3. SITE 468: PATTON ESCARPMENT[1]

Shipboard Scientific Party[2]

HOLES 468, 468A, 468B

Date occupied: 22 October 1978 (468); 23 October 1978 (468A); 24 October 1978 (468B)

Date departed: 23 October 1978 (468); 24 October 1978 (468A); 26 October 1978 (468B)

Position: 32°37.03′N, 120°07.07′W (468); 32°37.41′N, 120°06.55′W (468A, 468B)

Water depth (sea level; corrected m, echo-sounding): 1849 (468); 1737 (468A, 468B)

Bottom felt (m, drill pipe): 1849 (468); 1752 (468A, 468B)

Penetration (m): 241.0 (468); 35.5 (468A); 415.5 (468B)

Number of cores: 26 (468); 4 (468A); 37 (468B)

Total length of cored section (m): 241.0 (468); 35.5 (468A); 351.5 (468B)

Total core recovered (m): 83.74 (468); 27.69 (468A); 104.58 (468B)

Core recovery (%): 35 (468); 78 (468A); 30 (468B)

Oldest sediment cored:

Depth sub-bottom (m): 241.0 (468); 35.5 (468A); 415.5 (468B)

Nature: Claystone (468); foraminifer-nannofossil ooze (468A); dolomitic claystone (468B)

Chronostratigraphy: Middle Miocene (468, 468B); upper Miocene (468A).

Basement: Not reached

Principal results: Hole 468 on the Patton Escarpment was cored continuously to 241 meters and abandoned because of sloughing of middle Miocene volcanogenic sand and breccia into the hole. Hole 468A was spudded 1.2 km upslope, where the post-Miocene section is thicker and the volcanic sand thin or absent. Because of a parted sand line, the hole was re-spudded as Hole 468B and cored to 415.5 meters. Unit 1 is Quaternary olive gray glauconitic nannofossil-foraminifer ooze; it is 19 cm thick in Hole 468 and about 7 meters thick in Hole 468A. Unit 2 comprises nannofossil-foraminifer ooze, foraminifer-nannofossil ooze, and glauconitic silty sand deposited from the late Miocene to the late Pliocene. This unit extends from 19 cm to 4.1 meters in Hole 468 and from 7 to 35.5 meters in Holes 468A and B. Sediment accumulation rates for Units 1 and 2 are 6.5 m/m.y. in Holes 468A and B. A hiatus separates Units 2 and 3; it spans an interval of 0.4 m.y. to 4 m.y. and occurred between 6 and 10 m.y. ago. Unit 3 extends from 4.1 to 108 meters in Hole 468 and 35.5 to 149.5 meters in Hole 468B. It consists of interbedded nannofossil ooze and diatomaceous nannofossil ooze with terrigenous components (sand, silt, and clay) increasing downsection. The top of Unit 3 is marked by a sharp drop in abundance of foraminifers and glauconite; volcanic ash occurs near the base of the unit. Deposited from 10 to 14.5 m.y. ago, this unit shows a sharp increase in sedimentation rate at 45 meters (13 m.y. ago)—from 4 to 5 m/m.y. downsection to 60 m/m.y. Unit 4 is divided into Sub-unit 4a (108–184 m in Hole 468; 159–235 m in Hole 468B), which contains middle Miocene fossils as old as 16.5 m.y. with sedimentation rates of 60 m/m.y., and Sub-unit 4b, which is unfossiliferous except near the top, where it contains a faunule similar to overlying strata. Sub-unit 4a consists of diatomaceous, calcareous, sandy claystone with less common silty claystone, sandstone, ash, and pumiceous lapilli tuff. The boundary with Sub-unit 4b marks a sharp change in velocity (from 1.6–2.0 km/s to 2.2–5 km/s) and in density (from 1.6–1.8 g/cm^3 to 1.7–2.4 g/cm^3). Sub-unit 4b is well indurated, dolomitic, silty claystone alternating with andesite and dacite breccia, pumiceous lapilli tuff, and volcanogenic sandstone. Although unfossiliferous, the basal part of Sub-unit 4b is gradational into middle Miocene strata; the inferred underlying subduction complex was not reached. The presence of relatively well-preserved siliceous microfossils in the middle Miocene at Site 468 argues that a diagenetic effect was the reason for their absence in the upper Miocene at this site.

BACKGROUND AND OBJECTIVES

Paleoenvironmental objectives of Site 468 (Fig. 1) on the Patton Escarpment were similar to those at Site 467, i.e., to find clues to the late Cenozoic oceanographic–climatic history of the region by examining the associated oscillations in the biogeographic patterns of planktonic communities. We planned to core continuously some 600 meters of what we anticipated would be middle Miocene to Holocene sediments that unconformably overlie possibly off-scraped trench deposits. We expected that the nature of the sediments we would encounter would be similar to those cored at Site 467. Because of the shallow water depth at Site 468 (about 1850 meters), we expected to find well preserved calcareous and siliceous plankton assemblages. In spite of the shallow depth (2145 m) at Site 467, the upper and middle Miocene sediments at this site contained no siliceous microfossils and scarce or no planktonic foraminifers. Although the presence of opal-CT (cristobalite) in these sediments suggests some loss of biogenic silica owing to postdepositional remobilization, the low amount of planktonic foraminifers may be an indication of low productivity in the region, perhaps associated with the distal portion of the California Current during this time. We anticipated that the more southerly position of Site 468 and its proximity to Site 467 would enable us to compare and test these interpretations.

South of San Miguel Gap, the southeast-trending Patton Escarpment forms a west-facing slope 2.5 to 3.5

---

[1] *Initial Reports of the Deep Sea Drilling Project*, Volume 63.

[2] Robert S. Yeats (Co-Chief Scientist), Department of Geology, Oregon State University, Corvallis, Oregon; Bilal U. Haq (Co-Chief Scientist), Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; John A. Barron, U.S. Geological Survey, Menlo Park, California; David Bukry, U.S. Geological Survey, La Jolla, California; James K. Crouch, U.S. Geological Survey, Menlo Park, California (present address: Sohio Petroleum Co., San Francisco, California); Charles Denham, Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; A. G. Douglas, Department of Geology, The University, Newcastle-upon-Tyne, United Kingdom; Vladimir I. Grechin, Geological Institute of the Academy of Sciences of the U.S.S.R., Moscow, U.S.S.R.; Margaret Leinen, Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island; Alan R. Niem, Department of Geology, Oregon State University, Corvallis, Oregon; Surendra Pal, Instituto de Geofísica, Universidad Nacional Autónoma de Mexico, Mexico 20, D.F.; Kenneth A. Pisciotto, Deep Sea Drilling Project, Scripps Institution of Oceanography, La Jolla, California; Richard Z. Poore, U.S. Geological Survey, Menlo Park, California; Tsugio Shibata, Department of Earth Sciences, Okayama University, Tsushima, Okayama, Japan; and Reinhard Wolfart, Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Federal Republic of Germany.

km high that separates the California Continental Borderland from oceanic crust of the Pacific plate. The escarpment is the western boundary of the broad Patton Ridge, which is thought to be underlain by Mesozoic and lower Cenozoic(?) accretionary-wedge deposits. This acoustic basement unit is overlain by folded and faulted marine strata deposited in the late Oligocene(?) through the late Miocene, together with apparently Miocene volcanic rocks. East of the Patton Ridge are small silled basins with upper Miocene, Pliocene and Quaternary sediments, which overlie older strata with angular unconformity.

At about 32°40′N latitude, the Patton Escarpment is interrupted by an elongate shallow trough that opens westward toward the Pacific (Fig. 2). This trough is underlain by Pliocene and Quaternary deposits, and the position of its axis does not correspond to the location of the thicker section in the underlying Miocene. At Site 468, located on the north side of this trough, we expected to penetrate a thin, postmiddle Miocene sequence, a moderately thick (~ 450 m) middle Miocene-lower Miocene sequence, and the underlying accretionary-wedge complex that is acoustic basement (Fig. 3). Arkosic sandstones possibly deposited during the late Oligocene have been sampled farther north on Patton Ridge (Crouch, 1979a); these may be the oldest deposits above the accretionary-wedge basement. Stacking velocities and sonobuoy velocities are 3.9 to 4.8 km/s in the acoustic basement and 1.78 to 2.0 km/s in the sedimentary section.

The accretionary-wedge basement could provide evidence of the convergent margin between the American and Farallon plates. Elsewhere in the borderland, the blueschist-facies Catalina Schist is not known to be younger than Cretaceous; it is analogous to the Franciscan complex of central and northern California. Plate-tectonics theory, however, indicates that the California Borderland was a converging plate boundary into the early Tertiary, possibly as late as the Oligocene.

Fossil evidence indicates that laumontite-bearing Franciscan along the California coast north of San Francisco is as young as Eocene; laumontite-bearing sandstones on the Patton Ridge are as yet undated. Again, arkosic sandstones deposited during the late Oligocene(?) are possibly the oldest beds to overlie the accretionary-wedge complex. If these were discovered at Site 468 and if the underlying complex could be dated as Tertiary, we could determine when subduction ceased at this site.

The Oligocene(?) sequence is overlain with angular unconformity by lower, middle, and upper Miocene siltstone and claystone containing coccoliths and foraminifers. There may be an angular unconformity between the middle and upper Miocene, but the lower and middle Miocene sequence is apparently conformable.

The upper Miocene and older strata are folded, then overlain unconformably by Pliocene and Quaternary

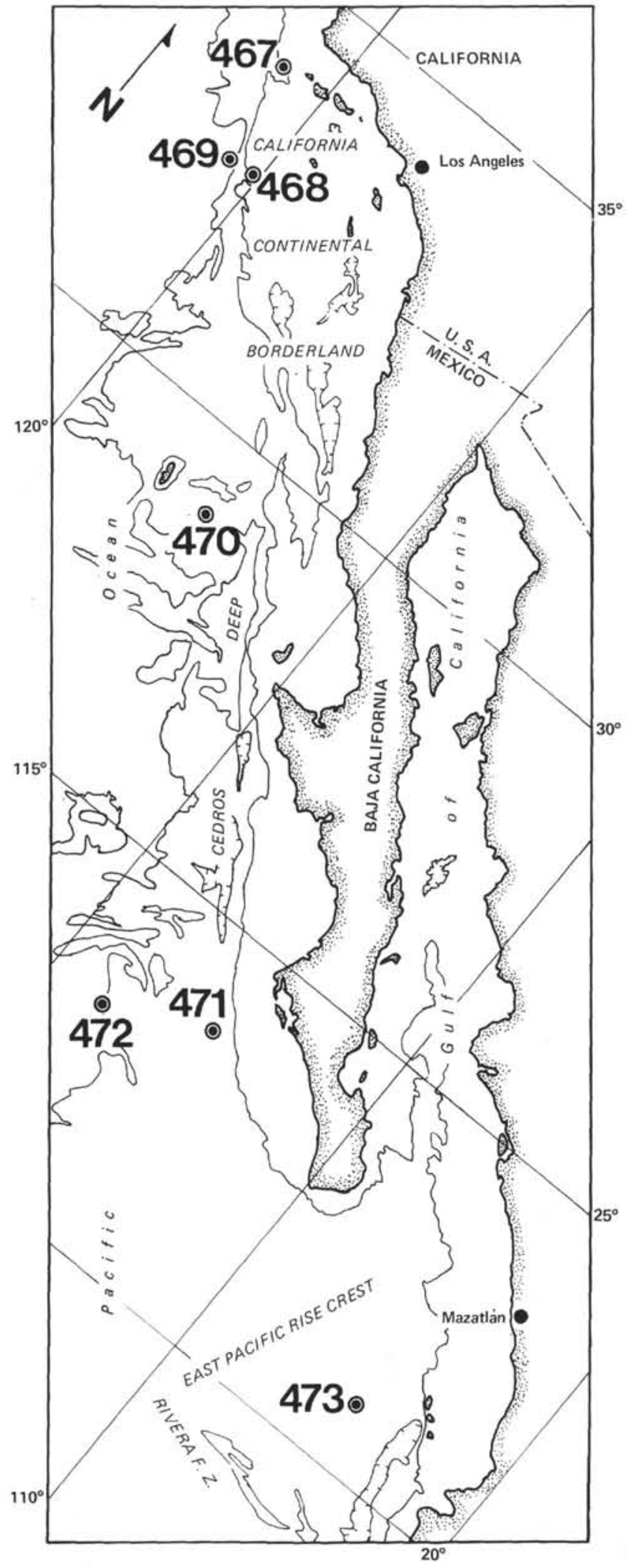


Figure 1. Site location map for Leg 63.

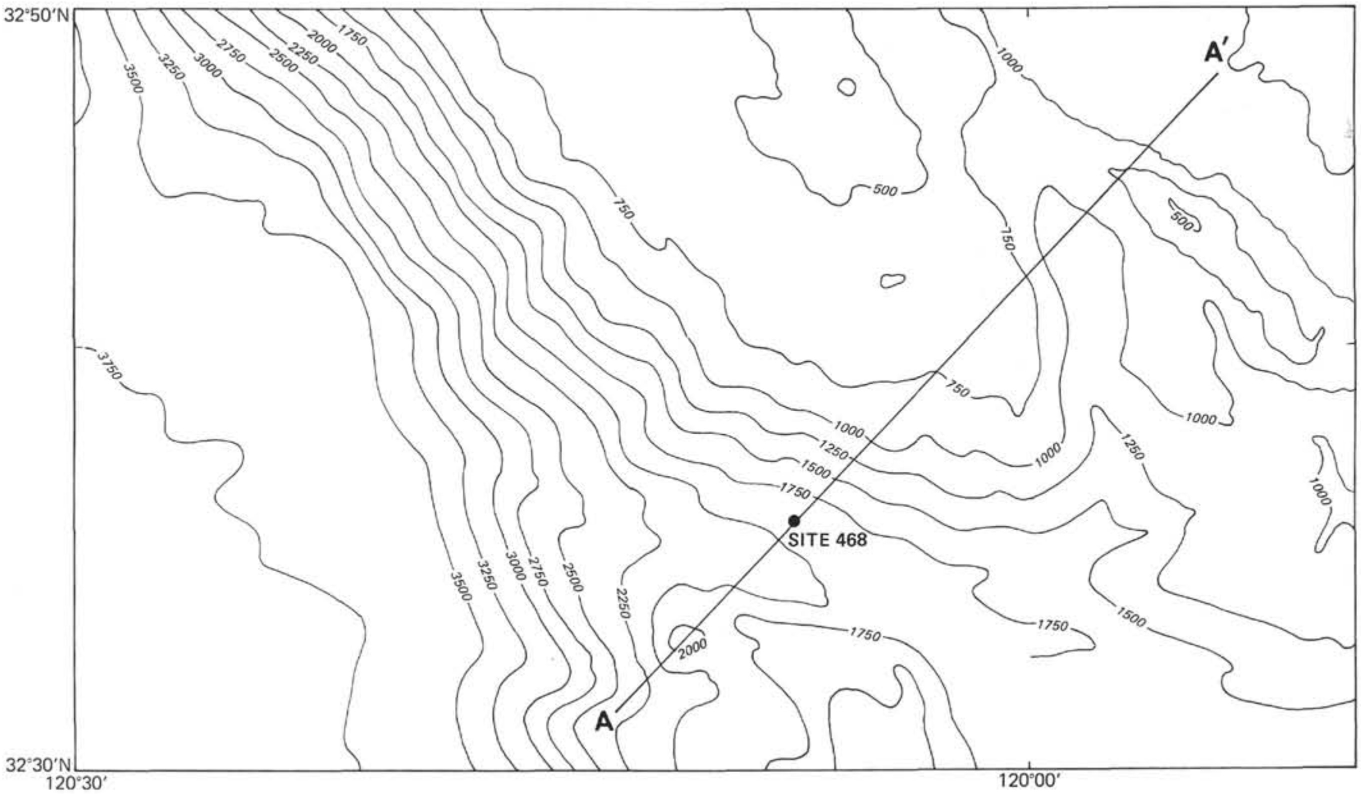


Figure 2. Bathymetric map of the Patton Ridge showing the location of Site 468. (Line AA′ marks the position of a multichannel seismic profile from the *S. P. Lee* shown in Fig. 3.)

sediments, which slope gently seaward. These sediments should be above the carbonate compensation depth (CCD), permitting good preservation of a calcareous fauna.

Site 468 will be compared with Site 469, located at the foot of the Patton Escarpment to the west. Plate tectonic reconstruction of the transform motion between the Pacific and American plates requires much more strike-slip motion than could have been accommodated in the San Andreas system. Possibly some of this early motion was accommodated on a strike-slip fault at the base of the Patton Escarpment that later became inactive. If so, Site 469 should show evidence of sediment accumulation far south of Site 468, even though the sites are now at the same latitude.

OPERATIONS

After spending just over two days at Long Beach for repairs to the gearbox of the bow thruster, the *Glomar Challenger* left port on 20 October at 2210 hours.[3] Half an hour outside the port, the repaired thruster and the positioning systems of the ship were tested. With the profiling gear out, we sailed in the general direction of San Clemente Island. Abeam the island at 0450 hours on 21 October, we headed at 250° (and later at 254°) towards the proposed Site 468 at 9.2 knots. While steaming toward the site, we encountered rough seas with gale-force winds. The winds subsided in the late afternoon of 21 October. We surveyed the area of the site across a single-channel *E. B. Scripps* line (Crouch et al., 1978), turned around beyond the site area at 1740 hours, and dropped a 13.5-kHz beacon at 1827 hours at 32°37.03′N and 120°07.07′W. After retrieving the profiling gear beyond the drop point, the ship turned around and positioned over the beacon at 2045 hours using the 3.5-kHz sub-bottom recorder. The next four hours were spent in troubleshooting and repairing problems in the motor control circuits of the number one drawworks. When the drill string was lowered and ready to spud, the positioning beacon failed, and a second (16-kHz) beacon had to be dropped. The ship was finally positioned over the new beacon at 1030 hours on 22 October. After two initial water cores, the hole was spudded at 1214 hours in 1849 meters of water.

The coring operations at Hole 468 were routine. The recovery was relatively high in the first nine cores, but it decreased downcore and, with the exception of Core 18, remained low to total depth (Table 1). Below a depth of 200 meters, torquing and sticking of pipe became progressively more acute, apparently owing to sloughing of sand and volcanic fragments, so that at 1330 hours on 23 October we were forced to stop drilling after Core 26 at 241 meters depth. We decided to re-spud upslope where a better section could be obtained. After plugging Hole 468 with 100 barrels of weighted mud, we moved 1.2 km upslope and, using the old beacon of Hole 468

---

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

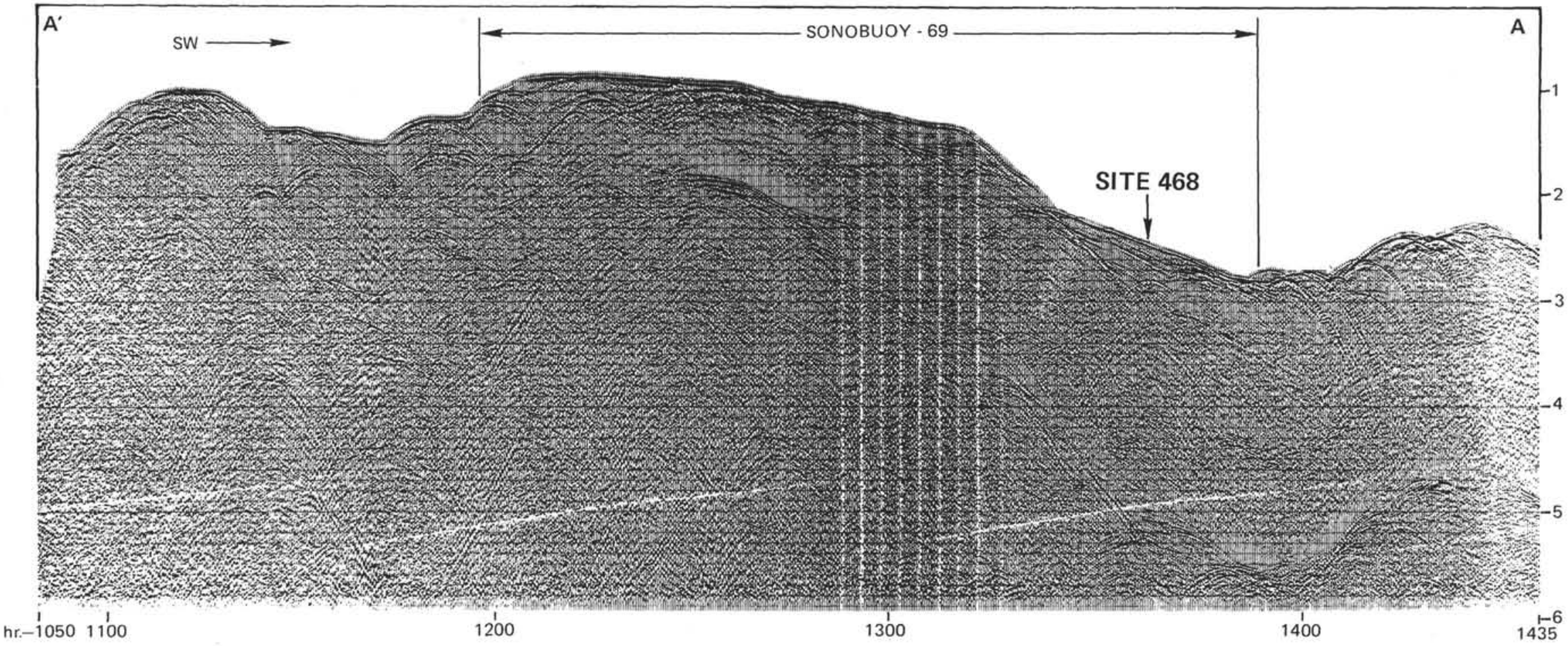


Figure 3. Multichannel seismic profile A′A from the *S.P. Lee* at Site 468 (location of profile on Fig. 2).

Table 1. Coring summary, Site 468.

Core No.	Date (Oct., 1978)	Time	Depth from Drill Floor (m)	Depth below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Core Recovered (%)
Hole 468							
1	22	1236	1859.0–1862.5	0.0–3.5	3.5	2.55	73
2	22	1330	1862.5–1872.0	3.5–13.0	9.5	5.74	60
3	22	1416	1872.0–1881.5	13.0–22.5	9.5	8.03	85
4	22	1515	1881.5–1891.0	22.5–32.0	9.5	7.17	75
5	22	1605	1891.0–1900.5	32.0–41.5	9.5	7.40	78
6	22	1700	1900.5–1910.0	41.5–51.0	9.5	9.18	97
7	22	1805	1910.0–1919.5	51.0–60.5	9.5	9.58	100±
8	22	1923	1919.5–1929.0	60.5–70.0	9.5	3.65	38
9	22	2020	1929.0–1938.5	70.0–79.5	9.5	8.91	94
10	22	2120	1938.5–1948.0	79.5–89.0	9.5	7.20	76
11	22	2215	1948.0–1957.5	89.0–98.5	9.5	2.66	28
12	22	2315	1957.5–1967.0	98.5–108.0	9.5	0.15	2
13	23	0005	1967.0–1976.5	108.0–117.5	9.5	1.20	13
14	23	0115	1976.5–1986.0	117.5–127.0	9.5	0.03	0.3
15	23	0200	1986.0–1995.5	127.0–136.5	9.5	0.12	1
16	23	0250	1995.5–2005.0	136.5–146.0	9.5	0.04	0.4
17	23	0343	2005.0–2014.5	146.0–155.5	9.5	0.22	2
18	23	0444	2014.5–2024.0	155.5–165.0	9.5	7.04	74
19	23	0541	2024.0–2033.5	165.0–174.5	9.5	0.19	2
20	23	0645	2033.5–2043.0	174.5–184.0	9.5	0.20	2
21	23	0745	2043.0–2052.5	184.0–193.5	9.5	1.15	12
22	23	0841	2052.5–2062.0	193.5–203.0	9.5	0.30	3
23	23	0946	2062.0–2071.5	203.0–212.5	9.5	0.47	5
24	23	1054	2071.5–2081.0	212.5–222.0	9.5	0.25	3
25	23	1145	2081.0–2090.5	222.0–231.5	9.5	0.25	3
26	23	1327	2090.5–2100.0	231.5–241.0	9.5	0.06	1
Total					241.0	83.74	35
Hole 468A							
1	23	2122	1752.0–1759.0	0.0–7.0	7.0	6.69	96
2	23	2206	1759.0–1768.5	7.0–16.5	9.5	7.17	75
3	23	2248	1768.5–1778.0	16.5–26.0	9.5	6.35	67
4	24	0900	1778.0–1787.5	26.0–35.5	9.5	7.48	80
Total					35.5	27.69	78
Hole 468B							
1	24	1551	1768.5–1778.0	16.5–26.0	9.5	6.97	73
2	24	1646	1778.0–1787.5	26.0–35.5	9.5	2.14	23
3	24	1743	1787.5–1797.0	35.5–45.0	9.5	7.14	75
4	24	1849	1797.0–1806.5	45.0–54.5	9.5	2.74	29
5	24	1939	1806.5–1816.0	54.5–64.0	9.5	Trace	0
6	24	2031	1816.0–1825.5	64.0–73.5	9.5	7.51	79
7	24	2116	1825.5–1835.0	73.5–83.0	9.5	Trace	0
8	24	2226	1835.0–1844.5	83.0–92.5	9.5	5.48	58
9	24	2321	1844.5–1854.0	92.5–102.0	9.5	5.97	63
10	25	0032	1854.0–1863.5	102.0–111.5	9.5	2.62	28
11	25	0145	1873.0–1882.5	121.0–130.5	9.5	0.14	1
12	25	0240	1892.0–1901.5	140.0–149.5	9.5	3.76	40
13	25	0337	1911.0–1920.5	159.0–168.5	9.5	7.18	76
14	25	0435	1930.0–1939.5	178.0–187.5	9.5	6.94	73
15	25	0540	1949.0–1958.5	197.0–206.5	9.5	2.05	22
16	25	0635	1958.5–1968.0	206.5–216.0	9.5	0.80	8
17	25	0740	1968.0–1977.5	216.0–225.5	9.5	6.57	69
18	25	0830	1977.5–1987.0	225.5–235.0	9.5	3.10	33
19	25	0927	1987.0–1996.5	235.0–244.5	9.5	0.26	3
20	25	1045	1996.5–2006.0	244.5–254.0	9.5	0.13	1
21	25	1145	2006.0–2015.5	254.0–263.5	9.5	4.37	46
22	25	1254	2015.5–2025.0	263.5–273.0	9.5	1.00	11
23	25	1402	2025.0–2034.5	273.0–282.5	9.5	0.30	3
24	25	1502	2034.5–2044.0	282.5–292.0	9.5	0.30	3
25	25	1612	2044.0–2053.5	292.0–301.5	9.5	3.42	36
26	25	1740	2053.5–2063.0	301.5–311.0	9.5	1.44	15
27	25	1853	2063.0–2072.5	311.0–320.5	9.5	3.60	38
28	25	2002	2072.5–2082.0	320.5–330.0	9.5	1.72	18
29	25	2127	2082.0–2091.5	330.0–339.5	9.5	0.93	10
30	25	2230	2091.5–2101.0	339.5–349.0	9.5	1.17	12
31	25	2355	2101.0–2110.5	349.0–358.5	9.5	2.21	23
32	26	0130	2110.5–2120.0	358.5–368.0	9.5	1.75	18
33	26	0257	2120.0–2129.5	368.0–377.5	9.5	2.51	26
34	26	0407	2129.5–2139.0	377.5–387.0	9.5	1.18	12
35	26	0530	2139.0–2148.5	387.0–396.5	9.5	2.33	25
36	26	0650	2148.5–2158.0	396.5–406.0	9.5	2.25	24
37	26	0755	2158.0–2167.5	406.0–415.5	9.5	2.60	27
Total					351.5	104.58	30

and the 3.5-kHz recorder, located Hole 468A at 32° 37.41′N and 120°06.55′W in 1752 meters of water. At 2330 hours on 23 October, shortly after spudding (after Core 4), the sand line broke. When the broken line was fished and the sand line restrung, it broke again, requiring a round trip to recover the sand line and Core 4 at 0900 hours on 24 October. Hole 468B was spudded on that same day at 1445 hours in 1752 meters of water. The upper 16.5 meters were washed, and the first core was taken between 1768.5 and 1778.0 meters depth. The upper ten cores were continuously cored to a depth of 111.5 meters. Below this depth through 197.0 meters, cores were taken only at alternate 9.5 meters because of the repeated section already recovered at Hole 468. Below 197.0 meters to total depth (T.D.) at 415.5 meters, coring was continuous. The sloughing problems of Hole 468 were avoided in Hole 468B, possibly due to the addition of mud in the hole. The recovery at Hole 468B was generally good in the upper 18 cores and moderate to poor in Cores 19 through 37. Minor amounts of H_2S were encountered in a few levels in Hole 468B (Cores 3, 4, and 5–12). Hydrocarbon gases were not encountered.

The coring operations stopped at 0800 hours on 26 October. The bit was released, and the hole was readied for Sonic, Caliper, and Temperature Logs. Attempts at logging, however, proved futile because of problems with the logging tools and the computer. When the time allocated for logging was spent, we decided to pull out of the hole. This was accomplished by 2115 hours, and, after a short postsite run over the beacon, we were under way to Site 469 by 2130 hours on 26 October.

LITHOLOGY

Hemipelagic, terrigenous, and volcanogenic sediments and sedimentary rock were recovered at Site 468. Foraminiferal–nannofossil ooze, nannofossil ooze, and diatom–nannofossil ooze dominate the upper part of the section. Dolomitic silty claystone and interbedded volcaniclastic rock are the main constituents of the lower part of the section. On the basis of the composite section of Holes 468, 468A, and 468B, we recognized four lithologic units at Site 468 (Table 2; Figs. 4 and 5).

Unit 1: Foraminiferal Ooze (Hole 468: 0–0.19 m; Hole 468A: 0–7 m)

This unit consists mainly of olive gray glauconitic nannofossil–foraminiferal ooze and silty ooze. Benthic and planktonic foraminifers are the predominant components (up to 50%), with approximately 20% nannofossils (chiefly coccoliths) and 15% subangular quartz and feldspar also present. Fine-grained green to greenish black glauconite composes about 10% to 12% of the sediment. Some grains are pseudomorphs of foraminifer tests. Radiolarians, some pseudomorphed by pyrite, and sponge spicules are also present (<10%). Minor components include grayish olive foraminiferal sandy silt and carbonized wood fragments.

The Unit 1/Unit 2 boundary in Hole 468 is marked by a sharp lithologic change between olive gray glauconitic foraminiferal ooze and the underlying, yellowish gray foraminiferal–nannofossil and nannofossil–foraminiferal ooze. In Hole 468A, this boundary has been obscured by drilling disturbance but is generally recognized by a decrease in the abundance of glauconite.

Table 2. Summary of lithologic units, Site 468.

Unit or Sub-unit	Hole	Core	Depth below Sea Floor (m)	Chronostratigraphy	Lithology
1	468	1	0.0–0.19	Quaternary	Glauconitic nannofossil–foraminifer ooze and silty ooze.
	468A	1	0.0–7.0	Quaternary	
2	468	1–2	0.19–4.1	Pliocene	Foraminifer–nannofossil ooze and nannofossil–foraminiferal ooze.
	468A	2–4	7.0–35.5	Pliocene to upper Miocene	
	468B	1–2	16.5–35.5	upper Miocene	
3	468	2–12	4.1–108.0	Pliocene to middle Miocene	Interbedded nannofossil ooze and diatom–nannofossil ooze with intervals of detrital sand, silt, and clay that become dominant in the lower portion of the unit.
	468B	3–12	35.5–149.5	upper Miocene to middle Miocene	
4a	468	13–20	108.0–184.0	middle Miocene	Diatomaceous and calcareous silty to sandy claystone with minor interbeds of volcaniclastic sandstone and rare ash.
	468B	13–18	159.0–235.0		
4b	468	21–26	184.0–241.0	middle Miocene	Dolomitic silty claystone with common interbeds of volcaniclastic sandstone and breccia.
	468B	18–37	235.0–415.5		

Unit 2: Nannofossil and Foraminiferal Ooze (Hole 468: 0.19–4.1 m; Hole 468A: 7.0–35.5 m; Hole 468B: 16.5–35.5 m)

Soft, interbedded, pale olive foraminiferal–nannofossil ooze and olive brown nannofossil–foraminiferal ooze are the dominant sediment types in Unit 2. Thin intervals of glauconitic silty sand and sandy clay are also present; glauconite makes up as much as 30% of this sediment. Several angular pebbles of greenish black glauconite and grayish black phosphorite(?) also occur in Unit 2.

Unit 3: Nannofossil Ooze and Diatom–Nannofossil Ooze (Hole 468: 4.1–108 m; Hole 468B: 35.5–149.5 m)

This unit is distinguished from Unit 2 by its finer texture, darker color, and fewer intervals of glauconitic foraminiferal silty sand and sandy clay. Interbedded, pale olive nannofossil ooze and olive brown diatom–nannofossil ooze make up the bulk of this unit. The sediment is commonly mottled, indicating various degrees of bioturbation. Thin lenses and patches of greenish black, glauconitic sand and sandy silt are scattered throughout Unit 3. Sponge spicules, which reach concentrations of 10% or more, are also an important component of the sediment.

Terrigenous components (clay, silt, and minor sand) increase downsection in Unit 3. In Hole 468, clay minerals (33%) and quartz and feldspar (7–15%) are the dominant constituents of the lower 30 meters.

