7. SITE 491[1]

Shipboard Scientific Party[2]

HOLE 491

Date occupied: 13 April 1979

Date departed: 20 April 1979

Time on hole: 182.1 hours

Position: 16°01.74′N; 98°58.33′W

Water depth (sea level; corrected m, echo-sounding): 2883

Water depth (rig floor; corrected m, echo-sounding): 2893

Bottom felt (m, drill pipe): 2870.0

Penetration (m): 542.0

Number of cores: 59

Total length of cored section (m): 542.0

Total core recovered (m): 388.0

Core recovery (%): 72

Oldest sediment cored:
Depth sub-bottom (m): 542
Nature: Muddy siltstone and sand
Age: Early Pliocene

Principal results: At Site 491 we penetrated 542 meters and recovered 59 cores that comprise three lithologic units (Table 1, Fig. 1). Unit 1 extends from 0 to 57.5 meters and consists of upper Pliocene to upper Quaternary mud. Unit 2 (57.5–437.5 m) is lower Pliocene muddy silt with minor fine sand layers. Unit 3 extends from 437.5 to 542 meters and is composed of lower Pliocene muddy silt and siltstone with interbedded fine to coarse pebbly sand.

Tilted beds and fracturing first occur at about 120 meters and continue the total depth through the lower two lithologic units. In Unit 2 dips are variable and range to nearly vertical; fracturing is present throughout, though slickensides are rare. Dip angles in Unit 3 range up to 30° and are more uniform than in Unit 2. Fracturing and slickenslides are more abundant in Unit 3 than in Unit 2, and a strong fissility develops locally. Paleomagnetic restorations of bedding in both Units 2 and 3 indicate modal dip directions to the north, though with considerable scatter.

Unit 3 and much of Unit 2 probably accumulated in a trench and/or lower slope environment. Deformation of these sediments occurred shortly after deposition and prior to being uplifted to the present midslope position.

BACKGROUND AND OBJECTIVES

Site 491 is located on the inner slope of the Middle America Trench at 16°01.74′N, 98°58.33′W in about 2.9 km of water (Fig. 2). The site lies about 2.1 km above and 14.25 km north-northeast of the adjacent trench floor on a steep average slope of about 9°. The multichannel seismic reflection profile adjacent to the site (Fig. 3) shows a thin slope blanket overlying a series of landward-dipping reflectors that are cut by a bottom-simulating reflector at about 0.75 s below the mudline.

Outcrops of a Mesozoic to Precambrian crystalline basement complex and a Mesozoic magmatic arc, anomalously close to the modern trench, argue for tectonic truncation of the Pacific margin off southern Mexico during the late Cretaceous or Paleogene (Karig et al., 1978). Results from Sites 489 and 490 demonstrate that the seaward margin of the basement complex extends to within 30 to 35 km of the trench. Seaward of the basement complex, the lower trench slope may be underlain by pelagic, hemipelagic, and trench sediments accreted during Neogene convergence in the Middle America Trench. A fundamental goal at Site 491 is to date any accreted deposits and compare their ages to similar sediment at Site 488 downslope and Site 492 upslope. If the simple accretionary model holds, then any class of off-scraped sediments should increase in age landward.

An imbricate stack of landward-dipping thrust faults constitutes one of the most popular structural models of accretion for the lower trench slope (e.g., Karig, 1974; Seely et al., 1974). The data supporting this model consist primarily of landward-dipping reflectors, which are exceptionally well shown in the seismic reflection line through Site 491 (Fig. 2). Packages of reflectors with slightly discordant contacts are interpreted bedded sedimentary sequences separated by thrust faults (Seely et al., 1974). Alternatively, some of the dipping reflectors beneath trench slopes may represent faults. Because none of the previous drilling at active margins has established the origin of landward-dipping reflectors, a prime objective at Site 491 is to penetrate these surfaces and determine whether they represent faults, tilted bedding surfaces, or some other phenomena.

A prominent bottom-simulating reflector occurs beneath the lower slope on the multichannel seismic reflection profile adjacent to the site (Fig. 2) as well as on other reflection profiles in the site survey area (Shipley, this volume). Comparable bottom-simulating reflectors have been observed off northern Panama and Columbia and along the Middle America Trench margin between

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Table 1. Coring summary, Hole 490.

Core	Cored Interval below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)	Remarks
1	0.0–10.0	10.0	9.59	104	
2	10.0–19.5	9.5	6.34	67	
3	19.5–29.0	9.5	9.59	101	
4	29.0–38.5	9.5	7.86	83	
5	38.5–48.0	9.5	5.26	55	
6	48.0–57.5	9.5	9.62	101	
7	57.5–67.0	9.5	9.42	99	
8	67.0–76.5	9.5	9.53	100	
9	76.5–86.0	9.5	9.10	96	
10	86.0–95.5	9.5	9.80	103	
11	95.5–101.0	5.5	5.13	93	
12	101.0–105.0	4.0	tr	0	
13	105.0–114.5	9.5	2.07	22	hole deviation 1.0°
14	114.5–124.0	9.5	8.34	88	
15	124.0–133.5	9.5	8.18	86	
16	133.5–143.0	9.5	9.00	95	
17	143.0–152.5	9.5	9.26	97	
18	152.5–162.0	9.5	8.11	85	
19	162.0–171.5	9.5	7.61	80	
20	171.5–181.0	9.5	3.40	36	
21	181.0–190.5	9.5	4.85	51	
22	190.5–200.0	9.5	7.28	77	
23	200.0–204.0	4.0	1.94	49	
24	204.0–209.5	5.5	0.15	02	
25	209.5–219.0	9.5	9.40	99	
26	219.0–228.5	9.5	9.54	100	
27	228.5–238.0	9.5	9.46	100	
28	238.0–247.5	9.5	6.92	73	
29	247.6–257.0	9.5	9.43	99	
30	257.0–266.5	9.5	9.49	100	
31	266.5–276.0	9.5	9.00	95	
32	276.0–285.5	9.5	7.94	84	
33	285.5–295.0	9.5	7.87	83	
34	295.0–304.5	9.5	8.31	87	
35	304.5–314.0	9.5	8.83	93	
36	314.0–323.5	9.5	7.62	80	
37	323.5–333.0	9.5	6.30	66	
38	333.0–342.5	9.5	2.95	31	
39	342.5–352.0	9.5	3.09	33	
40	352.0–361.5	9.5	8.52	90	
41	361.5–371.0	9.5	9.02	95	
42	371.0–380.5	9.5	7.30	77	
43	380.5–390.0	9.5	6.08	64	
44	390.0–399.5	9.5	4.98	52	
45	399.5–409.0	9.5	5.80	61	
46	409.0–418.5	9.5	1.68	18	
47	418.5–428.0	9.5	3.28	35	
48	428.0–437.5	9.5	9.22	97	
49	437.5–447.0	9.5	7.02	74	
50	447.0–456.5	9.5	8.48	89	
51	456.5–466.0	9.5	5.18	55	
52	466.0–475.5	9.5	3.52	37	
53	475.5–485.0	9.5	1.16	12	
54	485.0–494.5	9.5	3.39	36	
55	494.5–504.0	9.5	6.30	66	
56	504.0–513.5	9.5	6.18	65	
57	513.5–523.0	9.5	8.64	91	
58	523.0–532.5	9.5	5.17	54	
59	532.5–542.0	9.5	1.17	12	

Panama and Mexico (Shipley et al., 1979). These data all show increasing depth of the reflection with increasing water depth. They have high-amplitude reflections generally showing a reflection phase reversal and occurring at pressures and temperatures approximating the methane/hydrate, gas/solid phase boundary. Limited reflection amplitude and phase studies by Shipley et al. (1979), though restricted to areas where the seafloor is horizontal, suggest that the BSR along the Oaxaca–Guerrero transect may be a gas hydrate. However, 5° by 5° averages of thermal gradients (Langseth and Von Herzen, 1970) in the case of Mexico put the BSR well into hydrate stability field and not at the phase boundary. The bottom-simulating reflector may also represent a diagenetically induced mineral transition (e.g., Hein et al., 1978). In view of the uncertainty regarding the origin of the bottom-simulating reflector, we proposed to sample the sediments above it with a pressure core barrel to test for the presence of hydrate.

OPERATIONS

The *Glomar Challenger* steamed 9¼ nautical miles southeast from Site 490 to Site 491 in 2.25 hours. After dropping the beacon and lowering the pipe, we offset 850 meters to the north–northwest to attempt to locate on the multichannel reflection profile Line MX-16. Hole 491 was spudded at 0120 hours, 14 April and a completely full core obtained after the bit had been lowered to 2880 meters. One joint of pipe was set back, and a "punch core" extending to 2870.5 meters was attempted without recovery. Water depth was set at 2870 meters, 13 meters shallower than PDR depth.

The pressure core barrel was utilized in two unsuccessful attempts to recover cores under pressure in hopes of capturing gas hydrates. Otherwise, coring proceeded smoothly through a long and monotonous section of muddy silts and siltstones. Because of use of a special core bit with the pressure core barrel, the core diameter was somewhat reduced. Recovery was excellent and no hole problems were encountered, even in the lower 70 to 80 meters of loose, coarse sand. We terminated coring at 542 meters below the seafloor because of scheduling considerations.

We made 15-stand wiper trip to clear the hole to total depth. Unfortunately, the bit did not release, which precluded logging. The hole was filled with barite-weighted mud and the drill string recovered.

LITHOLOGIC SUMMARY

Site 491 is located midslope in a water depth of 2877 meters. Drilling penetrated 542 meters of early Pliocene to upper Quaternary argillaceous to sandy sediments. On the basis of the sedimentary characteristics, three units can be distinguished (Fig. 4, Chart 1, back pocket).

Unit 1, upper Pliocene to upper Quaternary (Cores 1–7, 0–67.0 m sub-bottom depth), consists mainly of grayish olive green (5GY 3/2) mud and muddy silt with minor thin lenses (1 mm–2 cm) of ash (Core 1, 4, 6) and calcareous concentrations (up to 6 cm, Cores 3–7). Sponge spicules (1–2 mm) and pyrite nodules are also present. The gas content of the sediment is high enough to produce numerous expansion cracks.

Bedding has not been observed, and fracturing is not apparent.

Unit 2, lower Pliocene (Cores 8–48, 67.0–437.5 m sub-bottom depth), is grayish olive green muddy silt locally indurated into muddy siltstone. Minor thin, fine-

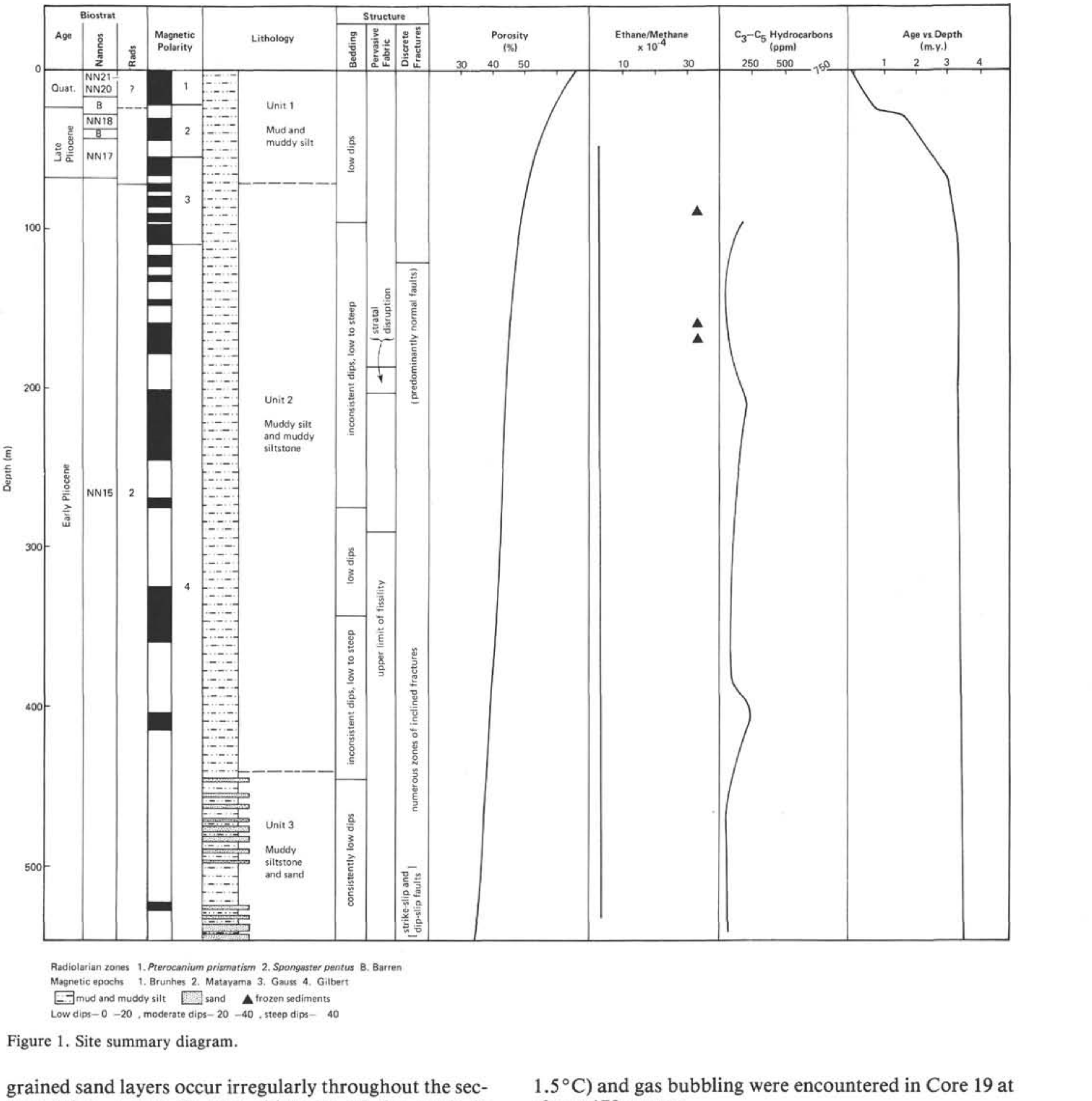

Figure 1. Site summary diagram.

grained sand layers occur irregularly throughout the section (Figs. 5 and 6). The thickness of the sands is generally from 1 mm to 2 cm but ranges locally to 10 cm. Various normal graded sand layers have been observed, which indicate upright bedding. Also, disseminated in the muddy silt are ash beds or lenses (top of the unit, Cores 8 and 16), pyrite nodules, and calcareous concentrations (Cores 28–31). The size ranges for ash, pyrite, and calcareous concentrations are the same as for Unit 1. Gas expansion cracks are also common in Unit 2 down to Core 17. Low temperatures (1°C and 1.5°C) and gas bubbling were encountered in Core 19 at about 170 meters.

Bedding is manifested in this unit by thin, silty laminations and fine sand layers. The dips average 20° and range from 0° to 85° (mostly apparent dips); in individual cores variation is generally high. The variable dips with the presence of probable slump folds can be partly explained by original synsedimentary disturbance prior to tectonic deformation. Fracturing is present throughout the unit; however, slickensides are rare. Normal faults offsetting drilling laminations are clearly due to

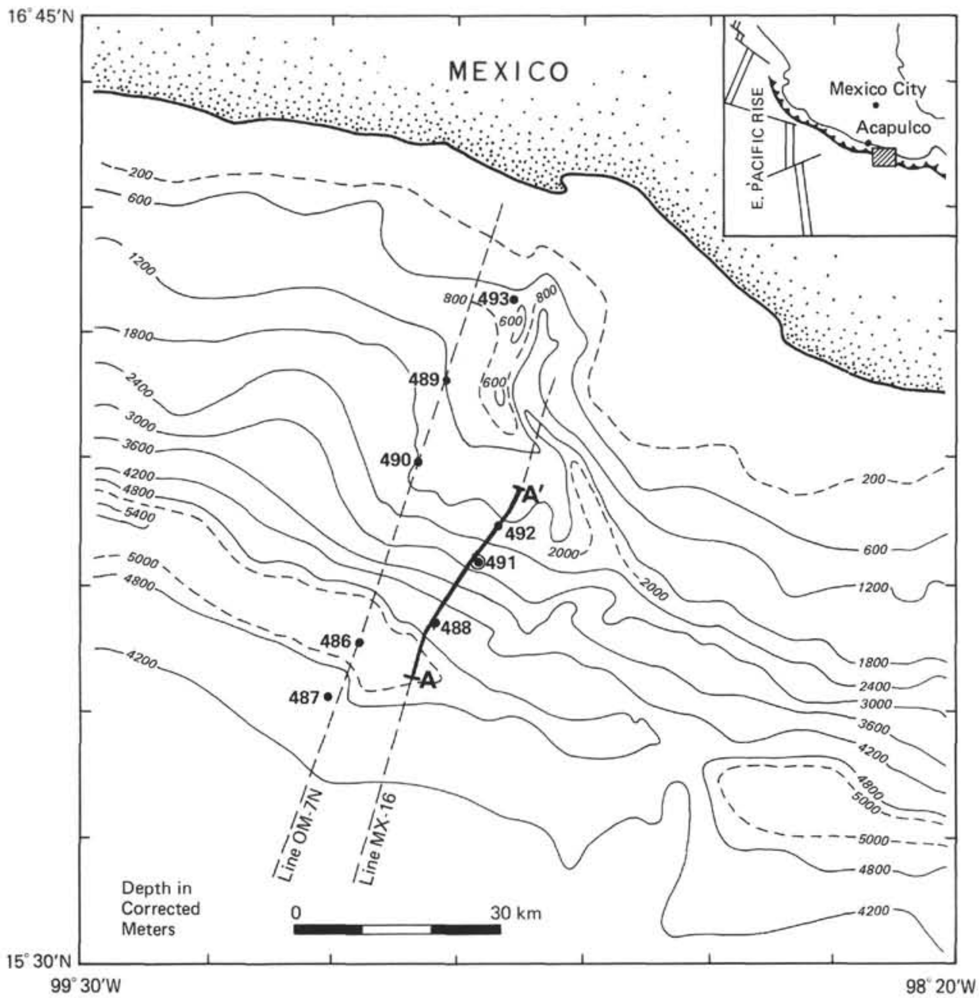

Figure 2. Site location map and index. A-A′ indicates segment of seismic profile Line MX-16 shown in Figure 3.

drilling disturbance and complicate analysis of the fractures. Nevertheless some fractures seem to be essentially tectonic features—for example, the normal faults in Cores 15, 48, 14, 15, 33, and 37 and reverse faults in Cores 22 and 43.

Unit 3, early Pliocene (Cores 49–59, 437.5–542 m sub-bottom depth), consists of muddy silt to muddy siltstone interbedded with fine to coarse pebbly sand. The thickness of the sandy layers ranges from a few centimeters up to 40 cm in Core 50. Sand is the dominant lithology in Cores 52 and 53 and probably accounts for the poor recovery in this interval (Fig. 7). Normal graded sandy beds were observed in Cores 49, 58, and 59, indicating lack of overturning. A worm cast in Core 54 also suggests upright bedding.

Structural deformation exists also in Unit 3 but is obscured by both drilling disturbance and relative abundance of sand. Nevertheless, the bedding has a mean value of 15°, ranging from 4° to 31° (mostly apparent dips); dips seem to be more uniform in individual cores than was the case in Unit 2. Fracturing and slickensides are more abundant than in Unit 2. Drilling faults are also present but account for only a small fraction of the deformation. A normal fault appears in Core 37.

Conclusions

Sedimentologic Data

The sedimentary sequence of Site 491 is very similar to that of Site 488, with the mean grain size increasing downhole, from mud through muddy silt, to coarse pebbly sand. However, the sediments at Site 488 are Quaternary, whereas those at Site 491 are mainly Pliocene. In this terrigenous sequence a genetic distinction can be made between the sands at the base (Unit 3) and the overlying muddy silt/mud (Units 1 and 2), as was determined for Site 488. Much of the interpretive discussion for site conclusions applies here. The sedimentologic arguments alone do not allow us to assign the sandy unit (Unit 3) with certainty to a former lower Pliocene trench environment; such coarse clastic sediments could have been deposited for example in a slope basin or channel cutting the slope. Definitive sedimentologic proof of origin of the sands as trench deposits would be the oc-

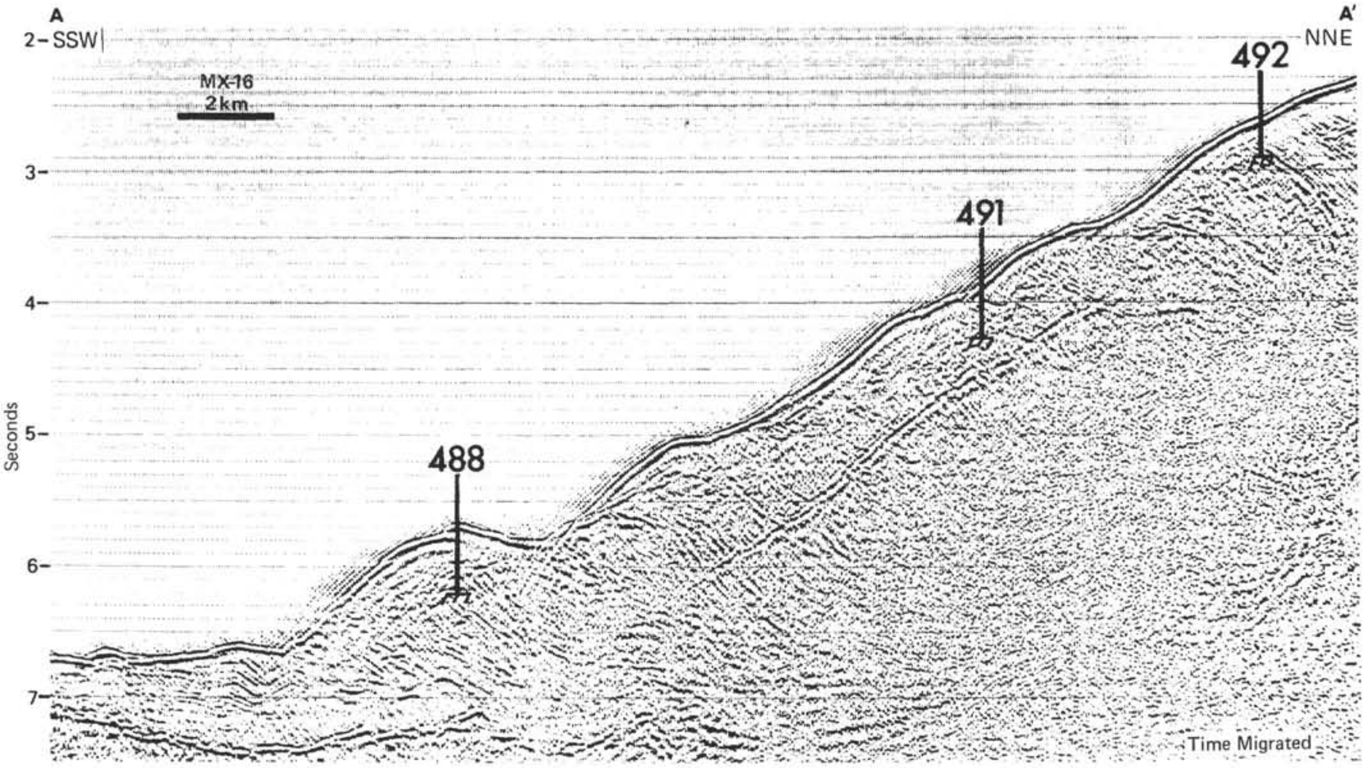

Figure 3. Migrated multichannel seismic reflection profile Line MX-16.

currence of pelagic clay lower in the sequence. Alternatively, we might expect to obtain an approximate paleodepth for the sandy unit of Site 491 from the microfossils below Core 4 (2 Ma ~Pleistocene/Pliocene boundary): planktonic foraminifers disappear and nannofossils are much less abundant; this probably indicates passage through the CCD (at approximately 3200 m) at this time. Lower in the sequence, in Core 27, a trace fossil assemblage suggests a depth of 4 km or greater (see Paleobathymetry and Vertical Tectonics), which favors deposition either in the trench or in a lowermost basin or channel.

Structural Data

Bedding dips of more than 10° and true tectonic fractures appear in Core 14, at about 120 meters in Unit 2 (lower to upper Pliocene). At greater depth, deformation becomes more intense. Variation in bedding dip in Unit 2 is probably due to synsedimentary disturbance before tectonic deformation. No unconformity (or disconformity) indicating the superposition of two different deformed units has been observed in this sequence. On the contrary, the increase of fracturing density is progressive; moreover, the first deformation appears about 300 meters above the top of coarse pebbly sands of Unit 3, in the so-called "slope apron deposits" (muddy silt of Unit 2). As for Site 488, we detected no tectonic repetition by paleontologic data in the whole drilled sequence.

BIOSTRATIGRAPHY

Site 491 penetrated a midslope lower Pliocene through Quaternary sedimentary section of sand and hemipelagic mud (Fig. 1). Calcareous fossils are partially or completely dissolved below Core 4 (40 m), but radiolarian and diatom preservation is generally good throughout. Reworked lower Miocene, upper Miocene, and Pliocene microfossils occur throughout the section, commonly in upper Pliocene and Quaternary sediments.

Radiolarians

Moderate to well-preserved radiolarians occur in nearly all cores from Site 491, although abundance varies markedly. Radiolarians are abundant and well preserved in Cores 1 to 9 but rare and poorly preserved in Cores 10 to 59, hampering biostratigraphic dating. This change in preservation and abundance coincides with an increase in sedimentation rate within Core 8. Reworking of lower and upper Miocene and Pliocene species, which occurs throughout the section at 491, hinders age determinations.

The good radiolarian preservation and reduced reworking in the upper part of Site 491 permit the identification and location of Quaternary and upper Pliocene radiolaria datum planes. As in other Leg 66 sites, mixtures of North Pacific and equatorial Pacific forms occur. The last occurrence of *Axoprunum angelinum* (0.4 Ma) occur at the base of Core 1 (10 m), and the last occurrence of *Anthocyrtidium angulare* (1.2 Ma) occurs in the lower part of Core 3 (28 m).

The lower part of Core 4 through Core 7 is within the *Pterocanium prismatium* zone, as suggested by the occurrence of *Lamprocyclas neoheteroporos* (Hays, 1970) and the first occurrences of *Amphirhopalum ypsilon* and *Anthocyrtidium angulare*, although *P. prismatium* itself is absent. The top of the *Spongaster pentas* zone,

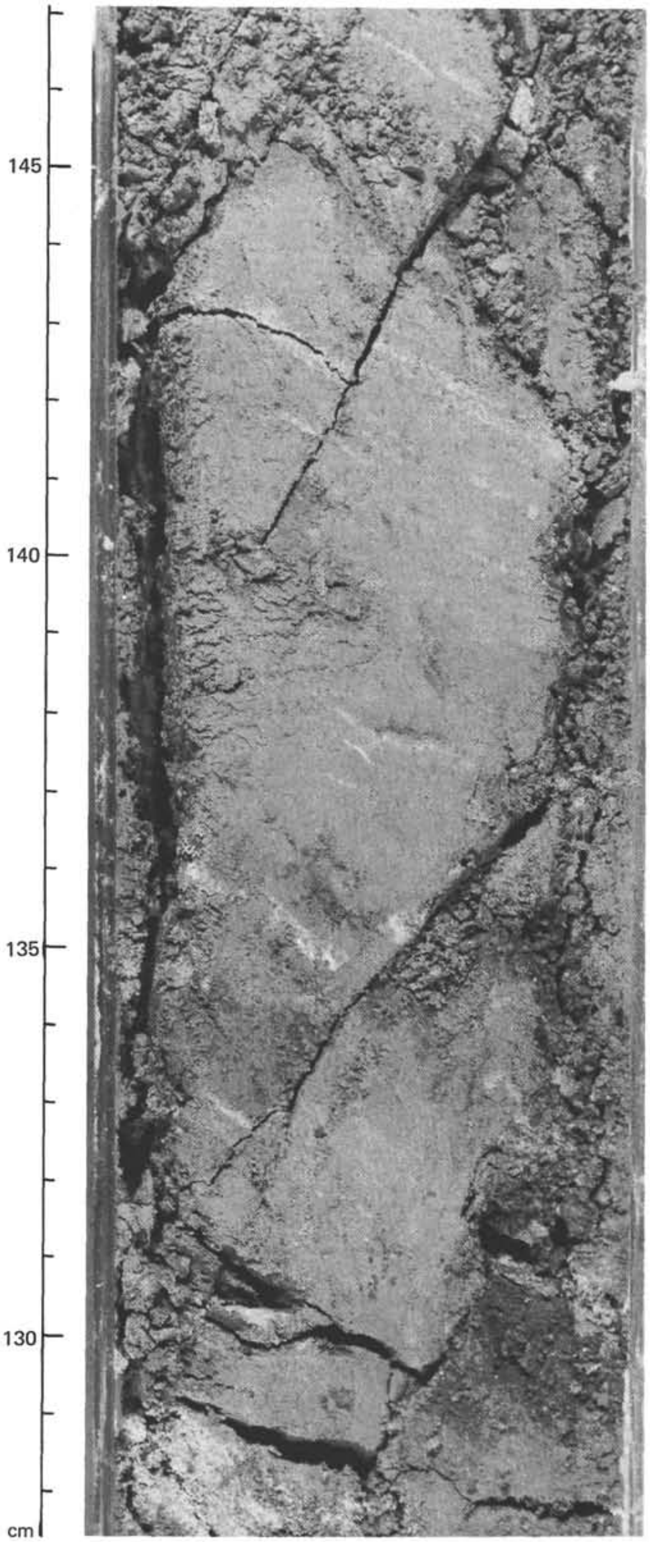

Figure 5. Very thin discontinuous silt beds of Unit 2, Sample 491-15-2, 130–145 cm.

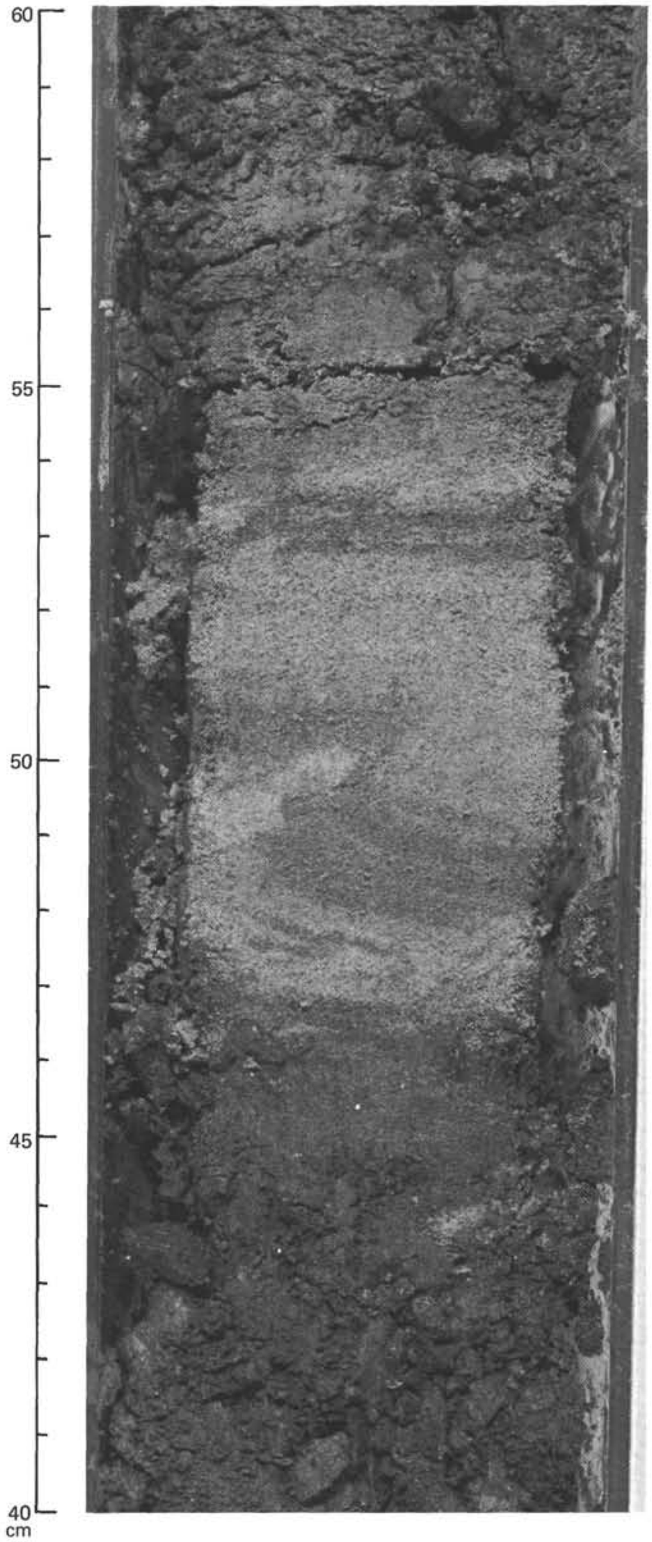

Figure 6. Fine-grained sand bed (Sample 491-19-4, 40–60 cm) representative of thickest sand beds observed in Unit 2. Note reverse fault of small displacement.

