DESCRIPTION

NANNO OOZE
Dusky yellow green (5GY5/2) with some sand filled burrows and some sandy layers at 18-2-105, 18-2-130, 18-2-140, 18-3-10, 18-3-25.

Smear 18-2-102

Sand 40%	Nannos	50%	Quartz	30-40%
Silt 20%	Forams	5%	Heavy Min.	5%
Clay 40%	Fish Debris	1- 2%	Zeolite	5%

Smear 18-3-80

Sand 5%	Nannos	70-80%	Quartz	5%
Silt 15%	Forams	5-10%	Pyrite	1%
Clay 80%			Dolo. Rhombs	1%

Some sand filled burrows.

Explanatory notes in chapter 1

Site 232 Hole A Core 19 Cored Interval: 330.0-339.5 m

AGE	ZONE			FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	C. tricorniculatus	N18-N17	S. peregrina	C/G	C/P	F/M	1	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2) with some sand filled burrows Color change to grayish olive (5GY3/2) at 19-1-100, to dusky yellow green (5GY5/2) at 19-2-5, to olive gray (5Y3/2) at 19-2-100. Sandy layer at 19-2-30.
							2				–	Smear 19-2-80 Sand 5% Nannos 80-90% Quartz 1% Silt 15% Forams 5% Clay 85% Rads 2% Fish Debris 1- 2%
					C/M		Core Catcher					

Site 232 Hole A Core 20 Cored Interval: 339.5-349.0 m

AGE	ZONE			FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	C. primus	N18-N17	S. peregrina	C/G	C/P	C/G	1	0.5, 1.0	VOID		–	NANNO OOZE Dusky yellow green (5GY5/2). Sandy layer at 20-1-65. Smear 20-1-68 Sand 30% Nannos 50-60% Quartz 30% Silt 20% Forams 5% Heavy Min. 5% Clay 50% Feldspar 2%
					C/P		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 21 Cored Interval: 349.0-358.5 m

AGE	ZONE		FOSSIL CHARACTER: NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	C. primus	N18-N17 / S. peregrina				1	0.5, 1.0	VOID			NANNO OOZE Dusky yellow green (5GY5/2)
			C/G	R/M	A/G	2					
						3				–	Color change to olive gray (5Y3/2) at 21-2-115 and back to dusky yellow green at 21-3-70. Sandy layer at 21-2-140 and 21-3-80 (with some burrows above). Smear 21-3-78 (Sandy layer) Sand 50% Nannos 40% Quartz 40% Silt 20% Forams 10% Heavy Min. 5% Clay 30% Fish Debris 1- 2% Pyrite 5% Mica 3% Dolo. Rhombs 1%
				C/P		4					Becoming semi-lithified toward bottom of core.
						5					
						6				–	Sandy layer 21-6-98 to 102, medium bluish gray (5B5/1) Smear 21-6-102 Sand 35% Nannos 50% Quartz 25% Silt 25% Forams 10% Heavy Min. 5% Clay 40% Fish Debris 1- 2% Pyrite 5% Feldspar 2% Volc. Glass 2%
				C/P		Core Catcher					

Explanatory notes in chapter 1

Site 232 Hole A Core 22 Cored Interval: 358.5-368.0 m

AGE	ZONE		NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	C. primus	N18-N17 / S. peregrina	F/M	C/M, C/M	R/M	1, 2, 3, Core Catcher	0.5, 1.0	VOID; Nanno ooze			See below

NANNO OOZE
Dusky yellow green (5GY5/2) changing to olive gray (5Y3/2) at 22-1-100.

Dusky yellowish brown (10YR2/2) from 22-2-0 on.

Smear 22-1-104

Sand 5%	Nannos 80-90%	Pyrite 5-10%	
Silt 15%	Fish Debris 1- 2%	Quartz 5%	
Clay 80%		Mica 2%	

Some burrows throughout.
Color change to olive gray (5Y3/2) at 22-3-80.

Smear 22-3-140

Sand 5%	Nannos 80-90%	Quartz 5%
Silt 15%	Forams 5%	Pyrite 5%
Clay 80%	Fish Debris 1- 2%	

Explanatory notes in chapter 1

Site 232 Hole A Core 23 Cored Interval: 368.0-377.5 m

AGE	ZONE		NANNOS	FORAMS	RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	C. primus	N18-N17	C/M	C/P, C/P, A/M	N	1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	VOID; Nanno ooze			See below

NANNO OOZE
Olive gray (5Y3/2) changing to dusky yellow green (5GY5/2) at 23-1-110.
Thin sand layers at 23-1-100, 23-2-125, 23-2-135, 23-2-150.

Smear 23-1-102

Sand 50%	Nannos 25%	Quartz 60%
Silt 30%	Forams 5%	Heavy Min. 5%
Clay 20%		Pyrite 5%
		Feldspar 3%

Some sand filled burrows.

Color change to olive gray (5Y3/2) at 23-2-110.

Color change to dusky yellow green (5GY5/2) at 23-3-20.

Smear 23-3-90

Sand 5%	Nannos 80-90%	Quartz 3%
Silt 15%	Forams 5%	Heavy Min. 1%
Clay 80%	Rads 1%	

Thin sandy layer and burrows at 23-4-30.

Grayish olive green (5GY3/2) zone at 23-5-0 to 45 and in 23-cc.

Explanatory notes in chapter 1

Site 232 Hole A Core 24 Cored Interval: 377.5-387.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	*C. primus* N18-N17		R/P		1	0.5, 1.0				NANNO OOZE Dusky yellow green (5GY5/2); some sand filled burrows.
			R/P		Core Catcher					Olive gray (5Y3/2) in 24-cc.

Site 232 Hole A Core 25 Cored Interval: 387.0-396.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	*C. primus*				Core Catcher					NANNO OOZE Olive gray (5Y3/2)

Site 232 Hole A Core 26 Cored Interval: 396.5-402.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	*C. primus*	P			Core Catcher					QUARTZ SANDSTONE Medium light gray (N6), calcareous cement.

Site 232 Hole A Core 27 Cored Interval: 402.5-412.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5, 1.0	VOID			
					Core Catcher					QUARTZ SANDSTONE Medium light gray (N6); calcareous cement.

Explanatory notes in chapter 1

Site 232 Hole A Core 28 Cored Interval: 412.0-421.5 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					Core Catcher					QUARTZ SANDSTONE Medium light gray (N6).

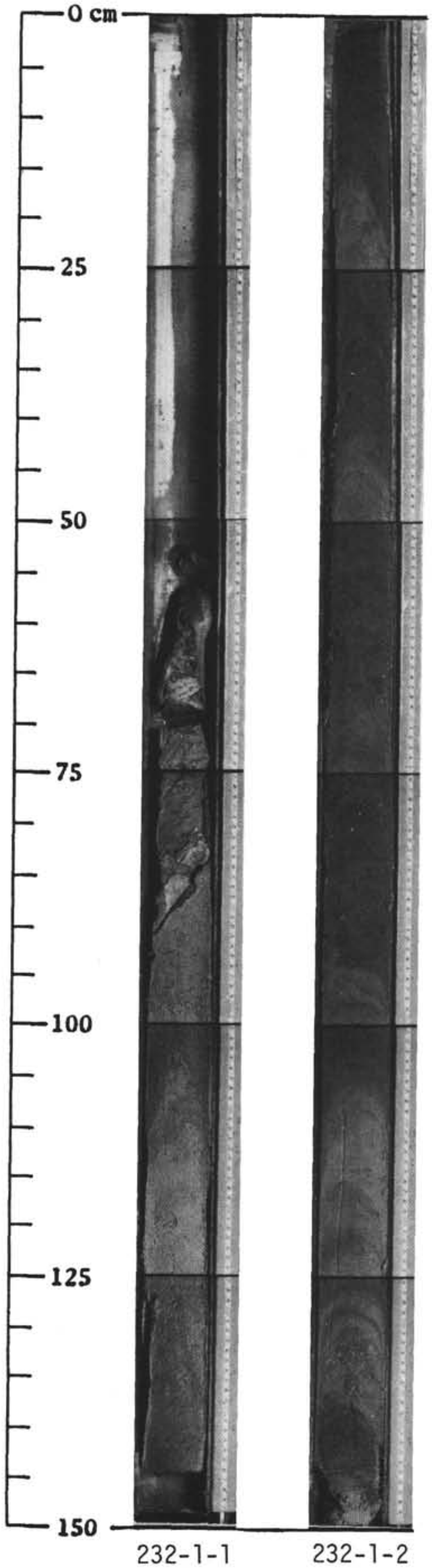
Site 232 Hole A Core 29 Cored Interval: 421.5-431.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5, 1.0	VOID			
					Core Catcher					NANNO OOZE Olive gray (5Y3/2) Smear 29-1-130 Sand 5%, Silt 25%, Clay 70% Nannos 80-90%, Fish Debris 1- 2% Quartz 2- 5%, Pyrite 2- 5%

Site 232 Hole A Core 30 Cored Interval: 431.0-434.0 m

AGE	ZONE	FOSSIL CHARACTER: NANNOS	FOSSIL CHARACTER: FORAMS	FOSSIL CHARACTER: RADS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					Core Catcher					NO RECOVERY

Explanatory notes in chapter 1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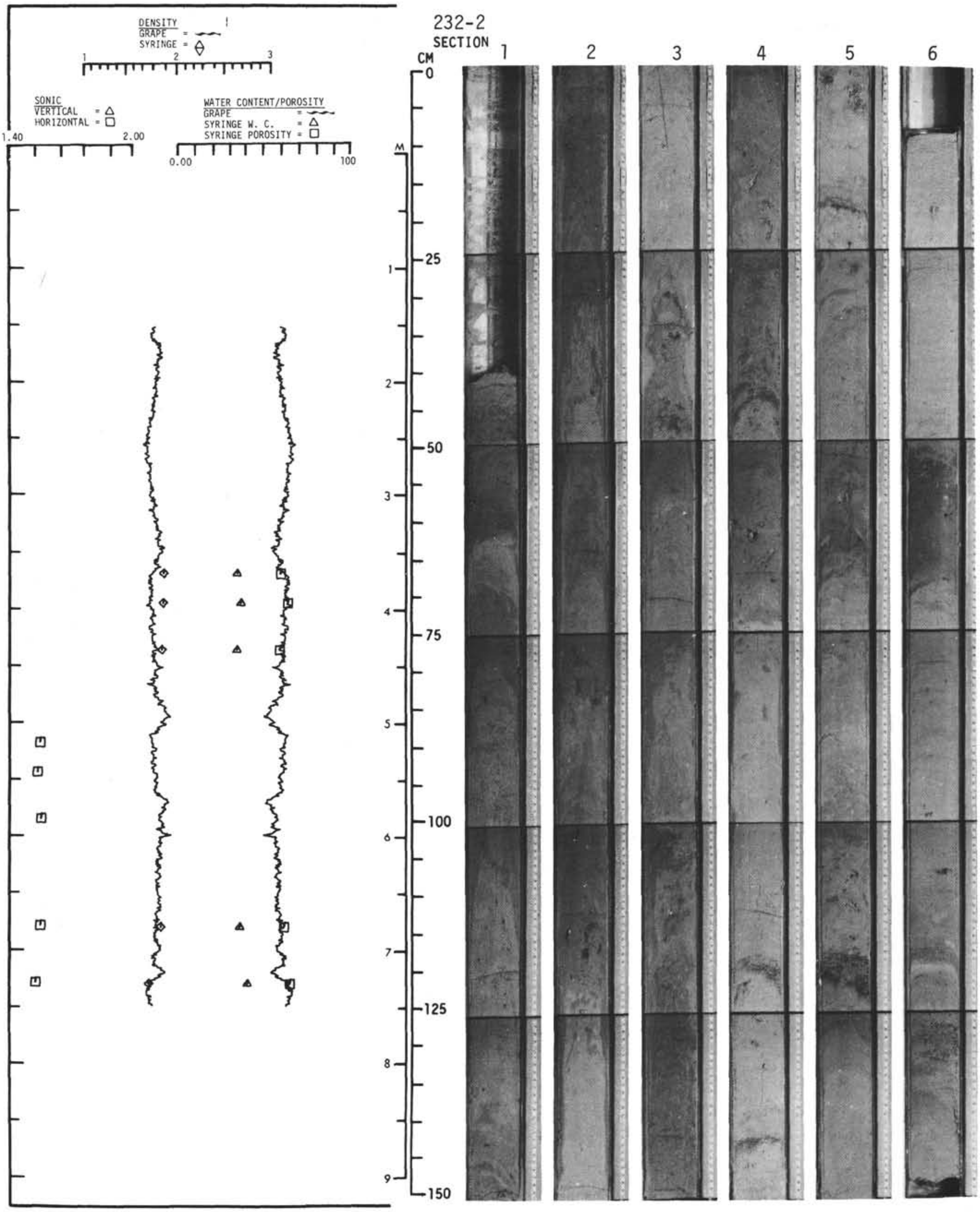
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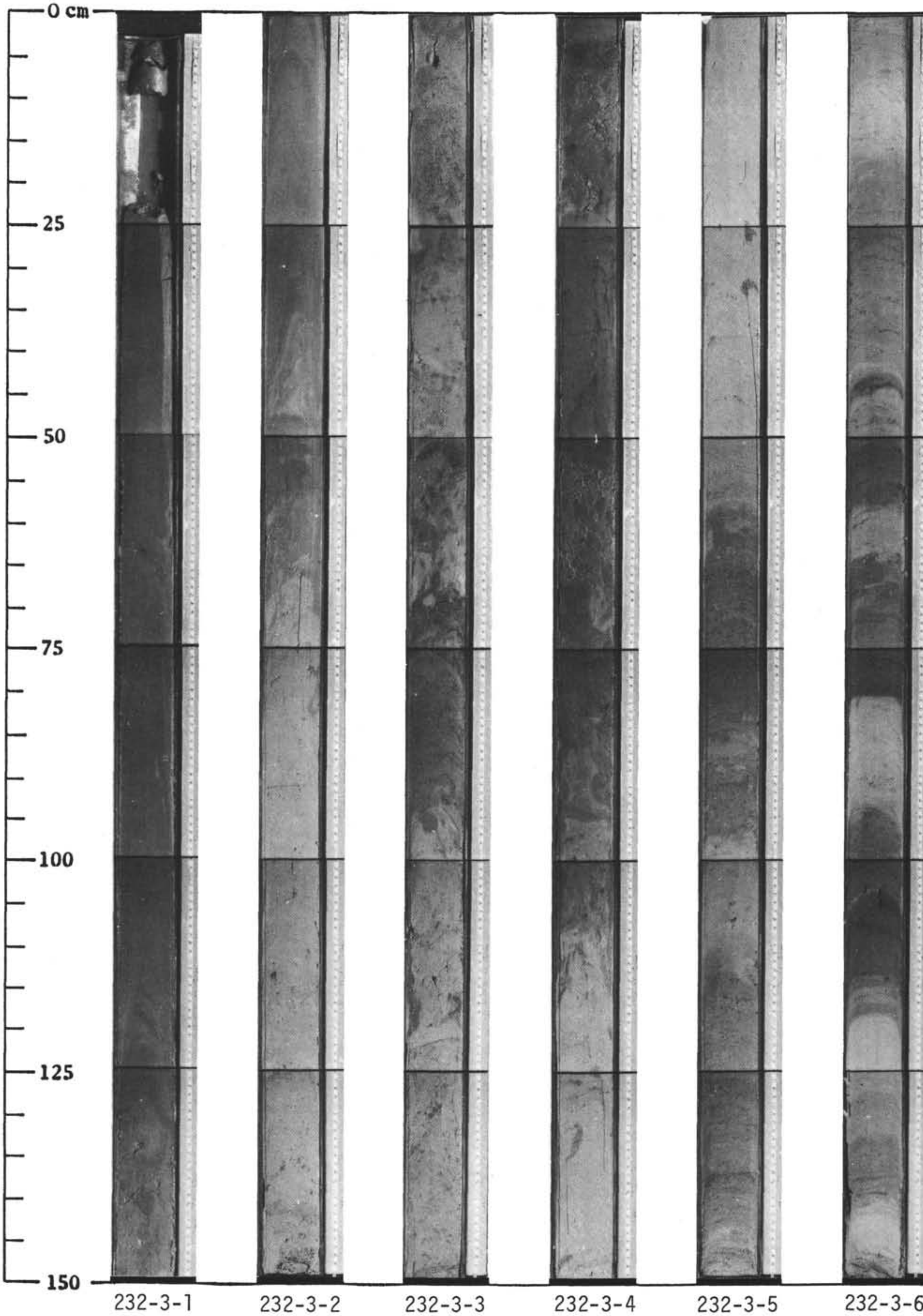
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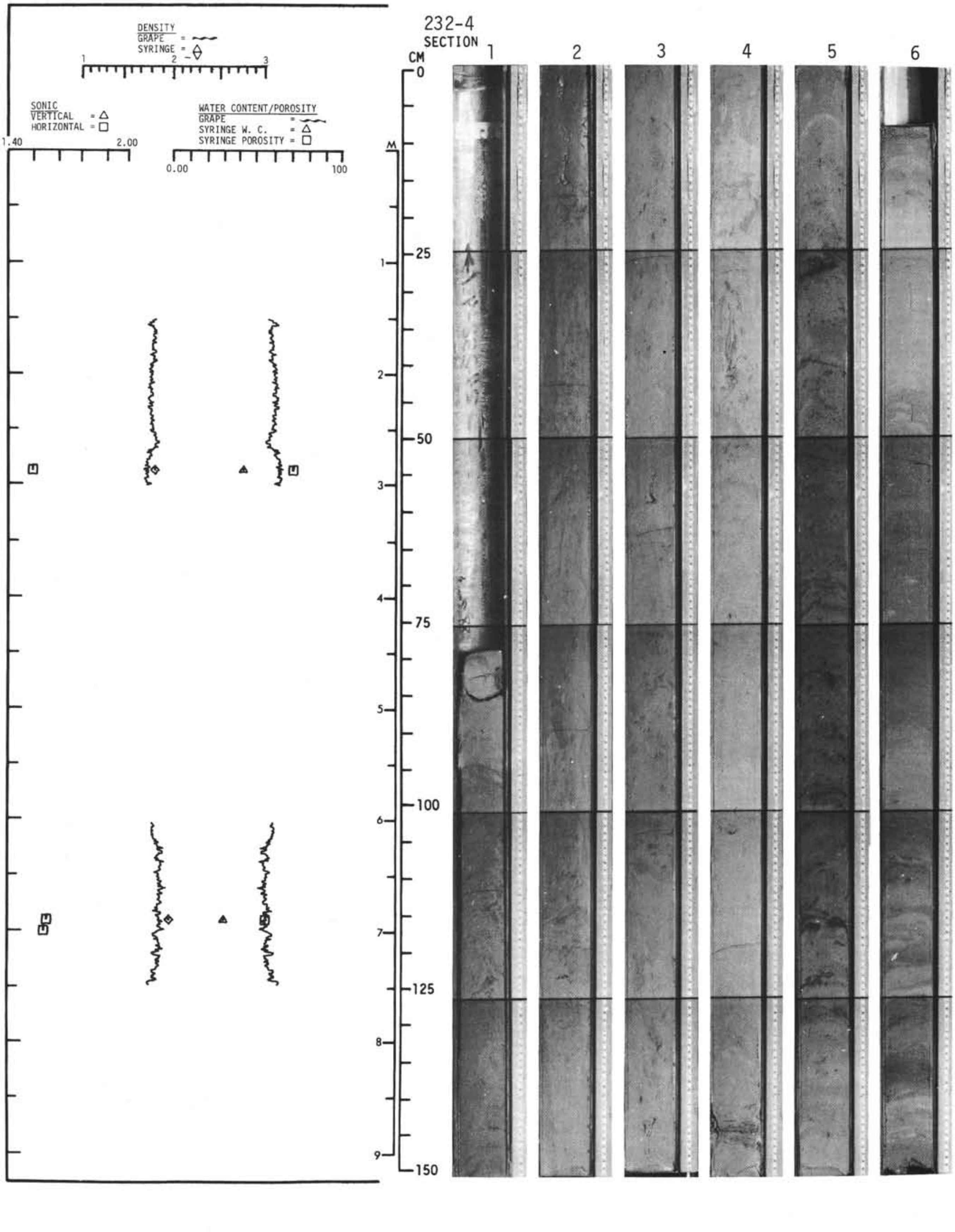
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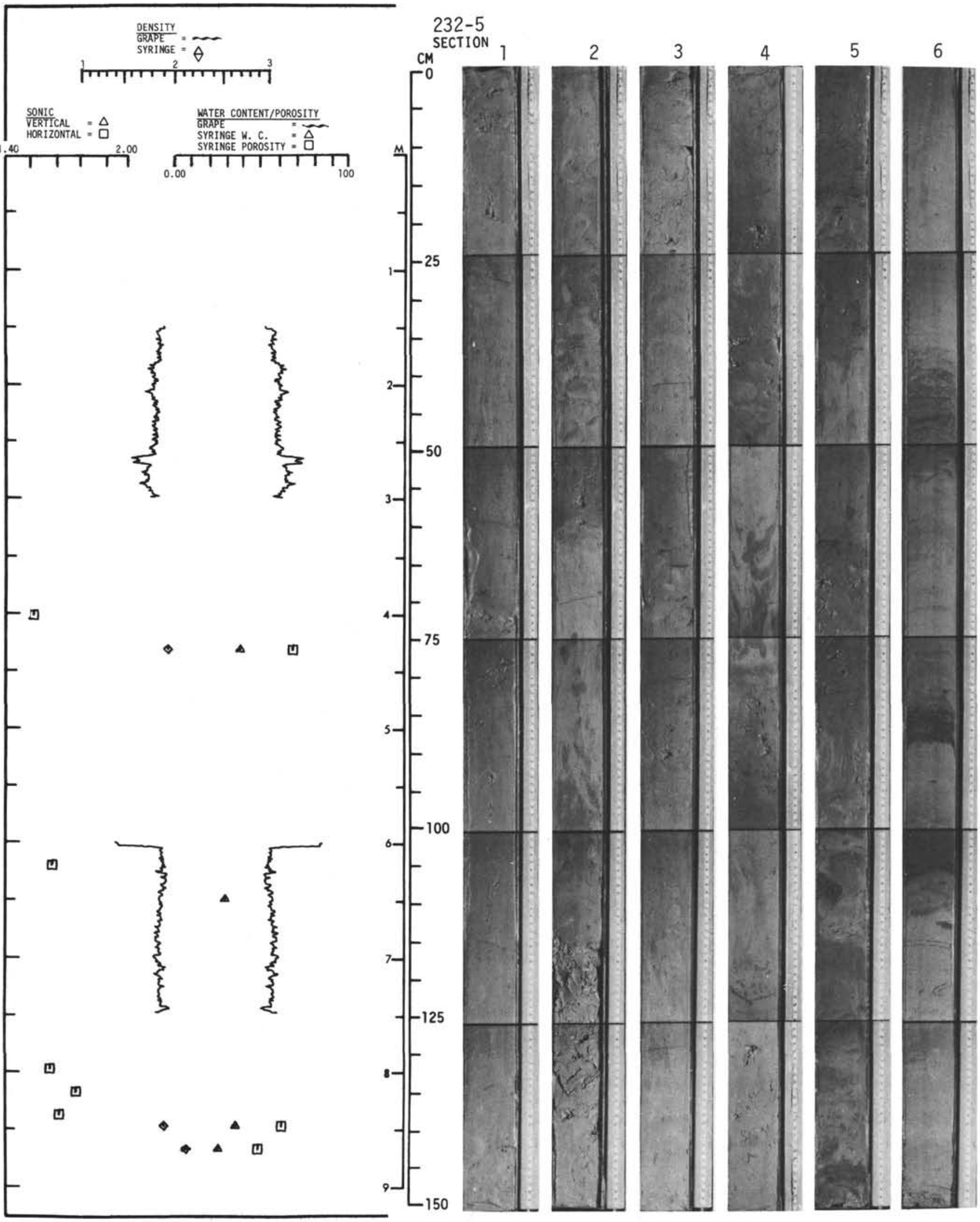
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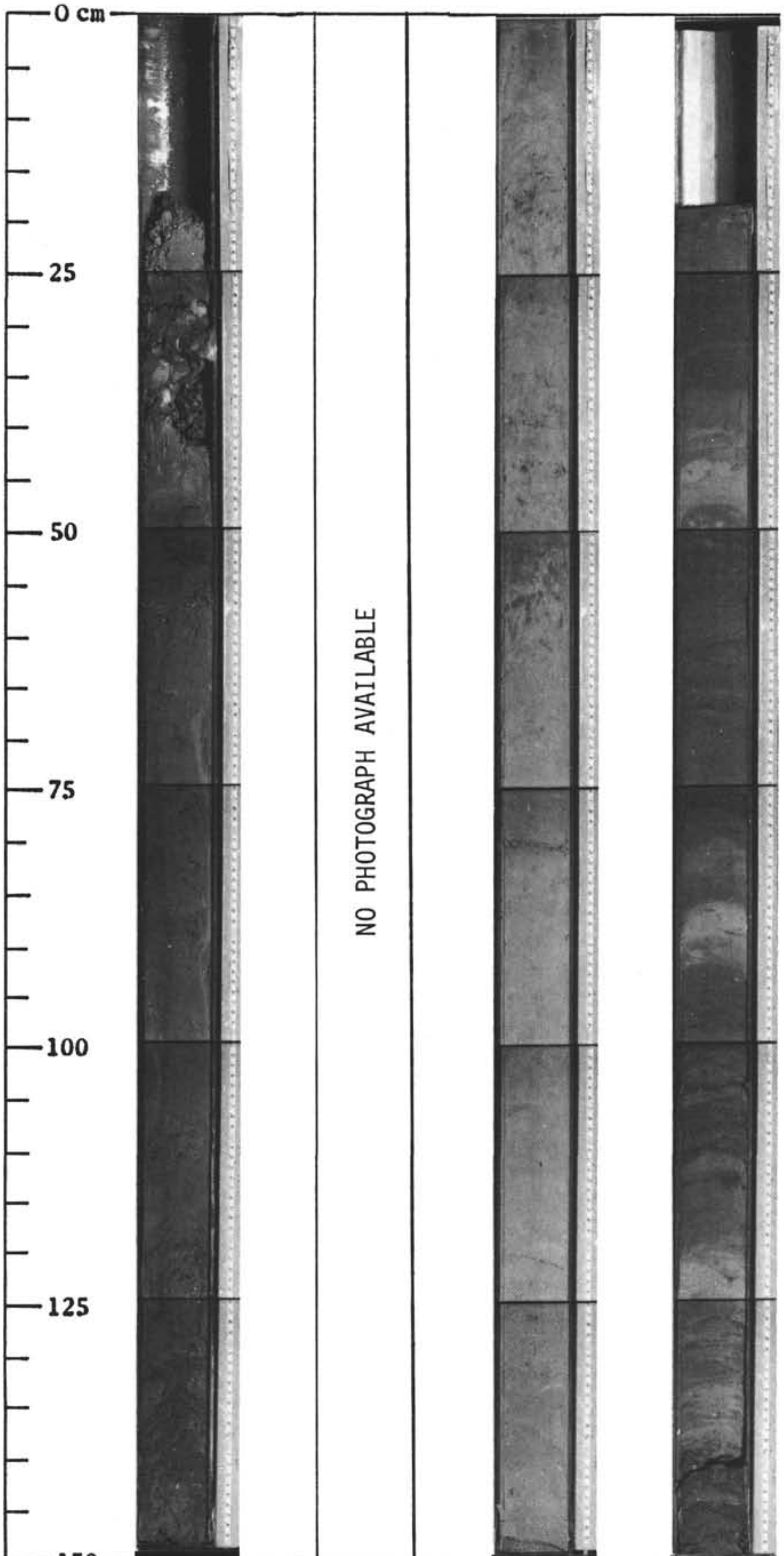

