5. SITE 514[1]

Shipboard Scientific Party[2]

Date occupied: 8 February 1980; 1709 (beacon dropped)

Date departed: 13 February 1980; 0007 (beacon close aboard)

Number of holes: 1

Time on hole: 103 hr.

Position: 46°02.769′S; 26°51.297′W

Water depth (sea level; corrected m, echo-sounding): 4318

Water depth (rig floor; corrected m, echo-sounding): 4328

Bottom felt (m, drill pipe): 4322

Penetration (m): 150.8

Number of cores: 35

Total length of cored section (m): 150.8

Total core recovered (m): 139.4

Core recovery (%): 92

Oldest sediment cored:
Depth sub-bottom (m): 150.8
Nature: Diatomaceous mud
Age: Early Pliocene (Gilbert Epoch)
Measured velocity (km/s): ~1.6

Principal results: Site 514 is situated on the lower flank of the Mid-Atlantic Ridge to the east of the Argentine Basin and about 250 mi. north of the present-day position of the Polar Front. Pliocene–Quaternary sediments were hydraulic piston cored to a depth of 150.8 meters below the seafloor. They consist of 130.3 meters of muddy diatomaceous ooze and diatomaceous clays underlain by 7.3 meters of gray and greenish gray muds and nannofossil muds, which are gradually replaced downward by 13.2 meters of stiff diatomaceous mud having 35 cm of hard muddy nannofossil chalk.

All high-latitude Pliocene–Quaternary diatom zones and all but one radiolarian zone were recognized. Calcareous plankton species are of low diversity but useful for paleoenvironmental reconstructions. Paleomagnetic measurement of the cores enabled recognition of the Brunhes, Matuyama (with Jaramillo and Olduvai events), Gauss (with Kaena and Mammoth events), and Gilbert (with Cochiti event) epochs. Correlation of the paleomagnetic scale with siliceous microfossil zonations is an important scientific achievement made by possible by the cores drilled at Site 514. The sequence of Pliocene–Quaternary is probably continuous, except for one hiatus in the middle Pliocene spanning approximately 0.8 m.y. and another possible hiatus in the Quaternary of less than 300,000 y.

Fluctuations of the Polar Front because of climatic changes were very pronounced. The most southerly positions of the Polar Front occurred in the Pliocene, during warm later Gilbert and middle Gauss epochs. Between these two intervals the Polar Front occupied a more northerly position, the uppermost suggesting cooler conditions during the Gilbert–earlier Gauss epochs. Late Pliocene–Quaternary time is marked by deterioration of climatic conditions with brief warmings near the Pliocene/Quaternary boundary (upper Matuyama) and at the end of the Quaternary (uppermost Matuyama, upper Brunhes).

The sedimentation rates partially reflect these fluctuations of the Polar Front. They decrease markedly from the earliest Pliocene through the Quaternary. The highest rate, 180 m/m.y., occured in the early Pliocene (Gilbert Epoch): the lowest rate, 2.3 m/m.y., occurred in the Quaternary (early Brunhes).

Higher sedimentation rates result from higher clay content in the sediments as well as higher fossil content. The scarcity of reworked microfossils in the clay suggests transportation and deposition by bottom currents. The unusually high sedimentation rates result in elevated concentrations of organic carbon because the material is protected from oxidation through fast burial.

BACKGROUND AND OBJECTIVES

Site 514 lies about 250 mi. north of the present position of the Polar Front (Fig. 1). Together with Site 513, this site provides a transect of the Polar Front at its most northerly inferred position during the late Cenozoic. The two sites make it possible to reconstruct the late Cenozoic history of the Polar Front, including its influence on biogenic productivity, stable isotopes, and biogeographic fluctuations. Detailed correlations between the two sites will permit us to compare the history of development of this water mass boundary with that established in the Southwest Pacific, where major sediment changes that occurred during the early Neogene reflect the migration of the Polar Front toward its present position. In the Southwest Pacific, calcareous and siliceous biogenic sediments of Oligocene age are replaced by purely siliceous biogenic sediments by the early Miocene. Siliceous biogenic productivity increased during the Neogene as upwelling rates increased. Sedimentation rates monitor the increase in turnover of the oceans toward a peak in the Quaternary. In the South Atlantic, Sites 513 and 514 are well located to study this evolution in a different sector of the Southern Ocean.

SURVEY AND OPERATIONS

The transit from Site 513 to Site 514 was completed in 20 hr. Two icebergs were passed at a safe distance and were the last to be seen on the voyage. A beacon was dropped at the new location, 130 mi. to the northwest at 1709 hr., 8 February, after a 4-hr. survey.

The *Challenger* arrived at the proposed site, located on the east–west-oriented *Conrad* 12–13 seismic line, at 1830 hr. (Fig. 2). Here the *Challenger* seismic line approaching the site (Fig. 3) did not resemble the *Conrad*

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

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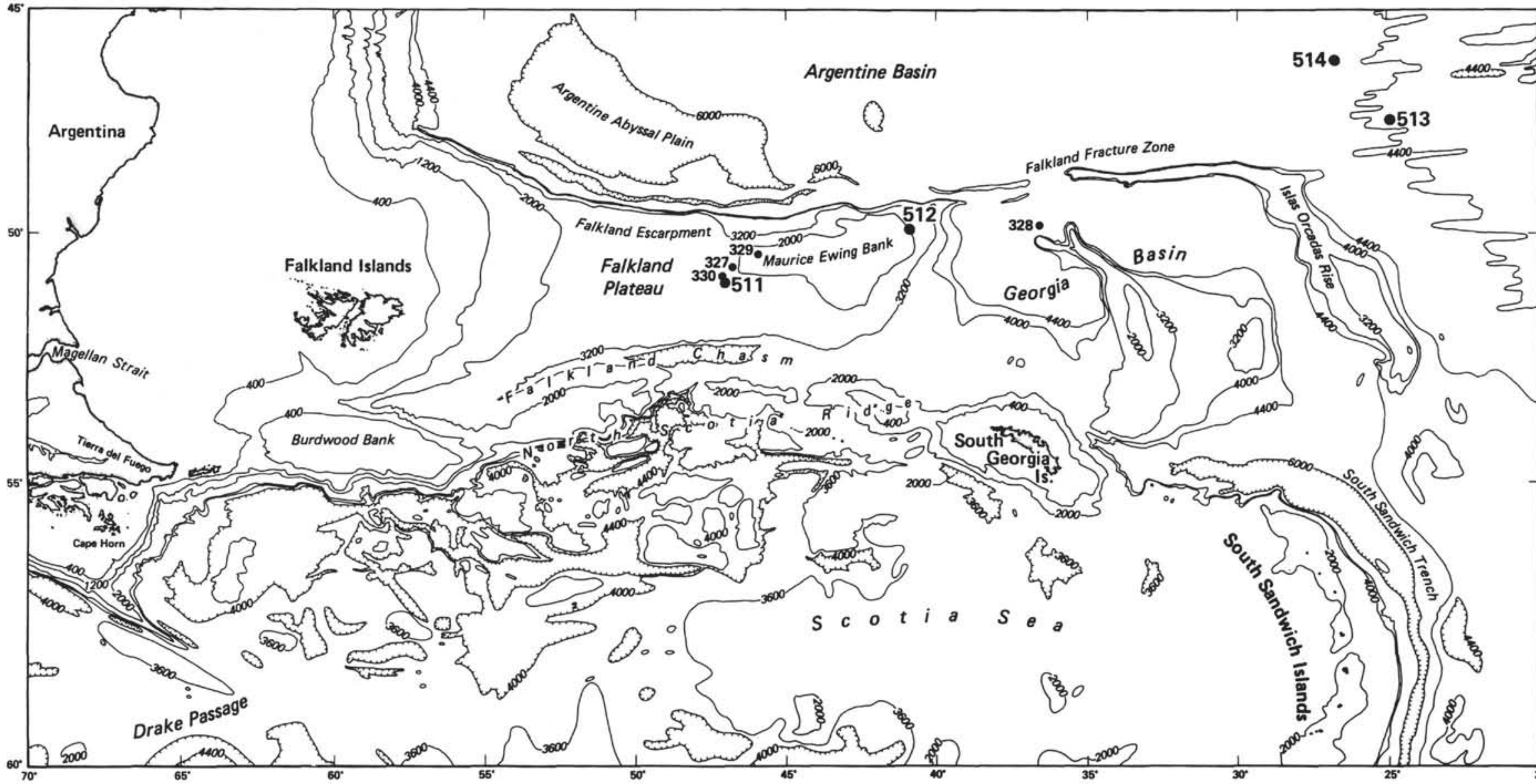

Figure 1. Locations of Site 514 and other Leg 71 drill sites.

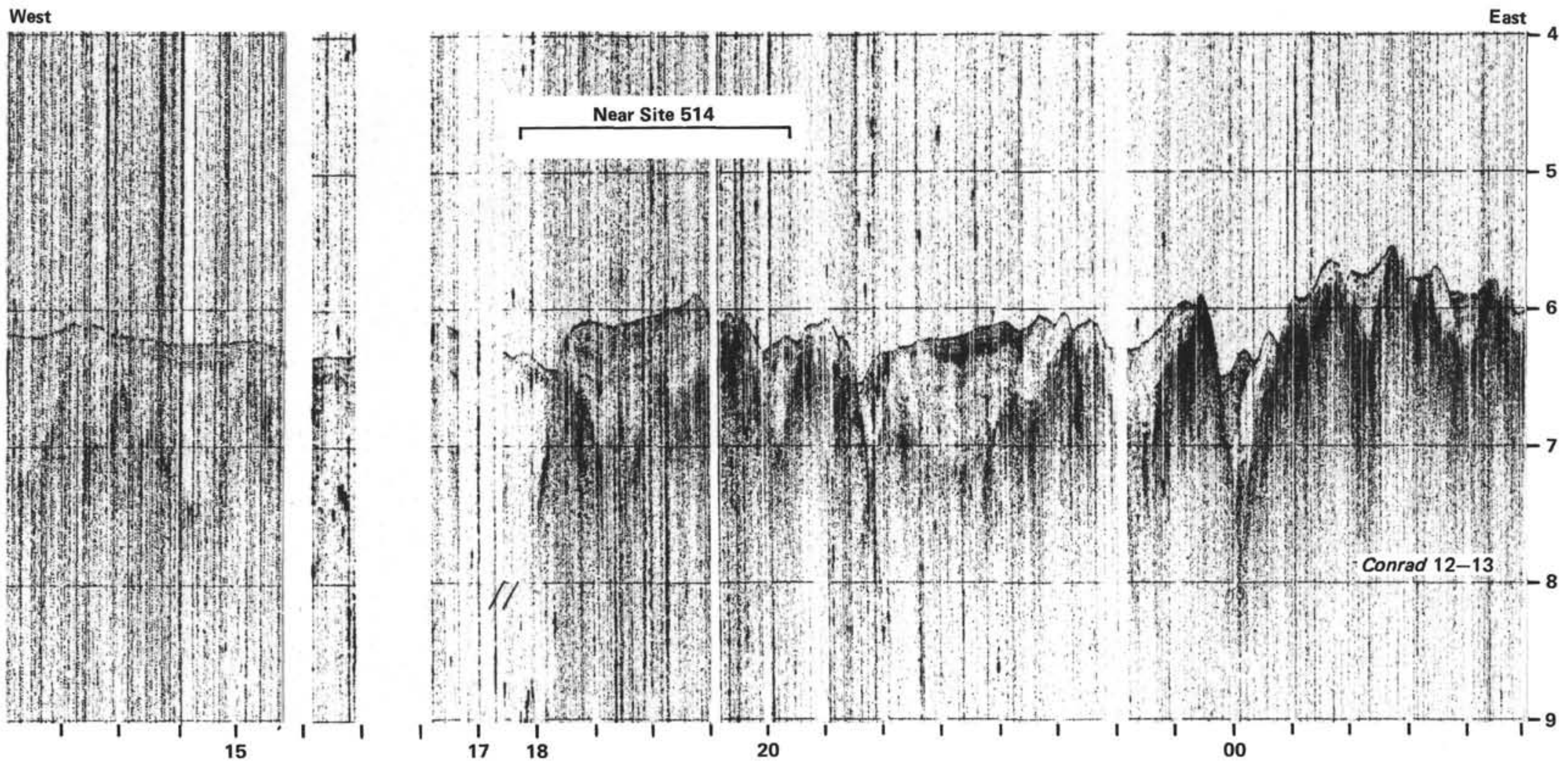

Figure 2. *Robert D. Conrad* 12-13 seismic reflection profile near Site 514. See Figure 4 for location.

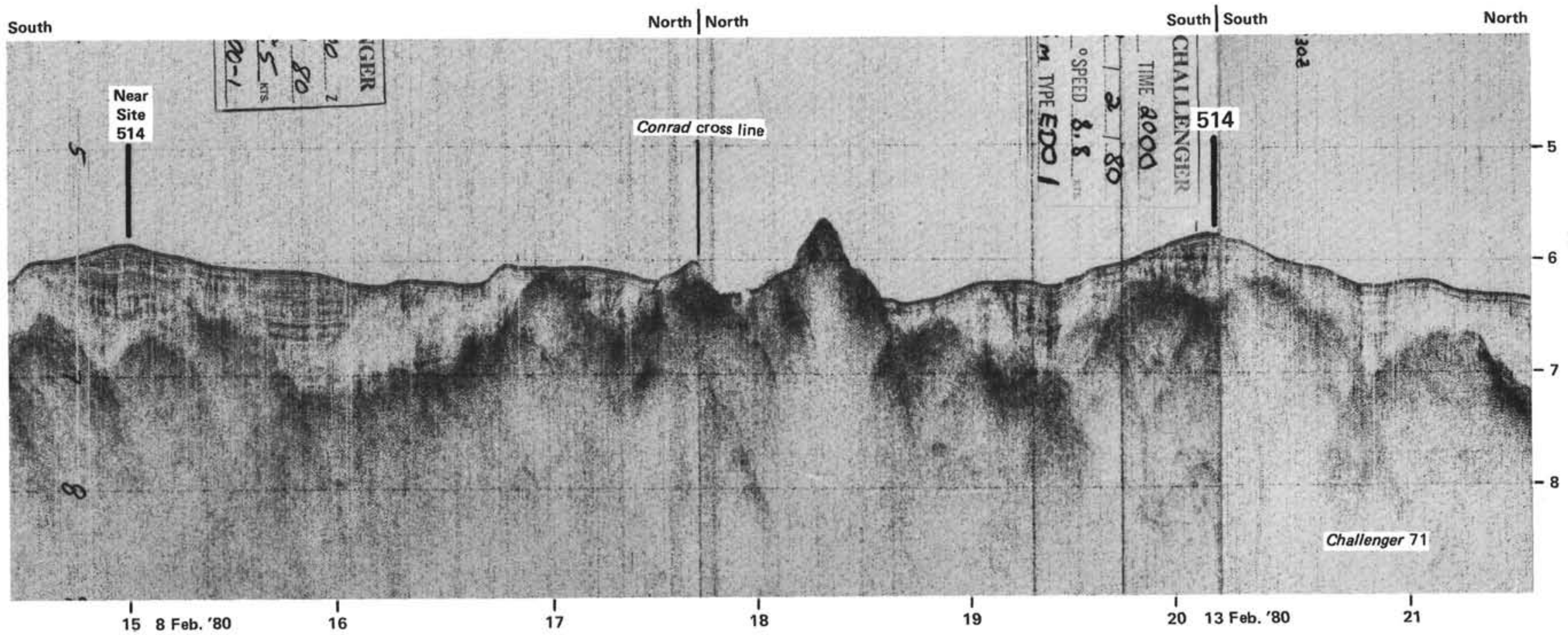

Figure 3. *Glomar Challenger* 71 seismic reflection profile near Site 514. See Figure 4 for location.

cross line, indicating navigational uncertainty arising from efforts to position the ship by dead reckoning between fixes. Rather than survey to match the *Conrad* line in an area of complex sub-bottom topography, we reversed course (Fig. 4) to a location passed earlier, where the sediment reflector pattern consists of a simple, subparallel configuration of reflectors draped over oceanic basement at a depth of about 0.50 s two-way travel time (425 m) below seafloor.

Our coring plan for Site 514 called for hydraulic piston coring of the Neogene sediment section, which was expected to be no more than 200 meters thick. After 43 hr., 150 meters had been cored (Table 1) and the base of the Pliocene sediments had not been reached. We then decided that, given the limited operating time remaining, scientific objectives could best be met by coring the entire section to basement. A round trip was begun for the conversion to a rotary coring bit and bottom hole assembly (BHA).

By the time the bit had reached spud-in position, however, weather conditions had deteriorated to a marginal level, with wind gusts that exceeded 35 kn. Operations were halted in anticipation of better conditions following the passage of the weather front. After 5 hr., the wind had not abated and growing seas were causing the vessel's motion to approach operational limits. The drill string was retrieved, although we continued to hope that conditions would improve and the trip could be reversed. No real signs of improvement were noted until the drill pipe had been recovered and only the BHA remained below the vessel. After another 3-hr. wait, wind, vessel motion, and station-keeping conditions had improved sufficiently for drilling operations to resume. The wind and seas continued to decrease for an additional 3 hr. while the drill pipe was run. Then, within a short time, the wind changed direction nearly 180° and regained its former strength. This caused a confused sea and swell condition which resulted in unavoidable rolling of the ship and disrupted positioning. With the BHA and 104 stands of pipe suspended, a stand of extra-high-strength pipe was picked up and another wait began. When over 4 hr. had elapsed and conditions had not improved enough for spudding, we finally conceded that too much time had been lost to weather conditions for further scientific objectives to be attained.

The drill string was recovered for the final time, and the rig was secured for getting under way to Santos, Brazil. Ironically, when the vessel departed Site 514 at 2328 hr., 12 February, operating weather conditions were quite good and remained so during the 8-day transit to port.

Table 1. Coring summary, Site 514.

Core No.	Date (Feb. 1980)	Time	Depth from Drill Floor (m)	Depth below Seafloor (m)	Length Cored (m)	Length Recovered (m)	Core Recovered (%)
1	9	0528	4322.2–4323.4	0–1.2	1.2	1.19	100
2	9	0652	4323.4–4327.8	1.2–5.6	4.4	4.29	97.5
3	9	0802	4327.8–4332.2	5.6–10.0	4.4	3.99	90.7
4	9	0920	4332.2–4336.6	10.0–14.4	4.4	4.53	100
5	9	1030	4336.6–4341.0	14.4–18.8	4.4	4.86	100
6	9	1140	4341.0–4345.4	18.8–23.2	4.4	4.53	100
7	9	1258	4345.4–4349.8	23.2–27.6	4.4	Trace	0
8	9	1415	4349.8–4354.2	27.6–32.0	4.4	3.61	82.0
9	9	1530	4354.2–4358.6	32.0–36.4	4.4	4.36	98.6
10	9	1647	4358.6–4363.0	36.4–40.8	4.4	4.73	100
11	9	1803	4363.0–4367.4	40.8–45.2	4.4	2.36	53.6
12	9	1912	4367.4–4371.8	45.2–49.6	4.4	3.25	73.9
13	9	2030	4371.8–4376.2	49.6–54.0	4.4	4.66	100
14	9	2138	4376.2–4380.6	54.0–58.4	4.4	3.64	82.7
15	9	2255	4380.6–4385.0	58.4–62.8	4.4	4.36	98.6
16	10	0007	4385.0–4389.4	62.8–67.2	4.4	4.54	100
17	10	0124	4389.4–4393.8	67.2–71.6	4.4	4.61	100
18	10	0235	4393.8–4398.2	71.6–76.0	4.4	4.52	100
19	10	0350	4398.2–4402.6	76.0–80.4	4.4	4.37	99.3
20	10	0501	4402.6–4407.0	80.4–84.8	4.4	4.14	94.1
21	10	0604	4407.0–4411.4	84.8–89.2	4.4	4.55	100
22	10	0737	4411.4–4415.8	89.2–93.6	4.4	4.50	100
23	10	0847	4415.8–4420.2	93.6–98.0	4.4	3.42	77.7
24	10	1002	4420.2–4424.6	98.0–102.4	4.4	4.10	93.2
25	10	1110	4424.6–4429.0	102.4–106.8	4.4	4.45	100
26	10	1230	4429.0–4433.4	106.8–111.2	4.4	4.01	91.1
27	10	1345	4433.4–4437.8	111.2–115.6	4.4	2.90	65.9
28	10	1456	4437.8–4442.2	115.6–120.0	4.4	4.18	95.0
29	10	1610	4442.2–4446.6	120.0–124.4	4.4	4.50	100
30	10	1805	4446.6–4451.0	124.4–128.8	4.4	4.31	97.7
31	10	1913	4451.0–4455.4	128.8–133.2	4.4	4.35	98.9
32	10	2028	4455.4–4459.8	133.2–137.6	4.4	4.37	99
33	10	2140	4459.8–4464.2	137.6–142.0	4.4	4.58	100
34	10	2250	4464.2–4468.6	142.0–146.4	4.4	4.23	96.1
35	11	0013	4468.6–4473.0	146.4–150.8	4.4	4.40	100

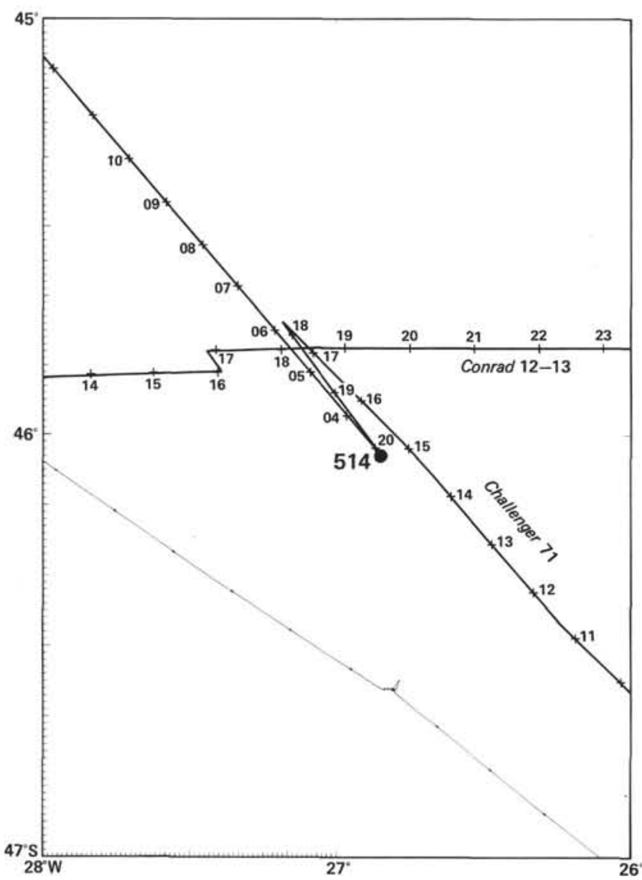

Figure 4. *Glomar Challenger* track approaching and departing Site 514.

LITHOLOGICAL SUMMARY

General Statement

The Plio–Pleistocene sediments sampled by continuous hydraulic piston coring to a depth of 150.8 meters consist of a single unit of predominantly diatomaceous muds and muddy diatomaceous oozes. The monotonous sequence of gray and greenish gray sediments is characterized by minor but frequent variations both in clay content and in intensity of bioturbation. The site is notable in that it has somewhat higher quartz contents than Holes 513 and 513A. The major features of the lithologic subunits are summarized in Figure 5.

Subunit 1A

This subunit of diatomaceous muds and muddy diatomaceous oozes extends to a sub-bottom depth of 130.3 meters.

The surficial part of the subunit (Core 1 to Sample 514-2-1, 130 cm) consists of an olive brown (2.5Y 4/4) to dark grayish brown (2.5Y 4/2) soft diatomaceous mud grading downward into a muddy diatomaceous ooze; it is characterized by minor to moderate bioturbation increasing with depth, disseminated manganese micronodules, and 5–7% disseminated quartz sand and silt. Olive, olive brown, and dark grayish layers, 3–6 cm thick and with sharp upper and lower contacts, occur throughout.

The surficial zone grades downward into greenish gray (5G 6/1 and 5G 4/1) to gray (5Y 5/1) diatomaceous muds and muddy diatomaceous oozes which extend to the base of Core 22 (93.6 m, sub-bottom). These sediments are soft, becoming firmer with depth, and are characterized by sections, from tens of centimeters to meters in thickness, in which abundant, well-defined, green and dark gray laminae (0.5–1 cm) alternate with homogeneous sections, similar in thickness but with little evidence of stratification. Within the well-stratified sequences, thin laminae (0.5 cm) of greenish gray, dark gray, and dusky purple are common; they occur both individually and as pairs. The paired laminae are always greenish gray over dark gray. The homogeneous sections are usually more intensely bioturbated than the well-stratified sections; solid burrows of very dark gray are most abundant, whereas "ring burrows" are encountered only occasionally.

Occasional pebbles, manganese nodules, manganiferous sediments, and disseminated manganese micronodules and sand occur in the upper part of this subunit. A very small lens (approximately 1 cm in diameter) of nearly pure, fine quartz sand was encountered in Sample 514-5-3, 106 cm, and occasional small lenses of very sandy mud occur in Core 8.

Contacts throughout the subunit are generally sharp. The sediment above 28 cm is an olive gray muddy diatomaceous ooze; below this sharp contact the sediment is a greenish gray muddy diatomaceous ooze. Immediately below the contact (28–29 cm), the sediment is somewhat stiffer than the material both above and below.

The clay content increases with depth in Subunit 1A, and the sediments below Core 22 (93.6–130.3 m, sub-bottom) are all diatomaceous muds that appear to be transitional to the underlying subunit of muds and nannofossil muds. In Cores 28 and 29, clasts (< 1 cm), small lenses, and layers (up to 4 cm thick) of pale olive (5Y 6/3) and white (5Y 8/2) hard, calcareous sediment, rich in nannofossils and "unspecified carbonate," were encountered.

