5. SITE 516: RIO GRANDE RISE[1]

Shipboard Scientific Party[2]

HOLES 516 TO 516F

Date occupied: 10 March 1980

Date departed: 29 March 1980

Time on site: 19 days, 1.7 hr.

Number of holes: 7 (The table below includes data *only* on the holes with core recovery; see Operations section for discussion of Holes 516C, 516D, and 516E.)

Position: 30°16.59′S, 35°17.10′W

Water depth (sea level; corrected m, echo-sounding): 1313.0

Water depth (rig floor; corrected m, echo-sounding): 1323.0

Bottom felt (m, drill pipe): 1327.9

	516	516A	516B	516F
Penetration (m):	183.3	69.5	23.2	1270.6
Number of cores:	44	16	1	128
Total length of cored section (m):	183.3	69.5	7.6	1101.5
Total core recovered (m):	148.7	61.10	4.52	691.72
Core recovery (%):	81	88	59	63

Oldest sediment cored:
Depth sub-bottom (m): 1250
Nature: Calcarenite
Age: Coniacian
Measured velocity (km/s): 3.5 to 4.5

Basement:
Depth sub-bottom (m): 1252.6
Nature: Basalt
Velocity range (km/s): 3.8 to 5.3

Principal results: Hydraulic piston core (HPC) objectives were successfully completed at Site 516 on the upper flanks of the Rio Grande Rise. HPC Holes 516 and 516A penetrated to 183 m sub-bottom, with 85% core recovery and duplication of the uppermost 70 m of the section. Holes 516B, 516C, 516D, and 516E were drilled for instrument development tests and heat flow measurements, and would have continued as rotary holes except for weather and bit loss problems. Rotary drilling at Hole 516F continued to 1270.6 m sub-bottom and recovered a virtually complete sedimentary sequence down to basal sediments of Coniacian age (approximately 82 Ma).

The stratigraphic succession is almost entirely calcareous, and virtually complete from the Recent to the basal sequence of Coniacian age. The lithologic section is continuous across the Cretaceous/Tertiary, Paleocene/Eocene, and Eocene/Oligocene boundaries. The Paleocene sequence is remarkably complete. Shipboard paleomagnetic measurements on more than 500 samples indicate sharp polarity transitions down to Anomaly 33/34. The excellent paleomagnetic and biostratigraphic continuity qualify Site 516 as an appropriate stratigraphic reference section for the South Atlantic, comparable in quality to the Gubbio section, but spanning a longer time interval. Measurements of sediment physical properties, including P-wave velocities, were made on more than 400 samples. These allow a detailed comparison between the extensive multichannel seismic coverage around the site and the lithostratigraphic succession. The 3.5 kHz precision depth recorder (PDR) provides 70-m sub-bottom penetration, which is of value in interpreting the shallow HPC section. The "midsection dome" reflectors coincide with a zone of middle to late Eocene limestones interbedded with volcanogenic turbidites and ash layers absent elsewhere in the section. The base of Hole 516F includes calcareous volcanogenic sediments, ferruginous chert, and two or more relatively fresh basalt flow units.

BACKGROUND AND OBJECTIVES

Site 516 on the Rio Grande Rise lies in 1313 m of water near 30°16′S, 35°17′W (Fig. 1). Sediment thickness on this part of the Rise varies between about 1100 and 1500 m (1.0 and 1.3 s).

The site is the shoalest of those drilled during Leg 72 and was designed to sample sediments deposited in the upper levels of the southwestern Atlantic water column through the Tertiary and late Cretaceous, whereas other sites (357 at 2109 m, 517 at 2963 m, 518 at 3944 m, and 515 at 4265 m) sampled sediments deposited in deeper water. The HPC samples are the basis for detailed studies of the short-period orbitally induced "Milankovich" effects on sedimentation during the Quaternary and probably into the Miocene (Perch-Nielsen, K. et al., 1977). Among other targets in what was expected to be a fairly continuous carbonate sequence were the Eocene/Oligocene and Cretaceous/Tertiary boundaries. An important objective was an improved understanding of the origin and subsequent subsidence history of the Rio Grande Rise, both as a contribution to the general problem of aseismic ridge development and to provide midwater paleoecologic datum levels in the southwestern Atlantic. This objective was achieved by penetration to crystalline basement.

Placement of a re-entry cone is so time-consuming that other Leg 72 objectives would have been compromised had one been used at Site 516. Therefore, an attempt was made before drilling to find a location where basement was reasonably shallow and to avoid hiatuses recognized in reflection profiles for the shal-

[1] Barker, P. F., Carlson, R. L., Johnson, D. A., et al., *Init. Repts. DSDP*, 72: Washington (U.S. Govt. Printing Office).

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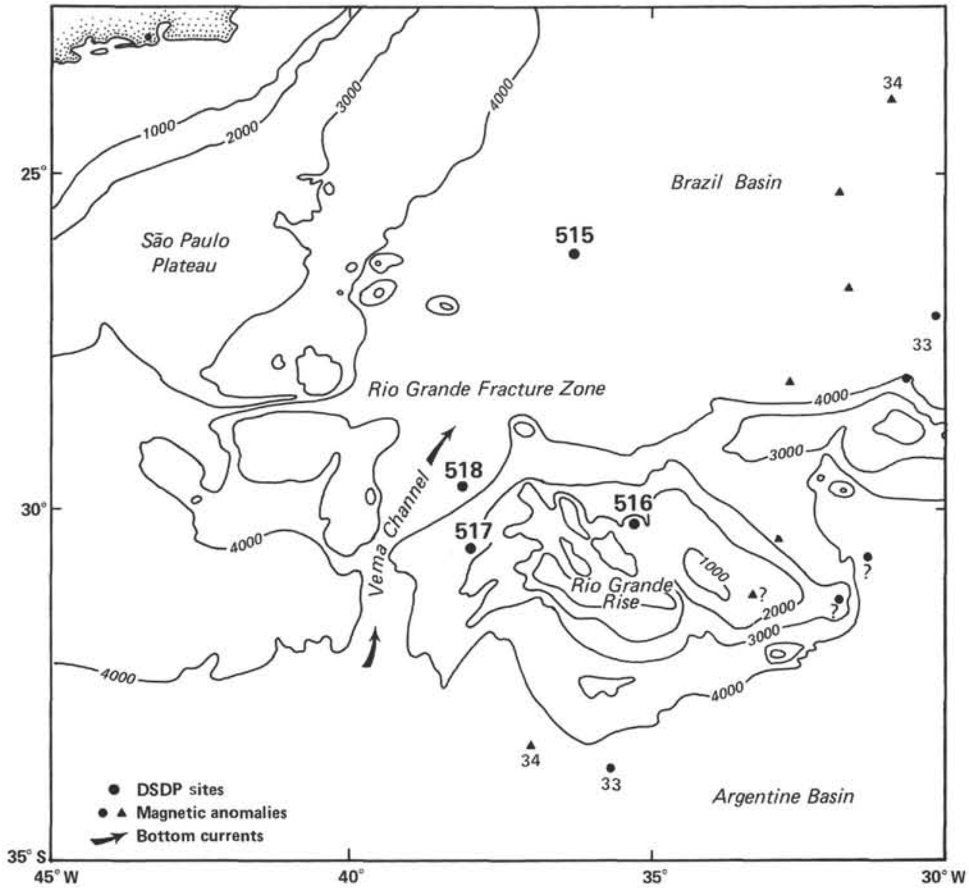


Figure 1. Location map showing positions of Leg 72 sites, marine magnetic anomalies, and generalized bathymetry.

low, HPC part of the section. The mandatory objective of our site survey was, however, to avoid the "midsection dome" reflectors first revealed in University of Texas Marine Science Institute (UTMSI) processed multichannel profiles. Earlier single-channel profiles fostered the belief that these reflectors represented crystalline basement, but at the time of Leg 72 drilling, basement was thought to lie 400–600 m deeper. The nature of these domes was uncertain before Hole 516F was drilled. Interpretations included such possibilities as: reefs fringing a Late Cretaceous Rio Grande island group, volcaniclastic debris flows from the same source, and even late-stage intrusive bodies. The nature of the well-bedded sediments beneath the domes was also uncertain; the Santonian limestones found beneath 700 m at Site 357 were the obvious candidate, because volcanic basement could not be much older even if it formed at the ridge crest. Volcaniclastic debris flows and ash layers were other possibilities. Site 357 lies about 800 m deeper than Site 516, so that processes related to sea level, such as reef formation, should have occurred later at Site 516.

OPERATIONS

We approached the vicinity of Site 516 on the Rio Grande Rise on the morning of 10 March. At 1112Z we passed near DSDP Site 22, reduced speed and changed course to 175°, beginning the required presite survey.

We first steamed south along a line some distance to the east of UTMSI multichannel line WSA13 for 30 miles, then crossed it and headed northward (354°) for 16 miles before selecting a site location on a small basement high. We then altered course to 160° and dropped the beacon at 1848Z. By 2035Z we were on site at 30°16.59′S, 35°17.11′W, in 1313 m of water (Fig. 2).

Our strategy for Site 516 was to use the HPC to the limit of its capability in the first hole, then pull to the mudline and repeat the upper part of the section in anticipation of heavy demand for samples. Hole 516 was cored to a depth of 183.3 m below the mudline, where HPC coring was terminated at the top of a stiff chalk zone at 1500Z on 12 March. Forty-four HPC cores were taken in Hole 516, and 148.7 m (81%) of sediment were recovered (Table 1). Hole 516A was spudded at 1716Z on 12 March and cored using the HPC to a depth of 69.5 m, of which 61.10 m (88%) were recovered. HPC operations were terminated at 0530Z on 13 March.

The hydraulic piston corer worked very well, but the upper 50 cm or so of each core were badly disturbed, probably because the bit was washed down to the top of the cored interval. Physical properties measurements in-

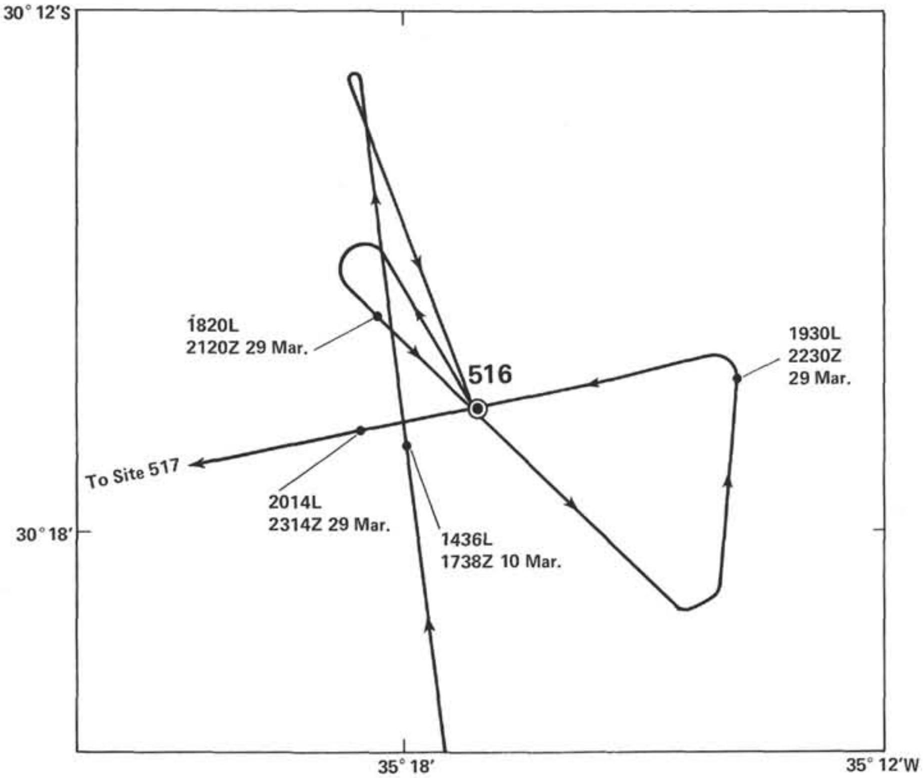


Figure 2. Approach and departure, Site 516.

dicate slight to moderate disturbance throughout. The dominant lithology in the upper part of the section at Site 516 is an unconsolidated foraminifer sand, and its coarse grain-size aggravates the degree of disturbance.

Upon completion of Holes 516 and 516A, the drill string was pulled to the rig floor and we prepared to test the pressurized core barrel. Hole 516B was used to conduct a bit motion experiment. The hole was spudded at 1813Z on 13 March and terminated at 1830Z. The hole was washed to a depth of 15.6 m, and one 7.6-m core was cut during the test; 4.52 m of core were recovered.

Hole 516C, spudded at 1947Z on 13 March, was used to test the pressurized core barrel (PCB). The hole was washed to 14.1 m and a 6.5-m core was cut. The PCB came up empty and had not held pressure. The bit was pulled clear of the mudline at 2042Z and pulled to the rig floor at 0030Z, 14 March. This complete round trip for the purpose of testing the PCB was necessary because it was proved at Site 515 that the PCB was not compatible with the hydraulic bit release.

By 0030Z on 14 March, the weather had deteriorated, and operations were suspended until 1012Z on 14 March because of high winds. Because our plan was to reach basement at an estimated depth of about 1100 m without benefit of re-entry, an F93CK bit was selected for rotary coring. A hydraulic bit release was included in the bottom-hole assembly in anticipation of logging the hole.

Hole 516D was spudded at 1532Z and washed to a depth of 90.1 m sub-bottom. We were unable to retrieve the wash core, and a second core barrel was dropped. Upon recovery, at 1900Z, the second core barrel contained about 1 m of sediment, which indicated that we had accidentally dropped the bit. The bit release probably shifted partially when it was greased, and it subsequently failed. The drill string was pulled to the surface by 2242Z on 14 March, thereby terminating Hole 516D.

Having lost our only 93 bit, we rigged an F94CK bit for Hole 516E. The 94 bit is designed for hard formations and has substantially shorter teeth than does the 93. Hole 516E was spudded at 0418Z on 15 March and drilled to 90.1 m sub-bottom. Between 0508Z and 0704Z on 15 March, we made a temperature measurement at 93.1 m sub-bottom, and then drilled to a depth of 128.1 m and made a second temperature measurement between 0757Z and 0924Z. The temperature probe worked fairly well on each run, but proved to be slightly out of time (slow) in each case and apparently skipped several registers on the second run. No data were lost.

After the second temperature measurement, the combination of wind and swell was such that we could not stay on site and operate safely. The bit was therefore pulled clear of the mudline at 1307Z on 15 March, and the remainder of the drill string was pulled by 2300Z, ending Hole 516E. The wind and sea did not moderate sufficiently for safe operations until 2306Z on 16 March, at which time we were again on site and running in the hole.

Hole 516F was spudded at 0314Z on 17 March and washed to 169.1 m sub-bottom, where another temperature measurement was made. After this measurement was completed at 0714Z, we began continuous coring operations. At 2108Z on 28 March, the hole was ter-

Table 1. Coring summary, Site 516.

Core	Date (March 1980)	Time	Depth from drill floor (m)	Depth below seafloor (m)	Length cored (m)	Length recovered (m)	Core recovered (%)
Hole 516							
1	10	2314	1327.9–1330.4	0.0–2.5	2.5	2.34	94
2	11	0031	1330.4–1334.8	2.5–6.9	4.4	3.53	80
3	11	0140	1334.8–1339.2	6.9–11.3	4.4	4.64	100+
4	11	0223	1339.2–1343.6	11.3–15.7	4.4	4.41	100+
5	11	0335	1343.6–1348.0	15.7–20.1	4.4	4.60	100+
6	11	0435	1348.0–1352.4	20.1–24.5	4.4	4.62	100+
7	11	0530	1352.4–1356.8	24.5–28.9	4.4	4.49	100+
8	11	0610	1356.8–1361.2	28.9–33.3	4.4	4.60	100+
9	11	0655	1361.2–1365.6	33.3–37.7	4.4	4.45	100+
10	11	0740	1365.6–1370.0	37.7–42.1	4.4	4.11	93
11	11	0834	1370.0–1374.4	42.1–46.5	4.4	4.13	94
12	11	0918	1374.4–1378.8	46.5–50.9	4.4	4.57	100+
13	11	1006	1378.8–1383.2	50.9–55.3	4.4	3.93	89
14	11	1045	1383.2–1387.6	55.3–59.7	4.4	4.44	100+
15	11	1125	1387.6–1392.0	59.7–64.1	4.4	2.81	64
16	11	1300	1392.0–1396.4	64.1–68.5	4.4	2.91	66
17	11	1335	1396.4–1400.8	68.5–72.9	4.4	4.65	100+
18	11	1424	1400.8–1405.2	72.9–77.3	4.4	2.59	59
19	11	1507	1405.2–1409.6	77.3–81.7	4.4	0.00	0
20	11	1554	1409.6–1414.0	81.7–86.1	4.4	4.30	98
21	11	1632	1414.0–1418.4	86.1–90.5	4.4	4.06	92
22	11	1714	1418.4–1422.8	90.5–94.9	4.4	3.34	76
23	11	1800	1422.8–1427.2	94.9–99.3	4.4	0.00	0
24	11	2146	1427.2–1431.6	99.3–103.7	4.4	4.67	100+
25	11	2232	1431.6–1436.0	103.7–108.1	4.4	2.78	63
26	11	2315	1436.0–1440.4	108.1–112.5	4.4	4.18	95
27	11	2403	1440.4–1444.8	112.5–116.9	4.4	4.42	100+
28	11	2438	1444.8–1449.2	116.9–121.3	4.4	4.54	100+
29	11	2522	1449.2–1453.6	121.3–125.7	4.4	4.47	100+
30	12	0202	1453.6–1458.0	125.7–130.1	4.4	3.84	87
31	12	0303	1458.0–1462.4	130.1–134.5	4.4	0.00	0
32	12	0358	1462.4–1466.8	134.5–138.9	4.4	4.39	100
33	12	0450	1466.8–1471.2	138.9–143.3	4.4	3.37	77
34	12	0530	1471.2–1475.6	143.3–147.7	4.4	4.07	93
35	12	0703	1475.6–1480.0	147.7–152.1	4.4	4.32	98
36	12	0830	1480.0–1484.4	152.1–156.5	4.4	2.37	54
37	12	0920	1484.4–1488.8	156.5–160.9	4.4	2.69	61
38	12	1010	1488.8–1493.2	160.9–165.3	4.4	2.89	66
39	12	1053	1493.2–1497.2	165.3–169.3	4.0	3.66	92
40	12	1150	1497.2–1501.2	169.3–173.3	4.0	4.05	100+
41	12	1233	1501.2–1505.2	173.3–177.3	4.0	0.00	0
42	12	1324	1505.2–1508.7	177.3–180.8	3.5	3.17	91
43	12	1410	1508.7–1510.2	180.8–182.3	1.5	0.62	41
44	12	1458	1510.2–1511.2	182.3–183.3	1.0	0.05	5
					183.3	148.07	81
Hole 516A							
1	12	1727	1327.9–1331.4	0.0–3.5	3.5	3.80	100+
2	12	1807	1331.4–1335.8	3.5–7.9	4.4	4.22	96
3	12	1852	1335.8–1340.2	7.9–12.3	4.4	3.62	82
4	12	2012	1340.2–1344.6	12.3–16.7	4.4	4.25	97
5	12	2109	1344.6–1349.0	16.7–21.1	4.4	4.30	98
6	12	2150	1349.0–1353.4	21.1–25.5	4.4	4.51	100+
7	12	2235	1353.4–1357.8	25.5–29.9	4.4	4.26	97
8	12	2315	1357.8–1362.2	29.9–34.3	4.4	4.35	99
9	13	0000	1362.2–1366.6	34.3–38.7	4.4	4.60	100+
10	13	0044	1366.6–1371.0	38.7–43.1	4.4	4.56	100+
11	13	0124	1371.0–1375.4	43.1–47.5	4.4	3.93	89
12	13	0211	1375.4–1379.8	47.5–51.9	4.4	4.66	100+
13	13	0250	1379.8–1384.2	51.9–56.3	4.4	3.96	90
14	13	0335	1384.2–1388.6	56.3–60.7	4.4	4.54	100+
15	13	0417	1388.6–1393.0	60.7–65.1	4.4	0.00	0
16	13	0509	1393.0–1397.4	65.1–69.5	4.4	1.54	35
					69.5	61.10	88
Hole 516B							
Washed	13		1327.9–1343.5	0.0–15.6			
1	13	1919	1343.5–1351.1	15.6–23.2	7.6	4.52	59
					7.6	4.52	59
Hole 516C							
Washed	13		1327.9–1342.0	0.0–14.1			
1	13	2126	1342.0–1348.5	14.1–20.6	6.5	0.00	0
					6.5	0.00	0
Hole 516D							
Washed	14		1327.9–1418.0	0.0–90.1			
Hole 516E							
Washed	15		1327.9–1418.0	0.0–90.1			
Hole 516F							
Washed	17		1327.9–1497.0	0.0–169.1			
1	17	0805	1497.0–1506.5	169.1–178.6	9.5	3.02	32
2	17	0910	1506.5–1516.0	178.6–188.1	9.5	9.65	100+
3	17	1015	1516.0–1525.5	188.1–197.6	9.5	9.78	100+
4	17	1135	1525.5–1535.0	197.6–207.1	9.5	9.49	100
5	17	1245	1535.0–1544.5	207.1–216.6	9.5	9.84	100+
6	17	1336	1544.5–1554.0	216.6–226.1	9.5	2.24	24
7	17	1419	1554.0–1563.5	226.1–235.6	9.5	4.51	47
8	17	1543	1563.5–1573.0	235.6–245.1	9.5	9.80	100+
9	17	1717	1573.0–1582.5	245.1–254.6	9.5	6.30	66
10	17	1854	1582.5–1592.0	254.6–264.1	9.5	4.79	50

Table 1. (Continued).

Core	Date (March 1980)	Time	Depth from drill floor (m)	Depth below seafloor (m)	Length cored (m)	Length recovered (m)	Core recovered (%)
Hole 516F Cont.							
11	17	1943	1592.0–1601.5	264.1–273.6	9.5	5.72	60
12	17	2038	1601.5–1611.0	273.6–283.1	9.5	1.55	16
13	17	2130	1611.0–1620.5	283.1–292.6	9.5	4.72	50
14	17	2231	1620.5–1630.0	292.6–302.1	9.5	0.16	2
15	17	2329	1630.0–1639.5	302.1–311.6	9.5	9.62	100+
16	18	0020	1639.5–1649.0	311.6–321.1	9.5	0.40	4
17	18	0108	1649.0–1658.5	321.1–330.6	9.5	3.31	35
18	18	0203	1658.5–1668.0	330.6–340.1	9.5	1.45	15
19	18	0314	1668.0–1677.5	340.1–349.6	9.5	5.06	53
20	18	0415	1677.5–1687.0	349.6–359.1	9.5	3.57	38
21	18	0523	1687.0–1696.5	359.1–368.6	9.5	5.70	60
22	18	0624	1696.5–1706.0	368.6–378.1	9.5	2.99	31
23	18	0722	1706.0–1715.5	378.1–387.6	9.5	4.46	47
24	18	0834	1715.5–1725.0	387.6–397.1	9.5	2.35	25
25	18	0937	1725.0–1734.5	397.1–406.6	9.5	6.27	66
26	18	1045	1734.5–1744.0	406.6–416.1	9.5	7.39	78
27	18	1324	1744.0–1753.5	416.1–425.6	9.5	8.80	93
28	18	1430	1753.5–1763.0	425.6–435.1	9.5	3.56	37
29	18	1526	1763.0–1772.5	435.1–444.6	9.5	8.25	87
30	18	1628	1772.5–1782.0	444.6–454.1	9.5	9.48	100
31	18	1722	1782.0–1791.5	454.1–463.6	9.5	7.61	80
32	18	1823	1791.5–1801.0	463.6–473.1	9.5	9.92	100+
33	18	1922	1801.0–1810.5	473.1–482.6	9.5	8.36	88
34	18	2031	1810.5–1820.0	482.6–492.1	9.5	4.12	43
35	18	2125	1820.0–1829.5	492.1–501.6	9.5	5.96	63
36	18	2215	1829.5–1839.0	501.6–511.1	9.5	5.95	63
37	18	2303	1839.0–1848.5	511.1–520.6	9.5	5.01	53
38	19	0010	1848.5–1858.0	520.6–530.1	9.5	1.77	19
39	19	0108	1858.0–1867.5	530.1–539.6	9.5	3.28	35
40	19	0210	1867.5–1877.0	539.6–549.1	9.5	3.21	34
41	19	0319	1877.0–1886.5	549.1–558.6	9.5	1.88	20
42	19	0419	1886.5–1896.0	558.6–568.1	9.5	0.84	9
43	19	0514	1896.0–1905.5	568.1–577.6	9.5	1.68	18
44	19	0614	1905.5–1915.0	577.6–587.1	9.5	0.94	10
45	19	0722	1915.0–1924.5	587.1–596.6	9.5	1.16	12
46	19	0840	1924.5–1934.0	596.6–606.1	9.5	0.53	6
47	19	0948	1934.0–1943.5	606.1–615.6	9.5	1.03	11
48	19	1125	1943.5–1953.0	615.6–625.1	9.5	2.54	27
49	19	1252	1953.0–1962.5	625.1–634.6	9.5	2.60	27
50	19	1445	1962.5–1972.0	634.6–644.1	9.5	2.87	30
51	19	1548	1972.0–1981.5	644.1–653.6	9.5	8.06	85
52	19	1650	1981.5–1991.0	653.6–663.1	9.5	6.42	68
53	19	1820	1991.0–2000.5	663.1–672.6	9.5	6.92	73
54	19	2005	2000.5–2010.0	672.6–682.1	9.5	9.00	95
55	19	2130	2010.0–2019.5	682.1–691.6	9.5	2.24	24
56	20	0110	2019.5–2029.0	691.6–701.1	9.5	9.74	100+
57	20	0257	2029.0–2038.5	701.1–710.6	9.5	0.01	0
58	20	0606	2038.5–2044.5	710.6–716.6	6.0	3.75	63
59	20	0756	2044.5–2048.0	716.6–720.1	3.5	2.36	67
60	20	1013	2048.0–2057.0	720.0–729.1	9.0	9.97	100+
61	20	1245	2057.0–2066.0	729.1–738.1	9.0	7.12	79
62	20	1433	2066.0–2075.0	738.1–747.1	9.0	4.87	54
63	20	1714	2075.0–2084.0	747.1–756.1	9.0	9.06	100+
64	20	1937	2084.0–2093.0	756.1–765.1	9.0	7.84	87
65	20	2219	2093.0–2102.0	765.1–774.1	9.0	2.86	32
66	21	0011	2102.0–2111.0	774.1–783.1	9.0	5.59	62
67	21	0247	2111.0–2114.0	783.1–786.1	3.0	3.21	100+
68	21	0522	2114.0–2120.0	786.1–792.1	6.0	5.01	84
69	21	0807	2120.0–2124.0	792.1–796.1	4.0	3.46	87
70	21	1058	2124.0–2129.0	796.1–801.1	5.0	2.59	52
71	21	1433	2129.0–2138.0	801.1–810.1	9.0	7.18	80
72	21	1803	2138.0–2142.5	810.1–814.6	4.5	5.10	100+
73	21	2127	2142.5–2151.5	814.6–823.6	9.0	7.36	82
74	22	0039	2151.5–2160.5	823.6–832.6	9.0	8.00	89
75	22	0338	2160.5–2169.5	832.6–841.6	9.0	9.68	100+
76	22	0522	2169.5–2178.5	841.6–850.6	9.0	7.76	86
77	22	0745	2178.5–2187.5	850.6–859.6	9.0	7.17	80
78	22	1045	2187.5–2196.5	859.6–868.6	9.0	5.80	64
79	22	1311	2196.5–2205.5	868.6–877.6	9.0	7.01	78
80	22	1441	2205.5–2214.5	877.6–886.6	9.0	4.20	47
81	22	1547	2214.5–2223.5	886.6–895.6	9.0	3.41	38
82	22	1822	2223.5–2228.5	895.6–900.6	5.0	2.87	57
83	22	1950	2228.5–2238.0	900.6–910.1	9.5	8.16	86
84	22	2129	2238.0–2247.5	910.1–919.0	9.5	8.09	85
85	22	2322	2247.5–2257.0	919.6–929.1	9.5	2.32	24
86	23	0108	2257.0–2266.5	929.1–938.6	9.5	9.57	100+
87	23	0300	2266.5–2276.0	938.6–948.1	9.5	9.37	99
88	23	0450	2276.0–2285.5	948.1–957.6	9.5	3.60	38
89	23	0725	2285.5–2295.0	957.6–967.1	9.5	8.78	92
90	23	0915	2295.0–2304.5	967.1–976.6	9.5	8.34	88
91	23	1055	2304.5–2314.0	976.6–986.1	9.5	8.68	91
92	23	1235	2314.0–2323.5	986.1–995.6	9.5	6.26	66
93	23	1517	2323.5–2333.0	995.6–1005.1	9.5	7.84	83
94	23	1816	2333.0–2342.5	1005.1–1014.6	9.5	8.58	90
95	23	2116	2342.5–2351.5	1014.6–1023.6	9.0	7.96	88
96	24	0109	2351.5–2357.5	1023.6–1029.6	6.0	3.68	61
97	24	0307	2357.5–2360.5	1029.6–1032.6	3.0	32.6	100+
98	24	0653	2360.5–2369.5	1032.6–1041.6	9.0	7.10	79
99	24	1010	2369.5–2372.0	1041.6–1044.1	2.5	0.90	36
100	24	1358	2372.0–2378.5	1044.1–1050.6	6.5	6.00	92
101	24	1911	2378.5–2383.5	1050.6–1055.6	5.0	3.60	72
102	24	2324	2383.5–2387.5	1055.6–1059.6	4.0	4.27	100+
103	25	0148	2387.5–2396.5	1059.6–1068.6	9.0	3.97	44
104	25	0630	2396.5–2405.5	1068.6–1077.6	9.0	8.03	89
105	25	1055	2405.5–2414.5	1077.6–1086.6	9.0	9.07	100+
106	25	1405	2414.5–2423.5	1086.6–1095.6	9.0	9.94	100+
107	25	1522	2423.5–2432.5	1095.6–1104.6	9.0	7.73	86
108	25	2033	2432.5–2437.0	1104.6–1109.1	4.5	5.53	100+

Table 1. (Continued).

Core	Date (March 1980)	Time	Depth from drill floor (m)	Depth below seafloor (m)	Length cored (m)	Length recovered (m)	Core recovered (%)
Hole 516F Cont.							
109	25	2244	2437.0–2446.0	1109.1–1118.1	9.0	7.06	78
110	26	0122	2446.0–2455.0	1118.1–1127.1	9.0	9.10	100+
111	26	0422	2455.0–2464.0	1127.1–1136.1	9.0	0.00	0
112	26	0812	2464.0–2473.0	1136.1–1145.1	9.0	8.66	96
113	26	1140	2473.0–2481.0	1145.1–1154.1	9.0	9.53	100+
114	26	1507	2481.0–2490.0	1154.1–1163.1	9.0	8.82	98
115	26	1518	2491.0–2500.0	1163.1–1172.1	9.0	5.90	66
116	26	2017	2500.0–2509.0	1172.1–1181.1	9.0	8.16	91
117	27	0215	2509.0–2518.0	1181.1–1190.1	9.0	8.98	99
118	27	0834	2518.0–2522.5	1190.1–1194.6	4.5	4.01	89
119	27	1409	2522.5–2531.5	1194.6–1203.6	9.0	6.57	73
120	27	1618	2531.5–2540.5	1203.6–1212.6	9.0	2.10	23
121	27	1814	2540.5–2549.5	1212.6–1221.6	9.0	0.68	8
122	27	2007	2549.5–2558.5	1221.6–1230.6	9.0	2.97	33
123	27	2205	2558.5–2567.5	1230.6–1239.6	9.0	0.94	10
124	28	0125	2567.5–2576.5	1239.6–1248.6	9.0	1.39	15
125	28	0421	2576.5–2580.5	1248.6–1252.6	4.0	1.60	40
126	28	0733	2580.5–2585.5	1252.6–1257.6	5.0	4.76	95
127	28	1316	2585.5–2594.5	1257.6–1266.6	9.0	5.75	64
128	28	1808	2594.5–2598.5	1266.6–1270.6	4.0	3.00	75
					1101.5	691.72	63

minated, after continuous coring to a depth of 1270.6 m sub-bottom. Basaltic basement was encountered at a depth of 1256.2 m and penetrated another 18.0 m, at which time the bit had been rotated for an incredible 157.8 hr. Of the 1270.6-m interval cored, we recovered 691.72 m (63%) in 128 cores (Table 1).

We attempted to log the hole on the morning of 29 March, but found it bridged at about 184 m sub-bottom. A wiper run was unsuccessful, and we were forced to abandon the hole.

We left Site 516 at 2050Z on 29 March, heading 330° for approximately two nautical miles before altering course back to the site on heading 135°, crossing the beacon at 2132Z. After maintaining that course for about three miles beyond Site 516, we followed a northerly course (006°) for another three miles in order to obtain a profile linking the site with multichannel line WSA13. At 2230Z on 29 March, we altered course to 260° enroute to Site 517 and crossed the beacon at Site 516 for the last time at 2302Z.

SEDIMENT LITHOLOGY

The drilled section at Site 516 is composed of eight different units distinguishable by the microfossil content, carbonate percentage, minor constituents, degree of induration or diagenesis, and sedimentary structures and colors (Fig. 3). (Depths in parentheses are sub-bottom depths.)

Unit 1: Calcareous Ooze (0–193 m)

Unit 1 is 193 m thick and spans Cores 1 to 44 (Hole 516); Cores 1 to 16 (Hole 516A); and Cores 1 to 4 (Hole 516F). It is Quaternary to early Miocene in age and consists of poorly consolidated calcareous ooze including: foraminiferal ooze (0–15 m sub-bottom, Cores 1 to 4 at Holes 516, 516A); foraminiferal-nannofossil ooze (15–135 m sub-bottom, Cores 5 to 32 at Hole 516; Cores 5 to 16 at Hole 516A); and nannofossil ooze (135–193 m sub-bottom, Cores 33 to 44 at Hole 516; Cores 1 to 3 at Hole 516F).

Principal constituents of Unit 1 are calcareous nannofossils and planktonic foraminifers. Total carbonate (entirely biogenic) averages 90% and exceeds 75% in all but 6 of more than 350 bomb analyses (Fig. 3). Remaining components are terrigenous clay (5–20%); feldspar, quartz, mica, and volcanic glass (rarely exceeding 3% combined); manganese micronodules or pyrite (0–2%); and minor siliceous biogenic debris (0–1%). Benthic foraminifers, pelecypod shells, and pteropods are also present, although in low abundance. The latter two are only occasionally noted.

Colors vary from pale brown in the foraminifer-rich cores, to white in the foraminiferal-nannofossil and nannofossil oozes, and occasionally to shades of light gray. Burrow mottling is ubiquitous, although often faint and barely perceptible. Minor parallel laminations of pale yellow, green, white, and gray occur in Core 21 (Hole 516) and from Core 27 (Hole 516) to the base of the unit. A layer of Mn-oxide sand and granule-sized foraminifers occurs at the same level in both HPC holes (Cores 16, Holes 516 and 516A). Those components are mixed with gastropod and pelecypod fragments and with fish ossicles (similar components occur in Samples 516-14,CC and 516-37,CC, although no textural difference was noted at those two locations). This sandy interval includes a hiatus (see Biostratigraphy section) and corresponds to an acoustic horizon seen in the 3.5-kHz seismic record. This interval may be related to slumping, but the coarse components could also be concentrated in graded zones produced by resettling during coring, and structures may not represent actual bedding.

Unit 1, in summary, is a typical calcareous ooze deposited in a tranquil environment above the calcite compensation depth (CCD) and the lysocline. There is little evidence of dissolution, cementation or reprecipitation.

Unit 2: Nannofossil and Foraminiferal-Nannofossil Chalks (193–332 m)

Early Miocene to late Oligocene in age, Unit 2 spans Cores 3 to 18 in Hole 516F. It is somewhat darker than Unit 1; the hues of Unit 2 are generally brown and yellow (white, light gray, brownish gray, and yellowish brown). Sponge spicules in a uniform concentration of approximately 10% characterize Unit 2 and are associated with thin chert laminations and concretions at various stratigraphic levels. Chert layers are greenish gray to white and very thin and hard; they are probably responsible for the poor recovery in some cores. Carbonate content ranges from 75 to 90%, and the main biogenic components are nannofossils (70–90%), foraminifers (10%), and sponge spicules (10%). The only sedimentary structures identified in this unit were burrows and a few intervals of parallel laminations.

Unit 3: Nannofossil and Nannofossil-Foraminiferal Chalks (332–634 m)

Unit 3 (Cores 19 to 50 of Hole 516F) consists of upper Oligocene to middle Eocene light gray, olive, olive gray, and greenish gray nannofossil and nannofossil-foraminifer chalks. The color change at the upper contact is slight, from yellowish brown to light brownish gray at the base of Unit 2 to light gray, white, and olive

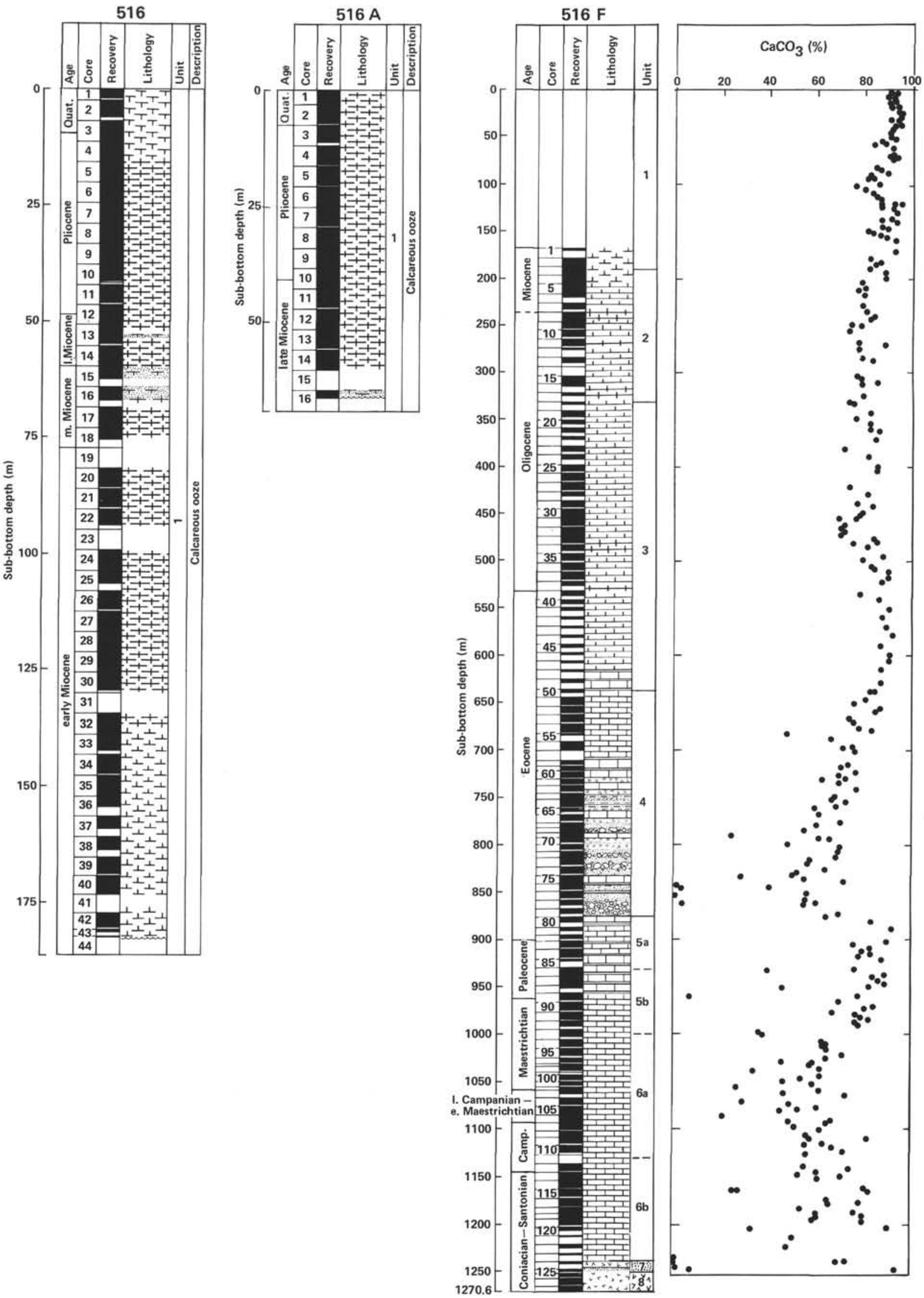


Figure 3. Major lithologic units and percent $CaCO_3$ at Site 516, Rio Grande Rise. Quat. = Quaternary. Note vertical scale change between HPC Holes 516 and 516A and rotary-cored Hole 516F. Symbols according to DSDP convention (Coulbourn, this volume).

gray at the top of Unit 3. The biogenic silica and chert that characterize Unit 2 are absent. Percentages of foraminifers (less than 10%) and of nannofossils (60–70%) decrease slightly in the top third of this unit, but in the remaining two-thirds, both foraminifers (up to 20%) and nannofossils (70–80%) increase. Small fluctuations in the relative fossil percentages indicate that Unit 3 is formed by alternations of argillaceous and slightly more consolidated nannofossil chalks, with nannofossil-foraminifer chalks. The carbonate percentage is uniform throughout the unit, ranging from 70 to 90%.

The minor components of this unit are a few bivalve shells, quartz grains, volcanic glass, micronodules (manganese), and unspecified carbonate and clay minerals.

In the upper part, the only sedimentary structures visible are burrows. These are preferentially horizontal to subhorizontal and characteristically occupy the entire core width. In the lower two-thirds of Unit 3, besides bioturbation, parallel laminations are very conspicuous (Sections 516F-33-3 and 516F-36-2, and core catchers of Sections 516F-38-1 and 516F-38-2). Probably the same structures are present in the upper part, but could not be detected because of drilling disturbance and the softness of the sediments.

Unit 4: Nannofossil and Foraminiferal Limestones (634–874 m)

Unit 4 (Cores 516F-50 to 516F-79) consists of middle Eocene dark gray, olive gray, yellowish brown, light gray, and reddish brown nannofossil and foraminiferal limestones.

Greenish gray montmorillonitic ash layers are interstratified with calcareous layers and turbidites rich in both glauconite and biotite (Cores 53, 61 to 64, 68, 72, 78, 79 of Hole 516F). Unit 4 is lithologically heterogeneous, and its carbonate content is as variable as its lithology. Carbonate content is high in the limestones (60–70%) and very low in the clayey sequences (3–50%). Limestones are similar to those of Unit 3, although $CaCO_3$ generally decreases down-section towards marly limestone. The relative abundance of nannofossils reaches 80%, and foraminifers 10%. The limestones are laminated, finely crystalline and intensely burrowed. The porosity of these layers is probably derived from the dissolution of foraminifers (moldic porosity). Some volcanic ash is present, but much of what was originally described as volcanic is in fact detrital clay (Bryan and Duncan, this volume). Fining-upward sequences (turbidites), rich in limestone fragments, glauconite, biotite, and montmorillonitic layers, are dispersed throughout the unit. The turbidite layers vary from 3 to 5 cm in thickness (Figs. 4 and 5). Several of these sequences are repeated, forming intervals tens of centimeters thick. Black to dark gray clayey layers usually underlie these fining-upward sequences. These layers in turn are underlain by 5–10 cm thick, nonbioturbated limestone. Usually only the "A" interval of the classic Bouma turbidite sequence is present; in Core 61, however, one nearly complete Bouma sequence was recovered associated with several thinner fining-upward sequences (Fig. 6). The graded components of the fining-upward

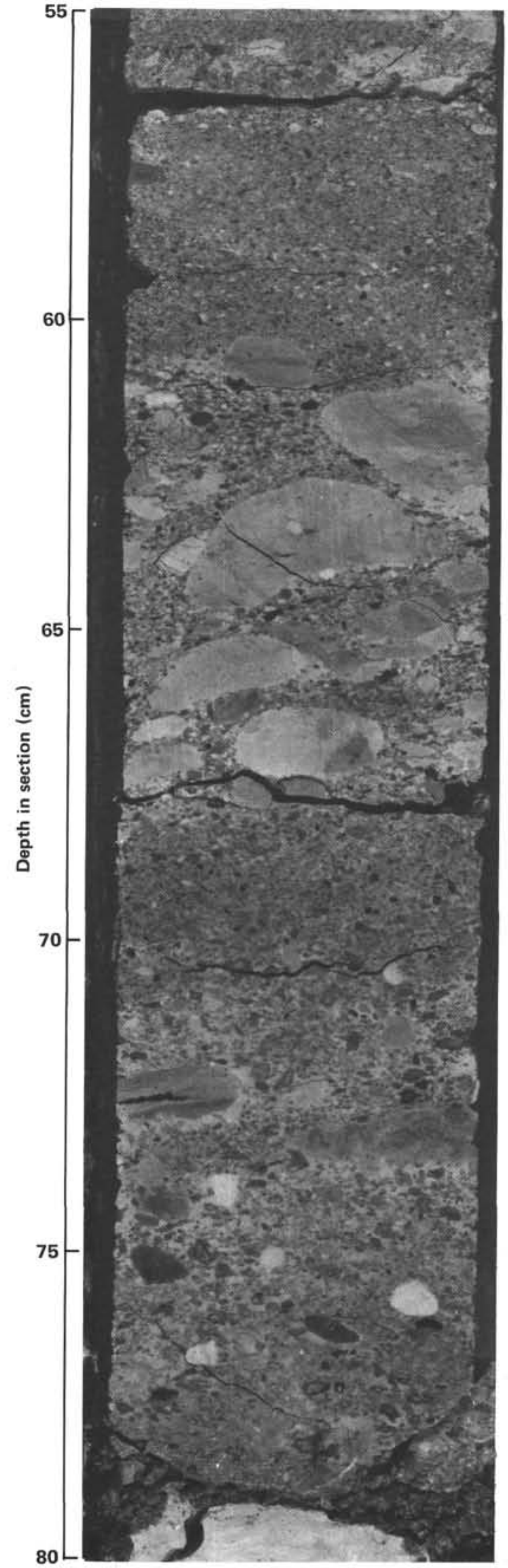


Figure 4. Calcareous sandstones and limestone breccia in 516F-68-3, 55–80 cm.

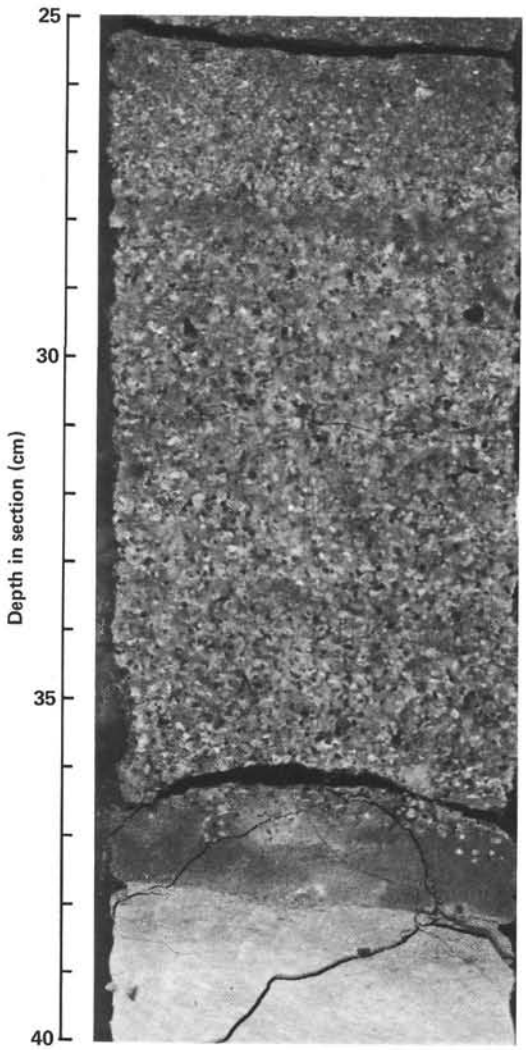


Figure 5. Turbidites in 516F-62-3, 25–40 cm.

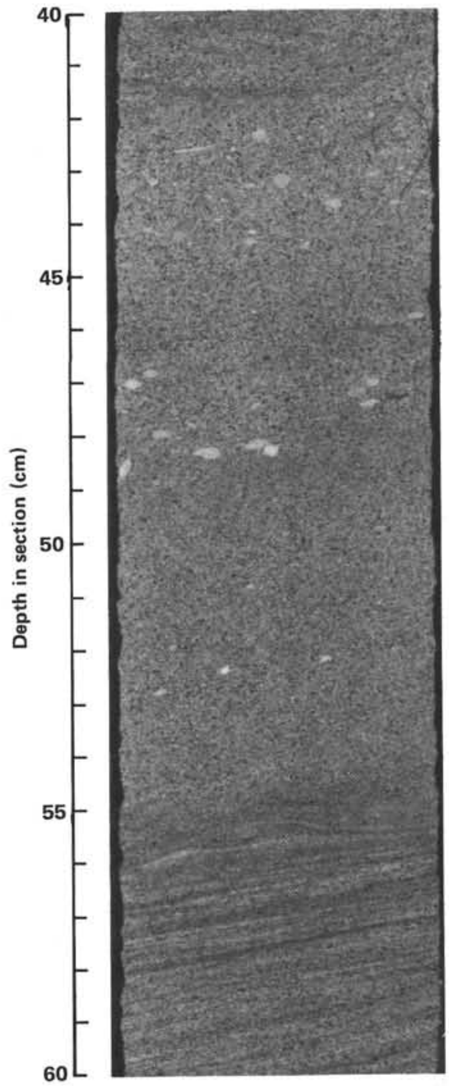


Figure 6. Bouma sequence in 516F-61-5, 40–60 cm.

sequences are montmorillonitic aggregates, biotite, pyrite, and fossil fragments. These components are grit size or coarse sand size at the base and grade upward to very fine clay.

The largest allochthonous contribution to Unit 4 is a 15-m thick deposit occupying much of Cores 78 and 79 (Fig. 7). Specifically, this interval contains two slump blocks of dark brown to dark red-brown limestone of Late Cretaceous age separated by a 30-cm thick layer of graded beds and small cobble-size clasts of volcanic rock and volcanogenic sediment. The Cretaceous limestone is undeformed in places, but its borders show considerable soft sediment deformation, which suggests that it was emplaced as a semiconsolidated ooze or chalk by downslope slumping.

In addition to the sedimentary structures described above, mottling (mainly due to bioturbation) and possible parallel and cross laminations are present in Unit 4. Mottling is conspicuous in the calcareous layers where recrystallization was not extensive. A large vertical burrow (1.5 cm diameter; 100 cm long) occurs in Section 516F-50-1 (Fig. 8). This burrow is mostly filled by medium gray calcarenite that is rich in large benthic foraminifers, as is the calcarenite layer that lies at the upper extremity of the burrow. Limestone clasts within a fanglomeratic layer are imbricated (Core 516F-63, Fig. 9). Parallel laminations and possible cross-bedding occur in Unit 4, but most of these structures are partially disturbed by compaction (Figs. 10 and 11).

The lower boundary of Unit 4 is placed at the base of the Cretaceous block (Section 516F-79-4). At that level, colors change from reddish brown and dark red at the base of Unit 4 to gray, light gray, and white at the top of Unit 5; the carbonate percentage increases rapidly from a variable level (5–50%) at the base of Unit 4 to uniformly higher levels near 80% at the top of Unit 5. The fining-upward, glauconite-rich turbidites and other volcanic-derived sediments common in Unit 4 are absent in Unit 5.

Unit 5: Limestones and Marly Limestones (874–1000 m)

Unit 5 (Cores 80 to 93 of Hole 516F) consists of 2 subunits: light gray limestones at the top (Subunit 5a) grading to reddish brown limestones and marly lime-

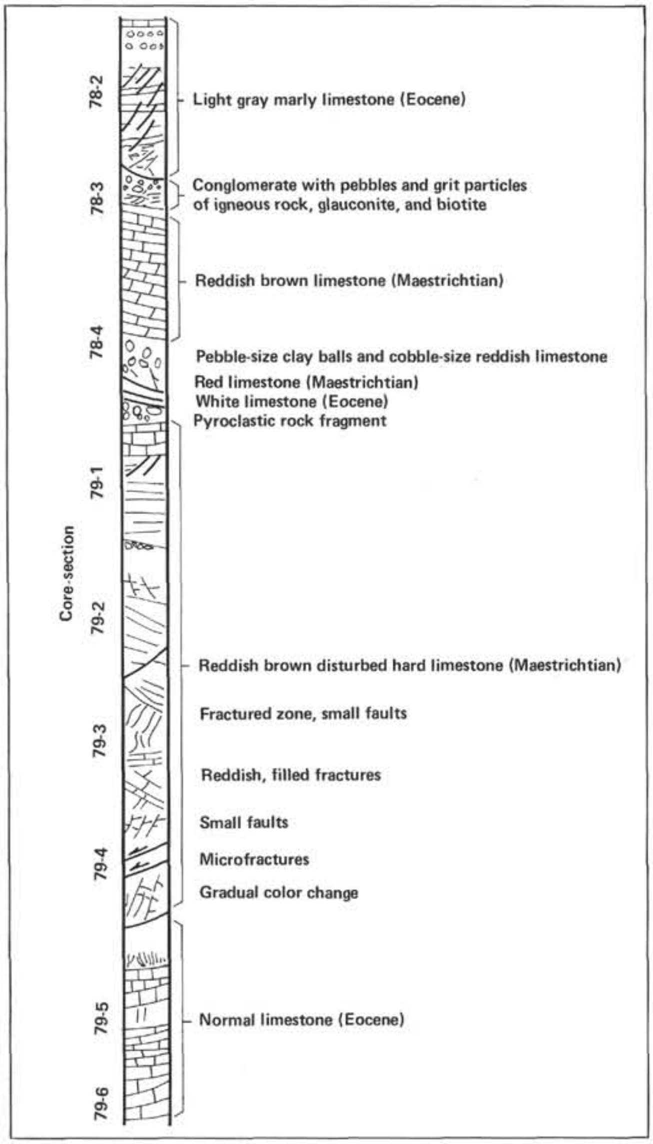


Figure 7. Graphic summary of Cores 516F-78 and 516F-79 showing Cretaceous slump block.

stones below 930 m sub-bottom (Subunit 5b). The subunit boundary is gradational and somewhat arbitrary.

Subunit 5a (874–930 m, Cores 80 to 86) contains middle Eocene to middle Paleocene, gray to light gray and light green limestones, with small intervals of dark greenish gray sediment slightly rich in organic matter. The limestones of Cores 81, 86, and 87 are partially dolomitized and harder than those in surrounding intervals.

Pressure solution has altered the internal organization of the carbonate components of Subunit 5a, producing a series of false sedimentary structures similar to convolute bedding, lenticular bedding, and parallel laminations. The only sedimentary structures still present in these rocks are burrows, some partially destroyed by dissolution and recrystallization. In some cases, flattened burrows and clay balls interpenetrate. Porosity increases slightly downcore in the Subunit 5a limestones.

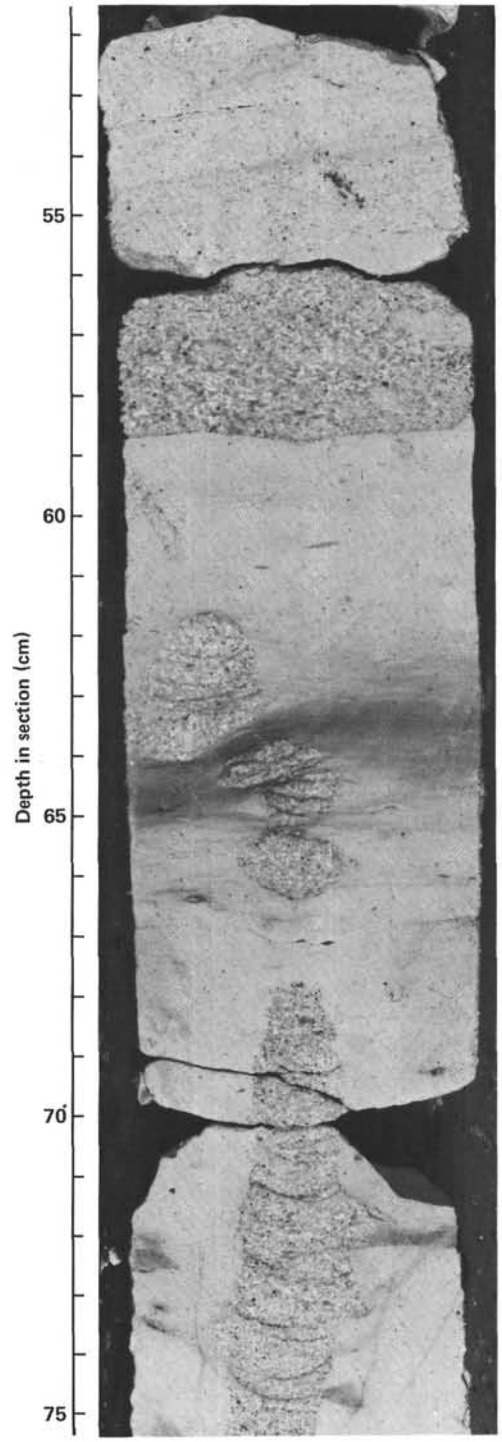


Figure 8. Large vertical burrow in 516F-50-1, 51–75 cm.

The 3 to 5 cm thick, dark greenish gray layers that are slightly rich in organic matter are marly limestone and are present in almost all cores of Unit 5.

Carbonate percentages are high, ranging from 75 to 90%, and the microfossil content is as follows: foraminifers 5–10%; nannofossils variable from 10 to 80%. The fossils are best preserved in the darker layers where recrystallization was less extensive, although initially the

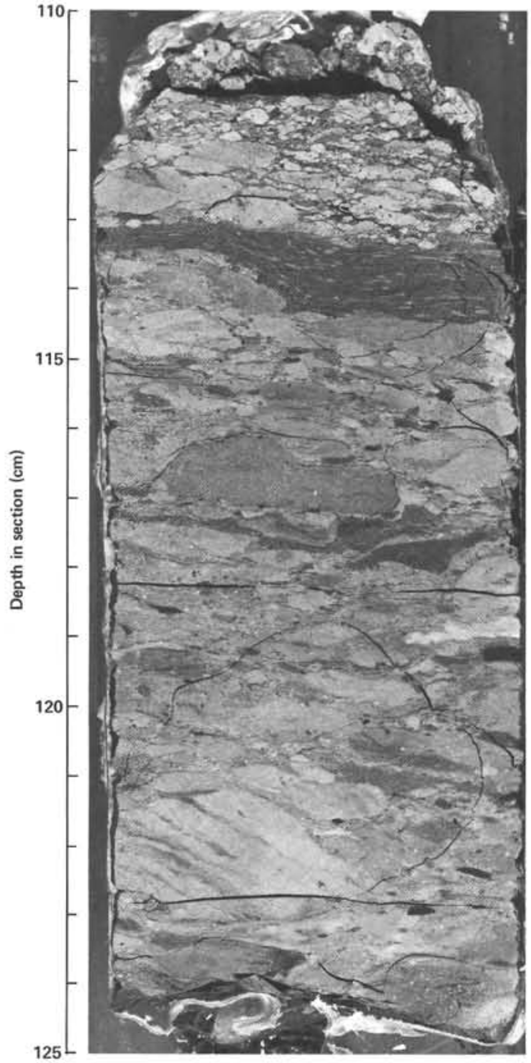


Figure 9. Imbricated limestone clasts in 516F-63-6, 110–125 cm.

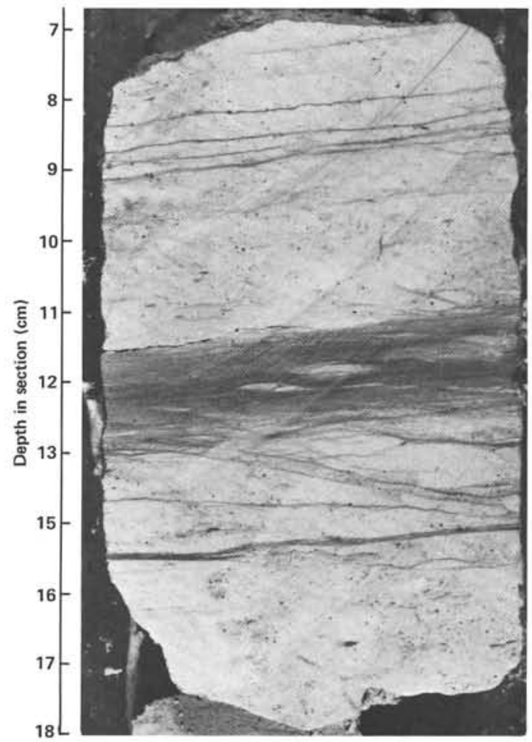


Figure 10. Parallel laminations in 516F-48-2, 7–18 cm.

carbonate content of those intervals was relatively low. Minor components are calcite and dolomite rhombs, detrital clays, volcanic glass, and quartz (2–3%). The lower boundary of this subunit is a gradational color change from white in Core 85 to light brownish gray in Core 86.

Subunit 5b (930–1000 m sub-bottom, Cores 86 to 93) consists of Paleocene and Maestrichtian interbedded reddish limestones and reddish brown marly limestones. The sediments of Subunit 5b are intensively burrowed, except in light-colored zones where recrystallization reaches a high degree. Kaolinite and illite are present in this subunit, but not above. The Cretaceous/Tertiary boundary occurs in Section 516F-89-5 (see frontispiece and Fig. 12). Its lithology is described in detail by Michel et al. (this volume).

Unit 6: Marly Limestones and Claystones (1000–1240 m)

Unit 6 (Cores 93 to 124 in Hole 516F) contains Maestrichtian to Coniacian-Santonian light gray to white, and gray to dark gray marly limestone and claystone. It consists of two subunits as follows.

Subunit 6a (1000–1130 m sub-bottom, Cores 93 to 111) contains marly limestones interbedded with micritic nannofossil limestones. Variegated colors range from light greenish gray to dark brownish red. The limestone is intensively burrowed throughout.

Subunit 6a is lithologically distinct from the unit above in that the pressure solution effects abundant in Unit 5 are absent. In addition, marly intervals are more common in Unit 6.

Some greenish gray, gray, and light gray marly limestones and claystones are present in the middle part of this subunit (Cores 98 to 103), and these have the lowest carbonate content of all sediments within Subunit 6a. Carbonate contents range from 70 to 30%. The terrigenous components—clay, detrital quartz (up to 10%), feldspar (up to 5%), biotite, zeolite (up to 5%), and volcanic glass—increase in relative abundance toward the base of Subunit 6a. Nannofossils (10–80%), foraminifers (up to 10%), and recrystallized calcite (up to 50%) account for the carbonate fraction. Remains of *Inoceramus* first appear at Core 101 (1050 m sub-bottom). A gradual color change from weak red, reddish brown, and light reddish brown to grays marks the base of Subunit 6a.

Subunit 6b (1130–1240 m sub-bottom, Cores 111 to 124) consists of Campanian and Santonian-Coniacian microcrystalline, light gray to white limestone and gray to dark gray marly limestone and claystone.

Bioturbation is intense in Cores 112 to 117, producing a mottled pattern apparent in the polished sections

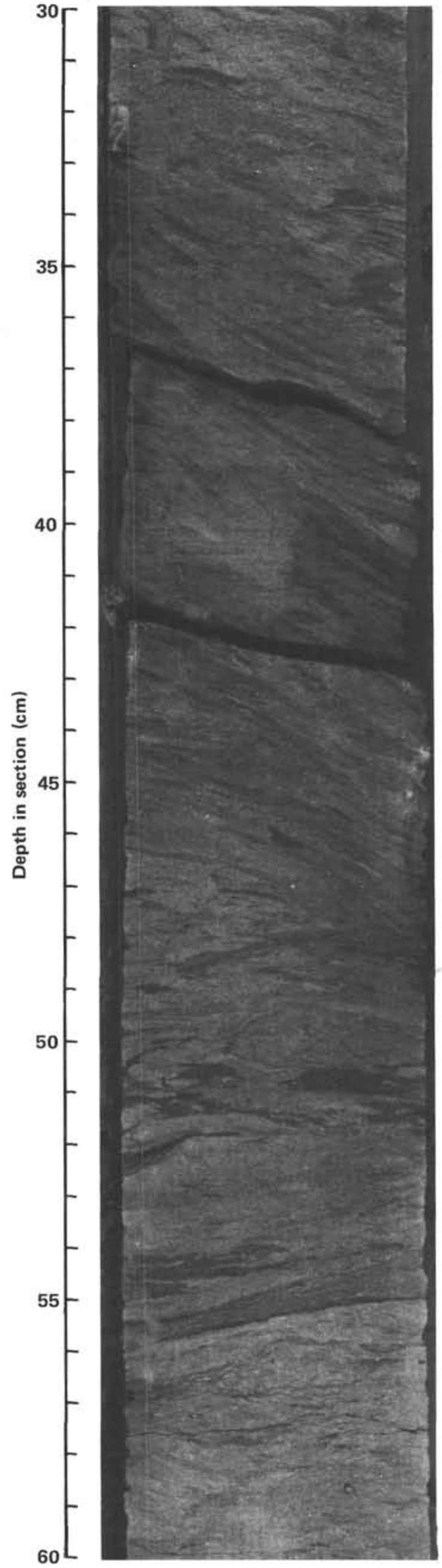


Figure 11. Cross-bedding in 516F-64-4, 30–60 cm.

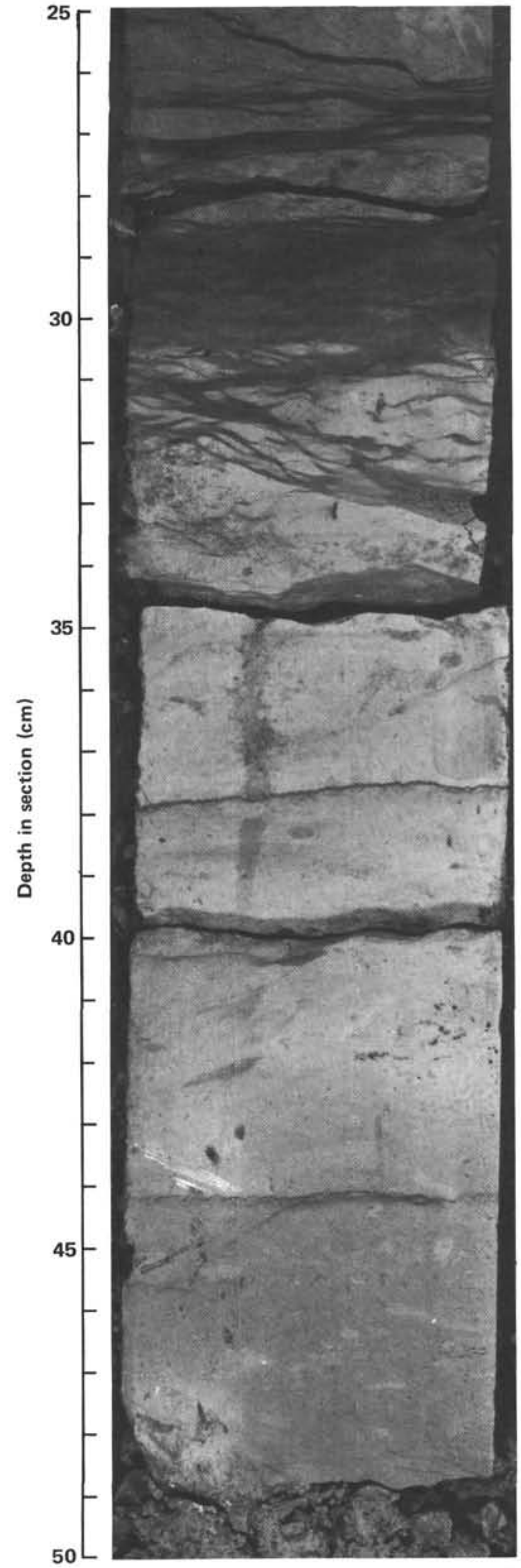


Figure 12. Cretaceous/Tertiary boundary recovered in 516F-89-5, 25–50 cm.

of these rocks. This section is cemented by dolomite, and is much harder than the otherwise similar rocks in Cores 108 to 110.

Carbonate content is variable, ranging from 25 to 91%. A few thin dark gray to black layers of claystone or mudstone are present in the intervals of low carbonate content. Some of them are richer in wood fragments and in organic matter than all other sediments recovered at this site. The thickest of these intervals is a 78 cm sequence of interbedded claystones and shales in Core 122 containing 95% organic carbon (Fig. 13 and de Quadros et al., this volume). From top to bottom, this sequence consists of 5 cm of laminated, but slightly burrowed shale; 15 cm of massive claystone; 30 cm of laminated shale; 23 cm of black massive claystone; and finally 3 cm of parallel-laminated shale at the base. The contacts of these dark gray to black claystones and shales with the limestone and marly limestone are usually very sharp.

Inoceramus fragments and shells are very abundant from Core 114 to the base of the unit, and occur as high as Section 516F-110-6 in scattered abundance. Foraminifers and nannofossils are present in low percentages at the top of the unit but are rare near the base; most of the carbonate is recrystallized. The terrigenous components are dark gray clays, quartz (2-3%), feldspars (trace), and mica.

Parallel laminations, faint cross laminations, and burrows are the most important structures and features of Subunit 6b, but some microfaults occur.

Unit 7: Ferruginous Chert, Limestones, Glauconite-rich Sands, Turbidites, and Shallow-Water Microfossils (1240–1252 m)

The calcareous, volcanogenic sediments of Unit 7 (Cores 124 and 125 of Hole 516F) consist of red, *Inoceramus*-rich baked calcareous mud; dusky red sandy mudstone with dispersed glauconite grains; dark altered volcanic glass, montmorillonite, and breccia; and some fining-upward sequences of coarse-grained to fine-grained sandstones rich in feldspar, glauconite, and biotite (green sandstones). On the top of this sedimentary section there is 10 cm of dark reddish gray ferruginous chert. The list below shows the composition of the ferruginous chert from Sample 516F-124-1, 1–10 cm (analysis courtesy of M. E. Cosgrove, Department of Geology, University of Southampton, Southampton, SO9 5NH, United Kingdom).

SiO_2	82.16	%
TiO_2	0.204	
Al_2O_3	0.481	
Fe_2O_3	11.99	
MgO	0.282	
CaO	0.530	
Na_2O	0.018	
K_2O	0.064	
P_2O_5	0.000	
Loss of ignition	4.67	
X-ray total	100.40	%
CO_2	0	
H_2O	0	

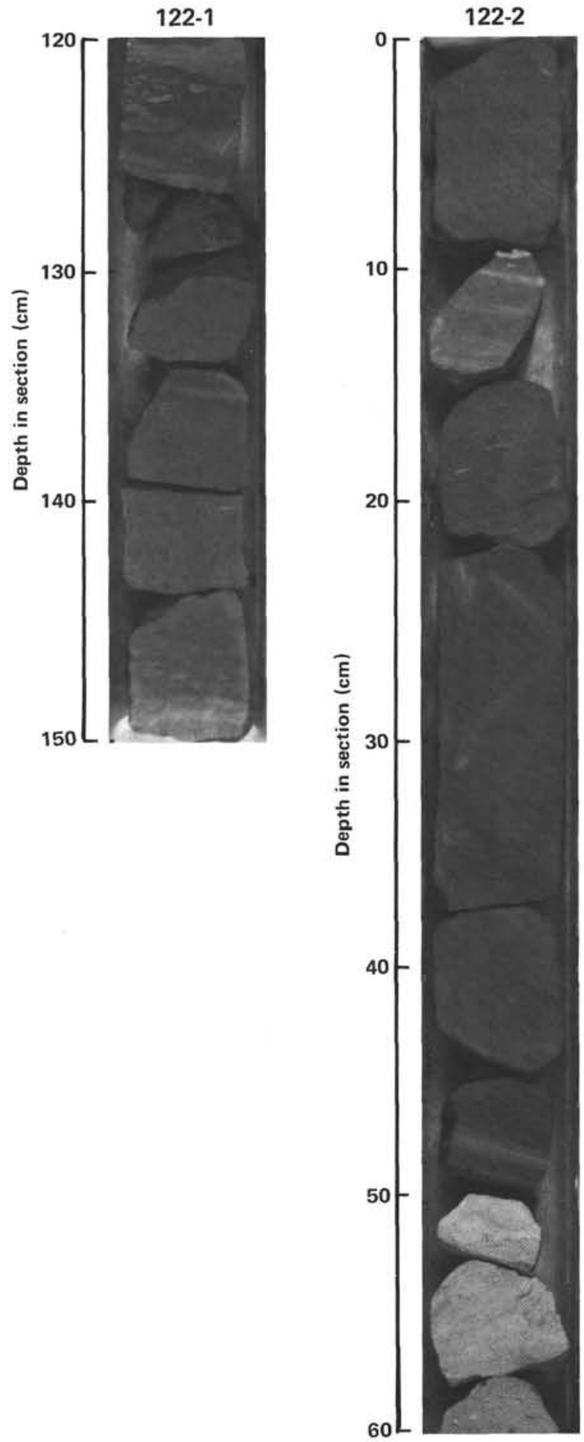


Figure 13. Interbedded claystone and shale, containing 0.95% organic carbon in Core 122.

Unit 8: Veined and Partly Altered Vesicular Basalt (1252–1271 m)

In Unit 8 (Cores 125 to 128 of Hole 516F), two flow units are distinguished on the basis of primary mineralogy and the degree of alteration. Both units were originally dark, fine-grained, variably vesicular plagioclase-pyroxene-phyric tholeiites. Plagioclase phenocrysts are commonly euhedral or lath shaped, often zoned. Pyroxene phenocrysts, usually only 1% by volume, are euhedral to subhedral and display zoning (sometimes oscillatory) and simple twinning. The groundmass consists of microlites of plagioclase, granular pyroxene, opaque minerals, and glass. Much of the glass is replaced by calcite or clay minerals and, in the more weathered samples, both plagioclase and pyroxene phenocrysts are partially replaced by calcite.

The upper flow unit (down to Sample 516F-127-4, 48 cm) is the more extensively veined and altered of the two, and it has more glass, less pyroxene in the groundmass, and smaller grains of iron oxide. The differences between the two units, however, are minor compared with their similarities, and they may represent a single flow. The scarcity of quench textures and lack of glassy selvages suggests emplacement as a thick flow, and leaves open the question of a submarine or subaerial origin.

Compared to normal (N-type) mid-ocean ridge basalts (MORB), the basalts of Hole 516F have high contents of the incompatible minor and trace elements (Ti, P, Zr, Nb, Y, La, Ce) and correspondingly low contents of Ni, Cr, and the more mobile, compatible trace elements (see Thompson et al., this volume, and Weaver et al., this volume). The degree of alteration casts doubt on the primary nature of the Mg, K, Rb, and Ba concentrations, but the high Sr content is probably unaffected.

Incompatible trace element ratios suggest an "enriched" parental magma compared with N-type MORB, and the high total iron, along with low levels of Ni, Cr, and possibly Mg, suggest high level fractionation of a magma with transitional (T-type) MORB characteristics (Wood et al., 1979). The argument for high level fractionation is strengthened by the petrographic evidence (oscillatory zoning of phenocrysts and the presence of augite). The chemistry of the Hole 516F basalts is similar to that of Reykjanes Ridge and Icelandic basalts, to tholeiites from the Azores, and to samples from the far eastern Walvis Ridge.

The basalt of Core 126 encloses a large vein filled primarily with quartz and calcite and with inclusions of clays and iron oxides. The calcite occurs as large crystals, sparite, and micrite enclosing *Inoceramus,* algal, and bryozoan fragments. A thin section of vein filling from Core 126 contains calcareous algae, bryozoans, oolites, and benthic foraminifers, indicating a shallow-water provenance. There is no evidence of downslope reworking or mixing with faunas from a deeper or pelagic environment (see Milliman, this volume).

SEDIMENTARY GEOCHEMISTRY

Carbonate Analyses

A total of 586 bomb carbonate analyses were made on Site 516 sediment samples, including 241 from Hole 516, 101 from 516A, and 244 from 516F. The values are listed in the core description forms accompanying this chapter. Estimated accuracy is approximately 3% for the values shown in Figure 3. This accuracy is less than normal, apparently because of a volume error with one measuring flask.

X-Ray Diffraction Analysis

X-ray diffractograms for 255 samples from Site 516 were collected as part of a shipboard study (Coulbourn, this volume), and additional samples were also analyzed as part of a shore-based study (Zimmerman, this volume). Calcite occurs throughout the section; quartz is present in most samples, with the exception of cores from Unit 4. Feldspar occurs as phenocrysts of the glomerophyric basalt of Cores 516F-126 and 516F-127.

The clay minerals montmorillonite, kaolinite, and illite are common in samples from below 625 m sub-bottom at Site 516. These minerals were recovered in samples from Unit 4, an interval of turbidites, ash, and allochthonous slump blocks of Cretaceous limestone. Montmorillonite may be the product of the alteration of volcanic glass. Illite is the clay that makes up marly intervals within the allochthonous red-brown Cretaceous limestone and marly limestone of Cores 516F-78 and 516F-79, and typifies the autochthonous Cretaceous rocks of Unit 6. In diffractograms produced from samples from the base of Subunit 6a, kaolinite and illite peaks are dominant. Kaolinite peaks intensify as illite peaks diminish downsection towards Subunit 6b. The clays of Subunit 6b are kaolinitic. Chert and dolomite generally do not co-occur; chert occurs above the Cretaceous/Tertiary boundary, and dolomite below.

The frequency of occurrence of chert and dolomite also corresponds to increases in velocity. Between 600 and 880 m sub-bottom, the frequency of occurrence of chert increases within Cores 516F-75 to 516F-82, the lower portion of Unit 4, and in Subunit 5a. A velocity inversion near 880 m sub-bottom probably corresponds to a diagenetic front, the lower boundary of silica cementation. Beneath 880 m sub-bottom, velocities again increase gradually, as does the frequency of occurrence of dolomite. Again, the increase in V_p probably corresponds to the extent of diagenesis within the sediment, the diagenetic effect arising this time from dolomitization rather than chertification.

Interstitial Water

Results of the shipboard analyses of interstitial water indicate fairly constant values for pH, salinity, chlorinity, alkalinity, and calcium ion concentration throughout the section cored at Site 516 (Table 2 and Fig. 14). The magnesium ion concentration decreases with depth,

Table 2. Interstitial water geochemistry, Holes 516A and 516F.

Core-section (interval in cm)	Sub-bottom depth (m)	pH	Salinity ‰	Chlorinity ‰	Alkalinity meq/l	Calcium mmol/l	Magnesium mmol/l
Hole 516A							
1-2, 144-150	2.94-3.00	7.324	35.2	19.14	2.687	10.94	58.36
12-2, 140-150	50.40-50.50	7.217	35.2	19.34	2.925	12.02	55.35
Hole 516F							
2-6, 140-150	187.50-187.60	7.142	35.2	19.48	3.838	14.71	44.16
7-2, 140-150	229.00-229.10	7.074	35.2	19.51	3.813	15.23	41.84
13-2, 140-150	286.00-286.10	7.071	37.7	19.51	4.289	16.04	38.29
19-3, 140-150	363.50-363.60	7.289	35.2	19.64	2.702	15.75	36.54
25-3, 140-150	401.50-401.60	7.356	35.2	19.88	1.377	15.35	33.34
30-5, 140-150	452.00-452.10	7.688	35.2	20.15	0.578	15.87	30.27
35-3, 140-150	496.90-496.60	7.422	35.2	20.01	1.685	16.04	32.21
51-3, 140-150	648.50-648.60	7.356	35.2	20.15	–	17.08	25.58

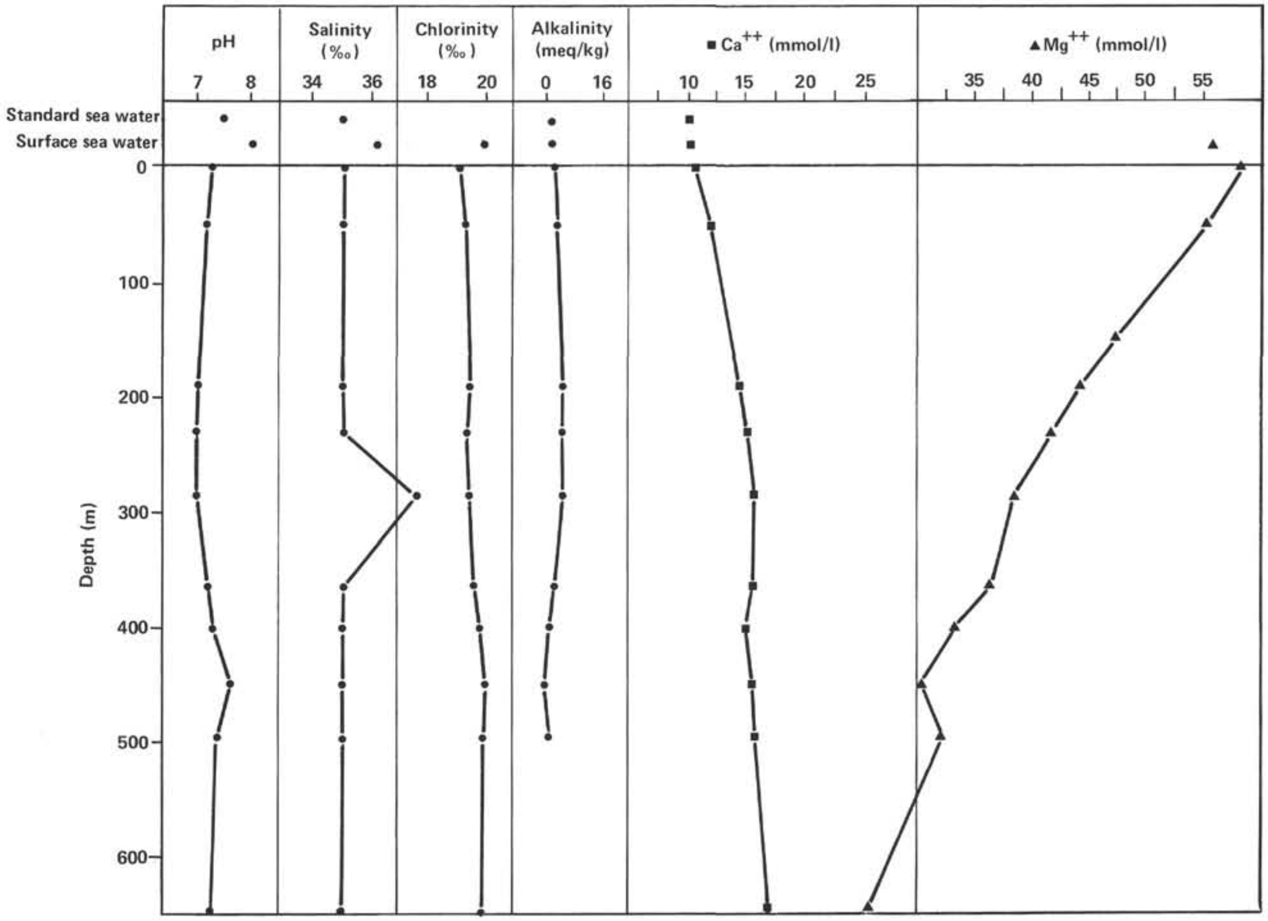


Figure 14. Interstitial water geochemistry, Site 516.

in inverse relation with the amount of dolomite detected in the X-ray diffraction analyses.

BIOSTRATIGRAPHY

Stratigraphic continuity and high rate of core recovery are the most significant aspects of the drilling results from Site 516. The continuous stratigraphic sequence from the Recent to the Late Cretaceous, approximately 80 Ma (Santonian/Coniacian), includes relatively unaltered basaltic basement. All calcareous microfossil groups are sufficiently abundant and well preserved to yield reliable age determinations. At Hole 516, 44 cores were recovered. The oldest level corresponds to the early Miocene. Hole 516A reached only the upper Miocene. The last hole, 516F, began at the base of the lower Miocene and extended to the Late Cretaceous limestones and basalt.

Two relatively minor stratigraphic gaps at Site 516 may correspond to hiatuses at nearby Site 357. Seismic reflection profiles suggest, however, that these are of local rather than regional significance. The intervals are as follows:

1) The uppermost Pliocene (Zone PL6 of Berggren, 1977a) is relatively condensed, indicating a possible unconformity of short duration.

2) The upper Miocene is partially missing. Foraminiferal Zone N15 (and perhaps N16) and nannofossil Zone NN10 are missing, and portions of Zones NN9 and NN11 may also be missing. Altogether, there is perhaps a gap of 2 Ma in the upper Miocene.

In spite of these minor gaps, Site 516 successfully recovered a continuous depositional record across the Santonian/Campanian boundary, Campanian/Maestrichtian boundary, the Cretaceous/Tertiary boundary, the Paleocene/Eocene boundary, and the Eocene/Oligocene boundary. The lowermost planktonic foraminiferal zone of the Danian (*Globigerina eugubina* Zone) is well represented, as well as the uppermost planktonic foraminiferal zone of the Maestrichtian below (*Abathomphalus mayaroensis*). Apparently, the Paleocene sequence is complete, which is uncommon in previous DSDP sites.

Microfossil Abundance and Preservation

All calcareous microfossil groups are common and very well preserved from the Recent to the middle Miocene. From that point to the middle Eocene, preservation gradually deteriorates, though all groups remain common in abundance. In the middle and lower Eocene samples, all calcareous components are relatively rare with moderate to poor preservation, with extensive fragmentation of nannofossils, and with common overgrowths of calcite on the planktonic foraminifers. In the Paleocene, the nannofossil assemblages become abundant and diverse, and remain so into the Maestrichtian. Planktonic foraminifers are moderately to poorly preserved in the Paleocene and Upper Cretaceous of Site 516, with the *Globotruncana* spp. largely unrecognizable because of clay adhering to the shell surfaces. Benthic foraminifers are well preserved in the lower Paleocene and upper Maestrichtian, but are poorly preserved at the base of the Maestrichtian and barely recognizable (though present) in the lower Campanian/Santonian. In a similar way, the preservation of the nannofossil assemblage begins to deteriorate in the lower Maestrichtian with significant calcite overgrowths and dissolution; this effect increases downward in the Campanian/Santonian section.

Reworking

As we expected for this location, reworking effects at Site 516 were minimal. Nannofossils and planktonic foraminifers show no evidence of contamination of any of the assemblages by stratigraphically older taxa. Benthic foraminiferal assemblages suggest the presence of minor, penecontemporaneous downslope reworking within portions of three stratigraphic intervals:

1) Shallow-water benthic foraminiferal taxa occur at the top of the middle Miocene, just below the probable unconformity.

2) Pelecypods and shallow-water benthic foraminifers are present intermittently within Cores 516F-5 through 516F-31, extending from the lower Miocene (Zone N4) to the upper Oligocene (Zone P20). The fact that planktonic assemblages in this interval show no evidence of reworking suggests penecontemporaneous downslope reworking and *not* the erosion of sediment from stratigraphically older sections exposed as outcrops nearby.

3) Reefal debris, containing calcareous algae, bryozoans, and larger foraminifers, is present in the middle Eocene (Cores 516F-50 and 516F-63). These Eocene (Zone NN14) limestones surround a lower Maestrichtian slump block.

Absence of downslope reworking throughout the Paleocene and Upper Cretaceous intervals contrasts with the presence of considerable reworking of Cretaceous sediments at Site 357 (Supko et al., 1977). This difference suggests that the downslope reworking during the Cretaceous was of local extent.

Within Core 516F-126, allochthonous fragments occur in hydrothermal veins cutting the basalt. The fragments include calcareous algae, *Inoceramus* prisms, and possibly bryozoans, suggesting that the basaltic vulcanism represented in the lowermost cores of Site 516 took place near sea level (see Milliman, this volume). In contrast, the overlying Santonian foraminiferal assemblages (e.g., the *Globotruncana* spp. in Core 516F-119) suggest accumulation in upper bathyal depths. Significant erosion and/or subsidence must have occurred during the 5 to 10 Ma immediately after the cessation of volcanism, because the bulk of the depositional sequence at Site 516 corresponds to a pelagic facies accumulating in bathyal (probably upper bathyal) depths.

Nannoplankton

The calcareous nannofossil-based age determinations and zonal boundaries for the Tertiary are based upon the zonation of Martini (1971). For the stratigraphic age determination of the Cretaceous sediments and for correlation with the biostratigraphy of Site 357 (Leg 39), the zonation of Perch-Nielsen (1977) was used.

Eight biostratigraphic intervals were identified:

1) Quaternary (Cores 516-1 to 516-3, 0–8.7 m, and 516A-1 to 516A-2, 0–7.9 m)

2) Pliocene (Cores 516-3 to 516-12, 10.2 to about 40 m, and Cores 516A-3 to 516A-10, 7.9–43.1 m)

3) Miocene (Cores 516-12 to 516-44, about 40 to 183.3 m; Cores 516A-11 to 516A-15, 43.1–65.1 m; and Cores 516F-1 to 516F-8, 169.1–245.1 m)

4) upper Oligocene to lower Miocene (Sample 516F-9,CC, 254.6 m)

5) Oligocene (Cores 516F-10 to 516F-38, 283.1–530.1 m)

6) Eocene (Cores 516F-39 to 516F-82, 539.6–900.6 m)

7) Paleocene (Cores 516F-83 to 516F-89, 910.1–961.4 m)

8) Cretaceous (Cores 516F-89 to 516F-124, 964.0–1240.4 m)

Quaternary

Well-preserved and abundant Quaternary nannoplankton assemblages occur in the intervals from 516-1-1, 0–2 cm to 516-3-2, 30–32 cm (0–8.7 m), and from 516A-1,CC to 516A-2,CC (0–7.9 m). The assemblages in the interval 516-1-1, 0–2 cm to 516-1-1, 5–6 cm belong to the *Emiliania huxleyi/Gephyrocapsa oceanica* Zone (NN21/NN20). The last occurrence of *Pseudoemiliania lacunosa* marks the base of the interval (NN21 to NN20). The principal floral components include *G. oceanica, Ceratolithus cristatus, Rhabdosphaera clavigera, Cyclococcolithus leptoporus*, and *Helicopontosphaera kamptneri.*

The assemblages from Samples 516-1-1, 42 cm to 516-3-2, 32 cm (1.9–8.7 m) contain *P. lacunosa* but lack discoasters, indicating the *P. lacunosa* Zone s.l. (NN19). No hiatus between the Pliocene and Quaternary exists in Holes 516 and 516A.

Pliocene

Pliocene floras were recovered in Samples 516-3-2, 41–42 cm to 516-11,CC (10.2 to about 40 m). The coccoliths and discoasters of the Pliocene are abundant, with moderate to good preservation in the upper Pliocene and moderate preservation in the lower Pliocene.

The presence of *Discoaster brouweri* without any other discoasters suggests that the sediments of Samples 516-3-3, 30–32 cm and 516A-3,CC are in Zone NN18. Zone NN17 occurs in Sample 516-3,CC. The nannofossil assemblages in Core 516-4 to Sample 516-5-2, 100 cm with *D. surculus* but without *Reticulofenestra pseudoumbilica* indicate Zone NN16.

The interval between Samples 516-5-2, 100 cm and 516-5-3, 100 cm with *R. pseudoumbilica* but without *Amaurolithus tricorniculatus* belong to *R. pseudoumbilica* Zone (NN15). Because of uncertainties regarding the first occurrence of *D. asymmetricus* in this section, it is impossible to distinguish the interval of the *Ceratolithus rugosus* Zone (NN13) from the *D. asymmetricus* Zone (NN14) in Cores 516-6 to 516-10. The top of this interval is determined by the last occurrence of *A. tricorniculatus*, and the base by the first occurrence of *C. rugosus.* The base of the Pliocene at Site 516 is placed within the *C. tricorniculatus* Zone (NN12) in Core 516-10, based on the first occurrence of *C. acutus.*

Miocene

Miocene sediments were recovered in Samples 516-14,CC to 516-44,CC (59.7–183.3 m) and in Samples 516F-1,CC to 516F-8,CC (169.1–245.1 m). The Miocene calcareous nannofossils are abundant with generally moderate preservation.

The top of the Miocene is within the *C. tricorniculatus* Zone (NN12). The *D. quinqueramus* Zone (NN11) is present in Sections 516-11-2 through 516-14-1, and it is determined by the range of that species. *D. calcaris* (NN10) is missing, and the lower part of the *D. quinqueramus* Zone (NN11) and upper part of the *D. hamatus* Zone (NN9) are probably also missing, indicating a hiatus at the base of the upper Miocene. Calcareous nannofossil assemblages containing *D. hamatus* in Sections 516-14-1 and 516-14-2 and matching intervals at Hole 516A indicate that this part of the section is in Zone NN9. In Sample 516A-16,CC, the assemblage is a mixture of Pliocene-Miocene nannofossils. In Cores 516-15 to 516-17, *D. challengeri* and *Cyclococcolithus neogammation* are present, whereas *D. pentaradiatus, D. exilis*, and *D. kugleri* are absent. The Pliocene/Miocene contact is probably somewhere within the *D. exilis* Zone (NN6) and the *D. kugleri* Zone (NN7). In the interval from 516-17-2, 110 cm to 516-20-3, *Sphenolithus heteromorphus* occurs without *Helicopontosphaera ampliaperta* and *H. parallela*, suggesting an age corresponding to Zone NN5. In Sections 516-20-3 to 516-25-2, the occurrence of *H. ampliaperta* without *S. belemnos* suggests Zone NN4. The interval from 516-25-2 to 516-32-3 belongs to Zone NN3. The top of this interval is defined by the last occurrence of *S. belemnos* and the bottom by the last occurrence of *Triquetrorhabdulus carinatus.* The *D. druggi* Zone (NN2) is very thick. The first occurrence of *S. belemnos* marks the top of this interval in Section 516-32-3, and the last occurrence of *T. carinatus* marks the bottom of Section 516F-3,CC. Assemblages lacking *D. druggi, S. ciperoensis*, and *H. recta* characterize the oldest Miocene sediments of Zone NN1. These and older sediments are seen only in cores from Hole 516F.

The nannoplankton assemblage Sample 516F-9,CC consists of *H.* cf. *recta* without *S. ciperoensis.* The questionable determination of *H.* species is not sufficiently certain to indicate an Oligocene age.

Oligocene

Oligocene assemblages were found in Section 516F-10,CC and in Cores 516F-12 through 516F-38 (283.1–530.1 m sub-bottom). The Oligocene section contains all calcareous nannoplankton zones according to Martini's (1971) zonation. The nannofossils are generally abundant but with poor to moderate preservation.

