4. SITE 513[1]

Shipboard Scientific Party[2]

Date occupied: 2 February 1980; 0548 hr. (dropped beacon)

Date departed: 7 February 1980; 1930 hr. (beacon close aboard)

Number of holes: 2

Time on hole: 134 hr.

Position: 47°34.99′S; 24°38.40′W

Water depth (sea level; corrected m, echo-sounding): 4373

Water depth (rig floor; corrected m, echo-sounding): 4283

Bottom felt (m, drill pipe): 4381

Penetration (m): 513 104
513A 387

Number of cores: 513 11
513A 36

Total length of cored section (m): 513 104
513A 321

Total core recovered (m): 513 53.8
513A 169.1

Core recovery (%): 513 51
513A 52

Oldest sediment cored:
Depth sub-bottom (m): 380.5
Nature: Nannofossil ooze with chert at the base
Age: Early Oligocene
Measured velocity (km/s): ~1.6

Basement:
Depth sub-bottom (m): 380.5
Nature: Basalt (sill)
Velocity range (km/s): 5.4

Principal results: Site 513 is located on the lower flank of the Mid-Atlantic Ridge to the east of the Argentine Basin at a water depth of 4383 meters, about 150 miles north of the present-day position of the Polar Front. It was drilled and continuously cored to the basement at a depth of 380.5 meters. Muddy diatomaceous ooze of early Miocene to Holocene age, 180 meters thick, is underlain by 53.9 meters of muddy diatomaceous nannofossil ooze and diatomaceous ooze spanning the early Miocene to late Oligocene. These sediments overlie 145.5 meters of nannofossil ooze ranging in age from late to early Oligocene with a white porcellanite bed at the base. The porcellanite rests on fine-grained phyric basalt interpreted to be a sill.

Periods of nondeposition or erosion are identified within the middle Pliocene (~3.85–3.05 m.y.), bracketing the Miocene/Pliocene boundary (a few hundred thousand years), within the late Miocene (~8.6–6.5 m.y.), and between the early and late Miocene (~19.0–9.5 m.y.). The Oligocene sections of Site 513 and 511 partially overlap; the composite section represents the most complete upper Eocene–lower Miocene sequence in southern high latitudes.

The age of the basal layers (lowermost Oligocene, 36.5 m.y.) corresponds closely to the age predicted by magnetic anomalies.

BACKGROUND AND OBJECTIVES

Deep-sea sediments surrounding Antarctica are distributed in three belts according to predominant sediment type. From south to north these are (1) a near-continent belt of glacial marine sediments, (2) a broad belt of siliceous ooze, and (3) a belt of calcareous, largely nannofossil ooze, with clay and muds in seafloor areas below the CCD (Goodell, 1973).

The belt of siliceous ooze is the result of high biologic productivity in the surface water between the Antarctic Divergence and the Antarctic Convergence, or Polar Front. The high productivity of this zone results from upwelling of Circumpolar Deep Water in the region of the Antarctic Divergence; this enriches with nutrients the Antarctic Surface Layer, which then flows northward to sink in the Polar Front region (Fig. 1). The position of the northern boundary of the Polar Front, which coincides approximately in position with the northern boundary of the siliceous ooze belt, is governed by the production of cold water in Antarctic regions. Hence, fluctuations in production as a consequence of long-and short-term changes in Antarctic climate result in migrations in the position of the northern boundary.

Site 513 lies slightly north of the present position of the Polar Front in the South Atlantic Ocean (Fig. 2) and between Magnetic Anomalies 13 and 15 (basal Oligocene, 36.5 Ma; Ludwig and Rabinowitz, Fig. 3, this volume). The objective at this site was to examine the Cenozoic evolution of the Polar Front and its migrations in an area distant from zonal topography. Results from this site can then be compared with the effects of Polar Front excursions across the Maurice Ewing Bank (Falkland Plateau) and the history of the Polar Front and siliceous biogenic evolution established in the Southwest Pacific Ocean.

There are no DSDP sites in the vicinity of Site 513. Hence, drilling in this area would give useful information concerning the stratigraphy of the whole Paleogene and Neogene sequence, lithologic character of basal layers, stratigraphic level of replacement of basal carbonates by clays and siliceous ooze, and erosional events that occurred at the Eocene/Oligocene and Oligocene/Miocene boundaries.

[1] Ludwig, W. J., Krasheninnikov, V. A., et al., *Init. Repts. DSDP*, 71: Washington (U.S. Govt. Printing Office).

[2] William J. Ludwig (Co-Chief Scientist), Lamont-Doherty Geological Observatory, Palisades, New York (present address: Gulf Oil Exploration and Production Co., Houston, Texas), Valery A. Krasheninnikov (Co-Chief Scientist), Geological Institute, U.S.S.R. Academy of Sciences, Moscow; Ivan A. Basov, Institute of the Lithosphere, U.S.S.R. Academy of Sciences, Moscow; Ulf Bayer, Institut für Geologie und Paläontologie, Universität Tübingen, Federal Republic of Germany; Jan Bloemendal, University of Liverpool, Liverpool, United Kingdom; Brian Bornhold, Pacific Geoscience Centre, Sidney, British Columbia, Canada; Paul F. Ciesielski, University of Georgia, Athens, Georgia; Elaine H. Goldstein, Florida State University, Tallahassee, Florida; Christian Robert, Centre Universitaire de Luminy, Marseilles, France; John C. Salloway, University of Edinburgh, Edinburgh, United Kingdom; John L. Usher, Scripps Institution of Oceanography, La Jolla, California; Hans von der Dick, Institut für Geologie, Geochemie und Lagerstätten des Erdöls und der Kohle, Rheinisch-Westfälische Technische Hochschule, Aächen, Federal Republic of Germany (present address: Petro Canada Research Laboratory, 40 Research Place NW, Calgary, Alberta, Canada); Fred M. Weaver, Exxon Production Research Co., Houston, Texas; Sherwood W. Wise, Jr., Florida State University, Tallahassee, Florida.

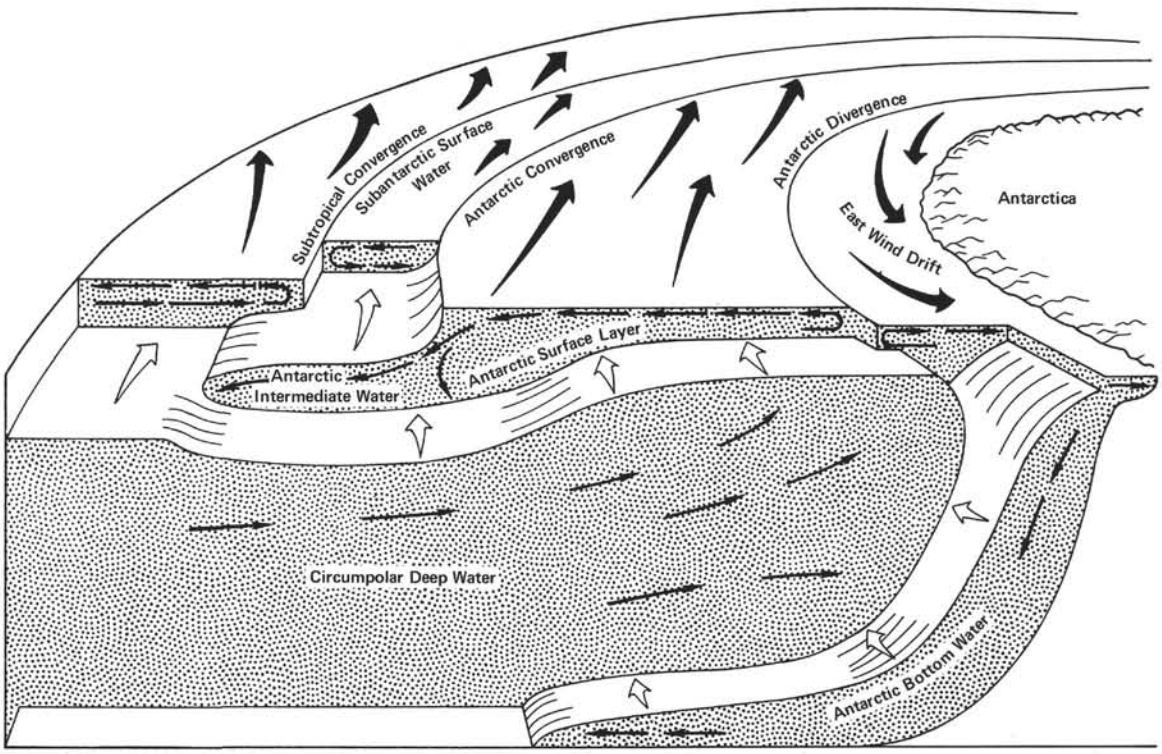


Figure 1. Scheme of bottom and surface water movement off Antarctica (from Wise, 1981).

SURVEY AND OPERATIONS

The route from Site 512 to the next proposed drill site took the vessel about 775 mi. due east. Several icebergs were detected by radar only a few hours after departure from Site 512. It was necessary to detour about 50 mi. to the north and take a parallel track to avoid these bergs and many more along the route. Nearly all ice encountered was noted to be south of 49°S latitude.

A positioning beacon was launched at 0628 hr., 31 January, at the proposed site (AB-3) in the southeast Argentine Basin. PDR water depth was 3991 meters. The wind began increasing as the long string of pipe was assembled. The trip was halted as gusts reached 35 knots and heavy seas affected vessel motion. After 3 hr. it was apparent that weather conditions were more than transitory and were continuing to deteriorate. With the bit only about 900 meters above the seafloor, it was necessary to reverse the trip and begin retrieving the drill string.

As the pipe trip continued in gale force winds, a group of icebergs of various sizes approached and surrounded the ship. The combined forces of wind and current were moving the bergs at speeds as high as 3 knots. This was the same ice that the vessel had passed en route to the site and more was known to be headed for the area. The hazard to the ship posed by the ice was considered too great for continued operations in the immediate area. Two hours were required to maneuver clear of the ice field before the vessel could be stopped and the positioning hydrophones housed for steaming.

At 0600 hr., 1 February, the *Challenger* got underway for an alternate drill site some 180 mi. to the northwest. A beacon was dropped at the "new" Site 513 at 0548 hr., 2 February.

Site 513 is located on the western flank of the Mid-Atlantic Ridge at a water depth of 4381 meters (Fig. 2). The *Challenger* seismic line approaching the site (Fig. 3) and the *Conrad* 12–14 reference line (Fig. 4) show a 0.45 s (approximately 450 m) thick sequence of weak to moderately stratified sediments draped over oceanic basement. Locations of the lines are shown in Figure 5. The sediments are more acoustically stratified and thicker to the south, presumably because of more pronounced fluctuations of the Polar Front and thicker siliceous versus carbonate sediments (see seismic profiles in Ludwig and Rabinowitz, this volume).

The pipe trip and beginning of coring operations at Site 513 were routine. The PDR water depth was 4383 meters and 4381 meters was established by drill pipe measurement on the first core (Table 1). Hole 513 was spudded at 1711 hr., 2 February. By midnight the wind had begun to rise and at 0800 hr. the following morning, vessel motion had reached operational limits because of the rising seas. Coring operations were abandoned after 104 meters had been penetrated and the drill string was pulled.

Strong gale conditions persisted through the pipe trip and vessel pitch reached 12°. The bit was brought on deck at 1710 hr. We waited 9 hr. until wind and swell conditions returned to levels suitable for handling pipe.

With weather conditions improving, the drill string was run back to the seafloor for a second attempt to core to basement. Hole 513A was spudded at 1315 hr., 4 February. The hole was drilled ahead to a depth of 56.5 meters BSF. The interval corresponding to the lower

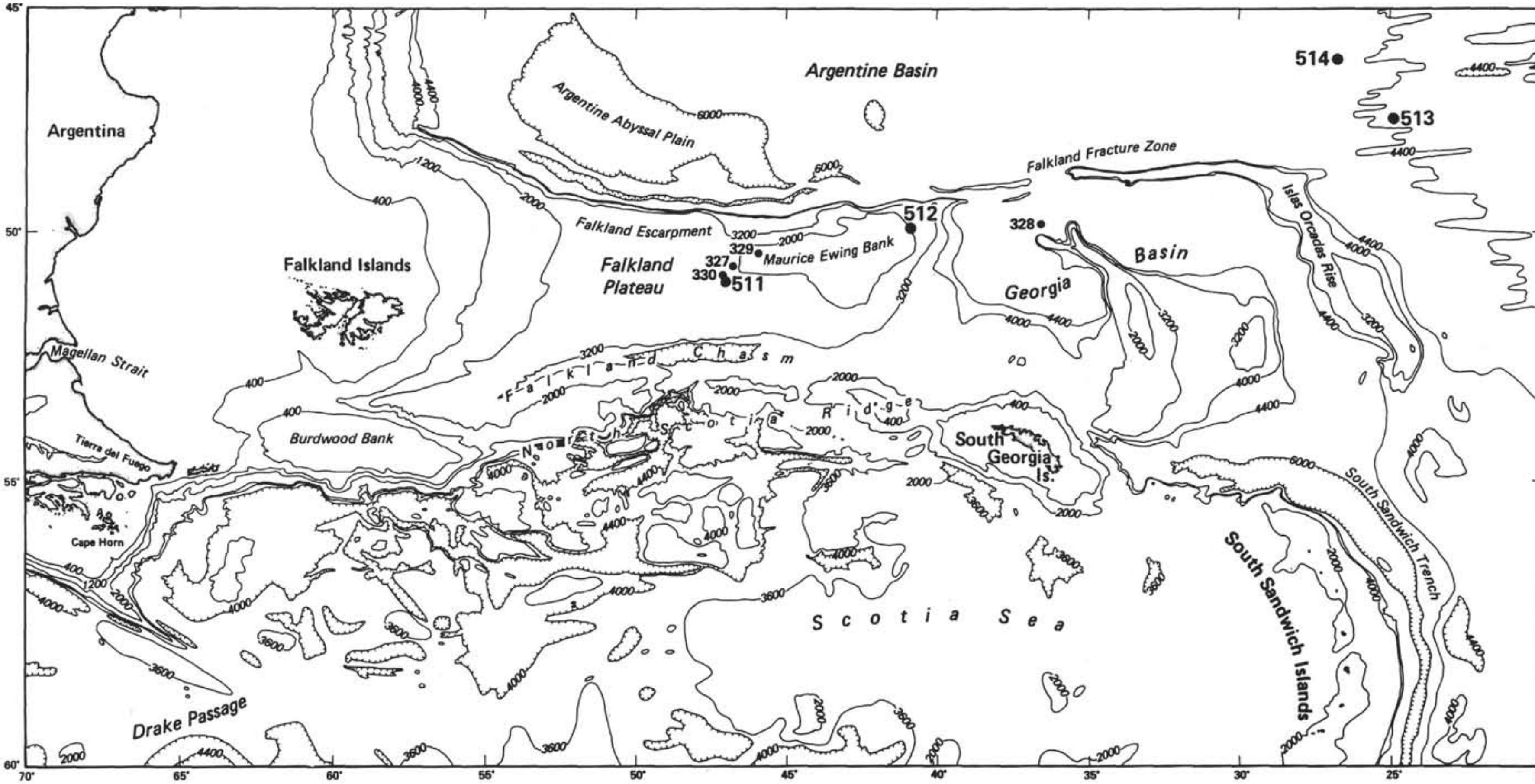


Figure 2. Location of Site 513 and other Leg 71 drill sites.

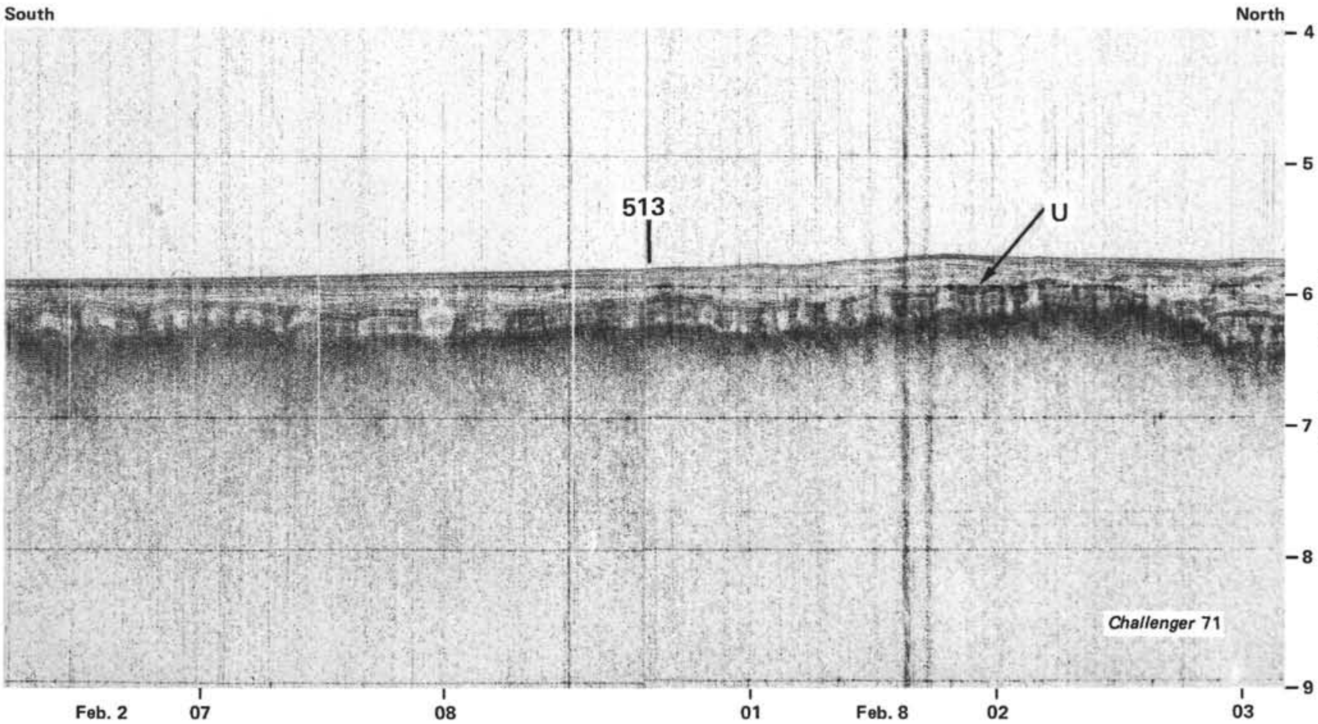


Figure 3. *Glomar Challenger* seismic reflection profile approaching and departing Site 513. See Figure 5 for location. U represents the unconformity discussed in the text and also in Ciesielski and Weaver, this volume.

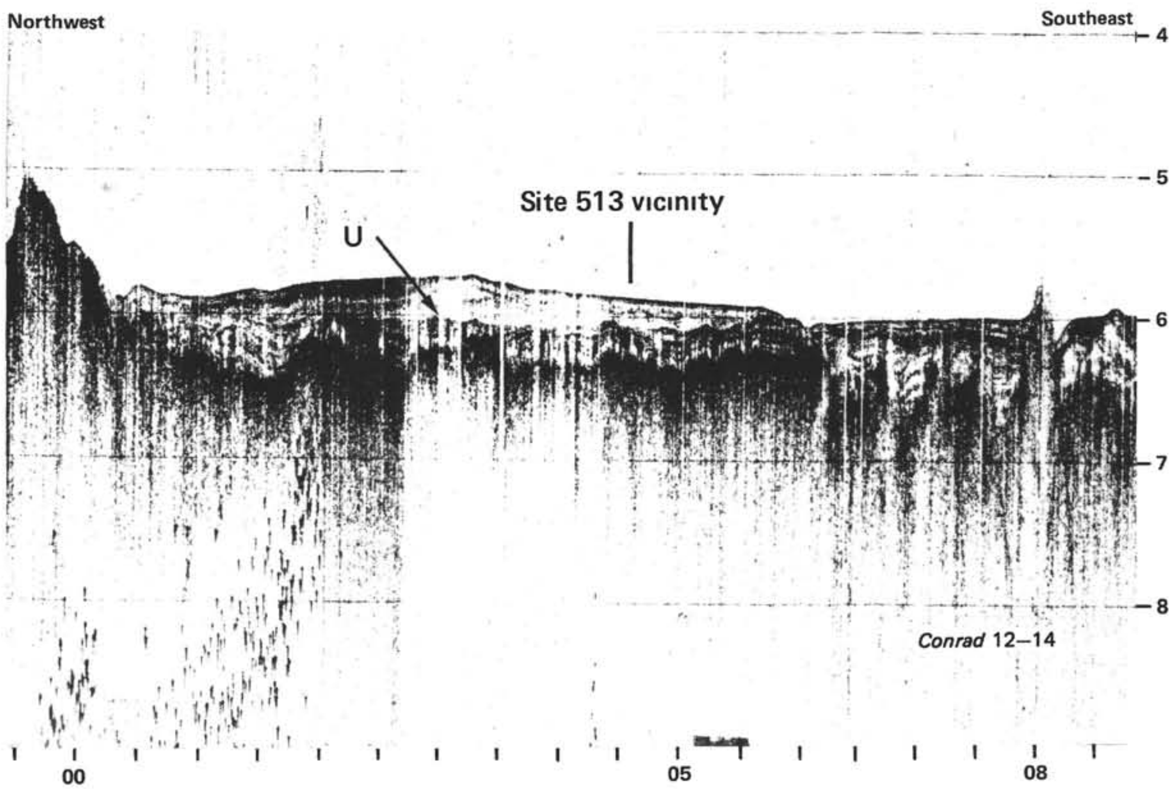


Figure 4. *Conrad* 12–14 seismic reflection profile near Site 513. See Figure 5 for location. U represents the unconformity discussed in the text and in Ciesielski and Weaver, this volume.

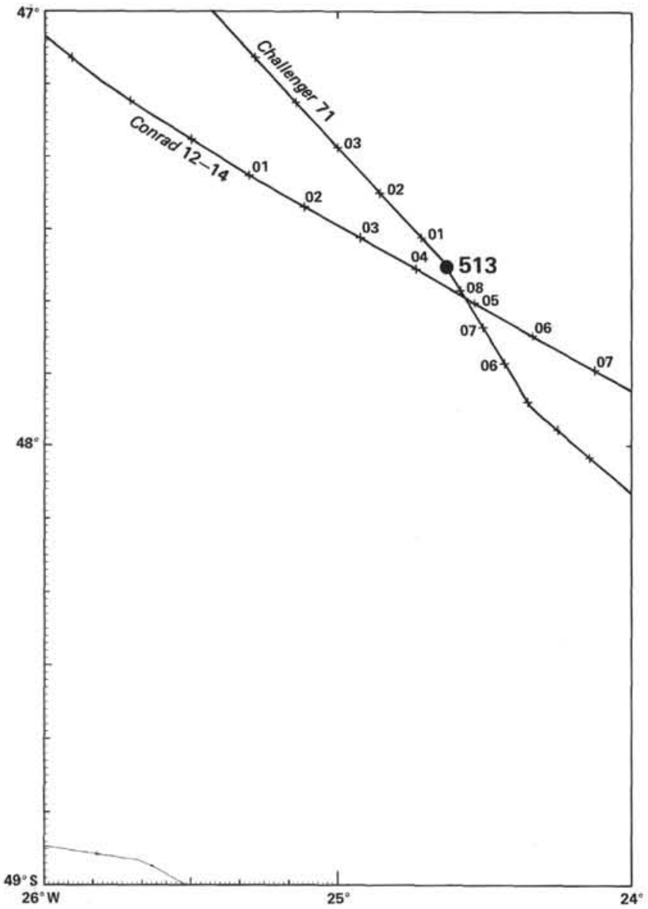


Figure 5. Locations of lines of seismic reflection measurements near Site 513.

Table 1. Coring summary, Site 513.

Core No.	Date (Feb. 1980)	Time	Depth from Drill Floor (m)	Depth below Seafloor (m)	Length Cored (m)	Length Recovered (m)	Core Recovered (%)
Hole 513							
1	2	1812	4381.0–4390.0	0–9.0	9.0	8.72	96.8
2	2	1935	4390.0–4399.5	9.0–18.5	9.5	0	0
3	2	2110	4399.5–4409.0	18.5–28.0	9.5	7.86	82.7
4	2	2235	4409.0–4418.5	28.0–37.5	9.5	8.80	92.6
5	2	2358	4418.5–4428.0	37.5–47.0	9.5	9.11	95.8
6	3	0130	4428.0–4437.5	47.0–56.6	9.5	9.51	100.1
7	3	0307	4437.5–4447.0	56.5–66.0	9.5	0	0
8	3	0430	4447.0–4456.5	66.0–75.5	9.5	0	0
9	3	0550	4456.0–4466.0	75.5–85.0	9.5	9.80	103.0
10	3	0730	4466.0–4475.5	85.0–94.5	9.5	0	0
11	3	1800	4475.5–4485.0	94.5–104.0	9.5	0	0
Total					104	53.8	51.7
Hole 513A							
1	4	1625	4437.5–4447.0	56.5–66.0	9.5	3.94	41.5
2	4	1750	4447.0–4456.5	66.0–75.5	9.5	8.54	89.9
3	4	1926	4466.0–4475.5	85.0–94.5	9.5	2.15	22.6
4	4	2048	4475.5–4485.0	94.5–104.0	9.5	9.41	99.0
5	4	2225	4485.0–4494.5	104.0–113.5	9.5	9.62	100
6	4	2351	4494.5–4504.0	113.5–123.0	9.5	9.43	99.2
7	5	0124	4504.0–4513.5	123.0–132.5	9.5	8.96	94.3
8	5	0302	4513.5–4523.0	132.5–142.0	9.5	6.05	63.7
9	5	0428	4523.0–4532.5	142.0–151.5	9.5	0.87	9.2
10	5	0602	4532.5–4542.0	151.5–161.0	9.5	9.27	97.6
11	5	0830	4542.0–4551.5	161.0–170.5	9.5	4.25	44.7
12	5	0905	4551.5–4561.0	170.5–180.0	9.5	6.04	63.6
13	5	1030	4561.0–4570.5	180.0–189.5	9.5	3.00	31.6
14	5	1150	4570.5–4580.0	189.5–199.0	9.5	2.96	28.3
15	5	1312	4580.0–4589.5	199.0–208.5	9.5	9.83	100
16	5	1443	4589.5–4599.0	208.5–218.0	9.5	9.78	100
17	5	1615	4599.0–4608.5	218.0–227.5	9.5	7.60	80.0
18	5	1800	4608.5–4618.0	227.5–237.0	9.5	6.86	72.2
19	5	1930	4618.0–4627.5	237.0–246.5	9.5	0.53	5.6
20	5	2121	4627.5–4637.0	246.5–256.0	9.5	3.63	38.2
21	5	2318	4637.0–4646.5	256.0–265.5	9.5	8.14	85.7
22	6	0053	4646.5–4656.0	265.5–275.0	9.5	0.20	2.1
23	6	0253	4656.0–4665.5	275.0–284.5	9.5	0.21	2.2
24	6	0455	4665.5–4675.0	284.5–294.0	9.5	2.49	26.2
25	6	0700	4675.0–4684.5	294.0–303.5	9.5	0.14	1.5
26	6	0834	4684.5–4694.0	303.5–313.0	9.5	tr.	0
27	6	1015	4694.0–4703.5	313.0–322.5	9.5	0.55	5.8
28	6	1207	4703.5–4713.0	322.5–332.0	9.5	6.22	65.4
29	6	1350	4713.0–4722.5	332.0–341.5	9.5	3.11	32.7
30	6	1532	4722.5–4732.0	341.5–351.0	9.5	6.31	66.4
31	6	1740	4732.0–4741.5	351.0–360.5	9.5	9.79	100
32	6	1911	4741.5–4751.0	360.5–370.0	9.5	4.57	48.1
33	6	2105	4751.0–4760.5	370.0–379.5	9.5	9.85	100
34	6	2359	4760.5–4761.5	379.5–380.5	1.0	0.08	8.0
35	7	0345	4761.5–4764.0	380.5–382.0	1.5	0.80	53
36	7	1045	4764.0–4769.0	382.0–387.0	5.0	4.11	82.2
Total					321.0	169.08	52.7

47.5 meters of Hole 513 was recored because core recovery had been low on the earlier attempt. Much better results were achieved on the second try and coring proceeded smoothly to about 235 meters, where a difficult stratum of nannofossil ooze was encountered. The material was quite dry and firm, but seemed virtually to disintegrate on contact with water. Continuous circulation could not be used. After considerable experimentation, a technique of alternate "dry drilling" and breaking circulation was developed that produced satisfactory recovery. Nevertheless an interval of about 85 meters was cored with only 18.5% recovery.

Chert and igneous rock were encountered at 380 meters BSF. Because the rate of penetration was less than 1 m/hr. and because of scheduling pressures, operations were terminated after only 6 meters of basalt basement had been penetrated. The pipe was recovered and the bit was brought on deck at 1810 hr., 7 February.

LITHOLOGICAL SUMMARY

Continuous coring at Holes 513 and 513A produced an almost continuous sequence of sediments ranging in age from early Oligocene through Pliocene and Pleistocene (Fig. 6). Lithologically this sequence is composed of muddy diatomaceous oozes in the upper part and nannofossil oozes in the lower part, with an intervening transitional unit. Three lithologic units and a fourth unit composed of basalt are distinguished. The major characteristics of the four units are summarized in Table 2 and Figure 6.

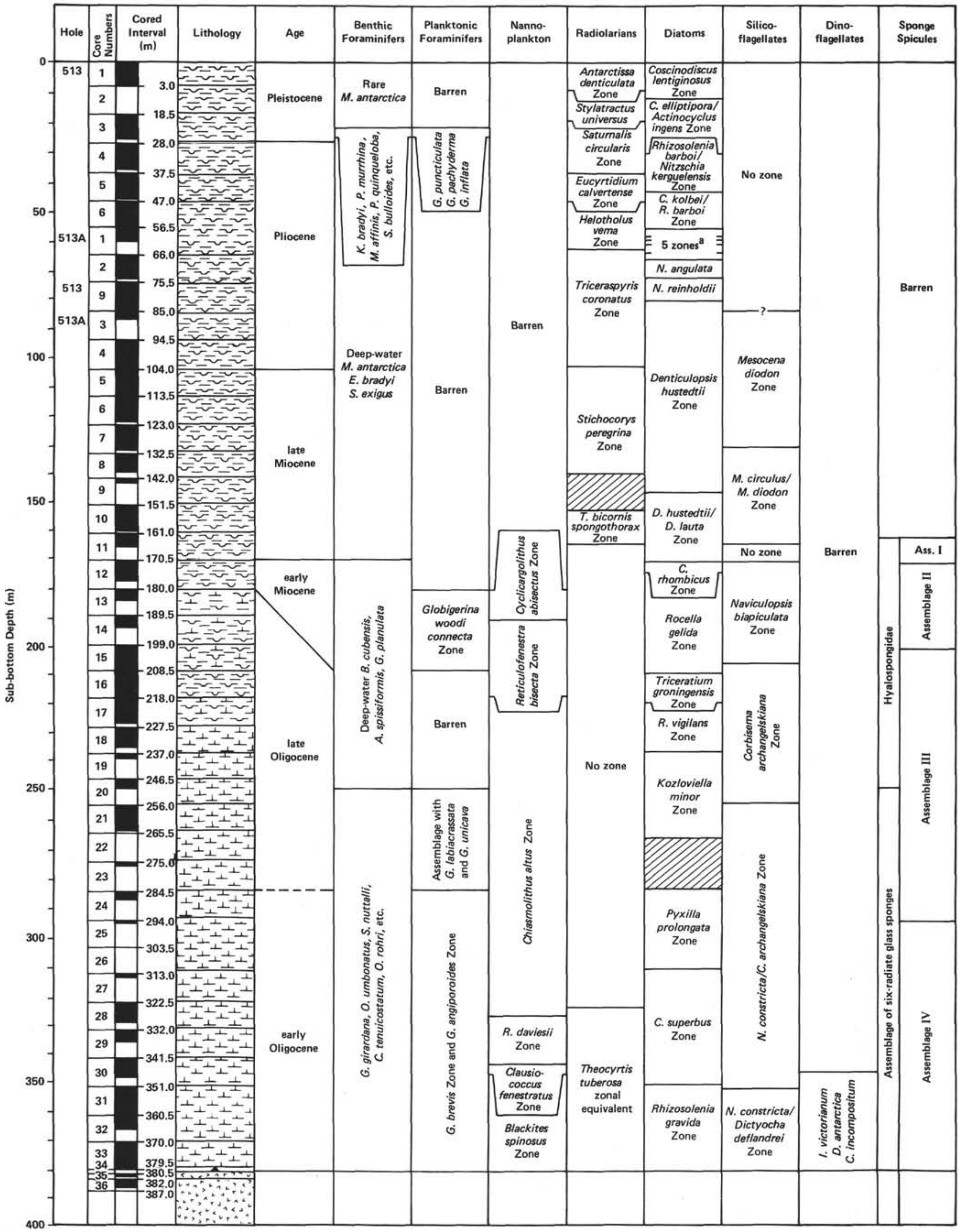
The first hole at Site 513 was drilled to a depth of 104.0 meters sub-bottom, but recovery beyond 56.5 meters was negligible. A second hole, 513A, was washed to that depth and coring resumed with conventional rotary drilling. Lithologic Unit I thus comprises the upper 56.5 meters of sediments recovered in Hole 513, and the 123.5 meters recovered in Cores 1–12 of Hole 513A.

Unit 1

Primarily a muddy diatomaceous ooze, Unit 1 has a moderate amount of interlayering of diatomaceous muds downward in the section. It is 180 meters in thickness and ranges from early Miocene through Quaternary.

Colors in Hole 513 range from light grayish brown in Core 513-1, to olive gray in Core 513-3, to greenish gray in Core 513-6. Mottling is generally sparse throughout, with colors including olive gray, greenish black, very dusky purple, greenish gray, and dark gray. Subangular to angular pebbles up to 4 cm in size were sparsely scattered throughout these cores.

Unusual features include a 7-cm zone of calcareous diatomaceous ooze in Section 513-3-1 and a 3-cm layer



[a] From top to bottom, these five zones are *C. vulnificus* Zone, *Cosmiodiscus insignis* Zone, *Nitzschia weaveri* Zone, *N. interfrigidaria/C. vulnificus* Zone, and *N. praeinterfrigidaria* Zone.

Figure 6. Columnar section of Site 513, showing the lithology recovered and biostratigraphic correlations. (Refer to Ludwig et al., Introduction, this volume, for a key to the lithologic symbols.)

Table 2. Lithologic summary of Holes 513 and 513A.

Core	Unit	Depth below Seafloor (m)	Color	Lithologic Description	Age
513-1-9	1: muddy diatomaceous ooze	0-104	Light brownish gray (2.5Y 6/2) Olive gray (5Y 4/2) Greenish gray (5G 6/1)	Sparse to moderate mottling throughout; disturbance is moderate to high. Manganese staining present in Sections 513-1-1 through 513-1-3. 7 cm zone of calcareous diatomaceous ooze in Section 513-3-1. 3 cm fine quartz sandy mud zone in Section 513-3-2	Plio/Pleistocene
513A-1-12	1: muddy diatomaceous ooze	56.5-180	Greenish gray (5G 6/1) Grayish brown (2.5Y 5/2)	Bioturbation; mottling is moderate in Cores 1-9, becoming more homogeneous below. Interlayering of diatom mud in Cores 3, 4, 6, 9, and 12	Pliocene to early Miocene
13-17	2A: muddy diatomaceous, nannofossil ooze	180-222.5	Very pale brown (10YR 7/3) Grayish brown (2.5YR 5/2) Light brownish gray (10YR 6/2)	Homogeneous near top of unit, moderate-heavy mottling beginning in Core 17	early Miocene to late Oligocene
17-18	2B: diatomaceous nannofossil ooze	225.5-233.9	Light gray (5Y 7/1) White (2.5Y 8/0)	Interlayering with nannofossil ooze; sparse mottling throughout	late Oligocene
18-33	3A: nannofossil ooze	233.9-379.5	Light gray (5Y 7/1) White (2.5Y 8/0)	All grades of mottling are present throughout. Chalk zones present beginning with Core 28. Induration in general increases with depth. Horizontal color banding in Core 33	late Oligocene to early Oligocene
33-34	3B: chert fragment, unidentified pebble	379.5-380.5			?
35, 36	4: basalt (sill)	380.5-387			late Eocene based on magnetic anomalies; early Oligocene based on age of overlying sediment

of fine quartz sandy mud in Section 513-3-2. The former is the only significant occurrence of calcareous material in Hole 513. The calcareous component contains approximately 11% foraminifers and 8% carbonate unspecified. In addition, a slight to moderate amount of manganese staining is present in Core 1, with intensity of staining decreasing to negligible below Section 513-1-3. These cores are moderately to highly disturbed, which tends to mix sediments that are high in diatoms and have a "cotton" texture with smoother-textured sediments.

