10. SITE 594: CHATHAM RISE[1]

Shipboard Scientific Party[2]

HOLE 594

Date occupied: 3 January 1983

Date departed: 5 January 1983

Time on hole: 52 hr.

Position: 45°31.41′S; 174°56.88′E

Water depth (sea level; corrected m, echo-sounding): 1204

Water depth (rig floor; corrected m, echo-sounding): 1214

Bottom felt (m, drill pipe): 1211

Penetration (m): 505.1

Number of cores: 53

Total length of cored section (m): 505.1

Total core recovered (m): 299.72

Core recovery (%): 59.3

Oldest sediment cored:
Depth sub-bottom (m): 505.1
Nature: Nannofossil ooze
Age: Late early Miocene
Measured velocity (km/s): 1.646 at 487 m

Basement: Not reached

HOLE 594A

Date occupied: 6 January 1983

Date departed: 7 January 1983

Time on hole: 29 hr., 40 min.

Position: 45°31.41′S; 174°56.88′E

Water depth (sea level; corrected m, echo-sounding): 1204

Water depth (rig floor; corrected m, echo-sounding): 1214

Bottom felt (m, drill pipe): 1211

Penetration (m): 639.5

Number of cores: 26

Total length of cored section (m): 249.6

Total core recovered (m): 161.55

Core recovery (%): 64.7

Oldest sediment cored:
Depth sub-bottom (m): 639.5
Nature: Siltstones (turbidites)
Age: Miocene
Measured velocity (km/s): 2.106 at 622 m

Basement: Not reached

HOLE 594B

Date occupied: 7 January 1983

Date departed: 7 January 1983

Time on hole: 8 hr., 8 min.

Position: 45°31.41′S; 174°56.88′E

Water depth (sea level; corrected m, echo-sounding): 1204

Water depth (rig floor; corrected m, echo-sounding): 1214

Bottom felt (m, drill pipe): 1212.2

Penetration (m): 42.9

Number of cores: 5

Total length of cored section (m): 42.9

Total core recovered (m): 34.18

Core recovery (%): 79.6

Oldest sediment cored:
Depth sub-bottom (m): 42.9
Nature: Hemipelagic ooze
Age: Quaternary
Measured velocity (km/s): 2.106 at 622 m

Basement: Not reached

Principal results: Site 594 is located at the southern margin of the Chatham Rise east of the South Island of New Zealand, in a water depth of 1204 m at a position of 45°31.41′S, 174°56.88′E. The site lies in the subantarctic water mass immediately south of the Subtropical Convergence, and is the southernmost of the series of sites forming a north–south transect. It is situated in a transitional region between oceanic and terrigenous influences, thus differing from all other sites on the southwest Pacific transect.

Site 594 consists of three holes cored to a maximum sub-bottom depth of 639.5 m. Excellent core recovery was obtained from 0 to 207.5 m sub-bottom depth (Holocene to latest Miocene), using the HPC to about 130 m in Holes 594 and 594A. The remaining section was rather poorly recovered using the XCB.

The section from the latest early Miocene to the Holocene contains unconformities in the middle late Miocene, over the Miocene/Pliocene boundary, in the middle Pliocene, and in the latest

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[1] Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP*, 90: Washington (U.S. Govt. Printing Office).

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Pliocene. A paleomagnetic stratigraphy has been identified down to the late part of the Gauss Chron (about 2.5 m.y. ago).

The sequences are assigned to two lithostratigraphic units, the lower one of which is subdivided into two subunits.

Unit I, of earliest Pliocene to Quaternary age, consists of an alternating sequence of pelagic and hemipelagic lithofacies, generally defined by bluish gray and greenish gray sediment, respectively.

The pelagic lithofacies consists mainly of blue gray foraminifer-bearing nannofossil ooze, foraminifer- and clay-bearing nannofossil ooze, or foraminifer-bearing clayey nannofossil ooze.

The hemipelagic lithofacies consists of a variety of sediment intergrades between a clay- and silt-bearing nannofossil ooze and a nannofossil-bearing clayey silt; this greenish-gray lithofacies commonly diatom- and sponge spicule-bearing, rarely foraminifer-bearing.

The contact between Units I and II is gradational over several meters, but is recognized by the change from the interbedded pelagic and hemipelagic facies of Unit I to a pelagic facies of Unit II. Unit II, of late early Miocene to earliest Pliocene age, is mainly a foraminifer-bearing nannofossil ooze (chalk) to nannofossil ooze (chalk). The ooze/chalk transition occurs at about 66 m in Hole 594.

Subunit IIA, of middle Miocene to earliest Pliocene age, is a light gray foraminifer-bearing nannofossil ooze that grades down into a nannofossil ooze and continues to about 466 m sub-bottom depth in Hole 594.

Subunit IIB, of late early to middle Miocene age, is a light gray nannofossil chalk with occasional interbeds of olive gray silt-bearing clayey nannofossil chalk below 534 m sub-bottom in Hole 594A; these are interpreted as turbidite layers.

Site 594 was well located to monitor the changing influences of terrigenous and pelagic sequences through the Neogene. The first influx of hemipelagic sequences during the late Neogene occurred about 6 m.y. ago, replacing a completely calcareous pelagic facies containing no significant terrigenous components. This dates the beginning of the Kaikoura Orogeny, when the New Zealand (southern) Alps were uplifted along the Alpine Fault.

Dated much earlier, about 17 m.y. ago, was a tectonic episode evidenced by the deposition of the clay turbidites of Subunit IIB. The upper part of the turbidite sequence forms a distinctive reflector which shows at about 600 m sub-bottom in the seismic profiles. The deposition of the turbidite sequence possibly coincided with major strike-slip motion along the Alpine Fault sector of the Indian/Pacific plate boundary. The volcanic ash layer sequences at this and other sites are probably also related to the associated volcanic activity. The two tectonic episodes were separated by about 10 m.y. of vertical tectonic quiescence during which pelagic calcareous sediments (Subunit IIA) were deposited.

Site 594 has much paleoceanographic potential. There is a useful biostratigraphic sequence of subantarctic elements from the middle Miocene to the Holocene, although this is broken in places by unconformities. Both calcareous and siliceous microfossil groups are well represented. The calcareous nannoplankton are typical cold-water assemblages and largely lack the warm-water forms so useful in biostratigraphic zonation. Considerable microfossil reworking, particularly of foraminifers, was associated with the early middle Miocene turbidites.

The latest Miocene to Holocene sequence of oscillations between dark hemipelagic and lighter pelagic biogenic sediments is climatically related. The pelagic episodes mark climatic warmings and high sea levels (interglacials). These have little biosiliceous sediment, less calcareous dissolution, and warmer-water planktonic foraminifer faunas. The hemipelagics mark cooler (glacial) episodes when low stands of sea level led to major sediment bypassing over the continental shelves and to the deposition of terrigenous materials in the basins surrounding New Zealand. These episodes exhibit cold planktonic foraminiferal faunas, rich siliceous microfossil assemblages, and much carbonate dissolution. Intergrades occur between the two extremes. Twenty-five major hemipelagic depositional episodes are recorded in the upper 200 m (6 m.y. ago to ?), although unconformities represent part of this sequence. The oldest hemipelagic episode coincides with the well-known Kapitean (Messinian) regression.

A distinct increase in radiolarian abundances occurs during the late Miocene. This may have been in response to the important paleoceanographic changes which may have led to the development of the Subtropical Convergence.

BACKGROUND AND OBJECTIVES

Southern Chatham Rise

Site 594 is located at the southern margin of the Chatham Rise east of the South Island of New Zealand (Fig. 1). The site lies in the subantarctic water mass immediately south of the Subtropical Convergence, and is the southernmost of a series of sites forming a north–south transect. It is situated in a transitional region between oceanic and terrigenous influences, thus differing from all other sites on the transect. It is located on a relatively flat, smooth seafloor, underlain by what appears to be a simple seismic stratigraphy of parallel reflectors (Fig. 2).

The primary scientific objectives for Site 594 were to obtain a high-resolution stratigraphic sequence from the Quaternary to the late Paleogene using the hydraulic piston corer (HPC) and extended core barrel (XCB). Multidisciplinary studies on the cores were expected to assist in understanding middle to late Cenozoic paleoceanographic and paleoclimatic history, biogenic evolution, and diagenesis. In addition, the site lies downwind from New Zealand and was expected to contain a valuable record of volcanism in the form of tephra layers. The location of Site 594 in subantarctic waters provided an additional opportunity, not available in higher-latitude sites of the transect, to study what should be distinct oscillations between glacial and interglacial episodes. Griggs et al. (1983), in studies of the late Quaternary using conventional piston cores, demonstrated that such oscillations are well represented in the region. Interglacial episodes are marked by a rich planktonic foraminiferal assemblage of southern temperate character, glacial episodes by a planktonic foraminiferal assemblage of distinctly subantarctic character, accompanied by noticeable abun-

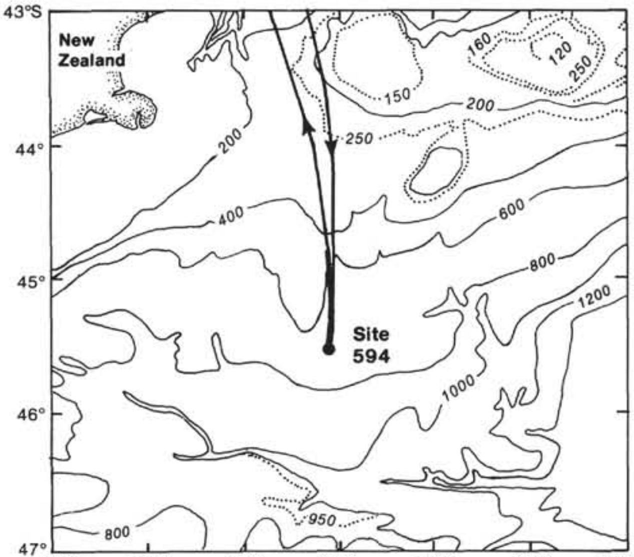

Figure 1. Regional bathymetry (fathoms) around Site 594, after Mammerickx et al. (1974). *Glomar Challenger* Leg 90 track shown; heavy portion locates water gun seismic profile illustrated in Fig. 2.

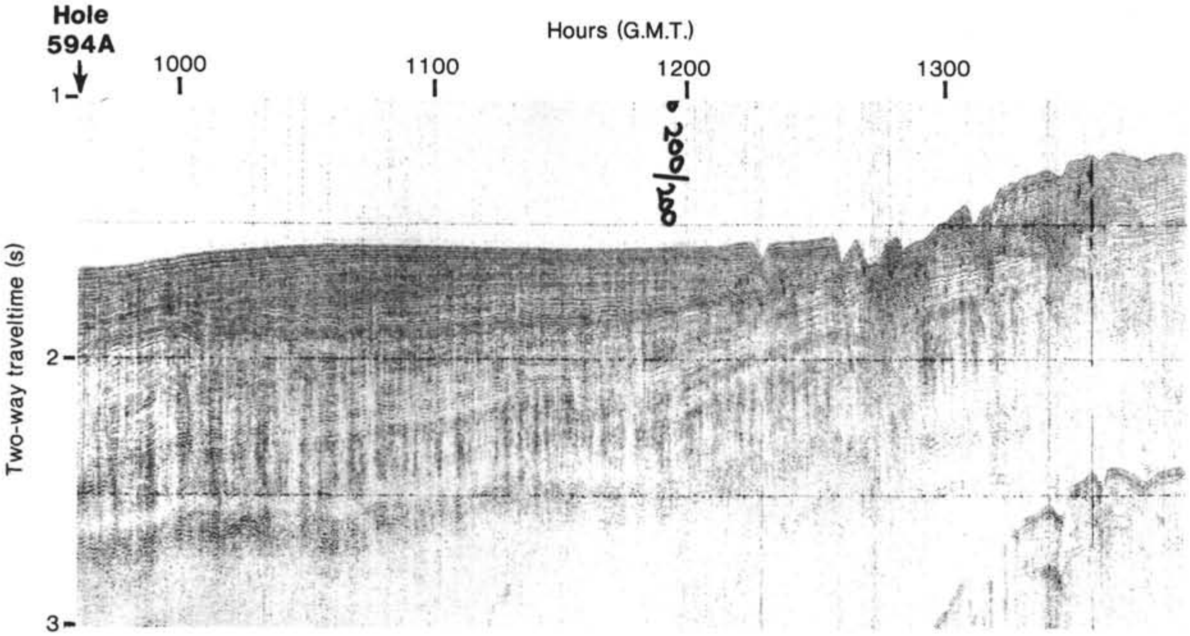

Figure 2. Water gun seismic profile (*Glomar Challenger* near Site 594; bandpass filter 40–160 Hz).

dances of mica and siliceous biogenic components including radiolarians, diatoms, and spicules, and showing clear evidence of dissolution. Site 594 was, therefore, expected to supply data on carbonate cycles and carbonate dissolution. The relative abundance of siliceous components was expected to allow studies of the biostratigraphy and paleoenvironments of these organisms, which occur only in minor amounts in the more northerly sites of the Leg 90 transect. Finally, it was hoped that the site would contain evidence of ice-rafting in the late Neogene, since ice-rafted erratics from Antarctica occur on the Chatham rise (Cullen, 1976).

OPERATIONS

Site 593 to Site 594

The transit between the final two sites provided some of the most pleasant weather and the finest scenery of the voyage. From Site 593 northwest of New Zealand the ship sailed through Cook Strait between New Zealand's North and South Islands and then south to Site 594 close to the Chatham Rise. The site was approached directly along the *Eltanin* 43 survey line and the beacon was dropped at 1449 hr., 3 January, on the basis of a good seismic profile. The 603.9-mi. trip was completed in 2 days, 12.6 hr., at an average speed of 10.0 knots.

Site 594 (SW-1): Chatham Rise and Bounty Trough

The PDR depth was questionable since the location of the site was almost exactly on the border between two adjacent watermass areas listed in Matthews's *Tables*. The combination variable length (VL) HPC/XCB bottom-hole assembly was made up and run to 1208.1 m for the first mudline attempt and a successful core with 5.95 m recovery was achieved (Table 1); thus the water depth was set at 1211.8 m. Later inspection of the first core showed it to be unusually firm and some suspicion was raised as to whether or not it contained the actual mudline.

In some upper sections of the piston coring sequence, recovery was poor because the core catcher failed, but the problem was rectified by Core 594-11. Piston coring quickly reached its limit with a mangled core liner and a barrel requiring to be washed over at Core 14. The XCB was then rigged and deployed and immediately cut a full core of exceptionally undisturbed quality. More XCB cores followed as the formation changed from firm blue gray hemipelagic sediment to primarily pelagic, with ooze beginning at about 210 m BSF. At 300 m a strong siliceous element began to emerge and core recovery fell off correspondingly.

Problems with the XCB latch continued to be a mild nuisance and resulted in little or no recovery in Cores 17, 22, 32, and 33.

As coring approached 500 m BSF, the weather began to deteriorate rapidly. Fifteen-foot swells and 40–50 knot winds plus a threatening weather prognosis left no choice but to pull the pipe in the interest of safety and terminate the hole. The pipe trip was completed successfully and the bit arrived on deck at 2035 hr., 5 January.

After a 9.5-hr. wait, the weather had improved noticeably. This and more recent weather charts showed that the severe prognosis chart received earlier had been badly in error. Therefore, starting at 0100 hr., 6 January, the pipe was again run in to take the repeat piston core sequence, to use the XCB to spot-core those intervals lost in the initial hole, and to attempt to continue from the termination point of Hole 594 to reach the scientific objectives somewhere between 500 and 800 m BSF.

Hole 594A

The same BHA was run and the hole was spudded at 0435 hr., 6 January. The bit was quickly washed to 41.3 m BSF to help bury the bumper subs as soon as possible, because weather conditions were still questionable. The upper five piston cores taken in the first hole were very complete, so that missing the interval the second time was a reasonable expediency. Nine 9.5-m VLHPC cores were then taken, with excellent recovery on all.

The bit was next washed to 149.9 m BSF and the XCB deployed to take a core which was missed in Hole 594. This procedure was repeated to recover the 9.6 m interval starting at 197.5 m BSF. The XCB was then used as a wash barrel and the bit was washed to 495.5 m BSF to commence continuous XCB coring to the Eocene objective.

XCB coring proceeded to 639.5 m BSF through carbonate chalk and interbedded turbidites. Cores were interesting but only the turbidite sequences were relatively undisturbed. The firm sediment tended to jam in the cutting shoe, keeping recovery totals low. The hole was terminated in Miocene sediments, when fossil preservation had decreased too far to be of further analytical value.

Hole 594B

The bit was pulled to the mudline and the 9.5-m VLHPC was again rigged. Time and weather conditions allowed the top five piston cores previously missed to be taken before leaving the site. The hole was spudded at 1052 hr., 7 January, with a mudline core which contained as a bonus one arm of an Ophiuoroid (brittle star). Water depth was established to be 1212.2 m. The five cores were taken with dispatch and the pipe was pulled for the final time on this voyage.

LITHOSTRATIGRAPHY

Site 594 consists of three holes (Fig. 3) cored to a maximum sub-bottom depth of 639.5 m. Hole 594 was continuously cored with the HPC from 0 to 130.7 m sub-bottom and continued to a total depth of 505.1 m with the XCB. HPC recovery was about 73%, and XCB recovery was 79% from 130.7 to 293.9 m sub-bottom, but only 36% from 293.9 to 505.1 m. Hole 594A was washed down to 41.3 m, continuously cored with the HPC from 41.3–127.7 m, and then washed with the XCB from 127.7–149.9 m and 159.5–197.9 m. Cores were taken from 149.9–159.5 and 197.9–207.5 m, thereby giving close to complete core recovery from 0–207.5 m sub-bottom depth (Holocene to latest Miocene). Below 207.5 m Hole 594A was washed to 495.5 m and thereafter continuously cored with the XCB to a total sub-bottom depth of 639.5 m (late early Miocene), but recovery over this last interval was generally low (44%). Hole 594B was continuously cored with the HPC from 0 to 42.9 m sub-bottom. These cores were not opened.

The recovered sequence at Site 594 is assigned to two lithostratigraphic units (I and II), the second of which is further subdivided into Subunits IIA and IIB (Fig. 3). Divisions are based primarily on differences in composition as reflected in color changes, as well as degree of lithification (Table 2).

Unit I consists of an alternating sequence of pelagic and hemipelagic lithofacies generally defined by bluish gray and greenish gray sediment, respectively. Pelagic–hemipelagic cycles range in thickness from 0.5 to 10 m.

Table 1. Coring summary, Site 594.

Core No.	Date (Jan. 1983)	Time	Depth from drill floor (m) Top Bottom	Depth below seafloor (m) Top Bottom	Length cored (m)	Length recovered (m)	Percentage recovered
Hole 594							
1	3	1950	1211.8–1217.7	0.0–5.9	5.9	5.95	100+
2	3	2130	1217.7–1227.3	5.9–15.5	9.6	8.87	92.3
3	3	2230	1227.3–1236.9	15.5–25.1	9.6	9.34	97.3
4	3	2330	1236.9–1246.5	25.1–34.7	9.6	8.84	92.0
5	4	0000	1246.5–1256.1	34.7–44.3	9.6	9.60	100
6	4	0045	1256.1–1265.3	44.3–53.9	9.6	5.39	56.1
7	4	0130	1265.7–1275.3	53.9–63.5	9.6	2.77	22.6
8	4	0205	1275.3–1284.9	63.5–73.1	9.6	1.77	18.4
9	4	0250	1284.9–1294.5	73.1–82.7	9.6	8.99	93.6
10	4	0315	1294.5–1304.1	82.7–92.3	9.6	2.69	28.0
11	4	0400	1304.1–1313.7	92.3–101.9	9.6	9.70	100+
12	4	0445	1313.7–1323.3	101.9–111.5	9.6	7.40	77.0
13	4	0535	1323.3–1332.9	111.5–121.1	9.6	7.74	80.6
14	4	0630	1332.9–1342.5	121.1–130.7	9.6	5.74	59.8
15	4	0750	1342.5–1352.1	130.7–140.3	9.6	9.64	100+
16	4	0830	1352.1–1361.7	140.3–149.9	9.6	9.54	99.3
17	4	0915	1361.7–1371.3	149.9–159.5	9.6	0.0	0.0
18	4	1010	1371.3–1380.9	159.5–169.1	9.6	8.56	89.1
19	4	1055	1380.9–1390.5	169.1–178.7	9.6	9.55	99.4
20	4	1145	1390.5–1400.1	178.7–188.3	9.6	7.41	77.2
21	4	1235	1400.1–1409.7	188.3–197.9	9.6	9.36	97
22	4	1330	1409.7–1419.3	197.9–207.5	9.6	0.0	0
23	4	1425	1419.3–1428.9	207.5–217.1	9.6	9.20	90
24	4	1525	1428.9–1438.5	217.1–226.7	9.6	8.79	91
25	4	1555	1438.5–1448.1	226.7–236.3	9.6	8.06	84
26	4	1650	1448.1–1457.7	236.3–245.9	9.6	7.15	74
27	4	1745	1457.7–1467.3	245.9–255.5	9.6	7.62	79
28	4	1820	1467.3–1476.9	255.5–265.1	9.6	7.05	73
29	4	1930	1476.9–1486.5	265.1–274.7	9.6	9.29	97
30	4	2000	1486.5–1496.1	274.7–184.3	9.6	8.52	89
31	4	2035	1496.1–1505.7	284.3–293.9	9.6	8.90	93
32	4	2135	1505.7–1515.3	293.9–303.5	9.6	0.00	0
33	4	2235	1515.3–1524.9	303.5–313.1	9.6	0.30	3
34	4	2335	1524.9–1534.5	313.1–322.7	9.6	7.43	77
35	5	0010	1534.5–1544.1	322.7–332.3	9.6	7.88	82
36	5	0120	1544.1–1553.7	332.3–341.9	9.6	6.87	71
37	5	0225	1553.7–1563.3	341.9–351.5	9.6	1.93	20
38	5	0310	1563.3–1572.9	351.5–361.1	9.6	3.64	38
39	4	0400	1572.9–1582.5	361.1–370.7	9.6	3.16	33
40	4	0430	1582.5–1592.1	370.7–380.3	9.6	5.74	60
41	4	0500	1592.1–1601.7	380.3–389.9	9.6	6.55	68
42	5	0540	1601.7–1611.3	389.9–399.5	9.6	5.73	60
43	5	0640	1611.3–1620.9	399.5–409.1	9.6	2.04	43
44	5	0730	1620.9–1630.5	409.1–418.7	9.6	1.99	21
45	5	0820	1630.5–1640.1	418.7–428.3	9.6	2.49	26
46	5	0915	1640.1–1649.7	428.3–437.9	9.6	2.95	31
47	5	1010	1649.7–1659.3	437.9–447.5	9.6	1.62	17
48	5	1040	1659.3–1668.9	447.5–457.1	9.6	3.19	33
49	5	1140	1168.9–1678.5	457.1–466.7	9.6	5.35	56
50	5	1250	1678.5–1688.1	466.7–476.3	9.6	2.34	24
51	5	1340	1688.1–1697.7	476.3–485.9	9.6	1.72	18
52	5	1410	1697.7–1707.3	485.9–495.5	9.6	2.79	29
53	5	1515	1707.3–1716.9	495.5–505.1	9.6	0.58	6
					505.1	299.72	59.3
Hole 594A							
	Wash		1211.8–1253.1	0.0–41.3			
1	6	0550	1253.1–1262.7	41.3–50.9	9.6	9.80	100+
2	6	0625	1262.7–1272.3	50.9–60.5	9.6	9.02	93.5
3	6	0700	1272.3–1281.9	60.5–70.1	9.6	8.16	85.0
4	6	0750	1281.9–1291.5	70.1–79.7	9.6	9.21	95.9
5	6	0835	1291.5–1301.1	79.7–89.3	9.6	9.35	97.4
6	6	0915	1301.1–1310.7	89.3–98.9	9.6	8.84	92.0
7	6	0940	1310.7–1320.3	98.9–108.5	9.6	8.62	89.8
8	6	1045	1320.3–1329.9	108.5–118.1	9.6	8.43	87.8
9	6	1140	1329.9–1339.5	118.1–127.7	9.6	9.43	96.0
	Wash						
10	6	1245	1361.7–1371.3	149.9–159.5	9.6	9.52	99.0
	Wash						
11	6	1355	1409.7–1419.3	197.9–207.5	9.6	7.57	79.0
H1	Wash						
12	6	1845	1707.3–1716.9	495.5–505.1	9.6	2.12	22.0
13	6	1930	1716.9–1726.5	505.1–514.7	9.6	8.17	85.0
14	6	2035	1726.5–1736.1	514.7–524.3	9.6	7.18	75.0
15	6	2120	1736.1–1745.7	524.3–533.9	9.6	4.55	47.0
16	6	2220	1745.7–1755.3	533.9–543.5	9.6	8.65	90.1
17	6	2305	1755.3–1764.9	543.5–553.1	9.6	6.35	66.1
18	7	0005	1764.9–1774.5	553.1–562.7	9.6	4.98	51.8
19	7	0100	1774.5–1784.1	562.7–572.3	9.6	2.36	24.6
20	7	0200	1784.1–1793.7	572.3–581.9	9.6	3.87	40.3
21	7	0300	1793.7–1803.3	581.9–591.5	9.6	2.60	27.0
22	7	0400	1803.3–1812.9	591.5–601.1	9.6	1.09	11.3
23	7	0515	1812.9–1822.5	601.1–610.7	9.6	2.86	29.7
24	7	0615	1822.5–1832.1	610.7–620.3	9.6	2.92	30.4
25	7	0720	1832.1–1841.7	620.3–629.9	9.6	3.17	33.0
26	7	0835	1841.7–1851.3	619.9–639.5	9.6	2.73	28.4
					249.60	161.55	64.7
Hole 594B							
1	7	1110	1212.2–1216.7	0.0–4.5	4.5	4.50	100
2	7	1142	1216.7–1226.3	4.5–14.1	9.6	8.36	87
3	7	1230	1226.3–1235.9	14.1–23.7	9.6	3.78	39
4	7	1300	1235.9–1245.5	23.7–33.3	9.6	8.61	90
5	7	1335	1245.5–1255.1	33.3–42.9	9.6	8.93	88
					42.90	34.18	79.6

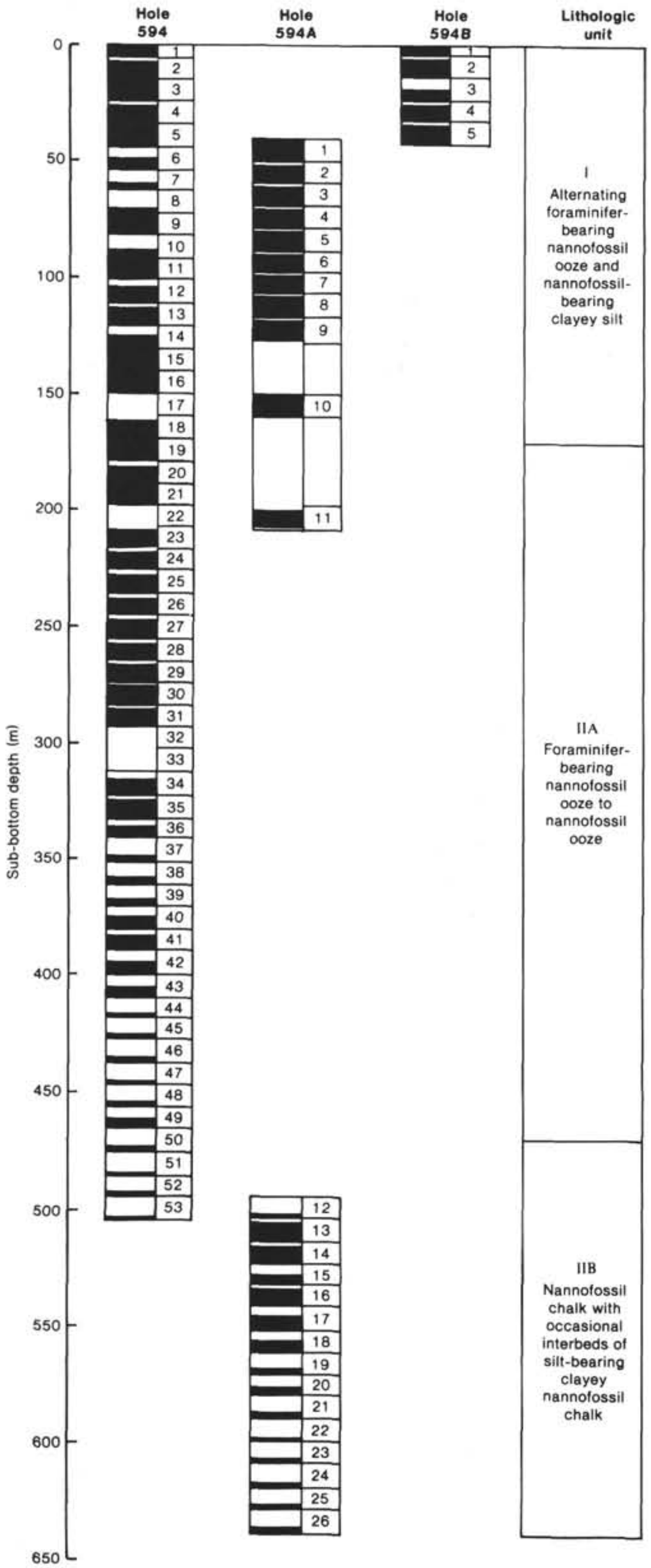

Figure 3. Summary of core recovery and lithostratigraphic units at Site 594 (recovery in black).

Table 2. Lithostratigraphy at Site 594.

Lithologic unit	Cores	Sub-bottom depth (m)	General lithology	Age
I	1-18 1A-10A 1B-5B	0.0-169.1 41.3-159.5 0.0-42.9	Alternating bluish gray foraminifer-bearing nannofossil ooze and greenish gray nannofossil-bearing clayey silt	late Quaternary to earliest Pliocene
IIA	19-49 11A	169.1-466.7 197.9-207.5	Light to very light gray foraminifer-bearing nannofossil ooze to nannofossil ooze.	Earliest Pliocene to early middle Miocene
IIB	50-53 12A-26A	466.7-505.1 495.5-639.5	Very light gray nannofossil chalk with occasional interbeds of olive gray silt-bearing clayey nannofossil chalk	Early middle Miocene to late early Miocene

Note: A, B indicate cores from Holes 594A, B, respectively.

Contacts between lithofacies are completely gradational, subtle color variations between the end-member bluish gray and greenish gray colors. Bioturbation is moderately intensive throughout the unit and color mottling by burrowing is especially well defined across and within the color gradation between lithofacies. Sediments are soft but stiff throughout.

The pelagic lithofacies consists mainly of foraminifer-bearing nannofossil ooze, foraminifer- and clay-bearing nannofossil ooze, or foraminifer-bearing clayey nannofossil ooze. It is light bluish gray (5B 7/1) to medium bluish gray (5B 5/1), less commonly light gray (N7). The intensity of blueness appears to increase with increased clay content. Sediments are massive, with common mottles and hues in pale olive (10Y 6/2) tones. Streaks and blebs of dark gray (N4) pyritized sediment are scattered throughout. The lithofacies is dominated by calcareous nannofossils, with rare to common foraminifers and clay minerals, and trace and rare amounts of quartz, feldspars, mica, and biogenic siliceous components that include sponge spicules, diatoms, and radiolarian fragments (Fig. 4). Other minor detrital grains include volcanic glass, ferromagnesium minerals, pyrite, and glauconite.

The hemipelagic lithofacies consists of a variety of sediment intergrades between a clay- and silt-bearing nannofossil ooze and a nannofossil-bearing clayey silt; the lithofacies is commonly diatom- and sponge-spicule-bearing, rarely foraminifer-bearing. It is greenish gray (5G 6/1) to dark greenish gray (5G 4/1), with common pale olive (10Y 6/2) to light gray (N7) burrow mottles and scattered dark gray (N4) pyritized spots. Dominant components are varying quantities of calcareous nannofossils, clay minerals, and silt-sized grains of quartz, feldspar, and mica (Fig. 4); occasionally the content of nannofossils drops to rare. Foraminifers and siliceous biogenic components are rare to common. Trace to rare quantities of volcanic glass, heavy minerals, and pyrite occur, and minor amounts of glauconite persist. Compared to the pelagic lithofacies, the sediment is relatively enriched in both terrigenous silt and clay and in biogenic siliceous components, notably sponge spicules and diatoms, and relatively depleted in both foraminifers and nannofossils (Fig. 4).

Distinctive, thin, light olive gray (5Y 6/1) vitric ash beds were observed in Unit I at 36.5, 103.8, and 121.0 m sub-bottom depth in Hole 594 and at 112.0 and 157.5 m sub-bottom depth in Hole 594A. A New Zealand source is most likely.

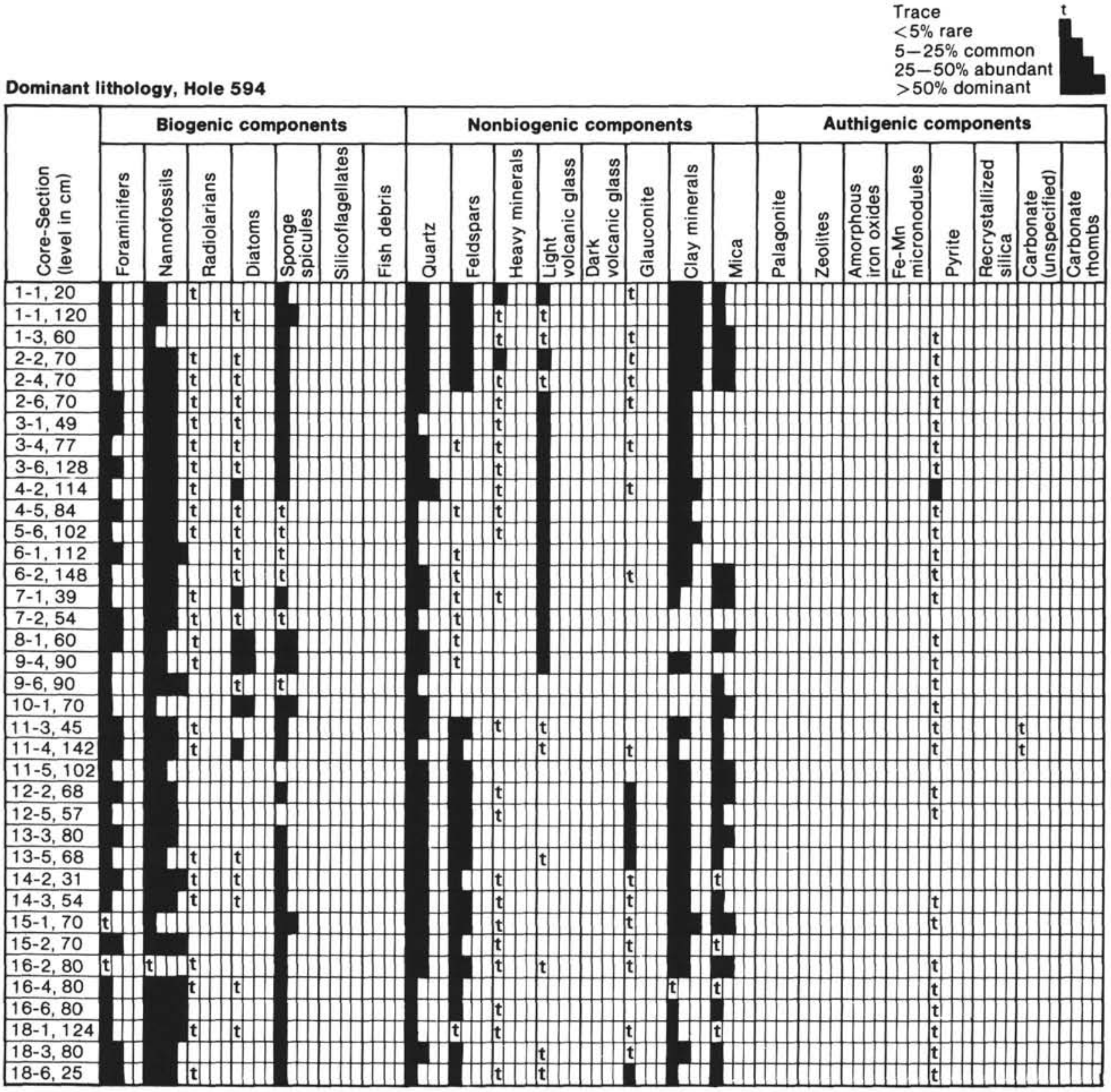

Figure 4. Smear slide summaries, Site 594. Asterisk indicates insoluble residue.

The contact between Units I and II is gradational over several meters but is recognized by the change from interbedded pelagic and hemipelagic facies of Unit I to a pelagic facies of Unit II. The major lithofacies of Unit II is a foraminifer-bearing nannofossil ooze (chalk) to nannofossil ooze (chalk). The ooze/chalk transition occurs at about 470 m sub-bottom depth and forms the basis for separating the two subunits of Unit II. The nannofossil chalk below 533.8 m sub-bottom depth includes conspicuous olive gray interbeds of silt-bearing clayey nannofossil chalk.

Subunit IIA is a very light to light gray (N8 to N7) foraminifer-bearing nannofossil ooze that grades down into a nannofossil ooze by 245 m sub-bottom depth. Occasional yellowish gray (5Y 8/1) hues and burrow mottles, rare pale purple (5P 6/2) pyritized blebs and streaks, and scattered dark gray (N4) pyrite specks are superimposed on the predominantly massive sediment. Calcareous nannofossils dominate the components and foraminifers are generally common above 245 m sub-bottom depth but they form only trace to rare amounts below this level. Biogenic siliceous remains persistently occur throughout in trace to rare abundances and several of the slightly darker gray (N6 to N7), thin interbeds are sufficiently enriched in these components to be diatom- and sponge spicule-bearing nannofossil oozes. Terrigenous material, including quartz, feldspar, mica, and clay minerals, is present in only rare to trace abundances and generally decreases in content with depth. Small concretionary nodules and blebs of pyrite, chert, and possibly celestite occur in rare abundances and are sometimes associated with burrow structures. Bioturbation is moderate to very intensive throughout, but is difficult to evaluate in several sections composed of almost totally

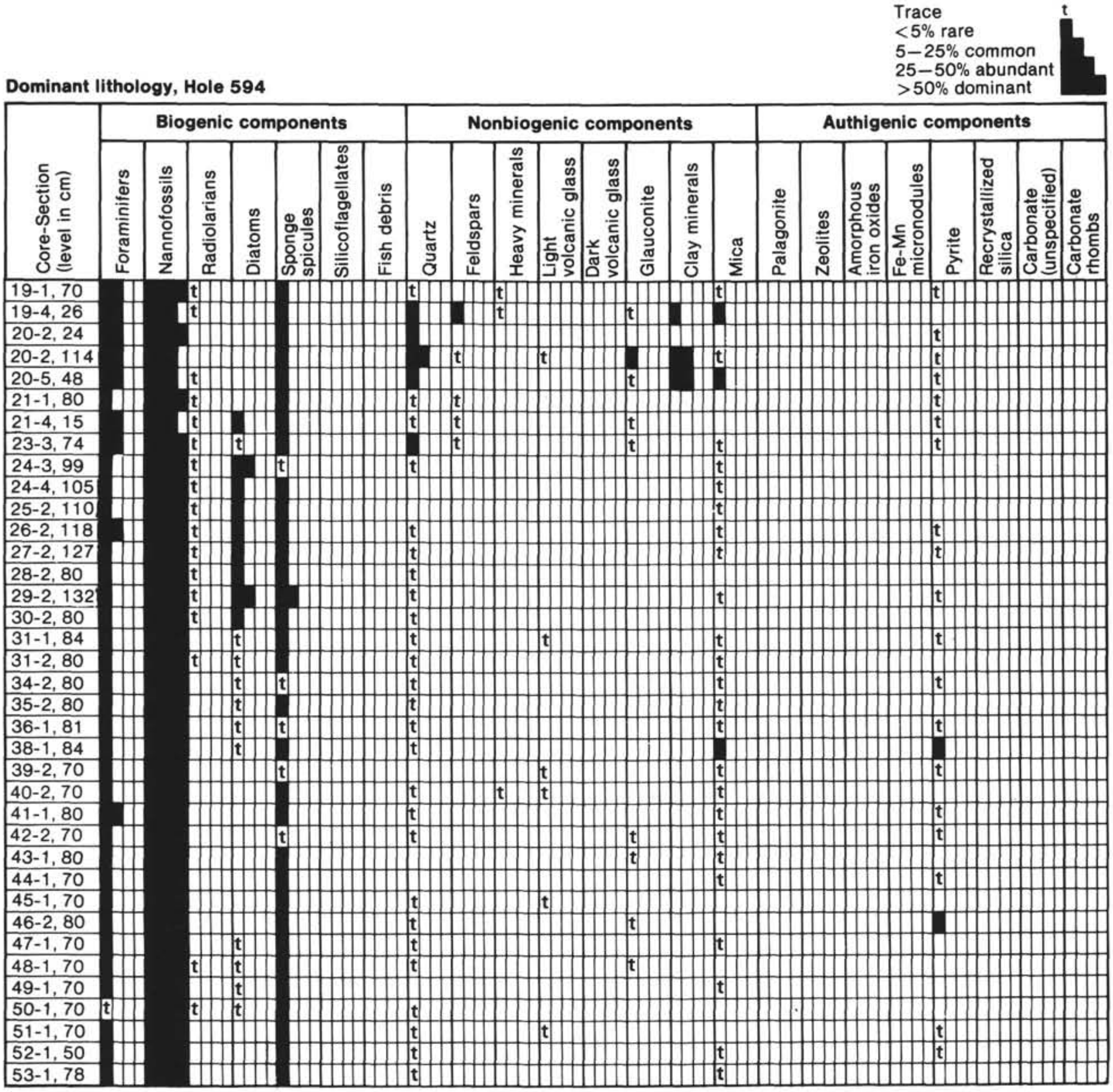

Figure 4. (Continued).

featureless nannofossil ooze, from about 300 m sub-bottom depth down to the ooze/chalk transition marking the boundary with Subunit IIB at about 466 m sub-bottom.

Subunit IIB comprises very light gray (N8) nannofossil chalk which includes interbeds of olive gray (5Y 4/1), silt-bearing, clayey nannofossil chalk below 533.8 m sub-bottom. The nannofossil chalk is rarely foraminifer-bearing, and exhibits progressive recrystallization of its biogenic carbonate grains with depth, especially below about 550 m sub-bottom. Flaser-like bedding is first observed at about the same depth. The flasers become more pronounced and begin to resemble stylolites at about 600 m. Distinctive pale to dark green (5G 7/2 to 10G 4/1) laminae, often in composite sets, occur commonly in the subunit. The laminae may represent altered volcanic glass, although some clearly cross-cut burrow structures, and their exact origin is uncertain. Bioturbate structures are well preserved, with many examples of Zoophycos, Chondrites, and Planolites traces depicted in yellowish gray (5Y 8/1) to light gray (N7) tones. They are dominated by calcareous nannofossils with common micas and clay minerals, rare foraminifers, and occasional quartz and feldspar grains. Biogenic siliceous components are also more conspicuous than in the intervening light gray nannofossil chalks, and some olive gray beds are sponge-spicule- and silt-bearing clayey nannofossil chalks. Textures range from medium to very fine silt at the base of beds to clay-dominated at the top. Habitat stratification is pronounced in the infaunal burrow types in the thicker beds in the upper portion of units, with Planolites between 0 and about 5 cm, Chondrites below to depths of

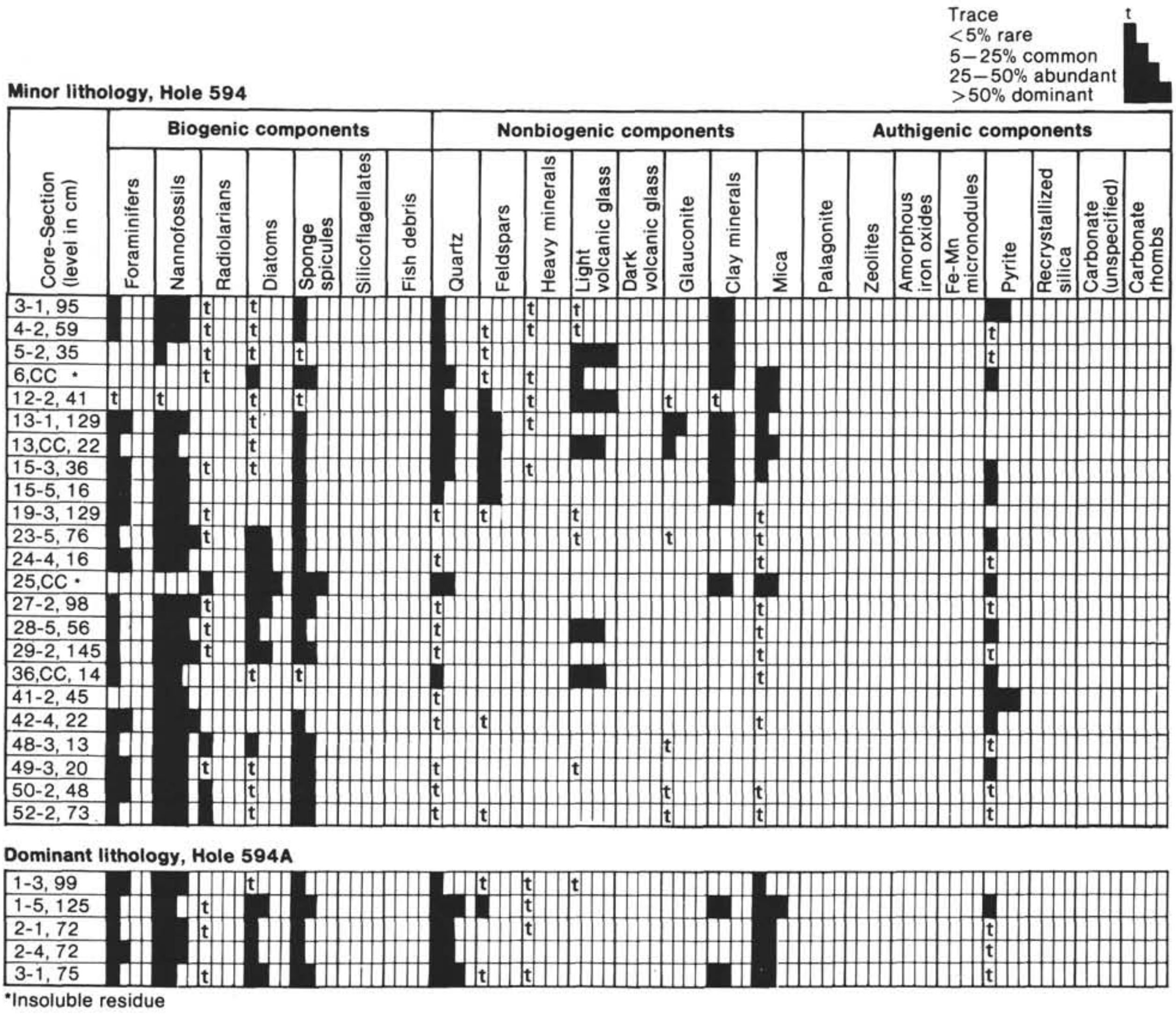

Figure 4. (Continued).

10 cm, and finally Zoophycos, to depths of 15 to 20 cm. The sedimentary structures indicate these sediments are turbidite deposits.

Discussion

Site 594 is a 640-m-thick sequence of pelagic nannofossil oozes (chalks) and hemipelagic silts and clays of late early Miocene through late Quaternary age. The upward stratigraphic succession (Table 2) from alternating pure and impure chalks (Subunit IIB) to alternating pelagic carbonate oozes and hemipelagic muds (Unit I) can be broadly interpreted in terms of changing tectonic tempo on the New Zealand landmass as well as paleoclimatic changes.

The nannofossil chalks in Subunit IIB are the sedimentary record of normal oceanic pelagic conditions in the late early to early middle Miocene. The interbedded clay- and silt-rich chalk–turbidites suggest that tectonism and erosion in the New Zealand region was sufficiently active to supply large volumes of fine terrigenous sediment to the area of Site 594. Accumulation rates for late early Miocene sediments at Site 594 probably exceeded 50 m/m.y. Significantly, major strike-slip motion was occurring along the Alpine Fault sector of the Indian/Pacific plate boundary at this time, and thick sequences of early Miocene flysch are characteristic of coeval sedimentary sequences in New Zealand (Carter and Norris, 1976; Nelson and Hume, 1978). The thin, pale green layers of probably altered ash in the chalk may have originated from explosive arc volcanism associated with the early Miocene inception of the Indian/Pacific plate boundary in its present form through New Zealand (Ballance, 1976). There is paleontological evidence for considerable reworking of microfaunas in the purer chalks of Subunit IIB.

The relatively homogeneous, pure nannofossil oozes of Subunit IIA record a period of less intensive uplift in the New Zealand region with virtually no terrigenous sediment influx at Site 594 for the remainder of most of the Miocene. Thin intervals within the subunit that are relatively enriched in diatoms, sponge spicules, and/or foraminifers may correspond to periods of accelerated

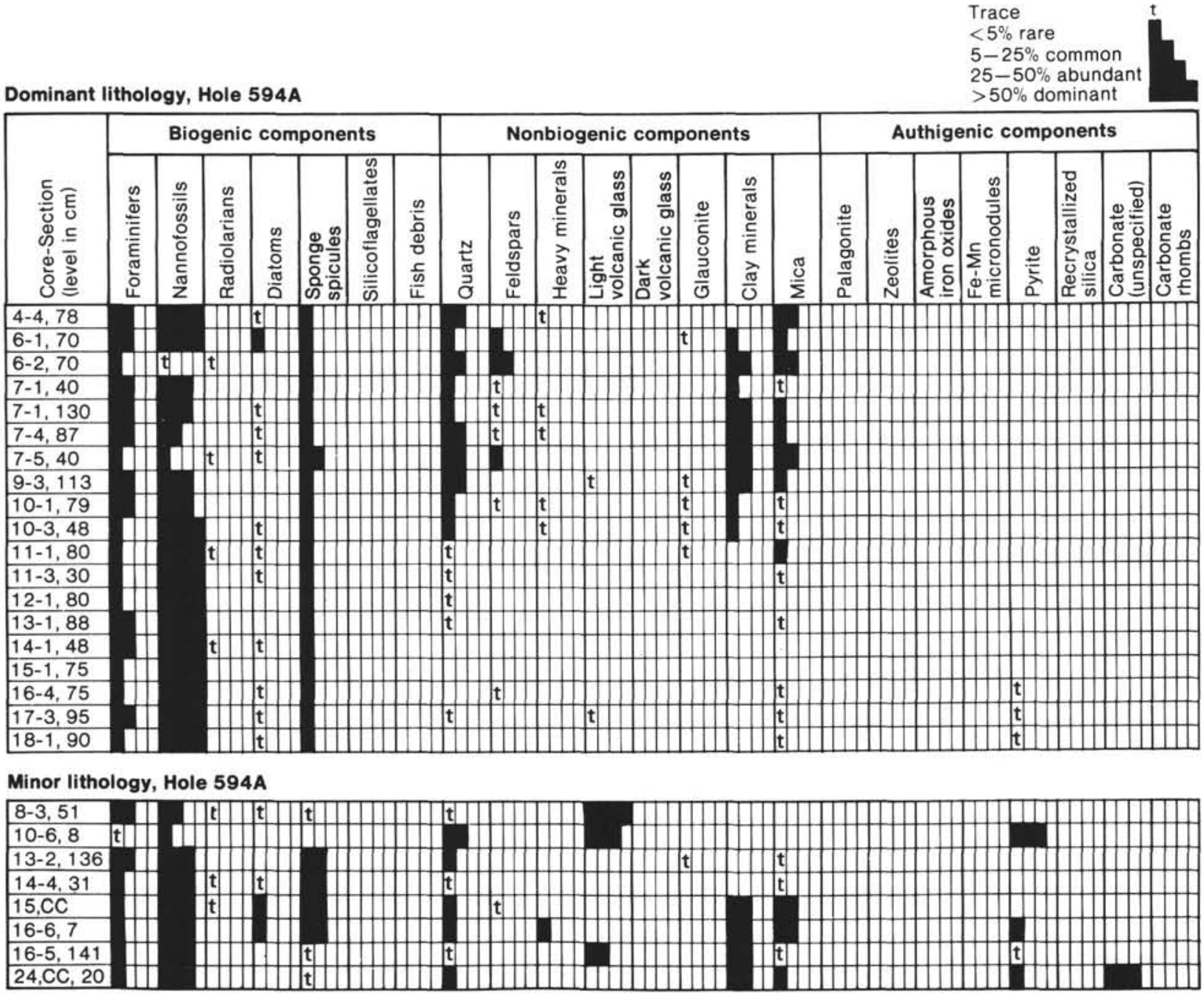

Figure 4. (Continued).

seafloor winnowing. These intervals increase in abundance within the upper levels of Subunit IIA at the same time as fine terrigenous material begins to reappear in more than trace amounts. Thin interbeds of clay-, silt-, and foraminifer-bearing nannofossil ooze occur below the transition into Unit I and may herald a fundamental change in both New Zealand tectonics and the global climatic regime about 5 to 6 m.y. ago.

