9. SITE 493[1]

Shipboard Scientific Party[2]

HOLE 493

Date occupied: 24 April 1979

Date departed: 28 April 1979

Time on hole: 95.2 hours

Position: 16°22.86′N; 98°55.53′W

Water depth (sea level; corrected m, echo-sounding): 645

Water depth (rig floor; corrected m, echo-sounding): 655

Bottom felt (m, drill pipe): 675

Penetration (m): 670.5

Number of cores: 60

Total length of cored section (m): 556.5

Total core recovered (m): 337.3

Core recovery (%): 61

Oldest sediment cored:
Depth sub-bottom (m): 652
Nature: Sand
Age: Early Miocene

Basement:
Depth sub-bottom (m): 652
Nature: Diorite

Principal results: Site 493 samples document the geologic history of the continental crust 25 to 30 km landward of the continent/accretionary zone boundary. A section complete except for the middle Miocene was recovered. Figure 1 summarizes our results.

The sedimentary record indicates a marine transgression approximately 21.5 Ma, followed by rapid subsidence to a depth about 3 km below sea level, then gradual uplift at a uniform rate to the present position.

Sediment deposition rates are consistent with the paleobathymetric pattern. Basal Miocene deposition was a relatively rapid 83 m/m.y., but the rate slowed to 39 m/m.y. throughout most of the lower Miocene. The middle Miocene is missing, probably because of erosion. Upper Miocene-Pliocene-Quaternary sediments were deposited at rates of about 45 m/m.y.

Diorites recovered from the basement closely resemble Cretaceous intrusive rocks outcropping on shore roughly 20 km from Site 493.

Gases, mainly of biogenic origin, were present in moderate amounts. We found no evidence of mature hydrocarbons.

HOLE 493A

Date occupied: 28 April 1979

Date departed: 28 April 1979

Time on hole: 2.0 hours

Position: 16°22.86′N; 98°55.53′W

Water depth (sea level; corrected m, echo-sounding): 645

Water depth (rig floor; corrected m, echo-sounding): 655

Bottom felt (m, drill pipe): 670.0

Penetration (m): 12.0

Number of cores: 2

Total length of cored section (m): 12.0

Total core recovered (m): 7.6

Core recovery (%): 63

Oldest sediment cored:
Depth sub-bottom (m): 12.0
Nature: Green mud
Age: Quaternary

Principal results: Inadvertent re-entry of Hole 493.

HOLE 493B

Date occupied: 28 April 1979

Date departed: 29 April 1979

Time on hole: 12.8 hours

Position: 16°22.86′N; 98°55.53′W

Water depth (sea level; corrected m, echo-sounding): 645

Water depth (rig floor; corrected m, echo-sounding): 655

Bottom felt (m, drill pipe): 670

Penetration (m): 126

Number of cores: 12

Total length of cored section (m): 114

Total core recovered (m): 60.1

Core recovery (%): 52

Oldest sediment cored:
Depth sub-bottom (m): 126
Nature: Muddy silt
Age: Early Pliocene

Principal results: Cored upper section bypassed in Hole 493 (see Hole 493 for results).

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[2] Joel S. Watkins (Co-Chief Scientist), Gulf Research and Development Company, Houston, Texas (present address: Geology and Interpretation Department, Exploration and Production Division, Gulf Science and Technology Company, Pittsburgh, Pennsylvania); J. Casey Moore (Co-Chief Scientist), Earth Sciences Board, University of California, Santa Cruz, California; Steven B. Bachman, Department of Geology, University of California, Davis, California (present address: Department of Geological Sciences, Cornell University, Ithaca, New York); Floyd W. Beghtel, Phillips Petroleum Company, Bartlesville, Oklahoma; Arif Butt, Institut und Museum für Geologie und Paläontologie, Universität Tübingen, Tübingen, Federal Republic of Germany; Borys M. Didyk, Research and Development Laboratory, Empresa Nacional del Petróleo (ENAP), Concon, Chile; Glen Foss, Deep Sea Drilling Project, Scripps Institution of Oceanography, La Jolla, California; Jeremy K. Leggett, Department of Geology, Imperial College of Science and Technology, London, United Kingdom; Neil Lundberg, Earth Sciences Board, University of California, Santa Cruz, California; Kenneth J. McMillan, Geophysics Laboratory, Marine Science Institute, University of Texas, Galveston, Texas (present address: at Geology and Interpretation Department, Exploration and Production Division, Gulf Science and Technology Company, Pittsburg, Pennsylvania); Nobuaki Niitsuma, Institute of Geosciences, Shizuoka University, Oya, Shizuoka, Japan; Les E. Shephard, Department of Oceanography, College of Geosciences, Texas A&M University, College Station, Texas (present address: Sandia National Laboratories, Division 4536, Albuquerque, New Mexico); Jean-François Stephan, Département de Géotectonique, Université Pierre et Marie Curie, Paris, France; Thomas H. Shipley, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California; and Herbert Stradner, Geologische Bundesanstalt, Vienna, Austria.

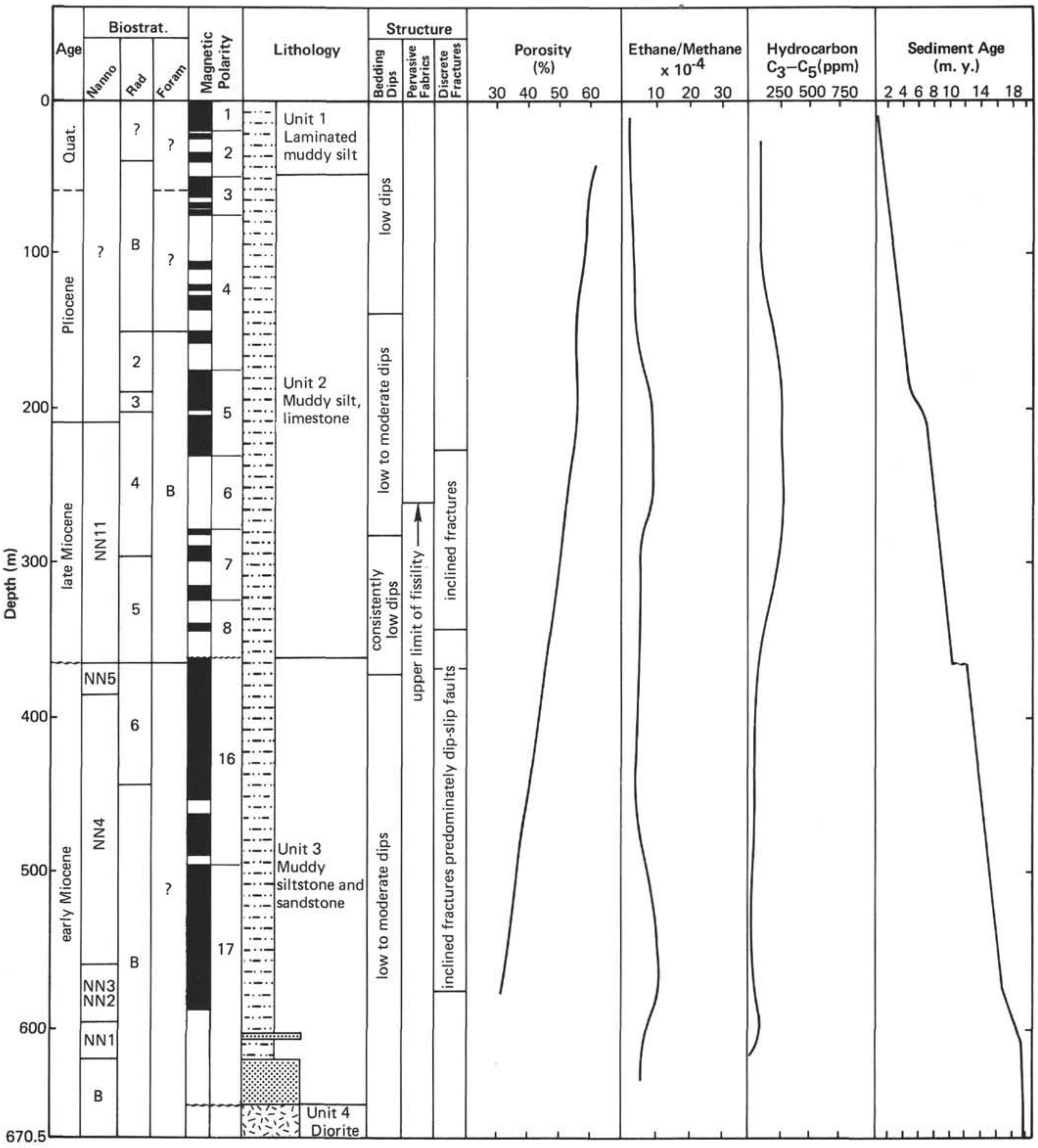

Figure 1. Summary of age, nannofossil and radiolarian zones (2 = *Spongaster pentas*, 3 = *Stichocorys peregrina*, 4 = *Ommatartus penultimus*, 5 = *O. antepenultimus*, 7 = *Calocycletta virginis*, B = barren), foraminiferal occurrences, magnetic polarity zones (black = normal, white = reversed), lithology, structures, porosity, organic geochemistry (C_2/C_1 and C_{3-5}), and age-depth relationships for recovered sediments. Radiolarian and nannofossil boundaries based on Berggren and Van Couvering (1974) and paleomagnetic ages based on Ryan et al. (1974).

BACKGROUND AND OBJECTIVES

Site 493 was drilled in order to sample the 600 meters or more of sediment overlying metamorphosed(?) continental basement rocks. Data from Hole 493 provide a record of the geologic history of the continental crust adjacent to the subduction zone prior to and during subduction.

Previous drilling in active margins has demonstrated the value of drilling reference holes at continental and oceanic ends of transects. Holes in the body of the transect provide data about tectonic, sedimentologic, and other detailed geologic aspects of the margin. Data from the body of one transect, however, seldom provide information about the limiting parameters such as age of subduction, sediment provenance, sediment flux, and so on. Data from reference sites outside the zone of deformation, on the other hand, provide this information.

The sea transgressed Site 489 during the early Miocene. The site sank below the CCD; then erosion erased a large segment of the sedimentary record, leaving us with an unconformity separating lower Miocene and Quaternary sediments. It was hoped that Site 493 cores would provide depositional and subsidence data for the missing interval.

A second objective at 493 was to obtain additional paleobathymetric data to supplement that obtained at 489. Site 493 is higher up the slope than 489. Thus Site 493 sediments were deposited in shallower, more precisely defined bathymetric zones than Site 489 sediments. Once the 489 seafloor dips below the CCD, details of subsidence are lost, but the higher elevation of 493 sediments may provide a better-detailed subsidence history of the Mexican margin (Fig. 2).

Data obtained at 493 were also expected to reveal more clearly details of the presubduction history of the margin, the early subduction history, and nearshore sedimentation processes during these intervals.

OPERATIONS

Hole 493

The final scheduled drill site was situated 37 km north of Site 492 and only about 16 km off the shoreline of Bahia Dulce. Transit time was 3 hours, and the positioning beacon was dropped at 1215 hours, 24 April in 645 meters of water as measured by the echo sounder.

The echo sounder depth was again off by more than 20 meters, and one "water core" was taken before a punch core indicated water depth to be 675 meters.

Since operations in such shallow water pose a particular hazard to unsupported drill collars, the hole was drilled to 120 meters sub-bottom to bury the bottom hole assembly before continuous coring commenced.

Coring proceeded smoothly through mudstones and siltstones with no hole problems to about 625 meters sub-bottom, where very fine and pure loose sand was encountered. The sand produced increasing hole fill following each core despite copious mud flushes. The bit struck hard rock at the end of what was to be the final core, and basement rock was recovered. An additional 19 meters was cored by pulling the bit back into the sand interval before retrieving each core and by pumping mud between the cores. This produced sufficient recovery of basement material for sampling.

The hole was then given another 100-barrel mud flush in preparation for logging. Two unsuccessful attempts to actuate the hydraulic bit release were made by pumping go-devils to the bit. It was evident that the standard suite of open hole logs could not be run. The pipe was pulled to leave only the bottom hole assembly in the hole, and a modified inner core barrel was chopped to hold the float valve open. The temperature log sonde was then lowered through the bit into open hole. The log was successful in measuring the geothermal gradient to a depth of 176 meters sub-bottom, where passage was blocked by an obstruction in the hole.

Following the logging operation, the pipe was run back down and the hole filled with weighted mud to about 250 meters sub-bottom. The pipe was pulled to 250 meters and a cement plug emplaced from that depth to about 60 meters. The drill string was pulled and the bit arrived on deck at 0845 hours, April 28.

Hole 493A

The special inner core barrel was recovered, the bit was inspected, and the drill string was run back to the seafloor with an abbreviated bottom hole assembly for the purpose of coring the upper 120 meters bypassed in Hole 493. The precision performance of the dynamic positioning system and excellent weather conditions on Hole 493 had proven this to be an acceptable risk.

Two punch cores were recovered to a total penetration of 12 meters. On the third attempt, the drill string took no weight and no sediment was recovered. A fourth attempt was made with the same results. It was deduced that the core bit had barely cleared the seafloor following Core 2 (as the pipe is routinely raised 12 meters) and that it had reentered Hole 493.

Hole 493B

The bit was pulled well clear of the seafloor and the vessel offset 300 meters to the east. On respudding, the bit was washed to 12 meters BSF and continuous coring was reinitiated. Hole 493B was cored to a total depth of 126 meters sub-bottom without incident. The hole was filled with heavy mud and the drill string was recovered by 0230 hours, April 29.

LITHOLOGIC SUMMARY

At Site 493, we penetrated 670.5 meters and recovered 75 cores (Table 1). The three holes, 493, 493A, and 493B, are considered together because of overlapping stratigraphy and proximity. The cores, divided into 4 units (see Fig. 3, Chart 1, back pocket), contain Quaternary, upper Pliocene, lower Pliocene, upper Miocene, and lower Miocene sediments as well as plutonic basement of probable pre-Neogene age.