The occurrence of *S. ciperoensis* in Sample 516F-10,CC without *S. distentus* distinguishes Zone NP25. Sample 516F-11,CC lacks index sphenoliths, but the presence of *H. recta* gives this sample an age between Zones NP24 and NP25. In Cores 12 to 18, *D. lidzii* is present; its range restricts this assemblage to Zone NP24. The overlap of *S. distentus* and *S. predistentus* without *D. lidzii* in Cores 19 to 25 assigns this interval to Zones NP23 to NP24. *Chiasmolithus oamaruensis* occurs in Sample 516F-26,CC; its last known occurrence is in Zone NP23, which indicates that this sample and those from Cores 27 to 31 belong to Zone NP23. The co-occurrence of *S. distentus* and *R. pseudoumbilica* characterize the interval from Cores 27 to 35. This overlap, which is not quoted by Martini (1971), assigns this interval to Zones NP22 to NP23. An assemblage with *R. pseudoumbilica* but without *S. distentus* occurs in Sample 516F-36,CC, assigned to Zone NP22. An assemblage containing *Cyclococcolithina formosa*, but lacking *D. saipanensis*, represents the base of the Oligocene, Zone NP21 in Sample 516F-38,CC. *C. formosa* has its last known occurrence in the base of Oligocene—Zone NP21.

No distinct hiatus between the Oligocene and Eocene was noted. Zones NP19 and NP20 represent the top of the Eocene, but determination of the youngest zone (NP20) was not possible due to the absence of *S. pseudoradians*, a species ranging from NP20 to NP23. Despite the absence of this key species, the evidence for the three oldest zones of the Oligocene (NP21 to NP23) is good.

Eocene

More than 350 m of Eocene sediment were recovered in Cores 516F-93 to 516F-82 (539.6–900.6 m). The calcareous nannofossils are few to abundant with poor to moderate preservation.

The upper part of the Eocene (Sample 516F-39,CC) belongs to Zones NP19 to NP20, because the index species for the last zone is missing. The top of interval is marked by the last occurrence of *D. saipanensis* and the bottom (Core 43) by the first occurrence of *Isthmolithus recurvus*. Cores 44, 45, and 46 belong to Zone NP18. The first occurrence of *Chiasmolithus oamaruensis* defines the base of this zone. The assemblages in Cores 47 to 51 (and probably to 53) identify Zone NP17, based on the presence of *D. saipanensis* and *H. compacta*, but without *C. solitus*. The last occurrence of *C. solitus* and *H. seminulum* in Core 516F-54 defines the top of Zone NP16, easily recognizable down to Sample 516F-58,CC. The assemblage in this interval lacks *Chiphragmalithus alatus* and *Rhabdosphaera gladius*. Sample 516F-59,CC contains *R.* cf. *gladius*, which last occurs at the top of the *Chiphragmalithus alatus* Zone (NP15), meaning that this zone should be present beneath this sample. The identification of this species is uncertain, however, and the interval down to Sample 516F-66,CC is assigned to Zones NP15 to NP16. *D. nonaradiatus* and *D. sublodoensis* are present in Sample 516F-67,CC; both have their last occurrence in Zone NP15. Their presence and the absence of *D. lodoensis* assign Cores 516F-67 to 516F-76 to Zone NP15. The presence of *D. lodoensis* in Sample 516F-77,CC and in the upper part of Core 516F-78 limits the age of this interval to Zones NP13 to NP14. Section 516F-78-3 is part of a lower Maestrichtian slump block (*Arkhangelskiella cymbiformis* Zone). The Eocene sediments below this slump in Sample 516F-79,CC belong to the same stratigraphic interval as above the slump. The exact determination of the first three Eocene cores (80 to 82) is difficult. Index fossils are missing, or fossils are not typical of the assemblages. Tentatively, Core 516F-80 belongs to Zone NP12, and Cores 516F-81 and 516F-82 to Zones NP10 to NP12.

Paleocene

No distinct hiatus between the Eocene and Paleocene was noted. The top of the Paleocene is represented with the youngest Paleocene zone (NP9).

The Paleocene sequence at Hole 516F is about 50 m thick (Cores 516F-83 to Sample 516F-89-3, 33.5 cm; 910.1–961.4 m). That is relatively thin compared to the Eocene and Cretaceous sections; nevertheless, it contains all nine Paleocene zones without any hiatus. Coccoliths and discoasters are few to abundant and fairly well preserved. Only at the base of the Paleocene are the nannofossils rare with poor preservation. Core 516F-83 to Sample 516F-84-3, 3–4 cm contains *D. multiradiatus*, an index species of Zone NP9. The presence of *Heliolithus riedeli* identifies the interval 516F-84-4, 13–14 cm to 516F-85-1, 46–47 cm as the zone of the same name (NP8). The co-occurrence of *D. mohleri* and *H. kleinpellii* assigns Sample 516F-85-2, 40–70 cm to the *D. mohleri* Zone (= *D. gemmeus* Zone) (NP7). In Samples 516F-85-1, 16–17 cm to 516F-86-5, 54–55 cm, *H. kleinpellii* is present and *D. mohleri* is missing, criteria necessary for identification of the *H. kleinpellii* Zone (NP6). The presence of *Fasciculithus tympaniformis* without *H. kleinpellii* determines the interval from Cores 516F-86-6, 50–51 cm to 516F-87-3, 55–56 cm as the *F. tympaniformis* Zone (NP5). Core 516F-87-4, 44–45 cm to 516F-87-5, 46–47 cm include the first occurrence of *Ellipsolithus macellus* to the first occurrence of *F. tympaniformis*, indicating the *E. macellus* Zone (NP4). Samples 516F-87-6, 17–18 cm to 516F-89-3, 86–87 cm contain *Chiasmolithus danicus* but *E. macellus* is missing, indicating the *C. danicus* Zone (NP3). The occurrence of *Cruciplacolithus tenuis* without *Chiasmolithus danicus* places Samples 516F-89-3, 142–143 cm to 516F-89-4, 38–39 cm in the *Cruciplacolithus tenuis* Zone (NP2). The *Markalius inversus* Zone (NP1) is the base of the Paleocene in Samples 516F-89-4, 138–139 cm to 516F-89-5, 33.5 cm.

Cretaceous

The Cretaceous/Tertiary boundary was recovered in Core 516F-89. Calcareous nannoplankton stratigraphy of that core indicates no hiatus between the Cretaceous and Paleocene. The oldest zone of the Paleocene (*M. inversus* Zone NP1) occurs in Sample 516F-89-5, 33.5 cm. The youngest zone of the Cretaceous (*Micula mura* Zone) is assigned to Sample 516F-89-5, 34.3 cm.

Cores 89 to 124 comprise the 284.5 m of Cretaceous sediments recovered from Hole 516F. Calcareous nannoplankton are abundant and fairly well preserved in the upper Maestrichtian. Lower Maestrichtian coccoliths vary downward from abundant to rare and the preservation ranges from good to poor. Dissolution and fragmentation increase downward. The ten zones present in the Cretaceous section span the Coniacian/Santonian to Maestrichtian. The *M. mura* Zone (Cores 89 to 91), with *M. mura* and *Nephrolithus frequens*, represents the top of the Cretaceous. In Cores 91 to 93, the assemblage lacks *M. mura* but *N. frequens* is still present, suggesting the *N. frequens* Zone. The top of the middle Maestrichtian (*Lithraphidites quadratus* Zone) is present in Samples 516F-93,CC through 516F-94-2, 25–26 cm, and the lower to middle Maestrichtian is indicated in Cores 94 to 96 by the *Arkhangelskiella cymbiformis* Zone. The first occurrence of *L. quadratus* defines the top of this interval, and the last occurrence of *Tetralithus trifidus* marks the base. The Campanian/Maestrichtian boundary is within the *T. trifidus* Zone (Cores 96 to 107). The *T. gothicus* Zone was recovered in Cores 107 and 108. The assemblage of this zone contains *T. gothicus*, but *T. trifidus* is missing. Similarly, the *T. aculeus* Zone (Cores 108 and 109) contains the index species but lacks *T. gothicus*. The interval from the last occurrence of *Marthasterites furcatus* and/or *Lithastrinus grillii* to the first occurrence of *T. aculeus* defines the *Broinsonia parca* Zone in Cores 110 to 113. The assemblage with *B.*

parca and *M. furcatus* assigns Cores 113 to 116 to the *Eiffellithus eximius* Zone of the late Santonian. The oldest Cretaceous samples recovered at Site 516 are Coniacian to Santonian and belong to the *M. furcatus* Zone (Cores 116 to 124). The assemblages contain *M. furcatus* and *L. grillii* but are lacking *B. parca.*

Planktonic Foraminifers

Usually one sample per section was examined for foraminifers, but in a few cases more samples were analyzed especially for the Quaternary and Cretaceous/Tertiary boundary intervals. The zonation of Berggren (1973, 1977a, b) is utilized for the Pliocene. Blow's (1969) zonation is retained for the other Neogene sequences, and that of Stainforth and others (1975) for the Paleogene sequence. Weiss (this volume) analyzed the Cretaceous sequence.

The assemblages are relatively well preserved and are summarized in the following categories:

1) Quaternary (between the top of Core 516-1 to Section 516-3-2; from the top of Core 516A-1 to Sample 516A-2,CC).

2) Pliocene (Sections 516-3-3 to 516-11-3; Sections 516A-3-4 to 516A-12-2)

3) Miocene (Sections 516-12-3 and 516A-12-3 to the base of each HPC hole—Samples 516-44, CC and 516A-16, CC; Core 516F-1 to Section 516F-5-6)

4) Oligocene (Sample 516F-5,CC to Section 516F-39-2)

5) Eocene (Cores 516F-39 to 516F-80)

6) Paleocene (Sections 516F-81-3 to 516F-89-5)

7) Cretaceous/Tertiary boundary (at Sample 516F-85-5, 21–26 cm)

8) Cretaceous (Section 516F-85-5 through Core 516F-122) (Weiss, this volume)

Quaternary

Well-preserved and abundant Quaternary foraminiferal assemblages occur in the intervals from 516-1-1, 0–2 cm to 516-3-2, 30–32 cm and from 516A-1-1, 0–2 cm to 516A-2,CC. In these two holes, right-coiling *Globorotalia hirsuta* determines Zone N23 (mudline to Samples 516-1-1, 30–32 cm and 516A-2-3, 50–52 cm). Below this level, the association of *G. truncatulinoides* with a subtropical to transitional assemblage indicates that the sequence is Pleistocene (Zone N22).

Pliocene

Pliocene microfauna were recovered in Section 516-3-3 to Sample 516-12,CC and in Sections 516A-3-1 to 516A-12-2. This microfauna is abundant with good preservation and may allow a differentiation of the zones proposed previously by Berggren (1977a, b) based on the first (FAD) or last appearance datum (LAD) of a few species, such as: *G. miocenica* (LAD), *Sphaeroidinella dehiscens* (FAD), *Globoquadrina altispira* (LAD), *Globorotalia multicamerata* (LAD), *Sphaeroidinellopsis* sp. (LAD), *Globigerina nepenthes* (LAD), *Globorotalia margaritae* (FAD), and *Globoquadrina dehiscens* (LAD).

The Miocene/Pliocene boundary is located at the last occurrence of *G. dehiscens*, and occurs in Sample 516-12,CC and Section 516A-12-2. It is difficult to determine if a hiatus exists between the upper Pliocene Zone PL6 and the Pleistocene, because of some reworking or contamination. Any gap in that interval must be less than that at Hole 357 (Berggren, 1977a).

Miocene

An extensive Miocene sequence was retrieved from Hole 516 and from the upper part of Hole 516A; the base of the Miocene occurs in the cored portion of Hole 516F. A high latitude indicator group, including *Globorotalia miozea conoidea* (upper Miocene to lower Pliocene), *G. zealandica*, and *Globigerina woodi* (lower Miocene) is abundant and shows dissolution effects, particularly in those from the middle to upper Miocene. An unconformity represented by a mixture of Quaternary, Pliocene, and Miocene fauna may span the uppermost middle to the lowermost upper Miocene in Core 516A-16. Contamination and reworking also occur in the uppermost lower Miocene of Hole 516.

The upper Miocene is characterized by the occurrence of *Globoquadrina dehiscens, Globorotalia miozea conoidea* group, and *Sphaeroidinellopsis seminulina.* This association is typical for the *G. conomiozea* and *G. mediterranea* zones of Berggren (1977b), and considered by that author as approximately correlative to Zone N17 (Blow, 1969). In Hole 516, however, the absence of typical *G. acostaensis* and the disappearance of the *G. siakensis* in Core 516-15 are negative criteria in zonal determinations, suggesting the absence of both Zones N15 and N16.

Orbulina first appears in Core 516-17. The fauna of the sequence between this event and the last occurrence of *G. siakensis* is not diversified. The *G. fohsi* group disappears with the first bed. It is, therefore, difficult to differentiate the zones of the middle Miocene or to confirm that they exist in this sedimentary sequence.

The lower Miocene is a long and complete sequence with a fairly monotonous fauna. The association includes: *Globigerinoides altiaperturus, Globorotalia zealandica, Globoquadrina* div. sp., *Catapsydrax dissimilis*, and, in the earliest part, *Globigerinoides primordius* and *Globorotalia kugleri.* An abundance of *Globigerinoides primordius* in Section 516F-5-6 signals the base of the Miocene.

Oligocene

The upper Oligocene *Globigerina angulisuturalis* Zone P22 is indicated between Cores 516F-5 and 516F-14 by the presence of the nominate taxon and by the absence of *Globorotalia opima opima.* In Hole 516F, the *Globigerina angulisuturalis–G. opima opima* Zone P21 and the *Globigerina ampliapertura* Zone P20 are recognized in Cores 15 to 24 and in Cores 25 to 31, respectively. *G. angulisuturalis* resembles the compact high-latitude forms more than the more open and flaring lower-latitude ones. The boundary between the upper and lower Oligocene is based at the last occurrence of *Pseudohastigerina barbadoensis.*

Older zones are difficult to differentiate because of the poor representation of tropical taxons. The sedimentary sequence between Cores 516F-32 to Section

516F-39-2 is, therefore, assigned to the *Cassigerinella chipolensis–P. micra* Zones (Stainforth et al., 1975) as the equivalent of the lower Oligocene. The foraminifers are often corroded, and the faunas are not diverse. The dominant species are *Globigerina galavasi, G. euapertura, Globigerinita unicava*, and, in the upper Oligocene, *Globigerina praebulloides* s.l.

Eocene

An extensive Eocene sequence, about 340 m thick, with common, high-latitude indicator species makes up the interval from Sample 516F-39,CC to Core 516F-78. An upper Eocene sequence begins with the occurrence of *Globorotalia cerroazulensis* and the disappearance of the keeled-margin and spinose *G.* in Section 516F-49-1. Below, the lower/middle Eocene contact is set at the first appearance of the genus *Hantkenina* in Core 516F-71. *G. bullbrooki* also appears at the base of the middle Eocene (Zone P10), but in Core 516F-77 the species occurs with *Globigerina frontosa*. Cores 78 and 79 of Hole 516F contain some *Globotruncana* sp. that are either contaminants or representatives of an lower Maestrichtian slump block. Foraminifers in samples of Core 516F-80 are barren or badly dissolved.

Paleocene

The Paleocene sequence at Hole 516F occurs in Cores 81 to 89. Cores 81 and 82 contain *Globorotalia velascoensis* and a few *G. subbotinae* and are assigned to Zone P6a. The *G. pseudomenardii* Zone is well represented with the nominate taxon in Section 516F-83-5 to Sample 516F-85,CC. Below, *G. angulata* and *G. pusilla* represent the upper part of Zone P3 in Core 516F-86 to Section 516F-88-2. Section 516F-88-3 contains the first *G. uncinata*, indicating Zone P2.

The interval between Sections 516F-89-1 and 516F-89-4 contains *G. praecursoria* and *G. compressa.* This assemblage belongs to the upper part of Zone P1 (P1d). The base of the Paleocene is represented by Zones P1b–c in Samples 516F-89-4, 96 cm to 516F-89-5, 0–21 cm.

The Cretaceous/Tertiary boundary was recovered in Section 516F-89-5. The oldest sediments without typical Cretaceous foraminifers are in Sample 516F-89-5, 21–26 cm. They contain only a few small foraminifers (*Eoglobigerina* div. sp.), preservation is moderate, and the coarse fraction (greater than 160 μ) is barren.

Cretaceous

Upper Cretaceous planktonic foraminifers were recovered in Cores 516F-89 to 516F-122. Frequency and preservation are moderate in the upper Maestrichtian and deteriorate from there to the base. Except for the upper Maestrichtian, therefore, the interval cannot be clearly delimited with the generally accepted foraminiferal zonation. Some of the important zonal markers, moreover, were missing, possibly for paleobiogeographic reasons.

The top of the Uppermost Cretaceous *Abathomphalus mayaroensis* Zone is assigned to Sample 516F-89-5, 29.3–31.2 cm. The base of the oldest zone of possible Santonian-Coniacian age ("*Globotruncana concavata*" Zone) occurs in Section 516F-119-2. The first planktonic foraminifers occur in Section 516F-122-1; they are double keeled and of *G. renzi* type. In all, five planktonic zones and two unzoned intervals are distinguished.

The *A. mayaroensis* Zone is the best identified and ranges from Sections 516F-89-5 through 516F-95-2. At Section 516F-95-2, *A. mayaroensis* first occurs with other globotruncanids, such as *Globotruncana lamellosa, G. stuarti, G. conica, G.* cf. *gansseri*, and *G. contusa*, and with heterohelicids, such as *Racemiguembelina fructicosa, Pseudoguembelina excolata, P. palpebra*, and *Planoglobulina acervulinoides.* Other tropical Tethyan species (such as *Globotruncana patelliformis, G. galeoides*, and *Planoglobulina multicamerata*) indicate the higher part of the *A. mayaroensis* Zone. The total range of the *A. mayaroensis* Zone is the upper Maestrichtian, according to the general planktonic foraminiferal zonation scheme.

The *G. falsostuarti* Zone spans the interval from the first appearance of *G. falsostuarti* to the first appearance of *A. mayaroensis*, That sequence occurs in Sections 516F-95-3 through 516F-104-4 and identifies these as possible lower to middle Maestrichtian rocks. The early to middle Maestrichtian zonal marker *G. gansseri* is absent within this interval. The long-range species (*G. fornicata, G. arca, G. linneiana*, and *Rugoglobigerina rugosa*) are dominant; single-keeled globotruncanids are rare. New species are *G. aegyptiaca, G. gagnebini*, and some multiserial heterohelicids, such as *Guembelina robusta, G. cuvillieri, P. riograndensis*, and *P. manuelensis*.

The Campanian/Maestrichtian boundary is placed between Sections 516F-101-3 and 516F-101-44. *Globotruncana calcarata* was not found; therefore, the first appearance of *G. falsostuarti* possibly indicates proximity to the Campanian-Maestrichtian transition.

Campanian

The interval from Sections 516F-101-4 through 516F-104-4 yielded no useful planktonic foraminifers and was not zoned. At the base, *G. scutilla* and some primitive multiserial planoglobulinids are evident. *Globotruncanella havanensis* appears in higher parts at Core 516F-103-3 and could indicate the *Globotruncana calcarata* Zone.

The *G. ventricosa* Zone includes Sections 516F-104-5 through 516F-112-2, and the index species refers the upper part of this section to the early and the lower part to the late Campanian. Together with this characteristic form, *G. rosetta, G. stuartiformis, G. stephensoni*, and *G. linneiana* have their first appearance. In the upper part, rare specimens of *G. subspinosa, G. obliqua, R. rugosa*, and *Pseudoguembelina costulata* were found.

The first appearance of *G. arca* to the first appearance of *G. ventricosa* defines the *G. arca* Zone and makes up the lower Campanian Sections 516F-112-3 to 516F-114-2. The faunal change within this zone is remarkable; specimens belonging to *G. renzi, G. coronata*, and *G.*

paraconcavata give way to a dominantly *G. arca* assemblage. Specimens of *G.* cf. *asymmetrica* are rare and poorly preserved.

The Campanian/Santonian boundary is based on the first appearance of *G. arca* at Section 516F-114-4, because neither typical *G. elevata* nor true *G. asymmetrica* could be identified.

Santonian

The sequence below the possible Campanian/Santonian boundary contains poorly preserved foraminifers of the *G. renzi, G. coronata, G. paraconcavata* type, and some large specimens of *G. fornicata;* forms that could only indicate a Santonian to Santonian-Coniacian age. The occurrence of *G.* cf. *concavata* between Core 516F-117 and Section 516F-119-2 allows a subdivision into the "*G. concavata*" Zone and an overlying unzoned interval between the last occurrence of *G.* cf. *concavata* and the first appearance of *G. arca.*

Benthic Foraminifers

In general benthic foraminifers occur frequently at Site 516 and are well preserved down to the upper middle Eocene. Below this level all foraminifers become diluted in the clastic sediments, and their preservation deteriorates with increased lithification.

The core-top assemblage (Sample 516-1-1, 1-2 cm) is dominated by *Hoeglundina elegans, Epistominella exigua*, and *Globocassidulina subglobosa.* The Pliocene assemblages exhibit a lower species dominance and lack *H. elegans* altogether. These rich assemblages include *Stilostomella* cf. *lepidula, G. subglobosa, Planulina wuellerstorfi, Cibicidoides kullenbergi, Nuttalides umbonifera, E. exigua, Oridorsalis umbonatus, Pullenia bulloides, P. quinqueloba, Bolivina globulosa, Uvigerina auberiana, Eggerella bradyi, Siphotextularia rolshauseni, Karreriella bradyi, Textularia flintii, Rectuvigerina multicostata, Bulimina subacuminata, Ehrenbergina carinata, Osangularia culter, Planulina karsteni, Laticarinina pauperata*, and *Sphaeroidina bulloides.* Upper and middle Miocene assemblages resemble those of the Pliocene. Dominant genera are *Stilostomella, Planulina, Cibicidoides, Globocassidulina*, and *Bolivina*, with *Uvigerina* and *Bulimina* abundant at certain levels.

Lower Miocene assemblages are distinctly different, partly because of changes in generic dominance, specifically increased frequencies of *Cibicidoides, Lenticulina*, and *Sphaeroidina*, and, at greater sub-bottom depths, *Osangularia* and *Siphonina. Planulina renzi* replaces *P. wuellerstorfi*, and both *Nuttalides umbonifera* and *Epistominella exigua* disappear. New faunal elements include *Siphonina tenuicarinata, Osangularia mexicana, Bulimina tuxpamensis, B. impendens, Astrononion pusillum, Anomalinoides* cf. *alazanensis*, and *A. spissiformis.*

The generic dominance in the upper Oligocene is much like that of the lower Miocene sediments, except for the increased abundance of *Cibicidoides* and the disappearance of *Sphaeroidina.* New species include *Uvigerina mexicana, Bolivina tectiformis, Cibicidoides* sp., *C. dickersoni*, and *C. ungerianus.* The Neogene species *S. bulloides, Textularia milletti, Rectuvigerina vesca, C. kullenbergi, C. cicatricosus*, and *O. culter* do not occur below the upper Oligocene. At many levels, the assemblages are dominated by *Bulimina impendens, B. tuxpamensis, P. renzi*, and *C. kullenbergi* (or *C. ungerianus*).

The dominant genera in the lower Oligocene and upper Eocene are *Cibicidoides, Lenticulina* and *Bulimina.* The assemblages of each interval share many characteristic species, such as *Gavelinella micra, C.* sp., *Hanzawaia cushman, U. havanensis, Bolivina byramensis, Anomalina corrugata, Discorbis subvilardeboanus, Siphonina tenuicarinata*, and *P. renzi.*

Benthic foraminifers are sparse in the expanded middle Eocene section. This heterogeneous, displaced series of pelagic limestones is interbedded with volcanic ash layers, turbidites, breccias, and strata with reefal debris, and contains low-diversity benthic assemblages even in the pelagic limestones. The assemblages are dominated by *Cibicidoides*, buliminids, *Lenticulina* and agglutinants, whereas *Globocassidulina, Siphonina*, and *Planulina* are no longer present. The most frequently occurring species are *C. ungerianus* and *Oridorsalis umbonatus. H. cushmani, Plectina elongata*, and *Bulimina impendens;* several unidentified species of *Pyramidina, Reussella*, and *Trifarina* are more irregular in their distribution. *Nuttallides truempyi* and *Buliminella grata* are abundant only at the base of the section.

A displaced block of upper Maestrichtian limestone separates the lower from the middle Eocene. The benthic assemblage of Sample 516F-79-2, 85-87 cm is dominated by *Gavelinella beccariiformis* and *Praebulimina reussi*, with lower frequencies of nodosariids, *Gyroidinoides* spp., *N. truempyi*, and representatives of *Gavelinella, Lenticulina, Pullenia*, and *Bolivinoides.*

The poorly preserved early Eocene assemblages (Zone P6b) exhibit low species diversity. The most commonly occurring species include *O. umbonatus, N. truempyi*, and *L.* spp. Also present are *Vulvulina mexicana, V. spinosa, Abyssamina poagi, Clinapertina inflata, Alabamina dissonata, Aragonia semireticulata, Buliminella grata, B. tuxpamensis, Nonion havanense*, and *Anomalina capitata.*

The Paleocene fauna differs radically from the overlying lower Eocene assemblages in its increased species diversity and by the predominance of *Gavelinella.* Numerous rapidly occurring extinctions initiated the faunal turnover in the latest Paleocene (Zone P6a). The transition occurs between Samples 516F-83-3, 115-172 cm and 516F-83-4, 12-20 cm. The dominant taxa of the Paleocene are *G. beccariiformis* and *N. truempyi* in association with *Anomalinoides welleri, Bulimina velascoensis, G. hyphalus, G. velascoensis, Gyroidinoides globosus, L. macrodisca, O. umbonatus, P. coryelli*, and *Tritaxia trilatera.* Additional species of limited stratigraphic range are *B. trinitatensis* (early Paleocene) and *Cibicidoides pseudoperlucidus* (late Paleocene).

Rapid change in the benthic fauna occurs across the Cretaceous/Tertiary boundary. Species diversity shows a moderate increase because about one-third of the latest Maestrichtian species do not survive the end of the Cretaceous.

The relatively richer benthic fauna recovered from Campanian and Maestrichtian sediments is characterized by *Gavelinella stephensoni, Gyroidinoides goudkoffi, G. nitidus, Nuttallinella florealis*, and *Praebulimina reussi*, together with the species listed above (except *B. velascoensis* and *A. welleri*), occurring throughout the Paleocene.

In Hole 516F, below Core 109, recrystallization hampers species identification, and much of this section is too highly indurated to be disaggregated. Faunal composition of Santonian assemblages (Cores 116 to 119) are poorly diversified, and probably only those species resistant to diagenetic processes are present. Taxa present include *Globorotalites multiseptus, Gyroidinoides praeglobosus, Lenticulina muensteri*, as well as various gavelinellids.

Paleobathymetry

Only two major assemblages of benthic foraminifers existed below 1 km water depth during the Paleocene, Eocene, and Oligocene, and the boundary between them did not remain isobathyal. Further differentiation of the early Cenozoic faunas offers a somewhat better resolution for the late Eocene and Oligocene.

Starting with the Oligocene, the assemblage in Hole 516F with its relative high abundance and diversity of uvigerinids is limited to bathyal depth, as are *Sphaeroidinella bulloides, Cibicidoides laurisae, Bulimina macilenta*, and *B. antegressa.* The presence (often in abundance) of *Siphonina, B. tuxpamensis, B. anastomosa, C. mexicana*, and *Planulina renzi* suggests a shallower, middle bathyal depth range. For the late Eocene, the occurrences of *Uvigerina basichordata, Siphonina, Discorbis* sp., *Tritaxia californica, Reussella mexicana*, and *Bulimina tuxpamensis* indicate a similar middle bathyal depth range.

The dominance of *Gavelinella, Nuttalides*, and *Cibicidoides* in Paleocene benthic assemblages and a generally high frequency of planktonic foraminifers suggest deeper bathyal depths before the onset of the Eocene.

Downward, progressive shallowing occurs in the Cretaceous section. Campanian and Maestrichtian sediments contain a fauna that, although not significantly different at the generic level from that of the Paleocene, includes increased abundances of nodosariids, buliminids, and gyroidinoids, suggesting middle bathyal to shallow lower bathyal depths. Benthic foraminiferal assemblages dominated by *Gavelinella, Globotalites, Gyroidinoides*, and *Lenticulina* and reduced abundance of the planktonic foraminifers indicate upper bathyal depths during the Santonian. The overall picture of the Coniacian-Santonian interval below 1200 m based on thin-section study is one of progressive shallowing downcore, from outer neritic-upper bathyal conditions in the younger part of this sequence to depths probably less than 20 m at the base of the sedimentary section.

Shallow Water Indications

Coarse levels containing concentrations of pelecypods, large benthics, or larger foraminifers occur at discrete intervals at Site 516. In HPC Hole 516, coarse levels occur characteristically in the upper 10 cm of every core and in some core catchers. In the first case, they are associated with pipe scale and probably are the result of washing out the hole after each piston core is taken.

In Hole 516, the core catchers of Cores 14 (upper Miocene) and 37 (lower Miocene) and Sections 1 and 2 of Core 16 contain small pelecypods, gastropods, otoliths, bryozoans, and large benthics in association with minor amounts of pipe scale. In Core 14, large agglutinated benthic foraminifers, such as *Karreriella bradyi, K. novangliae, Vulvulina pennatula*, and *Gaudryina* spp. form a conspicuous part of the assemblage. The calcareous part of the coarse fraction consists of large nodosariids, *Vaginulinopsis*, lenticulinids, *Planulina wuellerstorfi, Sphaeroidinella bulloides*, and *Gyroidinoides.* Core 37 contains smaller agglutinants (*Vulvulina, Karreriella bradyi*) but more large calcareous species, such as the pustulate *Lenticulina papillosa, Nodosaria, Sphaeroidinella bulloides, Globocassidulina subglobosa, Planulina wuellerstorfi, Cibicidoides kullenbergi*, and *Pyrgo* sp. Large agglutinants are abundant and concentrated at discrete levels in Core 516A-2. Thus, most contaminants (planktonics and benthics) throughout Holes 516 and 516A are Quaternary and the result of downhole caving and the HPC coring process.

In Hole 516F, pelecypods are concentrated at a few levels, mainly Core 5 (basal Miocene, Zone P4) and Cores 30 and 31 (upper Oligocene, base of Zone P20). Scattered pelecypods occur throughout the section. The accompanying association of large benthic foraminifers varies for each level, but includes calcareous genera such as *Lenticulina, Saracenaria, Vaginulinopsis, Nodosaria, Dentalina*, and agglutinated species such as *Dorothia, Martinottiella*, and *Vulvulina.* In particular, the association of calcareous benthic genera indicates a shallower water, approximately an outer shelf-upper slope environment.

Another episode of shallow water influx is found in the middle Eocene of Hole 516F. Reefal debris consisting of calcareous algae and bryozoans in association with larger foraminifers occur at two levels. In Core 50, a thin limestone bed contains *Discocyclina, Linderina*(?), and *Nummulites.* In Core 63, specimens of *Discocyclina, Asterocyclina*, and *Nummulites* were isolated from a soft nodule of reefal debris. These two levels occur in an interval of turbidites and of displaced Maestrichtian limestone. In the (smaller) benthic assemblage, this sedimentary regime is reflected by the unusually high frequencies of large agglutinant species, of which several have their optimal abundance on the upper slope.

Radiolarians

Radiolarian slides were prepared from core catcher samples of all cores at Holes 516, 516A, and 516F. In stratigraphic intervals containing radiolarians, additional samples were prepared from more closely spaced intervals.

Radiolarians are absent from Hole 516, Cores 1 to 34 (0–148 m sub-bottom; Quaternary to lower Miocene, Zone N6). In Cores 35 and 36, siliceous fragments appear for the first time and are increasingly abundant and more well preserved downward. Core 35 contains only spines of siliceous organisms; Core 36 contains scattered fragments of *Cyrtocapsella cornuta, C. tetrapera*, and *Dorcadospyris ateuchus*, which are consistent with an early Miocene age. Cores 37 through 41 contain rare, moderately preserved radiolarians of the early Miocene, probably belonging to the *C. tetrapera* Zone. Some samples within this interval are moderately well preserved, whereas others are poorly preserved and yield only spines or unidentifiable fragments. Cores 42 through 44 contain only spines, and no age can be assigned on the basis of the siliceous microfossils. On the basis of calcareous microfossils, these cores can be assigned to the earliest Miocene (Zone N4).

Radiolarians are totally absent from all samples examined from Hole 516A, Cores 1 to 16 (0–69.5 m sub-bottom; Quaternary to middle Miocene, Zone N9).

At Hole 516F, radiolarian samples were prepared from each of the cores. In Cores 1 to 16 (169–321 m sub-bottom), radiolarian spines and test fragments are present, but they are not sufficiently preserved to allow identification of the taxa. In Cores 18 through 125, no radiolarians were identified in any of the prepared samples. The coarse fraction (carbonate free) consisted almost entirely of clay aggregates and rare detrital mineral grains. A few samples in the interval between Cores 66 and 70 contain aggregates whose morphology bears a faint resemblance to a siliceous skeletal meshwork, suggesting that radiolarians may have been deposited during this interval, and the silica was subsequently remobilized. At Hole 516F, consequently, the radiolarian fragments remaining are insufficient to provide any form of stratigraphic control.

Diatoms

Diatoms were identified in a total of 61 samples prepared and examined from Hole 516F, Cores 1 through 18. Only rare and sporadic diatoms were observed in Cores 1 through 5. Two diatom zones of Gombos and Ciesielski (in press) occur in Cores 6 through 15. The *Rocella gelida* Zone, which straddles the Oligocene/Miocene boundary in the reference section (Site 513A, Leg 71), is present in Cores 6 through 10. The late Oligocene *Triceratium groningensis* Zone is present in Cores 11 through 15. In Cores 16 through 18, diatoms are not sufficiently well preserved to allow specific zonal designations.

PALEOMAGNETICS

Sedimentary Sequence

Introduction

A study of the downhole variation in sediment magnetism and the development of the magnetostratigraphy constitutes an important objective for the continuously cored sediment sequence recovered from Site 516.

As a historical background to this summary of results of remanence measurements, two earlier paleomagnetic investigations in the area are relevant. One of the first reliable polarity determinations to be made for sediment cored by *Glomar Challenger* was reported by Henry and Opdyke (1970) from Site 22. They determined that the upper Oligocene *Braarudosphaera* chalk unit had a reliable direction of magnetization, indicating deposition during an interval of normal geomagnetic polarity. Berggren (1977) described a preliminary magnetic investigation of samples from a number of piston cores collected in the vicinity of Site 357. The investigation was intended to provide a paleomagnetically calibrated chronology for the microfloral and microfaunal biozonations established from the Quaternary–upper Neogene sediments of the Rio Grande Rise. Unfortunately, this goal was not directly achieved because the magnetic signature in these shallow piston cores is somewhat confused and considered unreliable as a recorder of any polarity stratigraphy.

Following these studies, we have an excellent opportunity to appraise the magnetic characteristics of the more complete sequence of Cenozoic through upper Mesozoic sediment recovered at Site 516. The absence of major hiatuses makes this site particularly promising for the resolution of a continuous magnetostratigraphy. The uppermost sub-bottom section at the site cored with the HPC, Holes 516 and 516A, revealed a well-preserved carbonate sequence spanning a time interval from early Miocene to the present. Deeper targets were penetrated by conventional rotary coring, Hole 516F, to a terminal depth of 1270.6 m.

Remanence Measurements—HPC Holes 16 and 516A

Shipboard natural remanent magnetization (NRM) investigations included a study of 175 samples taken from the cores obtained from Holes 516 and 516A. Because Hole 516A duplicates the upper 60 m or so of Hole 516, it provides an ideal opportunity for a comparative spatial study of magnetic properties. Kukla and Zijderveld (1977) maintain that such duplication on a parallel section is a critical test for validating any proposed magnetic polarity stratigraphy.

Some constraint on the remanence investigations is imposed by the physical nature of the nannofossil-foraminifer ooze, the major lithologic unit recovered at the site by hydraulic piston coring. Dewatering on recovery and the generally dilatant character of these sediments made sampling difficult. Despite this problem, every effort was made to achieve a reasonable sampling coverage of the cored intervals; the initial goal was one sample every 0.5 m depth downhole. Low levels of magnetization caused a further difficulty for shipboard remanence measurement. Many samples have intensities close to or only just above instrument noise levels of approximately 0.3 mA/m. Because of this, relatively few samples were subjected to alternating field (AF) demagnetization as part of the shipboard procedure. Subsequently, we remeasured the majority of samples on shore and then subjected them to magnetic cleaning either using a peak AF of 20 mT or thermal demagnetization to 280°C. Although these nannofossil oozes and chalks exhibit some differences in their stability behavior, it is possible to determine the polarity from the cleaned remanence inclination value with a tolerable degree of certainty.

Inclination variations with sub-bottom depth correlate reasonably well between the two HPC holes through the overlap depth interval down to 60 m, confirming the inferred polarity reversal stratigraphy in the upper part of the sequence.

The mean (NRM) inclination values of 35.1 ± 19.0° (Hole 516, n = 144) and 35.4 ± 17.7° (Hole 516A, n = 31) are closely comparable. Corresponding values after demagnetization are 45.3 ± 15.3° (Hole 516, n = 72) and 39.2 ± 20.0° (Hole 516A, n = 32). The large scatter in these inclination values may reflect the character of the remanence carriers in these dominantly biogenous sediments. As observed in earlier paleomagnetic investigations, inclinations shallower than the computed axial geocentric dipole field inclination, 49.4° for Hole 516, are not uncommon and could be caused by an inclination error or compactive effects (Blow and Hamilton, 1975, 1978; Ellwood and Ledbetter, 1977).

The quality of the downhole inclination data for these HPC holes enables tentative conclusions to be drawn about the magnetostratigraphy (Fig. 15). Provisional assignments can be suggested according to the revised Cenozoic geomagnetic polarity time scales of Hailwood and others (1979), Ness and others (1980), and Lowrie and Alvarez (1981). The first reversal boundary identified at a sub-bottom depth of 4 m is correlated to the base of the Jaramillo Event, about 0.97 Ma. If the base of the Olduvai Event is correctly identified at 9 m sub-bottom depth (within Core 516-3), then the underlying Gauss Epoch spans the depth range from 11.5 m to 18.5 m. These assignments imply an average sediment accumulation rate of about 5 m/Ma through the late Pliocene and the Pleistocene. Much increased sedimentation rates characterize the lower Pliocene in Hole 516. Between 18.5 m and 52.5 m depth (Cores 516-5 through 516-13), an interval of dominantly reversed polarity, split by possibly five thin normal zones, is assigned to the Gilbert Epoch. The paleomagnetic evidence, although not conclusive, indicates that part of Epoch 5 (late Miocene) may be present just above a hiatus (inferred from biostratigraphic evidence) at approximately 55 m depth.

Core 516-14 and part of Core 516-15 are normally magnetized. An unambiguous assignment here is difficult; biostratigraphic studies (see Berggren et al., this volume) suggest the presence of a condensed sequence. Therefore, only tentative correlation to Magnetic Anomaly 5A (Epoch 11) is made.

A considerable degree of coring disturbance renders the interval from 63 to 85 m unsuitable for paleomagnetic study. Resolution of the polarity stratigraphy is better from 90 to 180 m, almost at the terminal depth of HPC recovery at Hole 516. The sequence spans the upper Miocene so that an interval from Anomaly 5C (Epoch 16, ~90–105 m depth) to the normal polarity event above Anomaly 6B (Epoch 21) is encountered.

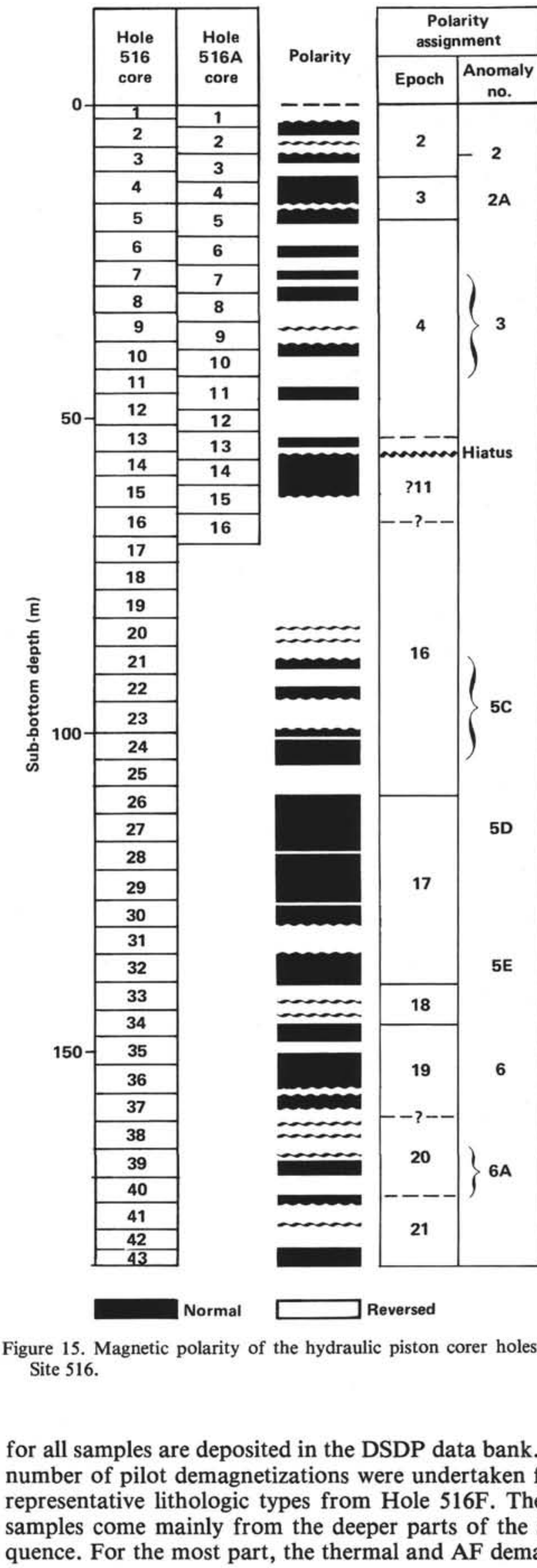


Figure 15. Magnetic polarity of the hydraulic piston corer holes at Site 516.

Remanence Measurements—Hole 516F

About 370 of the 400 samples obtained from the cores recovered from the deep penetration hole, 516F, were used for initial NRM measurements on the ship. The full results of NRM intensity and remanence directions for all samples are deposited in the DSDP data bank. A number of pilot demagnetizations were undertaken for representative lithologic types from Hole 516F. These samples come mainly from the deeper parts of the sequence. For the most part, the thermal and AF demagnetization studies indicate that the pelagic sediments at Hole 516F have a fair degree of stability.

As in the upper part of the sequence, the modal value of the NRM inclinations is shallower than the axial geocentric dipole value. Some two-thirds of sample population have negative NRM inclinations, however, which suggests a component of normal polarity overprinting. After magnetic cleaning, approximately equal numbers of the samples had positive and negative inclinations, confirming the effectiveness of the cleaning procedures in removing this normal overprint.

Figure 16 shows the observed downhole NRM inclination values for the entire hole, together with the inferred magnetic polarity. The polarity reversal stratigraphy is well preserved by the pelagic sediments of this hole. Clearly this is better resolved for the lower (Paleogene and late Mesozoic) part of the hole, which has a high sampling frequency. Assignment of the inferred Paleogene magnetostratigraphy is discussed by Hamilton and others (this volume).

Finally, we note an important reversal boundary detected in Section 516F-89-5 (965 m sub-bottom depth). This reversal occurs very close to the Cretaceous/Tertiary boundary. The underlying Maestrichtian through Santonian sediments are lithologically very similar to those studied paleomagnetically from the classic Late Cretaceous/Paleogene section of the Umbrian Appennines at Gubbio in Italy (Alvarez et al., 1977). The detailed magnetostratigraphy established for Gubbio can be used in the assessment of the Late Cretaceous polarity stratigraphy deduced for Site 516 (Hamilton and Suzyumov, this volume). The 289-m thick pelagic limestone sequence of the Rio Grande Rise preserves a well-defined magnetostratigraphy that can be correlated to the Gubbio Magnetozones A^- through H^+, marine Magnetic Anomalies 34 to 29.

The oldest sediments (recrystallized limestone), recovered in Core 516F-125, are normally magnetized and appear to belong to the upper part of the Late Cretaceous long normal interval, Anomaly 34.

Igneous Basement

Penetration and recovery of igneous basaltic basement from 1252 to 1271 m depth is achieved in Cores 516F-126 through 516F-128. Twelve samples from these basalts were selected for paleomagnetic study. The results of remanence and bulk susceptibility measurements made on these standard core samples are listed in Table 3.

All NRM inclinations are negative (normal polarity), and this is maintained after AF demagnetization up to 80 mT or after thermal demagnetization. The mean NRM inclination of $-68.5 \pm 5.3°$ is considerably steeper than the axial geocentric dipole field inclination of $-55°$ for the paleolatitude of the Rio Grande Rise in the Late Cretaceous. This mean inclination is not significantly changed from magnetic cleaning (mean inclination = $-65.5 \pm 11.4°$). It is difficult to account for the relative steepness of this inclination, except for the possibility that the drill hole was nonvertical at these depths or that there was postextrusion tectonic tilting. Another feature of interest is the apparently small scatter of the NRM in-

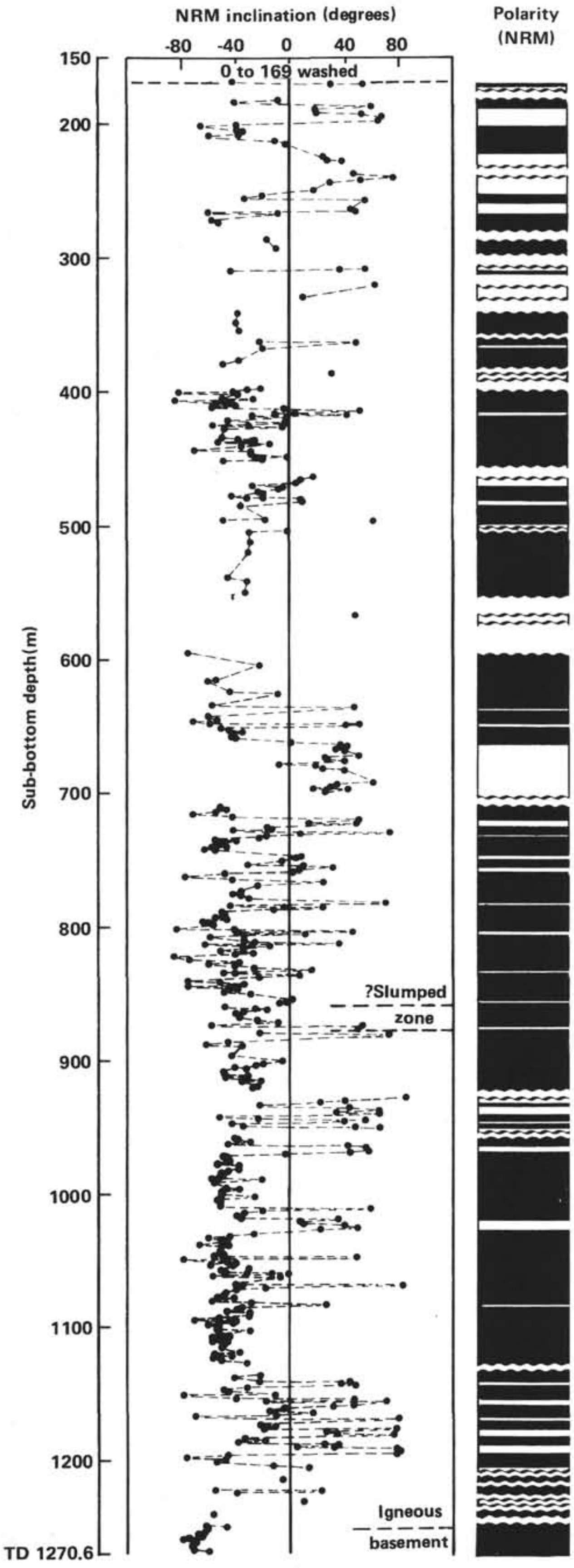


Figure 16. Downhole natural remanent magnetization (NRM) inclination and magnetic polarity for Hole 516F. TD = Terminal depth.

Table 3. Summary of magnetic data for Hole 516F basalts.

Core-section (interval in cm)	Sub-bottom depth (m)	NRM intensity (A/m)	Volume susceptibility ($\times 10^{-6}$)	Q′	Inclination (°) $I_{(0)}$	Inclination (°) $I_{(60)}$	Median destructive field (mT)
126-1, 99-101	1253.60	0.014	48	0.29	−62.6	−62.4	26
126-2, 32-34	1254.43	0.686	105	6.53	−67.1	−71.3	26
126-2, 145-147	1255.56	1.305	376	3.47	−66.2	−71.6	26
126-3, 59-61	1256.20	2.277	680	3.35	−66.6	−66.0*	—
126-3, 127-129	1256.88	0.485	157	3.09	−64.9	−58.3	2.5
127-1, 64-66	1258.25	0.663	773	0.86	−74.9	−76.0*	—
127-2, 54-56	1259.65	0.992	1007	0.99	−79.1	−72.8	23
127-3, 55-57	1261.16	0.073	98	0.75	−69.5	−74.4	20
127-4, 15-17	1262.26	0.175	79	2.22	−69.4	−68.3	41
127-4, 138-140	1263.49	2.705	891	3.04	−72.1	−33.2	18.5
128-1, 35-37	1266.96	1.420	273	5.20	−70.8	−67.0	49
128-3, 26-28	1269.87	2.299	850	2.71	−59.3	−65.4	34

Note: Q′ is a modified Konigsberger ratio (i.e., in a field strength of unity); * indicates cleaned inclination values after thermal demagnetization; dashes indicate no information available. $I_{(0)}$ and $I_{(60)}$ are inclinations before and after alternating-field demagnetization in a peak field of 60 mT.

clination values. Lack of scatter may indicate either a phase of rapid extrusion, which is short compared with the periods of secular variation (about 10^3 yr.), or alternatively point to a single episode of remagnetization during a later phase of reheating.

NRM intensities, susceptibilities, and modified Konigsberger ratios (Q′) given in Table 3 are towards the lower end of the range of values normally found for the drilled oceanic crust.

SEDIMENTATION RATES

Site 516 provides one of the most complete successions of Tertiary and Late Cretaceous marine sediments in the world. With the exception of a hiatus in the middle to late Miocene, there is no evidence of missing sections in this continuously cored sequence. Important stratigraphic boundaries are intact, including the Cretaceous/Tertiary boundary (Core 516F-89), the Eocene/Oligocene boundary (Core 516F-82 or 516F-83), and the preglacial to glacial transition of the Pliocene (Holes 516 and 516A, Cores 5 to 6).

Computed sedimentation rates are shown in Figure 17. Stratigraphic control comes from calcareous nannofossils, planktonic foraminifers, and magnetic reversals. In the Tertiary, the revised time scales of Berggren, Kent, and Van Couvering (in press) have been used for the Neogene, and Berggren, Kent, and Flynn (in press) have been used for the Paleogene. The only significant discrepancy among age assignments in the Tertiary is within the middle Eocene, and estimates of Tertiary sedimentation rates should be fairly good.

For the Cretaceous, biostratigraphic control is less precise. The stratigraphic scheme of van Hinte (1976) is accepted in a general way, but absolute ages are recalibrated using the measured magnetic reversal stratigraphy and the reversal time scale of Berggren, Kent, and Flynn (in press). Thus, the apparent consistency of nannofossil, foraminiferal, and magnetic reversal ages within the Cretaceous in Figure 17 is partly artificial.

Measured sedimentation rates in Figure 17 are not corrected for compaction. For comparison with modern sedimentation rates, the measured rates may be corrected to a common 60% (seabed) porosity, using the wet-bulk density measurements in Figure 18B, and a (calcite) grain density of 2.71 g/cm^3. "Seabed" rates are obtained by multiplying the measured rate in Figure 17 by $1.48\varrho_B - 1.521$, where ϱ_B is the wet-bulk density.

Sedimentation at Site 516 is predominantly pelagic, and sedimentation rates are typical for sediments beneath relatively productive surface waters. Rates are reduced abruptly at the Cretaceous/Tertiary boundary (see Hamilton et al., this volume), and Paleocene rates are extremely low. Pelagic sedimentation during the middle Eocene is augmented by partly volcanogenic turbidites derived probably by subaerial erosion from a tilted and uplifted block upslope (see Bryan and Duncan, this volume; Barker et al., this volume). High rates continued into the early Miocene, however, which suggest a real increase in productivity, possibly of local extent, following the middle Eocene uplift. An $^{40}Ar/^{39}Ar$ age (Mussett and Barker, this volume) for the basal lavas in Hole 516F is consistent with the age of the basal sediments, but the K-Ar age of 47.4 ± 0.7 Ma on biotites from an ash bed within Unit 4 (Bryan and Duncan, this volume), is compatible with only the nannoplankton age, in a region where ages are not mutually consistent.

PHYSICAL PROPERTIES

A large number of physical properties measurements were made at Site 516 in both the HPC holes (516 and 516A) and in the rotary hole (516F). Properties measured include shear strength, acoustic velocity, density, water content, porosity, and thermal conductivity. The principal purpose of this section is to describe the variation of physical properties down the hole and their relation to lithology. The mechanical properties of sediments in the upper part of the section are discussed by Walton and others (this volume). Tables of physical properties for Hole 516F are included in three chapters in this volume (Carlson et al., Schaftenaar et al., and Gebhard and Carlson).

Hole 516 was cored using the HPC to a depth of about 180 m. The physical properties of the sediments recovered appear to reflect the degree of disturbance caused by coring in carbonate oozes, as opposed to *in situ* properties. The first section of each core was often visibly disturbed. Furthermore, after the core was split, significant disturbance could be produced by tapping lightly on the core liner. Measured velocities also suggest disturbance because they fail to increase with depth. The average of 69 measurements made through the core liner is 1.58 km/s, with a standard deviation of only 0.02 km/s. By contrast, the near-surface velocity gradient in calcareous sediments of the equatorial Pacific is 1.83 s^{-1} and Hamilton (1979) has suggested that the gradient should be 1.5 to 1.8 s^{-1} in the upper 200 m of undisturbed carbonate sections.

Perhaps the most striking evidence of disturbance in the HPC cores is in the variation of shear strength (Fig. 19). The apparent shear strength shows a systematic decrease from about 160 g/cm^2 in the uppermost few meters of the section to about 0.85 g/cm^2 at a depth of 75 m. Below 80 m, the shear strength does increase, but so does the variability. Of the 31 cores in which two or more measurements were made, 17 show a net decrease

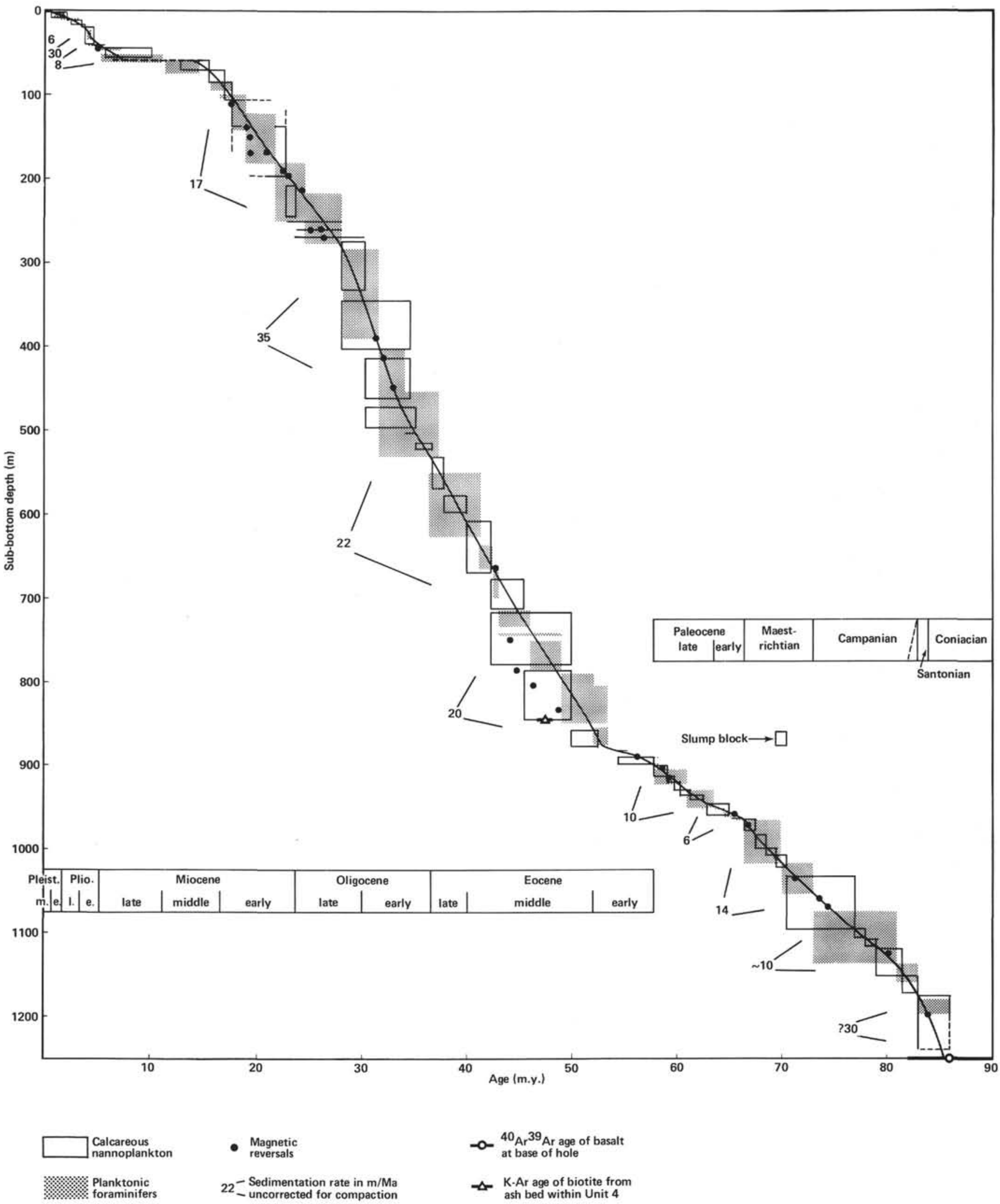


Figure 17. Accumulation rates based on calcareous nannoflora and planktonic foraminifers at Site 516.

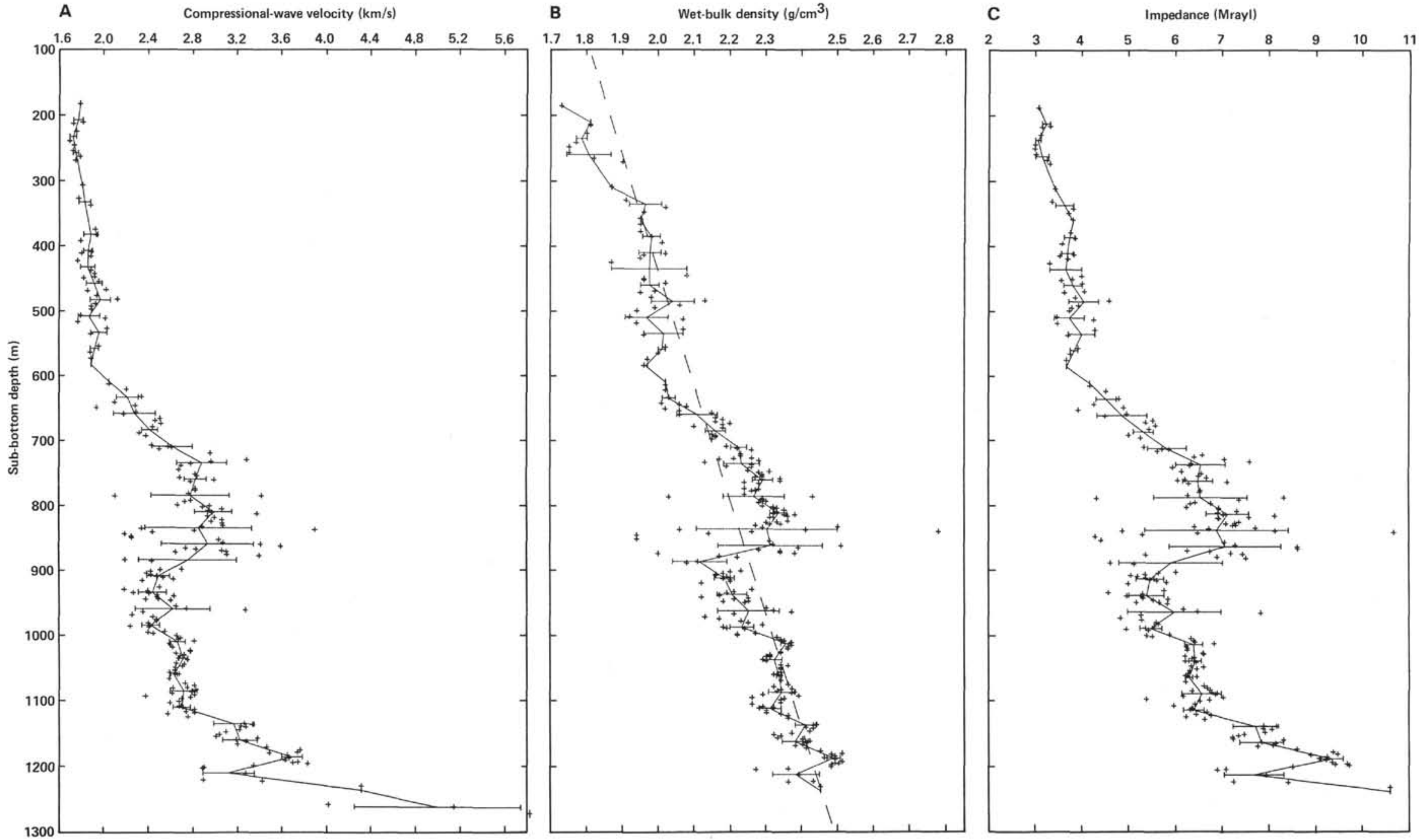


Figure 18. Physical properties measurements for Hole 516F. A. Compressional-wave velocity versus sub-bottom depth. B. Wet-bulk density versus sub-bottom depth. C. Impedance versus sub-bottom depth.

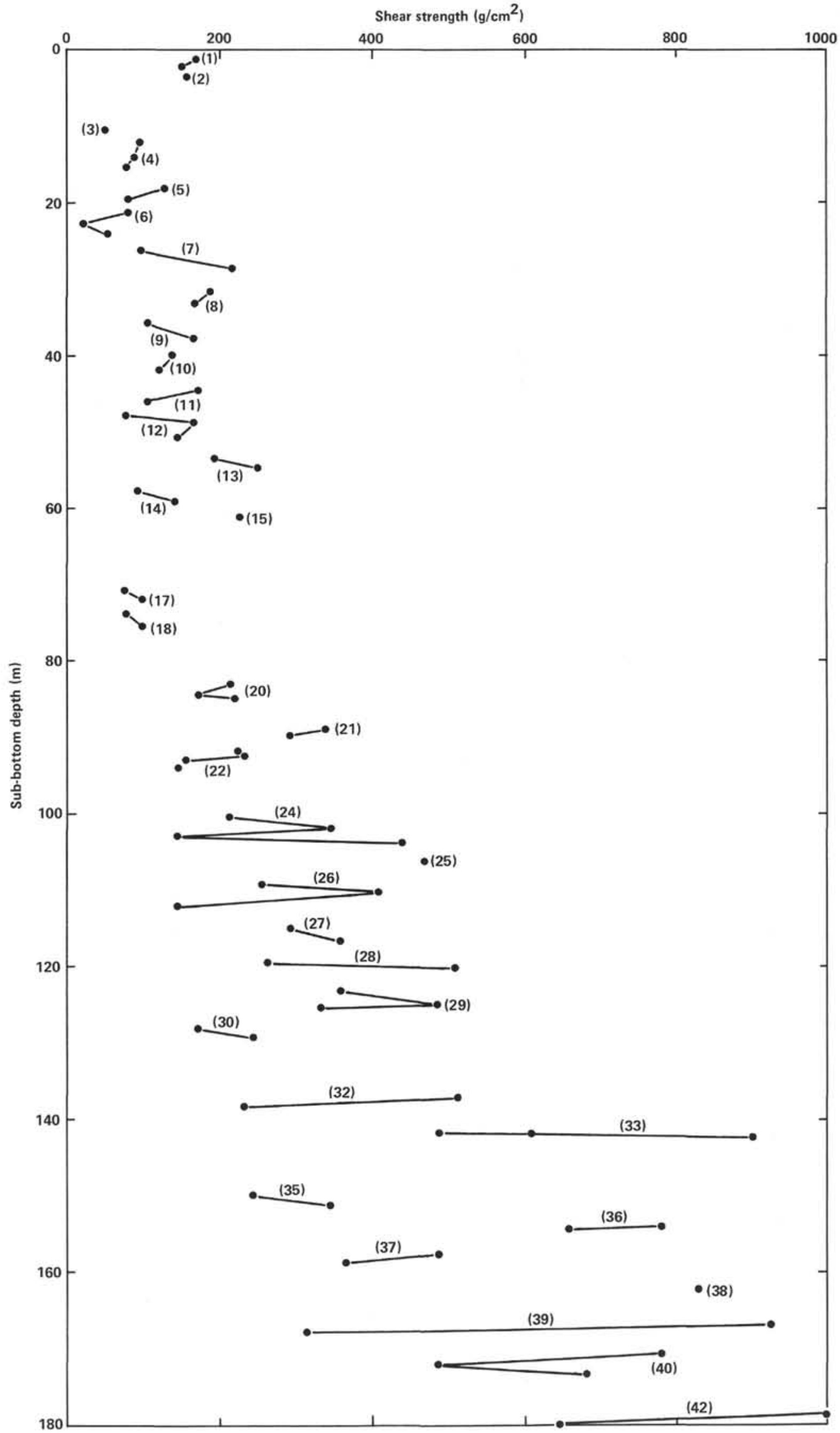


Figure 19. Shear strength versus sub-bottom depth in hydraulic piston corer Hole 516. Core numbers are in parentheses.

in shear strength down the core. In several cases, the magnitude of the decrease is quite large. The variation in shear strength within cores is often more than 100 g/cm^2, and frequently reaches magnitudes of 300 to 400 g/cm^2 in cores recovered from depths greater than 80 m. Results of a shore laboratory study of the mechanical properties of unconsolidated sediments sampled with the HPC (Walton et al., this volume) strongly support the conclusion that these sediments are significantly disturbed in the coring process, and that the measured properties are not representative of *in situ* values. Consequently, acoustic velocities, bulk densities, and porosities are not included in this report.

Continuous rotary coring in Hole 516F through more than one km of calcareous sediments, ranging in age from 20 Ma to about 84 Ma, provided an excellent opportunity to study the variation of physical properties downsection, and a large number of measurements was made. Figure 18 illustrates variations of compressional-wave velocity, density, and acoustic impedance with depth. Physical properties, including water content and porosity and the acoustic properties of indurated calcareous sediments from this site, are described in Schaftenaar and others and Carlson and others (both this volume). The elastic properties of the basalts are described by Gebhard and Carlson and Schaftenaar and others (both this volume).

Wet-bulk densities were measured by immersion or by the 2-minute GRAPE method, but only the immersion values are shown in Figure 18. Compressional-wave velocities were measured parallel (V_h) and perpendicular to bedding (V_v). The average sound velocity, $V_{av} = (V_v + 2V_h)/3$ is shown in the figure. Acoustic impedance is the product of density and velocity, here given in Mega rayls (1 rayl = 1 $kg \cdot m^{-2} \cdot s^{-1}$).

The variation of physical properties corresponds well with variations in lithologic characteristics and with the reflection profile (see next section). Because of coring disturbance, few measurements were made in Unit 2, a nannofossil ooze with chert nodules that has velocities in the range 1.6 to 1.7 km/s and bulk densities ranging from near 1.7 g/cm^3 to near 1.9 g/cm^3. Both velocity and density increase slightly at the top of Unit 3, a chalk and limestone sequence in which densities increase from about 1.95 to 2.05 g/cm^3 at a depth of 634 m. Velocities increase from 1.8 to about 1.95 km/s at a depth of 600 m, then increase rapidly to 2.1 km/s at the base of the unit. The abrupt change in velocity gradient does not correspond to an identifiable lithologic change, and the boundary between Units 3 and 4 is not marked by a significant change in the gradient. Bulk density increases slightly, however, across the contact. Unit 4, which extends from 634 to 874 m depth, consists of interbedded pelagic limestones, altered volcanic ash, and turbidites. Densities and velocities are highly variable. Average densities increase from 2.1 to 2.35 g/cm^3; velocities increase from 2.1 to 2.85 km/s. At a depth of about 740 m, the average velocity is near 2.8 km/s, and at this point the velocity gradient decreases abruptly. The boundary between Units 4 and 5 is the site of a marked inversion in physical properties; densities decrease abruptly from 2.35 to 2.15 g/cm^3, and velocities decrease from 2.85 to about 2.4 km/s. Unit 5 is a nannofossil limestone sequence in which both velocity and density exhibit slight depth gradients. Unit 6a is a sequence of interbedded limestones and marly limestones. Both velocity and density increase slightly at the top of the unit, which is characterized by a relatively low degree of scatter and low gradients; velocities in Subunit 6a are near 2.7 km/s and densities average 2.33 g/cm^3. The boundary between Subunits 6a and 6b is marked by an increase in density to about 2.4 g/cm^3. The acoustic velocity increases to 2.9 km/s. Subunit 6b is a recrystallized, dolomitic limestone in which the vertical velocity gradient is 12 to 14 s^{-1}; the velocity at the bottom of the unit is near 4.4 km/s. The corresponding increase in density is not so dramatic, and the drastic increase in velocity is probably related to cementation and dolomitization. The underlying basalts are highly altered and range in velocity from 4.3 km/s to more than 5.7 km/s (Gebhard and Carlson, this volume). Thus, the velocity contrast between the basal limestones and underlying basalts is small.

Abnormally high velocities are associated with Unit 4. If data in the interval between 600 and 884 m sub-bottom is neglected, the vertical velocity gradient in the upper 1000 m at Site 516 is 0.75 to 1.25 s^{-1}. Thus, the higher velocities in the middle of this section may be regarded as anomalous. Unit 4 includes a significant proportion of volcaniclastic debris and correlates with the "midsection domes" seen on regional reflection profiles. Velocities in this interval increase with decreasing carbonate content. These conditions suggest that the anomalous properties of rocks in this interval are related to diagenetic processes occurring in a sequence of calcareous and siliceous sediments. The fact that the anomalous velocity gradient at the top of Unit 4 extends into the lower part of Unit 3 appears to support this view.

CORRELATION OF REFLECTION PROFILER DATA WITH DRILLING RESULTS

The distribution of reflection profiles in the immediate vicinity of Site 516 is shown in Figure 20. Original site selection was based on the Lamont-Doherty *Vema* 26-06 profile (Fig. 21), in which basement appears to lie about 0.8 s sub-bottom. The potential Site 516 was then surveyed further during the UTMSI multichannel survey of most of the South Atlantic sites in July 1979. When the processed data became available in December 1979, it was clear that the 0.8 s reflector lay some distance above the base of the sediment pile. Figure 22, an extract of line WSA13 of that survey, shows acoustic basement at between 1.1 and 1.25 s; the earlier assumed basement is a strong composite midsection reflector in the form of domes rising to varying heights above a flatter base. *Glomar Challenger* was required to undertake further survey to ensure that the drill site avoided these domes, which were considered potential hydrocarbon reservoirs.

The *Glomar Challenger* profile approaching the site (Fig. 23) consists of one long section steamed northward, followed by a turn to the south for the final approach. Arrows on both of these crossings indicate the

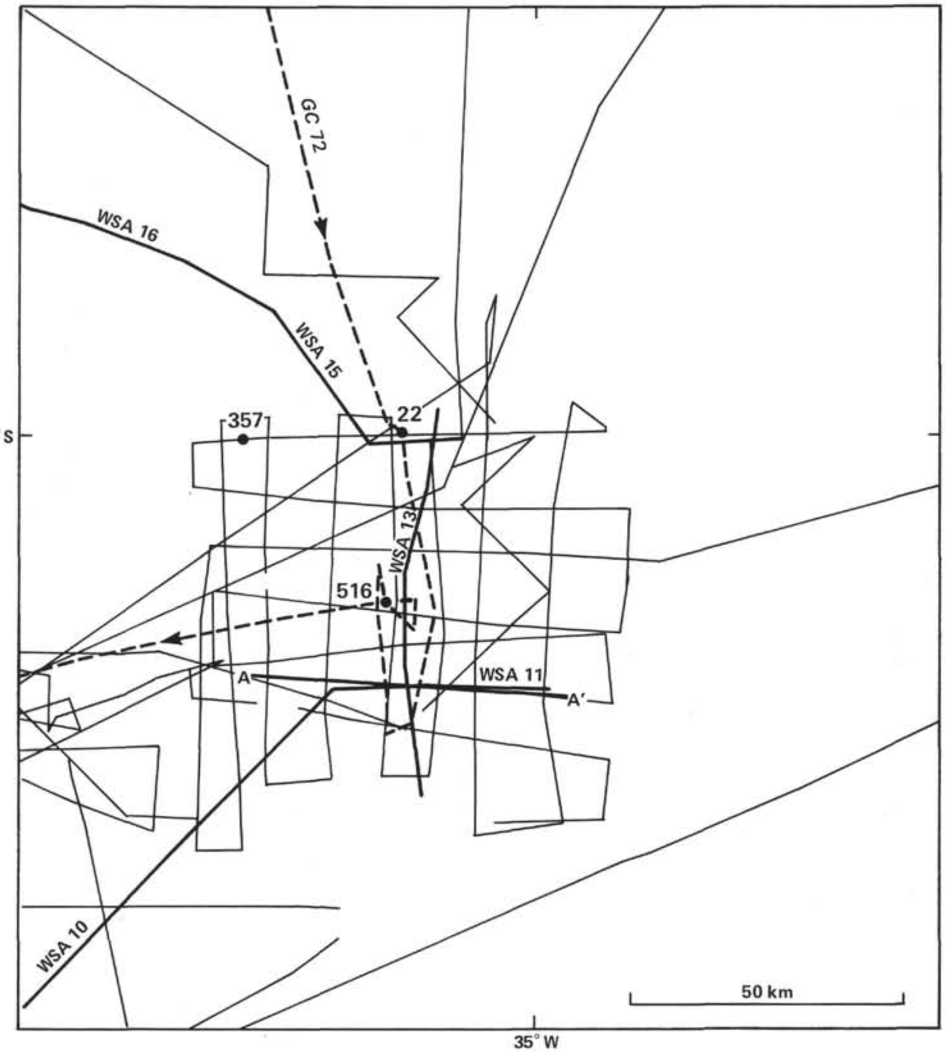


Figure 20. Track line plot of profiles around Site 516. Track segment AA′ is shown in Figure 21, dashed line is *Glomar Challenger* track (Figs. 23 and 24), and thick line is *Fred H. Moore* track (UTMSI profile, Fig. 22).

site location. The final position was chosen over a basement high (only 1.04 s sub-bottom) and on the edge of the "domes" province, so that the uppermost part of the dome reflector lies at 0.69 to 0.74 s. The site is about 3 n. miles away from the UTMSI line at its closest approach (arrow in Fig. 22), and was linked to this line by surveying after drilling.

Sonic velocity measurements on the samples cored at Site 516 are described in the Physical Properties section. Figure 24 shows a velocity model fitted to the data. Following experience at Site 515, and taking into account the measurements at elevated pressure (reported by Carlson, this volume; open circles in Fig. 24), the model is drawn as a slightly high-biased fit to the horizontal (parallel to bedding) shipboard measurements (solid dots in Fig. 24). It is consistently faster than almost all of the shipboard vertical velocity values. The data coverage is excellent, although only horizontal velocity measurements could be made in the less consolidated sediments above 185 m. Scatter of the measurements increases considerably below about 720 m, and uncertainty about an appropriate velocity model also increases.

The velocity structure down the hole results from progressive compaction and diagenesis of a uniform carbonate sequence, from ooze to chalk to limestone, interrupted in midsection (between about 600 and 880 m) by a much more cemented and recrystallized interval. As the carbonate content diagram clearly shows (Fig. 3), velocity and the proportion of noncalcareous sediment (possible volcanic ash layers, turbidites) are highly correlated. The highest velocities occur within limestones, whereas the turbidites are unconsolidated and possess low velocities. Some migration of fluids (probably mainly of silica) has likely taken place from the noncarbonate components and contributed to the cementation and diagenesis of the carbonates.

In general, wet-bulk density changes and velocity changes coincide so that the discontinuities in the ve-

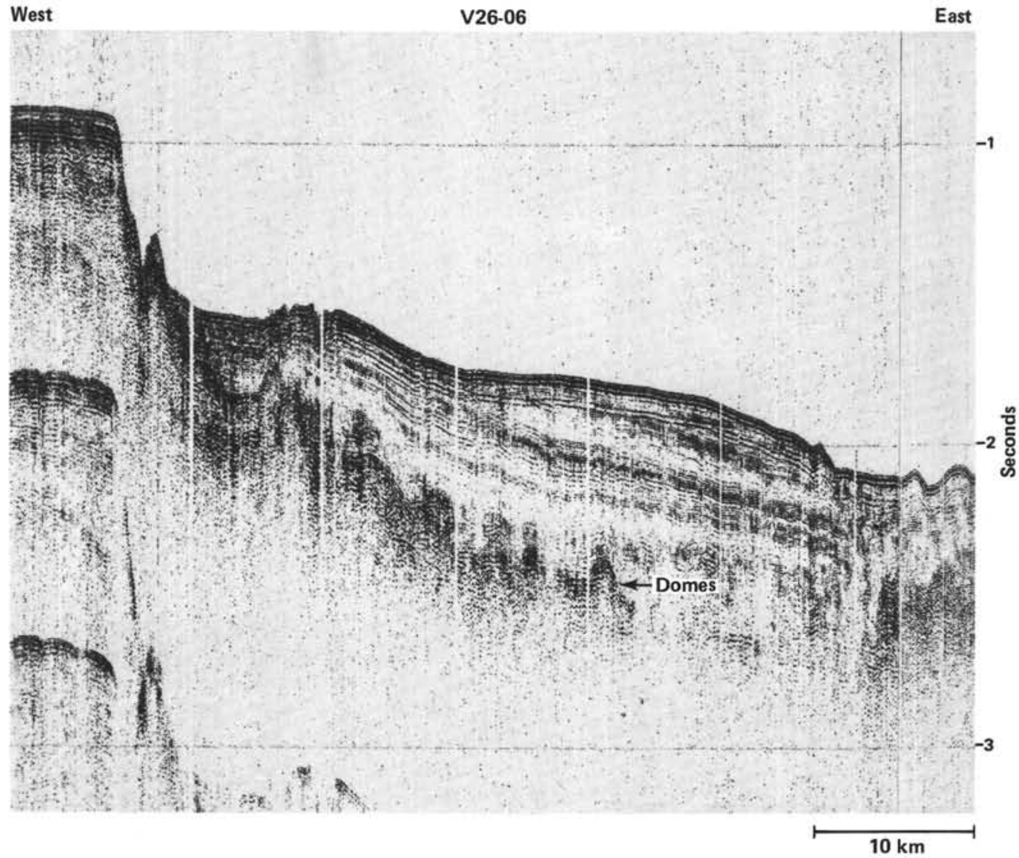


Figure 21. Lamont-Doherty Geological Observatory seismic reflection profile and location of middle Eocene "midsection domes."

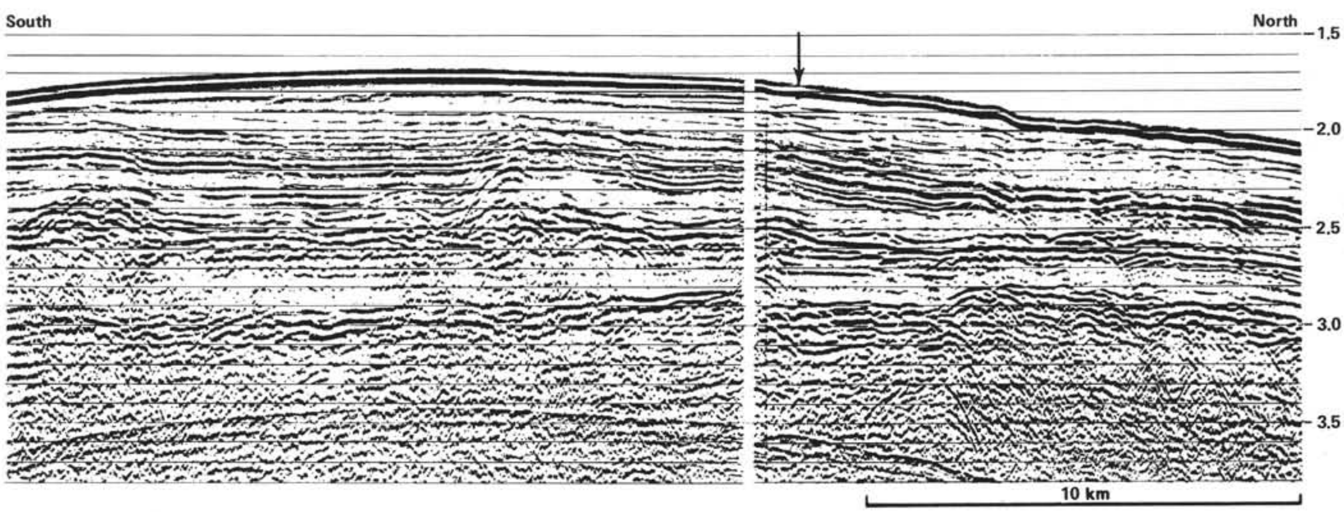


Figure 22. UTMSI processed multichannel line WSA13. Arrow indicates closest approach to Site 516 (3 n. mile).

locity structure, as picked out by the velocity model, should produce reflectors in the seismic record at approximately the times noted in Figure 24.

The most prominent features of the *Glomar Challenger* profile approaching the site (Fig. 23) are (1) the "basement" high at about 1.04 s, (2) the "midsection domes" horizon, the top of which lies with the range 0.69 to 0.74 s at the site, and (3) a suite of reflectors beneath 0.40 s that have the draped appearance of pelagic sediments. It seems clear, despite the slight discrepancy (less than 3%) between the velocity model's predictions and actual time to the reflectors, that these represent, respectively, (1) the velocity change at 1125 m; (2) the steep velocity gradient beneath 600 m; and (3) the step in the velocity model at 330 m. If this is accepted, it is possible to correlate the entire lithologic section with

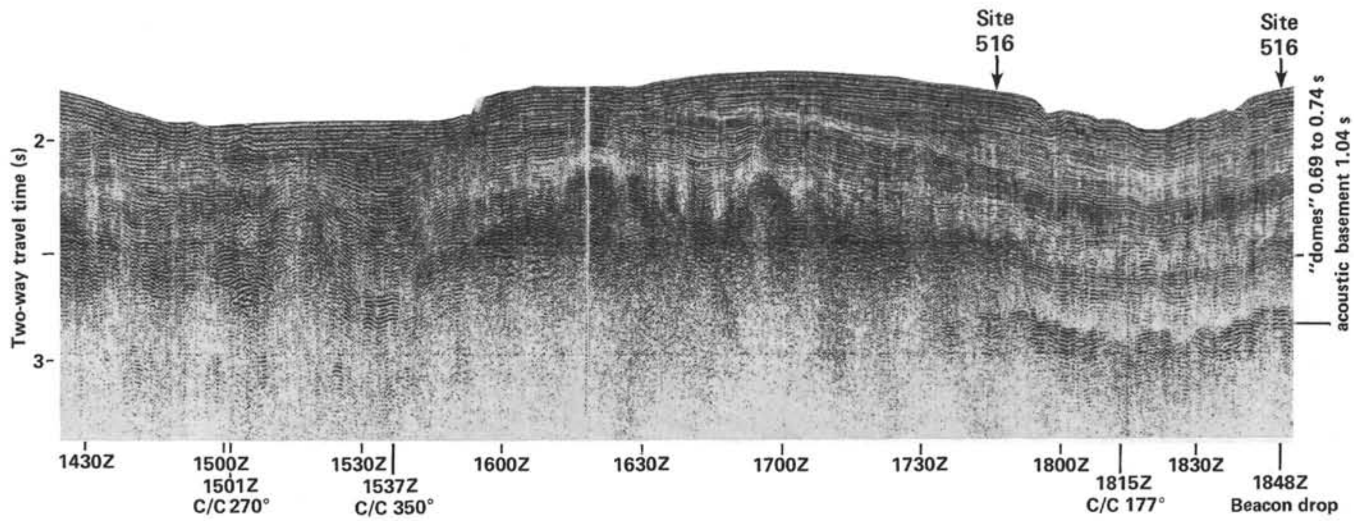


Figure 23. *Glomar Challenger* single-channel seismic profile showing the approach to Site 516. C/C = course change.

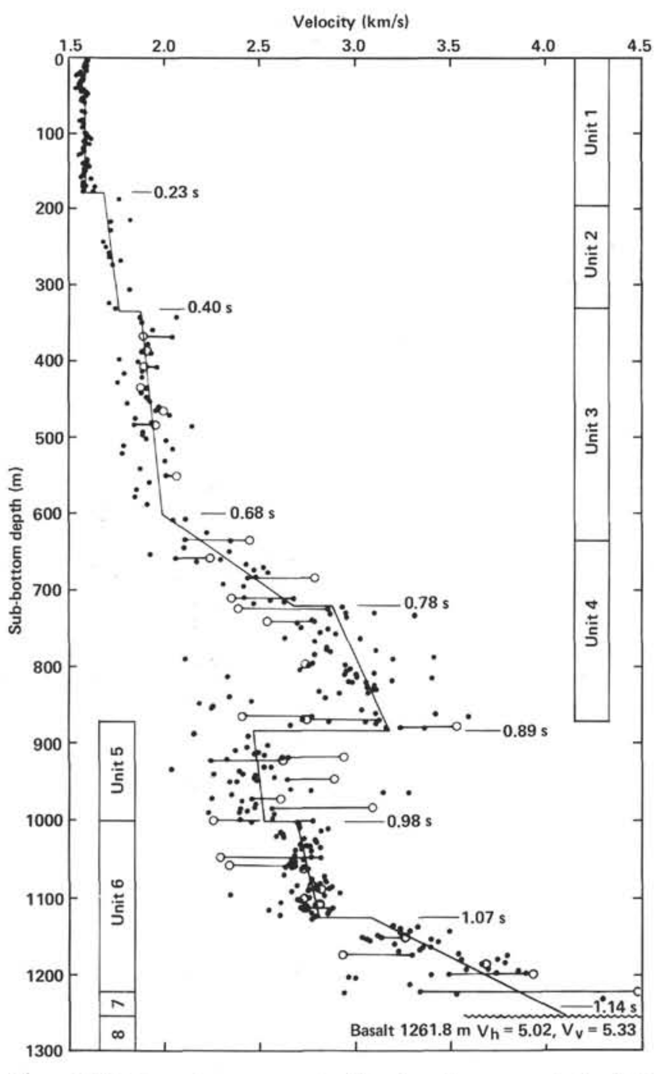


Figure 24. Shipboard measurements of horizontal p-wave velocity (V_h) plotted against depth (solid circles), and compared with lithologic units cored at Site 516. Open circles are vertical P-wave velocities (V_v) at 0.1 kbar confining pressure (Carlson et al., this volume).

the profile. Figure 25 is an enlargement of part of Figure 23, showing the identifications made.

Acoustic basement at 1.04 s is not the basaltic basement of Cores 516F-126 to 516F-128, but is the top of the white microcrystalline limestone and gray marly limestone and claystone of the top of Subunit 6b. Velocities within these sediments range up to 4.4 km/s, and it is not surprising that the basalt beneath them does not give rise to a distinct reflection at the site. A single-channel, *Glomar Challenger* seismic profile (Figs. 23 and 25) shows that Site 516 stands on a local basement high, which may be diagenetically controlled. The strong, widespread reflector of the multichannel profiles, which is probably basalt, lies slightly deeper at the intersection of the multichannel and the *Glomar Challenger* profiles. On the multichannel profiles, other reflectors occur beneath this basalt. Barker and others (this volume) interpret these reflectors as interbedded subaerial lavas and sediments produced by subaerial seafloor spreading, as in Iceland at present.

The other high-velocity, strongly recrystallized part of the drilled section lies between 600 and 800 m sub-bottom, the "midsection dome" sequence of the reflection profiles. The dome sequence is clearly thick and irregular in Figures 23 and 25, and, because of its depth range, is confidently identified with the middle to upper Eocene Unit 4 at the site. Its character away from the site is seen better in Figure 22, however, because of the reduced vertical exaggeration. The sequence has an irregular upper surface, a complicated internal structure and a relatively flat base. It does not appear to be influenced by the underlying "basement" topography, but the overlying reflectors are influenced by it, apparently undergoing differential compaction and faulting. It seems very likely that, away from the site also, the dome sequence is diagenetic; its distribution is controlled mainly by the availability of silica and reflects the distribution of volcanogenic sediment deposited as slumps, turbidite flows, or ash falls. Depth of subsequent burial would be an additional, probably secondary, influence.

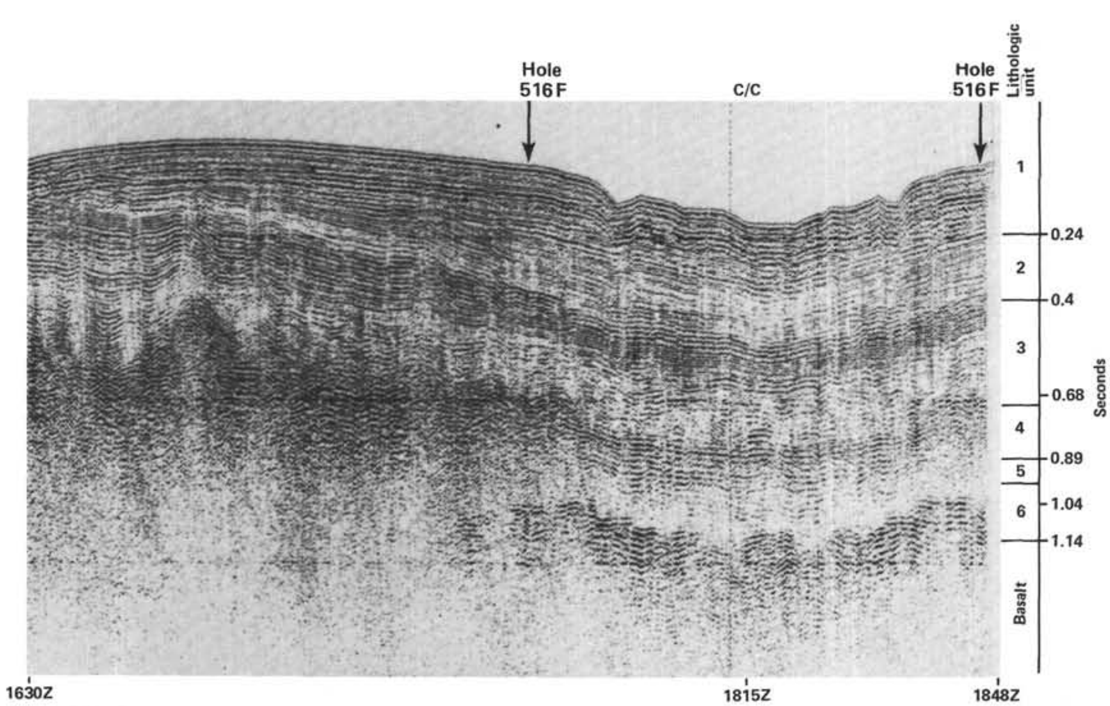


Figure 25. Enlargement of part of Figure 26: *Glomar Challenger* profile recorded during the vessel's approach to Site 516. C/C = course change.

At Site 357, 36 km downslope from Site 516 and more distant from the topographic highs, the middle Eocene noncarbonate component is more restricted, and the excursions in the physical properties were less pronounced (Supko et al., 1977), in accordance with this interpretation. Also, if the dome reflectors are associated with turbidites and slumps in the way suggested then they should become more extensive upslope, nearer to the source, and should die out downslope, which they appear to do (Fig. 21).

The reflectors above the domes follow the shape of the domes themselves. Sediments younger than middle Eocene (Units 2 to 3) are essentially pelagic and could merely have been draped over hummocky slump topography. Signs of high-angle faulting (Fig. 22), however, suggest that some differential compaction may be taking place, effectively propagating upward and preserving the dome topography. One such fault reaches the surface very near to Site 516 (Fig. 26).

The 3.5-kHz echo sounder proved most useful in providing penetration of the uppermost 50–100 m. This depth range lies within the wave train of the seabed reflection in normal air gun profiles, but is of great interest in the context of HPC sampling. Figure 26 shows the 3.5-kHz profile on the approach to Site 516, with an enlarged on-site record inset. Two prominent reflectors are visible in both records at sub-bottom depths of about 56 and 66 m. The higher, weaker of these lies within Core 14 of Holes 516 and 516A; the lower, stronger reflector lies within Core 16. Recovery in Cores 15 and 16 was severely disrupted in both holes, perhaps by a coarse foraminiferal sand with manganese nodules, which marks a hiatus of several million years' duration during the late and middle Miocene. The 3.5-kHz profile clearly shows that the relationship of these two reflectors is uncomformable and that the hiatus is probably more extensive upslope.

The seismic reflection character of Rio Grande Rise sediments and basement is considered in greater detail by Barker and others (this volume).

SUMMARY AND CONCLUSIONS

Site 516, located in 1313 m of water on the northeast flank of the Rio Grande Rise, occupied 19 days of Leg 72. Of the seven holes drilled, four were abandoned with little or no recovery either because of bad weather or because of equipment malfunction. Of the remainder, Hole 516 is an HPC hole continuously cored to 183.3 m with 81% recovery; 516A repeated the uppermost 69.5 m of the section, with 88% recovery, in anticipation of heavy sample demand; and Hole 516F was washed to 169.1 m and then rotary drilled with continuous coring to 1270.6 m. An attempt to log Hole 516F failed because of caving at 184 m.

