8. SITE 473: RIVERA PLATE[1]

Shipboard Scientific Party[2]

HOLE 473

Date occupied: 22 November 1978

Date departed: 25 November 1978

Position: 20°57.92′N, 107°03.81′W

Water depth (sea level; corrected m, echo-sounding): 3249

Bottom felt (m, drill pipe): 3267.5

Penetration (m): 287.5

Number of cores: 34

Total length of cored section (m): 287.5

Total core recovered (m): 142.07

Core recovery (%): 49

Oldest sediment cored:
Depth sub-bottom (m): 248.1
Nature: Siltstone, silty sand
Chronostratigraphy: Upper Miocene (6–6.5 m.y.)

Basement:
Depth sub-bottom (m): 287.5
Nature: Basalt

Principal results: Site 473 on the Rivera plate south of Tres Marías Islands was cored continuously to obtain an upper Neogene reference section at the mouth of the Gulf of California and to investigate the possibility that oceanic crust at the mouth of the gulf formed prior to 4 m.y. ago. Terrigenous clay that was deposited from the early Pliocene to the Quaternary, locally containing silt or ash, was cored to 143 meters, and moderately indurated diatomaceous and calcareous claystone deposited in the early Pliocene was cored from 143 to 181 meters. The boundary between these two sub-units, identified mainly on the basis of the difference in consolidation, is a seismic reflector. From 181 meters to the base of the sedimentary section at 248.1 meters, silty claystone and local silty quartzose sand, deposited in the late Miocene and early Pliocene, include turbidites with common Bouma T_c, T_d and T_c, T_d, and T_e sequences. The age of the basal sediments is 6 to 7 m.y.

Sediment velocities are 1.5 to 1.6 km/s from mudline to 181 meters, increasing to 1.98 km/s at the basal sediments. Densities are 1.5 g/cm^3, increasing downward to 1.7 g/cm^3. Heat-flow measurements at 67, 143, and 181.5 meters suggest a geothermal gradient of 64°C/km (heat flow—1.3 HFU [heat-flow units]), but measurements at 105 and 219 meters suggest a gradient of 173°C/km (3.9 HFU). A gradient of 126°C/km is suggested by a downhole Temperature Log from 133 to 185 meters (consistent with the temperature-sensitive first appearance of opal-CT [cristobalite] and the disappearance of siliceous microfossils at 181 meters). The reason for these discrepancies among gradients is unclear. Igneous rocks below the sediments are mainly massive, altered diabase with a density of 2.7 g/cm^3 and a velocity of 5.2 to 5.3 km/s, but a fragment of pillow basalt was found at the bottom of the last core.

Sediment accumulation rates are 40 m/m.y. for the last 3 million years (0–130 m depth) and 20 m/m.y. for the rest of the section. The high percentage of terrigenous material (including turbidites) at the site was surprising in view of the pelagic appearance of the sediments on the seismic record.

BACKGROUND AND OBJECTIVES

Site 473 is located in the mouth of the Gulf of California east of the crest of the East Pacific Rise (Figs. 1 and 2). The rise crest is seismically active, as are the Rivera fracture zone to the south and the northern end of the Middle America trench to the east. It is not entirely clear whether the Tamayo fracture zone north of Site 473 is also seismically active (Fig. 2). The Rivera fracture zone is a transform fault marking the displacement of the active rise crest from 109°W longitude in the mouth of the gulf to 105°W longitude farther south. The small segment of oceanic crust bounded by the East Pacific Rise, the Rivera fracture zone, and the Middle America trench is commonly known as the Rivera plate.

Striped magnetic anomalies symmetrical about the present East Pacific Rise crest indicate an age of 4 m.y. for the gulf's most recent episode of opening; the ocean floor just east of the tip of Baja California is assigned that age on the basis of magnetics. The ocean floor east of the rise crest in the Rivera plate is broader, and magnetic stripes at Site 473 suggest an age as old as 6 m.y. Figure 3 is a more detailed map showing the relation of the site to the Middle America trench and the abrupt scarp at the foot of the Tres Marías Islands.

Site 473 was proposed to date the oceanic crust of the Rivera plate as close to the Middle America trench as possible. Because of the shallow depth of the crust at this location, we anticipated finding a good Pliocene and Quaternary carbonate section. We also expected to discover some terrigenous contribution from the continental shelf to the northeast, where the Tres Marías Islands are located.

OPERATIONS

On 22 November 1978, we approached the proposed site near Tres Marías Islands from the west–northwest, subparallel to an existing seismic line (GAM 2, shown in Fig. 3); we intersected this line almost over the proposed

[1] *Initial Reports of the Deep Sea Drilling Project*, Volume 63.

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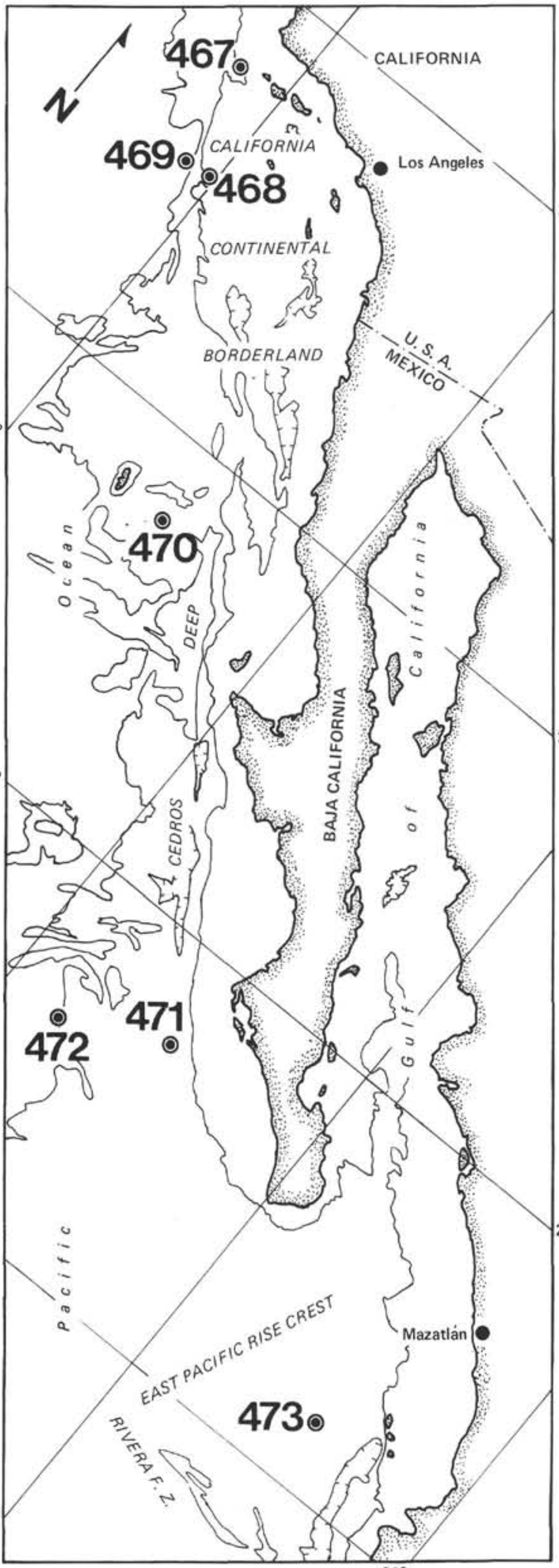

Figure 1. Location of Leg 63 sites.

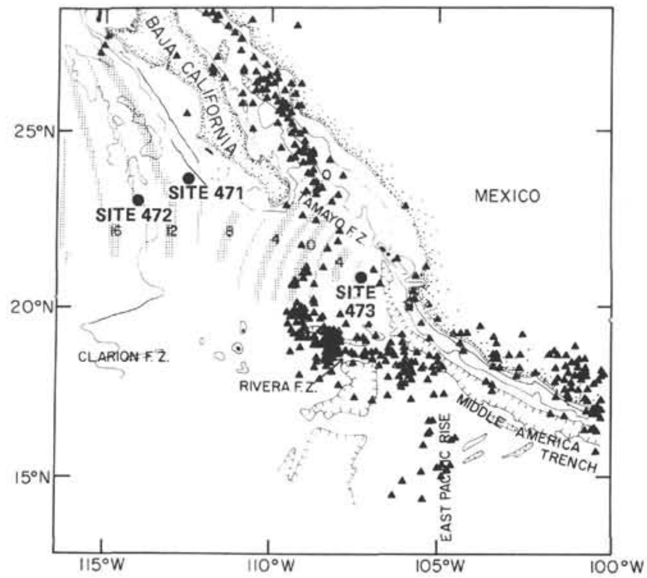

Figure 2. Earthquake epicenters and sea-floor ages at the mouth of the Gulf of California (after Atwater [1970] and Chase et al. [1970]. (Locations of Sites 471, 472, and 473 are shown.)

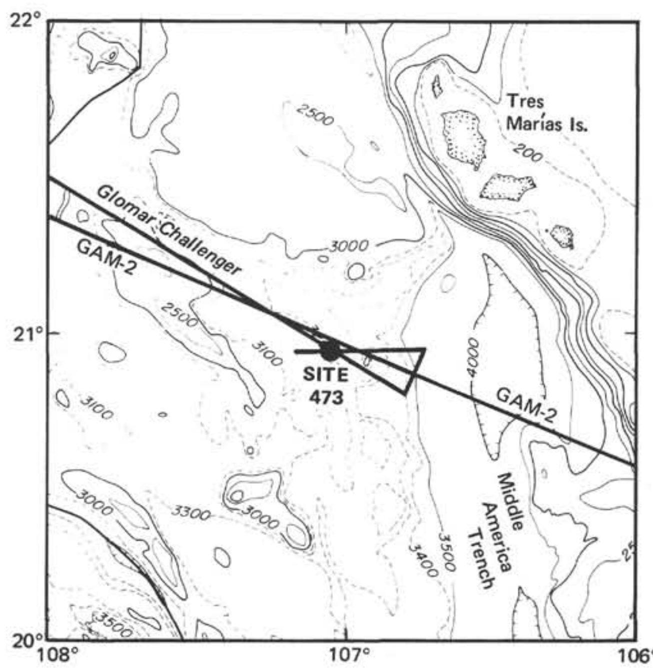

Figure 3. Detailed bathymetry (in meters) in the area near Site 473 north of the Rivera fracture zone (Mammerickx et al., 1978). (Line GAM-2 is a site survey seismic line. The *Challenger* line approaching Site 473 is also shown. Map scale is 8″ to 1° longitude.)

locality. After we had made an approximate site selection, we continued the survey along the same line for an hour and then changed course at 1500Z hours to 034° to survey north of the site. At 1600Z hours, we changed course once again to 270° to arrive at the site from the east (see Fig. 3). We reached the site at 1752Z hours and dropped a 13.5-kHz beacon immediately (1052 local time). The hole was spudded in 3267.5 meters of water over a fairly flat-topped topographic feature showing some 250 meters of sediments draped over irregular basement (Fig. 4).

The site was continuously cored, and coring operations were routine (Table 1). Softer terrigenous clay was recovered in the upper 143 meters and, below this, moderately to well indurated claystone to a depth of 248 meters. Below the claystone, 39.1 meters of diabase sill was cored, and the hole bottomed at 287.5 meters in pillow basalt.

Five *in situ* heat-flow measurements were made successfully at 67 meters, 105 meters, 143 meters, 181.5 meters, and 219 meters depth. Two of the measurements, at 105 and 219 meters, seem anomalously high, possibly owing to the friction of the probe in the hole.

Coring operations stopped at 1115 hours (local time) on 25 November, and the hole was readied for logging. The shifting tool released the bit, and pipe was raised to 132.5 meters below the mudline. The Sonic-Gamma Ray-Hole Caliper was run, but a sediment bridge was found at 185 meters below the mudline, preventing further penetration. A stand of pipe took weight at the bridge, then proceeded into open hole. The Sonic Log was run again, but the hole caliper showed hole size greater than 18 in. through most of the sediment column, rendering the Sonic Log virtually useless. Furthermore, the log would not penetrate into basalt, suggesting that the diameter of the hole in the basalt was too narrow. The Sonic Log was pulled, and a Temperature Log was run with sinker bar to get a bottom-hole temperature, because the open hole had been permitted to stand without circulation for over 12 hours. A Temperature Log was obtained from 133 meters to the sediment bridge at 185 meters, but it would not go below the bridge. The pipe was pulled, and the hole was abandoned.

LITHOLOGY

Sediments and Sedimentary Rocks

The sediment at Site 473 is dominated by clay, claystone, and silty claystone. We defined two lithologic units on the basis of mineralogy, sedimentary structures, microfossil abundances, and induration (Fig. 5, Table 2). Unit 1 is primarily clay and claystone. Unit 2 is primarily silty claystone, siltstone, and sandstone.

Unit 1: Clay and Claystone (0–181 m)

Unit 1 consists of clay with minor amounts of silty clay and diatomaceous clay. The unit can be subdivided into two parts on the basis of induration and a slight increase in the siliceous biogenic component of the sediment in the lower part.

The sediments of Sub-unit 1a (Cores 1–26; 0–143 m) consist of clay with subordinate amounts of silty clay and ash. The clay is olive gray to greenish gray and is mottled by reduction spots and streaks of finely disseminated pyrite. The clay contains up to 8% angular to subangular quartz and feldspar. Cores 1 and 2 and Cores 13 and 14 are mainly silty clay that contain up to 20% silt. The silty component consists of angular to subangular quartz, feldspar, and lithic fragments with minor amounts of mica, heavy minerals, glauconite, plant debris, and carbonized wood fragments. The clay contains a few per cent of calcareous nannofossils and foraminifers. Patches of vitric and altered ash occur

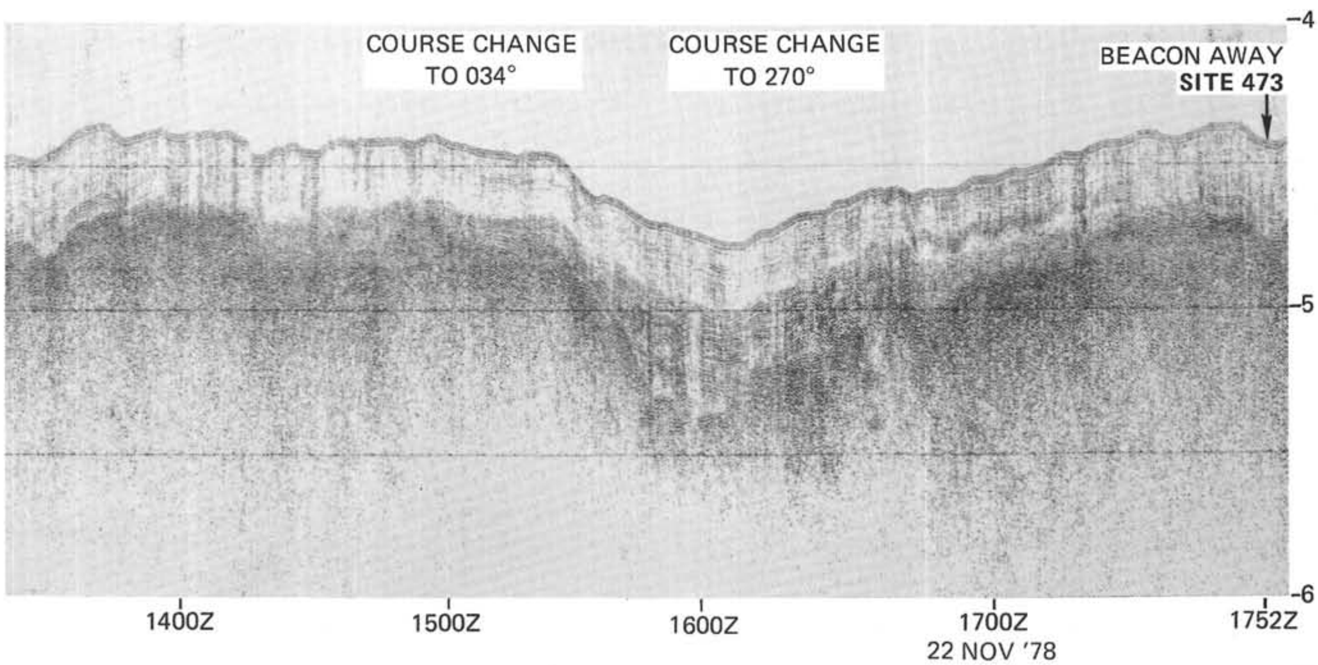

Figure 4. *Challenger* seismic profile approaching Site 473. (See Fig. 3 for location and text for description.)

Table 1. Coring summary, Site 473.

Core No.	Date (Nov. 1978)	Time	Depth from Drill Floor (m)	Depth below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Core Recovered (%)
1	22	1812	3267.5–3268.0	0.0–0.5	0.5	0.26	52
2	22	1915	3268.0–3277.5	0.5–10.0	9.5	7.35	77
3	22	2015	3277.5–3287.0	10.0–19.5	9.5	6.20	65
4	22	2114	3287.0–3296.5	19.5–29.0	9.5	4.80	51
5	22	2212	3296.5–3306.0	29.0–38.5	9.5	6.76	71
6	22	2307	3306.0–3315.5	38.5–48.0	9.5	2.89	30
7	23	0003	3315.5–3325.0	48.0–57.5	9.5	5.38	57
8	23	0104	3325.0–3334.5	57.5–67.0	9.5	3.43	36
9	23	0333	3334.5–3344.0	67.0–76.5	9.5	2.48	26
10	23	0428	3344.0–3353.5	76.5–86.0	9.5	2.43	26
11	23	0527	3353.5–3363.0	86.0–95.5	9.5	3.20	34
12	23	0630	3363.0–3372.5	95.5–105.0	9.5	2.92	31
13	23	1048	3372.5–3382.0	105.0–114.5	9.5	5.75	61
14	23	1147	3382.0–3391.5	114.5–124.0	9.5	3.33	35
15	23	1245	3391.5–3401.0	124.0–133.5	9.5	5.74	60
16	23	1351	3401.0–3410.5	133.5–143.0	9.5	8.48	89
17	23	1653	3410.5–3420.0	143.0–152.5	9.5	9.07	95
18	23	1803	3420.0–3429.5	152.5–162.0	9.5	3.29	35
19	23	1910	3429.5–3439.0	162.0–171.5	9.5	6.75	71
20	23	2016	3439.0–3448.5	171.5–181.0	9.5	8.66	91
21	23	2315	3448.5–3455.0	181.0–187.5	6.5	6.94	100+
22	24	0020	3455.0–3458.0	187.5–190.5	3.0	0.21	7
23	24	0129	3458.0–3467.5	190.5–200.0	9.5	4.86	51
24	24	0232	3467.5–3477.0	200.0–209.5	9.5	3.61	38
25	24	0336	3477.0–3486.5	209.5–219.0	9.5	2.25	24
26	24	0615	3486.5–3496.0	219.0–228.5	9.5	3.48	37
27	24	0725	3496.0–3505.5	228.5–238.0	9.5	1.40	15
28	24	0835	3505.5–3515.0	238.0–247.5	9.5	1.43	15
29	24	1000	3515.0–3519.5	247.5–252.0	4.5	0.65	14
30	24	1333	3519.5–3524.5	252.0–257.0	5.0	3.71	74
31	24	1942	3524.5–3533.5	257.0–266.0	9.0	2.14	24
32	25	0143	3533.5–3542.5	266.0–275.0	9.0	5.21	58
33	25	0556	3542.5–3551.5	275.0–284.0	9.0	3.74	42
34	25	1047	3551.5–3555.0	284.0–287.5	3.5	3.27	93
Total					287.5	142.07	49

throughout the unit, increasing in abundance downhole. Core 16 contains several patches and a 12-cm-thick layer of greenish gray vitric tuff.

