5. GUAYMAS BASIN SLOPE: SITES 479 AND 480[1]

Shipboard Scientific Party[2]

BACKGROUND AND OBJECTIVES

Drilling at these two sites on the continental slope of the northeast side of the Guaymas Basin, off the city of Guaymas, Sonora, had three principal objectives:

1) Knowledge of the history of the proto-Gulf of California.

2) The best possible core recovery of the laminated diatomaceous sediments from the oxygen minimum on this continental slope.

3) The first full-scale field test of the newly developed Serocki–Storms–Cameron hydraulic piston corer (HPC).

Moore and Buffington (1968) and Moore (1973) first pointed out that the Gulf is not closed in a reconstruction by taking out the sea floor apparently formed during the past 3.5 m.y. A marine basin of moderate water depth prior to that time is indicated by such a geometric reconstruction, by evidence from surrounding land geology and well information, and by structure and dredge samples from escarpments along the margins of the new basins. An excellent example of such a presumed proto-Gulf remnant lies along the mainland side of the Guaymas Basin, and Moore (1973) reported on a dredge sample (D-5) of Miocene or early Pliocene argillaceous siltstone from this scarp.

Sites 479 and 480 are located approximately on a profile from Moore (1973) (see Fig. 3). The Dredge Sample D-5 is from the scarp below these sites. Site 479 (GCA-29) is in the axis of the syncline above the scarp and was planned to penetrate two unconformities that might reveal some of the history of the present phase of opening and history of the transform fault that forms the scarp. If it had been possible to penetrate well below these unconformities, we might have been able to sample some of the proto-Gulf sediments analogous to the dredge sample and possibly basement of the proto-Gulf. Safety considerations halted our drilling, however, and the nature of this basement rock is not yet known. One hypothesis of the origin of the proto-Gulf is "back-arc" extension and formation either of oceanic crust or thinned continental crust that occurred during the Miocene (Karig and Jensky, 1972). Others have proposed an earlier period of rifting (Moore and Buffington 1978; Jensky, 1974; Mammerickx, 1980).

The Guaymas Basin is an area high in organic productivity, with strong diatom blooms generally extending somewhat randomly throughout the year—although there is apparently some tendency for increased numbers of blooms in autumn and spring. The basin also receives a large contribution of terrigenous sediment from major rivers on the mainland flank, especially from the Yaqui. Rains are highly seasonal and concentrated during most years in July, August, and September, although occasionally the area receives some of the winter rains of December and January—more typical of southern California in the climatic zone to the north. The result of these two seasonally influenced sources of sediment is deposition of alternating laminae of diatom-rich layers and layers rich in terrigenous sediment into laminae or varve pairs. Calvert (1964, 1966) concluded that the predominant seasonal influence is the terrigenous sediment supply.

The other environmental factor contributing to formation of these laminated sequences is preferential preservation in the strong oxygen minimum between 300 and 1400 meters (Fig. 1). Essentially the same seasonal sediment supplies are delivered to the slopes and to the basin floors, with the exception of additional turbidite supply to the basin floors, especially during times of lowered sea level. Benthic organisms destroy the laminations above and below the oxygen minimum but not within it (Figs. 2, 3).

Detailed sampling and study of these laminated sequences of sediment thus offer the possibility of gaining information and insight into varying environmental conditions, such as climatic changes and cycles, changes in circulation patterns, changes in depth of oxygen minimum, changes in sea level, and changes in floral and faunal assemblages. Sampling a sufficient thickness of a laminated sequence would furthermore make some study of diagenetic changes and lithification possible.

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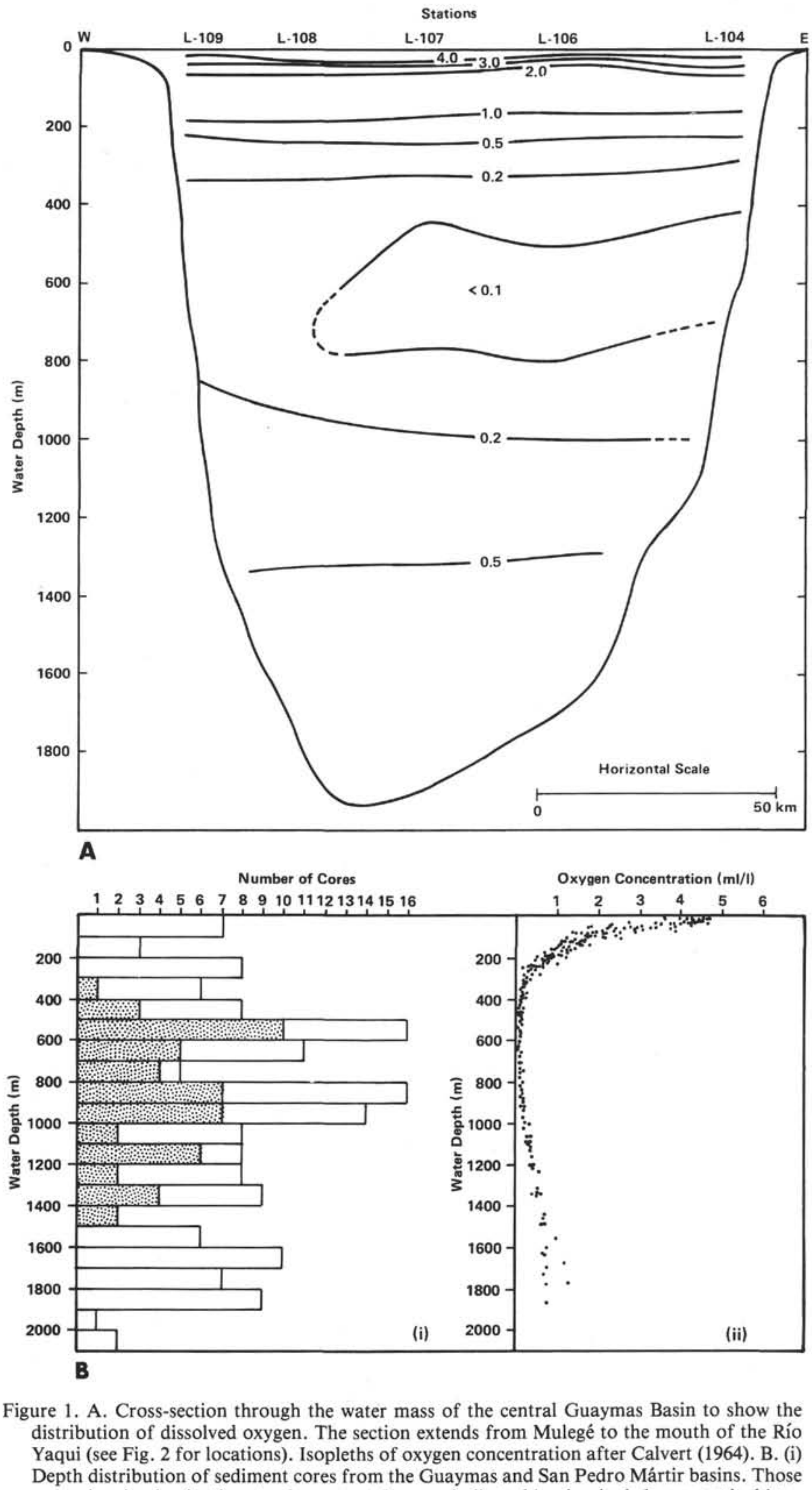

Figure 1. A. Cross-section through the water mass of the central Guaymas Basin to show the distribution of dissolved oxygen. The section extends from Mulegé to the mouth of the Río Yaqui (see Fig. 2 for locations). Isopleths of oxygen concentration after Calvert (1964). B. (i) Depth distribution of sediment cores from the Guaymas and San Pedro Mártir basins. Those cores showing laminations to the core surface are indicated by the shaded area on the histogram. The remaining cores are homogeneous, mottled, or partially laminated (homogeneous at the surface, but laminated at some variable depth in the core). (ii) Vertical distribution of dissolved oxygen from 20 hydrographic stations occupied in the Guaymas and San Pedro Mártir basins during October–November 1961. Each point represents a single determination from a Nansen bottle sample at the depth indicated (from Calvert, 1964).

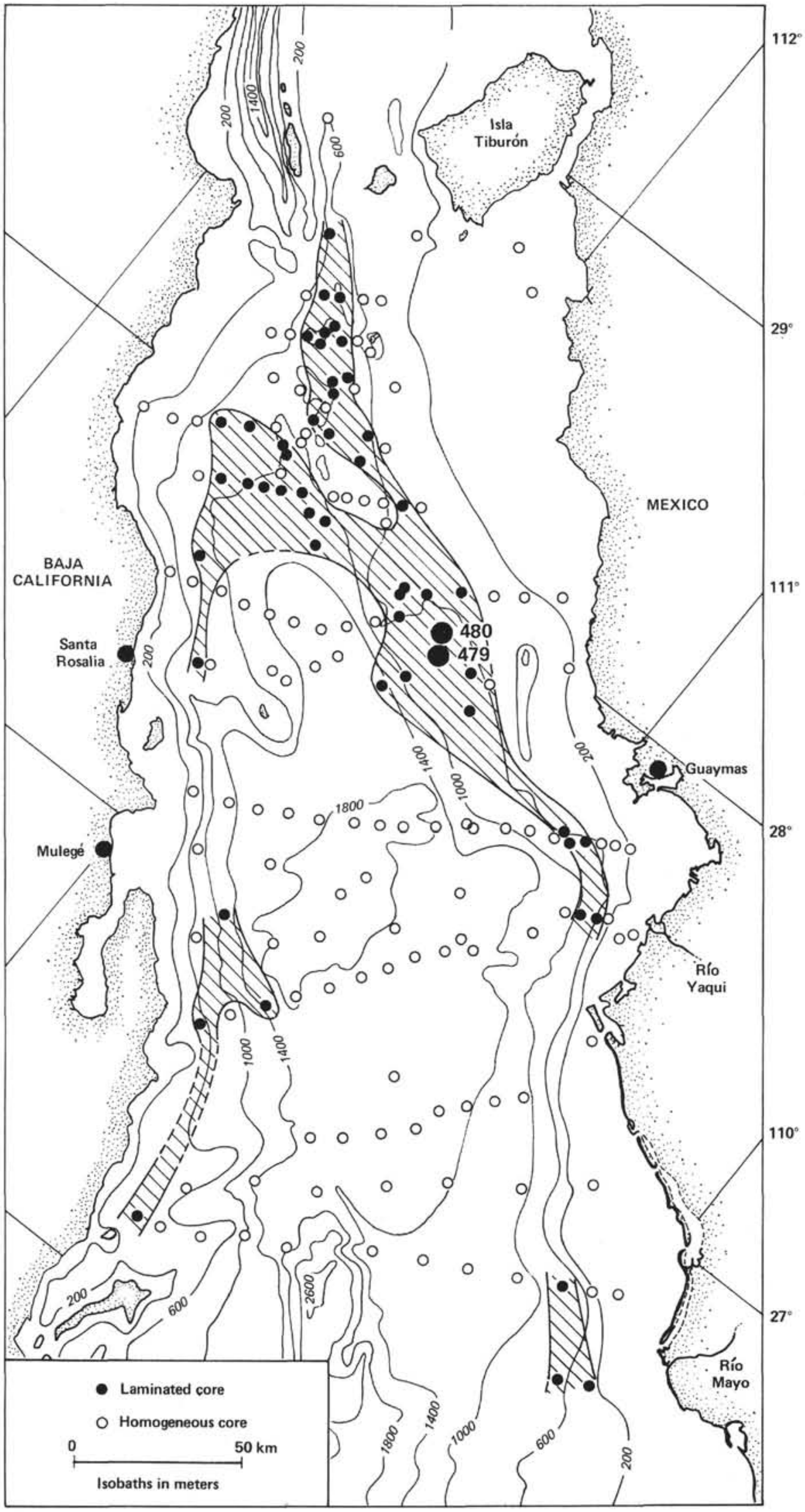

Figure 2. Distribution of sediment cores and their distinguishing structures. Data from *Vermillion Sea* Expedition (1959) and from the *Hugh H. Smith* Expedition (1961) (from Calvert, 1964).

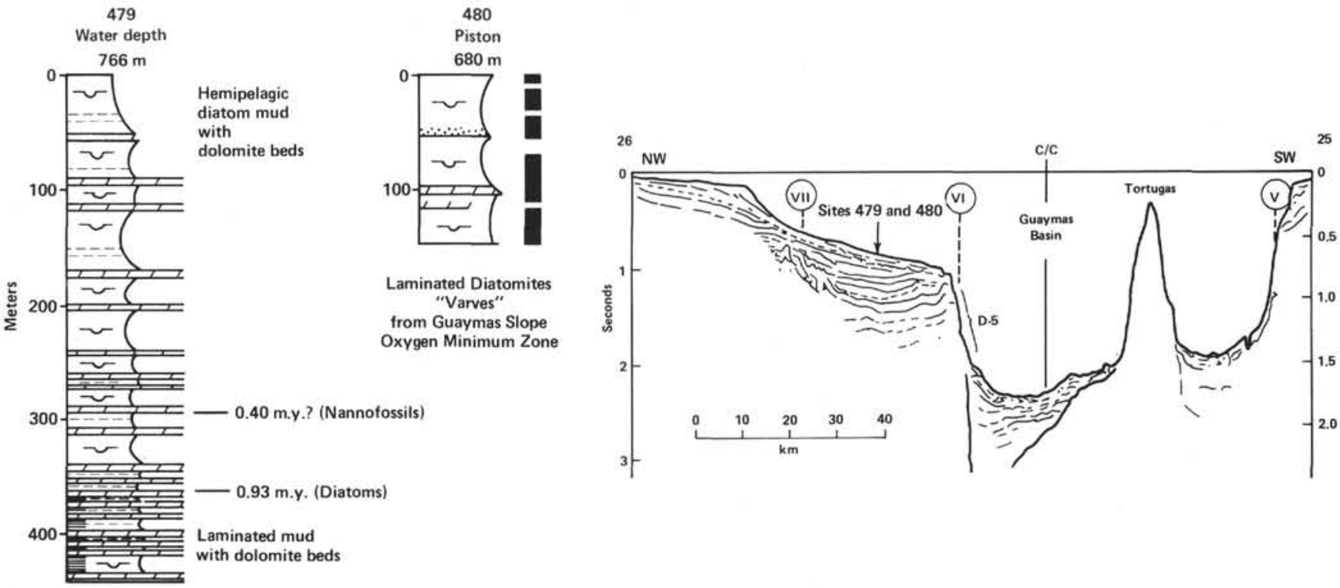

Figure 3. Simplified lithologic results from drilling and line drawing of a seismic section through Sites 479 and 480. (V, VI, and VII are transform faults.)

Site 479 was drilled first with conventional drill bit and coring. This site was selected as a compromise between proto-Gulf objectives and laminated sediment objectives. The plan was to then test the HPC at this same site after completion of the first hole if the upper part of the section consisted of good laminated sediments. Our experience on the ship was, however, that because of the excessive disturbance by conventional coring, we could not determine with confidence whether or not this upper section was well laminated. Rather than test the HPC at this site, we moved approximately 7 km to Site 480, where previous oceanographic ship-piston and gravity cores had demonstrated good lamination in the upper few meters of the sediment column.

PRINCIPAL RESULTS

These sites were drilled to test the hydraulic piston corer, to obtain a record of laminated diatomaceous sediments from the oxygen minimum, and to penetrate the upper part of the sedimentary section overlying proto-Gulf crust. The HPC test Site 480 was technologically and scientifically successful and obtained almost complete recovery of a 152-meter section of varved sediments. Drilling at Site 479 penetrated several unconformities and terminated in late Pliocene sediments. The correlation with seismic data suggests that uplift of this upper part of the section occurred in the past 1 m.y.

HOLE 479

Date occupied: 29 December 1978

Date departed: 31 December 1978

Time on hole (hrs.): 76.75

Postion: 27°50.76′N; 111°37.49′W

Water depth (sea level; corrected m; echo-sounding): 747

Water depth (rig floor; corrected m; echo-sounding): 757

Bottom felt at (m; drill pipe): 766

Penetration (m): 440

Number of cores: 47

Total length of cored section (m): 440

Total core recovered (m): 272.8

Core recovery (%): 62

Oldest sediment cored:
Depth sub-bottom (m): 440
Nature: Laminated mudstone
Age: Late Pliocene
Measured velocity (km/s): Not determined

Basement: Not reached

Principal results: Hole 479 lies on the northwest continental slope of the Guaymas Basin within the oxygen minimum and over presumed proto-Gulf of California sediments and crust. It was located by a predrilling survey in the axis of a syncline above the scarp of the transform fault of the basin where the drilled section outcrops at the sea floor. The objective was to sample these presumed proto-Gulf sediments as deeply as time would permit and to date the unconformities and folding above the scarp. The lithology of the section was Quaternary to late Pliocene and mainly muddy diatomaceous ooze with alternating sequences of varves and homogeneous, probably bioturbated, zones. Three lithological units were distinguished on the basis of diagenesis, degree of consolidation, and micropaleontology. These correlate rather well with the sediment sections between the unconformities in the seismic reflection records. We conclude that all uplift and folding indicated within the shallow part of the section drilled occurred during the Pleistocene. Drilling was terminated at 440 meters because of gas pressure, increasing C_2/C_1 ratio, and increase of hydrocarbons in the gasoline range. Heat flow was measured at 2.36 HFU.

HOLE 480

Date occupied: 31 December 1978

Date departed: 2 January 1979

Time on hole (hrs.): 39.62

Position: 27°54.10′N; 111°39.34′W

Water depth (sea level; corrected m; echo-sounding): 655

Water depth (rig floor; corrected m; echo-sounding): 665

Bottom felt at (m; drill pipe): 674.5

Penetration (m): 152

Number of cores: 31

Total length of cored section (m): 147.25

Total core recovered (m): 117.89

Core recovery (%): 80

Oldest sediment cored:
Depth sub-bottom (m): 152
Nature: Diatomaceous ooze
Age: Quaternary
Measured velocity (km/s): Not determined

Basement: Not reached

Principal results: Hole 480 lies only 7 km northwest of Site 479 and was occupied to test the HPC and to obtain the best section possible of varved diatomites within the oxygen-minimum zone. The piston corer was an unqualified success, and we duplicated the upper 152 meters of the section from Hole 479 with excellent recovery of undisturbed cores. Rhythmically laminated (varved) sequences alternate with bioturbated sections, perhaps as a function of movement of the oxygen minimum with Quaternary climate and sea-level changes. Study of the varves aboard ship was very limited, because the shipboard scientific party refrained from sampling in order to preserve the cores for shore-based studies, which require intact working halves of the cores. We proposed special curating and sample distribution procedures for the cores.

SITES 479 AND 480 OPERATIONS

We departed Site 478 on 29 December at 0512Z on course 350° toward a predrilling reflection seismic survey of the area around proposed Site 479 using *Glomar Challenger* seismic equipment. Site 479 was selected along an old (1967) *C. H. Davis* line run before satellite navigation (Fig. 4), and it was, therefore, of uncertain position. We thus needed an area survey to select the desired site in the axis of a syncline, as recommended by the JOIDES Safety Panel. We changed course to 035° at 1015Z on 29 December and began the survey. The survey track and the final sites selected for drilling are shown in Figure 4. Examples of the records (including seismic records) are given in the section on correlation of drilling results. We completed our survey at 1618Z, dropped a beacon, retrieved the profiling gear, hove to in the area, and lowered the positioning hydrophones—but alas, no beacon signals. After awaiting a satellite, we again began profiling in the area at 1755Z and at 1844Z let go a second beacon in 747 meters water depth. At 2000Z we positioned in automatic over the second beacon and began running-in the hole (Table 1).

Our first core was on deck at 2313Z; thereafter, until 0424Z on 31 December, we continuously cored 440 meters of Quaternary sediments with no drilling problems. Heat flow and pore water were sampled with the combination instrument at 88.5 and 221.5 meters. Drilling was terminated because of possible hydrocarbon pollution with further penetration. The C_2/C_1 ratio was rising, and increasing amounts of propane and butane were measured.

We then prepared the hole for logging, released the bit, and pulled the pipe to the mudline. Five logging runs were made between 0900 and 2000Z. Tools for the first were temperature, density, gamma, and caliper. The second utilized sonic caliper and gamma; the third was guard, neutron, and gamma; fourth, induction and gamma; and the fifth run used only the temperature tool. We next secured the logging equipment, placed a cement plug from 920 to 870 meters, and pulled out of the hole. At 2300Z we were underway for the next site, Site 480, which was selected to complement this site for piston coring.

Although the upper 100 meters of cores at Site 479 were, as usual, badly disturbed, we did not see any convincing evidence for laminated diatomaceous ooze. Site 480 is only about 6.8 km to the northwest and in an optimum locality for coring laminated diatomaceous ooze and mud. No seismic profiling was done on the short traverse from Site 479 to Site 480, because Site 480 is on one of the lines run in the survey for Site 479. We used the 3.5 kHz to record structure in the upper 50 meters. At 0000Z on January 1 we reached our position and dropped a beacon in 655 meters of water. From 0030 to 0230Z we then positioned in automatic over the beacon and ran pipe in the hole. The piston corer was then rigged, and our first core was on deck at 0715Z on 1 January 1979. We then took a very successful series of 31 piston cores, terminating at 1313Z on 2 January at a total depth of 152 meters. Only two cores contained no undisturbed sediments, and recovery was generally 80 to 95%. The cores are remarkably undisturbed, and throughout much of the sequence, finely laminated diatomaceous ooze and silt were recovered. Average time for each core was 1 hr. at this depth. This first operational use of the hydraulic piston corer was an unqualified technical and scientific success.

Because this same section had been logged at Site 479, just 6.8 km to the southeast (and since in any case only the lower 90 m could be logged), we opted not to relog, thereby saving time for drilling and logging our next and final site. We therefore pulled out of the hole and were underway for the next site at 1653Z on 2 January 1979.

SITE 479 SEDIMENTARY LITHOLOGY

In general, sediments at Site 479 are a uniform, somewhat monotonous, rather disturbed, thick, hemipelagic, Quaternary sequence of muddy diatomaceous ooze to mudstone. Most of the section was originally rhythmically laminated. Sedimentation has been rapid as might be expected from the nearby terrigenous sources and profusive diatom productivity at this locality within the belt of intense upwelling. Discrete, hard, lithified layers of calcareous mudstones to limestone—some laminated—are recurrent at several intervals but are more common with depth. On the composite stratigraphic section (Fig. 5), missing sediments and the position of indurated layers have been slightly modified from core-barrel depths by adjustment with the sonic- and bulk-density logging results.

Although the entire section at Site 479 seems to show a similar environment of deposition, we have decided to use subtle differences to designate three units (see Table 2) to delimit possible breaks in the record. These criteria include indurations, gas, the relative abundance of dia-

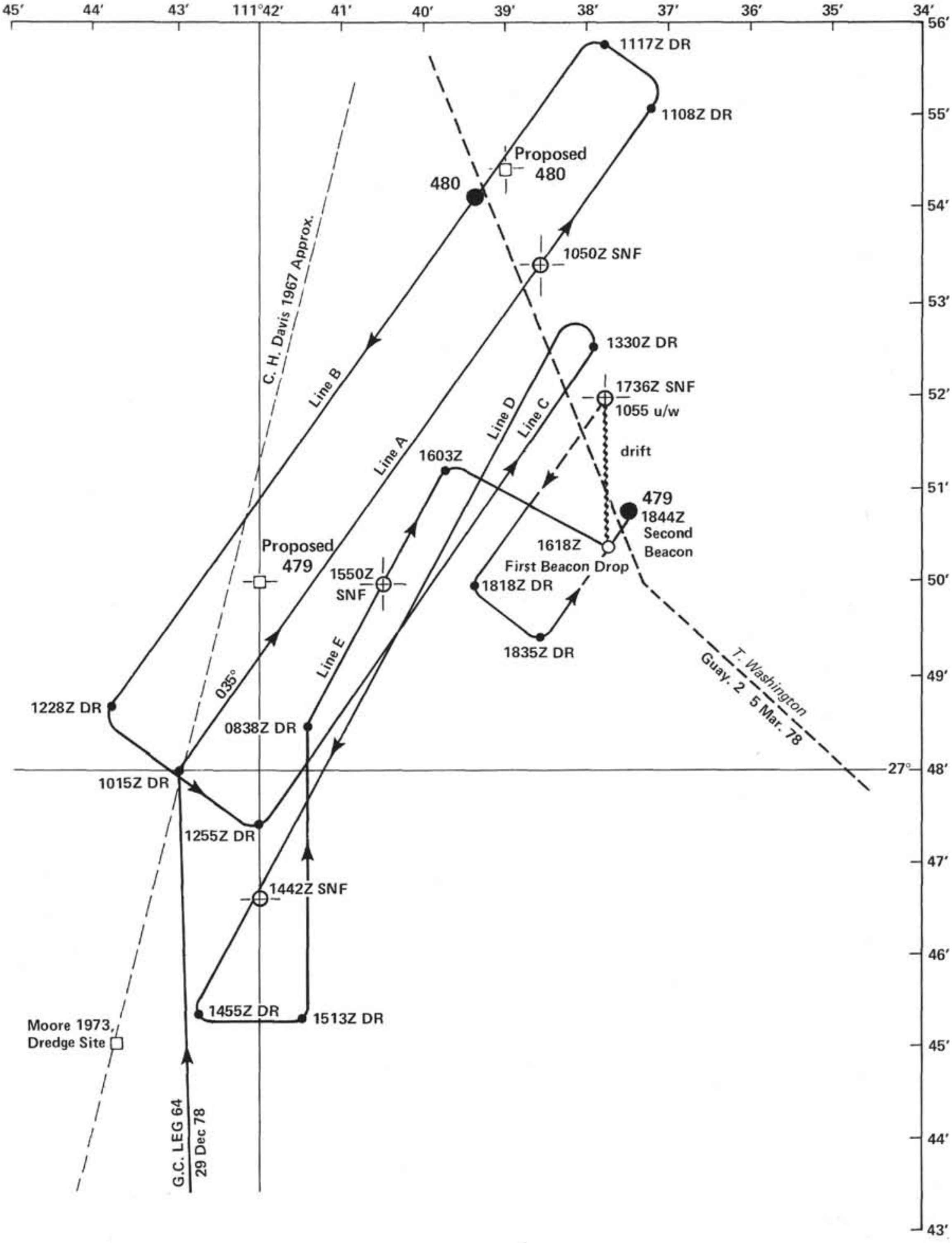

Figure 4. Tracks of *Glomar Challenger*, approaching Stations 479 and 480, a multichannel seismic-reflection line from Guaymas Expedition, Scripps Institution of Oceanography, and a 1967 *C. H. Davis* line.

toms, silicoflagellates, sands and laminates, and the recurring frequency of discrete dolomitic beds.

Unit I: Late Pleistocene (479-1 through 479-26,CC; 0–240.5 m)

The correlation with Hole 480 suggests that the soft and highly disturbed sediments from the upper part of Hole 479 also seem to consist mainly of rhythmically alternating thin layers of moderate olive brown (5Y 4/4) muddy diatomaceous ooze and millimeter-scale laminae of matted pale olive (10Y 6/2) diatomaceous ooze. Some layers are mainly diatomaceous mud or silty clays. Where undisturbed, laminations are subparallel to parallel (see lithology section, Site 480).

Table 1. Coring summary, Holes 479 and 480.

Core	Date (Dec. 1978)	Time	Depth from Drill Floor (m; top-bottom)	Depth below Sea Floor (m; top-bottom)	Length Cored (m)	Length Recovered (m)	Recovery (%)
479-1	29	1613	766.0-769.0	0-3.0	3.0	2.34	78
2	29	1631	769.0-778.5	3.0-12.5	9.5	0.00	0
3	29	1653	778.5-788.0	12.5-22.0	9.5	3.97	41
4	29	1712	788.0-797.5	22.0-31.5	9.5	0.00	0
5	29	1735	797.5-807.0	31.5-41.0	9.5	6.76	71
6	29	1812	807.0-816.5	41.0-50.5	9.5	8.40	88
7	29	1852	816.5-826.0	50.5-60.0	9.5	9.05	95
8	28	1915	826.0-835.5	60.0-69.5	9.5	8.10	85
9	29	1943	835.5-845.0	69.5-79.0	9.5	6.18	68
10	29	1959	845.0-854.5	79.0-88.5	9.5	9.56	101
11	29	2020	854.5-864.0	88.5-98.0	9.5	5.36	56
12	29	2140	864.0-873.5	98.0-107.5	9.5	9.35	98
13	29	2208	873.5-883.0	107.5-117.0	9.5	3.34	35
14	29	2226	883.0-892.5	117.0-126.5	9.5	7.88	83
15	29	2249	892.5-902.0	126.5-136.0	9.5	8.55	90
16	29	2311	902.0-911.5	136.0-145.5	9.5	4.42	47
17	29	2332	911.5-921.0	145.5-155.0	9.5	8.54	90
18	29	2357	921.0-930.5	155.0-164.5	9.5	3.28	35
19	30	0125	930.5-940.0	164.5-174.0	9.5	8.23	87
20	30	0152	940.0-949.5	174.0-183.5	9.5	8.79	93
21	30	0220	949.5-959.0	183.5-193.0	9.5	7.35	77
22	30	0252	959.0-968.5	193.0-202.5	9.5	6.59	69
23	30	0320	968.5-978.0	202.5-212.0	9.5	8.03	85
24	30	0353	978.0-987.5	212.0-221.5	9.5	8.24	87
25	30	0427	987.5-997.0	221.5-231.0	9.5	2.72	29
26	30	0604	997.0-1006.5	231.0-240.5	9.5	8.37	88
27	30	0645	1006.5-1016.0	240.5-250.0	9.5	6.61	70
28	30	0716	1016.0-1025.5	250.0-259.5	9.5	6.47	68
29	30	0751	1025.5-1035.0	259.5-269.0	9.5	5.68	60
30	30	0826	1035.0-1044.5	269.0-278.5	9.5	0.00	0
31	30	0911	1044.5-1054.0	278.5-288.0	9.5	8.27	87
32	30	0254	1054.0-1063.5	288.0-297.5	9.5	2.18	23
33	30	1037	1063.5-1073.0	297.5-307.0	9.5	0.00	0
34	30	1108	1073.0-1082.5	307.0-316.5	9.5	7.90	83
35	30	1141	1082.5-1092.0	316.5-326.0	9.5	7.55	79
36	30	1214	1092.0-1101.5	326.0-335.5	9.5	7.22	76
37	30	1256	1101.5-1111.0	335.5-345.0	9.5	7.02	74
38	30	1332	1111.0-1120.5	345.0-354.5	9.5	8.23	87
39	30	1400	1120.5-1130.0	354.5-364.0	9.5	7.16	75
40	30	1432	1130.0-1139.5	364.0-373.5	9.5	9.66	102
41	30	1505	1139.5-1149.0	373.5-383.0	9.5	1.48	16
42	30	1605	1149.0-1158.5	383.0-392.5	9.5	0.22	2
43	30	1654	1158.5-1168.0	392.5-402.0	9.5	2.50	26
44	30	1753	1168.0-1177.5	402.0-411.5	9.5	7.59	80
45	30	1913	1177.5-1187.0	411.5-421.0	9.5	3.01	32
46	30	2020	1187.0-1196.5	421.0-430.5	9.5	0.00	0
47	30	2124	1196.5-1206.0	430.5-440.0	9.5	9.05	95
480-1	1	0015	674.50-679.25	0.00-4.75	4.75	3.79	80
2	1	0118	679.25-684.00	4.75-9.50	4.75	4.12	87
3	1	0213	684.00-688.75	9.50-14.25	4.75	4.39	92
4	1	0312	688.25-693.50	14.25-19.00	4.75	4.55	96
5	1	0358	693.50-698.25	19.00-23.75	4.75	4.60	97
6	1	0448	698.25-703.00	23.25-28.50	4.75	4.50	95
7	1	0546	703.00-707.25	28.50-33.25	4.75	4.50	95
8	1	0642	707.75-712.50	33.25-38.00	4.75	4.55	96
9	1	0742	712.50-717.25	38.00-42.75	4.75	4.54	96
10	1	0820	717.25-722.00	42.75-47.50	4.75	4.45	94
11	1	0940	722.00-726.25	47.50-52.25	4.75	1.59	33
12	1	1040	726.75-731.50	52.25-57.00	4.75	0.20	4
(washed)			731.50-736.25	57.00-61.75	—	—	—
13	1	1259	736.25-741.00	61.75-66.50	4.75	4.35	92
14	1	1350	741.00-745.75	66.50-71.25	4.75	4.13	87
15	1	1440	745.75-750.50	71.25-76.00	4.75	2.23	47
16	1	1515	750.50-755.25	76.00-80.75	4.75	4.45	94
17	1	1558	755.25-760.00	80.75-85.50	4.75	3.95	83
18	1	1645	760.00-764.25	85.50-90.25	4.75	3.81	80
19	1	1735	764.75-769.50	90.25-95.00	4.75	4.30	90
20	1	1849	769.50-774.25	95.00-99.75	4.75	3.87	81
21	1	1944	774.25-779.00	99.75-104.50	4.75	4.20	90
22	1	2056	779.00-783.75	104.50-109.25	4.75	4.52	95
23	1	2150	783.75-788.50	109.25-114.00	4.75	3.67	77
24	1	2247	788.50-793.25	114.00-118.75	4.75	0.00	0
25	2	0020	793.25-798.00	118.75-123.50	4.75	4.60	97
26	2	0130	798.00-802.75	123.50-128.25	4.75	3.86	81
27	2	0213	802.75-807.50	128.25-133.00	4.75	4.49	95
28	2	0308	807.50-812.25	133.00-137.75	4.75	4.35	92
29	2	0405	812.25-817.00	137.75-142.50	4.75	4.58	96
30	2	0505	817.00-821.75	142.50-147.25	4.75	2.16	45
31	2	0613	821.75-826.50	147.25-152.00	4.75	4.59	97

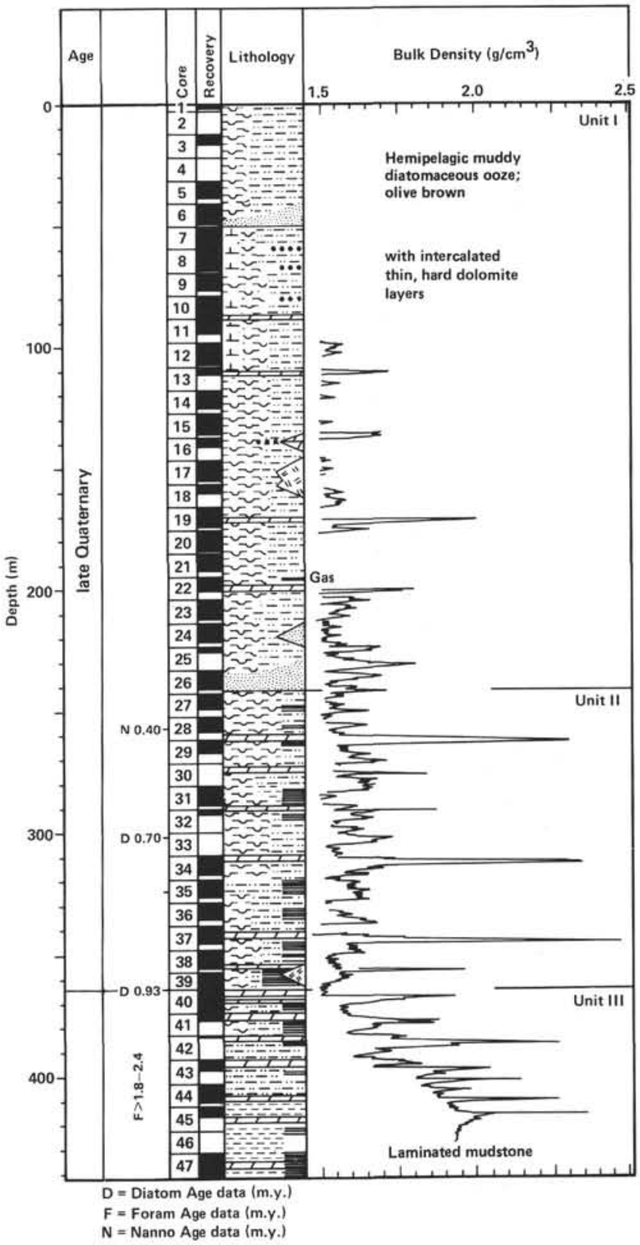

Figure 5. General lithology, lithologic units, core recovery, and bulk density, Site 479.

Diatoms comprise 20 to 50% of the sediment. Other biogenic components include nannofossils (2-15%), common silicoflagellates, and rare foraminifers or radiolaria. Terrigenous constituents are dominated by silt-sized angular to rounded feldspars, with quartz and minor amounts of opaque and heavy minerals, pyrite, and plant debris.

An H_2S odor is present through Core 479-10, and most of the unit shows a spongy or gelatinous, ruptured surface texture caused by the exolution of gas (biogenic CO_2 methane) when drilled. Gas is a prominent feature of Unit I and some sediments froth into the core barrel (Fig. 6).

Four hard, decimeter-thick, pale olive (10Y 6/2-5Y 3/2) to grayish olive (10Y 4/2) dolomite-cemented mudstone layers were recovered from 88.5, 110, 170, and 198 meters. Smear slides and thin sections show relict quartz grains and diatom fragments enmeshed in micrite-size, blocky dolomite. The first samples are moderately soft with individual rhombic grains. Some of the pieces are

Table 2. Lithology, Sites 479 and 480.

Site	Unit	Cores	Sub-bottom Depth (m)	Lithology	Paleoenvironment Interpretation	Age	Average Accumulation Rate
479	I	1 to 26,CC	0 to 240.5	Moderate olive brown, grayish olive to pale olive muddy diatomaceous ooze to diatom muds; alternations of rhythmically laminated and homogeneous zones; includes some sand and dolomite interlayers and gas-rich zones	Hemipelagic: outer slope episodically intersecting the O_2 minimum beneath zones of upwelling and high productivity	Late Quaternary	Rapid estimates: ~550 m/m.y.
				Contact: massive sand	Unconformity?		
	II	27-1 to 39,CC	240.5 to 364.5	Firm to hard, moderate-olive-brown, laminated and homogeneous zones of muddy diatomaceous ooze, includes diagenetic carbonates but few sand, ash, or gaseous layers	Hemipelagic	Quaternary (up to ~0.9 m.y.)	Moderate ~100–280 m/m.y.
				Contact	Hiatus		
	III	40-1 to 47,CC	364.5 to 440	Laminated, diatomaceous muds to laminated mudstone; induration increases, diatoms disappear; 7 to 8 hard, diagenetic dolomitic interlayers	Hemipelagic	Late Pliocene (1.8–2.4 m.y.)	Moderate ?
				Alternations of:			
480	I	480-1 to 480-31,CC	0 to 152.0	Type 1A: Rhythmically laminated, moderate-olive-brown (5Y 4/4), muddy diatomaceous ooze and pale-olive (10Y 6/2) to moderate-yellow (5Y 7/6) diatomaceous ooze	Hemipelagic outer slope; high diatom productivity with upwelling and sediments in O_2 minimum zone		~625[a] ~500[b]
				Type 1B: Homogeneous, moderate-olive-brown (5Y 4/4) diatomaceous mud and olive-gray (5Y 3/2) to light-olive-gray (5Y 5/2), diatomaceous, silty clay	Diatom production less; infauna present at ocean floor		
				Interruptions: sands (Cores 20, 21), dolomitic mudstone (Core 21)	Lowered sea level(?); diagenetic carbonate		

[a] From 16 varves/cm counted.
[b] From correlation with Site 479.

thinly laminated; others are bioturbated to homogenous (Fig. 7) (see Kelts and McKenzie, this volume, Pt. 2).

Other minor interlayers include a thin, unaltered, silt-sized, gray (N7) vitric rhyolitic ash in Sections 479-17-3 and 479-17-4 (152 m). Sands are quantitatively unimportant, and where present do not show grading. In Core 479-24-1, a thin gray sand also contains up to 10% pyrite, which suggests winnowing. A medium gray (N5) 50-cm-thick, well-sorted, coarse sand layer occurs at 50.5 meters (Core 479-6). The base of Unit I, however, is marked by a massive, 7-meter-thick, coarse-grained, well-sorted, dark greenish gray (5G 4/1) sand in Core 479-26. These sands seem to be winnowed of fines and have sharp upper and basal contacts. Compositionally, feldspars are more abundant than quartz and volcanic rock fragments with minor heavy minerals and micas (Aguayo, this volume, Pt. 2). Shallow- or deep-water carbonate is rare, although there are a few benthic foraminifers and a trace of reworked coccoliths and diatoms.

Unit II: Late Pleistocene (479-27 through 479-39,CC; 240.5–364.5 m)

Below the massive sand (Core 479-26), induration increases, and many sections are not badly disturbed by drilling. These show distinct rhythmic light and dark laminated zones (Fig. 8) between more homogeneous zones. Other differences are also present. The unit is less gaseous, and gas rupturing decreases; there are more abundant silicoflagellates in Cores 479-28, 479-32, 479-34, and 479-35. The frequency of limestone interlayers increases, and some preserve clear evidence of burrowing. Sands are rare. Some phosphate-rich zones occur.

In the laminated sequences, a common couplet type consists of a grayish olive (10Y 4/2) diatomaceous silty clay (dark) and pale olive (10Y 6/2) muddy diatomaceous ooze (light). The couplets seem slightly less diatomaceous with more terrigenous sediment than the upper section. Typical counts range from 22 to 30 couplets per centimeter.

Six hard dolomitic mudstones, several centimeters thick, were encountered in this section. They are thicker than similar Unit-I layers, and cut surfaces commonly show excellently preserved exponential-type burrowing down into a laminated sequence (Kelts and McKenzie, this volume, Pt. 2). Other, more indurated sections also show pervasive burrow structures that must represent the homogenous, clayey units.

Minor beds include fish-scale-rich hard clays (in Sections 479-35-4, 479-38-5) and several 1-cm-thick beds of black sand-sized particles composed of basaltic glass

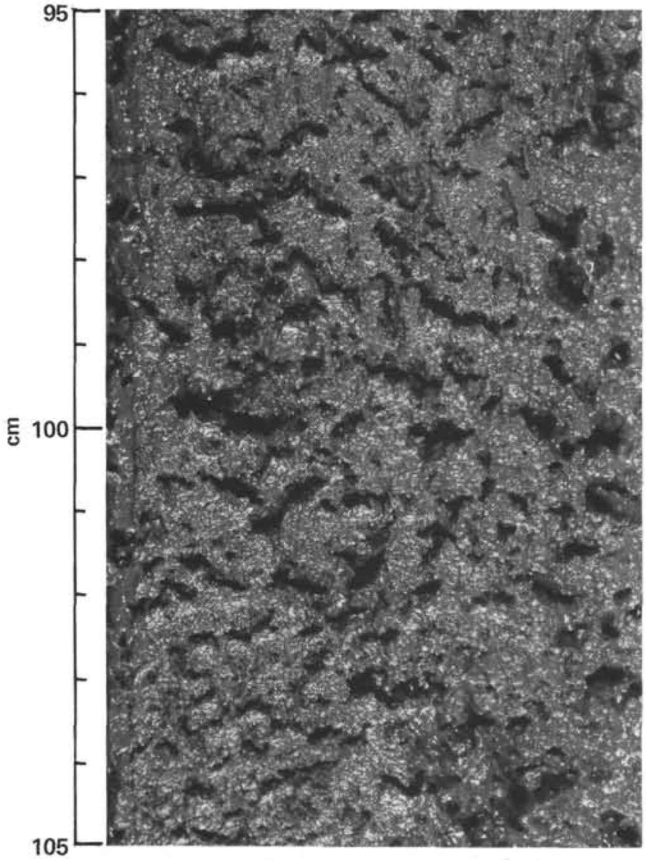

Figure 6. Photograph of a section of 479-5-1, showing gas exolution.

Figure 7. Photograph of 479-13,CC, showing fragment of hard, laminated, dolomitic mudstone.

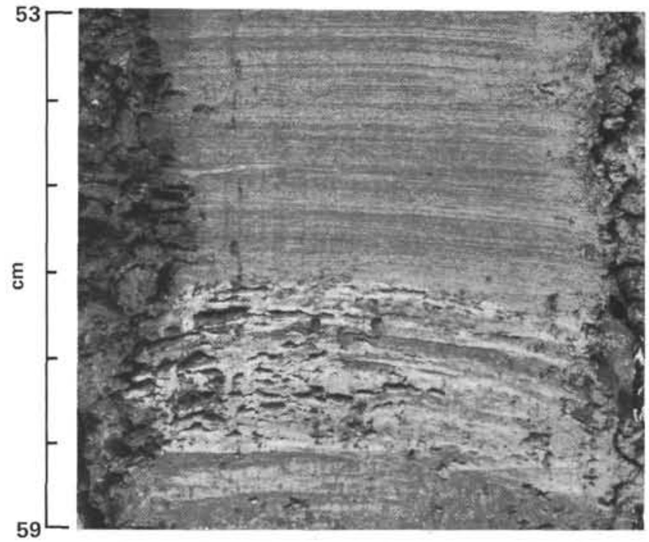

Figure 8. Photograph of 479-35-5, 53–59 cm, showing laminated diatomaceous mudstones of Unit II.

and feldspars coated with manganese oxyhydroxides and some quartz and diatoms (20%) suggesting a possible short time of slowed deposition.

Unit III: Pliocene (479-40 through 47,CC; 364.5–440.0 m)

The contact of Unit II/III is defined by a change in bulk density trends and by a jump to late Pliocene (Matoba and Oda, this volume, Pt. 2). Most of the section consists of thinly laminated mudstones, which are either grayish olive (10Y 4/2) or pale olive (10Y 6/2) silty clay to diatom mud. Sediments continue to show rhythmic, very fine laminations. Trends continue over a transitional zone that began about in Core 479-35. Diatom frustules diminish and disappear, as do most nannofossils. Once diatom abundance has dropped to minimum values, there is a clear linear increase in induration levels from Cores 479-39 to 479-47, which can be followed on the density log (Fig. 5). Layers rich in fish scales (e.g., Sections 479-40-6, 479-41-1, 479-43-2, 479-46-1, 479-46-2) become prominent. Cores 479-40, 479-42, 479-45, and 479-47 contain a few scattered, paper-thin white laminae that are an almost pure nannofossil ooze, containing a single cosmopolitan species indicative of special blooms.

Nine hard, dolomitic interlayers were counted. One example (Sample 479-47-2, 125–145 cm) shows a progressive change downward from relatively soft, extremely finely laminated claystones to harder limestones (see Kelts and McKenzie, this volume, Pt. 2). Initially parallel structures are completely preserved. Laminations become wavy, then intermittent, then broader and diffuse, mostly as a result of obliteration of the thin dark laminae, rich in organic matter. This suggests a progressive trend in the pattern of lithification of the limestone beds.

Depositional Environment

Sediments at Site 479 show a pattern of an outer-slope hemipelagic depositional environment throughout the time interval drilled.

There is also a good correlation with Site 480, which strongly suggests the upper, highly disturbed 150 meters are similarly composed of alternating zones of fine varve-like diatomaceous rhythmites and homogeneous muddy diatomaceous ooze. Conditions were generally favorable to the preservation of the laminations, which indicate a long-period stable location of the oxygen minimum, similar to that of today. Although some controversy surrounds the nature of the more homogeneous zones (see biostratigraphy, Site 480) in deeper, more indurated sections, pervasive burrowing is conspicuous. This indicates a fluctuating oxygen content in bottom waters during some discrete times.

There is little evidence for major turbidite sedimentation in most of the section at Site 479. We do not observe very silty beds or homogeneous muds typical of a deltaic environment. Sands, particularly graded ones, are rare. This is consistent with its present protected, low gradient, outer-slope location. But, the thick sand bed in Core 479-26 probably defines an unconformity. The composition of coarse-grained (250–600 μm) angular quartz, abundant feldspar, and rounded volcanic rock fragments without carbonates suggests a terrigenous fluvial source similar to the present Guaymas area. This layer is associated with a low-angle, but distinct unconformity visible on seismic records. These sands could indicate times of lowered sea levels or enhanced bottom currents.

Diagenesis and Varves

Based on decreasing drilling disturbance, general consolidation of the sediments begins below about 250 meters or below the zone enriched in biogenic gas. Large amounts of biogenic gas that charge the sediments indicate rather high accumulation rates and low oxidation potentials. These gases may counteract compaction to some degree. Induration is first apparent below Core 479-39 (360 m).

Diatom abundance decreases downhole from generally high levels midsection (45–60%), to intermittently high and low, then generally low below 360 meters. Below 390 meters (Core 479-43) diatoms disappear. This change is parallel to the induration pattern, which suggests silica diagenesis in progress.

Sediments both above and below the claystone boundary are rhythmically laminated with a couplet consisting of a light (A) and a dark (B) lamina. The light laminae lower in the section (Core 479-37) appear to contain more robust types of diatoms.

The last core (479-47) is an example of a claystone showing a continuous succession of very fine rhythmic couplets but containing no frustules (Fig. 9). Light and dark layers, if annual, indicate a span of about 27,000 y. for this core, (about 30–35 couplets per cm). Both light and dark laminae seem to have almost identical bulk compositions at present: dominantly clay (80–85%) with scattered fine carbonate grains.

Close inspection shows that a variety of other laminations or sublaminations are also present. Many of the darker laminations are underlain by a hairline (0.1 mm) reddish brown layer of pure organic matter. This may be a relict of diatom blooms or may instead indicate other seasonal algal productivity.