One of the most significant results of drilling at Site 516 is that the recovered carbonate sequence appears to be continuous from the Santonian-Coniacian to the Recent, with the exception of a minor unconformity in the upper Miocene. Several important boundaries were recovered intact, including the Cretaceous/Tertiary boundary, the Eocene/Oligocene boundary, and the lower Pliocene glacial to interglacial boundary. Absolute ages according to the time scale of Hardenbol and Berggren (1978) are well defined for the Tertiary, and age assignments based on assemblages of foraminifers and nannofossils are in agreement. For the Cretaceous, the nannofossil succession is not entirely consistent with that suggested by van Hinte (1976), but does agree with results from nearby Site 357. Sedimentation rates exceed 10 m/Ma (uncorrected for compaction), except within

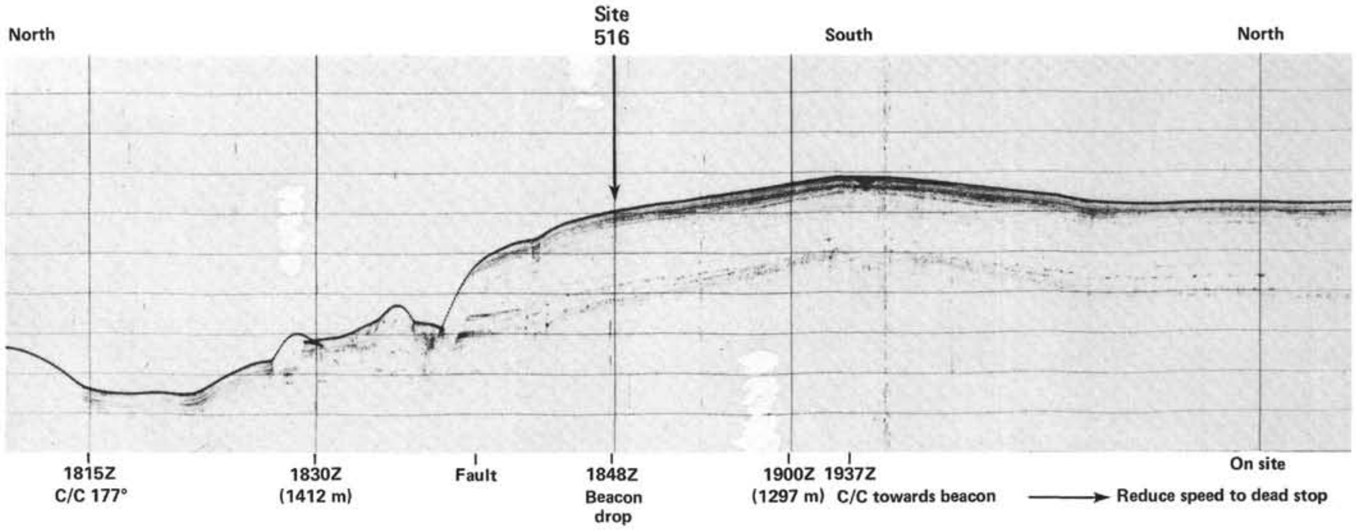


Figure 26. Seismic record (3.5 kHz) approaching Site 516 (see Figs. 2 and 23). C/C = course change.

the Paleocene and parts of the Neogene, and the sediments appear stably (though weakly) magnetized.

Because of its stratigraphic continuity, average sedimentation rate, generally moderate to well preserved microfossil assemblages, and stable magnetization, this dominantly carbonate sequence will probably become a biostratigraphic and magnetostratigraphic type section.

Eight lithologic units were distinguished on the basis of degree of lithification and diagenesis of an essentially continuous pelagic carbonate succession, and its contamination by mainly volcanogenic sediment. These units are tabulated in Table 4.

The eighteen meters of basalt cored below 1252.6 m sub-bottom is transitional (T-type) MORB, similar to that found on the eastern Walvis Ridge. Its $^{40}Ar/^{39}Ar$ radiometric age of 86.0 ± 4 Ma is essentially coincident with the estimate of 84.5 ± 0.5 Ma for the age of the mid-ocean ridge crest at the site, based on regional magnetic anomaly data. Two flow units are distinguished on the basis of their primary mineralogy and degree of alteration. The upper 5–10 m of basalt has a calcitized groundmass, but fresh rock lies beneath. The presence of large vesicles and an abundance of coralline algae, echinoid, bryozoan, and mollusk fragments in cracks in the basalt and in the overlying breccia suggest eruption in or near the photic zone.

A sharp transition above Unit 7 to the (upper?) bathyal Coniacian-Santonian limestones at the base of Unit 6 may encompass the magnetic polarity change of Amomaly 34. The normal magnetization of the basalt confirms other evidence that it is not a sill and suggests a period of rapid subsidence shortly after eruption. Sediments directly overlying basement also indicate rapid subsidence from a very shallow initial depth. Table 5 lists these lithologic indicators of paleodepth (after Daley, this volume; Milliman, this volume).

Deposition on the Rio Grande Rise during the middle Eocene (Unit 4) was dominantly calcareous but included volcanogenic turbidites and ash beds and a 15-m thick

Table 4. Summary of lithologic units distinguished at Site 516.

Unit	Depth (m)	Lithology	Age
1	0–193	Foraminiferal and nannofossil ooze	Recent to early Miocene
2	193–332	Foraminiferal-nannofossil semiconsolidated ooze and chalk	early Miocene to late Oligocene
3	332–634	Nannofossil and foraminiferal-nannofossil chalk	late Oligocene to late Eocene
4	634–874	Nannofossil and foraminiferal chalks and limestones with turbidites and ash layers	middle Eocene
5	874–1000	Microcrystalline limestones	middle Eocene to early Paleocene
6	1000–1240	Limestones, marly limestones, and claystones	early Paleocene to Santonian/Coniacian
7	1240–1252	Calcareous and volcanogenic breccia over basalt	Coniacian(?)
8	1252–1270	Basalt	

Table 5. Lithologic indicators of paleodepth, Hole 516F.

Core(s)	Age	Lithology	Paleodepth
125	Coniacian	Miliolids, ophthalmidiids, ostracodes in well-sorted skeletal grainstone	<20 m; high-energy environment
124	Coniacian	*Inoceramus* shell fragments, calcispheres, coralline algae, verneuilinids, miliolids, heterohelicid and globotruncanid planktonics; iron-stained mud matrix	20–150 m; open marine shelf conditions
123	Coniacian	Alternating layers of claystone and fine-grained skeletal debris in a claystone matrix; common *Inoceramus* prisms, ostracodes, and heterohelicid and hedbergellid planktonic foraminifers	200–500 m; deeper neritic or shallow bathyal depths
116–119	Santonian	Abundant deep-water benthics (including *Gavelinella beccariiformis*); no shallow indicators; high planktonic/benthic ratio (about 10:1); modest density, evidence of selective dissolution	500–1000 m; upper to middle bathyal depths
89–113	Campanian/Maestrichtian	Diverse and well-preserved benthic assemblages; High planktonic/benthic ratio; diverse gyroidinids and agglutinated benthics	1000–1500 m; middle bathyal to shallow lower bathyal depths
83–89	Paleocene	Benthics dominated by a deep water association; wide fluctuations in abundance in earliest Paleocene; pelagic character	1500–2000 m; lower bathyal depths

slide of Maestrichtian limestone. A K-Ar age of 47.4 ± 0.7 Ma based on fresh euhedral biotite from an ash bed confirms that early middle Eocene age of volcanism. The limestones within this sequence, particularly near the base, exhibit higher compressional-wave velocities than occur above, or for some depth beneath, Unit 4. This unit corresponds to the strong, irregular composite reflector that forms the "midsection domes" of the UTMSI multichannel seismic profiles and that was thought at one time to be crystalline basement. The cause of the high velocities is perhaps silicification of the calcareous material by silica-enriched fluids derived from the volcanogenic sediment (which itself yields abnormally low velocities). Thus the "domes" may be diagenetic "fronts" associated with and confined to the immediate vicinity of turbidites and slumps. Reflection profiles around Site 516 (Barker et al., this volume) show that a guyot located just upslope, which contains an uplifted and tilted oceanic section truncated by subaerial erosion, is the likely source of the slide and turbidites. The steep slope of the guyot is one wall of a graben that strikes west-northeast/east-southeast across the crest of the Rio Grande Rise, between other guyots with a similar summit depth. A short volcanotectonic event, interpreted as a midplate hot spot and probably unique in the history of the Rise, probably affected the entire crestal area.

A model for the tectonic evolution of the Rise has been constructed (Barker, this volume), in which the present Tristan da Cunha mantle inhomogeneity (hot spot) first helped initiate South Atlantic opening; then, with the slight westward drift of the mid-ocean ridge crest, it effected a series of captures of the ridge crest, causing the crest to jump eastward and to return to the hot-spot center. The mechanism proposed is reversal of the balance of ridge-push forces on the young lithosphere by the greater elevations of the hot-spot swell. The massive eastern Walvis and Rio Grande bodies therefore represent off-axis volcanism that succeeded in capturing a ridge crest, and the younger seamount province represents off-axis volcanism that failed.

A detailed subsidence history for the Rio Grande Rise in the vicinity of Site 516 is constructed based on the age and origin of the basal volcanics at Site 516 and the age and nature of the middle Eocene off-axis volcanic activity. The model uses an oceanic, thermal subsidence (age$^{1/2}$), but takes account of the hot-spot environment of the original subaerial spreading center and considers the effects of subaerial isostatic subsidence. It incorporates the middle Eocene event as partly a thermal rejuvenation (thinning) of the lithosphere, which is reversible, and partly a compositional change, which is not. The resulting subsidence curve for Site 516 starts at 180 m above sea level 84.5 Ma, passes through sea level 0.5 Ma later, and falls to 1260 m in the Paleocene, before rising rapidly to 600 m in the early middle Eocene and then falling more gently to its present depth of 1313 m. Assuming that, after the middle Eocene, the guyot upslope from Site 516 followed a similar thermal subsidence curve, its submergence below sea level 35 Ma is compatible with early Oligocene shallow water fauna found downslope near Site 357.

A similar subsidence history is applied to Site 357 so that the independent data set of paleoecological depth estimates from both sites may be compared with the tectonic subsidence model. The paleoecologic estimates are generally deeper (see Table 5), and it is difficult to see how the tectonic model may be modified to remove the discrepancy. The difficulty may lie in delays in the precise correction of comparison sites elsewhere in the world for the effects of thermal subsidence and sediment compaction. For this effort, Site 516 itself should provide a new and useful datum, even though some modification of this tectonic model is expected.

REFERENCES

Alvarez, W., Arthur, M. A., Fischer, A. G., Lowrie, W., Napoleone, G., Premoli Silva, I., and Roggenthen, W. M., 1977. Type section for the Late Cretaceous-Paleocene geomagnetic reversal time scale. *Bull. Geol. Soc. Am.*, 88:367–371.

Berggren, W. A., 1973. The Pliocene time scale: calibration of planktonic foraminiferal and calcareous nannoplankton zones. *Nature*, 243:391–397.

_______, 1977a. Late Neogene planktonic foraminiferal biostratigraphy of Site 357 (Rio Grande Rise). *In* Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP*, 39: Washington (U.S. Govt. Printing Office), 591–615.

_______, 1977b. Late Neogene planktonic foraminiferal biostratigraphy of the Rio Grande Rise (South Atlantic). *Mar. Micropaleontol.*, 2:265–313.

Berggren, W. A., Kent, D. V., and Flynn, J. J., in press. Paleogene geochronology and chronostratigraphy. *In* Snelling, N. J. (Ed.), *Geochrononology and the the Geologic Record:* London (Geol. Soc. London Spec. Publ.).

Berggren, W. A., Kent, D. V., and Van Couvering, J. A., in press. Neogene geochronology and chronostratigraphy. *In* Snelling, N. J. (Ed.), *Geochronology and the Geologic Record:* London (Geol. Soc. London Spec. Publ.).

Blow, R. A., and Hamilton, N., 1975. Paleomagnetic evidence from DSDP cores of northward drift of India. *Nature*, 257:570–572.

_______, 1978. Effect of compaction on the acquisition of a detrital remanent magnetization in fine-grained sediments. *Geophys. J. R. Astron. Soc.*, 52:13–23.

Blow, W. H., 1969. Late middle Eocene to Recent planktonic foraminiferal biostratigraphy. *In* Brönnimann, P., and Renz, H. H. (Eds.), *Proc. First. Int. Conf. Plankt. Microfossils:* Leiden (E. J. Brill), 1:199–422.

Ellwood, B. B., and Ledbetter, M. T., 1977. Antarctic bottom water fluctuations in the Vema Channel: effects of velocity changes in the particle alignment and size. *Earth Planet. Sci. Lett.*, 35: 189–198.

Hailwood, E. A., Bock, W., Costa, L., Dupeuble, L., Müller, C., and Schnitker, D., 1979. Chronology and biostratigraphy of northeast Atlantic sediments. *In* Montadert, L., Roberts, D. G., et al., *Init. Repts. DSDP*, 48: Washington (U.S. Govt. Printing Office), 1119–1141.

Hamilton, N., 1979. A paleomagnetic study of sediments from Site 397 northeast African continental margin. *In* von Rad, U., Ryan, W. B. F., et al., *Init. Repts. DSDP*, 47, Pt. 1: Washington (U.S. Govt. Printing Office), 463–477.

Hardenbol, J., and Berggren, W. A., 1978. A new Paleogene time scale. *In* Cohee, G. V., Glaessner, M. F., and Hedberg, H. D. (Eds.), *Contributions to the Geologic Time Scale:* Tulsa (Am. Assoc. Petrol. Geol. Studies in Geology), No. 6:213–234.

Henry, K. W., and Opdyke, N. D., 1970. Paleomagnetism of sediments from Leg 3 of the Deep Sea Drilling Project. *In* Maxwell, A. E., Von Herzen, R. P., et al., *Init. Repts. DSDP*, 3: Washington (U.S. Govt. Printing Office), 667–685.

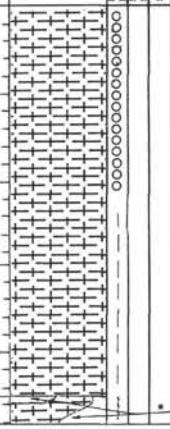
Kukla, G., and Zijderveld, J. D. A., 1977. Magnetostratigraphic pitfalls. *Nature*, 266:774–776.

Lowrie, W., and Alvarez, W., 1981. One hundred million years of geomagnetic polarity history. *Geology,* 9:392–397.
Martini, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In* Farinacci, A. (Ed.), *Proc. II Plankt. Conf. Roma:* Rome (Edizioni Tecnoscienza), 2:739–785.
Ness, G., Levi, S., and Couch, R., 1980. Magnetic anomaly time scales for the Cenozoic and Late Cretaceous: A prècis, critique and synthesis. *Rev. Geophys. Space Phys.,* 18:753–770.
Perch-Nielsen, K., 1977. Albian to Pleistocene calcareous nannofossils from the western South Atlantic, DSDP Leg 39. *In* Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP,* 39: Washington (U.S. Govt. Printing Office), 699–823.
Perch-Nielsen, K., Supko, P. R., and Shipboard Scientific Party, 1977. Site 357. *In* Supko, P. R., Perch-Nielsen, K., et al., *Init. Repts. DSDP,* 39: Washington (U.S. Govt. Printing Office), 231–328.
Stainforth, R. M., Lamb, J. L., Luterbacher, H., Beard, J. H., and Jeffords, R. M., 1975. Cenozoic planktonic foraminiferal zonation and characteristics of index forms. *Contrib. Univ. Kans.,* Article 62.
Supko, P. R., Perch-Nielsen, K., et al., 1977. *Init. Repts. DSDP,* 39: Washington (U.S. Govt. Printing Office).
van Hinte, J. E., 1976. A Cretaceous time scale. *Am. Assoc. Pet. Geol. Bull.,* 60:498–548.
Wood, D. A., Tarney, J., Varet, J., Saunders, A. D., Bougault, H., Joron, J. L., Treuil, M., and Cann, J. R., 1979. Geochemistry of basalts drilled in the North Atlantic by IPOD Leg 49: implications for mantle heterogeneity. *Earth Planet. Sci. Lett.,* 42:77–97.

Date of Initial Receipt: November 19, 1982

SITE 516 HOLE CORE (HPC) 1 CORED INTERVAL 0.0–2.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Quaternary	N23 (F) NN20–21 (N)	AG / AG	AG / AG			1	0.5, 1.0				
	N22 (F) NN19 (N)	AG	AG			2					
			AG	AG	B	CC					*



5Y 7/1

10YR 7/4

Gradational color change

10YR 8/2

10YR 8/3

VOIDS

NANNO-FORAM OOZE

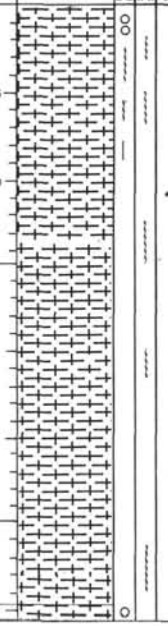
Very pale brown (10YR 7/4).

SMEAR SLIDE SUMMARY:

	CC D
Texture:	
Sand	60
Silt	10
Clay	30
Composition:	
Heavy minerals	TR
Foraminifers	70
Nannofossils	30

SITE 516 HOLE CORE (HPC) 2 CORED INTERVAL 2.5–6.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Quaternary	N22 (F) NN19 (N)	AG				1	0.5, 1.0				*
						2					
						3					
		AG	AG	B		CC					



10YR 7/3

10YR 8/2

NANNO-FORAM OOZE

Very pale brown (10YR 7/3).

SMEAR SLIDE SUMMARY:

	1-110 D
Texture:	
Sand	60
Silt	20
Clay	20
Composition:	
Mica	TR
Pyrite	TR
Foraminifers	50
Nannofossils	50

SITE 516 HOLE CORE (HPC) 3 CORED INTERVAL 6.9–11.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
Quaternary	N22 (F) NN19 (N)	AM				1	0.5, 1.0
		AM	AG			2	
upper Pliocene	NN18 (N)	AM	AM			3	
	PL6 (F)						
	PL5 (F) NN17 (N)		AM	AG	B	CC	

Samples: * (Section 2)

LITHOLOGIC DESCRIPTION

NANNOFOSSIL-FORAM OOZE

Slight mottling throughout. Mainly light gray to white (10YR 7/2–10YR 8/2) with mottling of white (10YR 8/1–10YR 8/2). Unspecified carbonate probably foram fragments. Discoasters present.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	60
Silt	20
Clay	20
Composition:	
Mica	TR
Carbonate unspecified	10
Foraminifers	50
Nannofossils	40

SITE 516 HOLE CORE (HPC) 4 CORED INTERVAL 11.3–15.7 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Pliocene	PL5 (F)	AG				1	0.5, 1.0
	PL4 (F)	AG				2	
	PL3 (F) NN16 (N)	AG				3	
		AM	A/MG			CC	

Samples: * (Section 2)

LITHOLOGIC DESCRIPTION

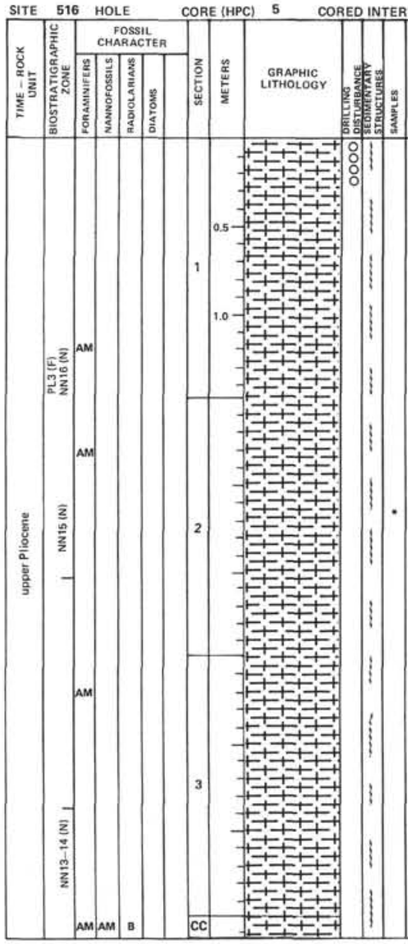
NANNOFOSSIL-FORAM OOZE

Dominantly light gray (10YR 7/1–7/2) with bands and mottles of white (10YR 8/1–8/2). Sandy. Unspecified carbonate mainly foram fragments.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	50
Silt	30
Clay	20
Composition:	
Heavy minerals	TR
Carbonate unspecified	10
Foraminifers	50
Nannofossils	40
Sponge spicules	TR

SITE 516 HOLE CORE (HPC) 5 CORED INTERVAL 15.7–20.1 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

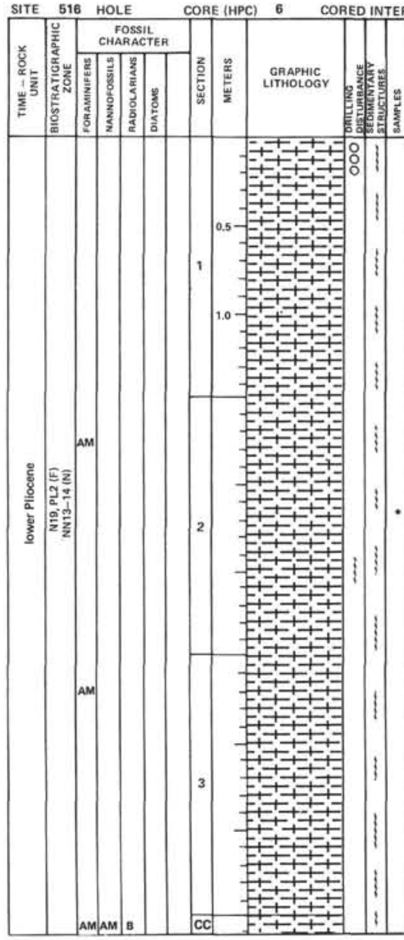
White (10YR 8/1) homogeneous foram-nanno ooze, slight mottling throughout. Mottling color is white.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	20
Silt	60
Clay	20
Composition:	
Foraminifers	35
Nannofossils	65

CARBONATE BOMB:
1-20 = 89
1-70 = 91
1-120 = 89
2-20 = 90
2-70 = 94
2-115 = 91
3-20 = 88
3-70 = 91
3-120 = 90

SITE 516 HOLE CORE (HPC) 6 CORED INTERVAL 20.1–24.5 m



LITHOLOGIC DESCRIPTION

FORAM-NANNOFOSSIL OOZE

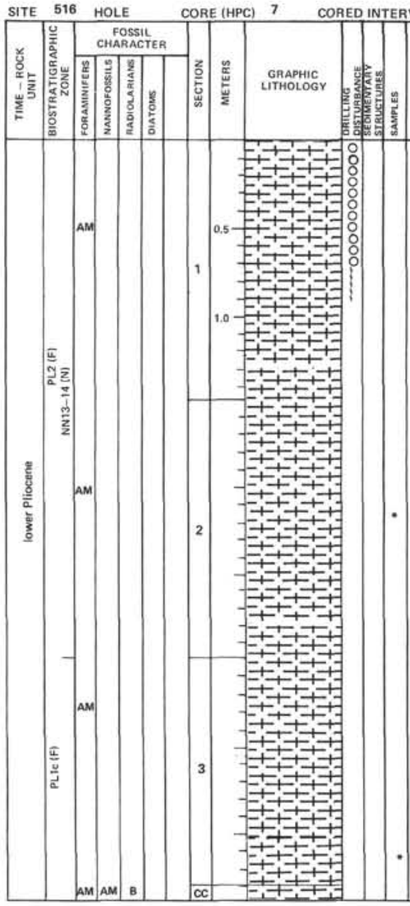
Color is 10YR 8/1 with subtle mottling of similar hue throughout. Sharp contact to light gray foram-nanno ooze at Section 3, 145 cm; gradational return to white at 9 cm in Core-Catcher.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	30
Silt	50
Clay	20
Composition:	
Foraminifers	20
Nannofossils	80

CARBONATE BOMB:
1-20 = 90
1-70 = 92
1-120 = 93
2-20 = 94
2-70 = 94
2-115 = 91
3-20 = 92
3-70 = 93
3-120 = 95

SITE 516 HOLE CORE (HPC) 7 CORED INTERVAL 24.5–28.9 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

White (10YR 8/1) uniform foram-nanno ooze. Yellow-brown flecks appear in Sections 2 and 3.

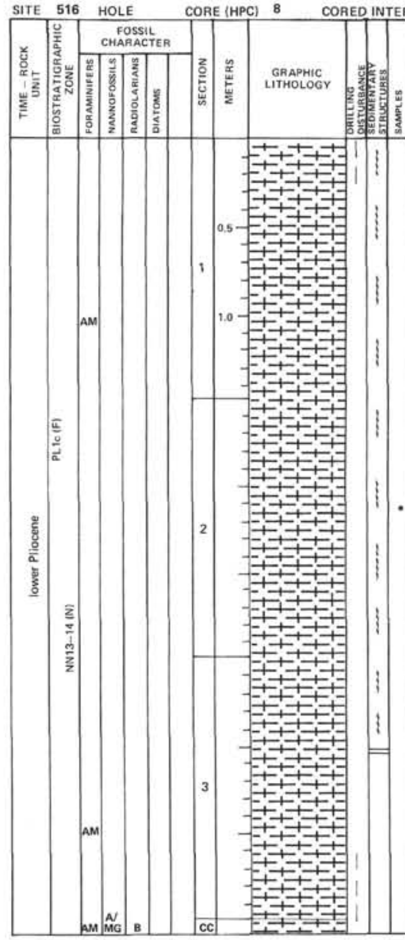
SMEAR SLIDE SUMMARY:

	2-70	3-118
	D	D
Texture:		
Sand	50	35
Silt	40	55
Clay	10	10
Composition:		
Foraminifers	50	40
Nannofossils	50	60
Volcanic glass	–	TR

CARBONATE BOMB:

1-20 = 94
1-70 = 95
1-120 = 96
2-20 = 94
2-65 = 91
2-120 = 94
3-20 = 94
3-70 = 94
3-120 = 95

SITE 516 HOLE CORE (HPC) 8 CORED INTERVAL 28.9–33.3 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

White (10YR 8/1) foram-nanno ooze with black spots and stained. Slightly mottled throughout.

SMEAR SLIDE SUMMARY:

	2-65
	M
Texture:	
Sand	40
Silt	50
Clay	10
Composition:	
Pyrite	2
Foraminifers	38
Nannofossils	60
Volcanic glass	TR

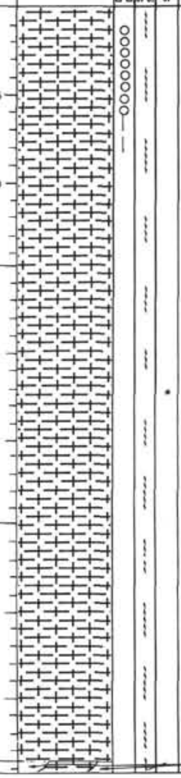
CARBONATE BOMB:

1-20 = 91
1-70 = 93
1-115 = 90
2-20 = 94
2-70 = 95
2-120 = 94
3-20 = 90
3-70 = 90
3-120 = 92

SITE 516 HOLE CORE (HPC) 9 CORED INTERVAL 33.3–37.7 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Pliocene	PL1c (F) NN13–14 (N)	AM				1	0.5, 1.0
		AM				2	
	PL1b (F)	AM				3	
		AM	AM	B		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

White (10YR 8/1) with black specks and streaks (pyrite?) in Section 1, changing to white (10YR 8/2 at Section 1, 130 cm with 10YR 8/1 mottling.

SMEAR SLIDE SUMMARY:

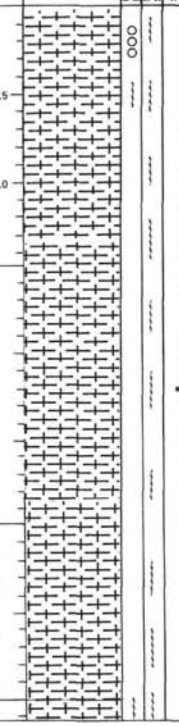
	2-70 D
Texture:	
Sand	25
Silt	40
Clay	35
Composition:	
Pyrite	TR
Foraminifers	25
Nannofossils	73
Total detrital	2
Volcanic glass	TR

CARBONATE BOMB:
1-70 = 93
1-120 = 91
2-20 = 94
2-70 = 90
2-115 = 94
3-20 = 94
3-70 = 93
3-120 = 90

SITE 516 HOLE CORE (HPC) 10 CORED INTERVAL 37.7–42.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Pliocene	NN13–14 (N) / PL1b (F)					1	0.5, 1.0
	NN12 (N)	AM				2	
	PL1a	AM				3	
		AM	AM	B		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

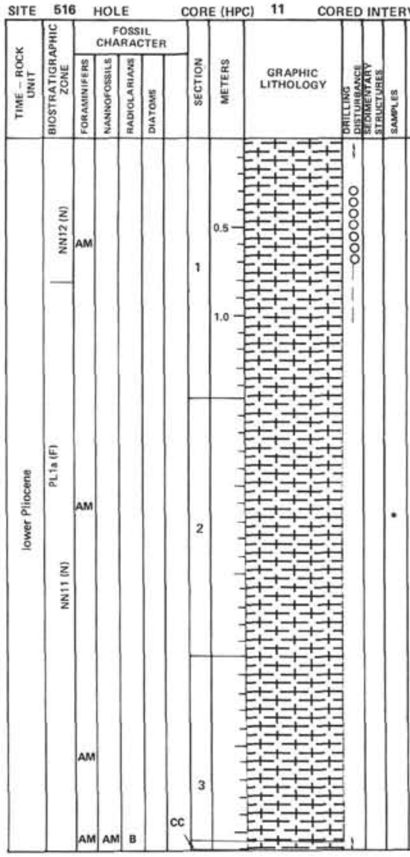
White (10YR 8/2) mottled with lighter white (10YR 8/1).

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	20
Silt	45
Clay	35
Composition:	
Feldspar	TR
Zeolites	TR?
Foraminifers	20
Nannofossils	78
Total detrital	1
Iron-oxide	1
Micronodules	TR

CARBONATE BOMB:
1-70 = 94
1-130 = 93
2-20 = 95
2-70 = 95
2-120 = 91
3-20 = 95

SITE 516 HOLE CORE (HPC) 11 CORED INTERVAL 42.1–46.5 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

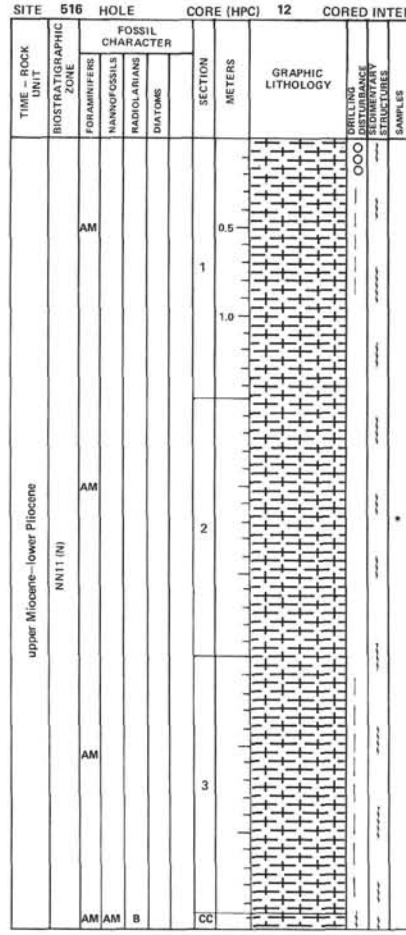
White (10YR 8/1) homogeneous foram-nanno ooze.

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	20
Silt	45
Clay	35
Composition:	
Foraminifers	20
Nannofossils	79
Iron-oxide	TR
Volcanic glass	TR

CARBONATE BOMB:
1-120 = 95
2-20 = 91
2-70 = 95
2-120 = 91
3-20 = 91
3-70 = 94

SITE 516 HOLE CORE (HPC) 12 CORED INTERVAL 46.5–50.9 m



LITHOLOGIC DESCRIPTION

FORAM-NANNOFOSSIL OOZE

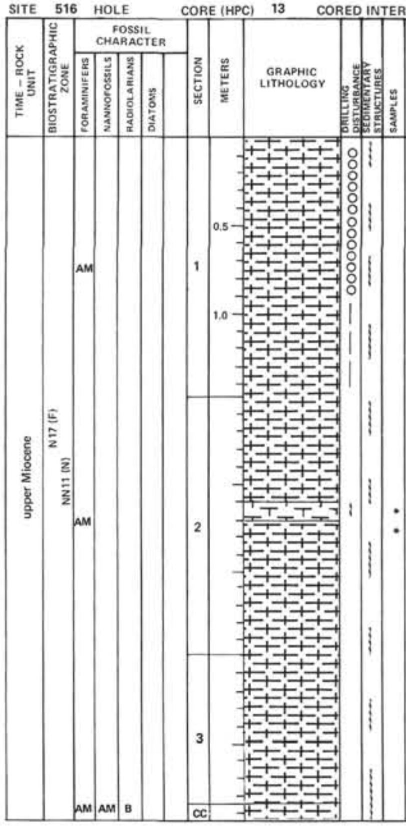
White (10YR 8/1) changing to white (10YR 8/2) with lighter mottles at 72 cm, Section 2 (gradual), and remains below. Lower unit mottled.

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	25
Silt	50
Clay	25
Composition:	
Pyrite	TR
Foraminifers	25
Nannofossils	72
Total detrital	1
Iron-oxide	1
Volcanic glass	1

CARBONATE BOMB:
1-20 = 90
1-70 = 90
1-120 = 95
2-20 = 89
2-70 = 91
2-120 = 90
3-20 = 87
3-70 = 92
3-120 = 84

SITE 516 HOLE CORE (HPC) 13 CORED INTERVAL 50.9–55.3 m



LITHOLOGIC DESCRIPTION

FORAM-NANNOFOSSIL OOZE

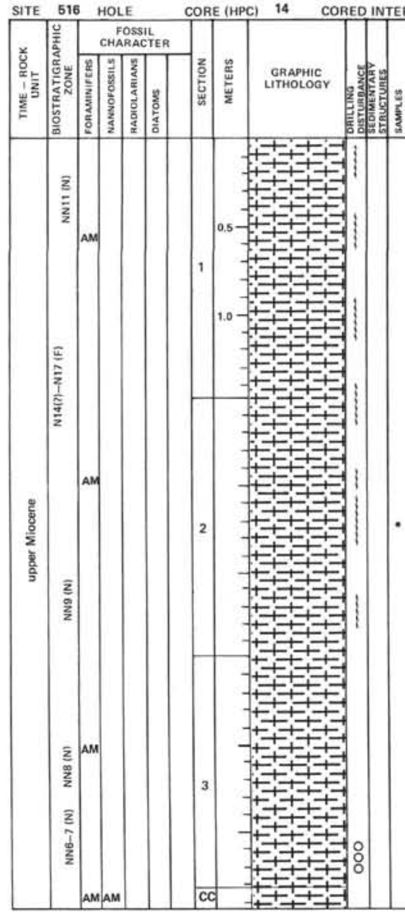
One thin layer of sandy foraminiferal ooze at Section 2, 61–69 cm. White (10YR 8/2) throughout, with mottling of 10YR 8/1. Foram ooze unit has yellow flecks on surface which are large forams under microscope. Watery layer of coarser sediment.

10YR 8/2

SMEAR SLIDE SUMMARY:

	2-65 M	2-75 D
Texture:		
Sand	80	25
Silt	15	55
Clay	5	20
Composition:		
Pyrite	TR	–
Carbonate unspecified	–	2
Foraminifers	85	33
Nannofossils	13	65
Total detrital	TR	TR
Iron-oxide	1	TR
Volcanic glass	1	TR
Sponge spicules	–	TR

SITE 516 HOLE CORE (HPC) 14 CORED INTERVAL 55.3–59.7 m



LITHOLOGIC DESCRIPTION

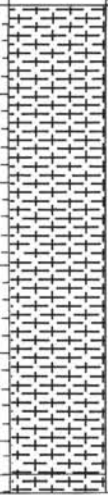
FORAM-NANNO OOZE

White (10YR 8/2) structureless. Homogeneous with very few dark spots (burrows?).

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	15
Silt	55
Clay	30
Composition:	
Foraminifers	15
Nannofossils	84
Volcanic glass	TR
Iron-oxides	TR

SITE 516 HOLE CORE (HPC) 15 CORED INTERVAL 59.7–64.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
middle Miocene	N2–N14 (F) NN6–7 (N)	AM, AM				1	0.5, 1.0				*	
						2						10YR 8/1
		AM	CM			CC						

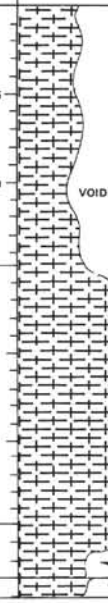
FORAM-NANNO OOZE

White (10YR 8/2) throughout.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	20
Silt	40
Clay	40
Composition:	
Quartz	1
Glauconite	1
Foraminifers	32
Nannofossils	60
Opaque minerals	1
Volcanic glass	5

SITE 516 HOLE CORE (HPC) 16 CORED INTERVAL 64.1–68.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
middle Miocene	N2–N14 (F) NN6–7 (N)					1	0.5, 1.0	 VOID				10YR 8/2
		AM				2					*	10YR 8/1; 10YR 8/4
				B		3						10YR 8/1; VOIDS
		AM	AM			CC						

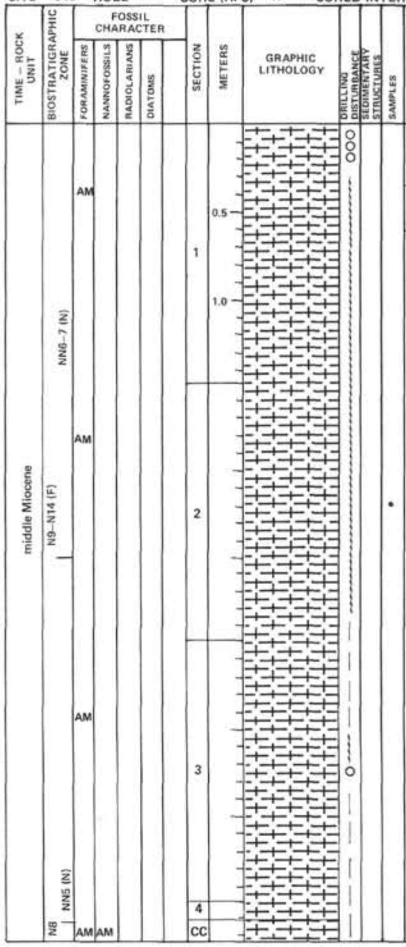
FORAM-NANNO OOZE

Badly deformed. Liner cracked at base and soup was adjusted upward in liner. Good preservation of benthic foraminifera (Section 2).

SMEAR SLIDE SUMMARY:

	2-47 D
Texture:	
Sand	30
Silt	20
Clay	50
Composition:	
Foraminifers	40
Nannofossils	60

SITE 516 HOLE CORE (HPC) 17 CORED INTERVAL 68.5–72.9 m



LITHOLOGIC DESCRIPTION

10YR 8/2

FORAM-NANNO OOZE

Rust and pipe debris throughout core, especially Section 1.

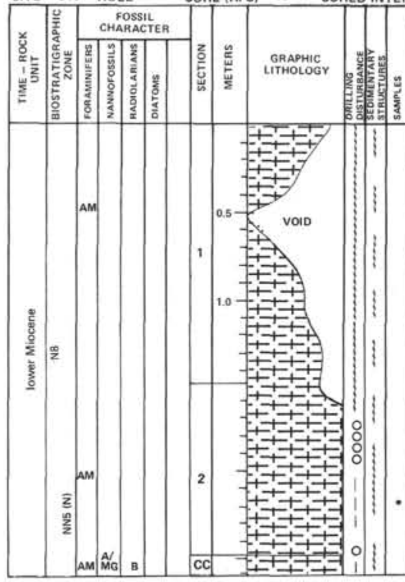
10YR 8/1

SMEAR SLIDE SUMMARY:

10YR 8/2

	2-70
	D
Texture:	
Sand	20
Silt	15
Clay	65
Composition:	
Foraminifers	30
Nannofossils	70

SITE 516 HOLE CORE (HPC) 18 CORED INTERVAL 72.9–77.3 m



LITHOLOGIC DESCRIPTION

NANNO-FORAM OOZE

10YR 8/2

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	20
Silt	30
Clay	50
Composition:	
Foraminifers	30
Nannofossils	70
Volcanic glass	TR

CARBONATE BOMB:
1-20 = 87
1-70 = 91
1-120 = 88
2-20 = 91
2-70 = 89

NOTE: Core 19, 77.3–81.7 m: No recovery.

SITE 516 HOLE CORE (HPC) 20 CORED INTERVAL 81.7–86.1 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER: FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION

lower Miocene

NN5 (N)

N8 (F)

NN4 (N)

AM

AM A/MG B

1

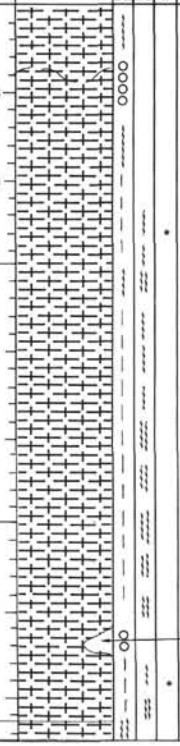
0.5

1.0

2

3

CC



10YR 8/2 worked into 10YR 7/3

10YR 8/2

10YR 8/2 in 10YR 7/3

FORAM-NANNO OOZE

HPC disturbed. Pipe debris and benthic foraminifera concentrated as a lag deposit from the hole walls.

SMEAR SLIDE SUMMARY:

	1-130	3-90
	D	D
Texture:		
Sand	40	20
Silt	20	20
Clay	40	60
Composition:		
Foraminifers	50	30
Nannofossils	50	70

SITE 516 HOLE CORE (HPC) 21 CORED INTERVAL 86.1–90.5 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER: FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION

lower Miocene

N8 (F)

NN4 (N)

AM A/MG B

1

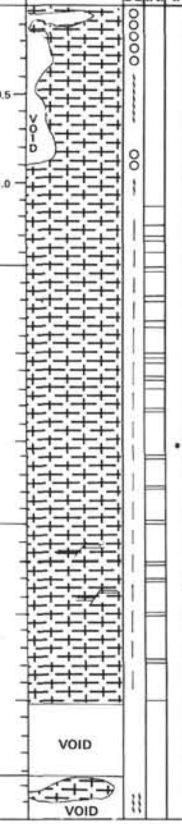
0.5

1.0

2

3

CC



FORAM-NANNO OOZE

Color: 10YR 8/2–10YR 8/1 with pale yellow laminations.

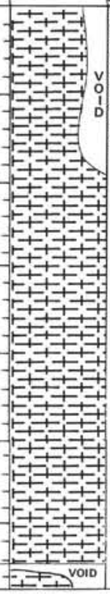
SMEAR SLIDE SUMMARY:

	2-102
	D
Texture:	
Sand	7
Silt	43
Clay	50
Composition:	
Foraminifers	20
Nannofossils	78
Volcanic glass	2

SITE 516 HOLE CORE (HPC) 22 CORED INTERVAL 90.5–94.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	N8 (F)					1	0.5, 1.0
	NN4 (N)	AM				2	
	N7					3	
	N7	AM	CA/M	B		CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

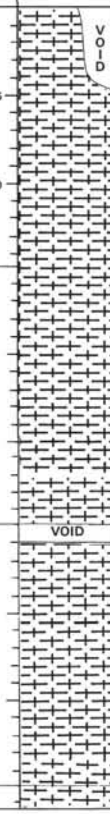
Color: 10YR 8/2–8/3 with light gray (10YR 7/1).

NOTE: Core 23, 94.9–99.3 m: No recovery.

SITE 516 HOLE CORE (HPC) 24 CORED INTERVAL 99.3–103.7 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	N7 (F)	AM				1	0.5, 1.0
						2	
		AM				3	
		AM	A/MG	B		CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

Challengerite: HPC lag formation includes pipe rust and benthic forams from the hole wall.

SMEAR SLIDE SUMMARY:

	1-120	2-145
	D	D
Texture:		
Sand	25	8
Silt	15	8
Clay	60	84
Composition:		
Quartz	–	TR
Mica	1	–
Foraminifers	25	10
Nannofossils	74	90

10YR 8/2

10YR 8/1

10YR 8/2

10YR 8/1

10YR 8/2 with 10YR 8/4 mottles

10YR 8/4

10YR 8/2 with 10YR 8/4 mottles

10YR 8/4

10YR 8/2 with 10YR 8/4 mottles

10YR 7/2

10YR 7/1 with 10YR 8/1 mottles

10YR 8/1

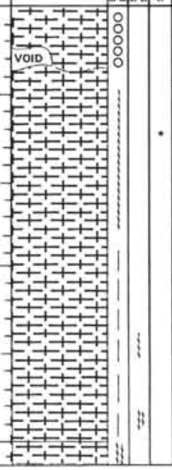
Biscuits 10YR 7/2

10YR 7/1

SITE 516 **HOLE** **CORE (HPC)** 25 **CORED INTERVAL** 103.7–108.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	N7 (F)	AM	A/MG	B		1, 2, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

10YR 8/2

10YR 7/1

FORAM-NANNO OOZE

Challengerite lag. Color: white (10YR 8/2) with mottles of 10YR 7/1. Core-Catcher: disturbed to the maximum.

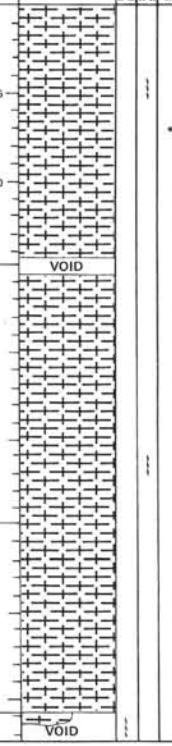
SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	30
Silt	10
Clay	60
Composition:	
Quartz	TR
Mica	1
Foraminifers	30
Nannofossils	67
Opaques	2

SITE 516 **HOLE** **CORE (HPC)** 26 **CORED INTERVAL** 108.1–112.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	N7 (F); NN3 (N)	AM	A/MG	B		1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

10YR 7/2

10YR 8/1

10YR 7/2

10YR 7/1

FORAM-NANNO OOZE

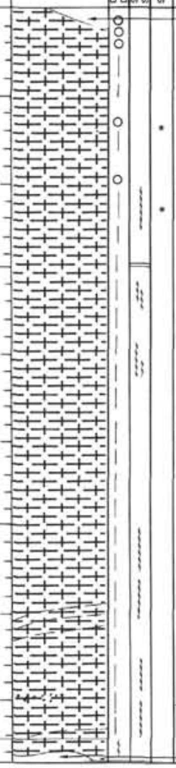
SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	30
Silt	10
Clay	60
Composition:	
Mica	1
Glauconite	TR
Foraminifers	28
Nannofossils	70

SITE 516 HOLE CORE (HPC) 27 CORED INTERVAL 112.5–116.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	N7 (F)	AM				1	0.5, 1.0
						2	
	N6 (F) NN3 (N)	AM				3	
		AM	A/MG	B		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



VOID

10YR 7/1

10YR 8/2

10YR 8/1

10YR 7/1

Black spots

10YR 8/1

VOID

LITHOLOGIC DESCRIPTION

FORAM-NANNO OOZE

Color: 10YR 7/1 and 10YR 8/1 with faint green laminae at base of Section 1.

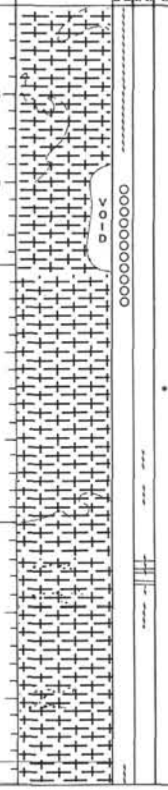
SMEAR SLIDE SUMMARY:

	1-70 D	1-119 D
Texture:		
Sand	5	25
Silt	30	10
Clay	65	65
Composition:		
Quartz	TR	3
Carbonate unspecified	5	–
Foraminifers	10	25
Nannofossils	85	72

SITE 516 HOLE CORE (HPC) 28 CORED INTERVAL 116.9–121.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene						1	0.5, 1.0
						2	
	N5–N6 (F) NN3 (N)					3	
		AM	A/MG	B		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



10YR 7/1

10YR 8/1

Irregular color contact 10YR 7/1

10YR 8/1

10YR 7/1

LITHOLOGIC DESCRIPTION

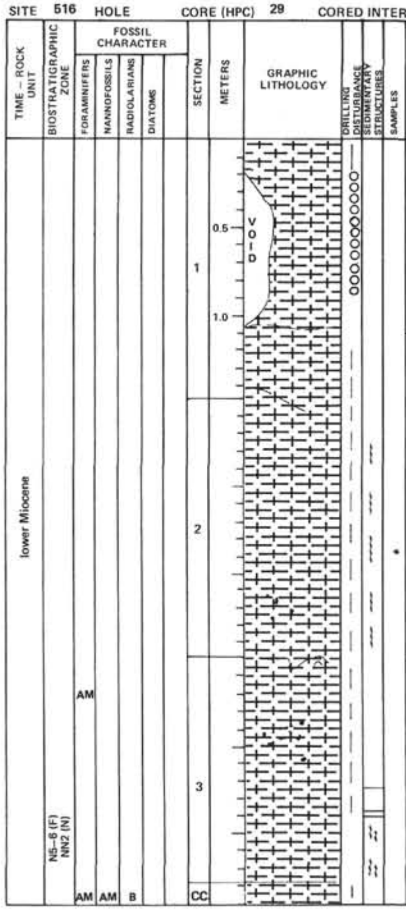
FORAM-NANNO OOZE

White (10YR 8/1), nanno-rich layers swirled into darker matrix, Section 2: 10YR 7/1 gradually whitening down section). *Dark spots, organic debris? (N3)* in Sections 2 and 3. Faint green and black laminations in Section 3.

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	35
Silt	10
Clay	55
Composition:	
Quartz	TR
Foraminifers	35
Nannofossils	65

SITE 516 HOLE CORE (HPC) 29 CORED INTERVAL 121.3–125.7 m



LITHOLOGIC DESCRIPTION

HPC deformation

10YR 7/1

5Y 7/1

10YR 7/1

Green crescent

10YR 8/1

10YR 7/1

10YR 8/1

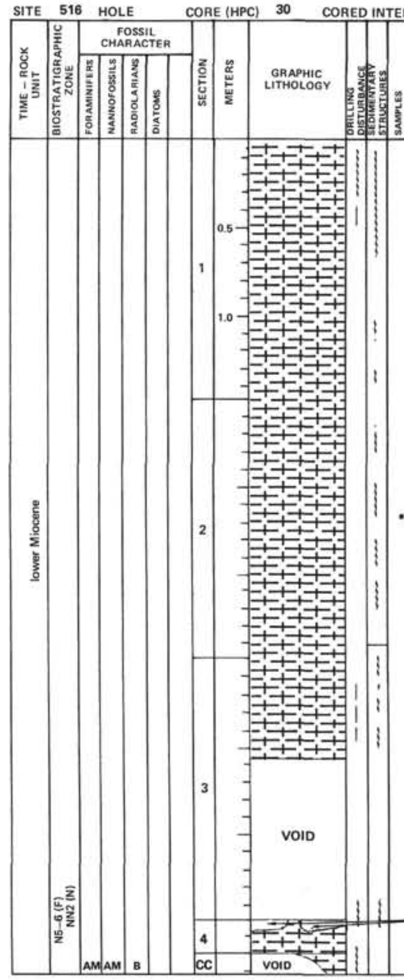
FORAM-NANNO OOZE

Color: light gray (10YR 7/1) with yellow staining and black (N3) spots.

SMEAR SLIDE SUMMARY:

	2-90
	D
Texture:	
Sand	30
Silt	10
Clay	60
Composition:	
Quartz	3
Mica	1
Foraminifers	30
Nannofossils	66

SITE 516 HOLE CORE (HPC) 30 CORED INTERVAL 125.7–130.1 m



LITHOLOGIC DESCRIPTION

10YR 8/1

10YR 8/2

10YR 8/2 with 10YR 6/1 mottles

5Y 7/1

10YR 5/1

10YR 8/1 mottled with 10YR 5/1

VOIDS

FORAM-NANNO OOZE

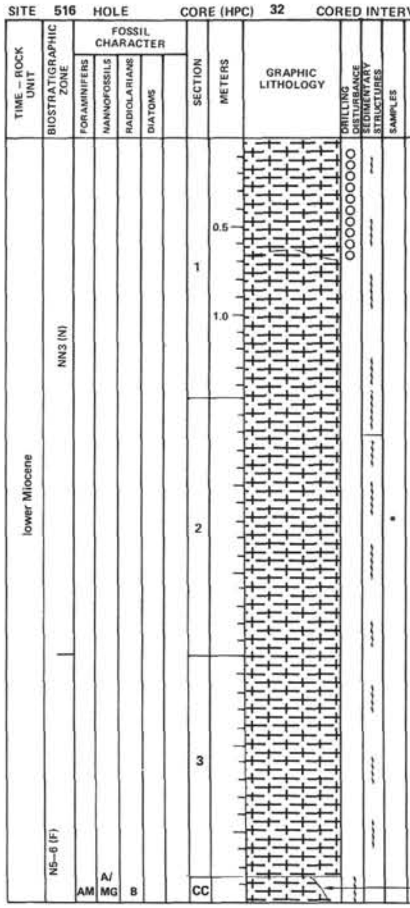
Dominant color 10YR 8/1 and 8/2).

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	20
Silt	60
Clay	20
Composition:	
Pyrite	TR
Foraminifers	20
Nannofossils	79
Micronodules	TR
Volcanic glass	TR

NOTE: Core 31, 130.1–134.5 m: No recovery.

SITE 516 HOLE CORE (HPC) 32 CORED INTERVAL 134.5–138.9 m



LITHOLOGIC DESCRIPTION

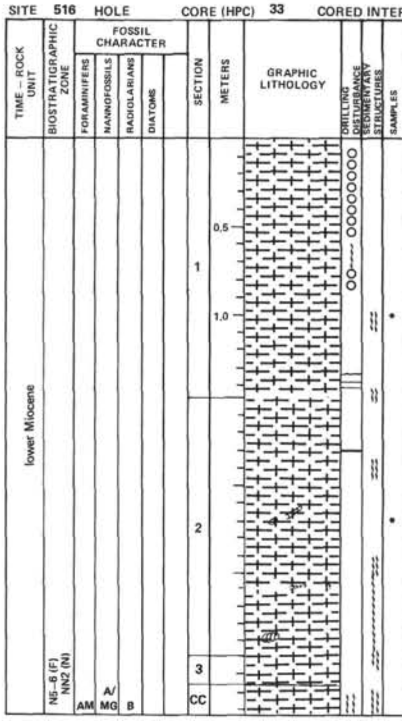
FORAM-NANNO OOZE

Section 1: white (10YR 8/1) with few dark spots (burrows) throughout. Sections 2 and 3: dominant color light gray (5Y 7/1) with white mottles and black rounded spots.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	10
Silt	70
Clay	20
Composition:	
Feldspar	TR
Pyrite	TR
Zeolites	TR
Other clay minerals	3
Foraminifers	10
Nannofossils	85
Volcanic glass	TR

SITE 516 HOLE CORE (HPC) 33 CORED INTERVAL 138.9–143.3 m



LITHOLOGIC DESCRIPTION

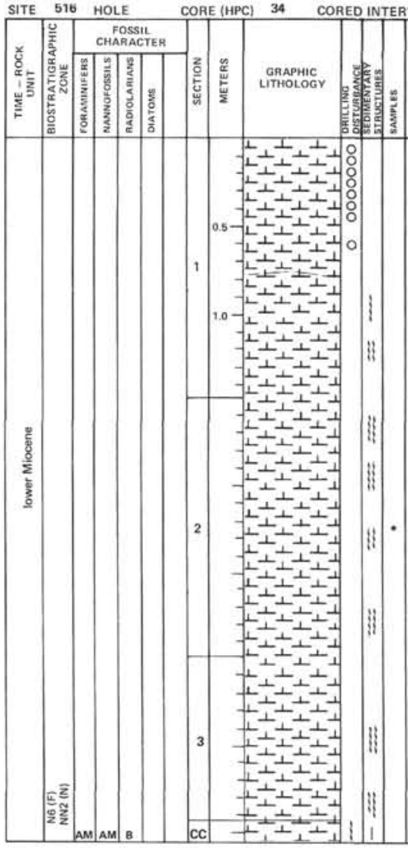
NANNOFOSSIL OOZE

Light gray (5Y 7/2) with intervals of lighter gray (N8). Moderate burrow mottling throughout. Large mottle of black sand-sized grains (Section 1, 97–100 cm), cubic shape in some small grains at high power suggests pyrite. Some scattered dark gray (N4) mottles throughout.

SMEAR SLIDE SUMMARY:

	1-100	2-70
	M	D
Texture:		
Sand	10	10
Silt	60	80
Clay	30	10
Composition:		
Quartz } Feldspar	2	–
Pyrite	20	–
Heavy minerals	TR	–
Zeolites	–	TR
Carbonate unspecified	2	–
Foraminifers	10	5
Nannofossils	65	94
Volcanic glass	TR	TR

SITE 516 HOLE CORE (HPC) 34 CORED INTERVAL 143.3–147.7 m



LITHOLOGIC DESCRIPTION

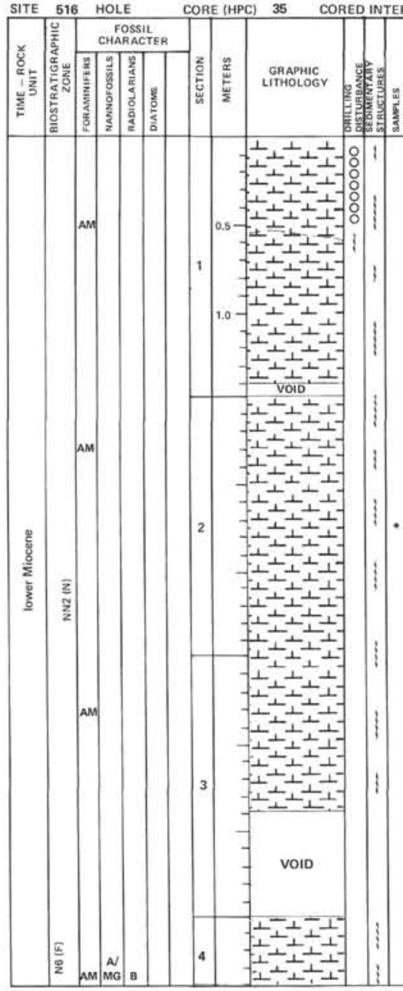
NANNO OOZE

Light greenish gray and very light gray (5GY 8/1 and N8), laminated and mottled together. Section 3: mostly 5GY 8/1 with some mottling of white (N8), medium gray (N5), and pale yellow (5Y 7/3).

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	5
Silt	80
Clay	15
Composition:	
Zeolites	1
Foraminifers	3
Nannofossils	95
Volcanic glass	TR

SITE 516 HOLE CORE (HPC) 35 CORED INTERVAL 147.7–152.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Light gray (5Y 7/1) with mottling of white (5Y 8/1) and medium gray (N5 and N6).

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	3
Silt	87
Clay	10
Composition:	
Heavy minerals	TR
Zeolites	TR
Carbonate unspecified	5
Foraminifers	5
Nannofossils	89
Volcanic glass	TR

SITE 516 HOLE CORE (HPC) 36 CORED INTERVAL 152.1–156.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Miocene	NN2 (N) / N6 (F)	AM / AM	A/MG	PM		1, 2, CC	0.5, 1.0	VOID			•	NANNOFOSSIL OOZE

NANNOFOSSIL OOZE

Light gray (5Y 7/1), stiff, nanno ooze mottled with white. Few dark spots.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	5
Silt	70
Clay	25
Composition:	
Quartz	} 1
Feldspar	} 1
Pyrite	TR
Heavy minerals	1
Other clay minerals	3
Foraminifers	5
Nannofossils	90
Diatoms	TR
Volcanic glass	TR
Sponge spicules	TR

SITE 516 HOLE CORE (HPC) 37 CORED INTERVAL 156.5–160.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Miocene	NN2 (N) / N6 (F)	AM / AM	AM	RP		1, 2, CC	0.5, 1.0	VOID			•	NANNOFOSSIL OOZE

NANNOFOSSIL OOZE

Mottled white (5Y 8/1) and light gray (5Y 7/1). Some medium gray (N5) mottles and laminations.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	5
Silt	65
Clay	30
Composition:	
Quartz	
Feldspar	TR
Pyrite	TR
Heavy minerals	TR
Zeolites	TR?
Other clay minerals	3
Foraminifers	4
Nannofossils	92
Radiolarians	TR
Sponge spicules	1

SITE 516 HOLE CORE (HPC) 38 CORED INTERVAL 160.9–165.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Miocene	NN2 (N) / N6 (F)	AM / AM	CM	RP		1, 2, CC	0.5, 1.0	VOID			•	NANNOFOSSIL OOZE; VOID

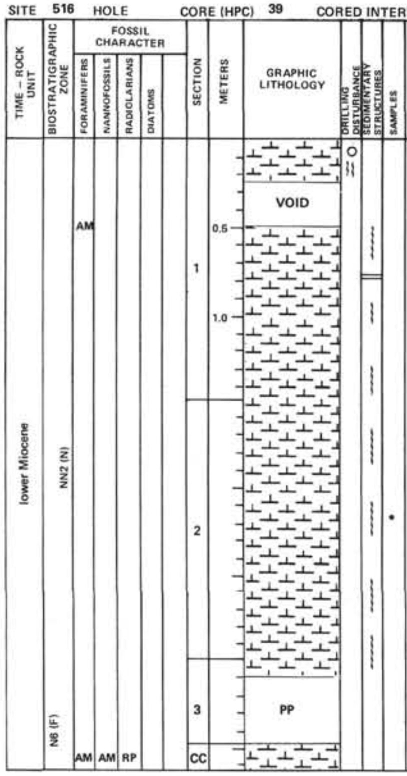
NANNOFOSSIL OOZE

Light gray (5Y 7/1) mottled with white (5Y 8/1) and medium gray (5Y 5/1). Section 2, 63–118 cm extruded on deck – no orientation.

SMEAR SLIDE SUMMARY:

	2-50
	D
Texture:	
Sand	5
Silt	60
Clay	35
Composition:	
Other clay minerals	2
Foraminifers	3
Nannofossils	95
Diatoms	TR
Volcanic glass	TR
Sponge spicules	TR
Micronodules	TR

SITE 516 HOLE CORE (HPC) 39 CORED INTERVAL 165.3–169.7 m



LITHOLOGIC DESCRIPTION

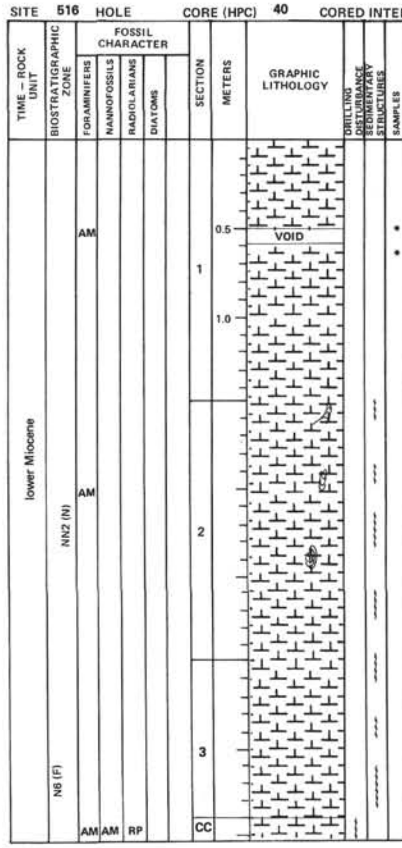
NANNOFOSSIL OOZE

Light gray (5Y 7/1), stiff nanno ooze mottled (light olive) and few black spots and few faint laminations.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	5
Silt	60
Clay	35
Composition:	
Zeolites	TR
Other clay minerals	1
Foraminifers	5
Nannofossils	93
Volcanic glass	TR
Micronodules	TR

SITE 516 HOLE CORE (HPC) 40 CORED INTERVAL 169.7–173.3 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

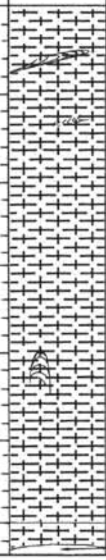
Section 1: light gray (5Y 7/1) nanno ooze, mottled. Fragments of shells up to 1.5 cm in size. Section 1, 60 cm is light greenish gray (5GY 8/1) and gradually turns light gray downward. Section 1, 110–150 cm: light gray (2.5Y 7/2) nanno ooze mottled with light olive and with dark spots. Sections 2 and 3: dominant color light gray (2.5Y 7/2), mottled throughout (burrows) and with faint laminations.

SMEAR SLIDE SUMMARY:

	1-50	1-66
	D	D
Texture:		
Sand	8	5
Silt	52	50
Clay	40	45
Composition:		
Quartz	–	TR
Pyrite	–	TR
Zeolites	1	1
Other clay minerals	5	5
Foraminifers	5	5
Nannofossils	88	91
Volcanic glass	TR	TR
Micronodules	TR	–
Mollusc fragments	1	–

NOTE: Core 41, 173.3–177.3 m: No recovery.

SITE 516 HOLE CORE (HPC) 42 CORED INTERVAL 177.3–180.8 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Miocene	NN2 (N)	AM				1	0.5, 1.0				*	
		AM				2						2.5Y 7/1 2.5Y 8/1 2.5Y 7/1 2.5Y 8/1
	N4 (F)	AM	AM	RP		CC						VOID

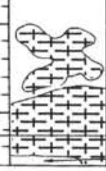
FORAM-NANNOFOSSIL OOZE

Deformed laminations and black staining. Vertical deformed bands (water escape?) in Section 2.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	25
Silt	25
Clay	50
Composition:	
Quartz	1
Other clay minerals	5
Carbonate unspecified	10
Foraminifers	10
Nannofossils	73
Sponge spicules	1

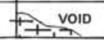
SITE 516 HOLE CORE (HPC) 43 CORED INTERVAL 180.8–182.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Miocene	N4 (F) NN2 (N)	AM				1	0.5, 1.0	VOID 				
		AM	AM	RP		CC						VOID

NANNOFOSSIL OOZE

Color: White (2.5Y 8/1). White (1.5Y 8/2), parallel laminae with black staining throughout.

SITE 516 HOLE CORE (HPC) 44 CORED INTERVAL 182.3–183.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Miocene	N4 (F) NN2 (N)	AM	AM	RP		CC		 VOID			*	

FORAM-NANNOFOSSIL OOZE

Color: white (2.5Y 8/1).

SMEAR SLIDE SUMMARY:

	CC
	D
Texture:	
Sand	25
Silt	25
Clay	50
Composition:	
Quartz	1
Other clay minerals	5

SITE 516 HOLE A CORE (HPC) 1 CORED INTERVAL 0.0–3.5 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION

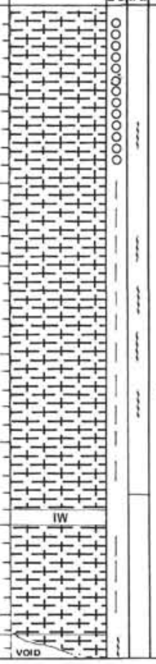
Quaternary

N23 (F)
NN19 (N)

AM
AM
AG MG B
A/

1
2
3
CC

0.5
1.0



10YR 6/4

10YR 7/4

FORAM-NANNO OOZE

Ostracods and pelecypod valves are present. Soup includes layer of nanno-bearing water oscillating over sediment beneath. Laminations may be artifact induced in core preparation.

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	10
Silt	20
Clay	70
Composition:	
Quartz	1
Heavy minerals	TR
Other clay minerals	TR
Foraminifers	15
Nannofossils	82
Diatoms	TR
Volcanic glass	1

SITE 516 HOLE A CORE (HPC) 2 CORED INTERVAL 3.5–7.9 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION

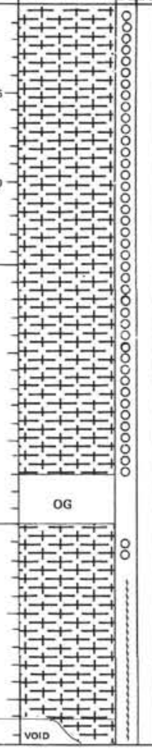
Quaternary

N 22 (F)
NN19 (N)

AM
AM
AM
AM AM B

1
2
3
CC

0.5
1.0



10YR 7/4

10YR 7/4 mottled with 10YR 8/2

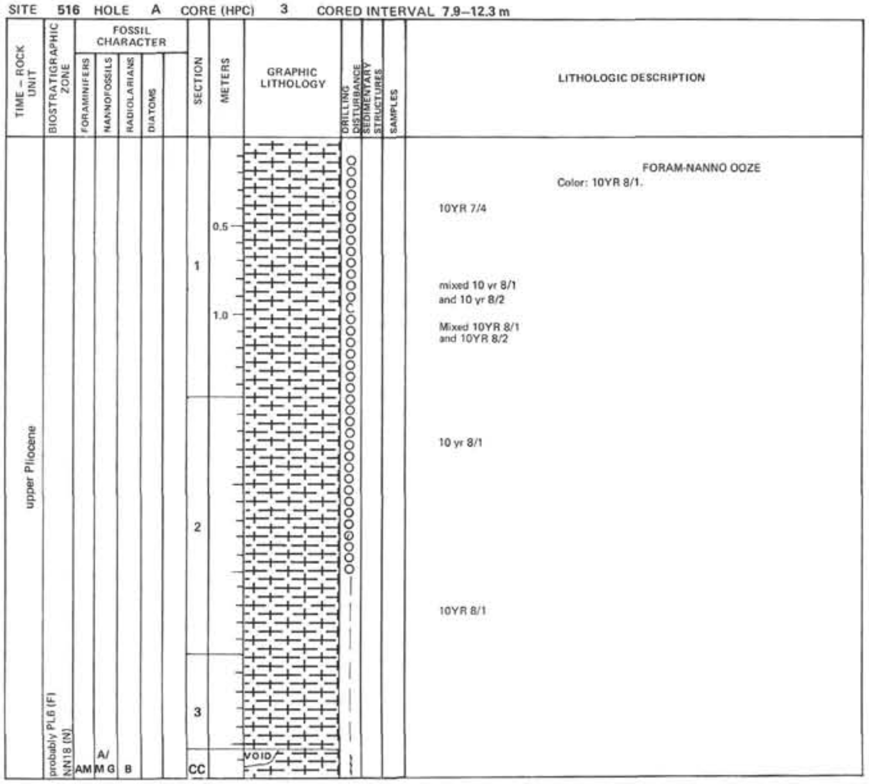
FORAM-NANNO OOZE

Agglutinated forams.

SMEAR SLIDE SUMMARY:

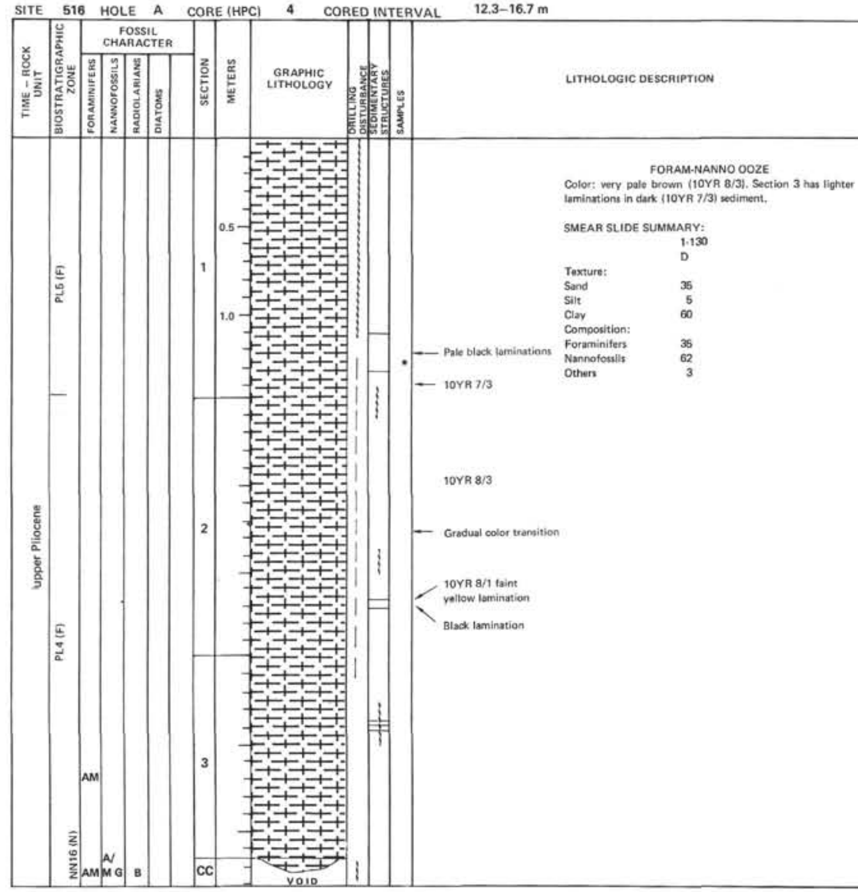
	2-70 D
Texture:	
Sand	25
Silt	30
Clay	45
Composition:	
Other clay minerals	1
Foraminifers	40
Nannofossils	59

SITE 516 HOLE A CORE (HPC) 3 CORED INTERVAL 7.9–12.3 m



FORAM-NANNO OOZE
Color: 10YR 8/1.

SITE 516 HOLE A CORE (HPC) 4 CORED INTERVAL 12.3–16.7 m



FORAM-NANNO OOZE
Color: very pale brown (10YR 8/3). Section 3 has lighter laminations in dark (10YR 7/3) sediment.

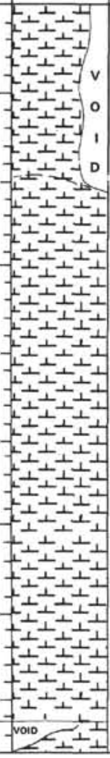
SMEAR SLIDE SUMMARY:

	1-130
	D
Texture:	
Sand	35
Silt	5
Clay	60
Composition:	
Foraminifers	35
Nannofossils	62
Others	3

SITE 516 HOLE A CORE (HPC) 5 CORED INTERVAL 16.7–21.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Pliocene	PL3 (F)	AM				1	0.5, 1.0
upper Pliocene	PL3 (F)	AM				2	
lower Pliocene	N19, PL2 (F) NN14–15 (N)	AM				3	
lower Pliocene	N19, PL2 (F) NN14–15 (N)	AM	AM	B		CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

10YR 8/2

NANNO OOZE
Color: 10YR 8/1 with hues of 10YR 8/2.

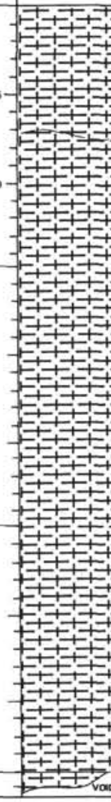
SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	5
Silt	30
Clay	65
Composition:	
Other clay minerals	1
Carbonate unspecified	5
Foraminifers	5
Nannofossils	87
Volcanic glass	2

SITE 516 HOLE A CORE (HPC) 6 CORED INTERVAL 21.1–25.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Pliocene						1	0.5, 1.0
lower Pliocene						2	
lower Pliocene		AM				3	
lower Pliocene	PL1c (F) NN14 (N)	AM	AG	B		CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

← Yellowish staining

← Yellow (10YR 7/6) lamination

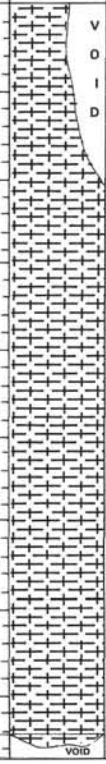
FORAM-NANNO OOZE
Color: white (10YR 8/2).

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	10
Silt	20
Clay	70
Composition:	
Carbonate unspecified	5
Foraminifers	12
Nannofossils	82
Volcanic glass	1

SITE 516 HOLE A CORE (HPC) 7 CORED INTERVAL 25.5–29.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Pliocene	PL 1c (F)	AM				1	0.5, 1.0	VOID				FORAM-NANNO OOZE Color: white (10YR 8/1).
						2						
		AM				3					*	
	NN14 (N)	AM	AM	B		CC		VOID				

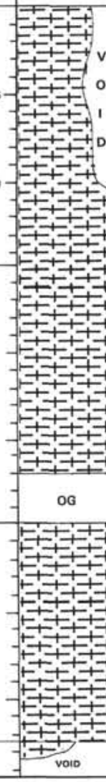


SMEAR SLIDE SUMMARY:

	3-45 D
Texture:	
Sand	25
Silt	5
Clay	70
Composition:	
Foraminifers	25
Nannofossils	73
Opaque minerals	2

SITE 516 HOLE A CORE (HPC) 8 CORED INTERVAL 29.9–34.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Pliocene	PL 1c (F)	AM				1	0.5, 1.0	VOID			*	FORAM-NANNO OOZE Color: white (10YR 8/1). Black spots
						2		OG				10YR 8/2
		AM				3						10YR 7/3 10YR 8/3 grading down to 10YR 8/1
	NN14 (N)	AM	AM	B		CC		VOID				

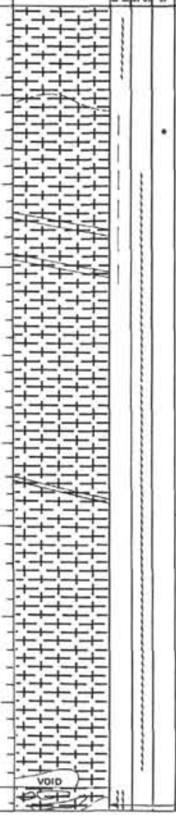


SMEAR SLIDE SUMMARY:

	1-140 D
Texture:	
Sand	15
Silt	5
Clay	80
Composition:	
Quartz	TR
Foraminifers	15
Nannofossils	85

SITE 516 HOLE A CORE (HPC) 9 CORED INTERVAL 34.3–38.7 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Pliocene	PL1b (F)					1	0.5, 1.0
						2	
		AM				3	
	NN14 (N)	AM	AM	B		CC	



LITHOLOGIC DESCRIPTION

10YR 8/1

10YR 6/1

Yellow stain

10YR 8/1 mottled with 10YR 7/1

VOID

FORAM-NANNO OOZE

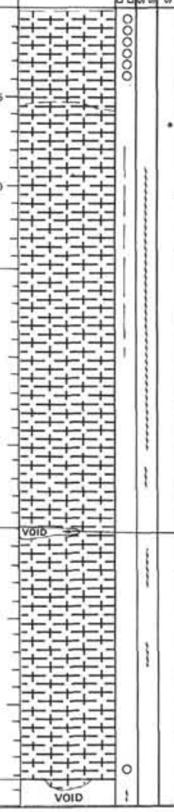
Inclined beds (base of Section 1 and 2) show as very slight color contrasts. Scaphopod appears in Section 3 at 80 cm.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	20
Silt	15
Clav	65
Composition:	
Carbonate unspecified	5
Foraminifers	25
Nannofossils	70

SITE 516 HOLE A CORE (HPC) 10 CORED INTERVAL 38.7–43.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Pliocene	PL1b (F)	AM				1	0.5, 1.0
						2	
	PL1a (F)					3	
	NN14 (N)	AM	AM	B		CC	



LITHOLOGIC DESCRIPTION

10YR 8/1 with mottles of 10YR 8/3

10YR 8/2

10YR 8/1

VOID

FORAM-NANNO CHALK

Color: white (10YR 8/1).

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	5
Silt	25
Clay	70
Composition:	
Carbonate unspecified	5
Foraminifers	10
Nannofossils	84
Sponge spicules	TR
Volcanic glass	1

SITE 516 HOLE A CORE (HPC) 11 CORED INTERVAL 43.1–47.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Pliocene	PL1a (F)	AM				1	0.5, 1.0	VOID			*	
						2						
	N17–18 (F) NN12–13 (N)	AM				3						
		AM	AM	B		CC						

NANNOFOSSIL OOZE

Color: 10YR 8/1 with gradual darkening downcore to 10YR 8/2.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	2
Silt	18
Clay	70
Composition:	
Quartz	1
Foraminifers	5
Nannofossils	93
Volcanic glass	1

SITE 516 HOLE A CORE (HPC) 12 CORED INTERVAL 47.5–51.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
lower Pliocene	PL1a (F)	AM				1	0.5, 1.0	VOID			*	
						2						
upper Pliocene	N17 (top) (F)	AM				3						Faint laminations 10YR 8/1 mottling and bedded with 10YR 7/1; 10YR 8/2 mottled with 10YR 8/1
		AM	AM	B		CC		VOID				

FORAM-NANNO OOZE

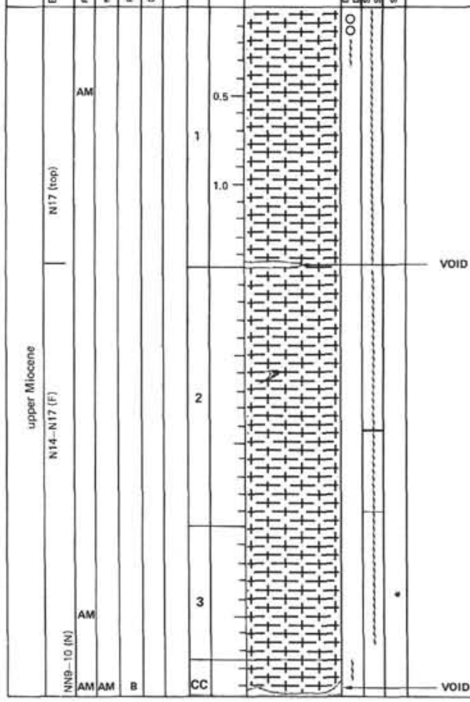
Color: 10YR 8/2 with some hues of 10YR 8/1.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	15
Silt	5
Clay	80
Composition:	
Foraminifers	15
Nannofossils	85

SITE 516 HOLE A CORE (HPC) 13 CORED INTERVAL 51.9–56.3 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION



FORAM-NANNO OOZE

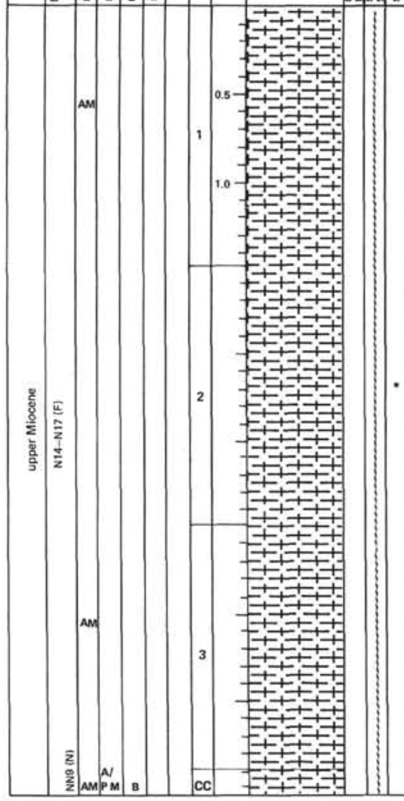
Homogeneous white (10YR 8/2) with slight mottling of white (10YR 8/1). Minor lamination of medium gray (N5) in Section 2.

SMEAR SLIDE SUMMARY:

	3-40
	D
Texture:	
Sand	15
Silt	65
Clay	20
Composition:	
Zeolites	TR
Foraminifers	15
Nannofossils	84
Volcanic glass	TR

SITE 516 HOLE A CORE (HPC) 14 CORED INTERVAL 56.3–60.7 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION



FORAM-NANNO OOZE

White (10YR 8/2) with slight mottling of white (10YR 8/1). One semicircular burrow mottle (5 cm diameter) at top of Section 1 indicates no disturbance from coring.

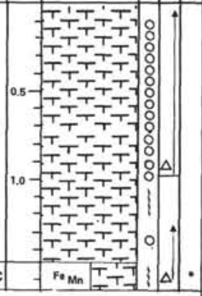
SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	10
Silt	80
Clay	10
Composition:	
Zeolites	TR
Foraminifers	10
Nannofossils	89
Volcanic glass	TR
Sponge spicules	TR

NOTE: Core 15, 60.7–65.1 m: No recovery.

SITE 516 HOLE A CORE (HPC) 16 CORED INTERVAL 65.1–69.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
?						1	0.5, 1.0					
	?	AM	AM			CC		Fe Mn			*	



FORAM SAND

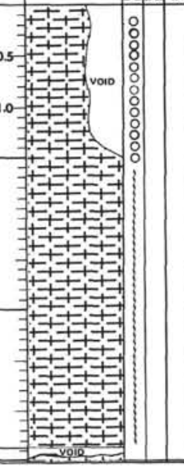
Highly disturbed core with fine foram sand from top to 118 cm; thin ooze layer (foram-nanno) at 118–136 cm; fine foram sand 136 cm–top of Core-Catcher; coarse sand/gravel of benthic forams, breccia, Mn-oxide crust fragments, gastropods, pelecypod fragments. (Slightly coarser basal layer at 117–118 cm also.) Colors: 10YR 8/2 except in 118–136 cm – mixed 10YR 8/2 and 8/1 and Core-Catcher where large rusty and black sand and granules are found. Large flakes probably to pipe scale.

SMEAR SLIDE SUMMARY:

	CC D
Texture:	
Sand	80
Silt	10
Clay	10
Composition:	
Foraminifers	70
Nannofossils	20
Pelecypod fragments	10

SITE 516 HOLE B CORE 1 CORED INTERVAL 15.6–23.2 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
						1	0.5, 1.0	VOID				
						2						
						3						
						CC		VOID				



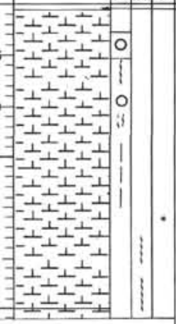
FORAM-NANNO OOZE

Totally deformed. This is an instrument test hole for bit motion studies (core came free).

SITE 516 HOLE F CORE 1 CORED INTERVAL 169.1–178.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	NN2 (N)					1	0.5, 1.0
	N5 (F)					2	
		AM	AM	RP		CC	

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



VOID

10YR 7/1

LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Light gray (10YR 7/1) nanno ooze with very few burrows. Layers of white (10YR 8/1) burrows frequent in the white layers in Section 2.

SMEAR SLIDE SUMMARY:

	2-70 D
Texture:	
Sand	8
Silt	42
Clay	50
Composition:	
Quartz	2
Heavy minerals	TR
Zeolites	2
Other clay minerals	15
Foraminifers	7
Nannofossils	72
Volcanic glass	TR
Micronodules	1
Sponge spicules	1

PHYSICAL PROPERTIES:

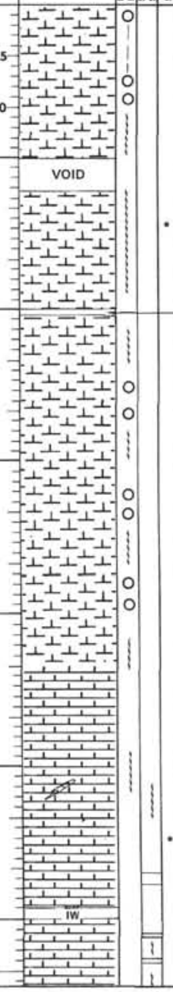
	2-92
V_v	—
V_h	1.636
Density	—
Water content	33.1

CARBONATE BOMB:
1-70 = 92

SITE 516 HOLE F CORE 2 CORED INTERVAL 178.6–188.1 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Miocene	N5 (F)					1	0.5, 1.0
						2	
	NN2 (N)					3	
				RP		4	
	N4 (F)					5	
						6	
						7	
		AM	A/PM			CC	

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



VOID

LITHOLOGIC DESCRIPTION

NANNO OOZE

Section 1–Section 5, 50 cm: mottled between white (10YR 8/1) and light gray (10YR 7/1). Burrows (few) and artifical flow structures.

NANNO CHALK

Section 5, 50 cm–Core-Catcher: white (10YR 8/1) nanno chalk, burrowed with faint laminations. Section 7 more burrowed with clear laminations.

SMEAR SLIDE SUMMARY:

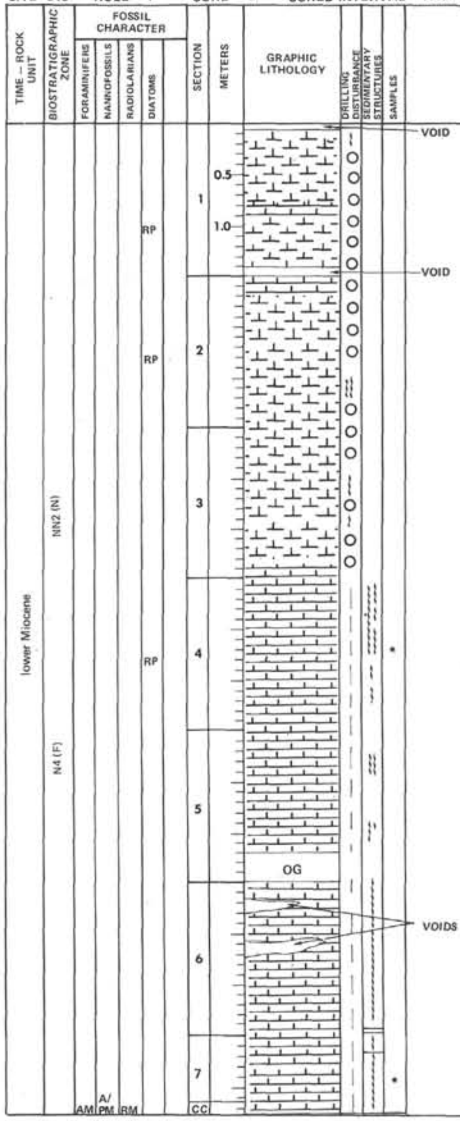
	2-70 D	6-70 D
Texture:		
Sand	5	1
Silt	75	59
Clay	20	40
Composition:		
Quartz	–	TR
Feldspar	–	TR
Heavy minerals	–	TR
Other clay minerals	5	20
Foraminifers	5	1
Nannofossils	88	77
Diatoms	TR	TR
Micronodules	TR	–
Sponge spicules	1	–
Volcanic glass	–	1

PHYSICAL PROPERTIES:

	7-22
V_v	1.78
V_h	1.77
Density	1.73
Water content	33.1

CARBONATE BOMB:
2-70 = 86
4-70 = 84
7-20 = 81

SITE 516 HOLE F CORE 3 CORED INTERVAL 188.1–197.6 m



LITHOLOGIC DESCRIPTION

NANNO-CHALK AND OOZE

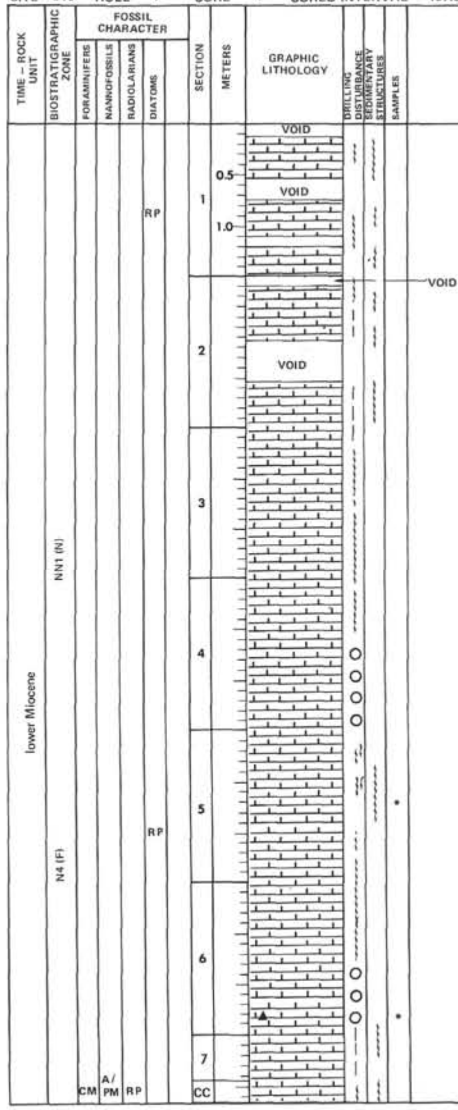
Dominant color: light gray (10YR 7/1) nanno ooze, very disturbed, with alternations of chalk and stiff ooze. Section 4, 10–88 cm is very burrowed. Section 6: burrowed and mottled (10YR 8/1–10YR 7/1).

SMEAR SLIDE SUMMARY:

	4-70	7-49
	D	D
Texture:		
Sand	7	3
Silt	43	37
Clay	50	60
Composition:		
Quartz	–	2
Feldspar	–	TR
Heavy minerals	TR	TR
Zeolites	TR	–
Other clay minerals	20	30
Foraminifers	8	3
Nannofossils	70	65
Radiolarians	1	–
Sponge spicules	1	–
Fish remains	TR	–
Volcanic glass	–	TR

CARBONATE BOMB:
4-70 = 88

SITE 516 HOLE F CORE 4 CORED INTERVAL 197.6–207.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

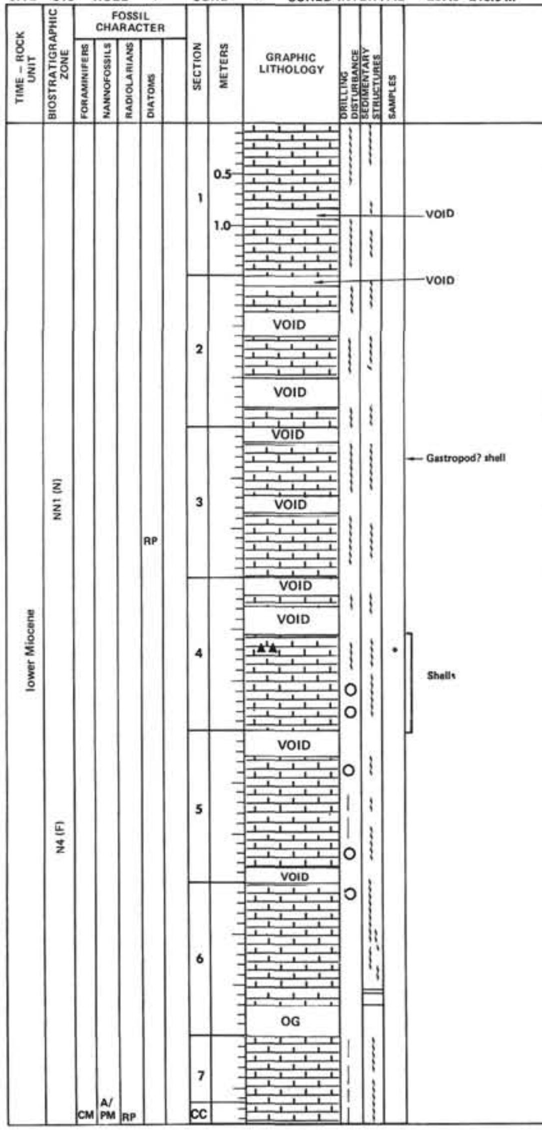
Nannofossil chalk with minor chert. Color between white (10YR 8/1) and light olive gray (5Y 6/1) with mottles, flecks, and burrows of medium to dark gray (N4–N6). Very badly deformed core, with intervals of soup, probably were initially ooze. Harder layers may be partly cemented by silica. Chert nodule approximately 1 cm diameter at Section 6, 120 cm.