The major component of Sub-unit 1b (Cores 17–20, 143–181 m) is also clay, but the sediments are more indurated and contain more siliceous microfossils than do those of Sub-unit 1a. The clay is grayish olive green to greenish gray and is moderately to intensely bioturbated. Cores 17 and 18 are diatomaceous and contain up to 50% diatoms. The remainder of the unit is claystone, with varying amounts of siliceous microfossils and a few thin layers of clayey nannofossil chalk. A few small patches of vitric and altered ash are also present. The sediment in this sub-unit is moderately well indurated. The boundary between Units 1 and 2 is located between Cores 20 and 21, where the microfossil abundance decreases and the claystone becomes distinctly more silty.

Unit 2: Silty and Sandy Claystones (181.0–248.1 m)

Unit 2 is composed of silty claystone, claystone, siltstone, sandstone, and minor porcellanite. The upper part of the unit is made up of intensely bioturbated grayish olive green to grayish green silty claystone. The silty component accounts for up to 40% of the sediment and is composed primarily of angular to subangular quartz (15–23%) and feldspar (2–6%), with traces of mica, heavy minerals, and volcanic ash. The silty claystone contains trace quantities of nannofossils and up to 2% pyritized siliceous microfossils.

Bouma sequences T_c, T_d, and T_e are represented in the lower portion of Unit 2 (Cores 26–28). The sandstones in these sequences have sharp basal contacts with the underlying laminated sediment. These sands are fine-grained and average about 1 cm thick. They contain about 60% angular to subangular quartz, 10% feldspar, lithic fragments (up to 5%), mica (up to 5%), and trace amounts of glauconite and heavy minerals, including pyrite. The sands grade upward to intensely bioturbated siltstone (Bouma T_d interval) and silty claystone (Bouma T_e interval). Bouma T_c, T_d, and T_e sequences are in aggregate about 25 cm thick in Core 26 and thin to about 15 cm in Cores 27 and 28.

Throughout Unit 2 some of the silty claystone is porcellaneous, and thin porcellanite intervals were recovered in Cores 24 and 27. The porcellanites have similar sedimentary structures and are the same color as the silty claystone in Unit 2. Some of the silty claystone in these sequences contains up to 20% altered ash. A few pieces of black silty claystone and silty sandstone occur in the diabase rocks at the base of Unit 2 (Core 29).

Igneous Rocks

Diabase (Cooling Unit 1) is the principal igneous rock recovered at Site 473 (Fig. 6). It is fine- to medium-grained, aphyric and massive, with chilled margins of glomeroporphyritic basalt at its upper and lower contacts. The boundaries of the chilled zones are gradational over about 1.5 meters, with grain size increasing gradually away from each contact. Otherwise the diabase is compositionally and texturally uniform, composed mainly of plagioclase, clinopyroxene, and minor opaque minerals. Greenish brown smectite is the common alteration mineral, filling vesicles as well as interstices between plagioclase laths and anhedral clinopyroxenes. Clay and calcite pseudomorphs after olivine occur occasionally. Calcite and clay also fill fractures. The texture of this diabase varies from intersertal to subophitic to intersertal.

The chilled margins (basalt) and a fine-grained interval of the diabase at about 268 meters have a glomeroporphyritic texture, with plagioclase and clinopyroxene phenocrysts set in an intersertal to subvariolitic groundmass. Clay and calcite pseudomorphs of olivine also occur with these phenocrysts. The groundmass consists of plagioclase microlites, equant clinopyroxenes, and opaque minerals set in an altered, clay-rich mesostasis. An increase in drilling rate between 275 and 279 meters may indicate a sedimentary layer between Cooling Units 1 and 2.

We tentatively distinguish a 10-cm-long piece of basalt (Cooling Unit 2) recovered from the base of Hole 473 from the overlying diabase solely on petrographic criteria: the basalt is less altered than is the diabase, and its texture and mineralogy are typical of tholeiitic basalts extruded on the ocean floor. This piece is dark gray, massive, and vesicular, the vesicles commonly filled with green clay. In thin section the texture is glomeroporphyritic, with plagioclase and clinopyroxene phenocrysts set in a hyalophitic groundmass. Brownish clay pseudomorphs of olivine occur together with the plagioclase and pyroxene. The groundmass is predominantly opaque, devitrified glass with minor skeletal plagioclase microlites and feathery clinopyroxenes. Although these quench morphologies suggest that the ba-

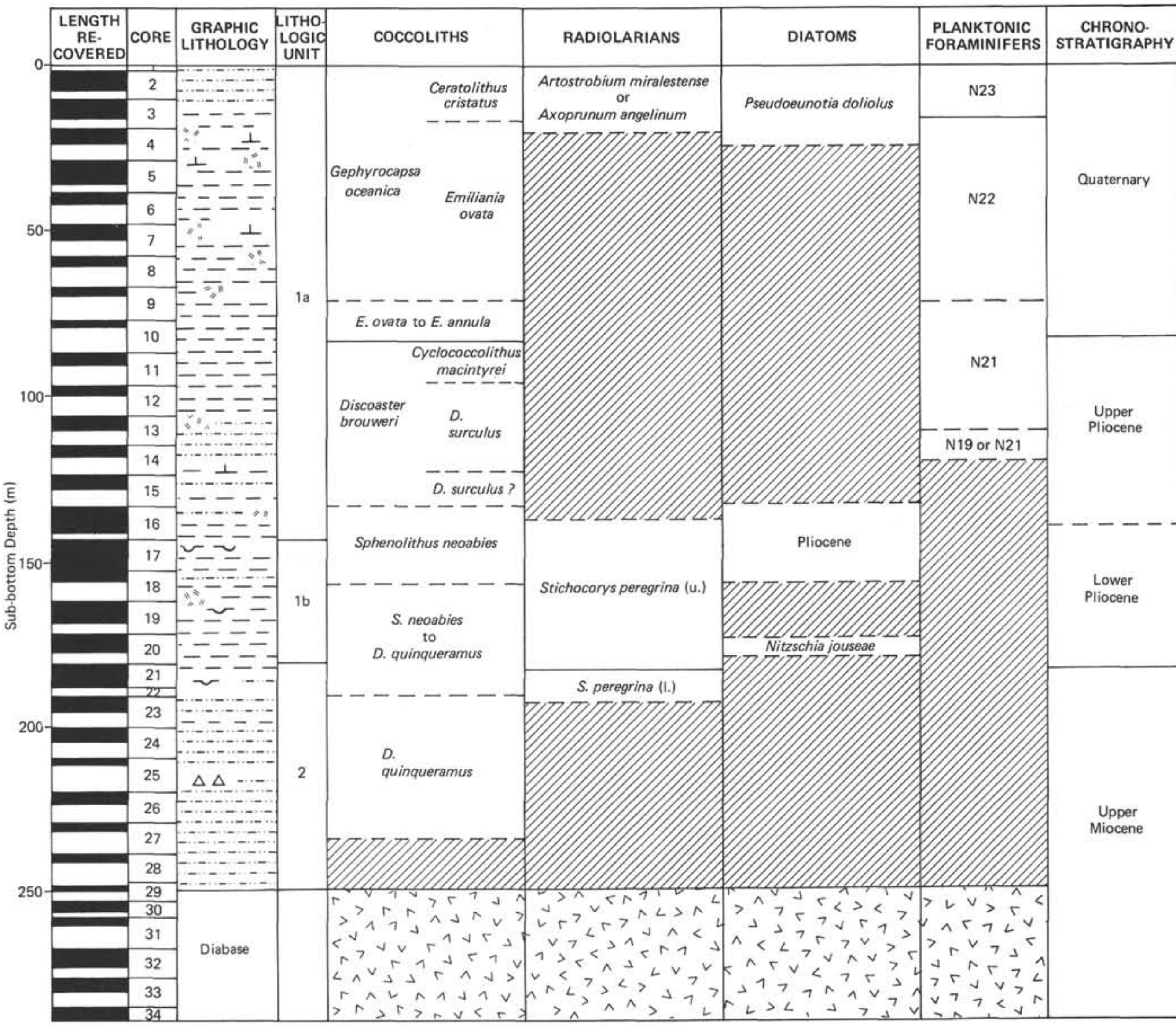

Figure 5. Lithologic and biostratigraphic summary, Site 473.

Table 2. Summary of lithologic units, Site 473.

Unit or Sub-unit	Core Number	Depth below Sea Floor (m)	Chronostratigraphy	Lithology
1a	1-16	0.0-143.0	Quaternary-lower Pliocene	Clay with minor amounts of silty clay and vitric and altered ash.
1b	17-20	143.0-181.0	lower Pliocene	Diatomaceous and calcareous claystone with minor amounts of claystone, silty diatomaceous sandstone, and minor vitric ash.
2	21-29	181.0-248.1	lower Pliocene-upper Pliocene	Silty claystone, claystone siltstone, silty quartzose sand, and minor porcellanite.

salt specimen is part of an extrusive pillow or flow, we recovered no glassy margins to support this inference. On the other hand, the overlying diabase is probably a sill, as suggested by the grain size that coarsens away from contacts, alteration of the overlying sediment, and the absence of pillow structures or quench morphologies.

BIOSTRATIGRAPHY

Upper Quaternary through upper Miocene sediments were recovered at Site 473. Rare to common calcareous nannofossils provide biostratigraphic control throughout the entire succession from Cores 1 through 27. Planktonic foraminifers are rare to common in the Quaternary section (Cores 1 through 10); below Core 10 they are mostly absent. Rare to common siliceous microfossils are present in the upper Quaternary (Cores 1 through 4) and in the lower Pliocene (Cores 16 through 20). Cores 28 and 29 are barren except for rare diatom fragments in Core 29.

The upper Quaternary (tropical *Pseudoeunotia doliolus* Zone) is indicated for Cores 1 through 4 on the basis of calcareous nannofossils and diatoms. The boundary between Quaternary and Pliocene is between Cores 10 and 11. Cores 11 through 15 can be assigned to the upper Pliocene, acording to coccoliths, but no

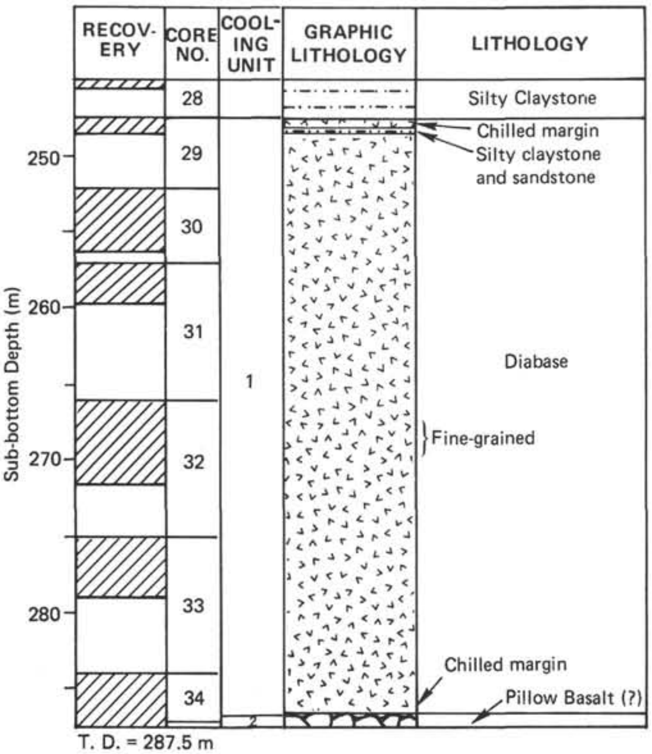

Figure 6. Igneous rock sequence at Site 473.

assemblages of the lower upper Pliocene *Discoaster tamalis* Subzone were found. Rare to common coccoliths (*Sphenolithus neoabies* Subzone), rare diatoms (*Nitzschia jouseae* Zone), and rare radiolarians (*Spongaster pentas* Zone) suggest that Cores 16 through 20 were deposited in the early Plicoene.

The boundary between Pliocene and Miocene is probably within the interval of Cores 21 and 22, according to the siliceous microfossils and coccoliths. Cores 23 through 27 are assigned to the upper Miocene (*Discoaster quinqueramus* Zone), which suggests that the sediment at the top of the diabase sill (Core 29) is about 2 m.y. old.

Figure 5 summarizes zone assignments for Hole 473; Figure 7 plots downhole variations in abundances of the microfossil groups.

Coccoliths

Hole 473 contains rare to common, poorly to moderately preserved Quaternary coccoliths in Cores 1 to 10 (0–86 m). The boundary between the upper Quaternary *Ceratolithus cristatus* Subzone and the *Emiliania ovata* Subzone (approximately 0.46 m.y. of age) lies between Cores 3 and 4. Preservation and abundance are worst in Cores 6 to 10 (38.5–86 m).

Upper Pliocene assemblages in Cores 11 to 15 (86–133.5 m) are sparse to few, with evident dissolution effects. No lower upper Pliocene *Discoaster tamalis* Subzone assemblages occur. The presence of *Ceratolithus rugosus* Bukry and Bramlette, *Reticulofenestra pseudoumbilica* (Gartner), and *Sphenolithus abies* Deflandre indicate that Cores 16 to 18 (133.5–162 m) were deposited in the early Pliocene. All three cores are tentatively assigned to the *Sphenolithus neoabies* Subzone because of the absence of younger *Discoaster tamalis* Kamptner and older *Amaurolithus* spp. The poor assemblages of Cores 19 to 22 and the lack of any *Amaurolithus* spp. in deeper cores make the duration of the *S. neoabies* Subzone and the placement of the Miocene/Pliocene boundary questionable.

Discoaster quinqueramus Gartner ranges through Cores 23 to 27 (190.5–238 m) and indicates either the upper upper Miocene *Discoaster quinqueramus* Zone (approximately 5.6–7 m.y.) or possibly reworking and redeposition by turbidite flows during the earliest Pliocene. An *in situ* occurrence of the *D. quinqueramus* Zone is favored, yielding an estimated age of 6 to 7 m.y. at the top of the diabase sill in Core 29. Core 28 is barren. Sediment recovered in diabase Core 30, Section 2 is barren as well.

Silicoflagellates

Silicoflagellates are sparse to few in upper Quaternary Cores 1 to 4 (0–29 m). The upper assemblages lack *Dictyocha aculeata* (Lemmermann), but it occurs in Core 4 without *Mesocena quadrangula* Ehrenberg ex Haeckel, thus indicating the *Dictyocha aculeata* Zone. Cores 5 to 15 (29–133.5 m) are barren. Lower Pliocene Cores 16 to 18 (133.5–162 m) contain few to common *Dictyocha* sp. aff. *D. perlaevis* Frenguelli, and few *D. brevispina* (Lemmermann), *Distephanus speculum* (Ehrenberg), and *D. boliviensis* (Frenguelli). Silicoflagellates are most common in Sample 16,CC and are absent in Pliocene and upper Miocene Cores 19 to 29. Elongate and panicoid opal phytoliths from terrestrial grasses occur in Cores 1, 3, 4, 9, 10, 11, and 16.

Radiolarians

Rare to common, poorly to moderately preserved upper Quaternary radiolarians were recovered from Cores 1 through 4. Cores 5 through 16 are barren or contain only very rare, mainly nondiagnostic radiolarians. Core 17 through Core 21, Section 1 yielded rare to abundant, poorly to well preserved lower Pliocene radiolarian assemblages. Rare and poorly preserved radiolarians from Core 21, Section 3 through Core 23, Section 3 indicate deposition in the late Miocene. Cores 24 through 28 are barren.

Samples 473-1,CC through 473-4,CC contain a mixed radiolarian assemblage composed of the typical equatorial species *Amphirhopalum ypsilon, Anthocyrtidium angulare, Ommatartus tetrathalamus, Pterocanium praetextum, Spongaster tetras, Theocorythium trachelium*, and *T. vetulum*, and of the northeast Pacific coldwater species *Lamprocyrtis haysi, L. neoheteroporos*, and *L. heteroporos*. According to Dinkelman (1973), the presence of *A. angulare* and *T. vetulum* suggests deposition in the early Quaternary, because both these species are assumed to be restricted to the basal Quaternary *A. angulare* Zone. In addition, *Collosphaera tuberosa* and *Buccinosphaera invaginata*, which make their earliest appearance in upper Quaternary sediments, are absent. Nannofossils, diatoms, and *L. haysi*

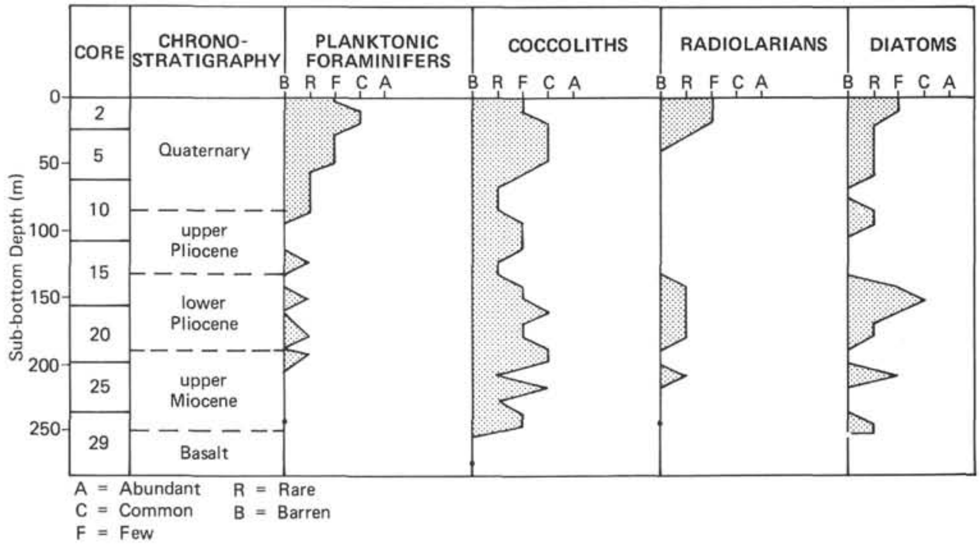

Figure 7. Plots of abundances of planktonic microfossils at Site 473.

indicate, however, deposition in the late Quaternary for Cores 1 through 4. Consequently, *A. angulare* and *T. vetulum* could not have become extinct during the early Quaternary but would have continued until the late Quaternary (0.45–0.7 m.y. ago). This means that the radiolarian zonation of the equatorial Quaternary cannot be used in the region of Site 473.

Sediments in Core 16, Section 1 through Core 21, Section 1 are assigned to the lower Pliocene (upper part of *Stichocorys peregrina* Zone), because this interval yielded rare to abundant individuals of *S. peregrina* and some rare specimens of (?)*Spongaster pentas, Ommatartus tetrathalamus, O. penultimus*, and *Lamprocyrtis heteroporos*. The boundary between the upper Miocene and lower Pliocene (i.e., between the lower and the upper part of the *S. peregrina* Zone) is placed beneath the first appearance of *L. heteroporos* (Section 21-1). The upper upper Miocene succession is part of the lower *S. peregrina* Zone, because it contains sporadic *S. peregrina* and *O. penultimus* (Section 21-3 through Section 23-3).

Diatoms

Rare to few diatoms in Cores 1 through 4 at Site 473 are assigned to the upper Quaternary, tropical *Pseudoeunotia doliolus* Zone because of the presence of *P. doliolus* and *Nitzschia marina* and the absence of *N. reinholdii*. Diatoms are rare or absent in Cores 5 through 15, although one specimen of the silicoflagellate *Distephanus boliviensis pentagonus* in Sample 473-10,CC suggests deposition in the late Miocene to the Pliocene. Rare freshwater diatoms, including *Stephanodiscus* sp., *Melosira granulata*, and fresh-water pennate diatoms in Sample 473-10,CC, may have been wind blown. Pliocene diatoms, including *Cussia* sp., *Nitzschia reinholdii, Thalassiosira convexa* var. *aspinosa*, and *T. oestrupii*, are rare in Cores 16 through 18. A well-preserved lower Pliocene diatom assemblage of the tropical *Nitzschia jouseae* Zone occurs in Sample 473-20-6, 52–54 cm; *Nitzschia jouseae, N. reinholdii, T. convexa* var. *aspinosa*, and *T. nativa* are among the diatoms present. Diatoms are absent or represented by pyritized fragments of *Coscinodiscus* spp. in the lower parts of Hole 473 (Cores 21 through 29).