The sudden increase in abundance of fine terrigenous sediment at the bottom of Unit I and its continued abundance throughout the unit are interpreted as indicating rapid uplift of the New Zealand Alps along the Alpine Fault Zone since about 6 m.y. ago. The inception of this orogenic phase, the Kaikoura Orogeny in New Zealand, coincides with the transition from Units II to I sediments. Unit I is characterized by a large number of oscillations between greenish gray hemipelagic and bluish gray calcareous biogenic facies. The former is enriched in terrigenous silt, clay, and fine sand, as well as biosiliceous components, whereas the latter is mainly a foraminifer-bearing nannofossil ooze. At least 25 major hemipelagic sediment episodes have occurred during the last 5 m.y. and numerous intermediate or lesser events are also recorded by color alternations. These sedimentary cycles are largely interpreted as resulting from sea level oscillations, the hemipelagic facies being deposited during glacial low stands of sea level.

PHYSICAL PROPERTIES

The initial 200 m consist of a hemipelagic sequence with gradually increasing bulk density, shear strength, and sonic velocity. Beyond this depth, alternating sequences of pelagic and hemipelagic sediments produce erratic physical properties records. Porosity results depict no consistent pattern until the 500-m level in Hole 594A, where this properly decreases sharply. Sonic velocity values increase beyond this depth and show large variations between measurements obtained through the light-colored chalk and those determined from the darker, irregular layers of turbidite deposits. Although the shear strength results are quite variable, it was possible to continue taking measurements down to a depth of 470 m before the sediment became too lithified and exceeded the capability of the miniature vane shear apparatus.

Physical properties data are shown in Figure 5.

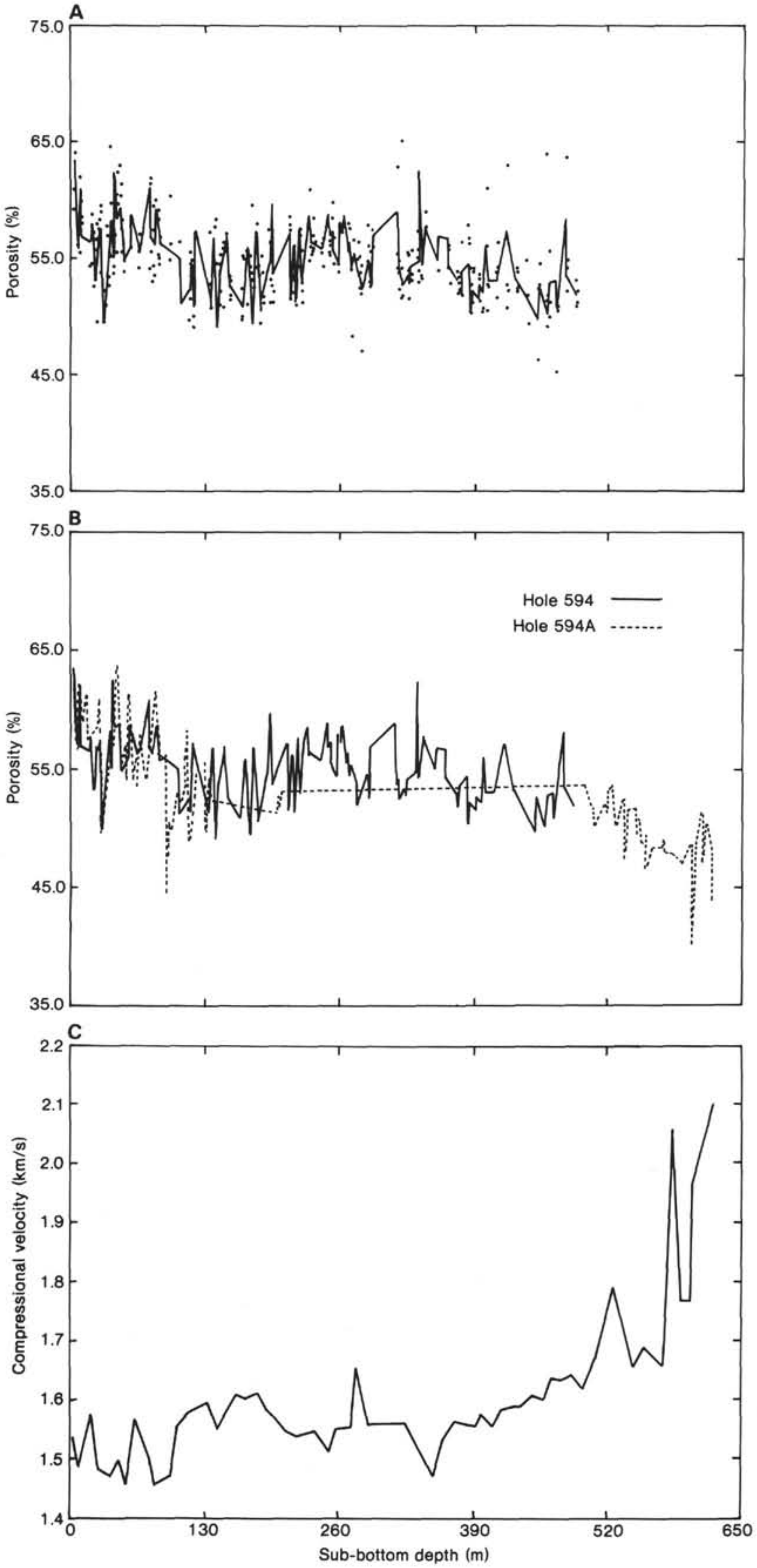

Figure 5. Physical properties results for Site 594. A. GRAPE porosity versus sub-bottom depth. B. GRAPE porosity versus sub-bottom depth (Holes 594 and 594A). C. Compressional velocity versus sub-bottom depth. D. Shear strength versus sub-bottom depth. E. Porosity versus compressional velocity. F. Porosity versus shear strength. G. Acoustic impedance versus sub-bottom depth.

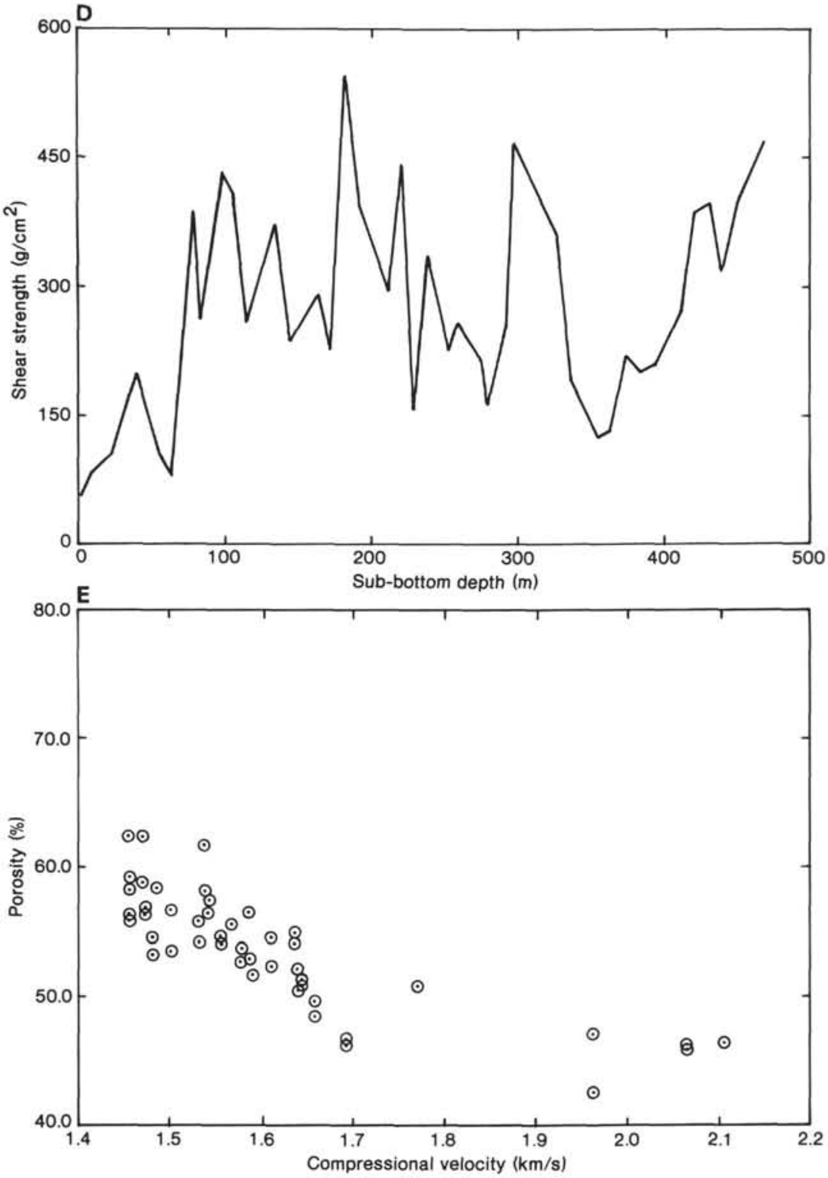

Figure 5. (Continued).

SEISMIC STRATIGRAPHY

Figure 6A illustrates part of the shipboard water gun seismic profile collected during the approach to Site 594. Figure 6B is an annotated line drawing of the profile, and Figure 7 is the *Eltanin* seismic Profile *E*-43 used for site selection. Site 594 lies immediately south and off-structure from a high region in the acoustic basement. This high region is draped by an anticlinal structure developed within the sediment blanket.

Unfortunately, because of the proximity of the high, acoustic horizons are somewhat confused immediately below the drill site. Only two acoustic Units, A and C, can be tentatively recognized there, overlying acoustic basement which is at about 1 s sub-bottom. However, a gently dipping regional reflector, Reflector X (Fig. 6B), can be seen to separate two zones of regional significance, and an additional acoustic unit, Unit B, forms a tongue above this reflector. Selection of acoustic units immediately below Site 594, therefore, has necessarily been influenced by the regional seismic profile.

Acoustic Unit A, about 0.32 s thick, comprises a series of relatively high amplitude, closely spaced, parallel reflectors. North of the northern limit of Figure 6, this unit thins out and appears to onlap Reflector A (Fig. 7).

Acoustic Unit B, best seen in Figure 6B, wedges out to the north near the northern limit of the figure. This unit is more transparent than A, but contains diffuse reflectors.

Acoustic Unit C at Site 594 encompasses a zone acoustically more transparent than Unit A. Like Unit B, it contains a series of coherent reflectors. However, the basal portion of C, immediately overlying basement, appears more transparent, with less coherent reflectors.

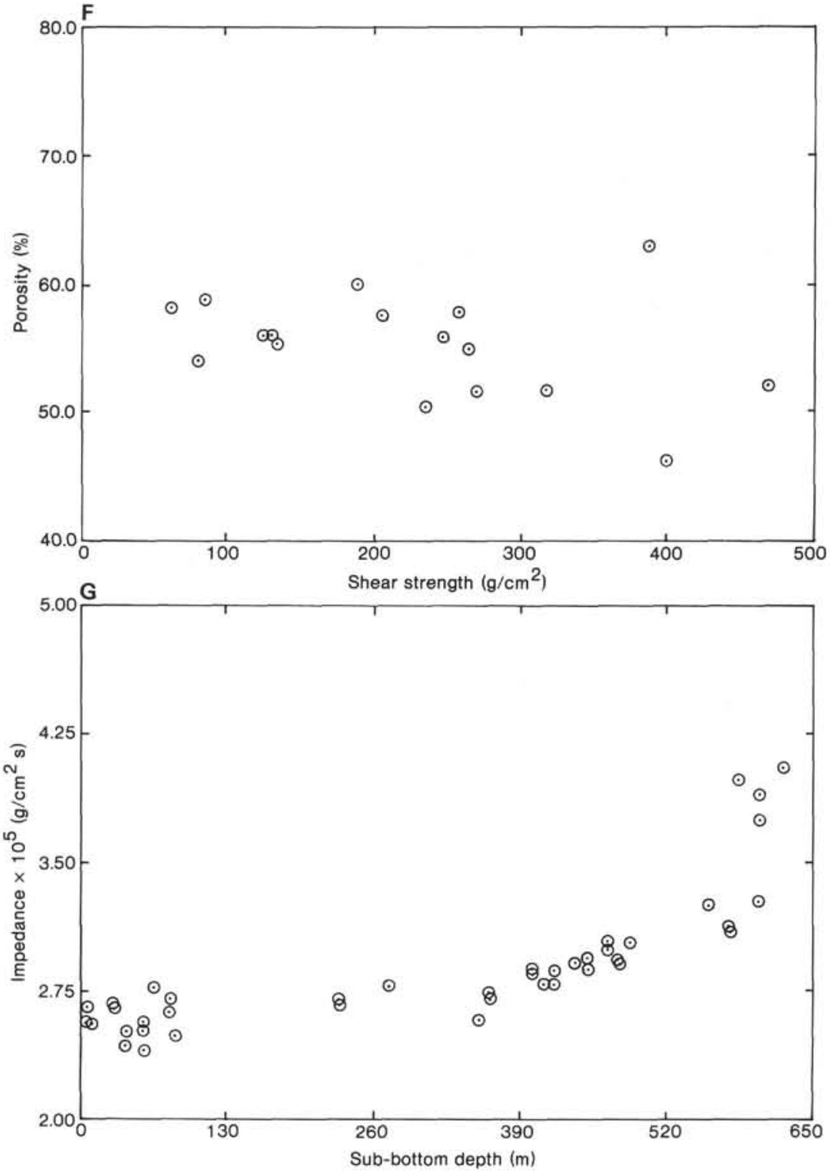

Figure 5. (Continued).

Site 594 was drilled to a total depth of 639.5 m. The sediments have been assigned to two lithologic units, Units I and II. Unit II is subdivided into Subunits IIA and IIB.

Unit I comprises an alternating sequence of pelagic and hemipelagic ooze of Pliocene to Quaternary age. Unit IIA is a foraminifer-bearing nannofossil ooze (chalk) to nannofossil ooze (chalk), and IIB is a nannofossil chalk with graded olive gray interbeds of silt-bearing clayey nannofossil chalk. The ooze/chalk boundary occurs at a sub-bottom depth of about 466 m in Hole 594.

An interval velocity of 1600 m/s is assumed for this site, based on averaged shipboard velocimeter measurements. Comparison of this lithologic sequence with the seismic profile is difficult in the immediate vicinity of Site 594 because of the problems mentioned earlier. However, if comparisons are made with the profile a few miles north of the site, it is apparent that acoustically stratified Unit A incorporates part of lithostratigraphic Unit I and the upper portion of IIA. The wedge-shaped acoustic Unit B presumably corresponds with part of the pelagic ooze lithologic Unit IIA. Reflector X, by this reasoning, may correspond with the top of lithostratigraphic Unit IIB, marking the upper level of the silty turbidite and chalk sequence cored toward the bottom of the hole.

BIOSTRATIGRAPHY

Site 594 is located on the southwestern side of the Chatham Rise in 1204 m of water; the Subtropical Convergence lies just to the north of the site. The nannofossil and planktonic foraminiferal zones are shown in Figures 8 and 9.

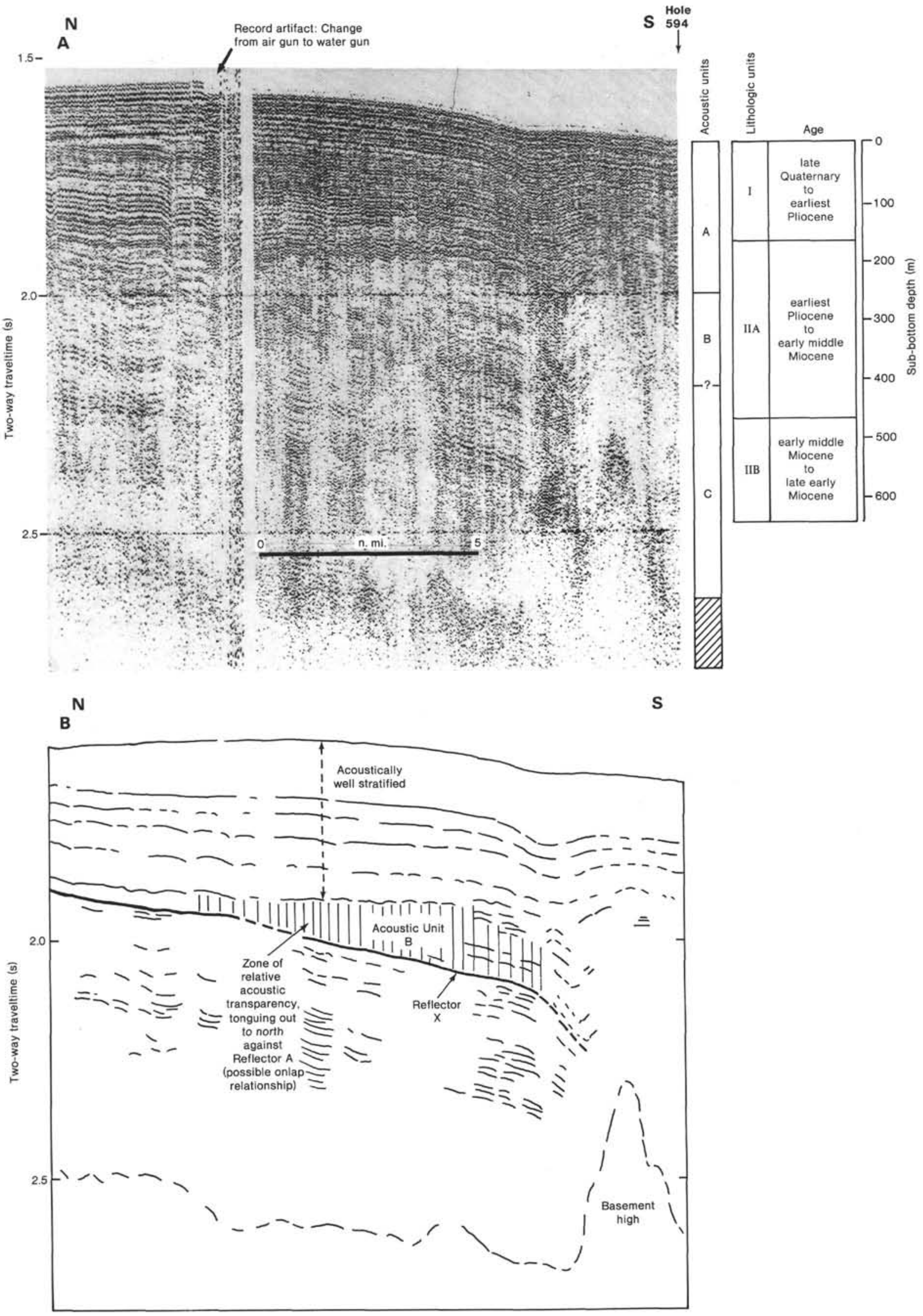

Figure 6. A. Comparison of acoustic Units A–C with lithologic Units I and II cored at Site 594; shipboard water gun seismic profile, collected during site approach; depths in meters estimated by assuming a sediment sound velocity of 1600 m/s. B. Line drawing of A.

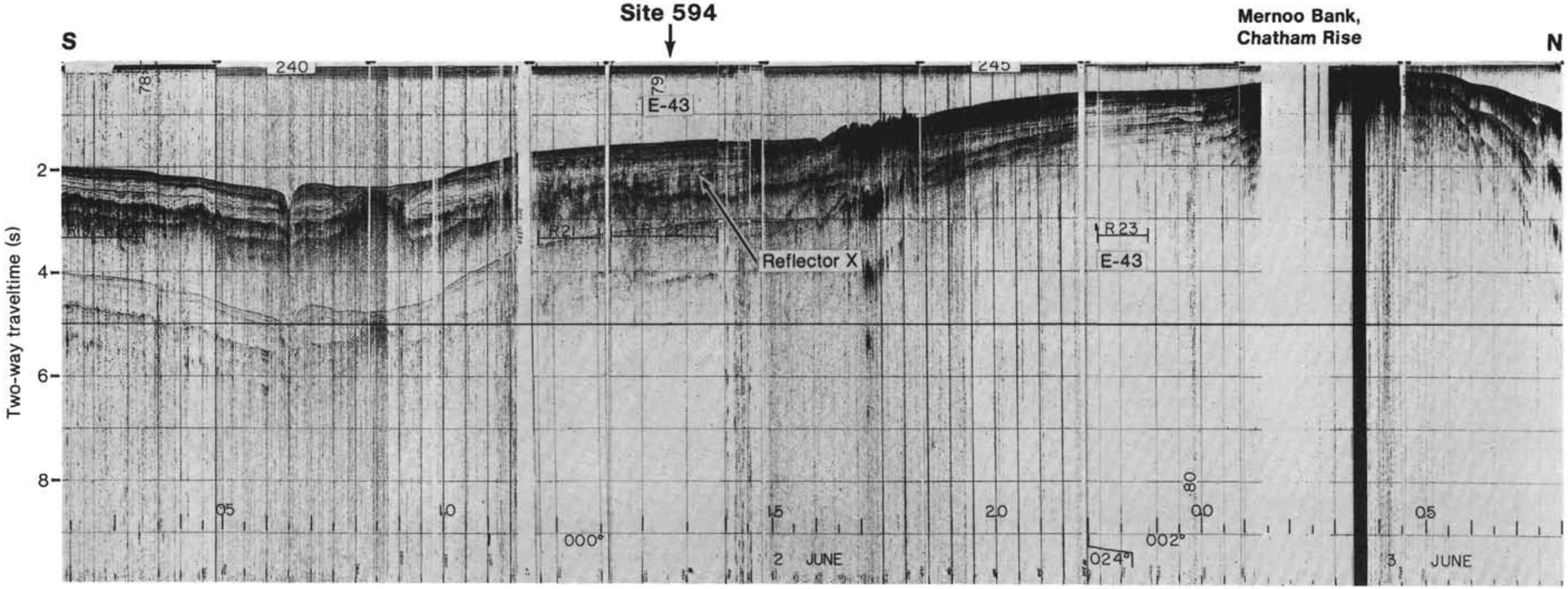

Figure 7. *Eltanin* E-43 seismic profile used for site selection.

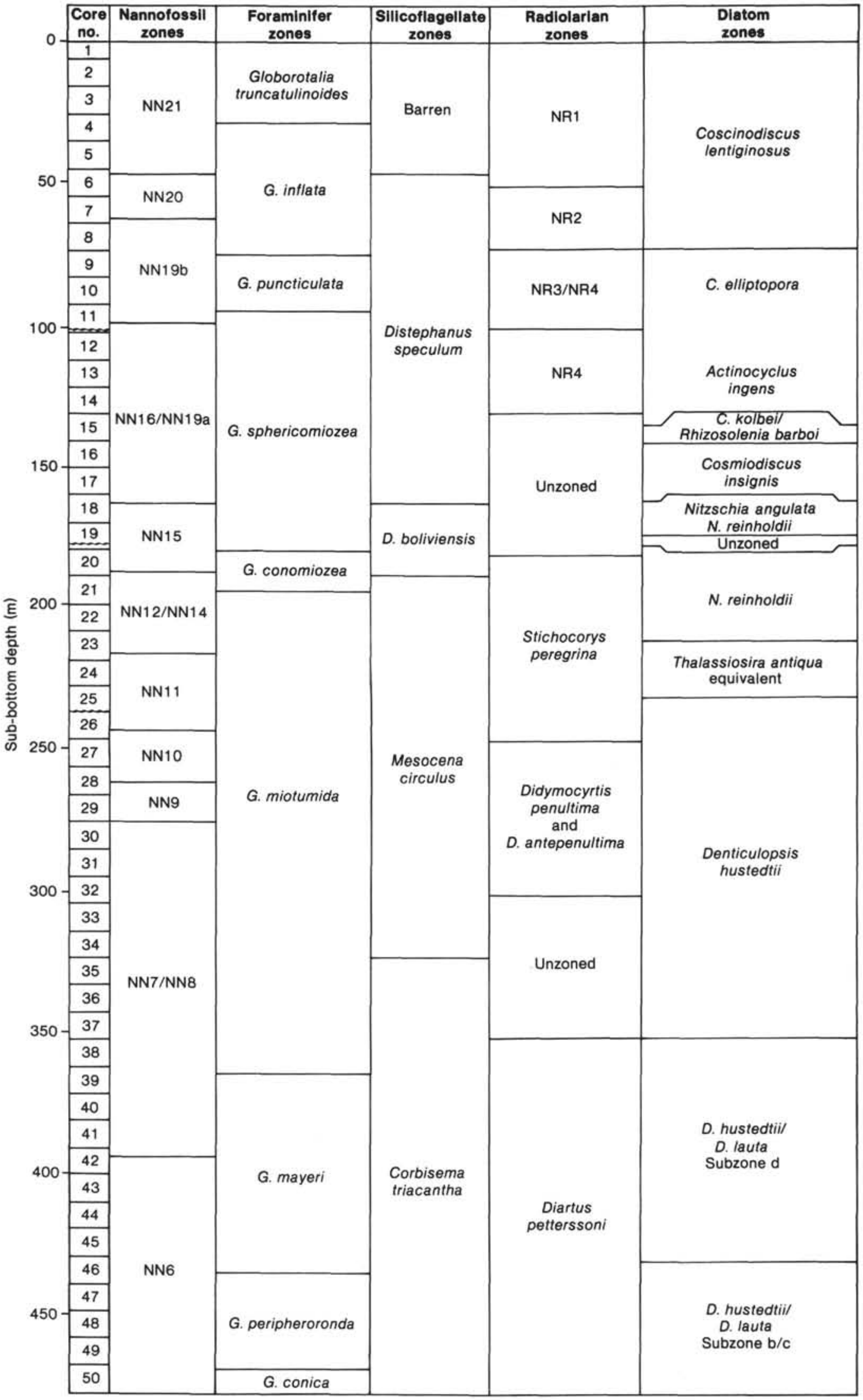

Figure 8. Biostratigraphy of Hole 594.

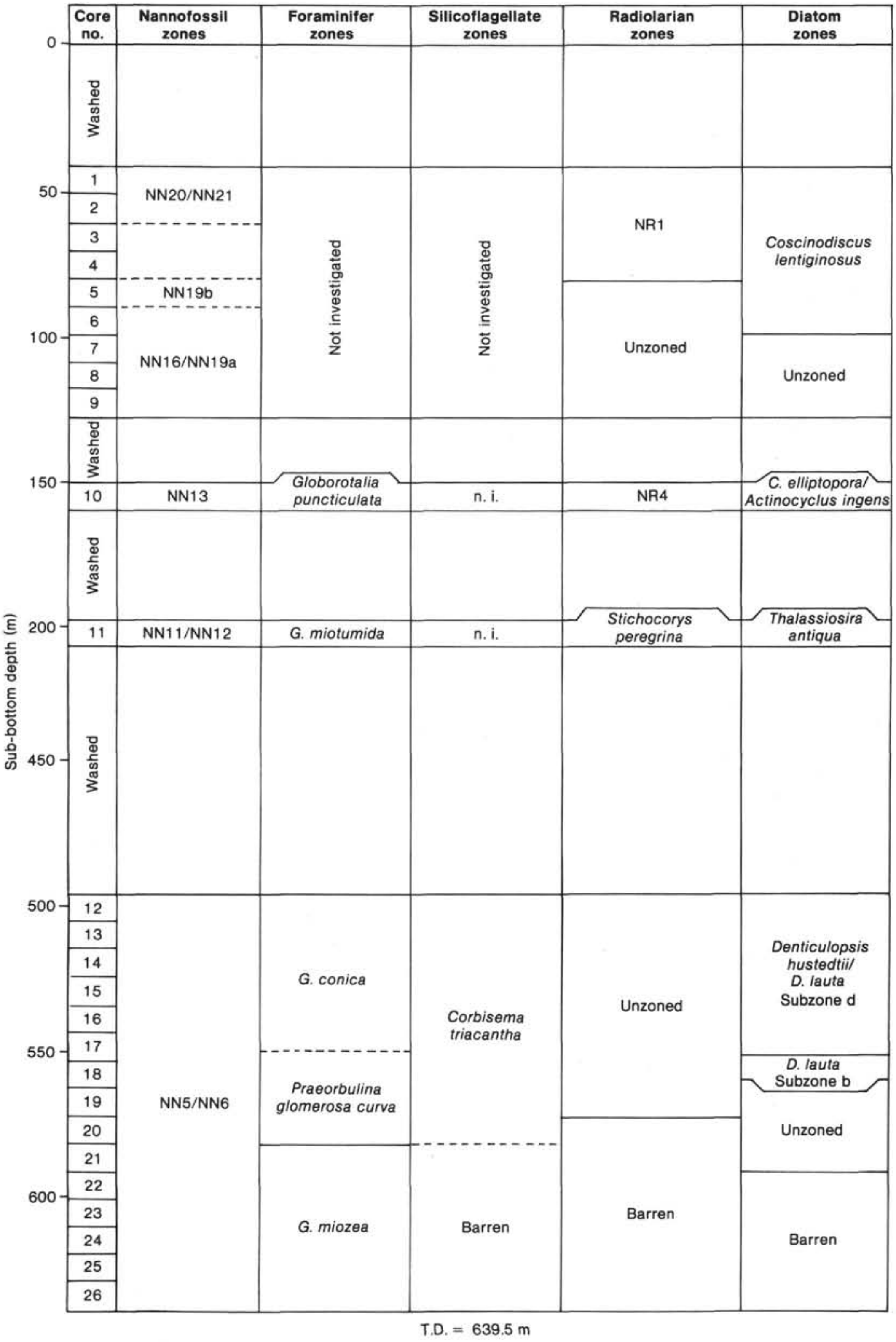

Figure 9. Biostratigraphy of Hole 594A.

The planktonic foraminifers exhibit low species diversity and at certain levels also low numbers of specimens. Preservation is generally good from Pleistocene to lower Miocene but deteriorates in the middle and lower Miocene. Calcareous nannoplankton exhibit low diversity throughout; preservation is moderate to good in the Pliocene–Pleistocene and moderate to poor in the Miocene. In the few well-preserved samples of the section, benthic foraminifers are abundant and generally well preserved; however, breakage is common throughout the section. Both benthic and planktonic foraminifers are recrystallized in the lower Miocene.

Radiolarians, diatoms, and silicoflagellates occur throughout the cored section; sponge spicules are very common in the coarse fractions.

Radiolarians are moderately well preserved, and because equatorial and high-latitude faunas are mixed the zonation uses zones from both regions. There is a significant change in Core 21 and above, where antarctic and subantarctic species become dominant.

Diatoms are best preserved in the middle to late Miocene and are present throughout in the sequence younger than the early Miocene. The diatom assemblages suggest that since the Miocene the site has been located below the subantarctic water mass. Diatom datums have been correlated with magnetostratigraphy established elsewhere.

Many planktonic foraminiferal markers are present in the Pleistocene to late middle Miocene, but in the early middle and late early Miocene there were some difficulties in recognizing established zones. The problems are due to (1) the sporadic occurrence of index species such as *Orbulina suturalis* and the lack of others, including *Praeorbulina glomerosa* and *Globigerinoides trilobus;* and (2) massive reworking of early Miocene faunas in Cores 594-50 to 594-53 and in 594A-12 to 594A-20. Another problem involved the late appearance of some zonal markers including *Globorotalia truncatulinoides* and *G. inflata* because of the position of the site in the subantarctic water mass.

Most zonal indicators of the calcareous nannoplankton are absent or extremely rare and the zones were partly determined by using auxiliary species.

Silicoflagellates were examined in all core-catcher samples; it was possible to place them within the zonation established during Leg 38 by Martini and Müller (1976).

Planktonic foraminiferal studies indicate alternations of cold and warm periods in the Pliocene–Pleistocene. These cold and warm faunas could be explained by assuming north–south fluctuations of the Subtropical Convergence over Site 594; currently the Convergence is situated north of the site.

Benthic faunas are depleted but indicate the presence of warmer bottom waters in the late early Miocene, and an episode of cool and corrosive waters in the early late Miocene.

Four unconformities were detected, mainly by diatom evidence, in the upper Miocene through Quaternary. In ascending order, they were located in (1) Core 24, (2) Core 20, (3) Core 16, and (4) Core 11.

Planktonic Foraminifers

Zones

The following zones were identified at Site 594; the zonal boundary markers are shown below:

Globorotalia truncatulinoides Zone
  I.A. *G. truncatulinoides*
Globorotalia inflata Zone
  I.A. *G. inflata*
Globorotalia puncticulata Zone
  L.A. *G. sphericomiozea*
Globorotalia sphericomiozea Zone
  L.A. *G. conomiozea*
Globorotalia conomiozea Zone
  I.A. *G. conomiozea*
Globorotalia miotumida Zone
  L.A. *G. mayeri*
Globorotalia mayeri Zone
  L.A. *G. peripheroronda*
Globorotalia peripheroronda Zone
  L.A. *G. conica*
Globorotalia conica Zone
  I.A. *G. conica*
Praeorbulina glomerosa curva Zone
  I.A. *P. glomerosa curva*
Globorotalia miozea Zone

The position of the site in subantarctic waters appears to have affected the faunas from the early Miocene to the Quaternary. Consequently, the zonal scheme is different from that at temperate-water Site 593; also, the boundaries of some zones at Site 594 could be higher and/or lower than at Site 593. For example, the initial appearance of *G. truncatulinoides* at Site 594 is within the late Pleistocene, as in other subantarctic areas.

Specimens of the evolutionary lineage of *Orbulina* are very rare at this site and it was not possible to identify properly the *O. suturalis* Zone. Similarly, because of the lack of *Globigerinoides* it was not possible to identify the *G. trilobus* Zone. Consequently, another set of zones, in ascending order, were established for Site 594: *Globorotalia miozea, Praeorbulina glomerosa curva, G. conica*, and *G. peripheroronda.*

Paleobiogeography

The planktonic foraminiferal faunas were reasonably well preserved from the Pleistocene through to the middle Miocene, where they deteriorated; they improved again in the lower Miocene. The species diversity is lower throughout, with low numbers of species; at certain horizons there is marked dissolution, as for example in the early Pliocene Sample 594-16,CC. In Samples 594-42,CC and 594-43,CC there was a low number of species and specimens which coincided with a massive influx of radiolarians.

The faunas of the Pleistocene through Pliocene appear to show alternating cold and warm episodes; the cold-water intervals are indicated by lower species diversity, whereas warmer waters supported such additional species as *Orbulina universa, Globorotalia crassaformis*, and *Globigerinatella aequilateralis.* One possible explanation is the latitudinal fluctuations of the Subtropical Convergence, which are probably associated with glacial-interglacial oscillations.

Benthic Foraminifers

Benthic foraminifers were examined from all core catchers from Hole 594 and in Samples 594A-12,CC to 594-26,CC. Throughout the entire section, only five to six samples are considered to contain undissolved benthic faunas. In the majority of the samples benthics are dissolved, broken, or have disappeared. In general, the larger the percentage of radiolarians or mica in a sample, the fewer the benthics and the worse their preservation.

In general the benthic faunas resemble those of Sites 592 and 593; cibicidids, uvigerinids, and *Oridorsalis* are common in most samples. *Ehrenbergina, Osangularia, Bolivina*, and, below the Pliocene, *Bulimina* are rarely found. In the best-preserved samples, specimens are very large, with the exception of a few species such as *Pleurostomella alternans*, which becomes both smaller and rarer at these southerly sites. Unlike at other sites, faunas at Site 594 often demonstrate unusually high dominance of one or two species at specific times. These include a pulse of *Nuttalides umbonifera* in the upper Miocene, of *Cibicides wuellerstorfi* in the lower Miocene, and of shallow-water angulogerinids and bolivinitids in the Quaternary and lower Pliocene.

Despite the poor preservation of the benthics through much of the Miocene, two important changes take place. The first, in the lower to middle Miocene (594A-16 to 594A-18,CC), involves a marked increase in the numbers of *C. wuellerstorfi*, accompanied by a loss of uvigerinids and the first and only appearance of *Osangularia bengalensis*, a species rare in the southern sites of this traverse. These faunal changes may reflect a late early Miocene warming and a decrease in nutrients at the bottom, or the positioning of the site near the Subtropical Convergence, which carries warmer, surface waters to greater depths.

In the upper Miocene (594-36 to 594-38,CC, lower *Globorotalia miotumida* Zone) there is a large increase in the abundance of *N. umbonifera* accompanied by important changes in the radiolarian assemblages. *N. umbonifera* is generally associated with Antarctic Bottom Water and corrosive bottom water. The benthic faunas suggest that there was an intense cooling pulse and/or an increase in the corrosiveness of the bottom-water environment at this site in the early late Miocene.

Because of poor preservation, the Miocene/Pliocene boundary could not be detected by changes in the benthic foraminifers. Varying faunas suggesting glacial-interglacial fluctuations began in the early Pliocene *G. puncticulata* Zone and intensified during the Pliocene and Pleistocene. Two general faunal assemblages are recognized. The first is associated with hemipelagic sediment and siliceous fossils, and contains opaque benthics, several of which are typical of shallow-water environments. Shallow-water costate to striate angulogerinids suggest anoxic conditions in the source areas. The second assemblage type, associated with decreased percentages of mica, sponge spicules, and radiolarians and an increase in planktonic foraminifers, contains clearer fossils. These tend to be transparent in the Quaternary. The faunal content resembles assemblages during the Pliocene and Pleistocene at Sites 592 and 593. However, there is a large influx of *Bulimina aculeata* in these faunas during the Pliocene *G. inflata* Zone (594-6 to 594-8,CC).

Calcareous Nannoplankton

Hole 594

Core-catcher samples from 53 cores were examined for calcareous nannoplankton. Species diversity is low throughout the section and preservation ranges from moderate to good in the Pleistocene and Pliocene and moderate to poor in the Miocene. Most zonal indicators are absent. Based upon a few auxiliary zone-determining species, the following zonation was established.

The occurrence of *Emiliania huxleyi* in Samples 594-1-1, 3–4 cm to 594-6-1, 25–26 cm places this interval in the late Quaternary *Emiliania huxleyi* Zone (NN21).

Samples 594-6-3, 3–4 cm to 594-7-1, 3–4 cm are above the last occurrence of *E. ovata* in Sample 594-7,CC and are placed in the late Quaternary Zone NN20. Samples 594-7,CC to 594-11-3, 3–4 cm, above the last occurrence of *Calcidiscus macintyrei* in 594-11-5, 3–4 cm, are placed in the upper subzone of the lower Pleistocene *E. ovata* Zone (NN19b). The next marker observed is *Reticulofenestra pseudoumbilica*, whose last occurrence is in Sample 594-18-3, 3–4 cm. Therefore, Samples 594-11-5, 3–4 cm to 594-18-1, 3–4 cm are in Zones NN16/19a. Zone NN15 includes Samples 594-18-3, 3–4 cm to 594-20-5, 3–4 cm, above the last occurrence of *Amaurolithus tricorniculatus* in Sample 594-20,CC. Samples 594-20,CC to 594-23-5, 3–4 cm are placed in the combined Zones NN12/NN14. The occurrence of *Discoaster quinqueramus* in Samples 594-23,CC and 594-26-5, 3–4 cm places this interval in the late Miocene *Discoaster quinqueramus* Zone (NN11).

Samples 594-26,CC to 594-28-3, 3–4 cm, above the last occurrence of *D. hamatus* in Sample 594-28-5, 3–4 cm, are placed in the late Miocene *D. calcaris* Zone (NN10). *Discoaster hamatus* occurs in Samples 594-28-5, 3–4 cm to 594-29,CC, which places this interval in the middle Miocene *D. hamatus* Zone (NN9).

The interval from Sample 594-30-1, 3–4 cm to 594-42-3, 3–4 cm, the first occurrence of *D. kugleri*, is placed in the combined Zones NN7/NN8. The boundary between NN7 and NN8 is based upon the first occurrence of *Catinaster coalitus*, which is not present at Site 594. Samples 594-42,CC to 594-53,CC are placed in the middle Miocene *Discoaster exilis* Zone (NN6).

Hole 594A

Samples 594A-1,CC to 594A-12,CC are repeats of the section drilled at Hole 594. Samples 594A-13-3, 3–4 cm to 594-15-3, 3–4 cm, above the last occurrence of *Sphenolithus heteromorphus* in Sample 594A-15,CC, are placed in the middle Miocene *Discoaster exilis* Zone (NN6). Samples 594A-15,CC to 594-26,CC are placed in the middle Miocene *Sphenolithus heteromorphus* Zone (NN5). Reworked Oligocene and possibly early Miocene species are present in many of the samples from this hole as well as Hole 594.

Silicoflagellates

Silicoflagellates occur throughout the Quaternary to Miocene sequence and are associated with sponge spicules and a few endoskeletal dinoflagellates. They form, however, only a minor component of the predominantly calcareous sediments.

Silicoflagellates only were investigated in detail in acid-treated core-catcher samples from Holes 594 and 594A. The assemblages found can be laced without difficulty in the northern high-latitude silicoflagellate zonation used during Leg 38 (Martini and Müller, 1976). Samples 594-6,CC to 594-16,CC belong to the *Distephanus speculum* Zone. Samples 594-18,CC to 594-20,CC seem to represent the early Pliocene *Distephanus boliviensis* Zone, although the nominate species was not found. In Samples 594-21,CC and 594-31,CC, *Mesocena circulus* was noted; consequently these samples are placed in the late middle to late Miocene *Mesocena circulus* Zone. In Sample 594-35,CC *Corbisema triacantha* was found, indicating the presence of the late early to early middle Miocene *Corbisema triacantha* Zone. The lowest sample of Hole 594 (594-53,CC) also contains *C. triacantha*, which in this sample is still associated with *M. diodon*. Thus these samples also belong in the *C. triacantha* Zone, as does Sample 594A-20,CC, because of the first occurrence of *M. diodon*. Samples 594A-21,CC to 594A-25,CC were barren of siliceous fossils.

Reworked Eocene silicoflagellates were found in most samples studied. In addition, in Sample 594-24,CC reworked Eocene diatoms (*Triceratium barbadense*) were noted.

Radiolarians

Radiolarians are rare throughout the cores recovered at Site 594, and moderately to well-preserved faunas are encountered in all cores.

Stratigraphic correlation of Neogene radiolarians at Site 594 is difficult because of the scarcity of siliceous material, the great dilution by terrigenous material, and changes of paleoenvironments. Because warm water and polar assemblages are mixed, zonations proposed for both regions have been employed.

Sections 594-1-1 to 594-6-4 contain a typical late Quaternary (less than 400,000 yr.) antarctic radiolarian assemblage that can be assigned to the *Antarctissa denticulata* Zone or Zone NR1. Common species include *A. denticulata, A. strelkovi, Theocalyptra davisiana*, and *Rhizosphaera antarctica*.

Sections 594-7-2 to 594-8-1, below the last appearance of *Stylatractus universus* in 594-7-2, are placed in Zone NR2 (Quaternary). The next marker observed was *Phormostichoartus pitomorphus*, whose last occurrence in Section 594-9-4 puts Sections 594-9-4 to 594-11-5 in Zone NR3/NR4 (early to middle Pleistocene) (the two zones are not distinguished because warmer-water species are missing).

Clathrocyclas bicornis (Hays) occurs sporadically between Sections 594-11-6 and 594-14-2. This occurrence is interpreted as reworking, because *A. denticulata* and *Theocalyptra bicornis* Popofsky were first found in Section 594-12-3. Thus Sections 594-11-6 to 594-14-4 are placed in Zone NR4.

The last consistent occurrence of *C. bicornis* (Hays) in Section 594-15-2 is used to mark the top of the Pliocene. Rare radiolarians occur in Section 594-15-2 to 594-20-3. Typical Pliocene species like *Pseudocubus vema* occur sporadically. Because of the poor preservation and scarcity of markers the interval between Sections 594-15-2 and 594-20-3 remains unzoned.

Sections 594-20-4 to 594-27-1, below the first occurrence of *Antarctissa ewingii* and above the first appearance of *Stichocorys peregrina*, are placed in the *Stichocorys peregrina* Zone (late Miocene). In the best preserved samples, forms like *Anthocyrtidium ehrenbergii* and *Hexacontium hootsi* indicate warmer conditions. Reworked specimens of Eocene to middle Miocene age occur in Sections 594-23-1 to 594-26-4.

The next markers observed were *Didymocyrtis antepenultima* and *Diartus hughesi*, whose first appearances are tabulated in Section 594-31-5. Thus, Sections 594-27-4 to 594-31-5 are placed in the *Didymocyrtis antepenultima/D. penultima* Zone. The *D. penultima* and *D. antepenultima* zones are amalgamated because the species *D. penultima* was not found in the radiolarian assemblages. Moreover, the base of the *D. penultima* Zone, which is also recognized in tropical areas at the top of the range of *Diartus hughesi*, cannot be located in Site 594 because the last occurrence of *D. hughesi* is tabulated in the *S. peregrina* Zone. It is possible that *D. hughesi* as well as *Didymocyrtis laticonus* and *D. antepenultima* have different ranges in the mid-latitude sediments. Close examinations of numerous specimens show distinct morphological differences from tropical forms (see Caulet, this volume).

Sections 594-31-6 to 594-37-1 contain poorly preserved and rare radiolarian assemblages. Barren levels occur sporadically throughout this interval, which cannot be related to a well-defined zone.

Most radiolarian species recognized in the samples below 594-37-1 are well known in the tropical assemblages of the *Diartus petterssoni* Zone (middle Miocene).

The most significant transition in the radiolarian fauna is observed between Cores 594-23 and 594-21. In Core 21 and above, most temperate or warm-water radiolarians have disappeared. Radiolarian abundances are greatly reduced and antarctic or subantarctic species become more dominant. Their occurrence suggests a northward migration of the Antarctic Convergence.

Diatoms

Diatoms are abundant to sparse in most processed samples from Site 594, except in Cores 594A-22 through 594A-26a, which are barren. In general, diatom preservation is best (fair to moderate) and diversity highest in the middle to upper Miocene. Although Pliocene–Quaternary preservation is fair and diversity low, the entire sequence contains sufficient marker species for reliable age determinations. Reworked Eocene and Oligocene diatoms are common throughout both holes.

Zonation and Sediment Age Determinations

No single zonal scheme could be employed for the entire middle Miocene–Quaternary. Migration of the Subtropical Convergence, which lies directly north of the site, has resulted in a shift in the predominance of subantarctic/antarctic to subtropical species through time. As a result, the zonal schemes employed herein are the antarctic/subantarctic zonations of Weaver and Gombos (1981) and Ciesielski (1983) and the mid-latitude zonations of Barron (1980, 1981).

The diatom assemblage suggests that the subantarctic water mass has prevailed at the site since the Miocene; therefore, the antarctic/subantarctic zonation of Ciesielski (1983) was used successfully in zonation of the entire Pliocene–Quaternary. The mixed occurrence of antarctic to mid-latitude index species in the middle to late Miocene precludes the use of a single zonal scheme for this interval. A new regional zonation is required for Site 594, utilizing the existing high to mid-latitude species, is given in Ciesielski (this volume). For the purpose of this site report, middle to late Miocene diatom zones are temporarily referred to as zonal equivalents of Barron's (1980, 1981) mid-latitude diatom zonation. It should be noted that correlations to Barron's zonation are tentative and incomplete because some index species are missing at Site 594.

In spite of difficulties in correlating with existing zonal schemes, Site 594 was reliably correlated to magnetostratigraphy by the identification of diatom datums which have been intercalibrated with magnetostratigraphy elsewhere or have been dated radiometrically. Table 3 lists these microfossil datums, their stratigraphic position, and their approximate age based upon direct correlation to magnetostratigraphy, citing diatom zones or zonal equivalents. The locations of major stratigraphic boundaries at Site 594, as determined by the application of all microfossil groups, are as follows (A indicates Hole 594A cores):

Boundary	Core-Section
Pliocene/Pleistocene	14,CC–15-2
early Pliocene/late Pliocene (unconformable boundary)	16,CC–10A-2
Miocene/Pliocene (unconformable boundary)	20-5–20-2
middle Miocene/late Miocene	38,CC–37,CC
early Miocene/middle Miocene	21,CC–20,CC

Unconformities

Four unconformities were detected within the upper Miocene through Quaternary of Holes 594 and 594A. The interval represented by each is noted here, with the evidence from Table 3. It is important to note that the Miocene/Pliocene boundary and the early/late Pliocene boundary fall within disconformities.

1. Chronozone 8–Chronozone 7, ~8.3–6.5 m.y. ago: close proximity of FAD of *H. karstenii* s.l. (Chronozone 6) in Core 24 to LAD of *D. hughesii* (basal Chronozone 8 or upper Chronozone 9) in Core 26.

2. Upper Chronozone 5–lower Gilbert Chronozone below the Sidufjall Subchronozone, ~5.4–4.5 m.y. ago (Miocene/Pliocene boundary disconformity): LAD of *C. insignis* f. *triangula* (mid to upper Chronozone 5) immediately below last constant *M. diodon* (~4.5 m.y.) in Core 20.

Table 3. Major biostratigraphic and magnetostratigraphic datums observed in Holes 594 and 594A (diatoms and radiolarians).