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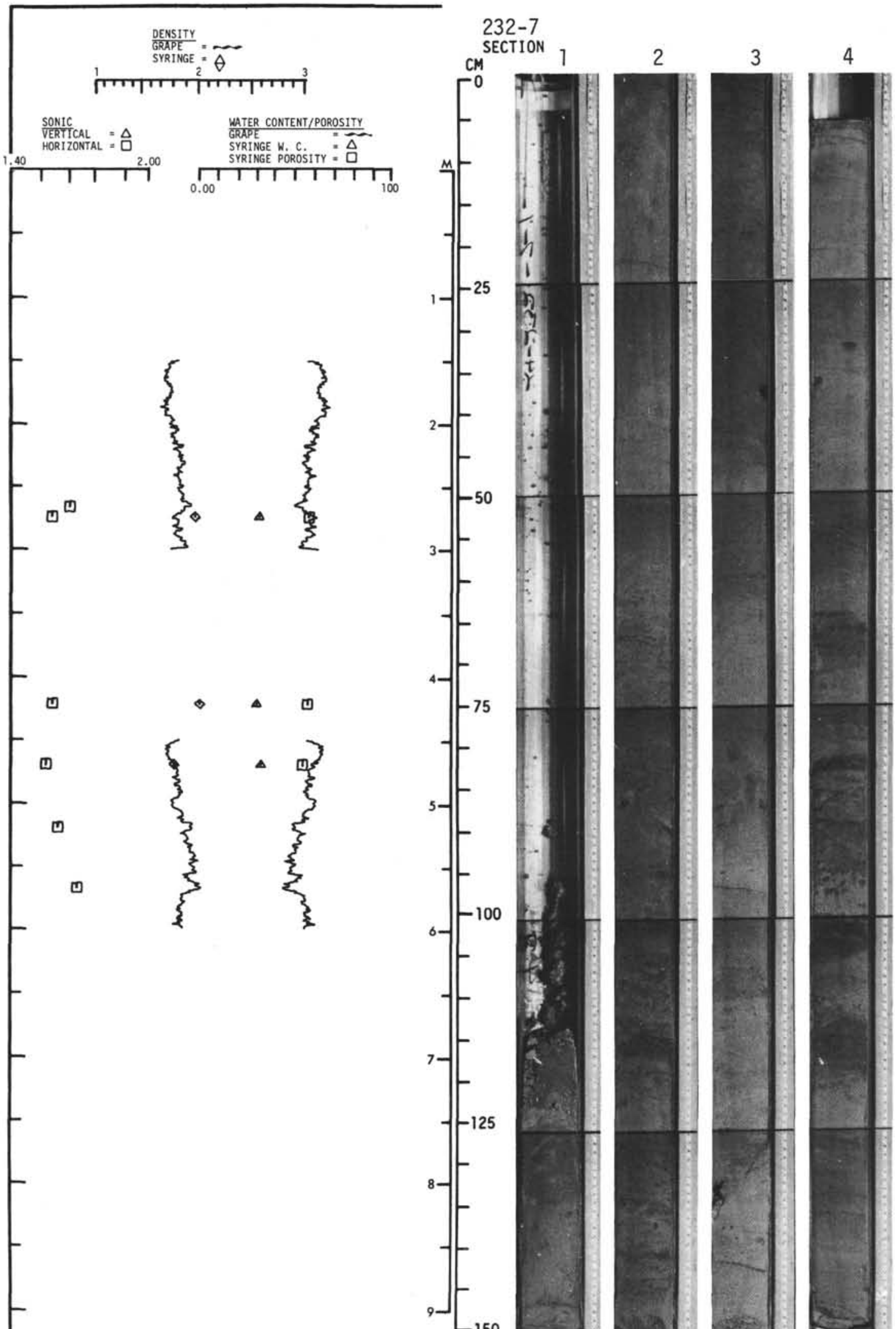
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WATER CONTENT/POROSITY
GRAPE
SYRINGE W. C.
SYRINGE POROSITY
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2.00
0.00
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232-7
SECTION
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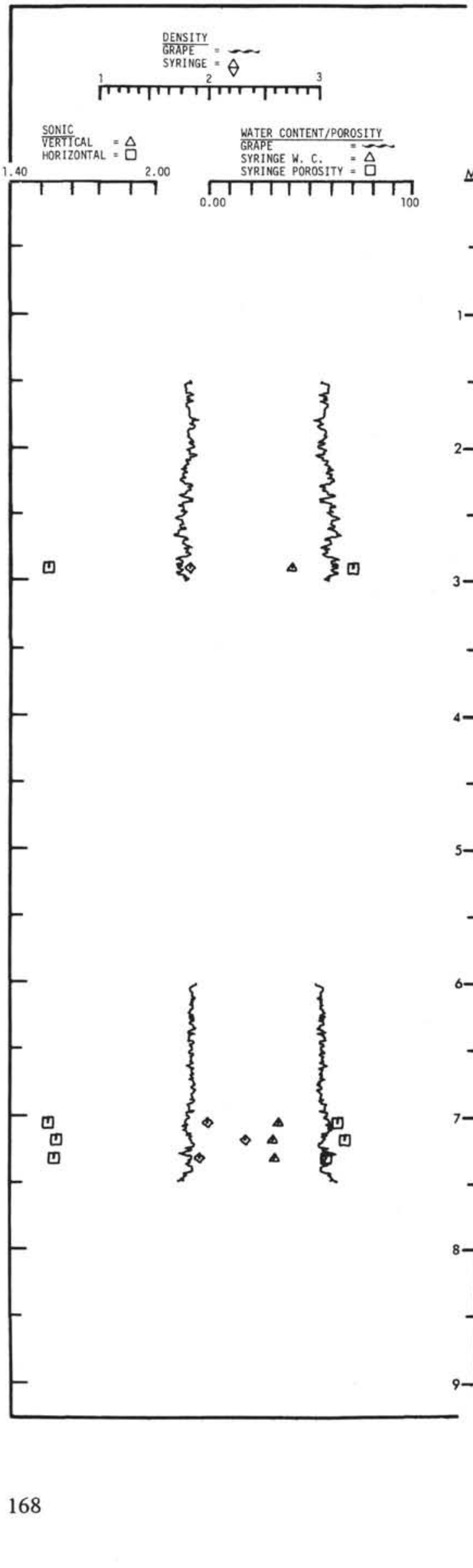
CM
M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SYRINGE
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VERTICAL
HORIZONTAL
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2.00
WATER CONTENT/POROSITY
GRAPE
SYRINGE W. C.
SYRINGE POROSITY
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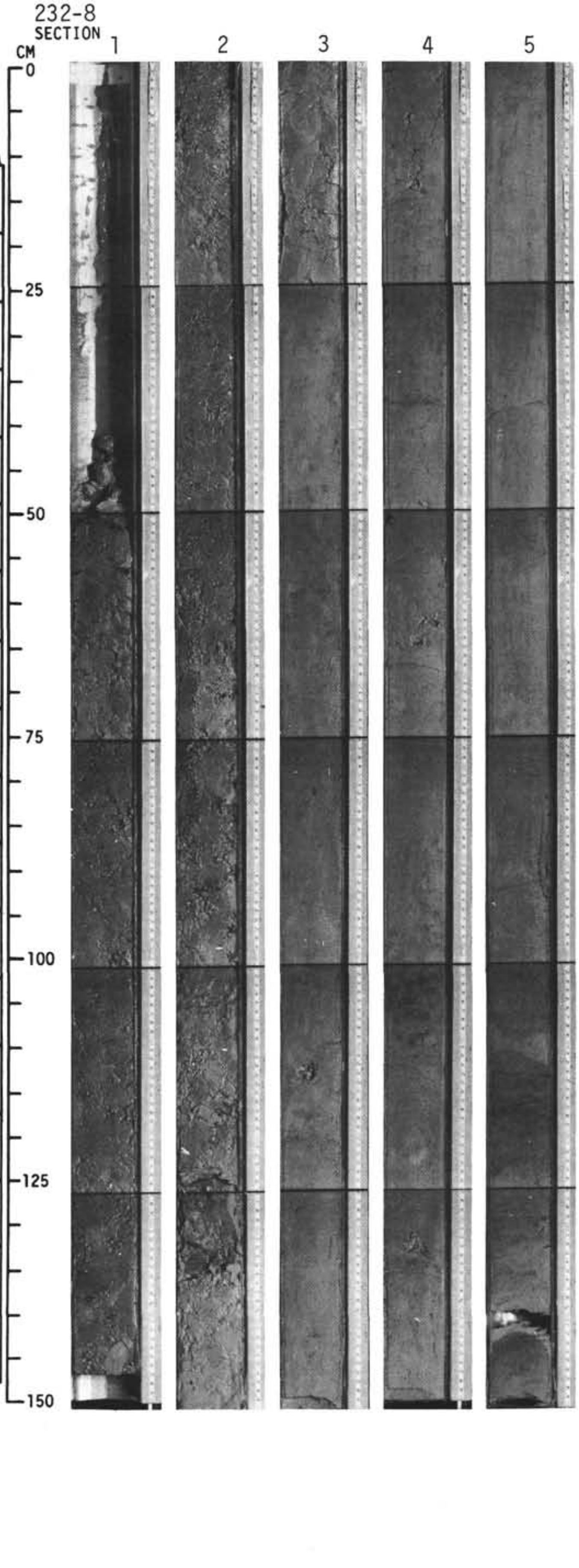
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SECTION
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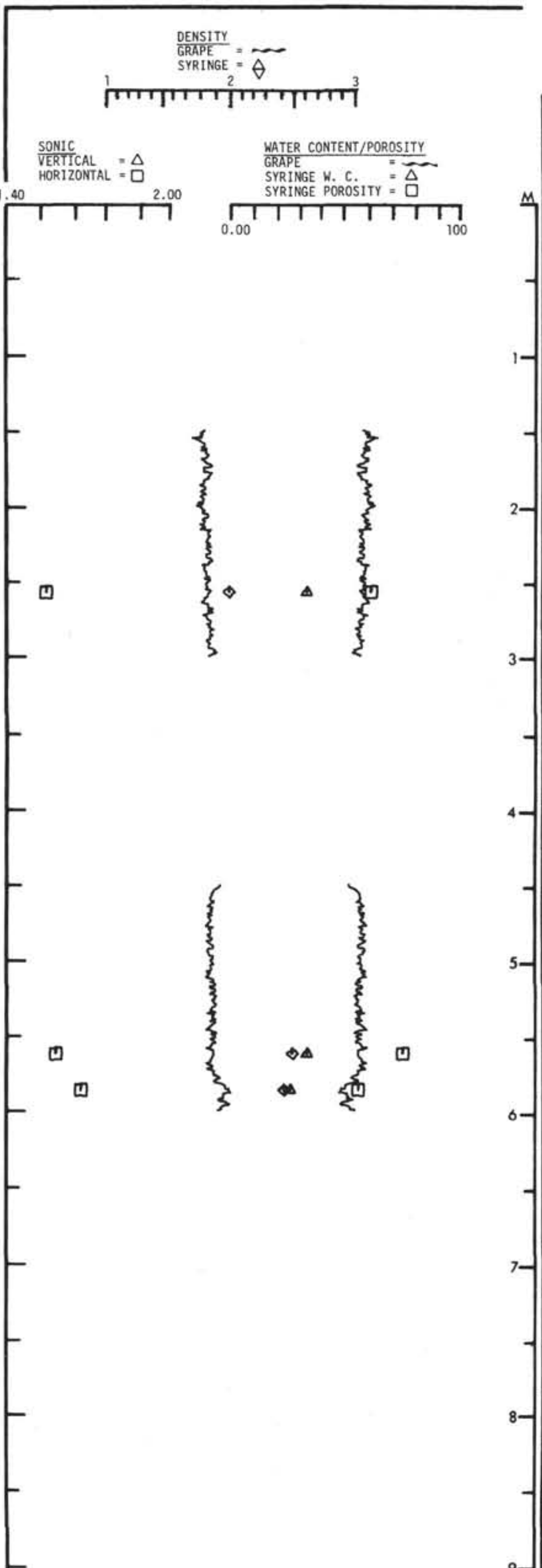
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2.00
WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
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100
M
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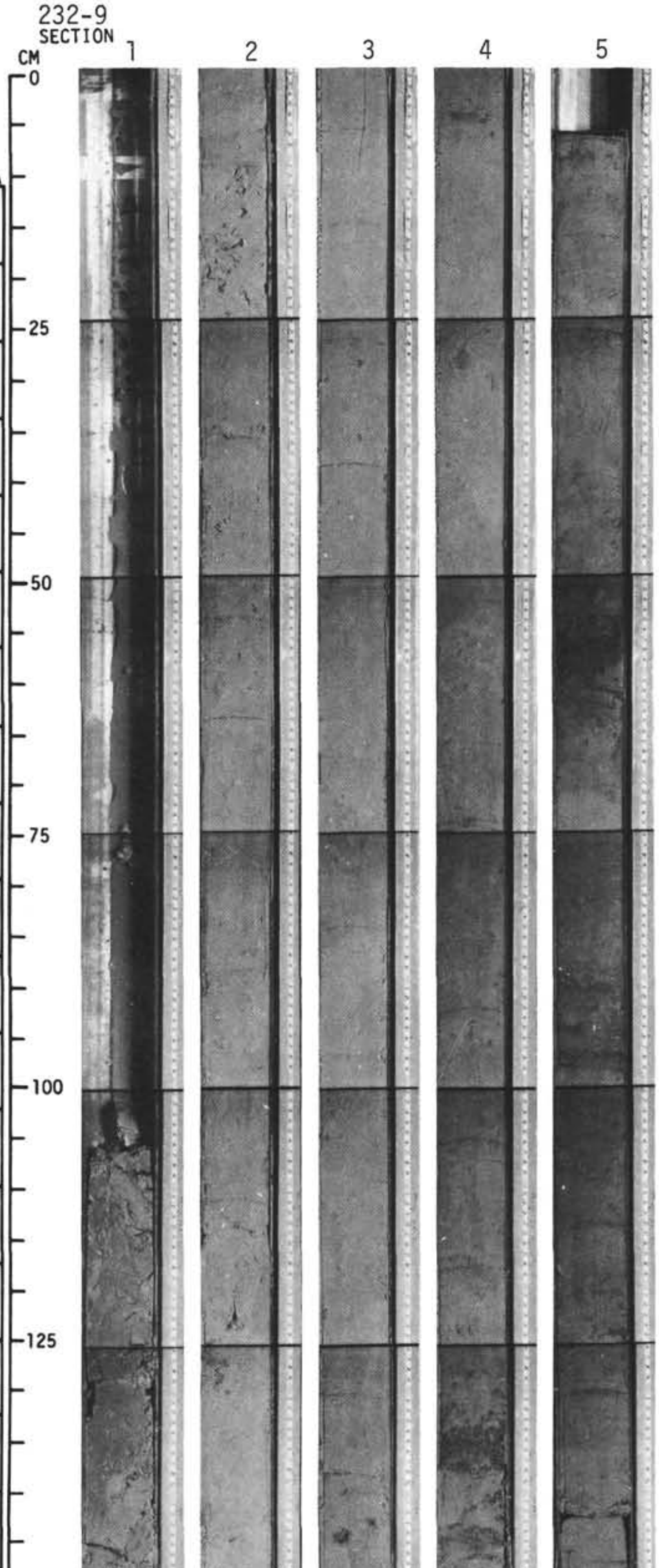
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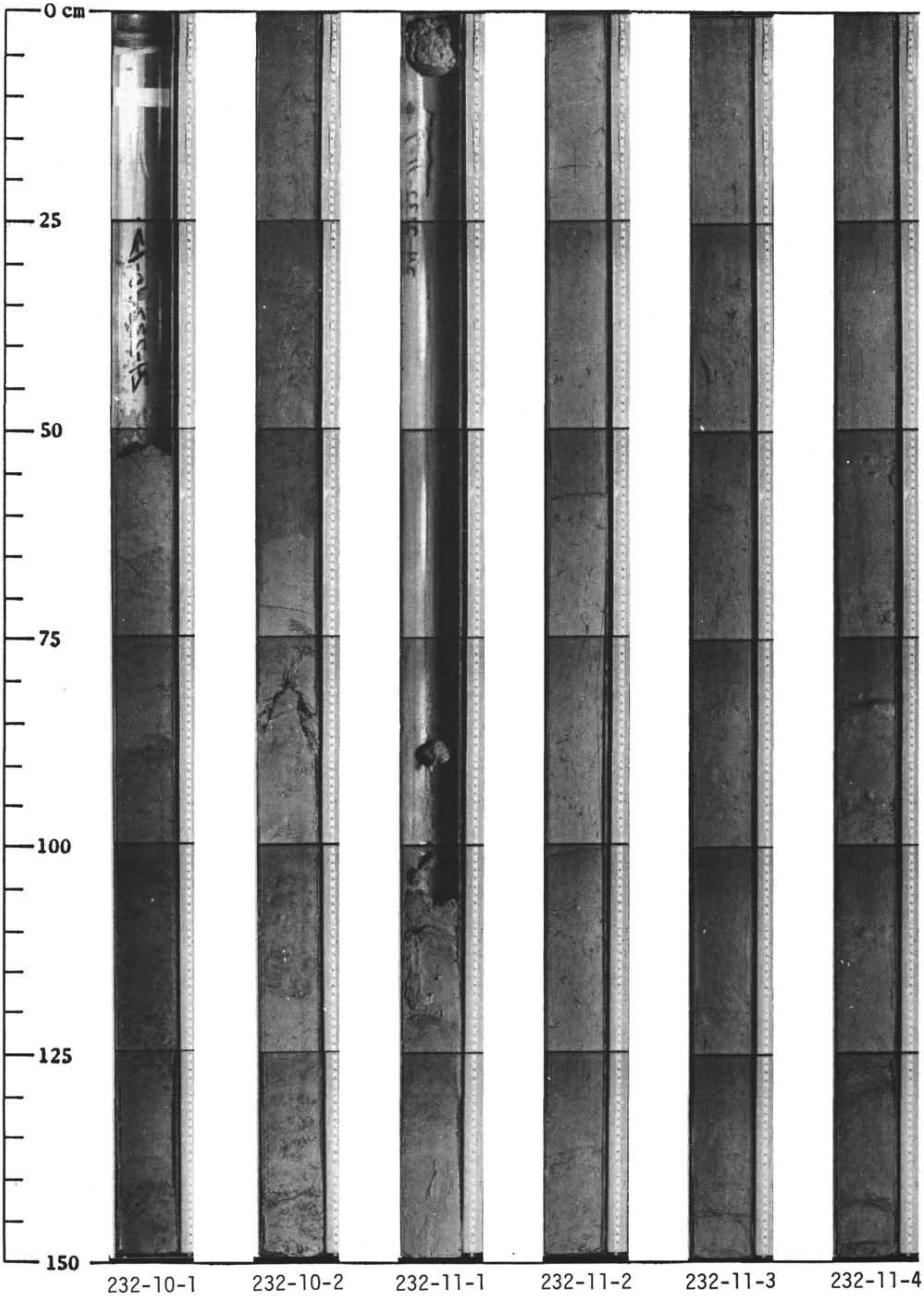
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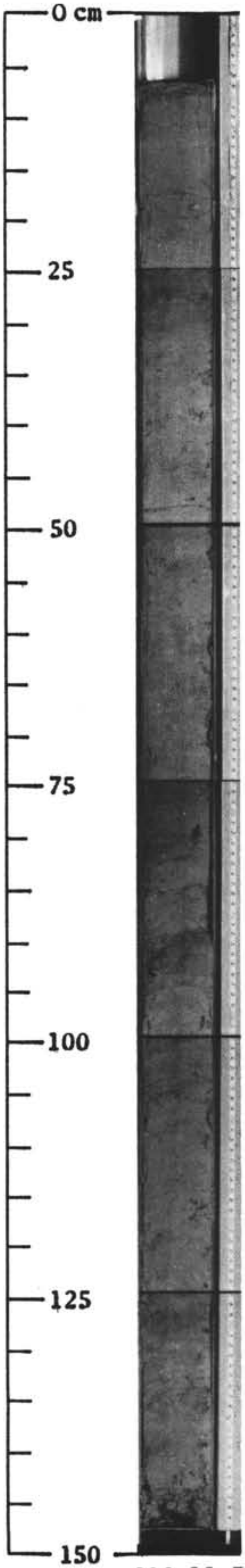
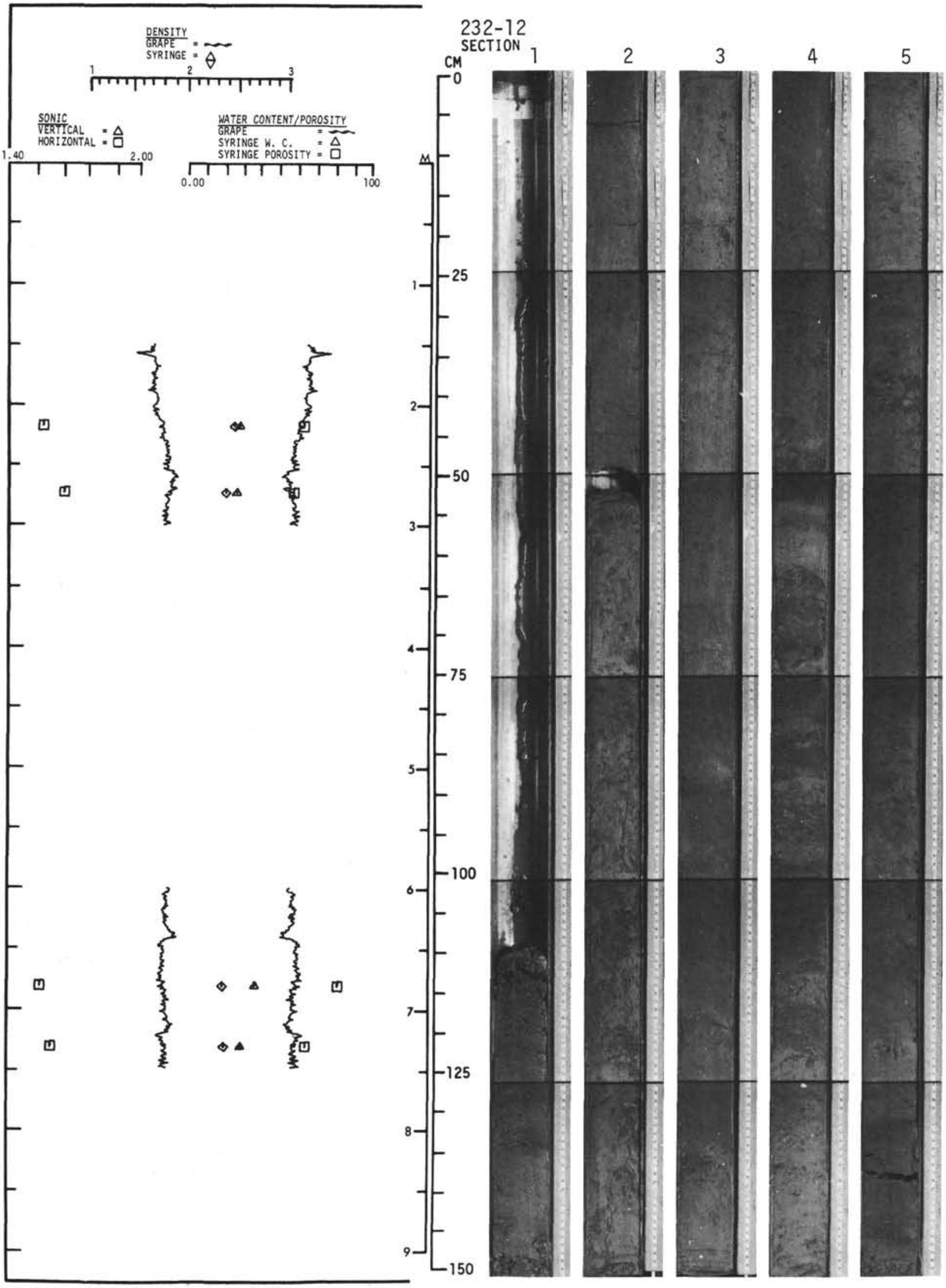
232-11-4