Foraminifers

Planktonic foraminifers are rare to common and moderately well preserved in the Quaternary to uppermost Pliocene section (Cores 1 through 10) of Hole 473. *Neogloboquadrina dutertrei, Globigerinoides sacculifer, G. ruber, Orbulina universa*, and keeled *Globorotalia* are usual constituents of the assemblages of this interval.

Below Core 10, foraminifers are rare or absent and, with the exception of *Globoquadrina altispira* and *Sphaeroidinellopsis seminulina* in Sample 473-14,CC, no stratigraphically diagnostic taxa were encountered.

SEDIMENT ACCUMULATION RATES

Selected coccolith (C) and radiolarian (R) events were used to construct the sediment accumulation rate curve for Site 473 (Fig. 8).

The plot indicates accumulation rates of about 40 m/m.y. for the Quaternary into the Pliocene and about 20 m/m.y. for the early Pliocene and late Miocene. A short hiatus may be present in the Pliocene between Cores 15 and 16.

GEOCHEMICAL MEASUREMENTS

Interstitial Water

The salinity, chlorinity, alkalinity, *p*H, and calcium and magnesium contents of five interstitial water samples from Site 473 were determined on board (Fig. 9). An alkalinity maximum occurs at 60 meters depth; upon opening, cores from this depth had a faint odor of H_2S, and the sediments contained abundant pyrite spots and streaks as well as pyritized diatoms and radio-

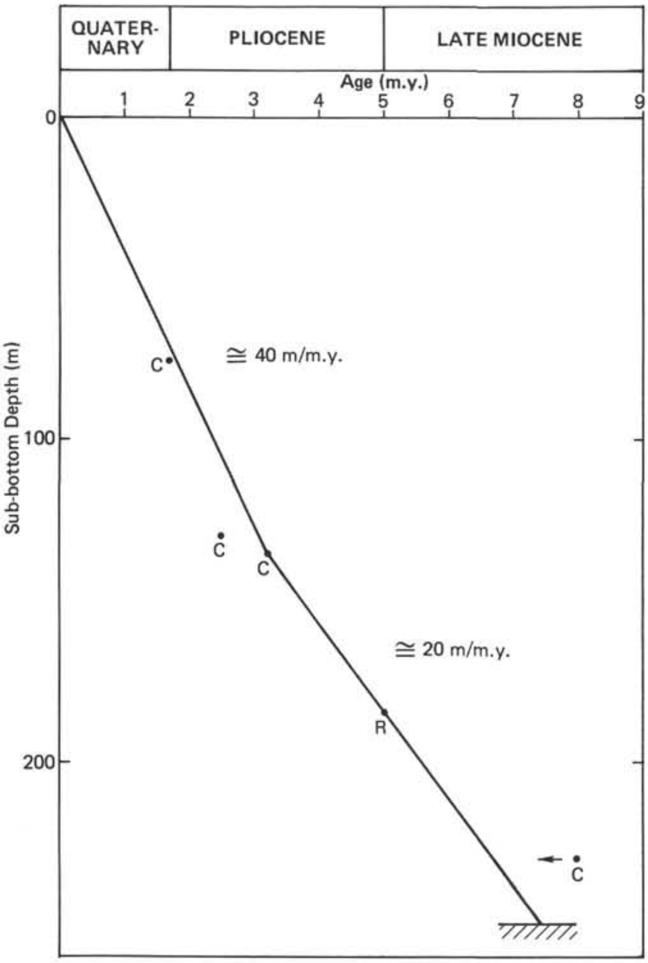

Figure 8. Sediment accumulation rates, Site 473.

larians. The alkalinity maximum may, therefore, reflect sulfate reduction in the sediments. The calcium content increases downcore, whereas the magnesium content decreases (as is common in the slowly accumulating terrigenous sediments cored in previous sites on this leg). An inflection in the magnesium concentration profile in the direction of magnesium removal from interstitial water occurs at the same depth as the alkalinity maximum.

Calcium Carbonate Content

The calcium carbonate contents of Site 473 samples were measured on board by the carbonate-bomb technique. The results of these determinations are included in the core descriptions in this chapter and plotted in Figure 10. The sediments at the site are dominated by terrigenous clay and silt, and the carbonate content of all sediments at the site is very low—0% to 8%.

PHYSICAL PROPERTIES AND DOWNHOLE LOGS

Figure 10 summarizes the physical-properties data for Site 473. Saturated bulk density is constant (~1.5 g/cm³) down to about 100 meters, then increases steadily to about 1.7 g/cm³ just above the igneous rocks. The altered diabase has an average density of 2.79 g/cm³. The velocity profile is similar to the density curve. Velocity is low (about 1.5 km/s) for the upper 150 meters, increasing to about 2.0 km/s just above the diabase. An anomalous zone at 190 to 220 meters, having velocities in the range 2.0 to 2.5 km/s, corresponds to an interval of common sandy and porcellaneous layers. The partial Velocity Log obtained in this hole (not shown in Fig. 10) records mostly water velocities, because the hole was washed out. However, several intervals at 192 to 196 meters and 202 to 208 meters that are not washed out have velocities near 1.6 to 1.7 km/s. The average velocity of the diabase from sample measurements is 5.1 km/s. Table 3 lists the average velocities and impedance contrasts for the lithologic units at this site.

Figure 11 displays the results of five heat-flow-probe runs made with the U/K probe at Site 473. The temperature recorded at a depth of 143 meters is fairly constant, except for a slight increase caused by frictional heating produced by lowering the pipe and probe. This appears to be the most reliable measurement. Runs at 67, 105, 181.5, and 219 meters show nonlinear increases of temperature with time. These warming curves indicate an increase in probe temperature with time toward a stable maximum value. The run at 219 meters has several anomalous points corresponding to frictional heating associated with lowering the pipe. A plot of temperature versus depth (Fig. 12) shows that the three measurements at 67, 143, and 181.5 meters define a linear gra-

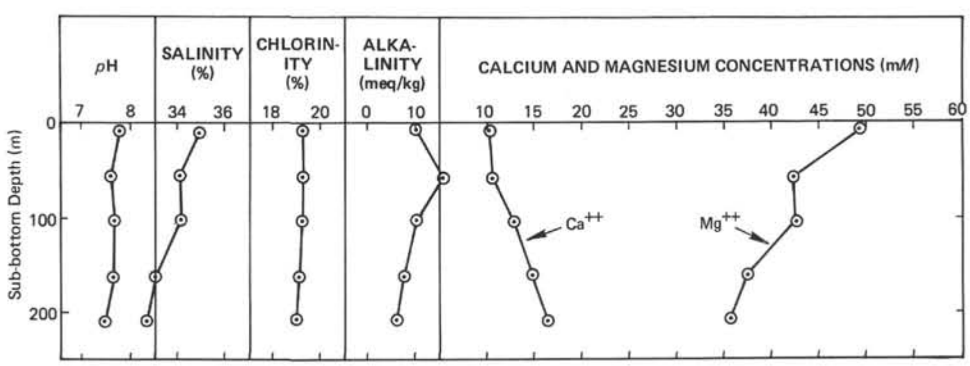

Figure 9. Interstitial water profiles, Site 473.

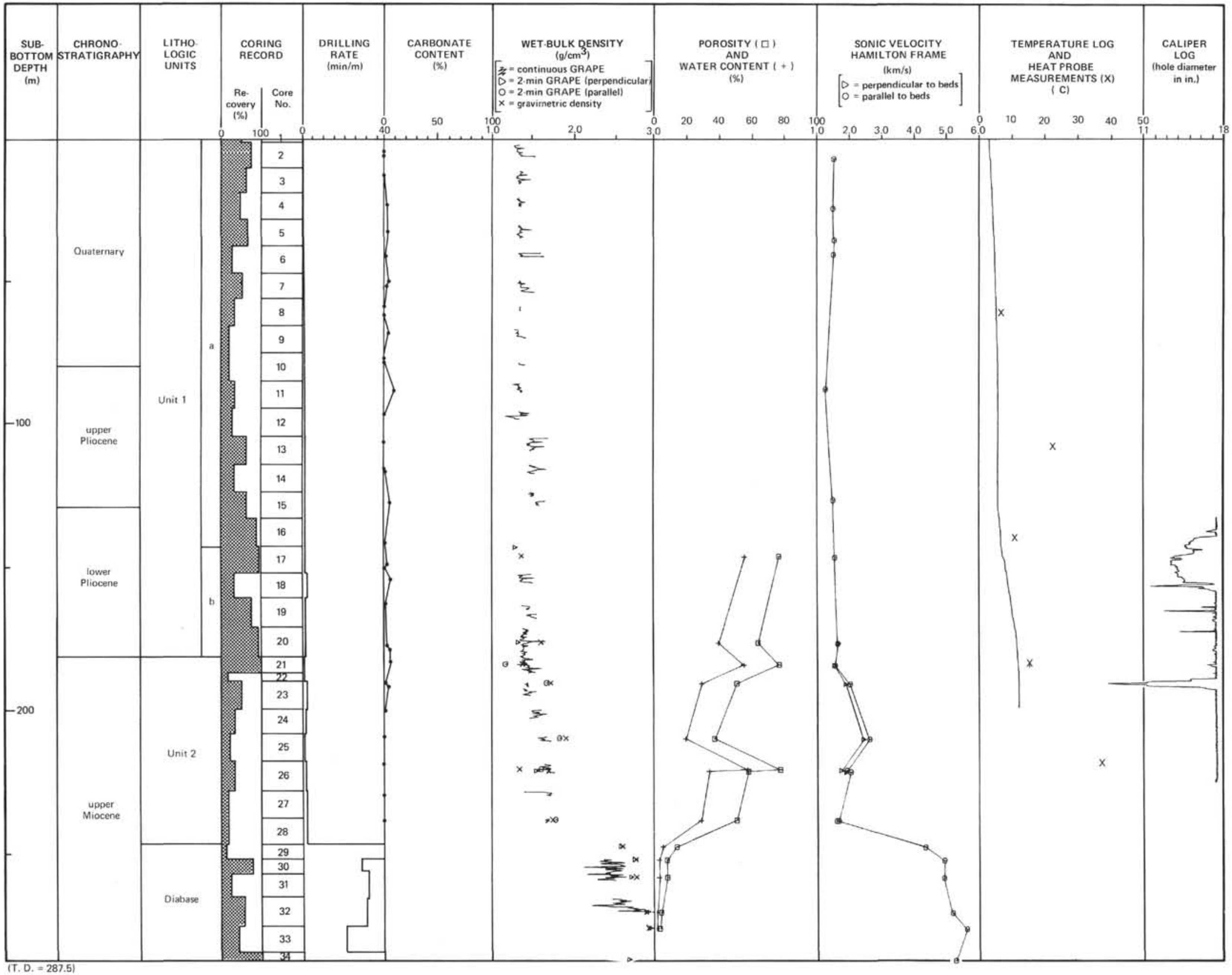

Figure 10. Summary of physical properties and downhole logs, Site 473.

Table 3. Summary of densities, velocities, and impedance contrasts for Site 473.

Lithologic Unit or Sub-unit	Sub-bottom Depth Interval (m)	Average Density (g/cm^3)	Average Velocity (km/s)	Impedance Contrast
1a	0–143	1.53	1.51	
1b	143–181	1.49	1.62	0.02
2	181–248	1.73	1.98	0.19
"Diabase"	248–T.D.	2.79	5.21	0.61

dient of 64°C/km. The two measurements at 105 and 219 meters yield temperatures that appear to be anomalously high. The measurement at 219 meters is suspect because of the steep decay curve and discontinuous breaks probably associated with frictional heat produced by lowering the pipe. The measurement at 105 meters, on the other hand, appear to be reliable; frictional heating may also be the cause of this anomalously high value, but we cannot eliminate it with certainty. The most reliable measurements appear to be at 67 and

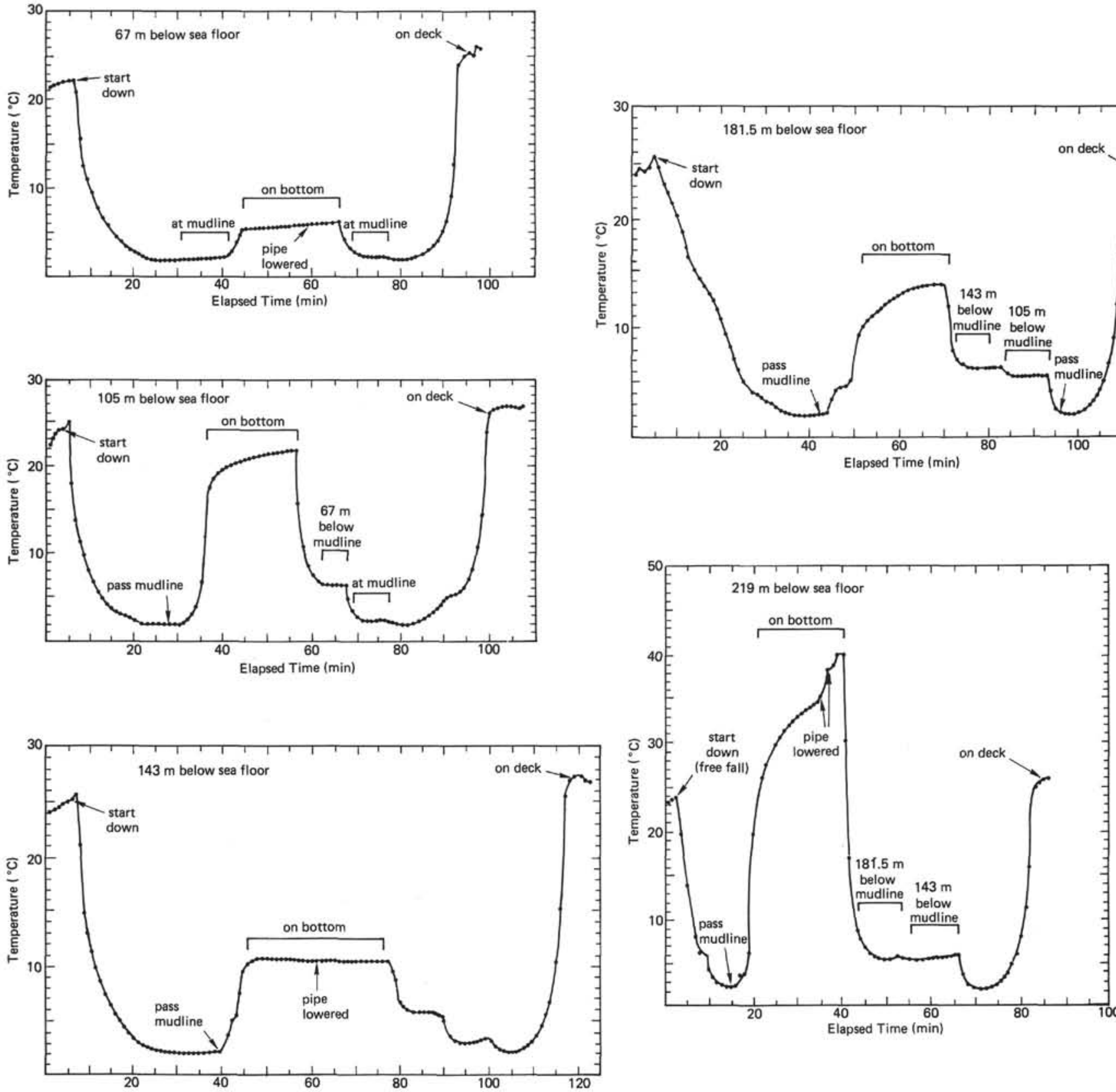

Figure 11. Heat-flow-probe runs at Site 473.

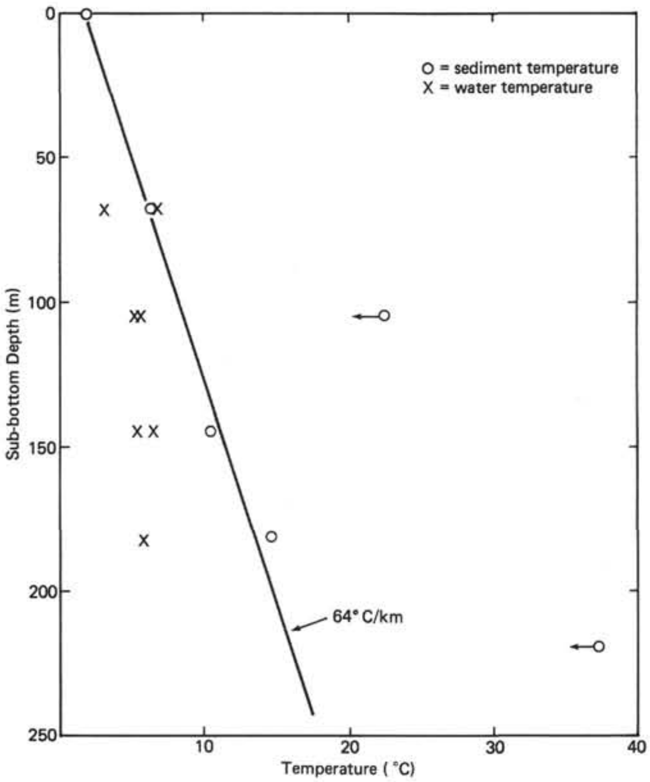

Figure 12. Estimated thermal gradient at Site 473 from heat-flow-probe temperatures (water and sediment values).

143 meters, where decay curves are quite flat. We favor these values and the similarity of the water-temperature measurements and thus suggest that the line in Figure 12 represents a true linear gradient of 64°C/km.

The partial Temperature Log does not help resolve the apparent anomalous temperatures suggested by the heat-probe measurements, because we were able to run the tool in only 50 meters of open hole. This profile shows a low gradient of 16°C/km for the first 100 meters in the hole (in pipe) (Fig. 10). The gradient increases sharply below this in the open hole to about 126°C/km. The tool rested on a ledge in the constricted part of the hole at 185 meters for about 5 min. before we retrieved it. The stable temperature after this time was 13.2°C. The water temperature measured earlier at 181.5 meters with the heat-flow probe was 5.5°C (Figs. 11 and 12). Using 2°C as the temperature at the top of the hole and 13.2°C at 185 meters, the computed linear geothermal gradient is 61°C/km, quite similar to the 64°C/km gradient estimated from the probe values (Figure 12).

Because we made no thermal-conductivity measurements of the material recovered at Site 473, we can only estimate heat flow. Using a gradient of 64°C/km and an assumed conductivity of 2.1 mcal/cm s °C, the estimated heat flow at Site 473 is about 1.3 HFU.

CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

The correlation of the stratigraphic column and the seismic-reflection profile obtained on the *Glomar Challenger's* approach to Site 473 (Fig. 4) is shown in Figure 13. The seismic profile shows an upper transparent acoustic unit that consists of very weak, discontinuous reflectors. Underlying this transparent unit is a lower acoustic unit characterized by closely spaced and somewhat more continuous reflectors.

The upper acoustic unit (0–0.19 s sub-bottom) correlates well with the Quaternary to Pliocene clay and silty clay that make up Lithologic Sub-unit 1a. The homogeneous lithology and the lack of any indurated beds within this unit probably account for its transparent character. The lower, more reflective acoustic unit correlates with Lithologic Sub-unit 1b and Unit 2, which consist of moderately well indurated diatomaceous and calcareous claystone and sand–silt–clay turbidite sequences. The top of acoustic basement, which has a hummocky surface marked by a pair of strong reflectors, correlates with the diabase recovered at Site 473.

CONCLUSIONS

1. The paleontological age of the basal sediments overlying diabase and basalt is approximately 6.5 m.y. and is no older than 8 m.y., as indicated by the presence of the *Discoaster quinqueramus* Zone. This age is in agreement with that indicated by magnetic anomalies (Larson et al., 1968).