In Hole 468, two layers of volcanic ash occur in Unit 3 (Cores 9 and 12). The upper ash layer is 4 cm thick, and the lower ash layer is about 25 cm thick. A smear slide of the ash from Core 12 contains 50% quartz and feldspar, 20% pumice, 10% volcanic rock fragments, 5% volcanic glass, and minor (<5%) clay and carbonate. Two sub-angular andesite(?) pebbles were also

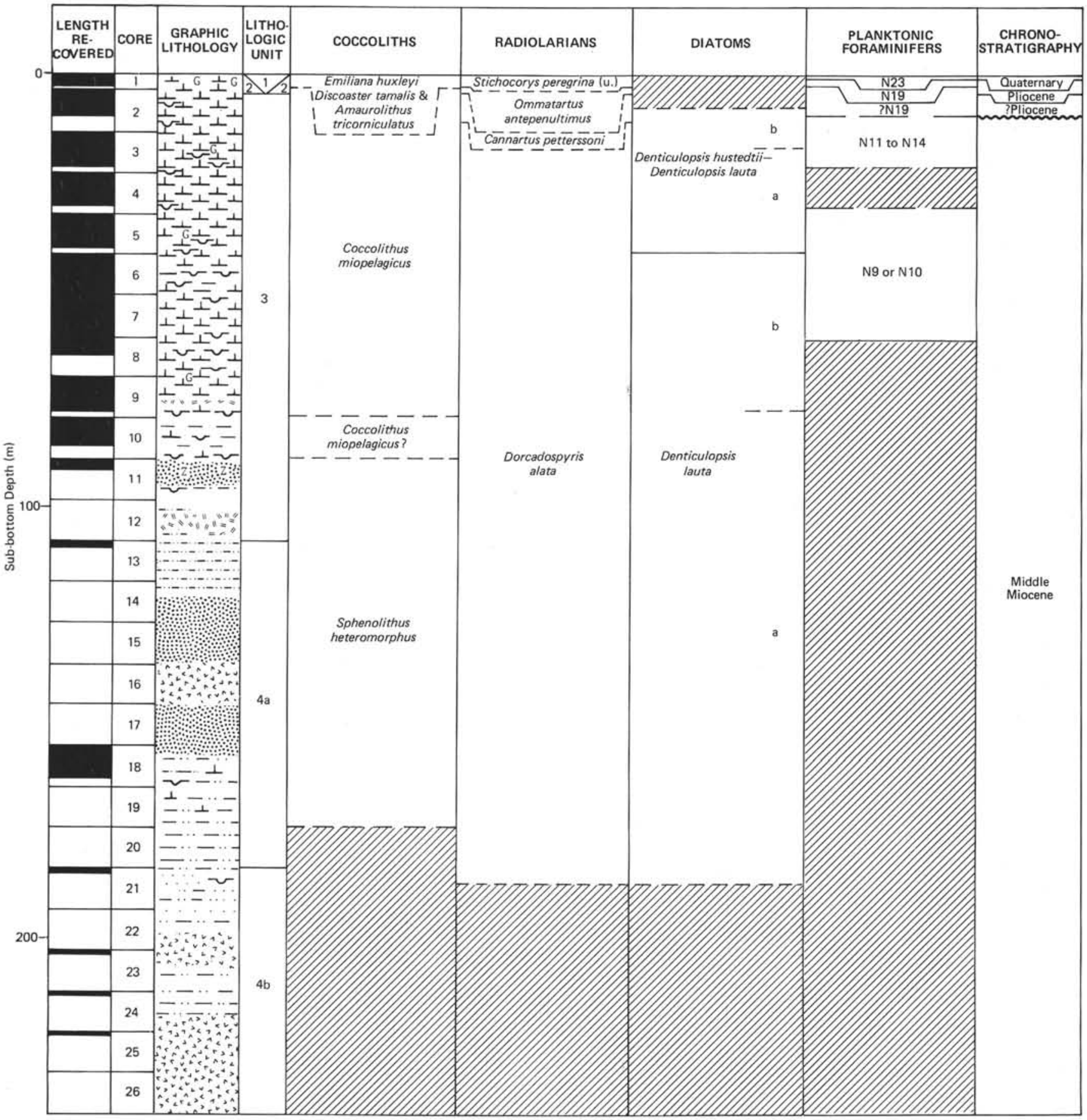


Figure 4. Stratigraphic and lithologic summary, Hole 468.

recovered in siliceous nannofossil ooze in Hole 468B (Core 10); their occurrence within the ooze suggests that they are probably rafted erratics.

Unit 4: Claystone and Volcaniclastic Rock (Hole 468: 108–241 m; Hole 468B: 159–415.5 m)

Unit 4 is distinguished from Unit 3 on the basis of a change in induration (from firm to moderately well indurated) and by a conspicuous decrease in diatoms, radiolarians, and nannofossils. Unit 4 is divided into two parts. Sub-unit 4a is moderately well indurated and contains common to abundant diatoms and coccoliths. In contrast, Sub-unit 4b is well indurated and consists chiefly of dolomitic silty claystone. The boundary between Subunits 4a and 4b corresponds closely to the disappearance of microfossils in the section and to a sharp increase in velocity from about 1.7 km/s to about 3.4 km/s.

In terms of both lithology and induration, Sub-unit 4a (Hole 468: 108–184 m; Hole 468B: 159–235 m) is

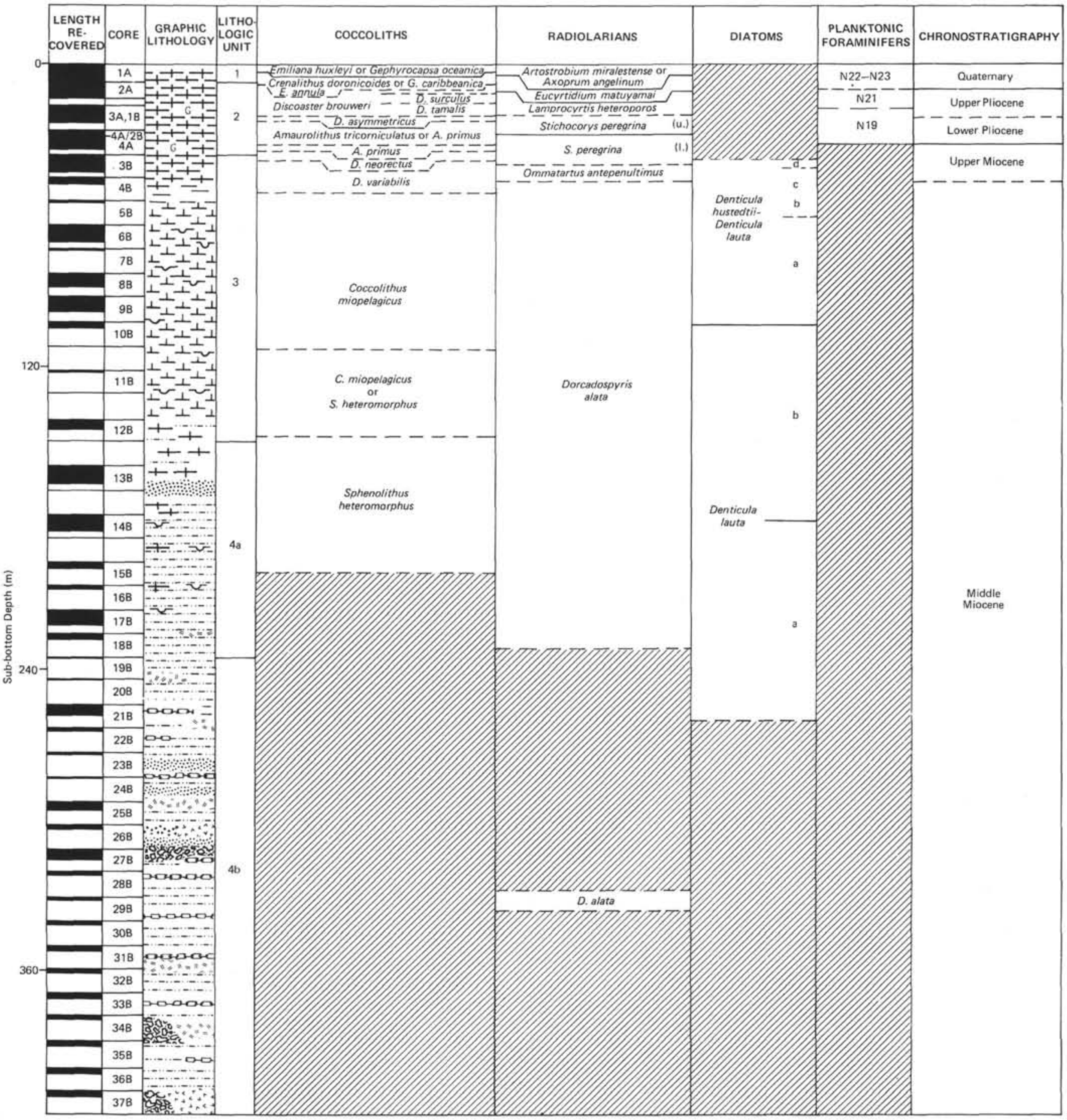


Figure 5. Lithologic and biostratigraphic summary, Holes 468A and 468B.

transitional between Unit 3 and Sub-unit 4b. Moderately well-indurated diatomaceous and nannofossil silty to sandy claystone, subordinate interbeds of volcaniclastic sandstone, and vitric ash characterize this unit. The claystone is olive gray to olive black, and the volcaniclastic rocks are gray. Silt- and sand-size grains are predominantly angular to sub-angular quartz (5–40%) and feldspar (3–10%) but also include minor amounts (<3%) of pyroxene, hornblende, and epidote. Volcanic glass and rock fragments (10–20%) and clay minerals 30–60%) are also important constituents. Rare patches of glauconitic foraminiferal silt and sand are also present. Mottling caused by bioturbation is common throughout Sub-unit 4a, and burrows are commonly filled with glauconitic sand.

Sub-unit 4b (Hole 468: 184–214 m; Hole 468B: 235–415.5 m) consists of well indurated, olive black, dolomitic silty claystone and interbedded volcaniclastic rock. The volcaniclastic rock is breccia composed of vesicular basaltic and andesitic rock fragments and tuffaceous and volcaniclastic sandstone. The dolomitic silty claystone appears to be the dominant lithotype, but poor core recovery, especially in the volcaniclastic sequences, makes determination of the relative abundances of these two lithotypes difficult. The dolomitic silty claystone is both laminated and lenticularly bedded. It commonly contains well preserved burrows, many filled with tuffaceous sandstone. Some slumped beds were also noted.

Thin-section study indicates that interbeds of silty dolomite are also present in the claystone sequences. Dolomite (50-60%) is the major constituent of these interbeds, followed by clay (5-20%), angular quartz (8-15%), and feldspar (5-8%); minor components (<4%) include glauconite, opaque heavy minerals (including pyrite), and some laminae composed of sand-size volcanic rock fragments and brown volcanic glass. Scattered silt-size angular quartz and feldspar occur in a matrix of dolomite and clay along with chalcedony- and opal-CT(cristobalite)-filled molds of diatoms, radiolarians, foraminifers, and sponge spicules.

A wide variety of interbedded basaltic to andesitic volcaniclastic rocks (including breccias, pyroclastics, and tuffaceous to volcaniclastic sandstone) was recovered in Sub-unit 4b. Usually only basaltic to andesitic pebble- to cobble-size rock fragments represent the breccia beds. However, a breccia bed 32 cm thick was recovered in Hole 468B (Core 27) that consisted of pebble-size aphanitic, vesicular basaltic, and andesitic rock fragments in a matrix of quartz, feldspar, and rare pumice fragments. A similar matrix probably supported the volcanic rock fragments in other cores but was washed away during drilling.

The volcanic sandstone is medium- to coarse-grained, compositionally immature, and usually moderately well sorted. Partly altered pumice and subrounded to well-rounded volcanic rock fragments make up 30% to 40% of the rock. Other constituents include quartz, plagioclase feldspar, altered glass shards, glauconite, clay, and carbonate cement.

BIOSTRATIGRAPHY

At Site 468 a relatively thin (3.5-40 m) cover of upper Neogene sediment rich in calcareous microfossils overlies a thicker sequence (about 220 m) of mixed calcareous and siliceous middle Miocene sediment. This, in turn, overlies sediment barren of microfossils.

Calcareous nannofossils provide the best stratigraphic control for the upper Neogene, although planktonic foraminifers and radiolarians are also useful. In the middle Miocene, diatoms and calcareous nannofossils allow consistent biostratigraphic interpretation, whereas radiolarians and planktonic foraminifers are more variable in their abundance. In Figure 6, the plots of abundance of the various microfossil groups in Holes 468, 468A, and 468B reveal these relationships.

Figures 4 and 5 summarize zone assignments of the holes drilled at Site 468. Holes 468A and 468B possess a thicker cover (about 40 m) of upper Neogene sediment than is present in Hole 468 (3.5-13 m). Microfossil correlations suggest that horizons within the middle Miocene are 50 to 60 meters lower in Hole 468B than they are in Hole 468. The peak abundance of radiolarians occurs at 15 to 25 meters (Cores 3 and 4) in Hole 468 and at about 70 meters (Core 6) in Hole 468B. The base of the *Denticula hustedtii-D. lauta* Zone is at about 45 meters (between Samples 468-5,CC and 468-6,CC) in Hole 468 and at about 104 meters (between Samples 468B-10-1, 56-58 cm and 468B-10,CC) in Hole 468B. Likewise, the first occurrence upsection of planktonic foraminifers is at about 110 meters (Sample 468-13,CC) in Hole 468 and at about 150 meters (Sample 468B-12,CC) in Hole 468B. The first calcareous nannofossil occurs at about 175 meters (Sample 468-19,CC) in Hole 468 and at about 225 meters (Sample 468B-17,CC) in Hole 468B.

Coccoliths

Warm-water coccoliths characterize the short Pliocene and Quaternary interval at Holes 468, 468A, and 468B. Most of the cores from Site 468 are barren or contain coccoliths from the middle Miocene *Discoaster exilis* Zone or the *Sphenolithus heteromorphus* Zone. Upper Miocene taxa occur in only a few cores, suggesting one or more major hiatuses. The upper Miocene to lower Pliocene assemblage at Hole 468A, Core 4, is notable for the presence of a cool-water biofacies with discoasters dominated by *Discoaster variabilis* Martini and Bramlette and a warm-water biofacies with discoasters dominated by *D. brouweri* Tan, *D. pentaradiatus* Tan, and *D. surculus* Martini and Bramlette. On the basis of *Ceratolithus* in the Pliocene and more common *Discoaster, Discolithina, Helicosphaera,* and *Sphenolithus* in the middle Miocene, Site 468 assemblages appear warmer than those of Site 467. Preservation is generally moderate throughout Site 468; solution is less severe than at Site 467. Overgrowth is minor, occurring only in some middle Miocene coccoliths.

Silicoflagellates

Silicoflagellates are well preserved but sparse at Site 468 and are restricted mainly to the middle Miocene strata. The assemblages associated with the *Discoaster exilis* Zone are characterized by *Distephanus crux* (Ehrenberg), *D. longispinus* (Schulz) s. ampl., and *D. speculum speculum* (Ehrenberg), with sporadic *Corbisema triacantha* (Ehrenberg) and *Dictyocha pulchella* Bukry. In the *Sphenolithus heteromorphus* Zone, *Distephanus crux, Dictyocha fibula* Ehrenberg s. ampl., and *Distephanus speculum hemisphaericus* (Ehrenberg) are typical, with sporadic *Cannopilus depressus* (Ehrenberg) and *Mesocena apiculata curvata* Bukry. In Sample 468B-30,CC, the unique appearances of *Corbisema flexuosa* (Stradner) and *Mesocena apiculata apiculata*

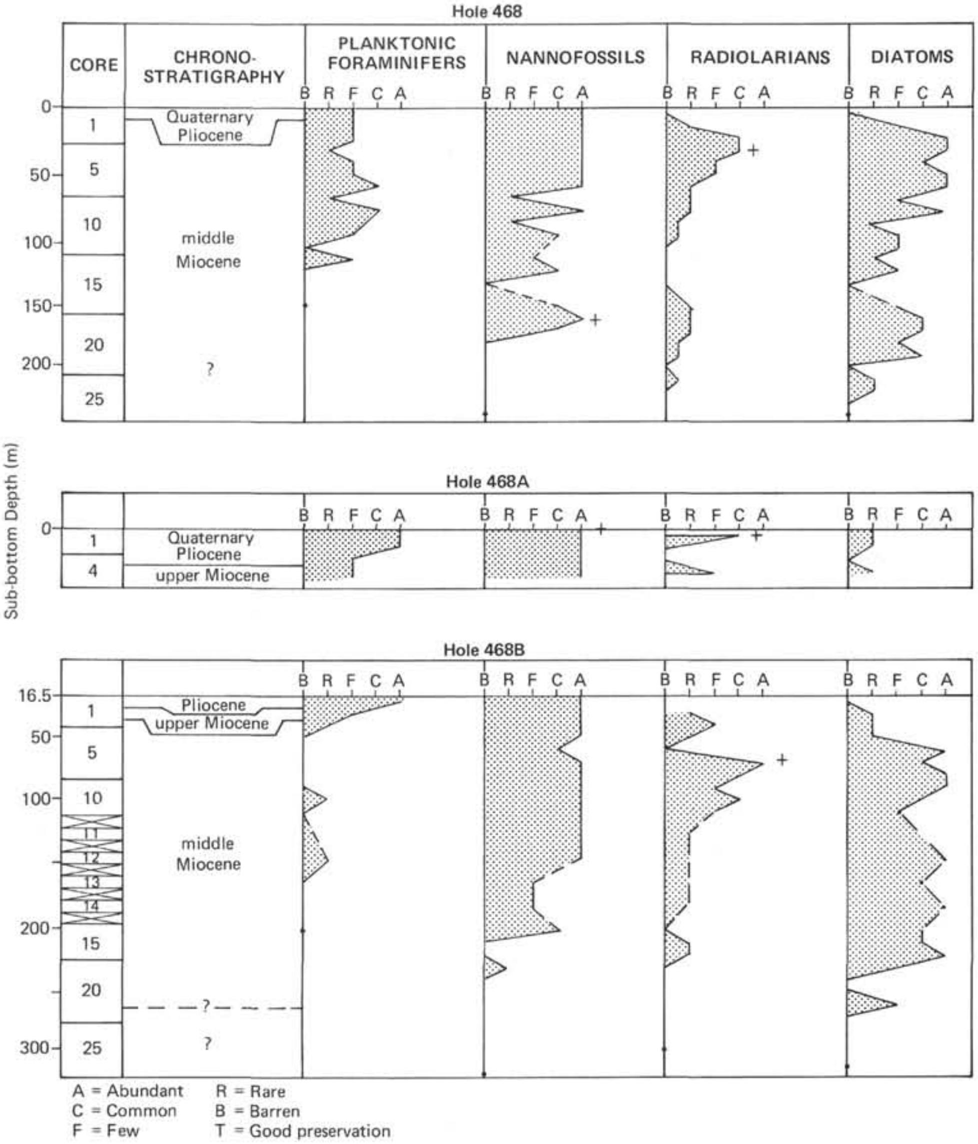


Figure 6. Plots of relative abundances of planktonic microfossils, Site 468.

(Schultz) suggest probable reworking into the lowermost middle Miocene, because the typical range of these species is upper Eocene to lower Miocene.

Radiolarians

The radiolarian abundance in Quaternary, Pliocene, and upper and middle Miocene sediments is generally rare to few and the preservation poor to moderate, except in Sections 2-1 through 3-1 and Sections 4-5 through 5-1 (Hole 468), and in Sections 3-2 through 9-2 (Hole 468B), which contain common to abundant well preserved radiolarians. Cores 1 and 2, Section 1 (Hole 468A) contain a well preserved Pleistocene radiolarian assemblage. Surface sediment in Hole 468A yields no datable radiolarians; neither do Cores 14 through 16 of Hole 468 and Core 5 of Hole 468B. Below Section 18-2 of Hole 468B, no remains of radiolarians are present (except in Sample 468B-29,CC).

The Quaternary sediments of Hole 468A yielded radiolarian assemblages described from the northeastern Pacific, and Kling's (1973) zonation is applicable. Sections 1 and 2 of Core 1 correlate with the upper Pleistocene *Axoprunum angelinum* Zone, as indicated by the presence of *Lamprocyrtis haysi* and the absence of *Eucyrtidium matuyamai*. The assemblages of Sections 1-3 through 2-1, which contain *E. matuyamai* and *Lamprocyrtis heteroporos*, are assigned to the lower Pleistocene *E. matuyamai* Zone. Single specimens of *Amphirhopalum ypsilon* and *Theocorythium vetulum*, which are typical of equatorial regions, are included in the Quaternary assemblages. The upper Pliocene sediments of Samples 468A-2-2, through 468A-2,CC and Samples 468B-1-1 through 468B-1-2, contain *Lamprocyrtis heteroporos* and only nondiagnostic radiolarians and therefore belong to the *L. heteroporos* Zone. The upper boundary of the lower Pliocene/uppermost Miocene *Stichocorys peregrina* Zone is indicated by the extension of *S. peregrina*. The Pliocene/Miocene boundary is marked by the first appearance of *L. heteroporos*. Radiolarian occurrences suggest only a thin capping sequence of Quaternary and Pliocene sediments. In Hole 468A, one or several sedimentation gaps or a very condensed sequence can be assumed between Core 1 and Sample 468A-2,CC.

Below the Quaternary-Pliocene beds, radiolarians restricted to the upper Miocene are rarely represented. Section 2-1 of Hole 468 contains few specimens of *Ommatartus antepenultimus*, which is indicative of lower upper Miocene. Section 4-5 of Hole 468A yielded abundant *Stichocorys peregrina* and is assigned to the uppermost Miocene. Equivalent layers were found in Sample 468B-2,CC through Section 3-4, which are again characterized by few specimens of *S. peregrina* and rare occurrences of *O. antepenultimus*. Only two sections of Hole 468B—Sample 3,CC and Section 4-1—could be placed into the lower upper Miocene *O. antepenultimus* Zone on the basis of the presence of rare to few specimens of *Ommatartus hughesi* and *O. antepenultimus*. It is obvious, then, that a large part of the upper Miocene is not represented by sediments. In Holes 468 and 468B, radiolarian assemblages of the *O. antepenultimus* Zone are identified, and fossils of the upper upper Miocene *Stichocorys peregrina* Zone are present in Holes 468A and 468B. Radiolarian assemblages of the *O. penultimus* Zone could not be recognized in any of the Site 468 holes; radiolarians of the lower *S. peregrina* Zone are lacking in Hole 468, those of the *O. antepenultimus* Zone have not been found in Hole 468A. It is probable, therefore, that the upper Miocene sediments constitute a rather thin, condensed (or incomplete) succession.

Only part of the middle Miocene seems to be well represented by a rather thick succession of sediments, because the radiolarian assemblage of the upper middle Miocene *Cannartus petterssoni* Zone—especially *C. petterssoni* itself—was not encountered in Holes 468A and B. In Hole 468, *C. petterssoni* is only present in Section 2-3, and the lower to middle middle Miocene *Dorcadospyris alata* Zone begins with Section 3-1 and ends possibly with Sample 468-18,CC. In its lower part, the middle Miocene succession is characterized by rare occurrences of *Cannartus mammiferus*, which is progressively replaced by rare to abundant individuals of *Cannartus laticonus* in the upper part. Besides mainly rare occurrences of *Eucyrtidium inflatum* and *Lithopera renzae*, which are assumed to be diagnostic for middle Miocene, various species of *Cyrtocapsella* and *Stichocorys* (except *S. peregrina*) occur rarely to abundantly. The succession below Core 18 in Hole 468 cannot be assigned securely either to the lower middle nor to the upper lower Miocene by means of radiolarians.

Besides rare, sporadic occurrences of *D. alata*, no radiolarians are present that mark precisely the lower boundary of the middle Miocene. On the other hand, mainly lower Miocene species, such as *Calocycletta, C. virginis*, and *Dorcadospyris simplex*, have been found rarely to commonly from Cores 17 through 21 (Hole 468). According to the results of diatom research, Sample 468-21,CC still contains middle Miocene species. The lower Miocene radiolarians are probably reworked.

In the region of Sites 467 and 468, the Quaternary radiolarian assemblages mainly consist of cold-water species. Site 468 differs from Site 467, however, in that some warm-water species (*Amphirhopalum ypsilon, Theocorythium vetulum*) have joined the North Pacific assemblage.

Diatoms

Abundant to rare middle Miocene diatoms were recovered from Holes 468 and 468B at Site 468. Younger sediments in both holes and in Holes 468A contain only rare diatoms that are reworked from the middle Miocene.

Samples 468-2-2, 130–132 cm through 468-3-1, 19–21 cm are assigned to Subzone b of the *Denticula hustedtii–D. lauta* Zone on the basis of the present of *Denticula praedimorpha* without *Rhizosolenia barboi*. Samples 468-3-5, 10–12 cm through 438-5,CC lack *D. praedimorpha* but contain *D. hustedtii* and are placed in Subzone a of the *D. hustedtii–D. lauta* Zone.

Cores 6 through 21 are assigned to the lower middle Miocene *Denticula lauta* Zone. The first occurrence of *Denticula hyalina* in Sample 468-9-4, 89–91 cm marks the top of Subzone a and the base of Subzone b.

A similar section was recovered in nearby Hole 468B in Cores 4 through 21. Cores 4 and 5 correspond to either Subzone c or Subzone b of the *Denticula hustedtii–D. lauta* Zone, and Samples 468B-6-3, 90–92 cm through 468B-10-1, 56–58 cm are correlated with Subzone a of the *D. hustedtii–D. lauta* Zone. Samples 468B-10,CC through 468B-21,CC are assigned to the lower middle Miocene *Denticula lauta* Zone, with the Subzone a/Subzone b boundary placed between Samples 468B-14-1, 84–86 cm and 468B-14-3, 84–86 cm.

Hole 468 includes a diatomaceous section that is truncated at its top to a greater extent than the section in Hole 468B. Sample 468B-3,CC contains diatoms correlated to middle to upper Miocene Subzone c of the *D. hustedtii–D. lauta* Zone, and Sample 468B-3-4, 130 cm contains upper Miocene diatoms assigned to Subzone d of the *D. hustedtii–D. lauta* Zone. The biostratigraphic interval represented by these samples was not present in Hole 468.

Foraminifers

Planktonic foraminifers are sparse or absent in samples examined from Site 468, except for the few exceptions noted here.

Relatively diverse Quaternary assemblages that include *Neogloboquadrina dutertrei, N. pachydeterma* (s.s.), *Globigerina bulloides*, and *Orbulina universa* occur in Samples 468-1-1, 3–5 cm and 468A-1,CC. A diverse upper Pliocene assemblage with *Neogloboquadrina atlantica, N. humerosa, N. pachyderma* (s.s.), *Globorotalia inflata*, and *G. tumida* occurs in Sample

468A-2,CC; lower Pliocene assemblages that include *Globorotalia puncticulata* occur in Samples 468B-1,CC and 468B-2,CC.

Samples 468-3,CC and 468-5,CC are assigned to the middle Miocene because of the occurrence of *Globigerina druryi* (3,CC) and *Globorotalia peripheroronda* (5,CC) with *Orbulina universa*.

Benthic foraminifer assemblages are relatively diverse and moderately well preserved in Cores 1 through 13 of Hole 468, Cores 1 through 4 of Hole 468A, and Cores 1 through 12 of Hole 468B. *Uvigerina senticosa*, *Melonis barleeanus*, and *Pullenia bulloides* are consistent members of the benthic assemblages and suggest Site 468 sediments were deposited in mid- to lower bathyal water depths. Taxa displaced from shallower water, however, are evident in most Miocene samples.

SEDIMENT ACCUMULATION RATES

The sediment accumulation rate curves (Fig. 7) for Site 468 were constructed from selected diatom (D), radiolarian (R), foraminifer (F), and coccolith (C) events. The combined curve for Holes 468A and 468B indicates a slow sediment accumulation rate of about 6 m/m.y. from the Quaternary into the late Miocene and a major hiatus during the late Miocene. An accumulation rate of about 20 m/m.y. in the late middle Miocene changes to one of at least 100 m/m.y. in the early middle Miocene and (?)early Miocene. Middle Miocene to (?)early Miocene accumulation rates for Hole 468 appear to be similar to those in Holes 468A and 468B; between Cores 2 and 3, a hiatus appears to be present from the late middle Miocene to the Pliocene.

GEOCHEMICAL MEASUREMENTS

Interstitial Water

Interstitial water was squeezed from samples at Holes 468 and 468B. Salinity, chlorinity, *p*H, alkalinity, calcium, and magnesium were determined on board ship. The interstitial water profile for Hole 468 is similar to the corresponding portion of the profile at Hole 468B, which is illustrated in Figure 8.

The interstitial water profiles from the upper 200 meters of sediment at Hole 468B are characterized by a slight increase in alkalinity, an increase in calcium concentration, and a corresponding decrease in magnesium concentration. Calcium concentration and magnesium concentration in the pore waters are linearly related. The pore-water constituent profiles in the upper 200 meters at the site are characteristic of those in terrigenous deposits of moderate sedimentation rate. The slight increase in alkalinity at this site is generally associated with sulfate reduction in pore waters (Manheim and Sayles, 1974).

Below 200 meters depth at Hole 468B, the pore-water calcium concentration first decreases to values near those of normal sea water, then increases. The magnesium concentration mirrors the calcium concentration

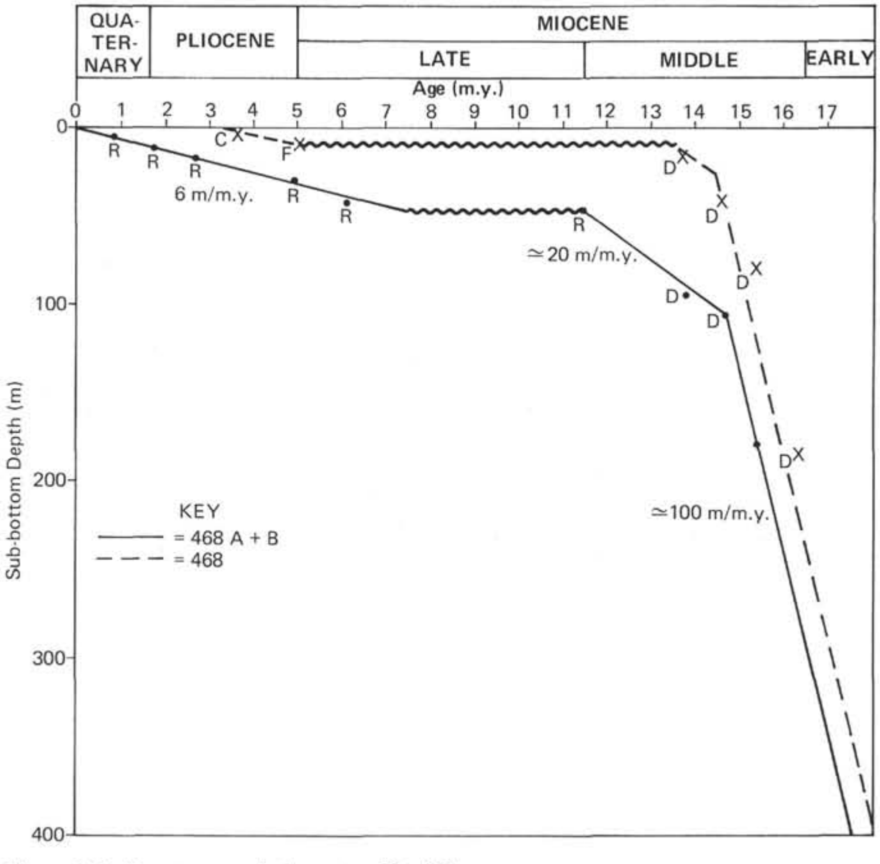


Figure 7. Sediment accumulation rates, Site 468.

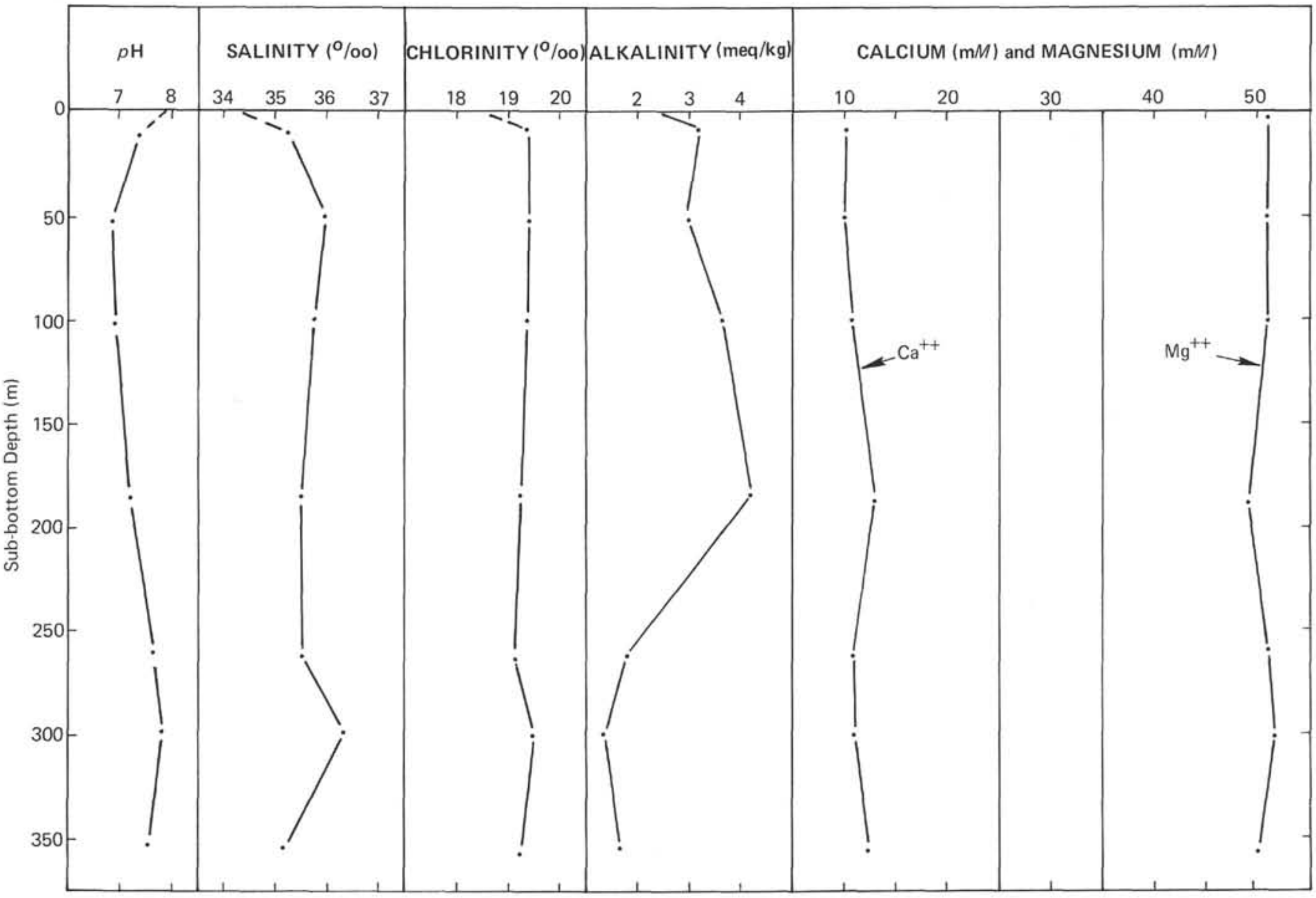


Figure 8. Interstitial water profile, Hole 468B.

by increasing, then decreasing. The depth interval over which the calcium decrease takes place corresponds to the interval of dolomitic silty claystone, and the complex calcium and magnesium concentration curves in the lower portion of the sediment column may be related to dolomitization reactions.