Unit 1, Quaternary (Core 493-1, 0–6.0 m; 493A-1–493A-3. 0–21.5 m; 493B-1–493B-4, 12.0–50.0 m), consists of muddy silt. Woody debris, ash layers, fine

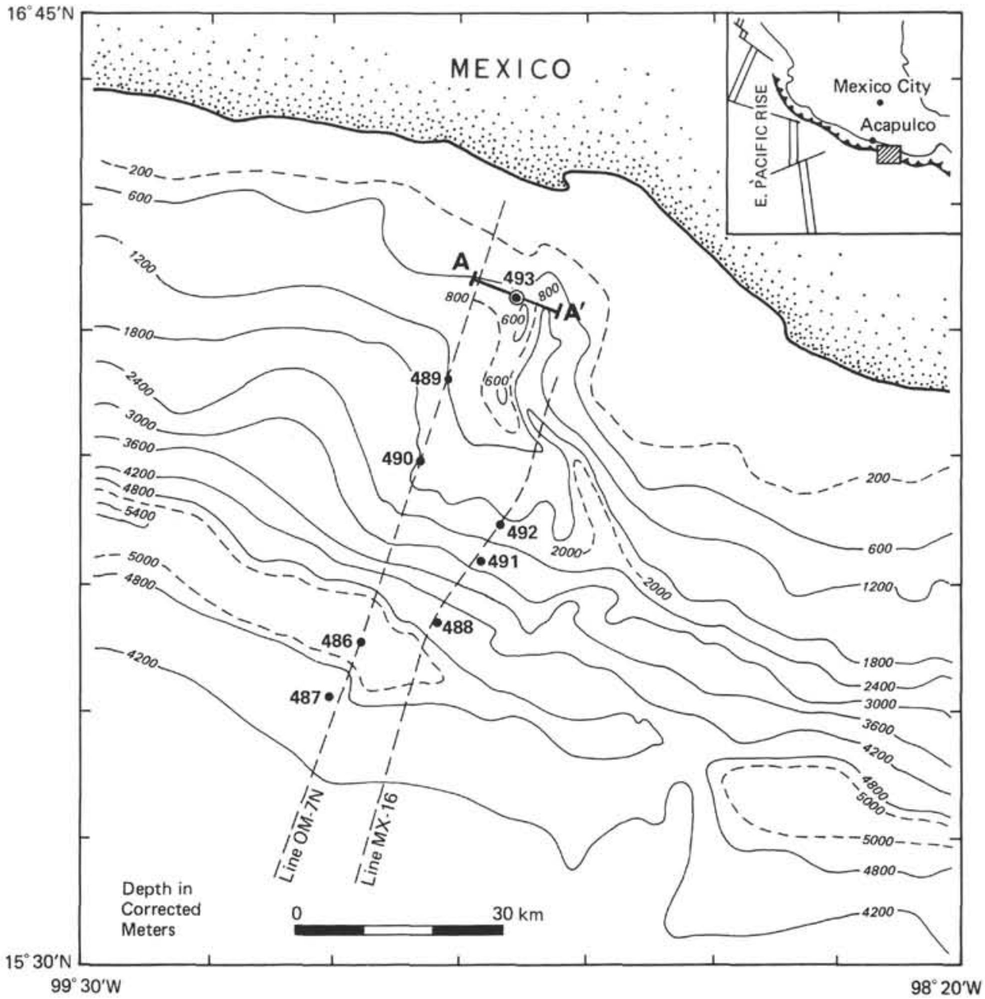

Figure 2. Location of Site 493. Gneisses were dredged from a wall of the canyon to the east of Site 493. A-A′ indicates location of profile shown in Figure 8.

sands, foraminifer layers, and shell fragments are common. Parallel lamination occurs throughout much of the section.

Unit 2, late Miocene and Pliocene (Cores 493-2–493-27, 120.0–365.0 m; 493B-5–493B-12, 50.0–126.0 m), is comprised of muddy silt, muddy siltstone, mud, and mudstone, becoming finer grained at the base of the unit. Thin ash beds, siliceous mudstone, and limestone beds are also present. The upper Miocene section is in large part finely laminated. Unit 2 also contains calcareous concretions, carbonized wood fragments, shell fragments, and indurated mud clasts, as shown in Figure 3. Locally, muddy silt beds are graded. Burrowing is nearly absent in the upper part of Unit 2 but increases somewhat down-section.

Bedding dips in Unit 2 average less than 15°; local higher dips may be due to slumping. Below 240 meters, the sediments become somewhat fissile, with fissility subparallel to bedding. Rarely, fissility is distinctly steeper than bedding. Inclined and vertical fractures, commonly slickensided, are also present below 240 meters. These are generally widely spaced, and local areas of closely spaced fractures display wispy, discontinuous bedding.

In *Unit 3, early Miocene* (Cores 493-27–493-58, 365–652 m), grain size generally increases downward from muddy siltstone to sandstone (see sand-silt-clay ratios of Fig. 3), although the sand fraction in the muddy siltstone is lowest in the middle part of the section. Coarse sands and sandstones in poorly recovered intervals at the base of the section may aggregate tens of meters in thickness; sand thickness has been estimated using drilling times (Fig. 4). The sands are often graded and granule-bearing. Devitrified ash and tuff beds and pods are common in Unit 3. The muddy siltstone is locally radiolarian-rich.

Slight to moderate bioturbation characterizes most of the unit. Laminations are evident when bioturbation decreases. Shell fragments and carbonized woody debris are evident at the top and near the base of Unit 3.

Gently to steeply dipping fractures in the section have slickensided surfaces suggesting primarily dip-slip movement and minor strike-slip movement. Fissility, similar to Unit 2, is present in zones throughout Unit 3. Bed-

Table 1. Coring summary, Site 493.

Core	Cored Interval below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)	Remarks
Hole 493					
1	0.0-6.0	6.0	6.00	100	
2	12.0-129.5	9.5	5.01	53	wash to 120 m
3	129.5-139.0	9.5	2.85	30	
4	139.0-148.5	9.5	2.02	21	
5	148.5-158.0	9.5	5.73	60	
6	158.0-167.5	9.5	3.73	39	
7	167.5-177.0	9.5	3.97	42	
8	177.0-186.5	9.5	6.39	67	
9	186.5-196.0	9.5	6.68	70	
10	196.0-205.5	9.5	7.21	76	
11	205.5-215.0	9.5	4.29	45	
12	215.0-224.5	9.5	1.59	17	
13	224.5-234.0	9.5	1.59	17	
14	234.0-243.5	9.5	7.62	80	
15	243.5-253.0	9.5	8.42	89	
16	253.0-262.5	9.5	3.73	39	
17	262.5-272.0	9.5	6.59	69	
18	292.0-281.5	9.5	9.62	101	
19	281.5-291.0	9.5	8.28	87	
20	291.0-300.5	9.5	9.59	101	
21	300.5-310.0	9.5	7.99	84	
22	310.0-319.5	9.5	7.57	80	
23	319.5-329.0	9.5	0.46	5	
24	329.0-338.5	9.5	9.17	97	
25	338.5-348.0	9.5	7.93	83	
26	348.0-357.5	9.5	2.62	28	
27	359.5-367.0	9.5	7.52	79	
28	367.0-376.5	9.5	7.80	83	
29	376.5-386.0	9.5	7.85	83	
30	386.0-395.5	9.5	9.30	98	
31	395.5-405.0	9.5	9.16	96	
32	405.0-414.5	9.5	5.37	57	
33	414.5-424.0	9.5	9.61	101	
34	424.0-433.5	9.5	8.42	89	
35	433.5-443.0	9.5	9.68	102	
36	443.0-452.5	9.5	6.25	66	
37	452.5-462.0	9.5	8.56	90	
38	462.0-471.5	9.5	4.63	49	
39	471.5-481.0	9.5	5.28	56	
40	481.0-490.5	9.5	2.54	27	
41	490.5-500.0	9.5	3.58	38	
42	500.0-509.5	9.5	7.59	80	
43	509.5-519.0	9.5	7.81	82	
44	519.0-528.5	9.5	4.82	51	
45	528.5-538.0	9.5	4.81	51	
46	538.0-547.5	9.5	9.16	86	
47	547.5-557.0	9.5	9.10	96	
48	557.0-566.5	9.5	4.44	47	
49	566.5-576.0	9.5	9.64	101	
50	576.0-585.5	9.5	7.19	76	
51	585.5-595.0	9.5	1.63	17	
52	595.0-604.5	9.5	2.58	27	
53	604.5-614.0	9.5	1.98	21	
54	614.0-623.5	9.5	7.01	94	
55	623.5-633.0	9.5	tr	0	loose sand
56	633.0-642.5	9.5	tr	0	loose sand
57	642.5-652.0	9.5	tr	0	
58	652.0-656.5	4.5	0.50	11	diorite
59	656.6-661.5	5.0	2.28	46	diorite
60	661.5-670.5	9.0	1.60	17	diorite + sand
		556.5	333.42	60	
Hole 493A					
1	0.0-2.5	2.5	2.63	105	
2	2.5-12.0	9.5	4.97	52	
Hole 493B					
1	12.0-21.5	9.5	5.31	56	wash to 12 m
2	21.5-31.0	9.5	9.49	100	
3	31.0-40.5	9.5	9.74	103	
4	40.5-50.0	9.5	9.66	38	
5	50.0-59.5	9.5	3.61	38	
6	59.5-69.0	9.5	5.24	55	
7	69.0-78.5	9.5	4.20	44	
8	78.5-88.0	9.5	2.06	22	
9	88.0-97.5	9.5	1.69	18	
10	97.5-107.0	9.5	1.35	14	
11	107.0-116.5	9.5	4.70	49	
12	116.5-126.0	9.5	2.78	29	
		114.0	59.83	52%	

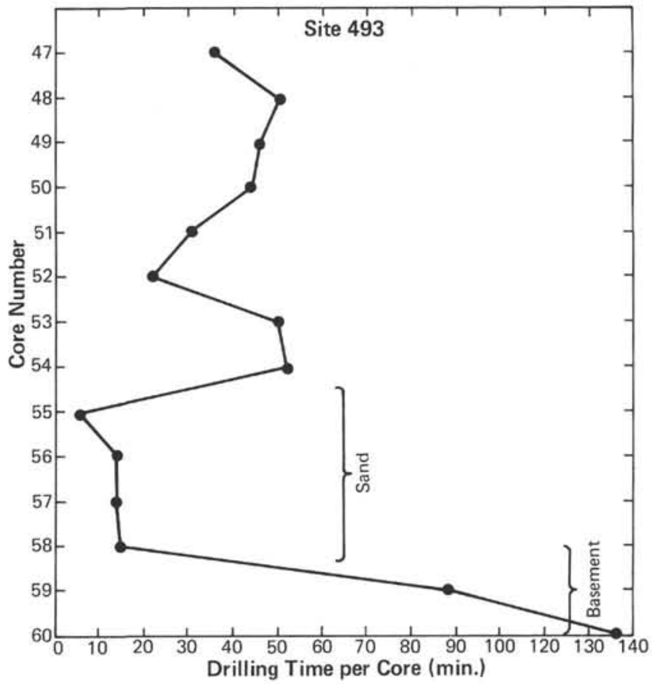

Figure 4. Drilling rates and inferred lithologic thicknesses.

ding dips from nearly horizontal to 46°, with higher dips probably associated with local slumping. Average dips increase downward in the section.

Unit 4 (Cores 493-58-60, 652-670.5 m), a basal unit for which onshore geology suggests a pre-Neogene age, consists of diorite. Thin section determinations indicate a composition of 4% quartz, 68% plagioclase, slightly more than 1% microcline, 7% biotite, and 20% hornblende (see Bellon et al., this volume, regarding details of petrology and radiometric dating).

Lithologic Interpretations

Site 493 is located above continental crust, landward of Site 489. Stratigraphic trends observed at Site 489 are repeated here, because a more complete section at Site 493 provides additional data.

Basal plutonic rocks represent continental crust probably correlative with igneous outcrops 20 km from Site 493 along the Mexican coast near Acapulco. Rb/Sr biotite dates near Acapulco are 48 ± 0.5 Ma and 90 to 100 Ma, with suggestions that the younger dates were reset (Guerrero et al., 1979). The overlying sands probably represent nearshore deposits, followed by a lower Miocene transgressive sequence. Paleobathymetric analysis also suggests a relative sea level rise during this time. Using the arguments presented for Site 489, this relative sea level rise largely results from early Miocene subsidence at Site 493. The sandier upper part of Unit 3 and the paleobathymetric indicators suggest the onset of regression and uplift during latest early Miocene time.

The upper Miocene laminated sequence of Unit 2 contains few fossils other than low-diversity benthonic foraminiferal assemblages and has little evidence of burrowing in fauna. This suggests deposition in or near the oxygen minimum zone or in a restricted basin. Paleobathymetric analysis suggests continued uplift in the

Pliocene and Quaternary to bring the site to its present depth. Erosion, probably by bottom currents and slumping, is represented by hiatuses between the early Miocene and late Miocene, late Miocene and early Pliocene, late Pliocene and early Quaternary, and in the latest Quaternary.

BIOSTRATIGRAPHY

Site 493 penetrates a lower Miocene through Quaternary transgressive–regressive sedimentary sequence consisting of coarse clastics and slope muds resting on diorite. Calcareous and siliceous microfossil groups occur, but carbonate dissolution hampers the record, particularly for planktonic foraminifers. Siliceous microfossils are poorly preserved in the early Miocene. Figure 1 shows the correlation of major microfossil groups at Site 493. In Hole 493 one large hiatus omits the entire middle Miocene, and a possible hiatus occurs in the late Miocene in Cores 9 and 10.

Calcareous Nannoplankton

Based on the nannofossil content, the sedimentary column at this site can be subdivided into four biostratigraphic zones:

1) Middle to upper Quaternary (0.15–1.6 Ma): The youngest part of the Quaternary the NN21 Zone (0.0–0.15 Ma), is missing at this site, either because of erosion or nondeposition. Cores 493-1,CC; 493A-1,CC to 493A-3,CC; and 493B-1,CC to 493B-4,CC contain a nannoflora assemblage which is assigned to the *Gephyrocapsa oceanica* Zone NN20. Common species are *Gephyrocapsa oceanica, Cyclococcolithus leptoporus, Helicosphaera carteri, Syracosphaera pulchra*, and *Thoracosphaera heimi*. Reworking is minor in these cores.