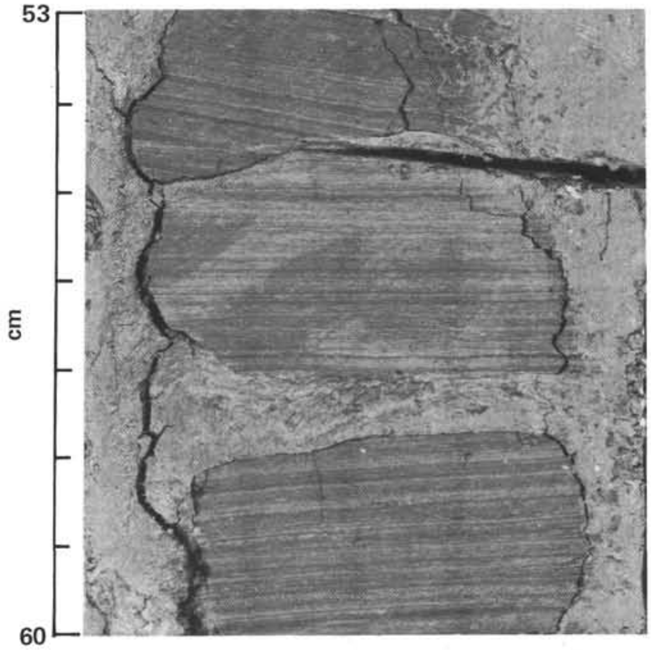

Figure 9. Photograph of 479-47-5, 53–60 cm, showing laminated mudstone from Unit III, without diatom frustules.

Successions are interrupted frequently by thin (2–3 mm), gray (N6) silty clays, which may derive from exceptional flood years.

Thin, homogeneous brown to tan silty clay (2–3 mm) bands are less frequent but may indicate burrowing or longer periods of low productivity. A few thin (0.3 mm), creamy white laminations stand out in darker sections. These proved to be a pure nannofossil bloom consisting of one dominant, dissolution-resistant species, *Coccolithus pelagicus*.

Some laminae consist of a single layer of fish scales, which is best detected along parted beds. In some zones, the sediment approaches a fish-scale clay. Commonly, the scales are concentrated at the top of the dark laminae, which appears microburrowed, and below thin organic-rich films occur.

Scattered, grayish orange bands and clumps are phosphate-rich. Both of these latter types of laminae indicate a deeper zone near strong upwelling.

Recurring Dolomitic Layers

Hard lithified layers show up on density log records (Fig. 31) as 18 to 20 thin beds, which increase in abundance downhole but show little relation to the overall diagenetic trend. Evidence suggests an *in situ* process cementing host lithologies. This curious recurrent pattern is difficult to explain. Possibly some layers were sedimented with more than a critical amount of carbonate, which would later recrystallize (Kelts and McKenzie, this volume, Pt. 2).

Volcanic Ashes

The occurrence of basaltic ash in lower sections of the hole (Cores 479-35–479-39) contrasts with more rhyolitic material at the top (Core 479-17). Both appear to have been transported mainly by wind, because the grains are well sorted and silt sized without admixture. These suggest basaltic and rhyolitic volcanism from mainland volcanoes during the Quaternary; some of the possible volcanic sources (weathered volcanoes) were visible 15 km away from the ship. The black coatings on the basaltic ash components may have been acquired before transport, as a rapid burial in anoxic oozes would seem to preclude a manganese coating.

SITE 480 SEDIMENT LITHOLOGY

Table 2 and Figure 5 summarize the lithologies of Sites 479 and 480. Because the hemipelagic environment of deposition changed little during this time, we recognize only one lithological unit that contains two main sediment types on the basis of primary sedimentary structures and biogenic composition. Type 1A consists of alternating dark (rich in terrigenous matter) and light (diatom-rich) laminations. Type 1B consists of homogeneous diatom muds (rich in terrigenous matter) to diatomaceous silt clays that are occasionally bioturbated at the contact with laminated sections. Contacts between these alternating subunits are usually gradational.

Unit I: late Quaternary (Core 480-1 through Section 480-31,CC; 0.0–152.0 m)

Laminated oozes consist of rhythmic couplets of moderate olive brown (5Y 4/4) muddy diatomaceous ooze and pale olive (10Y 6/2) to moderate yellow (5Y 7/6) diatomaceous ooze. The lighter diatomaceous ooze laminae have a consistently narrow compositional range of 70 to 80% diatoms, 15 to 25% clay, 1 to 2% quartz and feldspar, and 1 to 2% silicoflagellates. The darker muddy diatomaceous ooze layers are also consistent in composition with 45 to 50% clay, 25 to 45% diatoms, 1 to 8% quartz, 1 to 3% feldspar, and trace to 10% nannofossils. The laminae are consistently submillimeter to millimeter scale in thickness with rare examples of diatomaceous ooze laminae greater than 1 to 2 mm. Cores 480-1 and 480-2 exhibit a gelatinous consistency in the varved sections because of a very high water content. The laminations are indistinct but visible. At Core 480-3 the laminae consolidate sufficiently for recognition of the boundaries between light and dark layers. The number of dark/light couplets per centimeter is uniform throughout the section. Because of compaction, random counts of laminae give 12 to 15 couplets per centimeter in the top 4 cores and 12 to 20 couplets per centimeter in the bottom 4 cores.

Frequently, the rhythmic couplets have faint or vague boundaries from dark to light laminae. The lighter laminae are mostly pale olive.

Interruptions within the alternation pattern are uncommon. Notable exceptions occur in Cores 480-20 and 480-21. Core 480-20 has three medium gray (N5), massive, well-sorted sand layers in sharp contact with the laminations—in one instance unconformably so (see Fig. 10). Sands are arkosic, with angular to subangular grains. The sand composition seems typical of the Yaqui

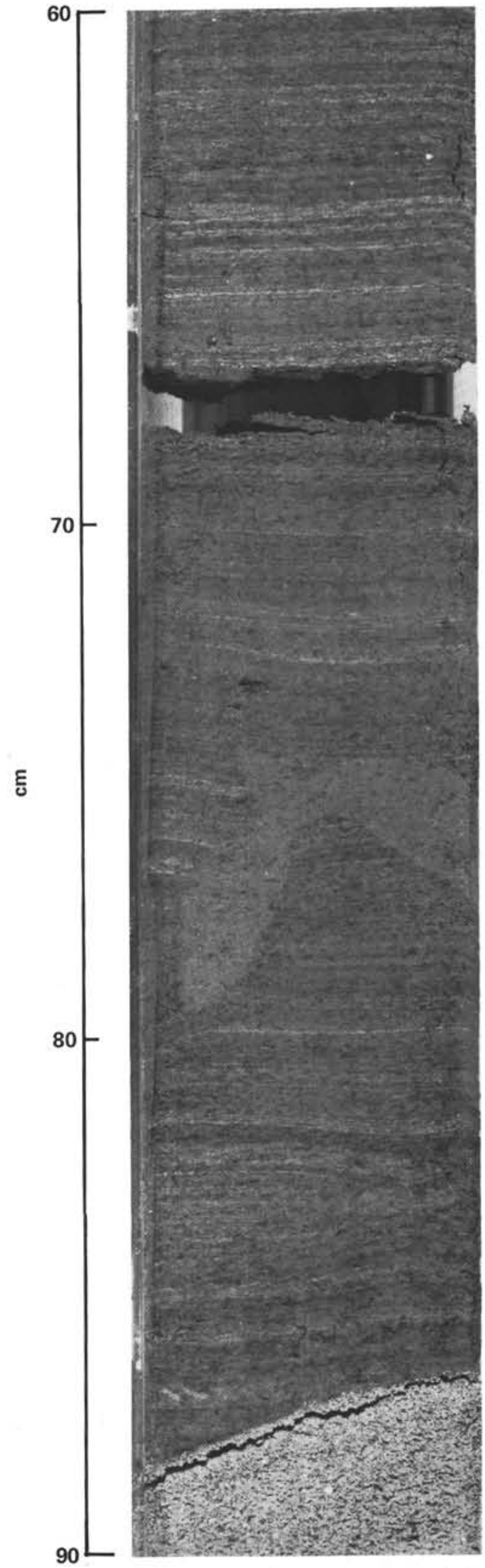

Figure 10. Photograph of 480-20-1, 60–90 cm, showing top of a rare coarse, gray sand and laminated muddy diatomaceous ooze. A smooth, irregular splotch around 75 to 78 cm was caused by bioturbation from a larger animal.

River province (van Andel, 1964) and consists of quartz and orthoclase with heavy minerals of epidote, hornblende, pyroxene, and minor biotite. A small percentage of the $>63\mu$ fraction includes red brown volcanic fragments. Core 480-21 contains a 10- to 15-cm section of well-indurated grayish yellow (5Y 8/4) dolomitic mudstone showing bioturbation structures. This was the only indurated sediment recovered in Site 480; we suspect, however, that other hard layers encountered in drilling—but not recovered—were also calcareous mudstones. Immediately below the calcareous mudstone is a 50-cm section of alternating, centimeter-scale, medium bluish gray (5B 5/1) quartz silt-clay layers with millimeter-scale basal sands and pale olive (10Y 6/2) to moderate olive brown (5Y 4/4) muddy diatomaceous ooze. There is grading in each of the quartz silt-clay layers suggesting small-scale turbidite deposition. Wood chips and shell fragments occur rarely within the rhythmic laminations.

Hydrogen sulfide gas is ubiquitous in the sediment section and is manifested by large gas pockets in the cores, gas fractures, cut sediment surfaces, and H_2S odor.

Altered basaltic ash with manganese oxyhydroxide coating on clays (Sample 480-14-1, 110 cm), unaltered rhyolitic ash (Sample 480-28-1, 115 cm), fish scales, and phosphatic material (Samples 480-9-1, 108 cm, 480-26-3, 60–140 cm) are present but rare.

Type 1B homogeneous diatomaceous muds consist of moderate olive brown (5Y 4/4) to olive gray (5Y 3/2) diatomaceous mud grading to light olive gray (5Y 5/2) nannofossil-bearing diatomaceous silty clay. These sediments show no rhythmic laminations or other primary sedimentary structures. Homogeneous sections are uniform in color with some evidence of bioturbation at lower contacts. Type 1B can be divided into two distinct textural groups. Diatomaceous silty clays are characterized by 50 to 60% clay, 10 to 15% each of diatoms and calcareous nannofossils, 6 to 10% quartz, 4 to 12% feldspar, and 1 to 3% each of mica, pyrite framboids in diatom frustules, and organic debris. Diatomaceous muds are characterized by 45% clay, 30 to 35% diatoms, 10 to 20% quartz, 2 to 5% feldspar, 1 to 3% pyrite, and 1 to 2% organic debris. Calcareous nannofossils are rare.

These homogeneous sections of the sediment column do not appear to be turbidites or redeposited sediments. There is no evidence of graded bedding or basal sands. In addition, contacts with the rhythmic laminations above and below these sections are gradational.

Sedimentary Processes, Upwelling, and the O_2 Minimum

Alternating zones of rhythmic couplets of dark (rich in terrigenous matter) and light (biogenic-rich) laminae, here interpreted to be annual varves, and the homogeneous diatomaceous mud zones suggest two possible sedimentary histories. Site 480 is in an O_2 minimum zone, which effectively prevents infaunal bioturbation. The O_2 minimum is the result of seasonal upwelling of deep, nutrient-rich bottom waters and concomitant high productivity in the surface waters. The massive pelagic "rain" of organic material depletes the O_2, and the stability of water masses allows the O_2 minimum to sustain its integrity. Consequently, the varve-like rhythms indicate seasonal fluctuation of surface water productivity or terrigenous input controlled by the interaction of oceanographic climatic conditions.

Homogeneous zones perhaps represent times when the O_2 minimum was not in existence or fluctuated (approximately 300–1400 m today). Bioturbation, however, is not readily apparent. Very few burrows are recognized, and these are only seen at the lower gradational contacts with varved zones (Cores 480-8, 480-13, 480-14, 480-19, 480-26).

Correlation of Sites 479 and 480

From smear-slide descriptions the sediment lithologies, textures and colors at Sites 479 and 480 are similar if not identical. Direct correlation of the two sites is, however, somewhat limited by intensive disturbance to the top 150 meters at Site 479. From the logging records at Site 479 (Fig. 31) it is possible to detect the exact location and thickness of indurated beds that may have been cored but not recovered. Two calcareous claystone layers that were recovered at Site 479 show strong jumps on the neutron, resistivity, and bulk density curves. Only one of these layers was recovered at Site 480; however, the drilling record indicates another hard layer drilled very close to the depth of the second calcareous mudstone at Site 479. Similarly, sand layers are present in both sections at approximately the same depth. The most equivocal correlation is that of two occurrences of vitric rhyolitic ash. The differences in depth make this correlation tenuous, and, in fact, the actual correlative ash bed in Site 480 may lie just below the termination depth of 152.0 meters.

SITE 479 ORGANIC GEOCHEMISTRY

The shipboard monitoring program was carried out in harried real-time—as each core arrived on deck it was sampled for gas from voids in the liner (if present) or later from the pressure build-up under the end caps; the core catcher samples were split and examined for fluorescence. The gases were analyzed mainly by the Carle Gas Chromatograph (GC), and spot checks were done with the Hewlett-Packard GC. The maturation of the organic matter was followed by the fluorescence of the toluene–ethanol extract of small sediment samples and microscopic examination of smear slides.

C_1–C_5 Hydrocarbon Analyses

Methane, ethane, carbon dioxide, and hydrogen sulfide were monitored in real-time, and selected samples were further analyzed for C_2–C_5 hydrocarbons. The CH_4 concentration is very scattered, with a general decrease in concentrations with depth, and the normalized data are shown in Figure 11. It shows a decrease ($\sim 60\%$) to about 100 meters sub-bottom, then remains level to about 250 meters. This is followed by a successive increase to 300 meters, a decrease to 450 meters, and an increase again to the bottom of the hole. The upper distribution to 100 meters represents the biogenic respira-

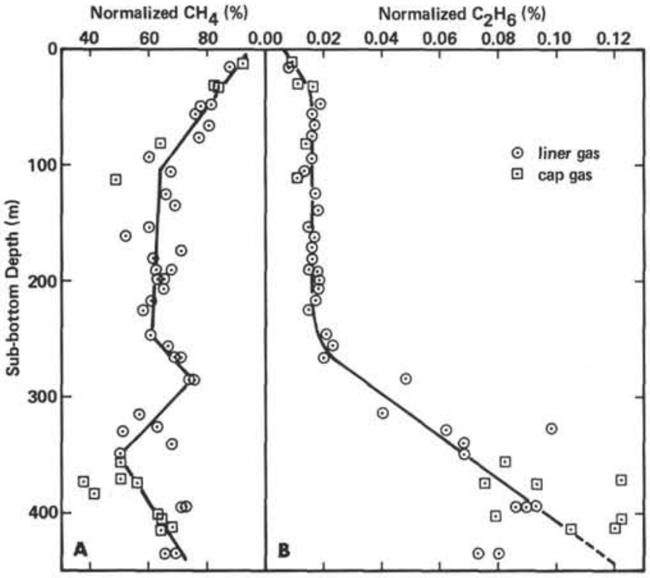

Figure 11. Concentrations of methane (A) and ethane (B) versus depth for Site 479.

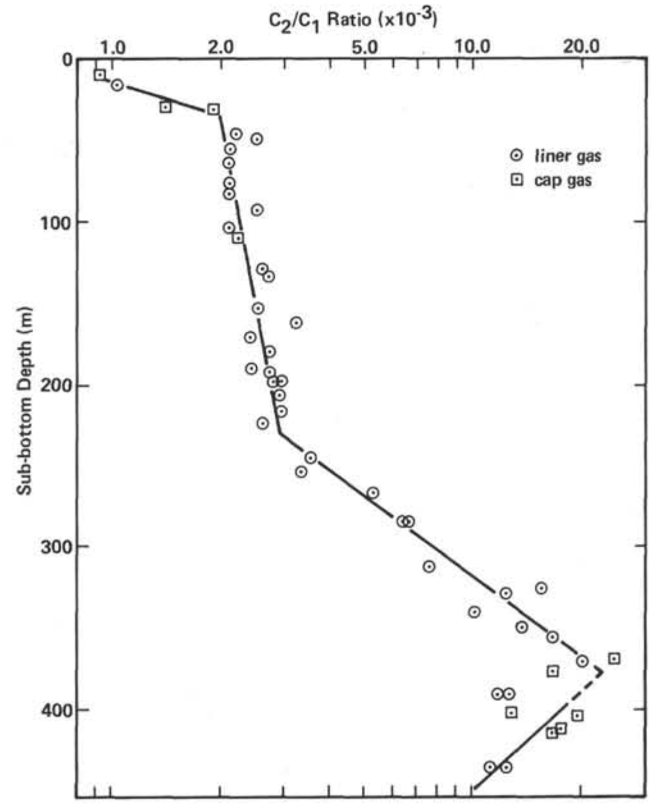

Figure 12. Ratio of ethane to methane versus depth at Site 479.

tion (cf. CO_2) followed by the biogenic products to about 250 meters (Claypool and Kaplan, 1974). The C_2H_6 data are also plotted in Figure 11, and the concentration increases to about 0.016% by about 50 meters sub-bottom; it then remains at that value to about 250 meters. This is followed by an increase to >0.1% with considerable scatter. The ethane-to-methane ratio is plotted versus depth in Figure 12. It exhibits a similar trend with an increase to about 50 meters, approximately constant to about 250 meters, followed by an increase and break at about 380 meters.

The $>C_2$ hydrocarbon concentrations were observed to increase, e.g., Section 479-31-5 at 285 meters shows an increase in C_3H_8 and Section 479-47-3 at 435 meters contains isobutane > propane. Thus a series of samples was analyzed to evaluate this hydrocarbon increase, and the results are plotted versus depth in Figure 13 (all the data are normalized to 100% CH_4). The ethane shows considerable scatter versus depth, but an inflection to higher concentration is evident at about 270 meters. The propane shows a steady increase with depth, with a definite minimum at about 270 meters and a decreasing trend below about 400 meters. Isobutane is at background levels to about 270 meters and then shows a rapid increase to a maximum concentration (greater than propane) at about 400 meters—also followed by a decreasing trend below that depth. Both *n*-butane and *n*-pentane remain at background levels throughout the hole. Isopentane also shows a rapid increase in concentration from about 270 meters to >435 meters, however, with some scatter. The maximum concentrations of the C_2-C_5 hydrocarbons are: $C_2 = 0.122\%$, $C_3 = 0.010\%$, $C_4 = 0.016\%$, and $C_5 = 0.0015\%$. The concentrations of $C_4 + C_5$ hydrocarbons are greater than those observed for the previous Sites 474, 477, and 478. These data indicated that we were approaching a zone with potential liquid hydrocarbons at depths >430 meters, and the concentration gradients indicate that the more volatile hydrocarbons (C_2-C_5) have migrated upward in the sedimentary column to just below the indurated "cap rock" sequences (~200–250 meters) and accumulated according to their volatility (i.e., boiling points). The propane and isobutane are at a maximum concentration above the isopentane. The absolute amount of thermogenic C_2-C_5 hydrocarbons superimposed on the endogenous hydrocarbons is small.

The carbon dioxide concentration versus depth is shown in Figure 14. The values show an initial increase to about 30% at 90 meters, remain level at that value (with some scatter) to 270 meters, and then increase and decrease with more variability to the bottom of the hole. Normalization of the data did not improve the scatter (cf. Figure 14). The trends of the CO_2 distribution do not follow the calcium concentration or the alkalinity. H_2S was detected by gas chromatography in only two shallow samples, but the odor persisted strongly from about 3 to 50 meters and faintly to about 200 meters.

Fluorescence

Fluorescence data were measured on (1) dried sediment and on tetrachloroethylene extract solutions of (2) dried sediment and (3) pyrolized sediment (red heat). None of the dried sediments exhibited any fluorescence, and the real-time fluorescence monitoring of split sections showed only fluorescence along the liners—a result of pipe dope contamination. The extracts of the dried sediments exhibit light orange to orange yellow fluorescence for the shallow and immature samples grading to light yellow, yellow, yellow green with depth,

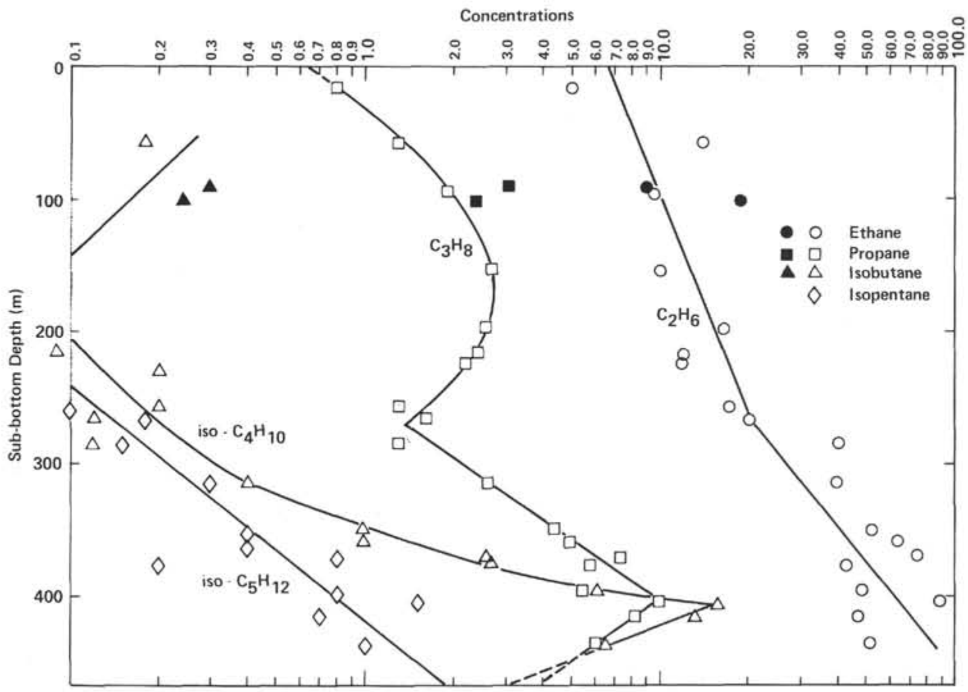

Figure 13. Concentrations of C_2–C_5 hydrocarbons versus depth at Site 479, with data from Site 480 (solid symbols) for comparison. All data normalized to 100% CH_4.

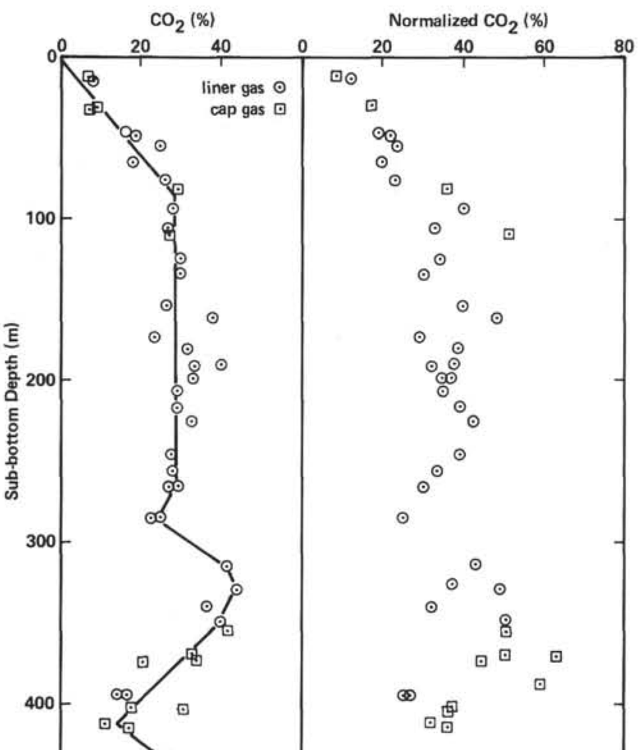

Figure 14. Concentration of CO_2 versus depth at Site 479. A. Raw data. B. Data normalized after correction for air.

which indicates some maturation of the lipid material. The extracts from the pyrolized samples exhibit a yellow blue to yellow white fluorescence in the upper sediment section, grading to a strong blue white below about 140 meters. This indicates that this sediment sequence has a petrogenic potential and can yield pyrolisate of a more aliphatic composition in the upper section and more aromatic at depths > 140 meters.

Organic Carbon and Organic Nitrogen

The samples were prepared and analyzed as already described, and the results are found in Appendix I, this volume, Pt. 2. The organic carbon and nitrogen contents are plotted in Figure 15. The organic carbon ranges from 3.6% near the surface to 1.2% at hole bottom, with an essentially linear distribution. The organic nitrogen values range from 0.4% near the surface to 0.17% at depth. The C/N ratio data are also found in Figure 15 and the range is from 9 to 16 with a mean value of 14. These values are typical for Recent immature sediments (~12; Ryther, 1956).

Conclusions

The surface sediments of Site 479 (to about 250 meters) are diatomites rich in organic matter (up to 3.6% organic carbon) and contain biogenic gas (CH_4, CO_2, H_2S, minor C_2H_6). Below about 250 meters the sediments become more indurated and the $> C_2$ hydrocarbon content of the interstitial gas rapidly increases. Propane and isobutane attain a maximum concentration at about 400 meters sub-bottom and isopentane is increasing to a maximum concentration below that depth. These data indicate that at greater depth the higher weight hydrocarbons ($> C_5$) would be encountered and that the C_3–C_5 hydrocarbons had migrated (diffused or distilled) upward from depth. This rapid increase in the relative concentrations of the C_3–C_5 hydrocarbons with their extent into the gasoline range (coupled with the increase of

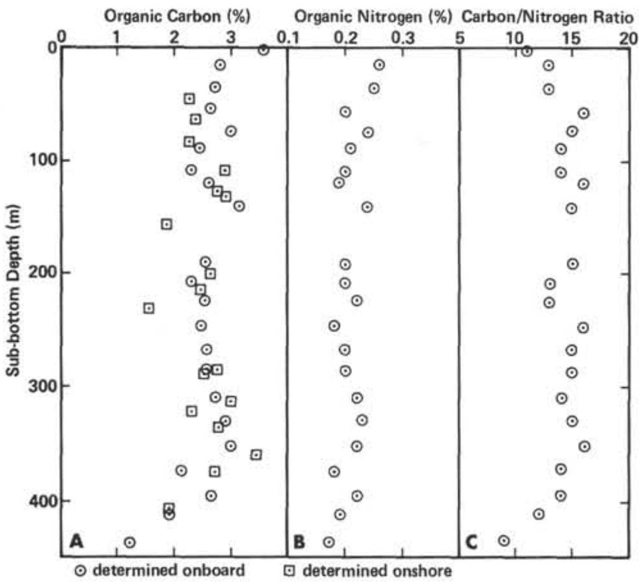

Figure 15. Organic-carbon (A) and organic-nitrogen (B) contents and ratios (C) versus depth at Site 479.

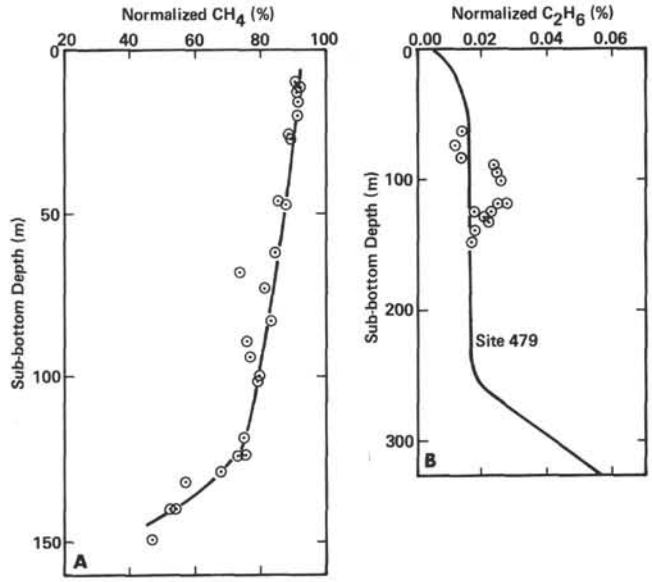

Figure 16. Concentrations of methane (A) and ethane (B) versus depth at Site 480. (Data are normalized after correction for air, and the ethane data are plotted in relation to the same data for Site 479).

the C_2/C_1 to about 20×10^{-4}) and the uncertainty of the numbers and thicknesses of sand layers that could accumulate these liquid hydrocarbons at greater depths led to the termination of drilling at Site 479.

SITE 480 ORGANIC GEOCHEMISTRY

The onboard monitoring program was again carried out in harried real-time. As each core arrived on deck it was sampled for gas from voids in the liner (if present) or later from the pressure build-up under the end caps; the core catcher samples were split and examined for fluorescence. The gases were analyzed mainly by the Carle GC, and spot checks were done with the Hewlett-Packard GC. The maturation of the organic matter was followed by the fluorescence of the toluene-ethanol extract of small sediment samples.

C_1-C_5 Hydrocarbon Analyses

The gases CH_4, C_2H_6, CO_2, and H_2S were monitored, and the normalized CH_4 and C_2H_6 data are plotted versus depth in Figure 16. The methane concentration shows a gradual decrease from 90% at 10 meters to about 75% at 125 meters, followed by a more rapid decrease to the bottom of the hole. The overall gas pressure that developed in the core liners increased with depth. The ethane concentration is low and shows a scattered distribution (cf., Fig. 16). The C_2/C_1 is plotted in Figure 17 with the approximate data distribution for Site 479. The C_2/C_1 shows a more rapid increase than for Site 479, indicating a higher influx of thermogenic hydrocarbons or a higher thermal gradient (assuming that the sedimentation rates are similar). This is further supported by the results of the $> C_2$ hydrocarbon analyses, where the ethane, propane, and isobutane are present at greater concentrations than at Site 479. The maximum concentrations of the C_1-C_4 hydrocarbons are:

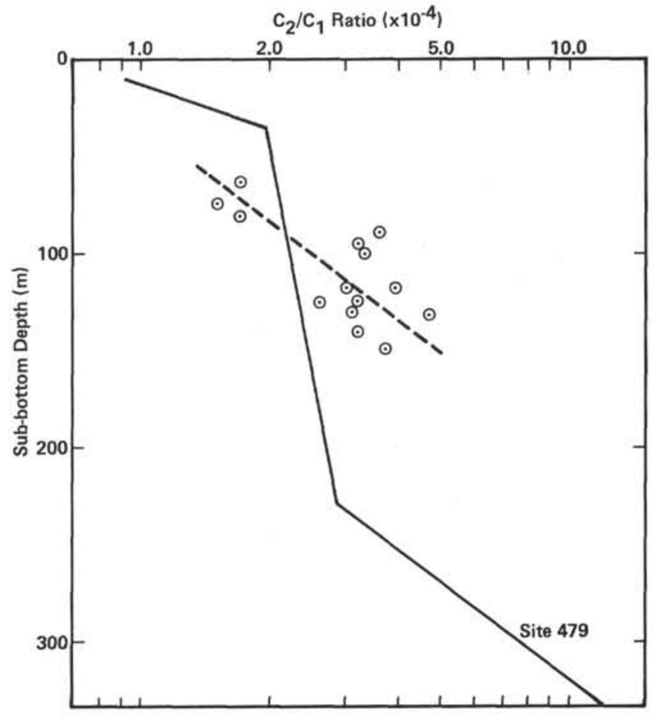

Figure 17. Ratios of ethane to methane versus depth at Site 480. The data are plotted in relation to the trend of C_2/C_1 at Site 479.

$C_1 = 91.8\%$, $C_2 = 0.035\%$, $C_3 = 0.003\%$, and $C_4 = 0.0003\%$.

The CO_2 concentration shows a gradual increase versus depth (Fig. 18) from about 10% at 10 meters to 50% at 150 meters. The hydrogen sulfide showed a more random distribution with depth. Large concentrations of H_2S were detected by GC (Fig. 18) and by odor through-

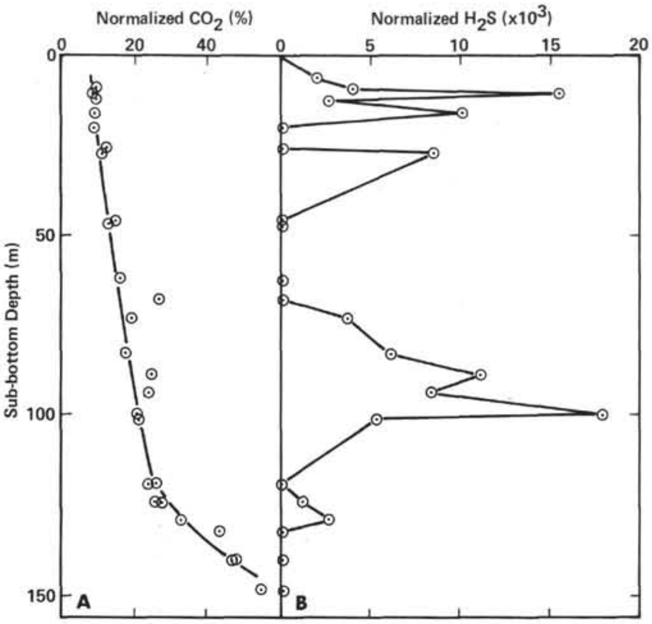

Figure 18. Concentrations of CO_2 (A) and H_2S (B) versus depth at Site 480 (data normalized after correction for air).

out the hole. The distribution maxima may be correlatable with lithology or possibly with fluctuations in oxicity of the paleoenvironment.

Organic Carbon and Organic Nitrogen

The samples were prepared and analyzed as already described, and the results are given in Appendix I, this volume, Pt. 2. The organic carbon and nitrogen contents and C/N ratios are plotted versus depth in Figure 19. The organic carbon ranges from 2.2 to 3.21% with an essentially uniform distribution, and the organic nitrogen content ranges from 0.16 to 0.27% with an analogous distribution to that of carbon and a slight decrease with depth. The C/N data show an increase from 12 to 16 with depth, and these values are typical for immature Recent sediments (~12; Ryther, 1956) and may reflect the onset of maturation.

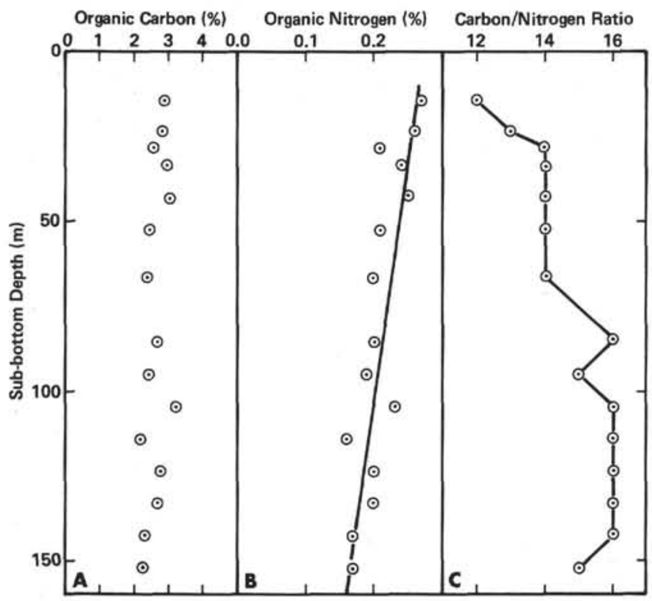

Figure 19. Organic-carbon (A) and organic-nitrogen (B) contents and ratios (C) versus depth at Site 480.

Conclusion

The sediments of Site 480 are laminated diatomites, rich in organic material, and contain biogenic gas (CH_4, CO_2, H_2S, minor C_2H_6). The C_2/C_1 of Site 480 increases more rapidly than at Site 479, possibly indicating a slightly higher maturation rate caused by a higher thermal gradient.

SITE 479 INORGANIC GEOCHEMISTRY

Interstitial Water Chemistry (Fig. 20)

Alkalinity and phosphate concentrations show large maxima at a depth of 15 meters and are the result of bacterial decomposition of organic carbon in these rapidly accumulated sediments. Of interest is the continuous increase in dissolved ammonia to a maximum of 26 mM at 220 meters. These large increases must be the result of the continued alteration of organic matter, presumably by methane-producing bacteria. Dissolved calcium shows a minimum, and dissolved magnesium shows a complex pattern. The sharp drop in magnesium at about 80 meters can be understood in terms of dolomite formation. Dissolved silica shows a steady state increase to 350 meters; below this depth, concentrations drop as a result of biogenic silica transformation reactions.

SITE 479 BIOSTRATIGRAPHY

The hemipelagic sediments recovered at Site 479 were rich in microfossils. Diatoms and silicoflagellates, generally well preserved, constituted the bulk of the fossil remains as far as Core 479-44; beneath this core, they disappear.

The coccoliths, less well preserved, occur inconsistently and in variable amounts; Cores 479-29 to 479-39 are barren of coccoliths. Radiolarians and benthic and planktonic foraminifers are minor components.

The diatoms and coccoliths indicate that the sediment section recovered at Site 479 is Pleistocene, but the planktonic foraminifers indicate uppermost Pliocene sediments in Core 479-44 to 479-47.

Tentatively, a late Pleistocene age (less than 400,000 y.) is assigned to Cores 479-1 through 479-25. Within the lower Pleistocene sequence, the *Mesocena elliptica* extinction datum (~0.7 m.y.) does occur in Core 479-32,CC, and the first occurrence datum (~0.93 m.y.) occurs in Core 479-39,CC.

Nannofossils

The late Pleistocene sediments recovered at Site 479 were generally poor in calcareous nannofossils. Because of their poor preservation, scarcity, and low diversity, the coccoliths do not allow a reliable biostratigraphic subdivision at this site. On the basis of the characteristics of the coccolith assemblages, the section is divided

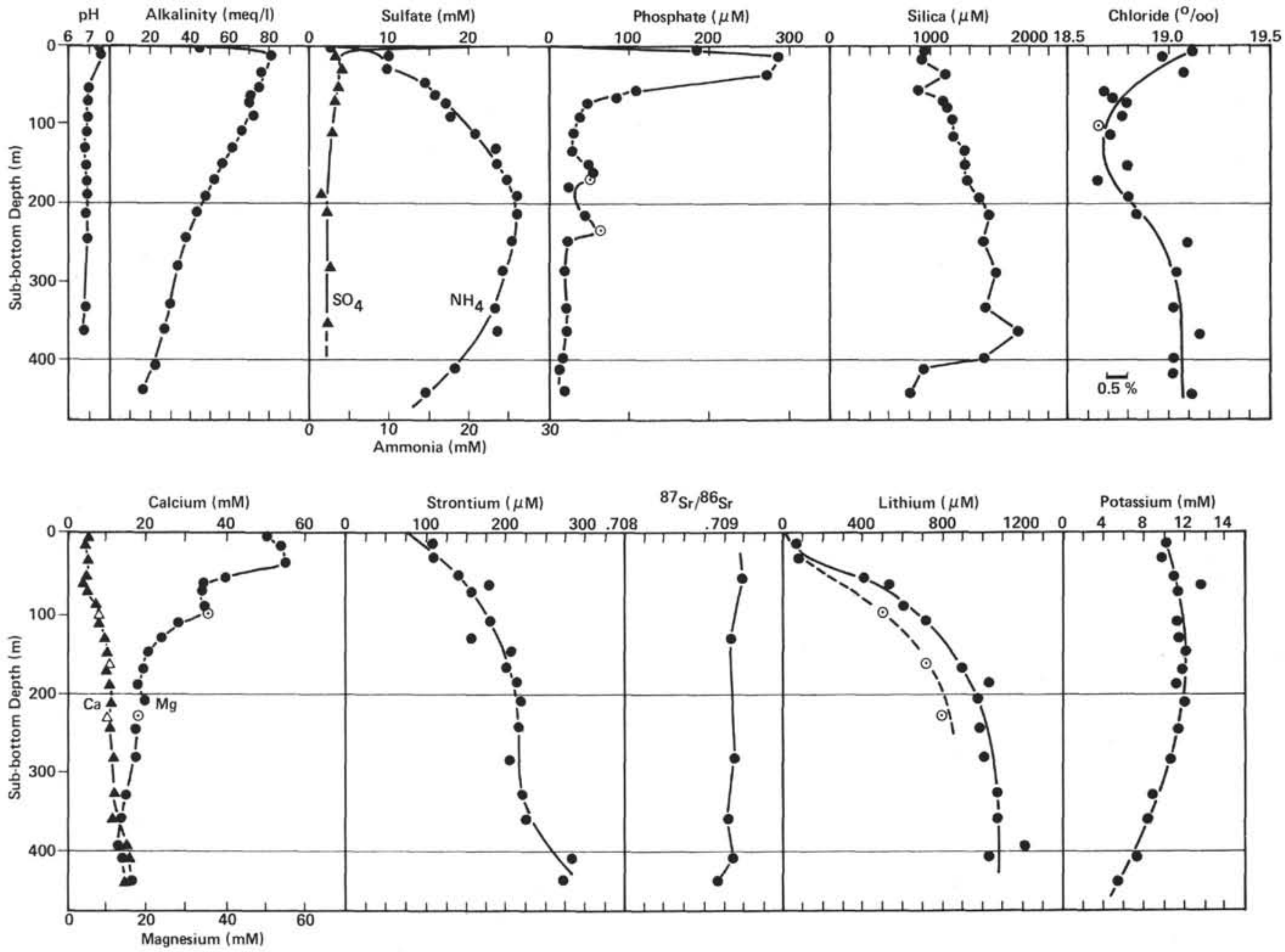

Figure 20. Composite plot of pore-water geochemistry, Site 479. (Open symbols show data from *in situ* pore-water samples.)

into two parts, separated by an almost barren interval. With the exception of Sample 479-32-1, 103–104 cm, which contains scarce and poorly-preserved Gephyrocapsids and *Cyclococcolithus leptoporus*, the interval between Samples 479-29-1, 59–60 and 479-40-2, 31–32 is barren of calcareous nannofossils. In the upper part, from Core 479-1 to 479-28, coccoliths are found in very irregular amounts, being either rare, common, or abundant. They may be absent. Coccoliths reworked from upper Cretaceous rocks are frequent.

In the lower part of the section, from Core 479-40 to 479-47, *Coccolithus pelagicus* strongly dominates the assemblages and can form thin monospecific nannofossil ooze layers: Samples 479-43-2, 48 cm; 479-44-3, 88 cm, 99 cm, 113 cm, 117 cm, 125 cm; Samples 479-44-4, 111 cm, 135 cm; Samples 479-45-3, 115 cm; Samples 479-45-6, 43 cm.

Diatoms

Diatoms and silicoflagellates were abundant and commonly well preserved at Site 479. Their preservation and abundance drop sharply below Core 479-43, and samples below Core 479-44 were barren.

The diatom assemblages were dominated by a meroplanktonic component consisting of *Actinocyclus ehrenbergii, Stephanopyxis turris, A. undulatus* a.o. Assemblages varied greatly within short intervals, representative of postulated (Schuette and Schrader, 1978a) species succession in sediments underlying coastal upwelling. A laminated section in Section 479-33,CC was sampled in detail and within 5 mm revealed the following assemblages: (1) *Thalassiosira oestrupii* (over 90%); (2) *T. oestrupii* (~50%) and oceanic component (~20%); and (3) *S. turris* with almost no *Chaetoceros* bristle fragments nor spores. Similarly, a high variation within the varved interval at Core 479-36 was observed. An increase in the oceanic component with *Pseudoeunotia doliolus* and *Rhizosolenia bergonii* commonly occurred also and will be useful in determining the influence of oceanic Pacific waters at distinct intervals.

Displaced marine benthic species were observed frequently throughout this site, whereas no displaced freshwater diatoms were found. Reworked, older index fossils were observed only in Section 479-35,CC with abundant *Rhizosolenia barboi* and *R. curvirostris*. This datum, representing the evolutionary transition, is established in the North Pacific near the Pliocene/Pleistocene boundary. Both species do occur only in colder environments, and thus far no clue is in hand to interpret their occurrence.

The *Nitzschia fossilis* datum was not observed at this site. The *Mesocena elliptica* extinction datum, which is placed at around 0.7 m.y., did occur in Section 479-32, CC and the first occurrence datum, ~0.93 m.y., in Section 479-39,CC. No other datum levels, either Equatorial Pacific or North Pacific, were observed except the extinction level of *N. reinholdii*, which is time transgressive from high to low latitudes. Thus, the oldest diatom-bearing sediments in Core 479-43 might not be older than about 1.7 m.y. (extinction level of *R. matuyamai*). Other datum levels using abundance of species and bimodal mean diameter size distribution of *Coscinodiscus nodulifer* will be established on shore.

Radiolarians

Only seven samples were analyzed from Site 479: Section 479-1,CC, and Cores 479-10, 479-20, 479-31, 479-37, 479-40, and 479-47. Radiolarian remains are strongly diluted by diatom frustules in the sediments.

In the samples *Ommatodiscus* sp. (Benson, 1966), *Teocalyptra davisiana, Dictyocoryne truncatum, Tetrapyle octacantha*, and *Euchitonia furcata* were among the common species.

In Section 479-31,CC, two incomplete reworked specimens of *Ommatartus avitus* were observed. This species became extinct during the middle Pliocene in the equatorial Pacific.

Foraminifers

Two (or three) cooler intervals are seen in the planktonic foraminiferal fauna in the section above Core 479-28. The lowest part of the section at this site, from Core 479-42 to 479-47, is indicated as the latest Pliocene by the co-occurrence of *Globigerinoides obliquus, G. bollii*, and *Pulleniatina obliquiloculata* (s.s.). The benthic fauna is characterized by the abundant occurrence of several species of genus *Bolivina* throughout the section; *Bolivina seminuda, B. subadvena, B. spissa, B. argentea*, and so forth. *Buliminella tenuata* and *Cassidulina cushmani* are also abundant.

SITE 480 BIOSTRATIGRAPHY

Nannofossils

The common occurrence and better preservation of the coccoliths in the detrital clayey laminae at Site 480 is surprising when compared with the absence of nannofossils in the diatomaceous laminae. The latter are interpreted as being accumulations derived from biogenic blooms caused by upwelling. The calcareous nannofossil assemblages at Site 480 are similar to those found in sediments of comparable age (late Pleistocene) at previous sites in the Guaymas Basin.

Foraminifers

One or two cooler intervals occur though the occurrence of planktonic foraminifera are scattered. As at Site 479, the benthic foraminifers are dominated by several species of *Bolivina*.

Diatoms and Silicoflagellates

A total of 152 meters of hemipelagic sediments were continuously piston cored; recovery was generally greater than 80%. The section can visually be subdivided into finely laminated and homogeneous intervals. The spacing of these intervals seems not to be cyclic. All sediments except for a few narrow sand and turbidite layers are very rich in diatoms and silicoflagellates and offer a unique opportunity to study in detail floral changes and relate them to local and over-regional climatic events.

Since the shipboard scientific party decided *not* to disturb the collected section by the usual plastic cylinder punching method but rather to postpone detailed sampling to a later shore-lab date, only the core catcher samples, in addition to a few sedimentological smear slides, were available for shipboard study.

The varved sediments present the fortunate opportunity of defining an absolute chronology obtainable by counting the annual laminae pairs. The first test thus was to confirm if indeed laminated sediments in the deeper cores might represent varves as defined by Calvert (1964) and amended later by Baumgartner et al. (1979).

A 0.5-cm-thick piece of laminated diatomaceous mud was used from Section 480-29,CC. We sliced into its white and greenish laminae as accurately as possible and mounted it separately. A total of 26 laminae were separated and microscopically analyzed for their diatom content. The following sequence was observed (Fig. 21).

1) Greenish with sublaminae (a); thicker than (b); opal phytoplankton preservation excellent, mostly consisting of *Chaetoceros* spores, meroplanktic species, *Thalassiosira nitzschioides* and to a much lower content of oceanic species, with abundant clay.

2) White layers without sublaminae (b); opal phytoplankton preservation poor, mostly consisting of *Coscinodiscus nodulifer*, without clay.

On the basis of sediments underlying recent coastal upwelling areas off Peru (Schuette and Schrader, 1981a) and off southwest Africa (Schuette and Schrader, 1981b) and containing similar flora, the greenish laminae with well-preserved meroplanktic diatoms are interpreted to represent coastal upwelling seasons, whereas the white laminae with poor to moderate, almost monospecific,

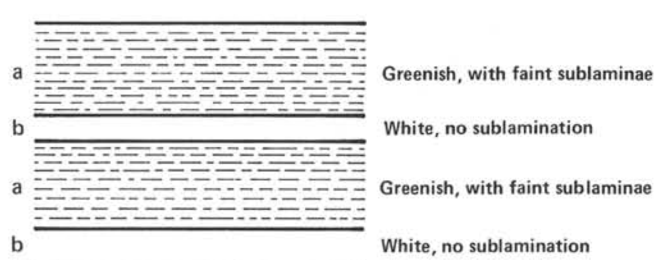

Figure 21. Makeup of laminated couplets, Core 480-29,CC: a: Laminae representing upwelling season; b: Laminae representing non-upwelling season.

assemblages (*C. nodulifer* in Section 480-29,CC and *C.* cf. *oculus-iridis* in Section 480-16,CC) represent non-upwelling seasons. The terms "coastal-upwelling" and "nonupwelling" influenced sediments will be used strictly in the later part of this chapter. An attempt to relate these to climatic patterns will be discussed in detail in the discussion and summary.

The greenish coastal-upwelling laminae (Type a) are generally (in Sections 480-29,CC and 480-16,CC) thicker than the white ones and contain, in addition to the well-preserved diatom component, a substantial amount of clay (up to 60%), whereas the white, nonupwelling laminae (Type b) are thinner and contain almost no clay or silty terrigenous components. Frequently, calcareous nannofossils were observed together with the white laminae (for discussion see below); they should represent times of lower sedimentation.

The higher number of laminae distinguished visually in Core 480-29,CC showed the following separation, using the above-outlined criteria: (1) non-upwelling, (2) upwelling, (3) non-upwelling, (4) upwelling, (5) non-upwelling, (6,7,8) upwelling, (9) non-upwelling, (10,11) upwelling, (12) non-upwelling, (13) upwelling, (14,15) non-upwelling, (16) upwelling, (17) non-upwelling, (18) upwelling, (19) non-upwelling, (20) upwelling, (21,22,23) non-upwelling, and (24,25,26) upwelling. In summary, a total of nine non-upwelling seasons, and a total of nine upwelling seasons could be separated (Fig. 21).

The lamination within the greenish intervals is faint and represents fluctuation and species succession during the highly variable upwelling season. As typical populations within these "upwelling" layers, the following could be separated: (1) *Chaetoceros* spores (<80%), meroplanktic component (~10%); (2) *Pseudoenotia doliolus* (40%), *Chaetoceros* spores (30%); (3) *Chaetocercs* spores (50%), *Thalassionema nitzschioides* (thin) (30%), *Coscinodiscus nodulifer* (10%); (4) *Chaetoceros* spores (40%), *Thalassiosira oestrupii* (20%).