Subunit 1B

This 7.3-meter subunit consists of muds and interstratified nannofossil muds ranging in color from gray (5Y 5/1) to dark greenish gray (5G 4/1). Three intervals in the subunit are apparent. The uppermost and lowermost 3 meters (Sections 514-31-2–3, and 514-32-2–3) are a very firm gray (5Y 5/1) mud with minor bioturbation and faint greenish black and gray horizontal laminae. The sediments contain minor concentrations of nannofossils and foraminifers.

Between these muddy intervals is a dark greenish gray (5G 4/1) stiff nannofossil mud (Section 514-32-1) with faint horizontal greenish black and dark gray laminae throughout.

Subunit 1C

The lowermost 13.2 meters cored at this site consist of dark greenish gray (5G 4/1) stiff diatomaceous muds with an intervening 35-cm layer (Sample 514-33-3, 65–100 cm) of hard muddy nannofossil chalk.

The diatomaceous muds are characterized by moderate to intense bioturbation with faint greenish black and gray laminae common throughout. Small clasts of nannofossil mud occur in Section 514-34-1.

The zone of nannofossil chalk is white (5Y 8/1) and is separated from the over- and underlying sediments by sharp contacts; the lower contact is bioturbated. Bioturbation, evident as pale olive mottling, is moderate throughout the chalk.

PALEONTOLOGY

Biostratigraphic Summary

At Site 514 a nearly continuous Pliocene through Quaternary sequence of diatomaceous clays and muddy diatomaceous oozes was hydraulic piston cored to a sub-bottom depth of 150.8 meters. Site 514 is about 250 mi. north of the present-day position of the Polar Front and about 130 mi. northwest of Site 513. A major objective at both sites was to determine the late Cenozoic history of the Polar Front.

Although pertinent groups of microfossils were recovered throughout the section at Site 514, siliceous groups are dominant and occur continuously in all cores; nannoplankton and calcareous benthic and planktonic foraminifers were encountered sporadically throughout the section. Preservation is generally good to moderate for siliceous fossils but, in contrast, poor for the calcareous fauna and flora except in some portions of the lowermost part of the section (below Core 30), where moderately well preserved nannofossils and foraminifers are present.

An abundant and diverse assemblage of diatoms and radiolarians is present in all 35 HPC cores recovered at Site 514. Throughout the hole, species diversity is low among silicoflagellates, which are sparse in Cores 1 through 10 and sparse to common below Core 10. In general, calcareous nannofossil occurrences are limited to a few dissolution-resistant species. Planktonic and benthic foraminifers also exhibit limited diversity.

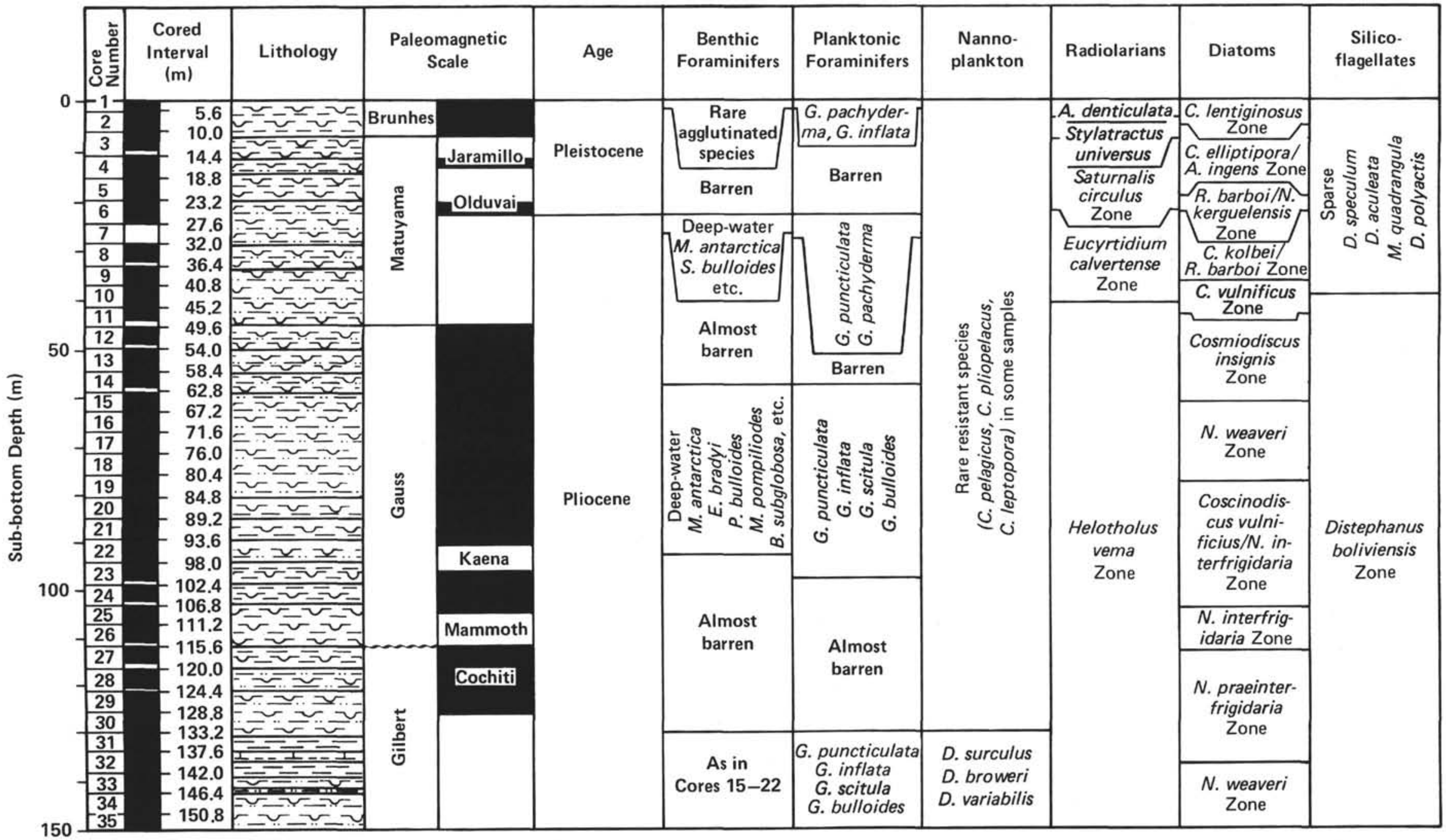

Figure 5. Columnar section of Hole 514 showing the lithology recovered and biostratigraphic correlations. (Refer to Ludwig et al., Introduction, this volume, for a key to the lithologic symbols.)

Site 514 provides a unique record of the temporal distribution of Pliocene through Quaternary siliceous microfossils because of their high abundance and diversity, and the high sediment accumulation rates, nearly continuous deposition, and excellent paleomagnetic record. All middle Pliocene through Quaternary diatom and radiolarian zones of high latitudinal zonal schemes (Chen, 1975; Weaver, 1976; McCollum, 1975; Weaver and Gombos, 1981) are recognized.

A revised Pliocene through Quaternary diatom zonation of the southern high latitudes is presented by Ciesielski (this volume) and is based on Site 514 and conventional piston cores. The upper 11 diatom zones of Ciesielski's revised diatom zonation are present in Hole 514.

Previous correlations of the diatom, radiolarian, and silicoflagellate biostratigraphies to the paleomagnetic stratigraphy of Antarctic piston cores (Ciesielski, 1975, 1978, this volume; McCollum, 1975; Weaver, 1976; Weaver and Gombos, 1981) are used to correlate the magnetic polarity sequence of Hole 514 (see Paleomagnetism, this chapter) to the standard paleomagnetic time scale. The magnetic reversal sequence is identified as follows: Brunhes Chron, (Cores 1–3), Matuyama Chron (Cores 3–12), Jaramillo Subchron (partial Core 4), Olduvai Subchron (partial Cores 5 and 6), Gauss Chron (Cores 12–26), Kaena Subchron (partial Core 21, Core 22, partial Core 23), Mammoth Subchron (partial Core 25, Core 26, partial Core 27), Gilbert Chron (Cores 27–35), Cochiti Subchron (partial Core 27, Cores 28 and 29, partial Core 30).

The section collected from Hole 514 appears to be continuous down to the boundary between Core 27 and Core 26. A hiatus is identified within the lower portion of the *Nitzschia interfrigidaria* diatom Zone, between Sample 514-26-3, 54–56 cm and Sample 514-27-1, 84–86 cm (Fig. 6). Characteristics of the diatom assemblage in the lower *N. interfrigidaria* Zone (Ciesielski, this volume) and the magnetic polarity record immediately above and below the disconformity indicate a hiatus separating middle Gauss and upper Gilbert Chronozone sediments. The missing interval represents about 700,000 yr. (~3.86–3.16 Ma) and spans a portion of the Mammoth Subchronozone, the entire lower, normal-polarity portion of the Gauss Chronozone, and most of the uppermost, reversed-polarity portion of the Gilbert Chronozone.

Abundant, reworked, siliceous microfossils are found in the upper Gauss Chronozone sediments of Core 19. In two samples from Section 1 (514-19-1, 20–22 cm and 514-19-1, 72–74 cm), uppermost Oligocene to lowermost Miocene diatoms and silicoflagellates outnumber their Gauss-age counterparts. This occurrence is particularly unusual because of the high sediment accumulation rate of upper Gauss Chronozone sediments and the scarcity of reworked forms in the remainder of this portion of the section. Deposition of these reworked microfossils occurred about 2.8 Ma, judging by the average sediment accumulation rate of the later Gauss Chron.

Paleoenvironmental Observations

One of the major objectives of drilling Hole 514 was to trace late Neogene paleomigrations of the Polar Front Zone. This has been done by an analysis of the water mass affinities of the radiolarian assemblages in Hole 514 core-catcher samples (see Radiolarians, this chapter). Figure 6 displays the position of Site 514 relative to the Polar Front through the middle Pliocene. The relative position of the Polar Front is based on Weaver's model (Weaver, this volume) of modern radiolarian biofacies distribution in the Antarctic and in subantarctic areas. The Polar Front migration curve of Figure 7 is correlated to the paleomagnetic stratigraphy of Site 514, a carbonate preservation curve, eustatic cycles, and significant climatic and glacial events.

Figure 6 illustrates that Site 514 was north of the Polar Front for most of the late Gilbert Chron—between ~4.1 and 3.86 Ma—and for the middle to late Gauss Chron—from ~3.16 to ~2.8 Ma. These two relatively warm periods were interrupted by at least two cooler intervals caused by the northward migrations of the Polar Front over Site 514. The first cool interval occurs within the newly defined *Nitzschia praeinterfrigidaria* diatom Zone (Sample 514-30,CC) and the second within the *N. interfrigidaria* diatom Zone (Sample 514-26,CC). The second of these cool intervals was accompanied by stronger Antarctic Bottom Water (AABW) flow, which caused the nondeposition or erosion responsible for forming the hiatus between Cores 26 and 27.

The relatively warm and stable conditions of the mid- to late Gauss Chron were ended by the last major northward migration of the Polar Front over the site, from about 2.8–2.6 Ma. This migration corresponds to the suggested onset of glaciation in the Northern Hemisphere (Berggren, 1972), to the development of the first glaciation in the Sierra Nevada Mountains in North America (2.7 Ma; Curray, 1966), and to a lowering of sea level (Vail and Hardenbol, 1979).

High sedimentation accumulation rates during the late Gauss Chron indicate that this northward migration of the Polar Front between 2.8 and 2.6 Ma was not accompanied by AABW velocities as severe as those responsible for the late Gilbert to early Gauss hiatus. The abundant, reworked, siliceous microfossils in Core 19, however, do indicate erosion of nearby upper Oligocene to earliest Miocene sediment by intense AABW flows which transported them to Site 514. Deposition of reworked microfossils in Core 19 occurred about 2.8 Ma and is correlated with the initial stages of the northward migration of the Polar Front. Possible source areas for the reworked microfossils are seen in a major scour zone identified on seismic profiles between Sites 513 and 514 (Ciesielski and Weaver, this volume). After 2.6 Ma, the Polar Front remained near or north of Site 514, except for three southward migrations during the latest Pliocene–Pleistocene to a position just south of the site. The three warming episodes responsible for these southward migrations of the Polar Front occurred just before the Pliocene–Pleistocene transition, just before the Jaramillo Subchron, and shortly before the Matuyama–Brunhes transition.

The relative preservation of calcareous foraminifers and calcareous nannofossils is given in Figure 7. Correlation of the preservation curve to the Polar Front migration curve on the same figure reveals that calcareous

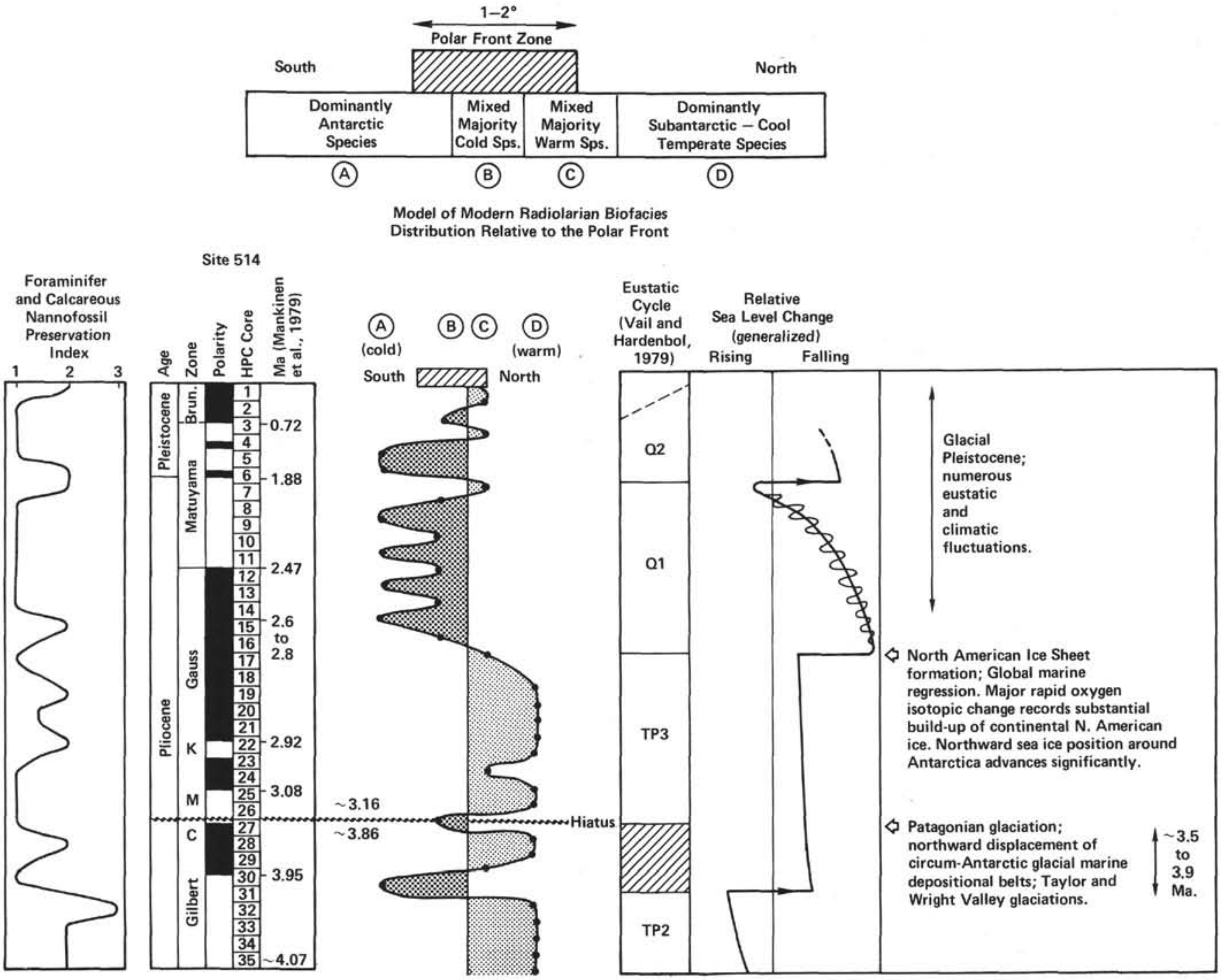

Figure 6. Pliocene–Pleistocene fluctuations of the Polar Front at Site 514, based on radiolarian assemblage characteristics of core-catcher samples. (See Ciesielski and Weaver, this volume, for a more thorough discussion.) Shown also are the paleomagnetic polarity record and a foraminifer and calcareous nannofossil preservation index. Fluctuations are correlated to eustatic cycles and selected paleoenvironmental events and episodes. (In the preservation index, position 1 represents the absence of planktonic foraminifers and calcareous nannofossils, position 2 corresponds to the preservation of a low-diversity assemblage of resistant planktonic foraminifers and a calcareous nannofossil assemblage of dissolution-resistant species, and position 3 represents the presence of common planktonic foraminifers and moderately well preserved calcareous nannofossils, as well as discrete carbonate layers.)

foraminifers and calcareous nannofossils are present only during those intervals when the Polar Front was located south of Site 514. The figure shows that the best preservation of both groups occurs in the basal portion of the section below the Cochiti Subchronozone. The better preservation of the calcareous microfauna and microflora in Cores 32–35 appears to be in part a response to a deeper CCD during deposition of these sediments. The sporadic presence of calcareous foraminifers and calcareous nannofossils elsewhere in Hole 514 is also related to several factors, including Polar Front migrations, increases and decreases in the productivity of calcareous microfauna and microflora in the surface water, and fluctuations of the CCD.

For a more detailed discussion of the paleoenvironment of Site 514, see the chapter by Ciesielski and Weaver (this volume).

Diatoms

Abundant and diverse diatom assemblages of early Pliocene to Quaternary age occur throughout all of Hole 514. This continuously cored HPC section is characterized by good preservation of siliceous microfossils, high sediment accumulation rates, nearly continuous deposition, and an excellent paleomagnetic record.

Site 514 and several piston cores were used to establish a revised diatom zonation of southern high-latitude sediments (Ciesielski, this volume). Thirteen diatom zones, including four new zones and three emended zones, are used to define the Pliocene through the Quaternary. Eleven of these diatom zones are recognized in Hole 514. The stratigraphic occurrence of each zone is as follows: Sample 514-1-1, 47–49 cm through Sample 514-3-1, 72–74 cm, *Coscinodiscus lentiginosus* Zone;

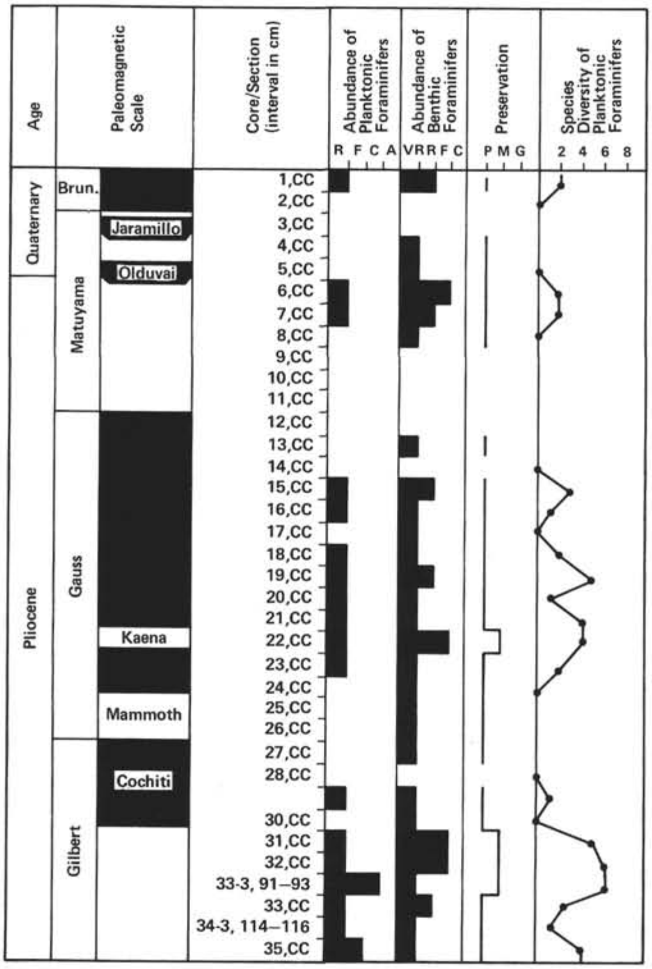

Figure 7. Abundance, preservation, and species diversity of foraminifers at Site 514. (Abundance: VR, very rare; R, rare; F, few; C, common; A, abundant. Preservation: P, poor; M, medium; G, good.)

Sample 514-3-2, 70–72 cm through Sample 514-5-4, 54–56 cm, *C. elliptipora/Actinocyclus ingens* Zone; Sample 514-6-1, 77–79 cm through Sample 514-6-2, 80–82 cm, *Rhizosolenia barboi/Nitzschia kerguelensis* Zone; Sample 514-6-3, 77–79 cm through Sample 514-9-2, 70–72 cm, *C. kolbei/R. barboi* Zone; Sample 514-9-3, 63–65 cm through Sample 514-12-1, 50–52 cm, *C. vulnificus* Zone; Sample 514-12-2, 26–28 cm through Sample 514-15-2, 70–72 cm, *Cosmiodiscus insignis* Zone; Sample 514-15-3, 70–72 cm through Sample 514-19-1, 72–74 cm, *N. weaveri* Zone; Sample 514-19-2, 72–74 cm through Sample 514-25-1, 95–97 cm, *N. interfrigidaria/Coscinodiscus vulnificus* Zone; Sample 514-26-1, 98–100 cm through Sample 514-27-2, 84–86 cm, *N. interfrigidaria* Zone; Sample 514-28-1, 90–92 cm through Sample 514-32-1, 77–79 cm, *N. praeinterfrigidaria* Zone; and Sample 514-33-1, 75–77 cm through Sample 514-35-3, 73–75 cm, *N. angulata* Zone.

All index diatom species found in the subantarctic Hole 514 are also common to antarctic sediments of similar age (Ciesielski, 1978; Weaver and Gombos, in press). The stratigraphic ranges of the zonal guide species of this site are also similar in the Antarctic (Ciesielski, this volume). Previous correlations of index diatom species to paleomagnetic stratigraphy elsewhere in the southern high latitudes (McCollum, 1975; Ciesielski, 1978; Weaver and Gombos, 1981; and Ciesielski, this volume) are used to correlate the magnetic polarity sequence of Hole 514 to the standard paleomagnetic timescale. A single hiatus is identified within the lower portion of the *N. interfrigidaria* Zone, between Sample 514-26-3, 54–56 cm and Sample 514-27-1, 84–86 cm. The diatom assemblage (Ciesielski, this volume) and magnetic polarity record immediately above and below the disconformity indicate that the missing interval represents a portion of the Mammoth Subchronozone, the entire lower, normal-polarity portion of the Gauss Chronozone, and most of the uppermost, reversed-polarity portion of the Gilbert Chronozone (~3.86–3.16 Ma).

Scattered occurrences of rare to few *Denticulopsis hustedtii* are reworked into Cores 25–30 and Core 34. Common to abundant reworked diatoms of the late Oligocene to earliest Miocene are found in upper Gauss Chronozone sediments of Core 19, Section 1 (20–22 cm and 72–74 cm). Common reworked diatoms in Core 19 include *Synedra jouseana, Hemiaulus tauris, Rossiella* sp. A, *Rocella gelida, R. vigilans*, and *Asterolampra affinis*. Several of these reworked species have stratigraphic ranges restricted to the *R. vigilans* through *R. gelida* zones of Gombos and Ciesielski (this volume); both of these date from the latest Oligocene to the early Miocene.

Radiolarians

Radiolarians are present in all 35 HPC cores recovered at Site 514. Abundance and diversity are high and preservation generally good. Age determinations were made using Chen's (1975) and Weaver's (1976) Southern Ocean radiolarian zonation. Thirty-five core-catcher samples from Hole 514 were examined, and in general these zonations are applicable. However, in intervals with warm-water radiolarian fauna, index species are extremely rare or absent. Below Core 30, for instance, no distinction could be made between the *Helotholus vema* and the *Desmospyris spongiosa* zones, because the appearance of *H. vema* in Hole 514 is not a first evolutionary appearance, but rather a climatically induced first appearance.

The stratigraphic occurrence of the radiolarian zones present in Hole 514, as defined by analysis of core-catcher samples, is as follows: Core 1, *Antarctissa denticulata* Zone (~200,000 y. ago); Core 2, *Stylatractus universus* Zone (~200,000–~400,000 y. ago) Cores 3–5, *Saturnalis circularus* Zone (0.7–1.8 Ma); Cores 6–10, *Eucyrtidium calvertense* Zone (1.8–2.4 Ma); Cores 11–30, *H. vema* Zone (2.4–3.95 Ma); Cores 31–35, lowermost *H. vema* Zone and uppermost *D. spongiosa* Zone, undifferentiated.

The section collected at Site 514 appears to be essentially continuous down through the Core 26/27 boundary, where an unconformity lasting ~700,000 y. separates Gauss from Gilbert Chronozone sediments. Details of this hiatus are discussed in Ciesielski (this volume).