SMEAR SLIDE SUMMARY:

	5-70	6-132 (near chert layer)
	D	D
Texture:		
Sand	10	3
Silt	60	70
Clay	30	27
Composition:		
Quartz	1	–
Feldspar	TR	–
Other clay minerals	10	20
Foraminifers	5	3
Nannofossils	80	75
Diatoms	TR	–
Radiolarians	1	–
Sponge spicules	3	TR
Chert fragments	1	–

CARBONATE BOMB:
2-70 = 88
4-70 = 78

SITE 516 HOLE F CORE 5 CORED INTERVAL 207.5–216.6 m



LITHOLOGIC DESCRIPTION

NANNO CHALK

Color: light gray (5Y 7/1) with N4.

SMEAR SLIDE SUMMARY:

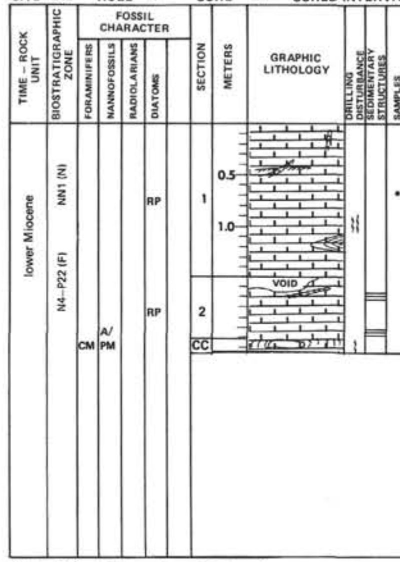
	4-70
	D
Texture:	
Sand	10
Silt	60
Clay	30
Composition:	
Quartz	2
Other clay minerals	20
Foraminifers	5
Nannofossils	60
Radiolarians	2
Chert fragments	3
Volcanic glass	TR
Sponge spicules	5

PHYSICAL PROPERTIES:

	6-107
V_v	1.74
V_h	1.82
Density	1.81
Water content	28.9

CARBONATE BOMB:
2-70 = 79
4-70 = 76

SITE 516 HOLE F CORE 6 CORED INTERVAL 216.6–226.1 m



LITHOLOGIC DESCRIPTION

NANNO-CHALK

Color: light gray (5Y 7/1). Contorted laminations(?) or burrow-fill in Section 1 with Section 2 having deformed laminations.

SMEAR SLIDE SUMMARY:

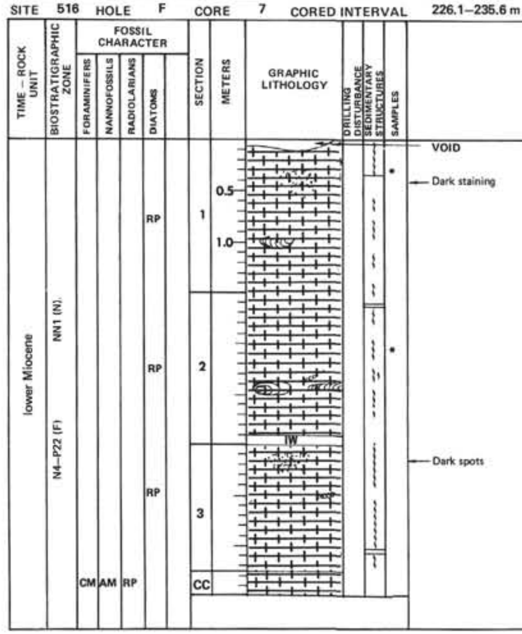
	1-70
	D
Texture:	
Sand	10
Silt	15
Clay	75
Composition:	
Mica	TR
Foraminifers	10
Nannofossils	80
Radiolarians	2
Sponge spicules	8

PHYSICAL PROPERTIES:

	1-90
V_v	1.67
V_h	1.73
Density	1.81
Water content	28.9

CARBONATE BOMB:
1-65 = 79

SITE 516 HOLE F CORE 7 CORED INTERVAL 226.1–235.6 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO CHALK

Section 2 is the beginning of alternation of light (10YR 6/1) matrix with dark (10YR 7/1) burrow fill and dark (10YR 7/1) matrix with light (10YR 6/1) burrow fill.

SMEAR SLIDE SUMMARY:

	1-37	2-60
	D	D
Texture:		
Sand	10	10
Silt	10	15
Clay	80	75
Composition:		
Quartz	–	TR
Other clay minerals	15	10
Foraminifers	7	20
Nannofossils	60	56
Diatoms	–	TR
Radiolarians	–	2
Micronodules	8	2
Sponge spicules	–	10
Volcanic glass	–	TR

PHYSICAL PROPERTIES:

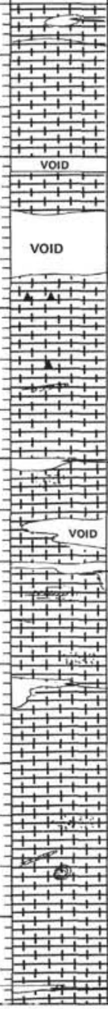
	3-34
V_v	1.76
V_h	1.72
Density	1.80
Water content	29.0

CARBONATE BOMB:
2-70 = 78

SITE 516 HOLE F CORE 8 CORED INTERVAL 235.6–245.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene–lower Miocene	NN1 (N)				FG	1	0.5, 1.0
					RP	2	
					RP	3	
					RP	4	
	P22 (F) N4 (F)				RP	5	
	Rocella gelida (D)				RM	6	
						7	
		FM	AM	RP		CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

VOID

Ooze

Biscuits

VOID

Black staining

VOID

Biscuited

Black staining

VOID

Dark spots

Light brownish gray (10YR 6/2)

10YR 7/1

VOID

LITHOLOGIC DESCRIPTION

FORAM-NANNO CHALK

Color: 10YR 7/2 and N3.

SMEAR SLIDE SUMMARY:

	1-70 D	3-130 D	7-10 D
Texture:			
Sand	10	10	–
Silt	15	20	–
Clay	75	70	–
Composition:			
Quartz	–	2	1
Zeolites	–	TR	–
Other clay minerals	20	20	20
Foraminifers	10	8	10
Nannofossils	57	60	59
Radiolarians	2	1	2
Micronodules	1	–	–
Sponge spicules	10	6	8
Volcanic glass	–	1	–

PHYSICAL PROPERTIES:

	6-76
V_v	1.66
V_h	1.68
Density	1.77
Water content	30.4

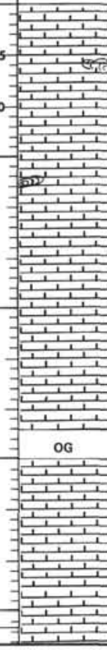
CARBONATE BOMB:
1-70 = 80
3-70 = 83
5-75 = 82

ORGANIC CARBON:
7, 5–12 = 0.12

SITE 516 HOLE F CORE 9 CORED INTERVAL 245.1–254.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Oligocene	NP25–NN1 (N)				RP	1	0.5, 1.0
					RP	2	
	P22–N4 (F)				RP	3	
					RP	4	
						5	
		CM	AM	RP		CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

Green hues

Green hues

10YR 7/1 with mottles of 10YR 7/2

Faint color change 10YR 6/1

10YR 7/1

10YR 6/1

LITHOLOGIC DESCRIPTION

NANNO CHALK

Extensive drilling deformation. Color: 10YR 7/1 with mottles of 10YR 7/2 and dark gray (10YR 4/1).

SMEAR SLIDE SUMMARY:

	1-70 D	1-76 M
Texture:		
Sand	2	20
Silt	20	20
Clay	78	60
Composition:		
Quartz	TR	2
Feldspar	–	2
Other clay minerals	5	14
Foraminifers	5	10
Nannofossils	85	60
Diatoms	TR	–
Radiolarians	TR	2
Volcanic glass	1	–
Sponge spicules	2	10

PHYSICAL PROPERTIES:

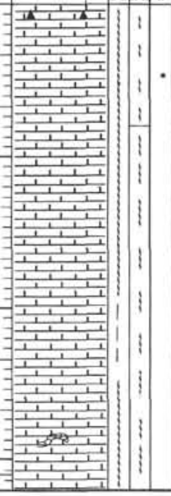
	4-72
V_v	1.75
V_h	1.70
Density	1.75
Water content	30.5

CARBONATE BOMB:
2-70 = 74
4-70 = 78

SITE 516 HOLE F CORE 10 CORED INTERVAL 254.6–264.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Oligocene	NP25 (N) / P22 (F)	FM	AM	RP	RP, CM, RP	1, 2, 3, 4, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



10YR 7/1

10YR 8/1

10YR 7/1 mottled with 10YR 7/2

LITHOLOGIC DESCRIPTION

NANNO CHALK

Biscuited, softer sediment between biscuits is very deformed. Color : 10YR 7/1 with mottles of 10YR 6/1 and 10YR 4/1.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	40
Clay	50
Composition:	
Quartz	TR
Feldspar	TR
Other clay minerals	10
Foraminifers	8
Nannofossils	72
Radiolarians	1
Volcanic glass	2
Micronodules	1
Sponge spicules	5

PHYSICAL PROPERTIES:

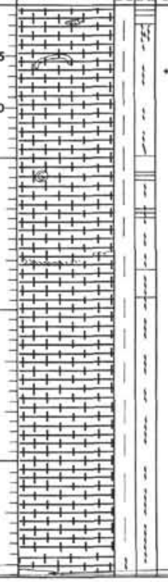
	4-1
V_v	1.69
V_h	1.71
Density	1.75
Water content	30.4

CARBONATE BOMB:
2-70 = 73

SITE 516 HOLE F CORE 11 CORED INTERVAL 264.1–273.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24–25 (N) / P22 (F)	CM	AM	RP	CM, RP, CG, CM	1, 2, 3, 4, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



← Bivalve shell

Black (N3) staining

VOID

LITHOLOGIC DESCRIPTION

FORAM-NANNO CHALK

Color: 10YR 8/1 mottled with 10YR 7/1. Black (N3) staining in Section 3.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	35
Clay	60
Composition:	
Quartz	1
Heavy minerals	TR
Other clay minerals	10
Carbonate unspecified	5
Foraminifers	11
Nannofossils	68
Radiolarians	TR
Volcanic glass	3
Micronodules	2

PHYSICAL PROPERTIES:

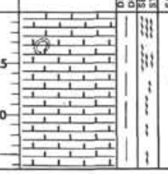
	1-0	3-80
V_v	—	1.75
V_h	1.72	1.78
Density	—	1.82
Water content	—	28.7

CARBONATE BOMB:
2-70 = 77
4-70 = 88

SITE 516 HOLE F CORE 12 CORED INTERVAL 273.6–283.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24 (N) / P22	CM	AM	RP	CM	1, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

NANNO-CHALK

Biscuited, light gray (10YR 7/1).

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	15
Clay	75
Composition:	
Quartz	2
Glauconite	TR
Other clay minerals	10
Foraminifers	9
Nannofossils	70
Radiolarians	1
Volcanic glass	1
Sponge spicules	7

PHYSICAL PROPERTIES:

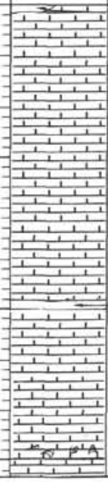
	1-12
V_v	1.72
V_h	1.73
Density	1.90
Water content	28.6

CARBONATE BOMB:
1-70 = 77

SITE 516 HOLE F CORE 13 CORED INTERVAL 283.1–292.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24 (N); probably P22 (F)				CM	1	0.5, 1.0
					RP	2	
						3	
		CM	A/MG			CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

VOID

10YR 7/1

10YR 8/1

IW

NANNO CHALK

Bisculted and extremely deformed between biscuits.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	35
Clay	60
Composition:	
Quartz	1
Other clay minerals	10
Foraminifers	5
Nannofossils	77
Radiolarians	TR
Volcanic glass	2
Sponge spicules	5

CARBONATE BOMB:
1-70 = 78
3-70 = 83

SITE 516 HOLE F CORE 14 CORED INTERVAL 292.6–302.1 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	probably P22 (F); NP24 (N)	CM	AM	RM		CC	

GRAPHIC LITHOLOGY

LITHOLOGIC DESCRIPTION

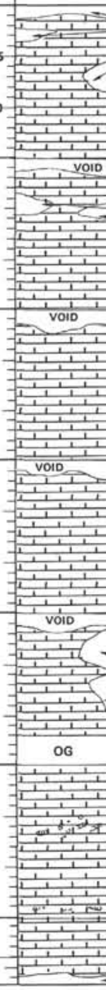
NANNO CHALK

Core-Catcher only.

SITE 516 HOLE F CORE 15 CORED INTERVAL 302.1–311.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24 (N); P21 (F)				RP	1	0.5, 1.0
					RP	2	
					RP	3	
					RP	4	
					RP	5	
	Triceratium groningensis (D)				RM	6	
						7	
		CM	CP	RM		CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

VOIDS

VOIDS

VOIDS

5Y 7/2
Burrow fill

Black staining
Light gray (5Y 7/1)

VOID

NANNO SOUP AND CHALK

Color: light gray (5Y 7/1). Burrow fill 5Y 7/2 in Section 6. Black staining appears in Section 7.

SMEAR SLIDE SUMMARY:

	1-62	6-60
	D	D
Texture:		
Sand	25	10
Silt	10	10
Clay	65	80
Composition:		
Quartz	–	1
Other clay minerals	15	9
Foraminifers	12	8
Nannofossils	55	75
Volcanic glass	3	–
Sponge spicules	12	7
Opaque minerals	3	–
Micronodules	1	–

CARBONATE BOMB:
2-70 = 76
6-70 = 85

SITE 516 HOLE F CORE 16 CORED INTERVAL 311.6–321.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24 (N); P21 (F)	AM	AM	RM		1, CC	

GRAPHIC LITHOLOGY

VOID

LITHOLOGIC DESCRIPTION

FORAM-NANNO CHALK

Light gray (5Y 7/1) with gray (5Y 6/1) mottles.

SMEAR SLIDE SUMMARY:

	1-10
	D
Texture:	
Sand	10
Silt	40
Clay	50
Composition:	
Other clay minerals	10
Carbonate unspecified	5
Foraminifers	12
Nannofossils	63
Volcanic glass	3
Micronodules	2
Sponge spicules	5

PHYSICAL PROPERTIES:

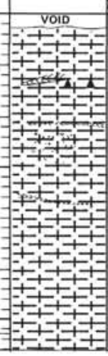
	1-0
V_v	1.73
V_h	1.82
Density	1.87
Water content	25.6

CARBONATE BOMB:
1-20 = 78

SITE 516 HOLE F CORE 17 CORED INTERVAL 321.1–330.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24 (N); P21 (F)	CM	AM			1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY



VOID

10Y 8/1

Black (N3) spots

5Y 8/1
5Y 6/2
5Y 8/1
5Y 6/2
5Y 8/1
5Y 7/1
5Y 8/1

LITHOLOGIC DESCRIPTION

NANNO-CHALK AND CHERT

Section 1: 5Y 6/2 with 5Y 8/1 mottles and burrow fill 5Y 8/1 with 5Y 7/1 mottles. Section 2: mottles of 5Y 7/1 and 5Y 3/1. Biscuited from 50 cm to end of core.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	2
Silt	38
Clay	60
Composition:	
Other clay minerals	20
Carbonate unspecified	10
Foraminifers	8
Nannofossils	59
Volcanic glass	2
Micronodules	1

PHYSICAL PROPERTIES:

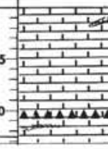
	CC
V_v	—
V_h	1.71
Density	—
Water content	—

CARBONATE BOMB:
2-70 = 79

SITE 516 HOLE F CORE 18 CORED INTERVAL 330.6–340.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP24 (N); P21 (F)	FM	AM			1, CC	0.5, 1.0

GRAPHIC LITHOLOGY



5Y 7/1
5Y 6/2
5Y 7/1
Chert layer, 5Y 6/1
5Y 7/1

LITHOLOGIC DESCRIPTION

NANNO CHALK

Color: light gray (5Y 7/1). Section 1, 20–40 cm: light olive gray (5Y 6/2) nanno chalk, quite burrowed and with faint laminations. Section 1, 40–100 cm: light gray (5Y 7/1) nanno chalk with few burrows but with several laminations. Section 1, 100–110 cm: chert layer, gray (5Y 6/1).

SMEAR SLIDE SUMMARY:

	1-30
	D
Texture:	
Sand	5
Silt	40
Clay	55
Composition:	
Quartz	TR
Heavy minerals	TR
Zeolites	TR
Other clay minerals	35
Foraminifers	5
Nannofossils	59
Silica fragments (cherts)	1
Micronodules	TR

PHYSICAL PROPERTIES:

	CC
V_v	1.77
V_h	1.75
Density	1.91
Water content	25.0

CARBONATE BOMB:
1-35 = 73
CC=15 = 75

SITE 516 HOLE F CORE 19 CORED INTERVAL 340.1–349.6 m

TIME – ROCK UNIT: upper Oligocene

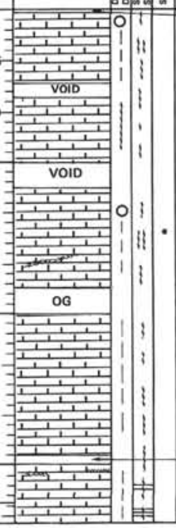
BIOSTRATIGRAPHIC ZONE: NP23–24 (N); P21 (F)

FOSSIL CHARACTER: FORAMINIFERS CG; NANNOFOSSILS AP; RADIOLARIANS B; DIATOMS

SECTION: 1, 2, 3, 4, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



VOID

5Y 7/1

IW

LITHOLOGIC DESCRIPTION

NANNO CHALK

Color: 5Y 7/1 with few burrows. Few scattered shell fragments in the lower part of Section 1. Section 1, 33–41 cm: heavily burrowed layer. Section 4 and Core-Catcher: burrowed nanno chalk with faint laminations.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	5
Silt	35
Clay	65
Composition:	
Quartz	TR
Heavy minerals	TR
Micronodules	1
Zeolites	1
Other clay minerals	35
Foraminifers	5
Nannofossils	58
Volcanic glass	TR
Sponge spicules	TR

PHYSICAL PROPERTIES:

	2-75	2-117
V_v	1.83	—
V_h	1.88	2.07
Density	2.02	1.89
Water content	24.5	—

CARBONATE BOMB:
2-80 = 82

SITE 516 HOLE F CORE 20 CORED INTERVAL 349.6–359.1 m

TIME – ROCK UNIT: upper Oligocene

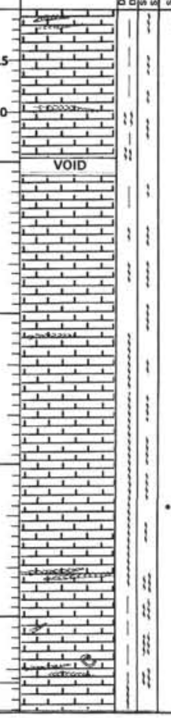
BIOSTRATIGRAPHIC ZONE: NP23–24 (N); P21 (F)

FOSSIL CHARACTER: FORAMINIFERS CG; NANNOFOSSILS AM; RADIOLARIANS B; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5Y 7/1

5Y 6/2

LITHOLOGIC DESCRIPTION

NANNO CHALK

Dominant color light gray (5Y 7/1) with faint laminations and burrows. There are two layers at Section 1 (11–21 and 62–76 cm) of light olive gray color that are harder and heavily burrowed. Section 2 has biscuits of undeformed sediments becoming very deformed. Sections 3 and 4 are very deformed. Section 5 and Core-Catcher have alternating layers of light gray and light olive gray and are burrowed throughout.

SMEAR SLIDE SUMMARY:

	1-12	4-48
	D	D
Texture:		
Sand	1	5
Silt	34	45
Clay	65	50
Composition:		
Quartz	TR	TR
Heavy minerals	TR	TR
Zeolites	TR	TR
Other clay minerals	35	20
Foraminifers	5	5
Nannofossils	60	75
Diatoms	–	TR
Sponge spicules	TR	TR
Volcanic glass	TR	–
Micronodules	TR	–

PHYSICAL PROPERTIES:

	1-11
V_v	—
V_h	1.89
Density	1.96
Water content	22.5

CARBONATE BOMB:
1-15 = 76
4-50 = 82

SITE 516 HOLE F CORE 21 CORED INTERVAL 359.1–368.6 m

TIME – ROCK UNIT: upper Oligocene

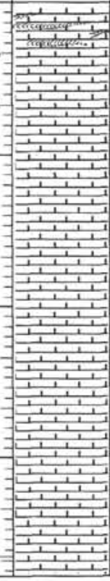
BIOSTRATIGRAPHIC ZONE: NP23–24 (N); P21 (F)

FOSSIL CHARACTER: FORAMINIFERS CM; NANNOFOSSILS A/PM; RADIOLARIANS B; DIATOMS

SECTION: 1, 2, 3, 4, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Gray, light gray, and white (5Y 6/1–8/1) intermixed throughout, plus burrowing and mottling of gray (N3–N5) and olive (5Y 5/3). Core disturbed in drilling, with biscuits separated by highly disturbed sections (particularly Section 2).

SMEAR SLIDE SUMMARY:

	2-65
	D
Texture:	
Sand	5
Silt	65
Clay	30
Composition:	
Zeolites	1
Other clay minerals	20
Carbonate unspecified	3
Foraminifers	5
Nannofossils	69
Dolomite(?)	TR
Volcanic glass	TR
Chert fragments(?)	3

PHYSICAL PROPERTIES:

	1-29
V_v	—
V_h	1.94
Density	1.95
Water content	22.9

CARBONATE BOMB:
1-25 = 82
2-65 = 86

SITE 516 HOLE F CORE 22 CORED INTERVAL 368.6–378.1 m

TIME – ROCK UNIT: upper Oligocene

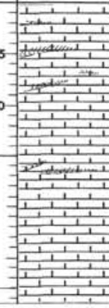
BIOSTRATIGRAPHIC ZONE: NP23–24 (N); P21 (F)

FOSSIL CHARACTER: FORAMINIFERS C/AM; NANNOFOSSILS A/PM; RADIOLARIANS B; DIATOMS

SECTION: 1, 2, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Extensively burrowed nannofossil chalk. Main colors: white (5Y 8/1), light gray (5Y 7/1), and light olive gray (5Y 6/2). Lower part of Section 1 consists of mottling and burrows of above colors plus grays (N6–N3). Section 2–Core-Catcher: dominant colors 5Y 7/1 and 5Y 8/1. Mottling of gray (N5–N6) and biscuited.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	5
Silt	65
Clay	30
Composition:	
Quartz	1
Feldspar	TR
Zeolites	1
Other clay minerals	20
Carbonate unspecified	2
Foraminifers	5
Nannofossils	70
Chert	3

PHYSICAL PROPERTIES:

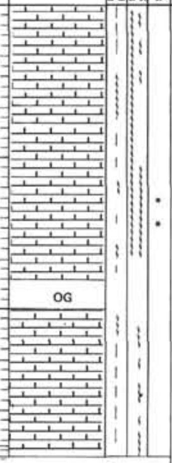
	1-5	1-7
V_v	—	—
V_h	—	2.04
Density	1.95	1.96
Water content	23.4	—

CARBONATE BOMB:
2-70 = 84

SITE 516 HOLE F CORE 23 CORED INTERVAL 378.1–387.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP23–24 (N); P21 (F)	CM	A/PM	B		1; 2; 3; CC	0.5; 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

5Y 6/1 to 5Y 8/1

5Y 7/1 to 5Y 8/1

NANNOFOSSIL CHALK

Bands of gray (5Y 6/1) in white (5Y 8/1). Darker layers have gradational burrowed contacts and contain small amounts of rhombohedral carbonate grains (dolomite?, see smear slide summary). Burrowing moderate to extensive throughout.

SMEAR SLIDE SUMMARY:

	2-45 D	2-70 M
Texture:		
Sand	3	5
Silt	60	70
Clay	37	25
Composition:		
Quartz	TR	–
Zeolites	1	1
Other clay minerals	20	20
Carbonate unspecified (dolomite?)	2	10
Foraminifers	5	3
Nannofossils	70	60
Volcanic glass	TR	TR
Chert?	TR	5
Micronodules	–	TR

PHYSICAL PROPERTIES:

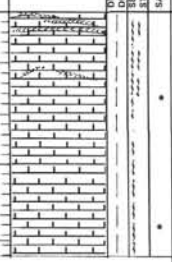
	2-12
V_v	1.88
V_h	1.91
Density	1.95
Water content	24.0

CARBONATE BOMB:
1-70 = 71

SITE 516 HOLE F CORE 24 CORED INTERVAL 387.6–397.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP23–24 (N); P21 (F)	CM	AP	B		1; 2; CC	0.5; 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light gray (5Y 7/1) in color and extensively burrowed. Section 1 130–135 cm is light olive gray (5Y 6/2) and harder than the lighter chalk. Section 1, 135–Section 2, 52 cm: light gray (5Y 7/1), extensively burrowed and with faint laminations. Section 2, 52 cm–Core-Catcher: light olive gray (5Y 6/2).

SMEAR SLIDE SUMMARY:

	1-90 D	2-70 D
Texture:		
Sand	3	1
Silt	57	54
Clay	40	45
Composition:		
Quartz	TR	1
Heavy minerals	TR	1
Volcanic glass	–	TR
Zeolites	TR	–
Other clay minerals	18	35
Foraminifers	3	1
Nannofossils	78	61
Dolomite	TR	TR
Micronodules	TR	TR
Amorphous silica	TR	1

PHYSICAL PROPERTIES:

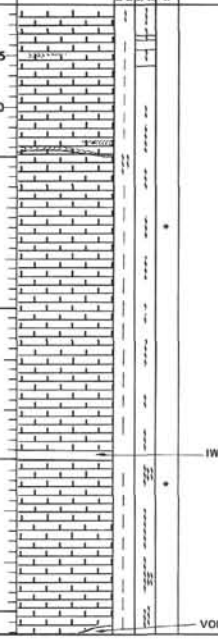
	1-17	1-49
V_v	—	1.87
V_h	1.88	1.94
Density	—	1.98
Water content	—	22.0

CARBONATE BOMB:
1-70 = 81

SITE 516 HOLE F CORE 25 CORED INTERVAL 397.1–406.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Oligocene	NP23–24 (N); P20 (F)	CM	AM	B		1; 2; 3; 4; CC	0.5; 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light gray (5Y 7/1) with two zones of darker medium gray (5Y 4/1–5/1). Several intervals of slightly darker light gray (5Y 6/1). Drilling has induced laminations separating thin biscuits; there is little flow of intervening soupy sediments. Dolomite(?) rhombs in darker units. One silicified burrow (2 x 10 mm) in Section 4 along liner.

SMEAR SLIDE SUMMARY:

	2-70 D	4-22 M
Texture:		
Sand	1	3
Silt	39	50
Clay	60	47
Composition:		
Quartz	TR	1
Feldspar	–	1
Heavy minerals	–	TR
Zeolites	TR	2
Other clay minerals	35	20
Carbonate unspecified (dolomite)	–	5
Foraminifers	1	2
Nannofossils	64	67
Micronodules	TR	1
Amorphous silica	–	2
Volcanic glass	TR	TR

PHYSICAL PROPERTIES:

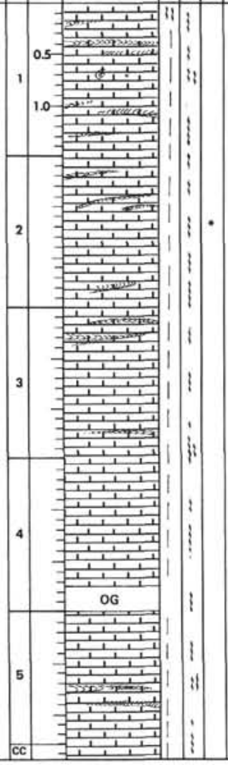
	1-15	3-44
V_v	1.78	—
V_h	1.77	1.87
Density	2.01	1.98
Water content	22.4	—

CARBONATE BOMB:
2-70 = 85
4-70 = 85

SITE 516 HOLE F CORE 26 CORED INTERVAL 406.6–416.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
upper Oligocene	NP23 (N) / P20 (F)	CM	A/PM	B	

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



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK .

Light gray (5Y 7/1) and extensively burrowed throughout. Burrows show flattening. At Section 1, 60 cm large forams in burrow fill.

SMEAR SLIDE SUMMARY:

	3-70
	D
Texture:	
Sand	3
Silt	52
Clay	45
Composition:	
Quartz	TR
Heavy minerals	TR
Zeolites	TR
Other clay minerals	15
Foraminifers	3
Nannofossils	82
Volcanic glass	TR
Dolomite	TR
Micronodules	TR

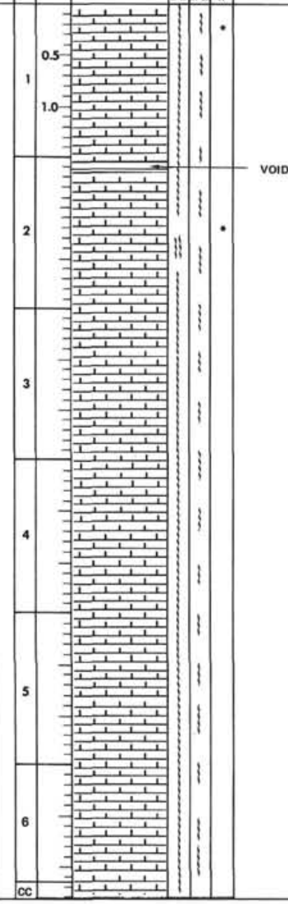
PHYSICAL PROPERTIES:

	1-17	5-124
V_v	—	1.84
V_h	1.97	1.89
Density	2.02	2.02
Water content	—	20.8

SITE 516 HOLE F CORE 27 CORED INTERVAL 416.1–425.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
upper Oligocene	NP23 (N) / P20 (F)	CM	A/PM	B	

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



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

The whole core was disturbed. Most of it had to be refilled into the liner. Section 1: dominant color is light greenish gray (5GY 8/1). Nanno chalk intensively burrowed. Burrows show some flattening. Between 24–27 cm of Section 1 there is a dark layer that starts with dark greenish gray (5GY 4/1) and turns to greenish (5GY 2/1) at the bottom. Dolomite rhombs are present in this layer. Section 2–Core-Catcher: light greenish gray (5GY 8/1) nanno chalk intensively burrowed.

SMEAR SLIDE SUMMARY:

	1-25	2-70
	M	D
Texture:		
Sand	1	1
Silt	64	64
Clay	34	34
Composition:		
Quartz	1	TR
Heavy minerals	TR	TR
Zeolites	TR	1
Other clay minerals	35	10
Foraminifers	1	1
Nannofossils	60	83
Amorphous silica	2	–
Micronodules	TR	TR
Dolomite	1	–
Sponge spicules	–	TR

PHYSICAL PROPERTIES:

	1-5	4-34
V_v	1.77	1.82
V_h	1.79	1.89
Density	1.96	1.95
Water content	24.6	23.0

CARBONATE BOMB:
3-70 = 81

SITE 516 HOLE F CORE 28 CORED INTERVAL 425.6–435.1 m

TIME – ROCK UNIT: upper Oligocene

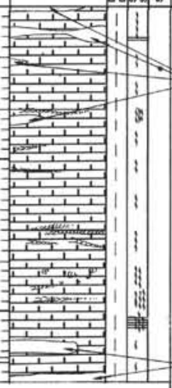
BIOSTRATIGRAPHIC ZONE: NP23 (N); P20 (F)

FOSSIL CHARACTER: FORAMINIFERS CM; NANNOFOSSILS CP; RADIOLARIANS B; DIATOMS

SECTION: 1, 2, 3, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Section 1: light gray (5Y 7/1) with mottles of gray (5Y 6/1). Section 2 is white (5Y 8/1) completely mottled with 5Y 6/1 and some dark gray (5Y 4/1).

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	3
Silt	30
Clay	67
Composition:	
Mica	1
Other clay minerals	20
Carbonate unspecified	5
Foraminifers	5
Nannofossils	77
Volcanic glass	2
Micronodules	TR

PHYSICAL PROPERTIES:

	2-73
V_v	1.72
V_h	1.76
Density	1.87
Water content	26.0

CARBONATE BOMB:
2-70 = 81

ORGANIC CARBON:
3, 0–5 = 0.42

SITE 516 HOLE F CORE 29 CORED INTERVAL 435.1–444.6 m

TIME – ROCK UNIT: upper Oligocene

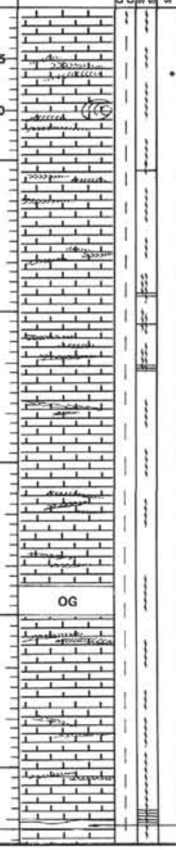
BIOSTRATIGRAPHIC ZONE: NP23 (N); P20 (F)

FOSSIL CHARACTER: FORAMINIFERS CG; NANNOFOSSILS AM; RADIOLARIANS B; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Mottled and cyclical color variations of about 30 cm (5Y 7/1, 5Y 8/1, and 5Y 6/1) throughout.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	1
Silt	20
Clay	79
Composition:	
Quartz	2
Other clay minerals	10
Carbonate unspecified	10
Foraminifers	3
Nannofossils	74
Micronodules	1

PHYSICAL PROPERTIES:

	1-41	5-90
V_v	—	1.84
V_h	1.91	1.88
Density	—	2.22
Water content	—	23.6

CARBONATE BOMB:
2-70 = 76
4-70 = 83

SITE 516 HOLE F CORE 30 CORED INTERVAL 444.6–454.1 m

TIME – ROCK UNIT: upper Oligocene

BIOSTRATIGRAPHIC ZONE: NP23 (N); P20 (F)

FOSSIL CHARACTER: FORAMINIFERS CM; NANNOFOSSILS AM; RADIOLARIANS B; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES

5Y 7/1

Black staining

Shell fragment

Flow structure?

Brecciated

Shell fragments

IW

5G 6/1 with 5Y 7/2 mottles

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Bioturbated throughout. Generally light gray (5Y 7/1) with burrow fill of 5Y 7/2 and 5Y 8/1. Section 3, 20–30 cm: large splotches? = deformed burrows. Section 3, 55–75 cm: slightly darker (5Y 6/1) interval with light colored burrow fill. Section 4, 35–55 cm: slightly darker (5Y 6/1) interval with light colored burrow fill. Section 6, 130 cm: greenish gray (5G 6/1) with 5Y 7/2 mottles.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	15
Clay	75
Composition:	
Mica	TR
Glauconite	TR
Other clay minerals	10
Foraminifers	10
Nannofossils	70
Volcanic glass	1
Opaque minerals	3
Micronodules	4

PHYSICAL PROPERTIES:

	2-142	6-38
V_v	1.88	1.85
V_h	1.91	1.93
Density	2.08	1.96
Water content	22.2	22.8

CARBONATE BOMB:
2-70 = 79
4-70 = 78
6-70 = 69

SITE 516 HOLE F CORE 31 CORED INTERVAL 454.1–436.6 m

TIME – ROCK UNIT: upper Oligocene

BIOSTRATIGRAPHIC ZONE: NP23 (N); P20 (F); (~P17–P19) (F)

FOSSIL CHARACTER: FORAMINIFERS CM; NANNOFOSSILS A/MG; RADIOLARIANS B; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES

5B 7/1

5GY 6/1

5GY 8/1

5GY 6/1

Shell fragment

5GY 8/1

5GY 6/1

Hard, black fragment

VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light gray (5GY 6/1) with horizontal to sub-horizontal burrows of greenish gray (5GY 6/1) and light greenish gray (5GY 8/1). Slight biscuiting throughout. Section 3, 0–25 cm: brecciated. Color alternations (5GY 6/1 with 5GY 8/1) from Section 3, 50 cm–Core-Catcher.

SMEAR SLIDE SUMMARY:

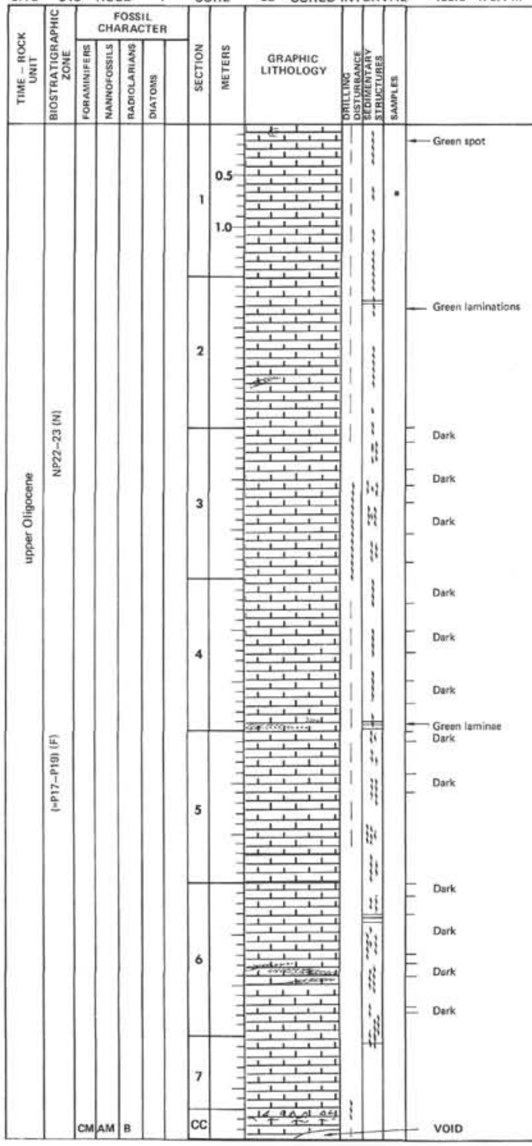
	1-70
	D
Texture:	
Sand	1
Silt	39
Clay	60
Composition:	
Feldspar	1
Mica	1
Other clay minerals	10
Carbonate unspecified	5
Foraminifers	7
Nannofossils	72
Volcanic glass	2
Micronodules	2

PHYSICAL PROPERTIES:

	1-31	4-77
V_v	1.80	1.87
V_h	1.81	1.97
Density	1.96	2.02
Water content	22.9	20.3

CARBONATE BOMB:
1-70 = 76
4-65 = 71

SITE 516 HOLE F CORE 32 CORED INTERVAL 463.6–473.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Alternating light–dark bands: light greenish gray (5GY 8/1) except where marked dark greenish gray (5GY 6/1).

SMEAR SLIDE SUMMARY:

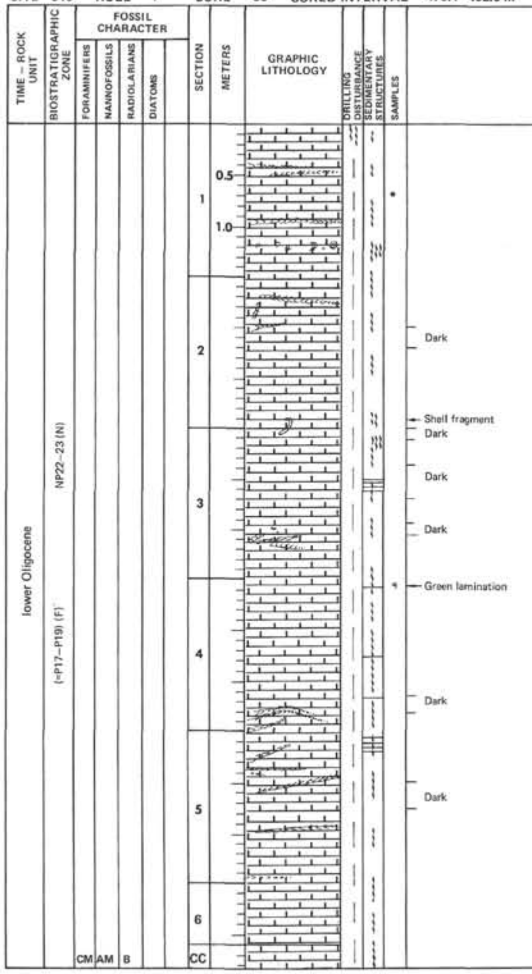
	1-70 D
Texture:	
Sand	5
Silt	30
Clay	65
Composition:	
Other clay minerals	10
Carbonate unspecified	5
Foraminifers	7
Nannofossils	71
Volcanic glass	5
Micronodules	2

PHYSICAL PROPERTIES:

	1-15	6-40
V_v	—	1.96
V_h	1.96	2.03
Density	—	1.99
Water content	—	21.8

CARBONATE BOMB:
2-60 = 70
4-60 = 71
6-55 = 70

SITE 516 HOLE F CORE 33 CORED INTERVAL 473.1–482.6 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO CHALK

Generally light gray (5Y 7/1) and burrowed throughout. Color alternations dark (5Y 6/1) otherwise 5Y 7/1.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	20
Silt	10
Clay	70
Composition:	
Glauconite	1
Other clay minerals	7
Carbonate unspecified	1
Foraminifers	20
Nannofossils	70
Radiolarians	TR
Chert	1

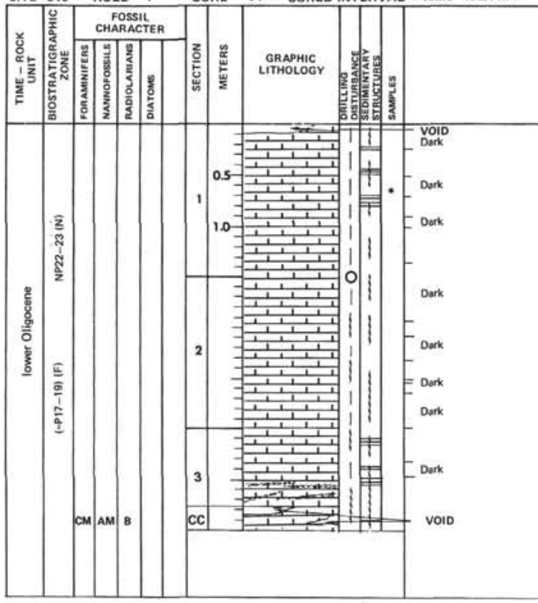
PHYSICAL PROPERTIES:

	1-57	6-43
V_v	1.82	1.89
V_h	1.85	1.94
Density	1.95	1.98
Water content	22.9	21.8

CARBONATE BOMB:
2-30 = 84
4-30 = 85
6-30 = 75

ORGANIC CARBON:
4, 8–15 = 0.71

SITE 516 HOLE F CORE 34 CORED INTERVAL 482.6–492.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light–dark alternations: light greenish gray (5GY 8/1) to dark greenish gray (5GY 6/1).

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	5
Clay	85
Composition:	
Quartz	1
Other clay minerals	22
Carbonate unspecified	6
Foraminifers	8
Nannofossils	60
Opaque minerals	2
Volcanic glass	1
Sponge spicules	TR

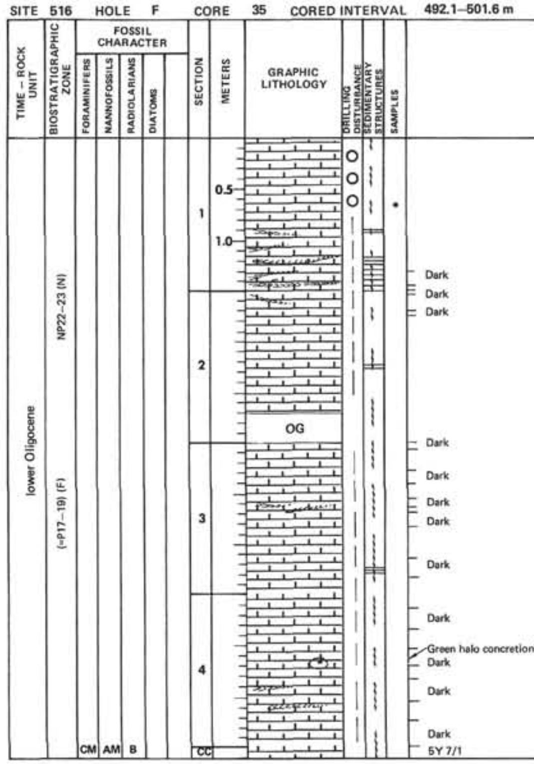
PHYSICAL PROPERTIES:

	1-25	3-45
V_v	—	2.03
V_h	1.86	2.14
Density	—	2.13
Water content	—	18.2

CARBONATE BOMB:

1-70 = 81

SITE 516 HOLE F CORE 35 CORED INTERVAL 492.1–501.6 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light greenish gray (5GY 8/1) except where otherwise noted dark greenish gray (5GY 6/1).

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	10
Clay	85
Composition:	
Quartz	3
Other clay minerals	15
Carbonate unspecified	10
Foraminifers	6
Nannofossils	66

PHYSICAL PROPERTIES:

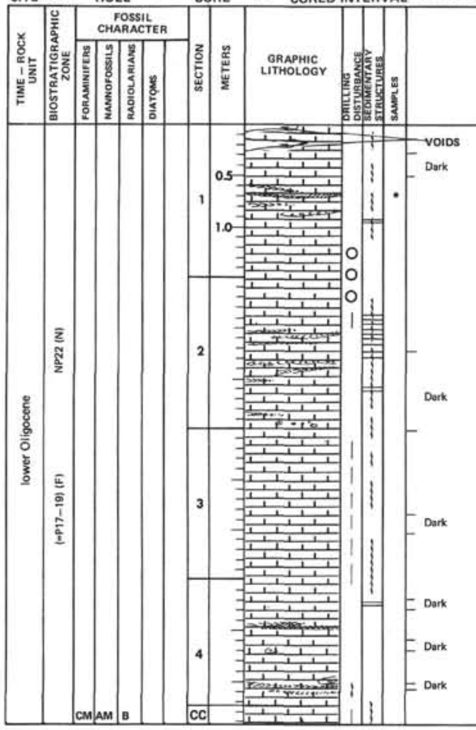
	1-128	4-57
V_v	1.94	1.84
V_h	1.90	1.89
Density	2.06	1.99
Water content	18.5	21.6

CARBONATE BOMB:

2-70 = 87

4-70 = 79

SITE 516 HOLE F CORE 36 CORED INTERVAL 501.6–511.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Color: 5GY 8/1 except where otherwise noted dark equals 5GY 6/1.

SMEAR SLIDE SUMMARY:

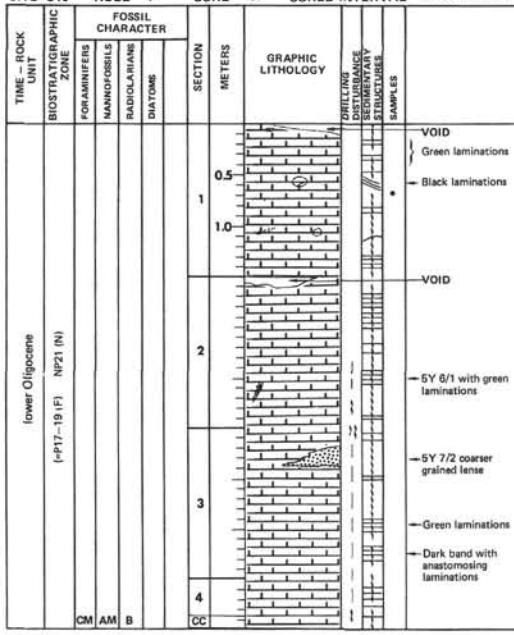
	1-70
	D
Texture:	
Sand	5
Silt	40
Clay	55
Composition:	
Other clay minerals	10
Carbonate unspecified	5
Foraminifers	8
Nannofossils	76
Volcanic glass	3
Micronodules	TR

PHYSICAL PROPERTIES:

	1-33	2-54
V_v	1.79	—
V_h	1.91	2.01
Density	1.94	—
Water content	23.4	—

CARBONATE BOMB:
2-70 = 82
4-70 = 84

SITE 516 HOLE F CORE 37 CORED INTERVAL 511.1–520.6 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Color: 5GY 8/1 mottled with 5Y 7/2.

SMEAR SLIDE SUMMARY:

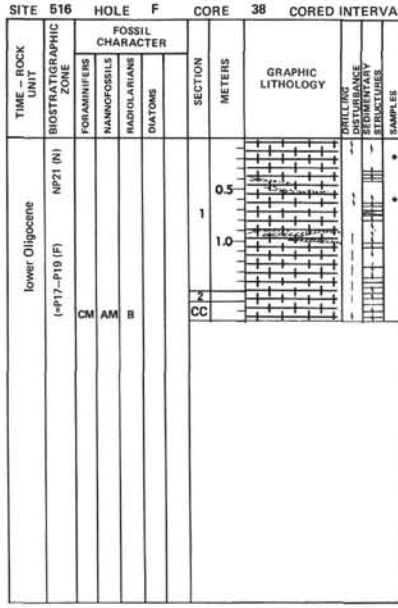
	1-70
	D
Texture:	
Sand	10
Silt	10
Clay	80
Composition:	
Other clay minerals	15
Carbonate unspecified	5
Foraminifers	10
Nannofossils	70

PHYSICAL PROPERTIES:

	1-28	3-114
V_v	1.75	1.91
V_h	1.79	2.05
Density	1.92	2.07
Water content	24.1	18.5

CARBONATE BOMB:
1-70 = 90
3-75 = 90

SITE 516 HOLE F CORE 38 CORED INTERVAL 520.6–530.1 m



LITHOLOGIC DESCRIPTION

FORAM-NANNO CHALK

Lots of benthic foraminifers, white (5Y 8/1). Section 1: parallel and cross-laminations, 5GY 6/1 intercalated with light greenish gray (5GY 8/1) nanno chalk. Section 2: green laminations with pyrite inclusions. Contorted green laminations in Core-Catcher.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	8
Silt	32
Clay	60
Composition:	
Quartz	1
Heavy minerals	TR
Other clay minerals	10
Foraminifers	10
Nannofossils	79
Micronodules	TR

PHYSICAL PROPERTIES:

	1-65
V_v	1.70
V_h	1.78
Density	1.94
Water content	22.1

CARBONATE BOMB:
1-70 = 87

SITE 516 HOLE F CORE 39 CORED INTERVAL 530.1–539.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Eocene	NP19–20 (N); (=P17–19 (F))	AM	AM	B		1, 2, 3, CC	0.5, 1.0

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Color: 5Y 8/1 with greenish gray (5GY 6/1) intervals.

SMEAR SLIDE SUMMARY:

	1-80
	D
Texture:	
Sand	7
Silt	10
Clay	83
Composition:	
Quartz	1
Other clay minerals	15
Carbonate unspecified	5
Foraminifers	7
Nannofossils	72

PHYSICAL PROPERTIES:

	1-78
V_v	1.93
V_h	2.06
Density	2.07
Water content	18.7

CARBONATE BOMB:
2-70 = 78

SITE 516 HOLE F CORE 40 CORED INTERVAL 539.6–549.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Eocene	NP19–20 (N); (=P15–P17) (part) (F)	CM	AM	B		1, 2, CC	0.5, 1.0

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LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Greenish gray (5G 6/1) laminations intercalated with light greenish gray (5GY 8/1) laminae.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	35
Clay	60
Composition:	
Other clay minerals	10
Carbonate unspecified	5
Foraminifers	6
Nannofossils	74
Volcanic glass	5

PHYSICAL PROPERTIES:

	1-2
V_v	1.85
V_h	1.88
Density	1.96
Water content	22.6

CARBONATE BOMB:
1-20 = 86

SITE 516 HOLE F CORE 41 CORED INTERVAL 549.1–558.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Eocene	NP19–20 (N); (=P15–P17) (part) (F)	F/CP	AM		B	1, 2, CC	0.5, 1.0

5GY 8/1

5Y 7/2

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Greenish gray (5GY 8/1) with greenish gray (5GY 6/1) laminations.

SMEAR SLIDE SUMMARY:

	1-70	2-15
	D	D
Texture:		
Sand	1	3
Silt	49	50
Clay	50	47
Composition:		
Quartz	5	–
Heavy minerals	1	–
Zeolites	TR	TR
Other clay minerals	15	20
Carbonate unspecified	10	10
Foraminifers	2	3
Nannofossils	67	66
Volcanic glass	TR	TR
Micronodules	TR	–
Dolomite	–	1

PHYSICAL PROPERTIES:

	1-85
V_v	—
V_h	2.02
Density	1.99
Water content	—

CARBONATE BOMB:
1-90 = 90

SITE 516 HOLE F CORE 42 CORED INTERVAL 558.6–568.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Eocene	NP19–20 (N); (=P15–P17) (part) (F)	CM	CM	B		1, CC	0.5

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light greenish gray (5GY 8/1) with few greenish gray (5GY 6/1) laminations.

SMEAR SLIDE SUMMARY:

	1-55
	M
Texture:	
Sand	–
Silt	50
Clay	50
Composition:	
Zeolites	1
Other clay minerals	20
Foraminifers	1
Nannofossils	74
Volcanic glass	TR
Micronodules	TR
Dolomite	3

PHYSICAL PROPERTIES:

	1-13
V_v	1.97
V_h	1.93
Density	2.02
Water content	19.7

CARBONATE BOMB:
1-20 = 87

SITE 516 HOLE F CORE 43 CORED INTERVAL 568.1–577.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY
upper Eocene	NP19–20 (N); (=P15–P17) (part) (F)	C/FM	A/MG	B		1, 2, CC	0.5, 1.0	VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Section 1: light gray (5Y 7/1), more homogeneous than the previous core, with faint laminations and burrows throughout. Rest of the layering could be flattened burrows. Section 2: light gray nanno chalk with laminations of olive gray (5Y 4/1) and dark greenish gray (5GY 4/1) color.

SMEAR SLIDE SUMMARY:

	1-103
	D
Texture:	
Sand	2
Silt	48
Clay	50
Composition:	
Quartz	TR
Heavy minerals	TR
Zeolites	TR
Other clay minerals	20
Foraminifers	3
Nannofossils	77
Dolomite	TR
Micronodules	TR

PHYSICAL PROPERTIES:

	1-6
V_v	1.87
V_h	1.87
Density	2.00
Water content	21.0

CARBONATE BOMB:
1-5 = 89

SITE 516 HOLE F CORE 44 CORED INTERVAL 577.6–587.1 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY
upper Eocene	NP18 (N); (=P15–P17) (part) (F)	CM	AM	B		1, CC	0.5	VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Color: white (5Y 8/1) with dark gray (5Y 4/1) laminations.

SMEAR SLIDE SUMMARY:

	1-8
	D
Texture:	
Sand	1
Silt	64
Clay	35
Composition:	
Quartz	2
Heavy minerals	TR
Zeolites	TR
Carbonate unspecified	5[a]
Foraminifers	2
Nannofossils	69
Volcanic glass	TR
Dolomite rhombs	2

[a] Replacement of siliceous sponge spicules by $CaCO_3$.

PHYSICAL PROPERTIES:

	1-4
V_v	1.91
V_h	1.85
Density	1.97
Water content	21.8

CARBONATE BOMB:
1-5 = 92

ORGANIC CARBON:
1, 77–81 = 0.08

SITE 516 HOLE F CORE 45 CORED INTERVAL 587.1–596.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Eocene	NP18 (N); (=P15–P17) (part) (F)	CM	AM	B		1, CC	0.5, 1.0

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light gray to light greenish gray (5Y 7/1–5GY 8/1) with thin (1–2 cm) darker zones of clay and very fine to coarse silt-sized opaque minerals (pyrite?).

SMEAR SLIDE SUMMARY:

	1-69	1-91
	D	D
Texture:		
Sand	3	–
Silt	50	30
Clay	47	70
Composition:		
Pyrite	–	60
Zeolites	1	–
Other clay minerals	10	–
Carbonate unsepcified	5	–
Foraminifers	3	–
Nannofossils	80	40
Volcanic glass	TR	TR
Dolomite	2	TR

PHYSICAL PROPERTIES:

	1-6	1-20
V_v	—	—
V_h	1.92	—
Density	1.96	1.96
Water content	—	22.2

CARBONATE BOMB:
1-70 = 87

SITE 516 HOLE F CORE 46 CORED INTERVAL 596.6–606.1 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Eocene	NP18 (N); (=P15–P17) (part)	CM	AM	B		1	0.5

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light greenish gray (5GY 8/1) to white (5Y 8/1). Two thin intervals of olive gray (5Y 5/2), similar to dark layers in previous core but without black basal or central layer.

SMEAR SLIDE SUMMARY:

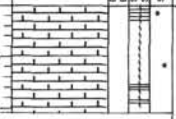
	1-34
	D
Texture:	
Sand	1
Silt	60
Clay	39
Composition:	
Zeolites	TR
Other clay minerals	10
Carbonate unspecified	1
Foraminifers	2
Nannofossils	84
Dolomite	TR
Volcanic glass	TR
Sponge spicules	TR

CARBONATE BOMB:
1-50 = 91

SITE 516 HOLE F CORE 47 CORED INTERVAL 606.1–615.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP17 (N); (=P15–17) (part)	CM	AM	B		1	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5GY 6/1

LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Light greenish gray (5GY 8/1) dominant color, with layer of greenish gray formed by fine laminations. Dolomite is present in the darker layer. Laminated intervals are greenish gray (5Y 6/1).

NOTE: This core is the last referred to as "chalk". The following are termed "limestone". The division is somewhat arbitrary and should not be construed as a contrast between Core 47 and 48.

SMEAR SLIDE SUMMARY:

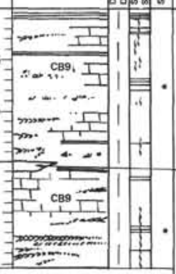
	1-2	1-65
	M	D
Texture:		
Sand	3	1
Silt	50	50
Clay	47	49
Composition:		
Zeolites	TR	TR
Other clay minerals	20	10
Carbonate unspecified	5	–
Foraminifers	2	3
Nannofossils	70	84
Volcanic glass	TR	–
Dolomite	2	TR

CARBONATE BOMB:
1-70 = 90

SITE 516 HOLE F CORE 48 CORED INTERVAL 615.6–625.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP17 (N); (=P15–P17) (part) (F)	FB				1	0.5, 1.0
			C/PM	B		2	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Light greenish gray (5G 8/1) limestone with greenish gray (5G 6/1) laminations. Burrowed throughout. The greenish laminations are stylolites or pressure solution planes. They are wavy, cut each other and have more dolomite than the dominant lithology.

SMEAR SLIDE SUMMARY:

	1-71	2-70
	M	D
Texture:		
Sand	–	TR
Silt	–	50
Clay	–	50
Composition:	1	TR
Mica	–	TR
Pyrite	–	TR
Heavy minerals	TR	TR
Other clay minerals	45	40
Carbonate unspecified	32	10
Foraminifers	TR	1
Nannofossils	15	49
Diatoms	TR	–
Volcanic glass	–	TR
Amorphous silica	5	–

PHYSICAL PROPERTIES:

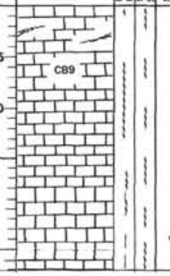
	1-133	1-139
V_v	1.99	—
V_h	2.05	2.12
Density	2.02	2.05
Water content	19.6	—

CARBONATE BOMB:
1-70 = 87

SITE 516 HOLE F CORE 49 CORED INTERVAL 625.1–634.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP17 (N); (=P15–P17) (part)					1	0.5, 1.0
						2	
			C/PM	B		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Light greenish gray (5G 8/1) matrix with numerous laminations (not specified). Laminae typically less than 1 mm thick, straight or wavy, both cut through or surrounded by burrows. Color of laminae changes near base of Section 1 from greenish gray (5GY 6/1) to gray (N3–N5).

SMEAR SLIDE SUMMARY:

	2-74
	D
Texture:	
Sand	3
Silt	50
Clay	47
Composition:	
Feldspar	3?
Zeolites	2
Other clay minerals	47
Foraminifers	2
Nannofossils	10
Volcanic glass	TR
Sponge spicules	TR

PHYSICAL PROPERTIES:

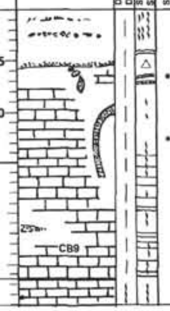
	1-3
V_v	2.11
V_h	2.23
Density	2.02
Water content	19.8

CARBONATE BOMB:
2-70 = 87

SITE 516 HOLE F CORE 50 CORED INTERVAL 634.6–644.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP17 (N); (probably =P14) (F)					1	0.5, 1.0
						2	
		CM	FC/P	B		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5YR 6/1
– Green laminatiosn
5Y 7/1
5YR 6/1
5Y 7/1
–Foram-rich layer
5YR 6/1

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Section 1, 50 cm: layer rich in larger foraminifera (Discocyclinidae or lepidocyclinidae). Section 1, 100–150 cm: large burrow continuous, over 1 mm long burrow fill is dark gray (N4).

SMEAR SLIDE SUMMARY:

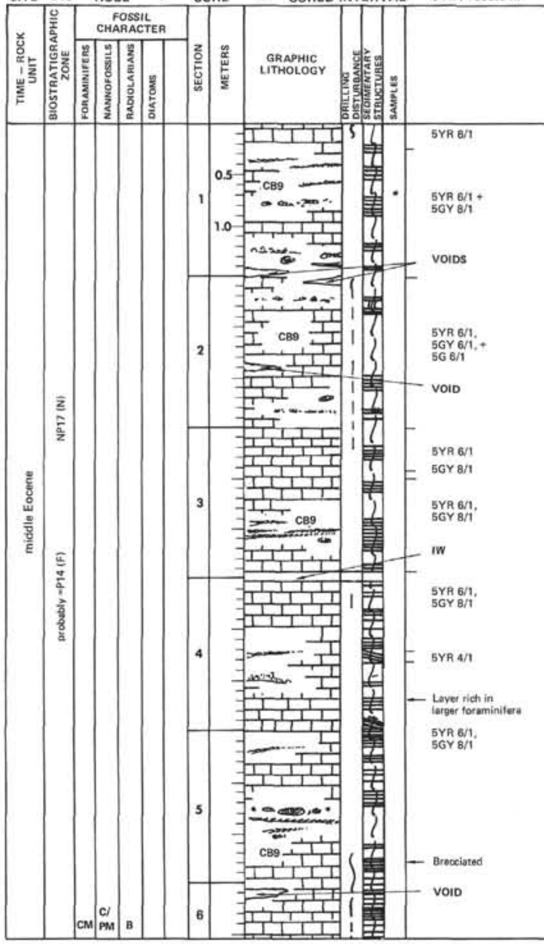
	1-70	1-130
	D	D
Texture:		
Sand	25	20
Silt	15	10
Clay	60	70
Composition:		
Quartz	1	–
Feldspar	1	–
Glauconite	1	–
Other clay minerals	7	–
Foraminifers	25	8
Nannofossils	65	47
Opaque minerals	–	15
Micronodules	–	30
Sponge spicules	TR	–

PHYSICAL PROPERTIES:

	1-100	2-54
V_v	—	2.27
V_h	2.11	2.35
Density	2.05	2.03
Water content	—	18.1

CARBONATE BOMB:
1-70 = 84
2-70 = 83

SITE 516 HOLE F CORE 51 CORED INTERVAL 644.1–653.6 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Poorly preserved microfossils. Section 1, 25–150 cm: laminated intervals 5YR 6/1 and massive, burrowed intervals light greenish gray (5GY 8/1). Section 2: 5YR 6/1, 5GY 6/1, and greenish gray (5G 6/1) laminae. Section 3, 50–140 cm: 5YR 6/1 in laminated portions and 5GY 8/1 in non-laminated portions. Sections 4–6: 5YR 6/1 in laminated intervals, otherwise 5GY 8/1.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	–
Silt	30
Clay	70
Composition:	
Other clay minerals	10
Carbonate unspecified	30
Foraminifers	5
Nannofossils	54
Micronodules	1

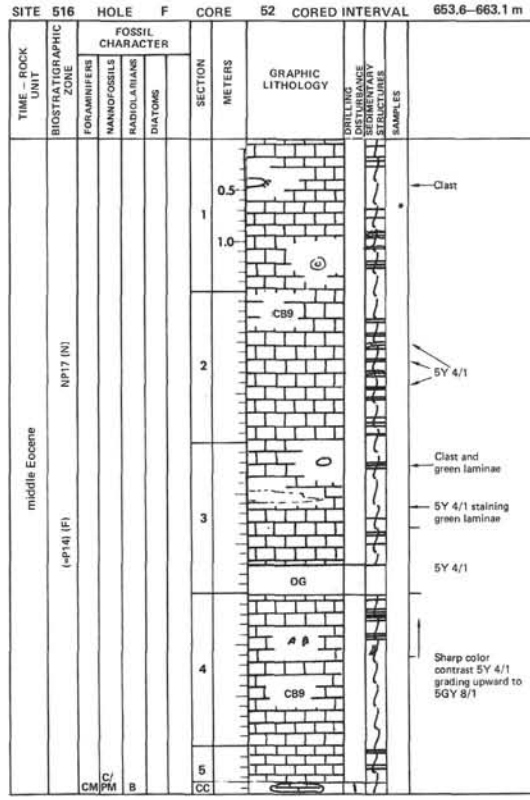
PHYSICAL PROPERTIES:

	1-100	3-2	5-21
V_v	2.03	—	2.11
V_h	2.11	—	2.35
Density	2.01	2.06	2.08
Water content	19.9	18.2	17.0

CARBONATE BOMB:
2-70 = 81
4-70 = 76

ORGANIC CARBON:
1, 90–96 = 0.14

SITE 516 HOLE F CORE 52 CORED INTERVAL 653.6–663.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Color: 5YR 6/1 except where otherwise noted. Laminations green to 90 cm (Section 1) then olive gray (5Y 4/1). Large green halo (approximately 3 cm in diameter) at 120 cm in Section 1.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	10
Clay	80
Composition:	
Quartz	1
Feldspar	1
Carbonate unspecified	20
Foraminifers	5
Nannofossils	72
Volcanic glass	1

PHYSICAL PROPERTIES:

	1-29	3-5	3-14	5-29
V_v	1.90	—	—	2.22
V_h	1.93	2.07	—	2.30
Density	2.02	—	2.06	2.15
Water content	19.5	—	18.3	15.1

CARBONATE BOMB:
2-70 = 87
4-70 = 85

SITE 516 HOLE F CORE 53 CORED INTERVAL 663.1–672.6 m

TIME – ROCK UNIT: middle Eocene

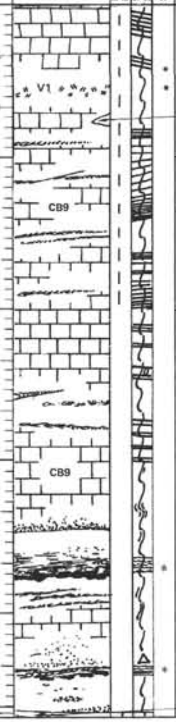
BIOSTRATIGRAPHIC ZONE: probably P14 (F); NP17? (N); (probably P13) (F)

FOSSIL CHARACTER: FORAMINIFERS: FP; DIATOMS: CC

SECTION: 1, 2, 3, 4, 5

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5G 8/1 with 5G 6/1

VOID

5YR 4/1 to 5YR 6/1

5YR 6/1

N3

5YR 6/1

N2

VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Light greenish gray (5G 8/1) with green (5G 6/1) laminations (inclined). Section 1, 80–90 cm: pure green layer of volcanic ash and clay. Section 2, 20 cm: slickensided surface = drilling deformation. Sharp basal contacts at Section 4, 50 cm and Section 5, 50 cm. Section 4, 60–70 cm: coarse layer recrystallized larger foraminifera, sharp basal contact. Section 5, 130–140 cm: coarse layers of benthic foraminifera.

SMEAR SLIDE SUMMARY:

	1-70	1-84
	D	M
Texture:		
Sand	1	–
Silt	20	–
Clay	79	–
Composition:		
Feldspar	–	1
Mica	–	5
Zeolites	–	30
Other clay minerals	5	34
Carbonate unspecified	50	10
Foraminifers	5	–
Nannofossils	38	5
Volcanic glass	2	15

PHYSICAL PROPERTIES:

	1-16	3-42	3-109	5-75
V_v	2.14	—	—	2.42
V_h	2.18	2.44	—	2.53
Density	2.06	—	2.16	2.18
Water content	18.0	—	15.6	14.3

CARBONATE BOMB:
2-70 = 74
4-70 = 76

ORGANIC CARBON:
4, 102–112 = 0.16
5, 51–54 = 0.32

SITE 516 HOLE F CORE 54 CORED INTERVAL 672.6–682.1 m

TIME – ROCK UNIT: middle Eocene

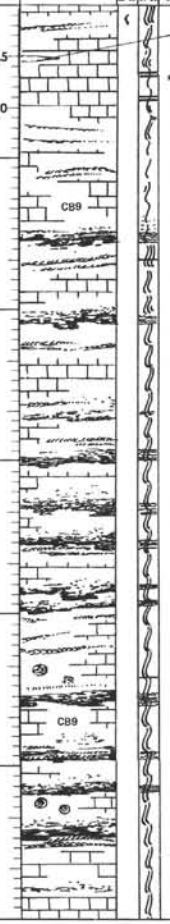
BIOSTRATIGRAPHIC ZONE: NP16 (N); (probably =P13) (F)

FOSSIL CHARACTER: FORAMINIFERS: CG; NANNOFOSSILS: C/PM; DIATOMS: B

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



VOID

5Y 6/1 grading to 5YR 6/1 and 5GY 6/1

5Y 6/1

N4

5Y 6/1

N4

5Y 6/1

5G 8/1

5Y 6/1

5G 8/1

N4

5Y 6/1

5G 8/1

5Y 6/1

5G 8/1

N4

5Y 6/1

5G 8/1

Green lamination

5Y 6/1

5G 8/1

N4

5Y 6/1

5G 8/1

5Y 6/1

5G 8/1

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

No obvious grain-size changes associated with color alternations. Section 1 light olive gray (5Y 6/1) grading to light brownish gray (5YR 6/1) and greenish gray (5GY 6/1). Basal contact at 80 cm (Section 2) and mixed downward by burrowing.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	35
Clay	60
Composition:	
Other clay minerals	10
Carbonate unspecified	20
Foraminifers	3
Nannofossils	62
Volcanic gless	3
Mg-calcite rhombs	2

PHYSICAL PROPERTIES:

	1-75	3-32	4-36	6-99
V_v	2.39	—	2.39	—
V_h	2.48	—	2.55	—
Density	2.16	2.20	2.18	2.10
Water content	14.6	14.1	14.6	16.3

CARBONATE BOMB:
2-70 = 78
4-70 = 83
6-70 = 47

SITE 516 HOLE F CORE 55 CORED INTERVAL 682.1–691.6 m

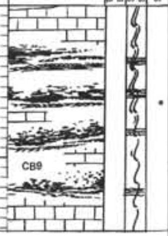
TIME – ROCK UNIT: middle Eocene

BIOSTRATIGRAPHIC ZONE: NP16 (N); (=probably P13) (F)

FOSSIL CHARACTER: NANNOFOSSILS C/PM; RADIOLARIANS B

SECTION: 1, 2

METERS: 0.5, 1.0



5YR 6/1

N4

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Cyclical color alternations corresponding to those described for Core 54. Basal contacts mixed downward by burrowing.

SMEAR SLIDE SUMMARY:

	1-90
	D
Texture:	
Sand	10
Silt	10
Clay	80
Composition:	
Quartz	1
Feldspar	1
Carbonate unspecified	15
Foraminifers	12
Nannofossils	69
Mg-calcite rhombs	2

PHYSICAL PROPERTIES:

	1-53	2-43
V_v	2.30	—
V_h	2.49	2.64
Density	2.18	—
Water content	15.0	—

CARBONATE BOMB:

1-70 = 66

SITE 516 HOLE F CORE 56 CORED INTERVAL 691.6–701.1 m

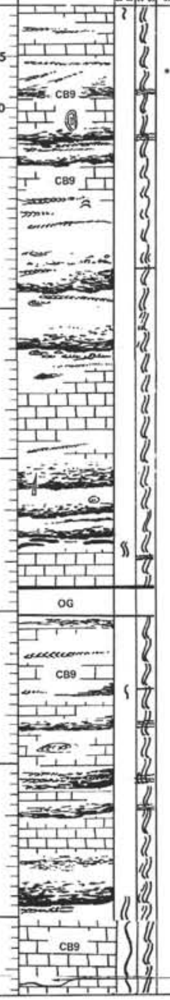
TIME – ROCK UNIT: middle Eocene

BIOSTRATIGRAPHIC ZONE: NP16 (N); (=probably P13) (F)

FOSSIL CHARACTER: FORAMINIFERS AM; NANNOFOSSILS C/PM; RADIOLARIANS B

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

METERS: 0.5, 1.0



N3

5YR 6/1
N3

5GY 8/1

5YR 6/1

Green structures

5GY 8/1

5G 6/1

N3

5G 8/1

5YR 6/1

5B 7/1

5YR 6/1

5YR 6/1
N3 mixed with 5G 8/1

5G 8/1

5G 6/1

VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Color grading, but not as sharp as in Cores 54 and 55. Basal contacts mixed downward by burrowing. Green halo at Section 1, 110 cm and Section 4, 40 cm. Section 3, 45, 55, and 65 cm: pyrite in burrows. Section 3, 105–120 cm: dark (5Y 6/1) band with gradational contacts above and below. Section 4, 10–30 cm: vertical burrow filled with glauconite and pyrite, green (5BG 3/2).

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	1
Silt	5
Clay	94
Composition:	
Quartz	TR
Other clay minerals	15
Carbonate unspecified	5
Foraminifers	TR
Nannofossils	80

PHYSICAL PROPERTIES:

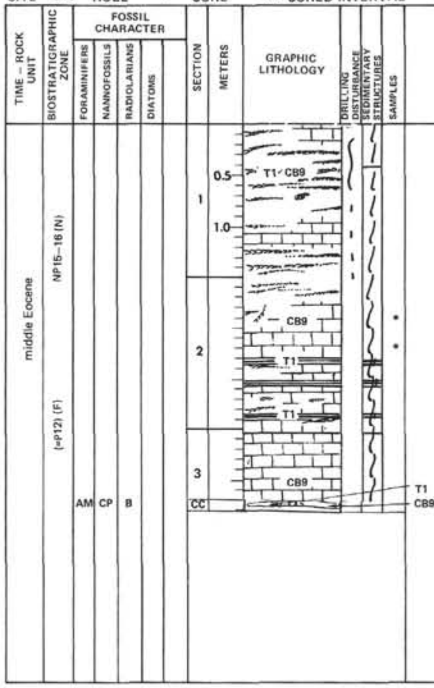
	1-62	3-9	4-43	5-55
V_v	2.27	—	2.24	—
V_h	2.32	—	2.42	—
Density	2.15	2.16	2.16	2.15
Water content	15.1	15.6	15.4	14.7

CARBONATE BOMB:

2-70 = 75
4-70 = 71
6-70 = 76

Note: Core 57, 701.1–710.6 m: No Recovery.

SITE 516 HOLE F CORE 58 CORED INTERVAL 719.6–716.6 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Light bluish gray (5B 7/1) marly limestone, mottled with medium gray (N5). Burrows throughout light gray (10YR 6/1). Section 2–Core-Catcher: same as above except there are zones in the core where the color is light gray, these intervals seem to be highly bioturbated.

SMEAR SLIDE SUMMARY:

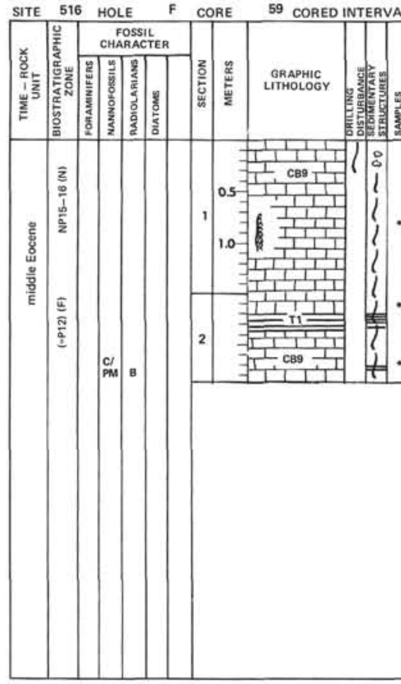
	2-47	2-70
	D	D
Texture:		
Sand	2	TR
Silt	15	40
Clay	83	60
Composition:		
Quartz	2	TR
Feldspar	TR	–
Heavy minerals	TR	TR
Zeolites	1	–
Other clay minerals	80	55
Carbonate unspecified	–	30
Foraminifers	–	TR
Nannofossils	2	15
Volcanic glass	TR	TR
Dolomite	10	TR
Micronodules	TR	TR
Fecal pellets(?)	5	–

PHYSICAL PROPERTIES:

	1-19	1-78	2-118	3-55
V_v	2.39	—	2.55	2.52
V_h	2.43	2.68	2.57	2.63
Density	2.19	2.22	2.22	2.22
Water content	13.9	—	12.9	13.2

CARBONATE BOMB:
2-70 = 73

SITE 516 HOLE F CORE 59 CORED INTERVAL 716.6–720.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Light greenish gray (5GY 8/1) marly(?) limestone with laminations and burrows of blue green (5BG 6/2–7/2) and light olive gray (5Y 6/1). Burrow, 34 cm long, in Section 1. Section 2: same as above but with zones of horizontal burrows or laminations of olive gray (5Y 4/1).

SMEAR SLIDE SUMMARY:

	1-81	2-15	2-70
	M	M	D
Texture:			
Sand	1	2	1
Silt	50	50	24
Clay	49	48	75
Composition:			
Quartz	–	TR	TR
Heavy minerals	–	–	TR
Zeolites	–	TR	–
Other clay minerals	38	40	40
Carbonate unspecified	2	5	40
Foraminifers	TR	3	TR
Nannofossils	60	50	20
Volcanic glass	TR	TR	–
Dolomite	2	1	–
Micronodules	–	–	TR

PHYSICAL PROPERTIES:

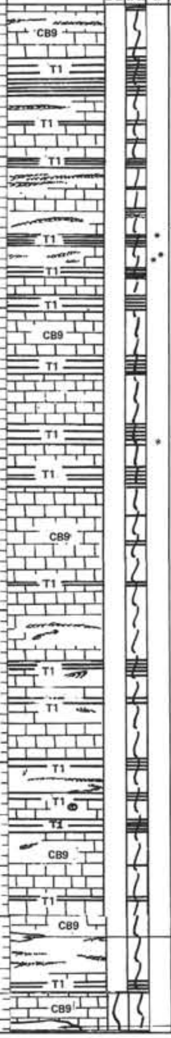
	1-4
V_v	2.49
V_h	2.48
Density	2.26
Water content	12.1

CARBONATE BOMB:
1-70 = 70

SITE 516 HOLE F CORE 60 CORED INTERVAL 720.1–729.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP15–16 (N)					1	0.5, 1.0
						2	
						3	
			C/PM			4	
	(=P12) (F)					5	
						6	
		AM				7	
						CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Dark greenish laminations

Stylolites

VOID

VOID

LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL LIMESTONE

Light greenish gray (5G 8/1) marly nannofossil limestone with zones of darker colors between light gray (5Y 6/1) and olive gray (5Y 5/2). Burrows are more abundant in the darker areas. Very fine green laminations. Section 2–Core-Catcher: same as above, but with some very fissile layers. These highly fissile layers are richer in clay minerals, olive gray (5Y 4/1). Nannofossils are better preserved within the fissile layers.

SMEAR SLIDE SUMMARY:

	2-70 D	2-104 M	2-106 M
Texture:			
Sand	–	TR	1
Silt	40	30	15
Clay	60	70	84
Composition:			
Quartz	TR	TR	TR
Feldspar	–	–	TR
Heavy minerals	TR	–	2
Zeolites	–	–	2
Other clay minerals	45	50	73
Carbonate unspecified	35	15	5
Foraminifers	TR	TR	TR
Nannofossils	20	34	7
Volcanic glass	–	1	3
Sponge spicules	–	–	7

PHYSICAL PROPERTIES:

	2-88	4-112	CC
V_v	2.95	—	—
V_h	2.94	2.86	3.11
Density	2.23	2.23	2.26
Water content	11.3	13.5	10.1

CARBONATE BOMB:

2-70 = 76

4-70 = 69

6-70 = 72

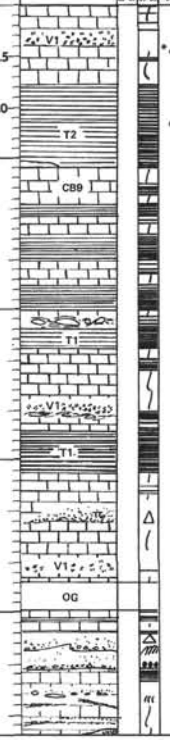
ORGANIC CARBON:

3, 141–142 = 0.27

SITE 516 HOLE F CORE 61 CORED INTERVAL 729.1–738.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP15–16 (N)					1	0.5, 1.0
						2	
						3	
	(=P12) (F)					4	
		FC/P	B			5	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5GY 7/1

5GY 6/1

5GY 2/1

5GY 7/1

5Y 5/3

5Y 4/2

5Y 7/1

5Y 7/1

5Y 4/2

5Y 5/1

5Y 4/2

5Y 7/1

5Y 4/2

Foraminifera-rich

5YR 6/1 mixed with 5GY 6/1

5YR 6/1

5GY 4/1

Clay balls

LITHOLOGIC DESCRIPTION

SILICEOUS MARLY LIMESTONE

Burrowing confined to light colored layers. Section 3, 100 cm: ash layer 5G 4/1 and pods of coarse sediment within laminations.

SMEAR SLIDE SUMMARY:

	1-40 D	1-45 D	1-46 D	1-120 D
Texture:				
Sand	10	–	1	–
Silt	50	–	29	–
Clay	40	–	60	–
Composition:				
Silica cement	–	–	–	25
Quartz	TR	1	3	1
Feldspar	–	–	2	1
Mica	2	5	–	–
Pyrite	10	–	–	–
Heavy minerals	–	–	1	TR
Zeolites	–	–	2	–
Other clay minerals	–	–	–	50
Carbonate unspecified	10	14	5	20
Foraminifers	5	TR	TR	–
Nannofossils	48	12	7	3
Volcanic glass and palagonite	25	68	72	–
Dolomite	–	–	5	–
Apatite/Chomasite	–	–	3	–

PHYSICAL PROPERTIES:

	1-88	2-0
V_v	—	—
V_h	2.96	2.88
Density	2.24	2.14
Water content	—	—

CARBONATE BOMB:

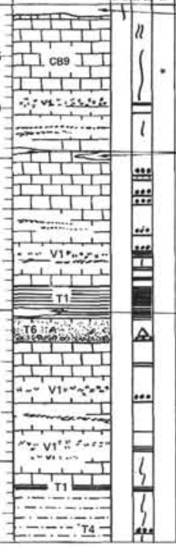
2-70 = 62

4-70 = 69

SITE 516 HOLE F CORE 62 CORED INTERVAL 738.1–747.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP15–16 (N)					1	0.5
							1.0
						2	
	P11–P12 (F)					3	
		C/PM	B			4	

GRAPHIC LITHOLOGY · DRILLING DISTURBANCE · SEDIMENTARY STRUCTURES · SAMPLES



VOID

N8

N7

VOIDS

VOID

5G 4/1

Crude grading

Green lamination

N7

LITHOLOGIC DESCRIPTION

GRADED MARLY LIMESTONE

Glauconite throughout. Section 2, 85–115 cm: dark greenish gray (5G 4/1) volcanic clay. Section 3, 10–32 cm: sand-size grains, heavy minerals and authigenic crystals.

SMEAR SLIDE SUMMARY

	1-70
	D
Texture:	
Sand	5
Silt	10
Clay	85
Composition:	
Other clay minerals	20
Carbonate unspecified	40
Foraminifers	8
Nannofossils	27
Volcanic glass	5

PHYSICAL PROPERTIES:

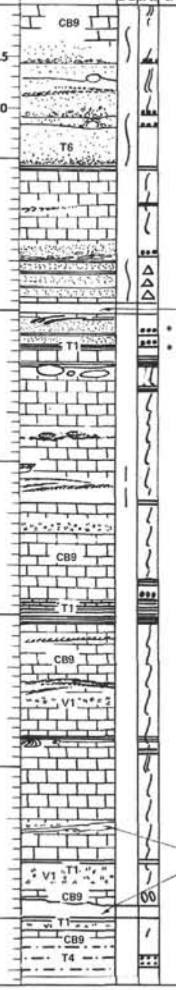
	1-70	2-48	3-56	4-21
V_v	2.73	—	2.62	—
V_h	2.79	2.80	2.71	—
Density	2.26	—	2.19	2.26
Water content	11.7	—	14.5	12.7

CARBONATE BOMB:
2-70 = 76

SITE 516 HOLE F CORE 63 CORED INTERVAL 747.1–756.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene						1	0.5
							1.0
						2	
	NP15–16 (N)					3	
						4	
	(=P11) (F)					5	
						6	
			RP	B		7	

GRAPHIC LITHOLOGY · DRILLING DISTURBANCE · SEDIMENTARY STRUCTURES · SAMPLES



N8

5G 6/1
N8
5G 4/1

5Y 4/1

N3
Sharp contact
5GY 8/1

5G 4/1 grading upward to 5GY 8/1 in each cycle

IW
5G 4/1

N3

N4

5YR 6/1

N3
10Y 4/2
with clasts

5YR 6/1

VOIDS
5GY 6/1

Clay balls

LITHOLOGIC DESCRIPTION

GRADED LIMESTONE

Disturbed interval 20–50 cm (Section 1). Abundant shallow water indicators: oncolites, nummilites, and bryozoans. Section 1, 120–150 cm: brecciated by drilling. Coarse layer clay, not graded above sand. Section 3, 0–10 cm: flow structures, drawn out lenses of coarser sediment. Section 3, 50–60 cm: large burrows. Section 3, 110–120 cm: bioturbated ash layer. Section 4, 25–35 cm: ash layer, 5G 4/1–N4. Coarse layer, N4, at Section 4, 135 cm to Section 5, 3 cm.

SMEAR SLIDE SUMMARY:

	3-20	3-38
	D	D
Texture:		
Sand	30	20
Silt	50	20
Clay	20	60
Composition:		
Quartz	1	5
Feldspar	4	–
Mica	4	5
Pyrite	5	–
Heavy minerals	–	3
Glauconite	–	30?
Carbonate unspecified	5	–
Nannofossils	3	1
Volcanic glass and palagonite	78	56

PHYSICAL PROPERTIES:

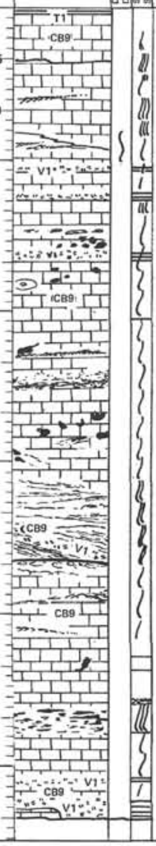
	1-72	2-70	3-86	5-56	6-7
V_v	2.54	—	—	—	2.77
V_h	2.72	—	2.87	—	2.83
Density	2.25	2.31	2.28	2.29	2.29
Water content	12.7	11.1	10.9	11.2	10.7

CARBONATE BOMB:
2-70 = 67
4-70 = 66
6-70 = 72

SITE 516 HOLE F CORE 64 CORED INTERVAL 756.1–765.1 m

TIME-ROCK UNIT: middle Eocene
BIOSTRATIGRAPHIC ZONE: NP15–16 (N); (=P11) (F)
FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS): RF/P B
SECTION: 1, 2, 3, 4, 5, 6
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Lighter
N3–5G 4/1
Crack
5GY 8/1
Ash pods
Green halo: recrystallized
5YR 4/1
5Y 6/1
5YR 4/1: blotches
N3
5YR 4/1
5YR 6/1
N7
Wavy, strung-out burrow traces 5YR 4/1

LITHOLOGIC DESCRIPTION

RECRYSTALLIZED LIMESTONE

Light olive gray (5Y 6/1) except where otherwise noted. Section 2: 5Y 4/1 burrow fill. Burrows recrystallized – blotches shown as black here. Section 3, 60–85 cm: irregular basal contact similar to gradations noted in Core 56. Only this is the recrystallized version. Section 4: strung-out burrows – angles are not a result of drilling deformation.

SMEAR SLIDE SUMMARY:

	1-140
	D
Texture:	
Sand	20
Silt	10
Clay	70
Composition:	
Quartz	5
Mica	3
Glauconite	2
Other clay minerals	20
Carbonate unspecified	70

PHYSICAL PROPERTIES:

	1-105	2-36	3-77	3-108	4-69	5-139
V_v	2.67	—	2.72	—	—	2.88
V_h	2.91	—	2.65	3.37	2.64	3.03
Density	2.29	2.27	2.34	—	2.29	2.34
Water content	10.8	12.4	10.6	—	12.6	9.3

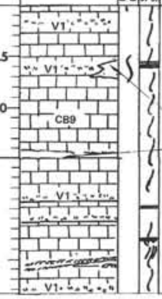
CARBONATE BOMB:
2-70 = 68
4-70 = 59

ORGANIC CARBON:
1, 1–3 = 0.20
6, 25–30 = 0.28

SITE 516 HOLE F CORE 65 CORED INTERVAL 765.1–774.1 m

TIME-ROCK UNIT: middle Eocene
BIOSTRATIGRAPHIC ZONE: NP15 (N); (=P11) (F)
FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS): CM B
SECTION: 1, 2
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5G 6/1
5YR 6/1
VOID
5G 6/1
5YR 6/1
5G 6/1

LITHOLOGIC DESCRIPTION

LIMESTONE (MICRITE)

Section 1, 60, 110, 125 cm and Section 2, 50 cm: green laminations.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	20
Clay	70
Composition:	
Other clay minerals	20
Carbonate unspecified	70
Foraminifers	5
Nannofossils	5

PHYSICAL PROPERTIES:

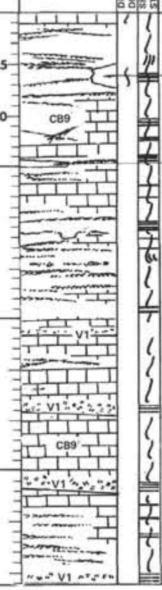
	1-139	2-93
V_v	2.71	—
V_h	2.80	—
Density	2.24	2.28
Water content	12.3	11.0

CARBONATE BOMB:
2-70 = 61

SITE 516 HOLE F CORE 66 CORED INTERVAL 774.1–783.1 m

TIME-ROCK UNIT: middle Eocene
BIOSTRATIGRAPHIC ZONE: NP15–16 (N); (=P11) (F)
FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS): CA/M B
SECTION: 1, 2, 3, 4
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



5YR 6/1
VOID
VOID
N7
5G 6/1
N7
5YR 4/1
5YR 6/1
5G 6/1
10YR 5/4
5Y 6/1
10YR 5/4

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Section 2, 70–130 cm: heavily burrowed layer.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	55
Clay	40
Composition:	
Other clay minerals	30
Carbonate unspecified	42
Foraminifers	8
Nannofossils	15
Volcanic glass	4
Micronodules	1

PHYSICAL PROPERTIES:

	1-118	1-122	2-103	3-100	4-66
V_v	—	—	2.71	—	2.68
V_h	—	2.86	2.86	—	2.88
Density	2.24	—	2.28	2.27	2.26
Water content	12.7	—	11.2	11.7	12.0

CARBONATE BOMB:
1-70 = 70
4-70 = 60

SITE 516 HOLE F CORE 67 CORED INTERVAL 783.1–786.1 m

TIME – ROCK UNIT: middle Eocene

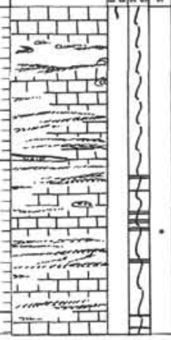
BIOSTRATIGRAPHIC ZONE: NP15 (N); (=P11) (F)

FOSSIL CHARACTER: FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS — CM B

SECTION: 1, 2, 3

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

NANNO LIMESTONE (MICRITE)

Light gray (5Y 6/1) with very fine green laminations and few darker areas where burrowing is more intense.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	1
Silt	40
Clay	59
Composition:	
Quartz	5
Feldspar	2
Heavy minerals	1
Zeolites	1
Other clay minerals	56
Carbonate unspecified	20
Nannofossils	10
Volcanic glass	TR
Dolomite	5
Micronodules	TR

PHYSICAL PROPERTIES:

	2-118
V_v	2.67
V_h	2.79
Density	2.24
Water content	12.9

CARBONATE BOMB:
2-70 = 55

SITE 516 HOLE F CORE 68 CORED INTERVAL 786.1–792.1 m

TIME – ROCK UNIT: middle Eocene

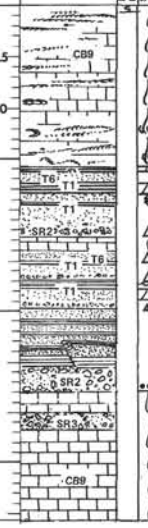
BIOSTRATIGRAPHIC ZONE: NP15 (N); P11 (F); P10 (F)

FOSSIL CHARACTER: FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS — AM RP B

SECTION: 1, 2, 3, 4

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

CALCAREOUS SANDSTONES AND LIMESTONE BRECCIA interbedded with MARLY LIMESTONE

158 cm of marly limestone overlies 190 cm of sand units, some graded, some cross-bedded, and all inferred to be turbidites. Coarse fraction of sands consists of carbonate, feldspar, and minor quartz plus other components. Most feldspar highly altered. Underlying sandstones are 2 limestone breccias, 15 and 30 cm thick, interbedded with marly limestone like unit at top of core. Clasts in breccias up to 2 cm diameter, angular, similar to limestone underlying.

