2. SITE 467: SAN MIGUEL GAP[1]

Shipboard Scientific Party[2]

HOLE 467

Date occupied: 10 October 1978

Date departed: 16 October 1978

Position: 33°50. 97′N, 120°45. 47′W

Water depth (sea level; corrected m, echo-sounding): 2127.8

Bottom felt (m, drill pipe): 2146

Penetration (m): 1041.5

Number of cores: 110

Total length of cored section (m): 1041.5

Total core recovered (m): 426.3

Core recovery (%): 41

Oldest sediment cored:
Depth sub-bottom (m): 1041.5
Nature: Claystone, silty claystone, clayey chalk
Chronostratigraphy: Middle Miocene (< 16.5 m.y. old)

Basement: Not reached

Principal results: Site 467 at San Miguel Gap was proposed to provide a Miocene to Quaternary reference section that would yield clues to the Neogene oceanographic history of the area. This site would also permit correlation between provincial California biostratigraphic sections and open-ocean tropical and midlatitude Pacific sequences dated by planktonic assemblages.

The Pliocene and Quaternary section consists of silty clay and diatomaceous nannofossil clay with local intervals of clayey dolomite and dolomitic limestone. Sediment accumulation rates increase downsection from 75 m/m.y. in the Quaternary to 150 m/m.y. in the early Pliocene. A hiatus from 0.9 to 1.5 m.y. is found in Core 8 at a depth of 70 meters, and another hiatus from 3.3 to 3.6 m.y. is found in Core 27 at a depth of 245 meters. The base of Lithologic Unit 1 is at 367 meters within the lower Pliocene, corresponding to a change from weak, discontinuous, low-frequency reflections in Unit 1 to strong, fairly continuous reflections in Unit 2. The Unit 1/Unit 2 boundary at 367 meters is a slight angular unconformity based upon single-channel seismic profiles, but this unconformity is neither confirmed nor precluded by paleontological evidence. The boundary is mainly a diagenetic break from clay to claystone. It also marks a velocity inversion from 1.71 km/s above to 1.61 km/s below, probably the result of high gas content in Unit 2.

Unit 2 consists of calcareous claystone deposited in the early Pliocene and late Miocene (with minor siliceous claystone becoming more indurated with depth). Sediment accumulation rates decrease downsection in the unit from 150 m/m.y. to 50 m/m.y. The interval that is 400 to 450 meters deep is characterized by disappearance downsection of siliceous microfossils and planktonic foraminifers; only coccoliths persist below this depth. This trend may be associated with paleoceanographic changes in the San Miguel Gap area, a diagenetic effect, or a change in biologic productivity. A major reflector occurs within the unit at a depth of 528 meters, corresponding to a downward increase in velocity from 1.61 km/s in relatively gassy sediments to 3.38 km/s in better-cemented strata.

Unit 3 is interbedded lapilli tuff and nannofossil clay chalk and limestone. Deposition of the material took place during the early late and late middle Miocene. The base of the unit is the lowermost tuff bed at 832.5 meters; the top is marked at the first lapilli tuff bed at 700 meters. At 747 meters, however, where lapilli tuff is the dominant lithology, a prominent seismic boundary separates an acoustic unit with strong, continuous low-frequency reflectors from an underlying acoustic unit with weak reflectors.

Unit 4 is similar to Unit 2, consisting of interbedded clayey chalk and calcareous claystone with minor fine-grained quartzofeldspathic sandstone. Deposited in the middle Miocene, the oldest faunal assemblages of the unit are slightly younger than 16.5 m.y.

BACKGROUND AND OBJECTIVES

The Neogene history of the California Current and the general oceanographic history of the northeastern Pacific were the major objectives of Site 467 as well as of most other DSDP Leg 63 sites (Fig. 1). The southward-flowing California Current is a major eastern boundary current that has dominated the hydrographic scene in this area at least since the Cretaceous (Sliter, 1972). During the Neogene, the intensity of the California Current oscillated considerably in response to major climatic changes. These oscillations are reflected in changes of the distribution patterns of marine biota in the marginal eastern Pacific.

Studies of planktonic foraminifers (Ingle, 1973) suggest that, following relatively stable temperature conditions in the middle Miocene, a major and sustained southward shift of isotherms (and thus subpolar planktonic assemblages) occurred during the late Miocene (ca. 10.5 to 5 m.y. ago). The 10°C isotherm may have been displaced as far south as 28°N latitude. The Miocene/Pliocene boundary is marked by even farther southward displacement of subpolar assemblages, followed by a northward incursion of temperate to subtropical assemblages, resulting in "mixed" assemblages as far north as 40°N latitude (von Huene and Kulm, 1973). The remainder of the Pliocene record is a series of minor oscillations that culminate in a major northward incursion of subtropical assemblages to 40°N

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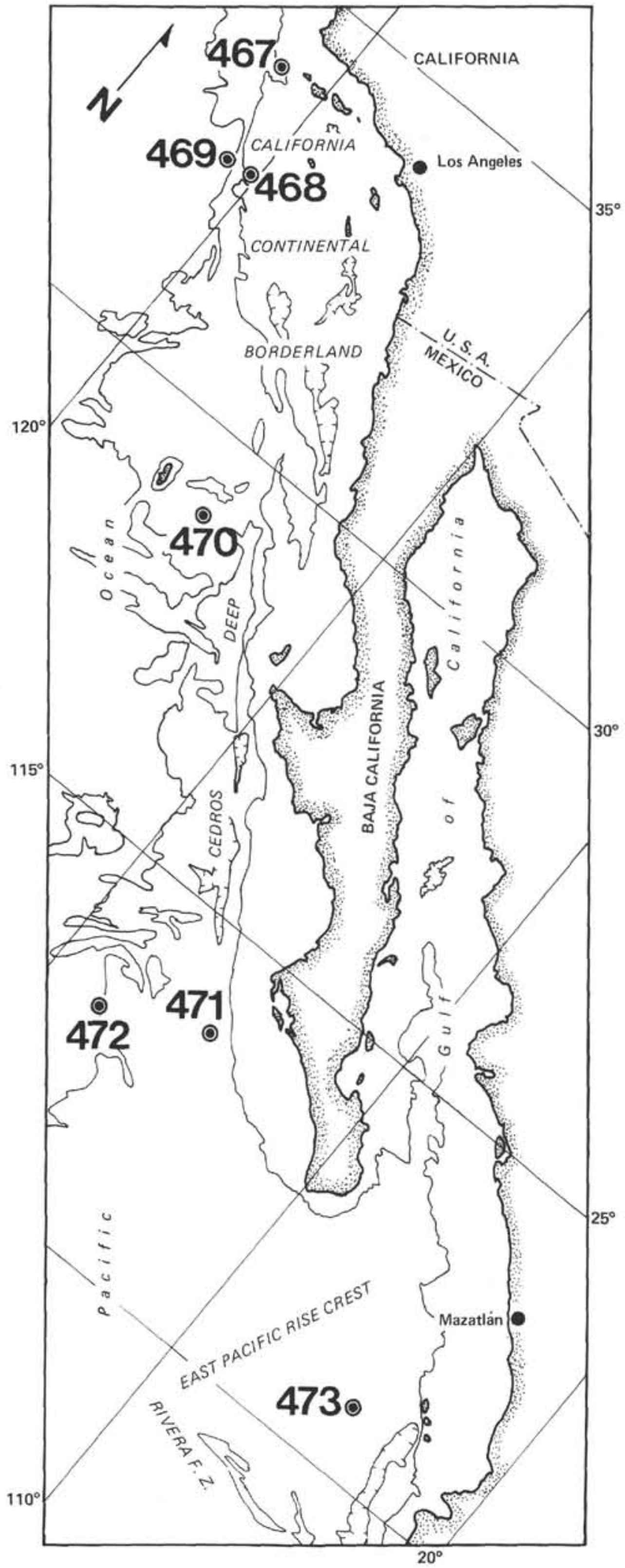

Figure 1. Locations of Leg 63 sites.

latitude. During the Pleistocene, subpolar assemblages characterized the eastern Pacific margin south to 30°N and perhaps as far south as 20°N into the Gulf of California. The last interglacial period (Holocene) was characterized by a northward migration of temperate assemblages.

Site 467 is located near the distal end of the present-day California Current, where changes in the planktonic assemblages should readily point to the major changes in intensity and extent the current has undergone in the past. In addition, it was thought that the expanded sedimentary section expected at Site 467 would be well suited for study of the biogeography and development of planktonic communities.

The California Continental Borderland constitutes a broad transition zone between continental rocks of coastal California and oceanic rocks at the foot of the Patton Escarpment, the local name for the continental slope (Fig. 2). The northern boundary is the west-trending Transverse Ranges at latitude 34°N. South of the Transverse Ranges, the borderland broadens to a width of 220 to 225 km; the zone tapers gradually southeast to Vizcaino Bay at about 28°N. The borderland may reflect the transition from a subducting plate boundary between the American and Farallon plates to a transform boundary between the American and Pacific plates as the Farallon plate was consumed at the continental margin. The borderland consists of a series of northwest-trending ridges and basins that began to form in the middle Tertiary and were accentuated in the late Tertiary and in the Quaternary (Vedder et al., 1974). Pre-middle Tertiary geology permits subdivision into three northwest-trending belts: (1) inner borderland, (2) island block, and (3) outer borderland (Yeats, 1976). In the inner borderland, blueschist-bearing basement (Catalina Schist—similar to blueschist in the Franciscan complex of central and northern California) (Platt, 1976; Crouch, 1979a) is overlain by middle Miocene and younger marine strata that contain clasts of the underlying basement. The island block comprises a thick Mesozoic and Paleogene sequence that contains only detritus from the continent and no clasts of Catalina Schist or other borderland basement. Ophiolitic basement on Santa Cruz Island (Hill, 1976) may belong to this block, but similar ophiolitic rocks are found on Santa Catalina Island (Platt, 1976) and in the western Los Angeles Basin. The sedimentary strata in this block are similar to the Great Valley forearc sequence of central California (Crouch, 1979a).

The outer borderland, where Site 467 is located, resembles the inner borderland in that a Miocene and younger sequence rests on a Franciscan-like basement (Crouch, 1979a). This basement is different, however, because it contains little blueschist but considerable laumontite; ultramafic rocks are also found. The age of this basement is unknown. Laumontite-bearing coastal-belt "Franciscan" of the northern California Coast Ranges has yielded Paleogene fossils, in contrast to the Cretaceous fossils of the Franciscan farther east. Thus it

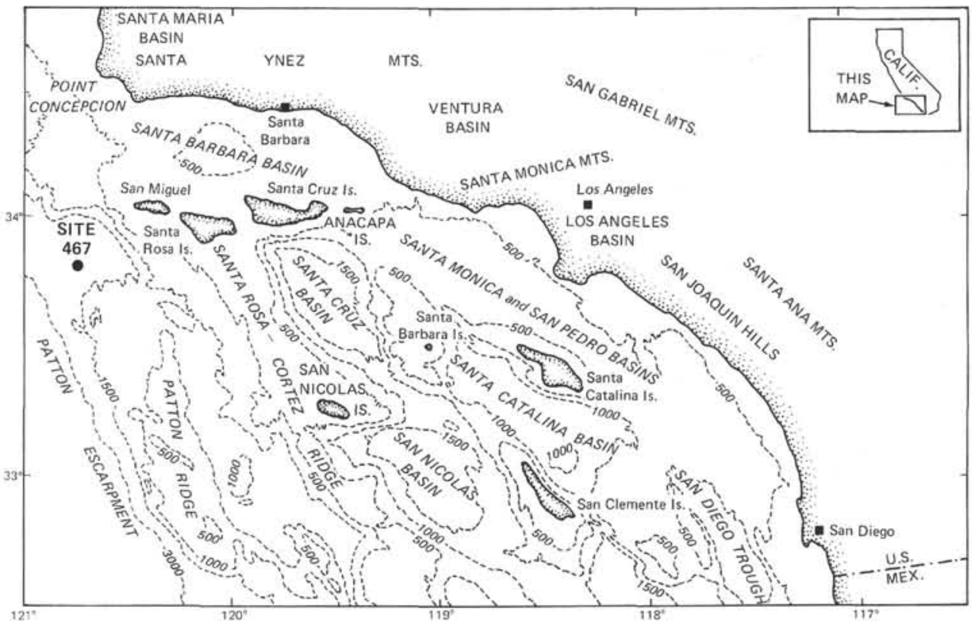

Figure 2. Generalized bathymetric map of the California Continental Borderland. (The location of Site 467 is indicated by the black circle.)

is possible that the basement of the outer borderland includes rocks that are Paleogene.

Mafic and intermediate volcanic rocks 14 to 17 m.y. old are common throughout the borderland, particularly on ridge tops. These include flows, breccias, dikes, and small plutons; larger plutons may underlie some of the ridges at considerable depth.

The west-facing Patton Escarpment is indented at 33°50′N by a broad embayment nearly 20 km in diameter called San Miguel Gap (Fig. 3). East of this indentation is a west-trending platform containing the northern Channel Islands. South of the indentation, the Patton Escarpment contains presumably Miocene volcanic rocks and micaceous, moderately hard siltstone and claystone of unknown age; farther south, laumontite-bearing lithic wackes that are possibly Franciscan are found on the escarpment.

San Miguel Gap may be underlain by similar Franciscan basement; the prominent basement reflector is underlain by east-dipping horizons that are suggestive of thrust planes (Figs. 4 and 5; Crouch et al., 1978). A broadly folded sequence overlying the basement may have been deposited during the early Miocene; it is not well bedded on the multichannel seismic record. Alternatively, it may be part of the Paleogene sequence known farther east in the island block. Stacking velocities in this sequence are 2.7 to 3 km/s, about 1.5 km/s slower than stacking velocities in the basement. Overlying strata are broadly draped on topographic highs on the basement surface; these lap onto the east-facing ridge of the Patton Escarpment and thus may all be younger than the Miocene volcanic rocks found on the escarpment. Prominent reflectors within this sequence may lie within the upper Miocene and the Pliocene, respectively. Stacking velocities are 2.05 to 2.45 km/s. The Recent to upper Pliocene portion of the sequence appears to rest with slight angular unconformity on older beds near the Patton Escarpment, but at the site these beds are parallel to one another. Stacking velocities in the youngest sequence are 1.6 to 1.84 km/s.

In the Channel Islands and adjacent Santa Barbara and Ventura basins, strata deposited in the early Miocene (Saucesian of Kleinpell, 1938) rest unconformably on Eocene marine rocks (Weaver, 1969). Strata deposited in the late Miocene (Mohnian of Kleinpell, 1938) unconformably overlie older rocks in the Santa Cruz submarine canyon between the Santa Cruz and Santa Rosa islands; an unconformity of this age is also found in the Santa Monica Mountains. After the Mohnian, the Ventura and Los Angeles basins assumed their present structural configuration, and the major lithology changed from the siliceous, organic Monterey Shale to the more terrigenous Pliocene deposits. A similar increase in terrigenous contributions that occurred at the same time was noted by Ingle (1973) at DSDP Site 173 off northern California. This increased terrigenous contribution may be related to an acceleration of vertical tectonics that began about 4 m.y. ago and resulted in vertical subsidence rates greater than 5 mm/yr about a million years ago (Yeats, 1978). We anticipated that Site 467 would contribute information regarding the age of unconformities in the outer borderland that could be related to tectonic events onshore, including motion on the San Andreas fault.

At Site 467, we expected to encounter a section of Pliocene–Quaternary strata (stacking velocities of 1.84 km/s and less) 370 meters thick, underlain by 800 meters of Miocene rocks with stacking velocities 2.05 to 2.45 km/s. We did not plan to penetrate the older sequence unconformably underlying the Miocene strata.

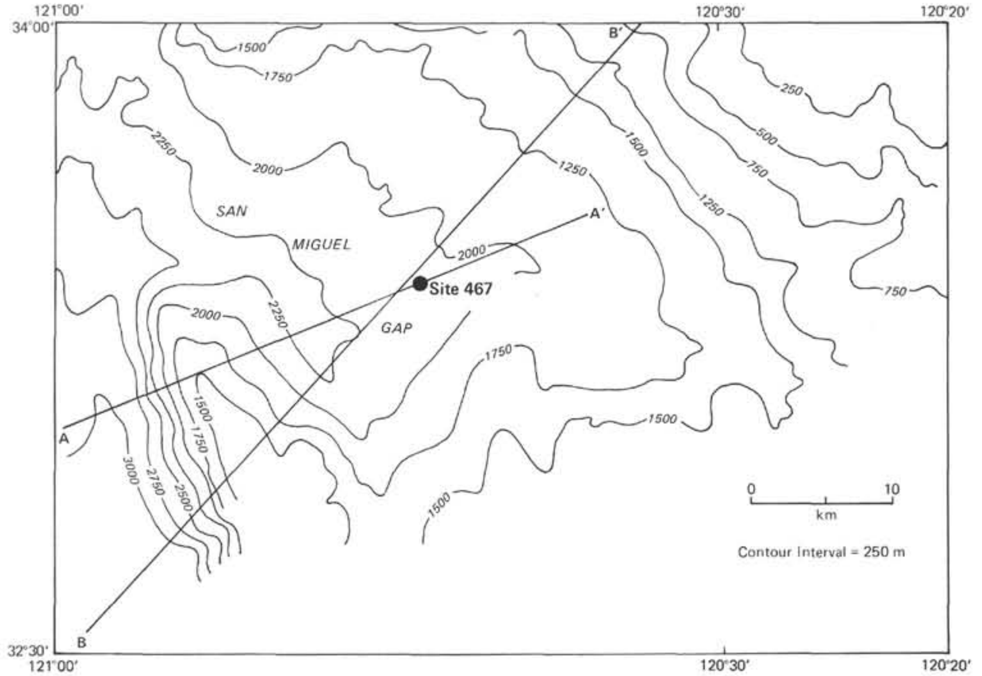

Figure 3. Detailed bathymetry (in meters) near Site 467. (Lines AA' and BB' give positions of the multichannel and single-channel seismic profiles in Figs. 4 and 5, respectively.)

OPERATIONS

The *Glomar Challenger* left Long Beach on 9 October 1978 at 0120 hours,[3] after the completion of drydock routines in the port of San Pedro. The operation of the newly overhauled thrusters was tested just out of the port in the San Pedro Channel some 6.5 nautical miles south of Point Fermin. After the successful testing of the thrusters, the ship sailed on a heading of 277°. At 0815 hours, some 65 miles southeast of the proposed Site 467, the heading was changed to northwest to arrive at the site diagonally across the multichannel line 4 of the *S. P. Lee* (line AA' on Fig. 2) and the single-channel *Bartlett* line (BB' on Fig. 2). The site was reached at 1756 hours. After dropping the beacon, we continued to profile some 4 miles beyond the drop-point to obtain seismic, 3.5 kHz, and precision depth recorder (PDR) data (Fig. 6). After retrieving the gear, we returned to the beacon at 1945 hours.

After the first core barrel was pulled without indication of sea-floor contact, the hole was spudded at 1053 hours on 10 October 1978, in 2146 meters of water. The first core barrel was retrieved with only traces of the bottom sediment in the core catcher. From the second core downward, the coring operations were essentially routine. The sediment recovery varied widely, from no recovery to over 100% in gas-charged sediments (Table 1). From Core 2 through Core 45, the recovery was generally high; from Core 46 and deeper, the recovery decreased, owing to changes in the lithology, and it remained generally low, with the exception of some intervals (Cores 57 and 58 and Cores 83 through 91).

During the drilling of the last lithologic unit, predominantly silty claystones (Cores 88 through 110), the diameter of the cored sediment decreased noticeably, indicating wear on the drill bit, and the drilling time increased from an average of 1 hr, 10 min per core to 1 hr, 30 min per core.

After termination of drilling on 16 October at 2155 hours, the hole was flushed and then filled with 400 barrels of gel mud to prepare it for a suite of downhole logs. A Sonic Caliper Log was attempted first and completed at 13 hours on 17 October. Next the temperature–density logging tool was lowered. But it became apparent that the tool had bridged in the open hole; the cable had overrun and become knotted below the drill pipe, preventing retrieval. The drill pipe and logging cable and tool were pulled together, and the logging tool was retrieved at 0400 hours on 18 October.

The heave compensator essentially remained inoperative throughout the coring of Site 467 because of a malfunction in the control-valve mechanism. It was tried only once, during Core 16, but its use was abandoned due to an inoperative antislingshot valve.

H_2S was encountered in almost all sediment cores in the upper 400 meters of the hole. Its levels dropped in the indurated sediments. Hydrocarbons were monitored throughout, and the C_2/C_1 ratios varied considerably, with a general trend toward increase in the ratios downcore. Once the hard, tuffaceous sediments were penetrated at 745 meters, the C_1 and C_2 levels dropped, and further monitoring until the bottom of the hole did not reveal any significant amounts of hydrocarbon gases.

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[3] All times specified in text are local time in hours; those in seismic-section figures are Zulu times.

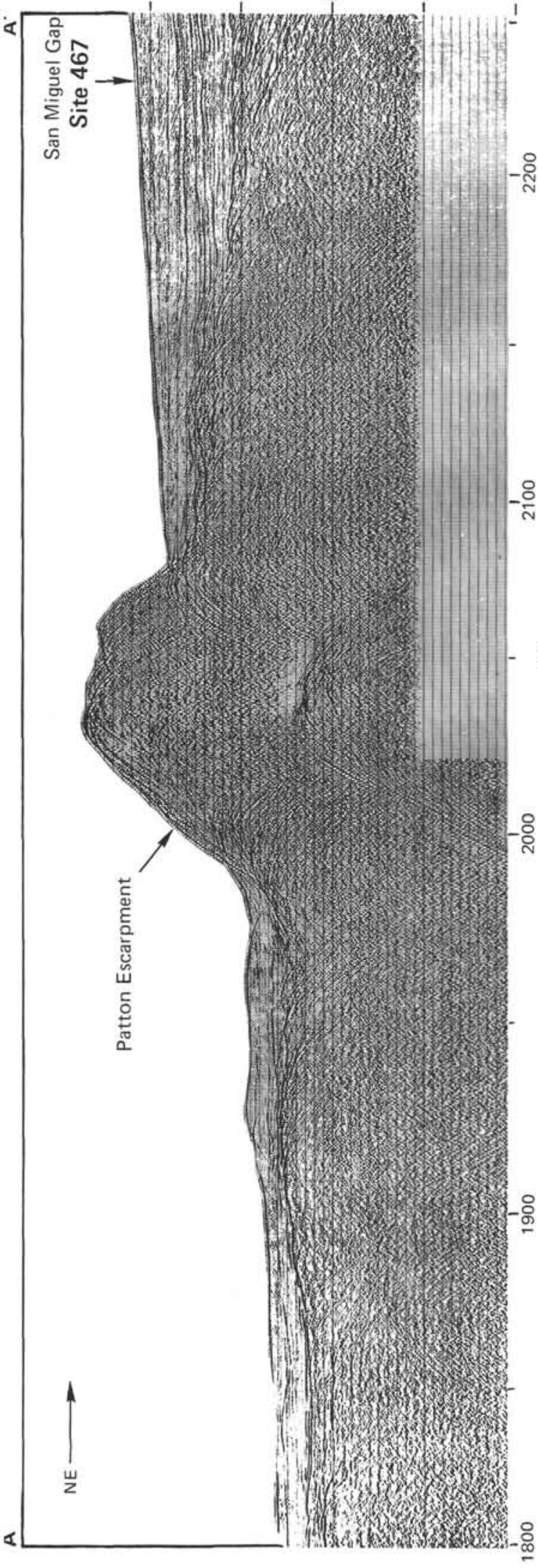


Figure 4. Multichannel seismic-reflection profile AA′ at Site 467 (from the *S.P. Lee* [Crouch et al., 1978]) showing the location of the profile on Fig. 3).

During the operations at Site 467, we noticed a potential problem with the gearbox of the forwardmost bow thruster. The absence of a spare gearbox onboard the *Challenger* necessitated our going into port to repair or replace the gearbox. DSDP suggested we go to Long Beach after the completion of our work at Site 467 because of the proximity of the labor and shops familiar with these kinds of repairs.

After a 2-hour post-site survey of the area, we headed toward Long Beach at 0600 hours on 16 October, arriving at Terminal Island Pier E at 2045 hours.

LITHOLOGY

Sediments and sedimentary rocks recovered at Site 467 include burrowed nannofossil clay, calcareous claystone, and clayey chalk as well as less abundant lithic lapilli tuff, silty clay, diatomaceous clay, and siliceous silty claystone. Minor intervals of clayey dolomitic limestone and sand(stone) are scattered but conspicuous components. We recognized four lithologic units on the basis of color, texture, mineralogic and fossil composition, degree of induration, and sedimentary structures (Table 2; Fig. 7).

Unit 1: Clay and Silty Clay (0–367 m)

This unit is predominantly olive gray clay with varying proportions of diatoms, calcareous nannofossils, and siliceous sponge spicules. Minor constituents include foraminifers; radiolarians; detrital grains of quartz, plagioclase, and mica; phosphatized fish fragments; and glauconite; the heavy minerals are pyrite, magnetite, zircon, epidote hornblende, garnet, and glaucophane.

The upper part of this unit (Cores 1–11, 0–101 m) is mottled, intensely deformed by drilling, and contains scattered pods of fine-grained sand, foraminifers, and carbonized wood fragments. Below 101 meters, the clay composing this unit is relatively firm and compact, only moderately deformed, and a more uniform olive gray. Six widely spaced, thin (20–40 cm) intervals of clayey dolomite and dolomitic limestone occur in the lower part of this unit, along with scattered thin sandy layers. The center of each limey interval is hard and well cemented, grading to soft, calcareous mudstone above and below. A layer of vitric ash 7 cm thick occurs in Core 14, and two subrounded dacitic clasts were recovered in Core 28. Diatoms are most plentiful in the middle part of Unit 1, with nannofossils common above and below them.

Unit 2: Calcareous Claystone (367.0–699.5 m)

Unit 2 comprises olive gray, dusky yellow brown, and olive black calcareous claystone. Greater induration, compositional differences, and abundant sedimentary structures distinguish rocks of this unit from those grouped in Unit 1. A sharp contact (in Section 2 of Core 40) between soft clay and firm, indurated claystone marks the boundary between these two units. Clay mineral content ranges from 35% to 80%. Carbonate occurs mainly as microcrystalline cement and scattered rhombic crystals and accounts for 5% to 40% of the rock. Coccoliths, diatoms, and radiolarians are com-

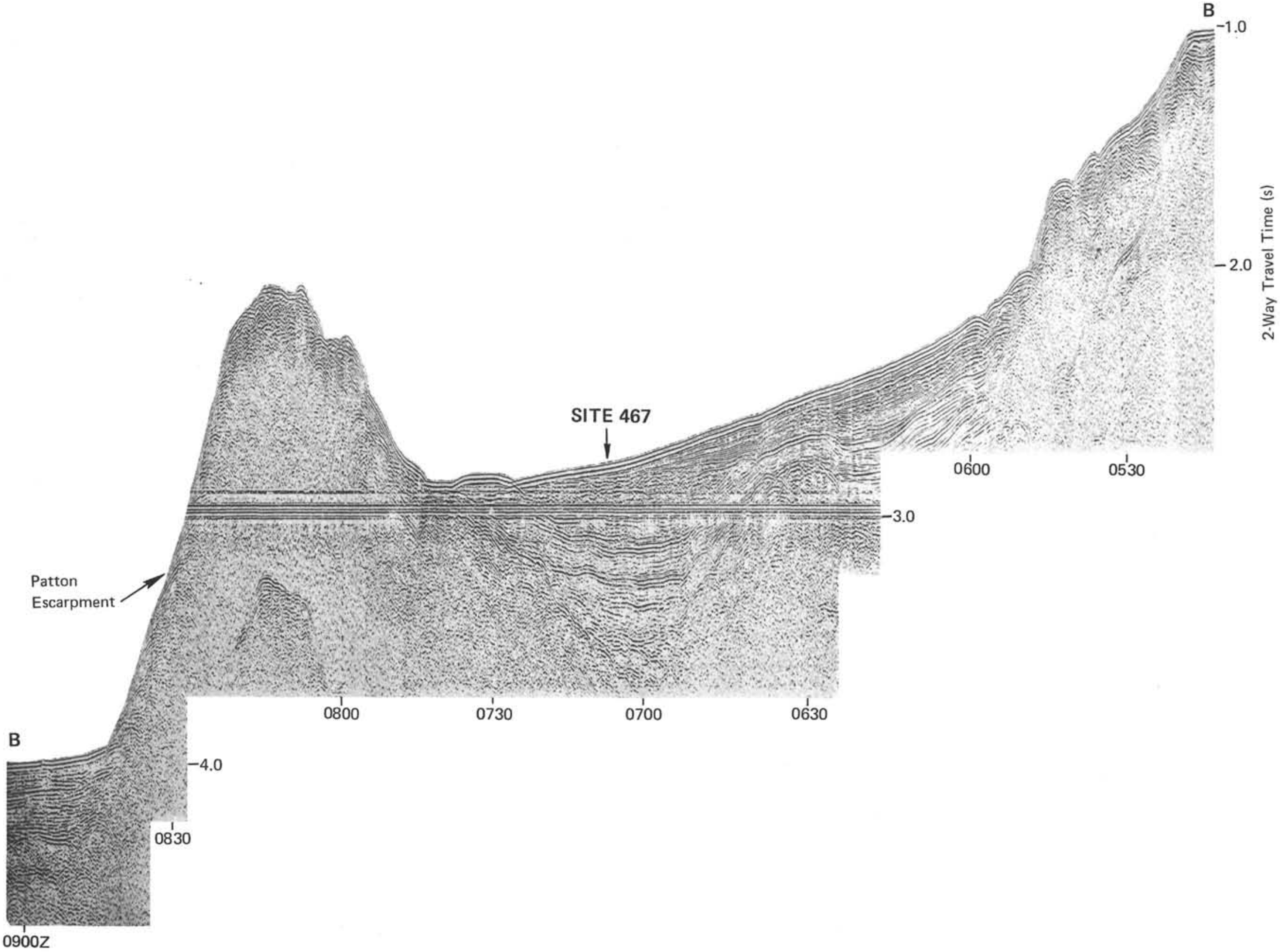
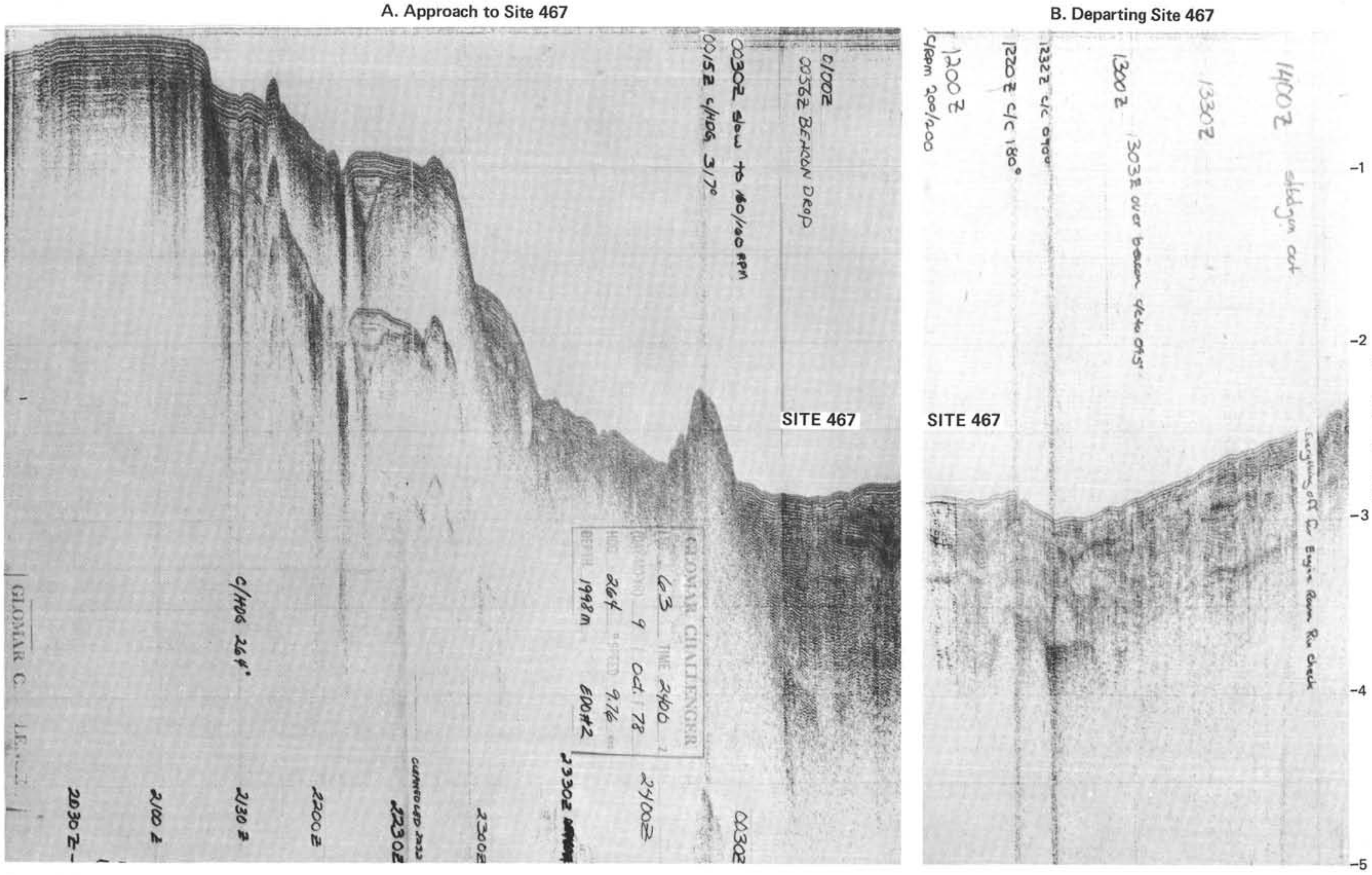


Figure 5. Single-channel seismic reflection profile BB′ at Site 467 (from the *Bartlett* [Crouch et al., 1978]) which indicates the location of the profile on Fig. 3.


A. Approach to Site 467

B. Departing Site 467

Figure 6. Single-channel *Glomar Challenger* seismic-reflection profiles at Site 467. (A. shows the approach to and B. the departure from the site.)

Table 1. Coring summary for Hole 467.

Core No.	Date (Oct. 1978)	Time	Depth from Drill Floor (m)	Depth below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Core Recovered (%)
1	10	1126	2146.0-2152.0	0.0-6.0	6.0	tr	0
2	10	1238	2152.0-2161.5	6.0-15.5	9.5	5.6	59
3	10	1346	2161.5-2171.0	15.5-25.0	9.5	7.1	75
4	10	1440	2171.0-2180.5	25.0-34.5	9.5	3.8	40
5	10	1550	2180.5-2190.0	34.5-44.0	9.5	8.4	88
6	10	1640	2190.0-2199.5	44.0-53.5	9.5	8.4	88
7	10	1735	2199.5-2209.0	53.5-63.0	9.5	7.6	80
8	10	1837	2209.0-2218.5	63.0-72.5	9.5	9.3	98
9	10	1937	2218.5-2228.0	72.5-82.0	9.5	5.4	57
10	10	2017	2228.0-2237.5	82.0-91.5	9.5	9.5	100
11	10	2115	2237.5-2247.0	91.5-101.0	9.5	8.3	87
12	10	2218	2247.0-2256.5	101.0-110.5	9.5	1.4	15
13	10	2318	2256.5-2266.0	110.5-120.0	9.5	6.6	69
14	11	0026	2266.0-2275.5	120.0-129.5	9.5	9.4	99
15	11	0119	2275.5-2285.0	129.5-139.0	9.5	1.9	20
16	11	0246	2285.0-2294.5	139.0-148.5	9.5	9.3	98
17	11	0344	2294.5-2304.0	148.5-158.0	9.5	4.8	51
18	11	0435	2304.0-2313.5	158.0-167.5	9.5	9.8	+100
19	11	0534	2313.5-2323.0	167.5-177.0	9.5	8.6	91
20	11	0645	2323.0-2332.5	177.0-186.5	9.5	6.5	68
21	11	0750	2332.5-2342.0	186.5-196.0	9.5	2.8	29
22	11	0850	2342.0-2351.5	196.0-205.5	9.5	0.0	0
23	11	0950	2351.5-2361.0	205.5-215.0	9.5	0.2	2
24	11	1050	2361.0-2370.5	215.0-224.5	9.5	0.3	3
25	11	1152	2370.5-2380.0	224.5-234.0	9.5	8.3	87
26	11	1310	2380.0-2389.5	234.0-243.5	9.5	3.8	40
27	11	1412	2389.5-2399.0	243.5-253.0	9.5	2.4	25
28	11	1518	2399.0-2408.5	253.0-262.5	9.5	1.4	15
29	11	1622	2408.5-2418.0	262.5-272.0	9.5	4.1	43
30	11	1755	2418.0-2427.5	272.0-281.5	9.5	3.5	37
31	11	1932	2427.5-2437.0	281.5-291.0	9.5	0.0	0
32	11	2044	2437.0-2446.5	291.0-300.5	9.5	4.1	43
33	11	2205	2446.5-2456.0	300.5-310.0	9.5	5.4	57
34	11	2333	2456.0-2465.5	310.0-319.5	9.5	6.1	64
35	12	0043	2465.5-2475.0	319.5-329.0	9.5	1.2	13
36	12	0150	2475.0-2484.5	329.0-338.5	9.5	5.5	58
37	12	0246	2484.5-2494.0	338.5-348.0	9.5	0.0	0
38	12	0348	2494.0-2503.5	348.0-357.5	9.5	0.2	2
39	12	0440	2503.5-2513.0	357.5-367.0	9.5	tr	0
40	12	0553	2513.0-2522.5	367.0-376.5	9.5	5.3	56
41	12	0705	2522.5-2532.0	376.5-386.0	9.5	7.5	79
42	12	0812	2532.0-2541.5	386.0-395.5	9.5	8.2	86
43	12	0920	2541.5-2551.0	395.5-405.0	9.5	tr	0
44	12	1040	2551.0-2560.5	405.0-414.5	9.5	7.3	77
45	12	1220	2560.5-2569.0	414.5-424.0	9.5	7.3	77
46	12	1330	2569.0-2578.5	424.0-433.5	9.5	0.0	0
47	12	1712	2578.5-2588.0	433.5-443.0	9.5	1.3	14
48	12	1832	2588.0-2597.5	443.0-452.5	9.5	4.4	46
49	12	1953	2597.5-2607.0	452.5-462.0	9.5	0.9	9
50	12	2128	2607.0-2616.5	462.0-471.5	9.5	0.6	6
51	12	2248	2616.5-2626.0	471.5-481.0	9.5	2.3	24
52	12	2350	2626.0-2635.5	481.0-490.5	9.5	3.2	34
53	13	0120	2635.5-2645.0	490.5-500.0	9.5	0.6	6
54	13	0230	2645.0-2654.5	500.0-509.5	9.5	3.8	40
55	13	0330	2654.5-2665.0	509.5-519.0	9.5	2.0	21
56	13	0500	2665.0-2674.5	519.0-528.5	9.5	3.4	36
57	13	0640	2674.5-2684.0	528.5-538.0	9.5	6.7	71
58	13	0800	2684.0-2693.5	538.0-547.5	9.5	5.5	58
59	13	0945	2693.5-2703.0	547.5-557.0	9.5	2.7	28
60	13	1100	2703.0-2712.5	557.0-566.5	9.5	2.9	31
61	13	1215	2712.5-2722.0	566.5-576.0	9.5	1.3	14
62	13	1332	2722.0-2731.5	576.0-585.5	9.5	1.7	18
63	13	1520	2731.5-2741.0	585.5-595.0	9.5	4.2	44
64	13	1845	2741.0-2750.5	595.0-604.5	9.5	1.7	18
65	13	2003	2750.5-2760.0	604.5-614.0	9.5	3.1	33
66	13	2145	2760.0-2769.5	614.0-623.5	9.5	1.1	12
67	14	0001	2769.5-2779.0	623.5-633.0	9.5	1.5	16
68	14	0140	2779.0-2788.5	633.0-642.5	9.5	2.2	23
69	14	0245	2788.5-2798.0	642.5-652.0	9.5	4.1	43
70	14	0450	2798.0-2807.5	652.0-661.5	9.5	3.7	39
71	14	0620	2807.5-2817.0	661.5-671.0	9.5	0.5	5
72	14	0735	2817.0-2826.5	671.0-680.5	9.5	0.7	7
73	14	0835	2826.5-2836.0	680.5-690.0	9.5	0.9	9
74	14	0956	2836.0-2845.5	690.0-699.5	9.5	2.1	22
75	14	1120	2845.5-2855.0	699.5-709.0	9.5	0.6	6
76	14	1300	2855.0-2864.5	709.0-718.5	9.5	2.2	23
77	14	1420	2864.5-2874.0	718.5-728.0	9.5	2.7	28
78	14	1614	2874.0-2883.5	728.0-737.5	9.5	1.7	18
79	14	1757	2883.5-2893.0	737.5-747.0	9.5	7.0	74
80	14	1920	2893.0-2902.5	747.0-756.5	9.5	2.7	28
81	14	2042	2902.5-2912.0	756.5-766.0	9.5	1.4	15
82	14	2317	2912.0-2921.5	766.0-775.5	9.5	1.4	15
83	15	0031	2921.5-2931.0	775.5-785.0	9.5	6.2	65
84	15	0144	2931.0-2940.5	785.0-794.5	9.5	7.2	76
85	15	0255	2940.5-2950.0	794.5-804.0	9.5	7.8	82
86	15	0403	2950.0-2959.5	804.0-813.5	9.5	6.9	73
87	15	0513	2959.5-2969.0	813.5-823.0	9.5	8.5	89
88	15	0631	2969.0-2978.5	823.0-832.5	9.5	4.3	45
89	15	0751	2978.5-2988.0	832.5-842.0	9.5	6.2	65
90	15	0929	2988.0-2997.5	842.0-851.5	9.5	5.7	60
91	15	1043	2997.5-3007.0	851.5-861.0	9.5	7.1	75
92	15	1210	3007.0-3016.5	861.0-870.5	9.5	1.7	18
93	15	1345	3016.5-3026.0	870.5-880.0	9.5	4.9	52
94	15	1510	3026.0-3035.5	880.0-889.5	9.5	2.7	28
95	15	1635	3035.5-3045.0	889.5-899.0	9.5	0.6	6
96	15	1817	3045.0-3054.5	899.0-908.5	9.5	4.3	45
97	15	1947	3054.5-3064.0	908.5-918.0	9.5	5.2	55
98	15	2120	3064.0-3073.5	918.0-927.5	9.5	5.0	53
99	15	2306	3073.5-3083.0	927.5-937.0	9.5	4.8	51
100	16	0050	3083.0-3092.5	937.0-946.5	9.5	3.2	34
101	16	0215	3092.5-3102.0	946.5-956.0	9.5	1.7	18
102	16	0403	3102.0-3111.5	956.0-965.5	9.5	1.0	11
103	16	0645	3111.5-3121.0	965.5-975.0	9.5	2.8	29
104	16	0845	3121.0-3130.5	975.0-984.5	9.5	3.4	36
105	16	1115	3130.5-3140.0	984.5-994.0	9.5	0.9	9
106	16	1255	3140.0-3149.5	994.0-1003.5	9.5	2.4	25
107	16	1450	3149.5-3159.0	1003.5-1013.0	9.5	4.5	47
108	16	1643	3159.0-3168.5	1013.0-1022.5	9.5	1.7	18
109	16	1921	3168.5-3178.0	1022.5-1032.0	9.5	3.5	37
110	16	2155	3178.0-3187.5	1032.0-1041.5	9.5	6.7	71
Total					1041.5	426.3	41

Table 2. Summary of lithologic units, Hole 467.

Unit	Cores	Depth below Sea Floor (m)	Chronostratigraphy	Lithology
1	1-39	0.0-367.0	Quaternary-lower Pliocene	Silty clay, diatomaceous and nannofossil clay with minor clayey limestone.
2	40-74	367.0-699.5	lower Pliocene-upper Miocene	Calcareous claystone with minor siliceous claystone and nannofossil claystone.
3	74-88	699.5-832.5	upper Miocene-middle Miocene	Lithic (pumiceous-scoriaceous) lapilli tuff and nannofossil clayey chalk, limestone and claystone.
4	88-110	832.5-1041.5	middle Miocene	Nannofossil claystone, clayey chalk, and silty claystone with minor sandstone interbeds.

mon in the upper part of this unit (Cores 40-56), but decrease downhole as carbonate cement becomes more abundant. Scattered circular and elongate molds, commonly filled with sparry calcite, suggest that many of these microfossils have been dissolved. Opal-CT (cristobalite) is present between Cores 58 and 77. Two thin intervals of clayey dolomitic limestone occur that are similar to those in Unit 1. Smear slides from Cores 40, 48, and 51 contain a few sand-size grains of glaucophane. Sedimentary structures include lenticular bedding and flattened subhorizontal burrows. In places the claystone is well laminated. In addition, there are scattered thin layers of foraminifers, glauconite grains, claystone rip-up clasts, and fine-grained sandstone. White sponge fragments are also present.

Unit 3: Lithic Lapilli Tuff (699.5–832.5 m)

Unit 3 consists of interbedded bluish gray to greenish gray lithic lapilli tuff and olive gray to yellowish gray nannofossil claystone, clayey chalk, and limestone. Individual pyroclastic layers are most abundant and thickest in the middle part of this unit, where they compose more than 80% of the section (Core 79-82). These layers thin and become less numerous above and below this interval, marking gradual transitions to the nannofossil claystone, chalk, and limestone. The boundaries of Unit 3 are placed at the first and last pyroclastic layers greater than 5 cm thick.

Tuff in Unit 3 is poorly to moderately well sorted and ranges in grain size from coarse ash to lapilli. Glassy vesicular volcanic fragments (scoria-pumice) make up

75% to 90% of the tuff and are extensively altered to greenish brown smectite. Other constituents include microlites and phenocrysts of plagioclase, andesitic and basaltic rock fragments, pyrite, calcite cement, zeolites, and some foraminifer fragments. Beds range from 2 cm to 122 cm thick, commonly with sharp basalt and gradational upper contacts. Normal and reverse grading, parallel laminations, load structures, microcross laminations, and flaser bedding are common sedimentary structures. Grading, parallel laminations, and cross laminations form Bouma T_{ab}, T_{abc}, and T_{cd} sequences.

Nannofossil clayey chalk and nannofossil claystone are interbedded with the tuff. Siliceous microfossils are absent in these rocks. Layers are either intensely bioturbated or laminated and lenticularly bedded. Pyroclastic debris fills some burrows. Thin, gray, carbonate-cemented layers of sandstone occur near the base of this unit. Core 76 contains a zone of brecciated clayey chalk with quartz- and calcite-filled fractures.

Unit 4: Nannofossil Clayey Chalk (832.5–1041.5 m)

Interbedded olive gray and yellow brown silty claystone, calcareous claystone, and clayey chalk make up Unit 4. The calcareous claystone forming the upper part of this unit is texturally and mineralogically similar to the claystone in Unit 2. Detrital clay, quartz, feldspar, and opaque heavy minerals occur together with variable amounts of carbonate cement. Heavy minerals include zircon, pyrite, barite, magnetite, and ilmenite. Calcareous nannofossils decrease markedly in Cores 89 through 99, below which calcareous silty claystone dominates. Thin (0.5–4.0 cm) layers of graded, fine-grained sandstone are scattered throughout the unit. The claystone is extensively burrowed. Some of these subhorizontal burrows are filled with sand. Laminated intervals are present but less common. Slump folds and microfaults occur in Cores 98 and 99.

BIOSTRATIGRAPHY

Quaternary through lower middle Miocene (*Sphenolithus heteromorphus* Zone) sediments were recovered at Site 467. Coccoliths, diatoms, radiolarians, and planktonic foraminifers are typically present in the uppermost Miocene, Pliocene, and Quaternary of Site 467, and coccoliths and diatoms provide good stratigraphic resolution in this interval (from the surface to about 450 m sub-bottom). Planktonic foraminifers and siliceous microfossils become scarce at or just below the Miocene/Pliocene boundary, and only coccoliths continue downsection (Fig. 8).

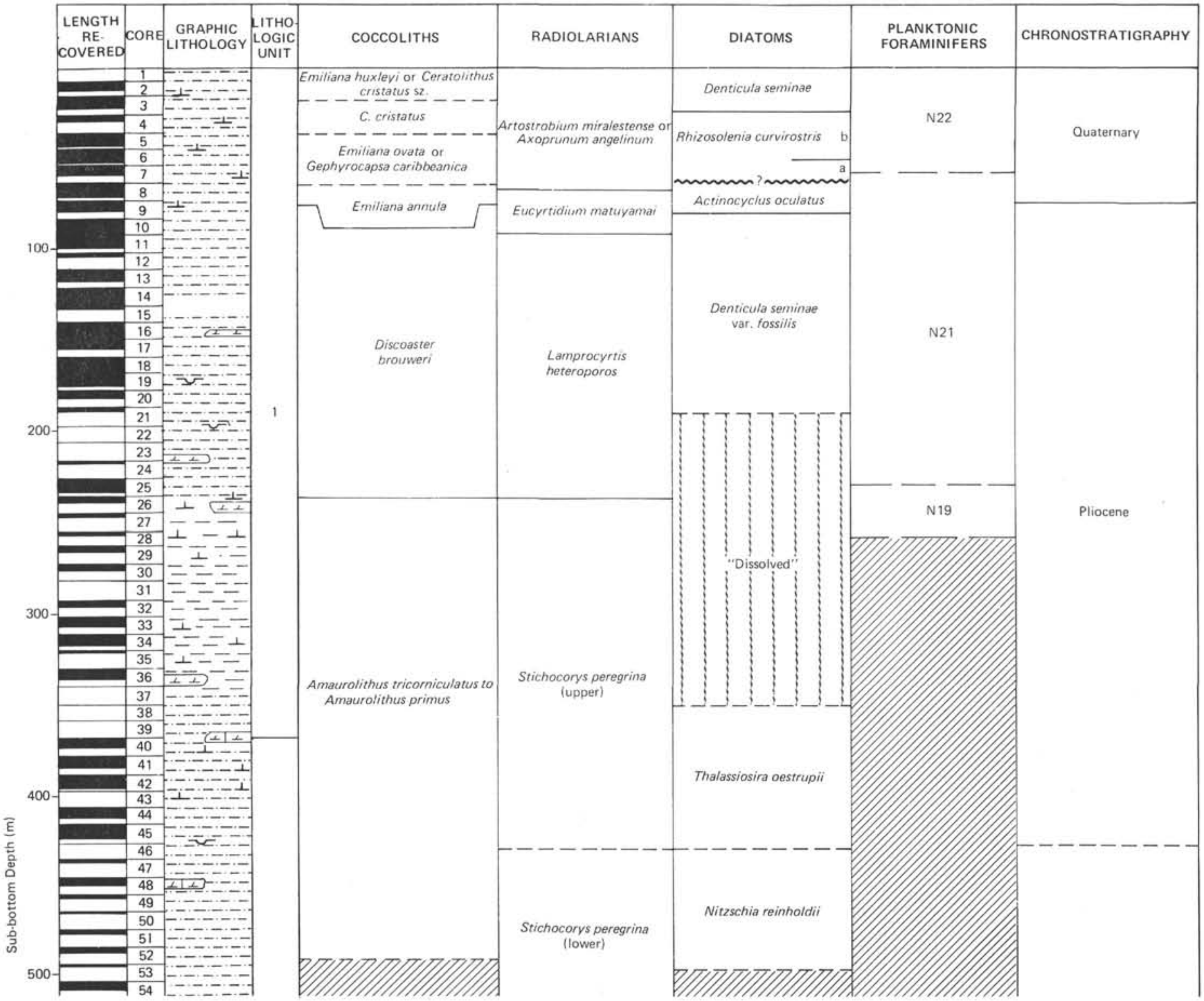
The Pliocene/Pleistocene boundary is placed in Core 9 at the top of the *Cyclococcolithina macintyrei* Subzone (coccolith) (72.5–78 m sub-bottom). The Miocene/Pliocene boundary is tentatively placed within the interval between Cores 45 and 47 (424.0–433.5 m sub-bottom). Placement of the middle Miocene/upper Miocene boundary is uncertain. Our best estimate is that it falls between Cores 80 and 84 (~750–787 m sub-bottom). Figure 7 summarizes zone assignments for Site 467.