The white layers are generally homogeneous and contain only one or two species—*Coscinodiscus nodulifer* and/or *Pseudoeunotia doliolus*. Because the size distribution of *C. nodulifer* seems to be climatically controlled, these layers offer a good chance to correlate the unimodal and/or bimodal size distribution in the Gulf to the eastern equatorial Pacific, where it has been tied into the $\delta^{18}O$ stratigraphy (Burckle and McLaughlin, 1976).

Four smear slides from a homogeneous section contained the following distinct floras:

1) 480-P4-1, 70 cm: *C. nodulifer* A, *P. doliolus* T, no marine benthic forms, and no fresh-water forms. Preservation was poor (representing a non-upwelling season).

2) 480-P4-2, 15 cm: *Chaetoceros* spores C, *P. doliolus* F, *T. oestrupii* F, *R. semispina R,* marine benthic forms (excellently preserved) ~2%, and fresh-water forms ~1%. Preservation excellent (representing an upwelling season).

3) 480-P4-2, 70 cm: *Thalassionema nitzschioides* C, *Cyclotella striata* F, *Chaetoceros* spores F, *P. doliolus* F, *Coscinodiscus nodulifer* R, no fresh-water forms, trace of marine benthic forms, poorly preserved. Preservation moderate (representing a mixture of an upwelling and a non-upwelling season).

4) 480-P4-3, 70 cm: *C. nodulifer* A, no fresh-water forms, marine benthic forms T (poorly preserved). Preservation poor (representing a non-upwelling season).

It seems that the homogeneous sections do contain a similar upwelling/non-upwelling diatomaceous signal. These signals might be visually disturbed by a rather constant supply of terrigenous material which blurs the lamination. On the other hand, such sharply expressed signals cannot be preserved in a bioturbated record; thus it might be postulated that parts of the homogeneous section are *not* bioturbated, or only bioturbated in surface layers. Calcareous nannoplankton, because of its oceanic habitat and its controversial environmental requirements compared to diatoms, should be commoner in those intervals interpreted as non-upwelling based on diatoms. The following percentages were found on the above-mentioned samples: (1) with ~10% and (4) with ~12% nannofossils, as determined by smear-slide sedimentological description.

Another, ~1-cm-thick slab of Core 480-16,CC revealed 12 distinct white and 11 greenish layers; again, the greenish layers were generally 50% thicker and showed again a sublamination similar to the one found in Core 480-29,CC.

Another distinct feature was the occurrence of a monolayer of fish scales at the bottom of each greenish layer; this became apparent on dry laminated pieces, whereas microscopic tests on the original wet samples did not readily resolve this structure (Fig. 22). The explanation for this type of cyclic occurrence of fish scales might be the depletion of available phytoplankton at the termination of an upwelling cycle, and change to more-uniform, constant oceanic conditions.

Three samples were available from Core 480-14:

1) 480-P14-1, 100 cm: clayey diatomaceous ooze: *T. nitzschioides* A, *Thalassiosira oestrupii* F, *Chaetoceros* spores F, *Octactis pulchra* F, *Cyclotella striata* R, preservation of opal phytoplankton excellent, with *Skeletonema costatum* as one index. Surprisingly, this sample contained about 10% calcareous nannoplankton and seems to be different from other findings (compare discussion above).

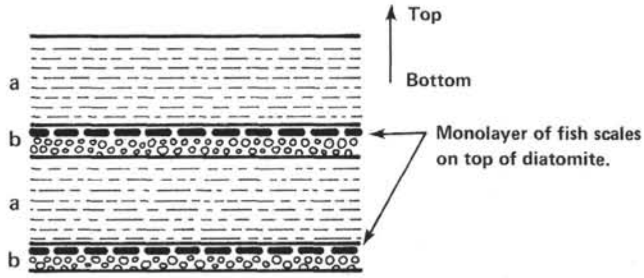

Figure 22. Microstructure of couplets of laminae, Cores 480-16 and 29,CC, illustrating monolayer of fish scales on top of pure diatomite layer with oceanic species: *Coscinodiscus nodulifer* in 29,CC, and *C. oculus-iridis*(?) in 16,CC.

2) 480-P14-1, 110 cm: dark diatomaceous ooze with volcanic glass: *Thalassionema nitzschioides* A, *Chaetoceros* spores R, *O. pulchra* F, meroplanktic component T, preservation of opal phytoplankton excellent. Again, similar to (1) about 7 to 8% calcareous nannoplankton was observed.

3) 480-P14-2, 70 cm: muddy diatomaceous ooze: *T. nitzschioides* A, *Chaetoceros* spores C, *Dictyocha fibula* F, marine benthic forms ~2% (moderately well preserved), *A. undulatus* F, *P. doliolus* F, *Cyclotella striata* F, *Coscinodiscus nodulifer* R, preservation moderate.

The homogeneous interval in Sections 480-14-2 and 480-14-3 again might carry the seasonal upwelling/non-upwelling signal, which is blurred by terrigenous input. On the other hand, the relatively high percentages of calcareous nannofossils might serve as an indication of decreased coastal upwelling and a decrease in depth of the upper oxygen-minimum boundary, which ultimately allows for bioturbation.

Another suite of samples was examined:

1) 480-P13-2, 66 cm: gray diatomaceous clayey layer: *Chaetoceros* spores A, *T. nitzschioides* (thin) C, *A. undulatus* F, no fresh-water nor marine benthic forms, *O. pulchra* T, assemblage excellently preserved, coccoliths trace, probably an upwelling layer.

2) 480-P15-2, 65 cm: diatomaceous clayey silt (stone?): *Chaetoceros* spores A, *T. nitzschioides* C (thin), *O. pulchra* F, *Cyclotella striata* R, well-preserved assemblage, probably an upwelling layer.

3) 480-P21-1, 134 cm: calcareous claystone: *Coscinodiscus nodulifer* A, poorly preserved assemblage, representing time of low productivity and warm oceanic conditions, probably a non-upwelling layer.

4) 480-P21-2, 18 cm: muddy diatomaceous ooze, pale olive layer: *P. doliolus* C, *O. pulchra* F, *Chaetoceros* spores F, *A. undulatus* F, assemblage excellently preserved, probably an upwelling assemblage (note also >40% clay).

5) 480-P21-2, 15 cm: gray layer: *Chaetoceros* spores C, *P. doliolus* F, *Thalassiosira oestrupii* R, marine benthic forms F, preservation good, probably an upwelling layer at the termination of coastal upwelling.

6) 480-P26-1, 83.4 cm: diatomaceous ooze white(?) layer (70% diatoms): *Thalassionema nitzschioides* A, *P. doliolus* F, *Thalassiosira oestrupii* F, *Chaetoceros* spores few, preservation excellent, probably an upwelling layer, with only little terrigenous input (25% clay).

7) 480-P26-1, 83.6 cm: muddy diatomaceous ooze, dark layer: *T. oestrupii* C, *Thalassionema nitzschioides* C, *A. undulatus* F, preservation excellent, probably an upwelling layer (50% clay).

Diatom and silicoflagellate species of equatorial to subtropical habitat (as defined in Baumgartner et al., 1979) were found frequently at distinct horizons (P21, P15, P14) (*O. pulchra, P. doliolus, Stephanopyxis palmeriana, Thalassiosira lineata*); cold-water species such as *Coscinodiscus marginatus, T. angunte-lineata, Dictyocha epidon* were found on the other hand only sporadically.

So far, no trend in an enrichment of cold- or warm-water species has been detected. Biostratigraphic index species were observed only in 480-29,CC, where about 1% of the *P. doliolus* assemblage consisted of *Nitzschia fossilis*, which became extinct in the equatorial Pacific around 0.26 Ma, and, if this datum level is synchronous in the Gulf, sediments below 480-29,CC should be older than 0.26 m.y. The exact position of this extinction datum cannot be defined yet, because of the lack of available material uphole. On the other hand, this type of rare occurrence, one individual out of 100 observed specimens, seems to be rather selective, especially in assemblages which do not carry a large number of *P. doliolus*.

SITE 479 PHYSICAL PROPERTIES

At Site 479, core disturbance by drilling and expanding gas was more intensive than at the other sites of Leg 64. The following cores were highly disturbed: 479-5 through 7, 479-11, 479-13 through 25. Core 479-34 contained drilling breccia. Small samples were taken for water content, porosity, and bulk density. Cores 479-2, 4, 30, 33, and 46 were empty. Downhole disturbances by gas decreased from Cores 479-28 and 29. Cores 479-38 through 47 were better preserved than those from the middle and upper part of the hole. From Core 479-32 downward it became difficult to use the "cheese cutter," but only the deepest core (479-47) had to be split entirely by the saw. Because of the many disturbed cores, a great part of the GRAPE measurements carried out on one or two sections of about half of all the cores cannot be evaluated.

Near the sea bottom, the partially varved sediments rich in diatoms have very high water contents (~80%) and porosities (~90%), and extremely low bulk densities (1.1 g/cm^3; Fig. 23). Down to about 80 meters, the physical properties change more or less in the common way, and then appear to become rather stable downhole to about 380 meters. This signifies that, down to this depth range, the relatively slowly increasing effective overburden pressure (see summary of physical properties, Einsele, this volume, Pt. 2) does not affect the sediments very much. Further evidence for this statement is the observation that varved sediments at 350 to 370 meters depth still have water contents and porosities about as high as at 50 meters sub-bottom (55–60% and 70–80%, respectively). These findings are confirmed by the density log, as well as by GRAPE measurements. The scatter of data in the depth range from 0 to 380 meters is caused mainly by changing composition of the sediments. Varved beds rich in biogenic silica have low average grain densities (often between 2.3 and 2.4 g/cm^3) and are less compacted than dark mud layers containing higher amounts of terrigenous material (see Fig. 23 and results for Site 480), but because of the bad preservation of most of the cores, the relationship of the samples to one of these two groups often could not be recognized. Therefore, the trend lines shown in Figure 23 represent more or less the average physical properties of the lighter olive-gray varved and darker homogeneous beds.

From about 370 to 390 meters downhole, the physical properties change considerably. These changes may be

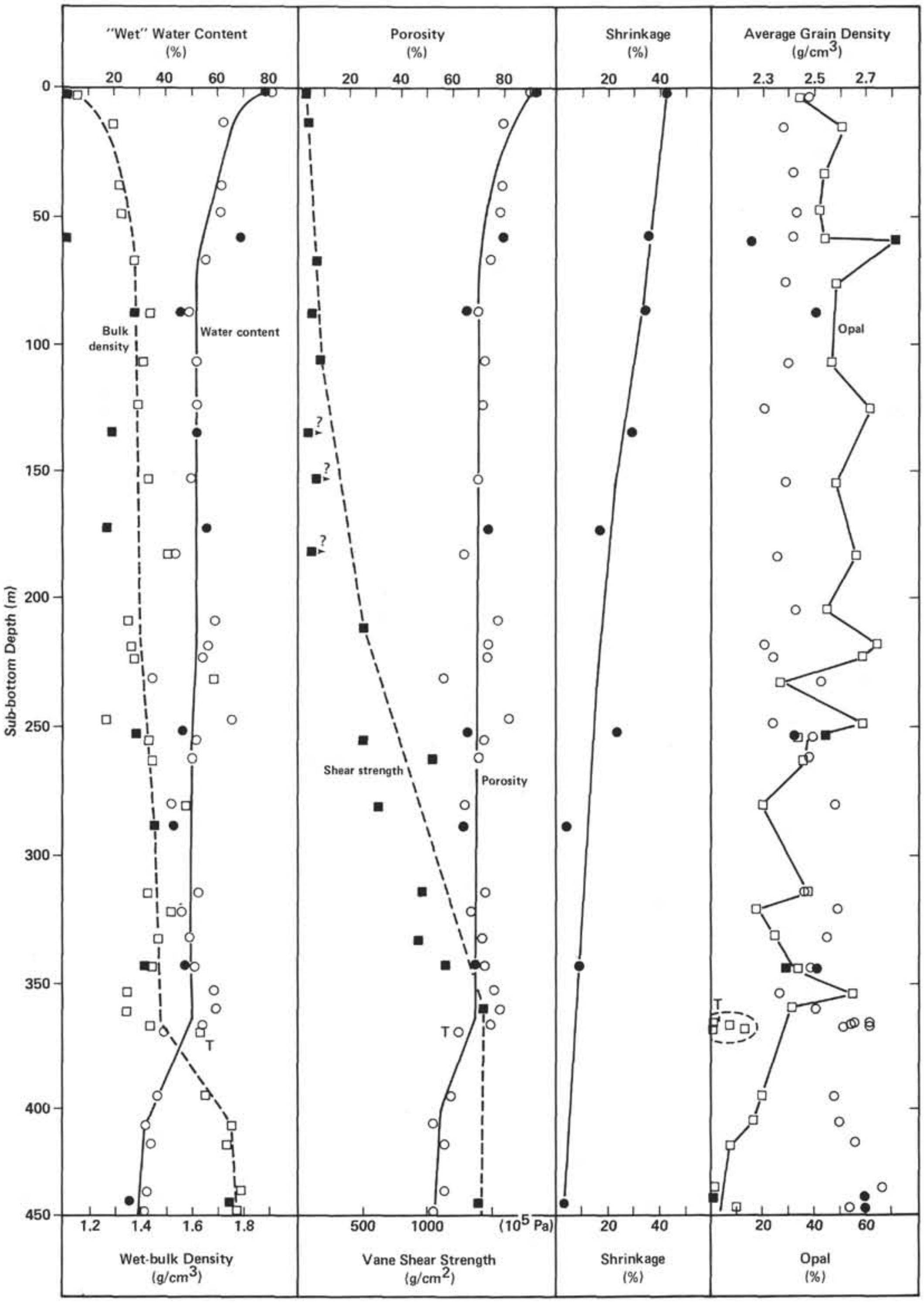

Figure 23. Mass physical properties, shrinkage, and content of opaline silica in sediments from Hole 479. The strong change of all properties at about 400 meters is related to an unconformity, as found in the seismic records. Smaller deviations of single data points from the general trend lines are mainly due to sampling from mud turbidites (T), or from layers rich in diatoms (i.e., about 350 to 360 m). Shear strength values marked ? are probably too low. (Closed symbols are cylinder samples. Open symbols are chunk samples.)

related in part to an unconformity in the section at approximately this depth. Water content decreases by 15 to 20% to 30 to 35%, porosity decreases by 10 to 15% to 55 to 60%, and bulk density increases by 0.2 to 0.3 g/cm^3 to 1.7 to 1.8 g/cm^3. These values correspond to those at 280 to 300 meters depth in Hole 474A, where at 250 to 260 meters depth already the same effective overburden pressure is reached as in Hole 479 at 380 meters depth (see Einsele, this volume, Pt. 2). The marked change in compaction at Hole 479 probably is caused mainly by the decrease of biogenic siliceous fossils (both in the original composition and by diagenesis), which can be derived also from the average grain densities (Fig. 23). However, other changes in the composition of the sediments also may have some influence. The higher compaction of the sediments in the lowermost part of the hole is confirmed by the density log (although the absolute figures of this log appear to be incorrect), and the GRAPE measurements.

Vane shear strength increases more slowly versus depth than at previous sites. This may be partly due to the low bulk density of the silica-rich varved layers, which cannot build up the same overburden pressure as terrigenous deposits at the corresponding depth. Furthermore, these deposits possibly develop only low cohesion because of their low content in clay minerals. But some of the values measured are certainly too low. At 360 meters and farther downhole, vane shear strength values between 1400 and 1500 g/cm^3 appear to be "normal."

From the few values determined for shrinkage it can be seen (Fig. 23) that the resistance of the grain framework against the forces of shrinkage (suction) increases downhole. Low values of shrinkage must be related primarily to diagenetic changes, but to some extent they also reflect the low content of clay minerals in layers rich in biogenic silica.

Some values of laboratory measurements of sonic velocity and bulk density are listed in Table 3.

SITE 480 PHYSICAL PROPERTIES

By using the newly developed piston corer in combination with the drilling pipe (see above), most of the cores were excellently preserved. Usually only a zone of less than 3 mm along the contact with the core liner was disturbed. It would have been a rare opportunity to determine physical properties on these cores, but they were reserved for special studies on varves. Therefore, we took no samples from the core sections, except from Sections 480-P1-1 and 2. All the other samples came from the core catcher of these piston cores and were rather disturbed and contorted. Therefore, we probed only with small cylinders (5 cm^3) and did not carry out vane tests.

Table 3. Laboratory measurements of sound velocity and wet-bulk density on core samples from Hole 479.

Section	Interval (cm)	Sample Description	Orientation	v_s (km/s)	Wet-Bulk Density (g/cm^3)
479-13,CC		Calcareous mudstone	=	4.40	2.57
479-20-3	82–84	Calcareous mudstone	=	4.79	2.57
479-29-1	22–24	Calcareous mudstone	=	4.05	2.48
479-32,CC		Calcareous mudstone		—	2.76
479-35-4	145–147	Silty clay, hard	⊥	1.49	—
479-40-3	0–2	Calcareous siltstone		—	2.77

Nevertheless, the physical-property data from Hole 480 yielded some information additional to the results at Site 479. In contrast to the badly preserved cores at the previous site, here it was possible to distinguish between relatively light olive-gray varved diatomaceous ooze and more or less homogeneous dark-gray core sections (clay-rich layers or mud turbidites). At all investigated depths, the physical properties of the dark beds differ considerably from those of the varved sections. The trend lines in Figure 24 mainly represent the varved sections, whereas the dark beds show lower water contents and porosities, but higher bulk densities and average grain densities. For that reason, the trend lines for the varved beds of Hole 480 start near the surface at even higher water contents (80–85%) and porosities (90–95%), and lower bulk densities (~ 1.1 g/cm^3) than in Hole 479. Principally, the trend lines of physical properties versus depth are similar in both holes. From 50 to 70 meters downhole, the values appear to become rather stable, as in Hole 479. Shrinkage is rather low in some light-colored varved beds, whereas the darker beds and also some turbidites show relatively high shrinkage at the corresponding depth. The content of opaline silica, as determined from average grain densities (see Site 474 report), is plotted in Figure 24.

On a limited number of sections, GRAPE measurements were performed. Because of the small core disturbances, the results are very good. The records reliably show the location of varved or homogeneous dark sections. From Core 479-P8 to the bottom of the hole, the varved sections consistently have GRAPE bulk densities of 1.2 to 1.3 g/cm^3 (in the lowermost sections, up to 1.35 g/cm^3), whereas the dark beds are considerably denser (1.45–1.6 g/cm^3). These measurements agree well with the bulk densities determined by gravimetric methods (Fig. 24).

Laboratory measurements of sonic velocity could not be carried out.

Conclusions for Sites 479 and 480:

1) The varved beds rich in biogenic silica keep up very high water content and porosities in combination with very low bulk densities, down to at least 350 meters below the sediment surface.

2) The gain of shear strength in relation to burial depth appears to be smaller in diatomaceous ooze than in sediments with higher amounts of clay and other terrigenous material.

3) Shrinkage, an indicator of the onset of diagenesis, can drop to 5 to 10% even at shallow depth (< 100 m) in sediments rich in biogenic silica.

4) Relatively strong variations in the relationship between physical properties and depth are caused by changing input of terrigenous material into the "host" sedimentation, consisting mainly of diatomaceous ooze. This can be clearly seen on the GRAPE record and the density log (Site 479).

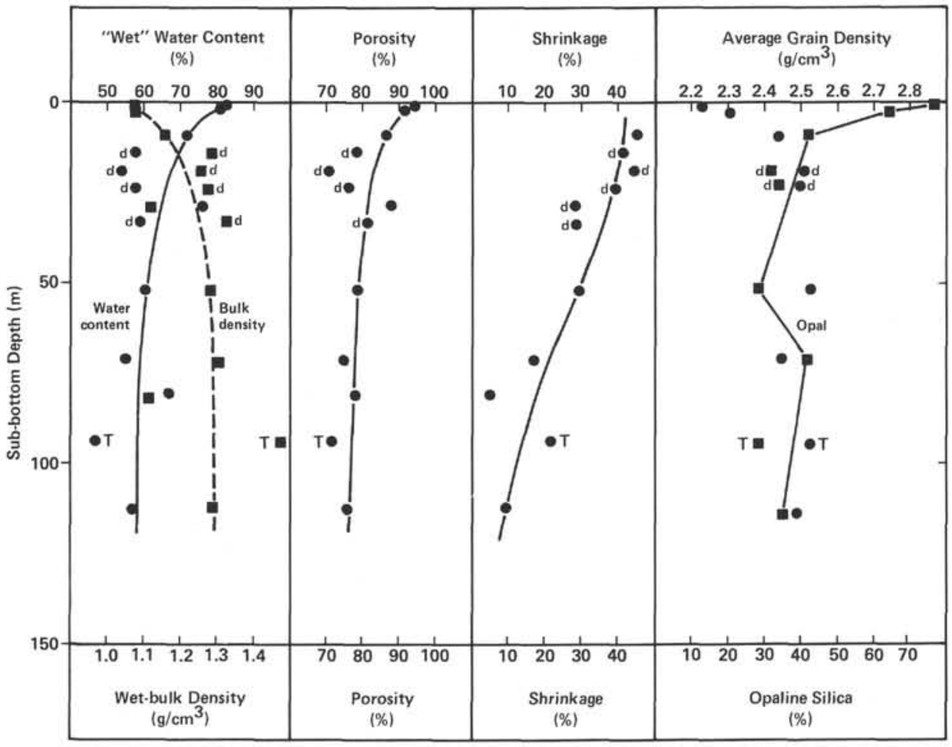

Figure 24. Mass physical properties, shrinkage, and content of opaline silica in sediments from Hole 480. (T) = turbidites, (d) = dark layers rich in clay.

SITE 479 HEAT FLOW

The undisturbed formation temperature at Site 479 was calculated from the final temperatures measured by the two logging runs, using the formula of Dowdle and Cobb (1974). In their notation, the measured temperature

$$T_{ws} = T_i - C \log \frac{t_k + \Delta t}{\Delta t}$$

where T_i is the formation temperature, C a constant to be determined, t_k is the circulation time, and Δt is the time after circulation ceased. Because we have two sets of values of Δt and T_{ws}, we solve for C and T_i. For Site 479 these values are

$$\begin{aligned} \text{Run 1: } T_{ws} &= 37.5°\text{C} \\ \Delta t &= 2 \text{ hr} \\ \text{Run 2: } T_{ws} &= 47.3°\text{C} \\ \Delta t &= 12 \text{ hr} \end{aligned}$$

Calculations for circulation time t_k of ½ hr and 1 hr gave nearly identical results; the bottomhole temperature (BHT) came out $T_i = 49.5°$C. The temperature at the mudline is 7.9°, leaving a difference of 41.60°. Dividing by the length of the hole (434 m) yields a gradient of 95.9°C/km.

Thermal conductivity is calculated from the lithology and some measurements on samples (Table 4). Because the diatomaceous sediments are likely to be more conducting *in situ*, the value 2.26 was adopted instead of 2.14 for the soft sediments from 0 to 360 meters. From 360 to 440 meters, the sediments become increasingly indurated to claystone, for which we assigned a conductivity of 4.04. The average conductivity for the whole rock column is

$$\langle K \rangle = \left[\left(\frac{360}{2.26} + \frac{80}{4.04}\right)\frac{1}{440}\right]^{-1} = 2.46 \text{ mcal/cm s°C}$$

The heat flow in Site 479 thus is 2.36 HFU.

Three temperatures were taken with the Uyeda instrument at this site. When the probe was in the sediment, the one at 98 meters gave a temperature nearly constant with time, the one at 165 meters gave a curve with decreasing slope, and the temperature at the deepest at 231 meters was rising with a constant slope. For the shallowest penetration, the temperature at which the curve leveled off was taken as the formation temperature. In the case of the measurement at 165 meters, it was estimated that the formation temperature was 1°C higher than the last-measured temperature. For the deepest penetration, 2°C was added to the last-measured temperature; the conductivity was taken to be 2.26 for all three measurements. Table 5 gives the details of the calculations. This is 88% of the value given by the bottomhole temperature from logging.

Comparison of the values from the Japanese instrument with those from bottomhole temperatures is essential to establish the best way of interpreting its readings. In any case, all logging tools should be equipped with maximum thermometers according to standard practice.

Table 4. Measurements of thermal conductivity.

Sample	K (mcal/ cm s °C)	
478-26-1, 114–116	4.54	Basalt
29-1, 23–26	4.59	Basalt
41-5, 56–58	4.38	Basalt
49-3, 56–58	4.31	Basalt
54-3, 16 –	3.80	Basalt
54-1, 5d	5.42	Basalt
54-4,	4.85	Basalt
	<4.56>	
	±0.50	
479-1-1, 104–107	1.68	Soft sediment
1,CC	2.40	
1,CC	2.28	
14, bottom	1.73	
23-7, 3-12	1.97	
3-7, 3-12	2.06	
12,CC	2.15	
29-1, 23–26	4.04	Calcified rock
29-1, 38–43	2.28	Soft sediment
37-2, 0–10	2.62	
40-2, 62–69	2.21	
	<2.14>	Without the rock
	±0.29	
481-P2-2, 50–55	1.76	Av. of 3 meas. spongy diatomaceous ooze expanded by gas
P4-1, 67–74	1.75	Av. of 2 meas. spongy diatomaceous ooze expanded by gas
P8-3, 94–100	1.94	Av. of 2 meas. spongy diatomaceous ooze expanded by gas
P11-3,	2.36	Av. of 2 meas. spongy diatomaceous ooze expanded by gas
1-2, 86–93	1.95	Av. of 6 meas. ±0.15 spongy diatomaceous ooze expanded by gas
481A-6-4, 23–24	2.48	
12-6, 45–50	2.58	Firm gray silt, not malleable
28-2, 36–41	2.46	
22-5, 4–8	2.34	
31-1,CC	3.68	Av. of 2 pieces vesicular basalt

Table 5. Measured temperatures and heat flow.

Sub-bottom Depth (m)	Measured Temperature (°C)	Estimated Corrected Temperature (°C)	Mudline Temperature (°C)	Heat Flow (HFU)
98	14.0	14.0	6.5	1.73
165	23.0	24.0	6.4	2.42
231	26.0	28.0	6.6	2.09
				<2.08> ± 0.35

CORRELATION OF DRILLING RESULTS WITH SEISMIC AND DOWNHOLE LOGGING DATA, SITES 479 AND 480

Site 479 was proposed on the basis of a 1967 survey line, near a new SIO multichannel lines. Figure 4 shows the survey made during the selection of Site 479 with *Glomar Challenger*. We will return to a discussion of these records shortly.

After completion of Site 479, we transited directly to the preselected location of Site 480, running only the 3.5-kHz echo sounder (Fig. 25). Thus, we could directly correlate the shallow reflectors at the two sites and attempt to correlate with the drilling results. These correlations are listed and explained in Table 6.

Examples of the seismic-reflection records from the *Glomar Challenger* survey are shown in Figures 26 through 28. Note the important regional unconformity, reflector K, drawn into each section. The overlying strata downlap onto this surface in a progressive manner, indicating that this has been a growth structure uplifted during deposition of much of the overlying section. In Figure 29, this unconformity is tied into the section which passes directly into Site 479, where we penetrated this horizon. An enlargement of the 5-second-sweep record of Line D is shown in Figure 27, marked with some of the unconformities and reflecting horizons discussed below and shown in Table 6. The 2-second-sweep record from the same line is shown in Figure 29. Note that the drill site is not located on Line D; it is shown projected approximately onto the line in order to demonstrate its position with respect to the synclinal axis. Some of the same reflecting horizons are shown carried into Line B (Fig. 30) across the location of Site 480, which penetrated only 152 meters into the same sedimentary sequence drilled at Site 479.

The reflectors are listed in Table 6, but will also be described somewhat more fully below. In making these correlations, we have attempted to assume reasonable seismic velocities and gently to force fits between lithology and the reflecting horizons. We have no reliable velocity information whatsoever here. The uppermost multichannel move-out velocity is calculated for the upper 650 meters; the downhole sonic-log velocities appear at face value to be too low; the sediments were too gassy for reliable laboratory measurements; and we have no sonobuoy data in this vicinity. The velocities we have assumed are indicated in Table 6. Furthermore, these relatively low-frequency seismic records are sometimes ambiguous and permit some license in selecting a recorded phase to measure and correlate, both for the sea floor and sub-bottom reflectors. The correlations are, therefore, to a certain extent what we think they should be.

The shallow reflectors in the 3.5-kHz records correlate well from site to site, but not necessarily as well with lithologies in the holes (Fig. 25). The best correlation is reflectors C and D, which delineate a sandy zone in the cores, and which also match a shallow unconformity in the 2-second records. This is an erosional surface with truncated underlying strata and some shelf-edge (marginal-plateau edge) erosion in Line D. This may represent a Pleistocene low sea-level stand, although the indications of oxygen minimum above and below this level and the present water depth would make subaerial exposure somewhat improbable.

Horizon E (Figs. 25 and 28) is also an erosional surface truncating underlying strata. It appears to correlate with either a sand layer at 96 meters or a dolomitic mudstone at 102 meters at Site 480, and it appears to correlate with a dolomite at Site 479. The mystery regarding

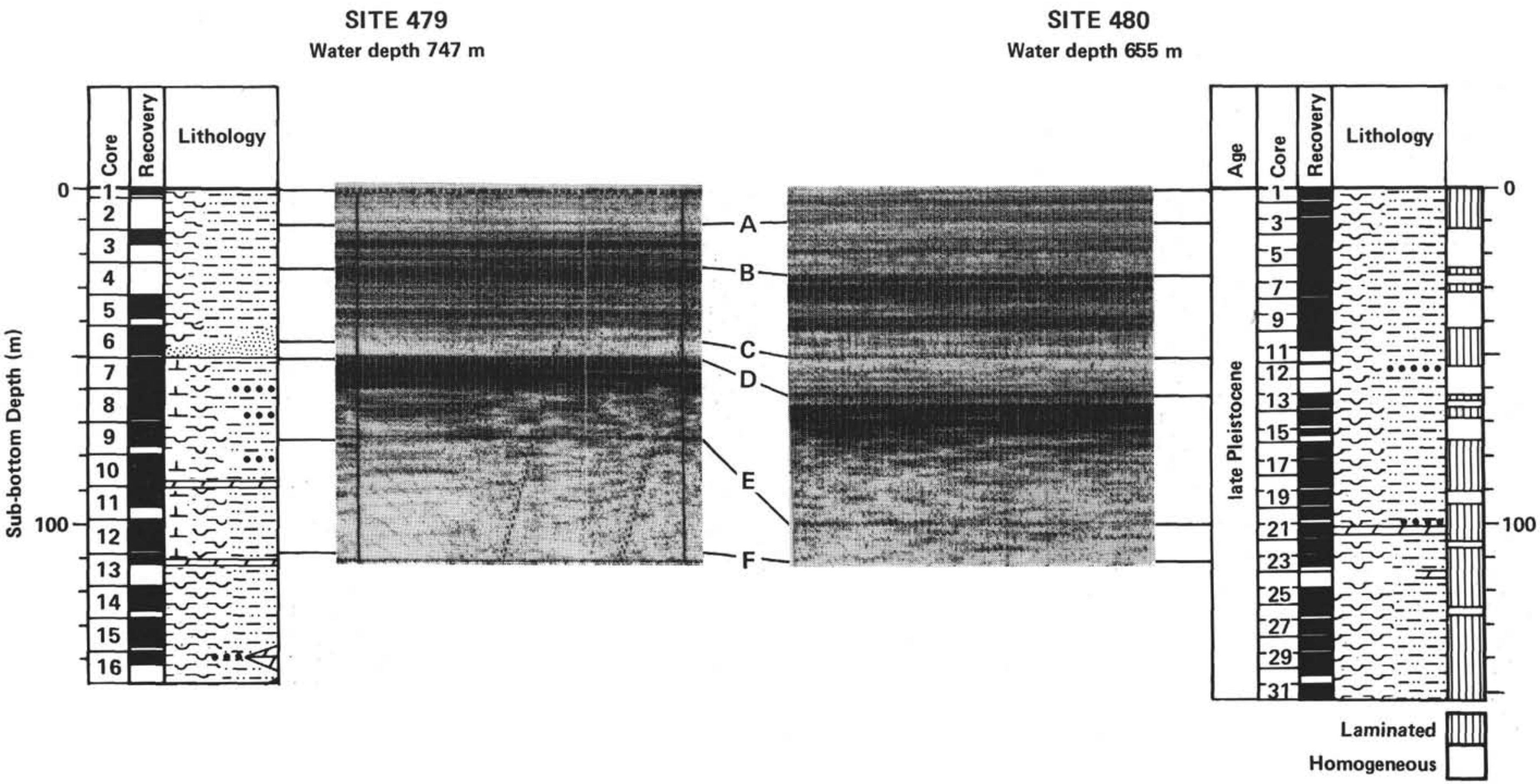

Figure 25. Correlation of drilling lithology and 3.5-kHz records from Sites 479 and 480. (See Table 6 for reflectors A–F.)

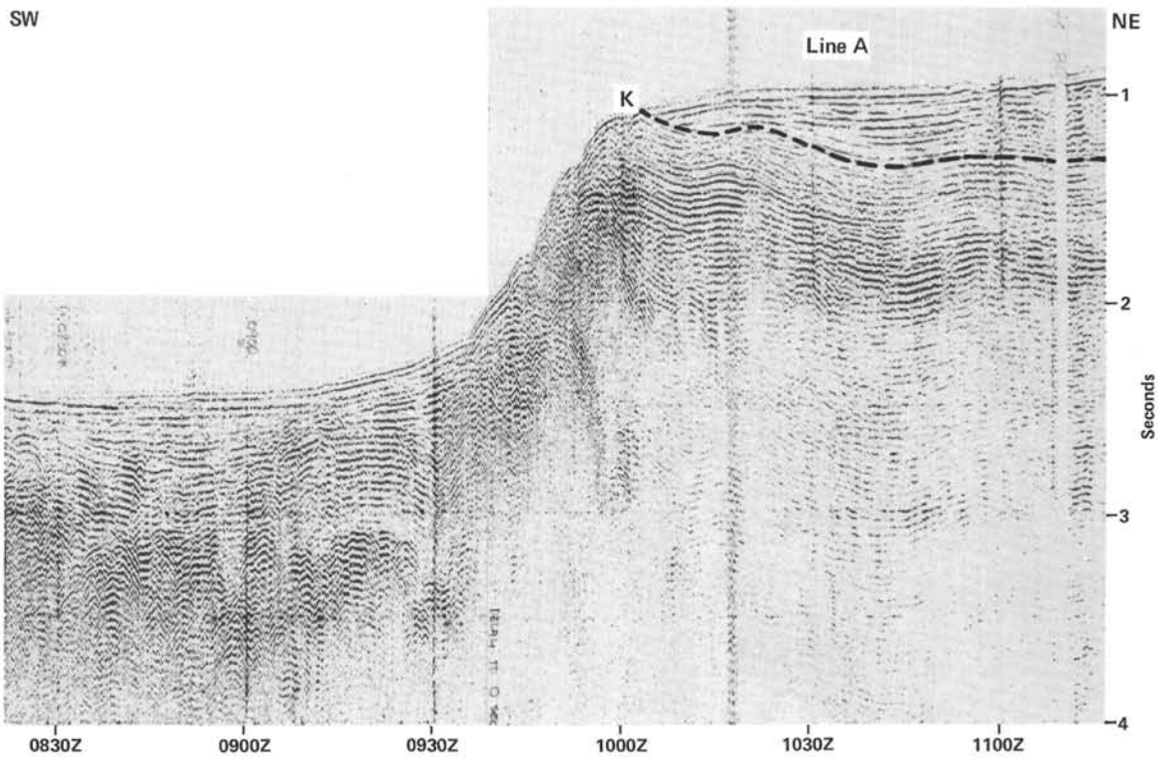

Figure 26. Reflecting Horizon K (Plio/Pleistocene contact) from Line A, *Glomar Challenger*, near Sites 479 and 480.

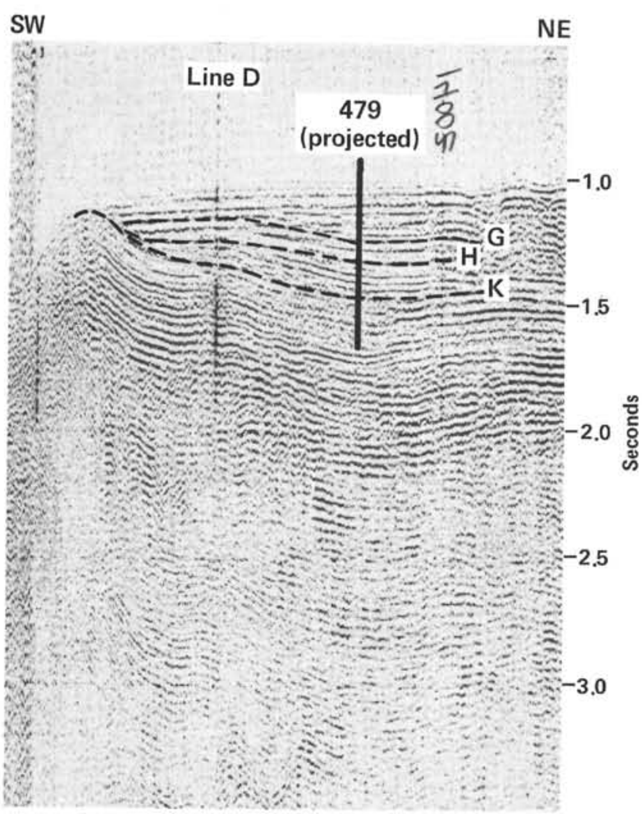

Figure 27. Correlation of drilling lithologies with 5-sec airgun reflection profile, Line D. Note that Site 479 is projected onto this section. (See Table 6 for reflectors G, H, K.)

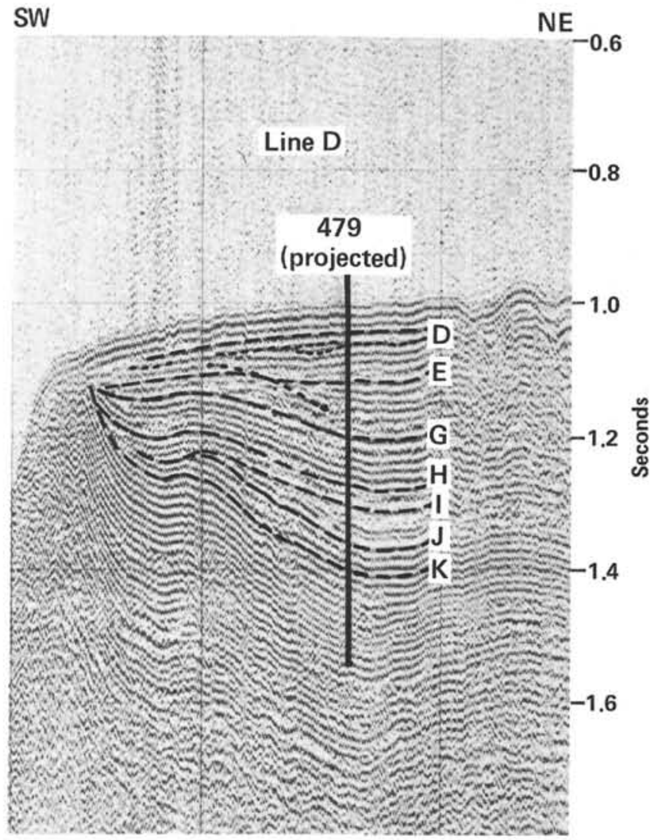

Figure 28. Correlation of drilling lithologies and unconformities in 2-sec airgun reflection profile, Line D. (See Table 6 for reflectors D–K.)

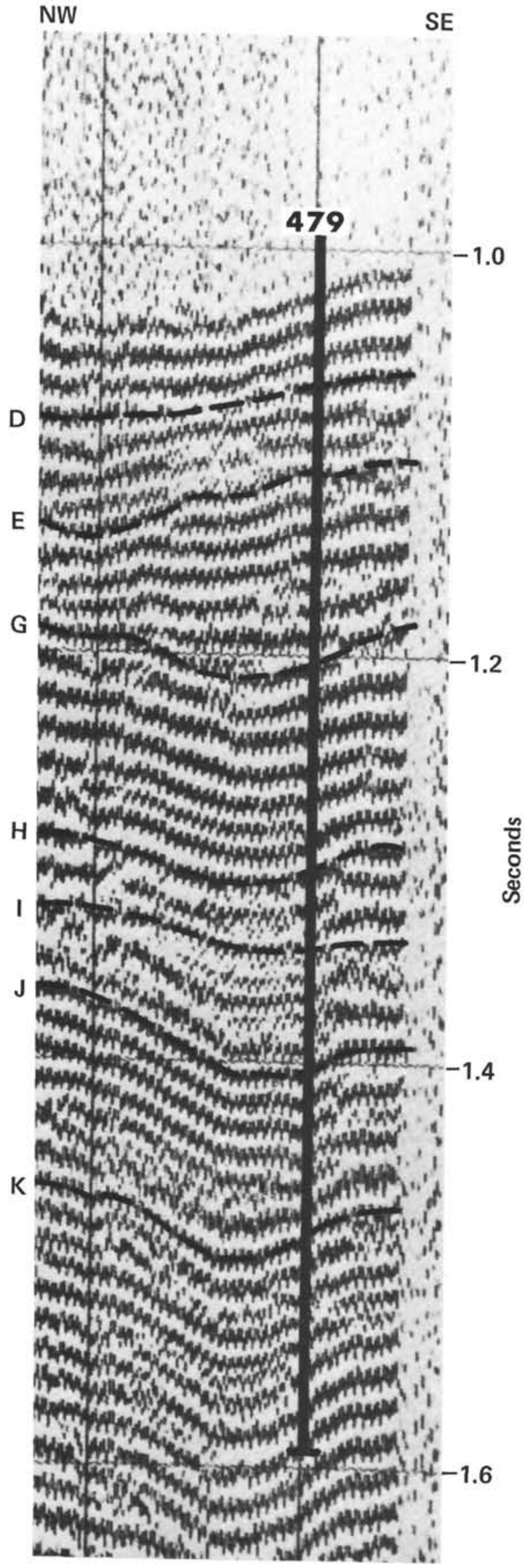

Figure 29. Correlation of drilling lithologies, Site 479, with 2-sec airgun reflection profile. (See Table 6 for reflectors D–K.)

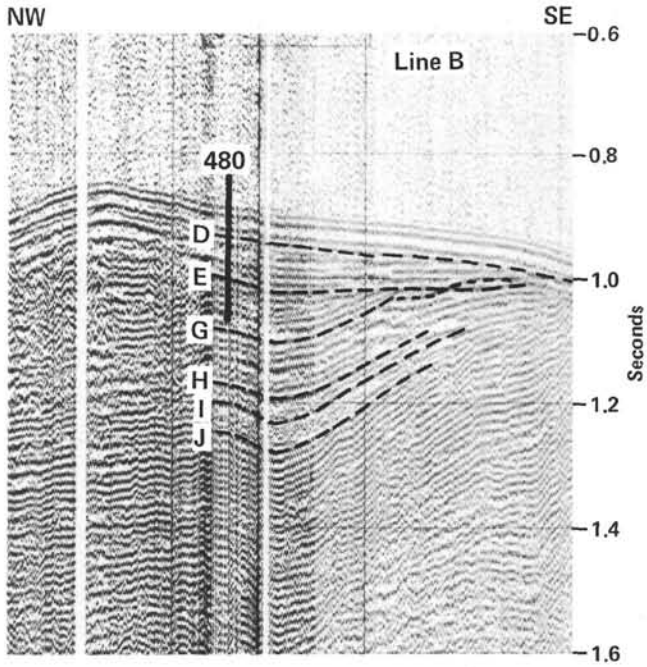

Figure 30. Correlation of drilling lithologies, Site 480, with 2-sec airgun reflection record, Line B; prominent unconformities also shown. (See Table 6 for reflectors D–J.)

Table 6. Correlation of seismic reflectors and lithology.

Reflector	Sub-bottom Depth, Hole 479 (m)	Sub-bottom Depth, Hole 480 (m)	Assumed Reflection Velocity (m/s)	Lithology
A	12	11	1.50	Approx. Holocene/Pleistocene contact; laminated/homogenous muds
B	26	26	1.50	Top of better-laminated muds
C	48	52	1.50	Top of sandy zone
D	53	63	1.50	Bottom of sandy and homogeneous zone, over better-laminated section
E	89	102	1.50	Sandy zone, correlating with erosional unconformity in airgun records, and/or dolomitic mudstone
F	112	115	1.50	Dolomite in 479, zone of no recovery in 480
G	140	—	—	
H	214	—	1.50	Increase in gamma ray curve
I	240	—	1.50	Contact Unit I/Unit II Changes in geochemistry
J	290	—	1.53	
K	364	—	1.55	Contact Unit II/Unit III; Increase in density log

this reflector is that in both Lines B and D another reflector appears to cross it at a location somewhat seaward of the site locations (Figs. 28 and 30).

Horizon G appears to subdivide the section into different characters of reflection of strata, but it cannot be related to the lithologies at this time. Horizon H serves the same function, but it can be quite definitely correlated with a jump upward in the trend of the natural-gamma-ray curve.

Horizon I appears to be of considerable significance. It coincides with the boundary between Lithologic Units 1 and 2, and it marks the level of pronounced changes in both organic and inorganic geochemistry. It appears to be an angular unconformity in Line D, but not so in Line B.

Reflector J is an easily recognized horizon in all lines of the survey, because it is a pronounced change in character of reflections, and other strata onlap upon it. Horizon K is the level of the onlap unconformity in the 5-second records and appears to coincide with the boundary between Lithologic Subunits IB and IC (Plio/Pleistocene contact) and with a significant change in physical properties and density determined by the logging. We conclude that this horizon indicates the time of initiation of a period of uplift along the transform fault lying to the southwest.

One of the objectives of this pair of sites was structural history and a test of the thesis that it might be related to history of the transition from proto-Gulf to modern Gulf and/or history of movement along this transform. It is premature to come to any final conclusions at this time, but it would appear that this escarpment underwent uplift between the times of Horizons K and E, possibly continuing to the time of Horizon D. This span is from the beginning of Pleistocene time to about 100,000 years (or possibly to as late as 65,000 years). Uplift may have continued past this time, but slowly enough to permit the draping of this marginal plateau with pelagic and hemipelagic sediments.

Finally, it must be emphasized that we are examining here only the latest episodes in a much longer geological history of the proto-Gulf of California. This marine embayment was formed during the Miocene, and the sedimentary section near here may be as much as 3 s. This is discussed by Moore and Curray (this volume, Pt. 2).

DOWNHOLE LOGGING FOR SITE 479

Results of Site 479 downhole logging, compared to lithology, calcium carbonate, and physical properties, are shown in Figure 31. (Original tapes are available from storage at the DSDP Information Handling Group.)

SUMMARY AND CONCLUSIONS, SITES 479 AND 480

Sites 479 and 480 were selected for two primary objectives: first, to test the proto-Gulf concept and tectonic history of the central Gulf, and, second, to sample and study the varved diatomaceous sediments of the oxygen minimum in the central Gulf. Site 479, the first target, lies on a marginal plateau, above the escarpment of the transform fault bounding the northeast side of Guaymas Basin. This plateau is presumed to overlie proto-Gulf sediments and basement, and although not an ideal drilling target, it was the best which could be located on the basis of the existing survey network and which was acceptable to the Safety Panel. Part of the sediment section could be penetrated, although drilling was restricted to the thickest part of the section in the axis of a syncline, and basement could not be reached. This site, and as a backup, Site 480, lie in the oxygen minimum where piston cores had previously recovered laminated (varved?) diatomaceous sediments.

Only Quaternary sediments were recovered in these two holes, and despite great difference in degree of disturbance, we conclude that the upper 152 meters is duplicated in the two holes. The column is divided into three units which do not differ greatly in lithologies. The first unit, 0 to 250 meters, consists of rhythmically alternating laminae or varves of muddy diatomaceous ooze, with sparse layers of calcareous diatomaceous mudstone and sands. The varved part of the section will be discussed more fully later. The second unit, 250 to 355 meters, consists of the same muddy diatomaceous-ooze varves, but with more frequent layers of calcareous mudstone. The third layer, 355 to 440 meters, consists of diatomaeous silty clay with frequent interlayers of calcareous diatomaceous mudstone. The three units are very similar, differing mainly in the proportion of calcareous-mudstone layers and in the relative abundance of diatoms, probably a function of diagenesis and consolidation. These sediments are mainly hemipelagic slope deposits, although a minor proportion of turbidites is also present.

These units can be recognized in a correlation with the seismic-reflection survey of the region of the two sites. The seismic section displays several reflecting horizons, some of which represent either erosional or onlap unconformities that can be related to the section recovered by drilling. Significant changes in geochemical and physical properties also occur across these unit boundaries. The C_2/C_1 ratio increases sharply at the 250-meter level, and decreases at approximately 355 meters. Propane and isobutane reach maxima at about this latter level but isopentane continues to increase below that depth. These data indicate that at a greater depth the higher weight hydrocarbons ($> C_5$) would be encountered and that the C_3–C_5 hydrocarbons had diffused or distilled upward from below. These increases and further anticipated increases led us to our decision to terminate Hole 479 at 440 meters. Heat flow measured in Hole 479 was 2.36 HFU.

The high sedimentation rates of organic-carbon-rich and siliceous sediments lead to high alkalinities and the highest ammonia concentrations recorded to date, the latter peaking at about 250 meters. Decrease in dissolved-magnesium concentrations suggests uptake into carbonate sediments and dolomitization of nannofossil carbonates at 70 meters, and dolomites occur below this depth. Dissolved silica increases with depth, correlating with disappearance of diatoms and increasing silicification of the sediments.