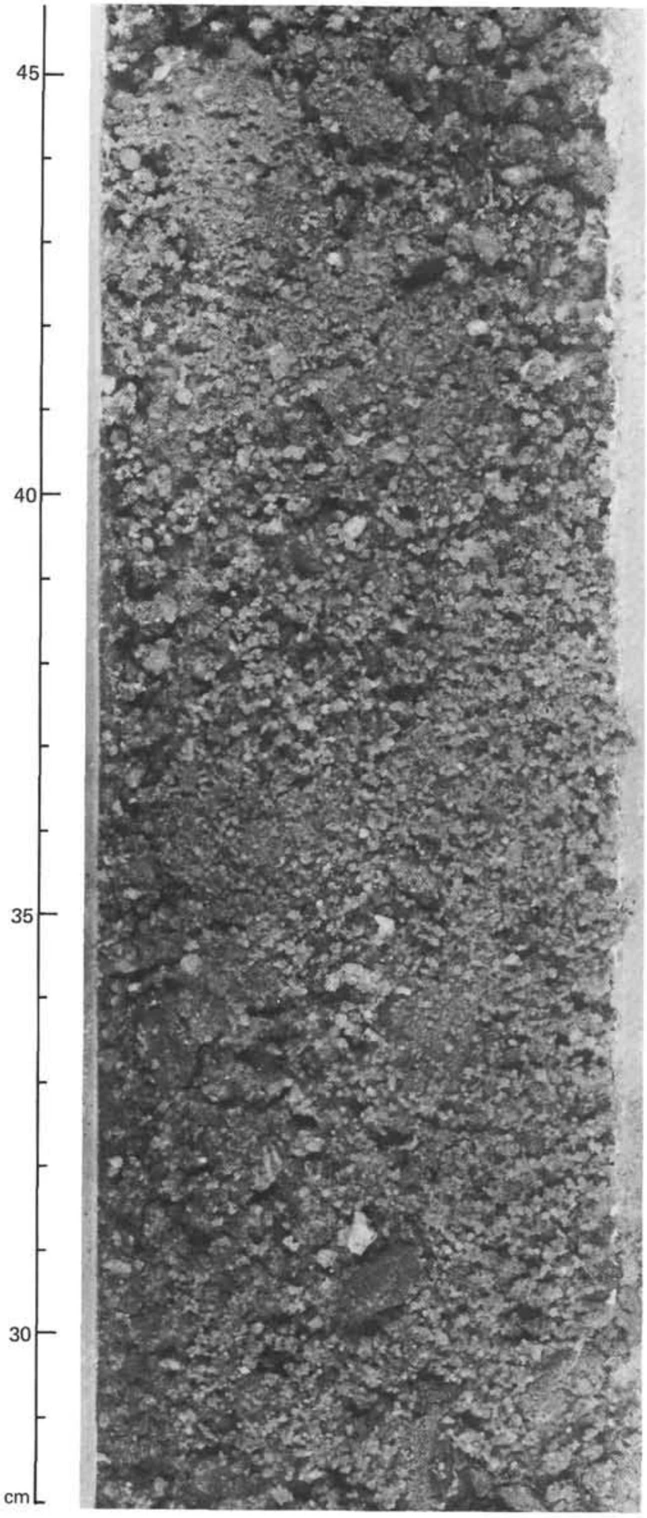

Figure 7. Coarse sand from Unit 3.

indicated by common *Stichocorys peregrina* and the appearance of *Spongaster pentas* shortly below, occurs within Core 9. Cores 10 to 59 may be within the *S. pentas* zone, as *S. pentas* is sporadic and *Ommatartus penultimus* never becomes common (Riedel and Sanfilippo, 1971). The early Pliocene age of Cores 10 to 59 is supported by calcareous nannoplankton.

Foraminifers

At Site 491, Cores 1 through 59 penetrate a Quaternary through Pliocene sedimentary section. Planktonic foraminifers are few to common in Cores 1 through 3, rare to very rare in Cores 4 through 6, and absent in Cores 7 through 59. Benthic foraminifers show almost the same pattern of distribution in the samples. Some samples in Cores 7 through 59, however, contain a few dwarf shelf-derived planktonic and benthic foraminifers. The planktonic specimens are usually juvenile and give no age indication.

Cores 1 through 3 include the following Quaternary foraminifers: *Globorotalia tumida, G. menardii, G. flexuosa, Globigerinoides ruber, G. sacculifer, G. triloba, Neogloboquadrina dutertrei,* and *Orbulina universa*. Although no index Pliocene species are encountered, occurrence of *Globorotalia* cf. *acostaensis* and *Neogloboquadrina humerosa* in Cores 4 and 5 may suggest an upper Pliocene age for these cores.

Paleoecology and Depositional Environment

Absence of *in situ* planktonic and benthic foraminifers in most of the Pliocene section indicates deposition below the CCD and dilution due to terrigenous influx. The occurrence of some shallow-water foraminifers in the samples, such as *Bolivina, Ammonia,* and *Gavelinella,* suggests reworking of the shelf assemblage. This Pliocene faunal assemblage corresponds to the modern trench fill fauna at Site 488. In contrast to the Pliocene environments, the upper Quaternary benthic foraminifers indicate a shallower depth (lower bathyal) corresponding to the modern water depth at this site. They include *Melonis pompilioides, Planulina wuellerstorfi, Hoeglundina elegans, Uvigerina proboscidea, U. hispida, Bulimina striata,* and *Pyrgo depressa*. The Quaternary assemblage contains both well-preserved and partially corroded foraminifers, indicating deposition within the foram lysocline or local excursions of the CCD.

Calcareous Nannoplankton and Silicoflagellates

The nannofossil assemblages of the sediment column from Section 491-1,CC to 491-59,CC can be assigned to four different biostratigraphic zones (Fig. 1):

1) Middle to upper Quaternary—Nannoplankton Zone NN20 in 1,CC to 2,CC (0.2–0.6 Ma): *Gephyrocapsa oceanica, G. caribbeanica, Helicosphaera carteri, Cycloccolithus leptoporus,* and *Ceratolithus cristatus.*

2) Upper Pliocene—Nannoplankton Zone NN18 in Core 4 (1.8–2.5 Ma): *Discoaster brouweri, Gephyrocapsa doronicoides*, and *Helicosphaera carteri*. This sediment was deposited after the extinction of *D. pentaradiatus.*

3) Upper Pliocene—Nannoplankton Zone NN17 in Cores 5–7 (2.5–2.7 Ma): *Discoaster pentaradiatus, D. brouweri,* and *Helicosphaera carteri.* Between Cores 7

and 8 there might be a hiatus, because the NN16 nannoplankton zone *D. surculus* was not found.

4) Lower Pliocene—Nannoplankton Zone NN15 in Cores 8-59 (3.5 Ma-?): *Reticulofenestra pseudoumbilica, Cyclococcolithus macintyrei, Discoaster pentaradiatus,* and *Sphenolithus neoabies.* Because of unfavorable deposition within a mostly siliceous sediment, the nannofossil assemblages from Core 9 down are impoverished, with only the more sturdy species preserved. As all the listed species of this zone have a long range from the Miocene up, no subdivision of this core interval can be given. No species restricted to the Miocene are found. Therefore a lower Pliocene age is the most probable one for the reduced nannofossil assemblages from Core 8 down. Ages are those used by Perch-Nielsen (1977).

Silicoflagellate assemblages were studied in Sections 491-1,CC and 491-4,CC. They constitute only a minor part of the siliceous sediment fraction consisting of mainly diatoms and radiolaria.

1) Core Catcher 1—middle to upper Quaternary, NN20: *Dictyocha stapedia stapedia* and *D. fibula,* 97%; *Distephanus octogonus,* 3%. This is a typical upper Quaternary assemblage, which fits into the *D. epiodon* Zone of Bukry and Foster (1973) as well as into the *D. octangulatus* Zone of Bukry (1973) for the eastern and eastern north Pacific or the *Dictyocha aculeata aculeata* Zone of Bukry (1978), respectively.

2) Core Catcher 4—upper Pliocene, NN18: *Dictyocha fibula* s.l., 96%; *Distephanus speculum* s.l., 4%. No *Mesocena elliptica,* or *D. octogonus* is found to indicate a date older than Quaternary which suggests that the associated nannofossils are not reworked. The occurrence of *Actiniscus tetrasterias* also gives evidence of an age near the Pliocene/Pleistocene boundary.

SEDIMENT ACCUMULATION RATES

The sediment accumulation rate curve (Fig. 8) is based on biostratigraphic datum points and paleomagnetic datum levels; the exact method used to construct the curve is outlined in the introductory chapter. No corrections have been made for compaction or deformation. Sediment accumulation rates in the upper part of Site 491 vary between 34.2 m/m.y. and 5 m/m.y. Below 70 meters, the minimum rate is 1055 m/m.y., if all sediment below 81 meters accumulated within the *Spongaster pentas* and NN15 zones. The higher accumulation rate in the lower part of Site 491 may result partly from tectonic thickening of the section which occurred at the lower slope (see Paleobathymetry) as well as from higher initial sedimentation rates. After 3 Ma, slope sediments were deposited at a much slower rate.

PALEOBATHYMETRY AND VERTICAL TECTONICS

Sedimentologic and paleontologic data permit us to construct a paleobathymetric curve for Site 491 (Fig. 9). The three points used are the present water depths, the point where sediments of Site 491 pass through the CCD at 3.2 km at 2 Ma (see McMillen, this volume); the basal sandy sediments, which were probably deposited on the lower slope or trench at 5 km about 3.7 Ma; and the *Teichichnus-Zoophycos-Chondrites* trace fossil assemblage occurring at 4 km or greater water depth in Core 27.

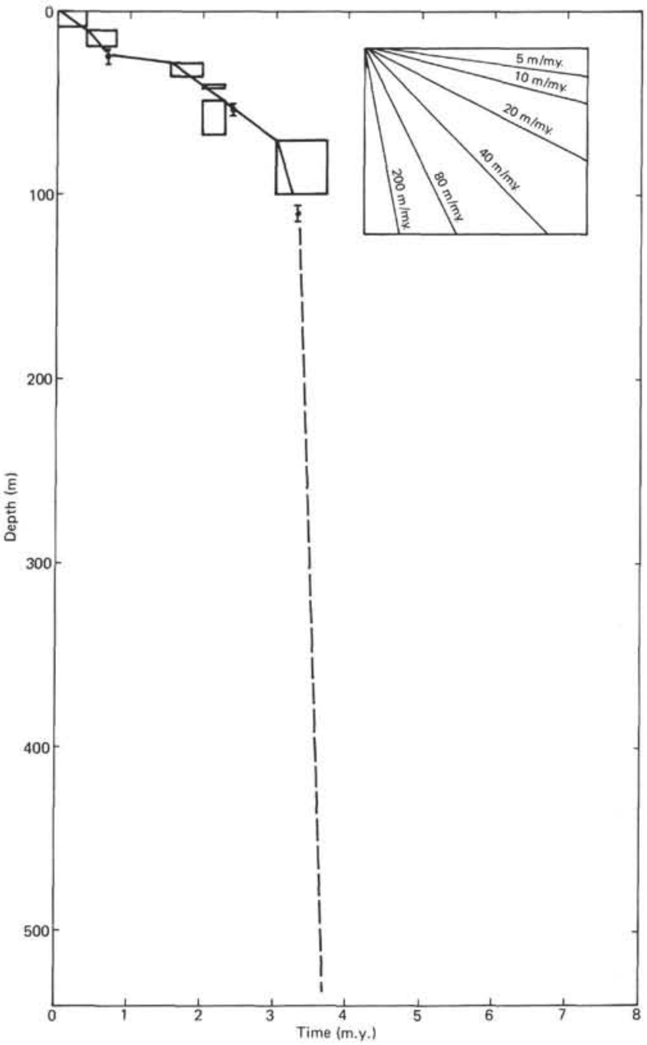

Figure 8. Sediment accumulation rate, Site 491. Rate uncorrected for compaction or tectonic tilt.

These three points define the paleobathymetric curve for Site 491 (Fig. 8). The most striking feature of the curve is that the uplift began at a high rate of about 800 m/m.y. and slowed to a rate of about 135 m/m.y. from 2 Ma onward. The higher rate prior to 2 Ma probably represents the emplacement of lower slope or trench sediment into the zone of accretion, and the slower rate after 2 Ma probably represents regional uplift of the slope due to sediment underplating of the accretionary zone.

PALEOMAGNETISM

Paleomagnetic analyses at Site 491 established magnetostratigraphy and determined dips of certain beds and faults. Sediments in Site 491 can be correlated mainly with the Gilbert reversed polarity epoch. Paleomagnetically oriented cores dip generally northward.

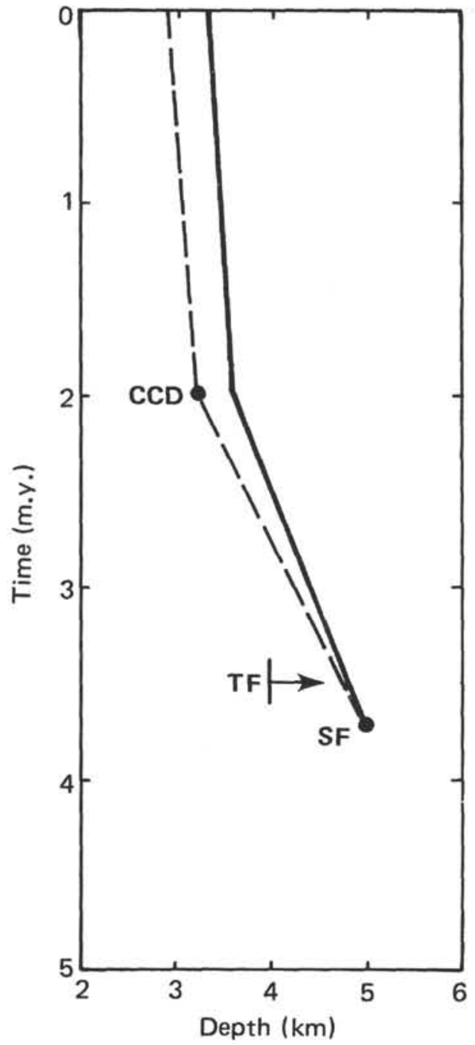

Figure 9. Paleobathymetry (dashed line) and vertical tectonics (solid line) for Site 491. Control points: CCD is the location of the carbonate compensation depth at 2 m.y., TF is the location of the *Zoophycos-Chondrites-Teichichnus* trace fossil assemblage indicative of water depths 4 km or greater, and SF is the location of the sandy facies interpreted as uplifted trench deposits. The tectonic curve is derived from the bathymetric curve by removing the sediment accumulation at any given time.

Cores from the upper 50 meters are disturbed by drilling showing laminations concave downward along core margins. Cores deeper than 220 meters in the hole are separated into pieces of several centimeters in thickness which are rotated relative to one another. Several cores from the middle of the hole have irregular bedding, possibly caused by slumping.

Using a plastic tube in the upper 480 meters and a minicore drill below 480 meters 67, oriented samples were collected from less disturbed portions of cores with regular bedding direction. Stability of remanent magnetization of selected samples was examined with stepwise AF demagnetization (Niitsuma, this volume). The magnetization of the samples shows stable orientation and a slow decrease in intensity with AF demagnetization. The noise level of magnetometer is $10^{-7.6 \pm 0.5}$ emu/cc. Structural corrections have been applied to the inclination values. Average intensity is $10^{-5.8 \pm 0.7}$ emu/cc after 15 mT AF demagnetization, although the intensity of upper 70 meters of the hole is one order weaker ($10^{-6.7 \pm 0.7}$ emu/cc). The sudden downhole increase in intensity at 70 meters coincided with lithologic change from calcareous nodule-bearing mud to mud with fine sand patches. Inclinations in the upper 140 meters of the hole changes sign frequently. Cores below 140 meters have mainly negative inclination except for three intervals of significant positive inclination. We believe that the Brunhes/Matuyama boundary occurs at about 24 meters, the Matuyama/Gauss boundary at about 53 meters, and the Gauss/Gilbert boundary at about 110 meters (Fig. 1). Below 100 meters the sediments probably are entirely in the Gilbert polarity epoch.

Sediment at Site 491 dip from 4° to 64°. Since the drilling core axis is nearly vertical, orientation of bedding plane can be calculated from magnetic inclination and declination (Niitsuma, this volume).

Dip direction of bedding plane are generally north-northeast, which is the opposite direction of submarine topographic slope. Clockwise direction of change of dips appears cyclically from westward to eastward depth (Niitsuma, this volume). Northward dip direction is accompanied with steeper dip angle and westward dip direction with shallower dip angle. This kind of regularity and cyclicity in dip angle and direction suggests either slump folding or small-scale tectonic deformation.

Several conjugate faults sets were observed in the lower portion of the cored section at Site 491 (Niitsuma, this volume). Paleomagnetic orientation of these faults suggests that the tensional axis is horizontal and almost parallel to the bedding dip direction.

ORGANIC GEOCHEMISTRY

The shipboard organic geochemistry monitoring program consisted of analysis of gases released in core liners, determination of organic carbon, hydrogen, nitrogen, and carbonate content of selected sediment samples, and visual inspection for fluorescence in split core.

Gases

Moderate amounts of gas were released in core liners from depths of about 20 meters and greater. The gas initially contained methane, CO_2, and small amounts of H_2S. The last, detectable by its distinctive odor, was present down to depths of about 60 meters. Methane content remained fairly constant with depth (Fig. 10) except for minima in the vicinity of 100, 175, 225, 350, and 450 meters.

Shallower than about 50 meters, ethane content was below the detection limit of the Carle gas chromatograph but increased gradually with depth and maintained a concentration of about 0.03% by volume except at the methane minima mentioned in the foregoing. The correspondence of low values in ethane + methane

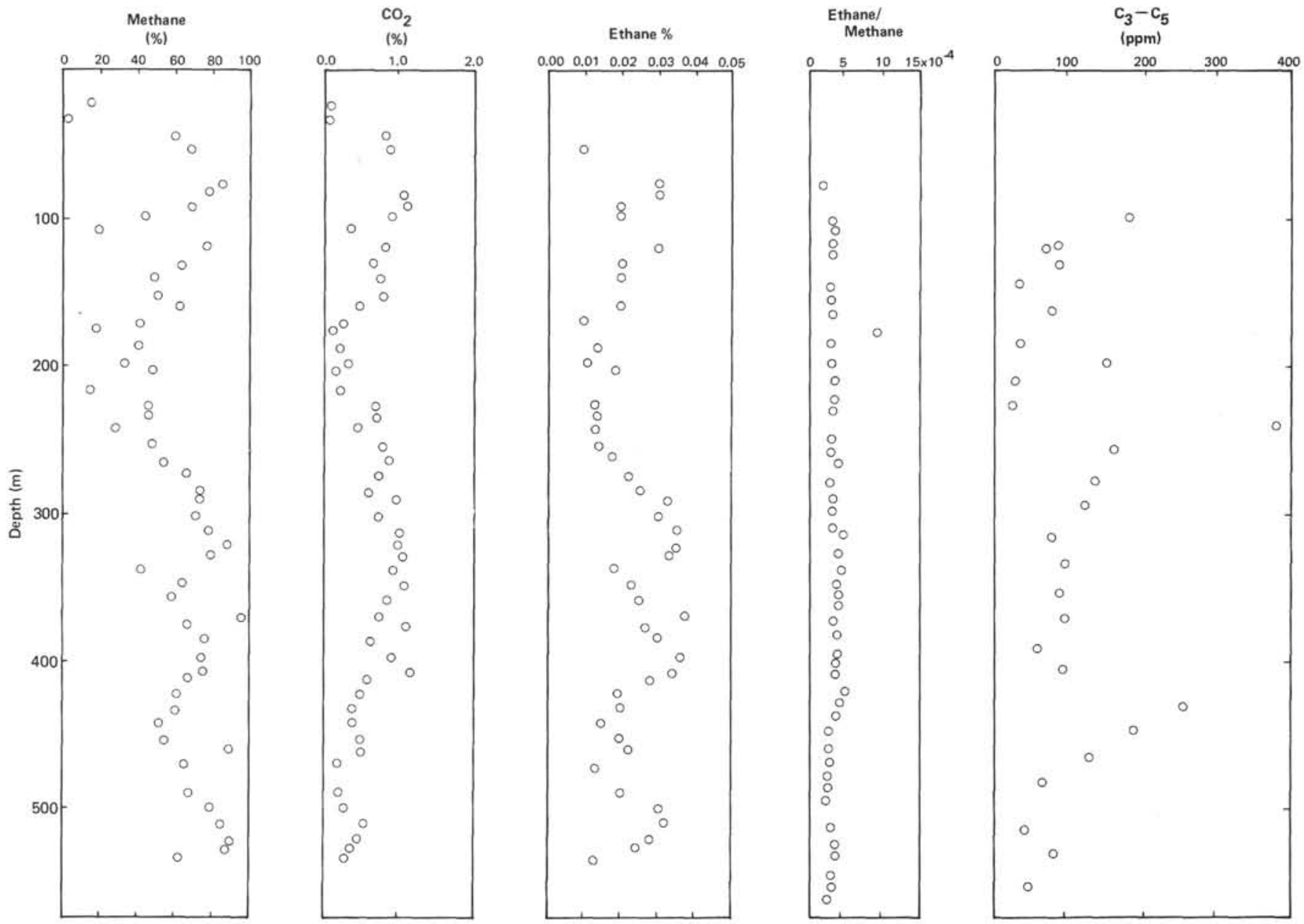

Figure 10. Gas concentrations, Site 491.

suggest air dilution, probably due to washout. The ethane to methane ratio (Fig. 10) seldom varied from a value of about 3×10^{-4} throughout the cored section.

CO_2 content in core liner gases varied from 0.06% to 2.04%, with both the highest and lowest concentrations occurring in the upper portion of the cored sequence.

Hydrocarbons in the C_3 to C_5 range were monitored on the Hewlett-Packard 5710-A gas chromatograph from a depth of 75 meters to TD. Their abundance was found to vary erratically with depth, showing a maximum of 381 ppm at 214.7 meters (Fig. 10).

Upon splitting Cores 10 and 19, gas-releasing ice inclusions or frozen sediment were observed from depths of 88.9 to 89.0 meters, 162.7 to 163.15 meters, and 168.3 to 168.35 meters, respectively (Figs. 1 and 11). One ice inclusion at 89 meters released gas equivalent to 7.2 times its volume, suggesting the presence of hydrate. The evolved gases consisted of methane and CO_2, with no ethane detectable on the Carle gas chromatograph.

Fluorescence

Split cores showed no evidence of fluorescence due to crude oil or bitumen impregnation.

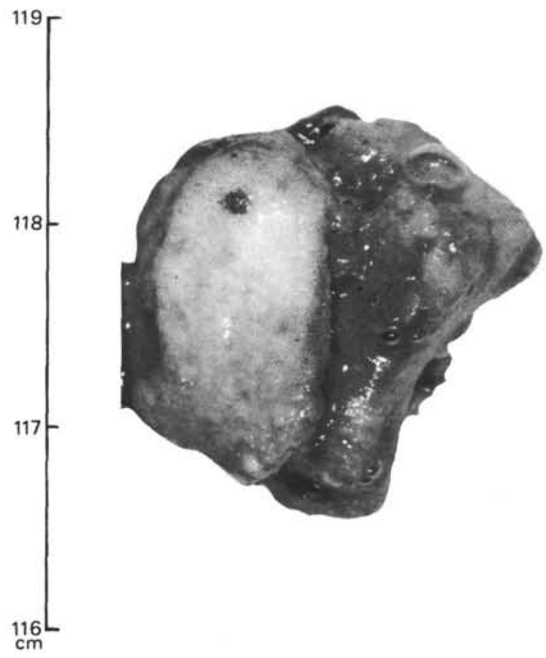

Figure 11. Probable hydrate-bearing ice inclusion at 89 meters (Sample 491-10-2, 145–147 cm).

Organic Carbon, Hydrogen, Nitrogen, and Carbonate

Samples for CHN and carbonate analysis were taken from selected cores. Within the cored sequence, the organic carbon content varied from 0.89% to 1.98% and the total nitrogen content from 0.08% to 0.17%. The organic potential of the sediments remained relatively constant and at an intermediate level throughout the hole.

The C/N ratio varied from 10.0 to 14.9, remaining approximately constant throughout the hole. This is in the range for organic matter associated with recent sediments (Fairbridge, 1972) and suggests that the organic matter present in these sediments has a low degree of thermal maturation. Low concentration of carbonates were detected, particularly in the lower portion of the hole.

Conclusions

Gases, mainly of biogenic origin, were detected throughout this hole, causing a low to moderate degassing of the cores. The organic potential of the sediments stayed at an intermediate level through the hole, being marginally higher for the upper section. The C/N ratio of the organic matter suggests a low degree of geothermal maturation. No evidence of petroleum or bitumen impregnation was detected.

Heavier hydrocarbons C_3 to C_5 varied erratically with depth without evidence of an increase in geothermal maturation. The origin of these gases is not known. They may originate in geothermally more matured sediments and be emplaced in shallower depths by migration, but a biogenic origin cannot be excluded.

The gas-generating ratio of one frozen sample at 88.9 to 89 meters suggests the presence of gas hydrate at Site 491.

PHYSICAL PROPERTIES

Physical property analyses of Site 491 sediments included porosity, water content, wet bulk density, and undrained shear strength (Fig. 12) (see Boyce, 1976, for procedures). Gas attenuation prevented compressional sound velocity measurements. Poor core recovery and increased core disturbance limited sampling density below 250 meters sub-bottom. The lack of logging precluded correlation with *in situ* properties.

Uniformly gradational changes in physical properties occur to 410 meters sub-bottom. Below 410 meters, variations in physical properties and the necessity to increase pump pressure to maintain drilling rates suggest increased induration. This increase may result from mass movement and/or tectonic processes or may reflect the influence of more permeable sand beds below which facilitated dewaterting of the interbedded muds at the time of deposition.

Porosity, Water Content, and Bulk Density

Porosity decreases uniformly from 66% at 0.50 meters to 33% at 525 meters (Fig. 12). Water content decreases from 44% at 0.50 meters to 15% at 525 meters. Both porosity and water content decrease more rapidly below 410 meters. Bulk density increases from 1.58 Mg/m^3 to 2.07 Mg/m^3 from 6.60 to 520 meters, respectively (Fig. 12).

Shear Strength

Shear strength increases regularly from 13.5 kPa at 0.5 meters to 122.5 kPa at 69 meters (Fig. 12). Good correlation exists between vane shear and torvane results.

INHOLE TEMPERATURE MEASUREMENTS

Of three downhole temperature measurements at Site 491 with the Uyeda Probe, none yielded typical temperature curves. The measurement at 304.5 meters yielded a bottomhole temperature of 14.5°C and a gradient of 2.5°C/100 m. The measurement at 304.5 meters yields a thermal gradient which is about twice as high as predicted from methane hydrate-phase relationships (Shipley et al., 1979) and three times conventional heat flow work of Langseth and Von Herzen (1970). The postulated relationship between a prominent reflection and the base of gas hydrates of Shipley et al. (1979) is based on the pressure and temperature of hydrate stability. If the gradient is as high as 4°C/100 m, then the base of the hydrate stability occurs much shallower than the depth to the so-called "bottom-simulating reflection" (BSR). See Shipley and Shephard (this volume) for a complete discussion of the temperature data.

CORRELATION OF SEISMIC REFLECTION DATA AND DRILLING RESULTS

Site 491 coincides with a zone of landward-dipping reflectors about halfway up the inner slope of the trench between Sites 488 and 490. A wave-equation-migrated multichannel profile about 1000 meters northwest of Site 491 shows a zone of discontinuous and indistinct reflections, extending to perhaps a 0.4 s sub-bottom and clearly separate from the deeper landward-dipping, more coherent reflectors (Fig. 13). The actual boundary between the two zones is not well defined (Fig. 14). A high-amplitude reflection at 0.7 s sub-bottom may correlate with the base of the gas hydrate layer (Shipley et al., 1979).

The multichannel seismic data reveal a fairly high velocity (2.2 km/s) for the interval from the seafloor to the gas hydrate(?) reflection. Using this velocity, the total drilled section of 542 meters corresponds to at least 0.49 s sub-bottom (Fig. 13). The base of the discontinuous and indistinct reflectors occurs at about 440 meters sub-bottom, coinciding with the top of Lithologic Unit 3, which is defined by the first appearance of significant sand beds downhole. However, thick sand beds, which are probable reflectors, do not occur above 470 meters. The higher velocity for the sediments, compared to Site 488, is manifested in both the greater age and fissility of these rocks versus any significant lithologic changes.

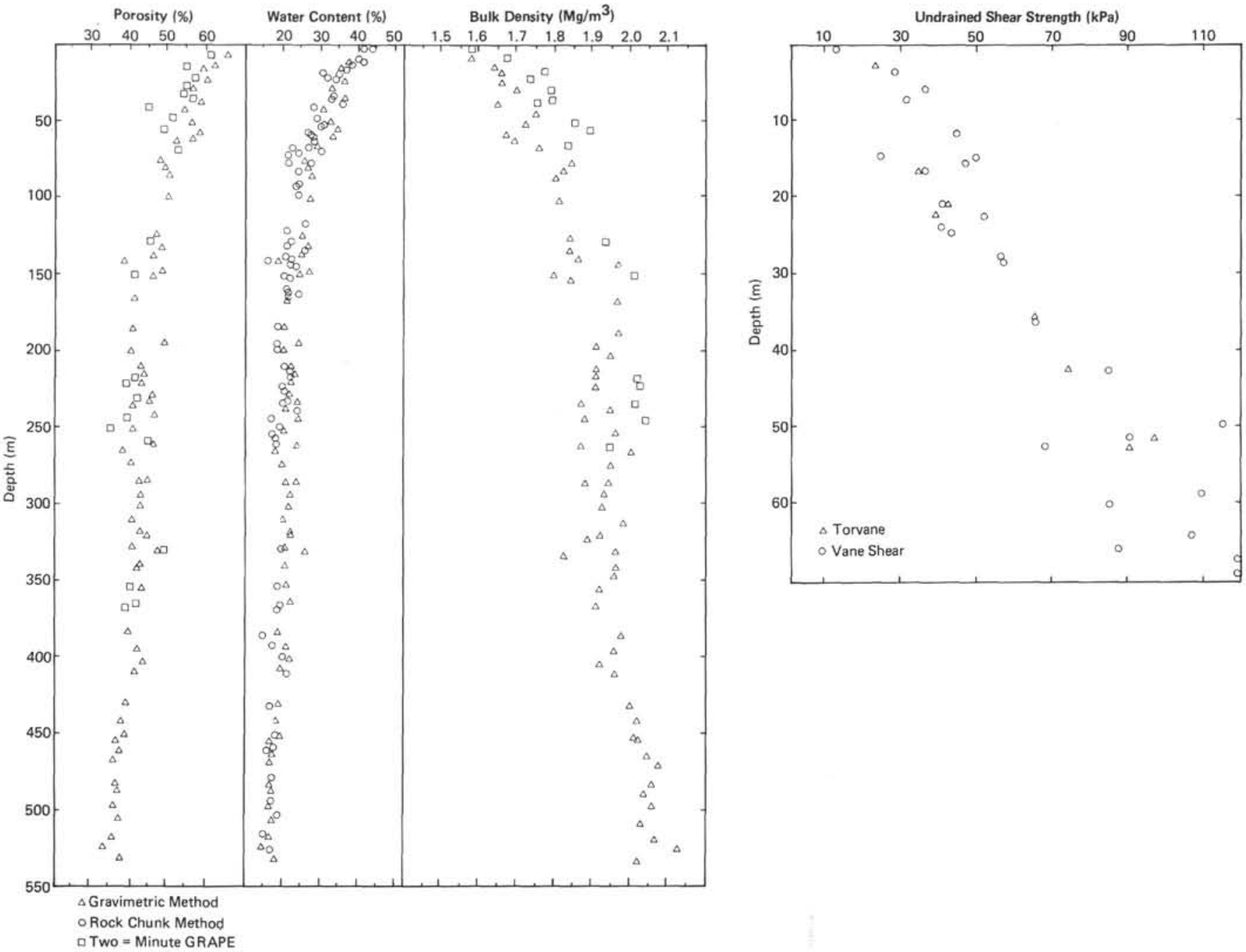

Figure 12. Physical properties summary profiles, Site 491.

SUMMARY AND CONCLUSIONS

At Site 491 we penetrated 542 meters and recovered 59 cores comprising three lithologic units. Unit 1 extends from 0 to 57.5 meters and consists of upper Pliocene to upper Quaternary mud and muddy silt with minor concentrations of ash and calcareous mud. Lower Pliocene muddy silt and muddy siltstone with minor fine sand layers constitutes Unit 2, cored between 57.5 and 437.5 meters. The most significant lithologic break occurs with Unit 3, which extends from 437.5 to 542 meters and is composed of lower Pliocene muddy silt and muddy siltstone with interbedded fine to coarse pebbly sand layers up to 40 cm thick.

Near-surface cores at Site 491 include a diverse microfossil assemblage; however, below 40 meters the calcareous components are partially or completely dissolved. Diatom and radiolarian preservation is good throughout the section, with radiolarians providing the best age control for deeper cores. Sediment accumulation rates, uncorrected for structure or compaction, are low (5–34 m/m.y.) above 70 meters but increase substantially (to about 1000 m/m.y.) below this depth to the base of the hole.

At Site 491 tilted beds and fracturing occur initially at about 120 meters and continue to total depth through the lower two lithologic units. In Unit 2 dips are variable and range to nearly vertical; fracturing is present throughout though slickensides are rare. Dip angles in Unit 3 range up to 30° and are more uniform than in Unit 2. A strong fissility develops locally. Paleomagnetic restorations of bedding in both Units 2 and 3 indicate modal dip directions to the north, though with considerable scatter. A separate deformational history for Unit 3 is suggested by discrete jumps in bulk density and porosity below 425 meters, though this variation may be simply the result of lithologic changes.