Coccoliths

The Miocene to Quaternary coccoliths at Site 467 in the San Miguel Gap constitute much of the micropaleontologic record of the California Current in the outer California Continental Borderland. Coccoliths occur in most of the 110 cores recovered. Middle Miocene to lowermost Pliocene coccoliths are generally few to common and are moderately to poorly preserved. Dissolution and fragmentation of both placolith and asterolith speciments are typical in Cores 37 to 110. Coccoliths are abundant and moderately well preserved in Quaternary and Pliocene Cores 1 to 36. Reworked coccoliths from the Eocene occur sparsely through Quaternary Cores 1 through 9 and in Cores 32 and 42 but are absent or rare in Miocene Cores 47 to 110.

Few of the 24 low-latitude coccolith units (zones and subzones) for the middle Miocene to Quaternary could be specifically identified because of the paucity of low-latitude marker species in the low-diversity (2 to 10 species) assemblages (Table 3). The cool-water *Discoaster variabilis* Zone (Leg 5, McManus, Burns, et al., 1970; Leg 18, Bukry, 1973a) had to be used for most of the upper Miocene and part of the middle Miocene (Cores 56–90). The *Amaurolithus tricorniculatus* Zone (Leg 15, Bukry, 1973b) that includes the Miocene/Pliocene boundary could not be divided effectively into subzones because of the scarcity or absence of *Ceratolithus acutus* Gartner and Bukry, *C. rugosus* Bukry and Bramlette, and *Triquetrorhabdulus rugosus* Bramlette and Wilcoxon. The Miocene/Pliocene boundary is provisionally drawn between Cores 45 and 47, on the basis of the presence of the silicoflagellate *Dictyocha aspera clinata* Bukry in Core 47.

The oldest zone identified at Site 467 is the *Sphenolithus heteromorphus* Zone (see Bukry, 1973b for a definition of this and other zones cited in the text); this zone is part of the lower middle Miocene (and is approximately 14.0–15.5 m.y. old). Poore (personal communication, 1978) has identified this zone in the type Luisian Stage onshore in California. The zonal assemblages at Site 467 include sparse *S. heteromorphus* Deflandre, *Helicosphaera carteri* (Wallich), and *Cyclococcolithina macintyrei* (Bukry and Bramlette); few *Coccolithus miopelagicus* Bukry, *Discoaster deflandrei* Bramlette and Riedel, *D. exilis* Martini and Bramlette, and *D. variabilis* Martini and Bramlette; and common *Cyclicargolithus floridanus* (Roth and Hay). Upper assemblages of the *Coccolithus miopelagicus* Subzone are characterized by *C. miopelagicus, Cyclicargolithus floridanus, D. exilis, Reticulofenestra haqii* Backman, and *R. pseudoumbilica* (Gartner). In the lower part of the subzone, the predominance of *Sphenolithus neoabies* over *R. pseudoumbilica* suggests some decrease in paleotemperature upward through the interval. However, the more common occurrence of discoasters in the *D. kugleri* Subzone, just below a long sequence of cool-temperature assemblages (Table 3), indicates that a rather warm environment prevailed at the time of depo-


LENGTH RE-COVERED
CORE
GRAPHIC LITHOLOGY
LITHO-LOGIC UNIT
COCCOLITHS
RADIOLARIANS
DIATOMS
PLANKTONIC FORAMINIFERS
CHRONOSTRATIGRAPHY
Sub-bottom Depth (m)
100
200
300
400
500
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
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1
Emiliana huxleyi or Ceratolithus cristatus sz.
C. cristatus
Emiliana ovata or Gephyrocapsa caribbeanica
Emiliana annula
Discoaster brouweri
Amaurolithus tricorniculatus to Amaurolithus primus
Artostrobium miralestense or Axoprunum angelinum
Eucyrtidium matuyamai
Lamprocyrtis heteroporos
Stichocorys peregrina (upper)
Stichocorys peregrina (lower)
Denticula seminae
Rhizosolenia curvirostris
b
a
?
Actinocyclus oculatus
Denticula seminae var. fossilis
"Dissolved"
Thalassiosira oestrupii
Nitzschia reinholdii
N22
N21
N19
Quaternary
Pliocene

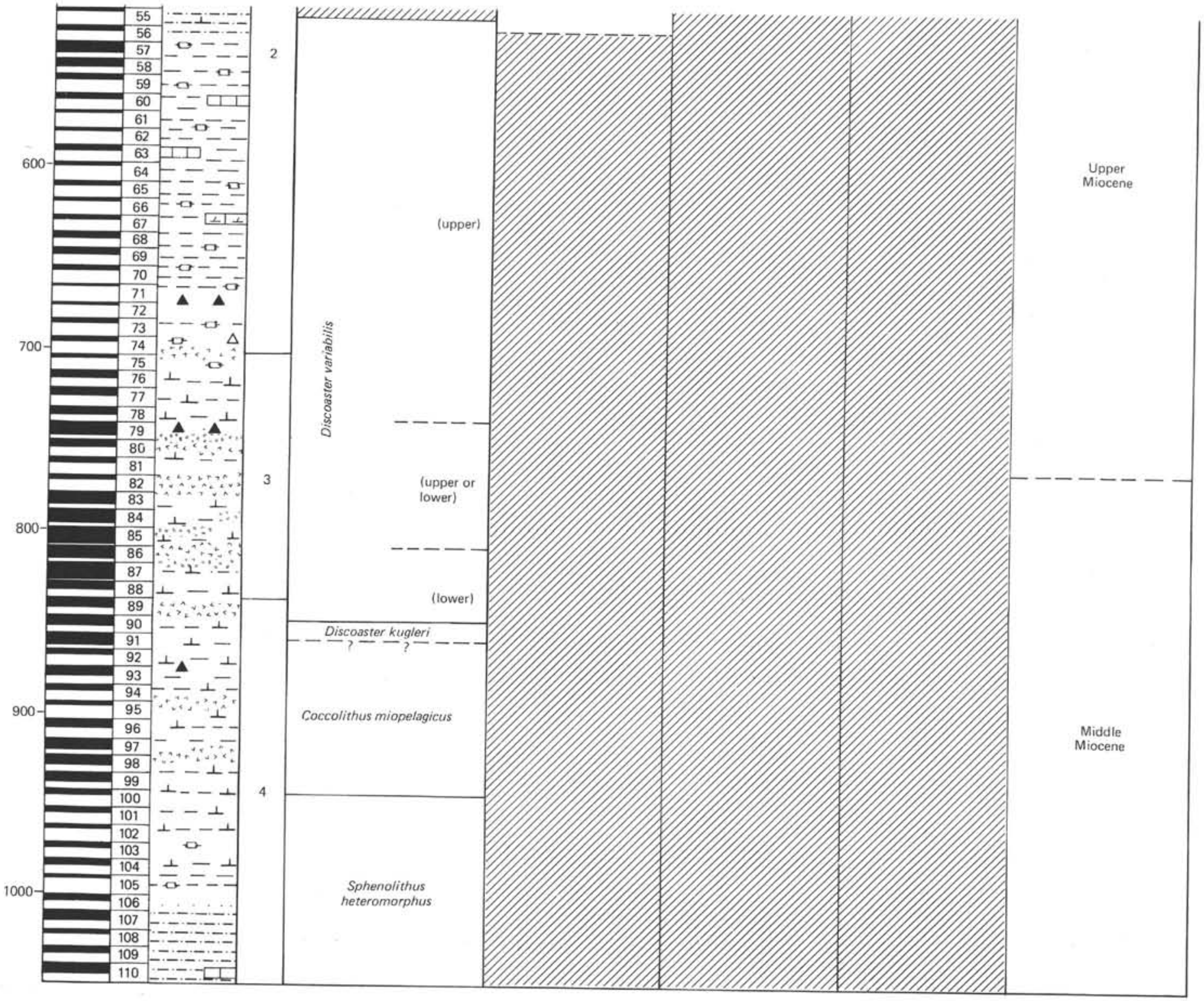

Figure 7. Lithologic and biostratigraphic summary, Hole 467. (Refer to Introduction and Explanatory Notes by Yeats et al. [this volume] for a key to the lithologic symbols.)

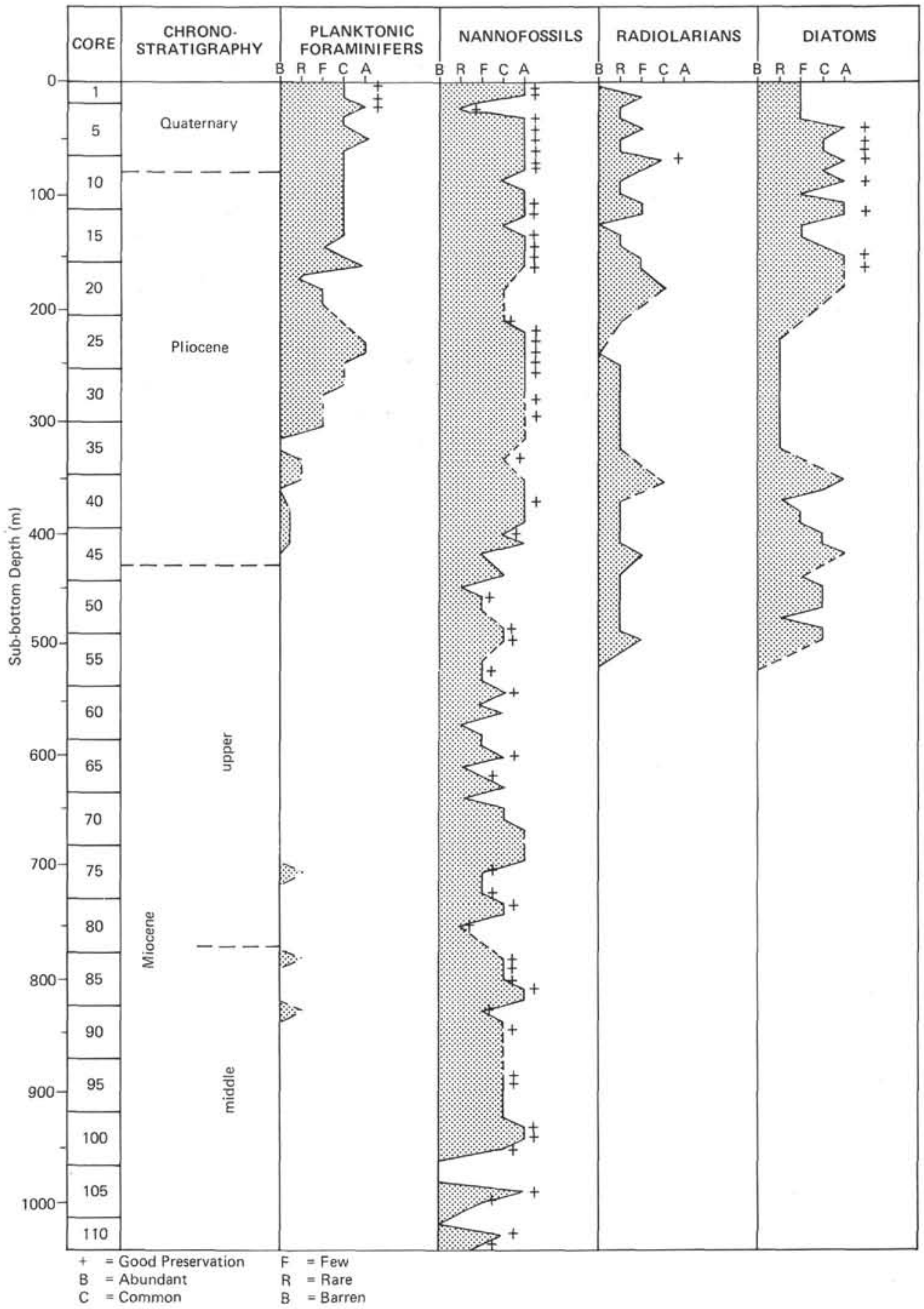

Figure 8. Plots of relative abundances of planktonic microfossils at Hole 467.

sition. The cooler, temperate, low-diversity coccolith assemblages (Cores 56 to 90) are dominated by species of *Reticulofenestra*, and *D. variabilis* is present. The long *D. variabilis* Zone interval can be divided into lower and upper parts by the appearances of *D. brouweri* Tan, s. ampl. and *Minylitha convallis* Bukry in the upper part (which corresponds to the upper Miocene *D. neohamatus* Zone of low latitude). Warm-water *D. neohamatus* Bukry and Bramlette is absent, emphasizing the nontropical character of the assemblages. However, no specimens of cool-water *D. mendomobensis* Wise were detected; this species flourished to the north at DSDP Site 173 at the northern end of the California Current for a short interval at the end of the *D. variabilis* Zone and occurs only rarely in the California Continental Borderland (D. Bukry, personal communication, 1978).

Sporadic occurrences of guide species *Amaurolithus delicatus* (Gartner and Bukry), *A. primus* (Bukry and Percival), and *D. quinqueramus* Gartner in the upper Miocene to lower Pliocene interval of Cores 27 to 55 make zonal assignments of individual samples difficult.

Table 3. Summary of coccolith zonation for Site 467.

Chronostratigraphy	Zone or Subzone	Core
Quaternary	*Emiliania huxleyi* or *Ceratolithus cristatus*	1–2
	?*Ceratolithus cristatus*	3
	?*Gephyrocapsa oceanica*	4
	Emiliania ovata or *Gephyrocapsa caribbeanica*	5–8
	Emiliania annula	8
Pliocene	*Cyclococcolithina macintyrei*	9–10
	Discoaster brouweri	11–24
	Discoaster tamalis or *Discoaster asymmetricus*	25
	Discoaster asymmetricus	26
Miocene or Pliocene	*Amaurolithus tricorniculatus* or *Amaurolithus primus*	27–48
Miocene	*Amaurolithus primus*	49–55
	?*Discoaster quinqueramus*	58
	upper *Discoaster variabilis*	56–78
	upper or lower *Discoaster variabilis*	79–85
	lower *Discoaster variabilis*	86–89
	Discoaster kugleri	90
	Coccolithus miopelagicus	92–99
	Sphenolithus heteromorphus	100–110

Cores 27 to 55 are assigned to an undifferentiated *A. primus* Subzone or *A. tricorniculatus* Zone because of the absence of warm-water ceratolith guide species.

The overlap of *D. tamalis* Kamptner and *D. asymmetricus* Gartner in Section 26-1 indicates the *D. tamalis* Subzone or *D. asymmetricus* Subzone. Therefore this level correlates to the type Repettian Stage onshore (R. Arnal and D. Bukry, personal communication, 1978).

Division of the upper Pliocene into subzones is doubtful at Site 467 because of the scarcity or absence of discoasters, especially *D. pentaradiatus* and *D. surculus* Martini and Bramlette; both taxa occur in the lower Pliocene at Site 467.

The highest occurrence of *D. brouweri* and common *Cyclococcolithina macintyrei* in Core 9 is used to correlate the top of the Pliocene. Sample 8,CC contains the last *C. macintyrei* without discoasters and is assigned to the lower Pleistocene *Emiliania annula* Subzone. The mixed-temperature environment of the Quaternary assemblages is indicated by the persistence of cool-water *Coccolithus pelagicus* (Wallich) and warm-water *Ceratolithus cristatus* Kamptner through Cores 1 to 5. Cold-water *Coccolithus pliopelagicus* Wise is sparser at Site 467 than at Site 173, and *C. pelagicus* is missing from coeval DSDP Leg 54 sites near the southern end of the California Current. Therefore, the Quaternary coccolith assemblages from the Site 467 region of the California Current indicate a gradational change in zonal assemblages southward along the current.

The coccolith record at Site 467 shows climatic changes from warm in early middle Miocene, to cool in late middle Miocene to early Pliocene, to warm in middle Pliocene, to mixed cool and warm in the Pleistocene, to warm in the Holocene. The lower 55 cores (most of them Miocene) lack diatoms, radiolarians, and even planktonic foraminifers, which suggests deposition from a sluggish or distal portion of any eastern boundary current. Changes in submarine topography or current circulation patterns in the late Miocene apparently brought the San Miguel Gap area under the active part of the California Current, because low-fertility coccolith claystones pass upward into diatom-, silicoflagellate-, radiolarian-, ebridian-, and dinoflagellate-bearing biogenic ooze, which demonstrates the higher fertility of upwelled waters, in contrast to the deeper cores, where coccolith predominance indicates low to moderate fertility.

Silicoflagellates

Silicoflagellate occurrences were noted incidentally during coccolith studies for Site 467. Although they are present in Cores 2 to 52, silicoflagellates are common in only a few samples. Cores 42 to 52 in the lower Pliocene and upper Miocene contain *Distephanus frugalis* (Bukry), *D. speculum elongatus* Bukry, and *Dictyocha pulchella* Bukry, suggesting that comparisons can be made with other North Pacific sites (173, 303, 304, and 310). A single specimen of *D. aspera clinata* Bukry s. ampl. in Core 47 suggests an upper Miocene correlation, on the basis of its range in the northwestern Pacific.

Silicoflagellates are sparse and sporadic in Cores 14 to 34; only the common cool-water *Distephanus speculum speculum* (Ehrenberg) and *D. speculum minutus* Bachmann of Core 18 are exceptions. Assemblages from Cores 5 to 13 are the most diverse. Samples 467-3,CC to 467-8-3, 100–102 cm are assigned to the upper Pleistocene cool-water *D. octangulatus* Zone (Bukry, 1973a; Ling, 1977). The occurrence of *Dictyocha aculeata* (Lemmerman) in Core 5 suggests a slight warming in the mid-Pleistocene.

The paucity of genus *Mesocena* through the section distinguishes Site 467 from mid-latitude sites of the northwestern Pacific.

Radiolarians

Radiolarians were studied from the coarse fraction components (>63 μm). Although they are sometimes the dominant component of the coarse fraction of uppermost Miocene through Quaternary sediments, their abundance is generally rare to few and their preservation poor to moderate. In Cores 57 through 110, no datable radiolarians were encountered. Other components such as foraminifers, echinoid spicules, and chitinous remains of arthropods are well preserved in most of the cores, but they are rare below Core 60.

In Section 2-1 through Section 8-4, radiolarians occur in the lower upper Pleistocene (*Axoprunum angelinum* Zone), indicated by the presence of *Lamprocyrtis haysi* and *Lamprocyrtis neoheteroporos* and the absence of *Eucyrtidium matuyamai*. Because of the presence of *E. matuyamai* and *Lamprocyrtis heteroporos*, Section 8-5 through Sample 10,CC are placed in the lower Pleistocene (*E. matuyamai* Zone).

Section 11-1 through Section 25-8 are part of the upper Pliocene *L. heteroporos* Zone, as indicated by the occurrence of a radiolarian assemblage with *L. heteroporos* and without *E. matuyamai* and *Stichocorys peregrina*. The first typical specimens of *S. peregrina* in Section 26-2 indicate the lower Pliocene; they are associated with *L. heteroporos* and other nondiagnostic Neogene radiolarians. The lower Pliocene succession comprises Section 26-2 through Sample 45,CC. *L. heteroporos* does not occur below Sample 45,CC. This occurrence and the presence of *S. peregrina* suggest that Cores 47 through 56, Section 2 were deposited during the late late Miocene (lower part of *S. peregrina* Zone). Rare specimens of various *Cyrtocapsella* species were found in Pliocene beds; these probably have been reworked from older layers of the Miocene.

The hard rocks of Cores 57 through 110 contain very rare (e.g., Core 58) and poorly preserved radiolarians that cannot be dated.

Diatoms

At Site 467, diatoms are few to abundant in the upper Pliocene to Quaternary (Cores 1 to 20), rare in the middle part of the Pliocene (Cores 23 to 36), few to abundant across the Miocene/Pliocene boundary (Cores 38 to 53), and absent in the middle and upper Miocene (Cores 56 to 110). Preservation generally follows abundance (Fig. 7). Good to moderate preservation prevails in the upper Pliocene and Quaternary, there is poor preservation in the middle part of the Pliocene, and moderate to poor preservation characterizes the lowermost Pliocene and uppermost Miocene.

The upper Pliocene and the Quaternary contain diatom assemblages typical of the high-latitude North Pacific, and Koizumi's (1975) zonation is applicable. Cores 1 through 3 correlate with the *Denticula seminae* Zone (ca. 0–0.26 m.y. old). The last occurrence of *Rhizosolenia curvirostris* in Sample 467-4,CC marks the top of the *R. curvirostris* Zone (ca. 0.26–0.9 m.y.), which extends through Sample 467-7,CC. The last occurrence of *Nitzschia reinholdii* (ca. 0.63 m.y. ago) is in Sample 467-7-1, 51–53 cm. Cores 8 and 9 correlate with the lower Quaternary *Actinocyclus oculatus* Zone (ca. 0.9–1.7 m.y.); these two cores lack *R. curvirostris* and consequently are low in the *A. oculatus* Zone. A hiatus between Samples 467-7,CC and 467-8,CC appears to have removed most of the *A. oculatus* Zone at this site. The last occurrence of *Thalassiosira antiqua* in Sample 467-10,CC marks the top of the *Denticula seminae* var. *fossilis* Zone (ca. 1.7–2.43 m.y. old). Assemblages through Core 18 are correlated with this zone because of the presence of *D. seminae* var. *fossilis* and *T. antiqua* and the lack of *D. kamtschatica*. The poor assemblages of Core 20 are tentatively assigned to this zone.

Cores 25 through 36 contain only reworked upper and middle Miocene diatoms. *Actinocyclus ingens, Denticula hustedtii, D. hyalina, D. lauta, Rhizosolenia barboi, Synedra jouseana*, and *T. antiqua* occur rarely in this interval.

Cores 38 through 45 are assigned to the lower Pliocene *Thalassiosira oestrupii* Zone, which is equivalent to the North Pacific Diatom Zone IX of Barron (1976). The diatom assemblage includes *Nitzschia reinholdii, T. antiqua*, and *T. oestrupii* s. ampl. without *Rouxia californica* and is similar to assemblages in the lower parts of the Sisquoc and Capistrano Formations onshore in Southern California. The silicoflagellate *Distephanus boliviensis frugalis* is also common in this interval.

Cores 47 through 53 are correlated with the upper Miocene *N. reinholdii* (equivalent to North Pacific Diatom Zone X of Barron [1976]) on the basis of the presence of *N. reinholdii* and the lack of *T. oestrupii*. The correlation of Cores 47 and 48 to the Miocene is tentative, however, because the last occurrence of the Miocene species *R. californica* is in Sample 467-49-1, 68–69 cm. One specimen of *T. miocenica* in Sample 467-53,CC suggests a maximum absolute age of 6 m.y.

Foraminifers

Planktonic foraminifers are common to abundant in Cores 1 through 18 (0–167.5 m sub-bottom) and, with the exception of Samples 467-11,CC and 467-15,CC, *Neogloboquadrina pachyderma* (s.s.) is the dominant taxon in this interval. Common accessory taxa include *Globigerina bulloides, Globorotalia scitula*, and *Orbulina universa*. Below Sample 467-10,CC, *Neogloboquadrina atlantica* and *Globigerina umbilicata* become persistent elements of the fauna; the first occurrence (downward) of *N. atlantica* in Core 8 is used to approximate the Pliocene/Pleistocene boundary in this sequence.

Sparse and poorly preserved planktonic foraminifers in samples from Cores 19 through 21 appear to represent a dissolution facies. The lower extent of this facies is uncertain because of poor recovery of Cores 21 through 23.

Samples 467-25,CC and 467-26,CC yielded diverse assemblages that include sparse representatives of warm-water taxa such as *Globigerinoides sacculifer, G. obliquus*, and *Sphaeroidinellopsis subdehiscens. Globigerina bulloides* is the most common taxon in samples from Cores 27 through 33. Accessory taxa include *Orbulina universa, Neogloboquadrina pachyderma* (s.l.), and *Globorotalia conomiozea* (Cores 27–29 only). Planktonic foraminifers are extremely sparse and poorly preserved below Sample 467-33,CC (307 m sub-bottom).

Benthic foraminifer assemblages from Hole 467 are relatively diverse and moderately well preserved in Cores 1 through 50 (0–462.5 m sub-bottom). Below Core 50 the occurrence of benthic foraminifers is sporadic, and, in general, the number of specimens per sample is low. The occurrence of *Pullenia bulloides, Uvigerina senticossa, Melonis pompiloides, M. barleeanus*, and *Bulimina striata mexicana* throughout the sequence suggests that Site 467 sediments were deposited in middle to lower bathyal water depths.

SEDIMENT ACCUMULATION RATES

Selected diatom (D), coccolith (C), and radiolarian (R) events were used to construct the sediment accumulation rate curve for Site 467 (Fig. 9). The plot indicates rates of ~75 m/m.y. for the Quaternary, ~150 m/m.y. for the late Pliocene, ~125 m/m.y. for the early Pliocene, and 50 m/m.y. for the late and middle Miocene. Data from siliceous microfossils and coccoliths suggest an early Quaternary hiatus of about 600 thousand years

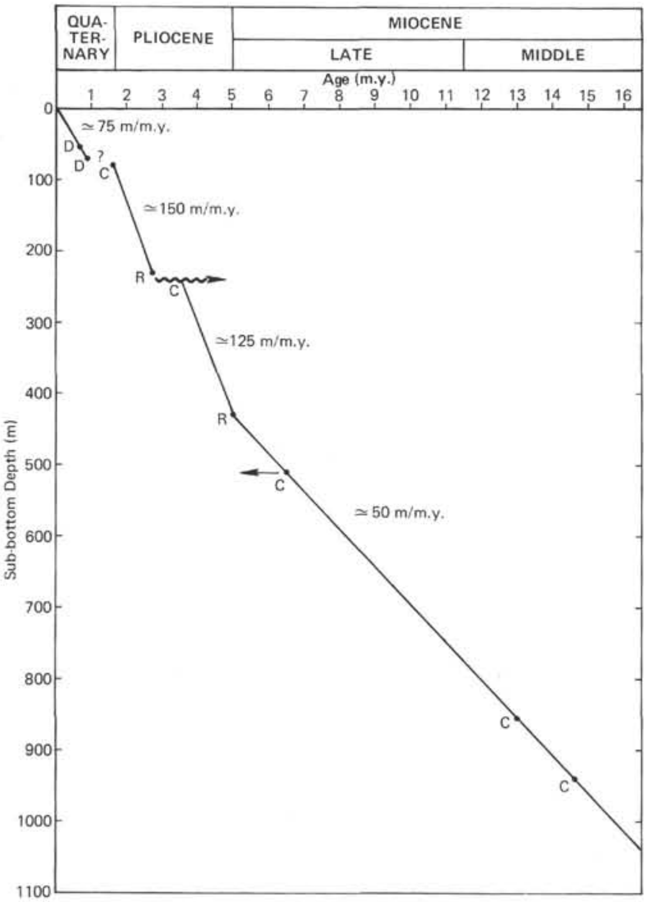

Figure 9. Sediment accumulation rates, Hole 467. (D = diatom, C = coccolith, and R = radiolarian events selected to construct this curve.)

within Core 8. A second hiatus of about 1 m.y. occurs between Cores 25 and 26 within the Pliocene.

GEOCHEMICAL MEASUREMENTS

Interstitial Water

Interstitial water was extracted from 11 samples from Site 467 and was analyzed on board the *Glomar Challenger* for salinity, titration alkalinity, dissolved calcium, magnesium, and chloride (Table 4; Fig. 10). These analyses were carried out using the techniques described by Gieskes (1974), with minor modifications. Because of induration, interstitial water samples could not be obtained in cores below 500 meters (with the exception of one sample at 794 meters in an altered lithic tuff).

The entire length of cored sediment is characterized by exceptionally high sediment accumulation rates of 50 to 150 m/m.y. The upper 400 meters of sediment at Site 467 were gassy, with a strong odor of H_2S on opening. Methane was present in cores between 70 and 375 meters depth. Pyrite was common in smear slides of sediments throughout the section, especially between 70 and 375 meters depth. The pore water measurements show a strong alkalinity maximum at about 160 meters depth, where alkalinity reaches a value more than 20 times that of sea water. Alkalinity is lower than normal sea-water values in the interstitial water sample from 794 meters depth, but the lack of data between 500 and 800 meters depth makes it impossible to determine the shape of the alkalinity profile over this interval or the depth at which alkalinity values return to normal.

Table 4. Interstitial water salinity, alkalinity, and concentrations of Ca^{++}, Mg^{++}, and Cl^{-}, Hole 467.

Core	Section	Depth below Sea Floor (m)	S (‰)	Alkalinity (meq/kg)	Ca^{++} (m*M*)	Mg^{++} (m*M*)	Cl^{-} (‰)
2	3	15.5	34.4	13.992	6.358	50.767	19.143
7	1	63.0	34.4	33.714	4.232	46.548	19.176
13	5	121.5	34.4	30.035	6.539	45.548	19.145
18	5	158.0	34.9	50.344	8.560	44.472	19.342
25	4	224.5	34.1	43.963	9.447	36.467	18.978
30	2	272.0	34.1	39.752	8.885	32.046	19.011
36	3	329.0	33.8	43.301	8.500	26.024	19.011
41	2	376.5	33.6	42.797	8.560	20.625	18.876
48	1	443.0	33.0	37.915	8.623	17.001	18.646
54	1	500.0	32.2	33.945	10.108	14.984	18.282
85	1	794.5	25.6[a]	1.13	22.464	14.984	18.282

[a] Contaminated with fresh water from the rock saw, taken from the working half of the cut core.

The downcore concentration gradients of Mg^{++} and Ca^{++} are complex. There is a strong Mg^{++} depletion in interstitial waters downcore, but Ca^{++} in the pore waters does not increase as Mg^{++} decreases in the upper 450 meters of sediment, as would be the case if these gradients were diffusional. Dissolved Ca^{++} is less than sea-water concentrations to a depth of 450 meters; a minimum is found at about 60 meters sub-bottom depth.

Organic-rich, terrigenous sediments with high rates of deposition are generally characterized by organic-matter reactions such as SO_4^{--} reduction (Manheim and Sayles, 1974; Gieskes, 1975). Alkalinity maxima in terrigenous sediments have been inferred to result from the production of bicarbonate during SO_4^{--} reduction (Manheim and Sayles, 1974). This reaction is often accompanied by $CaCO_3$ precipitation. Analyses of SO_4^{--} in the interstitial water are done on shore, and thus SO_4^{--} reduction could not be identified directly in the pore waters from Site 467. But the evidence of gas formation, pyrite, and a strong alkalinity maximum make it reasonable to assume that SO_4^{--} reduction is taking place in the upper 300 to 400 meters of the sediment column. The low Ca^{++} concentrations in the pore waters may reflect bicarbonate production and $CaCO_3$ precipitation during sulfate reduction. Sediments below about 400 meters were well indurated with calcareous cement.

Below 450 meters, Ca^{++} increases with depth. This is the same interval in which alkalinity decreases. Both of these trends are probably caused by a decrease of bicarbonate in the pore waters and an absence of SO_4^{--} reduction in the indurated sediments.

Calcium-Carbonate Content

The calcium-carbonate concentration in samples from Site 467 was determined on board by the carbonate bomb technique. The results of these determinations are included in the core descriptions in this chapter and plotted in Figure 11. The calcium-carbonate content

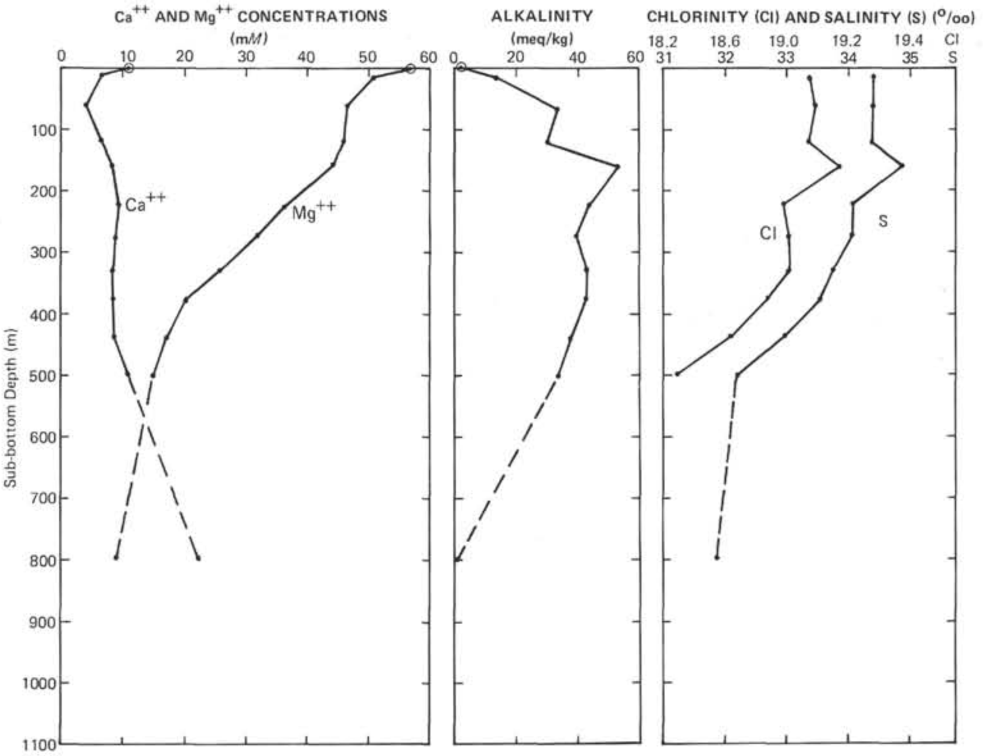

Figure 10. Interstitial water profiles, Hole 467. (Dashed lines indicate approximate profiles below 500 m.)

of the sediments reflects the assigned lithologic units in a general way. The sediments of Site 467, especially those from the lower three units, are characterized by alternating light and dark calcareous and clay-rich sediment layers. For example, carbonate concentration in three samples space 10 cm apart in Unit 2 ranges from 12% to 50%.

PHYSICAL PROPERTIES AND DOWNHOLE LOGS

Figure 11 summarizes the physical-property data for sediments and rocks recovered at Site 467. Considering general trends first, saturated bulk density is relatively constant over the first 400 meters, increasing gradually with depth from about 1.5 g/cm^3 to 1.7 g/cm^3. Below 400 meters, the sediments become firm and more indurated. Correspondingly, density values increase linearly from 1.6 g/cm^3 at this depth to about 2.3 g/cm^3 at the total depth (T.D.) i.e., 1041.5 meters. Porosities show the expected opposite trends, averaging about 60% to 70% over the first 400 meters, then decreasing to about 30% to 40% at the base of the hole. Similarly, water content, measured only for the lower 500 meters, decreases from about 25% to 15%.

In detail, anomalous densities and porosities correlate with the degree of carbonate cementation of the sediments. Layers or concretions of clayey dolomite and dolomitic limestone occur in the upper 700 meters of the section. These have saturated, bulk densities in the range 2.5 to 2.9 g/cm^3, porosities less than 15% and often less than 5%, and water contents less than 5%. These harder rocks are most conspicuous in the upper 500 meters of the section and between 550 and 700 meters. The interval of lapilli tuffs between about 700 and 830 meters (Lithologic Unit 3) has no distinct density of porosity anomalies associated with it.

Sonic velocities measured from core samples increase from 1.6 km/s to about 2.9 km/s between 500 and 1041.5 meters in the section. Above 500 meters, only one claystone was lithified enough to yield a reliable velocity (1.5 km/s—at 380 m). In contrast, layers or concretions of clayey dolomites and dolomitic limestones have much higher velocities in the range 4.0 to 5.5 km/s and are easily differentiated from the softer sediments and claystones. The Sonic Log provides a more detailed velocity profile. We distinguish the following intervals from this log:

1) From 137 to 388 meters, velocity increases linearly (from 1.6 km/s to about 1.9 km/s corresponding to compaction of soft clays, with distinct thin intervals of high velocity (3.4–5.0 km/s) corresponding to carbonate layers.

2) From 388 to 484 meters, velocity decreases slightly to values near 1.5 to 1.6 km/s. These lower values are somewhat puzzling, because the sediments become more indurated in this zone. Possibly this slight decrease in velocity reflects a high gas content of the sediments. (During the cutting of sections of cores from this interval, expanding gas caused end caps to pop off; in some instances, parts of cores jettisoned from liners. In addition, methane percentages reached maximum values in this interval.)

3) From 484 to 514 meters, velocity increases linearly from about 1.6 km/s to 1.9 km/s as clays pass to more

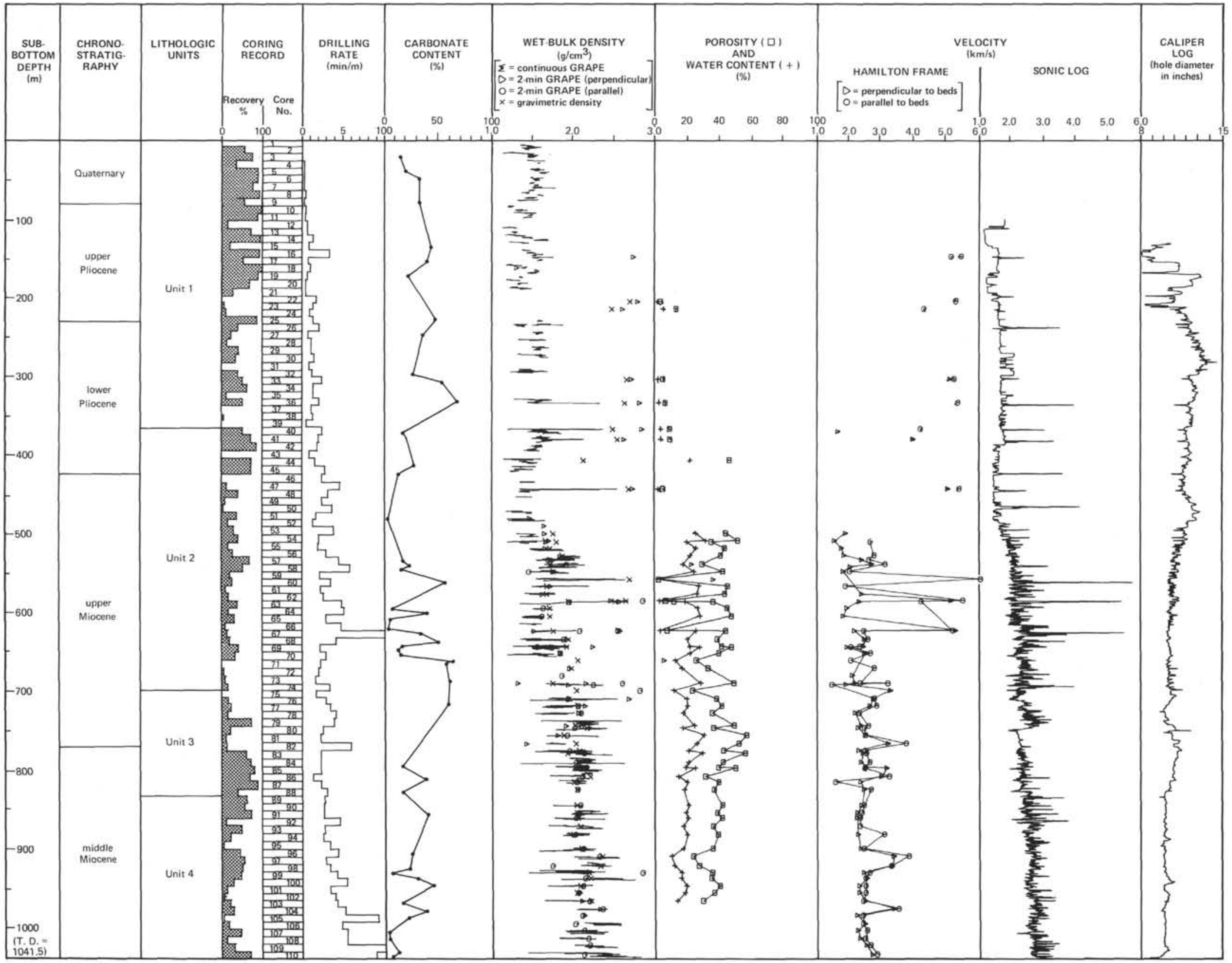

Figure 11. Summary of physical properties and downhole logs, Hole 467.

indurated claystones. Several distinct zones in this interval have velocities near 2.2 to 2.5 km/s. Although these higher-velocity zones do not contain limestone, they may have a higher carbonate content than do the surrounding claystones.

4) The interval from 514 to 749 meters is characterized by variable velocities ranging from 2.0 km/s to 3.2 km/s, which correspond to calcareous claystones, with occasional limestone layers that have considerably higher velocities (up to 5.4 km/s).

5) From 752 to 771 meters, there is a zone of relatively constant velocity of about 2.2 km/s. This interval corresponds to a continuous section of lapilli tuffs. A layer of calcareous claystone occurs within these tuffs, conspicuous by its higher velocity (~3.3 km/s).

6) From 771 meters to T.D. (1041.5 m), velocity increases linearly from about 2.2 km/s to 2.9 km/s, with several layers having velocities near 3.5 km/s. The dominant lithologies in this interval are nannofossil and calcareous silty claystones. The slightly higher velocities probably correspond to layers of harder clayey chalks. An interval of variable velocity occurs between 834 and 869 meters, perhaps reflecting a more cemented zone.

In addition to the Sonic and Caliper Logs we also obtained a partial Temperature Log at this site. Unfortunately the Temperature Log hung up in a restricted part of the open hole at 304 meters below the sea floor, forcing us to pull pipe and abandon further logging. The recorded values, however, indicate a bottom-water temperature of about 4.5°C and an "in-hole" temperature of about 23.5°C at 304 meters. The resulting minimum thermal gradient for the hole is about 63°C/km.

In summary, the physical-property and logging data match lithologic and compaction trends both generally and in detail. The progression from soft, porous clays to more indurated and lithified claystones translates to a distinct change in slope on the density and porosity profiles and on the Sonic Log at about 450 meters. Hard layers or concretions of clayey dolomite and dolomitic limestone are easily distinguished from clays and claystones by their higher velocities and densities. The average impedance contrasts between the softer clays and claystones and the intercalated hard carbonates are in the range 0.5 to 0.6, making them excellent reflectors where they are thick enough or closely spaced. The interval of lapilli tuffs (~750–770 m) shows no anomalous densities or velocities. The impedance contrast between this unit and the overlying calcareous claystones is about 0.2. A possible gas zone between about 380 and 480 meters is characterized by a slight but distinct decrease in velocity to values of 1.5 to 1.6 km/s. Enclosing sediments have velocities near 1.7 km/s to 1.9 km/s.

CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

The acoustic stratigraphy in the vicinity of Site 467 is well displayed on a common depth point (CDP) multichannel seismic-reflection profile that passes about 2 km southeast of the drill site (line AA′ in Fig. 4). This profile was collected by the U.S. Geological Survey's *S.P. Lee* (Crouch et al., 1978) using a 24-channel, 2400-meter streamer and a 1326-cubic-inch air-gun array. Characteristic reflecting horizons allowed direct correlation between the CDP profile and the crossing *Challenger* profile. Moreover, the Sonic Log at Site 467 (see Fig. 11) allowed close correlation of velocity intervals with stacking velocities and major reflectors on the CDP profile. In addition to the CDP profile, four (two USGS and two *Challenger*) single-channel seismic-reflection profiles across or close to Site 467 were available for interpretation. The higher resolution provided by the single-channel records illustrates several angular unconformities in the upper part of the drilled sequence that are difficult to identify on the CDP profile.

Table 5 briefly summarizes the correlation (displayed graphically in Fig. 12) of the CDP profile with the lithologic units at Site 467. The upper part of the sequence (Acoustic Unit A), which has a soupy to slightly cohesive texture, is characterized acoustically by a poorly stratified unit. The base of this unit is marked by a slight angular discordance with the top of Acoustic Unit B. Acoustic Unit B is characterized by very continuous, strong, evenly spaced reflectors in both the CDP profile and the single-channel profiles. The anomalously low velocity (~1.61 km/s) obtained from the Sonic Log perhaps results from the high concentration of gas found in this interval. The strong continuous reflectors appear to correlate with the well-lithified claystone beds in this interval. The strongest reflector on the CDP profile corresponds to the top of Acoustic Unit C; this reflector is relatively weak at the drill site, but is very strong east of the site (~0.65 s sub-bottom). This reflector marks the beginning of a well-indurated claystone and interbedded chalk–limestone sequence and presumably also correlates with a substantial decrease in the amount of gas in the sediments. A strong impedance contrast (0.5–0.6) at this horizon was also determined from the Sonic and Density Logs. The upper 133 meters of the underlying Acoustic Unit D consists of andesitic to dacitic lapilli tuffs that grade into claystones and minor, very fine-grained, volcaniclastic sandstones in the lower part of the sequence. With the exception of a few discontinuous, weak reflectors, Unit D is mainly transparent on the CDP profile. Reflectors are more common on the single-channel profiles in the upper (tuffaceous) portion of this sequence and are probably related to the chalk interbeds.

CONCLUSIONS

1. A major objective of this site was to obtain an expanded, well-preserved fossiliferous Miocene to Holocene sequence in order to study the oceanographic and climatic history of the region and the evolution of associated microplanktonic communities. However, diagenesis limits the usefulness of this site for those purposes. The siliceous record originally extended from at least the upper Miocene through Quaternary, as based on the distribution of opal-CT, but diagenesis now limits the useful record to the uppermost Miocene and younger strata lying above a depth of 500 meters. Siliceous microfossils are absent at greater depths. The upper and middle Miocene record is generally poor for cal-

Table 5. DSDP Site 467—acoustic and lithologic summary.

Acoustic Unit	Core	Interval (s)	Velocity (km/s)	Depth (m)	Chrono-stratigraphy	Lithologic Description	Thickness (m)	Acoustic Character
A	1–40	2.87–3.30	1.71	0–367	Quaternary to lower Pliocene	Silty clay diatomaceous and nannofossil clay with minor argillaceous limestone concretions. Lithologic Unit 1	367	Weak, discontinuous and indistinct reflectors.
B	40–57	3.30–3.50	1.61	367–528	lower Pliocene to upper Miocene	Calcareous claystone with minor siliceous claystone and nannofossil claystone interbeds. High gas content. Upper part of Lithologic Unit 2.	161	Strong, evenly spaced and continuous sequence of reflectors.
C	57–80	3.50–3.63	3.38	528–747	upper Miocene	Highly indurated calcareous claystone and interbedded limestone chalk. Lower part of Lithologic Unit 2 and upper part of Lithologic Unit 3.	219	Very strong, continuous reflectors with weaker and somewhat indistinct reflectors in the central portion.
D	80–110	3.63–3.86	2.70	747–1041	?upper Miocene to middle Miocene	Pumiceous lapilli tuff (andesitic) with minor nannofossil chalk interbeds from 747 to 880 m. Nannofossil claystone, clayey chalk, and calcareous silty claystone interbedded with minor very fine-grained quartzo-feldspathic sandstone from 830 to 1041 m. Remainder of Lithologic Unit 3 and all of Unit 4.	294	Very weak, indistinct and discontinuous reflectors.

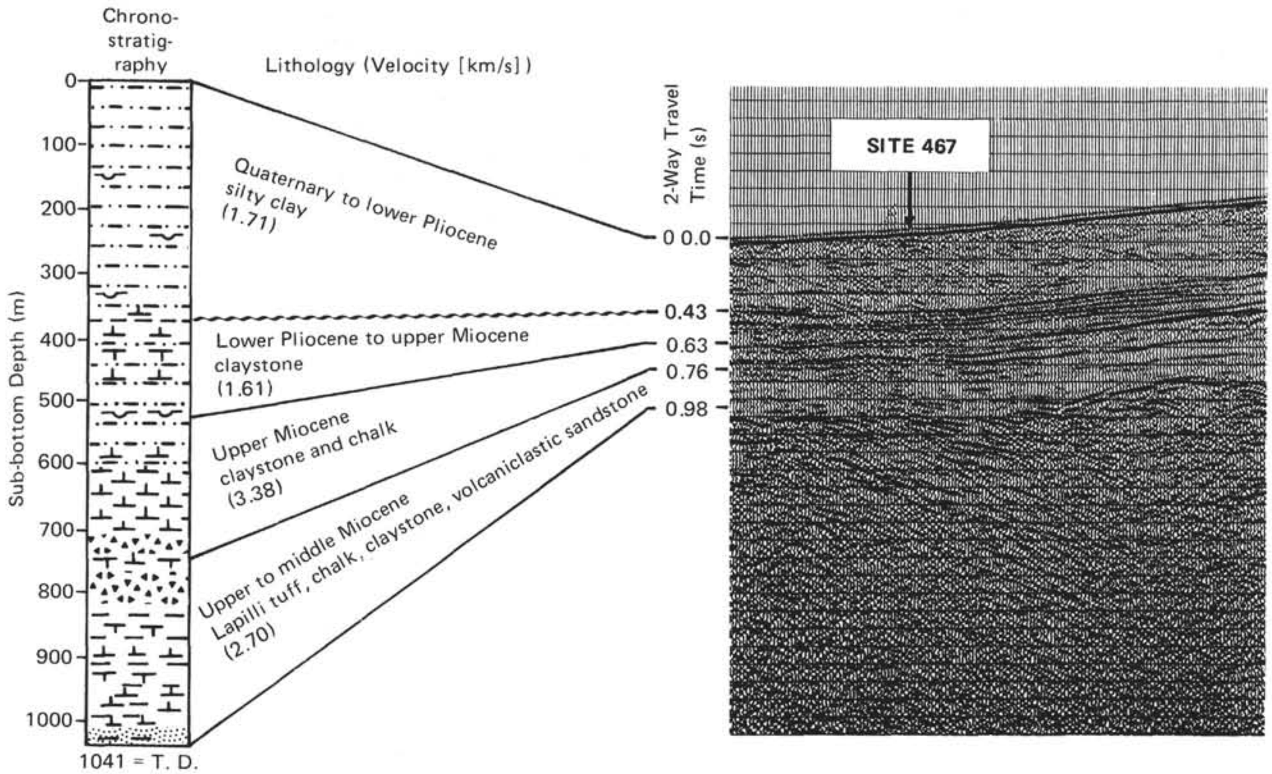

Figure 12. Correlation of lithologic units with the *S.P. Lee* multichannel seismic-reflection profile at Site 467.

careous nannoplankton, and it may not prove to be useful for the paleoceanographic studies. The calcareous record from the middle Pliocene to the Quaternary offers the most potential for paleoceanography.

2. Two unconformities at the site were noted, on the basis of missing microfaunal zones. The upper unconformity at 70 meters, representing a missing section from 0.9 to 1.5 m.y. old, is seen on the *Challenger* airgun records approaching and leaving Site 467. These profiles depict a north-northeast-trending syncline west of the site that is overlain unconformably by sediments with bedding parallel to the sea floor, as shown on the

Challenger 3.5-kHz sub-bottom recorder. The younger sequence is poorly observed because of the strong bubble pulse on the record. The lower unconformity represents a missing section from 3.0 to 3.6 m.y. old but is not detected on seismic profiles.

Poor resolution of microfaunal assemblage zones precludes the recognition of unconformities in the middle and lower upper Miocene. The base of Unit 1 at 367 meters (about 4.5 m.y. old) is marked by a slight angular unconformity, according to single-channel seismic profiles, but this is neither confirmed nor precluded by paleontological evidence. The boundary corresponds to a change from weak, discontinuous low-frequency reflections in Unit 1 to strong, fairly continuous reflections in underlying strata. Mainly the boundary is a diagenetic break from clay to claystone and a velocity inversion from 1.71 km/s above to 1.61 km/s below, probably due to high gas content in Unit 2.

3. Thin interbeds of clayey dolomite and dolomitic limestone occur in upper Miocene and Pliocene strata, with the shallowest at 148 meters depth. These interbeds are texturally and compositionally similar to concretionary carbonate beds in marine Tertiary sequences in coastal California.