Sediments from these holes have unusually high water contents ($\sim 80\%$ near the sea floor) and porosities ($\sim 90\%$), and low bulk densities (1.1 g/cm^3). These change rapidly with depth and level out between about 80 and 350 meters. Varved sediments at 350 meters still have water contents and porosities of 55 to 60% and 70 to 80%, respectively. From 340 to 380 meters, the depth range of an important unconformity and contact between Lithologic Sub-units IB and IC, there is a zone of even higher water content and porosity and lower bulk density, but below this level they decrease and increase more rapidly as expected.

Hole 480 was the first field test of the newly developed Serocki–Storms–Cameron hydraulic piston corer. This test was an unqualified technical and scientific success. Recovery for the 152-meter section averaged 80%, although it was generally about 90%, with zero or near zero recovery in a few sections now believed to be sands.

The result was recovery of a unique set of almost undisturbed cores of laminated (varved?) diatomaceous sediments previously sampled here in the oxygen minimum only by normal gravity and piston cores. Because this set of cores is so unique and potentially so valuable for study of climatology and other environmental changes in this area, the shipboard scientific party has refrained from sampling more than the core catcher samples in order to preserve the cores for varve studies on shore, which will require intact working halves of the cores. We are furthermore proposing to DSDP and NSF that these cores be curated and samples distributed in a special way.

Origin of these varves has been debated previously in the literature, and the debate has continued aboard *Glomar Challenger*, this time based on a much longer record, although with only minimal study because of our self-imposed restrictions on sampling. Two principal environmental controls have been responsible for formation and preservation of the laminations, which we believe to be varves, or annual laminae couples. First is a seasonal fluctuation in type of sediment deposited, and second is the oxygen minimum, which limits the number of burrowing organisms.

The laminae couples have dark laminae containing generally >60% clay and <20% diatoms, and light-colored laminae containing >60% diatoms. One seasonal influence is rainfall, concentrated in the drainage areas for this part of the Gulf in July, August, and September, with a minor mode in November and December. The second seasonal influence is the wind system, which controls upwelling, one of the major controls over diatom and silicoflagellate blooms. Upwelling and blooms on this northeast side of the Gulf should occur with the prevailing northwesterly winds from about November through April. At first examination, these influences would appear to be in phase to produce the observed laminae pairs: the dark layers during the rainy season, and the light layers during the upwelling-bloom season. Detailed observations of the flora, however, appear to contradict this simple explanation, because the species believed to be characteristic of blooms occur predominantly in the dark layers, and the oceanic forms of light-colored layers commonly are almost monospecific. Origin of the varves remains an open question requiring detailed studies we have not yet permitted ourselves to do.

Sequences of varves alternate with homogeneous sections of the cores. We assume that these homogeneous sections may represent bioturbated zones representing times when the oxygen minimum did not impinge on the sea floor, but a final interpretation must await shore-based studies with X-radiographs of the cores. A possible explanation is that the periods of migration or destruction of the oxygen minimum coincide with glacial low stands of sea level.

We have estimated two possible chronologies of the varved and homogeneous sections, based on different assumptions. Direct varve counts appear to give higher rates of sediment accumulation than paleontological zonation boundaries, but either chronology can be forced to fit glacial versus interglacial stages, sea-level fluctuation, and oxygen-isotope curves. Several possibilities occur to us as explanations for the difference between the two chronologies. The "varves" may not strictly represent 1-year periods, and we may not be able to differentiate the very fine laminae deposited during periods of drought. A second possibility is that the homogeneous sections might represent periods of much slower rate of sediment accumulation, although if these are periods of lowered sea level, they should represent higher sedimentation rates. Finally, a third possibility is that significant amounts of section are missing at some of the unconformities distinguished in the seismic-reflection records.

The unconformities in the seismic records are related to uplift associated with the transform fault. Some of them show onlap relations of the overlying strata only, but a few of them show truncation and erosion of a part of the underlying section. We cannot estimate how much removal of section might have occurred, but we judge that it could not have been very much, because neither site is located on the uplifted flank of the syncline above the fault.

Two of the objectives of these sites were accomplished, namely sampling of the varved sediments and dating the folding and uplift. The important objective of learning about the nature and history of the proto-Gulf could not have been accomplished at this site without penetration into the sediment section much deeper than safety would permit. Basement of this part of the proto-Gulf must remain an unknown, pending further work, which might be geophysics, dredging, or drilling.

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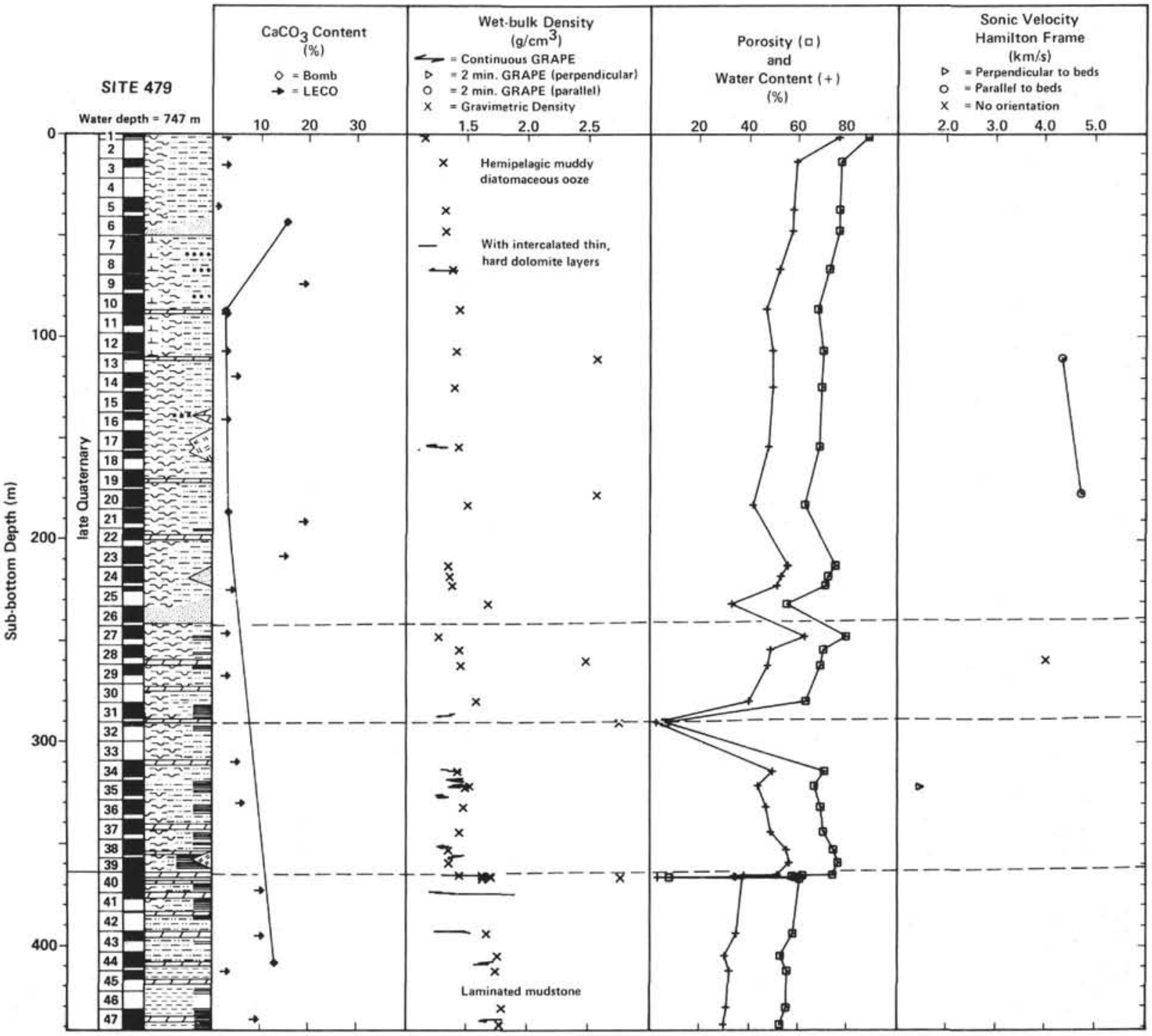

Figure 31. Results of Site 479 downhole logging, compared to lithology, calcium carbonate, and physical properties.

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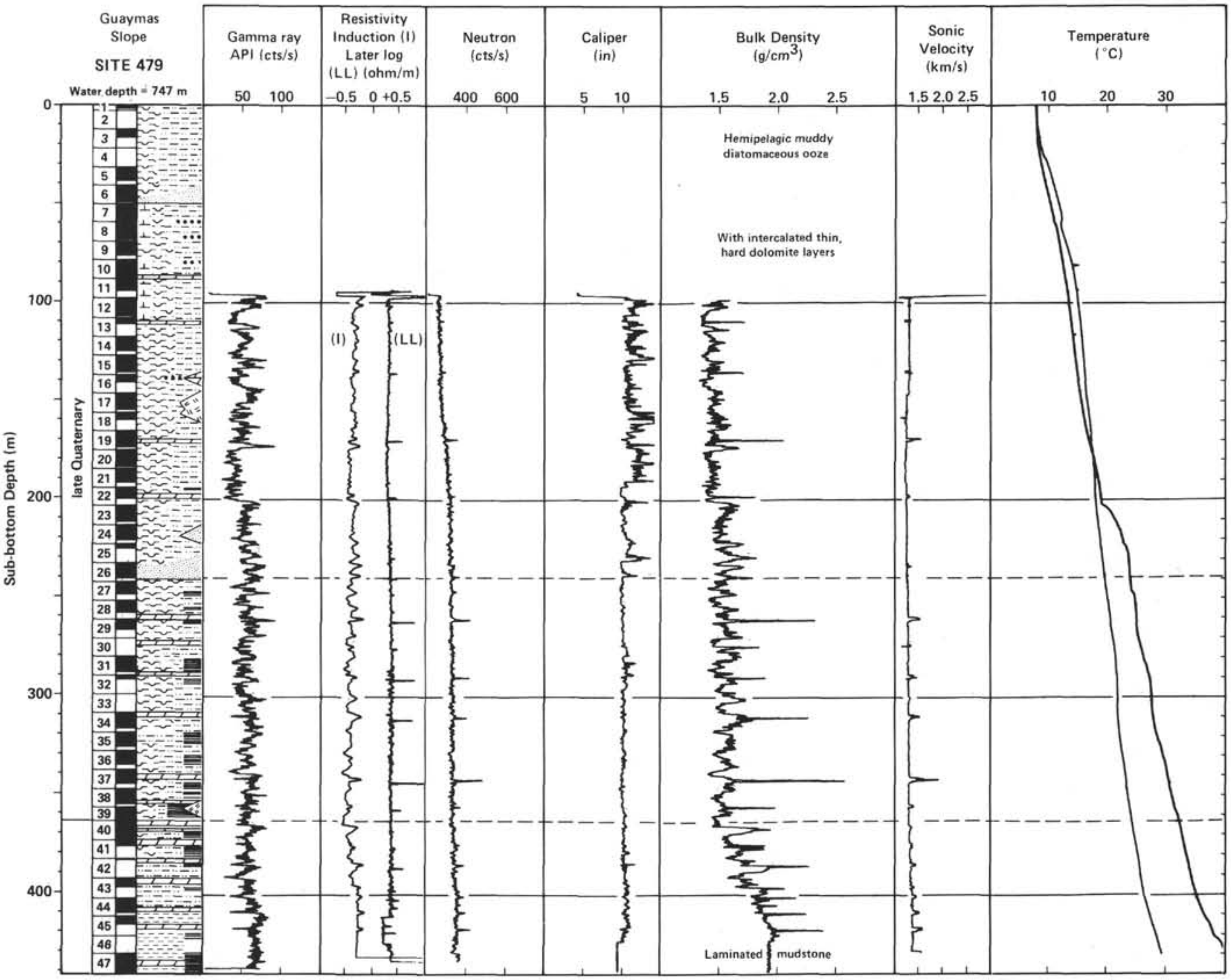
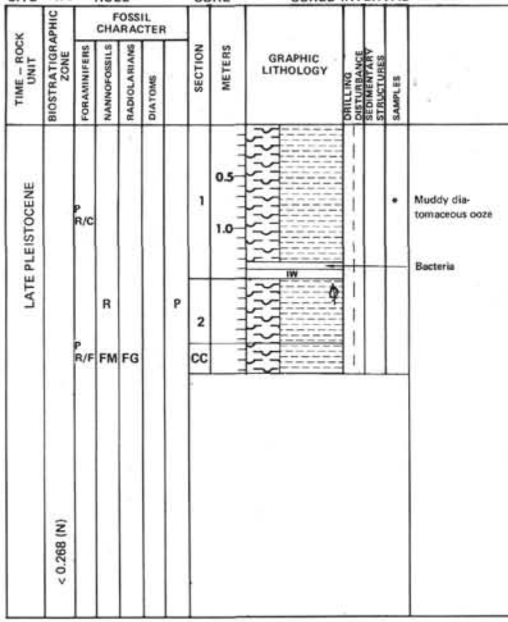


Figure 31. (Continued).

SITE 479 HOLE CORE 1 CORED INTERVAL 0.0–3.0 m



LITHOLOGIC DESCRIPTION

Moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** with some slightly lighter pale olive (10Y 6/2) layering visible in Section 2. High water content; soupy sediments with strong H_2S odor and gelatinous consistency. Gas rupturing occurs on the sediment surface. Some small bits of matted diatom laminae suggest varve-like couplets in some patches.

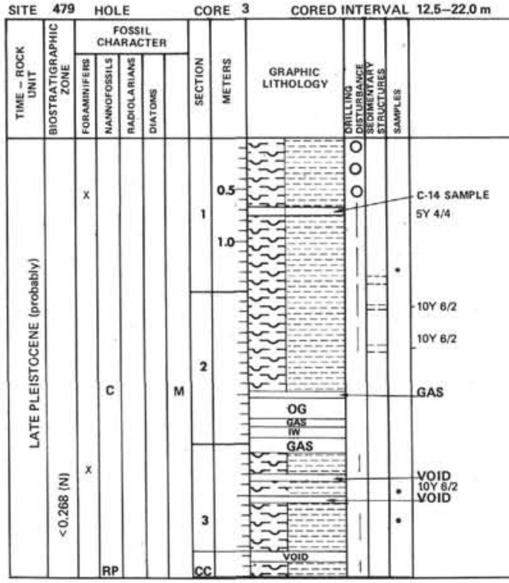
SMEAR SLIDE SUMMARY

	1-70 (D)
TEXTURE:	
Sand	–
Silt	60
Clay	40
COMPOSITION:	
Quartz	3
Feldspar	7
Clay	40
Pyrite	2
Carbonate unspec.	5
Calc. nannofossils	1-2
Diatoms	35
Radiolarians	TR
Sponge Spicules	TR
Silicoflagellates	1
Plant debris	5

CARBONATE BOMB: 1-130: 3%

Note: Site 479, Core 2, 3.0–12.5 m: No Recovery.

SITE 479 HOLE CORE 3 CORED INTERVAL 12.5–22.0 m



LITHOLOGIC DESCRIPTION

Moderately to intensely disturbed, moderate olive brown (5Y 4/4) **DIATOMACEOUS MUD** with minor traces of a pale olive (10Y 6/2) mm-scale interlayering of **DIATOM OOZE**, generally firm but some sections more gelatinous. Strong H_2S odor, gas pockets and spongy ruptured surface.

SMEAR SLIDE SUMMARY

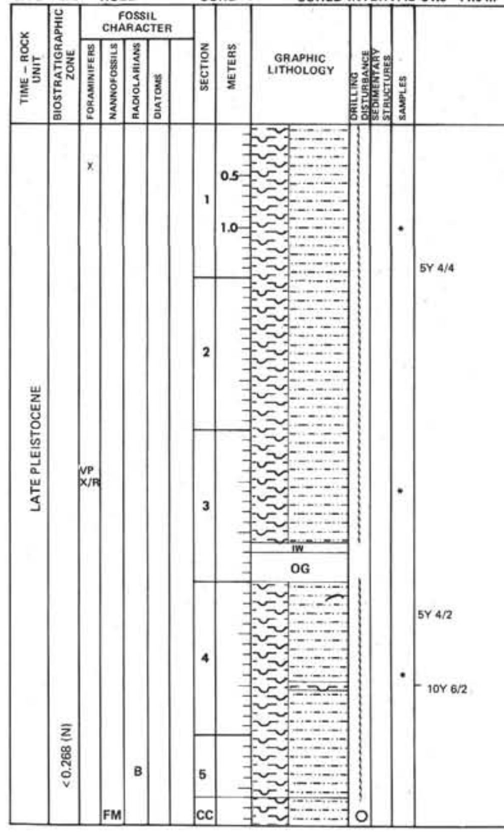
	1-128 (D)	3-47 (D)	3-75 (D)
TEXTURE:			
Sand	–	5	–
Silt	35	40	35
Clay	65	55	65
COMPOSITION:			
Quartz	5	5	5
Feldspar	5	5	5
Clay	55	55	55
Pyrite	1-2	TR	TR
Carbonate unspec.	2-3	1-2	5
Calc. nannofossils	7-8	7	5
Diatoms	20	25	25
Sponge spicules	2	–	TR
Silicoflagellates	–	–	TR
Plant debris	2-3[a]	–	5-6

[a]rhombs

CARBONATE BOMB: 2-99 = 3%

Note: Site 479, Core 4, 22.0–31.5 m: No Recovery.

SITE 479 HOLE CORE 5 CORED INTERVAL 31.5–41.0 m



LITHOLOGIC DESCRIPTION

Intensely disturbed moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE TO DIATOM MUD.** Generally homogeneous and firmer near the bottom of the core. Low in H_2S, no layering visible. Surface ruptured, spongy from gas expansion.

In Section 3, 90 cm traces of mm-scale matted dusky yellow to white **DIATOM OOZE** as evidence of rhythmic laminations. Section 4, 15 cm: large pelecypod shell fragment.

SMEAR SLIDE SUMMARY

	1-100 (D)	3-60 (D)	4-91 (M)
TEXTURE:			
Silt	10[a]	50	20
Clay	90	50	20
COMPOSITION:			
Quartz	5	4	2
Feldspar	2	4	–
Mica	1	–	–
Heavy minerals	–	–	TR
Clay	55	40	20
Pyrite	4	4	1
Carbonate unspec.	–	–	TR
Foraminifers	1	–	–
Diatoms	35	40	75
Radiolarians	–	TR	–
Sponge spicules	2	1	
Silicoflagellates	–	2	–
Plant debris	2	2	2

[a]terrigenous components only

CARBONATE BOMB: 3-107 = 1%

SITE 479 HOLE CORE 6 CORED INTERVAL 41.0–50.5 m

TIME – ROCK UNIT: LATE PLEISTOCENE

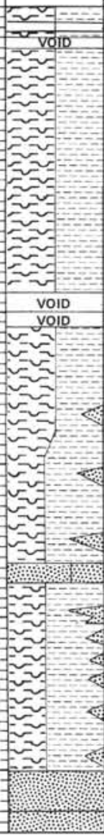
BIOSTRATIGRAPHIC ZONE: < 0.268 (N)

FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS): P A/A; P F/C; A; R; CM; M; M

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

- 10Y 4/2
- 5Y 4/4 (Muddy diatomaceous ooze)
- C-14 SAMPLE
- 5Y 4/4
- N5
- N5
- N5
- N7
- N7, clay
- N5

LITHOLOGIC DESCRIPTION

Highly disturbed, moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** with numerous, very contorted grayish (N5) well-sorted, coarse feldspathic sand layers, Diatomaceous layers are very gelatinous, spongy with little H_2S, and no clear lamination.

Section 1, 0–8 cm is a lighter grayish olive (10Y 4/2) **DIATOMACEOUS OOZE.**

SAND layers contain only terrigenous clasts well-washed of fines. May indicate basal portions of redeposited beds. Slightly calcareous, Sand coarse fraction (CF 4-122 cm) is rich in plag. feldspars (30%), quartz (30%), some K-feldspar (6%), and heavy minerals – mostly zircon, hornblende and epidote (28%). Plagioclase fresh to weathered and rock fragments (10%).

SMEAR SLIDE SUMMARY

	1-20 (D)	5-51 (M)
TEXTURE:		
Silt	5	60
Clay	95	40
COMPOSITION:		
Quartz	1	18
Feldspar	3	10(K-fe, Plg)
Mica	–	5
Heavy minerals	–	3
Clay	45	40
Pyrite	2	5-6
Carbonate unspec.	3	3
Foraminifers	3	–
Calc. nannofossils	1	–
Diatoms	45	15
Sponge spicules	2	–
Plant debris	1	3

CARBONATE BOMB: 4-80 = 0%

	2, 66–68
Lithology	Clayed silt
Sand	2.19
Silt	68.18
Clay	29.63

SITE 479 HOLE CORE 7 CORED INTERVAL 50.5–60.0 m

TIME – ROCK UNIT: LATE PLEISTOCENE

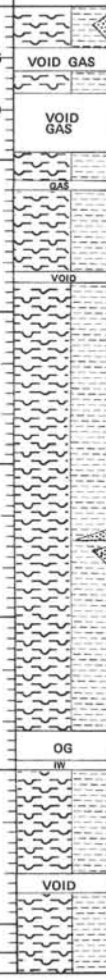
BIOSTRATIGRAPHIC ZONE: < 0.458 (N)

FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS): M A/A; M A/A; A; AM; GM

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

- 5Y 4/4
- N7
- N5
- Muddy diatomaceous ooze

LITHOLOGIC DESCRIPTION

Highly disturbed, very uniform, moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** with rare scattered, contorted patches of medium gray (N5) sand. No H_2S. A disturbed laminae above sand at Section 4, 70 cm is a thin layer of medium gray silty clay (2 cm) with a gradational contact. In Sections 5 and 6 scattered tuffs of pale olive matted laminae of **DIATOM OOZE.**

SMEAR SLIDE SUMMARY

	4-70 (D)
TEXTURE:	
Silt	15[a]
Clay	85[a]
COMPOSITION:	
Quartz	5
Feldspar	5
Clay	45
Pyrite	2
Diatoms	45
Silicoflagellates	2
Plant debris	4

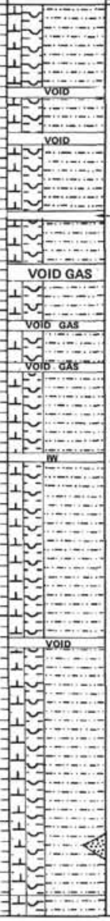
[a]terrigenous

CARBONATE BOMB: 5-106 = 0%

SITE 479 HOLE CORE 8 CORED INTERVAL 60.0–69.5 m

TIME – ROCK UNIT: LATE PLEISTOCENE
BIOSTRATIGRAPHIC ZONE: < 0.268 (N)
FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): X; B; A, M; RP
SECTION: 1, 2, 3, 4, 5, 6, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

5Y 4/4

C-14 SAMPLE

Silty

N4, sand

LITHOLOGIC DESCRIPTION

Highly disturbed, uniform muddy moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE TO NANNOFOSSIL DIATOM MUD.** Multiple gas pockets, and spongy surface. No H_2S odor; traces of laminations obliterated. A few faint wispy darker layers in Sections 2 and 3 and slight darkening down core. At Section 6, 65 cm small bleb of medium gray (N5) sand.

SMEAR SLIDE SUMMARY

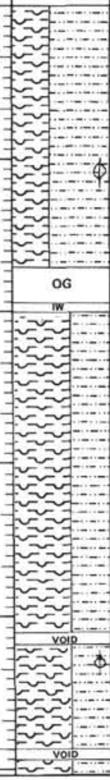
	5-70 (D)
TEXTURE:	
Silt	70
Clay	30
COMPOSITION:	
Quartz	20
Feldspar	5
Clay	20
Pyrite	8
Calc. nannofossils	15
Diatoms	25
Radiolarians	1
Sponge spicules	2
Plant debris	5

CARBONATE BOMB: 3-45 = –

SITE 479 HOLE CORE 9 CORED INTERVAL 69.5–79.0 m

TIME – ROCK UNIT: LATE PLEISTOCENE
BIOSTRATIGRAPHIC ZONE: < 0.268 (N)
FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): P R/C, R, P; AM
SECTION: 1, 2, 3, 4, 5, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

10Y 4/2 Muddy diatomaceous ooze

10Y 6/2 Diatomaceous mud

Wood

10Y 4/2

5Y 4/4

5Y 4/4

10YR 6/6 Wood

LITHOLOGIC DESCRIPTION

Very deformed, grayish olive (10Y 4/2) to moderate olive brown (5Y 4/4) **DIATOMACEOUS MUD TO MUDDY DIATOMACEOUS OOZE,** slightly calcareous. No H_2S or sand wisps. Gradational darker color and more diatomaceous below Section 3. Evidence for bedding from darker and lighter hues.

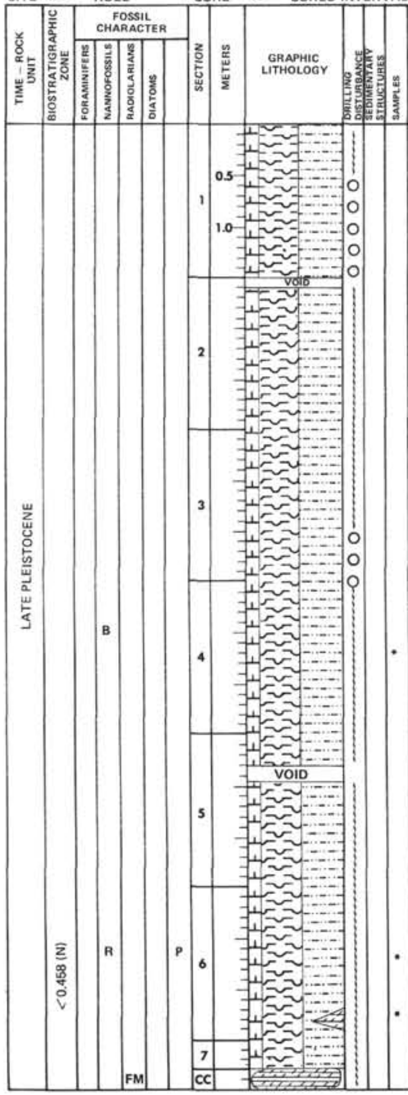
Below Section 4, evidence few disturbed laminations from pale olive (10Y 6/2) to dark yellowish orange (10YR 6/6) **DIATOM OOZE** wisps to layers.

SMEAR SLIDE SUMMARY

	1-40 (D)	1-100 (D)
TEXTURE:		
Sand	–	5
Silt	65	60
Clay	35	35
COMPOSITION:		
Quartz	4	5
Feldspar	4	6
Mica	–	1
Clay	30	40
Pyrite	2	6
Carbonate unspec.	3	12
Calc. nannofossils	8	5
Diatoms	50	25
Plant debris	–	3
Rock fragments + chert	1	–

CARBONATE BOMB: 3-99 = 19%

SITE 479 HOLE CORE 10 CORED INTERVAL 79.0–88.5 m



LITHOLOGIC DESCRIPTION

Very deformed, grayish olive (10Y 4/2) to moderate olive brown (5Y 4/4) nannofossil-bearing **MUDDY DIATOMACEOUS OOZE TO DIATOMACEOUS MUD.**

Sections 1–4 very uniform. Below Section 4, scattered lumps and layers of more indurated clayey pale olive (10Y 6/2) diatom mud; calcareous. Contains numerous rhombic carbonate crystals (Section 6, 129 cm) (approximately 20–30%). In the Core-Catcher there is a sharp contact to a 3 cm-thick layer of hard, calcareous diatom mudstone **(DOLOSTONE)** (pale olive [10Y 6/2]) with grayish (5Y 3/2) muddy diatom ooze.

No sand but some scattered large flakes of muscovite. No H_2S odor.

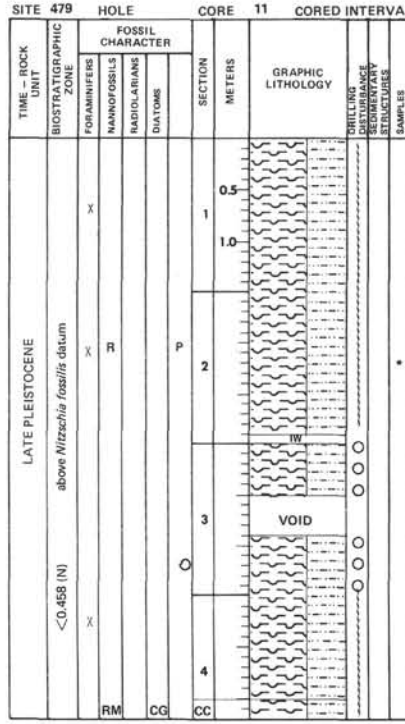
SMEAR SLIDE SUMMARY

	4-70 (D)	6-70 (D)	6-129 (M)
TEXTURE:			
Silt	70	60	80
Clay	30	40	20
COMPOSITION:			
Quartz	5	3	3
Feldspar	5	6	2
Heavy minerals	–	3	–
Clay	30	40	20
Pyrite	3	4	–
Carbonate unspec.	15	8	50(dolomite?)
Foraminifers	1	2	–
Calc. nannofossils	15	2	2
Diatoms	30	15	20
Radiolarians	1	2	–
Sponge spicules	–	2	–
Silicoflagellates	2	1	–
Plant debris	–	3	1
Rock fragments	–	3	–

CARBONATE BOMB: 4-65 = –
7-24 = 3%

	6, 26–28
Lithology	Silty clay
Sand	2.71
Silt	45.65
Clay	51.64

SITE 479 HOLE CORE 11 CORED INTERVAL 88.5–98.0



LITHOLOGIC DESCRIPTION

Very deformed, uniform. Moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE.** Faint wisps of firmer pale olive (10Y 6/2) laminae. No HCl reaction, sand, varves or H_2S odor. Some evidence for bedding of siltier ooze at Section 4, 80 cm.

SMEAR SLIDE SUMMARY

	2-70 (D)
TEXTURE:	
Silt	70
Clay	30
COMPOSITION:	
Quartz	3
Feldspar	7
Clay	25
Pyrite	3
Carbonate unspec.	1
Foraminifers	TR
Diatoms	55
Silicoflagellates	3

SITE 479 **HOLE** **CORE** 12 **CORED INTERVAL** 98.0–107.5 m

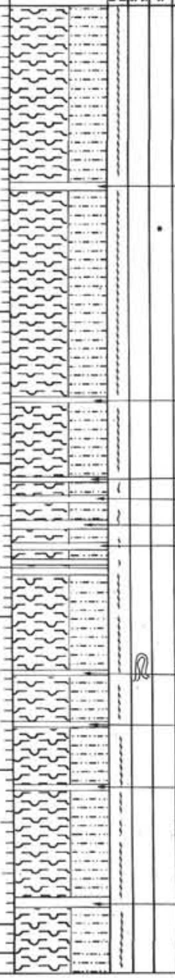
TIME – ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: above *Nitzschia fossilis* datum; <0.458 (N)

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): VP X/R; X; VP X/R, R, P; X, B; P C/A, C, P; CG

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

METERS: 0.5, 1.0



LITHOLOGIC DESCRIPTION

Very deformed, uniform, moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE.** Any bedding totally disturbed. Some lighter pale olive (10Y 6/2) **DIATOM OOZE** tuffs. No sand, varves, or H_2S odor. Multiple gas – separation pockets from exsolution. Section 5, 25 cm to Core-Catcher several more cohesive wisps of grayish olive (10Y 5/2).

SMEAR SLIDE SUMMARY

	2-70 (D)
TEXTURE:	
Silt	70
Clay	30
COMPOSITION:	
Quartz	2
Clay	30
Pyrite	2
Carbonate unspec.	2
Calc. nannofossils	1
Diatoms	55
Silicoflagellates	3

CARBONATE BOMB: 6-111 = 3%

SITE 479 **HOLE** **CORE** 13 **CORED INTERVAL** 107.5–117.0 m

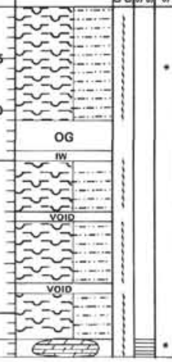
TIME – ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: above *Nitzschia fossilis* datum; <0.458 (N)

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): M F/A; A, GM; FM, CG

SECTION: 1, 2, 3, CC

METERS: 0.5, 1.0



LITHOLOGIC DESCRIPTION

Very deformed, moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE TO DIATOM OOZE.** No H_2S, sand, or evidence for bedding. No HCl reaction.

Core-Catcher: 2 cm wide piece of hard, grayish olive (10Y 4/2) calcareous mudstone with subparallel, fine wavy laminations (approximately 0.2–1 mm) lenticular structures. Mostly (60%) dolomite micrite, 48 μm crystals, some rhombs. **DOLOMITE.**

SMEAR SLIDE SUMMARY

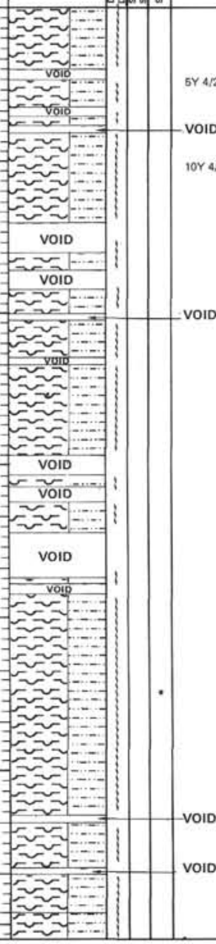
	1-60 (D)	CC (M)
TEXTURE:		
Silt	70	70
Clay	30	30
COMPOSITION:		
Quartz	1	–
Feldspar	3	–
Clay	25	25
Carbonate unspec.	2	65
Foraminifers	2	–
Calc. nannofossils	5	–
Diatoms	60	10
Radiolarians	2	–
Sponge spicules	1	–
Silicoflagellates	3	–
Rock fragments	1	–

CARBONATE BOMB: 1-110 = –

SITE 479 HOLE CORE 14 CORED INTERVAL 117.0–126.5 m

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

Foraminifers: X; P X/C; X; X; VP X/F
Nannofossils: B; B; B
Sections: 1 (0.5, 1.0), 2, 3, 4, 5, 6, CC



LITHOLOGIC DESCRIPTION

Very deformed, uniform, moderate olive brown (5Y 4/4) to grayish olive (10Y 4/2) to **MUDDY DIATOM OOZE**. Gas separation, spongy. No H_2S odor, sand, or indications of lamination.

SMEAR SLIDE SUMMARY

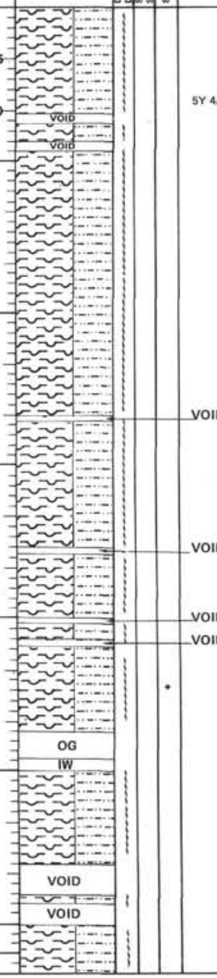
	5-70 (D)
TEXTURE:	
Silt	70
Clay	30
COMPOSITION:	
Quartz	1
Feldspar	3
Clay	25
Pyrite	1
Carbonate unspec.	2
Foraminifers	2
Calc. nannofossils	5
Diatoms	60
Radiolarians	2
Sponge spicules	1
Silicoflagellates	3

CARBONATE BOMB: 2-50 = 5%

SITE 479 HOLE CORE 15 CORED INTERVAL 126.5–136.0 m

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

Time–rock unit: LATE PLEISTOCENE
Biostratigraphic zone: above *Nitzschia fossilis* datum <0.458 (N)
Foraminifers: X; X; P F/C
Nannofossils: R; R; FM
Diatoms: P; P; CG
Sections: 1 (0.5, 1.0), 2, 3, 4, 5, 6, 7, CC



LITHOLOGIC DESCRIPTION

Very deformed, uniform texture. Moderate olive brown (5Y 4/4) to grayish olive (10Y 4/2) **MUDDY DIATOMACEOUS OOZE.** Terrigenous part of smear slides is mostly clay size. Gas separations and spongy surface. No calcareous component.

SMEAR SLIDE SUMMARY

	5-70 (D)
TEXTURE:	
Silt	60
Clay	40
COMPOSITION:	
Quartz	1-2
Feldspar	1-2
Opaques	TR
Clay	40
Pyrite	1
Carbonate unspec.	3
Calc. nannofossils	1
Diatoms	50
Radiolarians	1

CARBONATE BOMB: 2-97 = –
5-108 = –

SITE 479 HOLE CORE 16 CORED INTERVAL 136.0–145.5 m

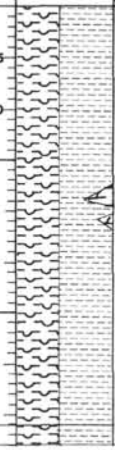
TIME – ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: above *Nitzschia fossilis* datum < 0.458 (N)

FOSSIL CHARACTER: FORAMINIFERS X; P X/R; VP X/R — NANNOFOSSILS R; R; CM — RADIOLARIANS — DIATOMS P; P; CG

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

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE — SEDIMENTARY STRUCTURES — SAMPLES

5Y 4/6

Calcareous (10Y 8/2)

5Y 4/4

LITHOLOGIC DESCRIPTION

Very deformed, uniform, moderate olive brown (5Y 4/6) **MUDDY DIATOM OOZE** with fine-grained clay fraction. Structureless, uniform. Surface spongy from degassing. Traces of carbonate. No laminations. Slight ammonia odor?

Section 2, 38 cm and 55 cm: pale yellow (10Y 8/2) wisps of calcareous mud, possibly dolomitic.

SMEAR SLIDE SUMMARY

	2-38 (M)	3-70 (D)
TEXTURE:		
Silt	20	45
Clay	80	55
COMPOSITION:		
Quartz	1	3
Feldspar	1	3
Opaques	TR	TR
Clay	3-4	45
Pyrite	TR	1
Carbonate unspec.	85	1-2
Calc. nannofossils	–	3-4
Diatoms	8	40
Radiolarians	–	TR
Sponge spicules	–	1-2

CARBONATE BOMB: 3-126 = 3%

SITE 479 HOLE CORE 17 CORED INTERVAL 145.5–155.0 m

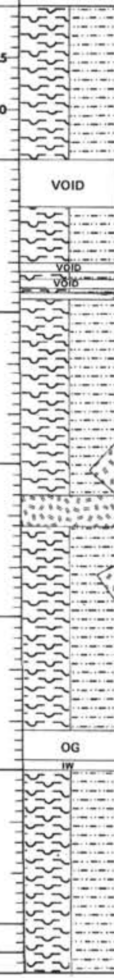
TIME – ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: above *Nitzschia fossilis* datum <0.458 (N)

FOSSIL CHARACTER: FORAMINIFERS P C/A; X; X; X; VP X/R; X — NANNOFOSSILS R; B; B; B; C — RADIOLARIANS — DIATOMS P; P; CM

SECTION: 1, 2, 3, 4, 5, 6, 7, CC — METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE — SEDIMENTARY STRUCTURES — SAMPLES

5Y 4/6

VOID

N7

N7

Clay (5YR 5/6)

N5

N7

N7

5Y 4/4

5Y 4/6

10Y 6/2 wisp

5YR 5/6

10Y 6/2

LITHOLOGIC DESCRIPTION

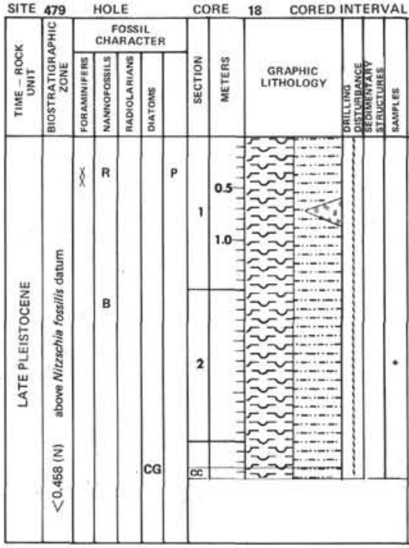
Very deformed, moderate olive brown (5Y 4/6) **MUDDY DIATOMACEOUS OOZE.** Bedding suggested by some rare vertical streaks including pale olive (10Y 6/2) (Section 7, 6 cm) clay and moderate brown (5YR 5/6) clay.

Sections 3 and 4: scattered pockets, blebs of gray (N7) **VITRIC ASH,** rhyolitic RI <1.52, uniform, grain size ≈0.100 mm, concentrated around Section 4, 30–70 cm. Well-sorted, very fresh.

SMEAR SLIDE SUMMARY

	3-102 (M)	4-60 (M,CF)	5-70 (D)
TEXTURE:			
Sand	–	35	–
Silt	–	65	60
Clay	100	–	40
COMPOSITION:			
Quartz	TR	1	4
Feldspar	TR	1	3
Mica	–	–	TR
Opaques	TR	1	1
Clay	98	–	40
Volcanic glass	–	97	–
Pyrite	–	–	1-2
Calc. nannofossils	–	–	TR
Diatoms	1	TR	50
Radiolarians	–	–	1-2
Sponge spicules	–	–	1
Silicoflagellates	–	–	1

SITE 479 HOLE CORE 18 CORED INTERVAL 155.0–164.5 m



LITHOLOGIC DESCRIPTION

Very deformed, uniform, moderately olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE,** gas ruptured, spongy.

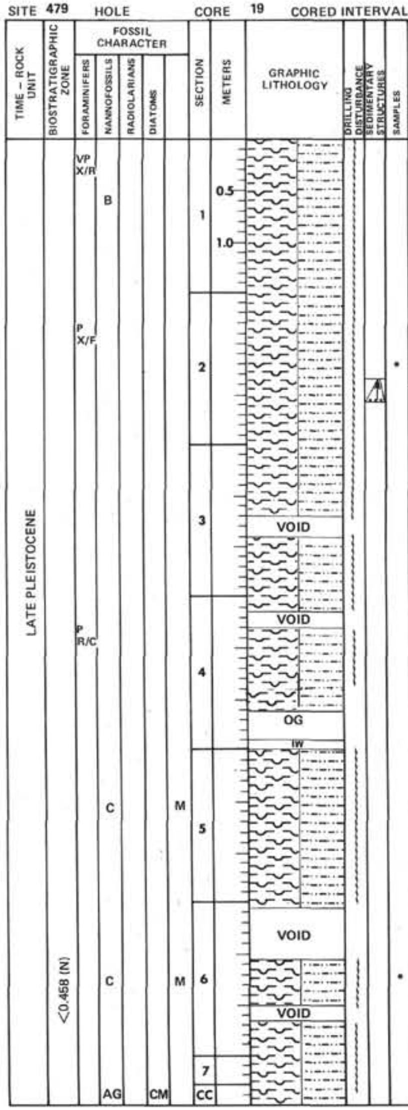
Section 1 has 2 small splothces (80 cm, 95 cm) of gray (N7) vitric, rhyolitic ash?

SMEAR SLIDE SUMMARY

	2-70 (D)
TEXTURE:	
Silt	60
Clay	40
COMPOSITION:	
Quartz	4
Feldspar	5
Opaques	2
Clay	35
Pyrite	1-2
Carbonate unspec.	3
Calc. nannofossils	5
Diatoms	45
Radiolarians	2
Sponge spicules	1

CARBONATE BOMB: 1-82 = 0%

SITE 479 HOLE CORE 19 CORED INTERVAL 164.5–174.0 m



LITHOLOGIC DESCRIPTION

Highly disturbed, uniform **MUDDY DIATOM OOZE** which mixes lighter and darker shades of moderate olive brown (5Y 4/4) and grayish olive (10Y 4/2). Darkens in some areas to 5Y 3/2. Grades finer to siltier in Sections 3 to 4 with scattered fish scales (e.g. Section 4, 60 cm and Section 7, 48 cm). Slightly calcareous with some sand sized specks.

Section 6, 55 cm changes to more moderate brown to yellowish (5Y 4/4), calcareous, very firm **MUDDY DIATOMACEOUS OOZE.**

Some rare brownish areas may be redeposited. One graded bed at Section 2, 85–100 cm. Extensive separation features from gas pressure.

SMEAR SLIDE SUMMARY

	2-70 (D)	6-70 (D)
TEXTURE:		
Sand	15	–
Silt	45	60
Clay	40	40
COMPOSITION:		
Quartz	10	5
Feldspar	12	6-7
Heavy minerals	TR	–
Clay	40	30
Pyrite	2	<1
Opaques	TR	TR
Carbonate unspec.	3	3-4
Foraminifers	2	2-11
Calc. nannofossils	TR	8
Diatoms	30	40
Radiolarians	–	1-2
Sponge spicules	–	TR
Silicoflagellates	–	1
Rock fragments	2	–

SITE 479 HOLE CORE 20 CORED INTERVAL 174.0–183.5 m

TIME – ROCK UNIT: LATE PLEISTOCENE

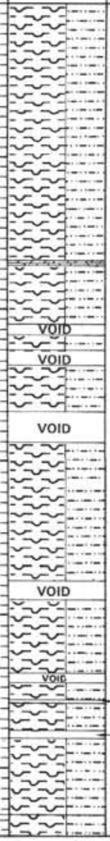
BIOSTRATIGRAPHIC ZONE: above *Nitzschia fossilis* datum; <0.458 (N)

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): P R/C; P F/C, C, G; R, P; X; VP X/R, R, P; AM RM FM

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

5Y 4/2

10Y 6/2 Hard

10Y 4/2

10Y 4/2

VOID

VOID

LITHOLOGIC DESCRIPTION

Completely disturbed, moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** with a few scattered patches of more silty grayish olive (10Y 4/2) **MUDDY DIATOM OOZE** in Section 1 becoming dominant below Section 2. Spongy from gas exsolution.

Core is highly disturbed to brecciated with some scattered chips of broken dolostone in Sections 1 and 2.

At Section 2, 100 cm: pale olive **DOLOSTONE** with regular fine, brownish parallel laminations on a sub mm-scale. Mostly dolomitic although staining indicates some calcite. Carbonate grains mostly anhedral, 10–40 microns.

SMEAR SLIDE SUMMARY

	2-102 (M)	4-70 (D)
TEXTURE:		
Sand	–	2-3
Silt	70	40
Clay	30	55
COMPOSITION:		
Quartz	–	5
Feldspar	–	6
Mica	–	TR
Clay	20	38
Pyrite	–	2(in frustules)
Opaques	–	1
Carbonate unspec.	77[a]	2
Calc. nannofossils	–	1
Diatoms	3	40
Radiolarians	–	1
Plant debris	–	TR

[a]dolomite

SITE 479 HOLE CORE 21 CORED INTERVAL 183.5–193.0 m

TIME – ROCK UNIT: LATE PLEISTOCENE

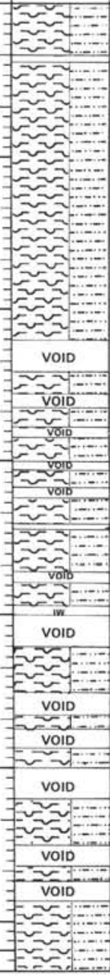
BIOSTRATIGRAPHIC ZONE: above *Nitzschia fossilis* datum; <0.458 (N)

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): X; P R/C, C, M; X, B; X; X, B; FM, FM

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

10Y 4/2

5Y 4/4

5Y 4/6

VOID

5Y 4/4

5Y 6/4

5Y 4/4

Muddy diatomaceous ooze

LITHOLOGIC DESCRIPTION

Highly disturbed, uniform **MUDDY DIATOMACEOUS OOZE**. Grayish olive (10Y 4/2) in Section 1 then moderate olive brown (5Y 4/4) below. Spongy from strong gas exsolution. A few dusky yellow (5Y 6/4) streaks of diatom ooze occur at Section 5, 90 and 110 cm, Section 6, and Section 7, 0–20 cm.

No H_2S odor structures, sand, or much carbonate but some faint traces of a cm-layering. The yellow streaks are remnants from diatom-rich laminae, 1–2 mm thick; clotted or matted.

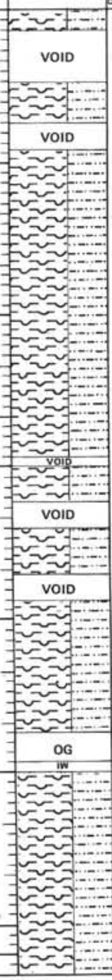
SMEAR SLIDE SUMMARY

	7-12 (M)	7-13 (D)
TEXTURE:		
Silt	55	55
Clay	45	45
COMPOSITION:		
Quartz	Tr	8
Feldspar	TR	10
Clay	30	40
Pyrite	1-2	1-2
Opaques	TR	1
Carbonate unspec.	–	2
Foraminifers	–	TR
Calc. nannofossils	–	3-4
Diatoms	65-75	35
Radiolarians	–	TR
Silicoflagellates	–	1
Rock fragments	–	1

CARBONATE BOMB: Little reaction 5-110 = 19%

SITE 479 HOLE CORE 22 CORED INTERVAL 193.0–202.5 m

TIME–ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LATE PLEISTOCENE	above *Nitzschia fossilis* datum ? <0.458 (N)	X; P X/R; VP X/R; X; X	R; C; RP		P; M; CM	1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0				• (Section 3); • (Section 6)



5Y 4/4
N9
5Y 3/2
darker
5Y 6/4
paler
5Y 3/2
5Y 4/4

LITHOLOGIC DESCRIPTION

Highly disturbed, uniform moderate olive brown (5Y 4/4 to 5Y 3/2 and 5Y 5/6) **MUDDY DIATOMACEOUS OOZE.** Spongy – gas exsolution textures. Includes some olive gray (5Y 5/3) patches as well as yellow streaks and patches of mottled **DIATOM OOZE.** Some evidence of former lamination (Section 4, 0–5 cm). Pale laminae mostly fragile, long diatom frustules.

