7. SITE 499: MIDDLE AMERICA TRENCH AXIS[1]

Shipboard Scientific Party[2]

HOLE 499

Date occupied: 12 June 1979

Date departed: 14 June 1979

Time on hole: 64.1 hr.

Position: 12°40.35′N; 90°56.65′W

Water depth (sea level; corrected m, echo sounding): 6105

Water depth (rig floor; corrected m, echo sounding): 6115

Bottom felt (m, drill pipe): 6126.5

Penetration (m): 229.0

Number of cores: 25

Total length of cored section (m): 229.0

Total core recovered (m): 118.9

Core recovery (%): 51.9

Oldest sediment cored:
Depth sub-bottom (m): 229.0
Nature: Calcareous ooze
Age: Late early Miocene

Basement: Not reached

Principal results: A pelagic sedimentary section was encountered beneath a wedge of trench-filling turbidites.

HOLE 499A

Date occupied: 14 June 1979

Date departed: 16 June 1979

Time on hole: 25.4 hr.

Position: 12°40.65′N; 90°56.78′W

Water depth (sea level; corrected m, echo sounding): 6108

Water depth (rig floor; corrected m, echo sounding): 6118

Bottom felt (m, drill pipe): 6132

Penetration (m): 43

Number of cores: 5

Total length of cored section (m): 43

Total core recovered (m): 12.59

Core recovery (%): 29.2

Oldest sediment cored:
Depth sub-bottom (m): 43
Nature: Mudstone
Age: Quaternary

Basement: Not reached

Principal results: A comparison with Hole 499 indicates no lateral facies change in trench-filling turbidities.

HOLE 499B

Date occupied: 15 June 1979

Date departed: 17 June 1979

Time on hole: 40 hr.

Position: 12°40.23′N; 90°56.68′W

Water depth (sea level; corrected m, echo sounding): 6105

Water depth (rig floor; corrected m, echo sounding): 6115

Bottom felt (m, drill pipe): 6126.5

Penetration (m): 286.5

Number of cores: 10

Total length of cored section (m): 85.5

Total core recovered (m): 21.35

Core recovery (%): 24.9

Oldest sediment cored:
Depth sub-bottom (m): 268
Nature: Chalk
Age: Early Miocene
Measured velocity (km/s): 1.6–1.8

Basement:
Depth sub-bottom (m): 285
Nature: Basalt
Velocity range (km/s): 5.6

Principal results: Portions of the stratigraphic section drilled at Hole 499 were repeated; we encountered weathered basalt at 285 meters sub-bottom depth.

HOLE 499C

Date occupied: 17 June 1979

Date departed: 18 June 1979

Time on hole: 25.6 hr.

Position: 12°40.30′N; 90°57.03′W

Water depth (sea level; corrected m, echo sounding): 6102

Water depth (rig floor; corrected m, echo sounding): 6112

Bottom felt (m, drill pipe): 6112

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[1] Aubouin, J., von Huene, R., et al., *Init. Repts. DSDP*, 67: Washington (U.S. Govt. Printing Office).

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Penetration (m): 263

Number of cores: 1

Total length of cored section (m): 3

Total core recovered (m): 0.3

Core recovery (%): 10

Oldest sediment cored: None

Basement:
Depth sub-bottom (m): 260
Nature: Basalt
Velocity range (km/s): 5.6

Principal results: We recovered weathered basalt at 260 meters sub-bottom depth.

HOLE 499D

Date occupied: 23 June 1979

Date departed: 25 June 1979

Time on hole: 36.3 hr.

Position: 12°40.45′N; 90°56.70′W

Water depth (sea level; corrected m, echo sounding): 6116

Water depth (rig floor; corrected m, echo sounding): 6126

Bottom felt (m, drill pipe): 6126

Penetration (m): 216

Number of cores: 1

Total length of cored section (m): 3.5

Total core recovered (m): 0.75

Core recovery (%): 21

Oldest sediment cored: Not available

Basement:
Depth sub-bottom (m): 213

Principal results: We encountered weathered basalt at a sub-bottom depth of 213 meters, about 60 meters shallower than the level at which rock was encountered in Holes 499B and 499C.

Principal results (Holes 499–499D): Site 499 includes five holes drilled on the trench floor (Figs. 1 and 2). Seismic-reflection records show a sequence of horizontal reflections, presumed to be trench fill, underlain by a sequence of reflections with a gentle landward dip, perhaps representative of the deep-ocean sedimentary section. Hole 499 was drilled just seaward of the trench axis (Fig. 2) and consisted of 201 meters of terrigenous mud overlying nannofossil chalk. Subsequently, the bottom of an axial depression was drilled at 499A to define lateral facies changes in the trench fill. Hole 499 was paralleled at 499B, which was drilled to a rubbly basalt. Because basalt cobbles from Hole 499B were altered and rounded and not a convincing indication of basement, another hole (499C), offset 1,000 ft. along strike, was washed to basement. Once again, rounded and altered basalt cobbles were cored. Hole 499D was washed to 216 meters for the purpose of logging, and a rubbly conglomerate was encountered about 50 meters above the seismic basement objective.

The lithologic sequence at Site 499 is the same as at Site 495, the oceanic reference site, but with the addition of a cover trench-fill turbidite. The turbidites, 117 meters thick, are predominantly muddy, although sandy layers may have been penetrated in intervals of poor recovery. About 1 km away, at Hole 499A, similar turbidite units appear in a channel indicating that the axial fill of the Middle America Trench is uniform at this location. At Site 499 the turbidites end abruptly and are underlain by burrow-mottled hemipelagic mud, calcareous ooze and chalk, and finally basalt rubble. The calcareous section is about one-third as thick as that at Site 495.

Microfossils occur in the same succession as at Site 495 with the addition of the Quaternary trench-fill sequence. The trench fill has abundant reworked and transported calcareous microfossils, and the 400,000-yr. radiolarian zonal marker clearly exists below the trench fill. Within the calcareous section, there is more dissolution of foraminifers than at Site 495, indicating deposition nearer the CCD. The oldest sediment was deposited in the earliest Miocene, as at Site 495.

In addition to lithology and biogenic constituents, the measured physical properties and gaseous hydrocarbons change downhole between the trench fill and the underlying deep-ocean section.

BACKGROUND AND OBJECTIVES

Site 499 is in the Middle America Trench axis off Guatemala, about 1 km from the seaward slope and in 6126 meters of water. This site was originally planned as an alternate if Hole 495 was not drilled; however, it was drilled in order to allow time for decisions on shore regarding further drilling at Site 494.

Both the multichannel reflection profiles GUA-13 and 18 and the single-channel records made from the *Challenger* show an upper horizontal reflective sequence underlain by a landward dipping sequence. Site 499 was positioned so that both sequences would be sampled, but not where they are thickest. At Site 499 we anticipated drilling ponded trench fill, an underlying sequence of hemipelagic sediment, calcareous ooze, and finally basalt analogous to the section at Site 495.

Our objective was to date the trench fill in order to provide an estimate of the maximum residence time a segment of ocean crust is in the trench axis. Considering the approximate 2.8-km width of the trench fill, if the ocean crust is converging with the continental crust at a rate of 9 cm/yr., the residence time of a segment of ocean crust under the trench fill should be about 320,000 yr. That time span is probably too short to be defined by biostratigraphic or paleomagnetic methods, however, we do not know if the maximum age of the trench fill was greater than 320,000 yr.

OPERATIONS

Glomar Challenger departed Site 498 on June 10, 1518L (Local Time), bound for Acajutla, El Salvador, to make an emergency call and pick up chemicals needed in the engine room. On June 11 the ship anchored outside the harbor and departed 7 hr. later enroute to Site 494. A message received from the Deep Sea Drilling Project ordered drilling at Site 499 instead.

Glomar Challenger crossed the 494 beacon and followed the GUA-13 and 18 seismic lines, passing over Site 499. The beacon to be deployed failed before launching, therefore no beacon was dropped during the first pass. On a return track, a new beacon was dropped and the *Challenger* was in position on the site on June 12, 0420L.

The first core was recovered at Site 499 on June 12 1852L (Table 1). Shortly thereafter a second message from DSDP requested immediate drilling at Site 494 to avoid simultaneous drilling and recovery of the HIG data package. The string was pulled above the mudline prior to reaching basalt. A short hole at 499A was drilled to test lateral facies variability in the trench fill, and then the drill pipe was brought on board. Still another message from DSDP arrived when the ship was depart-

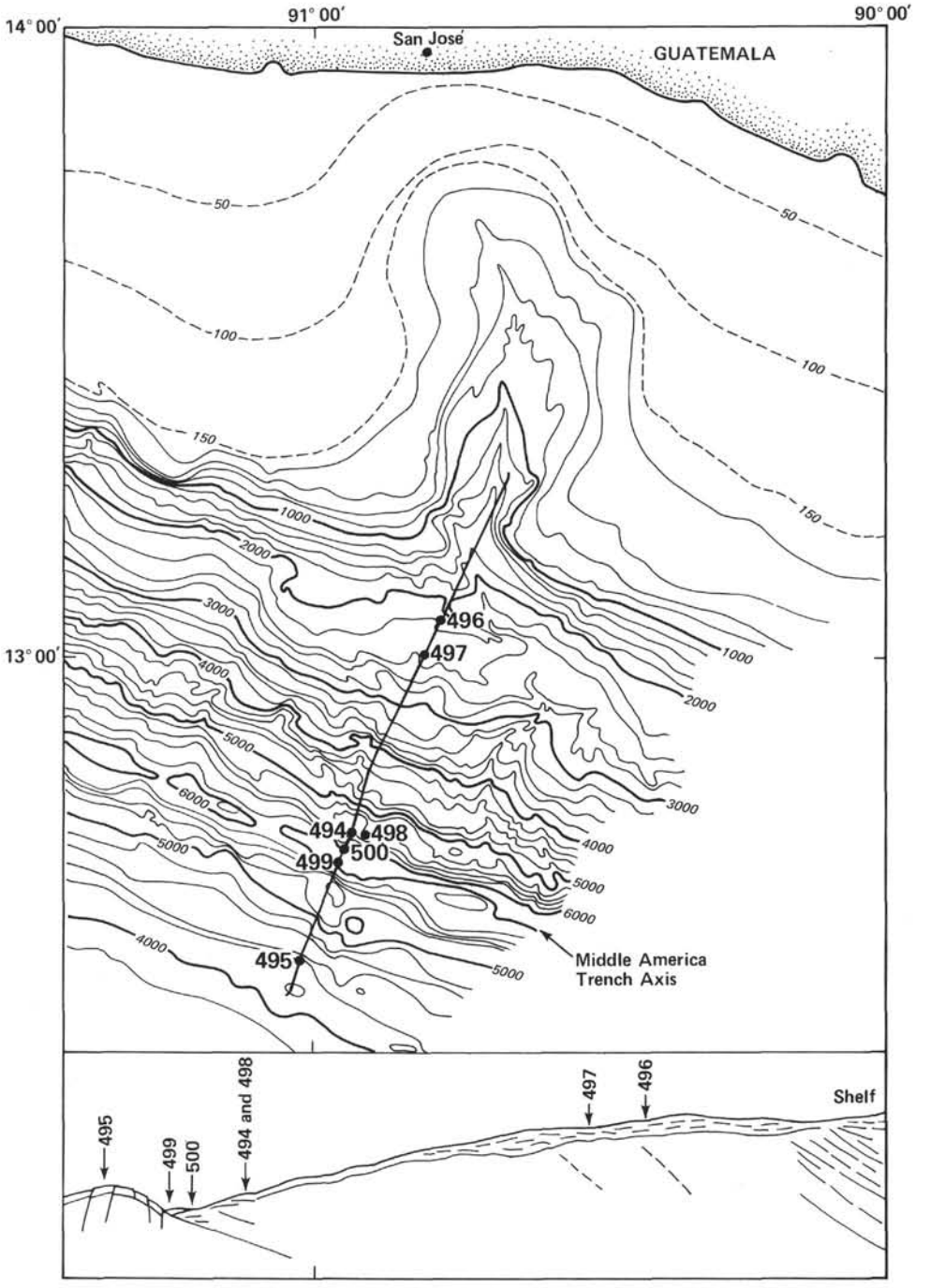


Figure 1. Location map for Site 499.

ing for Site 494. The Project disallowed drilling at Site 494 during retrieval of the HIG data package. Thus the drill string was again lowered and Hole 499B was drilled to basalt. The calcareous section was much thinner than at 495 and the basalt appeared to be from a rubble zone. Hole 499C, an offset along strike 1000 ft. from 499B, was washed down to recore the lower chalk and basalt. During wash down a hard layer was intercepted prior to lower chalk depth at Hole 499B. A 3-meter core brought up more basalt rubble with some drill-cut pieces. Following drilling operations at Site 500, Hole 499D was washed to an unexpectedly shallow rubble horizon at a sub-bottom depth of 213 meters.

LITHOSTRATIGRAPHY

At Site 499, five holes were drilled (499, 499A, 499B, 499C, and 499D) at water depths between 6112 and 6132 meters on the floor of the Middle America Trench off Guatemala. Site 499 is located approximately 20 km NNE (north-northeast) of Site 495, the Leg 67 oceanic reference site for pelagic and hemipelagic sediment of the Cocos Plate. The surface of the horizontal trench fill

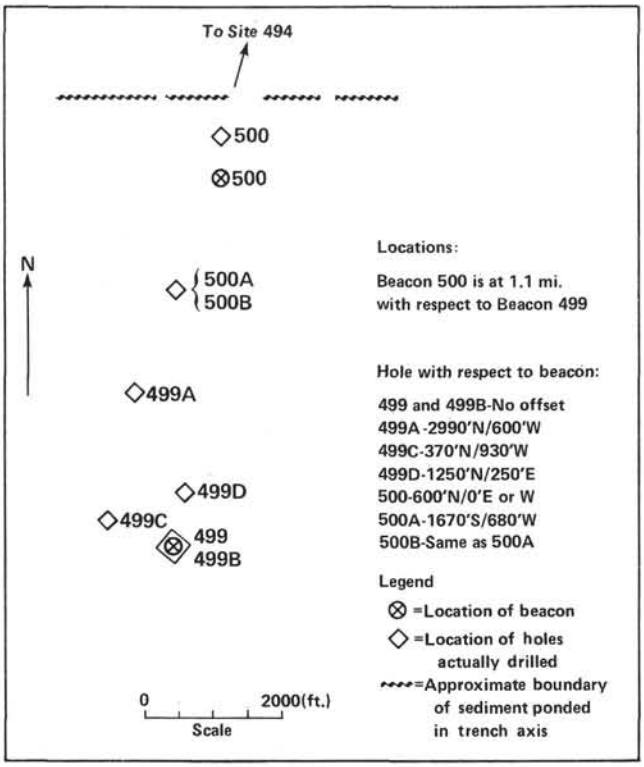


Figure 2. Detail of Middle America Trench axis showing relative positions of the eight holes drilled at Sites 499 and 500. (Holes 499 and 499B were drilled at the Site 499 beacon.)

is approximately 2.3 km wide at this locality. Hole 499 was placed at a slightly elevated position on the trench floor, approximately 1 km from the seaward slope rather than in the trench axis, to avoid possible poor core recovery should the somewhat deeper central portion represent a channel filled with coarse sediment. After drilling to the calcareous section in Hole 499, a second hole (499A) was drilled in the trench axis. Because plans to drill an additional hole at Site 494 were abandoned, it was possible for the *Challenger* to reoccupy Site 499 and attempt to penetrate oceanic basement under the trench floor. When the drill string stuck in Hole 499B short of this objective, a fourth hole (499C) offset along strike was drilled. A fifth hole was drilled for the purpose of logging (499D).

At Site 499 six lithologic units were distinguished; the uppermost is composed of terrigenous trench fill and the lowermost of basalt (Fig. 3). The four units between consist of hemipelagic and pelagic sediments that represent lateral equivalents of the oceanic sequence encountered at Site 495.

Unit 1 (Hole 499, Cores 1 to 14, Section 2, 42 cm, 0–117.0 m sub-bottom depth; Hole 499A, Cores 1 to 5, 0–43.0 m sub-bottom depth; Quaternary)

The sediment of Unit 1 is an alternate muddy and sandy upper Pleistocene to Holocene trench fill. Dark olive gray (5Y 3/2) or very dark olive gray (5Y 2.5/2) to greenish olive gray (5GY 4/1) diatomaceous, partly nannofossil- and/or ash-bearing muds, terrigenous and volcanogenic sand layers, and a few distinct ash layers (which are restricted to Cores 1 and 13) compose Unit 1 sediments.

The first distinct turbidite is in Core 3—a relatively light olive gray (5Y 4/2), nannofossil-rich mud layer that grades downward into laminated sandy mud. The latter occurs in Section 4 of Core 3, but it was not clear whether this turbidite includes the entire 4.0-meter-thick mud layer of Sections 2 and 3 as well as the upper half of Section 4 overlying the olive gray mud. In general, distinguishing turbidite muds from hemipelagic muds is difficult without the use of a specific X-radiography technique (e.g., Hesse, 1977), but in cores severely disturbed by drilling it may be impossible. Turbidite sands of Unit 1 are as badly affected by drilling disturbance as are the muds and rarely display primary sedimentary structures other than deformed laminations. Often the sand layers are broken into patches, swirls, and blobs (e.g., Core 6, Section 3). Even where grading was observed in thick, coarse, sand layers (e.g., Core 6, Section 4; Core 7, Section 4; Core 9, Section 1; Core 11, Section 1), it might have been produced by drilling, as shown by the graded drilling breccia recovered at Site 498 (Core 2, Section 1 and Core 4, Section 1). The maximum thickness of recovered turbidite sands in Hole 499 is 110 cm (e.g., Core 6, Section 4, Core 11, Section 1). The maximum grain size at the base of some of these layers is coarse sand. The sand to mud layer thickness ratio may not be meaningful for there is probably a minimum amount of sand recovered in Unit 1. Cores with no recovery (i.e., Cores 4 and 8 in Unit 1) may have been unconsolidated sand.

The sediment composing the trench fill includes a spectrum of microfossils and fossil fragments ranging from terrestrial plants (Cores 1–10) to shallow marine benthic foraminifers (Cores 1–5), echinoid spines, upper bathyal foraminifers (Cores 1–10), and lower bathyal abyssal foraminifers, which indicate redeposition (see the section on Biostratigraphy). Some of the redeposited muds, particularly lighter olive gray varieties, contain up to 30% calcareous nannofossils that must be allochthonous, because water depth of the trench floor is well below the calcite compensation level. The occurrence of limestone pebbles with lower Miocene nannofossils in the sand turbidite of Core 9, Section 1 also indicates redeposition of sediment from higher up on the slope.

Terrigenous volcanogenic sediment is abundant in the trench-fill sediment. The sand and silt-sized fractions are glass, feldspar, (quartz?), and a suite of heavy minerals (usually hypersthene, augite, epidote, titanium hornblende, etc.) that can be related to the Neogene volcanic rocks of Guatemala.

Paucity of bioturbation in the muds of Unit 1 as compared to Units 2 to 4 suggests that these may be dominantly turbiditic in origin.

In Cores 1 to 5 of Hole 499A (located about 1 km landward from Hole 499), a lithologic sequence nearly matches that of Hole 499. With better-quality cores, a layer-to-layer matching might have been achieved. The lack of substantially coarser sediments in Hole 499A suggests that the slight axial depression of the trench

Table 1. Coring summary for Holes 499, 499A, 499B, 499C, and 499D.

Core No.	Date (June, 1979)	Local Time (L)	Depth from Drill Floor (m; top-bottom)	Sub-bottom Depth (m; top-bottom)	Length Cored (m)	Length Recovered (m)	Recovery (%)
Hole 499							
1	12	1852	6126.5-6127.5	0.0-1.0	1.0	0.73	73
2	12	2041	6127.5-6137.0	1.0-10.5	9.5	9.99	100
3	12	2215	6137.0-6146.5	10.5-20.0	9.5	6.00	63
4	13	0353	6146.5-6156.0	20.0-29.5	9.5	0.0	0
5	13	0529	6156.0-6165.5	29.5-39.0	9.5	8.00	84
6	13	0706	6165.5-6175.0	39.0-48.5	9.5	5.84	61
7	13	0838	6175.0-6184.5	48.5-58.0	9.5	8.32	88
8	13	1020	6184.5-6194.0	58.0-67.5	9.5	0.0	0
9	13	1205	6194.0-6203.5	67.5-77.0	9.5	1.21	13
10	13	1406	6203.5-6213.0	77.0-86.5	9.5	6.08	64
11	13	1558	6213.0-6222.5	86.5-96.0	9.5	3.86	41
12	13	1741	6222.5-6232.0	96.0-105.5	9.5	3.70	39
13	13	1936	6232.0-6241.5	105.5-115.0	9.5	7.24	76
14	13	2132	6241.5-6251.0	115.0-124.5	9.5	3.87	41
15	13	2320	6251.0-6260.5	124.5-134.0	9.5	4.93	52
16	14	0101	6260.5-6270.0	134.0-143.5	9.5	0.45	5
17	14	0243	6270.0-6279.5	143.5-153.0	9.5	6.60	64
18	14	0415	6279.5-6289.0	153.0-162.5	9.5	8.74	92
19	14	0550	6289.0-6298.5	162.5-172.0	9.5	8.52	90
20	14	0731	6298.5-6308.0	172.0-181.5	9.5	0.0	0
21	14	0921	6308.0-6317.5	181.5-191.0	9.5	0.38	4
22	14	1110	6317.5-6327.0	191.0-200.5	9.5	9.31	98
23	14	1312	6327.0-6336.5	200.5-210.0	9.5	5.68	60
24	14	1459	6336.5-6346.0	210.0-219.5	9.5	4.62	49
25	14	1657	6346.0-6355.5	219.5-229.0	9.5	4.92	52
Hole 499A							
1	15	0047	6132.0-6137.0	0.0-5.0	5.0	2.92	58
2	15	0238	6137.0-6146.5	5.0-14.5	9.5	2.83	30
3	15	0417	6146.5-6156.0	14.5-24.0	9.5	5.35	56
4	15	0552	6156.0-6165.5	24.0-33.5	9.5	0.0	0
5	15	0719	6165.5-6175.0	33.5-43.0	9.5	1.49	16
Hole 499B							
1	16	1653	6327.0-6337.0	201.0-210.5	9.5	0.14	1
2	16	1830	6337.0-6346.5	210.5-220.0	9.5	2.30	24
3	16	2017	6346.5-6356.0	220.0-229.5	9.5	6.91	73
4	16	2206	6356.0-6365.5	229.5-239.0	9.5	4.25	45
5	16	2354	5365.5-6375.0	239.0-248.5	9.5	0.30	3
6	17	0132	6375.0-6384.5	248.5-258.0	9.5	1.22	13
7	17	0332	6384.5-6394.0	258.0-267.5	9.5	0.05	>1
8	17	0516	6394.0-6403.5	267.5-277.0	9.5	5.23	55
9	17	0802	6403.5-6412.0	277.0-285.5	8.5	0.55	6
10	17	0930	6412.0-6413.0	285.5-286.5	1.0	0.40	40
Hole 499C							
1	17	2132	6372.0-6375.0	260.0-263.0	3.0	0.30	10
Hole 499D							
1	24	0115	6338.5-6342.0	212.5-216.0	3.5	1.0	28

floor at Hole 499A (6 m deeper than marginal portions) does not represent a channel. Currents in a channel might have differentiated coarse channel-fill and finer spill-over facies on a levee. Because the trench floor is relatively narrow at this locality, it may serve as a "channel" itself, the entire width representing a channel floor without discernible levees.

Unit 2 (Hole 499, Core 14, Section 2, 42 cm to Core 23, Section 1, 30 cm, 117.0–201.0 m sub-bottom depth; lower Pleistocene to upper Pliocene)

Turbidite deposition disappears abruptly in Hole 499 below Core 14, Section 2, 42 cm, suggesting that the boundary between the trench fill (Unit 1) and the underlying sediments is sharp. The latter comprise an 84.0-meter-thick sequence of hemipelagic dark olive gray (5Y 3/2 to rarely 5Y 2/1) or dark greenish gray (5GY 4/1) diatomaceous mud. Volcanic glass is abundant. In Core 18, a fibrous authigenic carbonate produces a lighter-colored calcareous mud. The absence of biogenic $CaCo_3$ in the lower half of Unit 2 is noteworthy. Bioturbation is the outstanding structural feature of these sediments.

The occurrence of basalt cobbles at the top of Core 15 might be related to the occurrence of a fault scarp exposing basalt at the time when the oceanic crust approached the trench region.

Unit 3 (Hole 499, Core 23, Section 1, 30–83 cm, 201.0–201.5 m sub-bottom depth; lower Pliocene to upper Miocene)

Unit 3 consists of only 50 cm of the bioturbated, siliceous mud resembling that encountered in Unit 2 except for the addition of dark reddish gray colors (10R 3/1) occurring as bioturbated laminae, patches, or lumps. This thin unit covers a time span of 12 m.y., signaling extremely low sedimentation rates. The unit probably corresponds to the brown abyssal clay found in Unit 2 of Site 495.

Unit 4 (Hole 499, Core 23, Section 1, lower half, to Core 25, 201.5–229.0 m sub-bottom depth; Hole 499B, Cores 1 to 8, Section 3, 201.0–272.0 m sub-bottom depth; upper Miocene)

Nannofossil ooze and chalk of Unit 4 follow and are in sharp contact with Unit 3. The contact is well displayed in Hole 499, Core 23, Section 1 by the pronounced color contrast between the dark sediments of Unit 3 and the light-colored calcareous sediments of Unit 4. The

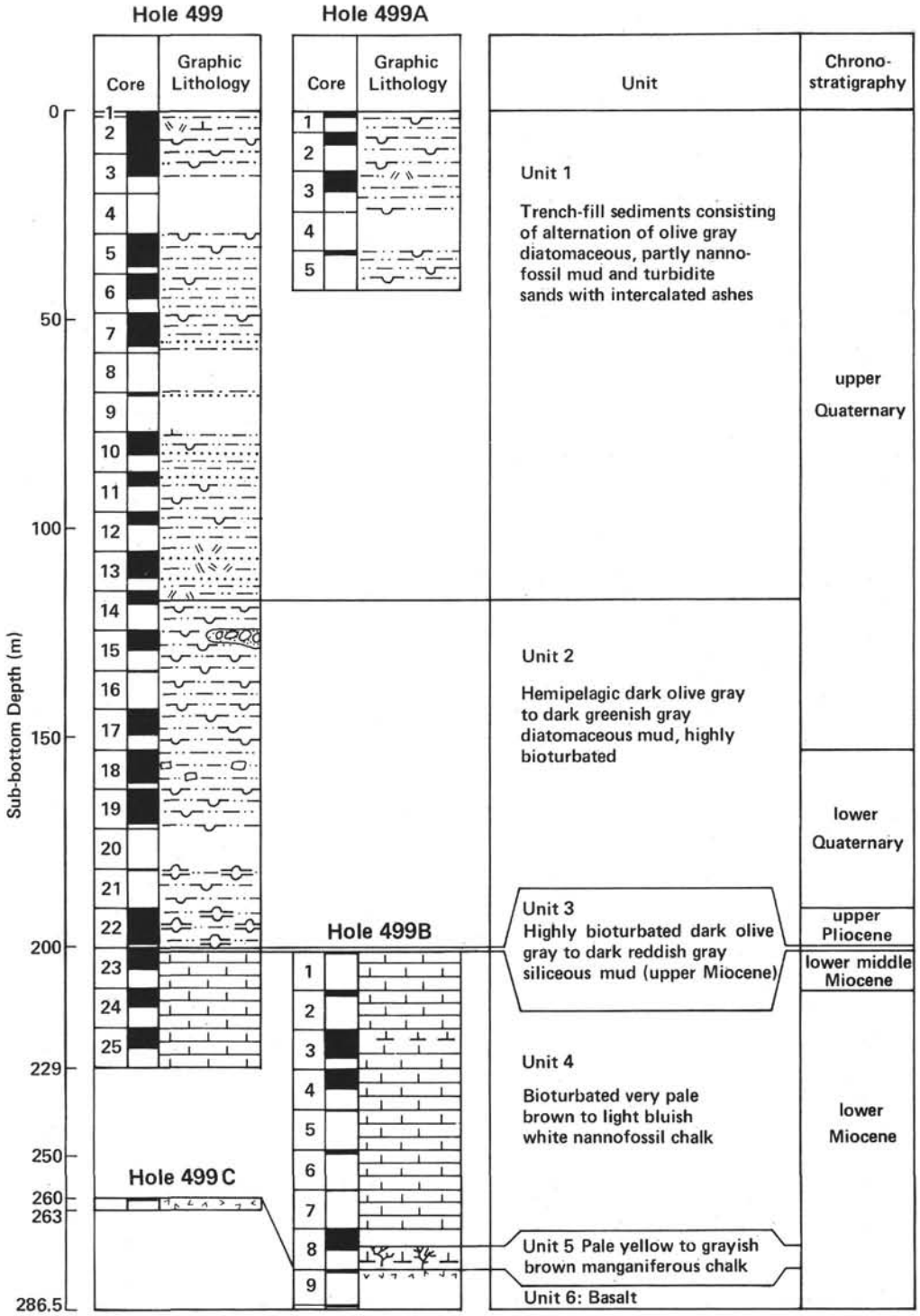


Figure 3. Summary lithologic column for Site 499. (Symbols follow DSDP format.)

boundary was also encountered in the core catcher of Core 1, Hole 499B, although there the sediment was disturbed by drilling. Colors in the nannofossil and foraminiferal chalk vary from very pale brown (10YR 7/3), brownish white (10YR 8/4), light brownish gray (10YR 6/2) to very light orange (10YR 8/3) or pinkish white (5YR 8/2) at the top (Cores 1 to 3, Hole 499B), to a dominant light bluish white (5B 8/1) in Cores 4 to 6. Starting with Core 7 light yellow white (5Y 8/1) colors reappear, which in Core 8 change to brownish hues. Thus the downhole color variation in the pelagic chalks of Holes 499 and 499B is very similar to the one observed in the upper and lower sub-units of Unit 3, Site 495. No radiolarians were found below Core 7, Hole

499B. The chalk at Site 499 is 70.0 meters thick, less than a third as thick as the 235 meters at Site 495. All sediments of Unit 4 are highly bioturbated.

Unit 5 (Hole 499B, Core 8, Section 3, 100 cm, to Core 9, 272.0–280.0 m sub-bottom depth; lower Miocene)

Six meters of pale yellow (5Y 8/3) and white (2.5Y 8/2) to grayish brown (10YR 5/2) manganiferous chalk compose Unit 5. Manganese minerals occur in the form of dark dendrites. The sediment is highly bioturbated.