4. Altered vesicular-lithic tuff interbedded with chalk, limestone, and claystone in Unit 3 ranges from middle to late Miocene, as old as 13 m.y. and as young as 11 m.y. This is younger that the age generally assigned to volcanism in the California Continental Borderland and adjacent coastal basins. Radiometric ages in the borderland volcanics range from 13 to 24 m.y., with most ages in the range 13 to 16 m.y. The volcanics are interbedded with marine strata containing middle Miocene benthic foraminifers (dated on the basis of Kleinpell's [1938] local California benthic stages). The lapilli tuff of Unit 3 resembles the middle member of the Blanca Formation of Santa Cruz Island, which consists predominantly of white to light gray lapilli tuff with lesser amounts of tuff-breccia, fallout tuff, volcanic conglomerate, and pebbly sandstone (Fisher and Charlton, 1976). The Blanca overlies the San Onofre Breccia, deposited during the early Miocene (according to the benthic stages of Kleinpell); dacite conglomerate similar to the Blanca underlies middle Miocene strata (McLean, et al., 1976). A clast from the middle member of the Blanca was K-Ar dated as 13 ±1.2 m.y. old, but a basalt flow in the upper member was K-Ar dated as 14.5 ±0.8 m.y. of age (McLean et al., 1976). The upper age limit of the Blanca is not determined at its type locality on Santa Cruz Island.

In contrast, sediments deposited at Site 467 at the same time as most borderland volcanism took place (i.e., 13–16 m.y. ago) contain no volcanic interbeds. However, volcanic rocks recovered from Patton Escarpment south of Site 467 and from the west flank of Santa Rosa-Cortez Ridge east of the site (Crouch, 1979b) may belong to the widespread middle Miocene volcanic episode and be older than Unit 3.

5. Sedimentation rates in beds older than 4 m.y. at Site 467 are similar to those in the Ventura Basin for the Monterey Shale of upper Ojai Valley, Sulphur Mountain, and Sespe Creek, where it consists mainly of fine-grained strata (Yeats, 1978). Sedimentation rates for the Pliocene and Quaternary are lower than those for older strata. This contrasts to the increase in sediment accumulation rates for the same time interval at Site 173 at the foot of the California continental escarpment near latitude 40°N (von Huene and Kulm, 1973) and in the onshore Ventura and Los Angeles basins (Yeats, 1978). The increase in these areas may be related to an increase in tectonic activity, and the decrease at Site 467 may be the result of increased isolation of the site from continental source areas.

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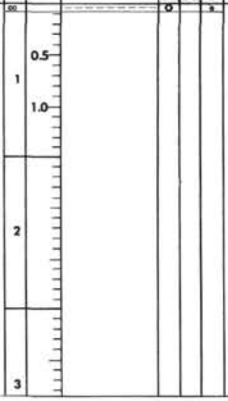
SITE 467 HOLE CORE 1 CORED INTERVAL 0.0–6.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
QUATERNARY	N.22 (F) *Emiliani huxleyi* to *Ceratolithus cristatus* subzone (N) *Denticula seminae* (D)	AG	AG		FM



LITHOLOGIC DESCRIPTION

CLAY, olive gray (5Y 4/1).

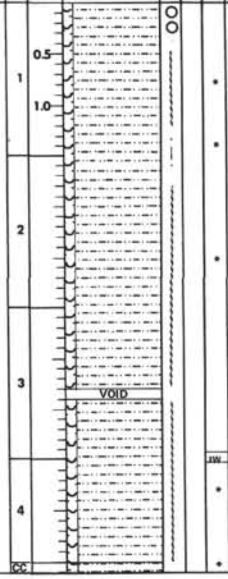
Core-Catcher only.

SMEAR SLIDE SUMMARY

	CC (D)
TEXTURE:	
Sand	2
Silt	14
Clay	74
COMPOSITION:	
Quartz	3
Feldspar	1
Mica	TR
Clay	70
Glauconite	TR
Pyrite	5
Foraminifers	5
Calc. Nannofossils	5
Diatoms	5
Radiolarians	TR
Sponge spicules	1
Fish remains	TR
Iron oxide	5

SITE 467 HOLE CORE 2 CORED INTERVAL 6.0–15.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
QUATERNARY	N.22 (F' *Emiliania huxleyi* to *Ceratolithus cristatus* subzone (N) *Denticula seminae* (D) *Artostrobium miralestense* to *Axoprunum angelinum* zone (R)	AG	FP AM	FM	FM



LITHOLOGIC DESCRIPTION

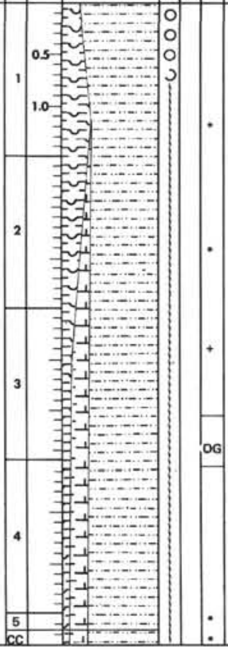
SILTY CLAY, mottled olive gray (5Y 4/1) to dark greenish gray (5GY 5/1). Very homogeneous with scattered black reduction spots and white, sand-size sponge fragments.

SMEAR SLIDE SUMMARY

	1-80 (D)	1-146 (D)	2-103 (M)	4-35 (D)	CC (D)
TEXTURE:					
Sand	2	2	10	3	2
Silt	28	30	40	25	25
Clay	70	68	50	72	73
COMPOSITION:					
Quartz	1	4	80	4	3
Feldspar	–	TR	20	2	TR
Mica	TR	1	–	TR	1
Heavy minerals	–	5	–	TR	–
Clay	76	65	–	–	70
Palagonite	–	–	–	TR	1
Glauconite	–	TR	–	1	–
Carbonate unspec.	–	–	–	2	–
Foraminifers	5	TR	–	2	3
Calc. Nannofossils	5	3	–	5	2
Diatoms	10	10	–	12	10
Radiolarians	TR	2	–	TR	–
Sponge spicules	3	5	–	5	5
Silicoflagellates	TR	3	–	3	TR
Fish remains	–	–	–	–	TR

SITE 467 HOLE CORE 3 CORED INTERVAL 15.5–25.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
QUATERNARY	N.22 (F' *Denticula seminae* (D) *Ceratolithus cristatus*(?) subzone (N) *Artostrobium miralestense* to *Axoprunum angelinum* zone (R)	AM	AM RM	RP	FM



LITHOLOGIC DESCRIPTION

DIATOMACEOUS SILTY CLAY, grading down section to **SILTY CLAY,** indistinctly mottled light olive gray (5Y 3/2) to olive gray (10Y 4/2), with scattered black reduction spots and white sponge fragments.

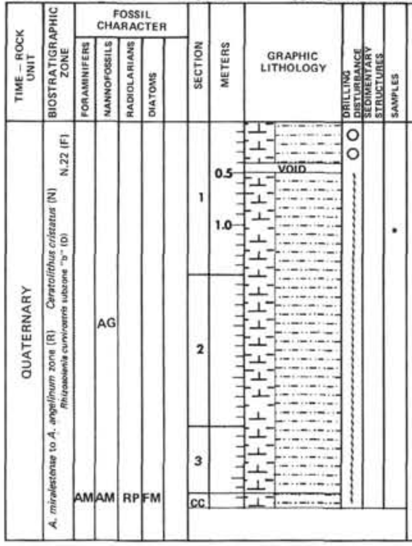
ORGANIC CARBON AND CARBONATE

	3-40
% Organic Carbon	–
% $CaCO_3$	13

SMEAR SLIDE SUMMARY

	1-120 (D)	2-95 (M)	5-12 (D)	CC-10 (D)
TEXTURE:				
Sand	4	–	10	5
Silt	40	–	30	30
Clay	56	–	60	65
COMPOSITION:				
Quartz	6	–	10	5
Feldspar	3	–	4	TR
Clay	40	–	40	70
Pyrite	1	–	2	TR
Carbonate unspec.	–	–	2	–
Foraminifers	3	–	2	3
Calc. Nannofossils	4	–	10	5
Diatoms	25	–	10	4
Radiolarians	4	3	TR	
Sponge spicules	4	100	6	5
Silicoflagellates	3	–	2	1
Iron oxide	3	–	3	–

SITE 467 HOLE CORE 4 CORED INTERVAL 25.0–34.5 m



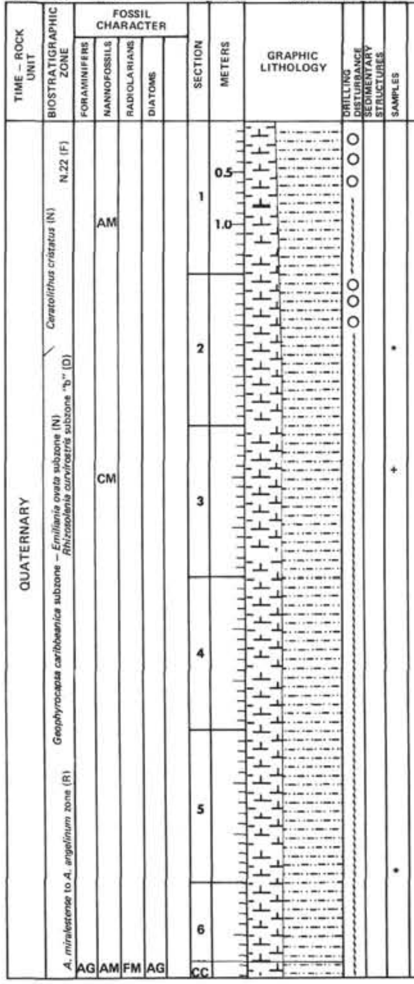
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAYEY SILT, grayish olive (10Y 4/2) to pale olive (10Y 6/2). Homogeneous except for some faint color mottling.

SMEAR SLIDE SUMMARY

	1-110 (D)
TEXTURE:	
Sand	15
Silt	45
Clay	40
COMPOSITION:	
Quartz	10
Feldspar	3
Mica	1
Heavy minerals	4
Clay	28
Pyrite	2
Carbonate unspec.	2
Foraminifers	1
Calc. Nannofossils	30
Diatoms	5
Radiolarians	2
Sponge spicles	5
Silicoflagellates	3
Fish remains	–
Iron oxide	4

SITE 467 HOLE CORE 5 CORED INTERVAL 34.5–44.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL SILTY CLAY, indistinctly mottled grayish olive (10Y 4/2–10Y 5/2). Very homogeneous; unspecified carbonate may be foraminifer fragments.

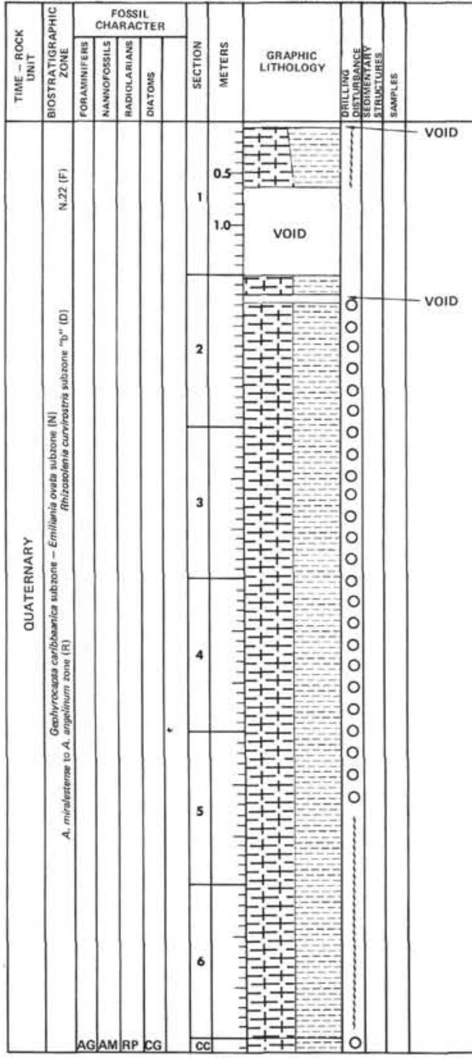
ORGANIC CARBON AND CARBONATE

	3-48
% Organic Carbon	–
% $CaCO_3$	18

SMEAR SLIDE SUMMARY

	2-127 (D)	5-145 (D)
TEXTURE:		
Sand	–	–
Silt	20	10
Clay	80	90
COMPOSITION:		
Quartz	5	4
Feldspar	TR	1
Mica	TR	TR
Heavy minerals	1	1
Clay	40	44
Pyrite	3	2
Carbonate unspec.	3	4
Foraminifers	5	–
Calc. Nannofossils		
Diatoms	3	2
Radiolarians	TR	2
Sponge spicules	5	4
Silicoflagellates	TR	–

SITE 467 HOLE CORE 6 CORED INTERVAL 44.0–53.5 m



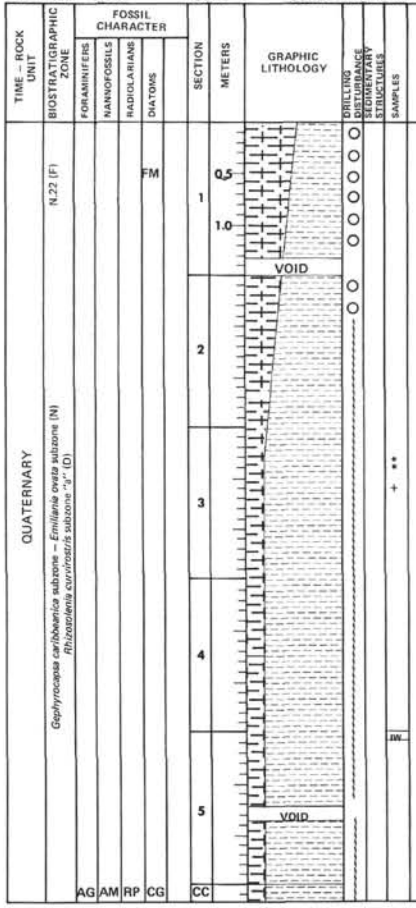
LITHOLOGIC DESCRIPTION

FORAMINIFER-NANNOFOSSIL CLAY, light olive gray (5Y 5/2) with some grayish olive (10Y 4/2) layers (eg. Section 1). Scattered sand-size, white sponge fragments throughout. Carbonized wood fragments in Section 1, 68 cm and Section 6, 52 cm. Faint H_2S odor.

SMEAR SLIDE SUMMARY

	1-60 (D)
TEXTURE:	
Sand	–
Silt	17
Clay	83
COMPOSITION:	
Quartz	4
Feldspar	TR
Mica	2
Heavy minerals	3
Clay	34
Pyrite	TR
Foraminifers	25
Calc. Nannofossils	30
Radiolarians	TR
Sponge spicules	2

SITE 467 HOLE CORE 7 CORED INTERVAL 53.5–63.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL-FORAMINIFERAL CLAY, mottled light olive gray (5Y 5/2) with less abundant, darker patches of grayish olive (10Y 4/2). 3mm long carbonized wood fragments in Section 2, 90 cm. Scattered white sponge fragments throughout.

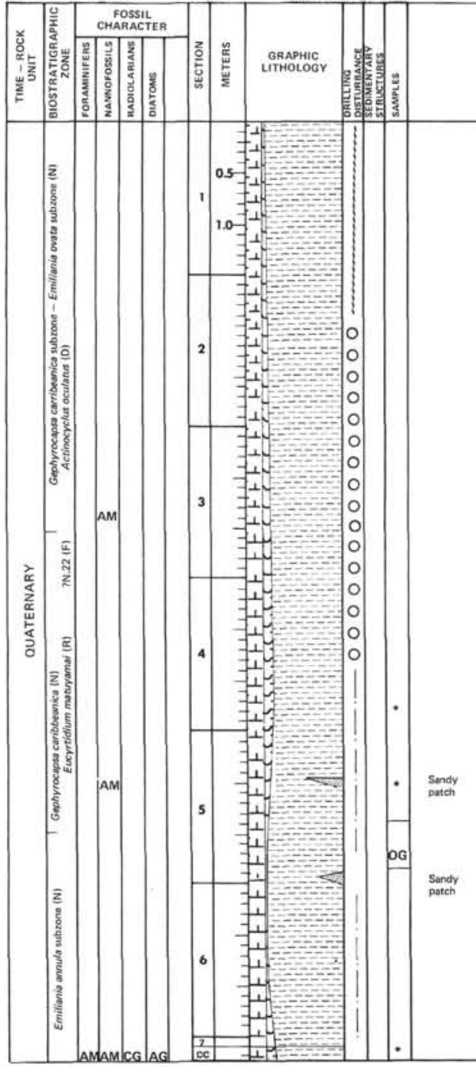
ORGANIC CARBON AND CARBONATE

	3-60
% Organic Carbon	–
% $CaCO_3$	32

SMEAR SLIDE SUMMARY

	3-33 (D)	3-40 (D)
TEXTURE:		
Sand	–	–
Silt	20	25
Clay	80	75
COMPOSITION:		
Quartz	5	5
Feldspar	2	TR
Mica	1	TR
Heavy minerals	3	3
Clay	69	62
Pyrite	2	2
Foraminifers	10	12
Calc. Nannofossils	TR	10
Diatoms	2	TR
Radiolarians	2	2
Sponge spicules	4	3
Silicoflagellates	TR	TR

SITE 467 HOLE CORE 8 CORED INTERVAL 63.0–72.5 m



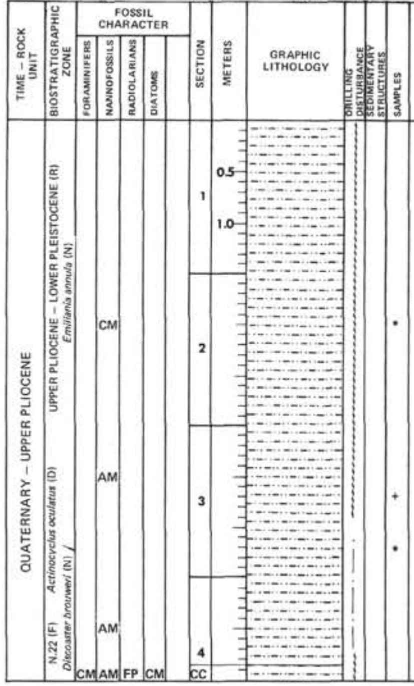
LITHOLOGIC DESCRIPTION

NANNOFOSSIL-DIATOMACEOUS CLAY, grayish olive (10Y 4/2) to olive gray (5Y 4/2). Homogeneous except for small patches of fine- to medium-grained foraminifer quartzose. Clayey sand in Section 5 (eg. Smear Slide 5-56). Alternating light and dark greenish-colored zones in top of Section 6.

SMEAR SLIDE SUMMARY

	4-130 (D)	5-56 (M)	CC (D)
TEXTURE:			
Sand	10	70	10
Silt	10	10	20
Clay	80	20	80
COMPOSITION:			
Quartz	4	40	8
Feldspar	1	8	1
Mica	1	3	1
Heavy minerals	2	5	2
Clay	42	20	51
Volcanic glass	1	–	–
Glauconite	2	1	1
Pyrite	3	2	2
Carbonate unspec.	4	–	5
Foraminifers	6	10	3
Calc. Nannofossils	10	4	6
Diatoms	11	1	10
Radiolarians	3	1	TR
Sponge spicules	8	5	8
Silicoflagellates	2	–	2

SITE 467 HOLE CORE 9 CORED INTERVAL 72.5–82.0 m



LITHOLOGIC DESCRIPTION

SILTY CLAY, mottled light olive gray (5Y 5/2) to moderate olive brown (5Y 5/4). Siliceous microfossil content is low but variable. Scattered sand-size white sponge fragments throughout. Strong H_2S odor.

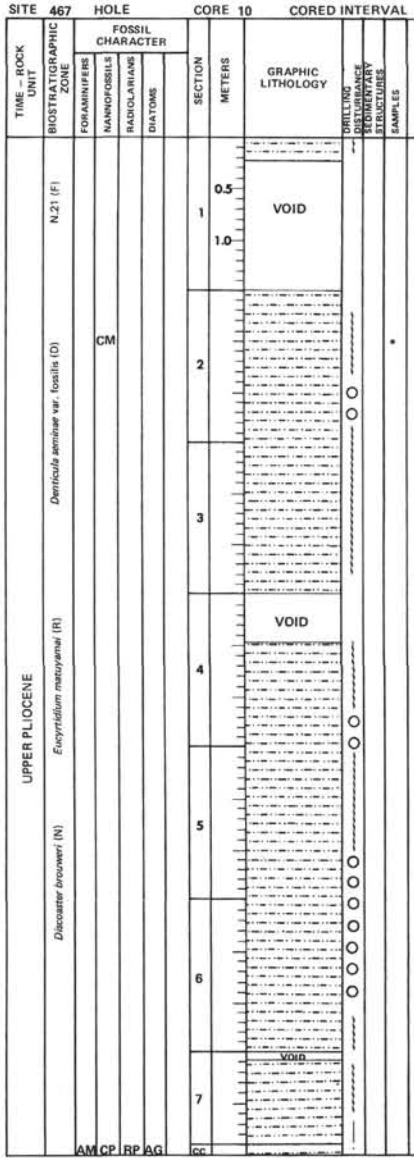
ORGANIC CARBON AND CARBONATE

	3-57
% Organic Carbon	–
% $CaCO_3$	32

SMEAR SLIDE SUMMARY

	2-50 (D)	3-122 (M)
TEXTURE:		
Sand	–	–
Silt	20	20
Clay	80	80
COMPOSITION:		
Quartz	5	2
Heavy minerals	2	1
Clay	86	80
Carbonate unspec.	–	5
Foraminifers	TR	–
Calc. Nannofossils	TR	TR
Diatoms	2	6
Radiolarians	TR	TR
Sponge spicules	5	6
Silicoflagellates	TR	–

SITE 467 HOLE CORE 10 CORED INTERVAL 82.0–91.5 m



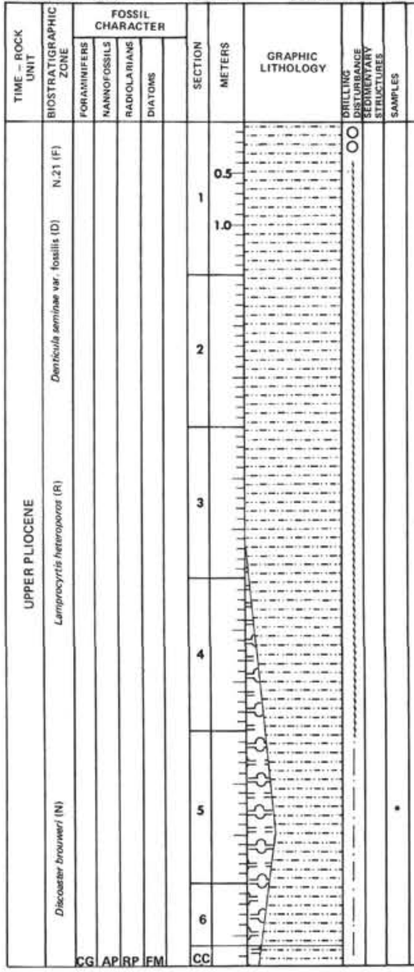
LITHOLOGIC DESCRIPTION

SILTY CLAY, olive gray (5Y 3/2) with some medium olive gray (5Y 4/2) mottles in Section 7. Homogeneous with rare sponge fragments. Strong H_2S odor.

SMEAR SLIDE SUMMARY

	2-50 (D)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	5
Heavy minerals	1
Clay	80
Carbonate unspec.	2
Diatoms	5
Radiolarians	TR
Sponge spicules	6
Silicoflagellates	TR

SITE 467 HOLE CORE 11 CORED INTERVAL 91.5–101.0 m



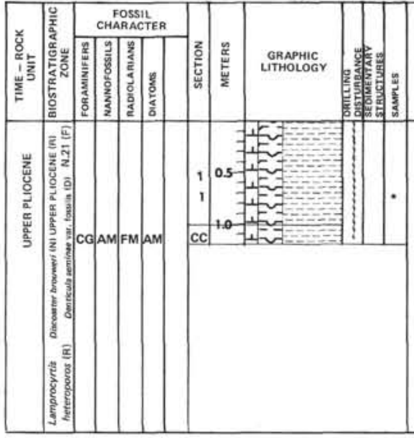
LITHOLOGIC DESCRIPTION

SILTY CLAY grading to **SPICULE-DIATOMACEOUS CLAY** down core, olive gray (5Y 3/2) to light olive gray (5Y 5/2), with scattered white sponge fragments.

SMEAR SLIDE SUMMARY

	5-80 (D)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	TR
Feldspar	TR
Clay	60
Carbonate unspec.	2
Foraminifers	1
Calc. Nannofossils	5
Diatoms	15
Radiolarians	TR
Sponge spicules	15
Silicoflagellates	1

SITE 467 HOLE CORE 12 CORED INTERVAL 101.0–110.5 m



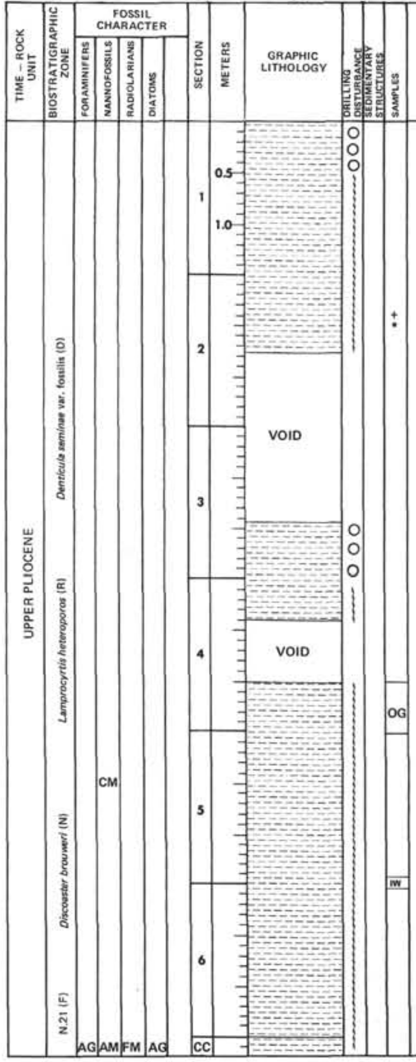
LITHOLOGIC DESCRIPTION

NANNOFOSSIL-DIATOMACEOUS CLAY, olive gray (5Y 3/2) to moderate olive brown (5Y 4/4).

SMEAR SLIDE SUMMARY

	1-76 (D)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	2
Clay	60
Carbonate unspec.	10
Foraminifers	1
Calc. Nannofossils	10
Diatoms	10
Radiolarians	1
Sponge spicules	8
Silicoflagellates	1

SITE 467 HOLE CORE 13 CORED INTERVAL 110.5–120.0 m



LITHOLOGIC DESCRIPTION

CLAY, moderate olive gray (5Y 4/2), homogeneous. Many of the unspecified carbonate fragments may be broken tests of foraminifers. Some scattered sponge fragments.

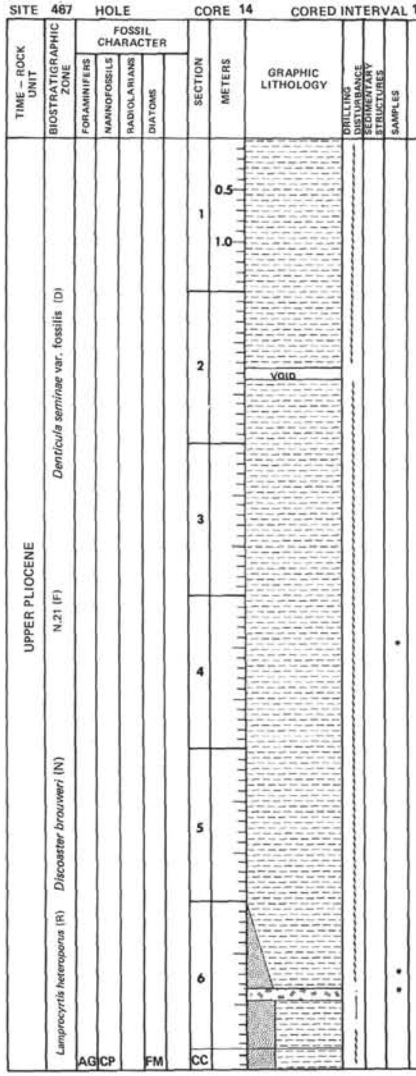
ORGANIC CARBON AND CARBONATE

	2-41
% Organic Carbon	–
% $CaCO_3$	40

SMEAR SLIDE SUMMARY

	2-60 (D)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	2
Feldspar	TR
Clay	75
Carbonate unspec.	8
Foraminifers	3
Calc. Nannofossils	8
Diatoms	7
Radiolarians	2
Sponge spicules	8
Silicoflagellates	1

SITE 467 HOLE CORE 14 CORED INTERVAL 120.0–129.5 m



LITHOLOGIC DESCRIPTION

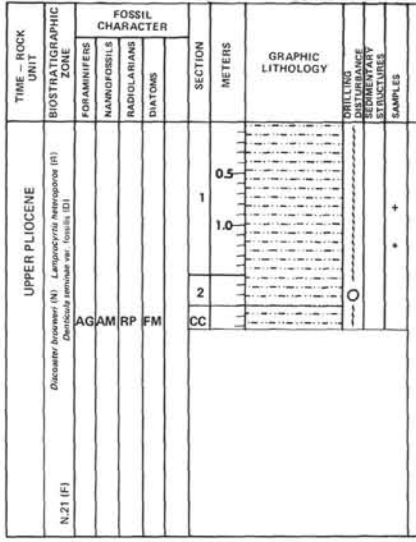
CLAY, moderate olive gray (5Y 4/2) with light olive gray (5Y 5/2) mottles. Changes gradationally to **CLAY AND SANDY CLAY** in Section 6. Sandy zones occur as patches. Thin (~8 cm) layer of **VOLCANIC ASH** in Section 6. Small white sponge fragments throughout core.

SMEAR SLIDE SUMMARY

	4-50 (D)	6-63 (M)	6-90 (M)
TEXTURE:			
Sand	–	35	50
Silt	20	10	10
Clay	80	55	40
COMPOSITION:			
Quartz	1	25	1
Feldspar	–	5	–
Heavy minerals	1	5	–
Clay	80	50	40
Carbonate unspec.	5	–	–
Foraminifers	TR	TR	TR
Calc. Nannofossils	5	10	5
Diatoms	2	TR	2
Sponge spicules	5	5	2

Ash layer

SITE 467 HOLE CORE 15 CORED INTERVAL 129.5–139.0 m



LITHOLOGIC DESCRIPTION

SILTY CLAY, light olive gray (5Y 5/2) with olive gray (5Y 3/2) mottles. Homogeneous composition with scattered sponge fragments.

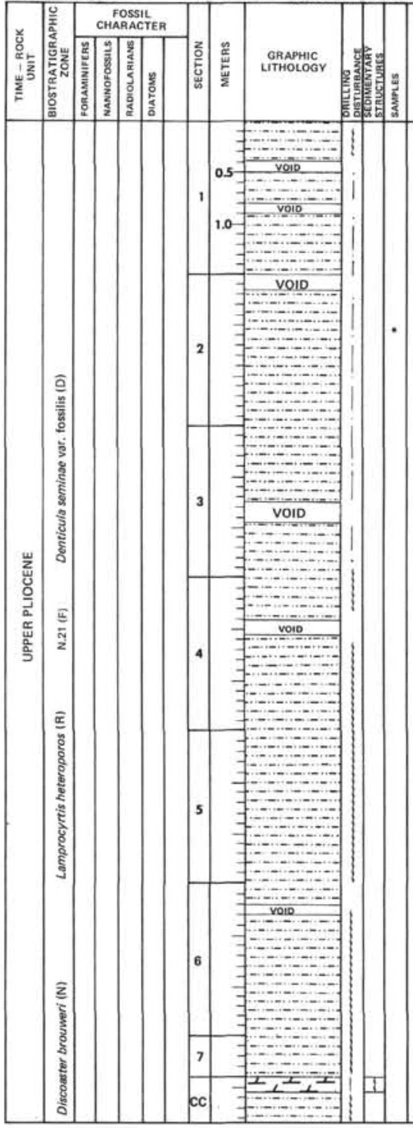
ORGANIC CARBON AND CARBONATE

	1-85
% Organic Carbon	–
% $CaCO_3$	42

SMEAR SLIDE SUMMARY

	1-126 (D)
TEXTURE:	
Sand	–
Silt	40
Clay	60
COMPOSITION:	
Quartz	5
Feldspar	2
Heavy minerals	1
Clay	75
Glauconite	TR
Foraminifers	5
Calc. Nannofossils	10
Diatoms	TR
Radiolarians	TR
Sponge spicules	2

SITE 467 HOLE CORE 16 CORED INTERVAL 139.0–148.5 m



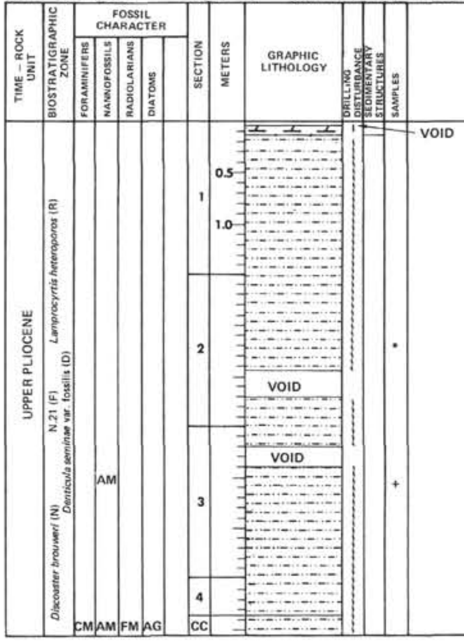
LITHOLOGIC DESCRIPTION

SILTY CLAY, medium olive gray (5Y 4/2) and light olive gray (5Y 5/2) with some olive brown (5Y 4/4) mottling in Section 4. Sponge fragments scattered throughout core. Section 1 contains carbonized wood fragments. A 16 cm thick (concretionary?) layer of olive gray (5Y 3/2) **CLAYEY DOLOMITE** in Core-Catcher is indistinctly burrowed.

SMEAR SLIDE SUMMARY

	2-60 (D)
TEXTURE:	
Sand	–
Silt	30
Clay	70
COMPOSITION:	
Quartz	10
Mica	2
Heavy minerals	1
Clay	60
Volcanic glass	5
Carbonate unspec.	10
Foraminifers	TR
Calc. Nannofossils	5
Diatoms	TR
Sponge spicules	5

SITE 467 HOLE CORE 17 CORED INTERVAL 148.5–158.0 m



LITHOLOGIC DESCRIPTION

SILTY CLAY, medium olive gray (5Y 4/2) with some olive gray (5Y 3/2) mottling. Homogeneous with scattered sponge fragments. A 4 cm thick interval of olive gray (5Y 3/2) **CLAYEY DOLOMITE** occurs at top of core.

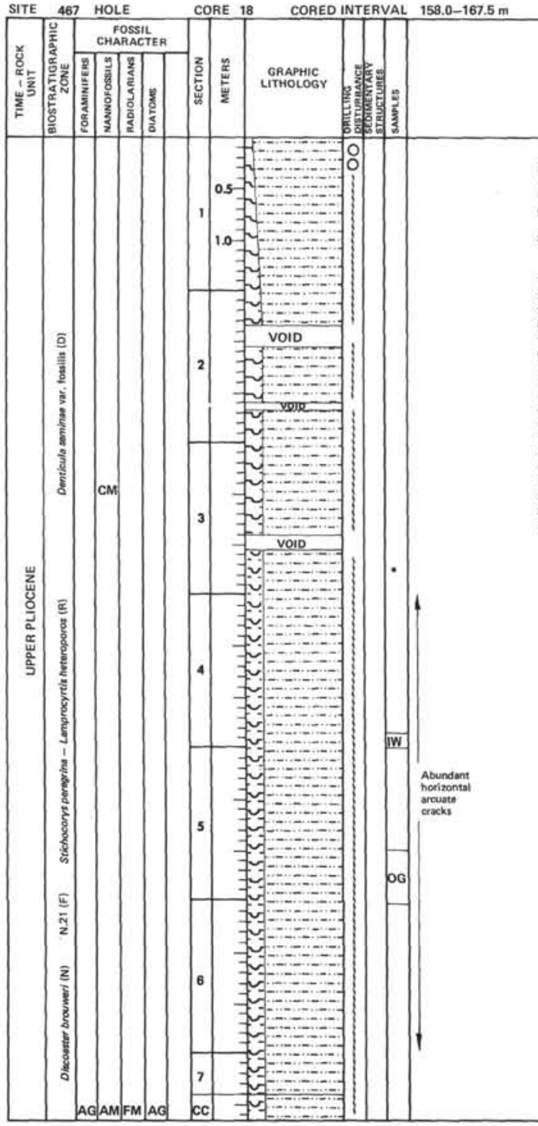
ORGANIC CARBON AND CARBONATE

	3-59
% Organic Carbon	–
% $CaCO_3$	40

SMEAR SLIDE SUMMARY

	2-70 (D)
TEXTURE:	
Sand	–
Silt	30
Clay	70
COMPOSITION:	
Quartz	10
Feldspar	3
Mica	TR
Heavy minerals	2
Clay	50
Glauconite	TR
Carbonate unspec.	10
Foraminifers	5
Calc. Nannofossils	10
Diatoms	2
Radiolarians	TR
Sponge spicules	8
Siicoflagellates	TR
Plant debris	TR

SITE 467 HOLE CORE 18 CORED INTERVAL 158.0–167.5 m



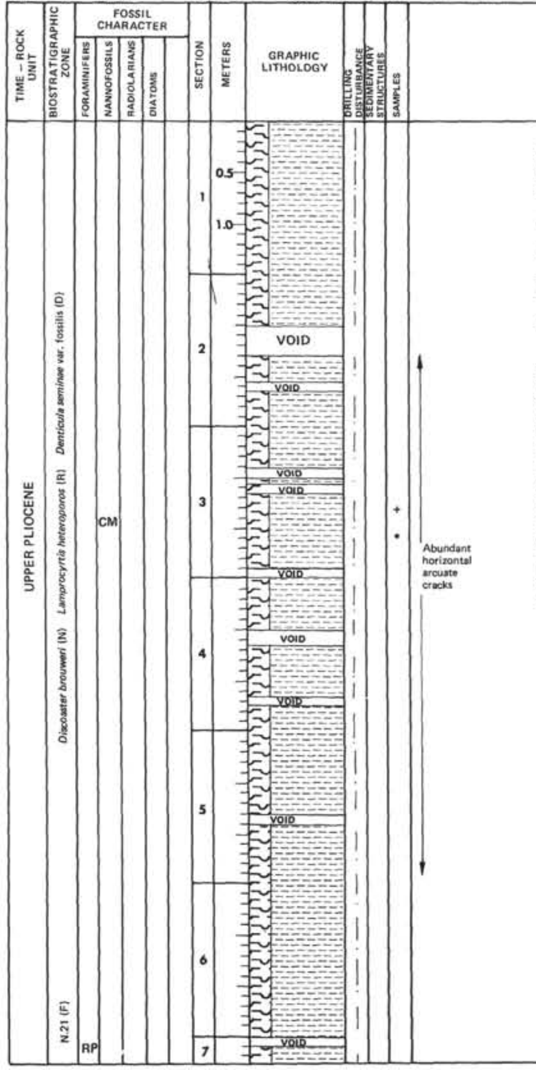
LITHOLOGIC DESCRIPTION

DIATOMACEOUS SILTY CLAY, medium olive gray (5Y 4/2) with some light olive gray (5Y 5/2) patches in Section 2. Abundant voids and horizontal arcuate cracks in core perhaps result of gas expansion.

SMEAR SLIDE SUMMARY

	3-130 (D)
TEXTURE:	
Sand	–
Silt	25
Clay	75
COMPOSITION:	
Quartz	3
Feldspar	2
Mica	TR
Heavy minerals	1
Clay	50
Carbonate unspec.	10
Foraminifers	TR
Calc. Nannofossils	10
Diatoms	15
Radiolarians	TR
Sponge spicules	10
Silicoflagellates	TR
Plant debris	TR

SITE 467 HOLE CORE 19 CORED INTERVAL 167.5–177.0 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY, medium olive gray (5Y 4/2) with some light olive gray (5Y 5/2) mottling in Section 7. Homogeneous. Abundant voids and horizontal arcuate cracks throughout core perhaps result of gas expansion.

No Core-Catcher.

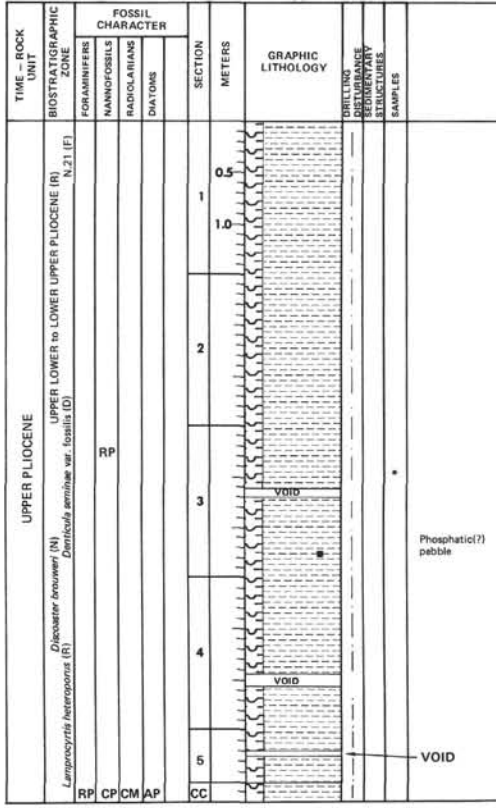
ORGANIC CARBON AND CARBONATE

	3-80
% Organic Carbon	–
% $CaCO_3$	22

SMEAR SLIDE SUMMARY

	3-110 (D)
TEXTURE:	
Sand	–
Silt	15
Clay	85
COMPOSITION:	
Quartz	3
Feldspar	1
Heavy minerals	1
Clay	50
Glauconite	TR
Carbonate unspec.	10
Foraminifers	TR
Calc. Nannofossils	10
Diatoms	15
Radiolarians	TR
Sponge spicules	10
Silicoflagellates	TR

SITE 467 HOLE CORE 20 CORED INTERVAL 177.0–186.5 m



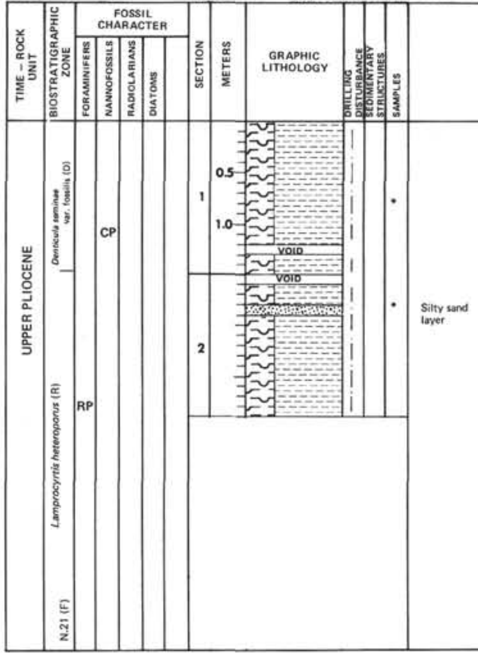
LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY, medium olive gray (5Y 4/2), homogeneous. Small phosphatic(?) pebble (~1 cm across) *occurs in Section 3, 120 cm.*

SMEAR SLIDE SUMMARY

	3-50 (D)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	3
Feldspar	1
Heavy minerals	1
Clay	50
Glauconite	TR
Carbonate unspec.	15
Foraminifers	TR
Calc. Nannofossils	5
Diatoms	20
Radiolarians	TR
Sponge spicules	5
Silicoflagellates	–
Plant debris	TR

SITE 467 HOLE CORE 21 CORED INTERVAL 186.5–196.0 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY, grayish olive (10Y 4/2). Sediment becoming more compact and firm. Some voids and horizontal cracks may be gas expansion features. Thin interval of structureless fine-grained, **SILTY SAND** in Section 2, 30–40 cm (See Smear Slide description below).

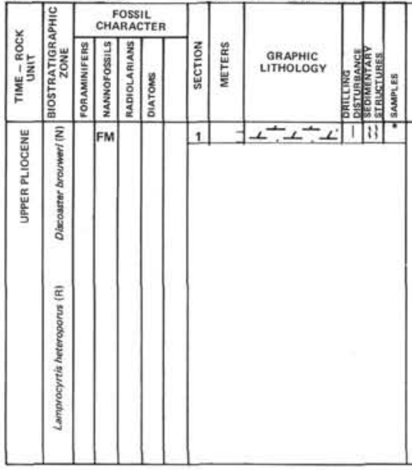
No Core-Catcher.

SMEAR SLIDE SUMMARY

	1-80 (D)	2-3 (M)
TEXTURE:		
Sand	5	75
Silt	15	20
Clay	80	5
COMPOSITION:		
Quartz	3	60
Feldspar	1	20
Mica	1	2
Heavy minerals	TR	2
Clay	58	5
Volcanic glass	–	TR
Glauconite	–	TR
Pyrite	2	2
Carbonate unspec.	–	4
Foraminifers	TR	2
Calc. Nannofossils	5	2
Diatoms	25	1
Radiolarians	TR	–
Sponge spicules	5	5
Volcanic rock fragments	–	TR

Note: Site 467, Core 22, 196.0–205.5 m: NO RECOVERY.

SITE 467 HOLE CORE 23 CORED INTERVAL 205.5–215.0 m



LITHOLOGIC DESCRIPTION

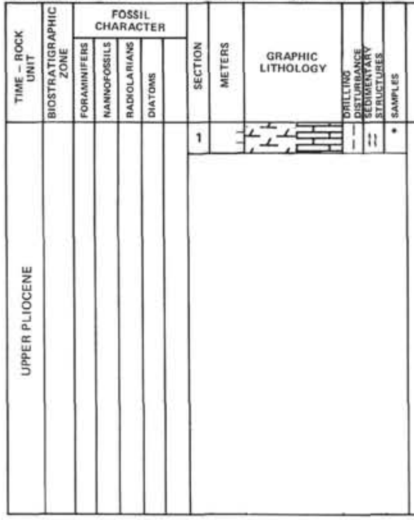
CLAYEY DOLOMITE, olive gray (5Y 3/2) to moderate olive brown (5Y 4/4), finely crystalline, homogeneous, and indistinctly burrowed. Hardness variable, becomes harder and better cemented below 6 cm.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	1-2 (D)
TEXTURE:	
Sand	–
Silt	30
Clay	70
COMPOSITION:	
Quartz	TR
Clay	30
Volcanic glass	TR
Pyrite	TR
Carbonate unspec.	70
Diatoms	TR

SITE 467 HOLE CORE 24 CORED INTERVAL 215.0–224.5 m



LITHOLOGIC DESCRIPTION

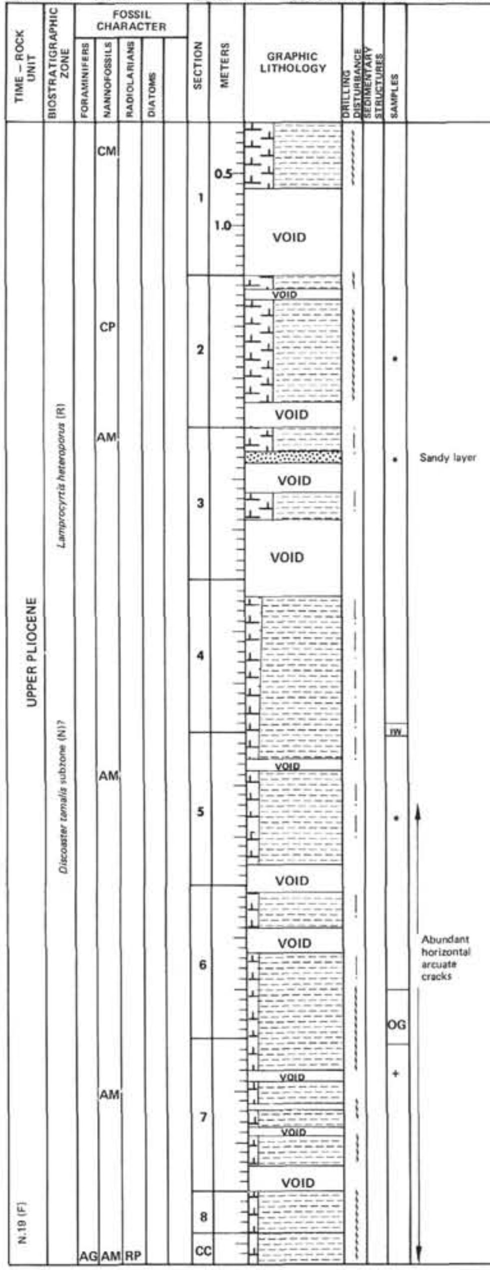
CLAYEY DOLOMITIC LIMESTONE, grayish olive (10Y 4/2), finely crystalline, homogeneous with distinct silt- and fine-sand-filled elongate burrows (1-2 cm in diameter). Some foraminifers noted.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	1-10 (D, T)
TEXTURE:	
Sand	10
Silt	20
Clay	70
COMPOSITION:	
Quartz	5
Feldspar	3
Clay	20
Pyrite	1
Zeolite	1
Carbonate unspec.	70
Foraminifers	8
Chert	1
Calcareous rock fragments	1

SITE 467 HOLE CORE 25 CORED INTERVAL 224.5–234.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAY, olive gray (5Y 3/2) and grayish olive (10Y 4/2) changing to light olive gray in Section 5. Contains many diffuse darker olive gray intervals of **SAND** composed mainly of clay, foraminifers, and fine-sand-size grains of quartz and feldspar. Layer at 31 cm in Section 3 is the most distinct of these (See Smear Slide composition below). Abundant voids and horizontal arcuate cracks throughout core perhaps result from expansion of gas in sediment.

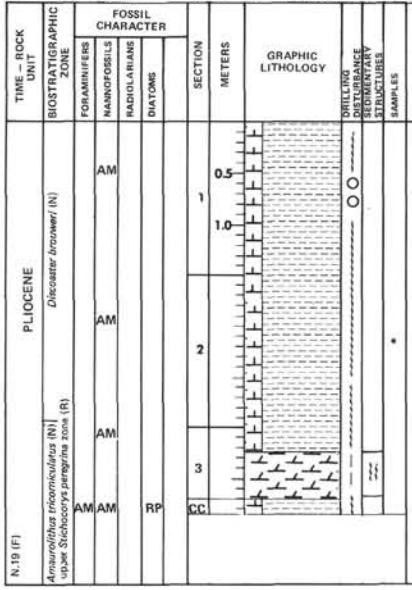
ORGANIC CARBON AND CARBONATE

	7-31
% Organic Carbon	–
% $CaCO_3$	47

SMEAR SLIDE SUMMARY

	2-89 (D)	3-31 (M)	5-81 (D)
TEXTURE:			
Sand	–	80	–
Silt	5	10	10
Clay	95	10	90
COMPOSITION:			
Quartz	1	35	10
Feldspar	1	25	5
Mica	TR	–	2
Heavy minerals	–	25	–
Clay	43	–	37
Volcanic glass	1	TT	–
Pyrite	3	–	–
Carbonate unspec.	10	–	10
Foraminifers	–	10	–
Calc. Nannofossils	31	–	16
Diatoms	5	–	5
Radiolarians	–	TR	–
Sponge spicules	5	5	15
Silicoflagellates	–	–	TR

SITE 467 HOLE CORE 26 CORED INTERVAL 234.0–243.5 m



LITHOLOGIC DESCRIPTION

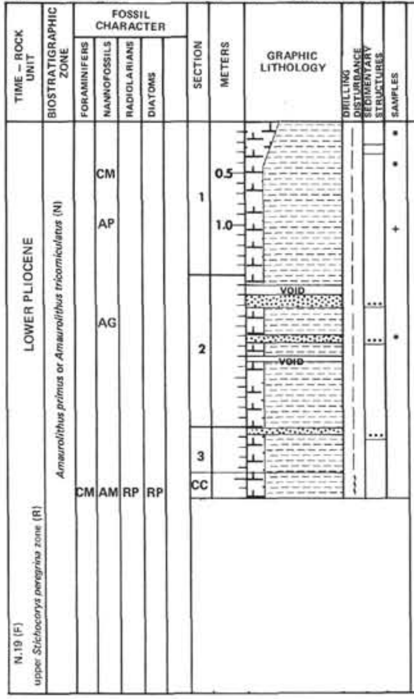
Clayey limestone

NANNOFOSSIL CLAY, light olive gray (5Y 5/2) with isolated patches of darker olive gray (5Y 3/2) clay scattered throughout Sections 1 and 2. 40 cm thick interval of grayish olive (10Y 4/2), finely crystalline **CLAYEY DOLOMITE** occur in Section 3. Limestone contains common silt-filled tubular burrows.