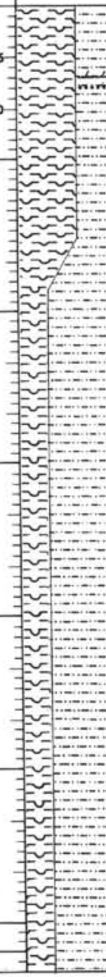
SMEAR SLIDE SUMMARY

	3-135 (M)	6-80 (D)
TEXTURE:		
Silt	85	60
Clay	15	40
COMPOSITION:		
Quartz	–	3
Clay	15	30
Pyrite	1	2
Carbonate unspec.	–	2
Calc. nannofossils	–	10
Diatoms	80	50
Silicoflagellates	2	2
Plant debris	–	1

CARBONATE BOMB: Little reaction
5-101 = –

SITE 479 HOLE CORE 23 CORED INTERVAL 202.5–212.0 m

TIME–ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LATE PLEISTOCENE	? above *Nitzschia fossilis* datum <0.458 (N)	P R/C; M A/A	A; C; RP		GM; GM; CM	1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0				• (Section 1); • (Section 3)



5Y 4/4
5Y 5/6
N3, sand
10Y 4/2
10Y 4/2
10Y 4/2

LITHOLOGIC DESCRIPTION

Section 1 to Section 2, 80 cm: uniform, very disturbed; moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** with some faint patches of olive gray (5Y 3/2). Surface extensively gas ruptured, spongy, slight HCl reaction and scattered white specks.

About 80 cm in Section 2, there is a gradual transition to more silty cohesive olive gray to grayish olive (10Y 4/2) **DIATOMACEOUS MUD** which continues to Section 7. Less gas separation, smoother surface. Calcareous components increase downward.

Section 1, 50-75 cm: a clump of light brown olive (5Y 5/6) dolomitic diatomaceous ooze which has a unilateral mantle below of thin gray (N3) sand about 1 mm thick.

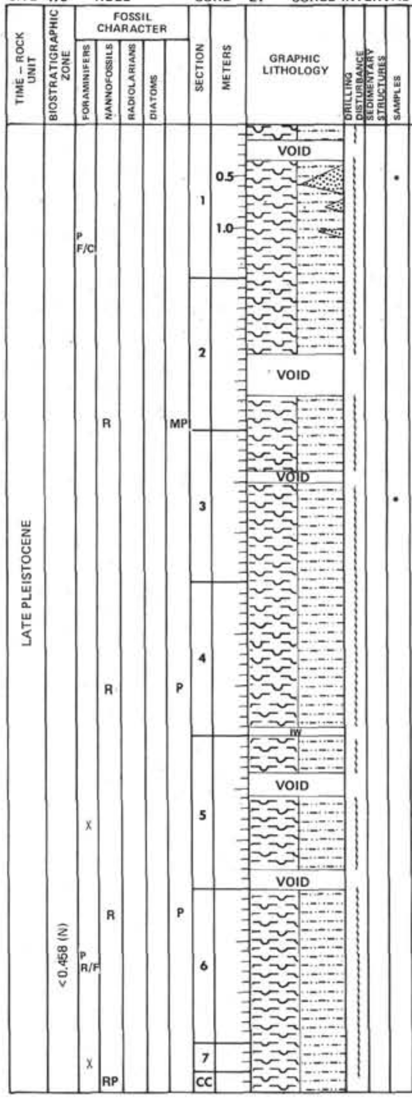
SMEAR SLIDE SUMMARY

	1-73 (M)	3-20 (D)
TEXTURE:		
Silt	90	70
Clay	10	30
COMPOSITION:		
Quartz	7	7
Feldspar	–	2
Mica	–	2
Clay	25	50
Pyrite	3	6
Carbonate unspec.	40[a]	2
Foraminifers	–	1
Calc. nannofossils	–	10
Diatoms	25	25
Plant debris	2	–
Rock fragments	–	1

[a]dolomite (?)

CARBONATE BOMB: 4-73 = 15%

SITE 479 HOLE CORE 24 CORED INTERVAL 212.0–221.5 m



LITHOLOGIC DESCRIPTION

N4, sandy

10Y 4/2

10Y 4/2

High deformed, spongy, grayish olive (10Y 4/2) **MUDDY DIATOMACEOUS OOZE.**

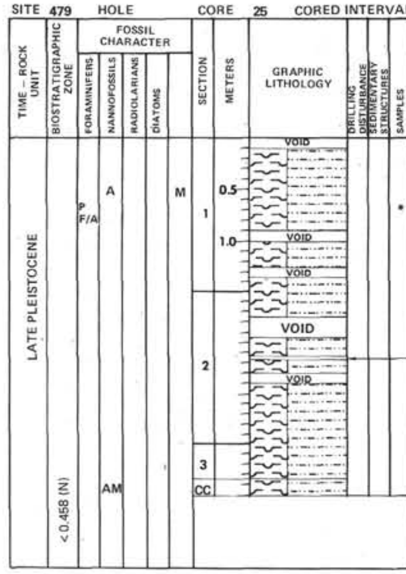
Section 1, 15–120 cm: splotches and patches of gray (N4) **SAND** and some minor slightly darker colored zones. Scattered whitish patches which may be parts of former mm-lamination.

SMEAR SLIDE SUMMARY

	1-54 (M)	3-70 (D)
TEXTURE:		
Sand	45	5
Silt	45	50
Clay	10	45
COMPOSITION:		
Quartz	35	10
Feldspar	30	10
Mica	–	1-2
Clay	10	45
Pyrite	3	1-2
Carbonate unspec.	2	TR
Foraminifers	TR	–
Calc. nannofossils	TR	–
Diatoms	5	40
Sponge spicules	TR	–
Silicoflagellates	–	1-2
Rock fragments	15	–

CARBONATE BOMB: 3-86 = –

SITE 479 HOLE CORE 25 CORED INTERVAL 221.5–231.0 m



LITHOLOGIC DESCRIPTION

10Y 4/2

VOID

10Y 4/2

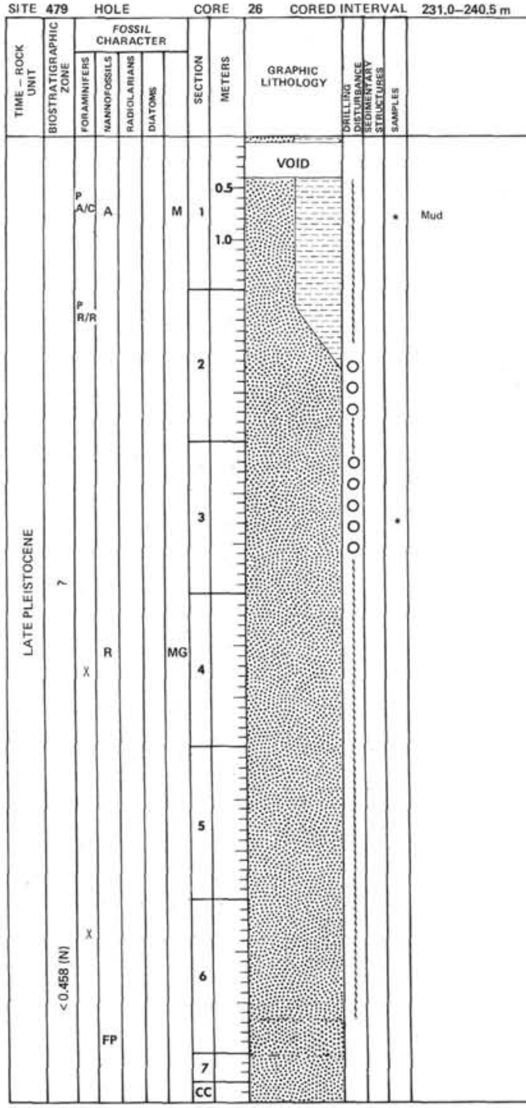
Highly disturbed uniform grayish olive (10Y 4/2) **DIATOMACEOUS MUD** with a spongy surface from gas expansion and separation.

SMEAR SLIDE SUMMARY

	1-70 (D)
TEXTURE:	
Sand	TR
Silt	40
Clay	60
COMPOSITION:	
Quartz	1
Feldspar	3
Mica	2
Clay	50
Pyrite	5
Carbonate unspec.	5
Calc. nannofossils	1-2
Diatoms	30
Silicoflagellates	1-2
Plant debris	TR

CARBONATE BOMB: 2-131 = 4%

SITE 479 HOLE CORE 26 CORED INTERVAL 231.0–240.5 m



LITHOLOGIC DESCRIPTION

Sections 1 and 2: highly disturbed chunks of fine-grained olive gray (5Y 3/2) **SILTY CLAY** in large blebs and dark greenish gray (5G 4/1) speckled unconsolidated **SAND.** Washed, sorted, ungraded. Grain-size is 250–600 μm. Contains angular quartz, abundant feldspars and some rounded rock fragments, little carbonate, some broken diatoms and scattered biotite flakes.

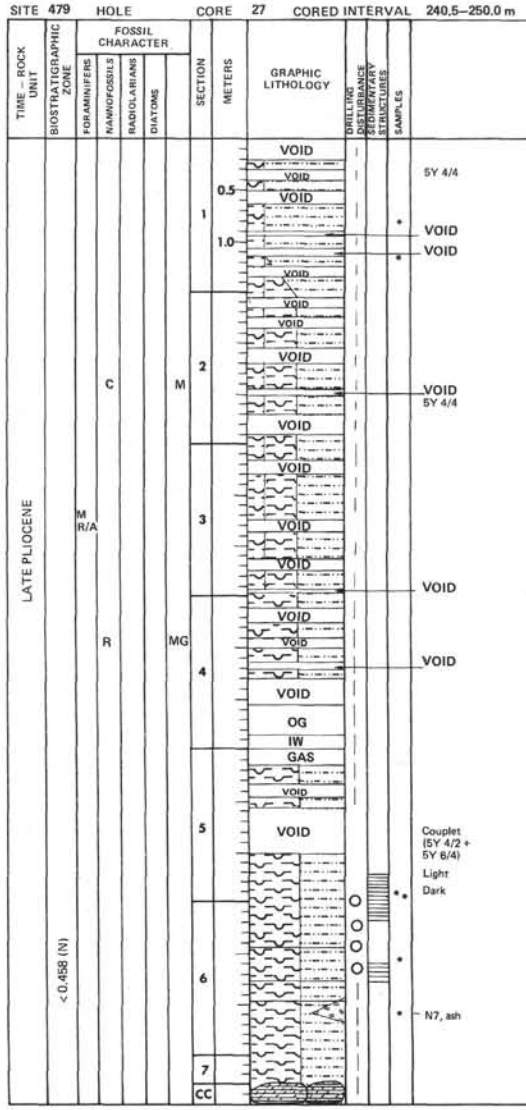
Below Section 2 mostly sand.

SMEAR SLIDE SUMMARY

	1-80 (D)	3-80 (D)
TEXTURE:		
Sand	–	55
Silt	60	30
Clay	40	15
COMPOSITION:		
Quartz	25	25
Feldspar	25	30
Mica	2-3	TR
Heavy minerals	2	–
Clay	40	15
Opaques	–	1
Pyrite	5	2
Carbonate unspec.	5	4
Calc. nannofossils	TR	TR
Diatoms	10	5-6
Silicoflagellates	1-2	
Plant debris	1-2	TR
Rock fragments	–	23

CARBONATE BOMB: 1-82 = –

SITE 479 HOLE CORE 27 CORED INTERVAL 240.5–250.0 m



LITHOLOGIC DESCRIPTION

Disturbed, partings parallel Section 1, 100 cm uniform, moderate olive brown (5Y 4/4) **SILTY CLAY TO DIATOM MUD.** Below Section 1, 100 cm: changes gradually to **MUDDY DIATOMACEOUS OOZE.** Slightly calcareous, rhythmic laminations occur in Sections 5 and 6, defined by a light dusky yellow (5Y 6/4) thin laminae of **DIATOM OOZE.** Light layer rich in fragile, long species. Sediment becomes firm below Section 3.

Section 6, 110 cm: weathered **VITRIC ASH,** light gray (N7). Glass RI <1.52 and numerous altered feldspars.

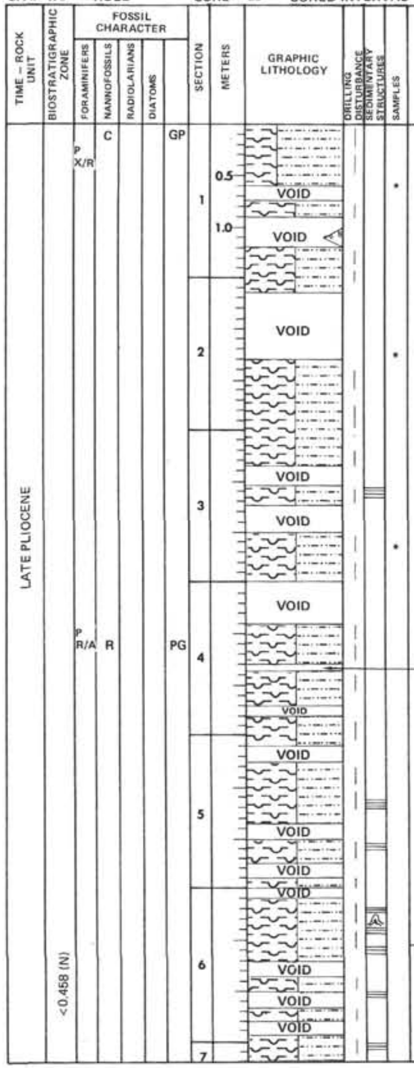
Core-Catcher: two pieces of hard lithified calcareous **DOLOSTONE** with diatoms, thinly laminated and partly burrowed.

SMEAR SLIDE SUMMARY

	1-80 (D)	5-148.5 (M) (light)	5-149 (M) (dark)	6-60 (D)	6-110 (M)
TEXTURE:					
Silt	55	70	55	55	70
Clay	45	30	45	45	30
COMPOSITION:					
Quartz	15	4	5	4	5
Feldspar	10	3	4	3	10
Clay	40	25	30	40	20
Volcanic glass	–	–	–	–	60
Opaques	1	–	1	1	–
Pyrite	2	1	1	1	–
Carbonate unspec.	2	1-2	2-3	2	–
Foraminifers	–	–	–	–	TR
Calc. nannofossils	–	–	TR	3	–
Diatoms	32	65	55	45	10
Radiolarians	TR	–	TR	–	–
Sponge spicules	–	–	–	TR	3
Silicoflagellates	1	TR	–	1-2	–
Rock fragments	–	–	1	–	–

CARBONATE BOMB: 4-72 = 3%

SITE 479 HOLE CORE 28 CORED INTERVAL 250.0–259.5 m



LITHOLOGIC DESCRIPTION

Moderately disturbed.

Section 1, 0–70 cm: darker moderate olive (5Y 4/3) brown, homogeneous diatom-rich **SILTY CLAY**, may be turbidite but structureless. Trace carbonate and very rich in silicoflagellates.

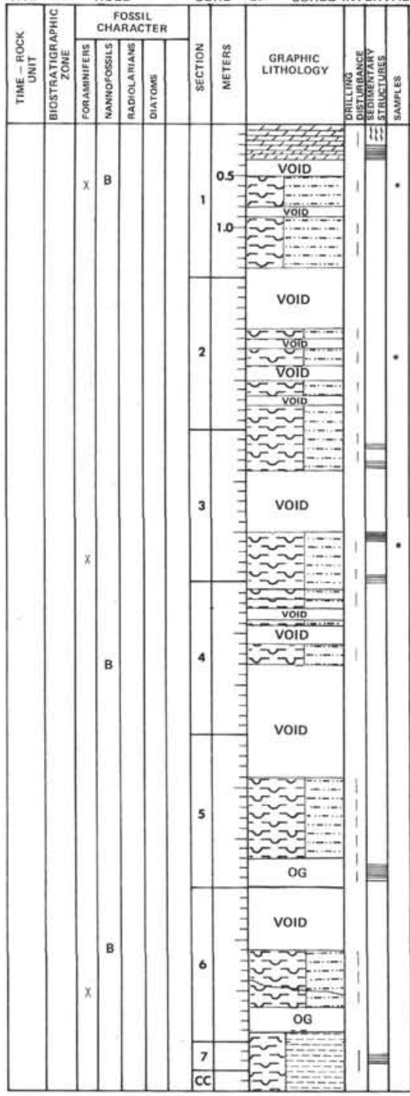
Below Section 1, 70 cm: moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE.** Some zones show locally well-developed fine rhythmic laminations on a sub-mm scale. Lighter pale to dusky yellow (5Y 6/4) part of couplet is **DIATOM OOZE.**

Section 1, 115 cm: minor bleb of vitric ash with some diatom mud, RI = 1.52.

SMEAR SLIDE SUMMARY

	1-30 (D)	1-115 (D)	6-54 (D)
TEXTURE:			
Sand	–	–	1
Silt	60	80	55
Clay	30	20	45
COMPOSITION:			
Quartz	10	–	5
Feldspar	10	–	3
Heavy minerals	–	2	–
Clay	40	5	35
Volcanic glass	–	60	–
Others	–	5	–
Pyrite	–	–	5
Carbonate unspec.	3	–	TR
Diatoms	20	20	45
Silicoflagellates	10	–	1
Plant debris	5	–	5

SITE 479 HOLE CORE 29 CORED INTERVAL 259.5–269.0 m



LITHOLOGIC DESCRIPTION

Section 1, 0–28 cm: light olive gray (5Y 5/2) to pale gray (5Y 7/2) series of lithified **DOLOMITIC BEDS.** Burrowed to laminated. One piece (4) has a thin white stringer of possible quartz. Contacts sharp.

Section 1, 31–150 cm: olive gray (5Y 5/3) silty **DIATOM MUD,** mostly homogeneous. Some pieces very hard. Brown in brown laminated couplets near base. No grading where homogeneous.

Sections 2 to 7: alternating bands of homogeneous, and zones of finely laminated firm **MUDDY DIATOMACEOUS OOZE.** Disturbance is moderate with some partings due to gas expansion.

Section 7: change to more borwnish black (5YR 2/1) **CLAYSTONE,** homogeneous, waxy, 45 cm thick then 15 cm laminated muddy diatom ooze.

TS 1-5: laminated dolostone. Equidimensional equigranular (10–20 microns) dolomite (70%) crystals. Rhombs, some large (60 microns) or subhedral grains as individual crystal framework. Encloses some diatom frustules (10%) which are fully preserved. Minor quartz and clay. Rare pyrite.

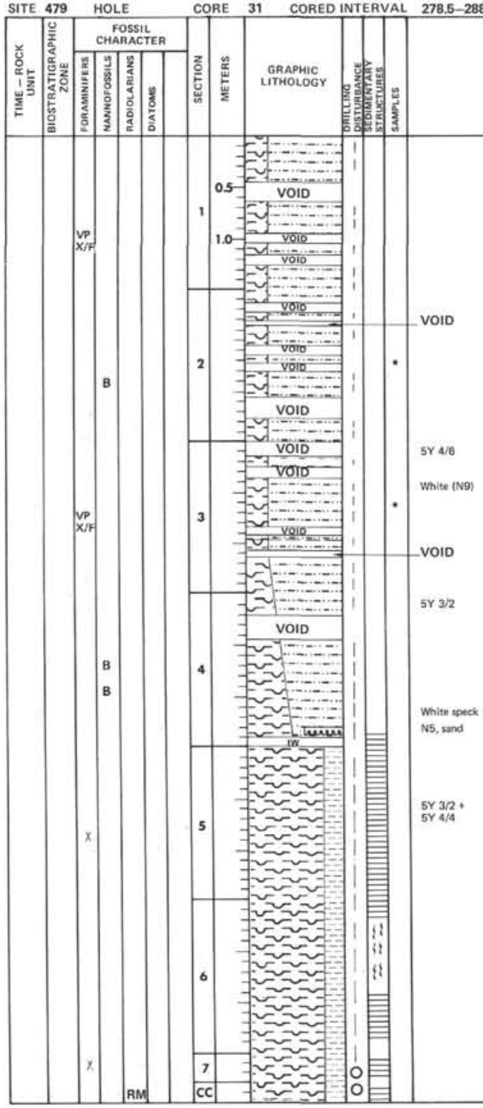
SMEAR SLIDE SUMMARY

	1-60 (D)	2-79 (M)	3-115 (D)
TEXTURE:			
Silt	60	85	65
Clay	40	15	35
COMPOSITION:			
Quartz	5	70	5
Feldspar	7	5	5
Clay	55	10	30
Pyrite	3	–	2
Carbonate unspec.	5	–	TR
Diatoms	25	10	60
Sponge spicules	–	2	–
Silicoflagellates	TR	–	TR
Plant debris	TR	–	TR

CARBONATE BOMB: 5-114 = 3%

Note: Site 479, Core 30, 269.0–278.5 m: No Recovery.

SITE 479 HOLE CORE 31 CORED INTERVAL 278.5–288.0 m



LITHOLOGIC DESCRIPTION

Disturbed including many partings from gas expansion.

Section 1–3, 100 cm: uniform, mostly olive gray (5Y 3/2) firm **DIATOMACEOUS CLAYEY SILT.** Diatoms mostly fragmented or robust species. Scattered reduction streaks, pyrite-rich, some small spots of light (N9) quartz **CLAY** (e.g. Section 3, 61 cm). Slightly calcareous.

Section 3, 100 cm to Section 4, 130 cm: slight color change to moderate olive brown (5Y 4/6) uniform. Distinct but gradational wisps of lighter colors intermixed.

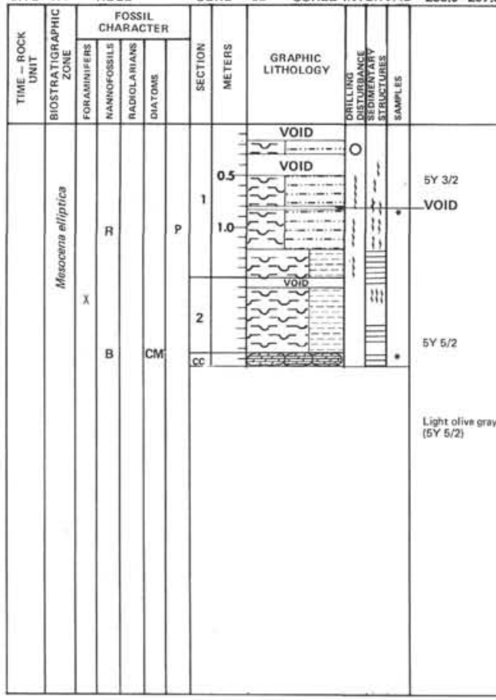
Below Section 4, 130 cm: alternating zones of laminated and homogeneous moderate olive brown (5Y 4/4 + 5Y 3/2) **MUDDY DIATOMACEOUS OOZE.** Contacts transitional. Laminae from sub-mm couplets (approximately 20–25 couplets/cm) comprising light diatom-rich and dark mud-rich elements. Homogeneous zones appear bioturbated, not graded. Upwelling species dominant.

SMEAR SLIDE SUMMARY

	2-70 (D)	3-61 (M)	6-143 (D)
TEXTURE:			
Silt	70	20	80
Clay	30	80	20
COMPOSITION:			
Quartz	12	5	5
Feldspar	15	3	5
Heavy minerals	3	–	–
Clay	30	80	20
Pyrite	7	TR	TR
Carbonate unspec.	10	TR	TR
Diatoms	25	10	70
Silicoflagellates	TR	–	–
Plant debris	5	2	1-2

CARBONATE BOMB: 5-69 = 0%
5-70 = 0%

SITE 479 HOLE CORE 32 CORED INTERVAL 288.0–297.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) **SILICEOUS MUD** comprising abundant silicoflagellates with diatoms. Mostly uniform, structureless. Sediment is very firm and shows fissle parallel drill-fractures.

Section 1, 130–150 cm and Section 2, 50–65 cm: intercalations of rhythmically laminated couplets of moderate olive brown (5Y 4/4) and pale olive (10Y 6/2) **MUDDY DIATOM OOZE.** Some laminae are subparallel, with lenticular features from burrowing.

Core-Catcher: 3 pieces of light olive gray (5Y 5/2) lithified **DOLOSTONE,** laminations subparallel; sub-mm, disturbed by some bioturbation.

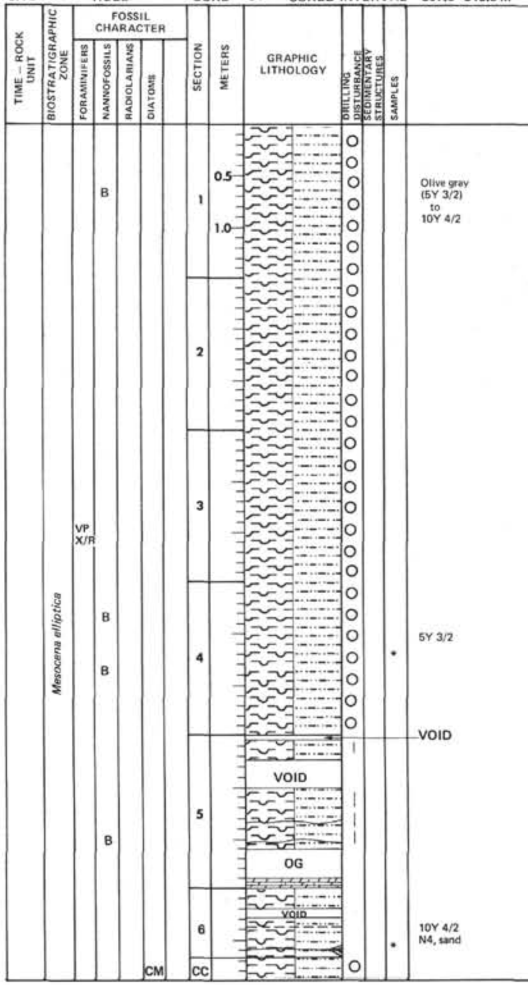
SMEAR SLIDE SUMMARY

	1-86 (D)	CC (M) (Dolomite)
TEXTURE:		
Sand	<1	–
Silt	60	–
Clay	40	100
COMPOSITION:		
Quartz	5	–
Feldspar	3	–
Mica	2	–
Clay	35	40
Pyrite	2	–
Carbonate unspec.	5	60
Foraminifers	1	–
Calc. nannofossils	3	–
Diatoms	20	–
Silicoflagellates	20	2
Plant debris	2	–

CARBONATE BOMB: 1-63 = –

Note: Site 479, Core 33, 297.5–307.0 m: No Recovery.

SITE 479 HOLE CORE 34 CORED INTERVAL 307.0–316.5 m



LITHOLOGIC DESCRIPTION

Drill brecciated and broken; olive gray (5Y 3/2) to grayish olive (10Y 4/2) **MUDDY DIATOMACEOUS OOZE**, very firm with abundant silicoflagellates (Mesocenids). Gas ruptured, no visible laminations, some reduction streaks in Section 5.

Section 5, 140–150 cm: grayish olive (10Y 4/2) lithified **CALCAREOUS DOLOMITIC MUDSTONE**; bioturbated with pale olive burrow fillings at the top, darker near bottom, but may mask considerable siliceous or clay component. Scrappings comprise mostly anhedral carbonate micrite but may mask considerable siliceous or clay component.

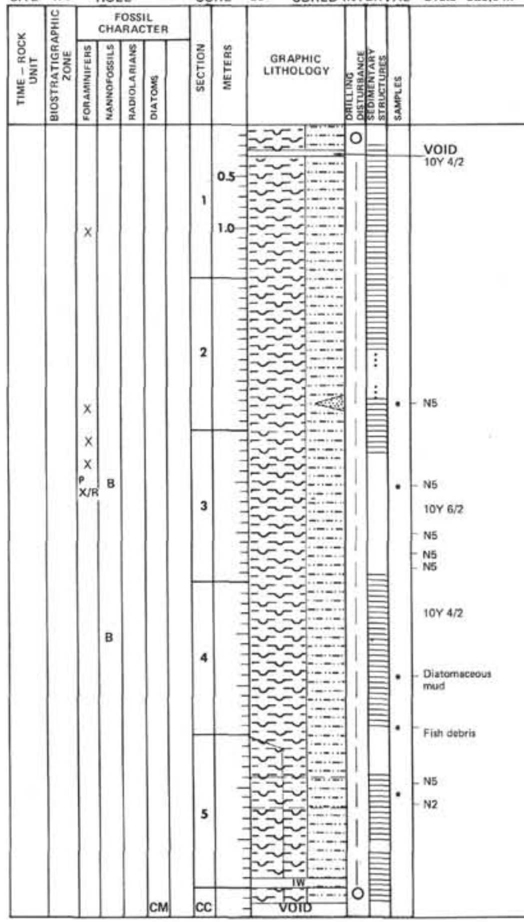
At Section 6, 64 cm: thin gray (N4) sand layer. Section 6: muddy diatom ooze comprises mostly fragile, wavy upwelling diatom species with very few silicoflagellates.

SMEAR SLIDE SUMMARY

	4-70 (D)	6-49 (D)
TEXTURE:		
Sand	–	1
Silt	60	40
Clay	40	40
COMPOSITION:		
Quartz	5	5
Feldspar	3	5
Clay	35	30
Pyrite	3	1-2
Carbonate unspec.	5	1-2
Calc. nannofossils	TR	–
Diatoms	40	60
Silicoflagellates	5	–
Plant debris	2	TR

CARBONATE BOMB: 2-84 = 5%
5-108 = –

SITE 479 HOLE CORE 35 CORED INTERVAL 316.5–326.0 m



LITHOLOGIC DESCRIPTION

Disturbed, grayish olive (10Y 4/2) **DIATOMACEOUS MUD TO OOZE** from laminated and non-laminated zones of more bioturbated character. Contacts transitional. Cm-scale dark medium gray (N5) clayey-silt layers. Rhythmic laminations on a sub-mm-scale very faint. Some clayey beds contain numerous large fish scales (e.g. Section 4, 145 cm). Sediment firm to fissle. Breaks along sub-parallel planes.

Below Section 4, 140 cm: grayish olive (10Y 4/2) with pale olive (10Y 6/2) diatom mud couplets; laminatedon a sub-mm-scale.

At Section 2, 125 cm: pyrite-rich (20%) gray (N5) clay band. Equigranular cubes + framboids.

At Section 3, 58 cm: dark gray (N5) clay-rich in terrestrial organic bits.

At Section 4, 94 cm: couplets rich in monospecific diatoms.

At Sectin 4, 145 cm: pocket of fish debris.

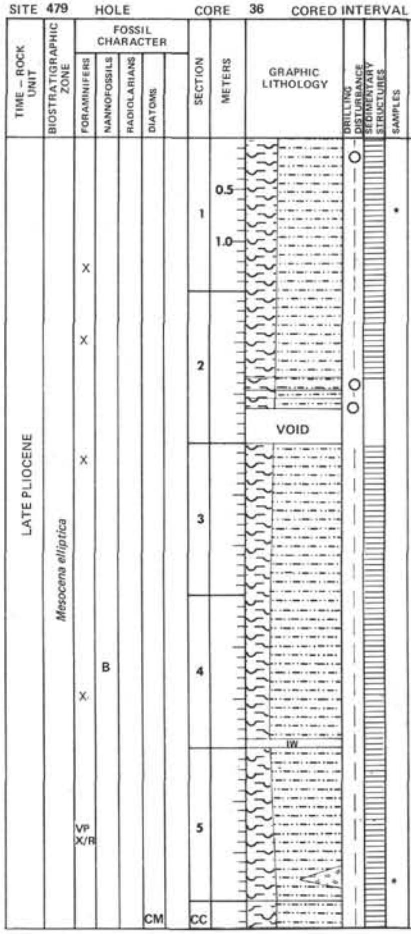
At Section 5, 69 cm: pyrite-rich with rhombs of siderite? (5%).

SMEAR SLIDE SUMMARY

	2-125 (M)	3-58 (D)	4-94 (D)	4-145 (M)	5-69 (M)
TEXTURE:					
Silt	45	45	50		40
Clay	55	55	50		60
COMPOSITION:					
Quartz	7	5	2		2
Feldspar	5	3	2		2
Mica	1	–	–		1
Heavy minerals	–	–	–		5
Clay	55	5	50		30
Pyrite	20	5	5		10
Carbonate unspec.	1-2	–	–		5
Calc. nannofossils	1-2	–	–		TR
Diatoms	5	5	45		30
Silicoflagellates	–	1-2	2-5		–
Fish remains	–	–	–	100	–
Plant debris	–	25	TR		TR

CARBONATE BOMB: 4-139 = –

SITE 479 HOLE CORE 36 CORED INTERVAL 326.0–355.5 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) **DIATOMACEOUS MUD (SILTY CLAY) TO MUDDY OOZE.** Entire core uniformly laminated with sub-mm regular rhythmic laminations. Light couplet member is pale olive (10Y 6/2).

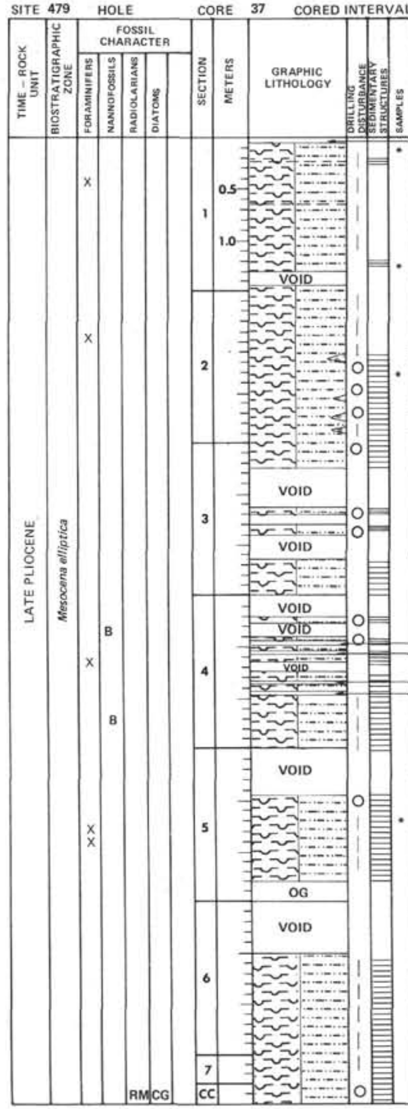
At Section 5, 128 cm: a thin black sand laminae is composed of brown basaltic glass and feldspars coated with opaques (manganese). Accompanied by some quartz (9%) and diatoms (20%). Glass partially altered.

SMEAR SLIDE SUMMARY

	1-70 (D)	5-128 (M)
TEXTURE:		
Sand	–	20
Silt	40	70
Clay	60	10
COMPOSITION:		
Quartz	5	9
Feldspar	3	10
Mica	1	–
Heavy minerals	1	–
Clay	45	
Volcanic glass	–	70
Pyrite	5	–
Carbonate unspec.	7	–
Calc. nannofossils	1-2	
Diatoms	40	20
Silicoflagellates	TR	–
Plant debris	TR	–

CARBONATE BOMB: 3-70 = 6%

SITE 479 HOLE CORE 37 CORED INTERVAL 335.5–345.0 m



LITHOLOGIC DESCRIPTION

Numerous voids due to gas partings. Grayish olive (10Y 4/2), firm, **DIATOMACEOUS SILTY CLAY** comprising sub-mm-scale rhythmic couplets.

Section 1, 20–130 cm and Section 2, 0–70 cm: several intercalated zeones are homogeneous, bioturbated, with gradational contacts to laminated areas. Parts are drill-brecciated, homogeneous.

At Section 2, 80 cm, 113 cm, 126 cm, 142 cm: thin black (N1) laminae of sandy basaltic glass and opaque coated feldspar grains. Glass highly altered.

At Section 1, 14 cm: thin bluish gray clay lamina , quartz-feldspar-rich.

SMEAR SLIDE SUMMARY

	1-14 (M)	1-127 (D)	2-80 (M)	5-70 (D)
TEXTURE:				
Sand	–	–	60	–
Silt	80	60	40	65
Clay	20	40	–	35
COMPOSITION:				
Quartz	40	8	–	8
Feldspar	35	6	30	7
Opaques	TR	<1	–	TR
Clay	10-15	35	–	35
Volcanic glass	–	–	60	–
Pyrite	1	1	–	<1
Carbonate unspec.	3	5-6	–	3-4
Calc. nannofossils	TR	TR	–	TR
Diatoms	TR	45	9	45
Sponge spicules	–	TR	–	–
Silicoflagellates	–	TR	–	TR

CARBONATE BOMB: 2-78 = –

SITE 479 HOLE CORE 38 CORED INTERVAL 345.0–354.5 m

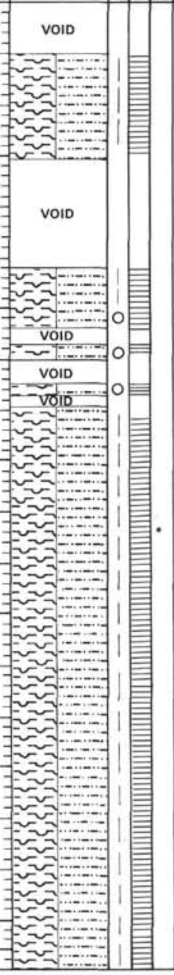
TIME–ROCK UNIT: LATE PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Mesocena elliptica*

FOSSIL CHARACTER: Nannofossils B; Diatoms CG

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

METERS: 0.5, 1.0



10Y 4/2

10Y 4/2

LITHOLOGIC DESCRIPTION

Unfiorm firm to hard grayish olive (10Y 4/2) **DIATOMACEOUS SILTY CLAY AND OOZE.** Laminated in rhythmic couplets on a sub-mm-scale. Some pale diatom-rich layers up to 1 mm thick. Average of 3 sections shows 25–30 cycles/cm. Sediments become fissile towards base.

SMEAR SLIDE SUMMARY

	4-70 (D)
TEXTURE:	
Silt	65
Clay	45
COMPOSITION:	
Quartz	8
Feldspar	7
Heavy minerals	TR
Clay	<40
Pyrite	1-2
Carbonate unspec.	TR
Diatoms	45
Radiolarians	TR
Silicoflagellates	TR
Plant debris	2

CARBONATE BOMB: 5-129 = 0%

SITE 479 HOLE CORE 39 CORED INTERVAL 354.5–364.0 m

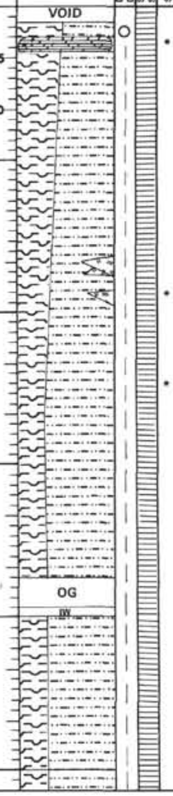
TIME–ROCK UNIT: LATE PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Mesocena elliptica* first Pleistocene appearance (~0.93 m.y.) < 0.93 – > 0.7 m.y.

FOSSIL CHARACTER: Nannofossils B; Diatoms AG

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

METERS: 0.5, 1.0



Dolostone

10Y 4/2

N1

N1

10Y 4/2

LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) **DIATOMACEOUS MUD AND OOZE** with regular, uniform, light-dark rhythmic laminated couplets. Diatom abundance decreases downward.

At Section 1, 30–45 cm: 5 pieces of hard grayish olive (10Y 4/2) indurated **CARBONATE (DOLOMITIC?)** laminated with original varve-like layers some of which appear discontinuous, possibly bioturbated. Carbonate micrite size anhedral grains.

At Section 2, 94, 97, and 130 cm are 1 cm-thick **BASALTIC ASH** beds, with sand-size glass and feldspar grains coated with manganese and moderately altered.

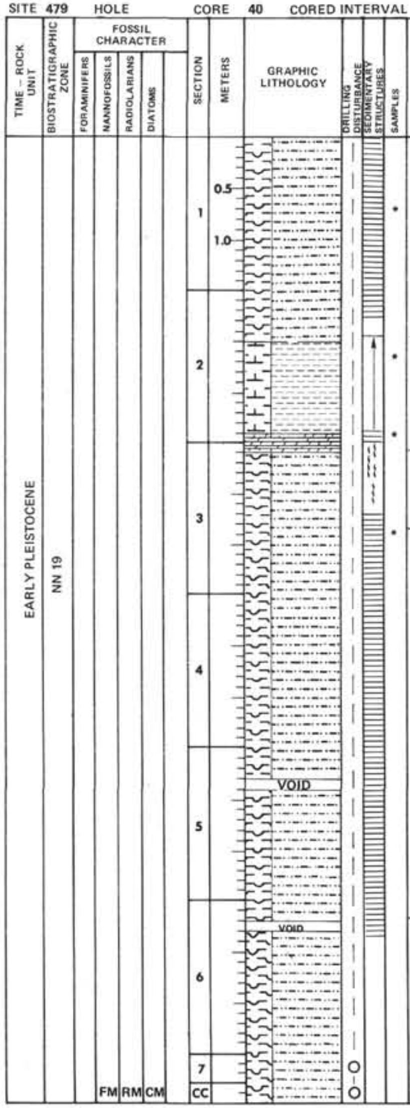
SMEAR SLIDE SUMMARY

	1-33 (M)	2-131 (M)*	3-70 (D)
TEXTURE:			
Sand	–	<10	–
Silt	80	80	50
Clay	20	10	50
COMPOSITION:			
Quartz	TR	–	11
Feldspar	TR	10	9
Heavy minerals	TR	–	1
Clay	30	20	45
Volcanic glass	–	30	–
Pyrite	TR	–	1
Opaques	–	40	–
Carbonate unspec.	70[a]	–	4
Calc. nannofossils	–	–	TR
Diatoms	–	3	35
Sponge spicules	TR	–	–
Silicoflagellates	–	–	TR

[a]dolomite

CARBONATE BOMB: 4-107 = –

SITE 479 HOLE CORE 40 CORED INTERVAL 364.0–373.5 m



LITHOLOGIC DESCRIPTION

5EY 4/2

N6

Fish scales

Partly crusted; grayish olive (10Y 4/2) **DIATOMACEOUS MUD** laminated with regular sub-mm light-dark couplets. Some scattered thick gray layers. Diatom abundance continues to decline. Fish scales common on clay laminae partings.

Section 2, 50–145 cm: ~ intercalated homogeneous, grayish-olive-green (5GY 4/2) nannofossil-bearing clay to silt. Upper contact transitional, grades downward from waxy texture to silty. Components include a few broken robust-type diatom frustules and scattered chips (brown, low b.f. clear, no cleavage) of either phosphate or fish debris. Land derived organics abundant have single dolomite rhombs. May be redeposited.

Section 2, 145 cm to Section 3, 85 cm: olive gray, hard, lithified **DOLOSTONE.** Shows preserved fine laminations and manganese stains.

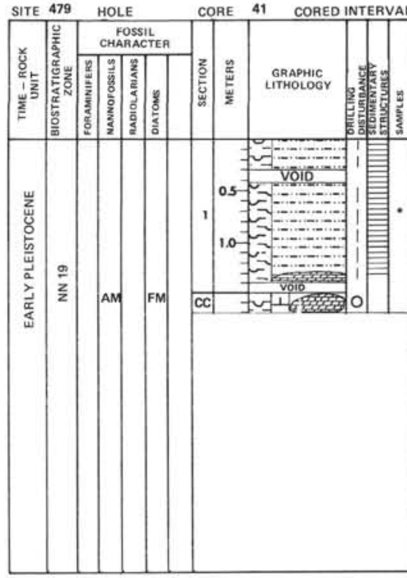
Section 3, 88 cm: light gray (N6) silt comprising altered and very fresh sub- to euhedral feldspars and opaques.

SMEAR SLIDE SUMMARY

	1-70 (D)	2-70 (M)	2-144 (M)	3-88 (M)
TEXTURE:				
Sand	–	–	–	15
Silt	50	60	60	85
Clay	50	40	40	–
COMPOSITION:				
Quartz	7	12	15	45
Feldspar	6	10	10	35
Mica	–	–	–	TR
Opaques	1	1	TR	5-6
Clay	45	50	35	15
Volcanic glass	–	–	–	TR
Pyrite	2-3	2	1-2	–
Carbonate unspec.	3	10	6	–
Diatoms	35	TR	15	TR
Silicoflagellates	TR	–	–	–
Fish remains	–	5	–	–
Rock fragments	–	–	–	TR

CARBONATE BOMB: 6-110 = 10%

SITE 479 HOLE CORE 41 CORED INTERVAL 373.5–383.0 m



LITHOLOGIC DESCRIPTION

10Y 4/2

Grayish olive (10Y 4/2) **DIATOM MUD** slightly calcareous. Rhythmic parallel laminations, on a sub-mm-scale. Scattered fish scales common. Some zones are badly brecciated by drilling.

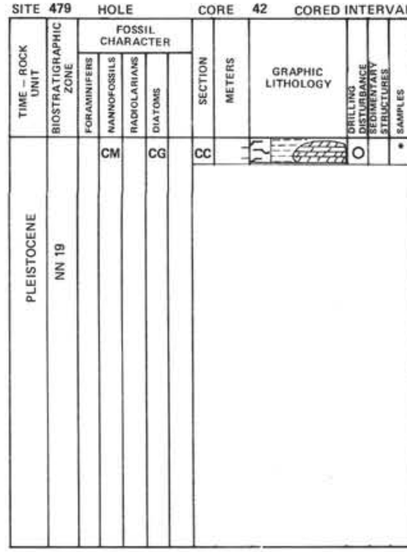
Section 1, 135 cm and Core-Catcher: four thin, platy **DOLOSTONE BEDS**, hard, no visible laminations. Occur imbedded in diatom mud.

SMEAR SLIDE SUMMARY

	1-70 (D)
TEXTURE:	
Silt	60
Clay	40
COMPOSITION:	
Quartz	12
Feldspar	8
Heavy minerals	1
Clay	35
Pyrite	3
Carbonate unspec.	10
Calc. nannofossils	10
Diatoms	25
Plant debris	3

CARBONATE BOMB: 1-99 = –

SITE 479 HOLE CORE 42 CORED INTERVAL 383.0–392.5 m



LITHOLOGIC DESCRIPTION

10Y 4/2

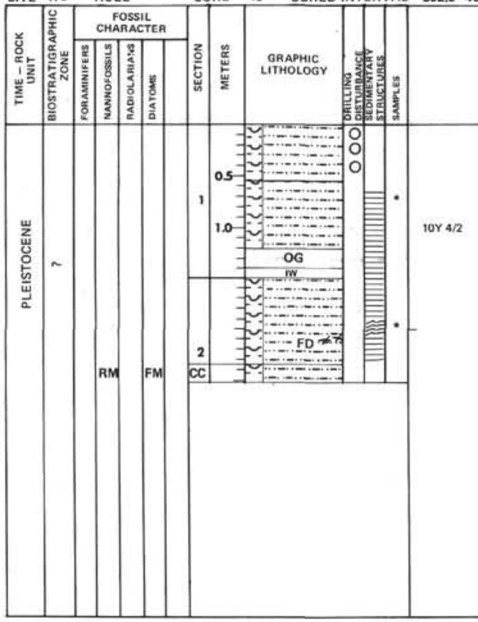
Grayish olive (10Y 4/2) hard **DIATOM-BEARING NANNOFOSSIL MUD.** Diatoms mostly fragments. Dolomite rhombs (20–40 microns) are common. Drill disturbed but evidence for fine-rhythmic laminations.

Core-Catcher: one piece of grayish olive (10Y 4/2) hard, fine-grained **DOLOSTONE.**

SMEAR SLIDE SUMMARY

	CC (D) (mud)
TEXTURE:	
Silt	20
Clay	80
COMPOSITION:	
Quartz	TR
Feldspar	TR
Heavy minerals	<1
Pyrite	41
Carbonate unspec.	15
Calc. nannofossils	20
Diatoms	15
Silicoflagellates	2
Plant debris	1

SITE 479 HOLE CORE 43 CORED INTERVAL 392.5–402.0 m



LITHOLOGIC DESCRIPTION

Moderately to slight disturbed grayish olive (10Y 4/2) **DIATOMACEOUS MUD,** slightly calcareous with some nannofossils. Scattered calcareous debris, some dolomitic thin zones showing homogeneous. Several partings along laminae are rich in fish scales.

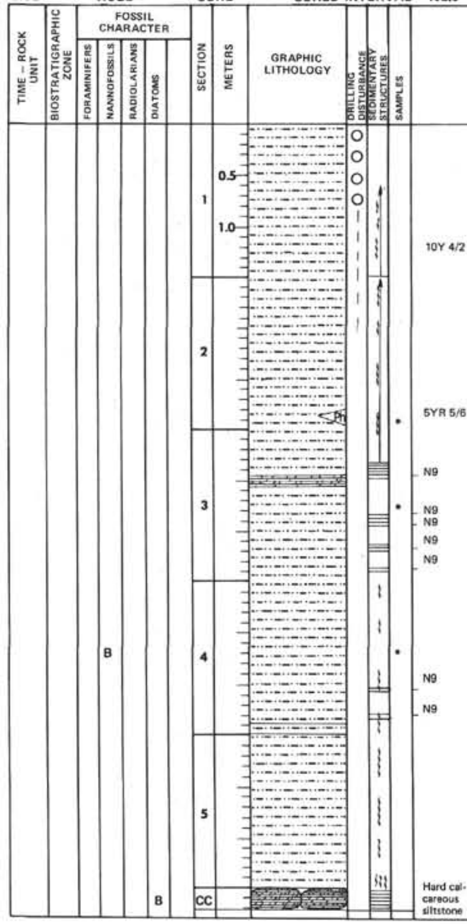
Section 2, 48–52 cm: several thin yellow layers along laminae are diatomaceous nannofossil ooze with a monospecific large nannofossil;matted, wavy laminations.

SMEAR SLIDE SUMMARY

	1-70 (D)	2-49 (D)
TEXTURE:		
Silt	35	–
Clay	65	–
COMPOSITION:		
Quartz	2	–
Feldspar	1	–
Opaques	1	–
Clay	45	10
Pyrite	2	TR
Carbonate unspec.	10	–
Calc. nannofossils	10	45
Diatoms	25	45
Radiolarians	TR	–
Silicoflagellates	1	–
Fish remains	3	–
Plant debris	2	–

CARBONATE BOMB: 2-82 = 10%

SITE 479 HOLE CORE 44 CORED INTERVAL 402.0–411.5 m



LITHOLOGIC DESCRIPTION

Hard, grayish olive (10Y 4/2) **CLAY TO SILTY CLAY.** Bioturbated. Some zones with rhythmic laminations.