One of the main objectives of drilling Hole 514 was to trace migrations of the Polar Front Zone through the late Neogene. It appears from a cursory examination of core-catcher samples at Site 514 that this exercise will be possible. Both warm- and cold-water Pliocene and Pleistocene radiolarian assemblages are intercalated throughout Hole 514 (to a greater degree in the glacial Pliocene and Pleistocene). Basically, four faunas can be recognized throughout Site 514: first, a dominantly antarctic assemblage; second, a dominantly subantarctic/cool temperate assemblage; third, a mixed warm- and cold-water fauna with a majority of warmer-water species; and finally a mixed fauna with a majority of cooler-water species. A generalized model of where these faunas are found in modern antarctic and subantarctic sediments and their position relative to the Polar Front Zone is shown in Figure 6. Utilizing this scheme, a plot of paleomigrations in the Polar Front Zone is illustrated. This curve is correlated to paleomagnetic stratigraphy, eustatic cycles, and significant climatic and glacial events.

Silicoflagellates

The Hole 514 silicoflagellate assemblage is well preserved but of low diversity. Silicoflagellates are sparse throughout most of Cores 1–10 and sparse to common throughout most of Cores 11–35.

Distephanus speculum s.l. is the only species consistently present in Cores 1 through 10. A few *Dictyocha aculeata* occur in Sample 1,CC, rare to few *Mesocena quadrangula* occur between Samples 514-4-1, 123–125 cm and 514-4,CC, and common *Distephanus polyactis* are found in Samples 514-6-1, 77–79 cm through 514-6-3, 77–79 cm.

The occurrences of *Dictyocha aculeata, M. quadrangula*, and *Distephanus polyactis* are consistent with the paleomagnetic record that Salloway and Bloemendal (this volume) identified for Cores 1–10. *Dictyocha aculeata* occurs only in the Brunhes Chronozone of Core 1; Ciesielski (1978) has also noted a restricted occurrence of this species in upper Brunhes Chronozone sediments of the Falkland Plateau. The range of *M. quadrangula* brackets a normal subchron within Core 4. At lower latitudes this species is a reliable stratigraphic marker with a restricted stratigraphic range, occurring in upper Matuyama Chronozone sediments of several ocean basins. Burckle (1977) noted that the range of *M. quadrangula* (1.3–0.78 Ma) brackets the Jaramillo Subchron (0.98–0.91 Ma) of the Matuyama. Thus, the range of *M. quadrangula* agrees with the designation of the short normal-polarity interval within Core 4 as the Jaramillo Subchron of the Matuyama Chron. *Distephanus polyactis* is present within and slightly below a short normal-polarity interval in lower Core 5 and upper Core 6. Ciesielski (1975, and unpublished data) noted the occurrence of *D. polyactis* within the Olduvai Subchronozone and lower Matuyama Chronozone, a finding that agrees with a designation of the normal-polarity zone within Cores 5 and 6 as the Olduvai Subchron.

The interval from Sample 514-11-1, 100–102 cm to the base of the hole is identified as the *D. boliviensis* Zone of Ciesielski (1975). Few to common *D. boliviensis* occur throughout the zone. More sporadically present are *D. boliviensis* (cannopilean) and *D. quinquangellus.* Both occur more consistently and are more common near the Gauss/Matuyama Chronozone boundary and in Gilbert Chronozone sediments below the Cochiti Subchronozone. In Hole 514 *D. crux* occurs only below the Cochiti Subchronozone. A few *M. elliptica* are present in Cores 26 and 27. *Dictyocha* species occur sporadically above the upper Gilbert–lower Gauss disconformity between Core 26 and Core 27 but are more consistently present below the disconformity.

There is only one significant occurrence of reworked silicoflagellates in Hole 514. Rare *Naviculopsis biapiculata* and few *M. apiculata* occur in two samples from Core 19, Section 1 (514-19-1, 20–22 cm and 514-19-1, 72–74 cm). In both samples these reworked silicoflagellates are accompanied by common reworked diatoms from the late Oligocene and earliest Miocene (Ciesielski, this volume). These common reworked diatoms occur within the upper normal paleomagnetic polarity zone of the Gauss Chronozone, a portion of the Hole 514 sequence with an extremely high sediment accumulation rate. Deposition of the reworked late Oligocene–earliest Miocene siliceous microfossils of Core 19 immediately preceded a major northward migration of the Polar Front over Site 514 (Ciesielski and Weaver, this volume).

Dictyocha species are common in all, or portions, of Cores 2, 28, 29, 31, and 33–35. In all cases, common occurrences of *D.* species are accompanied by a radiolarian biofacies which indicates that the Polar Front was south of the site at the time of deposition (Fig. 2 in Ciesielski and Weaver, this volume).

Foraminifers

Although planktonic and benthic foraminifers in the Pliocene–Quaternary siliceous oozes and clays of Site 514 are more numerous and diverse than at Site 513, their stratigraphic distribution is sporadic, reflecting paleoenvironmental changes near the Polar Front during the Pliocene–Quaternary. In general, planktonic and benthic foraminifers are rare, very rare, or absent. Exceptions are Samples 514-6,CC and 514-22,CC, where benthic foraminifers are more numerous but never common; Cores 31–33 and Core 19 contain common to few representatives of both groups. Preservation is generally poor except in Cores 31–33, which contain a foraminiferal fauna (Fig. 7) that is moderately or well preserved.

The main distribution patterns of planktonic and benthic foraminifers are as follows.

Core 1 contains only two species of planktonic foraminifers, *Globigerina pachyderma* and *Globorotalia inflata*, and a low-diversity assemblage of benthic species: *Cyclammina pusilla, Martinottiella antarctica, Psammosphaera fusca, Reophax nodulosa*, and *Uvigerina* aff. *dirupta.* This fauna reflects temperate cold water and lower bathyal–abyssal depths.

Cores 2–6 (except Sample 514-6,CC) are barren of planktonic foraminifers and contain only rare fragments of agglutinated benthic species belonging to the genus *Martinottiella.*

Samples 514-6,CC and 514-7,CC include planktonic assemblages of low species diversity, consisting of *Globorotalia puncticulata, G. inflata*, and *Globigerina pa-*

pachyderma. Comparatively diverse benthic foraminifers are represented by the arenaceous species *M. antarctica* and *Eggerella* sp., and by deep-water dissolution-resistant calcareous forms (*Melonis affinis, Sphaeroidina bulloides, Pullenia* sp., *Alabaminoides exiguus*, and *Bradynella subglobosa*) which are characteristic of recent abyssal sediments near the CCD level (Saidova, 1976; Khusid, 1978).

Cores 8-14 do not contain foraminifers except in some samples of Cores 8, 11, and 13, where rare specimens of the benthic species *Martinottiella antarctica* were encountered; this testifies to sedimentation well below the CCD.

More diverse and abundant assemblages are recovered in sediments of Cores 15-22. Planktonic foraminifers are represented by *Globorotalia puncticulata, G. inflata, G. hirsuta, Globigerina bulloides*, and *G. pachyderma*. The rather diverse benthic assemblages consist of *M. antarctica, E. bradyi, Melonis affinis, M. pompilioides, P. quinqueloba, P. bulloides, Gyroidina umbonata, Cibicidoides wuellerstorfi, Alabaminella weddellensis, Alabaminoides exiguus, B. subglobosa, Virgulina* sp., and others. Within this interval, however, planktonic and benthic foraminifers are scarce in Cores 16, 17, 18, and 20 and in some samples of Cores 19, 21, and 22. Taken together, these phenomena reflect fluctuations in preservation conditions near the CCD.

Cores 23-30 are almost barren of foraminifers. Only scarce fragments of benthic agglutinated species are found in this interval. Exceptions are Samples 514-28-2, 28-30 cm and 514-28-3, 29-31 cm, which contain arenaceous species and rare specimens of calcareous benthic and planktonic foraminifers.

The most diverse, abundant, and well-preserved foraminiferal assemblages characterize the lower part of the Hole 514 (Cores 31-35). The planktonic assemblage consists of *Globorotalia puncticulata, G. inflata, G. scitula, G.* aff. *scitula, Globigerina bulloides, G. pachyderma, G.* aff. *apertura, G.* sp. The benthic forms are represented by the same assemblages as in Cores 15-22, testifying to sedimentation at lower bathyal-abyssal depths above the CCD level and near the planktonic foraminiferal lysocline. Some samples in all these cores contain only rare benthic species.

Because species diversity of planktonic foraminifers is low, this group of microfossils cannot be used for precise age determinations. On the basis of other microfossil groups, Site 514 sediments are Pliocene-Quaternary. According to Jenkins (1971) and Poore (1979), *Globorotalia puncticulata* disappears at the Pliocene/Quaternary contact. On this basis, the Pliocene/Quaternary boundary could be drawn just above Sample 514-6,CC. But evidence for the age of the overlying sediments is "negative" because, in Cores 2-5, planktonic foraminifers are lacking. Nevertheless other authors (Kennett and Vella, 1975) describe *G. puncticulata* from Pleistocene sediments. This problem evidently can be solved through an investigation of the distribution of this species in lower-latitude sections that would make it possible to determine the precise level of its evolutionary disappearance.

The alternation, in the Hole 514 section, between layers with comparatively abundant and diverse planktonic and benthic foraminiferal assemblages and layers without any foraminifers or with scarce benthic arenaceous species is evidently related to climatic changes, to increases and decreases in the productivity of calcareous microfauna and microflora in the surface waters, and to deepening and shallowing of the CCD.

Calcareous Nannofossils

Coccoliths were present in only a few of the cores examined from the Plio-Pleistocene section recovered at Site 514. They are sparse except in a few intervals near the bottom of the hole. Preservation was poor to moderate, an indication of deposition close to the CCD. Forms preserved were primarily dissolution-resistant species such as *Coccolithus pelagicus, C. pliopelagicus*, and *Cyclococcolithina leptopora*. Such forms were found at various intervals in Cores 6, 7, 15, 19, 22, 28, and 31-33. All other cores were barren except for occasional specimens reworked from older strata.

The only significant accumulation of coccoliths occurred in discrete intervals of Cores 31-33, where some strongly etched nannofossil oozes are present. The greatest diversity was noted in Section 1 of Core 32, which contained a few astroliths, such as *Discoaster surculus, D. variabilis*, and a few four- to six-rayed members of the *D. brouweri* plexus. In general, the occurrences of coccoliths in Hole 514 coincided with warm-water maxima or with southerly shifts of the position of the Polar Front as recorded by the radiolarian biofacies (Fig. 6).

PALEOMAGNETISM

At Site 514 the hydraulic piston corer was used to retrieve sediments to a sub-bottom depth of 150.8 meters. Before being split, core sections were measured with the long core spinner. However, the same problems that were seen at Site 512 were encountered here, and no use is made of the long core spinner results.

A total of 477 samples were taken from the sediment in plastic cylinders. These were measured both on board and in Edinburgh, on Digico fluxgate spinner magnetometers. In Edinburgh, each measurement was duplicated; the results given hereafter are the average of two readings. Demagnetization was carried out in Edinburgh using the method described in the Site 511 report.

Natural remanent magnetization intensities are low to moderate (0.5-5.0 μG), with values of up to 30 μG at the top of the hole and in Cores 19 to 21. Occasionally single samples with high intensities (> 70 μG) occur, either at the top or bottom of the cores. These samples also have anomalous directions, and it is assumed that these are due to contamination by rust caused during the hydraulic piston coring process (see Site 512 report). Inclinations show clear changes in polarity, so that a magnetostratigraphy can be constructed. Declination values are not consistent between cores, suggesting that relative orientation has not been preserved. They do, however, show consistency within each core and change by about 180° coincident with the polarity reversals that are indicated by inclination. Demagnetization of samples indicates that the majority have stable remanences, probably primary magnetizations reflecting the geomagnetic field at the time of deposition. Inclinations after demagnetization are shown in Figure 8. Inclination averages 51.0° before and 53.7° after demagnetization, which gives a paleolatitude of 34° compared with a present-day latitude of 46°. This represents an inclination error of about 11°.

The Brunhes/Matuyama boundary is identified at a depth of 8.28 meters between Samples 514-3-2, 116-118 cm and 514-3-2, 118-120 cm. The Matuyama/Gauss boundary presumably lies in the unrecovered interval between Cores 11 and 12 (between 42.79 and 46.63 m beneath the seafloor). The Jaramillo and Olduvai events within the Matuyama Epoch are identified, although the former is represented by only two samples. The Jaramillo Event occurs in Core 4 at a depth of 13.2-13.4 meters (Samples 514-4-3, 15-17 cm and 514-4-3, 41-43 cm). The Olduvai Event occurs between Samples 514-5-4, 78-80 cm and 514-6-2, 118-120 cm and appears to be split by a short reversed interval near the beginning. Alternatively the lower normal period represents one of the two Réunion events; and a short hiatus occurs between this and the Olduvai Event. On purely paleomagnetic grounds, the boundary at 125.3 meters (between Samples 514-30-1, 87-89 cm and 514-30-1, 91-93 cm) would be assumed to be the Gauss/Gilbert boundary. However, diatom zonation places Cores 28-35 in the *Nitzschia praeinterfrigidaria* and *N. angulata* zones, which correlate with the reversed interval in the Gilbert Epoch between the Cochiti and Nunivak events. A hiatus occurs within Cores 26 and 27; the lowermost Gauss and uppermost Gilbert sediments are missing. The Kaena and Mammoth events are identified, respectively, at depths of 88.9-95.6 meters and between 103.1 meters and the hiatus at 110.6 meters (Samples 514-21-3, 112-114 cm to 514-23-2, 54-56 cm, and 514-25-1, 72-74 cm to 514-26-3, 75-77 cm). The Cochiti Event is seen between the top of Core 27, at a depth of 112.2 meters, and the previously mentioned reversal at 125.3 meters.

A short, normally magnetized event is seen in Core 32 between Samples 514-32-1, 92-94 cm and 514-32-1, 139-141 cm (depths of 134.1 meters and 134.6 m). At an estimated sedimentation rate of 16 cm/1000 y., this event lasted about 3000 y., a much shorter time than the Nunivak Event (150,000 y.; Mankinen and Dalrymple, 1979).

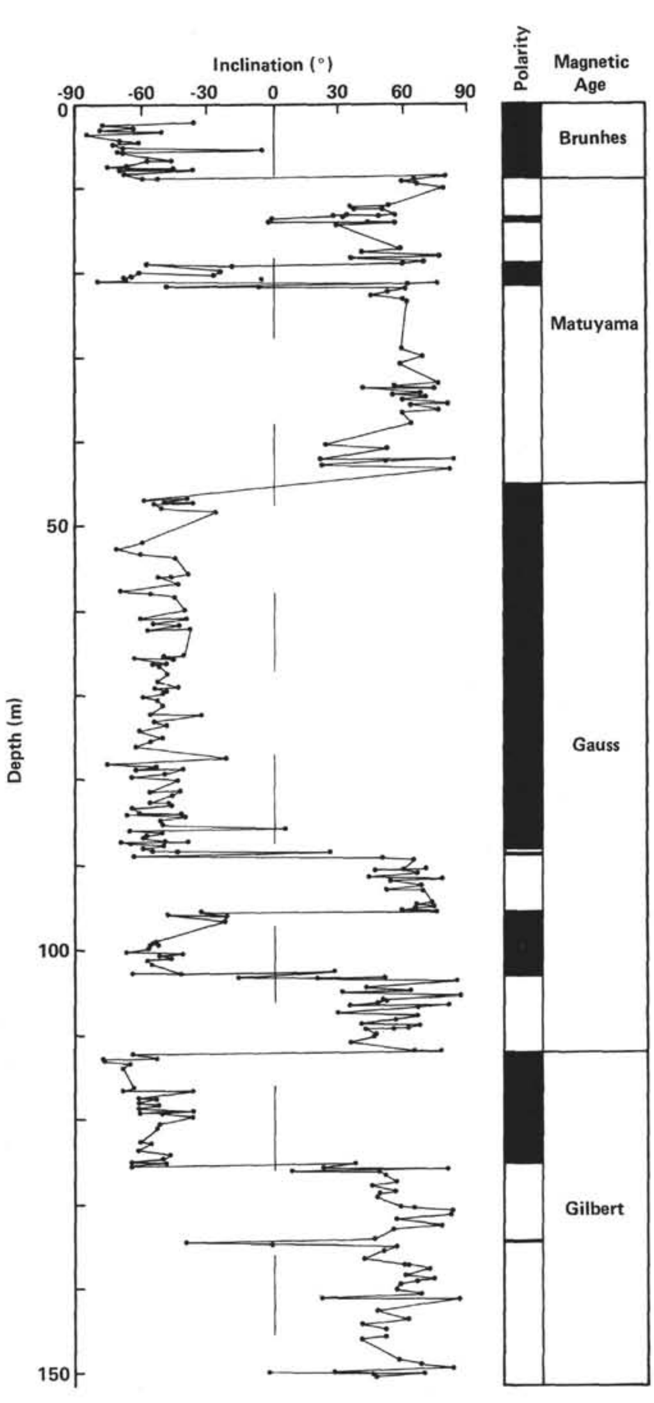

Figure 8. Downhole plot of inclination after demagnetization at 200 Oe, with polarity determinations for Site 514.

ORGANIC GEOCHEMISTRY

Analyses for Site 514 were the same as those for Site 513. Two "gas pockets" were analyzed, but the composition of the gas was found to be very close to atmospheric gas, with some increase of CO_2. The gas pockets were apparently a product of core slippage.

Organic carbon values range from 0.2% (Core 2, Section 3) to 0.67% dry weight and are considered to be quite uniform throughout the section, except for Core 2, Section 3, which is close to a postulated hiatus. The uniformity of values is in good agreement with the uniform lithology of this site. The average value of the entire sequence at Site 514 is approximately 1.5 times that of average deep sea sediments (0.3%). Despite great differences in sedimentation rates, the uniformity of carbon content throughout the section implies relatively constant environmental conditions controlling organic carbon accumulation.

Pyrolysis/fluorescence data again showed no increased values beyond the data of blank runs.

Both seawater and interstitial water exhibit higher alkalinity values than Site 513. Alkalinity, measured as liberated CO_2 as well as by titration, increased with depth.

PHYSICAL PROPERTIES

The seismic record at Site 514 indicates conditions similar to the upper seismic and lithologic unit of Site 513. Broad fluctuations in bulk density and water content are correlated with the main sedimentary components, clay minerals and diatoms. Correlation of the seismic record with physical properties and lithological structures seems possible, because all of these appear to be related to the Polar Front fluctuations, as the radiolarian paleontology indicates.

Observations

The *wet-bulk density* has widely scattered values in the uppermost 20 meters, corresponding to the Pleistocene. Within the Pliocene, bulk density tends to increase with depth down to 185 meters sub-bottom. Fluctuations of 25–50 meters in length are superimposed on the general trend. This pattern becomes more pronounced in *water content*. The overall trend follows a typical compaction curve between 30 and 140 meters below seafloor.

The porosity values repeat the general trend of the water content, but the superimposed fluctuations are not evident. Recalling that, by definition, water content is equal to (weight water)/(wet weight), that is, it is equal to $(\phi \varrho_w)/[\phi \varrho_w + (1 - \phi \varrho_s)]$, where porosity, ϕ = (volume water)/(wet volume), ϱ_s = mean grain density, and w = water, the observed difference between porosity and water content indicates that sinusoidal pattern is related to fluctuations in mean grain density. Some data points which are far outside the main concentration of points belong to thin calcareous layers which occur sporadically in the lower part of the section.

The *sonic velocity* throughout the section is very stable at about 1.6 km/s (arithmetic mean)—a feature which corresponds very well to Site 513. Some points outside the normal scattering between 1.58 and 1.62 km/s are very probably due to core disturbance. This is especially the case 30 meters below seafloor, where low velocities follow a core with zero recovery. Some higher values (1.66 km/s) at 140 meters are due to the sporadic occurrence of thin calcareous layers in this interval.

The peaks in *acoustic impedance* (velocity × density) are due to corresponding fluctuations in bulk density, because the sonic velocity is quite uniform.

The general trend in *vane shear values* is nearly linear. A remarkable drop at 40 meters below seafloor to lower values corresponds very well with a reduction in bulk density. Similar results were obtained for penetration values. Only the uppermost 20 meters deviate from the trend, with data points widely scattered because of core disturbance.

Interpretations

Smear slide descriptions for Site 514 clearly relate the fluctuations in bulk density and water content to sediment composition. Clay content and percentage of diatoms are negatively correlated; the clay maxima correspond clearly with maxima in bulk density. In contrast, water content is reduced with increasing clay content and increases with increasing diatom content. The wide scattering of bulk density within the uppermost few meters has its counterpart in the occurrence of higher quartz contents and a narrower period of clay–diatom alternation. In general, the quartz content seems to modulate the physical properties somewhat, even when the contents are very low. The quartz peak at 117 meters appears to correlate with an unconformity that is indicated by the paleontological data. Thus, in general, higher quartz contents may indicate lower sedimentation rates.

The relationship between physical properties and sediment composition also leads to an interpretation of the shear strength values. The drop in vane shear strength at 35 meters below seafloor and the associated increase in clay content indicate a negative correlation between these parameters.

Assuming a velocity of about 1.6 km/s, the impedance peaks at 60 and 100 meters correspond to reflectors at 0.75 and 1.55 s. Similarly the impedance peaks of Site 513 can be related to reflectors at reasonable positions. For both sites, however, a question arises from examination of the impedance values, for the differences are so small that we would not normally expect to find pronounced reflectors. One explanation is that, within these extremely constant velocity profiles, short-path multiples (Anstey, 1977) may build up enough reflected energy to be recognized in the seismic record. A similar acoustic bedding pattern might be produced by alternating sequences of thinly stratified intervals and of intervals that are homogeneous as a result of bioturbation.

SUMMARY AND CONCLUSIONS

Summary

Pliocene–Quaternary sediments were hydraulic piston cored to a depth of 150.8 meters. They consist of a rather monotonous succession of gray, greenish gray, and dark greenish gray diatomaceous clays and muddy diatomaceous oozes. Fine laminations consisting of paired laminae of greenish gray over dark gray sediments are common throughout the section. Bioturbation is also common, but it is mainly of minor intensity. The section is notable for having a higher quartz sand and silt content (5–7% in the upper part of the section) than Holes 513 and 513A. Three subunits can be recognized.

Subunit 1A. This is composed of 130.3 meters of olive brown, greenish gray, and gray muddy diatomaceous oozes and diatomaceous clays. Bioturbation is minor to moderate. Disseminated manganese and quartz silt and sand are present in the upper part of the subunit; lower parts are often finely laminated. The clay content increases downsection. Near the base of the subunit, one core section contains small (~4 cm) pale olive clasts high in "unspecified carbonate."

Subunit 1B. This interval consists of 7.3 meters of gray to dark greenish gray faintly laminated firm mud, in which the diatom content was low and in which local concentrations of nannofossils and foraminifers were present; 150 cm of dark greenish gray nannofossil mud were found mid-unit.

Subunit 1C. About 13.2 m of dark greenish gray stiff diatomaceous mud containing one 35-cm layer of whitish muddy nannofossil chalk composed this subunit. Bioturbation is moderate to intense; faint laminae are common throughout.

CONCLUSIONS

All high-latitude Pliocene (mid-Gilbert)–Quaternary diatom zones and all but one radiolarian zone were recognized at Site 514. Calcareous nannoplankton and foraminifers, although of low species diversity and limited stratigraphic value, play an important role in paleoenvironmental reconstructions. Paleomagnetic measurements of the cores identified the Brunhes Epoch, the Matuyama Epoch with the Jaramillo and Olduvai events, the Gauss Epoch with the Kaena and Mammoth events, and the Gilbert Epoch with the Cochiti Event. Correlation of the paleomagnetic time scale with siliceous fossil zonations is perhaps the most significant achievement of drilling at Site 514.

Only one hiatus (within the diatom *Nitzschia interfrigidaria* Zone and the radiolarian *Helotholus vema* Zone) is obvious in the otherwise continuous Pliocene–Quaternary sequence. The hiatus represents the 0.7 m.y. interval between later Gilbert (3.86 Ma) and earlier Gauss (3.16 Ma) and appears to be of regional significance, since it is contemporary with the time of cooling in East and West Antarctica and with the glaciation in Argentine Patagonia.

Analyses of siliceous and calcareous planktonic groups determine paleoceanographic changes connected with latitudinal migrations of the Polar Front. The Pliocene–Quaternary section recovered from Hole 514 contains antarctic cold-water, subantarctic cool temperate, and mixed cold- and warm-water species. Their succession in time clearly records fluctuations in the position of the Polar Front. On the basis of shipboard and laboratory analyses, it seems likely that the most southerly positions (warmings) of the Polar Front during the ~4.2 m.y. record drilled at Site 514 occurred in the later Gilbert and middle Gauss epochs. These southward fluctuations of the Polar Front are tentatively correlated with oceanographic and/or climatic events in the Tasman Sea (DSDP Site 283), in the Ross Sea (DSDP Site 274), and near East Antarctica (DSDP Site 266). Sediments of these epochs are characterized by cool-temperature subantarctic assemblages of siliceous microfossils, comparatively abundant, well-preserved, and diverse nannofossils, and planktonic and benthic foraminifers.

The warm periods were separated by a cool interval (latest Gilbert–early Gauss epochs) marked by accumulation of diatomaceous clay with cold-water assemblages of siliceous microfossils and without calcareous plankton. Intensification of bottom currents and erosion resulted in the hiatus mentioned earlier. Within the cooling interval, there were other oscillations of a yet undetermined number and amplitude.

In comparison, the late Pliocene to Quaternary interval (upper Gauss, Matuyama, and Brunhes epochs) is a time of pronounced cooling, evidenced by all microfossil groups. The onset of this deterioration corresponds to the beginning of late Pliocene–Quaternary glaciation in the Northern Hemisphere, increasing glaciation in the Southern Hemisphere, and lowering of sea level. Cooling was interrupted by brief warming near the Pliocene–Quaternary boundary (later Matuyama) and at the end of the Quaternary (latest Matuyama, late Brunhes).