Unit 6 consists of basalt (see the following section on Igneous Petrology).

Igneous Petrology

One fragment of basalt was recovered in the core catcher of Core 9 (Hole 499B), and both Core 10 from Hole 499B and Core 1 from Hole 499C contained several pieces of basalt. Most pieces are dark gray, medium-grained, phyric basalt containing up to 20% dark gray to yellow white clusters of plagioclase phenocrysts up to 5 mm in diameter. A few pieces contain 5% or less of 1- to 3-mm olivine(?) phenocrysts that have been completely altered to a soft, dark brown clay. Several pieces in Core 1 (499C) have color variations suggestive of weathered exteriors. Pieces 7 and 8 in this core are subrounded and smooth and have yellowish gray exteriors. Well-developed weathering rinds enclose darker gray cores. These pieces are aphyric and aphanitic and contain abundant disseminated pyrite grains.

Six thin sections from these cores were studied. The basalts typically have subophitic to intergranular, diabasic textures, and the groundmass consists of about 25% to 30% colorless to very pale brown clinopyroxene augite and 70% zoned plagioclase laths averaging 0.5 mm in length. Samples are coarser-grained and distinctly more porphyritic than those recovered at Site 495. Plagioclase phenocrysts up to 2 mm long are generally clustered and display oscillatory zoning. Piece 8 in Core 1 (499C) is finer grained and has intergranular texture; plagioclase microlites are 0.1 to 0.2 mm long.

The alteration mineralogy is unusual for oceanic ridge basalts in general. Each sample studied petrographically contains fine-grained, fibrous to prismatic, pale green amphibole tentatively identified as actinolite. The amphibole has partially replaced clinopyroxene, but in all but one thin section it is distributed in patches or localized in tiny veinlets. In Piece 1 of Core 1 (499C), nearly all of the augite has been replaced. Some preliminary optical data were obtained: $2V(-) > 70°$; positive elongation; $z \wedge c$ averages 16° but some extinction angles as large as 21° were noted; pleochroism Z = green, X = very pale green, Y = very pale yellowish green. Several sections also contain a very pale green, limpid intersertal mineral with low birefringence tentatively interpreted to be chlorite. All sections contain murky, greenish brown intersertal clay, which might have replaced clinopyroxene or possibly primary glass. Very rare relict olivine phenocrysts are totally replaced by brown clay and also, in Piece 6 in Core 10 (499B), by very fine-grained aggregates of a highly birefringent mineral that may be talc. Small disseminated pyrite grains constitute 2% to 5% of all samples studied. Neither chlorite nor actinolite were noted in basalts from Site 495, which instead contain clay minerals, zeolite, and calcite.

The actinolite and chlorite(?) in these samples are evidence of a high-temperature, probably hydrothermal, alteration that was induced at or near a spreading center. "Hydrothermal" actinolite was also noted in some basalts recovered on Leg 65 in the Gulf of California. Most oceanic basalts, however, are characterized by the alteration mineralogy encountered at Site 495, which forms during cold seawater–rock interactions. Samples from Site 499 also show the effects of submarine weathering, and even though their primary mineralogy is typical of oceanic basalts and diabases, the fragments might have accumulated in talus originating from submarine scarps exposing basaltic crust.

PHYSICAL PROPERTIES

Bulk Density and Water Content

Both parameters are sensitive to lithologic variation at Site 499. Three distinctly different units can be seen (Fig. 4A).

Unit 1 extends from the mud line down to 140 meters. Bulk density increases gradually through the first 50 meters to about 1.55 Mg/m^3 and shows considerable variability, perhaps attributable to alternating coarse- and fine-grained turbidite sediments. Water content decreases as expected to 90 meters and remains essentially constant at 80% to 140 meters.

Unit 2 extends from 140 meters down to 225 meters. Bulk density remains unusually constant at about 1.48 Mg/m^3. On the other hand, water content increases to values in excess of 100% (dry weight) and shows considerable variability. Intermittent lenses and layers of volcanic ash, interbedded with siliceous hemipelagic oozes occur through this unit and give it its water-rich character. Toward the base of the unit, bulk density increases significantly with the addition of a highly siliceous component.

Unit 3. Sampling above and below the contact with the white calcareous nannofossil chalk indicates sharp differences in water content (130% vs. 75%) and bulk density (from 1.47 Mg/m^3 vs. 1.70 Mg/m^3).

Figure 4B shows bulk density and water content for Hole 499A. They correspond with the values for Unit 1 (Hole 499), as expected.

Figure 4C shows bulk density and water content for Hole 499B. Cores 2 and 3 have bulk densities and water contents similar to Unit 3 of Hole 499 (Figs. 4A and 3) and characterize the physical properties of the Miocene chalk. There is a general increase in bulk density and decrease in water content approaching the basalt.

Compressional-Wave Velocity

Hole 499B

Figure 5 shows the compressional-wave velocity profile with depth in the Miocene chalks of Hole 499B. Velocities varied between 1.58 to 1.84 km/s, increasing to

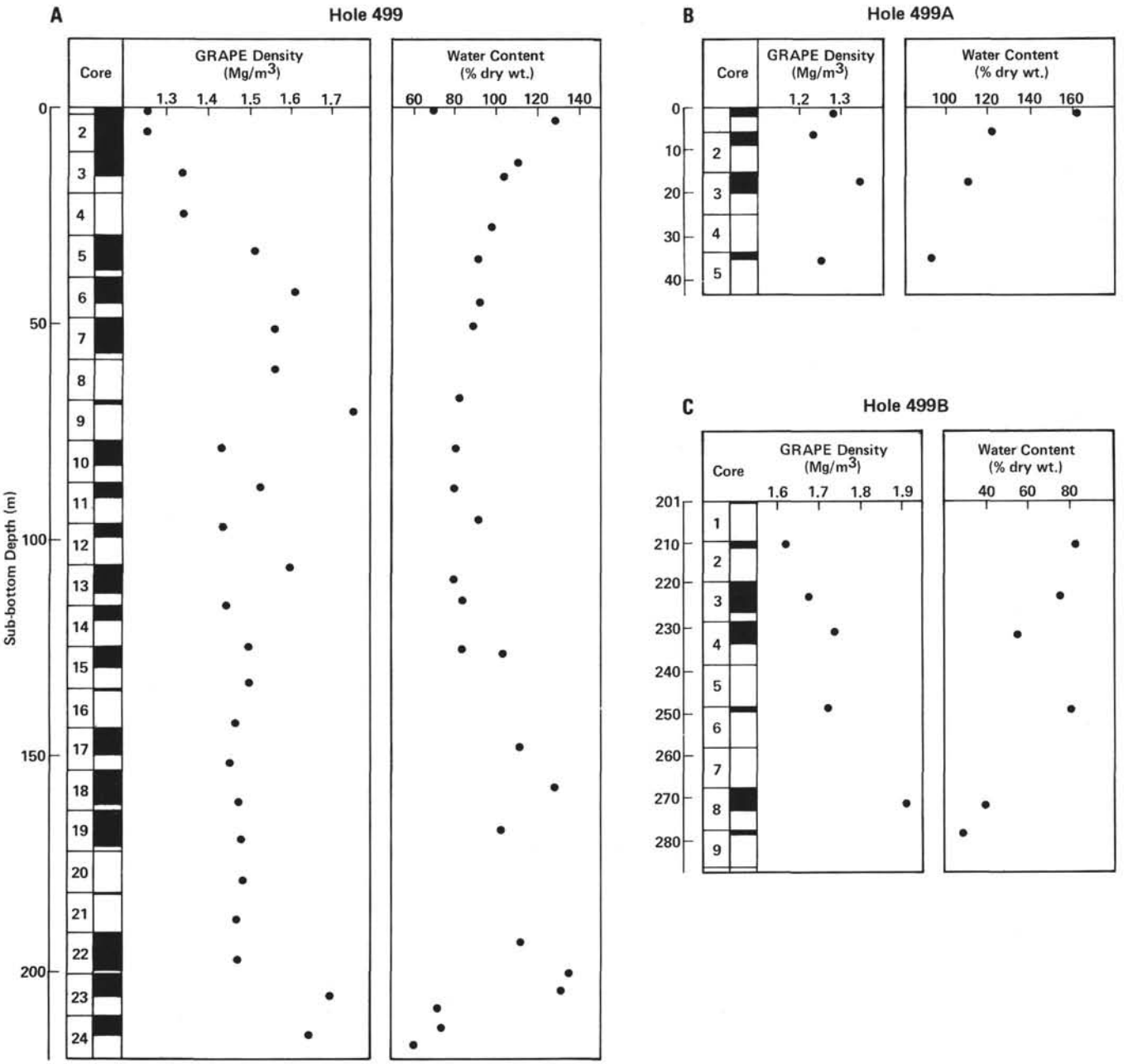


Figure 4. A–C Physical properties for Site 499.

the maximum in Core 8. The maximum velocity recorded (5.97 km/s) was measured on a basalt cobble from the base of the Core 9 core catcher (not plotted).

Determination of the velocity of the Quaternary sediments at Site 499 was unsuccessful.

Shear Strength

Hole 499

Shear strength remains low from the mud line down to 110 meters (Core 12), increasing to about 35 kPa (core average) to the base of the section (Fig. 6). Two distinct sedimentary units are thus outlined. (The shear strength measured at Core 12 represents a single measurement in a turbidite unit. If this measurement is disregarded, the strength profile would show a gradual increase to a maximum value at 140 meters [Core 15], corresponding to the break between Unit 1 and Unit 2 of Fig. 3.) Table 2 summarizes the physical properties for Holes 499, 499A, and 499B.

GEOPHYSICS

Site 499 is located on the floor of the Middle America Trench along seismic lines GUA-13 and 18. At Site 499 the trench fill and underlying ocean basin section were penetrated (Fig. 7). The seismic reflections of the trench fill are obscured by diffractions in the low-frequency multichannel records (Fig. 8). Figure 9 is a seismic record obtained by the *Challenger;* in it two reflective sequences can be seen, a shallower sequence with a gentle

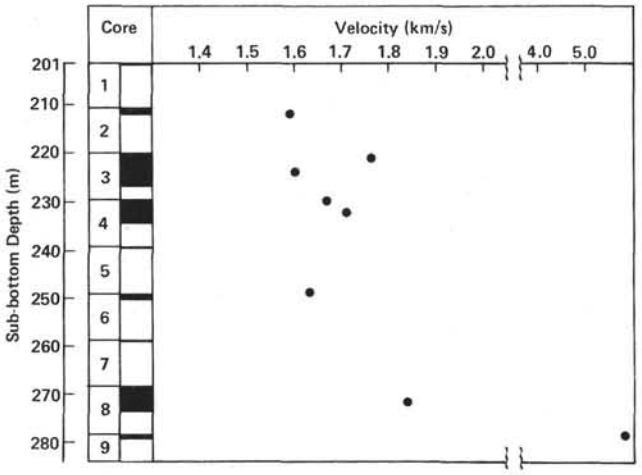


Figure 5. Compressional-wave velocity profile at Hole 499B.

landward dip and a deeper sequence with a steeper landward dip. Because of the 0.17-s bubble pulse, it is difficult to define precisely the interface between the two sequences. But an interface at 0.15 s sub-bottom would correlate well with the base of the turbidites recovered at 113 meters if a velocity of 1500 m/s is used to convert time to depth.

Figures 10 and 11 are 3.5-kHz records recorded by the *Challenger* that show details of the upper 50 meters of section cored at Site 499. Figure 10 shows the relative positions of the four holes drilled at the site. Three of them were drilled on the seaward side of the trench floor where the surficial layers dip gently landward. Hole 499A was drilled in an apparent channel in the axis of the trench. Figure 10 suggests thinning of the trench fill seaward and gentle deformation with depth. The latter is evidenced by gentle folding of a reflection just below the base of Hole 499A. This reflection rises seaward through a series of monoclinal steps. The turbidite sands recovered at Site 499 came from depths below the reflections seen on the 3.5-kHz records.

On Figure 11 the surficial sediments appear to cover and terminate against some deeper mounds that have no internal reflections. This record was made when the beacon was dropped for Site 499. The contrast between the well-bedded reflectors in the upper 20 to 50 meters and the deeper reflectorless zone would suggest a lithic contrast. However, no pronounced change in lithology was observed at that level.

On Figure 11 there are local regions where reflections pass laterally into zones in which reflection amplitudes are reduced (e.g., at 0920Z, Point A). In shallow water on the shelf in the Gulf of Mexico such white-out zones are associated with gas pockets. Possibly a similar explanation is valid here.

BIOSTRATIGRAPHY

Deposits from the Quaternary to the lower Miocene were recovered in Holes 499, 499A, and 499B (Fig. 12). Cores from Holes 499C and 499D contain only weathered basalt.

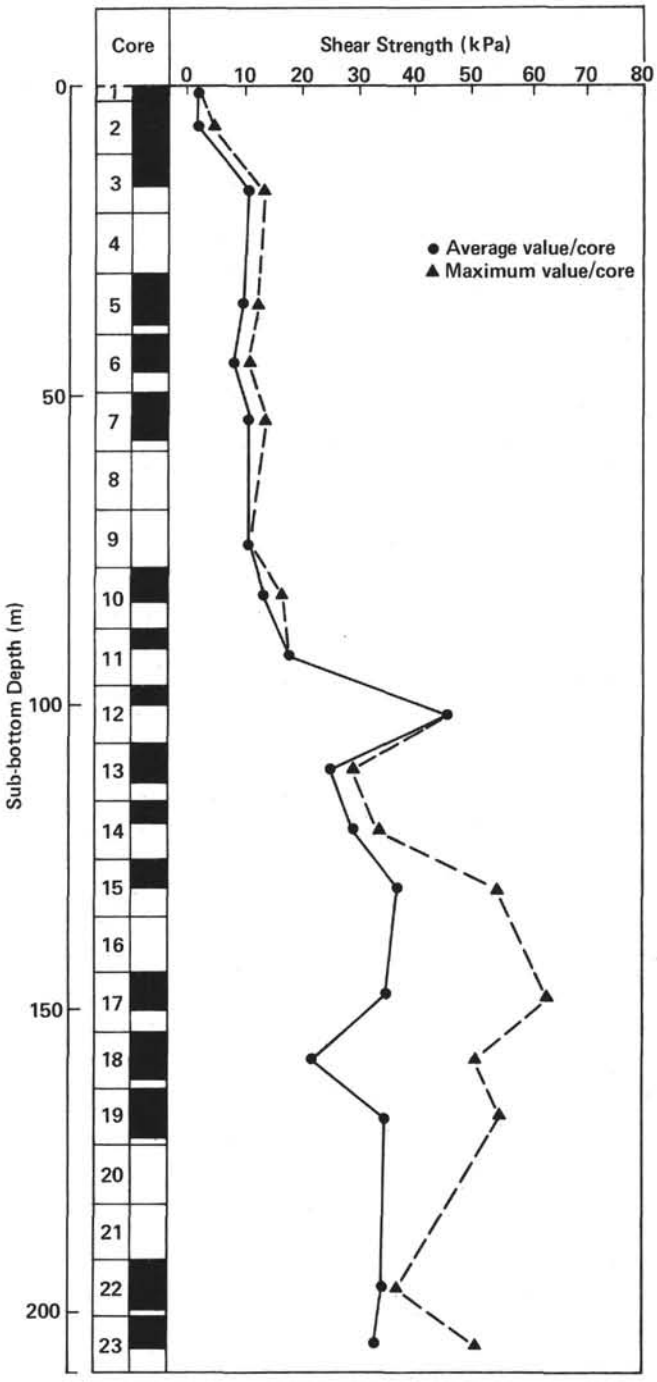


Figure 6. Shear strength profile at Hole 499.

The section begins with Holocene–upper Pleistocene turbidites about 120-meters thick. (Cores 1–13 of Hole 499, Cores 1–5 of Hole 499B). Benthic foraminifers found in these cores consist of three different bathymetric range groups: (1) shelf, (2) upper bathyal, and (3) lower bathyal. Reworked Miocene nannofossils and radiolarians are present in this interval. Microfossils indicate transport to the trench axis.

Below turbidites at Hole 499, nannofossils of the *Discoaster brouweri* Zone (Core 22) and radiolarians (Cores 21 and 22) date the sediment as late Pliocene. Accumu-

Table 2. Physical properties, Site 499.

Sample (core-section, interval in cm)	GRAPE Wet-Bulk Density (Mg/m^3)	*P*-Wave Velocity (km/s)	Acoustic Impedance ($\times 10^5$ $g/cm^2 \cdot s$)	Shear Strength (kPa)	Water Content (% dry wt.)	Porosity (vol. %)
Hole 499						
1-1, 138-140	—	—	—	2.29	69.90	63.92
2-4, 80-82	1.24	—	—	2.48	128.04	76.39
3-1, 133-136	1.35	—	—	10.43	115.90	74.62
5-1, 90-92	1.50	—	—	9.76	97.94	71.23
5-5, 130-132	—	—	—	11.68	90.98	69.58
6-4, 28-30	1.63	—	—	8.61	93.08	70.12
7-2, 70-72	—	—	—	9.76	89.05	69.15
9-1, 12-14	1.70	—	—	10.53	82.64	67.72
10-2, 128-130	1.52	—	—	16.85	81.23	67.22
11-3, 108-110	1.58	—	—	17.23	81.42	67.22
12-3, 130-132	—	—	—	45.96	93.93	70.34
13-4, 95-97	—	—	—	21.07	80.33	66.91
13-7, 38-40	—	—	—	28.73	—	—
14-3, 18-20	—	—	—	34.47	83.60	67.84
15-2, 140-142	—	—	—	18.38	102.60	72.33
15-4, 60-62	—	—	—	55.54	—	—
17-1, 100-101	1.51	—	—	28.72	—	—
17-3, 63-65	1.44	—	—	12.45	110.66	73.69
17-5, 29-31	—	—	—	64.15	—	—
18-2, 60-62	1.48	—	—	4.78	—	—
18-4, 60-62	—	—	—	9.57	128.60	76.50
18-6, 50-52	—	—	—	50.75	—	—
19-2, 27-29	1.50	—	—	10.53	—	—
19-4, 70-72	1.50	—	—	44.04	102.80	72.30
19-6, 50-52	—	—	—	55.54	—	—
22-1, 134-136	—	—	—	35.43	112.60	74.00
22-3, 134-136	—	—	—	34.47	—	—
22-5, 134-136	1.45	—	—	34.47	135.10	77.30
23-1, 58-60	—	—	—	22.98	131.00	76.70
23-1, 100-102	—	—	—	23.94	72.40	64.60
23-1, 140-142	—	—	—	19.15	131.00	76.70
23-2, 140-142	1.76	—	—	51.71	65.20	62.20
23-3, 138-140	1.65	—	—	47.88	74.80	65.30
24-1, 148-150	1.62	—	—	—	59.90	60.30
Hole 499A						
1-1, 50-52	—	—	—	6.70	160.1	80.2
1-3, 110-112	—	—	—	7.85	—	—
2-1, 100-102	—	—	—	6.12	—	—
2-2, 58-60	—	—	—	7.66	121.7	75.4
3-1, 60-62	—	—	—	11.68	—	—
3-4, 70-72	—	—	—	11.87	111.1	73.7
5-1, 110-112	—	—	—	7.27	93.6	70.2
Hole 499B						
2-1, 97-100	1.62	1.584	2.56	—	80.7	67.1
3-1, 53-55	—	1.765	—	—	—	—
3-3, 58-62	1.66	1.596	2.65	—	75.1	65.5
4-1, 125-127	1.76	1.677	2.95	—	54.0	57.7
6-1, 20-22	1.68	1.627	2.73	—	80.3	67.0
8-3, 63-65	1.86	1.865	3.47	—	39.2	49.9
9CC, 20-22	—	—	—	—	29.7	42.8

lation rates for this and subsequent intervals are indicated in Fig. 13.

A sharp contact between green mud and white chalk occurs in 499-23-1, 83 cm and in Core 1 of Hole 499B. Upper Miocene radiolarians co-occur with foraminifers representative of lower bathyal depth range.

The chalk part of Cores 499-23 and 499B-1 flank the lower to middle Miocene boundary. Below this level a continuous sequence of the lower Miocene chalk deposits with nannofossils, foraminifers, and radiolarians are recorded in Cores 499-24 and -25 and in Cores 499B-2 through -9. The formation of this deposit took place at a depth below the lysocline, because assemblages of foraminifers and nannofossils contain only dissolution-resistant species.

Foraminifers

Four lithofacies with distinctive suites of foraminifers were recovered from DSDP Site 499: a Quaternary turbidite trench fill derived from the continental slope, an upper Pliocene to lower Quaternary hemipelagic sequence, a carbonate-poor siliceous interval ranging from middle Miocene to lower Pliocene, and a carbonate-rich sequence of lower Miocene chalks resting on basalt.

The upper Quaternary turbidites (Hole 499, Cores 1-13; Hole 499A, Cores 1-5) contain foraminiferal assemblages varying in abundance from barren to very numerous and in preservation from highly dissolved to very fresh; often these turbidites include reworked older tests. Size sorting, and possibly shape sorting, are apparent. Typical age-diagnostic plankton taxa include *Neogloboquadrina eggeri, Globorotalia fimbriata*, and right-coiling *Pulleniatina*. Benthic taxa *Elphidium, Cribroelphidium, Textularia*, and *Ammonia* indicate downslope transport from depths less than 200 meters, *Angulogerina, Miliolina, Bolivina*, and *Spiroloculina* from upper bathyal depths less than 1500 meters, and *Pullenia, Uvigerina senticosa*, and *Melonis* from lower bathyal depths greater than 1500 meters.

No Pliocene, upper Miocene, or middle Miocene planktonic foraminifers were noted, except in reworked clasts, where they are stained by limonite(?). Lower bathyal or abyssal benthic foraminifers including *Martinottiella* and *Cyclammina* were found in the carbonate-poor interval in Samples 499-23-1, 75 cm and 499B-1-1, 9-11 cm. Those mottled siliceous units are possibly correlative to the brown clay at Site 495, Cores 16 through 19.

The lower Miocene chalks in Samples 499-23-1, 90 cm through 499-25,CC and in Hole 499B, Cores 2 through 9,CC are divided into two subgroups on the basis of carbonate preservation: The amber-colored chalks contain a large number of foraminiferal test fragments, few small individuals, and great quantities of dissolution-resistant materials such as radiolarians, echinoid spines, and fish teeth; the gray green to gray blue chalks, in contrast, have much higher species diversity, small-sized taxa, and fewer dissolution-resistant objects. Foraminiferal Zones N7 through N4 are present. The N7/N6 boundary is placed between Cores 3 and 4 in Hole 499B on the basis of the extinction of *Catapsydrax dissimilis*. The N6/N5 boundary based on the first appearance of *Globigerinatella insueta* and the N5/N4 boundary based on the extinction of *Globorotalia kugleri* could not be accurately located because of dissolution. Cores 8 and 9 in Hole 499B are in the upper part of Zone N4.

Radiolarians

Radiolarians from the lower Miocene to the Quaternary were recovered in cores from Site 499. Generally assemblages are diverse and moderately well preserved, but in the upper part, Cores 499-1 through -13 and 499A-1 through -5, they are diluted with terrigenous mud.

The usual Quaternary assemblage, found in all the sites of Leg 67, dominates the first 19 cores of Hole 499 and Cores 1 through 5 of Hole 499A. Substantial numbers of Miocene species were reworked in the samples examined from Hole 499—Cores 2, 3, 5, 6, 10, 12, 14, and 17. *Axoprunum angelinum*, first noted in Sample

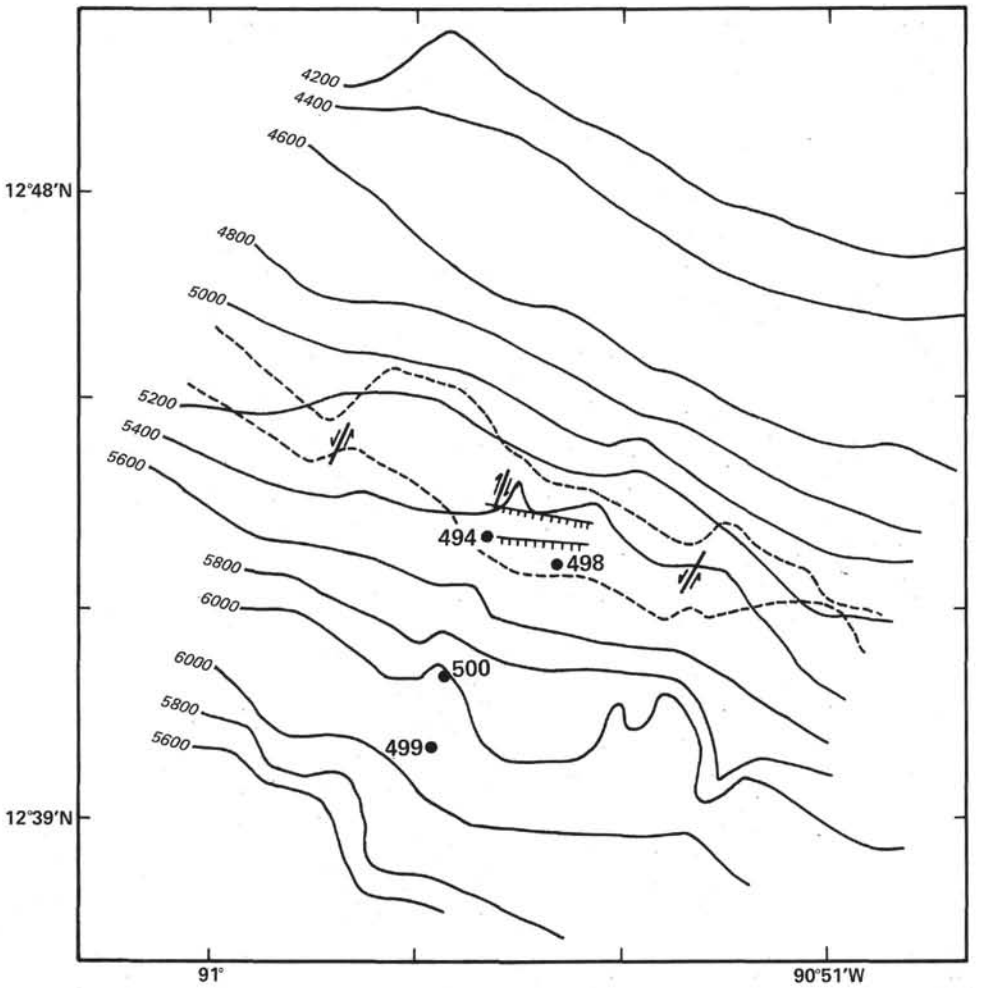


Figure 7. Bathymetry of the Middle America Trench axis off Guatemala.

499-15-3, 102–103 cm, indicates an age greater than 0.4 m.y. *Anthocyrtidium angulare* was found in very small numbers in samples from Cores 499-18 and -19, indicating the lowermost Quaternary.

The Pliocene/Pleistocene boundary cannot be determined with confidence on the basis of radiolarian evidence because of the absence of the marker species *Pterocanium prismatium* and the low numbers of *Lamprocyrtis heteroporos, L. neoheteroporos, Theocorythium vetulum*, and *T. trachelium*. However, *Anthocyrtidium angulare* occurs in Cores 18 and 19, and the lower boundary of that zone is therefore tentatively drawn between Samples 499-19-3, 110–112 cm and 499-19-6, 10–12 cm.

Core 499-23 shows a sharp contact between siliceous biogenic mud and nannofossil ooze at 83 cm. Three samples above the contact, at 20 to 22 cm, 40 to 42 cm, and 69 to 71 cm, are all from the upper Miocene *Didymocyrtis antepenultima* Zone. These samples span a period from about 10 to 8 Ma. The evolution of *D. laticonus* to *D. antepenultima* to *D. penultima* is easily seen in the relative abundances of those species. The extinction of *Diartus pettersoni* and increasing numbers of *Stichocorys peregrina* are also evident in this interval. Below the contact, at Sample 499-23-1, 102–104 cm and Sample 499-23,CC (10–12 cm), radiolarians are from the middle Miocene *Dorcadospyris alata* Zone of about 15 m.y. in age.

Sample 499-24-1, 16–18 cm contains a typical assemblage from the lower Miocene *Calocycletta costata* Zone. Smaller numbers of *C. costata* and *L. stauropora* in the next sample, 499-24-3, 84–86 cm, indicate the lowest part of that zone at about 17 Ma.

The deepest sample examined from Hole 499, Sample 499-25-4, 102–104 cm, is considered to be from the *S. wolffii* Zone (~19 m.y. old) because of the absence of *C. costata* and presence of *Lychnocanoma elongata*.

Hole 499B was washed to 201 meters, the level of Core 499-23. The core catcher of the first core showed three lithologies. A light colored, coarse layer contains a mixed assemblage of about 25% upper Miocene *D. antepenultima* Zone, and about 75% middle Miocene *D. alata* Zone. A sample from the dark green gray mud at 9 to 11 meters contained a good assemblage from *D. antepenultima* Zone, with a very small number of middle or lower Miocene species. The light nannofossil ooze at the bottom contains an assemblage from the *D. alata* Zone.