2. The sediment section is unexpectedly terrigenous in spite of its pelagic appearance on reflection profiles. Silts and sands in Cores 26 through 29 in the lower part of the section are distal turbidites with Bouma T_c and T_d and T_c, T_d, and T_e sequences. At present, the site is isolated from land by the Middle America trench, the East Pacific Rise crest, and a depression at the foot of the Tres Marias escarpment (Fig. 3). Clays in the upper part of the hole could have been derived by nepheloid transport across depressions. But the presence of turbidites near the base of the section must indicate greater accessibility to land areas, perhaps to the north, when the gulf was much narrower than it is today.

3. Sedimentation rates are estimated as 20 m/m.y. in the lower part of the hole and 40 m/m.y. in the upper part. This is surprising, because the coarser-grained sediments are concentrated in the lower part of the hole where sedimentation rates are lower. The lower rates may reflect greater compaction of the older, more lithified strata. These rates are somewhat speculative, however, because of poor fossil control resulting from dilution by terrigenous material.

4. The sediments are underlain by about 39 meters of massive, homogeneous, and extensively altered diabase showing quenched margins near the contact with sediments. An increase in drilling rate between 275 and 279 meters (Fig. 10) may reflect the presence of sediments in this interval. Pillow basalt was recovered from the base of the hole, suggesting that the diabase is underlain by flows.

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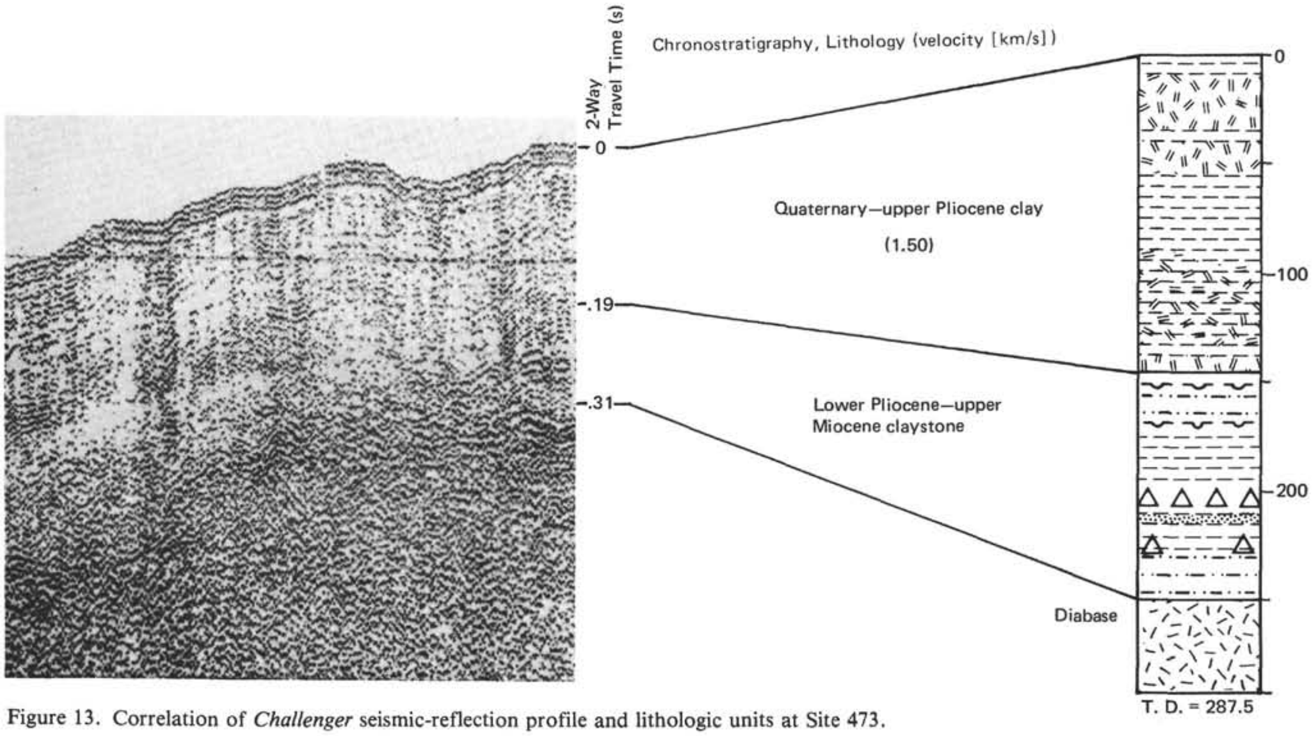
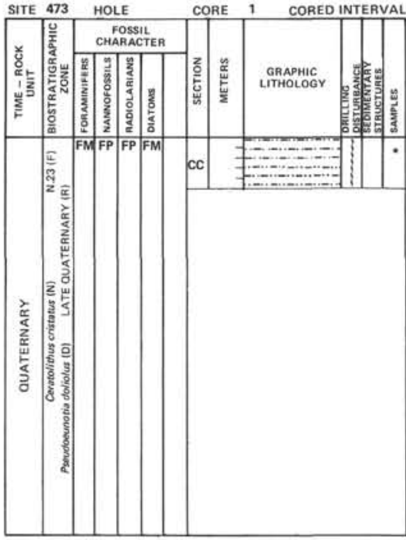


Figure 13. Correlation of *Challenger* seismic-reflection profile and lithologic units at Site 473.

SITE 473 HOLE CORE 1 CORED INTERVAL 0.0–0.5 m



LITHOLOGIC DESCRIPTION

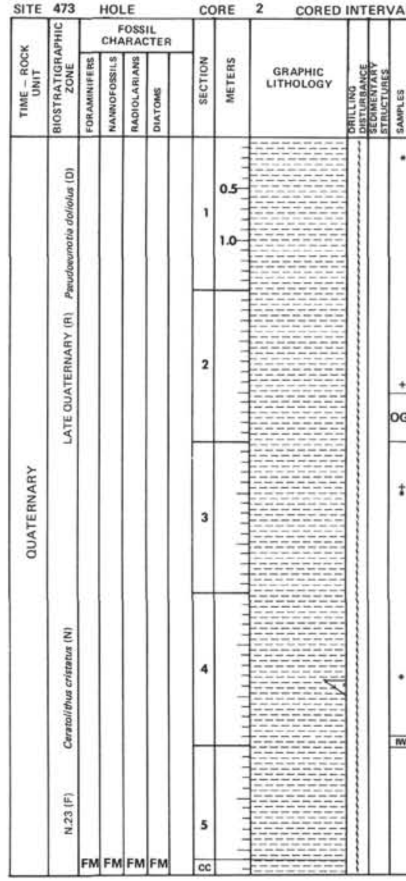
SILTY CLAY, grayish olive (10Y 4/2) to olive gray (5Y 3/2). Intense drilling deformation.

Core-Catcher only.

SMEAR SLIDE SUMMARY

	CC-13 (D)
TEXTURE:	
Sand	–
Silt	15
Clay	85
COMPOSITION:	
Quartz	5
Feldspar	2
Mica	TR
Heavy minerals	TR
Clay	80
Volcanic glass	1
Pyrite	2
Carbonate unspec.	TR
Foraminifers	TR
Calc. Nannofossils	2
Diatoms	4
Radiolarians	1
Silicoflagellates	2

SITE 473 HOLE CORE 2 CORED INTERVAL 0.5–10.0 m



LITHOLOGIC DESCRIPTION

CLAY, grayish olive (10Y 4/2) with some light olive gray (5Y 5/2) mottles. Patch of olive gray (10Y 4/2) **VITRIC ASH** in Section 4. Scattered faint pyrite-rich streaks and patches throughout. Intense drilling deformation.

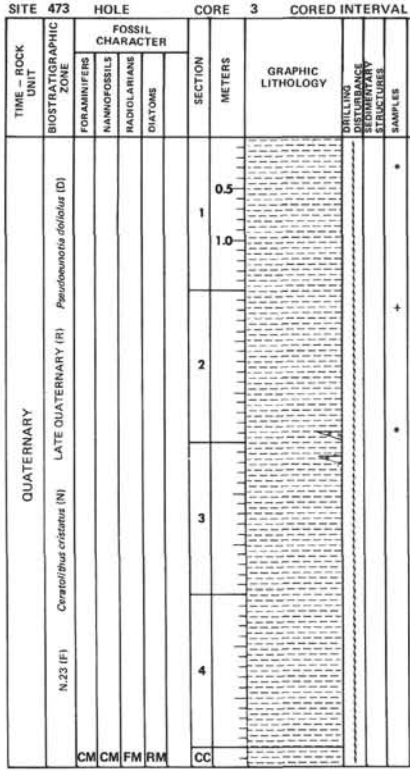
ORGANIC CARBON AND CARBONATE

	2-98	3-50
% Organic Carbon	1.69	–
% $CaCO_3$	0	0

SMEAR SLIDE SUMMARY

	1-20 (D)	3-51 (D)	4-88 (M)
TEXTURE:			
Sand	–	–	–
Silt	17	18	90
Clay	83	82	10
COMPOSITION:			
Quartz	5	5	–
Feldspar	3	2	–
Mica	TR	TR	TR
Heavy minerals	TR	TR	TR
Clay	80	80	9
Volcanic glass	1	–	90
Glauconite	–	TR	–
Pyrite	2	5	–
Carbonate unspec.	TR	TR	–
Foraminifers	TR	TR	–
Calc. Nannofossils	1	2	–
Diatoms	3	3	–
Radiolarians	1	TR	1
Sponge spicules	TR	TR	–
Silicoflagellates	2	2	–
Fish Remains	–	TR	–

SITE 473 HOLE CORE 3 CORED INTERVAL 10.0–19.5 m



LITHOLOGIC DESCRIPTION

CLAY, olive gray (10Y 4/2) and homogeneous. Several patches of light gray (N7) **VITRIC ASH** in Sections 2 and 3. Scattered dark pyrite-rich streaks throughout. Intense drilling deformation.

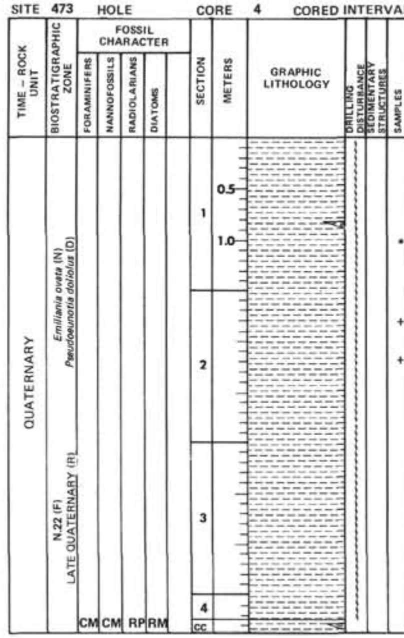
ORGANIC CARBON AND CARBONATE

	2-20
% Organic Carbon	–
% $CaCO_3$	0

SMEAR SLIDE SUMMARY

	1-30 (D)	2-143 (M)
TEXTURE:		
Sand	–	–
Silt	17	90
Clay	83	10
COMPOSITION:		
Quartz	3	1
Feldspar	2	2
Mica	TR	–
Heavy minerals	TR	–
Clay	80	–
Volcanic glass	1	97
Pyrite	1	–
Foraminifers	1	–
Calc. Nannofossils	3	–
Diatoms	5	–
Radiolarians	2	–
Sponge spicules	TR	–
Silicoflagellates	2	–
Apatite	–	TR
Hornblende	–	TR

SITE 473 HOLE CORE 4 CORED INTERVAL 19.5–29.0 m



LITHOLOGIC DESCRIPTION

CLAY, grayish olive (10Y 4/2) and homogeneous small patches of light gray (N7) **VITRIC ASH** in Section 1 and CC. Scattered dark pyrite-rich streaks throughout. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	2-35	2-70
% Organic Carbon	–	1.36
% $CaCO_3$	1	3

SMEAR SLIDE SUMMARY

	1-103 (D)
TEXTURE:	
Sand	–
Silt	15
Clay	85
COMPOSITION:	
Quartz	4
Feldspar	2
Clay	20
Volcanic glass	2
Pyrite	2
Carbonate unspec.	TR
Foraminifers	TR
Calc. Nannofossils	15
Diatoms	2
Radiolarians	1
Sponge spicules	TR
Silicoflagellates	2

SITE 473 HOLE CORE 5 CORED INTERVAL 29.0–38.5 m

TIME – ROCK UNIT: QUATERNARY

BIOSTRATIGRAPHIC ZONE: *Emiliania ovata* (N); N.22 (F)

FOSSIL CHARACTER: FORAMINIFERS FM; NANNOFOSSILS CM; RADIOLARIANS B; DIATOMS RM

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

LITHOLOGIC DESCRIPTION

CLAY, grayish olive (10Y 4/2), homogeneous, with scattered olive black (5Y 2/1), pyrite-rich streaks and patches. Several patches of dark and light gray (N3 and N7) **VITRIC ASH** in Section 2. Darker ash contains significant pyrite. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	2-70
% Organic Carbon	–
% $CaCO_3$	4

SMEAR SLIDE SUMMARY

	1-80 (D)	2-120 (M)
TEXTURE:		
Sand	–	–
Silt	13	100
Clay	87	–
COMPOSITION:		
Quartz	3	5
Feldspar	2	3
Mica	TR	–
Heavy minerals	TR	–
Clay	72	–
Volcanic glass	1	80
Pyrite	1	12
Carbonate unspec.	TR	–
Foraminifers	5	–
Calc. Nannofossils	15	–
Diatoms	1	–
Radiolarians	TR	–
Sponge spicules	TR	–
Silicoflagellates	TR	–

SITE 473 HOLE CORE 6 CORED INTERVAL 38.5–48.0 m

TIME – ROCK UNIT: QUATERNARY

BIOSTRATIGRAPHIC ZONE: *Emiliania ovata* (N); N.22 (F)

FOSSIL CHARACTER: FORAMINIFERS FM; NANNOFOSSILS CP; RADIOLARIANS B; DIATOMS RM

SECTION: 1, 2, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

VOID

LITHOLOGIC DESCRIPTION

CLAY, medium olive gray (5Y 4/2), homogeneous. Scattered pyrite-rich streaks throughout. Patch of light gray (N7) **VITRIC ASH** in Section 1. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	1-90	2-90
% Organic Carbon	–	1.14
% $CaCO_3$	1.5	2

SMEAR SLIDE SUMMARY

	1-40 (D)	1-50 (D)
TEXTURE:		
Sand	–	–
Silt	13	15
Clay	87	85
COMPOSITION:		
Quartz	3	6
Feldspar	2	2
Mica	TR	TR
Heavy minerals	TR	TR
Clay	75	72
Volcanic glass	1	1
Pyrite	1	TR
Foraminifers	2	–
Calc. Nannofossils	12	16
Diatoms	2	TR
Radiolarians	TR	TR
Sponge spicules	TR	TR
Silicoflagellates	2	2

SITE 473 HOLE CORE 7 CORED INTERVAL 48.0–57.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	*Emiliania ovata* (N)					1	0.5, 1.0				
						2					‡ • OG
						3					IW
	N.22 (F)					4					
		RM				CC		VOID			

LITHOLOGIC DESCRIPTION

CLAY, medium olive gray (5Y 4/2) with mottled medium dark gray (N4) to medium grayish olive (10Y 5/2) pyrite-rich streaks and patches. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	2-94	2-96
% Organic Carbon	–	1.38
% $CaCO_3$	4	3

SMEAR SLIDE SUMMARY

	2-85 (D)
TEXTURE:	
Sand	–
Silt	5
Clay	95
COMPOSITION:	
Quartz	6
Feldspar	1
Mica	1
Heavy minerals	TR
Clay	80
Pyrite	1
Carbonate unspec.	2
Foraminifers	2
Calc. Nannofossils	6
Diatoms	TR
Radiolarians	TR
Sponge spicules	1

SITE 473 HOLE CORE 8 CORED INTERVAL 57.5–67.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	*Emiliania ovata* (?) (N)					1	0.5, 1.0	VOID			•
						2					+ +
	N.22 (F)					3					
		RM	RP	B	B	CC					

LITHOLOGIC DESCRIPTION

CLAY, medium olive gray (5Y 4/2) with some greenish gray mottles (5G 6/1). Several small patches of very light gray (N8) **VITRIC ASH** at base of core. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	2-123	2-130
% Organic Carbon	–	1.14
% $CaCO_3$	0	0

SMEAR SLIDE SUMMARY

	1-50 (D)
TEXTURE:	
Sand	–
Silt	9
Clay	91
COMPOSITION:	
Quartz	4
Feldspar	2
Mica	TR
Heavy minerals	TR
Clay	84
Volcanic glass	TR
Carbonate unspec.	2
Foraminifers	1
Calc. Nannofossils	7
Radiolarians	TR
Sponge spicules	TR

SITE 473 HOLE CORE 9 CORED INTERVAL 67.0–76.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	*Emiliania ovata* (N)					1	0.5, 1.0				+ •
	N.22 (F)					2					
		RM	RP	B	B	CC					

LITHOLOGIC DESCRIPTION

CLAY, dark greenish gray (5GY 4/1) with medium dark gray (N4) mottles. Scattered patches of **VITRIC ASH** *throughout. Intense drilling deformation.*

ORGANIC CARBON AND CARBONATE

	1-70
% Organic Carbon	–
% $CaCO_3$	3

SMEAR SLIDE SUMMARY

	1-121 (D)
TEXTURE:	
Sand	–
Silt	8
Clay	92
COMPOSITION:	
Quartz	5
Feldspar	TR
Mica	TR
Heavy minerals	TR
Clay	92
Pyrite	2
Carbonate unspec.	1
Calc. Nannofossils	TR
Sponge spicules	TR

SITE 473 HOLE CORE 10 CORED INTERVAL 76.5–86.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	N.22(?) (F) QUATERNARY(?) (N)					1	0.5, 1.0				‡
						2					•
		FM	RP	B	RP	CC					

LITHOLOGIC DESCRIPTION

CLAY, dark greenish gray (5GY 4/1) to medium olive gray (5Y 4/2) intensely mottled with streaks of medium dark gray (N4). Minor patches of **VITRIC ASH** in Section 1. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	1-30	1-32
% Organic Carbon	–	1.09
% $CaCO_3$	0	0

SMEAR SLIDE SUMMARY

	2-50 (D)
TEXTURE:	
Sand	–
Silt	10
Clay	90
COMPOSITION:	
Quartz	3
Feldspar	TR
Mica	TR
Clay	90
Volcanic glass	2
Pyrite	TR
Carbonate unspec.	3
Foraminifers	2
Calc. Nannofossils	TR
Radiolarians	TR
Sponge spicules	TR

SITE 473 HOLE CORE 11 CORED INTERVAL 86.0–95.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	*Cyclococcolithia macintyrei* (N)		RP			1	0.5, 1.0				•	
			RP			2					+	
			FP	B	RP	CC						

CLAY, olive gray (5Y 3/2), mottled with medium greenish gray (5G 5/1) streaks. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	2-38
% Organic Carbon	–
% $CaCO_3$	8

SMEAR SLIDE SUMMARY

	1-106 (D)
TEXTURE:	
Sand	–
Silt	6
Clay	94
COMPOSITION:	
Quartz	4
Feldspar	1
Mica	1
Heavy minerals	TR
Clay	91
Pyrite	1
Calc. Nannofossils	1
Sponge spicules	TR

SITE 473 HOLE CORE 12 CORED INTERVAL 95.5–105.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	*Discoaster surculus* (N)					1	0.5, 1.0				•, ++, OG	
						2		VOID				
			FP	B	B	CC						

CLAY, olive gray (5Y 3/2) with medium greenish gray (5G 5/1) mottles throughout. Intense drilling deformation.