The sedimentation rates during the Pliocene–Quaternary in the area of Site 514 reflect, with minor variances, shifts of the Polar Front (Fig. 9). In the early Pliocene Gilbert Epoch, the rate was enormously high (180 m/m.y.). During the late Pliocene Gauss Epoch, it decreased to 69.4 m/m.y. A further, sharp diminution to 8.61 m/m.y. took place during the early Pleistocene Matuyama Epoch; in latest Matuyama time, sedimentation increased to 33.4 m/m.y. The lowest sedimentation rate, 2.3 m/m.y., occurred in the early Brunhes; during the late Brunhes, the rate did not exceed 17.5 m/m.y.

The average value of organic carbon in the sediments at Sites 514 is about 1.5 times greater than the average value (0.3%) in modern deep sea sediments. This high organic carbon content is attributed to the high sedimentation rates—fast burial protected the carbon from oxidation—and to the relatively constant environmental conditions in the area of Site 514.

In poorly consolidated, uniform sediments such as diatomaceous clays and oozes, physical properties are the most sensitive to subtle changes that may show up in seismic-reflection records but not in visual examination. Careful lithologic examination and description supply the tool by which variations in the physical properties may be interpreted. For example, evaluation of smear slide data from Site 514 clearly shows the relationship between fluctuations in bulk density and water content, on the one hand, and sediment composition, on the other. Clay content and diatom content are negatively correlated; clay maxima distinctly correspond with maxima in bulk density. In contrast, water content is reduced with increasing clay content, but increases parallel to the diatom content. Wide scattering of bulk density at one horizon at Site 514 is associated with the simultaneous occurrence of relatively high quartz content and a narrower period of clay–diatom alternation. Even when quartz content is very low, it seems in general to modulate the physical properties. Vane shear strengths also appear to decrease with an increase in clay content. Careful correlation of lithology and physical properties undoubtedly aids in the interpretation of the seismic records.

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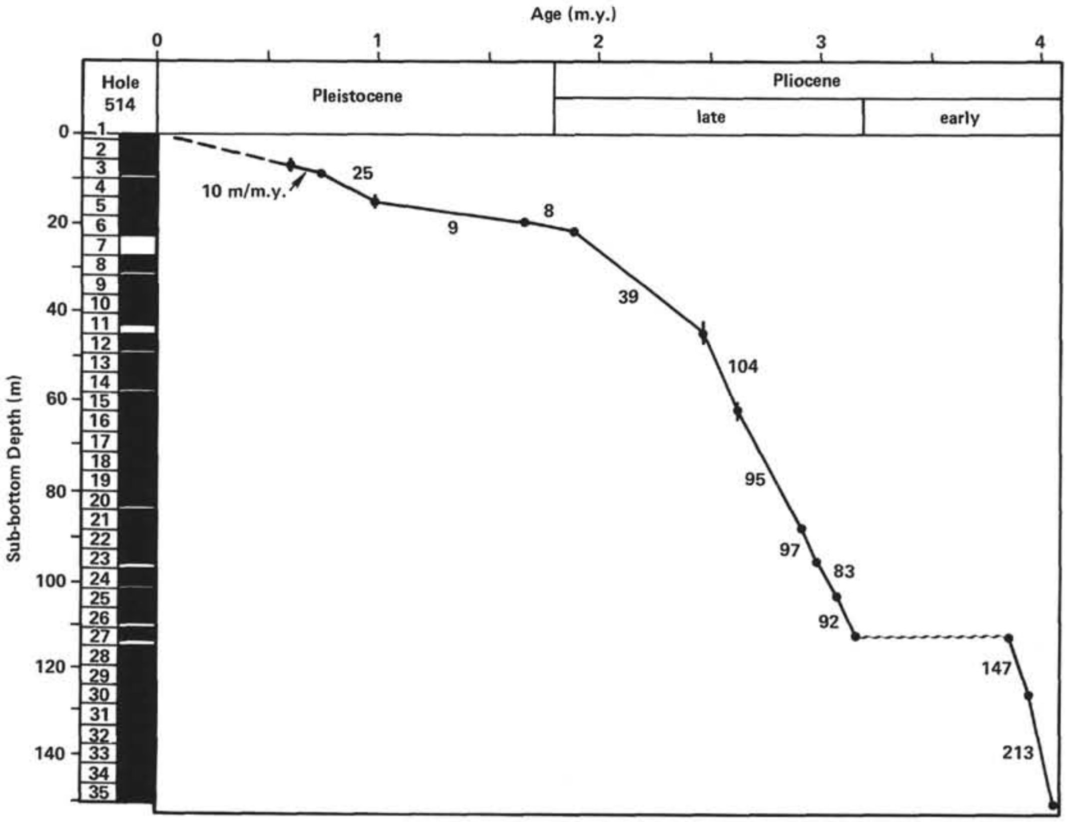
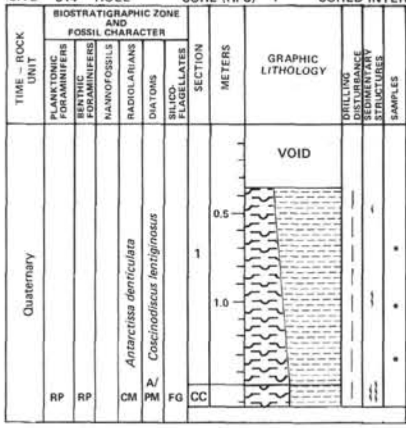


Figure 9. Sedimentation rates of the Pliocene-Quaternary sediments at Site 514.

SITE 514 HOLE CORE (HPC) 1 CORED INTERVAL 0.0–1.2 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Olive brown (2.5Y 4/4) with 3–5 cm zones of olive (5Y 4/3) and dark grayish brown (2.5Y 4/2).

Bioturbation minor to moderate.

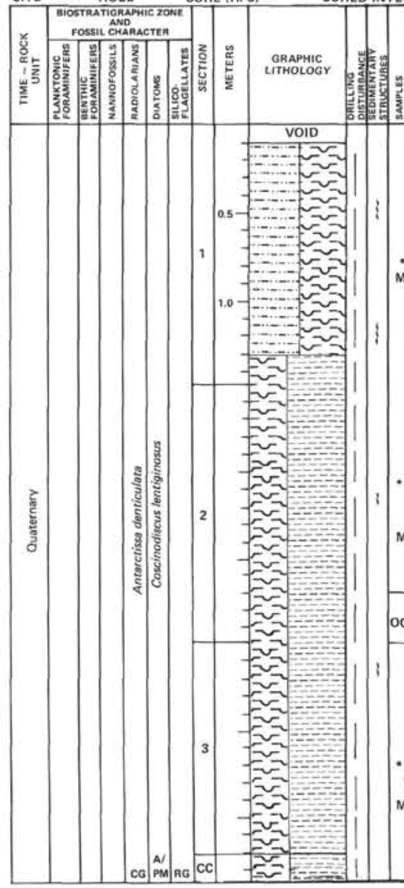
Diatom content increases downward.

Mn nodule, 4 cm, in Core-Catcher.

SMEAR SLIDE SUMMARY

	1-70	1-101	1-139
	D	M	M
Quartz	10	10	10
Feldspar	–	TR	5
Heavy minerals	1	–	–
Clay minerals	51	45	44
Zeolites	5	3	3
Diatoms	30	40	45
Radiolarians	3	1	3
Sponge spicules	–	1	TR

SITE 514 HOLE CORE (HPC) 2 CORED INTERVAL 1.2–5.6 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE AND DIATOMACEOUS CLAY
Diatomaceous ooze in Section 1, 5–130 cm, is olive brown to dark grayish brown (2.5Y 4/4–4/2) with minor grayish zones. Bioturbation is slight. Minor Mn micronodules (sand size) and 5–7% quartz sand disseminated throughout. Lower contact undulating, sharp.

Diatomaceous clay in balance of core is dark gray (5Y 5/1), homogeneous, locally highly disturbed. Some large, very dark gray (5Y 3/1) burrows in Section 1. Dark greenish black (Mn(?) nodule in Section 2, 98–99 cm in dark gray mottled zone, 92–102 cm. Vague horizontal layering. Greenish black (5GY 2/1) "granular" Mn(?)-rich zone Section 3, 0–10 cm. Bioturbation minor.

SMEAR SLIDE SUMMARY

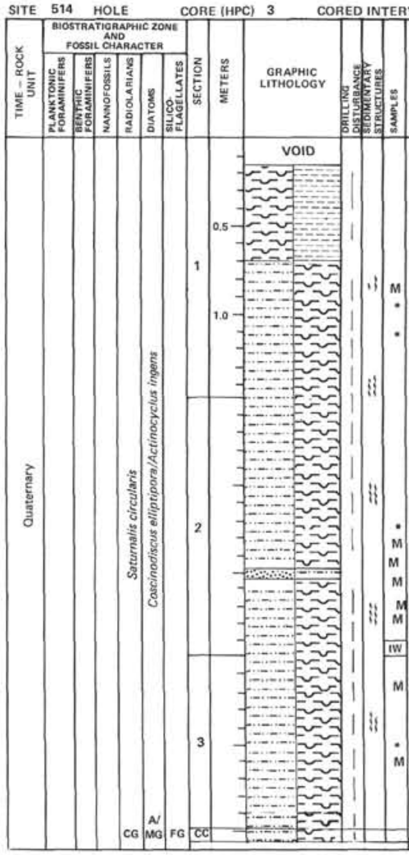
	1-80	2-60	3-70	3-77
	D	D	D	M
Quartz	7	7	10	10
Feldspar	1	1	TR	1
Heavy minerals	–	–	–	1
Clay minerals	33	46	46	53
Zeolites	5	2	TR	2
Carbonate unspec.	–	–	–	1
Diatoms	50	40	40	30
Radiolarians	3	3	3	1
Micronodules	1	1	1	–
Volcanic glass	–	–	–	1

CARBONATE BOMB:
1, 27–28 (0)

MAGNETIC DATA:	1-89	2-90	3-86
Inclination	–67.6	–56.1	–66.3
Declination	268.6	217.9	225.1
Intensity (emu/cc)	0.676E–05	0.421E–05	0.415E–05

GRAIN SIZE:
1-50 (2, 20, 78)
3-50 (2, 17, 81)

SITE 514 HOLE CORE (HPC) 3 CORED INTERVAL 5.6–10.0 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE AND DIATOMACEOUS CLAY
Diatomaceous clay, Section 1, 14–71 cm, gray (5Y 5/1) changing to olive gray (5Y 4/2) at 35–39 cm, to greenish gray (5G 6/1) at 34–42 cm. Layering at 30° dip.

Muddy diatomaceous ooze (Section 1, 71 cm–Section 2, 99 cm), greenish gray (5GY 6/1–5G 6/1), horizontally laminated (~ 1 cm) with zones of more indurated dark greenish gray (5GY 4/1). Section 1, 105–130 cm, gray (5Y 5/1) moderately bioturbated; 130–150 cm olive gray (5Y 4/2) firm, homogeneous with sparse lithic sand and granules (angular), continuing into Section 2, 0–51 cm. Gray zone, moderately bioturbated Section 2, 51–72 cm; olive gray 72–144 cm, bioturbated with disseminated sand grains. Mottled greenish gray (5GY 6/1) at 121–131 cm.

Angular, coarsely crystalline acidic igneous pebble (1x2 cm) in a sandy layer Section 2, 99–102 cm.

Vague horizontal stratification in Section 3. Large (2 cm) greenish black burrow Section 3, 38–40 cm; small (< 1 cm) pebble at 63 cm.

SMEAR SLIDE SUMMARY

	1-92	1-116	2-75	3-50
	D	M	D	D
Quartz	5	6	7	10
Feldspar	TR	–	–	1
Heavy minerals	–	–	1	–
Clay minerals	37	33	34	38
Glauconite	–	–	2	–
Zeolites	2	2	1	1
Diatoms	50	55	50	45
Radiolarians	5	5	5	5
Micronodules	1	TR	–	–

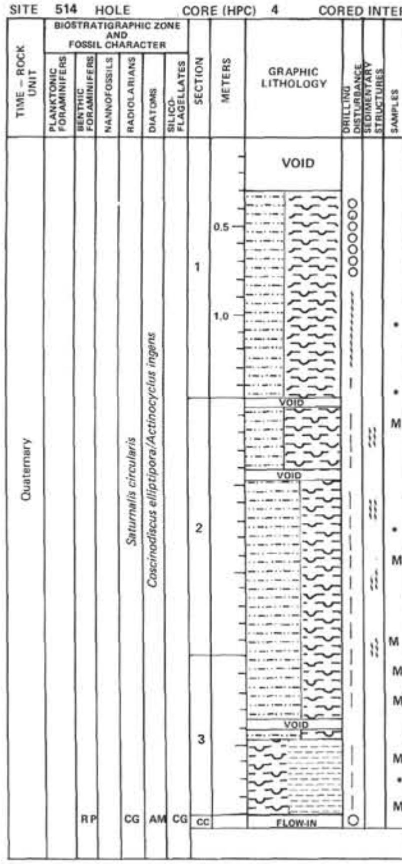
CARBONATE BOMB:
2, 53–54 (0)

MAGNETIC DATA:	1-69	2-79	2-92	2-105
Inclination	–45.0	–86.2	–73.2	–80.5
Declination	142.3	95.0	78.1	97.0
Intensity (emu/cc)	0.100E–04	0.487E–05	0.124E–05	0.778E–06

MAGNETIC DATA:	2-119	2-133	3-20	3-50
Inclination	59.2	75.2	61.2	77.0
Declination	15.0	296.2	311.6	301.0
Intensity (emu/cc)	0.390E–06	0.291E–05	0.980E–06	0.394E–05

GRAIN SIZE:
1-134 (3, 21, 76)
3-3 (4, 23, 73)

SITE 514 HOLE CORE (HPC) 4 CORED INTERVAL 10.0–14.4 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE AND DIATOMACEOUS CLAY
Muddy diatomaceous ooze varies in color down section: Section 1, 31–116 cm – dark gray (5Y 4/1) to greenish gray (5G 6/1); Section 1, 116 cm–Section 2, 88 cm – olive gray (5Y 5/2); Section 2, 88 cm–Section 3, 1 cm – gray (5Y 5/1) to greenish gray; Section 3, 1–44 cm – olive gray; Section 3, 44–91 cm – greenish gray.

Bioturbation moderate throughout.

Vague horizontal layering common.

Disseminated sand common in Section 1, less in Section 3.

Mn staining in upper part of Section 1; disseminated Mn micronodules in Section 2.

Diatomaceous clay, Section 3, 44–91 cm, greenish gray (5G 6/1), soft with 1–4 cm more indurated green zones; dark laminae (0.5 cm) at 57 cm.

Disseminated quartz and Mn grains in olive gray zone at 76–80 cm.

SMEAR SLIDE SUMMARY

	1-105	1-145	2-75	3-70
	M	D	D	
Quartz	7	3	15	10
Feldspar	1	–	2	1
Heavy minerals	–	–	TR	–
Clay minerals	30	39	35	42
Zeolites	TR	1	–	5
Diatoms	55	50	40	35
Radiolarians	7	5	7	5
Silicoflagellates	–	1	–	1
Micronodules	–	1	1	1

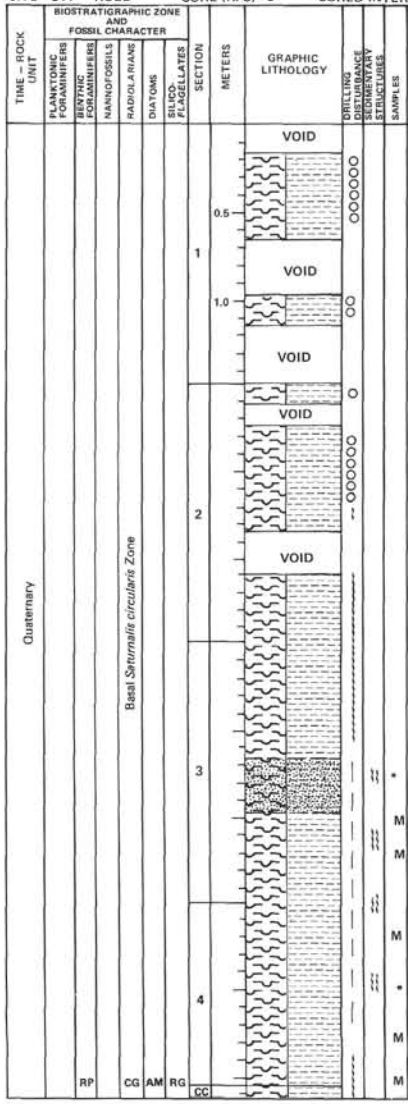
CARBONATE BOMB:
2, 34–35 (0)

MAGNETIC DATA:	2-16	2-90	2-142	3-3
Inclination	49.6	64.0	45.8	49.5
Declination	14.1	24.2	24.7	30.6
Intensity (emu/cc)	0.526E–05	0.134E–05	0.450E–06	0.820E–06

MAGNETIC DATA:	3-16	3-32	3-55	3-92
Inclination	–30.4	–35.2	24.6	30.2
Declination	226.9	222.4	347.4	66.9
Intensity (emu/cc)	0.800E–07	0.440E–06	0.560E–06	0.150E–06

GRAIN SIZE:
1-120 (3, 21, 76)
3-10 (3, 27, 70)

SITE 514 HOLE CORE (HPC) 5 CORED INTERVAL 14.4–18.8 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY

Olive gray (5Y 4/2), soupy in Sections 1 and 2; with minor disseminated quartz sand. Gray zone (5Y 5/1–6/1) in Section 2, 65–96 cm. Disseminated sand in Section 3, 65–96 cm and 1 cm lens nearly pure fine quartz sand in Section 3 at 106 cm. Bioturbation moderate and horizontal stratification prominent in Section 4. Greenish gray (5G 6/1) zones common in Section 4.

SMEAR SLIDE SUMMARY

	3-75	4-50
	D	D
Quartz	5	7
Feldspar	1	–
Clay minerals	46	49
Glauconite	–	TR
Zeolites	3	3
Diatoms	40	35
Radiolarians	5	5
Micronodules	–	1

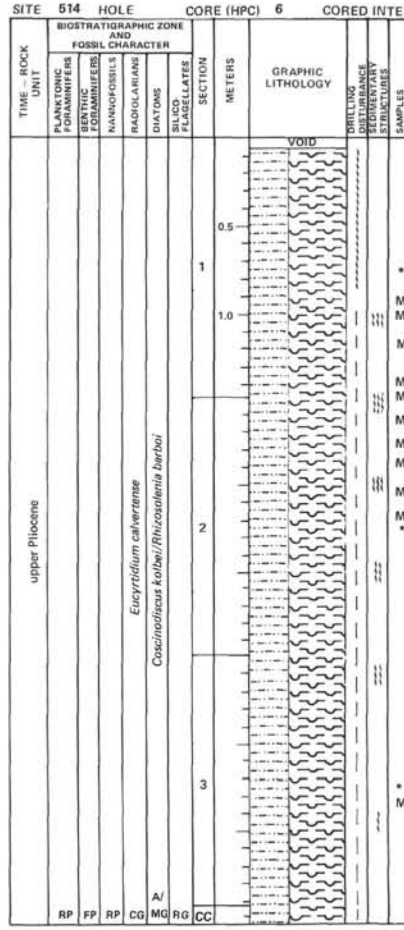
CARBONATE BOMB:
4, 44–45 (0)

MAGNETIC DATA:	3-100	3-114	4-16
Inclination	69.5	77.5	80.2
Declination	111.9	164.0	134.0
Intensity (emu/cc)	0.620E–06	0.160E–05	0.890E–06

MAGNETIC DATA:	4-77	4-90
Inclination	69.3	4.0
Declination	177.8	259.0
Intensity (emu/cc)	0.530E–06	0.159E–04

GRAIN SIZE:
4-20 (1, 26, 73)

SITE 514 HOLE CORE (HPC) 6 CORED INTERVAL 18.8–23.2 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Predominately olive gray (5Y 4/2) but with zones, from 2–40 cm thick, of greenish gray (5G 6/1) that are generally firmer. Contacts between the two colors are gradational or abrupt. Rare dark gray laminae; horizontal stratification apparent in Section 1, 86–150 cm.

Bioturbation moderate, locally intense. Prominent ring burrows Section 1, 57–68 cm, and Section 2, 33 cm. Solid burrows, Section 2, 38 and 56 cm.

Finely, disseminated quartz sand in Section 2, 67–150 cm.

Dark gray laminae common in Section 3.

SMEAR SLIDE SUMMARY

	1-75	2-75	3-75
	D	D	D
Quartz	5	5	5
Heavy minerals	–	2	–
Clay minerals	37	24	29
Zeolites	2	–	1
Carbonate unspec.	–	5	5
Diatoms	50	55	55
Radiolarians	5	7	5
Silicoflagellates	–	1	–
Micronodules	1	1	TR

CARBONATE BOMB:
2, 86–87 (2)

MAGNETIC DATA:	1-93	1-105	1-125	1-140
Inclination	–54.3	–60.1	–69.6	–65.2
Declination	215.7	221.8	211.9	217.1
Intensity (emu/cc)	0.370E–05	0.163E–05	0.261E–05	0.550E–05

MAGNETIC DATA:	2-4	2-15	2-31	2-45
Inclination	–57.0	–56.8	–58.4	–66.5
Declination	215.6	234.9	220.6	209.0
Intensity (emu/cc)	0.750E–06	0.510E–06	0.493E–05	0.544E–05

MAGNETIC DATA:	2-60	2-76	3-86
Inclination	62.9	76.1	62.0
Declination	291.3	35.5	5.9
Intensity (emu/cc)	0.560E–06	0.260E–06	0.927E–05

GRAIN SIZE:
1-108 (1, 25, 74)
3-108 (2, 35, 63)

NOTE: Core 7, 23.2–27.6 m: No recovery.

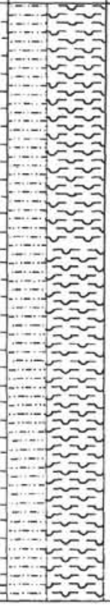
SITE 514 HOLE CORE (HPC) 8 CORED INTERVAL 27.6–32.0 m

TIME – ROCK UNIT: upper Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic foraminifers; Benthic foraminifers (RP); Nannofossils; Radiolarians: *Eucyrtidium calvertense* (CG); Diatoms: *Coscinodiscus kolbei/Rhizosolenia barboi* (A/MG); Silico-flagellates (RG)

SECTION: 1, 2, 3, CC — METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



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

LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Dark greenish gray (5GY 4/1), sparsely mottled throughout with very dusky purple (5P 2/2) and, in Sections 2 and 3, with greenish black (5GY 2/1). Dark gray (5Y 4/1) or very dark gray layers or lenses in Section 1, 136–139 cm; Section 2, 84–96 cm; Section 3, 28–29 cm. The latter interval is sandy, as is 1 cm lens in Section 1, 65–66 cm.

Section 2 highly disturbed with vertical color stringers of dusky purple and greenish black.

SMEAR SLIDE SUMMARY

	1-65	2-45	3-20
	D	D	D
Quartz	3	3	2
Feldspar	TR	TR	–
Clay minerals	31	35	33
Carbonate unspec.	2	1	1
Nannofossils	–	TR	–
Diatoms	60	58	60
Radiolarians	4	3	4
Silicoflagellates	TR	TR	TR
Ebridians	TR	TR	–

CARBONATE BOMB:
3, 19–20 (0)

MAGNETIC DATA:	1-145	2-50	3-15
Inclination	57.1	69.2	64.1
Declination	308.5	103.4	93.6
Intensity (emu/cc)	0.264E–05	0.770E–05	0.988E–05

GRAIN SIZE:
2-74 (1, 31, 68)

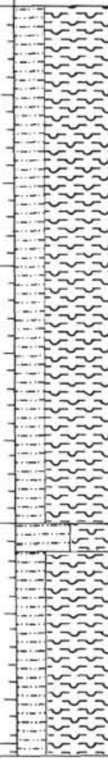
SITE 514 HOLE CORE (HPC) 9 CORED INTERVAL 32.0–36.4 m

TIME – ROCK UNIT: upper Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic foraminifers; Benthic foraminifers; Nannofossils; Radiolarians: *Eucyrtidium calvertense* (CG); Diatoms: *Coscinodiscus kolbei/Rhizosolenia barboi* (AM); Silico-flagellates (RG)

SECTION: 1, 2, 3, CC — METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



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

LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Alternating olive gray (5Y 4/2) and dark gray (5Y 4/1) as in previous core, with very dusky purple and greenish black horizontal laminae throughout, except Section 1 where upper 90 cm are highly disturbed and mottled with those colors.

Top 14 cm of Section 3 has high clay content and is olive gray.

SMEAR SLIDE SUMMARY

	1-105	2-20	2-80	3-5
	D	M	D	M
Quartz	2	1	1	2
Feldspar	TR	–	–	–
Clay minerals	23	25	22	43
Carbonate unspec.	TR	1	TR	TR
Diatoms	70	68	71	53
Radiolarians	4	4	5	2
Silicoflagellates	1	1	1	TR
Sponge spicules	TR	TR	TR	TR
Ebridians	TR	–	TR	–

CARBONATE BOMB:
2, 106–107 (1.5)

MAGNETIC DATA:	1-114	2-6	2-36	2-51
Inclination	41.2	18.2	58.1	38.7
Declination	121.9	123.3	177.1	130.6
Intensity (emu/cc)	0.605E–05	0.430E–06	0.510E–06	0.940E–06

MAGNETIC DATA:	2-81	2-96	2-115	2-146
Inclination	61.5	40.8	46.1	57.4
Declination	128.6	145.9	124.7	120.7
Intensity (emu/cc)	0.830E–06	0.873E–05	0.280E–06	0.450E–06

MAGNETIC DATA:	3-25	3-56	3-86	3-100
Inclination	35.4	62.5	62.1	63.5
Declination	118.1	156.5	139.2	140.6
Intensity (emu/cc)	0.450E–06	0.370E–06	0.970E–06	0.730E–06

MAGNETIC DATA:	3-116
Inclination	27.0
Declination	120.3
Intensity (emu/cc)	0.153E–05

GRAIN SIZE:
1-60 (2, 31, 68)
3-91 (1, 31, 68)

SITE 514 HOLE CORE (HPC) 10 CORED INTERVAL 36.4–40.8 m

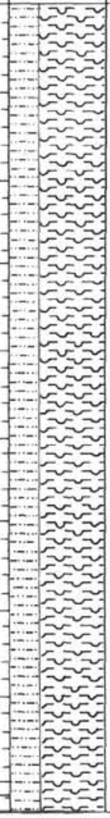
TIME – ROCK UNIT: upper Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Eucyrtidium calvertense* (Radiolarians); *Coscinodiscus kolbei/Rhizosolenia barboi* (Diatoms)

Fossil character (CC): CG (Radiolarians), A/MG (Diatoms), FG (Silicoflagellates)

SECTIONS: 1, 2, 3, 4, CC

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous core, but predominately gray (5Y 5/1) with olive color subordinate (Section 3, 101–126 cm).