Sections 499B-2-1 and 499B-3-1 are assigned to the *C.*

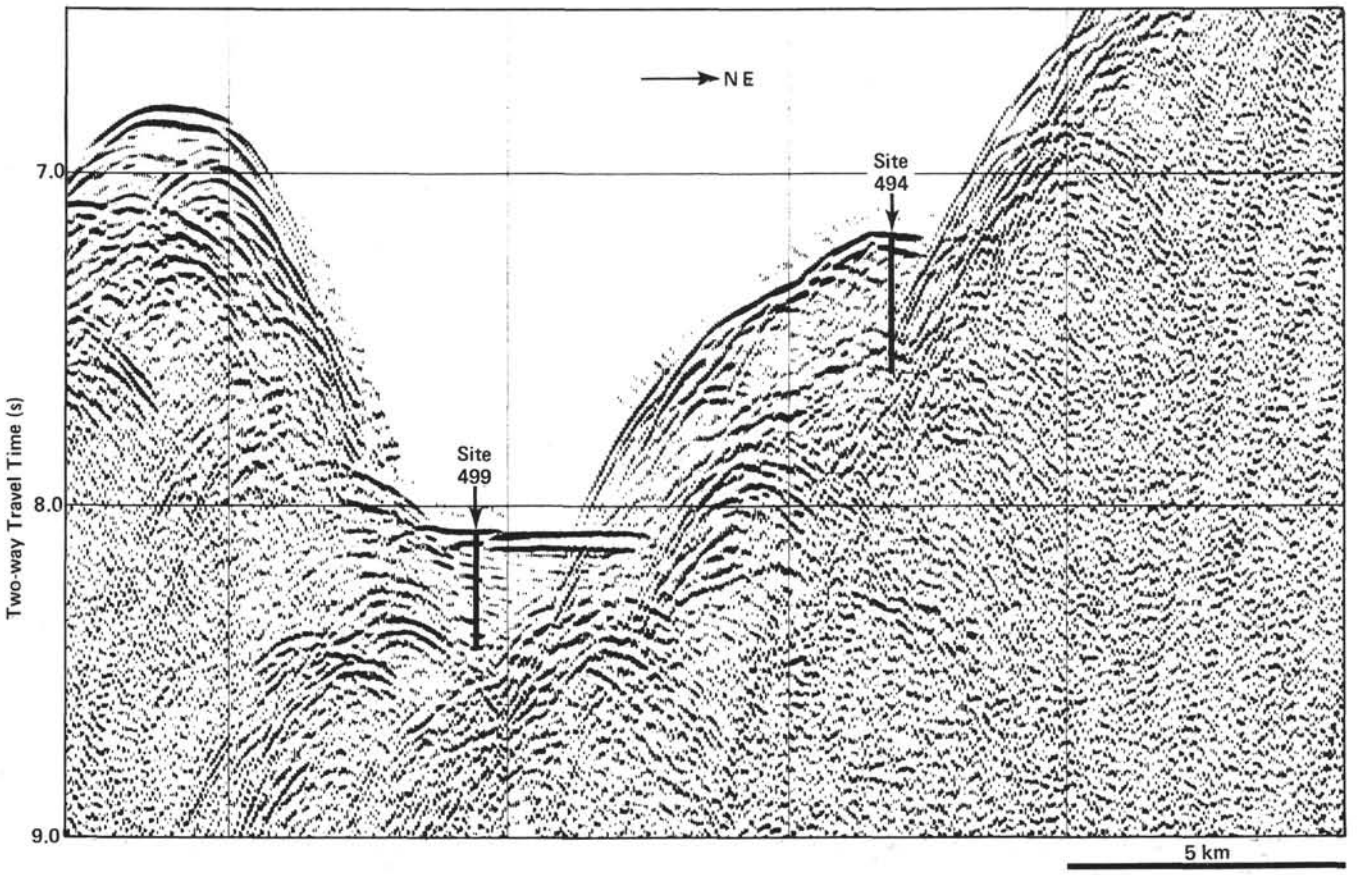


Figure 8. Low-frequency seismic-reflection profile GUA-13 recorded across the Middle America Trench axis.

costata Zone (16–17 m.y. old) because of the presence of *Dorcadospyris dentata, Eucyrtidium diaphanes*, and greater numbers of *Liriospyris stauropora* than its descendent, *L. parkerae*.

In Section 499B-3-4, the absence of *C. costata, D. dentata*, and *L. stauropora*, the presence of *L. elongata*, and the abundance of *S. wolffii* indicate the lower Miocene *S. wolffii* Zone (~19 m.y. old).

Hole 499B, Core 4, is evidently below the first appearance of *S. wolffii*, and contains greater numbers of *D. tubarius* than *D. violina*, indicating *S. delmontensis* Zone (about 19.5–21.5 m.y. old). Core 6 also contains an assemblage from this lower Miocene zone. No samples from Cores 5 or 7 were examined, and Cores 8 and 9 were barren of radiolarians. This termination of radiolarian assemblages in the *S. delmontensis* Zone, followed by a barren interval and then basalt, corresponds to the oceanic reference Site 495.

Nannoplankton

Turbidites of Cores 499-1 to 499-13 contain nannoplankton assemblages of *Emiliania huxleyi/Gephyrocapsa oceanica* Zones. Nannoplankton are rare to common, and their preservation is good. Core 9 includes a sandy layer, consisting of fragments of white chalk with a rich assemblage of the middle Miocene *Sphenolithus heteromorphus* Zone. Nannoplankton are rare in the muddy members of the section from Core 499-10 to Sample 499-22-2, 60–62 cm, and they are of the lower Pleistocene *Crenalithus doronicoides* Zone.

Core 499-22 mud corresponds with the upper Pliocene *Discoaster brouweri* Zone. Nannoplankton are rare to few.

The contact between siliceous biogenic muds and chalks is in Core 23. Nannoplankton were not found in muds of this core. Chalk of Cores 499-23 to 499-24 and of Cores 499B-1 to 499B-2 contain the lower Miocene *Sphenolithus heteromorphus* Zone assemblage with index species *D. exilis, D. deflandrei, D. signus*, and some others.

Cores 499-24 and 499-25 and Core 499B-3 correspond to the lower Miocene *Helicopontosphaera ampliaperta* Zone. Nannoplankton assemblages of *D. druggii* and *D. deflandrei* Subzones and *Triquetrorhabdulus carinatus* Zone were found in Core 499B-4 to Sample 499B-9,CC. The assemblage of this zone is distinguished from the subzones just mentioned by the presence of *T. carinatus*. The presence of *D. druggii* is characteristic of the upper subzone of the zone.

GEOCHEMISTRY

Organic Geochemistry

The hydrocarbon-monitoring program used at pre-

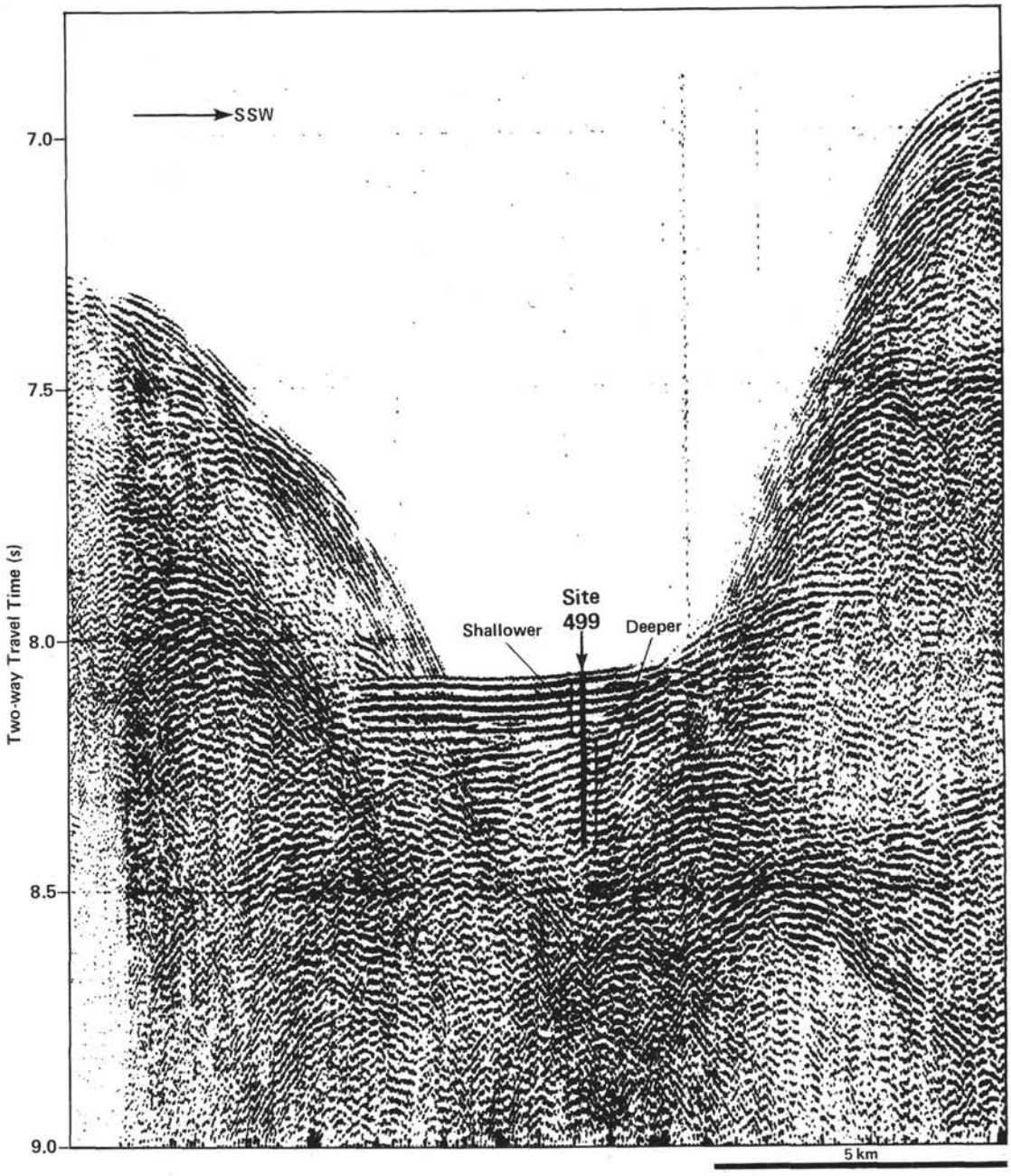


Figure 9. Seismic-reflection profile showing two reflective sequences (a shallower one and a deeper one) within the Middle America Trench axis.

vious Leg 67 sites was continued at Site 499. The methane/ethane ratios for Site 499 samples are shown in Figure 14. Ratio values for the upper one-half of the cores are greater than 100,000. In the lower portion of the penetrated section, there were three values less than 100,000 (38,900 at 100 m, 93,00 at 117 m, and 99,000 at 118 m). Below 150 meters, methane was less than 10% of the total gas sampled, and there were no indications of higher molecular-weight components. Thus detailed analyses on the Hewlett-Packard gas chromatograph were not made regularly. Figure 15 shows details of the methane and ethane distribution in Site 499 samples. Methane averaged about 65% to 75% (of total gas sampled and analyzed), except where poor core recovery resulted in unreliable sampling. Ethane was present only in trace quantities (maximum of 21 ppm) throughout the penetrated section.

The uppermost sediments at Site 499 are turbidites. The gaseous components present represent the original quantities minus that portion lost while the turbidite was emplaced. If the turbidite moved down the continental slope to the present trench site as a highly agitated and fluidized mass of water and sediment, it might be expected that a considerable portion of the initial gas content would have been lost in transit. By comparison, if sediment from the continental slope was transported

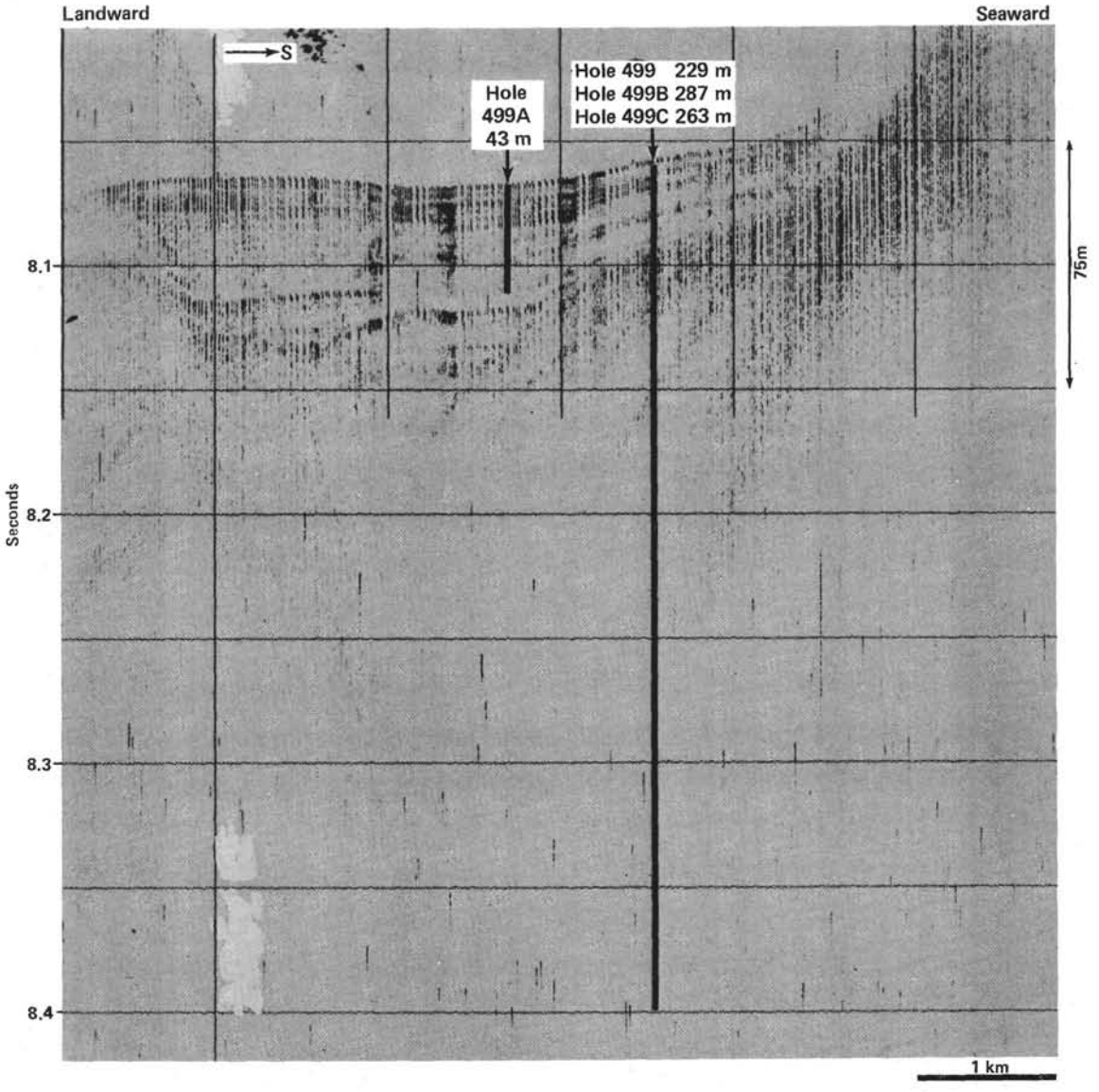


Figure 10. Details of the uppermost 50 meters of section cored at Site 499 are shown in this 3.5-kHz seismic-reflection profile.

as a relatively intact body, then a major portion of the original gas content might well have been preserved (except near the surface that underwent movement). The ethane content of previous Leg 67 slope sites was as much as several hundred ppm; thus the sediment transported downslope to Site 499 either must have had considerably lower initial ethane concentrations than Sites 496 or 497 or it must have lost most of the ethane and heavier components during transport. Methane content at Site 499 was about the same as that encountered at Sites 496 and 497. If the gas concentrations are similar everywhere on the Guatemalan slope, perhaps mechanism loss during transport is responsible for the low gas content of Site 499. The processes that resulted in significantly lower ethane concentrations at Site 499 would have affected methane in the same manner. Under these conditions, the methane found at Site 499 must be attributed to microbial processes and must have been generated after emplacement of the turbidite deposits.

Inorganic Geochemistry

Data from the shipboard interstitial water program are presented in Figure 16. Chlorinity and *p*H are fairly constant throughout the penetrated interval. Salinity, alkalinity, and magnesium have similar patterns; all three parameters have two maxima (at 9 and 120 m) and two minima at (46 and 223 m). These patterns are unusual and are undoubtedly affected by turbidite sedimentation. Calcium concentrations appear to be inversely related to those of magnesium. The calcium maximum occurs at about 55 meters, and this same point marks the minimum value for magnesium.

SUMMARY AND CONCLUSIONS

The five holes drilled at Site 499 on the Middle America Trench floor are at water depths between 6126.5 and 6132 meters. Seismic-reflection records across the trench in this location register a sequence of horizontal reflec-

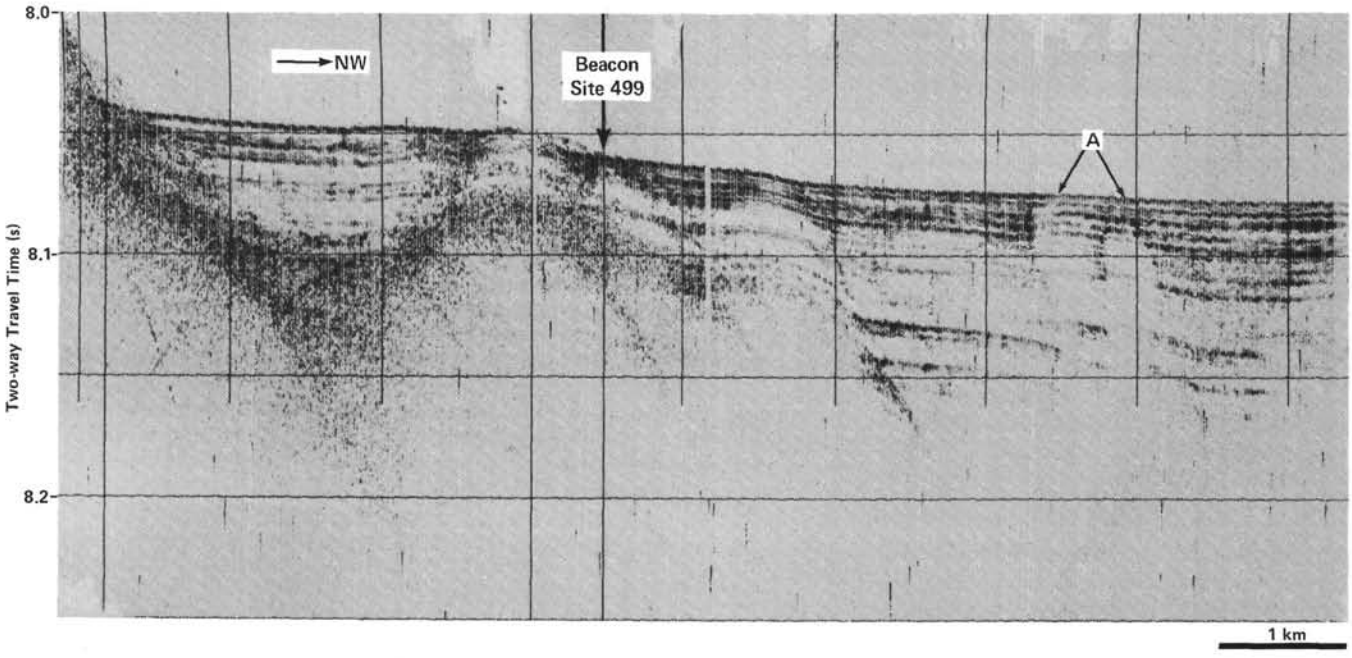


Figure 11. A 3.5-kHz seismic-reflection profile showing details of the uppermost 50 meters of section cored at Site 499.

Series	Sample (hole-core-section, interval in cm)	Approximate Sub-bottom Depth of Boundary (m)	Basis for Boundary Position
Quaternary	499-1 → 21, and 499A-1 → 5	191	Top of *D. brouweri* Zone
upper Pliocene	499-22	200.5	Base of *P. prismatium* Zone
upper Miocene	499-23-1, 0-83 cm	201.3	Base of *D. antepenultima* Zone
lower/ middle Miocene	499-23-1, 83 cm → 23,CC and 499B-1,CC	210	Base of *S. heteromorphus* Zone *D. alata* Zone, and N7
lower Miocene	499-24-1 → 25 and 499B-2 → 9,CC	277.4	Base of *D. deflandrei* Subzone
Basalt	499B-10	T.D. 286.5	

Figure 12. Stratigraphic series at Holes 499, 499A, 499B.

tions underlain by a sequence of gently landward-dipping reflections. The location of Hole 499 was selected to avoid sampling the thickest parts of both acoustic sequences and to avoid sampling sand that might fill an axial channel. After drilling a muddy upper section, the axial channel was drilled at 499A, without recovering sand. Hole 499 was paralleled and drilled to basement at Hole 499B. The rubbly nature of the basalt recovered impeded drilling, and Hole 499C, offset 1000 ft. along strike, was washed to rubbly, basaltic basement. Hole 499D was drilled for logging.

The lithologies at Site 499 are a repeat of those at Site 495, the oceanic reference site, but with the addition of a cover of trench-fill turbidite. These turbidites, 117 me-

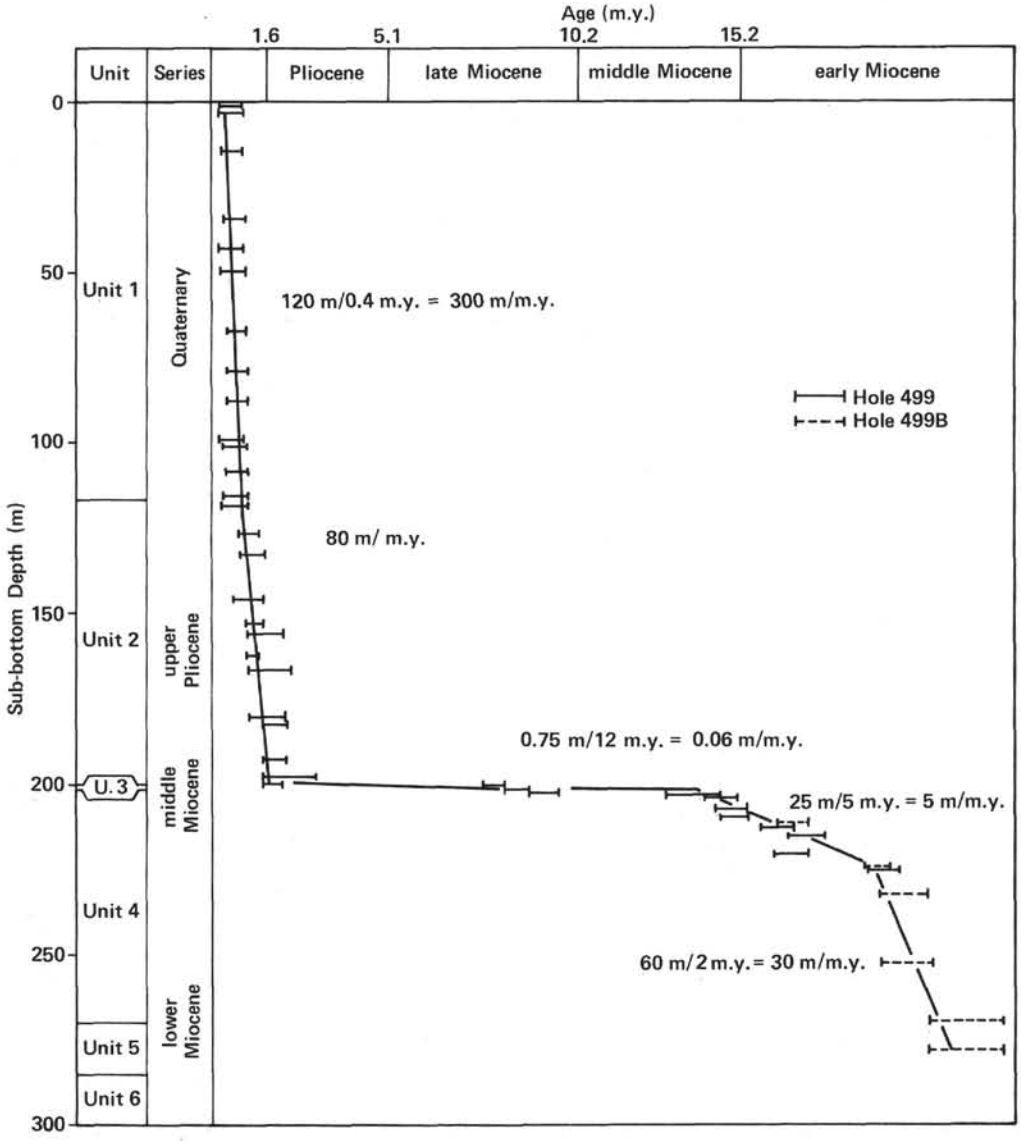


Figure 13. Sedimentation rate curve for Site 499.

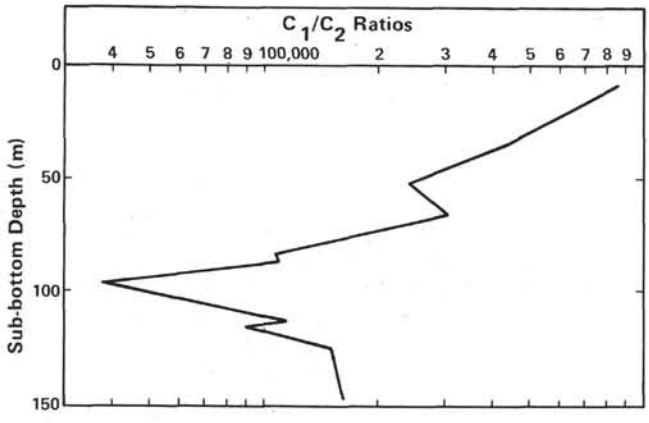


Figure 14. Methane/ethane ratios for Site 499.

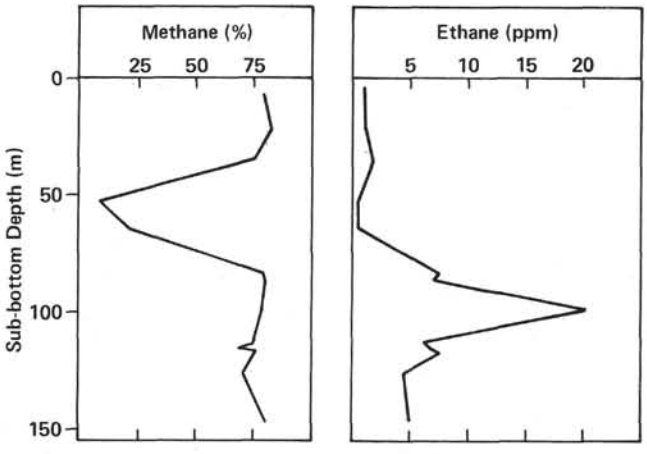


Figure 15. Methane and ethane concentrations at Site 499.

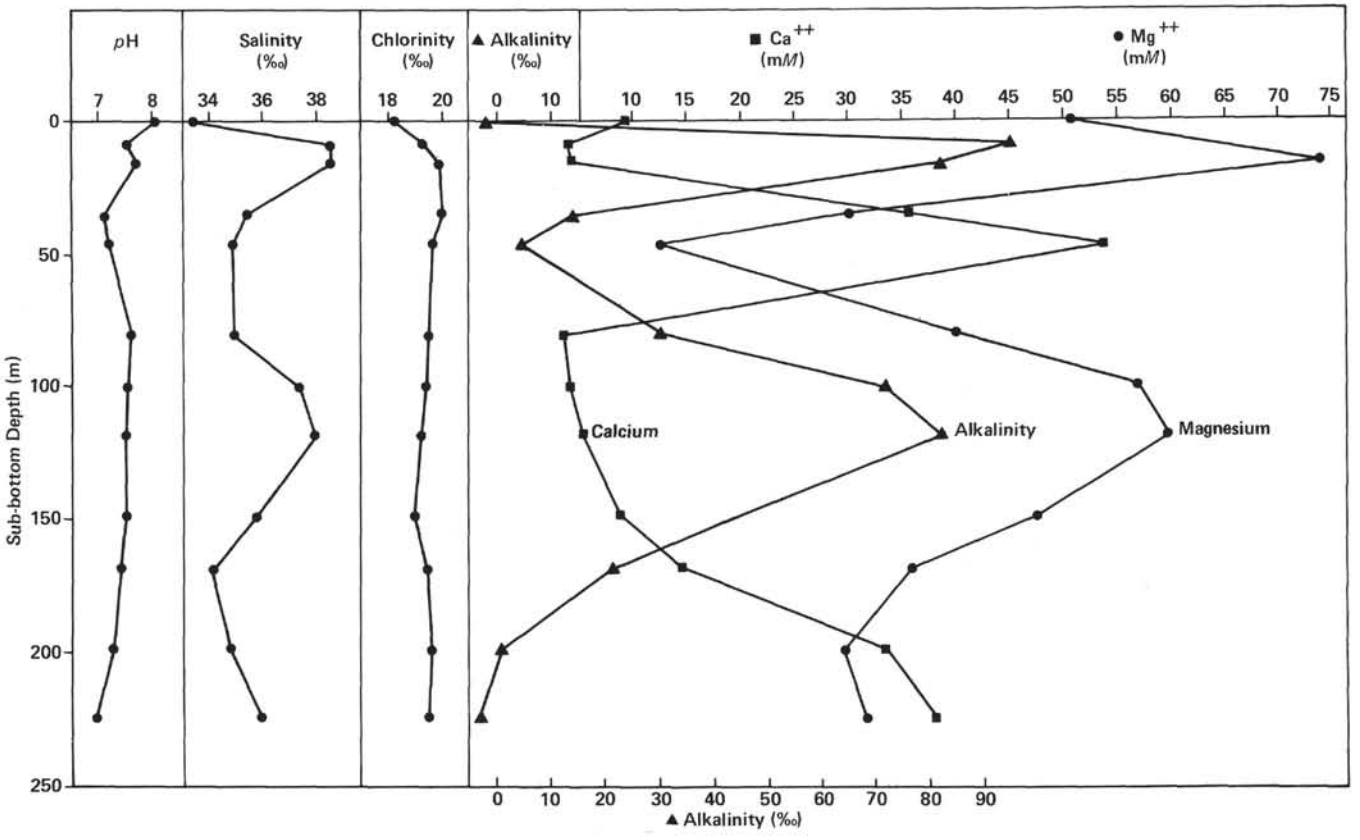


Figure 16. Interstitial water studies at Site 499.

ters thick, are predominantly muddy, although preferential recovery of mud versus sand is suspected. The same turbidite units appear in the channel, about 1 km away, at Hole 499A without any apparent lateral change. In Hole 499, turbidites end abruptly, and burrow mottled, hemipelagic muds, calcareous ooze and chalk, and basalt rubble follow in that order. Although the sequence resembles that cored at Site 495, the calcareous section at Site 499 is about one-third as thick.