Datum	Occurrence of datum in hole (Core-Section, interval in cm)	Age of datums (m.y.)
LAD *Stylatractus universus*	7-1 to 6-4	425,000 yr.
Brunhes/Matuyama boundary	11-5, 75–77	730,000 yr.
Matuyama Chronozone disconformity	~11-5	~1.6–~0.74
LAD *Clathrocyclas bicornis* (Hays)	11-6	
Last consistent *C. bicornis*	15-2 to 14-2	?1.8
LAD *Coscinodiscus kolbei*	15-2 to 13-5	1.89
LAD *Cosmiodiscus insignis*	16-2 to 15-5	2.50
FAD *Theocalyptra davisiana*	16-4	2.8–2.6
LAD *Coscinodiscus vulnificus*	16-2 to 15-5	2.22
LAD *Nitzschia weaveri*	10A-2 to 16-5	2.64
upper Gilbert–upper Gauss Chronozone disconformity	10A-2 to 16-5	~3.85–2.70
FAD *Nitzschia weaveri*	10A-5 to 10A-2	3.88
LAD *Stichocorys peregrina*	19-1	4.6–4.4
last consistent *Mesocena diodon*	20-2 to 19-5	4.45
Chronozone 5–lower Gilbert disconformity	20-5 to 20-2	~5.4 to ~4.5
LAD *Cosmiodiscus insignis* f. *triangula*	20-5 to 20-2	5.4
LAD *Asteromphalus* sp. 1	21-5 to 21-2	~5.6
FAD *C. insignis* f. *triangula*	23-2 to 11A-5	late Chron 6 (~6.0)
FAD *Nitzschia reinholdii*	23-5 to 23-2	early Chron (~6.4)
Last consistent *Mesocena circulus*	23-5 to 23-2	early Chron 6 (~6.4)
FAD *Hemidiscus karstenii* f. 1	24-5 to 24-5	mid to early Chron 6
Chronozone 8–Chronozone 7 disconformity	26-2 to 24-5 (exact location of hiatus not yet determined)	~8.5–6.5
LAD *Diartus hughesi*	—— to 26-2	~8.5
FAD *Stichocorys peregrina*	—— to 27-1	~8.5
LAD *Thalassionema hirosakensis*	29 to 28-5	
LAD *Lithodesmium reynoldsii*	30 to 29	~Chron 9/Chron 8 boundary
LAD *Cyrtocapsella japonica*	—— to 31-2	~8.7
FAD *Asteromphalus* sp. 1	31-5 to 31-2	~8.7
FAD *D. hughesi*	—— to 31-5	~8.7
FAD *Didymocyrtis antepenultima*	—— to 31-5	
Last consistent *Denticulopsis lauta*	35-5 to 35-2	late Chron 9 (~8.7–8.5)
Last common *Denticulopsis dimorpha*	39-1 to 38-1	10.2
LAD *Nitzschia denticuloides*	44-1 to 43-1	early Chron 10
FAD *Denticulopsis dimorpha*	46-2 to 45-2	11.1
LAD *Coscinodiscus lewisianus*	52-2 to 51-1	late Chron 13 (~12.5–12.6)
LAD *Denticulopsis nicobarica*	18A-1 to 17A-2	late Chron 14 (~12.8)
FAD *Denticulopsis praedimorpha*	19A-2 to 18A-1	earliest Chron 14 (~13.3?)
FAD *Denticulopsis hustedtii*	19A-2 to 18A-1	mid Chron 15 (~14.3?)
FAD *Brunia mirabilis*	19A-2 to 18A-1	

Note: A indicates cores from Hole 594A.

3. Upper Gilbert Chronozone above the Cochiti Subchronozone to upper Gauss Chronozone, ~3.85–2.7 m.y. ago: FAD of *N. weaveri* (~3.88 m.y.) immediately below LAD of *N. weaveri* (~2.64 m.y.).

4. Mid to upper Matuyama Chronozone, ~1.6–0.74 m.y. ago: occurs entirely within the *C. elliptopora*/*A. ingens* Zone; however, the disconformity is substantiated by the LAD of *C. bicornis* (Hays) (about 1.8 m.y.) immediately below the Brunhes/Matuyama boundary as noted by Barton and Bloemendal (this volume).

PALEOMAGNETISM

The two most notable paleomagnetic results were the location of the Brunhes/Matuyama boundary at 99 m sub-bottom depth, and the surprisingly low intensities of magnetization, given the higher terrigenous input at this site.

HPC cores from Holes 594 and 594A were sampled at 50 cm intervals. The XCB cores from Hole 594A were sampled at 150 cm intervals. Absolute orientations were obtained for only four cores from Hole 594. Laboratory NRM and low-field magnetic susceptibility measurements have been completed for most of Hole 594 (Table 4). The relatively high negative mean inclination is largely due to the preponderance of normal directions during the Brunhes.

Alternating peaks and troughs in magnetic susceptibility occur within the first 12 cores (0–108 m sub-bottom depth). Depths of the most prominent peaks are shown in Table 5 and generally coincide with higher intensities of magnetization. These variations have not yet been carefully compared with the lithologic variations during the Quaternary. However, it was noted that in the upper part of the sequence, where the alternating dark, fine-grained and light, coarser-grained sediments are most pronounced, the darker-colored sediments are characterized by higher NRM. Deeper in the sequence this contrast in NRM disappears well before the color zonations disappear. This suggests that gradual diagenesis of magnetic minerals of terrigenous origin is occurring on a time scale on the order of 10^5 yr.

No very thin, surficial, high-intensity layer was found in Hole 594. The general pattern of intensity variations is also shown in Hole 594. The general pattern of intensity variations is also shown in Table 4. A region of uniformly high intensity during the Miocene which was observed at previous sites was also not present.

A magnetic polarity stratigraphy based on NRM results for Hole 594 is presented in Figure 10. There is convincing evidence that the Brunhes/Matuyama boundary occurs within Core 594-11. Below this, the interpretation is less certain. A possible alternative to the illustrated (preferred) scheme is to assign the top of the Gauss Chron to the depth where the top of the Olduvai Subchron is illustrated. The Olduvai Subchron would then replace the Jaramillo in the figure. However, this interpretation is in poorer agreement with the diatom and radiolarian stratigraphy and is less probable. Below the top of the Gauss, directions are too scattered for polarity intervals to be resolved with any degree of confidence. There are some fairly long intervals with a predominantly normal inclination bias, which is indicative of partial secondary overprinting during the Brunhes Chron—probable because viscous remanence built up in fine-grained iron monosulfides.

Table 4. Preliminary NRM and magnetic susceptibility data for Hole 594.

Geometric mean intensity	0.072 μG
Scalar mean inclination (+ 1 s.d.)	−20.7° + 38.4°
Axial dipole inclination	−63.8°
Mean angle between repeats	15.4° (34 repeats)
NRM intensity variation	
0–10 m	High (0.1 to 10 μG, typically)
10–200 m	Intermediate (~0.1 μG)
200–350 m	Low (0.01 to 0.1 μG)
Below 350 m	Medium to low (0.01 to 0.3 μG)
Susceptibility variation	
0–108 m	Alternating peaks and troughs
0–30 m	Intermediate (5 to 25 μG Oe^{-2} typically)
30–179 m	Low (1 to 10 μG Oe^{-1})
179–184 m	Very low (0 to 1 μG Oe^{-1})
184–399 m	Weak diamagnetic
399–488 m	Low (0 to 2 μG Oe^{-1})

Table 5. Prominent peaks in magnetic susceptibility, Hole 594.

Core-Section (level in cm)	Sub-bottom depth (m)	Susceptibility (μG Oe^{-1})
1-4, 025	4.75	41.3
2-2, 125	8.65	29.6
3-3, 075	19.25	239.2
4-1, 125	26.35	64.2
4-3, 025	28.35	249.2
15-1, 025	130.95	11.2
16-2, 075	142.55	11.2
46-2, 025	430.05	10.3

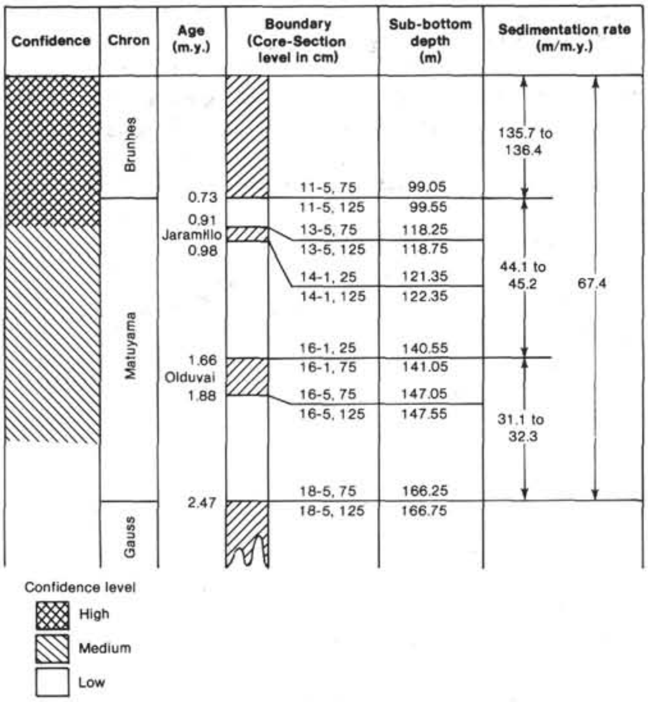

Figure 10. Magnetic polarity stratigraphy for Hole 594.

Results of partial AF demagnetization tests conduced on the *Glomar Challenger* on three sediment samples from the Brunhes Chron are summarized in Table 6. A viscous component amounting to 10 to 20% of the natural remanence was detected. The results show that these upper sediments preserve a stable primary remanence which dominates the NRM. As in previous sites, there is a strong case for arguing that the deterioration of the paleomagnetic record with depth is caused by a combination of very gradual diagenetic alteration of primary magnetic minerals (in a sulfur-rich environment) and compaction effects. In materials with a sufficiently large number of uniformly distributed magnetic grains, gradual compaction into a closer-packed structure will cause dispersion of the directions of remanence of individual

Table 6. Summary of progressive AF demagnetization data for three samples within the upper, long normal zone, Hole 594.

Core-Section (level in cm)	Sub-bottom depth (m)	J_0 (μG)	Stable range (Oe)	ΔI
1-4, 75	5.25	3.686	0-600	± 15°
5-4, 75	39.95	1.194	0-400	± 15°
6-3, 75	48.05	0.970	0-400	± 12°

Note: J_0 = NRM intensity, Stable Range is the range of peak demagnetizing field within which only small changes in direction occur, ΔI is the inclination change in this stable range.

grains without changing the statistical mean direction. The magnitude of the resultant magnetization will, of course, be less. When the density of magnetic grains falls to sufficiently low values, statistical averaging of the dispersed directions will no longer give the original mean, and the resultant directions of magnetization of specimens will become scattered.

As noted in the paleomagnetic report for Site 591, there was a marked decrease in magnetization after storage by a factor of two to three. Repeat measurements conducted on board the *Glomar Challenger* showed that most of these decays occur during the first 36 hr. of storage. The problem is a serious one which requires detailed investigation.

SEDIMENTATION RATES

Sedimentation rates are calculated upon the diatom and radiolarian datum ages provided in Table 3. The ages of the datums have been determined by intercalibration with magnetostratigraphy elsewhere. In most cases, the stratigraphic level of the datum is known only within certain depth limits, and hence the midpoint is used in the plot (Fig. 11).

Sedimentation rates were high (76–78 m/m.y.) during much of the middle and late Miocene during deposition of foraminifer-bearing nannofossil ooze and nannofossil ooze. Unlike nearly all of the sites drilled further north during Leg 90, rates at Site 594 (~30–40 m/m.y.) were relatively low during the latest Miocene and Pliocene, an interval punctuated by 3 disconformities. Rates of deposition began to increase dramatically at the base of the Pleistocene, were high during the early Pleistocene (late Matuyama chron; 89 m/m.y.) and even higher (avg. 138 m/m.y.) during the last 700,000 yr. (Brunhes Chron). Therefore, there are three broad, stratigraphic intervals marked by differing rates of sedimentation: intermediate rates during much of the middle and late Miocene, lowest rates during the latest Miocene and Pliocene, and highest rates during the Pleistocene.

SUMMARY AND CONCLUSIONS

Site 594 is located at the southern margin of the Chatham Rise east of the South Island of New Zealand, in a water depth of 1204 m at a position of 45°31.41′S, 174°56.88′E. The site lies in the subantarctic water mass immediately south of the Subtropical Convergence, and is the southernmost of a series of sites forming a north-

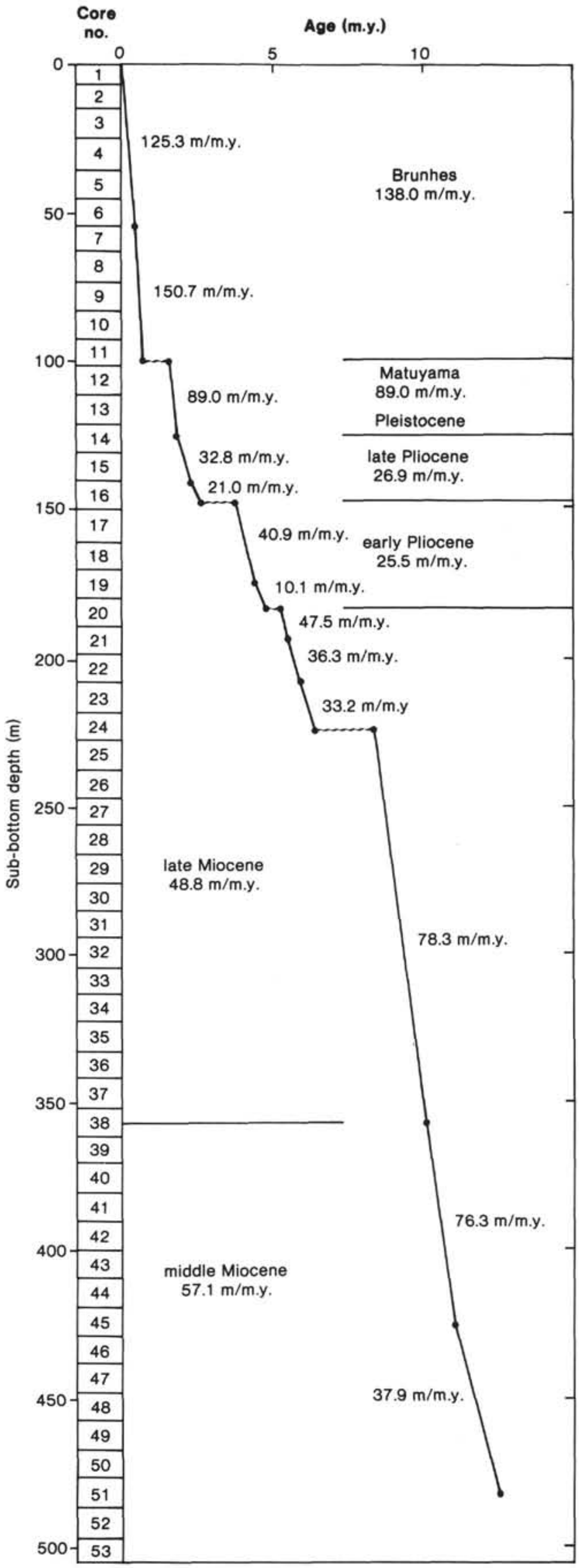

Figure 11. Sedimentation rates for Site 594.

south transect. It is situated in a transitional region between oceanic and terrigenous influences, thus differing from all other sites on the southwest Pacific transect. It is located on a relatively flat, smooth seafloor, underlain by what appears to be a simple seismic stratigraphy of parallel reflectors.

Site 594 consists of three holes cored to a maximum sub-bottom depth of 639.5 m. Excellent core recovery was obtained from 0 to 207.5 m sub-bottom depth (Holocene to latest Miocene) using the HPC to about 130 m in Holes 594 and 594A. The remaining section was rather poorly recovered using the XCB.

The section extends from the latest early Miocene to the Holocene and is cut by at least four unconformities. A paleomagnetic stratigraphy has been identified down to the late part of the Gauss Chron (about 2.5 m.y. ago).

The sequences are assigned to two lithostratigraphic units, the lower one of which is subdivided into two subunits (Fig. 12). Divisions are based mainly upon differences in composition that are clearly revealed in the color changes.

Unit I, of earliest Pliocene to Quaternary age, consists of an alternating sequence of pelagic and hemipelagic lithofacies generally defined by bluish gray and greenish gray sediment, respectively. Pelagic–hemipelagic cycles range in thickness from 0.5 to 10 m. Contacts between lithofacies are completely gradational, subtle variations in color between the bluish gray and greenish gray end-members.

The pelagic lithofacies consists mainly of blue gray foraminifer-bearing nannofossil ooze, foraminifer- and clay-bearing nannofossil ooze, or foraminifer-bearing clayey nannofossil ooze. The lithofacies is dominated by calcareous nannofossils, with rare to common foraminifers and clay minerals, and trace and rare amounts of quartz, feldspars, mica, and biogenic siliceous components that include sponge spicules, diatoms, and radiolarian fragments.

The hemipelagic lithofacies consists of a variety of sediment intergrades between a clay- and silt-bearing nannofossil ooze and a nannofossil-bearing clayey silt; this greenish gray lithofacies is commonly diatom- and sponge-spicule-bearing, and rarely foraminifer-bearing. Dominant components are varying quantities of calcareous nannofossils, clay minerals, and silt-sized grains of quartz, feldspar, and mica. Foraminifers and siliceous biogenic components are rare to common. Compared to the pelagic lithofacies, the sediment is relatively enriched in both terrigenous silt and clay and in biogenic siliceous components, notably sponge spicules and diatoms, with relative depletion of both foraminifers and nannofossils. A few volcanic ash layers are present.

The contact between Units I and II is gradational over several meters, but is recognized by the change from interbedded pelagic and hemipelagic facies of Unit I to a pelagic facies in Unit II. Unit II, of late early Miocene to earliest Pliocene age, is mainly a foraminifer-bearing nannofossil ooze (chalk) to nannofossil ooze (chalk). Separate ooze and chalk subunits are defined, the ooze/chalk transition occurring at about 466 m in Hole 594.

Subunit IIA, of early middle Miocene to earliest Pliocene age, is a light gray foraminifer-bearing nannofossil ooze that grades down into a nannofossil ooze near 245 m sub-bottom depth. Calcareous nannofossils dominate the components; foraminifers are generally common above 245 m but form only trace to rare amounts below this level.

Subunit IIB, of late early to early middle Miocene age, is a light gray nannofossil chalk with occasional interbeds of olive gray silt-bearing clayey nannofossil chalk below 534 m sub-bottom; these are interpreted as turbidite layers. Below 467 m sub-bottom depth (early middle Miocene), distinctive pale to dark green laminae occur commonly in the subunit. The laminae may represent altered volcanic glass.

The turbidite interbeds range in thickness from a few to 90 cm, have sharp erosional bases, are normally graded, and have burrowed gradational tops that grade upward into overlying chalk. They are dominated by calcareous nannofossils with common micas and clay minerals, rare foraminifers, and occasional quartz and feldspar grains. Textures range from medium to very fine silt at the base of beds to clay-dominated at the top. There is a pronounced habitat stratification in the infaunal burrow types in the thicker beds in the upper portion of units, with Planolites between 0 and about 5 cm, Chondrites to depths of 10 cm, and Zoophycos to depths of 15 to 20 cm in the beds.

Site 594 has much paleoceanographic potential. There is a fine biostratigraphic sequence of subantarctic elements from the middle Miocene to the Holocene. Both calcareous and siliceous microfossil groups are well represented. The calcareous nannoplankton assemblages are typical of cold water and largely lack the warm-water forms so useful in biostratigraphic zonations. Considerable microfossil reworking, particularly with respect to foraminifers, was observed associated with the early middle Miocene turbidites.

The latest Miocene to Holocene sequence of oscillations between dark hemipelagic and lighter pelagic biogenic sediments is climatically related. The pelagic episodes mark climatic warmings and high sea levels (interglacials). These have little biosiliceous sediment, less calcareous dissolution, and warmer-water planktonic foraminifer faunas. The hemipelagics mark cooler (glacial) episodes when low stands of sea level led to major sediment bypassing over the continental shelves and the deposition of terrigenous materials in the basins surrounding New Zealand. These episodes exhibit cold-water planktonic foraminiferal faunas, rich siliceous microfossil assemblages, and much carbonate dissolution. Intergrades occur between these two extremes. Twenty-five major hemipelagic episodes have occurred during that interval represented by sediments in the last 6 m.y. The oldest coincides with the well-known Kapitean (Messinian) regression.

A distinct increase in radiolarian abundances occurs during the latest Miocene in response to the important paleoceanographic changes then; perhaps it is related to the development of the Subtropical Convergence.

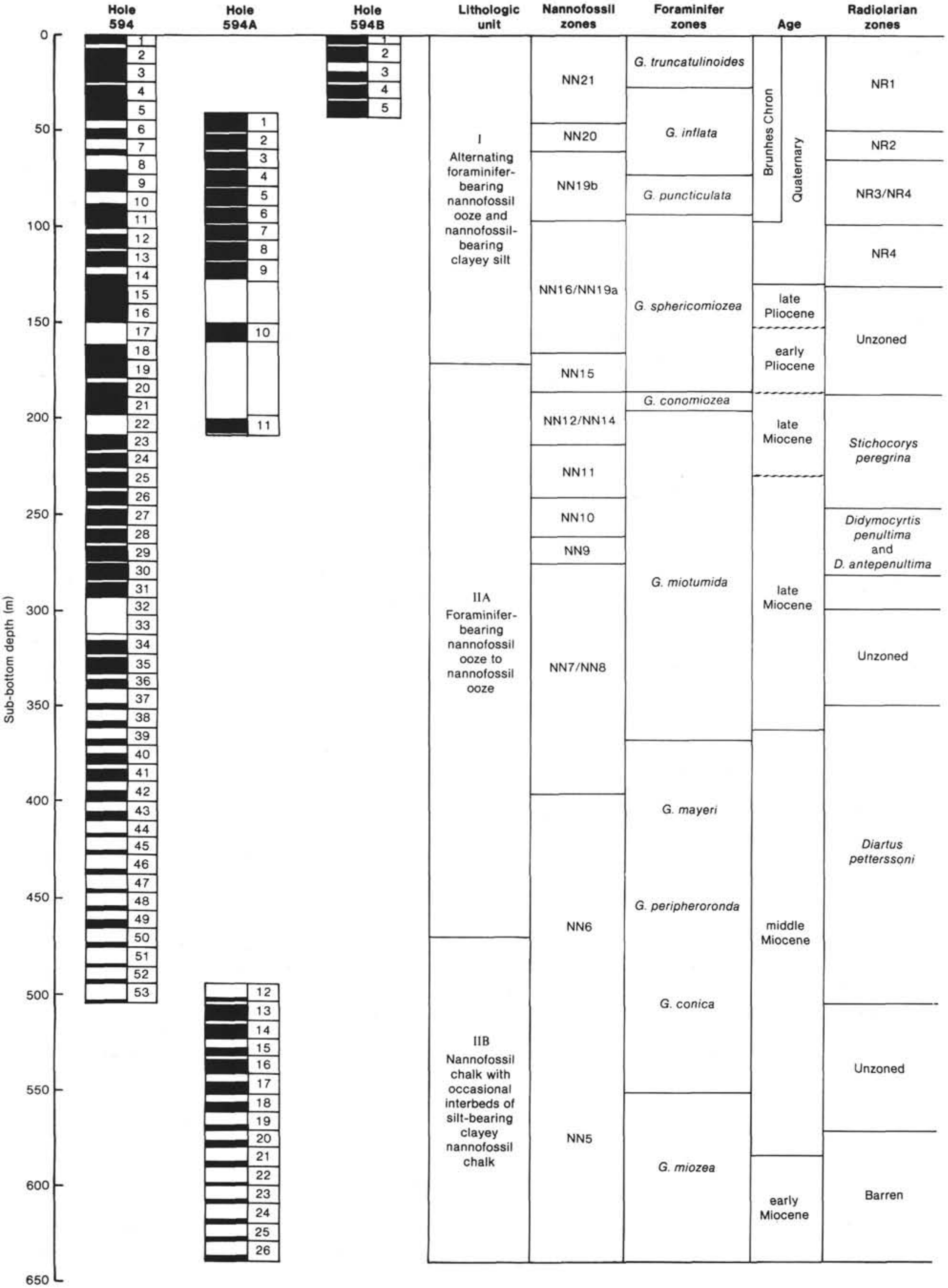

Figure 12. Summary lithology, biostratigraphy, and mass accumulation rates for Site 594. Core recovery shown in black.

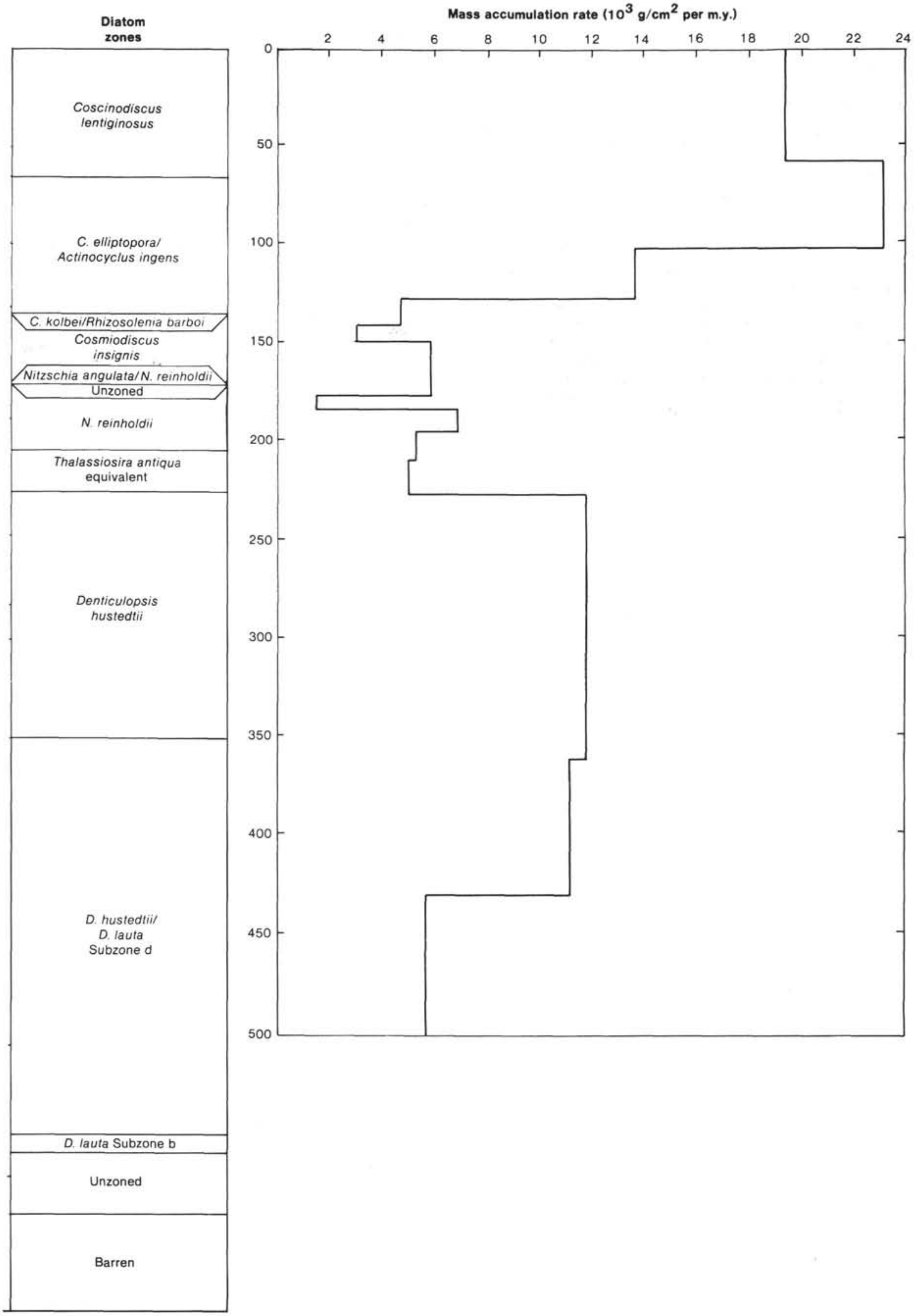

Figure 12. (Continued).

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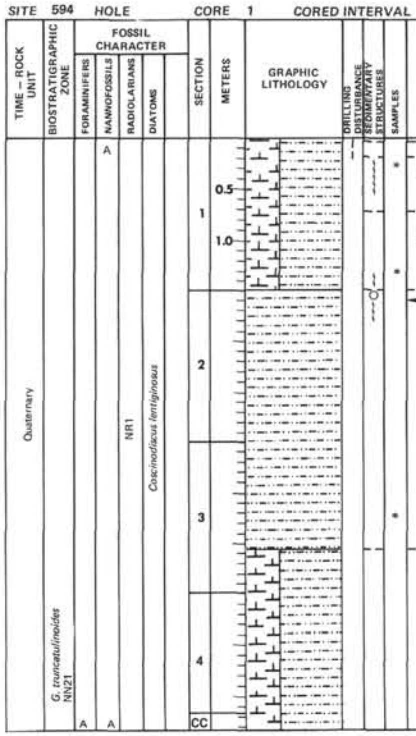
SITE 594 HOLE CORE 1 CORED INTERVAL 0.0–5.9 m



LITHOLOGIC DESCRIPTION

Yellowish gray (5Y 7/2) cap
5B 7/1
10Y 6/2 mottles
5B 7/1
5GY 6/1
5B 7/1 burrow
10Y 4/2
5G 6/1 to 5G 4/1

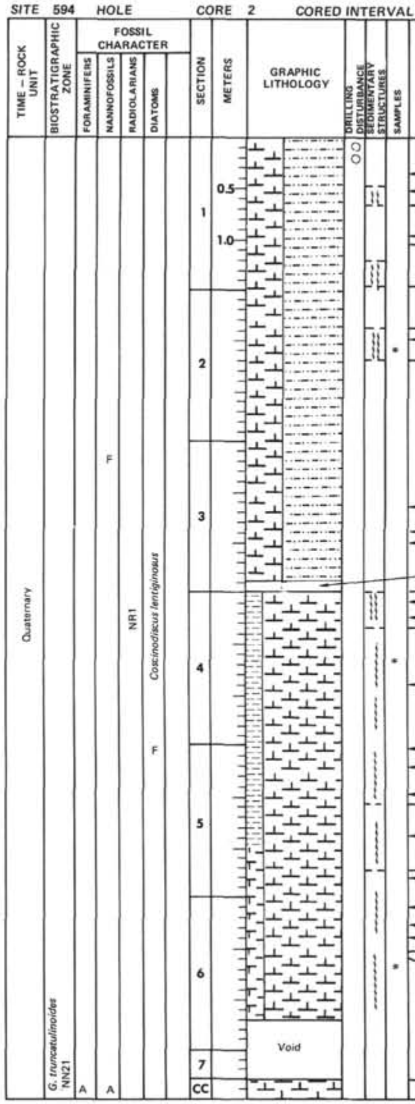
NANNOFOSSIL-BEARING SILT OR SILTY CLAY, light bluish gray (5B 7/1) to greenish gray (5GY 6/1), soft, massive, burrow mottled.

SILTY CLAY, grayish olive (10Y 4/2), soft, massive, scattered white benthic foraminifers, sponge spicules in smear slides.

SMEAR SLIDE SUMMARY:

	1, 20 D	1, 120 D	3, 60 D
Texture:			
Sand	C	C	–
Silt	A	A	C
Clay	A	A	A
Composition:			
Quartz	C	C	C
Feldspar	C	C	C
Mica	R	R	C
Heavy minerals	R	T	T
Clay	A	A	A
Volcanic glass	R	T	T
Glauconite	T	–	T
Pyrite	–	–	T
Foraminifers	R	R	T
Calc. nannofossils	C	C	R
Diatoms	–	T	–
Radiolarians	T	–	–
Sponge spicules	R	C	R

SITE 594 HOLE CORE 2 CORED INTERVAL 5.9–15.5 m



LITHOLOGIC DESCRIPTION

5GY 4/1
5GY 4/1 5G 4/1
10Y 6/2 burrows
10Y 6/2
5G 6/1
10Y 6/2 burrows
5G 4/1
5Y 8/1 chunk 5G 6/1
5G 4/1
N3 py.
N3
N3
IW
N4 py.
N4 5B 5/1
10Y 6/2 mottles
5B 7/1
10Y 6/2
N3
10Y 6/2
N3 5B 5/1
N3
5B 7/1
N4
10Y 6/2 mottles
10Y 6/2 + N4
10Y 6/2 mottles
5B 5/1

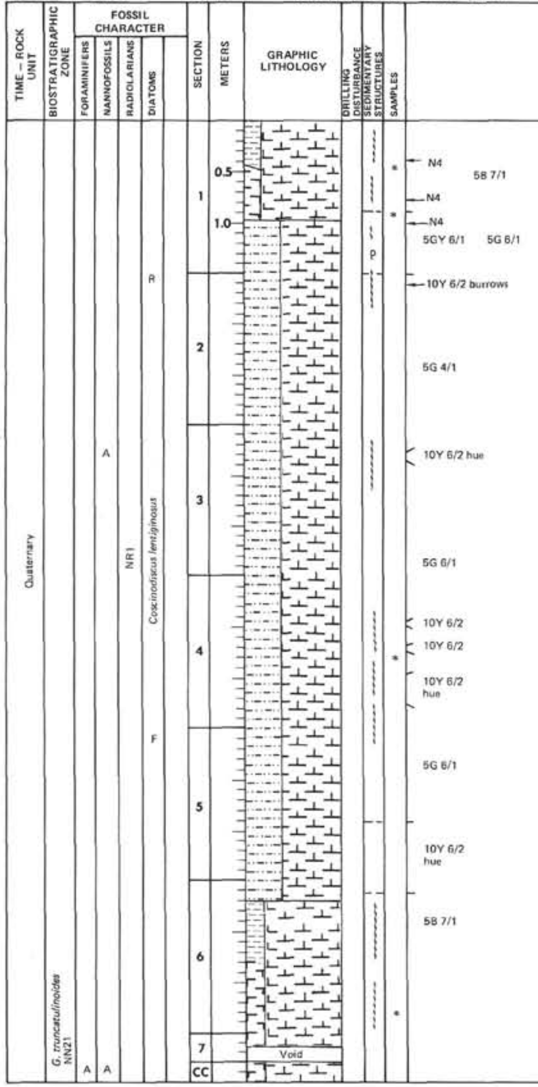
FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, light to medium bluish gray (5B 7/1 to 5B 5/1), soft, massive with common pale olive (10Y 6/2) burrow mottling and scattered dark gray (N3 to N4) pyrite blebs.

NANNOFOSSIL SILTY CLAY, greenish gray (5G 6/1) to dark greenish gray (5G 4/1), soft, massive with common pale olive (10Y 6/2) burrow mottles and scattered pyritized spots.

SMEAR SLIDE SUMMARY:

	2, 70 D	4, 70 D	6, 70 D
Texture:			
Sand	C	C	C
Silt	A	A	A
Clay	A	A	A
Composition:			
Quartz	C	C	C
Feldspar	C	C	–
Mica	C	C	–
Heavy minerals	R	T	T
Clay	A	A	C
Volcanic glass	R	T	R
Glauconite	T	T	T
Pyrite	T	T	T
Foraminifers	R	R	C
Calc. nannofossils	A	A	A
Diatoms	T	T	T
Radiolarians	T	T	T
Sponge spicules	R	R	R
Tunicate spicules	T	–	–

SITE 594 HOLE CORE 3 CORED INTERVAL 15.5–25.1 m



LITHOLOGIC DESCRIPTION

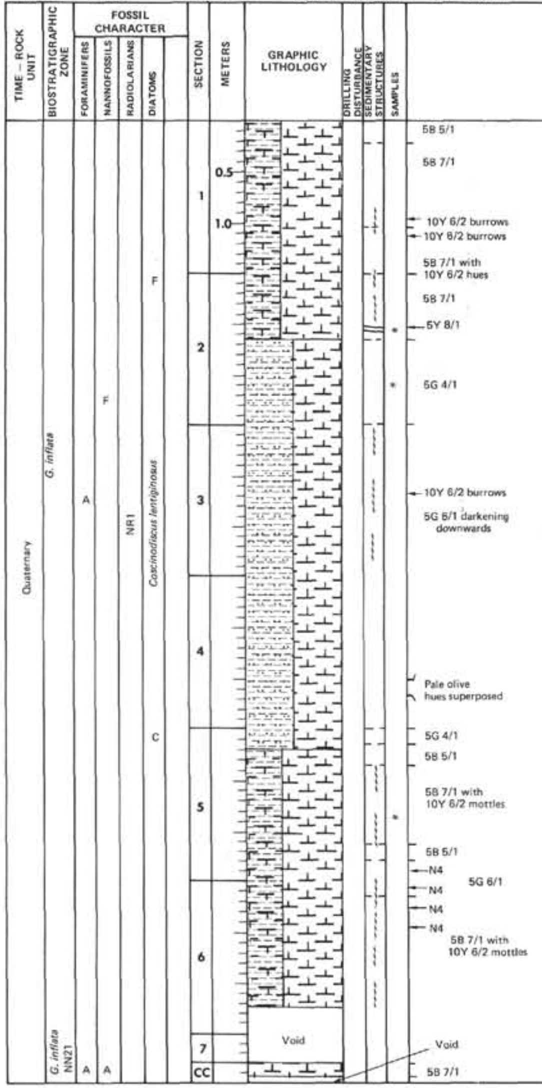
FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, light bluish gray (5B 7/1), soft but firm, massive with pale olive (10Y 6/2) hues and burrow mottles throughout, some pyrite specks.

CLAY- AND SILT-BEARING NANNOFOSSIL OOZE, soft to firm, dark greenish gray (5G 4/1) to greenish gray (5G 6/1), massive with pale olive (10Y 6/2) hues and burrows, alternates with FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, all color boundaries gradational.

SMEAR SLIDE SUMMARY:

	1, 49 D	1, 95 M	4, 77 D	6, 128 D
Texture:				
Sand	C	R	C	C
Silt	A	A	A	A
Clay	A	A	A	A
Composition:				
Quartz	R	–	C	C
Feldspar	–	–	T	–
Heavy minerals	T	T	T	T
Clay	–	C	C	C
Volcanic glass	–	T	R	R
Glauconite	–	–	T	–
Pyrite	T	C	T	T
Foraminifers	C	R	R	C
Calc. nannofossils	A	A	A	A
Diatoms	T	T	T	T
Radiolarians	T	T	T	T
Sponge spicules	R	R	R	R

SITE 594 HOLE CORE 4 CORED INTERVAL 25.1–34.7 m



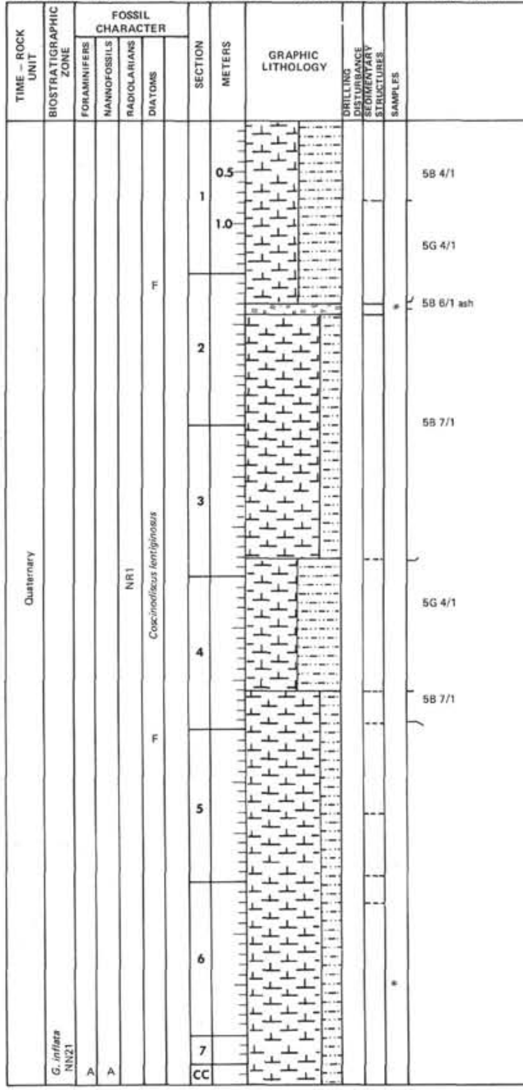
LITHOLOGIC DESCRIPTION

FORAMINIFER- AND CLAY-BEARING NANNOFOSSIL OOZE, light bluish gray (5B 7/1) to medium bluish gray (5B 5/1), soft but firm, massive with common burrow mottling in pale olive (10Y 6/2) colors, diffuse boundaries, alternates with CLAYEY SILTY NANNOFOSSIL OOZE, greenish gray (5G 6/1) to dark greenish gray (5G 4/1), soft but firm, massive with pale olive (10Y 6/2) burrow mottles and hues, scattered dark gray (N4) pyrite.

SMEAR SLIDE SUMMARY:

	2, 59 M	2, 114 D	5, 84 D
Texture:			
Sand	R	C	–
Silt	C	A	–
Clay	D	A	–
Composition:			
Quartz	R	A	R
Feldspar	T	–	T
Heavy minerals	T	T	T
Clay	C	A	–
Volcanic glass	T	R	R
Glauconite	–	T	–
Pyrite	T	R	T
Foraminifers	R	R	C
Calc. nannofossils	A	A	A
Diatoms	T	R	T
Radiolarians	T	T	T
Sponge spicules	R	R	T
Undefined, too small (clay?)	–	–	C

SITE 594 HOLE CORE 5 CORED INTERVAL 34.7–44.3 m



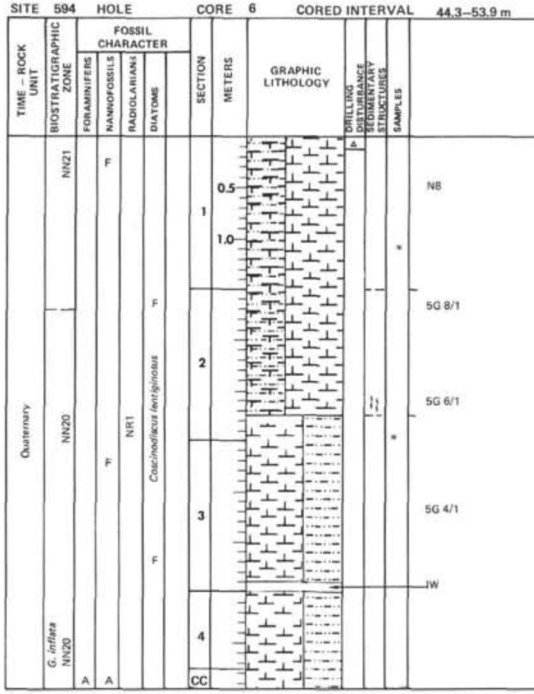
LITHOLOGIC DESCRIPTION

CLAYEY QUARTZOSE NANNOFOSSIL OOZE, dark gray and dark green (5B 5/1 and 5G 4/1) alternating with CLAYEY NANNOFOSSIL OOZE, light and very light gray (5B 7/1, 5G 8/1, 5B 8/1). *Contacts are gradational. Only* one megascopic ash.

SMEAR SLIDE SUMMARY:

	2, 35	6, 102
	M	D
Composition:		
Quartz	R	R
Feldspar	T	–
Heavy minerals	–	T
Clay	C	A
Volcanic glass	D	R
Pyrite	T	T
Foraminifers	–	R
Calc. nannofossils	R	A
Diatoms	T	T
Radiolarians	T	T
Sponge spicules	T	T

SITE 594 HOLE CORE 6 CORED INTERVAL 44.3–53.9 m



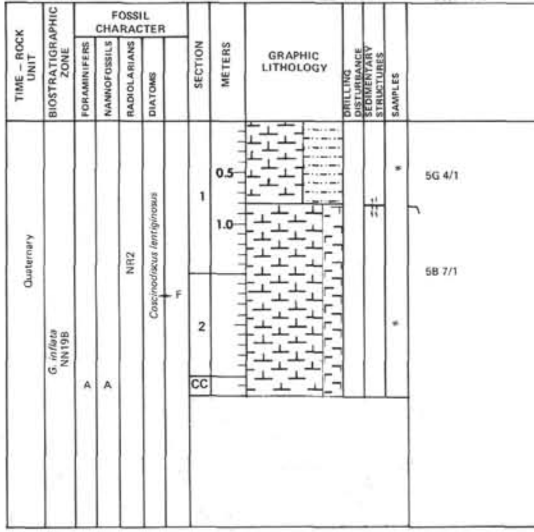
LITHOLOGIC DESCRIPTION

FORAMINIFER- AND CLAY(?)-BEARING NANNOFOSSIL OOZE (N8), homogeneous with color grading down into light greenish grays (5G 8/1 to 5G 6/1) overlying CLAY-, QUARTZ-, and MICA-BEARING NANNOFOSSIL OOZE, dark green (5G 4/1), homogeneous throughout.

SMEAR SLIDE SUMMARY:

	1, 112	2, 148
	D	D
Texture:		
Sand	R	R
Silt	A	A
Clay	D	A
Composition:		
Quartz	R	C
Feldspar	T	T
Mica	—	C
Clay	C	C
Volcanic glass	R	R
Glauconite	–	T
Pyrite	T	T
Foraminifers	C	R
Calc. nannofossils	D	A
Diatoms	T	T
Sponge spicules	T	T

SITE 594 HOLE CORE 7 CORED INTERVAL 53.9–63.5 m



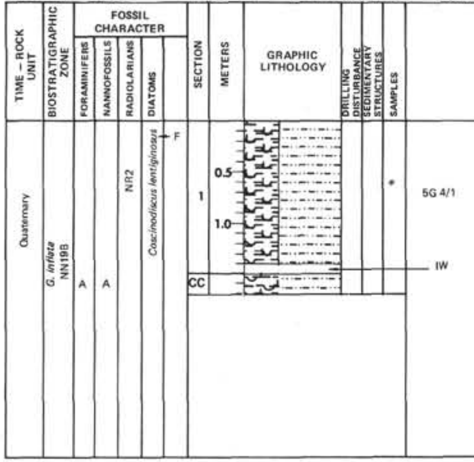
LITHOLOGIC DESCRIPTION

MICA- AND QUARTZ-BEARING NANNOFOSSIL OOZE, dark greenish (5G 4/1), homogeneous, H_2S-rich, pyrite-rich grading down into FORAMINIFER-BEARING NANNOFOSSIL OOZE, light bluish gray (5B 7/1), firm, stained slightly with yellowish iron oxide.

SMEAR SLIDE SUMMARY:

	1, 39	2, 54
	D	D
Texture:		
Sand	R	–
Silt	A	A
Clay	A	D
Composition:		
Quartz	C	R
Feldspar	T	T
Mica	C	–
Heavy minerals	T	–
Clay	R	–
Volcanic glass	R	R
Pyrite	T	–
Foraminifers	R	C
Calc. nannofossils	A	A
Diatoms	R	T
Radiolarians	T	T
Sponge spicules	R	T

SITE 594 HOLE CORE 8 CORED INTERVAL 63.5–73.1 m



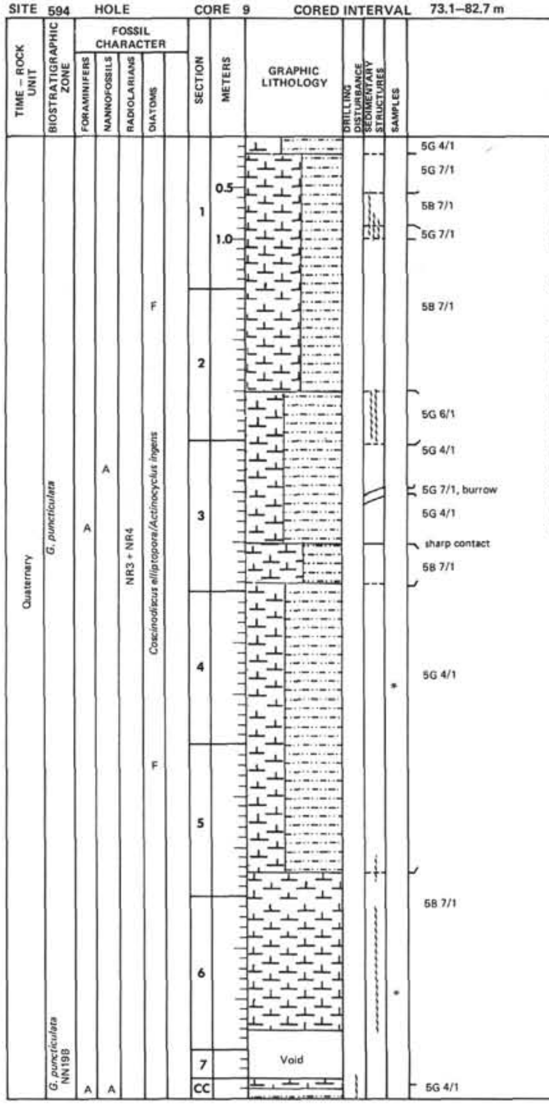
LITHOLOGIC DESCRIPTION

DIATOM, SPONGE SPICULE-, NANNOFOSSIL-, AND FORAMINIFER-BEARING SILT, dark greenish gray (5G 4/1), homogeneous, H_2S-rich, micaceous, gritty texture.

SMEAR SLIDE SUMMARY:

	1, 60 D
Texture:	
Sand	C
Silt	A
Clay	A
Composition:	
Quartz	C
Feldspar	T
Mica	C
Volcanic glass	R
Pyrite	T
Foraminifers	C
Calc. nannofossils	C
Diatoms	C
Radiolarians	T
Sponge spicules	C

SITE 594 HOLE CORE 9 CORED INTERVAL 73.1–82.7 m



LITHOLOGIC DESCRIPTION

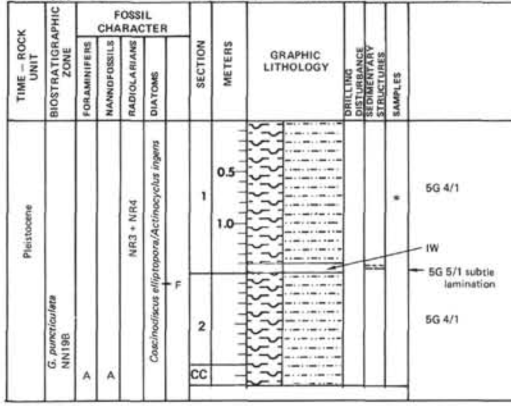
NANNOFOSSIL OOZE, light gray (5G 7/1, 5B 7/1), with subtle color cycles, somewhat bioturbated, some iron sulfide.

SPONGE SPICULE-BEARING, DIATOM-BEARING, NANNOFOSSIL-BEARING, FORAMINIFER-BEARING, CLAYEY SILT, dark greenish gray (5G 4/1, 5G 6/1), homogeneous, bioturbated, H_2S strong.

SMEAR SLIDE SUMMARY:

	4, 90 D	6, 90 D
Texture:		
Silt	–	C
Clay	–	D
Composition:		
Quartz	C	R
Feldspar	T	–
Mica	C	R
Clay	C	–
Volcanic glass	R	–
Pyrite	T	T
Foraminifers	R	R
Calc. nannofossils	C	D
Diatoms	C	T
Radiolarians	T	–
Sponge spicules	C	T

SITE 594 HOLE CORE 10 CORED INTERVAL 82.7–92.3 m



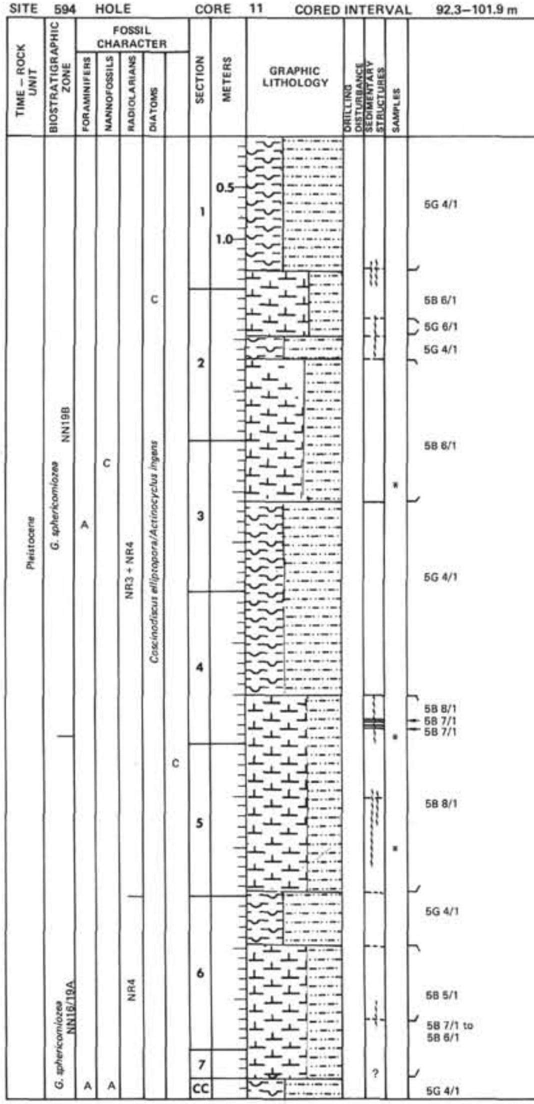
LITHOLOGIC DESCRIPTION

DIATOMACEOUS, SPONGE SPICULE SILT, dark green (5G 4/1), very fine-grained, homogeneous, occasional burrows.