232-11-5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SONIC
VERTICAL
HORIZONTAL
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WATER CONTENT/POROSITY
GRAPE
SYRINGE W. C.
SYRINGE POROSITY
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CM
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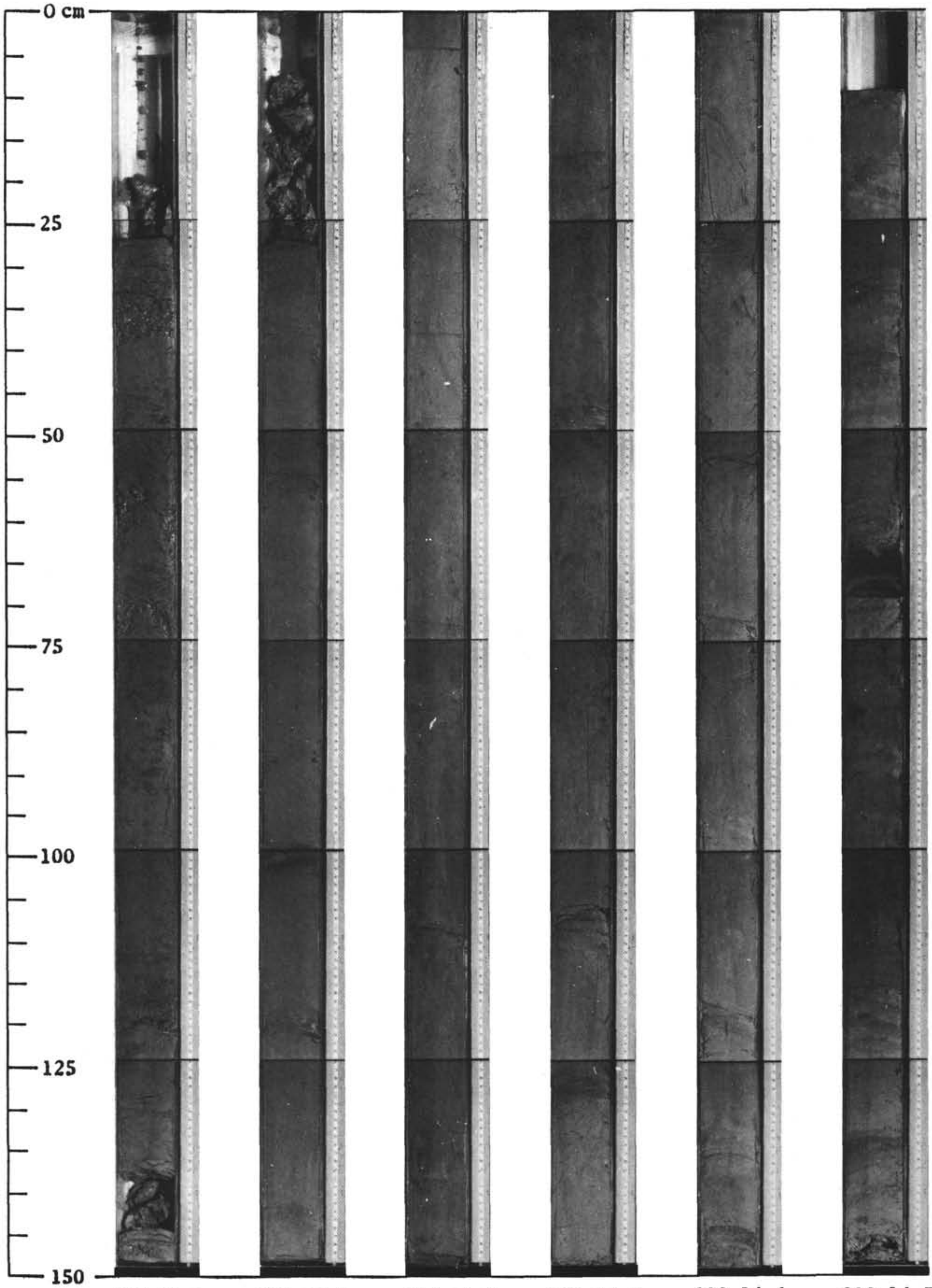