The multichannel seismic reflection profile through Site 491 shows a series of discontinuous and indistinct reflectors above about 0.4 s, overlying more coherent landward-dipping reflectors. At an interval velocity of 2.2 km/s the base of the discontinuous and indistinct reflections occurs at 440 meters near the top of Unit 3, which is defined by the first occurrence of sand. The

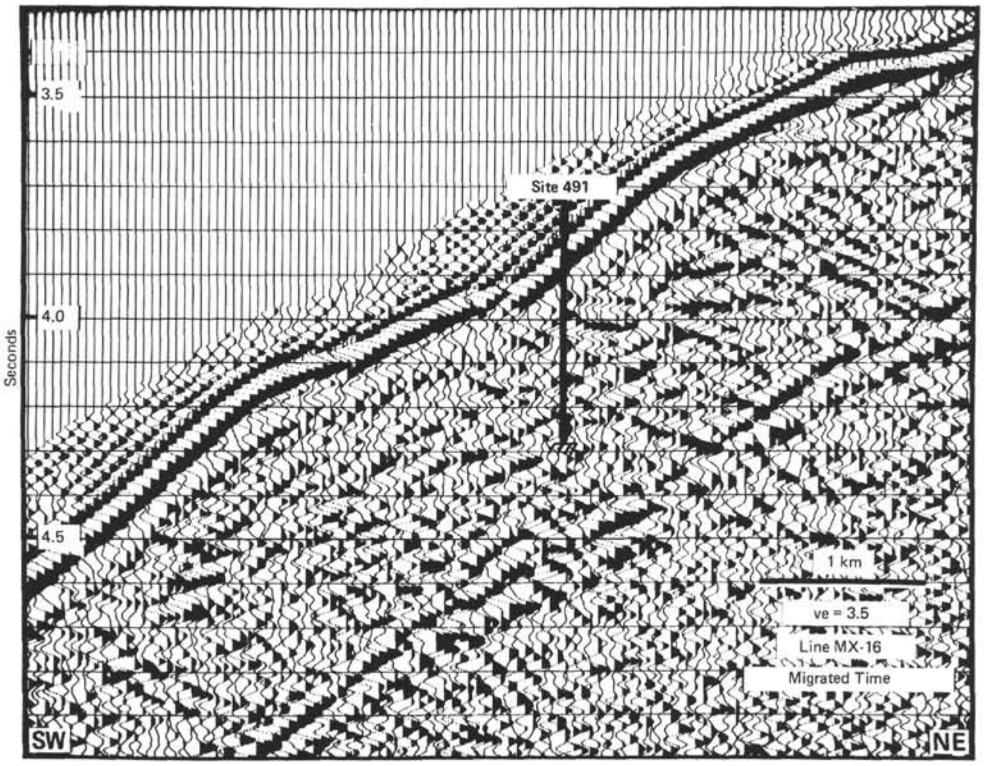

Figure 13. Detail of seismic profile Line MX-16.

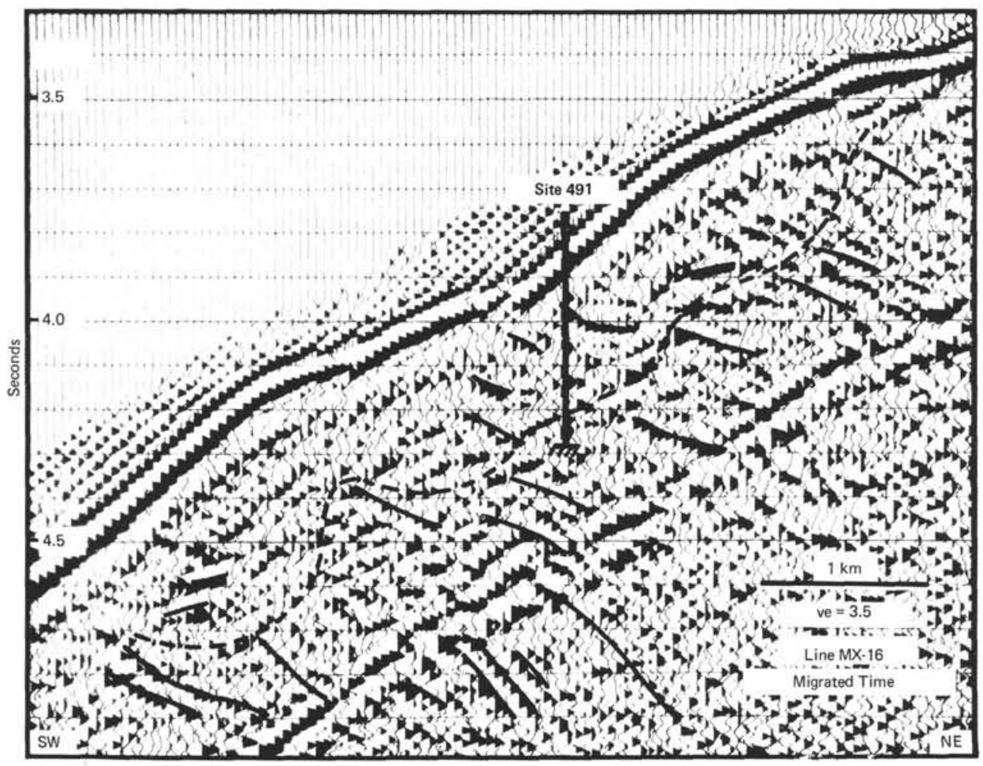

Figure 14. Interpretive line drawing of Figure 13.

thick sandbeds, the probable reflectors, are not apparent until 470 meters sub-bottom. The mean low, northerly dip of bedding in Unit 3 suggested by the paleomagnetic restorations is subparallel to the dips of the seismic reflectors.

The depositional environment of Site 491 sediment is most directly interpreted by reference to the modern sedimentary regime as well as to the Quaternary sequence of Site 488. Coarse sands similar to those cored in Unit 3 at Site 491 occur in the modern trench and presumably in the large submarine canyon feeding the trench but have not been recovered in piston cores from the slope (McMillen and Haines, this volume). As such, we prefer to interpret the sand-bearing Unit 3 as trench sediment, since the profiles through the site show no evidence of buried canyons (Shipley, this volume). Alternatively, the coarse sands may have accumulated in a slope basin, though the seismic data show no evidence of remnants of such a basin. Much of the muddy silt of Unit 2 at Site 491 accumulated below the CCD at sedimentation rates comparable to those at Site 488. Thus Unit 2 sediments were probably deposited as lower slope hemipelagic muds.

Deformation occurs primarily in sands and muddy silts accumulated at high sedimentation rates, probably in the trench and or lowermost slope environments. This deformed sequence is overlain by about 120 meters of largely undisturbed sediment, most of which accumulated at a low rate at or above the CCD. Thus the structural history of this site indicates deformation in the trench and/or lower slope environment associated with rapid uplift from about 4 to 3 Ma, followed by an interval of slow deformation and uplift. Apparently the toe of the trench slope is a zone of concentrated tectonism that diminishes in intensity upslope.

Hydrocarbon gases from C_1 to C_5 were detected throughout the hole, causing low to moderate degassing of the cores. Gas-releasing frozen sediments were observed in the 88.9 to 89.0 meter, 162.7 to 163.15 meter, and 168.3 to 168.35 meter intervals. The gas-generating ratio (7.2) of one of the samples (88.9–89 m) suggests the presence of hydrated sediments. Failure of the pressure core barrel prevented an attempt to sample the gas hydrates *in situ*.

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SITE 491 HOLE CORE 1 CORED INTERVAL 0.0–10.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20	RP	FM	AG / AM		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ

LITHOLOGIC DESCRIPTION

One cm diffuse dusky yellow green (5GY 5/2) ash spot

MUDDY SILT, soft, grayish olive green (5GY 3/2) with sporadic white sponge specks.

SMEAR SLIDES

	Ash	Muddy silt	Mud
	1-5 (M)	1-30 (D)	7-40 (M)
TEXTURE:			
Sand	1	1	–
Silt	89	69	40
Clay	10	30	60
COMPOSITION:			
Quartz	5	60	37
Feldspar	2	8	5
Mica	1	3	3
Heavy minerals	TR	TR	TR
Pyrite	1	1	1
Clay	10	25	50
Glass	81	TR	–
Nannofossils	–	TR	–
Radiolarians	TR	TR	TR
Diatoms	–	TR	1
Sponge spicules	TR	2	1
Silicoflagellates	–	–	1
Plant fragments	–	–	1

GRAIN SIZE

	3-52
Sand	2.7
Silt	62.3
Clay	34.9

One cm wood fragment

ORGANIC CARBON AND CARBONATE

	5-101
% Organic Carbon	1.9
% $CaCO_3$	0.0

Color change 5Y 5/2 with MUD 5Y 4/4 tinges

SITE 491 HOLE CORE 2 CORED INTERVAL 9.5–19.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20	RP	RP	AG / AG		1, 2, 3, 4, 5, CC	0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ

LITHOLOGIC DESCRIPTION

MUDDY SILT, soft, grayish olive green (5GY 3/2) moderate deformation, sponge spicules sporadic. Silty zones are probably concentrations in burrows. Black specks of pyrite common.

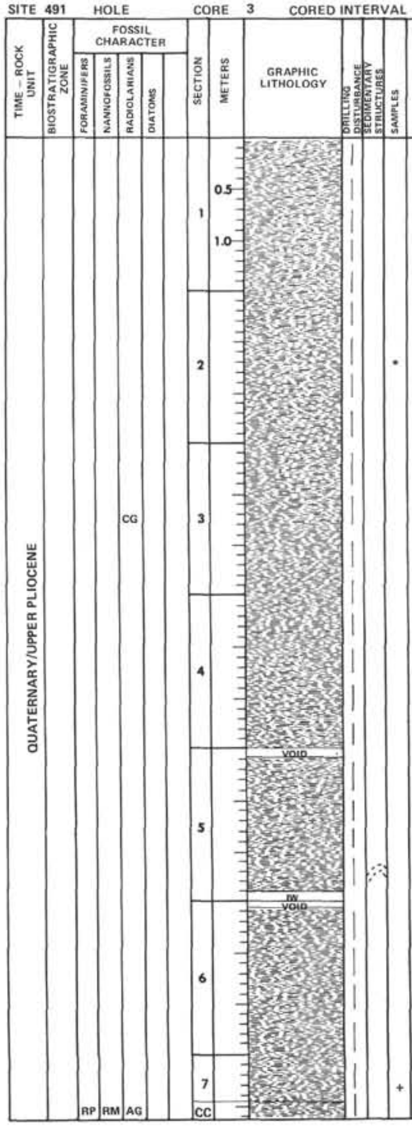
SMEAR SLIDES

	Mud	Muddy silt
	2-72 (D)	2-89 (M)
TEXTURE:		
Sand	2	10
Silt	40	70
Clay	58	20
COMPOSITION:		
Quartz	33	68
Feldspar	8	8
Mica	4	2
Heavy minerals	1	1
Pyrite	1	1
Clay	50	20
Glauconite	TR	TR
Radiolarians	TR	TR
Diatoms	TR	TR
Sponge spicules	TR	TR

GRAIN SIZE

	3-52
Sand	1.5
Silt	58.5
Clay	40.0

SITE 491 HOLE CORE 3 CORED INTERVAL 19.0–28.5 m



LITHOLOGIC DESCRIPTION

MUD, grayish olive green (5GY 3/2) moderately deformed. White sponge concentrations are less common; dark concentrations of pyrite are common; grayish olive (10Y 4/2) carbonate-rich zones occur in 2 or 3 places in each section. Section 4: gas expansion cracks common between 80 and 150 cm. Section 5: gas expansion cracks common from 3–90 cm; slight mottling 120–130 cm. Section 6: slight mottling, some silty concentrations in burrows(?).

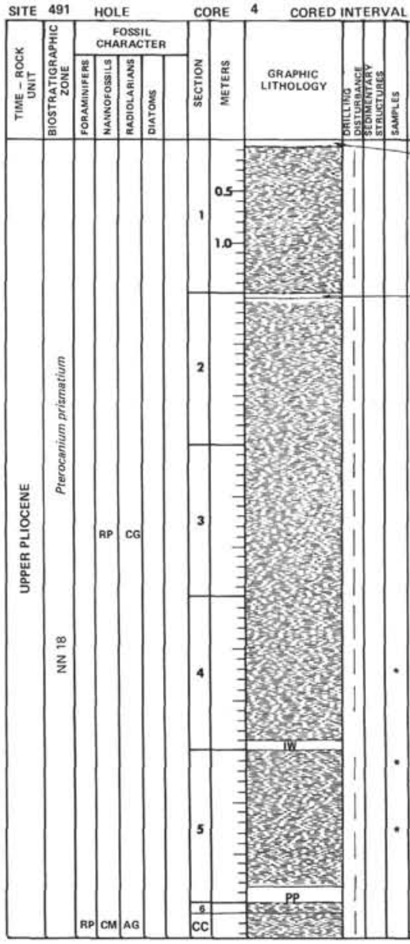
SMEAR SLIDES

	Mud 2-70 (D)
TEXTURE:	
Sand	2
Silt	45
Clay	53
COMPOSITION:	
Quartz	36
Feldspar	10
Mica	4
Heavy minerals	1
Pyrite	2
Clay	45
Radiolarians	TR
Diatoms	1
Sponge spicules	1
Plant fragments	TR

ORGANIC CARBON AND CARBONATE

	7-38
% Organic Carbon	2.0
% $CaCO_3$	0.0

SITE 491 HOLE CORE 4 CORED INTERVAL 28.5–38.0 m



LITHOLOGIC DESCRIPTION

Calcareous nodule
VOID

Calcareous nodule

VOID

Calcareous nodule: appears to be filled worm burrow

Diffuse ash concentrations in upper 20 cm

MUD, grayish olive green (5GY 3/2). Diffuse ASH concentrations occur in Section 5. Small calcareous concretions probably originally burrows(?) and gas expansion cracks are common. Section 4: gas expansion cracks 35–50 cm and 120–140 cm.

SMEAR SLIDES

	Mud 4-72 (D)	Ash 5-13 (M)	Micritic chalk 5-80 (M)
TEXTURE:			
Sand	–	80	–
Silt	40	20	–
Clay	60	–	–
COMPOSITION:			
Quartz	39	–	TR
Feldspar	8	–	–
Mica	4	–	–
Heavy minerals	1	–	–
Pyrite	2	TR	–
Clay	45	–	–
Glass	–	100	–
Radiolarians	TR	–	–
Diatoms	TR	–	–
Sponge spicules	1	–	–

SITE 491 HOLE CORE 5 CORED INTERVAL 38.0–47.5 m

TIME – ROCK UNIT: UPPER PLIOCENE

BIOSTRATIGRAPHIC ZONE: NN 17; *Pterocanium prismatium*

FOSSIL CHARACTER: FORAMINIFERS RP; NANNOFOSSILS FP; RADIOLARIANS AG; DIATOMS

SECTION: 1, 2, 3, 4, CC

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY: OG; IW

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Gas expansion cracks

Gas expansion cracks less common

Calcareous (worm tube? nodule)

MUD, grayish olive green (5GY 3/2), homogeneous, soft to firm; small calcareous zones (CHALK) which were originally burrows. Section 4: firm, no gas expansion cracks.

SMEAR SLIDES

	Mud 3-120 (D)
TEXTURE:	
Sand	2
Silt	48
Clay	50
COMPOSITION:	
Quartz	56
Feldspar	7
Mica	3
Heavy minerals	1
Pyrite	1
Clay	40
Calcite	1
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1
Plant fragments	TR

ORGANIC CARBON AND CARBONATE

	3-120
% Organic Carbon	1.2
% $CaCO_3$	0.0

SITE 491 HOLE CORE 6 CORED INTERVAL 47.5–57.5 m

TIME – ROCK UNIT: UPPER PLIOCENE

BIOSTRATIGRAPHIC ZONE: NN 17; *Pterocanium prismatium*

FOSSIL CHARACTER: FORAMINIFERS RP; NANNOFOSSILS FP; RADIOLARIANS AG; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY: VOID; PP; PP

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ

LITHOLOGIC DESCRIPTION

6x3x2 cm carbonate concretion

Ash

Carbonate ooze

Ash and 1.5x1x0.5 cm fragment carbonate concretion

Ash

2x1x1 cm fragment carbonate concretion

Ash

Silt spot

Mottled with carbonate ooze (60–70 cm)

Lithified 5Y 4/4 carbonate chalk

MUDDY SILT, grayish olive green (5GY 3/2). Small areas of ASH, light olive gray (5Y 6/1) diffuse areas of carbonate OOZE/CHALK moderate olive brown (5Y 4/4). Occasional minute (1–2 mm) concentrations of sponge spicules bluish white (5B 9/1).

SMEAR SLIDES

	Mud 2-85 (D)	Ash 1-97 (M)	Micritic chalk 5-94 (M)
TEXTURE:			
Sand	TR	10	–
Silt	48	85	–
Clay	52	5	–
COMPOSITION:			
Quartz	62	10	1
Feldspar	8	2	–
Mica	2	4	TR
Heavy minerals	2	TR	TR
Pyrite	2	1	
Clay	20	–	–
Glass	–	83	–
Carb. unspec.	2	–	–
Nannofossils	–	TR	–
Radiolarians	TR	–	–
Diatoms	1	TR	–
Sponge spicules	1	TR	

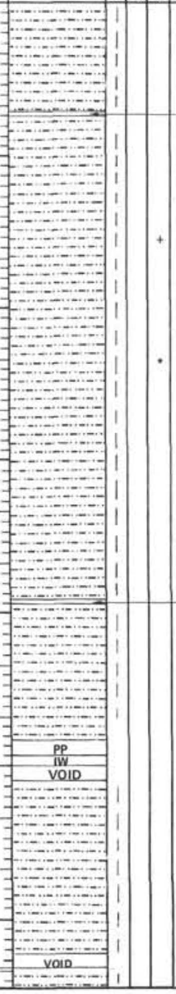
GRAIN SIZE

	2-84
Sand	3.1
Silt	59.0
Clay	37.9

SITE 491 HOLE CORE 7 CORED INTERVAL 57.5–67.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER PLIOCENE	NN 17 *Pteroranium prismatium*	B	FM	AG		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



Chalk
Chalk
VOID
Chalk
VOID
Chalk

LITHOLOGIC DESCRIPTION

MUDDY SILT, firm, grayish olive green (5GY 3/2), firm homogeneous. Small (1–5 mm) ASH blebs; occasional minute (1–2 mm) sponge remains; diffuse areas of CHALK.

SMEAR SLIDES

	Muddy silt 3-53 (D)
TEXTURE:	
Sand	1
Silt	55
Clay	44
COMPOSITION:	
Quartz	61
Feldspar	7
Mica	5
Heavy minerals	3
Pyrite	2
Clay	15
Glass	1
Carb. unspec.	1
Foraminifers	TR
Radiolarians	TR
Diatoms	3
Sponge spicules	2

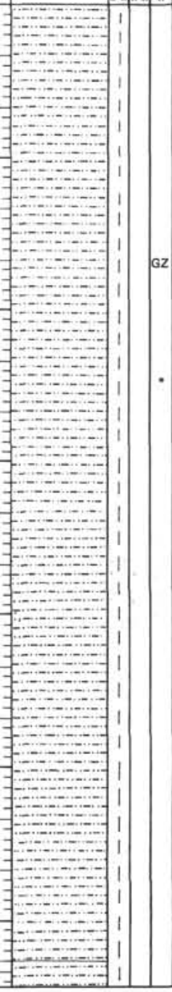
ORGANIC CARBON AND CARBONATE

	2-80
% Organic Carbon	1.2
% $CaCO_3$	0.0

SITE 491 HOLE CORE 8 CORED INTERVAL 67.0–76.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	NN 15	B	RM	CG		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2) to olive gray (5Y 3/2) very firm (Section 1) to firm mottled (other sections). Section 5: occasional small (2–3 mm) spots of ASH. Section 6: small ash spots.

SMEAR SLIDES

	Muddy silt 3-72 (D)
TEXTURE:	
Sand	5
Silt	55
Clay	40
COMPOSITION:	
Quartz	61
Feldspar	6
Mica	2
Heavy minerals	1
Pyrite	3
Clay	15
Glass	2
Carb. unspec.	2
Foraminifers	TR
Nannofossils	1
Radiolarians	TR
Diatoms	5
Sponge spicules	2
Plant fragments	TR

GRAIN SIZE

	2-110
Sand	6.2
Silt	62.5
Clay	31.3

SITE 491 HOLE CORE 9 CORED INTERVAL 76.5–86.0 m

TIME-ROCK UNIT: LOWER PLIOCENE

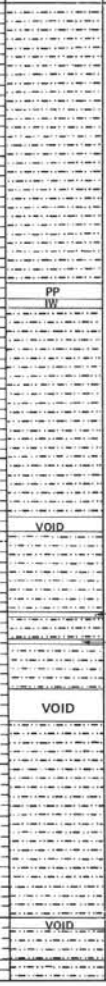
BIOSTRATIGRAPHIC ZONE: NN 15 *Spongaster pentas*

FOSSIL CHARACTER: FORAMINIFERS RP; NANNOFOSSILS RP; RADIOLARIANS AG; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ

LITHOLOGIC DESCRIPTION

Fine (1–5 mm) sandy layers

Fine (1 mm) sand layer

Fine sand

Fine sand 3 mm thick

Two sand layers, each 1 mm thick

Fine sand (0.5x0.5 cm) Ash 1x1 cm

VOID

Diffuse 1 cm thick fine sand layer

VOID

Fine sand (0.5x0.5 cm)

Fine sand (1x1 cm)

Fine sand (1x1.5 cm spot)

MUDDY SILT, olive gray (5Y 3/2) (Sections 1 and 2) to grayish olive green (5GY 3/2) (Section 3 and below); firm to very firm with fine sand layers.

SMEAR SLIDES

	Muddy silt 3-83 (D)
TEXTURE:	
Sand	3
Silt	55
Clay	42
COMPOSITION:	
Quartz	51
Feldspar	15
Mica	10
Heavy minerals	3
Pyrite	1
Clay	15
Glass	1
Carb. unspec.	TR
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	2
Sponge spicules	2
Plant fragments	TR

GRAIN SIZE

	3-81
Sand	3.1
Silt	61.8
Clay	35.1

ORGANIC CARBON AND CARBONATE

	3-83
% Organic Carbon	1.5
% $CaCO_3$	0.0

SITE 491 HOLE CORE 10 CORED INTERVAL 86.0–95.5 m

TIME-ROCK UNIT: LOWER PLIOCENE

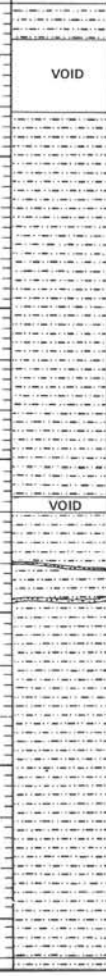
BIOSTRATIGRAPHIC ZONE: NN 15 *Spongaster pentas*

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

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ

LITHOLOGIC DESCRIPTION

Fine sand (2x4 mm)

Fine sand (3x4 mm)

Fine sand (0.5x2 cm)

Fine sand

Fine sand (2x1 cm)

Fine sand

Fine sand

Very fine to fine sand

Very fine to fine sand

MUDDY SILT, soft to firm, olive gray (5Y 3/2) (Sections 1–3) to grayish olive green (5GY 3/2) (Section 4 and below), Sections 1–3 mottled with 5GY 3/2. Thin (2–10 mm) layers and spots of fine to very fine sand occur occasionally in all the sections. Sections 1–3 5Y 3/2 mottled with 5GY 3/2.

SMEAR SLIDES

	Muddy silt 2-93 (D)	Pyrite pod 3-46 (M)
TEXTURE:		
Sand	3	–
Silt	60	–
Clay	37	–
COMPOSITION:		
Quartz	65	20
Feldspar	10	5
Mica	5	–
Heavy minerals	1	
Pyrite	1	75
Clay	10	–
Glass	2	–
Carb. unspec.	2	–
Nannofossils	TR	–
Radiolarians	TR	–
Diatoms	2	–
Sponge spicules	2	–

GRAIN SIZE

	2-50
Sand	17.8
Silt	59.6
Clay	22.6

SITE 491 HOLE CORE 11 CORED INTERVAL 95.5–100.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY
LOWER PLIOCENE	NN 15 *Spongaster pentas*	B	RP	FG		1, 2, 3, 4, CC	0.5, 1.0	OG, PP, VOID

Thin (3 mm) layers of fine sand at 94 and 138 cm inclined at 50–55°; artifact of drilling(?).

Fine sand

Fine sand

Fine sand

VOID

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2) mottled with minor olive gray (5Y 3/2) soupy to soft.

SMEAR SLIDES

	Muddy silt 3-76 (D)	Very fine to fine sand 3-18 (M)
TEXTURE:		
Sand	1	98
Silt	52	2
Clay	47	–
COMPOSITION:		
Quartz	49	95
Feldspar	15	5
Mica	2	–
Heavy minerals	3	–
Pyrite	1	–
Clay	20	–
Glass	1	–
Carb. unspec.	2	–
Foraminifers	TR	–
Nannofossils	TR	–
Diatoms	6	–
Sponge spicules	1	–

ORGANIC CARBON AND CARBONATE

	3-90
% Organic Carbon	1.1
% $CaCO_3$	0.0

SITE 491 HOLE CORE 12 CORED INTERVAL 100.5–105.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY
LOWER PLIOCENE	NN 15	RP	FP	CG				SMEARS

LITHOLOGIC DESCRIPTION

Smears on core liner. Deviation of the hole: 1.0°.

SITE 491 HOLE CORE 13 CORED INTERVAL 105.0–114.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY
LOWER PLIOCENE	NN 15 *Spongaster pentas*	B	B	RG		1, 2, CC	0.5, 1.0	

Diffuse fine sand layer

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2); slight mottling, minor concentrations of pyrite and fine SAND layer. Gas expansion cracks and voids common. Intense drilling deformation.

SMEAR SLIDES

	Muddy silt 2-18 (D)
TEXTURE:	
Sand	7
Silt	53
Clay	40
COMPOSITION:	
Quartz	52
Feldspar	10
Mica	2
Heavy minerals	1
Pyrite	2
Clay	30
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	1

SITE 491 HOLE CORE 14 CORED INTERVAL 114.5–124.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	NN 15 / *Spongaster pentas*	B	FM	FG		1, 2, 3, 4, 5, 6	0.5, 1.0	VOID, OG, IW, PP		GZ	*, *, +

Fine sand

Apparent bedding dip 20°

Apparent dip 25°

Fine sand

Diffuse sand in mud

Sand bed, apparent dip 14°

Sand; apparent dip 35°

Sand

Fine sand

Possible fault with offset of sandy layer

Sand

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2) with fine SAND layers, slightly mottled, with gas expansion cracks. Also same muddy silt, but slightly darker and without gas expansion cracks, firm and massive.

SMEAR SLIDES

	Muddy silt 1-128 (D)	Muddy silt 3-52 (D)
TEXTURE:		
Sand	20	30
Silt	60	45
Clay	20	25
COMPOSITION:		
Quartz	50	55
Feldspar	8	10
Mica	3	3
Heavy minerals	2	1
Pyrite	2	1
Clay	30	25
Carb. unspec.	1	3
Nannofossils	TR	–
Radiolarians	TR	TR
Diatoms	1	1
SPonge spicules	3	1

GRAIN SIZE

	4-98
Sand	11.6
Silt	63.1
Clay	25.3

ORGANIC CARBON AND CARBONATE

	4-100
% Organic Carbon	1.1
% $CaCO_3$	1.0

SITE 491 HOLE CORE 15 CORED INTERVAL 124.0–133.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	NN 15 / *Spongaster pentas*	B	B	FG		1, 2, 3, 4, 5, 6, CC	0.5, 1.0	VOID			*, *

Sand bed; apparent dip 12°

Possible normal faults (between 104 and 150 cm); 2 fault dips of 63°; bedding dip 28°, in opposite direction

Sand beds: apparent dip 30° (1–2 cm)

Sand lens: apparent dip 17°

Sand (stratified)

Normal fault?; apparent dip 75°

Sand beds (0.5–1 cm) with 20–25° apparent dip

Fine sand bed: apparent dip 30°

Fine sand beds: apparent dip 40°

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2); firm, slight mottling; very fine SAND beds better defined than in previous cores; gas expansion cracks common.

SMEAR SLIDES

	Fine sand 3-97 (M)	Muddy silt 5-70 (D)
TEXTURE:		
Sand	85	6
Silt	10	74
Clay	5	20
COMPOSITION:		
Quartz	74	55
Feldspar	12	10
Mica	4	4
Heavy minerals	2	2
Pyrite	1	2
Clay	45	20
Glass	–	TR
Carb. unspec.	2	2
Foraminifers	TR	–
Radiolarians	TR	TR
Diatoms	TR	4
Sponge spicules	TR	1

SITE 491 HOLE CORE 16 CORED INTERVAL 133.5–143.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	RP	RG		1, 2, 3, 4, 5, 6, CC

GRAPHIC LITHOLOGY: VOID (base of Section 6)

SAMPLES: GZ (Section 4)

LITHOLOGIC DESCRIPTION

Fault plane
Fault plane
Fault plane
Zeolites (yellow patch)
Fault plane
Sandy lens
Zeolite
Possible fault
Sandy concentration
Drilling biscuits?
Zeolite
ASH BED: apparent dip: 40°

MUDDY SILT, grayish olive green (5GY 3/2), firm, slightly mottled; some fine sand laminations (1 or 2 per section). One ASH bed and MUD, grayish olive green (5GY 3/2) and olive gray (5Y 3/2), very firm mottled; some drilling biscuits in Section 6.

SMEAR SLIDES

	Muddy silt	Mud	Fine sand
	1-115 (D)	6-113 (M)	6-124 (M)
TEXTURE:			
Sand	4	1	60
Silt	56	44	30
Clay	40	55	10
COMPOSITION:			
Quartz	45	36	71
Feldspar	7	7	12
Mica	2	2	2
Heavy minerals	1	TR	2
Pyrite	1	1	1
Clay	35	50	10
Zeolite	–	1	–
Carb. unspec.	3	2	2
Radiolarians	TR	TR	TR
Diatoms	3	TR	TR
Sponge spicules	3	1	TR

GRAIN SIZE

	4-70
Sand	11.8
Silt	63.1
Clay	25.1

SITE 491 HOLE CORE 17 CORED INTERVAL 143.0–152.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	CM	FG		1, 2, 3, 4, 5, 6, 7, CC

GRAPHIC LITHOLOGY: PP (top of Section 6)

SAMPLES: GZ (Section 3)

LITHOLOGIC DESCRIPTION

Sandy bed; apparent dip 22°
Sandy bed apparent dip 14°
Slickensided surface apparent dip 16°
Fracture: apparent dip 43°
Sandy beds: 56° apparent dip
Sandy laminations: 35° apparent dip
Sandy lamination: 30° apparent dip
Sandy lamination: apparent dip 30°
Sandy lamination: apparent dip 10°
Sandy lamination: apparent dip 12°
Sandy lamination: apparent dip 20°
Fracture: apparent dip 31°
Fracture: apparent dip 15°
Sandy lamination: apparent dip 17°
Fracture with possibly weakly developed slickensides; apparent dip 0°

MUDDY SILT, grayish olive green (5GY 3/2), firm, slightly mottled; numerous gas expansion cracks; minor very fine sand laminations; slickensides on some fractures. Some drilling biscuits are in the bottom half of Section 4.

SMEAR SLIDES

	Muddy silt
	3-98 (D)
TEXTURE:	
Sand	10
Silt	55
Clay	35
COMPOSITION:	
Quartz	55
Feldspar	8
Mica	2
Heavy minerals	1
Pyrite	1
Clay	30
Carb. unspec.	2
Radiolarians	TR
Diatoms	1
Sponge spicules	TR

GRAIN SIZE

	3-97
Sand	8.7
Silt	73.0
Clay	18.4

ORGANIC CARBON AND CARBONATE

	4-98
% Organic Carbon	1.4
% $CaCO_3$	0.0

SITE 491 HOLE CORE 18 CORED INTERVAL 152.5–162.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	NN 15 *Spongaster pentas*	B	B	RM		1, 2, 3, 4, 5, 6, CC	0.5, 1.0

GRAPHIC LITHOLOGY: VOID (Section 3); VOID (Section 4)

LITHOLOGIC DESCRIPTION

Development of polished surfaces; slickensides in soft mud; fractures 0–80°

Fine sand layer (deformed by drilling)

Pyrite

5 mm sand beds (apparent dip: 12°)

Diffuse sand

Diffuse sand apparent dip 46°

Slicks and polished surfaces as in Section 1

Apparent dip 26°

Apparent dip 27° Diffuse sand

Graded sands overlain by darker mud, possible T_{ad} sequence.

Fine to very fine sand, apparent dip 40° (possibly due to drilling)

MUDDY SILT, grayish olive green (5GY 3/2) to olive gray (5Y 3/2); becomes sandier from top to base (10–25%). Some very fine to fine SAND.

SMEAR SLIDES

	Muddy silt 1-50 (D)	Muddy silt 3-40 (D)	Fine to very fine sand 6-14 (M)
TEXTURE:			
Sand	10	25	77
Silt	60	45	15
Clay	30	30	8
COMPOSITION:			
Quartz	58	51	85
Feldspar	5	3	10
Mica	8	5	3
Heavy minerals	TR	TR	1
Pyrite	1	TR	1
Clay	25	30	8
Foraminifers	TR	–	–
Nannofossils	1	TR	TR
Radiolarians	TR	TR	–
Diatoms	1	1	TR
Sponge spicules	1	TR	TR

SITE 491 HOLE CORE 19 CORED INTERVAL 162.0–171.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	*Spongaster pentas*	B	FM	RG		1, 2, 3, 4, 5, 6	0.5, 1.0

GRAPHIC LITHOLOGY: IW, OG (Section 3)

SAMPLES: GZ

LITHOLOGIC DESCRIPTION

Very fine sand, 10GY 5/2

Very fine sand

Fine sand, 1°C gas bubbling off

Sequences

Fine to medium sand 1.5°C, gas bubbling off

Fine sand

Fine sand, apparent dip 12°

Sequences

Apparent dip 11°

Fine sand; 19° apparent dip

Sequence

Disturbed sand beds

Sequence

Fine sand

Sequence; 12° apparent dip

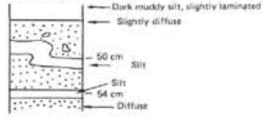
Disturbed bedding

Apparent dip 23°

MUDDY SILT, grayish olive green with very fine to fine SAND, more abundant and in thicker layers than previous cores, sequences observed. Only traces in Core-Catcher.