SMEAR SLIDE SUMMARY

	1-60 (D)
TEXTURE:	
Sand	–
Silt	7
Clay	93
COMPOSITION:	
Quartz	3
Feldspar	TR
Mica	TR
Heavy minerals	TR
Clay	92
Volcanic glass	2
Pyrite	1
Foraminifers	1
Calc. Nannofossils	1
Sponge spicules	TR
Silicoflagellates	TR

SITE 473 HOLE CORE 13 CORED INTERVAL 105.0–114.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	*Discoaster surculus* (N)					1	0.5, 1.0				+, •	
						2						
						3					IW	
	N.21? (F)					4		VOID	O			
		FM	FP	B	B	CC						

CLAY, dark greenish gray (5GY 3/1), mottled with patches of **CLAYEY SILT** and **VITRIC ASH** as marked. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	1-90
% Organic Carbon	–
% $CaCO_3$	0

SMEAR SLIDE SUMMARY

	1-120 (M)
TEXTURE:	
Sand	10
Silt	48
Clay	42
COMPOSITION:	
Quartz	30
Feldspar	7
Mica	1
Heavy minrals	4
Volcanic glass	2
Glauconite	TR
Pyrite	3
Plant debris	2
Lithic fragments	10

SITE 473 HOLE CORE 14 CORED INTERVAL 114.5–124.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	SAMPLES	
UPPER PLIOCENE	*Discoaster surculus* (N)		B			1	0.5, 1.0	•, +, •	Calcareous
						2		+, •	Altered ash?
	N.21(?) (F)					3			
		RM	RP	B	B	CC			

LITHOLOGIC DESCRIPTION

CLAY, dark greenish gray (5GY 4/1), slightly calcareous in places. Interval 93–104 cm in Section 2 is dark greenish gray clay formed by alteration of vitric ash. Intense drilling deformation.

ORGANIC CARBON AND CARBONATE

	1-90	2-30
% Organic Carbon	–	0.56
% $CaCO_3$	0	0

SMEAR SLIDE SUMMARY

	1-60 (D)	1-140 (M)	2-96 (M)
TEXTURE:			
Sand	–	–	–
Silt	15	20	10
Clay	85	80	90
COMPOSITION:			
Quartz	7	3	1
Feldspar	5	2	3
Mica	TR	TR	TR
Heavy minerals	TR	TR	TR
Clay	85	80	90
Volcanic glass	1	TR	TR
Pyrite	2	TR	5
Zeolite	–	–	1
Carbonate unspec.	–	15	–
Calc. Nannofossils	TR	TR	–
Diatoms	TR	–	–
Plant debris	TR	–	–
Lithic fragments	TR	–	–

SITE 473 HOLE CORE 15 CORED INTERVAL 124.0–133.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	SAMPLES	
UPPER PLIOCENE	*Discoaster brouweri*(?) (N)					1	0.5, 1.0	•	Calcareous patch
						2			
						3		•, +	
						4		•	Altered ash(?)
			RP	B	B	CC			

LITHOLOGIC DESCRIPTION

CLAY, dark greenish gray (5GY 4/1) with scattered patches of light olive gray (5Y 5/2) to grayish blue green (5BG 5/2) clay. Interval 44–66 cm in Section 6 is clay containing some volcanic glass, possibly an altered ash. Intense drilling deformation.

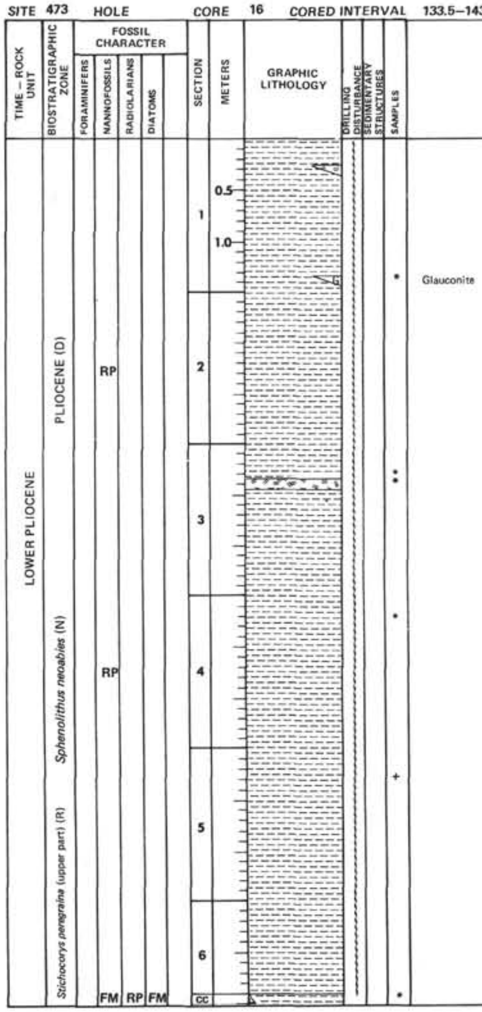
ORGANIC CARBON AND CARBONATE

	3-110
% Organic Carbon	–
% $CaCO_3$	2

SMEAR SLIDE SUMMARY

	1-145 (M)	3-50 (D)	4-54 (D)
TEXTURE:			
Sand	–	–	–
Silt	40	6	15
Clay	57	94	85
COMPOSITION:			
Quartz	2	3	3
Feldspar	1	2	5
Mica	TR	TR	1
Heavy minerals	TR	TR	TR
Clay	57	94	85
Volcanic glass	TR	TR	5
Pyrite	TR	1	–
Zeolite	–	TR	1
Carbonate unspec.	40	–	–
Calc. Nannofossils	TR	–	–

SITE 473 HOLE CORE 16 CORED INTERVAL 133.5–143.0 m



LITHOLOGIC DESCRIPTION

CLAY, dark greenish gray (5Y 4/1), fairly homogeneous with scattered patches of vitric ash and pyrite-rich streaks. Layer of **VITRIC TUFF** occurs in Section 3. Diatoms become common in clay of Core-Catcher. Sediment is firm especially the tuff layer. Drilling deformation is moderate to intense.

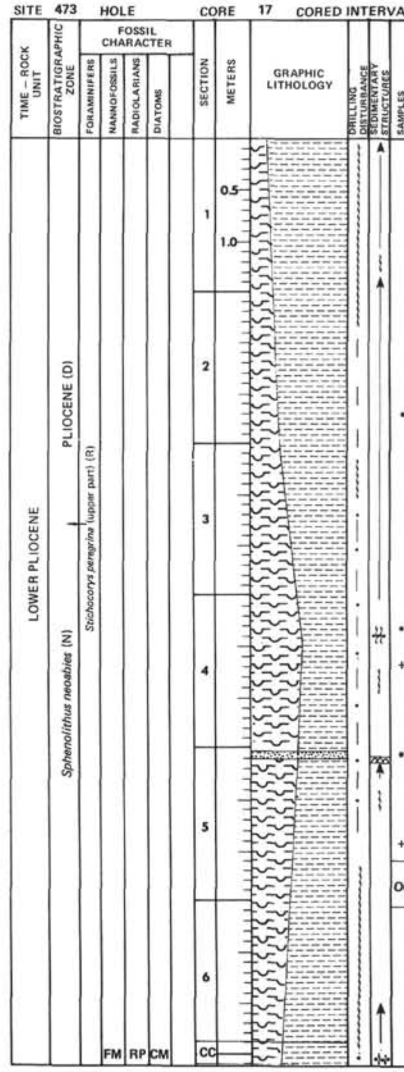
ORGANIC CARBON AND CARBONATE

	5-30
% Organic Carbon	–
% $CaCO_3$	0

SMEAR SLIDE SUMMARY

	1-127 (M)	3-34 (M)	3-41 (M)	4-27 (D)	CC-8 (D)
TEXTURE:					
Sand	–	–	–	–	–
Silt	40	57	100	9	25
Clay	60	43	–	81	75
COMPOSITION:					
Quartz	2	2	5	3	4
Feldspar	3	3	5	2	2
Clay	60	43	–	81	75
Volcanic glass	TR	50	80	1	1
Glauconite	25	–	–	–	–
Pyrite	10	2	10	2	2
Zeolite	–	–	–	1	–
Diatoms	–	–	–	–	10
Radiolarians	–	–	–	–	TR
Sponge spicules	–	–	–	–	1
Silicoflagellates	–	–	–	–	5

SITE 473 HOLE CORE 17 CORED INTERVAL 143.0–152.5 m



LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAYSTONE, grayish olive (10Y 4/2) to greenish gray (5GY 6/1), intensely burrowed, common lenticular bedding. Layer of olive gray (5Y 3/2) **SILTY SANDSTONE** in Section 5 is graded with convolute bedding in lower part and laminated near its top. Sandstone is diatomaceous and ash-rich. Claystone is firm and broken into drilling biscuits in most sections.

ORGANIC CARBON AND CARBONATE

	4-70	5-98
% Organic Carbon	–	0.55
% $CaCO_3$	0	0

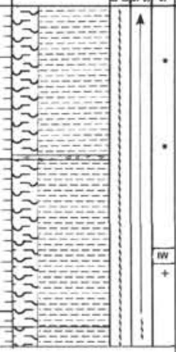
SMEAR SLIDE SUMMARY

	2-127 (D)	4-32 (D)	5-6 (M)
TEXTURE:			
Sand	–	–	60
Silt	40	90	23
Clay	60	10	17
COMPOSITION:			
Quartz	3	3	25
Feldspar	2	2	10
Mica	TR	TR	TR
Heavy minerals	TR	TR	TR
Clay	60	10	17
Volcanic glass	TR	TR	TR
Glauconite	TR	–	TR
Pyrite	2	25	3
Carbonate unspec.	TR	–	5
Diatoms	25	50	15
Radiolarians	1	2	1
Sponge spicules	1	3	1
Silicoflagellates	6	5	1
Fish remains	TR	–	–
Plant debris	–	–	TR
Lithic fragments	–	–	10

SITE 473 HOLE CORE 18 CORED INTERVAL 152.5–162.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	*Sphenolithus neoabies* (N); PLIOCENE (D); *Stichocorys peregrina* (upper part) (R)	FP	CP	RP	FM	1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



IW

LITHOLOGIC DESCRIPTION

DIATOMACEOUS CLAYSTONE, grayish olive (10Y 4/2), burrowed throughout and brecciated by drilling. Layer of dark gray (N3) pyritized **VITRIC TUFF** occurs at base of Section 1.

ORGANIC CARBON AND CARBONATE

	2-110
% Organic Carbon	–
% $CaCO_3$	3

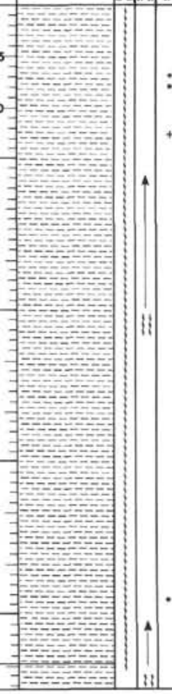
SMEAR SLIDE SUMMARY

	1-60 (D)	1-148 (M)
TEXTURE:		
Sand	–	–
Silt	50	100
Clay	50	–
COMPOSITION:		
Quartz	3	2
Feldspar	2	3
Mica	TR	–
Heavy minerals	TR	TR
Clay	50	–
Volcanic glass	2	80
Glauconite	TR	–
Pyrite	1	15
Carbonate unspec.	1	–
Diatoms	35	–
Radiolarians	TR	–
Sponge spicules	1	–
Silicoflagellates	5	–
Plant debris	TR	–

SITE 473 HOLE CORE 19 CORED INTERVAL 162.0–171.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	*Discoaster quinqueramus* to *Reticulofenestra pseudoumbilica* (N); *Stichocorys peregrina* (upper part) (R)		FP	RP	RP	1, 2, 3, 4, 5, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Ash-rich

CLAYSTONE, grayish olive green (5GY 3/2) to dark greenish gray (5GY 4/1) with scattered patches of yellowish gray (5Y 7/2) **CALCAREOUS CLAYSTONE.** Volcanic glass is common in the claystone in Section 1, 80 cm. Much of the claystone is burrowed. Core is brecciated by drilling.

ORGANIC CARBON AND CARBONATE

	1-130
% Organic Carbon	–
% $CaCO_3$	0

SMEAR SLIDE SUMMARY

	1-73 (D)	1-80 (D)	4-140 (D)
TEXTURE:			
Sand	–	–	–
Silt	5	30	85
Clay	95	70	15
COMPOSITION:			
Quartz	3	3	3
Feldspar	1	2	2
Mica	TR	TR	TR
Heavy minerals	TR	TR	TR
Clay	55	65	85
Volcanic glass	–	25	2
Pyrite	1	1	2
Zeolite	–	TR	2
Carbonate unspec.	25	–	2
Calc. Nannofossils	15	5	–
Diatoms	–	–	2
Sponge spicules	–	–	TR

SITE 473 HOLE CORE 20 CORED INTERVAL 171.5–181.0 m

TIME – ROCK UNIT: LOWER PLIOCENE; UPPER MIOCENE or LOWER PLIOCENE (N)

BIOSTRATIGRAPHIC ZONE: *Nitzschia jouseae* (D); *Stichocorys peregrina* (upper part) (R)

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): B; CG; FP RP RP

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

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

CLAYSTONE, dark greenish gray (5GY 4/1) to olive gray (5Y 4/1), lenticular bedding and burrows throughout. Several patches and thin intervals of dusky yellow (5Y 6/4) **CALCAREOUS CLAYSTONE** in Sections 3 and 6. Core is partially lithified and brecciated by drilling.

ORGANIC CARBON AND CARBONATE

	3-40	3-68
% Organic Carbon	–	1.31
% $CaCO_3$	1.5	2

SMEAR SLIDE SUMMARY

	2-110 (D)	6-23 (D)
TEXTURE:		
Sand	–	–
Silt	15	70
Clay	85	30
COMPOSITION:		
Quartz	3	1
Feldspar	2	1
Mica	TR	–
Heavy minerals	TR	–
Clay	83	41
Volcanic glass	1	–
Pyrite	1	2
Zeolite	TR	–
Carbonate unspec.	TR	25
Calc. Nannofossils	2	10
Diatoms	5	8
Radiolarians	TR	2
Sponge spicules	TR	TR
Silicoflagellates	3	5

SITE 473 HOLE CORE 21 CORED INTERVAL 181.0–187.5 m

TIME – ROCK UNIT: LOWER PLIOCENE / UPPER MIOCENE; UPPER MIOCENE OR LOWER PLIOCENE (N)

BIOSTRATIGRAPHIC ZONE: *Stichocorys peregrina* (upper part) (R); *Stichocorys peregrina* (lower part) (R)

FOSSIL CHARACTER (FORAMINIFERS, NANNOFOSSILS, RADIOLARIANS, DIATOMS): CP B B

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

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

Nannofossil chalk layers

Nannofossil chalk layers

LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, grayish olive green (5GY 3/2), burrowed throughout with thin layers of dusky yellow orange (10YR 7/6) **NANNOFOSSIL CHALK** in Sections 3 and 5 as marked. Radiolarians in chalk layers often pyritized. Core brecciated by drilling.

ORGANIC CARBON AND CARBONATE

	2-40
% Organic Carbon	–
% $CaCO_3$	3

SMEAR SLIDE SUMMARY

	1-50 (D)	1-127 (D)	3-75 (M)	4-50 (D)
TEXTURE:				
Sand	1	2	–	–
Silt	29	40	20	6
Clay	70	50	80	94
COMPOSITION:				
Quartz	12	18	TR	6
Feldspar	3	8	TR	1
Mica	TR	2	–	TR
Heavy minerals	TR	1	–	TR
Clay	6	56	13	90
Volcanic glass	–	1	–	–
Glauconite	–	–	–	TR
Pyrite	1	5	2	2
Carbonate unspec.	1	–	24	1
Foraminifers	TR	1	–	–
Calc. Nannofossils	2	2	55	–
Diatoms	8	4	1	–
Radiolarians	4	1	5	–
Sponge spicules	1	1	TR	–
Silicoflagellates	1	TR	TR	–

SITE 473 HOLE CORE 22 CORED INTERVAL 187.5–190.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	UPPER MIOCENE OR LOWER PLIOCENE (N) / *Stichocorys peregrina* (lower part) (R)	RM	CP	B	B	CC

LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, grayish olive green (5GY 4/2) and burrowed. Core brecciated by drilling.

Core-Catcher only.

SITE 473 HOLE CORE 23 CORED INTERVAL 190.5–200.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Discoaster quinqueramus*(?) (N) / *Stichocorys peregrina* (lower part) (R)		RP	B	B	1, 2, 3, 4, CC

Samples: OG

LITHOLOGIC DESCRIPTION

CLAYSTONE, grayish olive green (5GY 4/2) to grayish olive (10Y 4/2), moderately burrowed. Top Section 1 and base of Core-Catcher appear to be slightly silty. Core brecciated by drilling.

ORGANIC CARBON AND CARBONATE

	2-85	2-98
% Organic Carbon	–	0.94
% $CaCO_3$	0	–

SMEAR SLIDE SUMMARY

	1-50 (D)
TEXTURE:	
Sand	–
Silt	15
Clay	85
COMPOSITION:	
Quartz	9
Feldspar	2
Clay	83
VOlcanic glass	1
Pyrite	1
Calc. Nannofossils	2
Diatoms	1
Radiolarians	TR
Silicoflagellates	1

SITE 473 HOLE CORE 24 CORED INTERVAL 200.0–209.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Discoaster quinqueramus*(?) (N) / NEOGENE (R)	RP	CM, CM	RP	FP	1, 2, 3, CC

Samples: IW

LITHOLOGIC DESCRIPTION

CLAYSTONE AND SILTY CLAYSTONE, grayish olive green (5GY 4/2) to dusky yellow green (5GY 5/2), burrowed throughout. Siliceous microfossils commonly pyritized. Several fragments of **SILICEOUS(?) CLAYSTONE OR PORCELLANITE(?)** occur in Section 2, 145–151 cm, and in Core-Catcher, 11–13 cm. Core is brecciated by drilling.

ORGANIC CARBON AND CARBONATE

	1-76
% Organic Carbon	–
% $CaCO_3$	0

Porcellanite(?) fragments

Porcellanite(?) fragments

SMEAR SLIDE SUMMARY

	2-50 (D)	3-15 (D)	CC-8 (D)
TEXTURE:			
Sand	–	–	–
Silt	30	15	25
Clay	70	85	75
COMPOSITION:			
Quartz	23	15	20
Feldspar	3	2	2
Mica	TR	TR	1
Heavy minerals	TR	1	1
Clay	69	81	72
Volcanic glass	TR	–	–
Glauconite	–	TR	TR
Pyrite	1	1	2
Foraminifers	–	TR	TR
Calc. Nannofossils	1	TR	TR
Diatoms	2	TR	2
Radiolarians	1	–	TR
Sponge spicules	TR	–	TR
Silicoflagellates	TR	–	TR
Opal-CT(?)	–	TR	–

SITE 473 HOLE CORE 25 CORED INTERVAL 209.5–219.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER MIOCENE	*Discoaster quinqueramus*(?) (N)		RP	B	B	1, 2, CC

LITHOLOGIC DESCRIPTION

SILTY CLAYSTONE, grayish green (10GY 5/2) to medium olive gray (5Y 4/2), intensely burrowed throughout. Several thin intervals of **PORCELANEOUS(?) SILTY CLAYSTONE** occur in Section 1.

ORGANIC CARBON AND CARBONATE

	1-7	1-14
% Organic Carbon	–	0.37
% $CaCO_3$	0	0

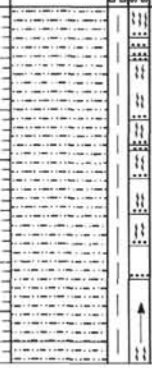
SMEAR SLIDE SUMMARY

	CC (D)
TEXTURE:	
Sand	–
Silt	40
Clay	60
COMPOSITION:	
Quartz	25
Feldspar	6
Mica	1
Heavy minerals	1
Clay	60
Volcanic glass	5
Calc. Nannofossils	1
Diatoms	1

SITE 473 HOLE CORE 26 CORED INTERVAL 219.0–228.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	*Discoaster quinqueramus*(?) (N)	FP	FP	B	B	1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Abundant thin sandy layers; bases marked by graded symbol

LITHOLOGIC DESCRIPTION

Interbedded **SILTY CLAYSTONE AND SILTY SANDSTONE.** Core consists of thin sandy sequences: (1) a basal medium dark gray (N4) sandy layer with a sharp bottom contact and laminated above, grading up to (2) olive gray (5Y 4/1) sandy siltstone and grayish green (10GY 5/2) clayey siltstone, burrowed, then dusky yellow brown (10YR 2/3) porcellaneous(?) silty claystone. At least 11 cycles are present averaging ~25 cm thick each. Silty claystone in Section 2 contains minor altered ash.