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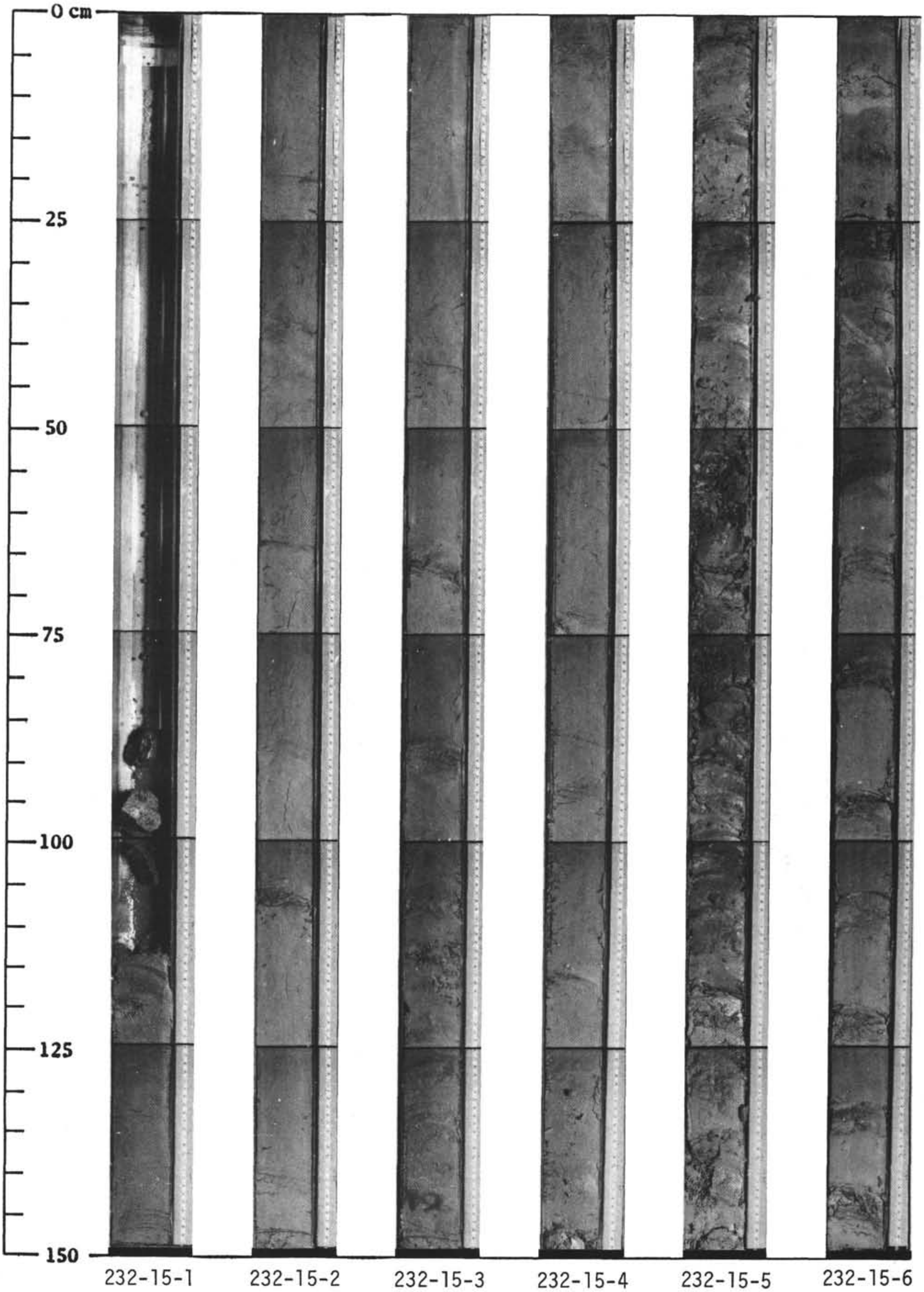
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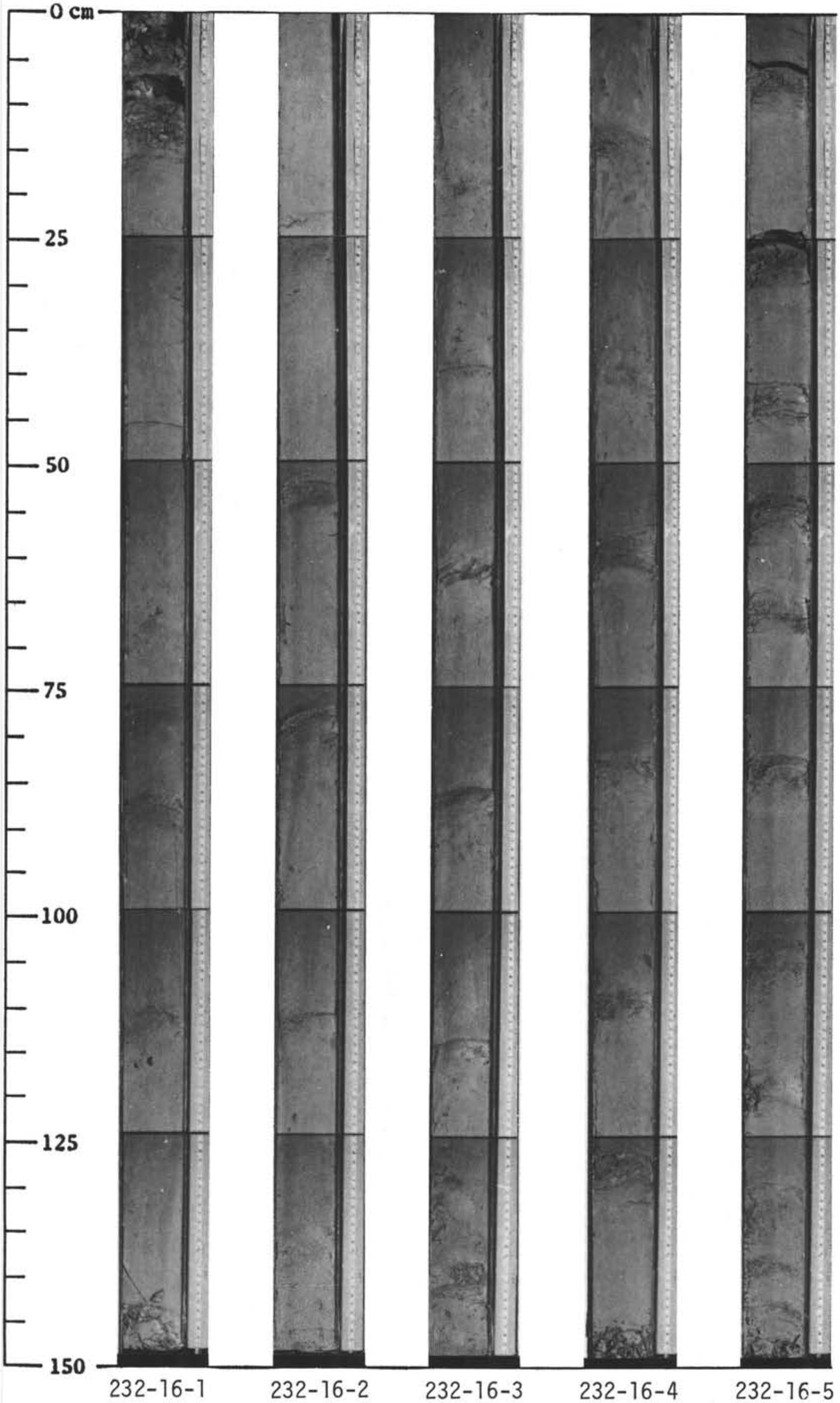
232-15-6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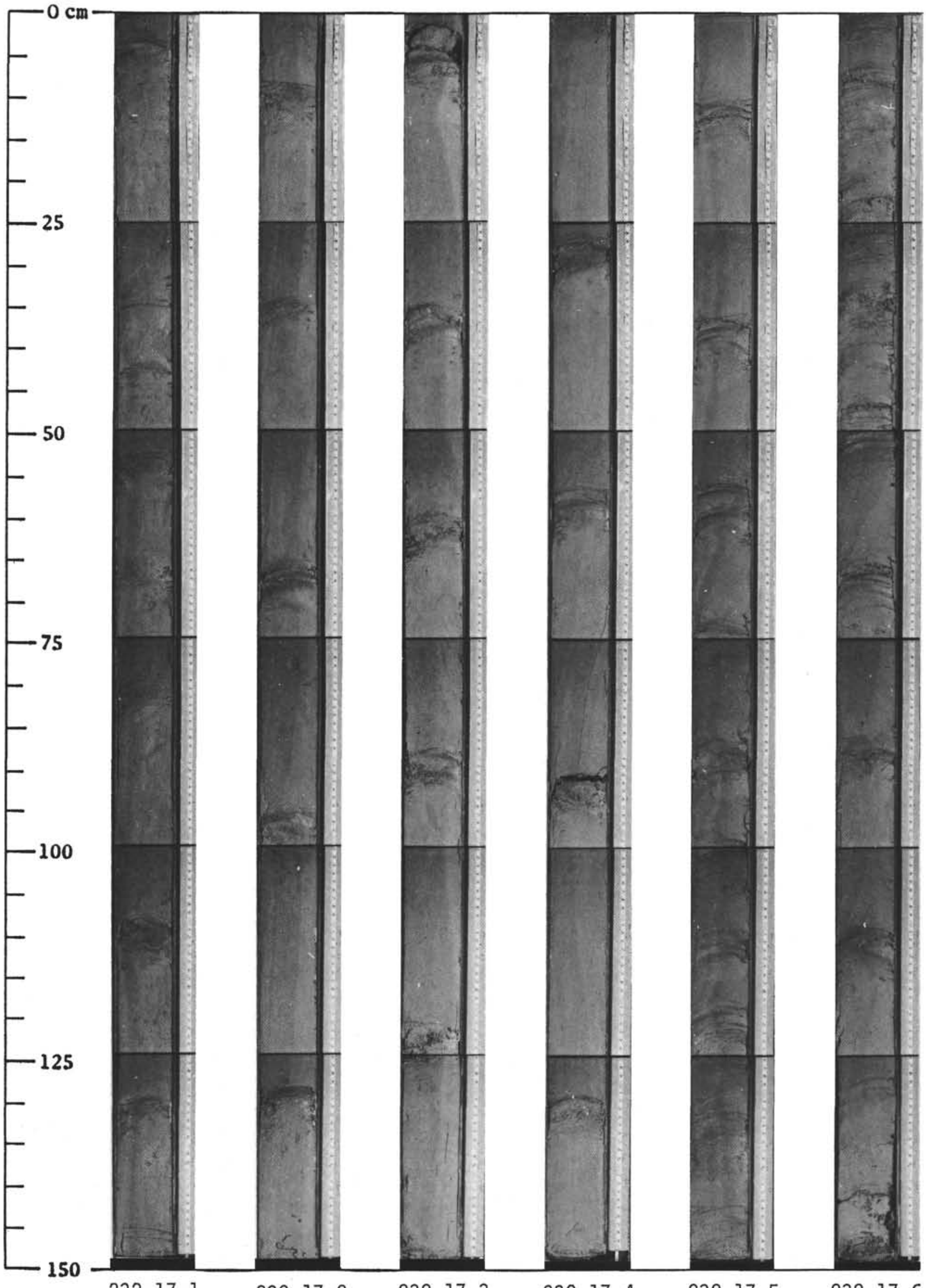
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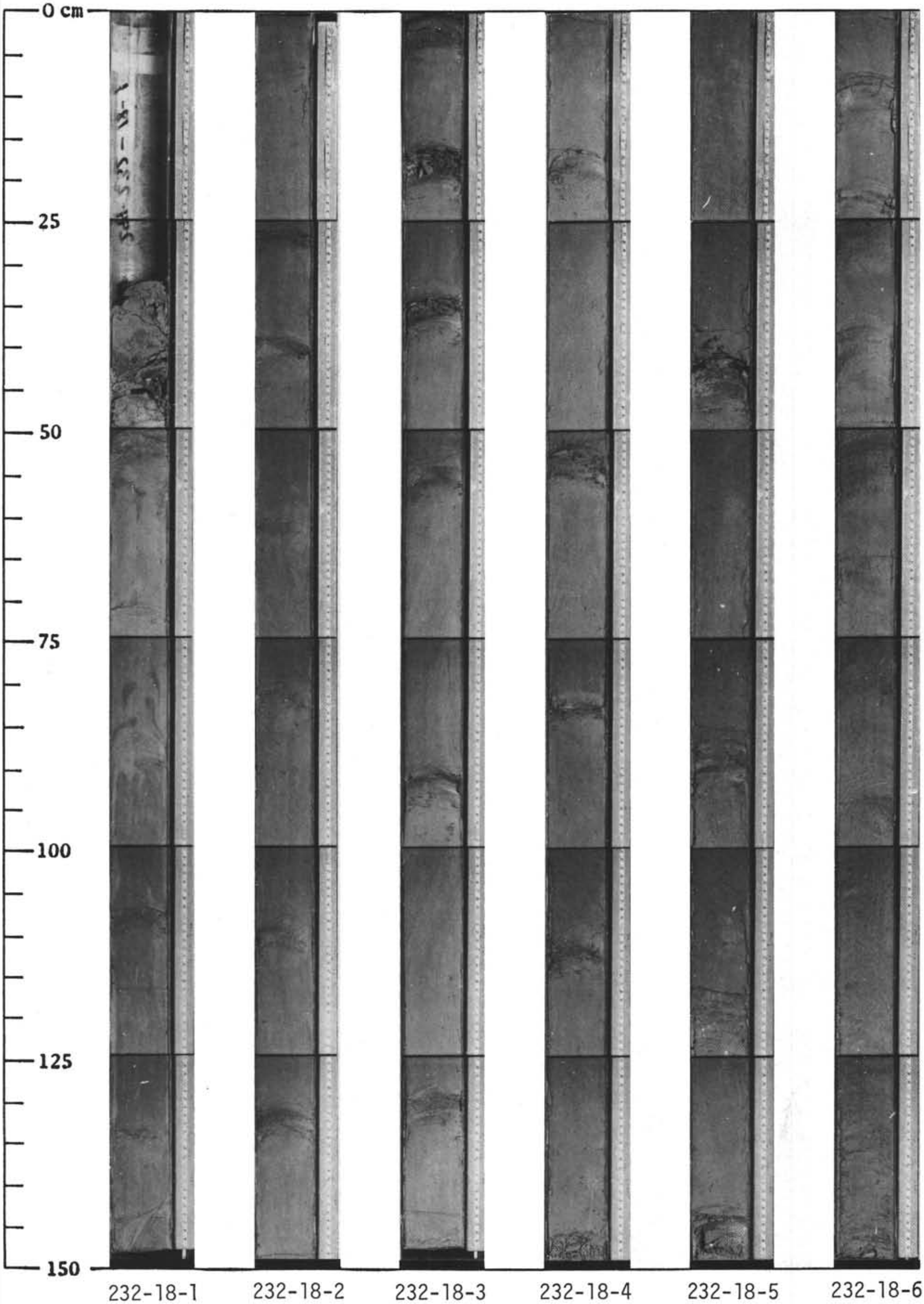
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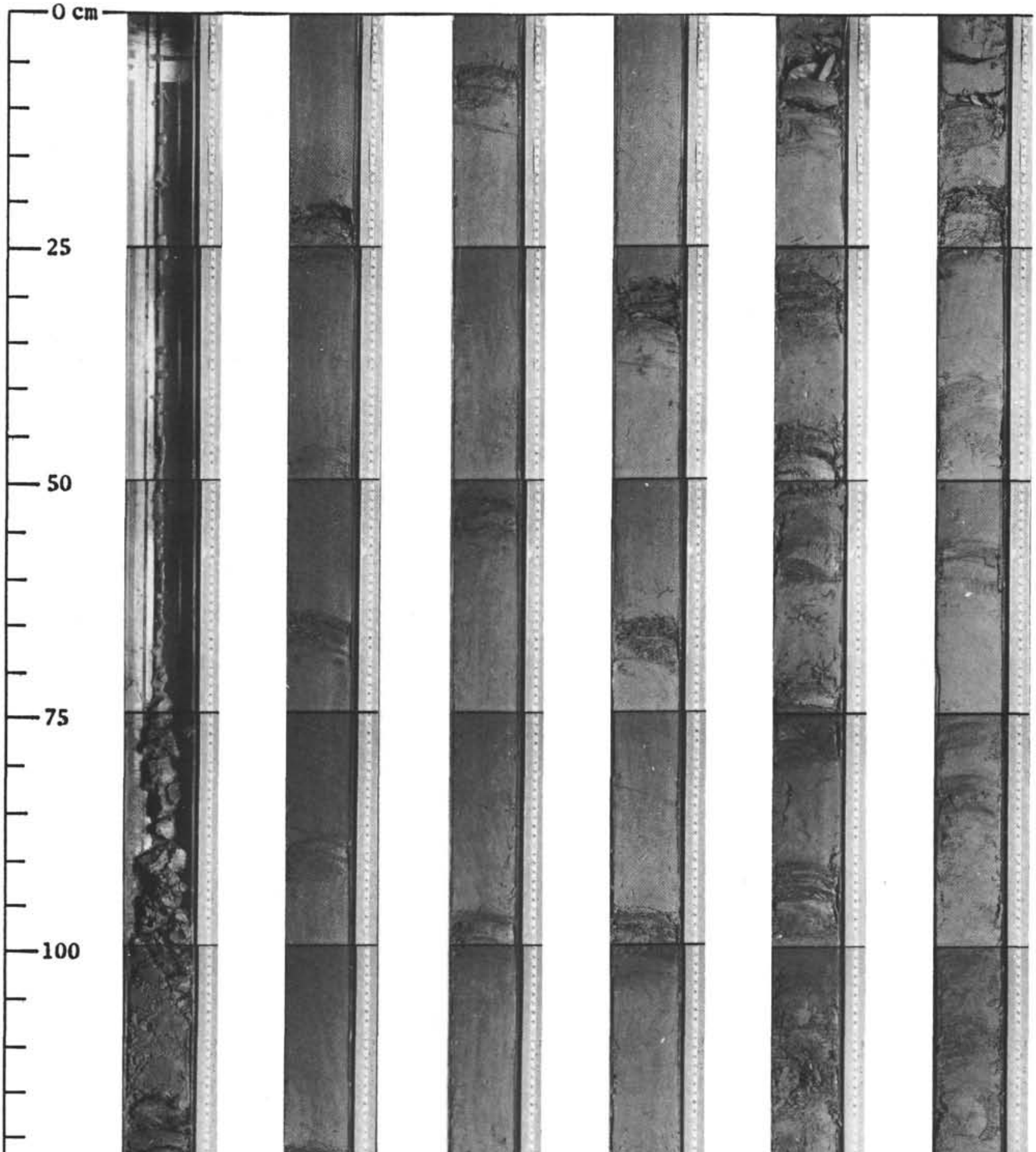
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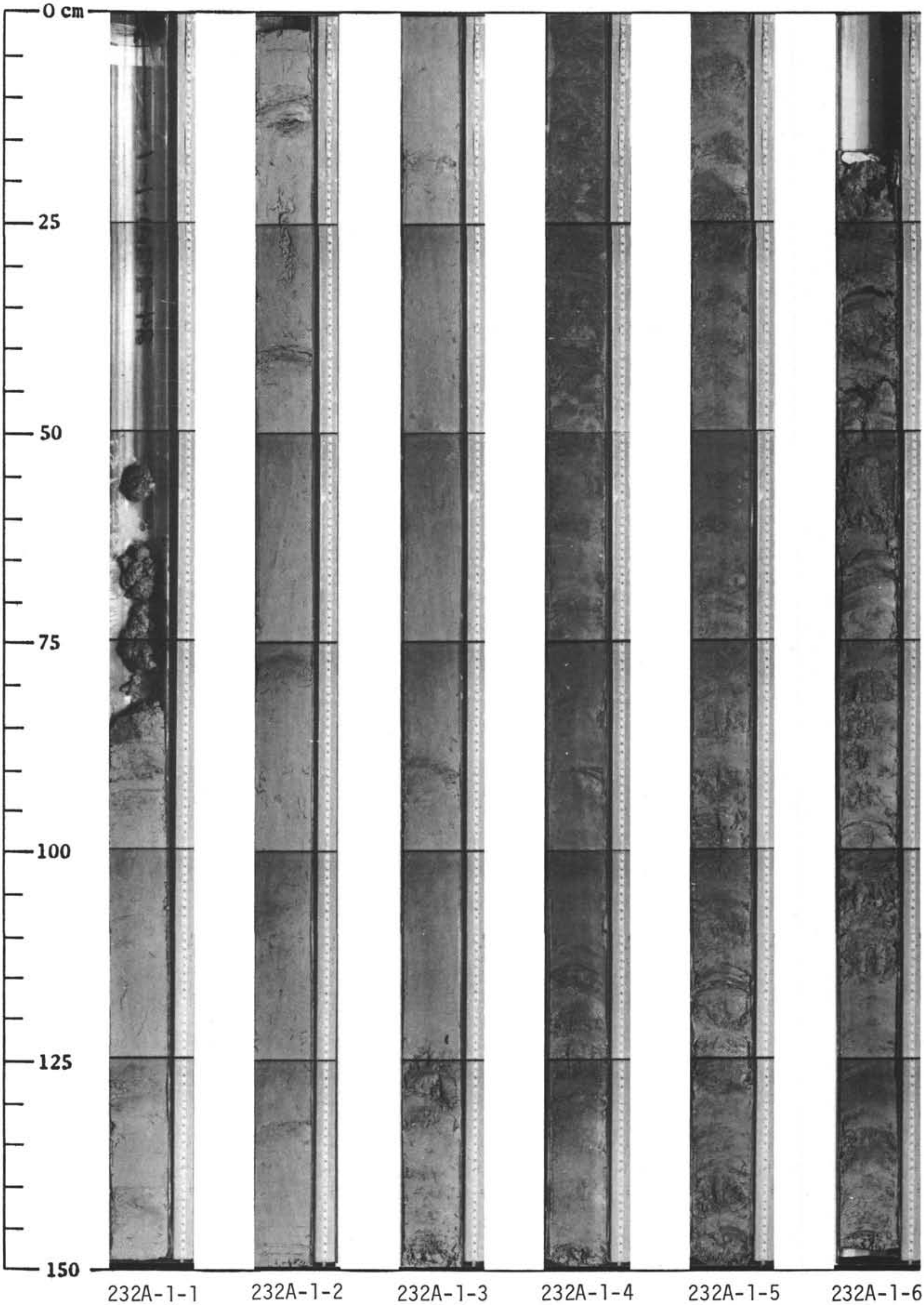
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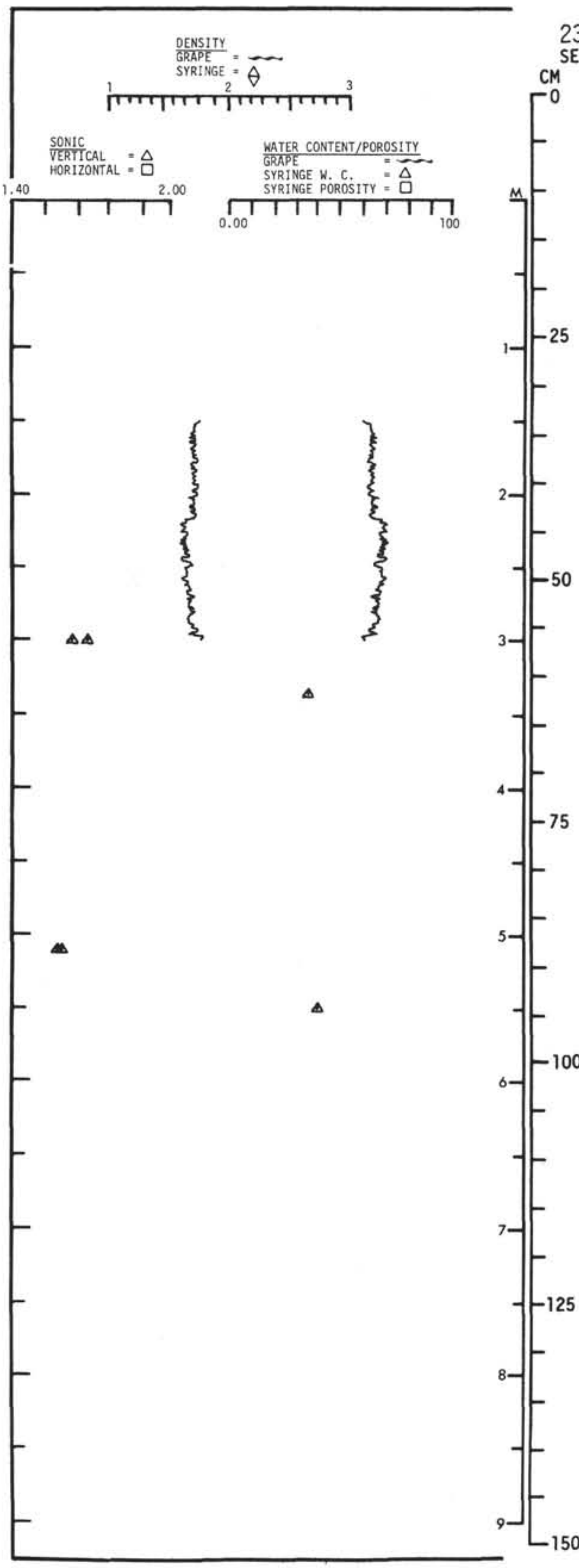
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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3
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CM
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75
100
125
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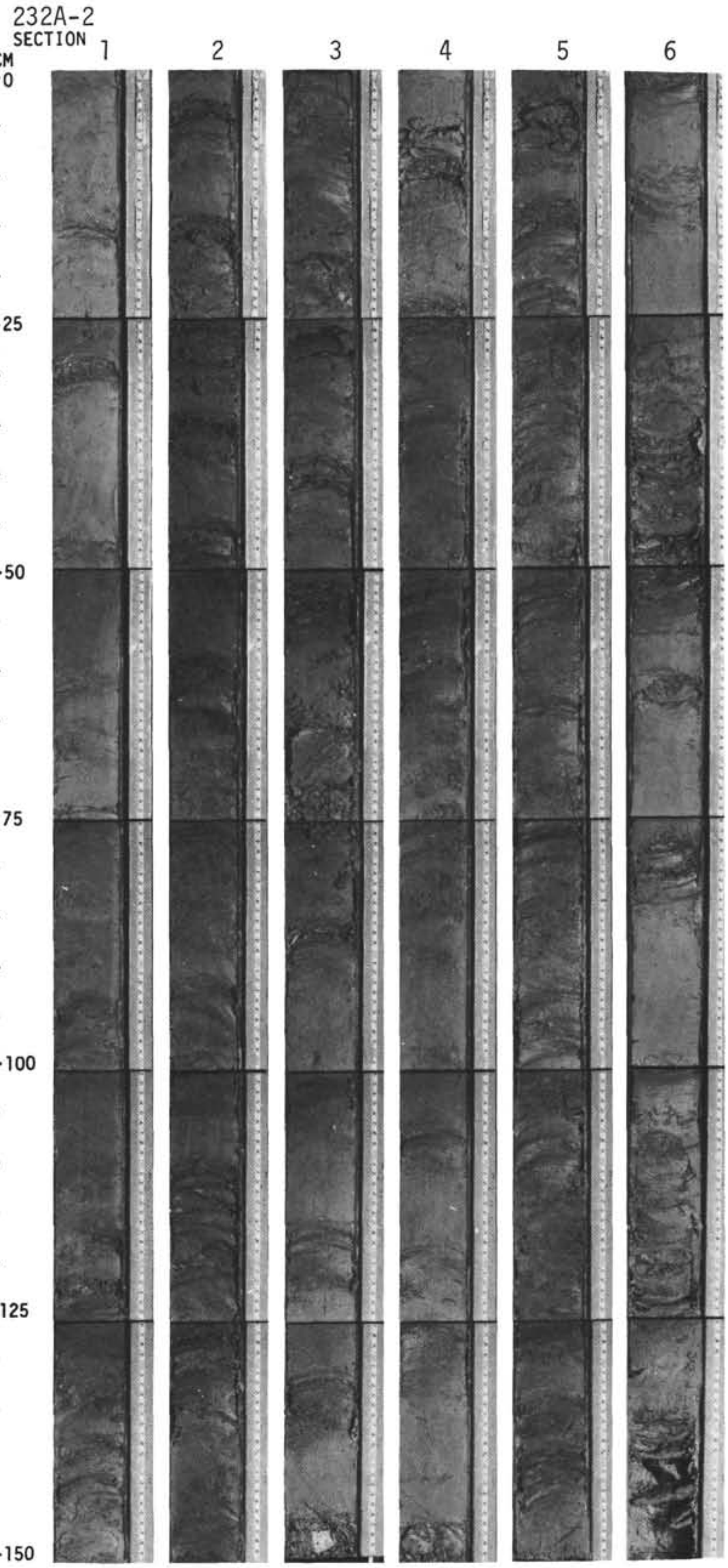
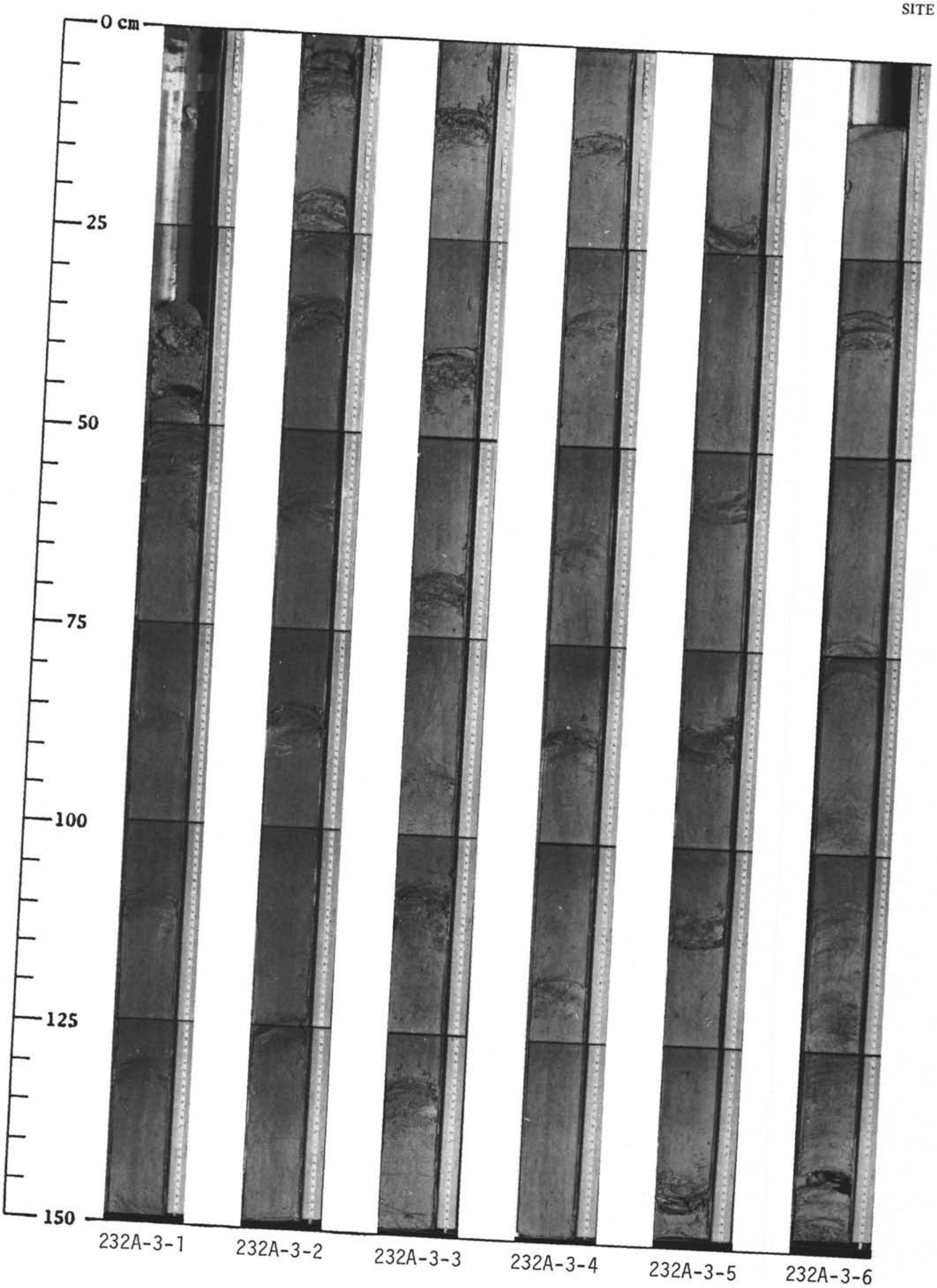