Sequences = Muddy silt (5GY 3/4) over sand with sharp or sometimes gradational contact, base of sand gradational or sharp contact.

Section 4: Possible slump fold



SMEAR SLIDES

	Muddy silt 3-70 (D)	Muddy silt 3-75 (M)
TEXTURE:		
Sand	20	10
Silt	50	50
Clay	30	40
COMPOSITION:		
Quartz	54	49
Feldspar	8	5
Mica	6	3
Heavy minerals	TR	TR
Pyrite	TR	2
Clay	30	40
Foraminifers	–	TR
Nannofossils	TR	TR
Radiolarians	TR	TR
Diatoms	1	1
Sponge spicules	1	TR

GRAIN SIZE

	3-16
Sand	8.5
Silt	60.5
Clay	30.9

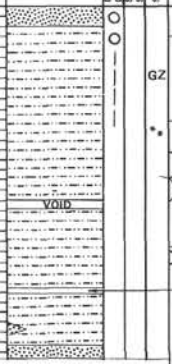
ORGANIC CARBON AND CARBONATE

	4-0
% Organic Carbon	0.9
% $CaCO_3$	0.0

SITE 491 HOLE CORE 20 CORED INTERVAL 171.5–181.0 m

TIME – ROCK UNIT: LOWER PLIOCENE
BIOSTRATIGRAPHIC ZONE: *Spongaster pentas?*
FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS B; RADIOLARIANS RG; DIATOMS
SECTION: 1, 2, 3
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ

LITHOLOGIC DESCRIPTION

Fine sand

Fractured, polished and slickensided surfaces in soft muddy silt

Bedding defined by color shade change
59° apparent dip
28° true dip

Highly contorted

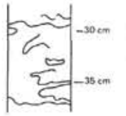
Slump fold?
Highly contorted

VOID

5 mm medium sand
10° apparent dip

MUDDY SILT, olive gray (5Y 3/2) with minor fine to medium SAND. Only traces in Core-Catcher. Whole Section 2 probably deformed.

Section 2:



SMEAR SLIDES

	Muddy silt 1-128 (D)	1-130 (D)
TEXTURE:		
Sand	5	25
Silt	65	45
Clay	30	25
COMPOSITION:		
Quartz	67	69
Fedlspar	10	8
Mica	7	5
Heavy minerals	1	1
Pyrite	TR	1
Clay	15	15
Radiolarians	TR	TR
Diatoms	TR	TR
Sponge spicules	TR	1

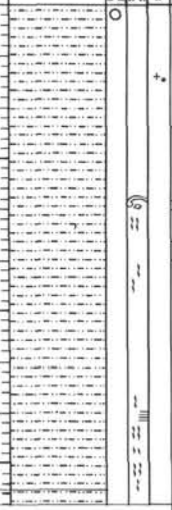
GRAIN SIZE

	1-70
Sand	14.5
Silt	56.3
Clay	29.2

SITE 491 HOLE CORE 21 CORED INTERVAL 181.0–190.5 m

TIME – ROCK UNIT: LOWER PLIOCENE
BIOSTRATIGRAPHIC ZONE: NN 15 *Spongaster pentas?*
FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS RP; RADIOLARIANS FM; DIATOMS
SECTION: 1, 2, 3, 4, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Near horizontal fractures, slickensides and polished surfaces

24° true dip
sand pods

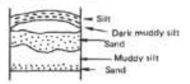
Darker muddy silt
overturned fold
Truncated or folded sand bed
Sand; apparent dip 51°
Chaotic discontinuous sand beds

30° apparent dip
Fine sand; 22° apparent dip, diffuse top, sharp base

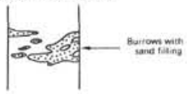
Parallel laminations

MUDDY SILT, grayish olive green (5GY 3/2) with fine to medium SAND.

Section 3, 43–48 cm:



Section 3, 107–109 cm:



SMEAR SLIDES

	Muddy silt 1-85 (D)
TEXTURE:	
Sand	20
Silt	45
Clay	35
COMPOSITION:	
Quartz	45
Feldspar	5
Mica	5
Heavy minerals	1
Pyrite	1
Clay	40
Nannofossils	TR
Radiolarians	TR
Diatoms	2
Spong spicules	1
Silicoflagellates	TR

ORGANIC CARBON AND CARBONATE

	1-84
% Organic Carbon	1.1
% $CaCO_3$	0.0

SITE 491 HOLE CORE 22 CORED INTERVAL 190.5–200.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	NN 15 *Spongaster pentas?*		RP			1, 2, 3, 4, 5	0.5, 1.0				GZ *	
		B	CM	RM								

Extensive fissility, polished surfaces; all soupy and brecciated by drilling

Extensive fissility, slickensides and polished surfaces

No fissility

Minor fissility

Sand

Stratified sand

Stratified sand near vertical

Sand pods

Discontinuous sand pods

27° apparent dip

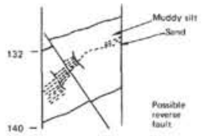
Sand: apparent dip 85°

Wispy thin discontinuous sand beds

Near horizontal apparent beds

MUDDY SILT, grayish olive green (5GY 3/2) with fine to medium SAND.

Section 4:



SMEAR SLIDES

	Muddy silt 3-73 (D)
TEXTURE:	
Sand	30
Silt	45
Clay	25
COMPOSITION:	
Quartz	66
Feldspar	8
Mica	4
Heavy minerals	1
Pyrite	1
Clay	20
Glauconite	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	TR

GRAIN SIZE

	3-69
Sand	11.5
Silt	66.5
Clay	22.0

SITE 491 HOLE CORE 23 CORED INTERVAL 200.0–204.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	RP	RM		1, 2	0.5, 1.0					

Very diffuse, poorly indurated sand

Abundant dispersed sand

MUDDY SILT, grayish olive green (5GY 3/2) and fine SAND beds intercalated (5GY 5/2). Muddy silt fissile with polished surfaces.

SITE 491 HOLE CORE 24 CORED INTERVAL 204.0–209.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	*Spongaster pentas?*	B	B	RM		1		VOID			*	

MUDDY SILT, grayish olive green (5GY 3/2). Deviation of hole: 0.7°.

SMEAR SLIDES

	Muddy silt 1-22 (D)
TEXTURE:	
Sand	4
Silt	66
Clay	30
COMPOSITION:	
Quartz	60
Feldspar	8
Mica	3
Heavy minerals	1
Pyrite	1
Clay	25
Foraminifers	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	TR

SITE 491 HOLE CORE 25 CORED INTERVAL 209.5–219.0 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Spongaster pentas?*

FOSSIL CHARACTER: FORAMINIFERS RM; NANNOFOSSILS B; RADIOLARIANS FG; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY: PP; OG; IW; VOID

SAMPLES: GZ

LITHOLOGIC DESCRIPTION

Scattered grains of dark-yellowish orange (10YR 6/6) (?) zeolite

VOID

Fault?

Sandy beds

Faults with slickensides

Fault with slickensides

Fault with slickensides

Fault with slickensides

Fault?

Fractures with slickensides

MUDDY SILTSTONE, grayish olive green (5GY 3/2) sporadic fractures, irregular with polished faces and slickensides. Apart from fine spots and beds (as shown) no other structures are visible. Section 3: occasional drilling laminations (less well-indurated than muddy siltstone and slightly darker in color). Sections 5 and 6: drilling laminations common.

SMEAR SLIDES

	Muddy silt
	4-72 (D)
TEXTURE:	
Sand	3
Silt	77
Clay	20
COMPOSITION:	
Quartz	64
Feldspar	9
Mica	3
Heavy minerals	TR
Pyrite	1
Clay	20
Car. unspec.	1
Radiolarians	TR
Diatoms	1
Sponge spicules	1

GRAIN SIZE

	1-20
Sand	10.5
Silt	65.1
Clay	24.4

ORGANIC CARBON AND CARBONATE

	1-3
% Organic Carbon	0.9
% $CaCO_3$	0.0

SITE 491 HOLE CORE 26 CORED INTERVAL 219.0–228.5 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Spongaster pentas?*

FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS B; RADIOLARIANS RG; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY: PP

SAMPLES: GZ

LITHOLOGIC DESCRIPTION

Two inclined drilling laminations

Drilling laminations

Healed fracture

Bioturbations

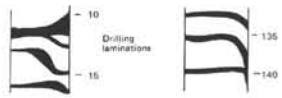
Plant fragment

Diffuse sandy layer

Examples of drilling artifacts: "normal faults" displacing drilling laminations

MUDDY SILT, firm to hard, grayish olive green (5GY 3/2), internally structureless. Section 2: siltstone toward base, drilling laminations throughout. Section 3: drilling laminations throughout, unusual thickness here, some up to 2 cm thick; biscuits have 3–4 cm thickness. Section 4: same comments, except laminations here 15 mm maximum; two instances worthy of note.

Section 4:



SMEAR SLIDES

	Muddy silt
	4-74 (D)
TEXTURE:	
Sand	4
Silt	71
Clay	25
COMPOSITION:	
Quartz	58
Feldspar	7
Mica	2
Heavy minerals	1
Pyrite	1
Clay	25
Carb. unspec.	2
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	2

GRAIN SIZE

	2-90
Sand	5.4
Silt	58.0
Clay	36.6

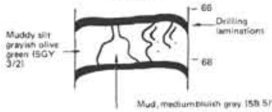
SITE 491 HOLE CORE 27 CORED INTERVAL 228.5–238.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	*Spongaster pentas?*	B	FP	RG		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0	VOID			GZ

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2), firm to hard drilling laminations abundant. Section 3: abstruse, somewhat swirling, color variations, truncated by common drilling laminations, as shown in example. Section 4: 40–50 cm: conjugate set of normal faults offsetting drilling laminations.

Section 3:



SMEAR SLIDES

	Muddy silt 3-63 (D)	Mud 3-69 (M)
TEXTURE:		
Sand	6	–
Silt	49	40
Clay	45	60
COMPOSITION:		
Quartz	48	38
Feldspar	8	7
Mica	4	3
Heavy minerals	1	1
Pyrite	1	1
Clay	35	50
Glauconite	TR	
Zeolite?	1	–
Carb. unspec.	2	–
Nannofossils	–	TR
Radiolarians	TR	TR
Diatoms	TR	TR
Sponge spicules	TR	TR

GRAIN SIZE

	3-30
Sand	6.7
Silt	54.2
Clay	39.0

ORGANIC CARBON AND CARBONATE

	3-40
% Organic Carbon	0.9
% $CaCO_3$	0.0

SITE 491 HOLE CORE 28 CORED INTERVAL 238.0–247.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	*Spongaster pentas ?*	B	RP	FM		1, 2, 3, 4, 5, CC	0.5, 1.0	PP			GZ

LITHOLOGIC DESCRIPTION

Dark yellowish orange (10YR 6/6) concentration of carbonate grains

MUDDY SILT, grayish olive green (5GY 3/2), with thin (1–2 mm) drilling laminations of dark gray (N3) MUD every 2–4 cm, soft to firm. Occasional sponge remains; slight bioturbations.

SMEAR SLIDES

	Carbonate concentration 1-25 (M)	Muddy silt 3-38 (D)
TEXTURE:		
Sand	–	1
Silt	–	60
Clay	–	39
COMPOSITION:		
Quartz	2	57
Feldspar	–	15
Mica	–	3
Heavy minerals	–	1
Pyrite	–	1
Clay	–	20
Glass	–	1
Carb. unspec.	98	2
Radiolarians	–	TR
Diatoms	–	TR
Sponge spicules	–	TR

GRAIN SIZE

	3-38
Sand	4.5
Silt	63.3
Clay	32.2

SITE 491 HOLE CORE 29 CORED INTERVAL 247.5–257.0 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Spongaster pentas?*

FOSSIL CHARACTER: FORAMINIFERS RP; NANNOFOSSILS B; RADIOLARIANS FM; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2), soft to firm. Drilling laminations abundant; laminations and biscuits of equal firmness. Minor normal faults offsetting drilling laminations.

Yellowish gray (5Y 7/2) calcareous ooze

Very soft broken up

SMEAR SLIDES

	Muddy silt 3-74 (D)
TEXTURE:	
Sand	2
Silt	60
Clay	38
COMPOSITION:	
Quartz	57
Feldspar	15
Mica	5
Heavy minerals	3
Pyrite	1
Clay	15
Glass	1
Carb. unspec.	1
Radiolarians	TR
Diatoms	1
Sponge spicules	1

ORGANIC CARBON AND CARBONATE

	3-73
% Organic Carbon	1.2
% $CaCO_3$	0.0

SITE 491 HOLE CORE 30 CORED INTERVAL 257.0–266.5 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: NN 15 *Spongaster pentas*

FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS B, RM; RADIOLARIANS RM; DIATOMS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY: VOID; VOID; OG; IW

DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES: * GZ

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2), soupy to soft. Section 1: minor incipient fissility defined by parting planes with polished surfaces, but generally lacking well-developed slickensides. Section 2: soft to firm; drilling laminations abundant below 54 cm; drilling laminations and biscuits of equal firmness. High angle (55–60° apparent dip) normal faults offsetting drilling laminations. Sections 3–6: drilling lamination throughout; lamination and biscuits of equal firmness.

Yellowish gray (5Y 7/2) area of calcareous ooze

8 mm thick parallel laminated bed 37° apparent dip

SMEAR SLIDES

	Muddy silt 3-105 (D)
TEXTURE:	
Sand	1
Silt	70
Clay	29
COMPOSITION:	
Quartz	57
Feldspar	20
Mica	5
Heavy minerals	2
Pyrite	1
Clay	15
Carb. unspec.	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	TR

GRAIN SIZE

	3-106
Sand	6.8
Silt	67.1
Clay	26.1

SITE 491 HOLE CORE 31 CORED INTERVAL 266.5–276.0 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Spongaster pentas?*

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

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

METERS: 0.5, 1.0

DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

LITHOLOGIC DESCRIPTION

Thin discontinuous calcareous layer

Thin subhorizontal pod of fine sand

Drilling lamination

Three thin (1 mm) layers of fine sand 24° apparent dip

Drilling lamination

MUDDY SILT, grayish olive green (5GY 3/2), soft to firm. Sections 1 and 2: broken up by drilling, infrequent small (up to 2 mm) pyrite nodules. Section 3: firm, drilling laminations throughout. Section 5: slightly bioturbated.

SMEAR SLIDES

	Muddy silt	Carbonate concentration
	3-80 (D)	1-144 (M)
TEXTURE:		
Sand	5	–
Silt	52	–
Clay	43	–
COMPOSITION:		
Quartz	52	–
Feldspar	15	–
Mica	7	–
Heavy minerals	2	–
Pyrite	1	–
Clay	20	–
Glass	TR	–
Carb. unspec.	2	100
Radiolarians	TR	–
Diatoms	TR	–
Sponge spicules	1	–

ORGANIC CARBON AND CARBONATE

	3-77
% Organic Carbon	1.1
% $CaCO_3$	0.0

SITE 491 HOLE CORE 32 CORED INTERVAL 276.0–285.5 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: *Spongaster pentas*

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

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

METERS: 0.5, 1.0

DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

GZ

LITHOLOGIC DESCRIPTION

Eleven fractures over 80 cm (drilling? tectonic?)

Sixteen major fractures over 110 cm of stiffer material

Drilling lamination

Drilling lamination

Three mm fine sand layer 15° true dip

Drilling laminations common

MUDDY SILT, firm to very firm, grayish olive green (5GY 3/2); appears as discrete blocks in soupy muddy silt. Section 3: more firm material and less soupy matrix. Section 4: soft to firm, slightly bioturbated, still very broken up.

SMEAR SLIDES

	Muddy silt
	3-95 (D)
TEXTURE:	
Sand	3
Silt	59
Clay	38
COMPOSITION:	
Quartz	47
Feldspar	15
Mica	8
Heavy minerals	2
Pyrite	2
Clay	20
Glass	1
Carb. unspec.	2
Foraminifers	TR
Nannofossils	TR
Radiolarains	TR
Diatoms	2
Sponge spicules	1
Plant fragments	TR

GRAIN SIZE

	3-95
Sand	8.2
Silt	68.7
Clay	23.1

SITE 491 HOLE CORE 33 CORED INTERVAL 285.5–295.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
LOWER PLIOCENE	*Spongaster pentas?*	B	B	RM	

GRAPHIC LITHOLOGY: Sections 1–7 (0.5, 1.0 m); VOID in Section 3–4.

LITHOLOGIC DESCRIPTION

Fractured (non-coherent pattern); well indurated

MUDDY SILTSTONE, grayish olive green (5GY 3/2), firm to well-indurated internally structureless. Section 2: irregular and straight discontinuous fractures. Section 4: well indurated, with minor softer material between the large blocks. Section 5: minor irregular discontinuous fractures. Section 6: straight fractures with polished surfaces.

ORGANIC CARBON AND CARBONATE

	7-40
% Organic Carbon	1.5
% $CaCO_3$	0.0

Vague bed apparent dip 12°

Horizontal bedding, clearly displaced by a discontinuous straight fracture (normal fault?)

Horizontal slickensides

SITE 491 HOLE CORE 34 CORED INTERVAL 295.0–304.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
LOWER PLIOCENE	NN 15 *Spongaster pentas*	B	RP	RM	

GRAPHIC LITHOLOGY: Sections 1–6 (0.5, 1.0 m)

LITHOLOGIC DESCRIPTION

MUDDY SILT and MUDDY SILTSTONE, grayish olive green (5GY 3/2). Chips of indurated material in soupy drilling breccia.

SMEAR SLIDES

	Muddy silt 2-73 (D)
TEXTURE:	
Sand	4
Silt	56
Clay	40
COMPOSITION:	
Quartz	54
Feldspar	7
Mica	3
Heavy minerals	1
Pyrite	TR
Clay	30
Carb. unspec.	2
Foraminifers	TR
Radiolarians	TR
Diatoms	2
Sponge spicules	1

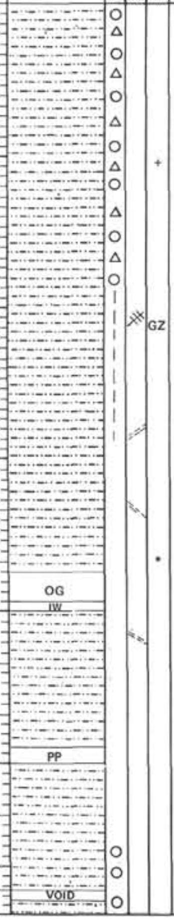
Intact but apparently structureless

Same as above but for occasional vague healed fractures (oblique)

SITE 491 HOLE CORE 35 CORED INTERVAL 304.5–314.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	RP	RM		1, 2, 3, 4, 5, 6, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2). Sections 1 and 2: soupy, structureless. Section 3: soft to firm, but verging on shaly in places. Section 4: firm to hard.

Fracture 28° dip
Slight fissility; bedding; apparent dip 38°

Very vague fissility? bedding; apparent dip 30°

Vague fissility apparent dip: 35°

Vague bedding apparent dip: 27°

SMEAR SLIDES

	Muddy siltstone 4-100 (D)
TEXTURE:	
Sand	20
Silt	50
Clay	30
COMPOSITION:	
Quartz	58
Feldspar	7
Mica	3
Heavy minerals	1
Pyrite	1
Clay	25
Carb. unspec.	2
Radiolarians	TR
Diatoms	1
Sponge spicules	2

GRAIN SIZE

	3-20
Sand	12.5
Silt	65.0
Clay	22.5

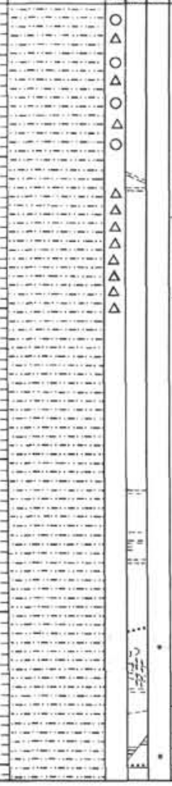
ORGANIC CARBON AND CARBONATE

	2-8
% Organic Carbon	1.1
% $CaCO_3$	0.0

SITE 491 HOLE CORE 36 CORED INTERVAL 314.0–323.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	FM	RM		1, 2, 3, 4, 5, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, grayish olive green (5GY 3/2). Section 1: indurated blocks in drilling breccia. Section 3: mostly soft, water saturated. Section 4: irregular, short, discontinuous fractures throughout core.

Fissility: 30° apparent dip
Semi-coherent
Fissility: horizontal

Drilling breccia

Vague fissility
8° apparent dip

Horizontal fissility

Vague fissility
Vague fissility, 10° apparent dip

Healed fault: 68° apparent dip
Subhorizontal bedding
1.5 cm fine sand bed, diffuse top with small ripples; 17° true dip

SMEAR SLIDES

	Muddy siltstone 5-141 (D)	Mudstone 5-36 (M)
TEXTURE:		
Sand	8	2
Silt	72	38
Clay	20	60
COMPOSITION:		
Quartz	65	38
Feldspar	8	7
Mica	3	2
Heavy minerals	1	TR
Pyrite	TR	1
Clay	20	50
Carb. unspec.	2	2
Radiolarians	TR	TR
Diatoms	1	TR
Sponge spiculus	TR	TR

SITE 491 HOLE CORE 37 CORED INTERVAL 323.5–333.0 m

TIME – ROCK UNIT: LOWER PLIOCENE

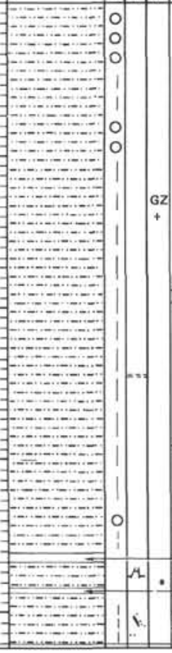
BIOSTRATIGRAPHIC ZONE: NN 15 *Spongaster pentas?*

FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS RP; RADIOLARIANS RP; DIATOMS

SECTION: 1, 2, 3, 4, 5

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES: GZ +; •

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2). Section 1: some drilling laminations, deformed moderate mottling (not sure if bioturbation). Sections 2 and 3: same as Section 1; soft to moderate firm. Section 5: all beds wispy, discontinuous. 0–90 cm: firm muddy silt, 100–150 cm: muddy siltstone.

Wispy, lenticular lighter colored muddy silt deformed by drilling?

Silt layer

Occasional drilling lamination

VOID

Offset fine sand bed, normal faults (drilling artifact?)

VOID

Well developed drilling laminations

Fault (no slickensides), discontinuous fine sand layers

SMEAR SLIDES

	Muddy silt
	4-120 (D)
TEXTURE:	
Sand	3
Silt	57
Clay	40
COMPOSITION:	
Quartz	55
Feldspar	8
Mica	5
Heavy minerals	TR
Pyrite	1
Clay	30
Radiolarians	TR
Diatoms	1
Sponge spicules	TR

GRAIN SIZE	2-50
Sand	8.8
Silt	63.7
Clay	27.5

ORGANIC CARBON AND CARBONATE

	2-60
% Organic Carbon	1.1
% $CaCO_3$	1.0

SITE 491 HOLE CORE 38 CORED INTERVAL 333.0–342.5 m

TIME – ROCK UNIT: LOWER PLIOCENE

BIOSTRATIGRAPHIC ZONE: NN 15 *Spongaster pentas?*

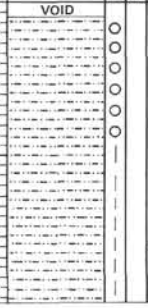
FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS RP; RADIOLARIANS RP; DIATOMS

SECTION: 1, 2

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY

VOID



SAMPLES: •, GZ

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2) with fine SAND pods. Section 1: soupy and soft, structureless. Section 2: sands very disturbed; only fragments of beds left; no apparent bedding, all chaotic.

Fine sand pods

Discontinuous sandy layer

SMERA SLIDES

	Muddy silt
	2-80 (D)
TEXTURE:	
Sand	5
Silt	55
Clay	40
COMPOSITION:	
Quartz	52
Feldspar	4
Mica	5
Heavy minerals	TR
Pyrite	1
Clay	35
Carb. unspec.	TR
Nannofossils	TR
Diatoms	2
Sponge spicules	1

GRAIN SIZE	2-90
Sand	11.4
Silt	60.9
Clay	27.7

SITE 491 HOLE CORE 39 CORED INTERVAL 342.5–352.0 m

TIME – ROCK UNIT: LOWER PLIOCENE

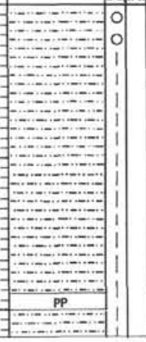
BIOSTRATIGRAPHIC ZONE: *Spongaster pentas?*

FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS B; RADIOLARIANS RP; DIATOMS

SECTION: 1, 2, 3

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



PP

SAMPLES: GZ, •

LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, olive gray (5Y 3/2) to grayish olive (10Y 4/2) with fine SAND. Section 1: light and dark shade changes define bedding at several cm-scale; also possible minor drilling laminations at base. Sections 2 and 3: apparent chaotic bedding.

Fissility dipping at 55–80° true

Wispy fine sand layers

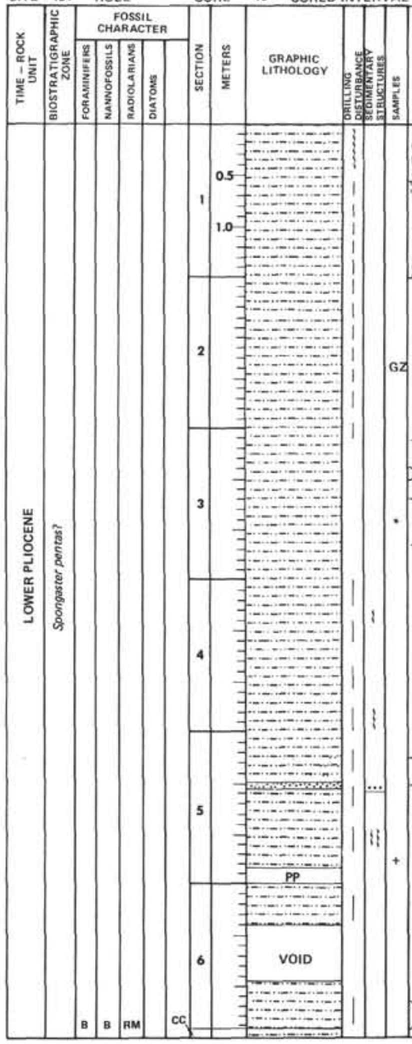
Fine sand

SMEAR SLIDES

	Muddy silt
	2-95 (D)
TEXTURE:	
Sand	15
Silt	55
Clay	30
COMPOSITION:	
Quartz	60
Feldspar	10
Mica	4
Pyrite	1
Clay	25
Glauconite	TR
Diatoms	TR
Sponge spicules	TR

GRAIN SIZE	1-80
Sand	12.3
Silt	67.7
Clay	20.0

SITE 491 HOLE CORE 40 CORED INTERVAL 352.0–361.5 m



LITHOLOGIC DESCRIPTION

Fissil

Drilling lamination

29° apparent dip

Fissil

28° apparent dip

31° apparent dip

Definite bioturbation

Silt

Fine to medium sand graded; 10° true dip

Wispy, discontinued beds

Fragments only

2 cm Core-Catcher

MUDDY SILT, grayish olive green (5GY 3/2) with fine to medium SAND. Section 1: firm to very firm. Section 2: very firm; mottled (bioturbations?); drilling laminations. Section 3: very firm, drilling laminations; wispy: discontinuous beds which look like small scale deformation, as in slumping. Section 4: moderately firm only a few drilling laminations. Section 5: moderately firm to firm; occasional drilling laminations. Section 6: moderately firm.

SMEAR SLIDES

	Muddy silt
	3-90 (D)
TEXTURE:	
Sand	15
Silt	60
Clay	25
COMPOSITION:	
Quartz	53
Feldspar	8
Mica	6
Heavy minerals	TR
Pyrite	2
Clay	20
Glauconite	TR
Carb. unspec.	TR
Diatoms	1
Sponge spicules	TR

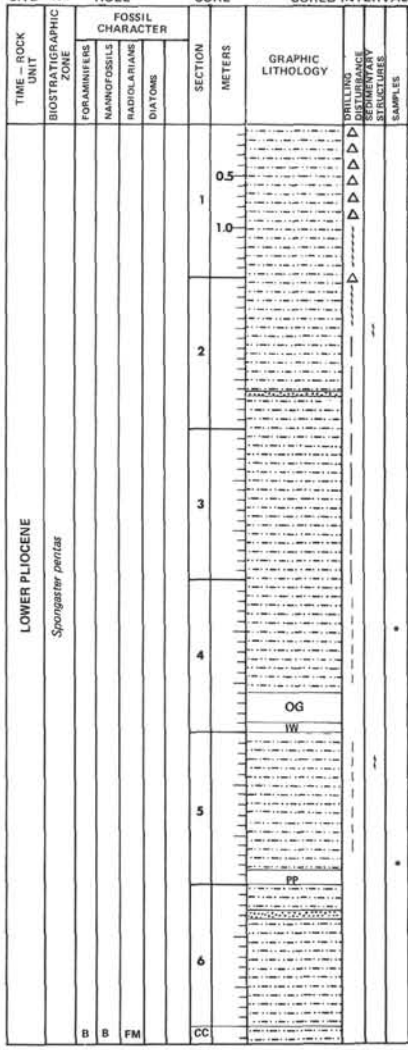
GRAIN SIZE

	2-90
Sand	9.5
Silt	69.7
Clay	20.8

ORGANIC CARBON AND CARBONATE

	5-126
% Organic Carbon	1.4
% $CaCO_3$	2.0

SITE 491 HOLE CORE 41 CORED INTERVAL 361.5–371.0 m



LITHOLOGIC DESCRIPTION

Drilling breccia

Drilling breccia

Dark (pyritic) silt
Fine sand, 9° true dip

Fissile

Silt, 11° true dip
Silt, apparent horizontal
Silts, 29° true dip
Fine sand, 0° apparent dip

Very fine sand, 39° true dip

Silt layer

(50–80 cm) highly contorted bedding, minor drilling laminations

27° apparent dip, some drilling laminations

Pyritic very fine sand, 11° apparent dip

Fine sand beds
Fine sand: 2° true dip
Pyritic silt
Fine sand, apparent dip 15°
Fine sand, apparent dip 0°
Sand

MUDDY SILTSTONE, grayish olive green (5GY 3/2) with fine SAND and SILT layers. Section 1: whole section fissil. Section 2: numerous high angle fractures without slickensides: probably drilling deformation. Section 4: same drilling laminations. Section 6: drilling laminations throughout.

SMEAR SLIDES

	Muddy silt	Muddy sand
	4-50 (D)	5-132 (M)
TEXTURE:		
Sand	25	45
Silt	45	35
Clay	30	20
COMPOSITION:		
Quartz	59	65
Feldspar	10	10
Mica	4	8
Heavy minerals	TR	2
Pyrite	1	5
Clay	25	10
Glauconite	TR	–
Carb. unspec.	TR	–
Foraminifers	TR	TR
Nannofossils	TR	TR
Radiolarians	–	TR
Diatoms	1	TR
Sponge spicules	TR	TR

SITE 491 HOLE CORE 42 CORED INTERVAL 371.0–380.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	NN 15 *Spongaster pentas?*			B		1	0.5, 1.0				
						2					
				FM		3					*
						4					
						5					GZ +
		B	RP	FM		CC					

LITHOLOGIC DESCRIPTION

MUDDY SILT, soft to hard, grayish olive green (5GY 3/2) to *olive gray* (5Y 3/2). Section 2: drilling laminations throughout (olive gray, 5Y 3/2). Section 3: in places muddy siltstone; sporadic drilling laminations; in places irregular hackly fracturing/incipient fissility (polished surfaces on fracture fragments). Section 4: soft to firm occasional drilling laminations. Section 5: firm muddy silt, in places muddy siltstone.

60–80 cm fissile

130–150 cm: extremely complex deformation: folded, overturned etc.,; picked out by grayish olive green (major) and olive gray (minor) color variations

35–50 cm: very soft zone

5Y 3/2 drilling lamination

2 cm thick drilling lamination

Healed fractures

VOID

Vague fissility

Vague healed fracture

SMEAR SLIDES

	Muddy silt
	3-82
	(D)
TEXTURE:	
Sand	25
Silt	45
Clay	30
COMPOSITION:	
Quartz	72
Feldspar	5
Mica	2
Heavy minerals	TR
Pyrite	1
Clay	20
Carb. unspec.	TR
Foraminifers	TR
Nannofossils	TR
Diatoms	TR
Sponge spicules	TR

GRAIN SIZE

	5-15
Sand	6.1
Silt	65.6
Clay	28.3

ORGANIC CARBON AND CARBONATE

	5-20
% Organic Carbon	1.3
% $CaCO_3$	2.0

SITE 491 HOLE CORE 43 CORED INTERVAL 380.5–390.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	NN 15 *Spongaster pentas?*					1	0.5, 1.0				*
						2					*
						3					
						4					
						5					
						6					
		B	RP	RM		CC					

LITHOLOGIC DESCRIPTION

Soupy; high fine sand content; possibly originally sequence of thin sand interbeds

MUDDY SILTSTONE, grayish olive green (5GY 3/2) (in places soft to firm silt with fine SAND beds.