SMEAR SLIDE SUMMARY:

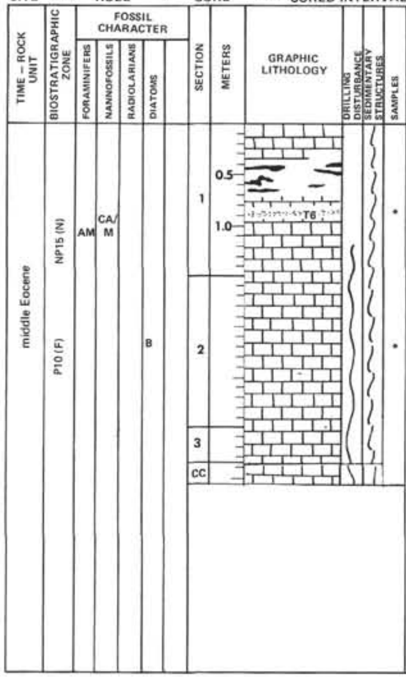
	2-80	2-88	3-42	3-48
	D	D	D	D
Texture:				
Sand	40	65	5	3
Silt	20	10	15	40
Clay	40	25	80	57
Composition:				
Volcanic glass	—	TR	—	—
Quartz }	10	3	TR	5
Feldspar (altered) }		15		
Unknown mineral	—	—	—	3
Heavy minerals	—	—	TR	—
Other clay minerals	40	25	80	57
Carbonate unspecified (silica)	—	5	10	18
Foraminifers	—	—	—	2
Nannofossils	—	—	10	5
Rounded, brown carbonate fragments	50	50	—	10
Silica (amorphous cement)	—	2?	—	—

PHYSICAL PROPERTIES:

	1-136	2-125	4-9
V_v	3.39	2.03	—
V_h	3.42	2.12	3.21
Density	2.43	2.03	2.29
Water content	7.8	22.6	10.5

CARBONATE BOMB:
2-70 = 24
4-50 = 61

SITE 516 HOLE F CORE 69 CORED INTERVAL 792.1–796.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Light gray (N7), same as the lower portion of Core 68. Burrowed throughout, but burrows very deformed. There are few green spots and faint shaded areas. Oolitic grain(?), with an aragonite rim = shallow water indicator.

SMEAR SLIDE SUMMARY:

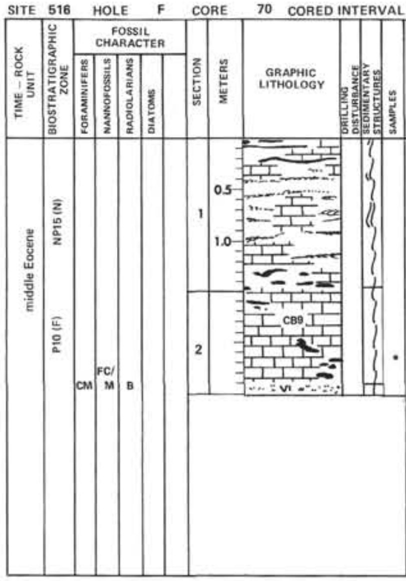
	1-89	2-70
	D	D
Texture:		
Sand	3	TR
Silt	47	40
Clay	50	60
Composition:		
Quartz	2	–
Feldspar	1	TR
Pyrite	5	–
Zeolites	2	–
Other clay minerals	50	55
Carbonate unspecified	5	35
Foraminifers	–	TR
Nannofossils	36	10
Volcanic glass	TR	TR
Micronodules	–	TR
Dolomite/Calcite	3	–

PHYSICAL PROPERTIES:

	1-47	2-130
V_v	2.63	2.73
V_h	—	2.79
Density	2.29	2.30
Water content	11.6	11.4

CARBONATE BOMB:
2-70 = 65

SITE 516 HOLE F CORE 70 CORED INTERVAL 796.1–801.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Greenish gray (5GY 6/1), very similar to the last core but little more burrowed. Burrowed throughout and with green and black shades and spots. Most of burrows 5YR 6/1.

SMEAR SLIDE SUMMARY:

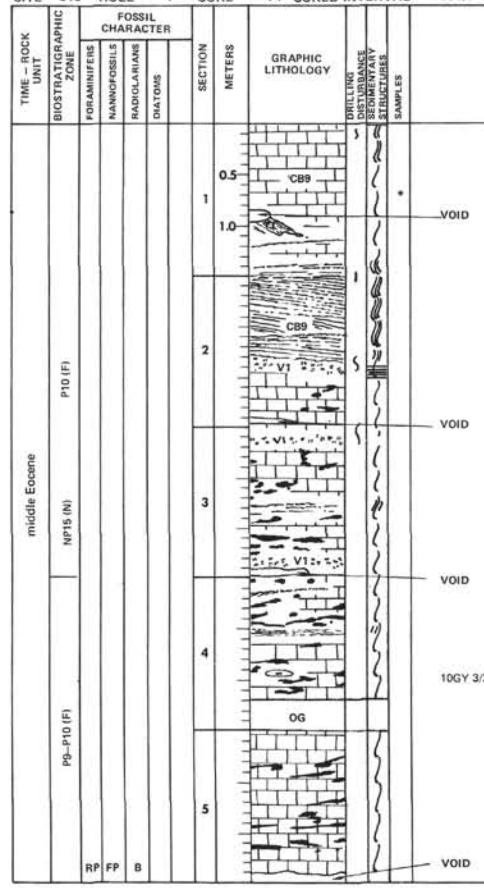
	2-70
	D
Texture:	
Sand	TR
Silt	40
Clay	60
Composition:	
Other clay minerals	45
Carbonate unspecified	40
Foraminifers	TR
Nannofossils	15
Volcanic glass	TR

PHYSICAL PROPERTIES:

	1-22	1-61
V_v	—	2.61
V_h	2.96	2.77
Density	2.28	2.28
Water content	11.5	11.7

CARBONATE BOMB:
2-50 = 48

SITE 516 HOLE F CORE 71 CORED INTERVAL 801.1–810.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Light bluish gray (N7–5B 7/1), mottled. Section 1, 90–95 cm: large yellow clast. Worm tube filled with expanding clay, N7. Streak of glauconite 5G 3/2. Flattened worm tubes. Section 2, 38 cm: green lamina, otherwise all laminae are 5YR 4/1 to 5YR 6/1 in N7 groundmass. Crenulated laminae? or flattened burrows? (looks more like flattened burrows). Section 2, 110 cm downward: burrows are blotches of 5YR 4/1–5YR 6/1 in N7 groundmass.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	–
Silt	50
Clay	50
Composition:	
Pyrite	TR
Other clay minerals	21
Carbonate unspecified	40
Foraminifers	7
Nannofossils	30
Volcanic glass	2

PHYSICAL PROPERTIES:

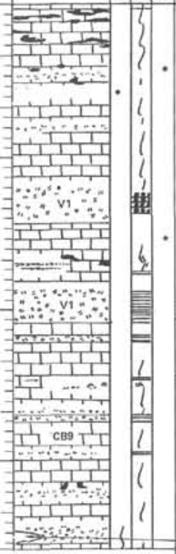
	1-113	2-70	3-86	4-85	5-88
V_v	2.51	2.85	2.69	—	2.94
V_h	2.72	2.98	2.96	—	3.11
Density	2.29	2.32	2.33	2.32	2.35
Water content	11.2	9.63	10.0	10.2	9.0

CARBONATE BOMB:
4-70 = 69

SITE 516 HOLE F CORE 72 CORED INTERVAL 810.1–814.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP15 (N); P9–P10 (F)	CP/M	FC/PM	B		1, 2, 3, 4	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



10GY 5/2

N4

Green laminations

5GY 7/2

N4 with 5GY 7/2 stripe

VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Blotches - recrystallized burrows 5YR 6/1. N7 = matrix color. Volcanic ash grayish green (10GY 5/2) in Section 1. Section 2, 30–64 cm: graded volcanic ash. Section 2, 35–45 cm approximately 8 cycles of 1 cm of 5G 6/1 bottom of interval and 5G 4/1 top of interval. Thin, green (5GY 7/1) laminations at 143–144 cm of Section 2. Expending clays and volcanic ash with a thin bed (5G 4/1) at 100 cm (Section 3). Section 4, 20–40 cm: expanding clays and ash.

SMEAR SLIDE SUMMARY:

	1-70 D	2-80 D
Texture:		
Sand	4	20
Silt	10	15
Clay	86	65
Composition:		
Quartz	TR	2
Feldspar	TR	2
Mica	3	–
Pyrite	—	4
Glauconite	5	16
Other clay minerals	7	4
Foraminifers	5	2
Nannofossils	70	60
Volcanic glass and palagonite	10	10

PHYSICAL PROPERTIES:

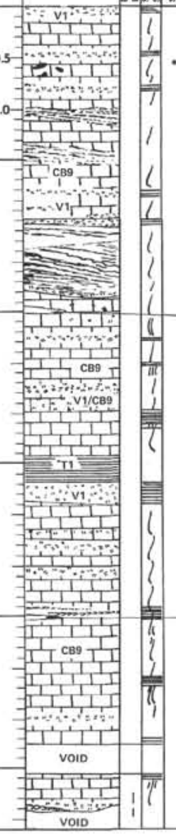
	1-48	2-4	2-55	3-61	4-43
V_v	2.86	—	—	2.84	—
V_h	2.96	3.14	2.34	3.02	—
Density	2.33	—	2.27	2.32	2.35
Water content	9.74	—	—	9.71	9.17

CARBONATE BOMB:
2-65 = 68

SITE 516 HOLE F CORE 73 CORED INTERVAL 814.6–823.6 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Eocene	NP15 (N); P9–P10 (F)		F/PM	B		1, 2, 3, 4, 5, 6	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Ash mixed with limestone

Glauconitic ash 5G 4/1

VOID

Green laminae

VOID
Good preservation of burrows and green laminae

Green laminae

5G 6/1

N7

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Greenish gray (5GY 6/1) and N7 groundmass. The lower part of Section 4 consists of ash and limestone becoming interspersed. Section 2, 60 cm: layer N4 with sharp upper–lower contacts. Small offset (Section 2, 65–90 cm) filled with black, dendritic-type growth. Section 2, 130 cm: black, ash layer seems to have acted as a decellement for dipping beds. Section 3, 35–65 cm: green (5G 4/1) and brown (5YR 4/1) laminations and at 66–139 cm ash interspersed in limestone with green laminations in N7 groundmass. Section 3, 140 cm–Section 4, 15 cm: massive claystone, N6. Good preservation of burrows and green laminae in area of Section 4, 140 cm.

SMEAR SLIDE SUMMARY:

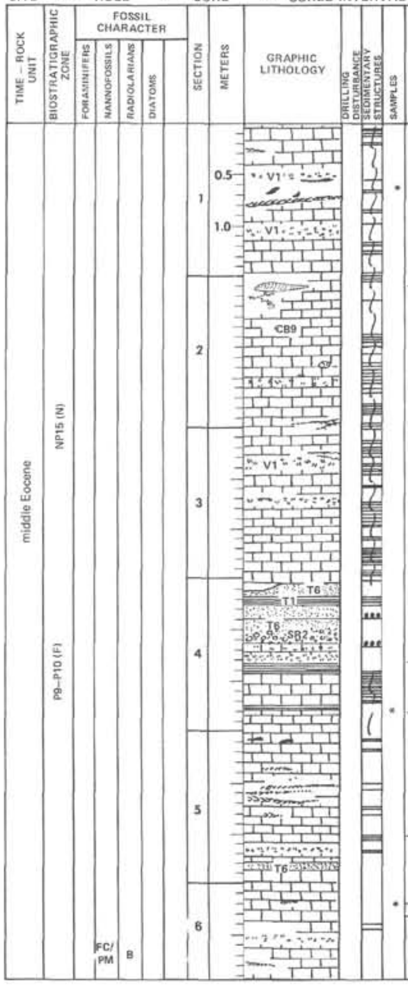
	1-60 D
Texture:	
Sand	10
Silt	15
Clay	75
Composition:	
Quartz	1
Feldspar	1
Mica	2
Glauconite	6
Carbonate unspecified	15
Foraminifers	TR
Nannofossils	60
Volcanic glass and palagonite	15

PHYSICAL PROPERTIES:

	1-65	2-117	3-120	4-57	5-68
V_v	3.28	—	2.81	—	2.82
V_h	3.40	3.20	2.97	2.99	3.06
Density	2.38	2.36	2.32	2.31	—
Water content	7.23	8.6	10.0	10.0	—

CARBONATE BOMB:
2-70 = 57
4-70 = 56

SITE 516 HOLE F CORE 74 CORED INTERVAL 823.6–832.6 m



5Y 7/2 burrow fill

Burrow

Massive claystone

Organic-rich clay

Limestone

5GY 6/1

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

All laminae green (10GY 3/2) unless otherwise indicated matrix is N7. Section 2, 100 cm: ash disseminated in limestone. Section 4 is similar to Core 68, Section 3.

SMEAR SLIDE SUMMARY:

	1-70	6-27
	D	D
Texture:		
Sand	2	2
Silt	38	45
Clay	60	53
Composition:		
Quartz	–	1
Pyrite	–	1
Heavy minerals	–	1
Glauconite	2	–
Zeolites	–	1
Other clay minerals	20	33
Carbonate unspecified	31	10
Foraminifers	5	–
Nannofossils	40	40
Volcanic glass	2	TR
Dolomite/Calcite(?)	–	10
Apatite/Chamosite	–	3

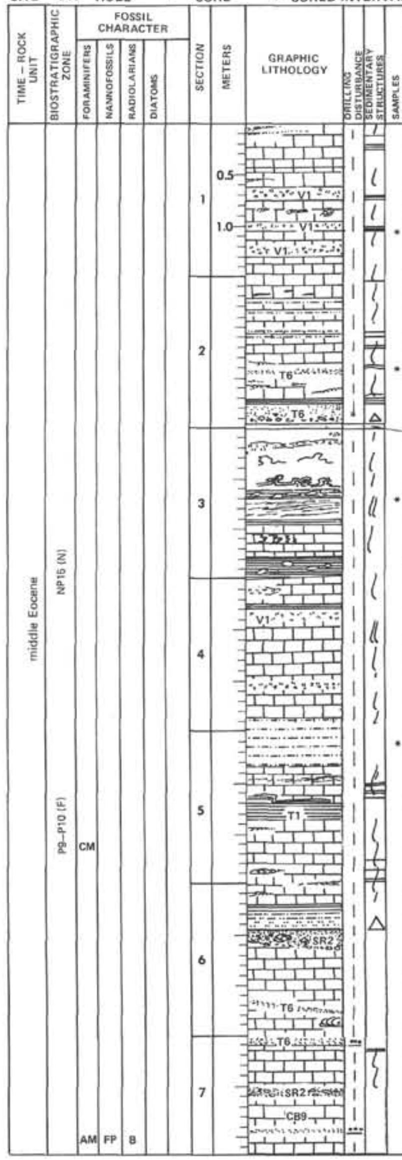
PHYSICAL PROPERTIES:

	1-117	2-11	3-81	4-140	5-40	6-68
V_v	2.93	—	2.71	—	2.91	—
V_h	3.11	3.11	3.07	3.11	3.12	2.82
Density	2.36	2.33	2.30	2.34	2.31	2.27
Water content	8.94	8.85	9.9	9.7	9.27	11.3

CARBONATE BOMB:
2-70 = 64
4-100 = 52
6-70 = 50

ORGANIC CARBON:
4, 120–121 = 0.30

SITE 516 HOLE F CORE 75 CORED INTERVAL 832.6–841.6 m



5RP 4/2

Medium dark gray

VOID

Limestone balls in claystone

6GY 6/1

T1
T2
T5

6GY 6/1

5RP 4/2

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Complex interbedding of muds, clays, ash, and crudely graded beds. Biscuited at most contacts. Greenish gray (6GY 6/1), 0–45 cm of Section 1, grading downward to grayish red purple (5RP 4/2). Section 1, 63–72 cm: ash, dark gray at base grading upward to greenish gray. Section 2, 20–60 cm: light olive gray layers with silty grain size. Convolute laminations and contorted beds appear in the upper part of Section 3.

SMEAR SLIDE SUMMARY:

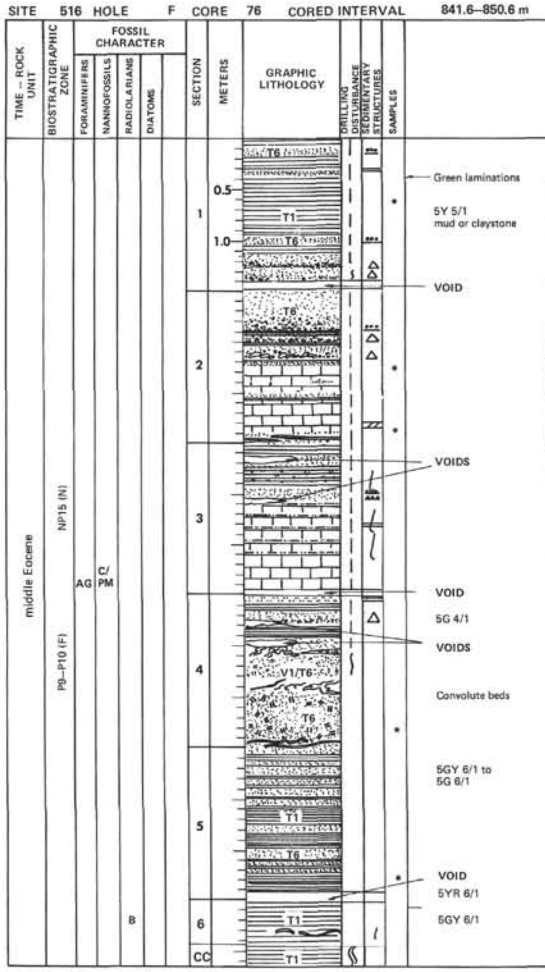
	1-109	2-93	3-80
	D	D	D
Texture:			
Sand	TR	50	5
Silt	50	15	25
Clay	50	35	70
Composition:			
Quartz	5	10	TR
Feldspar	5	40	TR
Pyrite	5	–	–
Heavy minerals	2	10	–
Glauconite	–	–	TR
Other clay minerals	41	35	37
Carbonate unspecified	1	1	40
Foraminifers	–	–	3
Nannofossils	40	2	20
Silicoflagellates	–	–	TR
Volcanic glass	1	2	TR
Micronodules	–	–	TR
Shale fragments	–	–	–

PHYSICAL PROPERTIES:

	1-89	2-108	4-110	5-3	5-84	6-143
V_v	3.02	2.76	—	2.27	3.99	2.68
V_h	3.08	2.92	3.36	2.35	3.83	2.86
Density	2.50	2.29	2.14?	2.06	2.78	2.26
Water content	8.6	10.7	7.58	21.9	5.36	12.2

CARBONATE BOMB:
1-90 = 28
2-105 = 55
4-110 = 71

SITE 516 HOLE F CORE 76 CORED INTERVAL 841.6–850.6 m



LITHOLOGIC DESCRIPTION

CALCAREOUS MUDSTONE

Color: 10YR 5/1. Section 2 (upper part): microconglomerate containing grains up to 3 mm, including quartz, basalt?, limestone, and volcanic glass. Section 3 is greenish gray and light brownish gray marly limestone, burrowed throughout. Section 5, 95–100 cm: winnowed sandy intervals.

SMEAR SLIDE SUMMARY:

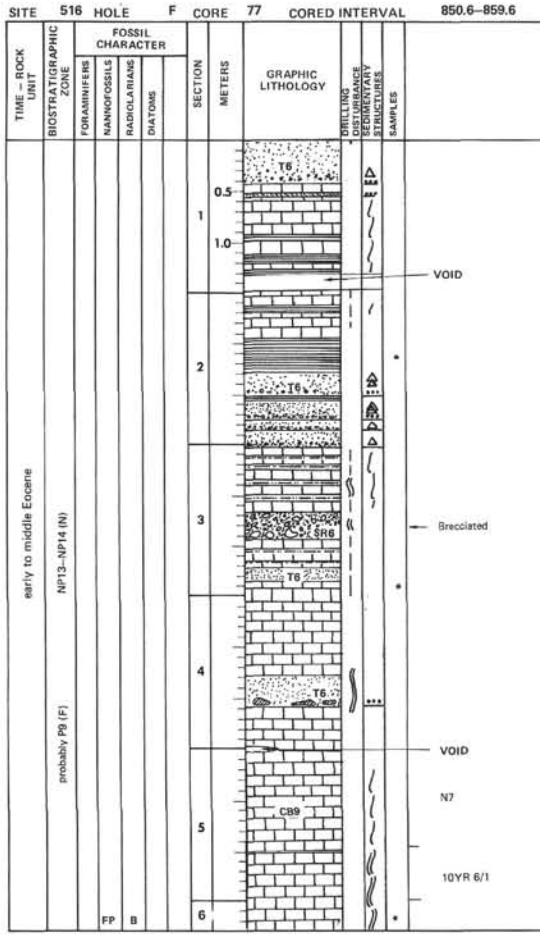
	1-70 D	2-76 D	2-145 D	4-130 D	5-130 D
Texture:					
Sand	–	TR	1	50	10
Silt	10	20	70	10	20
Clay	90	80	29	40	70
Composition:					
Quartz } Feldspar	3	3	– / TR	5	– / –
Heavy minerals	TR	4	–	5	–
Other clay minerals	91	65	–	40	100
Foraminifers	–	TR	–	–	–
Nannfoossils	5	25	–	TR	–
Diatoms	TR	–	–	–	–
Radiolarians	–	TR	–	–	–
Biotite	1	–	–	10	–
Micronodules	TR	TR	–	–	–
Limonite	–	–	100	–	–
Clay aggregates	–	–	–	40	–

PHYSICAL PROPERTIES:

	2-123	4-116
V_v	2.34	2.12
V_h	2.46	2.20
Density	2.14	1.94
Water content	15.8	25.3

CARBONATE BOMB:
1-70 = 1
2-120 = 4
3-90 = 40

SITE 516 HOLE F CORE 77 CORED INTERVAL 850.6–859.6



LITHOLOGIC DESCRIPTION

LIMESTONE (MICRITE)

Few nannofossils in the intervals examined. Limestone: light brownish gray (5YR 6/1) slightly sandy calcareous mudstone. Claystone: greenish gray (5G 6/1) burrowed with greenish gray (5GY 8/1). Sandstone: greenish gray (5G 6/1) with black, white flecks (sand-size). There is a pelecypod valve (2 cm) at Section 2, 32 cm. Section 3, 12–68 cm is a mixture of limestone and claystone. Section 4: mud clasts in sand to sandy silt matrix.

SMEAR SLIDE SUMMARY:

	2-64 D	3-148 D	6-24 D
Texture:			
Sand	3	–	10
Silt	27	5	6
Clay	80	95	85
Composition:			
Quartz } Feldspar	15	2	8
Pyrite	TR	–	–
Heavy minerals	TR	–	–
Zeolites	–	–	TR
Other clay minerals	80	95	85
Carbonate unspecified	–	1	1
Foraminfiers	TR	TR	1
Nannofossils	5	3	–
Silicoflagellates	–	TR	–
Volcanic glass	TR	TR	5

PHYSICAL PROPERTIES:

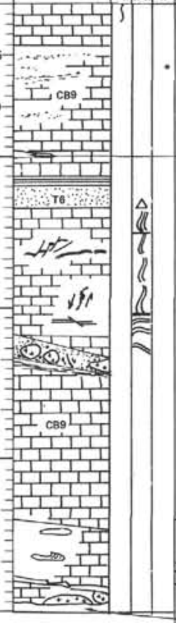
	1-16	2-93	4-73
V_v	2.15	2.18	2.97
V_h	2.27	2.26	3.04
Density	1.99	1.94	2.31
Water content	—	24.2	9.3

CARBONATE BOMB:
1-70 = 56
2-70 = 1
5-30 = 56

SITE 516 HOLE F CORE 78 CORED INTERVAL 859.6–868.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
early–middle Eocene	NP13–NP14 (N)		FC/PM			1	0.5, 1.0
			CM			2	
						3	
	probably P9 (F)				B	4	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



VOID
5G 7/1
7.5YR 6/2
N7
Red, limestone cobble
White
N7 clay with pumice
VOID

LITHOLOGIC DESCRIPTION

NANNOFOSSL LIMESTONE (MICRITE)

Faulted with graded beds. Limestone: light brownish gray (5YR 6/1) calcareous mudstone, slightly sandy. Sandstone: 5G 6/1 with darker and almost white flecks. Section 1 has small flecks? equals burrows.

REDDISH LIMESTONE first sppears at 75 cm of Section 2. Greenish-gray overlying limestone grades downward to reddish brown (5YR 5/3) through a series of thin, deformed beds at approximately 75 cm. Section 2, 115–145 cm is stained, near-vertical, offset traces. White laminations, offset 5G 8/1 bed in upper part of Section 3. There is color change (5G 8/1) at 60 cm Section 3. At Section 4, 110–120 cm a reduced red layer, green on contacts above and below.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	–
Silt	55
Clay	45
Composition:	
Other clay minerals	20
Carbonate unspecified	50
Foraminifers	5
Nannofossils	29
Volcanic glass	5
Micronodules	1

PHYSICAL PROPERTIES:

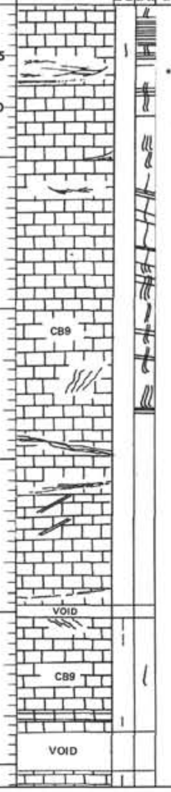
	1-71	2-133	4-1	4-120
V_v	2.92	3.36	—	3.54
V_h	3.13	3.42	2.79	3.60
Density	2.32	2.51	2.29	2.39
Water content	8.8	6.7	—	8.3

CARBONATE BOMB:
1-70 = 60
2-40 = 4
3-65 = 55

SITE 516 HOLE F CORE 79 CORED INTERVAL 868.6–877.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
early–middle Eocene	NP13–NP14 (N)					1	0.5, 1.0
						2	
						3	
	probably P9 (F)					4	
						5	
		B	RP			CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Small offsets
5YR 4/4
Microfaulting
5YR 4/4
Sub-horizontal fractures
Microshear
Large, straight faults
5GY 6/1
10GY 5/2
N8 fractures
N9
Olive gray
N9 limestone, no burrows

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Reddish brown (5YR 5/4) is the general color. Laminae are only slightly darker than the groundmass. Section 2 at the bottom is darker (5YR 4/4) zones more intensely mottled. Section 3, 65–75 cm: near vertical offset traces. Section 3, 75–95 cm is a darker (5YR 4/4) zone with microfaulted burrows. Section 4, 80–120 cm is microfractured.

SMEAR SLIDE SUMMARY:

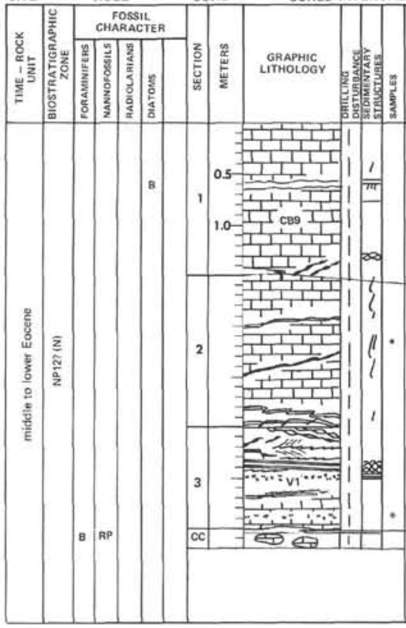
	1-70
	D
Texture:	
Sand	–
Silt	50
Clay	50
Composition:	
Other clay minerals	15
Carbonate unspecified	35
Foraminifers	5
Nannofossils	35
Volcanic glass	10
Opaque minerals	TR

PHYSICAL PROPERTIES:

	1-30	2-29	3-100	4-93	2-103	5-70
V_v	2.70	2.71	3.02	3.03	—	2.55
V_h	2.74	2.87	3.06	3.12	3.14	2.67
Density	2.28	2.34	2.34	2.38	2.32	2.00
Water content	11.4	10.0	9.5	8.8	–	17.9

CARBONATE BOMB:
3-100 = 70
5-70 = 64

SITE 516 HOLE F CORE 80 CORED INTERVAL 877.6–886.6 m



LITHOLOGIC DESCRIPTION

NANNO-FORAM LIMESTONE (MICRITE)

Dark layer of light olive gray (5Y 6/1). In Section 1 the groundmass is white (N9) and fractures filled with darker (N8) limestone. Section 2, 120–150 cm: N9 fracture filling in N8 groundmass. All contacts broken in Section 3. N7 coalesced laminations in N8 groundmass. Ash layers greenish gray (5G 6/1).

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	30
Silt	25
Clay	45
Composition:	
Quartz	1
Feldspar	2
Other clay minerals	10
Carbonate unspecified	47
Foraminifers	15
Nannofossils	20
Calcite rhombs	5

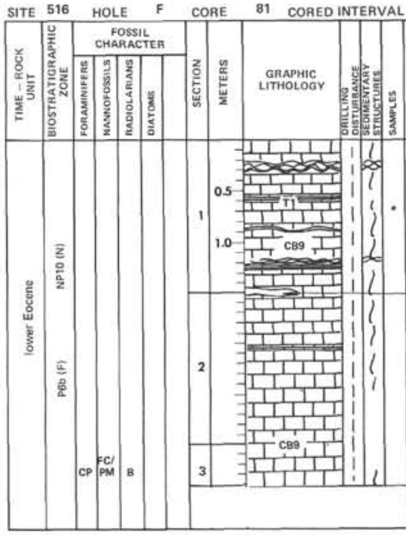
PHYSICAL PROPERTIES:

	1-113	2-108	2-32
V_v	2.95	3.41	—
V_h	3.17	3.37	3.25
Density	2.17	2.22	2.23
Water content	13.5	11.3	—

CARBONATE BOMB:
2-70 = 83

ORGANIC CARBON:
3, 97–99 = 0.24

SITE 516 HOLE F CORE 81 CORED INTERVAL 886.6–895.6 m



LITHOLOGIC DESCRIPTION

LIMESTONE (MICRITE)

Groundmass color white (N9). First two sections biscuited.

SMEAR SLIDE SUMMARY:

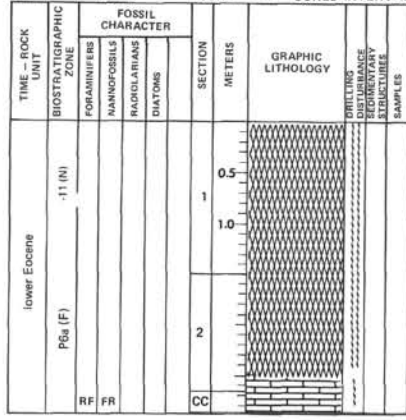
	1-70
	D
Texture:	
Sand	1
Silt	49
Clay	50
Composition:	
Other clay minerals	30
Carbonate unspecified	55
Foraminifers	8
Nannofossils	5
Volcanic glass	2

PHYSICAL PROPERTIES:

	1-104	2-106
V_v	2.18	2.35
V_h	2.18	2.45
Density	2.11	2.08
Water content	16.9	17.8

CARBONATE BOMB:
1-95 = 93

SITE 516 HOLE F CORE 82 CORED INTERVAL 895.6–900.6 m



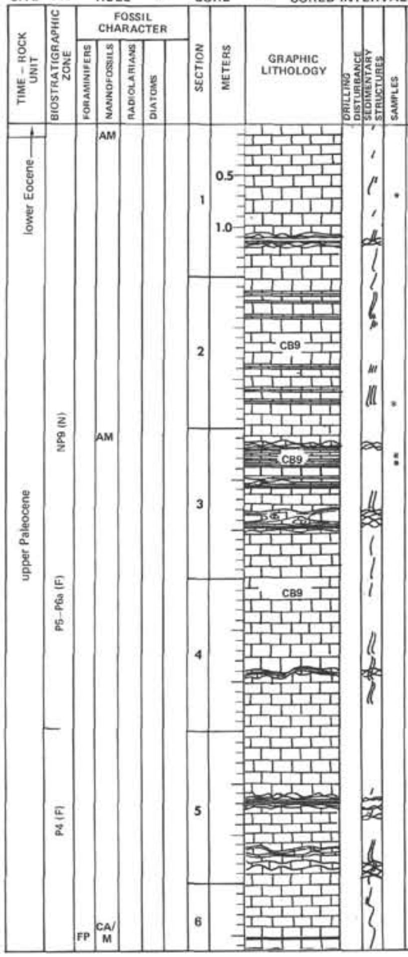
LITHOLOGIC DESCRIPTION

DRILL BRECCIA

Completely hashed during drilling. Blocks and breccia of limestone in Core-Catcher.

N9 limestone

SITE 516 HOLE F CORE 83 CORED INTERVAL 900.6–910.1 m



10YR 4/2

5Y 4/1

10YR 4/2

LITHOLOGIC DESCRIPTION

NANNO-FORAM LIMESTONE (MICRITE)

Groundmass N8. Section 1: grayish olive (10YR 4/2) bed bounded by wavy laminations. Section 3, 50 cm: black layer with lenticular inclusions of limestone matrix.

SMEAR SLIDE SUMMARY:

	1-70	3-35
	D	D
Texture:		
Sand	20	30
Silt	15	15
Clay	65	55
Composition:		
Quartz	3	3
Mica	4	3
Glauconite	–	TR
Other clay minerals	13	20
Carbonate unspecified	50	23
Foraminifers	20	5
Nannofossils	10	40
Opaques	–	5

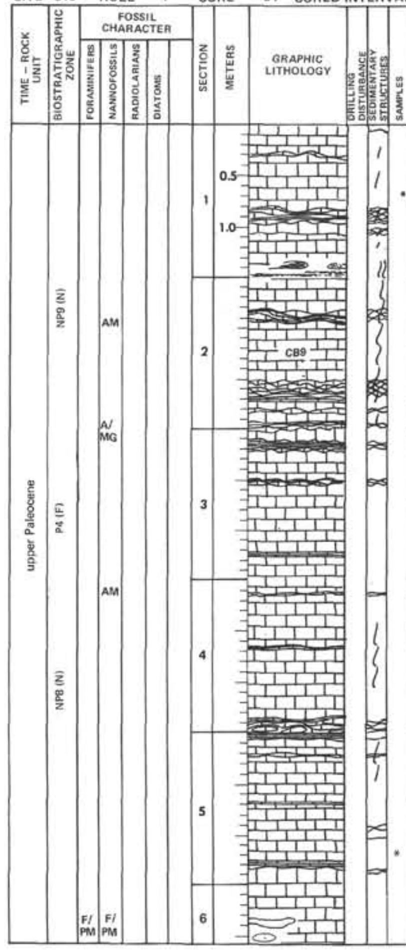
PHYSICAL PROPERTIES:

	1-90	2-80	4-22	5-29	6-41
V_v	2.69	2.38	2.33	—	2.33
V_h	2.69	2.55	2.45	2.33	2.39
Density	2.23	2.20	2.18	2.16	2.16
Water content	12.7	13.5	14.4	14.8	14.9

CARBONATE BOMB:
1-70 = 90
3-70 = 76
5-70 = 83

ORGANIC CARBON:
2, 121–124 = 0.08
3, 25–28 = 0.13

SITE 516 HOLE F CORE 84 CORED INTERVAL 910.1–919.6 m



5Y 4/1

5GY 6/1

5Y 4/1

Wavy laminations coalesce to form beds

Lenticular inclusions

10YR 4/2

5Y 6/1 burrow fill

Burrow, N8

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Groundmass is very light gray (N8) and generally massive with faint, light–dark contrasts that mark burrows. Wavy laminations and burrows, gray (5Y 6/1) in Section 2.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	5
Silt	35
Clay	60
Composition:	
Quartz	1
Other clay minerals	15
Carbonate unspecified	36
Foraminifers	8
Nannofossils	35
Volcanic glass	5

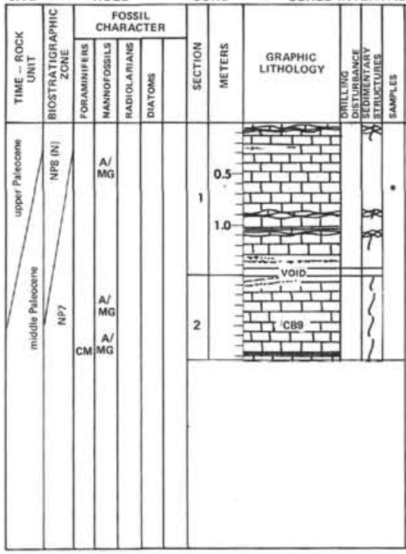
PHYSICAL PROPERTIES:

	1-46	2-62	3-35	4-21	5-135	6-20
V_v	2.35	2.38	2.41	2.48	2.57	—
V_h	2.44	2.51	2.49	2.54	2.63	2.67
Density	2.19	2.20	2.18	2.20	2.20	2.22
Water content	13.9	13.6	14.4	13.7	13.6	—

CARBONATE BOMB:
1-70 = 80
3-70 = 83
5-70 = 78

ORGANIC CARBON:
5, 119–123 = 0.10

SITE 516 HOLE F CORE 85 CORED INTERVAL 919.6–929.1 m



LITHOLOGIC DESCRIPTION

5YR 4/1

NANNO-FORAM LIMESTONE (MICRITE)

Color: white (N8), massive and micritic.

SMEAR SLIDE SUMMARY:

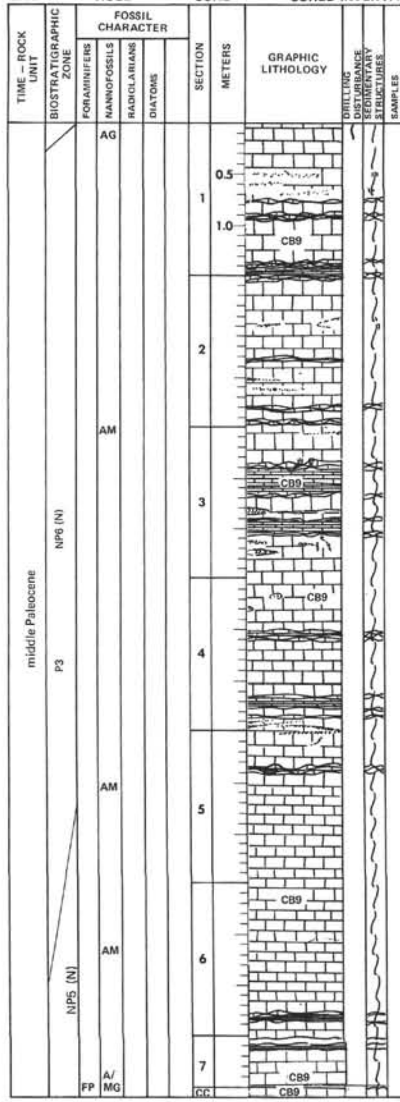
	1-70
	D
Texture:	
Sand	8
Silt	52
Clay	40
Composition:	
Pyrite	2
Other clay minerals	15
Carbonate unspecified	37
Foraminifers	12
Nannofossils	30
Volcanic glass	4

PHYSICAL PROPERTIES:

	1-29	2-28
V_v	2.31	—
V_h	2.34	2.26
Density	2.12	2.13
Water content	16.2	—

CARBONATE BOMB:
1-75 = 88

SITE 516 HOLE F CORE 86 CORED INTERVAL 929.1–938.6 m



LITHOLOGIC DESCRIPTION

5YR 4/1

– Bioturbation

5YR 3/1
5YR 6/1

NANNOFOSSIL LIMESTONE (MICRITIC)

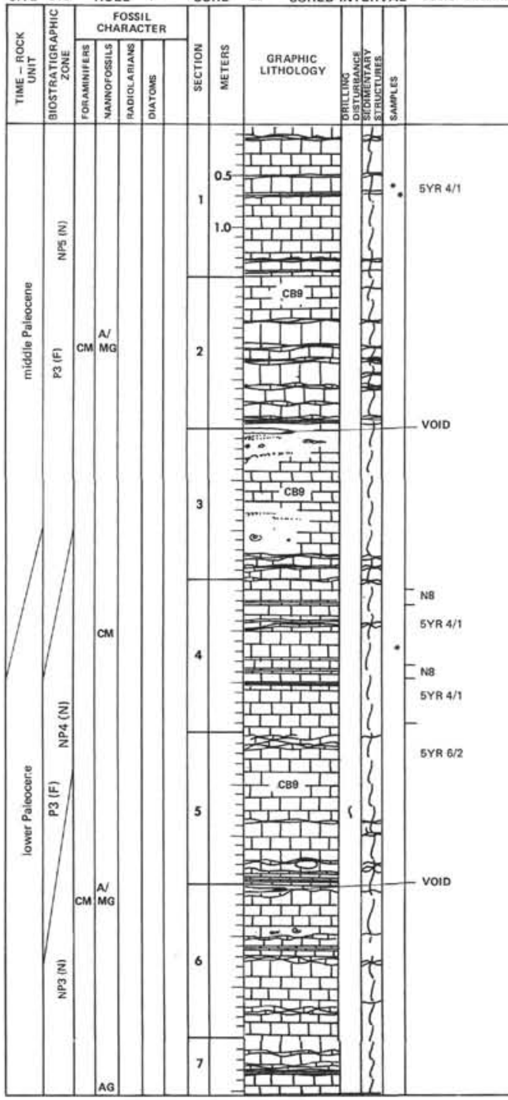
Light brownish gray (5YR 6/1). Burrows or burrow debris and fecal pellets in Section 1. Section 3, 30 cm: small vertical burrows filled with light colored limestone. Section 3, 90 cm: impurities expelled from burrow by pressure solution. Section 5, 30 cm: burrow fill offset by pressure solution.

PHYSICAL PROPERTIES:

	1-55	2-44	3-128	5-7	7-17
V_v	2.39	—	2.40	2.33	2.21
V_h	2.54	2.58	2.06	2.41	2.27
Density	2.26	2.24	2.21	2.19	2.17
Water content	12.0	—	13.5	14.1	14.7

CARBONATE BOMB:
1-110 = 76
3-55 = 40
5-145 = 89

SITE 516 HOLE F CORE 87 CORED INTERVAL 938.6–948.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITIC)

Color: dark gray (5YR 4/1). Light brownish gray (5YR 6/1) homogeneous limestone except for few burrows throughout, and areas of pressure solution where insoluble residues (clays, oxides, non-carbonate minerals) should be concentrated. The regions where pressure solution occur are darker brownish gray (5YR 4/1). The core is broken in large pieces with the cracks at the darker areas. Burrows are very deformed.

SMEAR SLIDE SUMMARY:

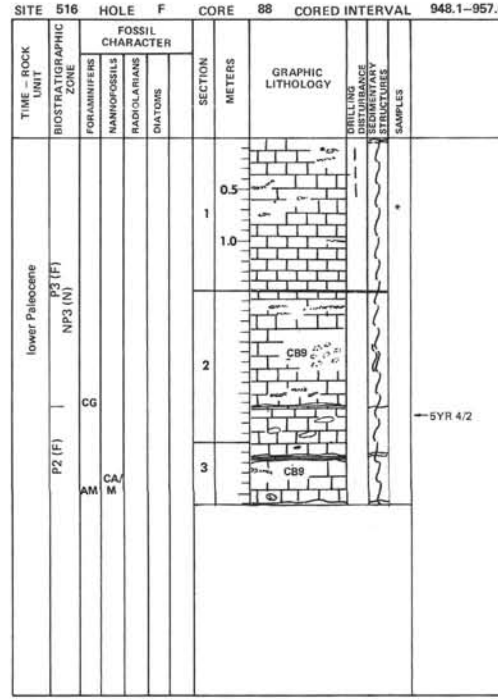
	1-67	1-70	4-70
	D	D	D
Texture:			
Sand	–	–	–
Silt	30	60	–
Clay	70	40	–
Composition:			
Quartz	TR	TR	–
Feldspar	–	–	TR
Pyrite	–	–	1
Other clay minerals	20	15	10
Carbonate unspecified	20	–	3
Foraminifers	–	TR	1
Nannofossils	60	85	85
Radiolarians	–	–	TR
Silicoflagellates	–	–	TR
Volcanic glass	TR	TR	TR
Micronodules	TR	TR	–

PHYSICAL PROPERTIES:

	1-59	2-140	3-131	4-144	5-112	7-0
V_v	2.32	2.42	2.68	2.42	—	2.43
V_h	2.43	2.49	2.59	2.49	2.66	2.50
Density	2.17	2.12	2.25	2.21	2.21	2.25
Water content	14.9	13.0	12.3	13.7	—	12.3

CARBONATE BOMB:
1-70 = 84
4-50 = 87
6-20 = 89

SITE 516 HOLE F CORE 88 CORED INTERVAL 948.1–957.6 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITE)

Limestone as the previous section. Dominant color is light reddish brown (5YR 6/3). Bioturbated throughout (less than 30%). Very deformed burrows. Section 2, 50–70 cm: very light gray (N8) grades up and down to the dominant color of 5YR 6/3. This light gray layer seems to have been more bioturbated than the rest of the core. Section 3 as above, with dark reddish gray zones where pressure solution was richer (stylolites). This section is bioturbated throughout (approximately 50%). Burrows very deformed.

SMEAR SLIDE SUMMARY:

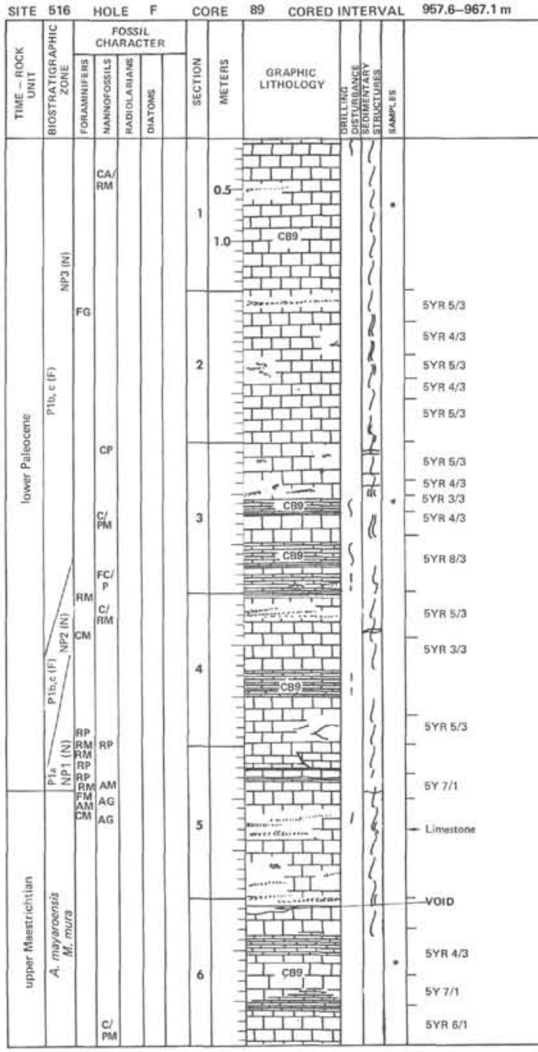
	1-70
	D
Texture:	
Sand	1
Silt	40
Clay	59
Composition:	
Feldspar	TR
Other clay minerals	10
Carbonate unspecified	37
Foraminifers	3
Nannofossils	50
Volcanic glass	TR

PHYSICAL PROPERTIES:

	2-3	3-2
V_v	2.37	2.58
V_h	2.36	2.59
Density	2.18	2.24
Water content	14.4	12.4

CARBONATE BOMB:
1-100 = 83
3-10 = 46

SITE 516 HOLE F CORE 89 CORED INTERVAL 957.6–967.1 m



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Cretaceous–Tertiary boundary. Sections 1 and 2: reddish brown colors varying from 5YR 4/3–5YR 5/3. The darker regions (4/3) are more bioturbated than the lighter color regions. The whole section is highly bioturbated, Burrows deformed. Section 3: limestone as in the previous sections, bioturbated and with pressure solution fractures, Reddish brown in color, intercalated with dark (5YR 3/3) layers. Dark reddish brown layers of calcareous mudstone. Section 4: intercalations of limestone and calcareous mudstone. Section 5 is 5YR 6/4 with clay layers being 5YR 3/3. Section 6 is limestone with layers of calcareous mudstone.

SMEAR SLIDE SUMMARY:

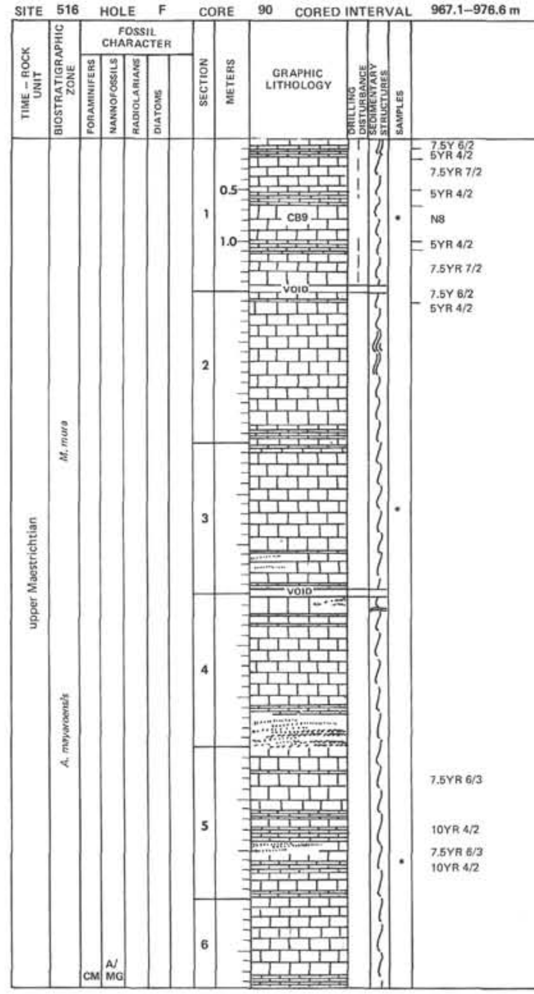
	1-70	3-60	6-60
	D	D	D
Texture:			
Sand	8	2	–
Silt	32	15	–
Clay	60	83	–
Composition:			
Quartz, Feldspar	2	2	TR
Heavy minerals	–	TR	–
Other clay minerals	30	60	5
Carbonate unspecified	3	20	–
Foraminifera	5	TR	–
Nannofossils	60	10	95
Volcanic glass	TR	1	TR
Micronodules	TR	2	TR
Iron-oxides	–	5	–

PHYSICAL PROPERTIES:

	1-42	3-88	4-140	5-9
V_v	2.56	2.63	—	3.20
V_h	2.67	2.78	3.16	3.29
Density	2.30	2.32	2.29	2.37
Water content	10.7	10.2	—	8.6

CARBONATE BOMB:
1-70 = 78
3-75 = 7
5-70 = 70

SITE 516 HOLE F CORE 90 CORED INTERVAL 967.1–976.6 m



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Dominant color pinkish gray (7.5YR 6/3) with dark reddish gray (5YR 4/2) interbedded. Burrows and mottles common to extensive throughout, though very faint in light intervals. Crenulate laminations (solution) extend into dominant lithology from darker marly zones.

SMEAR SLIDE SUMMARY:

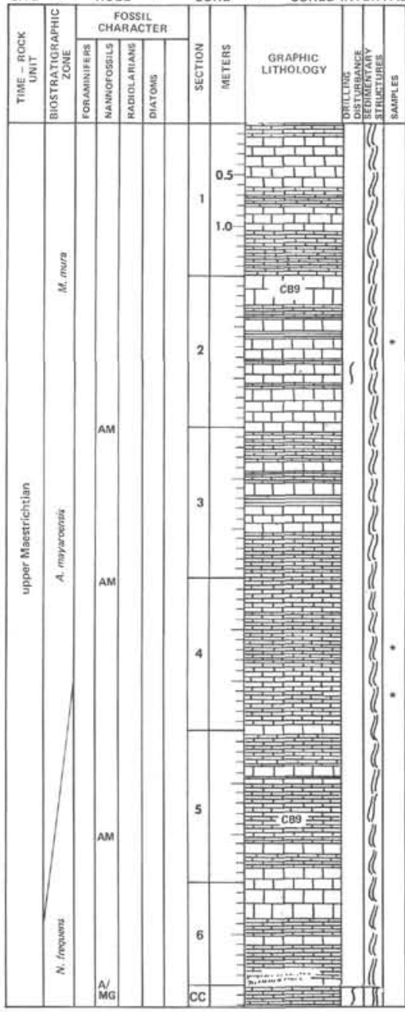
	1-80	3-70	5-110
	D	D	D
Texture:			
Sand	–	–	1
Silt	45	40	45
Clay	55	60	54
Composition:			
Quartz, Feldspar	TR	TR	5
Pyrite	–	–	1
Zeolites	1	–	1
Other clay minerals	7	12	49
Carbonate unspecified	10	25	30
Foraminifers	–	TR	–
Nannofossils	80	60	10
Rhombs (dolomite–Mg-calcite)	2	3	3
Volcanic glass	TR	TR	1
Micronodules	TR	TR	–

PHYSICAL PROPERTIES:

	1-5	3-123	4-20	6-3
V_v	2.27	—	2.21	2.44
V_h	2.37	2.48	2.26	2.42
Density	2.21	2.15	2.13	2.17
Water content	13.6	—	16.1	15.1

CARBONATE BOMB:
2-70 = 84
4-70 = 81
6-75 = 67

SITE 516 HOLE F CORE 91 CORED INTERVAL 976.6–986.1 m



LITHOLOGIC DESCRIPTION

5YR 4/2

5YR 6/2

5YR 4/2

5YR 6/2

INTERBEDDED NANNOFOSSIL LIMESTONE AND MARLY LIMESTONE (MICRITIC)

Limestone is pinkish gray (5Y 6/2); marly zones are dark reddish gray (5YR 4/2). Extensive burrowing; contacts are burrowed, and have fine crenulate laminations of dark extending several centimeters into light units. Alternations of light (5YR 6/2) and dark (5YR 4/2) zones.

SMEAR SLIDE SUMMARY:

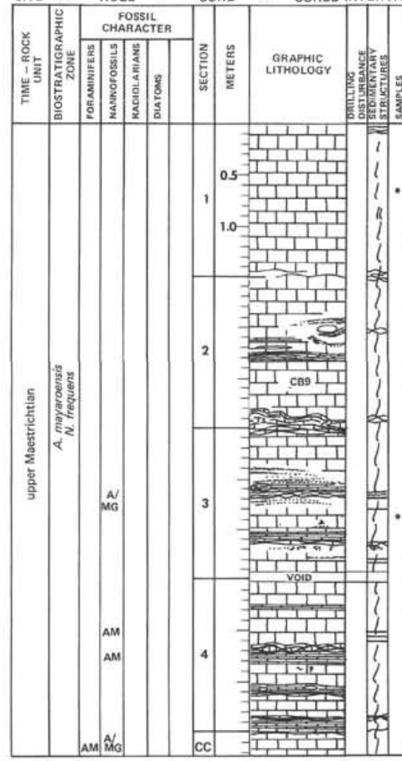
	2-70	4-70	4-114
	D	D	D
Texture:			
Sand	1	1	3
Silt	40	55	50
Clay	59	44	47
Composition:			
Quartz / Feldspar	} –	} TR	} 5
Pyrite	TR	TR	–
Heavy minerals	–	–	TR
Zeolites	–	1	–
Other clay minerals	28	25	42
Carbonate unspecified	55	20	30
Foraminifers	1	1	TR
Nannofossils	15	50	15
Rhombs (dolomite or Mg-Calcite)	1	3	7
Micronodules	–	–	1
Volcanic glass	TR	TR	–

PHYSICAL PROPERTIES:

	2-3	3-138	5-78	6-3
V_v	2.39	2.40	—	2.34
V_h	2.50	2.50	2.58	2.41
Density	2.23	2.25	2.27	2.29
Water content	12.8	12.4	—	11.3

CARBONATE BOMB:
2-70 = 77
4-75 = 79
6-70 = 83

SITE 516 HOLE F CORE 92 CORED INTERVAL 986.1–995.6 m



LITHOLOGIC DESCRIPTION

5YR 6/4
5YR 5/4
5YR 6/4
5YR 5/4
5YR 6/4
5YR 5/4
5YR 6/4
5YR 5/4
5Y 6/1
5Y 7/1
5Y 6/1
5YR 5/4
6YR 7/1
5YR 7/1
5YR 5/4
5YR 7/1
5YR 5/4
5YR 7/1
5YR 5/4
5YR 7/1
5YR 5/4
5YR 7/1

INTERBEDDED NANNOFOSSIL LIMESTONE AND MARLY LIMESTONE (MICRITIC)

Section 1: 5YR 6/4 massive, only slightly mottled. Section 3, 62–92 cm: light gray layer with greenish gray boundaries above and below.

SMEAR SLIDE SUMMARY:

	1-70	3-90
	D	D
Texture:		
Sand	10	8
Silt	15	15
Clay	75	77
Composition:		
Quartz	–	1
Other clay minerals	14	8
Carbonate unspecified	20	30
Foraminifers	5	6
Nannofossils	60	55
Rhombs	1	–

PHYSICAL PROPERTIES:

	1-126	2-145	3-94	4-21
V_v	2.30	2.17	2.35	—
V_h	2.45	2.25	2.41	2.59
Density	2.18	2.19	2.24	2.35
Water content	14.3	14.4	12.6	—

CARBONATE BOMB:
1-70 = 77
3-70 = 78

SITE 516 HOLE F CORE 93 CORED INTERVAL 995.6–1005.1 m

TIME – ROCK UNIT: upper Maestrichtian; middle Maestrichtian

BIOSTRATIGRAPHIC ZONE: N. frequens; A. mayaroensis; L. quadratus

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): AM; A/MG; AM; FC/M

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

5YR 6/2
5YR 4/2
5YR 6/2
5YR 4/2
5YR 7/2
5YR 4/2
2.5Y 7/2
5YR 6/2
5YR 5/2
5YR 6/2
5YR 4/2
5YR 7/1
5YR 4/2
2.5Y 7/2
5YR 4/2
5YR 6/2
5YR 5/2
5YR 7/2
N8
5G 6/1
5YR 5/3
5YR 7/2
5YR 5/3
5YR 7/1
5YR 5/3
5YR 7/2
5YR 5/3
5YR 6/2
5YR 5/3
5YR 6/2
5YR 3/4
5GY 8/1
5YR 4/2
5GY 8/1
5YR 4/2
5GY 8/1
5YR 4/2
5YR 6/2

INTERBEDDED NANNOFOSSIL LIMESTONE AND MARLY LIMESTONE (MICRITIC)

Varicolored.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	–
Silt	40
Clay	60
Composition:	
Other clay minerals	61
Carbonate unspecified	10
Foraminifers	4
Nannofossils	20
Volcanic glass	2
Micronodules	3

PHYSICAL PROPERTIES:

	1-129	2-129	3-124	4-126	5-130
V_v	2.45	2.32	2.35	—	2.51
V_h	2.58	2.42	2.47	2.79	2.71
Density	2.27	2.22	2.22	2.35	2.33
Water content	11.3	13.3	12.9	—	10.2

CARBONATE BOMB:
2-70 = 36
4-70 = 38

SITE 516 HOLE F CORE 94 CORED INTERVAL 1005.1–1014.6 m

TIME – ROCK UNIT: middle Maestrichtian; lower–middle Maestrichtian

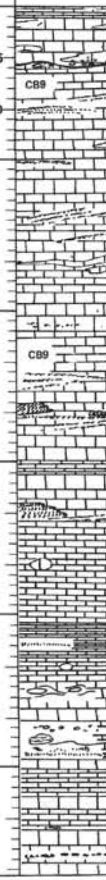
BIOSTRATIGRAPHIC ZONE: L. quadratus; A. mayaroensis; A. cymbiformis

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): A/PM; A/PM; CA/P; RP; CP

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

5YR 4/3
5YR 7/2
5YR 4/3
5G 8/1
5YR 5/3
5YR 7/1
5YR 5/3
5Y 8/1
5YR 5/3
5YR 6/1
5YR 5/3
5YR 6/1
5YR 6/2– to 5YR 5/3
5YR 7/2
5YR 5/3
5YR 7/2
5YR 5/3
5YR 7/2
5YR 5/3
5YR 6/2
5YR 4/2
5YR 6/2
5YR 4/2
5YR 6/2
5YR 4/2
5YR 6/2
Brecciated

NANNOFOSSIL LIMESTONE (MICRITIC) AND MARLY LIMESTONE

Section 1, 45–60 cm: light greenish gray burrow fill in 5YR 7/2 groundmass. Section 3, 0–15 cm: voids and black spots.

SMEAR SLIDE SUMMARY:

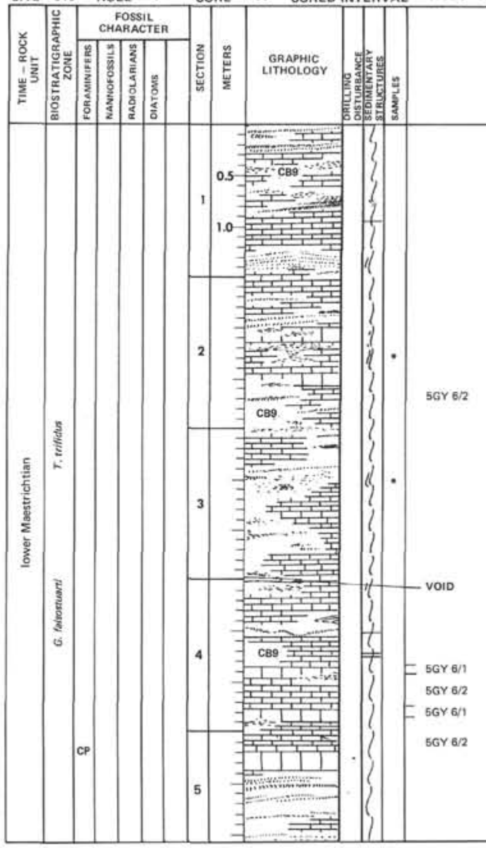
	1-70
	D
Texture:	
Sand	10
Silt	15
Clay	75
Composition:	
Quartz	2
Feldspar	2
Mica	2
Other clay minerals	9
Carbonate unspecified	33
Foraminifers	7
Nannofossils	45

PHYSICAL PROPERTIES:

	1-119	3-38	4-141	6-2
V_v	2.58	2.52	2.66	—
V_h	2.72	2.72	2.87	2.83
Density	2.34	2.35	2.37	2.32
Water content	10.0	9.6	8.9	—

CARBONATE BOMB:
1-70 = 63
4-50 = 65
6-70 = 64

SITE 516 HOLE F CORE 98 CORED INTERVAL 1032.6–1041.6 m



LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL LIMESTONE (MICRITIC)

Dominant color greenish gray (5G 6/1). Burrowed throughout. No visible sedimentary structures besides burrows. Section 1: light greenish gray (5GY 6/2) to greenish gray. Section 3: same as above but with few light layers greenish gray (5GY 6/1) where bioturbation is more intense. Lighter layers 50–67 and 95–107 cm in Section 3. The color change is gradational. Lighter layers at: Section 4, 83–91 and 125–135 cm and also Section 5, 15–32 cm.

SMEAR SLIDE SUMMARY:

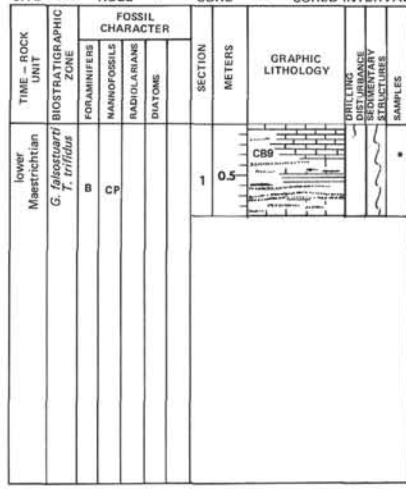
	2-80	3-56
	D	M
Texture:		
Sand	2	TR
Silt	48	40
Clay	50	60
Composition:		
Quartz	3	} 1
Feldspar	TR	
Other clay minerals	40	20
Carbonate unspecified	5	5
Foraminifers	TR	TR
Nannofossils	52	74
Micronodules	TR	TR

PHYSICAL PROPERTIES:

	1-39	1-100	4-4	5-92
V_v	—	2.53	2.57	2.64
V_h	2.83	2.74	2.70	2.79
Density	2.30	2.31	2.29	2.30
Water content	—	10.7	10.8	10.2

CARBONATE BOMB:
2-70 = 62
4-70 = 34

SITE 516 HOLE F CORE 99 CORED INTERVAL 1041.6–1044.1 m



LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL LIMESTONE (MICRITIC)

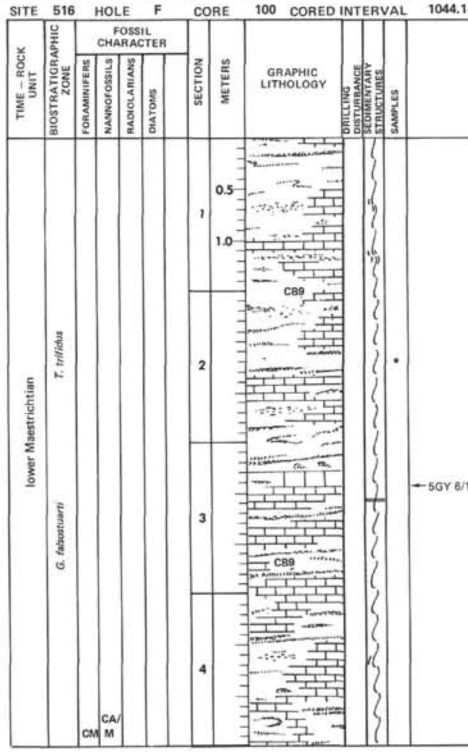
Dominant color greenish gray (5G 6/1) burrowed throughout. There are slightly lighter color intervals at 38–50 and 65–75 cm. These lighter intervals seem to be areas of more intense bioturbation.

SMEAR SLIDE SUMMARY:

	1-30
	D
Texture:	
Sand	–
Silt	30
Clay	70
Composition:	
Quartz	TR
Volcanic glass	TR
Other clay minerals	40
Carbonate unspecified	2
Foraminifers	58
Micronodules	TR

CARBONATE BOMB:
1-70 = 62

SITE 516 HOLE F CORE 100 CORED INTERVAL 1044.1–1050.6 m



LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL LIMESTONE (MICRITIC)

Dark green gray (5G 6/1). Lithology probably less homogeneous than shown.

SMEAR SLIDE SUMMARY:

	2-70
	D
Texture:	
Sand	3
Silt	47
Clay	50
Composition:	
Quartz	3
Feldspar	TR
Volcanic glass	2
Other clay minerals	50
Carbonate unspecified	5
Foraminifers	TR
Nannofossils	40
Micronodules	TR

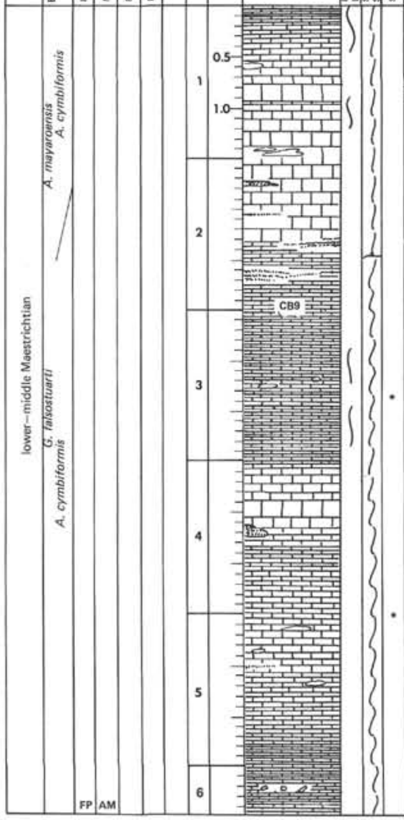
PHYSICAL PROPERTIES:

	1-96	2-94	3-49	4-95
V_v	2.51	2.55	—	2.57
V_h	2.70	2.79	2.84	2.75
Density	2.34	2.36	2.37	2.34
Water content	10.1	9.9	—	10.0

CARBONATE BOMB:
1-70 = 54
4-75 = 47

SITE 516 HOLE F CORE 95 CORED INTERVAL 1014.6–1023.6 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

5YR 4/3
5YR 5/3
5YR 7/1
5YR 5/3
5YR 6/3
5YR 6/2
5YR 5/3
5YR 4/3
5YR 5/3
5YR 6/3
5YR 4/3

INTERBEDDED NANNOFOSSIL LIMESTONE AND MARLY LIMESTONE

Reducing spots are represented by circles. Groundmass in Section 5 is 5YR 6/3.

SMEAR SLIDE SUMMARY:

	3-90	5-8
	D	D
Texture:		
Sand	30	20
Silt	20	15
Clay	50	65
Composition:		
Quartz	10	10
Feldspar	4	5
Mica	2	3
Carbonate unspecified	25	24
Foraminifers	10	10
Nannofossils	30	30
Volcanic glass	8	–
Miscellaneous	10	10
Opaques	–	8

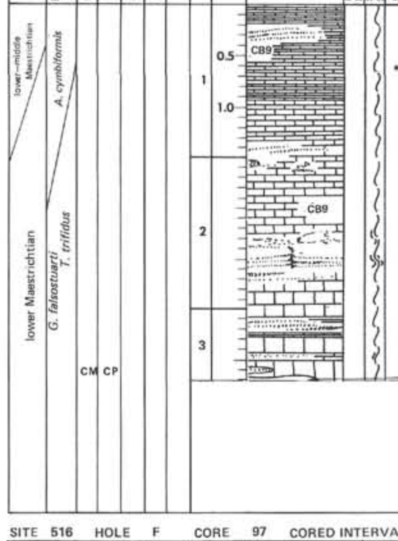
PHYSICAL PROPERTIES:

	1-63	3-12	4-6	5-17
V_v	2.48	2.47	—	2.53
V_h	2.62	2.64	2.60	2.64
Density	2.37	2.36	2.35	2.36
Water content	9.2	2.87	—	9.2

CARBONATE BOMB:
2-70 = 65
4-70 = 72

SITE 516 HOLE F CORE 96 CORED INTERVAL 1023.6–1029.6 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

5YR 3/4
5YR 4/3
5YR 5/3
5YR 6/1
5YR 6/2
5YR 5/2
5YR 6/2
5YR 5/2
5YR 7/1
VOID

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Dark reddish brown and reddish brown. Light–dark variations. Bioturbation prominent at color contrasts. White flecks of foraminifera at Section 2. Section 3: light green (5G 8/1) burrow fill.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	15
Clay	75
Composition:	
Quartz	10
Feldspar	7
Carbonate unspecified	33
Foraminifers	5
Nannofossils	30
Volcanic glass	10
Opaque minerals	5

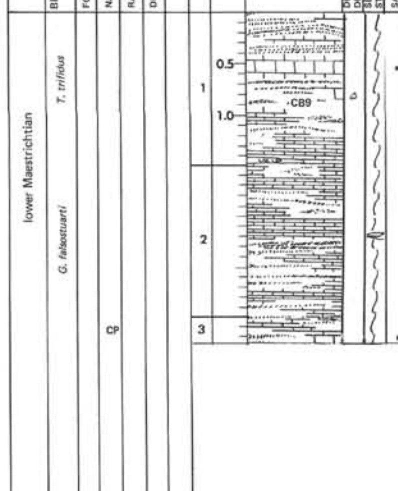
PHYSICAL PROPERTIES:

	1-29	2-35	3-25
V_v	—	2.68	2.67
V_h	2.75	2.80	2.81
Density	2.36	2.34	2.34
Water content	—	9.3	9.6

CARBONATE BOMB:
1-95 = 64
3-65 = 46

SITE 516 HOLE F CORE 97 CORED INTERVAL 1029.6–1032.6 m

TIME – ROCK UNIT | BIOSTRATIGRAPHIC ZONE | FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS) | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

10YR 6/1
5GY 6/1

MARLY NANNOFOSSIL LIMESTONE (MICRITIC)

Burrowed throughout. Light gray (10YR 6/1) with color change gradually downward to greenish gray (5GY 6/1).

SMEAR SLIDE SUMMARY:

	1-60	3-25
	D	D
Texture:		
Sand	TR	TR
Silt	10	25
Clay	90	75
Composition:		
Quartz	1	1
Volcanic glass	1	1
Other clay minerals	45	26
Carbonate unspecified	–	2
Foraminifers	TR	–
Nannfoossils	52	70
Micronodules	–	TR
Heavy minerals	–	TR
Iron-oxides	1	–

PHYSICAL PROPERTIES:

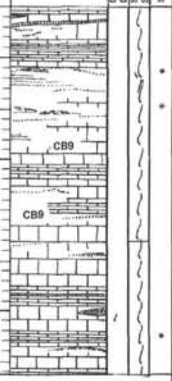
	1-36	1-39	2-77	3-16
V_v	2.55	—	2.60	2.58
V_h	2.68	2.73	2.76	2.77
Density	2.31	2.32	2.31	2.30
Water content	10.4	—	10.8	10.9

CARBONATE BOMB:
1-30 = 59
2-95 = 58

SITE 516 HOLE F CORE 101 CORED INTERVAL 1050.6–1055.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Maestrichtian	*T. trifidus*; *G. falsostuarti*	FM	C/PM			1, 2, 3	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

←*Inoceramus*

5G 4/1

5Y 7/1

INTERBEDDED NANNOFOSSIL LIMESTONE
AND MARLY LIMESTONE (MICRITIC)

Dark green gray. Light green layers grade into darker layers (marly) by gradual transition with considerable mixing by bioturbation.

SMEAR SLIDE SUMMARY:

	1-70	3-30
	D	D
Texture:		
Sand	6	–
Silt	10	–
Clay	84	–
Composition:		
Quartz	6	8
Feldspar	3	3
Volcanic glass	–	8
Carbonate unspecified	20	6
Foraminifers	10	5
Nannofossils	60	70

PHYSICAL PROPERTIES:

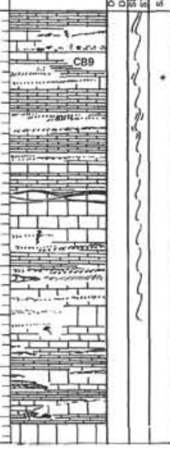
	1-123	2-95
V_v	2.52	—
V_h	2.68	2.71
Density	2.34	2.29
Water content	10.1	—

CARBONATE BOMB:
2-70 = 59

SITE 516 HOLE F CORE 102 CORED INTERVAL 1055.6–1059.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
upper Campanian	*T. trifidus*	FM	FC/M			1, 2, 3	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

5Y 7/1
5G 4/1

5Y 6/1
5Y 7/1

INTERBEDDED MARLY LIMESTONE
AND NANNOFOSSIL LIMESTONE (MICRITIC)

Dark greenish gray (5G 4/1).

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	8
Silt	27
Clay	65
Composition:	
Quartz	3
Mica	1
Volcanic glass	5
Other clay minerals	15
Carbonate unspecified	25
Foraminifers	10
Nannofossils	35
Micronodules	1

PHYSICAL PROPERTIES:

	1-80	2-121	3-92
V_v	2.52	—	2.41
V_h	2.67	2.70	2.66
Density	2.34	2.33	2.33
Water content	10.1	—	10.4

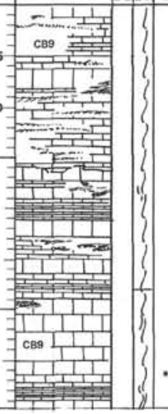
CARBONATE BOMB:
1-50 = 27
2-115 = 62

ORGANIC CARBON:
1, 92–97 = 0.07

SITE 516 HOLE F CORE 103 CORED INTERVAL 1059.6–1068.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Maestrichtian; upper Campanian	*T. trifidus*	FM	FC/PM			1, 2, 3	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

5G 6/1
5YR 6/1

N7

← Green lamination

INTERBEDDED MARLY LIMESTONE
AND NANNOFOSSIL LIMESTONE (MICRITIC)

Greenish gray to pinkish. Suble alternation of colors: convention – 5GY 6/1 = close spacing and N7 = wide spacing.

SMEAR SLIDE SUMMARY:

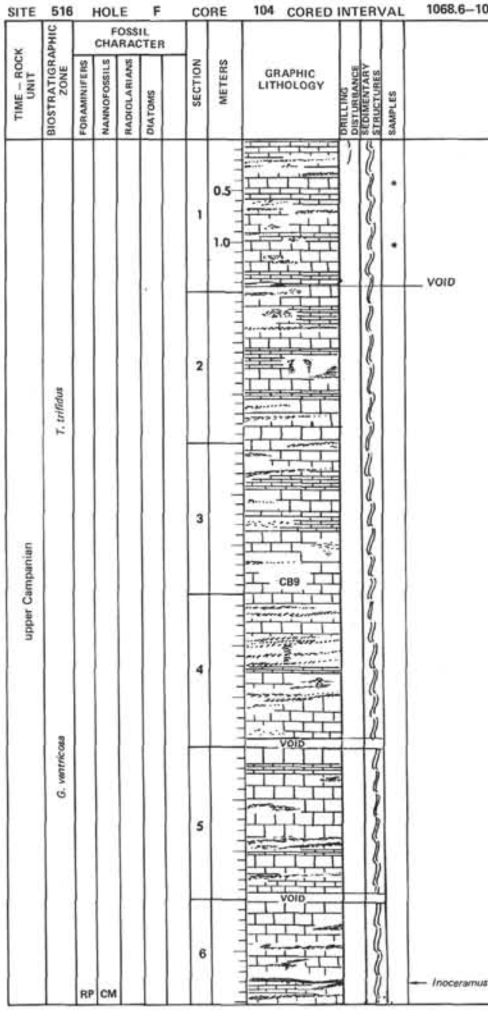
	3-70
	D
Texture:	
Sand	2
Silt	18
Clay	80
Composition:	
Quartz } Feldspar }	1
Volcanic glass	TR
Other clay minerals	15
Carbonate unspecified	3
Foraminifers	1
Nannofossils	80

PHYSICAL PROPERTIES:

	1-40	2-18	3-30
V_v	2.49	2.49	—
V_h	2.68	2.75	2.77
Density	2.32	2.34	2.30
Water content	10.9	10.1	—

CARBONATE BOMB:
1-60 = 47
3-55 = 73

SITE 516 HOLE F CORE 104 CORED INTERVAL 1068.6–1077.6 m



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Color variation from layers of greenish gray (5G 5/1) to layers of brownish gray (5YR 5/1). The change in color is gradation. Highly bioturbated throughout. Besides burrows, no sedimentary structures are visible. Section 1: close spacing = 5G 5/1 and wide spacing = 5YR 5/1. Section 2, 80–100 cm is 5GY 6/1 and 110–120 cm is 5GY 6/1, otherwise color convention as for Section 1. Section 3: close spacing = greenish gray (5GY 6/1) and wide spacing = light brownish gray (5YR 6/1). Sections 4 and 5: dominant color pale red (10R 5/2) with few areas of greenish gray. Bioturbated throughout. Section 6 dominant color brownish gray (5YR 6/1), few zones of greenish gray. Burrowed throughout. Section 6, 75–77 cm 6 separate *Inoceramus* fragments – largest is full core diameter (6 cm), and 8 mm thick.

SMEAR SLIDE SUMMARY:

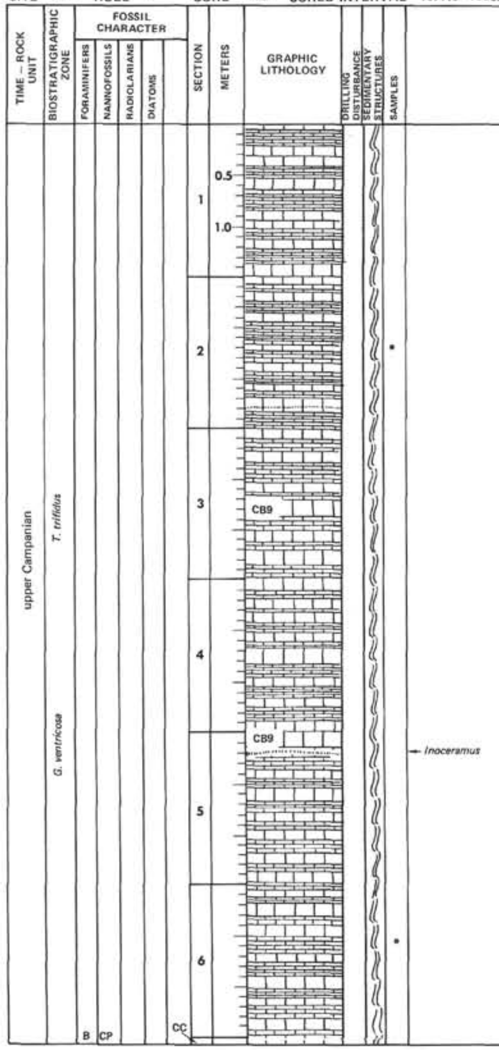
	1-45	1-100
	D	D
Texture:		
Sand	2	1
Silt	23	19
Clay	75	80
Composition:		
Quartz } Feldspar	2	2
Volcanic glass	1	TR
Other clay minerals	31	52
Carbonate unspecified	5	5
Foraminifers	1	1
Nannofossils	60	40
Micronodules	TR	TR

PHYSICAL PROPERTIES:

	1-40	3-31	5-85
V_v	2.42	—	2.57
V_h	2.65	2.86	2.79
Density	2.34	2.34	2.36
Water content	10.1	—	9.6

CARBONATE BOMB:
2-70 = 29
4-70 = 49
6-70 = 61

SITE 516 HOLE F CORE 105 CORED INTERVAL 1077.6–1086.6 m



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Section 1: marly limestone of pale red (1.5YR 5/2) with with zones of dark greenish gray. Color grades to reddish brown (2.5YR 5/4). Intense burrowing throughout. Section 2: marly limestone, dominant color reddish brown (2.5YR 5/4). Burrowed throughout. *Inoceramus* fragment at 124–130 cm (full core diameter). Intensely burrowed throughout. Section 3: dominant color weak red (2.5YR 4/2), marly limestone. Section 4: dominant color weak red (2.5YR 4/2) of marly limestone with bands of clay-rich layers.

SMEAR SLIDE SUMMARY:

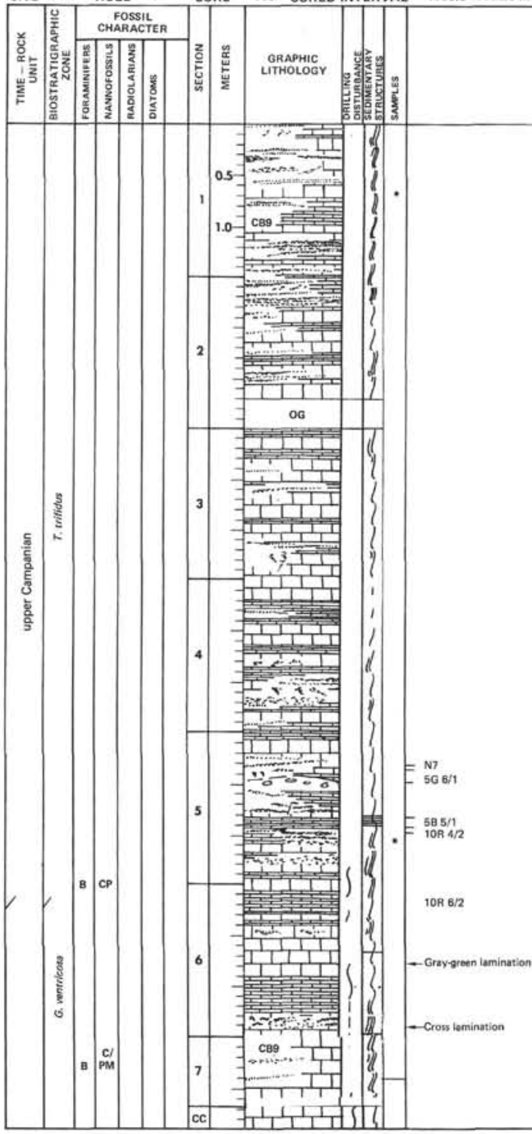
	2-70	6-55
	D	D
Texture:		
Sand	2	7
Silt	38	40
Clay	60	53
Composition:		
Quartz	3	10
Pyrite	–	1
Volcanic glass	TR	TR
Other clay minerals	45	51
Carbonate unspecified	40	10
Foraminifers	10	25
Sponge spicules	–	TR
Heavy minerals	1	2
Micronodules	1	TR

PHYSICAL PROPERTIES:

	1-107	3-128	4-104	5-0	6-3
V_v	2.66	2.54	2.39	—	2.64
V_h	2.87	2.83	2.71	2.82	2.90
Density	2.32	2.37	2.34	2.30	2.33
Water content	10.5	9.2	10.2	—	9.9

CARBONATE BOMB:
2-70 = 53
4-70 = 45
6-70 = 21

SITE 516 HOLE F CORE 106 CORED INTERVAL 1086.6–1095.6 m



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Closely spaced lines indicate marly and darker red intervals or reddish brown (2.5YR 4/4) to dark reddish brown (5YR 3/4). Widely spaced lines indicate more calcareous and lighter colored intervals or reddish brown (2.5YR 5/3) to light reddish brown (5YR 6/4).

SMEAR SLIDE SUMMARY:

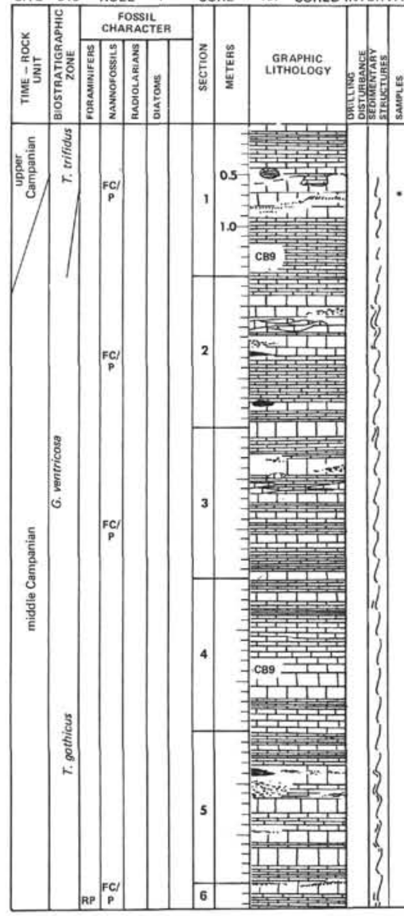
	1-70 D	5-108 D
Texture:		
Sand	7	10
Silt	33	30
Clay	60	60
Composition:		
Quartz	2	1
Volcanic glass	5	1
Zeolites	–	10
Other clay minerals	15	10
Carbonate unspecified	50	30
Foraminifers	2	15
Nannofossils	25	33
Opaques	1	–

PHYSICAL PROPERTIES:

	1-26	2-28	3-26	4-31	5-56	7-33
V_v	2.56	2.56	—	2.43	2.55	2.34
V_h	2.89	2.88	2.77	2.68	2.93	2.37
Density	2.38	2.37	2.24	2.29	2.39	2.26
Water content	9.0	9.1	—	11.3	8.4	12.0

CARBONATE BOMB:
1-70 = 67
4-70 = 49
6-70 = 65

SITE 516 HOLE F CORE 107 CORED INTERVAL 1095.6–1104.6 m



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Alternating light and dark intervals – assumption is that lithology follows color. Dark = dark reddish brown (5YR 4/4) clay-rich. Light = light reddish brown (5YR 6/4–5YR 5/4).

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	1
Silt	39
Clay	60
Composition:	
Quartz	TR
Feldspar	TR
Volcanic glass	5
Zeolites	10
Other clay minerals	15
Carbonate unspecified	33
Foraminifers	2
Nannofossils	33
Opaque minerals	2

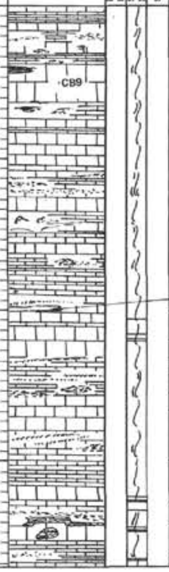
PHYSICAL PROPERTIES:

	1-139	3-17	4-125	6-7
V_v	2.59	2.50	—	2.52
V_h	2.85	2.78	2.71	2.73
Density	2.35	2.34	2.31	2.34
Water content	9.4	9.9	—	9.6

CARBONATE BOMB:
2-70 = 51
4-70 = 62

SITE 516 HOLE F CORE 108 CORED INTERVAL 1104.6–1109.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
middle Campanian	T. gothicus		C/ PM			1	0.5, 1.0
			CP			2	
lower Campanian	G. ventricosa / T. aculeus		C/ PM			3	
		RP	CA/ P			4	



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE
AND NANNOFOSSIL LIMESTONE (MICRITE)

Dark = olive brown (2.5Y 4/4) and light = light olive brown (2.5Y 5/3). Reduction spots, color - N7 around burrows. Section 3: transition to greenish gray and outstanding color contrasts between burrowing and groundmass. Section 4: light = 5YR 8/1 and dark = 5YR 6/1. Faint, black laminations.

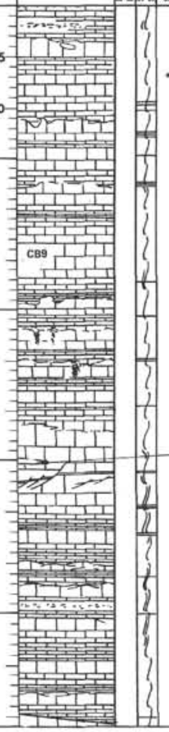
PHYSICAL PROPERTIES:

	1-138	3-114	4-79
V_v	2.48	–	2.52
V_h	2.63	2.81	2.76
Density	2.26	2.31	2.29
Water content	12.0	—	10.6

CARBONATE BOMB:
2-70 = 56
4-70 = 82

SITE 516 HOLE F CORE 109 CORED INTERVAL 1109.1–1118.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
Campanian	T. aculeus					1	0.5, 1.0
						2	
						3	
	G. ventricosa					4	
		FP	CP			5	



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE
AND NANNOFOSSIL LIMESTONE (MICRITIC)

Section 1: faint black laminations. Rythmic color gradations. White–rose gray (5YR 6/2).

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	40
Clay	50
Composition:	
Quartz	4
Volcanic glass	4
Other clay minerals	15
Carbonate unspecified	32
Foraminifers	15
Nannofossils	30

PHYSICAL PROPERTIES:

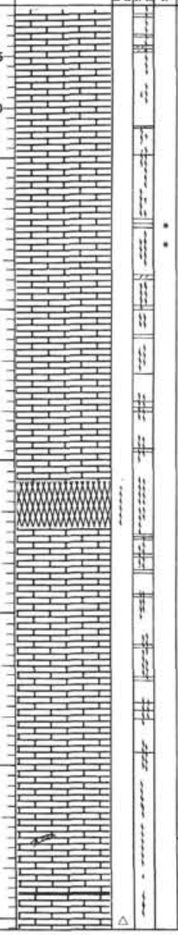
	1-137	2-141	3-107	4-122	5-40
V_v	2.51	2.57	—	—	2.62
V_h	2.74	2.76	2.90	2.57	2.89
Density	2.32	2.28	2.35	—	2.30
Water content	10.1	11.4	—	—	10.7

CARBONATE BOMB:
1-70 = 58
3-70 = 63
5-70 = 56

SITE 516 HOLE F CORE 110 CORED INTERVAL 1118.1–1127.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
early Campanian	*G. ventricosa*					1	0.5, 1.0
	B. parca		FC/P			2	
						3	
			C/PM			4	
						5	
						6	
			AM			CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

INTERBEDDED MARLY LIMESTONE AND NANNOFOSSIL LIMESTONE (MICRITIC)

Sections 1 and 2: dominant color greenish (5G 6/1). Bioturbation intense throughout. Few parallel and cross-laminations of green color. There are intervals of lighter color greenish gray (5GY 6/1) at 60–80 and 130–150 cm of Section 1. Laminations are green. Sections 3 and 4: same lithology as the above sections. There are variations in colors between 5GY 6/1 and 5G 6/1. Shades of light brownish gray (5YR 6/1) occur at the contacts between the green tones. All changes in color are gradational. As in the previous sections bioturbation is intense throughout. There are parallel and cross laminations of green color. Sections 5, 6, and Core-Catcher: dominant color between greenish gray (5GY 6/1) and light brownish gray (5YR 6/1). Intense burrowing throughout. Parallel and cross laminations.

SMEAR SLIDE SUMMARY:

	2-70 D	2-85 D
Texture:		
Sand	1	TR
Silt	29	15
Clay	70	85
Composition:		
Quartz }	1	TR
Feldspar }		–
Other clay minerals	57	35
Carbonate unspecified	5	5
Foraminifers	2	TR
Nannofossils	35	60
Micronodules	TR	TR

PHYSICAL PROPERTIES:

	1-89	2-103	4-12	5-52	6-127
V_v	2.59	2.65	2.42	—	2.63
V_h	2.79	2.88	2.63	2.81	2.80
Density	2.30	2.34	2.36	—	2.36
Water content	10.6	9.4	9.6	—	9.2

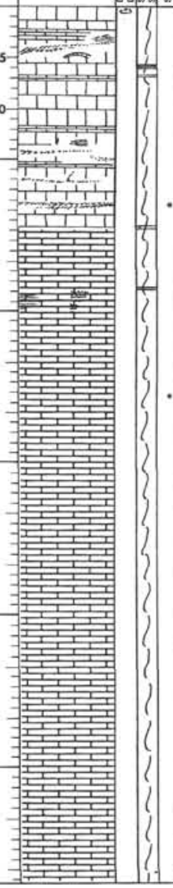
CARBONATE BOMB:
1-95 = 67
3-95 = 72
5-95 = 56

NOTE: Core 111, 1127.1–1136.1 m: No recovery.

SITE 516 HOLE F CORE 112 CORED INTERVAL 1136.1–1145.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Campanian	*G. ventricosa*					1	0.5, 1.0
						2	
	B. parca					3	
						4	
	G. arca					5	
		B	RP			6	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MARLY LIMESTONE (MICRITIC)

Alternating bands and burrows. Calcareous clay is dark greenish gray (5GY 4/1); limestone is greenish gray (5GY 6/1). Laminations are green.

SMEAR SLIDE SUMMARY:

	2-41 D	3-88 D
Texture:		
Sand	8	1
Silt	27	50
Clay	65	49
Composition:		
Quartz }	5	2
Feldspar }		
Mica	TR	–
Volcanic glass	5	TR
Other clay minerals	65	30
Carbonate unspecified	10	65
Foraminifers	5	1
Nannofossils	10	2

PHYSICAL PROPERTIES:

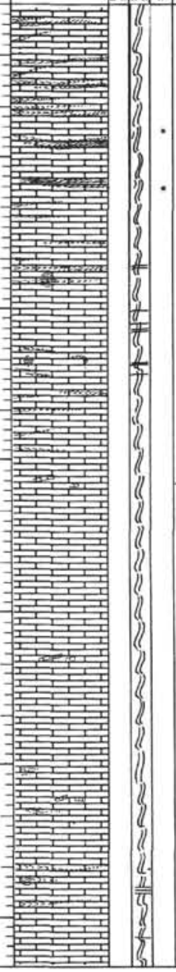
	1-56	2-10	4-16	5-6	6-12
V_v	3.30	3.28	3.14	3.17	—
V_h	3.22	3.34	3.25	3.31	3.51
Density	2.44	2.43	2.41	2.43	2.40
Water content	7.4	7.2	7.9	7.4	—

CARBONATE BOMB:
2-70 = 56
4-70 = 75
6-70 = 61

SITE 516 HOLE F CORE 113 CORED INTERVAL 1145.1–1154.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
early Campanian	*B. parca*		RP			1	0.5, 1.0
						2	
						3	
			RP			4	
	G. arca		RP			5	
	E. eximius		RP			6	
		B	R/PM				
						7	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



← *Inoceramus* fragment (Section 4)

← *Inoceramus* fragment (Section 5)

← *Inoceramus* fragment (Section 6)

LITHOLOGIC DESCRIPTION

MARLY LIMESTONE

Dominant color light gray (N7), with areas of dark greenish gray (5GY 4/1) in areas of intense burrowing. Intense burrowing throughout the section. Few thin green laminations. Burrows are brownish gray (5YR 4/1). Same as previous core. The higher layers are of micritic limestone. Section 4: No more laminations.