Calcium Carbonate Content

The calcium carbonate content of samples from Site 468 was determined by the carbonate bomb technique. The results of these determinations are included in the core descriptions in this chapter and plotted in Figures 9 and 10.

PHYSICAL PROPERTIES AND DOWNHOLE LOGS

Figures 9 and 10 summarize the physical-property and logging data for the three holes drilled at Site 468. Nannofossil ooze, clay, and silty clay that form the upper part of the section at each hole are characterized by low and relatively constant saturated bulk densities and sonic velocities. In contrast, the underlying sections of interbedded dacitic breccia, calcareous silty claystone, and volcaniclastic sandstone have distinctly higher and extremely variable densities and velocities. The break between these two portions of the sedimentary section is sharp in both cases, occurring at about 180 meters in Hole 468 and about 230 meters in Hole 468B.

Specifically, the upper part of the section in all holes lacks character. A semi-indurated sand occurs at about 108 meters in Hole 468. The impedance contrast between this layer and the enclosing clay and ooze is about 0.2. In contrast, the underlying section of interbedded dacitic breccia, calcareous silty claystone, and volcaniclastic sandstone is characterized by highly variable densities and velocities. The volcanic rocks have the highest and most constant values. Calcareous claystone is more variable, perhaps because of the degree of cementation. Indeed, between about 250 and 300 meters, the carbonate content of the claystone in Hole 468B is greatest, corresponding to some of the highest densities and velocities for these calcareous rocks (Fig. 10). Densities and velocities vary in a similar fashion for the interbedded volcaniclastic sandstone and sandy silt and perhaps also reflect the degree of lithification by cementation or by compaction.

The Caliper and Sonic Amplitude Logs in Hole 468B offer little help. The hole diameter is irregular between about 230 and 280 meters, probably corresponding to the washing out of softer clay interbedded with the volcanic and volcaniclastic rocks. The amplitude of the

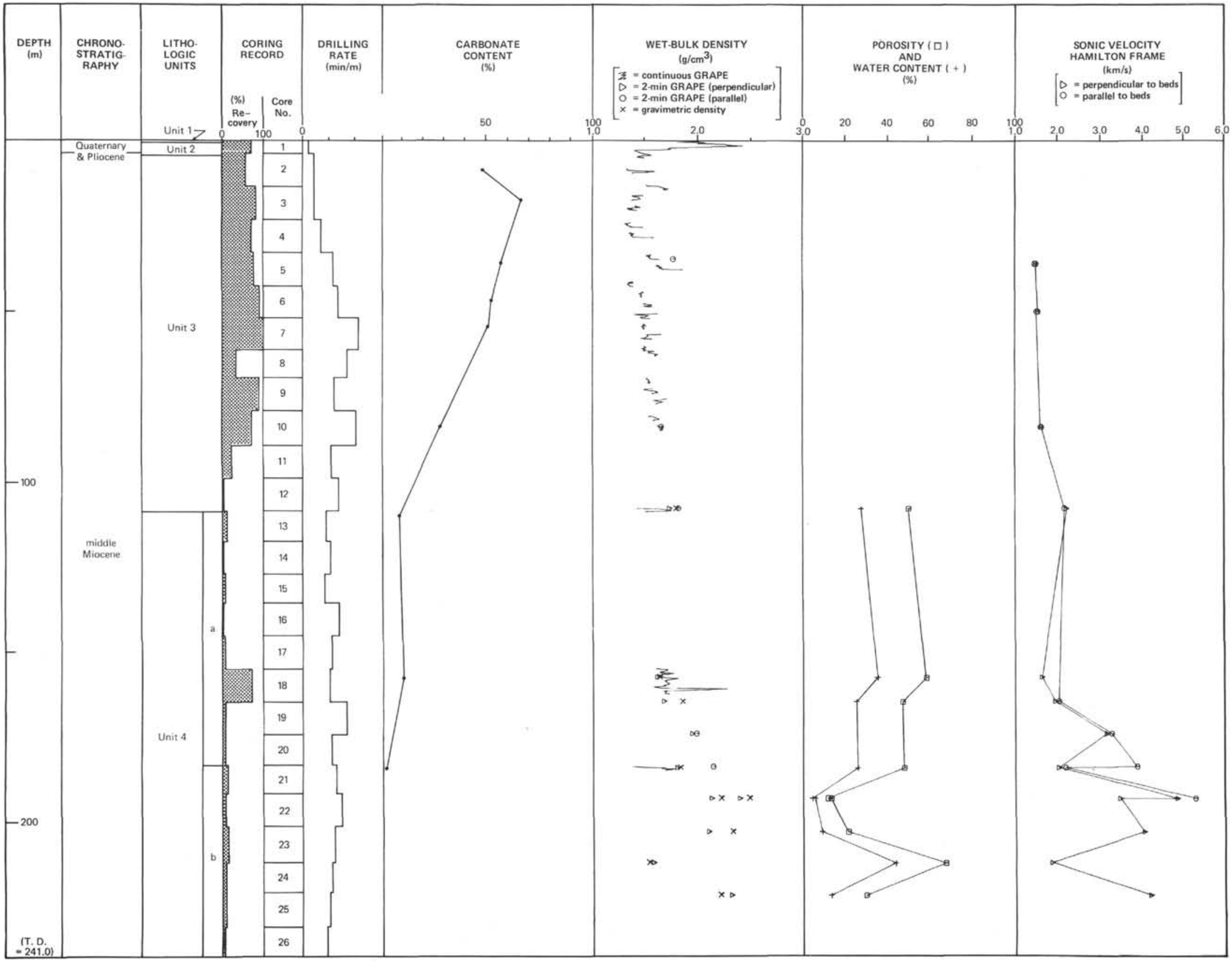


Figure 9. Summary of physical properties, Hole 468.

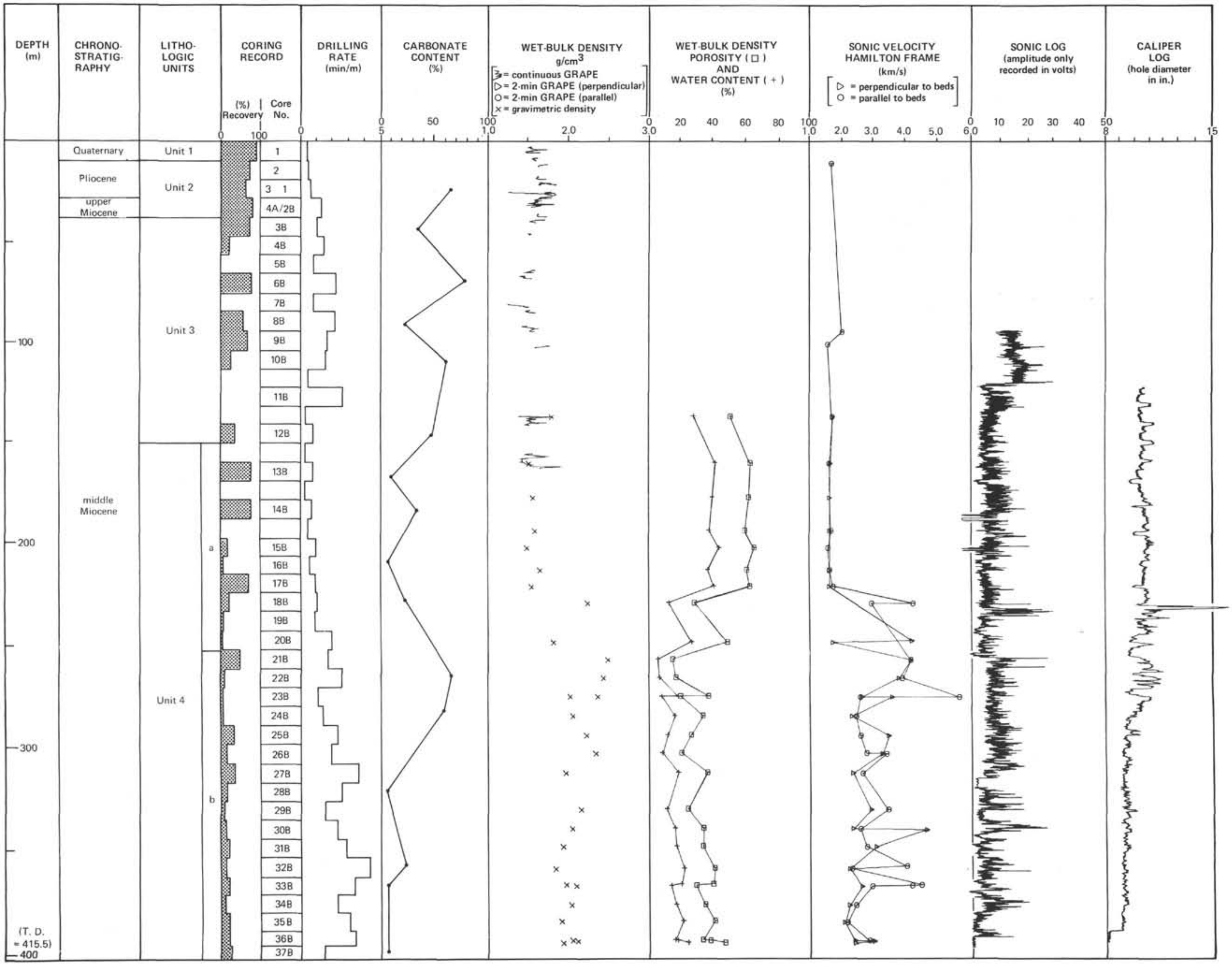


Figure 10. Summary of physical properties and downhole logs, Holes 468A and 468B.

sonic signal increases slightly between 255 and 315 meters, an interval of mostly calcareous claystone.

Physical properties such as porosity and water content derived from measured densities show the expected inverse trends, decreasing with greater depth of burial. The two measurements of shear strength of diatom nannofossil ooze at 50 and 84 meters in Hole 468 are slightly less than values of unconfined shear strength of carbonate ooze at comparable depths of burial (Bouma and Moore, 1975). Because carbonate ooze has the highest shear strengths of marine sediments, these true values probably indicate slight dilution of the carbonate with terrigenous and siliceous debris.

Table 3 gives the average densities and velocities of the upper ooze-clay part of the section and the lower interval of interbedded volcanic and sedimentary rocks for both Hole 468 and Holes 468A and B. Using these values, the impedance contrast between the upper and lower parts of the section (~180 m at Hole 468 and ~230 m at Hole 468B) is 0.43. This contrast is 0.58 if we use the average density and velocity values of the shallowest dacitic rocks (2.29 g/cm^3 and 4.56 km/s, respectively) instead of the average values for both volcanic and sedimentary rocks. In both cases, the impedance contrasts are high, indicating that the boundary between the upper soft sediments and the harder volcanic and sedimentary rocks in the lower part of the section is a good reflector. Computing acoustic impedance contrasts *within* the lower part of the section is much more tenuous, because softer rocks or sediments may not be represented in the cores. According to Table 3, the highest contrasts are between dacitic rocks and slightly calcareous claystone (impedance contrasts ~0.2–0.5). Where these are juxtaposed, such as at about 255 meters and 350 meters in Hole 468B, they may be good reflectors.

Table 3. Average values of density and porosity for Holes 468, 468A, and 468B.

Hole	Lithology	Depth Interval (m)	Density Range (g/cm^3)	Density Avg.	Velocity Range (km/s)	Velocity Avg.
468	Nannofossil ooze, clay, and silty clay	0–180	1.50–1.80	1.63	1.50–2.26	1.77
	Dacitic breccia[a]	180–T.D.	2.10–2.40	2.27	4.10–4.89	4.41
	Calcareous silty claystone	180–T.D.	1.95–2.15	2.08	3.21–3.92	3.86
	Sandstone/silty sand	180–T.D.	1.59–1.85	1.69	1.68–2.26	1.99
468A, B	Nannofossil ooze, clay, and silty clay	0–240	1.50–1.80	1.61	1.55–2.01	1.67
	Dacitic breccia[a]	240–T.D.	2.12–2.24	2.22	2.99–4.65	4.08
	Calcareous silty claystone	240–T.D.	1.70–2.47	2.10	1.73–4.23	2.86
	Sandstone/silty sand	240–T.D.	1.82–2.50	2.06	2.41–4.47	3.25

[a] We recovered only fragments of dacite in both holes and have interpreted these as clasts in breccias. Consequently, densities and velocities may not be representative of the lithologic unit.

The data at Site 468 show a distinct shift in all physical properties where nannofossil ooze, clay, and silty clay give way to underlying harder sedimentary and volcanic rocks. This break occurs about 50 meters deeper in Hole 468B than in Hole 468. The impedance contrast between these two units is about 0.4. Densities, porosities, and velocities appear to vary directly with degree of carbonate cementation in the lower claystone.

CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

The acoustic stratigraphy in the vicinity of Site 468 is shown on the common depth point (CDP) multichannel seismic-reflection profile (Fig. 3) obtained during a presite survey by the U.S. Geological Survey (Crouch et al., 1978). A pronounced upper middle Miocene unconformity that occurs at about 4 meters sub-bottom in Hole 468 and 35 meters sub-bottom in Hole 468B cannot be resolved on the CDP profile. This unconformity can be seen on a nearby U.S. Geological Survey single-channel record, however, where it separates relatively undeformed strata from underlying folded and faulted strata. The *Challenger* profiles approaching and leaving the site show little of the acoustic stratigraphy because of the high vertical exaggeration on these records and the steepness of the slope at Site 468.

At Site 468, the CDP profile shows acoustic units in the following succession:

1) an upper unit with weak interval reflectors that become stronger and more persistent near the base of the unit;

2) a pair of strong, very persistent reflectors at about 0.19 and 0.21 s below the sea floor in Hole 468; and

3) below the two strong reflectors, there is a lower unit characterized by an interval of very weak and discontinuous reflectors.

The sequence of acoustistratigraphic units at Site 468, as inferred from seismic profiles, a sonobuoy profile (Crouch et al., 1978), drilling rate, and cored stratigraphic sequence is displayed in Figure 11. The upper acoustic unit correlates with Lithologic Unit 1 through Sub-unit 4, consisting mainly of Quaternary to middle Miocene foraminiferal, nannofossil, and diatomaceous ooze that grades downward into moderately indurated diatom- and nannofossil-bearing silty claystone. The boundary between the upper and lower acoustic units correlates with the pair of strong continuous reflectors at 0.19 and 0.21 s below the sea floor. Beneath and subparallel to these strong reflectors are very weak, discontinuous reflectors that characterize the lower acoustic unit. The lower acoustic unit corresponds to Lithologic Sub-unit 4b, which consists of interbedded dolomitic silty claystone and volcaniclastic rocks of andesitic and dacitic composition. The weak and discontinuous reflectivity of this lower unit is probably the result of the small velocity and density contrasts between the dolomitic and volcaniclastic beds.

CONCLUSIONS

1. An unconformity at Site 468 corresponds to a widespread unconformity recognized in the California Continental Borderland by Crouch (1979b). However, relations at Hole 468 differ from those prevailing in the composite section at Holes 468A and 468B, despite the proximity of these holes (1.2 km apart). The upper mid-

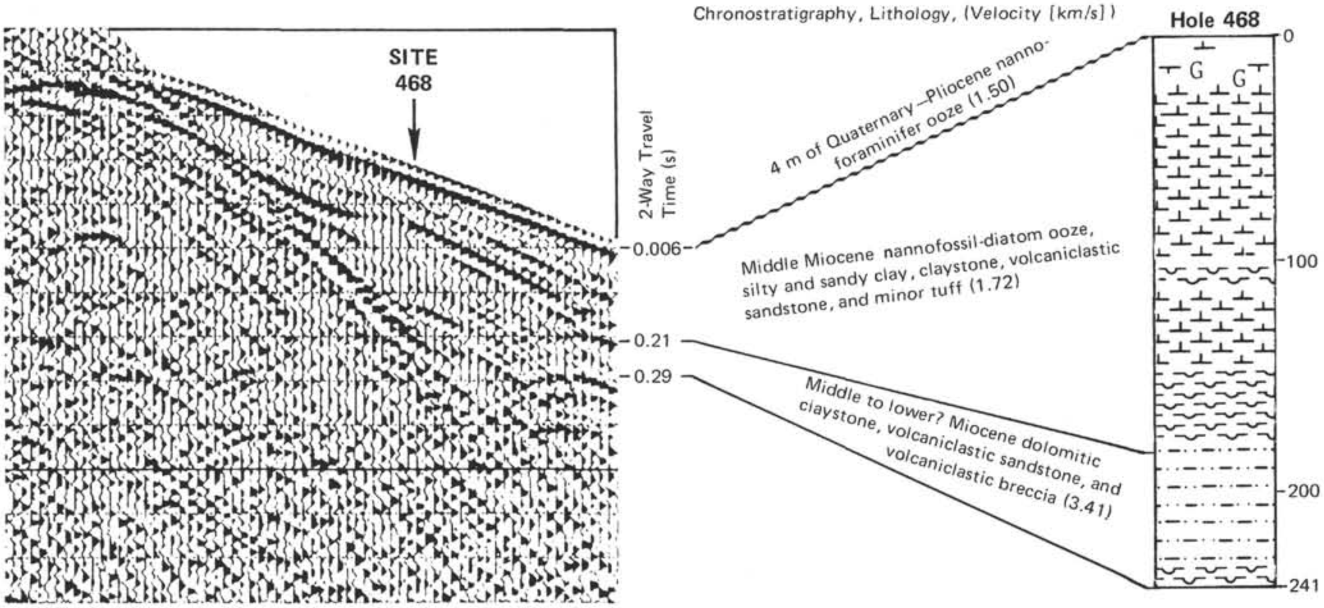


Figure 11. Correlation of lithologic units of Hole 468 with multichannel seismic profile at Site 468.

dle Miocene and upper Miocene section is missing at Hole 468, whereas only part of the upper Miocene is absent at Holes 468A and B.

2. Youngest andesitic volcaniclastic rocks are interbedded with sediments containing a *Sphenolithus heteromorphus* Zone fauna 15.5 ± 0.8 m.y. of age. Volcaniclastic rocks deposited during the middle and perhaps late early Miocene appear to be derived from a nearby source, probably on or near the Patton Ridge. Some of the volcanic clasts may have been recycled from older strata. The occurrence of Miocene andesitic and dacitic volcanic rocks so close to the continental margin suggests that the volcanics are related to the passage of the East Pacific Rise Crest and were not derived from subducted oceanic crust.

3. The change of facies in the late middle Miocene from volcaniclastic and terrigenous strata upsection to hemipelagic sediments may reflect subsidence of the outer California Continental Borderland after passage of the East Pacific Rise Crest.

4. A relatively well-preserved siliceous microfossil record was recovered only in the middle Miocene portion of the section. The calcareous microfossil record is generally poor throughout the section, and it may not reveal the detailed paleoclimatic data that had been expected.

REFERENCES

Bouma, A. H., and Moore, J. C., 1975. Physical properties of deep-sea sediments from the Philippine Sea and Sea of Japan. *In* Karig, D. E., Ingle, J. C., Jr., et al., *Init. Repts. DSDP*, 31: Washington (U.S. Govt. Printing Office), 535–568.

Crouch. J. K., 1979a. Neogene tectonic evolution of the California Continental Borderland and western Transverse Ranges. *Bull. Geol. Soc. Am.* Pt. 1, 90:338–345.

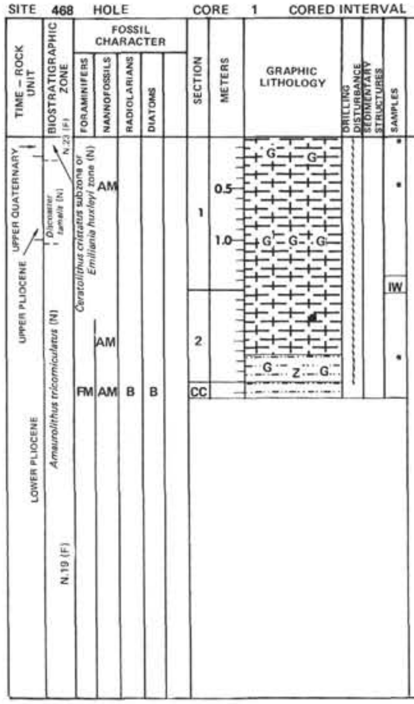
________, 1979b. Marine geology and tectonic evolution of the northwestern margin of the California Continental Borderland [Ph.D. thesis]. University of California, San Diego.

Crouch, J. K., Holmes, M. C., McCulloh, T. H., et al., 1978. Multichannel seismic reflection and sonobuoy refraction data in the outer Southern California borderland. *U.S. Geol. Surv. Open-File Rep. 78-706.*

Kling, S. A., 1973. Radiolaria from the eastern North Pacific, Deep Sea Drilling Project, Leg 18. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 617–674.

Manheim, F. T., and Sayles, F. L., 1974. Composition and origin of interstitial waters of marine sediments based on deep sea drill cores. *In* Goldberg, E. D. (Ed.), *The Sea, Marine Chemistry* (Vol. 7): New York, (John Wiley and Sons), 527–568.

SITE 468 HOLE CORE 1 CORED INTERVAL 0.0–3.5 m



LITHOLOGIC DESCRIPTION

5Y 5/2 sharp color change

5Y 7/2
Glauconite

Bored phosphatic(?) clast

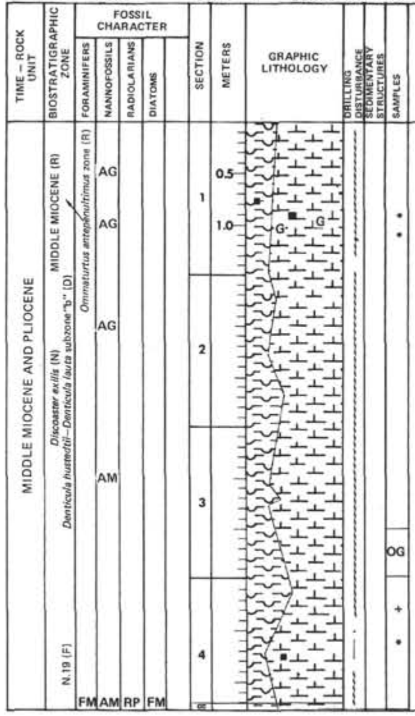
Sharp color change
Glauconite
5Y 3/2

FORAMINIFERA-NANNOFOSSIL OOZE, yellowish gray (5Y 7/2) with darker pale olive gray (10Y 6/2) and light olive gray (5Y 3/2) streaks. Upper 20 cm of core contains abundant foraminifers and is separated from underlying foraminifera-nannofossil ooze by sharp color change. Glauconite is common in the upper foraminifera-nannofossil ooze and at several intervals in the core (e.g. Section 1, 92-106 cm; Section 2, 70 cm). Phosphatic(?) clast ~3 cm across in Section 2 contains borings. Olive gray (5Y 3/2) **SILTY CLAY** from 70 cm, Section 2 to base of core contains common lath-shaped, partially corroded, euhedral zeolite (clinoptilolite?) crystals.

SMEAR SLIDE SUMMARY

	1-5 (D)	1-55 (D)	2-70 (D)
TEXTURE:			
Sand	25	21	10
Silt	25	15	50
Clay	50	64	40
COMPOSITION:			
Quartz	4	1	15
Feldspar	1	1	15
Mica	–	–	10
Heavy minerals	–	–	8
Clay	8	7	40
Glauconite	3	3	5
Pyrite	–	–	TR
Zeolite (clinop.?)	–	–	2
Carbonate unspec.	5	24	2
Foraminifers	25	2	TR
Calc. Nannofossils	46	58	5
Radiolarians	7	–	–
Sponge spicules	1	2	TR
Silicoflagellates	–	2	–

SITE 468 HOLE CORE 2 CORED INTERVAL 3,5–13.0 m



LITHOLOGIC DESCRIPTION

Phosphatic(?) clasts

10Y 4/2

5Y 7/2 Deformed but recognizable bedding
10Y 4/2

Sharp color change
10Y 8/2
Phosphatic(?) clast

DIATOM-NANNOFOSSIL OOZE, variable colors – yellowish gray (5Y 7/2) and dusky yellow (5Y 6/4) with darker grayish olive (10Y 4/2) streaks and intervals. Lighter colors generally indicate fewer diatoms. Several abrupt color changes in Section 3 (55–70 cm) and Section 4 (62 and 75 cm) marking nannofossil-rich zones. Glauconite common; often fills axial canals of sponge spicules. Phosphatic(?) clasts occur in Sections 1 and 4.

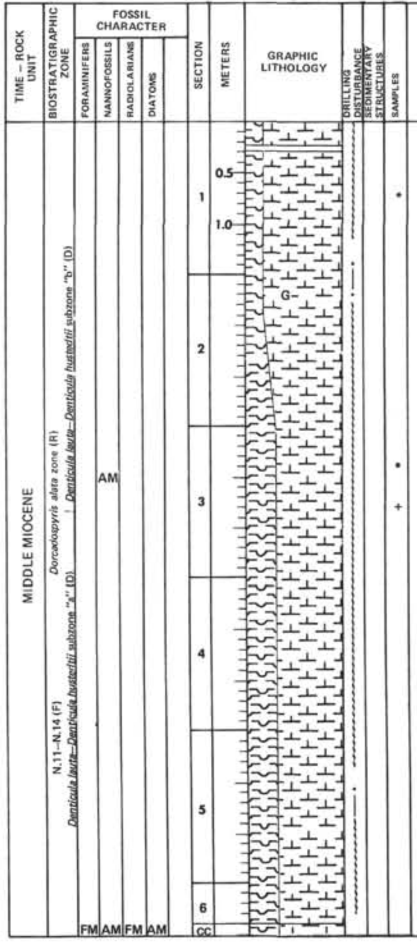
ORGANIC CARBON AND CARBONATE

	4-30
% Organic Carbon	–
% $CaCO_3$	49

SMEAR SLIDE SUMMARY

	1-94 (D)	1-118 (D)	4-67 (D)
TEXTURE:			
Sand	–	–	–
Silt	5	5	5
Clay	95	95	95
COMPOSITION:			
Quartz	–	1	TR
Feldspar	TR	–	TR
Mica	TR	–	–
Heavy minrals	TR	–	TR
Clay	10	3	6
Glauconite	3	2	1
Pyrite	TR	–	–
Carbonate unspec.	TR	5	2
Foraminifers	6	–	2
Calc. Nannofossils	70	63	76
Diatoms	4	14	8
Radiolarians	4	2	2
Sponge spicules	3	7	3
Silicoflagellates	–	3	–

SITE 468 **HOLE** **CORE** 3 **CORED INTERVAL** 13.0–22.5 m



LITHOLOGIC DESCRIPTION

5Y 6/4 and 10Y 6/2

Deformed light/dark sediment alternations

5Y 5/2

DIATOM-NANNOFOSSIL OOZE, dusky yellow (5Y 6/4) and pale olive (10Y 6/2) to light olive gray (5Y 5/2). Variable colors reflect percentages of diatoms (dark) and nannofossils (light). Thin deformed layers of alternating light and dark sediment top Section 2. Sponge fragments scattered throughout.

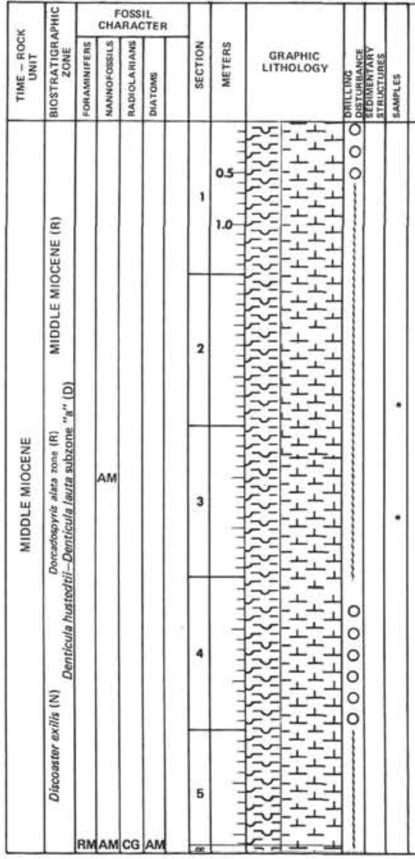
ORGANIC CARBON AND CARBONATE

	3-83
% Organic Carbon	–
% $CaCO_3$	67

SMEAR SLIDE SUMMARY

	1-77 (D)	3-41 (D)
TEXTURE:		
Sand	–	–
Silt	–	30
Clay	100	70
COMPOSITION:		
Quartz	–	2
Feldspar	–	1
Mica	TR	–
Heavy minerals	–	TR
Clay	9	6
Glauconite	–	1
Carbonate unspec.	TR	–
Foraminifers	2	3
Calc. Nannofossils	75	67
Diatoms	8	12
Raidolarians	3	4
Sponge spicules	3	3
Silicoflagellates	TR	1

SITE 468 **HOLE** **CORE** 4 **CORED INTERVAL** 22.5–32.0 m



LITHOLOGIC DESCRIPTION

5Y 6/4

to

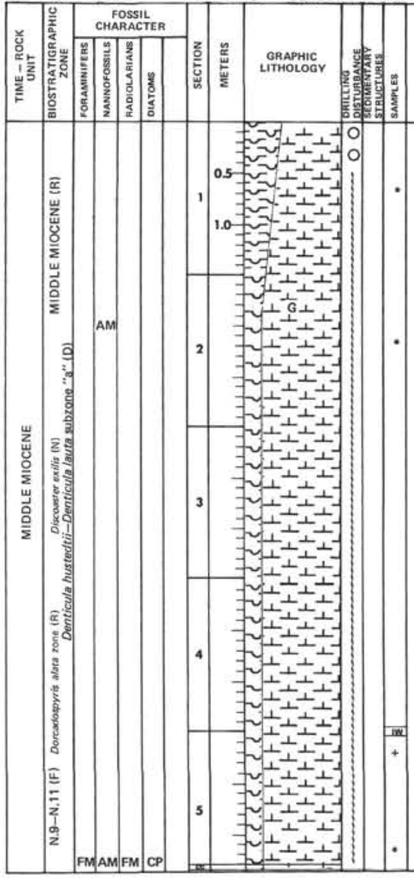
10Y 6/2

DIATOM-NANNOFOSSIL OOZE, dusky yellow (5Y 6/4) to pale olive (10Y 6/2) with dark gray (N3) and grayish black (N2) streaks and patches. Intense drilling deformation.

SMEAR SLIDE SUMMARY

	2-138 (D)	3-92 (D)
TEXTURE:		
Sand	–	–
Silt	20	17
Clay	80	83
COMPOSITION:		
Quartz	TR	2
Feldspar	1	1
Mica	1	TR
Heavy mienrals	TR	–
Clay	10	15
Glauconite	TR	–
Pyrite	TR	–
Foraminifers	TR	5
Calc. Nannofossils	45	40
Diatoms	35	30
Radiolarians	3	1
Sponge spicules	5	5
Silicoflagellates	TR	1

SITE 468 HOLE CORE 5 CORED INTERVAL 32.0–41.5 m



LITHOLOGIC DESCRIPTION

Glauconite-rich patch

DIATOM-NANNOFOSSIL OOZE, grayish olive (10Y 4/2) to pale olive (10Y 6/2), indistinctly mottled throughout with occasional glauconite-rich patches. Clay content increases near base Section 5.

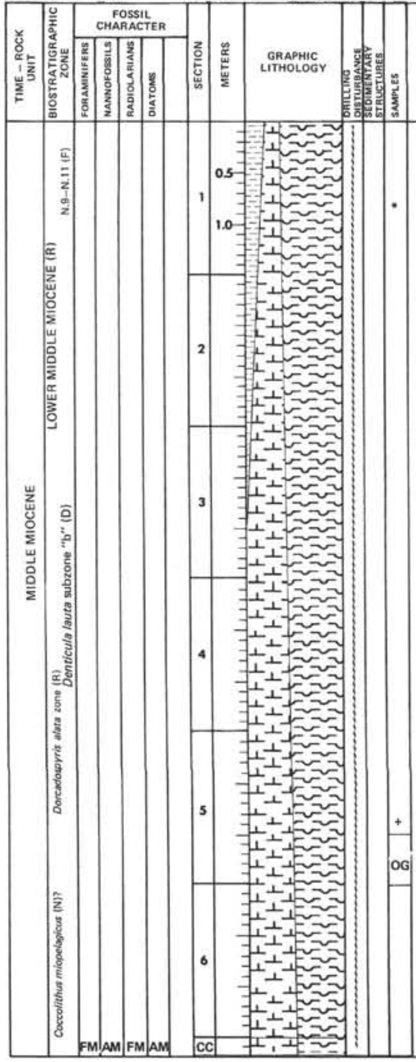
ORGANIC CARBON AND CARBONATE

	5-24
% Organic Carbon	–
% $CaCO_3$	57

SMEAR SLIDE SUMMARY

	1-70 (D)	2-70 (D)	5-120 (D)
TEXTURE:			
Sand	–	–	5
Silt	25	–	25
Clay	75	100	70
COMPOSITION:			
Quartz	–	–	4
Feldspar	–	–	1
Mica	–	TR	1
Heavy minerals	–	–	TR
Clay	8	5	10
Glauconite	TR	TR	1
Carbonate unspec.	1	–	2
Foraminifers	1	2	3
Calc. Nannofossils	70	78	43
Diatoms	10	3	20
Radiolarians	2	2	5
Sponge spicules	8	10	9
Silicoflagellates	TR	–	1

SITE 468 HOLE CORE 6 CORED INTERVAL 41.5–51.0 m



LITHOLOGIC DESCRIPTION

5Y 3/2

to

5Y 5/2

CLAYEY DIATOMACEOUS OOZE, olive gray (5Y 3/2) changing down-core to light olive gray (5Y 5/2) **NANNOFOSSIL-DIATOMACEOUS OOZE**. Some indistinct color mottling Section 5. Lighter colored sediment nannofossil-rich. Intense drilling deformation.