Section 1, 60–150 cm and Section 2, 10 to Section 3, 40 cm: muds appear to show faint grading; possible turbidite redeposited bed.

Section 2, 140 cm: streak of red to light brown (5YR 5/6) is possible phosphate concretion (isotropic, high R.I., yellow brown).

Section 3, 50 cm and Core-Catcher: thinly laminated, hard, lithified, **DOLOSTONE.** Preservation of primary burrows and laminations by dolomite cement.

Section 3, 90, 95, 116, and 130 cm and Section 4, 111 and 136 cm: laminae of pure white (N9) **NANNOFOSSIL OOZE** monospecific large types.

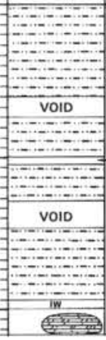
SMEAR SLIDE SUMMARY

	2-141 (M)	3-78 (M)	4-70 (D)
TEXTURE:			
Sand	–	–	5
Silt	–	100	40
Clay	–	–	55
COMPOSITION:			
Quartz	–	–	9
Feldspar	–	–	6
Opaques	–	–	1
Clay	–	–	55
Phosphate	100	–	–
Pyrite	–	–	1-2
Carbonate unspec.	–	–	25
Foraminifers	–	–	TR
Calc. nannofossils	–	100	2
Radiolarians	–	–	TR

CARBONATE BOMB: 3-93 = –

SITE 479 HOLE CORE 45 CORED INTERVAL 411.5–421.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
PLEISTOCENE	?		RP		B	1, 2, CC	0.5, 1.0	VOID, VOID, IW			•



10Y 4/2

VOID

N9

LITHOLOGIC DESCRIPTION

Very deformed, considerable drill-breccia. Grayish olive (10Y 4/2) **CLAY TO SILTY CLAY** without evidence of rhythmic laminations. Mostly homogeneous with some faint small burrow features.

Core-Catcher: grayish olive (10Y 4/2) hard, indurated dolostone, possibly with some silica. Dolomitic cement preserves primary laminations in upper part of sample.

Section 2, 45 cm: thin pure white (N9) **NANNOFOSSIL OOZE** laminae.

SMEAR SLIDE SUMMARY

	1-125 (D)
TEXTURE:	
Silt	20
Clay	80
COMPOSITION:	
Quartz	10
Feldspar	8
Heavy minerals	1
Clay	65
Pyrite	2
Opaques	2
Carbonate unspec.	10
Calc. nannofossils	2-1
Diatoms	TR
Fish remains	TR
Plant debris	3

CARBONATE BOMB: 1-81 = 3%

Note: Site 479, Core 46, 421.0–430.5 m: No Recovery.

SITE 479 HOLE CORE 47 CORED INTERVAL 430.5–440.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
PLEISTOCENE	?	FM	B	B		1, 2, 3, 4, 5, 6, CC	0.5, 1.0	OG, IW			•

5Y 7/2

5Y 3/2

Soft
Hard

LITHOLOGIC DESCRIPTION

Section 1, 0–17 cm: homogeneous yellow gray (5Y 7/2) to light olive gray (5Y 5/2) **DOLOMITIC CLAY TO SILTY CLAY.**

Below 17 cm: rather uniform, olive gray (5Y 3/2) **CLAYSTONE**, rhythmically laminated on a very fine, regular sub-mm-scale. Pinchout layers from compaction. Micro-scale discontinuous is not calcareous except certain laminae with pure nannofossil-ooze. Sections 1 and 2 rich in fish debris.

Section 2, 120–150 cm: hard, indurated laminated **DOLOSTONE** with downward increasing hardness and gradual disappearance of varve-like laminations. Seven types of layers occur as discrete laminae including: a) light clay part of couplet; b) dark clay; c) very dark red brown organic-rich laminae; d) thin gray (N6) bands of clastic influx; and e) brown or tan clay influxes; and f) thin creamy white nannofossil oozes laminae. Average couplet thicknesses: 36/cm–40/cm, some 20 cm estimate of 20 ,000 years for core. More calcareous layers towards the base.

SMEAR SLIDE SUMMARY

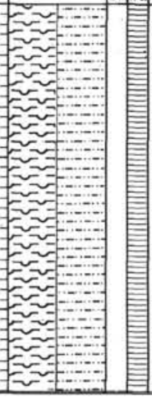
	1-10 (M)	1-62 (D)	2-150 (M)	(a) 3-52.6	(a) 3-63.4	(d) 3-62.3	3-76.3 (D)	(f) 3-117	(b) 3-141	(c) 4-40
TEXTURE:										
Sand	<1	–	–	–	–	–	–	–	–	–
Silt	20	25	40	13	15	15	20	–	–	–
Clay	80	75	60	85	85	85	80	–	–	–
COMPOSITION:										
Quartz	2	2	TR	–	5-6	4	4	2	3	>10
Feldspar	2	1	TR	6	2	1	2	2	1	21
Mica	TR	1	–	–	–	–	–	–	–	–
Opaques	–	–	–	TR	TR	TR	TR	TR	TR	TR
Clay	65	75	10-15	>80	85	85	80	<10	80	50
Pyrite	1-2	–	<1	<1	<1	>1	1	TR	<1	<1
Carbonate unspec.	30	2	85	5	5-6	10	15	TR	10	30
Calc. nannofossils	1-2	2	TR	TR	TR	TR	TR	90	4	4
Diatoms	–	–	–	–	–	–	–	–	–	TR
Fish remains	–	–	–	TR	–	–	–	–	–	–
Plant debris	TR	TR	–	–	–	–	–	–	–	–

CARBONATE BOMB: 4-108 = 9%

SITE 480 HOLE CORE 1 CORED INTERVAL 0.00–4.75 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
PLEISTOCENE - HOLOCENE (?)						1	0.5, 1.0
						2	
					CG	3	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE · SEDIMENTARY STRUCTURES · SAMPLES

Dark muddy diatomaceous ooze
Light diatomaceous ooze

LITHOLOGIC DESCRIPTION

Undisturbed hydraulic piston core. Rhythmically laminated mm-couplets of alternating moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE.** Pale laminae commonly matted texture from fibrous frustules. Core has gelatinous consistency due to high water content. Strong H_2S component.

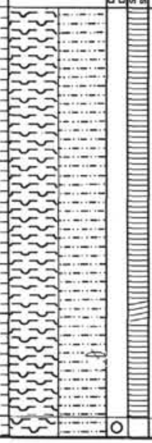
SMEAR SLIDE SUMMARY

	1-110.5 (D)	1-111 (M)
TEXTURE:		
Sand	–	–
Silt	40	70
Clay	60	30
COMPOSITION:		
Quartz	1	–
Feldspar	2	1
Mica	–	1
Clay	50	20
Pyrite	TR	–
Diatoms	45	75
Sponge spicules	1	1
Silicoflagellates	3	2
Plant debris	1	–
Pollen	–	2

SITE 480 HOLE CORE 2 CORED INTERVAL 4.75–9.50 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
PLEISTOCENE - HOLOCENE (?)						1	0.5, 1.0
			B			2	
						3	
		X			CG	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE · SEDIMENTARY STRUCTURES · SAMPLES

Unconformity

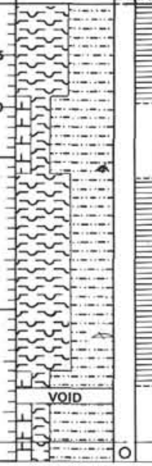
LITHOLOGIC DESCRIPTION

Rhythmic laminations of alternating moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE.** Some diatom ooze layers as thick as 0.75 cm with "paper"-like mats of diatoms (e.g. Section 1, 71 cm). Some deviation from horizontal bedding of laminae (coring effect?). Strong H_2S. Gelatinous consistency near the top of the core, but firms toward the bottom. Laminated couplets sub-mm- to sub-cm-scale in thickness, parallel with discordant layering Section 2, 130–150 cm.

SITE 480 HOLE CORE 3 CORED INTERVAL 9.50–14.25 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE / PLEISTOCENE - HOLOCENE	NN 20/21					1	0.5, 1.0
						2	
						3	
		P C/F	AM		CG	CC	

GRAPHIC LITHOLOGY



VOID

DRILLING DISTURBANCE · SEDIMENTARY STRUCTURES · SAMPLES

Nannofossil diatomaceous mud

LITHOLOGIC DESCRIPTION

Rhythmically laminated couplets of alternating moderate olive brown (5Y 4/4) muddy diatom ooze and pale olive (10Y 6/2) diatom ooze. Strong H_2S odor.

At Section 1, 90 cm to Section 2, 16 cm and Section 3, 55–125 cm: zones of homogeneous **DIATOMACEOUS MUD** with nannofossils. Silty bioturbated, upper unit contact gradational.

Section 2, 75 cm: crenulation.

SMEAR SLIDE SUMMARY

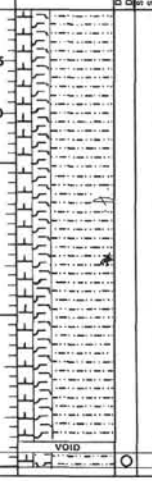
	1-120 (M)
TEXTURE:	
Sand	–
Silt	40
Clay	60
COMPOSITION:	
Quartz	2
Feldspar	4
Mica	2
Heavy minerals	1
Clay	55
Pyrite	1
Zeolite	1
Carbonate unspec.	2
Foraminifers	2
Calc. nannofossils	15
Diatoms	15
Sponge spicules	1
Fe-Mn opaques	1

CARBONATE BOMB: CC: 5%

SITE 480 HOLE CORE 4 CORED INTERVAL 14.25–19.00 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE	NN 20/21					1	0.5, 1.0
						2	
						3	
		M A/C	CM		AG	CC	

GRAPHIC LITHOLOGY



VOID

DRILLING DISTURBANCE · SEDIMENTARY STRUCTURES · SAMPLES

Diatomaceous mud
Silt

Diatomaceous mud

Diatomaceous mud
Silt

Nannofossil silty clay

LITHOLOGIC DESCRIPTION

Homogeneous, moderate olive brown (5Y 4/4) **DIATOM MUD,** with nannofossils, bioturbated, rather silty including **BENTHIC FORAMINIFERA.** Small pieces of shell scattered throughout the section. Some patchy mottles. There appears to be a subtle coarsening down the core but smear slides show little textural change. H_2S is strong with gas pimples common on the cut surfaces.

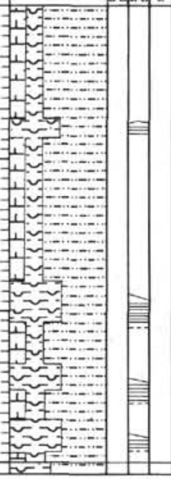
SMEAR SLIDE SUMMARY

	1-70 (D)	2-15 (M)	2-70 (D)	3-70 (D)
TEXTURE:				
Sand	1	–	–	–
Silt	44	55	60	50
Clay	55	45	40	55
COMPOSITION:				
Quartz	6	12	10	10
Feldspar	6	5	8	12
Mica	3	–	2	–
Heavy minerals	3	–	2	3
Clay	55	45	60	50
Pyrite	3	2	2	2
Carbonate unspec.	3	1	3	2
Calc. nannofossils	10	TR	TR	12
Diatoms	10	30	15	8
Radiolarians	1	TR	–	–
Sponge spicules	–	TR	–	–
Silicoflagellates	1	2	–	–
Plant debris	3	1	2	2
Opaques	–	2	–	–
Rock fragments	–	–	–	2

SITE 480 HOLE CORE 5 CORED INTERVAL 19.00–23.75 m

TIME – ROCK UNIT: LATE PLEISTOCENE
BIOSTRATIGRAPHIC ZONE
FOSSIL CHARACTER: FORAMINIFERS X; NANNOFOSSILS B; RADIOLARIANS; DIATOMS AG
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Unconformity (?)

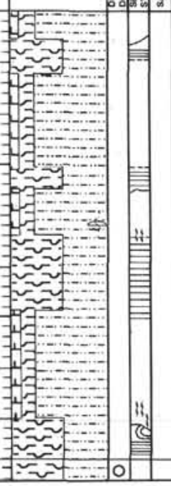
Zones of rhymically laminated couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE** alternating with zones of homogeneous, moderate olive brown (5Y 5/4) **DIATOM MUD.** Contacts partly diffuse to gradational. Homogeneous mottles common in laminated zones may be burrows. Strong H_2S odor. Scattered benthic *foraminifer-rich zones.*

CARBONATE BOMB: CC: 0%

SITE 480 HOLE CORE 6 CORED INTERVAL 23.75–28.50 m

TIME – ROCK UNIT: LATE PLEISTOCENE
BIOSTRATIGRAPHIC ZONE
FOSSIL CHARACTER: FORAMINIFERS X; NANNOFOSSILS B; RADIOLARIANS; DIATOMS AG
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Slump unconformity

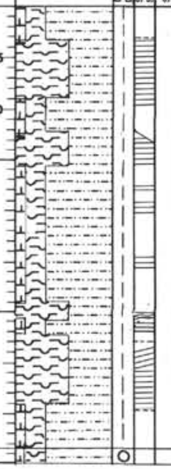
Rhythmically laminated mm-scale couplets of moderate olive brown (5Y 4/4) muddy diatom ooze and pale olive (10Y 6/2) diatom ooze. Varves alternating with zones of homogeneous moderate olive brown (5Y 4/4) diatom mud. Strong H_2S odor. Commonly laminated zones show disturbance in the form of clayey lumps which intersect the core liner.

CARBONATE BOMB: CC: 0%

SITE 480 HOLE CORE 7 CORED INTERVAL 28.50–33.25 m

TIME – ROCK UNIT: PLEISTOCENE / LATE PLEISTOCENE
BIOSTRATIGRAPHIC ZONE: ?
FOSSIL CHARACTER: FORAMINIFERS X; NANNOFOSSILS FP; RADIOLARIANS; DIATOMS CG
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Unconformity

Diatomaceous ooze
Varve

Rhythmically laminated couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE** alternate with zones of olive brown (5Y 4/4) **DIATOM MUD** in homogeneous sections. Strong H_2S odor. Laminated sections have some clayey homogeneous mottles indicative of disturbance. Sediment structures include a recumbent fold *at Section 1, 0–12 cm.*

Section 3, 93–98 cm: large fish bone.

SMEAR SLIDE SUMMARY

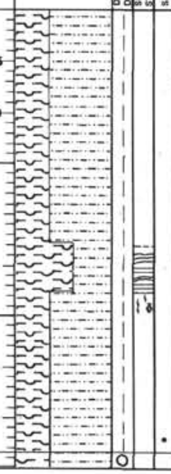
	3-54 (M)
TEXTURE:	
Sand	–
Silt	80
Clay	20
COMPOSITION:	
Quartz Feldspar	1
Opaques	TR
Clay	15
Pyrite	1
Carbonate unspec.	TR
Calc. nannofossils	TR
Diatoms	80
Radiolarians	TR
Silicoflagellates	2

CARBONATE BOMB: CC: 4%

SITE 480 HOLE CORE 8 CORED INTERVAL 33.25–38.00 m

TIME – ROCK UNIT: LATE PLEISTOCENE
BIOSTRATIGRAPHIC ZONE
FOSSIL CHARACTER: FORAMINIFERS X; NANNOFOSSILS B; RADIOLARIANS; DIATOMS AG
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Disturbed varves
Undisturbed varves
Disturbed varves
Large burrow
Muddy diatomaceous ooze

Moderate olive brown (5Y 4/4) grading to olive gray (5Y 3/2) **MUDDY DIATOM OOZE TO DIATOM MUD** with small zone of moderate olive brown (5Y 4/4) muddy diatom ooze and pale olive (10Y 6/2) diatom ooze rhythmic couplets, some of which appear disturbed. Homogeneous sections show evidence of large (2–3 cm) burrows indicating bioturbation at lower contact to laminated zone. Strong H_2S odor.

SMEAR SLIDE SUMMARY

	3-120 (D)
TEXTURE:	
Sand	–
Silt	50
Clay	50
COMPOSITION:	
Quartz	8- 9
Feldspar	2
Opaques	1
Clay	45
Pyrite	1- 2
Carbonate unspec.	1
Calc. nannofossils	TR
Diatoms	35
Silicoflagellates	1- 2
Plant debris	TR

CARBONATE BOMB: CC: 0%

SITE 480 HOLE CORE 9 CORED INTERVAL 38.00–42.75 m

TIME-ROCK UNIT: LATE PLEISTOCENE — PLEISTOCENE

FOSSIL CHARACTER: Foraminifers VP X/R; Nannofossils RP; Diatoms AG

Sections: 1, 2, 3, CC

Fish remains

LITHOLOGIC DESCRIPTION

Homogeneous light olive gray (5Y 5/2) **DIATOM MUD**, and bioturbated. Scattered fish vertebrae (e.g. Section 1, 84 and 109 cm and Section 3, 50 cm). Strong H_2S odor.

Section 2, 0–5 cm: trace of a zone of rhythmic couplets.

Small piece of silstone with rhyolitic ash at Section 1, 108 cm.

SMEAR SLIDE SUMMARY

	1-108 (M)
COMPOSITION:	
Opaques	1
Clay	35-40
Pyrite	TR
Diatoms	8
Fish remains	50

CARBONATE BOMB: CC: 10%

SITE 480 HOLE CORE 10 CORED INTERVAL 42.75–47.50 m

TIME-ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: NN 20/21

FOSSIL CHARACTER: Nannofossils CM; Diatoms AG

Sections: 1, 2, 3, CC

Unconformity

Unconformity

LITHOLOGIC DESCRIPTION

Section 1, 0–60 cm: homogeneous, moderate olive brown (5Y 4/4) to light olive gray (5Y 3/2) **DIATOM MUD** with some darker mottles which have organic (black) spots.

Below Section 1, 60 cm: Rhythmically laminated moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE** couplets. Unconformities in the laminae are observed. Laminations are faint near the top of the section, becoming more distinctive with depth.

Strong H_2S odor.

SITE 480 HOLE CORE 11 CORED INTERVAL 47.50–52.25 m

TIME-ROCK UNIT: LATE PLEISTOCENE

FOSSIL CHARACTER: Foraminifers M F/C; Nannofossils B; Diatoms AG

Sections: 1, CC

5Y 3/2
Diatomaceous clayey silt
5Y 4/4

LITHOLOGIC DESCRIPTION

Section 1, 0–70 cm: disturbed top section of olive gray (5Y 3/2) **DIATOM MUD** and moderate olive brown (5Y 4/4) muddy diatom ooze.

At 70 cm abrupt change to faint rhythmically laminated **MUDDY DIATOM OOZE.** Laminations become distinctive to the bottom of the core. Strong H_2S odor. Considerable gas rupturing and fracturing.

SMEAR SLIDE SUMMARY

	1-15 (M)
TEXTURE:	
Sand	–
Silt	55
Clay	45
COMPOSITION:	
Quartz	12
Feldspar	2
Opaques	2
Clay	45
Pyrite	3
Carbonate unspec.	TR
Diatoms	33
Radiolarians	TR
Sponge spicules	TR
Silicoflagellates	2
Plant debris	2
Rock fragments	1

CARBONATE BOMB: CC: 5%

SITE 480 HOLE CORE 12 CORED INTERVAL 52.25–57.00 m

TIME-ROCK UNIT: PLEISTOCENE

FOSSIL CHARACTER: Foraminifers RP, VP X/F; Diatoms ?

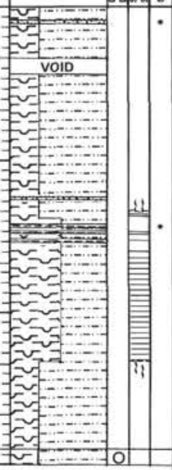
Sections: CC

LITHOLOGIC DESCRIPTION

Core-Catcher samply only. Encountered gray sand, washed to 61.75 m.

SITE 480 HOLE CORE 13 CORED INTERVAL 61.75–66.50 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
PLEISTOCENE	?					1	0.5, 1.0
LATE PLEISTOCENE						2	
						3	
		M R/A	RP		AG	CC	



CF

N6-N7 Diatomaceous clay

LITHOLOGIC DESCRIPTION

Section 1 to Section 2, 50 cm: light olive gray (5Y 5/2) diatom mud with medium light gray (N6) sand blebs and stringers grades into grayish olive (10Y 4/2) to moderate olive brown (5Y 4/4) diatom mud with possible evidence of bioturbation seen as pale olive (10Y 6/2) burrows. Medium sands, sorted, may be small turbidites but grading is subtle.

At Section 2, 50 cm: begin rhythmic couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZES.** Contact; burrowed transitional. Some light to medium light gray (N6–N7) silt layers are observed in the top of the laminated zone with mm-scale basal sands associated with each. These may be small turbidites or current deposits. Occasional clay lump disturbance. Rhythmites grade back to homogeneous (bioturbated) gray olive (10Y 4/2) diatom mud at the bottom of core (Section 3, 45 cm).

Strong H_2S odor.

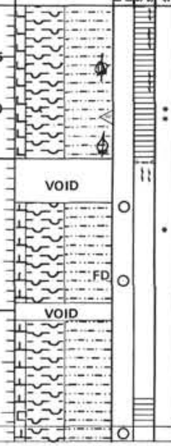
SMEAR SLIDE SUMMARY

	2-66 (M)
TEXTURE:	
Sand	–
Silt	40
Clay	60
COMPOSITION:	
Quartz	15
Feldspar	3
Opaques	2- 3
Clay	60
Volcanic glass	TR
Pyrite	2
Carbonate unspec.	3
Calc. nannofossils	TR
Diatoms	15
Radiolarians	TR
Silicoflagellates	TR

CARBONATE BOMB: CC: 1%

SITE 480 HOLE CORE 14 CORED INTERVAL 66.50–71.25 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE	NN 20/21					1	0.5, 1.0
						2	
						3	
		VP X/R	AM		AG	CC	



Muddy diatomaceous ooze with volcanic glass

Diatomaceous mud

LITHOLOGIC DESCRIPTION

Section 1 to Section 2, 10 cm: laminated couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE** with some clayey homogeneous mottles (disturbance). Wood chips common. Some diatom ooze couplets are mm-scale, most sub-mm.

At Section 2, 10 cm: grades to grayish olive (10Y 4/2) homogeneous (bioturbated?) **DIATOM MUD**, nannofossil-bearing.

At Section 1, 110 cm: dark fine-grained fragmental layer with some minor vitric ash. R. I. >1.52 and grains containing tiny opaques.

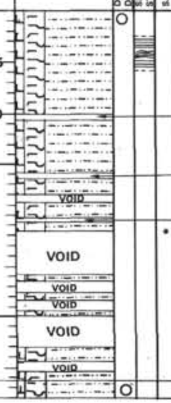
Strong H_2S odor.

SMEAR SLIDE SUMMARY

	1-100 (D)	1-110 (M)	2-70 (D)
TEXTURE:			
Sand	–	2- 3	–
Silt	40	62	50
Clay	60	35	50
COMPOSITION:			
Quartz	2- 3	3	4
Feldspar		1	1
Opaques	1	3	1
Clay	50	28	45
Volcanic glass	–	20	–
Pyrite	1- 2	TR	2
Carbonate unspec.	3	2	4- 5
Foraminifers	TR	1	TR
Calc. nannofossils	10	7- 8	12
Diatoms	35	35	35
Silicoflagellates	–	TR	–
Plant debris	–	–	TR

SITE 480 HOLE CORE 15 CORED INTERVAL 71.25–76.00 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE						1	0.5, 1.0
						2	
						3	
					AG	CC	



Unconformity

VOID

VOID

VOID

Diatomaceous clay Silt

LITHOLOGIC DESCRIPTION

Homogeneous grayish olive (10Y 4/2) to moderate olive brown (5Y 4/4) **DIATOM MUD.** Strong H_2S odor, gas separations. Faint mottles. Seems bioturbated.

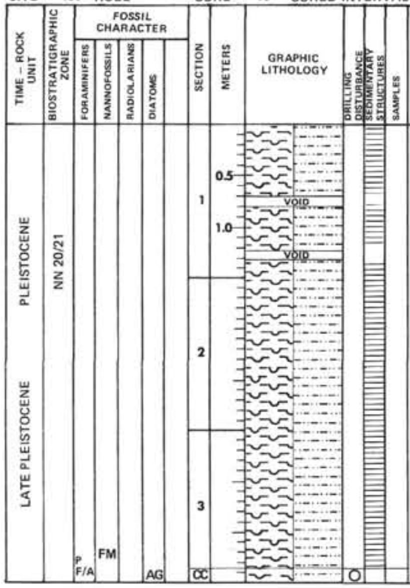
From Section 1, 43–50 cm: thin zone of rhythmically laminated, faint couplets moderate olive brown (5Y 4/4) of **MUDDY DIATOM OOZE.** Shows angular discordance at 45 cm. Lower package tilted.

Section 1, 147 cm: small rounded exotic pebble.

SMEAR SLIDE SUMMARY

	2-65 (D)
TEXTURE:	
Sand	–
Silt	50
Clay	50
COMPOSITION:	
Quartz	8
Feldspar	2- 3
Opaques	TR
Clay	45
Pyrite	2
Carbonate unspec.	3- 4
Foraminifers	1
Calc. nannofossils	9-10
Diatoms	30
Plant debris	TR
Rock fragments	1

SITE 480 HOLE CORE 16 CORED INTERVAL 76.00–80.75 m



LITHOLOGIC DESCRIPTION

Rhythmically laminated, moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** with pale olive (10Y 6/2) **DIATOMACEOUS OOZE** couplets. Some laminations folded. Strong H_2S odor.

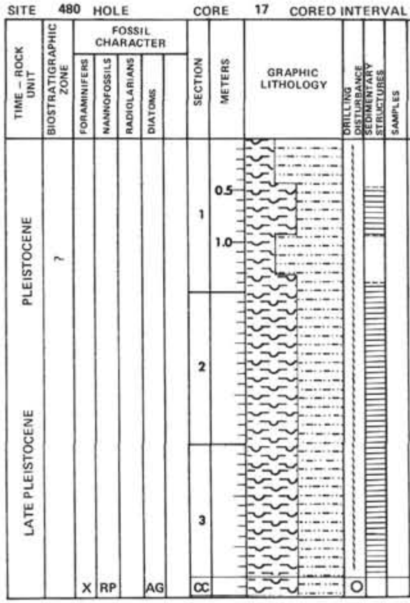
Several large irregular patches of mottled homogeneous muds (e.g., Section 1, 30 cm and Section 2, 30 cm). Cross-cut laminations (burrows?).

At Section 3, 50 cm: some very thick pale olive diatom ooze laminae.

In Section 3: fish scales prominent, scattered on surface and along partings. Scattered phosphate (e. g., Section 3, 35 cm).

At Section 3, 85 cm: on thin, pure nannofossil lamina.

SITE 480 HOLE CORE 17 CORED INTERVAL 80.75–85.50 m

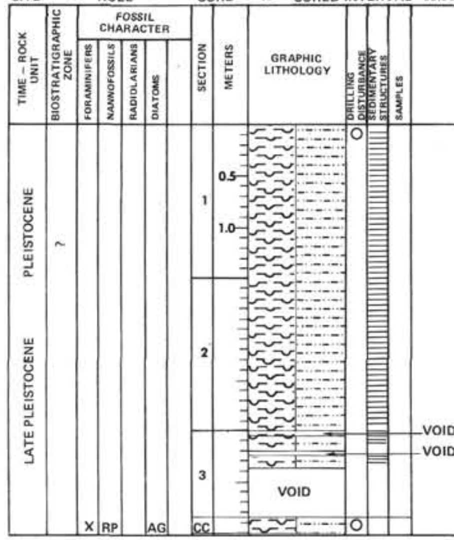


LITHOLOGIC DESCRIPTION

Very disturbed core mostly laminated, moderate olive brown (5Y 4/4) to grayish olive (10Y 4/2) **DIATOM OOZE AND MUDDY DIATOM OOZE.** Mixture of homogeneous and laminated zones with structures obliterated. Strong H_2S odor.

CARBONATE BOMB: CC: 0%

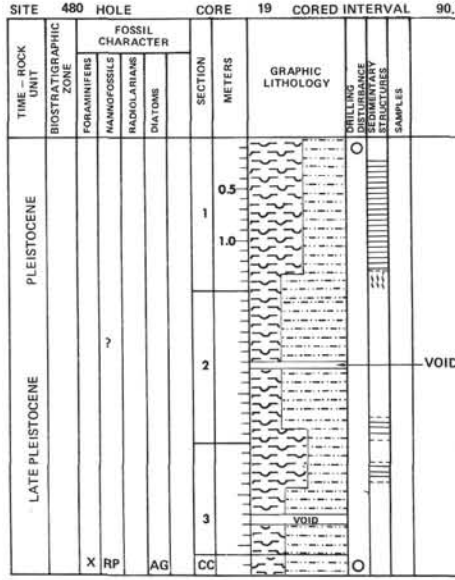
SITE 480 HOLE CORE 18 CORED INTERVAL 85.50–90.25 m



LITHOLOGIC DESCRIPTION

Rhythmically laminated moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** and pale olive (10Y 6/2) **DIATOMACEOUS OOZE** couplets with well-defined laminae. Several zones of thick diatom ooze layers suggest high productivity (Section 1, 90, 110, and 130 cm and Section 2, 7, 12, 27, 33, and 45 cm). These laminae have a more yellowish color (5Y 7/6). Strong H_2S odor.

SITE 480 HOLE CORE 19 CORED INTERVAL 90.25–95.00 m



LITHOLOGIC DESCRIPTION

Zones of rhythmically laminated couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE** alternate with zones of homogeneous, bioturbated grayish olive (10Y 4/2) to moderate olive brown (5Y 4/4) **DIATOM MUDS.** Light member (diatom-rich) grades in intensity suggesting higher and lower productivity or differences in terrigenous input on a small scale. Zones with numerous thicker pale olive laminae around Section 1, 100 cm; contacts between laminated and homogeneous commonly gradational. Some bioturbation? occurs in the gradational contact with the varves. Strong H_2S odor.

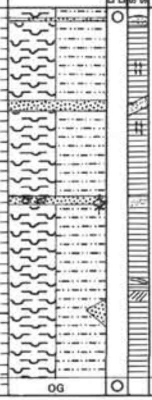
At Section 2, 125–130 cm: rhythmites are fainter.

CARBONATE BOMB: CC: 0%

SITE 480 HOLE CORE 20 CORED INTERVAL 45.00–99.75 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE		B				1	0.5, 1.0
						2	
						3	
		VP X/R			CG	CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



CF

Unconformity
En echelon laminae
(cross-bedding?)

LITHOLOGIC DESCRIPTION

Rhythmically laminated moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE** couplets.
At Section 1, 9–11 cm and 90–99 cm; and Section 2, 38–40 cm and 143 cm: medium gray (N5) well-sorted sand beds ungraded with sharp contacts. Laminations unconformably to the sand layers.

At Section 1, 90–100 cm **SAND** has scattered wood chips.

At Section 2, 120–130 cm: unconformities and apparent cross-bedding are observed within laminated zones.

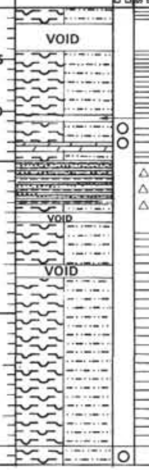
Strong H_2S odor.

CF 1-95: gray sand; angular to subangular components. Very feldspathic. Well-sorted, grains slightly weathered. Feldspars, mostly plagioclase (60%), angular quartz (25%), gray siltstone rock fragments (15%), fine-grained white (3%), biotite (2%), green hornblende (3%). No calcareous or fossil debris.

SITE 480 HOLE CORE 21 CORED INTERVAL 99.75–104.50 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE	NN 20/21					1	0.5, 1.0
						2	
						3	
		M A/A	AM		CG	CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



VOID

Dolomitic
claystone
5B 5/1
Quartz silt
10Y 6/2
Diatomaceous
mud

LITHOLOGIC DESCRIPTION

Interlayering of several lithologies:
1. Zones of rhythmically laminated couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOMACEOUS OOZE** and pale olive (10Y 6/2) diatom ooze, mm- to sub-mm-scale. Strong H_2S odor.

2. Several thicker laminae to cm-beds of greenish gray (5G 6/4) to medium bluish gray (5B 5/1) **SILTY CLAYS TO SANDY SILT**, in Section 1, at 41, 90, and 145–150 cm. In Section 2, they occur as a sequence of 17 rhythmic cm-thick beds from Section 2, 5–50 cm with 3 more from Section 2, 117–124 cm: these are clearly graded **TURBIDITES** with a well-sorted, thin sandy base. Some are separated by a few thin diatomaceous laminae. Upper and lower contacts are sharp. Immediately below the turbidite sequence is a gradational change downward (Section 2, 65–104 cm) from homogeneous to laminated oozes. Laminations below turbidite unit are fainter than above.

3. At Section 1, 130–142 cm: a grayish-yellow (5Y 8/4) lithified, **DOLOMITIC MUDSTONE** is intercalated into homogeneous diatomaceous muds, with some faint layering. This dolomitic bed is homogeneous with some faint burrow mottling. Along the lower contact is a 3–4 cm layer of bluish gray (5B 5/4) silty sand.

SMEAR SLIDE SUMMARY

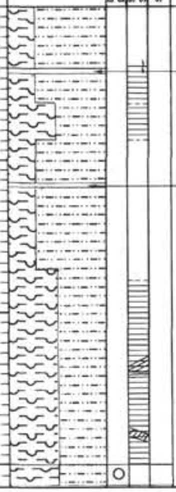
	1-136 (M)	2-15 (M)	2-18 (M)
TEXTURE:			
Sand	–	–	–
Silt	50	50	55
Clay	50	50	45
COMPOSITION:			
Quartz	–	4	5- 6
Feldspar	–	15	1
Opaques	–	3	1
Clay	40	70	40
Pyrite	1	2- 3	2
Carbonate unspec.	45	–	–
Calc. nannofossils	TR	–	–
Diatoms	5	8-10	50
Silicoflagellates	–	–	2- 3
Plant debris	–	4	TR

CARBONATE BOMB: CC: 10%

SITE 480 HOLE CORE 22 CORED INTERVAL 104.50–109.25 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE			B		AG	1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Interlayering of:

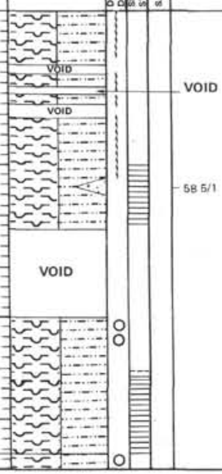
1. Two zones of homogeneous moderate olive brown (5Y 4/4) **DIATOM MUD** Section 1, 2–89 cm and Section 1, 120 cm to Section 2, 100 cm. Top 30 cm may be drill disturbed.

2. Two zones of rhythmically laminated couplets of sub-mm-scale moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE.** Contacts are transitional. The lower zone shows a downward increase in the frequency and number of thick pale olive laminae. There is a secondary cyclic development on a 5–10 cm scale. At Section 3, 50 cm laminated oozes are discordant, cutting off about 10 couplets. At Section 3, 78 cm: disrupted lamination, partially folded. At Section 3, 116 cm a minor 3-laminae recumbent sharp fold. Strong H_2S odor.

SITE 480 HOLE CORE 23 CORED INTERVAL 109.25–114.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE		X	B		AG	1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Intensely then moderately disturbed moderate olive brown (5Y 4/4) **DIATOM MUD** with minor medium gray (N5) sand blebs. Laminations rare in Sections 1 and 2.

At Section 3, 50 cm grades into undisturbed rhythmically laminated couplets (moderate olive brown [5Y 4/4] **MUDDY DIATOM OOZE** and pale olive [10Y 6/2] **DIATOM OOZE**).

At Section 2, 33–37 cm: a medium bluish gray (5B 5/1) 3–4 cm layer of quartz silt.

Strong H_2S odor.

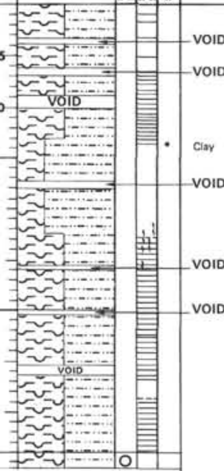
CARBONATE BOMB: CC: 0%

Note: Site 480, Core 24, 114.0–118.75 m: No Recovery.

SITE 480 HOLE CORE 25 CORED INTERVAL 118.75–123.50 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
PLEISTOCENE / LATE PLEISTOCENE	?	X	RM		AG	1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

1. Section 1, 0–75 cm and Section 1, 128 cm to Section 2, 97 cm: homogeneous, moderate olive brown (5Y 4/4) **DIATOM MUD.** Scattered tuffs of pale olive. Large paler homogeneous mottles form burrowing. In Section 2, transition to laminated is across a burrowed zone (Section 2, 70–97 cm) – showing relic and deformed bits of rhythmite. Upper contact of homogeneous zone is sharp. Sediment rather dry and crumbly with gas ruptures.

2. Section 1, 75–125 cm and Section 2, 95 cm to bottom: rhythmically laminated couplets of **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE.** Light and dark of similar thickness. Some intercalated homogeneous zones on a cm-scale. From Section 2, 95-140 cm: irregular, patchy homogeneous mottles (large burrows?) intersect laminae without deformation. Strong H_2S odor.

Fish debris is common at Section 1, 48–50 cm; Section 2, 49 and 110 cm; Section 3, 42, 99, and 122 cm.

SMEAR SLIDE SUMMARY

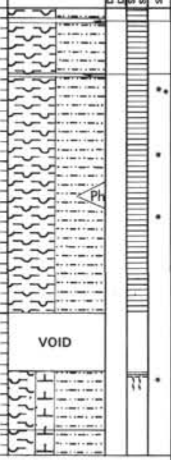
	1-135 (M)
TEXTURE:	
Sand	–
Silt	20
Clay	80
COMPOSITION:	
Quartz	8
Feldspar	1- 2
Opaques	1
Clay	80
Pyrite	2
Carbonate unspec.	1
Diatoms	5
Silicoflagellates	1

CARBONATE BOMB: CC: 0%

SITE 480 HOLE CORE 26 CORED INTERVAL 123.50–128.25 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
PLEISTOCENE	?					1	0.5, 1.0
						2	
LATE PLEISTOCENE	*Nitzschia fossilis*					3	
		P X/A	CM		AG	CC	

GRAPHIC LITHOLOGY; DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES



VOID

VOID
Light diatomaceous ooze
Dark

10YR 6/6
Grayish orange clay

Muddy diatomaceous ooze (redeposition, shallow benthic diatoms)

LITHOLOGIC DESCRIPTION

Sections 1 and 2: uniform, undisturbed sequence of rhymically laminated couplets of pale olive (10Y 6/2) and moderate olive brown (5Y 4/4) **DIATOM OOZE, AND MUDDY DIATOM OOZE.** Couplets very fine ranging from 0.2 mm/pair to 0.5 mm/pair. Thicker mattered "paper"-like diatom layers common: second order cycles on decimeter-scale. Diatom-rich layers are distinctive and relatively thick indications. Higher productivity and/or low terrigenous input. Light layers commonly fragile frustules. Section 3 and Core-Catcher: contact from laminated down to homogeneous sharp. Transitional zone Section 3, 50–60 cm to burrowed homogeneous with zones showing concentrations of phosphatic material and with fish scales.

At Section 2, 52 cm: grayish orange (10YR 6/6) phosphate, nodule, 2 cm, flattened lozenge. Isotropic fine anhedral phosphate.

Strong H_2S odor.

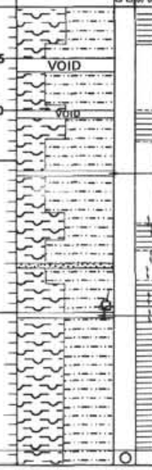
SMEAR SLIDE SUMMARY

	1-83.4 (D) (light)	1-83.6 (D) (dark)	1-137 (M)	2-53 (M)	3-63 (D)
TEXTURE:					
Sand	–	–	–	–	–
Silt	70	45	35	15	55
Clay	30	55	65	85	45
COMPOSITION:					
Quartz	1	4	1- 2	2	2
Feldspar	1	1			1
Mica	1	–	–	–	TR
Opaques	TR	1	–	TR	TR
Clay	25	60	–	–	40
Pyrite	< 1	TR	1	1	1
Carbonate unspec.	–	1- 2	–	–	3
Foraminifers	–	TR	–	–	2
Calc. nannofossils	–	TR	–	–	8- 9
Diatoms	70	40	45	10	40
Radiolarians	–	TR	–	–	TR
Sponge spicules	–	1	–	–	–
Silicoflagellates	1	–	TR	TR	–
Plant debris	–	TR	–	–	–
Rock fragments	–	–	–	–	1
Isotropic phosphate	–	–	53	85	1

SITE 480 HOLE CORE 27 CORED INTERVAL 128.25–123.00 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LATE PLEISTOCENE	*Nitzschia fossilis* (D)					1	0.5, 1.0
			B			2	
		B				3	
		X			AG	CC	

GRAPHIC LITHOLOGY; DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; SAMPLES



VOID

N5

VOID

LITHOLOGIC DESCRIPTION

1. Rhythmically laminated moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE.** Sharp and gradational contacts between laminated zones.

2. Moderate olive brown (5Y 4/4) homogeneous **DIATOM MUD.** In transitional zones, downward from homogeneous to laminated, evidence of burrowing by large animals as dark, homogeneous mottles or splotches which cut laminations or with relic laminated patches.

At Section 2, 50–70 cm: 12 couplets/cm.

13 couplets/cm in Section 3. General downward increasing frequency of thick pale olive laminae.

At Section 2, 105 cm: sub-cm lenses of gray sand and at Section 2, 145 cm scattered bits of wood.

Strong H_2S odor.

CARBONATE BOMB: CC: 0%

SITE 480 HOLE CORE 28 CORED INTERVAL 133.00–137.75 m

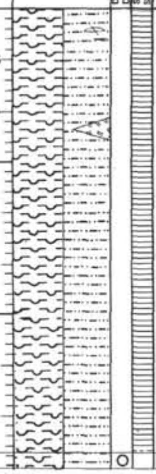
TIME – ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: *Nitzschia fossilis* (D)

FOSSIL CHARACTER: FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS: AG (CC)

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

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



Pumice

Diatomaceous ooze

LITHOLOGIC DESCRIPTION

Moderate olive brown (5Y 4/4) muddy diatom ooze and pale olive (10Y 6/2) diatom ooe in varved section. Wood chips are observed with some pumice ash. Varve couples average 16/cm. Beginning of transition to homogeneous (bioturbated?) zone at the bottom of core. Strong H_2S odor.

Uniform, rhythmically laminated couplets of moderate olive brown (5Y 4/4) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) **DIATOM OOZE.** Laminations regular, but have a second order cycle of more and fewer thicker pale olive laminae occuring on a 5-cm-scale. In Section 3, decrease in number of pale olive. Counts of 19, 14, 12–15, and 12 couplets/cm.

At Section 1, 115 cm: several pumice pebbles imbedded as exotics. Friable, rounded and hard.

At Section 1, 26 cm: reddish brown wood fragments.

At Section 1, 140–141 cm: several thin white laminae of pure nannofossil ooze, almost monospecific.

At Section 3, 126–136 cm: transitional changes to homogeneous.

SMEAR SLIDE SUMMARY

	1-115 (M)	1-115 (M)
TEXTURE:		
Sand	–	–
Silt	70	90
Clay	30	10
COMPOSITION:		
Quartz Feldspar	1- 2	1
Opaques	TR	–
Clay	25	10
Volcanic glass	–	75
Pyrite	TR	2
Diatoms	72	9-10
Radiolarians	TR	TR
Silicoflagellates	1	2
Plant debris	TR	–

SITE 480 HOLE CORE 29 CORED INTERVAL 137.75–142.50 m

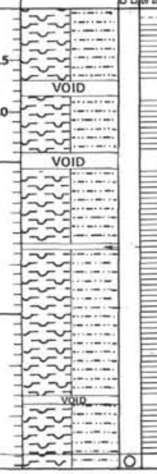
TIME – ROCK UNIT: LATE PLEISTOCENE

BIOSTRATIGRAPHIC ZONE: *Nitzschia fossilis* (D)

FOSSIL CHARACTER: FORAMINIFERS: B, X (CC) | NANNOFOSSILS | RADIOLARIANS | DIATOMS: AG (CC)

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

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



VOID

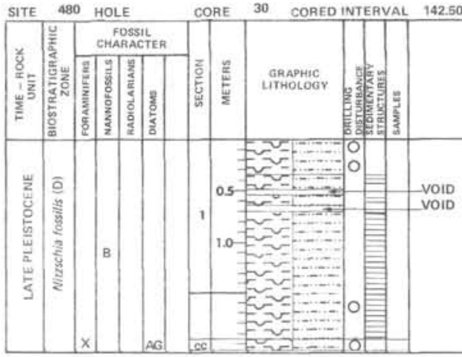
LITHOLOGIC DESCRIPTION

Complete core comprises undisturbed regular rhythmic laminations of moderate olive brown **MUDDY DIATOMACEOUS OOZE** and pale olive (10Y 6/2) to dusky yellow brown (5Y 6/4) **DIATOM OOZE** couplets. Some sections extremely finely laminated. Near base of Section 3, numerous very prominent thick diatom ooze-rich pale layers. Several secondary cycles of light to dark on a 10-cm-scale. Strong H_2S odor.

At Section 3, 57 cm: 3 disturbed laminae.

CARBONATE BOMB: CC: 1%

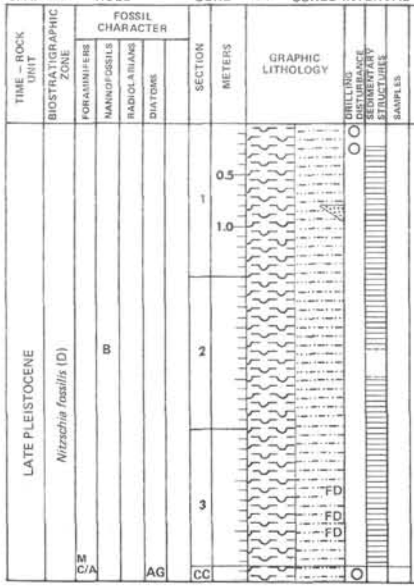
SITE 480 HOLE CORE 30 CORED INTERVAL 142.50–147.25 m



LITHOLOGIC DESCRIPTION

Finely laminated, moderate olive brown (5Y 4/4) to grayish olive (10Y 4/2) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) to moderate yellow (5Y 7/8) diatom ooze couplets. Thin pale olive laminae less prominent than previous cores giving general darker cast. Couplets, thinner on a sub-mm-scale. Evidence of minor bioturbation at Section 2, 22 cm. Strong H_2S odor.

SITE 480 HOLE CORE 31 CORED INTERVAL 147.25–152.00 m



LITHOLOGIC DESCRIPTION

Rhythmically laminated moderate olive brown (5Y 4/4) to gray olive (10Y 4/2) **MUDDY DIATOM OOZE** and pale olive (10Y 6/2) to moderate yellow (5Y 7/8) **DIATOM OOZE** couplets. Fade in intensity in some zones parallel with decrease in diatom abundance.

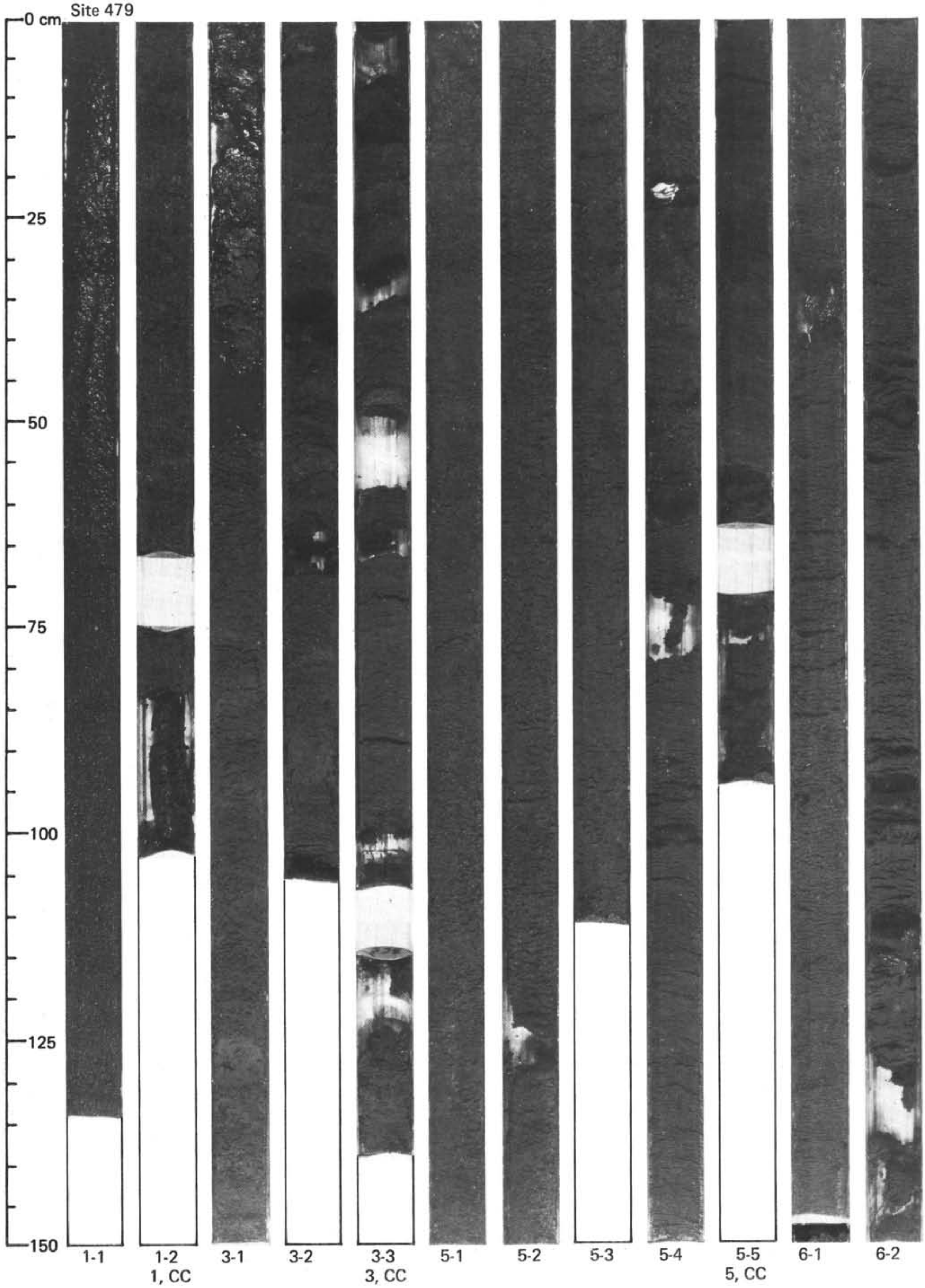
At Section 2, 65–90 cm: small section of grayish olive (10Y 4/2) homogeneous (bioturbated?) **DIATOM MUD** with gradational contact to laminated zones. Strong H_2S odor.