ORGANIC CARBON AND CARBONATE

	1-70
% Organic Carbon	–
% $CaCO_3$	0

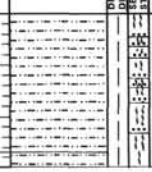
SMEAR SLIDE SUMMARY

	1-51 (D)	2-34 (D)
TEXTURE:		
Sand	60	–
Silt	24	6
Clay	16	94
COMPOSITION:		
Quartz	60	5
Feldspar	10	1
Mica	5	TR
Heavy minerals	2	TR
Clay	16	69
Volcanic glass	TR	25
Glauconite	2	–
Pyrite	2	TR
Carbonate unspec.	TR	TR
Lithic fragments	5	–

SITE 473 HOLE CORE 27 CORED INTERVAL 228.5–238.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	*Discoaster quinqueramus*(?) (N)		B, B, FP	B	B	1, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Abundant thin sandy layers; bases marked by graded symbol

LITHOLOGIC DESCRIPTION

Interbedded **SILTY CLAYSTONE AND SILTY SANDSTONE.** Color, composition, and bedding characteristics same as Core 26. At least 7 cycles noted.

ORGANIC CARBON AND CARBONATE

	1-30	1-45
% Organic Carbon	0.25	–
% $CaCO_3$	0	0

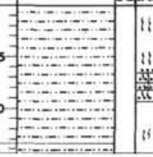
SMEAR SLIDE SUMMARY

	1-78 (D)
TEXTURE:	
Sand	–
Silt	40
Clay	60
COMPOSITION:	
Quartz	30
Feldspar	3
Mica	TR
Heavy minerals	TR
Clay	60
Volcanic glass	3
Pyrite	2
Carbonate unspec.	2
Calc. Nannofossils	TR

SITE 473 HOLE CORE 28 CORED INTERVAL 238.0–247.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
		B, B, B	B	RP		1, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



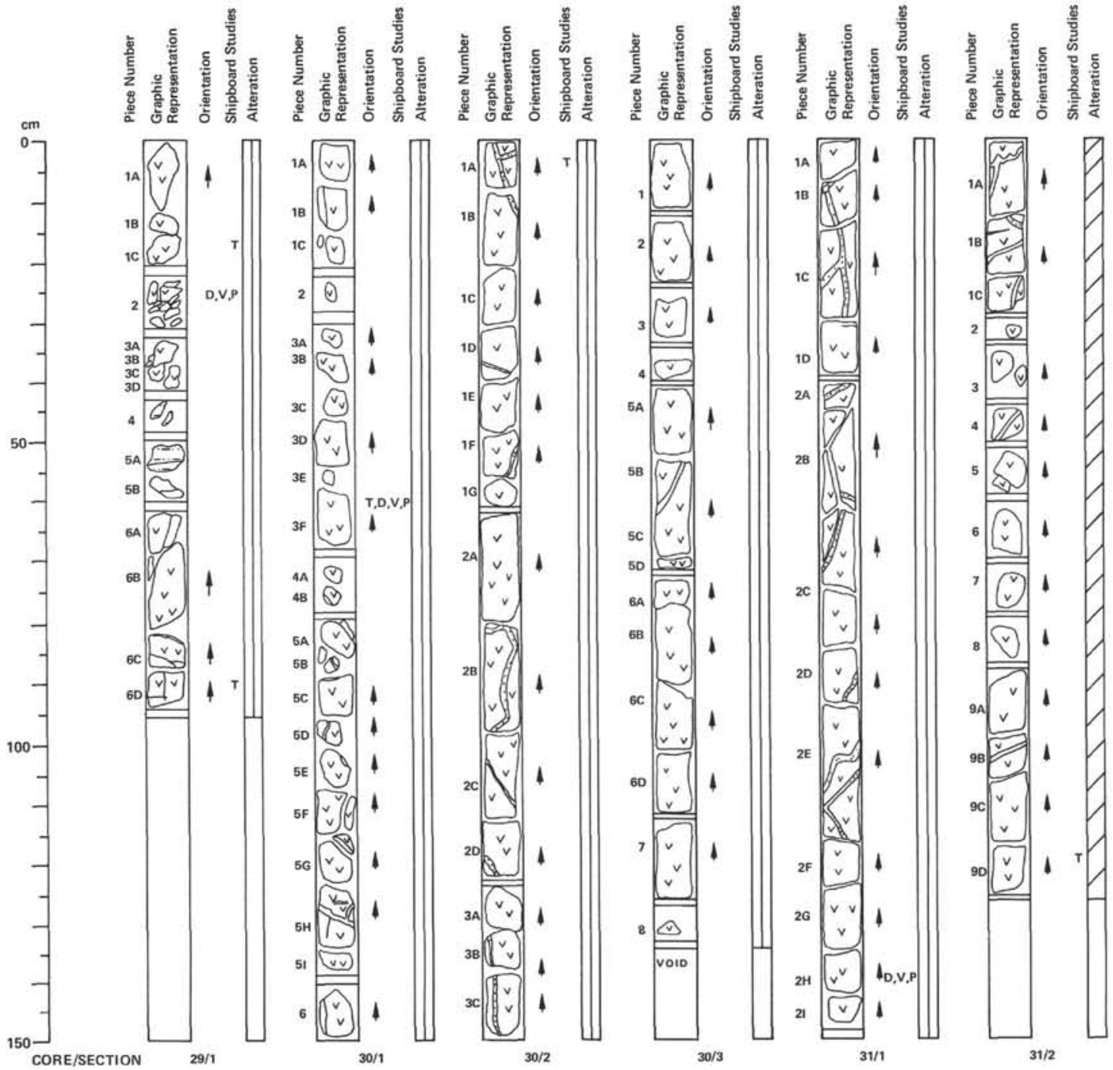
Sandy layers

LITHOLOGIC DESCRIPTION

Interbedded **SILTY CLAYSTONE AND SILTY SANDSTONE.** Color, composition, and bedding characteristics same as Cores 26 and 27. Four sandy layers noted (basal contacts marked by graded symbol). Burrows common.

ORGANIC CARBON AND CARBONATE

	1-93
% Organic Carbon	–
% $CaCO_3$	0



SITE 473, CORE 29, SECTION 1, 247.5–248.4 m

MAJOR ROCK TYPE – DIABASE

MINOR ROCK TYPES – SILTY CLAYSTONE, SILTY SANDSTONE

Macroscopic Descriptions

Diabase – medium gray to medium dark gray, fine- to medium-grained, aphyric, and badly altered. Grain size decreases noted in Pieces 1A and C, 3C, and 6A. Vesicles scattered throughout. Calcite veins in Pieces 6A and C.

Silty Claystone and Silty Sandstone – Pieces 4 and 5 are interbedded olive black (5Y 2/1) silty claystone and greenish gray (5GY 6/1), fine-grained silty sandstone. Sandstone occurs as thin layers and irregular pods in claystone. Sharp contacts between two lithologies.

Thin Section Descriptions

Basalt – Section 1, Piece 1C, 17–19 cm
Texture: glomeroporphyritic with intersertal groundmass
Phenocrysts: plagioclase, 5%, 0.2–1.0 mm, euhedral-subhedral; clinopyroxene, 2%, 0.1–0.7 mm, subhedral, equant; olivine(?) clay and calcite pseudomorphs), TR, euhedral
Groundmass: plagioclase, 30%, 0.05–0.1 mm, prismatic laths; clinopyroxene, 10%, 0.05–0.1 mm, anhedral, equant; opaques, 10%, 0.01–0.05, anhedral
Vesicles: 4%, 0.2–0.7 mm, circular, clay- and calcite-filled
Alteration: calcite (2%) and clays (37%) fill vesicles and replace olive and mesostasis

Basalt – Section 1, Piece 6D, 88–92 cm
Texture: intergranular to intersertal
Phenocrysts: –
Groundmass: plagioclase, 40%, 0.1–1.5 mm, subhedral, laths; clinopyroxene, 25%, 0.05–0.7 mm, anhedral, equant; olivine(?) (clay/calcite pseudomorphs), 1%, 0.5–1.0 mm, subhedral; opaques, 7%, 0.05–0.2 mm, anhedral
Vesicles: 2%, 0.8 mm, circular, clay-filled
Alteration: calcite (3%) and clays (22%) replace olivine and mesostasis and fill vesicles

Shipboard Data

Sample	D	V (∥)	V (⊥)	P
Section 1, Piece 1C, 19 cm	2.63	4.41	–	13

SITE 473, CORE 30, SECTIONS 1–3, 252.0–256.3 m

MAJOR ROCK TYPE – DIABASE

Macroscopic Description

Diabase – medium gray, fine- to medium-grained, aphyric, and badly altered. Fractured with some fractures filled with calcite or green clay. Ore minerals(?) in vein in Piece 1A, Section 2.

Thin Section Descriptions

Diabase – Section 1, Piece 3F, 61–62 cm
Texture: intersertal to subophitic
Phenocrysts: –
Groundmass: plagioclase, 40%, 0.1–2 mm, subhedral–anhedral; clinopyroxene, 39%, 0.1–1 mm, anhedral; opaques, 7%, 0.05–0.2 mm, anhedral
Alteration: clays (10%), calcite (4%) and zeolite (TR) replace part of mesostasis

Diabase – Section 2, Piece 1A, 3–5 cm
Texture: intergranular to intersertal
Phenocrysts: –
Groundmass: plagioclase, 20%, 0.1–2 mm, subhedral; clinopyroxene, 20%, 0.1–0.5 mm, anhedral, equant; opaques, 5%, 0.05–0.2 mm, anhedral
Alteration: clay (15%) replaces mesostasis; calcite (10%) and quartz (30%) in veins

Shipboard Data

Sample	D	V (∥)	V (⊥)	P
Section 1, Piece 2, 23 cm	2.79	5.00	–	7

SITE 473, CORE 31, SECTIONS 1–2, 257.0–259.7 m

MAJOR ROCK TYPE – DIABASE

Macroscopic Description

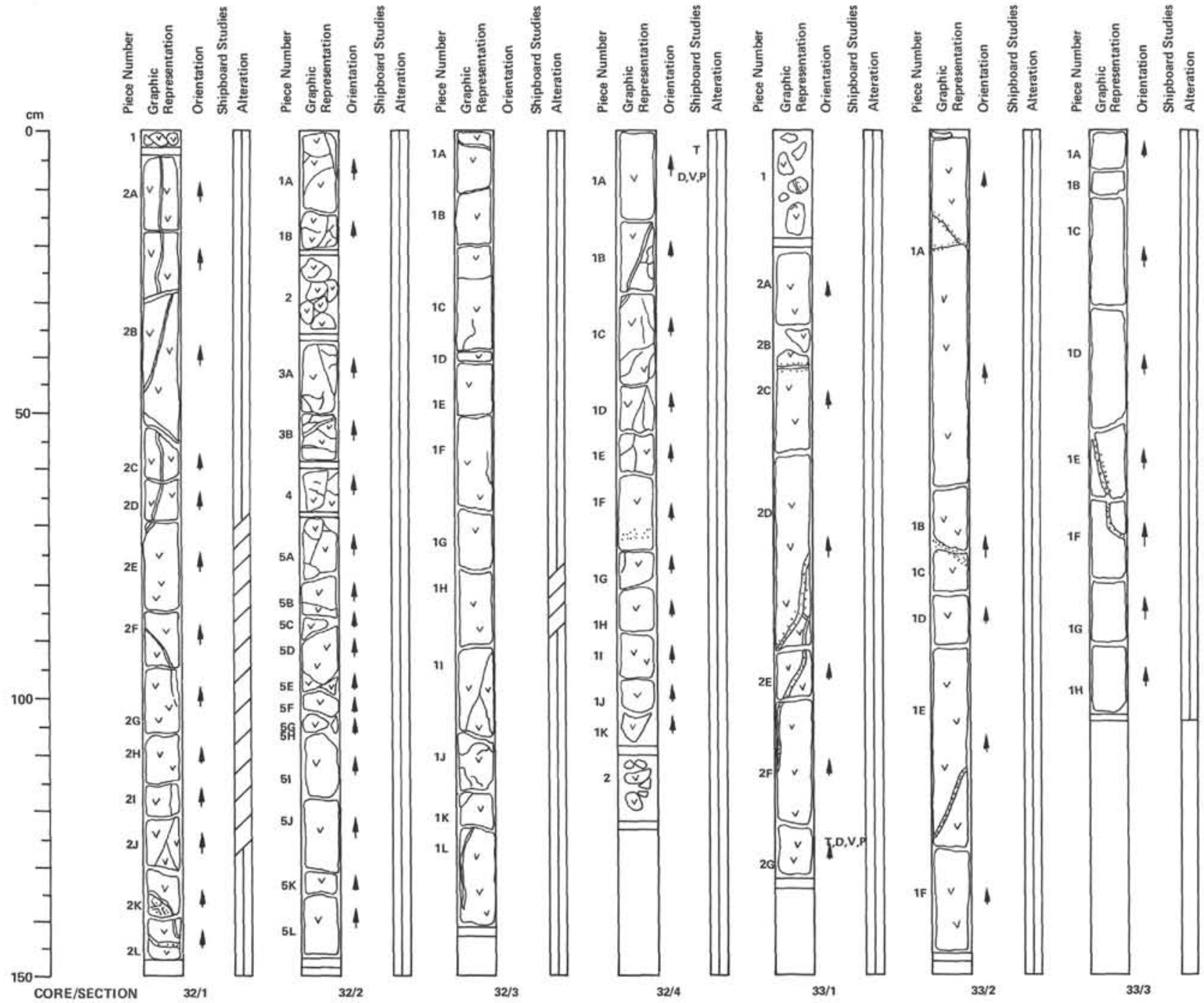
Diabase – medium gray, fine- to medium-grained, aphyric, and moderately to badly altered. Homogeneous throughout. Fractures filled with clay and calcite.

Thin Section Description

Diabase – Section 2, Piece 9D, 116–120 cm
Texture: intersertal to subophitic
Phenocrysts: –
Groundmass: plagioclase, 39%, 0.1–2 mm, subhedral-euhedral; clinopyroxene, 38%, 0.1–1 mm, anhedral; opaques, 8%, 0.05–0.2 mm, anhedral
Alteration: clay (15%), calcite (TR), and zeolite (TR) replace mesostasis

Shipboard Data

Sample	D	V (∥)	V (⊥)	P
Section 1, Piece 2H, 122 cm	2.80	4.99	–	8



SITE 473, CORE 32, SECTIONS 1–4, 266.0–271.7 m

MAJOR ROCK TYPE – DIABASE

Macroscopic Description

Diabase – medium gray to dark gray, fine- to medium-grained, aphyric, and moderately to badly altered. Vesicular in part; vesicles increase in size down core in Section 2, 70–140 cm. Fractures filled with calcite and clay. Pieces 2K and L are almost completely altered to clay.

Thin Section Description

Diabase – Section 4, Piece 1A, 2–4 cm

Texture: intersertal to intergranular

Phenocrysts: –

Groundmass: plagioclase, 39%, 0.1–2 mm, subhedral to anhedral; clinopyroxene, 38%, 0.1–1.5, anhedral; opaques, 8%, 0.05–0.5 mm, anhedral

Alteration: clay (15%) and calcite (TR) replace mesostasis

Shipboard Data

Sample	D	V (∥)	V (⊥)	P
Section 4, Piece 1A, 7 cm	2.92	5.26	–	4

SITE 473, CORE 33, SECTIONS 1–3, 275.0–279.0 m

MAJOR ROCK TYPE – DIABASE

Macroscopic Description

Diabase – medium gray to dark gray fine- to medium-grained, aphyric, and badly altered. Homogeneous throughout. Fractures filled calcite and clay. Drilling rates indicate possibly soft sediment encountered, but none recovered.

Thin Section Description

Diabase – Section 1, Piece 2G, 121–123 cm

Texture: intersertal to subophitic

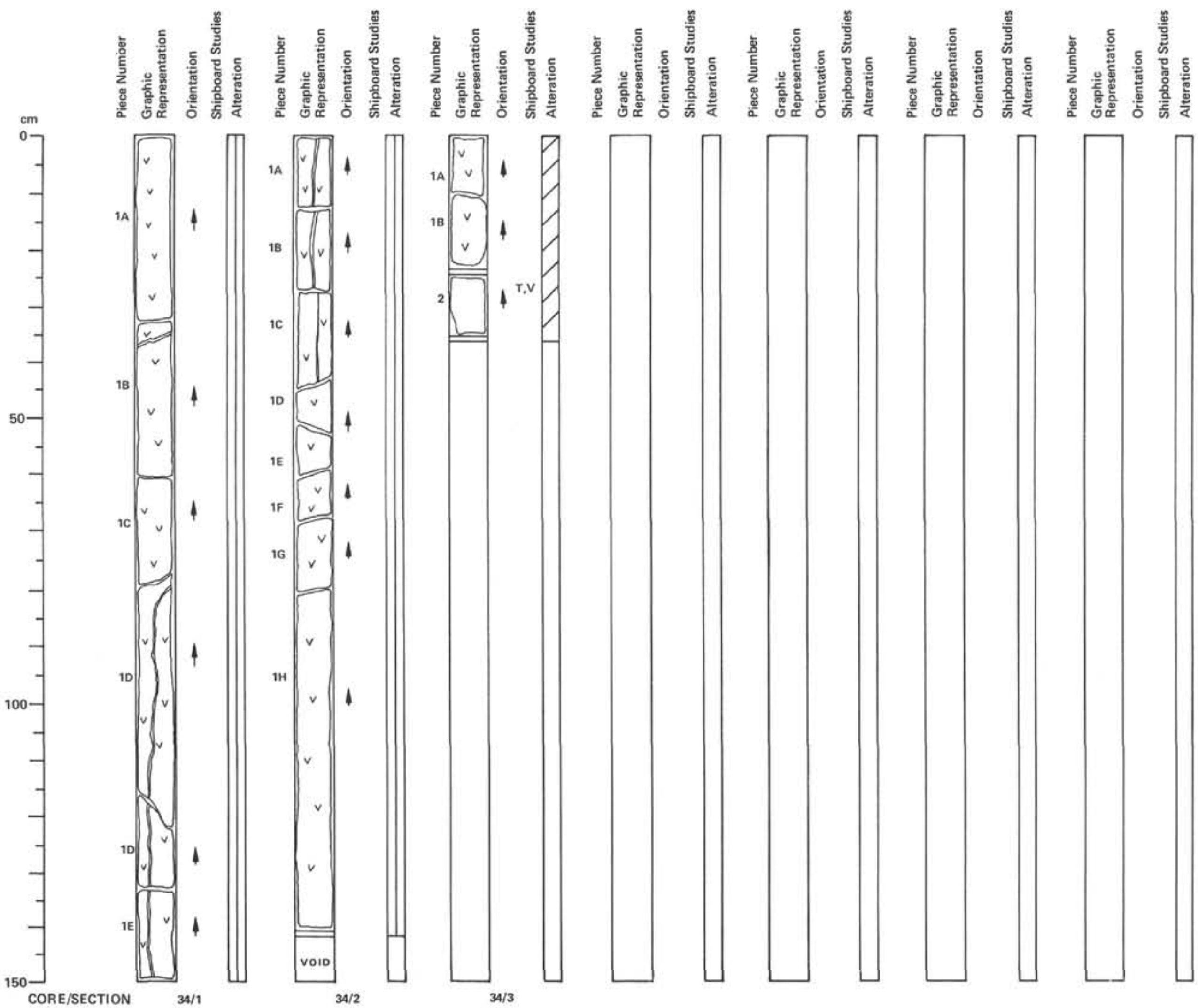
Phenocrysts: –

Groundmass: plagioclase, 39%, 0.1–2 mm, subhedral-anhedral; clinopyroxene, 38%, 0.1–2 mm, subhedral-anhedral; opaques, 8%, 0.05–0.3 mm, anhedral

Alteration: clay (15%) and calcite (TR) replace mesostasis

Shipboard Data

Sample	D	V (∥)	V (⊥)	P
Section 1, Piece 2G, 121 cm	2.95	5.69	–	6



SITE 473, CORE 34, SECTIONS 1–3, 284.0–287.4 m

MAJOR ROCK TYPE – DIABASE

MINOR ROCK TYPE – BASALT

Macroscopic Descriptions

Diabase – medium gray to dark gray, fine- to medium-grained, aphyric and badly altered. Grain size decreases slightly toward base Section 2. Calcite- and clay-filled fractures.