The lower two-thirds of Unit 1 are represented in the uppermost 12 cores of Hole 513A. The color is predominantly greenish gray, with a gradation to grayish brown in Core 513A-11. Bioturbation and mottling are moderate in Cores 513A-1-9, with sediment becoming homogeneous below. Cores 513A-3, 4, 6, 9, and part of 12 have an increased clay percentage, and are described as diatomaceous muds. A 7-cm pebble zone is present in Core 513A-1, containing subangular to subrounded fragments up to 4.5 cm. Within Core 513A-10 is a prominent 2-cm layer composed almost entirely of fine, clear volcanic ash.

Unit 2

Unit 2, 53.9 meters thick, is a transitional unit between the muddy diatomaceous oozes of Unit 1 and the underlying nannofossil oozes of Unit 3, and represents a major change in paleoenvironment. The unit has been subdivided into two subunits, A and B, the former with a high mud and diatom content, the latter with an increased carbonate content. Each of these subunits contains an irregular interlayering of various lithologies, ranging from muddy diatomaceous ooze through muddy nannofossil diatomaceous ooze and diatomaceous nannofossil ooze to diatomaceous clay and nannofossil ooze. The boundary between the subunits was arbitrarily chosen below the lowest layer of muddy diatomaceous ooze.

Subunit 2A

The uppermost 42.5 meters of Unit 2 are composed predominantly of muddy diatomaceous nannofossil ooze, with colors ranging from very pale brown to grayish brown and light brownish gray. The age of the unit extends from late Oligocene through early Miocene, and its sub-bottom depth lies between 180 and 222.5 meters (Core 513A-13 to Section 513A-17-3) in Hole 513A.

Subunit 2A is composed of irregularly alternating layers of muddy diatomaceous nannofossil ooze, diatomaceous clay, and muddy diatomaceous ooze ranging in thickness from 0.6 to 9.5 meters. The sediment is generally homogeneous to Core 513A-17, where mottling becomes moderate to intense.

Subunit 2B

This subunit comprises 11.4 meters of late Oligocene age (sub-bottom interval 222.5–233.9 m) in Section 513A-17-4 to Section 513A-17-5 of irregularly alternating layers of diatomaceous nannofossil ooze and nannofossil ooze, with colors ranging from light gray to white. Mottling is sparse throughout.

Discussion

Unit 2 is transitional in nature, reflecting a change from calcareous to muddy, diatomaceous deposition. Subunit 2B is distinctive because of its predominantly calcareous nature, and represents the beginning of an influx of mud and diatoms into a paleoenvironment which had been dominated by calcareous oozes. The ultimate result is the almost complete elimination of carbonate deposition.

The irregular variations in the percentage of mud throughout the entire unit may reflect sporadic variations in local current velocity. In addition, the entire transitional unit reflects the progressive subsidence of the seafloor and possibly, as well, the onset of shallowing of the CCD, as evidenced by variations in the amount and eventual absence of carbonate.

Unit 3

Subunit 3A

This subunit of 145.5 meters thickness (sub-bottom depth 233.9–379.5 m, Cores 513A-18-33) is composed almost entirely of nannofossil ooze, the only exception being a 165-cm unit of diatomaceous nannofossil ooze in Section 513A-32-3. The age of the subunit ranges from early through late Oligocene. Colors throughout are mainly light gray and white with mottling being moderate to intense in the upper portion, becoming less significant in and below Core 513A-22. Some slight horizontal color banding is apparent in Sections 513A-33-1–3; colors include pale yellow, greenish gray, very dark gray, and sparse amounts of grayish purple. The same core contains a sparse amount of black chert fragments throughout.

Induration generally increases with depth; highly indurated chalk zones alternating with slightly less indurated zones appear in Core 513A-28 and continue downward through the remainder of the subunit.

Subunit 3B

Core 513A-34, containing the whole of Subunit 3B, consists of a core-catcher sample in which two pebbles were present, one an unidentified, black, subrounded to subangular lithoclast, apparently downhole contamination, the other a piece of white chert.

Unit 4

Unit 4, composed of Cores 513A-35 and 36, consists of 6 meters of fine-grained phyric basalt.

PALEONTOLOGY

Biostratigraphic Summary

Site 513 is situated on the lower flank of the Mid-Atlantic Ridge to the east of the abyssal plain of the southeast Argentine Basin. Eleven continuous cores were taken at Hole 513 before bad weather terminated the hole at a sub-bottom depth of 104 meters. At Hole 513A, drilling was discontinuous to 85 meters, with only two cores taken (56.5–75.5 m) to fill in recovery gaps in Hole 513 (Cores 7 and 8; Fig. 7). Below 85 meters drilling was continuous into a sill at a depth of 380.5 meters.

Site 513 was intended to be a southerly companion to Site 514, taken approximately 1.5° of latitude to the north. The principal objective at these two sites was to obtain a late Paleogene–Neogene sedimentary sequence to be used to trace the evolution of the Polar Front in an area where its paleo-position has not been influenced by bottom topography. This site and Site 514 are located ~150 and 250 mi. north of the present mean position of the Polar Front, in the region of its most northerly position during the late Cenozoic. A major objective was to compare the history of the Polar Front of this region with the Southwest Pacific record (off East Antarctica). It was thought that Sites 513 and 514 would provide a much more detailed record of the climatically induced fluctuations of the Polar Front than has been interpreted from patterns of siliceous biogenic sedimentation in the Southwest Pacific.

Siliceous microfossil groups are well represented throughout the lower Oligocene to Quaternary sequence of Hole 513 and 513A. Calcareous nannofossils and planktonic and benthic foraminifers are scarce or entirely absent in the muddy diatomaceous ooze and diatomaceous mud of Hole 513 and Cores 513A-1-12. The diatomaceous nannofossil ooze and nannofossil ooze from Core 513A-13 to the sill (Core 513A-34) also contain sparse quantities of poorly preserved foraminifers, except in the lower portion of the section (Cores 513A-28-33) where they become more numerous and diverse. Calcareous nannofossils are abundant and moderately to well preserved in Cores 513A-13-33 but are of low diversity.

Those microfossil groups dealt with in these reports include benthic and planktonic foraminifers, calcareous nannofossils, radiolarians, diatoms, silicoflagellates, and sponge spicules. The siliceous microfossil groups provide the most detailed stratigraphy of Site 513; only in the lower Oligocene–lower Miocene of Hole 513A are calcareous microfossils abundant enough to allow correlation of the site to other studied sections in the high to middle latitudes. Lower Oligocene–lower Miocene calcareous and siliceous microfossil group zonal schemes are correlated in Figure 8.

Upper Miocene–Quaternary Stratigraphy

The predominantly diatomaceous mud and muddy diatomaceous ooze of Hole 513 and Core 513A-1 through Sample 513A-12-1, 9–11 cm was continuously cored and is late Miocene–Quaternary in age (Fig. 6). Calcareous microfossils are scarce within this interval, and sediment age assignments are based entirely on siliceous microfossil biostratigraphy (Ciesielski; Weaver; Shaw and Ciesielski; and Ciesielski and Weaver; all in this volume).

Previous correlation of the late Miocene–Quaternary siliceous microfossil stratigraphy to magnetostratigraphy by these and other researchers has allowed for a detailed correlation of Site 513 sediments to magnetostratigraphy. A detailed discussion of magnetostratigraphic–biostratigraphic correlations is given in the diatom section that follows and in Ciesielski (this volume), and the

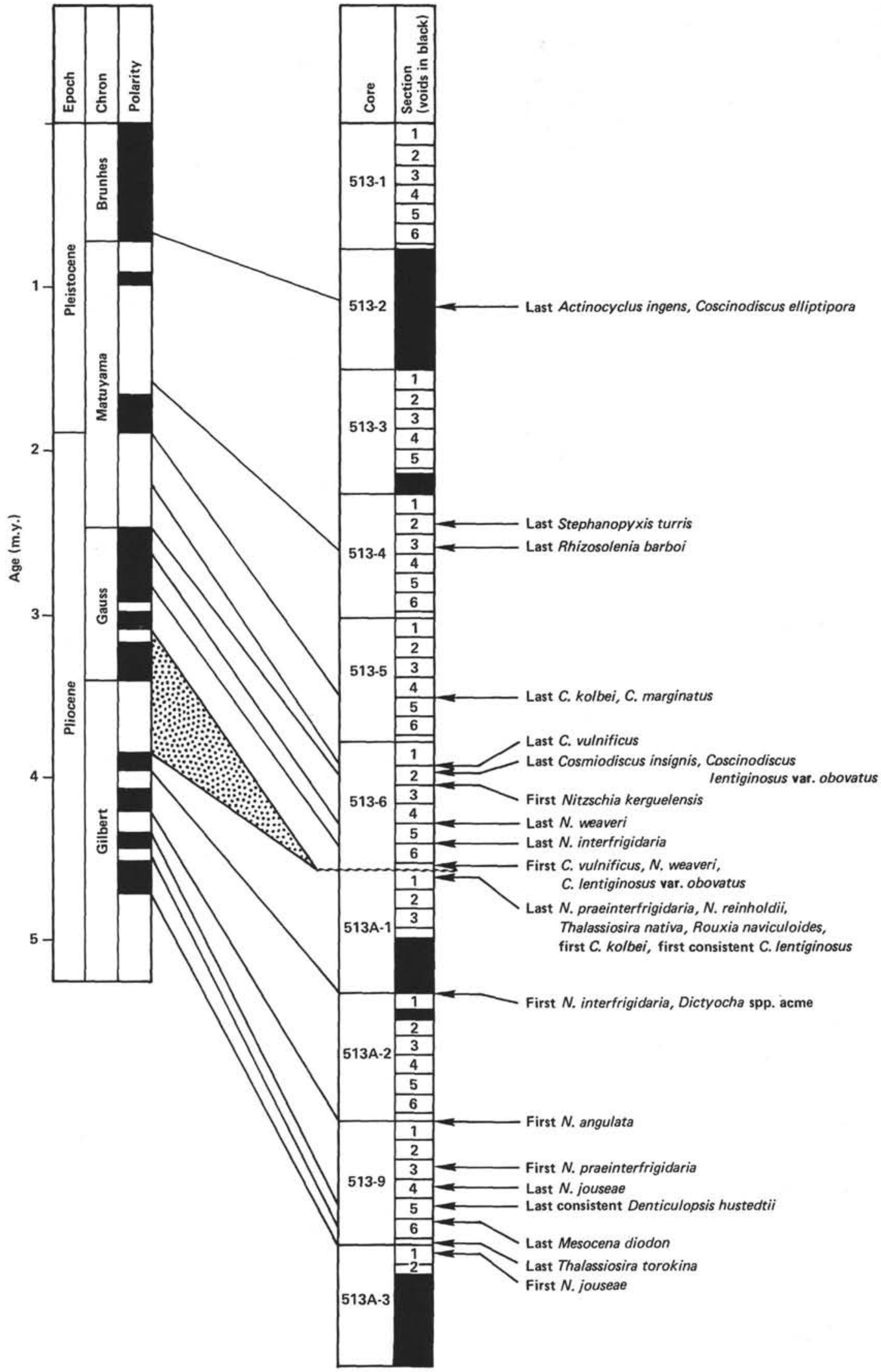


Figure 7. Diatom and silicoflagellate datums within the Pliocene–Quaternary of Site 513. Datums are correlated to paleomagnetic stratigraphy (Ciesielski, this volume). Stippled area represents disconformity between Cores 513-6 and 513A-1.

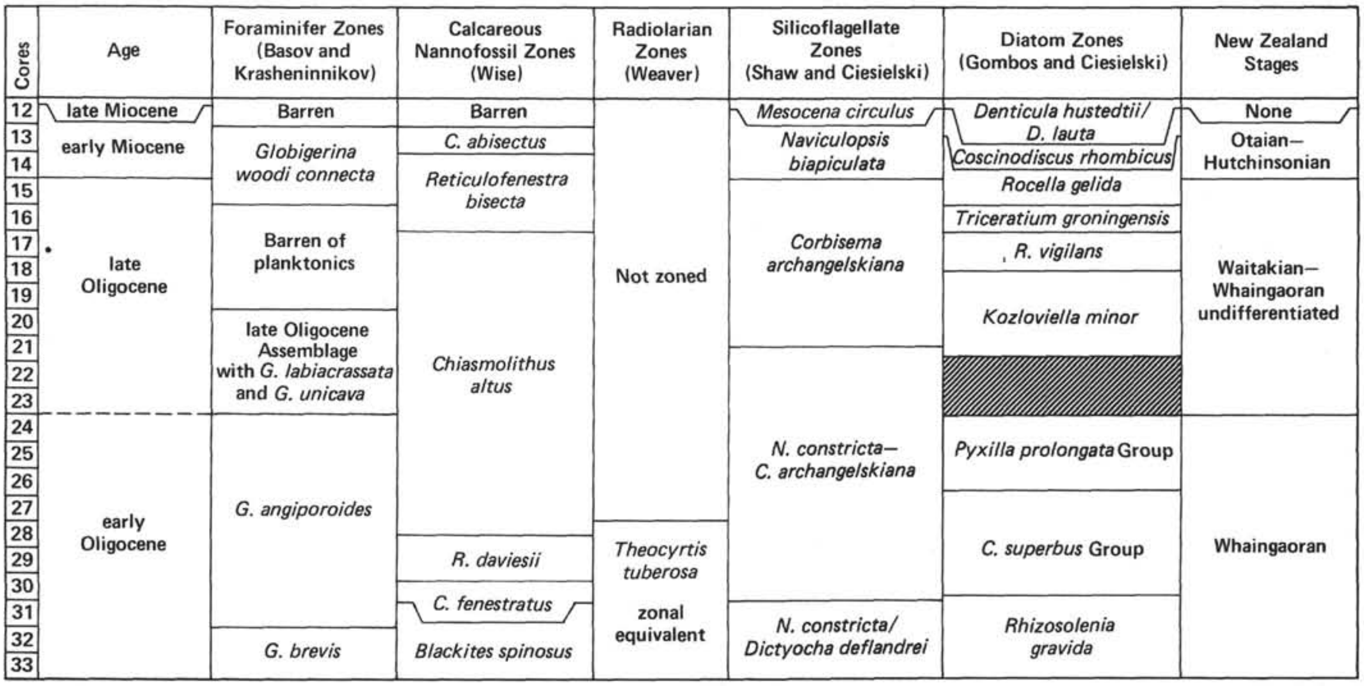


Figure 8. Correlation and occurrence of calcareous and siliceous microfossil zones found in the lower Oligocene–lower Miocene section of Hole 513A.

correlations are summarized in Figures 7, 9–10. Figure 7 shows the depth of some of the major diatom and silicoflagellate datums within the Pliocene–Quaternary of Site 513 (Hole 513 and Cores 513A-1–4) and their correlation to magnetostratigraphy. Figures 9 and 10 present the depth of major diatom, radiolarian, and silicoflagellate datums within the late Miocene (Core 513A-5 through Sample 513A-12-1, 9–11 cm) and their correlation to magnetostratigraphy.

Correlation of Hole 513 and Hole 513A, Cores 1–11 to magnetostratigraphy indicates that there are three disconformities within this sequence. The youngest disconformity occurs between Core 513-6 and Core 513A-1 (Fig. 7). The hiatus spans ~800,000 yr. between the mid-Gauss Chron (~3.05 Ma) and late Gilbert Chron (~3.85 Ma). The second disconformity occurs between Cores 513A-4 and 5, bracketing the Miocene/Pliocene boundary and probably representing no more than a few hundred thousand years (Figs. 9 and 10). A third disconformity must occur in the unrecovered sediment of Hole 513A, Core 9, between Sample 513A-9-1, 69–71 cm and Sample 513A-10-1, 13–15 cm (Figs. 9 and 10). The missing interval spans most or all of Magnetic Chron 8, Chron 7, and earliest Chron 6 (~8.6–6.5 Ma).

Sample 513A-10-1, 13–15 cm through Sample 513A-12-1, 9–11 cm is also late Miocene but probably represents upper Chronozone 9–lower Chronozone 8 (Fig. 10). A $^{40}Ar/^{36}Ar$ versus $^{39}Ar/^{36}Ar$ isochron age of 8.7 m.y. ± 0.2 m.y. for a volcanic ash in the middle portion of this interval (Sample 513A-10-7, 10–13 cm) correlates with upper Chronozone 9 or lower Chronozone 8 (Fig. 11), depending on the magnetostratigraphic time scale employed. Two meters beneath the volcanic ash, between Samples 513A-11-2, 52–53 cm and 513A-12-1, 9–11 cm, sediments of Magnetic Chronozone 9 are distinctly different from those above. This lower interval is well oxidized, as its brown color attests, and contains common to abundant reworked siliceous microfossils which are primarily late Oligocene and middle Miocene.

Lower Oligocene–Lower Miocene Stratigraphy

The fourth and deepest hiatus in Site 513 occurs between Samples 513A-12-1, 9–11 cm and 513A-12-1, 123–125 cm; it probably corresponds to the lithology change in Sample 513A-12-1, 82 cm. This disconformity separates the upper Miocene above from an apparently continuous sequence of lower Miocene through lower Oligocene sediments from Sample 513A-12-1, 123–125 cm to the basalt sill encountered in Core 513A-34. This lower Miocene–upper Miocene disconformity can be traced as a regional disconformity on seismic reflection profile records (Figs. 3–5 and Ciesielski and Weaver, this volume).

The 210-meter-thick lower Oligocene–lower Miocene section of Hole 513A represents the most complete section of this stratigraphic interval anywhere in the southern high latitudes. The top of the section in Core 12 is probably slightly younger than 19 m.y. (Ciesielski, this volume) and the base is slightly younger than the Eocene/Oligocene boundary (Fig. 8); thus the sequence contains approximately an 18 m.y. record of sedimentation. A stratigraphic overlap in the lower Oligocene of this site and Site 511 provides a continuous upper Eocene–lower Miocene record (Gombos and Ciesielski; Wise; Weaver; all in this volume).

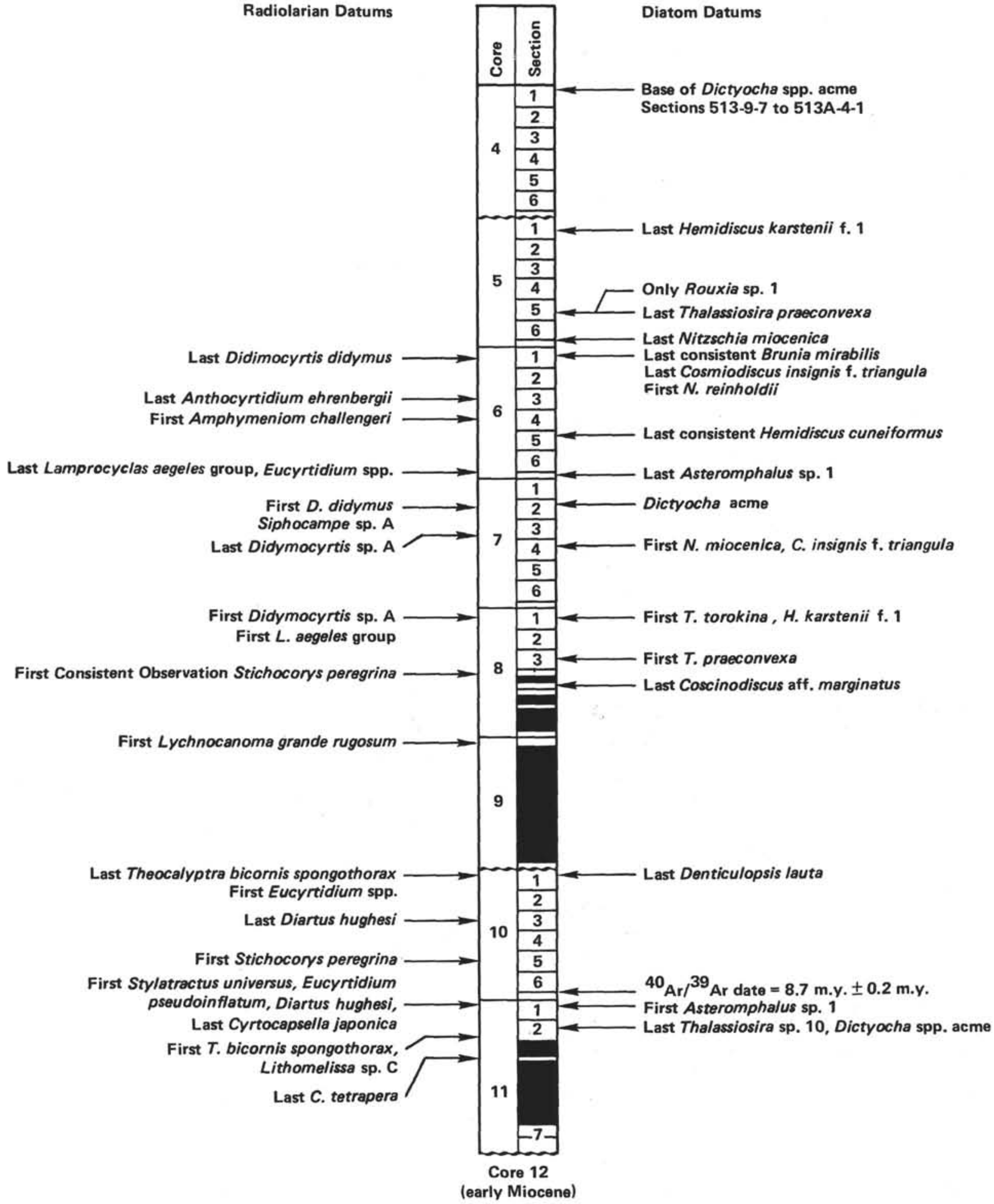


Figure 9. Important radiolarian, diatom, and silicoflagellate datums within the upper Miocene–lower Pliocene of Hole 513A. This section is correlated to magnetostratigraphy in Ciesielski and Weaver (this volume) and Figure 10.

Sedimentation Rates

Sediment accumulation rates shown in Figure 12 attest to relatively constant rates of sedimentation during the late Miocene (35.2 m/m.y.) and early Pliocene (32.8 m/m.y.). After the formation of the middle Pliocene disconformity between ~3.85 and 3.05 Ma., sediment accumulation rates decreased to 18.5 m/m.y. during the late Pliocene–Quaternary. Even though late Pliocene–Quaternary sediment accumulation rates were only half as high as preceding rates, sedimentation was more continuous than during the late Miocene–early Pliocene.

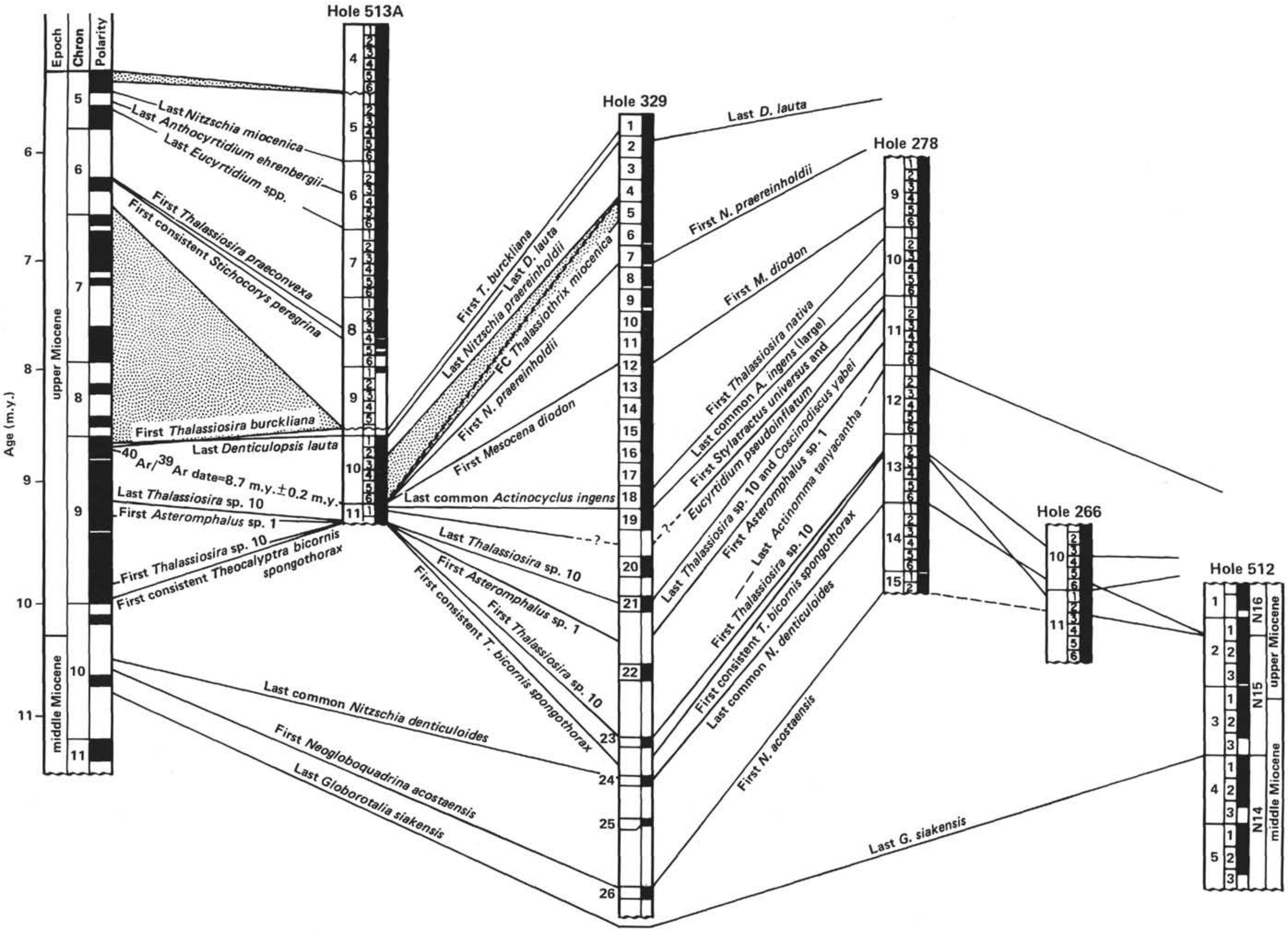


Figure 10. Correlation of the upper Miocene of Hole 513A to magnetostratigraphy and to Holes 266, 278, 329, and 512. The lower portion of Core 11, containing abundant reworked microfossils, is not shown but is probably also Chron 9 in age (from Ciesielski and Weaver, this volume).

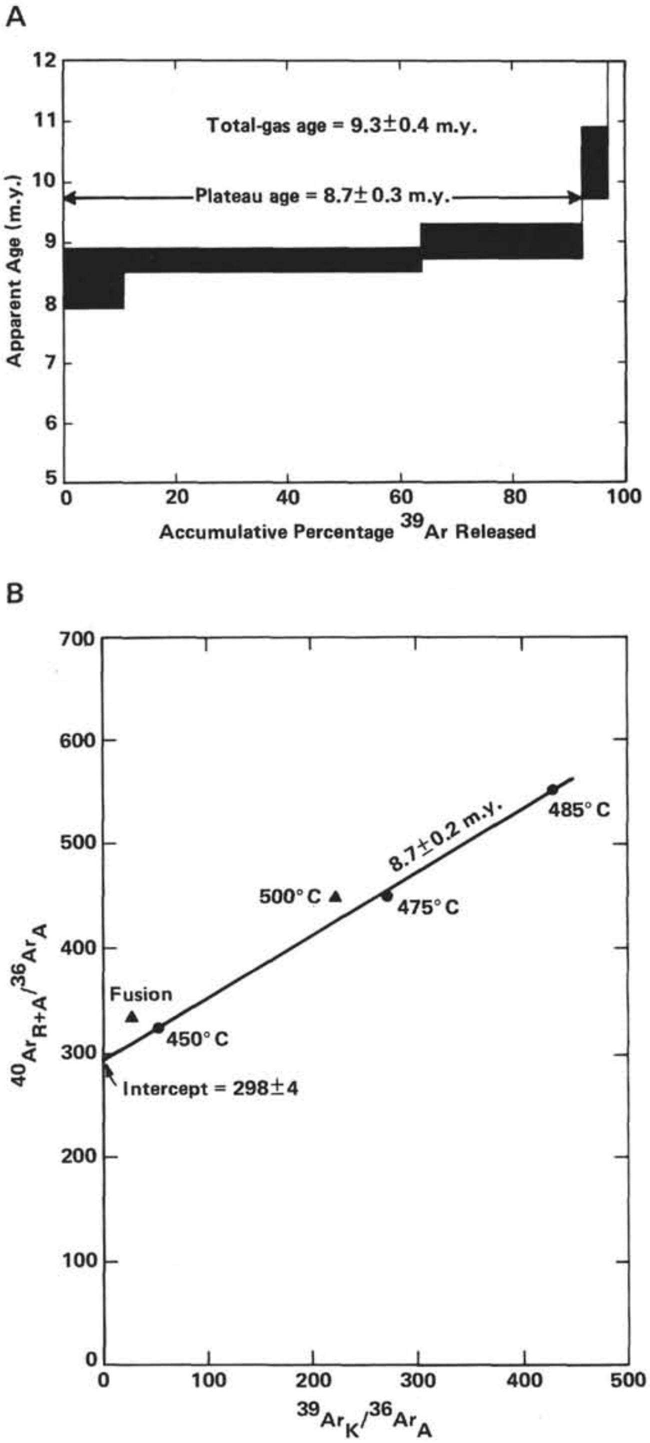


Figure 11. A. $^{40}Ar/^{39}Ar$ age spectra of volcanic glass from Sample 513A-10-7, 10–13 cm; uncertainties in calculated ages shown by width of bar (two sigma). B. Isochron plot of $^{40}Ar/^{39}Ar$ results with increment temperatures indicated; plateau increments (solid circles) define an isochron age of 8.7 ± 0.2 m.y. with a $^{40}Ar/^{36}Ar$ intercept of 298 ± 4. Analyses by R. D. Dallmeyer, K-Ar Laboratory, University of Georgia, Athens, Georgia.

Sediment accumulation rates calculated for the late Oligocene sequence in Hole 513A, Cores 15–23, were 10.7 m/m.y. whereas the early Oligocene sediment accumulation rate was a minimum of 19 m/m.y. The lack of adequate biostratigraphic resolution prevents an estimate of the early Miocene sediment accumulation rate in Cores 513A-12–14.

Calcareous Nannofossils

At Site 513, calcareous nannofossils are absent in the upper 180 meters of the section except for occasional specimens reworked from underlying strata. Below 180 meters, coccoliths are common to abundant in most samples and in general are moderately to well preserved. Assemblages are of low diversity, as would be expected for samples from this high latitude (48°S).

Sections 513A-13-2 to 513A-14-2 contain an assemblage dominated by *Coccolithus pelagicus, Cyclicargolithus floridanus*, and *C. abisectus*. Occasional *Chiasmolithus altus* are poorly preserved and are considered reworked; thus the interval is assigned to the upper Oligocene *Cyclocargolithus abisectus* Zone of Bukry (1973). *R. bisecta bisecta* is common beginning in Section 513A-14-6. This core and those down through Sample 513A-16,CC are assigned to the *R. bisecta* Zone whereas the interval from 513A-17-1 to 513A-28-3 belongs to the *Chiasmolithus altus* Zone. *R. umbilica* first appears commonly downhole, in Section 513A-28-4, and the interval from there to Sample 513A-29,CC is assigned to the lower Oligocene *R. daviesii* Zone. Core 30 belongs to the *Clausiococcus fenestratus* Zone. Cores 31 through 33 contain common *Ismolithus recurvus* and are assigned to the *Blackites spinosus* Zone (*B. rectus* Zone of Edwards, 1971), which extends to the base of the Oligocene. There was no indication in the nannofloras that Eocene sediments were cored before Hole 513A was terminated in basalt.

Foraminifers

Distribution of planktonic and benthic foraminifers in sediments of Site 513 is closely related (directly or indirectly) to the sediment type present. In calcareous sediments of the lower portion of the section (Cores 513A-13-33) planktonic and benthic foraminifers are common to few; in siliceous oozes of the upper part of the section (Cores 513A-1-12 and 513-1-9) they are rare or missing. The abundance, diversity, and preservation pattern of Site 513 foraminifers are given in Figure 13.

Planktonic foraminifers are very rare in siliceous sediments from Cores 513-1-9 and 513A-1-12. They are rare in slightly calcareous sediments from Cores 513A-13-27 and few or common in calcareous nannofossil ooze from Cores 513A-28-33. Preservation of planktonic foraminifers is poor throughout the section, except in Core 513A-33, where they are moderately well preserved (Fig. 13).

Benthic foraminifers are extremely rare or absent in deep-water, siliceous, upper Miocene–Quaternary sediments of Cores 513-1-9 and Cores 513A-1-11. Their paucity is related partially to dilution by diatoms and radiolarian skeletons. Benthic foraminifers are represented only by the agglutinated forms *Martinottiella antarctica, Cyclammina pusilla, Eggerella bradyi*, and *Silicosigmoilinella* sp. Preservation of tests is poor. Exceptions are Samples 513-3-1, 133–135 cm and 513-3-2, 38–40

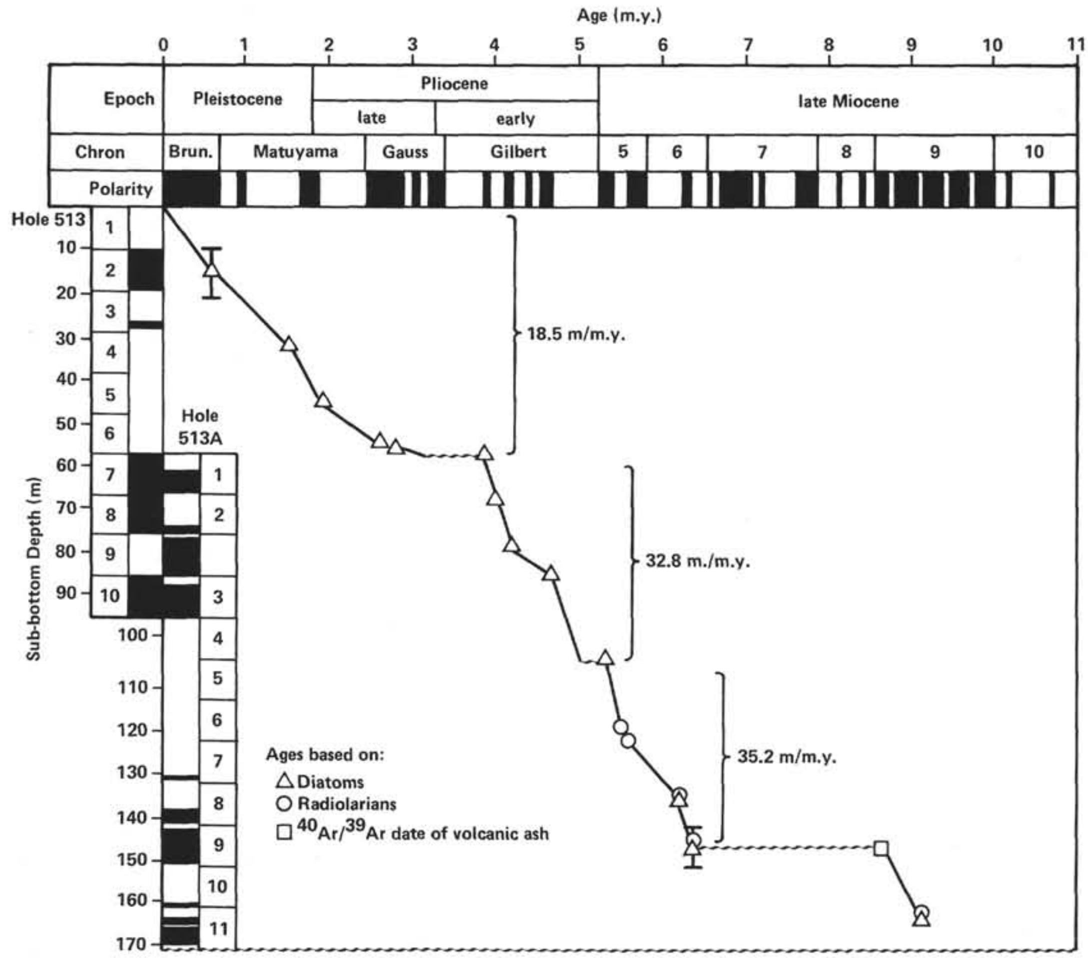


Figure 12. Sedimentation rate at Site 513. (Sedimentation rates for Sample 513A-12-1, 123–125 cm to Core 513A-3, lower Oligocene–lower Miocene, are given in the text.)

cm, which show a much higher species diversity (17), consisting mainly of the calcareous species *Pyrgo murrhina, Quinqueloculina pygmaea, Melonis affinis, M. pompiloides, Oridorsalis umbonatus, Pullenia quinqueloba, Alabaminoides exiguus, Sphaeroidina bulloides, Bradynella subglobosa*, and others. These species are evidently indicative of the same depths, but domination of the benthic assemblage by calcareous species as well as the presence of planktonic forms testifies to the site being above the CCD during some of the Quaternary.