Intense irregular fracturing

Fine sand: sharp base/diffuse top; 15° apparent dip

Fissility: 14° apparent dip

Discontinuous fine sand bed, possibly displaced along a reverse fault

Fractured region; planes in highly irregular pattern

Fine sand: 13° apparent dip

Bedding 8° apparent dip

Bedding picked out by sandier unit in muddy siltstone: 15° apparent dip

Fine sand: 18° apparent dip

Fractured with some slickensides

Bedding 10–20° apparent dip

Sponge

Fine sand: 20° apparent dip

Zone of complex color (5Y 3/2) bands (up to 1 cm thick) contorted "folds" and vertical streaks common

Minor short fractures with polished surfaces

Bedding in muddy siltstone 3° apparent dip

Fracture: 50° apparent dip

Silty bed 22° true dip

12° apparent dip
12° apparent dip
20° apparent dip

Drilling fractures and lamination common

Bedding 20° true dip

Zone of healed fractures

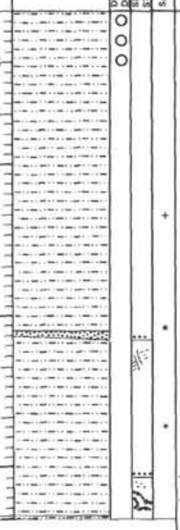
Graded sand bed medium ↑ fine

SMEAR SLIDES

	Fine sand	Muddy silt
	1-7	2-10
	(M)	(D)
TEXTURE:		
Sand	4	70
Silt	56	20
Clay	40	10
COMPOSITION:		
Quartz	57	74
Feldspar	7	9
Mica	2	3
Heavy minerals	TR	1
Pyrite	1	2
Clay	30	10
Glass	TR	–
Carb. unspec.	1	1
Foraminifers	TR	–
Radiolarains	TR	–
Diatoms	1	TR
Sponge spicules	1	TR

SITE 491 HOLE CORE 44 CORED INTERVAL 390.0–399.5 m

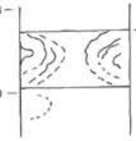
TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	RP	RM		1, 2, 3, 4, CC	0.5, 1.0				



LITHOLOGIC DESCRIPTION

MUDDY SILT (SILTSTONE), grayish olive green (5GY 3/2) with fine SAND and SANDY MUD. Section 1: soft, structureless. Section 2: soft, firm toward the base. Section 3: firm to hard, locally classifiable as MUDDY SILTSTONE "swirly" color bands in muddy siltstone: ? compacted ball and pillow structure?.

Section 3:



Fine to medium sandy mud Parallel lamination, graded, highly irregular, base as shown

Bedding in muddy silt and healed fractures

Diffuse fine sand concentration

1 cm graded fine sand bed

Darker area, curving bands as illustrated

SMEAR SLIDES

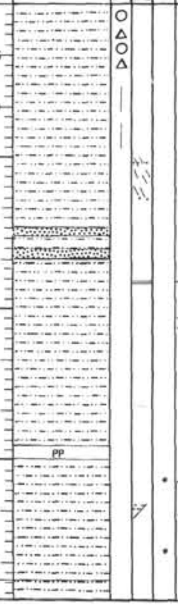
	Sandy mud	Muddy silt
	3-15 (M)	3-114 (D)
TEXTURE:		
Sand	2	35
Silt	68	10
Clay	30	55
COMPOSITION:		
Quartz	60	40
Feldspar	8	5
Mica	3	2
Heavy minerals	TR	1
Pyrite	1	TR
Clay	25	55
Carb. unspec.	1	TR
Nannofossils	TR	–
Radiolarians	TR	–
Diatoms	1	TR
Sponge spicules	1	TR

ORGANIC CARBON AND CARBONATE

	2-49
% Organic Carbon	1.3
% $CaCO_3$	2.0

SITE 491 HOLE CORE 45 CORED INTERVAL 399.5–409.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	RP	FM		1, 2, 3, 4, CC	0.5, 1.0	PP			



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE with MUDSTONE both grayish olive green (5GY 3/2) and fine to medium SAND. Section 1: fractured blocks in drilling breccia, soupy matrix.

Sand beds and muddy siltstone cut by a predominant 60–65° fracture system

Fine sand beds (no clear internal details) ~15° apparent dip

Vague parallel lamination

Fine sand: 18° true dip

Prominent sand concentration

Vague diffuse concentration of fine sand

Bedding within muddy siltstone: apparent dip 10°

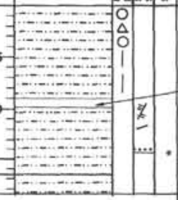
Bedding apparent dip 12° and healed fracture 55° apparent dip

SMEAR SLIDES

	Mudstone	Muddy siltstone
	4-42 (M)	4-96 (D)
TEXTURE:		
Sand	7	15
Silt	53	30
Clay	40	55
COMPOSITION:		
Quartz	59	43
Feldspar	6	6
Mica	3	1
Heavy minerals	TR	TR
Pyrite	1	TR
Clay	30	50
Carb. unspec.	TR	TR
Nannofossils	TR	–
Diatoms	TR	–
Sponge spicules	1	–

SITE 491 HOLE CORE 46 CORED INTERVAL 409.0–418.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	*Spongaster pentas?*	B	RP	FM		1, 2, CC	0.5, 1.0				



LITHOLOGIC DESCRIPTION

Siltstone fragments in drilling breccia soup

MUDDY SILT, grayish olive green (5GY 3/2).

VOID

Bedding: 22° apparent dip

Healed fault: 48° apparent dip

Healed fracture: 18° apparent dip

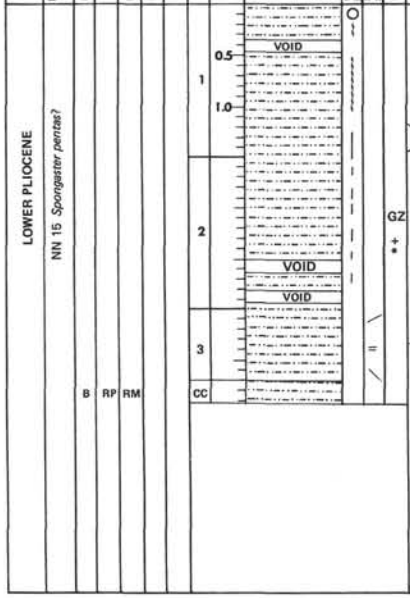
(145 cm) 1 cm thick fine sand bed (sharp base, diffuse top)

SMEAR SLIDES

	Muddy silt
	1-141 (D)
TEXTURE:	
Sand	10
Silt	60
Clay	30
COMPOSITION:	
Quartz	64
Feldspar	7
Mica	2
Heavy minerals	TR
Pyrite	TR
Clay	25
Carb. unspec.	1
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1

SITE 491 HOLE CORE 47 CORED INTERVAL 418.5–428.0 m

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



Faint drilling lamination

43° true dip (fracture)

1 mm thick truncated beds of fine sand

47° apparent dip (fracture)

MUDDY SILT, grayish olive green (5GY 3/2). Section 1: soupy to firm. Section 2: soft to firm, drilling laminations abundant.

SMEAR SLIDES

	Muddy silt 2-92 (D)
TEXTURE:	
Sand	10
Silt	55
Clay	35
COMPOSITION:	
Quartz	50
Feldspar	25
Mica	2
Heavy minerals	2
Pyrite	3
Clay	15
Glass	1
Carb. unspec.	1
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	TR

GRAIN SIZE

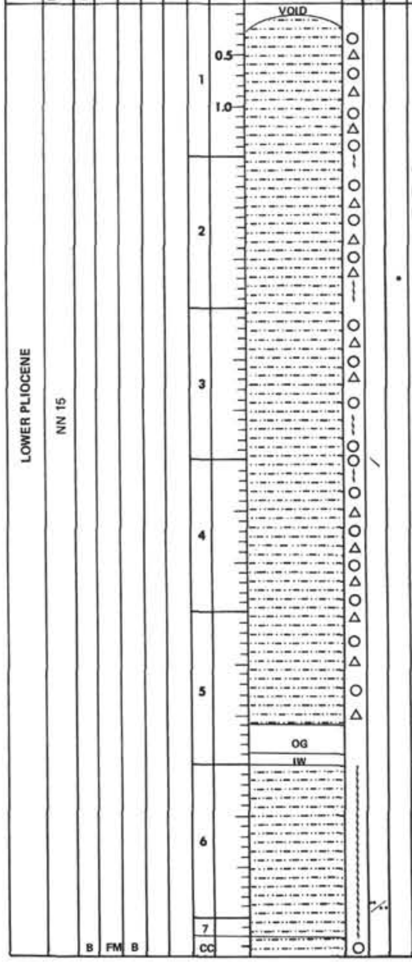
	2-60
Sand	11.5
Silt	66.5
Clay	22.0

ORGANIC CARBON AND CARBONATE

	2-84
% Organic Carbon	1.2
% $CaCO_3$	2.0

SITE 491 HOLE CORE 48 CORED INTERVAL 428.0–437.5 m

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



Drilling breccia and soup

Soft, sandy soup with angular fragments of lithified muddy siltstone

12° apparent dip

51° true dip (fissility)

1.5 cm fine sand bed (20° true dip)

Normal fault

MUDDY SILT, grayish olive green (5GY 3/2) soupy to firm and brecciated; disturbed by drilling.

SMEAR SLIDES

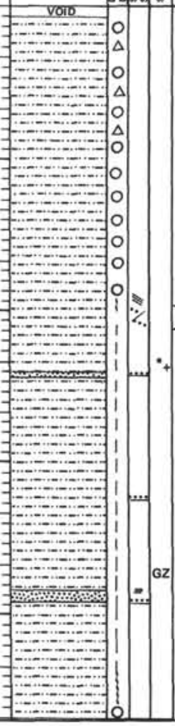
	Muddy silt 2-128 (D)
TEXTURE:	
Sand	7
Silt	55
Clay	38
COMPOSITION:	
Quartz	48
Feldspar	20
Mica	5
Heavy minerals	2
Pyrite	1
Clay	20
Glass	1
Nannofossils	TR
Radiolarians	TR
Diatoms	2
Sponge spicules	1
Plant fragments	TR

SITE 491 HOLE CORE 49 CORED INTERVAL 437.5–447.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	NN 15 *Spongaster pentas?*	B	RP	RM		1	0.5
							1.0
						2	
						3	
						4	
						5	

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES

VOID



GZ

31° apparent dip of thin (2–3 mm) sand beds

Parallel laminations

1 cm bed of very fine to fine sand: 20° apparent dip

17° apparent dip

2 cm fine sand

4 cm fine sand (18° true dip)

2 cm fine sand

1 cm fine sand

Parallel graded (T_{abd})

18° apparent dip

1 cm fine sand

LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2). Section 1: soupy with angular fragments of indurated muddy silt. Section 2: firm muddy silt (140–150 cm), soupy elsewhere. Section 3: poorly indurated muddy siltstone with 2 mm to 5 cm fine sand layers, parallel laminations present sporadically.

SMEAR SLIDES

	Muddy silt 3-53 (D)
TEXTURE:	
Sand	2
Silt	70
Clay	28
COMPOSITION:	
Quartz	65
Feldspar	15
Mica	5
Heavy minerals	1
Pyrite	1
Clay	10
Glass	1
Carb. unspec.	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	1

GRAIN SIZE

	4-119
Sand	17.3
Silt	58.9
Clay	23.7

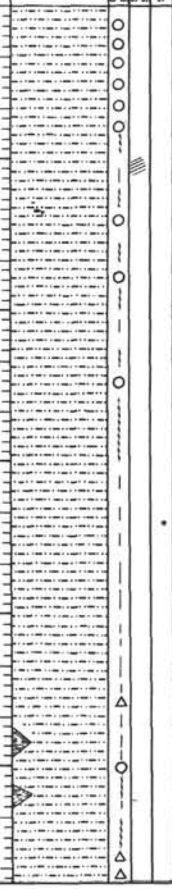
ORGANIC CARBON AND CARBONATE

	3-54
% Organic Carbon	1.5
% $CaCO_3$	2.0

SITE 491 HOLE CORE 50 CORED INTERVAL 447.0–456.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER PLIOCENE	*Spongaster pentas?*	B	B	RM		1	0.5
							1.0
						2	
						3	
						4	
						5	
						6	

GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



Incipient fissility
Parallel to bedding
17° true dip

Incipient fissility

7° apparent dip

2 cm sand bed

2 cm fine sand

Incipient fissility

5 cm fine sand
2 cm fine sand

Drilling breccia of mud chips

Angular chips of muddy siltstone set in unconsolidated sand

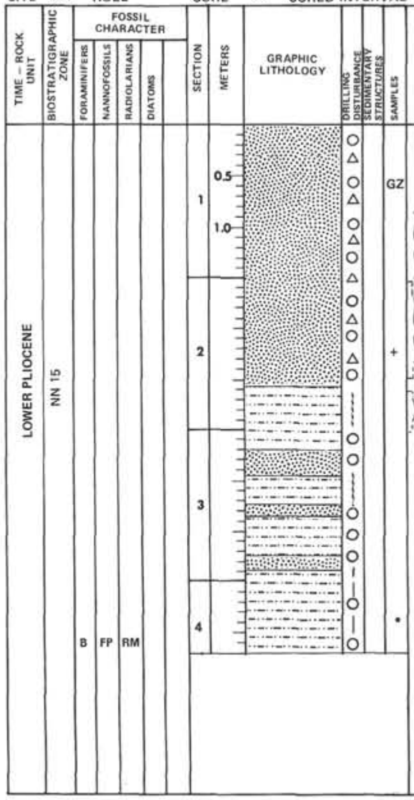
LITHOLOGIC DESCRIPTION

MUDDY SILT to MUDDY SILTSTONE, grayish olive green (5GY 3/2) with fine to medium SAND of variable color as noted below. Section 1: soupy to indurated. Section 2: more indurated muddy siltstone and less muddy silt. Section 3: poorly indurated muddy siltstone with thin (1–2 mm) sand layers. Section 5 (below 95 cm): unconsolidated 5GY 5/2 medium to fine sand with interbeds of indurated muddy siltstone. Section 6: unconsolidated grayish olive (10Y 4/2) medium to fine sand with minor interbeds of indurated muddy siltstone.

SMEAR SLIDES

	Muddy silt 4-61 (D)
TEXTURE:	
Sand	3
Silt	67
Clay	30
COMPOSITION:	
Quartz	50
Feldspar	25
Mica	7
Heavy minerals	3
Pyrite	1
Clay	10
Glass	1
Carb. unspec.	1
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	1

SITE 491 HOLE CORE 51 CORED INTERVAL 456.5–466.0 m



LITHOLOGIC DESCRIPTION

Chips (cuttings?) of 5GY 3/2 muddy siltstone

Angular chips and blocks (drilling artifacts)

Muddy siltstone with dispersed coarse to fine sand, very broken up by drilling

MUDDY SILTSTONE, grayish olive green (5GY 3/2) and coarse to fine SAND, dark greenish gray (5GY 4/1). Section 1: coarse to fine sand with angular chips (up to 3 cm maximum dimension) of muddy siltstone concentrated in lower half of section (probably due to settling in core barrel). Sections 3 and 4: alternating intervals of fractured indurated grayish olive green (5GY 3/2) muddy siltstone, and angular chips of same in loose sand (same as in Section 1.).

SMEAR SLIDES

	Muddy silt 4-41 (D)
TEXTURE:	
Sand	5
Silt	70
Clay	25
COMPOSITION:	
Quartz	65
Feldspar	15
Mica	5
Heavy minerals	1
Pyrite	2
Clay	15
Carb. unspec.	1
Foraminifers	TR
Nannofossils	TR
Diatoms	TR
Sponge spicules	1

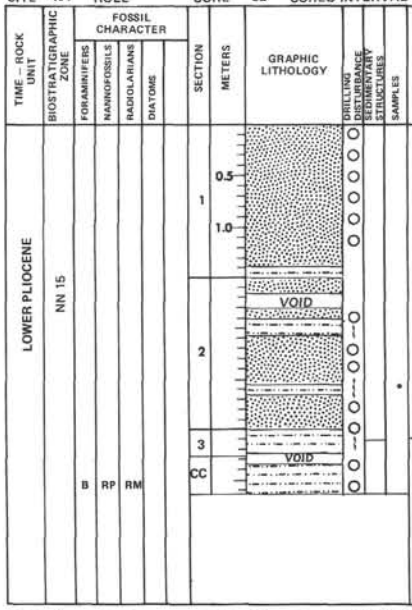
GRAIN SIZE

	1-61
Sand	84.9
Silt	11.5
Clay	3.7

ORGANIC CARBON AND CARBONATE

	2-73
% Organic Carbon	1.1
% $CaCO_3$	2.0

SITE 491 HOLE CORE 52 CORED INTERVAL 466.0–475.5 m



LITHOLOGIC DESCRIPTION

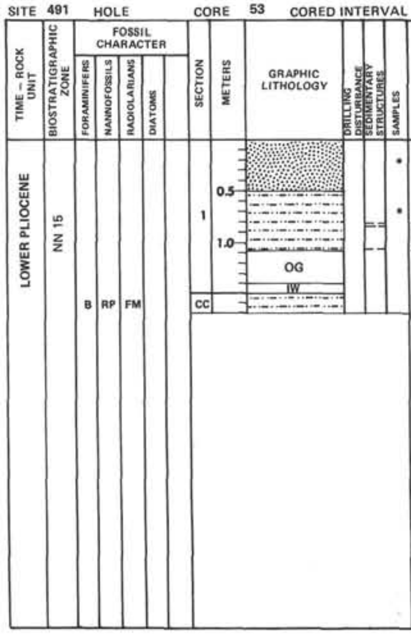
0.7 cm fine sand: 11° true dip

Fine to very coarse SAND, unconsolidated, dark greenish gray (5GY 4/1) with SILT, grayish olive green (5GY 3/2). Section 1: fine to very coarse sand with granules and pebbles up to 5 mm; minor intervals of silt. Section 3: very firm (5GY 3/2, 5GY 5/2, and 5Y 3/2) silt with 0.7 cm interbed of medium dark gray (N4) fine sand.

SMEAR SLIDES

	Silt 2-110 (D)
TEXTURE:	
Sand	10
Silt	81
Clay	9
COMPOSITION:	
Quartz	60
Feldspar	25
Mica	7
Heavy minerals	1
Pyrite	1
Clay	5
Glass	TR
Carb. unspec.	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1
Plant fragments	TR

SITE 491 HOLE CORE 53 CORED INTERVAL 475.5–485.0 m



LITHOLOGIC DESCRIPTION

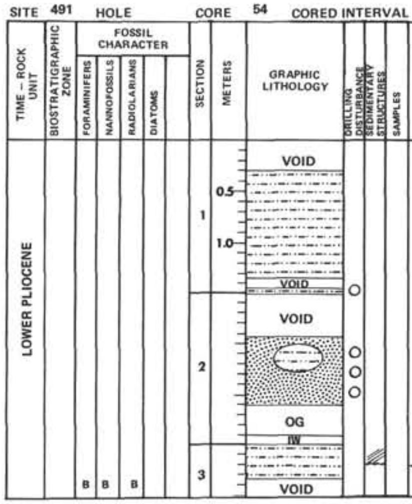
Fissility

Unconsolidated coarse pebbly SAND, dark greenish gray (5G 4/1), grading through to coarse grained–medium grained at top; includes 2 cm clast of muddy siltstone grading primary?; clasts rounded to sub-angular (very variable), very poorly sorted and MUDDY SILTSTONE, grayish olive green (5GY 3/2). 50–110 cm: indurated fracture-bound blocks of muddy siltstone, separated between 54 and 82 cm by a soft mixture of fine sand and muddy silt.

SMEAR SLIDES

	Coarse sand 1-26 (D)	Muddy silt 1-72 (M)
TEXTURE:		
Sand	10	75
Silt	50	20
Clay	40	5
COMPOSITION:		
Quartz	58	91
Feldspar	8	2
Mica	3	2
Heavy minerals	TR	TR
Pyrite	TR	TR
Clay	35	5
Nannofossils	TR	–
Diatoms	TR	–
Sponge spicules	1	TR

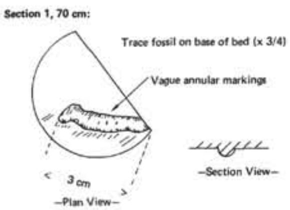
SITE 491 HOLE CORE 54 CORED INTERVAL 485.0–494.5 m



LITHOLOGIC DESCRIPTION

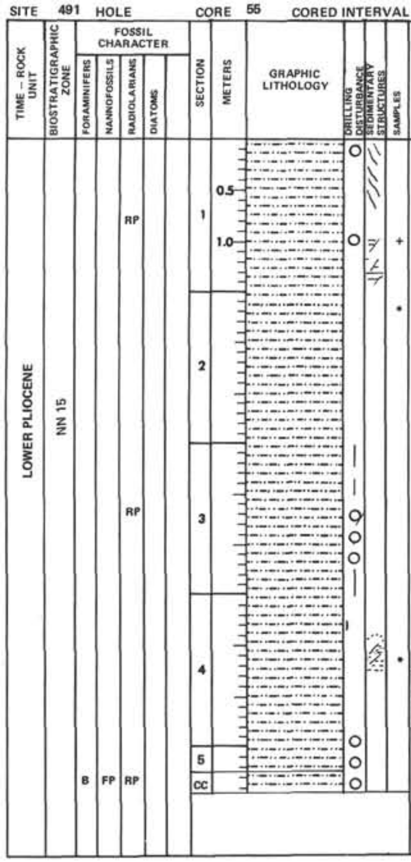
MUDDY SILTSTONE, grayish olive green (5GY 3/2), indurated, some probably in original position, in a soupy matrix rich in FINE SAND to COARSE SAND. In Section 2 fewer muddy silt blocks, none in original position.

Section 1, 70 cm:



14° apparent dip, vaguely bedded in sandy unit, peculiar slightly wavy drilling lamination

SITE 491 HOLE CORE 55 CORED INTERVAL 494.5–504.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, grayish olive green (5GY 3/2), intensely fractured.

Section 1: intense fracturing:
0–60 cm: close (generally <1 cm), slightly irregular—dip 50–60°.
60–88 cm: 1–2 cm spaced, predominantely horizontal and sub-horizontal.
88–100 cm: close fractures, soupy matrix.
100–150 cm: 2 sets of fractures apparent (as illustrated) (1) 0–12° and (2) 45–60°, one example with slickensides.

Section 2 and 3: fractured throughout, variable intensity. Straight fractures are horizontal or steeply inclined (60–80°) in both directions. Soft muddy silt matrix permeates between fracture-bound blocks in several places.

Very intense fracturing, finer sand distributed as shown, suggesting two broken-up beds.

Firm silt to siltstone with irregular healed fractures.

Faults: 48° and 55° dip

Parallel laminations: 18° dip

Muddy siltstone, appears structureless

Same drilling laminations

SMEAR SLIDES

	Muddy siltstone	Fine sand
	2-20 (D)	4-66 (M)
TEXTURE:		
Sand	12	80
Silt	68	15
Clay	20	5
COMPOSITION:		
Quartz	68	80
Feldspar	6	8
Mica	4	3
Heavy minerals	1	2
Pyrite	TR	1
Clay	20	5
Carb. unspec.	1	1
Foraminifers	TR	–
Nannofossils	TR	–
Radiolarians	TR	–
Diatoms	TR	TR
Sponge spicules	TR	TR

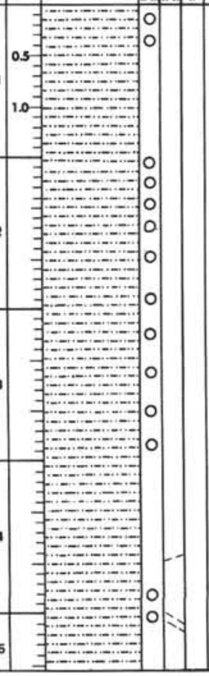
ORGANIC CARBON AND CARBONATE

	1-99
% Organic Carbon	1.1
% $CaCO_3$	1.0

SITE 491 HOLE CORE 56 CORED INTERVAL 504.0–513.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
LOWER PLIOCENE	NN 15	B	FM	FM		1, 2, 3, 4, 5

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, grayish olive green (5GY 3/2). Section 1: fracture-bounded blocks separated by minor soupy matrix; horizontal and sub-horizontal fracturing often closely-spaced and flaggy predominates: probably bedding. Section 2: becoming more matrix-rich, so that blocks are all displaced. Section 4: is soft to firm, core largely intact, little internal structures visible.

1 cm thick sand bed (fine sand)

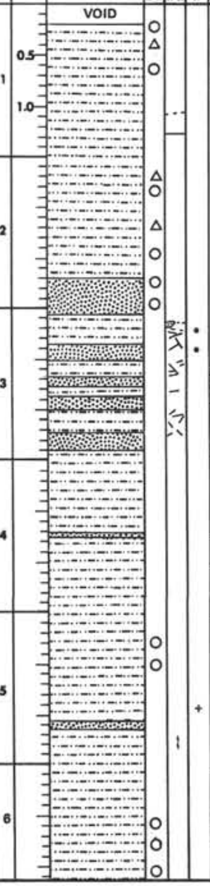
Bedding? trace

Inclined fissility 20° apparent dip

SITE 491 HOLE CORE 57 CORED INTERVAL 513.5–523.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
LOWER PLIOCENE	NN 15	B	RP	RM		1, 2, 3, 4, 5, 6

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Chips floating in soft soupy matrix

Fissility, 8° apparent dip

Bedding trace?

Fine sand, soupy, minor fragments of muddy siltstone

Fissility: probably bedding

Prominent fractures

Parallel lamination, fine-grained muddy sand

4° apparent dip, no structure evident

Irregular, faint grading

Parallel lamination toward top, 10° apparent dip

Bottom displaced 1 cm by normal fault

Diffuse concentration of fine to medium sand and smaller than usual siltstone chips

Very fine muddy sand

Very fine muddy sand

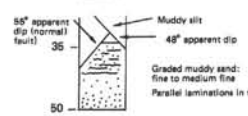
Faint bioturbation

Very fine muddy sand layer

Incomplete sandy beds

MUDDY SILTSTONE, grayish olive green (5GY 3/2) with fine to medium SAND. In Section 2 chips float in soft soupy matrix, in places rich in fine sand.

Section 3:



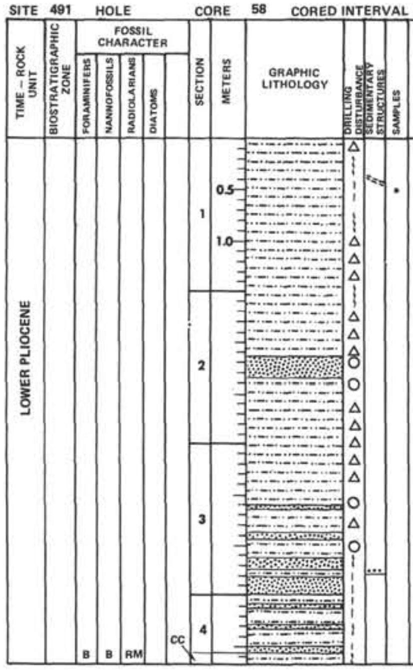
SMEAR SLIDES

	Muddy siltstone 3-28 (D)	Muddy sand 3-41 (M)
TEXTURE:		
Sand	8	60
Silt	62	20
Clay	30	20
COMPOSITION:		
Quartz	61	70
Feldspar	7	6
Mica	3	3
Heavy minerals	1	1
Pyrite	1	TR
Clay	25	20
Glass	TR	–
Carb. unspec.	1	–
Foraminifers	TR	–
Nannofossils	TR	–
Radiolarians	TR	–
Diatoms	1	–
Sponge spicules	TR	–
Plant fragments	TR	–

ORGANIC CARBON AND CARBONATE

	5-94
% Organic Carbon	0.9
% $CaCO_3$	0.0

SITE 491 HOLE CORE 58 CORED INTERVAL 523.0–532.5 m



LITHOLOGIC DESCRIPTION

Silt lamination
28° apparent dip

Drilling breccia

Drilling breccia

Soupy, fine sand, same color as muddy siltstone

Drilling breccia

Fine sand

Fine sand

Graded sand, coarse to fine

Fine sand
Fine sand

Very fine sand

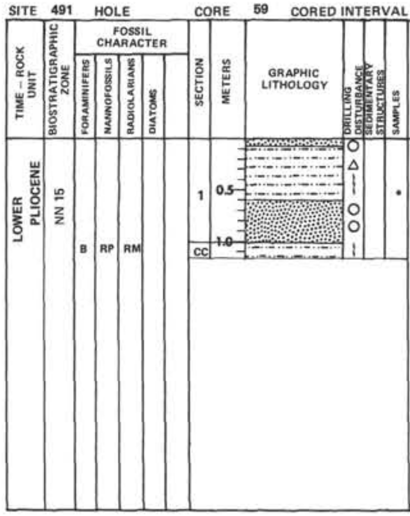
Very fine sand

MUDDY SILTSTONE, grayish olive green (5GY 3/2) with very fine to coarse SAND.

SMEAR SLIDES

	Muddy silt
	1-50 (D)
TEXTURE:	
Sand	15
Silt	55
Clay	30
COMPOSITION:	
Quartz	60
Feldspar	9
Mica	4
Heavy mineral	TR
Pyrite	1
Clay	25
Carb. unspec.	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	TR

SITE 491 HOLE CORE 59 CORED INTERVAL 532.5–542.0 m



LITHOLOGIC DESCRIPTION

Medium sand

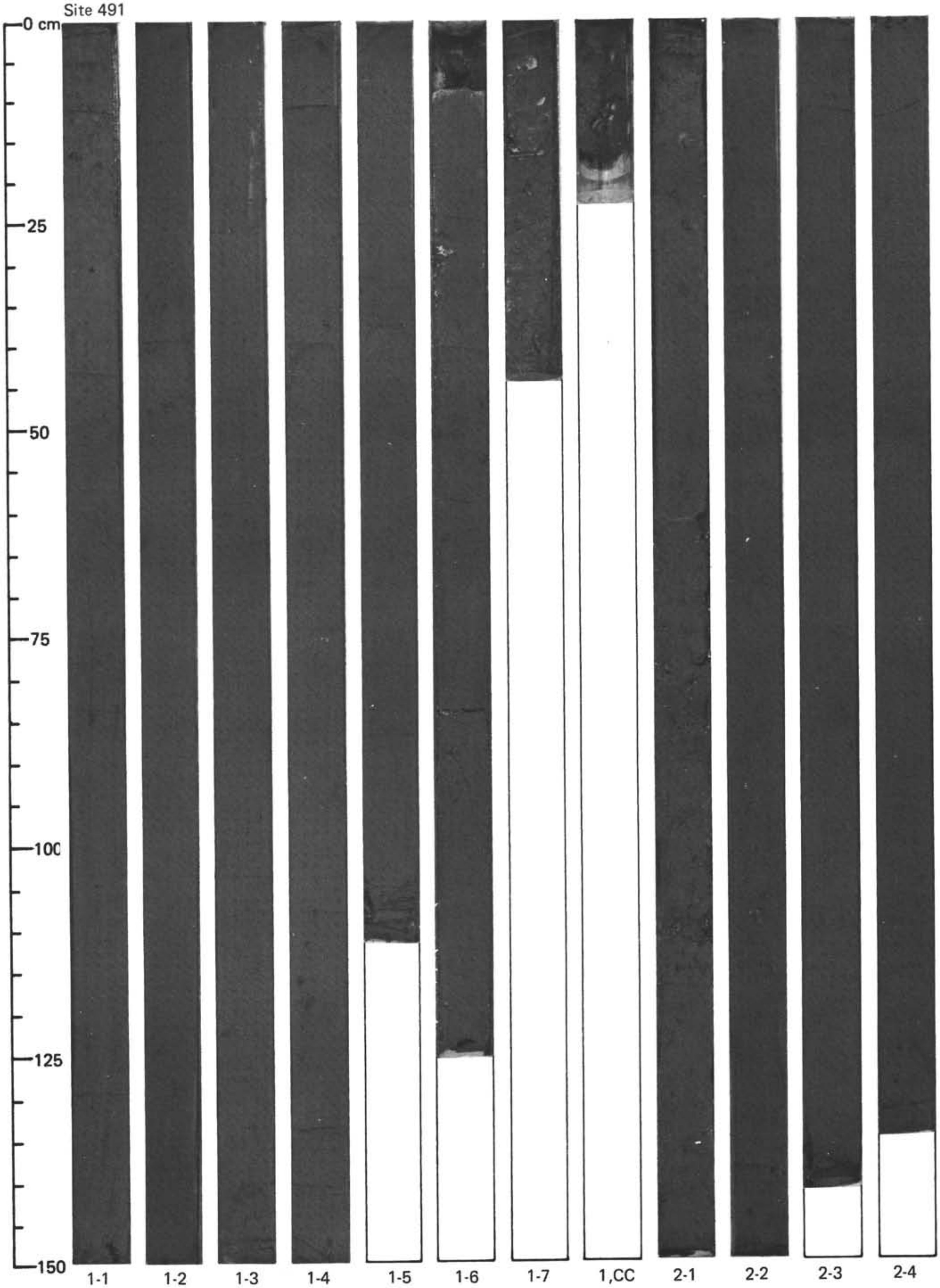
Drilling breccia

Coarse to medium sand, probably graded

MUDDY SILTSTONE and coarse to medium SAND.