Much drilling disturbance; original very dusky purple and greenish black laminae distorted, often to vertical position.

Very dark gray lenses <1 cm sparse in Section 1; black (5Y 2/1) lens in Section 2, 88–100 cm.

Horizontal laminae Section 3, 88–101 cm.

SMEAR SLIDE SUMMARY

	1-80	2-85	3-115
	D	D	D
Quartz	2	2	2
Clay minerals	28	25	25
Carbonate unspec.	TR	1	2
Foraminifers	–	–	TR
Nannofossils	–	TR	–
Diatoms	67	65	68
Radiolarians	3	6	3
Silicoflagellates	TR	1	TR
Sponge spicules	TR	TR	TR
Ebridians	TR	–	–

MAGNETIC DATA:	1-111	3-92
Inclination	45.3	25.8
Declination	323.2	140.2
Intensity (emu/cc)	0.300E–06	0.222E–06

GRAIN SIZE:
1-19 (2, 33, 66)
3-19 (1, 33, 66)

SITE 514 HOLE CORE (HPC) 11 CORED INTERVAL 40.8–45.2 m

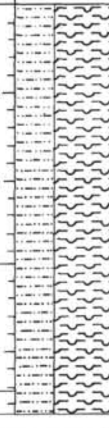
TIME – ROCK UNIT: upper Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Helotholus vema* (Radiolarians); upper *Cosmiodiscus insignis* (Diatoms)

Fossil character (CC): CG (Radiolarians), A/PM (Diatoms), FG (Silicoflagellates)

SECTIONS: 1, 2, CC

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous core, predominately gray (5Y 5/1) with greenish black and very dusky purple laminae distorted in most part into vertical stringers. Mottling and bioturbation sparse.

SMEAR SLIDE SUMMARY

	1-110	2-60
	D	D
Quartz	1	3
Clay minerals	33	39
Carbonate unspec.	TR	1
Diatoms	62	55
Radiolarians	4	2
Silicoflagellates	TR	TR
Sponge spicules	TR	TR
Ebridians	–	TR

CARBONATE BOMB:
2, 21–22 (0)

MAGNETIC DATA:	1-136	2-44
Inclination	46.2	52.9
Declination	252.6	71.4
Intensity (emu/cc)	0.290E–06	0.918E–05

GRAIN SIZE:
1-91 (2, 39, 59)

SITE 514 HOLE CORE (HPC) 12 CORED INTERVAL 45.2–49.6 m

TIME – ROCK UNIT: upper Pliocene

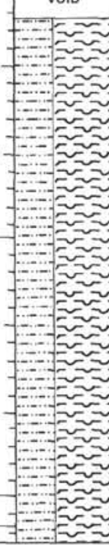
BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Helotholus vema* (Radiolarians); *Cosmiodiscus insignis* (Diatoms)

Fossil character (CC): CG (Radiolarians), AM (Diatoms), FG (Silicoflagellates)

SECTIONS: 1, 2, 3, CC

GRAPHIC LITHOLOGY

VOID



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

As in previous cores, gray, with olive zones in Section 2, 129–131 and 137–142 cm and Section 3, 5–12 cm.

Greenish black and very dusky purple laminae and stringers as before. Bioturbation sparse to moderate.

Core-Catcher is dark gray (5Y 4/1).

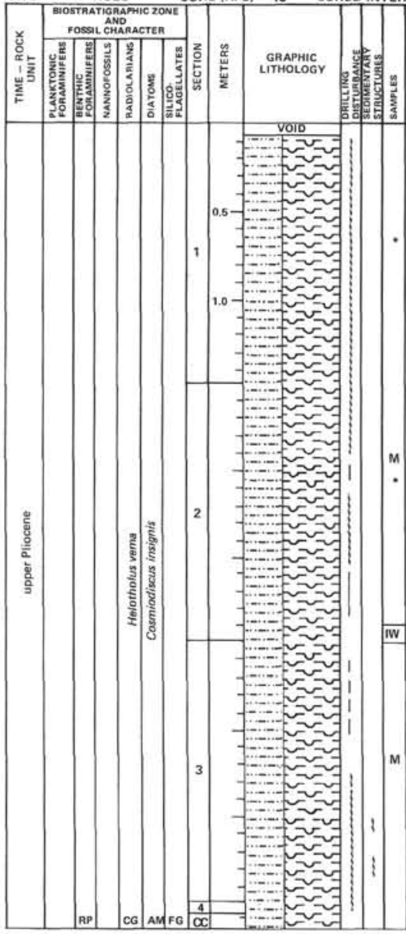
SMEAR SLIDE SUMMARY

	1-106	2-34	2-140
	D	D	M
Quartz	4	4	1
Clay minerals	37	42	35
Carbonate unspec.	1	1	TR
Nannofossils	TR	TR	TR
Diatoms	55	50	60
Radiolarians	3	3	3
Silicoflagellates	TR	TR	1
Sponge spicules	TR	TR	TR

MAGNETIC DATA:	2-27	2-136
Inclination	–68.1	–66.4
Declination	173.7	201.3
Intensity (emu/cc)	0.271E–05	0.870E–06

GRAIN SIZE:
2-71 (1, 38, 62)

SITE 514 HOLE CORE (HPC) 13 CORED INTERVAL 49.6–54.0 m



LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE
As in previous cores, olive gray (5Y 4/2) in Section 1; gray (5Y 5/1) in balance. Greenish black and very dusky purple laminae or, where disturbed, vertical stringers as before. Mottling sparse.

Section 1, 6–24 cm: highly disturbed with numerous cave-in lithic grains.

SMEAR SLIDE SUMMARY

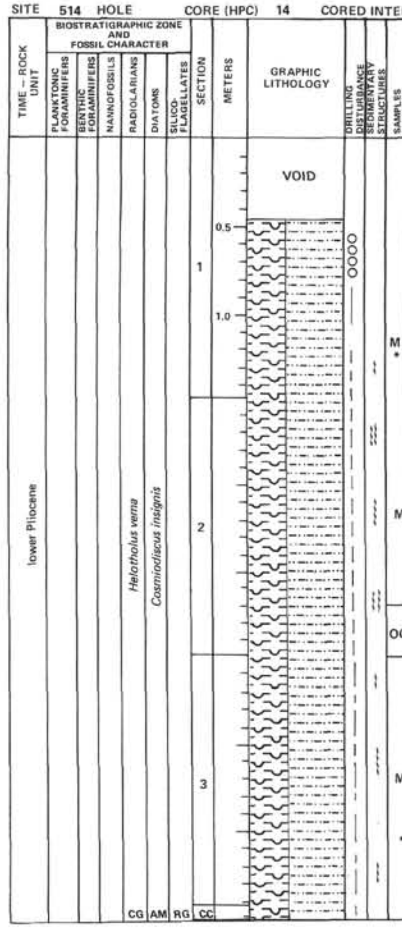
	1-69	2-54
	D	D
Quartz	1	3
Clay minerals	20	38
Carbonate unspec.	TR	1
Nannofossils	TR	–
Diatoms	75	50
Radiolarians	3	7
Silicoflagellates	1	1
Sponge spicules	–	TR
Ebridians	–	TR

CARBONATE BOMB:
3, 17–18 (0)

MAGNETIC DATA:	2-56	3-69
Inclination	–46.4	–64.5
Declination	217.8	169.6
Intensity (emu/cc)	0.180E–06	0.113E–05

GRAIN SIZE:
1-110 (1, 43, 57)
3-110 (1, 21, 79)

SITE 514 HOLE CORE (HPC) 14 CORED INTERVAL 54.0–58.4 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
Dark greenish gray (5GY 4/1). Greenish black and very dusky purple mottling where highly disturbed; as laminae where not. Black bioturbations sparse to moderate in Section 2. Very sparse light olive gray (5Y 6/2) mottling and sparse black (5Y 2/1) mottling in Section 3 and Core-Catcher.

SMEAR SLIDE SUMMARY

	1-122	3-106
	D	D
Quartz	3	3
Clay minerals	66	65
Carbonate unspec.	1	1
Nannofossils	–	TR
Diatoms	27	30
Radiolarians	3	1
Silicoflagellates	TR	TR
Sponge spicules	TR	–

CARBONATE BOMB:
3, 74–75 (0)

MAGNETIC DATA:	1-140	2-65	3-68
Inclination	–51.2	–43.5	–48.4
Declination	128.2	118.9	137.0
Intensity (emu/cc)	0.133E–05	0.165E–05	0.180E–05

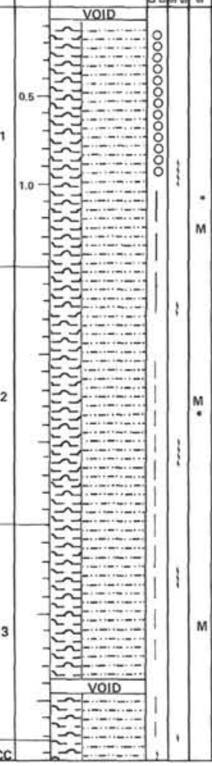
GRAIN SIZE:
1-98 (1, 21, 78)
3-98 (1, 21, 78)

SITE 514 HOLE CORE (HPC) 15 CORED INTERVAL 58.4–62.8 m

TIME-ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Radiolarians: *Helotholus vema*; Planktonic foraminifers RP; Benthic foraminifers RP; Nannofossils CG; Radiolarians A/PM; Diatoms FG

SECTION: 1, 2, 3, CC



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
Dark greenish gray (5GY 4/1), fairly homogeneous with sparse black (5Y 2/1) mottling, in Section 1 and Section 2, 0–66 cm.

Balance of core gray (5Y 5/1), with sparse black mottling, and very sparse pale olive (5Y 6/3) mottling.

Bluish gray (5B 5/1) and very dusky purple (5P 2/2) laminae in Section 2, 67–133 cm. Greenish black and very dusky purple laminae in 2–3 cm intervals in Section 3, 10–104 cm.

SMEAR SLIDE SUMMARY

	1-110 D	2-87 D
Quartz	2	1
Clay minerals	77	66
Carbonate unspec.	TR	2
Nannofossils	TR	–
Diatoms	20	25
Radiolarians	1	5
Silicoflagellates	–	1
Ebridians	TR	–

CARBONATE BOMB:
2, 119–120 (2)

MAGNETIC DATA:	1-133	2-80	3-64
Inclination	–39.5	–50.4	–57.2
Declination	27.0	248.2	259.9
Intensity (emu/cc)	0.236E–05	0.132E–05	0.195E–05

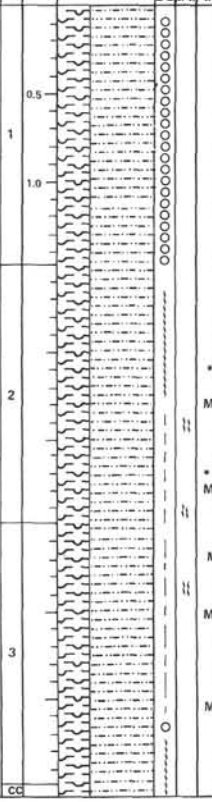
GRAIN SIZE:
1-102 (1, 18, 81)
3-102 (0, 18, 82)

SITE 514 HOLE CORE (HPC) 16 CORED INTERVAL 62.8–67.2 m

TIME-ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Radiolarians: *Helotholus vema*; Planktonic foraminifers RP; Benthic foraminifers RP; Nannofossils CG; Radiolarians A/PM; Diatoms RG

SECTION: 1, 2, 3, CC



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
As in Core 15; dark greenish gray with laminae and stringers of greenish black and very dusky purple. Moderate bioturbation in black and very dark purple in Sections 2 and 3.

SMEAR SLIDE SUMMARY

	2-60 D	2-120 D
Quartz	1	4
Clay minerals	66	70
Carbonate unspec.	1	TR
Nannofossils	1	–
Diatoms	27	23
Radiolarians	3	3
Silicoflagellates	1	TR
Sponge spicules	TR	TR

MAGNETIC DATA:	2-87	2-121	3-24
Inclination	–65.1	–56.1	–57.9
Declination	251.3	268.6	269.8
Intensity (emu/cc)	0.202E–05	0.111E–05	0.458E–06

MAGNETIC DATA:	3-54	3-103
Inclination	–57.6	–51.0
Declination	293.4	303.9
Intensity (emu/cc)	0.375E–06	0.577E–05

GRAIN SIZE:
2-71 (2, 25, 73)

SITE 514 HOLE CORE (HPC) 17 CORED INTERVAL 67.2–71.6 m

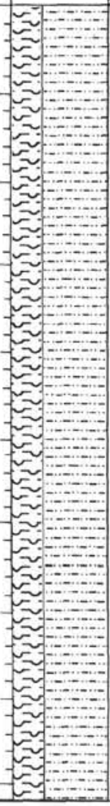
TIME – ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Helotholus vema*; Benthic foraminifers RP; Diatoms AM; Silicoflagellates CG

SECTION: 1, 2, 3, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD

Gray (5Y 5/1) with greenish black and black (5Y 2/1) sparse laminae throughout. Pale olive (5Y 6/3) mottling sparse in Section 1 and in Section 3, 4–7 and 84–86 cm where it has "cotton" texture. "Cotton" texture also in Section 3, 44–68 and 94–150 cm.

Sparse to moderate black bioturbation in Section 1.

Core-Catcher is dark greenish gray (5GY 4/1).

SMEAR SLIDE SUMMARY

	1-75	3-6	3-40
	D	M	D
Quartz	2	TR	1
Clay minerals	70	68	68
Carbonate unspec.	1	TR	TR
Foraminifers	–	TR	–
Nannofossils	TR	TR	TR
Diatoms	24	29	27
Radiolarians	2	1	3
Silicoflagellates	1	2	1
Sponge spicules	TR	TR	TR

CARBONATE BOMB:
1, 106–107 (0)

MAGNETIC DATA:	1-41	1-71	1-96	1-121
Inclination	–42.8	–58.6	–43.8	–53.1
Declination	67.8	94.8	84.4	76.6
Intensity (emu/cc)	0.379E–05	0.166E–05	0.740E-́06	0.384E–05

MAGNETIC DATA:	1-141	2-11	2-41	2-71
Inclination	–49.3	–38.5	–48.2	–48.4
Declination	90.5	75.5	98.6	82.8
Intensity (emu/cc)	0.272E–05	0.679E–05	0.491E–05	0.646E–05

MAGNETIC DATA:	2-96	2-121	2-141	3-11
Inclination	–49.4	–48.7	–59.9	–33.3
Declination	87.3	81.3	88.5	101.3
Intensity (emu/cc)	0.109E–04	0.900E–05	0.601E–05	0.637E–05

MAGNETIC DATA:	3-41	3-81	3-107
Inclination	–50.2	–33.6	–58.6
Declination	93.5	79.4	85.9
Intensity (emu/cc)	0.681E–05	0.185E–05	0.197E–05

GRAIN SIZE:
1-74 (1, 28, 71)
3-74 (1, 26, 73)

SITE 514 HOLE CORE (HPC) 18 CORED INTERVAL 71.6–76.0 m

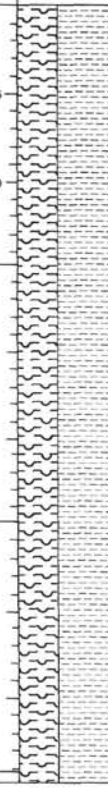
TIME – ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Helotholus vema*; Planktonic foraminifers RP; Benthic foraminifers RP; Radiolarians CG; Diatoms A/MG; Silicoflagellates RG

SECTION: 1, 2, 3, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY

Dark greenish gray (5GY 4/1) to greenish gray (5G 6/1), firm; moderate bioturbation, mainly solid burrows. Frequent laminae of green, dark gray and greenish gray ~1 cm thick; commonly they are couplets of green over dark gray, with repetition interval of 4–6 cm.

Section 3, 120, 130, and 138 cm: prominate 1 cm green layers.

Conspicuous ring burrows (1.0–1.5 cm, Section 3, 74–80 cm).

SMEAR SLIDE SUMMARY

	1-75	2-75	3-75
	D	D	D
Quartz	2	2	5
Heavy minerals	–	–	TR
Clay minerals	60	65	61
Diatoms	35	25	30
Radiolarians	2	1	3
Micronodules	1	1	1

CARBONATE BOMB:
3, 59–60 (0)

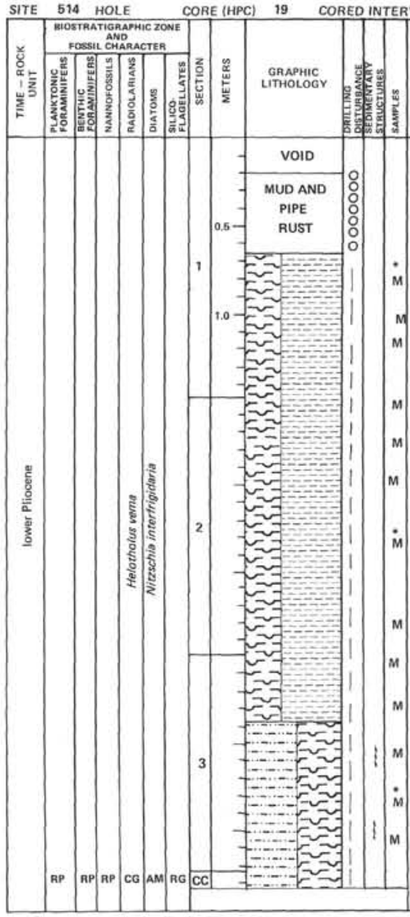
MAGNETIC DATA:	1-49	1-79	1-119	2-20
Inclination	–67.8	–40.8	–44.1	–53.6
Declination	248.9	265.9	270.5	263.9
Intensity (emu/cc)	0.289E–05	0.755E–05	0.950E–05	0.139E–04

MAGNETIC DATA:	2-49	2-79	2-107	2-139
Inclination	–43.7	–60.4	–57.5	–62.9
Declination	260.4	245.1	266.2	260.2
Intensity (emu/cc)	0.836E–05	0.408E–05	0.650E–05	0.295E–05

MAGNETIC DATA:	3-20	3-49	3-79	3-116
Inclination	–47.2	–56.4	–51.4	–52.8
Declination	286.7	281.9	294.6	170.7
Intensity (emu/cc)	0.542E–05	0.700E–05	0.567E–05	0.688E–05

GRAIN SIZE:
1-42 (4, 33, 63)
3-138 (1, 31, 67)

SITE 514 HOLE CORE (HPC) 19 CORED INTERVAL 76.0–80.4 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Section 1, 21–66 cm: soupy mud and pipe rust.

Section 1, 66 cm–Section 3, 38 cm: dark greenish gray (5GY 4/1 to greenish gray (5G 6/1), firm. Moderate to intense mottling. Stratification not as prominent as in Core 18, from horizontal (Section 1, 125–150 cm) to 30°dip (Section 1, 66–125 cm). Large (2–3 cm) dark gray burrow Section 1, 144 cm.

MUDDY DIATOMACEOUS OOZE
Section 3, 38–126 cm and Core-Catcher: greenish gray (5GY 6/1) to dark greenish gray (5GY 4/1) with gray and green lamination couplets as in Core 18. Moderate bioturbation. Very diatomaceous at 110–120 cm.

SMEAR SLIDE SUMMARY

	1-75	2-75	3-75
	D	D	D
Quartz	5	7	5
Feldspar	1	1	–
Heavy minerals	–	TR	TR
Clay minerals	60	54	42
Zeolites	–	1	TR
Diatoms	30	30	45
Radiolarians	2	3	1
Micronodules	2	2	1

CARBONATE BOMB:
2, 69–70 (0)

MAGNETIC DATA:	1-80	1-108	1-133	2-10
Inclination	–51.3	–31.0	–17.4	–18.4
Declination	31.5	93.7	87.4	118.9
Intensity (emu/cc)	0.222E–05	0.430E–05	0.828E–05	0.793E–05

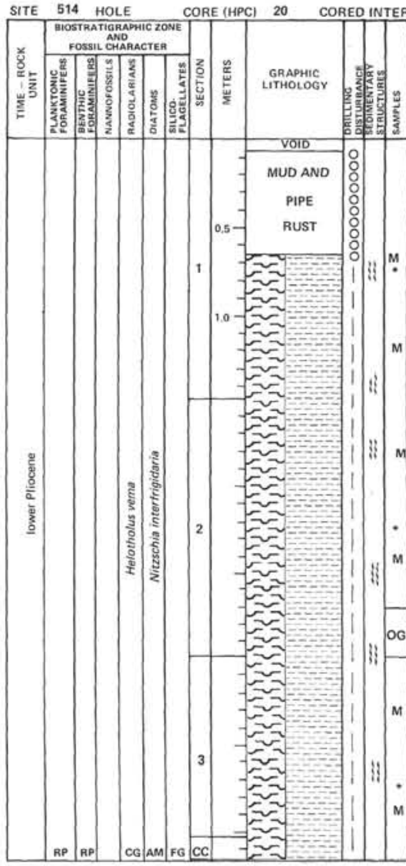
MAGNETIC DATA:	2-32	2-56	2-80	2-132
Inclination	–46.9	–70.7	–50.3	–38.7
Declination	62.1	110.0	83.4	76.0
Intensity (emu/cc)	0.130E–06	0.818E–05	0.118E–04	0.109E–04

MAGNETIC DATA:	3-10	3-32	3-55	3-80
Inclination	–44.7	–45.7	–46.6	–66.6
Declination	89.5	86.0	92.5	116.2
Intensity (emu/cc)	0.973E–05	0.602E–05	0.319E–05	0.165E–05

MAGNETIC DATA:	3-106
Inclination	–49.4
Declination	101.8
Intensity (emu/cc)	0.265E–05

GRAIN SIZE:
1-85 (1, 28, 71)
3-40 (1, 47, 52)

SITE 514 HOLE CORE (HPC) 20 CORED INTERVAL 80.4–84.8 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Section 1, 5–63 cm: soupy mud and pipe rust.

Remainder olive gray (5Y 4/2) with minor greenish gray (5G 6/1) in Section 1, becoming greenish gray to dark greenish gray in Sections 2 and 3. Moderate bioturbation, Laminae faint in Section 1, more pronounced in Sections 2 and 3 with gray and green couplets at 3–5 cm intervals in Section 3. More diatomaceous with depth.

SMEAR SLIDE SUMMARY

	1-75	2-75	3-75
	D	D	D
Quartz	3	3	10
Clay minerals	58	60	39
Zeolites	–	–	2
Nannofossils	–	TR	TR
Diatoms	35	30	40
Radiolarians	3	5	7
Micronodules	1	2	2

CARBONATE BOMB:
2, 59–60 (3)

MAGNETIC DATA:	1-83	1-124	2-32
Inclination	–60.4	–40.4	–63.7
Declination	12.4	51.7	46.7
Intensity (emu/cc)	0.285E–05	0.430E–05	0.396E–05

MAGNETIC DATA:	2-88	3-32	3-89
Inclination	–68.0	–67.6	–66.3
Declination	49.2	137.8	75.8
Intensity (emu/cc)	0.156E–05	0.265E–05	0.127E–05

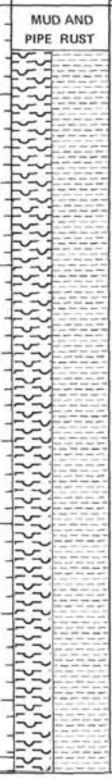
GRAIN SIZE:
1-70 (1, 24, 75)

SITE 514 **HOLE** **CORE (HPC)** 21 **CORED INTERVAL** 84.8–89.2 m

TIME – ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic foraminifers RP; Benthic foraminifers RP; Radiolarians CG, *Helotholus vema*; Diatoms A/PM, *Nitzschia interfrigidaria*; Silicoflagellates RG

SECTION: 1, 2, 3, CC



SAMPLES: * M (Section 1); M * (Section 2); * M (Section 3)

LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY

Section 1, 0–26 cm: mud and rust.

Remainder dark gray (5Y 4/1) grading to olive gray (5Y 4/2) in Section 1, 70–120 cm; then to dark greenish gray (5GY 4/1) from 120–150 cm; firm. Moderate to intense bioturbation. Stratification vague in Section 1; more apparent in Section 2 and thin (0.5 cm) gray lamine abundant near bottom of Section 3. Color changes to greenish gray (5G 6/1) in bottom of Section 2 and Section 3. Prominent very dark gray burrow, 1.0 cm, Section 2, 65 cm and elongate burrow Section 3, 54–62 cm.