Basalt – Piece 2, Section 3, is medium dark gray, moderately altered, vesicular basalt. Clay fills some vesicles. Plagioclase phenocrysts (~1 mm long) are visible on cut surface.

Thin Section Description

Basalt – Section 3, Piece 2, 27–29 cm

Texture: glomeroporphyritic with hyaloophitic groundmass

Phenocrysts: plagioclase, 7%, 0.2–1 mm, euhedral; clinopyroxene, 5%, 0.1–0.5 mm, euhedral-subhedral; olivine(?) (clay pseudomorphs), TR, 0.5 mm

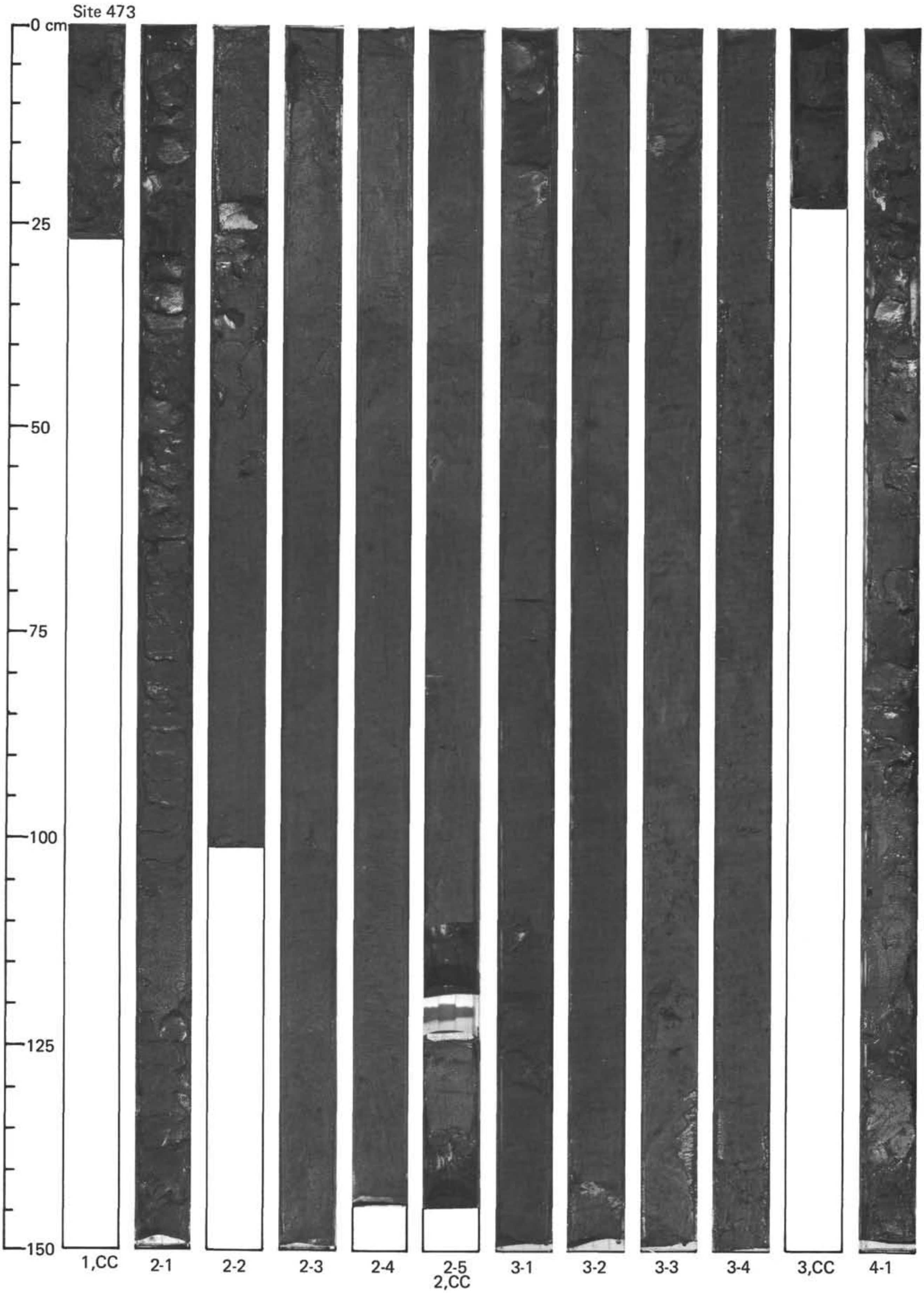
Groundmass: devitrified glass, 55%; plagioclase, 10%, 0.01–0.5 mm, skeletal, hollow; clinopyroxene, 5%, 0.01–0.05 mm, skeletal, feathery; opaques, 8%, 0.01 mm, anhedral

Vesicles: 10%, 0.1–2 mm, oval, clay- and zeolite(?)-filled

Alteration: clay (9%) replaces olivine and fills vesicles; zeolite(?) (1%) fills vesicles