SMEAR SLIDES

	Muddy silt
	1-55 (D)
TEXTURE:	
Sand	10
Silt	60
Clay	30
COMPOSITION:	
Quartz	59
Feldspar	8
Mica	5
Heavy minerals	TR
Pyrite	2
Clay	25
Diatoms	1
Sponge spicules	TR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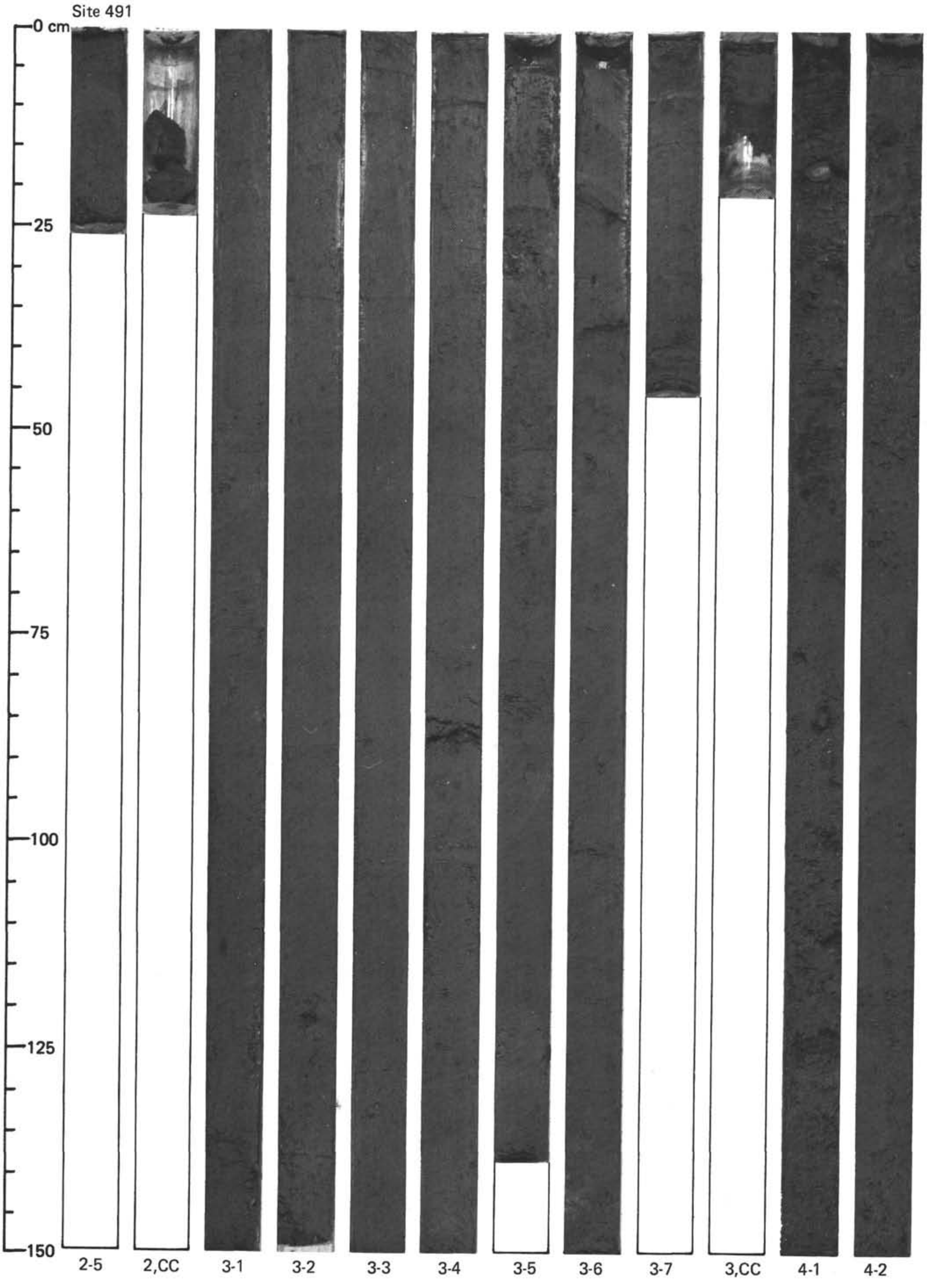
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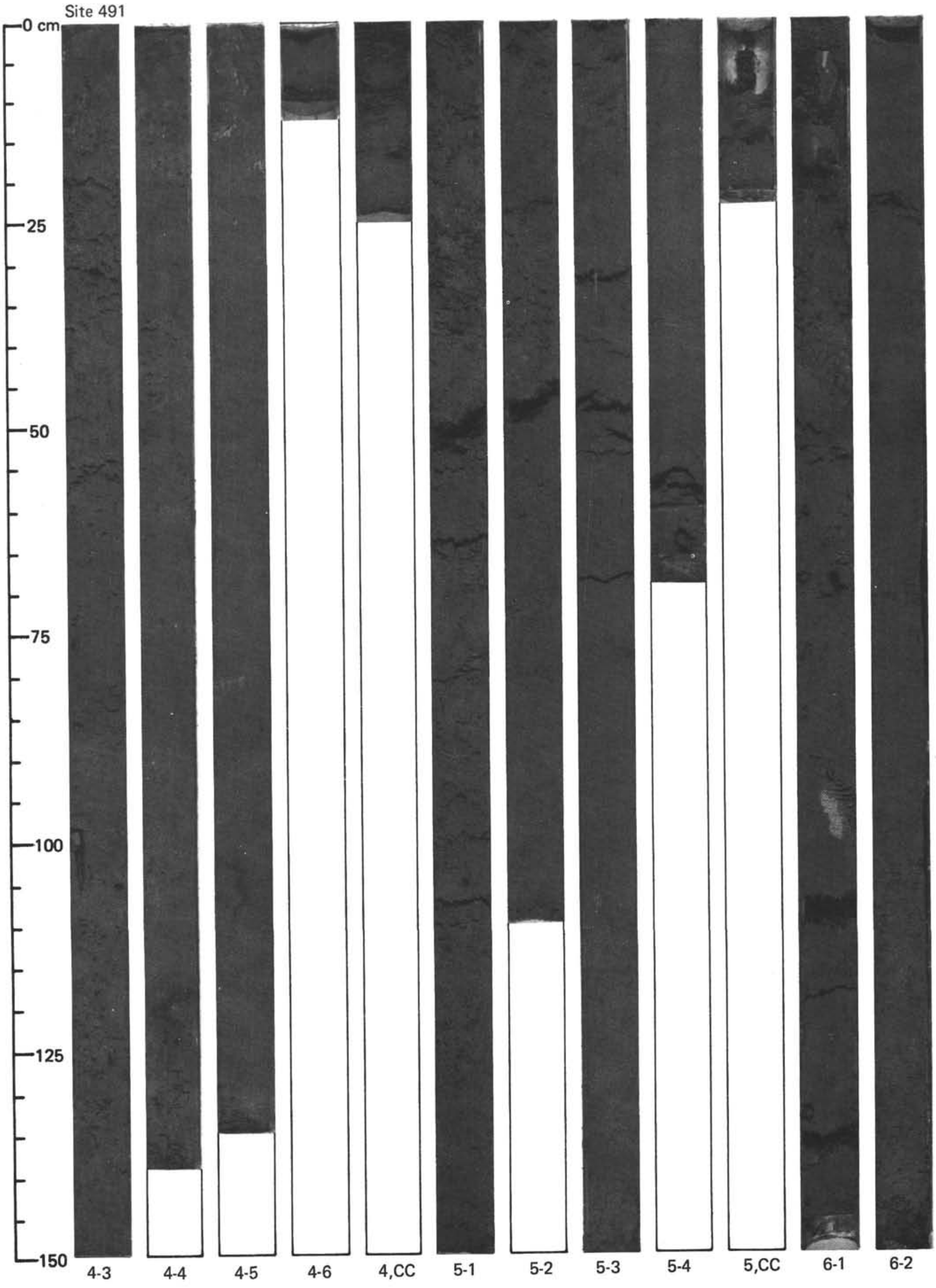
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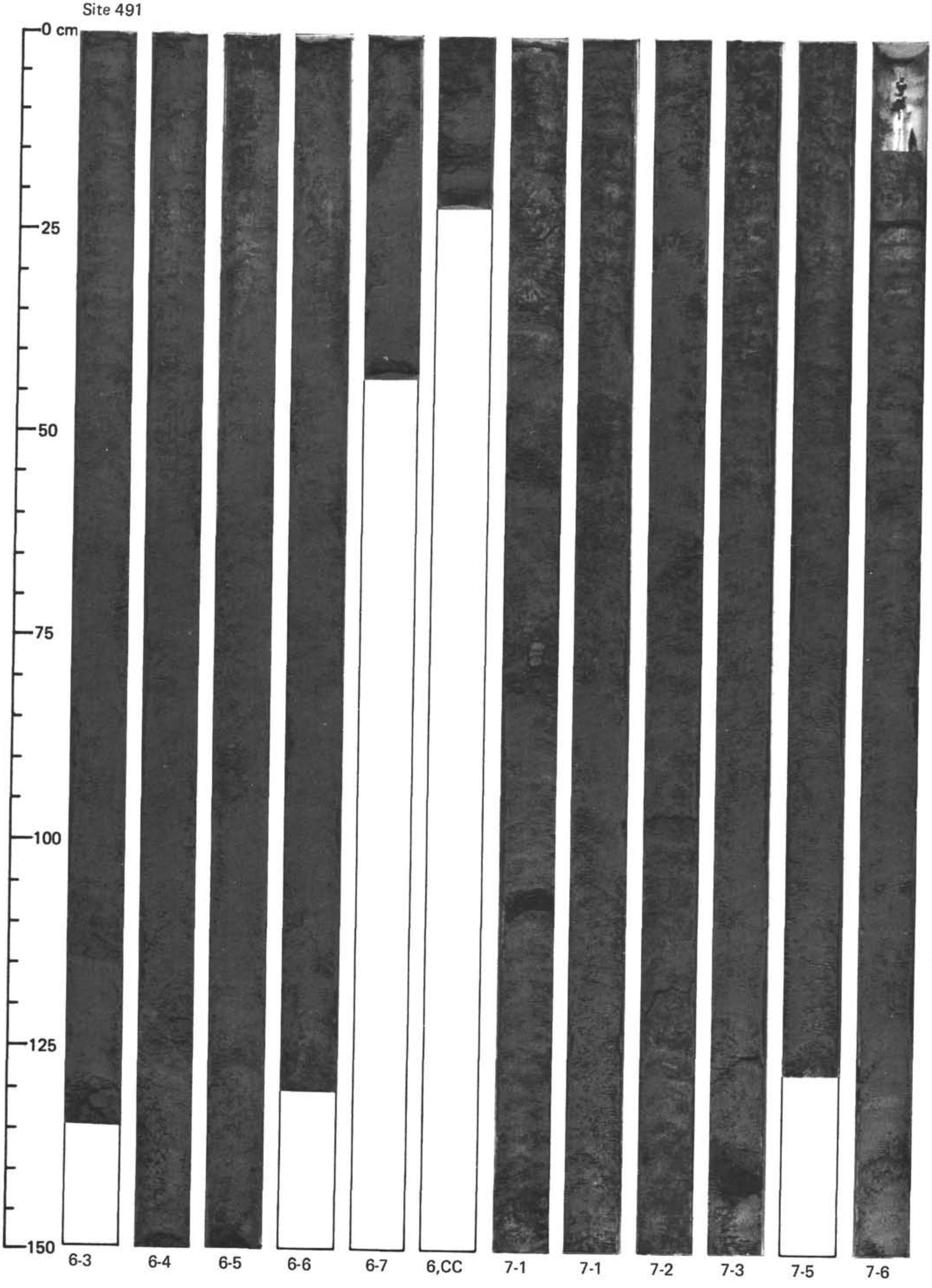
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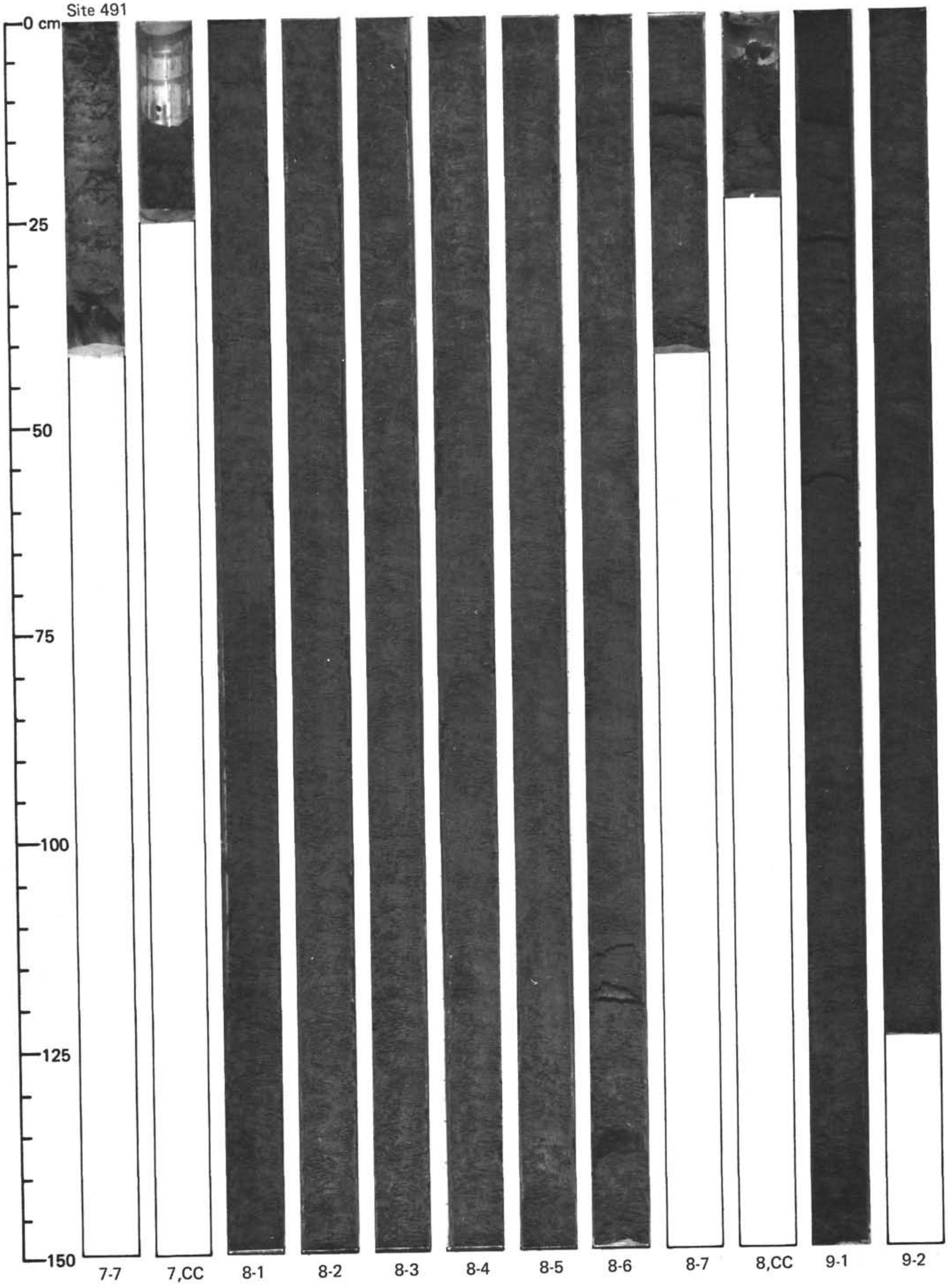
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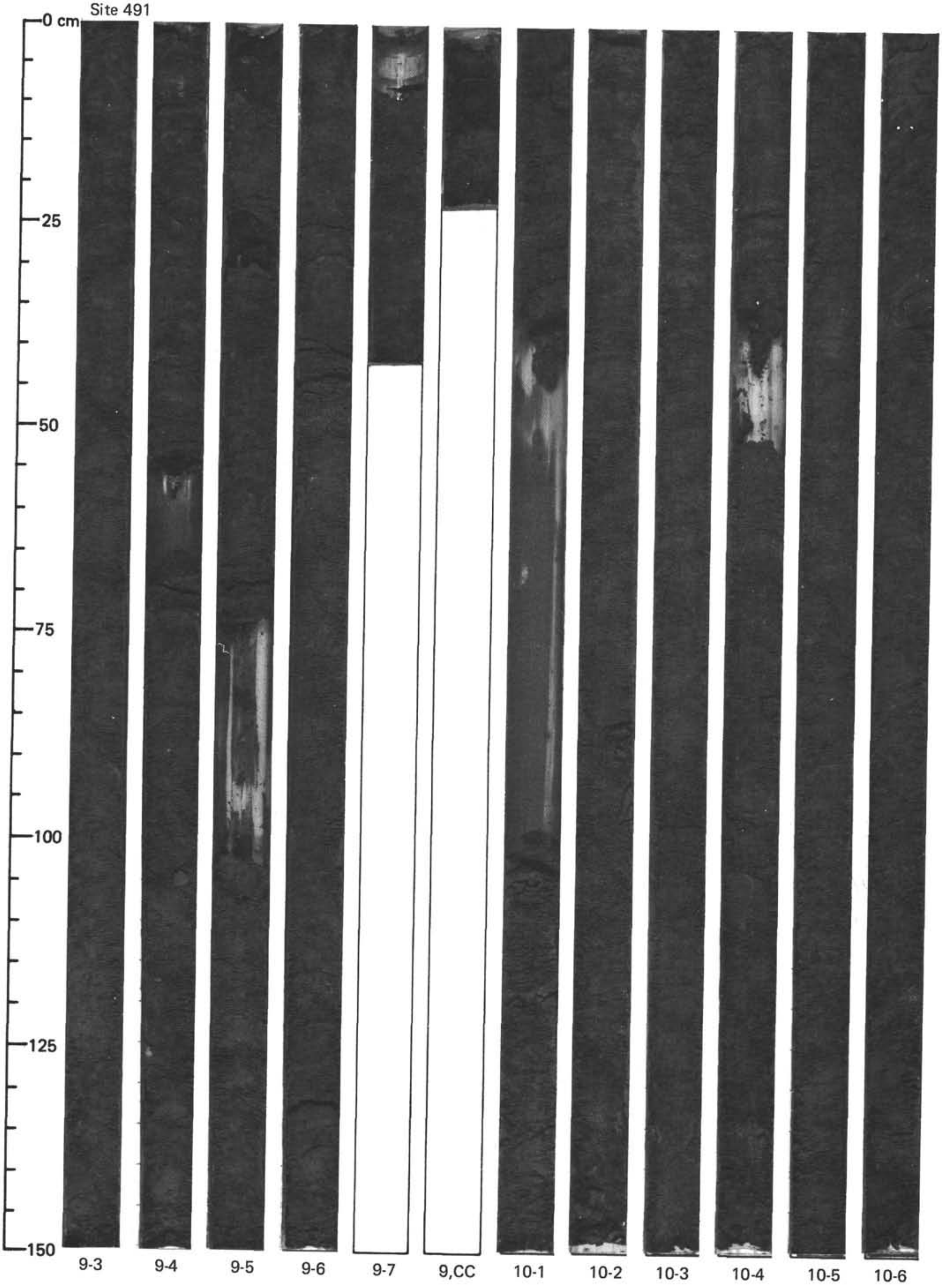
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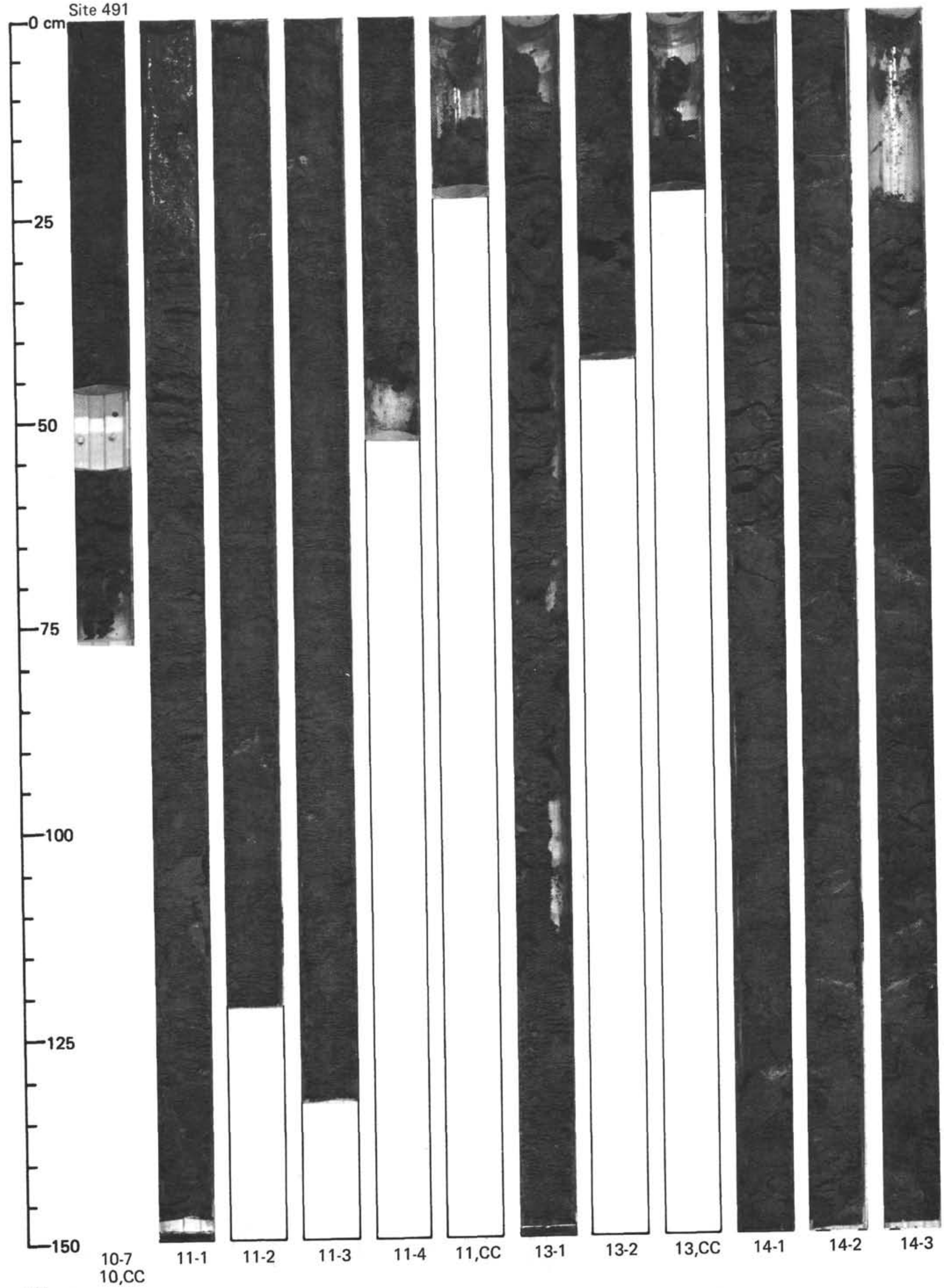
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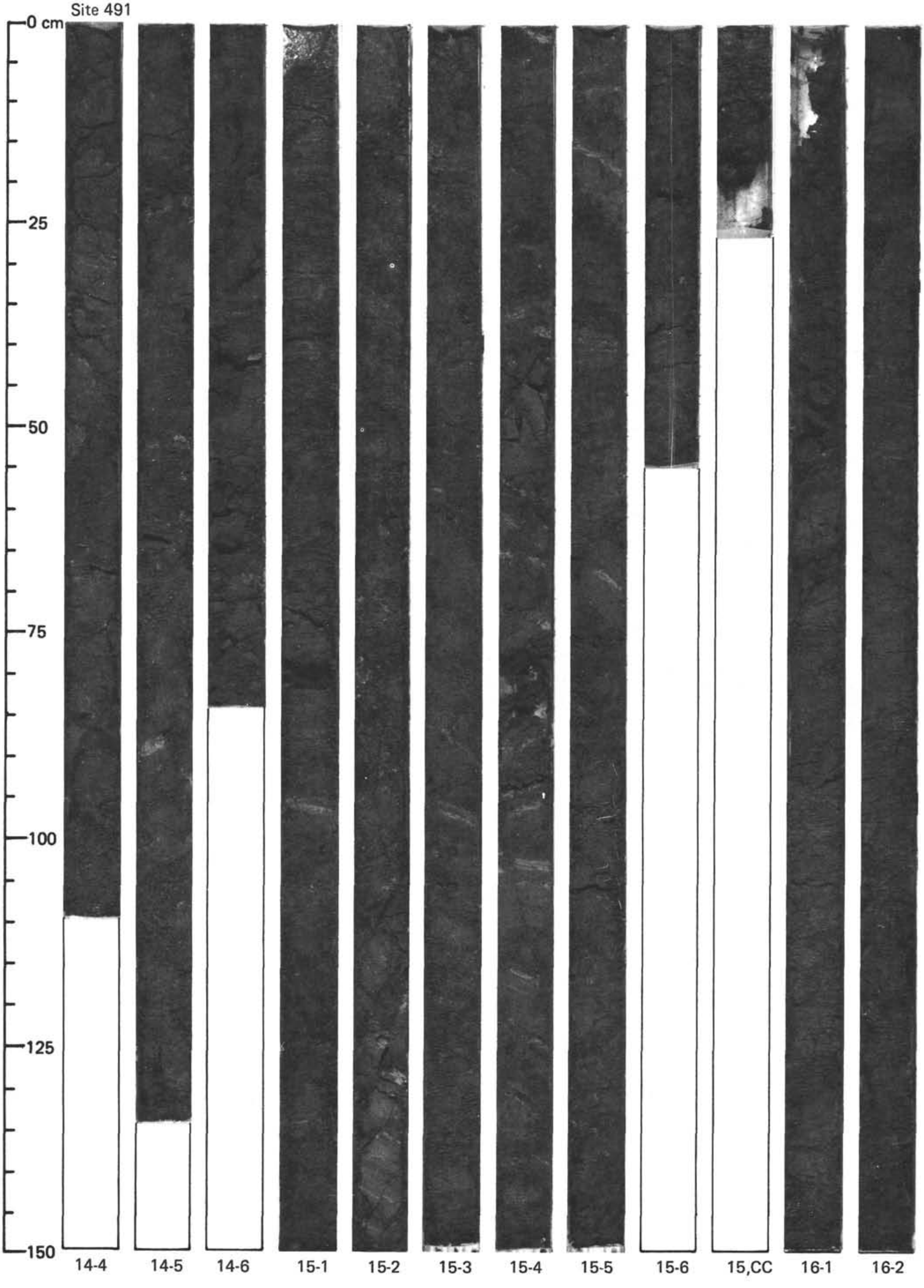
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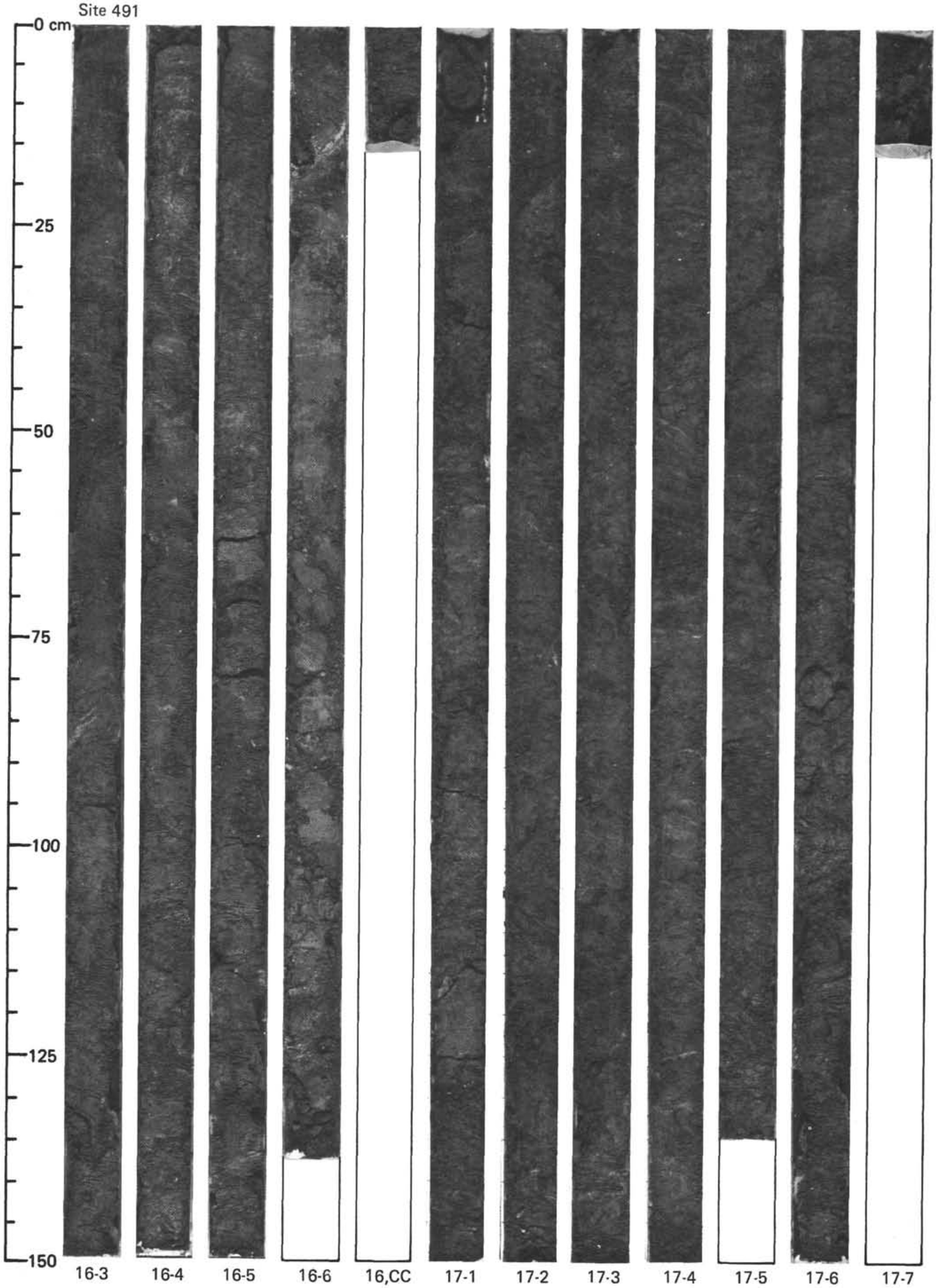