2) Upper Pliocene and lower Quaternary (about 1.6–2.5 Ma): The core intervals 493-5,CC to 493-10,CC and 493B-5,CC to 493B-12,CC have much reworking and mixing. Nannoplankton age determinations vary between upper Pliocene, lower Pliocene, upper Miocene, and lower Quaternary, possibly because of coring contamination. Among the rare discoasters, five-rayed species dominate. The youngest index fossil in core catcher 12,CC of 493B is *Emiliania annula*, which indicates upper Pliocene to lower Quaternary. Reworked sphenoliths are common.

3) Upper Miocene (5.0–9.5 Ma): A nannoplankton assemblage, which can be assigned to the *Discoaster quinqueramus* Zone NN11, is found in Cores 493-11,CC to 493-26,CC. The five-rayed form *D. quinqueramus* has heavy knobs on either side of the central disc, and some specimens may be assigned to *D. berggrenii*. There are also *Reticulofenestra pseudoumbilica, Sphenolithus abies, S. neoabies, Coccolithus miopelagicus, D. pseudovariabilis*, and *Lithostromation perdurum*.

4) Lower Miocene (19–24 Ma): The sediments from Sample 493-27-3, 89–90 cm down to 493-60-1 are assigned to Nannoplankton Zones NN5 to NN2 (or 1?). The *Sphenolithus heteromorphus* Zone (NN5) with *Discoaster variabilis, D. exilis, D. pansus, Cyclicargolithus floridanus*, and *Cyclococcolithus rotula* is found in Sections 493-27,CC to 493-29,CC. The *Helicosphaera ampliaperta* Zone (NN4) with both *H. ampliaperta* and *S. heteromorphus* ranges from Sections 493-30,CC to 493-42,CC.

The *S. belemnos* Zone (NN3), with rare *S. belemnos* and *D. druggi*, occurs only in Sections 493-49,CC to 493-51,CC. *Triquetrorhabdulus tricarinatus*, which becomes extinct at the top of the NN2 zones, is very rare in Section 493-53,CC. Thus the oldest sediments at this site are assigned to NN1 to NN2. Common species are *Coccolithus miopelagicus, Cyclicargolithus floridanus, Reticulofenestra gartneri, Helicosphaera euphratis, S. moriformis*, and *D. deflandrei*.

Silicoflagellates and diatoms occur only in very few samples studied so far. At Site 493, Section 493-19,CC, the occurrence of *Dictyocha fibula* permits assignment to the *D. fibula* Zone (upper Miocene to lower Pliocene). In Sections 493-29,CC and 493-32,CC the occurrence of the diatom *Annellus californicus* indicates an age of about 16 m.y. The range of this index diatom is within lower Paleomagnetic Epoch 15 (17.2 Ma) and upper Epoch 16 (14.5 Ma). Associated with the mass occurrence of *A. californicus* are the silicoflagellates *Mesocena elliptica, D. ausonia*, and rare *Corbisema triacantha*. This assemblage may tentatively be assigned to the *C. triacantha* Zone, which corresponds to the NN4 to NN6 nannoplankton zones.

Foraminifers

At Site 493, the sedimentary section yields common to abundant Miocene through Quaternary foraminifers. Diagnostic planktonic species permit age determinations, and benthonic assemblages give environmental information. Cores 493-1, 493A-1 through 493A-3, and 493B-1 through 493B-5 contain common to abundant planktonic foraminifers. Their abundance declines in the lower section of Hole 493 (Cores 2–54). The planktonic foraminifers are well preserved and indicate a Quaternary age for Cores 493-1, 493A-1 through 493A-3, and 493B-1 through 493B-5. They include such species as *Globorotalia tumida, G. menardii, G. frimbriata, G. ungulata, Globigerinoides ruber, G. sacculifer, Neogloboquadrina dutertrei, Globigerina bulloides, G. falconensis, Orbulina universa*, and *Pulleniatina obliquiloculata*.

Cores 493B-6 through 493B-11 contain rare upper Pliocene planktonic foraminifers, although some samples in the sandy layers in Cores 6 and 8 contain concentrations of foraminifers. They include *Globorotalia tumida, G. acostaensis, N. humerosa, Globigerinoides ruber, G. fistulosus, G. triloba, O. universa*, and *P. obliquiloculata*.

The lower Pliocene through upper Miocene section in Cores 2 through 26 at Hole 493 contains very rare planktonic foraminifers; several samples (3,CC–8,CC and 15,CC–26,CC) are barren of planktonic species, but they contain rare to common benthic foraminifers. The planktonic species are long ranged and include *G. ruber, G. obliquus*, and *Globigerina falconensis*.

Cores 27 through 54 in Hole 493 yield lower Miocene planktonic foraminifers. Rare to common planktonic species occur in the following samples in Hole 493: 27,CC to 28,CC, 30,CC, 32,CC, 34,CC to 38,CC, 41,CC to 42, and 55,CC to 54; remaining samples however, contain abundant terrigenous sand and are barren of planktonic foraminifers. Typical early Miocene species include *Globorotalia peripheroronda* (Cores 42–27), *Globigerinoides triloba, G. sicanus, G. diminutus, G. obliquus, Catapsydrax unicavus, Globigerina venezuelana*, and *Globoquadrina altispira*.

Depositional Environment

The benthic foraminifers in the Miocene through Quaternary sections represent the following four assemblages and indicate depositional history of the upper slope.

Assemblage I (lower part of early Miocene)

Assemblage I is associated with clastic transgressive sediments above basement. The assemblage indicates a relatively deep shelf environment and includes *Lenticulina, Dentalina, Gavelinella, Hoeglundina elegans, Epistomina*, and *Unicosiphonia*.

Assemblage II (upper part of early Miocene)

Assemblage II occurs in light gray greenish silty mud, commonly bioturbated owing to *Chondrites* burrows. The benthic foraminifers indicate upper mid-bathyal environment. The planktonic foraminifers are rare to common, but siliceous fossils such as diatoms and radiolarians are common to abundant in the sand fraction (e.g., Samples 32,CC and 34,CC). The assemblage includes *Hoeglundina elegans, Cibicidoides, Gyroidina* cf. *soldanii, Oridosalis* cf. *umbonatus, Uvigerina peregrina, U. aculeata, Cassidulina subglobosa, Siphonia, Vulvulina* sp., and *Stilostomella*.

Assemblage III (late Miocene through Pliocene)

Assemblage III occurs in the dark gray laminated facies. Planktonic foraminifers are very rare, but benthic foraminifers are relatively abundant. Other microfossils also include common diatoms (Core 493-26) and radiolarians (e.g., Core 493-20). The assemblage indicates a relatively shallow upper bathyal environment with low oxygen levels and restricted bottom circulation. The specialized assemblage possibly is composed of *Bolivina* and *Uvigerina* cf. *peregrina, U.* sp. (smooth walled), *Gavelinella, Anomalinoides, Angulogerina, Valvulineria, Cassidulina crassa,* and *C. laevigata*. The fauna is also associated with very abundant fish bones and teeth and abundant pyrite.

Assemblage IV (Quaternary)

The benthic Assemblage IV is associated with abundant planktonic foraminifers and in contrast to Assemblage III includes large species corresponding to the present water depth of Site 493. The assemblage includes *Cassidulina, Gyroidina, Planulina, Uvigerina, Bolivinia, Angulogerina, Cancris*, and *Pullenia*.

Radiolarians

Radiolaria are well preserved at Site 493 up to the lower Miocene, where they become recrystallized and difficult to impossible to identify. Radiolarian abundance is generally high, but terrigenous dilution in the lower Quaternary to Pliocene section in the upper part of Hole 493 and the lower part of Hole 493B creates local barren zones.

Cores 1 through 4 at Hole 493B are all Quaternary, but the absence of *Collosphaera tuberosa, Buccinosphaera invaginata*, and *Axoprunum angelinum* prevents zonation. Nannoplankton evidence places this interval in the NN20 to NN21 zones (0–0.35 Ma). Cores 493B-5 through 493B-10 are either barren or contain no significant stratigraphic species. Cores 11 and 12 have late Pliocene fauna from the *Spongaster pentas* Zone.

Hole 493 begins in unzonable Quaternary equivalent to the NN20 to NN21 nannofossil zones. Cores 2, 3, and 4 beneath the 120-meter wash interval are barren. Cores 5, 6, 7, and 8 are in the *S. pentas* Zone, based on the appearance of *S. pentas* and *Ommatartus penultimus* (Dinkelman, 1973). Cores 9 and 10 are in the *Stichocorys peregrina* Zone, based on the presence of *S. peregrina, O. penultimus, O. antepenultimus* and lack of *S. pentas* (Dinkelman, 1973). Cores 11 through 19 are in the *O. penultimus* Zone, based on the presence of *O. penultimus, O. antepenultimus*, and *Stichocorys delmontensis* and lack of *S. peregrina* (Dinkelman, 1973). Cores 20 through the upper part of Core 27 are in the *O. antepenultimus* Zone, based on the presence of *O. antepenultimus, O. hughesi, S. delmontensis* and lack of *O. penultimus* (Riedel and Sanfilippo, 1971).

The lower part of Hole 493 from Cores 27 through 35 is in the early Miocene *Calocycletta costata* zone, based on the presence of *C. costata, C. virginis, Cannartus mammiferus, S. delmontensis*, and *Cannartus violina*. Cores below 35 have badly recrystallized radiolarians that are unidentifiable. The entire middle Miocene seems to be missing from Site 493.

Reworking radiolarians are rare at Site 493. In Hole 493 only late Pliocene Core 2 and late Miocene Core 17 have reworked early Miocene microfossils.

SEDIMENT ACCUMULATION RATES

A lack of siliceous and calcareous microfossils precludes an accurate determination of Quaternary and Pliocene sediment accumulation rates, but the rate is grossly about 44 m/m.y. (Fig. 5). Accumulation slows in the upper Miocene–lower Pliocene *Stichocorys peregrina* radiolarian zone, possibly because of a hiatus there. Upper Miocene accumulation rates of 45 m/m.y. are similar to Pliocene–Pleistocene rates. The entire middle Miocene section is missing, probably owing to submarine erosion. Most lower Miocene sediments accumulated at rates of 39 m/m.y., similar to upper Miocene and Pliocene–Pleistocene rates. Basal Miocene sediments seem to have accumulated at a higher rate of 83 m/m.y.

Most of the deposition at Site 493 is at a uniform rate, with one definite hiatus at the middle Miocene and two possible ones in the lower and uppermost Miocene, all of which may mark episodic occurrences of submarine erosion.

PALEOBATHYMETRY

Three lines of evidence are used to reconstruct the paleobathymetry of Site 493: (1) benthonic foraminiferal assemblages, (2) trace fossil assemblages, and (3)

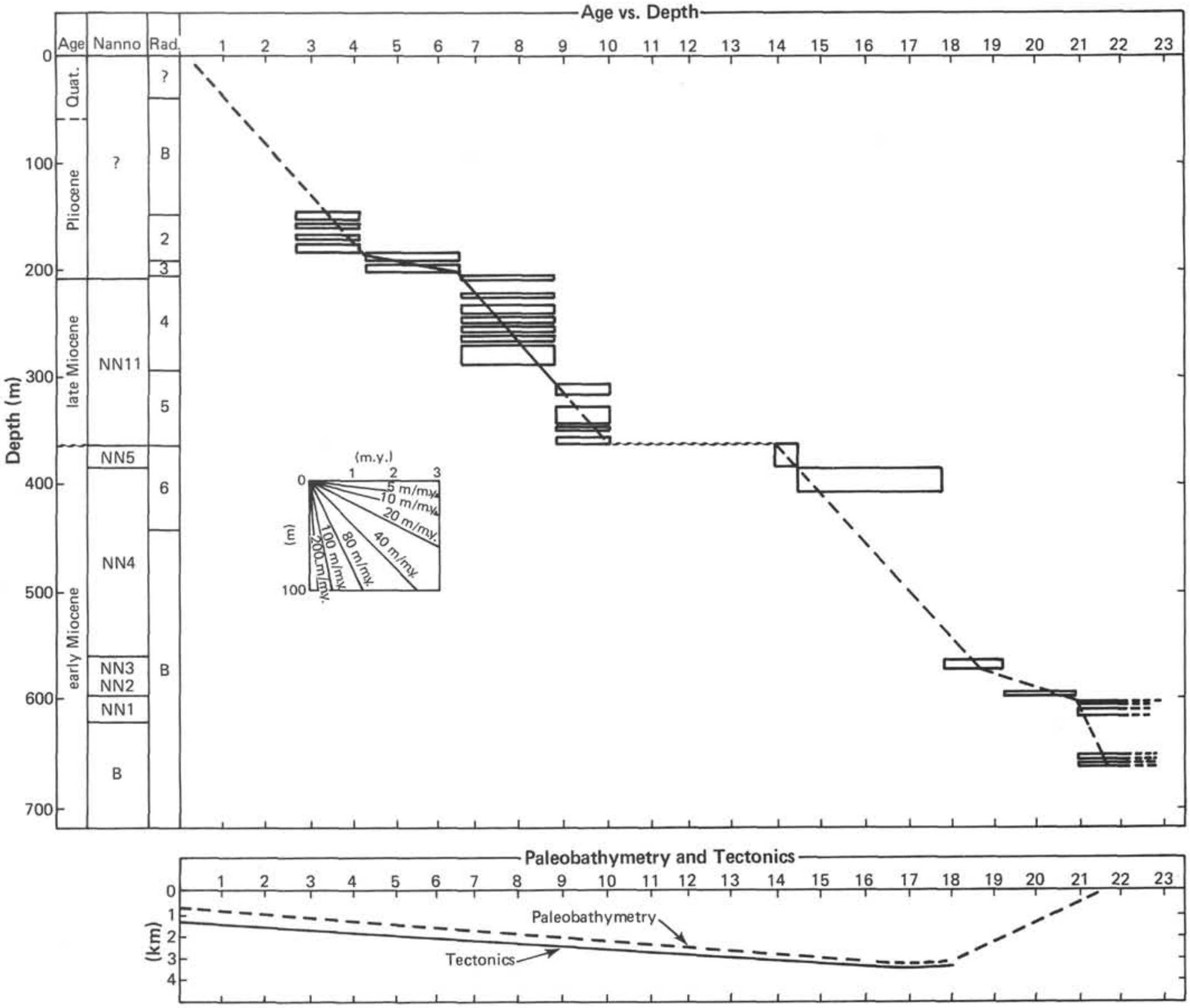

Figure 5. Depth versus age and paleobathymetry at Site 493.

carbonate preservation of foraminifers (Fig. 5). Benthonic foraminiferal assemblages show a deepening trend in transgressive lower Miocene sediments from neritic and upper bathyal to middle bathyal, with a mixture of shallower water forms. The lower Miocene sediments also contain a trace fossil assemblage composed of *Zoophycos* and *Chrondrites* (indicated on Fig. 1) that is indicative of deep water (Ekdale, 1977).