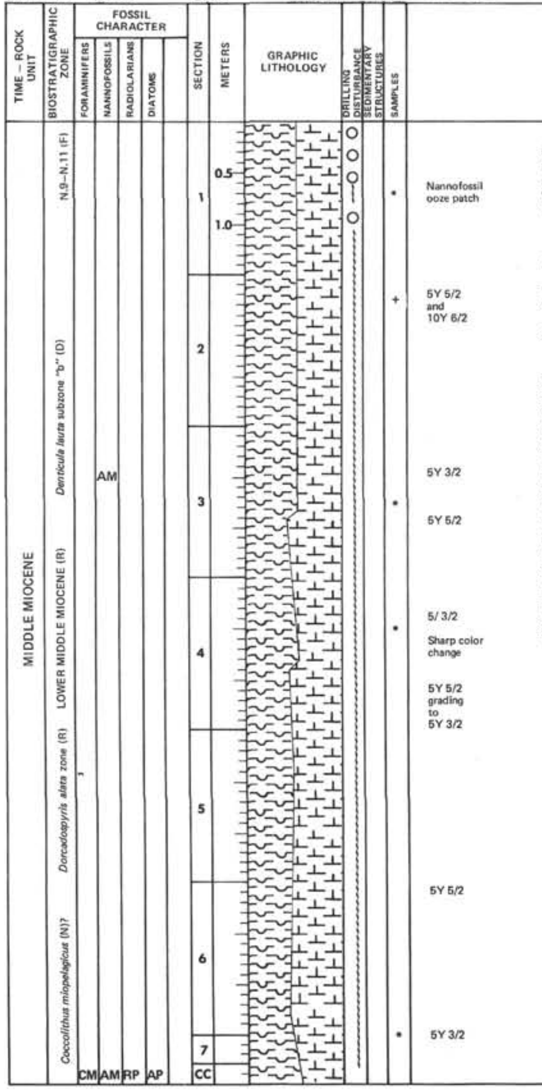
ORGANIC CARBON AND CARBONATE

	5-90
% Organic Carbon	2.78
% $CaCO_3$	49

SMEAR SLIDE SUMMARY

	1-81 (D)
TEXTURE:	
Sand	–
Silt	50
Clay	50
COMPOSITION:	
Mica	TR
Heavy minerals	TR
Clay	20
Glauconite	1
Pyrite	TR
Carbonate unspec.	10
Foraminifers	1
Calc. Nannofossils	12
Diatoms	50
Radiolarians	2
Sponge spicules	4

SITE 468 HOLE CORE 7 CORED INTERVAL 51.0–60.5 m



LITHOLOGIC DESCRIPTION

DIATOM-NANNOFOSSIL OOZE, light olive gray (5Y 5/2) and pale olive (10Y 6/2) to olive gray (5Y 3/2), darker colors correspond to higher diatom and clay content. Several patches of yellowish gray (5Y 7/2) **NANNOFOSSIL OOZE** in Section 1. Intense drilling deformation.

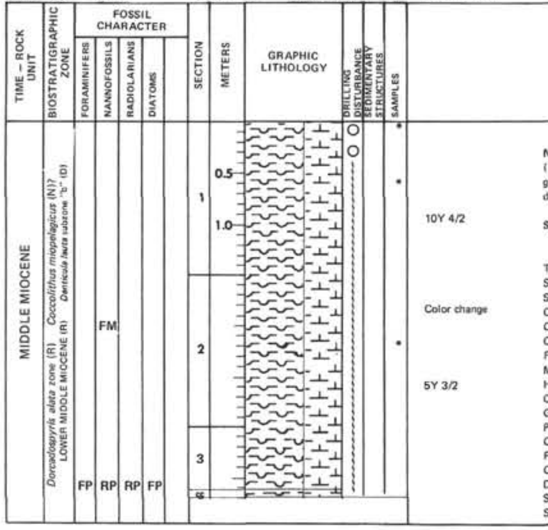
ORGANIC CARBON AND CARBONATE

	2-30
% Organic Carbon	–
% $CaCO_3$	51

SMEAR SLIDE SUMMARY

	1-73 (M)	3-82 (D)	4-58 (D)	7-7 (D)
TEXTURE:				
Sand	–	–	–	10
Silt	8	40	25	30
Clay	92	60	75	50
COMPOSITION:				
Quartz	2	TR	2	8
Feldspar	TR	–	TR	2
Mica	TR	–	TR	TR
Heavy minerals	–	–	–	1
Clay	3	14	14	30
Glauconite	TR	TR	1	3
Pyrite	TR	TR	–	2
Carbonate unspec.	–	TR	10	10
Foraminifers	3	TR	TR	1
Calc. Nannofossils	82	35	25	6
Diatoms	7	40	40	20
Radiolarians	1	2	3	–
Sponge spicules	1	8	6	15
Silicoflagellates	1	1	TR	–

SITE 468 HOLE CORE 8 CORED INTERVAL 60.5–70.0 m



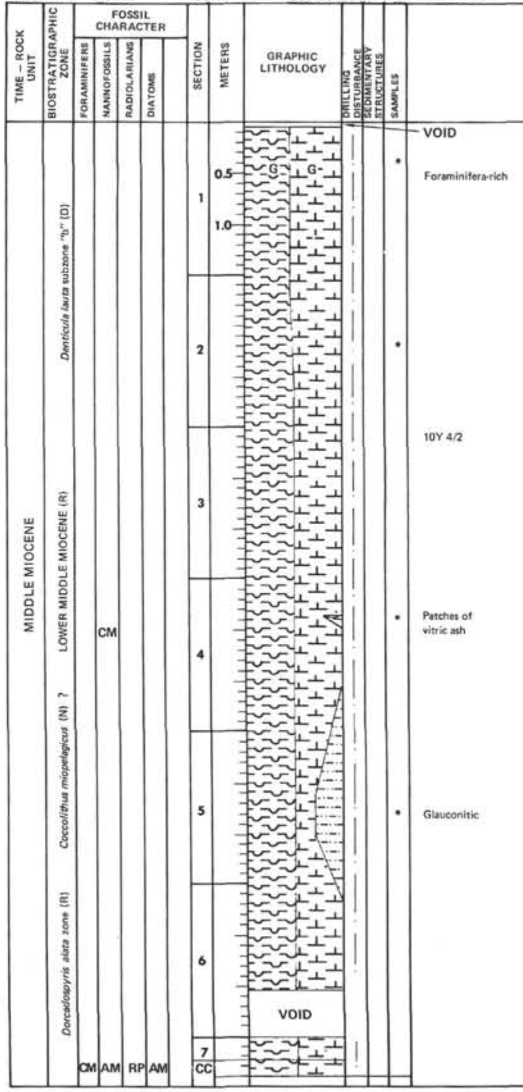
LITHOLOGIC DESCRIPTION

NANNOFOSSIL-DIATOMACEOUS OOZE, grayish olive (10Y 4/2) to olive gray (5Y 3/2), contains more silt-size grains of quartz and feldspar than Core 7. Intense drilling deformation.

SMEAR SLIDE SUMMARY

	1-5 (D)	1-66 (D)	2-76 (D)
TEXTURE:			
Sand	–	2	5
Silt	55	18	55
Clay	45	80	40
COMPOSITION:			
Quartz	7	TR	10
Feldspar	4	TR	5
Mica	TR	–	1
Heavy minerals	2	1	1
Clay	5	12	10
Glauconite	2	1	3
Pyrite	TR	1	2
Carbonate unspec.	5	5	–
Foraminifers	25	20	2
Calc. Nannofossils	40	45	44
Diatoms	2	3	2
Sponge spicules	7	12	20
Silicoflagellates	1	–	–

SITE 468 HOLE CORE 9 CORED INTERVAL 70.0–79.5 m



LITHOLOGIC DESCRIPTION

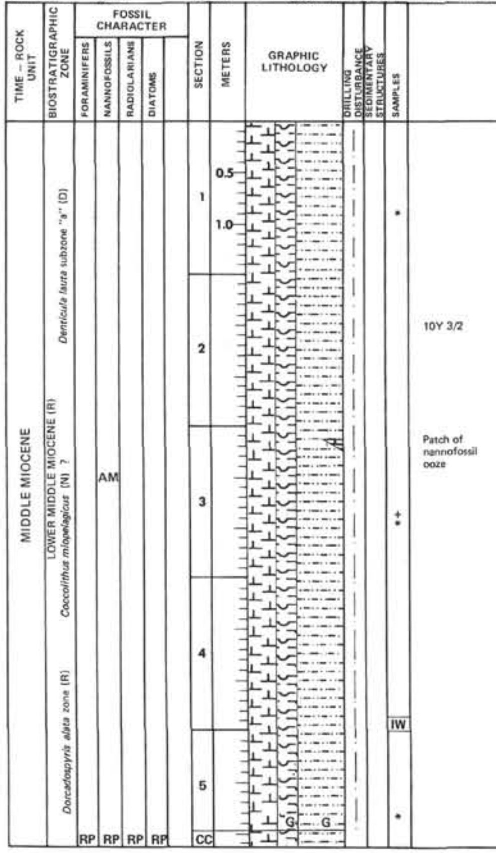
NANNOFOSSIL-DIATOMACEOUS OOZE, grayish olive (10Y 4/2) with dark grayish olive (10Y 3/2) mottles. Clay-rich with patches of oraminifera- and glauconitic-silty clay. **DIATOMACOUS SILTY CLAY** Section 5, 68–117 cm. Patches of vitric ash Section 4, 40 and 44 cm.

Collapsed core liner Section 6, 102–150 cm.

SMEAR SLIDE SUMMARY

	1-43 (M)	2-75 (D)	4-42 (M)	5-81 (D)
TEXTURE:				
Sand	–	–	10	–
Silt	40	30	85	20
Clay	60	70	5	80
COMPOSITION:				
Quartz	15	10	–	10
Feldspar	2	2	–	2
Mica	–	–	–	1
Heavy minerals	1	1	–	1
Clay	13	20	–	38
Volcanic glass	–	–	98	–
Glauconite	5	2	–	7
Pyrite	TR	–	–	–
Carbonate unspec.	10	3	–	2
Foraminifers	10	2	–	3
Calc. Nannofossils	35	25	1	TR
Diatoms	1	30	1	15
Radiolarians	5	7	–	5
Sponge spicules	3	2	–	7
Silicoflagellates	TR	1	–	1

SITE 468 HOLE CORE 10 CORED INTERVAL 79.5–89.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL-DIATOMACEOUS SILTY CLAY, dark grayish olive (10Y 3/2) with scattered glauconitic and foraminifera-rich patches. Patch of grayish olive (10Y 4/2) nannofossil ooze Section 3, 12 cm. Scattered sponge fragments throughout.

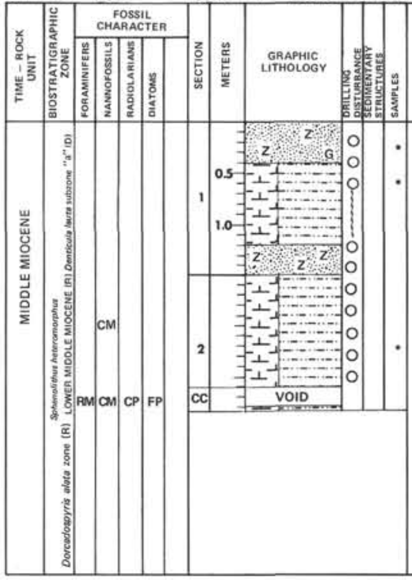
ORGANIC CARBON AND CARBONATE

	3-90
% Organic Carbon	–
% $CaCO_3$	27

SMEAR SLIDE SUMMARY

	1-92 (D)	3-92 (D)	5-88 (M)
TEXTURE:			
Sand	–	–	–
Silt	20	20	40
Clay	80	80	60
COMPOSITION:			
Quartz	4	7	25
Feldspar	–	1	3
Mica	–	1	1
Clay	25	31	24
Glauconite	2	–	25
Carbonate unspec.	5	5	5
Foraminifers	5	7	5
Calc. Nannofossils	25	20	–
Diatoms	25	20	5
Radiolarians	1	–	–
Sponge spicules	7	7	7
Silicoflagellates	–	1	–

SITE 468 HOLE CORE 11 CORED INTERVAL 89.0–98.5 m



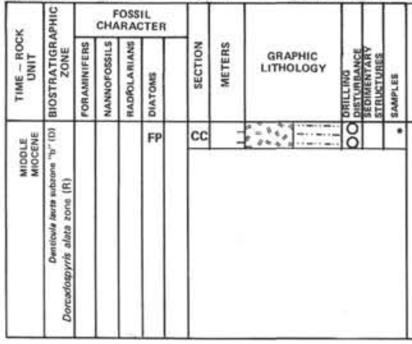
LITHOLOGIC DESCRIPTION

ZEOLITIC SILTY SAND, olive gray (5Y 3/2) and **NANNOFOSSIL SILTY CLAY**, dark grayish olive (10Y 3/2). Silty clay mixed with vitric ash in Section 2. Zeolite occus as blocky or prismatic crystals covering surfaces of detrital grains. Glauconite is also common in sandy sediments. Vitric ash most abundant in base Section 2.

SMEAR SLIDE SUMMARY

	1-30 (D)	1-62 (D)	2-78 (M)
TEXTURE:			
Sand	80	5	90
Silt	12	15	10
Clay	8	80	–
COMPOSITION:			
Quartz	40	10	10
Feldspar	10	5	2
Mica	–	–	3
Heavy minerals	–	1	–
Clay	10	35	70
Volcanic glass	1	1	–
Glauconite	10	5	–
Zeolite	12	–	–
Carbonate unspec.	1	1	5
Calc. Nannofossils	1	25	–
Diatoms	–	7	TR
Sponge spicules	–	10	TR
Lithic fragments	15	–	10

SITE 468 HOLE CORE 12 CORED INTERVAL 98.5–108.0 m



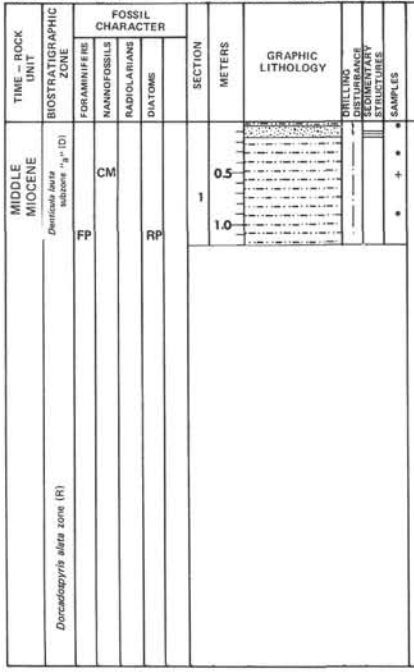
LITHOLOGIC DESCRIPTION

NANNOFOSSIL(?) SILTY CLAY and **VITRIC ASH**, grayish olive (10Y 4/2), mixed and homogenized by drilling.

SMEAR SLIDE SUMMARY

	CC-10
TEXTURE:	
Sand	30
Silt	60
Clay	10
COMPOSITION:	
Feldspar	1
Volcanic glass	99

SITE 468 HOLE CORE 13 CORED INTERVAL 108.0–117.5 m



LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, olive gray (5Y 3/2) to olive black (5Y 2/2) with thin interval of laminated **SILTY SANDSTONE** (Section 1, 5–15 cm) composed of detrital quartz and feldspar, volcanic glass, opaque rock fragments and some foraminifers and glauconite. Silty claystone includes some nannofossils. Some opaque sand-size grains may be phosphatic. First indurated sediments.

No Core-Catcher.

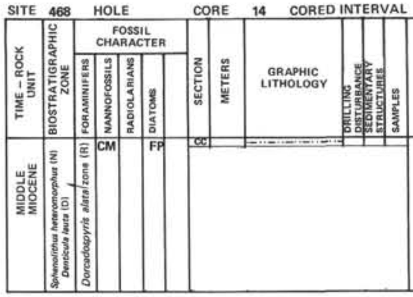
ORGANIC CARBON AND CARBONATE

	1-54
% Organic Carbon	–
% $CaCO_3$	9

SMEAR SLIDE SUMMARY

	1-10 (M)	1-37 (D)	1-95 (D)
TEXTURE:			
Sand	75	25	20
Silt	25	35	35
Clay	–	40	45
COMPOSITION:			
Quartz	35	10	5
Feldspar	20	5	5
Heavy minerals	2	3	1
Clay	TR	40	40
Volcanic glass	15	5	10
Glauconite	5	5	2
Carbonate unspec.	5	10	2
Foraminifers	3	TR	1
Calc. Nannofossils	–	10	10
Diatoms	–	2	1
Sponge spicules	–	3	3
Lithic fragments (opaque)	17	10	20

SITE 468 HOLE CORE 14 CORED INTERVAL 117.5–127.0 m

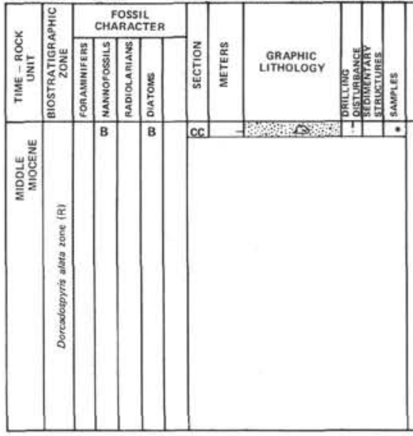


LITHOLOGIC DESCRIPTION

SILTY SANDSTONE, olive gray (5Y 3/2), composed mainly of sand-size feldspar and opaque lithic fragments.

Core-Catcher only.

SITE 468 HOLE CORE 15 CORED INTERVAL 127.0–136.5 m



LITHOLOGIC DESCRIPTION

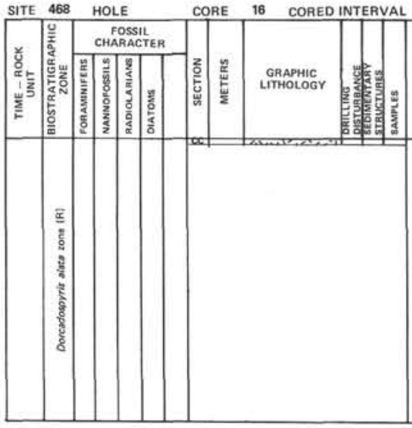
SILTY SANDSTONE, dark gray (N3); feldspar and opaque lithic fragments most abundant detrital grains. Glauconite and detrital grains of spherulitic zeolite(?) common **ANDESITE/DACITE** clast recovered with sandstone.

Core-Catcher only.

SMEAR SLIDE SUMMARY

	CC-3
TEXTURE:	
Sand	80
Silt	20
Clay	–
COMPOSITION:	
Quartz	35
Feldspar	5
Volcanic glass	25
Glauconite	5
Zeolite	3

SITE 468 HOLE CORE 16 CORED INTERVAL 136.5–146.0 m



LITHOLOGIC DESCRIPTION

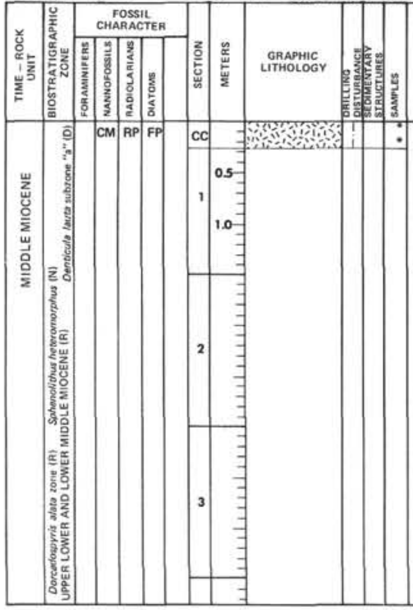
Clast of medium gray (N5) porphyritic **ANDESITE/DACITE**.

Core-Catcher only.

THIN SECTION DESCRIPTION

Phenocrysts:		
plag.	4%	euhedral–subhedral
clinopyx.	1%	euhedral–subhedral
orthopyx.	TR	euhedral–subhedral
Groundmass:		
plag.	40%	acicular, prisms
glass	42%	altered mesostasis
opaque	3%	
Vesicles:	10%	
Alteration:		
clays	TR	(in vesicles)
zeolites	TR	

SITE 468 HOLE CORE 17 CORED INTERVAL 146.0–155.5 m



LITHOLOGIC DESCRIPTION

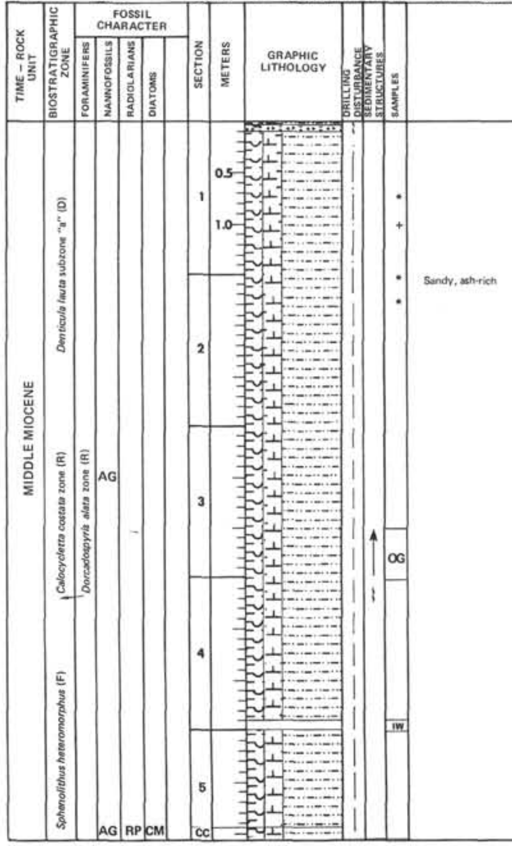
SANDY CLAYSTONE, greenish black (5GY 2/1). Yellowish gray (5Y 7/2) nannofossil-rich mottle at 13 cm.

Core-Catcher only.

SMEAR SLIDE SUMMARY

	CC-6 (D)	CC-13 (M)
TEXTURE:		
Sand	25	–
Silt	10	10
Clay	65	90
COMPOSITION:		
Quartz	8	–
Feldspar	4	–
Heavy minerals	1	–
Clay	60	10
Glauconite	10	–
Carbonate unspec.	2	2
Calc. Nannofossils	2	70
Diatoms	1	10
Sponge spicules	–	8
Silicoflagellates	2	–
Lithic fragments	10	–

SITE 468 HOLE CORE 18 CORED INTERVAL 155.5–165.0 m



LITHOLOGIC DESCRIPTION

DIATOM-NANNOFOSSIL SILTY CLAYSTONE, dark grayish olive (10Y 3/2), with patches of glauconitic and foraminifera sand. Indistinct burrows top Section 4 filled with silty sand. Thin layer of **VOLCANIC LAPILLI TUFF** Section 1. Largest lapilli 1 cm across. Scattered sponge fragments throughout core. Sediment becoming lithified.

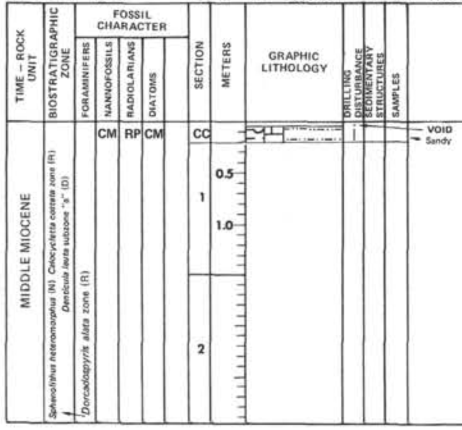
ORGANIC CARBON AND CARBONATE

	1-100
% Organic Carbon	1.83
% $CaCO_3$	11

SMEAR SLIDE SUMMARY

	1-80 (D)	2-9 (M)	2-30 (D)
TEXTURE:			
Sand	–	80	25
Silt	20	20	35
Clay	80	–	40
COMPOSITION:			
Quartz	5	25	10
Feldspar	–	10	5
Heavy minerals	–	–	1
Clay	32	–	30
Volcanic glass	–	10	–
Glauconite	5	4	–
Carbonate unspec.	–	–	5
Foraminifers	5	5	2
Calc. Nannofossils	25	30	30
Diatoms	20	TR	5
Radiolarians	3	–	–
Sponge psicules	5	3	2
Lithic fragments	–	10	2

SITE 468 HOLE CORE 19 CORED INTERVAL 165.0–174.5 m

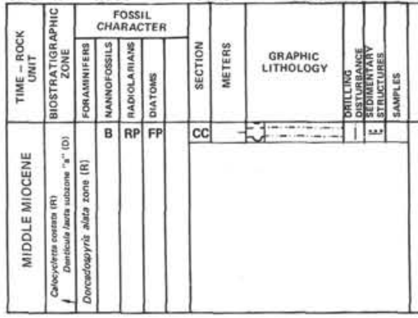


LITHOLOGIC DESCRIPTION

DIATOM-NANNOFOSSIL SILTY CLAY, grayish olive (10Y 4/2), becoming sandy near base of core.

Core-Catcher only.

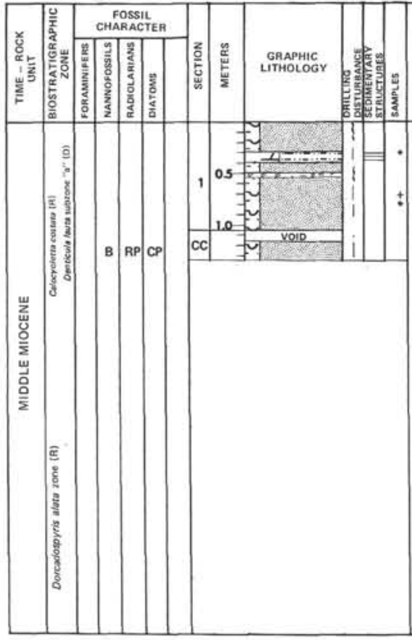
SITE 468 HOLE CORE 20 CORED INTERVAL 174.5–184.0 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS SILTY CLAYSTONE, olive black (5Y 2/1), graded silty layers ~5 mm thick near base of core.

SITE 468 HOLE CORE 21 CORED INTERVAL 184.0–193.5 m



LITHOLOGIC DESCRIPTION

DIATOMACOEUS CLAYEY SANDSTONE, olive black (5Y 2/1), with abundant volcanic lithic fragments. Laminated **DOLOMITIC SILTY CLAYSTONE** (31–42 cm, Section 1) contains angular quartz and feldspar grains, dolomite rhombs, and foraminifera molds filled with chalcedony and opal-CT(?).

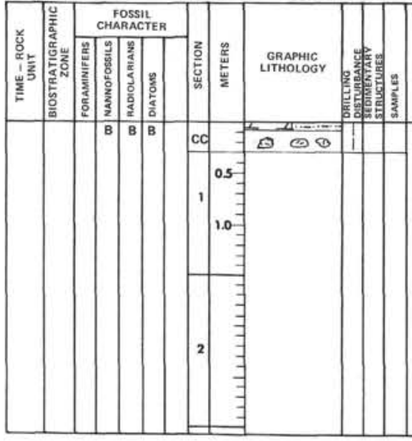
ORGANIC CARBON AND CARBONATE

	1-78
% Organic Carbon	–
% $CaCO_3$	2

SMEAR SLIDE SUMMARY

	1-34 (M,T)	1-85 (D)
TEXTURE:		
Sand	10	50
Silt	30	20
Clay	50	30
COMPOSITION:		
Quartz	15	15
Feldspar	7	5
Mica	TR	–
Heavy minerals	2	–
Clay	34	25
Glauconite	3	4
Pyrite	2	–
Carbonate unspec.	–	1
Diatoms	–	12
Sponge spicules	–	8
Lithic fragments	5	15
Dolomite	25	–
Chalcedony/ Opal-CT(?)	1	–

SITE 468 HOLE CORE 22 CORED INTERVAL 193.5–203.0 m



LITHOLOGIC DESCRIPTION

Fragments of **DOLOMITIC SILTY CLAYSTONE** followed by several pieces of vesicular **PYROXENE ANDESITE.**

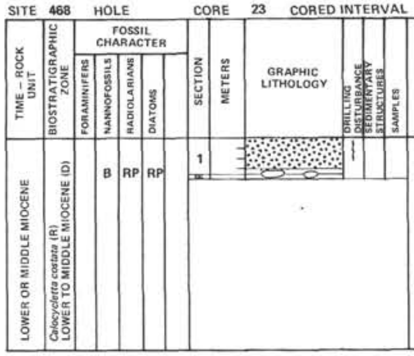
Core-Catcher only.

THIN SECTION DESCRIPTION (Pyroxene Andesite)

Glomeroporphyritic texture

Phenocrysts:		
plag.	4%	euhedral–subhedral
clinopyx.	2%	euhedral–subhedral
orthopyx.	1%	euhedral–subhedral
Groundmass:		
plag.	30%	prismatic
clinopyx.	TR	euhedral
glass	28%	
opaque	20%	anhedral
Vesicles:	15%	
Alteration:		
zeolites	TR	

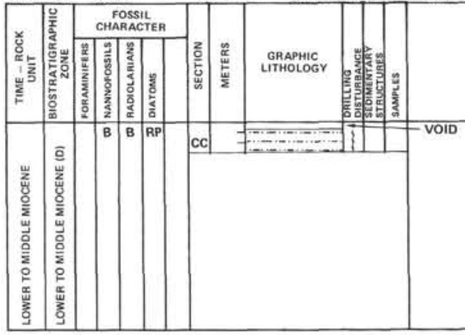
SITE 468 HOLE CORE 23 CORED INTERVAL 203.0–212.5 m



LITHOLOGIC DESCRIPTION

Drilling breccia composed of lithic fragments and sand-size quartz and feldspar. Lithic fragments are mostly volcanic – up to 8 mm across.

SITE 468 HOLE CORE 24 CORED INTERVAL 212.5–222.0 m

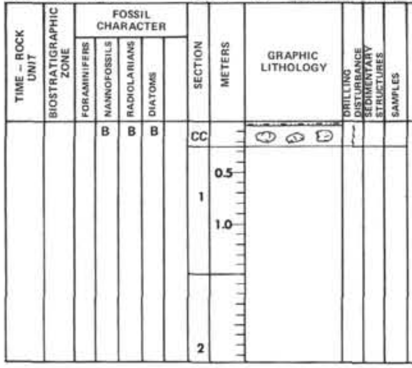


LITHOLOGIC DESCRIPTION

Drilling breccia composed of fragments of olive gray (5Y 3/2) **SILTY CLAYSTONE** and some **SANDSTONE.** Pieces 0.5–5 cm across.

Core-Catcher only.

SITE 468 HOLE CORE 25 CORED INTERVAL 222.0–231.5 m



LITHOLOGIC DESCRIPTION

Drilling breccia of olive gray (5Y 3/2) **SILTY CLAYSTONE** and three pieces of vesicular, aphanitic **ANDESITE.**

Core-Catcher only.

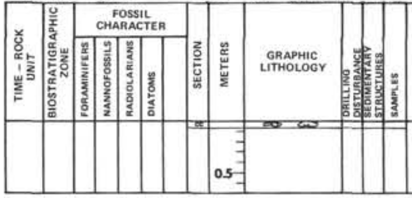
THIN SECTION DESCRIPTION (Andesite)

Hyalopilitic texture

Groundmass:

plag.	7%	0.1–0.3 mm laths
clinopyx.	TR	
glass	82%	devitrified
opaque	< 1%	
Vesicles:	10%	
Alteration:		
clays	TR	

SITE 468 HOLE CORE 26 CORED INTERVAL 231.5–241.0 m

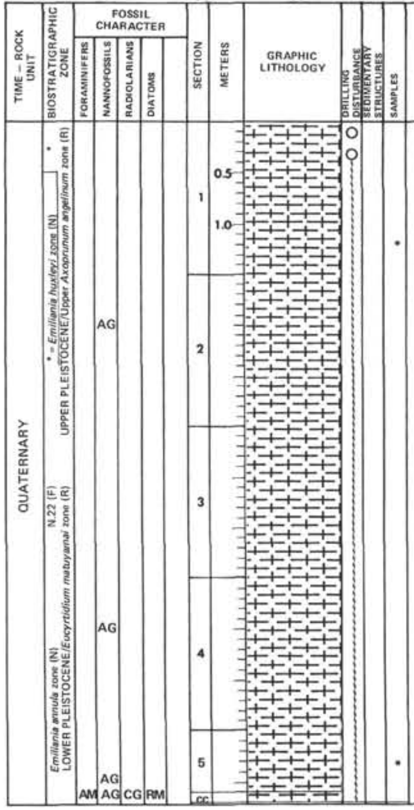


LITHOLOGIC DESCRIPTION

Two small pieces of aphanitic, vesicular **ANDESITE.**

Core-Catcher only.

SITE 468 **HOLE** A **CORE** 1 **CORED INTERVAL** 0.0–7.0 m



LITHOLOGIC DESCRIPTION

5Y 5/2

Sandy patch 10Y 4/2

Sandy patch

10Y 6/2 mottle

10Y 4/2

5Y 5/2

10Y 4/2

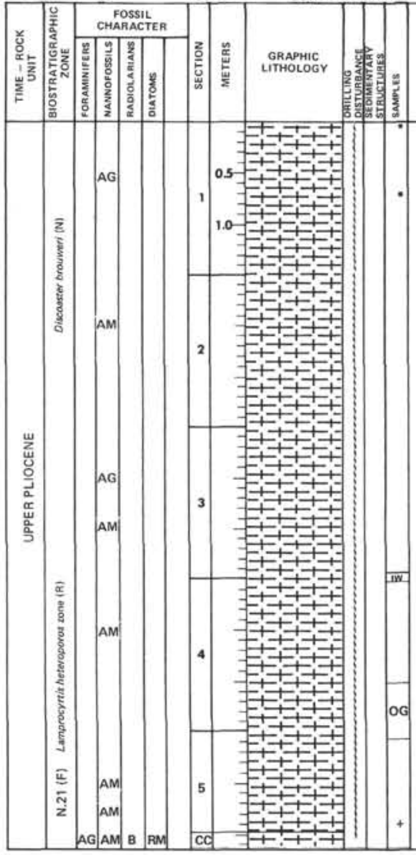
5Y 5/2

FORAMINIFERA-NANNOFOSSIL OOZE, light olive gray (5Y 5/2) with pale olive gray (10Y 6/2) and grayish olive (10Y 4/2) mottles. Scattered patches of grayish olive (10Y 4/2) **FORAMINIFERA SANDY SILT** (e.g. smear slide 1-124) contain glauconite. Small carbonized wood fragments scattered throughout core. Intense drilling deformation.