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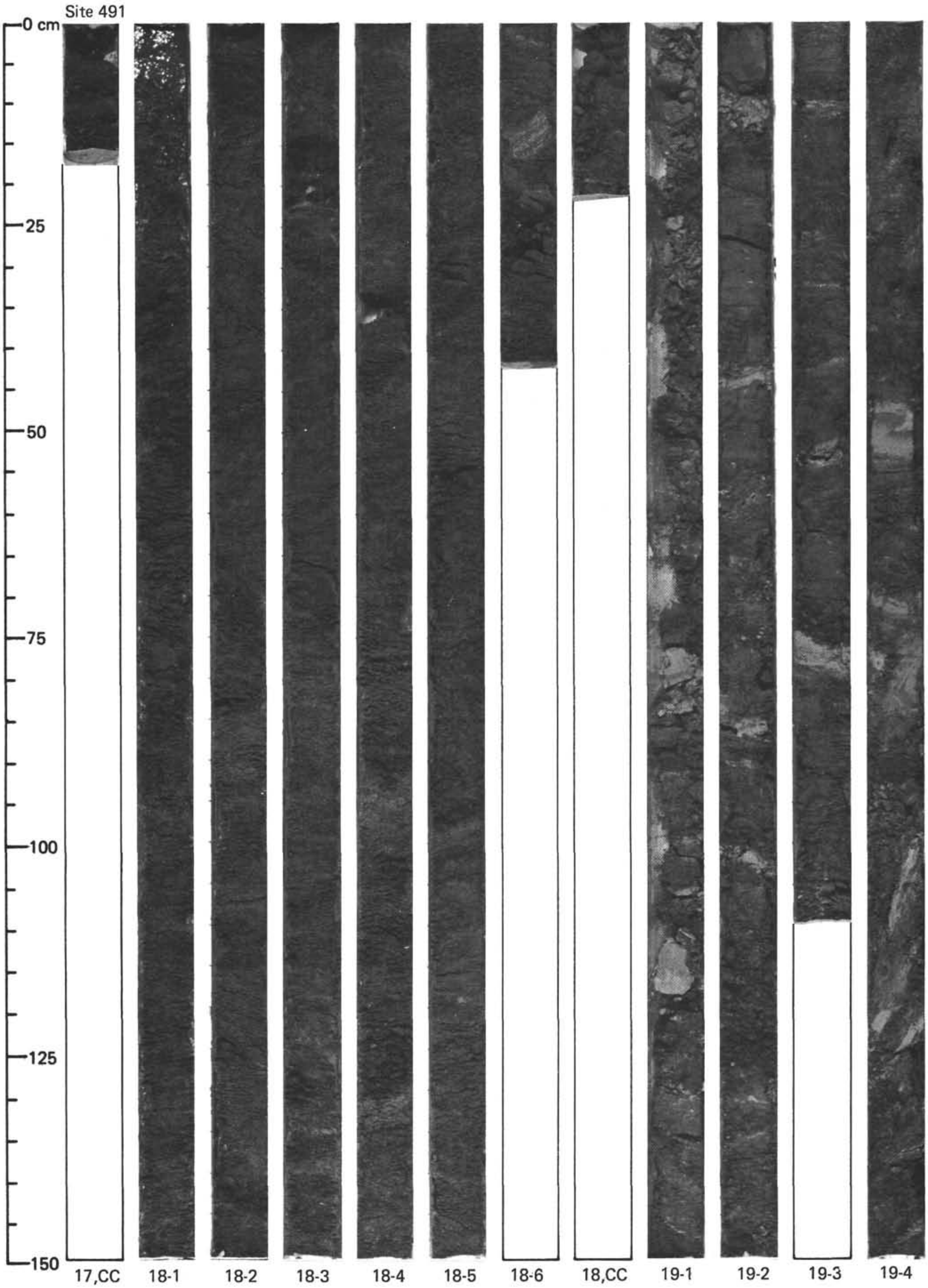
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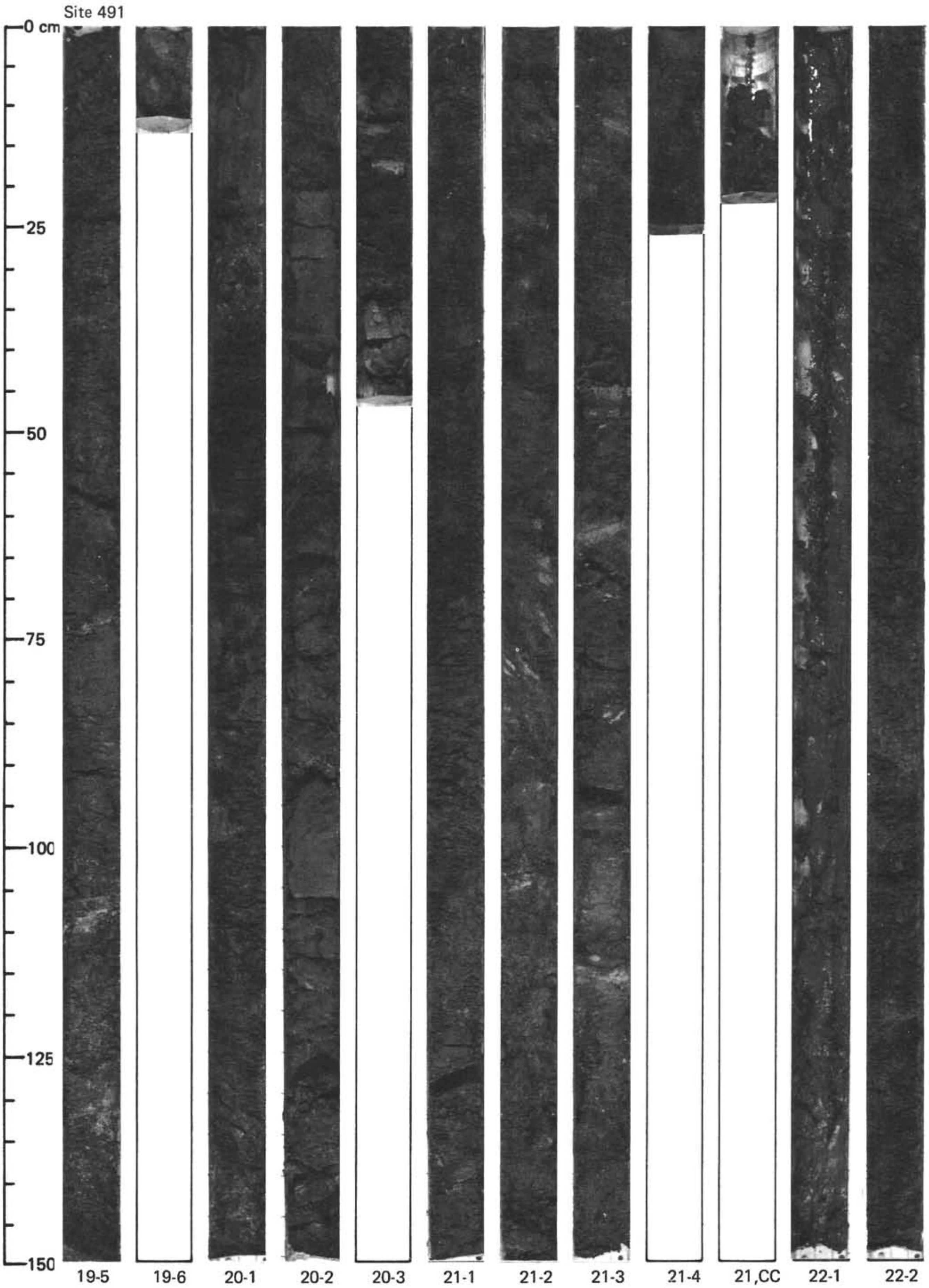
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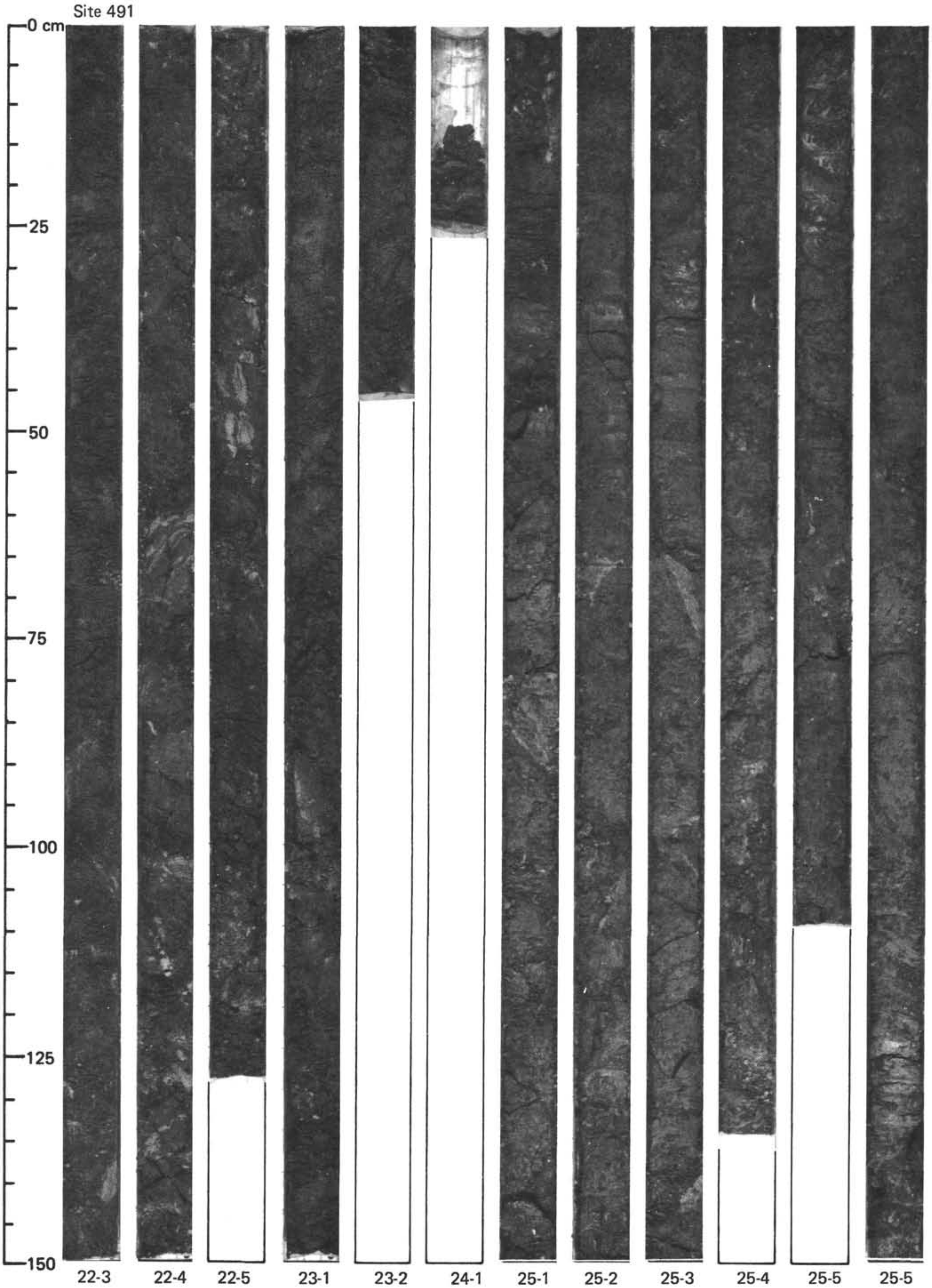
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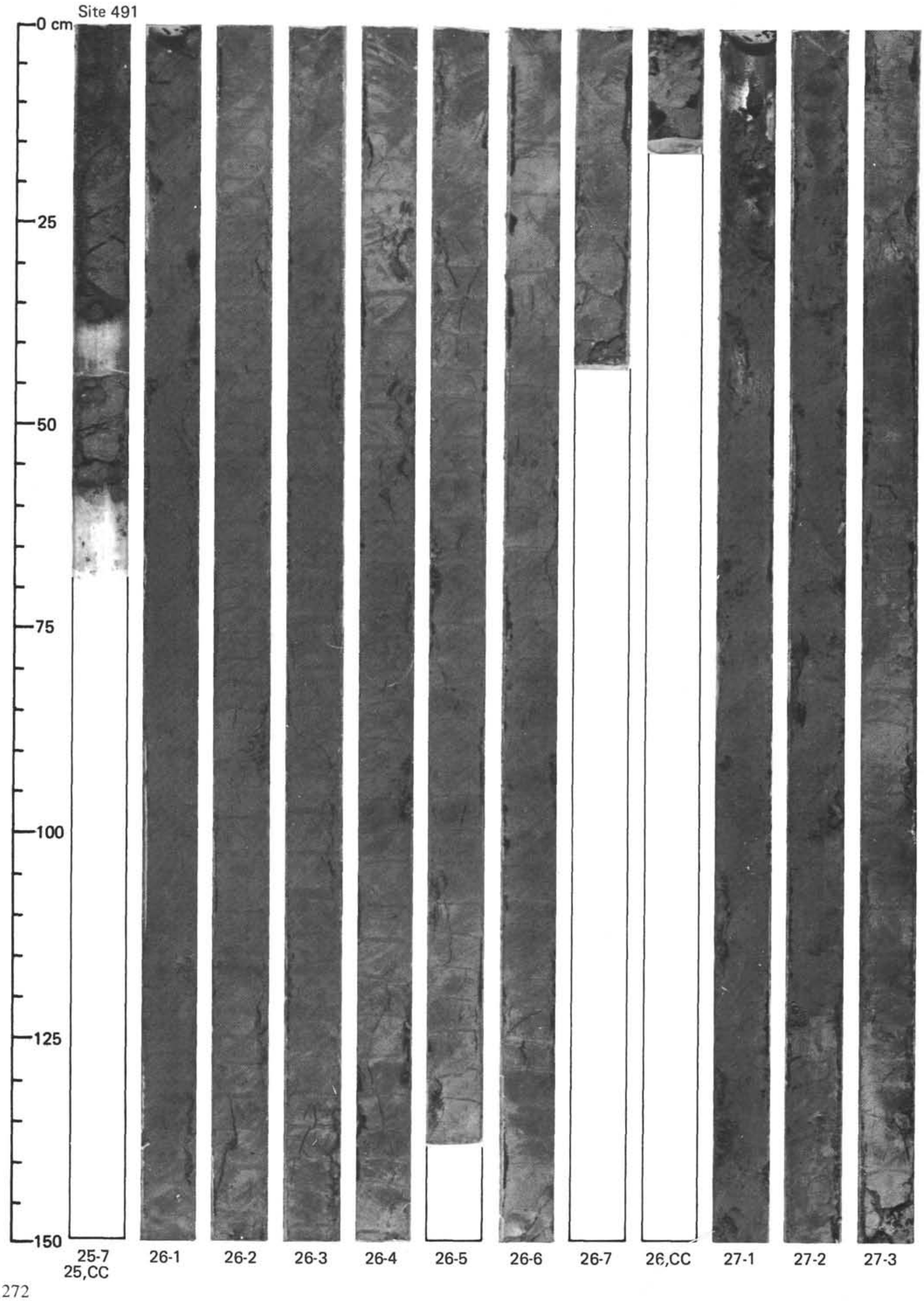
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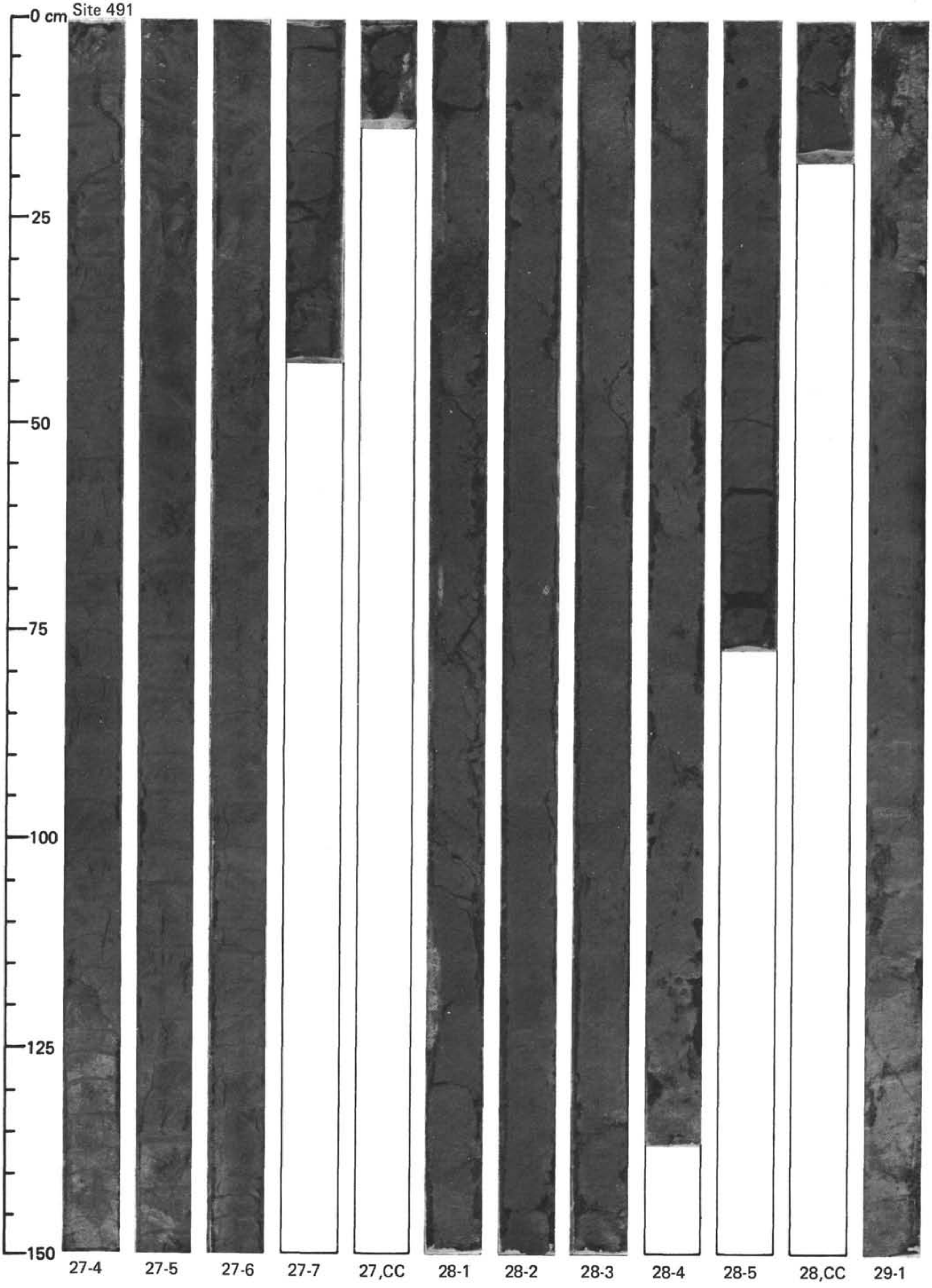
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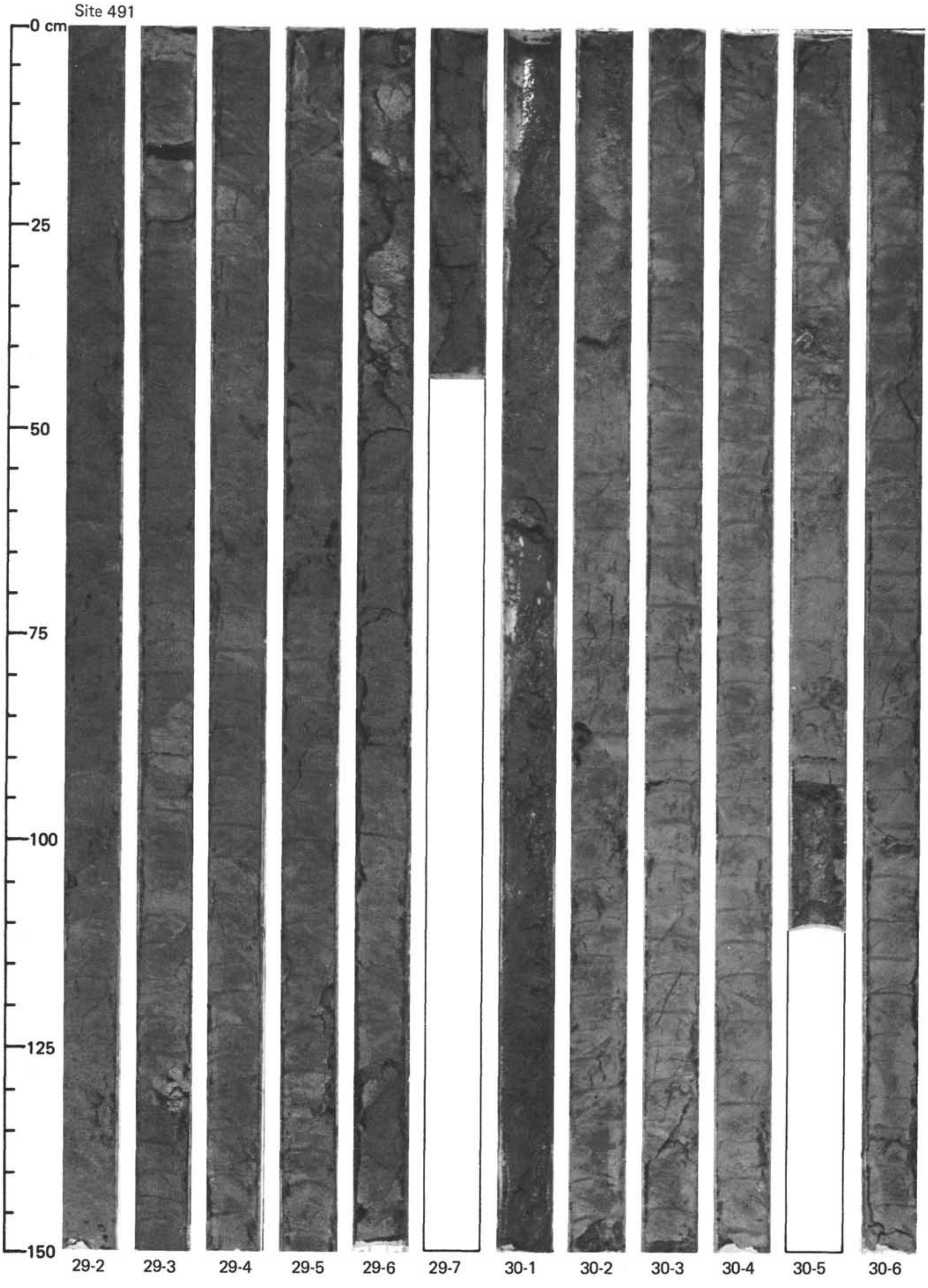
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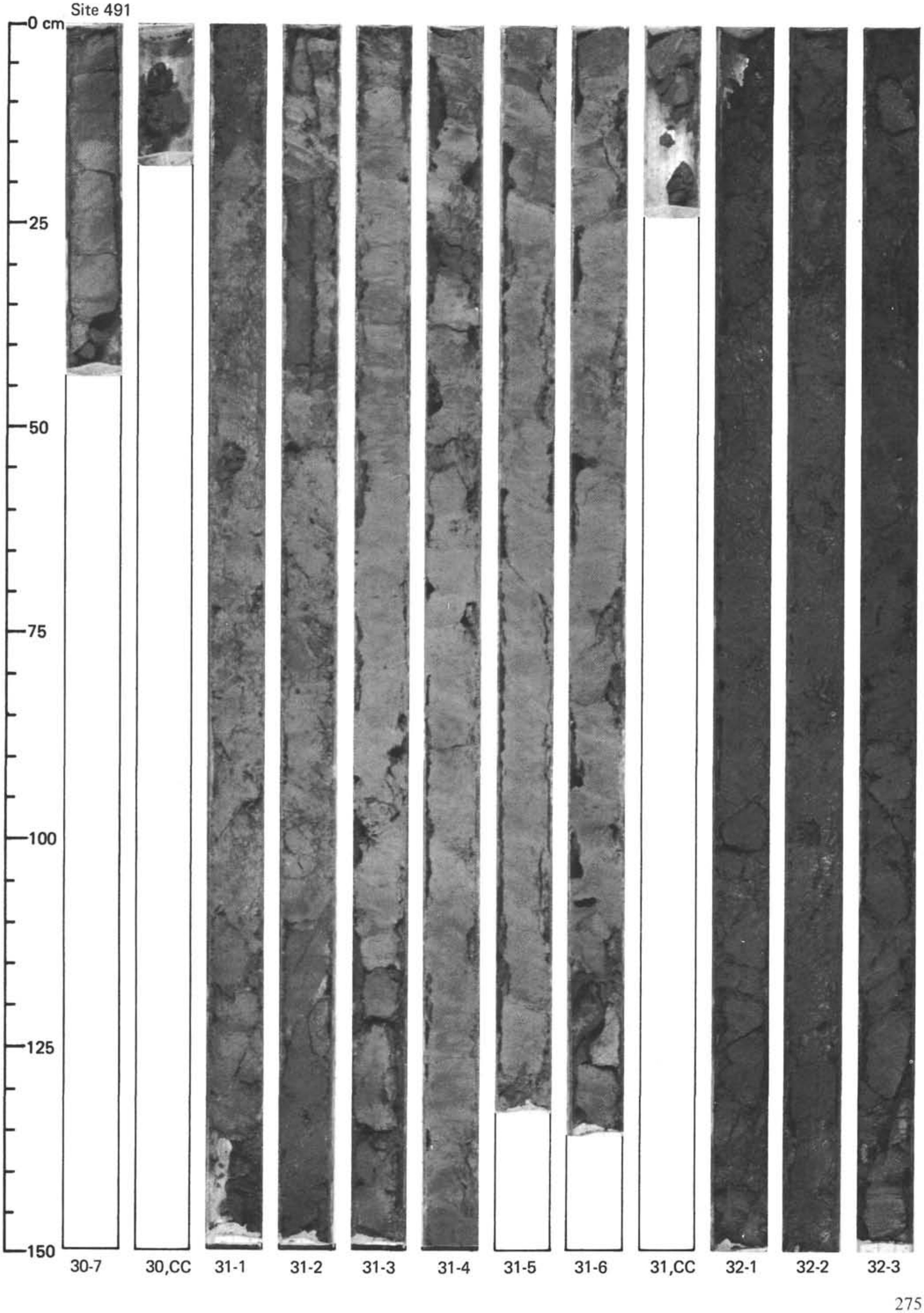
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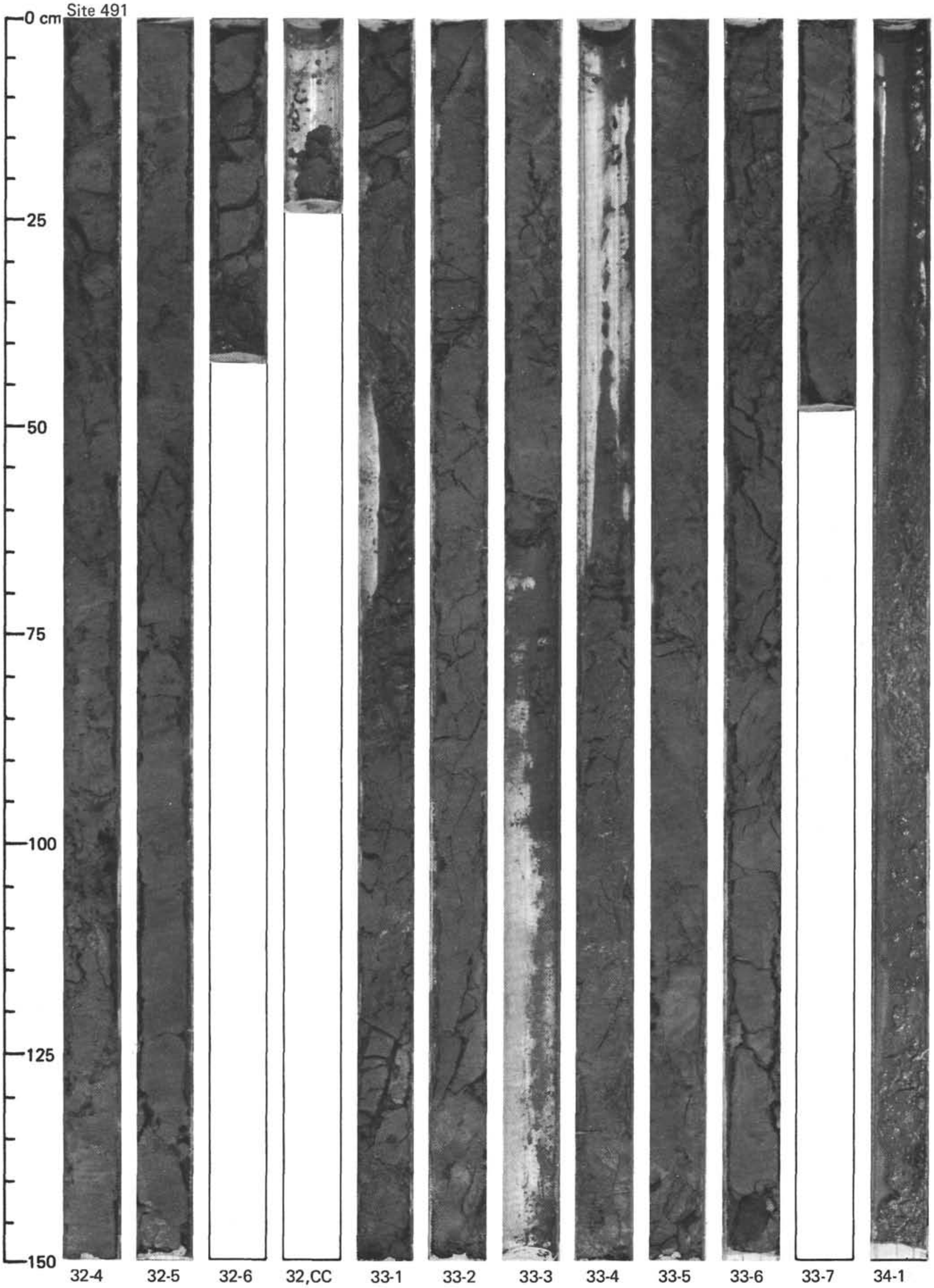
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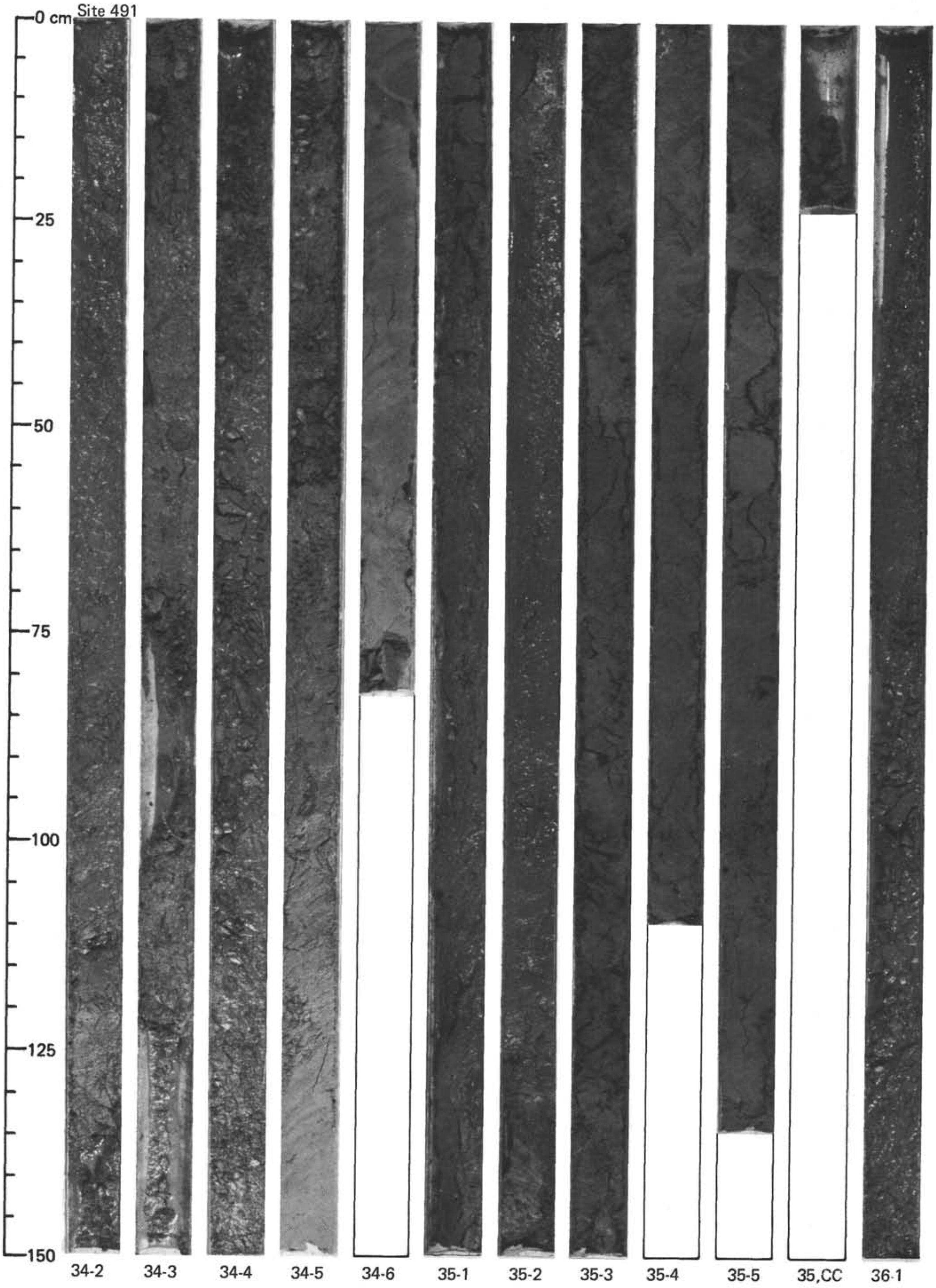
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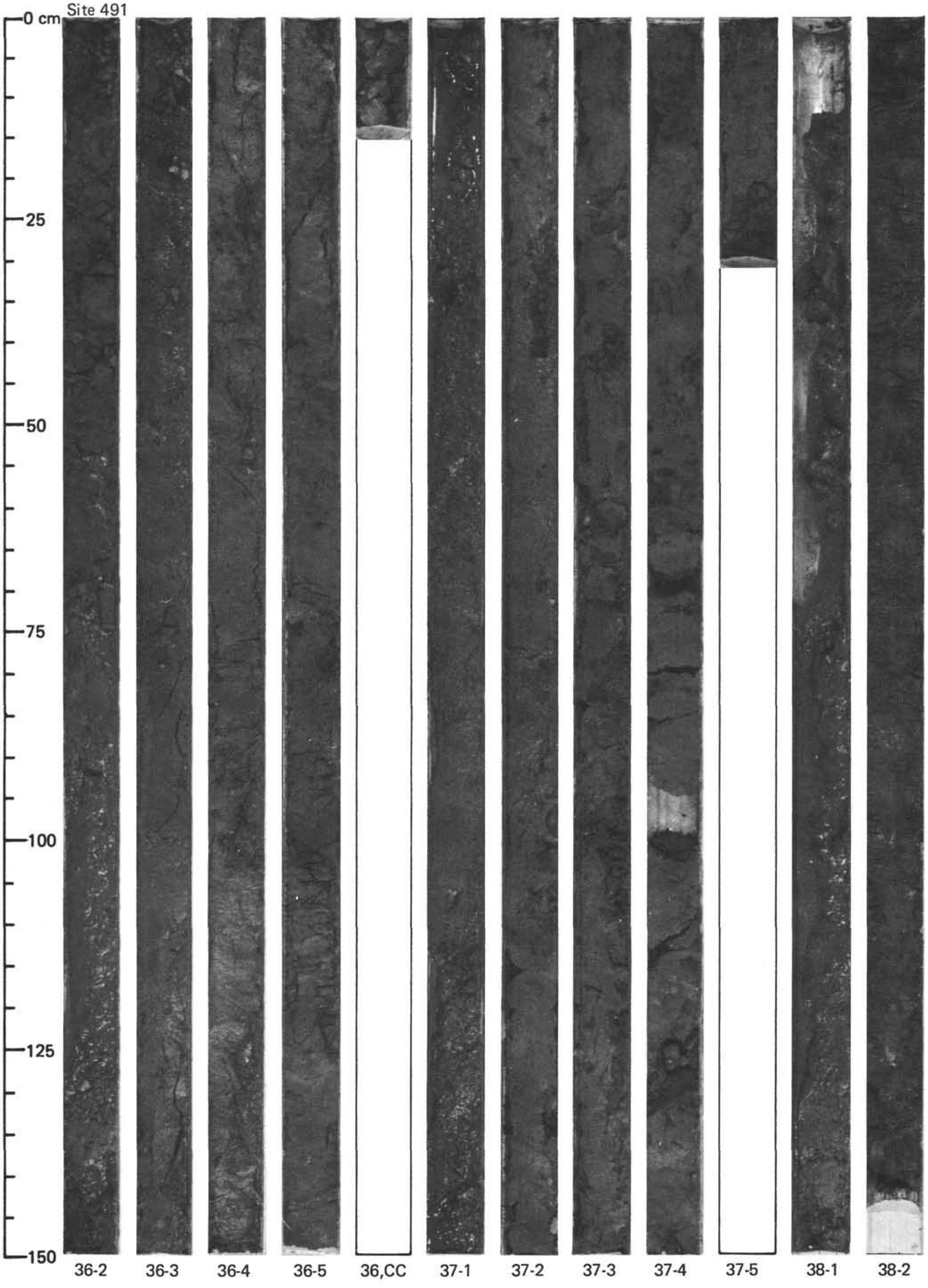