SMEAR SLIDE SUMMARY

	2-70 (D)
TEXTURE:	
Sand	10
Silt	20
Clay	70
COMPOSITION:	
Quartz	5
Feldspar	5
Mica	2
Heavy minerals	TR
Clay	51
Glauconite	TR
Pyrite	1
Zeolite	TR
Carbonate unspec.	3
Foraminifers	4
Calc. Nannofossils	19
Diatoms	2
Radiolarians	TR
Sponge spicules	5
Glaucophane	TR

SITE 467 HOLE CORE 27 CORED INTERVAL 243.5–253.0 m



LITHOLOGIC DESCRIPTION

5Y 5/2
5Y 3/2
5Y 7/2
Sharp color changes

5Y 5/2 Gradational color change

5Y 5/2
5Y 7/2
Sharp contact and color change

NANNOFOSSIL CLAY, colors variable – light olive gray (5Y 5/2) dark olive gray (5Y 3/2), grayish olive (10Y 5/4) and yellowish gray (5Y 7/2), changes in color often sharp. Several thin layers of fine-grained, foraminifer-rich, quartzofeldspathic **SAND** occur in Sections 2 and 3. Basal contacts are sharp, tops are gradational.

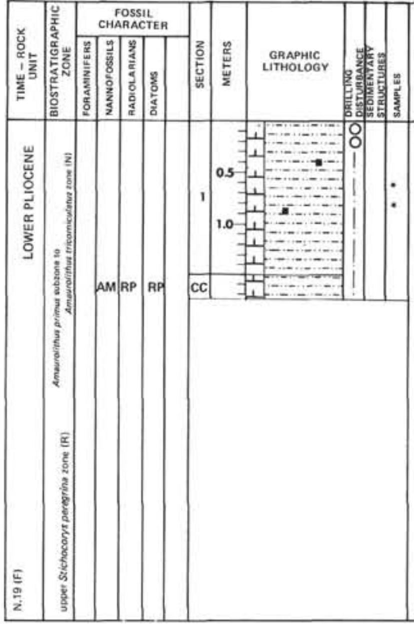
ORGANIC CARBON AND CARBONATE

	1-108
% Organic Carbon	–
% $CaCO_3$	36

SMEAR SLIDE SUMMARY

	1-15 (D)	1-42 (D)	2-63 (M)
TEXTURE:			
Sand	5	5	90
Silt	15	10	8
Clay	80	85	2
COMPOSITION:			
Quartz	5	8	35
Feldspar	2	3	25
Mica	3	1	–
Heavy minerals	1	1	1
Clay	49	46	2
Pyrite	1	2	2
Foraminifers	6	–	15
Calc. Nannofossils	25	20	–
Diatoms	2	8	3
Radiolarians	TR	TR	–
Sponge spicules	6	10	5
Silicoflagellates	–	1	–
Lithic fragments	–	–	8
Glaucophane	–	TR	1

SITE 467 HOLE CORE 28 CORED INTERVAL 253.0–262.5 m



LITHOLOGIC DESCRIPTION

Dacite clast

Dacite clast

NANNOFOSSIL SILTY CLAY, medium olive gray (5Y 4/2), homogeneous and contains two rounded dacitic clasts.

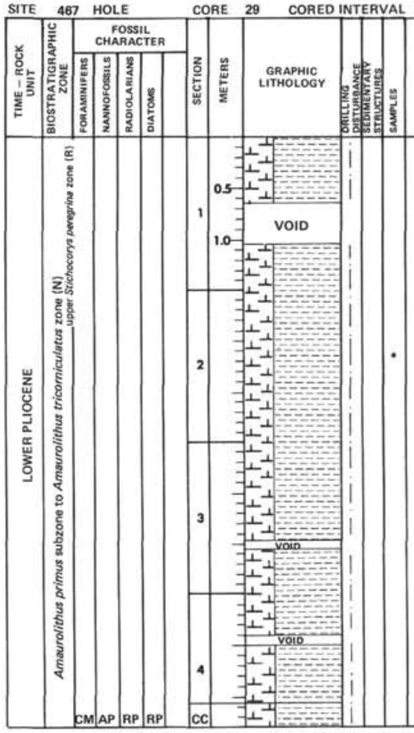
THIN SECTION DESCRIPTION (Porphyritic dacite clast at 1-82)

Phenocrysts: plag., 32%, 1–7 mm, euhedral; qtz., 4%, 2–5 mm, euhedral; hornblende, 4%, 1–3 mm, euhedral
Groundmass: plag., 24%, <0.3 mm; qtz., 27%, <0.3 mm; K-spar, 6%, <0.3 mm; sphene, TR
Vesicles: ~3%, round-irregular

SMEAR SLIDE SUMMARY

	1-68 (D)
TEXTURE:	
Sand	–
Silt	25
Clay	75
COMPOSITION:	
Quartz	10
Feldspar	2
Mica	1
Heavy minerals	–
Clay	51
Pyrite	4
Zeolite	TR
Foraminifers	4
Calc. Nannofossils	20
Diatoms	8
Radiolarians	TR
Sponge spicules	8
Silicoflagellates	2

SITE 467 HOLE CORE 29 CORED INTERVAL 262.5–272.0 m



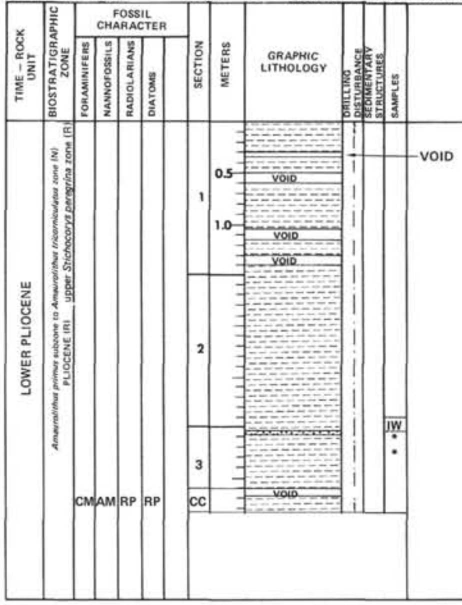
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAY, medium olive gray (5Y 4/2), homogeneous except for thin (~1 cm) foraminifer-rich sandy layer in Section 1, 55 cm.

SMEAR SLIDE SUMMARY

	2-70 (D)
TEXTURE:	
Sand	2
Silt	8
Clay	90
COMPOSITION:	
Quartz	5
Feldspar	1
Mica	1
Clay	42
Pyrite	4
Carbonate unspec.	8
Foraminifers	TR
Calc. Nannofossils	28
Diatoms	3
Radiolarians	TR
Sponge spicules	8

SITE 467 HOLE CORE 30 CORED INTERVAL 272.0–281.5 m



LITHOLOGIC DESCRIPTION

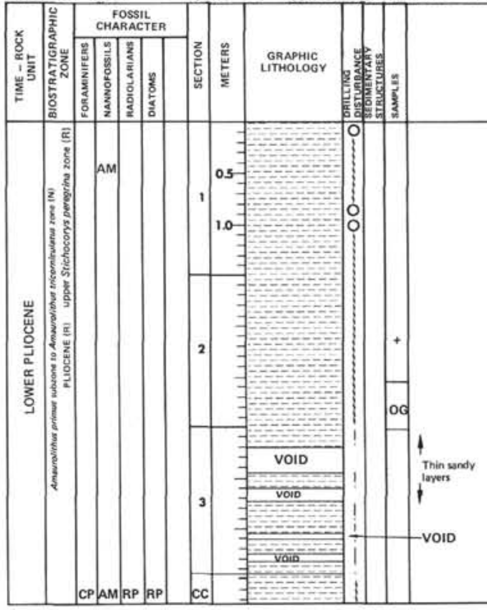
CLAY, medium olive gray (5Y 4/2), with occasional thin (~1 cm thick) layers of dark olive gray (5Y 3/2) foraminifer-rich, fine-grained **SAND** (Smear Slide description, Sample 3-8). Sand is moderately well-sorted; many clasts subangular. No sedimentary structures.

SMEAR SLIDE SUMMARY

	3-8 (M)	3-26 (D)
TEXTURE:		
Sand	85	6
Silt	10	11
Clay	5	84
COMPOSITION:		
Quartz	36	6
Feldspar	20	2
Mica	2	1
Heavy minerals	6	–
Clay	5	45
Pyrite	3	3
Carbonate unspec.	–	5
Foraminifers	6	20
Calc. Nannofossils	6	–
Diatoms	3	2
Sponge spicules	10	–
Actinolite	1	1
Iron oxides	–	15
Glaucophane	2	–

Note: Site 467, Core 31, 281.5–291.0 m: NO RECOVERY.

SITE 467 HOLE CORE 32 CORED INTERVAL 291.0–300.5 m



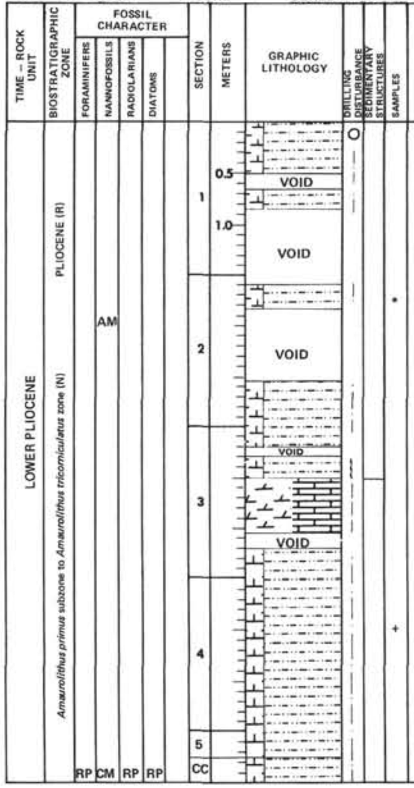
LITHOLOGIC DESCRIPTION

CLAY, medium olive gray (5Y 4/2) mottled with patches of olive black (5Y 2/1), thin (~1 cm), grayish brown (5YR 3/2) **SAND** layers common in Section 3.

ORGANIC CARBON AND CARBONATE

	2-63
% Organic Carbon	–
% $CaCO_3$	28

SITE 467 HOLE CORE 33 CORED INTERVAL 300.5–310.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL SILTY CLAY, light olive gray (5Y 5/2) grading to medium olive gray (5Y 4/2) in Section 4. 5Y 4/2 mottles scattered throughout. 56 cm thick interval of medium olive gray and dark olive gray (5Y 3/2) **CLAYEY DOLOMITIC LIMESTONE** in Section 3. Limestone is hard in center but less well-cemented near top and base. Indistinct mottling in limestone may be burrows. Thin sandy layers and patches occur in limestone and throughout core.

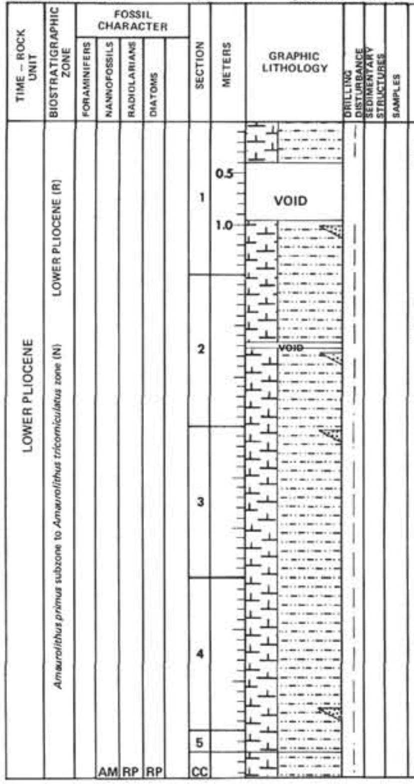
ORGANIC CARBON AND CARBONATE

	2-30
% Organic Carbon	–
% $CaCO_3$	53

SMEAR SLIDE SUMMARY

	2-30 (D)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	10
Feldspar	5
Mica	TR
Heavy minerals	2
Clay	50
Glauconite	TR
Carbonate unspec.	3
Foraminifers	3
Calc. Nannofossils	20
Diatoms	2
Sponge spicules	5
Silicoflagellates	TR

SITE 467 HOLE CORE 34 CORED INTERVAL 310.0–319.5 m



LITHOLOGIC DESCRIPTION

5Y 4/2 grades to

5Y 5/2 grades to

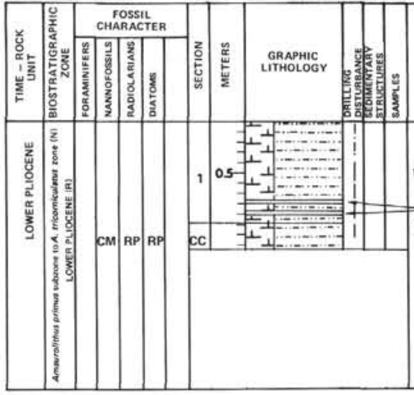
5Y 4/2

NANNOFOSSIL SILTY CLAY, medium olive gray (5Y 4/2) to light olive gray (5Y 5/2), with patches and thin layers of quartzo-feldspathic **SAND** (Smear Slide 2-77) scattered throughout core.

SMEAR SLIDE SUMMARY

	2-77 (M)	3-12 (D)
TEXTURE:		
Sand	90	5
Silt	10	20
Clay	–	75
COMPOSITION:		
Quartz	45	6
Feldspar	25	3
Mica	TR	–
Heavy minerals	2	–
Clay	–	57
Pyrite	–	1
Carbonate unspec.	5	–
Foraminifers	TR	–
Calc. Nannofossils	–	27
Diatoms	–	1
Sponge spicules	TR	2
Lithic fragments	15	–
Actinolite	8	–

SITE 467 HOLE CORE 35 CORED INTERVAL 319.5–329.0 m



LITHOLOGIC DESCRIPTION

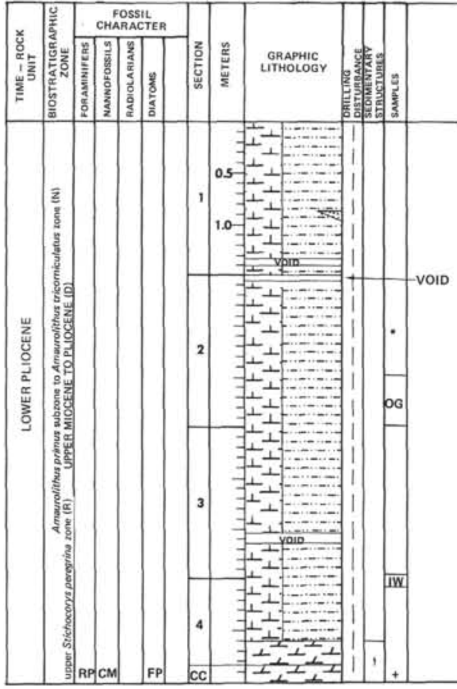
5Y 4/2 grades to

5Y 5/2

VOIDS

NANNOFOSSIL SILTY CLAY, medium olive gray (5Y 4/2) to light olive gray (5Y 5/2), homogeneous.

SITE 467 HOLE CORE 36 CORED INTERVAL 329.0–338.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL SILTY CLAY, mottled medium olive gray (5Y 4/2) to light olive gray (5Y 5/2). Sandy patch occurs in Section 1. Medium olive gray (5Y 4/2), finely crystalline **CLAYEY DOLOMITE** in Section 4 and Core-Catcher. Contains few sponge fragments and is indistinctly mottled.

ORGANIC CARBON AND CARBONATE

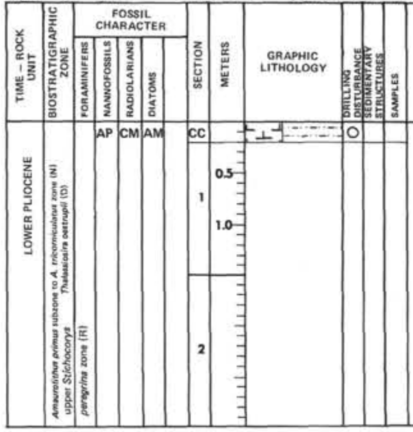
	CC
% Organic Carbon	–
% $CaCO_3$	68

SMEAR SLIDE SUMMARY

	2-60 (D)
TEXTURE:	
Sand	–
Silt	30
Clay	70
COMPOSITION:	
Quartz	10
Feldspar	6
Heavy minerals	2
Clay	30
Carbonate unspec.	4
Diatoms	TR
Radiolarians	2
Sponge spicules	6

Note: Site 467, Core 37, 338.5–348.0 m; NO RECOVERY.

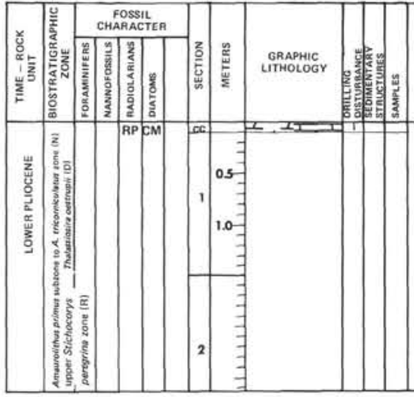
SITE 467 HOLE CORE 38 CORED INTERVAL 348.0–357.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL SILTY CLAY, medium olive gray (5Y 4/2), homogeneous.

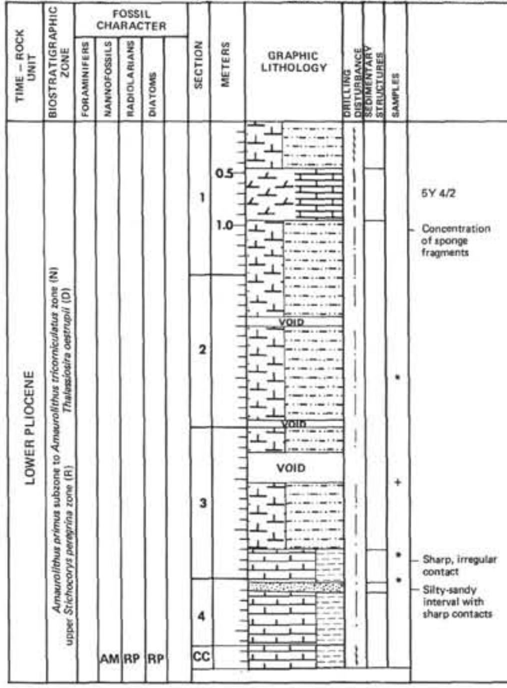
SITE 467 HOLE CORE 39 CORED INTERVAL 357.5–367.0 m



LITHOLOGIC DESCRIPTION

CLAYEY DOLOMITIC LIMESTONE, medium olive gray (5Y 4/2), only two small fragments recovered.

SITE 467 HOLE CORE 40 CORED INTERVAL 367.0–376.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL SILTY CLAYSTONE, mottled medium olive gray (5Y 4/2) to olive gray (5Y 3/2), fairly homogeneous through Section 3, 120 cm. Massive, finely crystalline **CLAYEY DOLOMITIC LIMESTONE** containing several echinoid spines occurs in Section 1. Light grayish olive (10Y 5/2) to mottled pale olive (10Y 6/2) **CLAYEY CHALK** below Section 3, 120 cm. Silty sandy wedge-shaped layer with sharp top and bottom contacts in Section 4. Sediments are firm; core below Section 2, 50 cm, broken into drilling biscuits.

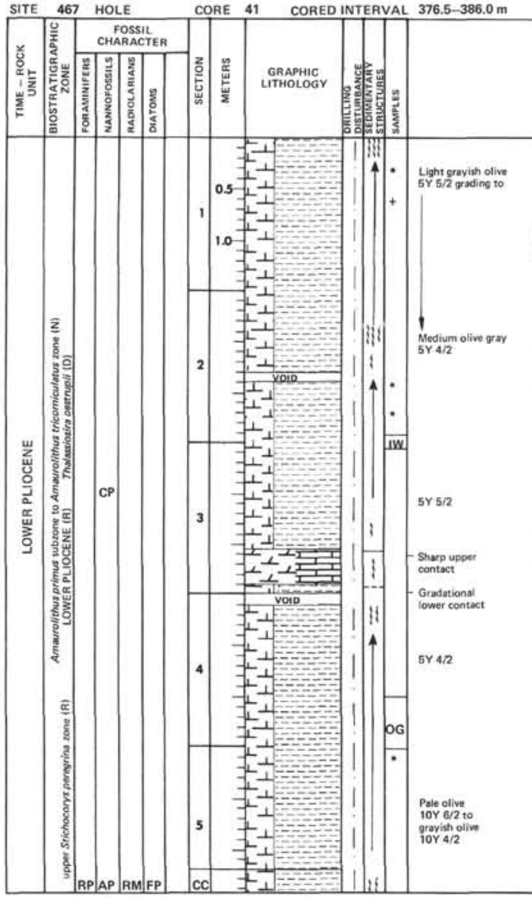
ORGANIC CARBON AND CARBONATE

	3-57
% Organic Carbon	–
% $CaCO_3$	18

SMEAR SLIDE SUMMARY

	2-100 (D)	3-130 (D)	4-5 (M)
TEXTURE:			
Sand	–	–	10
Silt	40	10	15
Clay	60	90	75
COMPOSITION:			
Quartz	5	3	5
Feldspar	2	1	2
Heavy minerals	1	1	–
Clay	40	20	25
Glauconite	TR	TR	–
Pyrite	TR	–	3
Carbonate unspec.	–	–	10
Foraminifers	20	TR	2
Calc. Nannofossils	40	70	50
Diatoms	2	–	–
Radiolarians	TR	TR	1
Sponge spicules	5	5	5
Silicoflagellates	TR	TR	–
Glaucophane	TR	–	–

SITE 467 HOLE CORE 41 CORED INTERVAL 376.5–386.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAYSTONE, dominantly light olive gray (5Y 5/2) changing to pale olive (10Y 6/2) down core, but abundant mottling and gradational color changes. Claystone is slightly to intensely bioturbated throughout. Finely crystalline **CLAYEY DOLOMITIC LIMESTONE** occurs in Section 3 with sharp upper contact but gradational lower boundary. Drilling biscuits.

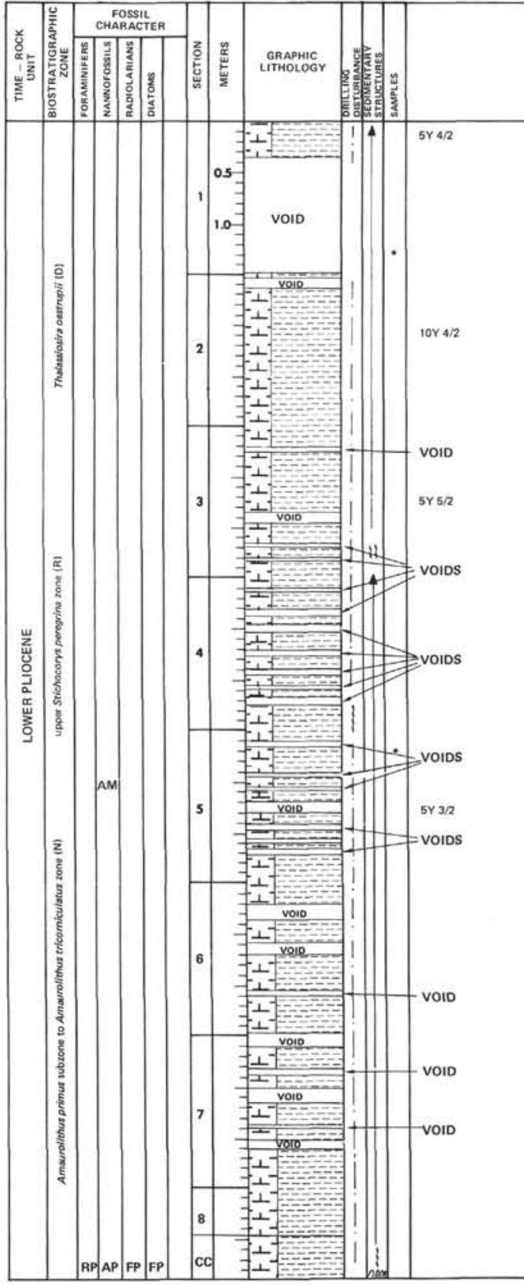
ORGANIC CARBON AND CARBONATE

	1-65
% Organic Carbon	3.56
% $CaCO_3$	21

SMEAR SLIDE SUMMARY

	1-37 (D)	2-88 (D)	2-120 (D)	5-13 (D)
TEXTURE:				
Sand	–	–	1	2
Silt	10	15	14	8
Clay	90	85	85	90
COMPOSITION:				
Quartz	7	7	7	3
Feldspar	3	3	3	1
Heavy minerals	TR	TR	TR	–
Clay	45	45	50	60
Pyrite	3	7	10	–
Carbonate unspec.	5	3	2	1
Foraminifers	–	–	–	–
Calc. Nannofossils	27	28	20	30
Diatoms	2	1	2	1
Radiolarians	–	–	–	–
Sponge spicules	8	6	6	4
Silicoflagellates	–	–	–	–

SITE 467 HOLE CORE 42 CORED INTERVAL 386.0–395.5 m



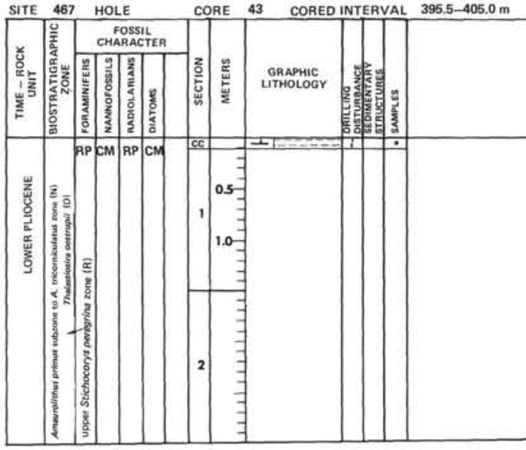
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAYSTONE, mottled light olive gray (5Y 5/2), olive gray (5Y 3/2) and grayish olive (10Y 4/2), homogeneous, slightly to intensely burrowed. Contorted laminations (slump folds?) common below Section 3. Core has abundant voids and subhorizontal arcuate cracks caused by expansion of gas in claystone. Drilling biscuits.

SMEAR SLIDE SUMMARY

	2-132 (D)	5-24 (D)
TEXTURE:		
Sand	–	–
Silt	15	5
Clay	85	95
COMPOSITION:		
Quartz	10	7
Feldspar	4	2
Mica	TR	TR
Heavy minerals	2	TR
Clay	50	44
Glauconite	–	1
Pyrite	2	2
Foraminifers	–	–
Calc. Nannofossils	30	27
Diatoms	TR	4
Radiolarians	2	2
Sponge spicules	4	10
Silicoflagellates	1	1

SITE 467 HOLE CORE 43 CORED INTERVAL 395.5–405.0 m



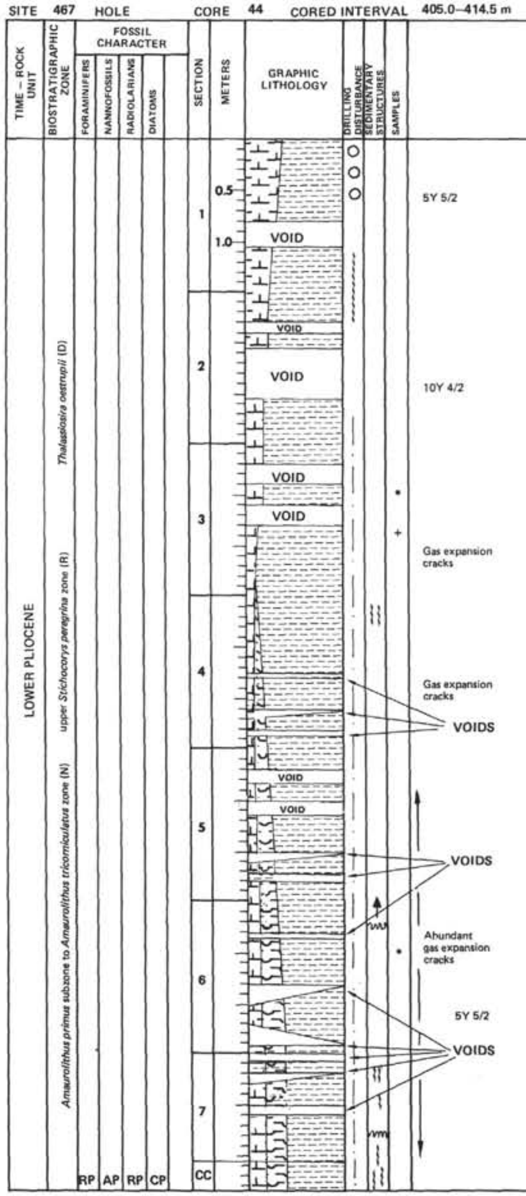
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAYSTONE, grayish olive (10Y 4/2), only small fragment recovered in Core-Catcher.

SMEAR SLIDE SUMMARY

	CC (D)
TEXTURE:	
Sand	5
Silt	10
Clay	85
COMPOSITION:	
Quartz	5
Feldspar	3
Mica	TR
Heavy minerals	1
Clay	50
Pyrite	1
Calc. Nannofossils	30
Sponge spicules	10

SITE 467 HOLE CORE 44 CORED INTERVAL 405.0–414.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAY AND CLAYSTONE grading to **DIATOMACEOUS CLAYSTONE** down core, gradational color changes from light olive gray (5Y 5/2) to grayish olive (10Y 4/2) to olive gray (5Y 3/2), bioturbated zones in Sections 4 and 7; contorted laminations common near top Section 6. Abundant voids and horizontal arcurate cracks throughout core result of gas expansion.

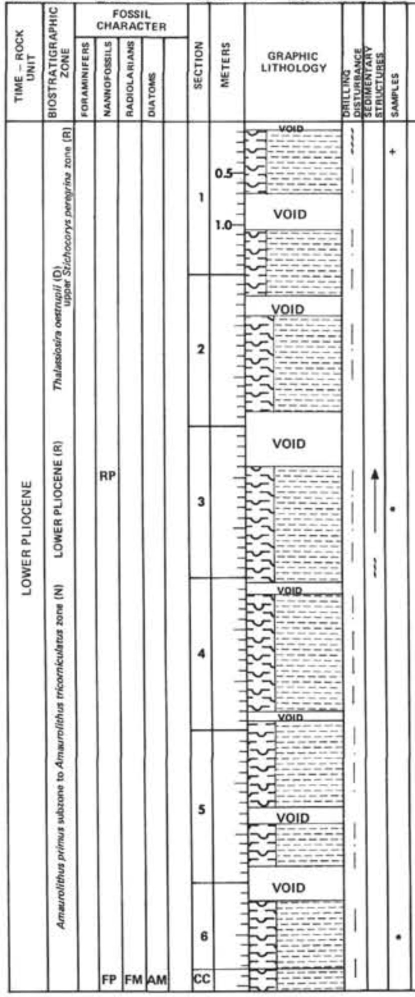
ORGANIC CARBON AND CARBONATE

	3-89
% Organic Carbon	4.32
% $CaCO_3$	29

SMEAR SLIDE SUMMARY

	3-50 (D)	6-50 (D)
TEXTURE:		
Sand	–	–
Silt	20	20
Clay	80	80
COMPOSITION:		
Quartz	7	10
Feldspar	6	6
Mica	1	1
Heavy minerals	2	1
Clay	57	42
Glauconite	TR	–
Pyrite	TR	1
Foraminifers	TR	1
Calc. Nannofossils	15	8
Diatoms	2	13
Radiolarians	1	8
Sponge spicules	8	6
Silicoflagellates	1	3

SITE 467 HOLE CORE 45 CORED INTERVAL 414.5–424.0 m



LITHOLOGIC DESCRIPTION

Mottled

Mottled

Mottled

Mottled

DIATOMACEOUS CLAYSTONE, olive gray (5Y 3/2), faintly mottled, homogeneous. Core is darker than previous core. Faint petroliferous odor. Voids and cracks partly due to gas expansion. Drilling biscuits.

ORGANIC CARBON AND CARBONATE

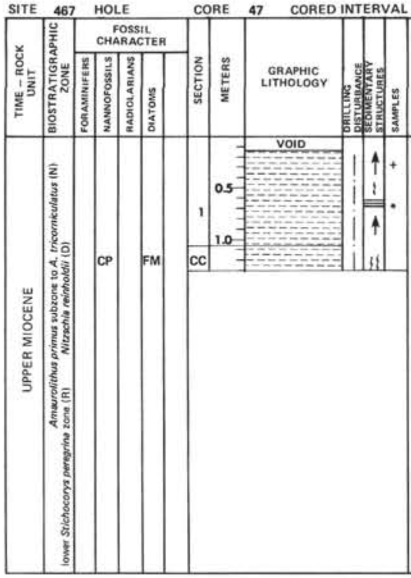
	1-30
% Organic Carbon	–
% $CaCO_3$	12

SMEAR SLIDE SUMMARY

	3-89 (D)	6-54 (D)
TEXTURE:		
Sand	5	5
Silt	10	15
Clay	85	80
COMPOSITION:		
Quartz	3	5
Feldspar	2	3
Mica	1	1
Heavy minerals	2	1
Clay	46	58
Pyrite	2	2
Foraminifers	–	TR
Calc. Nannofossils	5	3
Diatoms	25	15
Radiolarians	TR	TR
Sponge spicules	12	12
Silicoflagellates	2	–

Note: Site 467, Core 46, 424.0–433.5 m: NO RECOVERY.

SITE 467 HOLE CORE 47 CORED INTERVAL 433.5–443.0 m



LITHOLOGIC DESCRIPTION

Echinod spines(?) or gastropod fragments(?)

Echinoid spines(?) or gastropod fragments(?)

CLAYSTONE, olive gray (5Y 3/2), faintly mottled, homogeneous, burrowed. Laminations at 60–70 cm. Drilling biscuits.

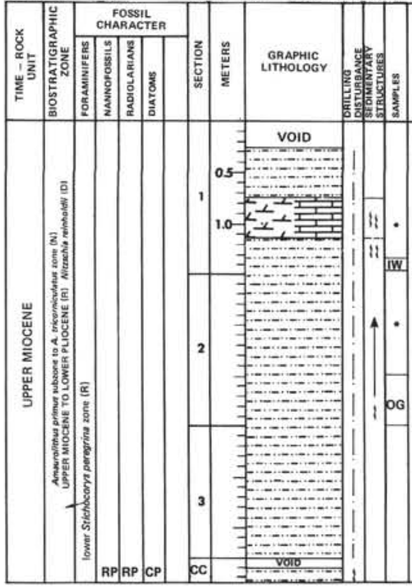
ORGANIC CARBON AND CARBONATE

	1-30
% Organic Carbon	4.89
% $CaCO_3$	12

SMEAR SLIDE SUMMARY

	1-72 (D)
TEXTURE:	
Sand	–
Silt	12
Clay	88
COMPOSITION:	
Quartz	9
Feldspar	2
Mica	–
Heavy minerals	TR
Clay	75
Pyrite	1
Foraminifers	–
Calc. Nannofossils	8
Diatoms	2
Radiolarians	1
Sponge spicules	2
Silicoflagellates	TR

SITE 467 HOLE CORE 48 CORED INTERVAL 443.0–452.5 m



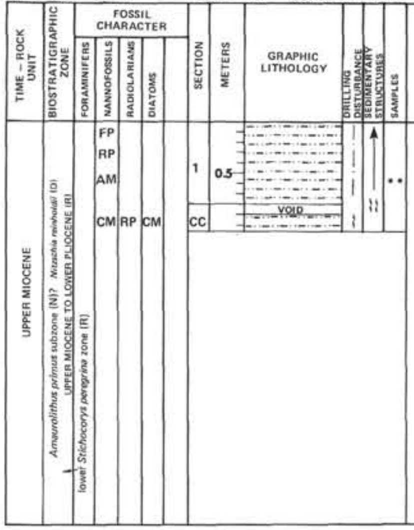
LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, olive gray (5Y 3/2), with common tube-shaped burrows subparallel to bedding. Finely crystalline, light olive gray (5Y 5/2) **CLAYEY DOLOMITIC LIMESTONE** in Section 1 contains many tube-shaped burrows 1–2 cm in diameter. Drilling biscuits.

SMEAR SLIDE SUMMARY

	1-103 (M, T)	2-52 (D)
TEXTURE:		
Sand	10	5
Silt	50	25
Clay	40	70
COMPOSITION:		
Quartz	5	10
Feldspar	2	5
Mica	1	1
Heavy minerals	–	3
Clay	10	56
Glauconite	–	TR
Pyrite	–	2
Carbonate unspec.	73	4
Foraminifers	6	
Diatoms	–	6
Radiolarians	–	TR
Sponge spicules	3	8
Silicoflagellates	–	TR
Echinoid spines	TR	–

SITE 467 HOLE CORE 49 CORED INTERVAL 452.5–462.0 m



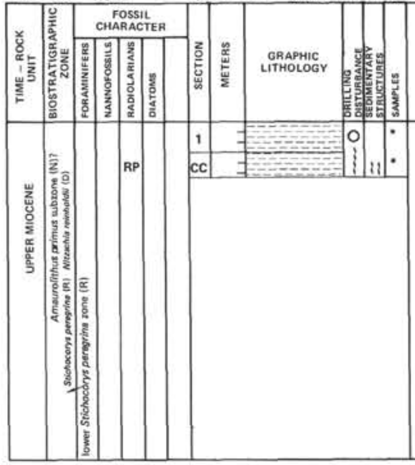
LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, mottled, with irregular subparallel alternation of light grayish olive (10Y 4/2) and dark olive gray (5Y 3/2) layers. Burrows common throughout core. Drilling biscuits.

SMEAR SLIDE SUMMARY

	1-63 (D, light layer)	1-63 (D, dark layer)
TEXTURE:		
Sand	5	3
Silt	20	25
Clay	75	72
COMPOSITION:		
Quartz	8	6
Feldspar	5	4
Mica	1	2
Heavy minerals	2	2
Clay	60	54
Glauconite	TR	–
Pyrite	3	3
Carbonate unspec.	–	4
Calc. Nannofossils	3	6
Diatoms	6	8
Sponge spicules	10	10
Silicoflagellates	1	TR
Dolomite	–	1

SITE 467 HOLE CORE 50 CORED INTERVAL 462.0–471.5 m



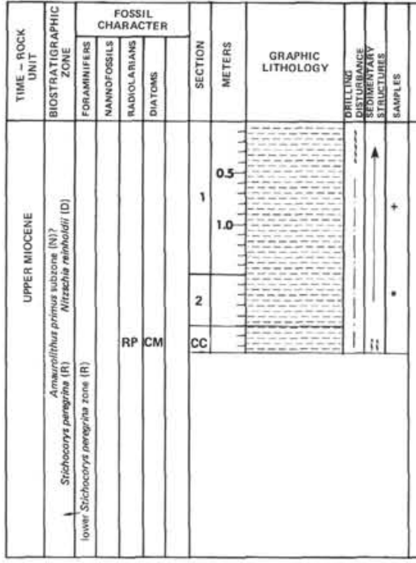
LITHOLOGIC DESCRIPTION

CLAYSTONE, olive black (5Y 2/1) with dark olive gra (5Y 3/2) mottles and burrows. Drilling biscuits.

SMEAR SLIDE SUMMARY

	1-17 (D)	CC (D)
TEXTURE:		
Sand	1	–
Silt	9	10
Clay	90	90
COMPOSITION:		
Quartz	5	5
Feldspar	3	2
Heavy minerals	1	1
Clay	65	65
Pyrite	1	1
Carbonate unspec.	7	5
Foraminifers	TR	TR
Calc. Nannofossils	8	7
Diatoms	3	5
Sponge spicules	7	8
Dolomite	–	1

SITE 467 HOLE CORE 51 CORED INTERVAL 471.5–481.0 m



LITHOLOGIC DESCRIPTION

5Y 2/1
grades to
10Y 4/2

CLAYSTONE, olive black (5Y 2/1) with olive gray mottles to olive gray (10Y 4/2), homogeneous and burrowed throughout. Drilling biscuits.

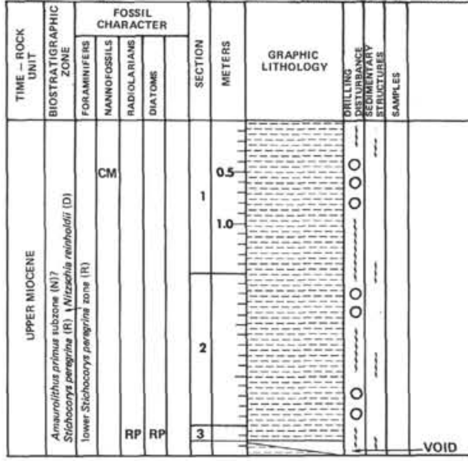
ORGANIC CARBON AND CARBONATE

	1-88
% Organic Carbon	–
% $CaCO_3$	5

SMEAR SLIDE SUMMARY

	2-23 (D)
TEXTURE:	
Sand	–
Silt	10
Clay	90
COMPOSITION:	
Quartz	5
Feldspar	3
Heavy minerals	1
Clay	67
Pyrite	1
Carbonate unspec.	3
Foraminifers	TR
Calc. Nannofossils	5
Diatoms	6
Radiolarians	TR
Sponge spicules	9
Glaucophane	TR

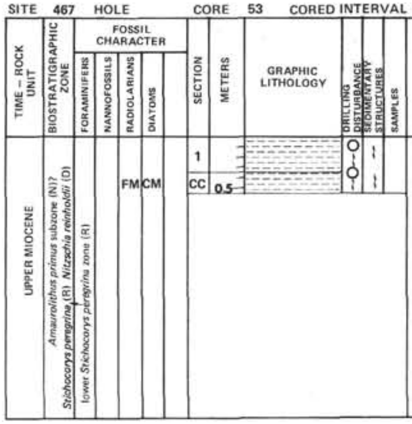
SITE 467 HOLE CORE 52 CORED INTERVAL 481.0–490.5 m



LITHOLOGIC DESCRIPTION

CLAYSTONE, olive gray (5Y 3/2) to moderate olive brown (10Y 4/2) to grayish olive, burrowed. Drilling breccia.

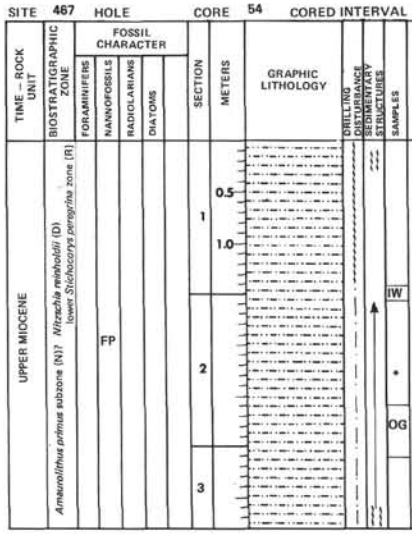
SITE 467 HOLE CORE 53 CORED INTERVAL 490.5–500.0 m



LITHOLOGIC DESCRIPTION

CLAYSTONE, medium olive gray (5Y 4/2) with olive gray (5Y 3/2) mottles, homogeneous. Pieces of undisturbed claystone show burrows. Drilling breccia.

SITE 467 HOLE CORE 54 CORED INTERVAL 500.0–509.5 m



LITHOLOGIC DESCRIPTION

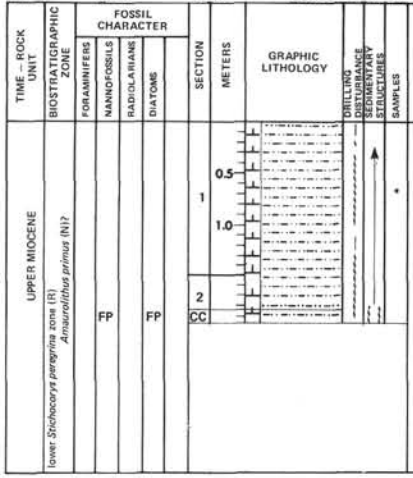
SILTY CLAYSTONE, dusky yellowish brown (10YR 2/2) to mottled grayish olive (10Y 4/2), fractured and brecciated by drilling. Contains fragments and patches of calcareous silty claystone (Sections 2 and 3). Drilling breccia and biscuits.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	2-88 (D)
TEXTURE:	
Sand	–
Silt	25
Clay	75
COMPOSITION:	
Quartz	5
Feldspar	1
Heavy minerals	1
Clay	70
Glauconite	1
Pyrite	TR
Carbonate unspec.	5
Foraminifers	1
Radiolarians	TR
Sponge spicules	8
Plant debris	1

SITE 467 HOLE CORE 55 CORED INTERVAL 509.5–519.0 m



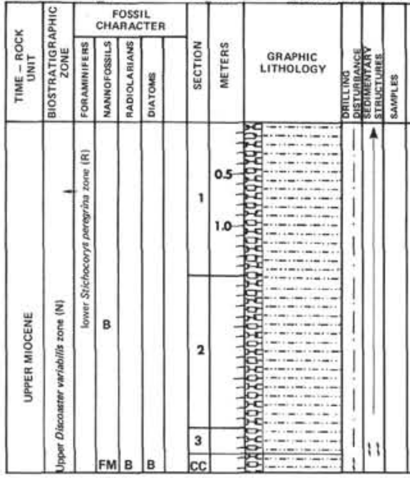
LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, dark yellowish brown (10YR 3/2), mottled and burrowed. Carbonate occurs as cement. Drilling breccia and biscuits.

SMEAR SLIDE SUMMARY

	1-70 (D)
TEXTURE:	
Sand	–
Silt	25
Clay	75
COMPOSITION:	
Quartz	3
Feldspar	2
Heavy minerals	2
Clay	60
Glauconite	TR
Carbonate unspec.	15
Foraminifers	2
Calc. Nannofossils	10
Diatoms	1
Sponge spicules	5
Plant debris	TR

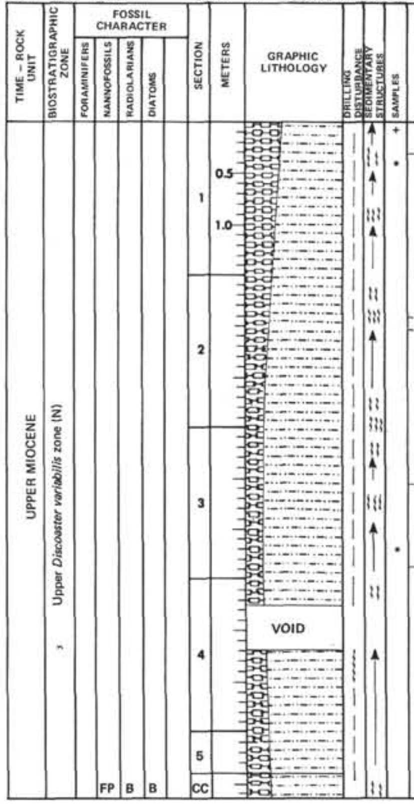
SITE 467 HOLE CORE 56 CORED INTERVAL 519.0–528.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, dark yellowish brown (10YR 3/2), homogeneous and extensively burrowed. Contains scattered foraminifers, glauconite and organic debris. Two pieces of very hard claystone at base of Section 2. Drilling biscuits.

SITE 467 HOLE CORE 57 CORED INTERVAL 528.5–538.0 m



LITHOLOGIC DESCRIPTION

- Dark clayey patch
5Y 2/2
Extensively burrow interval
5Y 4/2
5Y 2/2
5Y 4/2
- Inclined dark band
- Large irregular burrow
5Y 2/2
5Y 4/2
- Back-filled burrow
- Light olive patch of calcareous claystone with sharp contacts
5Y 2/2
5Y 4/2

CALCAREOUS SILTY CLAYSTONE, olive black (5Y 2/2) to medium olive (5Y 4/2) mottled and extensively burrowed throughout. Burrows/lenticular layers especially common Section 1, 65–100 cm. Most burrows are long, 1–3 cm in diameter, and subparallel to bedding. Fragment in Section 3 at 135 cm has patch of light olive calcareous claystone with sharp boundaries with darker silty claystone.

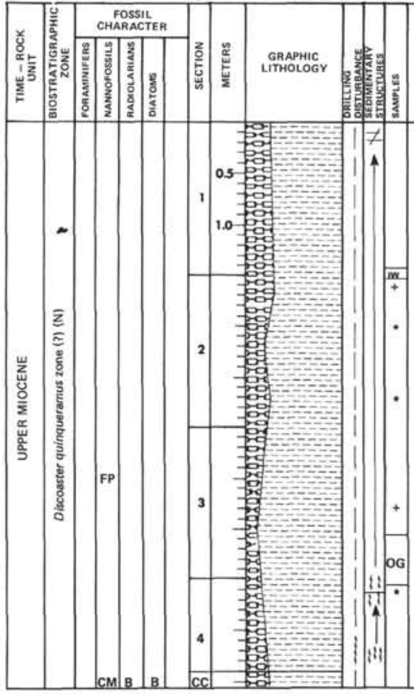
ORGANIC CARBON AND CARBONATE

	1-10
% Organic Carbon	4.67
% $CaCO_3$	17

SMEAR SLIDE SUMMARY

	1-44 (D, T)	3-125 (D)
TEXTURE:		
Sand	–	–
Silt	20	25
Clay	80	75
COMPOSITION:		
Quartz	6	5
Feldspar	3	1
Mica	–	–
Heavy minerals	10	2
Clay	55	60
Glauconite	TR	1
Pyrite	–	TR
Zeolite	TR	–
Carbonate unspec.	25	10
Foraminifers	TR	TR
Calc. Nannofossils	TR	20
Radiolarians	–	TR
Sponge spicules	TR	TR
Plant debris	–	1

SITE 467 HOLE CORE 58 CORED INTERVAL 538.0–547.5 m



LITHOLOGIC DESCRIPTION

Sharp microfaulted contact
~Bedding parallel burrows-lenticular layers common
Drilling biscuits
Sandy layer
Many burrows

CALCAREOUS CLAYSTONE, grayish olive (10Y 4/2) with light olive gray (5Y 5/2) and olive black (5Y 2/1) mottling. Abundant ~bedding parallel burrows and lenticular layers throughout core. Some burrows deformed by compaction. Scattered sponge fragments throughout core. Thin (1 cm thick) **SAND** layer at top Section 4.

ORGANIC CARBON AND CARBONATE

	2-11	3-86
% Organic Carbon	–	9.91
% $CaCO_3$	23	15

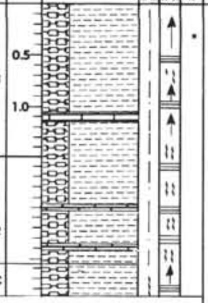
SMEAR SLIDE SUMMARY

	2-58 (D)	2-124 (D)	4-8 (M)
TEXTURE:			
Sand	2	5	90
Silt	18	20	10
Clay	80	75	–
COMPOSITION:			
Quartz	5	6	55
Feldspar	3	2	38
Mica	1	1	3
Heavy minerals	3	2	2
Clay	61	59	–
Volcanic glass	–	–	–
Glauconite	–	–	1
Pyrite	2	2	2
Carbonate unspec.	20	24	–
Sponge spicules	5	2	–

SITE 467 HOLE CORE 59 CORED INTERVAL 547.5–557.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Upper Discoaster variabilis zone* (N)					1
						2
		FP	B	B		CC

METERS / GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Alternations of laminated (lenticular) and burrowed zones

CALCAREOUS CLAYSTONE, olive black (5Y 2/1) with thin moderate olive brown (5Y 4/4) laminations or lenticular layers and intervals of grayish brown (5YR 3/2) **CLAYEY LIMESTONE.** Claystones has alternations of burrowed and laminated/lenticular zones each ~10–50 cm thick. Limestone is burrowed; may be concretionary.

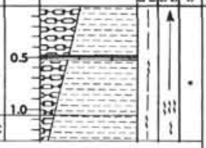
SMEAR SLIDE SUMMARY

	1-47 (D)
TEXTURE:	
Sand	1
Silt	9
Clay	90
COMPOSITION:	
Quartz	6
Feldspar	3
Mica	1
Clay	57
Pyrite	2
Carbonate unspec.	30
Foraminifers	–
Calc. Nannofossils	1
Diatoms	TR
Radiolarians	–

SITE 467 HOLE CORE 61 CORED INTERVAL 566.5–576.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Upper Discoaster variabilis zone* (N)					1
		RP	B	B		CC

METERS / GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Abundant large burrows

Limey interval

CALCAREOUS CLAYSTONE, olive gray (5Y 4/1) to dusky brown (5YR 2/2). Intensively burrowed zone in Section 1, 0–30 cm, has large elongate burrows 1–3 cm in diameter marked by sharp color contrasts (olive gray versus darker olive gray – 5Y 5/2). Grayish brown (5YR 3/2) finely crystalline interval of **CLAYEY LIMESTONE** occurs near center Section 1.