A lack of foraminifers in sediments of Hole 493B, between Cores 38 and 48, suggests deposition below the CCD at roughly 3 km depth, between 16 and 18 Ma. Subsequent uplift raised the seafloor to its present position at a rate of 125 m/m.y. (McMillen and Bachman, this volume).

PALEOMAGNETISM

Paleomagnetic analyses in Holes 493, 493A, and 493B established magnetostratigraphy and determined dips of bedding planes and fault planes.

Cores from the upper 60 meters of Hole 493B were disturbed by drilling, with laminations concave downward along core tube margins. We collected 121 oriented samples of sediments from less disturbed parts with regular bedding direction in Holes 493, 493A, and 493B, using a plastic tube in Hole 493A and 493B and in the upper 270 meters of Hole 493 and minicore drill below 270 meters in Hole 493. Stability of remanent magnetization of selected samples was examined with stepwise AF demagnetization (Niitsuma, this volume). All samples were cleaned with 15 mT AF demagnetization. The samples from the upper 360 meters of Hole 493 were cleaned twice with 15 mT AF demagnetization.

All inclination values were corrected for dip. Average intensity was $10^{-6.8 \pm 0.5}$ emu/cc. The noise level during the measurements was $10^{-7.6 \pm 0.4}$ emu/cc. Dual measurements of samples above 360 meters in Site 493 showed that the remanent magnetization after 15 mT AF demagnetization was not affected by ARM and that the orientation of remanent magnetization is reliable when intensity is larger than $1 \sim 2 \times 10^{-7}$ emu/cc. Cores above subdepth of 360 meters in Holes 493, 493A, and 493B show alternation of positive and negative inclination. Sediment cores from below 360 meters in Hole 493 have mainly positive inclinations, with two intervals of negative inclination. Changes in inclination suggest eight magnetozones. These magnetozones can be correlated with intervals from the Brunhes normal polarity epoch to Epoch 8 and Epoch 16 to 17 (Fig. 1).

Sediments from 275 to 285 meters in Hole 493 and below 360 in Hole 493 dip up to 42°. Since the drilling core axis is nearly vertical, orientation of bedding plane can be calculated from magnetic inclination and declination (Niitsuma, this volume). Dips at 275 to 285 meters strike north–south, with one dipping east and the other west. Slumping probably caused the difference in direction. Other bedding plane dips are generally southward, which is concordant with slope of submarine topography and with seismic data. Dips are predominantly either southeast or south–southwest. South–southwest direction is concordant with slope direction of submarine topography, and southeast direction agrees with the direction of the dip of the fault planes. Anticlockwise change in dip direction appears from northwest to south with subdepth in the interval from 370 to 510 meters (Niitsuma, this volume).

Several conjugate fault sets and fracture zones were observed in the lower portion of the cored section at Site 493, 560 to 580 meters. The tensional axis is horizontal and has northwest–southeast direction. This direction agrees with one of the predominant bedding plane dip directions.

Seven oriented samples were collected from basement igneous rocks of Hole 493, using minicore drill. Intensities of natural remanent magnetization are scattered, and the average value is $10^{-4.7 \pm 0.9}$ emu/cc. The strongest intensity of the igneous rocks is $10^{-3.34}$ emu/cc, which is one order of magnitude weaker than the intensity of basalt. Average susceptibility is $10^{-4.1 \pm 0.2}$ CGS. Inclination of NRM is $63.7° \pm 7.5°$, which is remarkably steeper than that of axial dipole (29°). Stability of the remanent magnetization was examined with stepwise AF demagnetization (Niitsuma, this volume). The remanent magnetization has unstable direction with AF demagnetization.

ORGANIC GEOCHEMISTRY

The shipboard organic geochemistry monitoring program consisted of analysis of gases released in core liners and visual inspection for fluorescence in split core.

Gases

Moderate amounts of gas were released in core liners from depths of about 30 meters and below. The gas initially contained CH_4, CO_2, and small amounts of H_2S. The last, detectable by its distinctive odor, was present down to depths of about 40 meters. Methane content remained fairly constant with depth (Fig. 6), increasing slightly for the lower section (350+ m) of the hole. Some intervals correspond to sediments with a high sand content, which causes substantial gas and sediment loss from washout and dilution of core liner gas with air gases, resulting in a dispersion of the analytical results.

In cores above 50 meters, ethane content was below the detection limit of the Carle gas chromatograph. It increased gradually with depth and reached a concentration of about 0.06% by volume (Fig. 6) before decreasing near the bottom of the hole. The methane to ethane ratio remained fairly constant near a value of about 8×10^{-4} throughout the cored section.

CO_2 content in core liner gases varied from 8.1% to 0.03%, was higher in the upper portion of the cored sequence, and decreased to very low values below 400 meters.

C_{3-5} hydrocarbons were monitored on the Hewlett-Packard 5710-A gas chromatograph from a depth of 30 meters to the bottom of the hole. Their abundance was found to decrease with depth, as shown in Figure 6, reaching a maximum in the upper portion of the cored section and decreasing toward the bottom of the hole. Some variations in gas composition were observed near the 386- and 550-meter levels.

Fluorescence

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

Conclusions

Gases in the C_1 to C_5 range were detected throughout this site, causing a low to moderate degassing of the cores. C_{3-5} hydrocarbon concentration decreased with depth and showed relative maxima near 150 meters and 340 meters, suggesting that emplacement by migration is not significant and *in situ* origin for the gases is most likely.

No evidence of petroleum or bitumen impregnation was detected.

PHYSICAL PROPERTIES

Physical property analyses of Site 493 sediments included porosity, water content, bulk density, compressional sound velocity, and undrained shear strength (Fig. 7). Sound velocity and shear strength measurements were limited because of attenuation and core disturbance. Measurements were made according to standard DSDP procedures (Boyce, 1976).

Major variations in Site 493 physical property trends correspond to a Miocene unconformity at 365 meters and increasing amounts of sand below 435 meters.

Porosity, Water Content, and Bulk Density

Porosity decreases gradually from 62.5% at 40 meters to 48% at 360 meters. Below 360 meters porosity decreases to 43% at 365 meters, then gradually to 32% at 570 meters. Scatter in the porosity depth profile results from variations in sand silt clay ratios, gas expansion, and sediment spalling during volume measurements. Water content decreases gradually from 44% at 43 meters to 27% at 360 meters. From 360 meters to 435 meters water content remains relatively constant (24%).

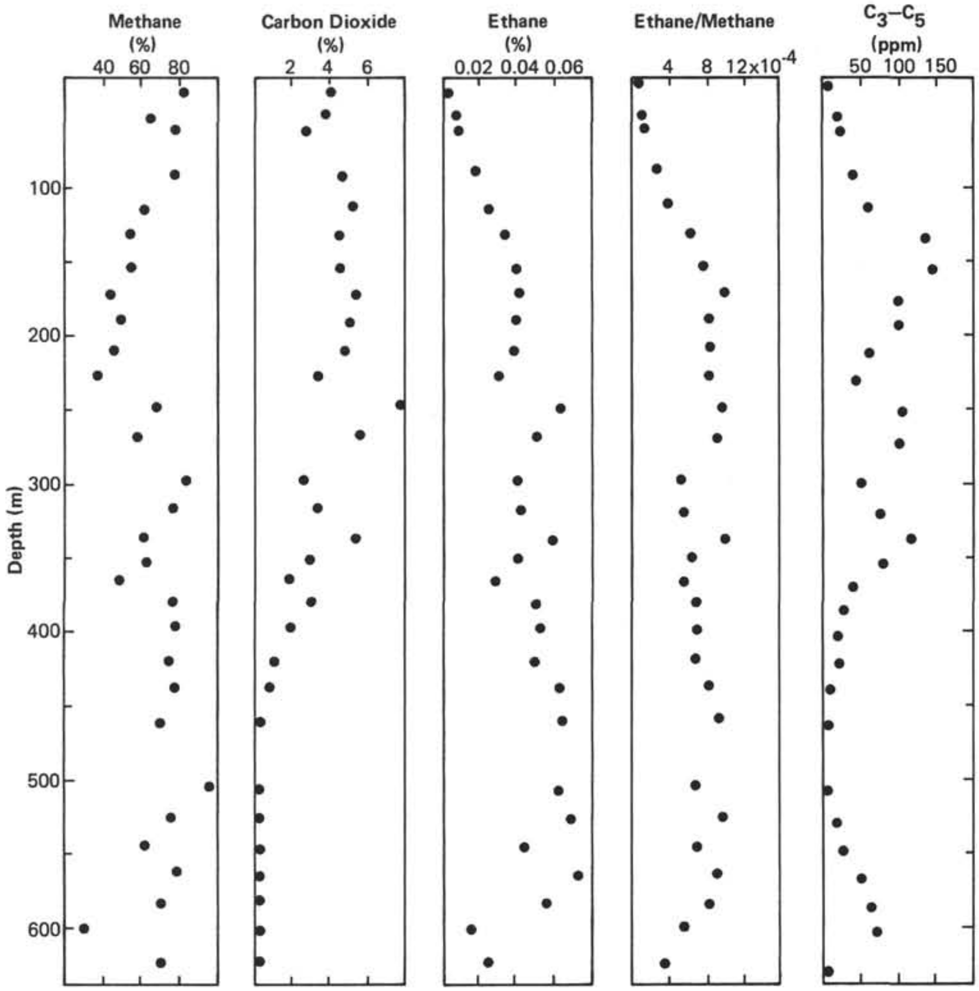

Figure 6. Core liner gas composition.

Below 435 meters water content decreases (19%), then remains constant to 579 meters.

Bulk density is variable in the upper 365 meters, increasing from 1.60 Mg/m^3 at 40 meters to 1.79 Mg/m^3 at 360 meters. Below 360 meters density abruptly increases to 1.95 Mg/m^3 at 365 meters, then continues to increase to 2.10 Mg/m^3 at 465 meters. Below 465 meters bulk density remains relatively constant.

Shear Strength

Shear strength increases from 17 kPa at 12.45 meters to 121 kPa at 127 meters (Fig. 7). Scatter in the shear strength profile results from variations in silt:clay ratios and core disturbance.

INHOLE TEMPERATURE MEASUREMENTS

Inhole temperature measurements were made possible at Site 493 by passing the Gearhart-Owens differential temperature logging tool through the bit. We were still unable to release the bit for full logging. Hole conditions and the light weight of the temperature tool prevented penetration to maximum hole depth. Open hole measurements yield a gradient of 3.2°C/100 m.

CORRELATION OF SEISMIC REFLECTION DATA AND DRILLING RESULTS

Site 493 lies on the upper slope just west of a submarine canyon deeply incised into the slope and crystalline basement. The upper slope sedimentary section has several important unconformities identified on the seismic sections in the area.

Figure 8 is a northwest-trending (strike line) seismic profile about 2200 meters northeast of the site, and Figure 9 is a line drawing of the same line. The data show three major unconformities inclusive of the sea floor (labeled 1, 2, and 3 in Fig. 9). Three sedimentary intervals are thus defined by the termination of reflections and by significantly different velocities which increase with depth (1.8, 2.0, and 2.3 km/s, respectively). Basement at Site 493 is about 0.65 s sub-bottom and has a refraction velocity of 3.3 to 4.0 km/s.

Unconformities were predicted at 270 meters (0.30 s), 440 meters (0.47 s), and basement at 647 meters (0.67 s). Drilling results record a break in the sedimentation rate or hiatus of about 2 m.y. at about 200 meters, a hiatus of 3 m.y. at about 360 meters, and diorite, presumably a Cretaceous intrusion into the Precambrian basement, at

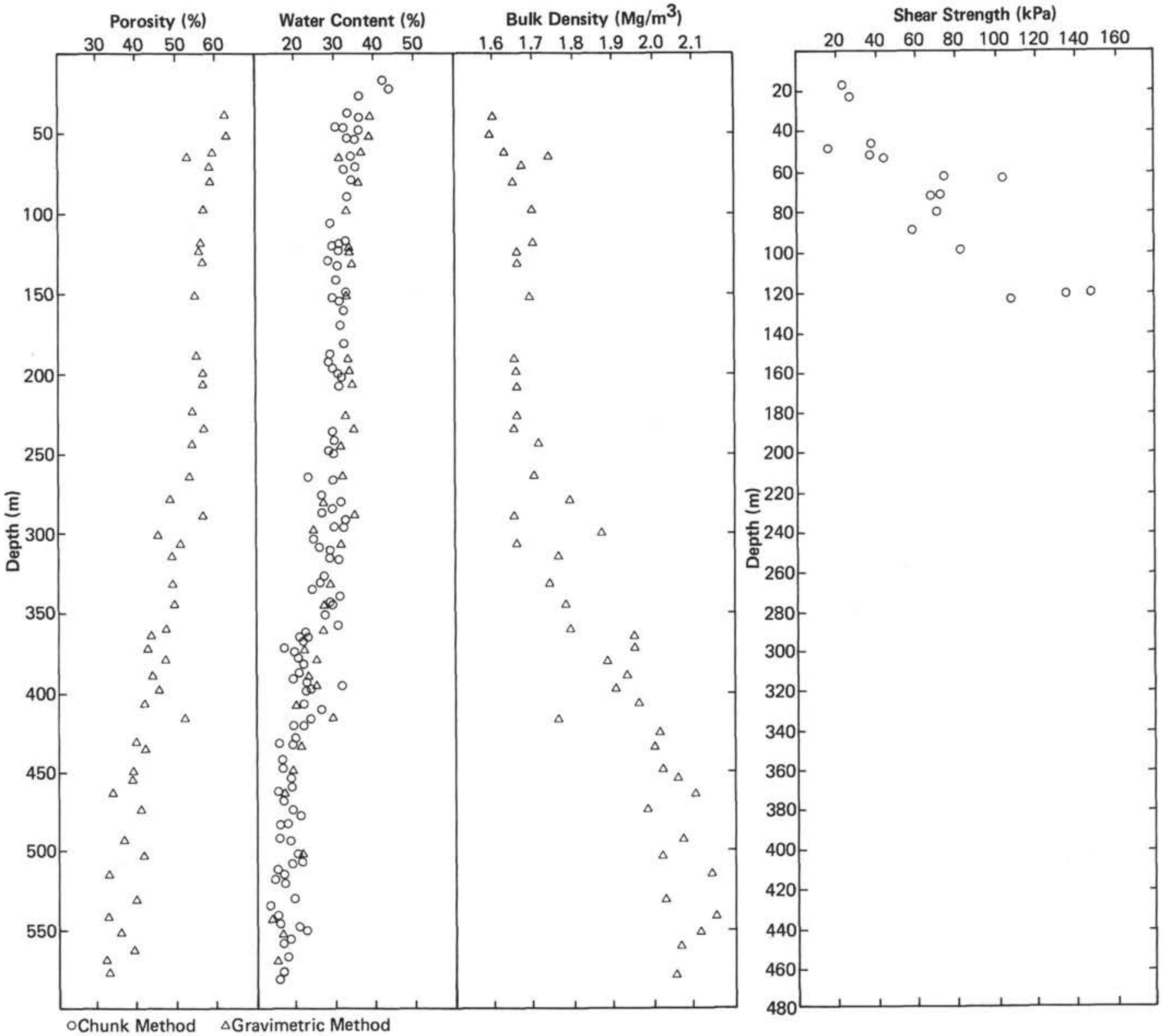

Figure 7. Physical properties summary profiles, Site 493.