SMEAR SLIDE SUMMARY:

	1, 70
	D
Composition:	
Quartz	C
Mica	C
Pyrite	T
Foraminifers	R
Calc. nannofssils	R
Diatoms	C
Radiolarians	T
Sponge spicules	C
Unidentified	C

SITE 594 HOLE CORE 11 CORED INTERVAL 92.3–101.9 m



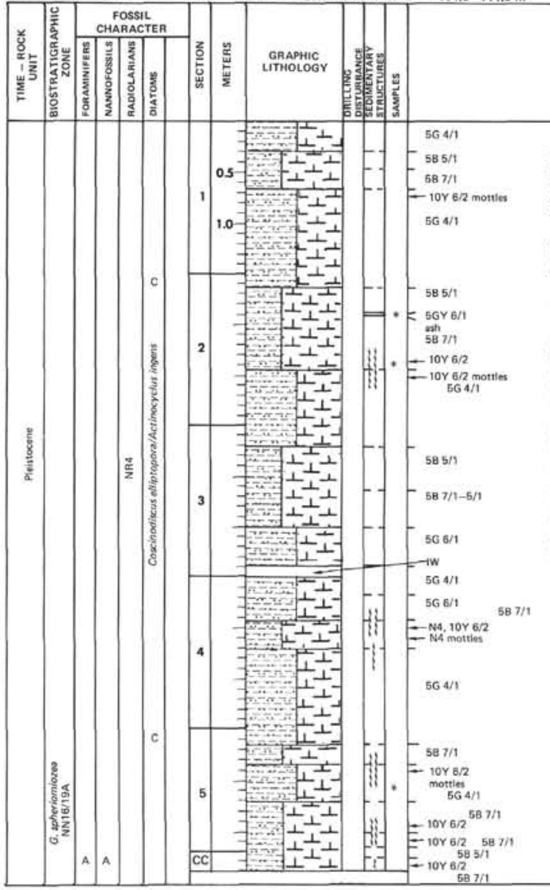
LITHOLOGIC DESCRIPTION

DIATOMACEOUS SPONGE SPICULE SILT, dark greenish gray (5G 4/1, 5G 5/1), homogeneous, minor burrowing and FORAMINIFER-BEARING SILTY NANNOFOSSIL OOZE, light bluish gray (5B 7/1, 5B 6/1), burrow mottled, common large benthic forams, disseminated pyrite.

SMEAR SLIDE SUMMARY:

	3, 45	4, 142	5, 102
	D	D	D
Texture:			
Silt	A	C	A
Clay	A	A	A
Composition:			
Quartz	C	R	C
Feldspar	C	R	C
Mica	R	R	C
Heavy minerals	T	–	–
Clay	C	R	C
Volcanic glass	T	T	–
Glauconite	–	T	–
Pyrite	T	T	–
Carbonate unspec.	T	T	–
Foraminifers	C	C	R
Calc. nannofossils	A	A	C
Diatoms	–	R	–
Radiolarians	T	T	–
Sponge spicules	R	R	–

SITE 594 HOLE CORE 12 CORED INTERVAL 101.9–111.5 m



LITHOLOGIC DESCRIPTION

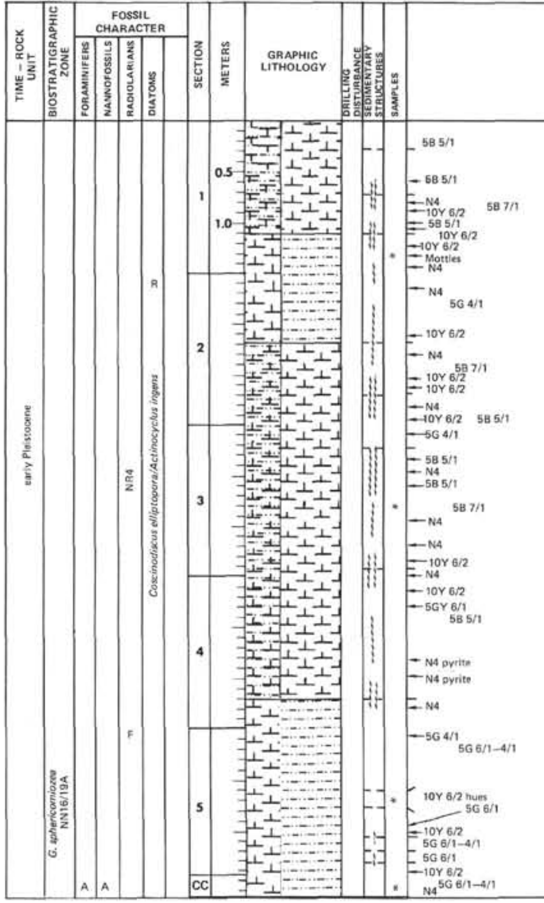
FORAMINIFER-BEARING SILTY NANNOFOSSIL OOZE, bluish gray (5B 5/1 to 5B 7/1), soft, massive with rare color mottles in pale olive (10Y 6/2), especially evident across color boundaries, minor pyrite specks 2 cm ash layer in Section 2.

CLAYEY SILTY NANNOFOSSIL OOZE, greenish gray (5G 4/1 to 5G 6/1), soft, massive, occasional color mottles only.

SMEAR SLIDE SUMMARY:

	2, 41	2, 68	5, 57
	M	D	D
Texture:			
Silt	D	A	A
Clay	–	A	A
Composition:			
Quartz	R	C	C
Feldspar	R	C	C
Mica	C	C	R
Heavy minerals	T	T	T
Clay	T	R	C
Volcanic glass	D	–	–
Glauconite	T	R	R
Pyrite	–	T	T
Carbonate unspec.	–	–	R
Foraminifers	T	C	R
Calc. nannofossils	T	A	A
Diatoms	T	–	–
Sponge spicules	T	R	–

SITE 594 HOLE CORE 13 CORED INTERVAL 111.5–121.1 m



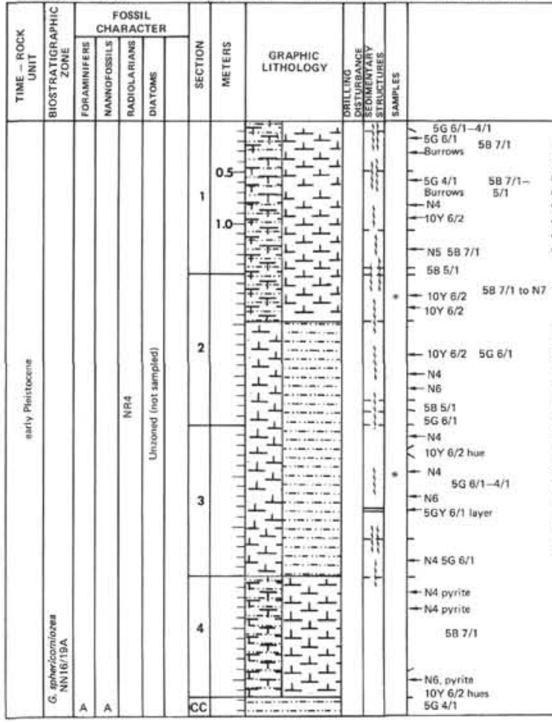
LITHOLOGIC DESCRIPTION

FORAMINIFER-, SILT- AND CLAY-BEARING NANNOFOSSIL OOZE, bluish gray (5B 5/1 to 5B 7/1), soft but firm, massive with prominent burrow mottling in pale olive (10Y 6/2) shades, scattered pyrite (N4) specks, diffuse contacts with NANNOFOSSIL CLAYEY SILT, greenish gray (5G 4/1 to 5G 6/1), soft to firm, massive with common pale olive (10Y 6/2) burrow mottles and hues, rare pyrite specks.

SMEAR SLIDE SUMMARY:

	1, 129	3, 80	5, 68	CC
	M	D	D	M
Texture:				
Sand	–	–	–	C
Silt	A	C	A	A
Clay	D	D	A	C
Composition:				
Quartz	C	C	C	C
Feldspar	C	C	C	C
Mica	R	C	M	C
Heavy minerals	T	–	–	–
Clay	C	C	A–C	C
Volcanic glass	–	–	–	A
Glauconite	C	R	R	R
Foraminifers	C	C	R	R
Calc. nannofossils	A	A	C–A	C
Diatoms	T	–	T	T
Radiolarians	–	–	T	–
Sponge spicules	R	R	R	R

SITE 594 HOLE CORE 14 CORED INTERVAL 121.1–130.7 m



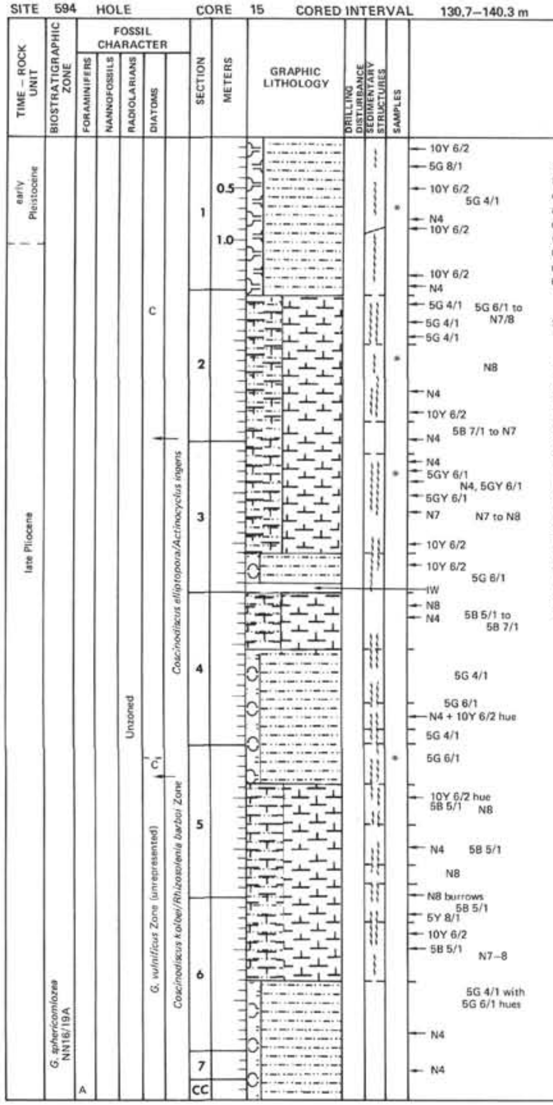
LITHOLOGIC DESCRIPTION

FORAMINIFER-, CLAY- AND SILT-BEARING NANNOFOSSIL OOZE, bluish gray (5B 5/1 to 5B 7/1), soft to firm, massive with extensive pale olive (10Y 6/2) and other color burrow mottling, scattered pyrite specks, alternating with NANNOFOSSIL CLAYEY SILT, greenish gray (5G 4/1 to 5G 6/1) with much local color variation due principally to burrow mottles with pale olive (10Y 6/2) hues, rare pyrite (N4 to N6).

SMEAR SLIDE SUMMARY:

	2, 31	3, 54
	D	D
Texture:		
Silt	A	A
Clay	D	D
Composition:		
Quartz	C	C
Feldspar	R	C
Mica	T	R
Heavy minerals	T	T
Clay	C	C
Glauconite	T	T
Pyrite	–	T
Foraminifers	C	R
Calc. nannofossils	D	A
Diatoms	T	T
Radiolarians	T	T
Sponge spicules	R	R

SITE 594 HOLE CORE 15 CORED INTERVAL 130.7–140.3 m



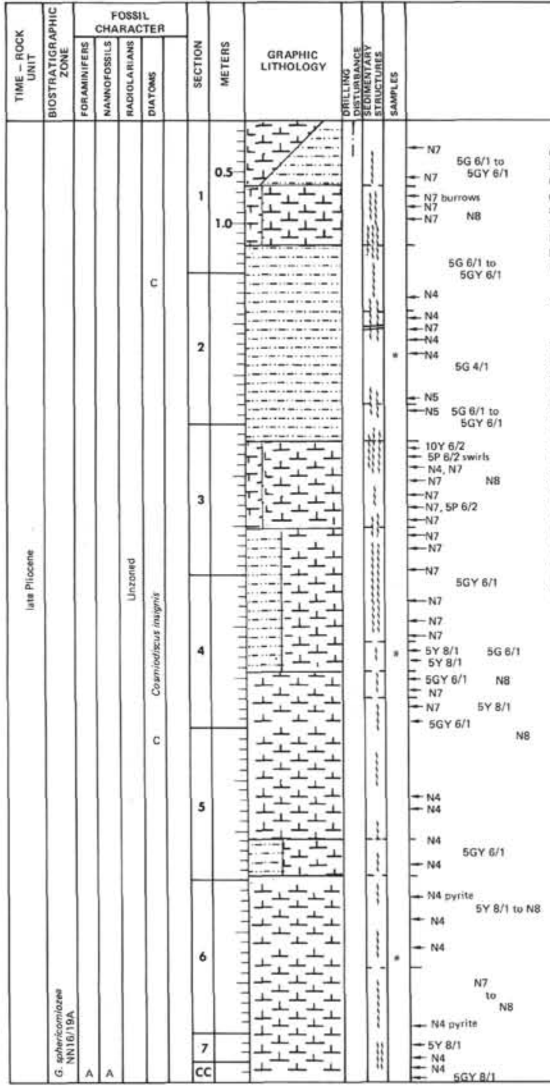
LITHOLOGIC DESCRIPTION

FORAMINIFER-, SILT- AND CLAY-BEARING NANNOFOSSIL OOZE, bluish gray (5B 7/1 to 5B 5/1) to very light or light gray (N8 or N7), stiff, massive with color mottling and hues in pale olive (10Y 6/2) tones, extensive burrowing especially evident across color boundaries, scattered pyrite (N4), alternating with SPONGE SPICULE-BEARING CLAYEY SILT, greenish gray (5G 4/1 to 5G 6/1), stiff, massive with hues and burrow mottling of pale olive (10Y 6/2) color, scattered pyrite (N4).

SMEAR SLIDE SUMMARY:

	1, 70	2, 70	3, 36	5, 16
	D	D	M	M
Texture:				
Sand	–	–	R	R
Silt	A	C	C	C
Clay	A	D	D	D
Composition:				
Quartz	C	C	C	R
Feldspar	C	R	C	C
Mica	C	T	R	–
Heavy minerals	T	T	T	–
Clay	A	C	C	C
Volcanic glass	T	–	–	–
Glauconite	T	T	–	–
Pyrite	T	–	R	R
Foraminifers	T	C	C	C
Calc. nannofossils	R	D	A	A
Diatoms	–	–	T	–
Radiolarians	–	–	T	–
Sponge spicules	C	R	R	R

SITE 594 HOLE CORE 16 CORED INTERVAL 140.3–149.9 m



LITHOLOGIC DESCRIPTION

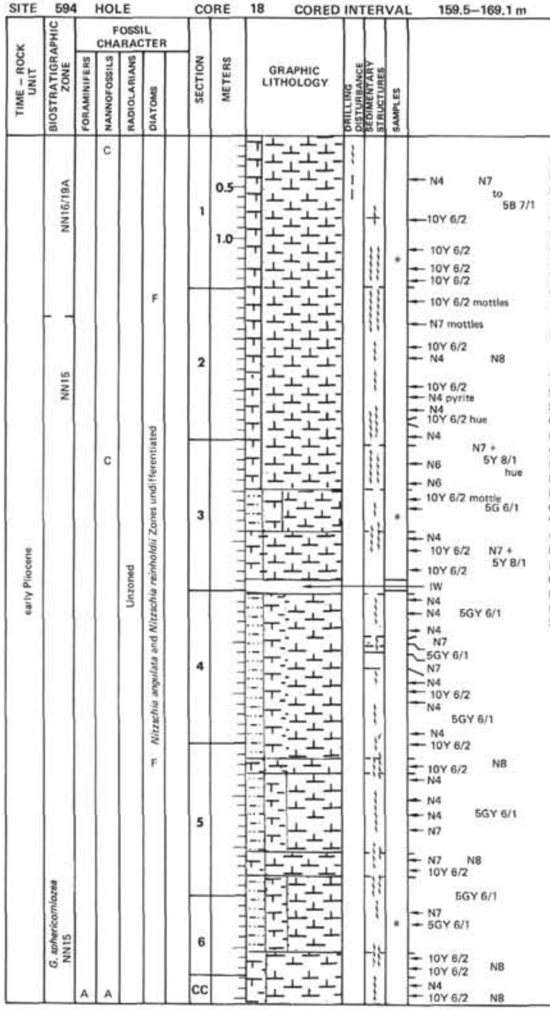
CLAYEY SILT TO CLAY- AND SILT-BEARING NANNOFOSSIL OOZE, greenish gray (5G 4/1, 5G 6/1 and 5GY 6/1), stiff, massive but burrow mottling pervasive in light grays (N7) and other colors, scattered pyrite specks (N4/5), alternating with (FORAMINIFER-BEARING) NANNOFOSSIL OOZE, light or very light gray (N7 or N8) to yellowish gray (5Y 8/1), stiff, massive but intensely bioturbated and burrow mottled in light grays (N7), pale purples (5P 6/2) and pale olives (10Y 6/2), rare pyrite (N4) specks.

SMEAR SLIDE SUMMARY:

	2, 80	4, 80	6, 80
	D	D	D
Texture:			
Sand	R	–	–
Silt	A	R	C
Clay	A	D	D
Composition:			
Quartz	C	R	R
Feldspar	C	R	R
Mica	C	T	R
Heavy minerals	T	–	T
Clay	C	T	R
Volcanic glass	T	–	–
Glauconite	T	–	–
Pyrite	T	T	T
Foraminifers	T	R	R
Calc. nannofossils	T	D	D
Diatoms	–	T	–
Radiolarians	T	T	–
Sponge spicules	R	R	R

Core 17 – no recovery.

SITE 594 HOLE CORE 18 CORED INTERVAL 159.5–169.1 m



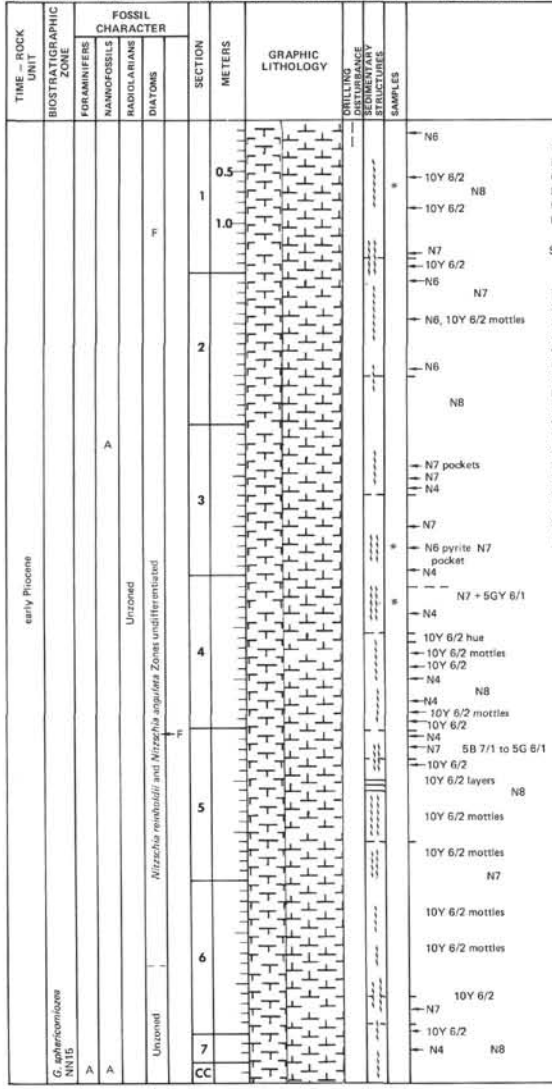
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE TO FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light to light gray (N8 to N7), sometimes with light bluish gray (5B 7/1) or yellowish gray (5Y 8/1) hues, stiff, massive but extensively burrow mottled in pale olive (10Y 6/2) and gray (N7) tones, small sandy pockets throughout, scattered pyrite (N4), alternating with FORAMINIFER-, SILT- AND/OR CLAY-BEARING NANNOFOSSIL OOZE, greenish gray (5G 6/1 to 5GY 6/1), stiff, silty feel, prominently burrow mottled in pale olive (10Y 6/2) and other hues, common pyrite (N4).

SMEAR SLIDE SUMMARY:

	1, 124	3, 80	6, 125
	D	D	D
Texture:			
Sand	–	–	R
Silt	R	A	C
Clay	D	A	D
Composition:			
Quartz	R	C	R
Feldspar	T	R	R
Mica	T	R	R
Heavy minerals	T	–	T
Clay	R	C	C
Volcanic glass	–	T	T
Glauconite	T	T	R
Pyrite	T	T	T
Foraminifers	R	C	C
Calc. nannofossils	D	C	A
Diatoms	T	–	–
Radiolarians	T	–	T
Sponge spicules	R	R	R

SITE 594 HOLE CORE 19 CORED INTERVAL 169.1–178.7 m



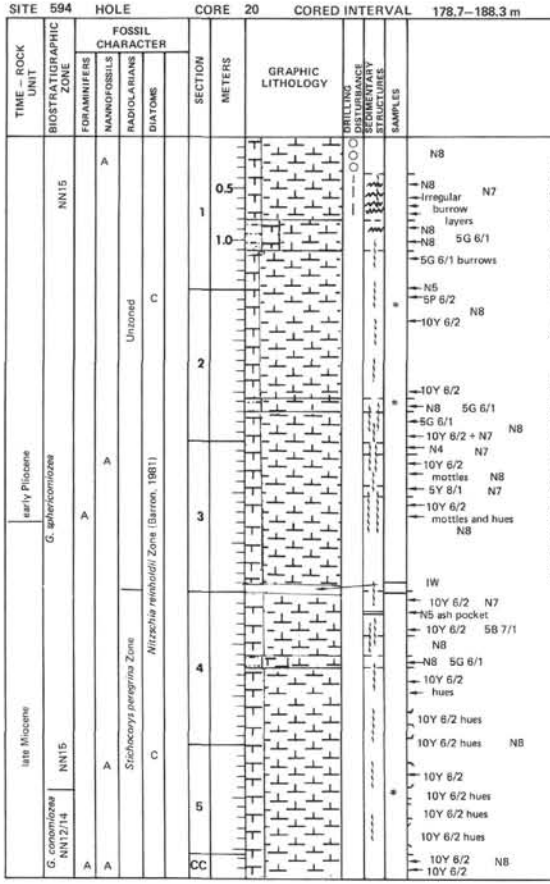
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light to light gray (N8 to N7) with common pale olive (10Y 6/2) or yellowish gray (5GY 6/1) tones superimposed, burrow mottled in similar colors, stiff, massive, prominent burrow structures, scattered pyrite (N4 to N6), occasional hard layers.

SMEAR SLIDE SUMMARY:

	1, 70 D	3, 129 M	4, 26 D
Texture:			
Sand	–	A	–
Silt	C	C	C
Clay	D	C	A
Composition:			
Quartz	T	T	R
Feldspar	–	T	R
Mica	T	T	R
Heavy minerals	T	–	T
Clay	–	–	R
Volcanic glass	–	T	–
Glauconite	–	–	T+
Pyrite	T	R	–
Foraminifers	C	C	C
Calc. nannofossils	D	A	A
Radiolarians	T	T	T
Sponge spicules	R	R	R
Microteklite	–	T	–

SITE 594 HOLE CORE 20 CORED INTERVAL 178.7–188.3 m



LITHOLOGIC DESCRIPTION

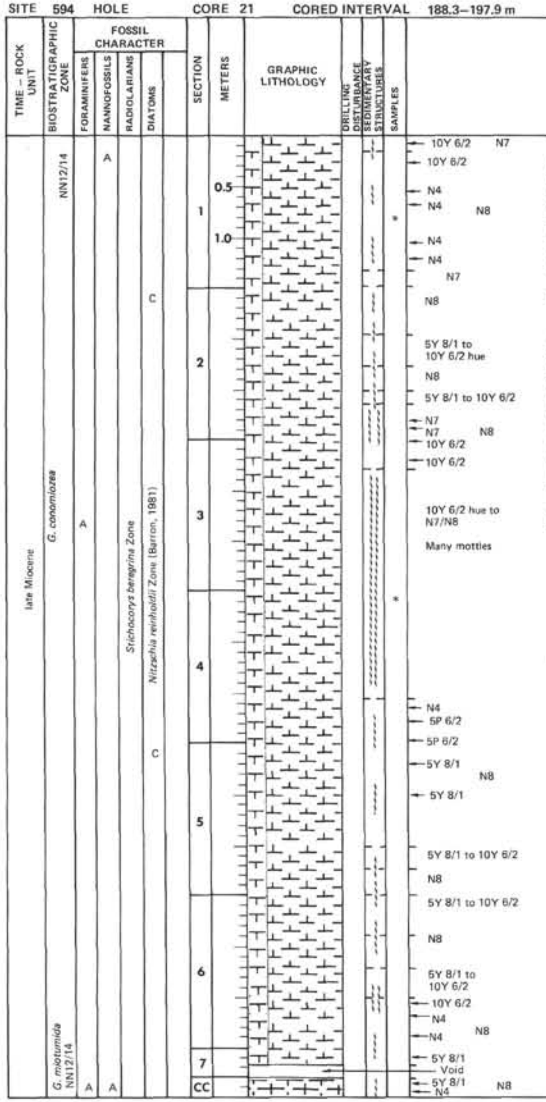
FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light to light gray (N8 to N7) or bluish gray (5B 7/1) with subtle superimposed shades of pale olive (10Y 6/2) at several levels (these may be clay-bearing), stiff with hard layers occasionally, strongly burrow mottled.

CLAY-, SILT- AND FORAMINIFER-BEARING NANNOFOSSIL OOZE, greenish gray (5G 6/1) with similar characteristics to FORAMINIFER-BEARING NANNOFOSSIL OOZE.

SMEAR SLIDE SUMMARY:

	2, 24 *D*	2, 114 *D*	5, 48 *D*
Texture:			
Silt	C	–	C
Clay	D	–	D
Composition:			
Quartz	R	C	R
Feldspar	–	T	–
Mica	–	T	R
Clay	–	C	C
Volcanic glass	–	T	–
Glauconite	–	R	T
Pyrite	T	T	T
Foraminifers	C	C	C
Calc nannofossils	D	A	A
Radiolarians	–	–	T
Sponge spicules	R	R	R

SITE 594 HOLE CORE 21 CORED INTERVAL 188.3–197.9 m



LITHOLOGIC DESCRIPTION

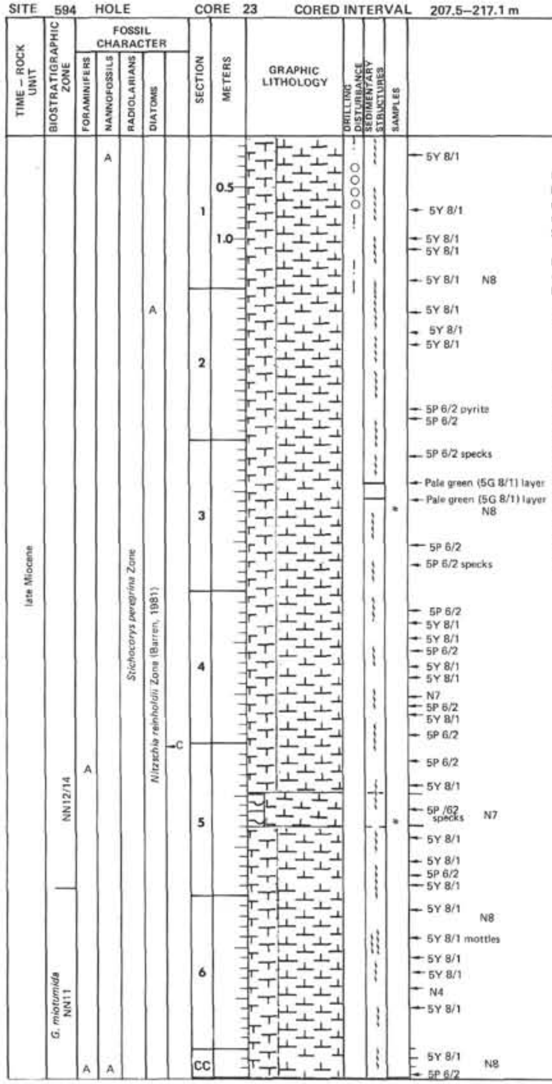
FORAMINIFER-BEARING NANNOFOSSIL OOZE TO NANNOFOSSIL OOZE, light to very light gray (N7 to N8) with yellowish gray (5Y 8/1) to pale olive (10Y 6/2) mottles and hues which become sufficiently uniform to form discrete interbeds (which are enriched in foraminifers, contain more biogenic silica, and more silt and sand sized material), stiff with occasional hard layers, profusely burrow mottled and scattered pyritized specks (N4).

SMEAR SLIDE SUMMARY:

	1, 80	4, 15
	D	D
Texture:		
Sand	–	R
Silt	R	C
Clay	D	A
Composition:		
Quartz	T	T
Feldspar	T	T
Glauconite	–	T
Pyrite	T	T
Foraminifers	R	C
Calc. nannofossils	D	A
Radiolarians	T	R
Sponge spicules	R	T+
Silicoflagellates	–	R

Core 22 – no recovery.

SITE 594 HOLE CORE 23 CORED INTERVAL 207.5–217.1 m



LITHOLOGIC DESCRIPTION

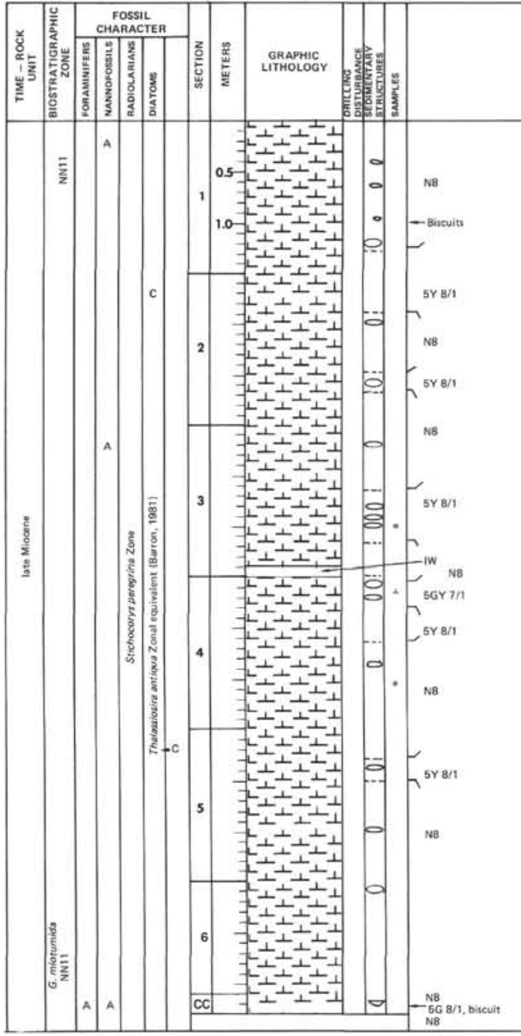
FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8) with occasional yellowish gray (5Y 8/1) mottles and rare pyritized pale purple (5P 6/2) streaks, soft to firm with some hard layers, pale green (5G 8/1) layers in Section 3.

DIATOM-BEARING NANNOFOSSIL OOZE, light gray (N7) with similar characteristics as FORAMINIFER-BEARING NANNOFOSSIL OOZE.

SMEAR SLIDE SUMMARY:

	3, 74	5, 76
	D	M
Texture:		
Silt	C	C
Clay	D	D
Composition:		
Quartz	R	–
Feldspar	T	–
Mica	T	T
Volcanic glass	–	T
Glauconite	T+	T
Pyrite	T	–
Foraminifers	C	R
Calc. nannofossils	D	D
Diatoms	T	C
Radiolarians	T+	T
Sponge spicules	R	R

SITE 594 HOLE CORE 24 CORED INTERVAL 217.1–226.7 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft, with occasional biscuits of harder chalk, pyrite specks. Some interbeds of DIATOM-BEARING NANNOFOSSIL OOZE, grayish yellow (5Y 8/1), streaks of pyrite.

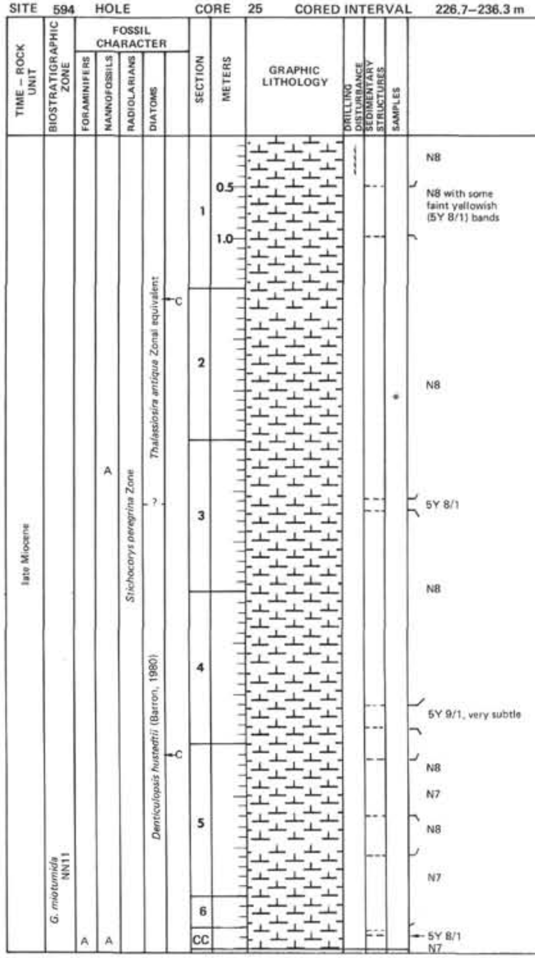
SMEAR SLIDE SUMMARY:

	3, 99 D	4, 16 M	4, 105 D
Texture:			
Silt	A	–	C
Clay	A	–	D
Composition:			
Quartz	T	T	–
Mica	T	T	T
Pyrite	–	T	–
Foraminifers	R	C	R
Calc. nannofossils	D	A	D
Diatoms	C	C	R
Radiolarians	T	T	T
Sponge spicules	T	R	R

○ = Biscuit

- - - = Gradational contact

SITE 594 HOLE CORE 25 CORED INTERVAL 226.7–236.3 m



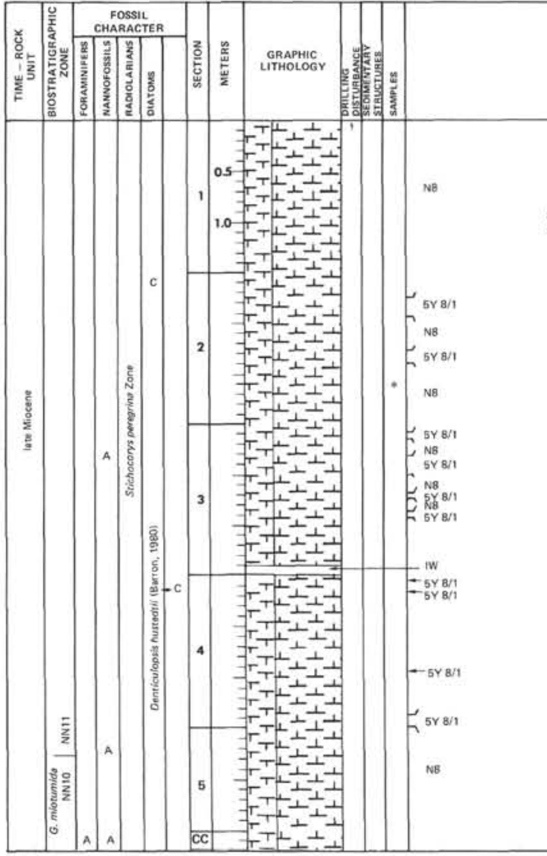
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft almost homogeneous, some pyrite, cycles are not obvious.

SMEAR SLIDE SUMMARY:

	2, 110 D
Texture:	
Silt	A
Clay	A
Composition:	
Mica	T
Foraminifers	R
Calc. nannofossils	D
Diatoms	R
Radiolarians	T
Sponge spicules	R

SITE 594 HOLE CORE 26 CORED INTERVAL 236.3–245.9 m



LITHOLOGIC DESCRIPTION

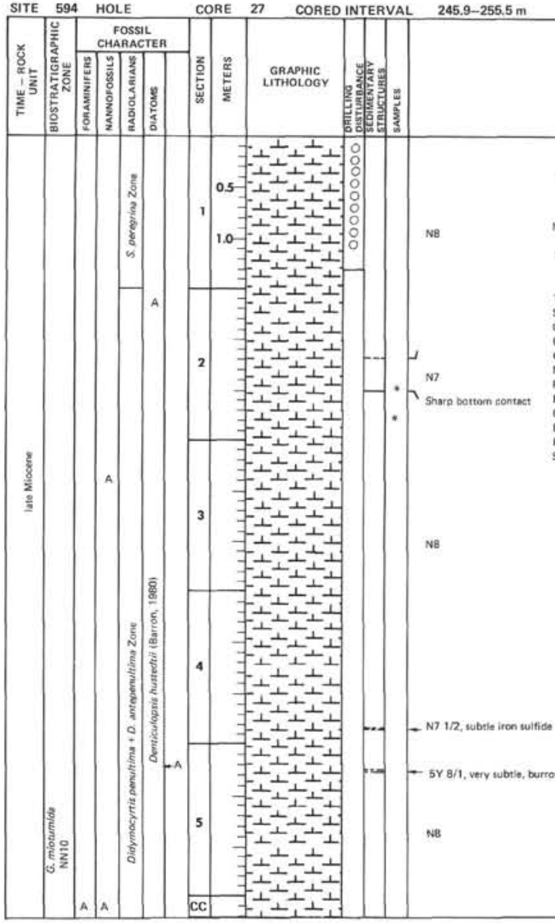
FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8), homogeneous, streaks of iron sulfide, cycles are suppressed; some drilling disturbance.

Subtle layers of yellowish hue are richer in diatoms and sponge spicules.

SMEAR SLIDE SUMMARY:

	2, 118
	D
Texture:	
Sand	R
Silt	A
Clay	A
Composition:	
Quartz	T
Mica	T
Pyrite	T
Foraminifers	C
Calc. nannofossils	D
Diatoms	R
Radiolarians	T
Sponge spicules	R

SITE 594 HOLE CORE 27 CORED INTERVAL 245.9–255.5 m



LITHOLOGIC DESCRIPTION

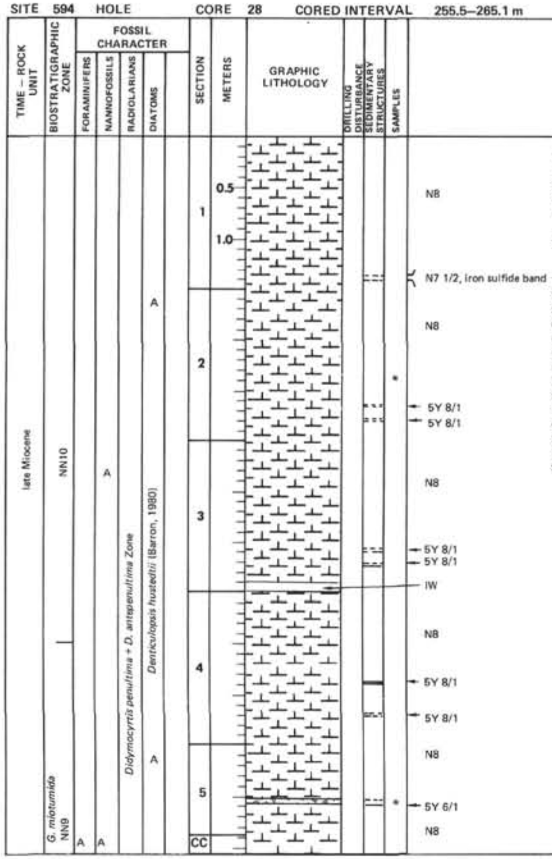
NANNOFOSSIL OOZE, very light gray (N8), soft, homogeneous except a few specks of iron sulfide and DIATOM- AND SPONGE-BEARING NANNOFOSSIL OOZE, grayer (N7).

No more cycles apparent.

SMEAR SLIDE SUMMARY:

	2, 98	2, 127
	M	D
Texture:		
Silt	A	–
Clay	A	–
Composition:		
Quartz	T	T
Mica	T	T
Pyrite	T	T
Foraminifers	R	R
Calc. nannofossils	D	D
Diatoms	C	R
Radiolarians	T	T
Sponge spicules	C	R

SITE 594 HOLE CORE 28 CORED INTERVAL 255.5–265.1 m



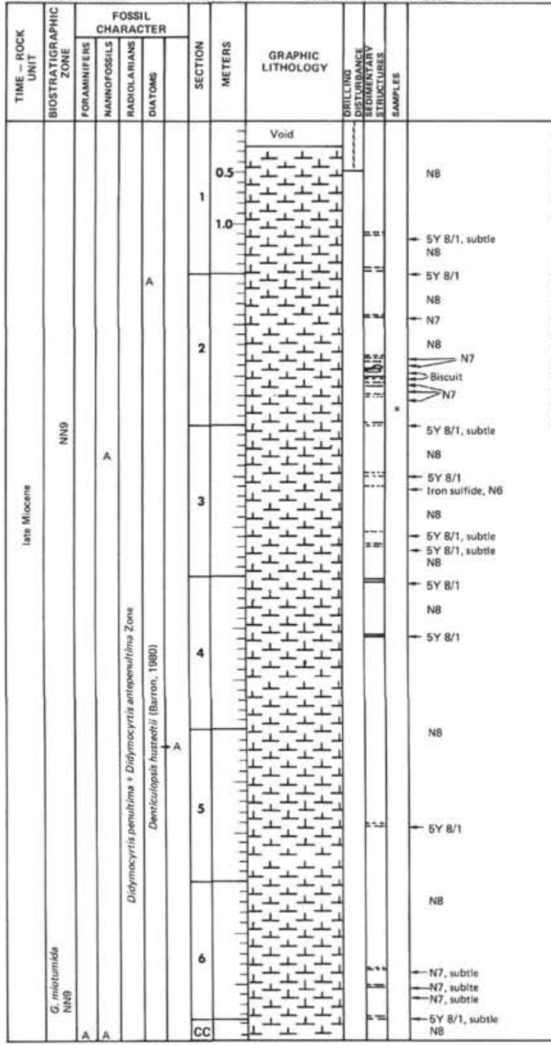
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), firmer, pyrite stains throughout, subtle light grayish yellow (5Y 8/1) burrows and VOLCANIC ASH, light olive gray (5Y 6/1), minor lithology at Section 5, 55–57 cm, sharp bottom contact and gradational upper contact.

SMEAR SLIDE SUMMARY:

	2, 80	5, 56
	D	M
Texture:		
Sand	–	R
Silt	C	A
Clay	D	A
Composition:		
Quartz	T	T
Mica	–	T
Volcanic glass	–	A
Pyrite	–	R
Foraminifers	R	R
Calc. nannofossils	D	A
Diatoms	R	R
Radiolarians	T	T
Sponge spicules	R	R

SITE 594 HOLE CORE 29 CORED INTERVAL 265.1–274.7 m



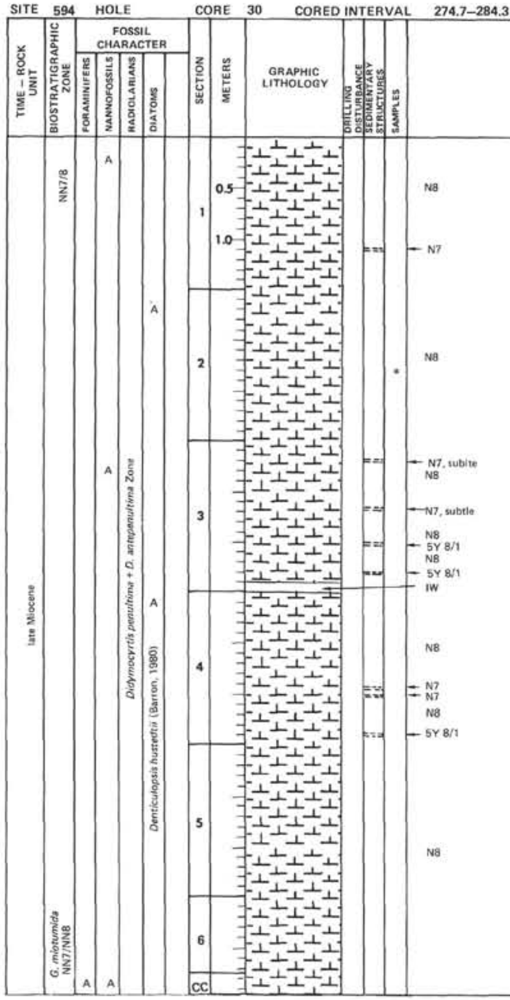
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), with specks of iron sulfide of light gray (N7); with biscuits of firmer ooze and SPONGE SPICULE- AND DIATOM-BEARING NANNOFOSSIL OOZE, light yellowish gray bands (5Y 8/1).

SMEAR SLIDE SUMMARY:

	2, 132	2, 145
	D	M
Texture:		
Silt	A	–
Clay	A	–
Composition:		
Quartz	T	T
Mica	T	T
Pyrite	T	T
Foraminifers	R	R
Calc. nannofossils	D	D
Diatoms	C	C
Radiolarians	T	T
Sponge spicules	C	C

SITE 594 HOLE CORE 30 CORED INTERVAL 274.7–284.3 m



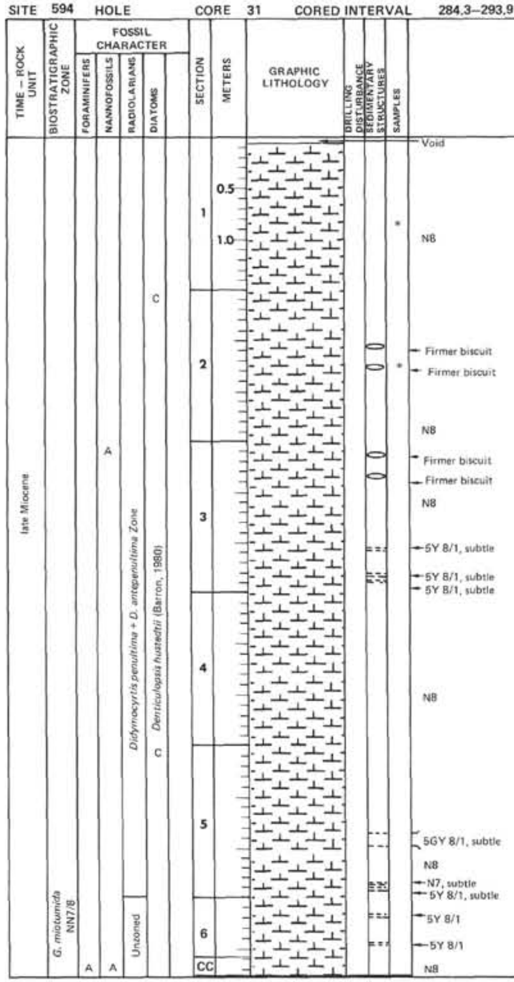
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), with specks of iron sulfide (N7), homogeneous except for variations of firmer and less firm ooze.

SMEAR SLIDE SUMMARY:

	2, 80
	D
Texture:	
Silt	C
Clay	D
Composition:	
Quartz	T
Foraminifers	R
Calc. nannofossils	D
Diatoms	R
Radiolarians	T
Sponge spicules	R

SITE 594 HOLE CORE 31 CORED INTERVAL 284.3–293.9 m



LITHOLOGIC DESCRIPTION

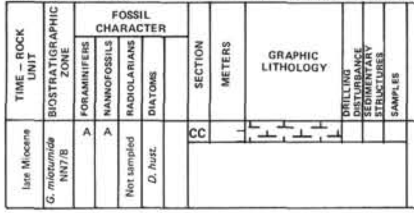
NANNOFOSSIL OOZE, very light gray (N8), homogeneous except a few specks of iron sulfide, a few biscuits of firmer ooze, and a few silica-rich(?) yellowish bands.

SMEAR SLIDE SUMMARY:

	1, 84	2, 80
	D	D
Composition:		
Quartz	T	T
Mica	T	T
Volcanic glass	T	–
Pyrite	T	–
Foraminifers	R	R
Calc. nannofossils	D	D
Diatoms	T	T
Radiolarians	–	T
Sponge spicules	R	R

NOTE: Core 32, 293.9–303.5 m: no recovery.

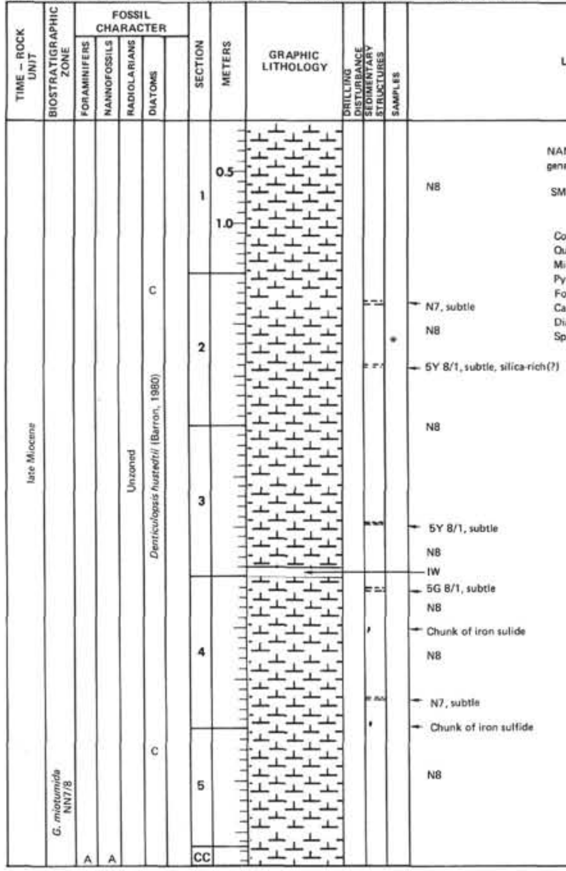
SITE 594 HOLE CORE 33 CORED INTERVAL 303.5–313.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), as in previous cores.