In the calcareous lower Miocene–Oligocene sediments of Cores 513A-13 to 513A-33, the character of benthic foraminifers is quite different. Assemblages include both agglutinated and calcareous forms; species diversity sharply increases, reaching 10–15 species per sample, and the quantity of specimens also increases (but does not exceed more than a few). Preservation at first is poor, consisting mainly of shell fragments; downsection it becomes moderate. The following species were encountered: *Bolivinopsis cubensis, Martinottiella* sp., *Dorothia* sp., *Silicosigmoilinella* sp., *Eggerella bradyi, Cyclammina* sp., *Karreriella bradyi, Laticarinina pauperata, Cibicidoides floridanus, Anomalinoides spissiformis, Bradynella subglobosa, Pullenia subcarinata, P. quinqueloba, Melonis affinis, M. pompiloides, Astrononion pusillum, Gyroidina octocamerata, G. soldanii, Oridorsalis tenerus, Osangularia* sp., *Bulimina* sp., *Fissurina* sp., *Nodosaria* sp., *Pleurostomella alternans, P. acuta, Stilostomella nuttali, S. curvatura, S. bradyi, Guttulina adhaerens, Ellipsodimorphina* sp., *Sphaeroidina bulloides, Alabaminoides exiguus, Nonion havanense, Orthomorphina rohri, Chrysalogonium tenuicostatum*, and others (a total of about 70 species). Species composition of lower Miocene and Oligocene benthic foraminifers is similar but some Oligocene species (*N. havanense, Alabamina dissonata, G. adhaerens*) do not range into the lower Miocene sediment of Site 513.

Planktonic foraminifers do not yield a high stratigraphic resolution because of their low species diversity, poor preservation, reduced abundance, and the presence of long-ranging species.

In the intervals between Cores 513-1-9 and Cores 513A-1-11, only two samples (Samples 513-3-1, 133–135 cm and 513-3-2, 38–40 cm) contain a low-diversity assemblage of planktonic species: *Globigerina pachyderma, G. bulloides, Globorotalia inflata*, and *G. puncticulata*. According to Jenkins (1978) the latter species is not found above the Pliocene/Quaternary boundary. To the contrary, Kennett and Vella (1975) described this species from Pleistocene sediments. Consequently, *Glo-*

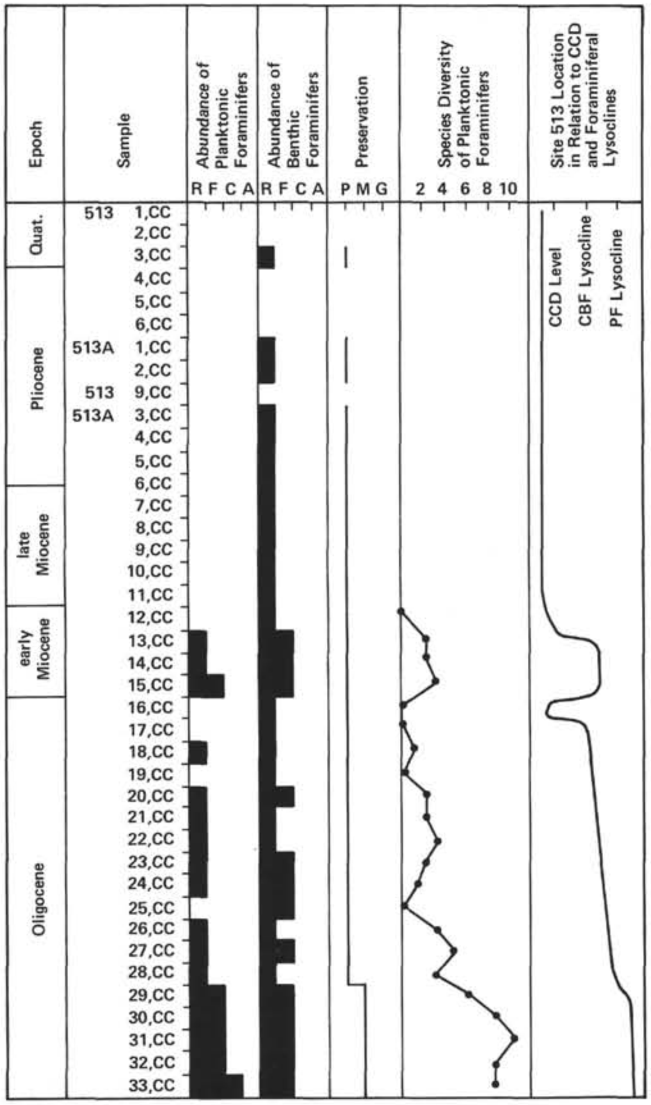


Figure 13. Abundance, preservation, and species diversity of foraminifers at Site 513. (Abundance: R, rare; F, few; C, common; A, abundant. Preservation: P, poor; M, medium; G, good. CBF, calcareous benthic foramineral lysocline; PF, planktonic foraminiferal lysocline.)

borotalia puncticulata cannot at the moment be used for demarcation of the Pliocene/Pleistocene boundary at Site 513.

Rare planktonic foraminifers were encountered in Cores 513A-13–15. Specimens identified include *Globigerinita dissimilis, G. unicava, Globigerina woodi woodi*, and *G. woodi connecta*. Apparently these sediments belong to the *Globigerina woodi connecta* Zone (basal lower Miocene) of the New Zealand zonal scheme (Jenkins, 1971). In Leg 40 sediments (the Cape Basin, Site 360) these species co-occur with *Globorotalia kugleri* and *Globigerinoides primordius*, thus permitting Toumarkine (1978) to correlate the *Globigerina woodi connecta* Zone with the *Globigerinoides primordius–Globorotalia kugleri* Zone of the tropical–subtropical scheme (the base of lower Miocene). We suggest that sediments of Core 513A-15 are near the Oligocene/Miocene boundary.

Cores 513A-16–19 are barren of planktonic foraminifers. Cores 513A-20–23 contain scarce *Globigerinita unicava, G.* sp., *Globigerina* aff. *prasaepis, G.* aff. *linaperta*, and *G. labiacrassata*. On the basis of the latter species the sediments can be assigned to the upper part of Oligocene. In the interval from Core 513A-24–28 (Sample 513A-28-3, 76–78 cm), rare specimens of *Globigerina angiporoides, G.* aff. *linaperta, Globigerinita unicava primitiva, G. martini scandretti, Globorotaloides suteri, G.(T.) munda*, and *Chiloguembelina cubensis* were identified (the lower part of Oligocene, which corresponds partly to the *Globigerina angiporoides* Zone of the New Zealand zonal scheme).

Comparatively rich assemblages of planktonic foraminifers were found in the section from Core 513A-28 (from Sample 513A-28-4, 76–78 cm) to Core 513A-33, where the species diversity is 7–10 species per sample and abundance is few to common. The list of species includes *Globigerina angiporoides, G. angustiumbilicata, G.* aff. *linaperta, Chiloguembelina cubensis, Globigerinita unicava unicava, G. unicava primitiva, G. martini scandretti, Globorotaloides suteri, Globorotalia gemma*, and *G. munda*. In Samples 513A-32-1, 110–112 cm and 513A-32-2, 110–112 cm, few specimens of *Globigerina brevis* were found. On the basis of this assemblage, sediments can be correlated to the lowermost part of Oligocene (the *Globigerina brevis* Zone and partly the *Globigerina angiporoides* Zone of the New Zealand zonal scheme).

Planktonic and benthic foraminifers clearly demonstrate the history of oceanic subsidence of the Site 513 area and the position of the CCD level during Oligocene–Miocene time. During the early Oligocene, Site 513 was located well above the planktonic foraminiferal lysocline; calcareous sediments overlying basalts contain rich assemblages with good preservation. These pelagic sediments contain deep-water benthic foraminifers. In the late Oligocene, Site 513 was below the planktonic foraminiferal lysocline (only the most resistant species are preserved in sediments), but above the benthic calcareous foraminiferal lysocline (calcareous species are preserved). In the early Miocene, Site 513 was above the CCD level; alteration of samples with and without calcareous foraminifers evidently reflects fluctuations of the CCD. In late Miocene–Quaternary time Site 513 was well below the CCD, calcareous foraminifers are absent (except in Core 513-3), and only their agglutinated representatives were recovered.

Diatoms

Diatoms are well represented throughout the entire lower Oligocene to Quaternary sequence of Holes 513 and 513A. In Pliocene–Quaternary sediments diatoms are common to abundant, diverse, and moderately preserved. Diatoms are common to abundant, poorly to moderately well preserved, and of moderate to high diversity in Miocene sediments. The abundance of diatoms varied greatly in the thick Oligocene section of

Hole 513A. In this interval, whole-fraction smear slide descriptions cite the percentage of diatoms in the sediment as varying from 1 to 65%. Diatom abundance appears to be controlled by the amount of carbonate dilution. The quantity of diatoms is highest (>10%) in the upper (Cores 15-20) and lower (Cores 28-33) portions of the section, where carbonate content is lowest. The preservation and diversity of the Oligocene assemblage is also variable; however, preservation is generally moderate and diversity relatively high.

Age determinations of Miocene–Quaternary sediments were made using the zonal scheme of McCollum (1975), as modified by Weaver (1976), Weaver and Gombos (1981) and Ciesielski (this volume). Major diatom datums found within the lower Miocene–Quaternary of Holes 513 and 513A are given in Figures 7 and 9. Figure 7 presents a correlation of the Pliocene–Quaternary of Site 513 to magnetostratigraphy; a similar correlation of the upper Miocene of Hole 513 (Cores 5-11) is given in Figure 10.

Cores 1-6 of Hole 513 contain an apparently continuous sequence of the upper Pliocene–Quaternary. Within this interval the youngest eight zones of Ciesielski's revised diatom zonation (this volume) are present. The *Coscinodiscus lentiginosus* Zone of the Brunhes Magnetic Chron is present from the surface through Sample 513-1-6, 115-117 cm. The *C. elliptipora/Actinocyclus ingens* Zone of the lowermost Brunhes–upper Matuyama Chronozone occurs from Sample 513-3-1, 45-47 cm through Sample 513-4-2, 90-92 cm; thus the boundary between these two zones (~620,000 y.B.P.) and the Brunhes/Matuyama Chronozone boundary (720,000 y.B.P.) probably fall in the unrecovered interval of Core 2. The mid-Matuyama Chronozone is represented between Samples 513-4-3, 90-92 cm and 513-5-4, 5-7 cm, where the *Rhizosolenia barboi/Nitzschia kerguelensis* Zone is encountered. Lower Matuyama Chronozone sediments represented by the *C. kolbei/R. barboi* Zone and *C. vulnificus* Zone are found from 513-5-5, 02-04 cm to 513-6-1, 02-04 cm and at 513-6-2, 02-04 cm, respectively.

Gauss Chronozone sediments are first encountered in Sample 513-6-2, 73-75 cm which has been assigned to the *Cosmiodiscus insignis* Zone. The Matuyama/Gauss boundary, which occurs in the lowermost *Coscinodiscus vulnificus* Zone, thus probably occurs between 4 cm and 73 cm of Core 6, Section 2. Samples 513-6-2, 73-75 cm through 513-6-4, 2-4 cm contain the *Cosmiodiscus insignis* Zone, and the underlying *N. weaveri* Zone occurs only in Sample 513-6-5, 2-4 cm; both zones represent the upper normal-polarity interval of the Gauss Chronozone. The *N. interfrigidaria/Coscinodiscus vulnificus* Zone is present between 513-6-6, 2-4 cm and 513-6-7, 34-36 cm. This later zone is indicative of the mid-Gauss Chronozone, from the lower portion of the upper normal-polarity sequence to between the Kaena and Mammoth subchronozones.

No sediments were recovered from Cores 7 and 8 of Hole 513; however, this interval (56.5-75.5 m) was partially recovered in Cores 1 and 2 of Hole 513A. The youngest sediment examined from Hole 513A (Core 1-1, 40-42 cm) was assigned to the *Nitzschia praeinterfrigidaria* Zone of the Gilbert Chronozone. The *N. interfrigidaria* Zone is thus absent, or is restricted to the interval of less than 1 meter that lies between samples examined from the base of Hole 513 and the top of Hole 513A. The presence of a hiatus between 513-6-7, 34-36 cm and 513A-1-1, 40-42 cm is also supported by numerous first and last species occurrences at these levels, including the last occurrence of *N. praeinterfrigidaria, N. reinholdii, Rouxia naviculoides*, and *Thalassiosira nativa* in Sample 513A-1-1, 40-42 cm, as well as the first occurrence of *Cosmiodiscus insignis, N. weaveri, Coscinodiscus vulnificus*, and *C. lentiginosus* f. *obovatus* in Sample 513-6-7, 34-36 cm. This Pliocene hiatus represents the earlier Gauss Chronozone, below the normal-polarity interval between the Kaena and Mammoth subchronozones, and the Gilbert Chronozone above the Cochiti Subchronozone. The age of the sediment bracketing the disconformity, when calculated by assuming constant sedimentation rates from known datums above and below the disconformity, is 3.05 Ma and 3.85 Ma, respectively. This calculated age is in agreement with diatom and radiolarian assemblages above and below the disconformity.

An alternative explanation for the Pliocene hiatus between Core 513-6 and Core 513A-1 is that the missing *N. interfrigidaria* Zone may be accounted for by an inaccurate sub-bottom depth estimate for the base of Hole 513 and the top of Hole 513A. This explanation seems unlikely, however, because the missing interval should be 10-20 meters thick, if sedimentation rates were one-half of or equal to the prior 18.5 m/m.y. rate of sedimentation, and a depth error of more than a few meters seems unreasonable.

Sediments of the Gilbert Chronozone are present between Samples 513A-1-1, 40-42 cm and 513A-4-7, 25-27 cm; the interval represents most of Gilbert from the base of the Cochiti Subchronozone to the lower Gilbert below the Thvera Subchronozone (Fig. 7). Diatom zones present within this interval include the *N. praeinterfrigidaria* Zone, 513A-1-1, 40-42 cm through 513A-2-1, 5-7 cm; the *N. angulata* Zone, 513A-2-2, 70-72 cm through 513-9-1, 7-9 cm; the *N. reinholdii* Zone, 513-9-2, 66-68 cm through 513-9-4, 66-68 cm; and the *Denticulopsis hustedtii* Zone, 513-9-5, 66-68 cm through 513A-4-7, 25-27 cm.

Diatom and radiolarian assemblages in Hole 513A, Core 5, indicate the presence of a hiatus between Cores 4 and 5 (Fig. 9; Ciesielski, this volume; Weaver, this volume). This hiatus spans an interval including the Miocene/Pliocene boundary (uppermost Chronozone 5 and lowermost Gilbert Chronozone). Samples 513A-5-1, 140-142 cm through 513A-9-1, 69-71 cm represent the late Miocene portion of the *D. hustedtii* Zone. Diatom and radiolarian datums within this interval (Fig. 9) allow a correlation of this interval to Magnetic Chronozones 5 and 6 (Fig. 10; Ciesielski and Weaver, this volume).

A third disconformity occurs at Site 513 within a zone where no sediment was recovered between Samples 513A-9-1, 69-71 cm and 513A-10-1, 13-15 cm (Fig. 9).

This disconformity separates the sediments of the *D. hustedtii* Zone above from the *D. hustedtii/D. lauta* Zone sediments below. The missing interval includes lower Chronozone 6, Chronozone 7, and most or all of Chronozone 8.

The *D. hustedtii/D. lauta* Zone occurs between Samples 513A-10-1, 13–15 cm and 513A-12-1, 9–11 cm. Age control for this interval was provided by a $^{40}Ar/^{39}Ar$ analysis of volcanic ash from Sample 513A-10-7, 10–13 cm. The plateau age for the incremental gas analysis was 8.7 m.y. ± 0.2 m.y. (Fig. 11); thus the interval represented at this site by the *D. hustedtii/D. lauta* Zone can be correlated to upper Chronozone 9 or lower Chronozone 8.

A major change occurs in the late Miocene diatom assemblage between Samples 513A-11-2, 53–55 cm and 513A-11-2, 120–122 cm. Abundant middle Miocene and Oligocene diatoms are reworked in the upper Miocene sediments between 513A-11-2, 120–122 cm and 513A-12-1, 9–11 cm. These reworked diatoms were apparently transported to the site by bottom currents from exposure of nearby older sediment, seen on seismic reflection profile records (Figs. 3–5; Ciesielski and Weaver, this volume). Reworked middle Miocene diatoms include representatives of the upper *N. maleinterpretaria* Zone, *Coscinodiscus lewisianus* Zone, *N. denticuloides* Zone. Reworked Oligocene diatoms come primarily from lower Oligocene *Pyxilla prolongata* Group Zone and all four upper Oligocene zones of Gombos and Ciesielski (this volume).

The fourth and lowermost detected disconformity occurs between Samples 513A-12-1, 9–11 cm and 513A-12-1, 123–125 cm; it separates the upper Miocene above from a lengthy and apparently continuous lower Oligocene–lower Miocene section. Eight diatom zones occur in Hole 513A between Sample 513A-12-1, 123–125 cm and the chert and basalt sill encountered in Cores 34–36; 7 of these zones are described for the first time by Gombos and Ciesielski (this volume). Samples 513A-12-1, 123–125 cm through 513A-12-4, 44–46 cm contain part of the *Coscinodiscus rhombicus* Zone of Weaver and Gombos (1981). Samples 513A-12-4, 122–124 cm through 513A-15-7, 55–57 cm contain the *Rocella gelida* Zone; Sample 513A-16-1, 23–25 cm through Sample 513A-16-7, 12–14 cm contain the *Triceratium groningensis* Zone; Sample 513A-17-1, 96–98 cm through Sample 513A-18-5, 64–66 contain the *R. vigilans* Zone; Sample 513A-19-1, 34–36 cm through Sample 513A-22,CC contain the *Kozloviella minor* Zone; Sample 513A-24-1, 16–18 cm through Sample 513A-25,CC contain the *Pyxilla prolongata* Group Zone; Sample 513A-26,CC through Sample 513A-30-5, 5–7 cm contain the *C. superbus* Group Zone; and Sample 513A-31-1, 105–107 cm through Sample 513A-33-7, 61–63 cm contain the upper portion of the *Rhizosolenia gravida* Zone; all of the latter zones are defined by Gombos and Ciesielski (this volume).

Silicoflagellates

Silicoflagellates occur only sporadically in Quaternary and lower to upper Pliocene sediments between Samples 513-1-1, 123–125 cm and 513A-1-3, 40–42 cm. No zonal assignment was made for this material because of its low diversity and abundance.

Silicoflagellates are generally common and consistently present in the upper Miocene through lower Pliocene between Sample 513A-2-1, 5–7 and Sample 513A-11-7, 46–48 cm. The *Mesocena diodon* Zone is identified between Samples 513-9-6, 6–8 cm and 513A-7-2, 70–72 cm and the *M. circulus/M. diodon* Zone occurs between Samples 513A-7-4, 70–72 cm and 513A-11-2, 53–55 cm. Samples 513A-11-2, 120–122 cm through 513A-11-7, 46–48 cm contain rare silicoflagellates and are not given a zonal assignment.

Diatoms and other microfossil groups indicate the presence of a disconformity between Samples 513A-12-1, 9–11 cm and 513A-12-1, 123–125 cm, separating the upper Miocene and lower Miocene sediments (Gombos and Ciesielski, this volume). Cores 12 through 33 contain a succession of lower Oligocene through lower Miocene sediments, apparently free of major disconformities.

Samples 513A-12-3, 128–130 through 513A-14-6, 46–48 are assigned to the newly defined *Naviculopsis biapiculata* Partial Range Zone. The age of this zone is early Miocene according to the planktonic foraminifer studies of Basov and Krasheninnikov (this volume) and the base of the zone approximates the Oligocene/Miocene boundary. Silicoflagellates are rare and poorly preserved in Core 12; however, they are common and well preserved in Cores 13 and 14. Diversity within this zone is low; *Distephanus crux crux, D. boliviensis hemisphaericus*, and *N. biapiculata* dominate the assemblage.

Samples 513A-15-3, 119–221 cm through 513A-21-1, 70–72 cm are placed in the newly established *Corbisema archangelskiana* Range Zone of the upper Oligocene. Silicoflagellates from this interval are moderately diverse and well preserved; the most abundant species include *C. archangelskiana, D. boliviensis hemisphaericus, D. crux crux, D. quinquangellus, Mesocena apiculata*, and *N. biapiculata. N. trispinosa* has its last occurrence in Sample 513A-16-3, 23–25 cm and the diatom *Rocella gelida*, formerly thought to be a silicoflagellate (Gombos and Ciesielski, this volume), has its uppermost Oligocene acme in Core 15.

Samples 513A-22-1, 14–16 cm through 513A-30-2, 29–31 cm are assigned to the newly defined *N. constricta-C. archangelskaia* Interval Zone which brackets the lower/upper Oligocene boundary. The remainder of Hole 513A, from 513A-31-2, 21–23 cm through 513A-33-7, 55–57 cm is placed in the newly defined *Naviculopsis constricta/Dictyocha deflandrei* Partial Range Zone. The detailed assemblage characteristics of these two zones are presented in the chapter by Shaw and Ciesielski (this volume).

Sponge Spicules

Sponge spicules are incorporated in almost all samples of Cores 513A-11 to 513A-33. Their distribution in Oligocene and Miocene sediments is relatively even. The vast majority of spicules are fragments of a compact skeleton of sixradiate glass sponges from the class Hyalospongiae. Best preserved are outer rays of this skeleton that protrude over the surface of the sponge body. These spicules are more massive than rays composing the dictyional skeleton. Such spicules are especially indicative of sponges with a skeleton built by a tangled (intricate) net of desmas. In addition, there are in the spicule complex other fragments of a compact skeleton, as well as isolated macroscleres and microscleres of glass sponges. Rare specimens of tetraradiate sponges from the order Tetraxonida occur sporadically.

In the interval under study four large sponge assemblages were identified, each morphologically distinct from the other. The first assemblage is found in Sample 513A-11,CC (middle Miocene). The second assemblage was observed in Cores 513A-12 to 513A-14 (lower Miocene). The third assemblage is characteristic of upper Oligocene sediments (Cores 513A-16 to 513A-24). The fourth assemblage is typical of the lower part of Oligocene (Cores 513A-25 to 513A-33). The last assemblage is similar to a sponge spicule assemblage from lower Oligocene sediments at Site 511 (Cores 2–17). The detailed characteristics of these assemblages and plates of the morphologic types of sponge spicules found at this site are given in Ivanik (this volume).

PALEOMAGNETISM

Sediments

Paleomagnetic investigations were not carried out on the sediment from Hole 513, since there was too much drilling disturbance. A total of 51 oriented samples were taken, however, from the undisturbed parts of Hole 513A sediment. Sampling and measurement techniques are described in the Site 511 site chapter (this volume). Pilot demagnetization of 7 samples displayed a fair degree of stability, although one sample (513A-18-3, 54–56 cm) showed erratic behavior. The remaining 6 samples showed small secondary magnetizations which were removed by demagnetization up to 150 Oe. In some cases the samples started to develop anhysteretic remanent magnetizations (ARM) at 300 Oe, and the direction of remanence began to change. Demagnetization of the stronger remaining samples at 150 Oe produced increases in inclination of up to 30°, and decreases of about 20–30% in intensity.

The magnetizations are considered stable enough to allow the assignation of polarity. Average absolute inclination is 47.9 ± 11.4°, which is low compared to that expected for the latitude (65.4°), but illustrates that there is a marked difference between positive and negative inclinations. The polarity sequence is given by Salloway (this volume).

Basalts

Thirteen oriented samples were drilled from the 4.80 meters of basement recovered in Hole 513A. Samples were selected from the larger pieces of basalt, which had probably not rotated with respect to the uphole direction. Where possible, two or more samples were taken from groups of pieces that could be fitted together, so that declination could be compared. The basalt is fine- to medium-grained in Sections 513A-35-1 and 513A-36-1 (between depths of 380.5 and 383.5 m). The upper part of Section 513A-36-2 is fine-grained; below, the basalt is slightly coarser.

Natural remanent magnetization was measured using the Digico spinner magnetometer (see Table 3). Intensities were high, ranging from 2300 μG to 9300 μG. Higher intensities occur in fine-grained intervals (Samples 513-36-2, 21–23 cm, and 513-36-2, 76–78 cm), and in general, the finer basalts of the upper part of the section have higher intensities than the lower, coarser samples. Average intensity is 5744.3 ± 2240.0 μG through Sample 513-36-2, 76–78 cm, and 3917.3 ± 1860.6 μG below that point.

Alternating field demagnetization up to peak fields of 900 Oe, as described in the Site 511 site chapter (this volume), was carried out on 5 of the samples (see Fig. 14). None of them showed any significant change in direction, even at high fields. The sample group can be divided into two sets on the basis of median destructive field (MDF). Samples 513-35-1, 30–32 cm, 513-36-1, 28–30 cm, and 513-36-2, 21–23 cm had MDF values of 368, 327, and 435 Oe respectively, and showed steady decrease of intensity with demagnetization. The two samples from the lower part of the hole (513-36-2, 140–142 cm and 513-36-3, 104–106 cm) decreased rapidly in intensity up to 200 Oe, after which intensity levelled off at 10% of the NRM value. Median destructive fields were 160 and 112 Oe respectively. Demagnetization shows that NRM is stable, and probably represents a primary magnetization.

Inclinations are all positive, varying between 48.3° and 60.1°. An arithmetic average gives an inclination of 53.2 ± 4.2°, implying a paleolatitude of 33.8°, low compared to the present latitude (47.6°). This difference may be due to tilting of the basalt flows or failure to average out secular variation. Where two samples were taken from the same group of pieces, declination values agree, differing by less than 10°, except for Samples 513-36-1, 28–30 cm, and 513-36-1, 59–61 cm, which differ by 30°. The hole was drilled between Anomalies 13 and 15. The basalt sill is reversely magnetized; its position probably corresponds more closely to Anomaly 15.

Susceptibility was measured in Edinburgh using a Digico susceptibility bridge. Values increase with depth and can be divided into two groups in the same manner as intensity and demagnetization characteristics. Susceptibility averages 540.6 ± 194.6 μG/Oe above Sample

Table 3. Paleomagnetism of basalts, Hole 513A.

Core/Section (interval in cm)	NRM Intensity (μG)	Susceptibility (μG/Oe)	Q Ratio	MDF (Oe)	Inclination NRM (°)	Inclination Stable (°)	Declination NRM (°)	Declination Stable (°)
35-1, 30–32	6521.95	417.4	15.63	368	55.9	51.7	175.0	168.9
35-1, 54–56	3931.46	440.8	8.92		55.0		172.4	
35-1, 70–72	3146.71	418.5	7.52		56.5		273.6	
36-1, 28–30	5501.32	500.4	10.99	327	49.0	48.3	236.8	239.5
36-1, 59–61	5976.15	933.6	6.40		45.0		216.4	
36-1, 94–96	3379.23	745.4	4.53		50.5		216.6	
36-2, 21–23	8146.06	387.8	21.00	435	60.1	60.1	180.9	181.2
36-2, 76–78	9351.15	480.5	19.46		54.6		179.7	
36-2, 108–110	3029.86	1062.3	2.85		51.8		287.1	
36-2, 140–142	6612.01	962.1	6.87	160	54.5	57.5	291.6	290.2
36-3, 39–41	5082.54	1334.1	3.81		48.3		197.3	
36-3, 77–79	2323.31	2366.6	0.98		53.7		252.6	
36-3, 104–106	2538.95	1328.3	1.91	112	57.3	59.2	262.3	269.8

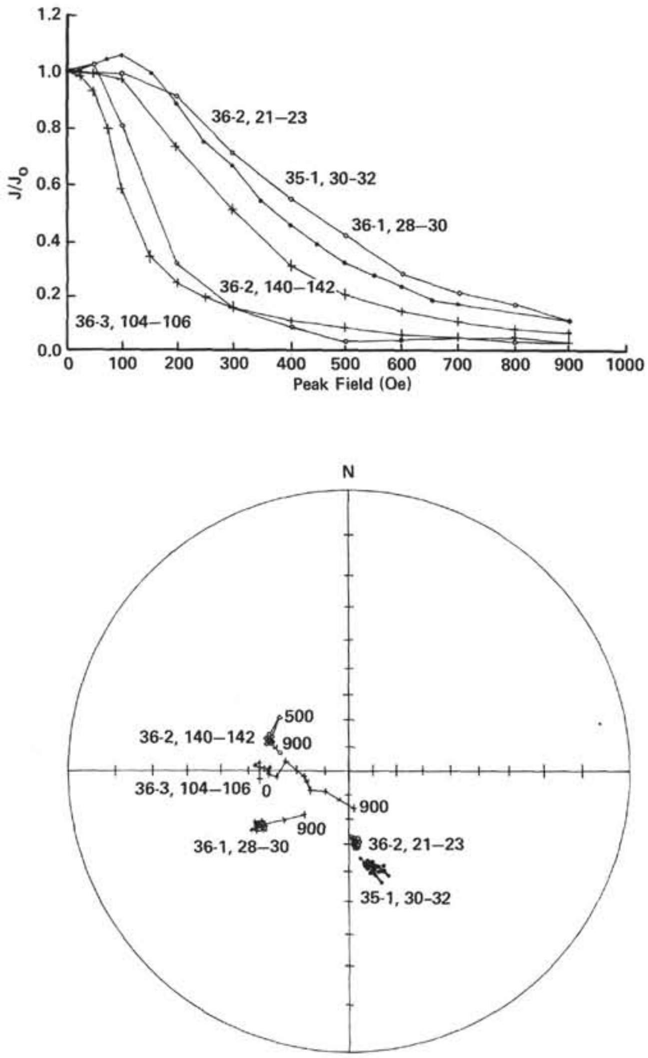


Figure 14. Alternating field demagnetization of basement samples from Hole 513A.

513-36-2, 76–78 cm and 1410.7 ± 558.8 μG/Oe below. Q-ratios (NRM intensity divided by suceptibility) decrease with depth, averaging 11.81 ± 6.18 in the upper part of the section, and 3.28 ± 2.26 in the lower part.

ORGANIC GEOCHEMISTRY

In Holes 513 and 513A there were no gas pockets; organic geochemical studies were confined to organic carbon, nitrogen content, and gases in interstitial water and pyrolysis/fluorescence.

Results

Organic carbon values vary within a large range between 0.07% and 0.66% (Figure 15A) and they can be roughly divided into 3 groups (Table 4).

The features of organic carbon variation shown above might reflect changes in the Polar Front, effects of subsidence and the concomitant changes of bioproductivity in surface waters, benthic life at the sediment/water interface, and the ultimate fate of organic carbon incor-

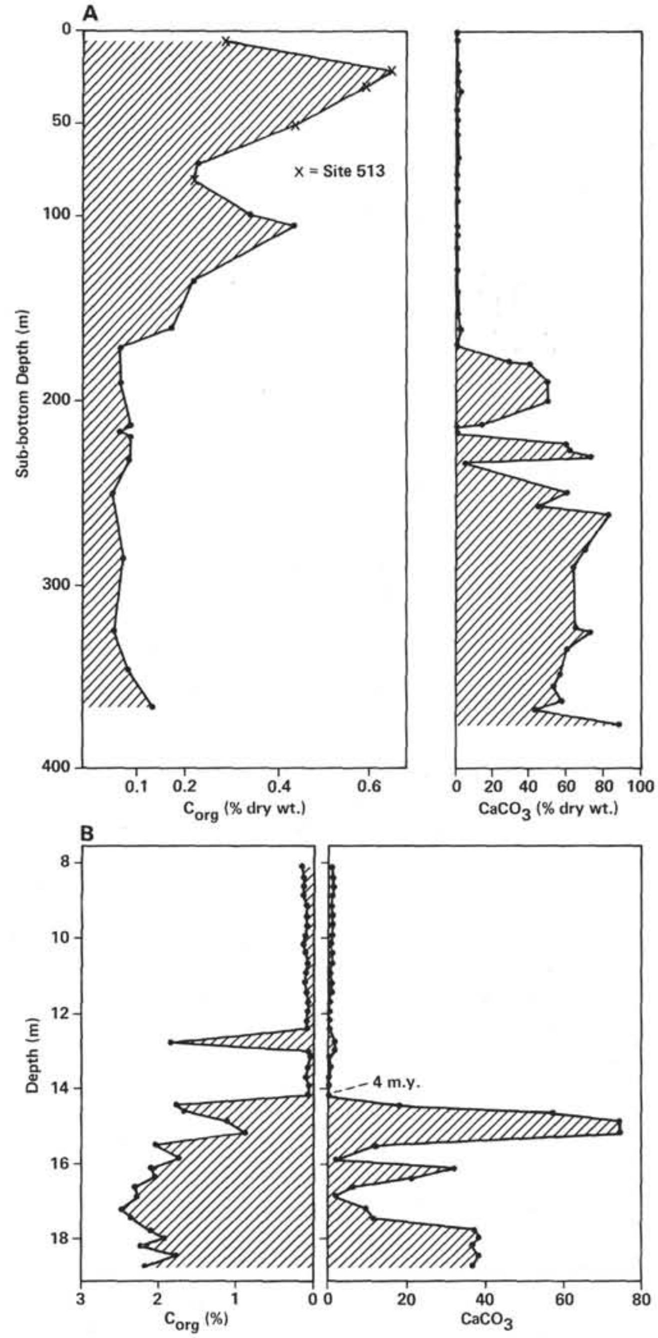


Figure 15. Covariation of organic carbon and calcium carbonate at Site 513 (A) and in core Y71-7-36P from the southeast Pacific Ocean (B). In B, the decrease in calcium carbonate at 5 Ma marks the migration of the core site through the CCD because of seafloor spreading. (B adapted from Heath et al., 1977.)

Table 4. Organic carbon content.

Group	Core No.	Average C_{org}	Main Lithology	Age	C/N Ratio
I	513-1-6	>0.5	Muddy diatomaceous ooze	Plio/Pleistocene	8.8
II	513-9 513A-2-11	~0.3	Muddy diatomaceous ooze	Pliocene to late Miocene	6.5
III	513A-12-33	≤0.1	Diatomaceous-nannofossil ooze and nannofossil ooze	early Miocene to early Oligocene	3.5

porated into sediments. Together with the paleontologists' data, this pattern of organic carbon distribution substantiates the importance of paleoenvironmental conditions of deposition. The bulk of the organic carbon is derived from marine organisms. The contribution of argillaceous material (from continental runoff) drops in units with enriched organic carbon content.

Sediments in Hole 513 (Table 4, Group I) can be assigned to a cold-water microfossil assemblage: Hole 513A seems to be distinguished by a more temperate assemblage down to a depth of about 170 meters (Table 4, Group II). The sedimentation rates of the diatomaceous oozes are considered to be high, thus assuming a high bioproductivity in high-latitude waters enriched in nutrients. High bioproductivity in general implies high production of organic as well as inorganic material in the form of skeletal stroma. A decrease or increase of bioproductivity, therefore, should not shift this ratio within a large range. Indeed, content and accumulation rates of organic carbon apparently follow the pattern of sedimentation rates if regarded in a larger context (Heath et al., 1977); variation and fluctuation of organic carbon content then seems to be mainly affected by the environmental conditions at and within the sediment layer. Holes 513 and 513A seem to support this thesis; that is, the upper part of the section is enriched in organic carbon although sediments were deposited below the CCD in great water depth. Once organic particles reached the sediment interface of the deep-sea environment, they were apparently better preserved from total destruction and dissolution. One reason for this may be the fact that the deep-sea environment of the open oceans often shows a remarkably low degree of benthic and especially bacterial activity (Degens and Mopper, 1976), thus reducing further the destruction of organics. In addition, the increased sedimentation rate at Site 513 should prevent organics from oxidation by a quicker burial.