SMEAR SLIDE SUMMARY

	1-75	2-75	3-75
	D	D	D
Quartz	3	5	5
Feldspar	1	–	–
Heavy minerals	–	–	1
Clay minerals	60	48	54
Zeolites	1	1	1
Nannofossils	–	TR	–
Diatoms	30	40	30
Radiolarians	3	3	7
Micronodules	2	3	2

CARBONATE BOMB:
2, 79–80 (1)

MAGNETIC DATA:	1-77	2-43	3-89
Inclination	–27.0	–62.9	–37.0
Declination	52.8	/348.5	33.7
Intensity (emu/cc)	0.500E–06	0.989E–06	0.128E–05

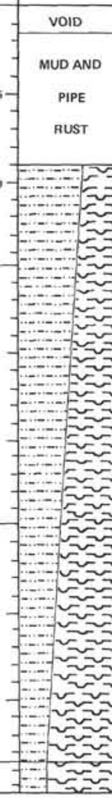
GRAIN SIZE:
1-94 (1, 24, 75)
3-94 (1, 28, 72)

SITE 514 **HOLE** **CORE (HPC)** 22 **CORED INTERVAL** 89.2–93.6 m

TIME – ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: Planktonic foraminifers R/PM; Benthic foraminifers F/PM; Nannofossils RM; Radiolarians CG, *Helotholus vema*; Diatoms A/PM, *Nitzschia interfrigidaria*; Silicoflagellates RG

SECTION: 1, 2, 3, CC



SAMPLES: * M (Section 1); M * (Section 2); * M (Section 3)

LITHOLOGIC DESCRIPTION

MUDDY DIATOMACEOUS OOZE

Section 1, 16–90 cm: mud, pipe rust, and small pebbles.

Remainder greenish gray (5G 6/1) with frequent greenish and grayish laminae, 0.5 cm, at 4–8 cm spacing. Bioturbation intense. Prominent burrows Section 1, 103–110 cm.

Prominent olive gray (5Y 4/2) zone in Section 2, 63–66 cm and burrow in Section 3, 67 cm.

SMEAR SLIDE SUMMARY

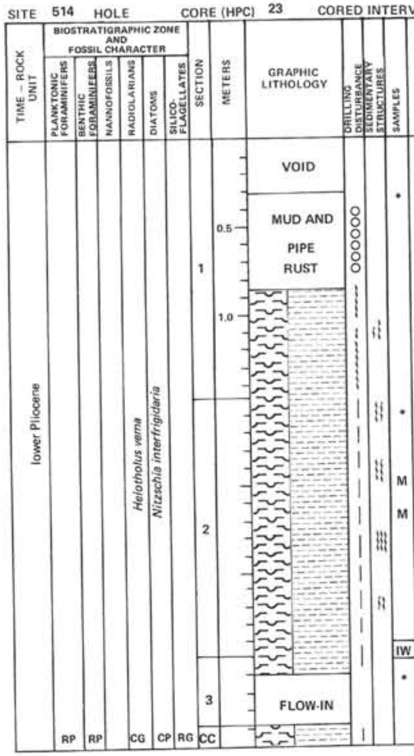
	1-115	2-75	3-75
	D	D	D
Quartz	7	3	3
Heavy minerals	1	–	–
Clay minerals	59	44	34
Zeolites	1	1	2
Carbonate unspec.	1	–	–
Nannofossils	1	–	–
Diatoms	25	45	55
Radiolarians	5	5	5
Micronodules	–	2	1

CARBONATE BOMB:
2, 79–80 (3.1)

MAGNETIC DATA:	1-122	2-41	3-84
Inclination	57.8	44.0	57.9
Declination	285.2	266.3	226.5
Intensity (emu/cc)	0.755E–05	0.104E–05	0.830E–06

GRAIN SIZE:
1-112 (1, 29, 71)
3-15 (1, 25, 74)

SITE 514 HOLE CORE (HPC) 23 CORED INTERVAL 93.6–98.0 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Section 1, 32–86 cm: soupy mixture of mud, rust, and pebbles (one large 5x4 cm pebble).

Remainder greenish gray (5G 6/1), firm; moderate to intense bioturbation; vague horizontal gray laminae in Section 1, 140–150 cm that become more greenish and more prominent in Section 2. Clay color darker greenish gray (5G 4/1) in Section 3.

Section 1 also contains homogeneous masses of pale olive (5Y 6/3) calcareous ooze at 88–94 cm.

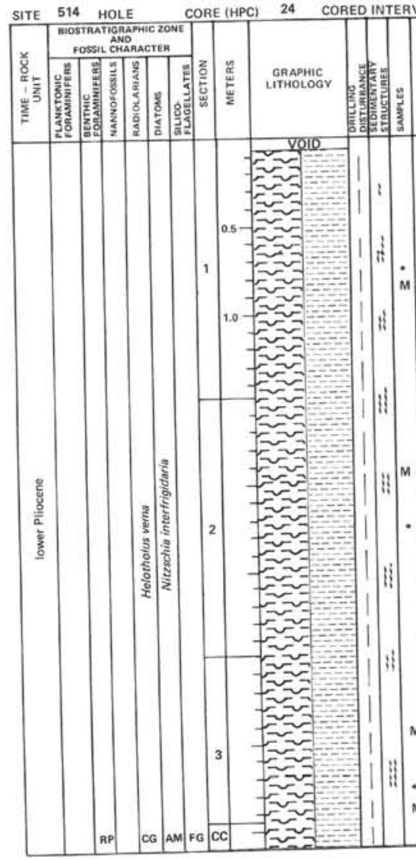
SMEAR SLIDE SUMMARY

	1-31 M	2-10 D	3-10 D
Quartz	1	2	3
Clay minerals	52	61	62
Zeolites	–	–	1
Carbonate unspec.	40	–	–
Diatoms	5	30	35
Radiolarians	1	7	7
Micronodules	1	TR	2

MAGNETIC DATA:	2-5	2-70
Inclination	43.3	–78.8
Declination	130.9	252.6
Intensity (emu/cc)	0.270E–06	0.125E–05

GRAIN SIZE:
2-20 (1, 24, 76)

SITE 514 HOLE CORE (HPC) 24 CORED INTERVAL 98.0–102.4 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Dark greenish gray (5GY 4/1) to greenish gray (5G 6/1). Moderately to highly bioturbated; dark gray burrows. Faint horizontal stratification; laminae more prominent in Sections 2 and 3 with gray/green couplets as before. Bioturbation less with depth; ring burrow in Section 3, 66 cm.

SMEAR SLIDE SUMMARY

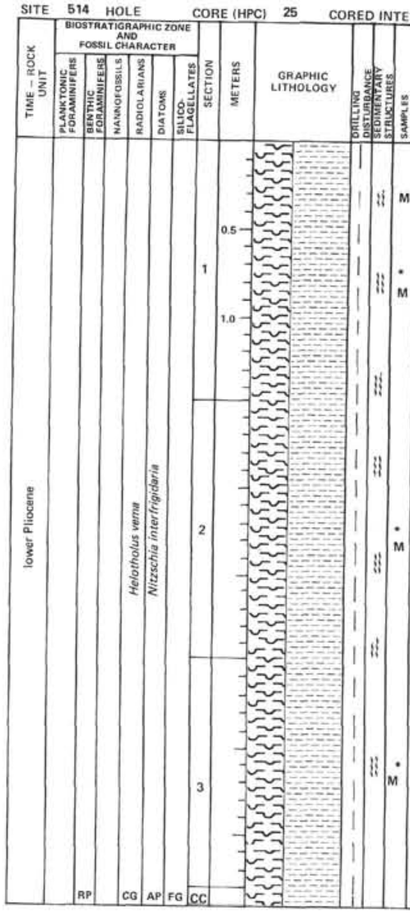
	1-75 D	2-75 D	3-75 D
Quartz	2	5	3
Clay minerals	49	41	53
Zeolites	TR	2	TR
Diatoms	40	45	40
Radiolarians	7	5	3
Micronodules	2	2	1

CARBONATE BOMB:
1, 59–60 (2.5)

MAGNETIC DATA:	1-78	2-45	3-41	3-79
Inclination	–69.9	–72.0	–58.8	–62.3
Declination	120.2	258.4	120.8	259.4
Intensity (emu/cc)	0.100E–05	0.184E–05	0.459E–05	0.210E–05

GRAIN SIZE:
1-35 (1, 26, 73)
3-35 (1, 21, 79)

SITE 514 HOLE CORE (HPC) 25 CORED INTERVAL 102.4–106.8 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Continuation of Core 24. Prominent ring burrow (1x2 cm) Section 3, 115 cm.

SMEAR SLIDE SUMMARY

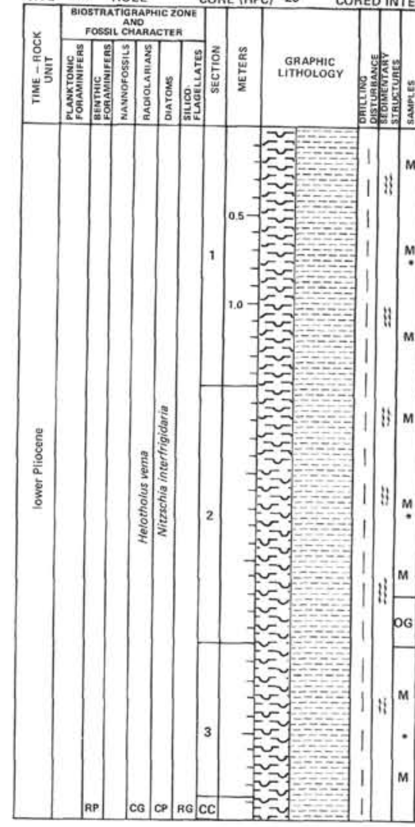
	1-75	2-75	3-60
	D	D	D
Quartz	3	5	10
Clay minerals	56	52	58
Zeolites	2	2	1
Diatoms	35	35	25
Radiolarians	3	5	5
Micronodules	1	1	1

CARBONATE BOMB:
3, 101–102 (2.5)

MAGNETIC DATA:	1-35	1-79	2-79	3-65
Inclination	−17.7	38.6	59.7	41.0
Declination	313.7	230.4	230.0	250.5
Intensity (emu/cc)	0.240E−06	0.570E−06	0.659E−05	0.430E−05

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

SITE 514 HOLE CORE (HPC) 26 CORED INTERVAL 106.8–111.2 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Section 1, 0–140 cm, as in Cores 24 and 25, with very stiff greenish zone at 131–140 cm. Gradational contact with underlying dark olive gray (5Y 3/2), very homogeneous stiff clay, moderately bioturbated, unlaminated.

SMEAR SLIDE SUMMARY

	1-75	2-75	3-50
	D	D	D
Quartz	5	10	10
Feldspar	1	–	–
Clay minerals	61	61	60
Zeolites	–	1	2
Nannofossils	TR	–	–
Diatoms	30	25	25
Radiolarians	3	2	2
Silicoflagellates	TR	–	–
Micronodules	TR	1	1

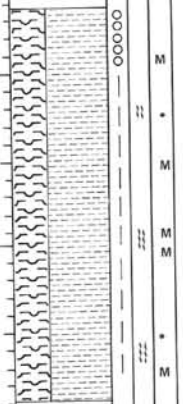
MAGNETIC DATA:	1-21	1-66	1-120	2-21
Inclination	80.7	47.6	79.8	46.9
Declination	100.0	4.1	59.7	341.8
Intensity (emu/cc)	0.700E−06	0.141E−05	0.223E−05	0.211E−05

MAGNETIC DATA:	2-66	2-110	3-28	3-77
Inclination	59.4	28.8	61.3	52.8
Declination	351.2	340.2	346.2	33.0
Intensity (emu/cc)	0.170E−05	0.300E−05	0.334E−05	0.800E−06

GRAIN SIZE:
1-14 (1, 18, 81)
3-14 (0, 21, 79)

SITE 514 HOLE CORE (HPC) 27 CORED INTERVAL 111.2–115.6 m

TIME – ROCK UNIT	PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene				*Helotholus vema*	*Nitzschia interfrigidaria*		1	0.5, 1.0	VOID			M, •, M, M, M
							2		FLOW-IN			•, M
		RP		CG	AP	RG	CC					



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAY
Gray (5Y 5/1) with laminae of dark gray, greenish gray, dark greenish gray, and olive gray. Very firm and stiff; well stratified with green/gray couplets at 8 cm intervals. Moderate bioturbation.

SMEAR SLIDE SUMMARY

	1-75	2-50
	D	D
Quartz	3	10
Barite	–	TR
Other heavy minerals	TR	–
Clay minerals	52	56
Zeolites	1	2
Nannofossils	10	–
Diatoms	30	25
Radiolarians	3	5
Micronodules	1	2

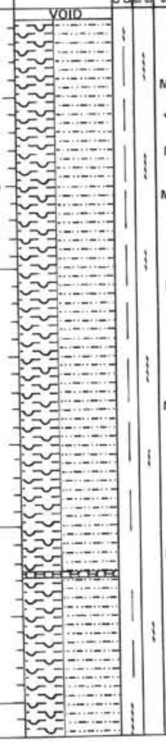
MAGNETIC DATA:	1-47	1-101	1-145
Inclination	–22.2	–81.3	–80.3
Declination	356.5	303.4	283.6
Intensity (emu/cc)	0.129E–04	0.400E–06	0.210E–05

MAGNETIC DATA:	2-13	2-72
Inclination	–80.7	–68.4
Declination	334.9	339.1
Intensity (emu/cc)	0.281E–05	0.426E–05

GRAIN SIZE:
1-62 (1, 23, 76)

SITE 514 HOLE CORE (HPC) 28 CORED INTERVAL 115.6–120.0 m

TIME – ROCK UNIT	PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene				*Helotholus vema*			1	0.5, 1.0	VOID			M, •, M, M, M
							2					M, M
							3					M •, M •
				CG	AM	CG	CC					



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
As in previous cores; dark greenish gray with dark gray and very dusky purple laminae; couplets in Section 3. Black bioturbation and mottling sparse throughout core.

Section 1, 26–30 cm: small (< 1 cm) pale olive (5Y 6/3) indurated clasts high in fine carbonate "unspecified"; white (5Y 8/2) inclusions, < 0.5 cm, high in carbonate in Section 2, 25–48 cm and Section 3, 23–27 cm; bioturbation of same color in Section 3, 0–23 and 27–47 cm. Faint light olive gray (5Y 6/2) mottles sparse in Section 3, below 50 cm.

SMEAR SLIDE SUMMARY

	1-63	3-26	3-83
	D	M	D
Quartz	TR	–	1
Clay minerals	57	8	60
Carbonate unspec.	3	86	1
Nannofossils	TR	TR	–
Diatoms	32	6	35
Radiolarians	3	TR	3
Silicoflagellates	TR	–	TR
Sponge spicules	–	TR	TR
Ebridians	–	–	TR

MAGNETIC DATA:	1-41	1-82	1-116	2-15
Inclination	–75.0	–64.1	–74.2	–64.8
Declination	307.2	235.0	194.4	246.0
Intensity (emu/cc)	0.310E–05	0.930E–06	0.237E–05	0.278E–05

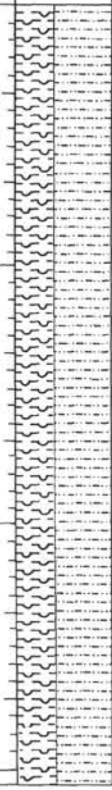
MAGNETIC DATA:	2-82	2-136	3-14	3-82
Inclination	–52.7	–69.4	–72.9	–62.3
Declination	294.2	296.9	298.7	327.8
Intensity (emu/cc)	0.108E–05	0.158E–05	0.900E–06	0.850E–06

GRAIN SIZE:
1-70 (1, 18, 81)
2-70 (1, 31, 69)

SITE 514 HOLE CORE (HPC) 29 CORED INTERVAL 120.0–124.4 m

TIME – ROCK UNIT	PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene	RP	RP		CG *Helotholus vema*	AM *Nitzschia interfrigidaria*	FG	1, 2, 3, CC	0.5, 1.0				*, M, *, M, M, M, M, *, M, M

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD

As in previous cores, dark greenish gray with sparse pale olive mottles; black bioturbations, and laminae sparse in Section 1, more prominent down section. Couplets present in Section 3. Pale olive (5Y 6/3) lens high in carbonate in Section 1, 32–37 cm.

SMEAR SLIDE SUMMARY

	1-35 M	1-100 D	3-50 D
Quartz	TR	2	5
Feldspar	–	–	TR
Clay minerals	31	60	64
Carbonate unspec.	60	1	1
Diatoms	8	32	26
Radiolarians	1	4	4
Silicoflagellates	TR	1	TR
Sponge spicules	TR	TR	TR

CARBONATE BOMB:
2, 54–55 (2.5)

MAGNETIC DATA:	1-91	2-26	2-91	2-126
Inclination	–60.8	–58.5	–61.0	–60.3
Declination	96.6	116.6	129.1	113.2
Intensity (emu/cc)	0.166E–05	0.103E–05	0.173E–05	0.106E–05

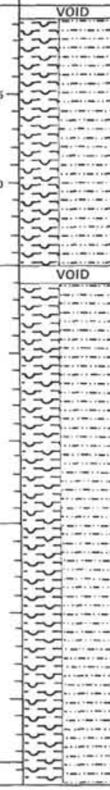
MAGNETIC DATA:	3-26	3-91	3-126
Inclination	–64.8	–51.5	–49.4
Declination	56.2	64.8	84.0
Intensity (emu/cc)	0.141E–05	0.278E–05	0.132E–05

GRAIN SIZE:
1-43 (1, 24, 75)
3-43 (0, 24, 76)

SITE 514 HOLE CORE (HPC) 30 CORED INTERVAL 124.4–128.8 m

TIME – ROCK UNIT	PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene		RP		CG *Helotholus vema*	CP *Nitzschia angulata*	RG	1, 2, 3, CC	0.5, 1.0	VOID, VOID			M, *, M, M, M, M, M, M, M, M, M, *, M, M

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD

As in previous cores, mottling sparse. Laminae sparse in Section 1; laminae couplets common in Sections 2 and 3.

SMEAR SLIDE SUMMARY

	1-60 D	3-50 D
Quartz	2	2
Clay minerals	68	72
Carbonate unspec.	1	2
Nannofossils	–	TR
Diatoms	25	20
Radiolarians	4	4
Silicoflagellates	TR	TR
Sponge spicules	TR	TR

MAGNETIC DATA:	1-36	1-88	1-92	1-98
Inclination	–71.4	–70.0	41.4	32.4
Declination	185.3	327.6	40.9	300.9
Intensity (emu/cc)	0.720E–06	0.270E–06	0.790E–06	0.280E–06

MAGNETIC DATA:	1-115	1-131	2-27	2-88
Inclination	70.0	25.5	33.9	59.6
Declination	359.6	325.9	20.2	40.8
Intensity (emu/cc)	0.410E–06	0.740E–06	0.600E–06	0.104E–05

MAGNETIC DATA:	2-131	3-36	3-88	3-121
Inclination	71.0	70.6	46.7	54.4
Declination	38.1	11.7	15.3	16.0
Intensity (emu/cc)	0.650E–06	0.390E–06	0.214E–05	0.127E–05

GRAIN SIZE:
1-83 (1, 20, 79)
3-83 (1, 21, 78)

SITE 514 HOLE CORE (HPC) 31 CORED INTERVAL 128.8–133.2 m

TIME – ROCK UNIT: lower Pliocene

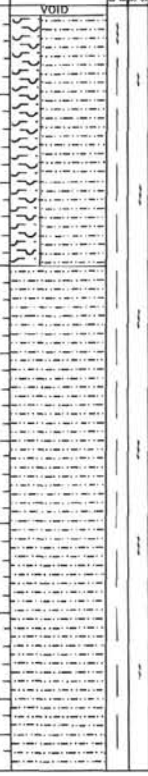
BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Helotholus vema/Desmospyris spongiosa* undifferentiated

PLANKTONIC FORAMINIFERS | BENTHIC FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | SILICO-FLAGELLATES | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

RM FM CG AP RG

Sections: 1, 2, 3, CC; Meters: 0.5, 1.0

VOID



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD AND MUD

As in previous cores, with laminae couplets common in all sections. Black mottles sparse as is pale olive (5Y 6/3) mottles. Increased carbonate content in Section 2 and locally in Section 3.

MUD

Diatom content markedly decreased in Sections 2 and 3, otherwise the sediment is the same as before.

SMEAR SLIDE SUMMARY

	1-85 D	2-70 D	3-30 D
Quartz	3	1	1
Clay minerals	77	83	88
Carbonate unspec.	1	5	2
Foraminiferss	–	1	–
Nannofossils	TR	2	–
Diatoms	15	6	6
Radiolarians	4	2	3
Silicoflagellates	TR	TR	TR
Sponge spicules	TR	TR	TR

CARBONATE BOMB:
2, 64–65 (3)

MAGNETIC DATA:	1-45	1-89	1-131	2-45
Inclination	51.7	70.2	57.7	59.9
Declination	209.3	137.6	227.1	296.5
Intensity (emu/cc)	0.315E–05	0.120E–06	0.730E–06	0.950E–06

MAGNETIC DATA:	2-89	2-131	3-45	3-89
Inclination	77.3	45.4	80.9	48.7
Declination	146.2	301.3	182.4	245.5
Intensity (emu/cc)	0.580E–06	0.102E–05	0.122E–05	0.340E–06

GRAIN SIZE:
1-13 (1, 23, 77)
3-13 (1, 23, 77)

SITE 514 HOLE CORE (HPC) 32 CORED INTERVAL 133.2–137.6 m

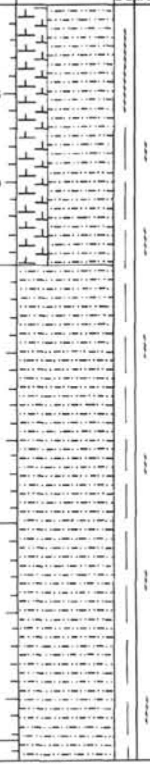
TIME – ROCK UNIT: lower Pliocene

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER: *Helotholus vema/Desmospyris spongiosa* undifferentiated

PLANKTONIC FORAMINIFERS | BENTHIC FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | SILICO-FLAGELLATES | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

RM FM CM AM CG

Sections: 1, 2, 3, CC; Meters: 0.5, 1.0



LITHOLOGIC DESCRIPTION

NANNOFOSSIL MUD AND MUD

Nannofossil mud in Section 1, 0–150 cm dark greenish gray (5G 4/1) with faint, sparse, greenish black and very dusky purple laminae and rare couplets. Sparse black bioturbations.

Mud (5G 4/1) in Sections 2 and 3, with laminae couplets faint but common. Sparse black bioturbations. Very sparse pale olive (5Y 6/3) mottles as in previous core.

SMEAR SLIDE SUMMARY

	1-90 D	2-60 D	3-65 D
Quartz	–	2	2
Clay minerals	74	83	82
Carbonate unspec.	5	2	1
Foraminifers	3	1	1
Nannofossils	15	TR	TR
Diatoms	–	9	10
Radiolarians	5	3	4
Silicoflagellates	TR	TR	TR
Sponge spicules	TR	TR	TR

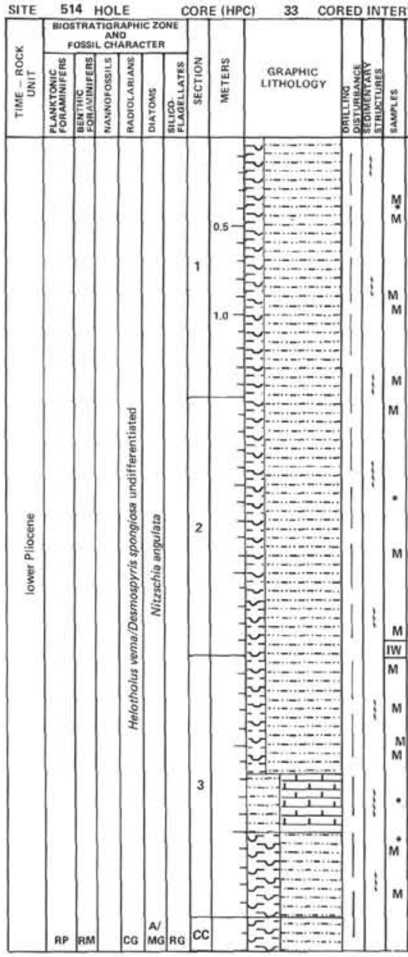
MAGNETIC DATA:	1-73	1-93	1-97	1-115
Inclination	60.0	–35.2	–32.4	–10.9
Declination	290.2	5.7	150.1	21.4
Intensity (emu/cc)	0.860E–05	0.120E–06	0.240E–06	0.900E–07

MAGNETIC DATA:	1-140	2-25	2-68	2-101
Inclination	– 7.3	60.3	54.9	64.3
Declination	228.9	37.2	129.3	110.8
Intensity (emu/cc)	0.140E–06	0830E–06	0.950E–06	0.750E–06

MAGNETIC DATA:	3-39	3-68	3-101
Inclination	58.1	38.8	55.7
Declination	99.8	56.8	118.4
Intensity (emu/cc)	0.420E–06	0.680E–06	0.530E–06

GRAIN SIZE:
1-21 (5, 21, 75)
3-21 (1, 22, 78)

SITE 514 HOLE CORE (HPC) 33 CORED INTERVAL 137.6–142.0 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
Dark greenish gray (5G 4/1); sparse greenish black and very dusky purple laminae; laminae couplets common. Black mottling throughout. Ring burrows common in Sections 2 and 3. Pale olive mottles sparse to moderate.

MUDDY NANNOFOSSIL CHALK
Section 3, 65–100 cm: white (5Y 8/1), with moderate pale olive mottling at 86–89 cm. Lower contact at 100 cm sharp, bioturbated.