232A-2
SECTION 1 2 3 4 5 6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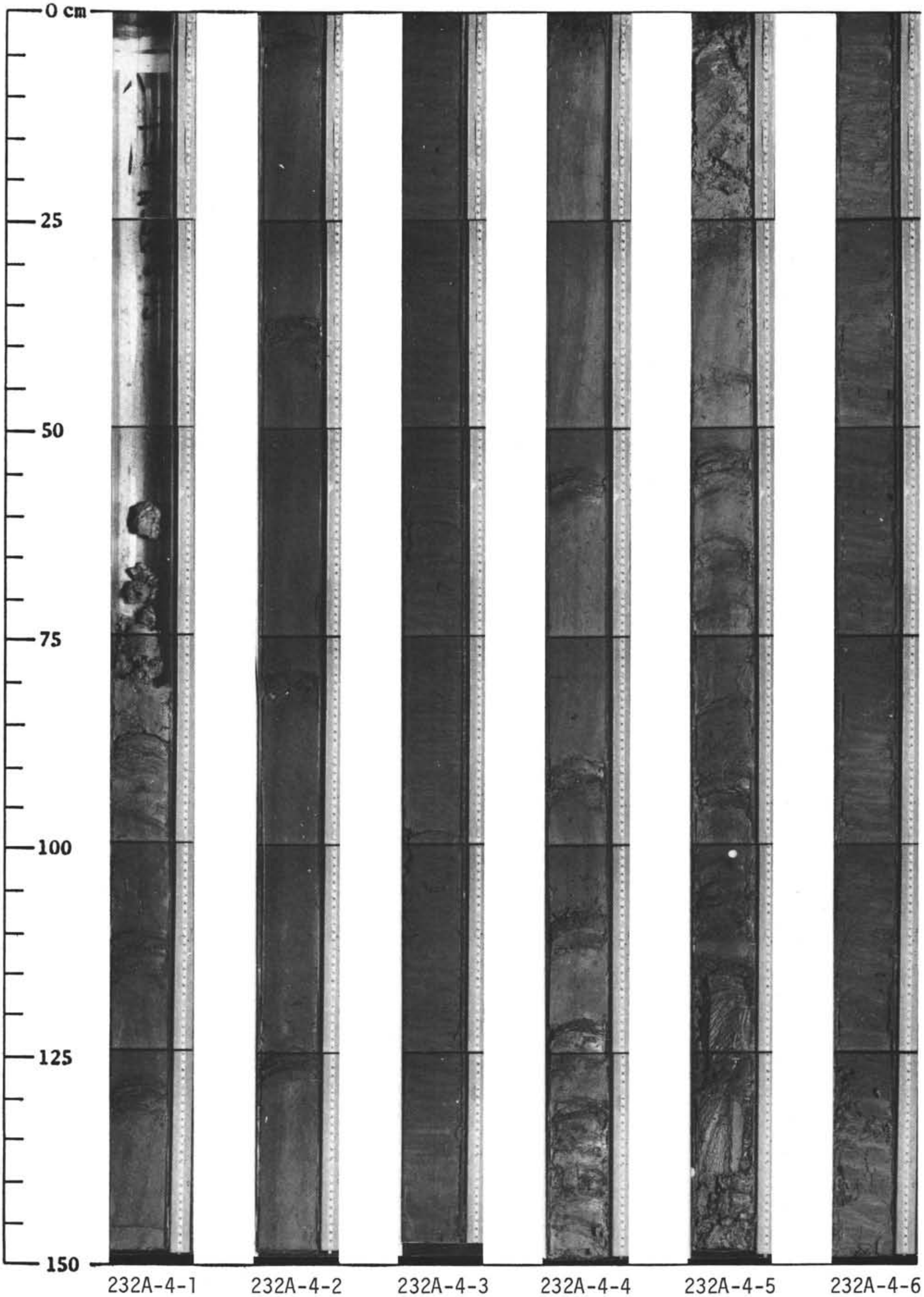
232A-3-5
232A-3-6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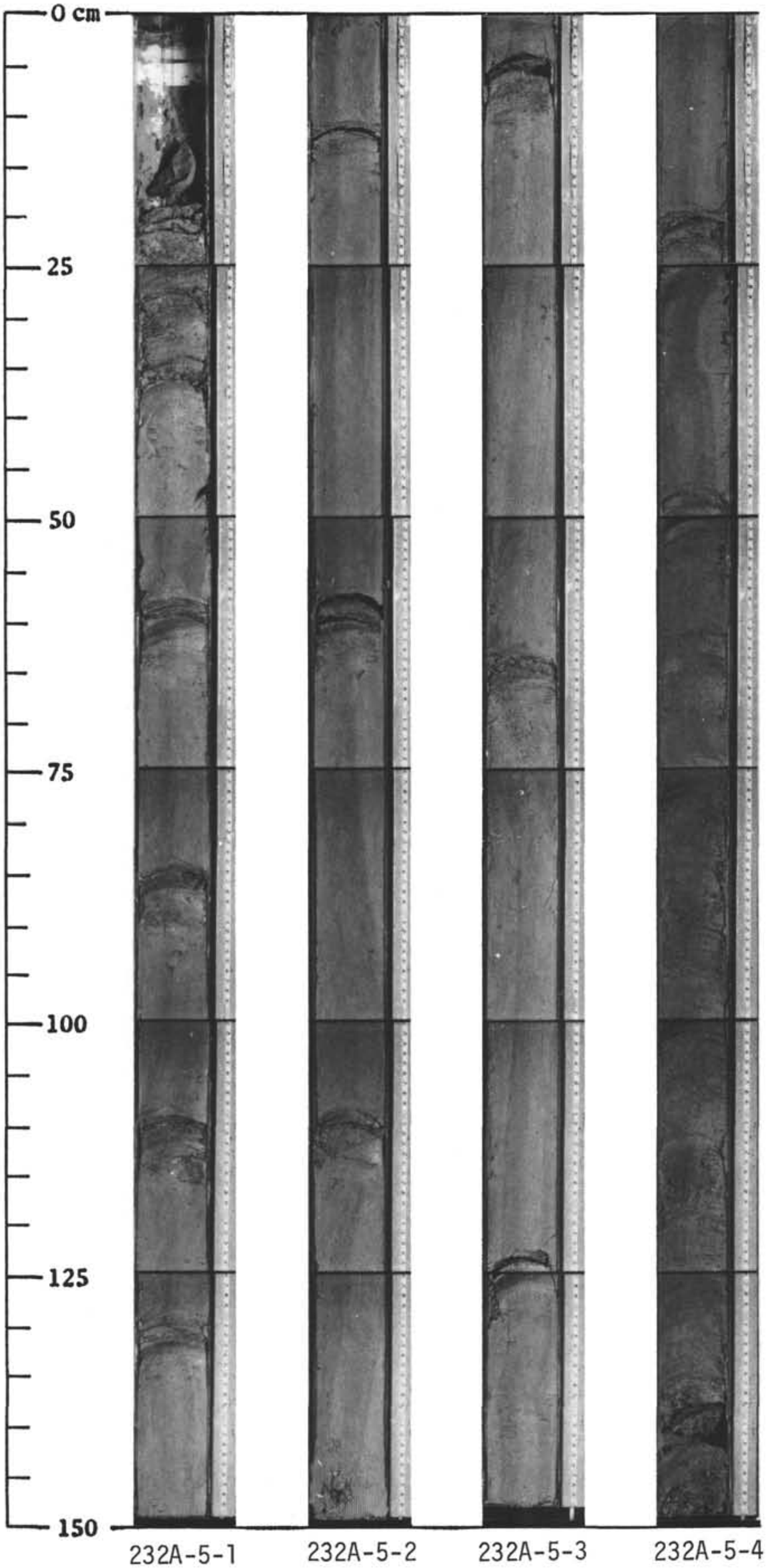
232A-4-5
232A-4-6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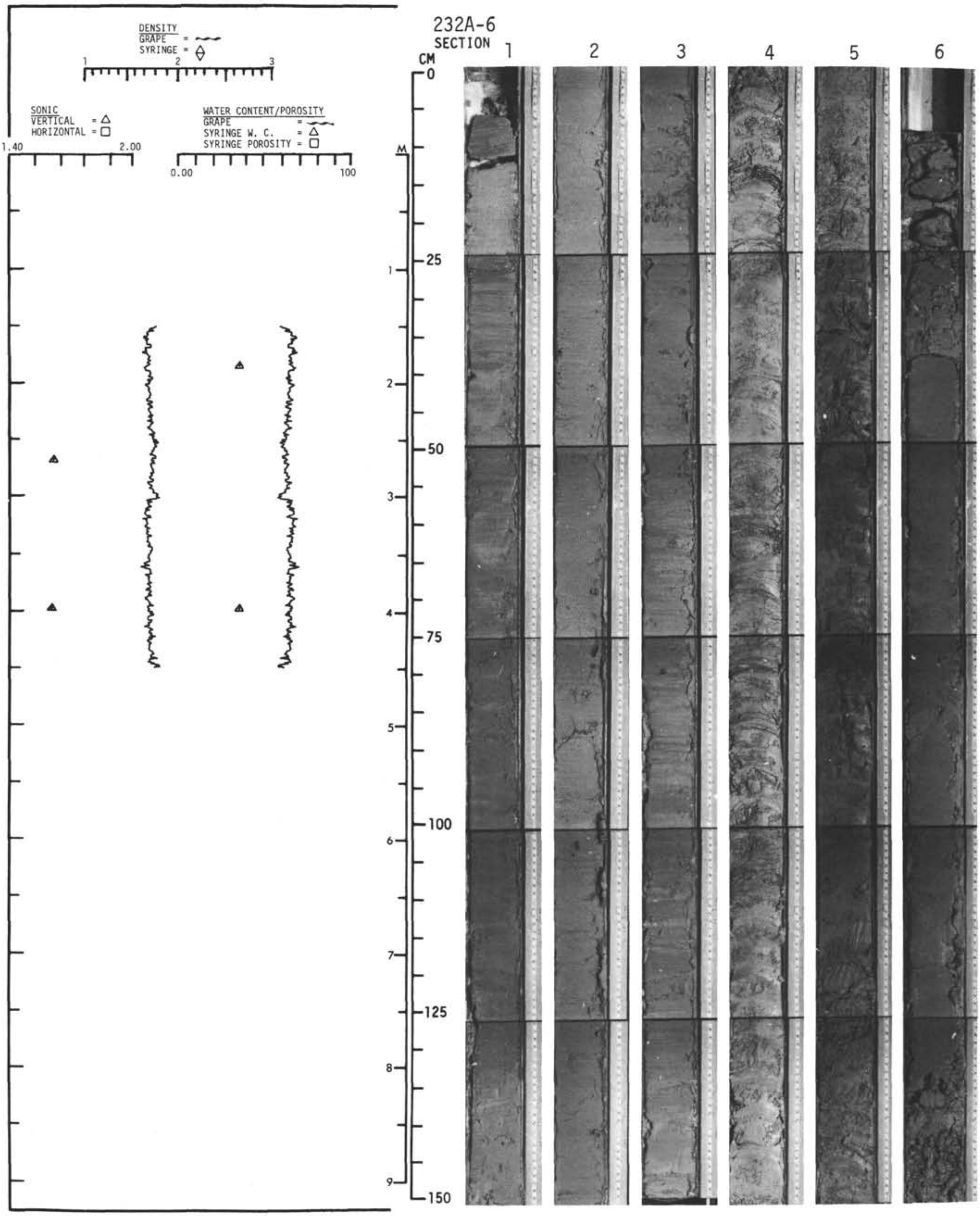
232A-5-2
232A-5-3
232A-5-4