Organic carbon values seem to drop to very low but uniform values at the depth (or time) at which carbonate content increases (Figure 15A). The extremely low values may be a result of acid treatment and subsequent washing, but a marked decrease is already indicative within the diatomaceous ooze sequence. If this dramatic drop is valid, it would indicate that preservation of organics was much less favorable when they were deposited above the CCD in shallower water. A diverse and abundant population of benthic foraminifers (Basov and Krasheninnikov, this volume) was clearly feeding on organic aggregates deposited at the sediment surface. The small amount of organics still present in the sediment may represent the refractory residue, unsuitable for further utilization.

Organic matter exposed to an oxic environment is relatively depleted in organic carbon and enriched in total nitrogen (Muller, 1975), thus exhibiting low C/N ratios (Table 4). C/N ratios of the refractory organic matter encountered in the lower part of Hole 513A are typically lowered and are, therefore, taken to represent NO_3^- besides the organic nitrogen. Values contrary to the results given in Figure 15A, reported by Heath et al. (1977), from the Bauer Deep in the southeast Pacific (Figure 15B), may have originated under different environmental conditions and from a different type and structure of organic matter coating the calcite plates of coccoliths.

Interstitial water analyzed for Hole 513A showed no indications of any dissolved hydrocarbons in the C_1–C_5 range. Only air and CO_2 were detected. CO_2 was quantified in terms of ppm of interstitial water. The method used to liberate the gases from water can also be applied as a quick estimation for alkalinity (Skirrow, 1965). The strongly acidic milieu converts both bicarbonate and carbonate ions to CO_2:

$$3H_3O^+ + HCO_3^- + CO_3^{--} = 5H_2O + 2CO_2$$

These same trends, low surface water alkalinity, a slight decrease in alkalinity with core depth, and a marked drop in alkalinity in Core 30, were observed in the standard shipboard interstitial water titrations.

Data from pyrolysis/fluorescence do not indicate any hydrocarbon potential. Values obtained are all low and within the tolerances of experimental error.

PHYSICAL PROPERTIES

An extensive physical properties sampling program was conducted on cores from Site 513 to correlate seismic reflectors with lithology in as much detail as possible. The results are listed in the Barrel and Core Summaries at the end of this chapter.

General Trends

Within the late Miocene–Quaternary section, down to 140 meters, the wet-bulk density scatters around a mean value of approximately 1.35 g/cm^3, and water content and porosity decrease slightly (water content from 65% to 55%, porosity from 85% to 45%). The variations in bulk density seem to be caused mainly by variations in water content. In the Oligocene section (below 220 m), increasing bulk densities and decreasing porosities are due to an increase in carbonate content; in the lowermost Oligocene interval, however, bulk density tends to decrease, whereas the porosity values stay stable below 320 meters.

The overall trend in sonic velocity is parallel to the bulk density values. Throughout the section the values are very low (~1.58 gm/s down to 200 m, 1.61–1.62 below 200 m). A major alteration of velocity at 220 meters corresponds to the lowered porosity and the increased carbonate content of this interval. Penetration and vane shear give similar information. Penetration seems somewhat more sensitive to core disturbance, and within the uppermost 40 meters, depends primarily on position within the core: high values are found at the top of the core and low values at the bottom. From penetration and vane shear values the sedimentary section in Hole 513A can be divided into at least 4 units that correspond to time-stratigraphic intervals. The Pleistocene section shows low shear values, increasing with depth. Within the Pliocene section the vane shear values are highly scattered and do not show a distinct trend. The short

Miocene section has again very low shear strength values and high penetrations. In the uppermost Oligocene, vane shear values increase rapidly with wide scattering, but toward the bottom of the hole they tend again to lower values. The decrease in shear strength between 240 and 260 meters may not correspond to a softening of the sediment but to fracturing during coring, which may also have caused the extremely low recovery between 260 and 320 meters. The drilling times indicate that the mechanical properties of the material do not change very much during this interval, and in general these times correspond very well to the vane shear values and to carbonate content.

Small-Scale Fluctuations

As the seismic record indicates, small-scale fluctuations of physical properties occur throughout the section. In the Pleistocene–Pliocene sequence these fluctuations seem to be caused mainly by variations in water content that could indicate changes in grain size and grain packing arising from variations in lithological composition. Near the Pleistocene/Pliocene boundary, a somewhat stronger fluctuation in sonic velocity indicates a stronger reflection horizon. Within the Oligocene section, fluctuation in carbonate content seem to be the prime cause of variations in physical properties.

CORRELATION OF SEISMIC REFLECTORS WITH LITHOLOGY

The *Challenger* seismic reflection profile approaching and departing Site 513 is shown in Figure 3. The reflection pattern of the sediments consists of a simple, parallel to subparallel configuration with fair continuity of closely spaced reflectors overlying oceanic basement (Layer 2) at a depth of 0.5 sec TWTT below seafloor. Oceanic basement in the Site 513 area has an unusually smooth upper surface, typical of a sill.

The major reflectors are correlated with the time-stratigraphic units cored at Site 513 in Figure 16. The basis for correlation is a plot of acoustic impedance (density × velocity) versus depth, determined from measurements of physical properties. On the figure, only two lithologic units can readily be identified with seismic reflectors; the Unit 1/Unit 2 boundary at 180 meters depth and the sediment/sill interface at 380 meters depth. The Unit 2/Unit 3 boundary also seems to be represented by an impedance change, which may represent the reflector at a corresponding depth on the seismic record. However, there are numerous closely spaced reflectors. Some, of course, represent sound source reverberations that can mask primary reflections, thus making correlation of thin layers impossible. It should also be noted that impedance contrasts in the section are many and are quite small. Fluctuations in carbonate content seem to be the main cause of variations in physical properties in the Oligocene section and may account for the closely spaced reflectors below 200 meters (see Physical Properties section, this chapter). The Neogene section is carbonate-free. The comparatively weak sequence of parallel reflectors observed in the Neogene part of the section may be due largely to changes in physical properties caused by variations in water content.

SUMMARY AND CONCLUSIONS

Summary

Hole 513 was drilled and continuously cored to 104 meters sub-bottom. A second hole, 513A, was washed to 56.5 meters, a level where core retrieval in Hole 513 had been negligible, and then drilled and continuously cored to termination in basement basalt at 387 meters sub-bottom.

The site is situated about 150 mi. north of the present-day position of the Antarctic Convergence (Polar Front). The principal drilling objective was to obtain a complete late Paleogene–Neogene biostratigraphic sequence and, from study of mixed siliceous and calcareous fauna, to determine the history of the Polar Front during the late Cenozoic. The stratigraphic section consists, from the top downward, of the following lithologic units (Fig. 6).

Lithostratigraphy

Unit 1. 180 meters of muddy diatomaceous ooze with a moderate amount of interlayered diatomaceous clays down the section. Subangular to angular pebbles up to 4 cm, of varying lithologies and presumably of ice-rafted origin, occur in the upper part of the unit. Its age extends from early Miocene to Pleistocene, with three hiatuses within the unit.

Unit 2. There are 53.9 meters of muddy diatomaceous nannofossil ooze and diatomaceous nannofossil ooze in this unit, spanning the late Oligocene to the early Miocene; it is transitional between Units 1 and 3, the contacts with which are somewhat arbitrary. It has been divided into two subunits, the upper one with a high mud and diatom content and the lower with an increased carbonate content. Subunit 2A consists of 42.5 meters of muddy diatomaceous nannofossil ooze alternating with diatomaceous clay and muddy diatomaceous ooze; colors range from very pale brown to brownish gray. Its age is late Oligocene through early Miocene. Subunit 2B consists of 11.4 meters of light gray to white diatomaceous nannofossil ooze alternating with nannofossil ooze; its age is late Oligocene.

Unit 3. This unit is composed of 145.5 meters of light gray and white nannofossil ooze and contains some indurated chalk zones; its age ranges from early through late Oligocene. A single white chert core fragment was recovered from the core catcher of the lowest core of this unit; its age is undetermined.

Unit 4. About 6 meters of fine-grained phyric basalt was drilled and interpreted to be a sill.

Conclusions

Unit 2 reflects the change from calcareous to muddy diatomaceous deposition in the early Miocene and may very well relate to the opening of the Drake Passage and oceanic subsidence and possibly to the CCD fluctuation. Although there is a hiatus of ~800,000 y. in the middle Pliocene, a short hiatus bracketing the Miocene/

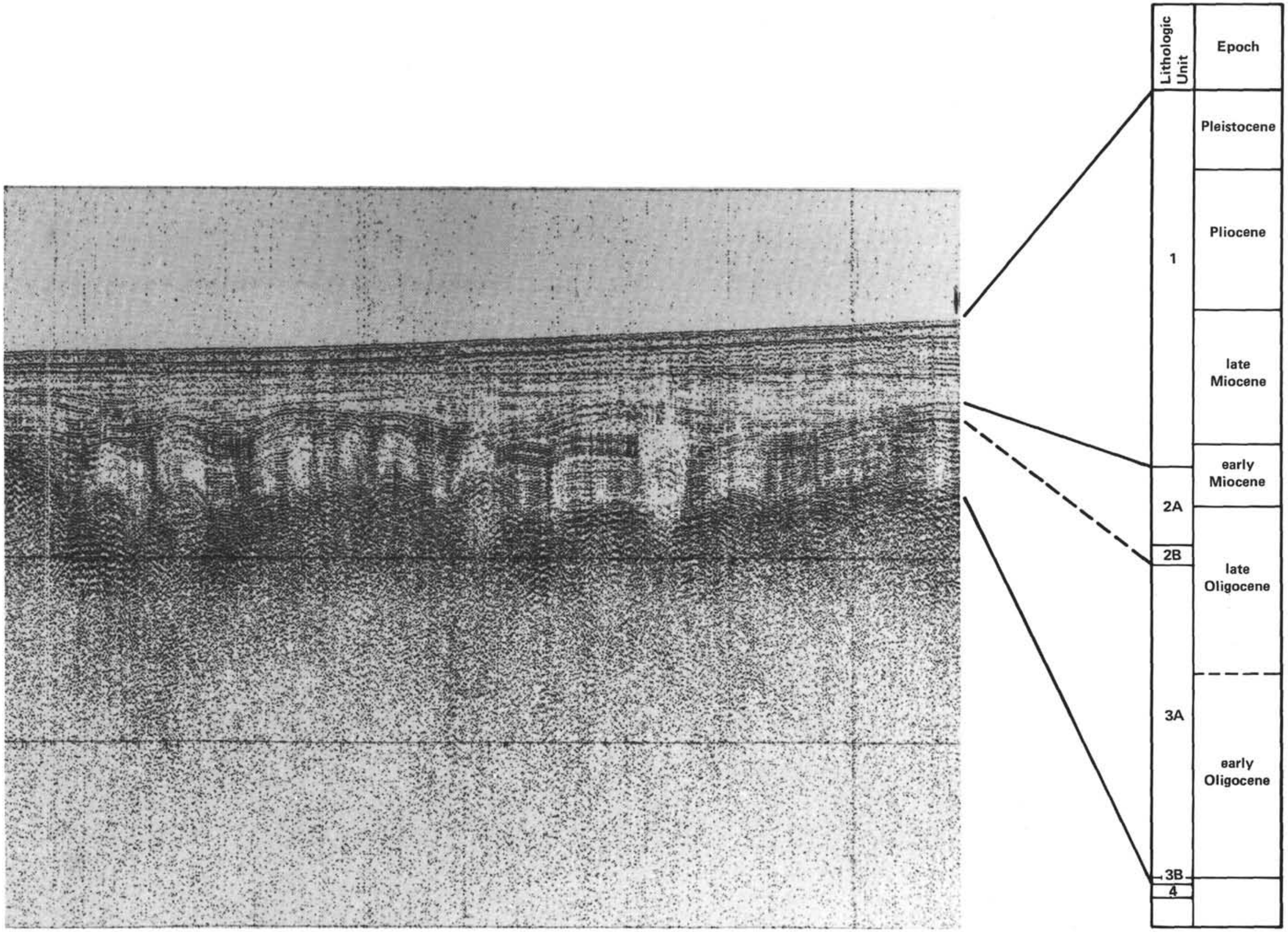


Figure 16. Correlation of seismic reflectors with the lithology cored at Site 513.

Pliocene boundary, an ~2 m.y. late Miocene hiatus, and at least a 9 m.y. hiatus between upper and lower Miocene, these temporal gaps do not invalidate the high stratigraphic resolution of diatom and radiolarian zonation that is inherent in this siliceous Neogene section.

Overlap of the Oligocene sections of Sites 511 and 513 provides the most complete Oligocene biostratigraphy thus far obtained in southern high latitudes. The abundant siliceous microfossils and the somewhat limited calcareous microfauna in this series permit correlations with the New Zealand zonal scheme and probably with the temperate subtropical zonation. The differences between the microfaunas of Sites 511 and 513 are useful for paleoclimatic reconstructions. Diatom and particularly radiolarian assemblages exhibit paleotemperature fluctuations that reflect, for instance, a warming period in the latest Miocene–earliest Pliocene, followed by a deterioration of climate.

Site 513 provides important information on the paleodepth of the CCD and the foraminiferal lysocline. During the early Oligocene, the site was above the CCD and the planktonic foraminifer lysocline; in the late Oligocene, it was below the planktonic foraminifer lysocline; but above the benthic calcareous foraminifer lysocline; during the Neogene, it occupied a position well below the CCD.

A sedimentation rate of 10.7 m/m.y. for the late Oligocene and 4.0 m/m.y. for early Miocene is an approximate calculation; about 35 m/m.y. characterizes the late Miocene, and early Pliocene (Gilbert Chron) rates were similar (33 m/m.y.). Decrease followed in the mid-Gauss Chron to a nearly constant 18.5 m/m.y. throughout the balance of the Neogene.

Because the organic carbon percentage in Site 513 sediments appears to decrease to very low but constant values wherever carbonate content increases, it is concluded that organic carbon content is sensitive to bioproductivity changes induced by the onset and fluctuations of the Polar Front. The upper part of the section at Site 513 (that is, middle Miocene to Holocene) is enriched in organic carbon deposited below the CCD, whereas the lower part is depleted. High productivity associated with advances of the Polar Front appears to result in an increased sedimentation rate, which in turn protects the organic material from oxidation, through fast burial.

The increase in carbonate content in the lower (Oligocene) part of the section is reflected by increasing bulk densities and decreasing porosities. Fluctuations in carbonate content seem to be the main cause of variations in physical properties, which may account for the closely spaced, parallel reflection configuration observed in the seismic record of the area.

REFERENCES

Degens, E. T., and Mopper, K., 1976. *In* Riley, J. P., and Chester, R. (Eds.), *Chemical Oceanography* (2nd. ed., Vol. 6): New York (Academic Press).

Edwards, A. R., 1971. A calcareous nannoplankton zonation of the New Zealand Paleogene. *In* Farinacci, A. (Ed.), *Proc II Planktonic Conf.*, Rome (Edizioni Tecnoscienza), pp. 381–519.

Goodell, H. G., 1973. The sediments. *Marine Sediments of the Southern Oceans,* Antarctic Map Folio Series, Folio 17: New York (American Geographic Society).

Heath, G. R., Moore, T. C., Jr., and Dauphin, J. P., 1977. Organic carbon in deep sea sediments. *In* Andersen, N. R., and Malahoff, A., (Eds.) *The Fate of Fossil Fuel CO_2 in the Oceans.* Marine Science (Vol. 6): New York (Plenum Press), 605–625.

Jenkins, D. G., 1971. New Zealand Cenozoic planktonic foraminifera. *New Zealand Geol. Surv. Paleontol. Bull.*, 42:1–278.

_______, 1978. Neogene planktonic foraminifers. *In* Bolli, H. M., Ryan, W. B. F., et al., *Init. Repts. DSDP*, 40: Washington (U.S. Govt. Printing Office), 723–739.

Kennett, J. P., and Vella, P., 1975. Late Cenozoic planktonic foraminifera and paleoceanography at DSDP Site 284 in the cool subtropical South Pacific. *In* Kennett, J. P., Houtz, R. E., et al., *Init. Repts. DSDP*, 29: Washington (U.S. Govt. Printing Office), 769–797.

McCollum, D. W., 1975. Diatom stratigraphy of the Southern Ocean, Leg 28. *In* Hayes, D. E., Frakes, L. A., et al., *Init. Repts. DSDP*, 28: Washington (U.S. Govt. Printing Office), 515–572.

Muller, P., 1975. Zur Diagenese strickstoffhaltiger Substanzen in marinen Sedimenten unter oxidierenden und reduzierenden Bedingungen [Ph.D. dissert.]. University of Kiel.

Skirrow, G., 1965. The dissolved gases: carbon dioxide, *In* Riley, J. P. (Ed.), *Chemical Oceanography* (Vol. 1): New York (Academic Press).

Toumarkine, M., 1978. Planktonic foraminiferal biostratigraphy of the Paleogene of Sites 360 to 364 and the Neogene of Sites 326A, 363 and 364 Leg 40. *In* Bolli, H. M., Ryan, W. B. F., et al., *Init. Repts. DSDP*, 40: Washington (U.S. Govt. Printing Office), 679–722.

Weaver, F. M., 1976. Late Miocene and Pliocene radiolarian paleobiogeography and biostratigraphy of the Southern Ocean [Ph.D. dissert.]. Florida State University, Tallahassee.

Weaver, F. M., and Gombos, A. M., 1981. Southern high-latitude diatom biostratigraphy. *In* Warme, J. E., Douglas, R. E., and Winterer, E. L. (Eds.), *The Deep Sea Drilling Project: A Decade of Progress*: Soc. Econ. Paleontol. Mineral. Spec. Pub., 32: 445–470.

Wise, S. W., 1981. Deep-sea drilling in the Antarctic: Focus on late Miocene glaciation and applications of smear-slide biostratigraphy. *In* Warme, J. E., Douglas, R. G., and Winterer, E. L. (Eds.), *The Deep Sea Drilling Project: A Decade of Progress*: Soc. Econ. Paleontol. Mineral. Spec. Pub., 32:471–487.

SITE 513 HOLE CORE 1 CORED INTERVAL 0.0–9.0 m

TIME – ROCK UNIT: Pleistocene

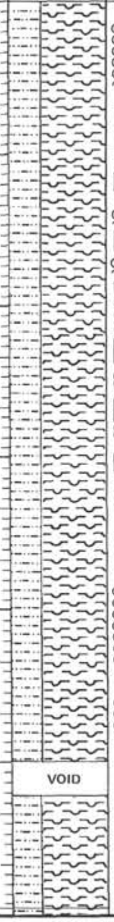
BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: PLANKTONIC FORAMINIFERS; BENTHIC FORAMINIFERS; NANNOFOSSILS; RADIOLARIANS: *Antarctissa denticulata* Zone; DIATOMS: *Coscinodiscus lentiginosus* Zone; SILICOFLAGELLATES

CG AM RM

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



VOID

DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES

LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Light brownish gray (2.5Y 6/2) and olive brown (2.5Y 4/4). Soupy to highly disturbed core. Below Section 1, predominant color is gray (5Y 5/1). Olive brown portions have manganese staining, as in Section 1; Section 2, 15–66 cm and 122–145 cm; Section 3, 32–33 cm; less common below. Mottling slight to very slight throughout less disturbed core. Burrows evident in Section 3, 66–120 cm (very dark gray [2.5Y 3/0]); Section 4, 39–90 cm; and in Sections 5 and 6.

Clay content increases from Section 1 through Section 3; clay-rich zones firm.

Slaty lithoclast (0.5 cm) Section 2, 109–110 cm.

SMEAR SLIDE SUMMARY

	1-145	2-42	3-116	5-135
	D	D	D	D
Quartz	4	2	2	3
Mica	TR	–	–	–
Heavy minerals	–	TR	–	–
Clay minerals	15	20	27	14
Carbonate unspec.	–	–	3	TR
Foraminifers	–	–	TR	–
Nannofossils	–	–	TR	–
Diatoms	75	69	63	73
Radiolarians	6	7	5	10
Silicoflagellates	–	TR	TR	–
Sponge spicules	–	–	TR	TR
Volcanic glass	TR	–	–	–
Micronodules	–	2	–	–

CARBONATE BOMB:
3, 75–76 (0)
5, 140–141 (0)

GRAIN SIZE:
1-143 (5, 33, 62)
3-143 (3, 36, 61)
5-143 (5, 39, 57)

NOTE: Core 2, 9.0–18.5 m: No core; only Core-Catcher contained 2 lithoclasts – a 3 cm black, subangular pebble of undetermined composition and a 1.5 cm piece of pumice.

SITE 513 HOLE CORE 3 CORED INTERVAL 18.5–28.0 m

TIME – ROCK UNIT: Pleistocene

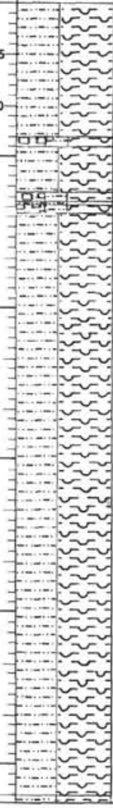
BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: PLANKTONIC FORAMINIFERS; BENTHIC FORAMINIFERS: RP; NANNOFOSSILS; RADIOLARIANS: *Saturnalis circularis* Zone; DIATOMS: *Coscinodiscus elliptipora/Actinocyclus ingens* Zone; SILICOFLAGELLATES

CG AM RM

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES

LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Olive gray (5Y 4/2) becoming greenish gray (5G 6/1) below Section 5, 113 cm. Gray (5Y 5/1) zones in Section 1, 49–63 cm, and as laminae in Section 2, 33–35 cm and 42–44 cm. Light gray (5Y 7/1) zones in Section 1, 129–136 cm; Section 2, 35–42 cm and 48–54 cm; these are CALCAREOUS MUDDY DIATOM OOZES, the uppermost of which is high in foraminifers. Other light gray zones in Section 3, 24–59 and 100–131 cm; Section 4, 17–28, 87–112, 126–132 and 138–141 cm. Greenish gray (5G 6/1) zones occur in Section 5, 10–16 and 43–55 cm and as irregular lenses between 68–81 and 91–113 cm.

Laminae and zones of very dusky red purple (5RP 2/2) are common, i.e. Section 2, 16–19 and 70–76 cm; Section 3, 34–45 and 100–131 cm; Section 4, 16–18 and 80–99 cm; and Section 5, 46–52 and 125–142 cm.

Slight mottling (mostly very dark gray [2.5Y 3/0]) is present throughout core.

"Cottony" zones, apparently containing a high content of pennate diatoms, are common, i.e. Section 1, 0–50 and 60–125 cm; in olive gray zones of Sections 2 and 3; Section 4, 0–20 and 55–120 cm; Section 5, 92–113 and below 132 cm.

Fine-grained quartz sand, olive gray (5Y 4/2) in Section 2, 91–94 cm; increase in quartz sand in Section 4 below 131 cm.

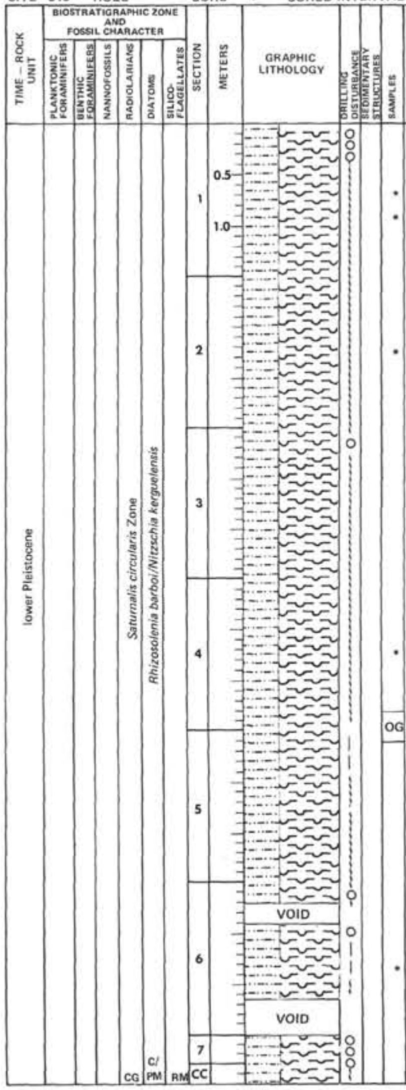
SMEAR SLIDE SUMMARY

	1-78	2-38	3-44	5-115
	D	M	M	D
Quartz	1	TR	4	3
Feldspar	–	–	–	TR
Heavy minerals	–	–	TR	–
Clay minerals	17	20	19	28
Carbonate unspec.	TR	8	–	–
Foraminifers	–	11	–	–
Diatoms	78	57	72	66
Radiolarians	4	4	5	3
Silicoflagellates	TR	–	TR	TR
Sponge spicules	–	–	–	TR
Micronodules	TR	–	–	–
Ebridians	–	TR	–	–
Volcanic glass	–	–	TR	–

CARBONATE BOMB:
1, 139–140 (0)
3, 51–52 (0)

GRAIN SIZE:
1-70 (10, 37, 54)
3-70 (3, 37, 60)
5-70 (9, 37, 54)

SITE 513 HOLE CORE 4 CORED INTERVAL 28.0–37.5 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous cores; gray (5Y 5/1) irregularly intermixed with olive gray (5Y 4/2) becoming dark gray (5Y 4/1) intermixed with greenish gray (5G 6/1) below Section 2.

Very dusky purple (5P 2/2) and dusky red streaks and laminae present in all core sections; occasionally as mottles possibly resulting from disturbance.

Rare dark greenish gray (5G 6/1) staining and mottles in upper half of core.

"Cotton" texture in Section 6, 70–115 cm.

Slate lithoclast, 4 cm long, Section 6, 86–87 cm.

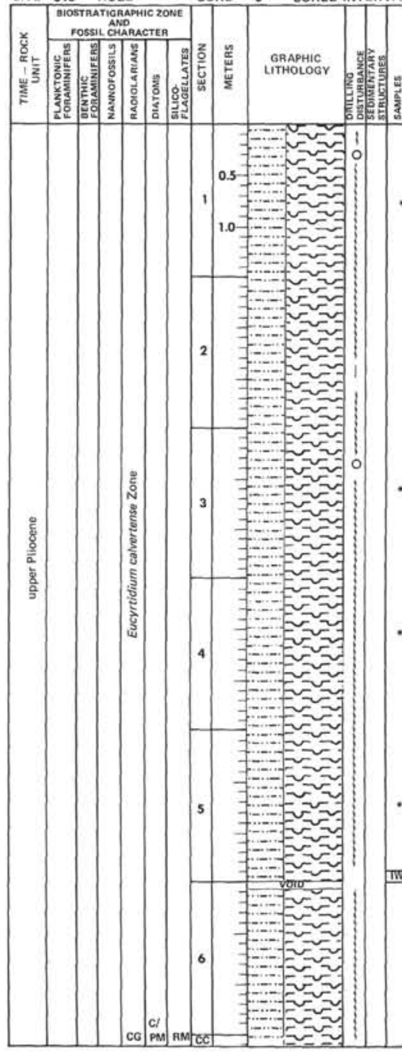
SMEAR SLIDE SUMMARY

	1-70	1-96	2-73	4-73	6-81
	D	D	D	D	D
Quartz	3	4	2	1	2
Feldspar	–	–	TR	TR	TR
Clay minerals	20	33	32	33	19
Diatoms	73	55	60	60	73
Radiolarians	4	7	5	5	6
Silicoflagellates	TR	1	1	1	TR
Sponge spicules	TR	TR	TR	TR	TR
Volcanic glass	–	–	–	–	TR

CARBONATE BOMB:
2, 76–77 (0)

GRAIN SIZE:
1-130 (3, 40, 57)
3-130 (3, 34, 64)
5-130 (1, 19, 80)

SITE 513 HOLE CORE 5 CORED INTERVAL 37.5–47.0 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous core, gray (5Y 5/1), in Section 1; irregularly intermixed with olive gray (5Y 4/2) in balance of core.

Very dusky purple mottling sparse throughout but occurring as laminae in Section 1, 0–18, 52–60, and 122–136 cm; Sections 2 and 3; Section 4, 25–33 and 74–98 cm; Section 5 and Section 6, 11–22, 66–67, and 102–107 cm.

Greenish black (5G 2/1) staining or mottling in Sections 4, 5, and 6.

Very dark gray stringers (2.5Y 3/0) in Section 1, 20–30 and 95–106 cm.

Basalt(?) lithoclast, 4 cm, subangular, Section 4, 32–36 cm.

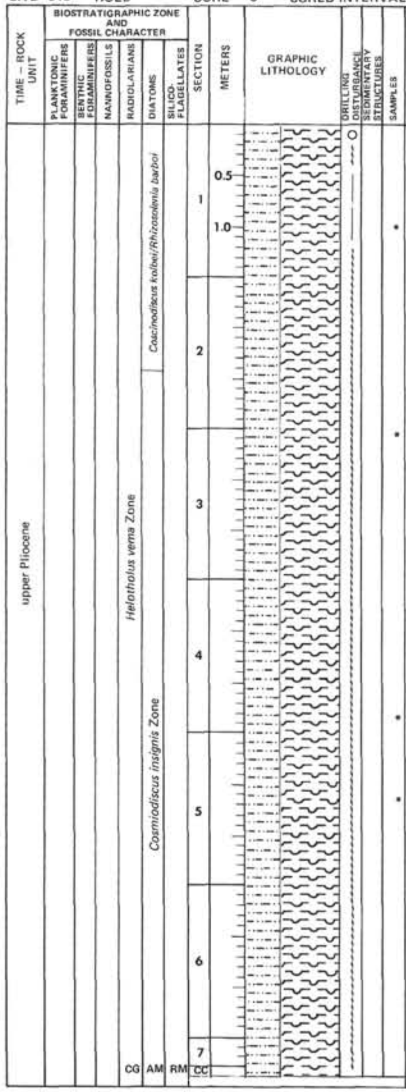
SMEAR SLIDE SUMMARY

	1-74	3-68	4-56	5-79
	D	D	D	D
Quartz	2	3	2	4
Feldspar	–	TR	–	–
Clay minerals	18	17	23	30
Carbonate unspec.	4	TR	TR	–
Diatoms	71	71	70	62
Radiolarians	4	8	5	4
Silicoflagellates	1	1	TR	TR
Sponge spicules	TR	TR	TR	TR
Ebridians	TR	–	–	–
Volcanic glass	–	–	–	TR

CARBONATE BOMB:
1, 134–135 (2)
4, 59–60 (0)

GRAIN SIZE:
1-10 (3, 23, 74)
3-10 (2, 22, 77)
5-10 (2, 24, 74)

SITE 513 HOLE CORE 6 CORED INTERVAL 47.0–56.5 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous cores, with following color changes through the predominant greenish gray (5G 6/1) of the core.

Section 1: intermixing with olive (5Y 4/4) below 115 cm.

Section 2: intermixed with dark greenish gray (5G 4/1) and below 76 cm, dark gray (5Y 4/1).

Section 3: alternations of olive gray (5Y 4/2) and zones of very dark gray mottling.

Section 4: mixed with olive gray (5Y 4/2).

Section 5: greenish gray at 0–61 and 77–150 cm, separated by olive gray at 61–77 cm.

Section 6: olive brown at 79–87 and 135–139 cm and in Section 7, 0–13 and 34–43 cm.

Very dusky purple laminae, mottles and staining are common throughout the core.

Dark greenish gray mottles and staining sparse to moderate.

SMEAR SLIDE SUMMARY

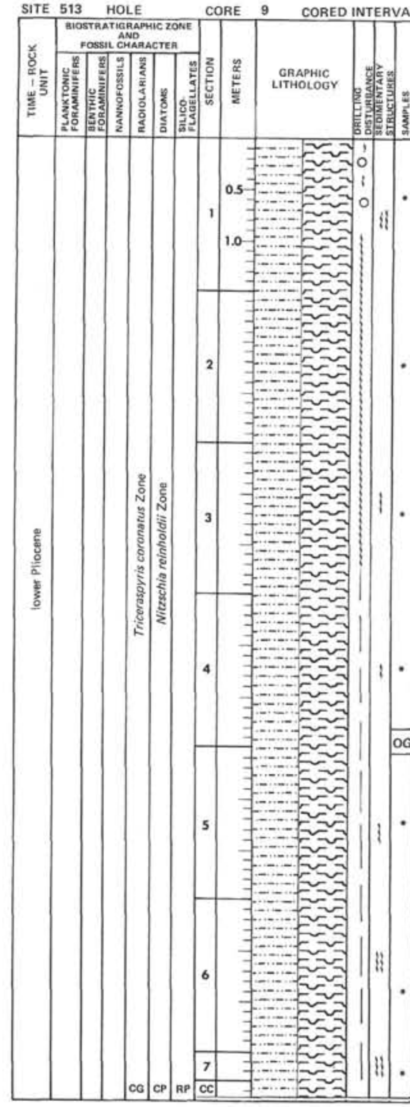
	1-101	3-17	4-133	5-66
	D	D	M	D
Quartz	1	9	10	2
Feldspar	–	–	TR	–
Heavy minerals	–	–	TR	–
Clay minerals	20	18	19	17
Carbonate unspec.	–	–	–	TR
Diatoms	75	67	61	78
Radiolarians	4	6	10	3
Silicoflagellates	TR	TR	TR	TR
Sponge spicules	–	–	TR	–

CARBONATE BOMB:
2, 50–51 (0)
2, 134–135 (0)

GRAIN SIZE:
2-10 (2, 20, 78)
4-10 (2, 21, 77)
6-10 (1, 21, 77)

NOTE: Core 7, 56.5–66.0 m: No core; only Core-Catcher contained two basalt(?) lithoclasts, subangular, 2 and 4 cm, Core 8, 66.0–75.5 m: No core; only Core-Catcher contained two gray rounded to subangular lithoclasts, 2.5 and 3 cm.

SITE 513 HOLE CORE 9 CORED INTERVAL 75.5–85.0 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous cores, greenish gray (5G 6/1) with mottles and zones of olive gray (5Y 5/2), dark gray (5Y 4/1), and dark greenish gray (5G 4/1) throughout. Intense mottling results mainly from intense disturbance.

Laminae of darker grays commonly distorted. Minor to moderate bioturbation is present in Sections 1, 3, 4, 5, 6, and 7.

SMEAR SLIDE SUMMARY

	1-60	2-75	3-75	4-75	5-75	6-95	7-65
	D	D	D	D	D	D	M
Quartz	10	7	7	10	5	10	15
Feldspar	2	2	2	1	2	1	2
Other heavy minerals	1	–	–	1	–	–	–
Clay minerals	33	28	21	29	27	31	31
Zeolites	5	5	5	5	5	3	5
Carbonate unspec.	2	2	2	1	1	–	–
Diatoms	40	50	55	45	55	50	40
Radiolarians	TR	5	7	7	5	5	7
Silicoflagellates	–	–	–	–	–	–	1
Sponge spicules	–	–	1	–	–	–	–
Micronodules	–	1	–	1	–	–	1

CARBONATE BOMB:
3, 53–54 (0)
5, 12–13 (0)

GRAIN SIZE:
2-90 (1, 34, 65)
4-90 (1, 19, 80)
6-90 (1, 20, 79)

SITE 513 HOLE CORE 10 CORED INTERVAL 85.0–94.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER	SECTION	METERS	GRAPHIC LITHOLOGY	LITHOLOGIC DESCRIPTION
lower Pliocene	Diatoms: *Nitzschia reinholdii* (C/PM); Silicoflagellates: RG	1, CC	0.5, 1.0	VOID	Trace of MUDDY DIATOMACEOUS OOZE in Core-Catcher. NOTE: Core 11, 94.5–104.0 m: No core recovery.