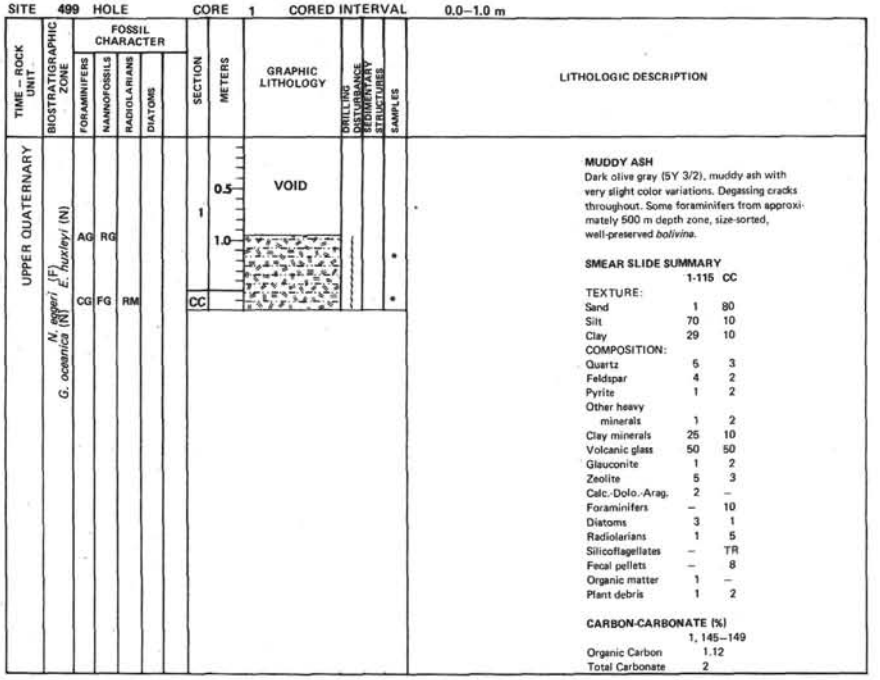
Microfossils occur in the same succession as at Site 495, with the addition of the sequence in the Quaternary trench fill. The trench fill has abundant reworked and transported calcareous microfossils, and the 400,000-yr. radiolarian zonal marker becomes abundant below the trench fill. Within the calcareous section there is more dissolution of foraminifers than at 495, indicating deposition nearer the CCD. The oldest sediment was deposited in the earliest Miocene, as at Site 495.

The trench is filled with a uniform upper Quaternary sequence (slightly less than 400,000 yr. old) of alternating muddy and sandy turbidites, transported from shallower areas landward and deposited rapidly. The youth of these deposits implies rapid subduction, but the age is not known with enough precision to test more than gross rates of plate convergence. The basalt rubble encountered at various depths above seismic basement may be depositional rather than oceanic crust. Beneath the turbidite fill, there is an abbreviated but complete oceanic section, therefore the sequence of sediment corresponds to the two units suggested by the seismic reflectors. The cause of the abbreviated oceanic section is undetermined, but it may result from irregularities in basement relief perhaps inherited from conditions at the spreading center. Alternatively, the section at Site 495 may be anomalously thick.

REFERENCES

Hess, R., 1977. Softer radiographs of sliced piston cores from the Japan and southern Kuril Trench and slope areas. *In* Honza, E. (Ed.), *Geological Investigation of Japan and Southern Kurile Trench and Slope Areas*, GH76-2 Cruise, April–June 1976. *Geol. Surv. Jpn. Cruise Rep. 7*, pp. 86–108.

SITE 499 HOLE CORE 1 CORED INTERVAL 0.0–1.0 m



MUDDY ASH

Dark olive gray (5Y 3/2), muddy ash with very slight color variations. Degassing cracks throughout. Some foraminifers from approximately 500 m depth zone, size-sorted, well-preserved *bolivina*.

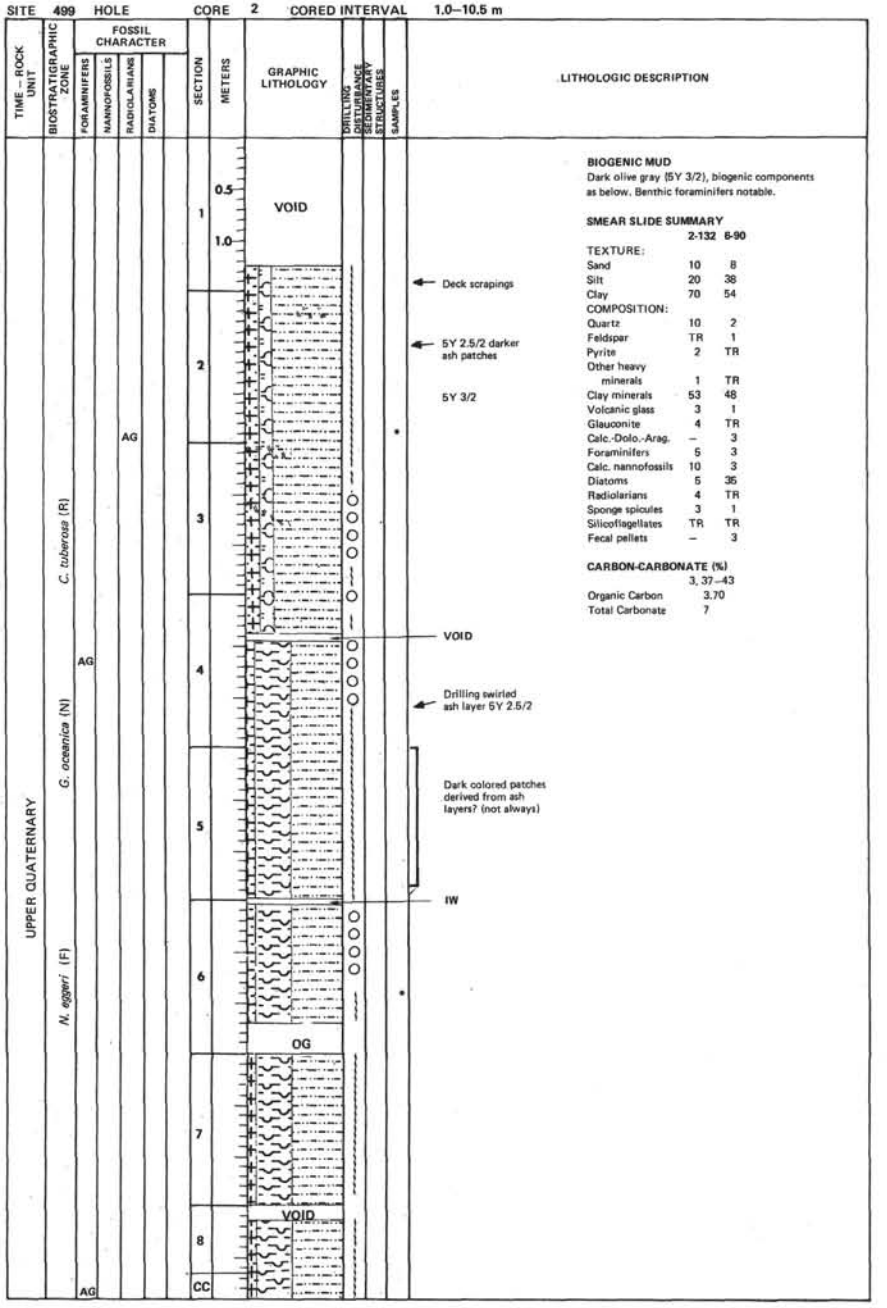
SMEAR SLIDE SUMMARY

	1-115	CC
TEXTURE:		
Sand	1	80
Silt	70	10
Clay	29	10
COMPOSITION:		
Quartz	5	3
Feldspar	4	2
Pyrite	1	2
Other heavy minerals	1	2
Clay minerals	25	10
Volcanic glass	50	50
Glauconite	1	2
Zeolite	5	3
Calc.-Dolo.-Arag.	2	–
Foraminifers	–	10
Diatoms	3	1
Radiolarians	1	5
Silicoflagellates	–	TR
Fecal pellets	–	8
Organic matter	1	–
Plant debris	1	2

CARBON-CARBONATE (%)

	1, 145–149
Organic Carbon	1.12
Total Carbonate	2

SITE 499 HOLE CORE 2 CORED INTERVAL 1.0–10.5 m



BIOGENIC MUD

Dark olive gray (5Y 3/2), biogenic components as below. Benthic foraminifers notable.

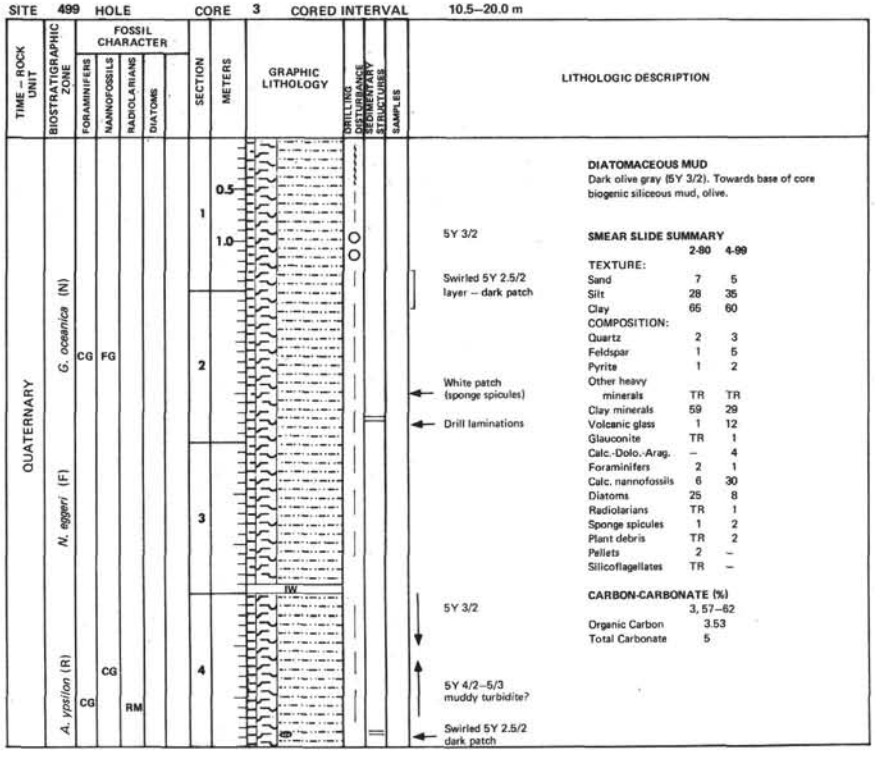
SMEAR SLIDE SUMMARY

	2-132	8-90
TEXTURE:		
Sand	10	8
Silt	20	38
Clay	70	54
COMPOSITION:		
Quartz	10	2
Feldspar	TR	1
Pyrite	2	TR
Other heavy minerals	1	TR
Clay minerals	53	48
Volcanic glass	3	1
Glauconite	4	TR
Calc.-Dolo.-Arag.	–	3
Foraminifers	5	3
Calc. nannofossils	10	3
Diatoms	5	35
Radiolarians	4	TR
Sponge spicules	3	1
Silicoflagellates	TR	TR
Fecal pellets	–	3

CARBON-CARBONATE (%)

	3, 37–43
Organic Carbon	3.70
Total Carbonate	7

SITE 499 HOLE CORE 3 CORED INTERVAL 10.5–20.0 m



DIATOMACEOUS MUD
Dark olive gray (5Y 3/2). Towards base of core biogenic siliceous mud, olive.

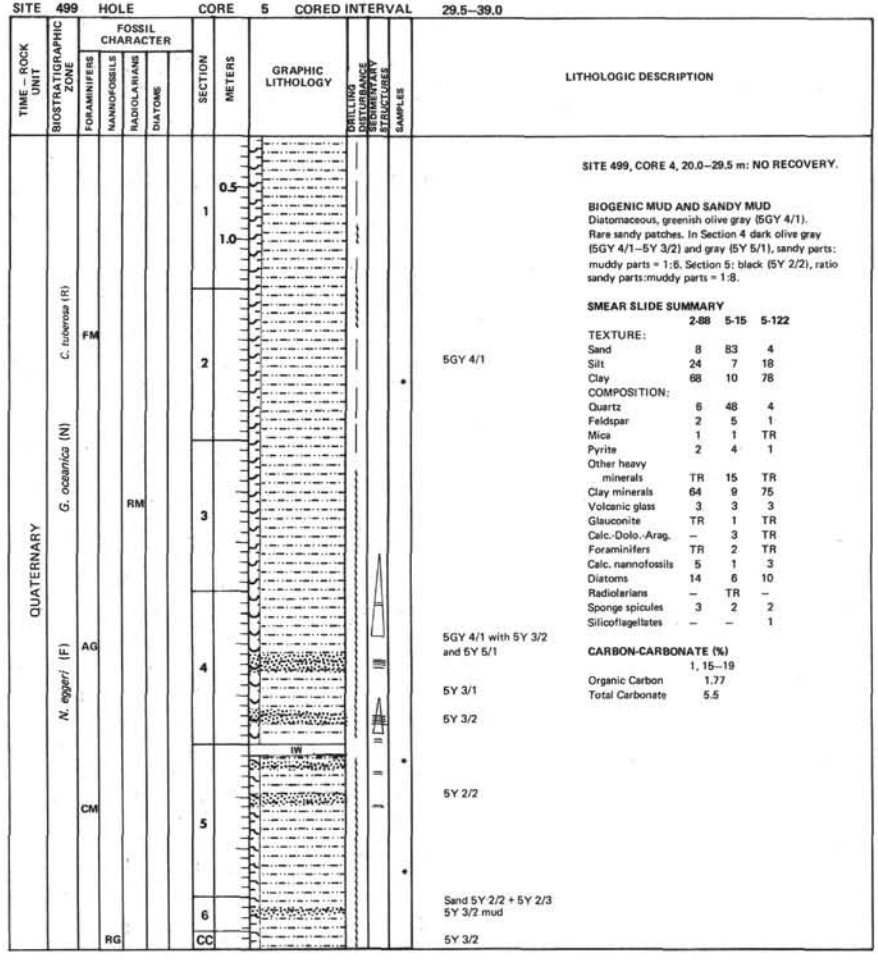
SMEAR SLIDE SUMMARY

	2-80	4-99
TEXTURE:		
Sand	7	5
Silt	28	35
Clay	65	60
COMPOSITION:		
Quartz	2	3
Feldspar	1	5
Pyrite	1	2
Other heavy minerals	TR	TR
Clay minerals	59	29
Volcanic glass	1	12
Glauconite	TR	1
Calc.-Dolo.-Arag.	–	4
Foraminifers	2	1
Calc. nannofossils	6	30
Diatoms	25	8
Radiolarians	TR	1
Sponge spicules	1	2
Plant debris	TR	2
Pellets	2	–
Silicoflagellates	TR	–

CARBON-CARBONATE (%)

	3, 57–62
Organic Carbon	3.53
Total Carbonate	5

SITE 499 HOLE CORE 5 CORED INTERVAL 29.5–39.0



SITE 499, CORE 4, 20.0–29.5 m: NO RECOVERY.

BIOGENIC MUD AND SANDY MUD
Diatomaceous, greenish olive gray (5GY 4/1). Rare sandy patches. In Section 4 dark olive gray (5GY 4/1–5Y 3/2) and gray (5Y 5/1), sandy parts: muddy parts = 1:6. Section 5: black (5Y 2/2), ratio sandy parts:muddy parts = 1:8.

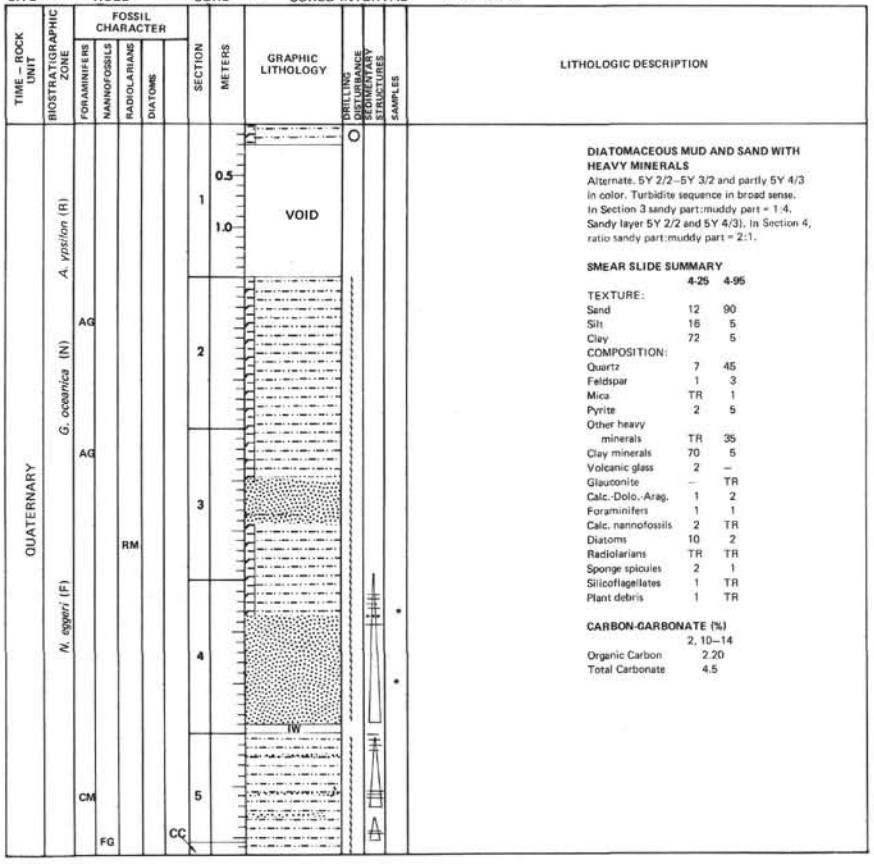
SMEAR SLIDE SUMMARY

	2-88	5-15	5-122
TEXTURE:			
Sand	8	83	4
Silt	24	7	18
Clay	68	10	78
COMPOSITION:			
Quartz	6	48	4
Feldspar	2	5	1
Mica	1	1	TR
Pyrite	2	4	1
Other heavy minerals	TR	15	TR
Clay minerals	64	9	75
Volcanic glass	3	3	3
Glauconite	TR	1	TR
Calc.-Dolo.-Arag.	–	3	TR
Foraminifers	TR	2	TR
Calc. nannofossils	5	1	3
Diatoms	14	6	10
Radiolarians	–	TR	–
Sponge spicules	3	2	2
Silicoflagellates	–	–	1

CARBON-CARBONATE (%)

	1, 15–19
Organic Carbon	1.77
Total Carbonate	5.5

SITE 499 HOLE CORE 6 CORED INTERVAL 39.0–48.5 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD AND SAND WITH HEAVY MINERALS

Alternate. 5Y 2/2–5Y 3/2 and partly 5Y 4/3 in color. Turbidite sequence in broad sense. In Section 3 sandy part:muddy part = 1:4. Sandy layer 5Y 2/2 and 5Y 4/3). In Section 4, ratio sandy part:muddy part = 2:1.

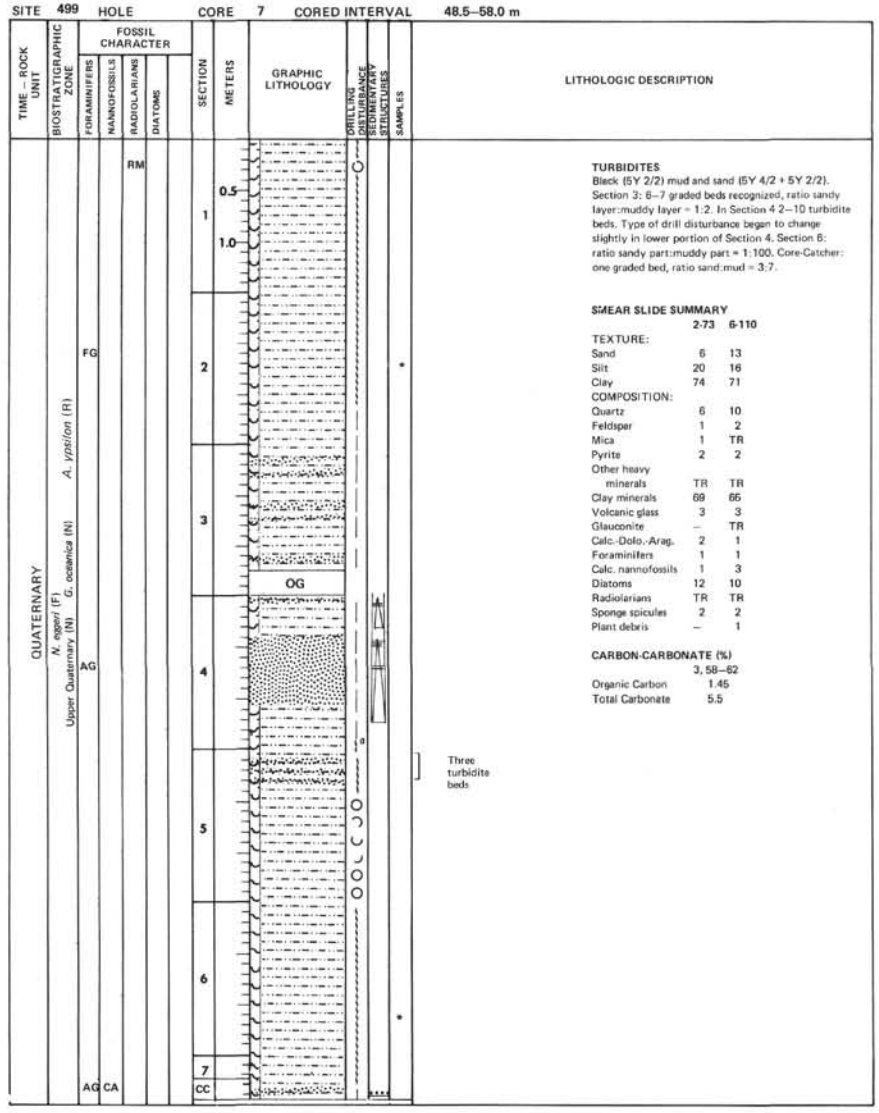
SMEAR SLIDE SUMMARY

	4-25	4-95
TEXTURE:		
Sand	12	90
Silt	16	5
Clay	72	5
COMPOSITION:		
Quartz	7	45
Feldspar	1	3
Mica	TR	1
Pyrite	2	5
Other heavy minerals	TR	35
Clay minerals	70	5
Volcanic glass	2	–
Glauconite	–	TR
Calc.-Dolo.-Arag.	1	2
Foraminifers	1	1
Calc. nannofossils	2	TR
Diatoms	10	2
Radiolarians	TR	TR
Sponge spicules	2	1
Silicoflagellates	1	TR
Plant debris	1	TR

CARBON-CARBONATE (%)

	2, 10–14
Organic Carbon	2.20
Total Carbonate	4.5

SITE 499 HOLE CORE 7 CORED INTERVAL 48.5–58.0 m



LITHOLOGIC DESCRIPTION

TURBIDITES

Black (5Y 2/2) mud and sand (5Y 4/2 + 5Y 2/2). Section 3: 6–7 graded beds recognized, ratio sandy layer:muddy layer = 1:2. In Section 4 2–10 turbidite beds. Type of drill disturbance began to change slightly in lower portion of Section 4. Section 6: ratio sandy part:muddy part = 1:100. Core-Catcher: one graded bed, ratio sand:mud = 3:7.

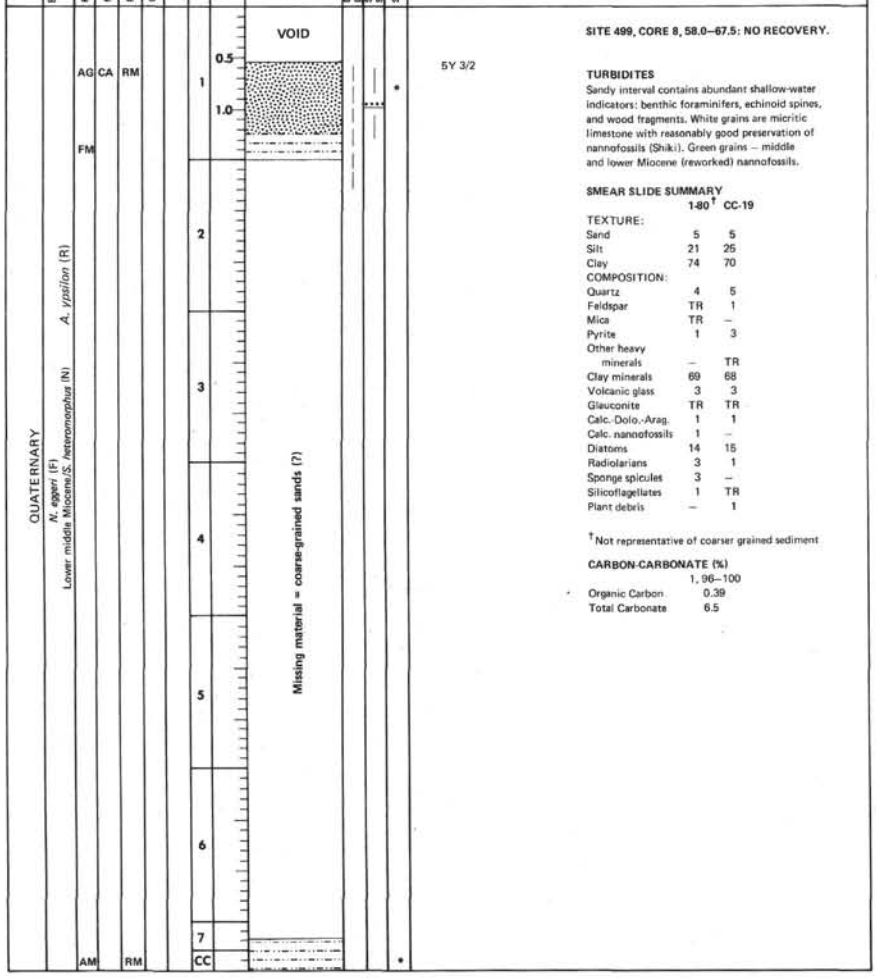
SMEAR SLIDE SUMMARY

	2-73	6-110
TEXTURE:		
Sand	6	13
Silt	20	16
Clay	74	71
COMPOSITION:		
Quartz	6	10
Feldspar	1	2
Mica	1	TR
Pyrite	2	2
Other heavy minerals	TR	TR
Clay minerals	69	66
Volcanic glass	3	3
Glauconite	–	TR
Calc.-Dolo.-Arag.	2	1
Foraminifers	1	1
Calc. nannofossils	1	3
Diatoms	12	10
Radiolarians	TR	TR
Sponge spicules	2	2
Plant debris	–	1

CARBON-CARBONATE (%)

	3, 58–62
Organic Carbon	1.45
Total Carbonate	5.5

SITE 499 HOLE CORE 9 CORED INTERVAL 67.5–77.0 m



SITE 499, CORE 8, 58.0–67.5: NO RECOVERY.

TURBIDITES

Sandy interval contains abundant shallow-water indicators: benthic foraminifers, echinoid spines, and wood fragments. White grains are micritic limestone with reasonably good preservation of nannofossils (Shiki). Green grains – middle and lower Miocene (reworked) nannofossils.

SMEAR SLIDE SUMMARY

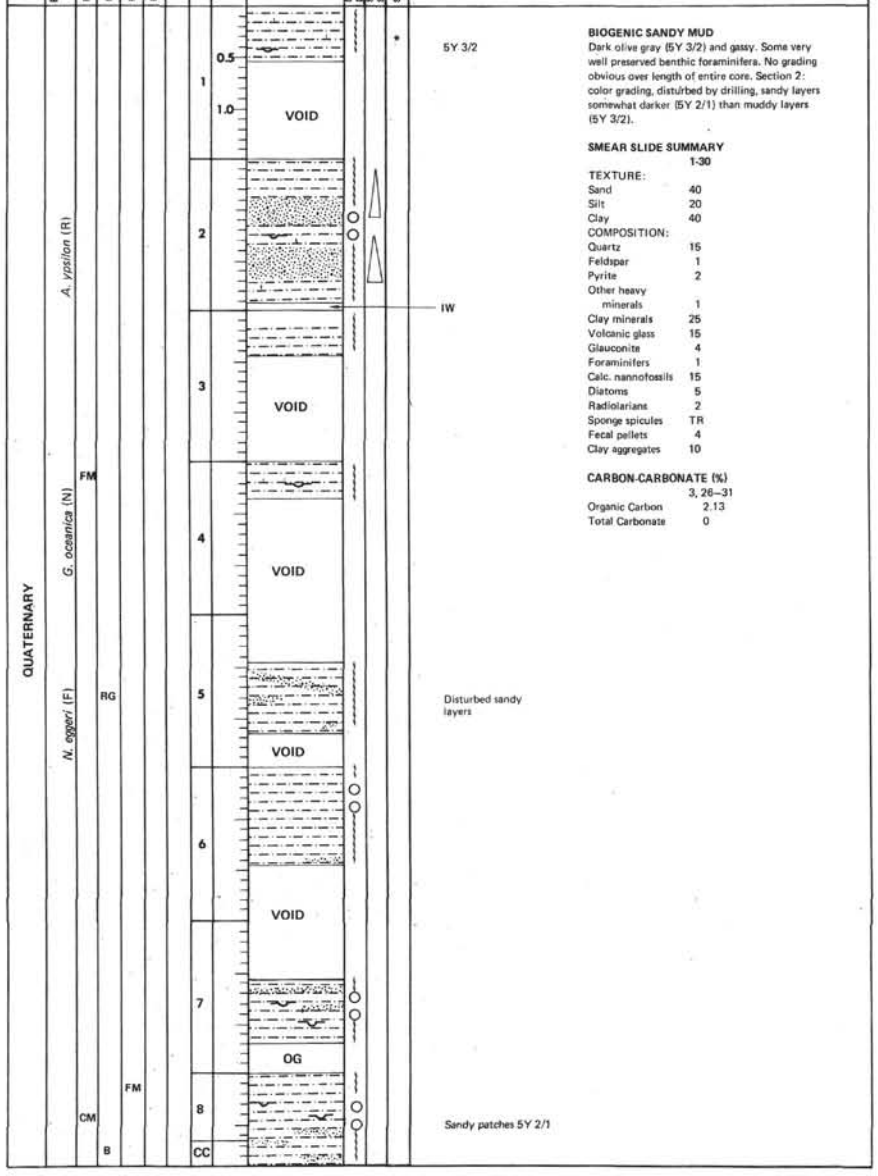
	1-80†	CC-19
TEXTURE:		
Sand	5	5
Silt	21	25
Clay	74	70
COMPOSITION:		
Quartz	4	5
Feldspar	TR	1
Mica	TR	–
Pyrite	1	3
Other heavy minerals	–	TR
Clay minerals	69	68
Volcanic glass	3	3
Glauconite	TR	TR
Calc.-Dolo.-Arag.	1	1
Calc. nannofossils	1	–
Diatoms	14	15
Radiolarians	3	1
Sponge spicules	3	–
Silicoflagellates	1	TR
Plant debris	–	1

†Not representative of coarser grained sediment

CARBON-CARBONATE (%)

	1, 96–100
Organic Carbon	0.39
Total Carbonate	6.5

SITE 499 HOLE CORE 10 CORED INTERVAL 77.0–86.5 m



BIOGENIC SANDY MUD

Dark olive gray (5Y 3/2) and gassy. Some very well preserved benthic foraminifera. No grading obvious over length of entire core. Section 2: color grading, disturbed by drilling, sandy layers somewhat darker (5Y 2/1) than muddy layers (5Y 3/2).