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SONIC
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WATER CONTENT/POROSITY
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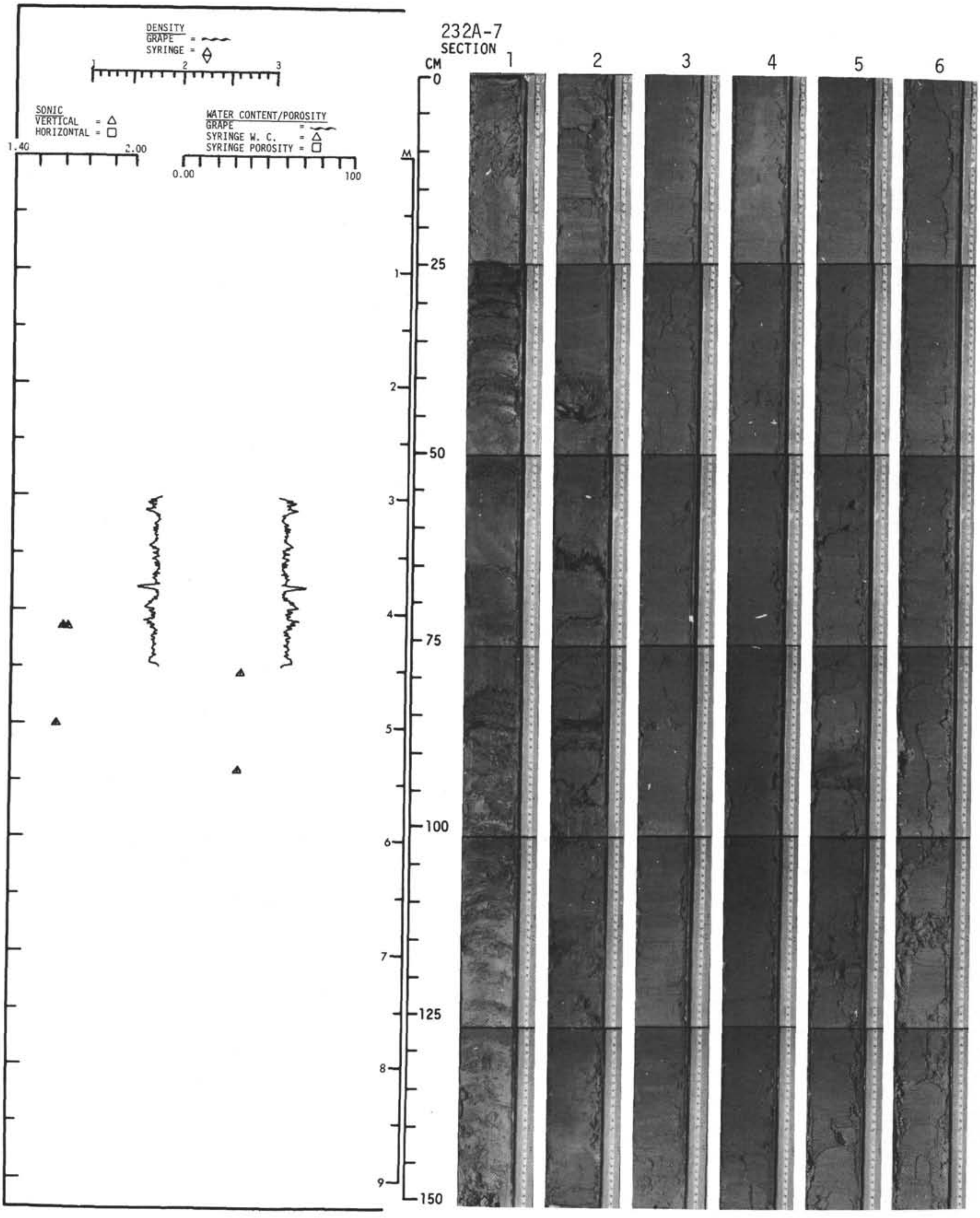
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SYRINGE POROSITY = □
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232A-7
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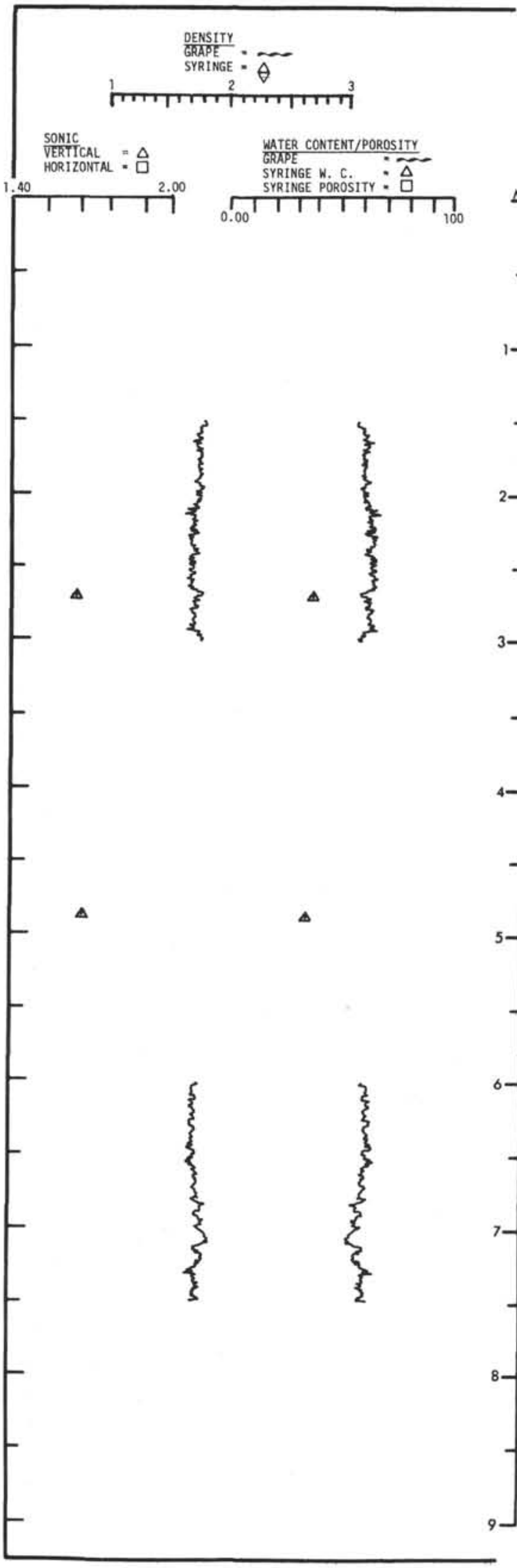
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
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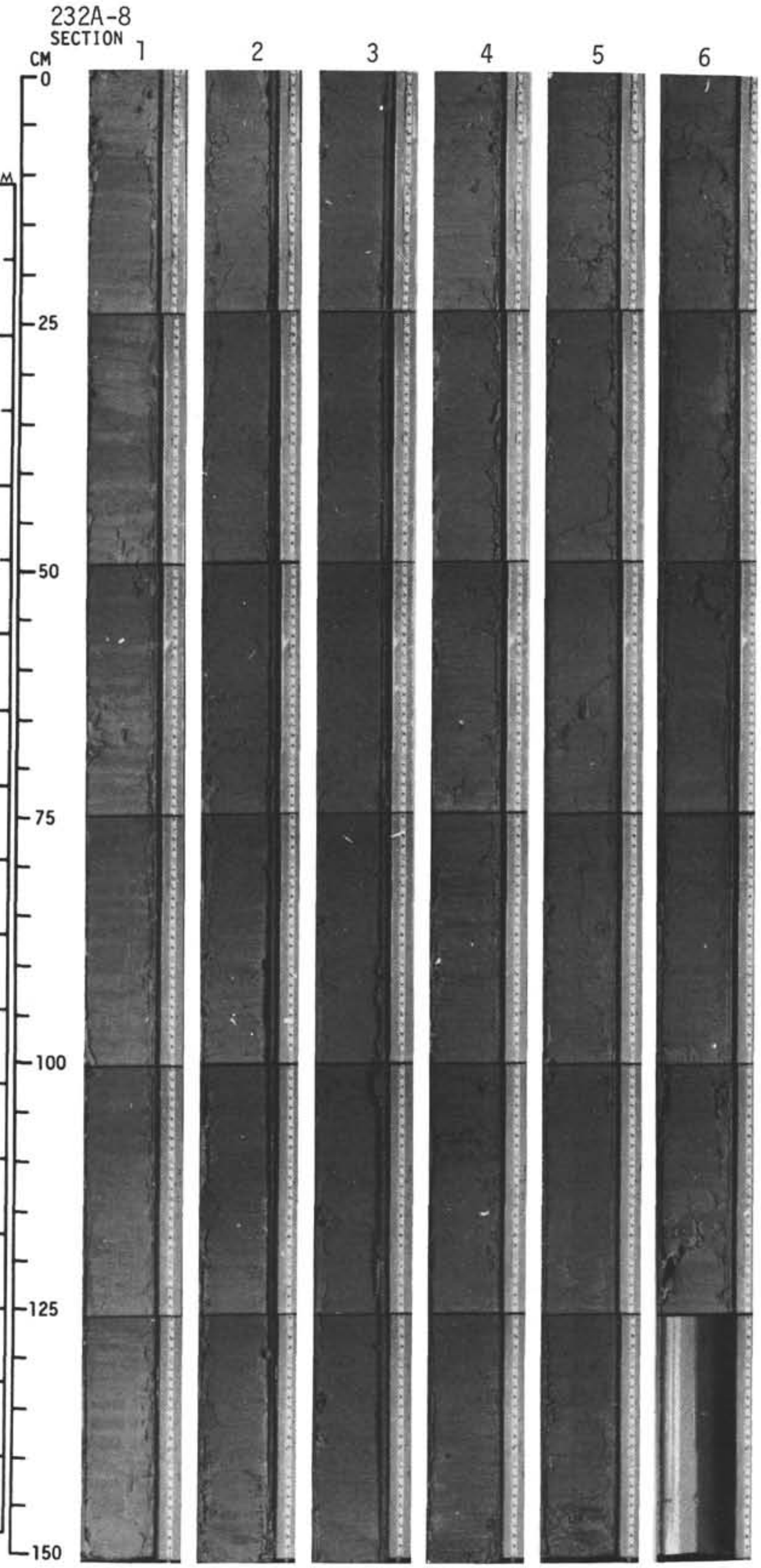
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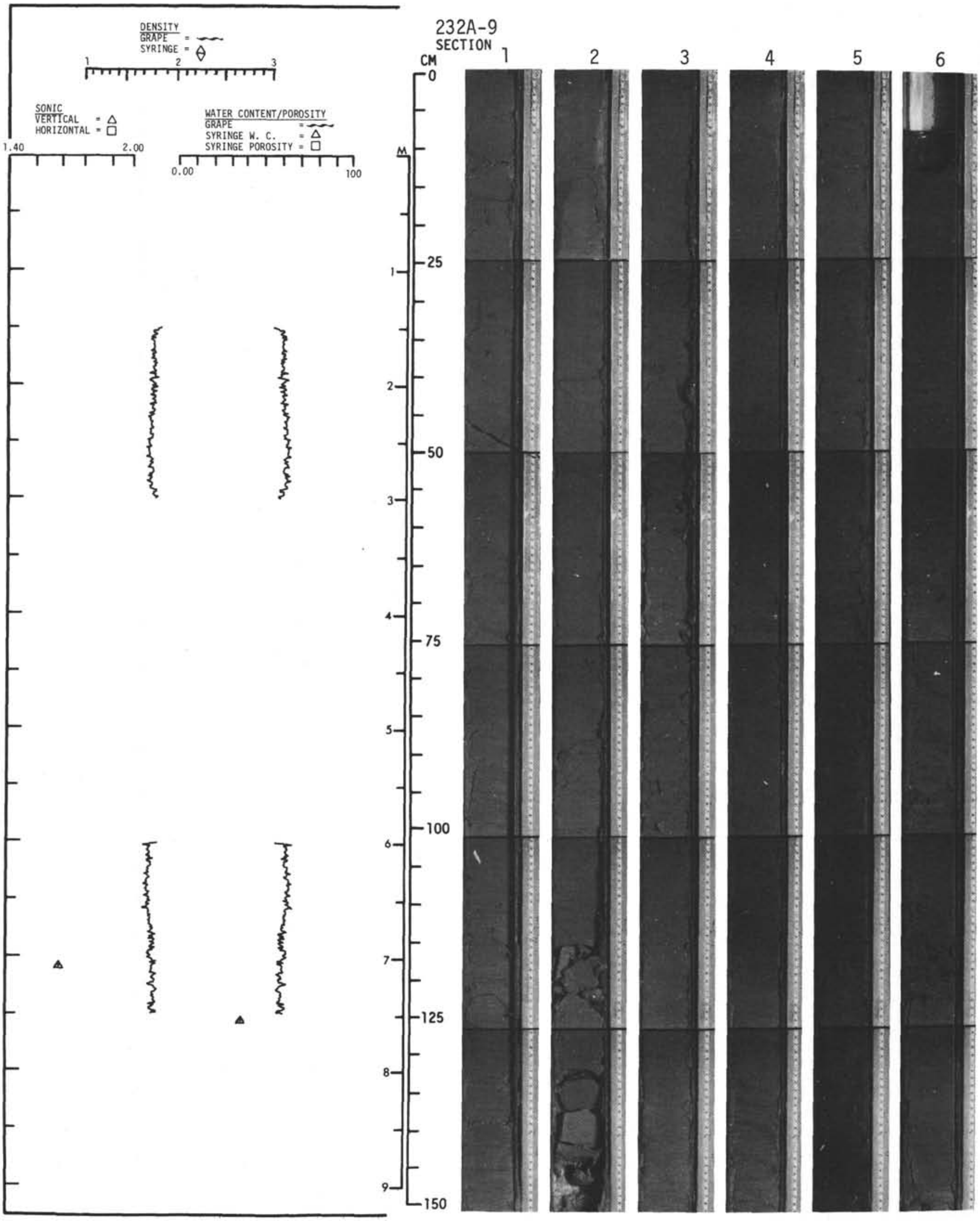
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GRAPE
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SONIC
VERTICAL
HORIZONTAL
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WATER CONTENT/POROSITY