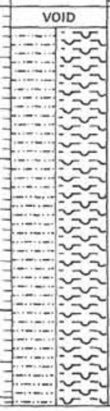
SITE 513 HOLE A CORE 1 CORED INTERVAL 56.5–66.0 m

Columns: TIME – ROCK UNIT; BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER (PLANKTONIC FORAMINIFERS, BENTHIC FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS, SILICO-FLAGELLATES); SECTION; METERS; GRAPHIC LITHOLOGY; DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES; LITHOLOGIC DESCRIPTION

Time-rock unit: lower Pliocene

Fossil character: Benthic foraminifers RP; Radiolarians *Helotholus vema* CG; Diatoms *Nitzschia angulata* AM; Silicoflagellates FG

Sections: 1, 2, 3, CC



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Greenish gray (5G 4/1) to olive gray (5Y 5/2) with zones of dark gray (5Y 5/1–4/1) in Section 2, 0–13 and 42–56 cm; light gray (5Y 7/1) zones in Section 3.

Moderate bioturbation Sections 1 and 2; less so in Section 3. Small mottles in Section 1, 125–127 and 144–150 cm.

Section 3 with "cotton" zones and lenses, i.e. 30–40 cm (high in plumose diatoms), very light gray (5Y 7/2).

Pebble zone, Section 2, 123–130 cm; lithoclasts, subangular to subrounded, of sediments, metasediments, graywackes and slates; appear to be *in situ*.

SMEAR SLIDE SUMMARY

	1-75	2-75	3-33	3-75
	D	D	M	D
Quartz	5	10	3	10
Feldspar	TR	2	–	–
Mica	–	–	–	TR
Clay minerals	26	22	26	15
Zeolites	2	1	TR	TR
Carbonate unspec.	3	–	–	2
Nannofossils	TR	TR	TR	–
Diatoms	60	60	25	65
Radiolarians	3	5	5	7
Silicoflagellates	–	–	–	1
Sponge spicules	–	–	2	–
Micronodules	1	–	–	–
Fibers (?nannofossil debris)	–	–	40	–

CARBONATE BOMB:
1, 112–113 (0)

GRAIN SIZE:
1-35 (2, 18, 80)
3-35 (1, 22, 77)

SITE 513 HOLE A CORE 2 CORED INTERVAL 66.0–75.5 m

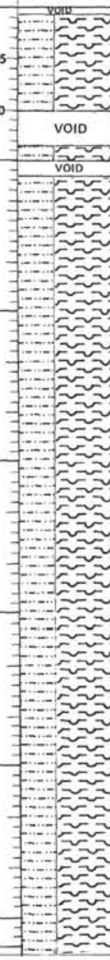
Columns: TIME – ROCK UNIT; BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER (PLANKTONIC FORAMINIFERS, BENTHIC FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS, SILICO-FLAGELLATES); SECTION; METERS; GRAPHIC LITHOLOGY; DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES; LITHOLOGIC DESCRIPTION

Time-rock unit: lower Pliocene

Fossil character: Benthic foraminifers RP; Radiolarians CG; Diatoms A/MG; Silicoflagellates RG

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

Samples: OG



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Medium bluish gray (5B 5/1) with slight intermixing of light olive gray (5Y 6/2) in Section 2, 106–150 cm; Section 3, 3–10, 51–67, 86–98 and 104–150 cm; Section 4, 126–130 cm; Section 5, 0–100 cm; Section 6, 45–60, 80–84, 92–101, and 107–120 cm; and in Section 7.

Grayish purple staining (5P 4/2) slight to moderate throughout core, in irregularly spaced zones.

Greenish black (5G 2/1) to black (5Y 2.5/1) stringers, much disturbed by coring, may originally have been laminae; they are present in Sections 1, 4, 5, and 6. Dark greenish gray staining in upper segments of Section 6.

"Cotton" zone (*high in plumose diatoms*) in Section 2, 135–150.

Slight mottling in Section 3, 70–150 cm and in Section 4.

Black (5Y 2.5/1) lenses in Section 5, 28–32 cm.

SMEAR SLIDE SUMMARY

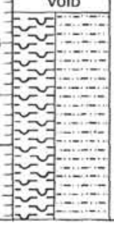
	1-64	2-139	3-75	6-70
	D	M	D	D
Quartz	3	2	6	3
Feldspar	–	–	TR	TR
Clay minerals	25	15	38	40
Nannofossils	–	–	–	TR
Diatoms	66	75	50	50
Radiolarians	6	7	5	6
Silicoflagellates	TR	1	1	1
Sponge spicules	TR	TR	TR	TR
Ebridians	–	–	–	TR

CARBONATE BOMB:
5, 70–71 (0)

GRAIN SIZE:
1-40 (1, 26, 72)
3-40 (2, 24, 74)
5-40 (2, 22, 77)

SITE 513 HOLE A CORE 3 CORED INTERVAL 85.0–94.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene		RP		*Triceraspyris coronatus* CG	AG	CG	1, 2	0.5, 1.0	VOID			•



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD

Medium bluish gray (5B 5/1) intermixed with olive (5Y 5/3).

Grayish purple stain and laminae throughout Section 1.

Black, disturbed laminae present throughout core.

Prominent "cotton" texture in Section 2, 48–50 and 56–74 cm – monospecific diatom accumulations.

SMEAR SLIDE SUMMARY

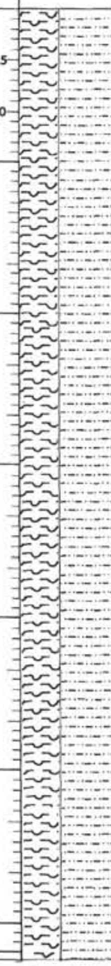
	1-60 D
Quartz	4
Clay minerals	57
Carbonate unspec.	TR
Diatoms	35
Radiolarians	3
Silicoflagellates	1
Sponge spicules	TR
Ebridians	TR

CARBONATE BOMB:
2, 38–39 (0)

GRAIN SIZE:
1-48 (1, 16, 83)

SITE 513 HOLE A CORE 4 CORED INTERVAL 94.5–104.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene		RP		*Triceraspyris coronatus* CG	AM	CG	1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0				•, •, •, IW, •



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD

Greenish gray (5G 4/1) with greenish black (5GY 2/1) light staining throughout. Olive (5Y 5/3) sparsely intermixed throughout. Black sediment (5Y 2.5/1) as stringers (often vertical from drilling disturbance) present throughout; possibly they originally were laminae.

"Cotton" zones in Section 1, 38–39 and 57–62 cm; sparse in Section 2, and in Section 6, 0–30 cm and 79–84 cm, and in Core-Catcher.

Very dark gray (5Y 3/1) staining slight to moderate in Section 3, 95–130 cm.

Pale yellow staining present in Sections 3–7.

Irregular black lenses in Section 4, 86–89 cm and sparse through 110–137 cm. In Section 5, 23–25 cm, a 1 cm subangular dark gray pebble.

SMEAR SLIDE SUMMARY

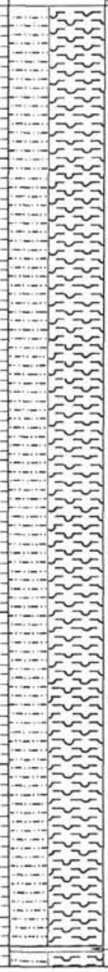
	1-85 D	2-70 D	4-70 D	6-86 M
Quartz	4	4	6	1
Clay minerals	48	56	52	35
Carbonate unspec.	–	TR	TR	TR
Nannofossils	–	–	TR	–
Diatoms	43	38	38	58
Radiolarians	5	2	4	6
Silicoglagellates	TR	TR	TR	TR
Sponge spicules	TR	TR	TR	TR
Ebridians	TR	TR	TR	TR

CARBONATE BOMB:
2, 122–123 (0)

GRAIN SIZE:
1-20 (1, 21, 79)
3-20 (1, 25, 74)
5-20 (1, 21, 78)

SITE 513 HOLE A CORE 5 CORED INTERVAL 104.0–113.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
upper Miocene		RP		Basal *Triceraspyris coronatus*/Top *Stichocorys peregrina* CG	AM	FG	1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0			O	•, •, OG, •	VOID



MUDDY DIATOMACEOUS OOZE

Greenish gray (5G 6/1) with:

greenish black (5GY 2/1) staining throughout the core, sparse to moderate and as vertical stringers in Section 6, 120–130 cm;

dark greenish gray staining heavy in Section 1, 0–19 and 43–70 cm, moderate 75–122 cm;

very dark gray (2.5Y 3/0) staining, as irregular vertical stringers and occasional irregular lenses in Sections 1, 2, 3, and 5;

pale yellow staining sparse in Sections 2, 3, 4, 5, and 7;

white (2.5Y 8/0) lenses <1 cm, with "cotton" texture, very sparse in Section 4, 10–121 cm and Section 6, 48–60 cm;

grayish purple (5P 4/2) staining abundant in Section 3, sparse in Sections 5 and 7.

"Cotton" texture sparse to very sparse in Sections 2, 3, 4, 5, 6, 7, and Core-Catcher.

SMEAR SLIDE SUMMARY

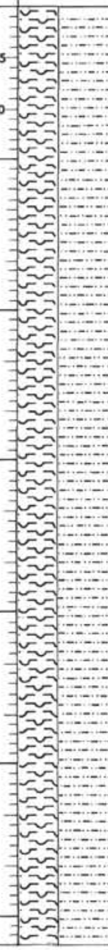
	1-75	3-40	5-60
	D	D	D
Quartz	3	3	1
Clay minerals	38	43	35
Zeolites	–	1(?)	–
Carbonate unspec.	TR	–	–
Diatoms	56	50	61
Radiolarians	3	3	3
Silicoflagellates	TR	TR	TR
Ebridians	TR	TR	–
Micronodules(?)	–	TR	–

CARBONATE BOMB:
3, 12–13 (0)
5, 77–78 (0)

GRAIN SIZE:
1-20 (1, 21, 79)
3-20 (1, 23, 77)
5-20 (0, 26, 74)

SITE 513 HOLE A CORE 6 CORED INTERVAL 113.5–123.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
upper Miocene		RP		*Stichocorys peregrina* CG	*Denticulopsis hustedtii* A/PM	*Mesocena diodon* RG	1, 2, 3, 4, 5, 6, 7	0.5, 1.0				•, •, •, •	



DIATOMACEOUS MUD

As in previous section except clay content exceeds diatom abundance. Colors the same – basically greenish gray (5G 6/1) with:

greenish black sparse to moderate in all sections except Section 4 where it is moderate to heavy;

grayish purple moderate to sparse in all sections;

pale yellow very sparse to sparse in all sections except in Section 6, 136–150 cm where it is heavy;

very dark gray irregular lenses in Section 3, 73–80 and 93–100 cm, as vertical stringers in Section 5, below 60 cm.

"Cotton" texture sparse in Sections 1, 3, and 7.

Slate lithoclast, ~4.5 cm in Section 6, 142–144 cm.

SMEAR SLIDE SUMMARY

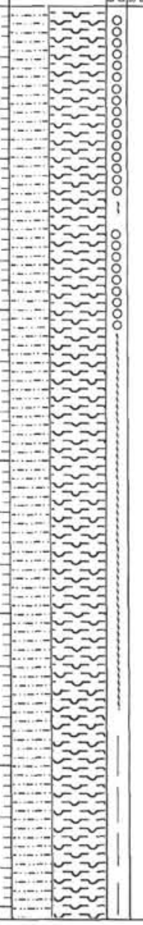
	1-50	1-85	3-70	5-80
	D	D	D	D
Quartz	1	3	3	4
Clay minerals	71	65	65	67
Carbonate unspec.	TR	–	TR	TR
Nannofossils	TR	TR	TR	–
Diatoms	25	29	28	25
Radiolarians	3	3	4	4
Silicoflagellates	–	TR	–	–
Sponge spicules	–	TR	TR	TR
Ebridians	–	TR	–	TR

CARBONATE BOMB:
4, 35–38 (0.2)

GRAIN SIZE:
1-20 (1, 23, 77)
3-20 (0, 28, 72)
5-20 (1, 28, 71)

SITE 513 HOLE A CORE 7 CORED INTERVAL 123.0–132.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER	SECTION	METERS	GRAPHIC LITHOLOGY	SAMPLES
upper Miocene	*Stichocorys peregrina* (Radiolarians); *Denticulopsis hustedtii* (Diatoms); Benthic foraminifers RP; Radiolarians CG; Diatoms AM; Silicoflagellates FG	1, 2, 3, 4, 5, 6, CC	0.5, 1.0		•, •, M, •



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Greenish gray (5G 6/1) as in previous cores, with:

grayish purple sparse to moderate in all sections;

pale yellow stains and stringers;

greenish purple in Section 4, 107–151 cm;

medium bluish gray (5B 5/1) heavy in Section 5, 12–30 and 98–150 cm;

light bluish gray (5B 7/1) moderate in Section 5, 60–84 cm;

greenish black moderate in Section 5, 40–55 cm.

White lenses, ~1 cm with "cotton" texture sparse in Section 5, 0–70 cm.

SMEAR SLIDE SUMMARY

	3-42	5-91	CC
	D	D	D
Quartz	3	2	2
Clay minerals	37	29	35
Carbonate unspec.	TR	TR	TR
Nannofossils	TR	TR	–
Diatoms	55	63	58
Radiolarians	5	6	5
Silicoflagellates	–	–	TR
Sponge spicules	TR	TR	TR
Ebridians	TR	–	–

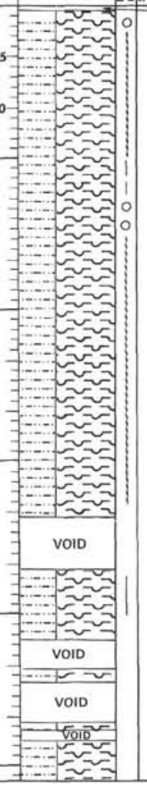
CARBONATE BOMB:
5, 105–106 (0.2)

MAGNETIC DATA:	6-17
Inclination	–56.0
Declination	11.1
Intensity (emu/cc)	0.236E–05

GRAIN SIZE:
3-20 (2, 36, 62)
5-20 (2, 40, 58)

SITE 513 HOLE A CORE 8 CORED INTERVAL 132.5–142.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER	SECTION	METERS	GRAPHIC LITHOLOGY	SAMPLES
upper Miocene	*Stichocorys peregrina* (Radiolarians); *Denticulopsis hustedtii* (Diatoms); Benthic foraminifers RP; Radiolarians CG; Diatoms A/PM; Silicoflagellates RM	1, 2, 3, 4, 5, CC	0.5, 1.0	VOID, VOID, VOID, VOID	M, •, IW, OG, •



LITHOLOGIC DESCRIPTION

–VOID

MUDDY DIATOMACEOUS OOZE

As in previous cores, greenish gray with:

dark gray (5Y 4/1) zones in Section 1, 32–35 cm; Section 2, below 80 cm;

very dark gray (5Y 3/1) mottling in Section 1, 32–38 cm; in Section 3, below 19 cm it is mixed with greenish black, pale yellow and grayish purple colors;

grayish purple color less common than before, commonly mixed with yellow and very dark gray in Section 3 below 19 cm and Section 4, 0–24 cm and very sparse below 104 cm.

"Cotton" texture associated with white (2.5Y 8/0) lenses up to 1 cm in Section 1, 95–150 cm; Section 2, 0–36 cm and 130–143 cm; sparsely throughout Sections 3 and 4; and in Section 5, 109–112 and below 130 cm.

SMEAR SLIDE SUMMARY

	1-120	3-45	5-130
	D	D	D
Quartz	2	3	4
Clay minerals	22	42	44
Carbonate unspec.	TR	TR	TR
Nannofossils	–	TR	–
Diatoms	73	50	49
Radiolarians	3	5	3
Silicoflagellates	TR	TR	–
Sponge spicules	TR	TR	TR
Ebridians	–	TR	TR

MAGNETIC DATA:	1-121
Inclination	72.2
Declination	227.3
Intensity (emu/cc)	0.930E–06

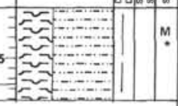
GRAIN SIZE:
1-87 (1, 36, 62)
3-87 (1, 29, 70)

SITE 513 HOLE A CORE 9 CORED INTERVAL 142.0–151.5 m

TIME – ROCK UNIT: upper Miocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic Foraminifers; Benthic Foraminifers: RP; Nannofossils; Radiolarians: CG — *Eucyrtidium pseudoinflatum*; Diatoms: AM — *Denticulopsis hustedtii*; Silico-Flagellates: RG — *Mesocena circulus/M. diodon*

SECTION: 1, CC — METERS: 0.5 — GRAPHIC LITHOLOGY — DRILLING DISTURBANCE — SEDIMENTARY STRUCTURES — SAMPLES: M, *



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
Greenish gray with:
grayish purple, moderate to heavy, Section 1, 42–58 cm;
dark greenish gray (5G 4/1) heavy in Section 1, 58–76 cm;
dark gray vertical stringers sparse, Section 1, 60–78 cm.

"Cotton" texture slight in Section 1, 0–53 cm, moderate below.

SMEAR SLIDE SUMMARY

	1-35 D
Quartz	3
Clay minerals	53
Carbonate unspec.	TR
Diatoms	40
Radiolarians	4
Sponge spicules	TR
Ebridians	TR

CARBONATE BOMB:
1, 61–62 (0)

MAGNETIC DATA:	1-32
Inclination	24.5
Declination	188.1
Intensity (emu/cc)	0.400E–06

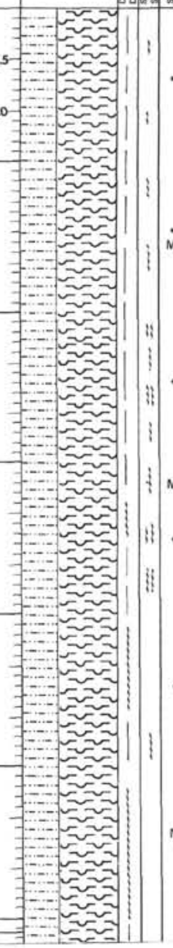
GRAIN SIZE:
1-10 (1, 34, 65)

SITE 513 HOLE A CORE 10 CORED INTERVAL 151.5–161.0 m

TIME – ROCK UNIT: upper Miocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic Foraminifers; Benthic Foraminifers: RP; Nannofossils; Radiolarians: CG — *Theocalyptra bicornis spongothorax*; Diatoms: AM — *Denticulopsis hustedtii/D. lauta*; Silico-Flagellates: PG — *Mesocena circulus/M. diodon*

SECTION: 1, 2, 3, 4, 5, 6, 7, CC — METERS: 0.5, 1.0 — GRAPHIC LITHOLOGY — DRILLING DISTURBANCE — SEDIMENTARY STRUCTURES — SAMPLES: *, *, M, *, M, *, *, M, *



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE
As in previous cores, greenish gray (5G 6/1); very homogeneous with minor mottling and "cotton" texture throughout Section 1. Faint deformed bedding Section 1, 75–110 cm. Two pebbles (2x2x1 cm and 2x3x8 cm) subangular – ?graywacke lithology.

Bioturbation slight to moderate throughout; dark greenish gray (5G 4/1) very firm burrows, ~1 cm diameter, in Section 5, 61–84 and 126–131 cm.

In Section 7, 10–12 cm, prominent ash layer, 98% fine clear ash shards; layer is gray (5Y 6/1) with sharp upper and lower contacts.

SMEAR SLIDE SUMMARY

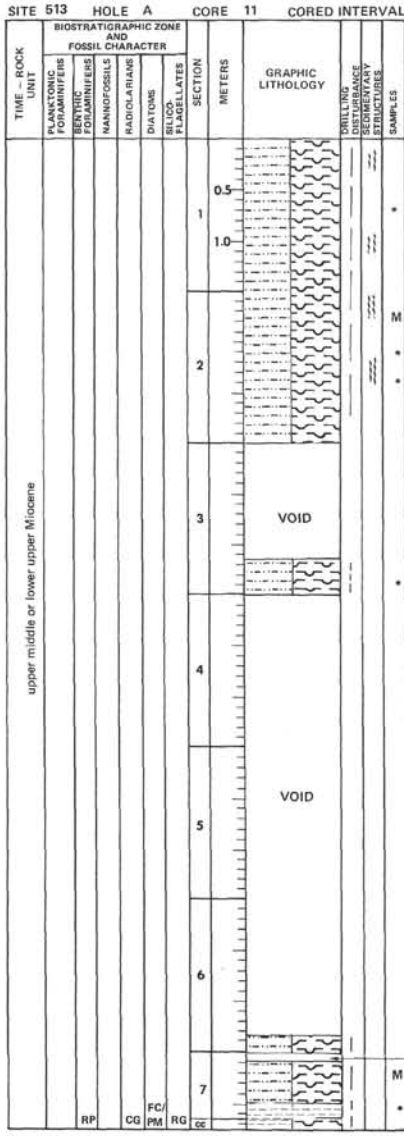
	1-75 D	2-75 D	3-75 D	4-75 D	5-75 D	6-75 D
Quartz	7	7	7	5	7	7
Feldspar	TR	–	1	1	TR	TR
Clay minerals	37	32	34	43	40	38
Zeolites	1	–	–	–	1	1
Carbonate unspec.	–	1	–	–	–	1
Diatoms	50	55	50	45	45	50
Radiolarians	5	5	5	5	7	3
Sponge spicules	–	–	3	1	TR	–
Micronodules	TR	–	–	TR	–	–

CARBONATE BOMB:
3, 82–83 (0)

MAGNETIC DATA:	2-78	4-20	6-66
Inclination	–4.4	–46.8	27.6
Declination	183.2	191.2	200.1
Intensity (emu/cc)	0.460E–06	0.630E–06	0.218E–05

GRAIN SIZE:
1-126 (2, 41, 57)
3-126 (2, 37, 62)
5-126 (1, 38, 62)

SITE 513 HOLE A CORE 11 CORED INTERVAL 161.0–170.5 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE
Greenish gray (5G 6/1) mixed with light olive gray (5Y 6/1) in top 40 cm of Section 1, becoming greenish gray from Section 1, 40 cm to Section 2, 78 cm below which color is grayish brown (2.5Y 5/2) with only minor greenish gray zones. Sediment firm, homogeneous; with moderate bioturbation.

Section 3, 114–150 cm, Section 6, 135–140 cm, and Section 7, 8–43 cm, grayish brown (10YR 5/2). Section 7, 43–67 cm yellowish brown (10YR 5/4) to light yellow brown (10YR 6/4) CLAY.

Core-Catcher: disturbed mixture of grayish brown and yellowish brown sediments.

SMEAR SLIDE SUMMARY

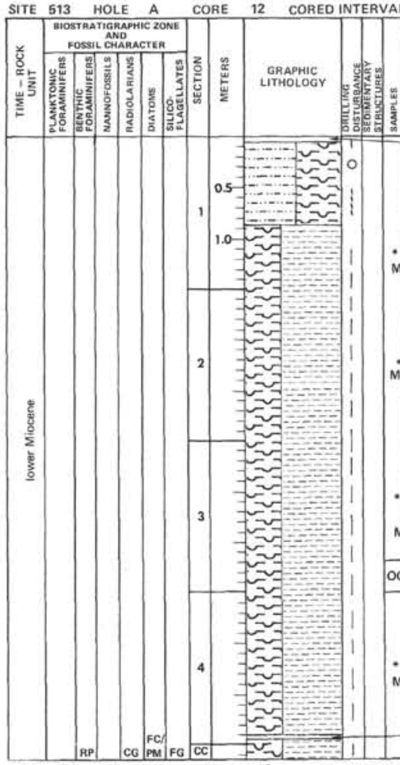
	1-75	2-65	2-90	3-140	7-55
	D	D	D	D	D
Quartz	10	7	10	10	5
Feldspar	–	1	TR	1	TR
Mica	TR	TR	–	–	–
Clay minerals	37	38	41	42	82
Zeolites	1	–	1	–	–
Carbonate unspec.	–	–	3	1	1
Diatoms	45	50	40	40	10
Radiolarians	7	3	5	5	1
Silicoflagellates	–	1	–	–	TR
Sponge spicules	–	–	–	1	–
Volcanic glass	–	–	–	–	1

CARBONATE BOMB:
2, 42–43 (1)

MAGNETIC DATA:	2-35	7-17
Inclination	–74.9	–51.0
Declination	329.1	307.5
Intensity (emu/cc)	0.970E–06	0.101E–04

GRAIN SIZE:
2-66 (1, 41, 58)
7-27 (2, 41, 57)

SITE 513 HOLE A CORE 12 CORED INTERVAL 170.5–180.0 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE
Grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/4), highly disturbed in Section 1, 4–32 cm.

Balance of Core 12 is DIATOMACEOUS CLAY, yellowish brown (10YR 5/4), homogeneous, without any evidence of bioturbation or stratification.

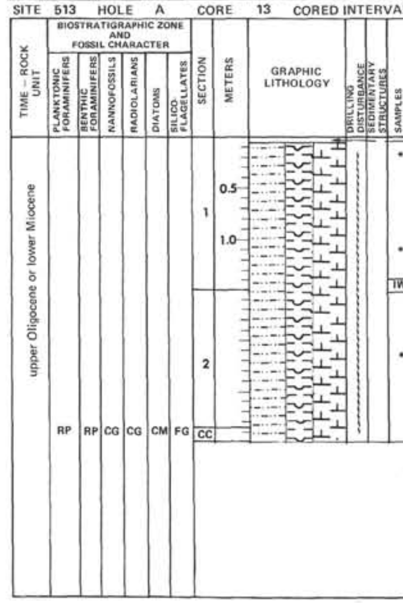
SMEAR SLIDE SUMMARY

	1-120	2-75	3-60	4-75
	D	D	D	D
Quartz	5	5	3	5
Feldspar	–	–	1	–
Clay minerals	74	66	73	70
Zeolites	1	2	1	2
Carbonate unspec.	–	–	1	–
Diatoms	15	20	15	15
Radiolarians	5	5	5	7
Sponge spicules	–	2	1	1

MAGNETIC DATA:	1-134	2-83	3-83	4-83
Inclination	–75.1	–54.3	–48.1	20.9
Declination	160.3	333.4	257.1	141.6
Intensity (emu/cc)	0.618E–05	0.899E–05	0.493E–05	0.125E–05

GRAIN SIZE:
2-94 (1, 31, 68)
4-94 (1, 17, 82)

SITE 513 HOLE A CORE 13 CORED INTERVAL 180.0–189.5 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS NANNOFOSSIL OOZE
Light yellowish brown (10YR 6/4) in Section 1, 3–35 cm and in Section 2, 28–86 cm. Between these intervals the color is very pale brown (10YR 7/3). Sediment is homogeneous, structureless and much disturbed.

Note: Core 13 had a zero section in which there were ~30 cm of light yellowish brown muddy diatomaceous ooze as in the upper 35 cm of Core 1.

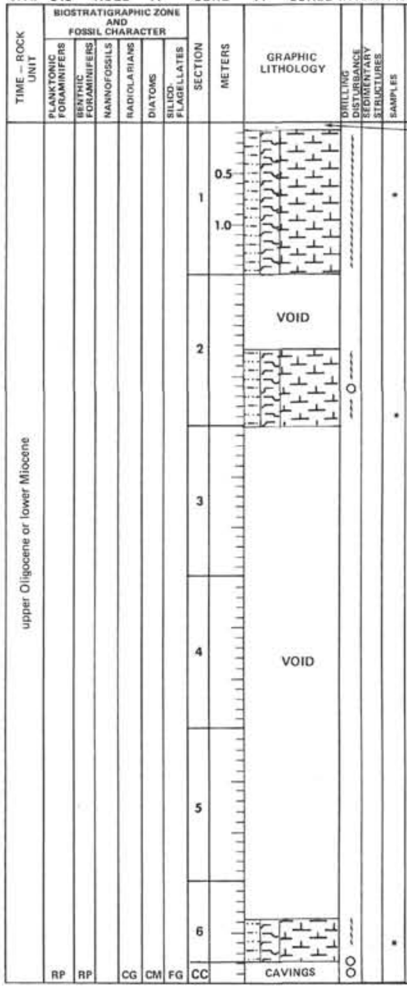
SMEAR SLIDE SUMMARY

	1-20	1-110	2-75
	D	D	D
Quartz	–	–	TR
Heavy minerals	1	–	1
Clay minerals	37	30	30
Carbonate unspec.	–	–	3
Nannofossils	30	50	40
Diatoms	25	15	20
Radiolarians	7	5	5
Silicoflagellates	–	1	–
Sponge spicules	–	–	1

CARBONATE BOMB:
1, 17–18 (27)
1, 137–138 (39)

GRAIN SIZE:
2-64 (2, 17, 81)

SITE 513 HOLE A CORE 14 CORED INTERVAL 189.5–199.0 m



LITHOLOGIC DESCRIPTION

VOID

MUDDY DIATOMACEOUS NANNOFOSSIL OOZE
As in Core 13, very pale brown (10YR 7/3), structureless, homogeneous.

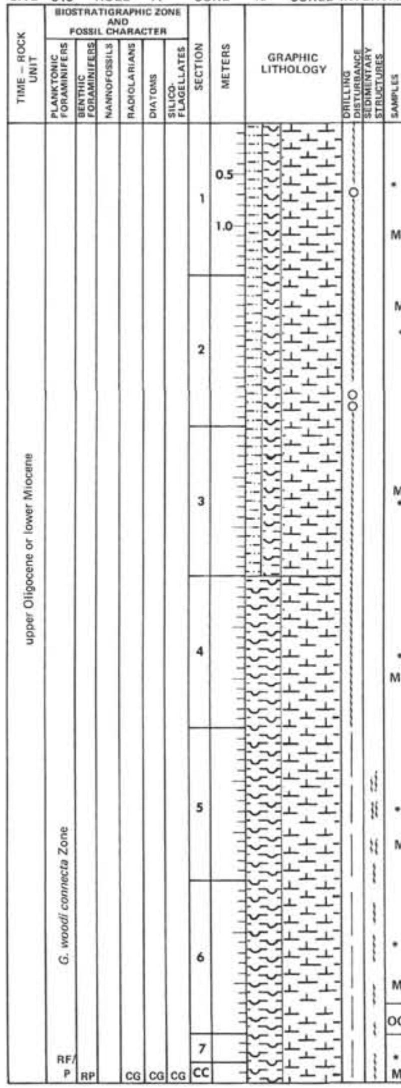
Core-Catcher, 0–18 cm: soupy mixture of gray blue, gray brown and pale brown granule-sized sedimentary clasts, possibly drill cuttings or cave-in.

SMEAR SLIDE SUMMARY

	1-75	2-140	6-60
	D	D	D
Quartz	1	–	1
Mica	–	–	TR
Clay minerals	20	21	18
Carbonate unspec.	–	–	TR
Nannofossils	55	60	55
Diatoms	15	15	20
Radiolarians	7	3	5
Silicoflagellates	2	1	–
Sponge spicules	–	–	1

GRAIN SIZE:
1-60 (1, 24, 76)

SITE 513 HOLE A CORE 15 CORED INTERVAL 199.0–208.5 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS NANNOFOSSIL OOZE
As in previous Cores 13 and 14, very pale brown (10YR 7/3), homogeneous and structureless, becoming from Section 4 downward a DIATOMACEOUS NANNOFOSSIL OOZE as clay content decreases to less than 10%.

In Section 5, 40–107 cm: light gray, moderately bioturbated, with upper gradational contact and sharp lower contact at 107 cm with less bioturbated lower part of core.

Section 6, 0–61 cm: ooze is pale brown (10YR 6/3), firm, slightly bioturbated, passing down to very pale brown with slightly darker zones in Section 7, 10–12 and 28–30 cm.

Note: Section 7 is 66 cm long.

SMEAR SLIDE SUMMARY

	1-60	2-60	3-75	4-75	5-75	6-60	7-50
	D	D	D	D	D	D	D
Quartz	1	TR	–	1	1	1	1
Clay minerals	18	10	10	7	7	5	5
Carbonate unspec.	–	1	1	–	3	–	2
Foraminifers	–	–	2	–	–	–	–
Nannofossils	55	65	60	66	64	60	61
Diatoms	15	15	20	15	15	20	20
Radiolarians	7	7	5	10	7	10	7
Silicoflagellates	1	1	–	–	1	1	2
Sponge spicules	3	1	2	1	2	3	2

CARBONATE BOMB:
3, 45–46 (48)

MAGNETIC DATA:	1-114	2-37	3-71	4-108
Inclination	47.2	54.8	62.7	26.6
Declination	23.2	70.5	202.7	45.1
Intensity (emu/cc)	0.883E–05	0.376E–05	0.459E–05	0.150E–05

MAGNETIC DATA:	5-118	6-94	7-39
Inclination	35.2	65.9	60.3
Declination	294.4	92.5	180.9
Intensity (emu/cc)	0.104E–05	0.630E–08	0.328E–05

GRAIN SIZE:
2-14 (1, 25, 74)
4-14 (1, 26, 73)
6-14 (1, 22, 77)

SITE 513 HOLE A CORE 16 CORED INTERVAL 208.5–218.0 m

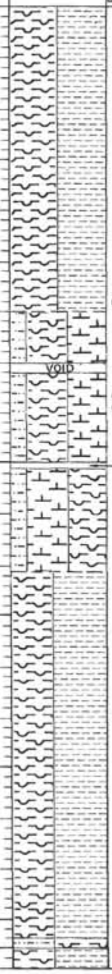
TIME-ROCK UNIT: upper Oligocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic foraminifers; Benthic foraminifers RP; Nannofossils CG; Radiolarians CM; Diatoms CG; Silicoflagellates

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



VOID

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY, MUDDY DIATOMACEOUS NANNOFOSSIL OOZE, AND MUDDY DIATOMACEOUS OOZE

Sections 1 and 2: pale brown (10YR 6/3), homogeneous, structureless diatomaceous clay passing downward in Section 3 to pale brown and light brownish gray (10YR 6/2) muddy diatomaceous nannofossil ooze, through muddy nannofossil-rich diatom ooze in the upper ~100 cm of Section 4 to diatomaceous clay in the lower ~50 cm of Section 4 through Sections 5, 6, and 7. In the latter section is a 10 cm interval (20–30 cm) of muddy diatomaceous ooze.

Note: Section 7 is 67 cm long.

SMEAR SLIDE SUMMARY

	1-75 D	2-75 D	3-100 D	4-75 D	5-75 D	6-75 D	7-30 D
Quartz	3	2	1	–	7	10	3
Mica	–	TR	–	–	1	–	–
Heavy minerals	–	–	–	–	1	–	–
Clay minerals	40	40	21	17	50	43	32
Carbonate unspec.	–	–	1	–	–	1	2
Nannofossils	15	7	35	30	–	–	10
Diatoms	30	40	30	45	35	40	45
Radiolarians	10	7	10	5	3	3	5
Silicoflagellates	–	1	–	1	–	–	1
Sponge spicules	2	3	2	2	3	3	2
Volcanic glass	TR	–	–	–	–	–	–

MAGNETIC DATA:	1-102	2-77	3-109
Inclination	–60.3	–70.4	–70.5
Declination	265.9	39.9	38.0
Intensity (emu/cc)	0.280E–06	0.800E–06	0.830E–06

MAGNETIC DATA:	4-73	5-69	6-70
Inclination	–72.3	–81.9	–56.5
Declination	336.2	219.0	3.5
Intensity (emu/cc)	0.120E–05	0.129E–05	0.174E–05

GRAIN SIZE:
1-18 (1, 28, 71)
3-18 (1, 28, 71)
5-18 (2, 31, 67)

SITE 513 HOLE A CORE 17 CORED INTERVAL 218.0–227.5 m

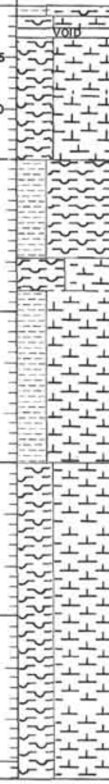
TIME-ROCK UNIT: upper Oligocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic foraminifers; Benthic foraminifers RP; Nannofossils CG; Radiolarians; Diatoms C/MG; Silicoflagellates AG

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



VOID

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: IW, OG, M

LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE AND DIATOMACEOUS NANNOFOSSIL OOZE

Interbedded through Sections 1–3; Sections 4 and 5 are diatomaceous nannofossil ooze.

Muddy diatomaceous ooze (Section 1, 0–10 cm; Section 2, 0–92 and 133–150 cm; Section 3, 0–150 cm) grayish brown (10YR 5/2), heavily mottled for the most part, moderately so in Section 3 below 40 cm.

Diatomaceous nannofossil ooze (Section 1, 10–150 cm and Section 2, 92–133 cm) light gray (10YR 7/2) changing in Section 1 at 31 cm to light brownish gray (10YR 6/2) and back to light gray in Section 2. Sparsely mottled in Section 1, moderate to heavy in Section 2. In Section 4 color is light brownish gray; in Section 5 it is light gray (10 YR 7/1) at 0–25 and 111–146 cm and white (10YR 8/1) at 25–111 cm.