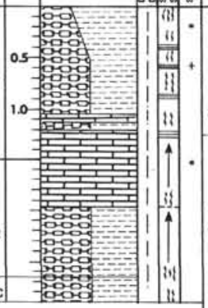
SMEAR SLIDE SUMMARY

	1-80 (D)
TEXTURE:	
Sand	2
Silt	20
Clay	78
COMPOSITION:	
Quartz	6
Feldspar	2
Mica	1
Heavy minerals	1
Clay	79
Pyrite	2
Carbonate unspec.	?
Foraminifers	1
Calc. Nannofossils	8

SITE 467 HOLE CORE 60 CORED INTERVAL 557.0–566.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Upper Discoaster variabilis zone* (N)		AM			1
						2
		CP	B	B		CC

METERS / GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Alternations of burrowed and laminated zones

Sharp change

Gradational change

CALCAREOUS CLAYSTONE, light olive gray (5Y 5/2) and light/dark grayish brown (5YR 3/2) to pale olive (10Y 6/2) and dusky brown (5YR 2/2). Section 1 has alternations of burrowed and laminated/lenticular bedded zones; Section 2 is burrowed throughout. Grayish brown (5YR 3/2) **CLAYEY LIMESTONE** at base Section 1 – top Section 2 is finely crystalline, burrowed, with sharp upper contact and gradational lower contact. Thin section shows spherical patches of sparry carbonate – possibly molds of radiolarians.

ORGANIC CARBON AND CARBONATE

	1-58
% Organic Carbon	–
% $CaCO_3$	57

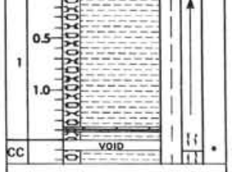
SMEAR SLIDE SUMMARY

	1-25 (D)	2-2 (D, T)
TEXTURE:		
Sand	3	–
Silt	12	–
Clay	85	–
COMPOSITION:		
Quartz	3	4
Feldspar	2	1
Mica	TR	TR
Heavy minerals	1	4
Clay	55	30
Glauconite	1	–
Pyrite	–	5
Carbonate unspec.	30	52
Foraminifers	1	3
Calc. Nannofossils	8	–
Diatoms	TR	–
Sponge spicules	–	1
Chalcedony(?)	1	–

SITE 467 HOLE CORE 62 CORED INTERVAL 576.0–585.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Upper Discoaster variabilis zone* (N)		B			1
		FP	B	B		CC

METERS / GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

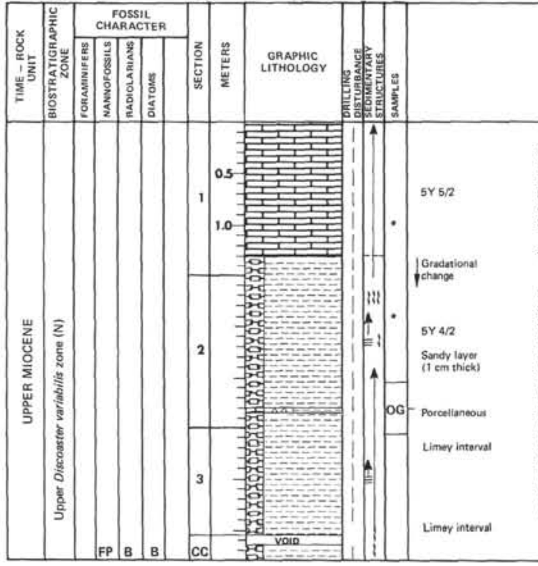
Sharp color change– top piece of Core-Catcher

CALCAREOUS CLAYSTONE, mottled moderate olive gray (5Y 4/2) and dusky yellowish brown (10YR 2/2) to pale olive (10Y 6/2) and moderate olive gray (5Y 4/2), burrowed with thin interval of **CLAYEY LIMESTONE** at 140 cm, Section 1.

SMEAR SLIDE SUMMARY

	CC (D)
TEXTURE:	
Sand	2
Silt	8
Clay	90
COMPOSITION:	
Quartz	6
Feldspar	2
Mica	1
Heavy minerals	2
Clay	52
Pyrite	2
Carbonate unspec.	20
Calc. Nannofossils	15

SITE 467 HOLE CORE 63 CORED INTERVAL 585.5–595.0 m



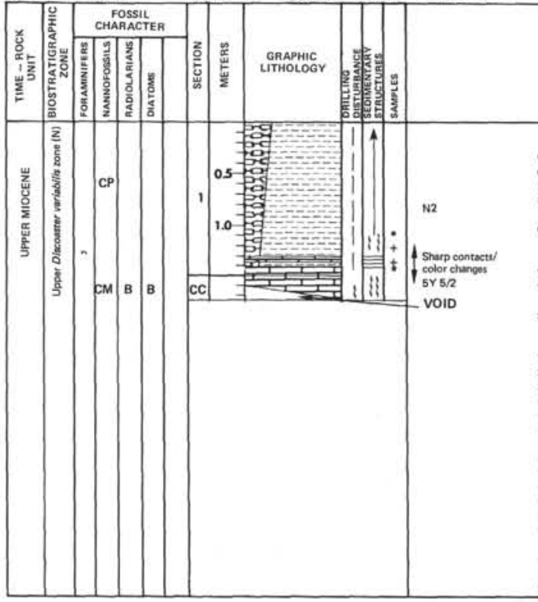
LITHOLOGIC DESCRIPTION

CLAYEY LIMESTONE, light olive gray (5Y 5/2), grades to grayish olive (5Y 4/2) **CALCAREOUS CLAYSTONE** near base of Section 1. Burrows common throughout core. Subparallel laminations/lenticular layers Section 2, 45–75 cm. Other limey intervals at top and base of Section 3. Sandy layer (~1 cm thick) Section 2.

SMEAR SLIDE SUMMARY

	1-100 (D, T)	2-44 (D)
TEXTURE:		
Sand	5	2
Silt	10	8
Clay	85	90
COMPOSITION:		
Quartz	3	6
Feldspar	1	2
Mica	TR	1
Heavy minerals	5	2
Clay	25	62
Glauconite	TR	2
Pyrite	TR	–
Carbonate unspec.	67	20
Foraminifers	3	–
Calc. Nannofossils	–	5
Altered lithic fragments	TR	–

SITE 467 HOLE CORE 64 CORED INTERVAL 595.0–604.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, grayish black (N2) changing to light olive gray (5Y 5/2) **CLAYEY LIMESTONE** near base Section 2. Burrowed throughout. Contains few thin lenticular beds.

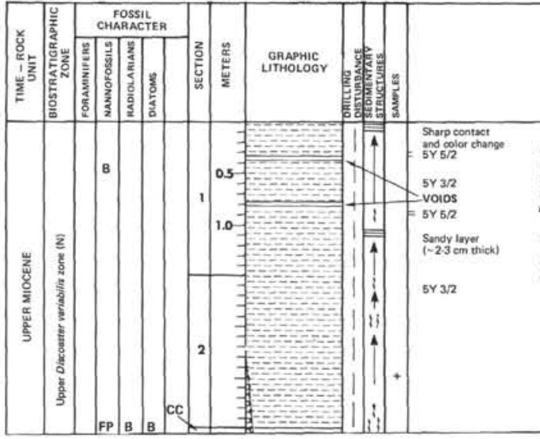
ORGANIC CARBON AND CARBONATE

	1-128 (dark)	1-138 (light)
% Organic Carbon	8.92	–
% $CaCO_3$	8	41

SMEAR SLIDE SUMMARY

	1-119 (D, dark)	1-144 (D, light)
TEXTURE:		
Sand	2	2
Silt	8	8
Clay	90	90
COMPOSITION:		
Quartz	5	4
Feldspar	2	2
Mica	1	1
Heavy minerals	3	4
Clay	60	42
Glauconite	TR	–
Pyrite	1	3
Carbonate unspec.	15	23
Foraminifers	–	1
Calc. Nannofossils	11	15
Diatoms	TR	–
Sponge spicules	2	5

SITE 467 HOLE CORE 65 CORED INTERVAL 604.5–614.0 m



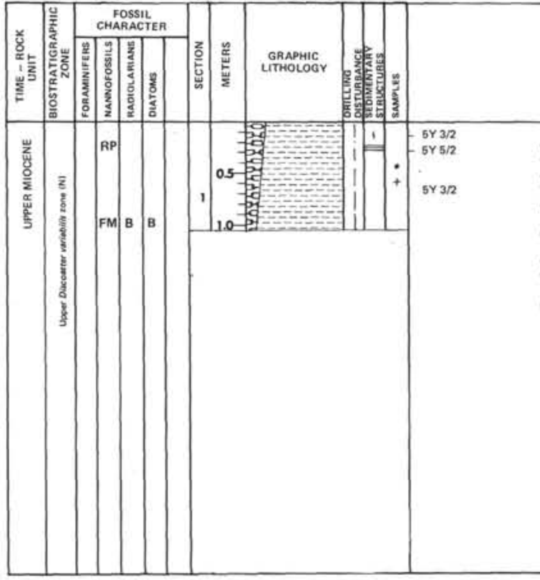
LITHOLOGIC DESCRIPTION

CLAYSTONE, olive gray (5Y 3/2) with thin intervals of light olive gray (5Y 5/2) **CALCAREOUS CLAYSTONE**, burrowed throughout with two thin intervals with parallel laminations/lenticular layers. Foraminifers and broken echinoid spines scattered throughout.

ORGANIC CARBON AND CARBONATE

	2-97
% Organic Carbon	7.12
% $CaCO_3$	6

SITE 467 HOLE CORE 66 CORED INTERVAL 614.0–623.5 m



LITHOLOGIC DESCRIPTION

CLAYSTONE, olive brown (5Y 3/4) and olive gray (5Y 3/2) to light olive gray (5Y 5/2). Lighter color (eg. 20–35 cm) usually indicates higher carbonate content. Burrows and lenticular beds common 20–35 cm. Foraminifers and broken echinoid spines scattered throughout.

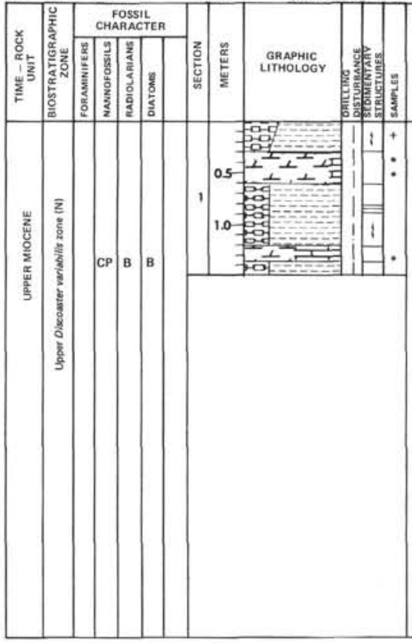
ORGANIC CARBON AND CARBONATE

	1-60
% Organic Carbon	8.33
% $CaCO_3$	5

SMEAR SLIDE SUMMARY

	1-45 (D)
TEXTURE:	
Sand	–
Silt	10
Clay	90
COMPOSITION:	
Quartz	4
Feldspar	2
Mica	1
Heavy minerals	2
Clay	53
Pyrite	2
Carbonate unspec.	20
Foraminifers	2
Calc. Nannofossils	4
Silica?	10?

SITE 467 HOLE CORE 67 CORED INTERVAL 623.5–633.0 m



LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, olive gray (5Y 4/1) to light olive gray (5Y 5/2) with fine, lighter colored, more carbonate-rich mottles. Two intervals of **CLAYEY DOLOMITIC LIMESTONE** – upper zone is very light olive gray (5Y 6/2), finely crystalline with sharp contacts; lower limestone is olive black (5Y 2/1) calcite-veined and has a vitreous texture (siliceous?). Claystone is homogeneous and burrowed with occasional laminations. Thin section of claystone at 140 cm shows diatom/rad(?) molds filled with chalcedony. Scattered sponge fragments in claystone.

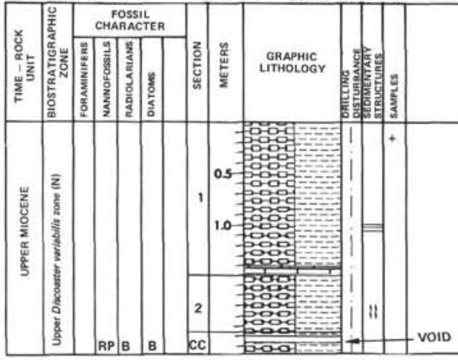
ORGANIC CARBON AND CARBONATE

	1-13
% Organic Carbon	5.48
% $CaCO_3$	34

SMEAR SLIDE SUMMARY

	1-40 (M)	1-107 (D)	1-140 (D, T)
TEXTURE:			
Sand	–	–	3
Silt	10	10	7
Clay	90	90	90
COMPOSITION:			
Quartz	3	3	3
Feldspar	2	2	–
Mica	TR	TR	1
Heavy minerals	1	1	8
Clay	40	65	46
Carbonate unspec.	50	25	30
Foraminifers	TR	TR	10
Calc. Nannofossils	3	2	–
Diatoms	TR	–	–
Chalcedony	1	2	2

SITE 467 HOLE CORE 68 CORED INTERVAL 633.0–642.5 m



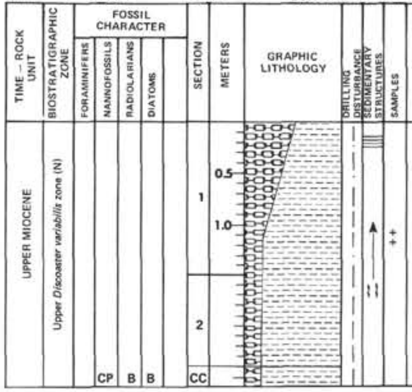
LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, medium olive gray (5Y 4/2) to moderate olive brown (5Y 4/4) with dark mottles. Light olive gray (5Y 5/2) **CLAYEY LIMESTONE** (very clay-rich) base SEction 1. Claystone is fairly homogeneous and contains scattered foraminifers and sponge fragments.

ORGANIC CARBON AND CARBONATE

	1-14
% Organic Carbon	5.05
% $CaCO_3$	52

SITE 467 HOLE CORE 69 CORED INTERVAL 642.5–652.0 m



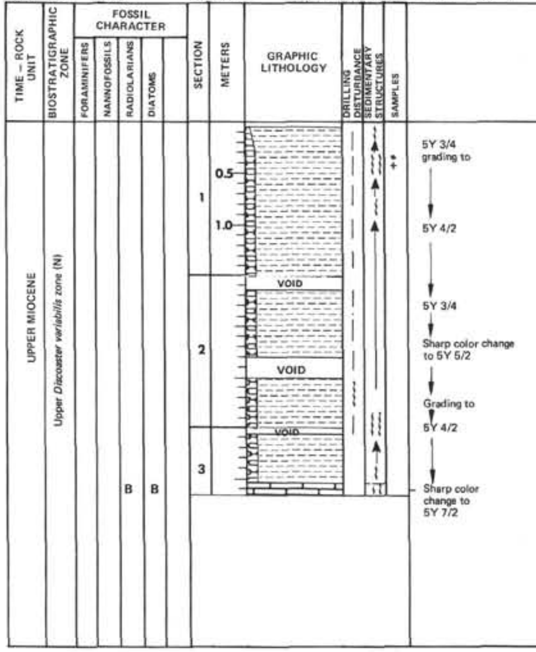
LITHOLOGIC DESCRIPTION

CALCAREOUS AND DOLOMITIC CLAYSTONE, moderate olive brown (5Y 4/4) to olive black (5Y 4/1), fairly homogeneous and burrow mottled. Fine sandy layers (<1 cm thick) in Section 2 between 120–140 cm and in Section 3 between 70–75 cm.

ORGANIC CARBON AND CARBONATE

	1-126 (D)	1-128 (D)
% Organic Carbon	6.56	–
% $CaCO_3$	17	13

SITE 467 HOLE CORE 70 CORED INTERVAL 652.0–661.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, variable colors from olive brown (5Y 3/4) to medium and light olive gray (5Y 4/2, 5Y 5/2). Lighter colors generally indicate more carbonate-rich claystone. Sub-horizontal burrows common throughout core. Yellowish gray (5Y 7/2) burrow mottled **CLAYEY LIMESTONE** base Section 3. Silt-size material fills many burrows.

No Core-Catcher.

ORGANIC CARBON AND CARBONATE

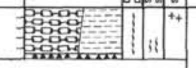
	1-49
% Organic Carbon	6.26
% $CaCO_3$	15

SMEAR SLIDE SUMMARY

	1-39 (D, T)
TEXTURE:	
Sand	2
Silt	10
Clay	88
COMPOSITION:	
Quartz	5
Feldspar	2
Mica	2
Heavy minerals	–
Clay	75
Pyrite	2
Carbonate unspec.	8
Foraminifers	1
Diatoms	TR
Sponge spicules	TR
Silica(?)	5

SITE 467 HOLE CORE 71 CORED INTERVAL 661.5–671.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	Upper *Discoaster variabilis* zone (N)		CP AM	B	B	1	



LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE AND CLAYEY CHALK, medium olive gray (5Y 4/2) with several pieces of yellowish gray (5Y 7/2) **CLAYEY LIMESTONE,** burrow mottled. Fragment of light olive gray (5Y 5/2) vitreous, calcareous, opal-CT **CHERT** at base of core. Except for large pieces 0–10 cm and 30–40 cm, core consists of drilling breccia.

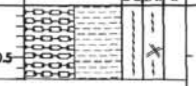
No Core-Catcher.

ORGANIC CARBON AND CARBONATE

	1-5	1-6
% Organic Carbon	–	6.24
% $CaCO_3$	63	58

SITE 467 HOLE CORE 72 CORED INTERVAL 671.0–680.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	Upper *Discoaster variabilis* zone (N)			B	B	1	0.5



- Quartz-filled fractures

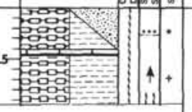
LITHOLOGIC DESCRIPTION

Drilling breccia of **CALCAREOUS CLAYSTONE, CLAYEY CHALK AND CLAYEY LIMESTONE,** medium to light olive gray (5Y 4/2, 5Y 5/2). Claystone fragment at 62 cm has fractures filled with black quartz.

No Core-Catcher.

SITE 469 HOLE CORE 73 CORED INTERVAL 680.5–690.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	Upper *Discoaster variabilis* zone (N)		AP AM	B	B	1	0.5



LITHOLOGIC DESCRIPTION

Drilling breccia consisting of fragments of olive gray (5Y 3/2) **CALCAREOUS SILTY SANDSTONE,** medium olive gray (5Y 3/2) **CLAYEY CHALK AND CALCAREOUS CLAYSTONE,** and light olive gray (5Y 5/2) to yellowish gray (5Y 7/2) **CLAYEY LIMESTONE.** Claystone contains some sandy layers (~ 1 cm thick) that are graded.

ORGANIC CARBON AND CARBONATE

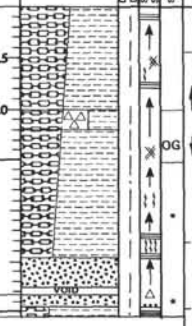
	1-72
% Organic Carbon	6.87
% $CaCO_3$	61

SMEAR SLIDE SUMMARY

	1-25 (M)
TEXTURE:	
Sand	50
Silt	20
Clay	30
COMPOSITION:	
Quartz	20
Feldspar	7
Mica	TR
Heavy minerals	2
Clay	25
Glauconite	1
Carbonate unspec.	15
Foraminifers	25
Calc. Nannofossils	5

SITE 467 HOLE CORE 74 CORED INTERVAL 690.0–699.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	Upper *Discoaster variabilis* zone (N)					1	0.5 1.0
						2	
			AM	B	B	CC	



- Calcite-filled fractures
- Interval of brecciated calcareous claystone
- 5Y 5/2
- N4
- Sharp contact

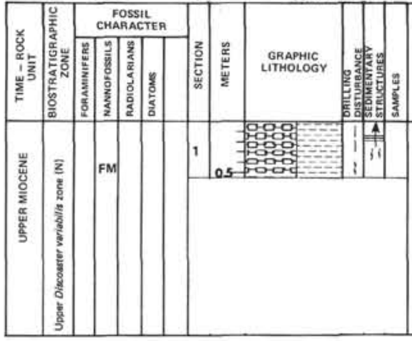
LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, light olive gray (5Y 5/2), with alternating laminated and burrowed zones. Claystone is brecciated in Section 1, 70–140 cm, with angular clasts of siliceous(?) claystone cemented by white sparry calcite and some silica. Porcellaneous from 100–123 cm, Section 1. Foraminifers locally abundant. A 50 cm-thick interval of medium dark gray (N4), graded, silicified **LAPILLI TUFF** occurs at base Section 2 and Core-Catcher. Tuff fines upward; contains subangular to subrounded pumice fragments up to 1 cm across. Microcrystalline quartz (devitrified volcanic glass) replaces/cements tuff matrix and lines vesicles of fragments. Some fragments are black glass with feldspar phenocrysts.

SMEAR SLIDE SUMMARY

	2-61 (D)	CC-5 (D, T)
TEXTURE:		
Sand	–	
Silt	15	
Clay	85	
COMPOSITION:		
Quartz	–	65 (devitrified glass)
Feldspar	–	2
Mica	TR	–
Heavy minerals	TR	–
Clay	60	10
Volcanic glass	–	5
Glauconite	TR	–
Pyrite	3	–
Carbonate unspec.	30	–
Foraminifers	2	–
Calc. Nannofossils	5	–
Pumice fragments	–	3
Opaques	–	15

SITE 467 HOLE CORE 75 CORED INTERVAL 699.5–709.0 m

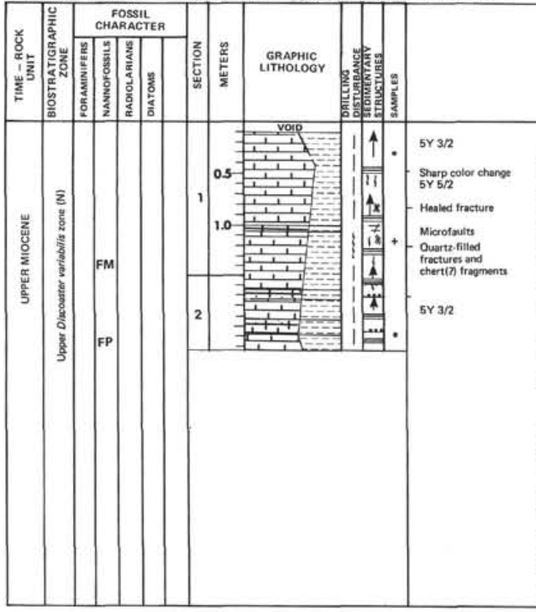


LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, light olive gray (5Y 5/2), burrowed 0–25 cm; drilling breccia 25–57 cm. Some inclined laminations at 15–20 cm. Scattered sponge fragments.

No Core-Catcher.

SITE 467 HOLE CORE 76 CORED INTERVAL 709.0–718.5 m



LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL CHALK AND NANNOFOSSIL CLAYSTONE, olive gray (5Y 3/2) to light olive gray (5Y 5/2), with alternating burrowed and massive zones. Several intervals of graded **CLAYEY NANNOFOSSIL-FORAMINIFER CHALK** in Sections 1 and 2. Microfaults, healed and quartz-filled fractures common in Section 1, 80–120 cm. Black **CHERT** fragments in Section 1, 117–120 cm probably are pieces of quartzose veins.

No Core-Catcher.

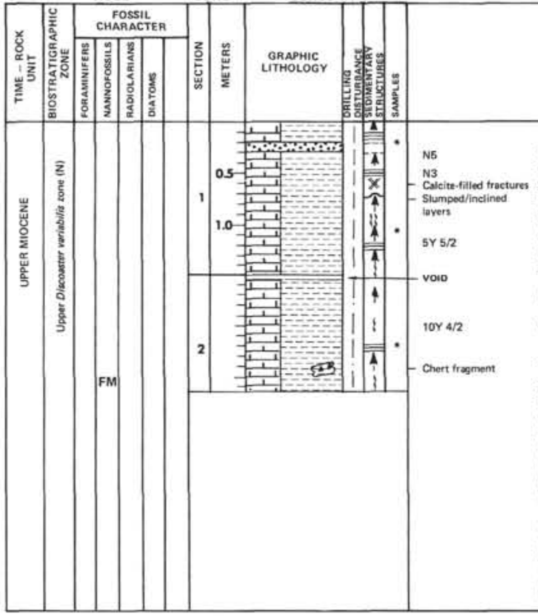
ORGANIC CARBON AND CARBONATE

	1-115
% Organic Carbon	5.6
% $CaCO_3$	61

SMEAR SLIDE SUMMARY

	1-39 (D)	2-60 (M, T)
TEXTURE:		
Sand	–	–
Silt	–	–
Clay	–	–
COMPOSITION:		
Quartz	TR	3
Feldspar	TR	2
Clay	20	52
Glauconite	TR	1
Pyrite	5	2
Carbonate unspec.	10	10
Foraminifers	–	30
Calc. Nannofossils	65	–

SITE 467 HOLE CORE 77 CORED INTERVAL 718.5–728.0 m



LITHOLOGIC DESCRIPTION

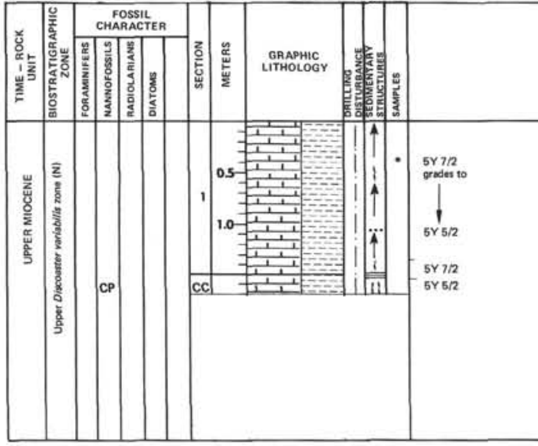
NANNOFOSSIL CLAYSTONE (CALCAREOUS), light olive gray (5Y 5/2) and grayish olive (10Y 4/2) to dark gray (N3), with alternating burrowed and laminated intervals. Rock is essentially a claystone with abundant nannofossils and carbonate cement. Inclined or slumped layers in Section 1, 65–75 cm. Thin layer of altered (clays), medium gray (N5) **LITHIC LAPILLI TUFF** in Section 1. Contains abundant pumic fragments and some carbonate cement. Fragment of gray black (N2) opal-CT **CHERT** base Section 2.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	1-21 (M)	1-110 (D)	2-77 (D)
TEXTURE:			
Sand	55	–	–
Silt	30	10	10
Clay	15	90	90
COMPOSITION:			
Quartz	2	3	3
Feldspar	20	2	2
Mica	TR	TR	TR
Heavy minerals	5	2	1
Clay	16 (auth.)	60	60
Pyrite	–	TR	TR
Zeolite	2	–	–
Carbonate unspec.	5	8	4
Foraminifers	–	5	5
Calc. Nannofossils	–	20	25
Pumice fragments	50	–	–

SITE 467 HOLE CORE 78 CORED INTERVAL 728.0–737.5 m



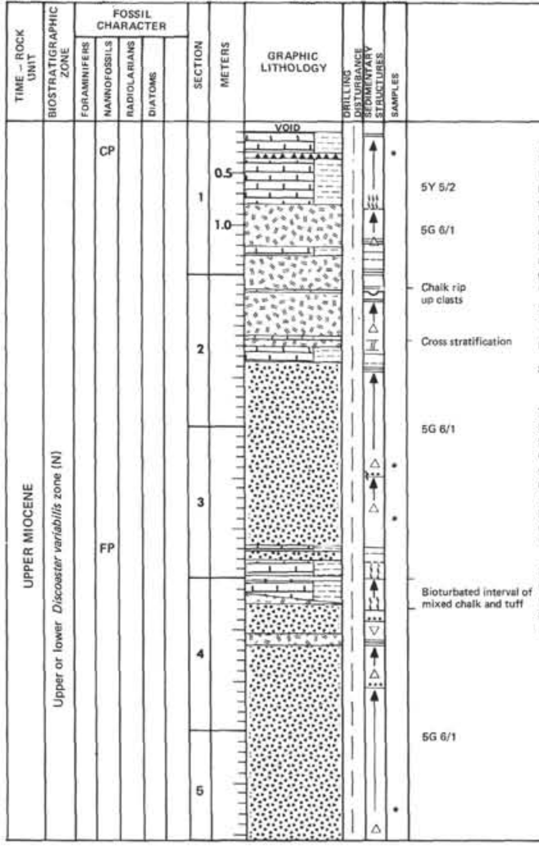
LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL CHALK, yellowish gray (5Y 7/2) to light olive gray (5Y 5/2), burrow mottled with one lenticular bedded interval 70–110 cm. Burrows are often subparallel to bedding. Lighter colored rocks generally correspond to higher carbonate content.

SMEAR SLIDE SUMMARY

	1-40 (D)
TEXTURE:	
Sand	1
Silt	9
Clay	90
COMPOSITION:	
Quartz	TR
Mica	TR
Heavy minerals	1
Clay	22
Pyrite	2
Carbonate unspec.	30
Calc. Nannofossils	45

SITE 467 HOLE CORE 79 CORED INTERVAL 737.5–747.0 m



LITHOLOGIC DESCRIPTION

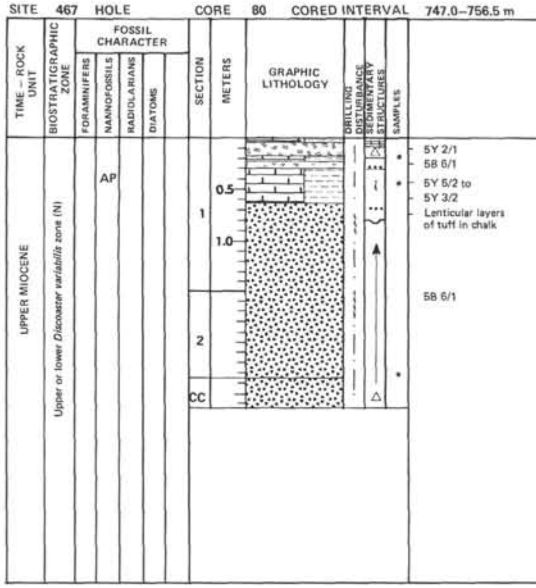
Interbedded **CLAYEY NANNOFOSSIL CHALK AND LITHIC TUFF AND LITHIC LAPILLI TUFF.** Chalk is olive gray (5Y 5/2) to yellowish gray (5Y 7/2) and often extensively burrowed. Contacts with interbedded greenish gray (5G 6/1) tuff variable – sharp or gradational. Lapilli tuff has abundant sedimentary structures: graded and fining-upward sequences common; tops of some beds are burrowed; coarsening-upward sequences and cross-laminations less common. Lapilli and ash are scoriaceous pumice composed of slightly altered brown glass with plagioclase microphenocrysts; vesicles sometimes filled with green clay; calcite is minor cement and cubic pyrite crystals scattered throughout. Calcareous quartzose **CHERT** in Section 1, 30–34 cm.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	1-38 (D)	3-40 (D, T)	3-94 (D)	5-80 (D, T)
TEXTURE:				
Sand	–		–	
Silt	10	(Lapilli)	5	(Lapilli)
Clay	90		95	
COMPOSITION:				
Quartz	–	–	–	TR
Feldspar	–	1	–	1
Heavy minerals	TR	–	–	–
Clay	17	4	28	5
Volcanic glass (matrix)	–	9	–	7
Pyrite	3	1	1	1
Carbonate unspec.	15	5	30	2
Calc. Nannofossils	65	–	40	–
Silicoflagellates	–	–	1	–
Lithic fragments (scoriaceous pumice)	–	80	–	85

SITE 467 HOLE CORE 80 CORED INTERVAL 747.0–756.5 m



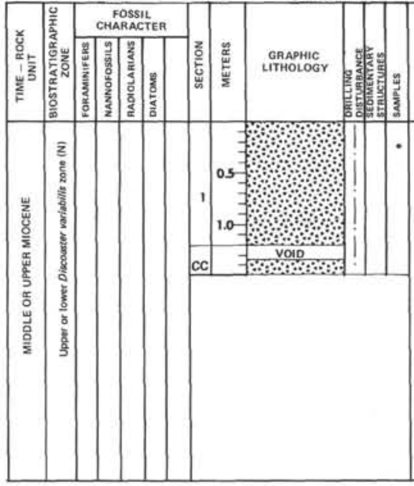
LITHOLOGIC DESCRIPTION

Interbedded **CLAYEY NANNOFOSSIL CHALK, LITHIC TUFF AND LITHIC LAPILLI TUFF.** Chalk is light olive gray (5Y 5/2) to olive gray (5Y 3/2) – parts are laminated, others burrowed. Base of lowest chalk contains lenses of lithic tuff; sharp basal contact with load cast. Particle size of light bluish gray (5B 6/1) tuff increases down core from ash to lapilli. Fragments are dominantly scoriaceous pumice composed of altered (clay) and partially devitrified brown glass with plagioclase microphenocrysts. Minor calcite cement.

SMEAR SLIDE SUMMARY

	1-20 (D, T)	1-42 (D)	2-81 (D)
TEXTURE:			
Sand		–	
Silt	(Ash)	10	(Lapilli)
Clay		90	
COMPOSITION:			
Quartz	–	TR	–
Feldspar	3	TR	2
Clay	7	24	15
Volcanic glass (matrix)	10	–	–
Pyrite	TR	1	1
Carbonate unspec.	TR	35	2
Calc. Nannofossils	–	40	–
Lithic fragments (pumice)	80	–	80

SITE 467 HOLE CORE 81 CORED INTERVAL 756.5–766.0 m



LITHOLOGIC DESCRIPTION

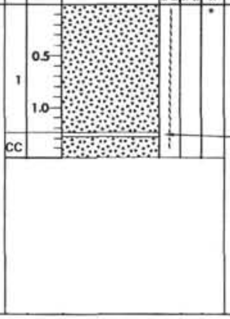
LITHIC LAPILLI TUFF, medium gray (N5) to dark gray (N3), with lapilli up to 2 cm across. No sedimentary structures although tuff is noticeably coarser grained than that in base of Core 80, so Core 81 (and 82) are basal coarse-grained parts of a fining-upward sequence. Lapilli are scoriaceous pumice composed of altered and partially devitrified brown glass. Abundant vesicles sometimes lined or filled with clay or calcite cement. Pumice fragments also contain plagioclase microphenocrysts.

SMEAR SLIDE SUMMARY

	1-23 (D, T)
TEXTURE:	
Sand	
Silt	(Lapilli)
Clay	
COMPOSITION:	
Quartz	9
Volcanic glass	16
Lithic fragments (pumice)	75

SITE 467 HOLE CORE 82 CORED INTERVAL 766.0–775.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
MIDDLE OR UPPER MIOCENE	Upper or lower *Discoaster variabilis* zone (N)											



VOID

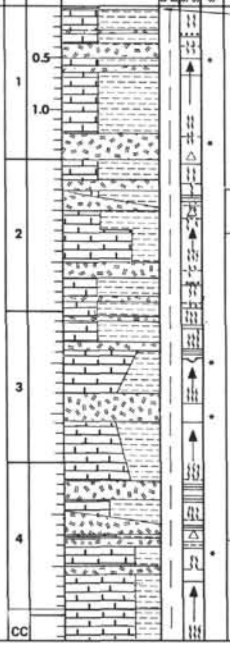
LITHIC LAPILLI TUFF, medium bluish gray (5B 5/1), with angular to subangular lapilli up to 1.5 cm across. No sedimentary structures – drilling disturbance intense. Basal part of a fining upward sequence in Cores 80–82. Lapilli are scoriaceous pumice composed of brown glass partially devitrified and extensively altered to green clay in parts. Pumice also contains feldspar microphenocrysts.

SMEAR SLIDE SUMMARY

	1-8 (D)
TEXTURE:	
Sand	
Silt	(Lapilli)
Clay	
COMPOSITION:	
Feldspar	10
Clay	
Lithic fragments	5
(pumice)	85

SITE 467 HOLE CORE 83 CORED INTERVAL 775.5–785.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
MIDDLE OR UPPER MIOCENE	Upper or lower *Discoaster variabilis* zone (N)											



VOID

5Y 5/2
to 5Y 3/2

N4

Interlaminated
tuff and claystone
5Y 2/2

Sharp color change
5Y 7/2

Land structures

Intense
bioturbation

N4
Sharp contact and
color change 5Y 7/2

Interbedded, **NANNOFOSSIL CLAYSTONE, CLAYEY NANNOFOSSIL CHALK AND LITHIC (PUMICEOUS) TUFF.** Claystone is olive gray (5Y 3/20 to light olive gray (5Y 5/2); darker portions contain more clay. This grades or changes abruptly to light olive gra (5Y 5/2) to yellowish gray (5Y 7/2) chalk with abundant nannofossils. Chalk and claystone intensively burrowed. Medium gray (N4) tuff contains abundant sand-size scoriaceous pumice fragments composed of altered (clays) brown glass with plagioclase phenocrysts. Calcite and a low briefringence zeolite(?) are minor cements. Tuff layers often graded, fine-upward, and have sharp top and bottom contacts except where burrowed.

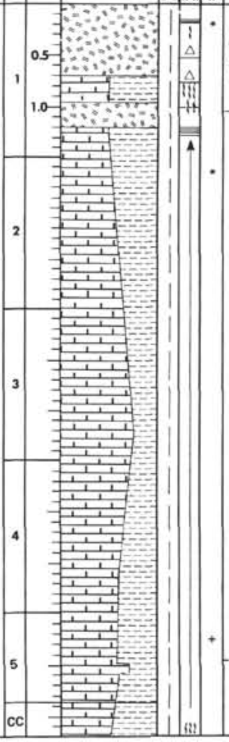
SMEAR SLIDE SUMMARY

	1-59 (D)	1-140 (D)	3-53 (D)	3-102 (D, T)	4-96 (D)
TEXTURE:					
Sand	–	5-	5-	7-	–
Silt	15	30	30	20	20
Clay	85	20	20	10	80
COMPOSITION:					
Quartz	TR	TR	–	–	TR
Feldspar	–	10	3	10	–
Heavy minerals	–	2	–	–	–
Clay	55	65	45	10	20
Volcanic glass	2	20	45	–	–
Pyrite	2	–	–	TR	TR
Zeolite	–	1	–	1	–
Carbonate unspec.	35	–	–	1	55
Calc. Nannofossil	10	–	–	–	25
Lithic fragments (pumice)	–	–	–	78	–

Note: Volcanic glass in Smear Slides = pumice in Thin Section.

SITE 467 HOLE CORE 84 CORED INTERVAL 785.0–794.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
MIDDLE OR UPPER MIOCENE	Upper or lower *Discoaster variabilis* zone (N)											



5B 5/1

Two fining-upward
sequences

5Y 4/2 to
5Y 5/2

Tuff contains
claystone layers

5Y 4/2
grades to

5Y 7/2 and
5Y 8/2
grades to

5Y 5/2
and
5Y 3/2

Chalk interval
5Y 8/2

5Y 3/2

Interbedded **NANNOFOSSIL CLAYSTONE, CLAYEY NANNOFOSSIL CHALK AND LITHIC (PUMICEOUS) TUFF.** Claystone is olive gray (5Y 3/2) to light olive gray (5Y 5/2) and grades to yellowish gray (5Y 7/2) and pale yellowish gray (5Y 8/2) nannofossil chalk (especially Section 3). Darker color indicates more clay. Both chalk and claystone intensely bioturbated; elongate burrows often subparallel to bedding. Medium bluish gray (5B 5/1) tuff composed of silt- and sand-size fragments of scoriaceous pumice (altered brown volcanic glass with plagioclase phenocrysts). Several fining upward sequences noted in upper tuff interval.

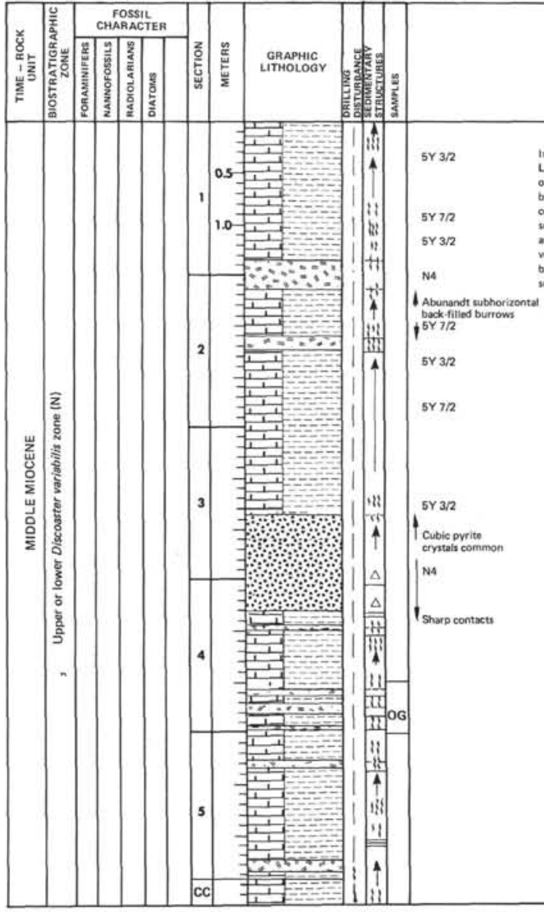
ORGANIC CARBON AND CARBONATE

	5-28
% Organic Carbon	1.97
% $CaCO_3$	16

SMEAR SLIDE SUMMARY

	1-28 (D, T)	2-16 (D)
TEXTURE:		
Sand	50	–
Silt	40	10
Clay	10	90
COMPOSITION:		
Quartz	–	2
Feldspar	10	1
Mica	–	1
Heavy minerals	–	1
Clay	10	44
Volcanic glass	–	1
Carbonate unspec.	–	10
Calc. Nannofossils	–	40
Lithic fragments (pumice)	80	–

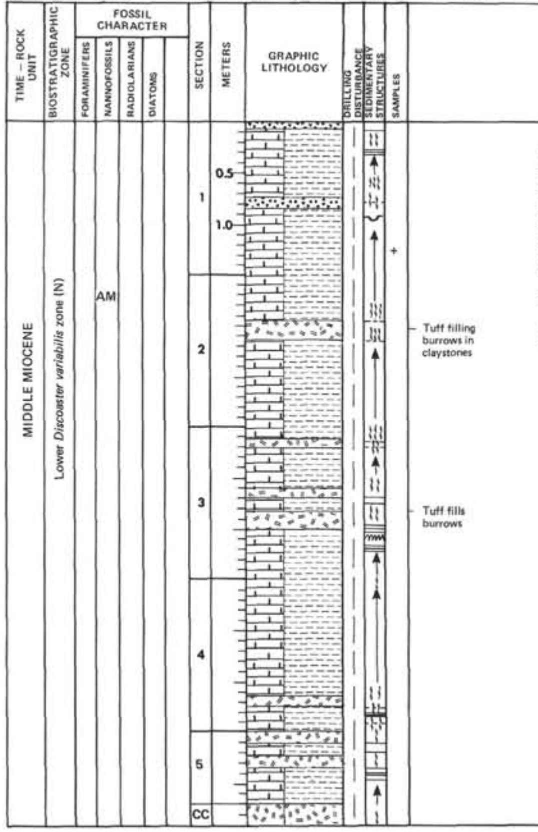
SITE 467 HOLE CORE 85 CORED INTERVAL 794.5–804.0 m



LITHOLOGIC DESCRIPTION

Interbedded **(CALCAREOUS) NANNOFOSSIL CLAYSTONE, LITHIC TUFF, AND LITHIC LAPILLI TUFF.** Claystone is olive gray (5Y 3/2) to yellowish gray (5Y 7/2), extensively burrowed with a variable nannofossil/carbonate content (darker color = more clay). Lapilli in tuff in Section 3 – Section 4 is scoriaceous pumice composed of altered brown glass; contains authigenic, cubic pyrite crystals. Other tuffs are fine-grained versions of lapilli tuff. Some calcite cement. Tuffs generally burrowed only at tops; some have subtle fining-upward sequences.

SITE 467 HOLE CORE 86 CORED INTERVAL 804.0–813.5 m



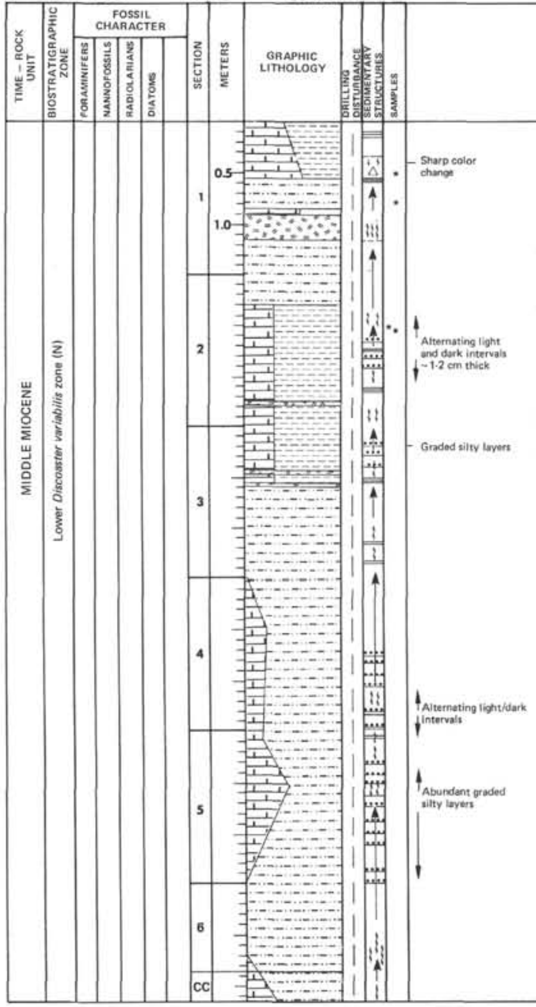
LITHOLOGIC DESCRIPTION

Interbedded **(CALCAREOUS) NANNOFOSSIL CLAYSTONE AND LITHIC (PUMICEOUS) TUFF AND LAPILLI TUFF.** Claystone is olive gray (5Y 3/2) to light olive gray (5Y 5/2). Extensively burrowed throughout. Tuff is bluish gray (5B 5/1) and extensively burrowed and mixed with claystone in parts. Lapilli and silt-/sand-size fragments are scoriaceous pumice composed of altered brown glass. Most contacts of tuff with claystone are burrowed. Burrows in claystone sometimes filled with tuff. Calcite is minor cement in tuff.

ORGANIC CARBON AND CARBONATE

	1-123
% Organic Carbon	1.49
% $CaCO_3$	40

SITE 467 HOLE CORE 87 CORED INTERVAL 813.5–823.0 m



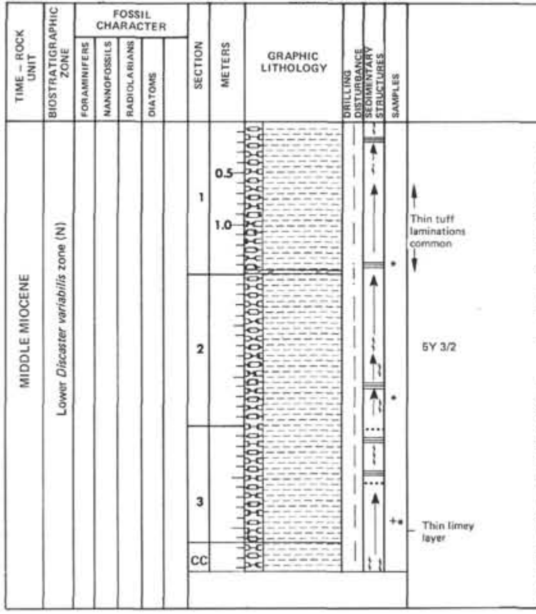
LITHOLOGIC DESCRIPTION

Interbedded **NANNOFOSSIL CLAYSTONE, CLAYEY NANNOFOSSIL CHALK, SILTY CLAYSTONE AND LITHIC (PUMICEOUS) TUFF.** Nannofossil claystone/chalk varies from olive gray (5Y 3/2) to yellowish gray (5Y 7/2), lighter colors indicating higher carbonate content. Some parts (Sections 2 and 4) have alternations of light/dark intervals ~2 cm thick superimposed on finer, faint laminations. Most claystone/chalk extensively burrowed. Silty claystone is dark olive brown (5Y 5/6) to olive gray (5Y 3/2) and grades into nannofossil-rich lithologies; parts have numerous thin graded layers ~1 cm thick. Thin, bluish gray (5B 5/1) tuff layers burrowed. Contain glass from pumice.

SMEAR SLIDE SUMMARY

	1-50 (D)	1-80 (D)	2-55 (D)	2-58 (D)
TEXTURE:				
Sand	–	–	–	–
Silt	15	30	20	20
Clay	85	70	80	80
COMPOSITION:				
Quartz	2	15	5	3
Feldspar	1	10	3	2
Mica	–	TR	TR	TR
Heavy minerals	2	2	3	2
Clay	40	70	70	60
Volcanic glass	–	TR	–	–
Glauconite	–	1	TR	TR
Zeolite	–	TR	–	–
Carbonate unspec.	15	2	4	10
Foraminifers	TR	TR	–	3
Calc. Nannofossils	40	TR	15	20
Sponge spicules	TR	–	–	–

SITE 467 HOLE CORE 88 CORED INTERVAL 823.0–832.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS CLAYSTONE, olive gray (5Y 3/2) to light olive gray (5Y 5/2), with thin laminations and lenticular layers; burrows common. Interlaminated with light bluish gray (5B 7/1) **TUFF** near base Section 1. Tuff contains some calcite but most glass altered to clays. Calcareous sandy(?) layer (calcite-cemented, altered tuff?) occurs near base Section 3.

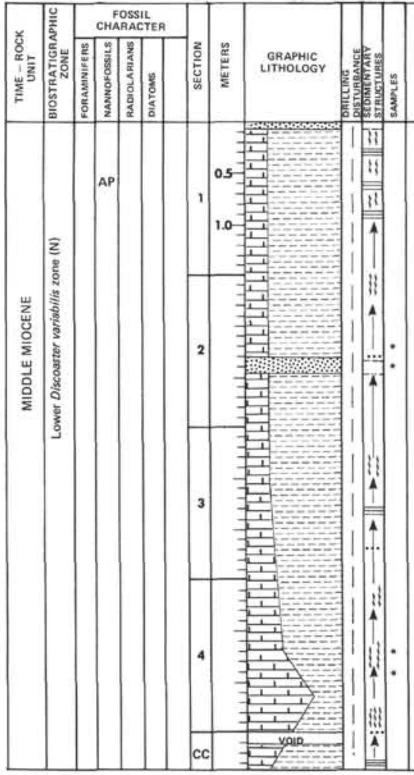
ORGANIC CARBON AND CARBONATE

	3-93
% Organic Carbon	2.79
% $CaCO_3$	17

SMEAR SLIDE SUMMARY

	1-148 (M)	2-121 (D)	3-95 (M)
TEXTURE:			
Sand	–	–	25
Silt	10	10	50
Clay	90	90	25
COMPOSITION:			
Quartz	–	5	TR
Feldspar	–	2	TR
Mica	–	TR	–
Heavy minerals	–	2	–
Clay	97	70	20
Volcanic glass	1	–	5
Glauconite	–	–	TR
Pyrite	–	1	–
Zeolite	TR?	–	–
Carbonate unspec.	2	15	75
Calc. Nannofossils	–	5	–

SITE 467 HOLE CORE 89 CORED INTERVAL 832.5–842.0 m



LITHOLOGIC DESCRIPTION

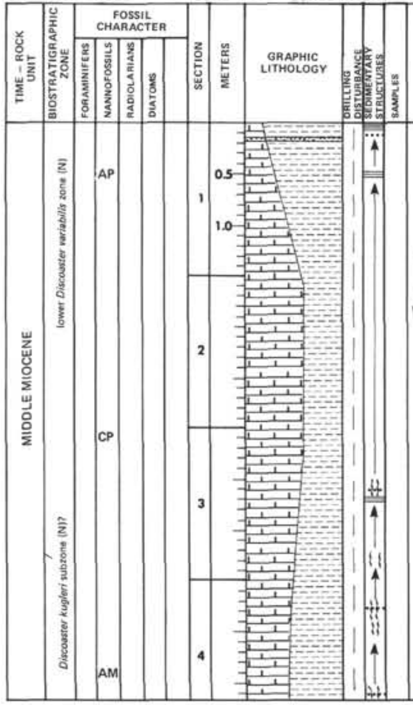
NANNOFOSSIL CLAYSTONE, light olive gray (5Y 5/2) to olive gray (5Y 3/2), with alternating laminated/lenticular layered intervals and zones of intense burrowing. Burrows often elongate and subparallel to bedding commonly filled with lighter colored, carbonate-rich sediment (cause of lenticular bedding). Thin layers of olive gray (5Y 5/2) carbonate-cemented, fine-grained **SANDSTONE** in Section 1 and Section 2 composed of angular quartz and feldspar with scattered foraminifers in carbonate cement.