SITE 594 HOLE CORE 34 CORED INTERVAL 313.1–322.7 m



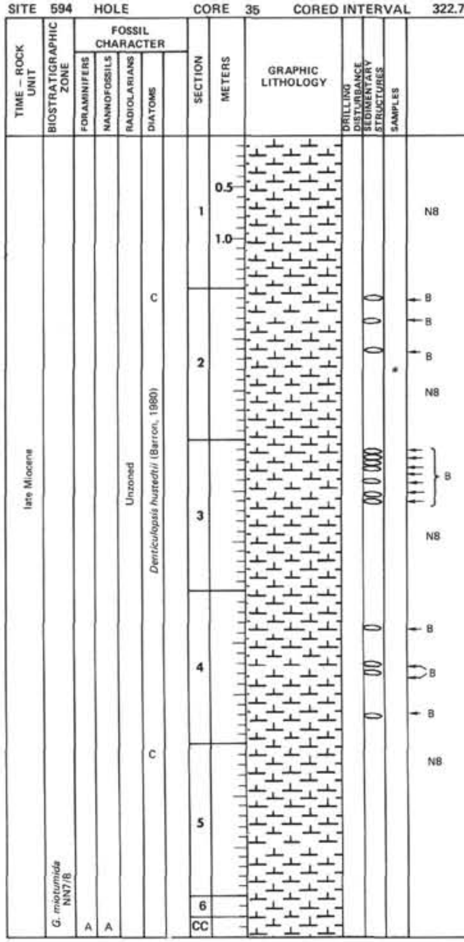
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8). Totally homogenous except for a few specks of iron sulfide (N7).

SMEAR SLIDE SUMMARY:

	2, 80
	D
Composition:	
Quartz	T
Mica	T
Pyrite	T
Foraminifers	R
Calc. nannofossils	D
Diatoms	T
Sponge spicules	R

SITE 594 HOLE CORE 35 CORED INTERVAL 322.7–332.3 m



LITHOLOGIC DESCRIPTION

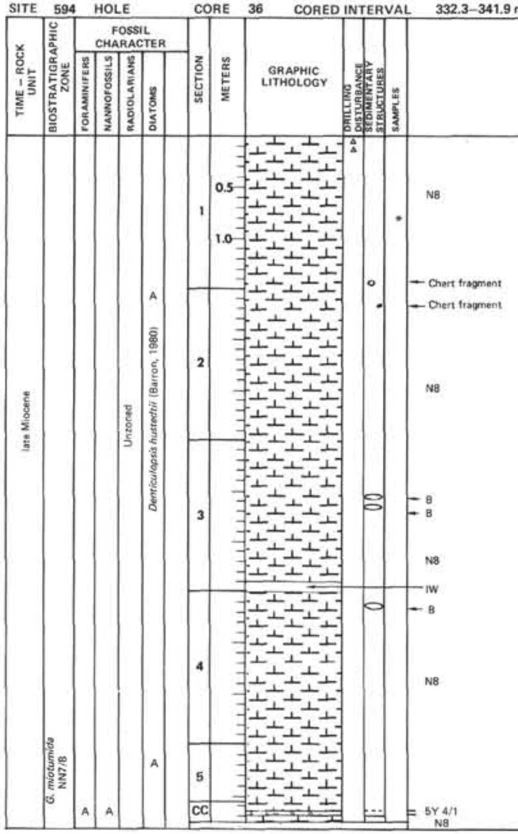
NANNOFOSSIL OOZE, very light gray (N8), subtle variations between firmer and less firm biscuits, toherwise entirely homogeneous.

SMEAR SLIDE SUMMARY:

	2, 80
	D
Composition:	
Quartz	T
Mica	T
Foraminifers	R
Calc. nannofossils	D
Diatoms	T
Sponge spicules	R

B = biscuits

SITE 594 HOLE CORE 36 CORED INTERVAL 332.3–341.9 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), firmer, specks of pyrite, firmer biscuits, and a chert fragment.

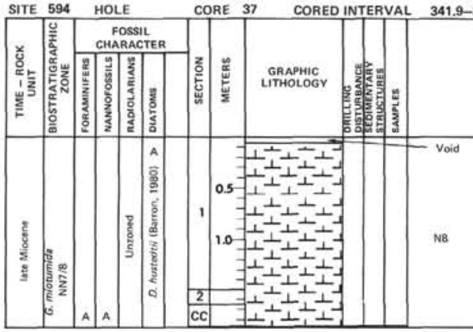
VOLCANIC ASH in Core Catcher, olive gray (5Y 4/1) grading upward to light olive gray (5Y 7/1) with sharp bottom contact.

SMEAR SLIDE SUMMARY:

	1, 81 D	CC, 14 M
Composition:		
Quartz	T	R
Mica	T	T
Volcanic glass	–	A
Pyrite	T	R
Foraminifers	R	R
Calc. nannofossils	D	C
Diatoms	T	–
Sponge spicules	T	T

B = Biscuit

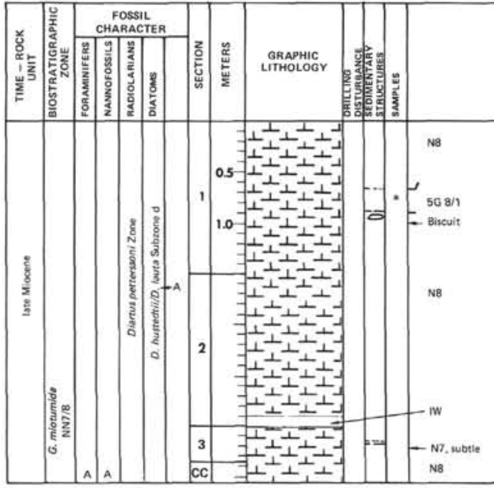
SITE 594 HOLE CORE 37 CORED INTERVAL 341.9–351.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), homogeneous except for a few firmer biscuits.

SITE 594 HOLE CORE 38 CORED INTERVAL 351.5–361.1 m



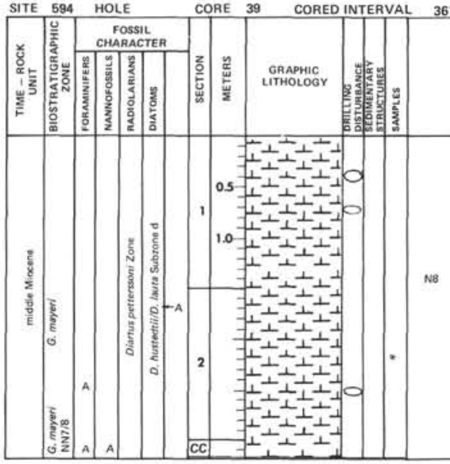
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), almost homogeneous except for iron sulfide layers (N8) and biscuits and light greenish gray (5G 8/1) layer of slightly more siliceous composition.

SMEAR SLIDE SUMMARY:

	1, 84
Composition:	
Quartz	T
Mica	R
Pyrite	R
Foraminifers	R
Calc. nannofossils	D
Diatoms	T
Sponge spicules	R

SITE 594 HOLE CORE 39 CORED INTERVAL 361.1–370.1 m



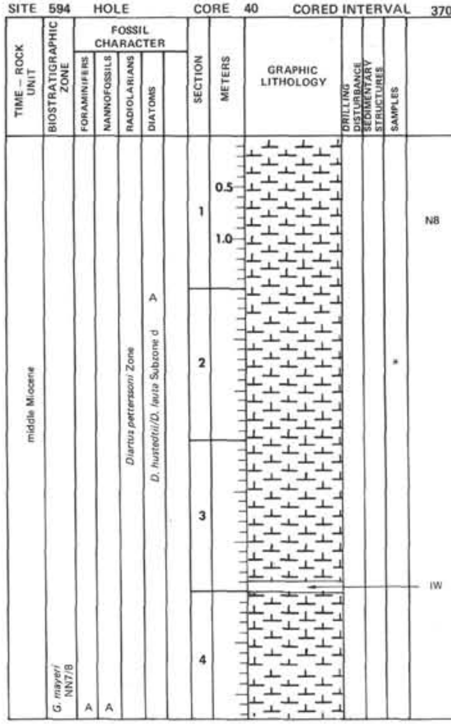
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft with firm biscuits as shown, massive, no clear bioturbation.

SMEAR SLIDE SUMMARY:

	2, 70
	D
Texture:	
Silt	R
Clay	D
Composition:	
Mica	T
Volcanic glass	T
Pyrite	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	T

SITE 594 HOLE CORE 40 CORED INTERVAL 370.1–380.3 m



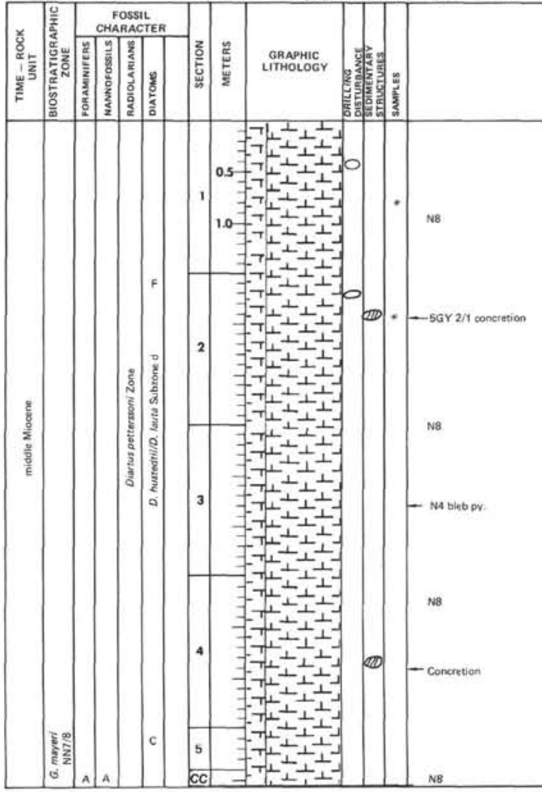
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft, massive, bioturbation not evident.

SMEAR SLIDE SUMMARY:

	2, 70
	D
Texture:	
Silt	C
Clay	D
Composition:	
Quartz	T
Mica	T
Heavy minerals	T
Volcanic glass	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE CORE 41 CORED INTERVAL 380.3–389.9 m



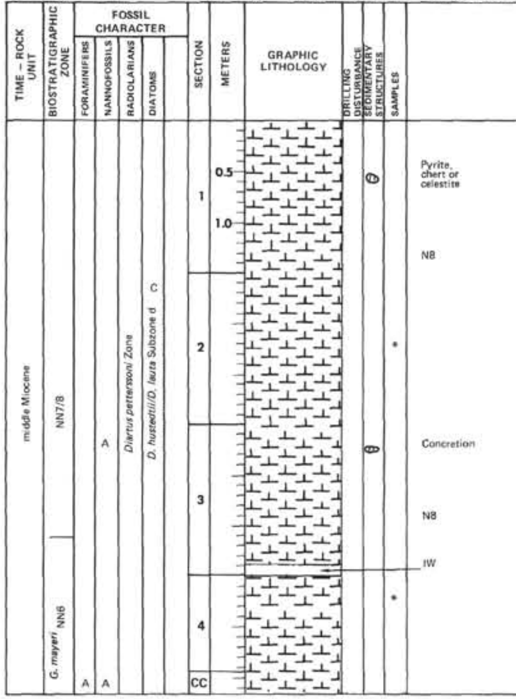
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8), soft with biscuits where shown, pyritic concretion in Section 2, little evidence of bioturbation.

SMEAR SLIDE SUMMARY:

	1, 80	2, 45
	D	M
Texture:		
Silt	C	A
Clay	D	A
Composition:		
Quartz	T	T
Mica	T	–
Pyrite	T	A
Micronodules	–	A
Foraminifers	C	–
Calc. nannofossils	D	A
Sponge spicules	R	–

SITE 594 HOLE CORE 42 CORED INTERVAL 389.9–399.5 m



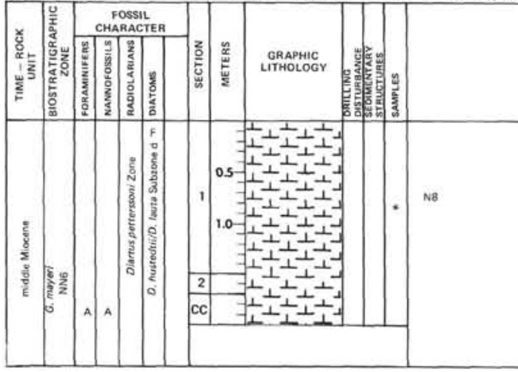
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft, massive, little clear bioturbation, concretions of mixed pyrite, chert and/or celestite in Sections 1 and 3.

SMEAR SLIDE SUMMARY:

	2, 70	4, 22
	D	M
Texture:		
Silt	–	C
Clay	D	D
Composition:		
Quartz	T	T
Feldspar	–	T
Mica	T	T
Glauconite	T	–
Pyrite	T	R
Foraminifers	R	C
Calc. nannofossils	D	D
Sponge spicules	T	R

SITE 594 HOLE CORE 43 CORED INTERVAL 399.5–409.1 m



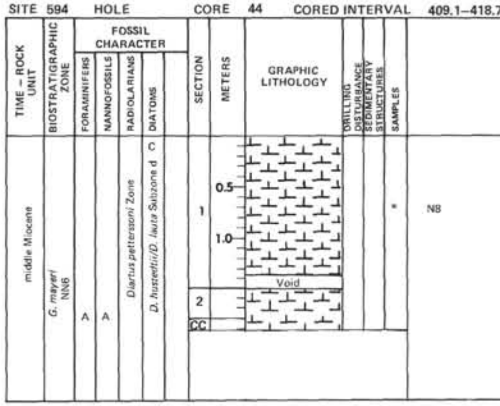
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft, massive, homogeneous, little clear bioturbation.

SMEAR SLIDE SUMMARY:

	1, 80
	D
Texture:	
Silt	R
Clay	D
Composition:	
Mica	T
Glauconite	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE CORE 44 CORED INTERVAL 409.1–418.7 m



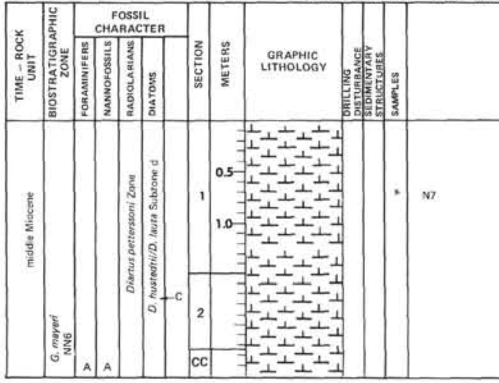
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, very light gray (N8), soft, massive, homogeneous.

SMEAR SLIDE SUMMARY:

	1, 70
	D
Texture:	
Silt	R
Clay	D
Composition:	
Mica	T
Pyrite	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE CORE 45 CORED INTERVAL 418.7–428.3 m



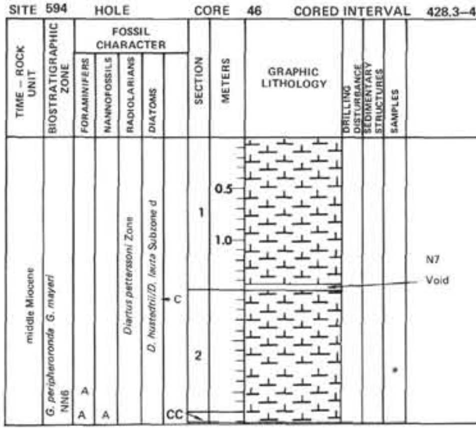
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, light gray (N7), soft to stiff, little structure.

SMEAR SLIDE SUMMARY:

	1, 70
	D
Texture:	
Silt	C
Clay	D
Composition:	
Quartz	T
Feldspar	T
Volcanic glass	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE CORE 46 CORED INTERVAL 428.3–437.9 m



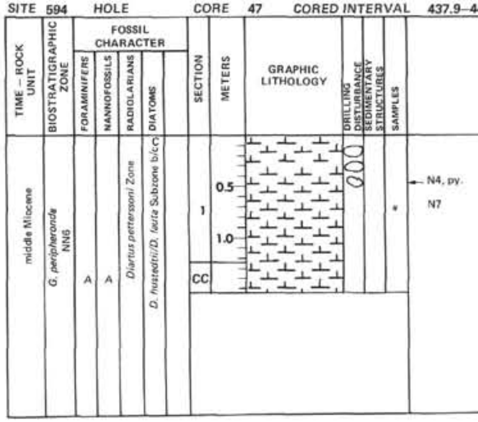
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, light gray (N7), stiff, little structure.

SMEAR SLIDE SUMMARY:

	2, 80
	D
Texture:	
Silt	C
Clay	D
Composition:	
Quartz	T
Glauconite	T+
Pyrite	R
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE CORE 47 CORED INTERVAL 437.9–447.5 m



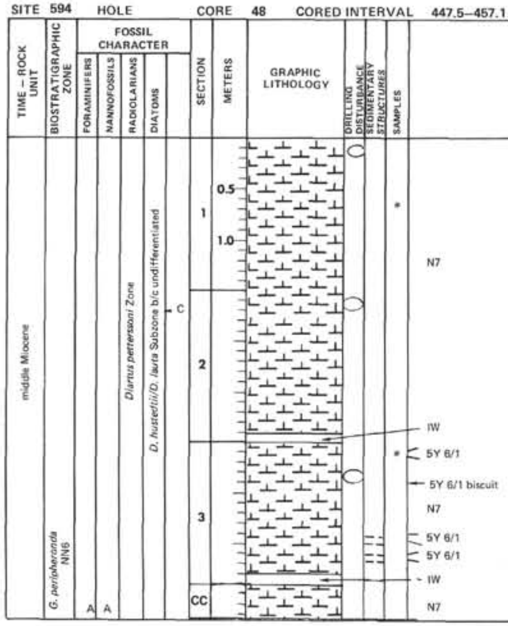
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, light gray (N7), stiff, little structure, occasional biscuits as shown.

SMEAR SLIDE SUMMARY:

	1, 70
	D
Texture:	
Silt	R
Clay	D
Composition:	
Quartz	T
Mica	T
Foraminifers	R
Calc. nannofossils	D
Diatoms	T
Sponge spicules	R

SITE 594 HOLE CORE 48 CORED INTERVAL 447.5–457.1 m



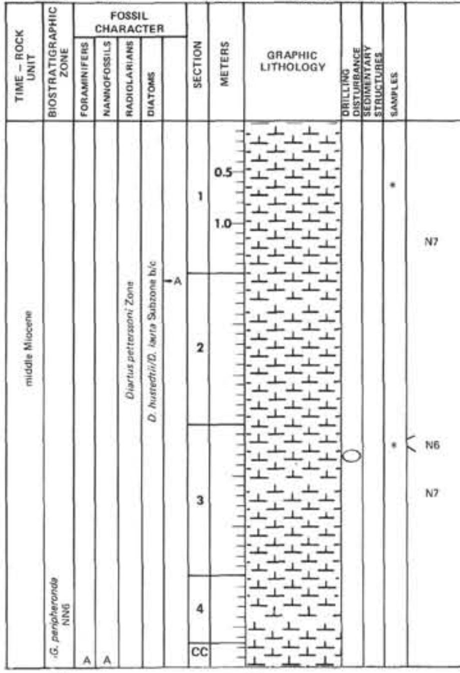
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, light gray (N7), stiff, little structure, occasional sediment biscuits.

SMEAR SLIDE SUMMARY:

	1, 70	3, 13
	D	M
Texture:		
Silt	C	A
Clay	D	A
Composition:		
Quartz	T	–
Glauconite	T	T
Pyrite	–	T
Foraminifers	R	R
Calc. nannofossils	D	A
Diatoms	T+	R
Radiolarians	T	R
Sponge spicules	R	C

SITE 594 HOLE CORE 49 CORED INTERVAL 457.1–466.7 m



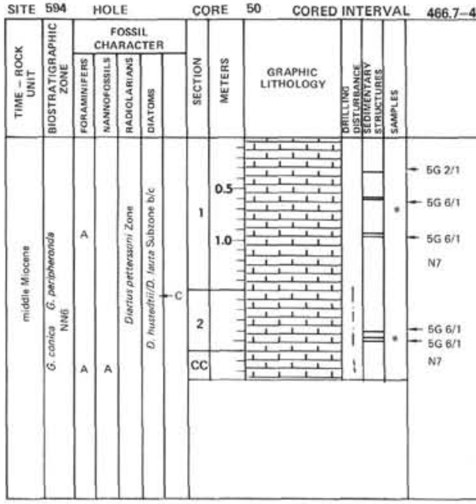
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, light gray (N7), stiff, biscuits throughout, some bioturbation and faint pyritized streaks.

SMEAR SLIDE SUMMARY:

	1, 70	3, 20
	D	M
Texture:		
Sand	–	C
Silt	R	C
Clay	D	A
Composition:		
Quartz	–	T
Mica	T	–
Volcanic glass	–	T
Pyrite	–	R
Foraminifers	R	C
Calc. nannofossils	D	A
Diatoms	T	T
Radiolarians	–	T
Sponge spicules	R	C

SITE 594 HOLE CORE 50 CORED INTERVAL 466.7–476.3 m



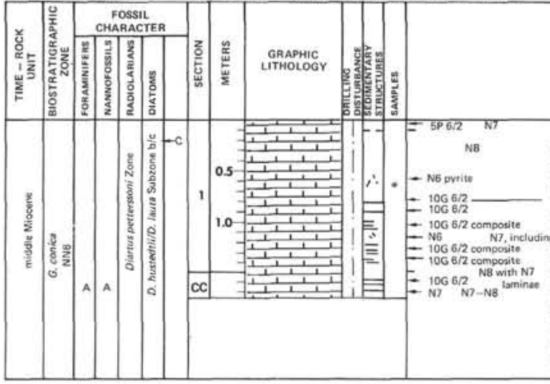
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK (OOZE), light gray (N7), firm (to stiff ooze), biscuited from coring, greenish (5G 6/1) layers occasionally.

SMEAR SLIDE SUMMARY:

	1, 70	2, 48
	D	M
Texture:		
Sand	–	R
Silt	R	A
Clay	D	A
Composition:		
Quartz	T	T
Mica	–	T
Volcanic glass	–	T
Glauconite	–	T
Pyrite	–	T
Foraminifers	T	C
Calc. nannofossils	D	A
Diatoms	T	T
Radiolarians	T	R
Sponge spicules	R	C

SITE 594 HOLE CORE 51 CORED INTERVAL 476.3–485.9 m



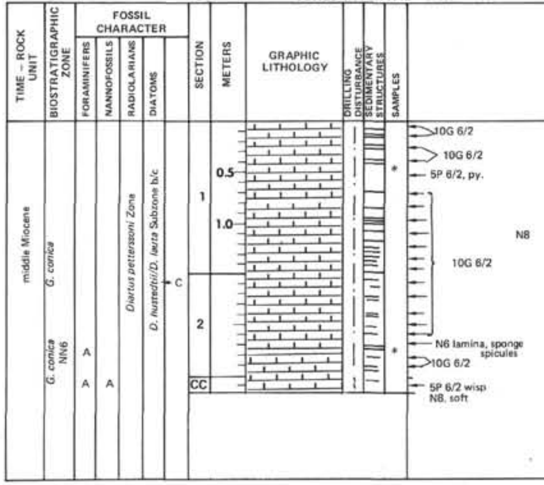
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), generally massive with some mottling and laminae of light gray (N7) and pale purple (5P 6/2), distinctive pale green (10G 6/2) laminae (?ash), sediment partly disrupted by coring.

SMEAR SLIDE SUMMARY:

	1, 70
	D
Composition:	
Quartz	T
Volcanic glass	T
Glauconite	T
Pyrite	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE CORE 52 CORED INTERVAL 485.9–495.5 m



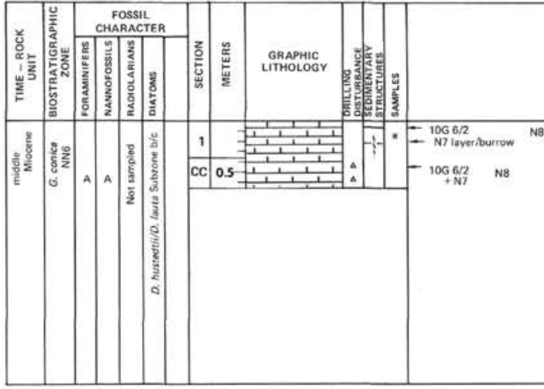
LITHOLOGIC DESCRIPTION

NANNOFOSSIL 'CHALK', very light gray (N8), stiff, massive with many pale green (10G 6/2) laminae and scattered pyritized (5P 6/2) specks and streaks, green laminae harder and fractured by drilling.

SMEAR SLIDE SUMMARY:

	1, 50	2, 73
	D	M
Texture:		
Silt	R	–
Clay	D	–
Composition:		
Quartz	T	T
Feldspar	–	T
Mica	T	T
Glauconite	T	T
Pyrite	T	T
Foraminifers	R	R
Calc. nannofossils	D	A
Diatoms	–	T
Radiolarians	–	R
Sponge spicules	R	C

SITE 594 HOLE CORE 53 CORED INTERVAL 495.5–505.1 m



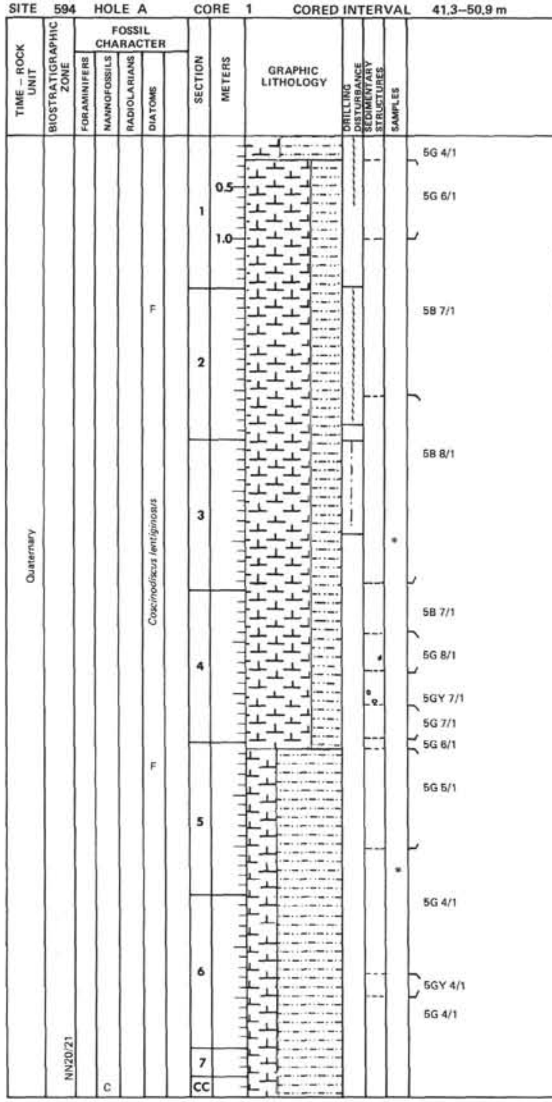
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), soft with hard layers, disruption by drilling, burrow mottled in light gray (N7) hues.

SMEAR SLIDE SUMMARY:

	1, 18
	D
Texture:	
Silt	R
Clay	D
Composition:	
Quartz	T
Mica	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE A CORE 1 CORED INTERVAL 41.3–50.9 m



LITHOLOGIC DESCRIPTION

DIATOM-, SPONGE SPICULE-, NANNOFOSSIL BEARING CLAYEY SILT, dark greenish gray to greenish gray (5G 4/1 to 5G 8/1).

FORAMINIFER-BEARING NANNOFOSSIL OOZE, light bluish gray (5B 7/1), with pyrite specks, otherwise homogeneous; some yellowish iron oxide(?) streaks. H_2S odor.

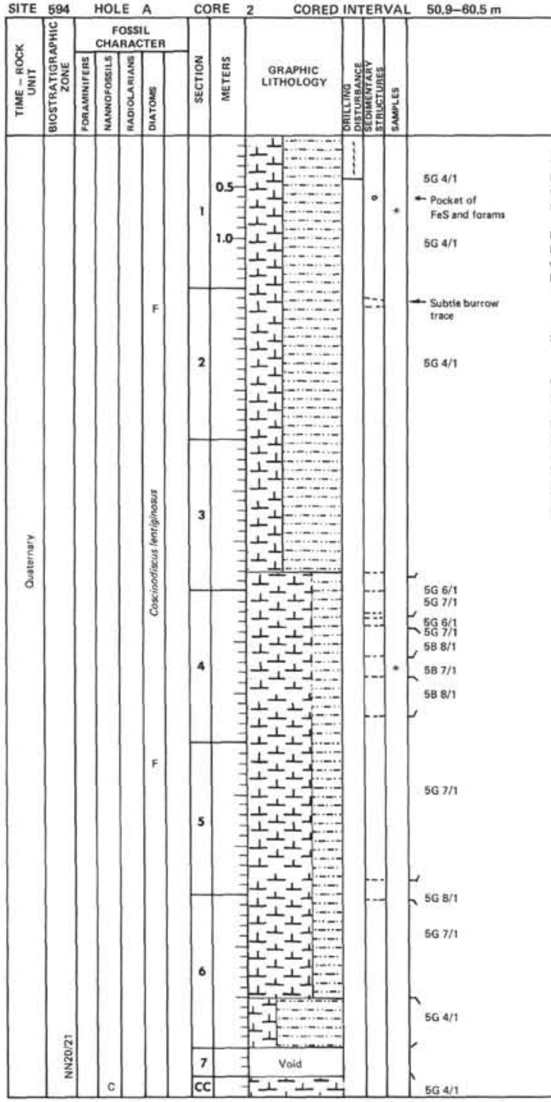
Light greenish gray (5G 8/1) to greenish gray (5G 6/1) lithology is intermediate in amount of terrigenous component.

Pockets of foraminifer-rich sediment at Section 4, 70, 98, and 110 cm.

SMEAR SLIDE SUMMARY:

	3, 99	5, 125
	D	D
Composition:		
Quartz	R	A
Feldspar	T	R
Heavy minerals	T	T
Volcanic glass	T	–
Clay minerals	–	C
Mica	R	A
Pyrite	–	R
Foraminifers	C	R
Calc. nannofossils	A	C
Radiolarians	–	T
Diatoms	T	C
Sponge spicules	R	C

SITE 594 HOLE A CORE 2 CORED INTERVAL 50.9–60.5 m



LITHOLOGIC DESCRIPTION

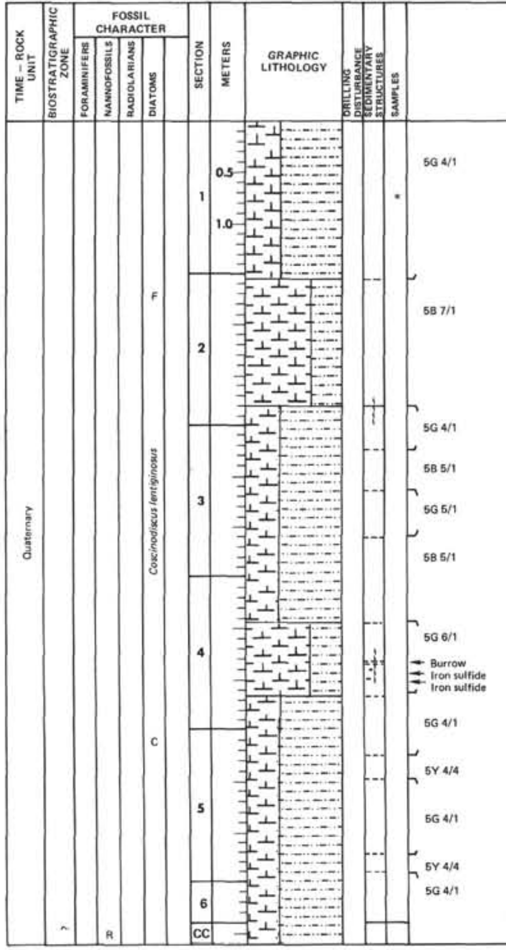
NANNOFOSSIL-BEARING CLAYEY SILT TO SILT-BEARING NANNOFOSSIL OOZE, dark green (5G 4/1) to lighter green (5G 6/1), homogeneous, minor pyrite throughout.

MICA-, QUARTZ- AND FORAMINIFER-BEARING NANNOFOSSIL OOZE, light bluish gray (5B 7/1 to 5B 8/1) with moderate bioturbation, pryite staining and pockets. H_2S odor.

SMEAR SLIDE SUMMARY:

	1, 72	4, 72
	D	D
Composition:		
Quartz	C	C
Heavy minerals	T	–
Mica	C	C
Pyrite	T	T
Foraminifers	R	C
Calc. nannofossils	A	A
Radiolarians	T	–
Diatoms	R	R
Sponge spicules	R	R

SITE 594 HOLE A CORE 3 CORED INTERVAL 60.5–70.1 m



LITHOLOGIC DESCRIPTION

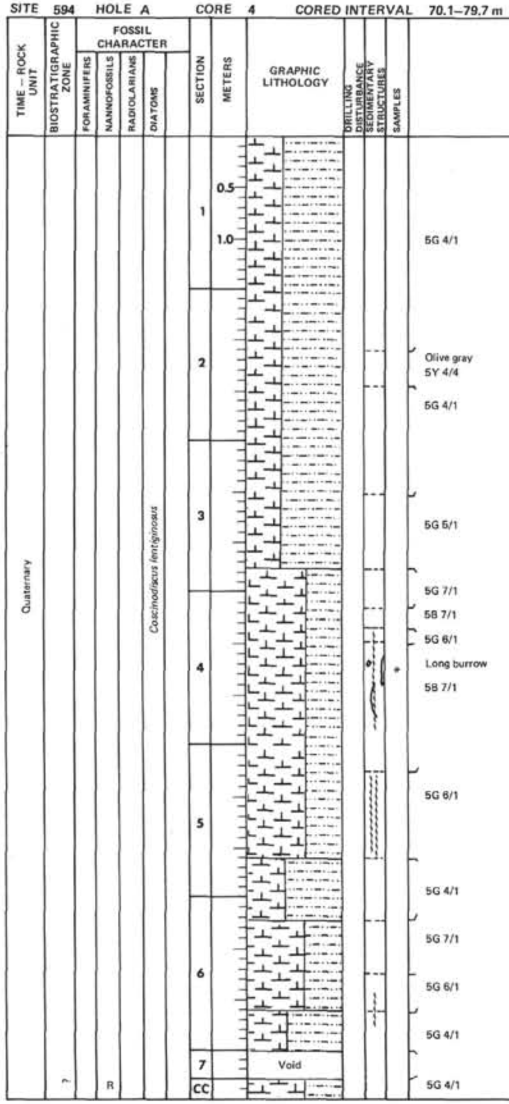
NANNOFOSSIL-, DIATOM-, AND SPONGE SPICULE-BEARING CLAYEY SILT, dark green (5G 4/1), homogeneous.

FORAMINIFER-BEARING NANNOFOSSIL OOZE, light bluish gray (5B 7/1), H_2S odor.

SMEAR SLIDE SUMMARY:

	1, 75
	D
Composition:	
Quartz	A
Feldspar	T
Heavy minerals	T
Clay minerals	C
Mica	C
Pyrite	T
Foraminifers	R
Calc. nannofossils	C
Radiolarians	T
Diatoms	C
Sponge spicules	C

SITE 594 HOLE A CORE 4 CORED INTERVAL 70.1–79.7 m



LITHOLOGIC DESCRIPTION

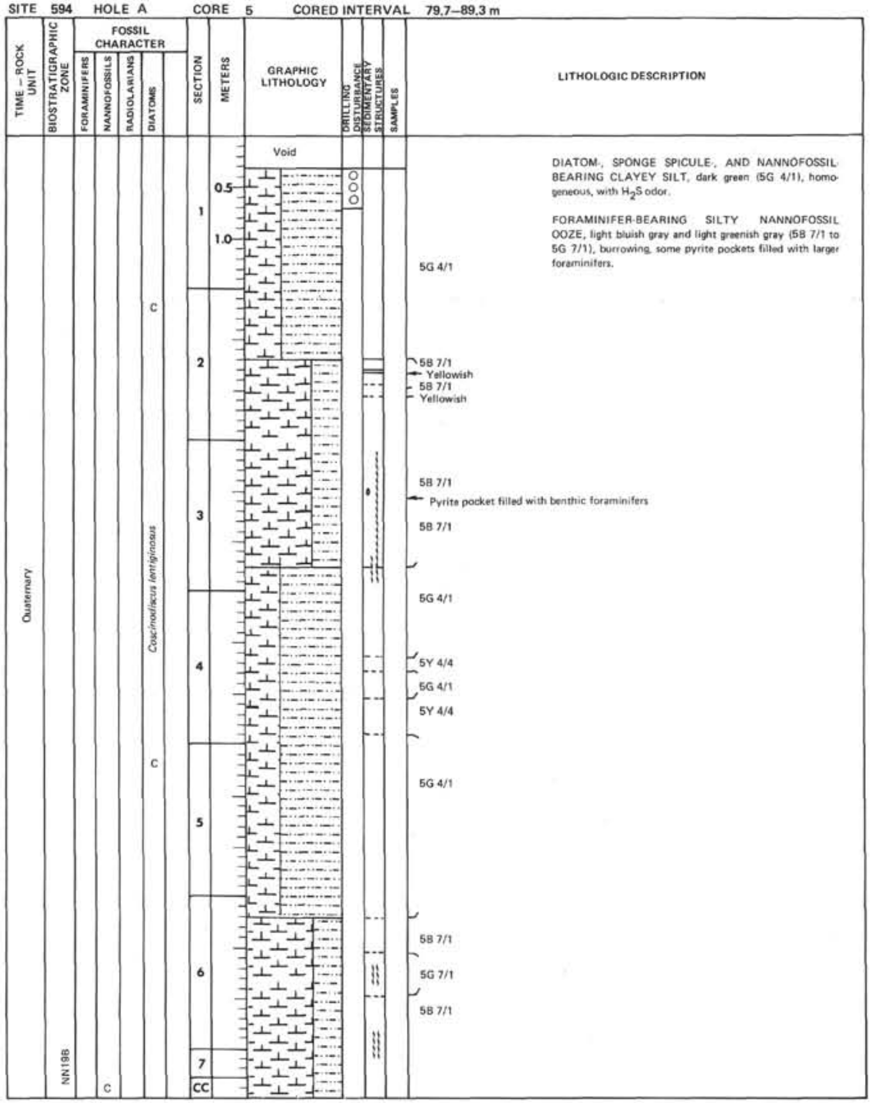
DIATOM-, SPONGE SPICULE-, AND NANNOFOSSIL-BEARING CLAYEY SILT, dark green (5G 4/1), homogeneous, abundant H_2S.

QUARTZ-, MICA- AND FORAMINIFER-BEARING NANNOFOSSIL OOZE, light blue gray (5B 7/1), burrowed, stained with iron sulfide.

SMEAR SLIDE SUMMARY:

	4, 78
	D
Composition:	
Quartz	C
Heavy minerals	T
Mica	C
Pyrite	T
Foraminifers	C
Calc. nannofossils	A
Diatoms	T
Sponge spicules	R

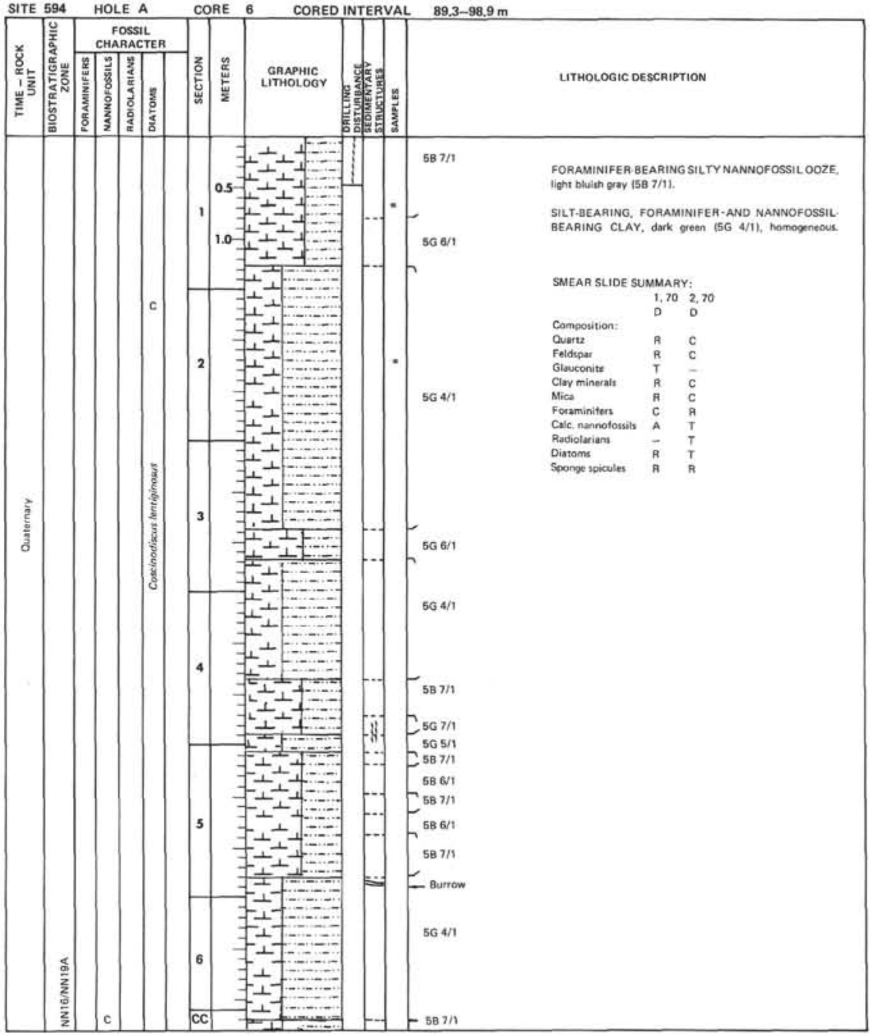
SITE 594 HOLE A CORE 5 CORED INTERVAL 79.7–89.3 m



DIATOM-, SPONGE SPICULE-, AND NANNOFOSSIL-BEARING CLAYEY SILT, dark green (5G 4/1), homogeneous, with H_2S odor.

FORAMINIFER-BEARING SILTY NANNOFOSSIL OOZE, light bluish gray and light greenish gray (5B 7/1 to 5G 7/1), burrowing, some pyrite pockets filled with larger foraminifers.

SITE 594 HOLE A CORE 6 CORED INTERVAL 89.3–98.9 m



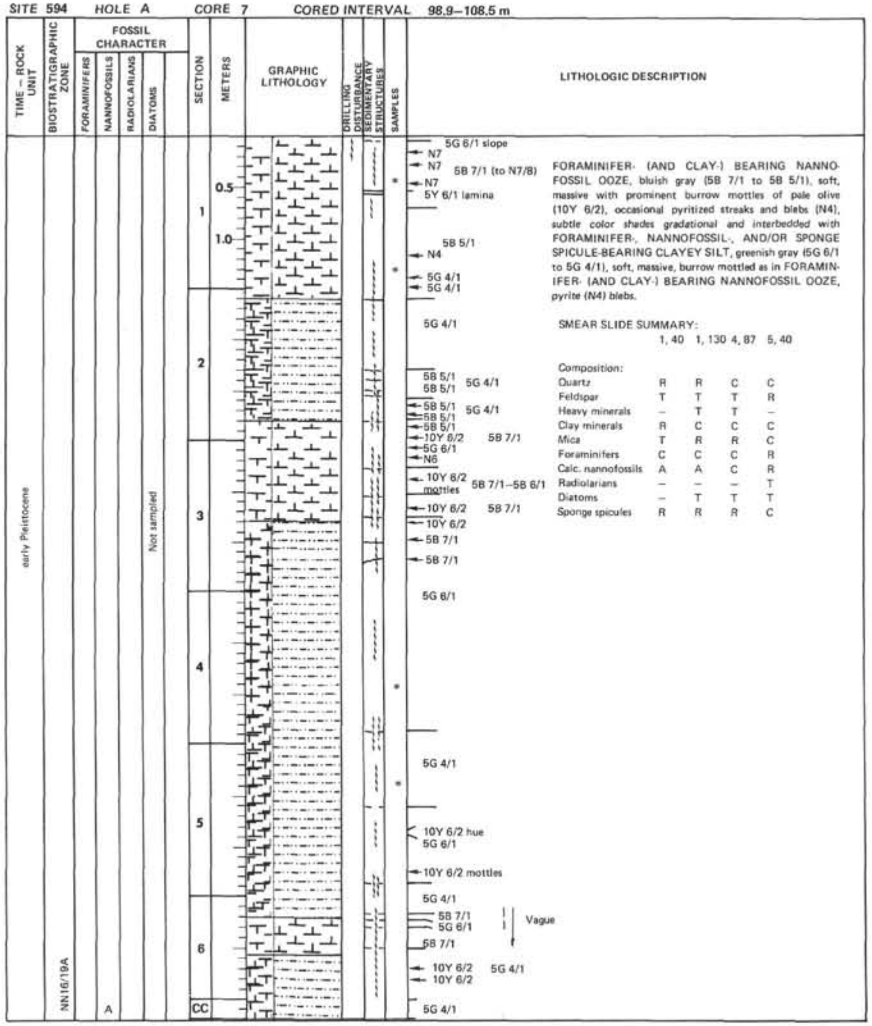
FORAMINIFER-BEARING SILTY NANNOFOSSIL OOZE, light bluish gray (5B 7/1).

SILT-BEARING, FORAMINIFER-AND NANNOFOSSIL-BEARING CLAY, dark green (5G 4/1), homogeneous.

SMEAR SLIDE SUMMARY:

	1, 70	2, 70
	D	D
Composition:		
Quartz	R	C
Feldspar	R	C
Glauconite	T	–
Clay minerals	R	C
Mica	R	C
Foraminifers	C	R
Calc. nannofossils	A	T
Radiolarians	–	T
Diatoms	R	T
Sponge spicules	R	R

SITE 594 HOLE A CORE 7 CORED INTERVAL 98.9–108.5 m

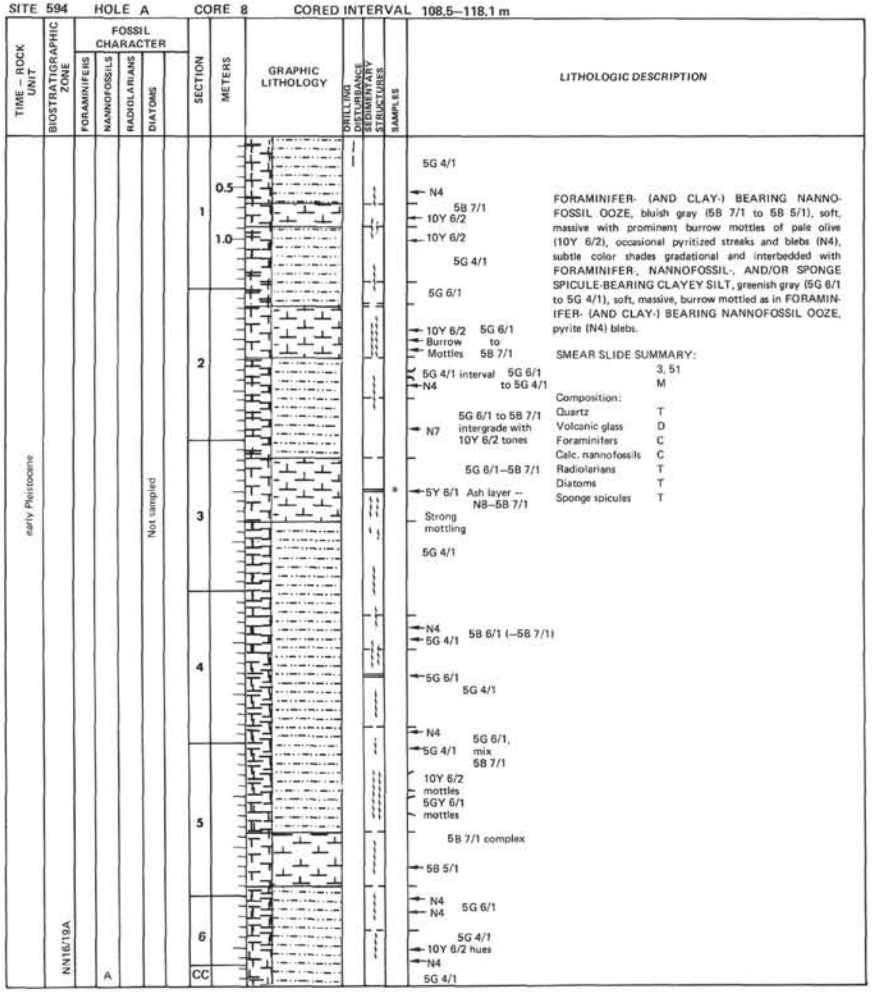


FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, bluish gray (5B 7/1 to 5B 5/1), soft, massive with prominent burrow mottles of pale olive (10Y 6/2), occasional pyritized streaks and blebs (N4), subtle color shades gradational and interbedded with FORAMINIFER-, NANNOFOSSIL-, AND/OR SPONGE SPICULE-BEARING CLAYEY SILT, greenish gray (5G 6/1 to 5G 4/1), soft, massive, burrow mottled as in FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, pyrite (N4) blebs.

SMEAR SLIDE SUMMARY:

	1, 40	1, 130	4, 87	5, 40
Composition:				
Quartz	R	R	C	C
Feldspar	T	T	T	R
Heavy minerals	–	T	T	–
Clay minerals	R	C	C	C
Mica	T	R	R	C
Foraminifers	C	C	C	R
Calc. nannofossils	A	A	C	R
Radiolarians	–	–	–	T
Diatoms	–	T	T	T
Sponge spicules	R	R	R	C

SITE 594 HOLE A CORE 8 CORED INTERVAL 108.5–118.1 m



FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, bluish gray (5B 7/1 to 5B 5/1), soft, massive with prominent burrow mottles of pale olive (10Y 6/2), occasional pyritized streaks and blebs (N4), subtle color shades gradational and interbedded with FORAMINIFER-, NANNOFOSSIL-, AND/OR SPONGE SPICULE-BEARING CLAYEY SILT, greenish gray (5G 6/1 to 5G 4/1), soft, massive, burrow mottled as in FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, pyrite (N4) blebs.

SMEAR SLIDE SUMMARY:

	3, 51 M
Composition:	
Quartz	T
Volcanic glass	D
Foraminifers	C
Calc. nannofossils	C
Radiolarians	T
Diatoms	T
Sponge spicules	T

SITE 594 HOLE A CORE 9 CORED INTERVAL 118.1–127.7 m

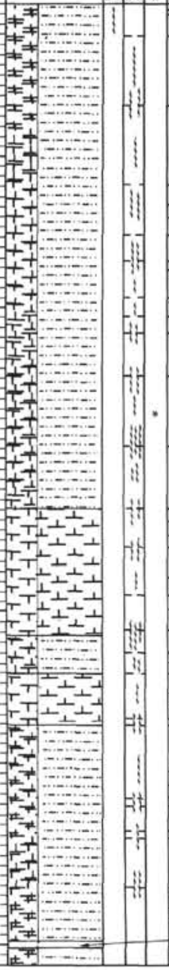
TIME – ROCK UNIT: early Pleistocene

BIOSTRATIGRAPHIC ZONE: NN16/19A

FOSSIL CHARACTER: FORAMINIFERS A; NANNOFOSSILS; RADIOLARIANS; DIATOMS Not sampled

SECTION: 1, 2, 3, 4, 5, 6, 7, CC

METERS: 0.5, 1.0



LITHOLOGIC DESCRIPTION

5B 7/1 layer 5G 4/1 to 5B 5/1

5G 6/1 to 5G 4/1

5G 4/1

5G 5/1 with 10Y 6/2 mottles

5G 4/1

10Y 6/2 hue

5G 6/1

5B 5/1 5B 7/1 to 5G 6/1

5G 6/1 + 10Y 6/2 tone

5G 4/1

5G 6/1 to 5GY 6/1

5G 4/1 → 5G 6/1

5G 4/1

N4 5B 7/1

10Y 6/2

5B 6/1

10Y 6/2 hue

N4

5B 7/1 (to N8)

5G 6/1 5G 4/1

N4 5G 6/1

N4 N8 (to 5B 7/1)

N4

10Y 6/2 hue

5G 6/1

N4

5G 4/1

5G 4/1

5G 6/1

5G 4/1

5G 6/1 to 5G 4/1

5GY 6/1 laminae 5G 6/1

5GY 6/1 lamina

5G 4/1 Void

5G 6/1

5G 6/1

N4

FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, bluish gray (5B 7/1 to 5B 5/1), soft, massive with prominent burrow mottles of pale olive (10Y 6/2), occasional pyritized streaks and blebs (N4), subtle color shades gradational and interbedded with FORAMINIFER-, NANNOFOSSIL-, AND/OR SPONGE SPICULE-BEARING CLAYEY SILT, greenish gray (5G 6/1 to 5G 4/1), soft, massive, burrow mottled as in FORAMINIFER- (AND CLAY-) BEARING NANNOFOSSIL OOZE, pyrite (N4) blebs.