SMEAR SLIDE SUMMARY

	1-124 (M)	5-36 (D)
TEXTURE:		
Sand	35	15
Silt	42	10
Clay	23	75
COMPOSITION:		
Quartz	13	TR
Feldspar	4	TR
Mica	1	TR
Heavy minerals	2	–
Clay	5	4
Glauconite	6	TR
Pyrite	TR	–
Foraminifers	47	23
Calc. Nannofossils	18	71
Diatoms	2	TR
Radiolarians	2	1
Sponge spicules	TR	1
Silicoflagellates	TR	TR
Dolomite	TR	–

SITE 468 **HOLE** A **CORE** 2 **CORED INTERVAL** 7.0–16.5 m



LITHOLOGIC DESCRIPTION

10Y 6/2

10Y 4/2

10Y 6/2

FORAMINIFERA-NANNOFOSSIL OOZE, pale olive (10Y 6/2) with grayish olive (10Y 4/2) and light olive (10Y 5/4) mottles and streaks. Intense drilling deformation.

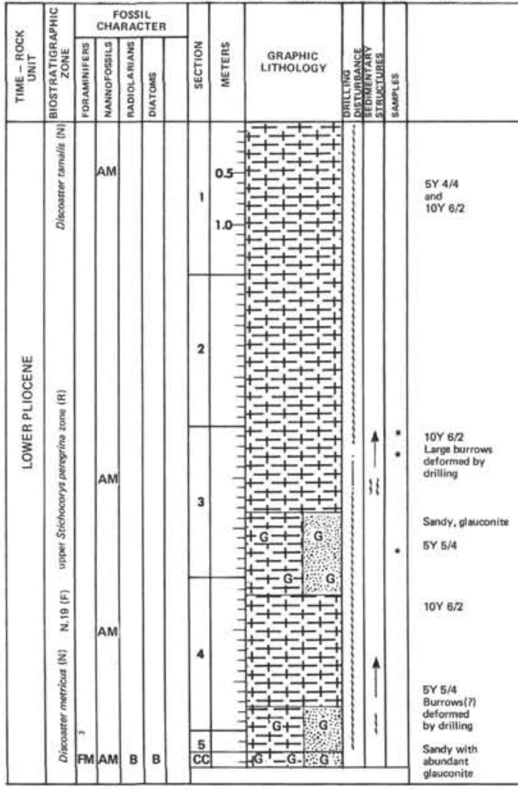
ORGANIC CARBON AND CARBONATE

	5-96
% Organic Carbon	1.40
% $CaCO_3$	57

SMEAR SLIDE SUMMARY

	1-8 (D)	1-73 (D)
TEXTURE:		
Sand	50	10
Silt	5	18
Clay	45	42
COMPOSITION:		
Quartz	1	TR
Feldspar	TR	TR
Mica	TR	TR
Heavy minerals	–	TR
Clay	7	5
Glauconite	3	TR
Pyrite	–	TR
Foraminifers	48	18
Calc. Nannofossils	38	73
Diatoms	TR	TR
Radiolarians	2	2
Sponge spicules	1	2
Silicoflagellates	–	–

SITE 468 HOLE A CORE 3 CORED INTERVAL 16.5–26.0 m



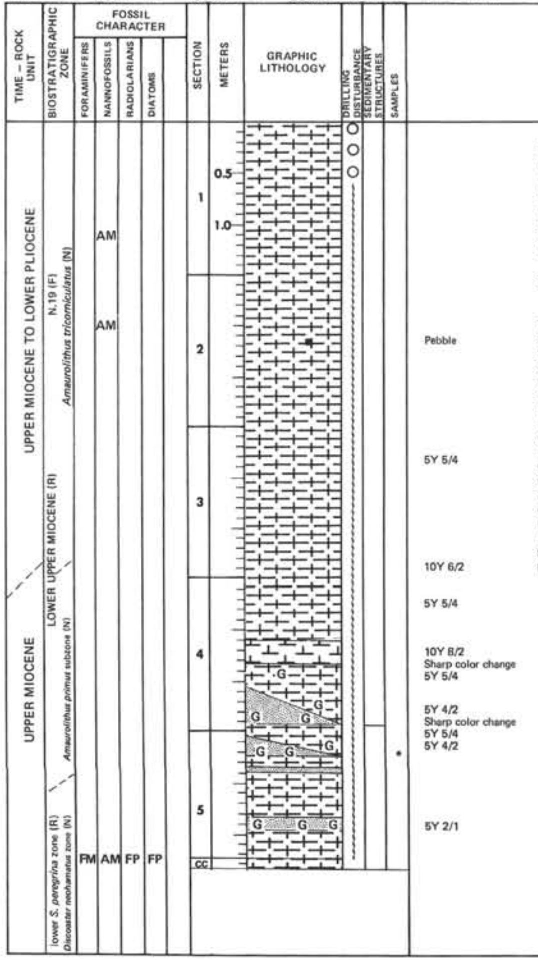
LITHOLOGIC DESCRIPTION

FORAMINIFERA-NANNOFOSSIL OOZE, pale olive (10Y 6/2) to light olive brown (5Y 5/4), lighter colors are nannofossil-rich. Ooze mixed (by drilling) with dark gray (N3) **GLAUCONITIC SILTY SAND,** especially Sections 3, 4, and 5. Base of core contains abundant glauconite. Glauconite occurs as subrounded sand-size grains. Few brown phosphatic pellets occur with glauconite in sandy intervals. Glauconitic sandy sediment probably layers disturbed and mixed by drilling. Large distorted burrows Section 3 and possible burrows base Section 4.

SMEAR SLIDE SUMMARY

	3-10 (D)	3-30 (D)	3-125 (M)
TEXTURE:			
Sand	15	15	50
Silt	10	10	30
Clay	75	75	20
COMPOSITION:			
Quartz	TR	1	15
Feldspar	TR	TR	5
Mica	TR	TR	–
Clay	3	5	5
Volcanic glass	–	–	TR
Glauconite	TR	1	35
Pyrite	–	1	2
Carbonate unspec.	5	65	5
Foraminifers	20	25	10
Calc. Nannofossils	70	–	15
Diatoms	TR	–	TR
Sponge spicules	2	1	2
Lithic fragments	–	–	5
Phos. pellet	–	–	1

SITE 468 HOLE A CORE 4 CORED INTERVAL 26.0–35.5 m



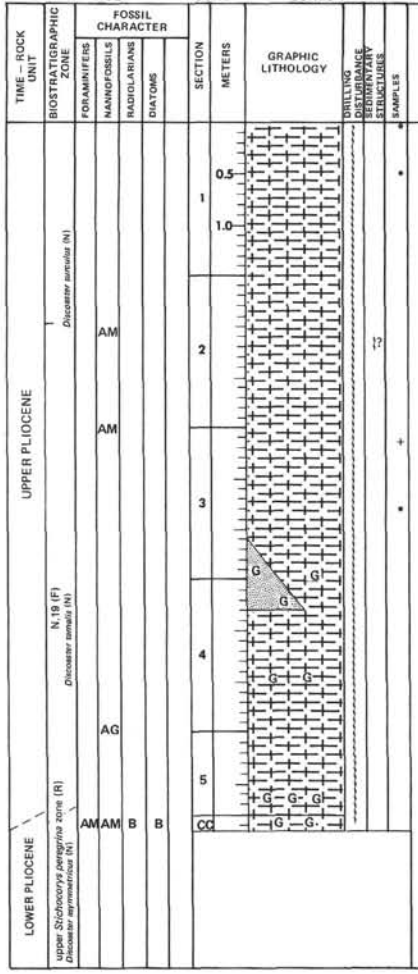
LITHOLOGIC DESCRIPTION

FORAMINIFERA-NANNOFOSSIL OOZE, light olive (10Y 5/4) and light olive brown (5Y 5/4) to yellowish gray (5Y 7/2) and pale olive (10Y 6/2); lighter colors more nannofossil-rich. Several zones of medium olive gray (5Y 4/2) and olive black (5Y 2/1) **GLAUCONITIC SANDY CLAY.** Contacts with ooze thoroughly mixed by drilling. Pale greenish yellow (10Y 8/2) **NANNOFOSSIL OOZE** Section 4, 142–150 cm.

SMEAR SLIDE SUMMARY

	5-26 (M)
TEXTURE:	
Sand	20
Silt	20
Clay	60
COMPOSITION:	
Quartz	15
Feldspar	1
Heavy minerals	1
Clay	39
Volcanic glass	2
Glauconite	25
Carbonate unspec.	5
Foraminifers	2
Calc. Nannofossils	2
Diatoms	1
Radiolarians	2
Sponge spicules	5
Phos. pellets(?)	TR

SITE 468 HOLE B CORE 1 CORED INTERVAL 16.5–26.0 m



LITHOLOGIC DESCRIPTION

10Y 6/2

5Y 6/4

FORAMINIFERA-NANNOFOSSIL OOZE, pale olive (10Y 6/2) to dusky yellow (5Y 6/4) with streaks and irregular patches of greenish black (5GY 3/1) **GLAUCONITIC SANDY CLAY** mixed by drilling. Some indistinct color mottling may be burrows deformed by drilling.

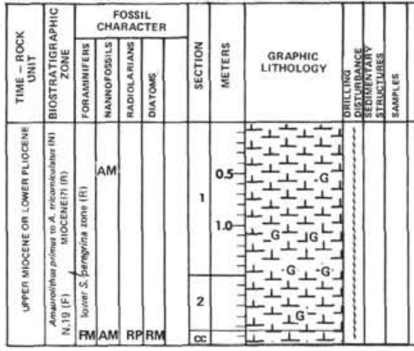
ORGANIC CARBON AND CARBONATE

	3-20
% Organic Carbon	–
% $CaCO_3$	67

SMEAR SLIDE SUMMARY

	1-3 (M)	1-50 (D)	3-85 (D)
TEXTURE:			
Sand	17	10	8
Silt	50	10	16
Clay	33	80	76
COMPOSITION:			
Quartz	8	TR	TR
Feldspar	3	TR	TR
Mica	TR	TR	TR
Heavy minerals	TR	TR	–
Clay	5	4	8
Glauconite	3	1	1
Pyrite	TR	–	–
Carbonate unspec.	6	2	–
Foraminifers	28	16	22
Calc. Nannofossils	47	76	68
Radiolarians	–	–	1
Sponge spicules	TR	–	TR
Silicoflagellates	–	TR	TR

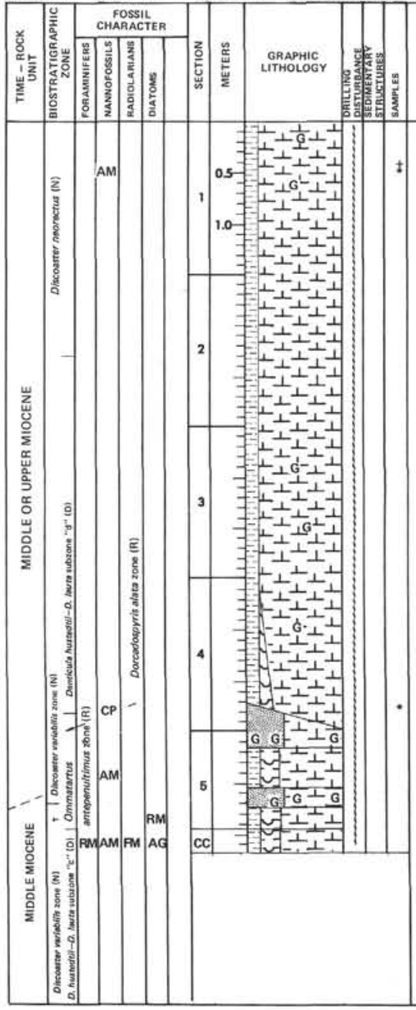
SITE 468 HOLE B CORE 2 CORED INTERVAL 26.0–35.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, pale olive (10Y 6/2) with grayish olive (10Y 4/2) and patches of greenish black (5GY 3/1) **GLAUCONITIC SANDY CLAY.** Intense drilling deformation.

SITE 468 HOLE B CORE 3 CORED INTERVAL 35.5–45.0 m



LITHOLOGIC DESCRIPTION

5Y 5/2

5Y 7/2

5Y 5/2

5GY 3/1

5Y 5/2

Sharp color change
5GY 3/1
Sharp color change
5Y 5/2

CLAYEY NANNOFOSSIL OOZE, light olive gray (5Y 5/2) to yellowish gray (5Y 7/2) becoming more diatomaceous base Section 4 to Section 5. Greenish black (5GY 3/1) **GLAUCONITIC SANDY CLAY** streaks, patches and zones scattered throughout but most abundant base Section 4 and Section 5. Sharp color changes mark contacts between nannofossil-rich and glauconitic sediments Section 5. Intense drilling disturbance.

ORGANIC CARBON AND CARBONATE

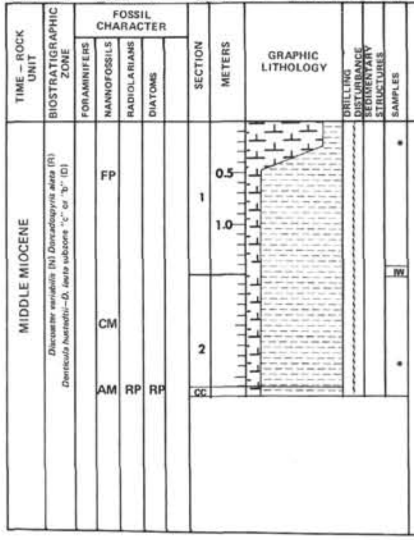
	1-40
% Organic Carbon	–
% $CaCO_3$	33

SMEAR SLIDE SUMMARY

	1-50 (D)	4-130 (D)
TEXTURE:		
Sand	4	7
Silt	12	25
Clay	84	68
COMPOSITION:		
Quartz	6	3
Feldspar	1	1
Mica	TR	TR
Heavy minerals	TR	TR
Clay	5	18
Glauconite	1	1
Carbonate unspec.	6	15
Foraminifers	4	TR
Calc. Nannofossils	80	40
Diatoms	–	18
Sponge spicules	–	3
Silicoflagellates	1	TR

† = *Discoaster kugleri* subzone (N)

SITE 468 HOLE B CORE 4 CORED INTERVAL 45.0–54.5 m



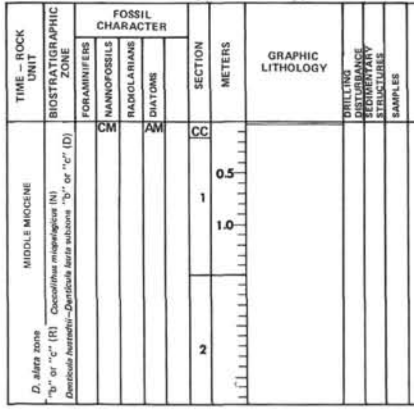
LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL OOZE, pale olive (10Y 6/2) to light olive (10Y 5/4) grades to greenish black (5G 2/1) **NANNOFOSSIL CLAY.** Drilling disturbance obscures contact. Nannofossil clay is glauconitic.

SMEAR SLIDE SUMMARY

	1-23 (M)	2-91 (D)
TEXTURE:		
Sand	–	–
Silt	2	20
Clay	98	80
COMPOSITION:		
Quartz	TR	8
Feldspar	–	2
Mica	TR	–
Clay	12	60
Glauconite	–	6
Pyrite	–	TR
Carbonate unspec.	–	2
Foraminifers	1	–
Calc. Nannofossils	85	14
Diatoms	TR	1
Radiolarians	TR	–
Sponge spicules	2	7
Silicoflagellates	–	–

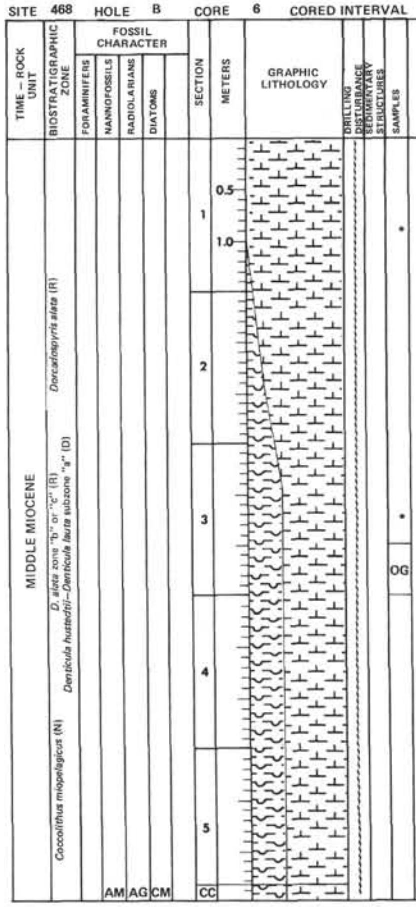
SITE 468 HOLE B CORE 5 CORED INTERVAL 54.5–64.0 m



LITHOLOGIC DESCRIPTION

Traces of **DIATOM-NANNOFOSSIL OOZE** in Core-Catcher.

SITE 468 HOLE B CORE 6 CORED INTERVAL 64.0–73.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, pale olive (10Y 6/2) changing to moderate olive brown (5Y 4/4) **DIATOM-NANNOFOSSIL OOZE** in Section 3. Intense drilling deformation.

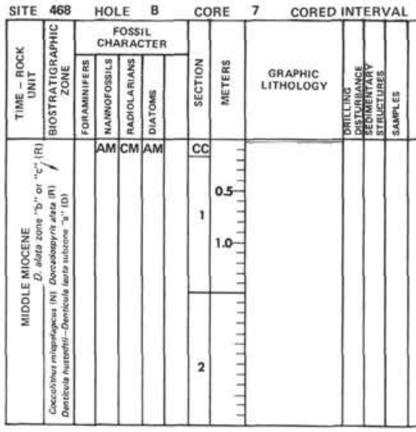
ORGANIC CARBON AND CARBONATE

	1-90
% Organic Carbon	–
% $CaCO_3$	79

SMEAR SLIDE SUMMARY

	1-90 (M)	3-78 (D)
TEXTURE:		
Sand	–	–
Silt	10	38
Clay	90	62
COMPOSITION:		
Quartz	TR	TR
Feldspar	TR	–
Mica	TR	–
Clay	8	10
Glauconite	TR	–
Foraminifers	2	2
Calc. Nannofossils	81	46
Diatoms	4	38
Radiolarians	1	1
Sponge spicules	3	3
Silicoflagellates	1	TR

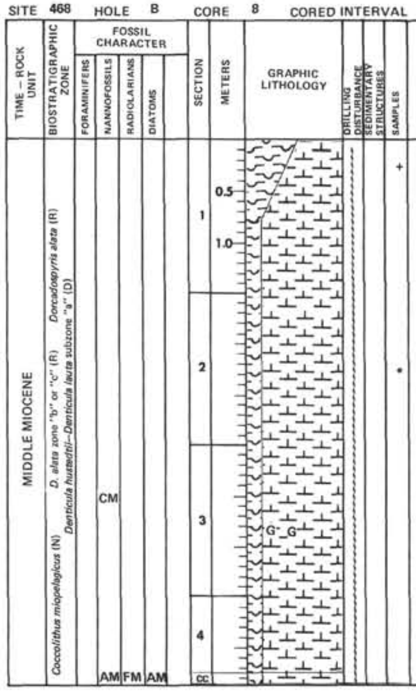
SITE 468 HOLE B CORE 7 CORED INTERVAL 73.5–83.0 m



LITHOLOGIC DESCRIPTION

Traces of **DIATOM-NANNOFOSSIL OOZE** in Core-Catcher.

SITE 468 HOLE B CORE 8 CORED INTERVAL 83.0–92.5 m



LITHOLOGIC DESCRIPTION

10Y 4/2
grades to
10Y 4/4

10Y 4/4

10Y 6/2

Dark layer,
diatom-rich

NANNOFOSSIL-DIATOMACEOUS OOZE, moderate olive brown (10Y 4/2) changing to **DIATOM-NANNOFOSSIL OOZE** in Section 1. Nannofossil ooze is moderate olive brown (10Y 4/4) to pale olive (10Y 6/2). Patches of **GLAUCONITIC SANDY CLAY** occur in Section 3, 82–91 cm. Intense drilling deformation.

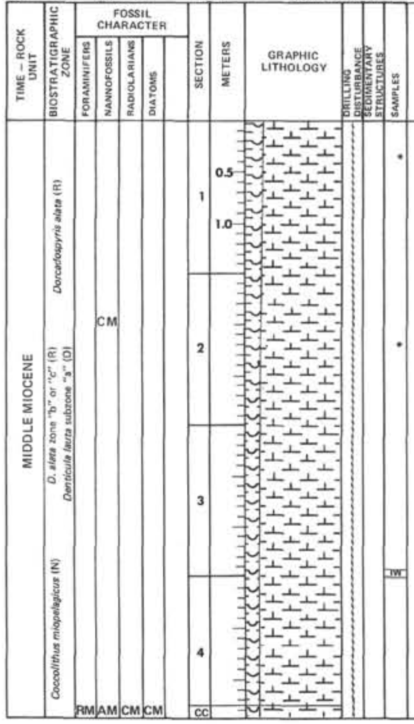
ORGANIC CARBON AND CARBONATE

	1-30
% Organic Carbon	–
% $CaCO_3$	22

SMEAR SLIDE SUMMARY

	2-80 (D)
TEXTURE:	
Sand	2
Silt	20
Clay	78
COMPOSITION:	
Quartz	TR
Feldspar	TR
Mica	TR
Heavy minerals	TR
Clay	11
Carbonate unspec.	2
Foraminifers	2
Calc. Nannofossils	67
Diatoms	9
Radiolarians	4
Sponge spicules	5
Silicoflagellates	TR

SITE 468 HOLE B CORE 9 CORED INTERVAL 92.5–102.0 m



10Y 6/2

Mottled
10Y 6/2
and
10Y 4/2

10Y 6/2

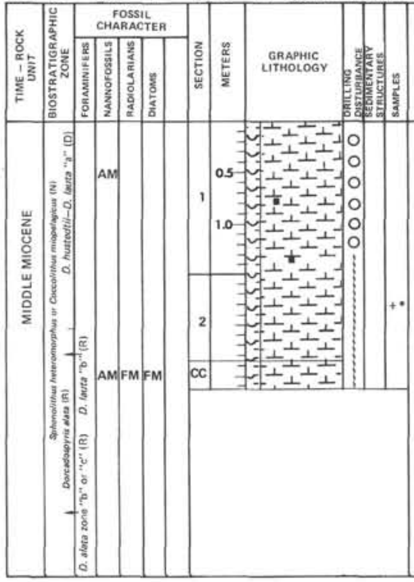
LITHOLOGIC DESCRIPTION

DIATOM-NANNOFOSSIL OOZE, pale olive (10Y 6/2) to grayish olive (10Y 4/2), intense mottling in Section 2 due to drilling disturbance. Darker colored sediments more diatom-rich. Scattered streaks of **GLAUCONITIC SANDY CLAY** and occasional sponge fragments. Intense drilling deformation.

SMEAR SLIDE SUMMARY

	1-40 (D)	2-74 (D)
TEXTURE:		
Sand	5	5
Silt	25	25
Clay	70	70
COMPOSITION:		
Quartz	2	5
Feldspar	1	2
Mica	TR	TR
Heavy minerals	TR	TR
Clay	7	11
Glauconite	3	3
Pyrite	2	2
Carbonate unspec.	5	5
Foraminifers	5	5
Calc. Nannofossils	45	49
Diatoms	20	10
Sponge spicules	10	5
Plant debris	TR	2
Lithic fragments	TR	–

SITE 468 HOLE B CORE 10 CORED INTERVAL 102.5–111.5 m



Andesite
clast

Andesite
clast

LITHOLOGIC DESCRIPTION

DIATOM-NANNOFOSSIL OOZE, pale olive to light grayish olive (10Y 5/4) with two **ANDESITE** fragments in Section 1. Intense drilling deformation.

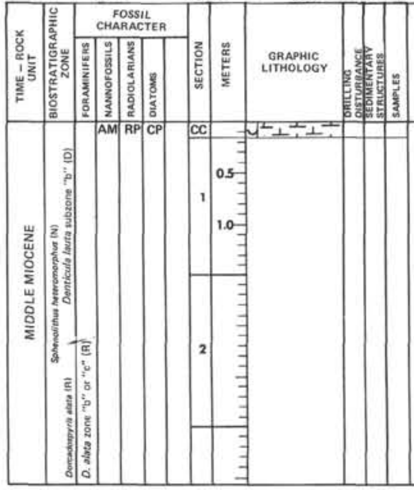
ORGANIC CARBON AND CARBONATE

	2-35
% Organic Carbon	–
% $CaCO_3$	59

SMEAR SLIDE SUMMARY

	2-35 (D)
TEXTURE:	
Sand	5
Silt	25
Clay	65
COMPOSITION:	
Quartz	2
Feldspar	TR
Mica	TR
Clay	3
Glauconite	1
Pyrite	2
Carbonate unspec.	5
Foraminifers	5
Calc. Nannofossils	65
Diatoms	4
Sponge spicules	8
Plant debris	TR
Dolomite(?)	5

SITE 468 HOLE B CORE 11 CORED INTERVAL 121.0–130.5 m

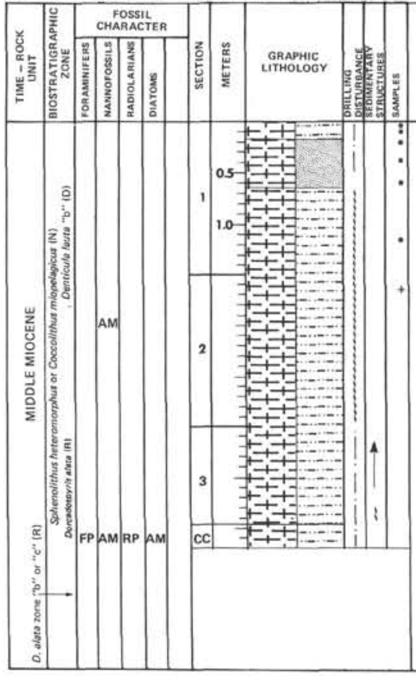


LITHOLOGIC DESCRIPTION

DIATOM-NANNOFOSSIL OOZE, light grayish olive (10Y 5/2).

Core-Catcher only.

SITE 468 HOLE B CORE 12 CORED INTERVAL 140.0–149.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAY, gray (5Y 3/2) to moderate olive borwn (5Y 4/4), with common glauconite, foraminifers and nannofossils. Burrows in Section 3. Interval of semi-lithified **CALCAREOUS SANDY CLAYSTONE,** moderate olive brown (5Y 4/4), Section 1. Much of carbonate unspecified appears to be fragments of broken foram tests.

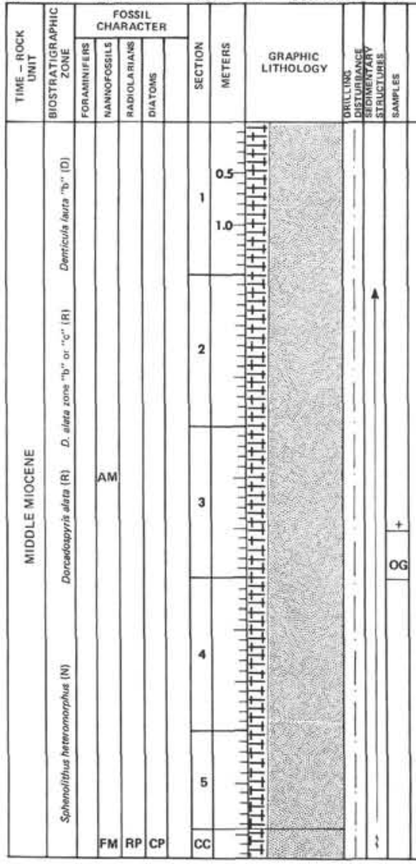
ORGANIC CARBON AND CARBONATE

	2-20
% Organic Carbon	–
% $CaCO_3$	48

SMEAR SLIDE SUMMARY

	1-4 (M)	1-10 (M)	1-25 (D)	1-43 (D)	1-66 (D)	1-120 (D)
TEXTURE:						
Sand	1	25	20	25	5	5
Silt	25	15	30	20	20	20
Clay	75	60	60	55	75	75
COMPOSITION:						
Quartz	5	3	5	10	5	2
Feldspar	–	–	–	3	–	–
Heavy minerals	1	–	–	1	–	–
Clay	20	40	30	25	40	25
Volcanic glass	–	–	–	7	–	–
Glauconite	5	2	3	5	3	2
Pyrite	–	–	–	2	–	–
Carbonate unspec.	20	25	30	20	25	20
Foraminifers	10	5	–	7	5	2
Calc. Nannofossils	20	15	20	10	35	10
Diatoms	10	10	10	2	10	10
Radiolarians	–	TR	2	–	TR	2
Sponge spicules	5	10	8	3	–	5
Silicoflagellates	–	–	–	–	2	–
Dolomite(?)	–	–	–	5	5	–

SITE 468 HOLE B CORE 13 CORED INTERVAL 159.0–168.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SANDY CLAYSTONE, moderate olive brown (5Y 4/4) and olive gray (5Y 3/2) to dark olive brown (5Y 3/4), common indistinct burrows throughout. Sediment becoming lithified.

ORGANIC CARBON AND CARBONATE

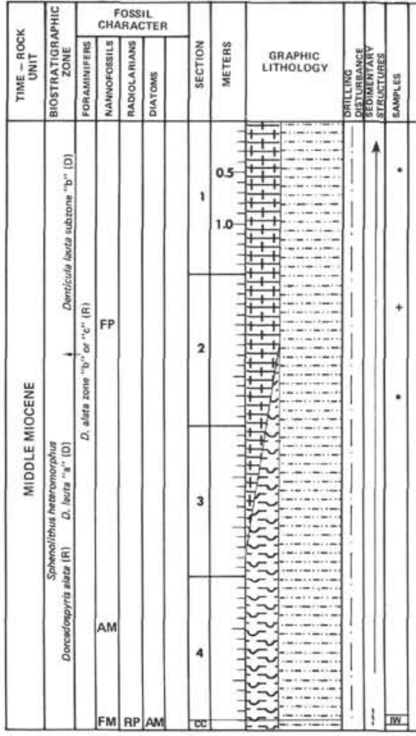
	3-94
% Organic Carbon	3.25
% $CaCO_3$	9

5Y 4/4
grades to

5Y 3/2

5Y 3/4

SITE 468 HOLE B CORE 14 CORED INTERVAL 178.0–187.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 3/2) changing to **DIATOMACEOUS SILTY CLAYSTONE,** olive black (5Y 2/2) down core. Indistinctly burrowed throughout. Abundant open vertical fractures (drilling-induced?) in Sections 1, 3, and 4.

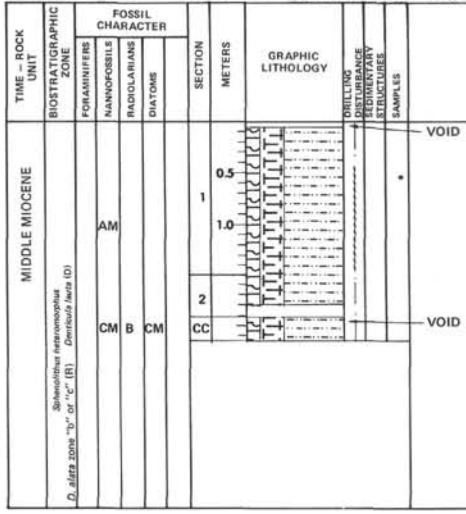
ORGANIC CARBON AND CARBONATE

	2-38
% Organic Carbon	–
% $CaCO_3$	34

SMEAR SLIDE SUMMARY

	1-50 (D)	2-125 (D)
TEXTURE:		
Sand	–	–
Silt	20	25
Clay	80	75
COMPOSITION:		
Quartz	5	15
Feldspar	2	2
Mica	TR	–
Clay	45	44
Volcanic glass	–	2
Glauconite	3	3
Pyrite	3	–
Carbonate unspec.	10	4
Foraminifers	5	–
Calc. Nannofossils	10	1
Diatoms	8	20
Radiolarians	–	5
Sponge spicules	7	5
Plant debris	2	–

SITE 468 HOLE B CORE 15 CORED INTERVAL 197.0–206.5 m



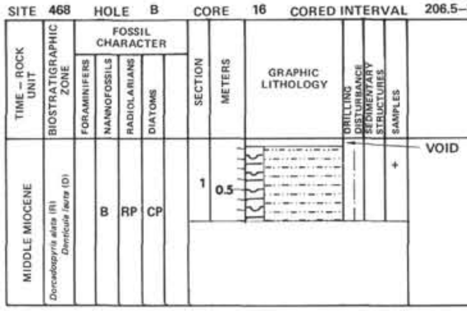
LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 3/2), with sponge fragments scattered throughout. Drilling breccia Section 1, 50–120 cm.