SMEAR SLIDE SUMMARY

	2-82 (M, T)	2-92 (M)	4-75 (D)	4-96 (D)
TEXTURE:				
Sand	80	80	–	–
Silt	10	–	20	5
Clay	10	10	80	95
COMPOSITION:				
Quartz	20	5	18	1
Feldspar	10	1	7	–
Mica	–	–	TR	–
Heavy minerals	–	10	TR	–
Clay	10	–	47	35
Glauconite	2	–	3	–
Pyrite	3	–	2	–
Carbonate unspec.	30	84	20	47
Foraminifers	10	–	–	2
Calc. Nannofossils	–	–	3	15
Lithic fragments (volcanic)	15	–	–	–

Note: Many sand-size fragments in Section 2, 92 cm are crushed pieces of carbonate cement.

SITE 467 HOLE CORE 90 CORED INTERVAL 842.0–851.5 m



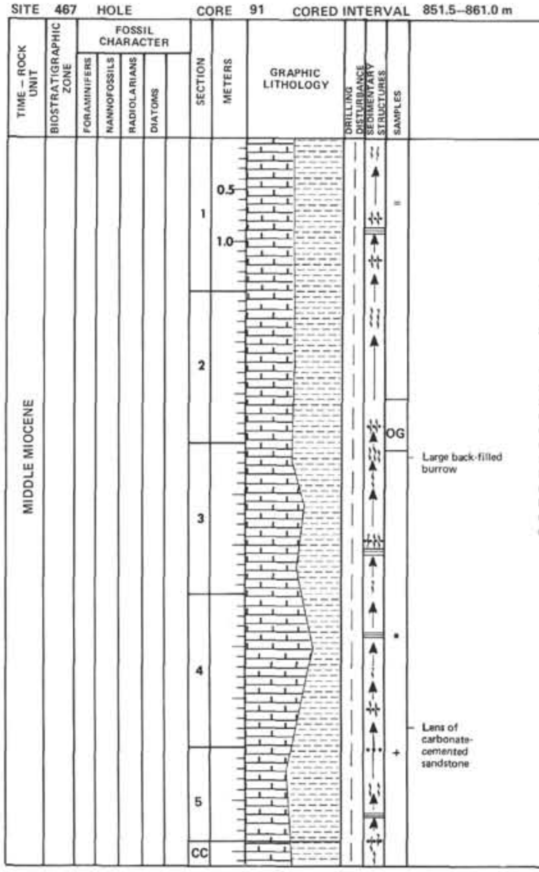
LITHOLOGIC DESCRIPTION

Nannofossil claystone grading to nannofossil chalk

NANNOFOSSIL CLAYSTONE AND CLAYEY NANNOFOSSIL CHALK, grayish olive (10Y 4/2) to light olive gray (5Y 5/2) and pale olive (10Y 6/2) darker colors = higher clay content, contains few well laminated intervals but most of core has lenticular bedding and abundant burrows. Thin, fine-grained tuffaceous(?) **SANDSTONE** layer occurs in Section 1.

No Core-Catcher.

SITE 467 HOLE CORE 91 CORED INTERVAL 851.5–861.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAYSTONE AND CLAYEY NANNOFOSSIL CHALK, olive gray (5Y 4/2) to light olive gray (5Y 5/2), change from one lithology to next is gradational and alternates throughout core. Laminated/lenticular bedded and burrowed zones common and also alternate in core.

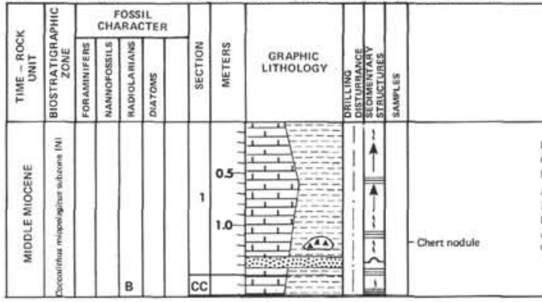
ORGANIC CARBON AND CARBONATE

	5-3
% Organic Carbon	1.98
% $CaCO_3$	41

SMEAR SLIDE SUMMARY

	4-40 (D)
TEXTURE:	
Sand	–
Silt	–
Clay	100
COMPOSITION:	
Quartz	TR
Feldspar	TR
Heavy minerals	1
Clay	30
Pyrite	2
Carbonate unspec.	15
Calc. Nannofossils	52

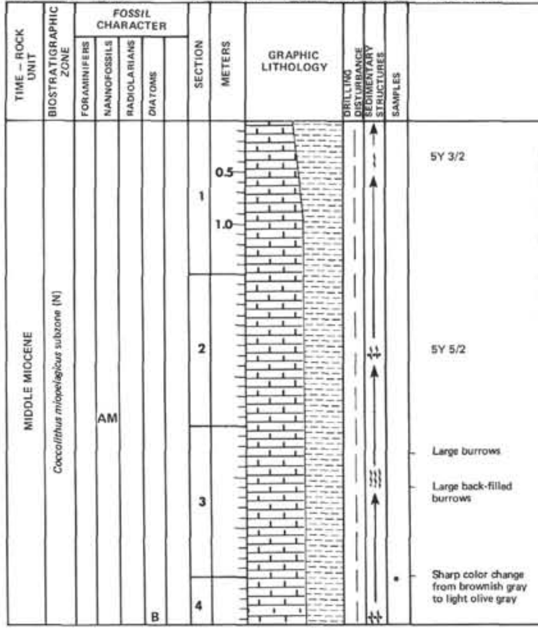
SITE 467 HOLE CORE 92 CORED INTERVAL 861.0–870.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CLAYSTONE AND CLAYEY NANNOFOSSIL CHALK, olive gray (5Y 3/2) and yellowish gray (5Y 7/2) to light olive gray (5Y 5/2), lithologic changes gradational, alternating laminated and burrowed zone; dolomitic in places. Thin layer of carbonate-cemented **SANDSTONE** base Section 1 composed of angular quartz and feldspar and contains slump fold. Fragment of black, vitreous nodular quartzose **CHERT** at 120 cm occurs in chalk.

SITE 467 HOLE CORE 93 CORED INTERVAL 870.5–880.0 m



LITHOLOGIC DESCRIPTION

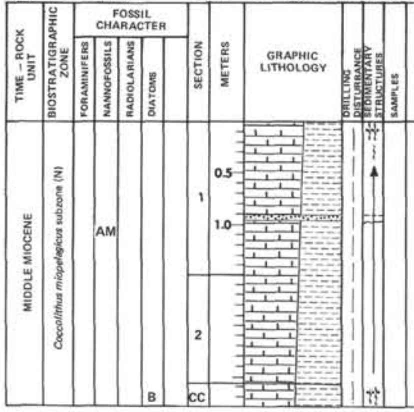
CLAYEY NANNOFOSSIL CHALK, olive gray (5Y 3/2) to light olive gray (5Y 5/2), intensely burrowed throughout with zones of lenticular bedding.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	4-4 (D)
TEXTURE:	
Sand	5
Silt	30
Clay	55
COMPOSITION:	
Quartz	6
Feldspar	1
Mica	TR
Heavy minerals	3
Clay	33
Pyrite	2
Carbonate unspec.	25
Calc. Nannofossils	30

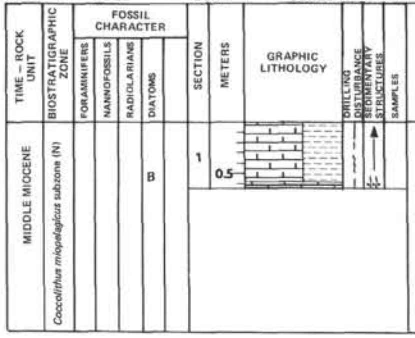
SITE 467 HOLE CORE 94 CORED INTERVAL 880.0–889.5 m



LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL CHALK, yellowish gray (5Y 7/2) and light olive gray (5Y 5/2) to moderate brown (5YR 3/4), lenticular bedding and extensive burrowing throughout; dolomitic in places. Layer of carbonate-cemented **SANDSTONE** Section 1, 90–96 cm. Thin (1 cm thick) foraminifer sand Section 2, 68–69 cm.

SITE 467 HOLE CORE 95 CORED INTERVAL 889.5–899.0 m

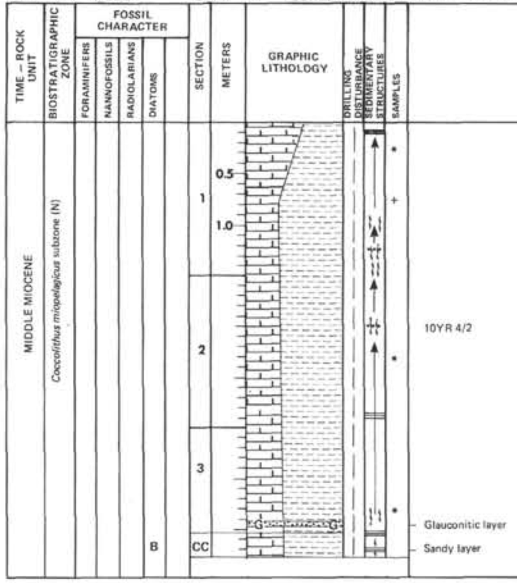


LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL CHALK, yellowish gray (5Y 7/2), lenticular bedding and burrows throughout. Medium gray (N5) **CLAYEY LIMESTONE** at base of core. Thin (3 mm thick sandy layer at 58 cm.

No Core-Catcher.

SITE 467 HOLE CORE 96 CORED INTERVAL 899.0–908.5 m



LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL CHALK grading to **(CALCAREOUS) NANNOFOSSIL CLAYSTONE,** dark yellowish brown (10YR 4/2), burrowed with lenticular bedding and occasional laminations. Thin layer of calcite-cemented **GLAUCONITIC SANDSTONE** base Section 3. Thin sandy lenses in Core-Catcher. Scattered sponge fragments throughout core.

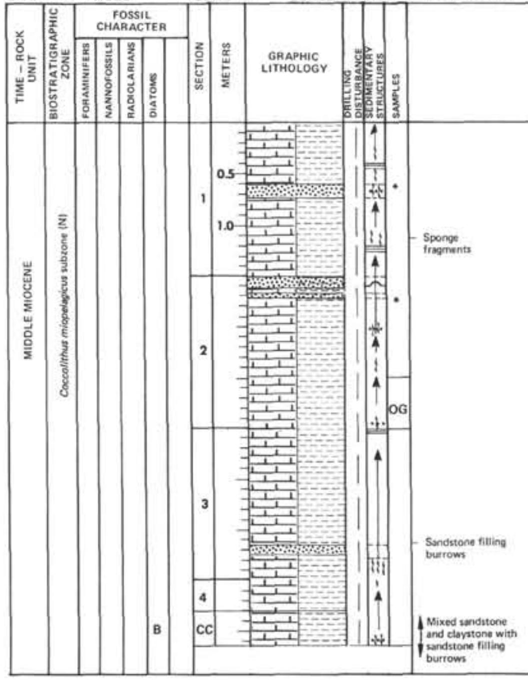
ORGANIC CARBON AND CARBONATE

	1-78
% Organic Carbon	1.18
% $CaCO_3$	28

SMEAR SLIDE SUMMARY

	1-29 (D)	2-86 (D)	3-93 (M)
TEXTURE:			
Sand	–	5	50
Silt	10	2	15
Clay	90	93	35
COMPOSITION:			
Quartz	5	10	4
Feldspar	TR	2	1
Mica	–	TR	1
Heavy minerals	–	–	5
Clay	30	60	20
Glauconite	–	–	30
Pyrite	3	3	–
Carbonate unspec.	35	20	40
Calc. Nannofossils	30	5	–

SITE 467 HOLE CORE 97 CORED INTERVAL 908.5–918.0 m



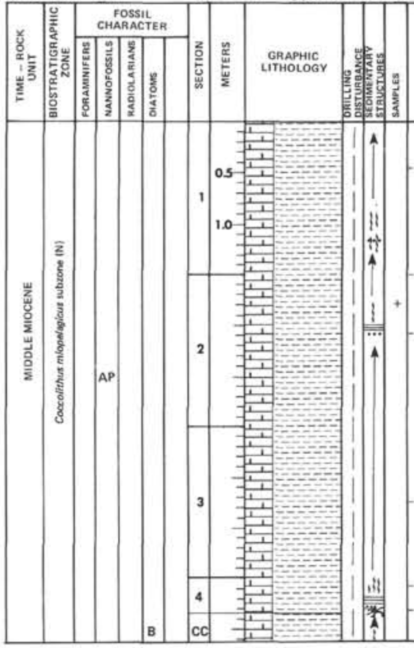
LITHOLOGIC DESCRIPTION

NANNOFOSSIL (CALCAREOUS) CLAYSTONE with thin interbeds of carbonate-cemented **SANDSTONE** as marked. Claystone is medium olive gray (5Y 4/2), with some lenticular bedding and abundant burrows. Sandstone is medium dark gray (N4), fine-grained composed of angular quartz, feldspar and foraminifers in carbonate cement. Sandstone/claystone contacts gradational and two lithologies often mixed by burrowing (eg. Section 4 and Core-Catcher). Scattered sponge fragments throughout with distinct concentration in Section 1, 112 cm.

SMEAR SLIDE SUMMARY

	1-67 (M, T)	2-25 (D)
TEXTURE:		
Sand	70	1
Silt	15	4
Clay	15	95
COMPOSITION:		
Quartz	40	2
Feldspar	15	TR
Heavy minerals	6	–
Clay	–	50
Glauconite	1	–
Pyrite	7	3
Carbonate unspec.	10	30
Foraminifers	9	–
Calc. Nannofossils	–	15
Lithic fragments (including chert)	12	–

SITE 467 HOLE CORE 98 CORED INTERVAL 918.0–927.5 m



LITHOLOGIC DESCRIPTION

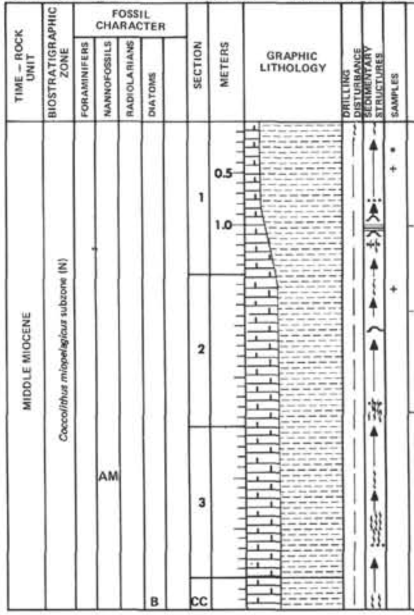
- Sandy
- Sandy
- Sandy
- Sandy
- Large burrows
- Contorted bedding or slump

NANNOFOSSIL (CALCAREOUS) CLAYSTONE, olive gray (5Y 4/1) to yellowish gray (5Y 7/2) – darker color indicates higher clay content. Extensively burrowed with only thin laminated or lenticular bedded intervals. Abundant patches of medium gray (N5) sandy clay probably were once sandstone layers homogenized by burrowing. Contorted bedding or slump folds in claystone base Section 4.

ORGANIC CARBON AND CARBONATE

	2-30
% Organic Carbon	–
% $CaCO_3$	23

SITE 467 HOLE CORE 99 CORED INTERVAL 927.5–937.0 m



LITHOLOGIC DESCRIPTION

- Slump folds
- Slump folds
- Abundant small burrows

NANNOFOSSIL (CALCAREOUS) CLAYSTONE, olive gray (5Y 4/1) and greenish gray (5GY 6/1) with yellowish gray (5Y 7/1) and brownish gray (5YR 4/1) mottles, alternating burrowed zones and zones of burrowed/lenticular bedding. Slump folds common base Section 1, top Section 2. Scattered sponge fragments Section 1.

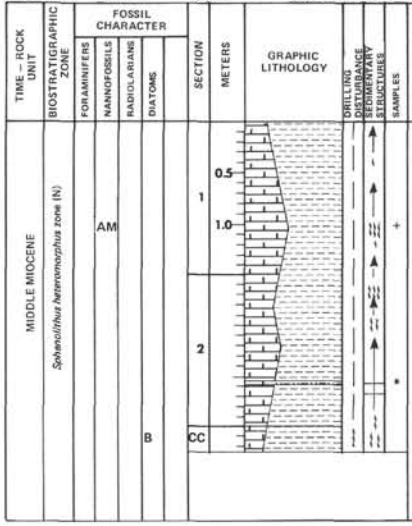
ORGANIC CARBON AND CARBONATE

	1-48	2-17
% Organic Carbon	1.55	3.35
% $CaCO_3$	10	33

SMEAR SLIDE SUMMARY

	1-30 (D)
TEXTURE:	
Sand	–
Silt	10
Clay	90
COMPOSITION:	
Quartz	3
Feldspar	2
Mica	TR
Heavy mineras	1
Clay	40
Glauconite	TR
Carbonate unspec.	20
Foraminifers	4
Calc. Nannofossils	30
Sponge spicules	TR

SITE 467 HOLE CORE 100 CORED INTERVAL 937.0–946.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS NANNOFOSSIL CLAYSTONE, olive gray (5Y 4/1) to yellowish gray (5Y 7/1), burrowed thoughout. Thin layer of **CALCAREOUS CLAYEY SILTSTONE** in Section 2 has sharp lower and upper contacts. Sandy burrow fillings below siltstone.

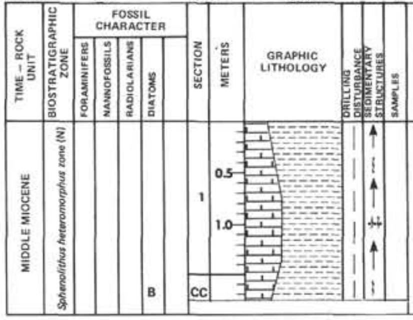
ORGANIC CARBON AND CARBONATE

	1-103
% Organic Carbon	1.13
% $CaCO_3$	45

SMEAR SLIDE SUMMARY

	2-104 (M)
TEXTURE:	
Sand	10
Silt	60
Clay	30
COMPOSITION:	
Quartz	20
Feldspar	5
Mica	1
Heavy minerals	2
Clay	40
Glauconite	2
Carbonate unspec.	30

SITE 467 HOLE CORE 101 CORED INTERVAL 946.5–956.0 m



LITHOLOGIC DESCRIPTION

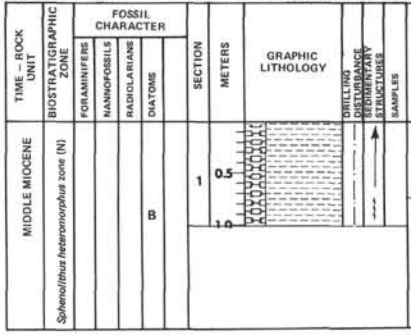
5Y 4/1

5Y 7/1

5Y 4/1

CALCAREOUS NANNOFOSSIL CLAYSTONE, olive gray (5Y 4/1) to yellowish gray (5Y 7/1), burrowed with lenticular bedding and abundant burrows 55–100 cm. Carbonate content variable – darker colors – more clay. Scattered sponge fragments 0–70 cm.

SITE 467 HOLE CORE 102 CORED INTERVAL 956.0–965.5 m



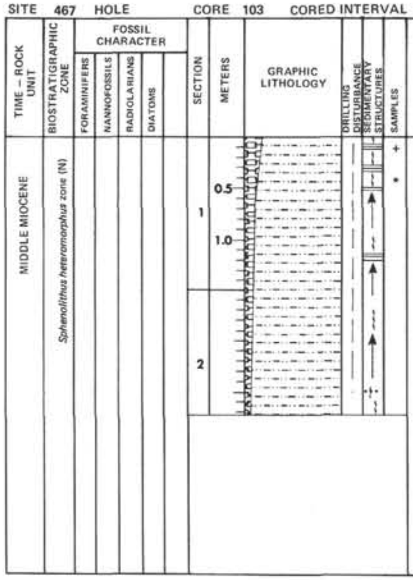
LITHOLOGIC DESCRIPTION

- Sand-filled burrows
- Sandy

CALCAREOUS CLAYSTONE, dusky yellowish brown (10YR 2/2) to olive gray (5Y 4/1), faint laminations/lenticular bedding, common burrows. Burrows at 82–84 cm filled with sand. Patches of medium gray (N4) calcareous **SILTY CLAYSTONE** at base of core.

No Core-Catcher.

SITE 467 HOLE CORE 103 CORED INTERVAL 965.5–975.0 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, dusky yellowish brown (10YR 2/2) to yellowish gray (5Y 7/2), faintly laminated in parts, rest of core is moderately burrowed with faint lenticular bedding. Carbonate content variable but generally low for whole core. Thin layer of medium gray (N4) **SANDY SILTSTONE** Section 1, 23 cm. Scattered sponge fragments.

No Core-Catcher.

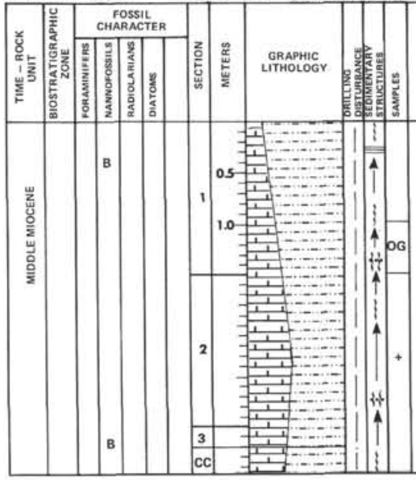
ORGANIC CARBON AND CARBONATE

	1-10
% Organic Carbon	2.08
% $CaCO_3$	16

SMEAR SLIDE SUMMARY

	1-48 (D)
TEXTURE:	
Sand	–
Silt	25
Clay	75
COMPOSITION:	
Quartz	10
Feldspar	5
Mica	TR
Heavy minerals	1
Clay	75
Carbonate unspec.	9

SITE 467 HOLE CORE 104 CORED INTERVAL 975.0–984.5 m



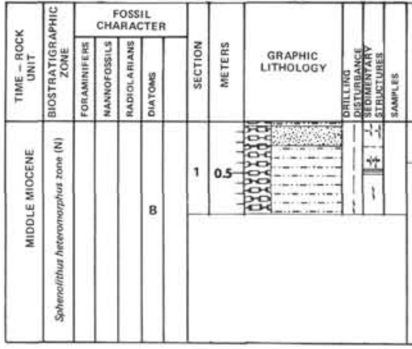
LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, dusky yellowish brown (10YR 2/2) to yellowish gray (5Y 7/2), faint laminations near top Section 1, lenticular bedding Section 2, 45–115 cm, moderately burrowed. Scattered sponge fragments.

ORGANIC CARBON AND CARBONATE

	2-78
% Organic Carbon	1.66
% $CaCO_3$	47

SITE 467 HOLE CORE 105 CORED INTERVAL 984.5–994.0 m



LITHOLOGIC DESCRIPTION

10YR 2/2
N4
Burrows back-filled with sandy silt
5Y 3/6
to
5Y 6/4

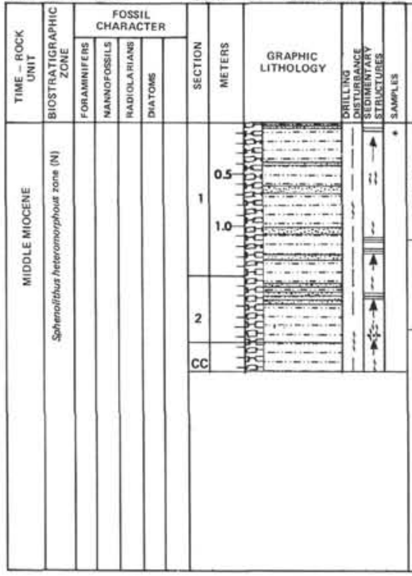
CALCAREOUS SILTY CLAYSTONE, dusky yellowish brown (10YR 2/2), dark olive brown (5Y 3/6) to dusky yellow (5Y 6/4), burrowed with some faint laminations and lenticular bedding. Layer of medium gray (N4) **CALCAREOUS SANDY SILTSTONE** at Section 4, 25 cm has burrowed upper contact.

No Core-Catcher.

ORGANIC CARBON AND CARBONATE

	1-25
% Organic Carbon	–
% $CaCO_3$	21

SITE 467 HOLE CORE 106 CORED INTERVAL 994.0–1003.5 m



LITHOLOGIC DESCRIPTION

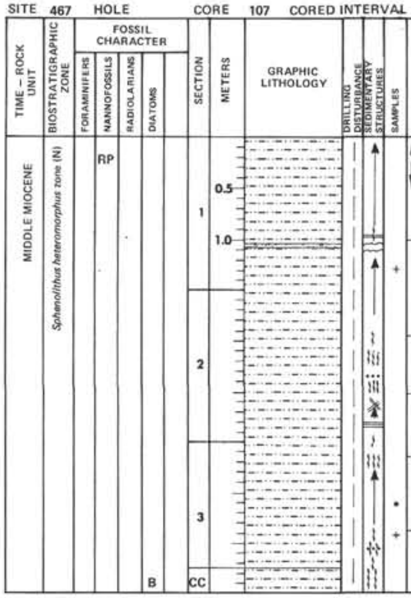
Abundant sand-filled burrows
Drilling breccia
Sandstone/claystone interlaminations
Sand-filled burrows

Interbedded **CALCAREOUS SILTY CLAYSTONE AND CALCAREOUS SILTY SANDSTONE.** Claystone is pale brown (5YR 5/2) to dusky brown (5YR 2/2), faintly burrowed with intervals of sand-filled burrows and interlaminated sandstone and claystone. Sandstone is medium gray (N4) and occurs as very thin interbeds. Most sandstone/claystone contacts are burrowed and gradational. Sharp contacts for sandstone Section 1, 2–4 cm. Sandstone and claystone slightly calcareous.

SMEAR SLIDE SUMMARY

	2-7 (D)
TEXTURE:	
Sand	–
Silt	37
Clay	63
COMPOSITION:	
Quartz	18
Feldspar	5
Mica	TR
Heavy minerals	4
Clay	56
Glauconite	1
Pyrite	2
Carbonate unspec.	6
Foraminifers	2
Calc. Nannofossils	6

SITE 467 HOLE CORE 107 CORED INTERVAL 1003.5–1013.0 m



LITHOLOGIC DESCRIPTION

Thin sandy layers common

Sharp wavy contacts

Phosphatic/glauconitic debris

Sand-filled burrows

Sand-filled burrows

Calcite veins

Sand-filled burrows

Sand-filled burrows

SILTY CLAYSTONE, grayish brown (5YR 3/2) bioturbated with common faint laminations and scattered sponge fragments. Contains thin laminations and interbeds of medium gray (N4) **SILTY SANDSTONE** and common zones of sand-filled burrows. Carbonate content of sandstone and claystone is low.

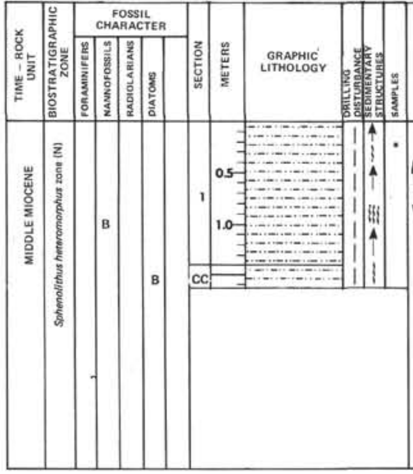
ORGANIC CARBON AND CARBONATE

	1-142	3-39
% Organic Carbon	–	2.73
% $CaCO_3$	6	7

SMEAR SLIDE SUMMARY

	3-62 (D)
TEXTURE:	
Sand	1
Silt	25
Clay	74
COMPOSITION:	
Quartz	8
Feldspar	5
Mica	1
Heavy minerals	1
Clay	73
Pyrite	1
Carbonate unspec.	11

SITE 467 HOLE CORE 108 CORED INTERVAL 1013.0–1022.5 m



LITHOLOGIC DESCRIPTION

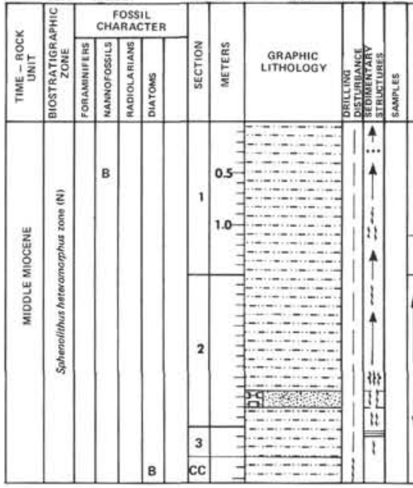
Sand-filled burrows

SILTY CLAYSTONE, dusky brown (5YR 2/2) to brownish gray (5YR 4/1), burrowed. Burrows at ~50–100 cm filled with medium bluish gray (5B 5/1) carbonate-cemented silty sand. Dolomite is minor cement in claystone.

SMEAR SLIDE SUMMARY

	1-29 (D)
TEXTURE:	
Sand	–
Silt	25
Clay	75
COMPOSITION:	
Quartz	8
Feldspar	6
Mica	1
Heavy minerals	2
Clay	73
Glauconite	TR
Carbonate unspec.	10

SITE 467 HOLE CORE 109 CORED INTERVAL 1022.5–1032.0 m



LITHOLOGIC DESCRIPTION

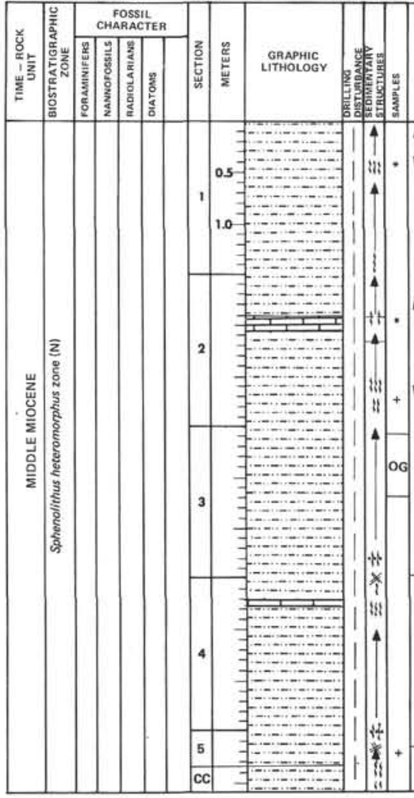
Sand-filled burrows

Sandy layer

Abundant sand-filled burrows

SILTY CLAYSTONE, dusky brown (5YR 2/2) to light olive gray (5Y 5/2), moderately burrowed with a zone of intense bedding parallel burrows Section 2, 30–150 cm. Burrows filled with medium gray (N5) carbonate-cemented **SILTY SANDSTONE.** Sandstone forms thin bed Section 2, 104–119 cm. Scattered sponge fragments.

SITE 467 HOLE CORE 110 CORED INTERVAL 1032.0–1041.5 m



LITHOLOGIC DESCRIPTION

Sand-filled burrows

Abundant sand-filled burrows

Calcite veins

Calcite veins

CALCAREOUS SILTY CLAYSTONE, dusky brown (5YR 2/2), burrowed throughout with several intervals of abundant burrows filled with carbonate-cemented silty sand. Two intervals of light olive gray (5Y 5/2) **CLAYEY LIMESTONE** with gradational contacts. Carbonate is minor cement in claystone.

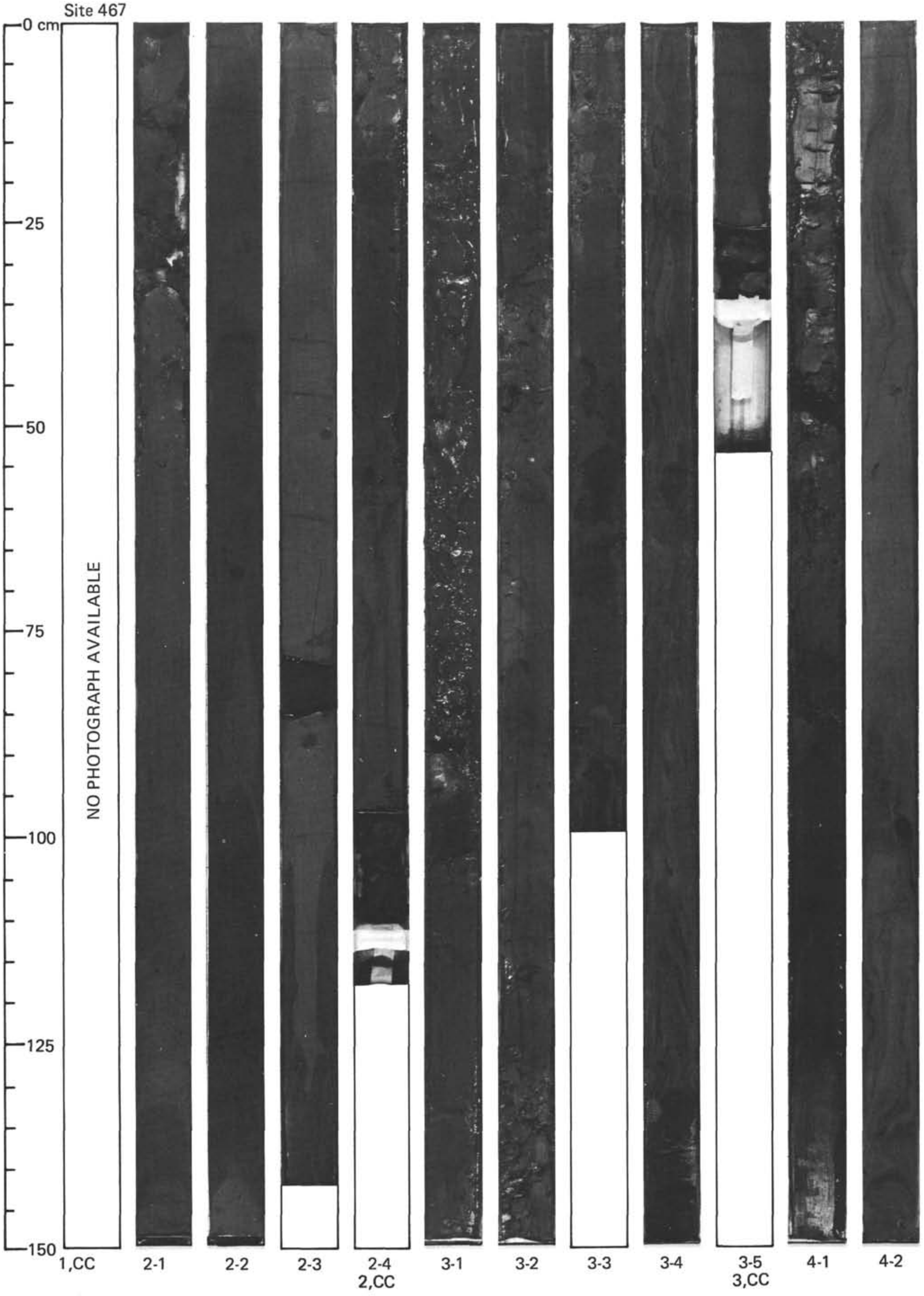
ORGANIC CARBON AND CARBONATE

	2-121	5-24
% Organic Carbon	–	1.15
% $CaCO_3$	13	9

SMEAR SLIDE SUMMARY

	1-42 (D, T)	2-48 (D)
TEXTURE:		
Sand	50	–
Silt	30	–
Clay	20	–
COMPOSITION:		
Quartz	30	2
Feldspar	10	–
Mica	TR	–
Heavy minerals	TR	–
Clay	–	28
Carbonate unspec.	5	70
Foraminifers	5	–
Lithic fragments	30	–