SMEAR SLIDE SUMMARY:

	1-125	2-33
	D	D
Texture:		
Sand	TR	2
Silt	70	20
Clay	30	78
Composition:		
Quartz, Feldspar	–	5
Pyrite	–	TR
Volcanic glass	–	2
Other clay minerals	20	78
Carbonate unspecified	80	7
Foraminifers	TR	3
Nannofossils	TR	5

PHYSICAL PROPERTIES:

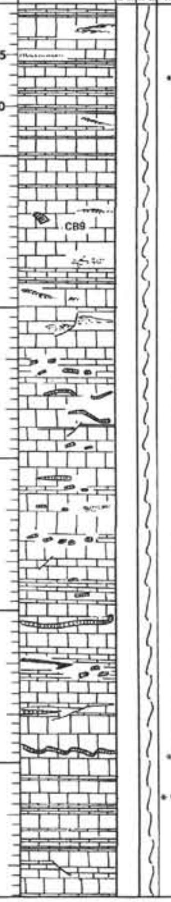
	2-3	4-30	5-78	7-4
V_v	3.10	2.97	—	2.92
V_h	3.26	3.14	3.15	3.07
Density	2.42	2.37	2.32	2.34
Water content	7.5	9.0	10.2	9.9

CARBONATE BOMB:
2-70 = 53
4-70 = 71
6-70 = 61

SITE 516 HOLE F CORE 114 CORED INTERVAL 1154.1–1163.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
lower Campanian	*G. arca*					1	0.5, 1.0
						2	
						3	
						4	
upper Santonian						5	
						6	
		RP	RP				

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



← *Inoceramus* fragment

← Pyrite dendrites

← Offset burrows

← Small offset

← *Inoceramus*

← Pyrite dendrites

← *Inoceramus* valve

← *Inoceramus*

LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE (MICRITIC)

Gray, bioturbated. Colors: range from N8 to N4 wide spacing represents lighter shading for major color alternations. Note: bioturbation has worked light and dark colors throughout core in spots and mottles too small to itemize. Section 3, 70–110 cm: *Inoceramus* well preserved between biscuits at 85 cm.

SMEAR SLIDE SUMMARY:

	1-70	6-34
	D	D
Texture:		
Sand	10	25
Silt	20	35
Clay	70	40
Composition:		
Quartz, Feldspar	1	10
Volcanic glass	–	20
Other clay minerals	20	5
Carbonate unspecified	58	37
Foraminifers	9	5
Nannofossils	10	2
Palagonite	–	20
Opaque minerals	–	1

PHYSICAL PROPERTIES:

	1-26	2-143	4-13	6-26
V_v	—	2.79	3.20	3.07
V_h	3.41	3.09	3.45	3.23
Density	2.35	2,33	3.40	2.42
Water content	—	10.1	7.75	7.1

CARBONATE BOMB:
6-10 = 81
6-30 = 28

ORGANIC CARBON:
6, 1–8 = 0.09
6, 32–38 = 0.17

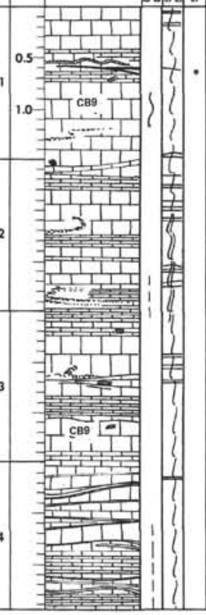
SITE 516 HOLE F CORE 115 CORED INTERVAL 1163.1–1172.1 m

TIME – ROCK UNIT: upper Santonian

BIOSTRATIGRAPHIC ZONE: *E. eximus*

FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS RP

SECTION: 1, 2, 3, 4



LITHOLOGIC DESCRIPTION

MICRITIC LIMESTONE

Gray, bioturbated. Color: range from N4 to N8. Wide spacing = light colors. Section 1: inclined laminations (flattened burrows). Section 3: *Inoceramus* fragments: generally concentrated in darker intervals. Section 3, 80–100 cm: loaded with *Inoceramus* prisms. Irregular laminations = deformed burrow traces if burrows, then noticibly more compressed than higher in section.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	7
Silt	20
Clay	73
Composition:	
Quartz	2
Pyrite	1
Volcanic glass	5
Other clay minerals	12
Carbonate unspecified	73
Foraminifers	5
Nannofossils	2

PHYSICAL PROPERTIES:

	1-113	2-39	3-72	4-88
V_v	3.06	—	—	3.06
V_h	3.36	3.41	3.35	3.24
Density	2.41	2.36	2.40	2.38
Water content	7.31	—	7.6	8.5

CARBONATE BOMB:
1-60 = 83
1-70 = 25

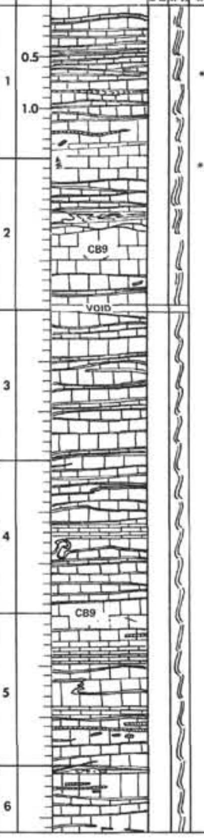
SITE 516 HOLE F CORE 116 CORED INTERVAL 1172.1–1181.1 m

TIME – ROCK UNIT: upper Santonian; Coniacian–middle Santonian

BIOSTRATIGRAPHIC ZONE: *E. eximius*; *M. furcatus*

FOSSIL CHARACTER: FORAMINIFERS RP; NANNOFOSSILS RP, RP, RP

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



Flattened burrows

Inoceramus

Convolute bedding

Foram-rich

White specks? = foraminifera

Inoceramus

Inoceramus

Inoceramus

LITHOLOGIC DESCRIPTION

MICRITIC LIMESTONE

Gray, bioturbated. Recrystallized, color range from N4 to N8. Wide spacing represents lighter shades of gray. Burrows dark; internal structure obliterated. Section 4, 50–60, 72–100, 135–150 cm faint rose tint in white.

SMEAR SLIDE SUMMARY:

	1-70
	D
Texture:	
Sand	10
Silt	20
Clay	70
Composition:	
Quartz	2
Volcanic glass	5
Other clay minerals	10
Carbonate unspecified	66
Foraminifers	8
Nannofossils	2
Palagonite	5
Opaque minerals	2

PHYSICAL PROPERTIES:

	1-32	2-110	4-21	6-59
V_v	3.24	—	3.63	3.66
V_h	3.55	3.31	3.81	3.76
Density	2.41	2.35	2.45	2.51
Water content	7.5	—	6.4	5.0

CARBONATE BOMB:
1-110 = 65
3-110 = 79
5-20 = 66

ORGANIC CARBON:
2, 5–16 = 0.09

SITE 516 HOLE F CORE 117 CORED INTERVAL 1181.1–1190.1 m

TIME – ROCK UNIT: Coniacian–middle Santonian

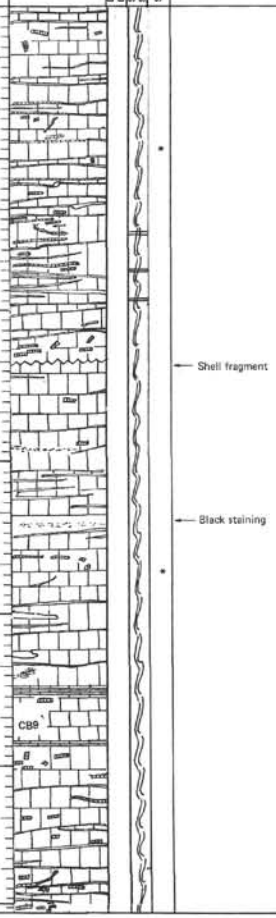
BIOSTRATIGRAPHIC ZONE: "G. concavata" / M. furcatus

FOSSIL CHARACTER — FORAMINIFERS: RP; NANNOFOSSILS: RP; RADIOLARIANS; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MICRITIC LIMESTONE

Colors varying from light gray (5Y 7/1) to gray (5Y 5/1). The darker areas are more intensely bioturbated. There are pinkish shaded zones throughout the core, pinkish gray (5YR 7/1). All color changes are gradual. There are several large *Inoceramus* fragments throughout the core. The darker layers are richer in terigenous material. *Inoceramus* scattered throughout core. Pink tints at Section 1, 52–66, 72–80, and 115–125 cm; Section 2, 60–74, 104–107, and 120–122 cm; and Section 3, 45–62 and 86–94 cm. Section 2 having few green laminations.

SMEAR SLIDE SUMMARY:

	1-147	4-110
	D	D
Texture:		
Sand	2	2
Silt	18	68
Clay	80	30
Composition:		
Quartz } Feldspar	3	–
Volcanic glass	1	–
Other clay minerals	77	25
Carbonate unspecified	12	73
Foraminifers	5	TR
Nannofossils	2	2
Diatoms	TR	–
Heavy minerals	TR	–
Inoceramus fragments	TR	–
Iron-oxides	TR	–

PHYSICAL PROPERTIES:

	1-40	3-9	4-115	6-24
V_v	3.28	3.51	—	3.57
V_h	3.57	3.70	3.67	3.69
Density	2.48	2.49	2.46	2.49
Water content	5.5	5.3	6.5	5.1

CARBONATE BOMB:
1-130 = 54
3-120 = 77
5-80 = 61

SITE 516 HOLE F CORE 118 CORED INTERVAL 1190.1–1194.6 m

TIME – ROCK UNIT: Coniacian–middle Santonian

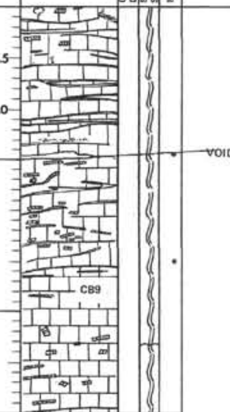
BIOSTRATIGRAPHIC ZONE: "G. concavata" / M. furcatus

FOSSIL CHARACTER — FORAMINIFERS: RP, B; NANNOFOSSILS; RADIOLARIANS; DIATOMS

SECTION: 1, 2, 3

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MICRITIC LIMESTONE

Zones of siliceous-cemented calcareous mudstone (zones heavily bioturbated). Dominant color varying between gray (5Y 6/1 and 5Y 5/1), with pinkish shades throughout (light brownish gray [5YR 7/1]). Intense bioturbation throughout burrows mostly olive gray (5Y 4/1). Several *Inoceramus* fragments throughout the core.

SMEAR SLIDE SUMMARY:

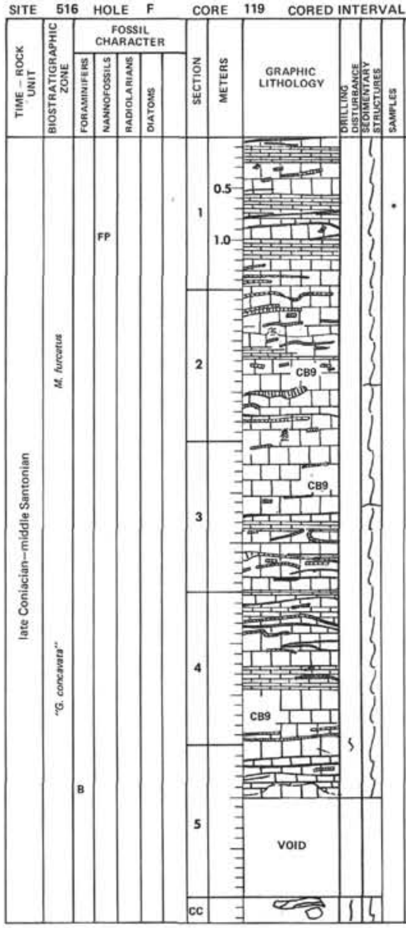
	1-144	2-100
	D	D
Texture:		
Sand	3	2
Silt	12	50
Clay	85	48
Composition:		
Quartz } Feldspar	1	TR
Pyrite	TR	–
Volcanic glass	–	TR
Other clay minerals	83	40
Carbonate unspecified	14	60
Nannofossils	1	TR
Heavy minerals	TR	–

PHYSICAL PROPERTIES:

	1-141	2-75	3-97
V_v	3.43	—	3.45
V_h	3.71	3.60	3.87
Density	2.51	2.51	2.49
Water content	5.0	—	5.4

CARBONATE BOMB:
1-30 = 80
1-145 = 61

SITE 516 HOLE F CORE 119 CORED INTERVAL 1194.6–1203.6 m



LITHOLOGIC DESCRIPTION

MICRITIC LIMESTONE

N8 to N4 with shades of pink (5YR 8/1) in lighter color intervals. Closer spacing of pattern indicates darker tones. *Inoceramus* scattered throughout.

SMEAR SLIDE SUMMARY:

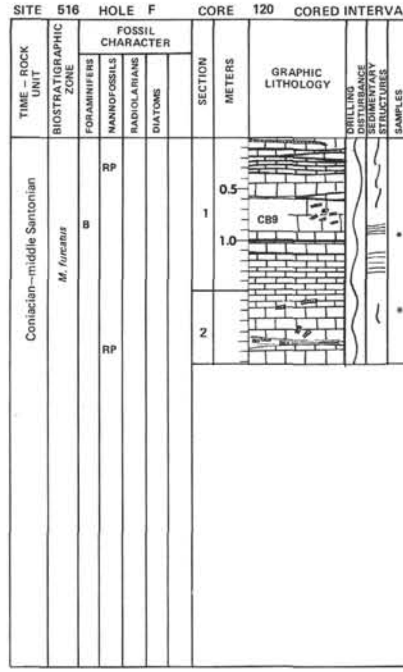
	1-70
	D
Texture:	
Sand	10
Silt	20
Clay	70
Composition:	
Pyrite	2
Other clay minerals	5
Carbonate unspecified	75
Foraminifers	15
Nannofossils	3

PHYSICAL PROPERTIES:

	1-124	2-127	3-62	4-123
V_v	3.55	3.64	—	3.16
V_h	3.75	3.90	3.50	3.42
Density	2.50	2.48	2.39	2.48
Water content	4.9	5.4	—	6.1

CARBONATE BOMB:
1-95 = 80
1-100 = 59

SITE 516 HOLE F CORE 120 CORED INTERVAL 1203.6–1212.6 m



LITHOLOGIC DESCRIPTION

CALCARENITE

Medium light gray (N6) with medium dark gray (N4) burrows. Variety of grain-size and section texture. Glauconite pellets. Section 1, 98–102, and 109–118 cm foram-ooze now chertified, N8. Wide spacing = lighter tones. Section 1, 120 cm: chertified tests of foraminifera. *Inoceramus* scattered throughout.

SMEAR SLIDE SUMMARY:

	1-92
	D
Texture:	
Sand	30
Silt	20
Clay	50
Composition:	
Quartz	8
Glauconite	25
Other clay minerals	24
Foraminifers	9
Nannofossils	27
Chert	5
Black minerals	2

PHYSICAL PROPERTIES:

	1-49	2-33
V_v	2.68	2.56
V_h	2.99	3.02
Density	2.36	2.27
Water content	9.1	11.1

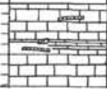
CARBONATE BOMB:
1-115 = 91
1-125 = 33

ORGANIC CARBON:
1, 113–120 = 0.38

SITE 516 HOLE F CORE 121 CORED INTERVAL 1212.6–1221.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
Coniacian–middle Santonian	*M. furcatus*	B	FP			1	0.5

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

CALCARENITE

Inoceramus scattered thorughout core. Gray (N6–N5), darker intervals = closer spacing.

SMEAR SLIDE SUMMARY:

	1-70 D
Texture:	
Sand	15
Silt	15
Clay	70
Composition:	
Quartz	3
Volcanic glass	5
Other clay minerals	10
Carbonate unspecified	60
Foraminifers	10
Nannofossils	2
Palagonite	5
Micronodules	5

PHYSICAL PROPERTIES:

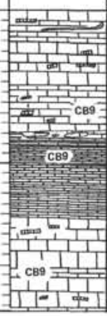
	1-19
V_v	3.17
V_h	3.31
Density	2.39
Water content	7.9

CARBONATE BOMB:
1-35 = 51

SITE 516 HOLE F CORE 122 CORED INTERVAL 1221.6–1230.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
Coniacian–middle Santonian	*M. furcatus*		RF			1, 2	0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

CALCARENITE AND CALCAREOUS BLACK CLAYSTONE

Color: N6–N7. Closer spacing indicates darker shades. Black claystone = dark gray (N3). *Inoceramus* scattered throughout.

SMEAR SLIDE SUMMARY:

	1-140 D
Texture:	
Sand	–
Silt	–
Clay	–
Composition:	
Feldspar	2
Other clay minerals	30
Carbonate unspecified	63
Micronodules	5

PHYSICAL PROPERTIES:

	1-77	1-146	2-89
V_v	—	2.70	3.13
V_h	4.36	2.97	3.55
Density	2.45	2.43	2.36
Water content	—	8.3	8.3

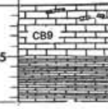
ORGANIC CARBON:
1, 140–143 = 0.31
2, 23–27 = 0.95

CARBONATE BOMB:
1-135 = 49

SITE 516 HOLE F CORE 123 CORED INTERVAL 1230.6–1239.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
						1	0.5

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

← Thin section across contact

LITHOLOGIC DESCRIPTION

LIMESTONE AND CALCAREOUS BLACK CLAYSTONE

Medium light gray (N6) with laminations of light gray (N7). *Inoceramus* at top of core.

PHYSICAL PROPERTIES:

	1-38
V_v	4.28
V_h	4.30
Density	2.45
Water content	8.4

SITE 516 HOLE F CORE 124 CORED INTERVAL 1239.6–1248.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
Coniacian–middle Santonian	*M. furcatus*		B, B, PR, PR			1, 2	0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

CALCARENITE AND BRECCIA

Section 1, 0–10 cm: ferruginous chert. Section 1, 10–30 cm: pale red (10R 6/4), baked calcareous mud with *Inoceramus*. Section 1, 31–75 cm: dusky red (10R 3/2), sandy mudstone. Weakly graded and impregnated with greenish black (5GY 2/1) to dusky blue green (5BG 3/2) glauconitic grains at Section 1, 75–95 cm with volcanic and altered glass. Section 1, 96–133 cm: breccia and claystone with layered sequence of dark blue green (5BG 3/2) and lowermost graded sequence being 5G 6/1 matrix. Section 1, 134–146 cm: veins or altered bands 5RP 4/2 with green (5BG 3/2) veins. Important quantities of volcanic glass location in Section 2 to end of core. Medium light gray (N6) sandstone appears at 70 cm of Section 2.

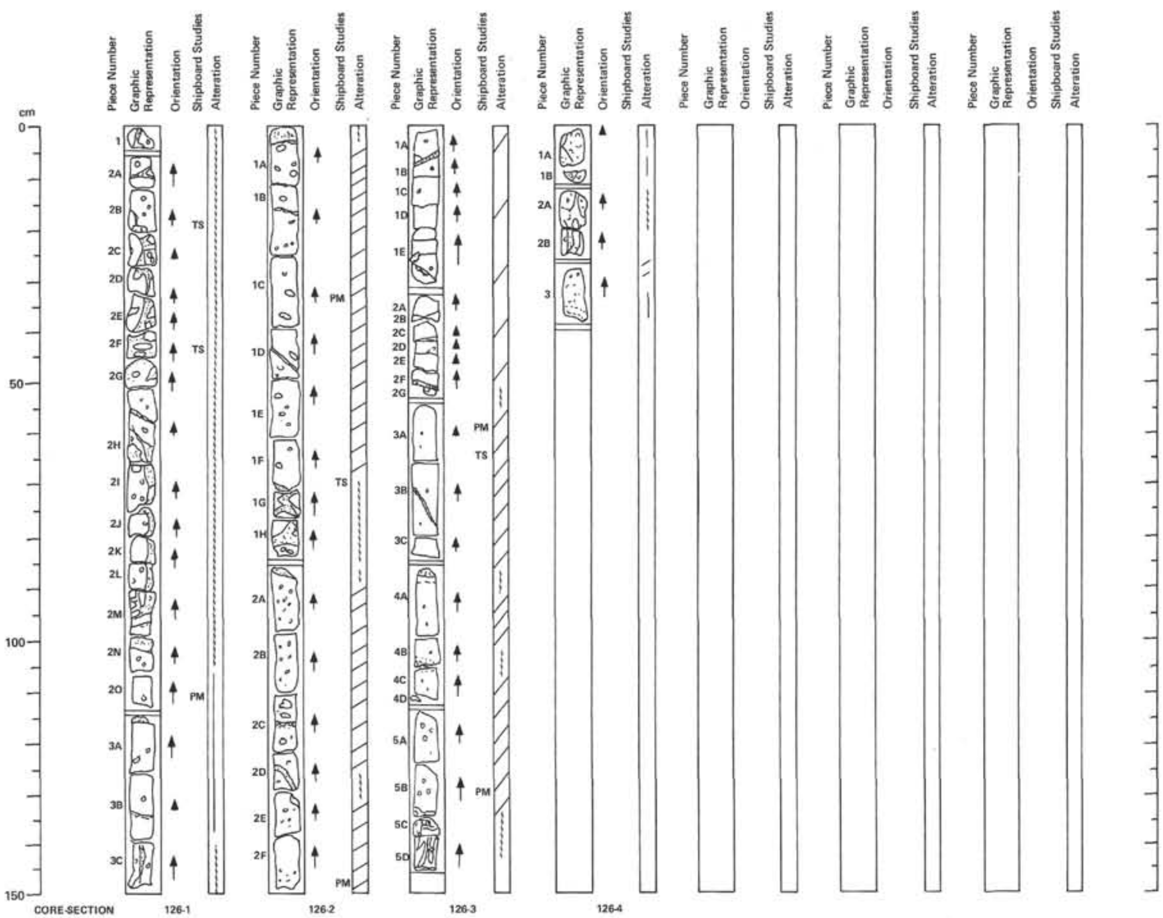
SMEAR SLIDE SUMMARY:

	1-80 D
Texture:	
Sand	40
Silt	30
Clay	30
Composition:	
Volcanic glass	60
Glauconite	20
Palagonite	20

PHYSICAL PROPERTIES:

	1-0
V_v	4.45
V_h	—
Density	—
Water content	—

CARBONATE BOMB:
1-14 = 73
1-30 = 1
1-57 = 0
1-76 = 0
2-24 = 1
2-49 = 68



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Section 1 — Depth: 1252.6–1254.1 m

VEINED PHYRIC BASALT
Vesicules are common brecciated intervals: 40–50, 95–105, and 125–150 cm.
Veins intersected between 0 and 105 cm infilling: quartz, calcite, smectite, and iron oxides.

Thin Sections
126-1, 39–42 cm (vein fill): sparitic and micritic calcite with fragments of altered basalt – microgranular quartz – chlorite – *Inoceramus*, bryozoan, and algal skeletal remains.

126-1, 17–20 cm: altered, phyric basalt.

Section 2 — Depth: 1254.1–1255.6 m

PHYRIC BASALT
Slightly vesicular: 0–70 cm. Vesicular: 85–135 cm. Veined and brecciated: 70–85 cm.

Thin Section
126-2, 67–71 cm: fine-grained variolitic plagioclase laths with fretted margins – calcite replacement of most of groundmass – large number of glomerporphyritic clots with first generation feldspar – olivine replaced by calcite – opaque minerals common in groundmass.

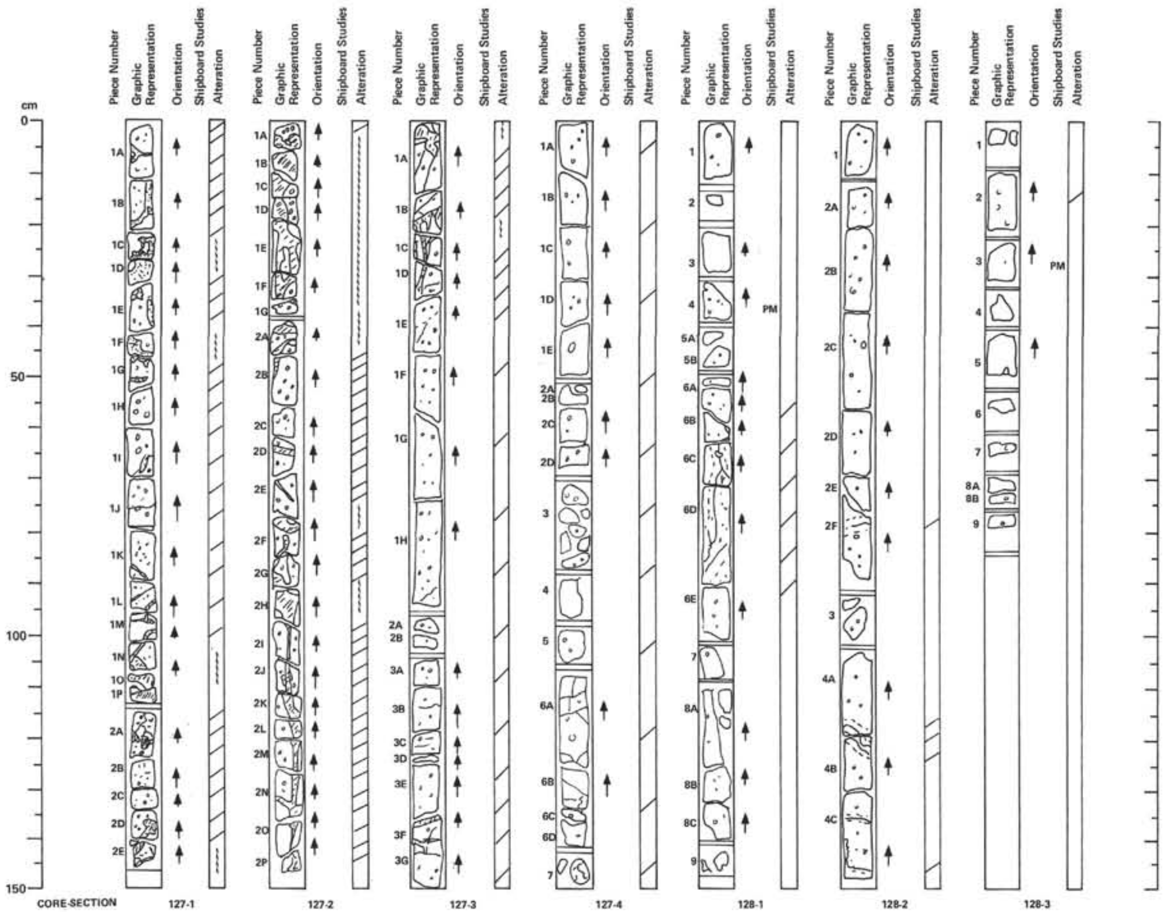
Section 3 — Depth: 1255.6–1257.1 m

PHYRIC BASALT
Barely vesicular: 0–115 cm. Moderately vesicular: 115–135 cm. Brecciated and veined: 135–150 cm.

Thin Section
126-3, 61–66 cm: Fine-grained variolitic plagioclase – calcite replacement of groundmass but fresh pyroxene phenocrysts are present – glomeroporphyritic clots with first generation feldspar.

Section 4 — Depth: 1257.1–1257.6 m

PHYRIC BASALT
Veined: 0–27 cm. Highly vesicular: 27–40 cm.



72-516F-127

Section 1 — Depth: 1257.6–1259.1 m

PHYRIC BASALT
Vesicular: 0–20 cm. Veined and vesicular: 20–115 cm. Vuggy: 115–147 cm.

Section 2 — Depth: 1259.1–1260.6 m

PHYRIC BASALT
Extensive vein filling: 0–40 cm (two generations of infilling at least – calcite fills inner portions and quartz lines margins – iron oxides interspersed in calcitic portion).
Veined: 40–150 cm.

Section 3 — Depth: 1260.6–1262.1 m

PHYRIC BASALT
Notably less altered than overlying rocks. Veined: 0–32 cm.

Section 4 — Depth: 1262.1–1266.6 m

PHYRIC BASALT
Isolated vugs and thin, cross-cutting veins. Flow Unit 1/Unit 2 boundary: 50–60 cm.

72-516F-128

Section 1 — Depth: 1266.6–1268.1 m

PHYRIC BASALT
Isolated vugs, thin veins. Coarse-grained: 52–92 cm.

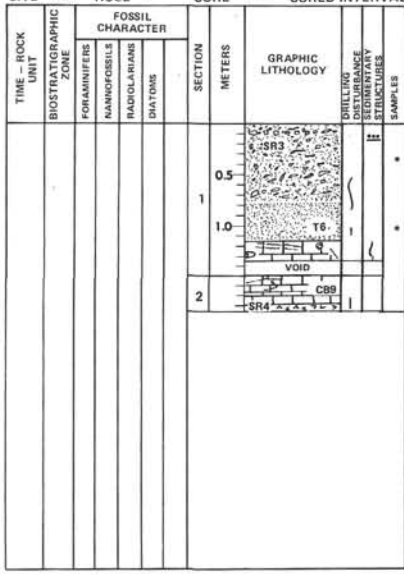
Section 2 — Depth: 1268.1–126.96 m

PHYRIC BASALT
Isolated vugs. Fresh (cut surface has a metallic luster). Isolated vugs throughout. Coarse-grained: 75–150 cm. Sulphide mineralization with pyrite, quartz, and calcite: 118–122 cm.

Section 3 — Depth: 1269.6–1270.6 m

PHYRIC BASALT
One or two isolated vugs. Fresh (cut surface has metallic luster).

SITE 516 HOLE F CORE 125 CORED INTERVAL 1248.6–1252.6 m



LITHOLOGIC DESCRIPTION

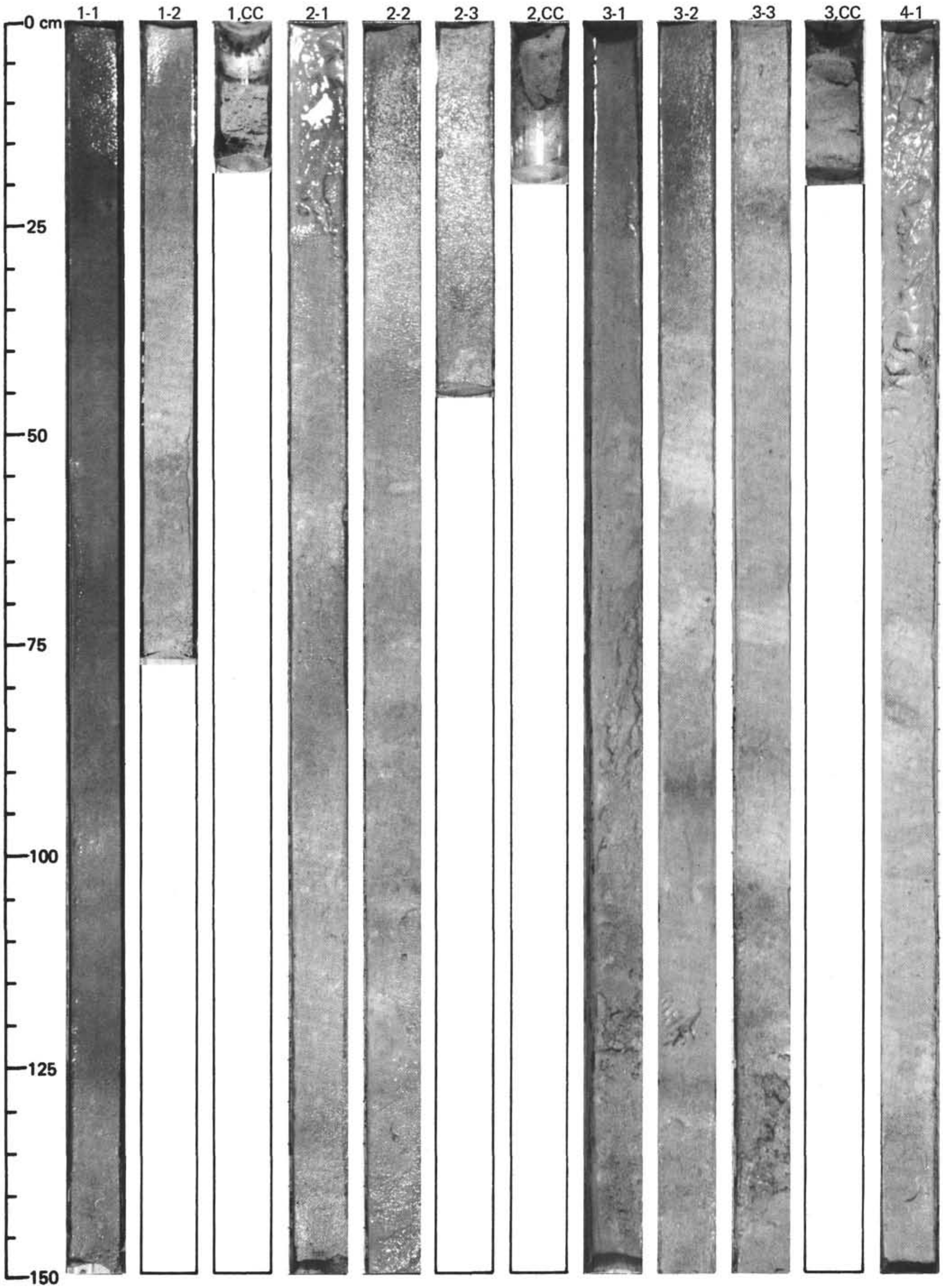
SEDIMENTARY BRECCIA, SANDSTONE, AND CALCARENITE

Section 1, 0–78 cm: micro-sedimentary breccia fragments up to 0.5 cm – shells and rock in a micritic matrix. Color: dusky blue green (5BG 3/2) to moderate blue green (5BG 4/6). Section 1, 78–115 cm: sandstone lithic fragments, calcareous fragments and glauconite (celadonite). Section 2, 30 cm: calcarenite, yellowish gray (5Y 8/1) includes shell fragments and stylolites. Section 2, 30–35 cm: basalt.

SMEAR SLIDE SUMMARY:

	1-35	1-100
	D	D
Texture:		
Sand	30	40
Silt	40	35
Clay	30	25
Composition:		
Feldspar	–	15
Glauconite	70	–
Other clay minerals	–	15
Carbonate unspecified	–	30
Nannofossils	–	TR
Clay and silica cement	30	10
Aggregates	–	30

CARBONATE BOMB:
1-27 = 8
1-63 = 2


1-1
1-2
1,CC
2-1
2-2
2-3
2,CC
3-1
3-2
3-3
3,CC
4-1
0 cm
25
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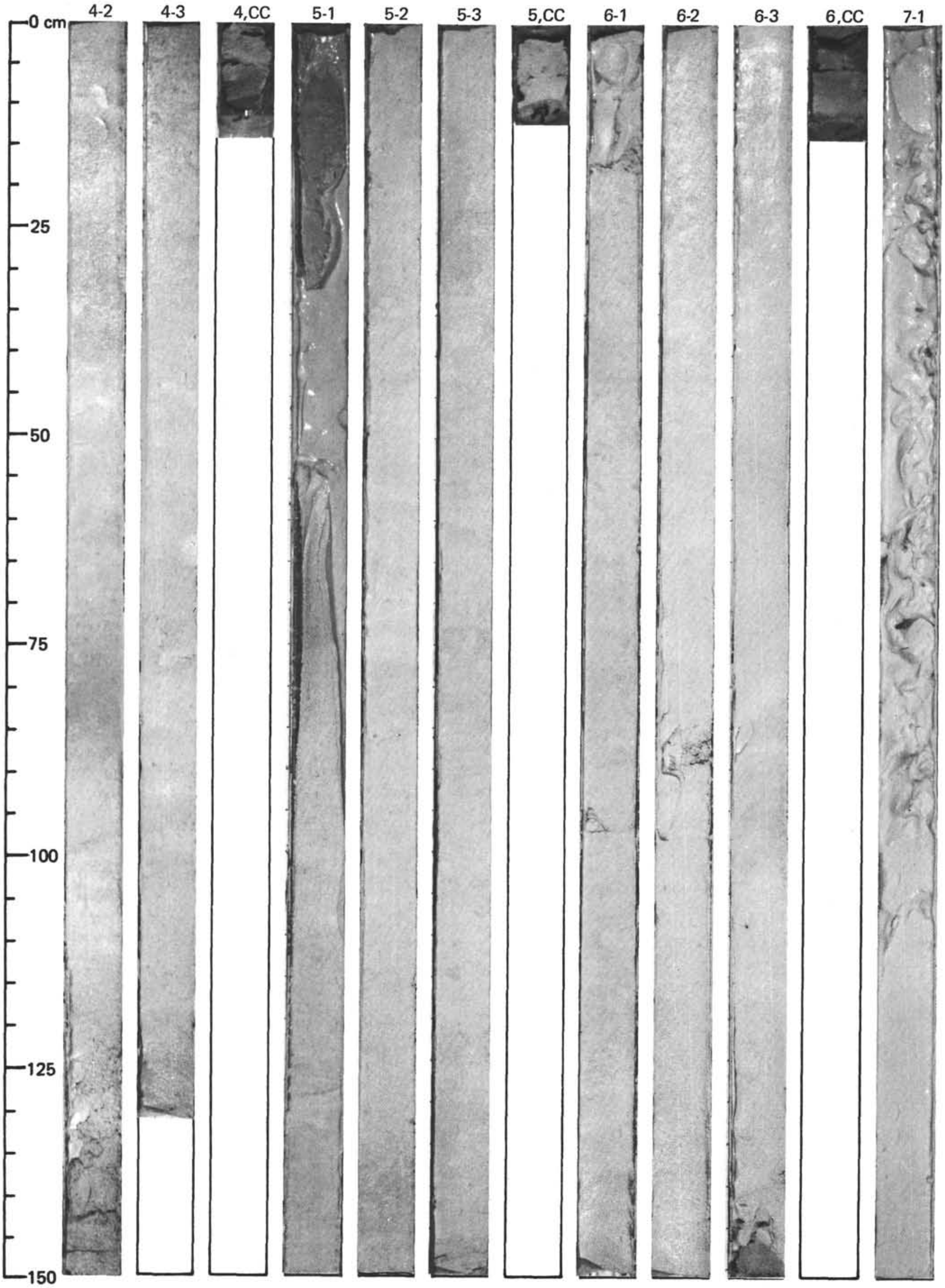
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4-3
4,CC
5-1
5-2
5-3
5,CC
6-1
6-2
6-3
6,CC
7-1
0 cm
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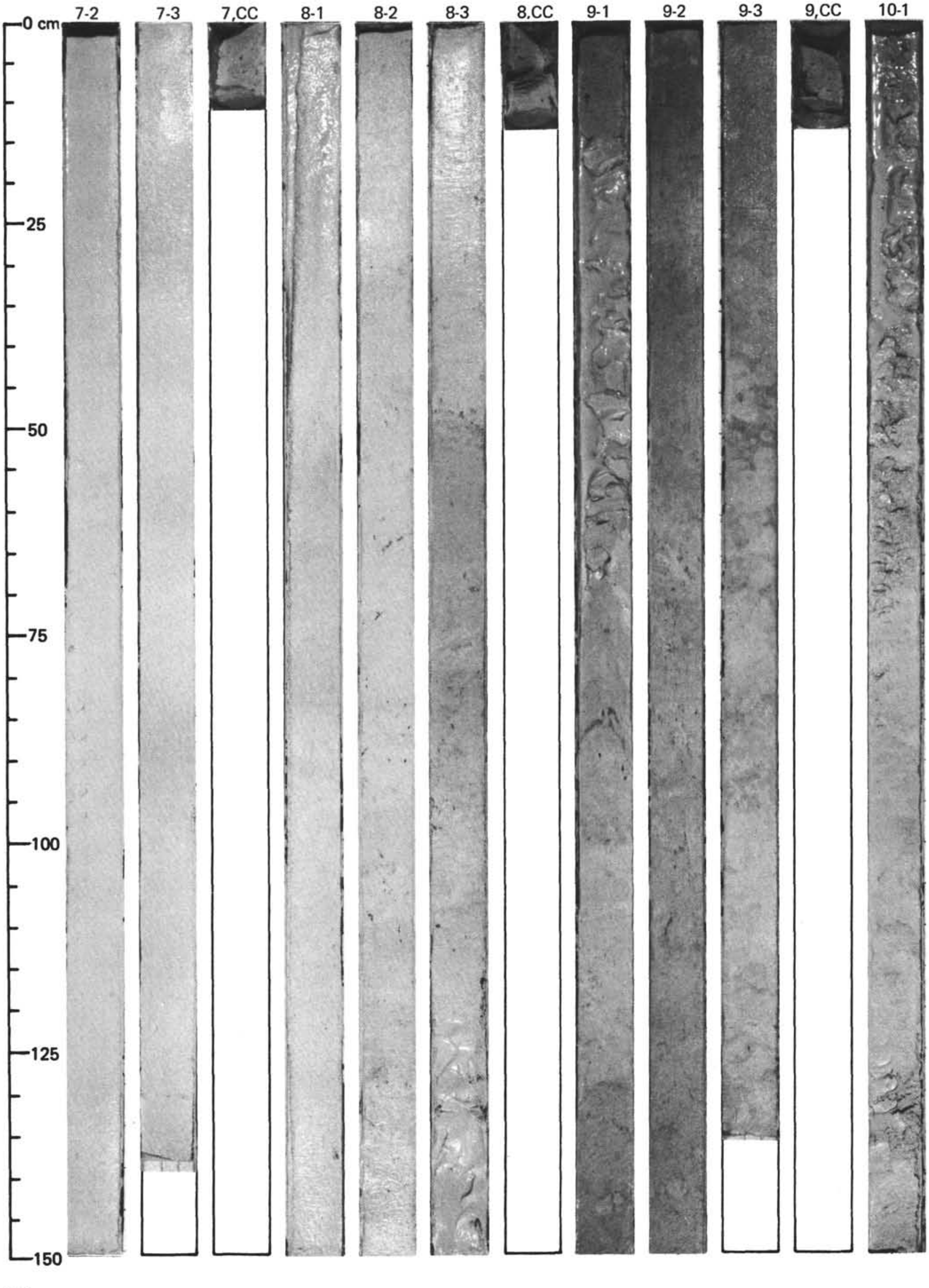
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7-3
7,CC
8-1
8-2
8-3
8,CC
9-1
9-2
9-3
9,CC
10-1
0 cm
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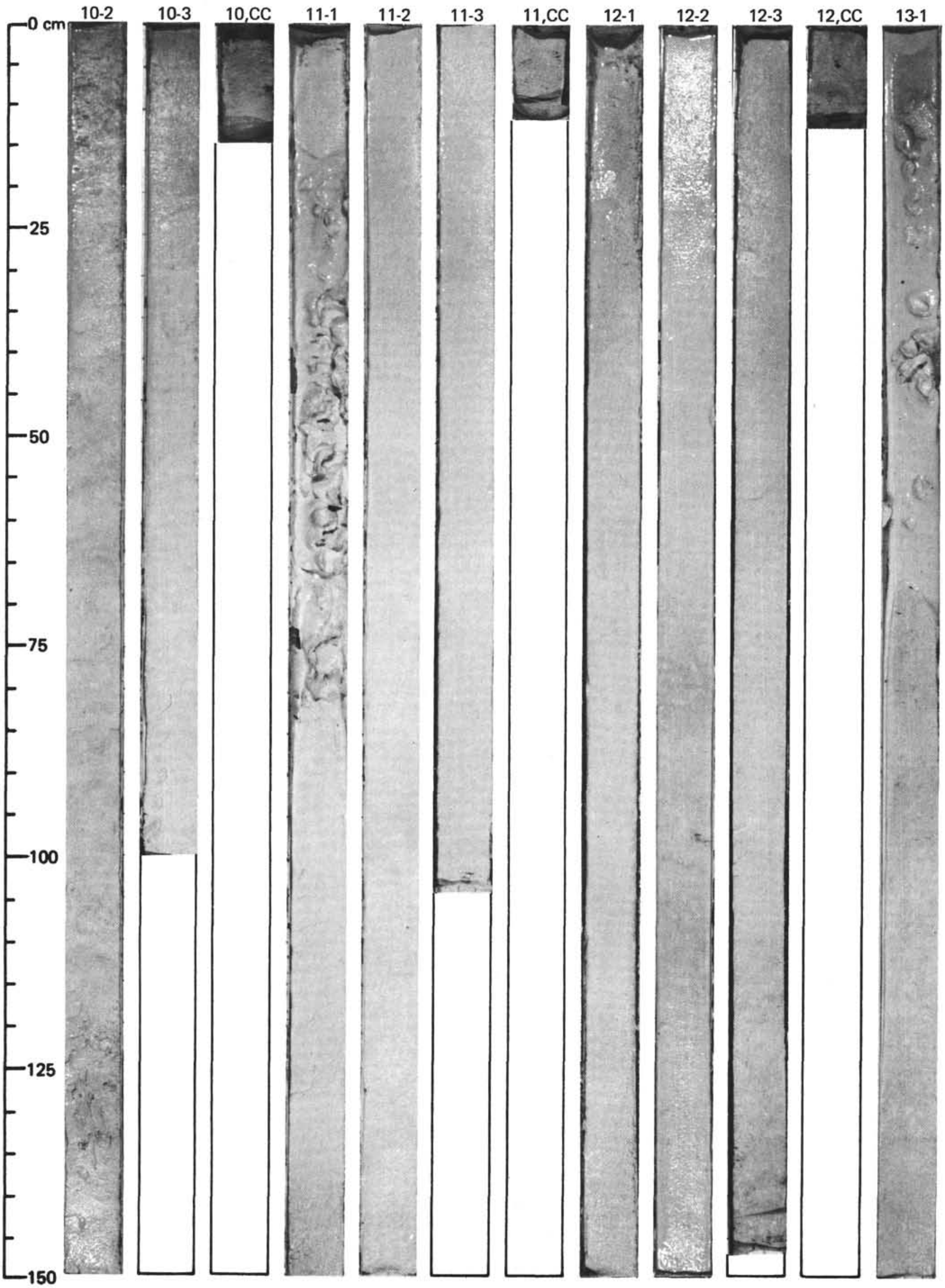
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11-1
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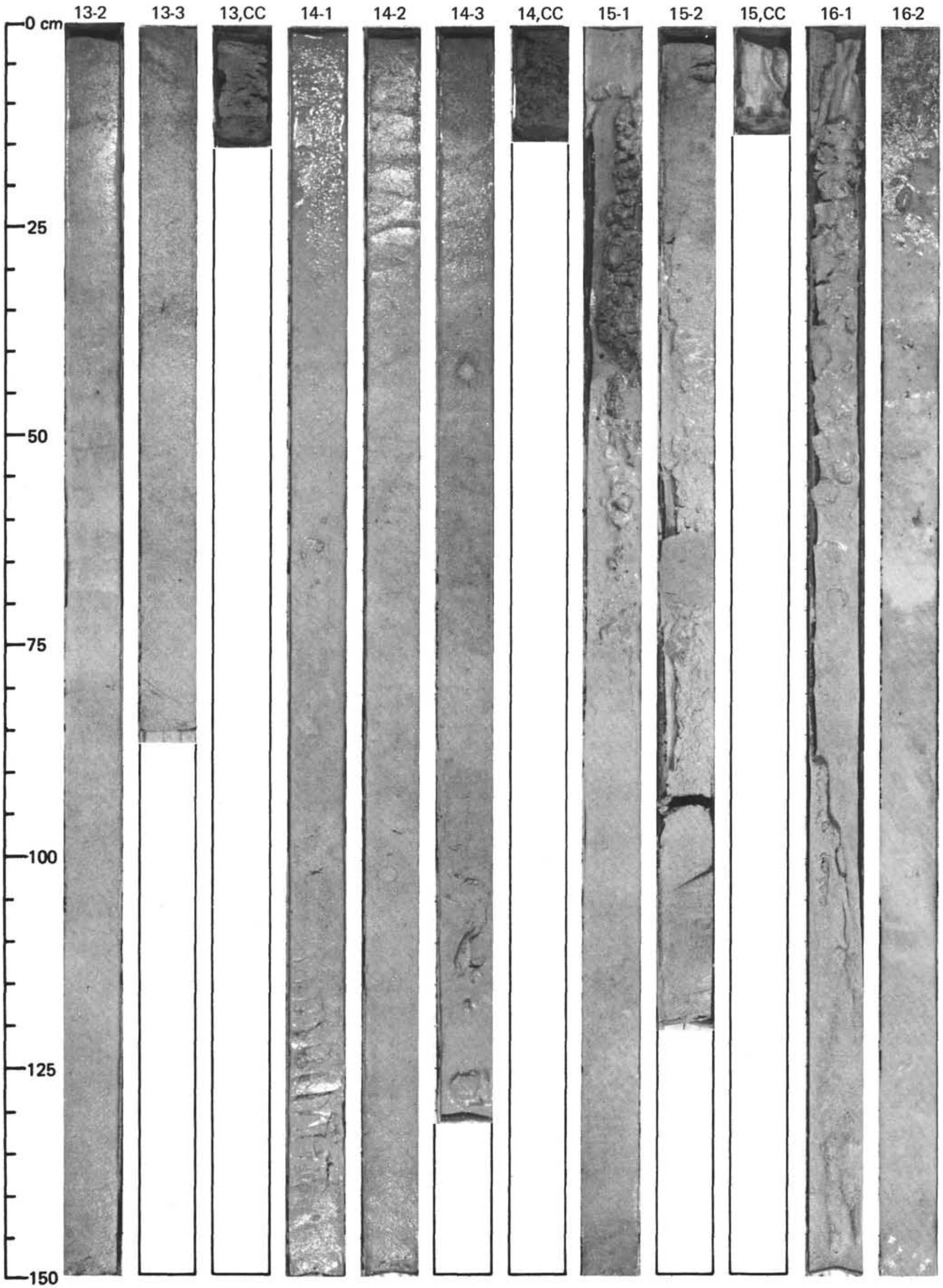
11-3
11,CC
12-1
12-2
12-3
12,CC
13-1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13-3
13,CC
14-1
14-2
14-3
14,CC
15-1
15-2
15,CC
16-1
16-2
0 cm
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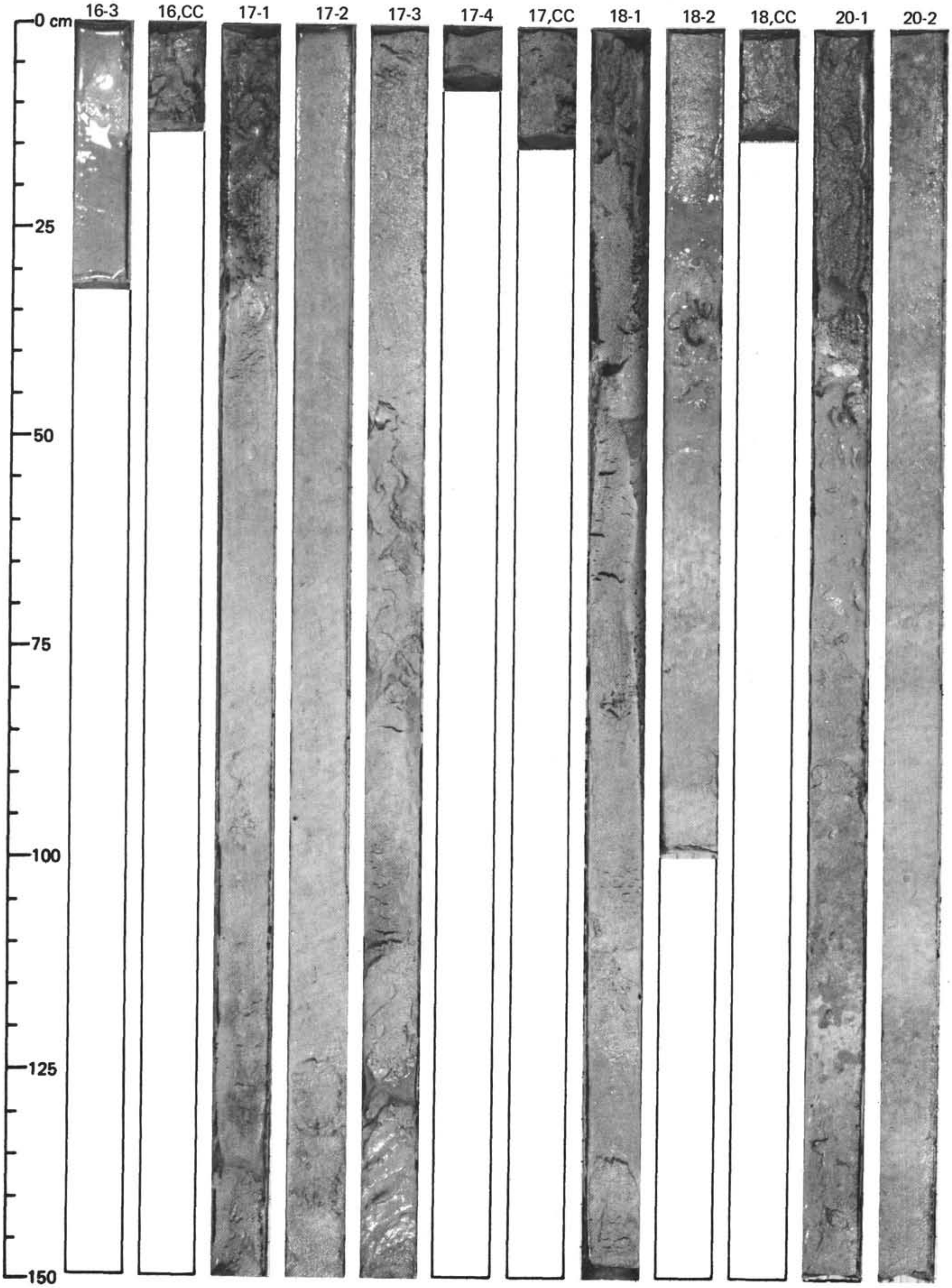
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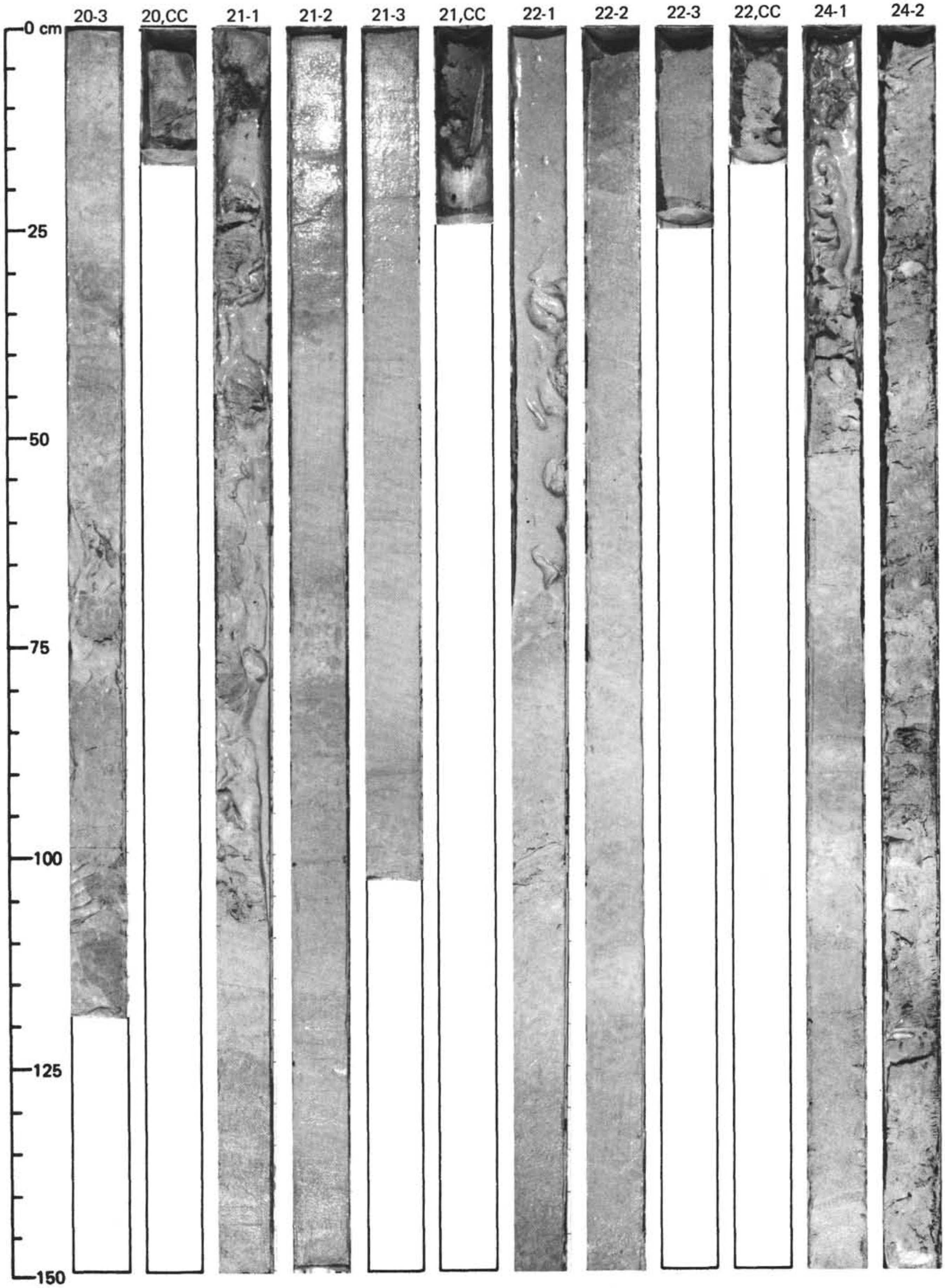
17-1
17-2
17-3
17-4
17,CC
18-1
18-2
18,CC
20-1
20-2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20,CC
21-1
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21-3
21,CC
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22-3
22,CC
24-1
24-2
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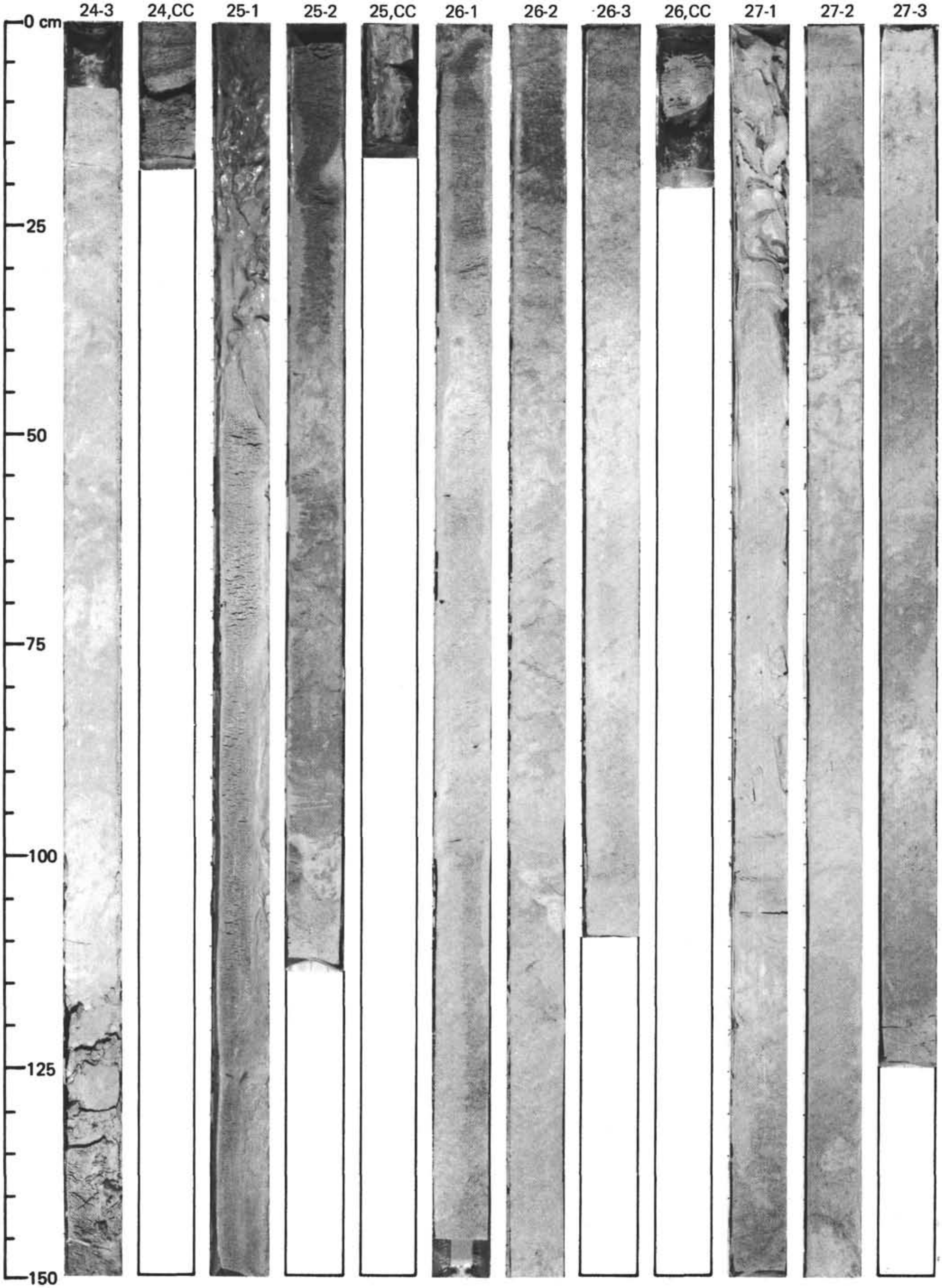
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26-2
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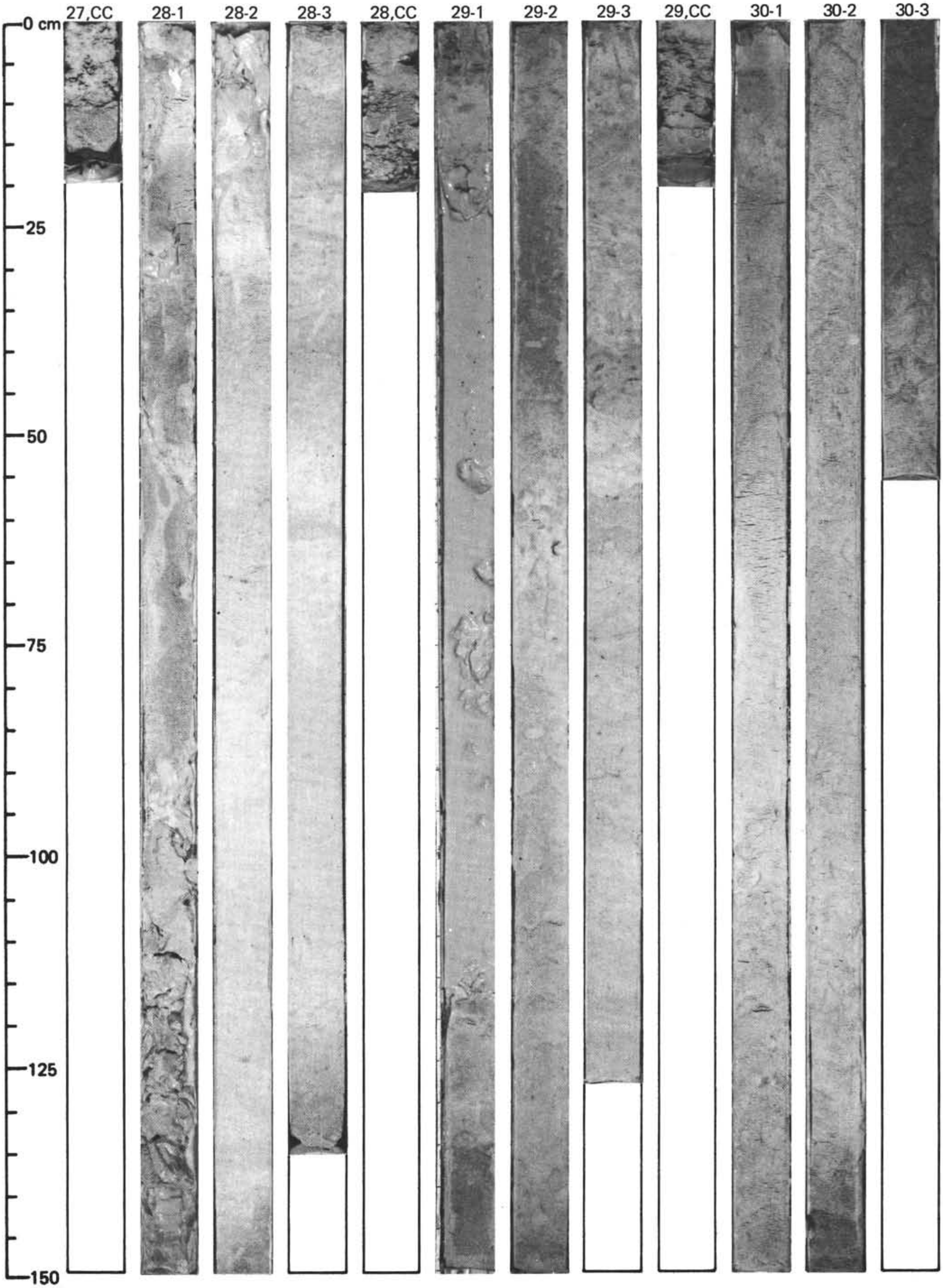
27-1
27-2
27-3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28-3
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29-1
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30-1
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30-3
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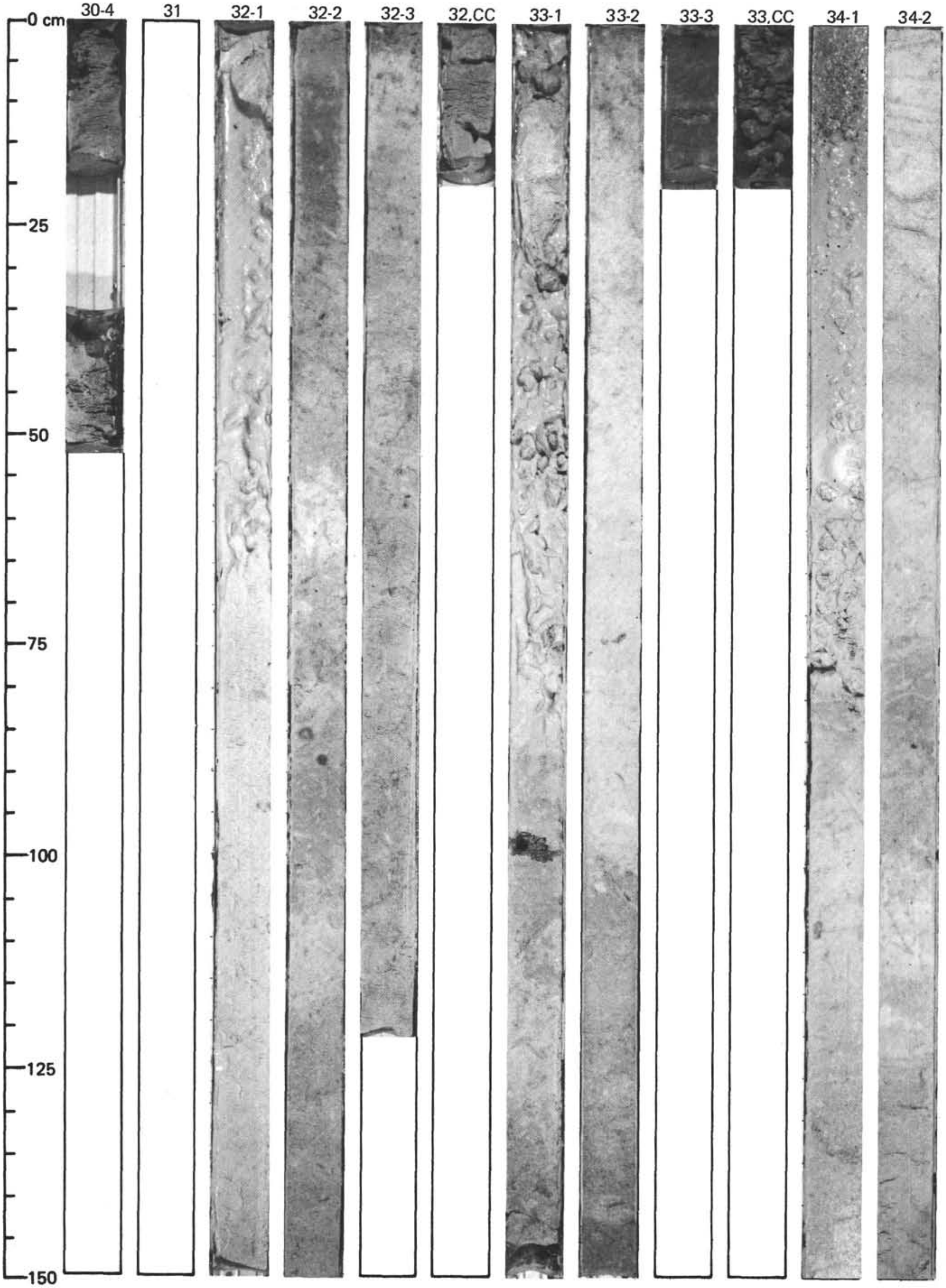
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32-2
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32,CC
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33-2
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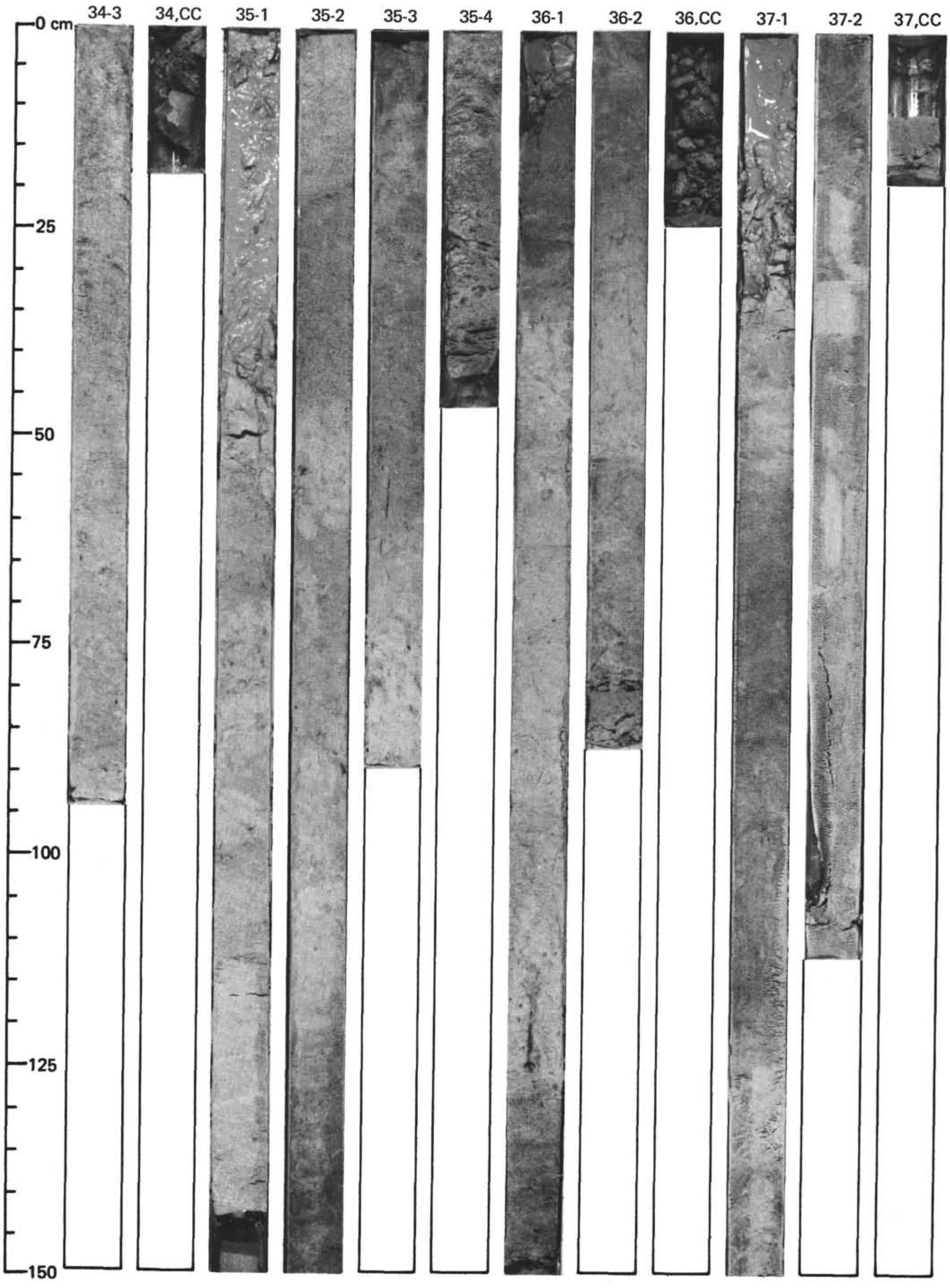
33,CC
34-1
34-2



34-3
34,CC
35-1
35-2
35-3
35-4
36-1
36-2
36,CC
37-1
37-2
37,CC
0 cm
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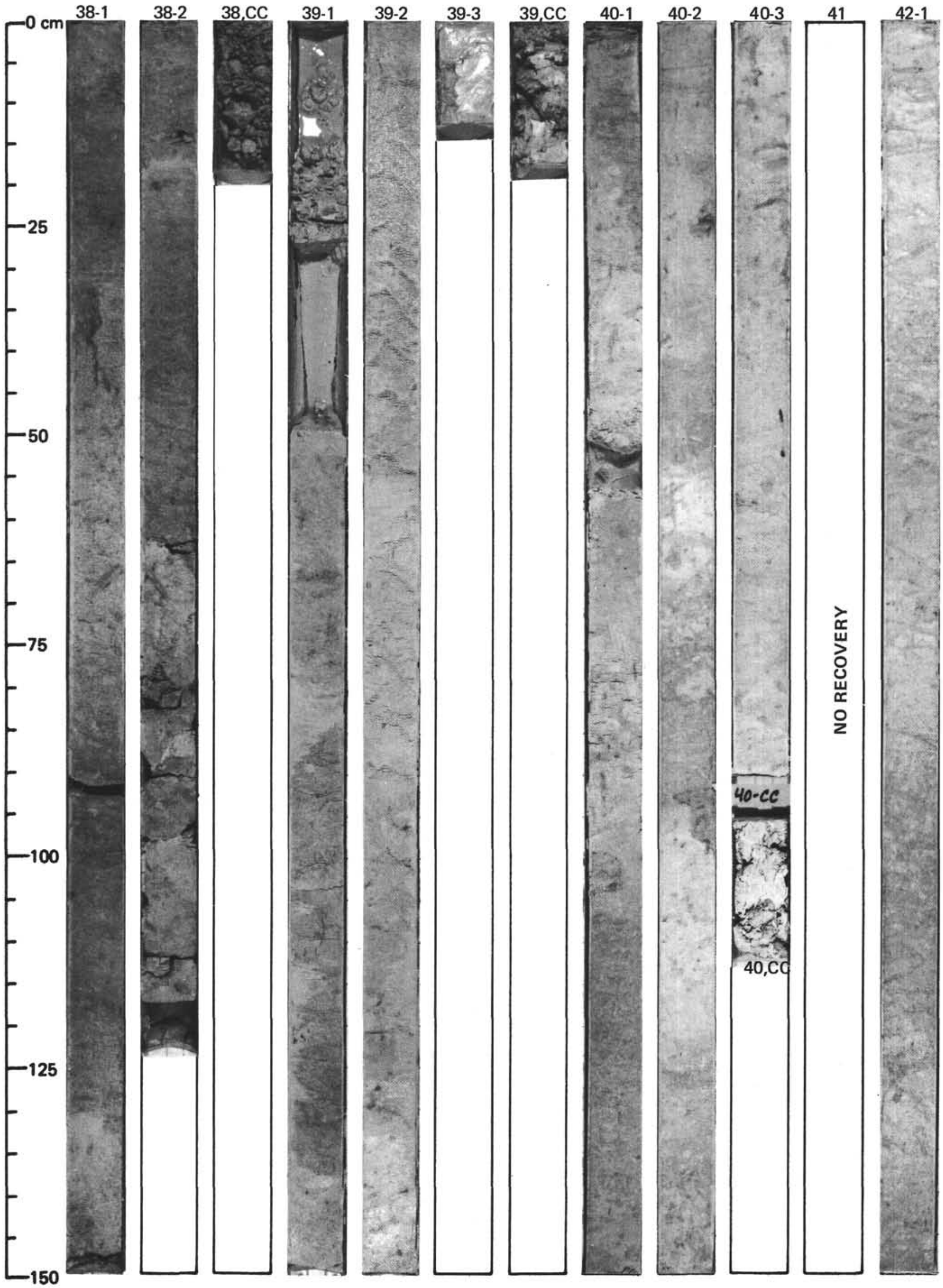
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38-2
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39-2
39-3
39,CC
40-1
40-2
40-3
41
42-1
40-CC
40,CC
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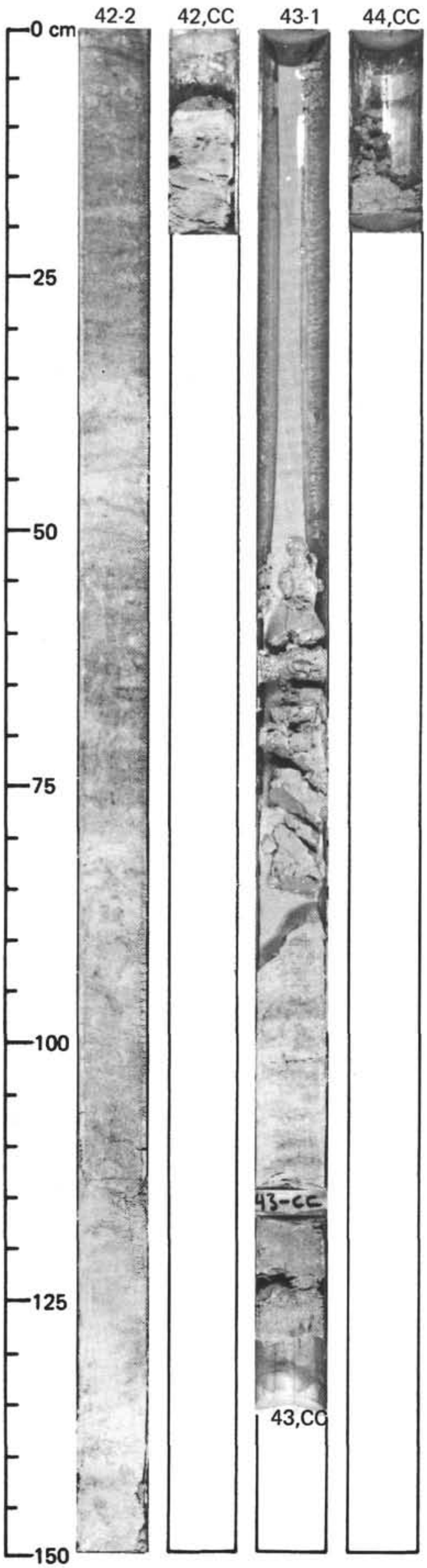
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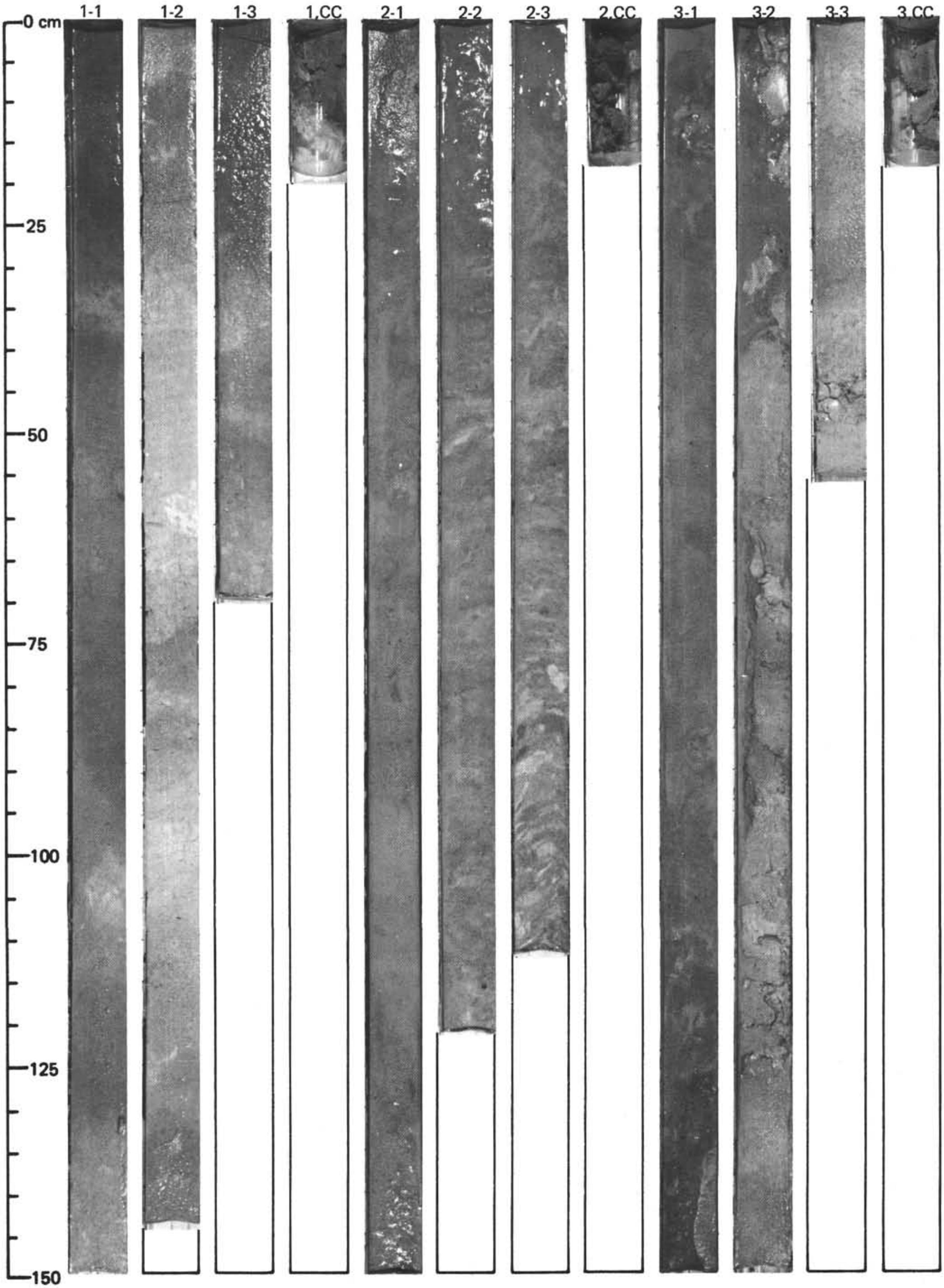
43-CC
43,CC