SMEAR SLIDE SUMMARY:

	3, 113
	D
Composition:	
Quartz	C
Volcanic glass	T
Glauconite	T
Clay minerals	C
Mica	R
Foraminifers	C
Calc. nannofossils	A
Sponge spicules	R

SITE 594 HOLE A CORE 10 CORED INTERVAL 149.9–159.5 m

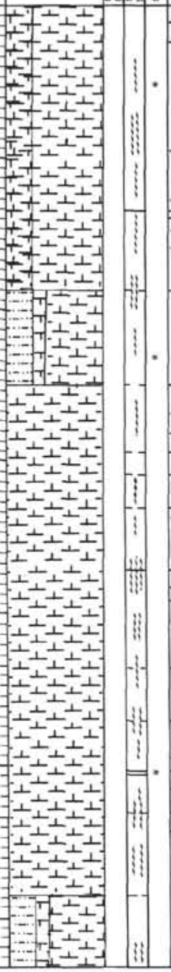
TIME – ROCK UNIT: early Pliocene

BIOSTRATIGRAPHIC ZONE: *G. puncticulata* NN13/15

FOSSIL CHARACTER: FORAMINIFERS A; NANNOFOSSILS A; RADIOLARIANS; DIATOMS *Nitzschia praeinterfrigidaria* ←C; *Nitzschia reinholdii* and *N. angulata* Zones undifferentiated ←F

SECTION: 1, 2, 3, 4, 5, 6, 7, CC

METERS: 0.5, 1.0



LITHOLOGIC DESCRIPTION

N4

N4

N8 + 5Y 8/1

10Y 6/2 mottles

N4 streaks

N4

N4

5Y 8/1

5Y 8/1 N7

5Y 8/1 hue

5G 6/1

Lightens ↓ N7

N8 to 5Y 8/1

N4

N4

N7

N7/8

5Y 8/1

N7

10Y 6/2 hue and mottles

N4

N4

10Y 6/2 N8 + 5Y 8/1

N7

N7

N7 to N8

10Y 6/2 hue

N7 N8 + mottles

N7

10Y 6/2

N3 layer ash

10Y 6/2 N7 + N8

10Y 6/2

N7

10Y 6/2

10Y 6/2 mottles

10Y 6/2

5GY 6/1

N7

N7

5G 6/1

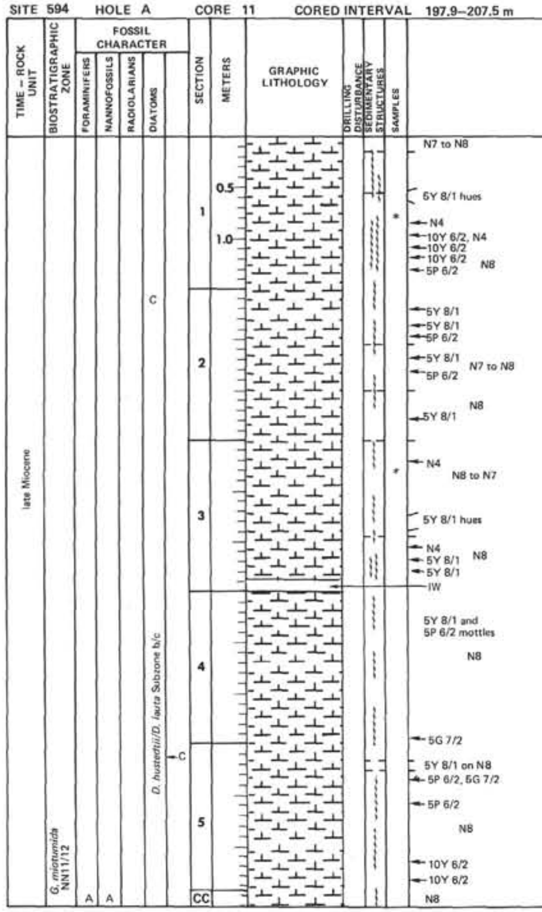
NANNOFOSSIL OOZE TO FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8) to light gray (N7) with yellowish gray (5Y 8/1) overtones, soft but stiff, massive, burrow mottled in pale olive (10Y 6/2) hues and scattered pyritized (N4) blebs and streaks.

As for NANNOFOSSIL OOZE TO FORAMINIFER-BEARING NANNOFOSSIL OOZE but with greenish (5G 6/1) to yellowish (5GY 6/1) tones, commonly CLAY- AND/OR SILT-BEARING.

SMEAR SLIDE SUMMARY:

	1, 79	3, 46	6, 8
	D	D	M
Composition:			
Quartz	R	R	C
Heavy minerals	T	T	–
Volcanic glass	–	–	A
Glauconite	T	T	–
Clay minerals	R	R	–
Mica	T	T	–
Foraminifers	C	R	T
Calc. nannofossils	A	D	R
Diatoms	–	T	–
Sponge spicules	R	R	–

SITE 594 HOLE A CORE 11 CORED INTERVAL 197.9–207.5 m



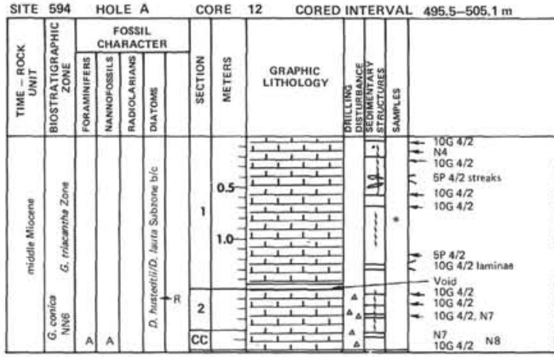
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE TO FORAMINIFER-BEARING NANNOFOSSIL OOZE, light to very light gray (N7 to N8) with yellowish gray (5Y 8/1) hues at several levels, burrow mottles in 5Y 8/1 and 10Y 6/2, soft to stiff with occasional hard layers, generally massive except for bioturbate structures.

SMEAR SLIDE SUMMARY:

	1, 80	3, 30
	D	D
Composition:		
Quartz	T	T
Glauconite	T	—
Mica	R	T
Foraminifers	R	R
Calc. nannofossils	D	D
Radiolarians	T	—
Diatoms	T	T
Sponge spicules	R	R

SITE 594 HOLE A CORE 12 CORED INTERVAL 495.5–505.1 m



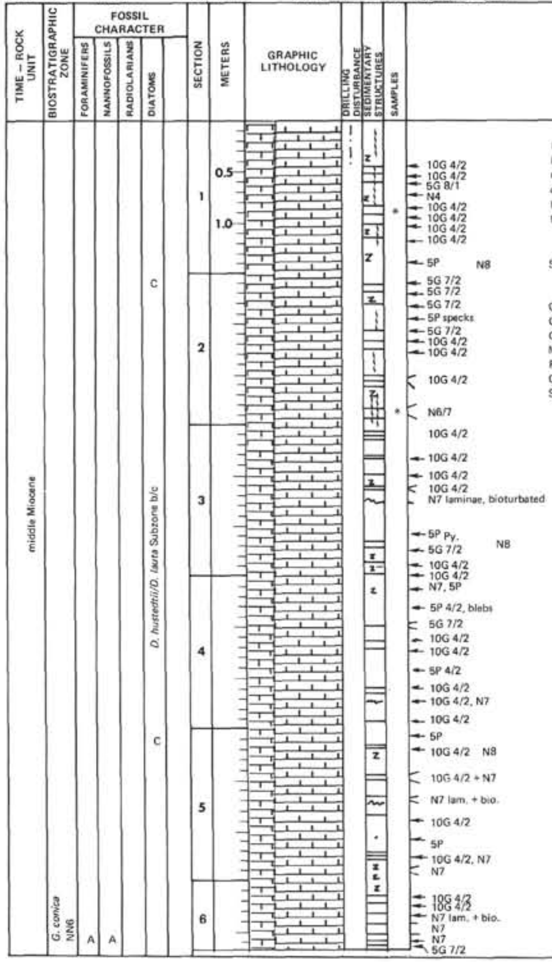
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), stiff to firm, massive with diffuse bioturbate structures in subtle gray hues, pyritized streaks (5P 4/2) and common grayish green (10G 4/2) laminae, often composite. Evidence of biscuiting in Section 1.

SMEAR SLIDE SUMMARY:

	1, 80
	D
Composition:	
Quartz	T
Foraminifers	R
Calc. nannofossils	D
Sponge spicules	R

SITE 594 HOLE A CORE 13 CORED INTERVAL 505.1–514.7 m



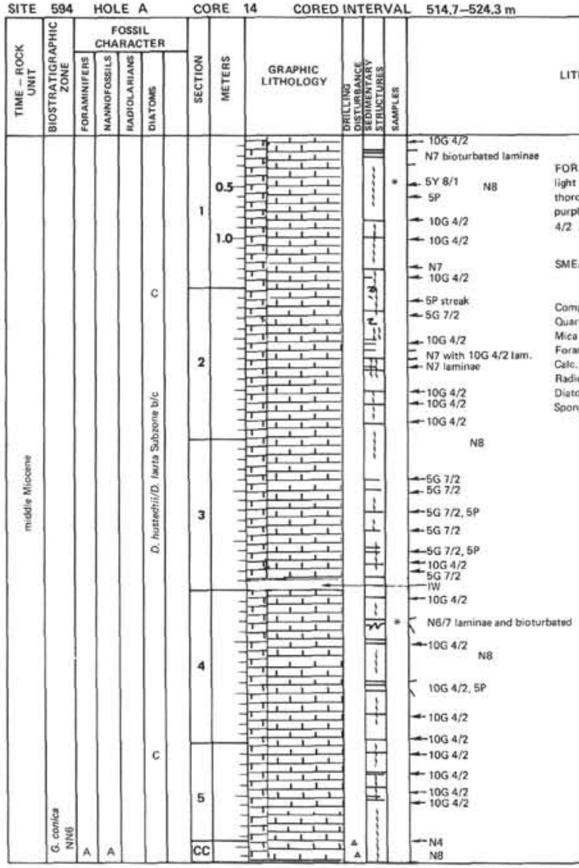
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (N8), firm (but biscuiting produces soft sections), massive but thoroughly bioturbated (includes *Zoophycos, Chondrites,* and *Planolites*) and mottled, common pyritized (5P) specks and streaks, conspicuous secondary green (10G 4/2 to 5G 7/2) color laminae throughout.

SMEAR SLIDE SUMMARY:

	1, 88	2, 136
	D	M
Composition:		
Quartz	T	R
Glauconite	–	T
Mica	T	T
Foraminifers	C	C
Calc. nannofossils	D	A
Sponge spicules	R	C

SITE 594 HOLE A CORE 14 CORED INTERVAL 514.7–524.3 m



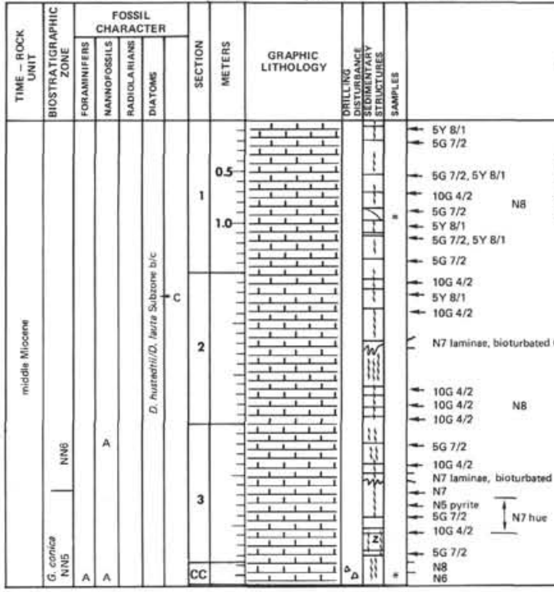
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (N8), firm but soft portions due to biscuiting, thoroughly bioturbated and burrow mottled with common purplish (5P) streaks and blebs, conspicuous green (10G 4/2 and 5G 7/2) color laminae. Occasional *Zoophycos.*

SMEAR SLIDE SUMMARY:

	1, 48	4, 31
	D	M
Composition:		
Quartz	–	T
Mica	–	T
Foraminifers	C	R
Calc. nannofossils	D	A
Radiolarians	T	T
Diatoms	T	T
Sponge spicules	R	C

SITE 594 HOLE A CORE 15 CORED INTERVAL 524.3–533.9 m



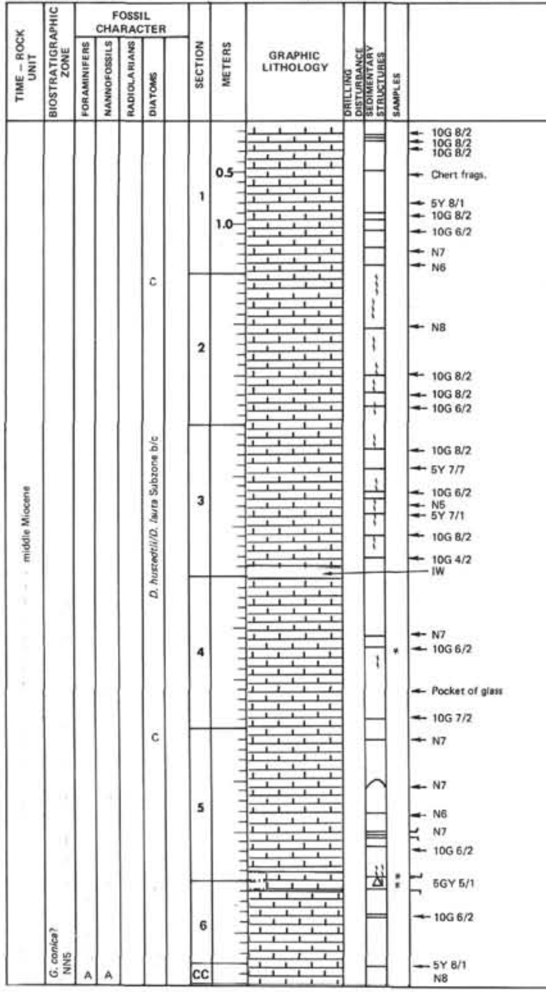
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), firm, massive but thoroughly bioturbated and swirled in colors of yellowish gray (5Y 8/1), light gray (N7) and purples (5P), scattered pyrite specks, prominent green (10G 4/2 to 5G 7/2) color laminae. *Planolites*-like burrows.

SMEAR SLIDE SUMMARY:

	1, 75	CC
	D	M
Composition:		
Quartz	–	R
Feldspar	–	T
Clay minerals	–	C
Mica	–	C
Foraminifers	R	R
Calc. nannofossils	D	A
Radiolarians	–	T
Diatoms	–	R
Sponge spicules	R	C

SITE 594 HOLE A CORE 16 CORED INTERVAL 533.9–543.5 m



LITHOLOGIC DESCRIPTION

ENTIRE CORE BROKEN INTO BISCUITS BY CORING.

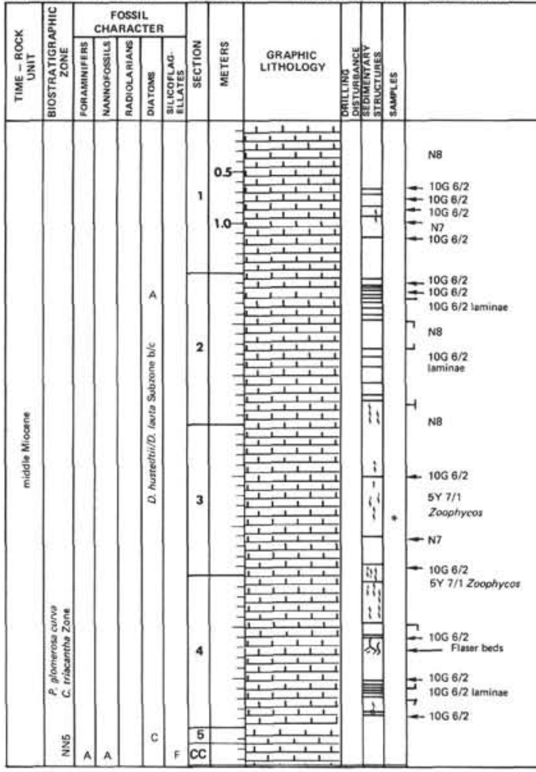
NANNOFOSSIL CHALK, very light gray (N8), numerous pale green laminae (10G 6/2 to 10G 8/2) and thin (<2 mm) medium light gray (N6) laminae. Burrows common.

SPONGE SPICULE-BEARING CLAYEY NANNOFOSSIL CHALK, olive gray to brown (5Y 4/2), very hard (porcellainitic) with *Chondrites* burrows. Layer continues into top 10 cm of Section 6. Probable turbidite.

SMEAR SLIDE SUMMARY:

	4, 75	5, 141	6, 7
	D	M	M
Composition:			
Quartz	–	T	R
Feldspar	T	–	–
Heavy minerals	–	–	R
Volcanic glass	T	C	–
Clay minerals	–	C	C
Mica	T	T	C
Pyrite	T	T	R
Foraminifers	R	R	R
Calc. nannofossils	D	A	A
Diatoms	T	–	R
Sponge spicules	R	T	C

SITE 594 HOLE A CORE 17 CORED INTERVAL 543.5–553.1 m



LITHOLOGIC DESCRIPTION

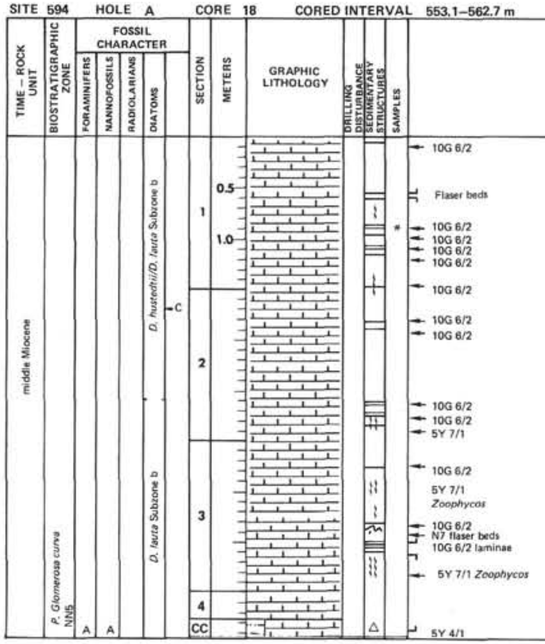
ENTIRE CORE BROKEN INTO BISCUITS BY CORING.

NANNOFOSSIL CHALK, white (N8 to N9) with abundant pale green (10G 6/2), thin (<2 mm) laminae. Almost all burrows gray (N4). Some sulfide stains. Flaser beds in Section 4.

SMEAR SLIDE SUMMARY:

	3, 95
	D
Composition:	
Quartz	T
Mica	T
Pyrite	T
Foraminifers	C
Calc. nannofossils	D
Diatoms	T
Sponge spicules	R

SITE 594 HOLE A CORE 18 CORED INTERVAL 553.1–562.7 m



LITHOLOGIC DESCRIPTION

ENTIRE CORE BROKEN INTO BISCUITS BY CORING.

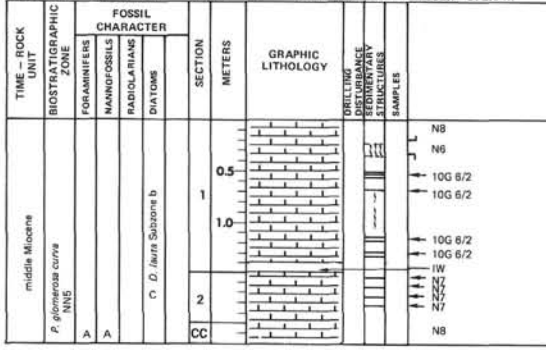
NANNOFOSSIL CHALK, white (N8) with abundant pale green (10G 6/2) laminae. Burrowing, *Chondrites* and *Zoophycos* abundant. Flaser beds occur in Sections 1 and 3.

Core catcher has layer of SPICULE-BEARING RECRYSTALLIZED NANNOFOSSIL CHALK, olive gray brown (5Y 4/1), probable turbidite.

SMEAR SLIDE SUMMARY:

	1, 90
	D
Composition:	
Mica	T
Pyrite	T
Foraminifers	R
Calc. nannofossils	D
Diatoms	T
Sponge spicules	R

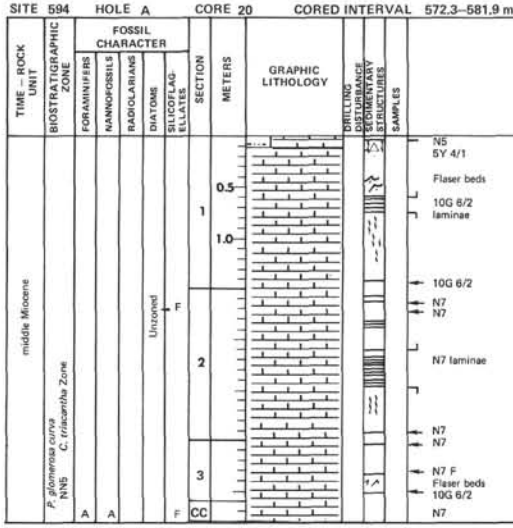
SITE 594 HOLE A CORE 19 CORED INTERVAL 562.7–572.3 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), with gray sulfide-rich burrows and green (10G 6/2), thin (<2 mm) laminae.

SITE 594 HOLE A CORE 20 CORED INTERVAL 572.3–581.9 m



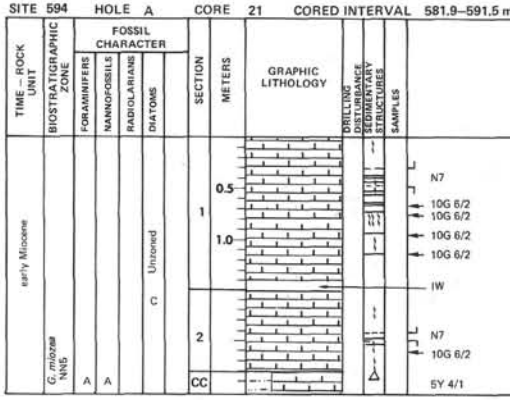
LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), numerous pale green (10G 6/2) thin (<2 mm) laminae.

At 5 to 15 cm: MICA- AND QUARTZ-BEARING NANNOFOSSIL CHALK, brown (5Y 4/1), probable turbidite.

Abundant gray (N7) laminae in Section 2.

SITE 594 HOLE A CORE 21 CORED INTERVAL 581.9–591.5 m

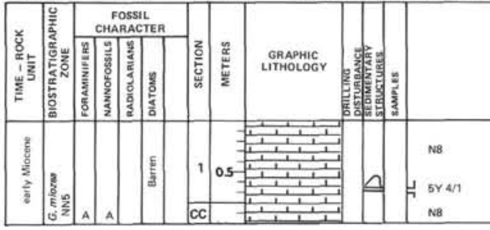


LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), numerous very pale green (10G 6/2) laminae and gray (N7) burrows.

Core catcher has: MICA- AND QUARTZ-BEARING NANNOFOSSIL CHALK, brown (5Y 4/1) with white (N9) burrows, probable turbidite.

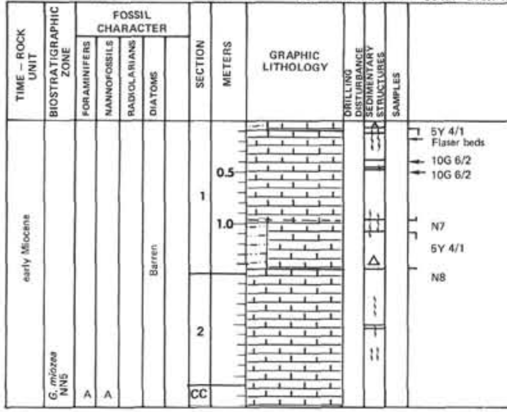
SITE 594 HOLE A CORE 22 CORED INTERVAL 591.5–601.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), badly disturbed by coring into biscuits.

SITE 594 HOLE A CORE 23 CORED INTERVAL 601.1–610.7 m

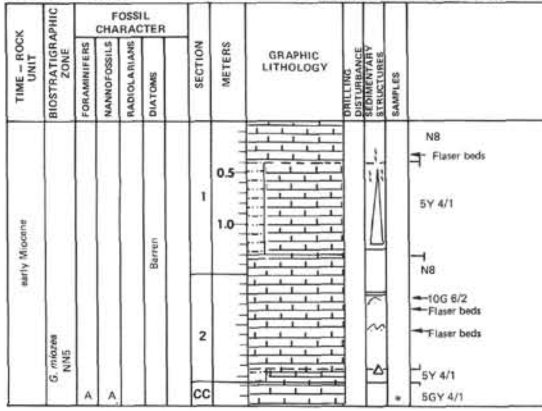


LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, very light gray (N8), with pale green (10G 6/2), laminae and streaks of iron sulfide and blebs (N6, N7).

MICA- AND QUARTZ-BEARING NANNOFOSSIL CHALK, olive gray (5Y 4/1), heavily burrowed at top with *Chondrites*, *Planolites*, and *Zoophycos*.

SITE 594 HOLE A CORE 24 CORED INTERVAL 610.7–620.3 m



LITHOLOGIC DESCRIPTION

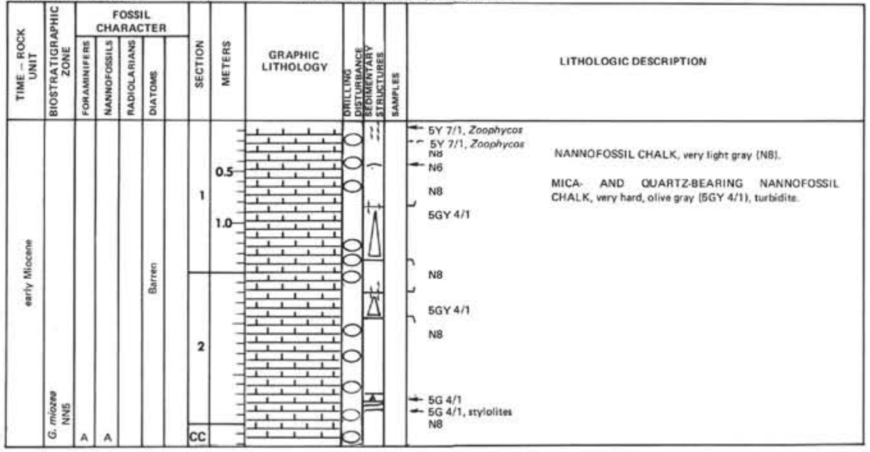
TERRIGENOUS CLAYEY NANNOFOSSIL RECRYSTALLIZED CHALK, olive gray (5Y 4/1), hard and almost limestone, with scoured sharp lower contact and graded upper contact. Turbidite. Burrowed on top with *Zoophycos* (~20 cm deep), then *Chondrites* (~10 cm deep), then *Planolites* (< 5 cm deep).

CLAYEY NANNOFOSSIL CHALK, dark greenish gray (5GY 4/1), hard, burrowed.

SMEAR SLIDE SUMMARY:

	CC M		
Composition:			
Quartz	R	Carbonate unspec.	A
Clay minerals	C	Foraminifers	R
Mica	R	Calc. nannofossils	A
Pyrite	R	Sponge spicules	T

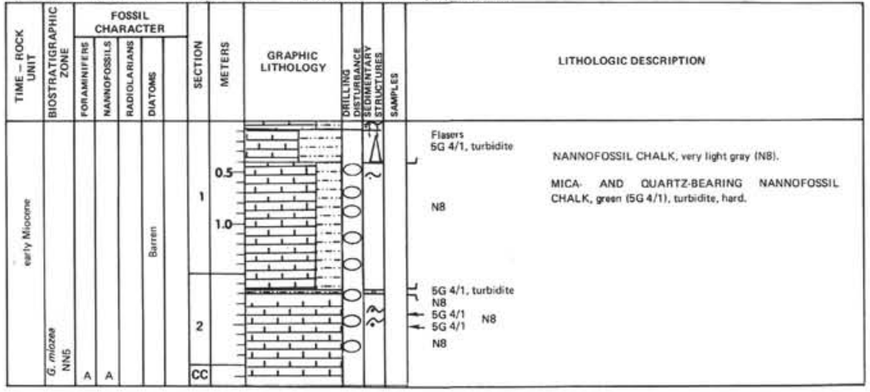
SITE 594 HOLE A CORE 25 CORED INTERVAL 620.3–629.9 m



NANNOFOSSIL CHALK, very light gray (N8).

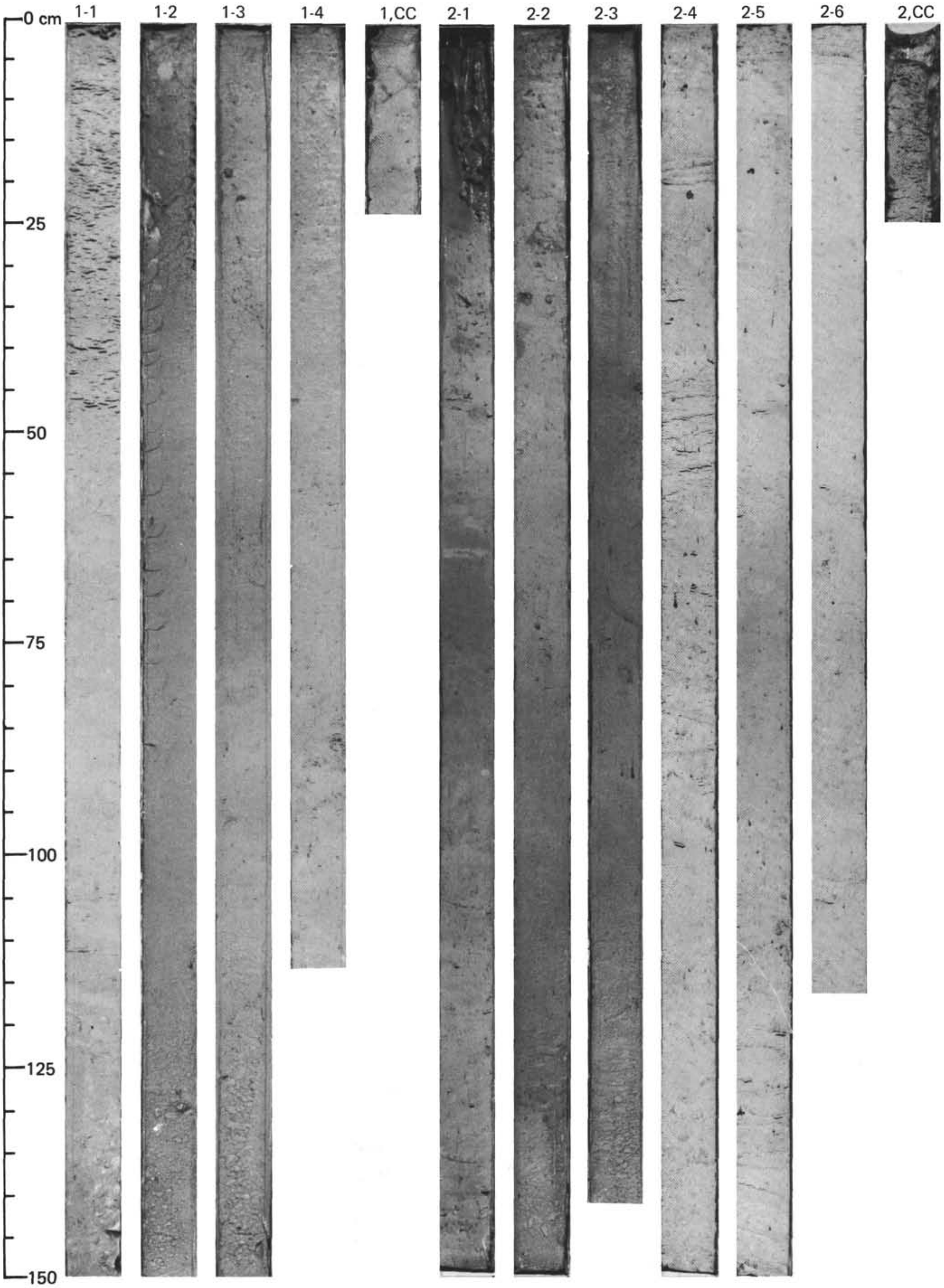
MICA- AND QUARTZ-BEARING NANNOFOSSIL CHALK, very hard, olive gray (5GY 4/1), turbidite.

SITE 594 HOLE A CORE 26 CORED INTERVAL 629.9–639.5 m



NANNOFOSSIL CHALK, very light gray (N8).