Section 1, 86–101 cm: finger-like, oblique homogeneous sandy intrusion in rhythmites. Upper part homogeneous mud. May be drill disturbance or burrow track.

Section 3: several scattered occurrences of fish/crab debris. One large crunchy pod at Section 3, 84.5 cm.

Section 3, 62 cm: angular discordance in rhythmites. General 10–20 cm secondary cycle of lighter to darker zones.

CARBONATE BOMB: CC: 0%


Site 479
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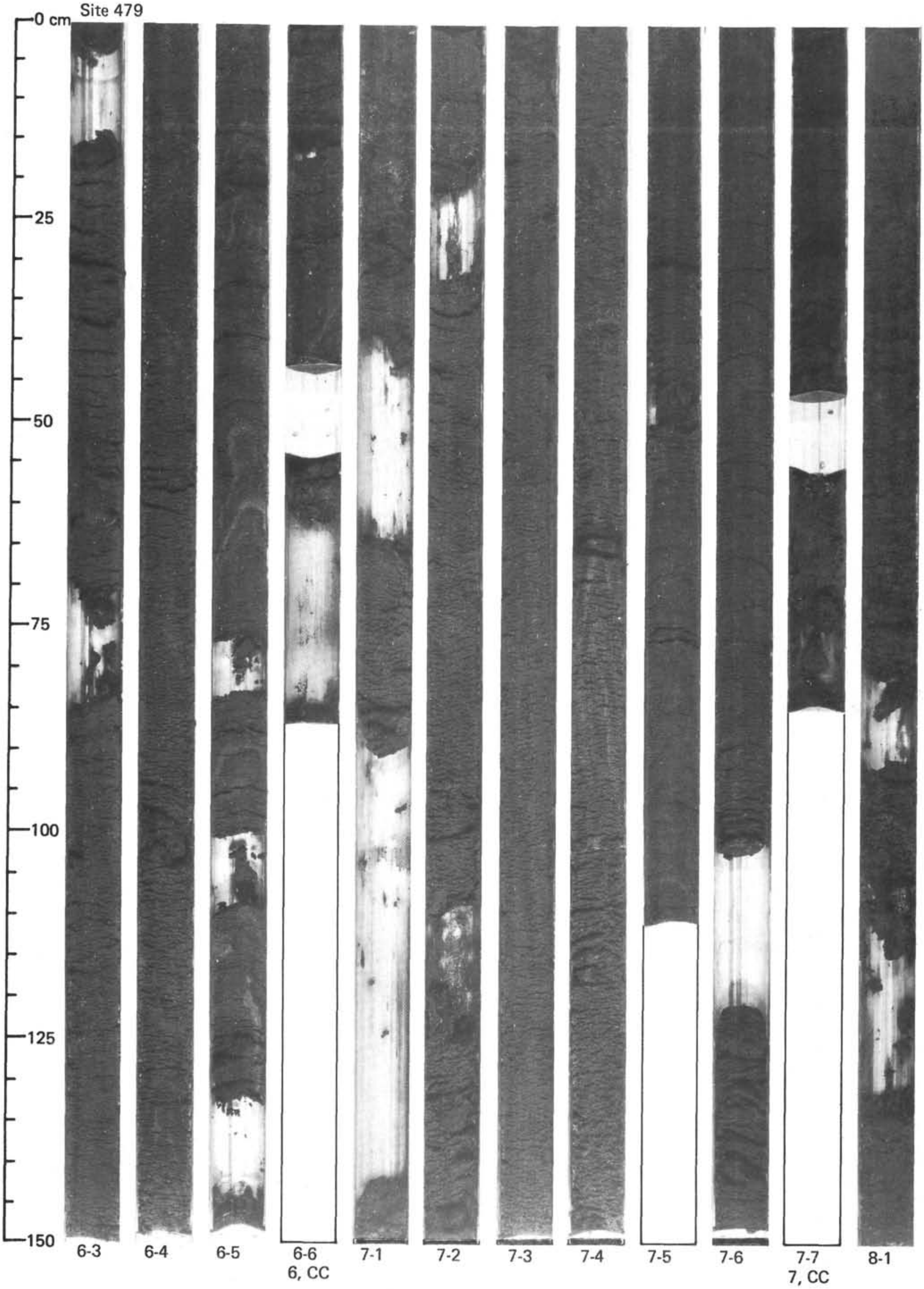
5, CC
6-1
6-2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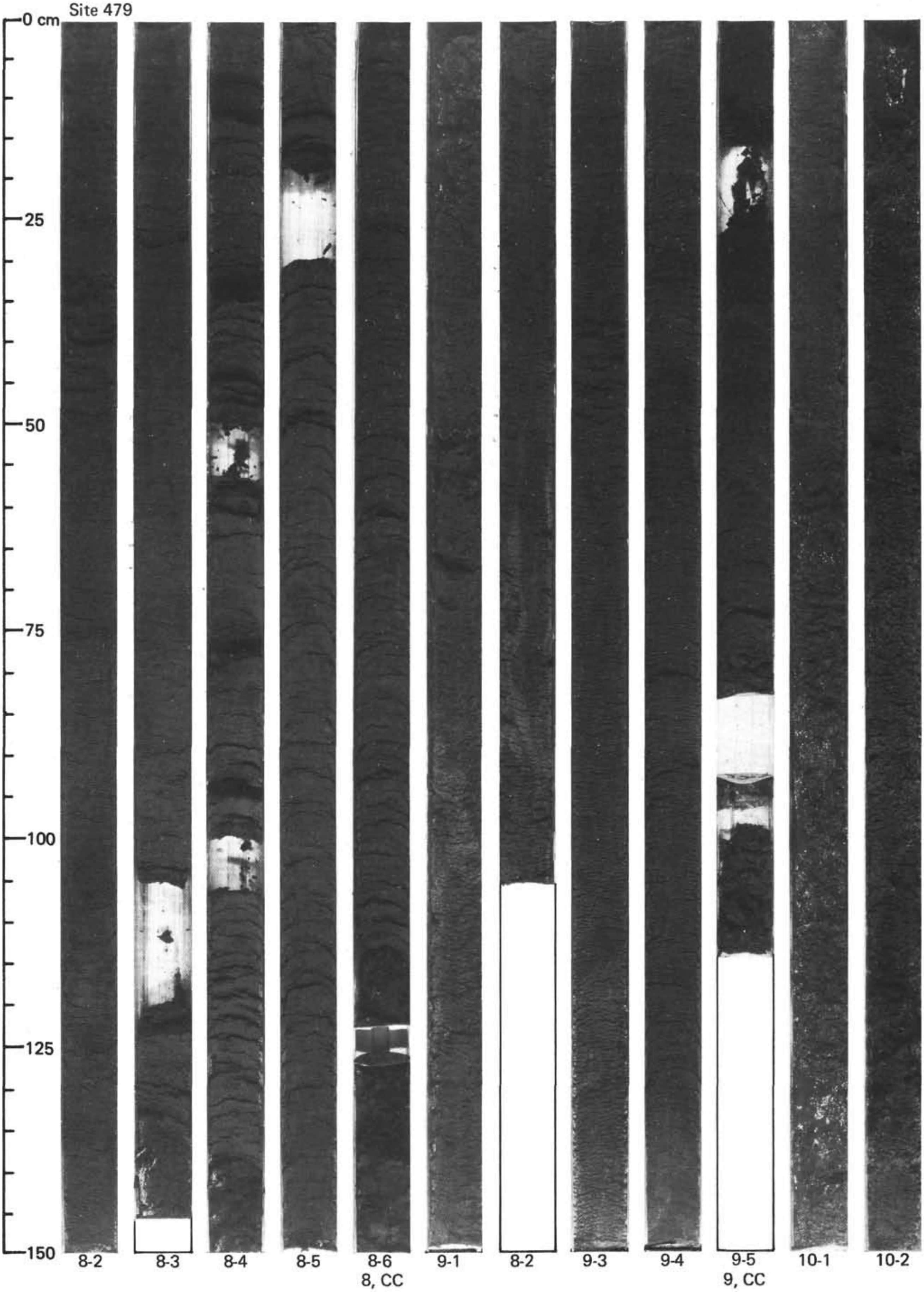
7, CC
8-1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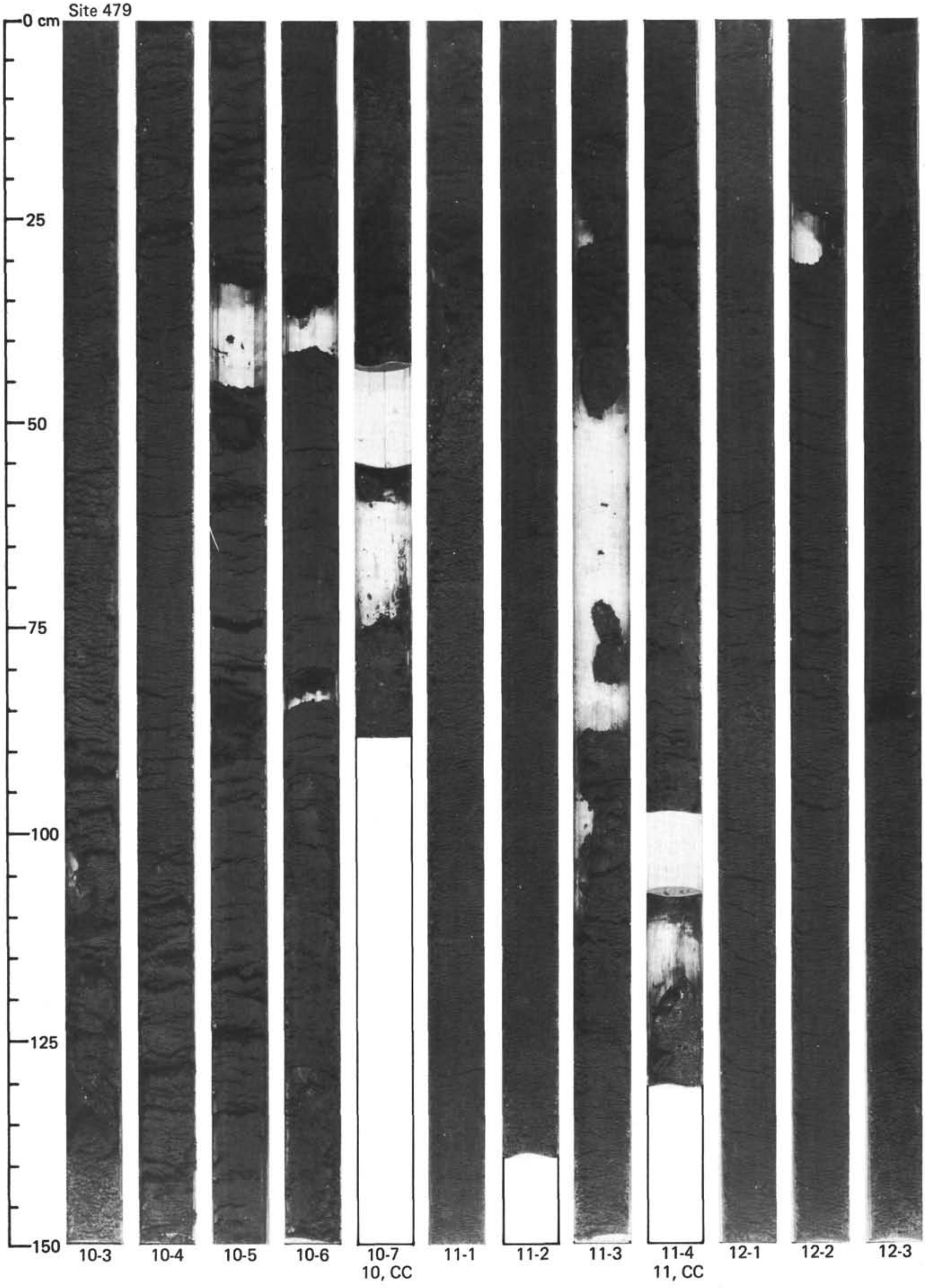
9, CC
10-1
10-2



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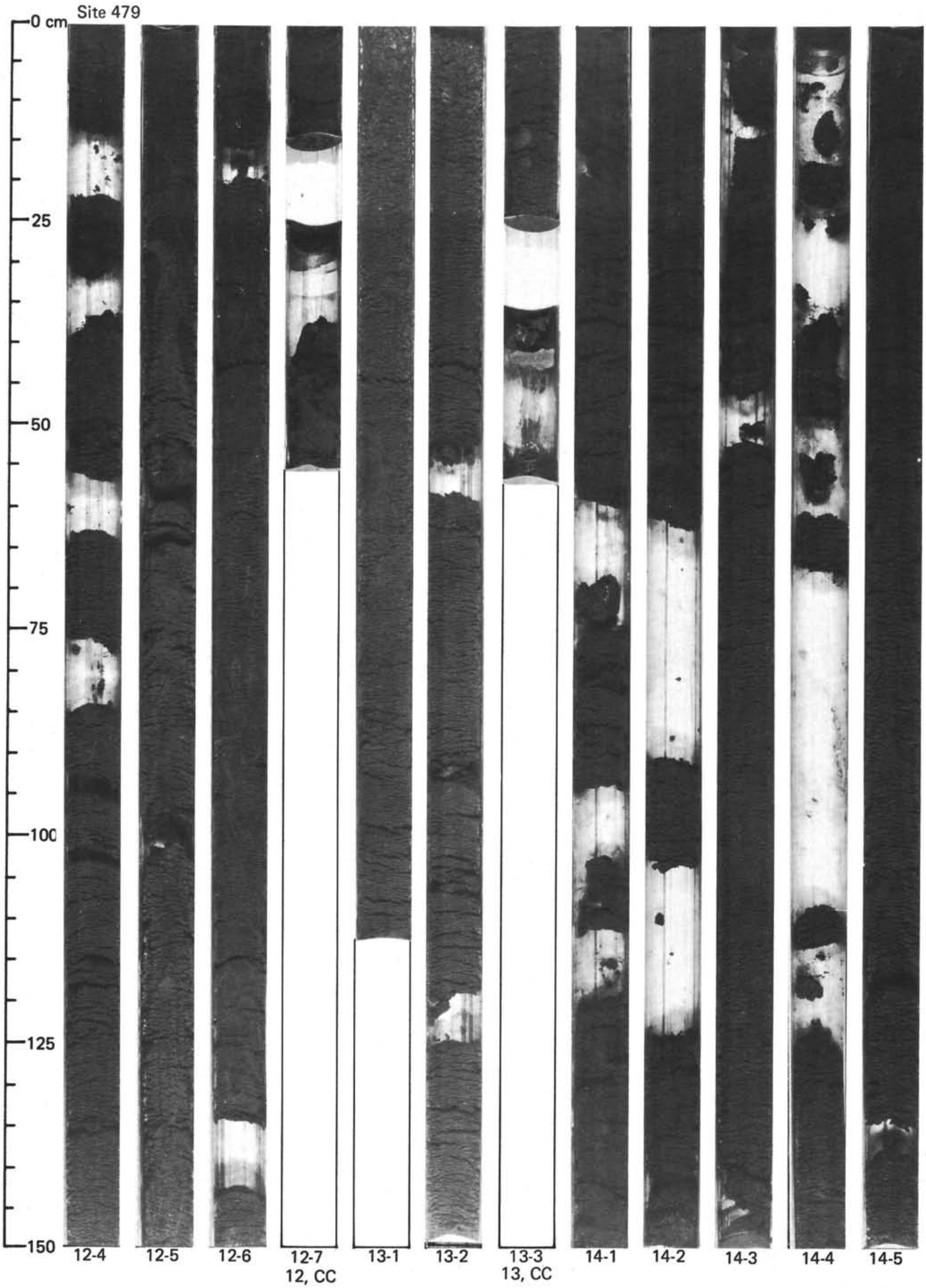
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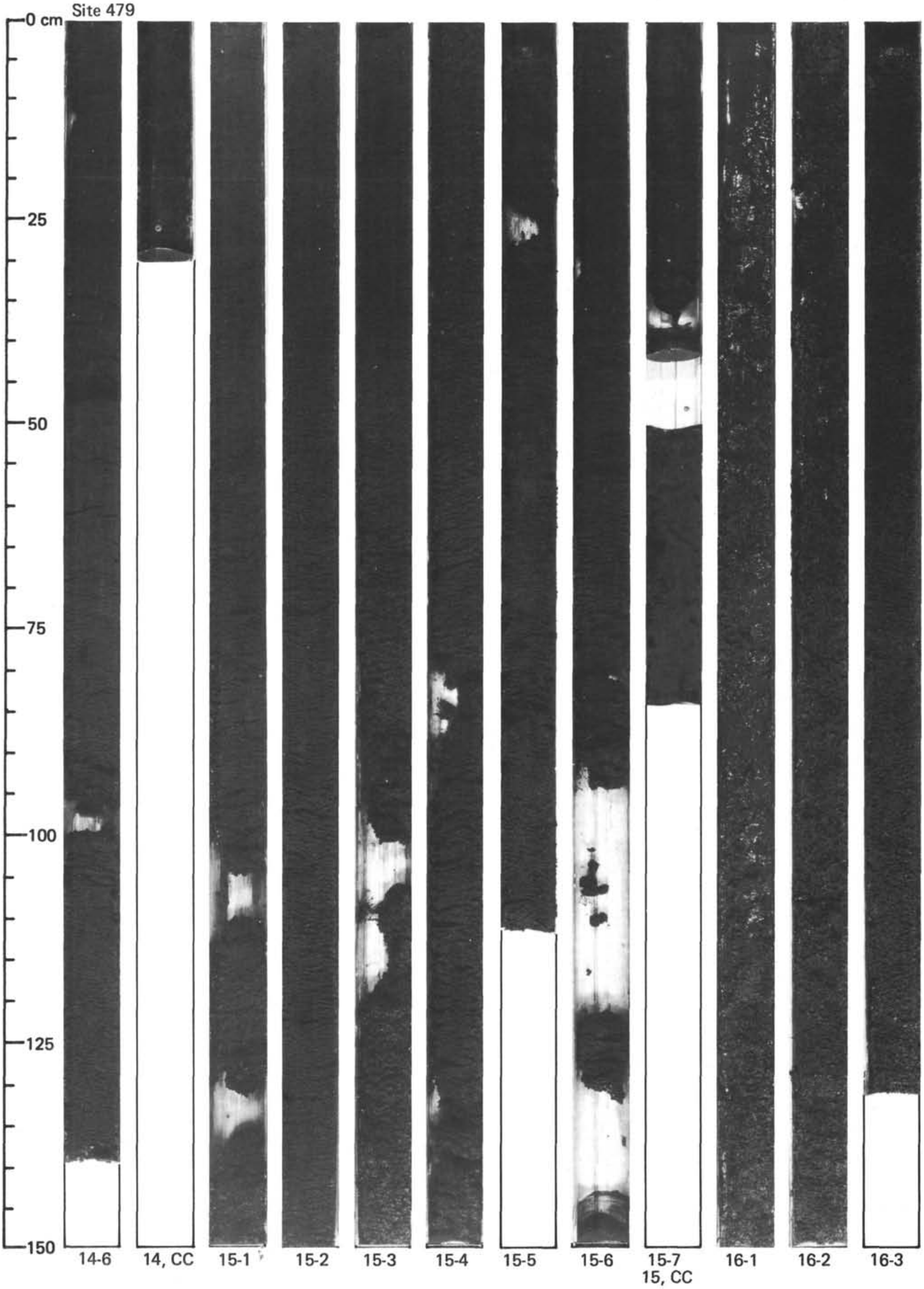
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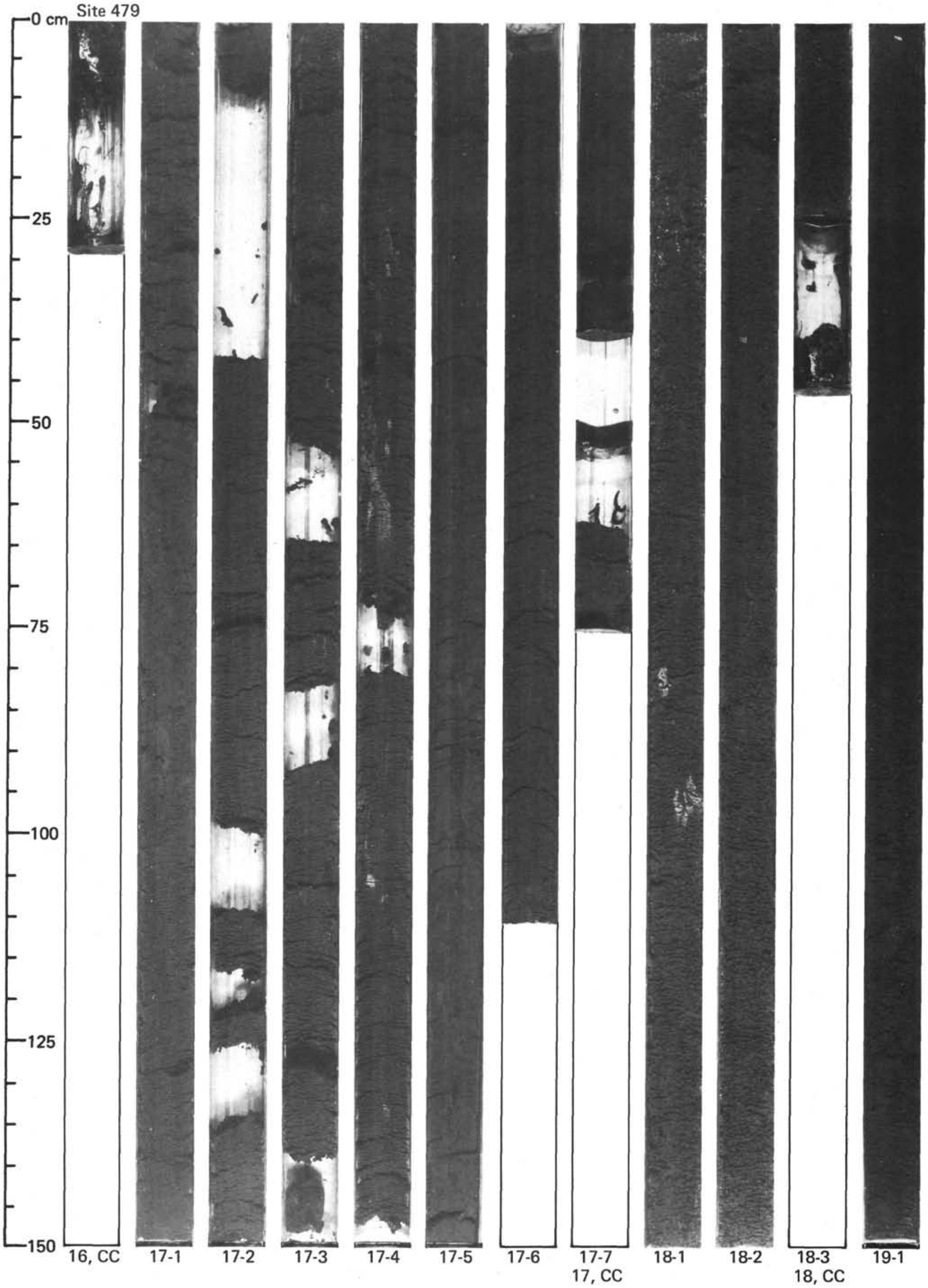
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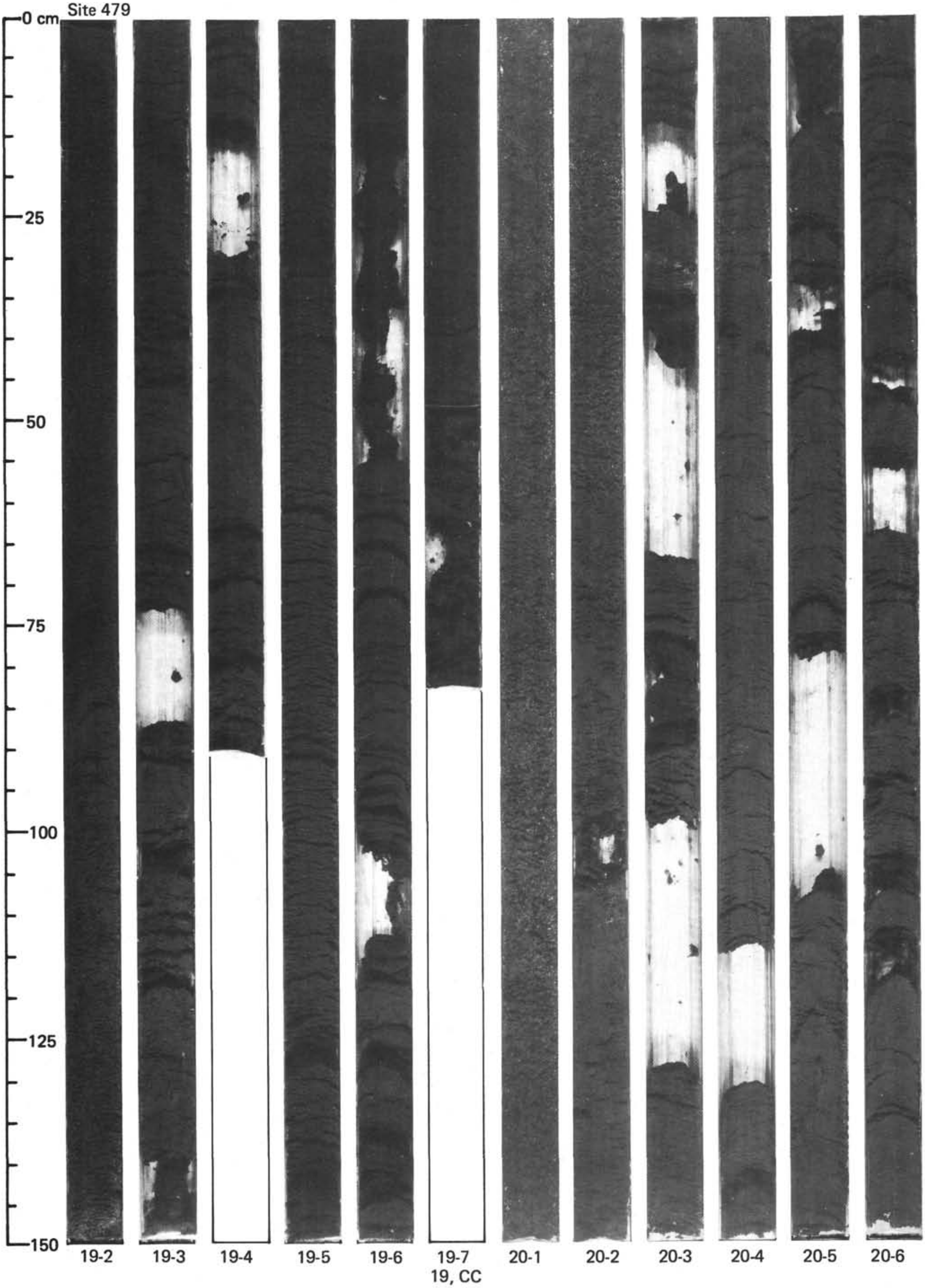
18, CC
19-1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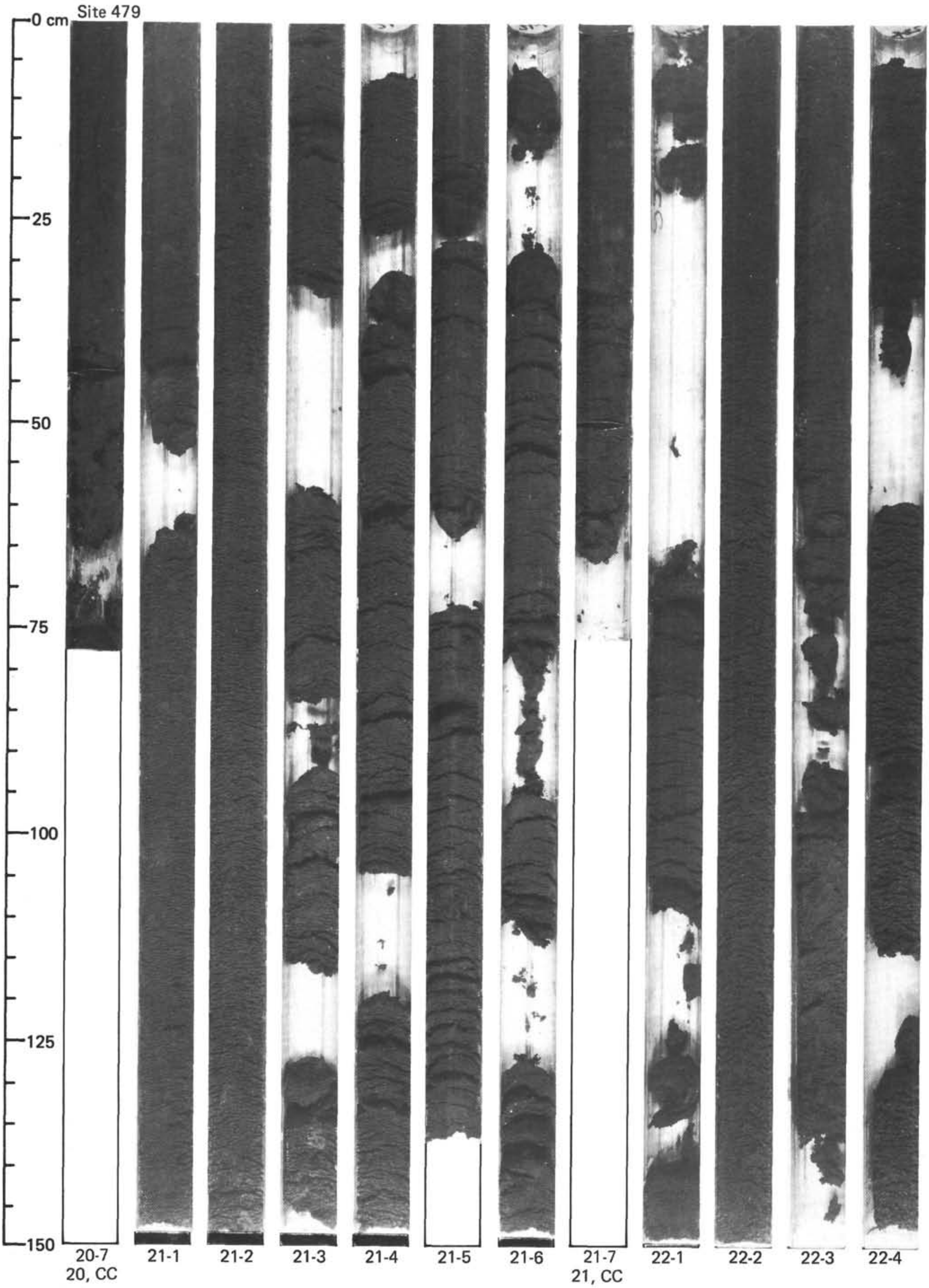
20-5
20-6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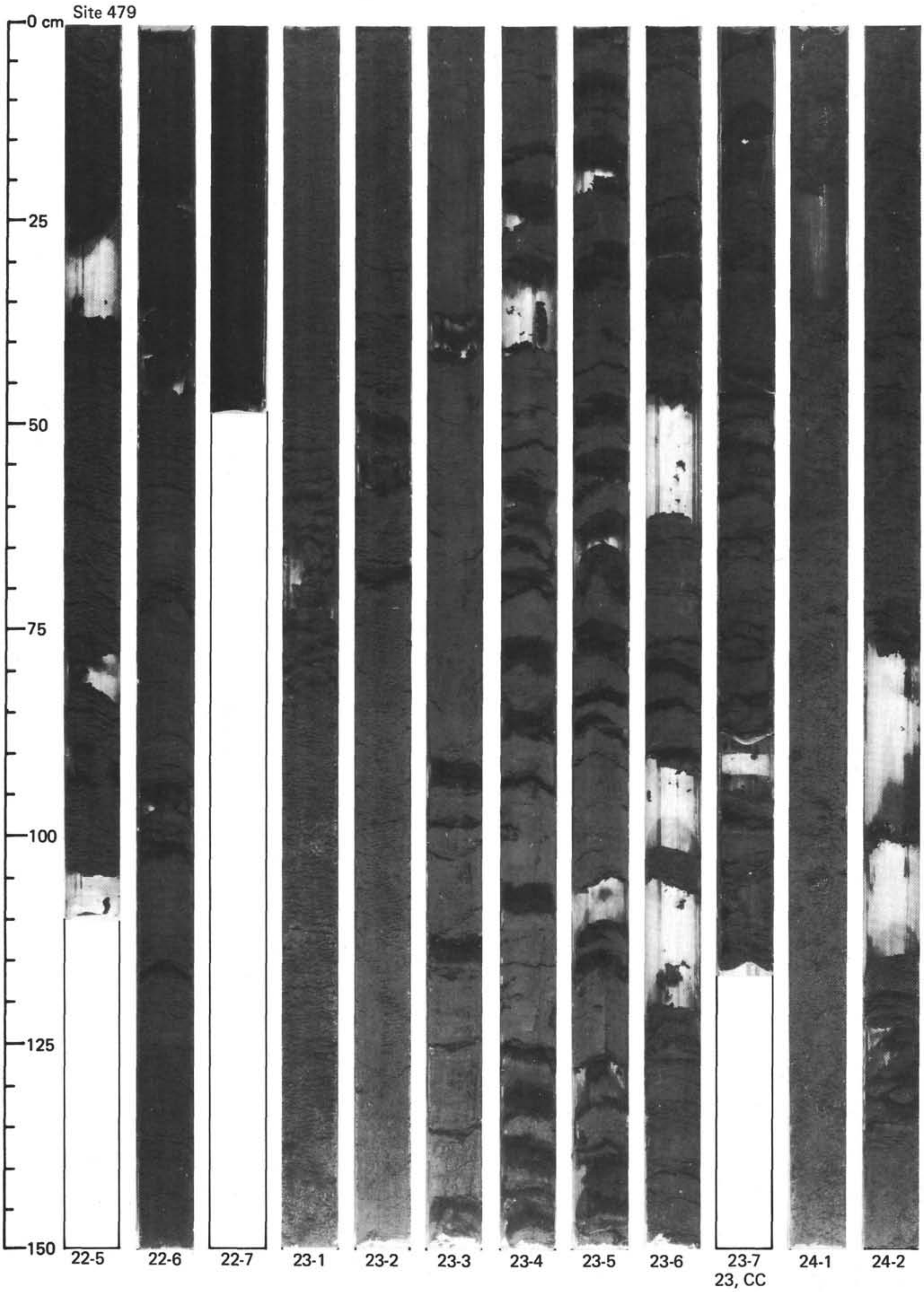