SMEAR SLIDE SUMMARY

	1-40	2-60	3-82	3-105
	D	D	M	D
Quartz	3	1	–	3
Clay minerals	76	75	26	66
Carbonate unspec.	1	1	5	1
Foraminifers	–	1	7	1
Nannofossils	–	TR	55	1
Diatoms	15	17	6	25
Radiolarians	5	5	1	3
Silicoflagellates	TR	TR	TR	TR
Sponge spicules	TR	TR	TR	TR

CARBONATE BOMB:
2, 64–65 (2.5)
3, 84–85 (70)

MAGNETIC DATA:	1-37	1-53	1-87	1-93
Inclination	59.6	56.7	64.1	68.5
Declination	343.4	346.0	316.8	26.5
Intensity (emu/cc)	0.360E–06	0.450E–06	0.115E–05	0.640E–06

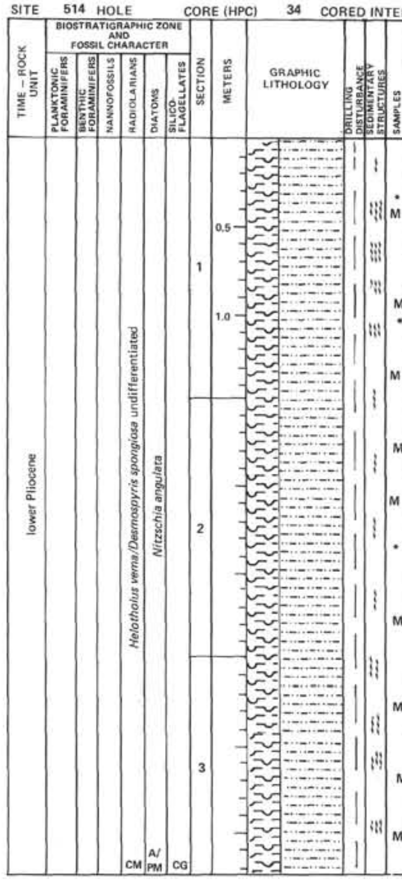
MAGNETIC DATA:	1-133	2-10	2-87	2-133
Inclination	57.1	69.4	64.4	67.3
Declination	275.5	49.3	25.6	31.2
Intensity (emu/cc)	0.630E–06	0.480E–06	0.310E–06	0.550E–06

MAGNETIC DATA:	3-10	3-28	3-48	3-51
Inclination	61.7	57.8	– 1.3	42.8
Declination	34.9	356.0	119.5	78.5
Intensity (emu/cc)	0.930E–06	0.760E–06	0.810E–06	0.330E–06

MAGNETIC DATA:	3-109	3-133
Inclination	44.1	33.8
Declination	40.3	75.4
Intensity (emu/cc)	0.640E–06	0.940E–06

GRAIN SIZE:
1-40 (1, 24, 76)
3-40 (1, 9, 90)

SITE 514 HOLE CORE (HPC) 34 CORED INTERVAL 142.0–146.4 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD
As in previous core, with sparse black (5Y 2/1), greenish black, and pale olive (5Y 6/3) mottling, the latter color intensely mottled in Section 1, 30–117 cm. Faint greenish black laminae sparse throughout. Pale yellow mottling moderate through Section 3, heavy in Section 3, 58–102 cm.

White sedimentary clasts (up to 4 cm) in upper 35 cm of Section 1, composed of nannofossil chalk.

SMEAR SLIDE SUMMARY

	1-34	1-101	2-88
	M	D	D
Quartz	TR	3	3
Clay minerals	68	76	63
Carbonate unspec.	4	1	1
Foraminifers	7	–	–
Nannofossils	18	–	TR
Diatoms	3	18	30
Radiolarians	TR	2	2
Silicoflagellates	–	TR	1
Sponge spicules	–	TR	TR

CARBONATE BOMB:
3, 42–43 (3.1)

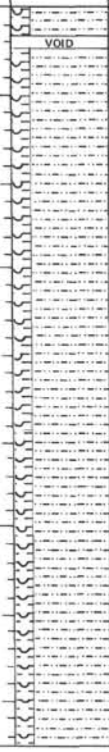
MAGNETIC DATA:	1-46	1-99	1-136	2-31
Inclination	45.6	37.9	59.1	42.9
Declination	257.1	226.4	260.8	259.5
Intensity (emu/cc)	0.990E–06	0.910E–06	0.102E–05	0.810E–06

MAGNETIC DATA:	2-67	2-136	3-31	3-67
Inclination	50.4	42.5	48.7	17.3
Declination	226.0	257.9	203.3	289.4
Intensity (emu/cc)	0.770E–06	0.460E–05	0.141E–05	0.136E–05

MAGNETIC DATA:	3-99
Inclination	30.0
Declination	122.5
Intensity (emu/cc)	0.284E–04

GRAIN SIZE:
1-108 (1, 19, 80)

SITE 514 HOLE CORE (HPC) 35 CORED INTERVAL 146.4–150.8 m

TIME – ROCK UNIT	PLANKTONIC FORAMINIFERS	BENTHIC FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SILICO-FLAGELLATES	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
lower Pliocene	RP	RP		*Helotholus vema/Desmospyris spongiosa* undifferentiated; CG	*Nitzschia angulata*; AM	CG	1, 2, 3	0.5, 1.0				•, M, M, M, M, M, M, M, •, M

BIOSTRATIGRAPHIC ZONE AND FOSSIL CHARACTER

LITHOLOGIC DESCRIPTION

DIATOMACEOUS MUD

As in previous cores, dark greenish gray (5GY 4/1), homogeneous with sparse black (5Y 2/1) mottling throughout. Sparse bioturbation throughout. Greenish black and very dusky purple laminae, with numerous couplets, in Sections 2 and 3.

SMEAR SLIDE SUMMARY

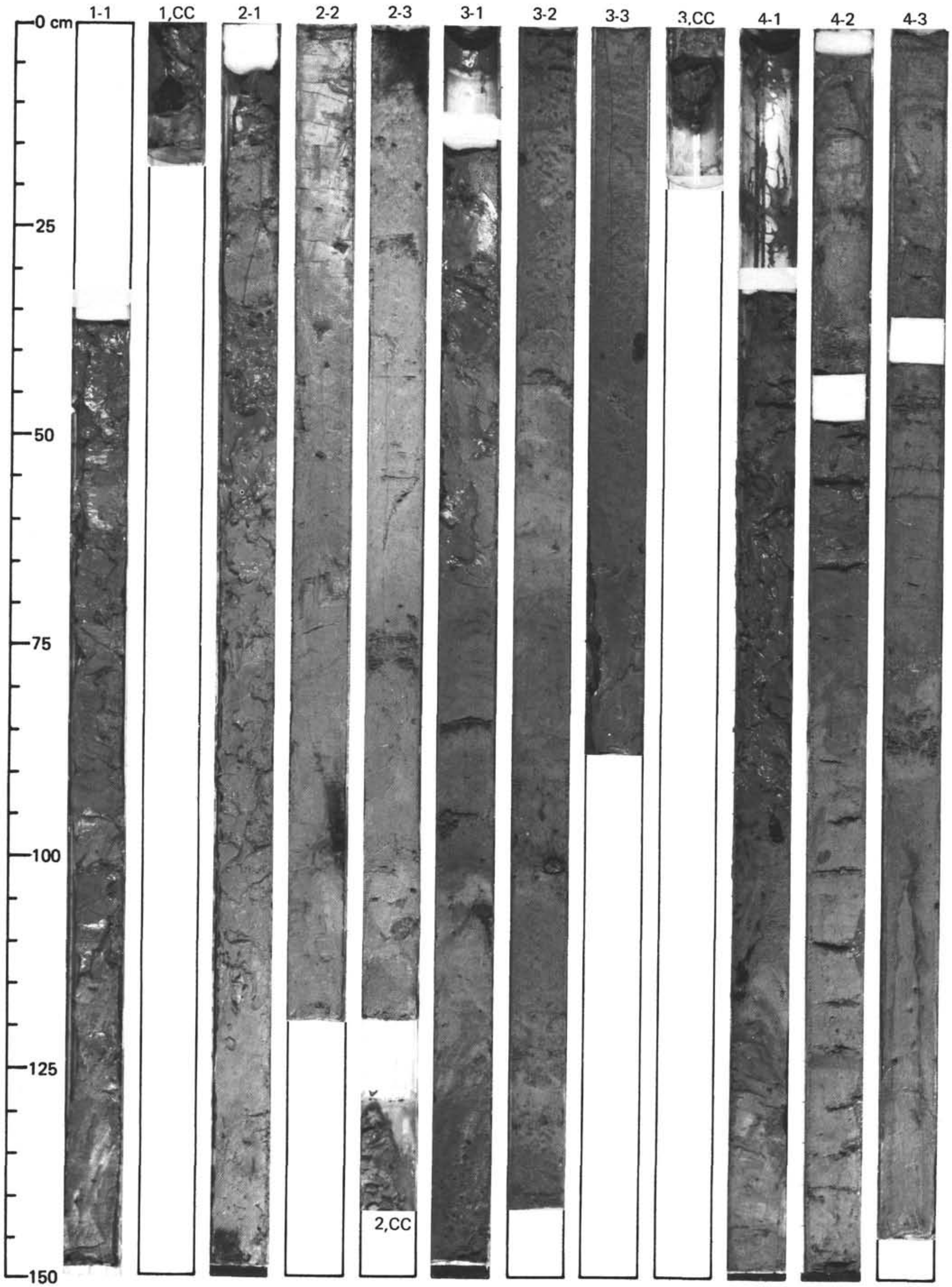
	1-80	3-65
	D	D
Quartz	3	2
Clay minerals	77	75
Carbonate unspec.	1	1
Nannofossils	TR	–
Diatoms	17	18
Radiolarias	2	3
Silicoflagellates	TR	1
Sponge spiucles	TR	TR

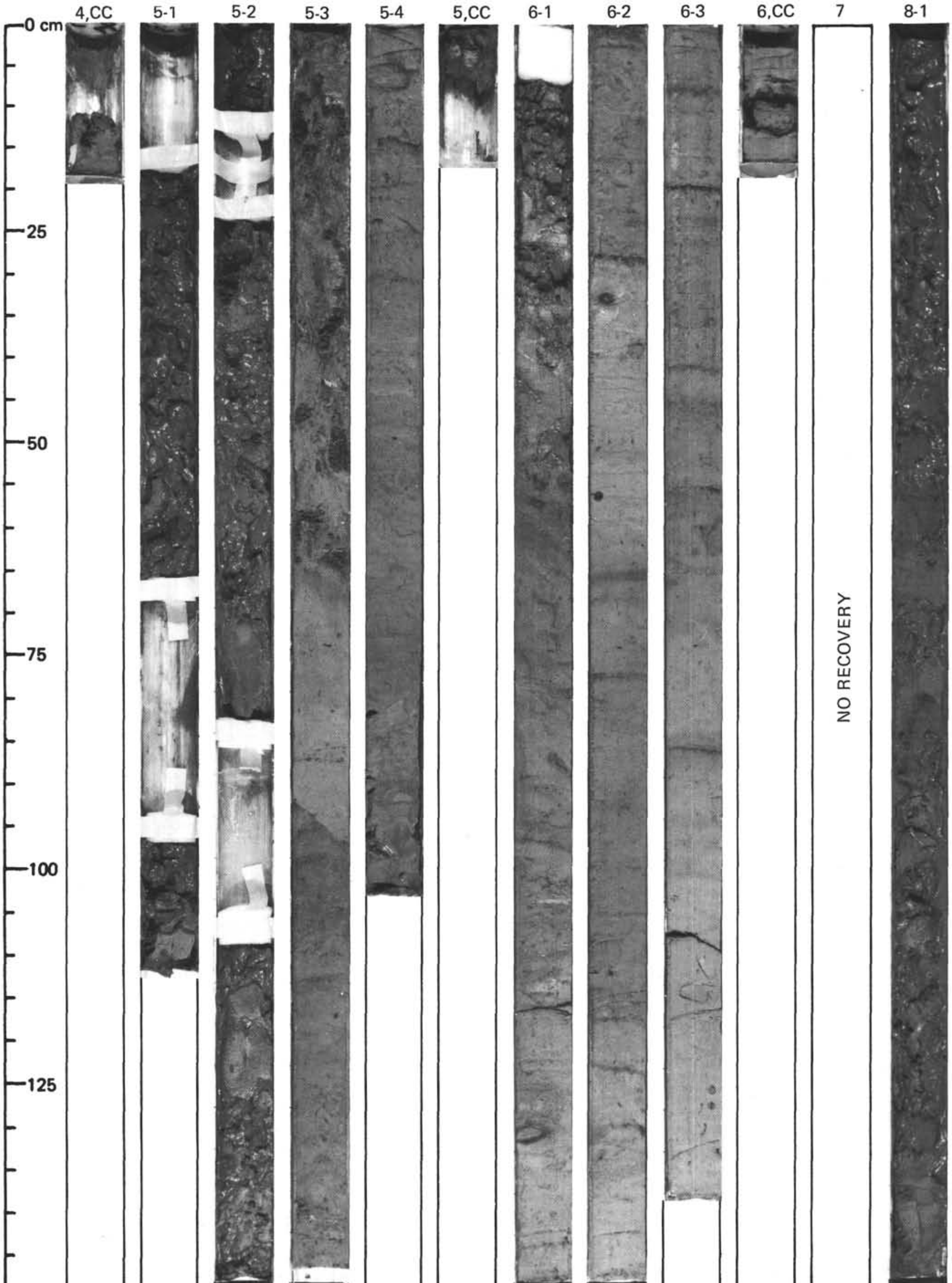
CARBONATE BOMB:
3, 48–49 (2.5)

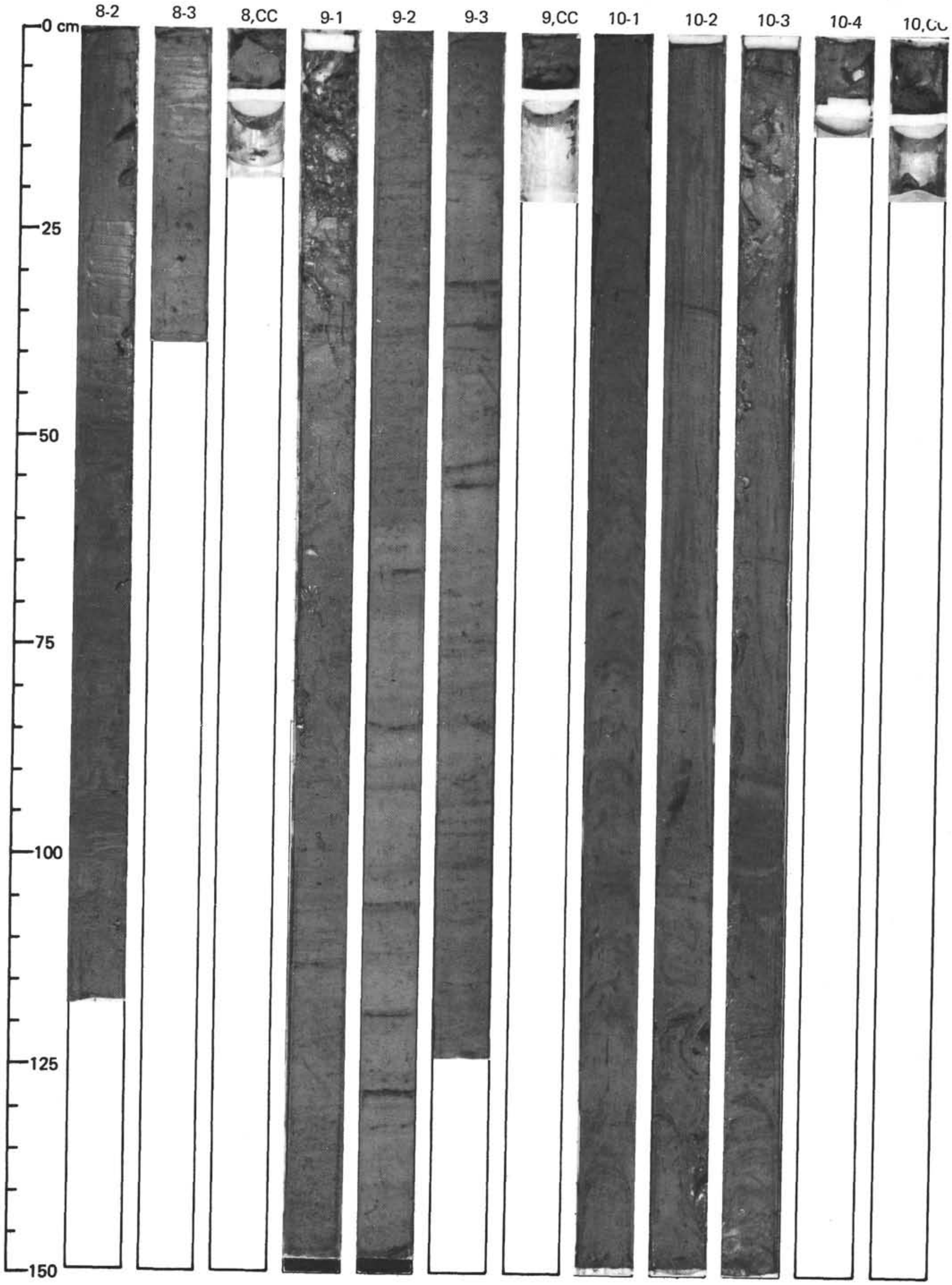
MAGNETIC DATA:	2-24	2-84	2-139	3-12
Inclination	63.1	42.4	70.5	63.3
Declination	175.8	199.3	245.3	222.0
Intensity (emu/cc)	0.920E–06	0.910E–06	0.630E–06	0.860E–06

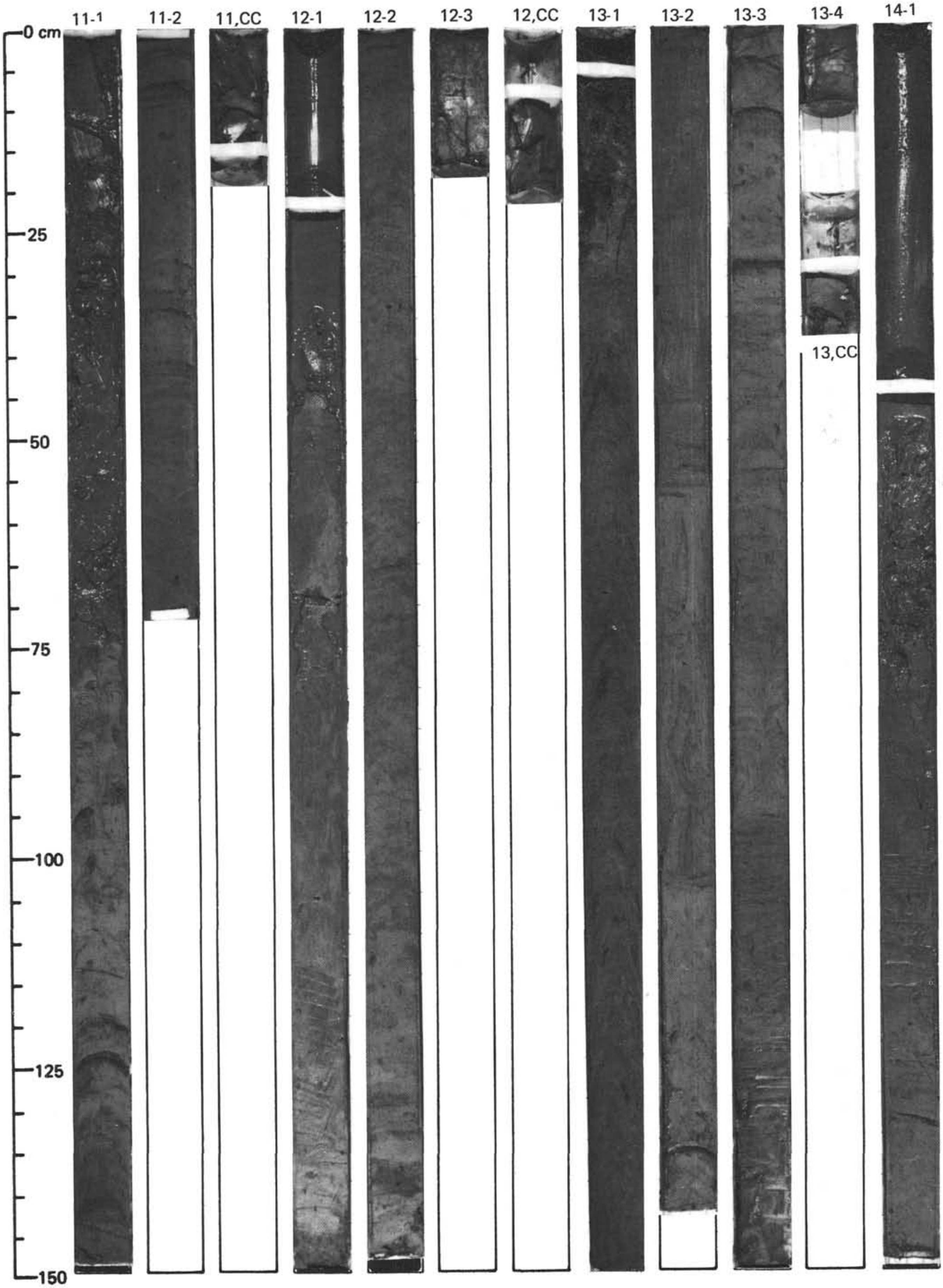
MAGNETIC DATA:	3-24	3-28	3-43	3-69
Inclination	–11.0	65.8	76.1	48.0
Declination	26.6	187.5	15.9	92.9
Intensity (emu/cc)	0.413E–05	0.870E–06	0.130E–05	0.480E–06

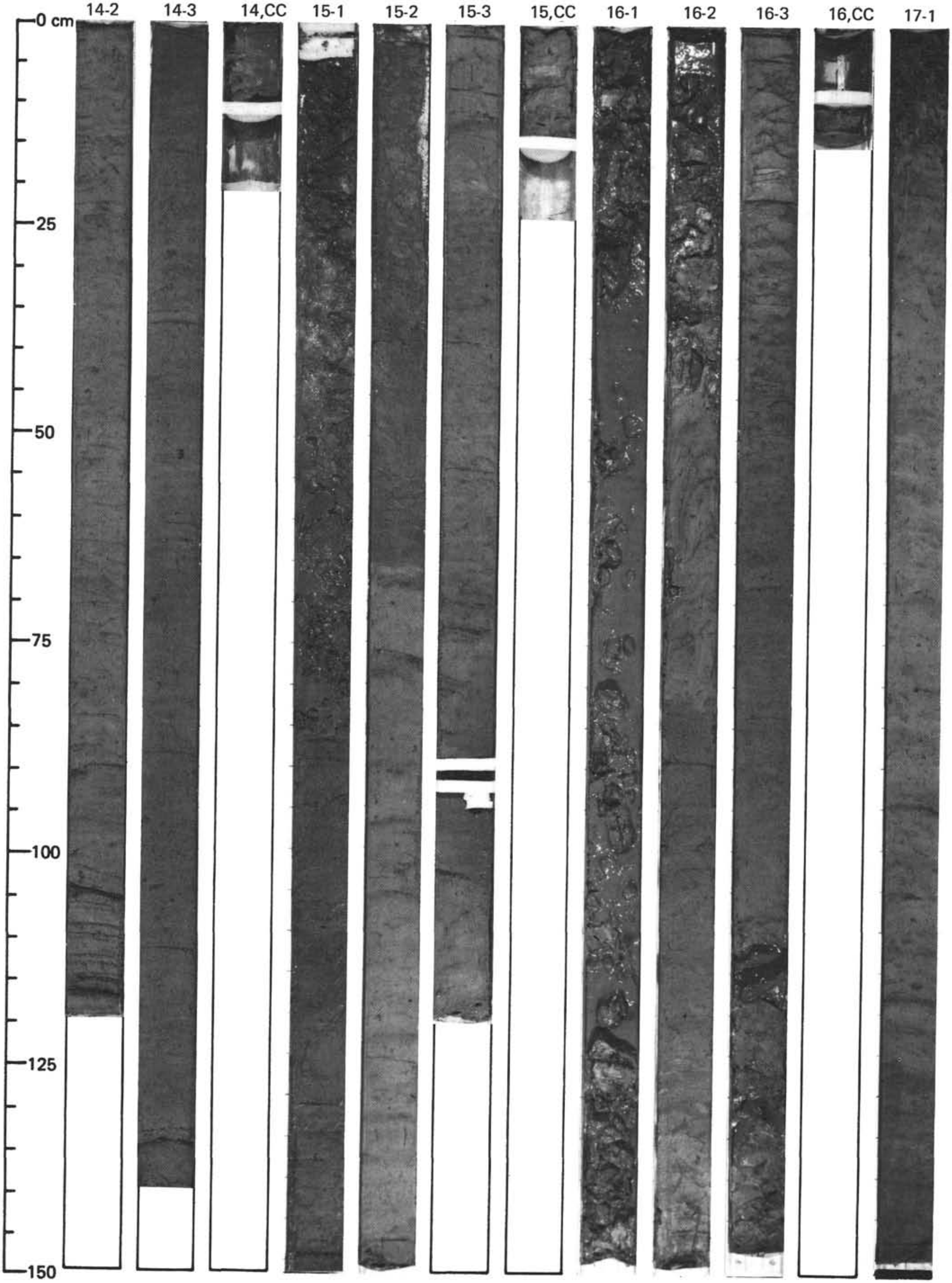
GRAIN SIZE:
1-50 (2, 26, 73)
3-50 (1, 29, 71)