SMEAR SLIDE SUMMARY

	1-60 (D)
TEXTURE:	
Sand	–
Silt	40
Clay	60
COMPOSITION:	
Quartz	5
Feldspar	2
Mica	TR
Clay	35
Volcanic glass	1
Glauconite	2
Pyrite	3
Carbonate unspec.	10
Foraminifers	5
Calc. Nannofossils	13
Diatoms	15
Sponge spicules	7
Plant debris	2

SITE 468 HOLE B CORE 16 CORED INTERVAL 206.5–216.0 m



LITHOLOGIC DESCRIPTION

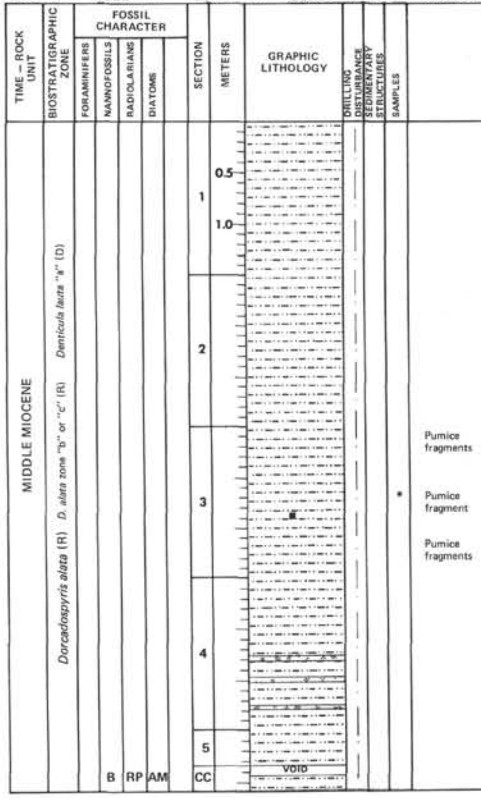
DIATOMACEOUS SILTY CLAYSTONE, olive gray (5Y 3/2).

No Core-Catcher.

ORGANIC CARBON AND CARBONATE

	1-28
% Organic Carbon	–
% $CaCO_3$	6

SITE 468 HOLE B CORE 17 CORED INTERVAL 216.0–225.5 m



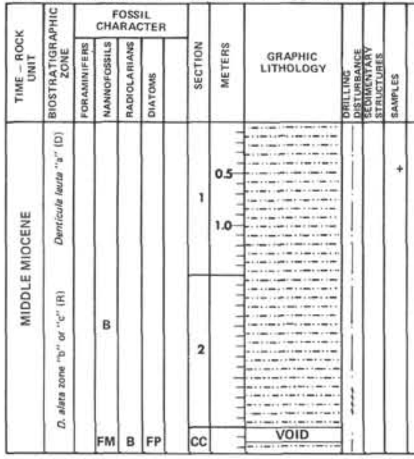
LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, olive black (5Y 2/2), with scattered pumice fragments (0.3–1 cm across) in Sections 2, 3, and 4. Large pumice fragment at 82 cm, Section 3. Thin layers of **ASH,** Section 4. Open drilling fractures throughout.

SMEAR SLIDE SUMMARY

	3-70 (D)
TEXTURE:	
Sand	–
Silt	45
Clay	55
COMPOSITION:	
Quartz	7
Feldspar	3
Mica	TR
Clay	55
Volcanic glass	5
Glauconite	2
Pyrite	3
Carbonate unspec.	5
Diatoms	7
Sponge spicules	8
Plant debris	5

SITE 468 HOLE B CORE 18 CORED INTERVAL 225.5–235.0 m



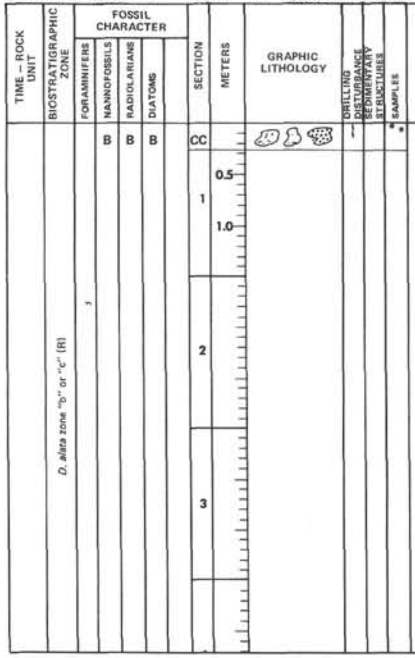
LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, dark olive gray (5Y 3/2) with scattered patches and thin layers of ash.

ORGANIC CARBON AND CARBONATE

	1-47
% Organic Carbon	–
% $CaCO_3$	22

SITE 468 HOLE B CORE 19 CORED INTERVAL 235.0–244.5 m



LITHOLOGIC DESCRIPTION

Fragments of dark gray (N3) porphyritic **DACITE**, medium dark gray (N4) zeolitic volcaniclastic **SANDSTONE**, and grayish olive (10Y 4/2) **SILTY CLAYSTONE.** Dacite and sandstone described below.

Core-Catcher only.

THIN SECTION DESCRIPTION (Dacite, 8 cm)

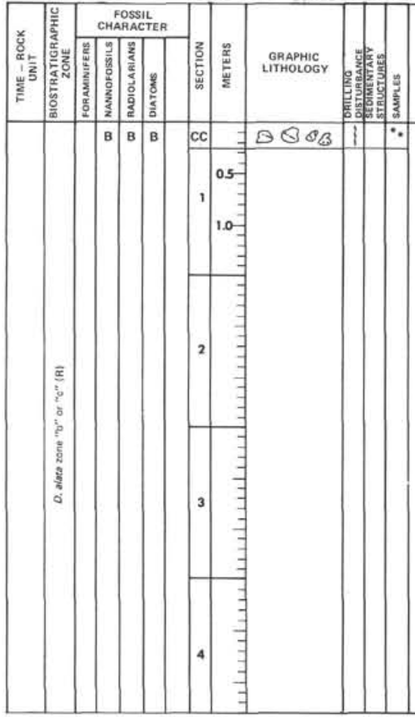
Porphyritic texture

Phenocrysts:		
plag.	5%	0.3–2 mm rounded, resorbed
Groundmass:		
plag.	30%	
glass	48%	devitrified
opaques	7%	
Vesicles:	10%	0.5–3 mm quartz and chalcedony-filled

SMEAR SLIDE SUMMARY

	CC-5 **(T, Sandstone)**
TEXTURE:	
Sand	70
Silt	20
Clay	10
COMPOSITION:	
Quartz	25
Feldspar	15
Clay	10
Volcanic glass	8
Glauconite	2
Zeolite	10
Carbonate unspec.	5
Lithic fragments	25

SITE 468 HOLE B CORE 20 CORED INTERVAL 244.5–254.0 m



LITHOLOGIC DESCRIPTION

Fragments of light olive gray (5Y 5/2) to grayish olive (10Y 4/2) **CALCAREOUS SILTY CLAYSTONE**, dark gray (N4) **VOLCANICLASTIC SANDSTONE**, and dark gray (N3) vesicular **DACITE.**

Core-Catcher only.

THIN SECTION DESCRIPTION (Dacite, 15 cm)

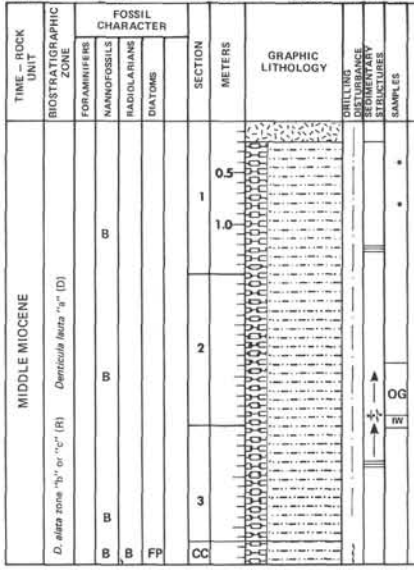
Porphyritic texture

Phenocrysts:		
plag.	5%	0.3–2 mm subhedral
Groundmass:		
plag.	50%	
glass	31%	devitrified
quarts	TR	
opaques	7%	
Vesicles:	7%	0.2–5 mm quartz/chalcedony filled
Alteration:		
clays	TR	

SMEAR SLIDE SUMMARY

	1-10 **(T, Calcareous Silty Claystone)**
TEXTURE:	
Sand	20
Silt	70
Clay	10
COMPOSITION:	
Quartz	15
Feldspar	5
Mica	TR
Heavy minerals	TR
Clay	20
Volcanic glass	2
Glauconite	1
Pyrite	2
Carbonate unspec.	50
Lithic fragments	5

SITE 468 HOLE B CORE 21 CORED INTERVAL 254.0–263.5 m



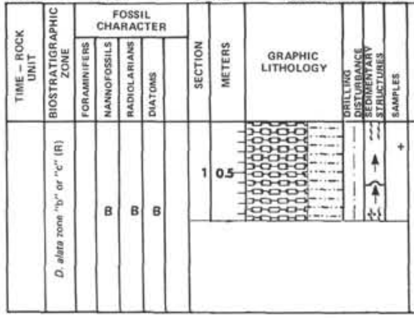
LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, dark gray (N3), with several laminated intervals. Dark gray (N3), vesicular **DACITE** in sharp contact with claystone in Section 1 (no evidence of baking). Scattered sponge fragments throughout.

SMEAR SLIDE SUMMARY

	1-44 (T)	1-81 (D)
TEXTURE:		
Sand	20	10
Silt	60	30
Clay	20	60
COMPOSITION:		
Quartz	10	17
Feldspar	8	5
Mica	TR	6
Heavy minerals	2	TR
Clay	15	38
Glauconite	1	8
Pyrite	2	–
Zeolite	–	1
Carbonate unspec.	60	25
Lithic fragments	2	–

SITE 468 HOLE B CORE 22 CORED INTERVAL 263.5–273.0 m



LITHOLOGIC DESCRIPTION

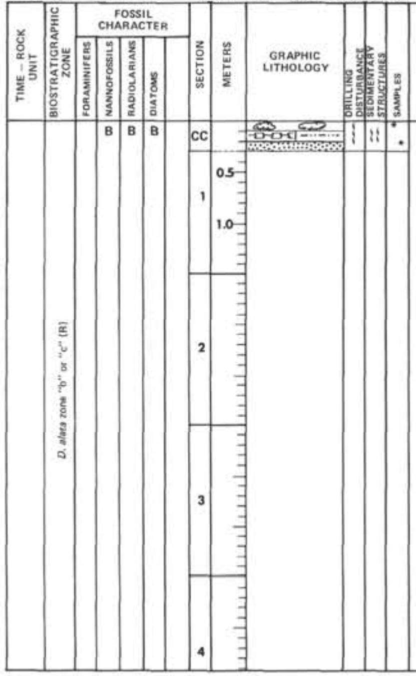
CALCAREOUS SILTY CLAYSTONE, medium gray (N5) to dark gray (N3), burrows common. Lenticular bedding near base of core and slump(?) folds and steeply dipping layers 35–60 cm.

No Core-Catcher.

ORGANIC CARBON AND CARBONATE

	1-26
% Organic Carbon	–
% $CaCO_3$	64

SITE 468 HOLE B CORE 23 CORED INTERVAL 273.0–282.5 m



LITHOLOGIC DESCRIPTION

Fragments of medium dark gray (N4), **VOLCANICLASTIC SANDSTONE**, medium gray (N5) **DACITE** and medium to dark gray (N5-N3) **CALCAREOUS SILTY CLAYSTONE.** Sandstone is moderate well-sorted, composed of pumice fragments, quartz, and feldspar. Claystone is indistinctly burrowed.

Core-Catcher only.

THIN SECTION DESCRIPTION (Dacite, 4 cm)

Porphyritic texture

Phenocrysts:

plag.	4%	0.3–2 mm subhedral

Groundmass:

plag.	50%	
glass	32%	devitrified
quartz	TR	
opaque	7%	
Vesicles:	7%	

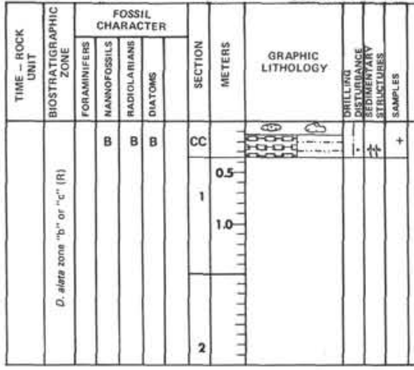
Alteration:

quartz-chalcedony fills vesicles.

SMEAR SLIDE SUMMARY

	CC-26 (M, Sandstone)
TEXTURE:	
Sand	95
Silt	4
Clay	1
COMPOSITION:	
Quartz	44
Feldspar	20
Heavy minerals	5
Glauconite	1
Lithic fragments (pumice)	30

SITE 468 HOLE B CORE 24 CORED INTERVAL 282.5–292.0 m



LITHOLOGIC DESCRIPTION

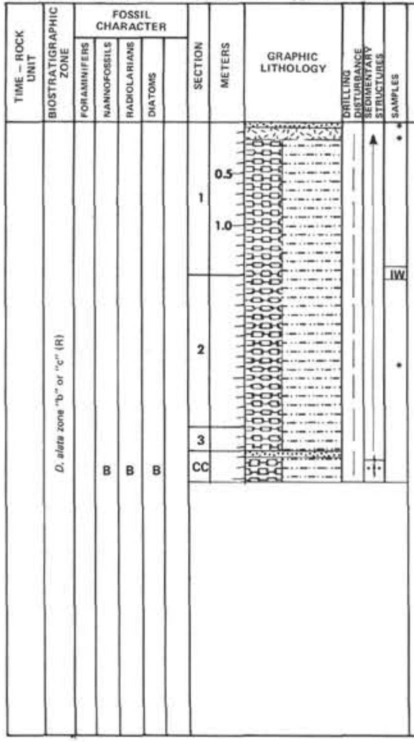
CALCAREOUS SILTY CLAYSTONE, medium dark gray (N3), burrowed with faint lenticular bedding. Scattered sponge fragments throughout. Core also contains fragments of dark gray (N3), vesicular **DACITE** and medium dark gray (N4) **VOLCANICLASTIC SANDSTONE.** Sandstone composed of pumice lapilli, subangular grains of quartz, feldspar, and other volcanic lithic fragments.

Core-Catcher only.

ORGANIC CARBON AND CARBONATE

	CC-22
% Organic Carbon	–
% $CaCO_3$	57

SITE 468 HOLE B CORE 25 CORED INTERVAL 292.0–301.5 m



LITHOLOGIC DESCRIPTION

Sand-filled burrows

CALCAREOUS SILTY CLAYSTONE, dusky brown (5YR 2/3), indistinct burrows and lenticular bedding throughout. Larger burrows filled with volcaniclastic sandstone. Scattered sponge fragments throughout. Medium dark gray (N4), coarse-grained **VOLCANICLASTIC SANDSTONE** in Section 1 and Core-Catcher contains abundant volcanic lithic fragments. Two pieces of medium light gray (N5) vesicular **PYROXENE ANDESITE** near top Section 1.

THIN SECTION DESCRIPTION

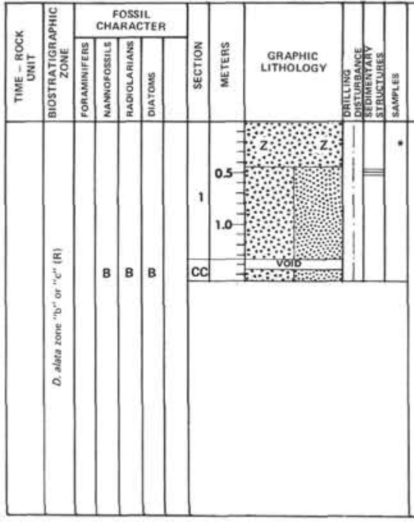
(Pyroxene Andesite, 10 and 17 cm)

Phenocrysts:	
plag.	3-15%
clinopyx.	2- 5%
orthpyx.	0- 2%
opaques	TR
Groundmass:	
plag.	10-20%
clinopyx.	10-15%
opaque	2- 5%
glass	43-67%
Vesicles:	3- 5%

SMEAR SLIDE SUMMARY

	2-90 (D)
TEXTURE:	
Sand	5
Silt	25
Clay	70
COMPOSITION:	
Quartz	7
Feldspar	5
Mica	TR
Heavy minerals	1
Clay	66
Glauconite	2
Pyrite	3
Carbonate unspec.	15
Lithic fragments	1

SITE 468 HOLE B CORE 26 CORED INTERVAL 301.5–311.0 m



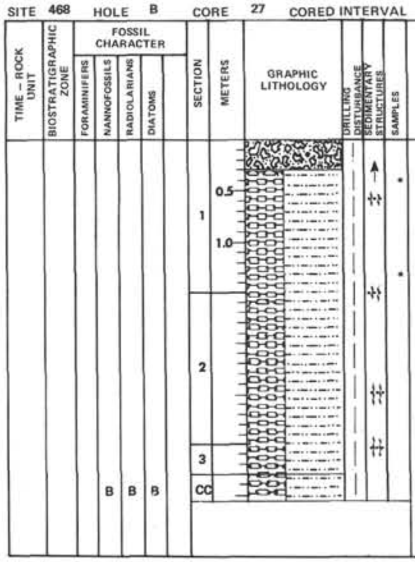
LITHOLOGIC DESCRIPTION

ZEOLITIC LAPILLI TUFF, medium gray to medium dark gray (N4-N5), moderately sorted and consisting of sand-size quartz and feldspar grain with abundant volcanic lithic fragments (pumice). Zeolite is fine silt-size lath-shaped or prismatic clinoptilolite(?). Medium dark gray (N4) **VOLCANICLASTIC SANDSTONE** underlies tuff at 43 cm. Contains abundant volcanic lithic fragments. Indistinct laminations at ~50 cm. Sandstone broken into drilling biscuits.

SMEAR SLIDE SUMMARY

	1-25 (D)
TEXTURE:	
Sand	80
Silt	15
Clay	5
COMPOSITION:	
Quartz	25
Feldspar	10
Glauconite	1
Zeolite	3
Lithic fragments (pumice)	42

SITE 468 HOLE B CORE 27 CORED INTERVAL 311.0–320.5 m



LITHOLOGIC DESCRIPTION

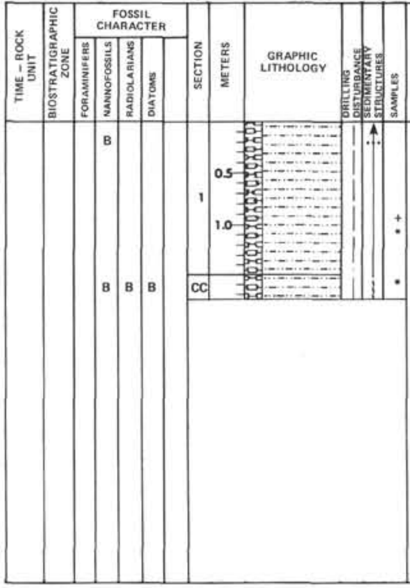
Highly fractured by drilling

LAPILLI TUFF BRECCIA, medium gray (N5), consists of large fragments of vesicular andesite in lapilli tuff composed of volcanic lithic (pumice) fragments and sand-size quartz and feldspar. Dusky yellow brown (10YR 2/2) **CALCAREOUS SILTY CLAYSTONE** occurs below breccia at 30 cm, Section 1. Lenticular bedding and indistinct burrows at several intervals. Some burrows filled with sand.

SMEAR SLIDE SUMMARY

	1-44 (T)	1-136 (M, ash)
TEXTURE:		
Sand	5	–
Silt	25	10
Clay	70	90
COMPOSITION:		
Quartz	8	6
Feldspar	5	TR
Mica	TR	–
Heavy minerals	1	4
Clay	25	50
Volcanic glass	–	40
Glauconite	1	–
Pyrite	2	–
Carbonate unspec.	55	–
Lithic fragments	3	–

SITE 468 HOLE B CORE 28 CORED INTERVAL 320.5–330.0 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, dusky yellowish brown (10YR 2/2), indistinctly burrowed throughout with some intervals of lenticular bedding. Rock is essentially carbonate-cemented silty claystone. Carbonate commonly in rhombic silt-size grains. Foraminifera molds filled with carbonate and chalcedony.

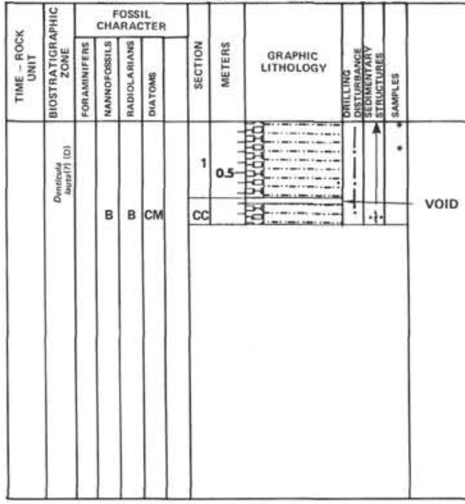
ORGANIC CARBON AND CARBONATE

	1-91
% Organic Carbon	–
% $CaCO_3$	6

SMEAR SLIDE SUMMARY

	1-110 (D)	CC (D)
TEXTURE:		
Sand	5	5
Silt	25	30
Clay	70	65
COMPOSITION:		
Quartz	5	10
Feldspar	2	5
Heavy minerals	–	1
Clay	60	40
Glauconite	1	–
Pyrite	2	2
Carbonate unspec.	30	35
Chalcedony	–	7

SITE 468 HOLE B CORE 29 CORED INTERVAL 330.0–339.5 m



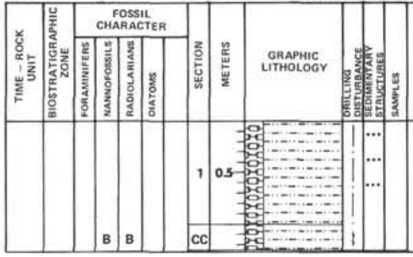
LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 3/2), indistinct lenticular bedding and burrows throughout. *Core broken and fractured by drilling.*

SMEAR SLIDE SUMMARY

	1-5 (D)	1-30 (D)
TEXTURE:		
Sand	–	5
Silt	30	30
Clay	70	65
COMPOSITION:		
Quartz	5	5
Feldspar	5	3
Clay	68	65
Volcanic glass	2	1
Glauconite	TR	1
Pyrite	2	3
Zeolite	TR	TR
Carbonate unspec.	20	20
Diatoms	TR	TR
Sponge spicules	TR	3
Plant debris	TR	5
Lithic fragments	–	4

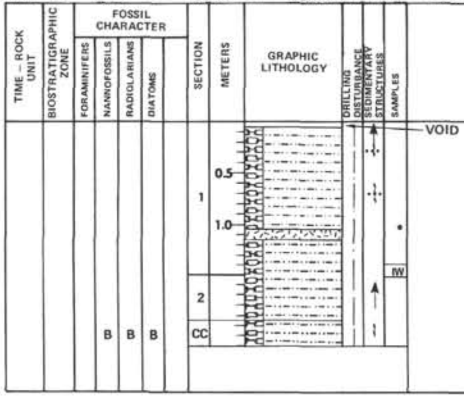
SITE 468 HOLE B CORE 30 CORED INTERVAL 339.5–340.0 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 3/2), some intervals have indistinct lenticular bedding. Core broken and fractured by drilling.

SITE 468 HOLE B CORE 31 CORED INTERVAL 340.0–358.5 m



LITHOLOGIC DESCRIPTION

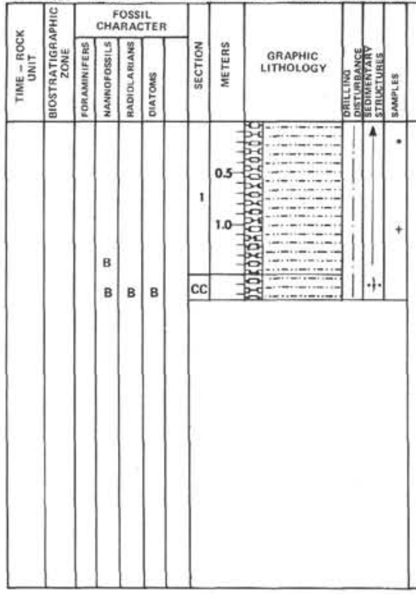
CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 3/2), indistinctly burrowed with faint lenticular bedding. Two fragments of vesicular pyroxene andesite Section 1, 106–117 cm.

THIN SECTION DESCRIPTION (Pyroxene Andesite, 1-106)

Glomeroporphyritic texture

Phenocrysts:		
plag.	15%	0.2–1 mm euhedral
clinopyx.	4%	0.2–1 mm euhedral
orthpyx.	2%	0.2–1 mm euhedral
Groundmass:		
plag.	22%	0.01–0.1 mm acicular microlites
clinopyx.	16%	0.01–0.1 mm acicular microlites
glass	30%	devitrified
opaques	5%	
Vesicles:	5%	

SITE 468 HOLE B CORE 32 CORED INTERVAL 358.5–368.0 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 3/2), indistinct burrows common and intervals of faint lenticular bedding. Occasional thin sandy layers. Core broken into drilling biscuits.

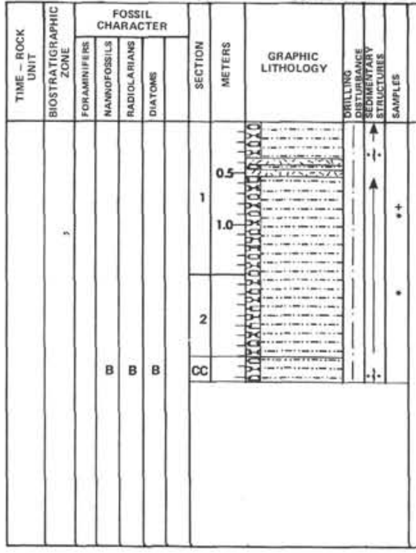
ORGANIC CARBON AND CARBONATE

	1-102
% Organic Carbon	–
% $CaCO_3$	22

SMEAR SLIDE SUMMARY

	1-25 (D)
TEXTURE:	
Sand	5
Silt	30
Clay	65
COMPOSITION:	
Feldspar	7
Mica	3
Clay	65
Volcanic glass	1
Glauconite	1
Pyrite	2
Zeolite	TR
Carbonate unspec.	15
Diatoms	TR
Sponge spicules	TR
Plant debris	2
Lithic fragments	4

SITE 468 HOLE B CORE 33 CORED INTERVAL 368.0–377.5 m



LITHOLOGIC DESCRIPTION

CALCAREOUS SILTY CLAYSTONE, olive gray (5Y 2/1) to olive black (5Y 4/1), lenticular bedding and burrows throughout. Scattered sponge fragments and pumice lapilli. Pieces of vesicular **ANDESITE** Section 1, 35–52 cm. Drilling biscuits.

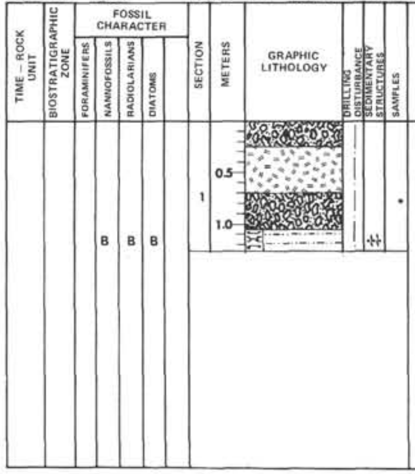
ORGANIC CARBON AND CARBONATE

	1-85
% Organic Carbon	–
% $CaCO_3$	7

SMEAR SLIDE SUMMARY

	1-96 (D)	2-22 (D)
TEXTURE:		
Sand	20	1
Silt	25	29
Clay	55	70
COMPOSITION:		
Quartz	10	5
Feldspar	5	3
Clay	57	70
Volcanic glass	TR	1
Glauconite	3	TR
Pyrite	–	1
Carbonate unspec.	10	17
Plant debris	–	1
Lithic fragments	15	2

SITE 468 HOLE B CORE 34 CORED INTERVAL 377.5–387.0 m



LITHOLOGIC DESCRIPTION

Interbedded dark gray (N3) to light brownish black (5YR 3/1) **ANDESITIC BRECCIA,** medium dark gray (N4) **LITHIC TUFF,** and olive black (5Y 2/1) **CALCAREOUS SILTY CLAYSTONE.** Breccia is lapilli tuff and some claystone with clasts of andesite. Lithic tuff composed mainly of pumice fragments. Claystone is burrowed and has lenticular bedding. Most of core broken into drilling biscuits/breccia.

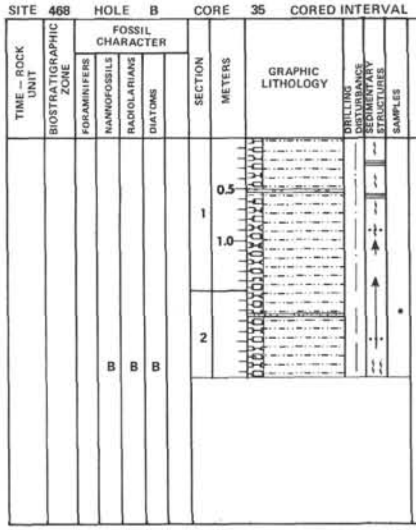
No Core-Catcher.

THIN SECTION DESCRIPTION (Andesite fragment, 1-81)

Porphyritic texture

Phenocrysts:		
plag.	3%	0.2–2 mm subhedral
clinopyx.	1%	0.2–2 mm subhedral
Groundmass:		
plag.	20%	0.01–0.1 mm acicular prisms
clinopyx.	1%	0.01–0.1 mm acicular prisms
glass	65%	
opaques	5%	0.01 mm anhedral
Vesicles:	5%	

SITE 468 HOLE B CORE 35 CORED INTERVAL 387.0–396.5 m



Large sand-filled burrow

LITHOLOGIC DESCRIPTION

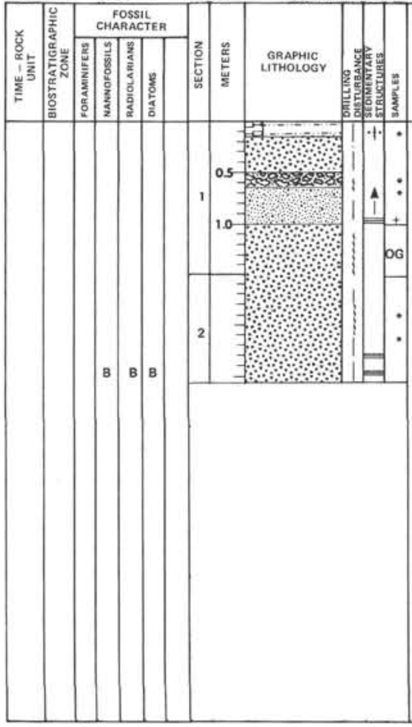
CALCAREOUS SILTY CLAYSTONE, olive black (5Y 2/1), burrowed with lenticular bedding and occasional laminations. Larger burrows often filled with tuffaceous sand. Thin tuff layer at 50–52 cm, Section 1. Zeolitic, pyrite-rich **SILTY SANDSTONE,** Section 2. Drilling biscuits.

No Core-Catcher.

SMEAR SLIDE SUMMARY

	2-25 (M)
TEXTURE:	
Sand	40
Silt	38
Clay	22
COMPOSITION:	
Quartz	25
Feldspar	10
Clay	22
Volcanic glass	3
Pyrite	15
Zeolite	5
Carbonate unspec.	10
Fish remains	TR

SITE 468 HOLE B CORE 37 CORED INTERVAL 406.0–415.5 m



LITHOLOGIC DESCRIPTION

Interbedded olive gray (5Y 3/2) **CALCAREOUS SILTY CLAYSTONE,** light olive brown (5Y 3/1) **LAPILLI TUFF,** light brownish black (5YR 3/1) **ANDESITIC BRECCIA,** and light olive brown (5Y 2/1) **VOLCANICLASTIC SILTY SANDSTONE.** Claystone is burrowed with faint lenticular bedding. Breccia consists of pebble-size clasts of vesicular andesite set in lapilli tuff rich in pumice fragments. Volcaniclastic silty sandstone is laminated with several thin layers of lapilli tuff. Carbonate cement and glauconite present in sandstone. Base of tuff in Section 2 (50–105 cm) is sandy. No obvious grading in sandy/volcaniclastic units. Most contacts destroyed by drilling.