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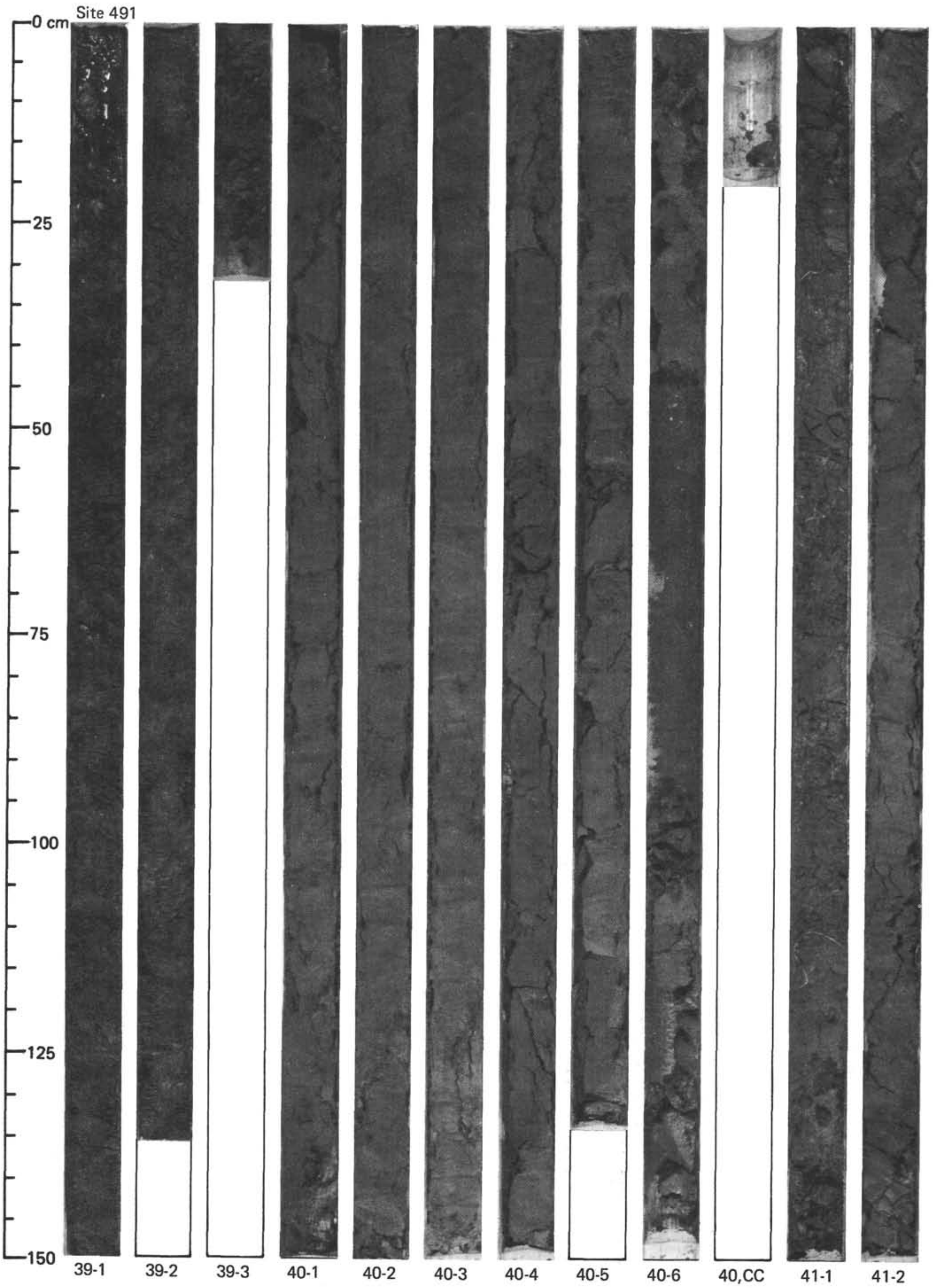
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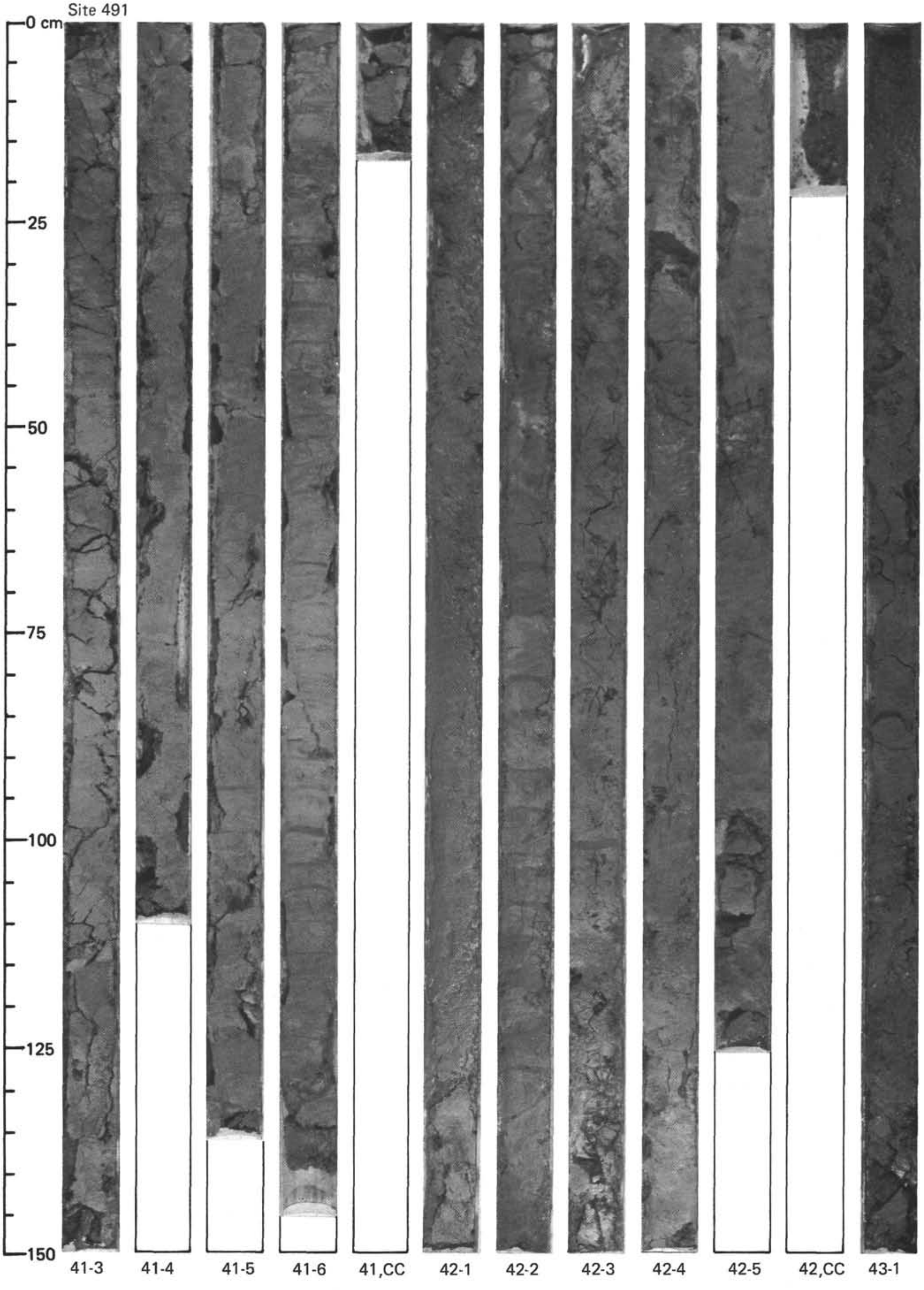
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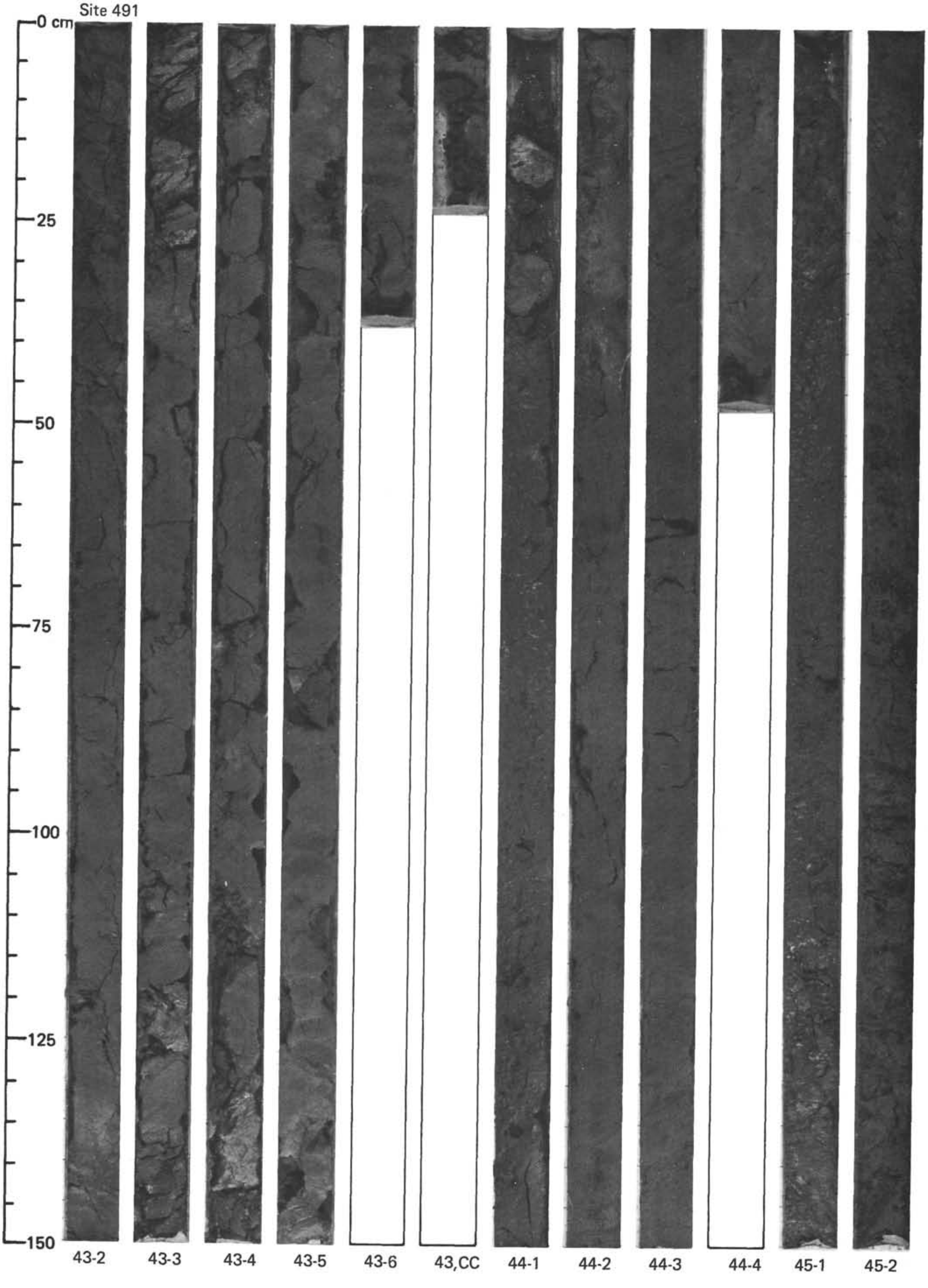
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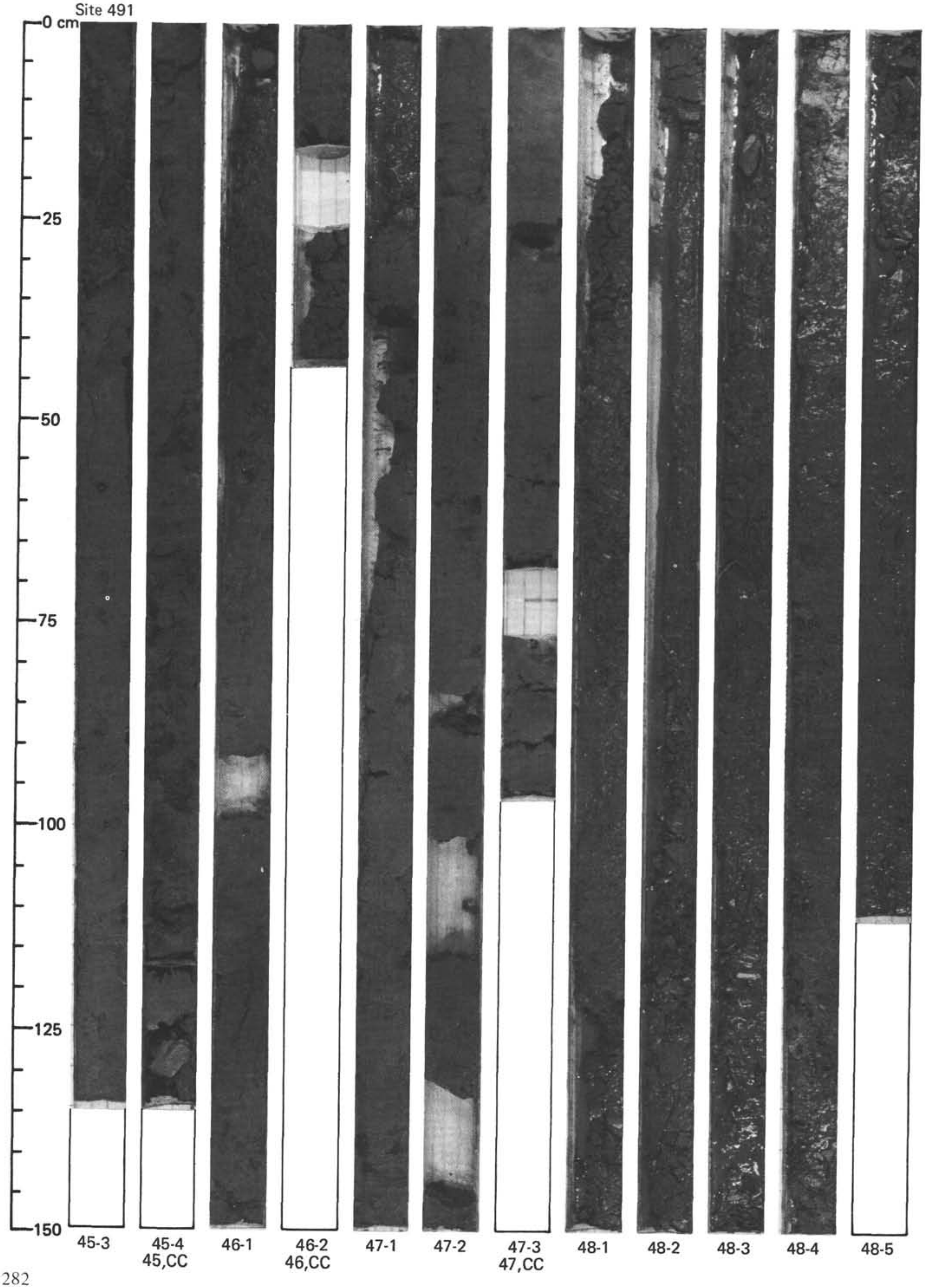
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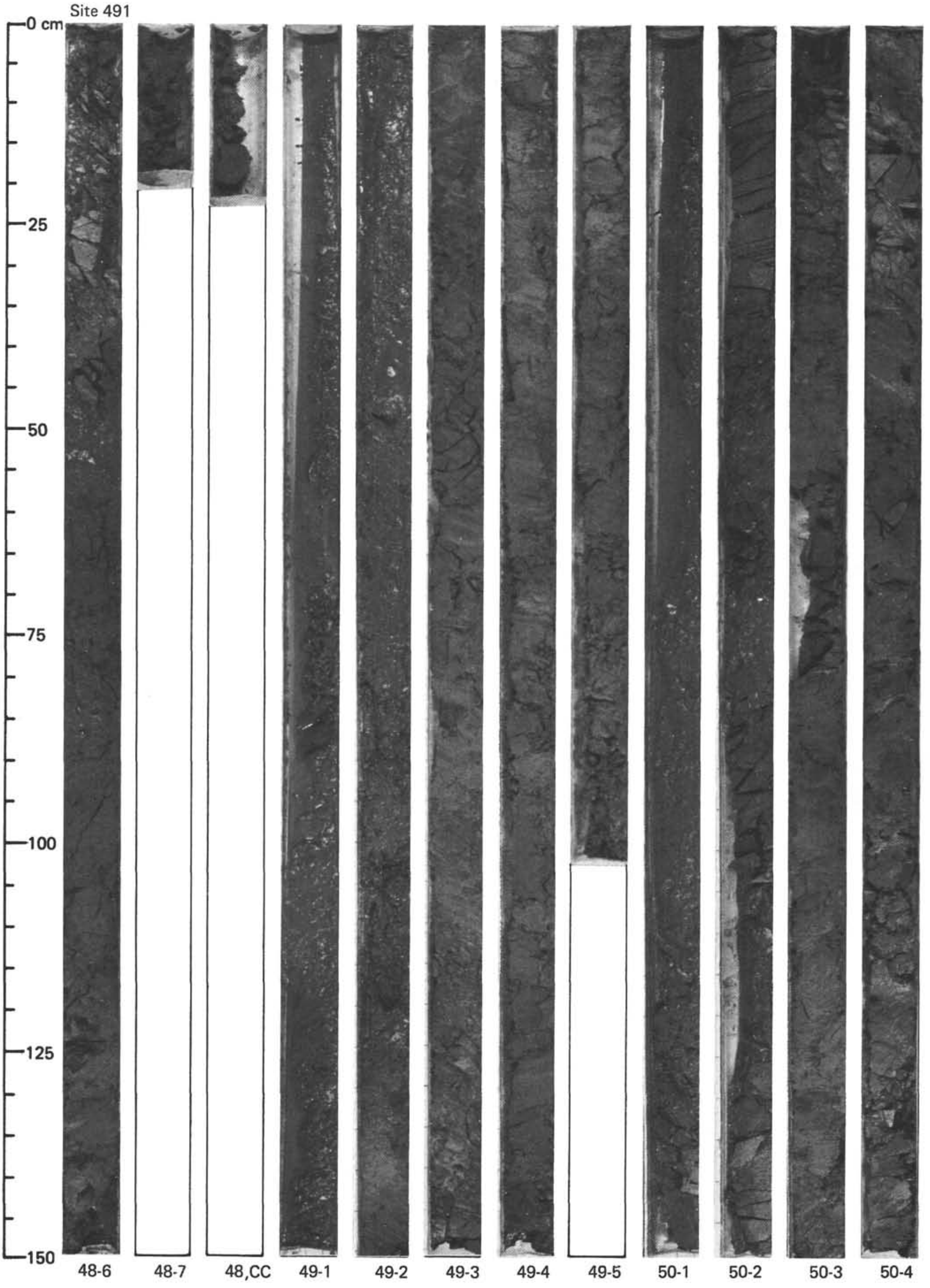
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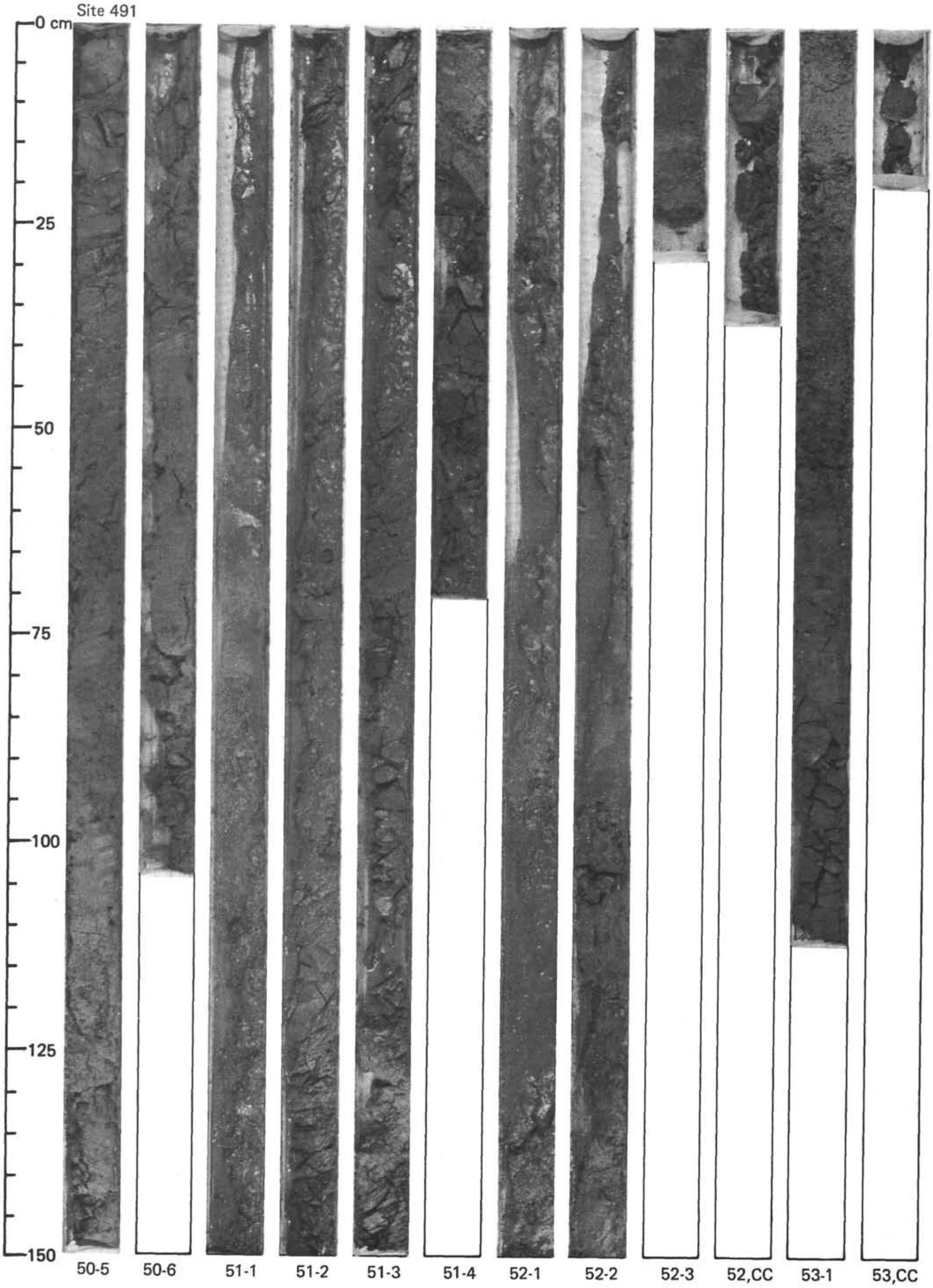
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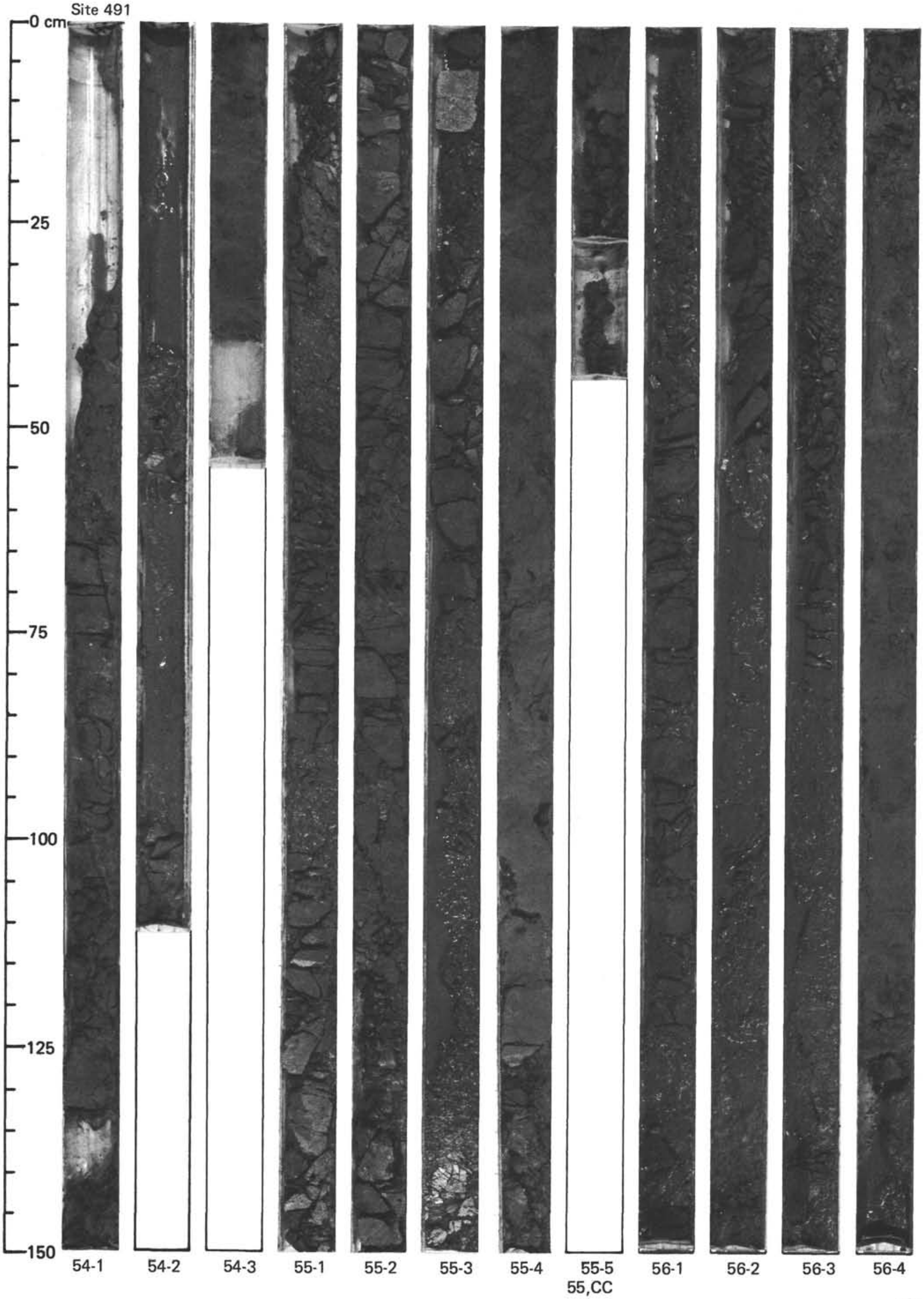
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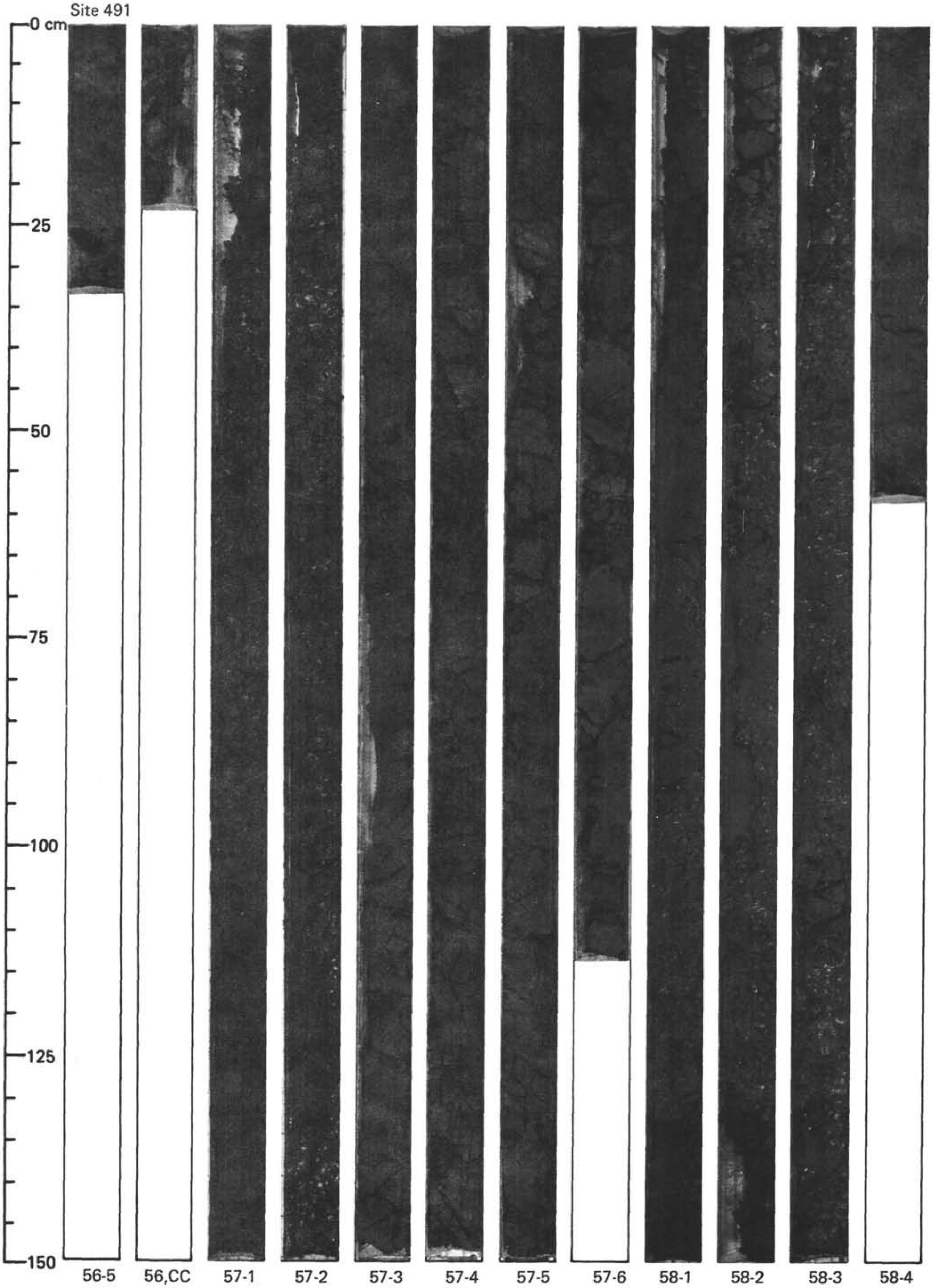
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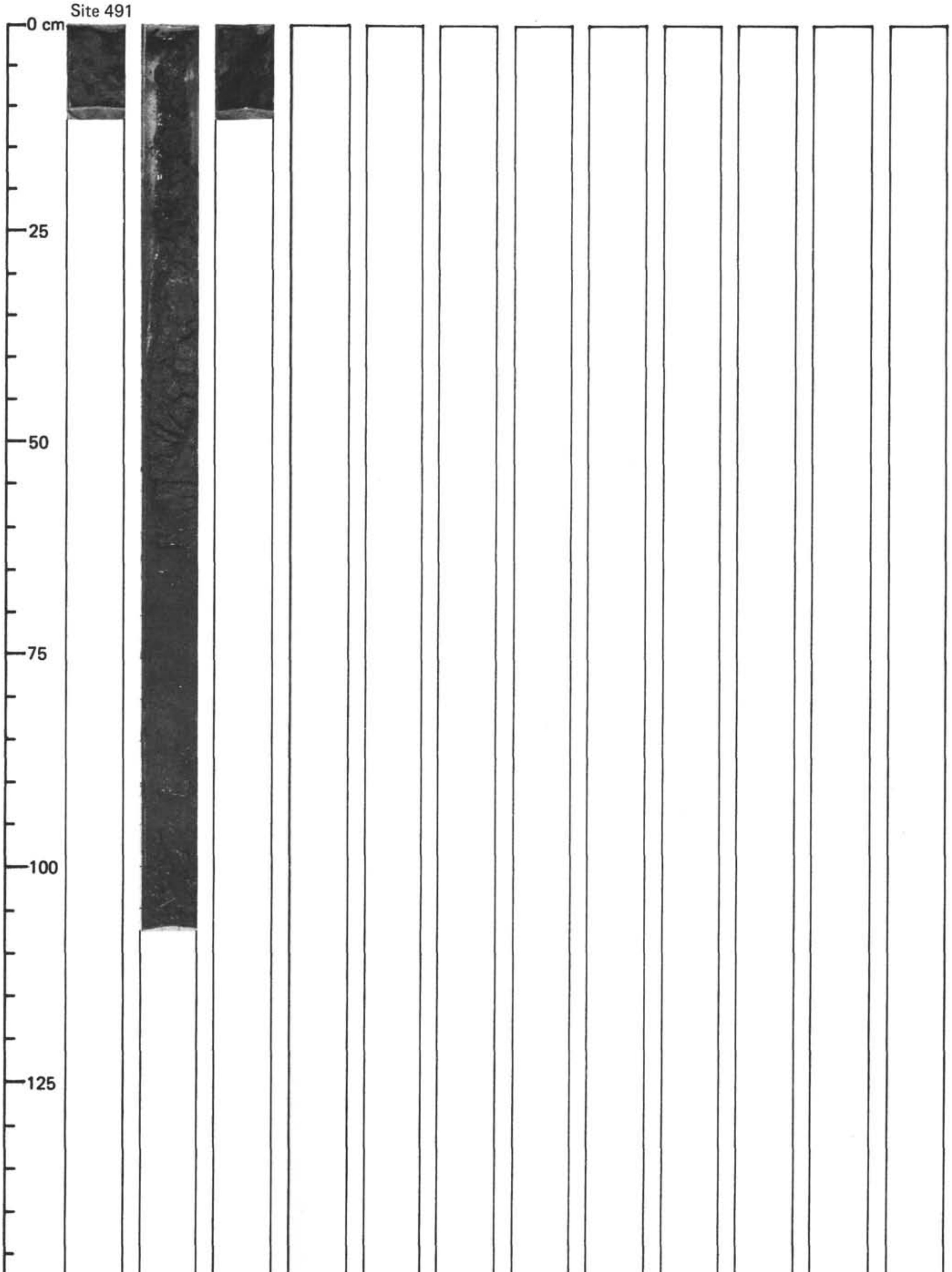

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