Shipboard Data

Sample	D	V (∥)	V (⊥)	P
Section 3, Piece 2, 27 cm	–	5.34	–	–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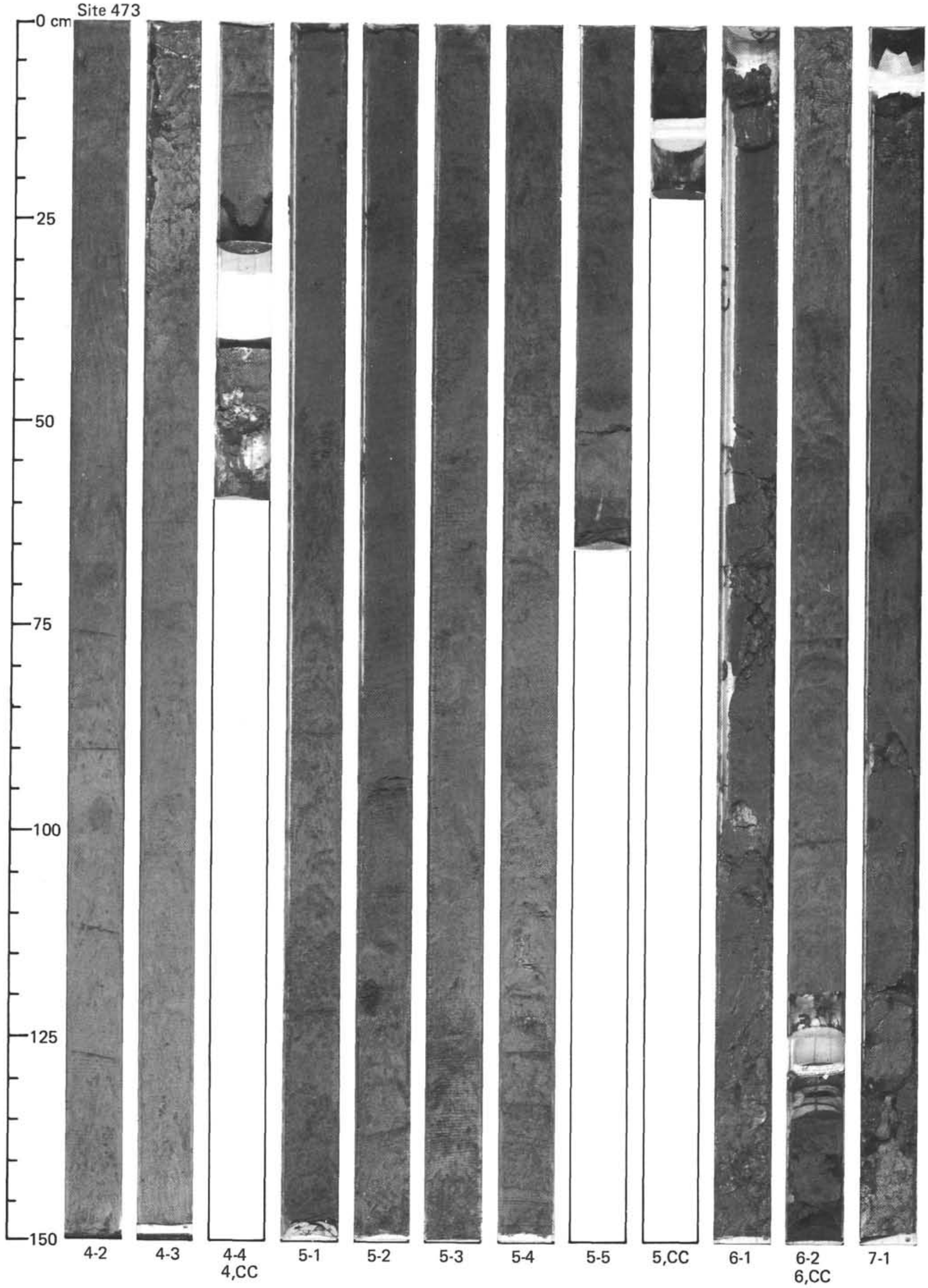
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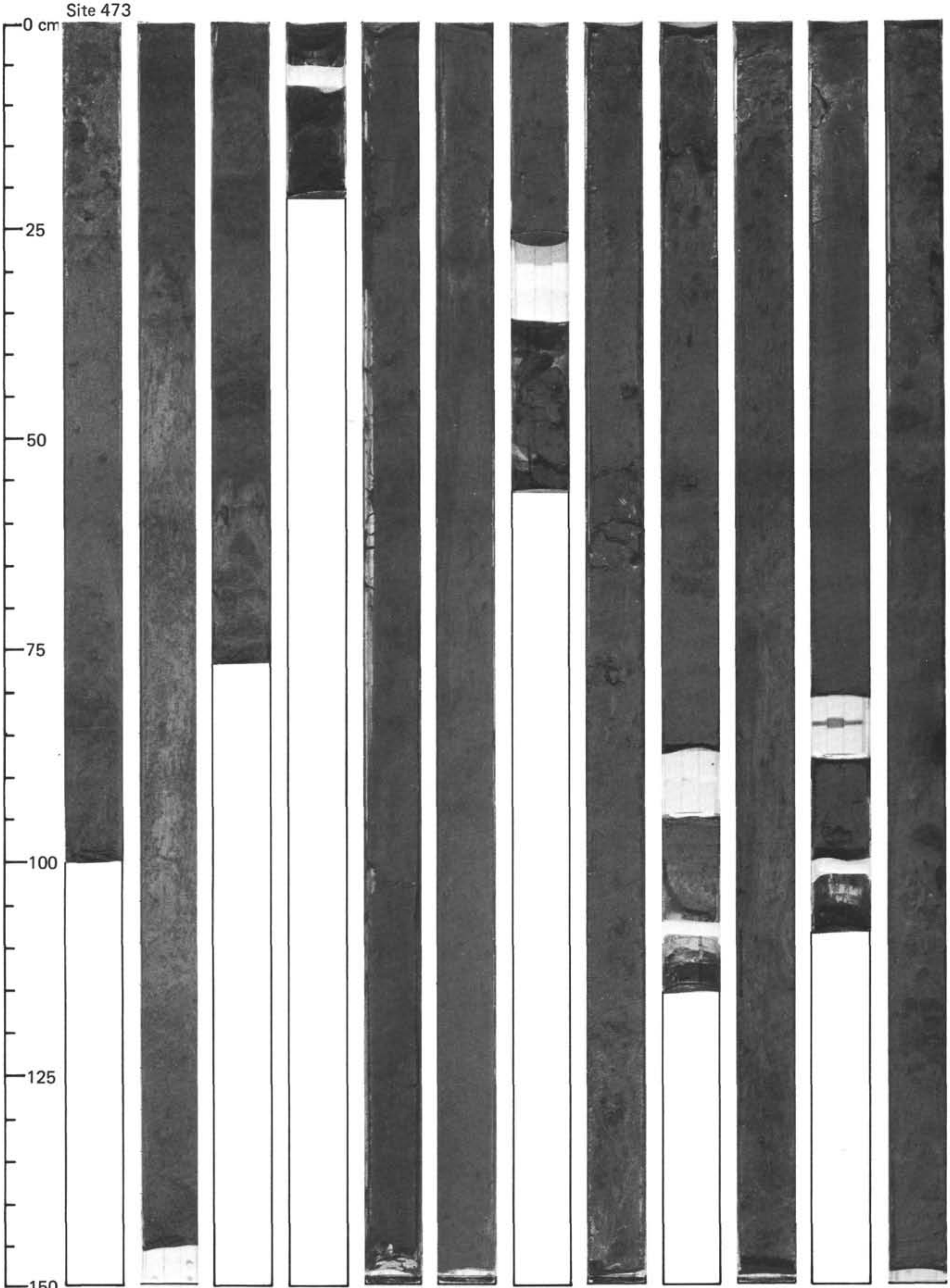
7-1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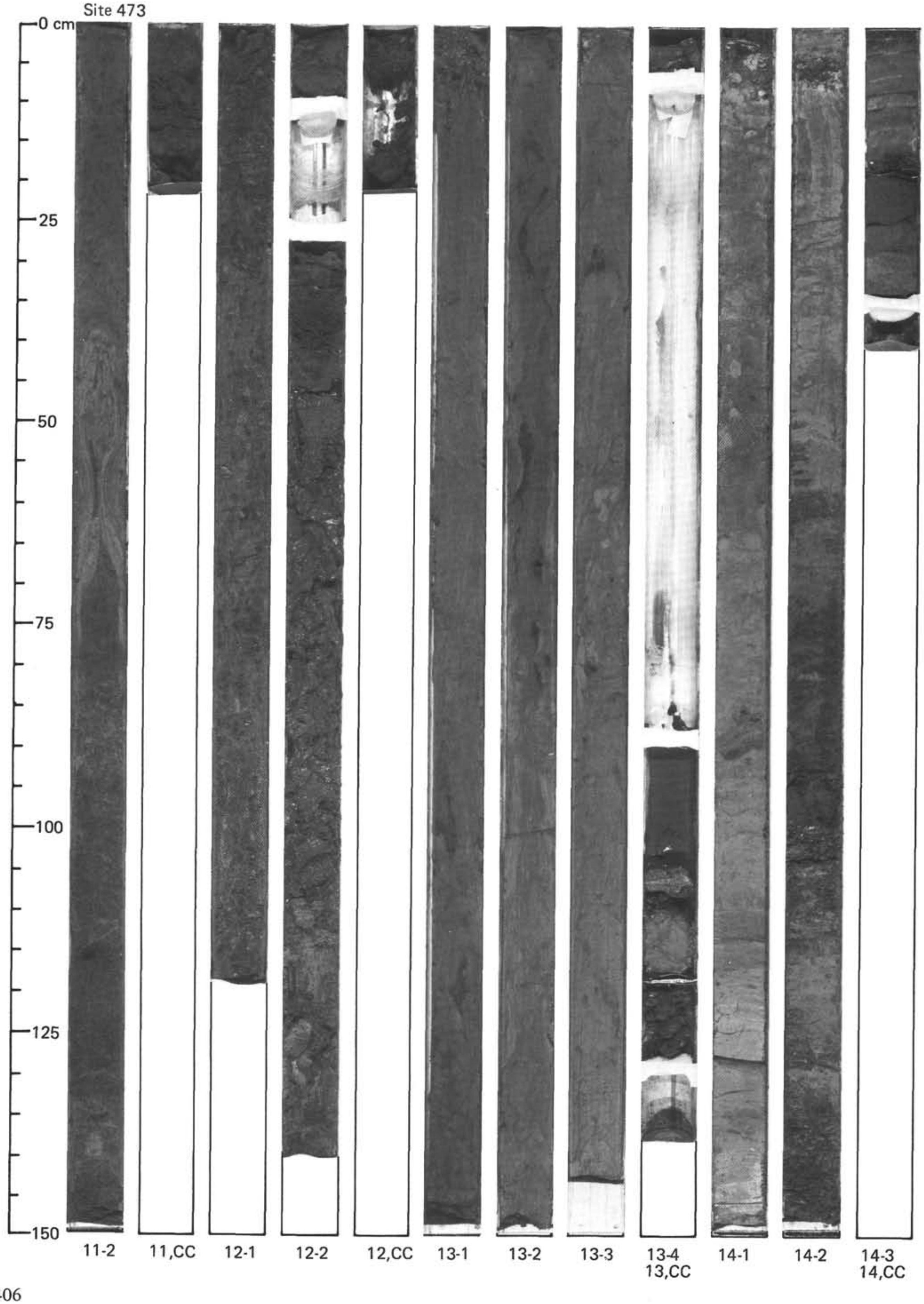
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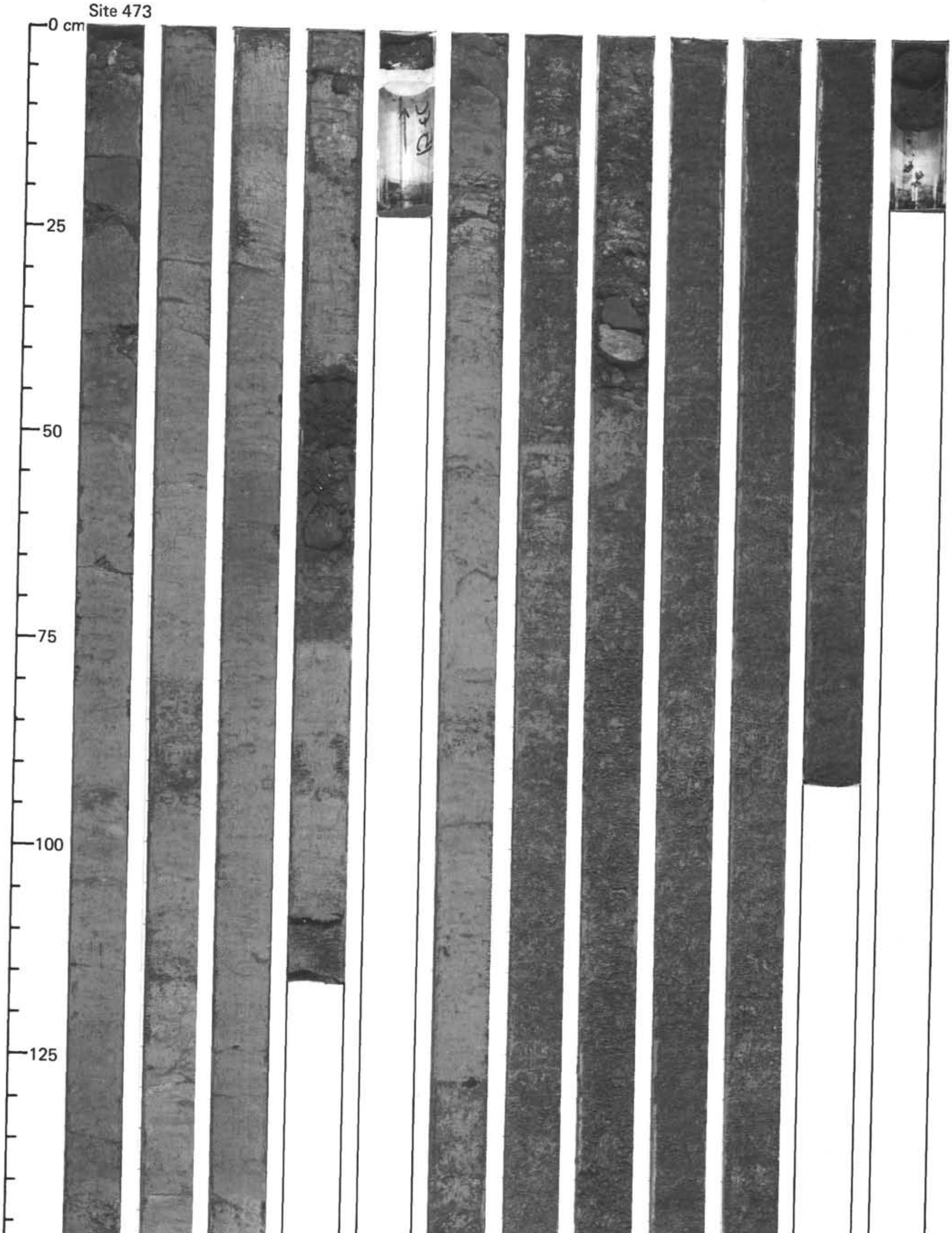
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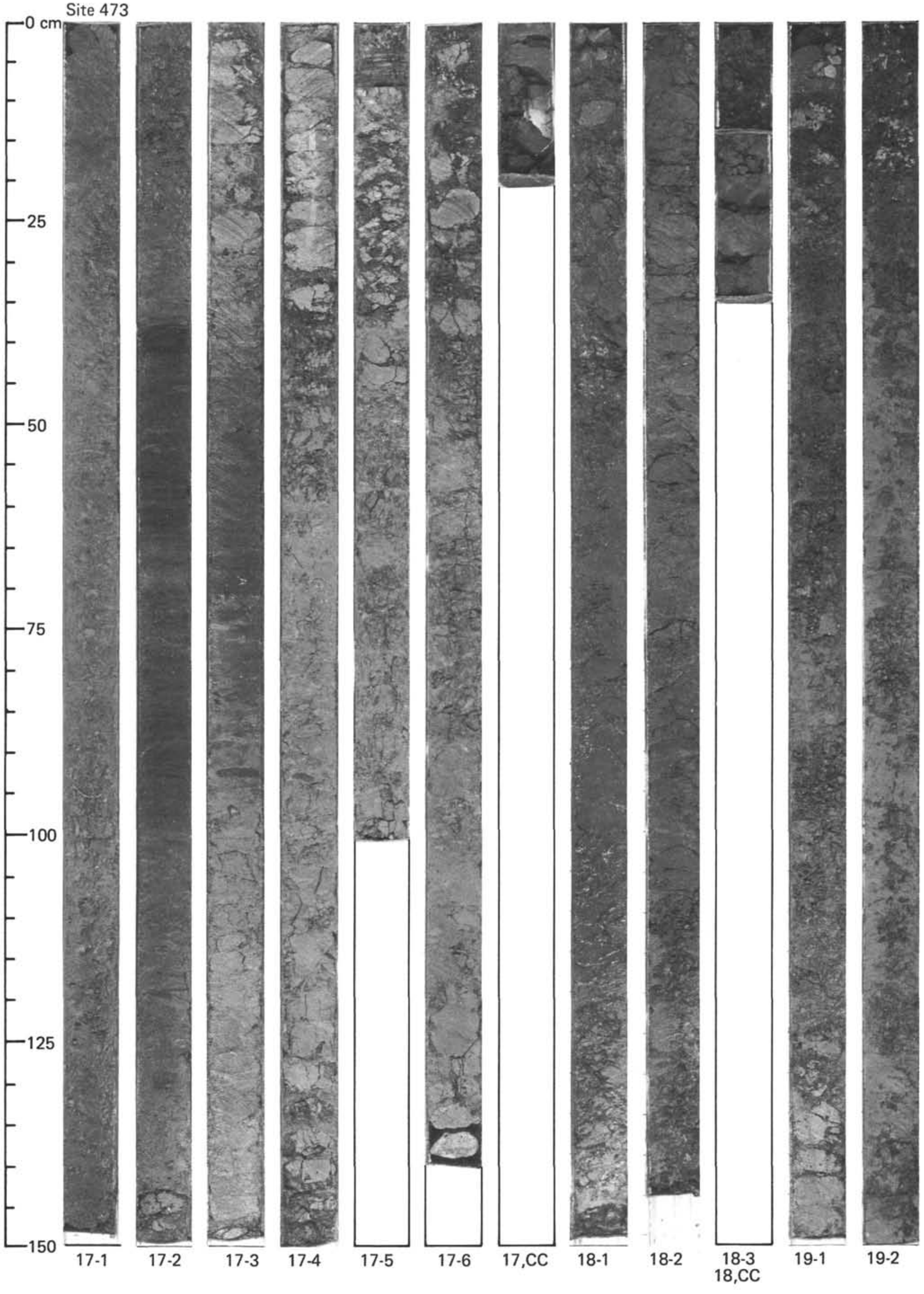
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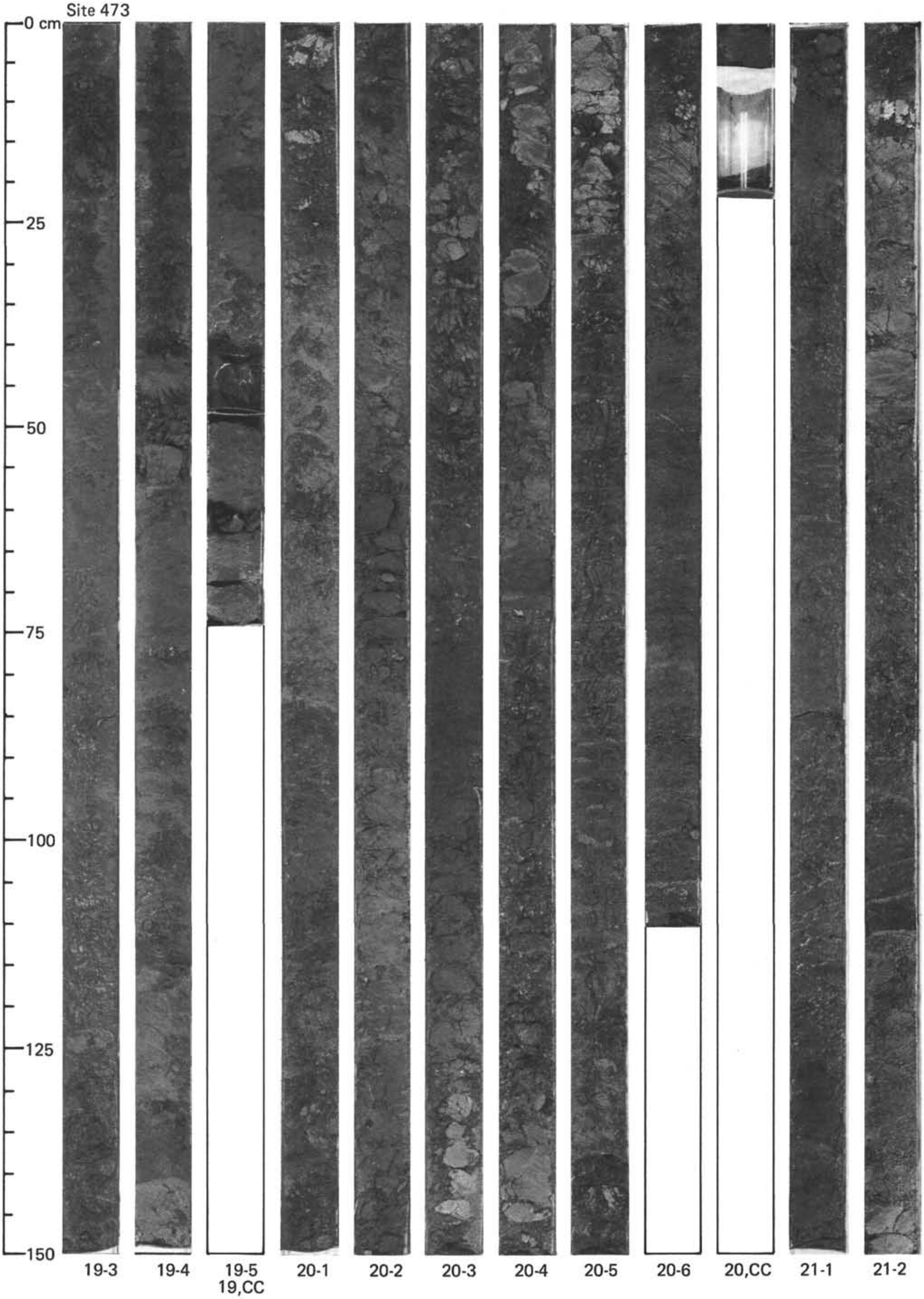
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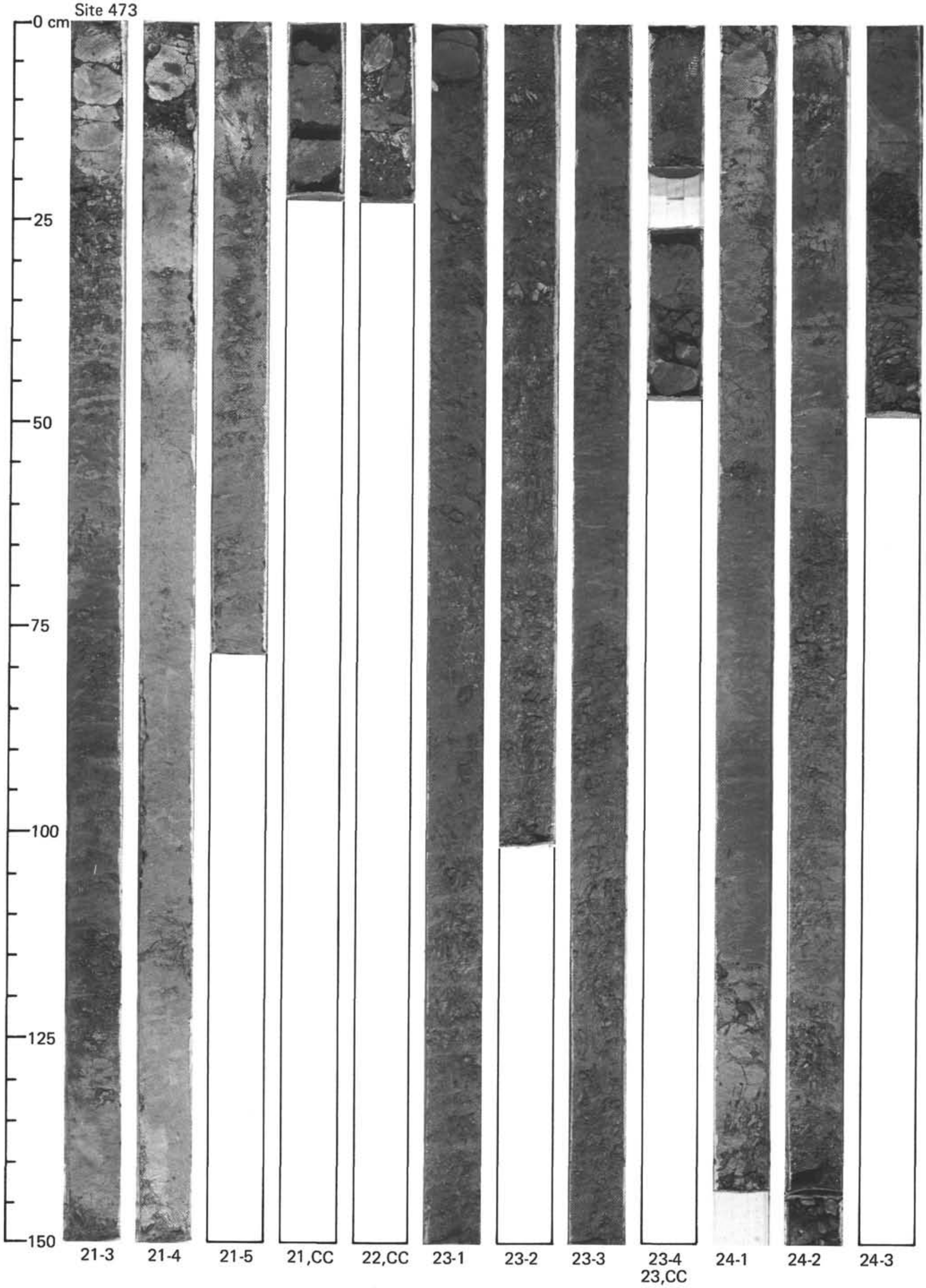
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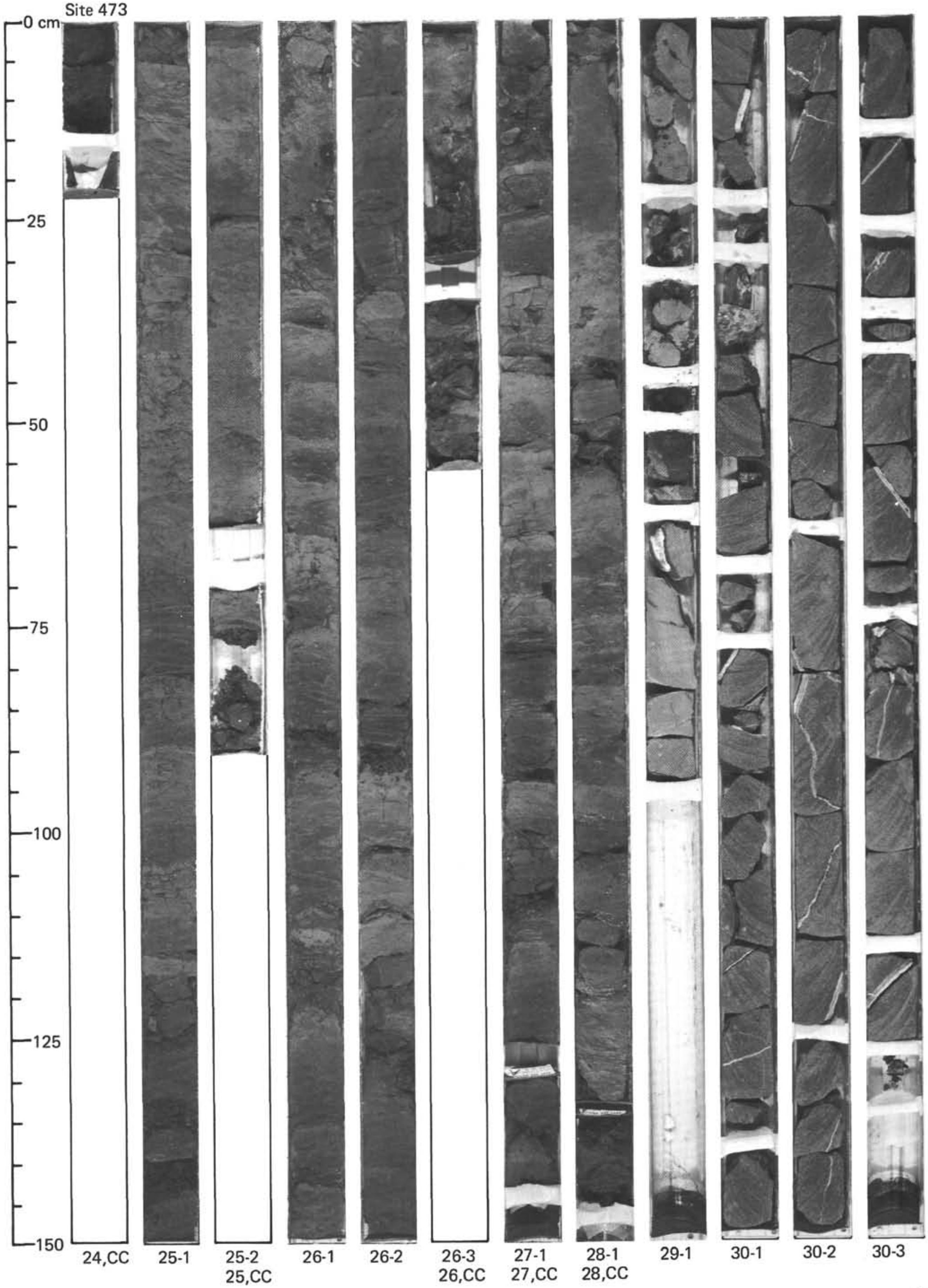
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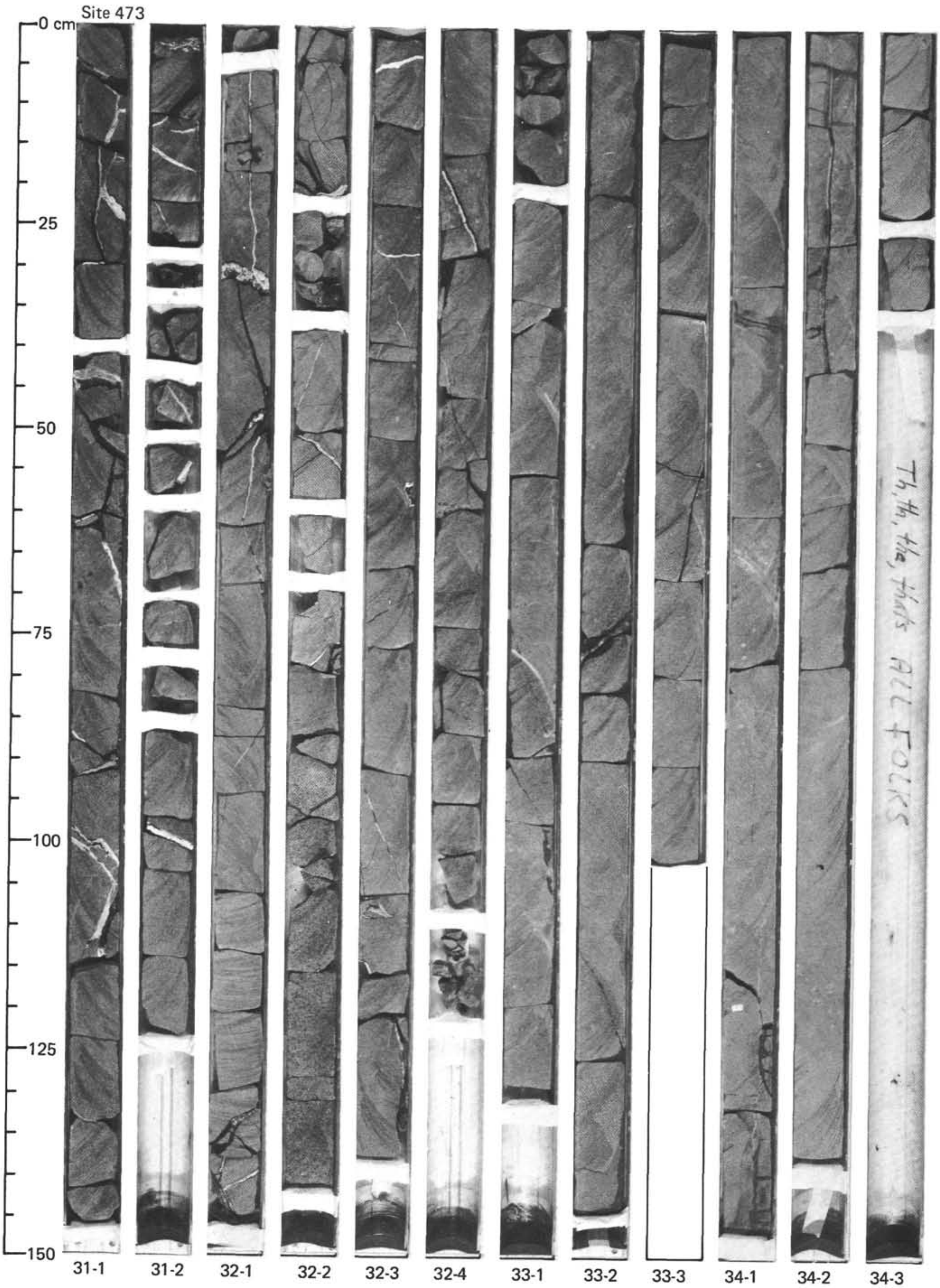
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Th, th, tha, thats ALL FOLKS