Note: Spl. 1-42 (T) is sandy burrow-fill.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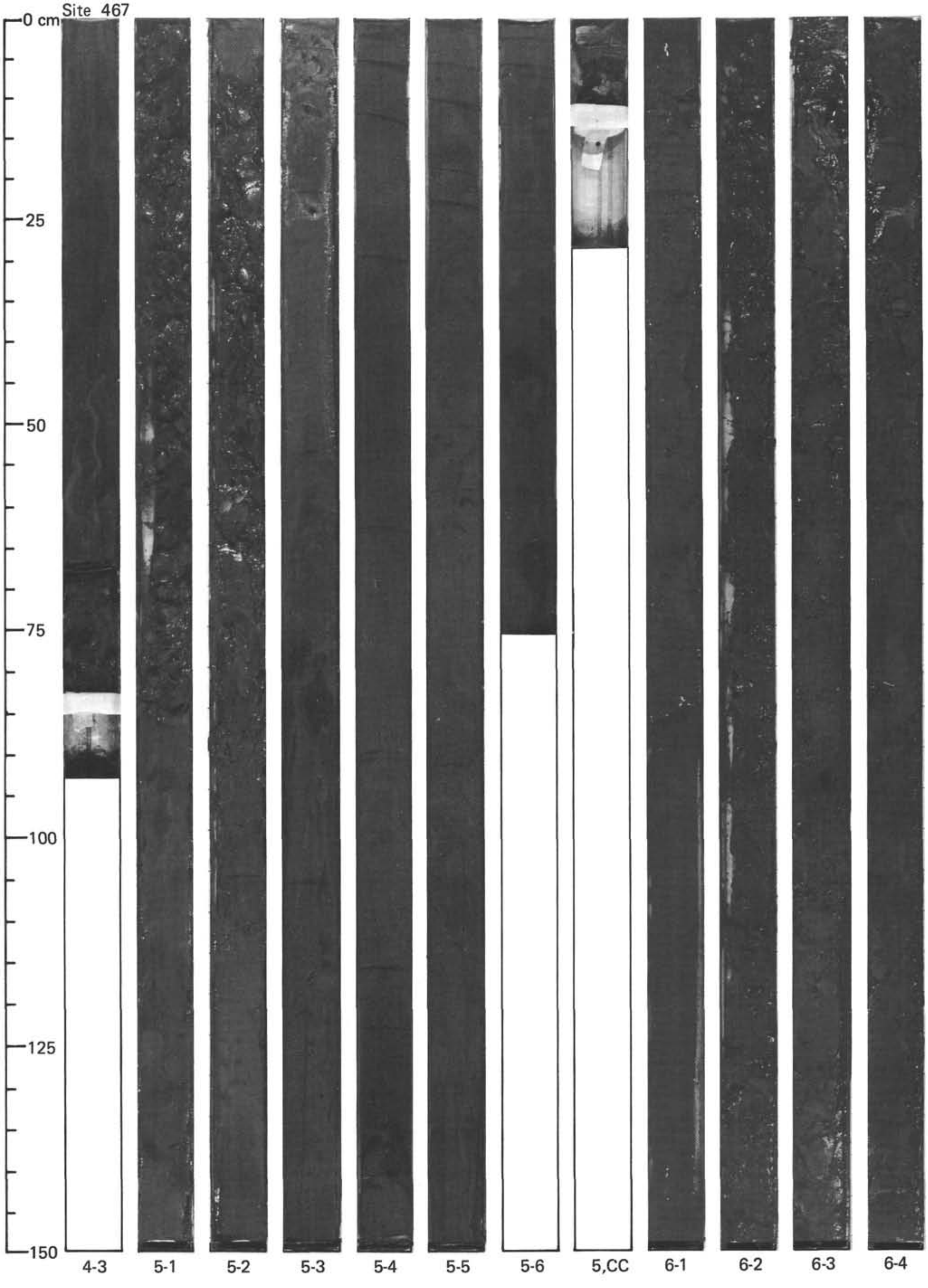
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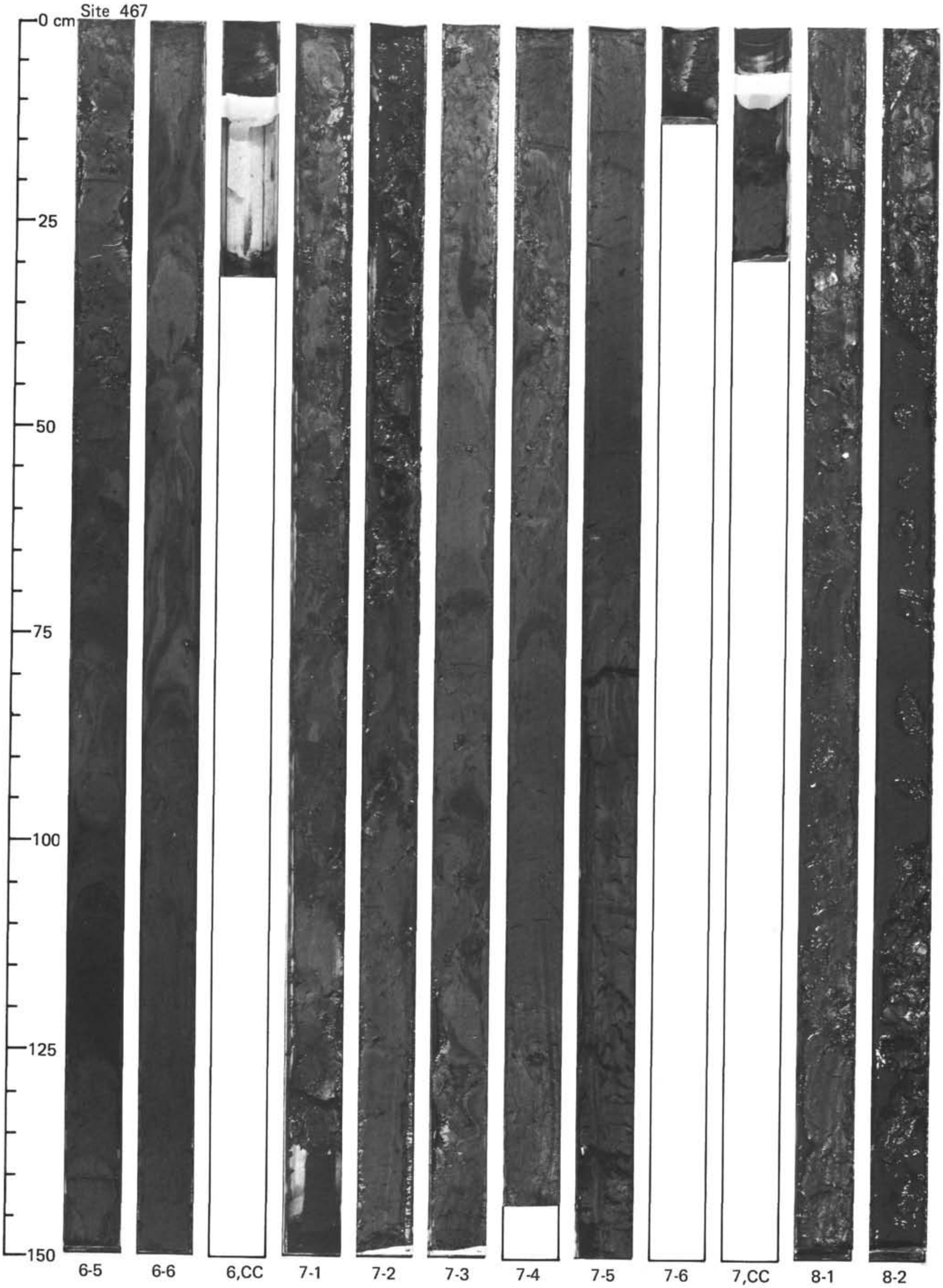
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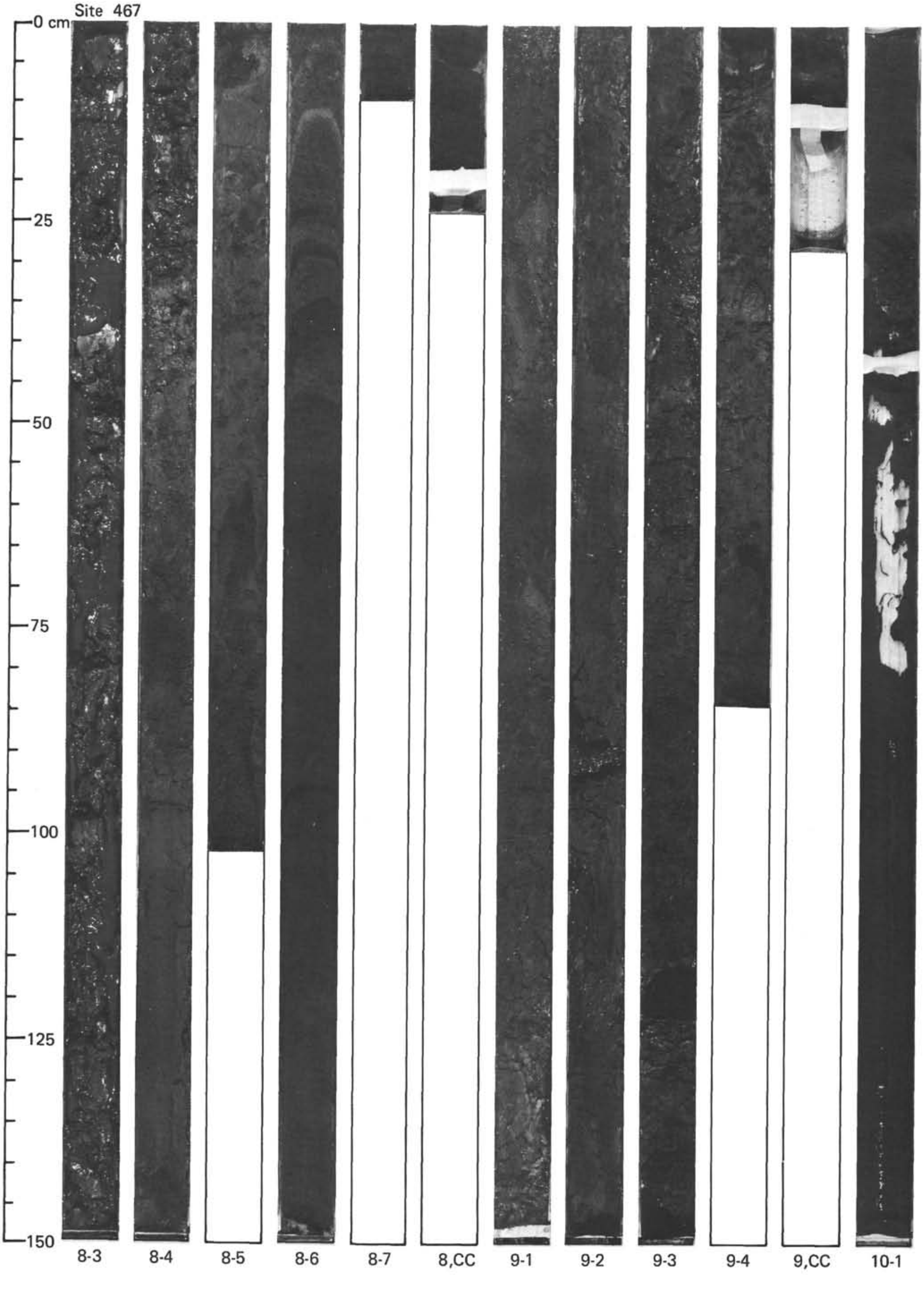
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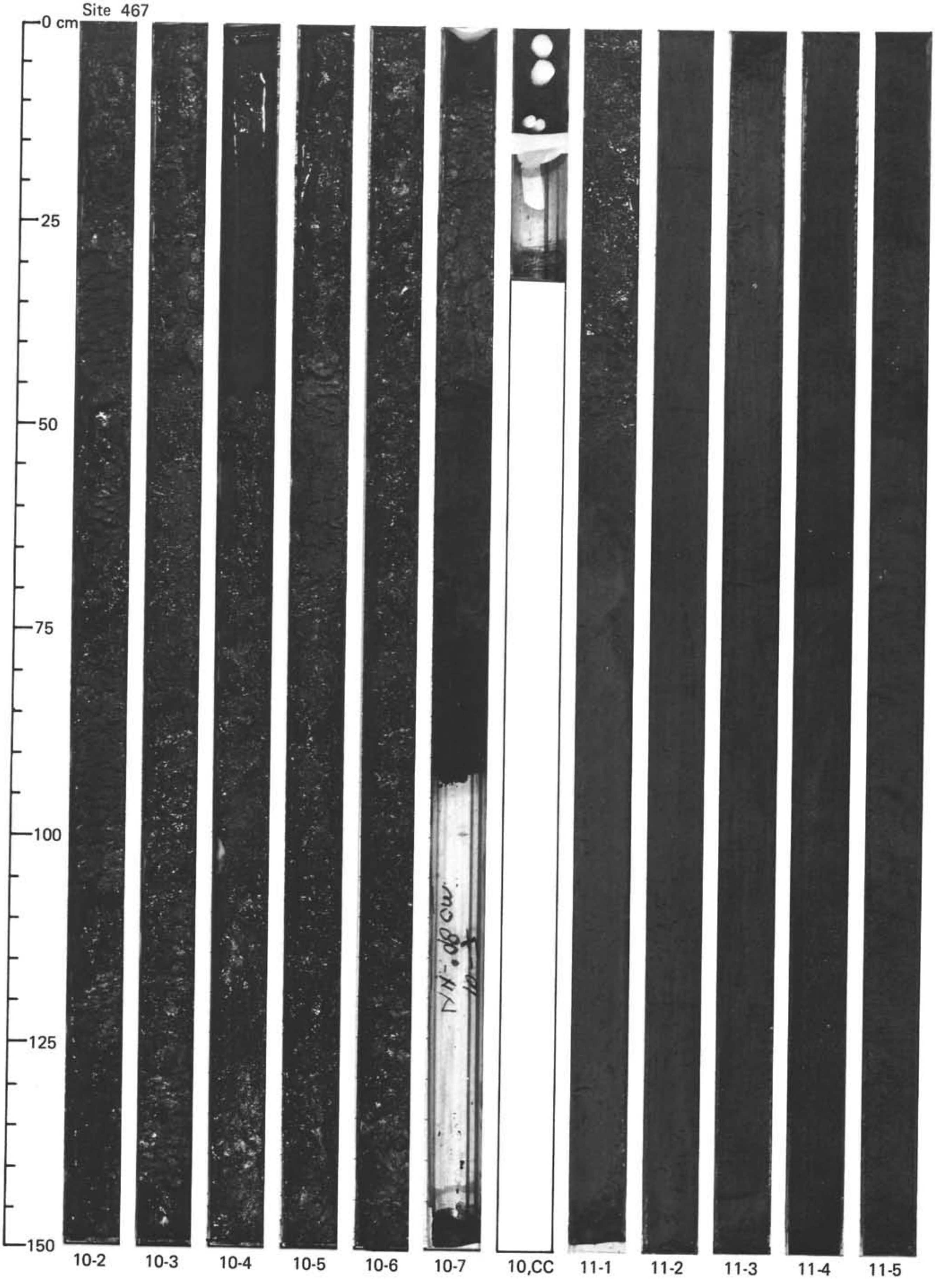
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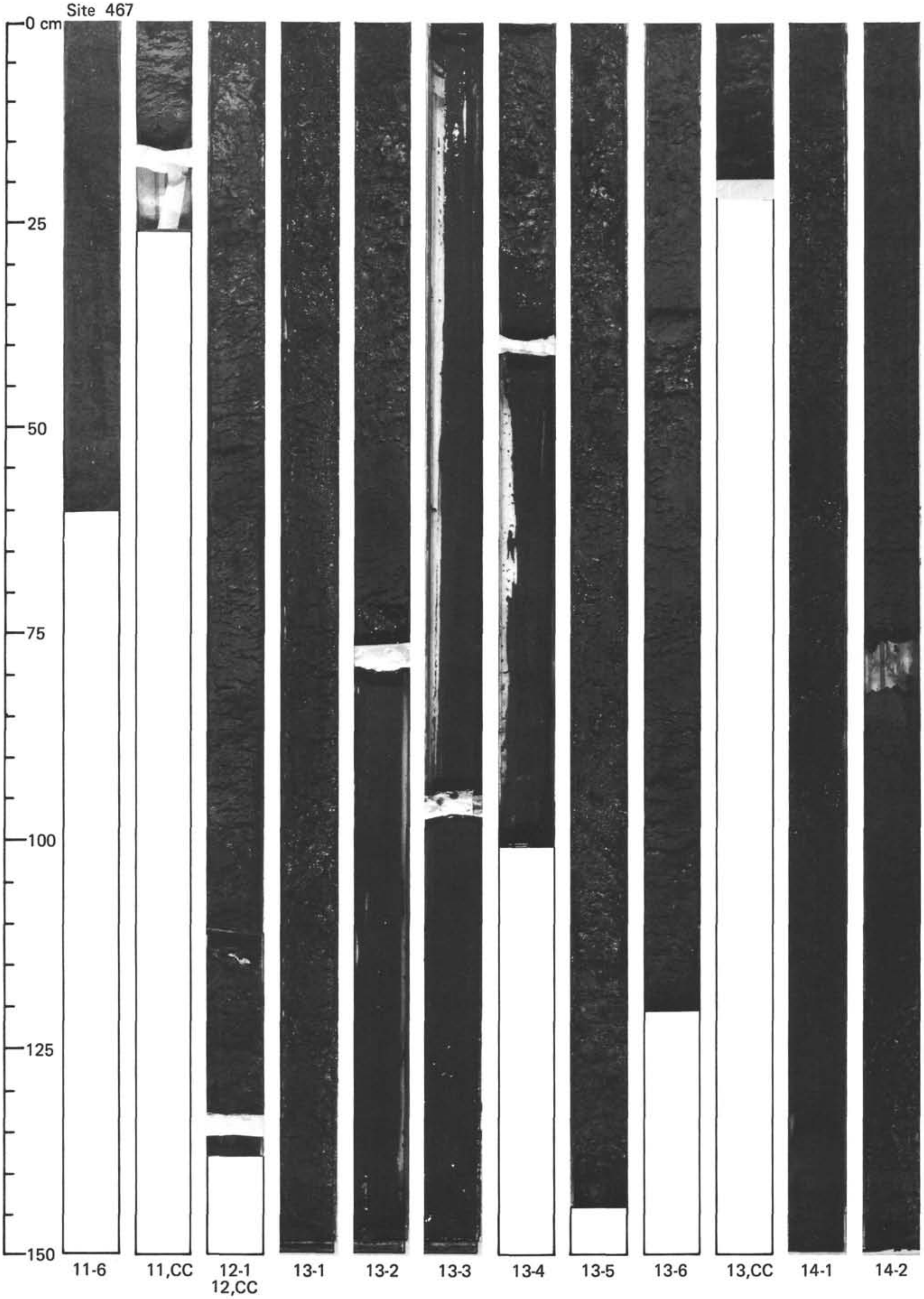
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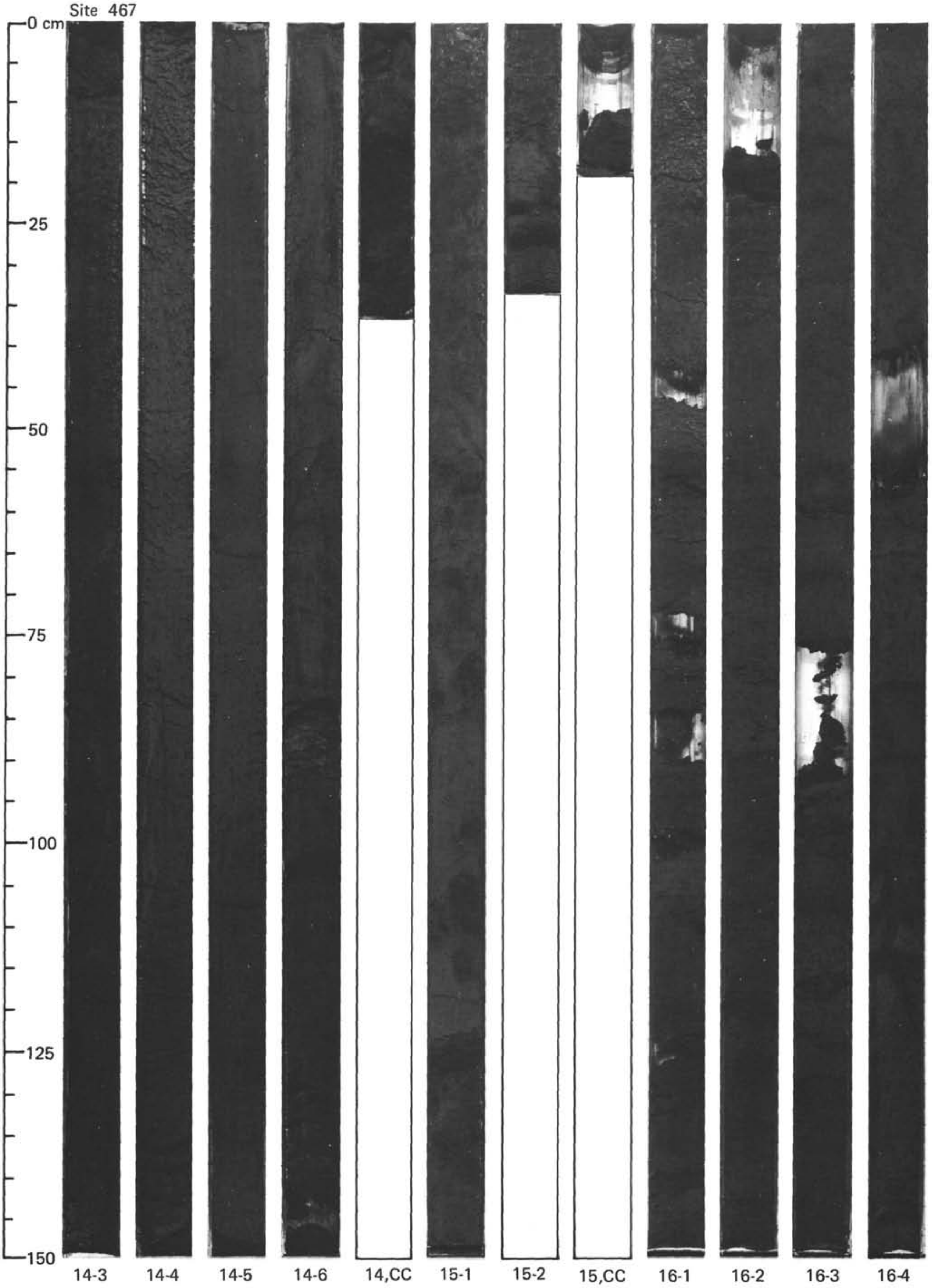
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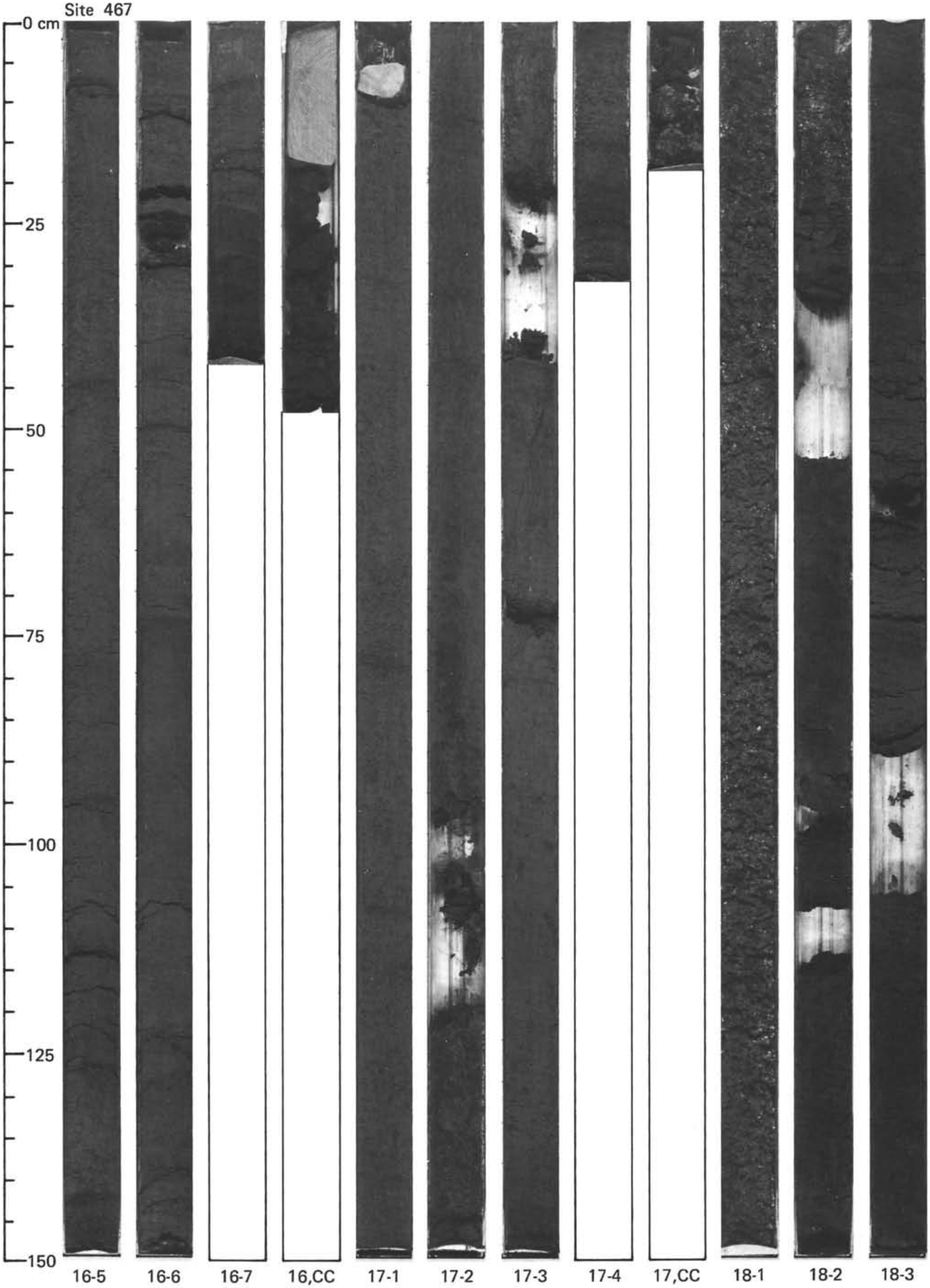
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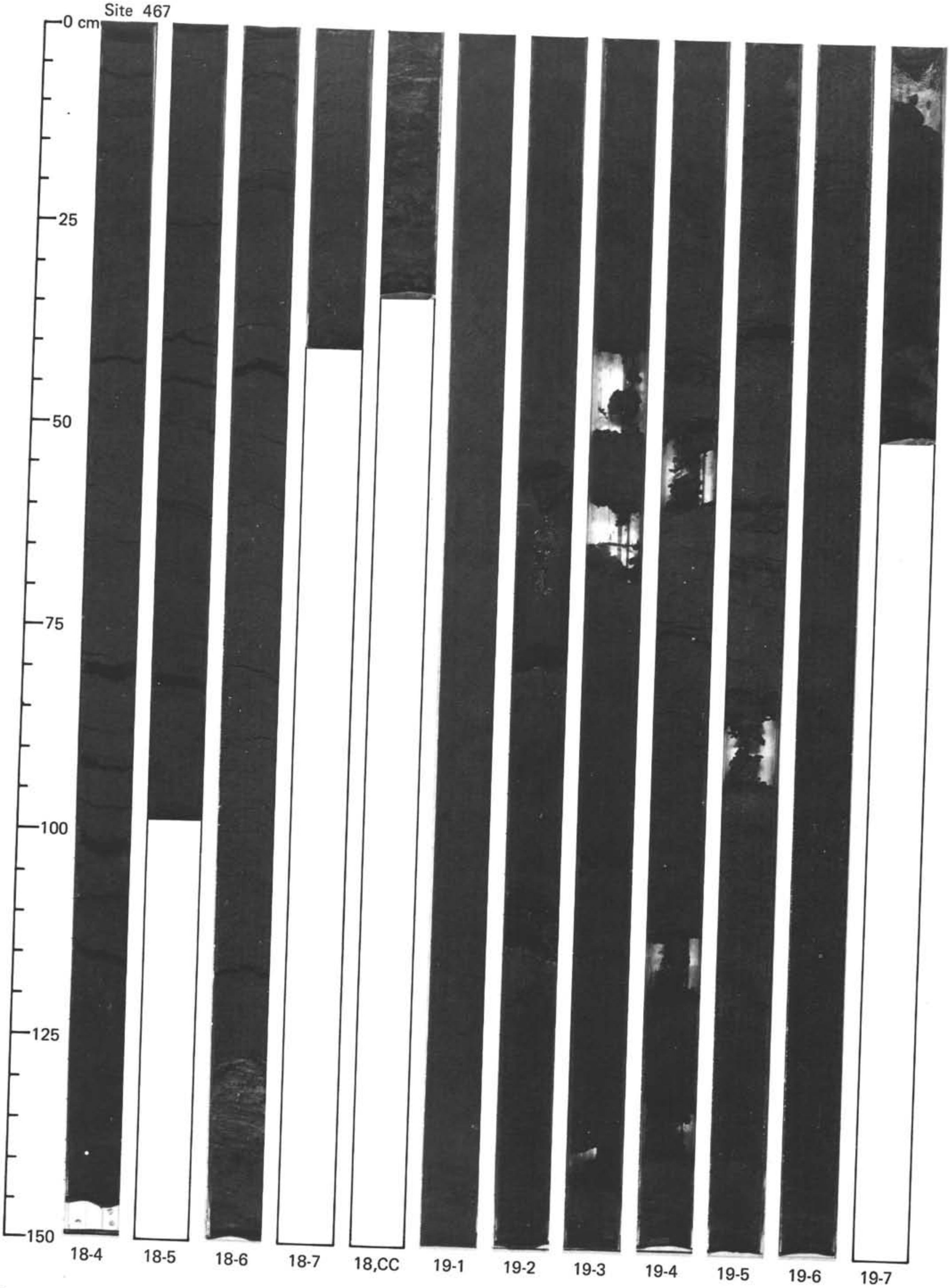
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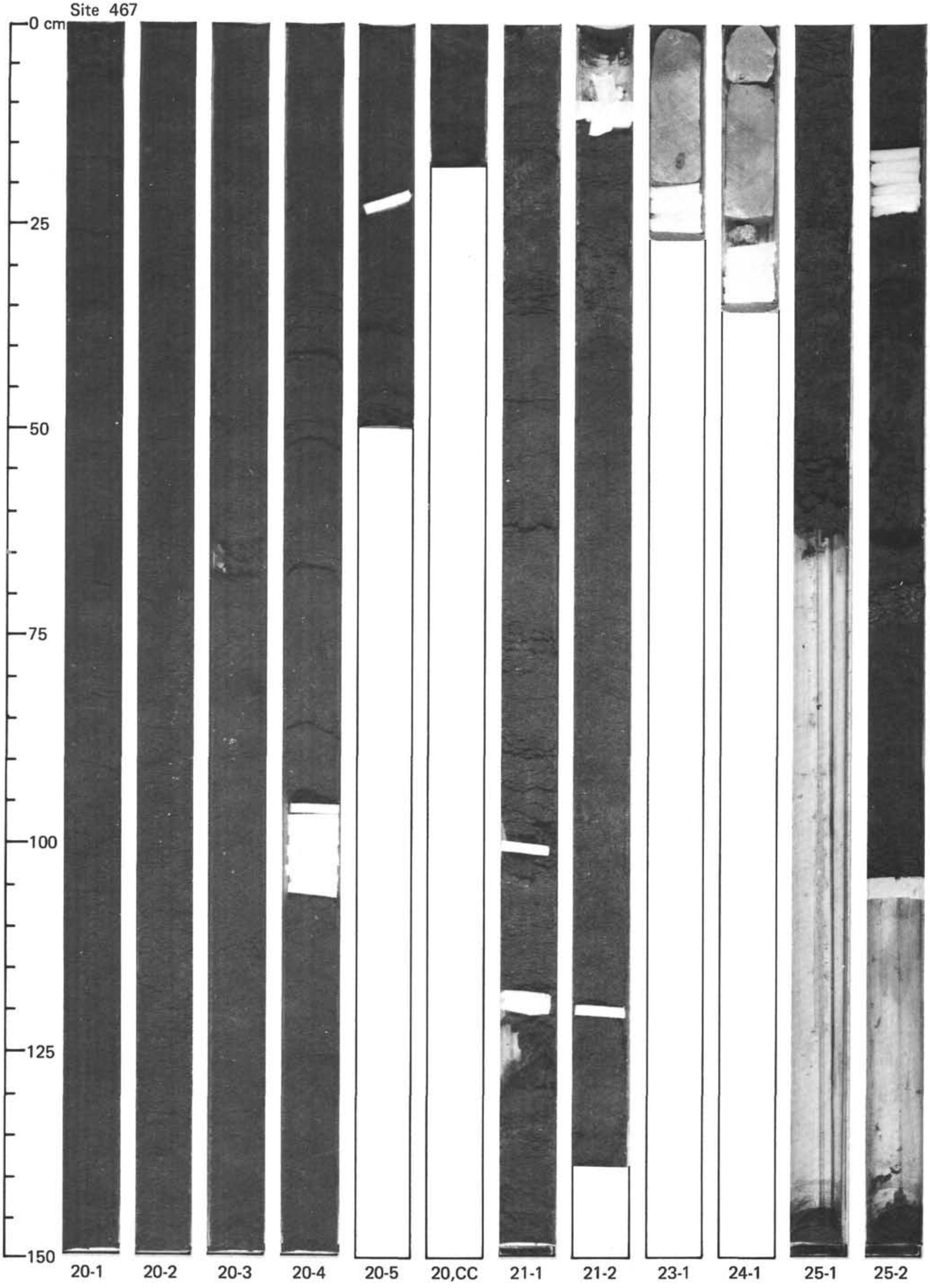
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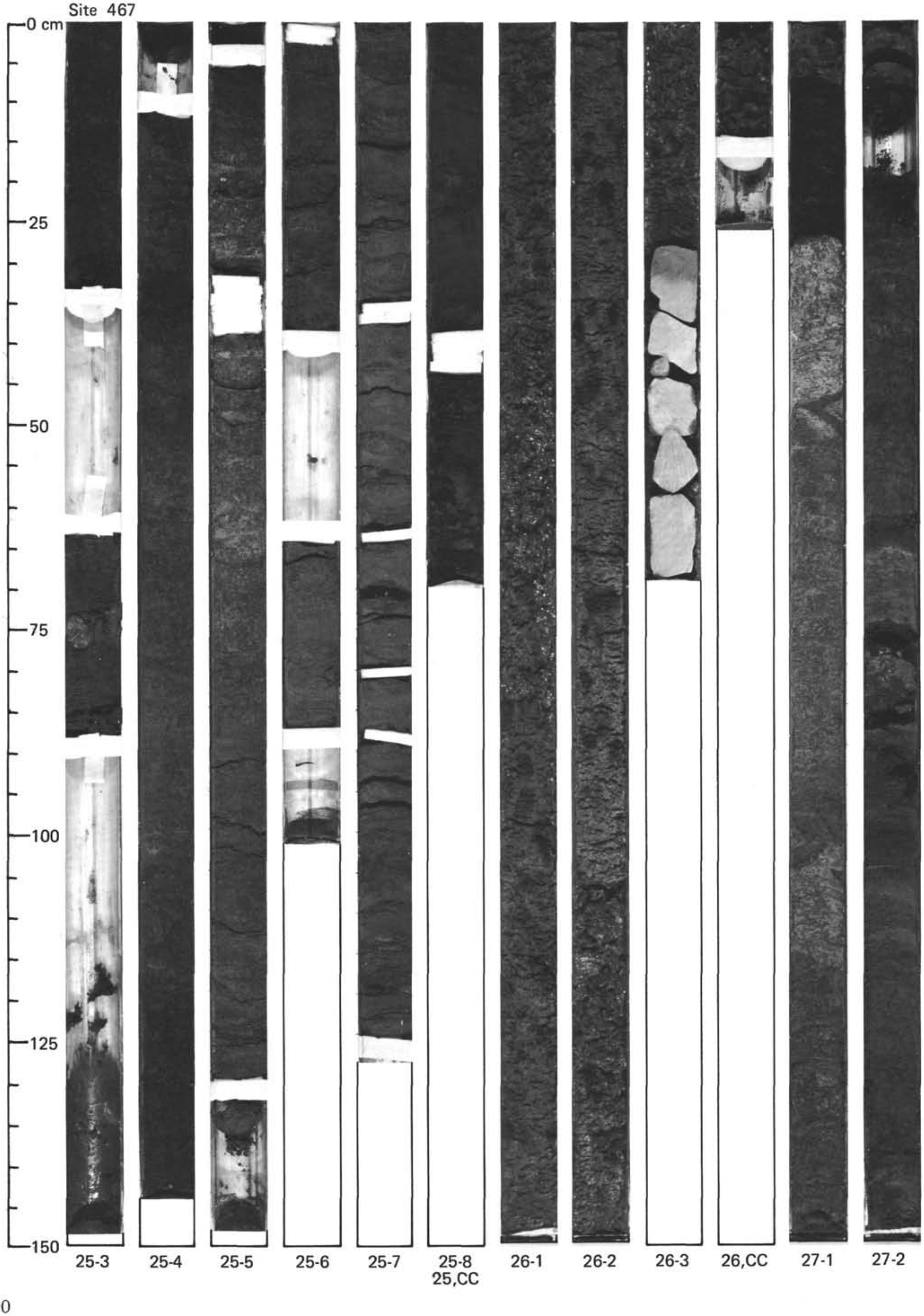
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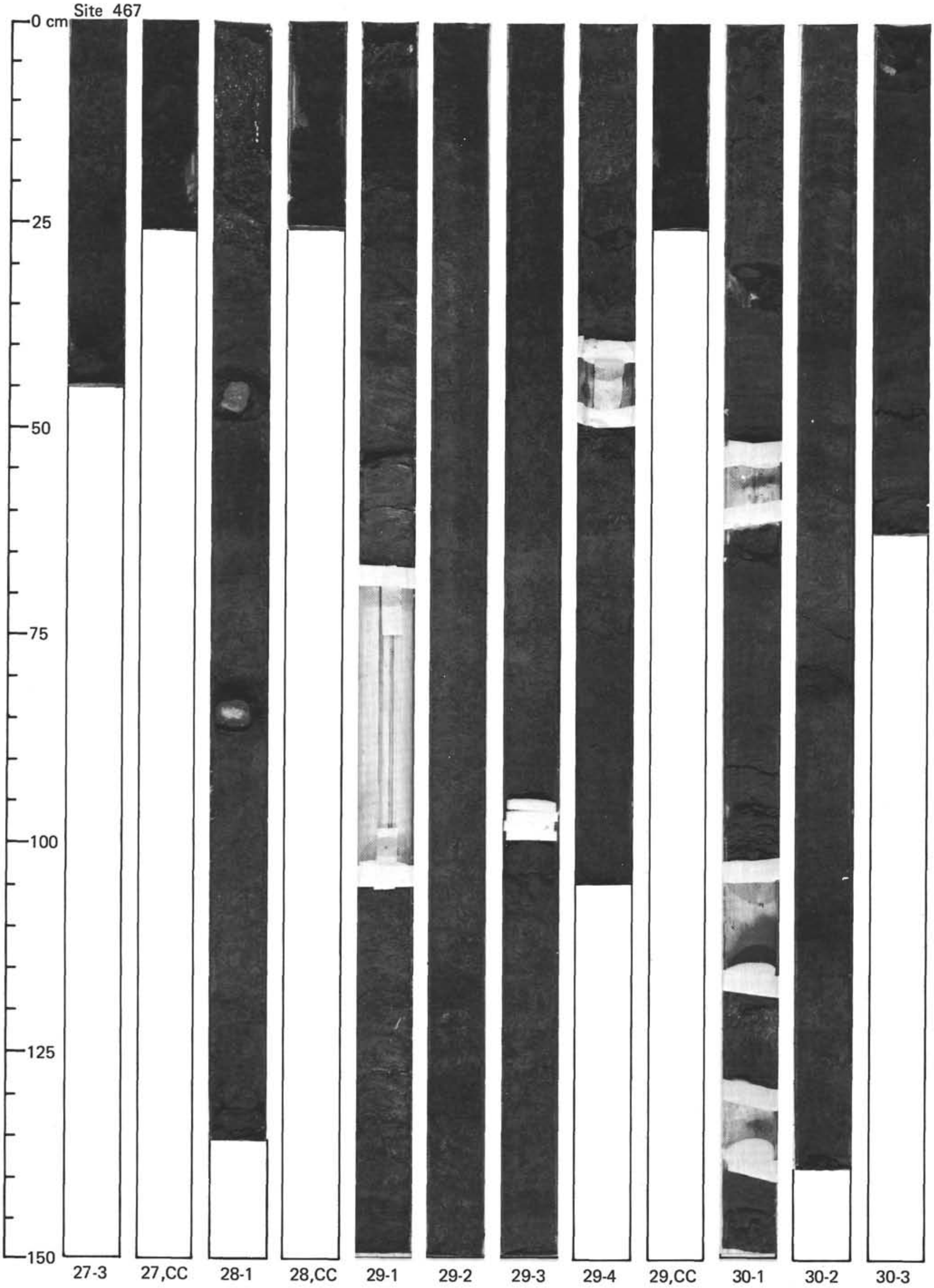
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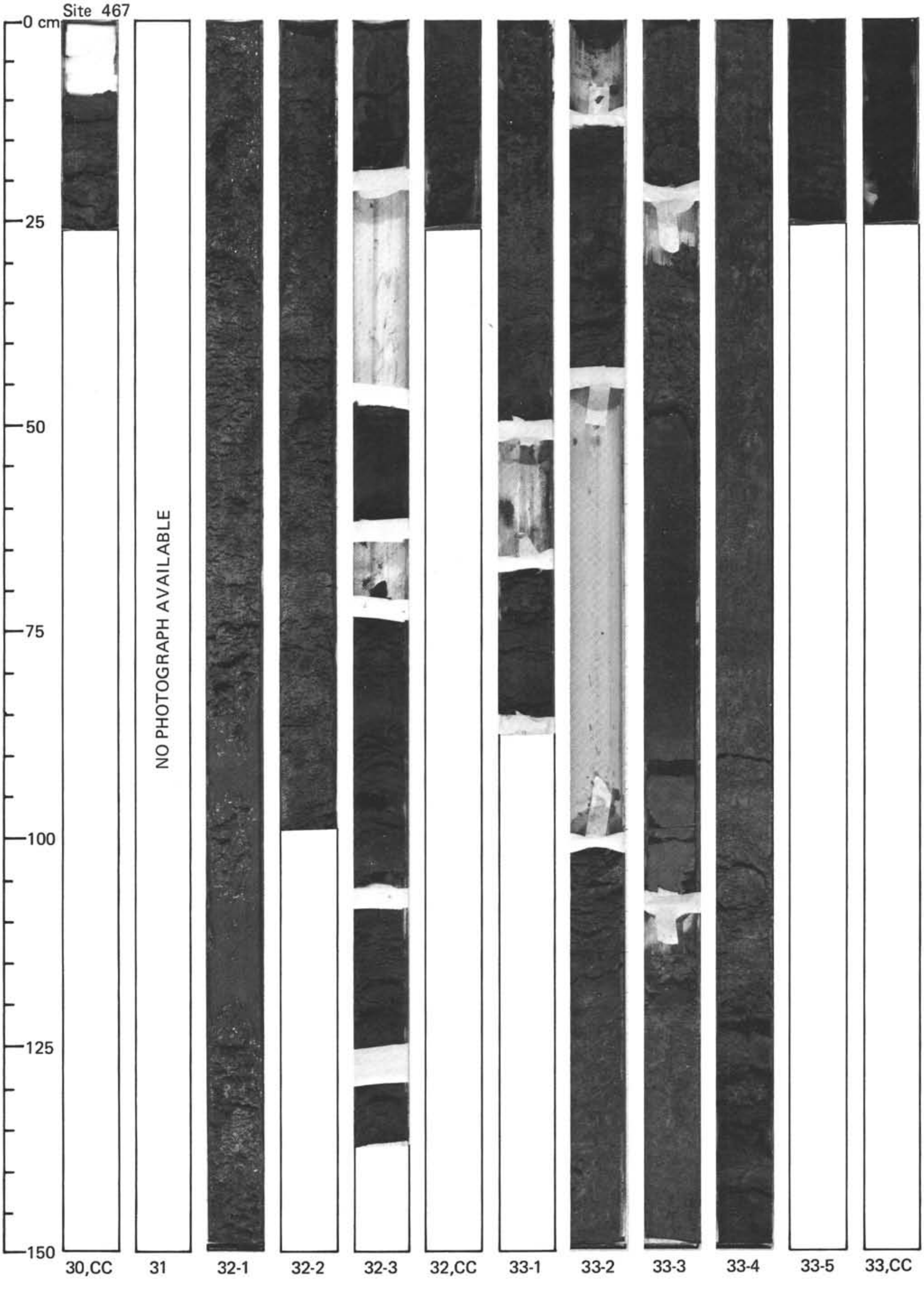
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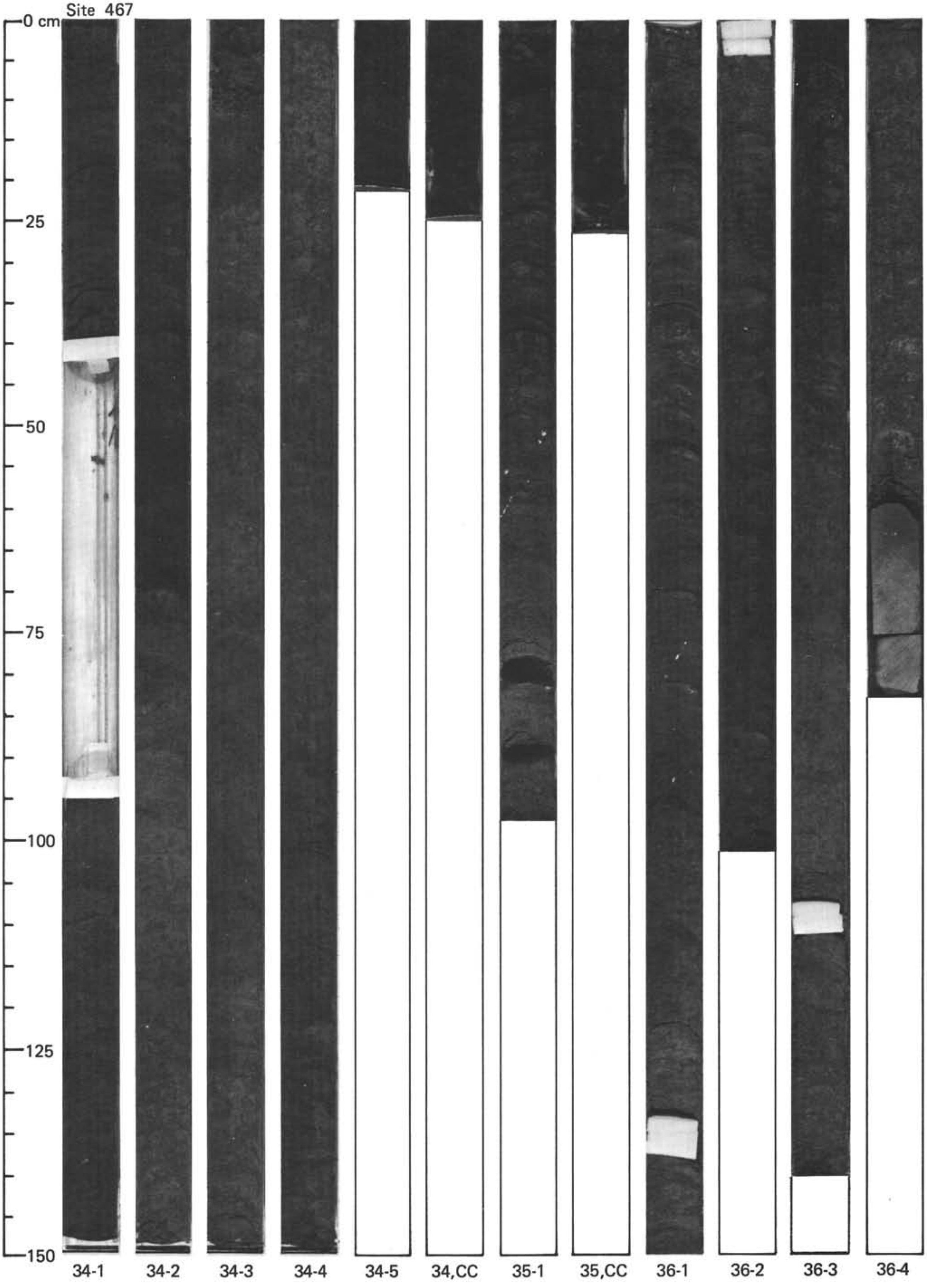
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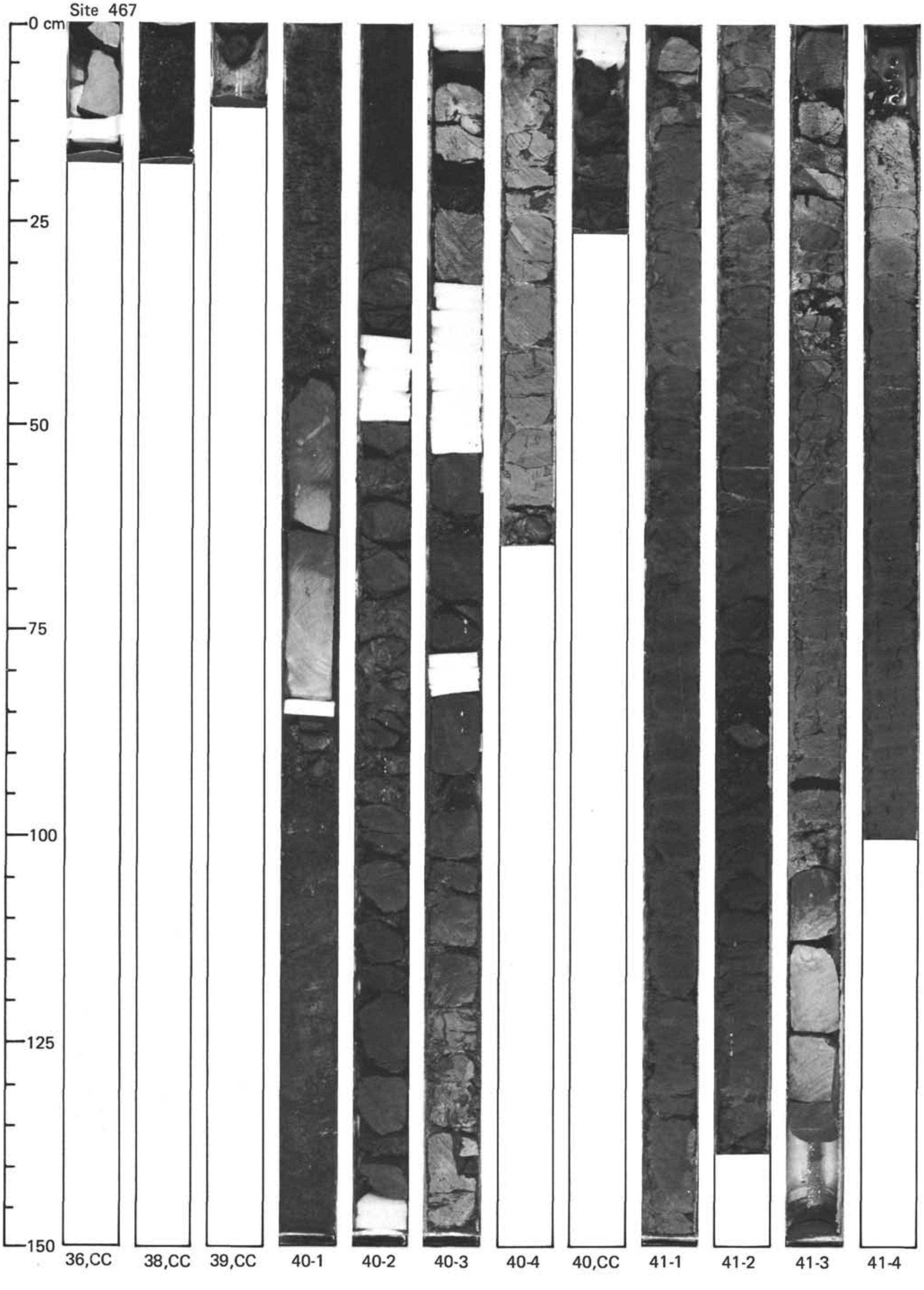
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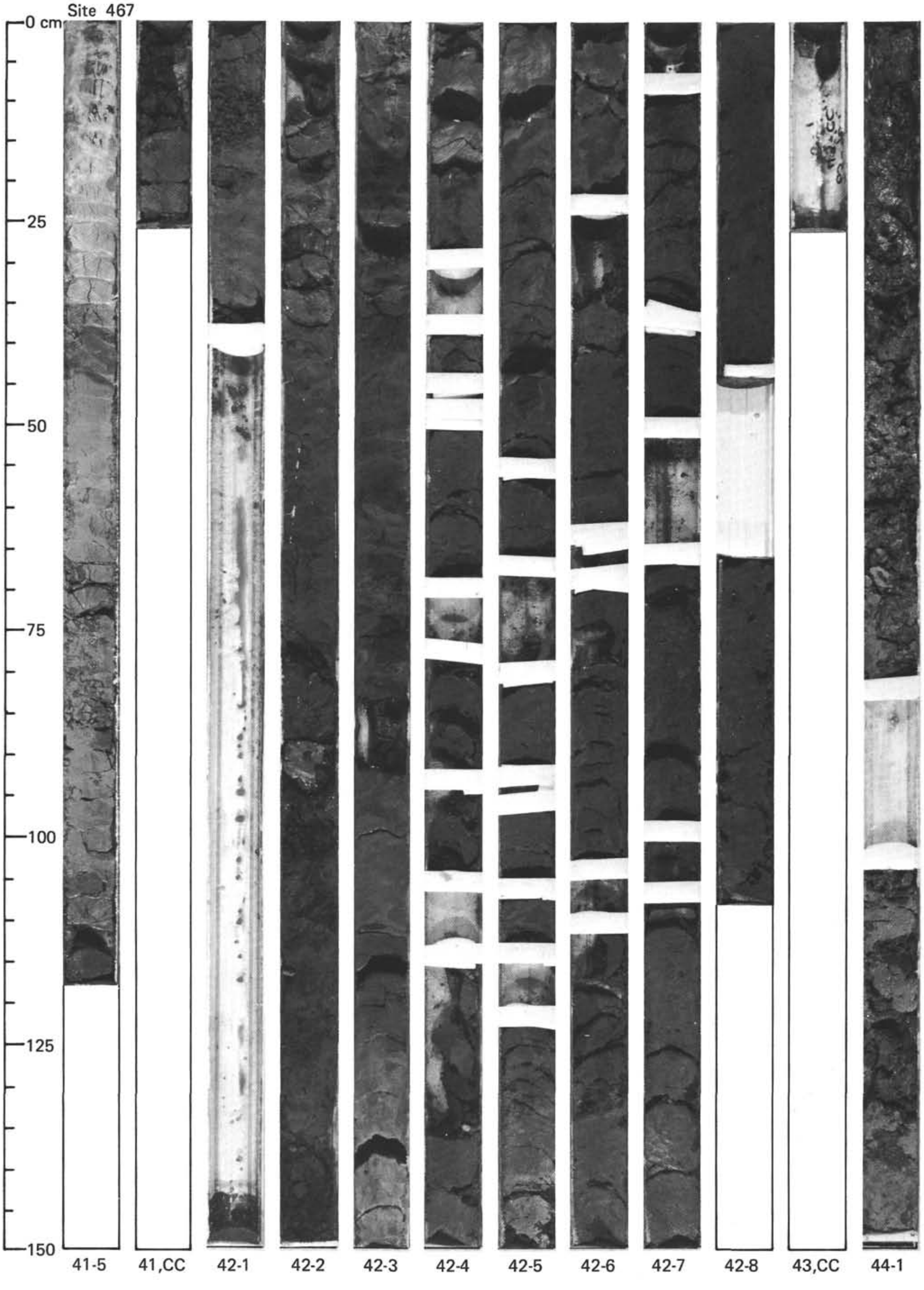
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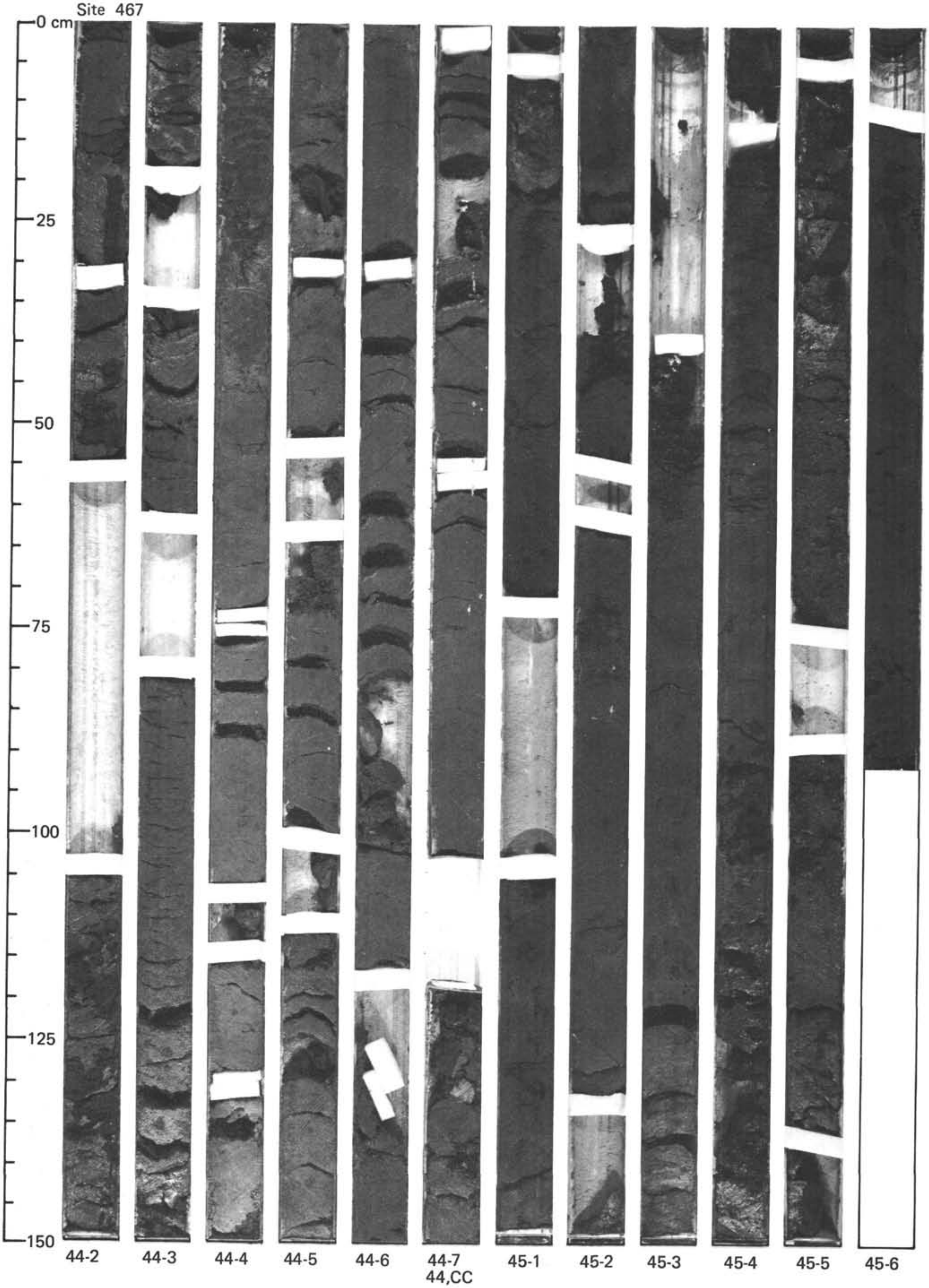