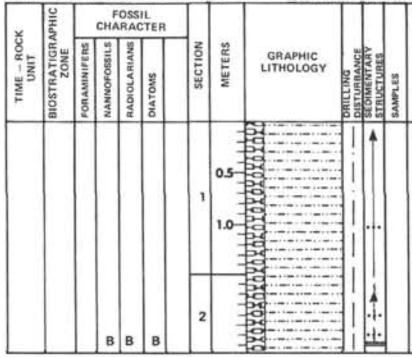
ORGANIC CARBON AND CARBONATE

	1-97
% Organic Carbon	0.44
% $CaCO_3$	8

SMEAR SLIDE SUMMARY

	1-13 (D)	1-68 (T)	1-73 (D)	2-48 (T)	2-70 (D)
TEXTURE:					
Sand	5	15	40	70	40
Silt	30	50	30	30	30
Clay	65	35	30	–	30
COMPOSITION:					
Quartz	7	2	10	15	10
Feldspar	5	5	5	5	7
Mica	TR	–	TR	–	TR
Heavy minerals	–	–	TR	–	TR
Clay	65	–	30	–	30
Volcanic glass	–	70	20	–	15
Glauconite	1	–	2	3	TR
Pyrite	–	–	–	2	–
Micronodules	–	7	–	–	–
Zeolite	–	–	5	5	5
Carbonate unspec.	15	3	15	15	15
Foraminifera	–	5	–	–	–
Lithic fragments	5	8	10	55	15

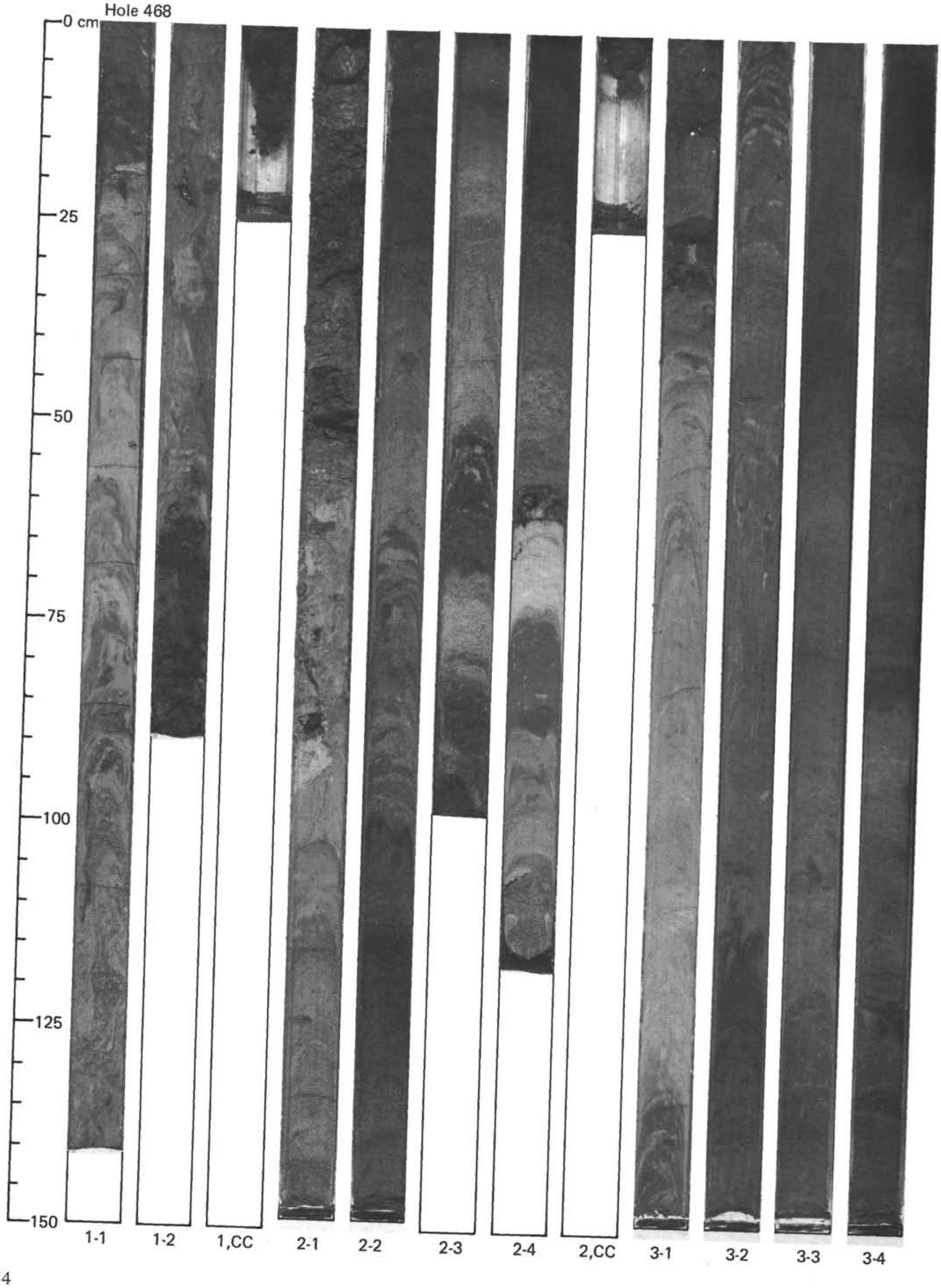
SITE 468 HOLE B CORE 36 CORED INTERVAL 396.5–406.0 m

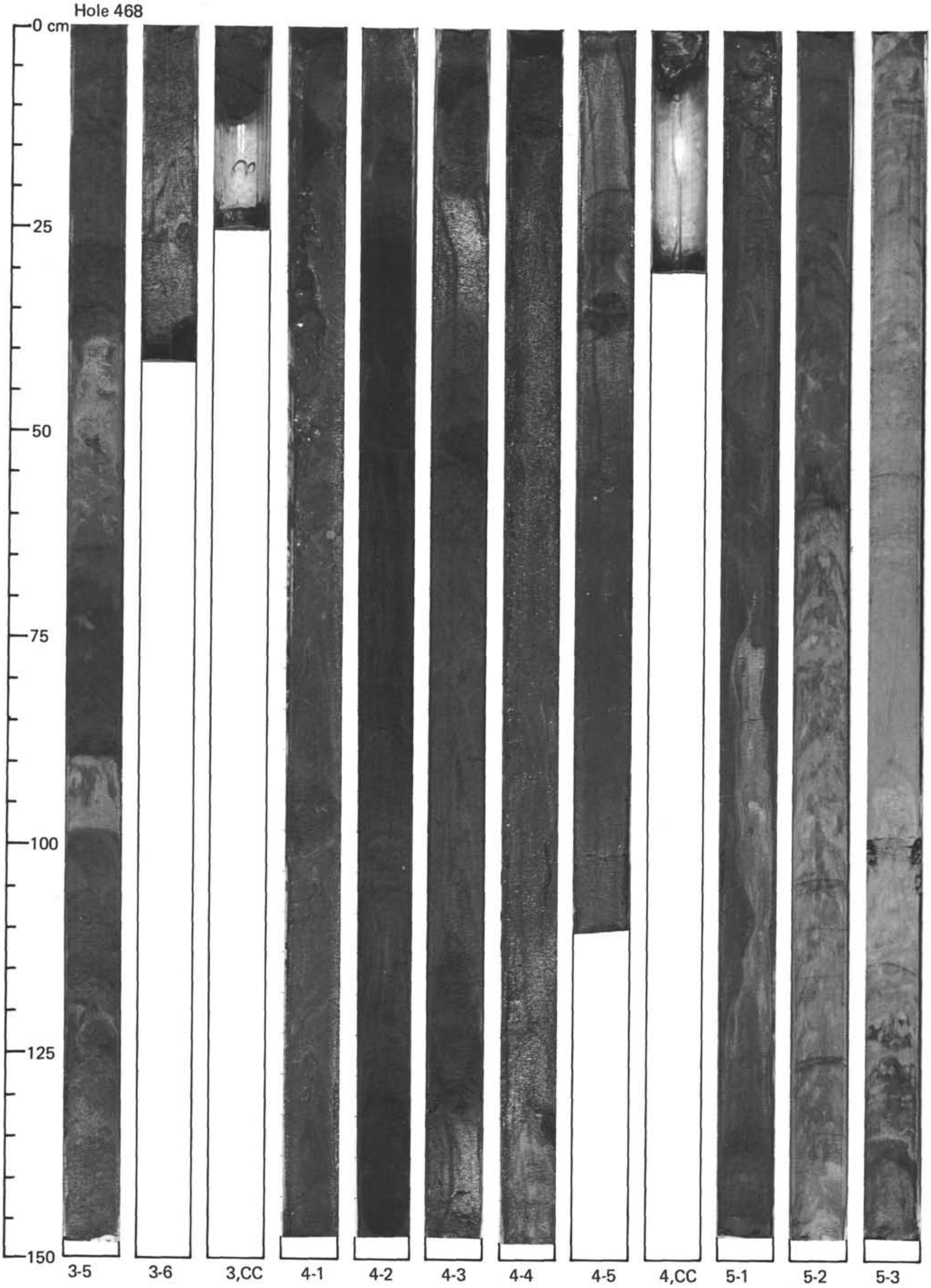


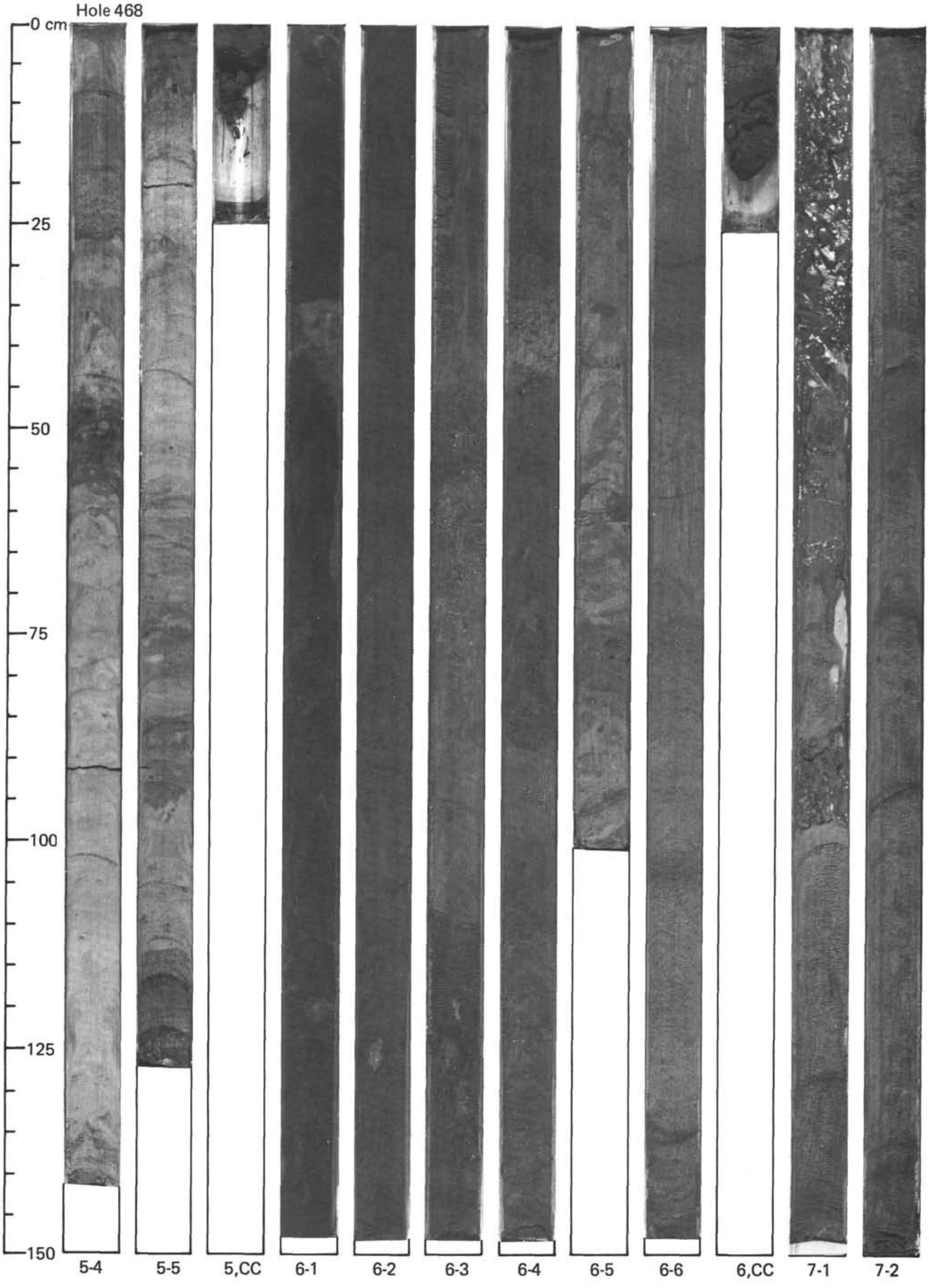
LITHOLOGIC DESCRIPTION

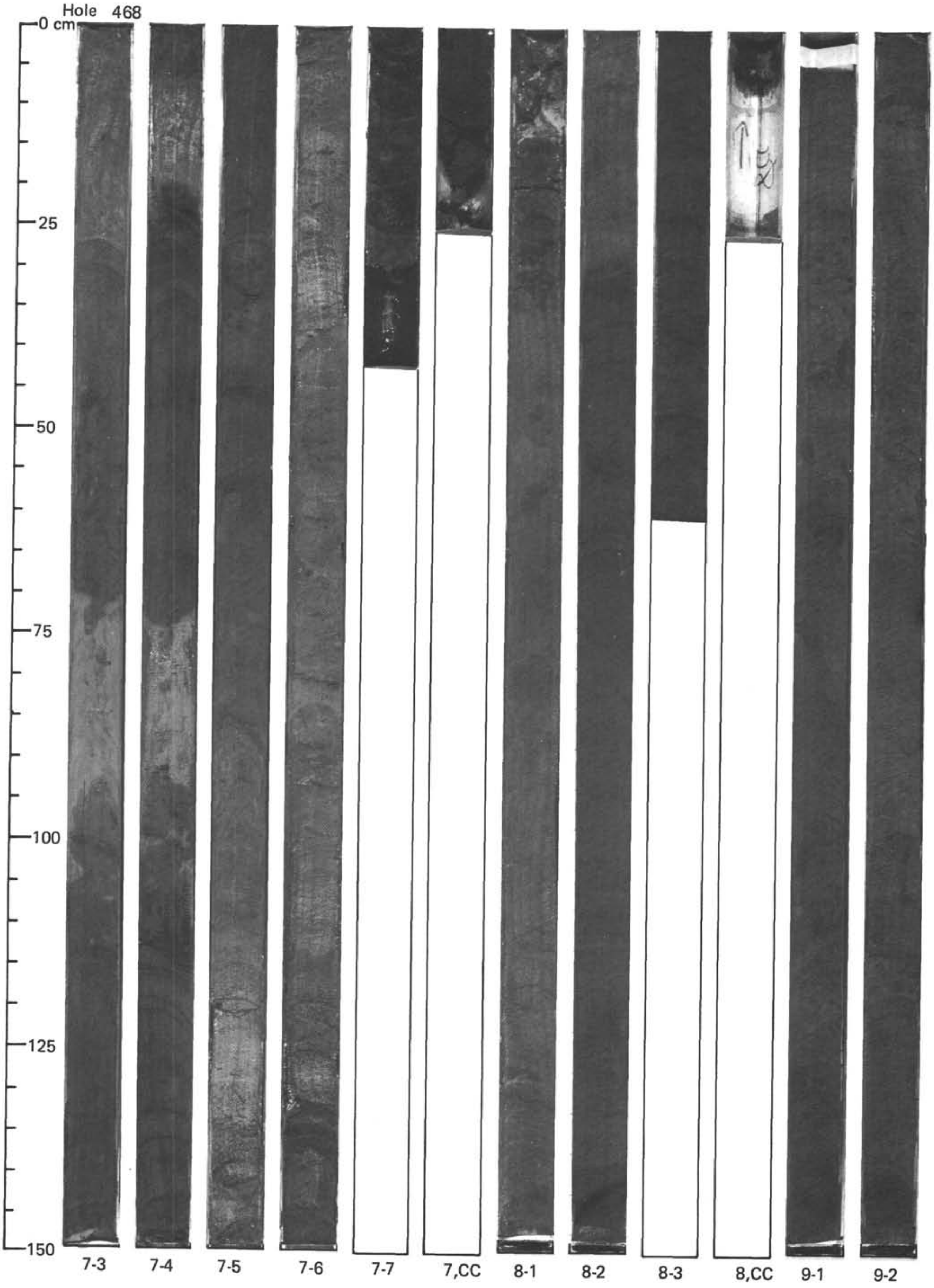
CALCAREOUS SILTY CLAYSTONE, olive black (5Y 2/1), burrowed throughout with some lenticular bedding and occasional laminations. Some burrows filled with tuffaceous sand. Scattered pumice lapilli. 0–90 cm, Section 1, broken by drilling.

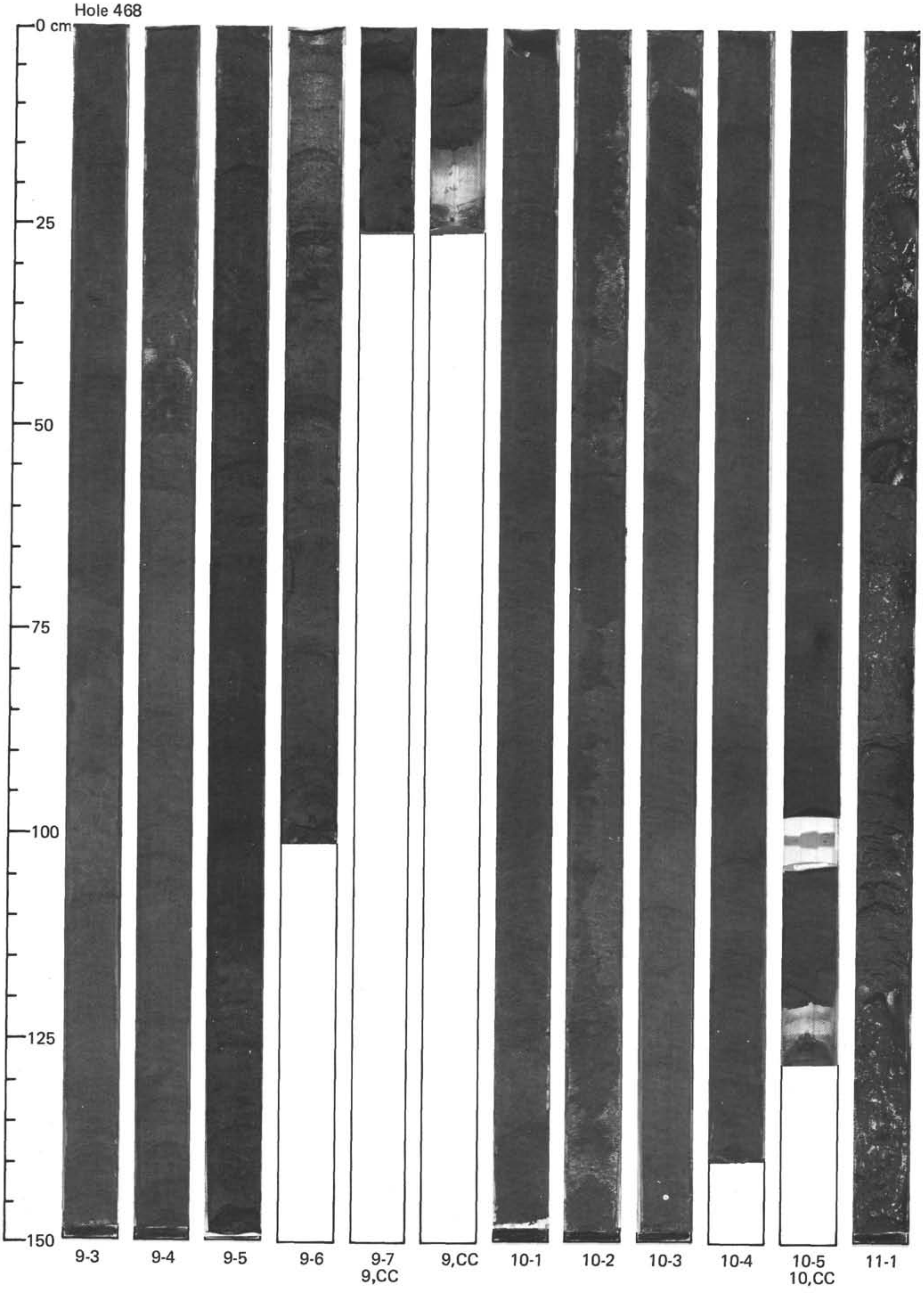
No Core-Catcher.


Hole 468
0 cm
25
50
75
100
125
150
1-1
1-2
1,CC
2-1
2-2
2-3
2-4
2,CC
3-1
3-2
3-3
3-4

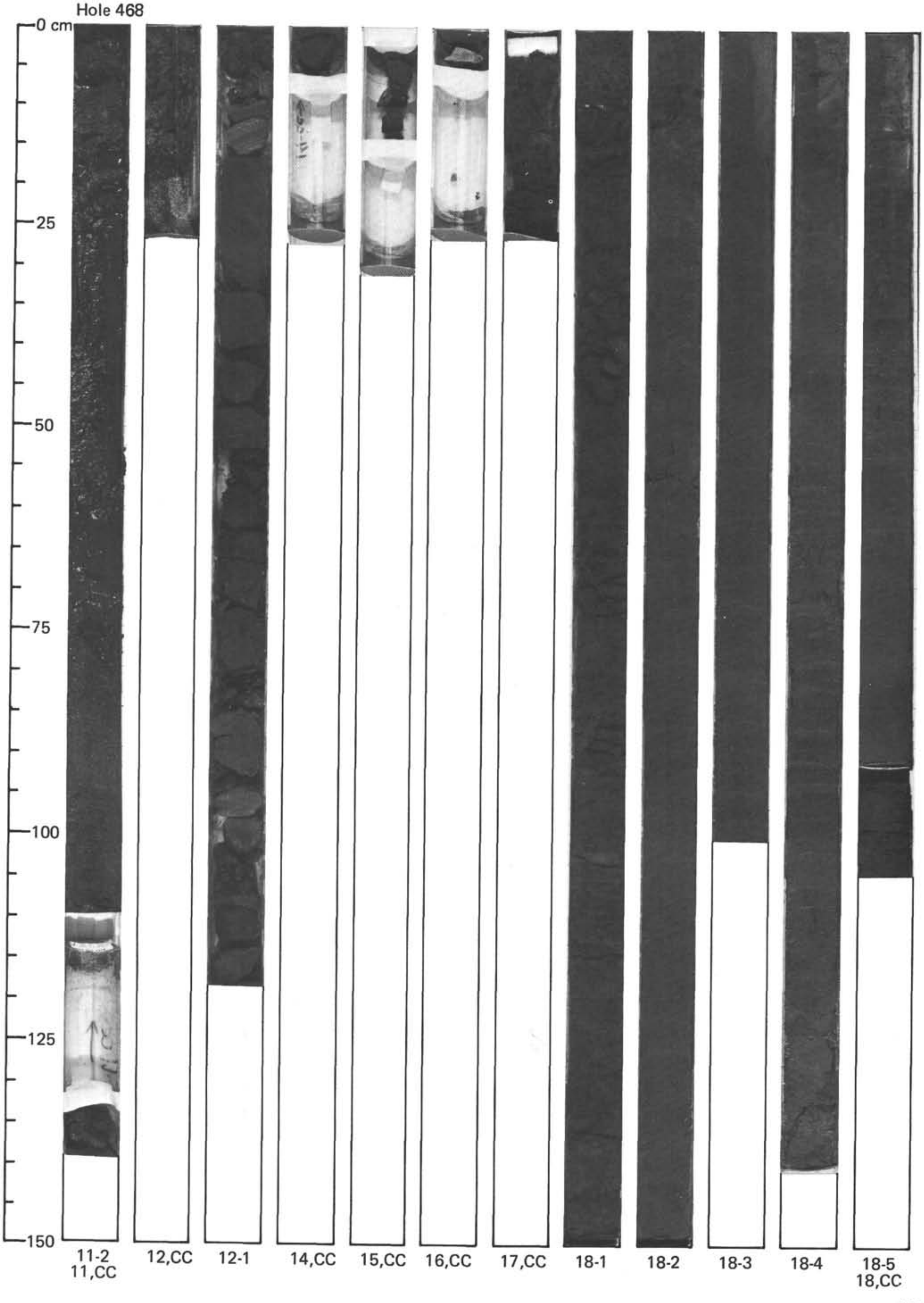

Hole 468
0 cm
25
50
75
100
125
150
3-5
3-6
3,CC
4-1
4-2
4-3
4-4
4-5
4,CC
5-1
5-2
5-3

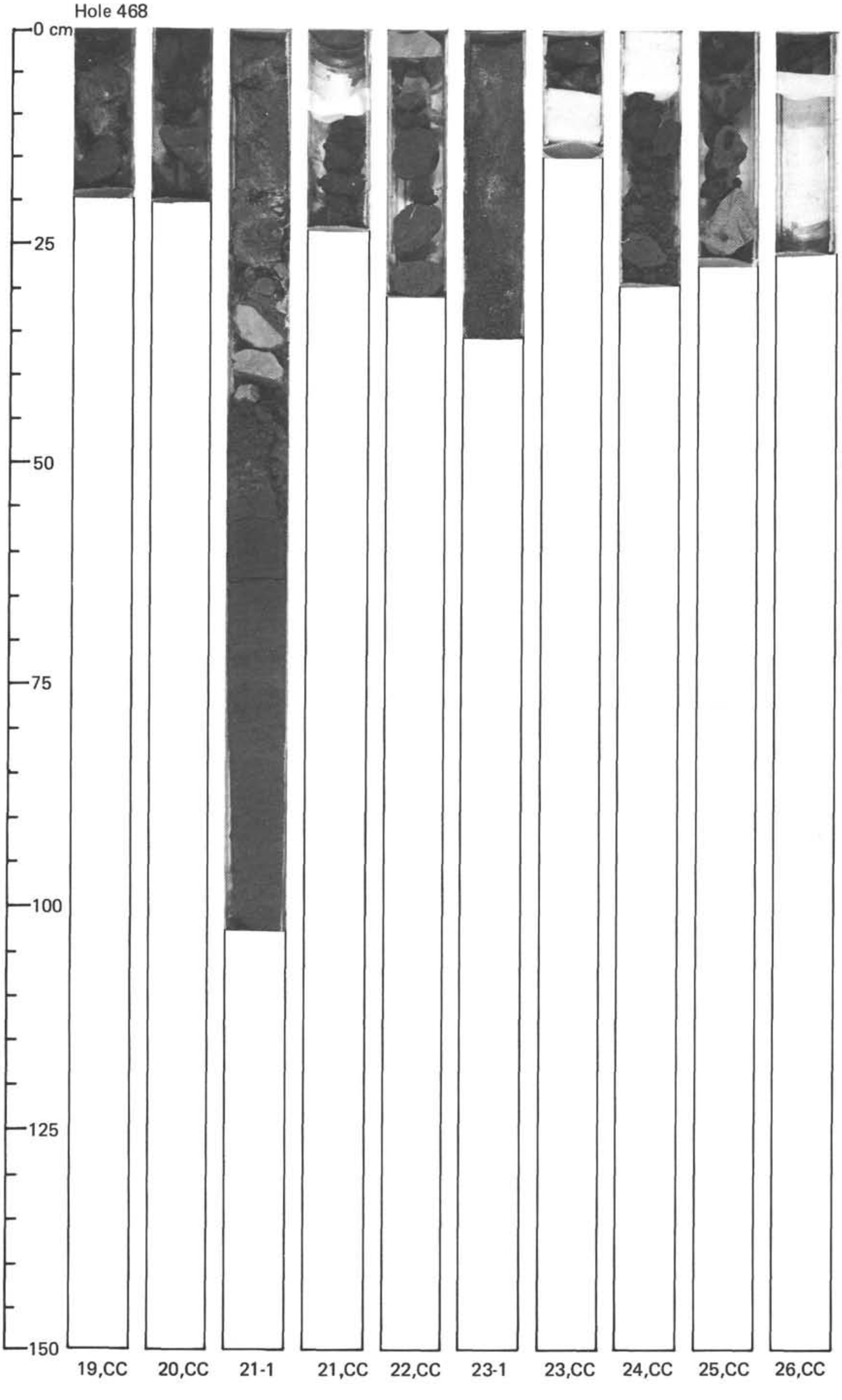

Hole 468
0 cm
25
50
75
100
125
150
5-4
5-5
5,CC
6-1
6-2
6-3
6-4
6-5
6-6
6,CC
7-1
7-2

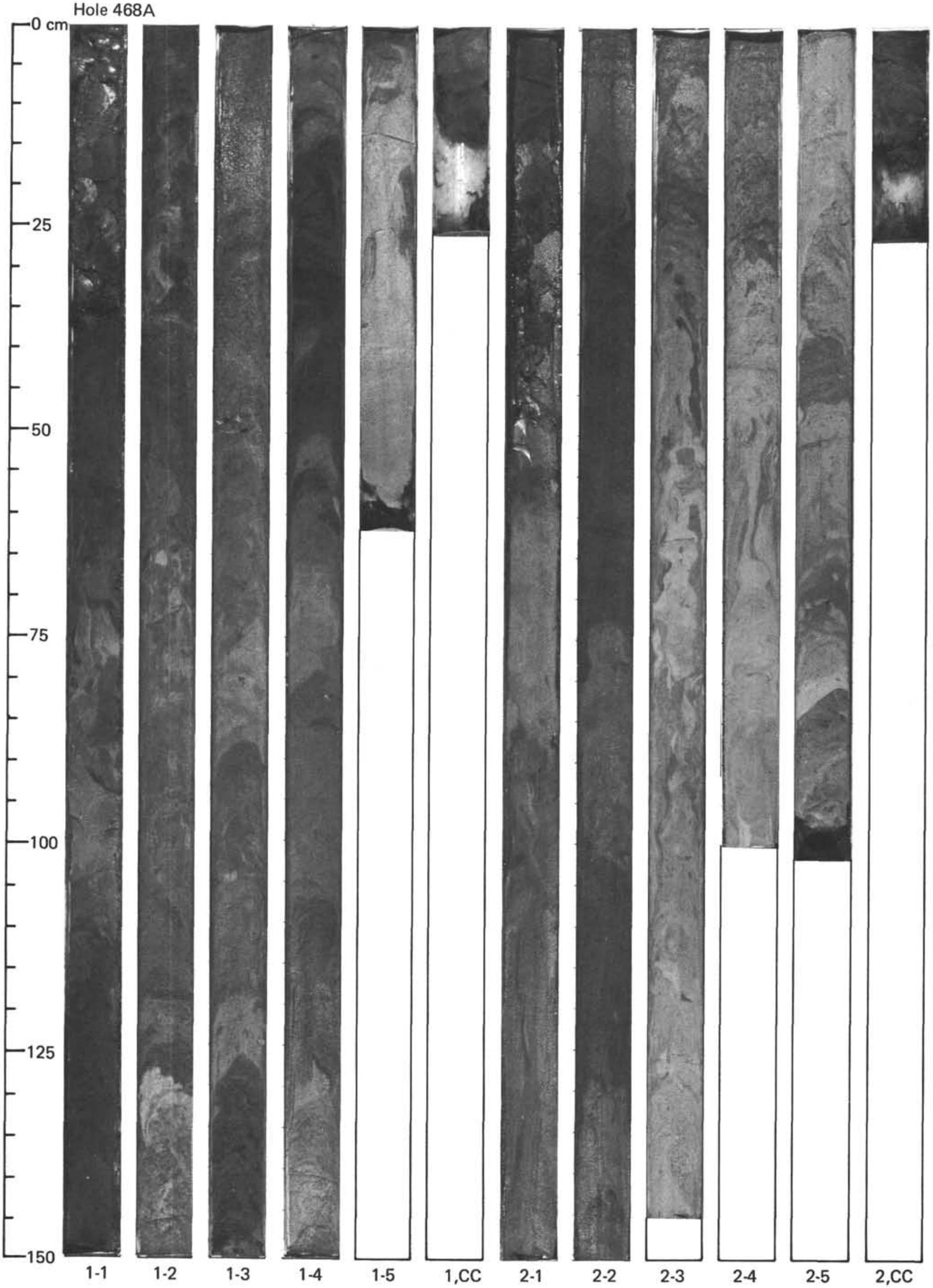

Hole 468
0 cm
25
50
75
100
125
150
7-3
7-4
7-5
7-6
7-7
7,CC
8-1
8-2
8-3
8,CC
9-1
9-2

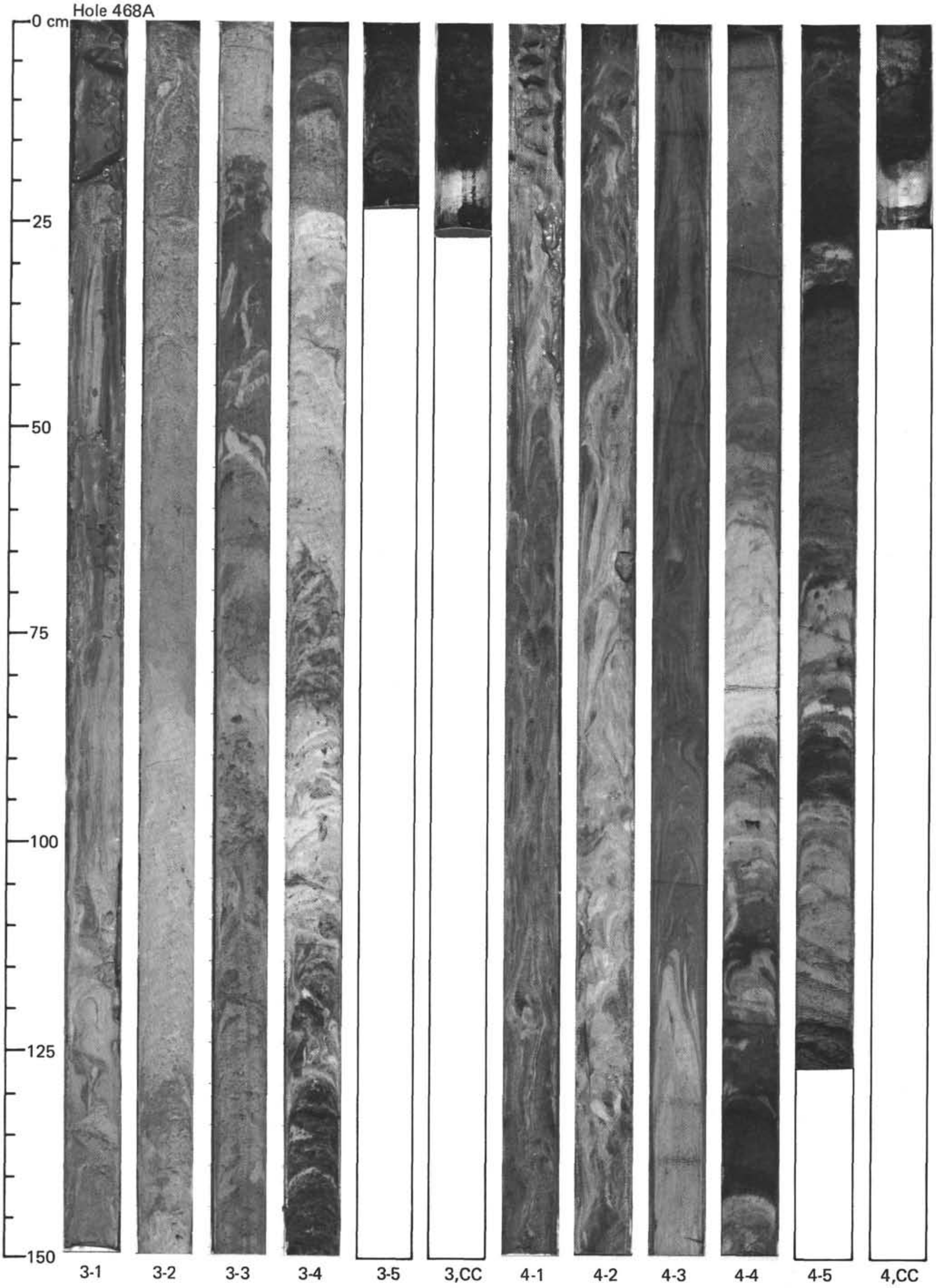


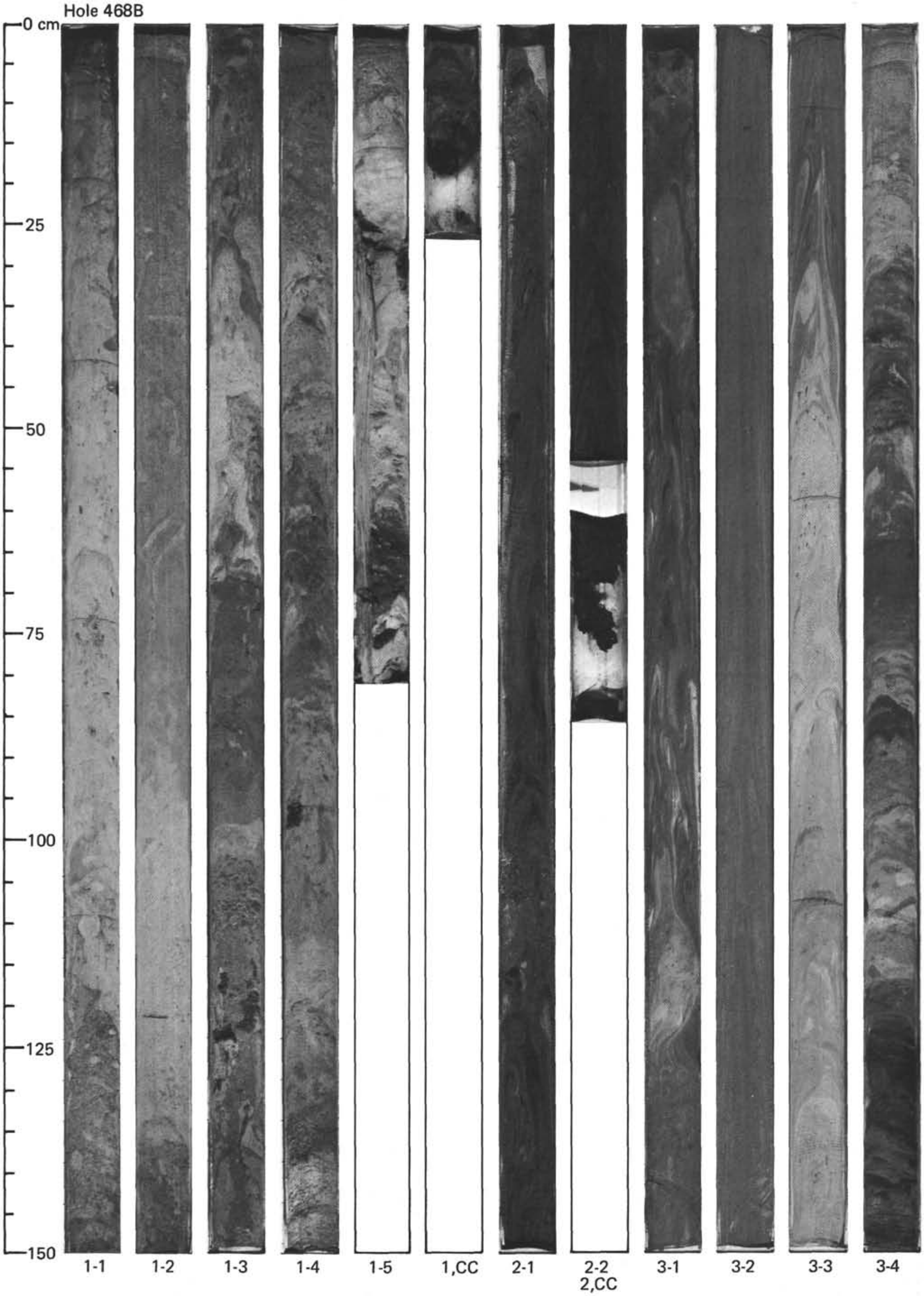
Hole 468
0 cm
25
50
75
100
125
150
9-3
9-4
9-5
9-6
9-7
9,CC
9,CC
10-1
10-2
10-3
10-4
10-5
10,CC
11-1