1-1
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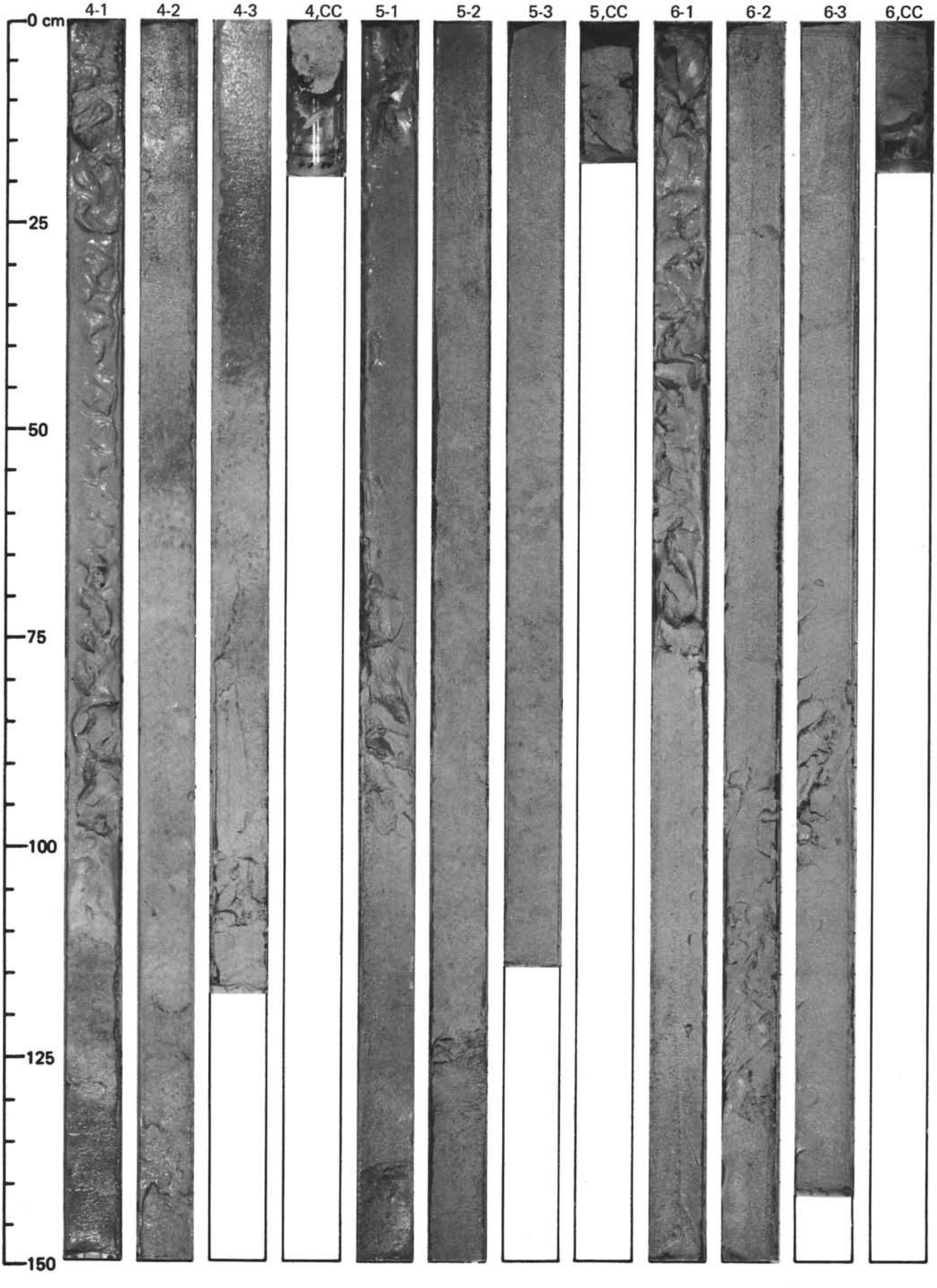
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5-2
5-3
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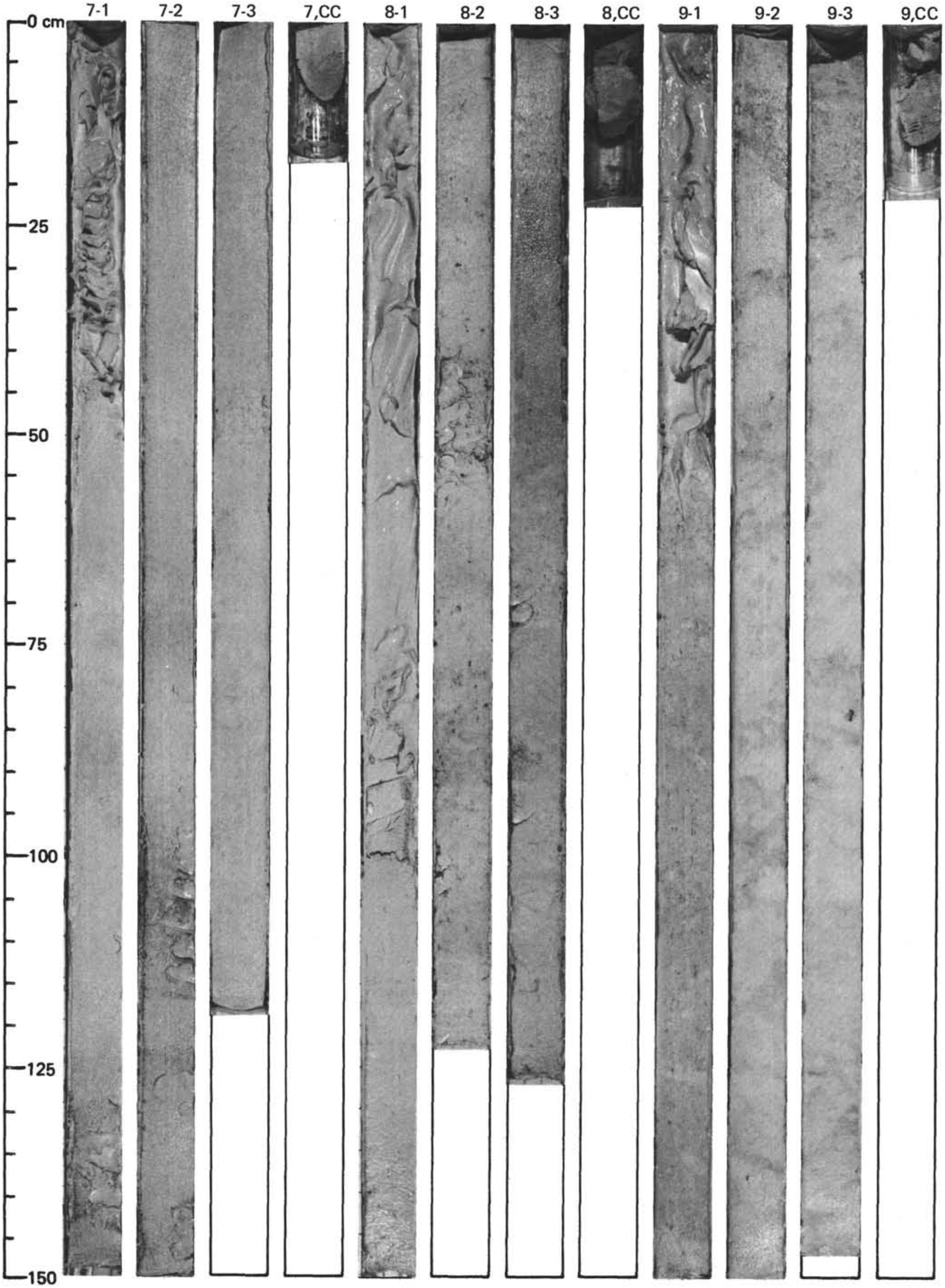
6-2
6-3
6,CC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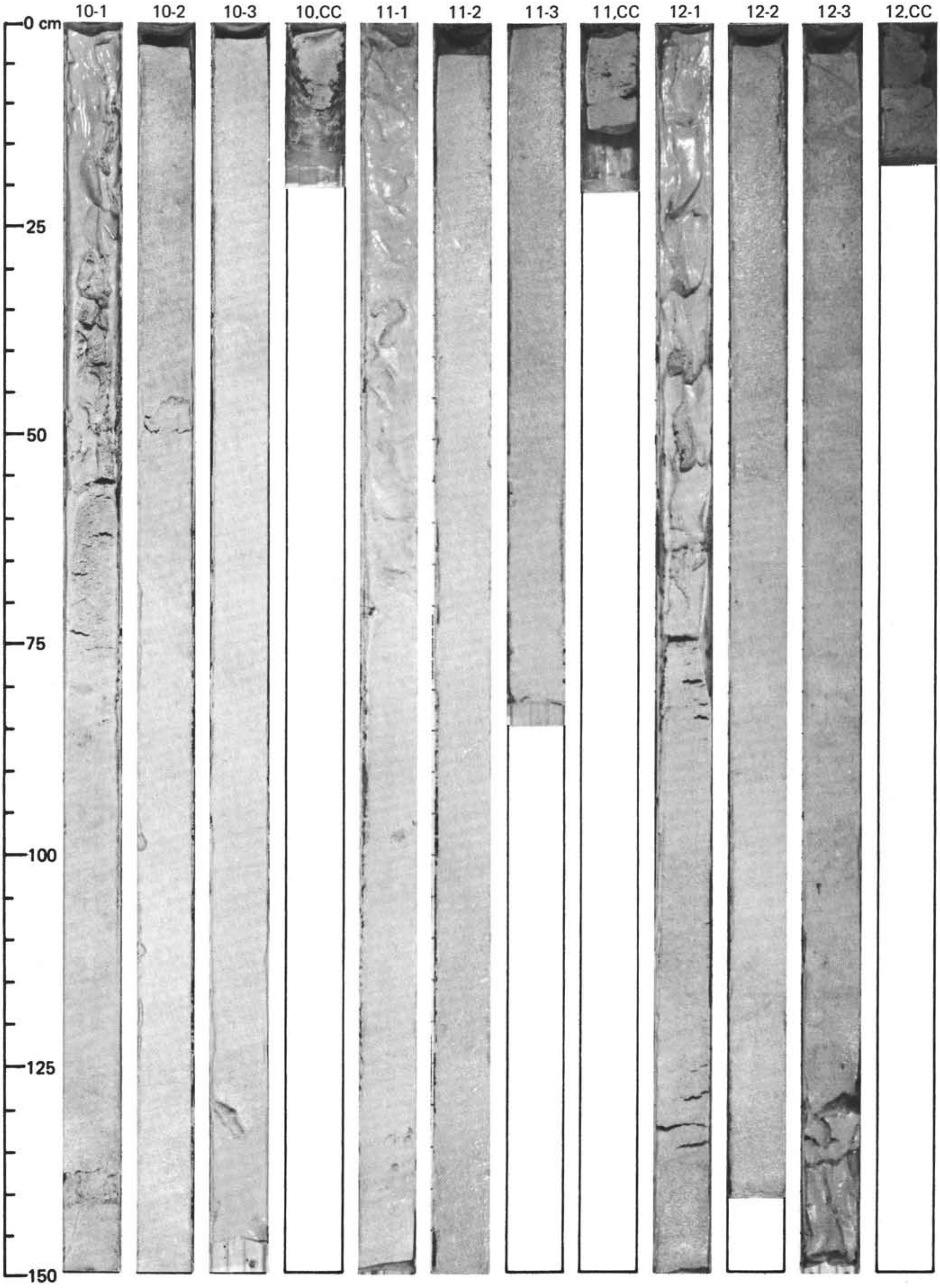
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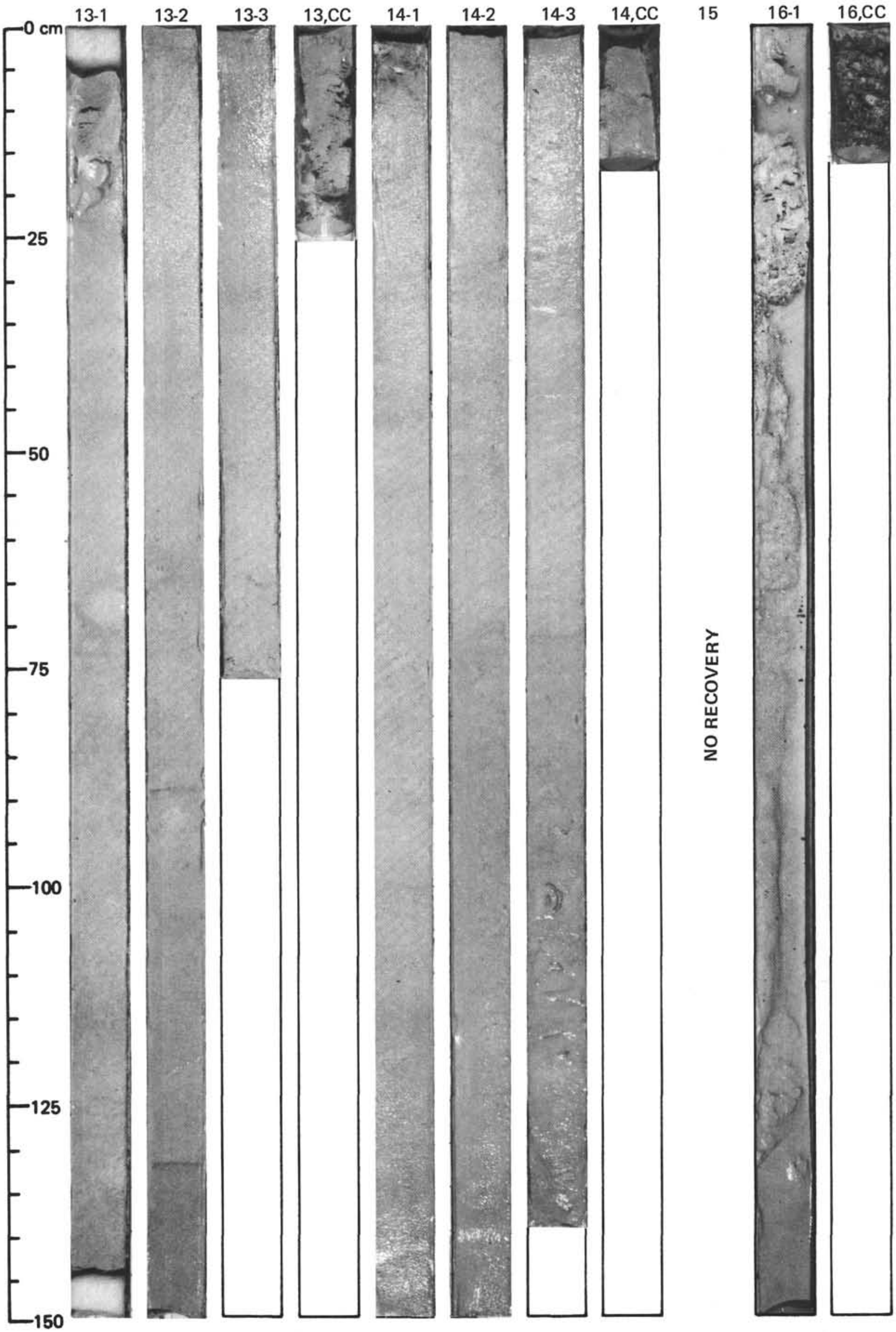
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13,CC
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14,CC
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16-1
16,CC
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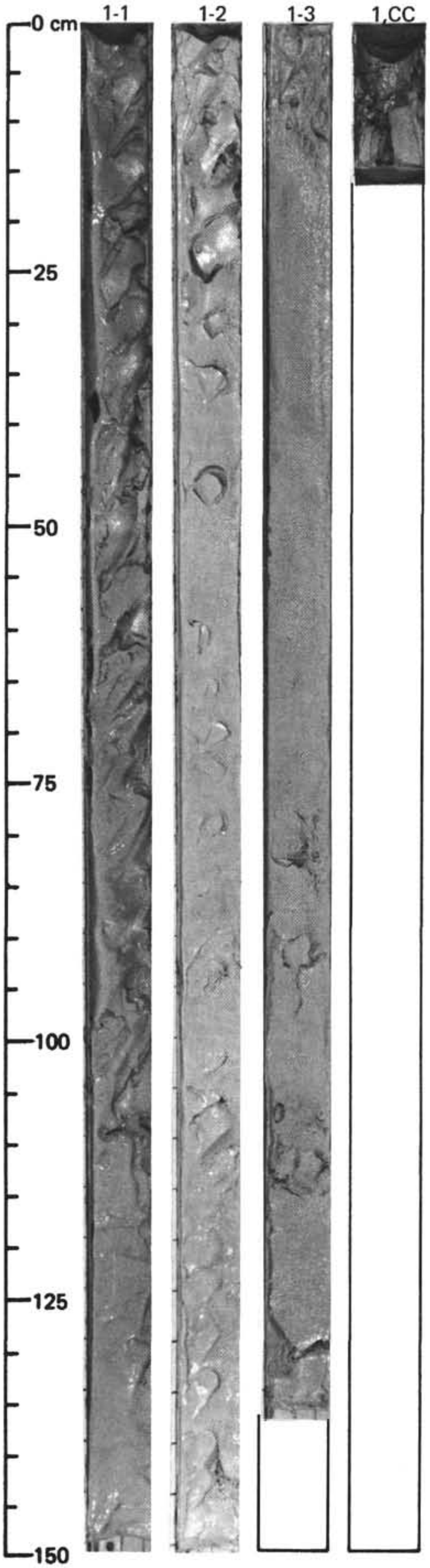
NO RECOVERY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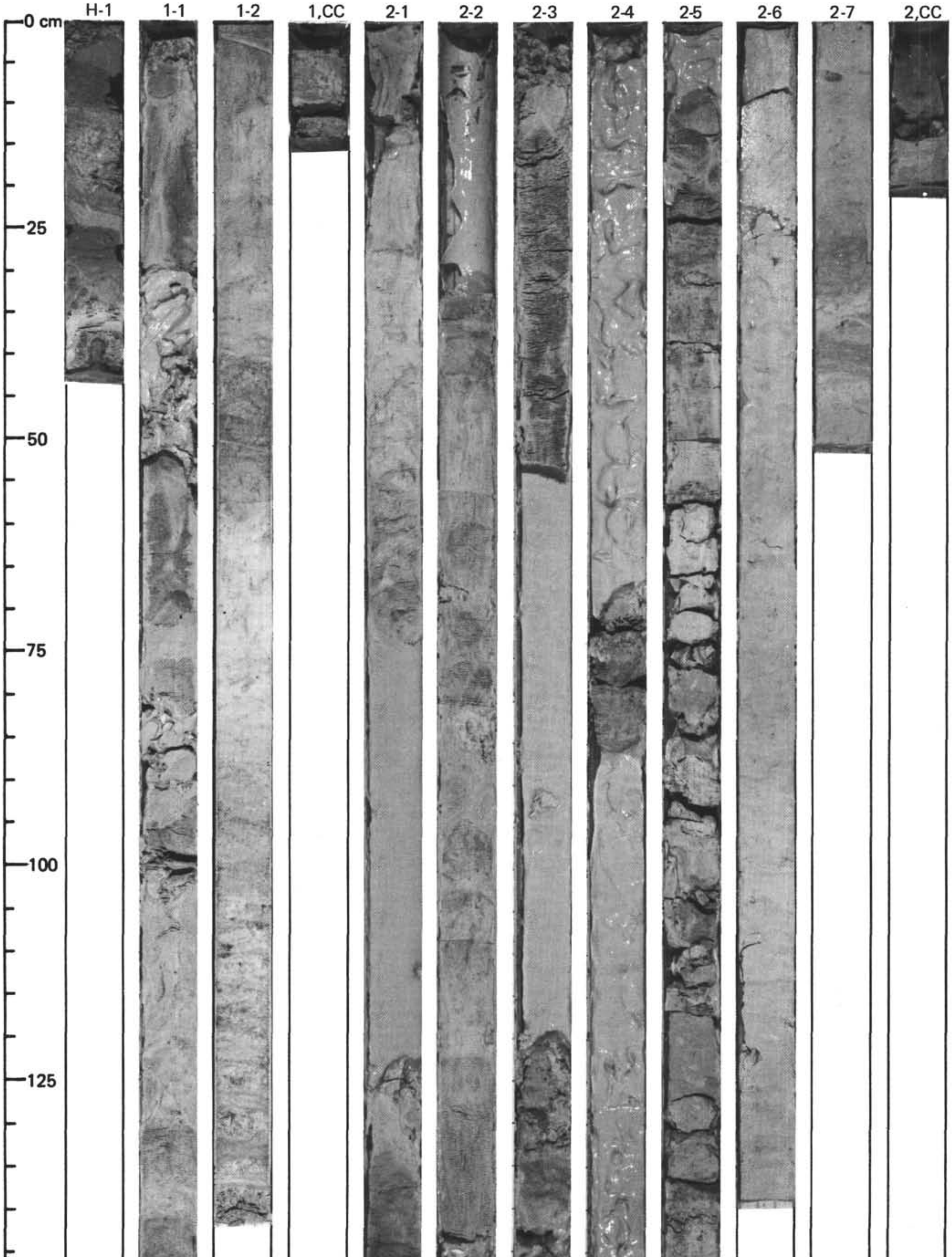
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2-2
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2-4
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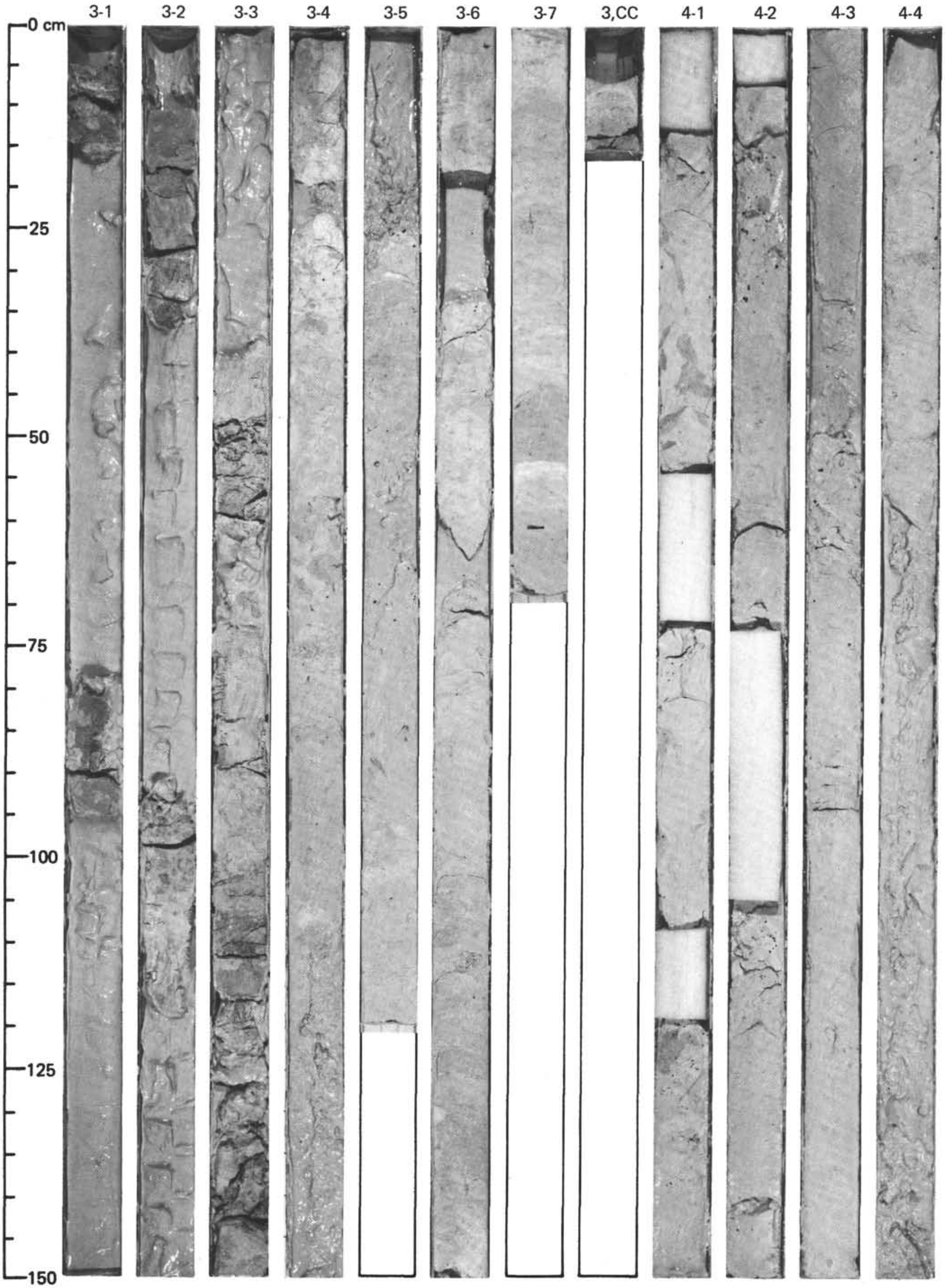
2-7
2,CC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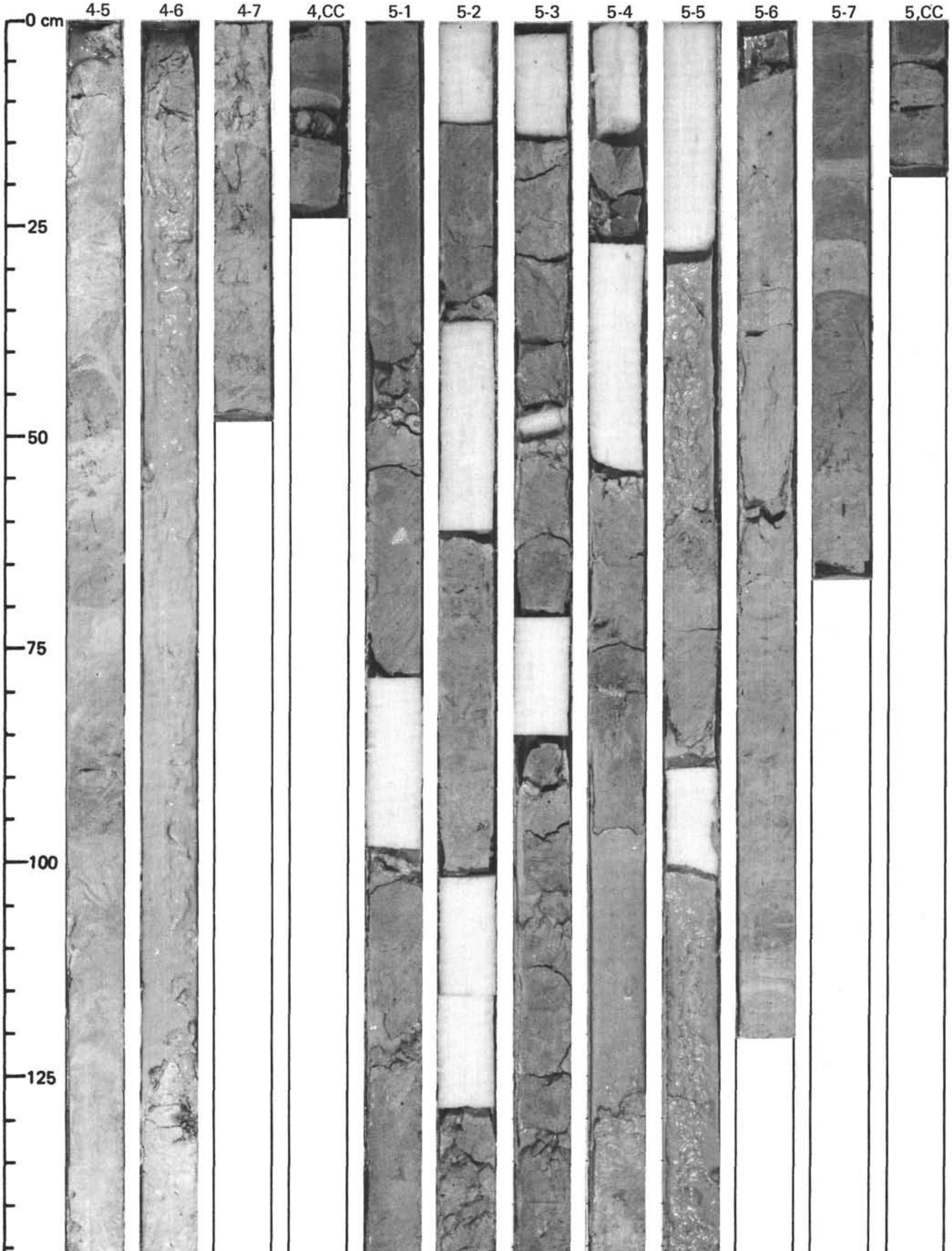
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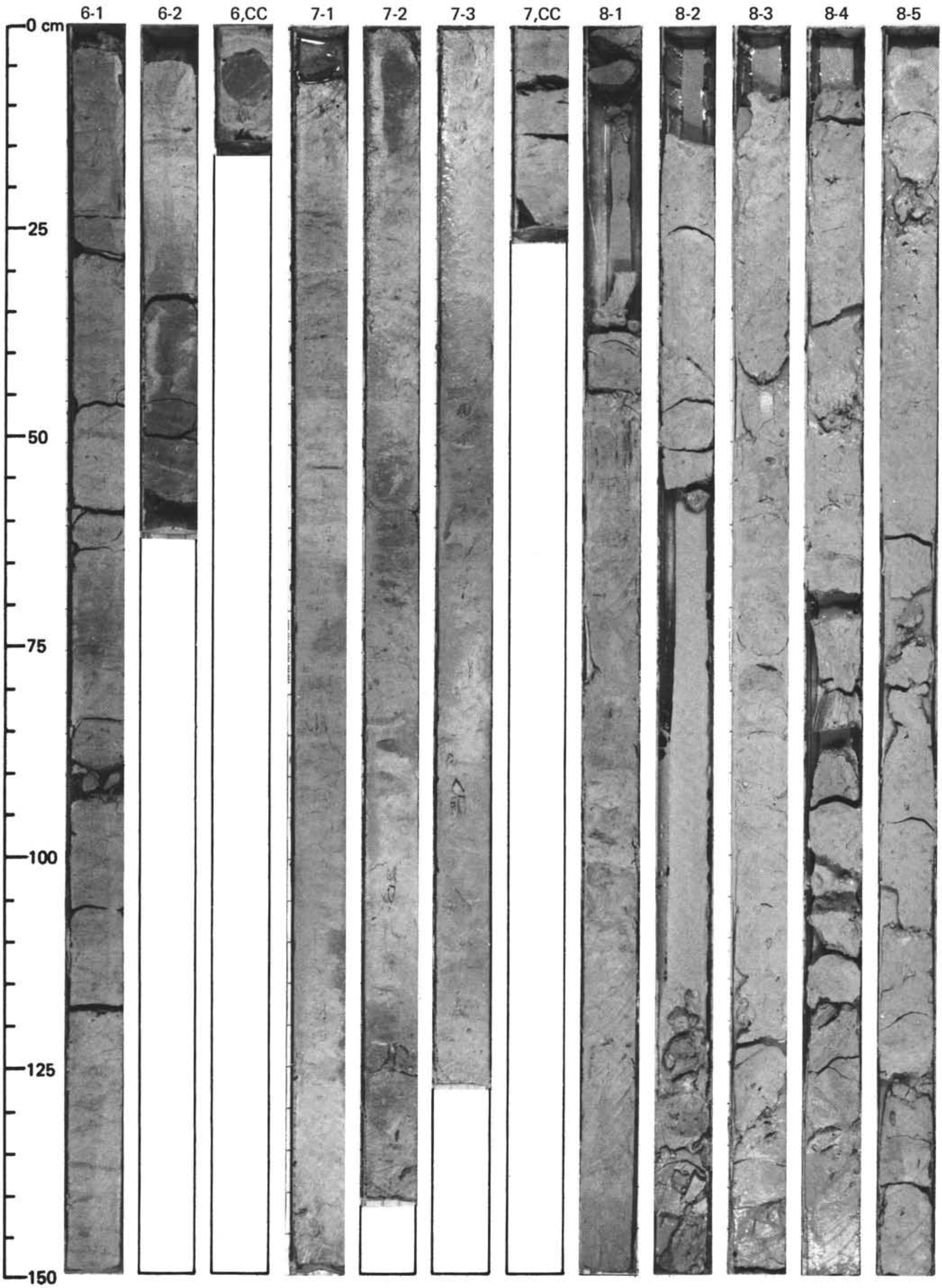
5,CC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6,CC
7-1
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8-1
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8-3
8-4
8-5
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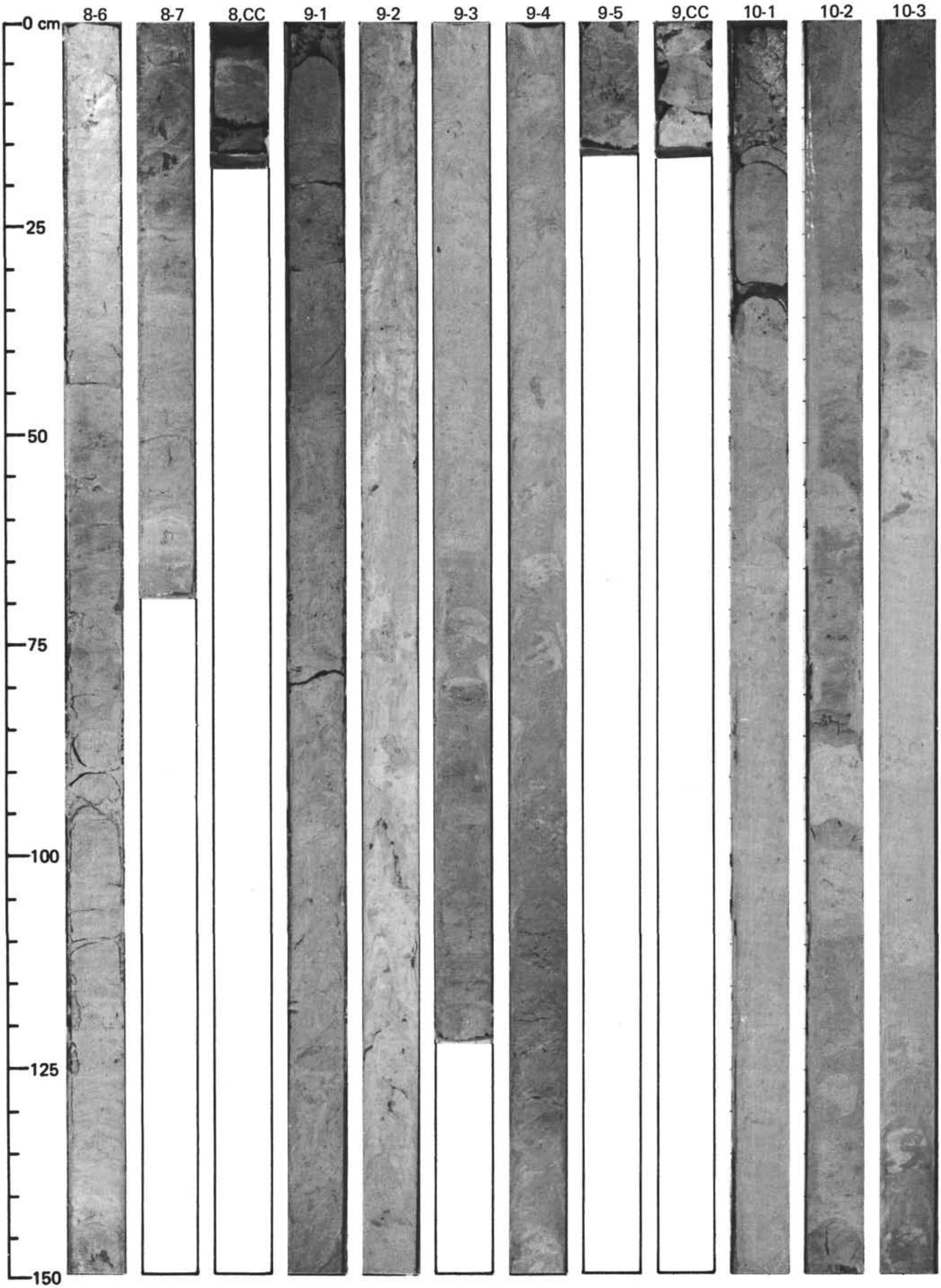
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9-1
9-2
9-3
9-4
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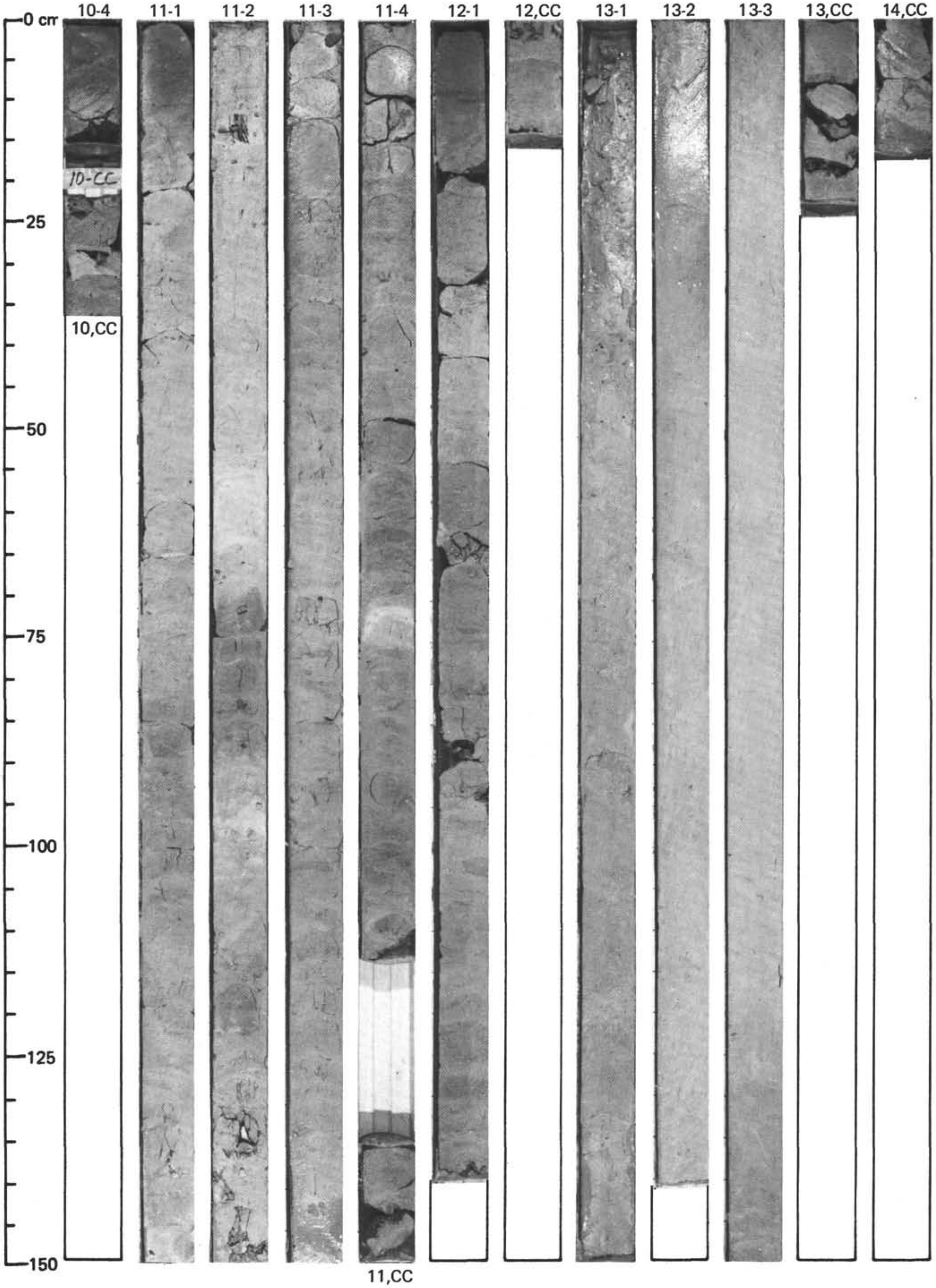
10-1
10-2
10-3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10-CC
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12-1
12,CC
13-1
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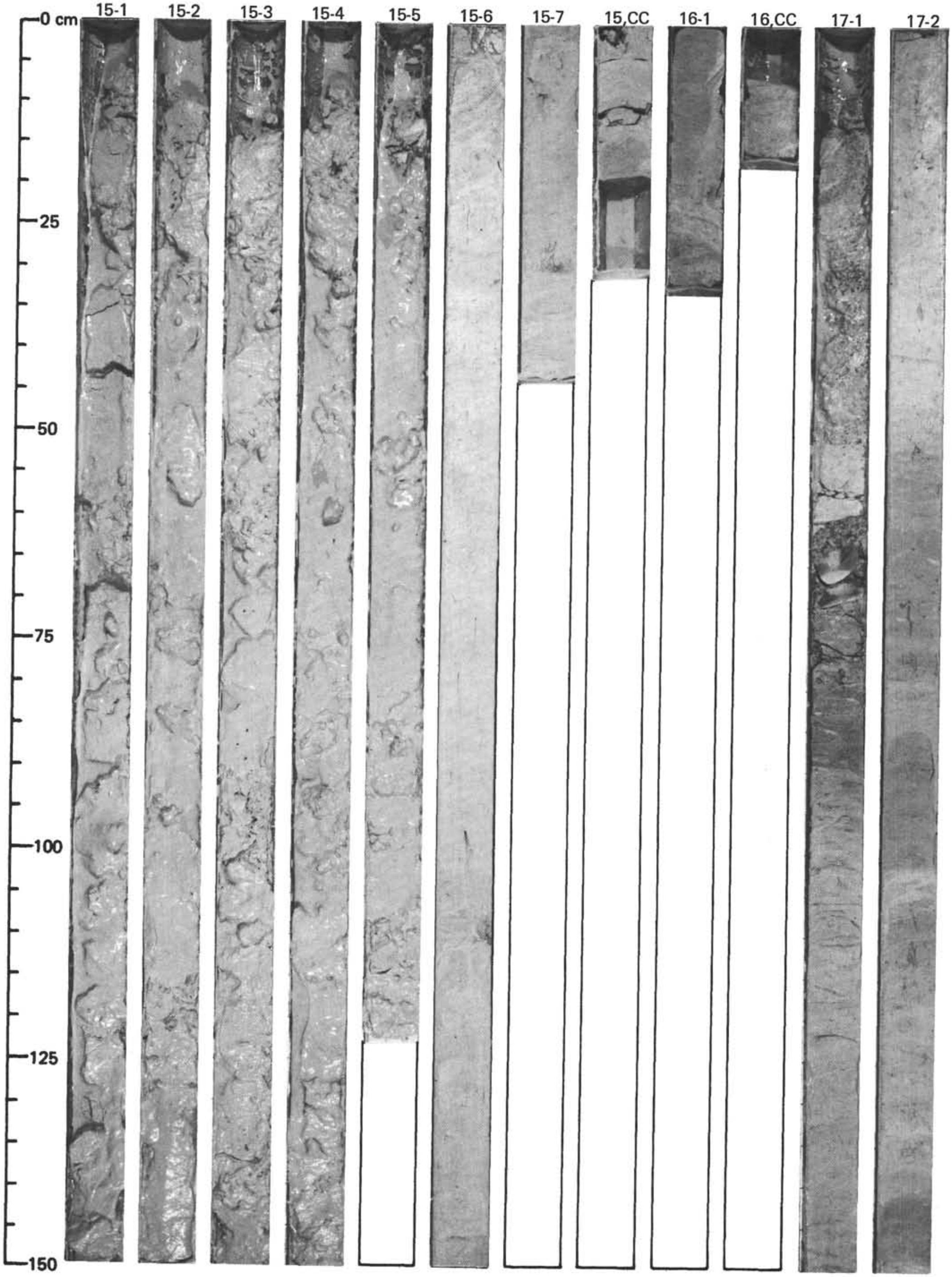
14,CC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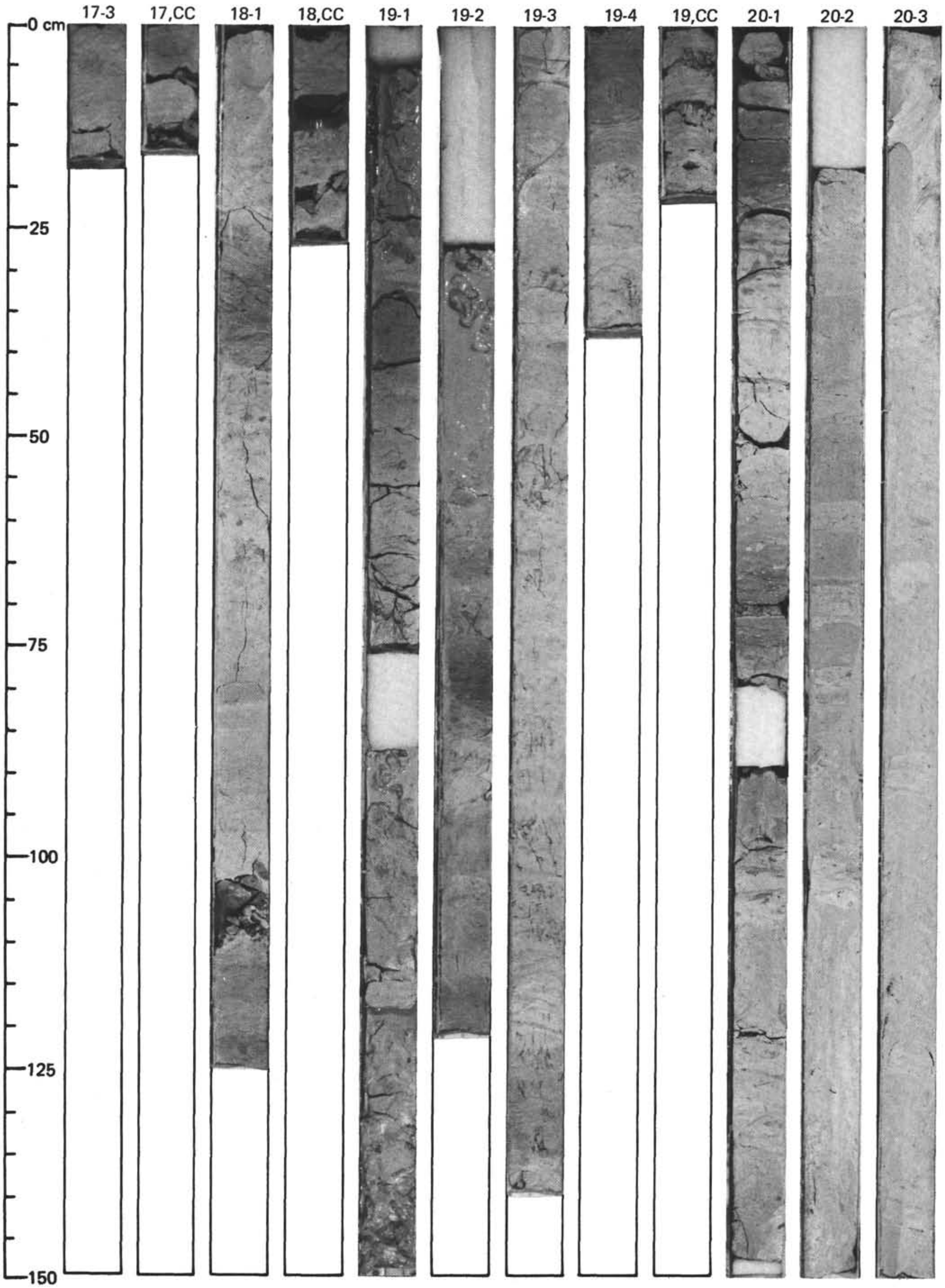
17-1
17-2


17-3
17,CC
18-1
18,CC
19-1
19-2
19-3
19-4
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20-1
20-2
20-3
0 cm
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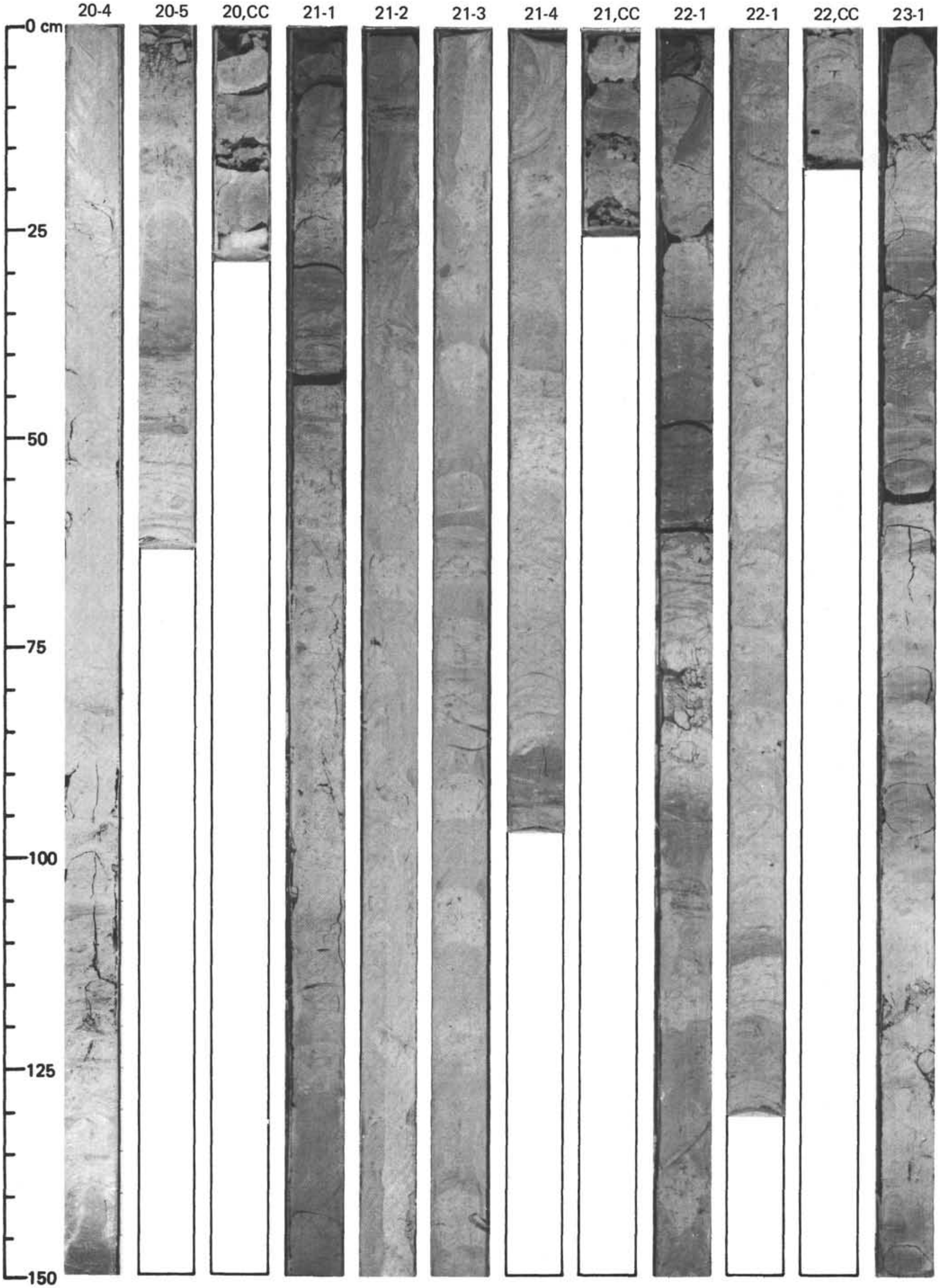
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21-2
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21,CC
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22-1
22,CC
23-1
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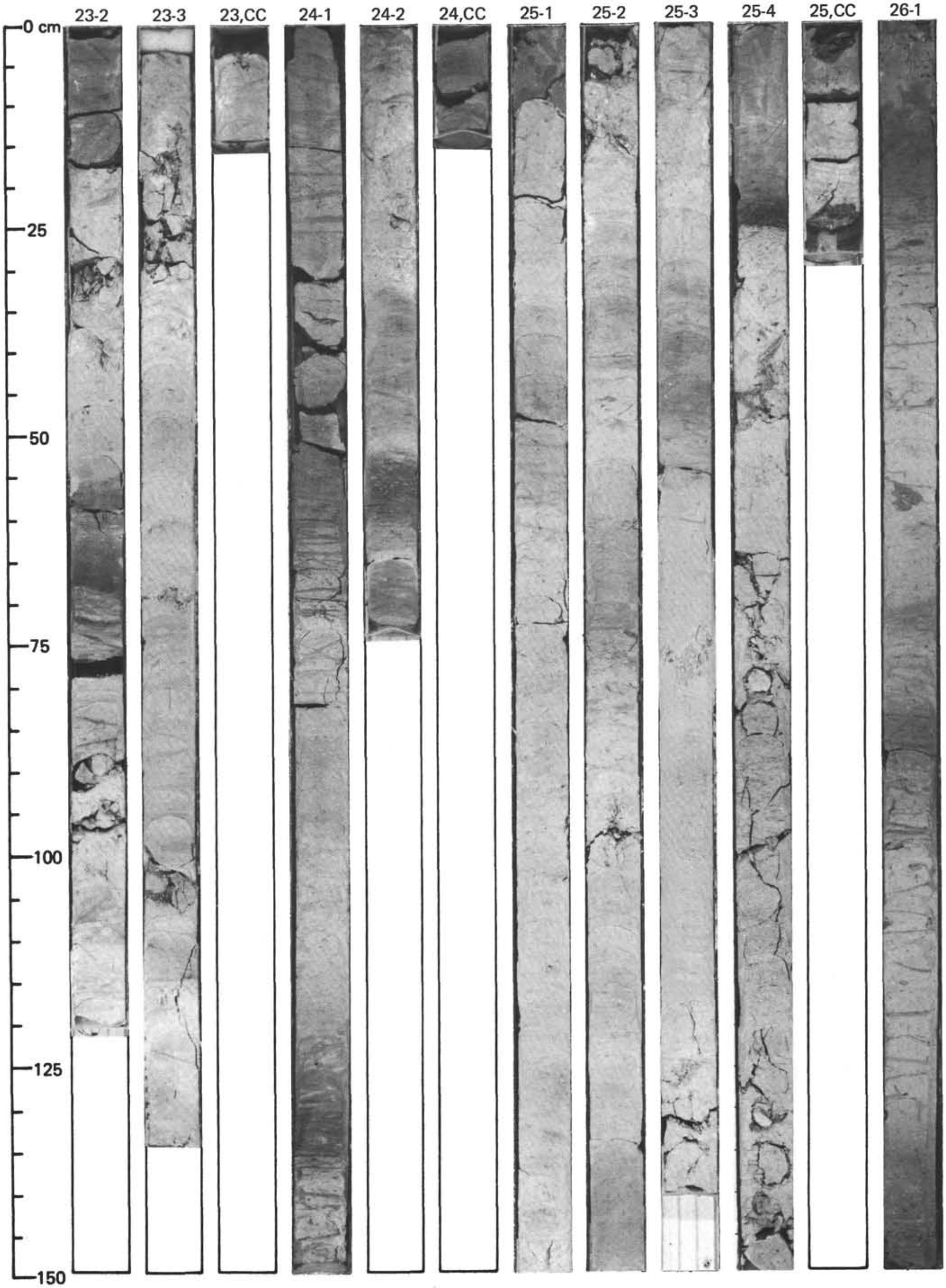
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24-1
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25-2
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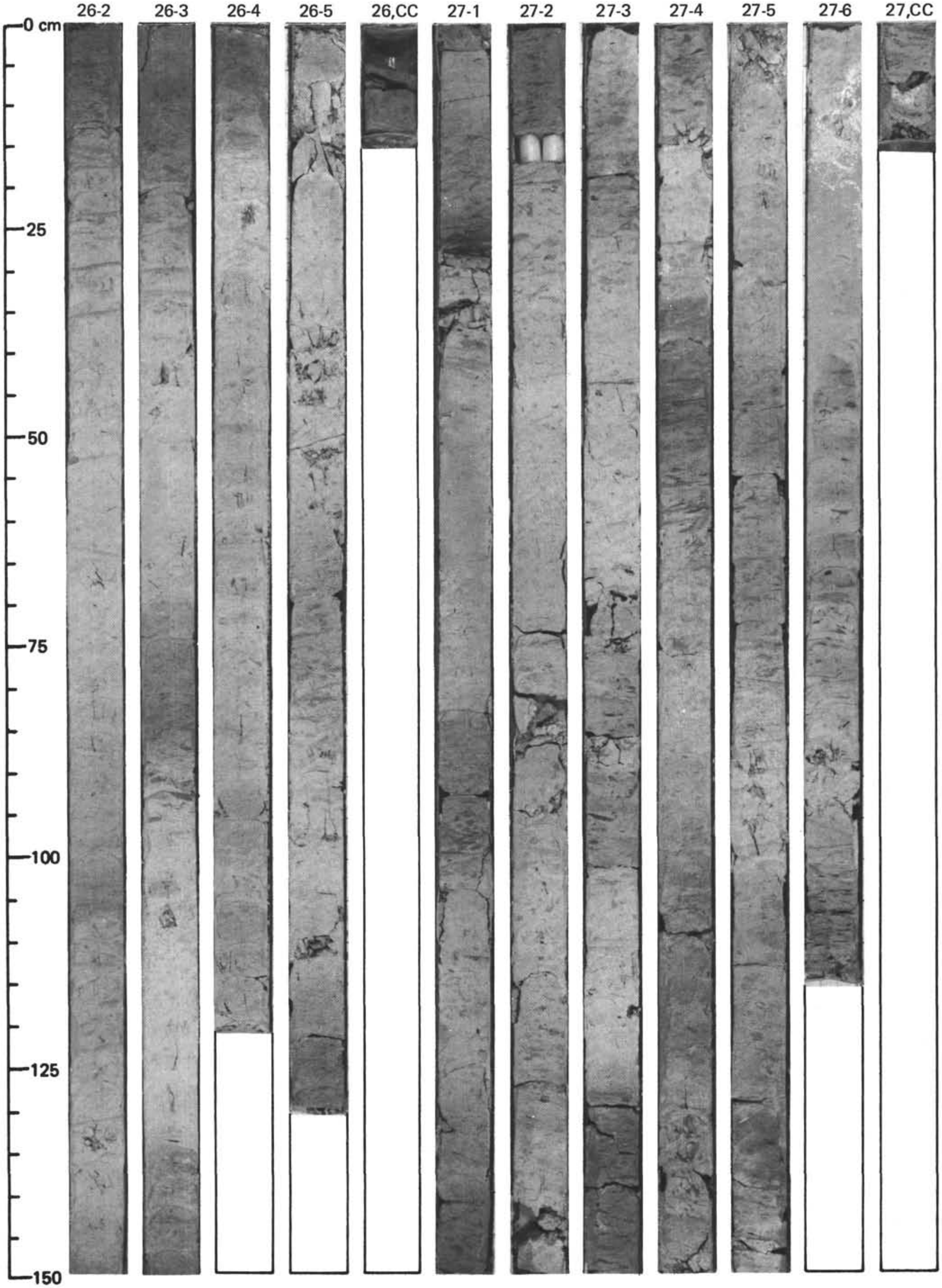
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26-5
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27-6
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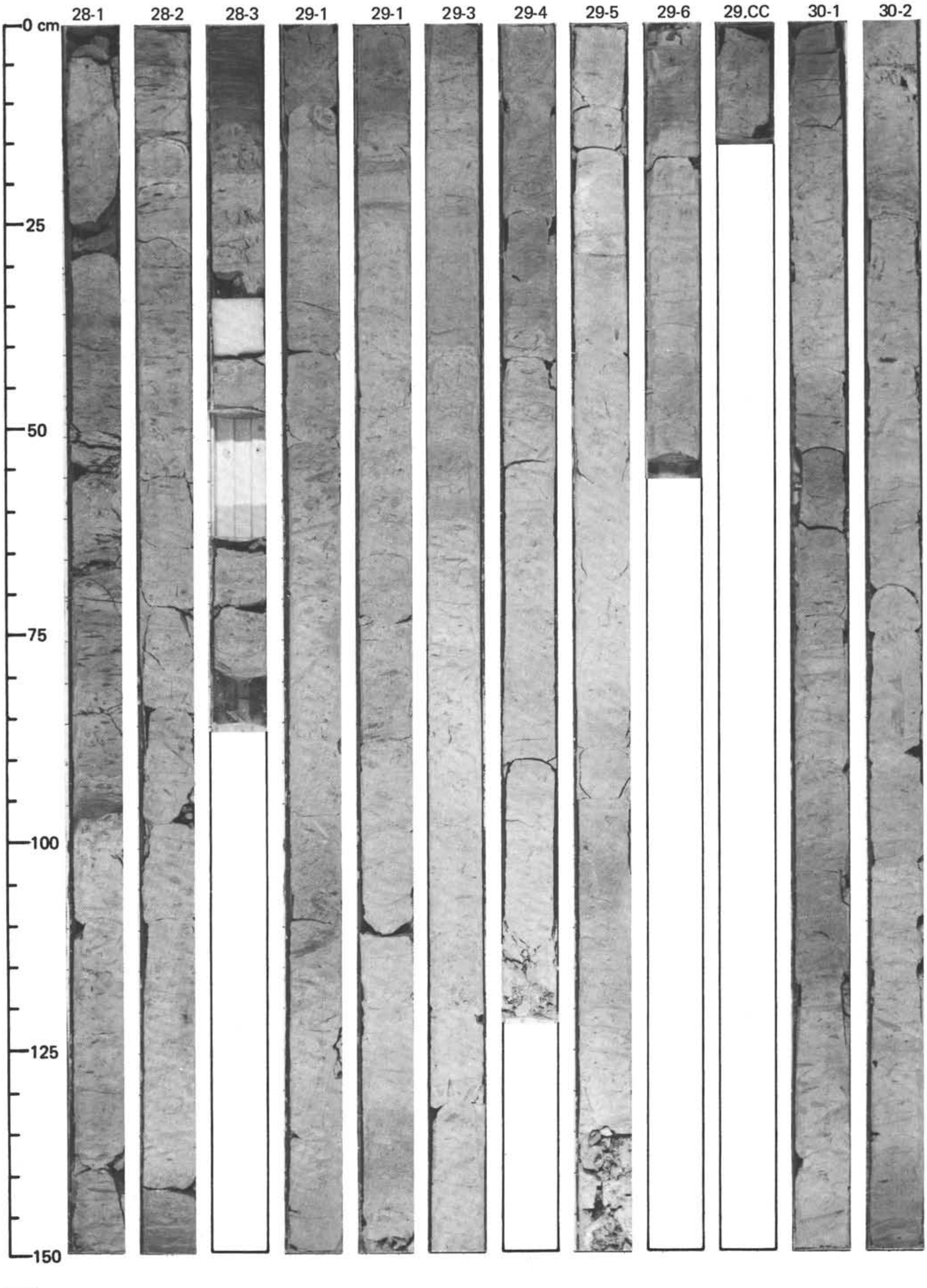
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28-2
28-3
29-1
29-1
29-3
29-4
29-5
29-6
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30-2
0 cm
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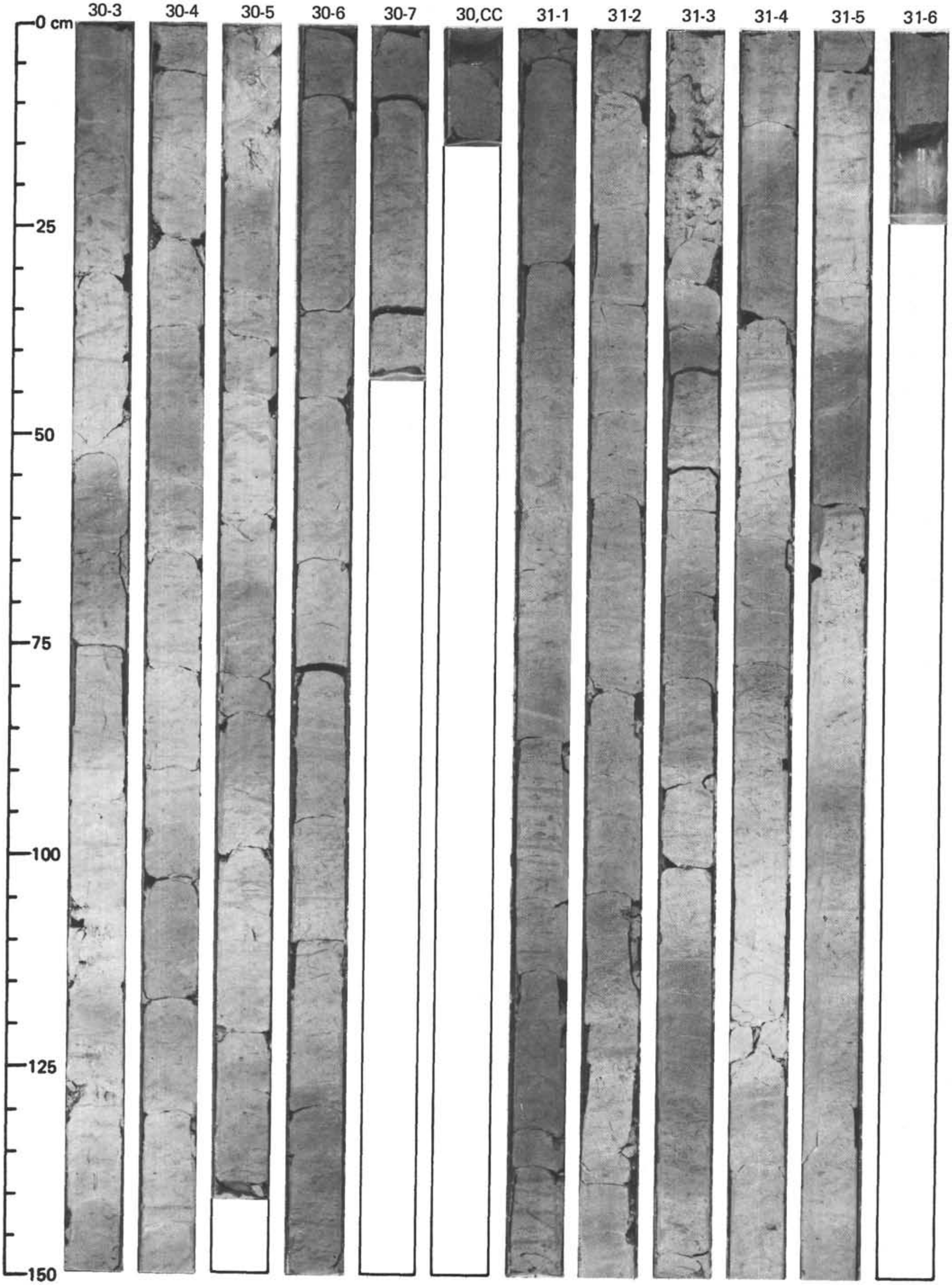
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30-5
30-6
30-7
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31-2
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31-4
31-5
31-6
0 cm
25
50
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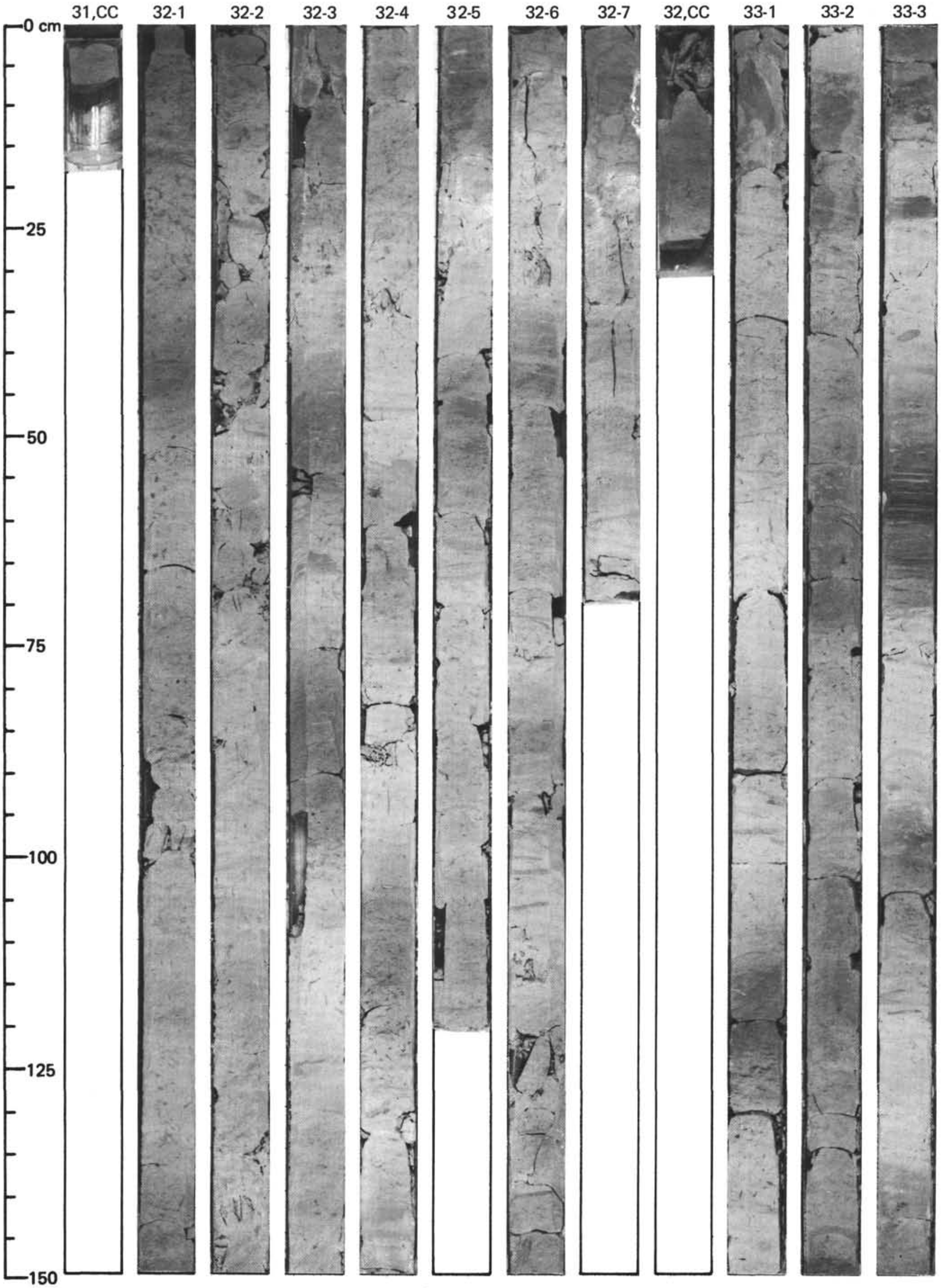
125
150


31,CC
32-1
32-2
32-3
32-4
32-5
32-6
32-7
32,CC
33-1
33-2
33-3
0 cm
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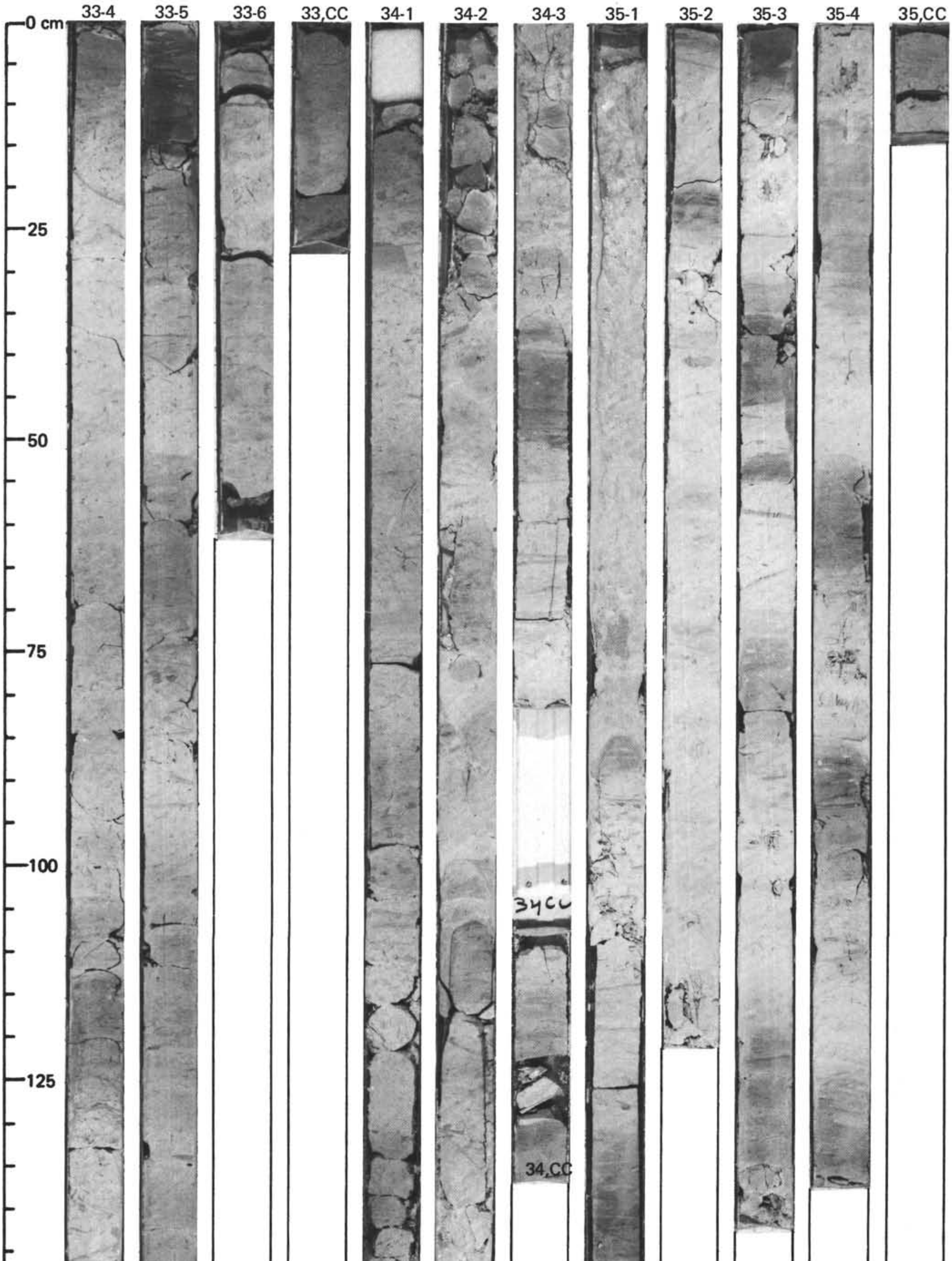

33-4
33-5
33-6
33,CC
34-1
34-2
34-3
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35-2
35-3
35-4
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0 cm
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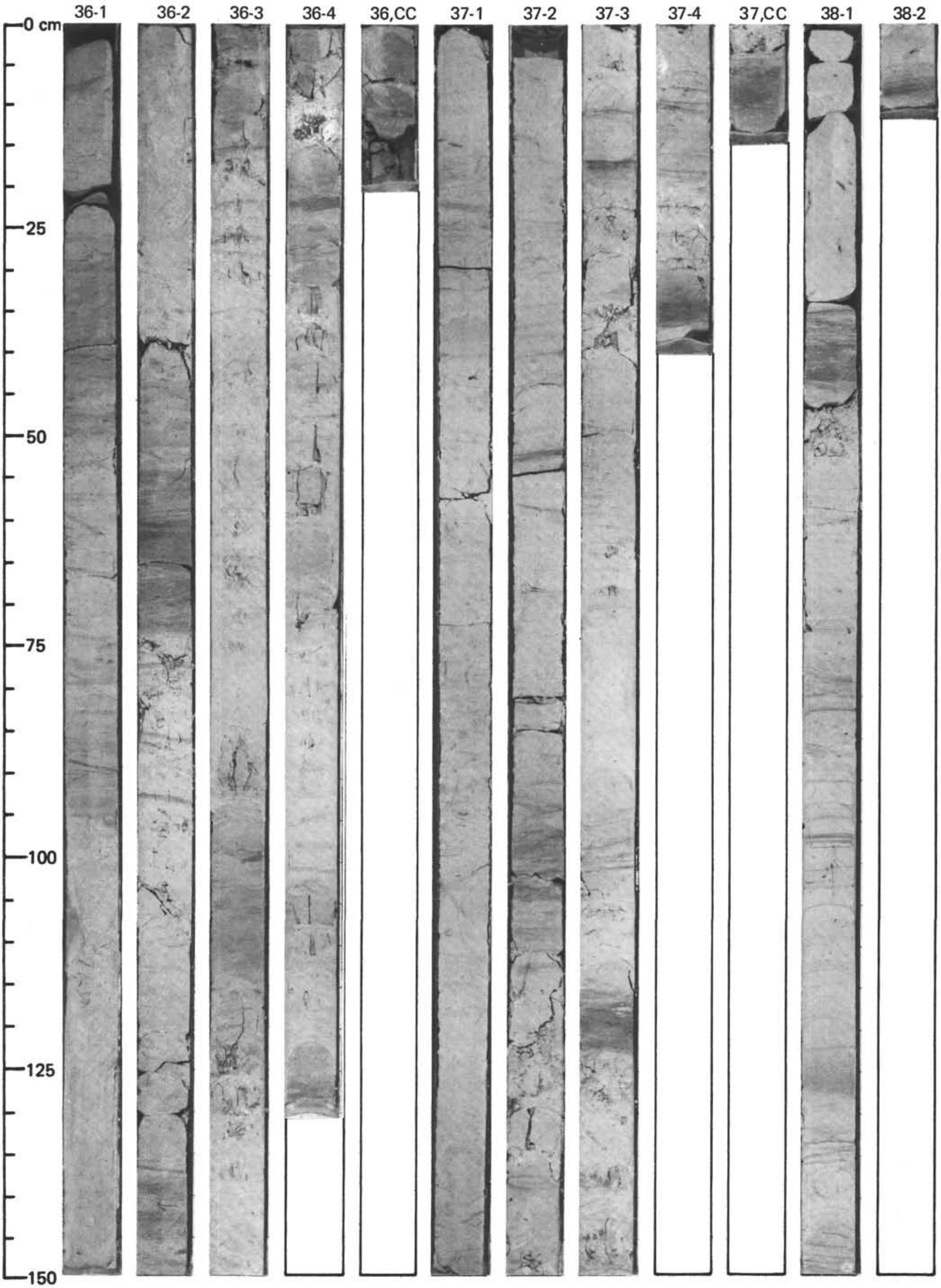
34CC
34,CC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36-3
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37,CC
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38-2
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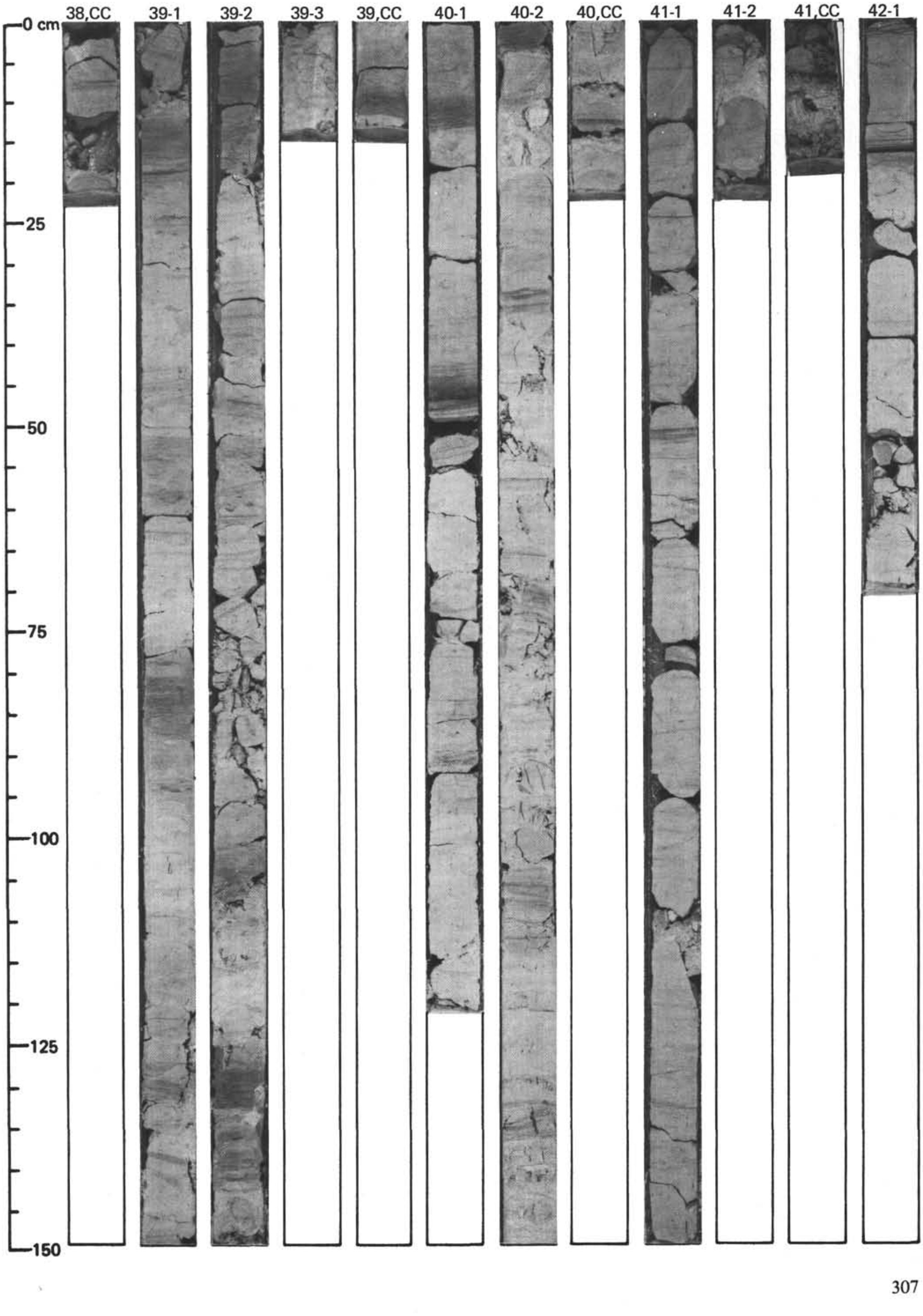
38,CC
39-1
39-2
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40,CC
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41-2
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42-1
0 cm
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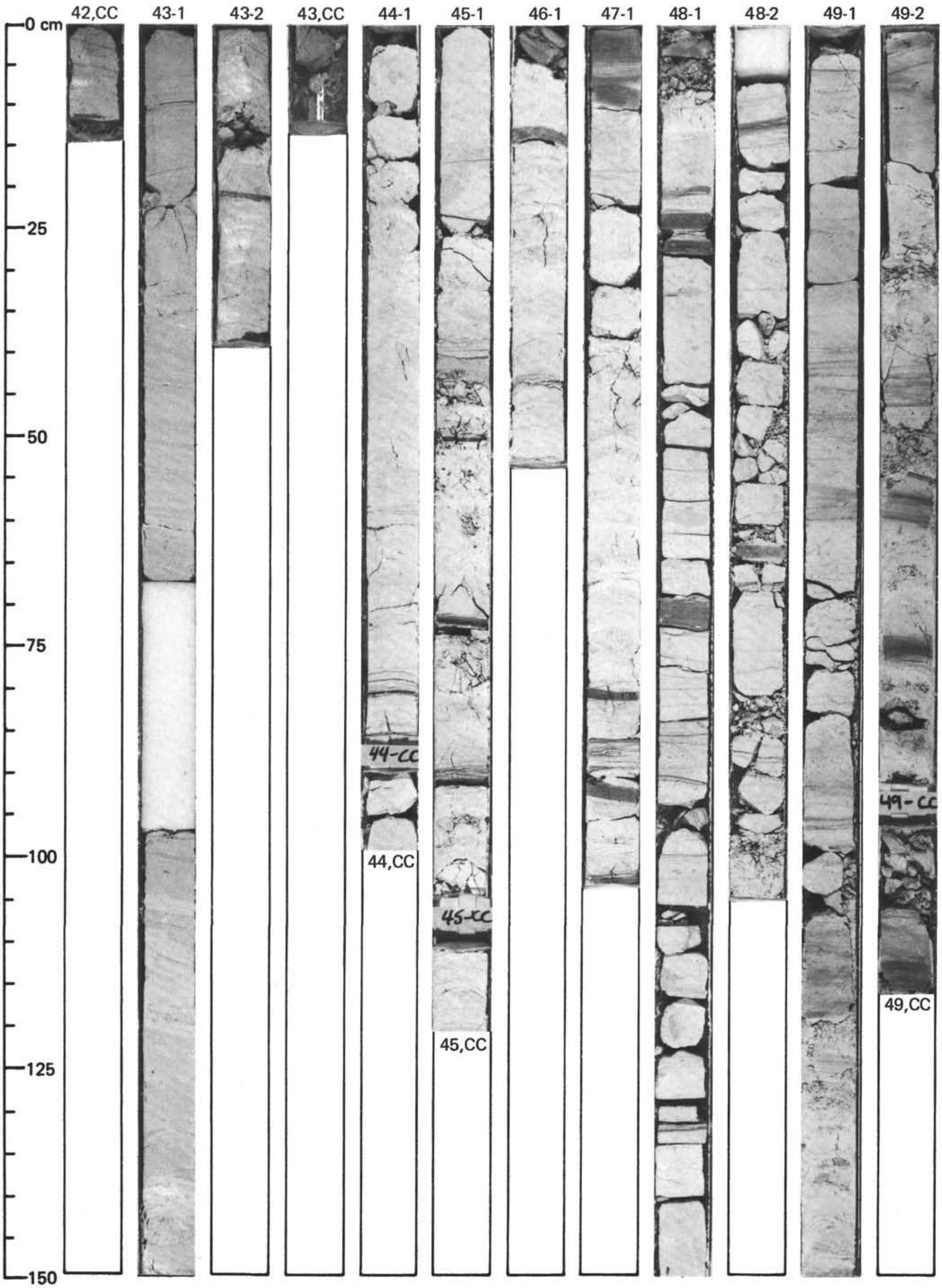

42,CC
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43-2
43,CC
44-1
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46-1
47-1
48-1
48-2
49-1
49-2
0 cm
25
50
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100
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44,CC
45-CC
45,CC
49-CC
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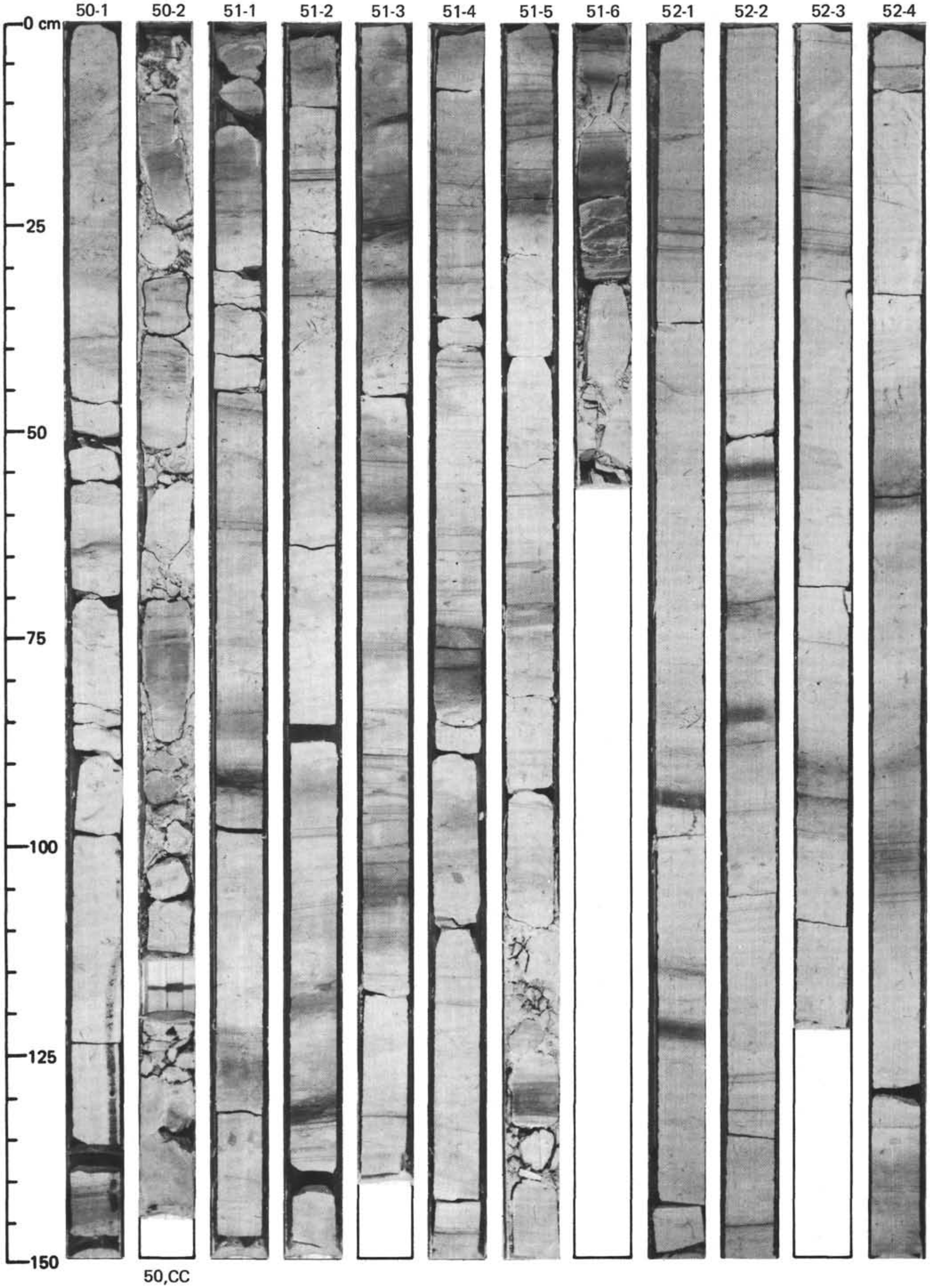
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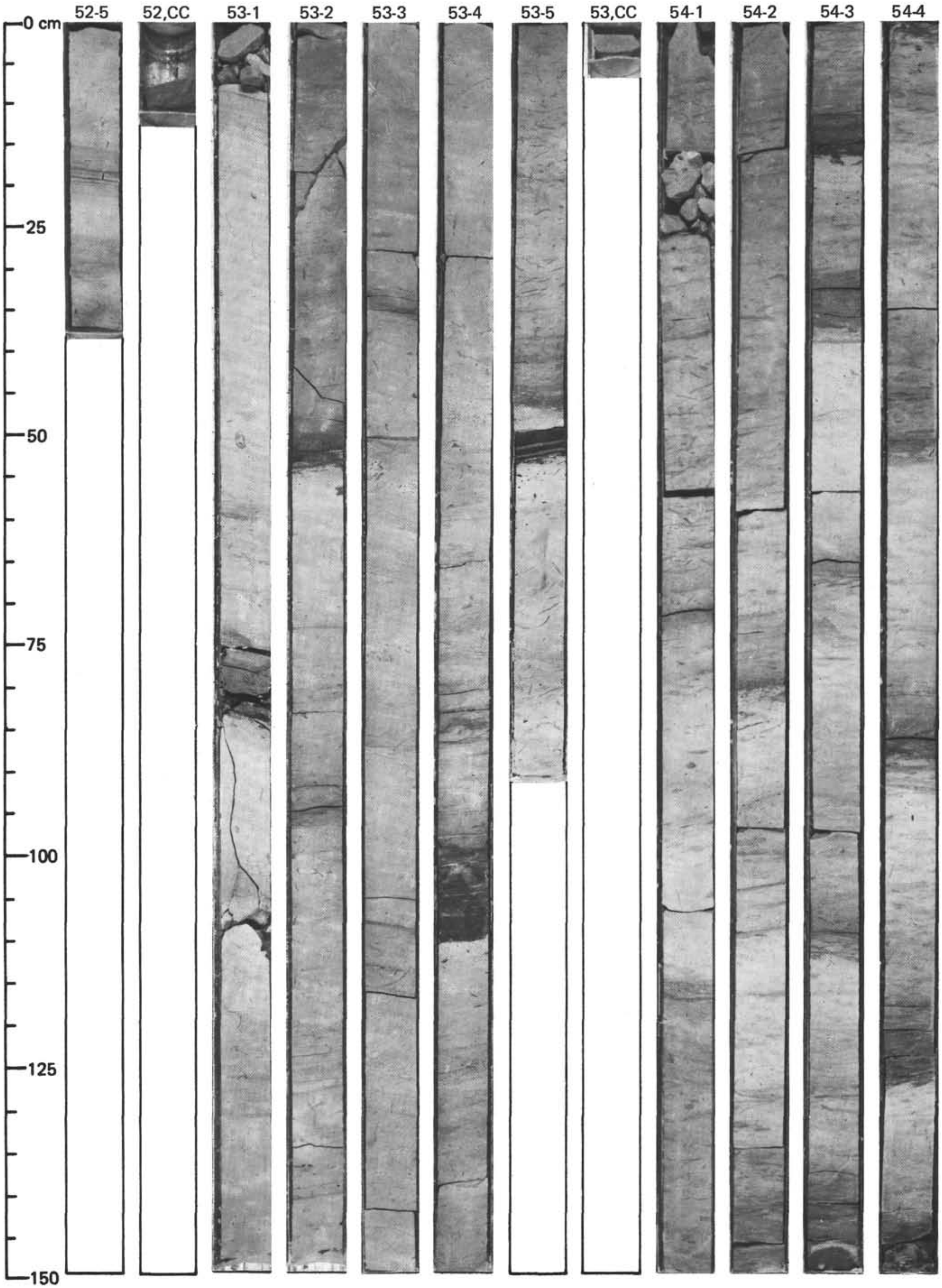

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53-2
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53,CC
54-1
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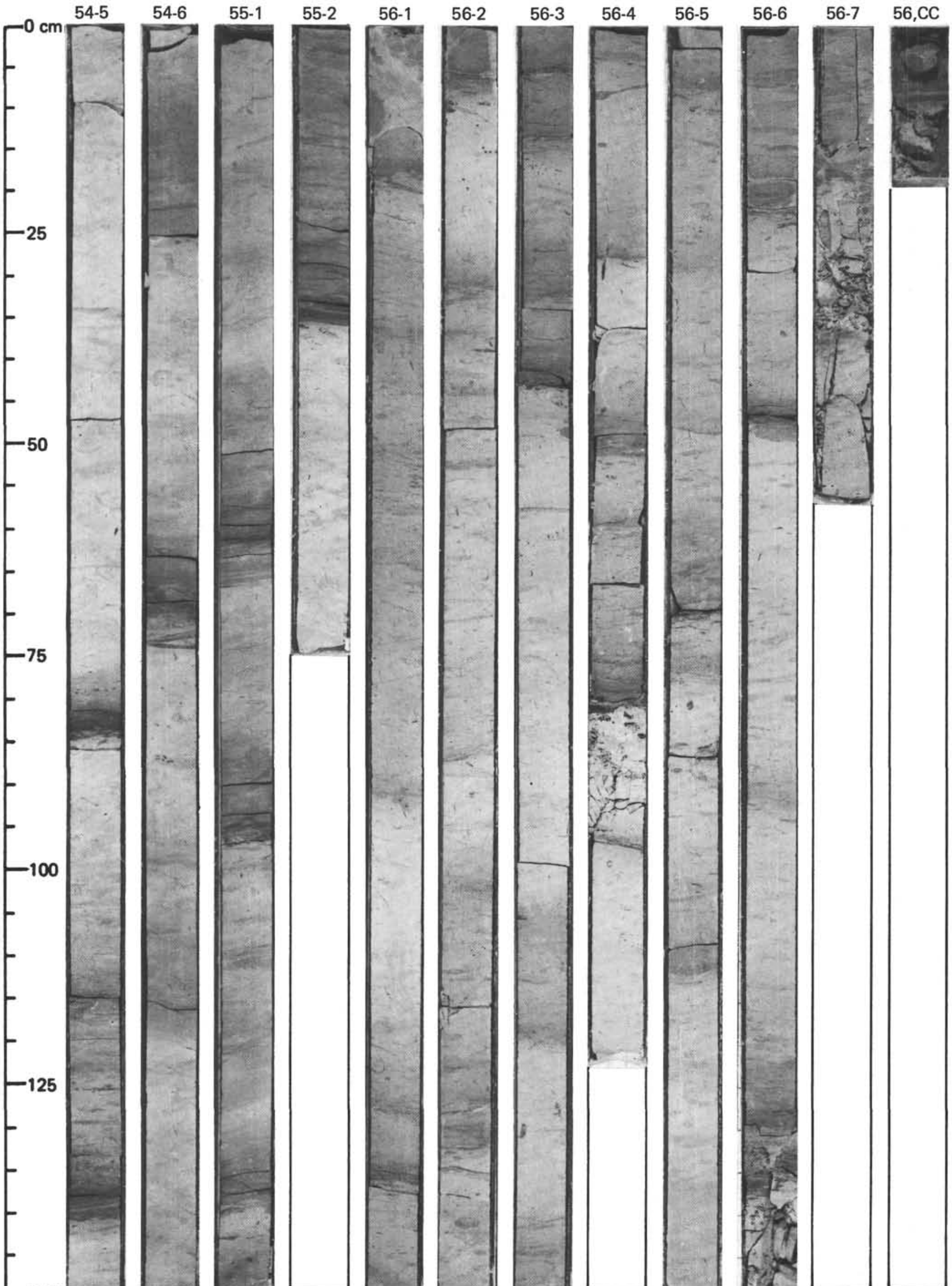
54-3
54-4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55-2
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56-6
56-7
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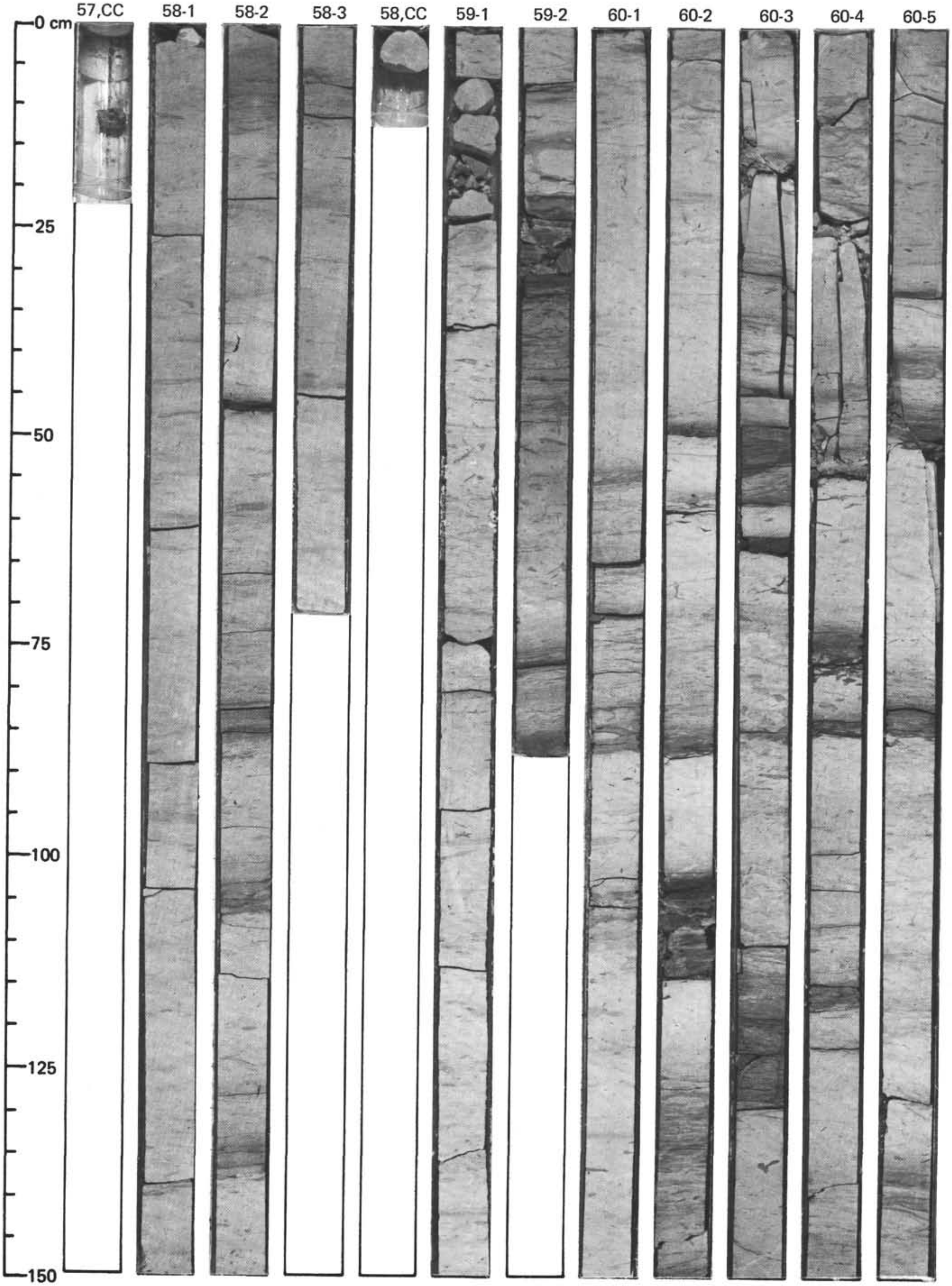