GRAPE
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232A-9
SECTION
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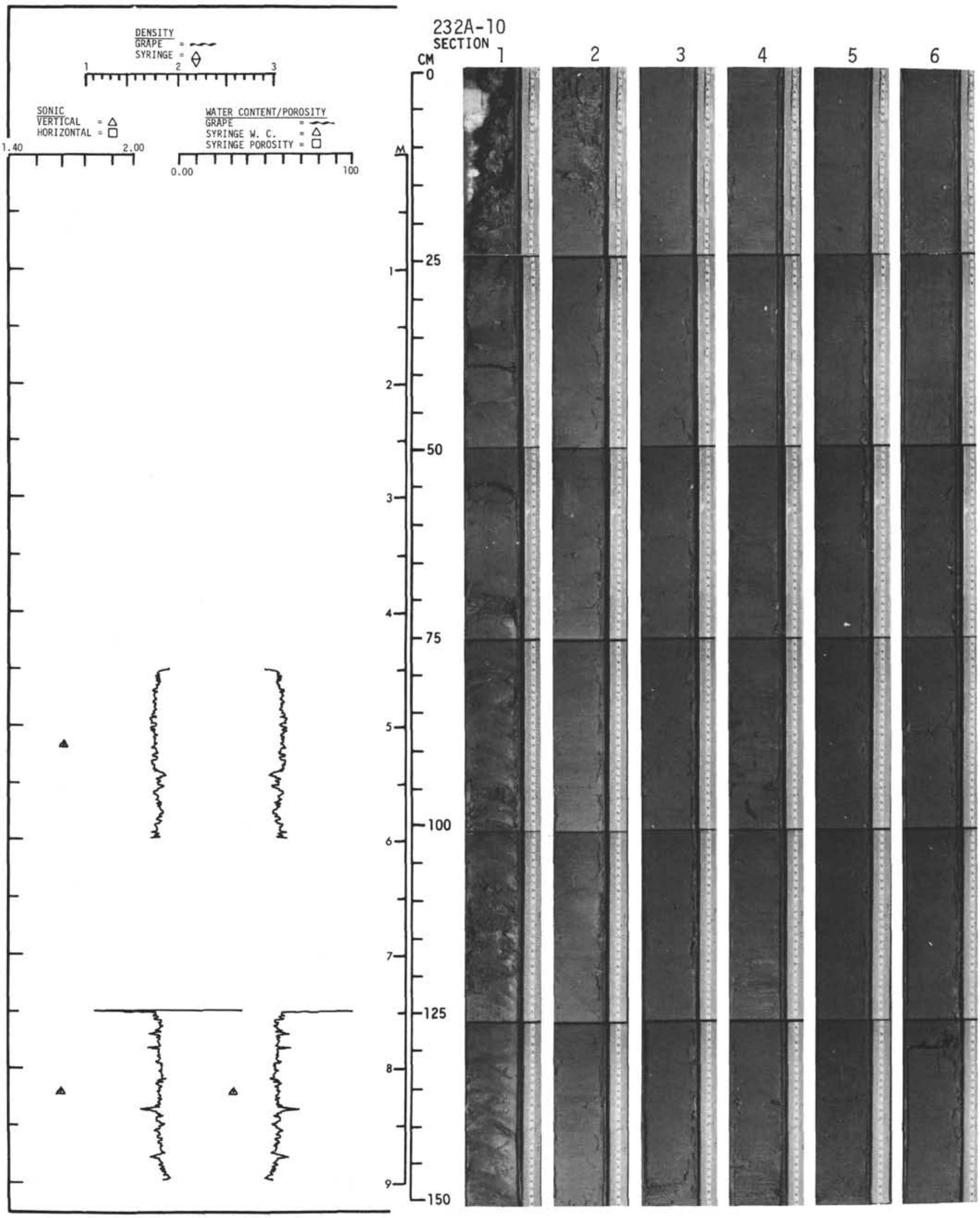
6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GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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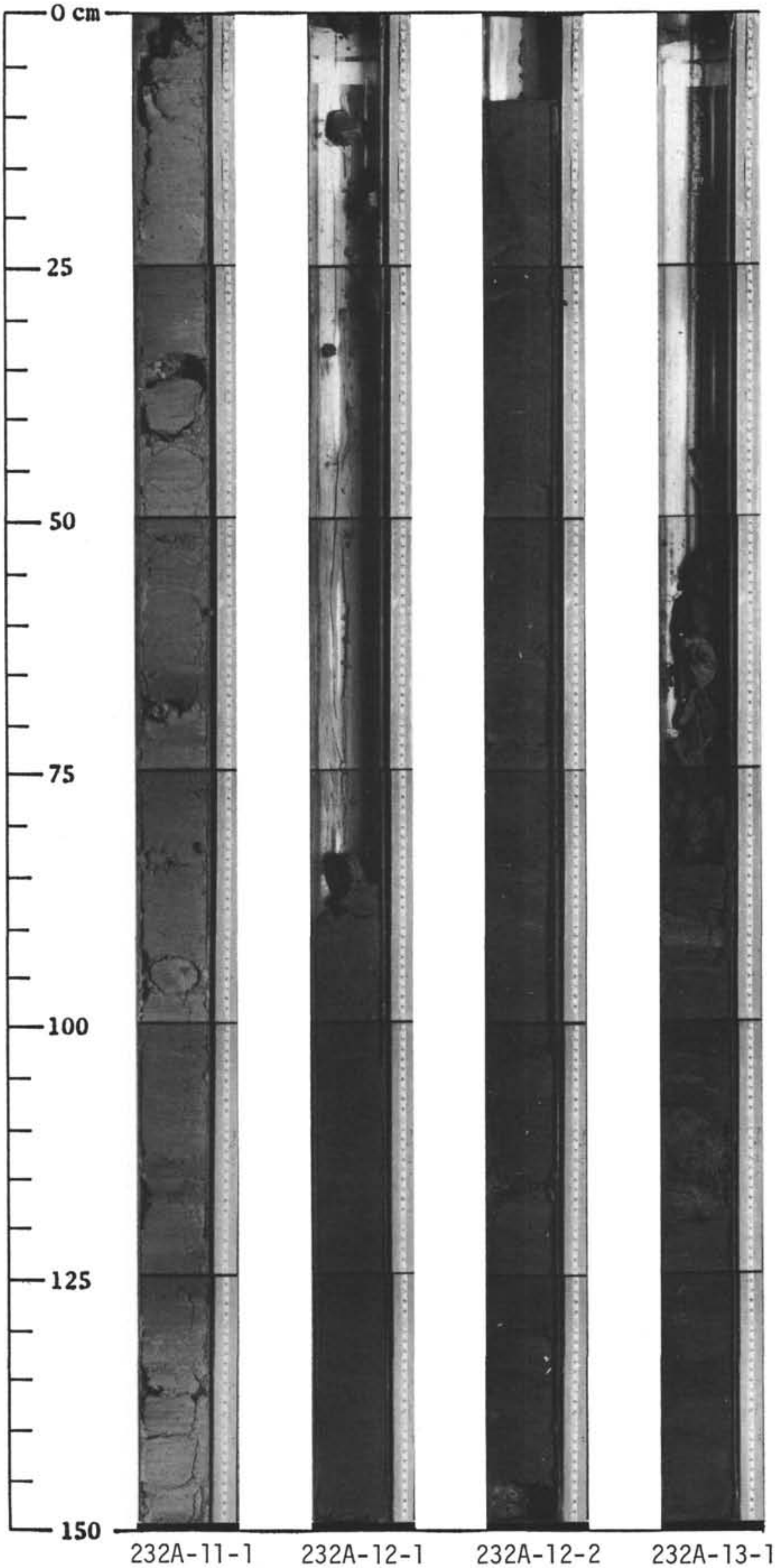
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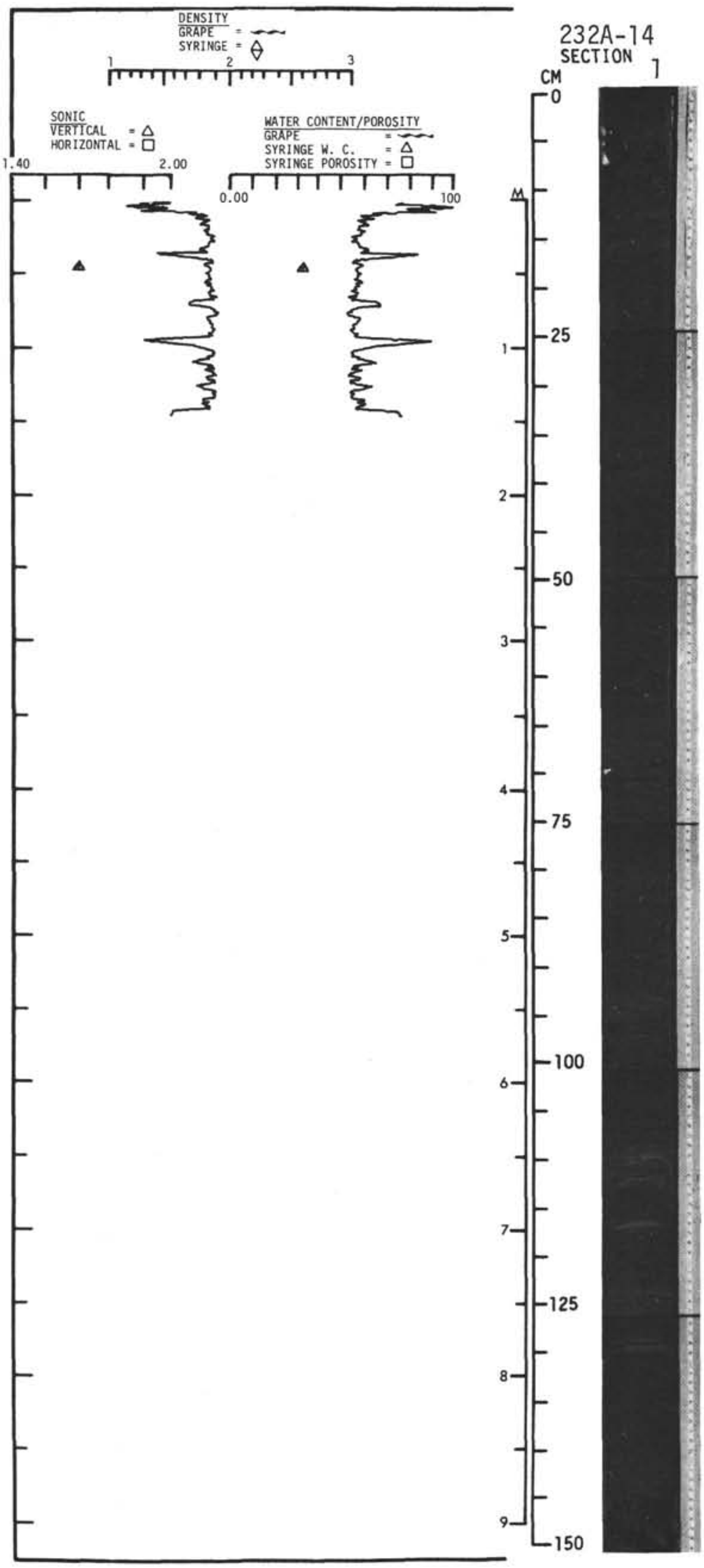
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
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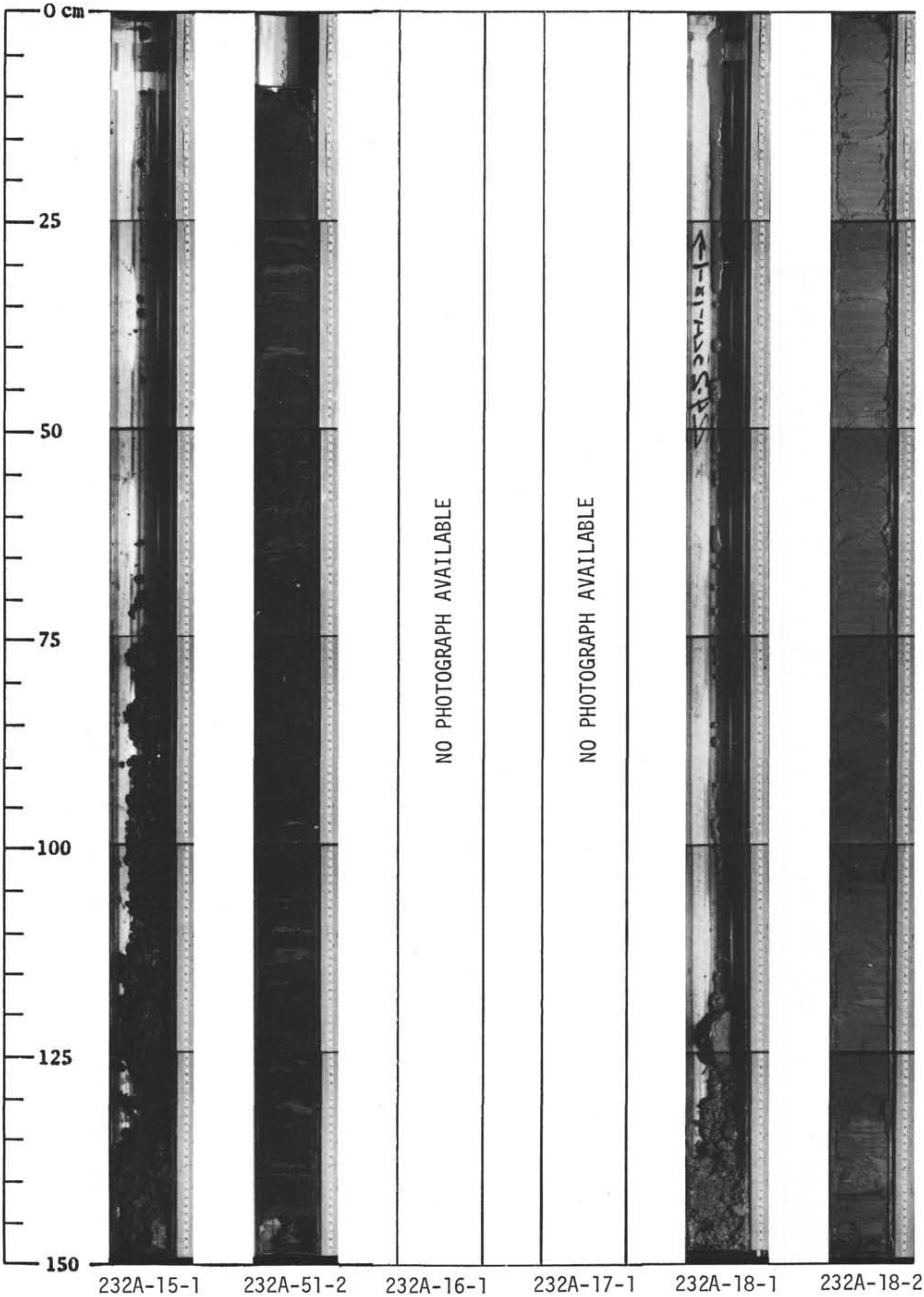
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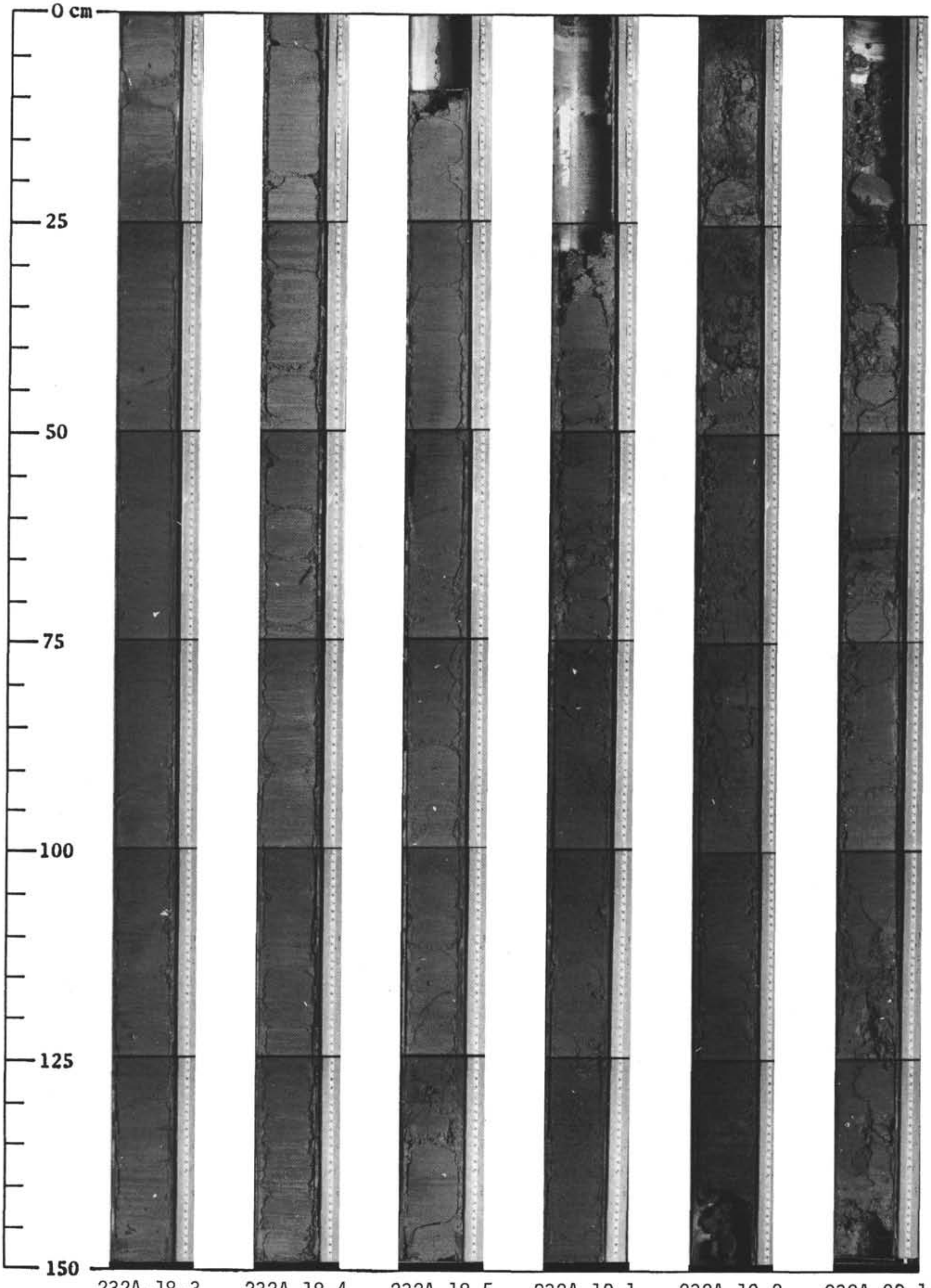
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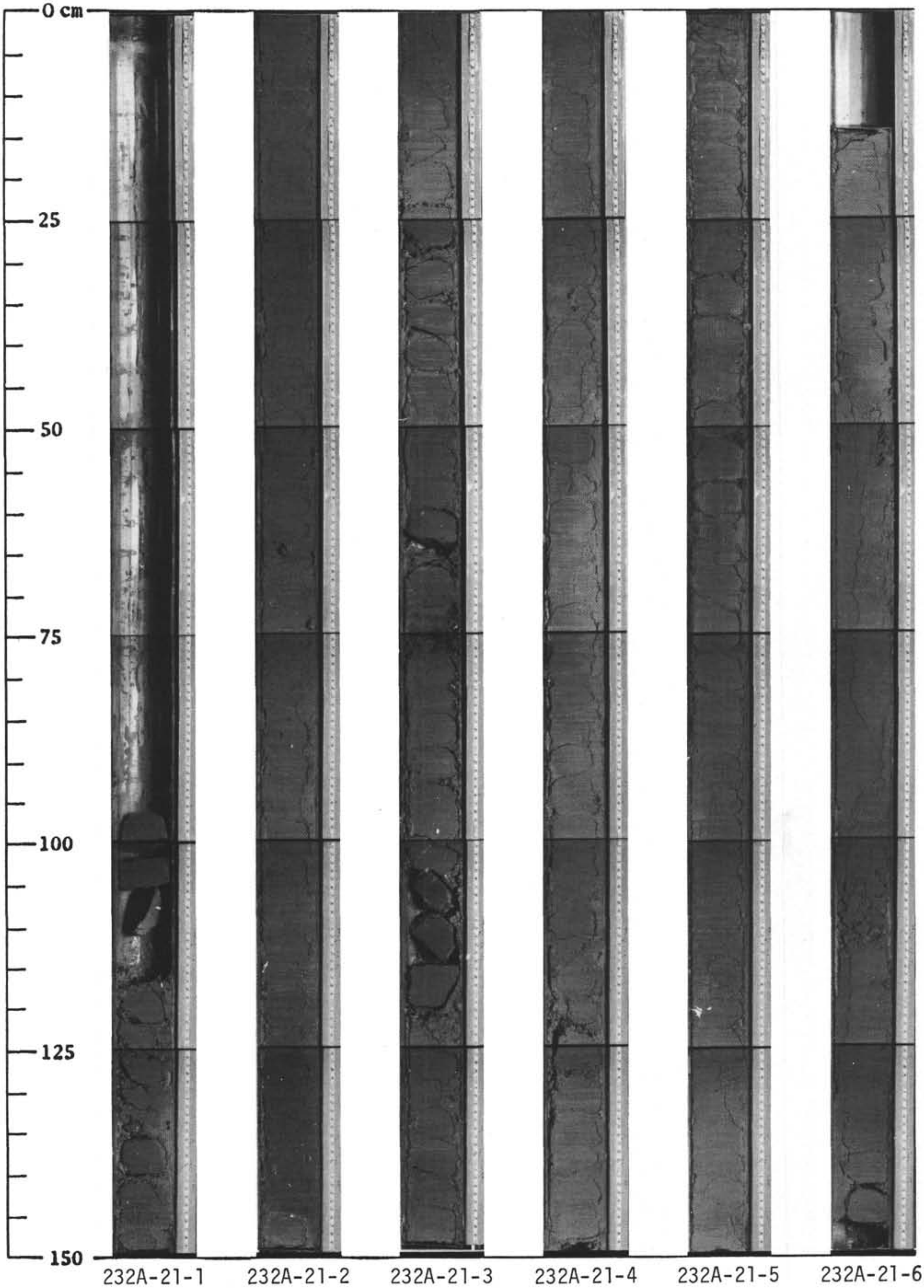
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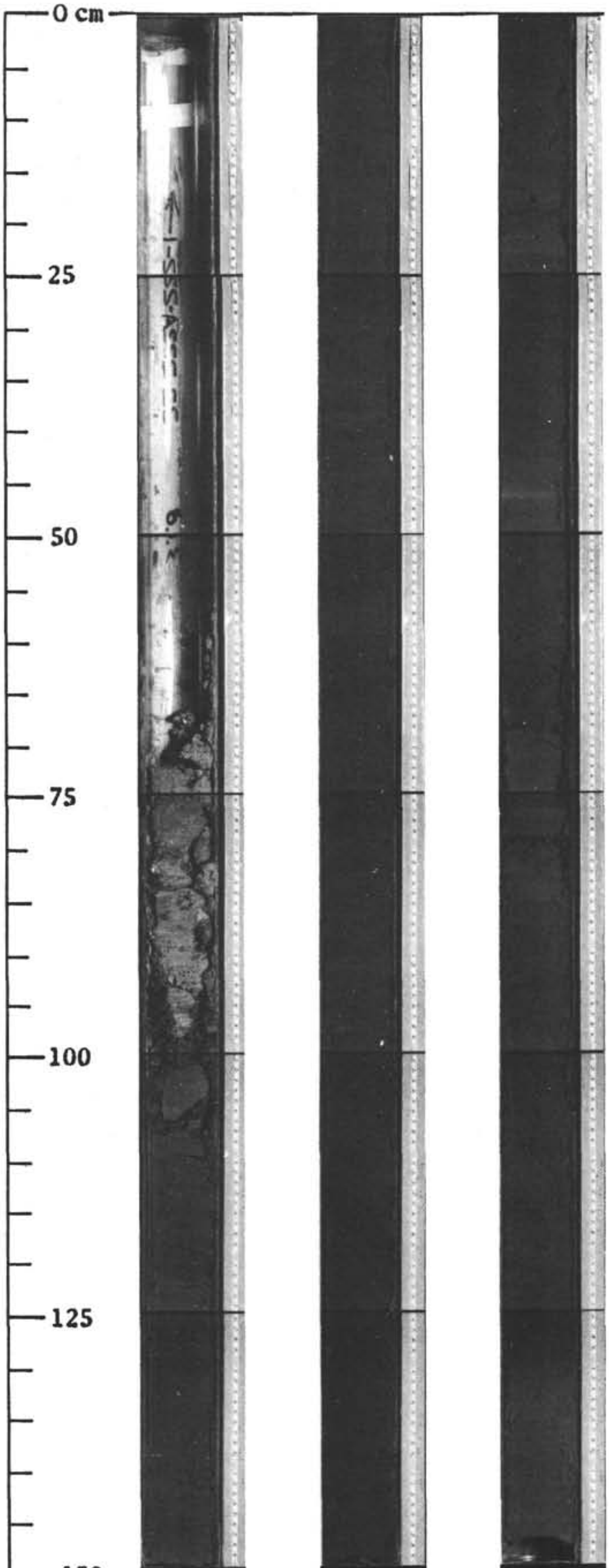