655 meters. Thus the seismic data do not correlate well with the drilling results, possibly because the seismic line is about 2200 meters northeast of the actual drilling site. The *Challenger* seismic data at the site are useless because of reverberations.

SUMMARY AND CONCLUSIONS

Site 493 comprises three holes drilled in 675 meters of water about 15 km from the Mexican mainland (Fig. 2). Hole 493 covered the 120- to 676.5-meter interval subseafloor, 493B the 12- to 120-m interval and 493A the 0-to 12-meter interval. 493B was spudded after inadvertent reentry into 493 at 12 meters while drilling 493A.

Site 493 constitutes the continental reference site. Seismic and dredge evidence strongly suggested continental basement between 650 and 700 meters sub-bottom. Sediments above basement were expected to provide paleoenvironmental data from continental parts of the margin, in contrast to Site 488, 491, and 492, which probably overlie accreted deep sea sediments.

Results from Site 493 were similar to but more definitive than results from 489. Complementary data from these sites on continental crust of the North American Plate add support to our interpretation.

Data from 493 reveal a marine transgression in the early Miocene at roughly the same time as at 489. Both Sites 489 and 493 began to rebound at 18 to 19 Ma. The 489 sediment record during rebound is missing but is relatively complete at 493 and indicates a gradual rising at the rate of 125 m/m.y. There is no evidence to suggest that Site 489 did otherwise.

We interpet the sinking as the thermal response of the Mexican margin to the rifting or transforming away of a seaward segment of the margin in the pre-Miocene or

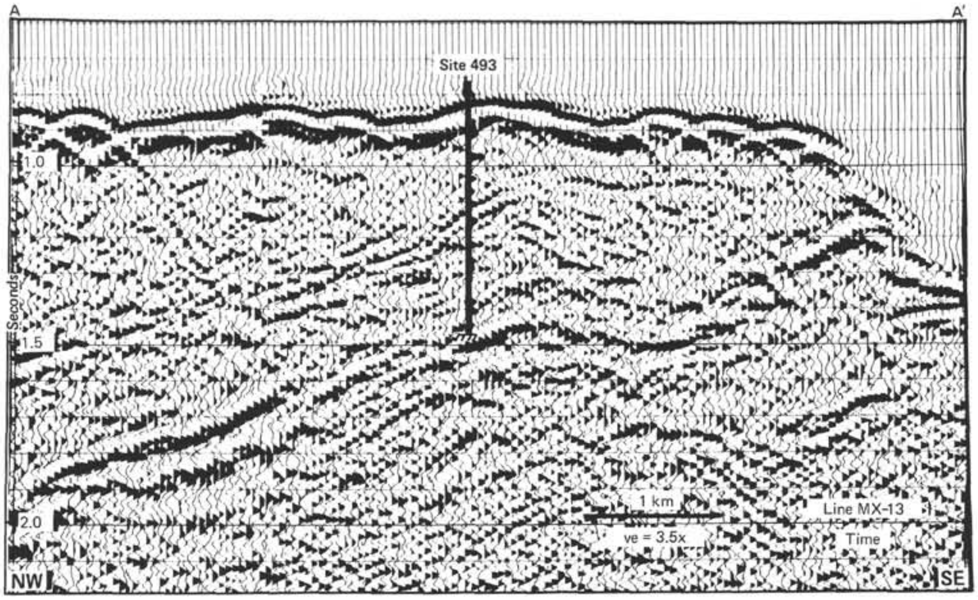

Figure 8. Portion of multichannel seismic reflection profile, Line MX-13, near Site 493.

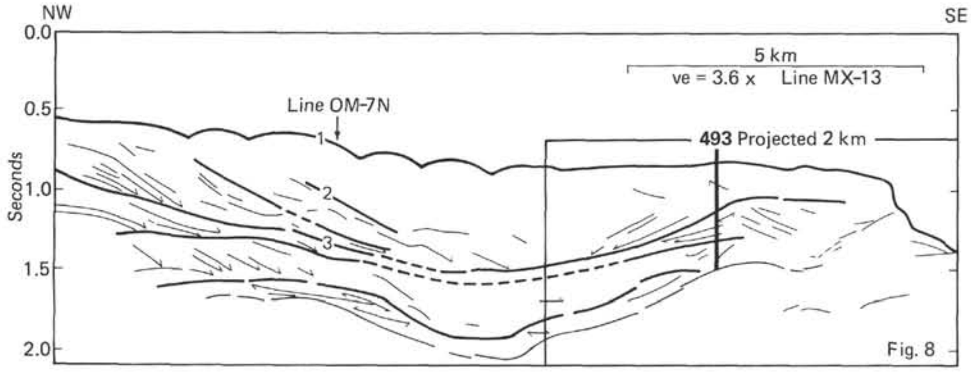

Figure 9. Line drawing interpretation of Line MX-13 reflection profile.

possibly as due to tectonic erosion of the base of the crust. Uplift may represent the beginning of underplating during the early stages of subduction, or it may represent an upward buckling of the continental margin during trench formation.

Depositional rates were remarkably uniform, ranging from 83 m/m.y. in the basal Miocene, to 39 m/m.y. in the lower Miocene, to 44 to 45 m/m.y. during the upper Miocene, Pliocene, and Quaternary. Unconformities mark periods of erosion, including one in which the middle Miocene was removed.

Impoverished faunal assemblages and thinly laminated sediment suggest an oxygen-deficient environment from the late Miocene through the Quaternary. This condition may have been caused by elevation of the section through the oxygen minimum zone or by formation of a basin with restricted circulation.

Basement rocks consist of diorite closely resembling outcrops of Cretaceous intrusives on shore roughly 20 km from the site. Basement rocks in the region are diverse, as evidenced by diorites at 493, schists at 489, and gneisses dredged from a canyon wall about 5 to 10 km from 493.

Gas, mainly of biogenic origin, was present in moderate amounts in Site 493 cores. We found no quantities of mature evidence of hydrocarbons or of bitumens.

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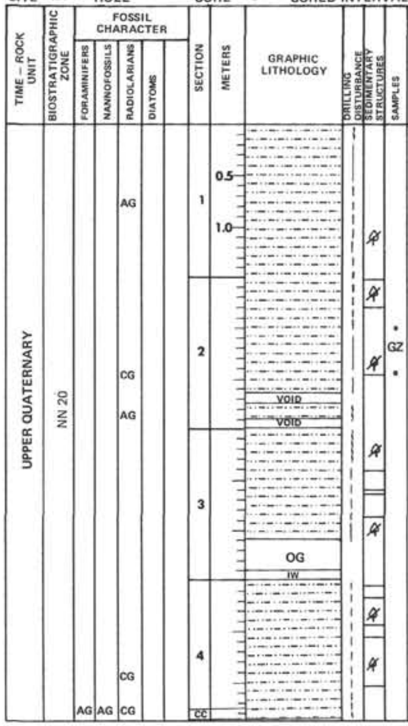
SITE 493 HOLE CORE 1 CORED INTERVAL 0.0–6.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2), soft, with interbeds of medium light gray (N6) silt, 5–10 mm. Wood, debris common.

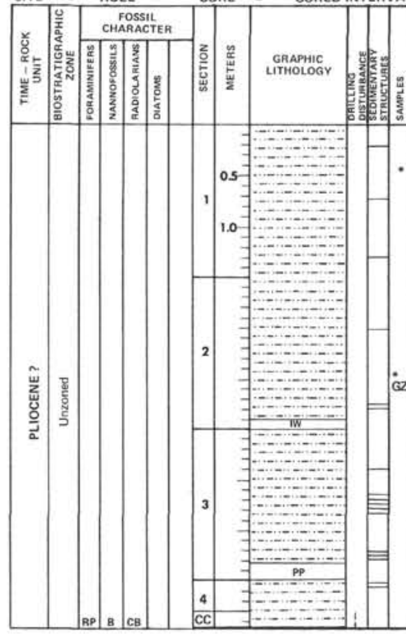
SMEAR SLIDES

	Muddy silt	Muddy silt
	2-50 (D)	2-96 (M)
TEXTURE:		
Sand	1	–
Silt	69	60
Clay	30	40
COMPOSITION:		
Quartz	60	52
Feldspar	2	3
Mica	2	2
Heavy minerals	TR	TR
Pyrite	3	1
Clay	30	40
Carb. unspec.	TR	TR
Foraminifers	–	TR
Radiolarians	TR	–
Diatoms	1	1
Sponge spicules	2	1

GRAIN SIZE

	2-70
Sand	7.4
Silt	65.6
Clay	27.0

SITE 493 HOLE CORE 2 CORED INTERVAL 120.0–129.5 m



LITHOLOGIC DESCRIPTION

9° true dip

Calcareous concentration

Zeolite clump

MUDDY SILT, olive gray (5Y 3/2), firm, with thin beds (to 2 cm) of mud, medium light gray (N6).

SMEAR SLIDES

	Mud	Mud
	1-47 (M)	2-100 (D)
TEXTURE:		
Sand	1	1
Silt	29	34
Clay	70	65
COMPOSITION:		
Quartz	22	25
Feldspar	2	5
Mica	3	2
Heavy minerals	TR	–
Pyrite	2	1
Clay	70	65
Nannofossils	–	TR
Radiolarians	TR	TR
Diatoms	TR	–
Sponge spicules	1	1
Plant fragments	–	1

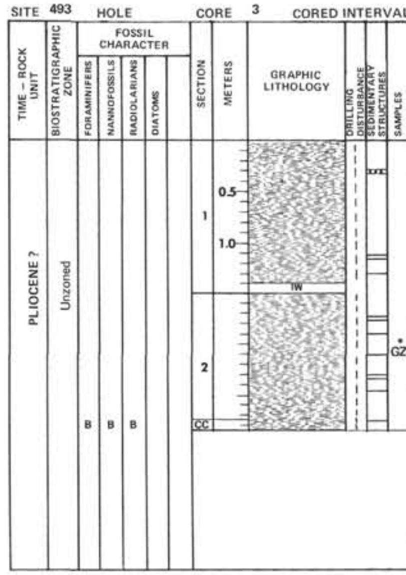
GRAIN SIZE

	2-100
Sand	0.4
Silt	57.9
Clay	41.8

Calcareous concentration

Indurated calcareous block-probably concretion

SITE 493 HOLE CORE 3 CORED INTERVAL 129.5–139.0 m



LITHOLOGIC DESCRIPTION

Slight graded, 35° true dip (probably drilling induced)

Well indurated calcareous mud clast with opal vein (reworked clast?)

13° true dip
18° true dip
12° true dip
probably drilling induced

MUD, olive gray (5Y 3/2), firm with interbeds of medium light gray (N6) mud. In Core-Catcher, vertical bed due to drilling disturbance.

SMEAR SLIDES

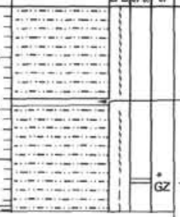
	Mud
	2-50 (D)
TEXTURE:	
Sand	1
Silt	34
Clay	65
COMPOSITION:	
Quartz	28
Feldspar	2
Mica	2
Pyrite	3
Clay	65
Carb. unspec.	TR
Sponge spicules	TR

GRAIN SIZE

	2-50
Sand	0.3
Silt	49.7
Clay	50.0

SITE 493 HOLE CORE 4 CORED INTERVAL 139.0–148.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
PLIOCENE ?	Unzoned	B	B	B		1, 2, CC	0.5, 1.0				*, GZ



LITHOLOGIC DESCRIPTION

MUDDY SILT, firm, olive gray (5Y 3/2). At 88 cm in Section 1, indurated clast of calcareous mud, non-calcareous veins (opal?). Silt spots at base of core.