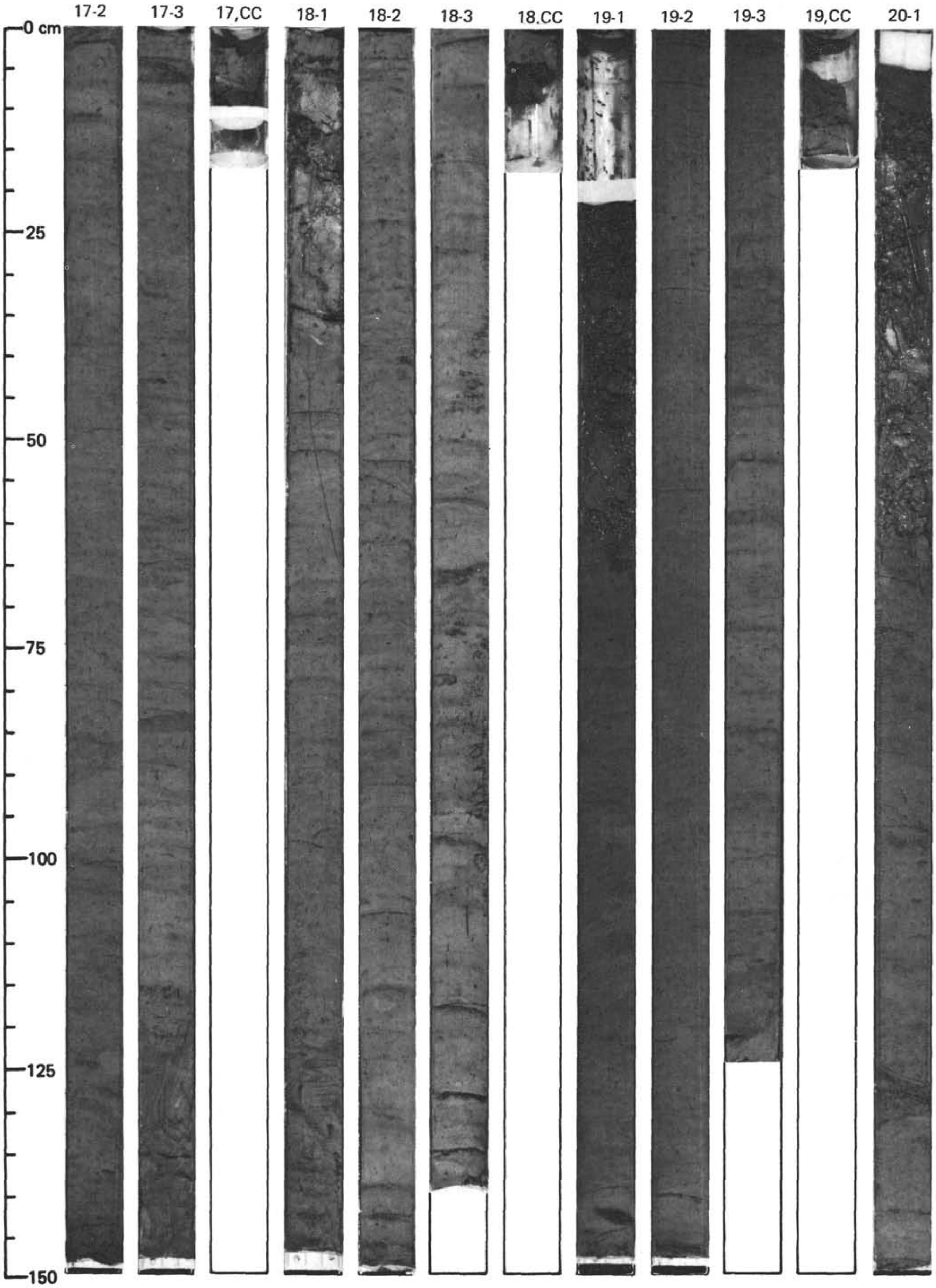

0 cm
25
50
75
100
125
150
1-1
1,CC
2-1
2-2
2-3
3-1
3-2
3-3
3,CC
4-1
4-2
4-3
2,CC

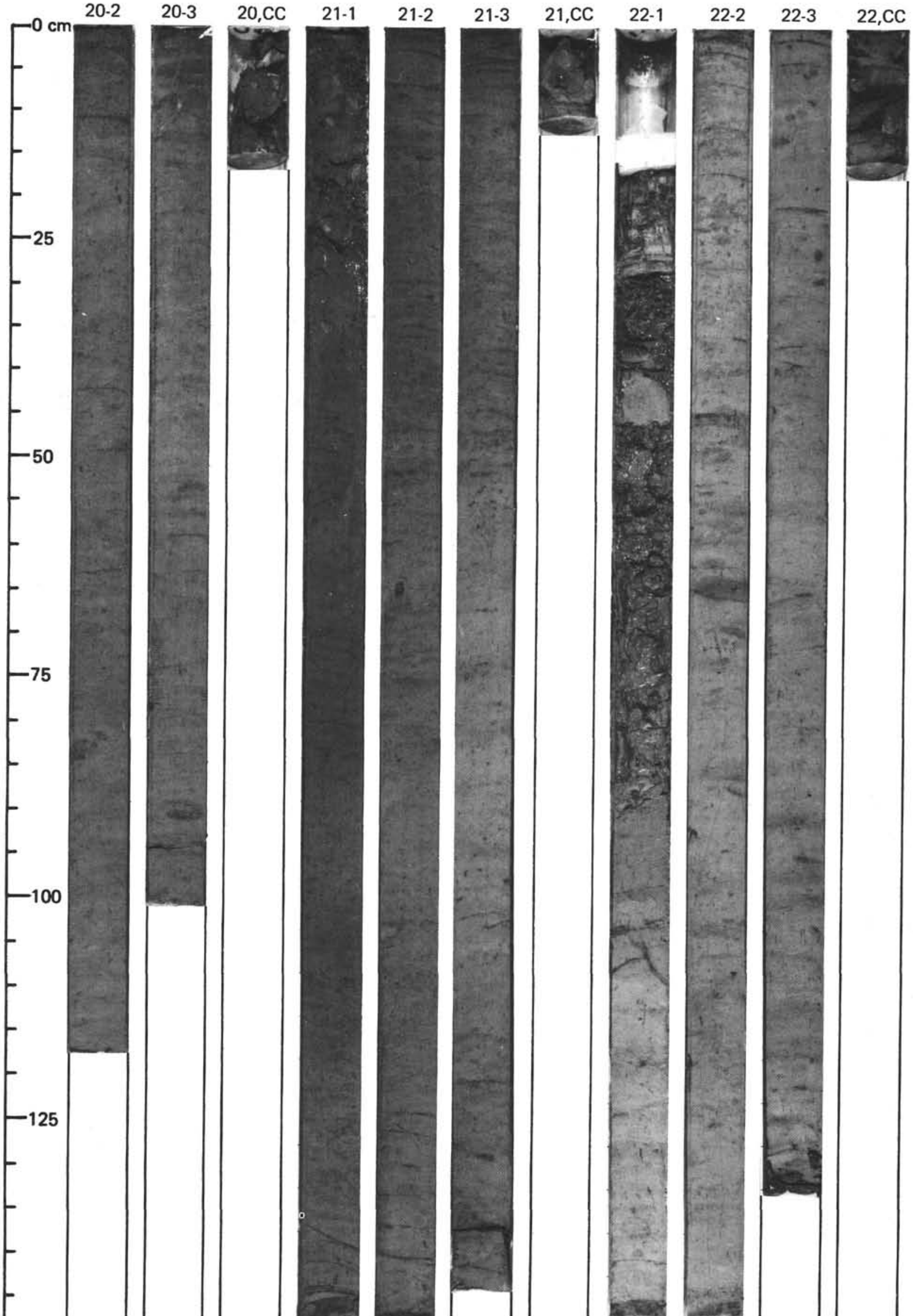

0 cm
25
50
75
100
125
150
4,CC
5-1
5-2
5-3
5-4
5,CC
6-1
6-2
6-3
6,CC
7
8-1
NO RECOVERY

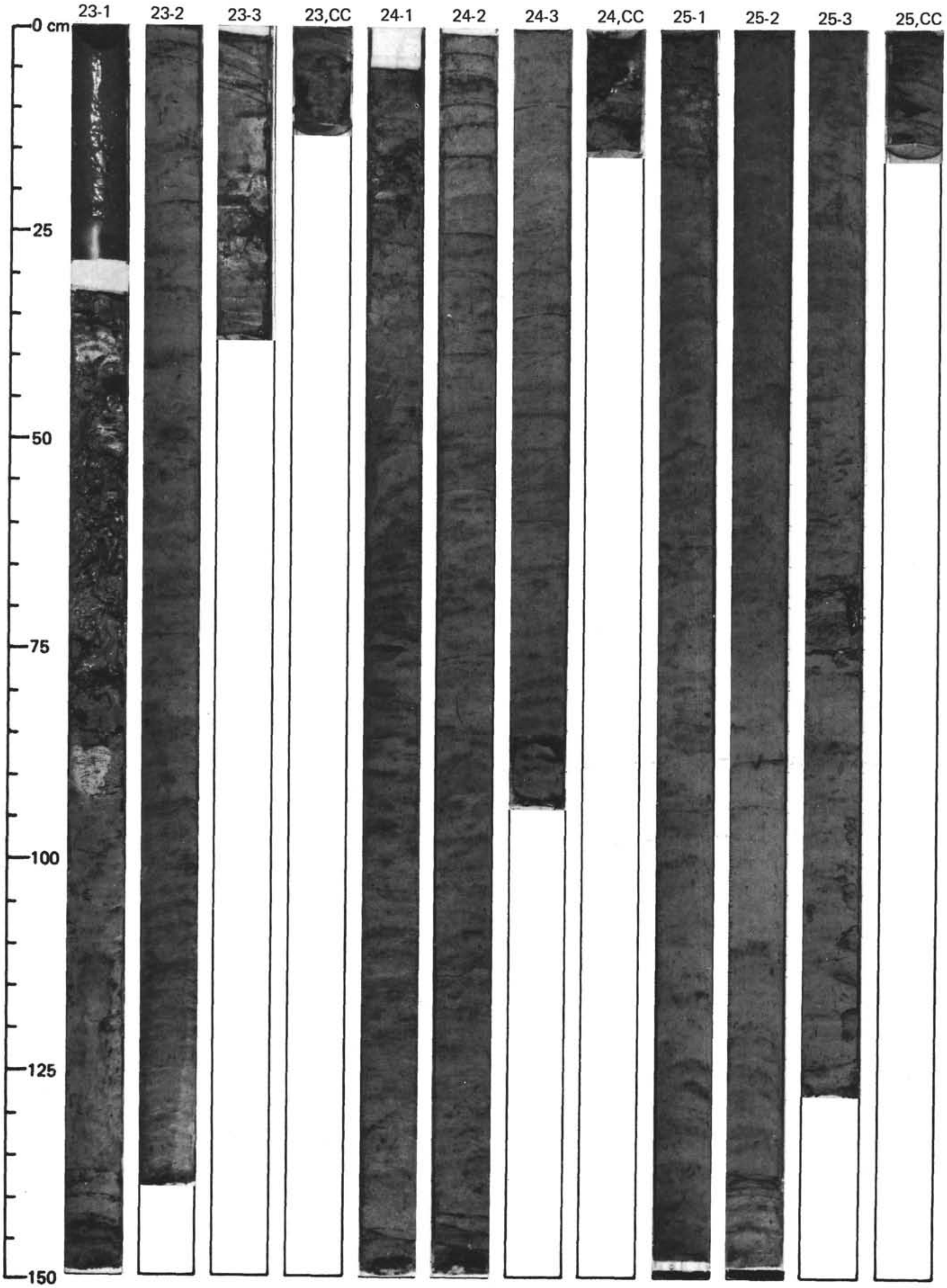

8-2
8-3
8,CC
9-1
9-2
9-3
9,CC
10-1
10-2
10-3
10-4
10,CC
0 cm
25
50
75
100
125
150

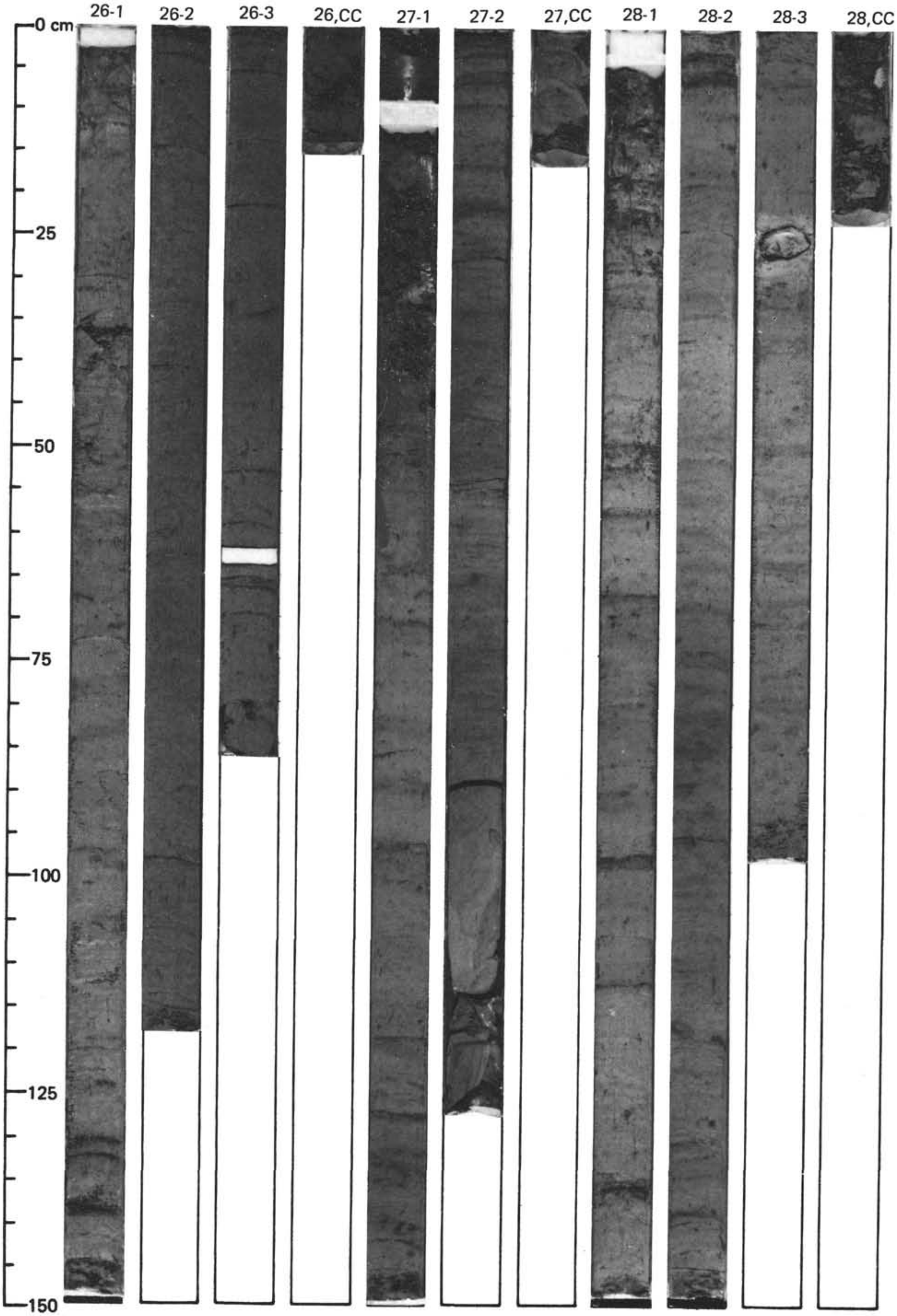

11-1
11-2
11,CC
12-1
12-2
12-3
12,CC
13-1
13-2
13-3
13-4
14-1
13,CC
0 cm
25
50
75
100
125
150

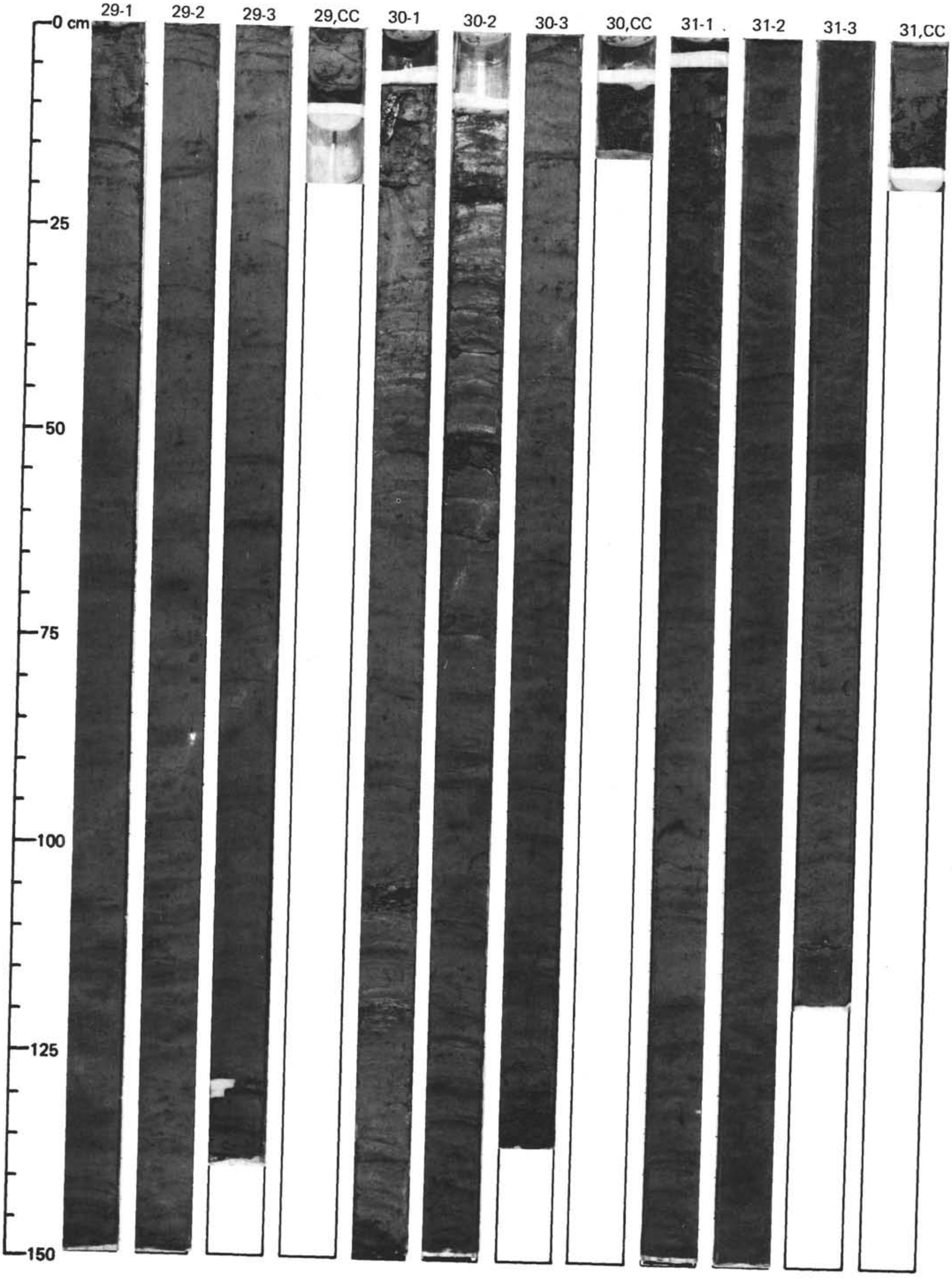

14-2
14-3
14,CC
15-1
15-2
15-3
15,CC
16-1
16-2
16-3
16,CC
17-1
0 cm
25
50
75
100
125
150


17-2
17-3
17,CC
18-1
18-2
18-3
18.CC
19-1
19-2
19-3
19,CC
20-1
0 cm
25
50
75
100
125
150

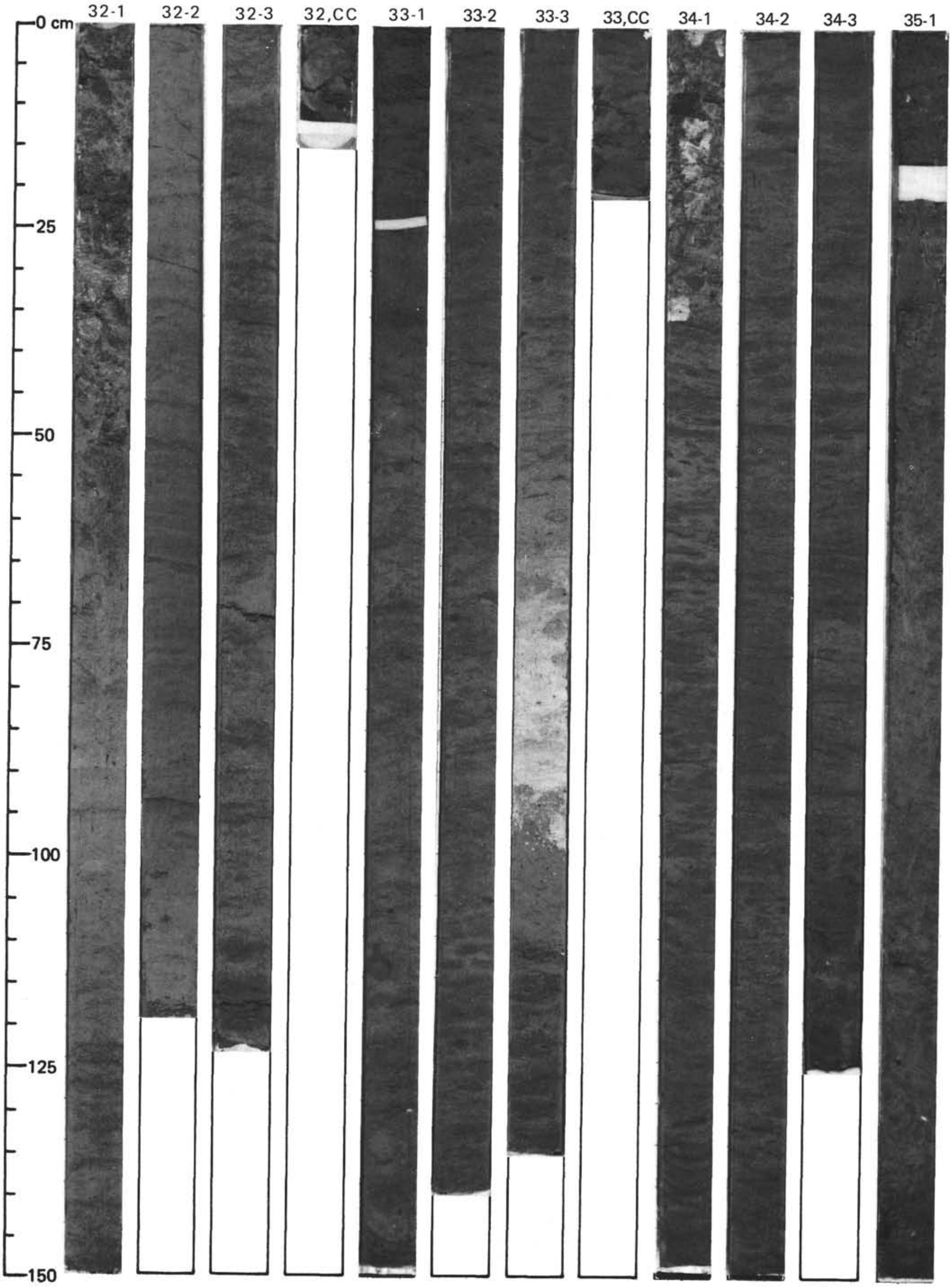

20-2
20-3
20,CC
21-1
21-2
21-3
21,CC
22-1
22-2
22-3
22,CC
0 cm
25
50
75
100
125
150

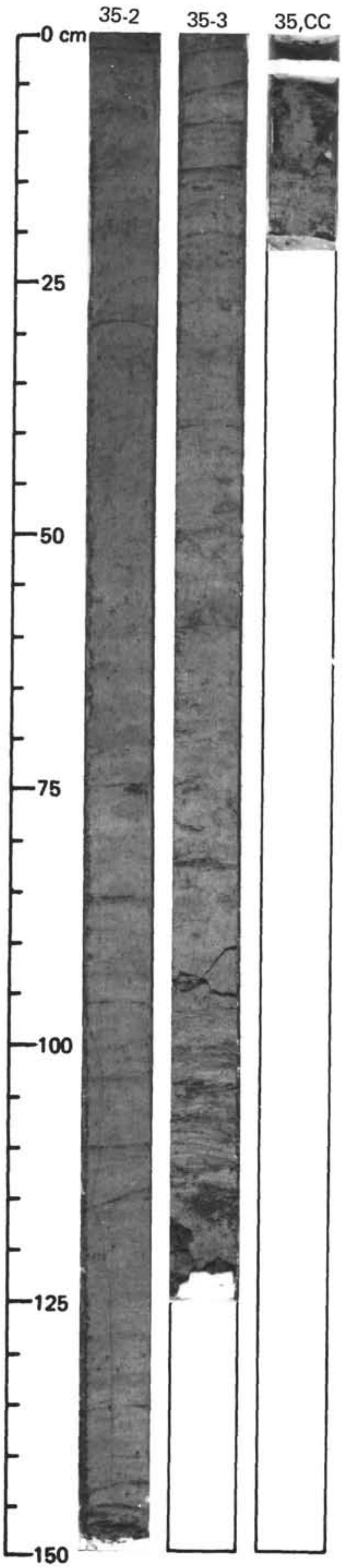

23-1
23-2
23-3
23,CC
24-1
24-2
24-3
24,CC
25-1
25-2
25-3
25,CC
0 cm
25
50
75
100
125
150


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



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


32-1
32-2
32-3
32,CC
33-1
33-2
33-3
33,CC
34-1
34-2
34-3
35-1
0 cm
25
50
75
100
125
150


35-2
35-3
35,CC
0 cm
25
50
75
100
125
150