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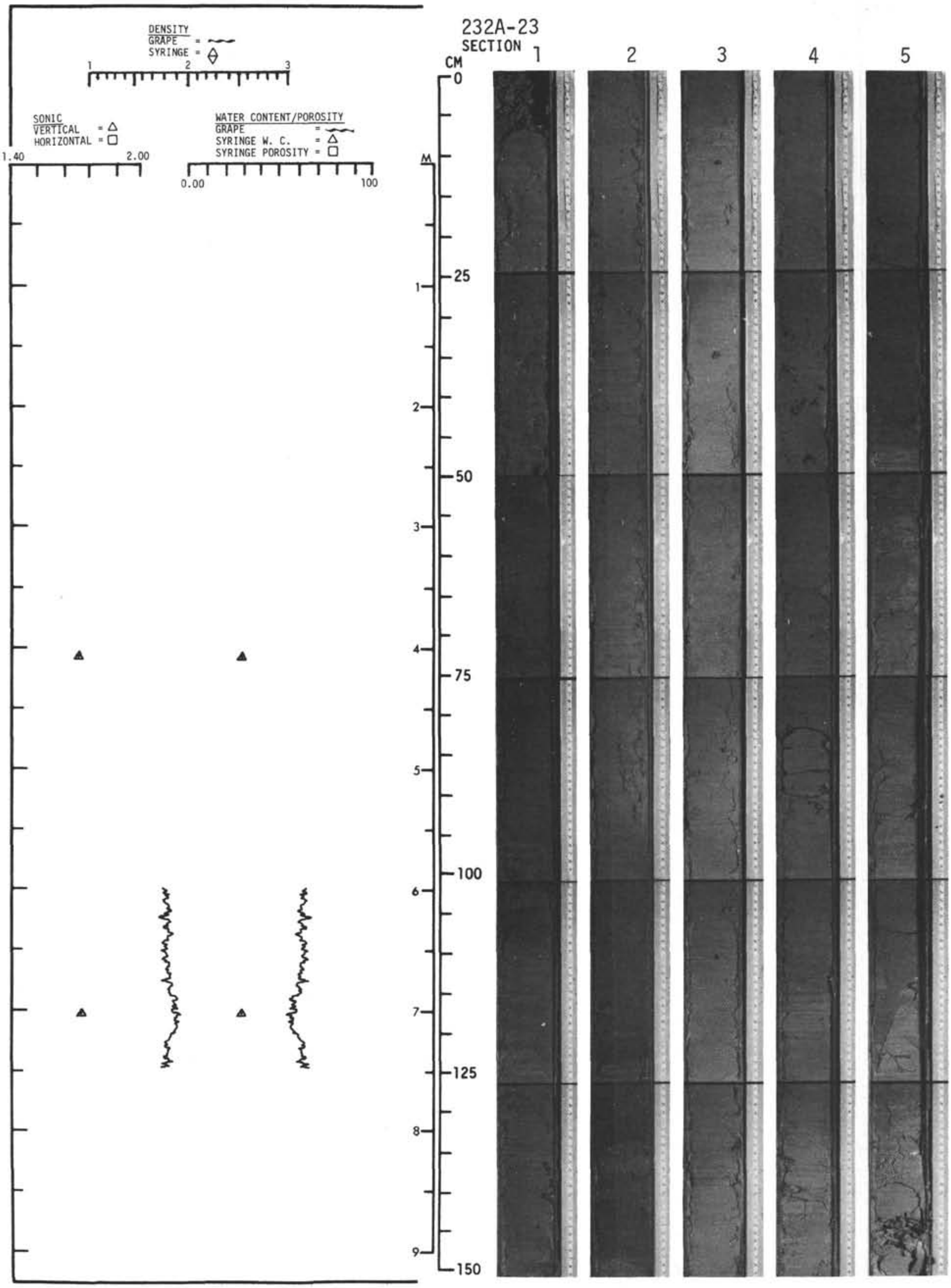
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VERTICAL = △
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WATER CONTENT/POROSITY
GRAPE =
SYRINGE W. C. = △
SYRINGE POROSITY = □
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100
M
232A-23
SECTION
1
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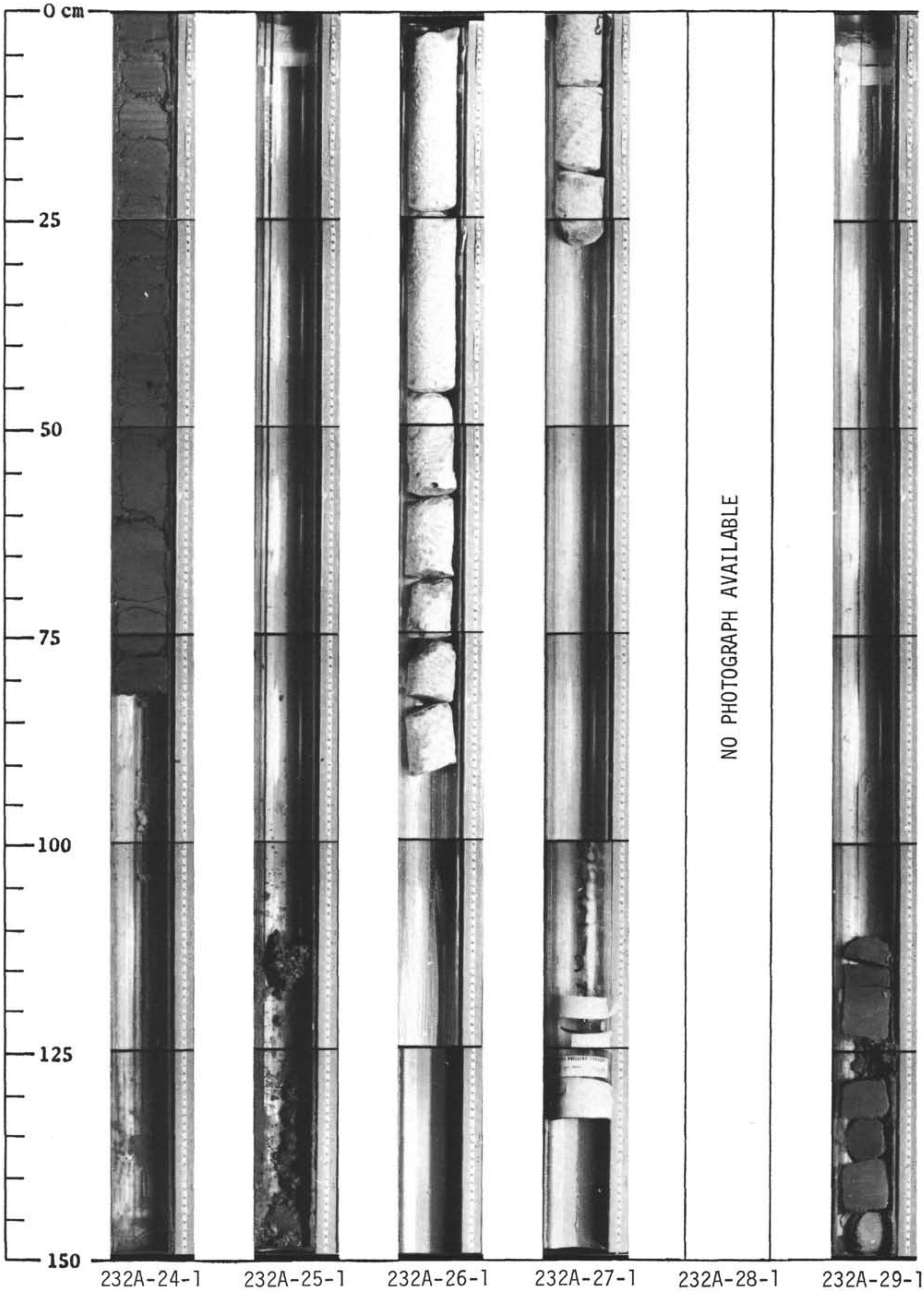
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232A-25-1
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232A-28-1
232A-29-1