SMEAR SLIDES

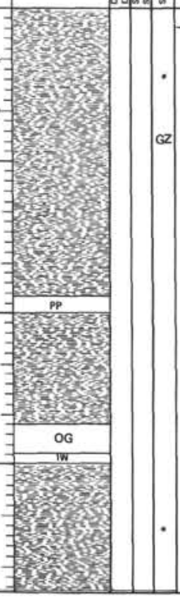
	Mud
	2-20 (D)
TEXTURE:	
Sand	2
Silt	23
Clay	75
COMPOSITION:	
Quartz	17
Feldspar	2
Mica	2
Pyrite	3
Clay	75
Carb. unspec.	TR
Sponge spicules	TR
Plant fragments	1
Fish remains	TR

GRAIN SIZE

	2-20
Sand	15.2
Silt	46.3
Clay	38.6

SITE 493 HOLE CORE 5 CORED INTERVAL 148.5–158.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	*Spongaster pentas*	CP	CM	FM		1, 2, 3, 4	0.5, 1.0				*, GZ, *



LITHOLOGIC DESCRIPTION

MUD, olive gray (5Y 3/2), firm. At Section 1, 135–145 cm and Section 2, 15 cm, 20–25 cm, and 71–78 cm, greenish gray (5G 6/1), non-calcareous irregular discolorations. At Section 3, 45–75 cm and Section 4, 2–70 cm, moderate olive brown (5Y 4/4) slightly calcareous discolorations. In Section 4, local NANNOFOSSIL MUD. Deviation 2.5°.

SMEAR SLIDES

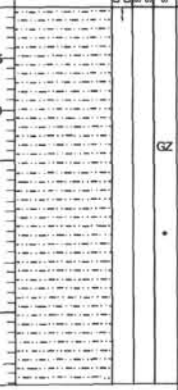
	Mud	Nannofossil Mud
	1-70 (D)	4-68 (M)
TEXTURE:		
Sand	–	2
Silt	30	25
Clay	70	73
COMPOSITION:		
Quartz	31	11
Feldspar	5	2
Mica	1	1
Heavy minerals	TR	TR
Pyrite	2	5
Clay	60	70
Glass	–	TR
Carb. unspec.	TR	1
Foraminifers	–	TR
Nannofossils	TR	10
Sponge spicules	TR	TR
Plant fragments	1	–

GRAIN SIZE

	1-130
Sand	0.2
Silt	49.7
Clay	50.1

SITE 493 HOLE CORE 6 CORED INTERVAL 158.0–167.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
LOWER PLIOCENE	*Spongaster pentas*	CM	B	CG		1, 2, 3	0.5, 1.0				GZ, *



LITHOLOGIC DESCRIPTION

MUDDY SILT, moderate olive brown (5Y 4/4). Calcareous spots at Section 1, 31 cm, 40 cm, and 105 cm and Section 2, 6 cm, 60 cm, 100 cm, 130 cm, and 140 cm.

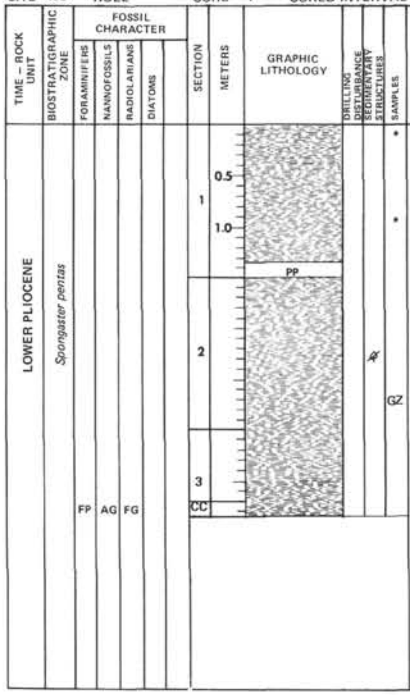
SMEAR SLIDES

	Muddy silt
	2-70 (D)
TEXTURE:	
Sand	1
Silt	59
Clay	40
COMPOSITION:	
Quartz	43
Feldspars	5
Mica	TR
Heavy minerals	TR
Pyrite	10
Clay	40
Glass	TR
Carb. unspec.	2
Foraminifers	TR
Nannofossils	TR
Diatoms	TR
Sponge spicules	TR

GRAIN SIZE

	1-136
Sand	0.1
Silt	51.3
Clay	48.6

SITE 493 HOLE CORE 7 CORED INTERVAL 167.5–177.0 m



LITHOLOGIC DESCRIPTION

MUD, olive gray (5Y 3/2), firm, structureless. Greenish gray (5G 6/1) discolored areas at Section 1, 9–14 cm and Section 3, 30–32 cm. ASH spots, very light gray (N8) at Section 1, 55 cm. Fine-grain LIMESTONE, structureless, color of matrix at Section 2, 70 cm. Organic fragment as shown.

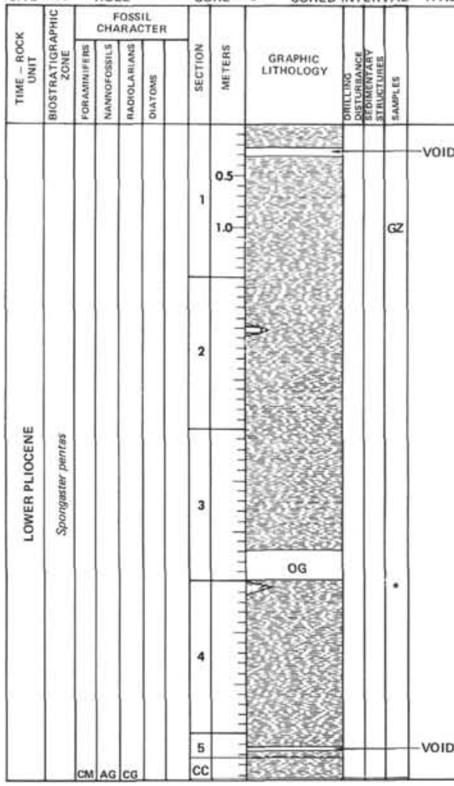
SMEAR SLIDES

	Muddy silt 1-12 (M)	Muddy silt 1-97 (D)
TEXTURE:		
Sand	–	–
Silt	80	80
Clay	20	20
COMPOSITION:		
Quartz	72	66
Feldspar	4	4
Mica	2	2
Heavy minerals	TR	TR
Pyrite	2	5
Clay	20	20
Glass	TR?	–
Carb. unspec.	TR	2
Foraminifers	–	TR
Nannofossils	–	1
Radiolarians	–	TR
Diatoms	–	TR
Sponge spicules	–	TR

GRAIN SIZE

	2-126
Sand	0.3
Silt	46.9
Clay	52.8

SITE 493 HOLE CORE 8 CORED INTERVAL 177.0–186.5 m



LITHOLOGIC DESCRIPTION

MUD, olive gray (5Y 3/2), firm, structureless. Dark greenish gray (5G 4/1) non-calcareous discolorations at Section 1, 100 cm; Section 2, 8–10 cm and 78–80 cm; Section 3, 44–46 cm; and Section 4, 20 cm. Moderate olive brown (5Y 4/4) calcareous discolorations at Section 1, 126 cm; Section 3, 40–42 cm; Section 4, 68–70 cm; and Section 5, 5 cm. Micritic LIMESTONE nodule at Section 2, 29 cm, 49 cm, and 52–56 cm. ASH pod at Section 4, 5 cm.

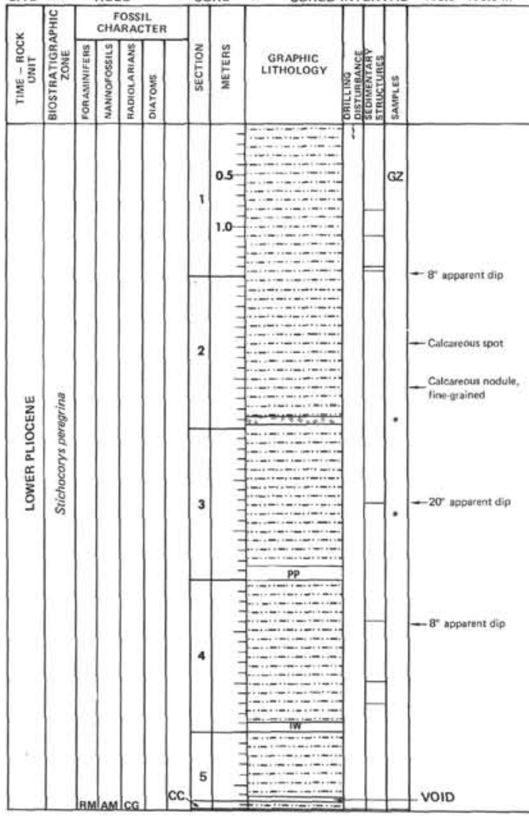
SMEAR SLIDES

	Ash 4-5 (M)
TEXTURE:	
Sand	–
Silt	–
Clay	–
COMPOSITION:	
Glass	100

GRAIN SIZE

	1-100
Sand	0.2
Silt	42.4
Clay	57.4

SITE 493 HOLE CORE 9 CORED INTERVAL 186.5–196.0 m



LITHOLOGIC DESCRIPTION

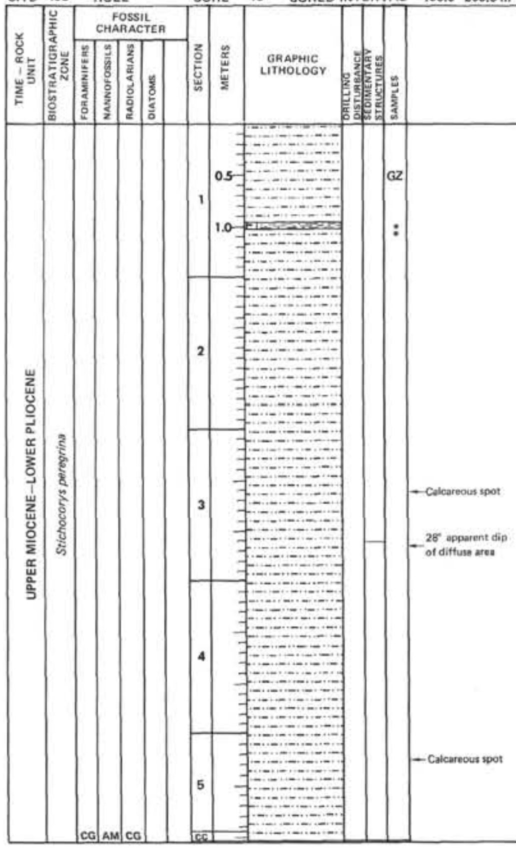
MUDDY SILT, olive gray (5Y 3/2), firm, structureless with dark greenish gray (5G 4/1) laminations at Section 1, 87 cm, 110 cm, and 145 cm; Section 3, 75 cm; and Section 4, 40 cm, 101 cm, and 120 cm. Single ASH layer, light gray (N7) in Section 2.

SMEAR SLIDES

	Ash	Muddy silt
	2-140 (M)	3-85 (D)
TEXTURE:		
Sand	–	1
Silt	–	59
Clay	–	40
COMPOSITION:		
Quartz	TR	51
Feldspar	TR	4
Mica	TR	2
Heavy minerals	–	TR
Pyrite	–	3
Clay	–	35
Class	100	TR
Carb. unspec.	–	1
Foraminifers	–	TR
Nannofossils	–	3
Radiolarians	–	TR
Diatoms	–	1
Silicoflagellates	–	TR

GRAIN SIZE	1-50
Sand	0.5
Silt	51.5
Clay	48.0

SITE 493 HOLE CORE 10 CORED INTERVAL 196.0–205.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), structureless with minor SILICEOUS MUD, dark greenish gray (5G 4/1) non-calcareous diffuse areas, dark greenish gray (5G 4/1), possibly siliceous at Section 3, 66 cm, 84 cm, 105 cm, and 118 cm and Section 4, 25 and 111 cm; and Section 5, 30 and 66 cm.

SMEAR SLIDES

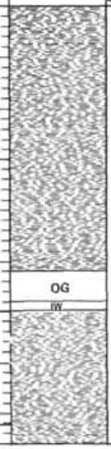
	Siliceous mud	Mud
	1-103 (M)	1-110 (D)
TEXTURE:		
Sand	–	2
Silt	40	30
Clay	60	68
COMPOSITION:		
Quartz	30	19
Feldspar	4	4
Mica	1	TR
Heavy minerals	TR	–
Pyrite	3	4
Clay	50	60
Glass	TR	TR
Carb. unspec.	1	3
Foraminifers	TR	1
Nannofossils	TR	3
Radiolarians	TR	TR
Diatoms	1	TR
Sponge spicules	7	1
Silicoflagellates	1	TR
Undetermined siliceous	2	5

GRAIN SIZE	1-50
Sand	1.4
Silt	52.3
Clay	46.3

SITE 493 HOLE CORE 11 CORED INTERVAL 205.5–215.0 m

TIME – ROCK UNIT: UPPER MIOCENE
BIOSTRATIGRAPHIC ZONE: *Ommartartus penultimus*
FOSSIL CHARACTER: FORAMINIFERS FM; NANNOFOSSILS B; RADIOLARIANS CG; DIATOMS
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



SAMPLES: GZ, •

LITHOLOGIC DESCRIPTION

MUD, firm, olive gray (5Y 3/2) with a dark greenish gray (5G 4/1) color band at Section 1, 60 cm and indurated limestone nodules at Section 2, 2 cm and Section 3, 9 cm and 52–63 cm.

SMEAR SLIDES

	Mud
	1-100 (D)
TEXTURE:	
Sand	2
Silt	40
Clay	58
COMPOSITION:	
Quartz	35
Feldspar	5
Mica	1
Heavy minerals	TR
Pyrite	4
Clay	45
Glass	2
Carb. unspec.	3
Foraminifers	1
Nannofossils	4
Radiolarians	TR
Ditoms	TR
Sponge psicules	TR

GRAIN SIZE

	1-50
Sand	0.2
Silt	47.7
Clay	52.0

SITE 493 HOLE CORE 12 CORED INTERVAL 215.0–224.5 m

TIME – ROCK UNIT: UPPER MIOCENE
BIOSTRATIGRAPHIC ZONE: *Ommartartus penultimus*
FOSSIL CHARACTER: FORAMINIFERS; NANNOFOSSILS; RADIOLARIANS; DIATOMS
SECTION: 1
METERS

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE: Δ Δ

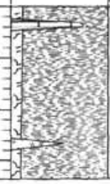
LITHOLOGIC DESCRIPTION

LIMESTONE blocks, greenish black (5G 2/1), very fine-grained, structureless. Non-calcareous dark areas, hard, may be opal. Blocks appear to break on veins of non-calcareous material.