0 cm
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57,CC
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58-2
58-3
58,CC
59-1
59-2
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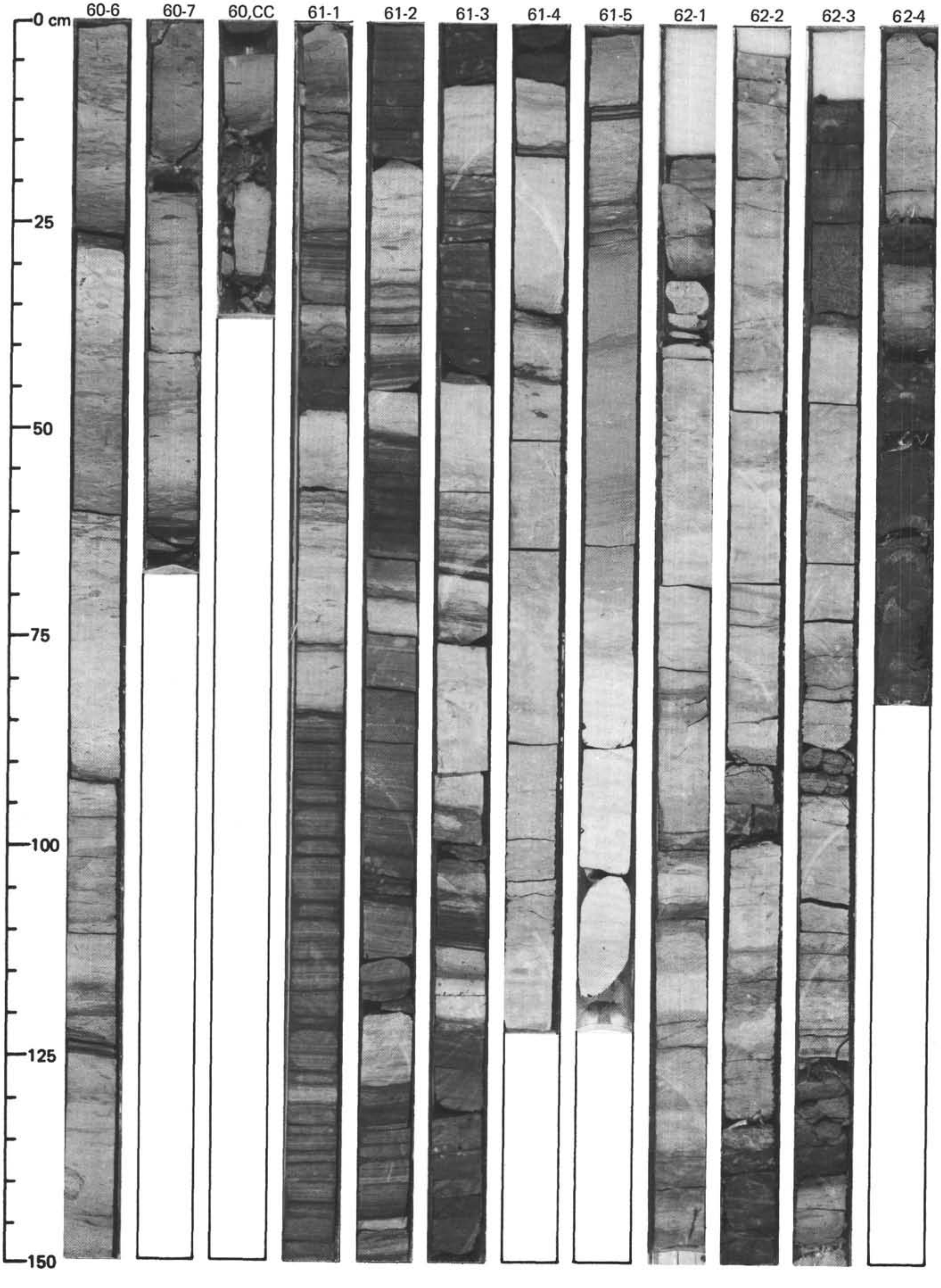
60-3
60-4
60-5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61-1
61-2
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61-5
62-1
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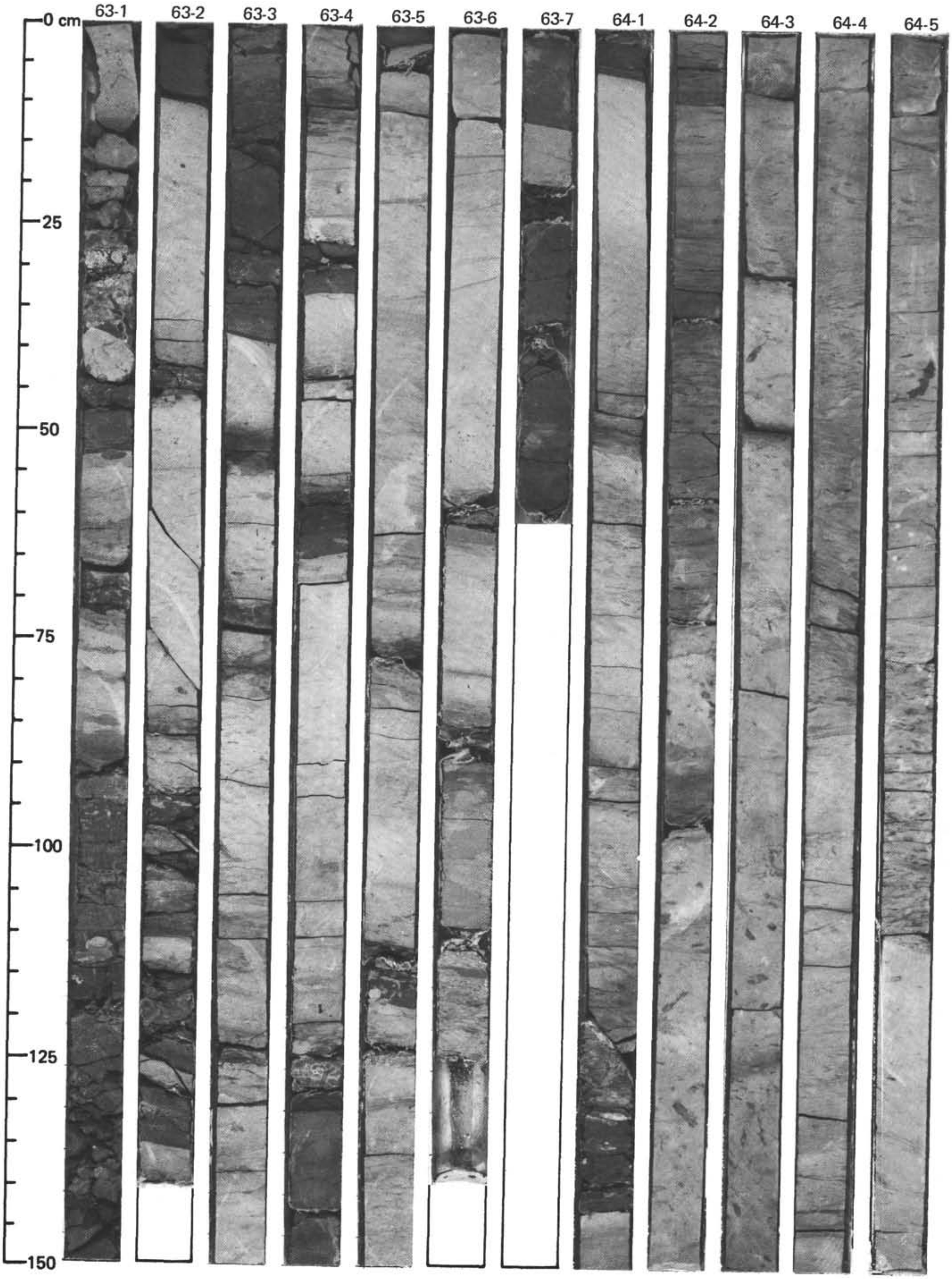
62-3
62-4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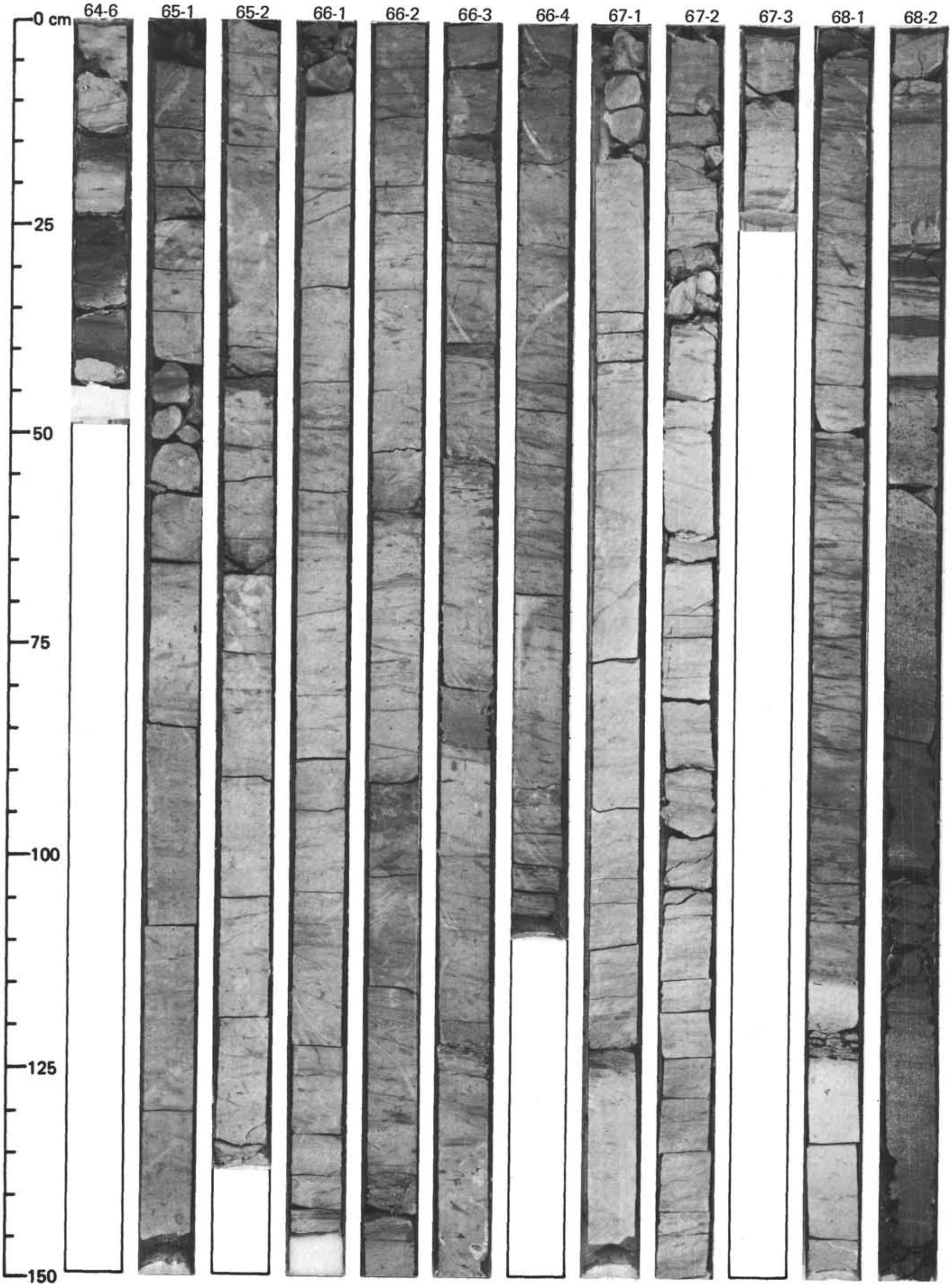
64-5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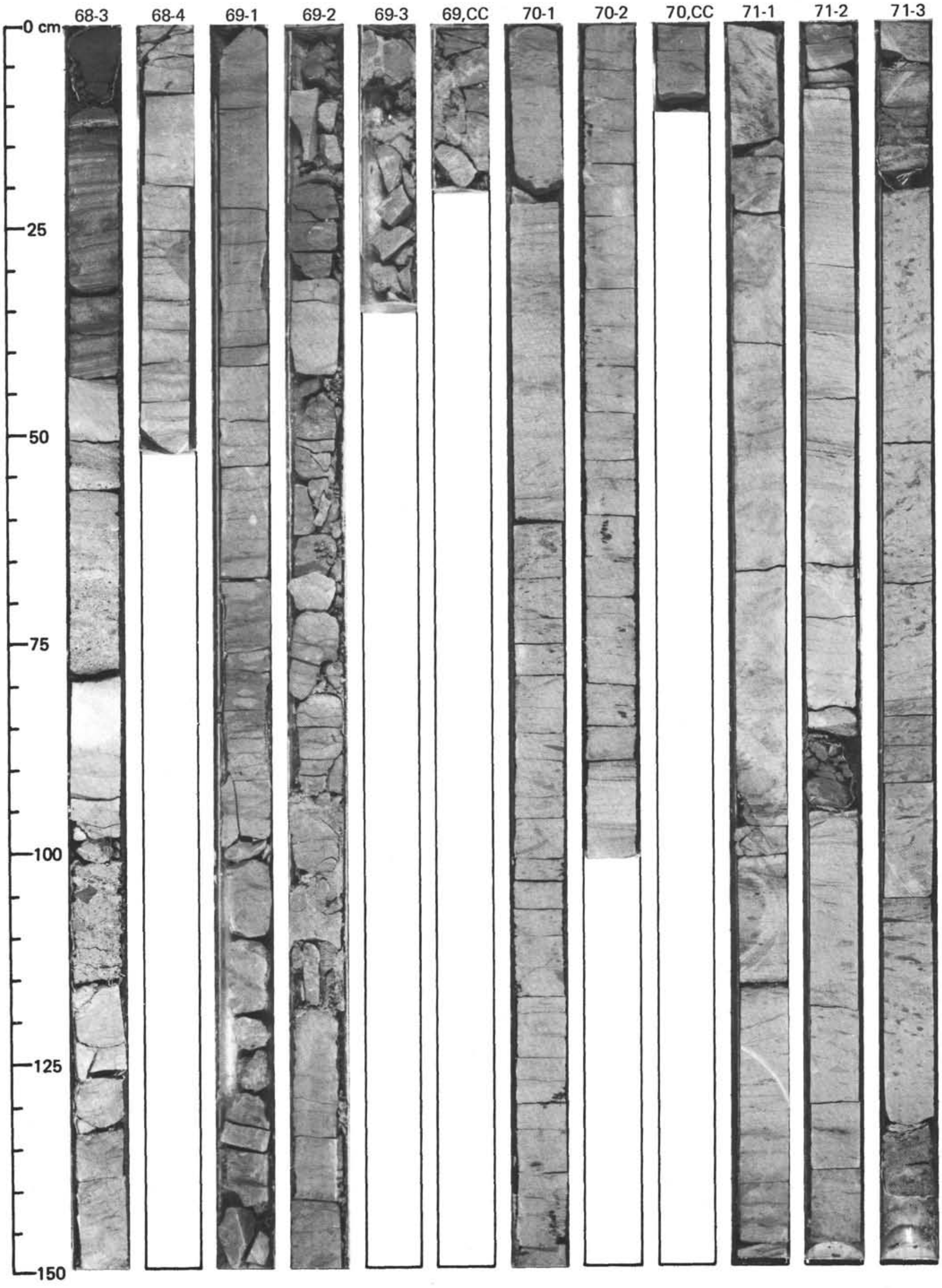
67-2
67-3
68-1
68-2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69-1
69-2
69-3
69,CC
70-1
70-2
70,CC
71-1
71-2
71-3
0 cm
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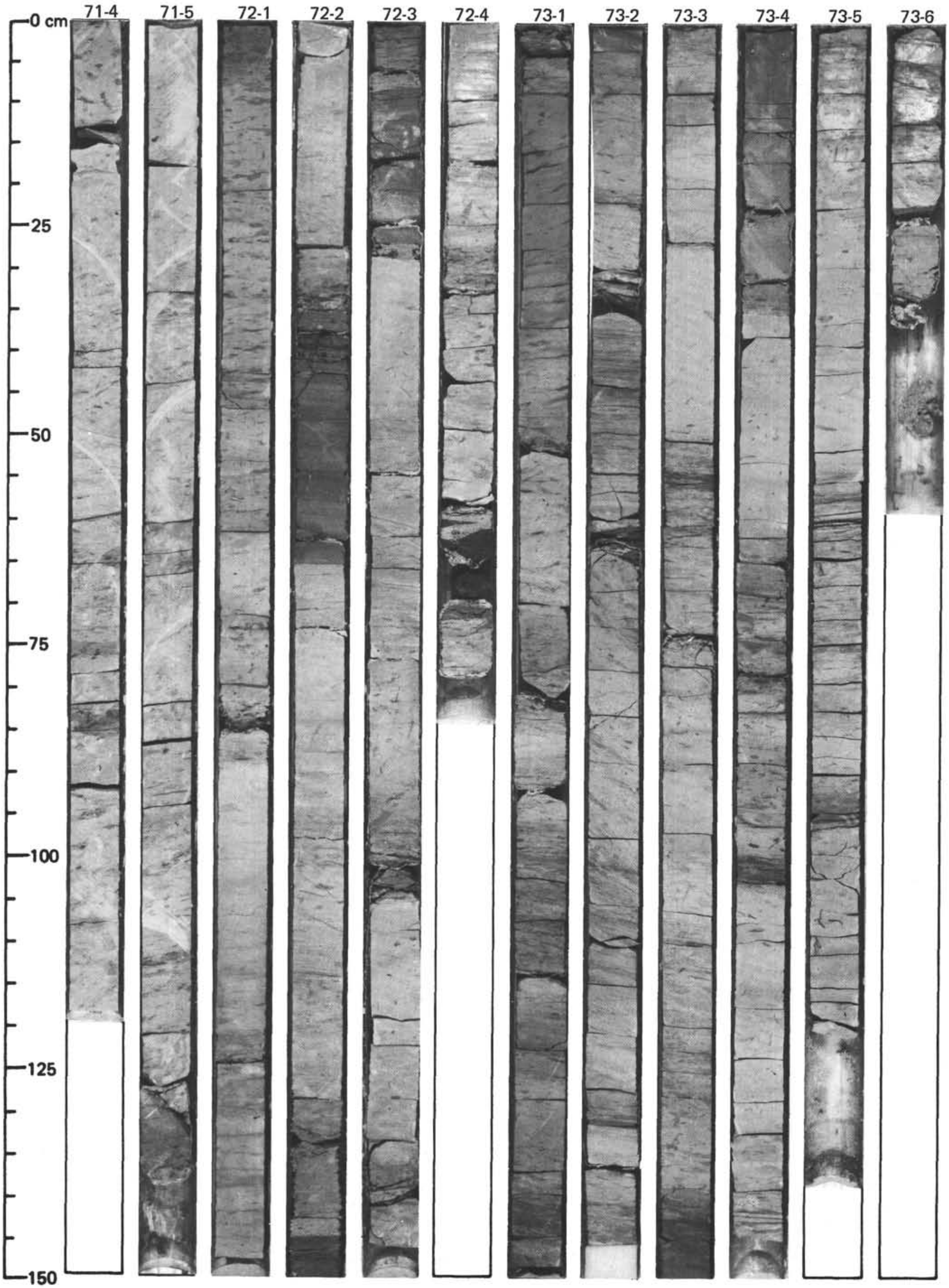
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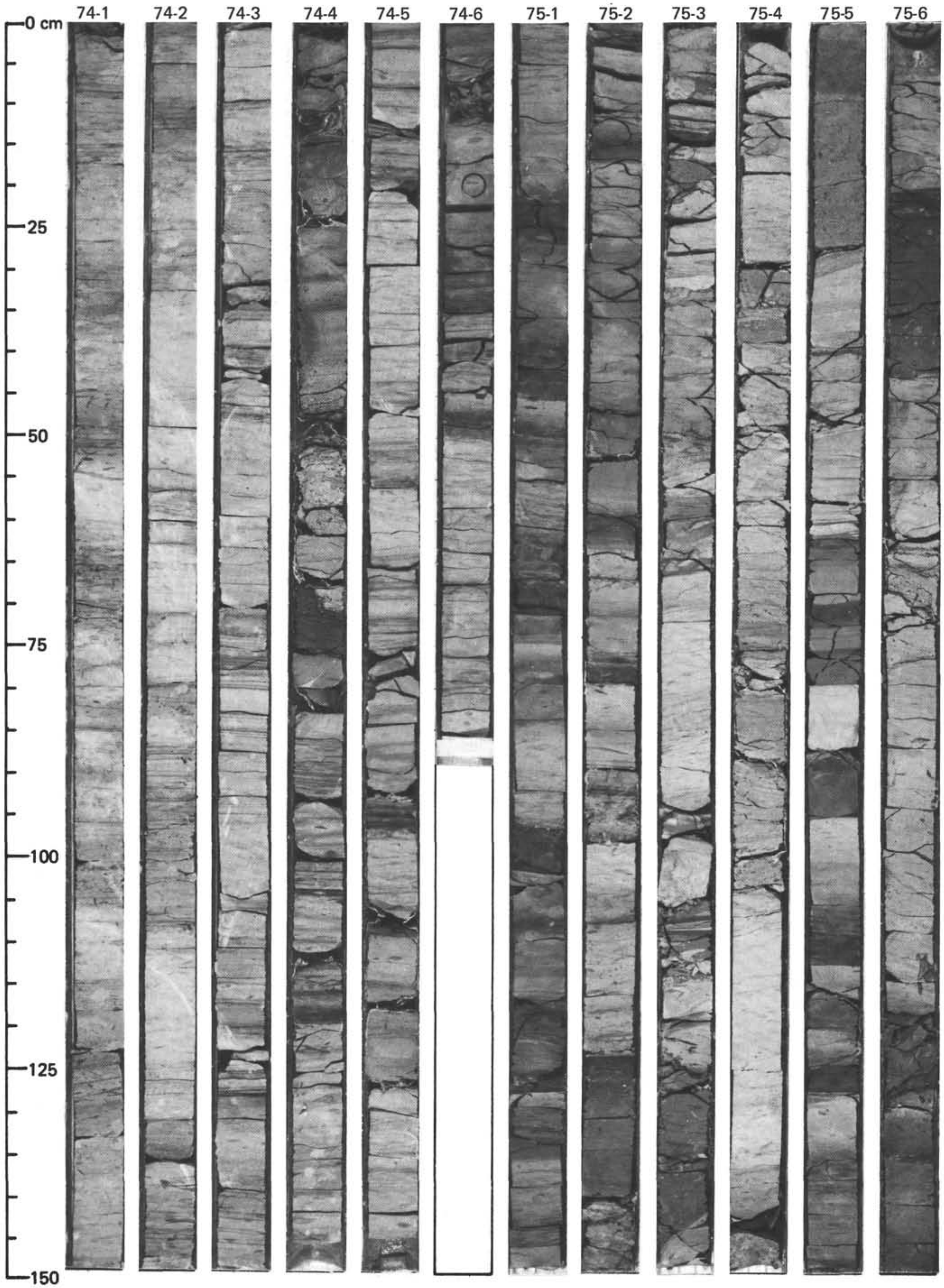
73-6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0 cm
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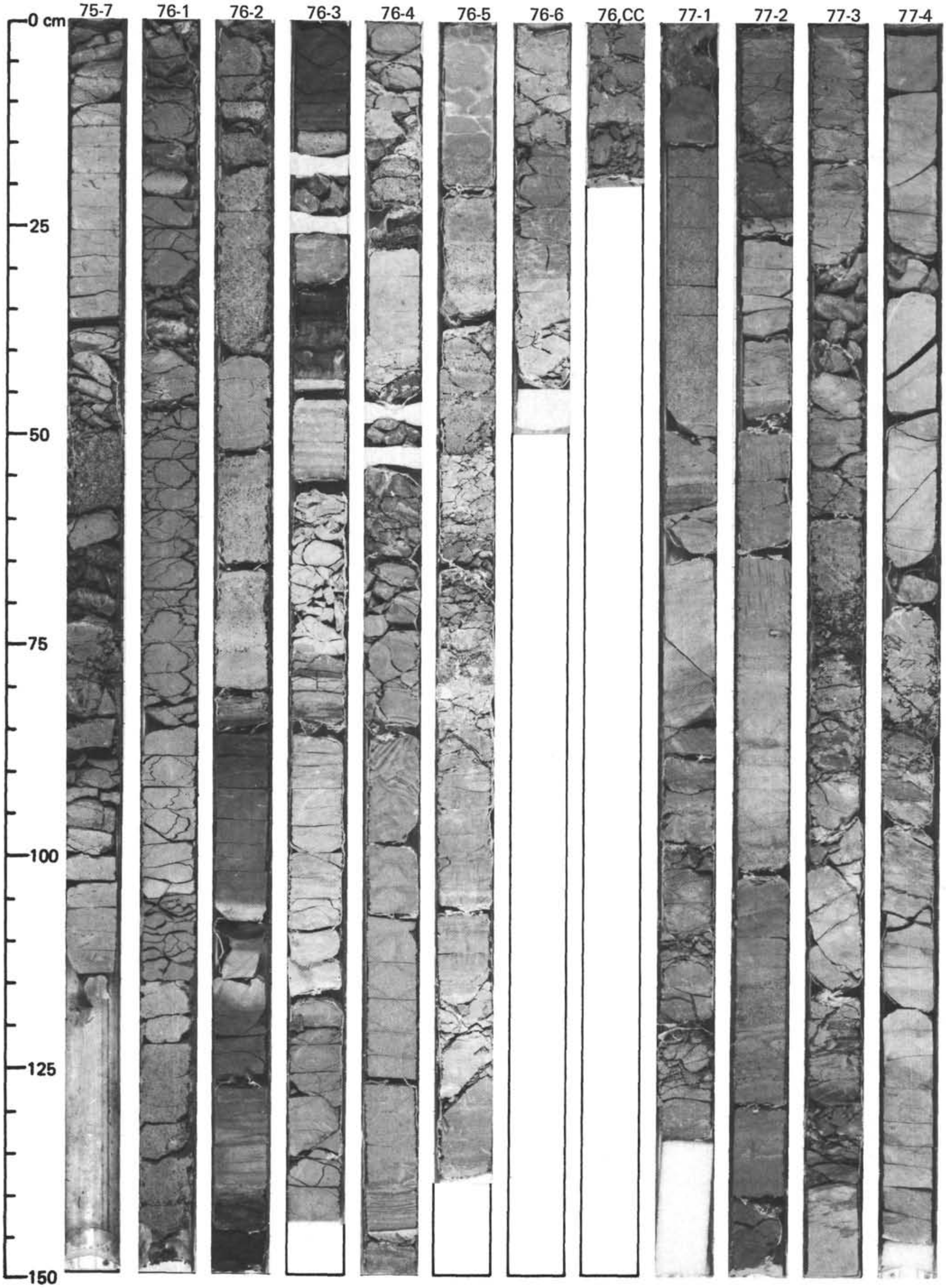
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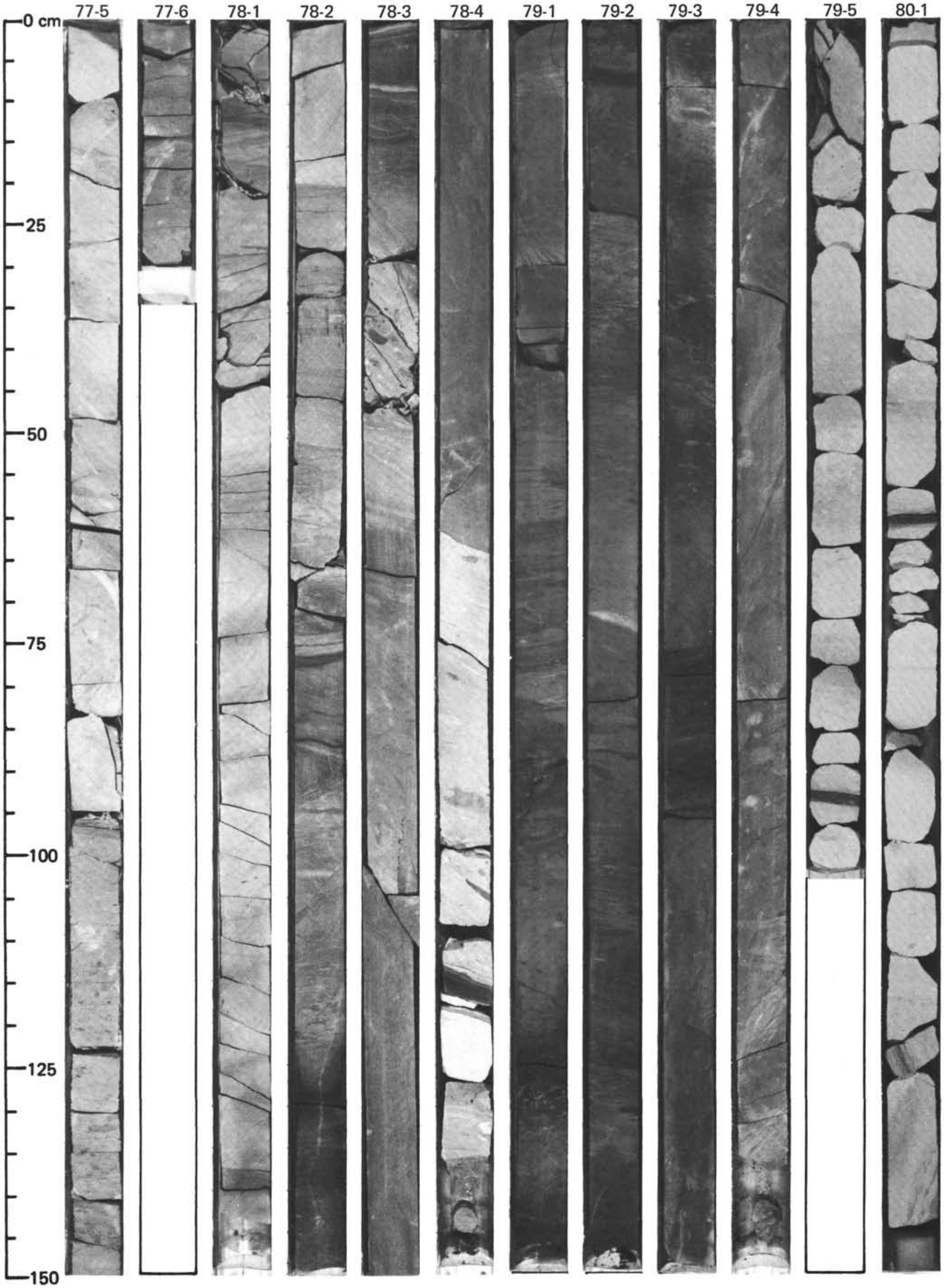
77-4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79-2
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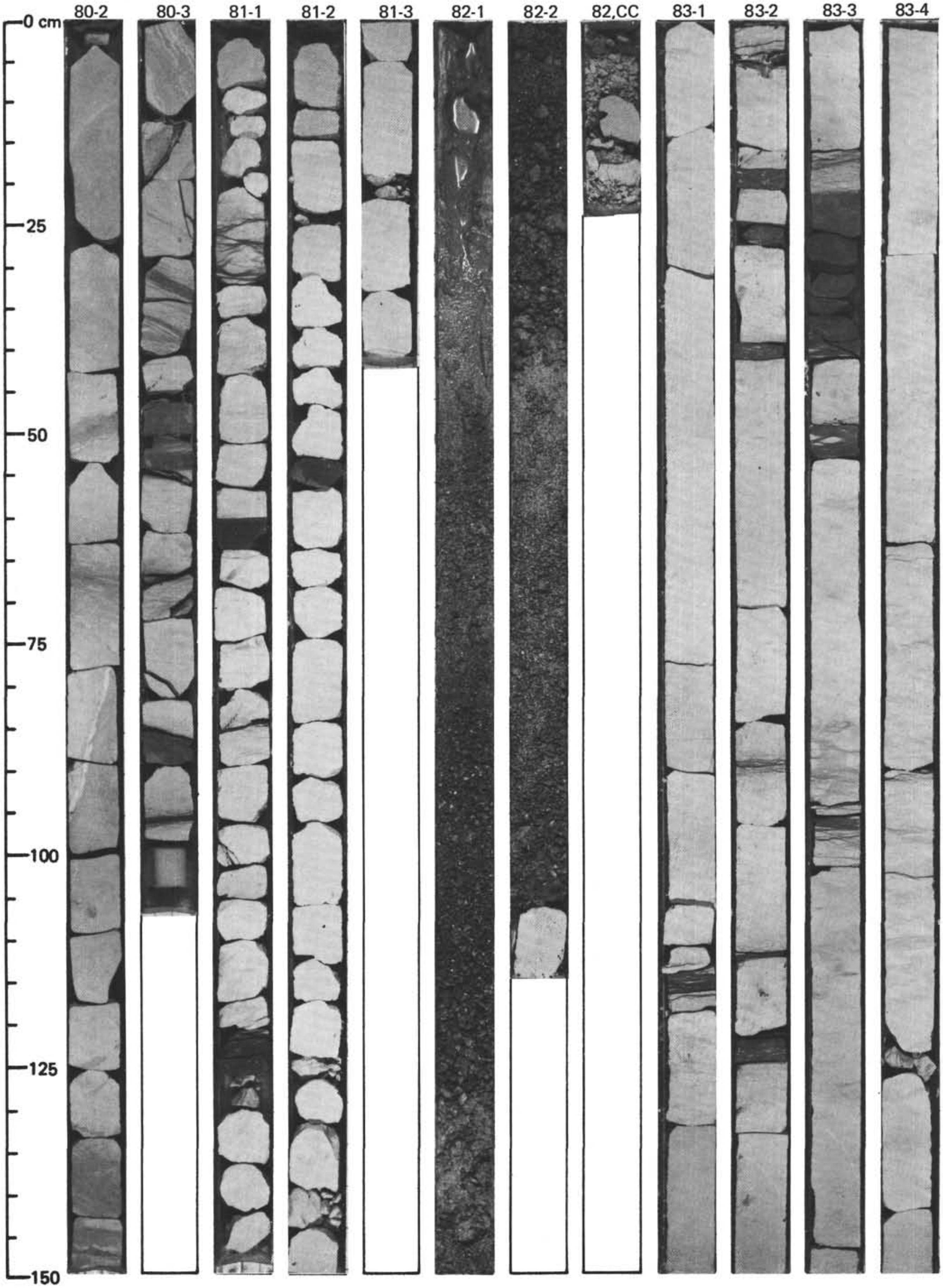
79-5
80-1



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81-1
81-2
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82,CC
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83-3
83-4
0 cm
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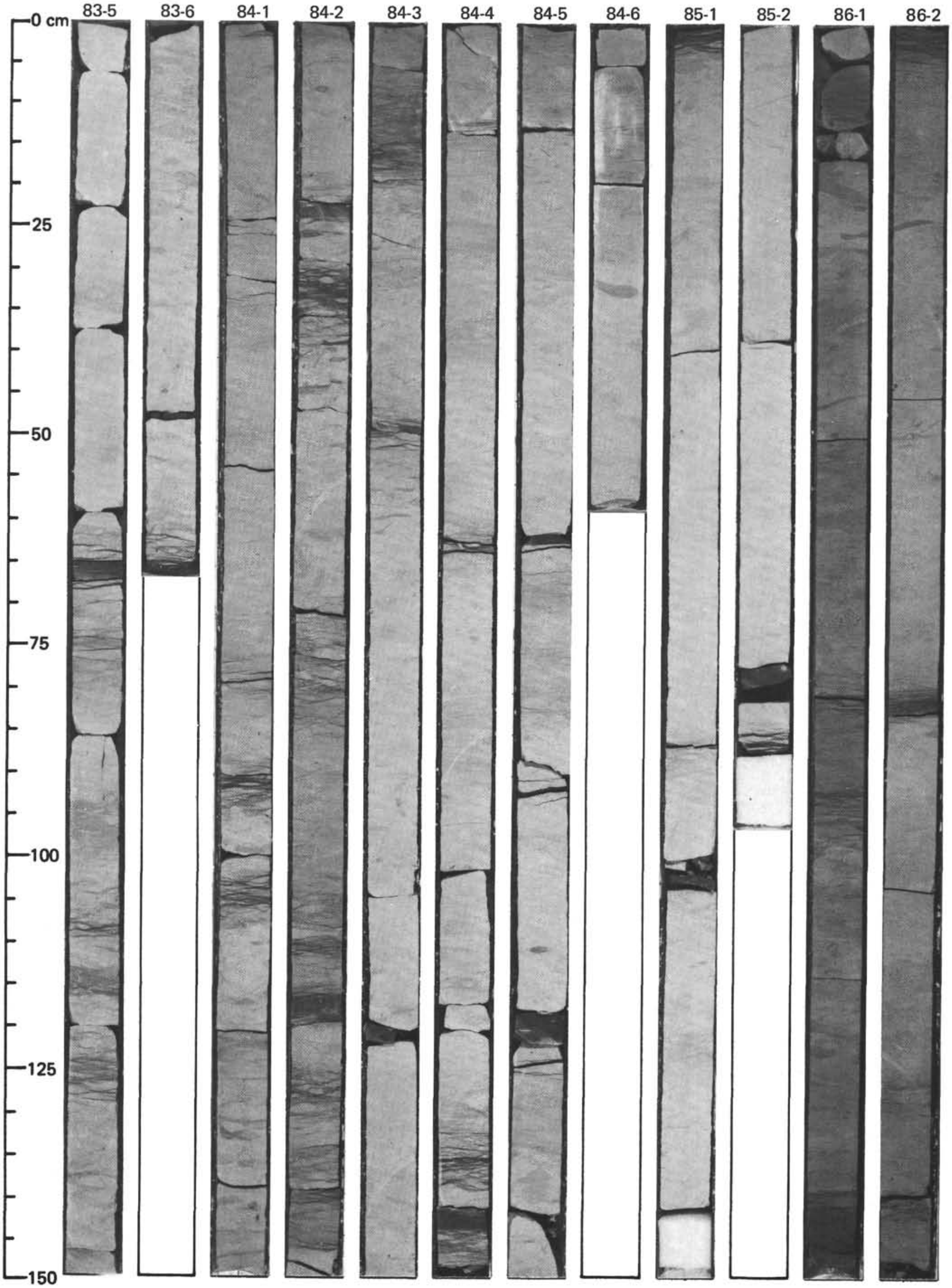
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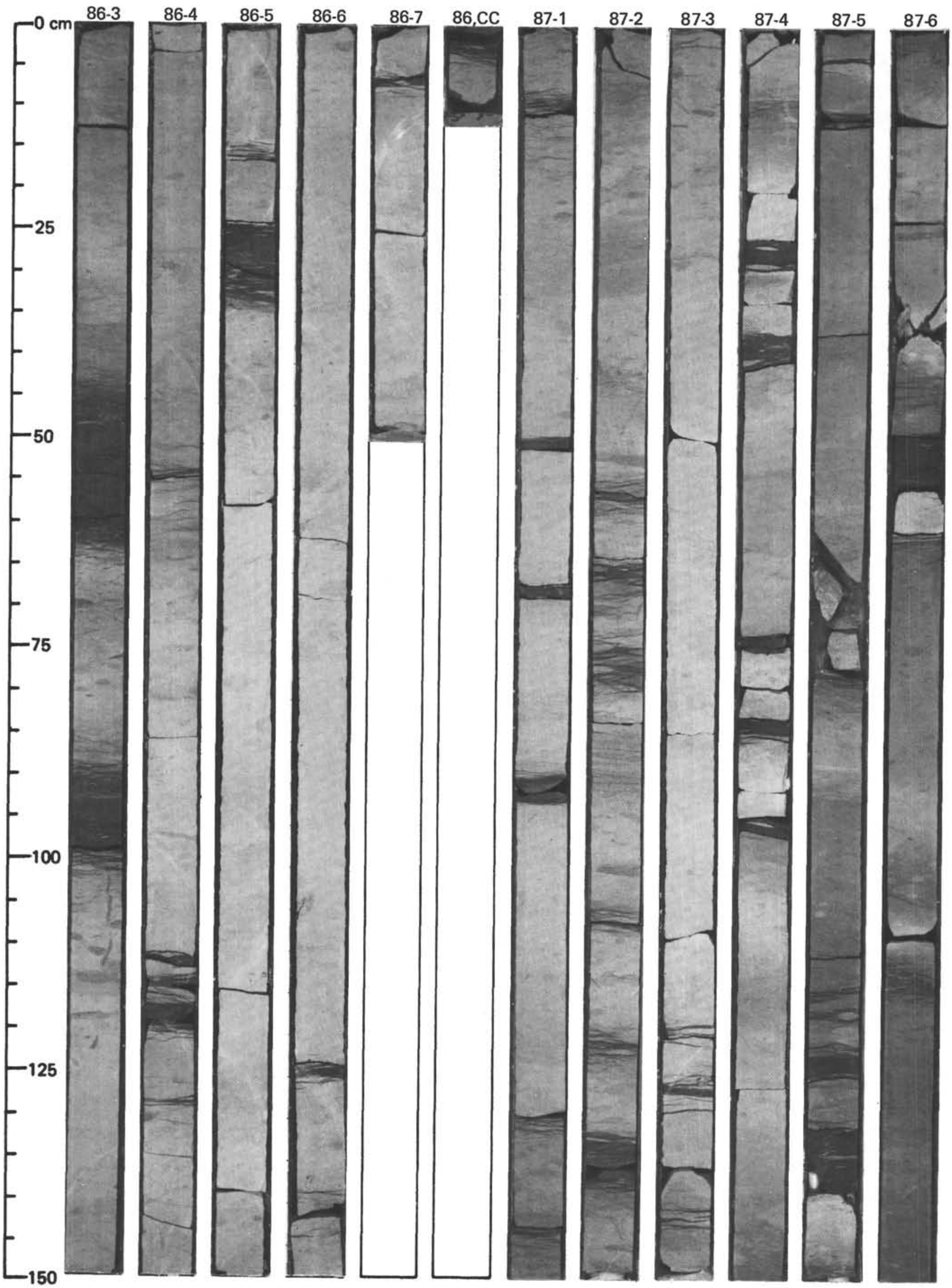
86-1
86-2



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86-6
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86,CC
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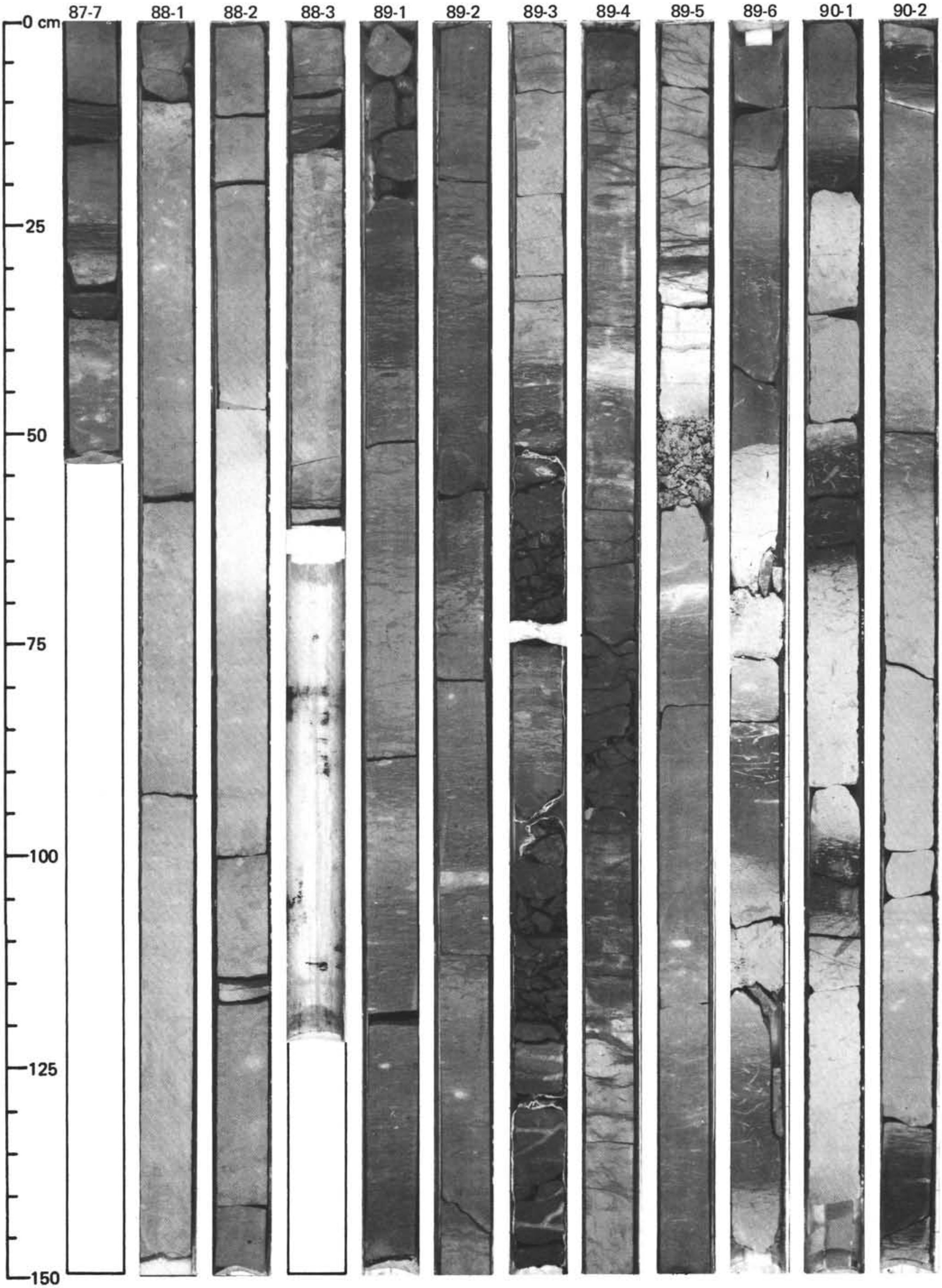
87-5
87-6



87-7
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88-2
88-3
89-1
89-2
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89-5
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90-1
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0 cm
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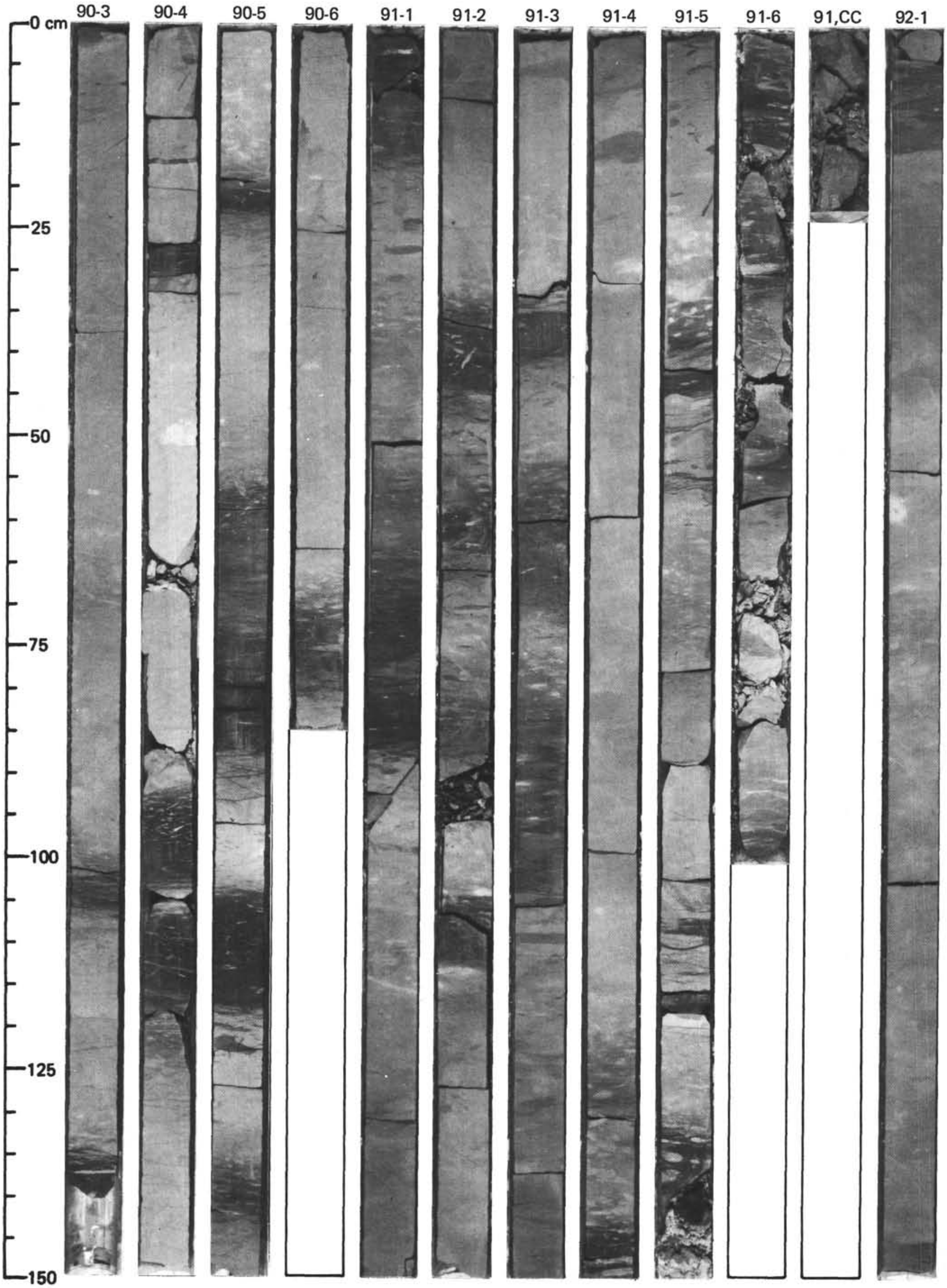
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91,CC
92-1
0 cm
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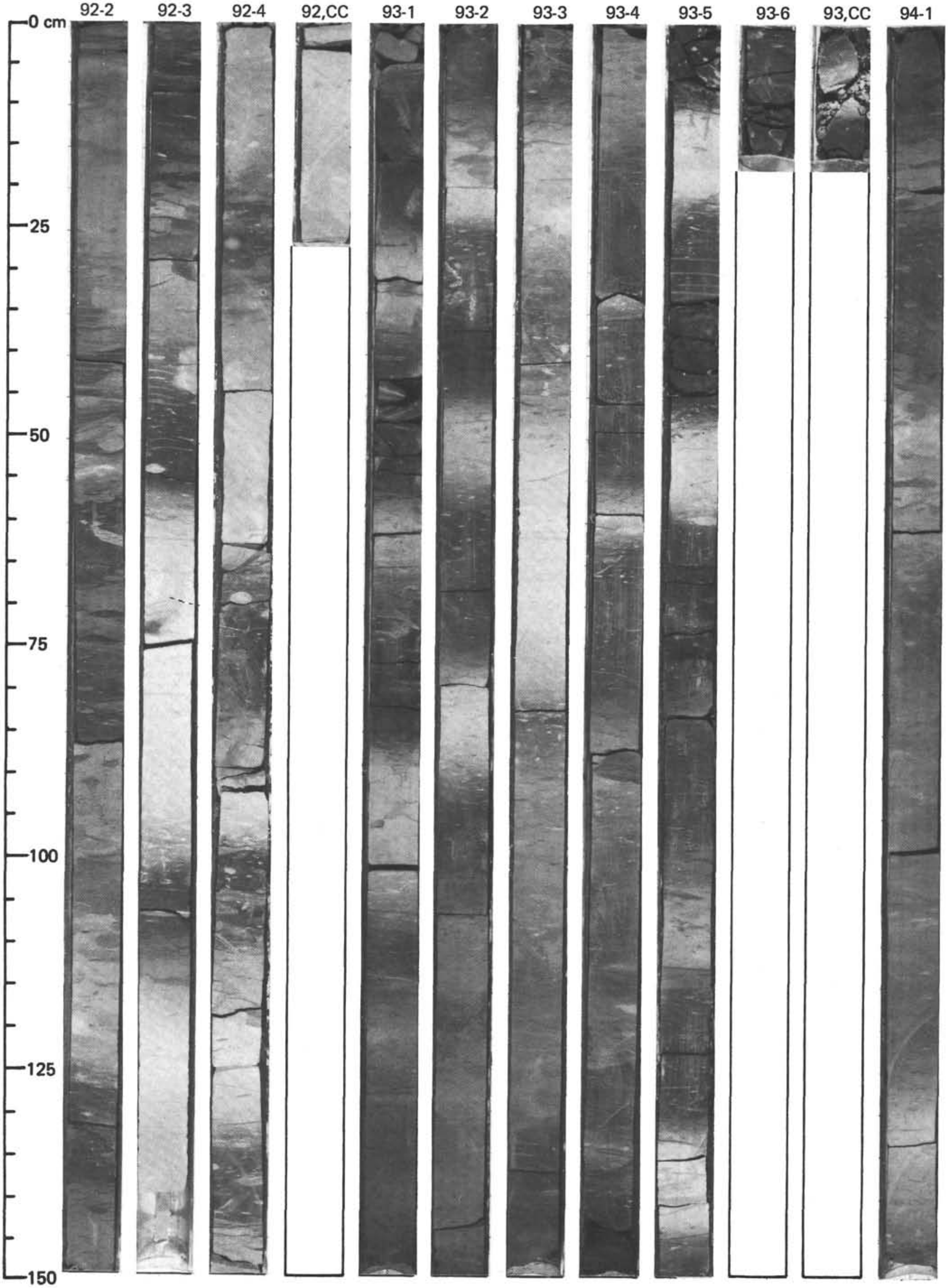
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92-3
92-4
92,CC
93-1
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93-5
93-6
93,CC
94-1
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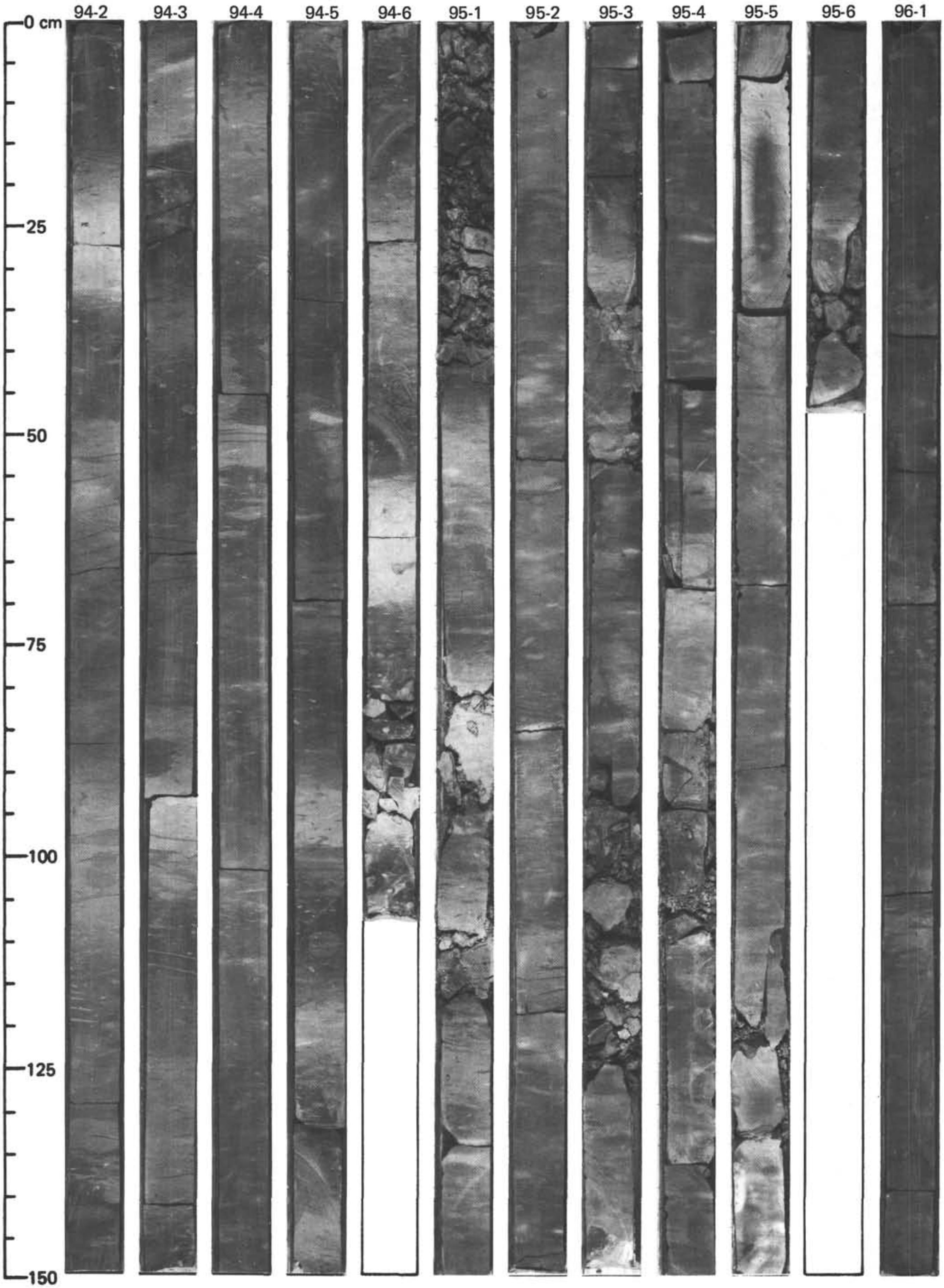
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94-5
94-6
95-1
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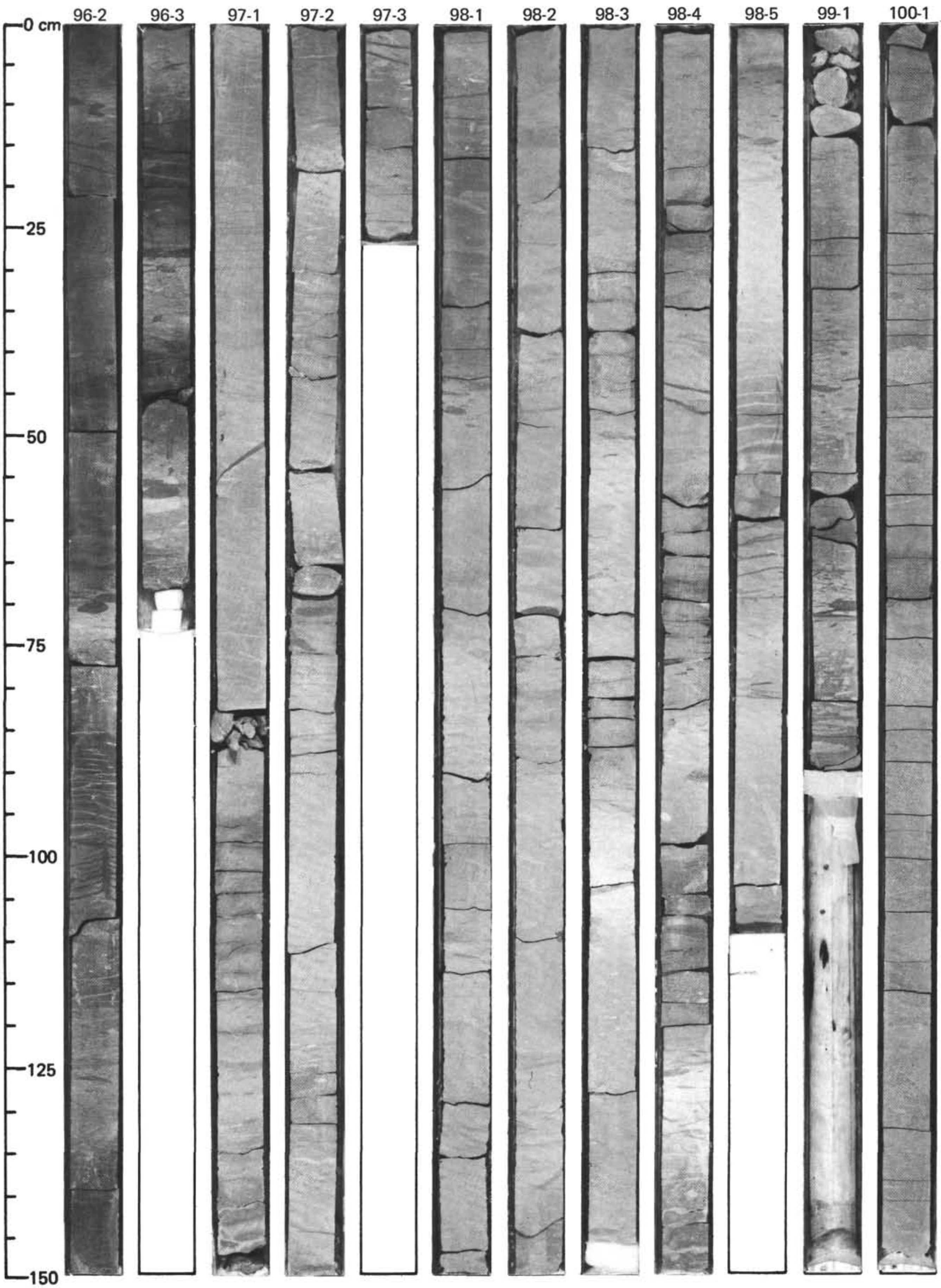
95-6
96-1



96-2
96-3
97-1
97-2
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99-1
100-1
0 cm
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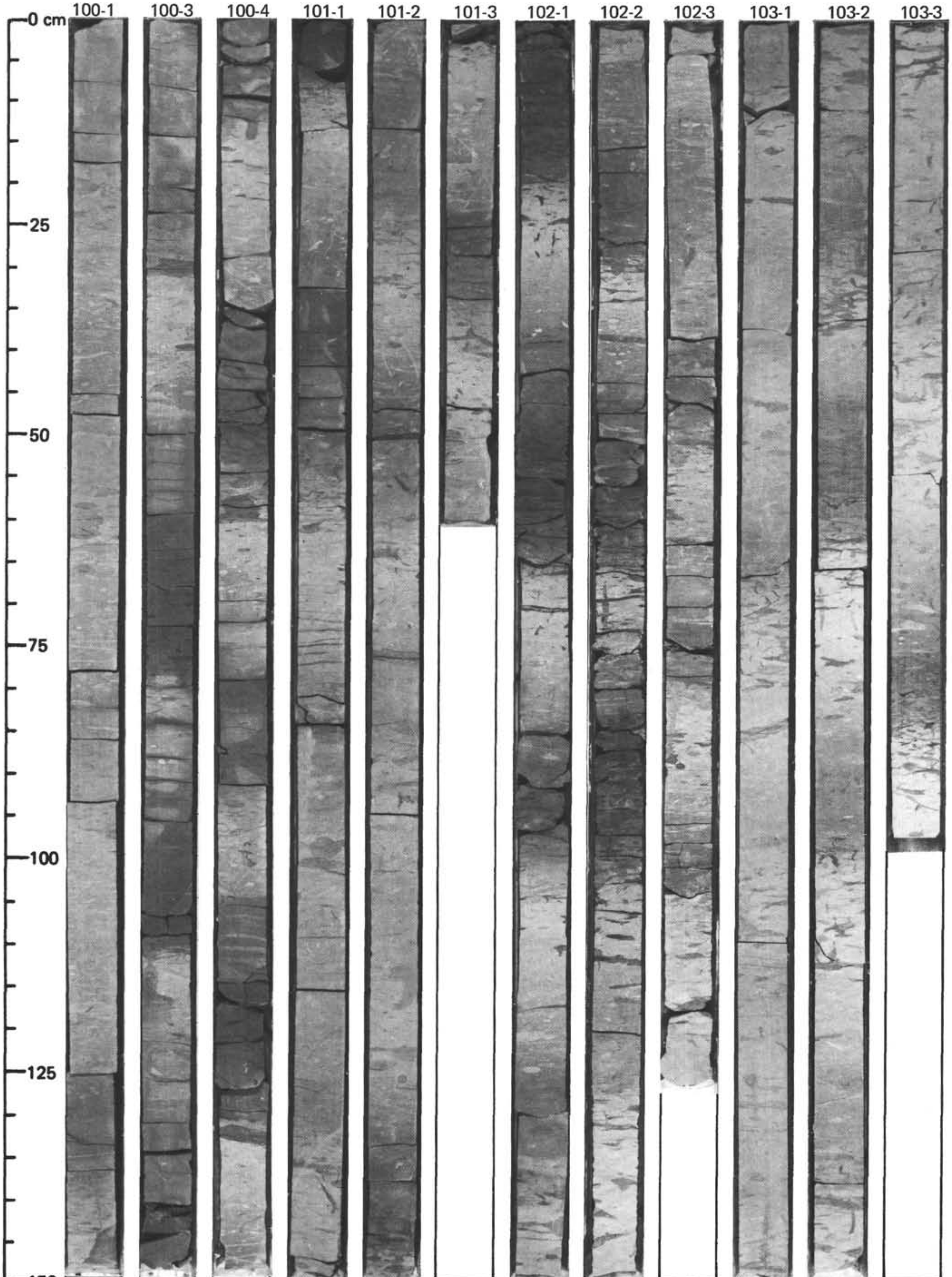
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101-3
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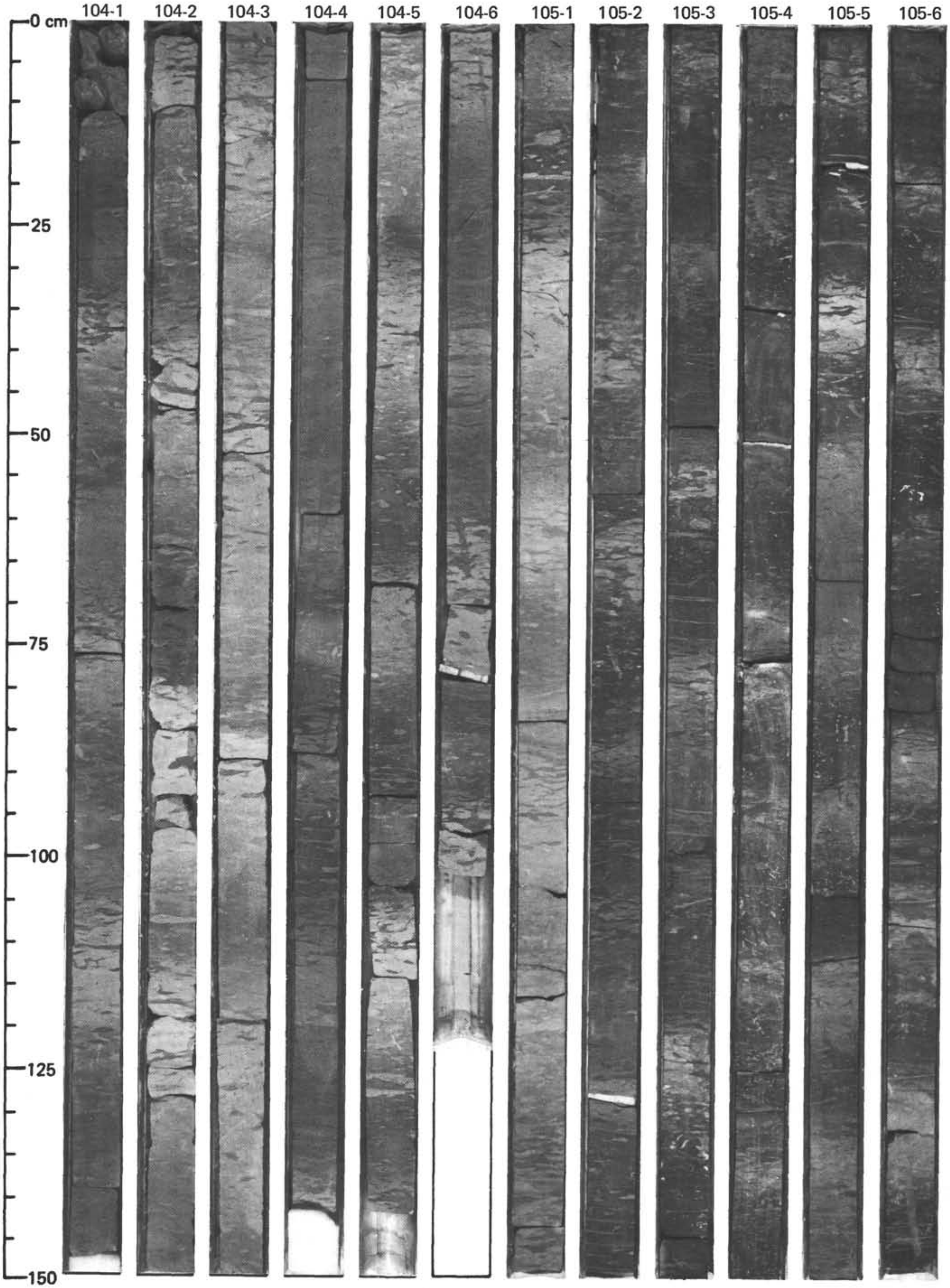
103-2
103-3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104-4
104-5
104-6
105-1
105-2
105-3
105-4
105-5
105-6
0 cm
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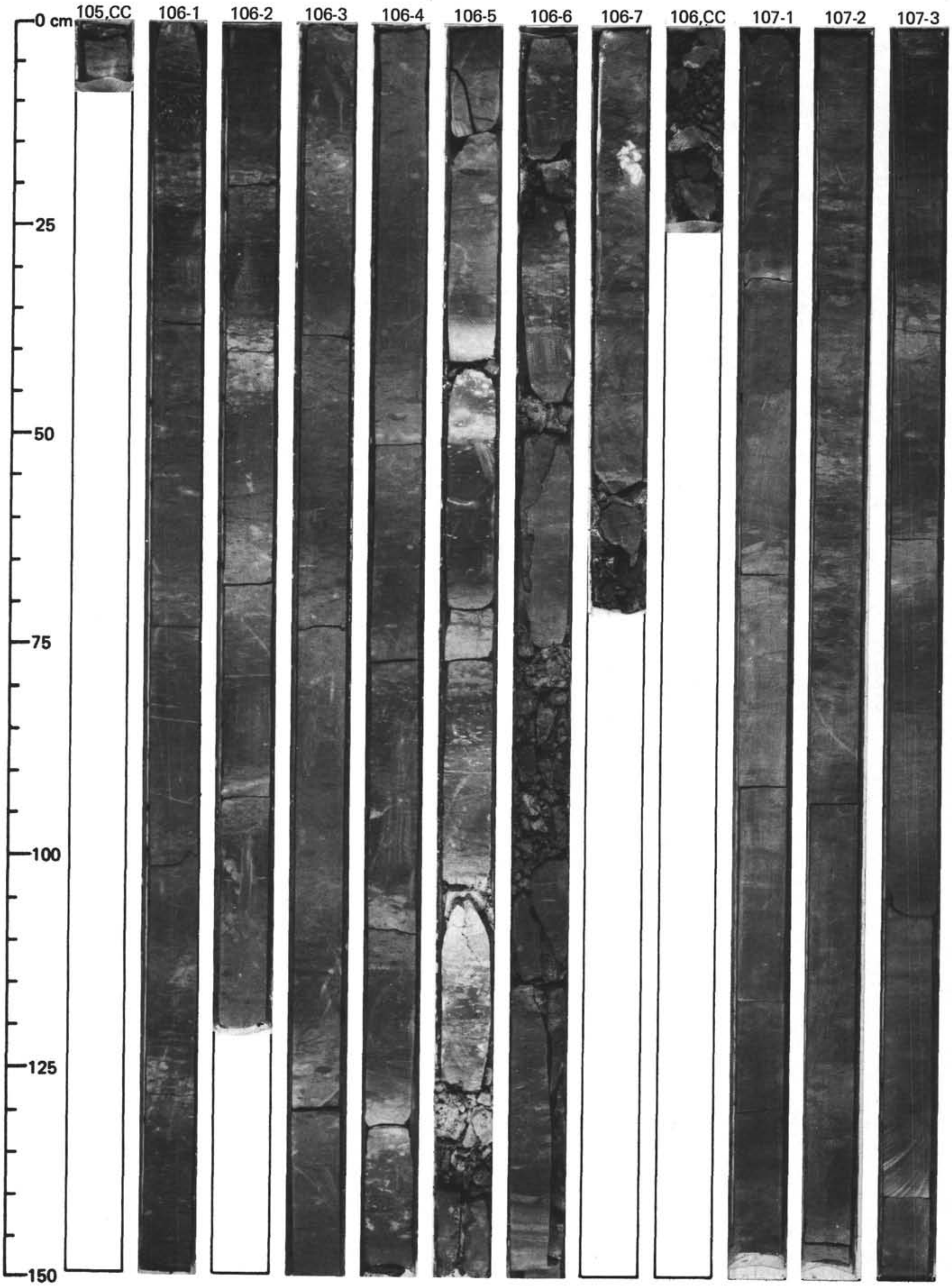
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106-5
106-6
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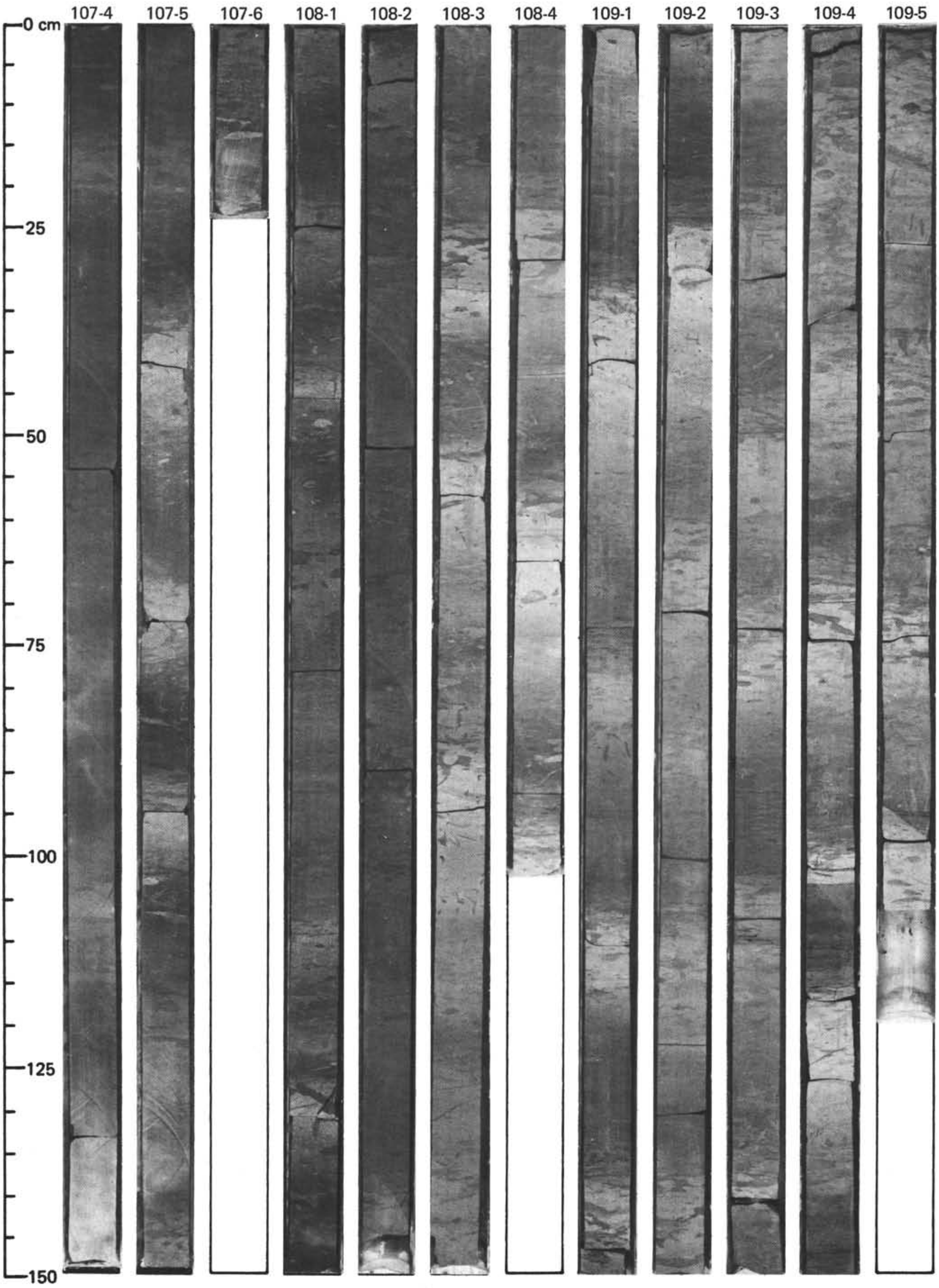
107-1
107-2
107-3


107-4
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107-6
108-1
108-2
108-3
108-4
109-1
109-2
109-3
109-4
109-5
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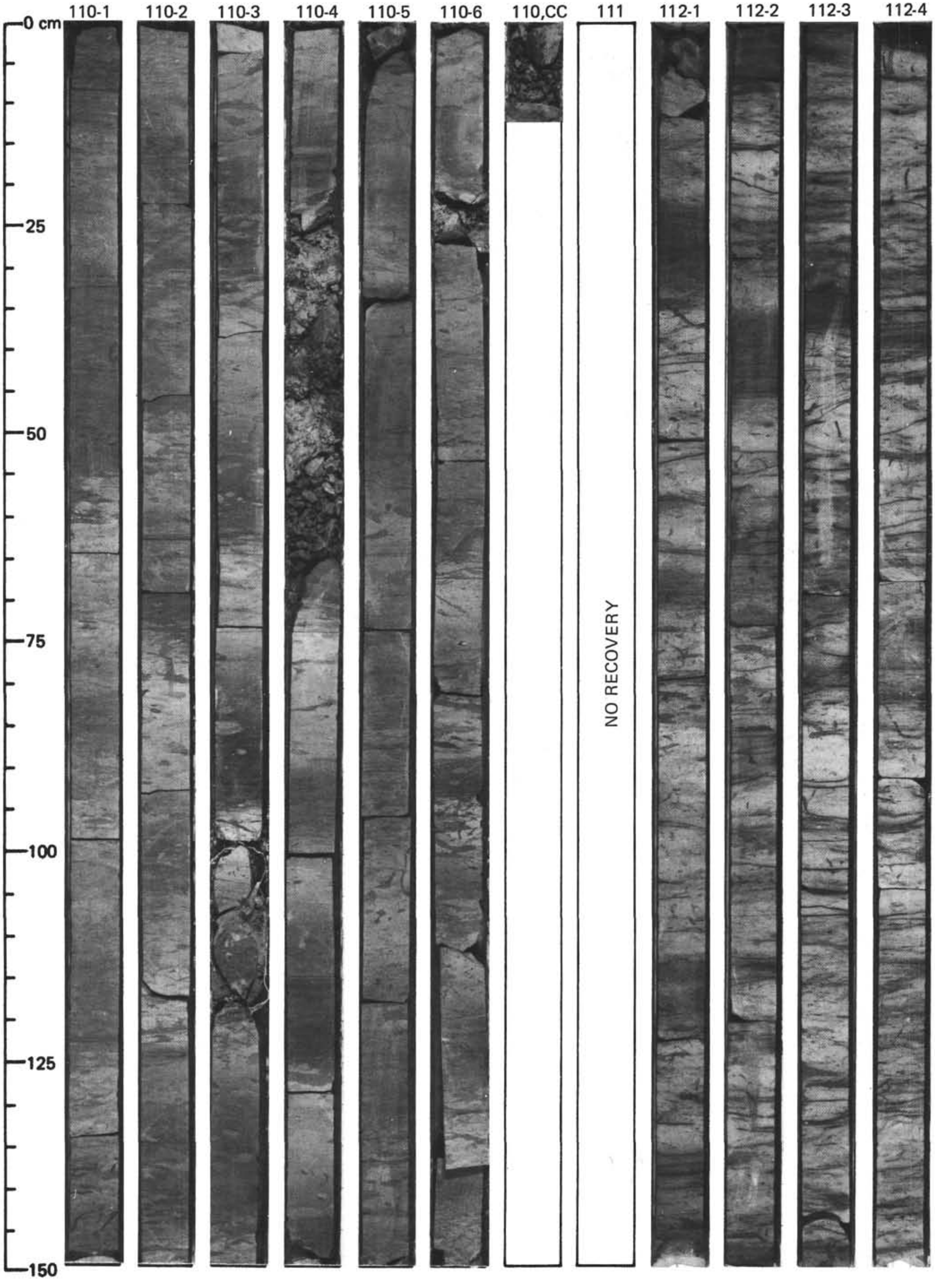
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110-1
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110-4
110-5
110-6
110,CC
111
112-1
112-2
112-3
112-4
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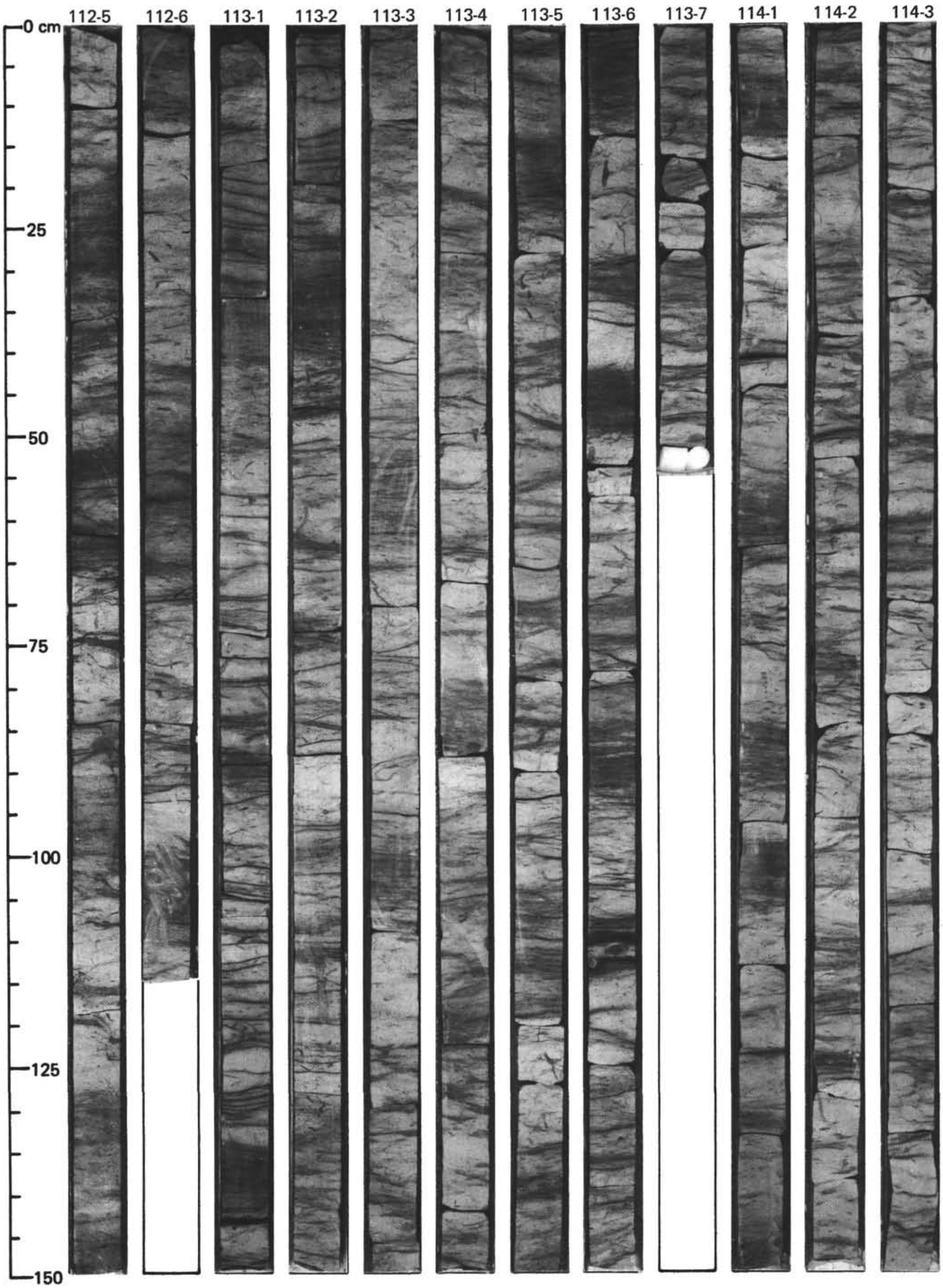
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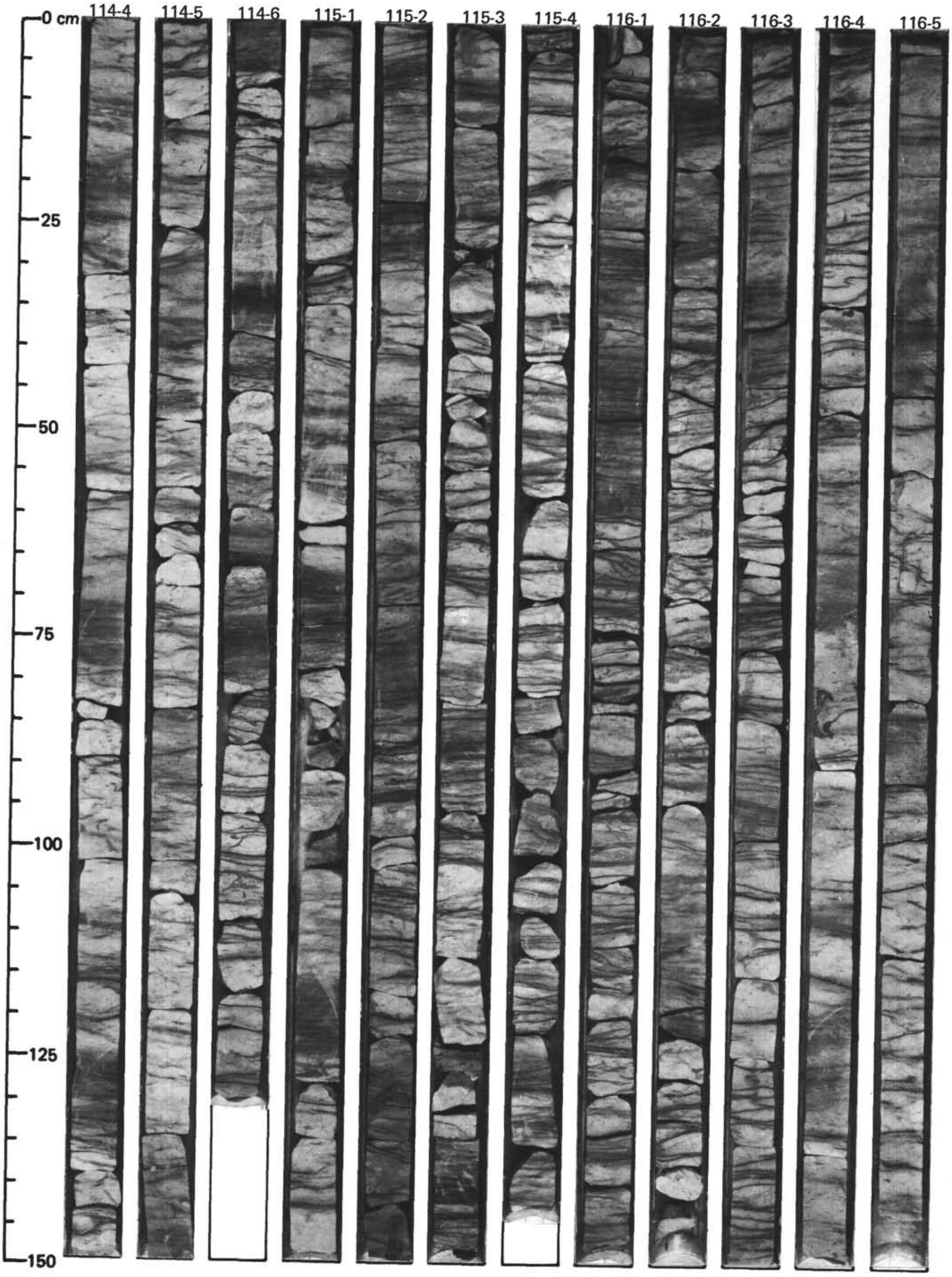
114-3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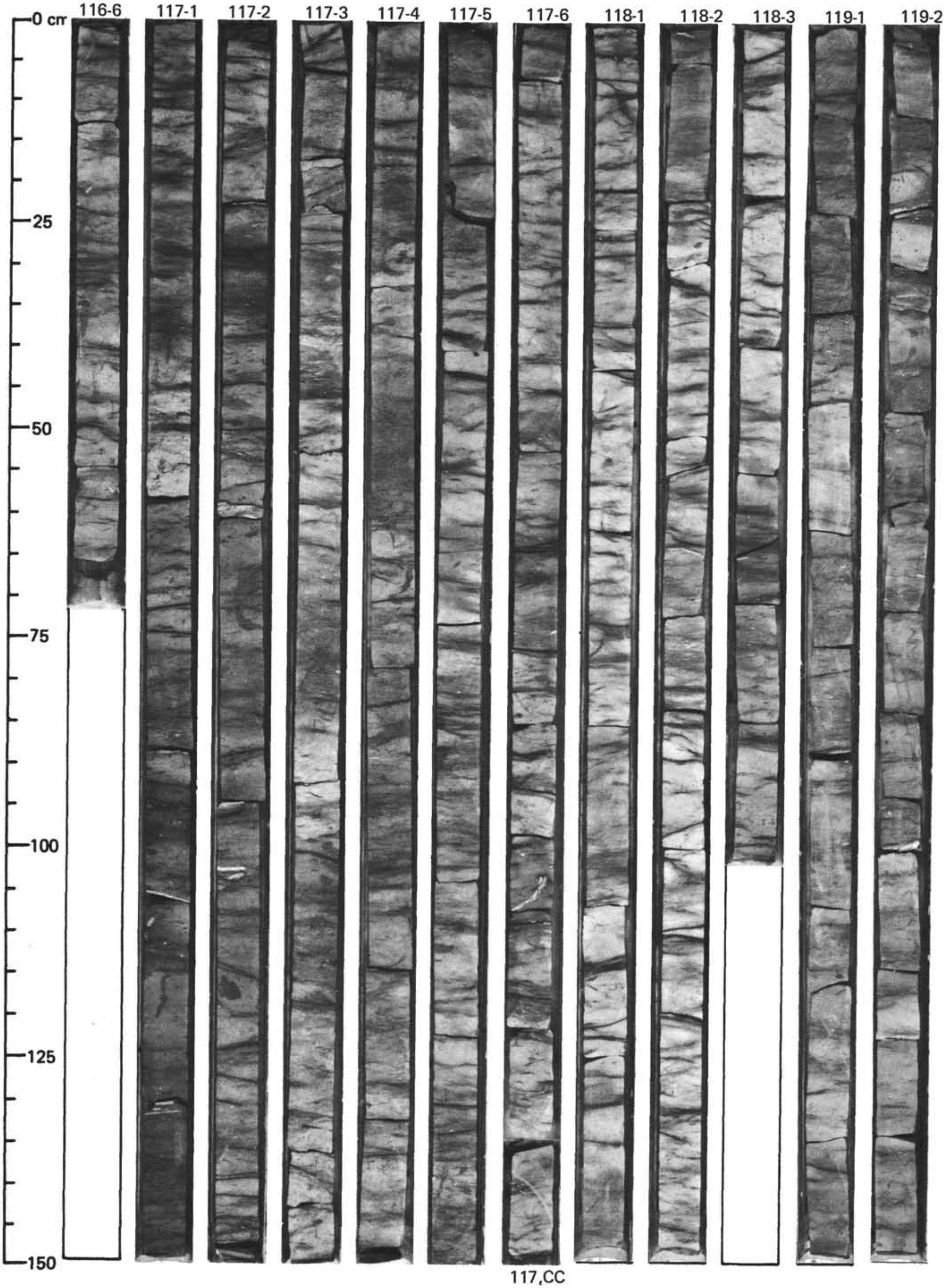
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118-2
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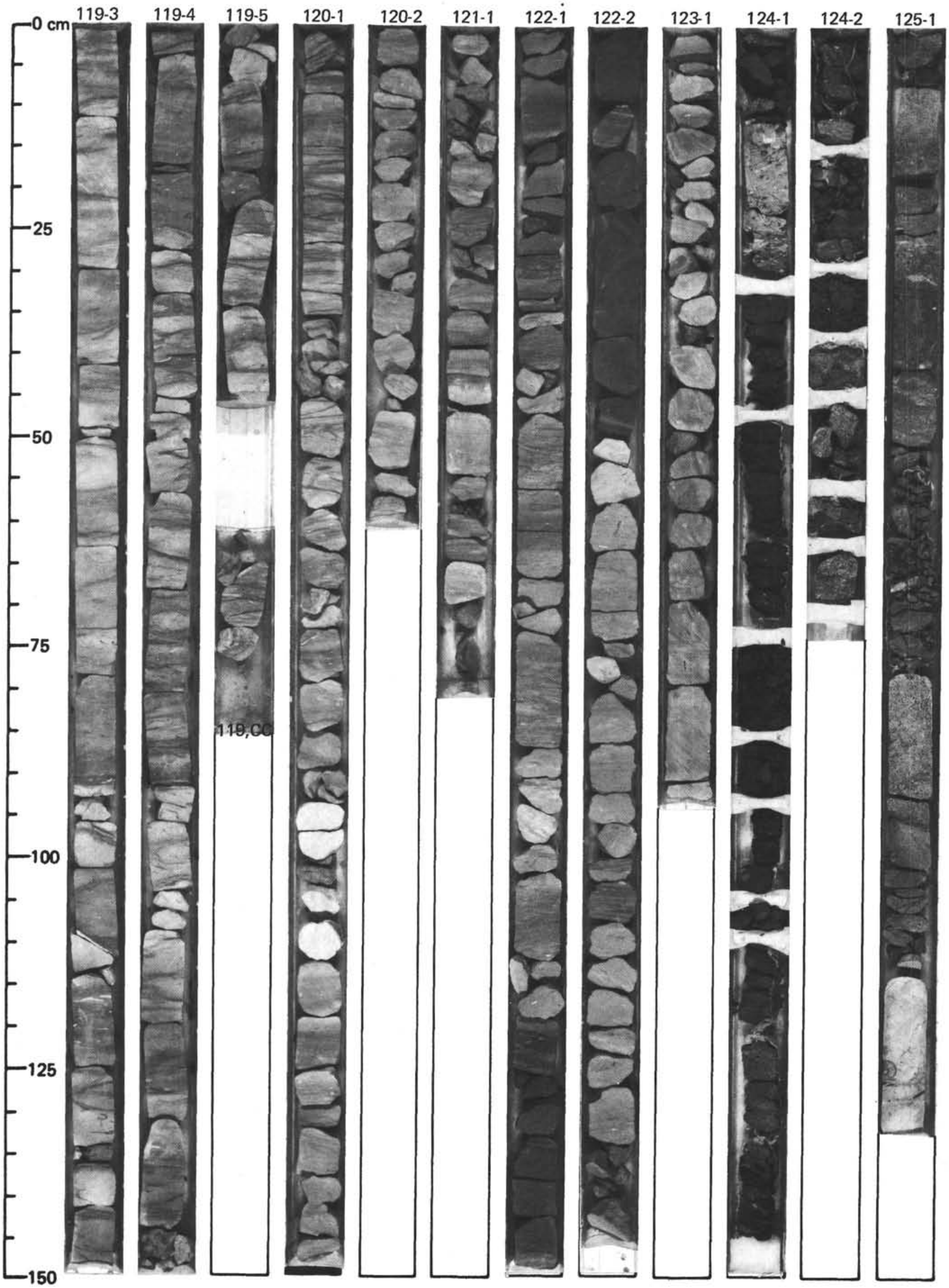
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123-1
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124-2
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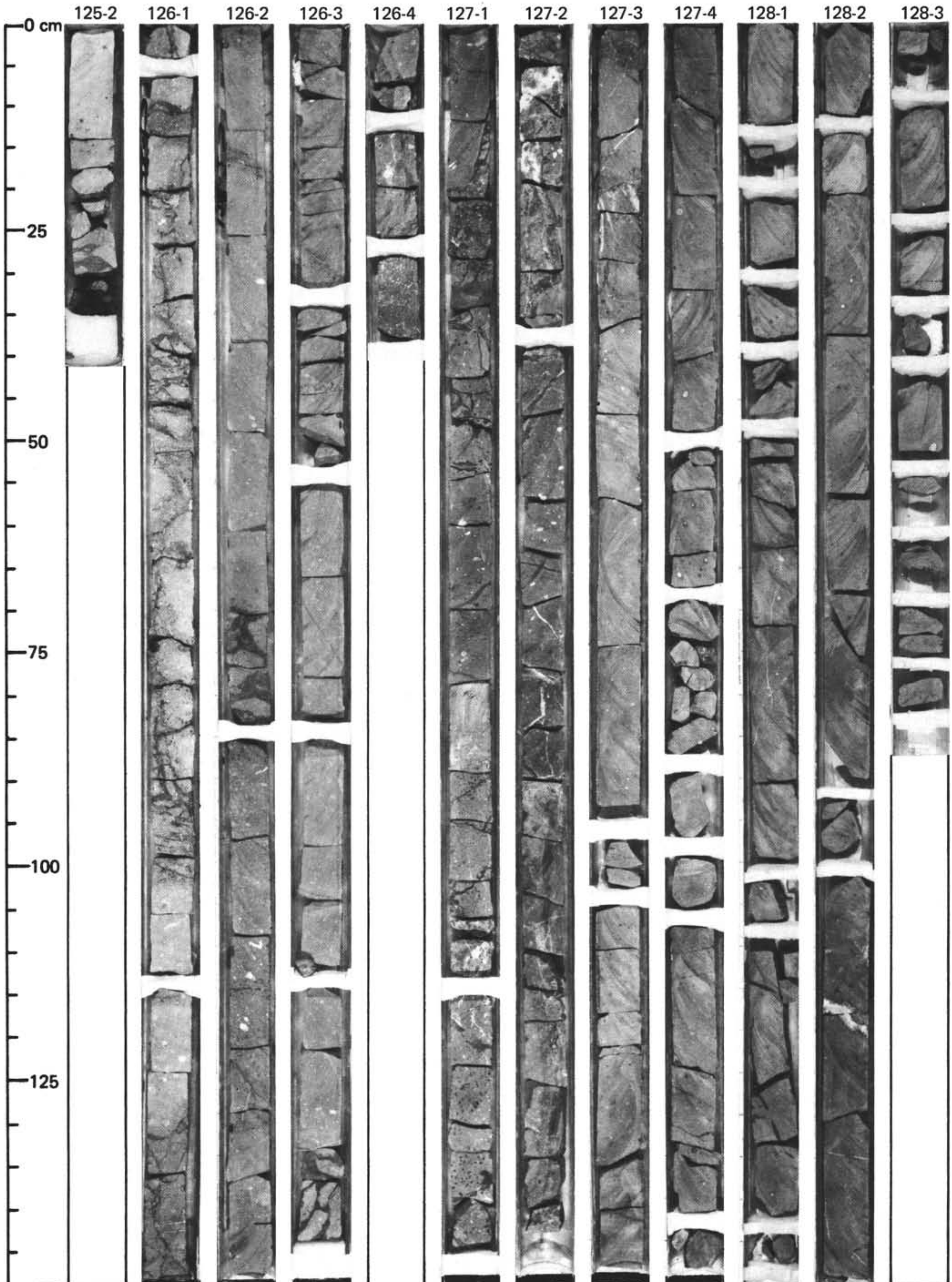
125-2
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126-3
126-4
127-1
127-2
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127-4
128-1
128-2
128-3
0 cm
25
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