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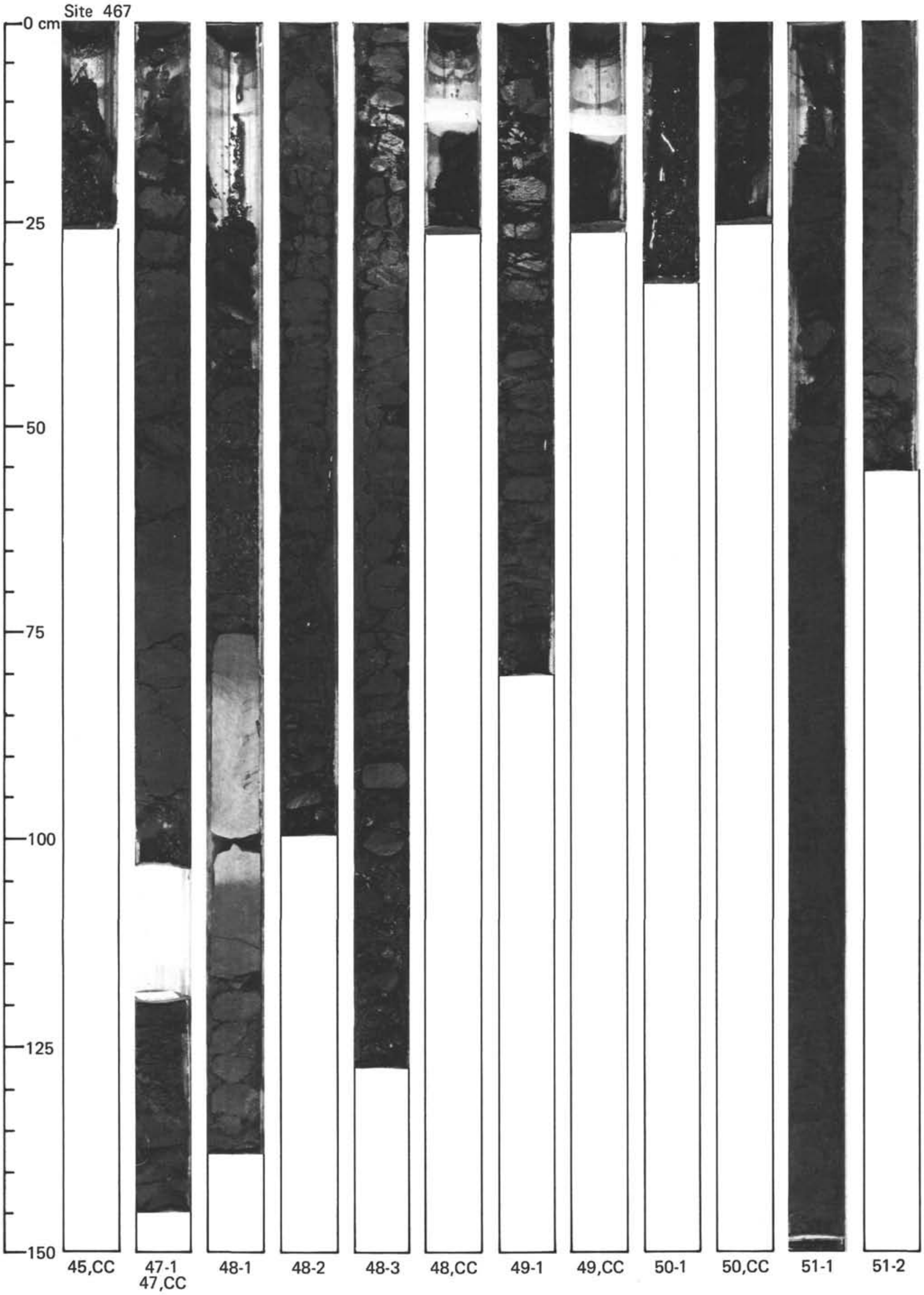
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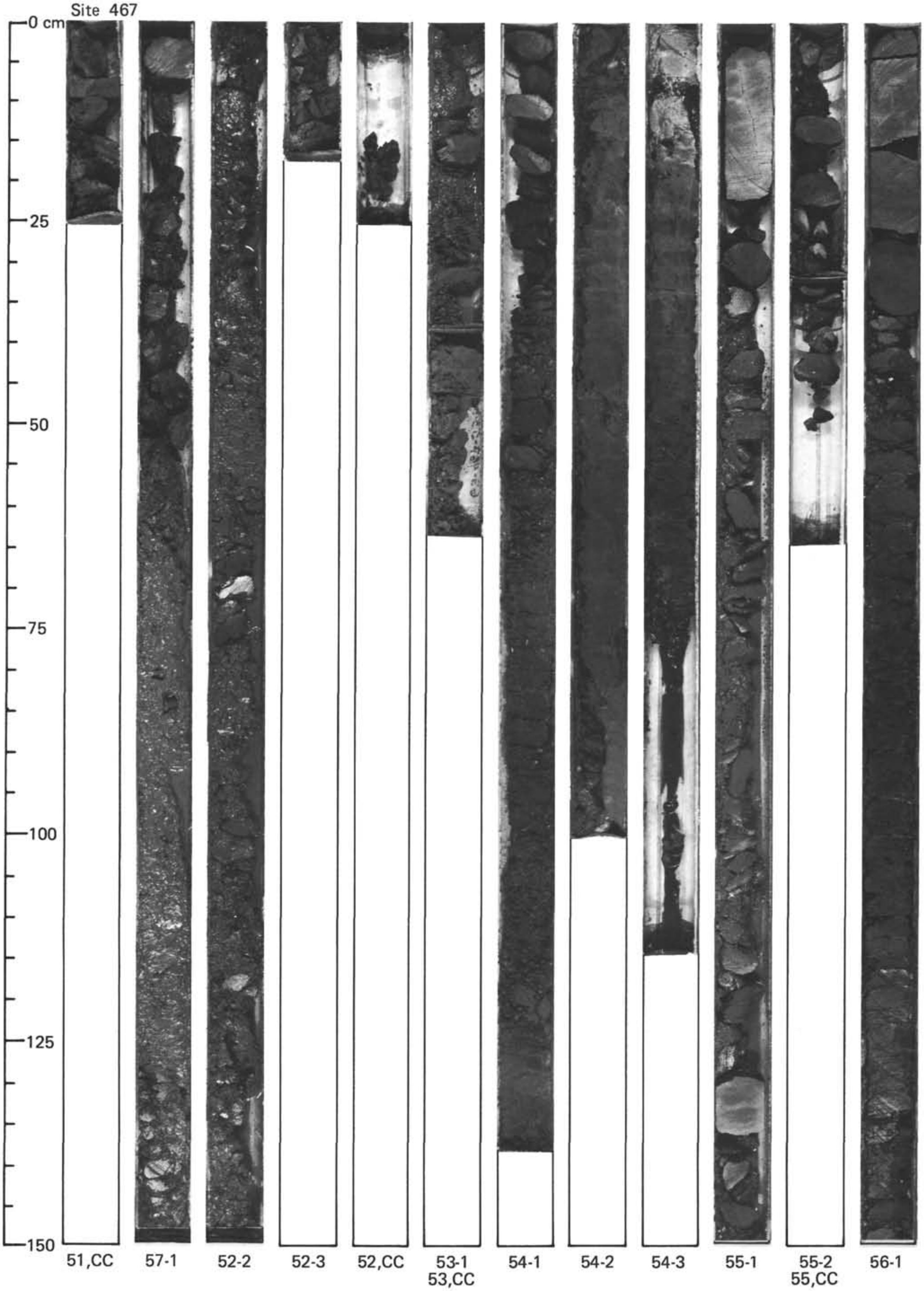
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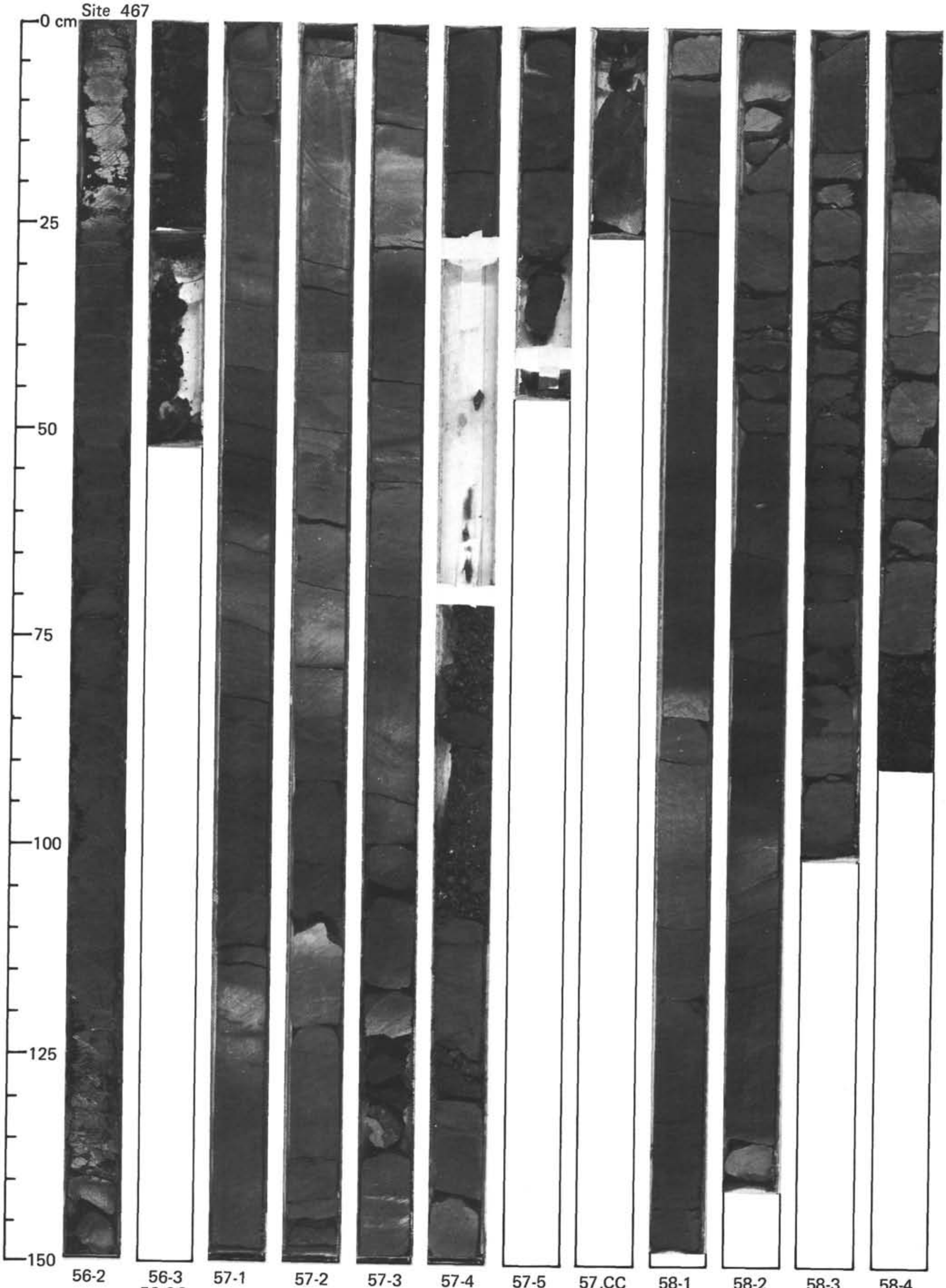
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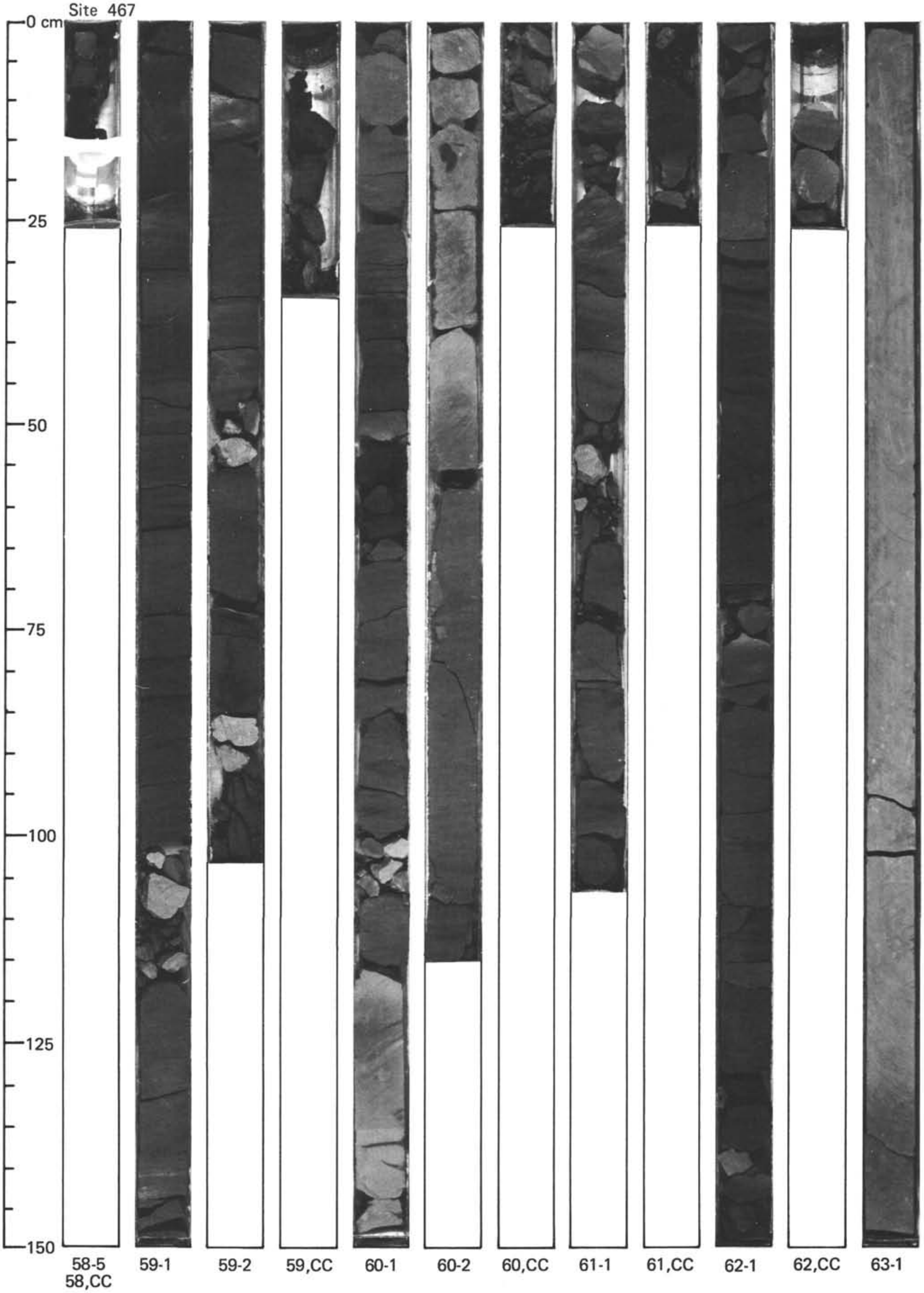
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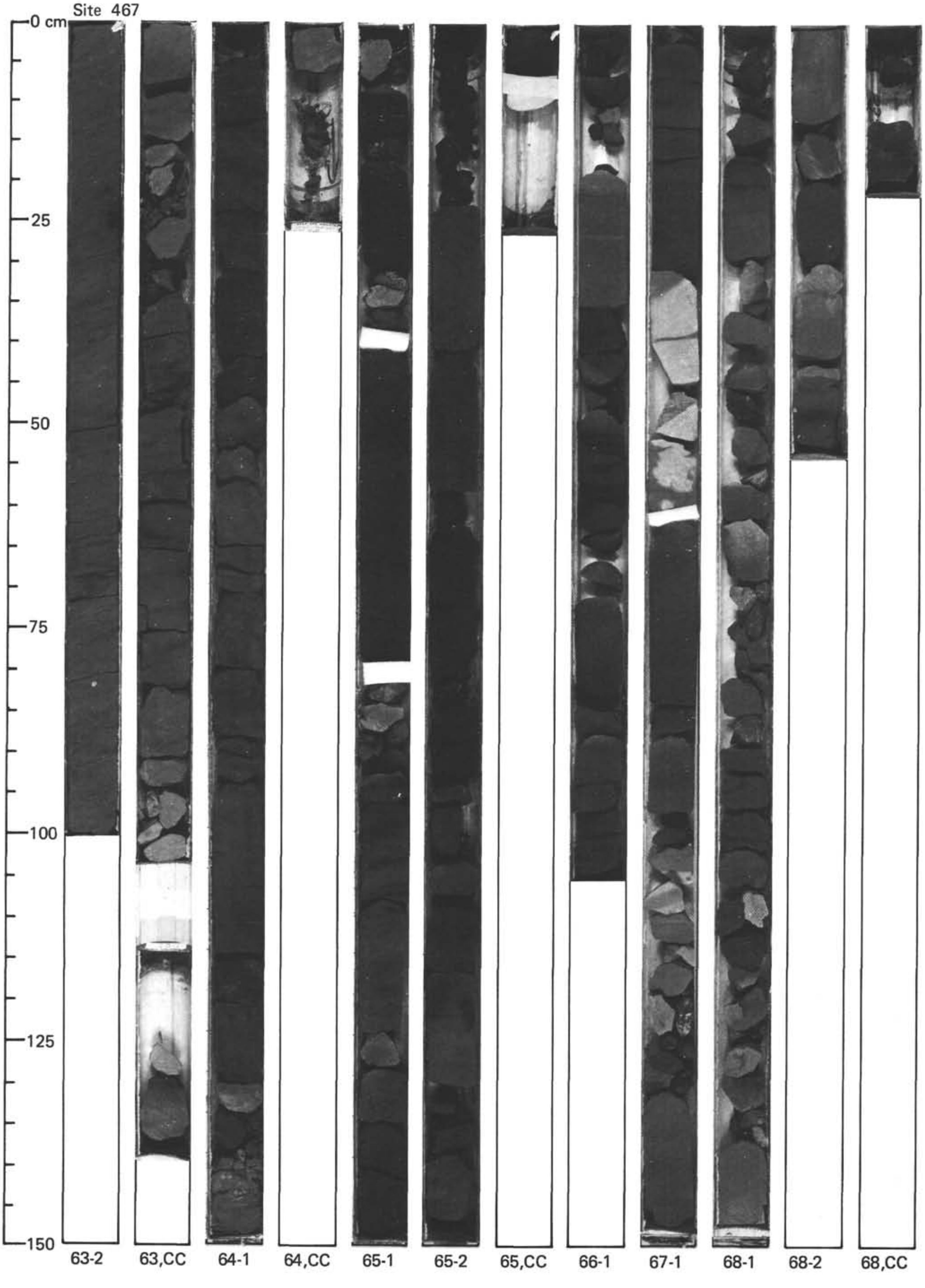
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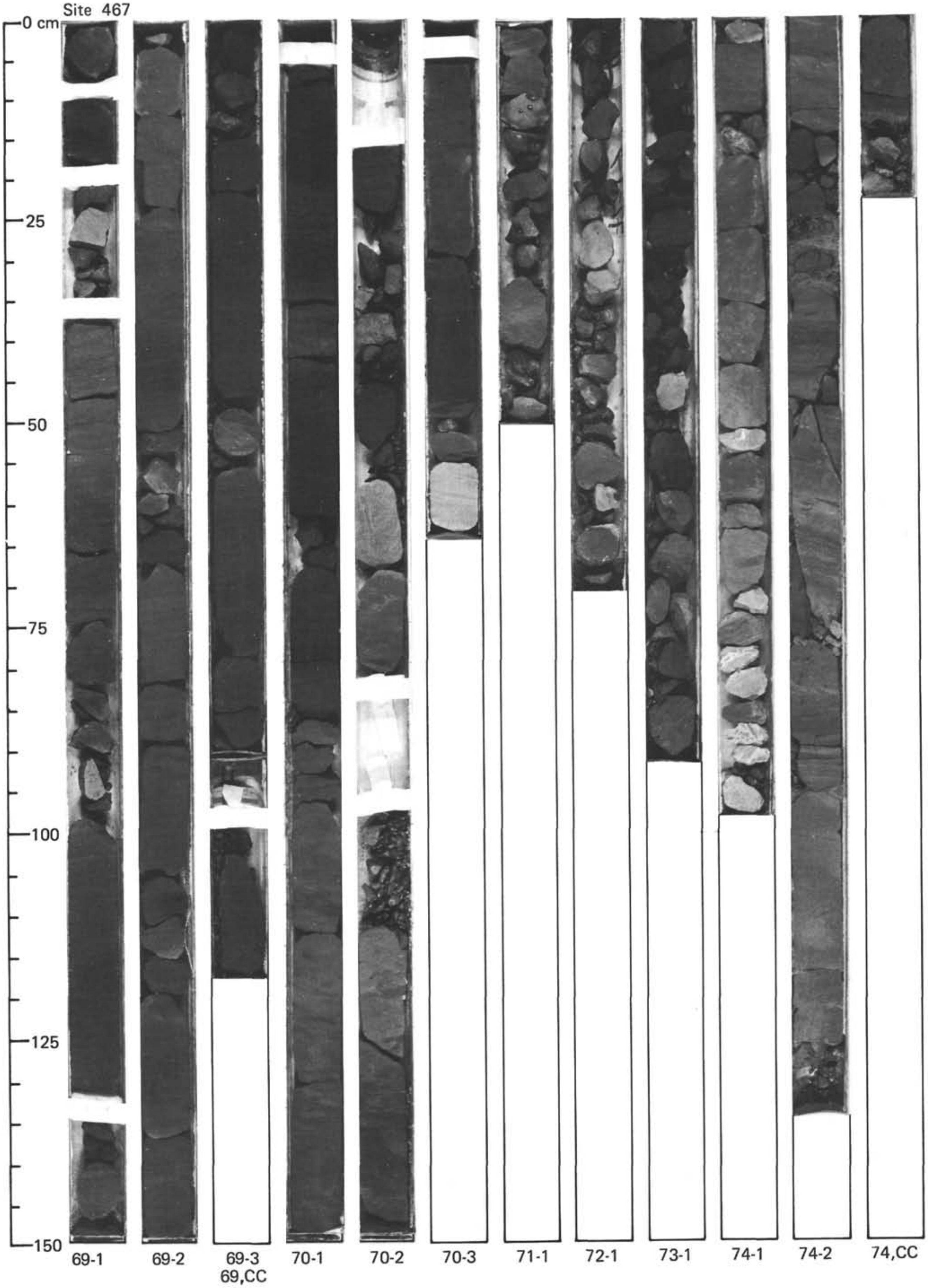
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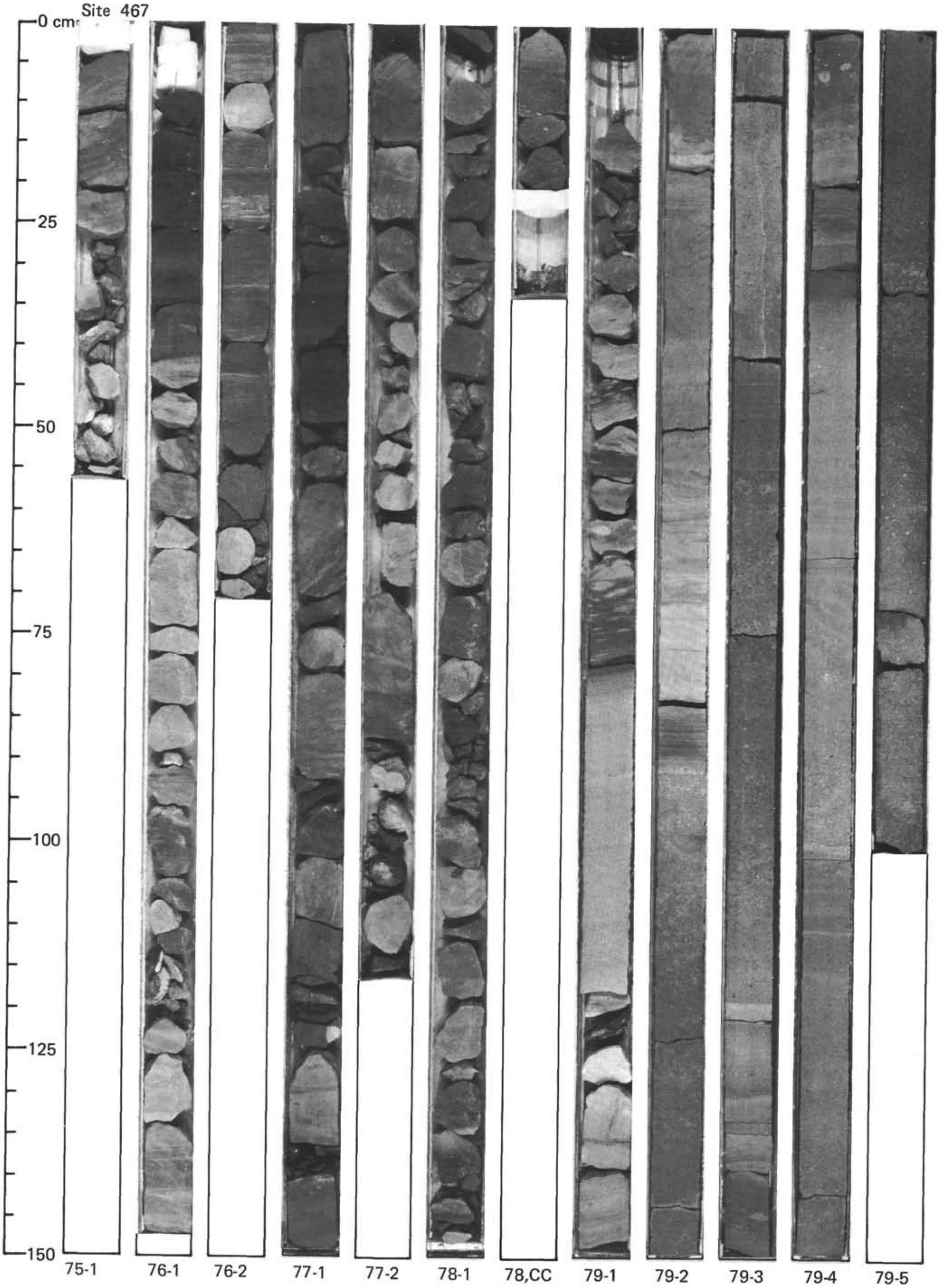
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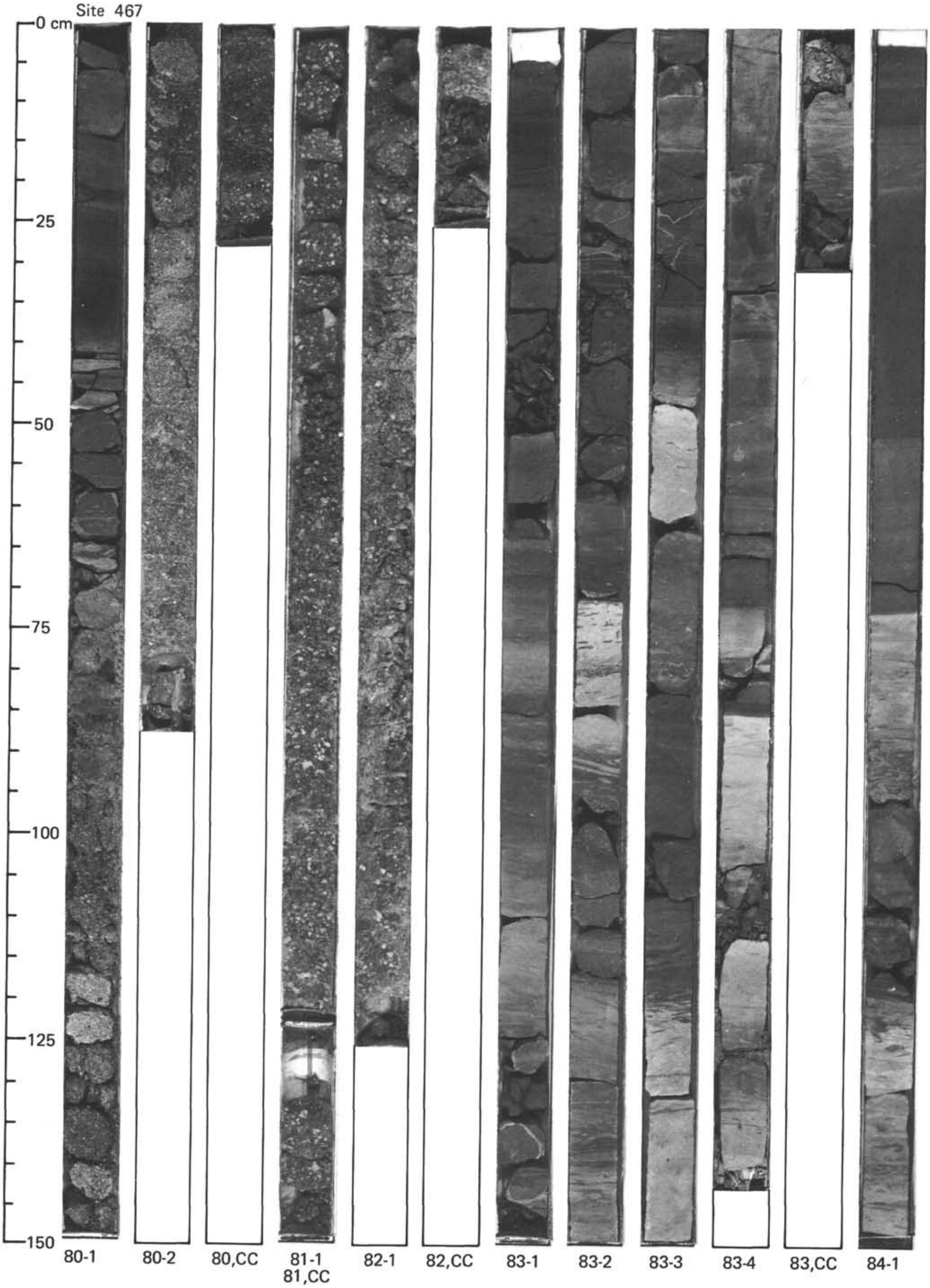
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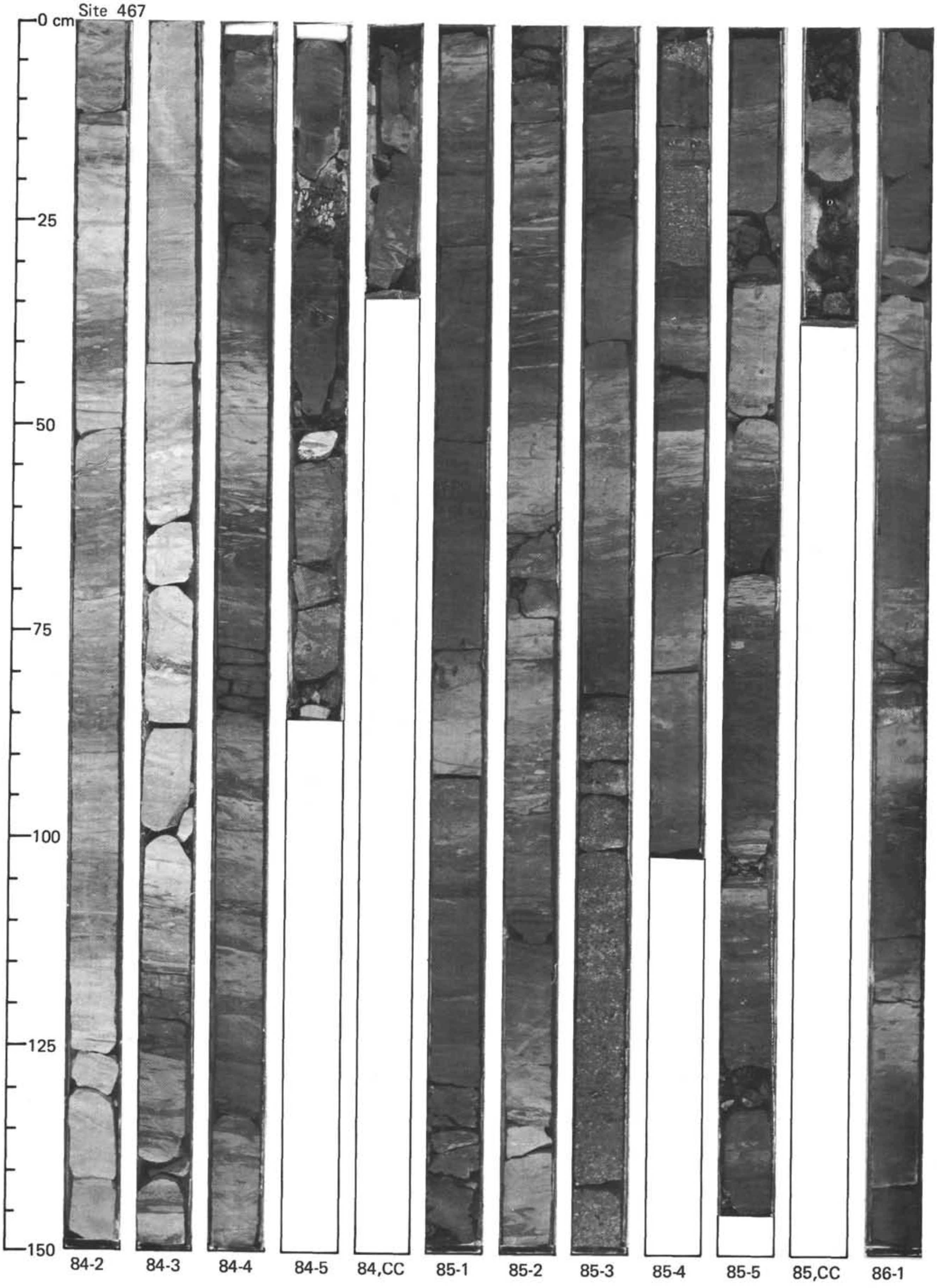
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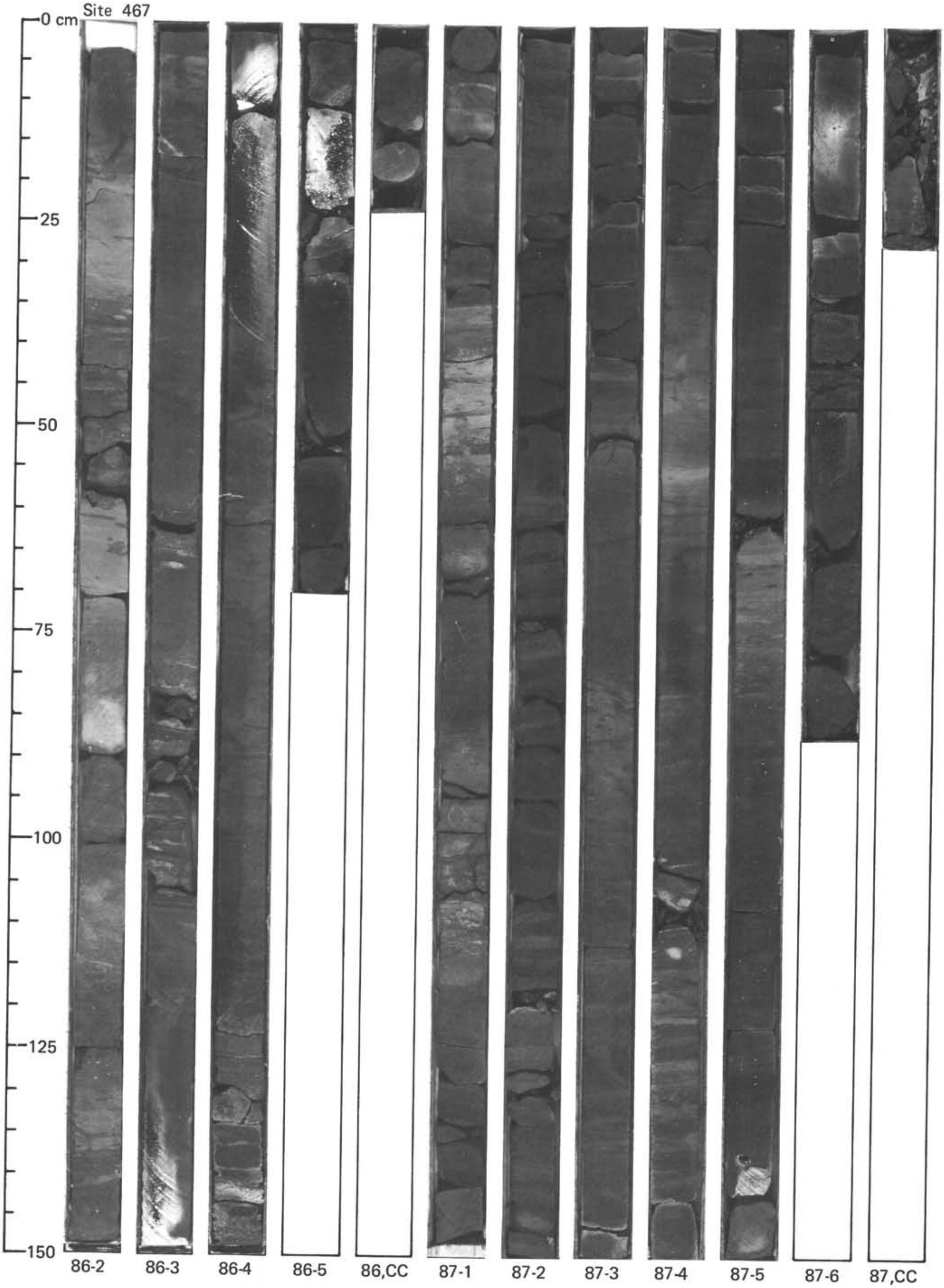
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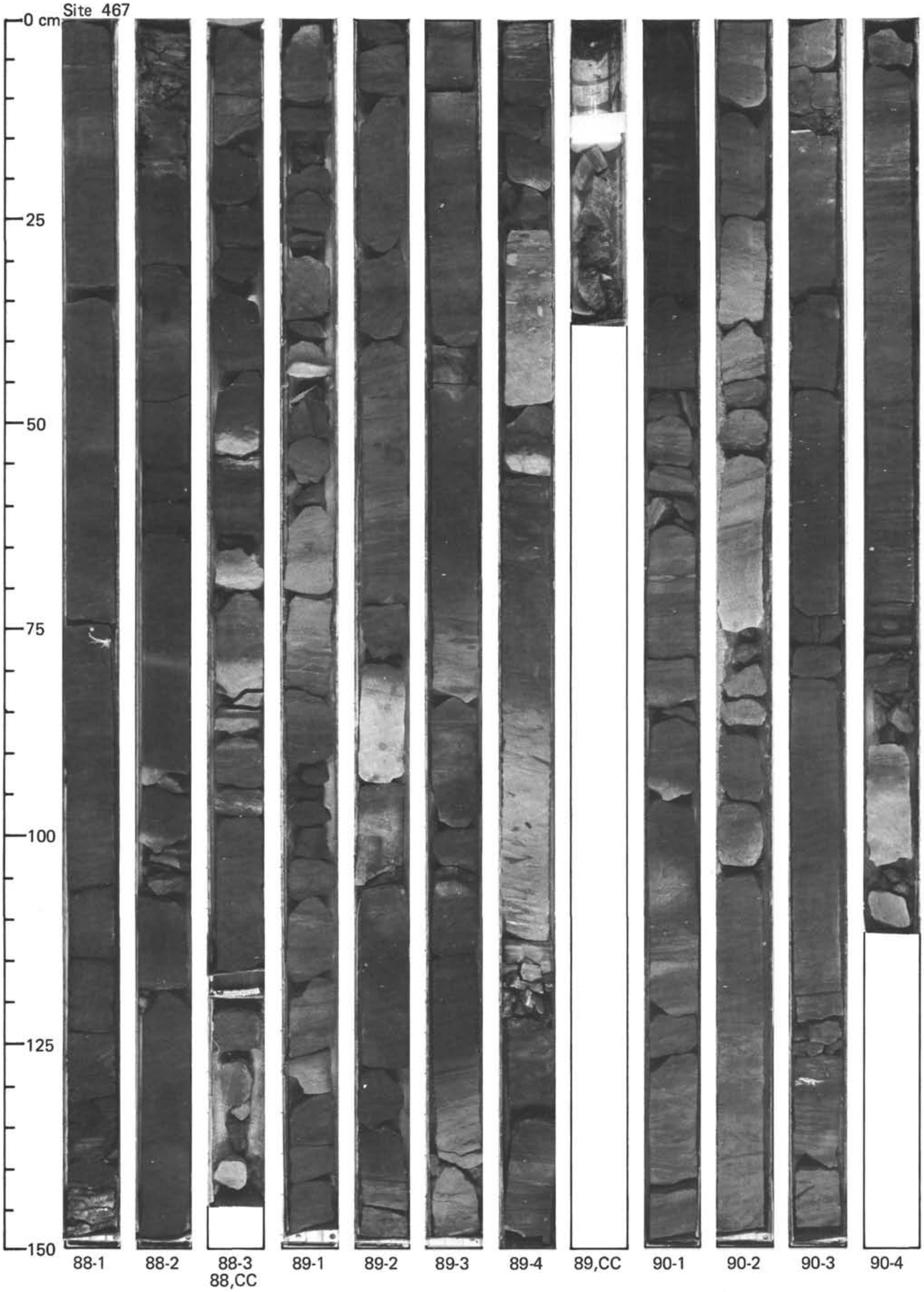
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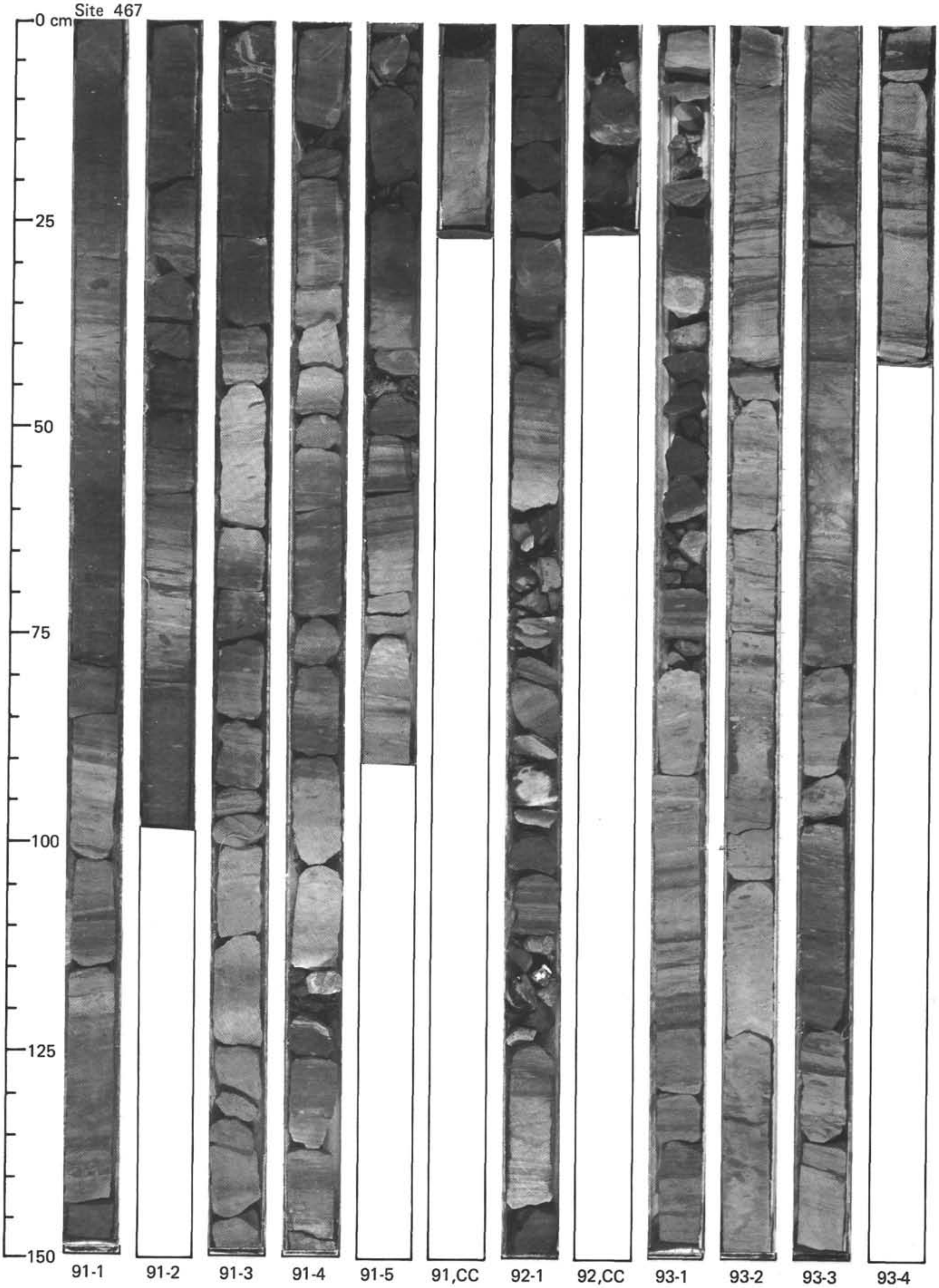
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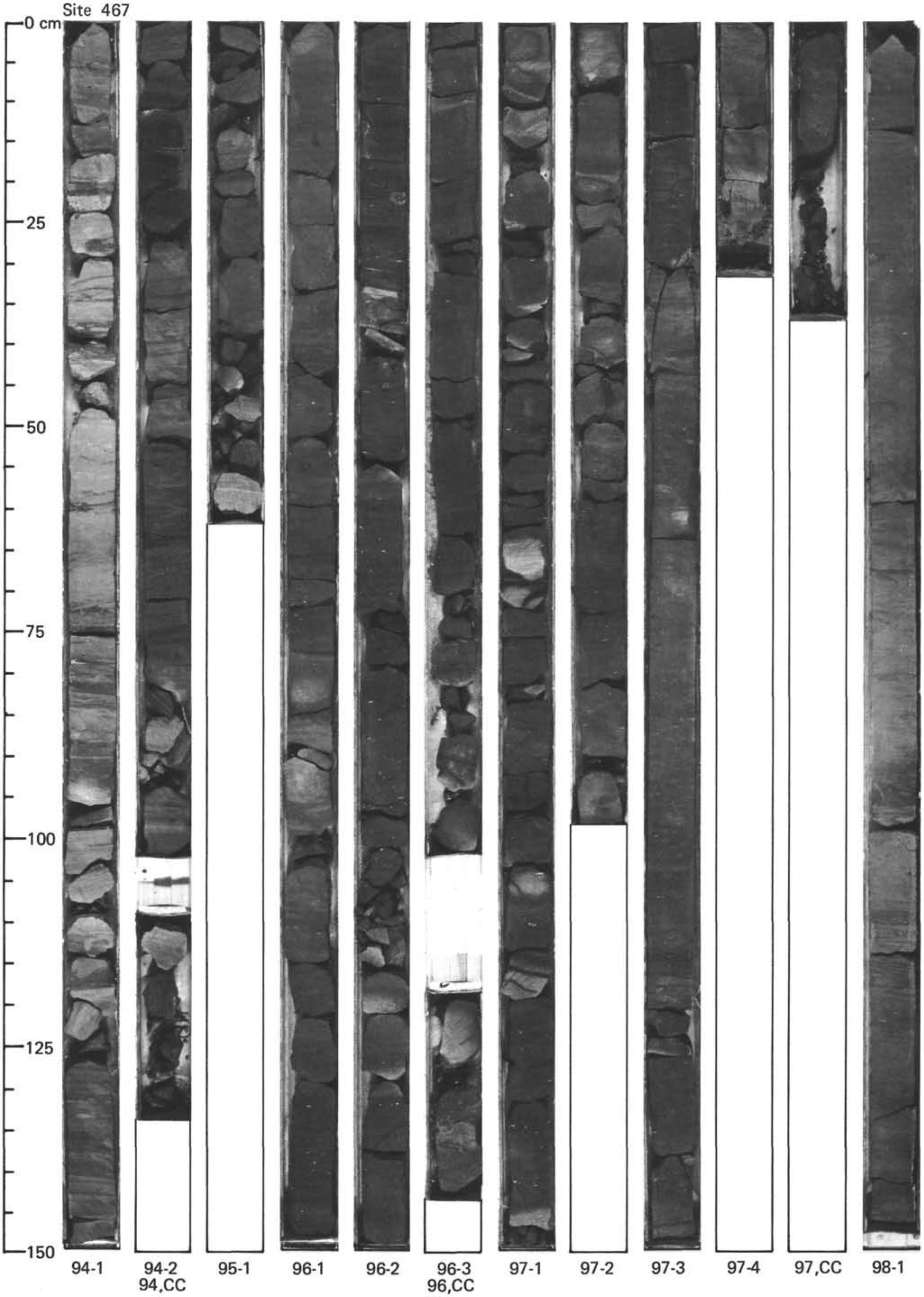
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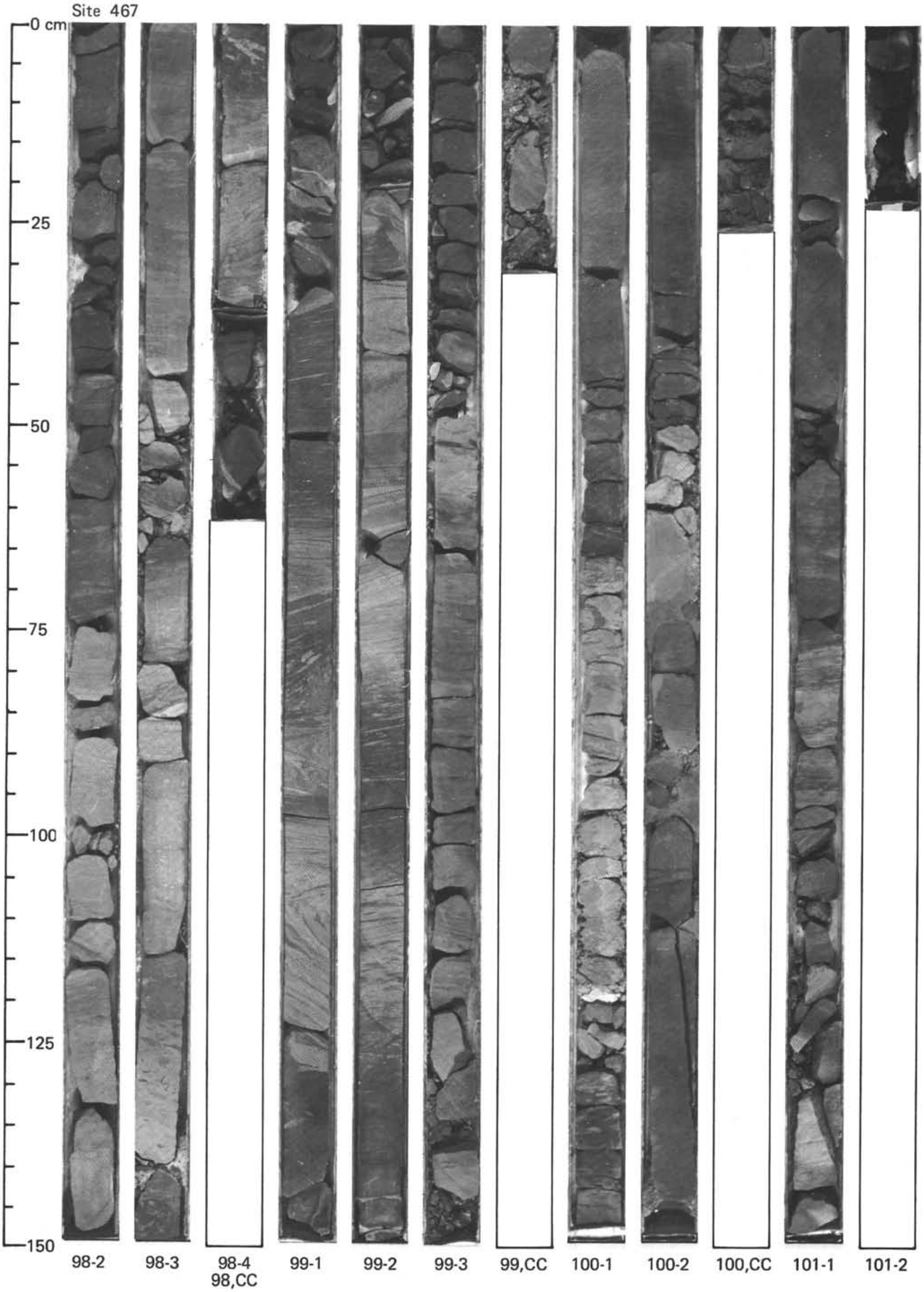
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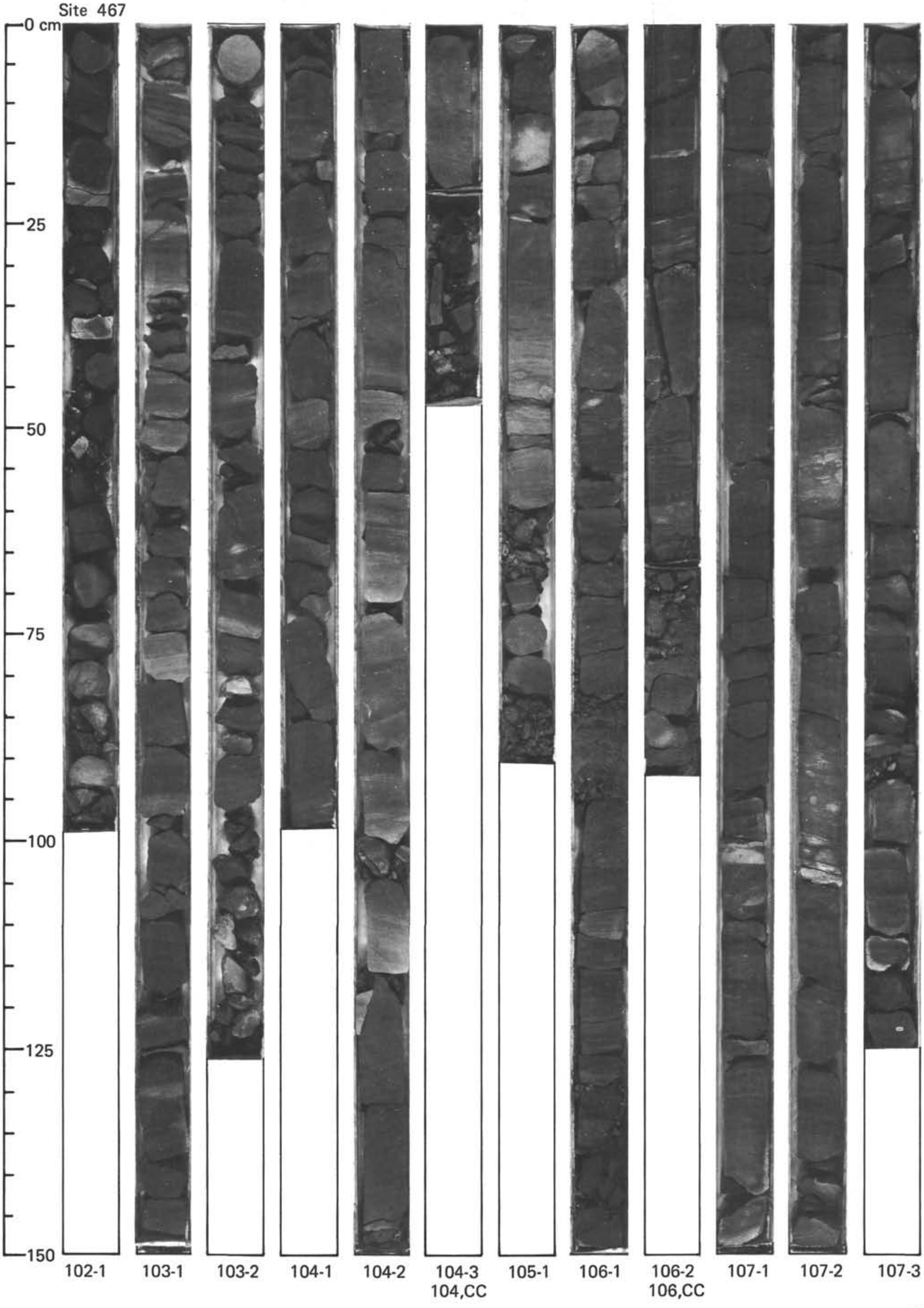
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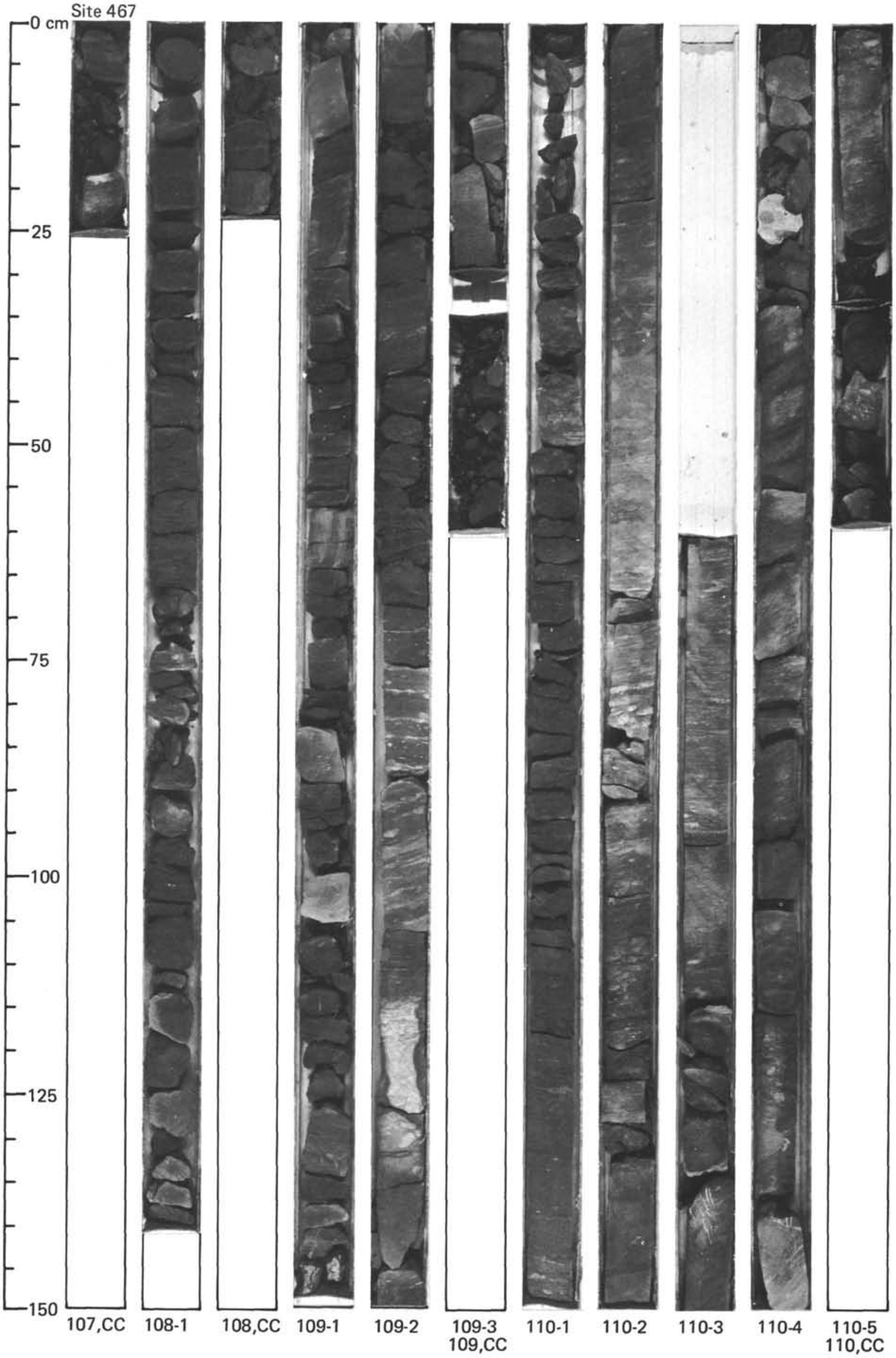
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