SITE 493 HOLE CORE 13 CORED INTERVAL 224.5–234.0 m

TIME – ROCK UNIT: UPPER MIOCENE
BIOSTRATIGRAPHIC ZONE: *Ommartartus penultimus*; NN 11
FOSSIL CHARACTER: FORAMINIFERS CG; NANNOFOSSILS AM; RADIOLARIANS CG; DIATOMS
SECTION: 1, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE: O, O
SAMPLES: GZ, •, •

LITHOLOGIC DESCRIPTION

SILICEOUS MUD, olive gray (5Y 3/2) firm. LIMESTONE blocks, very fine-grained, greenish black (5G 2/1) at Section 1, 15–24 cm and 141 cm. Fine silt layers, dark greenish gray (5G 4/1) at Section 1, 53 cm, 111 cm and 122 cm. ASH spots at Section 1, 135–140 cm.

SMEAR SLIDES

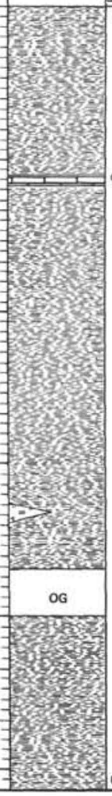
	Siliceous muddy silt	Fine silt
	1-82 (D)	1-111 (M)
TEXTURE:		
Sand	2	–
Silt	78	92
Clay	20	8
COMPOSITION:		
Quartz	54	82
Feldspar	5	5
Mica	TR	1
Heavy minerals	–	TR
Pyrite	4	3
Clay	20	8
Carb. unspec.	3	–
Foraminifers	TR	TR
Nannfoossils	3	TR
Radiolarians	TR	–
Diatoms	TR	–
Sponge spicules	1	1
Unidentified siliceous	10	–

GRAIN SIZE

	1-50
Sand	0.2
Silt	44.8
Clay	55.0

SITE 493 HOLE CORE 14 CORED INTERVAL 234.0–243.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS)	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES	LITHOLOGIC DESCRIPTION
UPPER MIOCENE	NN 11 *Ommartartus penultimus*	FM CM CG	1, 2, 3, 4, 5, CC	0.5, 1.0	OG	GZ	



- Well indurated calcaeous area
- Wood fragment
- Apparent dip 3°
- Apparent dip 4°
- Healed normal fault
- Apparent dip horizontal
- At 128–140 cm, fractured
- At 145 cm, subtle grading in muddy silt, 5° apparent dip

MUD, olive gray (5Y 3/2) hard. Angular LIMESTONE clasts, same color as mud. Section 3, first to be cut with saw, shows many more features (ones above may be masked by cheese-cutter splitting). Very fine parallel laminations, horizontal or sub-horizontal. Drilling laminations frequent. Drilling biscuits common. Irregular curvilinear to vertical fractures from Section 3, 100–130 cm and Section 4, 10–95 cm. Incipient fissility beginning in Section 4. ASH at Section 4, 50 cm. Graded muddy silt at Section 5, 48 cm and minor plant fragments.

SMEAR SLIDES

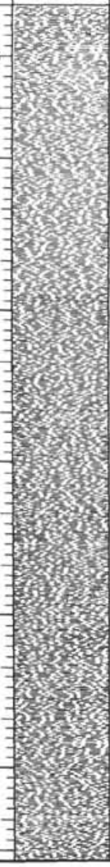
	Muddy silt 1-12 (D)	Muddy silt 5-47.5 (M)
TEXTURE:		
Sand	1	–
Silt	59	80
Clay	40	20
COMPOSITION:		
Quartz	41	64
Feldspar	6	12
Mica	1	2
Heavy minerals	TR	TR
Pyrite	3	2
Clay	40	20
Carb. unspec.	5	–
Foraminifers	TR	–
Nannofossils	4	–
Diatoms	TR	TR
Sponge spicules	–	TR
Silicoflagellates	–	TR
Fish remains	–	TR

GRAIN SIZE

	1-50
Sand	0.4
Silt	48.0
Clay	51.6

SITE 493 HOLE CORE 15 CORED INTERVAL 243.5–253.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER (FORAMINIFERS / NANNOFOSSILS / RADIOLARIANS / DIATOMS)	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES	LITHOLOGIC DESCRIPTION
UPPER MIOCENE	NN 11 *Ommartartus penultimus*	FM CM CG	1, 2, 3, 4, 5, 6, CC	0.5, 1.0		GZ	



- 18° true dip
- Maximum apparent dip 16°
- Maximum apparent dip 11°
- Maximum apparent dip 11°
- Maximum apparent dip 19°
- Maximum apparent dip 19°

MUDSTONE, olive gray (5Y 3/2), fissile throughout, occasional discrete inclined fractures (some with slickensides), drilling biscuits common. Carbonate-rich laminations, light olive gray (5Y 5/2) at Section 1, 15 cm and 128 cm; Section 2, 49 cm and 77 cm; Section 3, 90 cm, 119 cm, and 114 cm; Section 4, 30 cm, 42 cm, 67 cm, and 104 cm; Section 5, 15 cm and 56 cm; and Section 6, 26 cm. Thin MUD beds, light bluish gray (5B 7/1), with sharp bases and slightly gradational tops at Section 1, 96 cm; Section 2, 70 cm, 96 cm, and 130 cm; Section 3, 52 cm; Section 4, 18 cm, 47 cm, and 71 cm; and Section 5, 140 cm. At Section 5, 80–86 cm, these beds are wispy, appears due to discrete small faults. Section 4, occasional discrete inclined fractures, some with slickensides. Deviation 2.6°.

SMEAR SLIDES

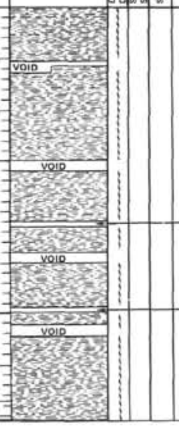
	Muddy silt 3-101 (D)	Mud 4-18 (M)
TEXTURE:		
Sand	2	–
Silt	63	40
Clay	35	60
COMPOSITION:		
Quartz	53	32
Feldspar	3	2
Mica	2	2
Heavy minerals	TR	TR
Pyrite	2	3
Clay	35	60
Carb. unspec.	1	–
Foraminifers	TR	–
Nannofossils	1	TR
Radiolarians	TR	–
Diatoms	2	TR
Sponge spicules	1	1
Silicoflagellates	–	TR

GRAIN SIZE

	1-50
Sand	0.6
Silt	47.2
Clay	52.2

SITE 493 HOLE CORE 16 CORED INTERVAL 253.0–262.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	*Ommartartus penultimus*; NN 11	FM	AM	CG		1, 2, 3, CC	0.5, 1.0

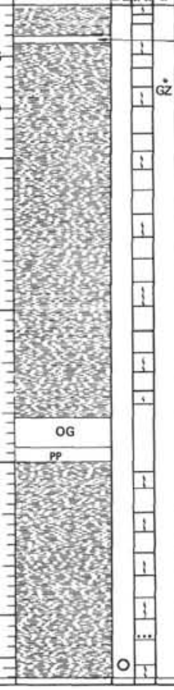


LITHOLOGIC DESCRIPTION

MUD, soft, grayish olive (10Y 4/2). Possibly pulverized during drilling. Base of Core-Catcher has 4 cm well-indurated MUDDY SILTSTONE – perhaps whole core was this material.

SITE 493 HOLE CORE 17 CORED INTERVAL 262.5–272.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	*Ommartartus penultimus*	B	B	AG		1, 2, 3, 4, 5, CC	0.5, 1.0



LITHOLOGIC DESCRIPTION

Apparent dips 0–16°

Maximum apparent dip 22°

Maximum apparent dip 14°

Maximum apparent dip 3°

MUDSTONE, olive gray (5Y 3/2), fissile, parallel laminated, minute (< 1 mm) burrowing, common inclined fractures (some slickensided), drilling biscuits throughout core. Carbonate-rich layers or pods, light olive gray (5Y 5/2) at Section 1, 24 cm, 48 cm, and 118 cm; Section 2, 38 cm, 56 cm, and 84 cm; Section 3, 46 cm; Section 4, 35 cm, 45 cm, 72 cm, and 119 cm; Section 5, 16 cm, 23 cm, 28 cm, and 38 cm; and Core-Catcher. Very thin, discontinuous layers of mud, light bluish gray (5B 7/1) at Section 1, 85 cm; Section 2, 9 cm, 34 cm, and 130 cm; Section 3, 4 cm, 44 cm, 74 cm, 85 cm, and 100 cm; Section 4, 20 cm, and 75 cm; Section 5, 26 cm and 31 cm; and Core-Catcher. Section 5, subtle graded beds.

SMEAR SLIDES

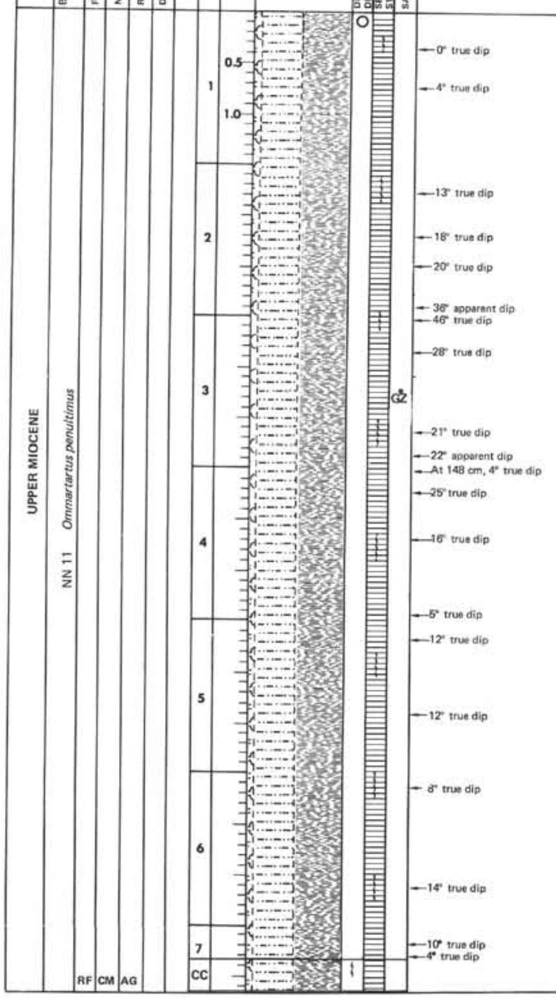
	Muddy silt 1-80 (D)
TEXTURE:	
Sand	1
Silt	64
Clay	35
COMPOSITION:	
Quartz	52
Feldspar	3
Mica	2
Heavy minerals	TR
Pyrite	3
Clay	35
Carb. unspec.	TR
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	3
Sponge spicules	2
Silicoflagellates	TR
Fish remains	TR

GRAIN SIZE

	1-77
Sand	0.2
Silt	47.4
Clay	52.4

SITE 493 HOLE CORE 18 CORED INTERVAL 272.0–281.5 m

TIME-ROCK UNIT: UPPER MIOCENE | BIOSTRATIGRAPHIC ZONE: NN 11 *Ommartartus penultimus* | FOSSIL CHARACTER: FORAMINIFERS RF, NANNOFOSSILS CM, RADIOLARIANS AG, DIATOMS | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

Fine-scale interbedding of MUDDY SILTSTONE, MUDSTONE, and SILICEOUS MUDSTONE. Olive gray (5Y 3/2), fissile, occasional discrete inclined fractures (slickensided). Parallel lamination throughout, minute burrowing throughout, drilling laminations throughout. Mud, light bluish gray (5B 7/1) interbedded with dominant lithologies. Carbonate-rich layers and pods (light olive gray, 5Y 5/2) at Section 1, 116 cm and 134 cm; Section 2, 16 cm, 26 cm, 66 cm, 122 cm, 140 cm, and 146 cm; Section 3, 15 cm, 74 cm, 81 cm, and 112 cm; Section 4, 35 cm and 70 cm; Section 5, 110 cm; and Section 6, 18 cm, 66 cm, 80 cm, 91 cm, 108 cm, and 146 cm.

Steeper dips probably due to tilting of drilling biscuits.

SMEAR SLIDES

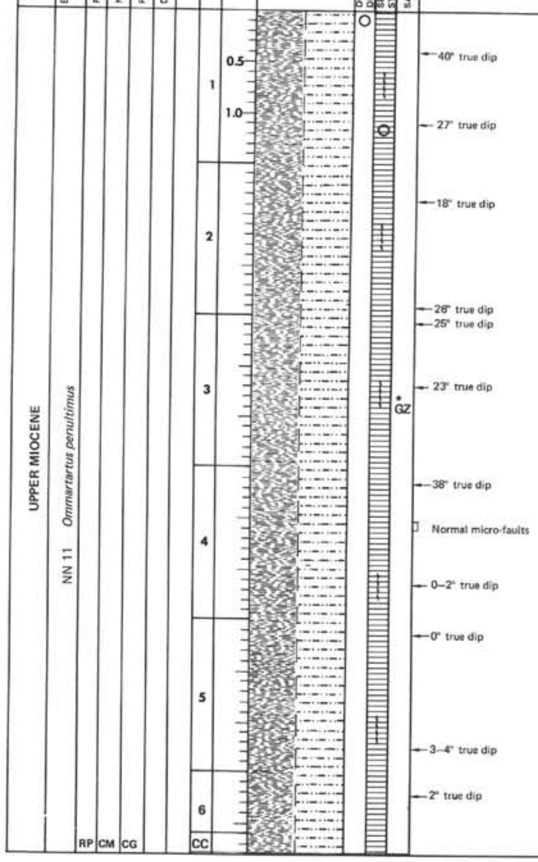
	Mud 3-76 (D)
TEXTURE:	
Sand	2
Silt	43
Clay	55
COMPOSITION:	
Quartz	35
Feldspar	2
Mica	1
Pyrite	2
Clay	55
Carb. unspec.	TR
Nannofossil	TR
Radiolarians	TR
Diatoms	2
Sponge spicules	3

GRAIN SIZE

	3-74
Sand	0.1
Silt	47.9
Clay	52.0

SITE 493 HOLE CORE 19 CORED INTERVAL 281.5–291.0 m

TIME-ROCK UNIT: UPPER MIOCENE | BIOSTRATIGRAPHIC ZONE: NN 11 *Ommartartus penultimus* | FOSSIL CHARACTER: FORAMINIFERS RP, NANNOFOSSILS CM, RADIOLARIANS CG, DIATOMS | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | SAMPLES



LITHOLOGIC DESCRIPTION

Interbedded MUDSTONE and MUDDY SILTSTONE, olive gray (5Y 3/2), parallel laminations throughout, with minute, flattened burrows. Fissile, occasional discrete inclined slickensided fractures. Drilling biscuits are extensive. MUD layers and pods, light bluish gray (5B 7/1) are common. Carbonate-rich layers and pods, light olive gray (5Y 5/2) at Section 1, 113 cm and 145 cm; Section 2, 11 cm, 20 cm, 33 cm, and 46 cm; Section 3, 5 cm and 131 cm; Section 4, 105 cm; Section 5, 25 cm, 84 cm, 103 cm, and 113 cm; Section 6, 26 cm and 39 cm.