MICA- AND QUARTZ-BEARING NANNOFOSSIL CHALK, green (5G 4/1), turbidite, hard.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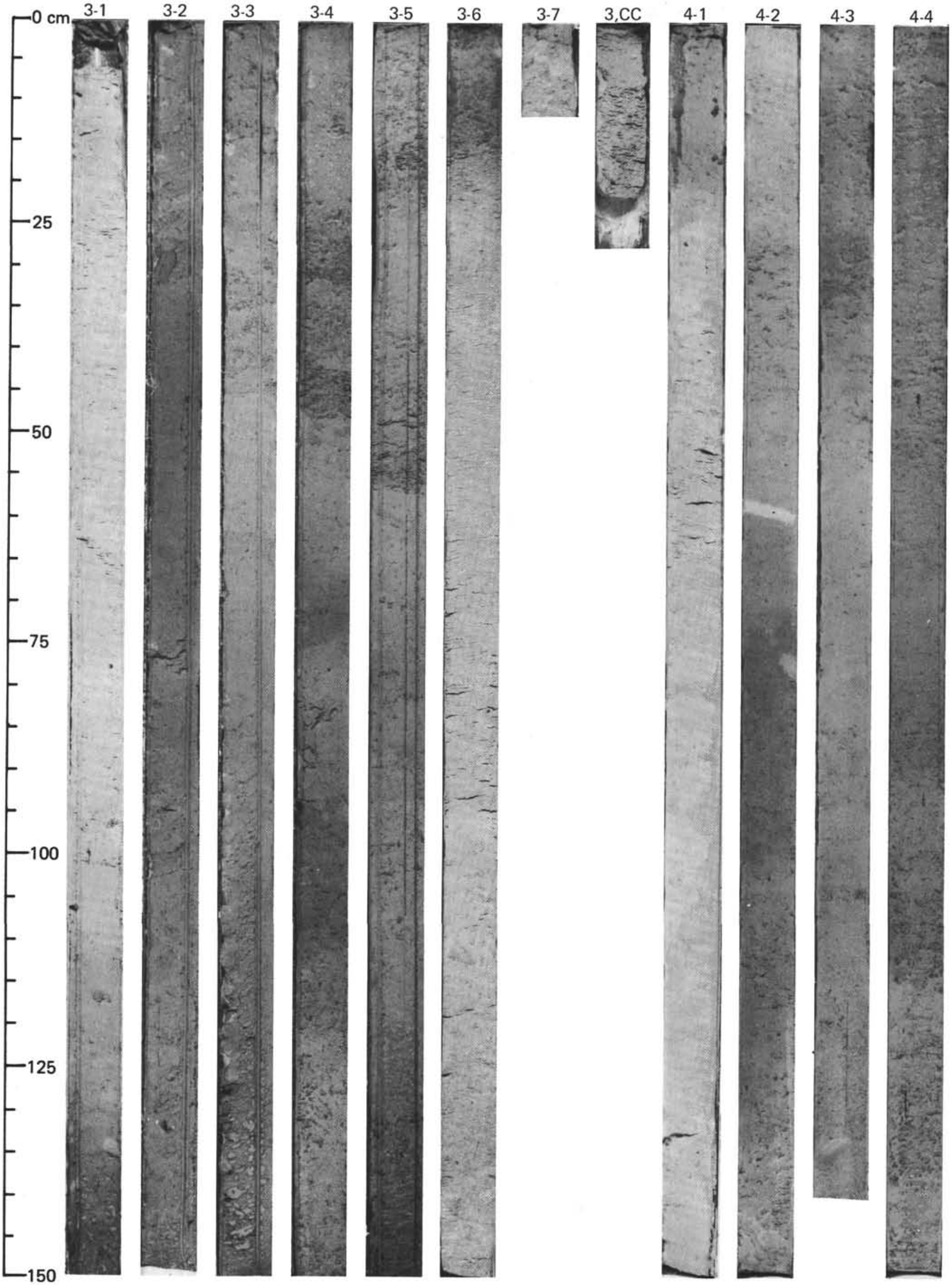
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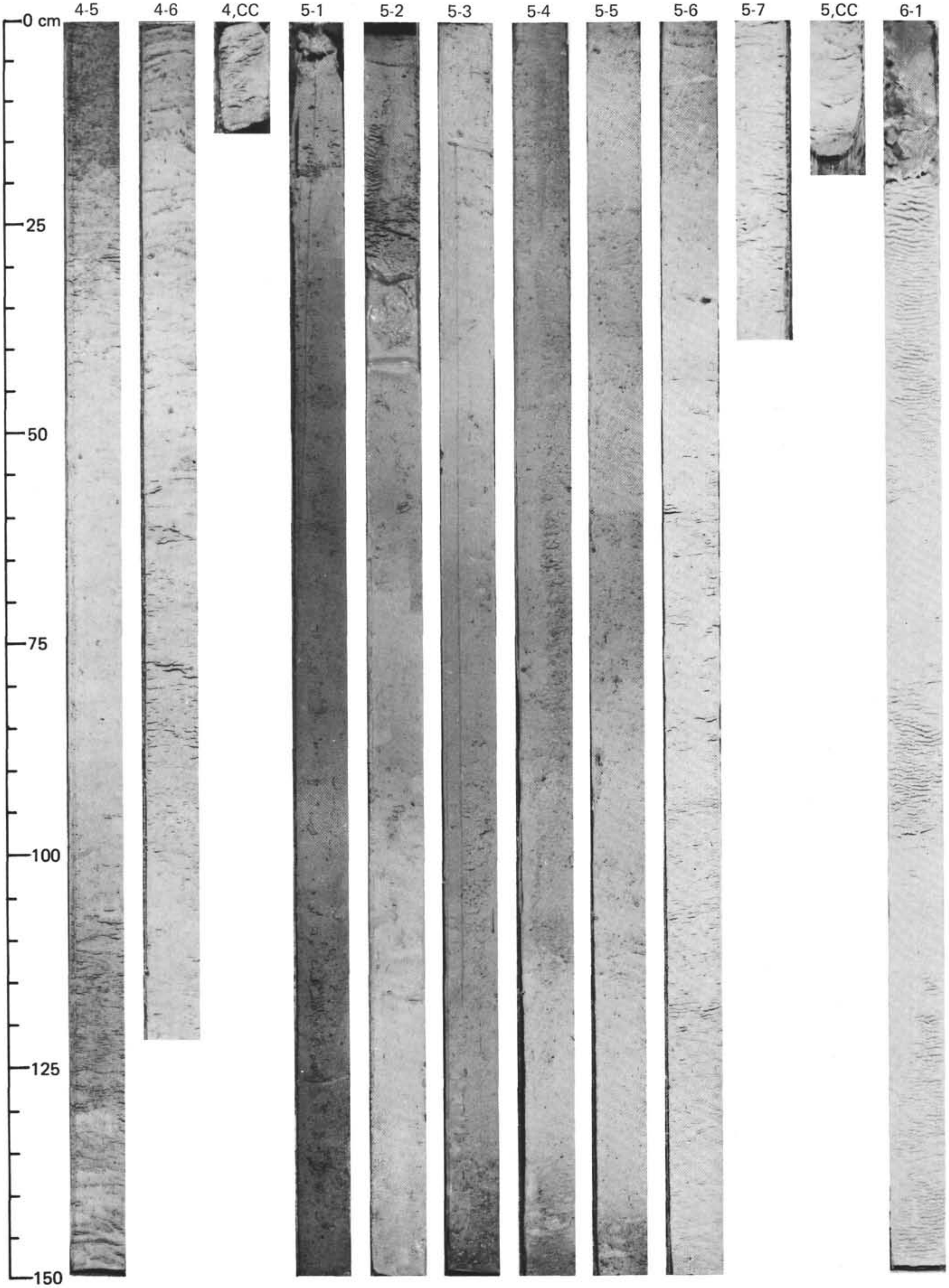
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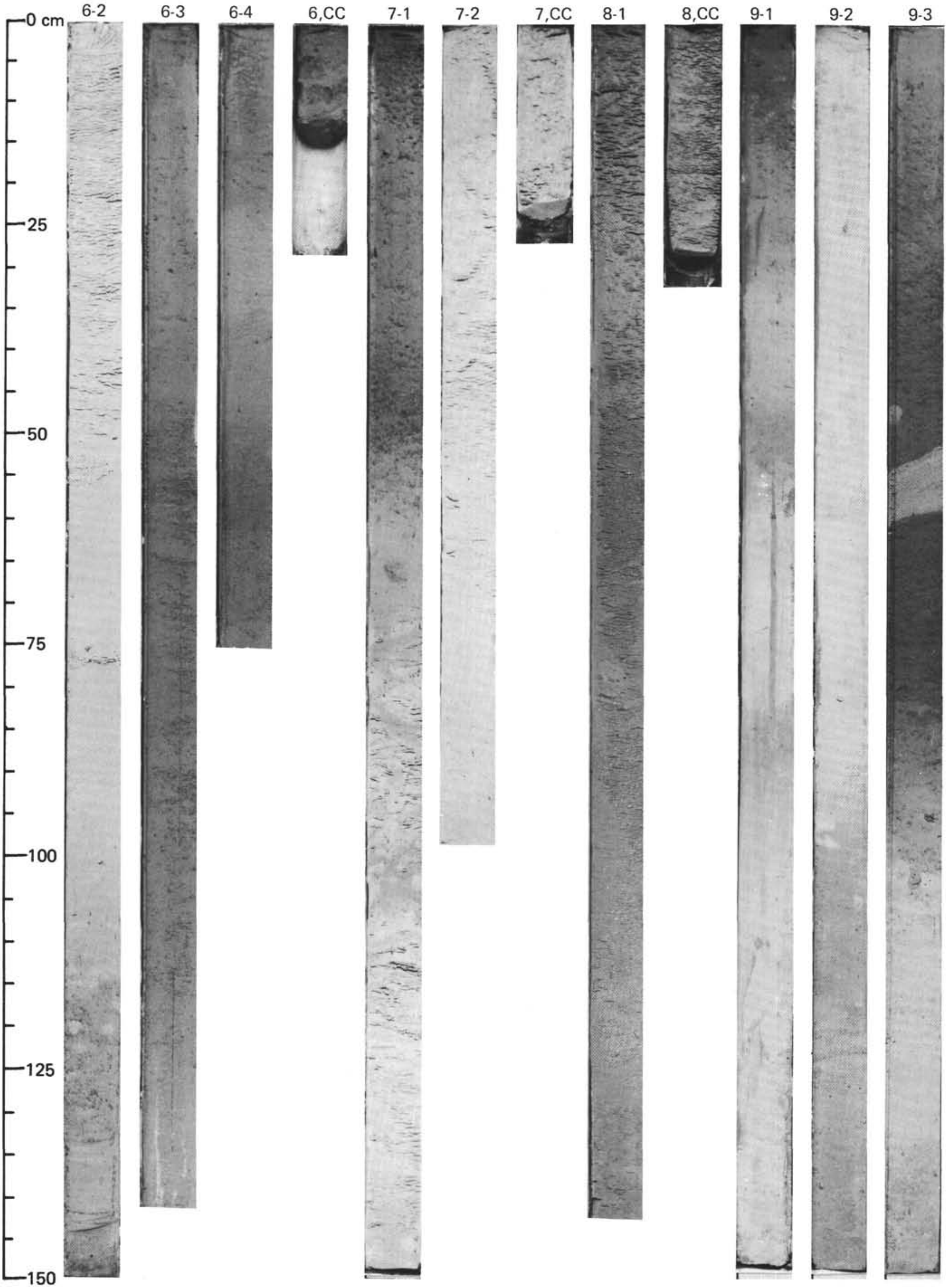
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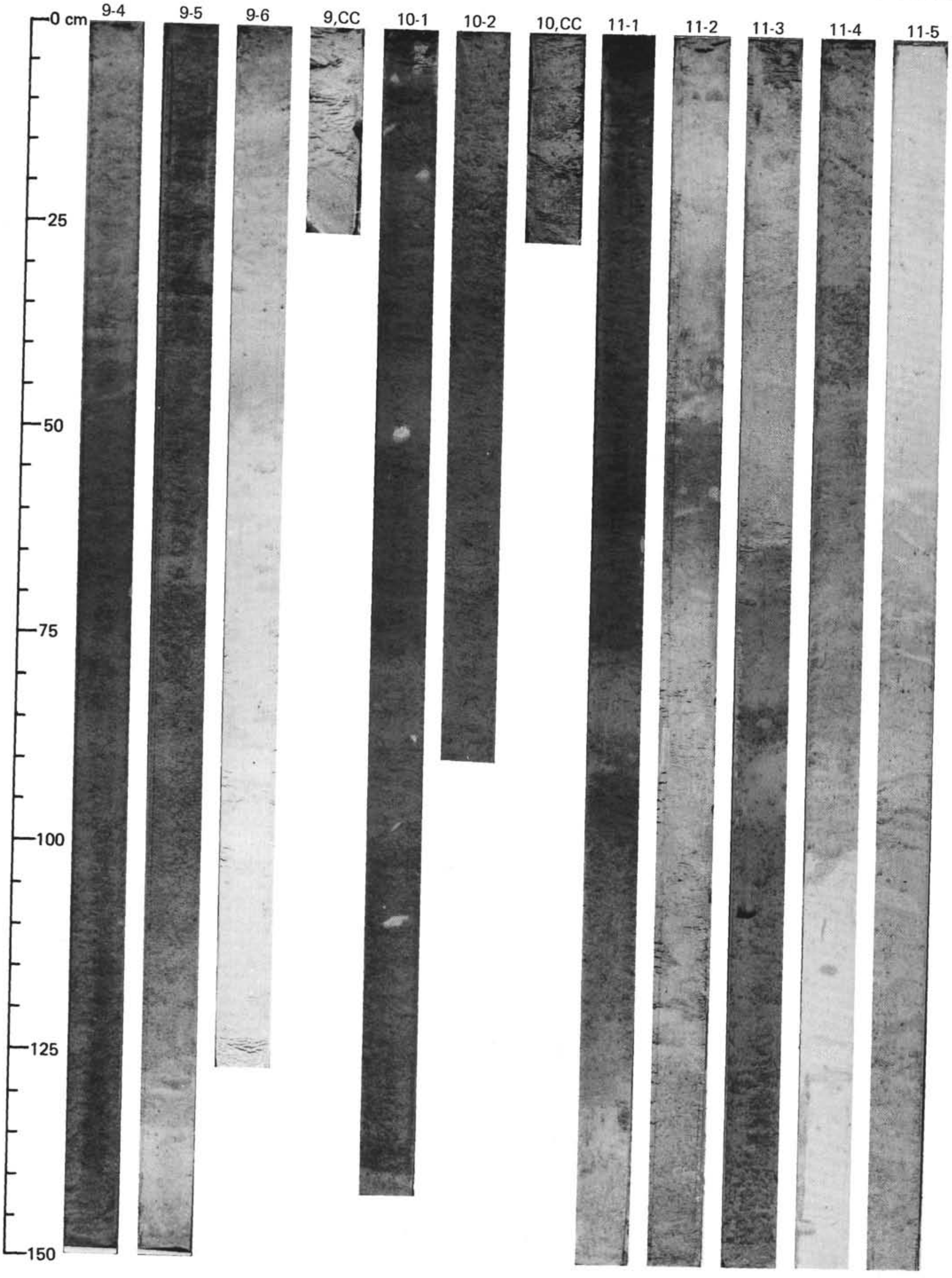
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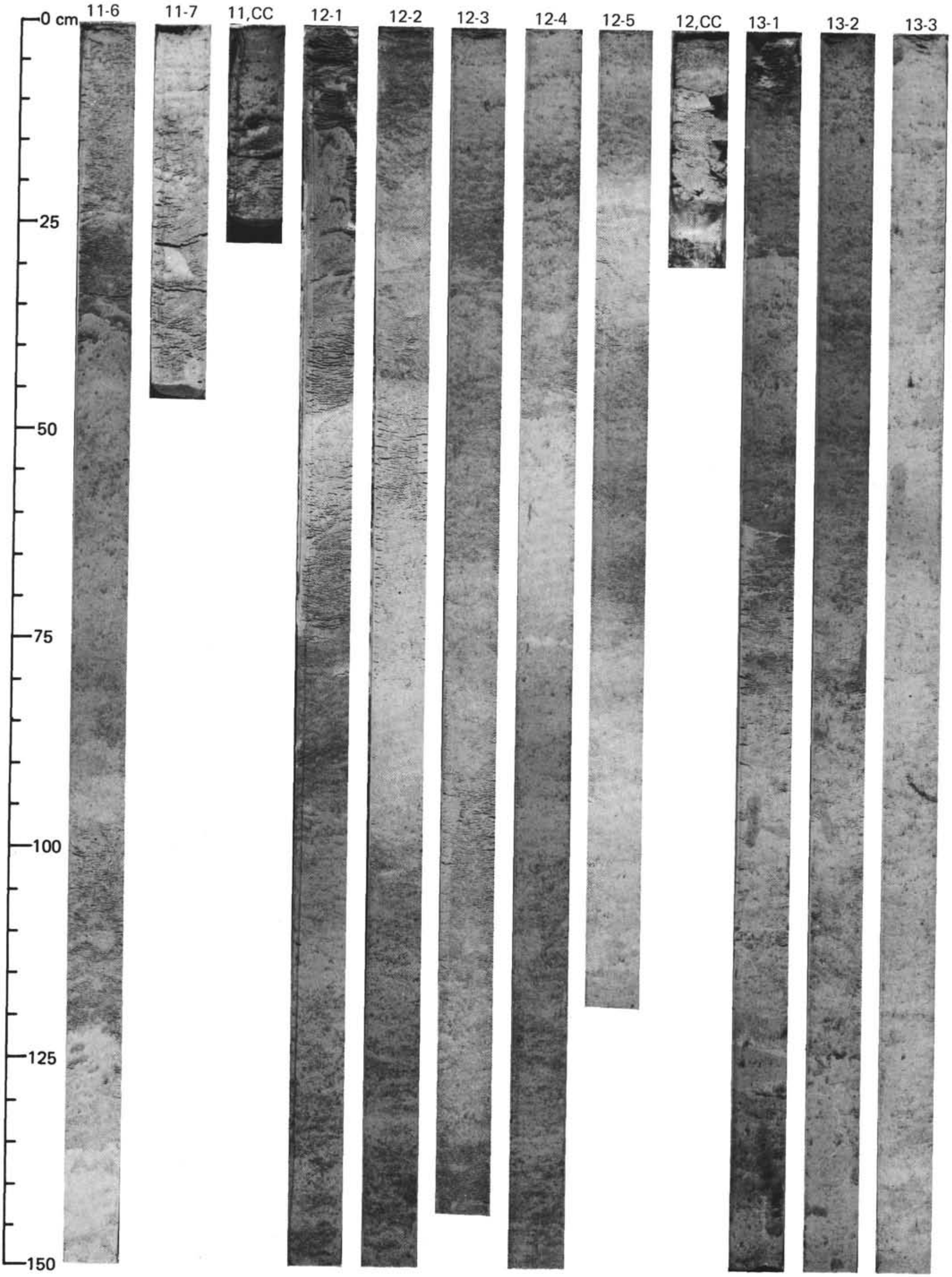
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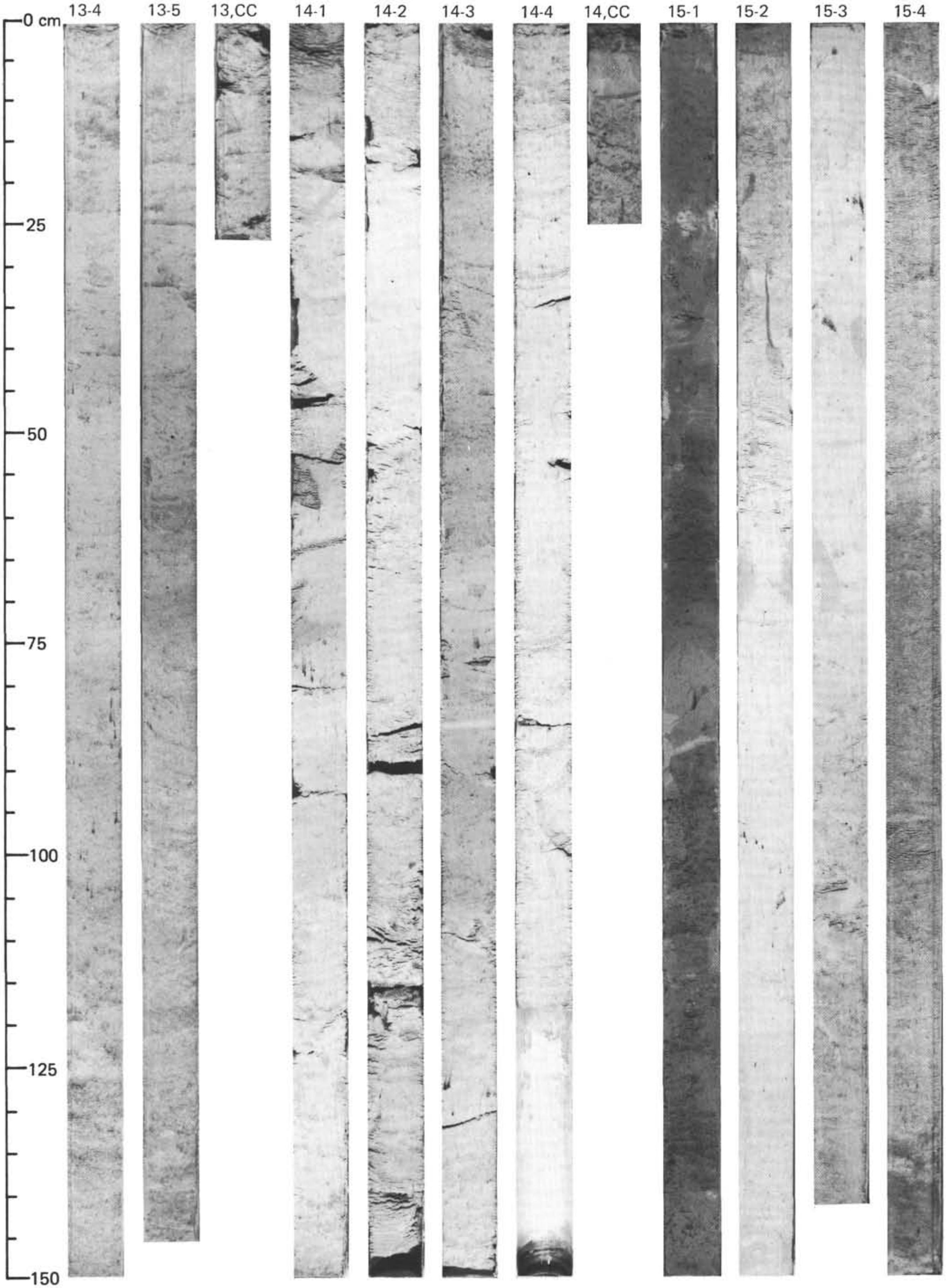
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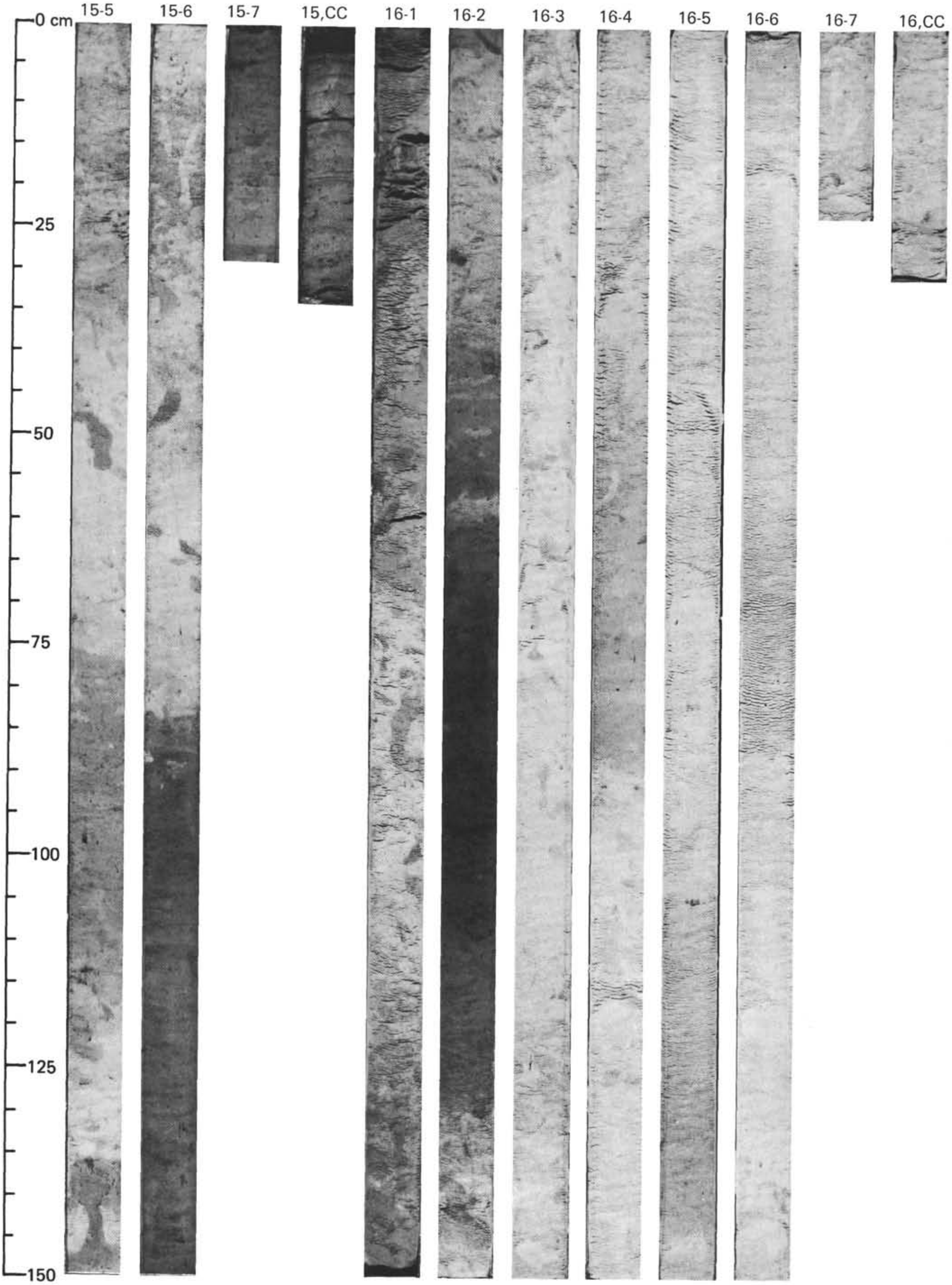
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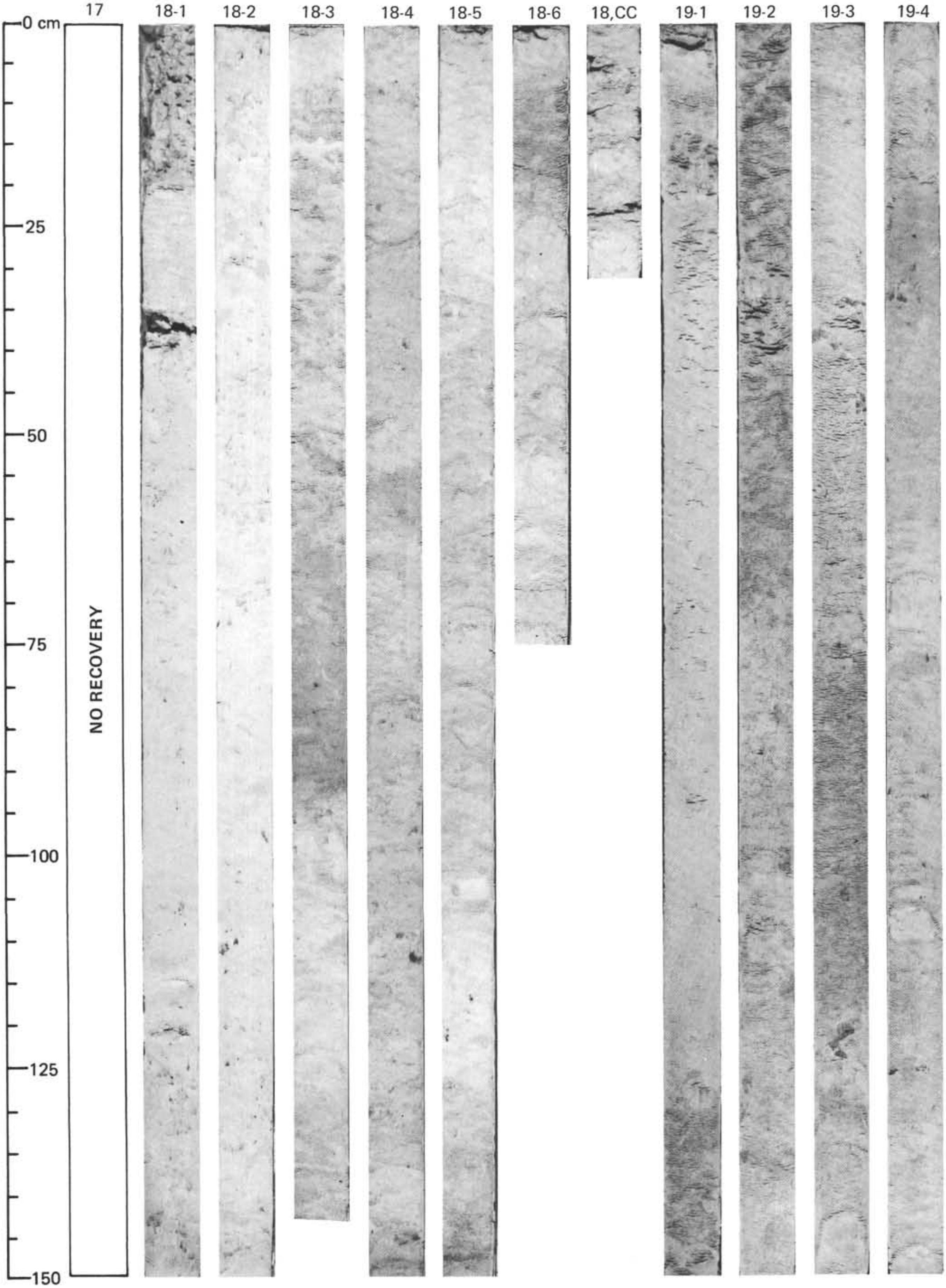
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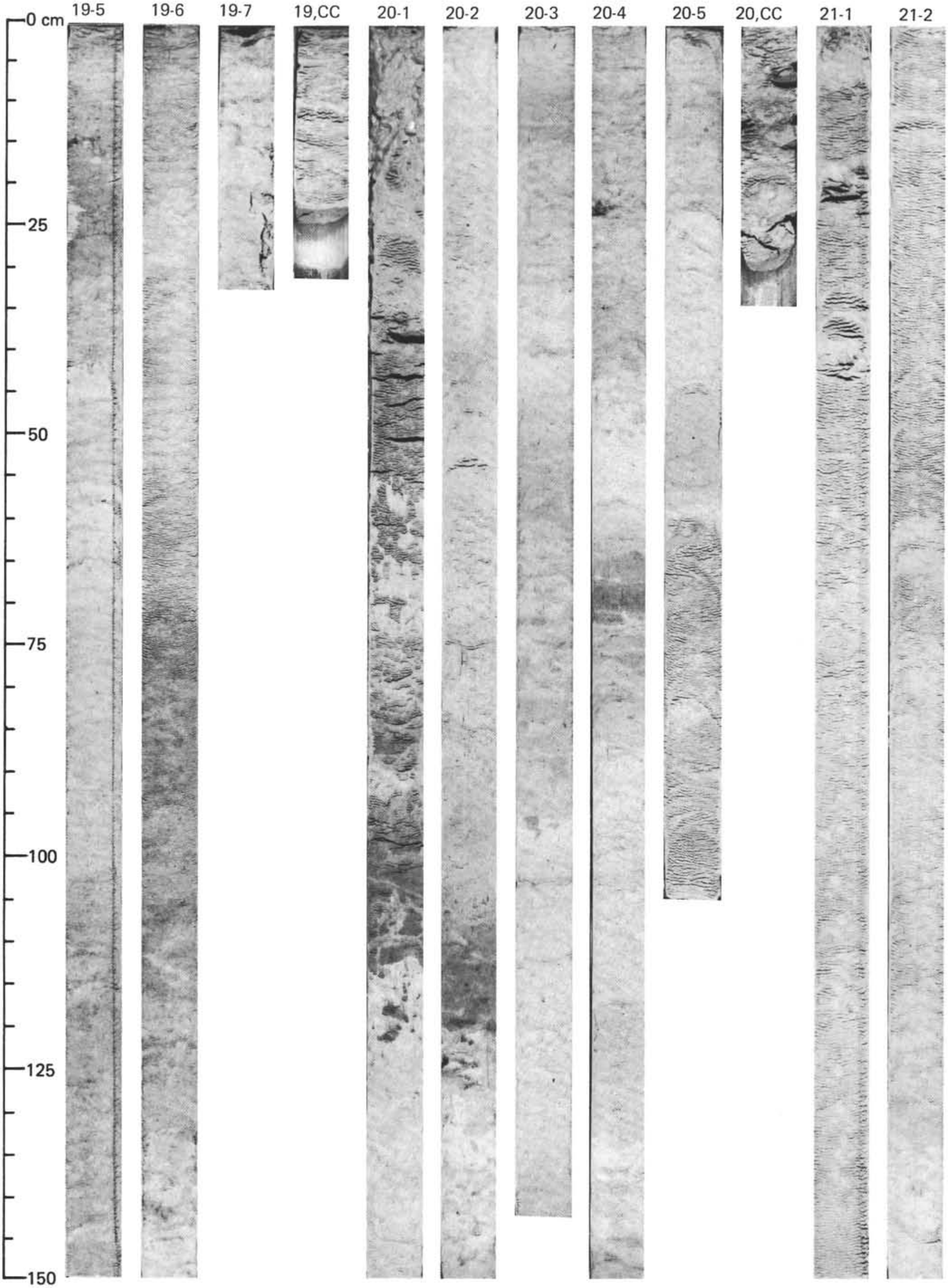
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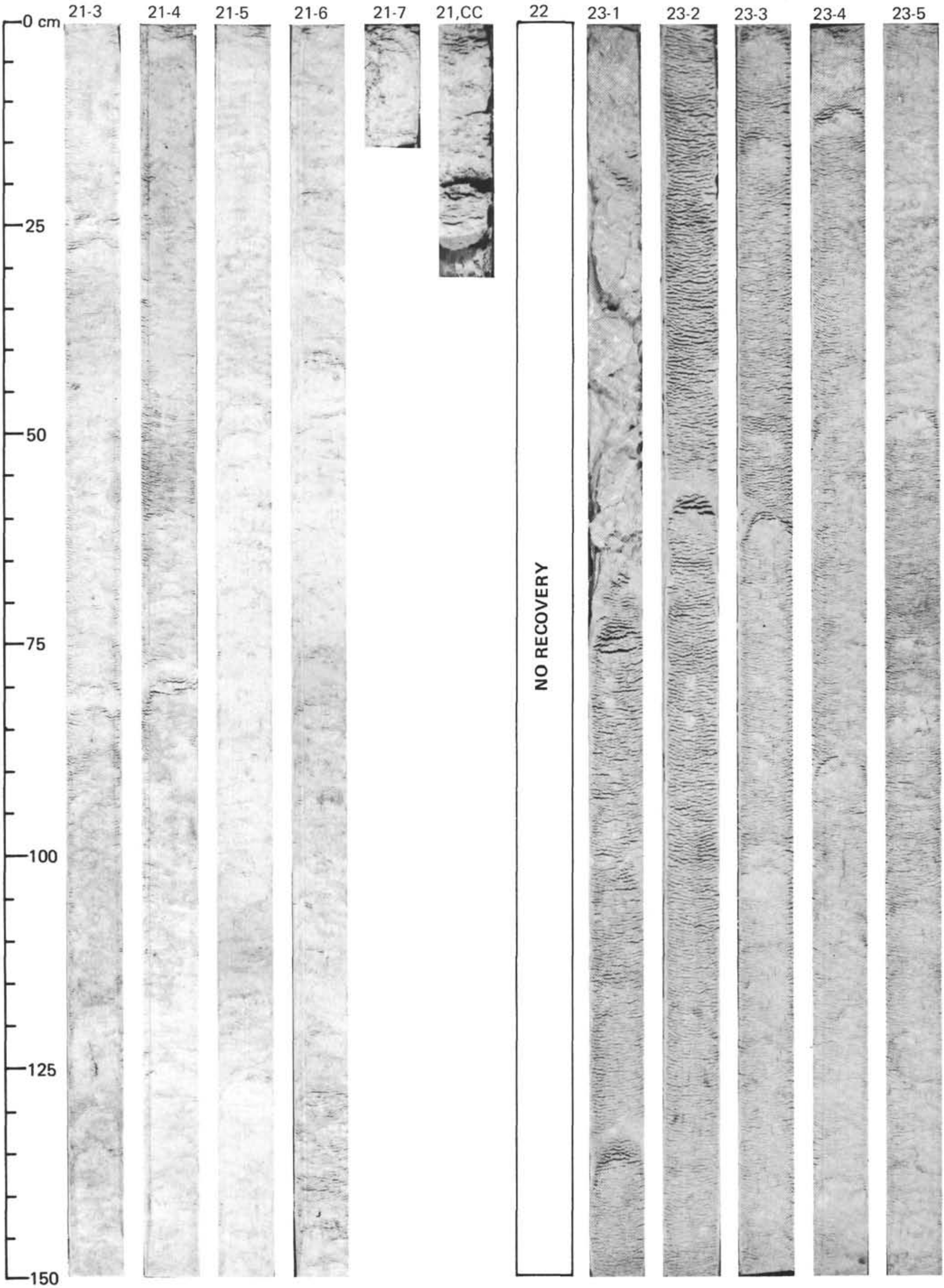
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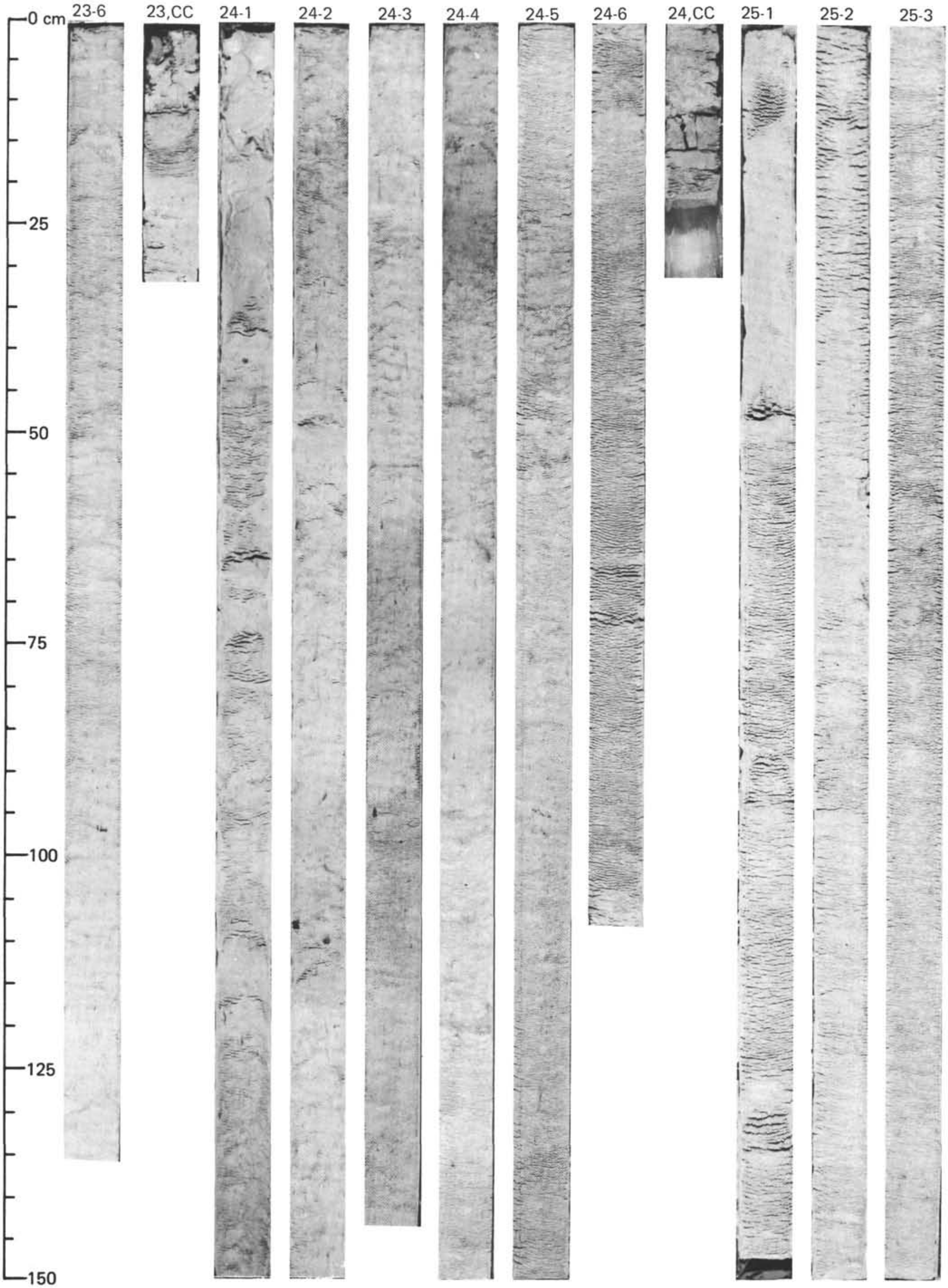
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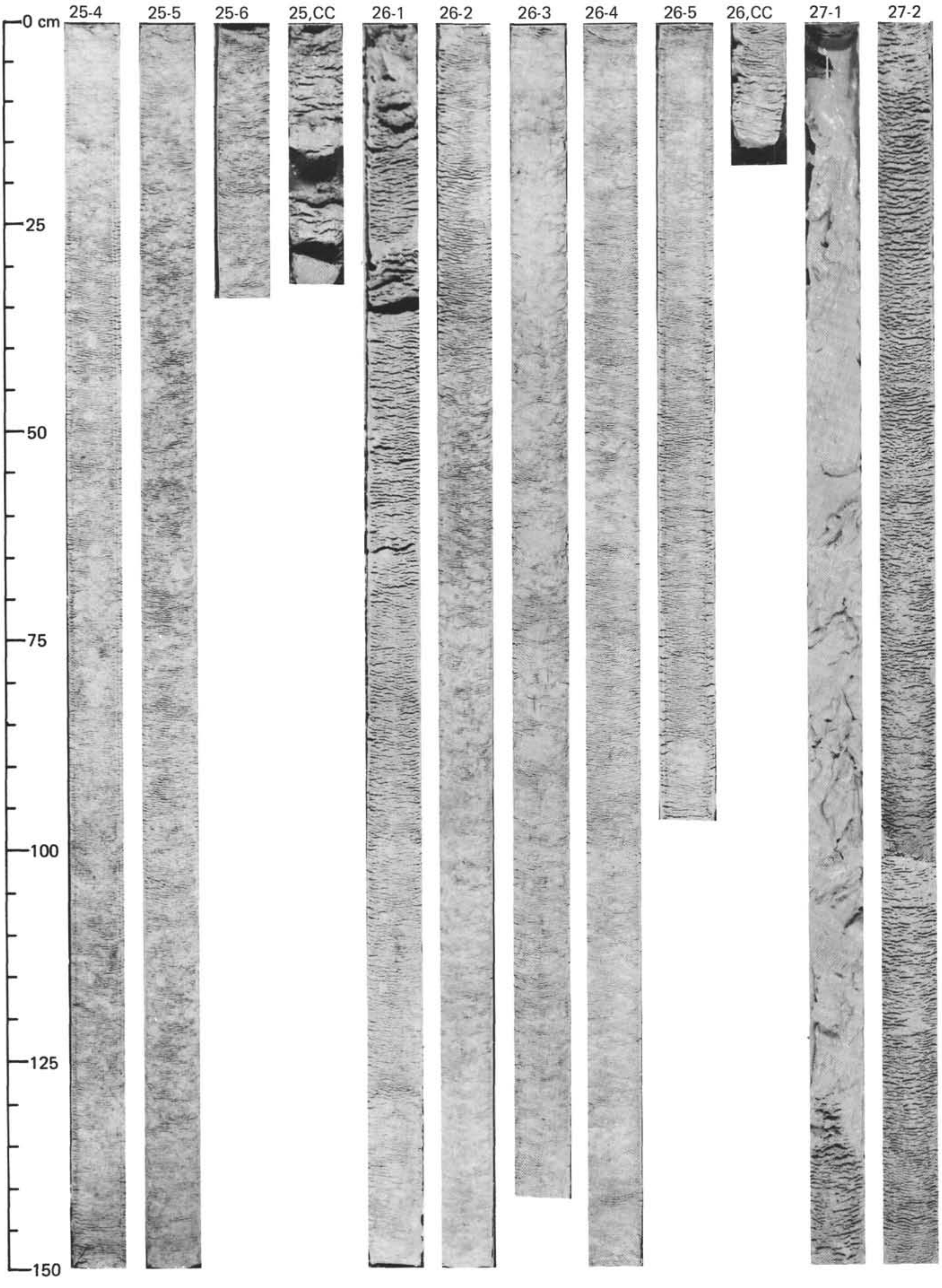
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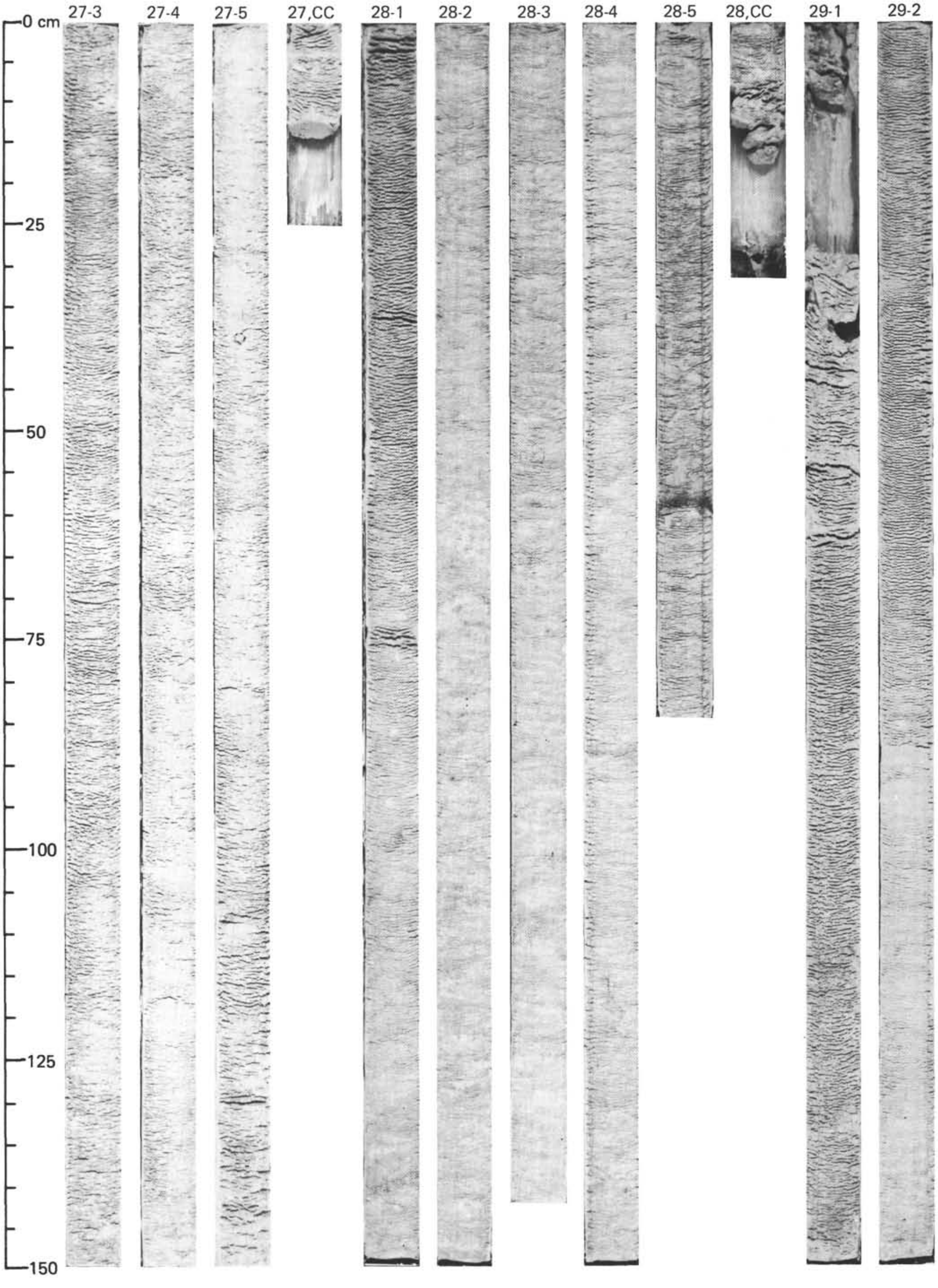
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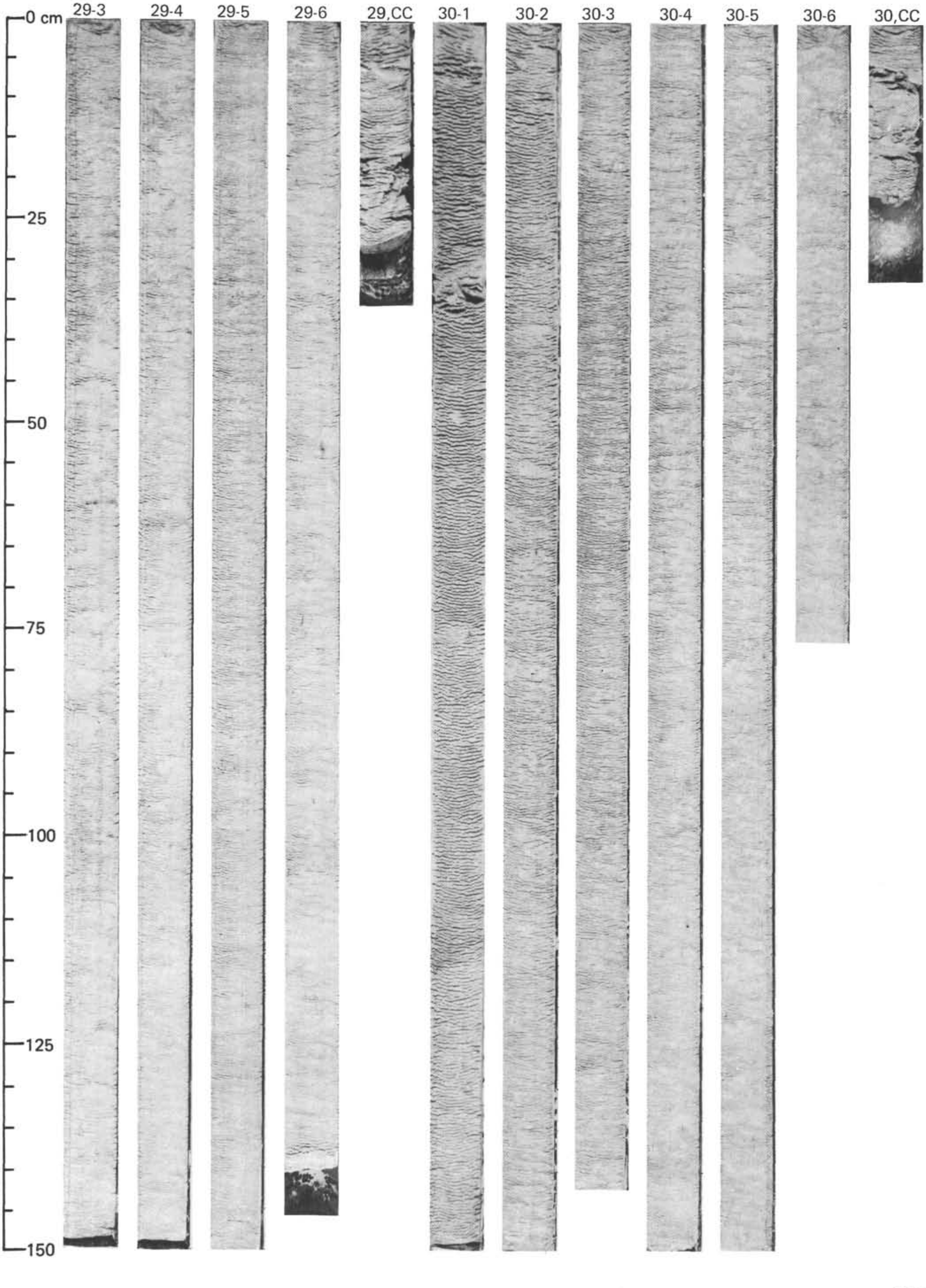
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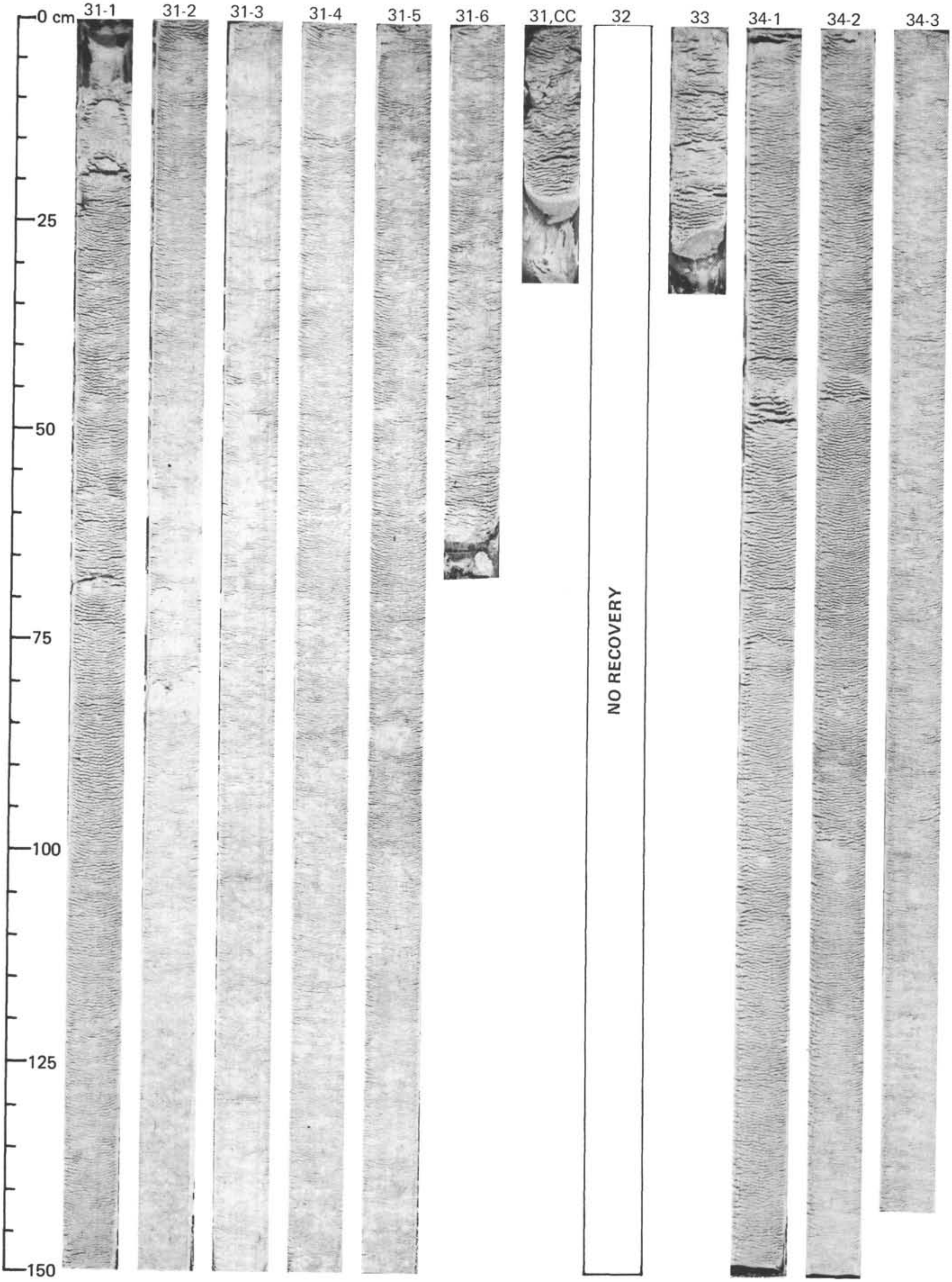
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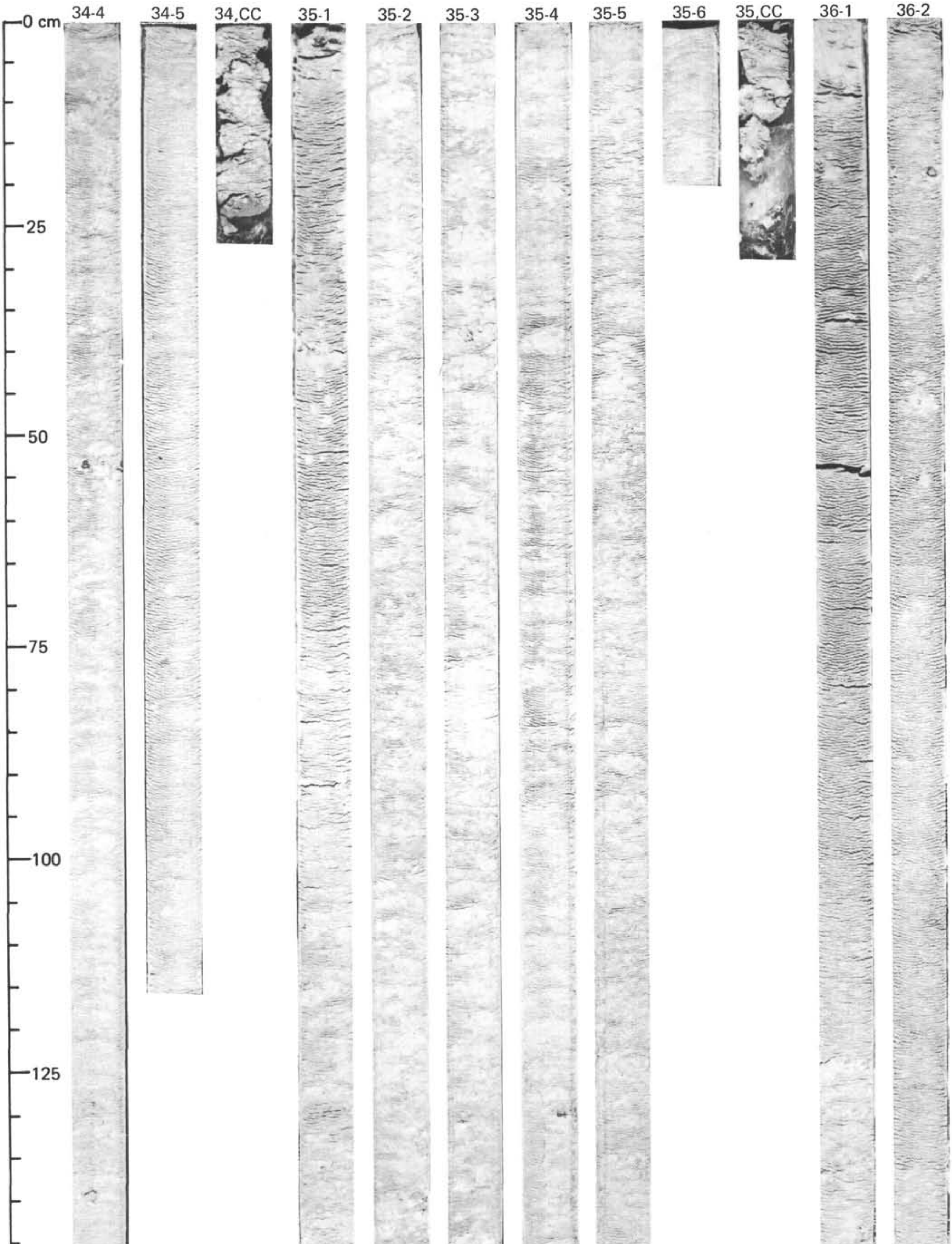
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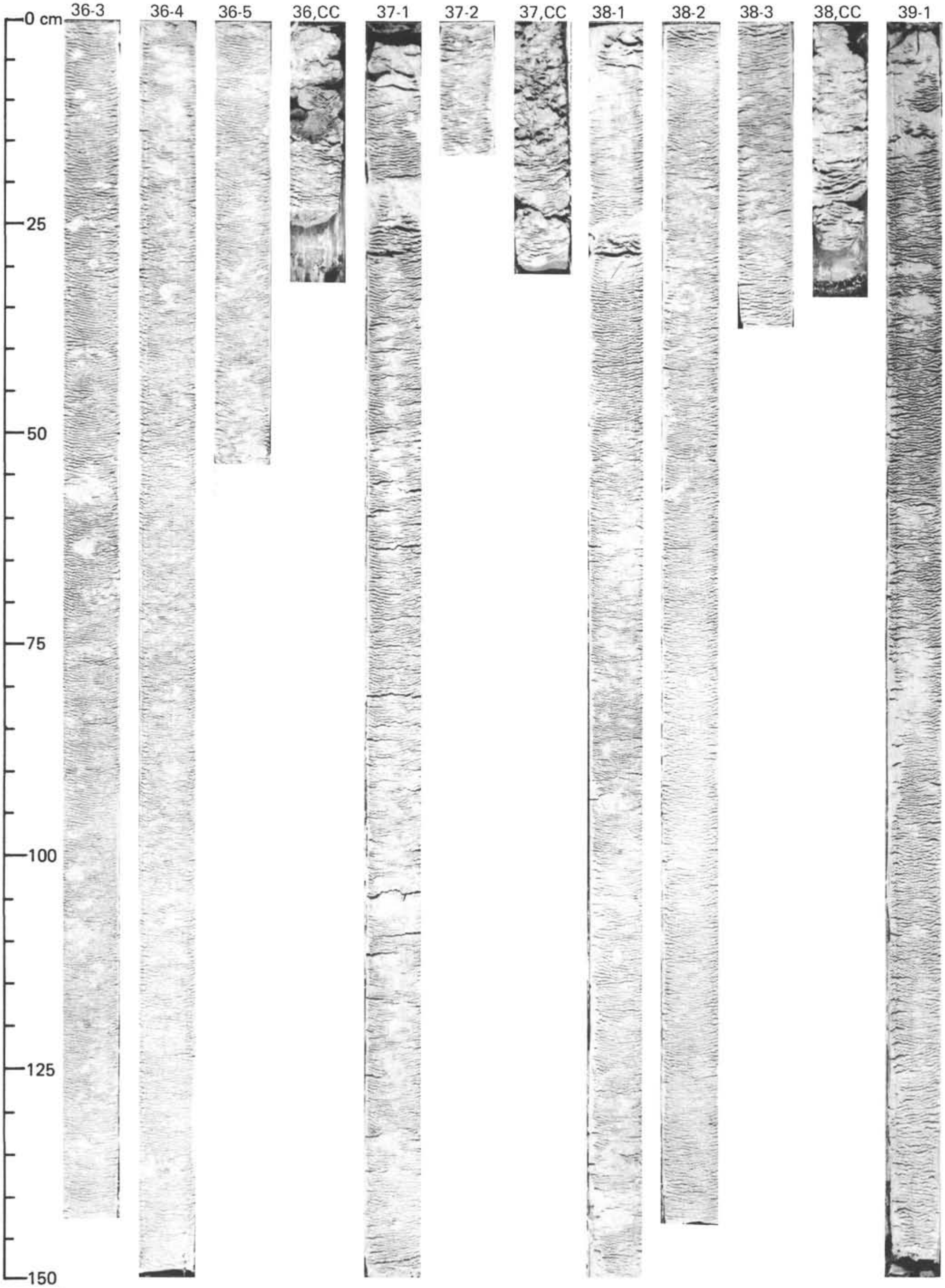
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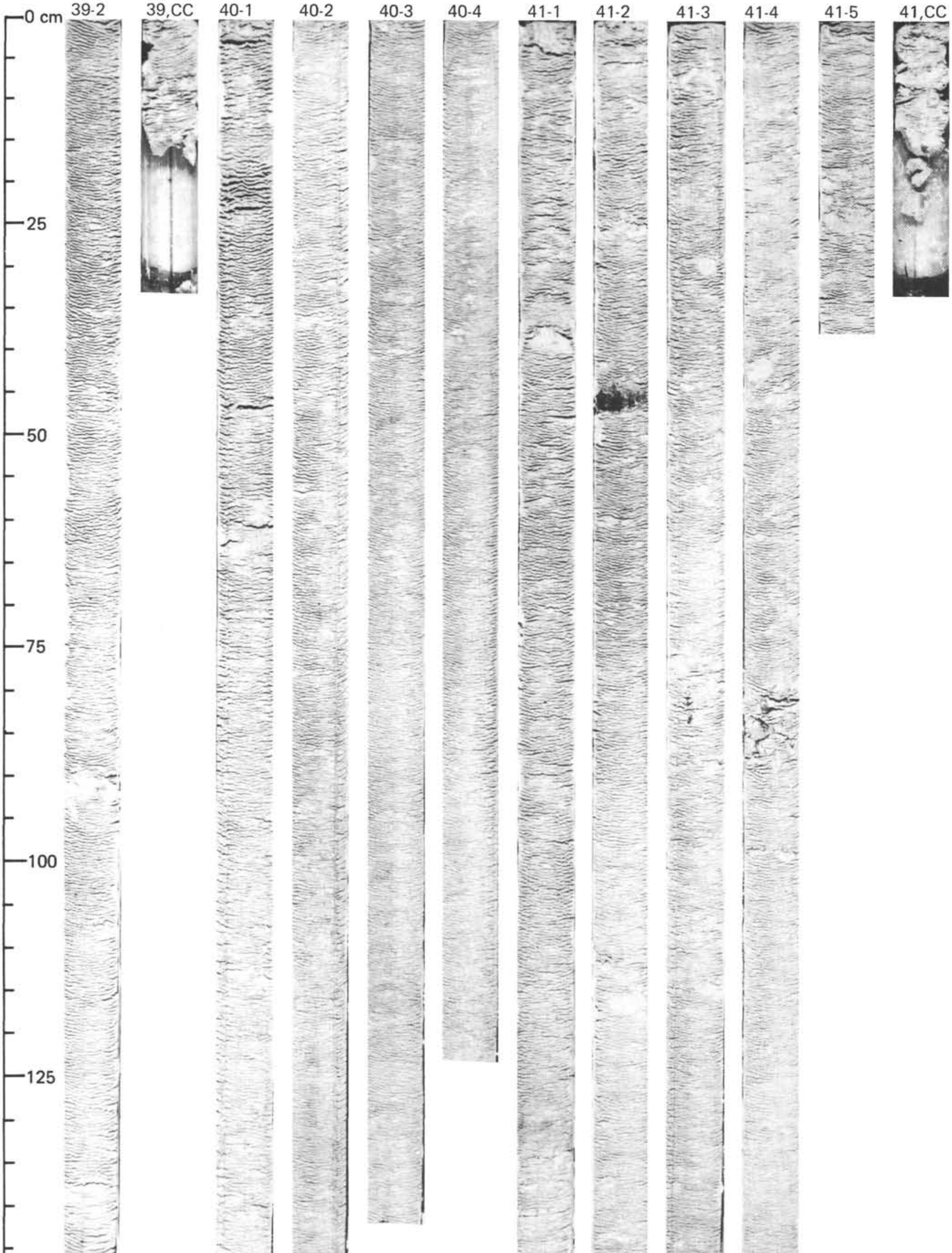
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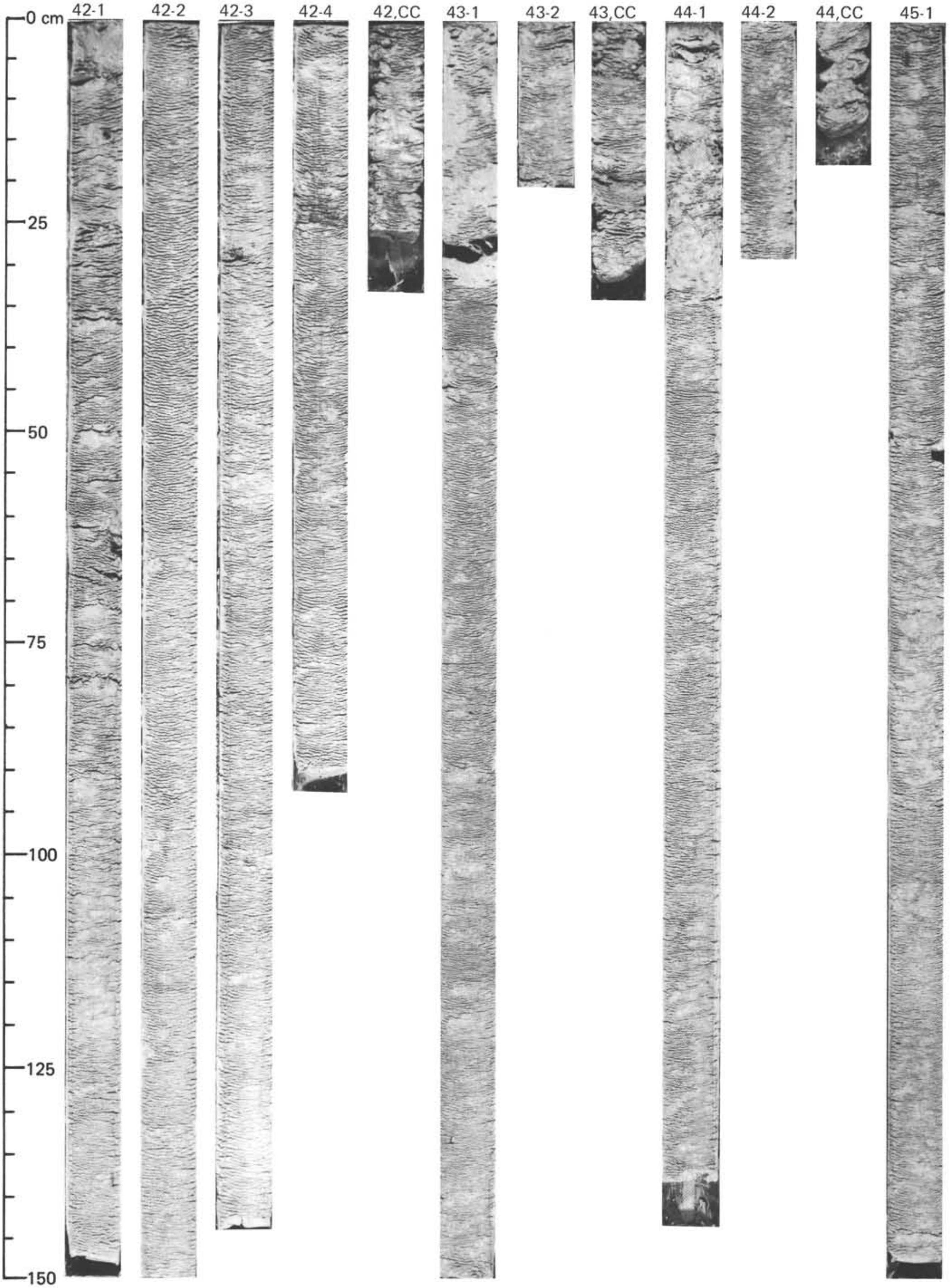
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44-1
44-2