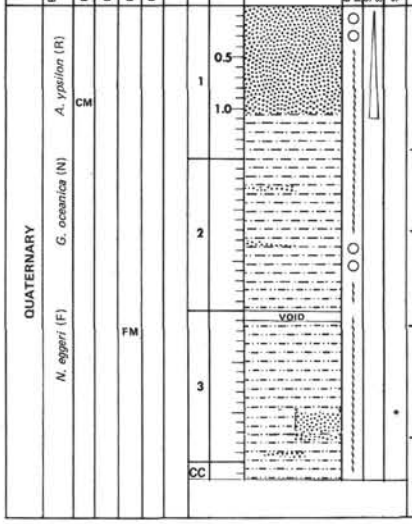
SMEAR SLIDE SUMMARY

	1-30
TEXTURE:	
Sand	40
Silt	20
Clay	40
COMPOSITION:	
Quartz	15
Feldspar	1
Pyrite	2
Other heavy minerals	1
Clay minerals	25
Volcanic glass	15
Glauconite	4
Foraminifers	1
Calc. nannofossils	15
Diatoms	5
Radiolarians	2
Sponge spicules	TR
Fecal pellets	4
Clay aggregates	10

CARBON-CARBONATE (%)

	3, 26–31
Organic Carbon	2.13
Total Carbonate	0

SITE 499 HOLE CORE 11 CORED INTERVAL 86.5–96.0 m



LITHOLOGIC DESCRIPTION

TURBIDITES
5Y 3/2 mud and 5Y 2/1 sand. Only the remnants of what might once have been grading. Section 1: grains of gray white limestone shell fragments.

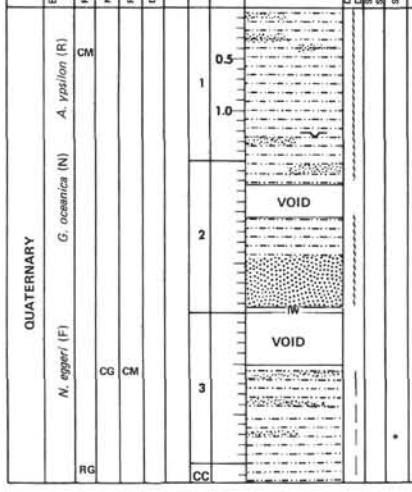
SMEAR SLIDE SUMMARY

	3-97
TEXTURE:	
Sand	20
Silt	48
Clay	32
COMPOSITION:	
Quartz	3
Feldspar	5
Pyrite	2
Other heavy minerals	2
Clay minerals	16
Volcanic glass	10
Glauconite	2
Calc.-Dolo.-Arag.	10
Foraminifers	5
Calc. nannofossils	15
Diatoms	6
Radiolarians	3
Sponge spicules	1
Fecal pellets	20

CARBON-CARBONATE (%)

	3, 51–56
Organic Carbon	2.54
Total Carbonate	3.5

SITE 499 HOLE CORE 12 CORED INTERVAL 96.0–105.5 m



LITHOLOGIC DESCRIPTION

TURBIDITES
Biogenic mud with pyritic, heavy mineral sands.

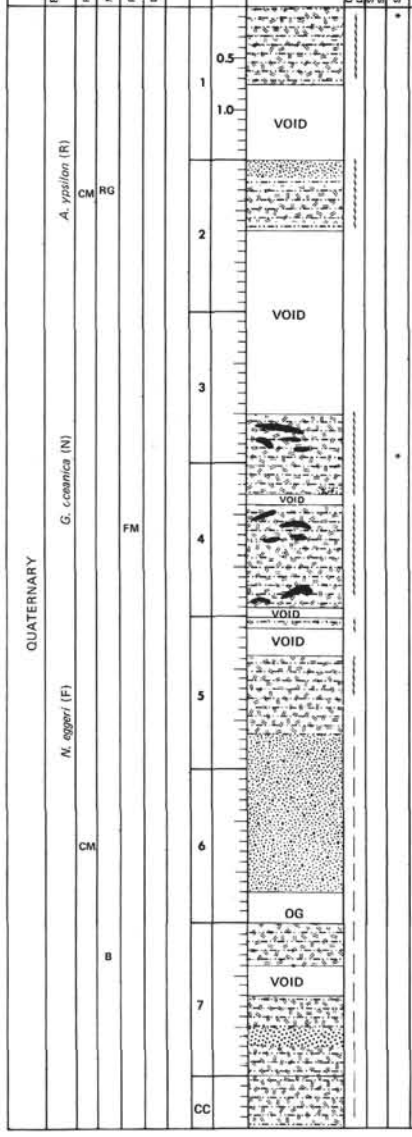
SMEAR SLIDE SUMMARY

	3-113 (Sandy layers)
TEXTURE:	
Sand	93
Silt	1
Clay	6
COMPOSITION:	
Quartz	12
Feldspar	5
Pyrite	6
Other heavy minerals	42
Volcanic glass	8
Calc.-Dolo.-Arag.	TR
Foraminifers	1
Calc. nannofossils	TR
Diatoms	1
Pyritic pellets	25

CARBON-CARBONATE (%)

	3, 83–90
Organic Carbon	2.44
Total Carbonate	1.5

SITE 499 HOLE CORE 13 CORED INTERVAL 105.5–115.0 m



LITHOLOGIC DESCRIPTION

TURBIDITES
Section 1: muddy ash. Sandy patches and muddy patches in dark olive gray (5Y 3/2) matrix. Section 2: muddy ash – matrix. Sandy layers: rich in heavy minerals/volcanic glass. Muddy patches: diatomaceous mud. Section 3: Ash – medium gray (5Y 6/1), mud – 5Y 2/1 and sandy mud – 5Y 3/2. Section 5, 110 cm–Section 6: 5Y 4/2 muddy vitric ash.

SMEAR SLIDE SUMMARY

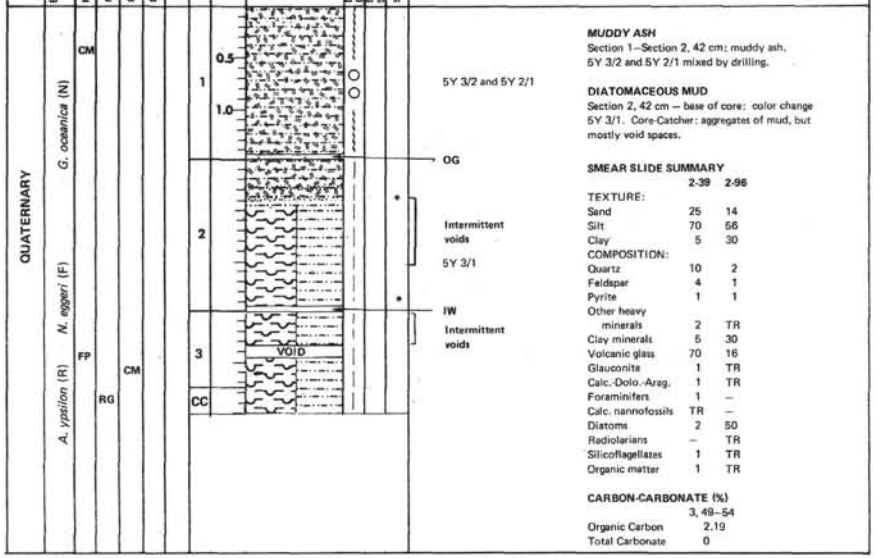
	1-10†	3-149
TEXTURE:		
Sand	1	90
Silt	35	10
Clay	64	–
COMPOSITION:		
Quartz	2	10
Feldspar	–	8
Pyrite	4	2
Other heavy minerals	–	8
Clay minerals	40	–
Volcanic glass	3	70
Glauconite	1	–
Calc.-Dolo.-Arag.	8	–
Foraminifers	3	1
Calc. nannofossils	8	–
Diatoms	20	–
Radiolarians	2	–
Sponge spicules	1	–
Plant debris	8	–

† black, fine-grained clast)

CARBON-CARBONATE (%)

	4, 84–89
Organic Carbon	1.61
Total Carbonate	4

SITE 499 HOLE CORE 14 CORED INTERVAL 115.0–124.5 m



MUDDY ASH
Section 1–Section 2, 42 cm: muddy ash, 5Y 3/2 and 5Y 2/1 mixed by drilling.

DIATOMACEOUS MUD
Section 2, 42 cm – base of core: color change 5Y 3/1. Core-Catcher: aggregates of mud, but mostly void spaces.

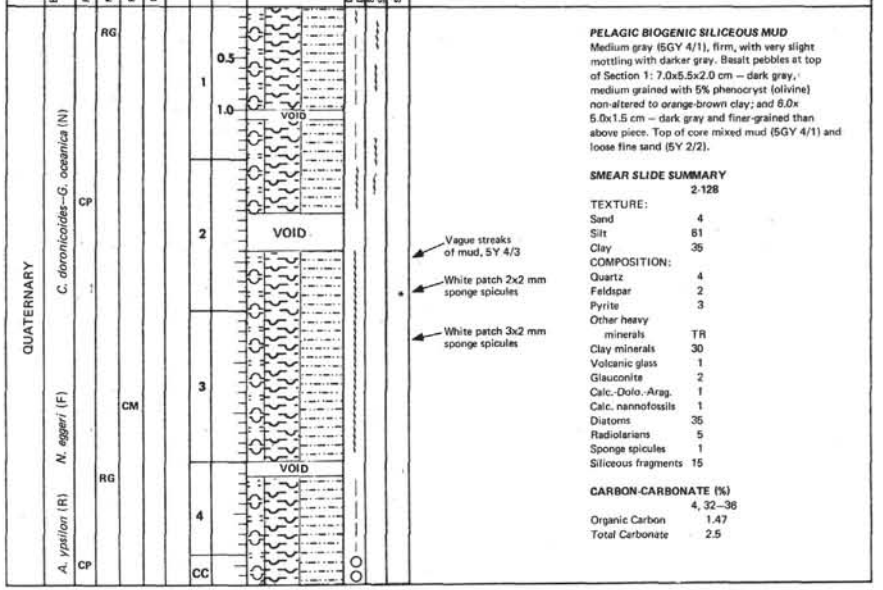
SMEAR SLIDE SUMMARY

	2-39	2-96
TEXTURE:		
Sand	25	14
Silt	70	56
Clay	5	30
COMPOSITION:		
Quartz	10	2
Feldspar	4	1
Pyrite	1	1
Other heavy minerals	2	TR
Clay minerals	5	30
Volcanic glass	70	16
Glauconite	1	TR
Calc.-Dolo.-Arag.	1	TR
Foraminifers	1	–
Calc. nannofossils	TR	–
Diatoms	2	50
Radiolarians	–	TR
Silicoflagellates	1	TR
Organic matter	1	TR

CARBON-CARBONATE (%)

	3, 49–54
Organic Carbon	2.19
Total Carbonate	0

SITE 499 HOLE CORE 15 CORED INTERVAL 124.5–134.0 m



PELAGIC BIOGENIC SILICEOUS MUD
Medium gray (5GY 4/1), firm, with very slight mottling with darker gray. Basalt pebbles at top of Section 1: 7.0x5.5x2.0 cm – dark gray, medium grained with 5% phenocryst (olivine) non-altered to orange-brown clay; and 6.0x 5.0x1.5 cm – dark gray and finer-grained than above piece. Top of core mixed mud (5GY 4/1) and loose fine sand (5Y 2/2).

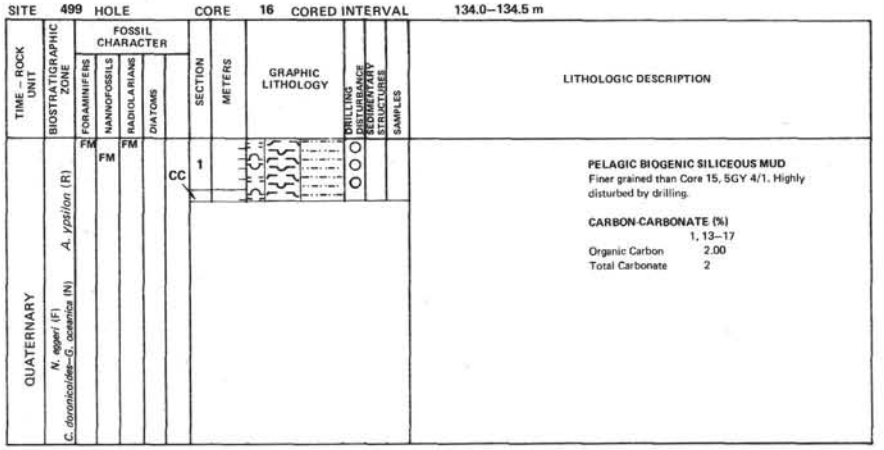
SMEAR SLIDE SUMMARY

	2-128
TEXTURE:	
Sand	4
Silt	61
Clay	35
COMPOSITION:	
Quartz	4
Feldspar	2
Pyrite	3
Other heavy minerals	TR
Clay minerals	30
Volcanic glass	1
Glauconite	2
Calc.-Dolo.-Arag.	1
Calc. nannofossils	1
Diatoms	35
Radiolarians	5
Sponge spicules	1
Siliceous fragments	15

CARBON-CARBONATE (%)

	4, 32–36
Organic Carbon	1.47
Total Carbonate	2.5

SITE 499 HOLE CORE 16 CORED INTERVAL 134.0–134.5 m

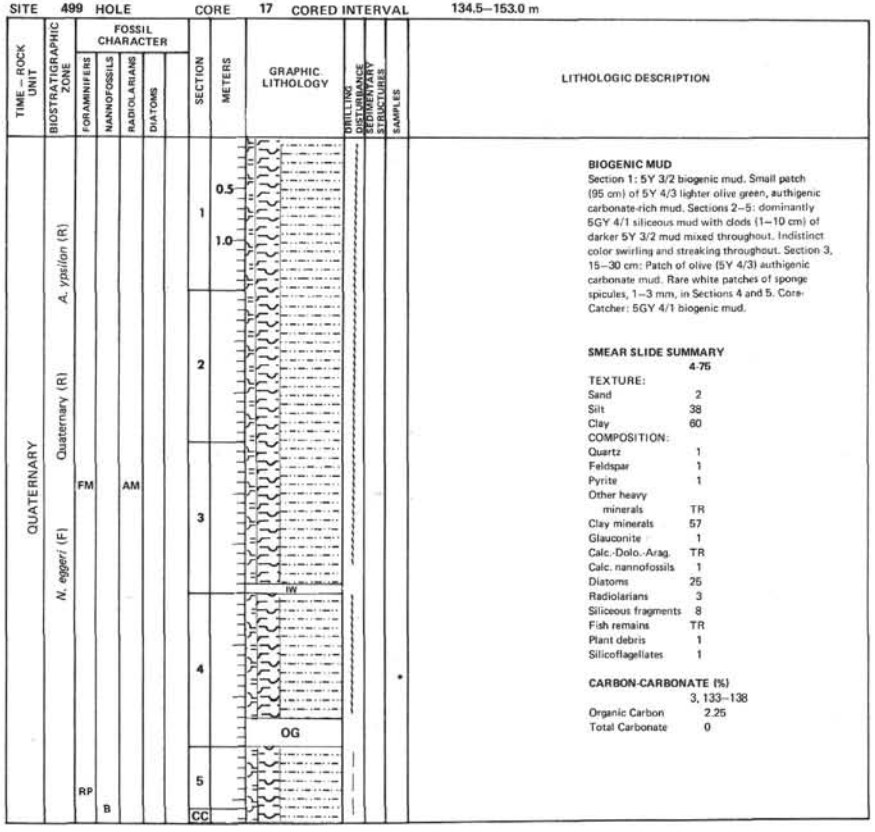


PELAGIC BIOGENIC SILICEOUS MUD
Finer grained than Core 15, 5GY 4/1. Highly disturbed by drilling.

CARBON-CARBONATE (%)

	1, 13–17
Organic Carbon	2.00
Total Carbonate	2

SITE 499 HOLE CORE 17 CORED INTERVAL 134.5–153.0 m



LITHOLOGIC DESCRIPTION

BIOGENIC MUD

Section 1: 5Y 3/2 biogenic mud. Small patch (95 cm) of 5Y 4/3 lighter olive green, authigenic carbonate-rich mud. Sections 2–5: dominantly 5GY 4/1 siliceous mud with clods (1–10 cm) of darker 5Y 3/2 mud mixed throughout. Indistinct color swirling and streaking throughout. Section 3, 15–30 cm: Patch of olive (5Y 4/3) authigenic carbonate mud. Rare white patches of sponge spicules, 1–3 mm, in Sections 4 and 5. Core-Catcher: 5GY 4/1 biogenic mud.

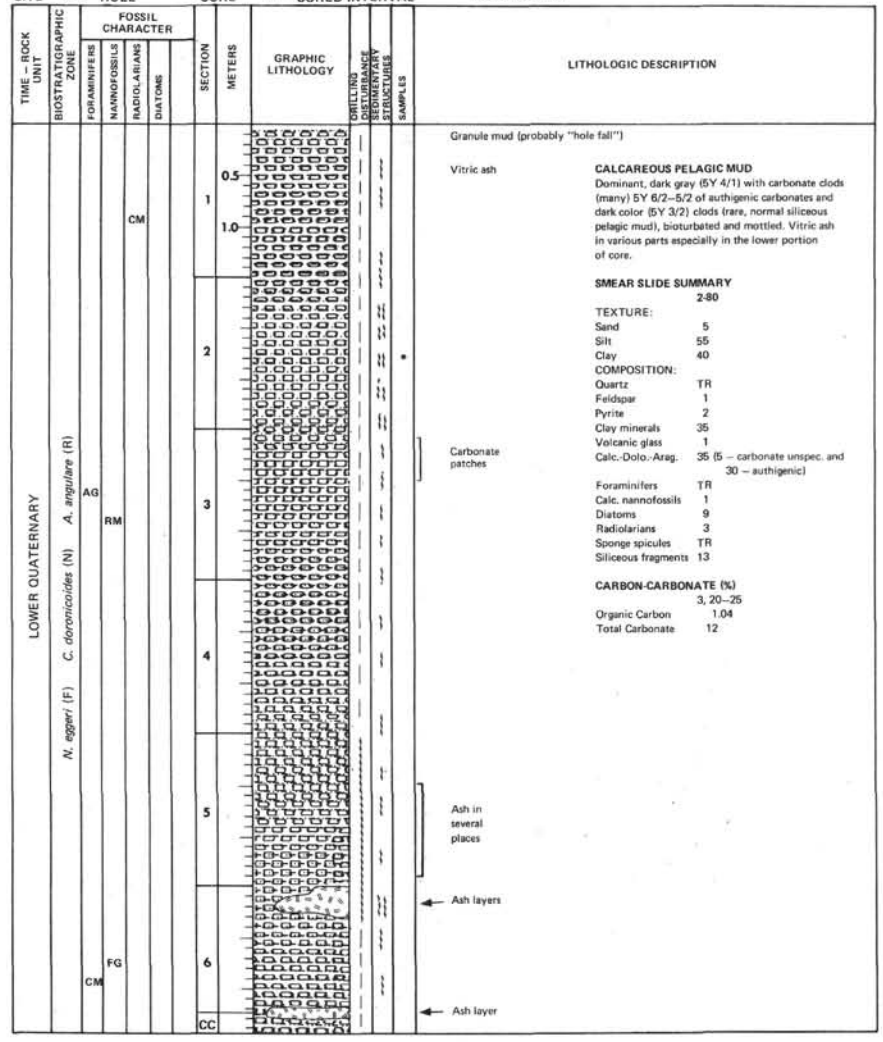
SMEAR SLIDE SUMMARY

	4-75
TEXTURE:	
Sand	2
Silt	38
Clay	60
COMPOSITION:	
Quartz	1
Feldspar	1
Pyrite	1
Other heavy minerals	TR
Clay minerals	57
Glauconite	1
Calc.-Dolo.-Arag.	TR
Calc. nannofossils	1
Diatoms	25
Radiolarians	3
Siliceous fragments	8
Fish remains	TR
Plant debris	1
Silicoflagellates	1

CARBON-CARBONATE (%)

	3, 133–138
Organic Carbon	2.25
Total Carbonate	0

SITE 499 HOLE CORE 18 CORED INTERVAL 153.0–162.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS PELAGIC MUD

Dominant, dark gray (5Y 4/1) with carbonate clods (many) 5Y 6/2–5/2 of authigenic carbonates and dark color (5Y 3/2) clods (rare, normal siliceous pelagic mud), bioturbated and mottled. Vitric ash in various parts especially in the lower portion of core.

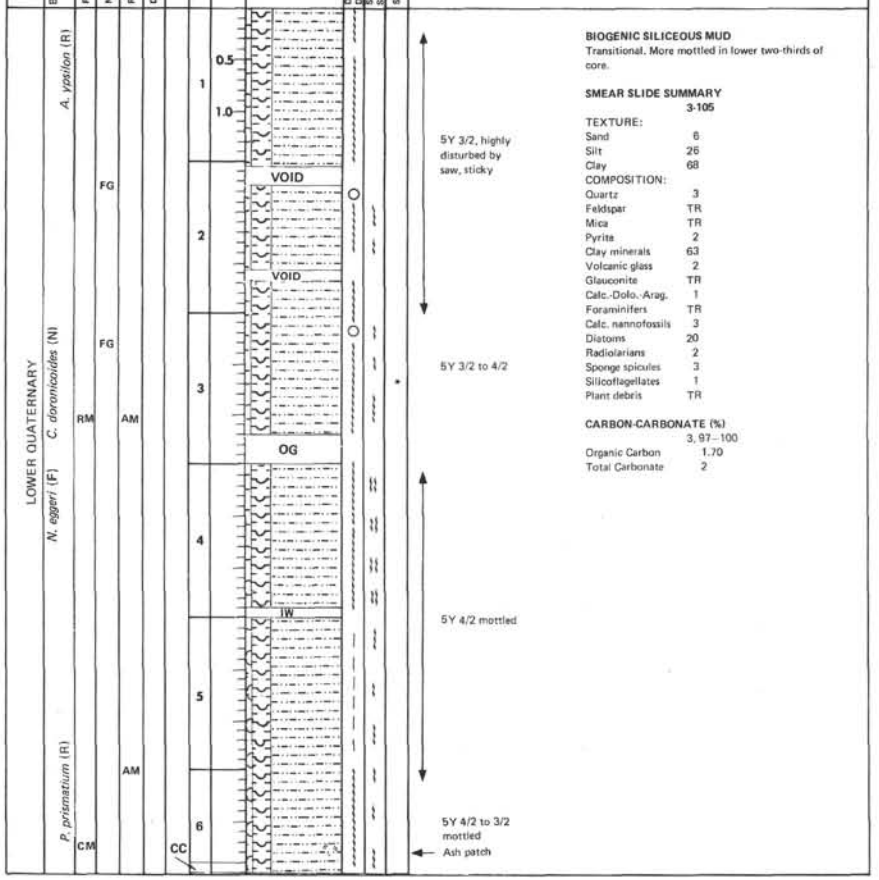
SMEAR SLIDE SUMMARY

	2-80
TEXTURE:	
Sand	5
Silt	55
Clay	40
COMPOSITION:	
Quartz	TR
Feldspar	1
Pyrite	2
Clay minerals	35
Volcanic glass	1
Calc.-Dolo.-Arag.	35 (5 – carbonate unspec. and 30 – authigenic)
Foraminifers	TR
Calc. nannofossils	1
Diatoms	9
Radiolarians	3
Sponge spicules	TR
Siliceous fragments	13

CARBON-CARBONATE (%)

	3, 20–25
Organic Carbon	1.04
Total Carbonate	12

SITE 499 HOLE CORE 19 CORED INTERVAL 162.5–172.0 m



BIOGENIC SILICEOUS MUD
Transitional. More mottled in lower two-thirds of core.

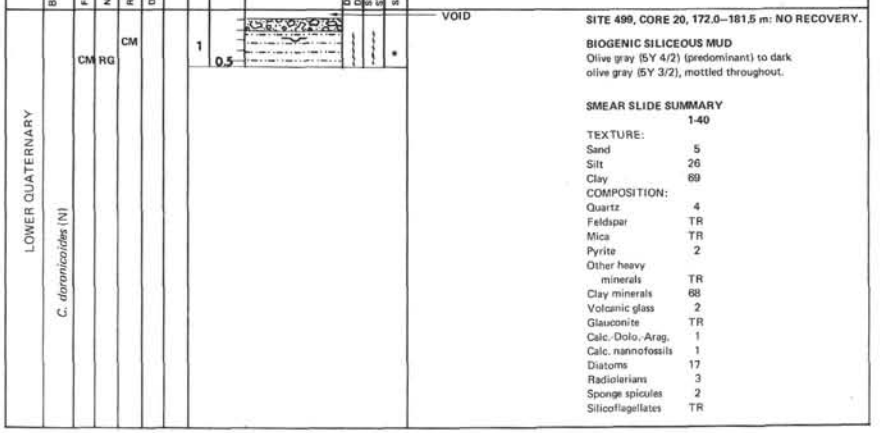
SMEAR SLIDE SUMMARY

	3-105
TEXTURE:	
Sand	6
Silt	26
Clay	68
COMPOSITION:	
Quartz	3
Feldspar	TR
Mica	TR
Pyrite	2
Clay minerals	63
Volcanic glass	2
Glauconite	TR
Calc.-Dolo.-Arag.	1
Foraminifers	TR
Calc. nannofossils	3
Diatoms	20
Radiolarians	2
Sponge spicules	3
Silicoflagellates	1
Plant debris	TR

CARBON-CARBONATE (%)

	3, 97–100
Organic Carbon	1.70
Total Carbonate	2

SITE 499 HOLE CORE 21 CORED INTERVAL 181.5–191.0 m



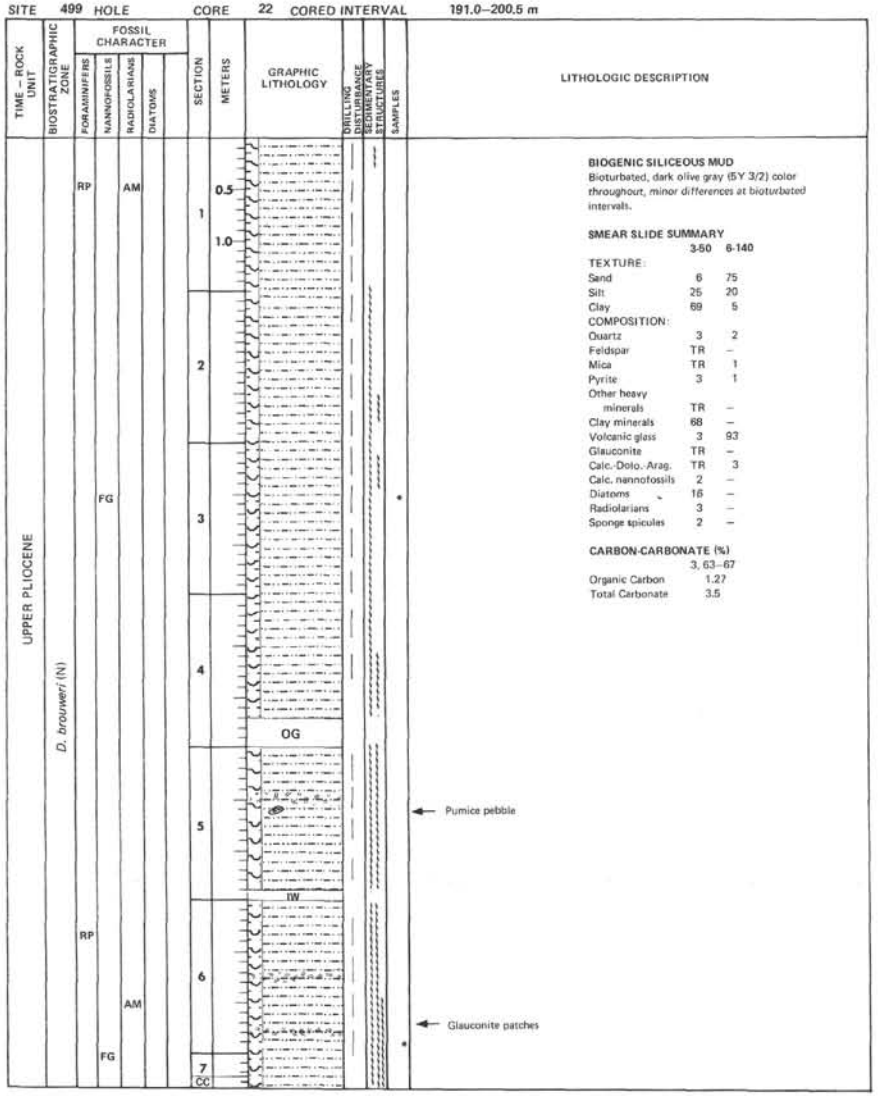
SITE 499, CORE 20, 172.0–181.5 m: NO RECOVERY.

BIOGENIC SILICEOUS MUD
Olive gray (5Y 4/2) (predominant) to dark olive gray (5Y 3/2), mottled throughout.

SMEAR SLIDE SUMMARY

	1-40
TEXTURE:	
Sand	5
Silt	26
Clay	69
COMPOSITION:	
Quartz	4
Feldspar	TR
Mica	TR
Pyrite	2
Other heavy minerals	TR
Clay minerals	68
Volcanic glass	2
Glauconite	TR
Calc.-Dolo.-Arag.	1
Calc. nannofossils	1
Diatoms	17
Radiolarians	3
Sponge spicules	2
Silicoflagellates	TR

SITE 499 HOLE CORE 22 CORED INTERVAL 191.0–200.5 m



BIOGENIC SILICEOUS MUD
Bioturbated, dark olive gray (5Y 3/2) color throughout, minor differences at bioturbated intervals.