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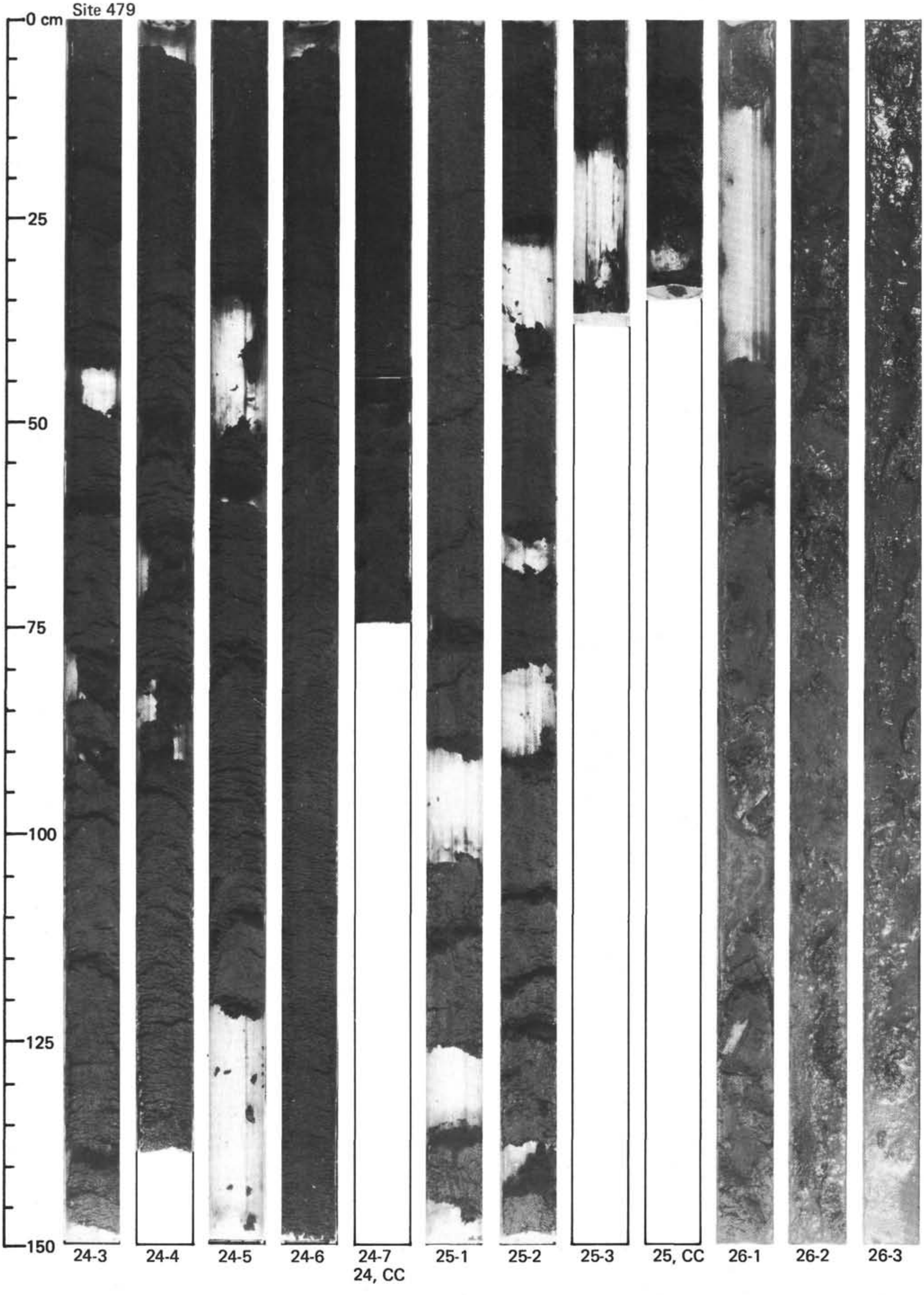
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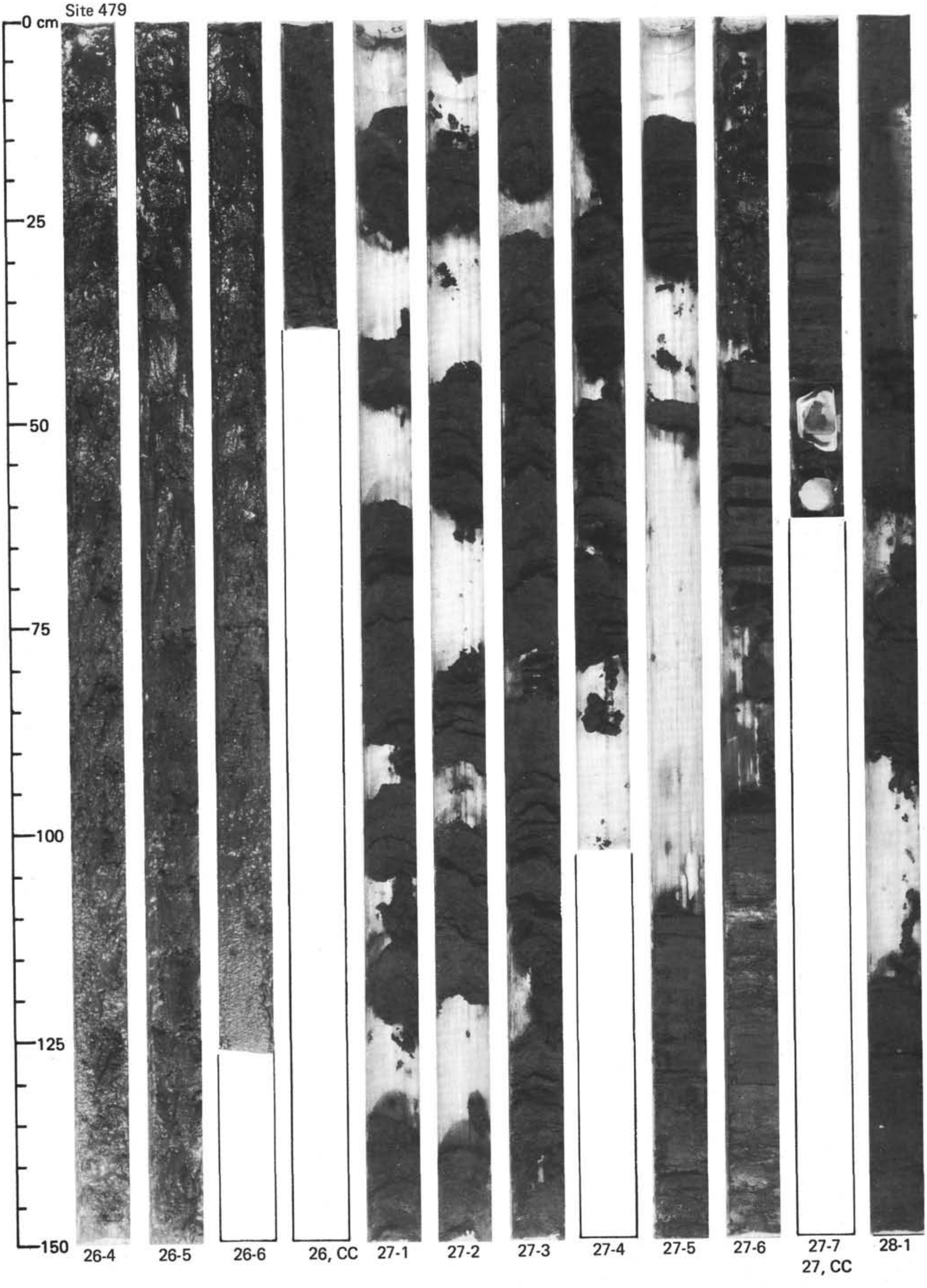
26-3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27, CC
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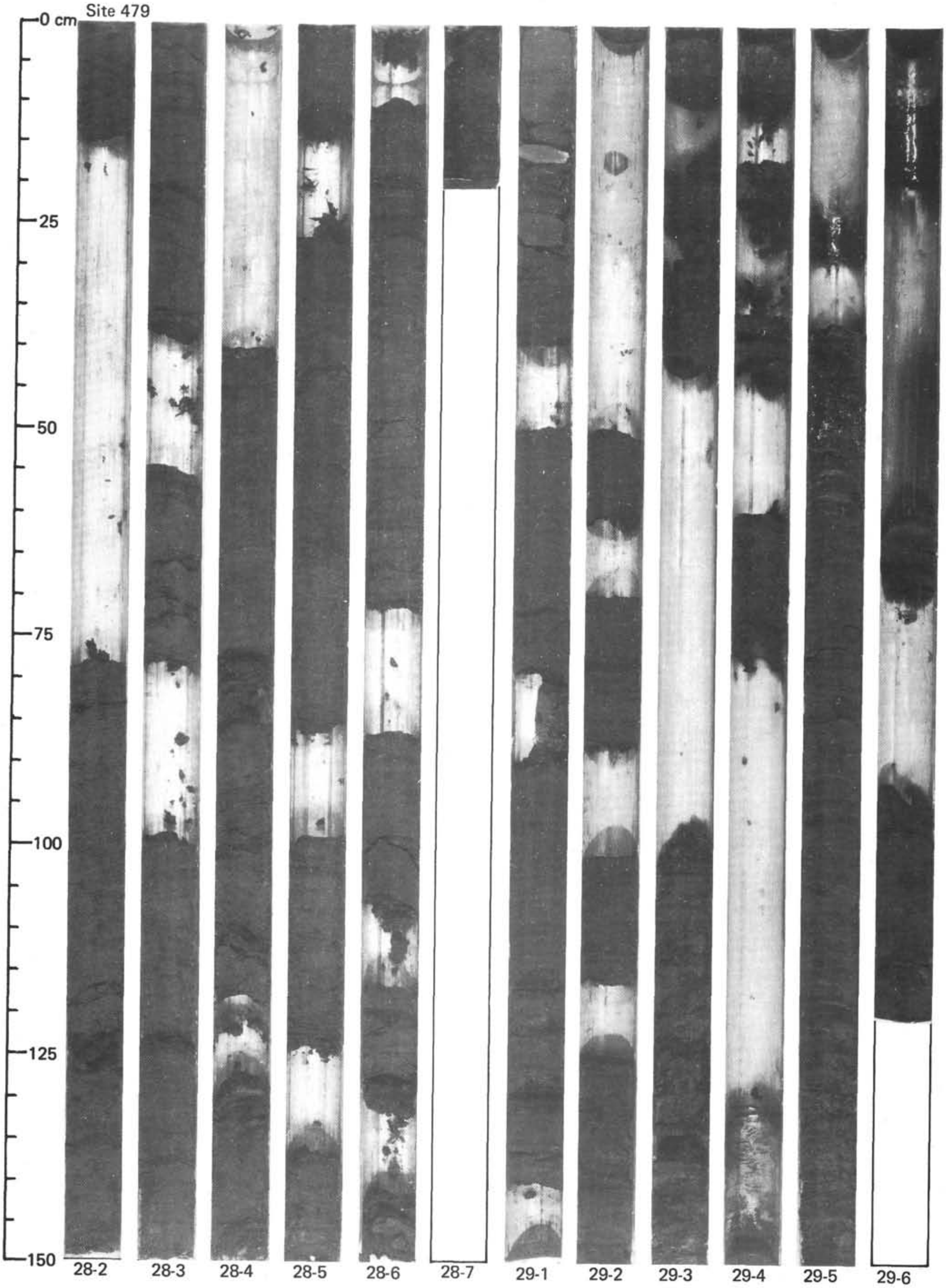
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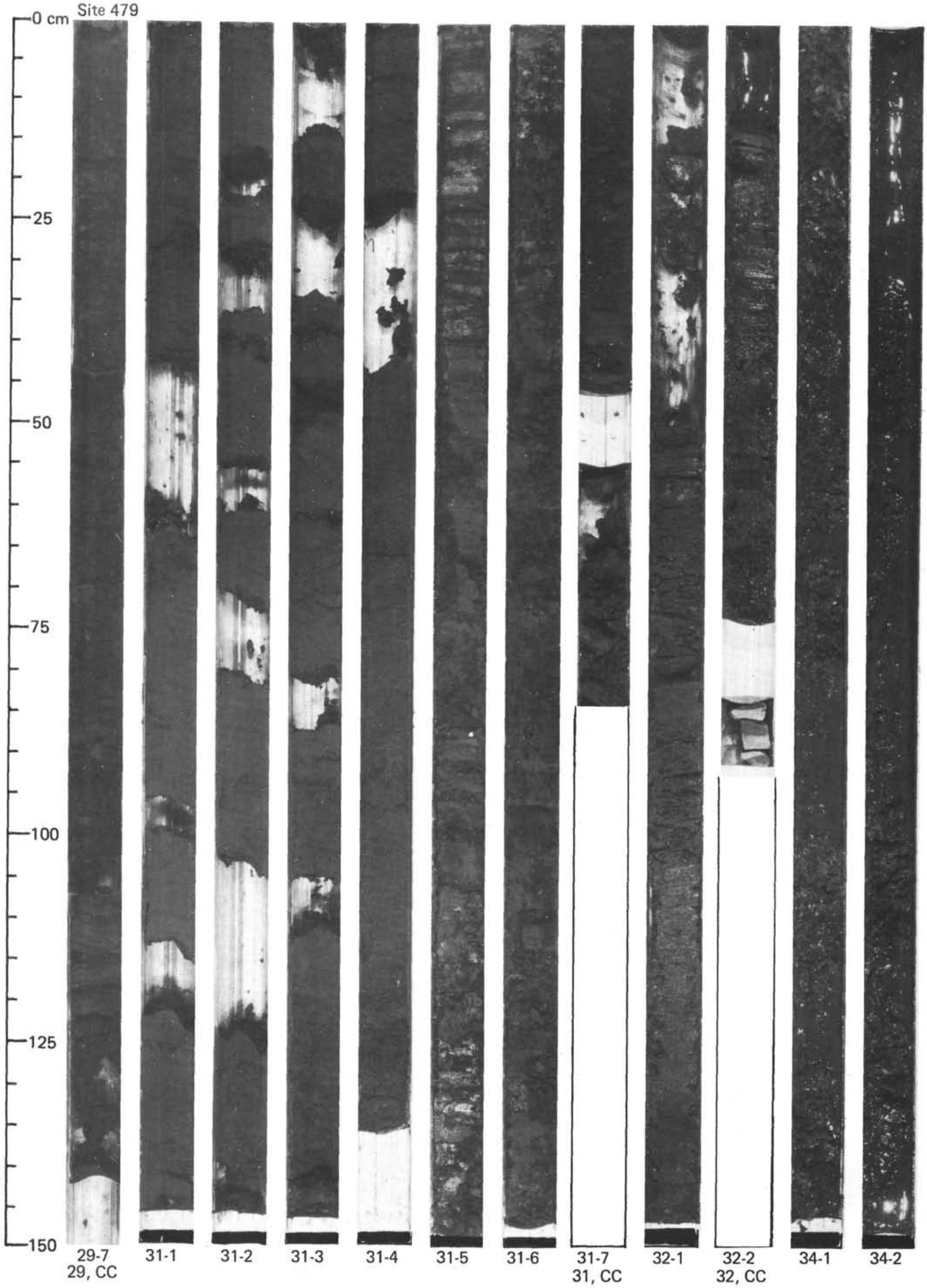
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29, CC
31-1
31-2
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31-7
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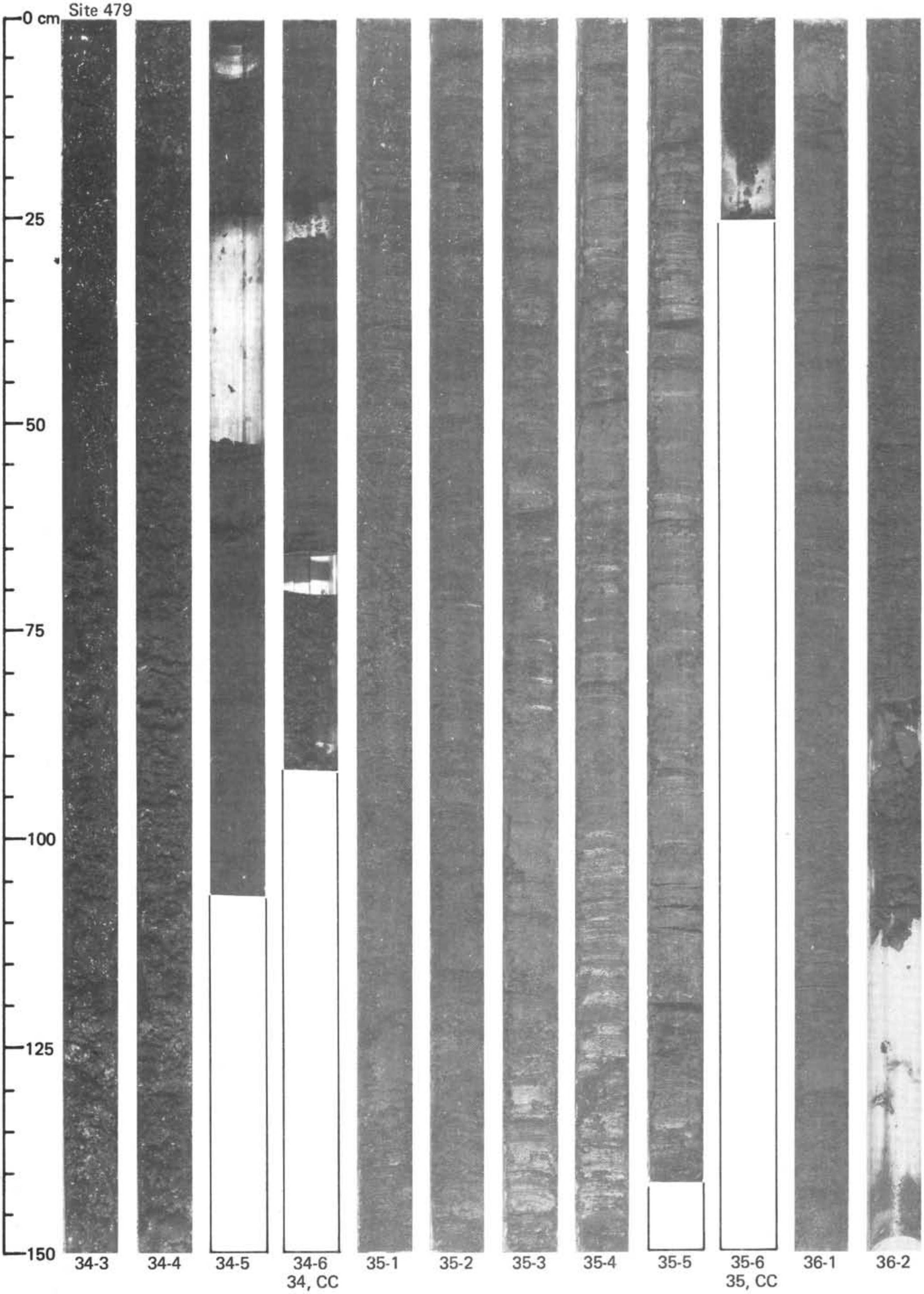
32-1
32-2
32, CC
34-1
34-2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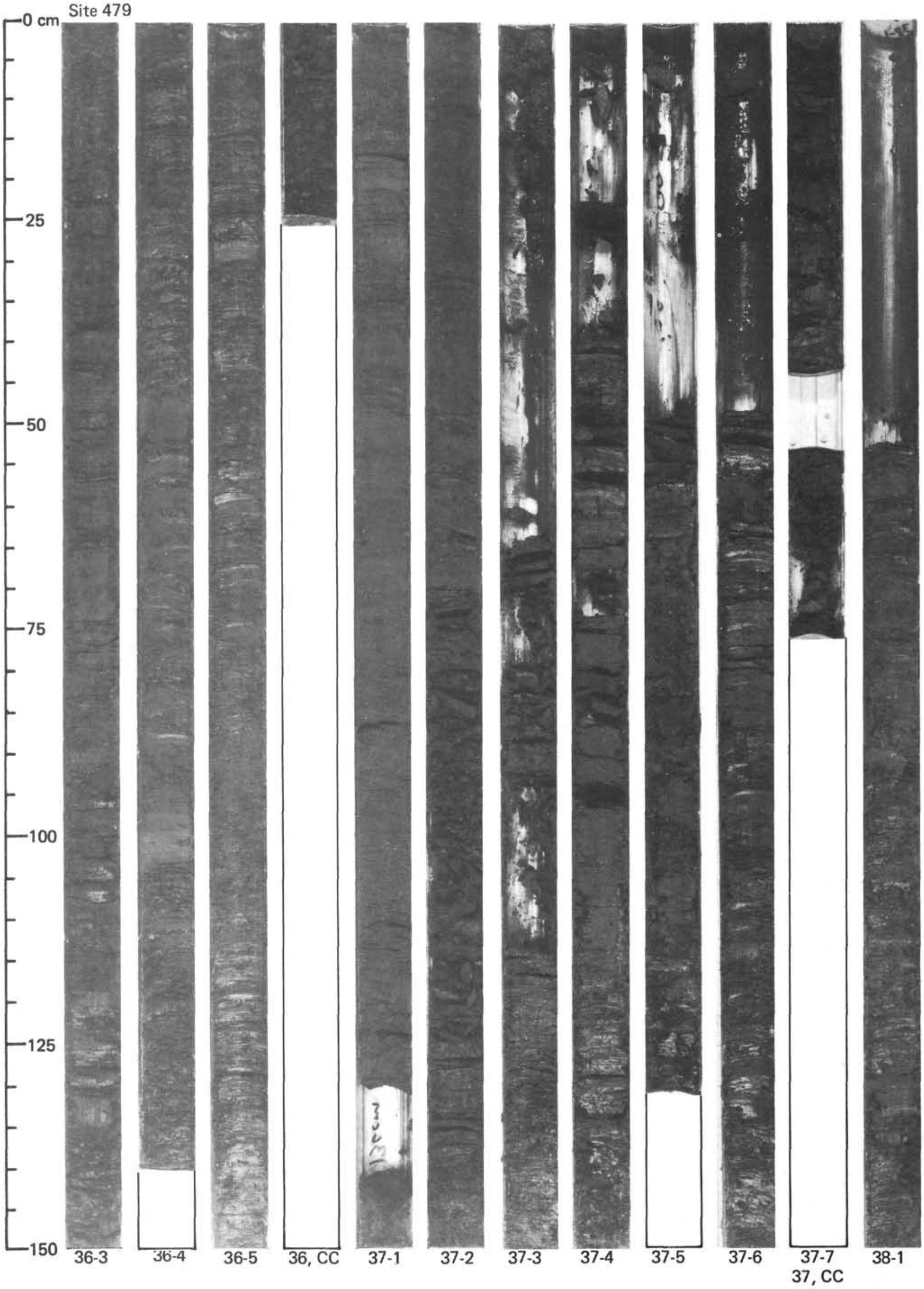
35, CC
36-1
36-2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37-7
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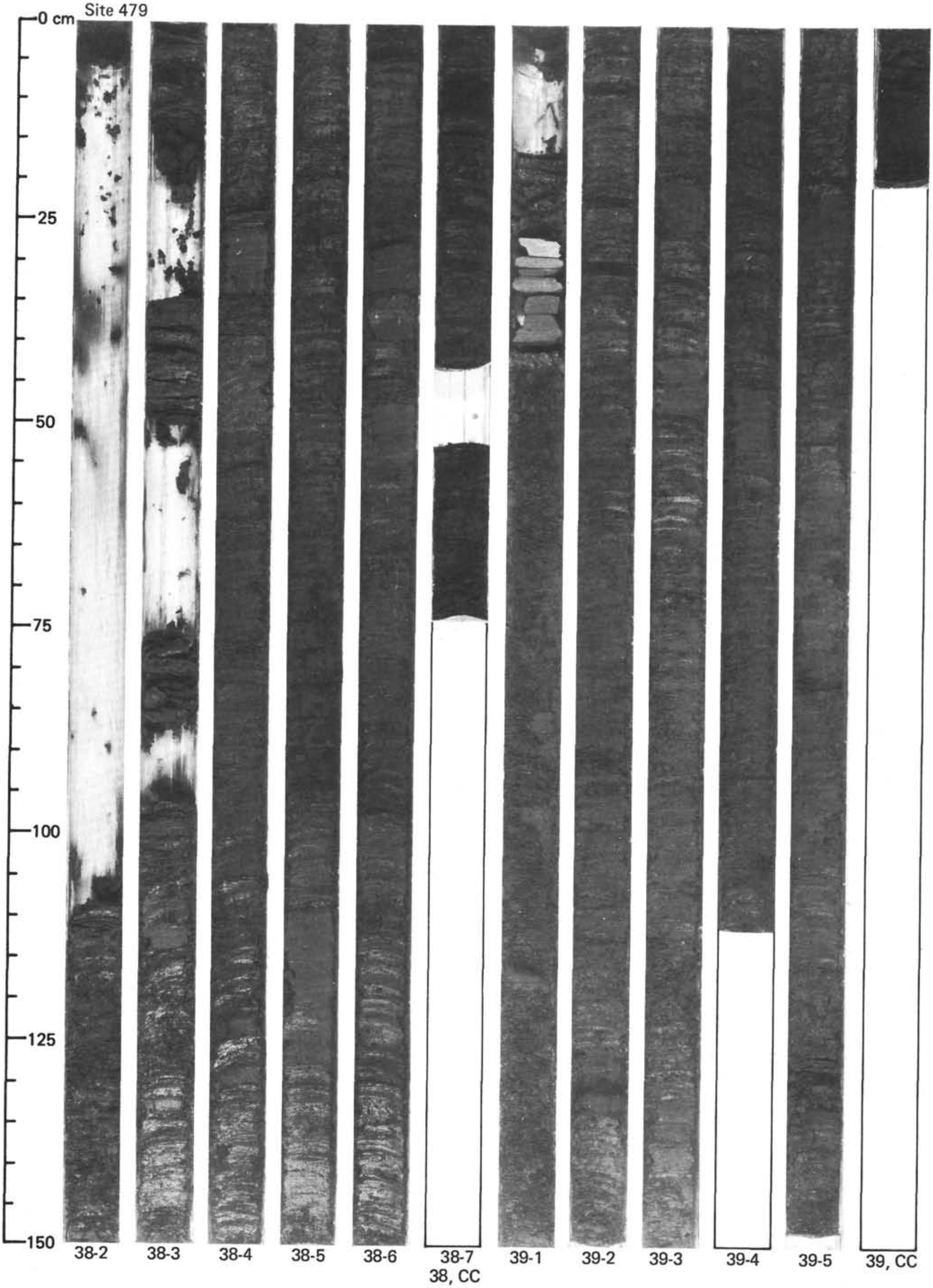
38-1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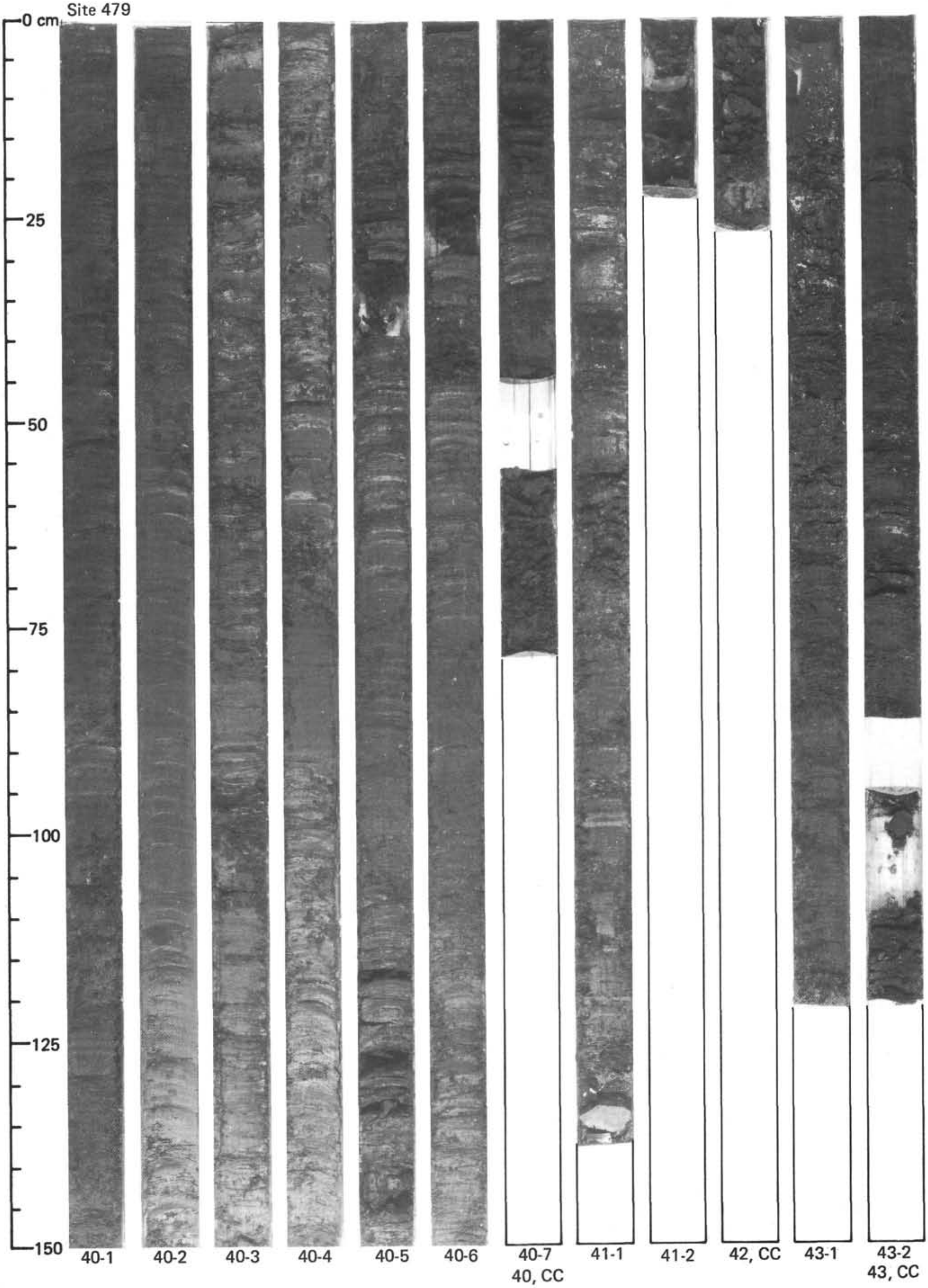
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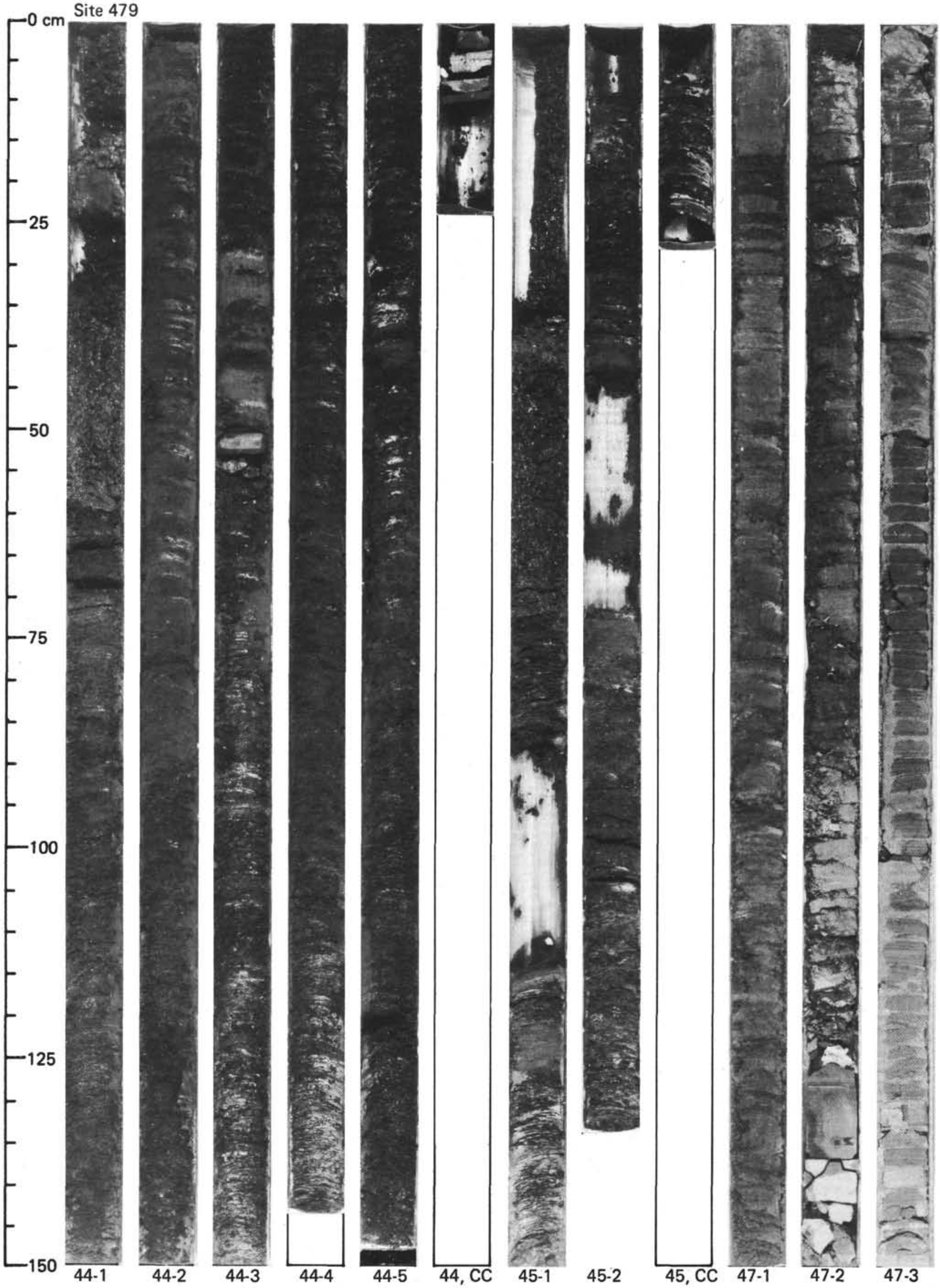
43, CC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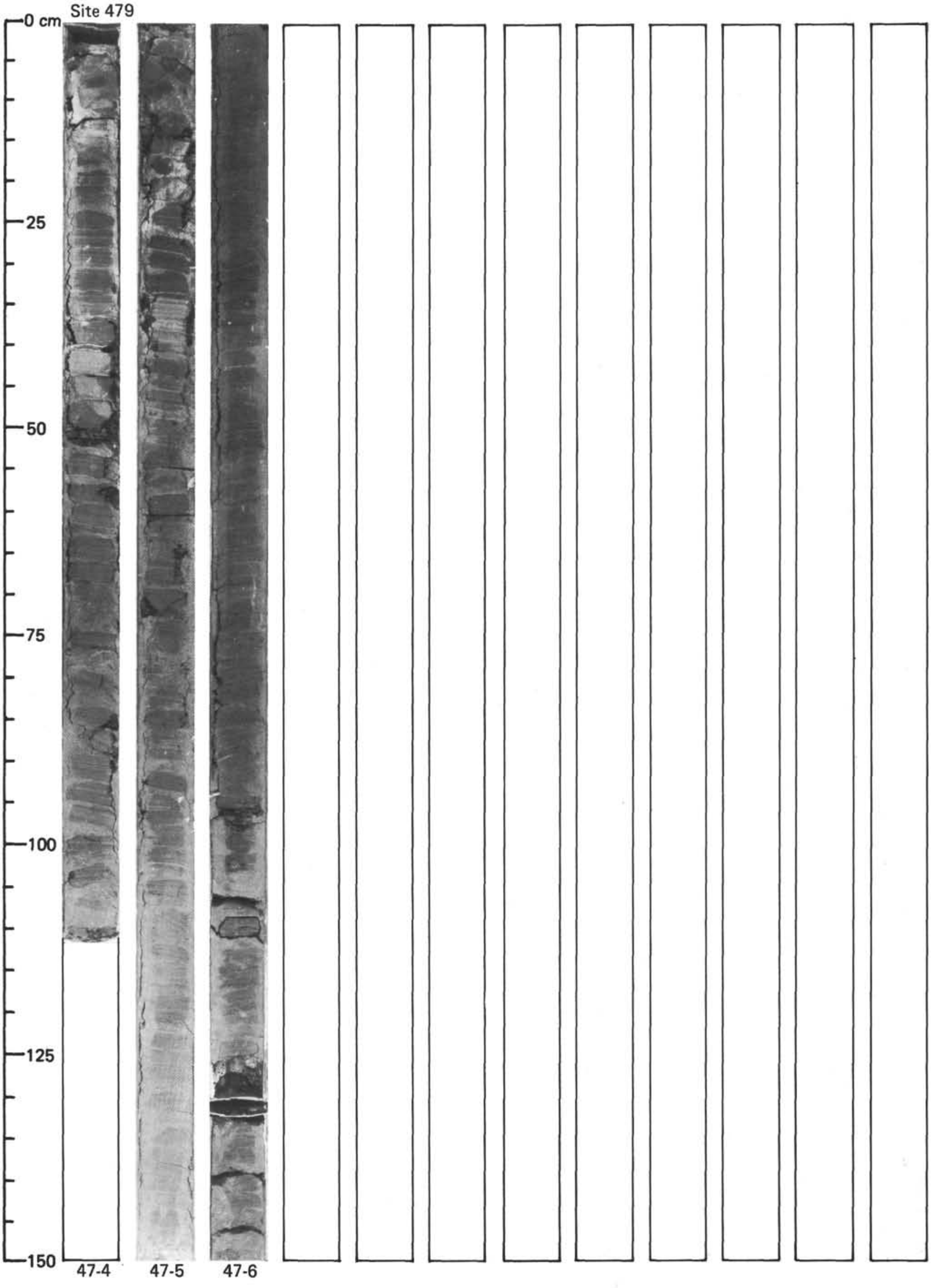
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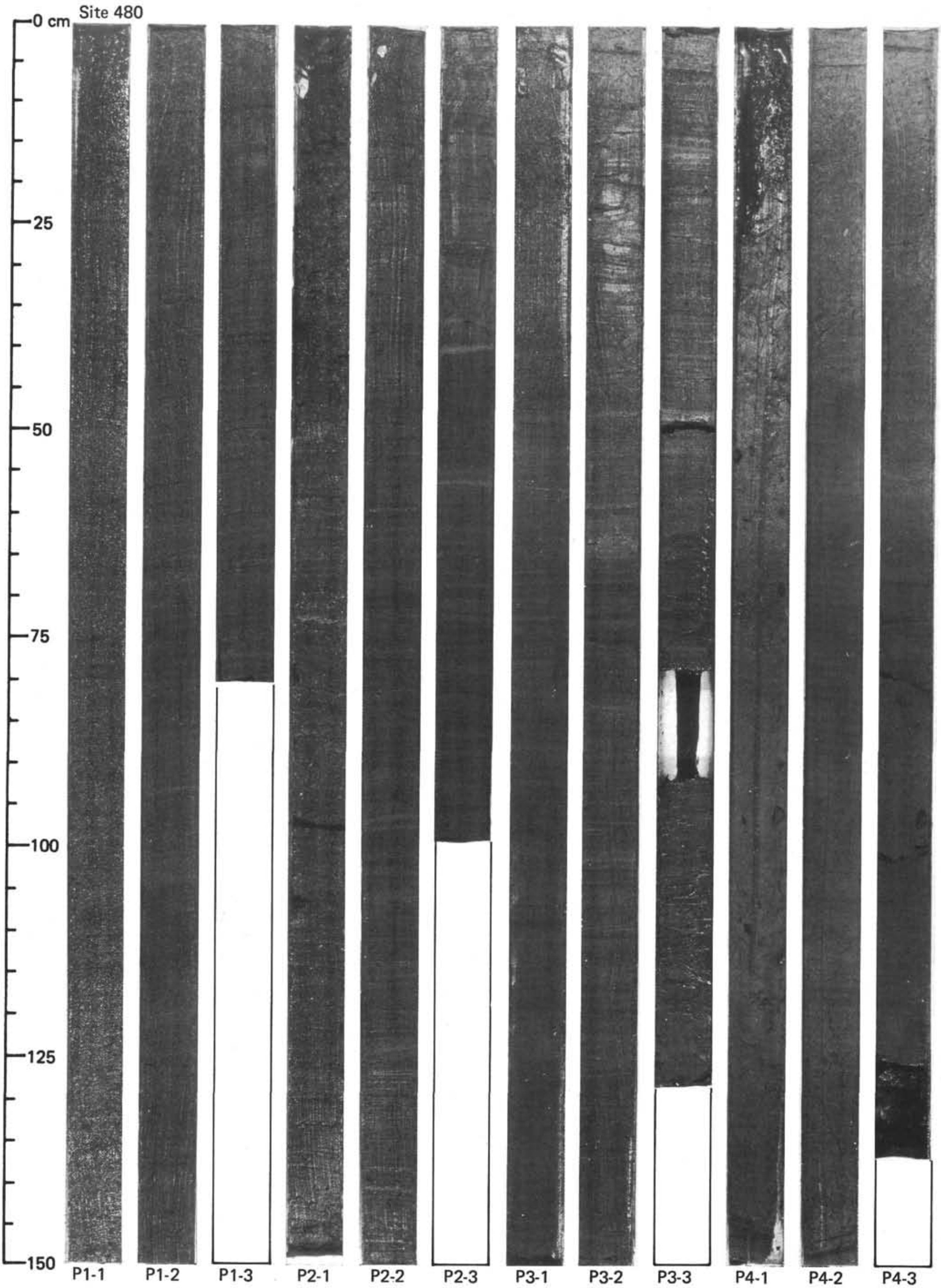
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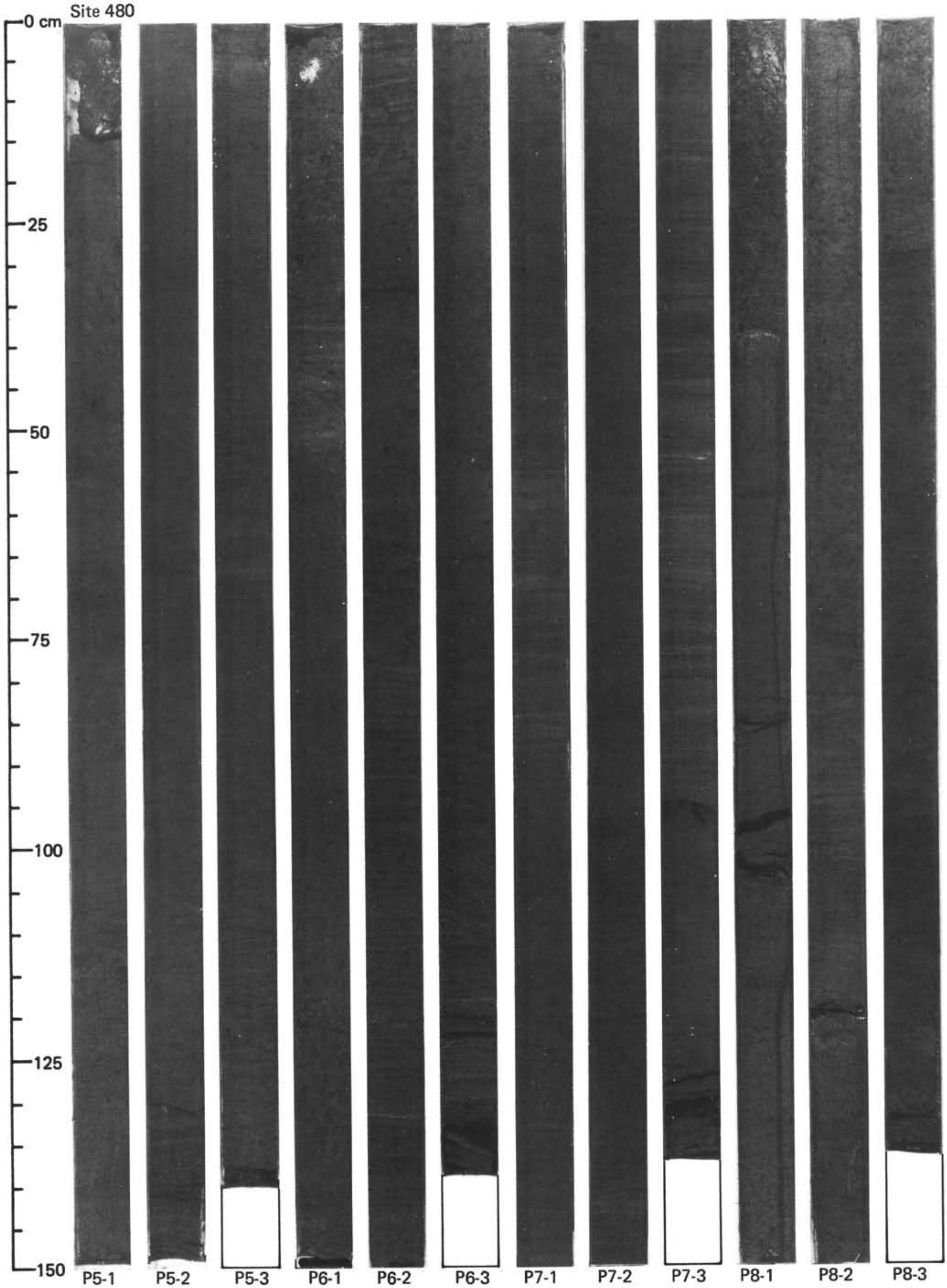
P4-3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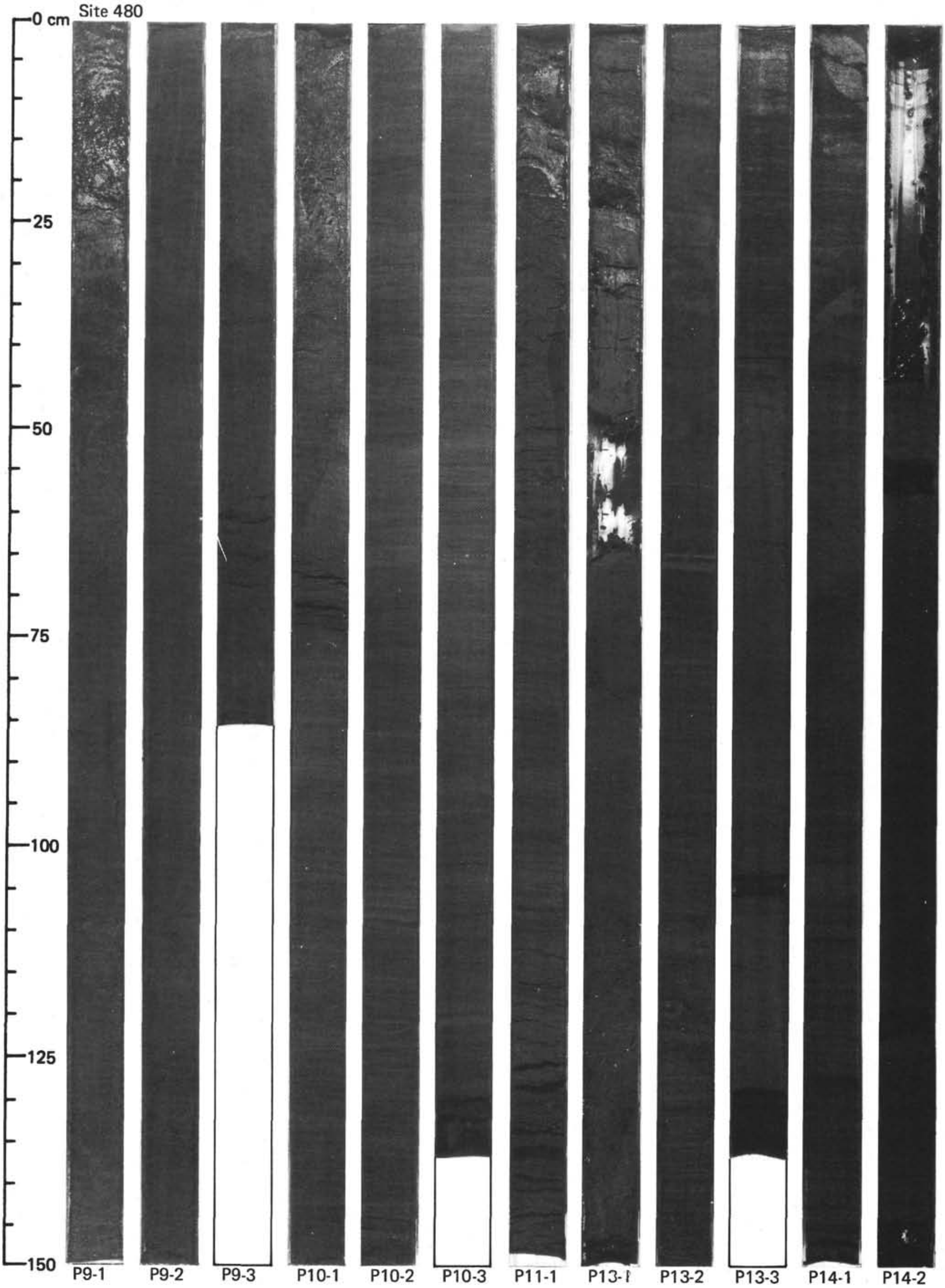
P8-1
P8-2
P8-3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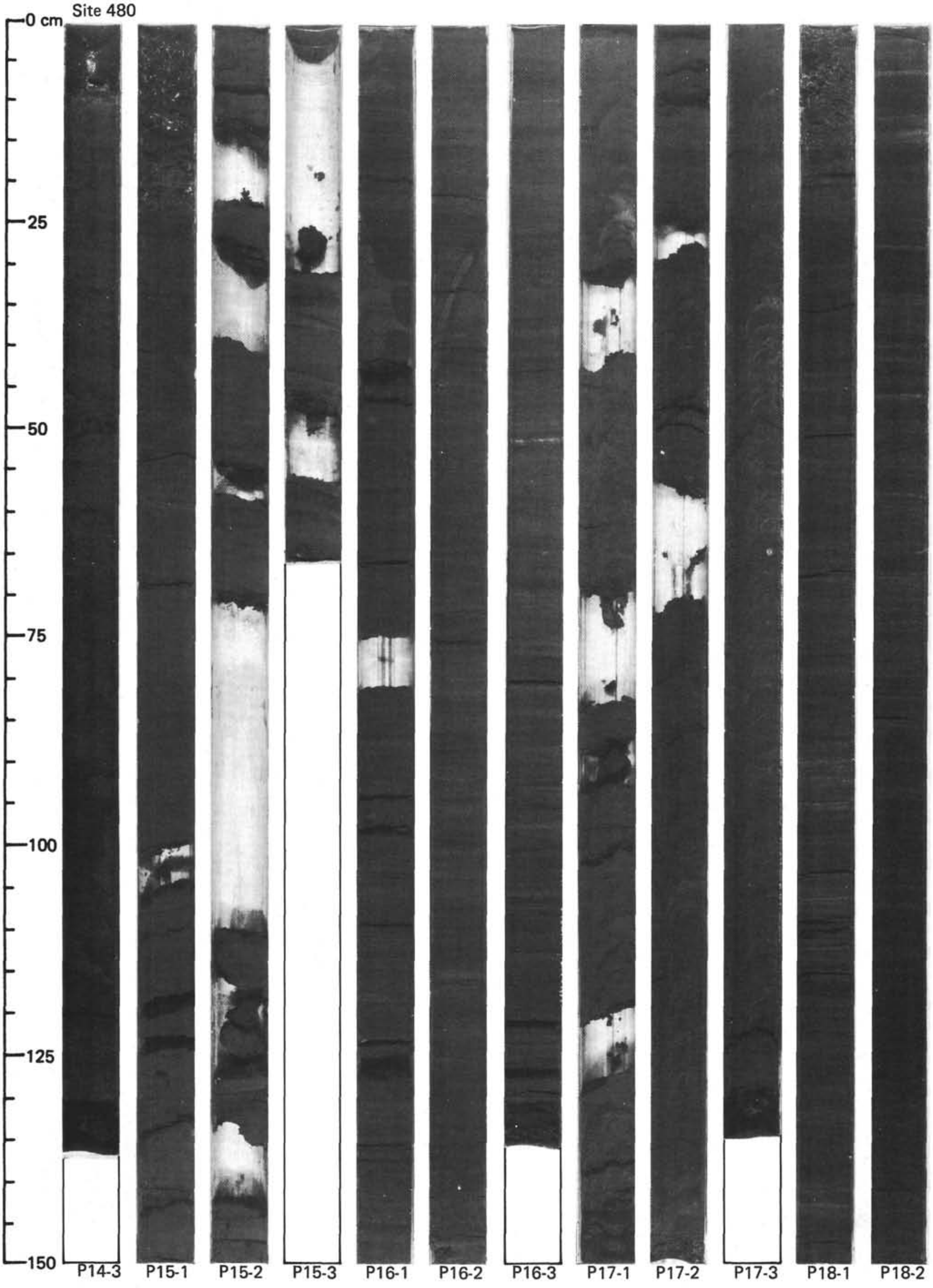
P11-1
P13-1
P13-2
P13-3
P14-1
P14-2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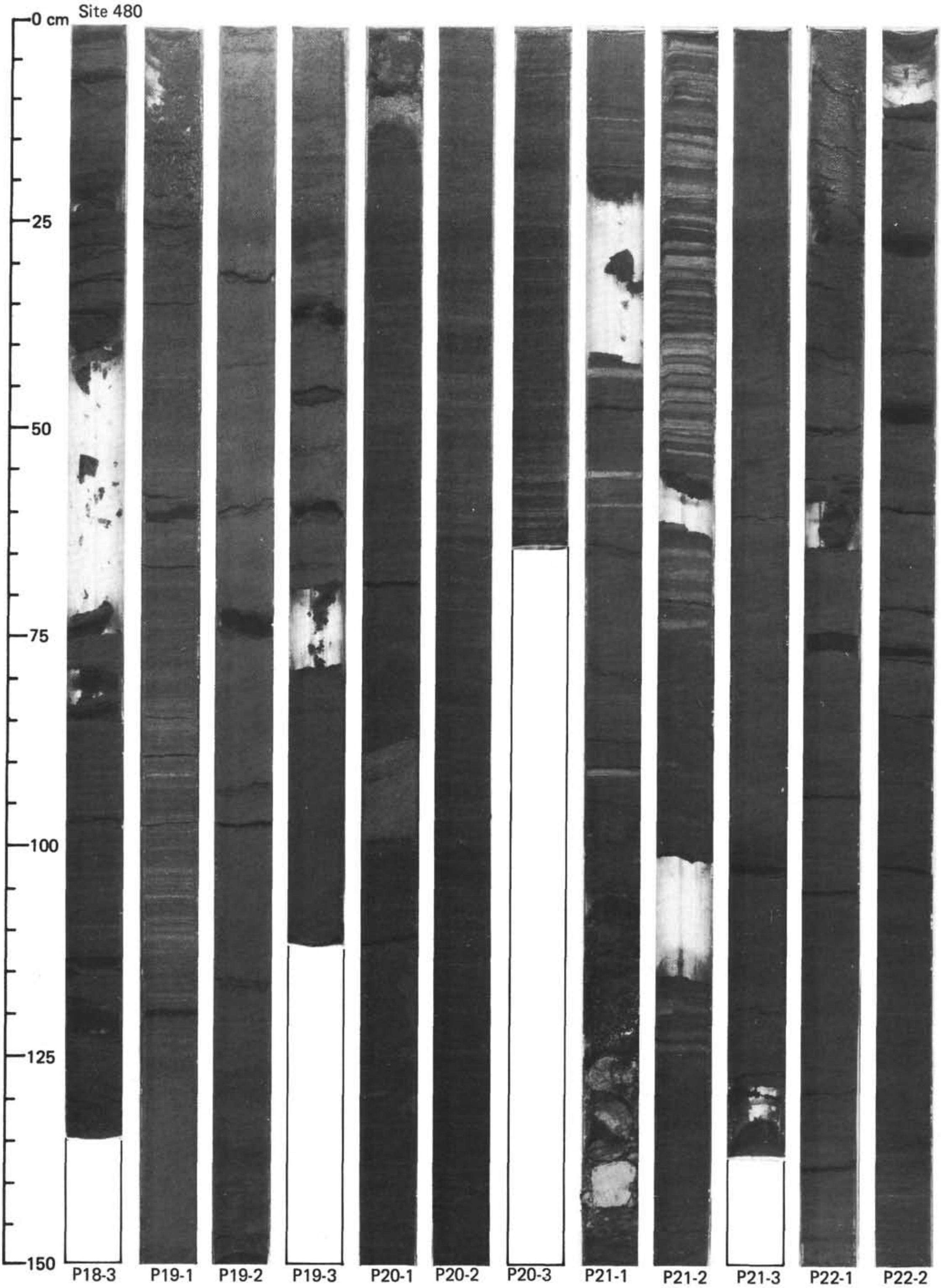
P18-2



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P20-3
P21-1
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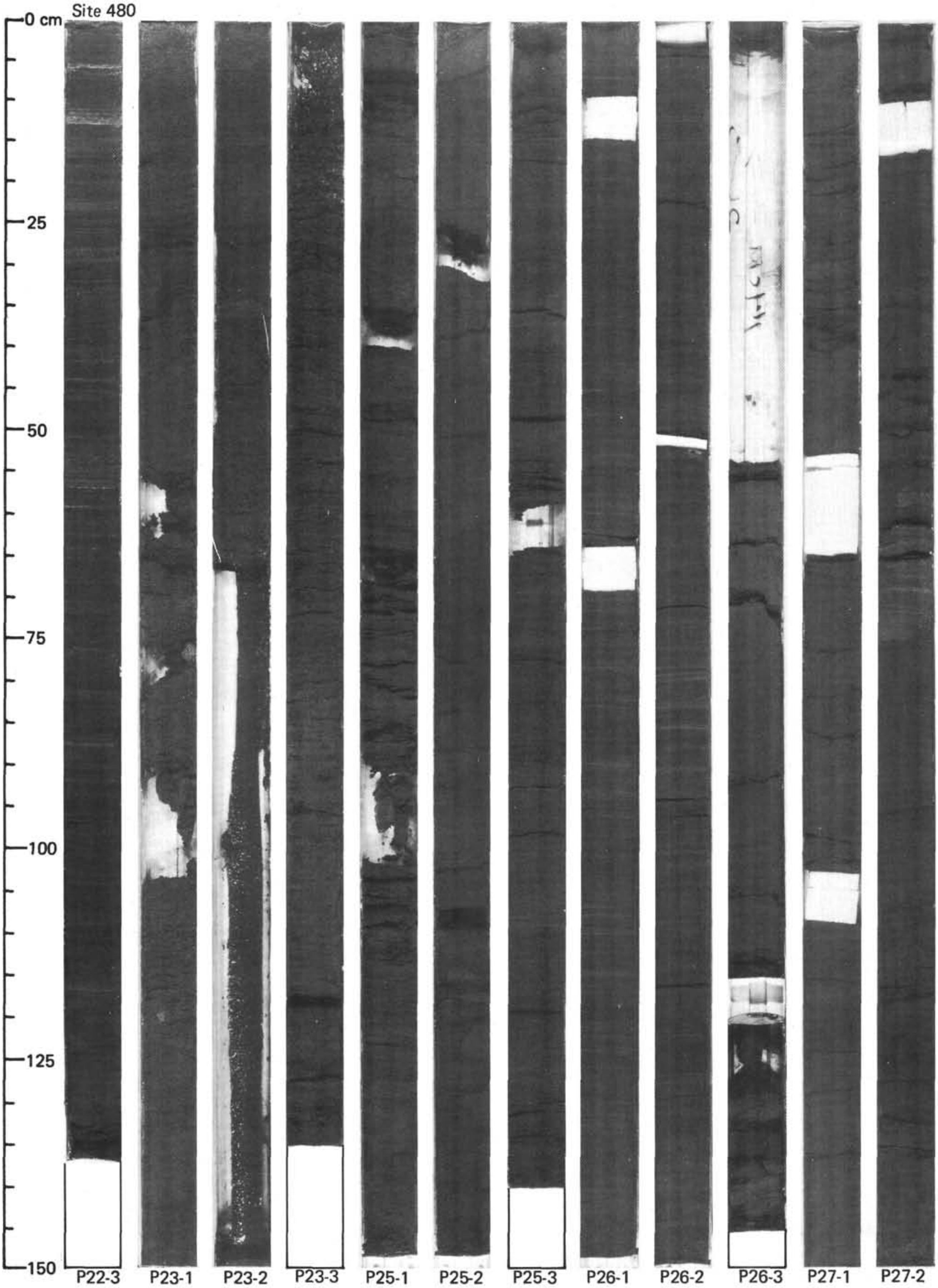
P22-2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P23-1
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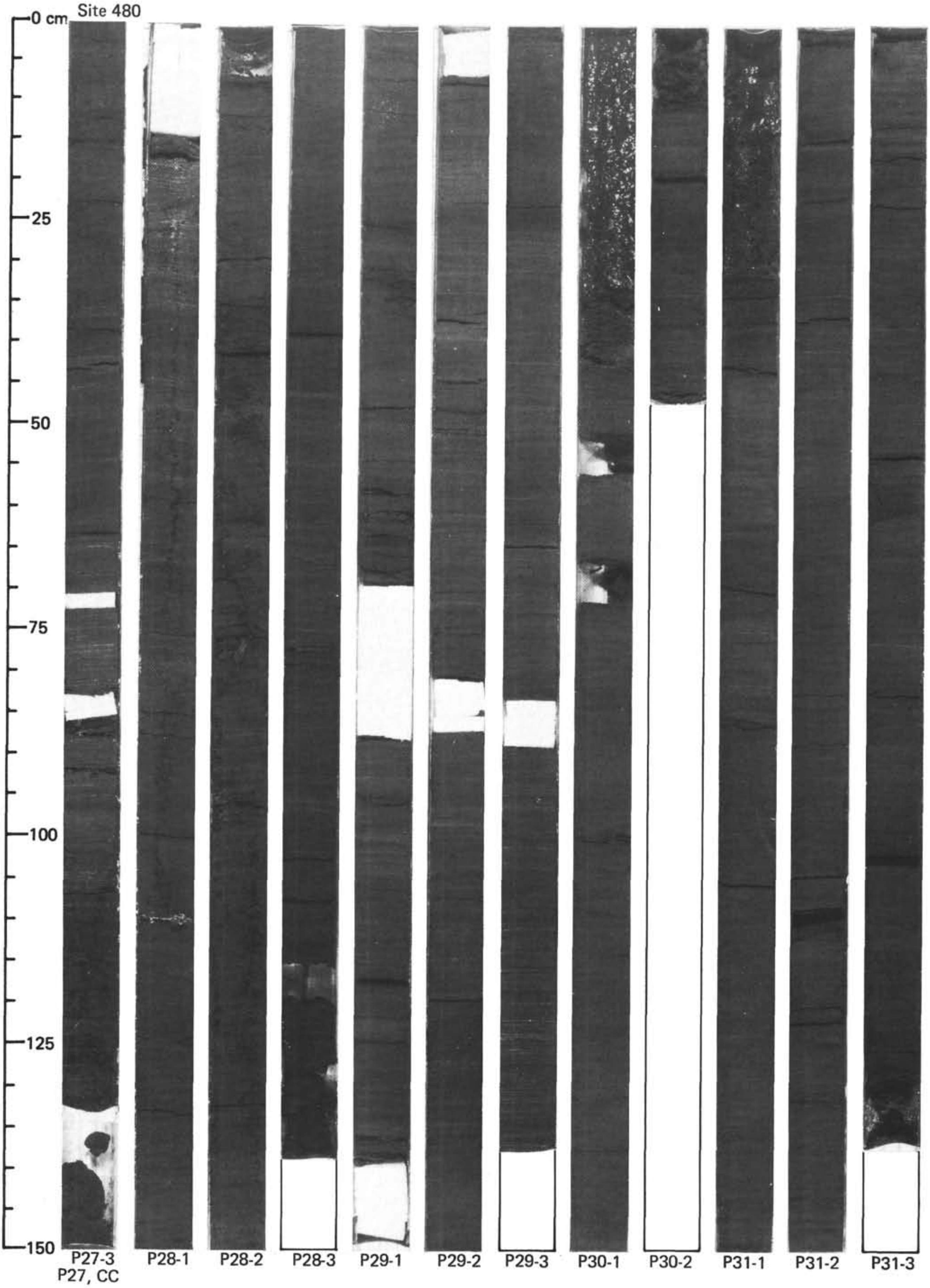
P27-2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P27-3
P27, CC
P28-1
P28-2
P28-3
P29-1
P29-2
P29-3
P30-1
P30-2
P31-1
P31-2
P31-3