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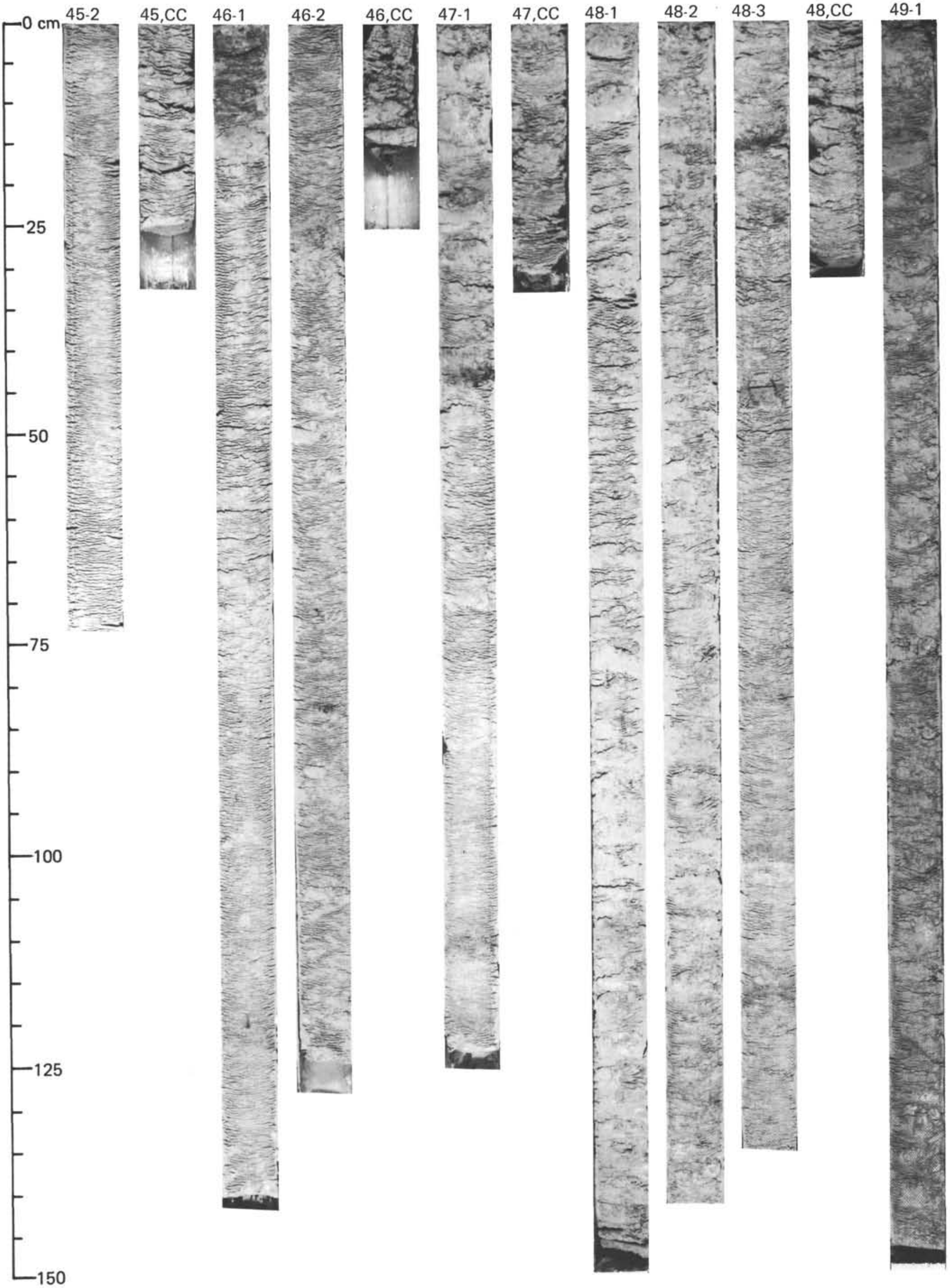
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48-2
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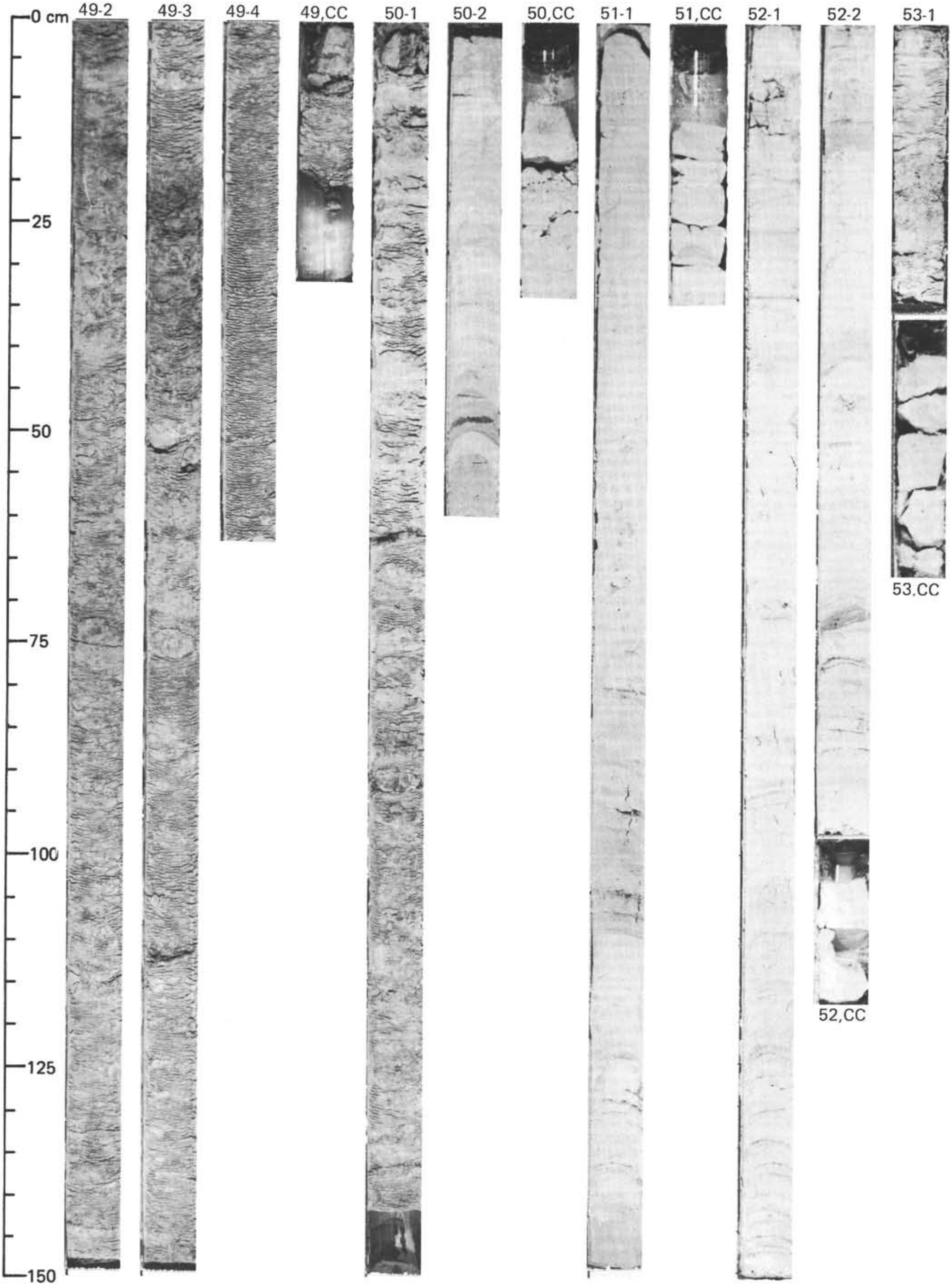
49-1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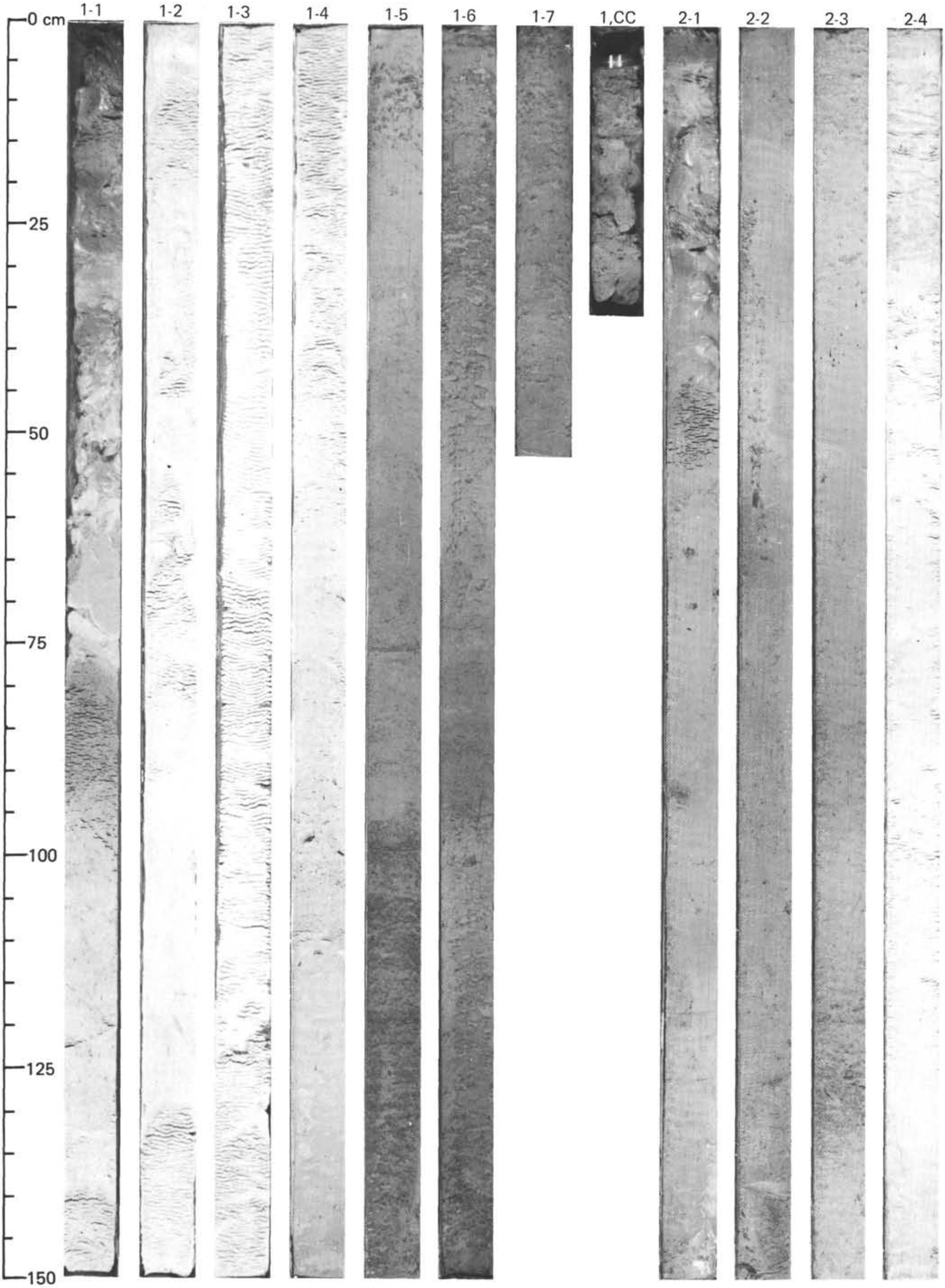
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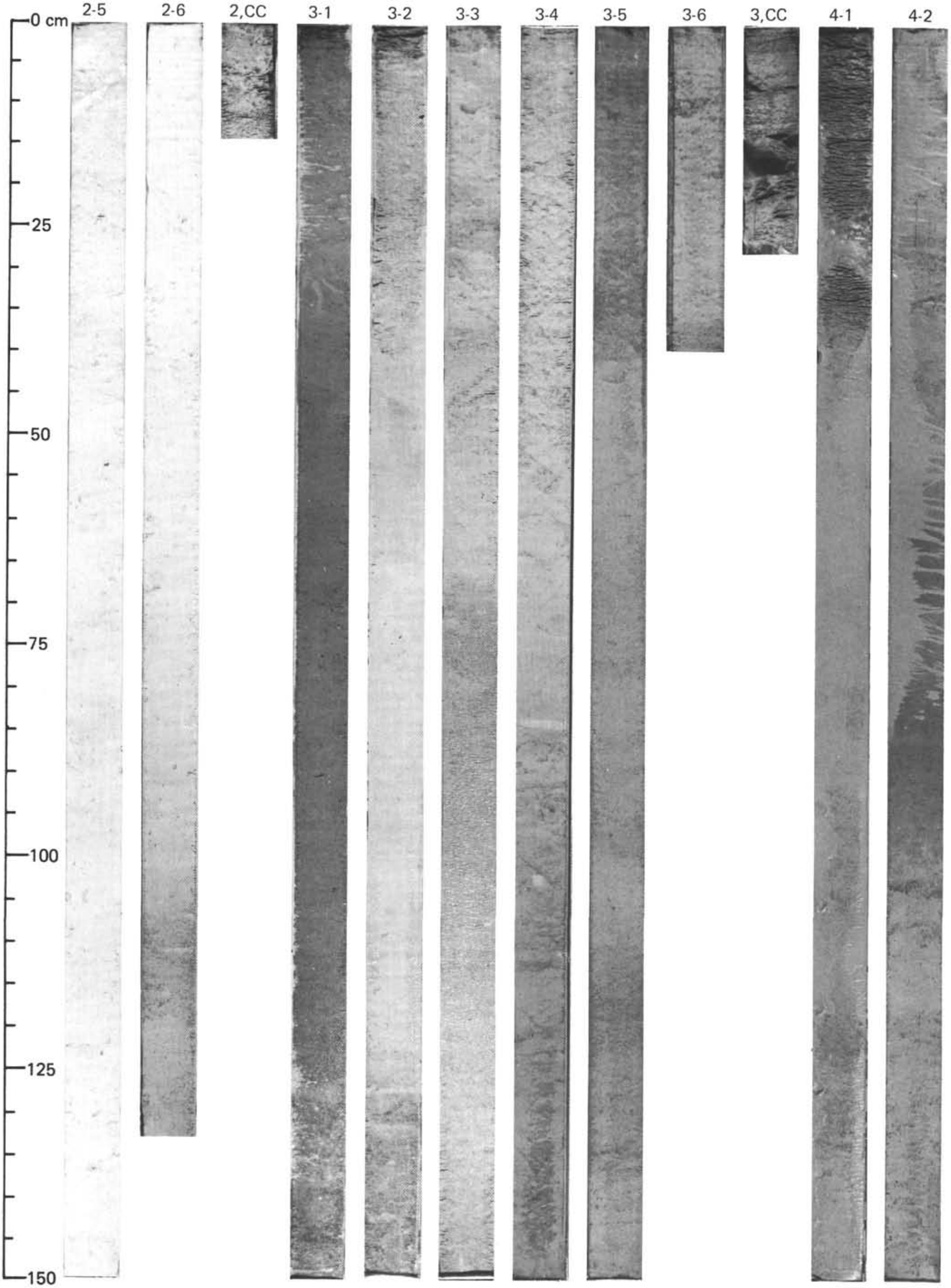
2-3
2-4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4-2
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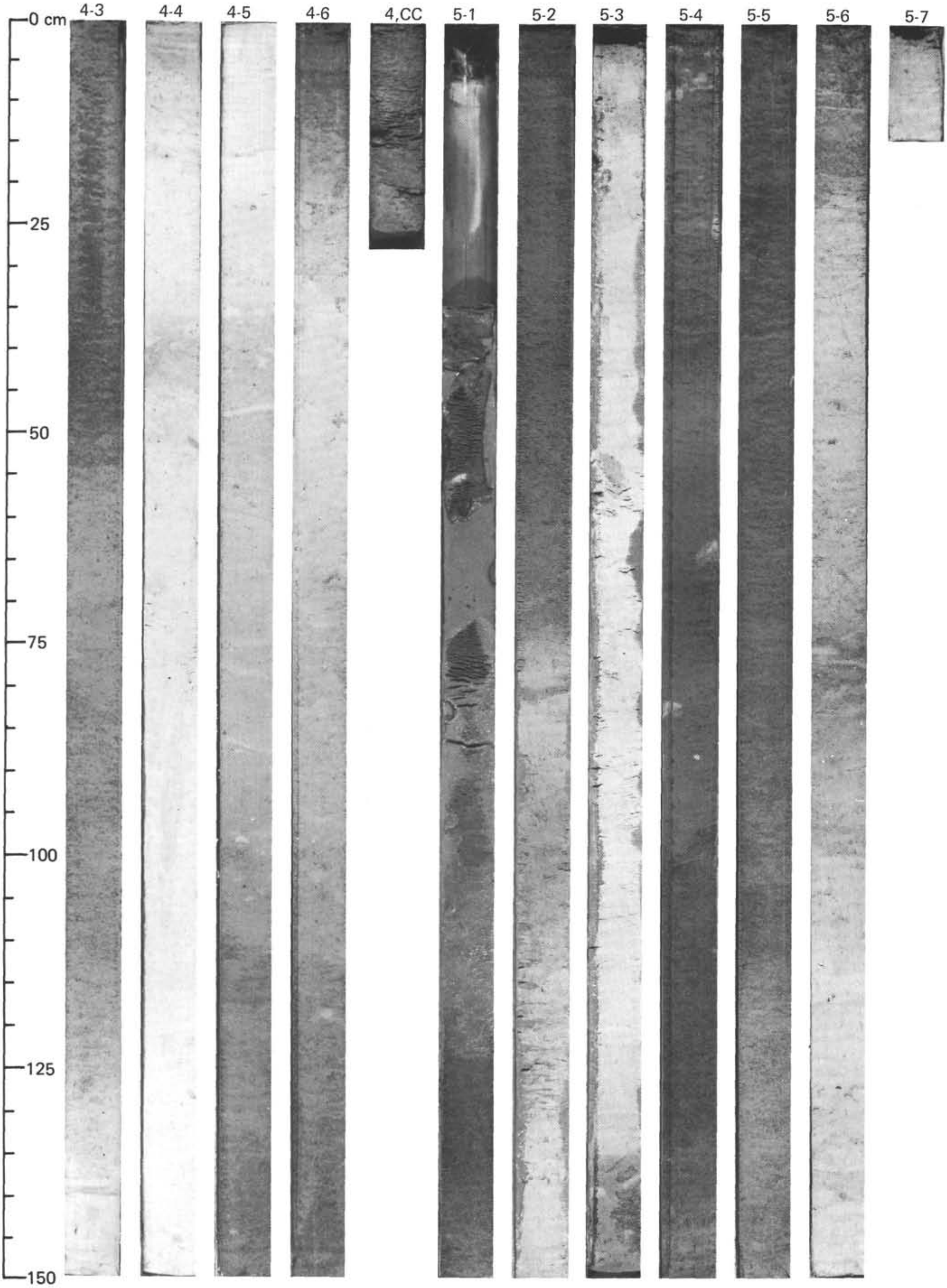
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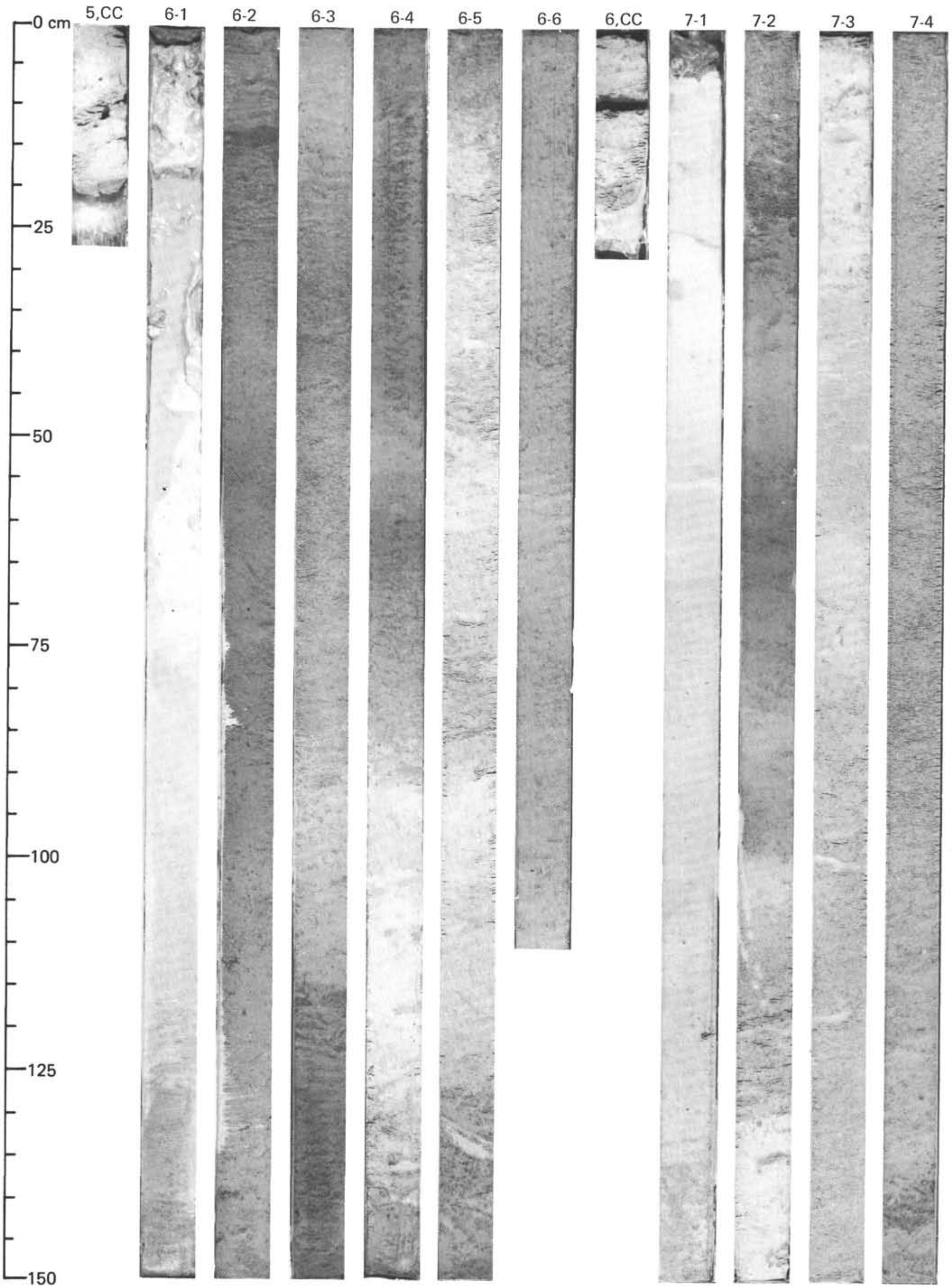
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6,CC
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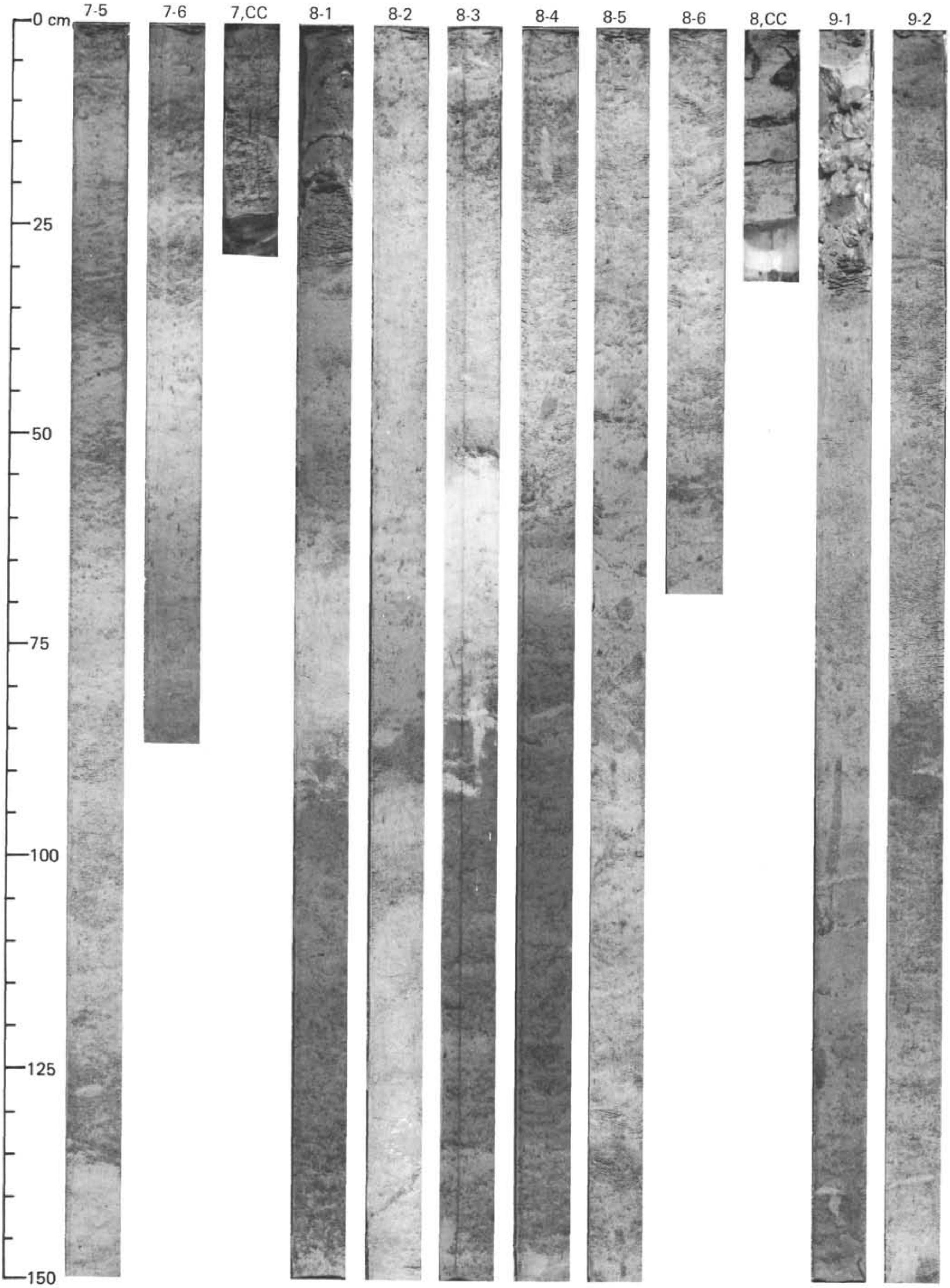
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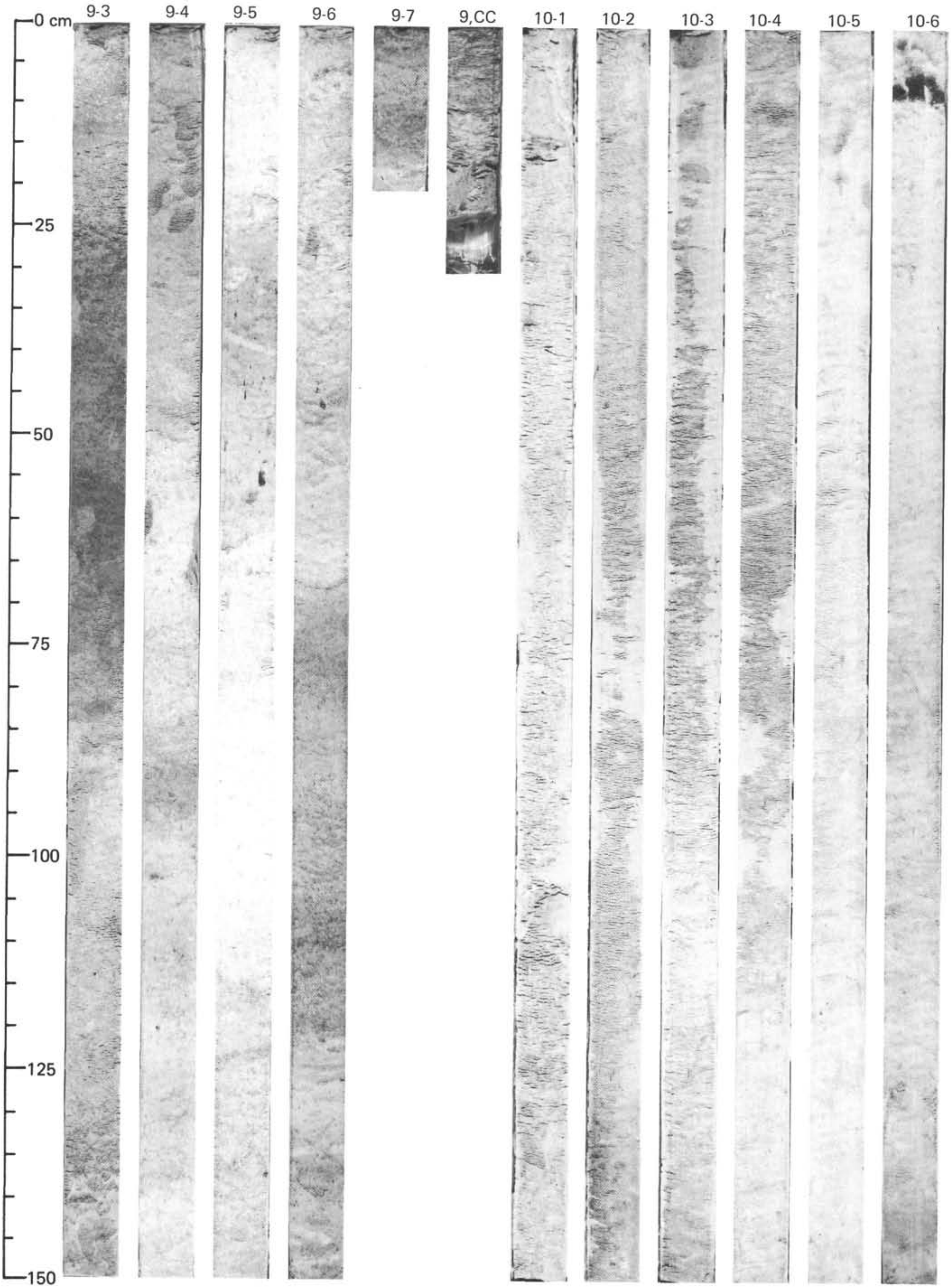
9-2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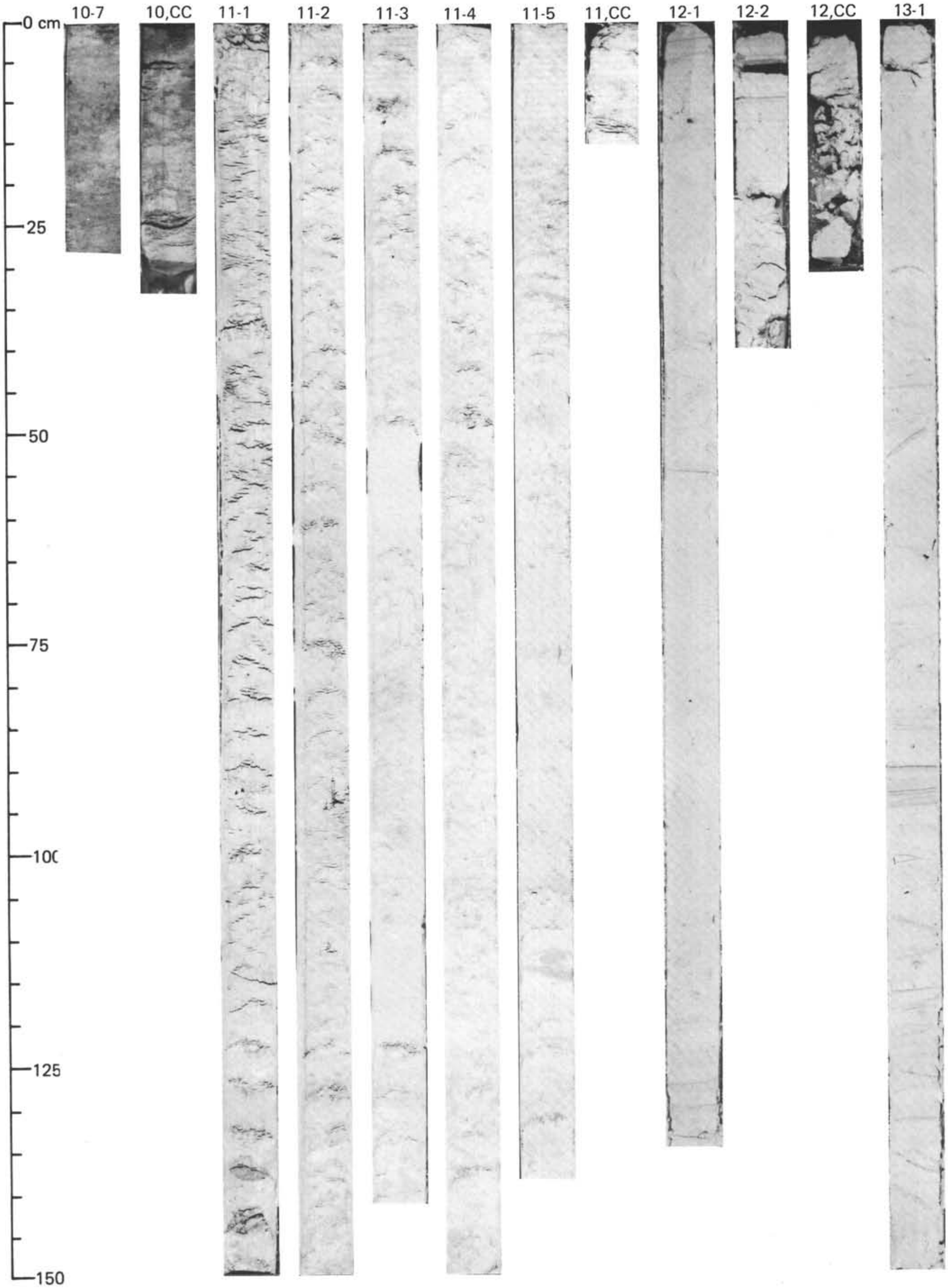
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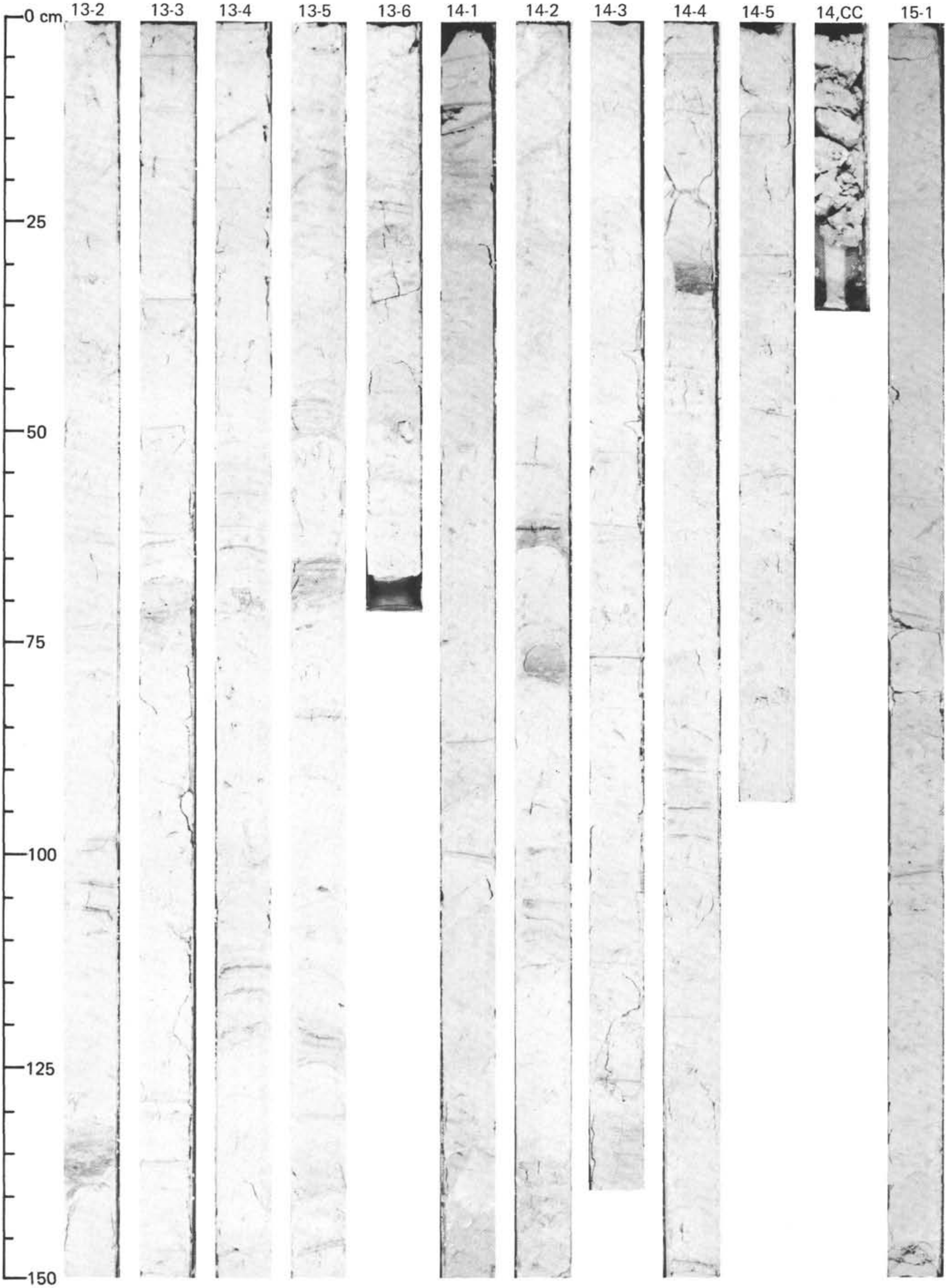
11,CC
12-1
12-2
12,CC
13-1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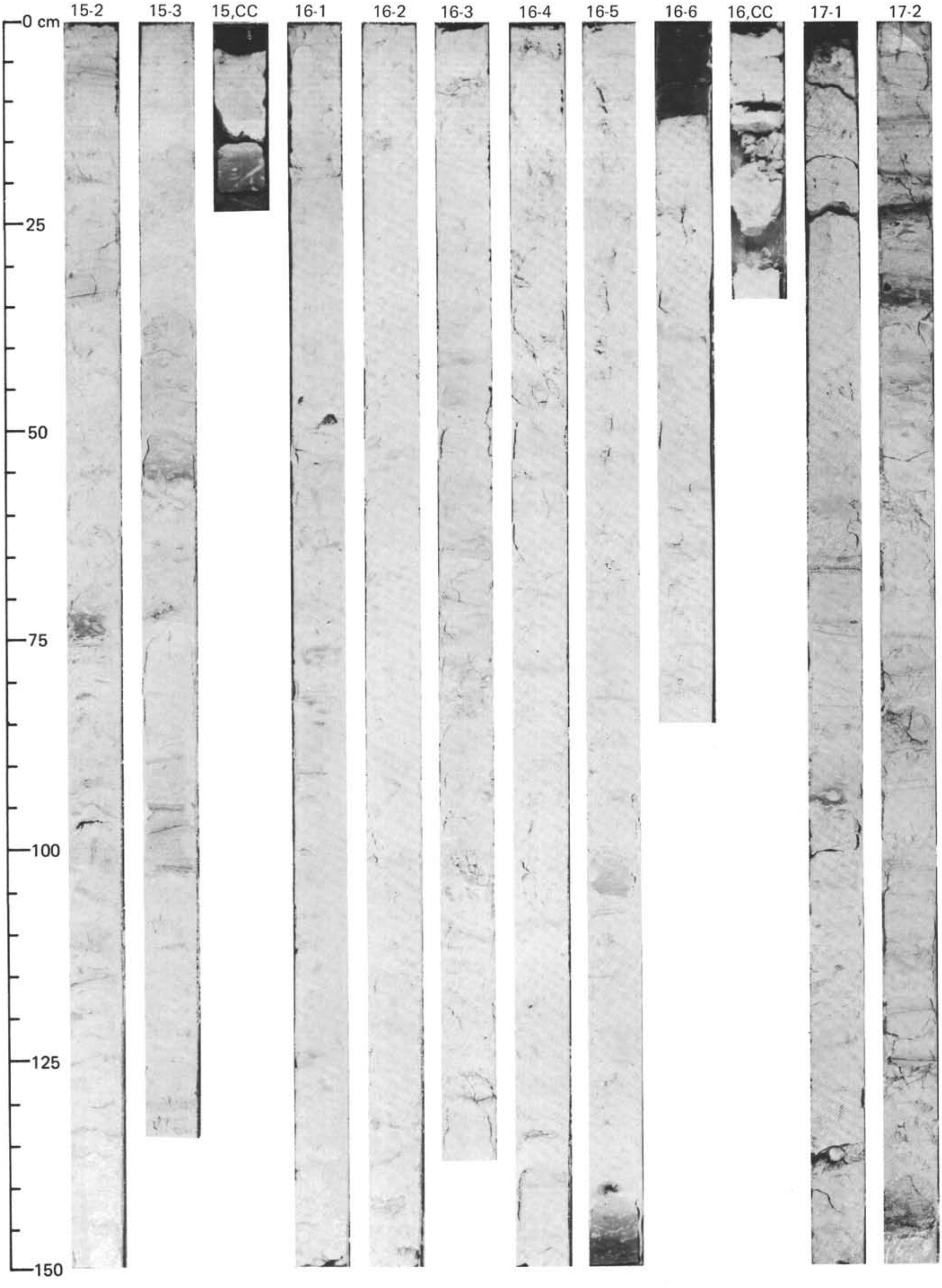
15-2
15-3
15,CC
16-1
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16-3
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16-5
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16,CC
17-1
17-2
0 cm
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0 cm
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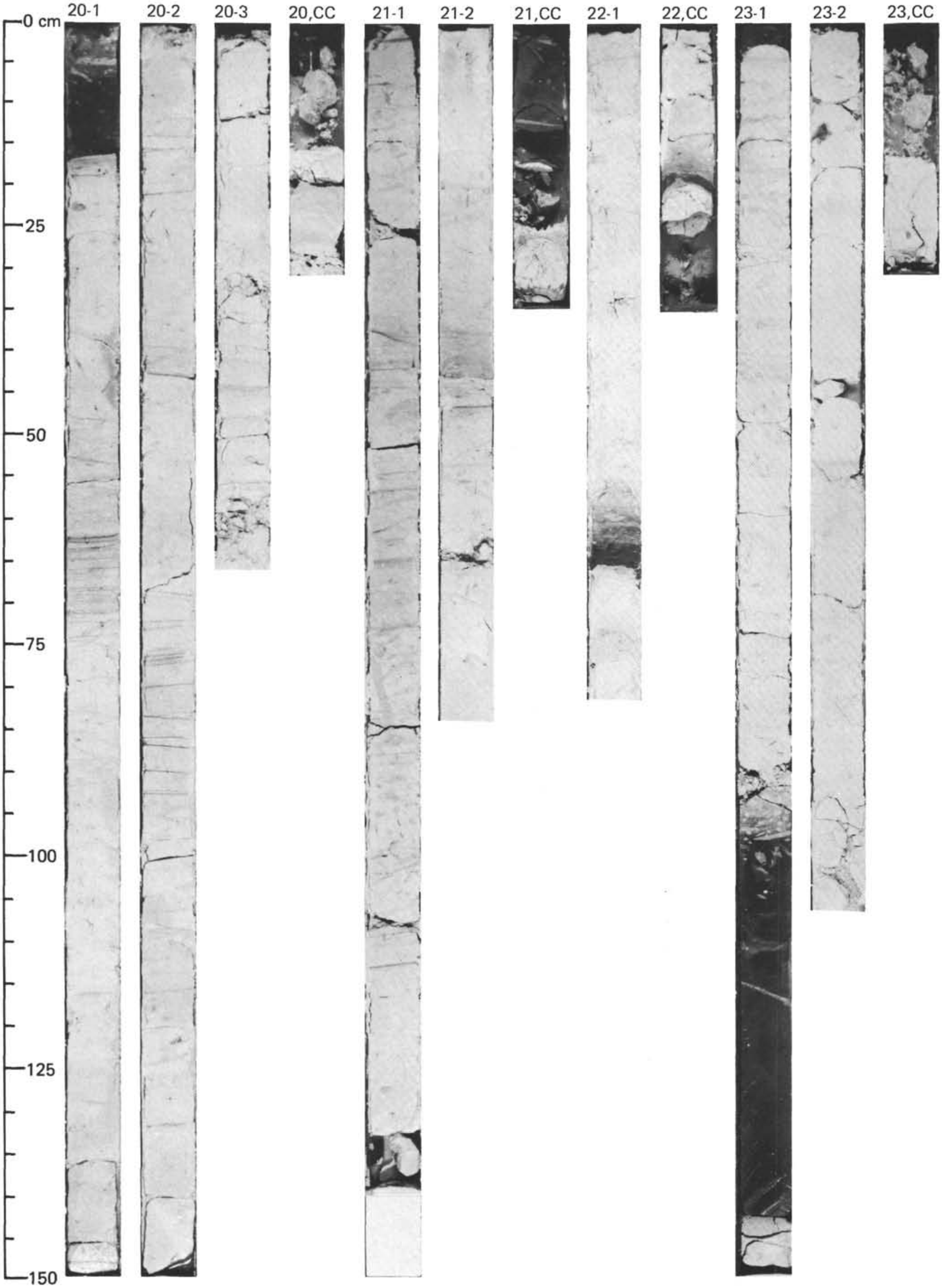
17-3
17-4
17-5
17,CC
18-1
18-2
18-3
18-4
18,CC
19-1
19-2
19,CC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20-3
20,CC
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22-1
22,CC
23-1
23-2
23,CC
0 cm
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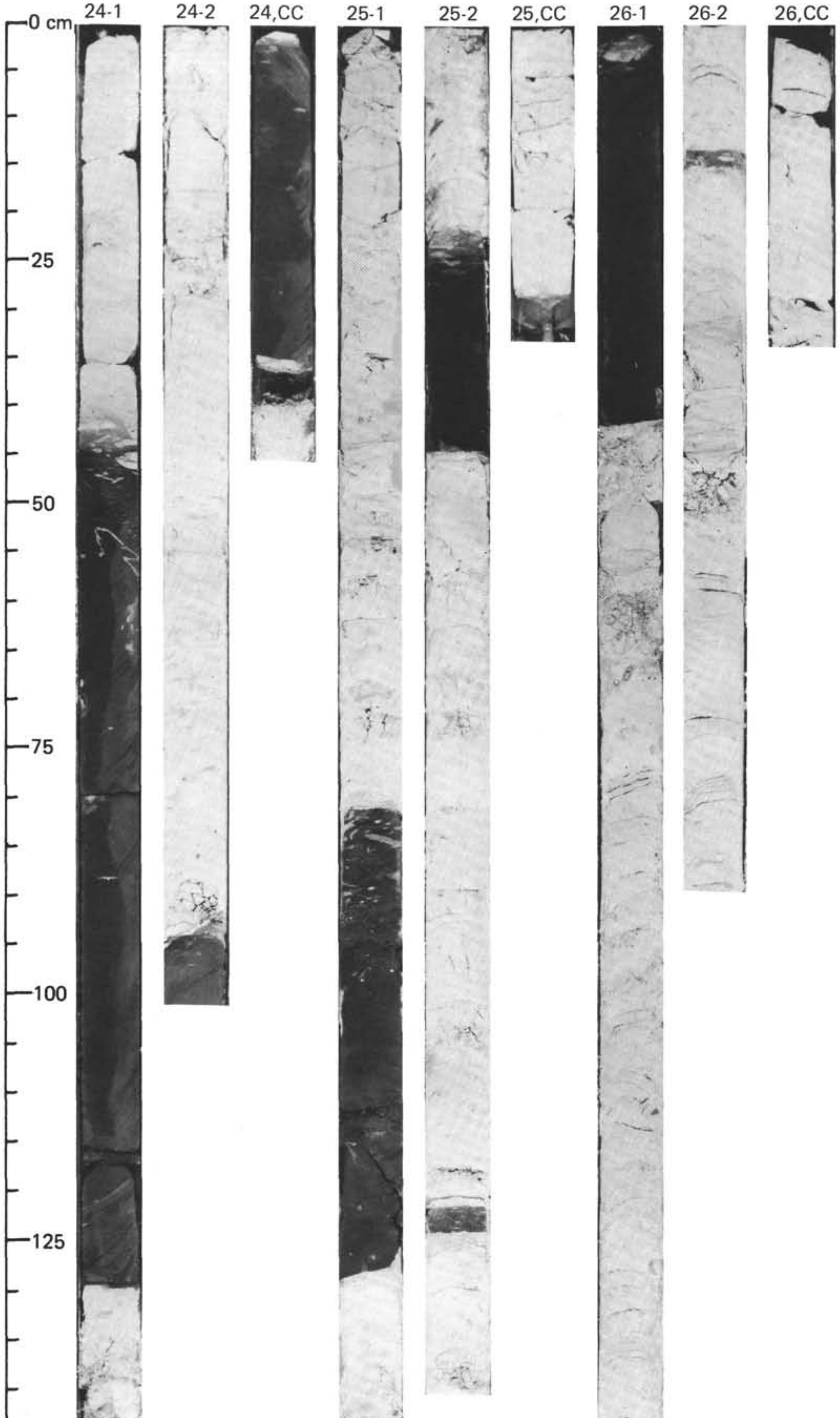
0 cm
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25-2
25,CC
26-1
26-2
26,CC