"Cotton" texture common throughout core. White lenses exceptionally rich in nannofossils are present in Sections 2 and 3.

SMEAR SLIDE SUMMARY

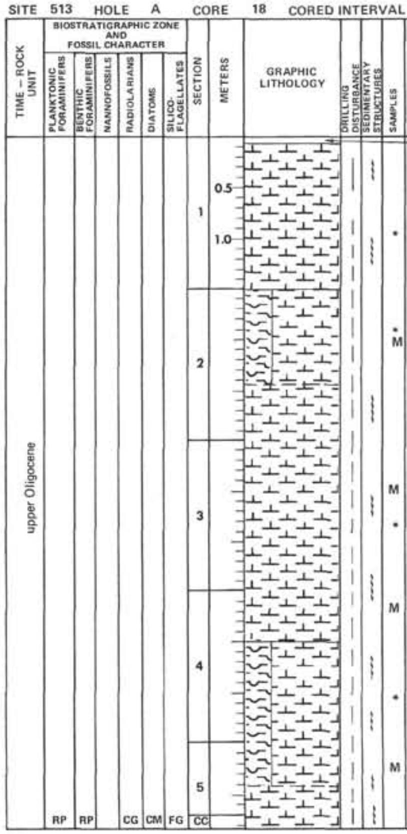
	1-9 D	1-94 D	3-67 D	4-76 D	5-73 D	5-138 D
Quartz	1	TR	1	TR	–	–
Clay minerals	17	5	18	3	2	–
Carbonate unspec.	TR	TR	1	TR	TR	TR
Nannofossils	2	58	5	58	71	58
Diatoms	75	28	65	30	20	35
Radiolarians	5	7	8	7	7	7
Silicoflagellates	TR	1	1	1	TR	TR
Sponge spicules	TR	1	1	1	TR	TR

CARBONATE BOMB:
5, 60–61 (59)

MAGNETIC DATA:	5-38	5-126
Inclination	36.2	44.8
Declination	254.6	269.2
Intensity (emu/cc)	0.700E–07	0.300E–06

GRAIN SIZE:
1-44 (2, 27, 71)
3-44 (2, 28, 70)
5-44 (1, 34, 65)

SITE 513 HOLE A CORE 18 CORED INTERVAL 227.5–237.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE AND DIATOMACEOUS NANNOFOSSIL OOZE

Nannofossil ooze – Section 1; Section 2, 95–150 cm; Section 3, Section 4, 0–44 cm and Section 5, 39–72 cm – white (10YR 8/1), sparsely mottled. In Section 5 and Core-Catcher – very sparse light bluish gray mottling.

Diatomaceous nannofossil ooze – Section 2, 0–95 cm; Section 4, 44–150 cm; Section 5, 0–39 cm – light gray (10YR 7/1) in Section 2 to light brownish gray in Sections 4 and 5, changing downward in Section 4 to grayish brown (10YR 5/2). Mottling is sparse; light bluish gray in Section 5.

SMEAR SLIDE SUMMARY

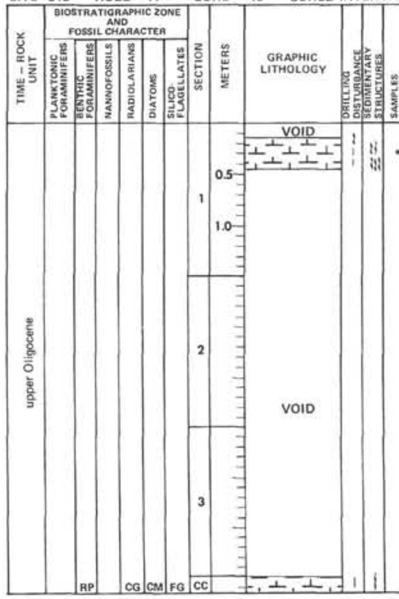
	1-95	2-40	3-88	4-108
	D	D	D	D
Quartz	–	–	–	TR
Carbonate unspec.	–	TR	TR	TR
Foraminifers	TR	TR	–	–
Nannofossils	86	66	89	75
Diatoms	10	28	8	20
Radiolarians	4	6	3	5
Silicoflagellates	TR	TR	TR	TR
Sponge spicules	TR	TR	TR	TR

CARBONATE BOMB:
3, 39–40 (71)

MAGNETIC DATA:	2-55	3-55	4-28	5-30
Inclination	–19.8	–78.9	– 1.0	–58.5
Declination	3.8	13.1	301.5	104.7
Intensity (emu/cc)	0.440E–06	0.980E–06	0.500E–07	0.180E–06

GRAIN SIZE:
1-16 (1, 76, 23)
3-16 (1, 30, 69)
5-16 (1, 24, 75)

SITE 513 HOLE A CORE 19 CORED INTERVAL 237.0–246.5 m



LITHOLOGIC DESCRIPTION

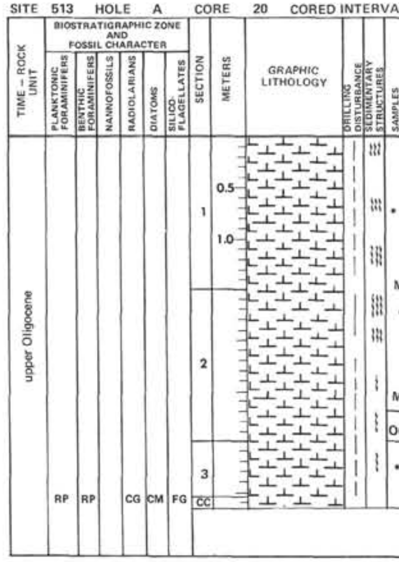
NANNOFOSSIL OOZE
White (2.5Y 8/0); moderate to heavy mottling where light brownish gray (2.5Y 6/2) color prevails.

Core-Catcher: with sparse mottling.

SMEAR SLIDE SUMMARY

	1-29
	D
Quartz	TR
Nannofossils	90
Diatoms	6
Radiolarians	4
Silicoflagellates	TR
Sponge spicules	TR

SITE 513 HOLE A CORE 20 CORED INTERVAL 246.5–256.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE
White, as before. Heavily mottled with light brownish gray (2.5Y 6/2) and light bluish gray (5B 7/1) in Section 1 and Section 2, 0–70 cm; below that, mottling is sparse.

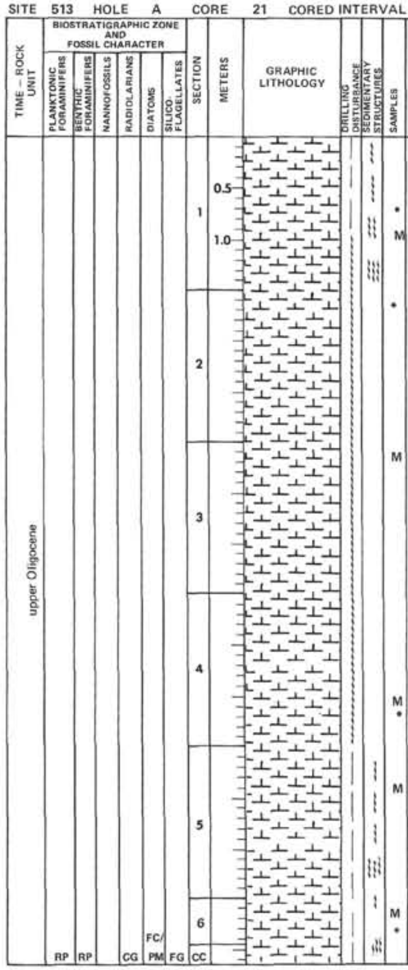
SMEAR SLIDE SUMMARY

	1-77	2-28	3-26
	D	D	D
Quartz	TR	TR	TR
Carbonate unspec.	TR	TR	TR
Foraminifers	TR	TR	TR
Nannofossils	86	86	85
Diatoms	12	11	12
Radiolarians	2	3	3
Silicoflagellates	TR	TR	TR
Sponge spicules	TR	TR	TR

MAGNETIC DATA:	1-146	2-103
Inclination	–66.2	– 8.2
Declination	126.6	221.1
Intensity (emu/cc)	0.144E–05	0.130E–06

GRAIN SIZE:
1-20 (2, 30, 68)
3-20 (1, 33, 66)

SITE 513 HOLE A CORE 21 CORED INTERVAL 256.0–265.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE
White (2.5Y 8/0) changing to light gray (5Y 7/1) in Sections 2, 3, and in Section 4, 0–55 cm below which it is again white.

Mottling is apparent in Sections 1 and 5 (as shown) where drilling disturbance has not destroyed it. Mottling includes light brownish gray (2.5Y 6/2) and very dusky purple (5P 2/2).

SMEAR SLIDE SUMMARY

	1-74	2-15	4-116	6-25
	D	D	D	D
Quartz	TR	TR	TR	–
Carbonate unspec.	TR	1	1	1
Foraminifers	TR	TR	TR	TR
Nannofossils	93	89	92	93
Diatoms	5	8	5	5
Radiolarians	2	2	2	1
Silicoflagellates	TR	TR	TR	TR
Sponge spicules	TR	TR	TR	–

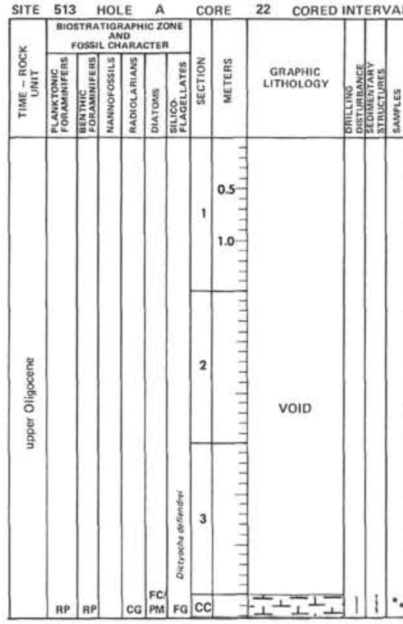
CARBONATE BOMB:
2, 87–88 (43)
4, 134–135 (8)

MAGNETIC DATA:	1-105	3-14	4-99
Inclination	23.9	– 2.5	5.8
Declination	234.4	220.8	208.3
Intensity (emu/cc)	0.800E–07	0.230E–06	0.600E–07

MAGNETIC DATA:	5-39	6-17
Inclination	25.7	43.0
Declination	159.1	349.7
Intensity (emu/cc)	0.140E–06	0.210E–06

GRAIN SIZE:
1-140 (1, 22, 77)
3-140 (1, 24, 75)
5-140 (0, 31, 69)

SITE 513 HOLE A CORE 22 CORED INTERVAL 265.5–275.0 m



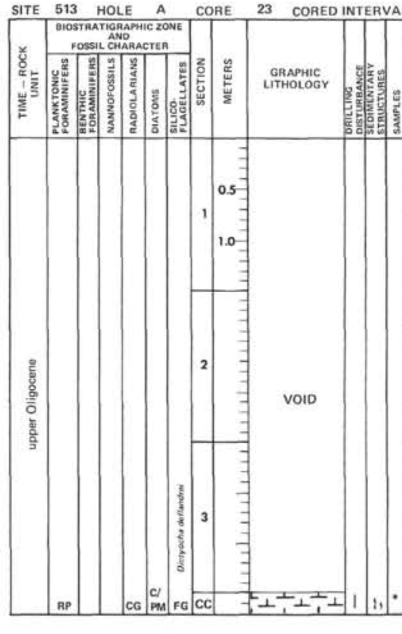
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE
Core-Catcher: light brownish gray (2.5Y 6/2), sparsely mottled in top 13 cm where diatom content is higher than the lower 6 cm which are white (2.5Y 8/0).

SMEAR SLIDE SUMMARY

	CC, 6	CC, 16
	D	D
Quartz	TR	TR
Clay minerals	3	–
Carbonate unspec.	1	1
Foraminifers	–	TR
Nannofossils	82	91
Diatoms	9	5
Radiolarians	5	3
Silicoflagellates	TR	–
Sponge spicules	TR	TR

SITE 513 HOLE A CORE 23 CORED INTERVAL 275.0–284.5 m



LITHOLOGIC DESCRIPTION

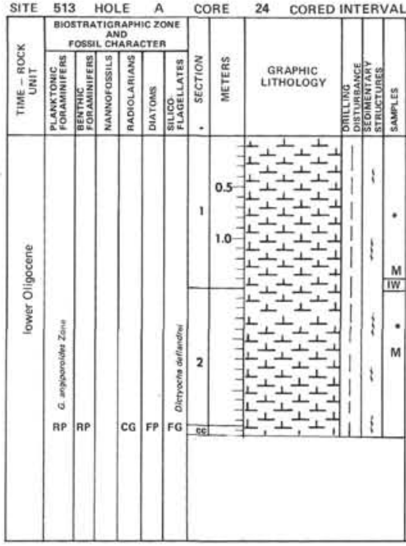
NANNOFOSSIL OOZE
Core-Catcher: white in top 14 cm, light gray in lower 7 cm, with dark greenish gray (5G 4/1) wedge between, which is a siliceous nannofossil ooze, Mottling is moderate to sparse.

In top 4 cm, a 4 cm black, rounded pebble (?chert).

SMEAR SLIDE SUMMARY

	CC, 5	CC, 11
	D	D
Clay minerals	–	6
Carbonate unspec.	1	–
Foraminifers	TR	TR
Nannofossils	87	78
Diatoms	8	10
Radiolarians	4	6
Silicoflagellates	TR	TR
Sponge spicules	TR	TR

SITE 513 HOLE A CORE 24 CORED INTERVAL 284.5–294.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE
Bluish white (5B 9/1) to white (N9) becoming, down section, slightly greenish (5GY 8/1) to light greenish gray (5G 8/1) to greenish gray (5G 6/1) in Section 2. Sediment is structureless, very firm, slightly bioturbated. A 4 cm pebble at top.

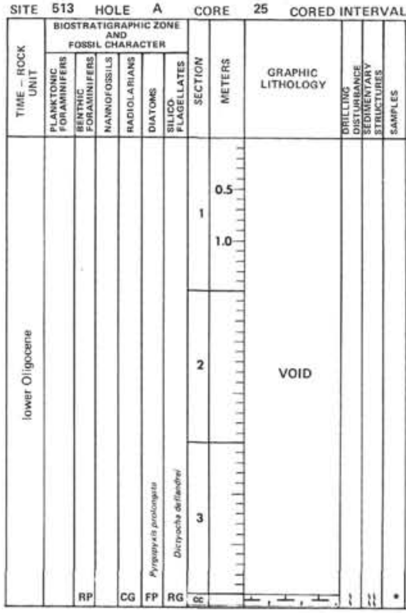
SMEAR SLIDE SUMMARY

	1-75	2-40
	D	D
Quartz	1	TR
Clay minerals	5	5
Nannofossils	90	91
Diatoms	3	3
Sponge spicules	1	1
Micronodules	–	TR

MAGNETIC DATA:	1-137	2-69
Inclination	–70.9	56.8
Declination	246.9	17.2
Intensity (emu/cc)	0.120E–06	0.100E–03

GRAIN SIZE:
2-54 (1, 30, 70)

SITE 513 HOLE A CORE 25 CORED INTERVAL 294.0–303.5 m



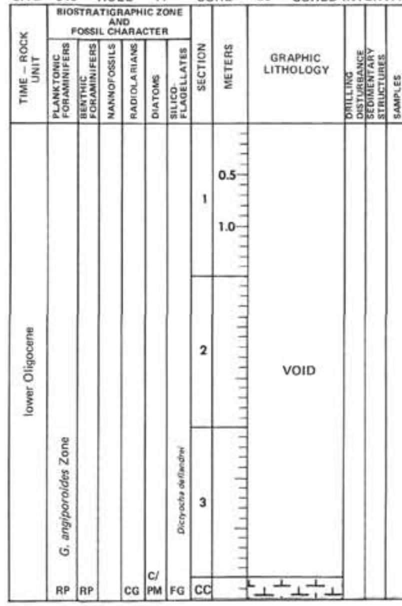
LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE
Core-Catcher: light gray (5Y 7/1), very firm, moderately bioturbated; uppermost few cm slightly greenish.

SMEAR SLIDE SUMMARY

	CC, 6
	D
Quartz	1
Clay minerals	3
Foraminifers	TR
Nannofossils	95
Diatoms	1

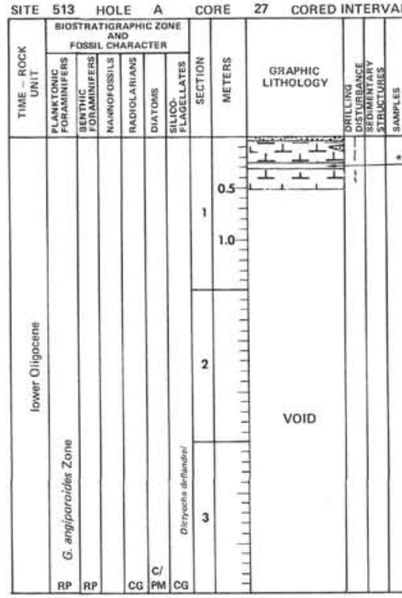
SITE 513 HOLE A CORE 26 CORED INTERVAL 303.5–313.0 m



LITHOLOGIC DESCRIPTION

Core-Catcher: Contained 3 pebbles and a trace of nannofossil ooze.

SITE 513 HOLE A CORE 27 CORED INTERVAL 313.0–322.5 m



LITHOLOGIC DESCRIPTION

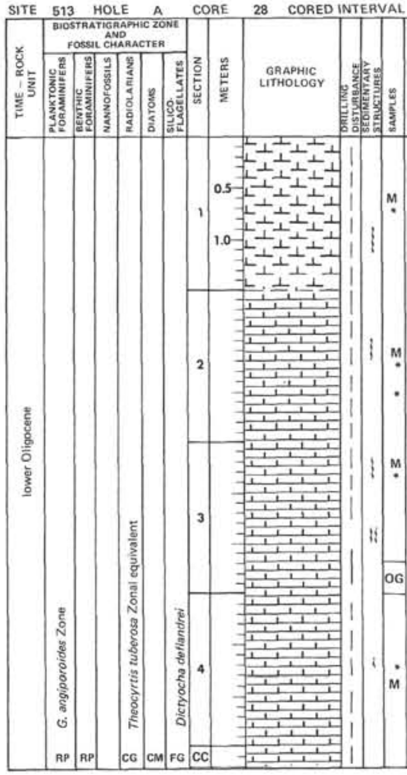
- VOID

NANNOFOSSIL OOZE
Gray (5Y 6/1) with darker gray (0.5 cm) lamina at 20 cm and white diffuse zone (1 cm) at 16–17 cm. Very slightly greenish at 22–26 cm.

SMEAR SLIDE SUMMARY

	1-24
	D
Quartz	1
Clay minerals	5
Carbonate unspec.	1
Foraminifers	1
Nannofossils	85
Diatoms	5
Radiolarians	2
Sponge spicules	TR

SITE 513 HOLE A CORE 28 CORED INTERVAL 322.5–332.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE AND CHALK

Light gray (5Y 7/1) to light greenish gray (5GY 8/1) firm nannofossil ooze in Section 1 with numerous, 2–3 cm intervals of more indurated chalk. Below Section 1, induration sufficiently great to apply the term "chalk" rather than ooze.

In Section 3, 50–75 cm: chalk is white (5Y 8/1) with gradational upper and sharp lower contact at the latter of which color changes to light gray (5Y 7/1) and gray (5Y 6/1) with greenish tint. In Section 5, greenish gray zones ~5–10 cm thick – interbedded with occasional gray or white zones.

Bioturbation slight to moderate.

In Section 2, 105–106 cm: a thin wedge of diatomaceous nannofossil ooze.

SMEAR SLIDE SUMMARY

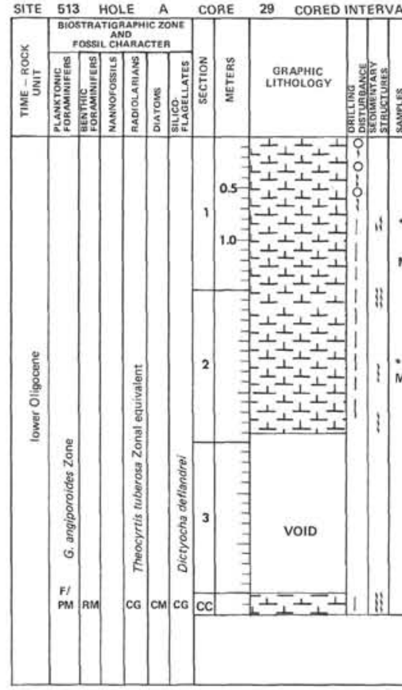
	1-75	2-75	2-106	3-35	4-75
	D	D	M	D	D
Quartz	–	–	–	1	–
Clay minerals	5	5	5	3	3
Carbonate unspec.	2	1	2	1	1
Foraminifers	1	–	3	–	3
Nannofossils	75	82	55	78	71
Diatoms	15	10	30	15	20
Radiolarians	2	2	3	2	1
Silicoflagellates	–	–	2	TR	1
Sponge spicules	TR	TR	–	–	–

CARBONATE BOMB:
2, 64–65 (63)

MAGNETIC DATA:	1-72	2-71	3-37	4-86
Inclination	0.2	–10.8	–41.3	65.4
Declination	219.5	186.2	181.7	134.1
Intensity (emu/cc)	0.700E–07	0.160E–06	0.400E–07	0.140E–06

GRAIN SIZE:
2-18 (1, 38, 61)
4-18 (2, 52, 45)

SITE 513 HOLE A CORE 29 CORED INTERVAL 332.0–341.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Greenish gray (5GY 6/1) to light greenish gray (5GY 8/1) with more indurated (chalk) zones throughout, 4–5 cm average thickness.

Top 54 cm of Section 1 soupy to highly disturbed where ooze is mixed with rusty pipe flakes. Bioturbation minor to moderate. One prominent gray burrow (1 cm) in Section 1, 66–67 cm.

Large (?)volcanic breccia pebble (8x5x2 cm) in Section 1, 61–66 cm.

In Section 5, 46–53 cm, gray (5Y 6/1) zone.

SMEAR SLIDE SUMMARY

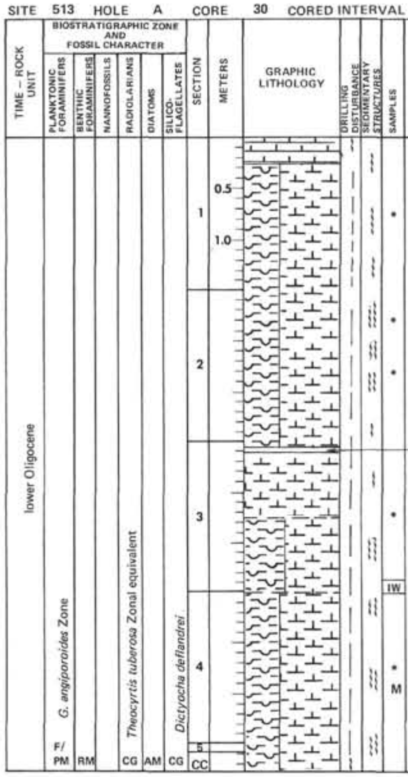
	1-80	2-75
	D	D
Quartz	1	1
Clay minerals	5	3
Zeolites	TR	–
Carbonate unspec.	1	1
Foraminifers	1	TR
Nannofossils	70	74
Diatoms	20	20
Radiolarians	1	TR
Silicoflagellates	–	1
Sponge spicules	TR	–
Micronodules	1	–

CARBONATE BOMB:
2, 108–109 (59)

MAGNETIC DATA:	1-132	2-84
Inclination	– 5.3	72.2
Declination	354.9	177.1
Intensity (emu/cc)	0.230E–06	0.180E–06

GRAIN SIZE:
2-36 (2, 51, 48)

SITE 513 HOLE A CORE 30 CORED INTERVAL 314.5–351.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE AND CHALK AND DIATOMACEOUS NANNOFOSSIL OOZE

Light greenish gray (5GY 8/1), homogeneous, slightly bioturbated. Indurated chalk Section 1, 0–27 cm. Pebble of dark fine-grained sedimentary lithology Section 1, 30–32 cm and volcanic(?) pebble at Section 2, 102 cm.

In Section 2, 80–101 cm: prominent burrows and highly disturbed laminae, very dark gray (5Y 3/1).

In Section 3, gradual downward change to light gray (5Y 7/2) and ooze becomes more diatomaceous. Several 5–10 cm more indurated chalk zones in this section.

In Section 4, slightly lighter green with depth, with minor light olive gray (5Y 6/2), moderate dark to medium gray bioturbation, and gray (5Y 5/1) 0.5 cm laminae at 104 and 130 cm.

SMEAR SLIDE SUMMARY

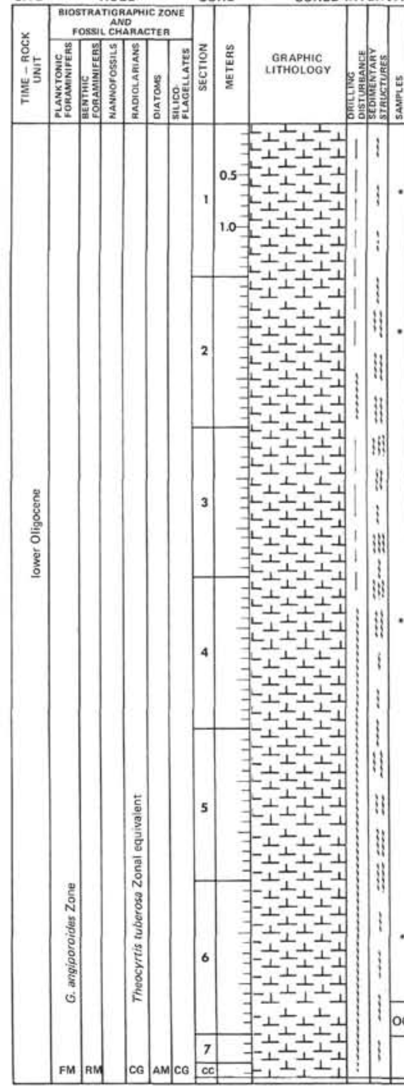
	1-75	2-30	2-88	3-75	4-75
	D	D	M	D	D
Quartz	–	–	–	TR	–
Clay minerals	3	3	5	10	10
Carbonate unspec.	1	1	1	1	1
Foraminifers	–	1	1	2	1
Nannofossils	65	73	70	49	57
Diatoms	30	20	20	35	30
Radiolarians	1	2	2	3	1
Sponge spicules	TR	–	–	TR	TR
Micronodules	–	–	1	–	–

CARBONATE BOMB:
4, 128–129 (55)

MAGNETIC DATA: 4-97
Inclination 5.1
Declination 90.5
Intensity (emu/cc) 0.100E–06

GRAIN SIZE:
1-74 (2, 46, 52)
3-74 (2, 41, 58)

SITE 513 HOLE A CORE 31 CORED INTERVAL 351.0–360.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE with numerous ~2 cm "chalk" intervals, that are more indurated, throughout the core.

White and light greenish gray (5GY 8/1) in Section 1; gray zone in Section 2, 0–94 cm underlain by white (5Y 8/1) through to Section 3, 0–87 cm. Below that in Sections 3 and 4 color is light bluish gray (5B 7/1) to light gray (5Y 7/1) in Sections 5 and 6.

Mottling sparse to heavy.

Very dark gray (2.5Y 3/0) stringers and gray (5Y 6/1) laminae ~1 cm are present but sparse to moderately abundant throughout the core.

Note: Section 7 is 64 cm long.

SMEAR SLIDE SUMMARY

	1-69	2-52	4-40	6-56
	D	D	D	D
Clay minerals	5	4	–	–
Carbonate unspec.	5	2	2	7
Foraminifers	1	TR	4	5
Nannofossils	74	79	78	74
Diatoms	11	12	13	11
Radiolarians	3	3	3	3
Silicoflagellates	1	TR	TR	TR
Sponge spicules	TR	TR	TR	TR

CARBONATE BOMB:
4, 32–33 (51)

MAGNETIC DATA: 1-87
Inclination 47.0
Declination 160.5
Intensity (emu/cc) 0.300E–07

GRAIN SIZE:
1-18 (3, 45, 52)
3-18 (2, 48, 50)
5-18 (2, 39, 60)
7-18 (2, 48, 50)

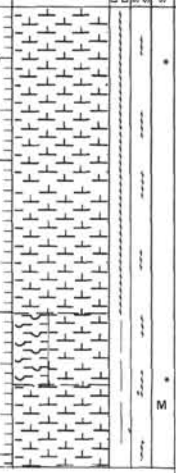
SITE 513 HOLE A CORE 32 CORED INTERVAL 360.5–370.0 m

TIME-ROCK UNIT: lower Oligocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER:
- Planktonic Foraminifers: *G. angiporoides* Zone — FM
- Benthic Foraminifers: RM
- Radiolarians: *Theocyrtis tuberosa* Zonal equivalent — CG
- Diatoms: CM
- Silicoflagellates: *Dictyocha deflandrei* Zone; *Naviculopsis trispinosa* Subzone — CG

SECTION: 1, 2, 3, CC

METERS: 0.5, 1.0



SAMPLES: *, *, M

LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Continuation of Core 31 – white (2.5Y 8/0) with sparse mottling and very dark gray stringers as before. "Chalk" indurated 2–3 cm intervals common as before. Becoming more diatomaceous in lower part of Section 2 and diatoms abundant in Section 3, 0–65 cm where ooze is light gray (2.5Y 7/0) and gray (2.5Y 8/0).

In Section 3, 28–52 cm, very dark gray and greenish black (5GY 2/1) laminae. At 130–136 cm, very dark gray and grayish purple laminae. Between 65–90 cm, horizontal color banding.

SMEAR SLIDE SUMMARY

	1-52	3-70
	D	D
Carbonate unspec.	6	10
Foraminifers	5	1
Nannofossils	80	57
Diatoms	7	30
Radiolarians	2	2
Silicoflagellates	TR	TR
Sponge spicules	TR	TR

CARBONATE BOMB:
2, 55–56 (56)

MAGNETIC DATA:	3-95
Inclination	70.2
Declination	251.5
Intensity (emu/cc)	0.170E–06

GRAIN SIZE:
1-88 (3, 61, 35)
3-88 (3, 52, 45)

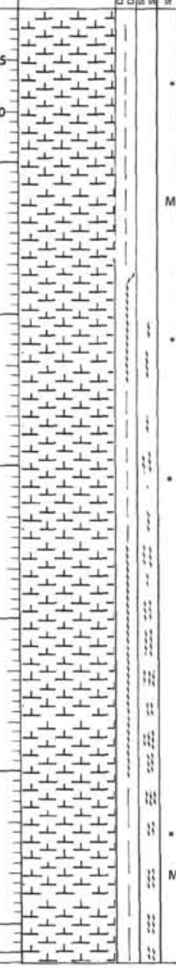
SITE 513 HOLE A CORE 33 CORED INTERVAL 370.0–379.5 m

TIME-ROCK UNIT: lower Oligocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER:
- Planktonic Foraminifers: *G. angiporoides* Zone — CM
- Benthic Foraminifers: RM
- Radiolarians: *Theocyrtis tuberosa* Zonal equivalent — CG
- Diatoms: AM
- Silicoflagellates: CG

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

METERS: 0.5, 1.0



SAMPLES: *, M, *, *, *, M

LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

As in previous Cores 31 and 32, white (2.5Y 8/0), becoming mixed with light gray (5Y 7/1) in Section 5 and white (5Y 8/1) again in Section 6.

Horizontal color banding slight to moderate in Sections 1–3, in pale yellow (5Y 7/4), greenish gray (5G 6/1), very dark gray (5Y 3/1) and sparse grayish purple (5P 4/2).

Very firm indurated (chalk) intervals as in previous cores.

Mottling of pale yellow (5Y 7/3) is present in Section 4 and is mixed with greenish gray and dark gray, in sparse to moderate amounts through balance of the core, being heavy in places.

In Sections 5 and 6, several black chert pebbles, < 1 cm, coated with glauconite-green substance are present. They are more abundant and up to 2 cm in Section 7 and Core-Catcher.

SMEAR SLIDE SUMMARY

	1-74	3-25	4-15	6-60
	D	D	D	D
Carbonate unspec.	5	5	5	8
Foraminifers	1	5	4	3
Nannofossils	85	78	80	81
Diatoms	8	10	10	6
Radiolarians	1	2	1	2
Silicoflagellates	TR	TR	TR	TR
Sponge spicules	TR	TR	TR	TR

CARBONATE BOMB:
4, 13–14 (79)

MAGNETIC DATA:	2-44	6-93
Inclination	–32.4	26.4
Declination	186.9	130.2
Intensity (emu/cc)	0.130E–06	0.100E–07

GRAIN SIZE:
1-2 (2, 56, 42)
3-2 (2, 61, 38)
5-2 (1, 52, 47)
7-2 (2, 45, 53)

SITE 513 HOLE A CORE 34 CORED INTERVAL 379.5–380.5 m

SECTION: CC

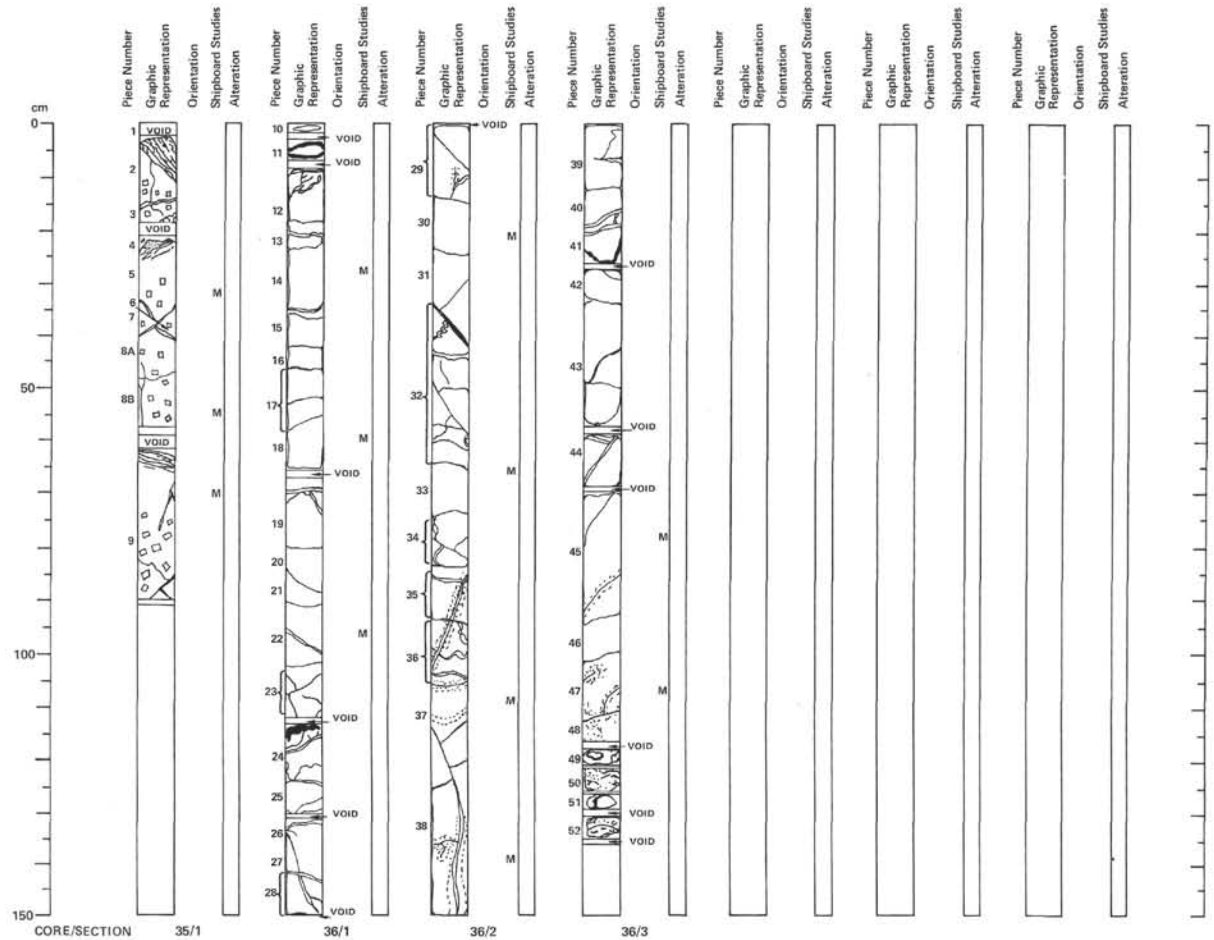
LITHOLOGIC DESCRIPTION

Core-Catcher: contained two rock fragments:

1) 6.5 cm wide, rounded (?drilled) buffish white (5Y 8/1) chert "cobble"; and

2) 4 cm gray subangular to subrounded igneous(?) basalt fragment that, from its shape appears to be a glacial erratic, hence cave-in.