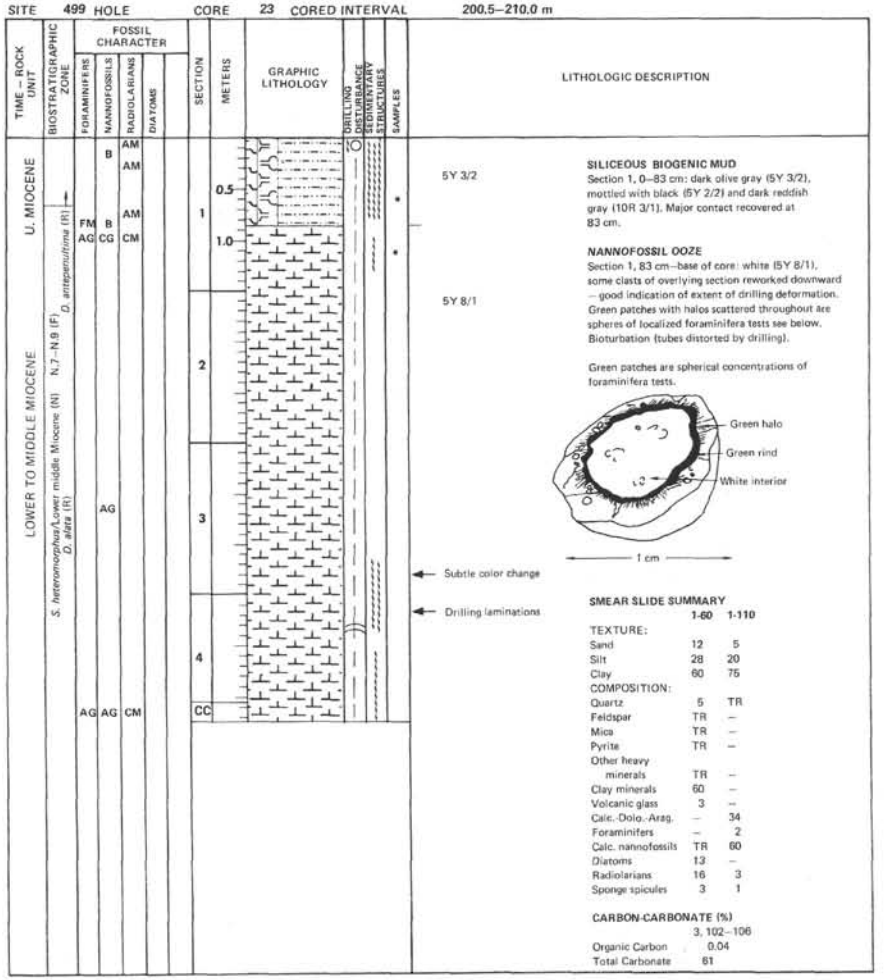
SMEAR SLIDE SUMMARY

	3-50	6-140
TEXTURE:		
Sand	6	75
Silt	25	20
Clay	69	5
COMPOSITION:		
Quartz	3	2
Feldspar	TR	–
Mica	TR	1
Pyrite	3	1
Other heavy minerals	TR	–
Clay minerals	68	–
Volcanic glass	3	93
Glauconite	TR	–
Calc.-Dolo.-Arag.	TR	3
Calc. nannofossils	2	–
Diatoms	16	–
Radiolarians	3	–
Sponge spicules	2	–

CARBON-CARBONATE (%)

	3, 63–67
Organic Carbon	1.27
Total Carbonate	3.5

SITE 499 HOLE CORE 23 CORED INTERVAL 200.5–210.0 m



SILICEOUS BIOGENIC MUD
Section 1, 0–83 cm: dark olive gray (5Y 3/2), mottled with black (5Y 2/2) and dark reddish gray (10R 3/1). Major contact recovered at 83 cm.

NANNOFOSSIL OOZE
Section 1, 83 cm–base of core: white (5Y 8/1), some clasts of overlying section reworked downward – good indication of extent of drilling deformation. Green patches with halos scattered throughout are spheres of localized foraminifera tests see below. Bioturbation (tubes distorted by drilling).

Green patches are spherical concentrations of foraminifera tests.

SMEAR SLIDE SUMMARY

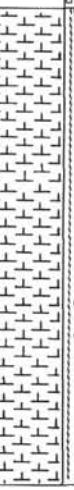
	1-60	1-110
TEXTURE:		
Sand	12	5
Silt	28	20
Clay	60	75
COMPOSITION:		
Quartz	5	TR
Feldspar	TR	–
Mica	TR	–
Pyrite	TR	–
Other heavy minerals	TR	–
Clay minerals	60	–
Volcanic glass	3	–
Calc.-Dolo.-Arag.	–	34
Foraminifers	–	2
Calc. nannofossils	TR	60
Diatoms	13	–
Radiolarians	16	3
Sponge spicules	3	1

CARBON-CARBONATE (%)

	3, 102–106
Organic Carbon	0.04
Total Carbonate	61

SITE 499 HOLE CORE 24 CORED INTERVAL 210.0–219.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	N. 7 (F) *C. costata* (R) *H. ampliaperta* (N)	AG		AM		1	0.5, 1.0					7.5Y 8/2
						2					* *	
				AM		3						
		CM	AG			CC						



NANNOFOSSIL CHALK (in biscuits) OOZE (between)
Pinkish white (7.5Y 8/2). Strong drilling deformation in Section 2.

SMEAR SLIDE SUMMARY

	1-117	2-65
TEXTURE:		
Sand	15	4
Silt	10	15
Clay	75	81
COMPOSITION:		
Volcanic glass	TR	TR
Glauconite	–	TR
Calc.-Dolo.-Arag.	10	16
Foraminifers	10	2
Calc. nannofossils	74	80
Radiolarians	5	2
Sponge spicules	1	TR

CARBON-CARBONATE (%)

	1, 76–78
Organic Carbon	0.06
Total Carbonate	57.5

SITE 499 HOLE CORE 25 CORED INTERVAL 219.5–229.0

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	*C. costata* (R)					1	0.5, 1.0	VOID				7.5Y 8/2 and 5Y 3/2
	N. 7 (F)					2		VOID				
	H. ampliaperta (N)	AG				3		OG IW				
	S. wolffii (R)	AG		AG AM		4						10YR 8/4, 10YR 8/3, 10YR 6/4, 5Y 7/1
		AG				CC						5G 8/1

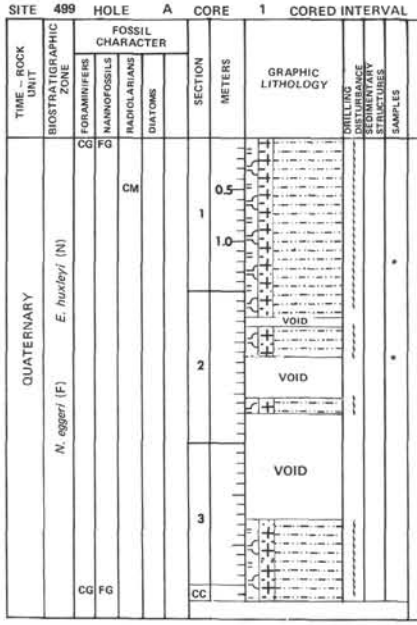
DRILL BRECCIA
Pinkish white (7.5Y 8/2) nannofossil chalk and dark olive gray (5Y 3/2).

NANNOFOSSIL CHALK AND OOZE
Section 3–base of core.

CARBON-CARBONATE (%)

	4, 88–92
Organic Carbon	0.03
Total Carbonate	75

SITE 499 HOLE A CORE 1 CORED INTERVAL 0.0–5.0 m



LITHOLOGIC DESCRIPTION

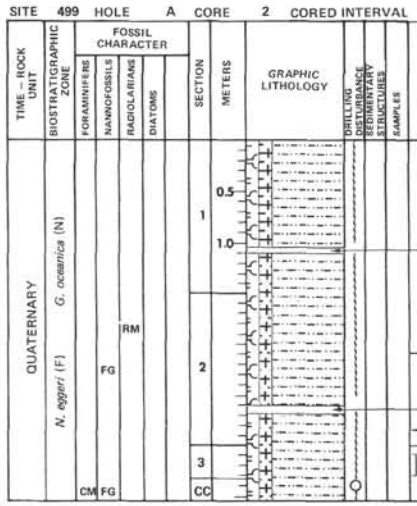
BIOGENIC MUD

Predominantly (80%) dark olive gray (5Y 3/2), contains foraminifers, nannofossils, and diatoms. Black (5Y 2/1) biogenic siliceous mud (20%), swirled and streaked throughout by drilling. Patches (3 mm) sponge spicules noted at 75–78 mm in Section 1. Core-Catcher: 12 cm.

SMEAR SLIDE SUMMARY

	1-123	2-65
TEXTURE:		
Sand	2	15
Silt	22	20
Clay	76	65
COMPOSITION:		
Quartz	3	3
Feldspar	2	4
Pyrite	1	3
Other heavy minerals	1	TR
Clay minerals	60	60
Volcanic glass	1	3
Glauconite	TR	1
Calc.-Dolo.-Arag.	4	7
Foraminifers	5	2
Calc. nannofossils	4	3
Diatoms	14	10
Radiolarians	TR	3
Sponge spicules	1	–
Plant debris	2	–
Fecal pellets	2	–
Silicoflagellates	TR	1

SITE 499 HOLE A CORE 2 CORED INTERVAL 5.0–14.5 m

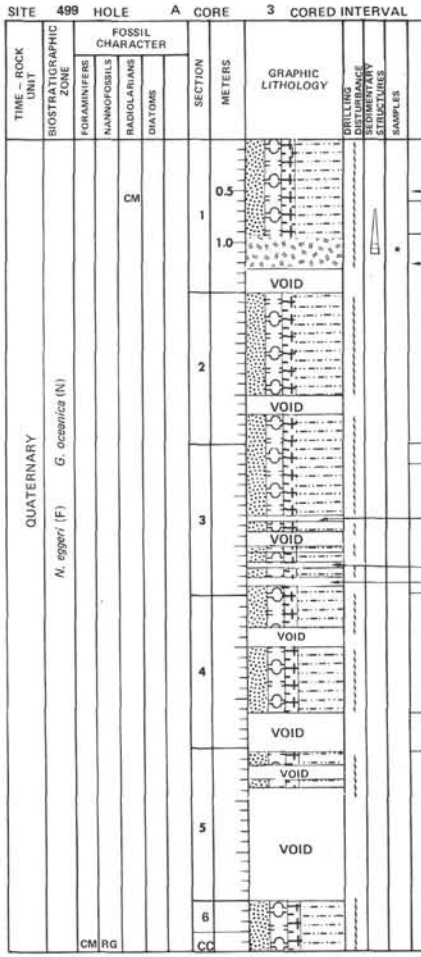


LITHOLOGIC DESCRIPTION

BIOGENIC SILICEOUS MUD

Dominant: dark olive gray–very dark olive gray. Intensely disturbed (swirled) by drilling. Many fractures and cracks by cutting.

SITE 499 HOLE A CORE 3 CORED INTERVAL 14.5–24.0 m



LITHOLOGIC DESCRIPTION

BIOGENIC SILICEOUS MUD

Section 1, 100 cm: Olive gray (5Y 4/2) clayev sand with lamination. 110–125 cm: Muddy ashy sand 5Y 5/3.5. Section 2, 5Y 4/2 and 5Y 2.5/2 striped mud; 50 cm: white ash spot (1 cm); and 80–83 cm: white and black ash clod. Section 4: Olive (5Y 4/4), probably highly disturbed monotonous lithology except in lower part. Sandy layer:mudy layer = 1:20. Section 5: Completely disturbed.

SMEAR SLIDE SUMMARY

	1-105
TEXTURE:	
Sand	42
Silt	13
Clay	45
COMPOSITION:	
Quartz	26
Feldspar	3
Mica	TR
Pyrite	3
Other heavy minerals	TR
Clay minerals	43
Volcanic glass	3
Glauconite	TR
Calc.-Dolo.-Arag.	3
Foraminifers	6
Calc. nannofossils	3
Diatoms	8
Sponge spicules	1
Silicoflagellates	TR

SITE 499 HOLE A CORE 5 CORED INTERVAL 33.5–43.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
QUATERNARY	*N. eggeri* (F) *G. oceanica* (N)	CM	FG	B		1 CC	0.5 1.0				*	Very dark ashy layer

Site 499A, Core 4: 24.0–33.5 m: No recovery.

BIOGENIC SILICEOUS MUD

Dark olive blue gray (5GY 4/1). Black scattered patches throughout base of Section 1.

SMEAR SLIDE SUMMARY

	1-93
TEXTURE:	
Sand	80
Silt	12
Clay	8
COMPOSITION:	
Quartz	60
Feldspar	6
Mica	TR
Pyrite	2
Mag. hematite	6
Clay minerals	6
Volcanic glass	TR
Glauconite	1
Calc.-Dolo.-Arag.	9
Foraminifers	7
Calc. nannofossils	2
Diatoms	3
Sponge spicules	1
Silicoflagellates	TR

SITE 499 HOLE B CORE 1 CORED INTERVAL 201.0–210.5 m

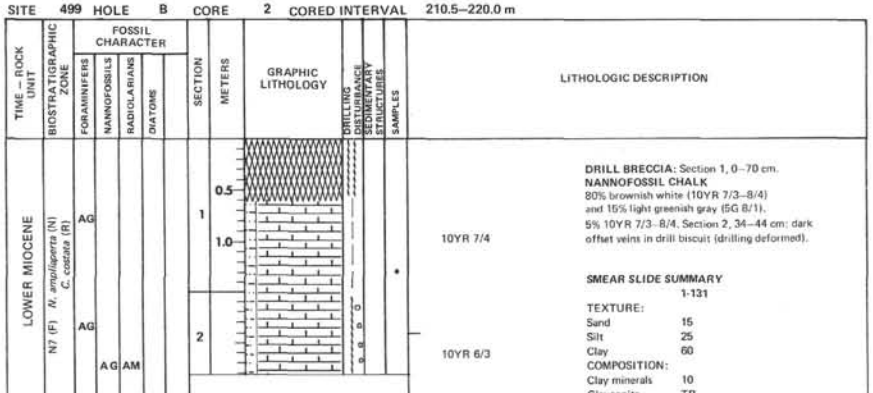
DIATOMACEOUS MUD
0–13 cm, 5Y 3/2

NANNOFOSSIL OOZE
13–16.5 cm, 10YR 8/1

SMEAR SLIDE SUMMARY

	CC-8	CC-16
TEXTURE:		
Sand	5	3
Silt	18	12
Clay	77	85
COMPOSITION:		
Quartz	4	–
Feldspar	TR	–
Mica	TR	–
Pyrite	1	–
Other heavy minerals	TR	–
Clay minerals	76	–
Volcanic glass	2	TR
Glauconite	TR	TR
Calc.-Dolo.-Arag.	–	15
Foraminifers	–	1
Calc. nannofossils	–	82
Diatoms	12	–
Radiolarians	3	2
Sponge spicules	2	TR
Silicoflagellates	TR	–

SITE 499 HOLE B CORE 2 CORED INTERVAL 210.5–220.0 m



DRILL BRECCIA: Section 1, 0–70 cm.
NANNOFOSSIL CHALK
80% brownish white (10YR 7/3–8/4) and 15% light greenish gray (5G 8/1).
5% 10YR 7/3–8/4. Section 2, 34–44 cm: dark offset veins in drill biscuit (drilling deformed).

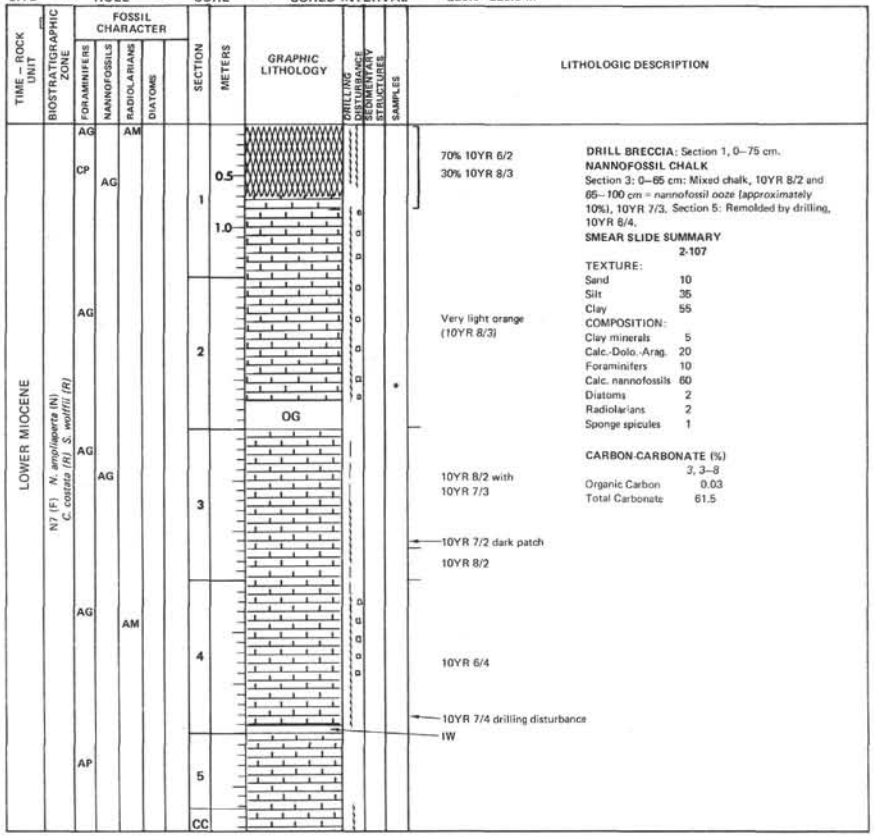
SMEAR SLIDE SUMMARY

	1-131
TEXTURE:	
Sand	15
Silt	25
Clay	60
COMPOSITION:	
Clay minerals	10
Glauconite	TR
Calc.-Dolo.-Arag.	45
Foraminifers	15
Calc. nannofossils	30
Radiolarians	1

CARBON-CARBONATE (%)

	2, 51–56
Organic Carbon	0.04
Total Carbonate	61.5

SITE 499 HOLE B CORE 3 CORED INTERVAL 220.0–229.5 m



DRILL BRECCIA: Section 1, 0–75 cm.
NANNOFOSSIL CHALK
Section 3: 0–65 cm: Mixed chalk, 10YR 8/2 and 65–100 cm = *nannofossil ooze (approximately 10%)*, 10YR 7/3. Section 5: Remolded by drilling, 10YR 8/4.

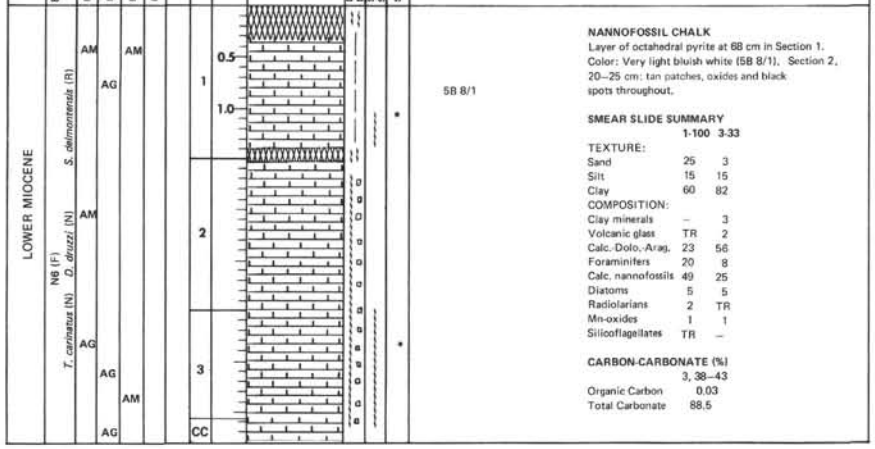
SMEAR SLIDE SUMMARY

	2-107
TEXTURE:	
Sand	10
Silt	35
Clay	55
COMPOSITION:	
Clay minerals	5
Calc.-Dolo.-Arag.	20
Foraminifers	10
Calc. nannofossils	60
Diatoms	2
Radiolarians	2
Sponge spicules	1

CARBON-CARBONATE (%)

	3, 3–8
Organic Carbon	0.03
Total Carbonate	61.5

SITE 499 HOLE B CORE 4 CORED INTERVAL 229.5–239.0 m



NANNOFOSSIL CHALK
Layer of octahedral pyrite at 68 cm in Section 1. Color: Very light bluish white (5B 8/1). Section 2, 20–25 cm: tan patches, oxides and black spots throughout.

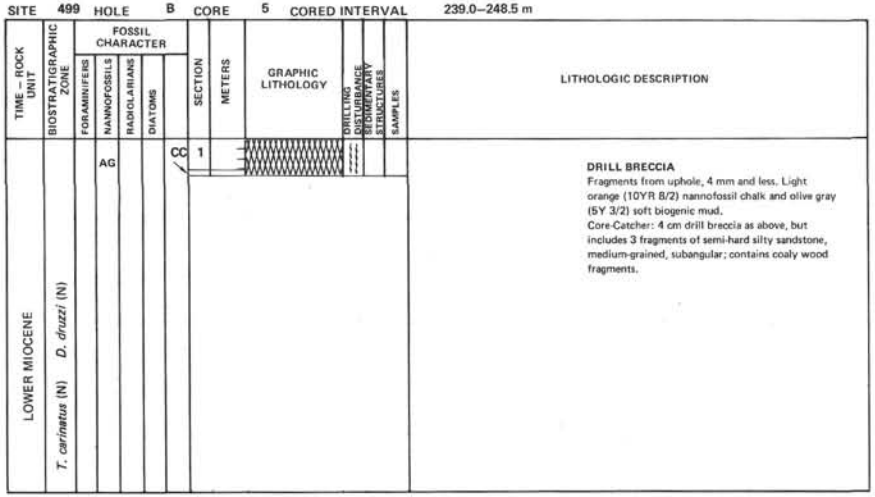
SMEAR SLIDE SUMMARY

	1-100	3-33
TEXTURE:		
Sand	25	3
Silt	15	15
Clay	60	82
COMPOSITION:		
Clay minerals	–	3
Volcanic glass	TR	2
Calc.-Dolo.-Arag.	23	56
Foraminifers	20	8
Calc. nannofossils	49	25
Diatoms	5	5
Radiolarians	2	TR
Mn-oxides	1	1
Silicoflagellates	TR	–

CARBON-CARBONATE (%)

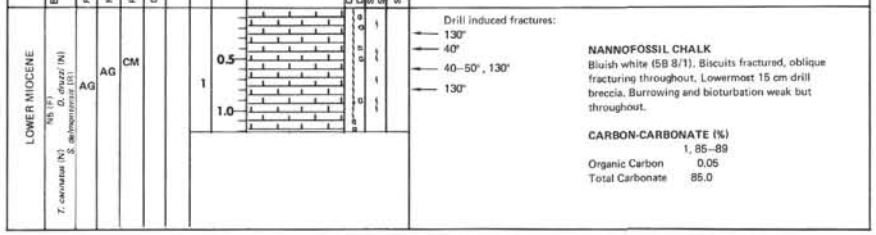
	3, 38–43
Organic Carbon	0.03
Total Carbonate	88.5

SITE 499 HOLE B CORE 5 CORED INTERVAL 239.0–248.5 m



DRILL BRECCIA
Fragments from uphole, 4 mm and less. Light orange (10YR 8/2) nannofossil chalk and olive gray (5Y 3/2) soft biogenic mud.
Core-Catcher: 4 cm drill breccia as above, but includes 3 fragments of semi-hard silty sandstone, medium-grained, subangular; contains coaly wood fragments.

SITE 499 HOLE B CORE 6 CORED INTERVAL 248.5–258.0 m

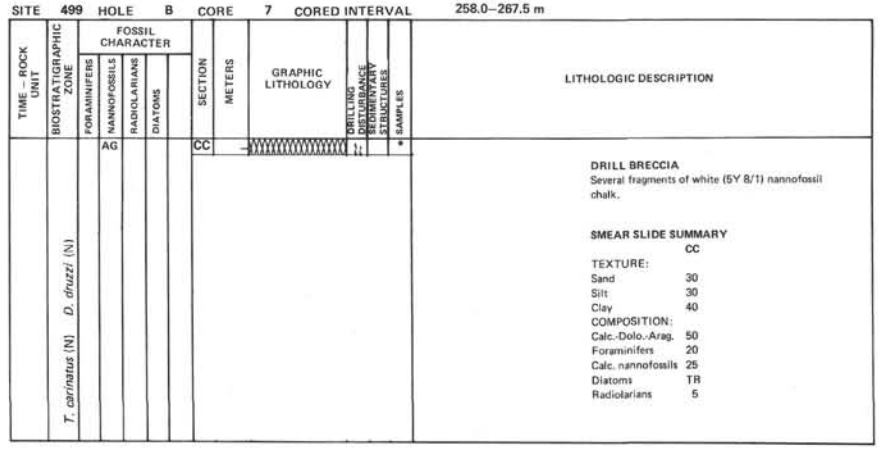


NANNOFOSSIL CHALK
Bluish white (5B 8/1). Biscuits fractured, oblique fracturing throughout. Lowermost 15 cm drill breccia. Burrowing and bioturbation weak but throughout.

CARBON-CARBONATE (%)

	1, 85–89
Organic Carbon	0.05
Total Carbonate	85.0

SITE 499 HOLE B CORE 7 CORED INTERVAL 258.0–267.5 m



DRILL BRECCIA
Several fragments of white (5Y 8/1) nannofossil chalk.

SMEAR SLIDE SUMMARY

	CC
TEXTURE:	
Sand	30
Silt	30
Clay	40
COMPOSITION:	
Calc.-Dolo.-Arag.	50
Foraminifers	20
Calc. nannofossils	25
Diatoms	TR
Radiolarians	5

SITE 499 HOLE B CORE 8 CORED INTERVAL 267.5–277.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	N4 (F) *T. carinatus* (N) *D. deflandrei* (N)	AG, AP, AG, AG, AG	AG, AG, AG	B, B, B		1, 2, 3, 4, CC	0.5, 1.0	IW			*	Soft, partly light gray (5Y 7/2) bioturbated; Fracture 55°; Fracture 60°; 90°; Fracture 60°; 90°

NANNOFOSSIL CHALK
Mottling moderate. Section 1, 50 cm–Section 3, 100 cm: 5Y 8/3–2.5Y 8/2. Manganese patches, scattered throughout. Section 2, 100 cm–Core-Catcher: 10YR 8/1.5 with 10YR 5/2 dusty pattern.

SMEAR SLIDE SUMMARY

	1-130
TEXTURE:	
Sand	5
Silt	7
Clay	88
COMPOSITION:	
Clay minerals	TR
Glauconite	TR
Calc.-Dolo.-Arag.	69
Foraminifers	6
Calc. nannofossils	35

CARBON-CARBONATE (%)

	4, 29–34
Organic Carbon	0.01
Total Carbonate	92.5

SITE 499 HOLE B CORE 9 CORED INTERVAL 277.0–285.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	N4 (F) *T. carinatus* (N) *D. deflandrei* (N)	CP, AP	AG			1, CC						10YR 7/2–6/2

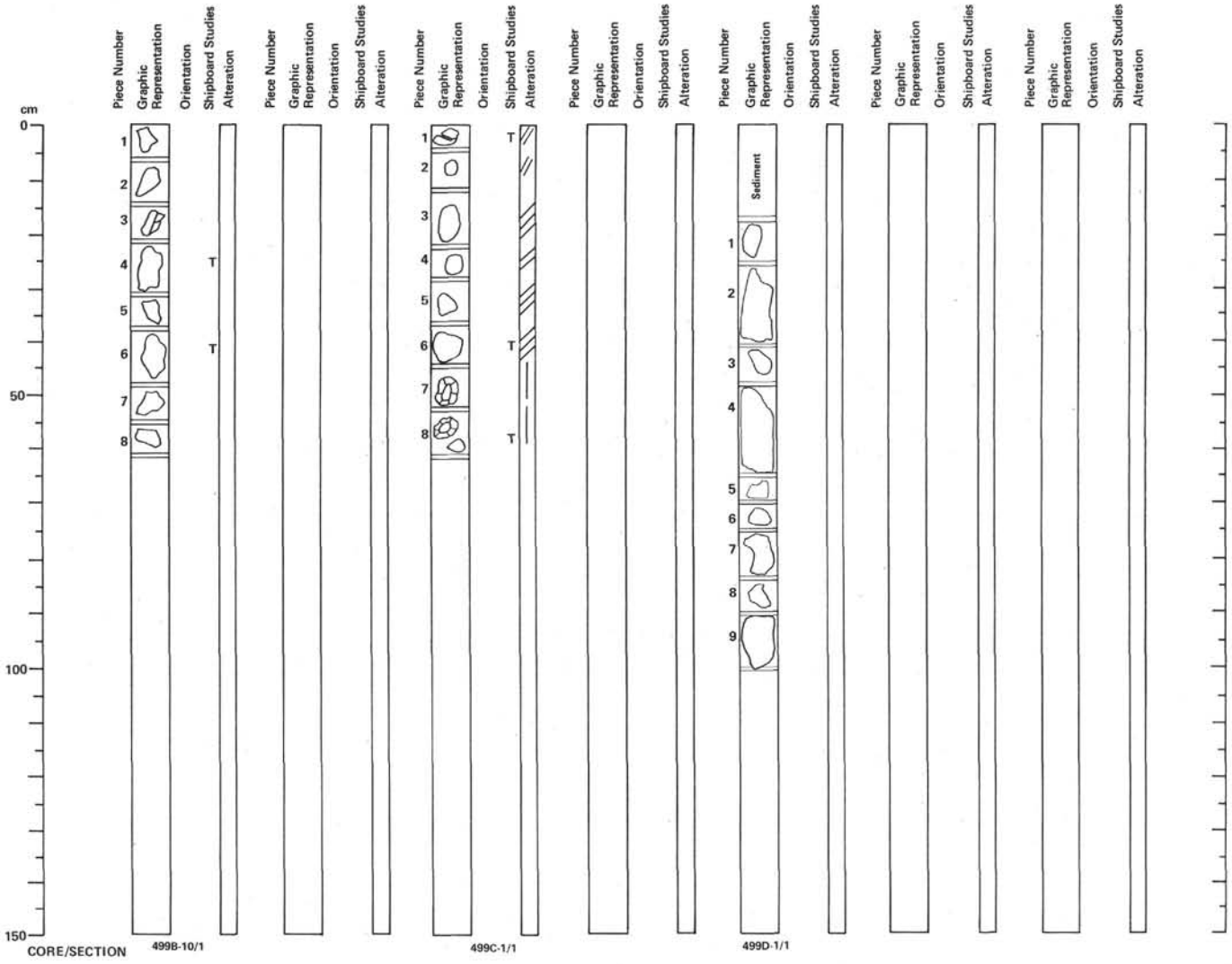
NANNOFOSSIL CHALK
Base of Core-Catcher: Basalt (dolerite).