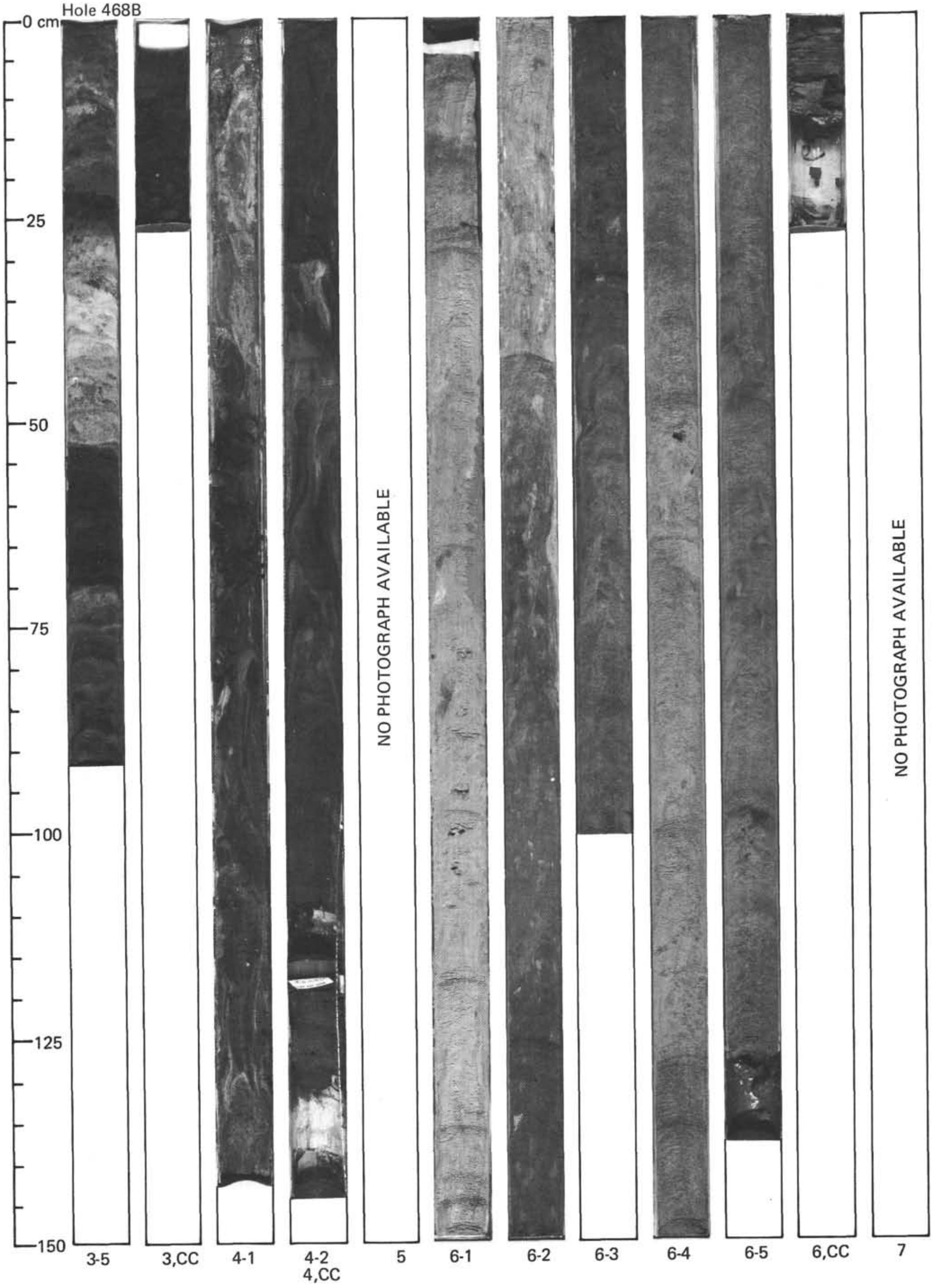

Hole 468
0 cm
25
50
75
100
125
150
11-2
11,CC
12,CC
12-1
14,CC
15,CC
16,CC
17,CC
18-1
18-2
18-3
18-4
18-5
18,CC

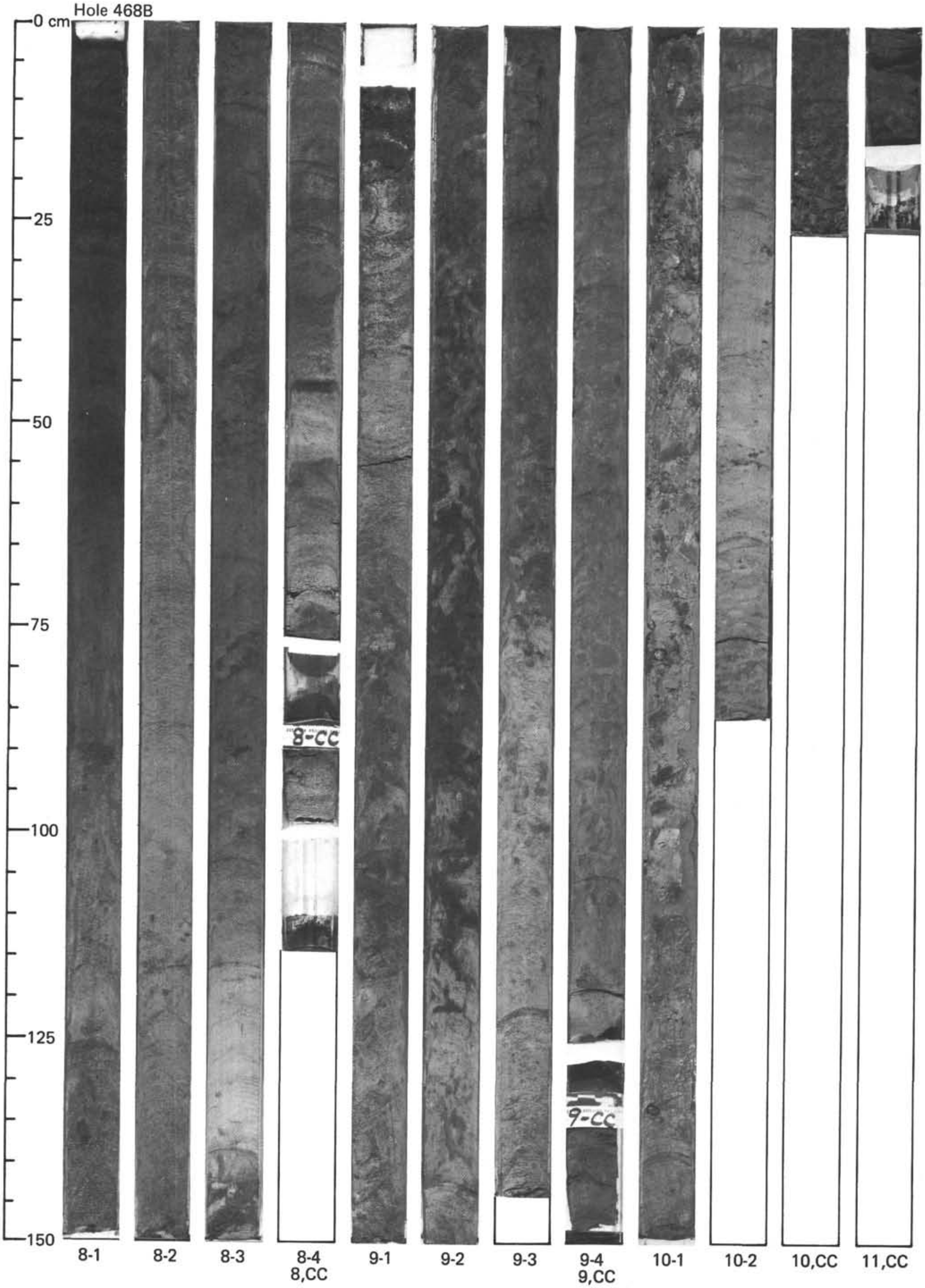

Hole 468
0 cm
25
50
75
100
125
150
19,CC
20,CC
21-1
21,CC
22,CC
23-1
23,CC
24,CC
25,CC
26,CC

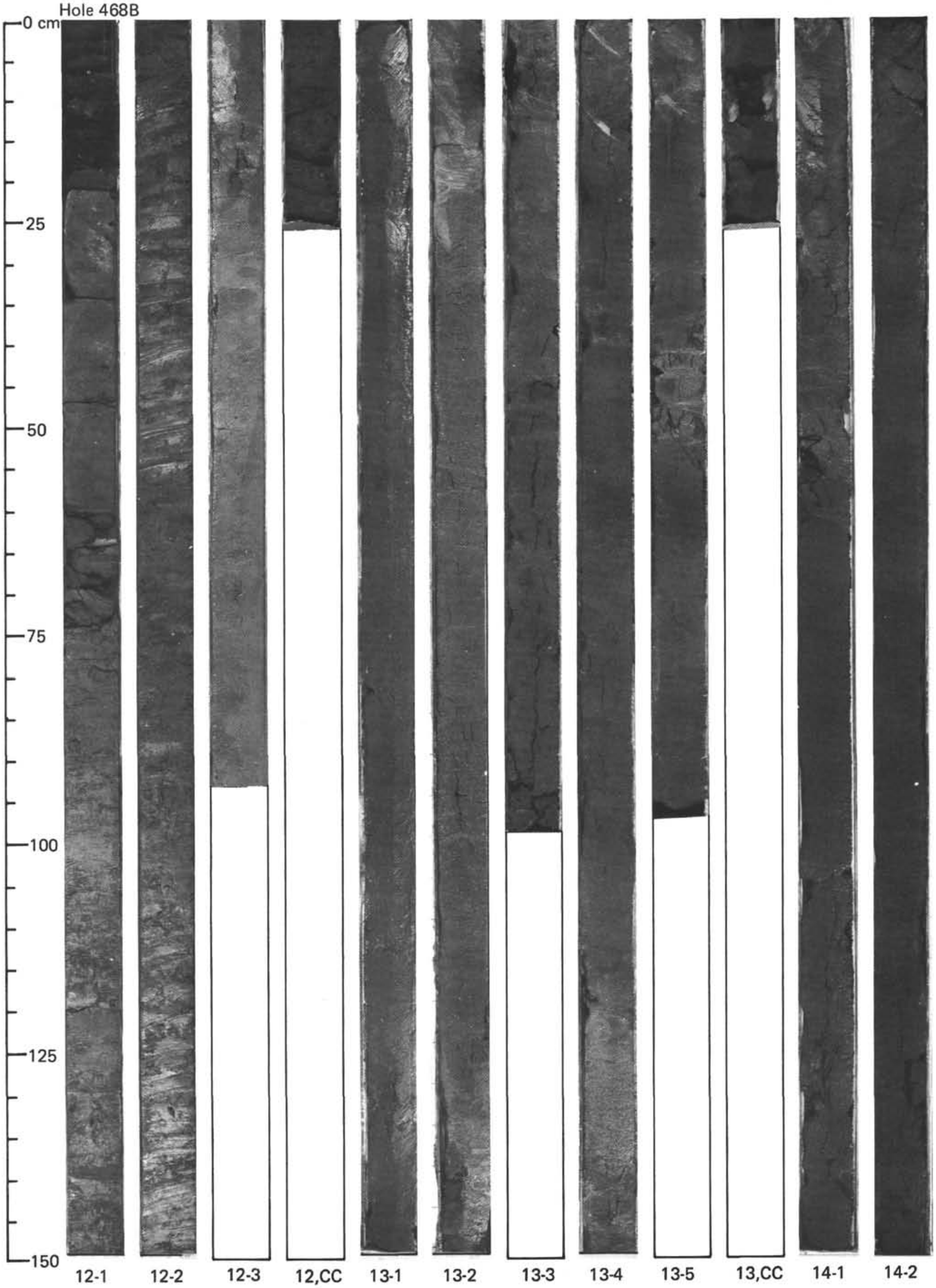

Hole 468A
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1-4
1-5
1,CC
2-1
2-2
2-3
2-4
2-5
2,CC

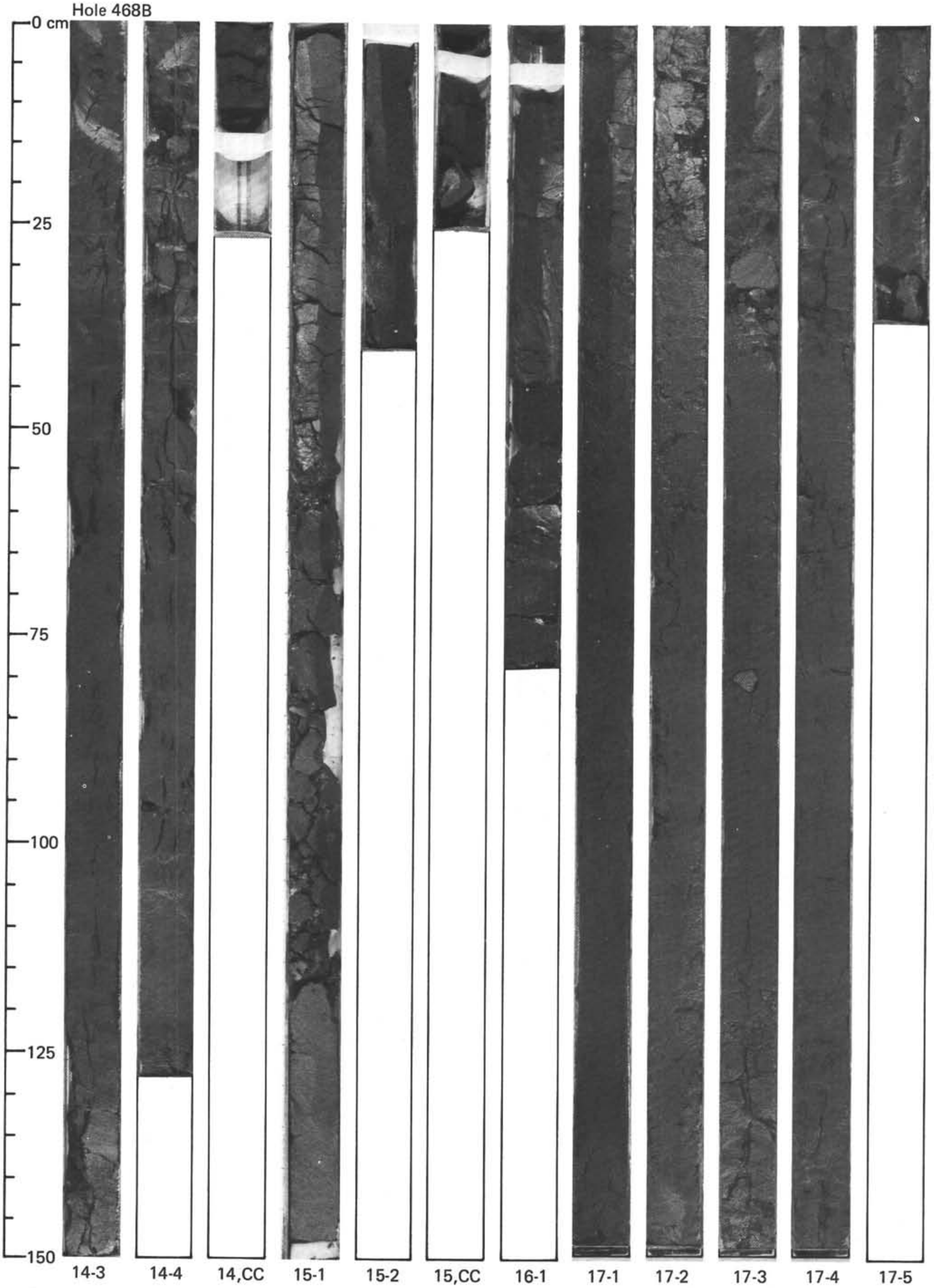

Hole 468A
0 cm
25
50
75
100
125
150
3-1
3-2
3-3
3-4
3-5
3,CC
4-1
4-2
4-3
4-4
4-5
4,CC

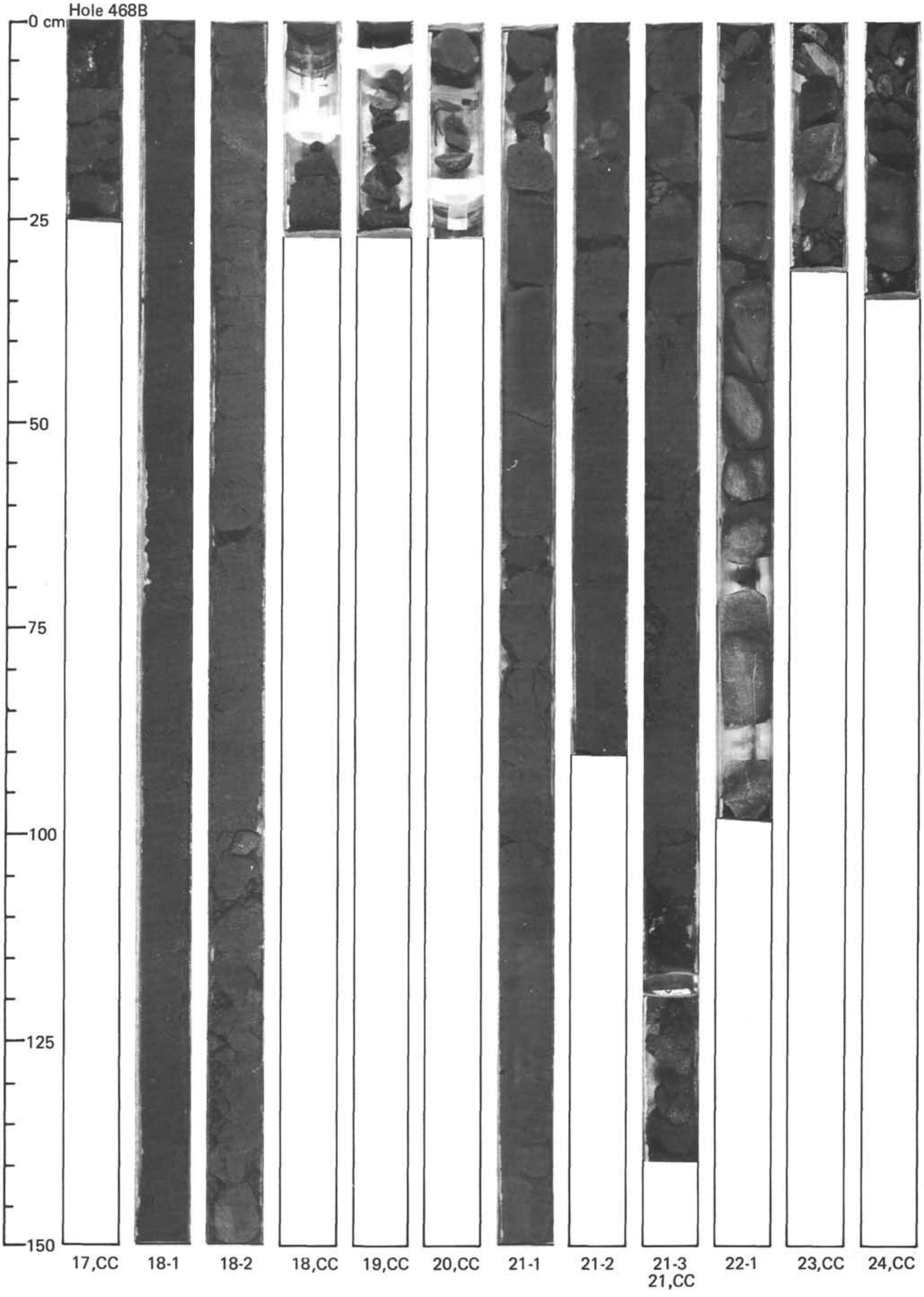

Hole 468B
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1-4
1-5
1,CC
2-1
2-2
2,CC
3-1
3-2
3-3
3-4

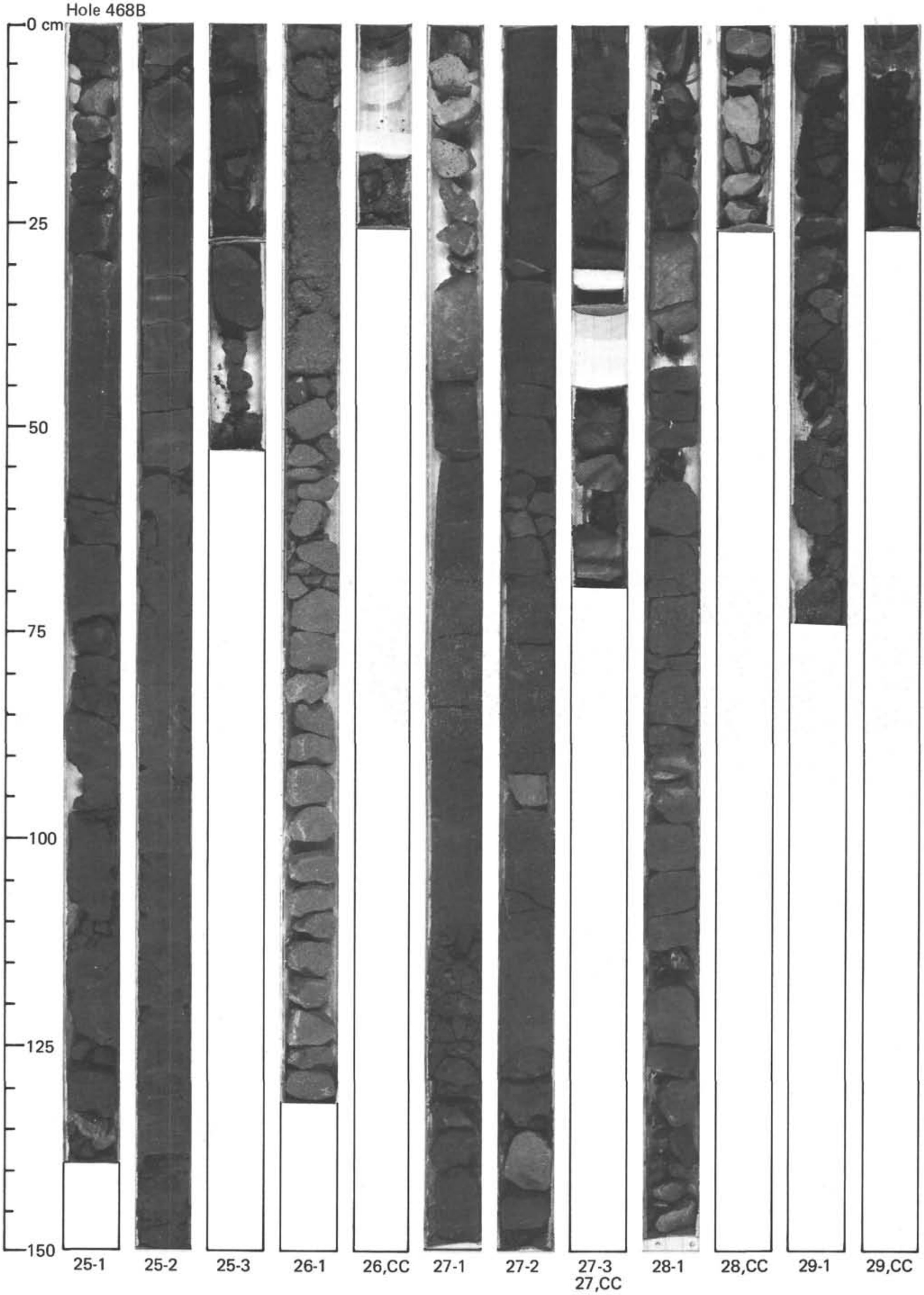

Hole 468B
0 cm
25
50
75
100
125
150
NO PHOTOGRAPH AVAILABLE
NO PHOTOGRAPH AVAILABLE
3-5
3,CC
4-1
4-2
4,CC
5
6-1
6-2
6-3
6-4
6-5
6,CC
7

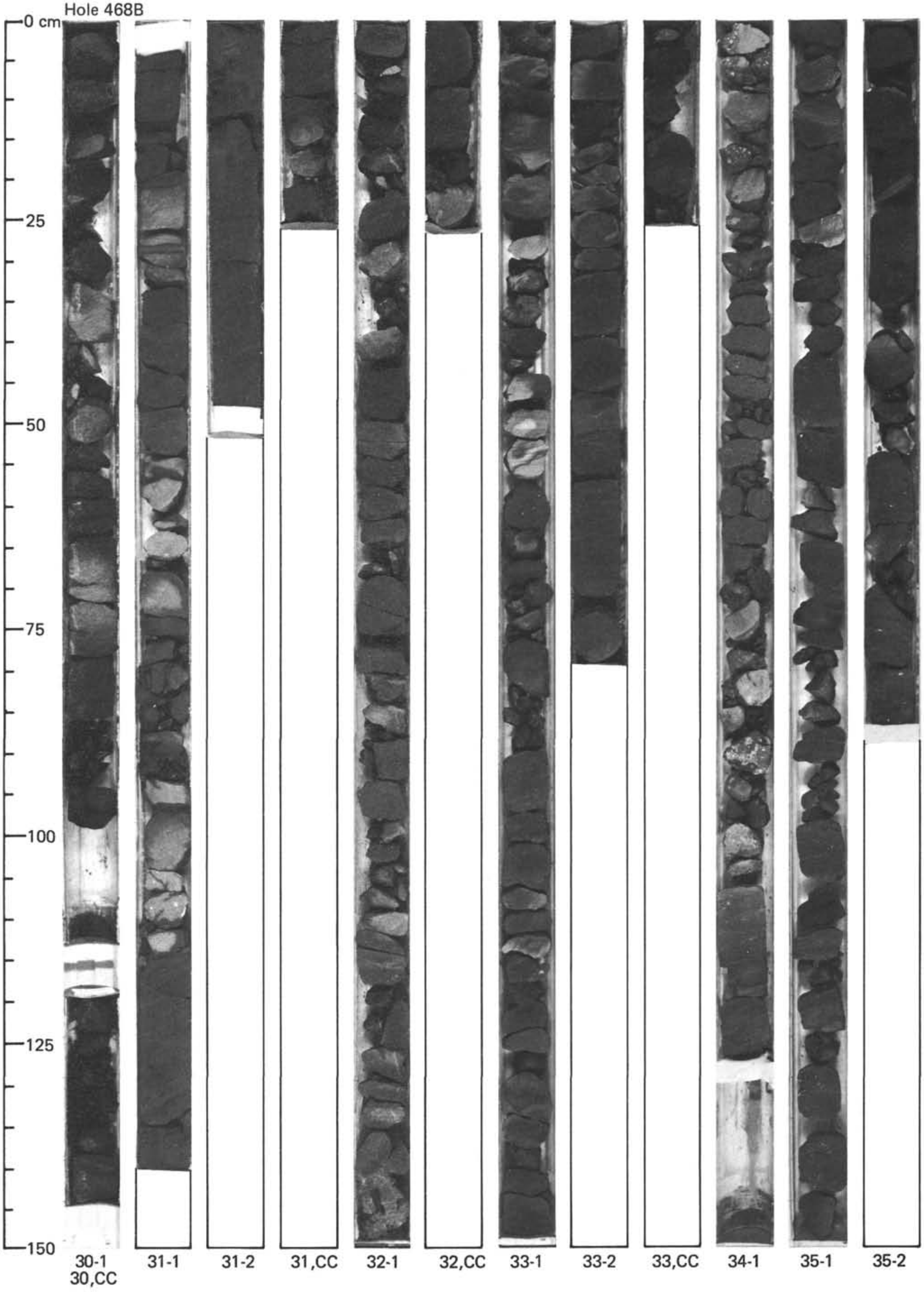

Hole 468B
0 cm
25
50
75
100
125
150
8-CC
9-CC
8-1
8-2
8-3
8-4
8,CC
9-1
9-2
9-3
9-4
9,CC
10-1
10-2
10,CC
11,CC


Hole 468B
0 cm
25
50
75
100
125
150
12-1
12-2
12-3
12,CC
13-1
13-2
13-3
13-4
13-5
13,CC
14-1
14-2

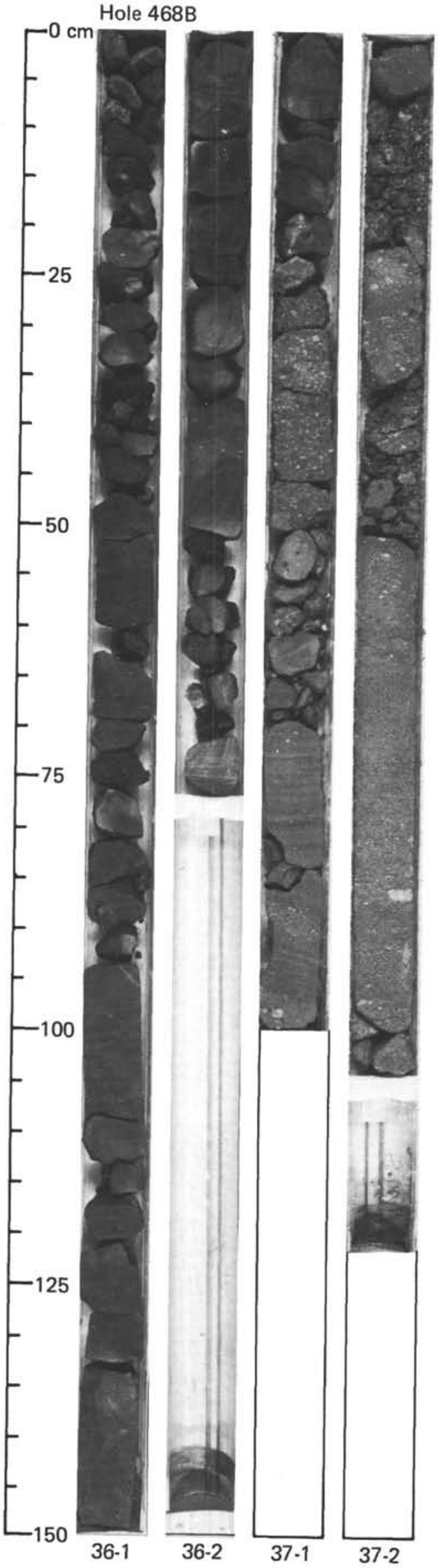

Hole 468B
0 cm
25
50
75
100
125
150
14-3
14-4
14,CC
15-1
15-2
15,CC
16-1
17-1
17-2
17-3
17-4
17-5


Hole 468B
0 cm
25
50
75
100
125
150
17,CC
18-1
18-2
18,CC
19,CC
20,CC
21-1
21-2
21-3
21,CC
22-1
23,CC
24,CC


Hole 468B
0 cm
25
50
75
100
125
150
25-1
25-2
25-3
26-1
26,CC
27-1
27-2
27-3
27,CC
28-1
28,CC
29-1
29,CC



Hole 468B
0 cm
25
50
75
100
125
150
30-1
30,CC
31-1
31-2
31,CC
32-1
32,CC
33-1
33-2
33,CC
34-1
35-1
35-2


Hole 468B
0 cm
25
50
75
100
125
150
36-1
36-2
37-1
37-2