The chert may very well be bedrock.



HOLE 513A, CORE 35, SECTION 1 **Depth: 380.5–382.0 m**

4–20 cm: Fine-grained basalt
- 4.0–5.5 cm: interlaminated glass and baked sediment; carbonate veinlets
- 5.5–20 cm: progressively coarser grained with depth, conspicuous phenocrysts (< 2 mm); little fracturing; one fine, carbonate-filled veinlet (< 1 mm) running length of unit (5.5–20 cm); small glassy zone at base of unit

23–26 cm: glass and white carbonate
26–59 cm: fine-grained basalt; few yellowish narrow fractures, filled with carbonate (< 1 mm); conspicuous intersecting fractures at 38 cm, with carbonate filling; coarser grained in interior of unit with progressive increase in phenocrysts and grain size away from upper and lower glassy zones
59–60 cm: thin white carbonate over black glass; glass fractured, with small carbonate-filled veinlets
65–66 cm: glassy zone
66–71 cm: interlayered, fine and slightly more coarsely grained basalt; becoming coarser with depth
71–90 cm: fine- to medium-grained basalt

HOLE 531A, CORE 36, SECTION 1 **Depth: 382.0–383.5 m**

1–3 cm: granitic(?) pebble
4–7 cm: fine-grained basalt with 2–3 mm glassy zone along lower edge
8–111 cm: fine-grained basalt
- 8–8.5 cm: glassy zone grading downwards into very fine-grained basalt (8.5–10 cm) (glassy zone is horizontal)
- 10–16 cm: grades downward into slightly more coarsely grained basalt with few fractures and veinlets
- 8.5–12 cm: minor veinlets (<1.5 mm) of carbonate
- 16–111 cm: uniform fine- to medium-grained basalt

111–116 cm: glassy zone with abundant carbonate, minor fracturing at 30° to horizontal. Large calcite-filled vug at 111–113 cm.
116–148 cm: fine-grained basalt; prominent calcite veinlet (3–5 mm thick) at 139–145 cm

HOLE 513A, CORE 36, SECTION 2 **Depth: 383.5–385.0 m**

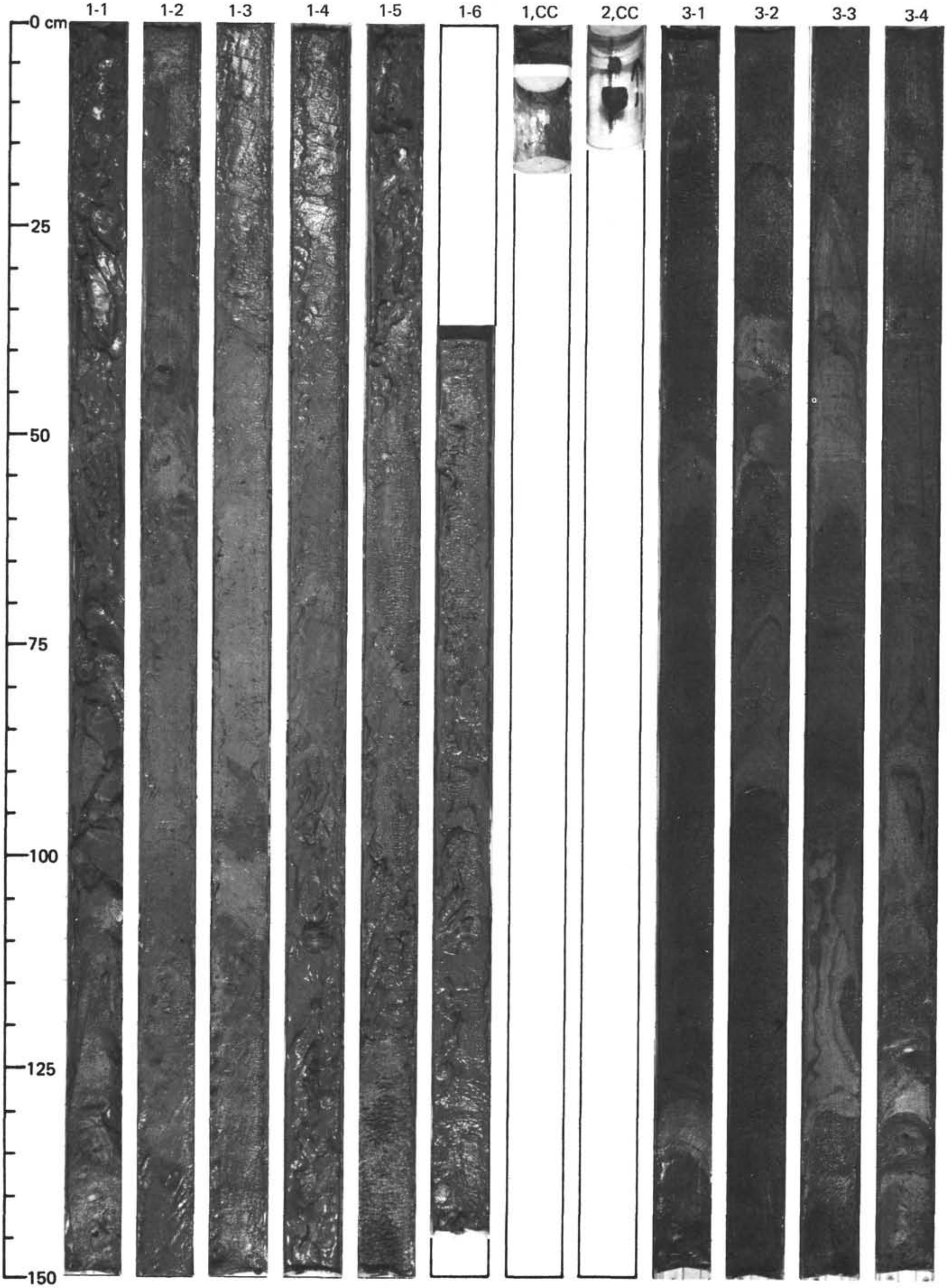
0–150 cm: fine-grained basalt; prominent near-vertical, calcite-filled vein 43–62 cm; minor alteration along some fractures and veinlets

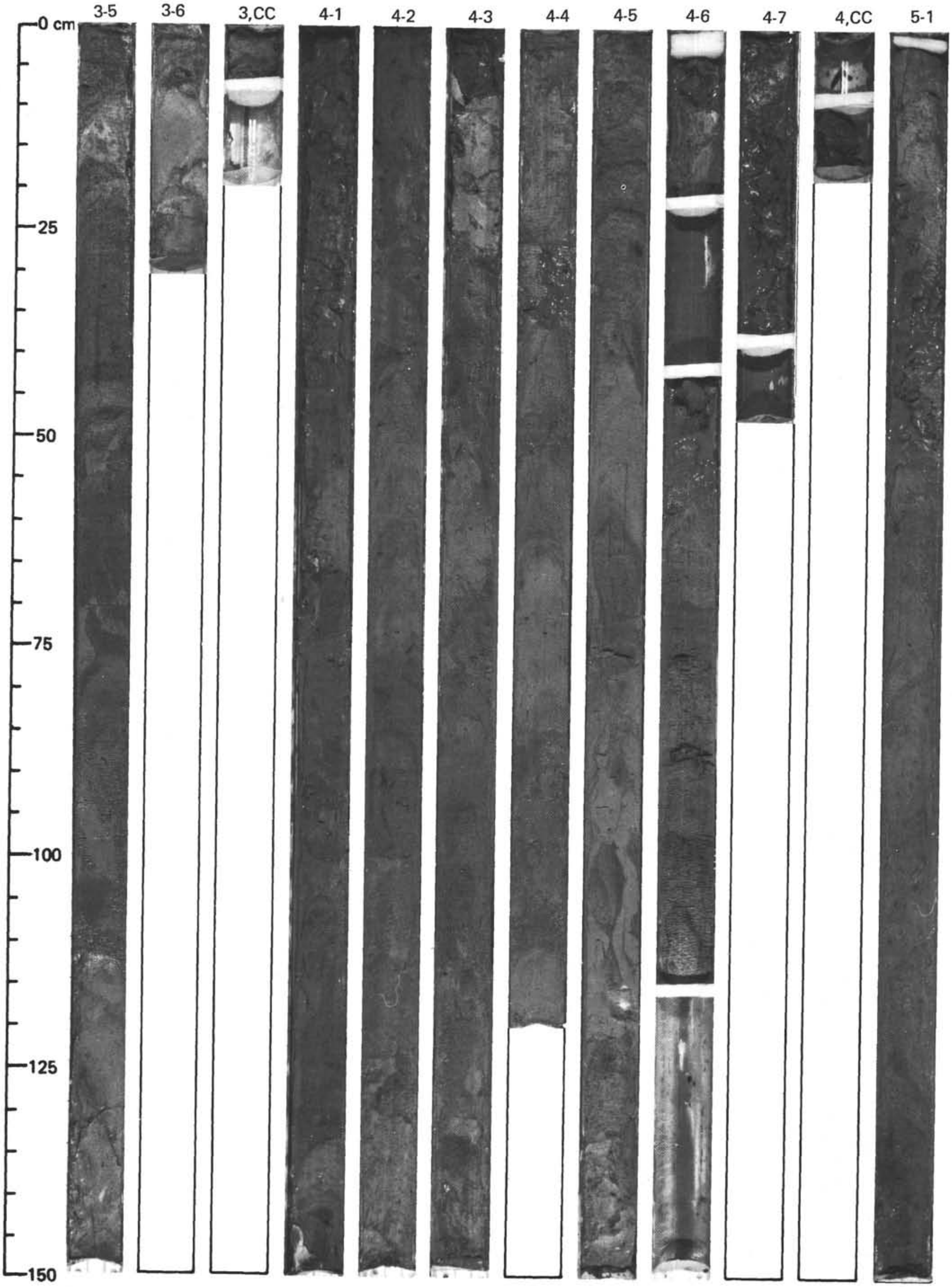
HOLE 513A, CORE 36, SECTION 3 **Depth: 385.0–386.32 m**

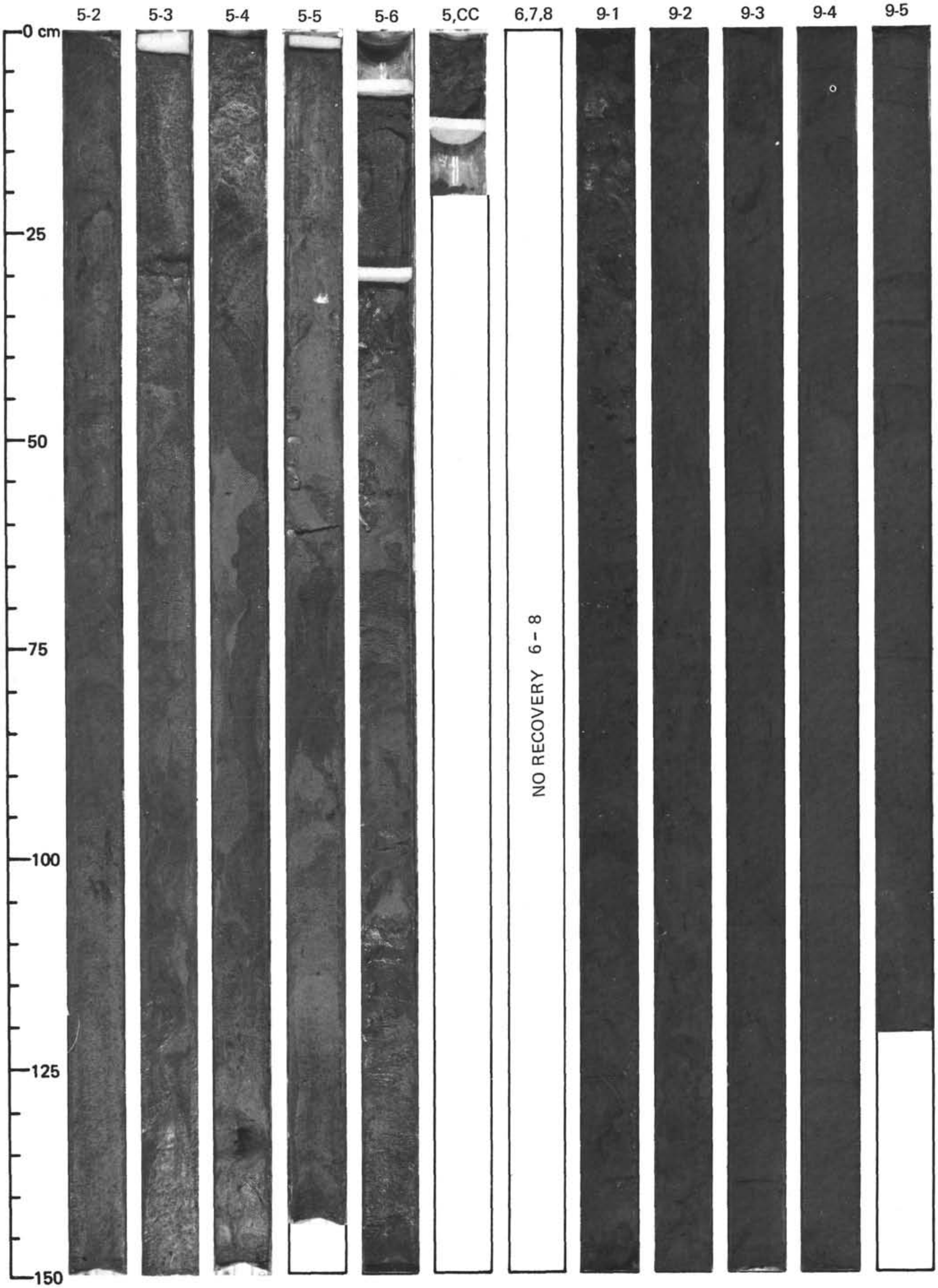
0–115 cm: fine-grained basalt with minor fracturing and calcite-filled veins (< 1.5 mm); minor alteration along some veinlets and fractures
116–133 cm: glassy zone with prominent vug filled partially with calcite crystals at 117 cm
128–133 cm: mixed glass and breccia zone; angular basaltic fragments (0.5–3 cm) in calcite matrix

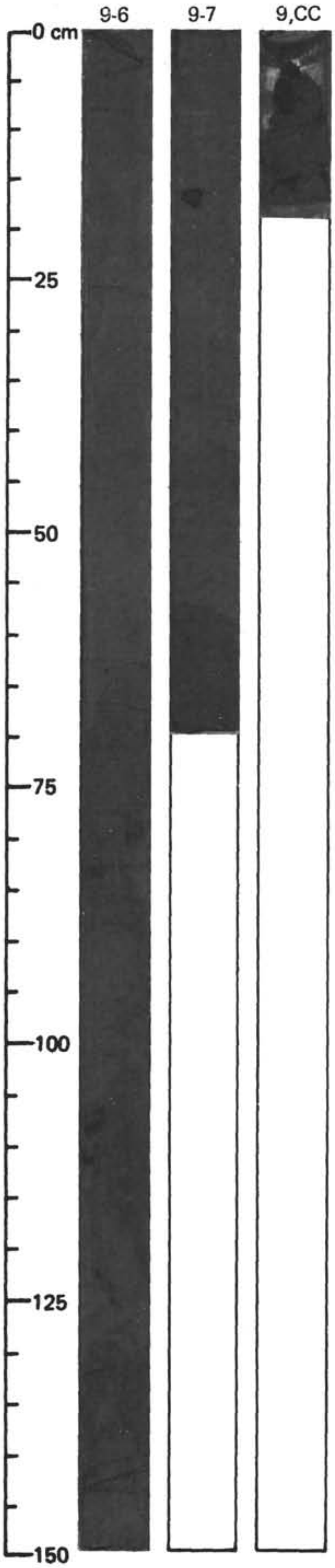
MAGNETIC DATA:

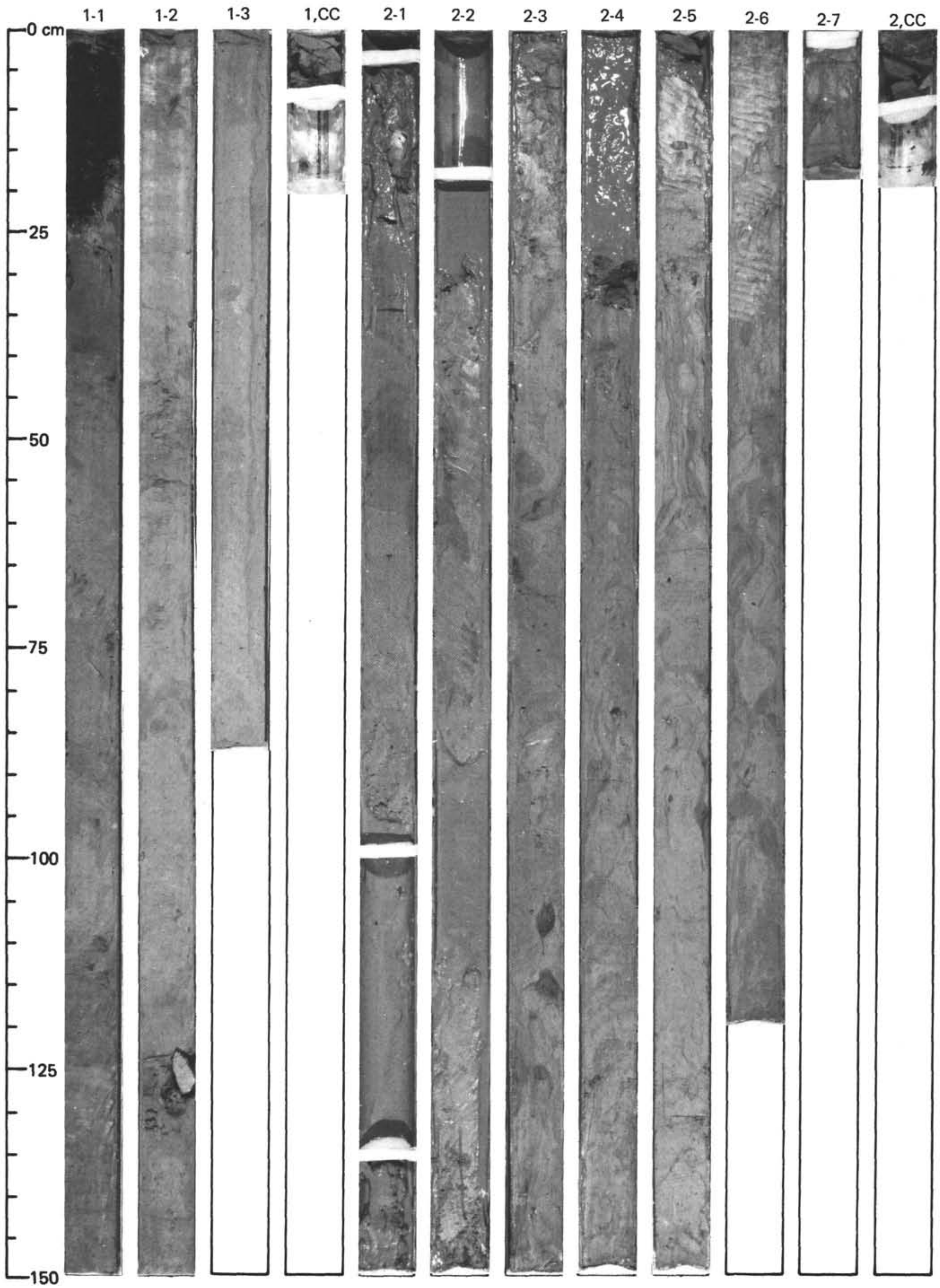
Sample	Inclination	Declination	Intensity (emu/cc)
35-1, 31 cm	55.9	175.0	0.652E–02
35-1, 55 cm	55.0	172.4	0.393E–02
35-1, 71 cm	56.5	273.6	0.315E–02
36-1, 29 cm	49.0	236.8	0.550E–02
36-1, 60 cm	45.0	216.4	0.598E–02
36-1, 95 cm	50.5	216.6	0.338E–02
36-2, 22 cm	60.1	180.9	0.815E–02
36-2, 77 cm	54.6	179.7	0.936E–02
36-2, 109 cm	51.8	287.1	0.303E–02
36-2, 140 cm	54.5	291.6	0.661E–02
36-3, 40 cm	48.3	197.3	0.508E–02
36-3, 78 cm	53.7	252.6	0.232E–02
36-3, 105 cm	57.3	262.3	0.254E–02