SMEAR SLIDE SUMMARY

	CC-18
TEXTURE:	
Sand	1
Silt	20
Clay	79
COMPOSITION:	
Manganese	1
Volcanic glass	TR
Calc.-Dolo.-Arag.	33
Foraminifers	1
Calc. nannofossils	65

CARBON-CARBONATE (%)

	CC, 13–18
Organic Carbon	0.02
Total Carbonate	85.0



67-499B-10 Depth: 285.5–286.5 m

SECTION 1

Macroscopic Description

Predominantly dark gray basalt. Groundmass is crystalline and microlitic and contains plagioclase microphenocrysts (laths up to 2 mm in Piece 2) and olivine microphenocrysts (size <2 mm) in Piece 4, altered in orange-brown material. All the pieces, except Piece 1 (color pale yellow), fresh dark gray basalt.

Note: In Pieces 4 and 6 probably pyroxene (size <2 mm). Rare calcite veins in Pieces 3 and 7.

67-499C-1 Depth: 260.0–263.0 m

SECTION 1

Macroscopic Description

PHYRIC BASALT

Pieces 1–6: Dark gray, medium-grained phyric basalt; 5% 1–3 mm olivine phenocrysts, now completely altered to soft brown clay, 20%; clusters of plagioclase phenocrysts up to 5 mm diameter. In Pieces 3, 5, and 6, suggestion of weathering rinds developed on parts of the pieces. Glomerophenocrysts of plagioclase are lighter and more evident than they are in fresher cores.

APHYRIC WEATHERED BASALT

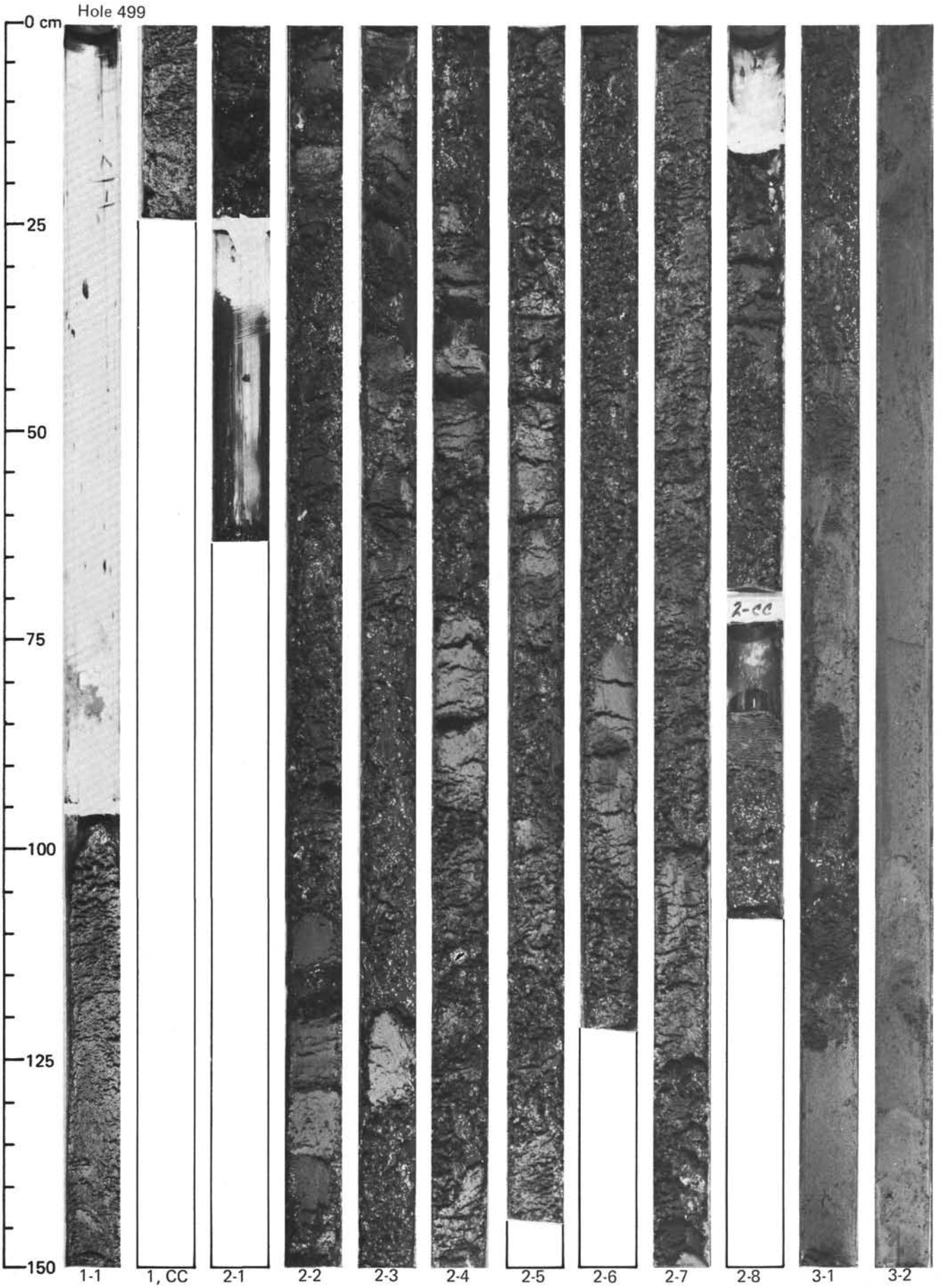
Pieces 7 and 8 are smoother and subrounded and have pale yellowish-gray exteriors. Weathering rinds are well developed, surrounding darker gray cores. These pieces are aphyric and aphanitic; tiny pyrite grains are abundant and disseminated throughout.

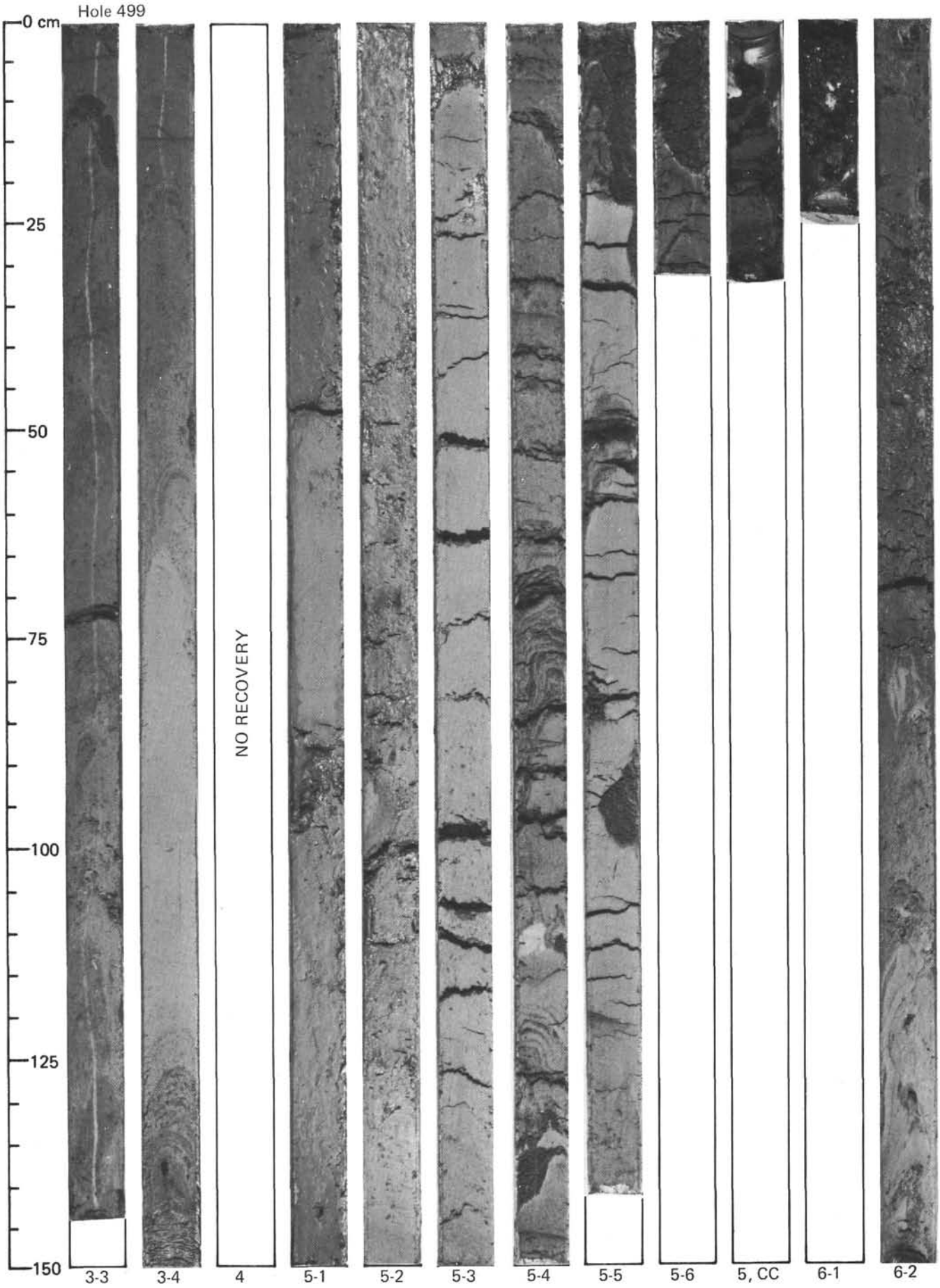
67-499D-1 Depth: 212.5–216.0 m

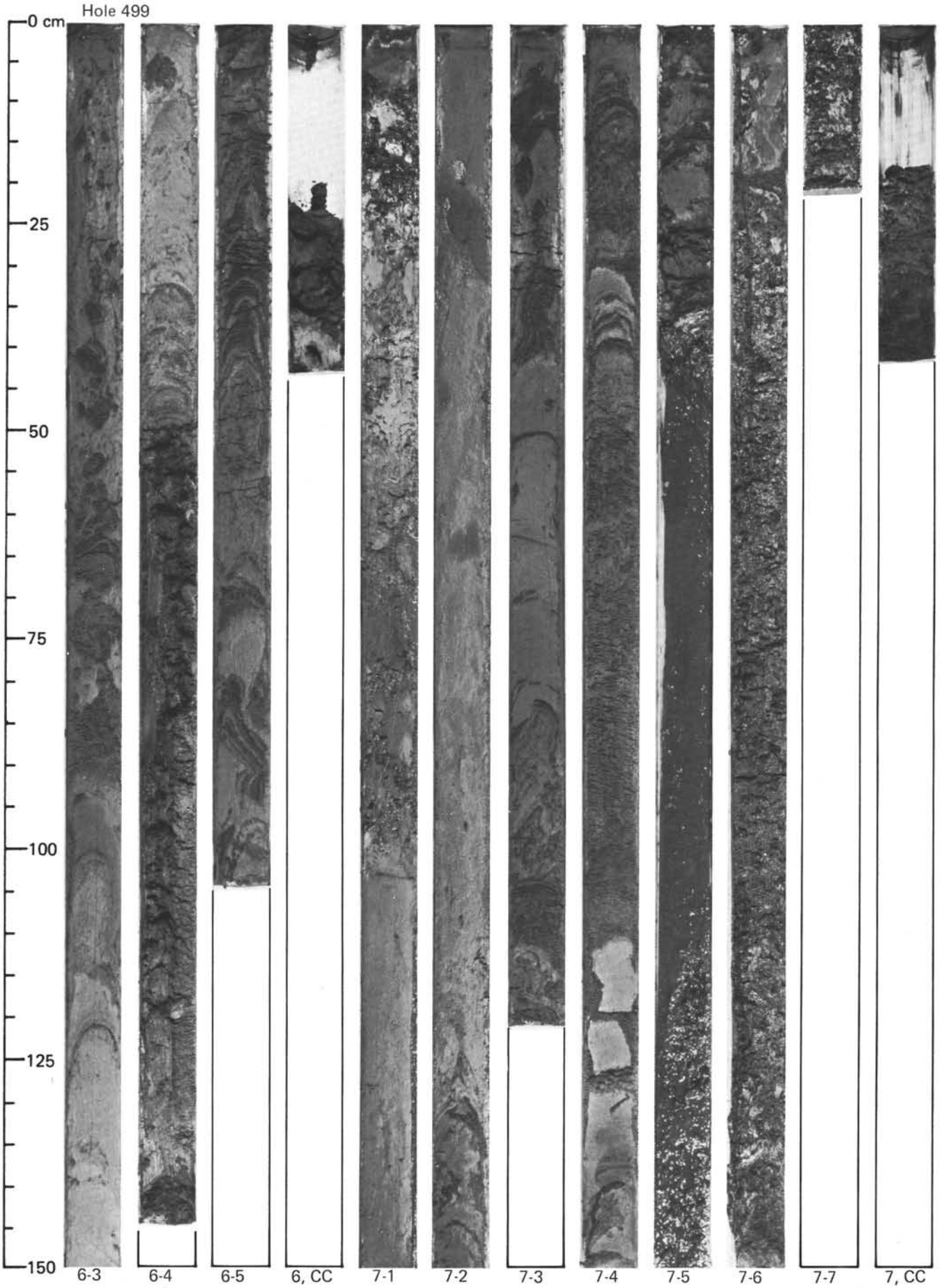
SECTION 1

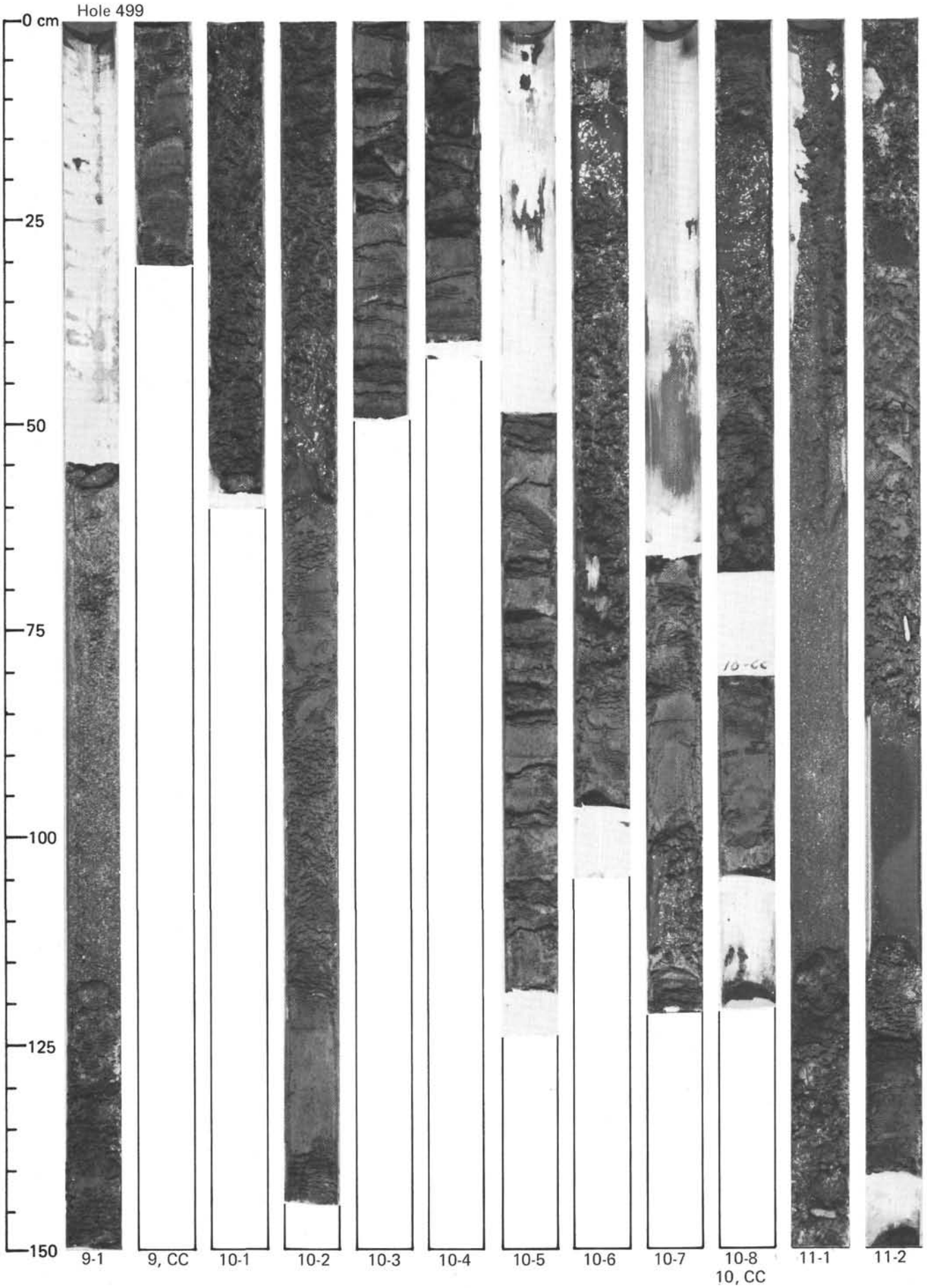
Macroscopic Description

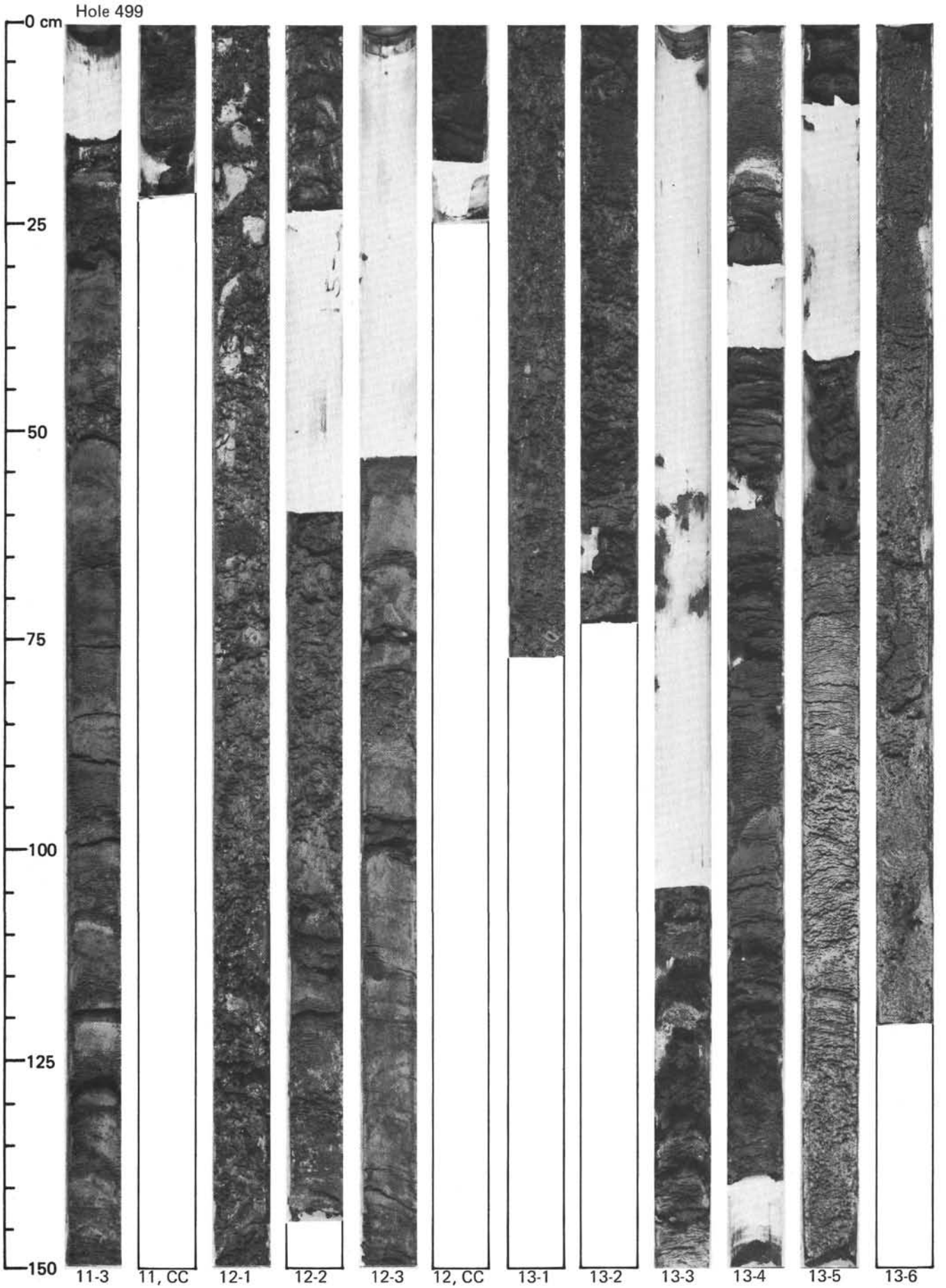
Weathered basalt (no detailed description available).

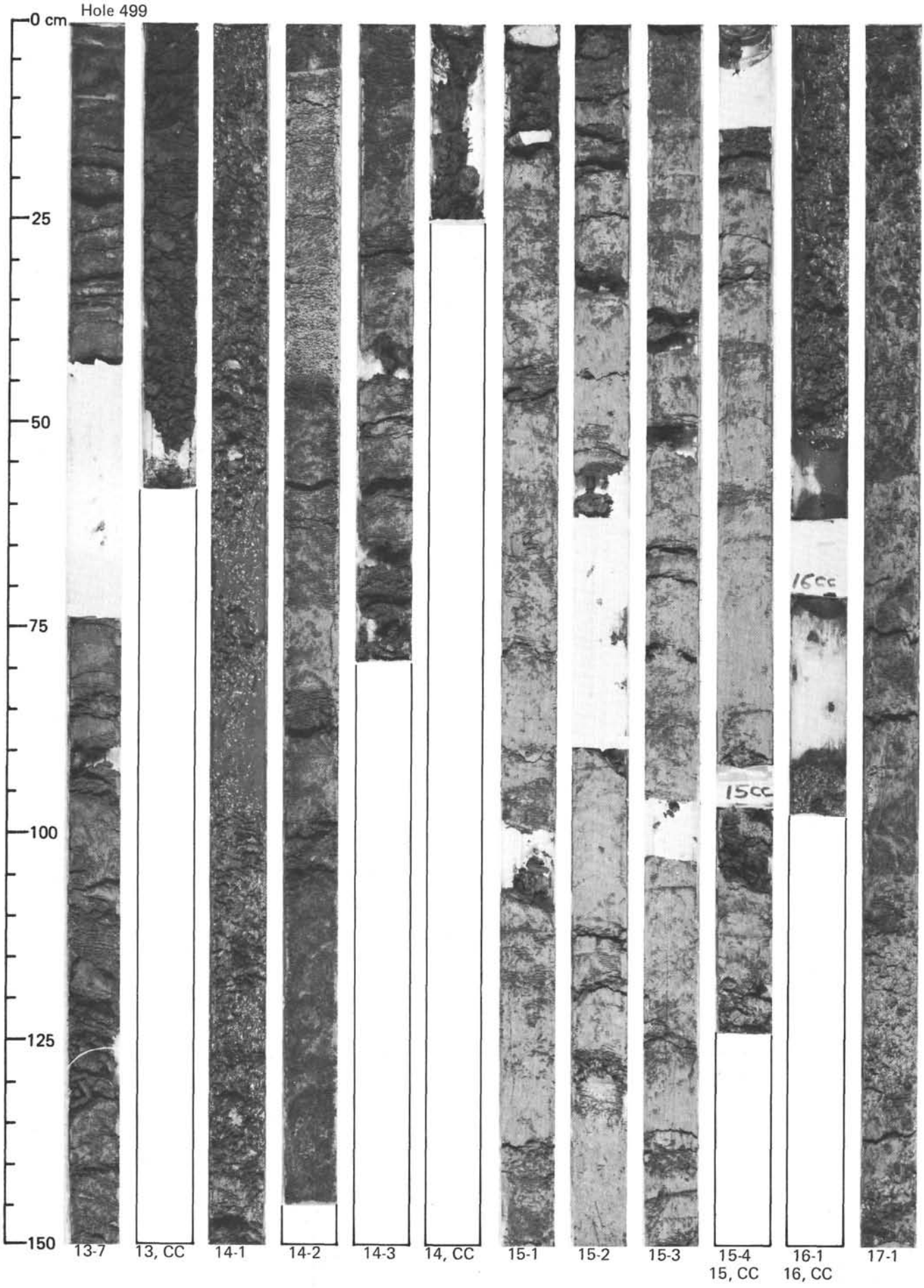

Hole 499
0 cm
25
50
75
100
125
150
2-CC
1-1
1, CC
2-1
2-2
2-3
2-4
2-5
2-6
2-7
2-8
3-1
3-2

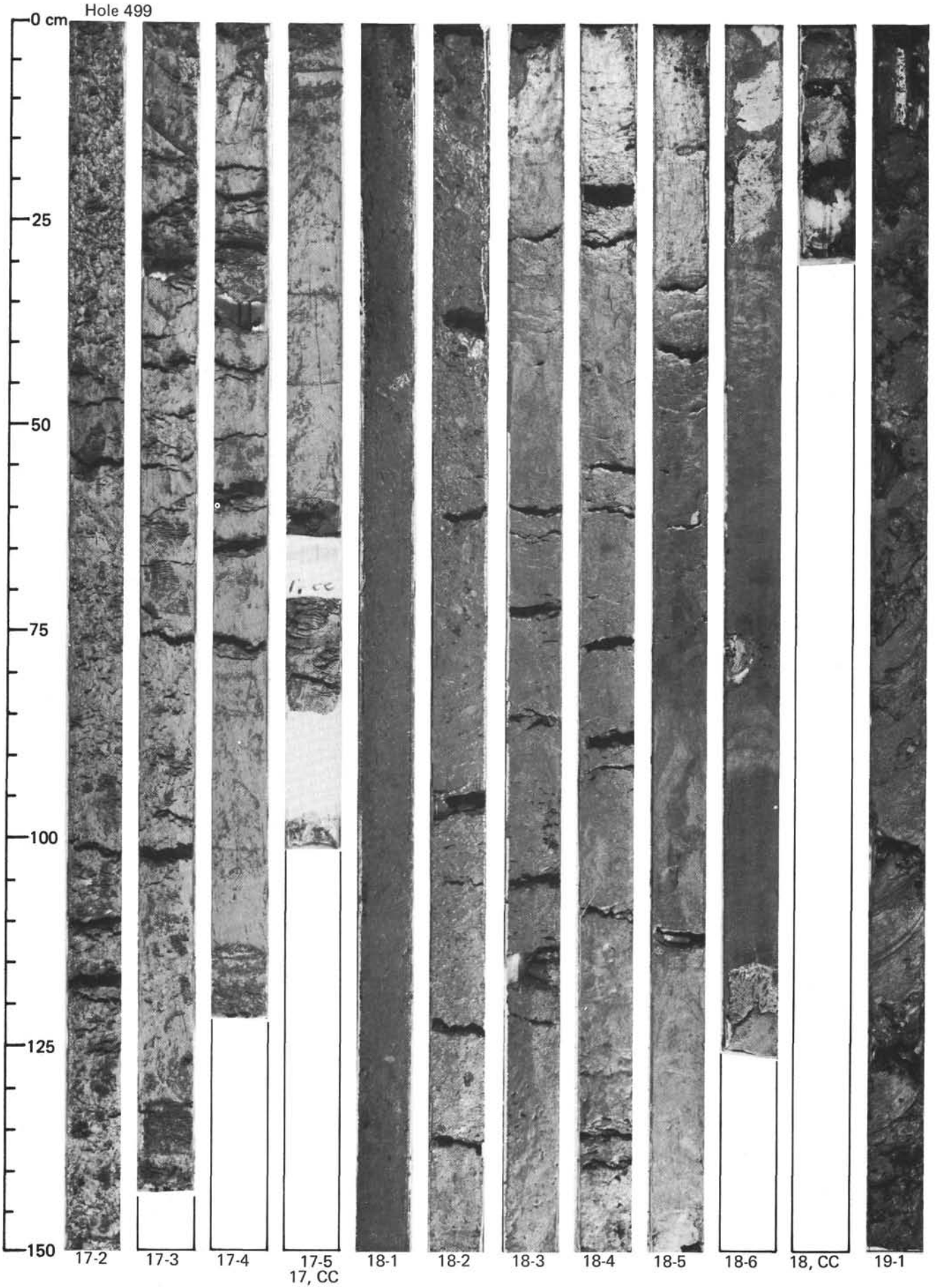

Hole 499
0 cm
25
50
75
100
125
150
NO RECOVERY
3-3
3-4
4
5-1
5-2
5-3
5-4
5-5
5-6
5, CC
6-1
6-2

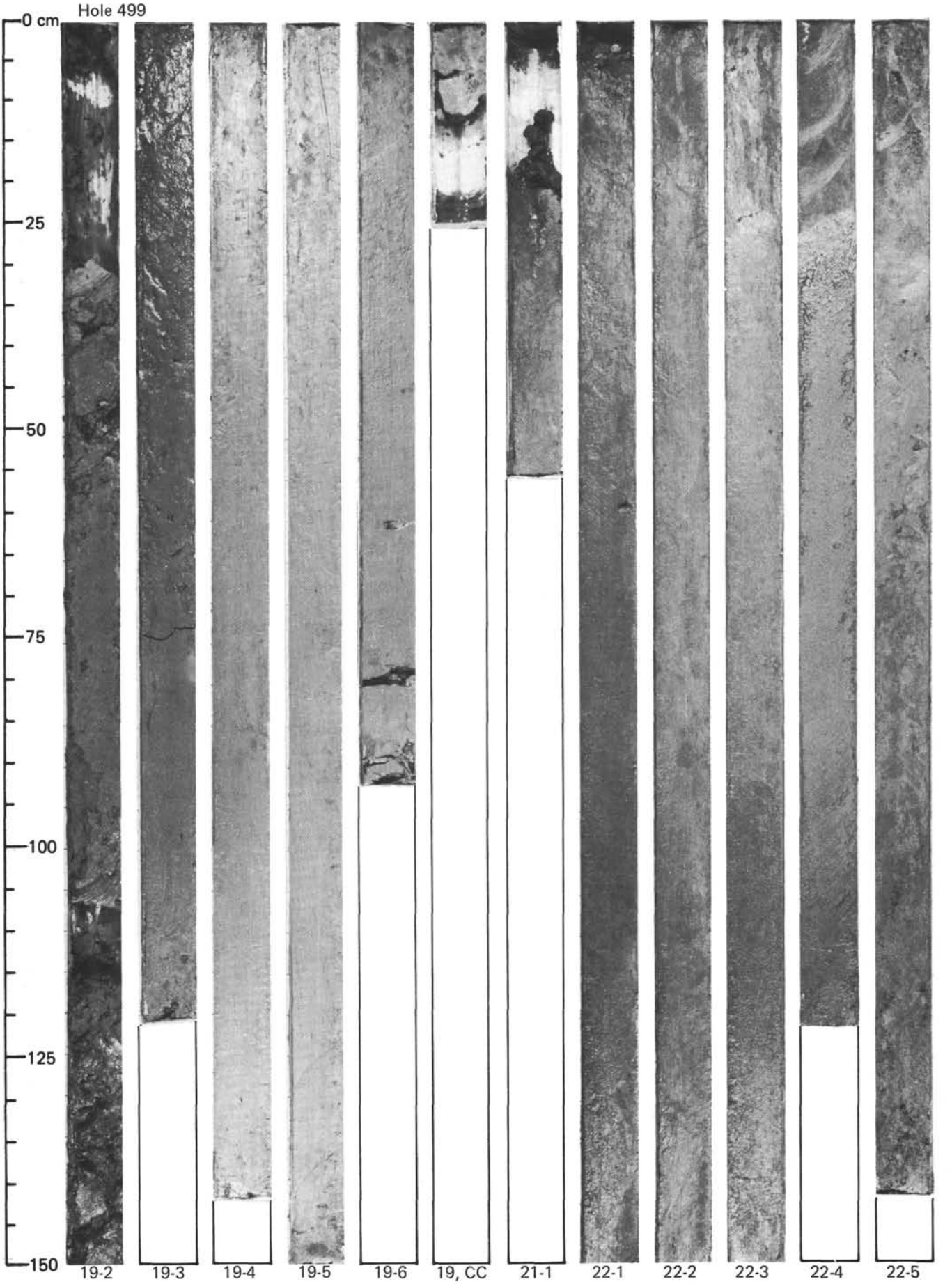

Hole 499
0 cm
25
50
75
100
125
150
6-3
6-4
6-5
6, CC
7-1
7-2
7-3
7-4
7-5
7-6
7-7
7, CC

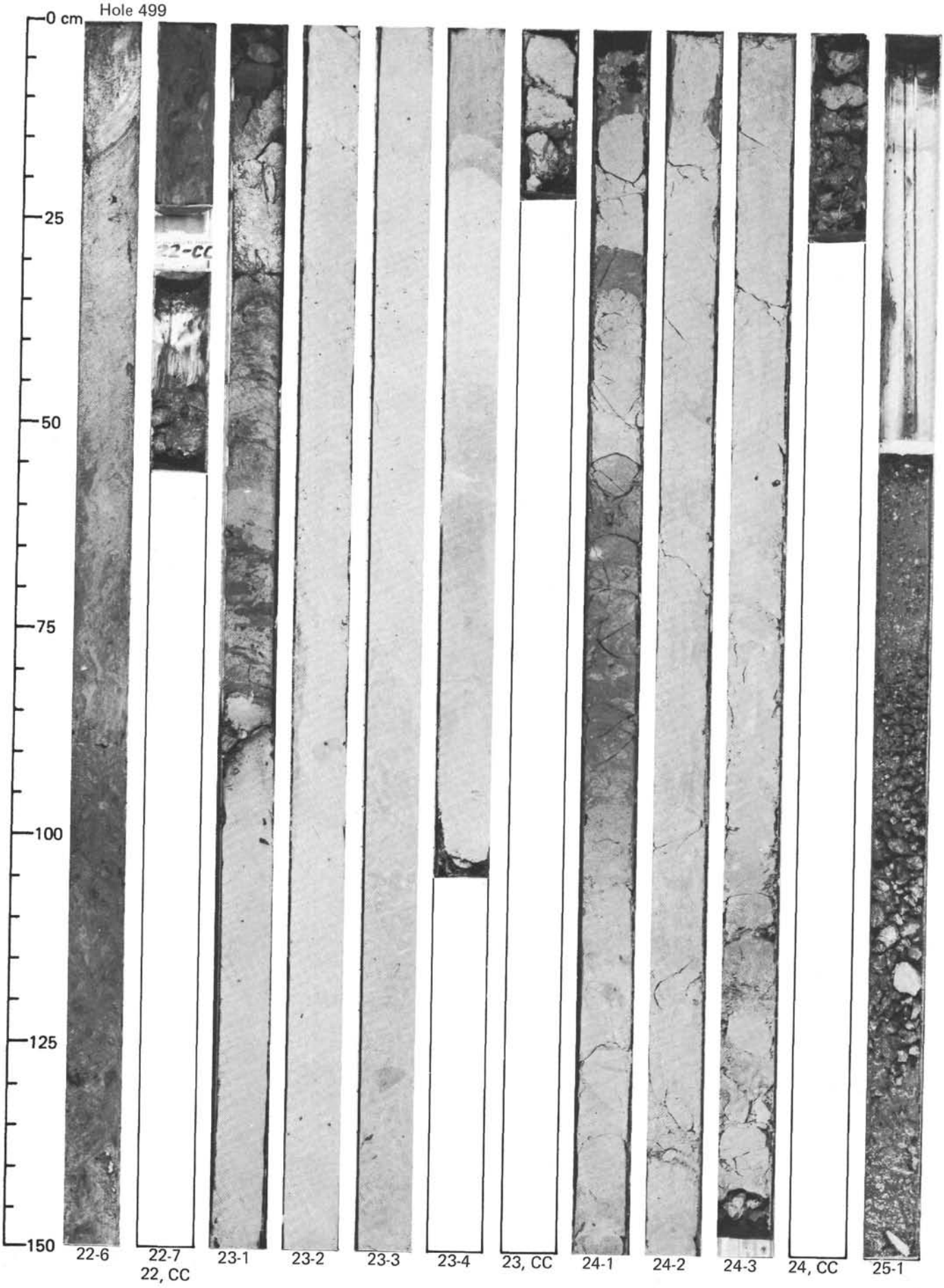

Hole 499
0 cm
25
50
75
100
125
150
9-1
9, CC
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10-8
10, CC
11-1
11-2

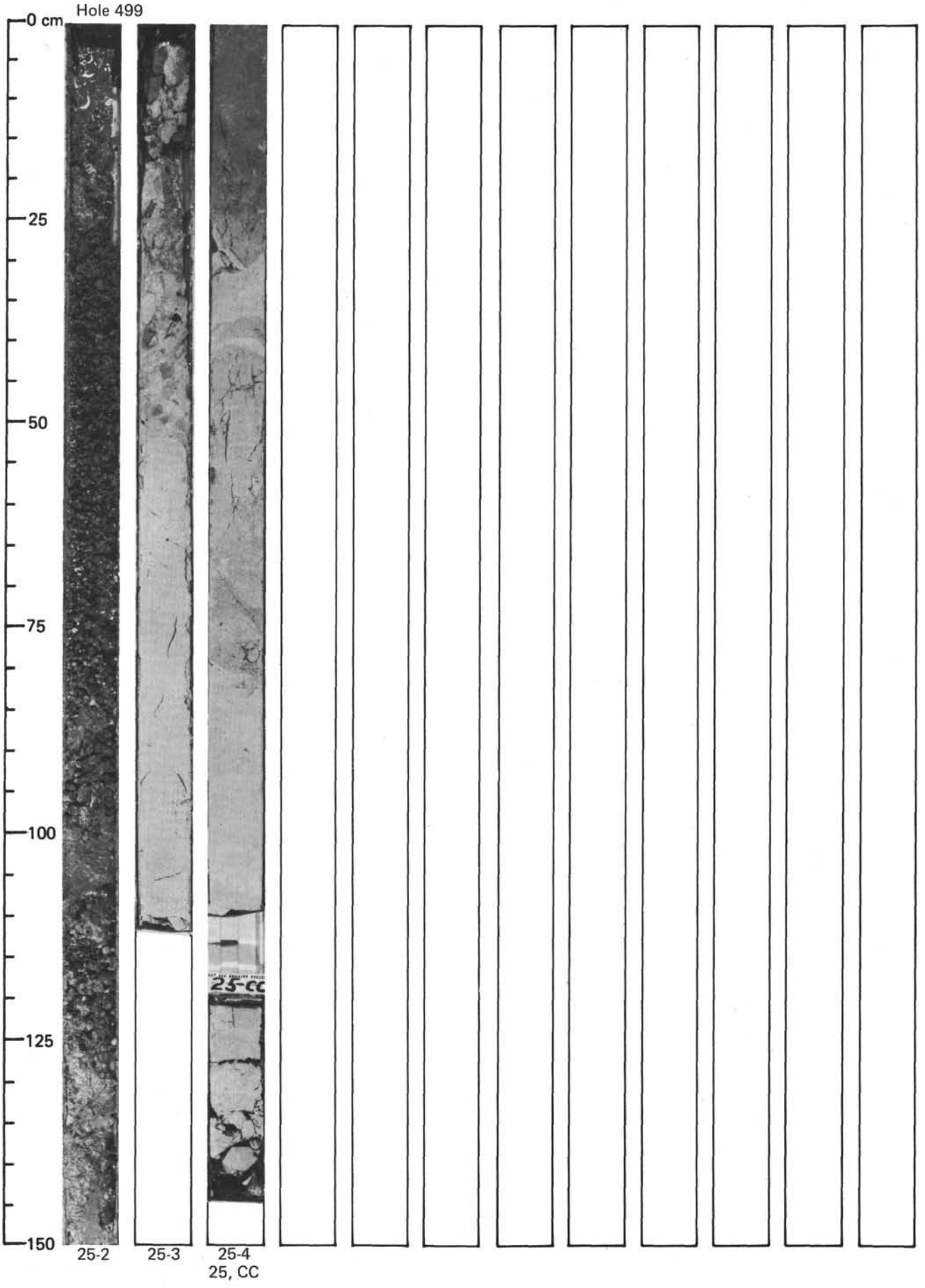

Hole 499
0 cm
25
50
75
100
125
150
11-3
11, CC
12-1
12-2
12-3
12, CC
13-1
13-2
13-3
13-4
13-5
13-6


Hole 499
0 cm
25
50
75
100
125
150
16cc
15cc
13-7
13, CC
14-1
14-2
14-3
14, CC
15-1
15-2
15-3
15-4
15, CC
16-1
16, CC
17-1


Hole 499
0 cm
25
50
75
100
125
150
17-2
17-3
17-4
17-5
17, CC
18-1
18-2
18-3
18-4
18-5
18-6
18, CC
19-1


Hole 499
0 cm
25
50
75
100
125
150
19-2
19-3
19-4
19-5
19-6
19, CC
21-1
22-1
22-2
22-3
22-4
22-5


Hole 499
0 cm
25
50
75
100
125
150
22-6
22-7
22, CC
23-1
23-2
23-3
23-4
23, CC
24-1
24-2
24-3
24, CC
25-1


Hole 499
0 cm
25
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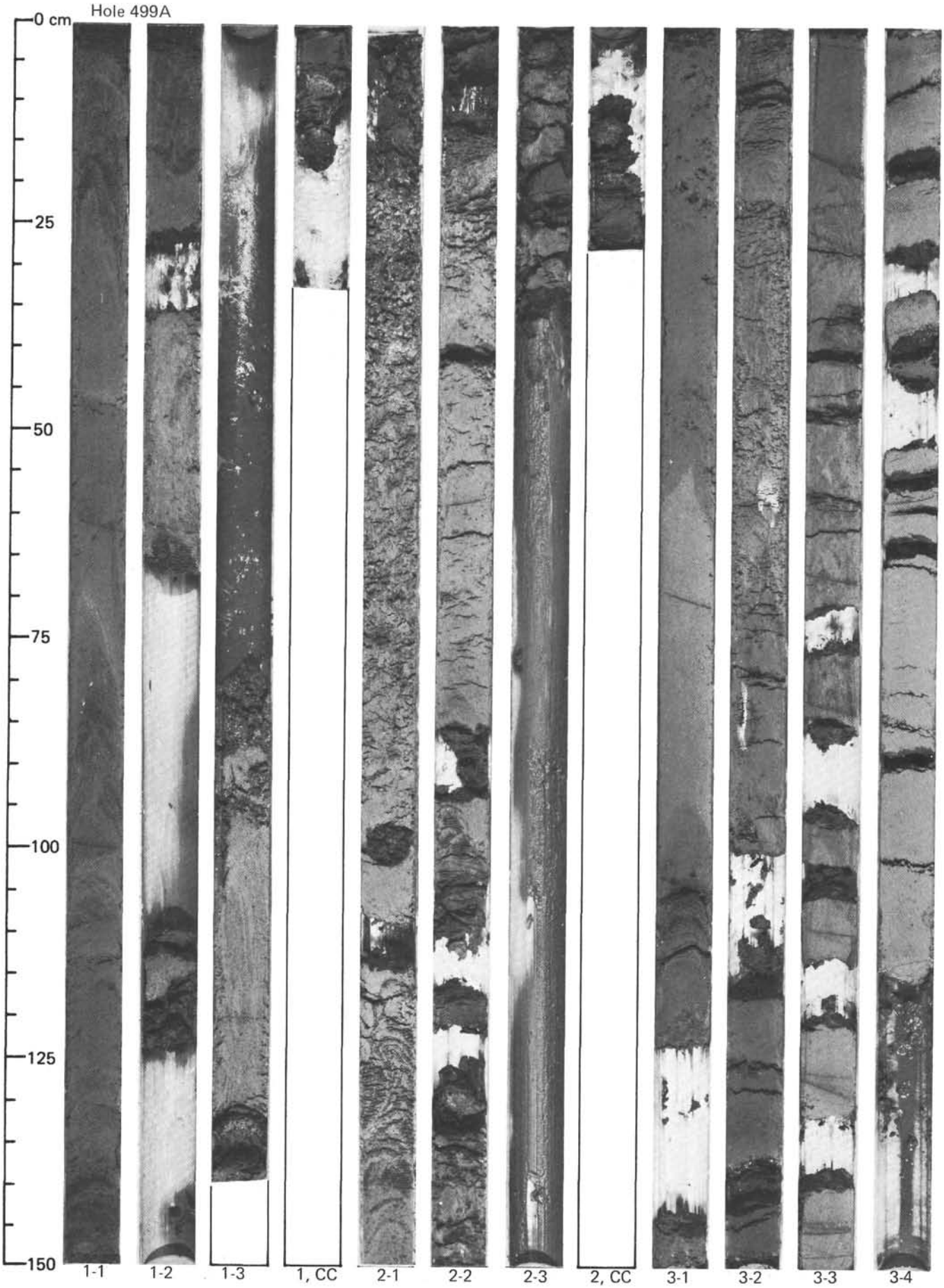
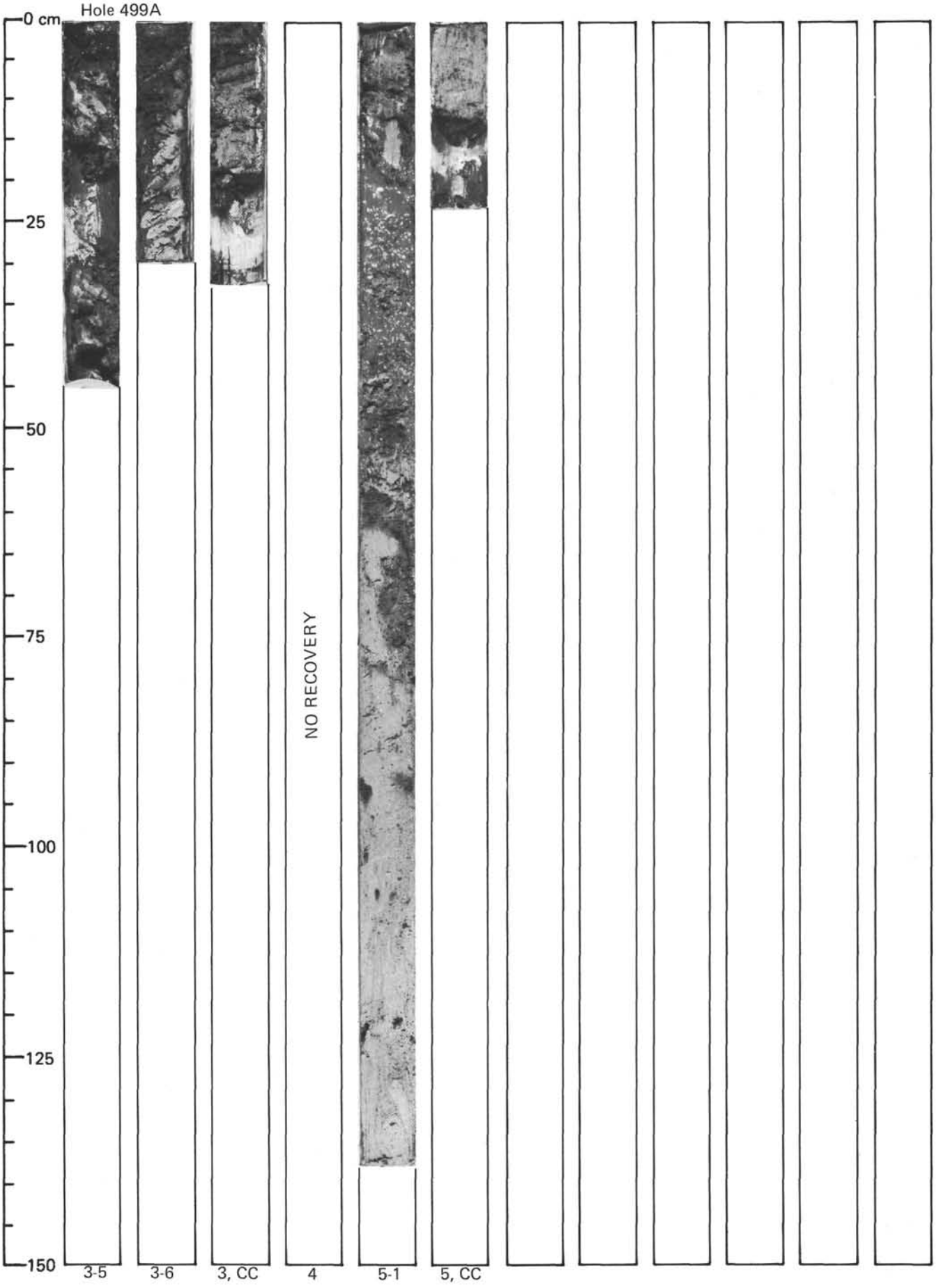
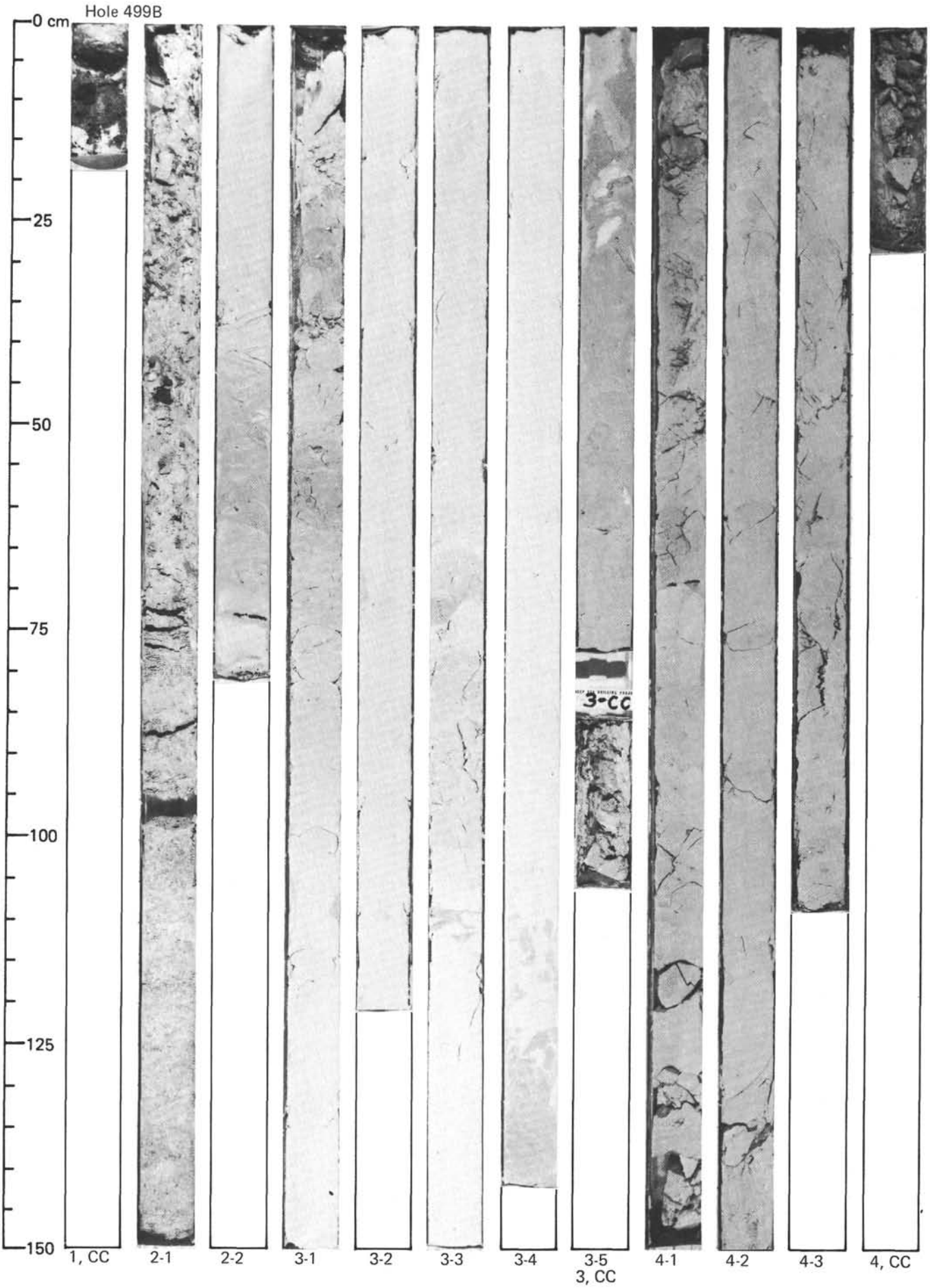
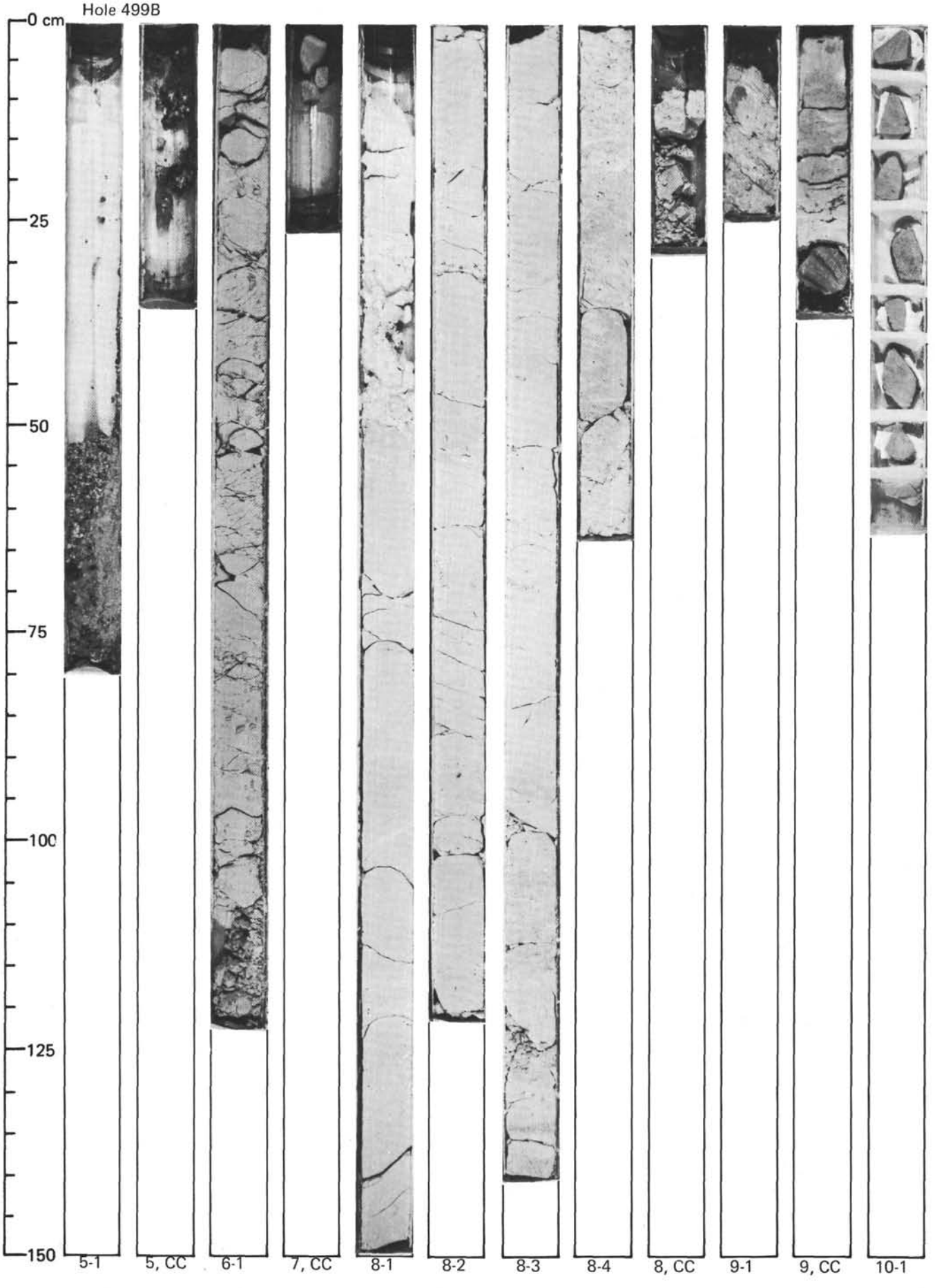
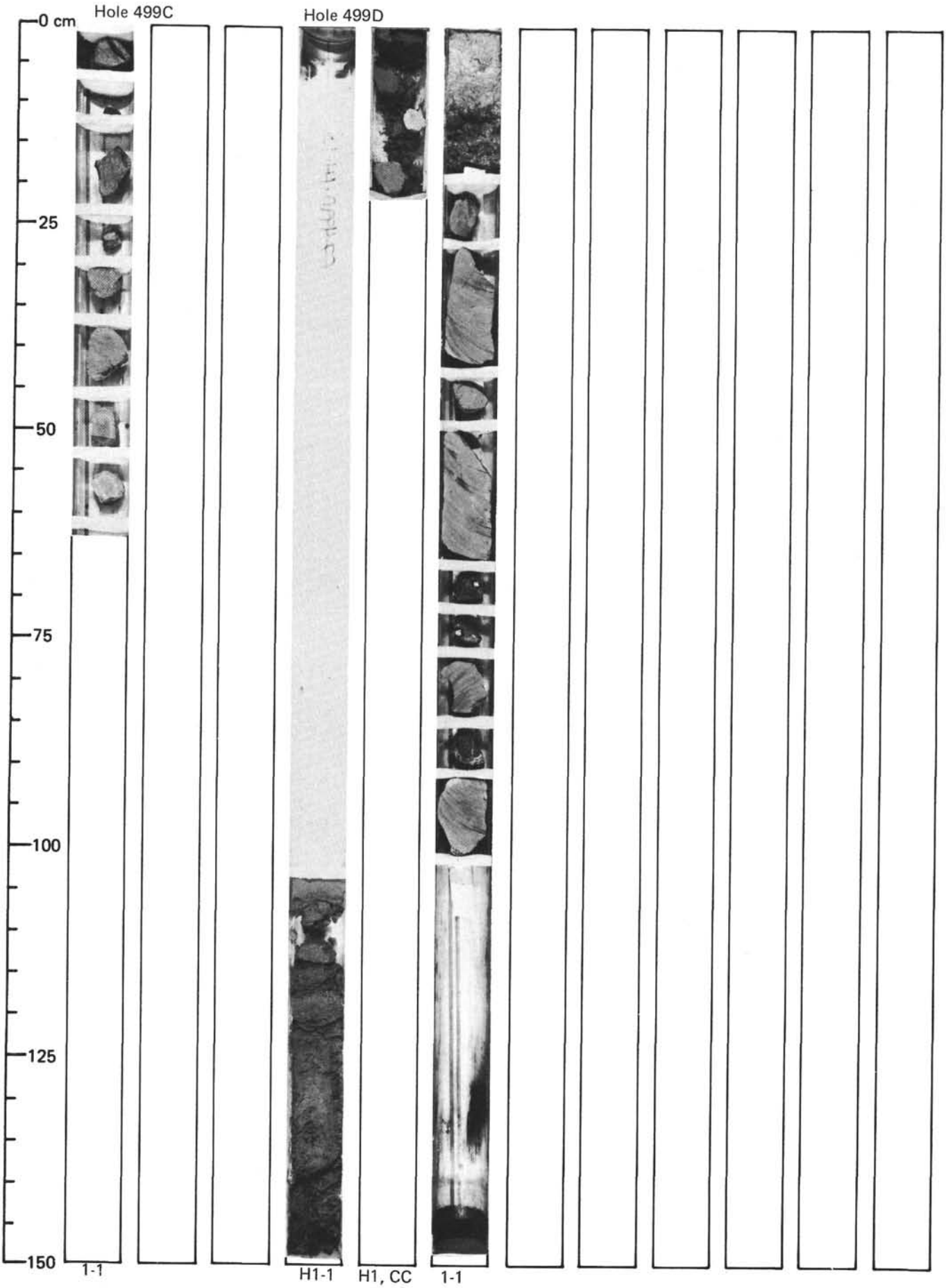
75
100
125
150
25-2
25-3
25-4
25, CC


Hole 499A
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1, CC
2-1
2-2
2-3
2, CC
3-1
3-2
3-3
3-4


Hole 499A
0 cm
25
50
75
100
125
150
NO RECOVERY
3-5
3-6
3, CC
4
5-1
5, CC


Hole 499B
0 cm
25
50
75
100
125
150
3-CC
1, CC
2-1
2-2
3-1
3-2
3-3
3-4
3-5
3, CC
4-1
4-2
4-3
4, CC


Hole 499B
0 cm
25
50
75
100
125
150
5-1
5, CC
6-1
7, CC
8-1
8-2
8-3
8-4
8, CC
9-1
9, CC
10-1


Hole 499C
Hole 499D
0 cm
25
50
75
100
125
150
1-1
H1-1
H1, CC
1-1