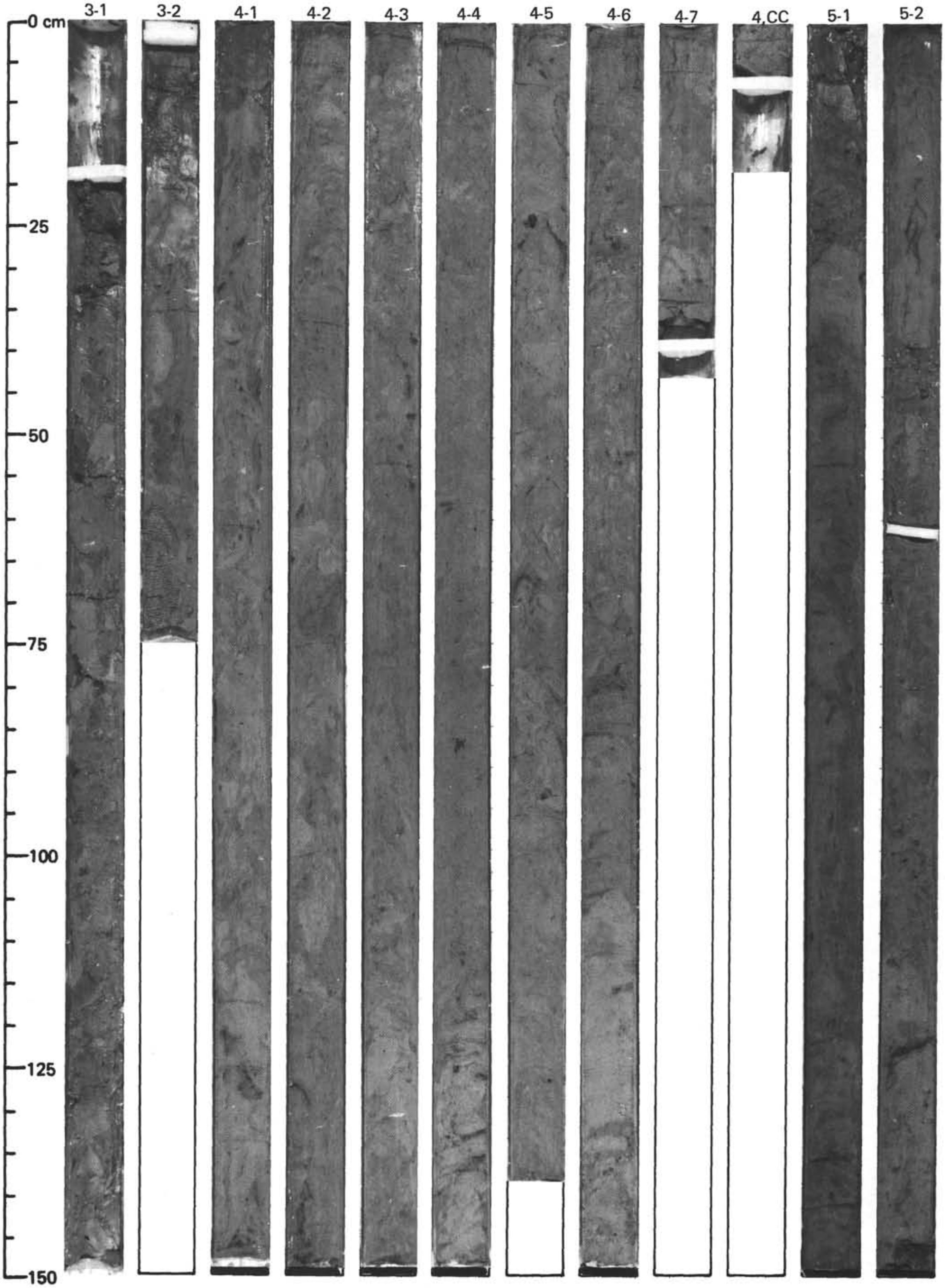

1-1
1-2
1-3
1-4
1-5
1-6
1,CC
2,CC
3-1
3-2
3-3
3-4
0 cm
25
50
75
100
125
150

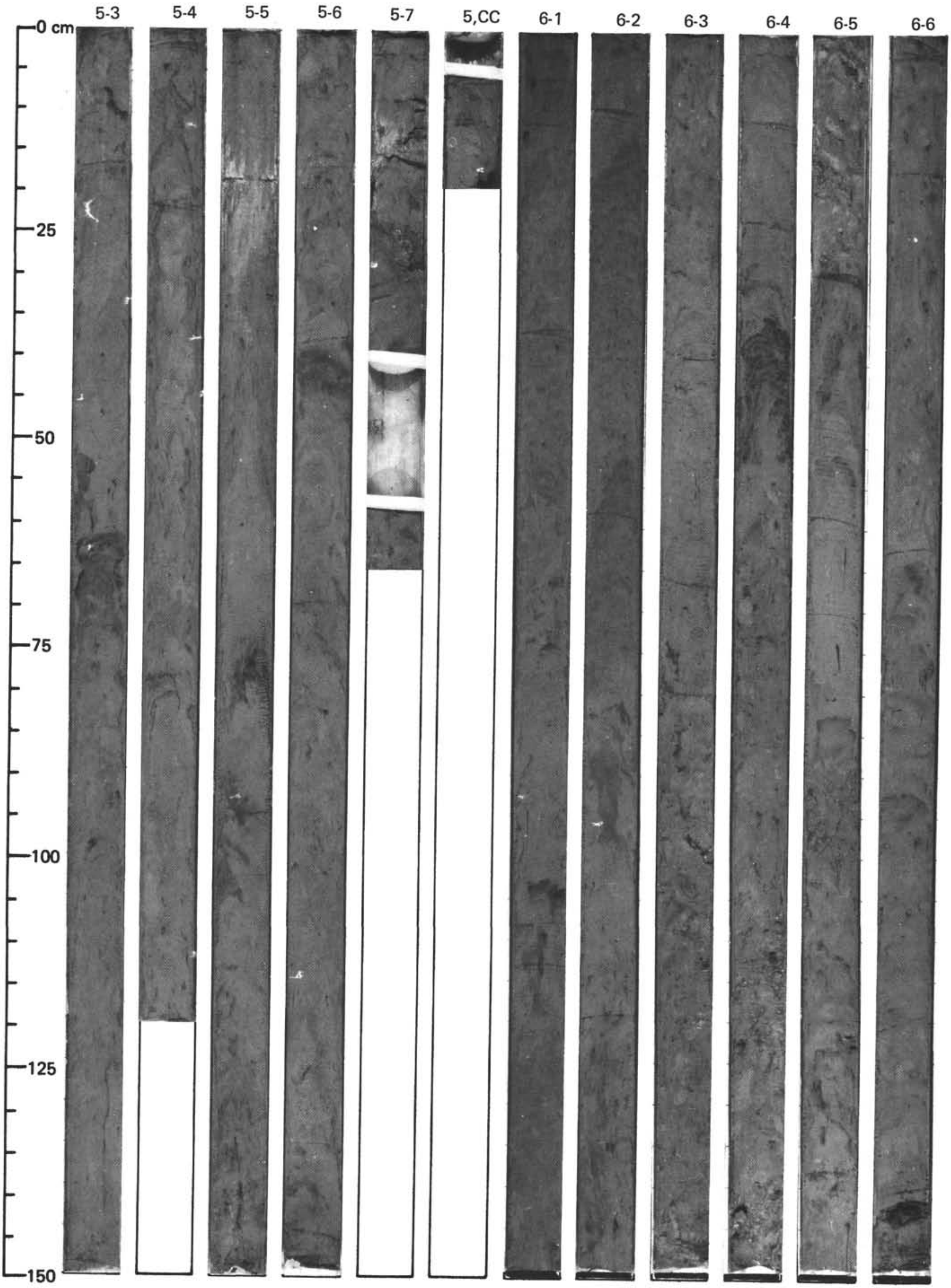

0 cm
25
50
75
100
125
150
3-5
3-6
3,CC
4-1
4-2
4-3
4-4
4-5
4-6
4-7
4,CC
5-1


5-2
5-3
5-4
5-5
5-6
5,CC
6,7,8
9-1
9-2
9-3
9-4
9-5
0 cm
25
50
75
100
125
150
NO RECOVERY 6 – 8

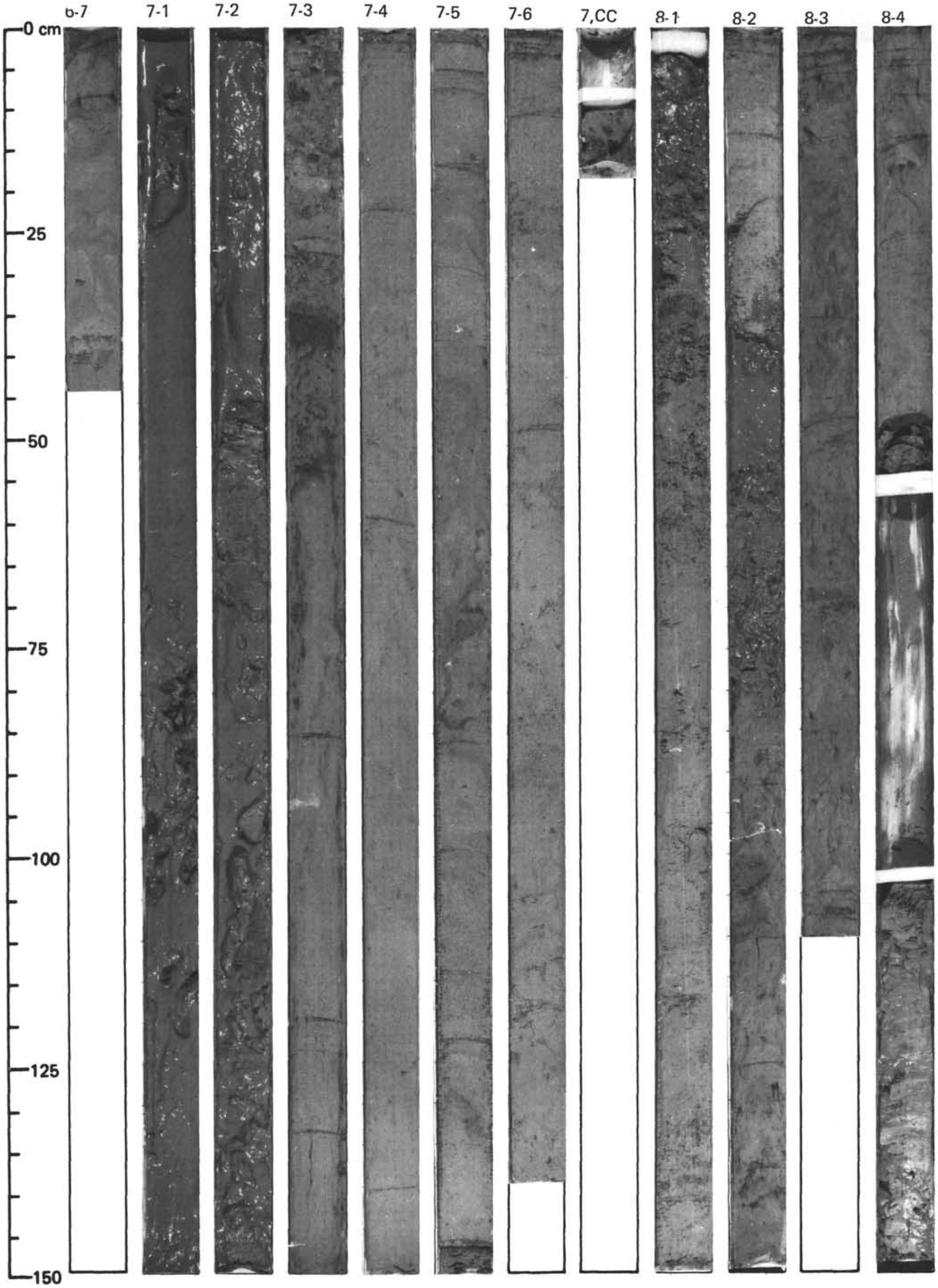

9-6
9-7
9,CC
0 cm
25
50
75
100
125
150

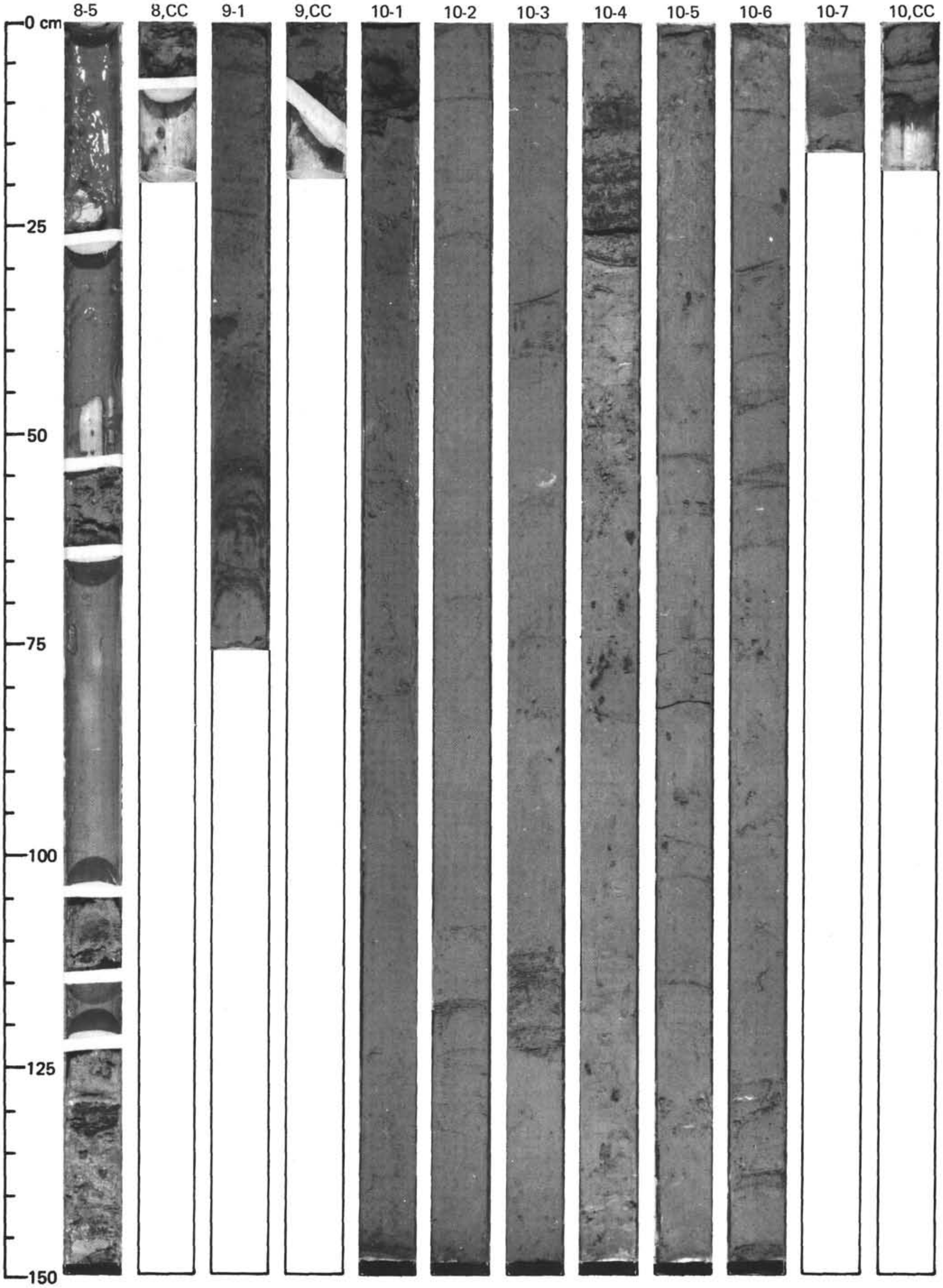

1-1
1-2
1-3
1,CC
2-1
2-2
2-3
2-4
2-5
2-6
2-7
2,CC
0 cm
25
50
75
100
125
150

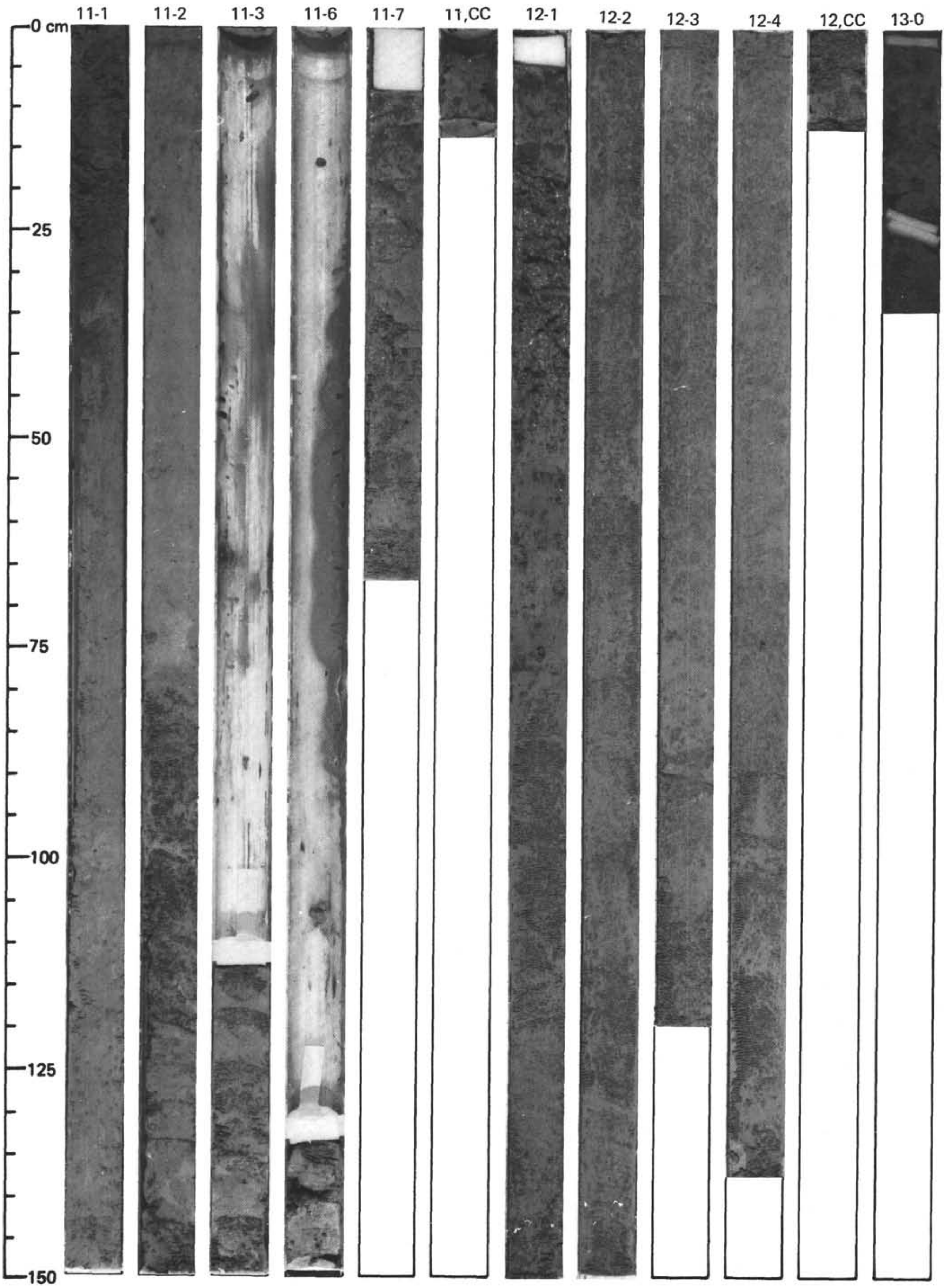

3-1
3-2
4-1
4-2
4-3
4-4
4-5
4-6
4-7
4,CC
5-1
5-2
0 cm
25
50
75
100
125
150

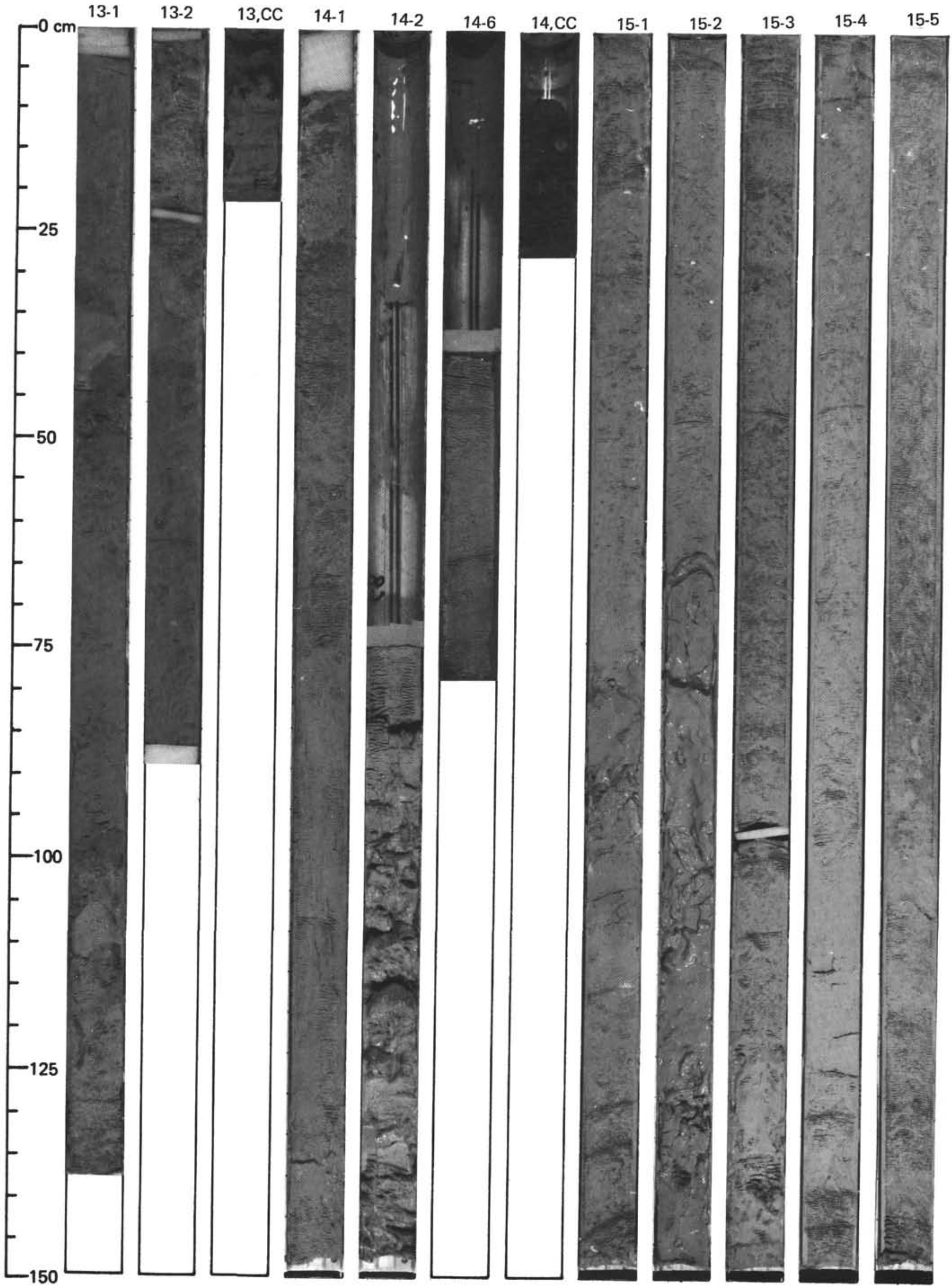


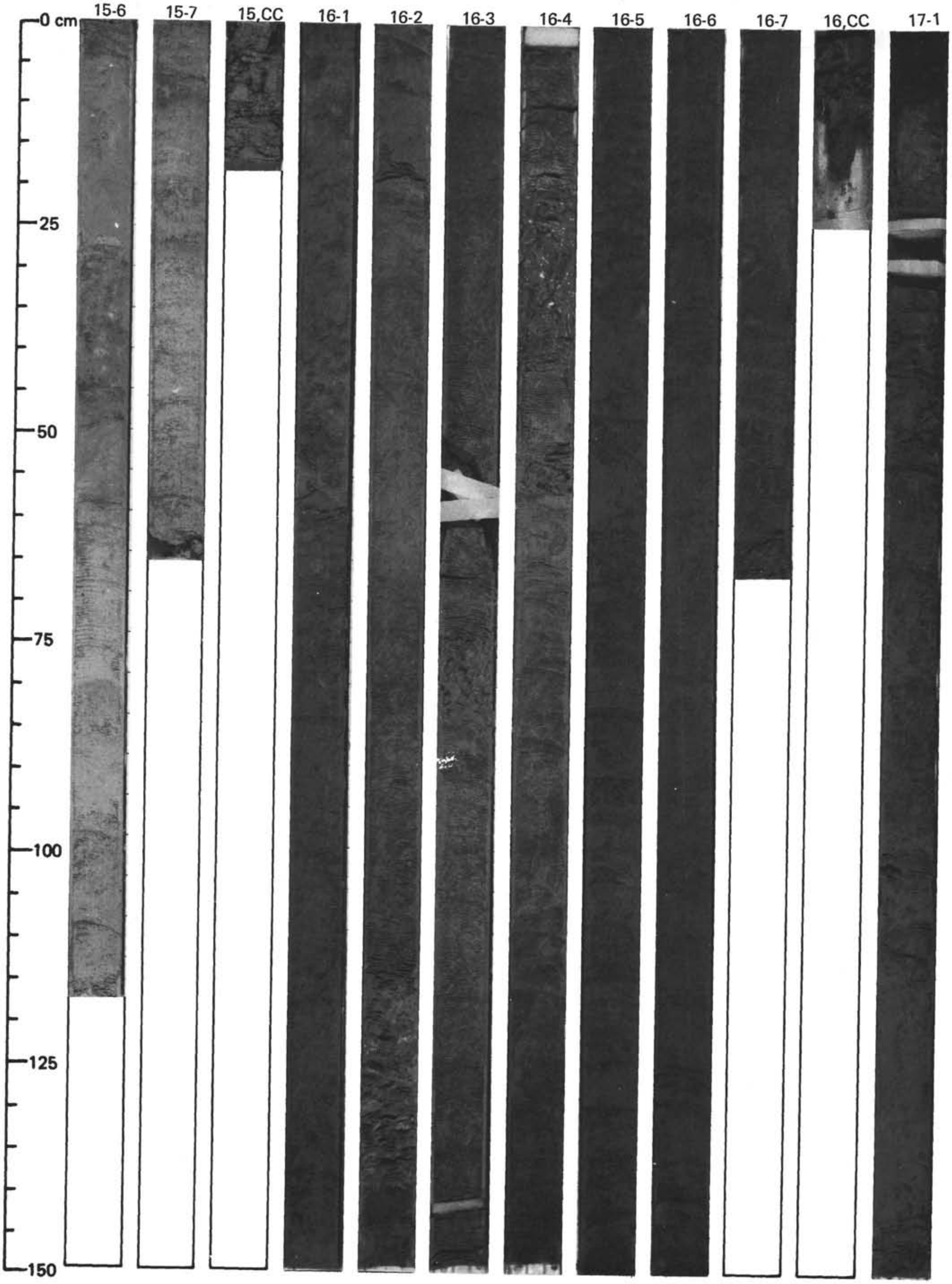
5-3
5-4
5-5
5-6
5-7
5,CC
6-1
6-2
6-3
6-4
6-5
6-6
0 cm
25
50
75
100
125
150

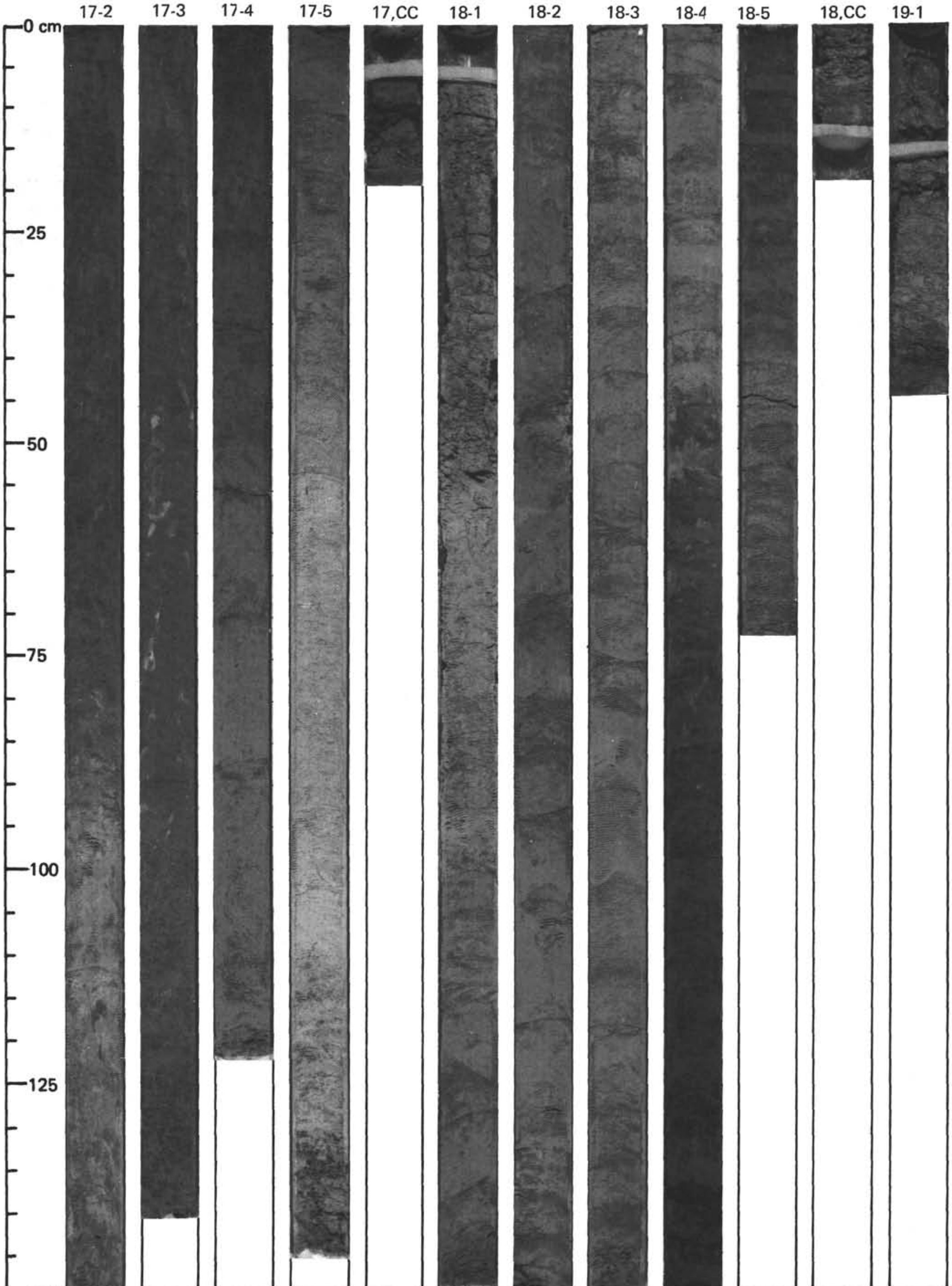

6-7
7-1
7-2
7-3
7-4
7-5
7-6
7,CC
8-1
8-2
8-3
8-4
0 cm
25
50
75
100
125
150

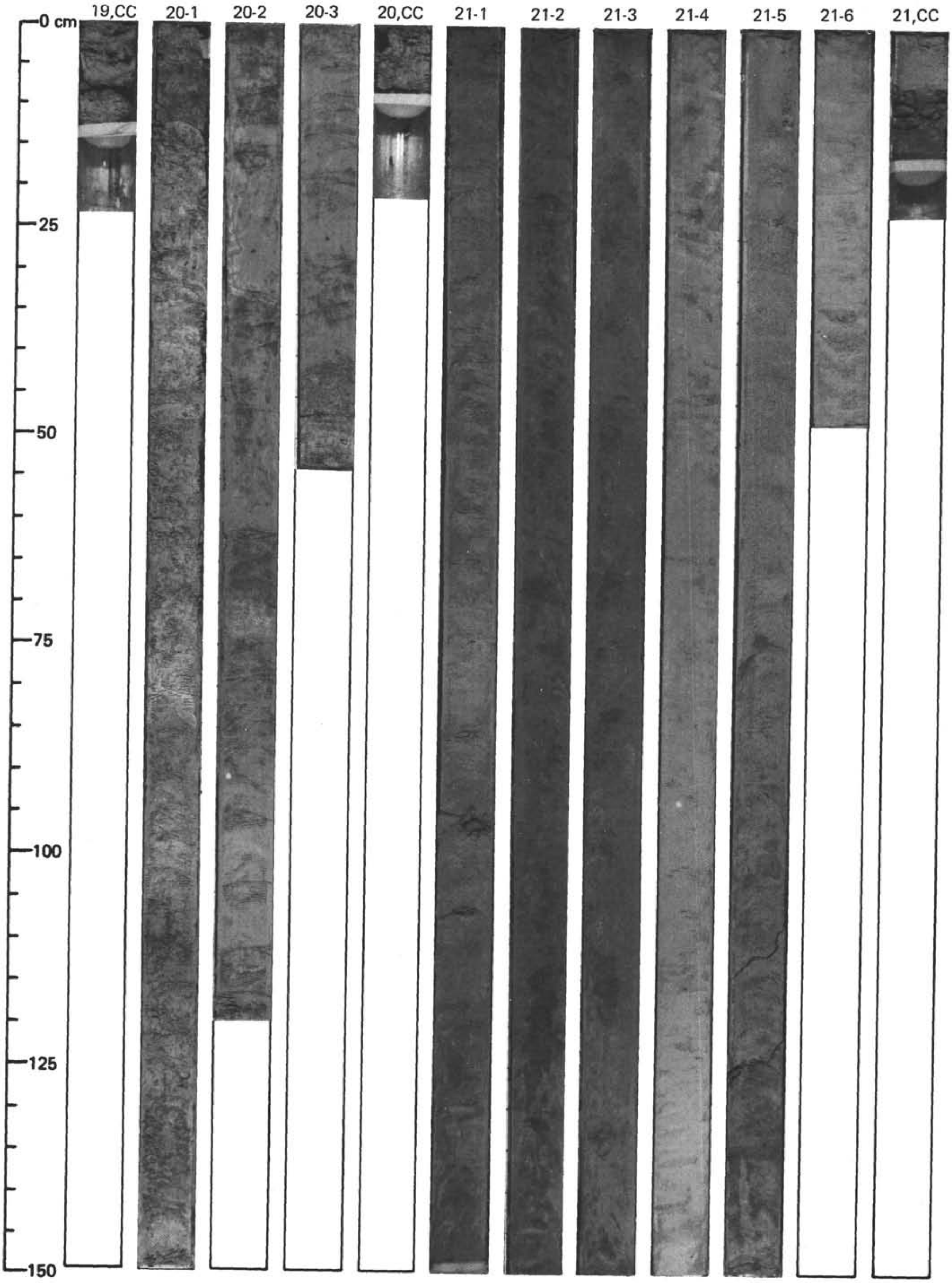

8-5
8,CC
9-1
9,CC
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10,CC
0 cm
25
50
75
100
125
150

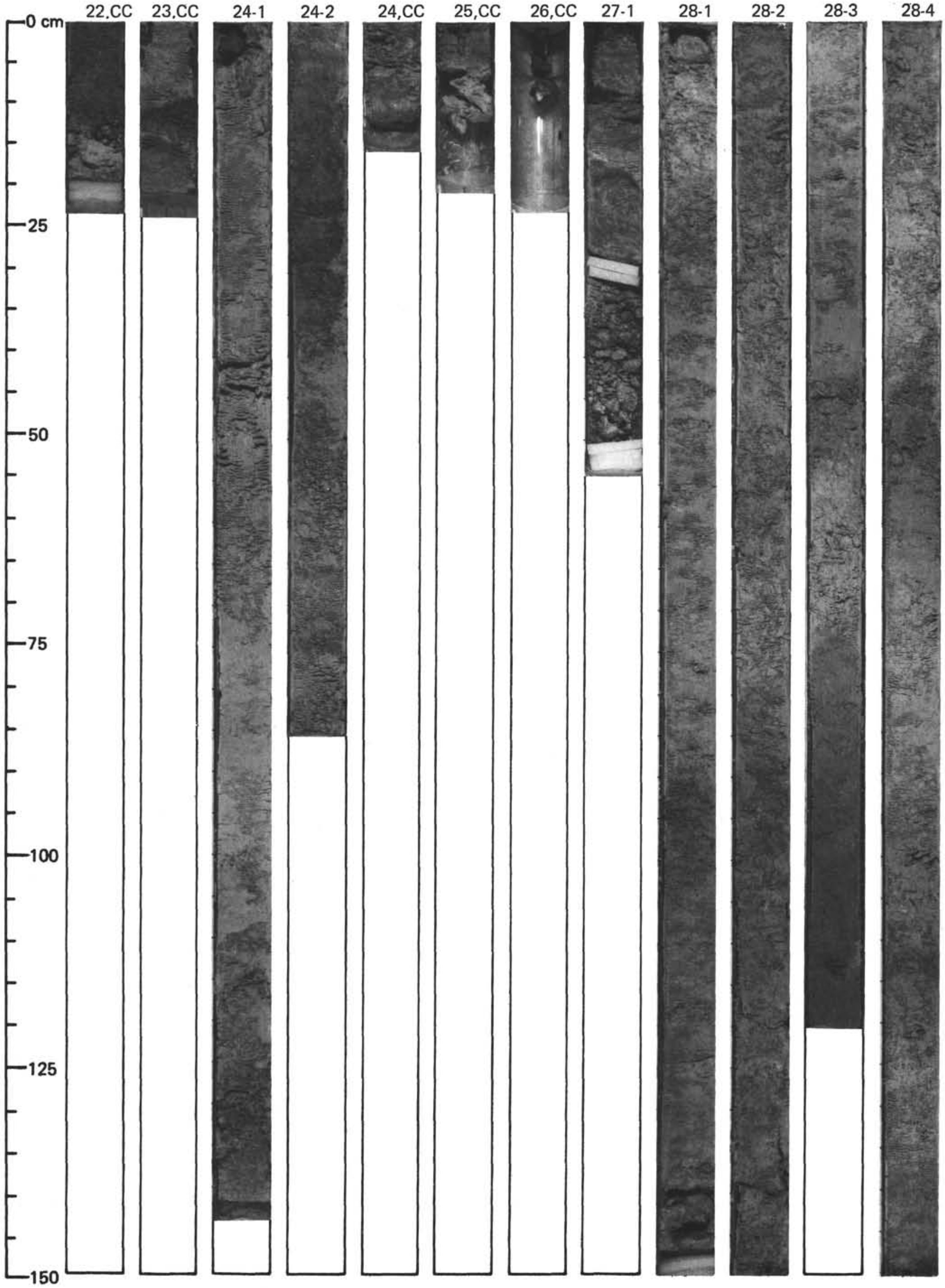

11-1
11-2
11-3
11-6
11-7
11,CC
12-1
12-2
12-3
12-4
12,CC
13-0
0 cm
25
50
75
100
125
150

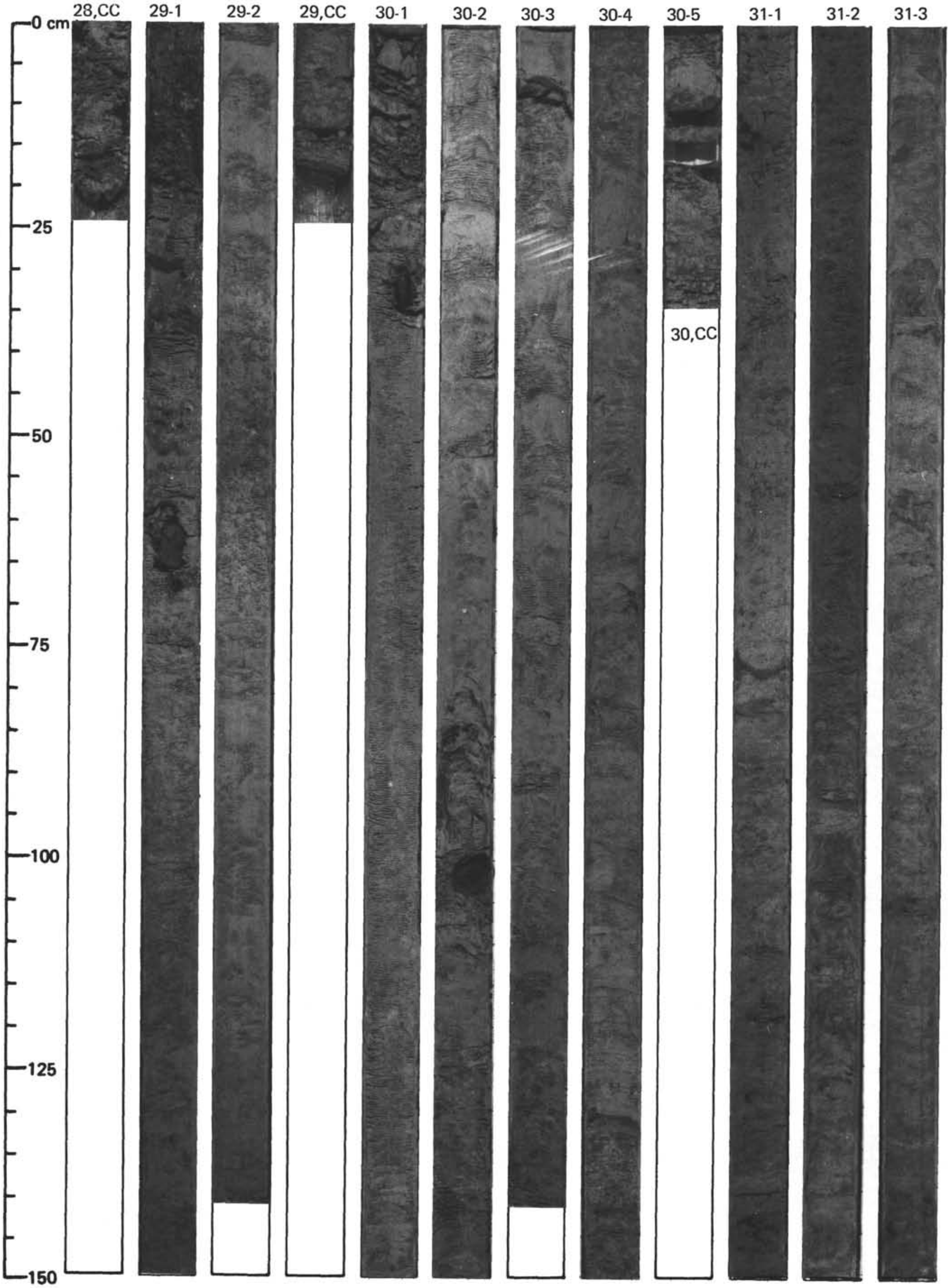

13-1
13-2
13,CC
14-1
14-2
14-6
14,CC
15-1
15-2
15-3
15-4
15-5
0 cm
25
50
75
100
125
150

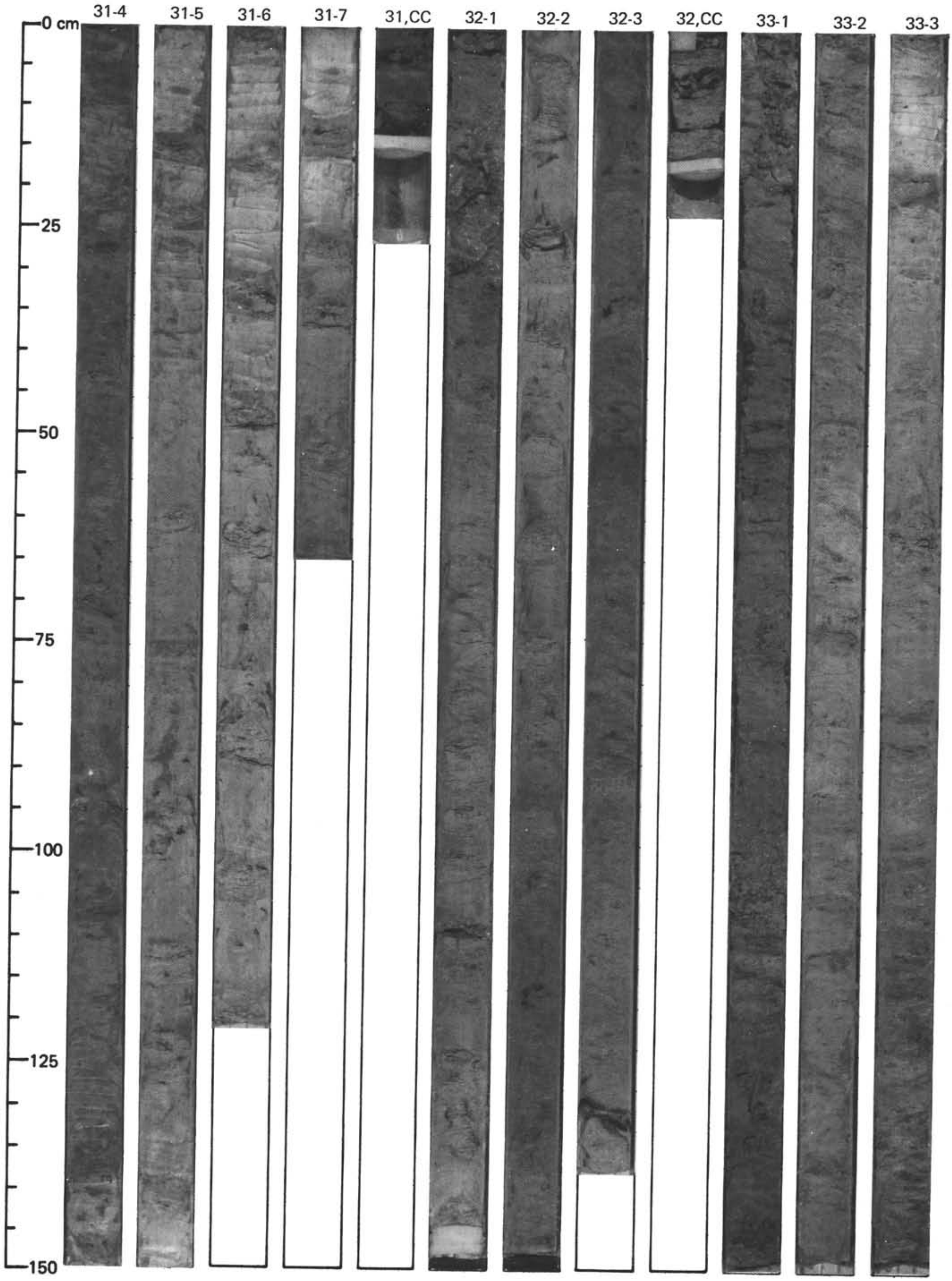

15-6
15-7
15,CC
16-1
16-2
16-3
16-4
16-5
16-6
16-7
16,CC
17-1
0 cm
25
50
75
100
125
150

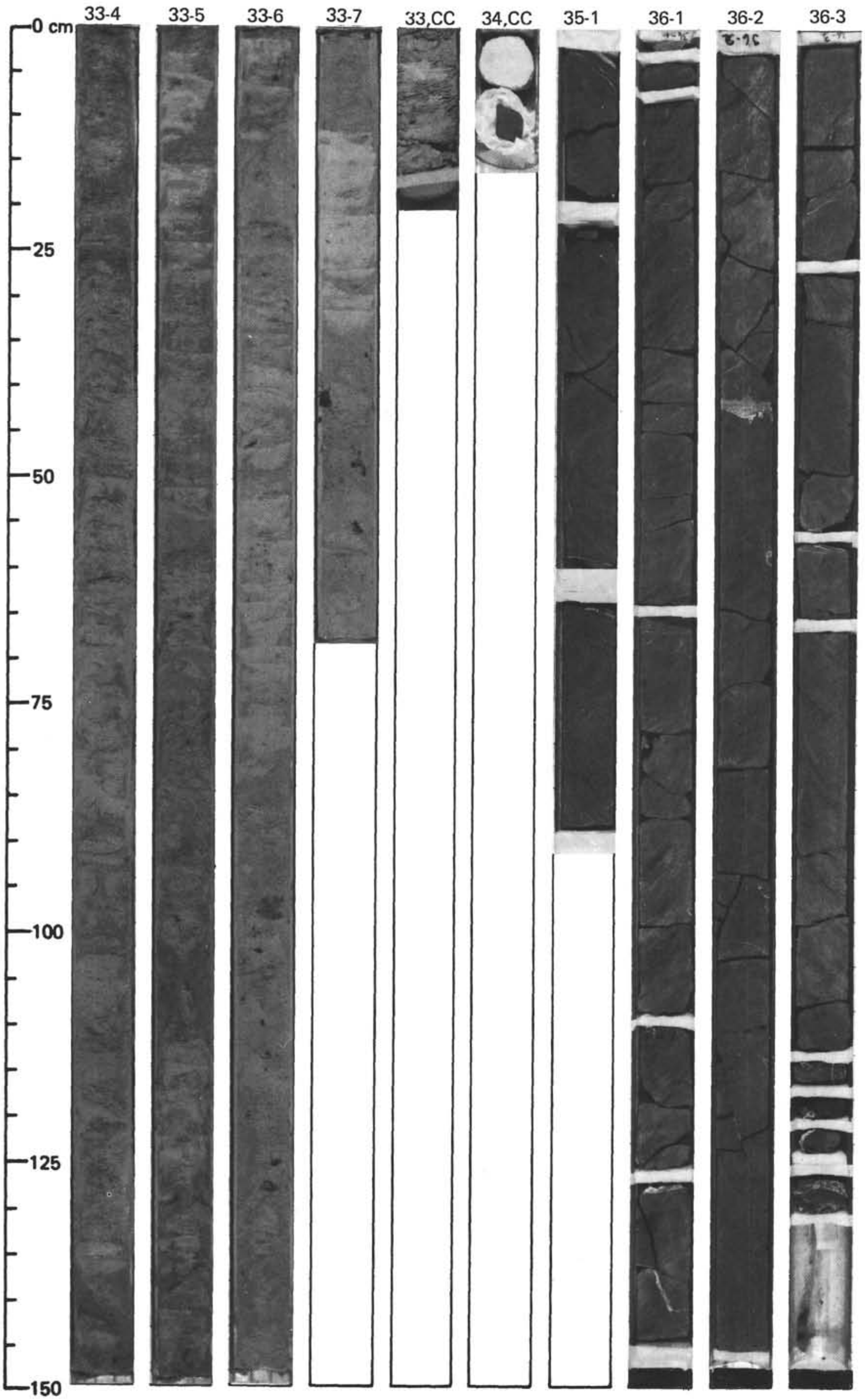

17-2
17-3
17-4
17-5
17,CC
18-1
18-2
18-3
18-4
18-5
18,CC
19-1
0 cm
25
50
75
100
125
150


0 cm
25
50
75
100
125
150
19,CC
20-1
20-2
20-3
20,CC
21-1
21-2
21-3
21-4
21-5
21-6
21,CC


0 cm
25
50
75
100
125
150
22,CC
23,CC
24-1
24-2
24,CC
25,CC
26,CC
27-1
28-1
28-2
28-3
28-4


0 cm
25
50
75
100
125
150
28,CC
29-1
29-2
29,CC
30-1
30-2
30-3
30-4
30-5
30,CC
31-1
31-2
31-3


31-4
31-5
31-6
31-7
31,CC
32-1
32-2
32-3
32,CC
33-1
33-2
33-3
0 cm
25
50
75
100
125
150


33-4
33-5
33-6
33-7
33,CC
34,CC
35-1
36-1
36-2
36-3
0 cm
25
50
75
100
125
150