Steeper dips probably due to tilting of drilling biscuits.

SMEAR SLIDES

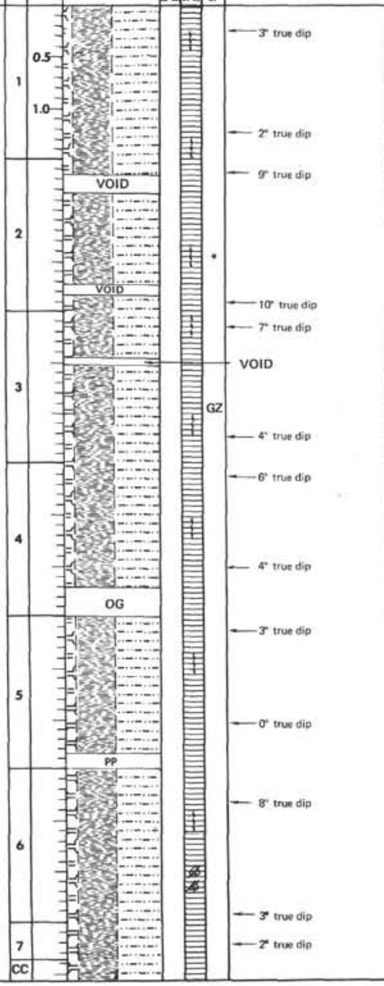
	Muddy silt 3-90 (D)
TEXTURE:	
Sand	2
Silt	58
Clay	40
COMPOSITION:	
Quartz	51
Feldspar	2
Mica	2
Pyrite	2
Clay	40
Nannofossils	TR
Radiolarians	TR
Diatoms	2
Sponge spicules	1
Silicoflagellates	TR
Fish remains	TR

GRAIN SIZE

	3-89
Sand	0,2
Silt	52.9
Clay	46.9

SITE 493 HOLE CORE 20 CORED INTERVAL 291.0–300.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
UPPER MIOCENE	*Ommartartus penultimus / Ommartartus antepenultimus ?*	FP	B	B		1–7, CC					



LITHOLOGIC DESCRIPTION

Interbedded SILICEOUS MUDDY SILTSTONE, SILTSTONE, and MUDSTONE, olive gray (5Y 3/2), parallel laminations, minute burrows, drilling biscuits, fissile, discrete fractures (inclined to vertical, slickensided). Woody debris as shown. Light bluish gray (5B 7/1) mud layers common. CHALK layers and carbonate-rich pods (light olive gray, 5Y 5/2) and concretions (as shown) at Section 1, 91 cm; Section 2, 62 cm; Section 3, 119 cm; Section 4, 110 cm; Section 5, 36 cm, 63 cm, and 92 cm; Section 6, 56 cm, 72 cm, 74 cm, 130 cm, and 132 cm; Section 7, 10–38 cm. Concentration of foraminifer tests at Section 5, 109 cm.

SMEAR SLIDES

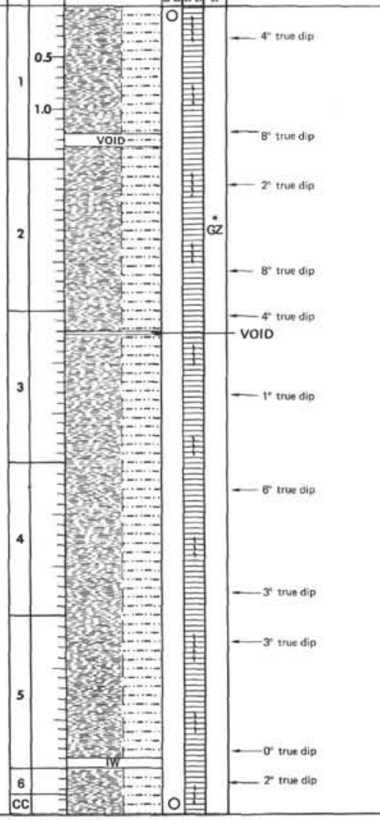
	Siliceous muddy silt
	2-92 (D)
TEXTURE:	
Sand	2
Silt	68
Clay	30
COMPOSITION:	
Quartz	50
Feldspar	3
Mica	1
Pyrite	3
Clay	30
Carb. unspec.	2
Foraminifers	TR
Nannofossils	1
Radiolarians	TR
Diatoms	5
Sponge spicules	5
Silicoflagellates	TR

GRAIN SIZE

	3-91
Sand	0.2
Silt	43.7
Clay	56.1

SITE 493 HOLE CORE 21 CORED INTERVAL 300.5–310.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
UPPER MIOCENE	*Ommartartus antepenultimus ?*	B	B	FG		1–6, CC					



LITHOLOGIC DESCRIPTION

Interbedded MUDSTONE and MUDDY SILTSTONE, olive gray (5Y 3/2), parallel laminated, minute burrows, drilling biscuits throughout. Fissile subparallel to bedding, with rare discrete inclined and slickensided fractures. Carbonate-rich layers and pods, light olive gray (5Y 5/2) at Section 1, 23 cm, 29 cm, 53 cm, 58 cm, 66 cm, 76 cm, 88 cm, 98 cm, 112 cm and 144 cm; interspersed through much of Sections 2 and 3; Section 4, 46 cm and 125 cm; Section 5, 7 cm and 56 cm; and Section 6, 5 cm and 15 cm. Some may be dolomite (only fizzes in HCl when powdered). Minor interbeds of mud, light bluish gray (5B 7/1).

SMEAR SLIDES

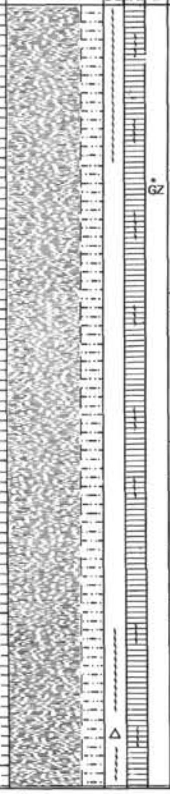
	Mud
	2-60 (D)
TEXTURE:	
Sand	–
Silt	30
Clay	70
COMPOSITION:	
Quartz	25
Feldspar	1
Mica	1
Pyrite	2
Clay	70
Carb. unspec.	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1
Fish remains	TR

GRAIN SIZE

	2-60
Sand	1.0
Silt	42.3
Clay	56.7

SITE 493 HOLE CORE 22 CORED INTERVAL 310.0–319.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	NN 11 *Ommartartus antepenultimus*	FP	FM	FM		1, 2, 3, 4, 5, CC	0.5, 1.0



LITHOLOGIC DESCRIPTION

MUDSTONE, interbeds of MUDDY SILTSTONE, olive gray (5Y 3/2). Parallel laminated, small-scale burrows, fissile subparallel to bedding, occasional to common inclined, slickensided fractures, drilling biscuits throughout. Carbonate-rich layers, light olive gray (5Y 5/2) at Section 1, 27 cm, 40 cm, and 52 cm; Section 2, 15 cm, 49 cm, 80 cm, 104 cm, 135 cm and 145 cm; Section 3, 4 cm and 90 cm; Section 4, 62 cm, 86 cm, 100 cm, 130 cm, and 135 cm; Section 5, 4 cm, 14 cm, 45 cm, and 95 cm; and Core-Catcher. Carbonate concretions, well-indurated, at Section 1, 85 cm and Section 4, 125 cm. Occasional mud lamination, light bluish gray (5B 7/1).

SMEAR SLIDES

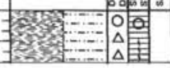
	Mud 2-25 (D)
TEXTURE:	
Sand	2
Silt	33
Clay	65
COMPOSITION:	
Quartz	25
Feldspar	1
Mica	1
Pyrite	2
Clay	65
Carb. unspec.	1
Foraminifers	2
Nannofossils	1
Radiolarians	TR
Diatoms	TR
Sponge spicules	1

GRAIN SIZE

	2-25
Sand	0.3
Silt	42.8
Clay	56.9

SITE 493 HOLE CORE 23 CORED INTERVAL 319.5–329.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	NN 11 *Ommartartus penultimus*	FM	CM	B		1, CC	

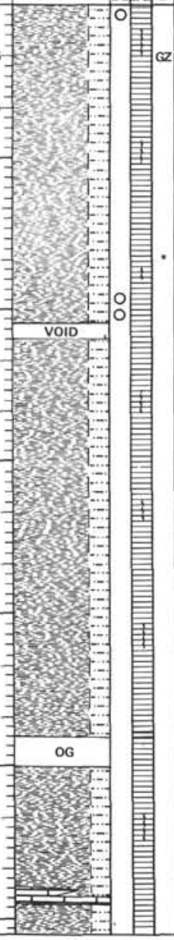


LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE and MUDSTONE, olive gray (5Y 3/2). Fissile, very small burrows, parallel laminations, drilling biscuits. At Section 1, 10–15 cm, calcareous concretion.

SITE 493 HOLE CORE 24 CORED INTERVAL 329.0–338.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
UPPER MIOCENE	NN 11 *Ommartartus antepenultimus*	RP	RP	FG		1, 2, 3, 4, 5, 6, CC	0.5, 1.0



LITHOLOGIC DESCRIPTION

MUDSTONE, with interbeds of MUDDY SILTSTONE, olive gray (5Y 3/2), subtle parallel laminations, small-scale burrows, fissile subparallel to bedding (except as noted), occasional to common inclined slickensided fractures. Drilling biscuits. Carbonate-rich, light olive gray (5Y 5/2) areas evident throughout. True dip of bedding <5° throughout core. Fissility sub-vertical at Section 1, 90–100 cm, Section 2, 0–100 cm, and Section 4, 0–85 cm.

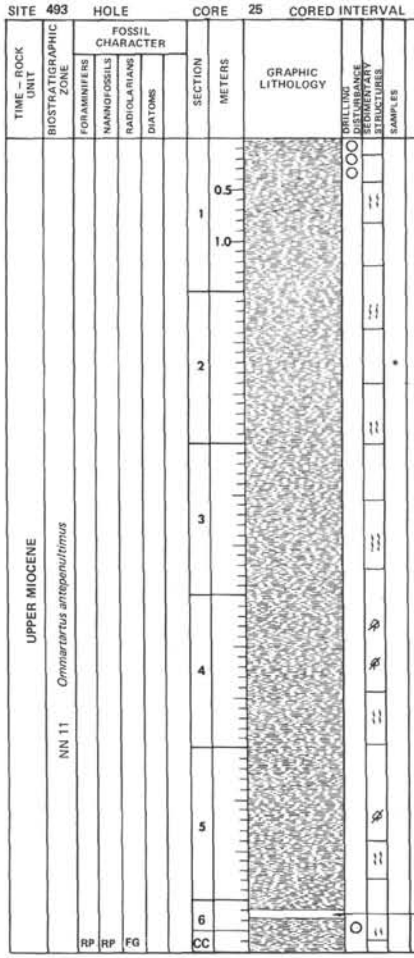
SMEAR SLIDES

	Mud 2-100 (D)
TEXTURE:	
Sand	3
Silt	37
Clay	60
COMPOSITION:	
Quartz	35
Feldspar	5
Mica	TR
Heavy minerals	TR
Pyrite	2
Clay	50
Glauconite	TR
Carb. unspec.	2
Foraminifers	2
Nannofossils	1
Radiolarians	TR
Diatoms	1
Sponge spicules	2
Plant fragments	TR

GRAIN SIZE

	1-50
Sand	0.1
Silt	32.3
Clay	67.6

SITE 493 HOLE CORE 25 CORED INTERVAL 338.5–348.0 m



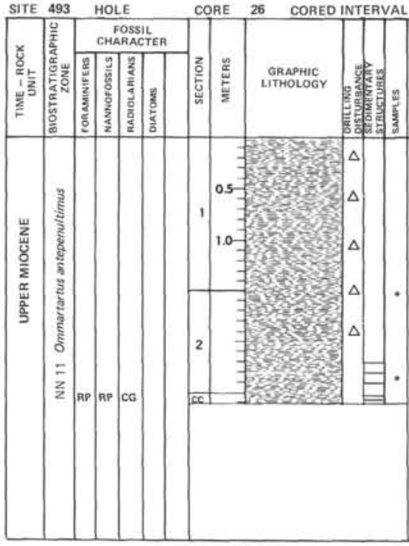
LITHOLOGIC DESCRIPTION

MUDSTONE, olive gray (5Y 3/2), subtle parallel laminations defined by flattened and aligned burrows (small). Moderate bioturbation, fissile subparallel to bedding, bedding is horizontal. Rare to occasional inclined, slickensided fractures. Drilling biscuits. Carbonate-rich layers and pods, light olive gray (5Y 5/2) at Section 1, 81 cm and 106 cm; Section 2, 42 cm and 94 cm; Section 3, 118 cm; Section 4, 31 cm; and Section 5, 64 cm. Carbonized wood fragments as shown.

SMEAR SLIDES

	Mud 2-70 (D)
TEXTURE:	
Sand	2
Silt	33
Clay	65
COMPOSITION:	
Quartz	25
Feldspar	1
Mica	1
Pyrite	1
Clay	65
Carb. unspec.	TR
Foraminifers	2
Nannofossils	TR
Radiolarians	1
Diatoms	1
Sponge spicules	3

SITE 493 HOLE CORE 26 CORED INTERVAL 348.0–357.5 m



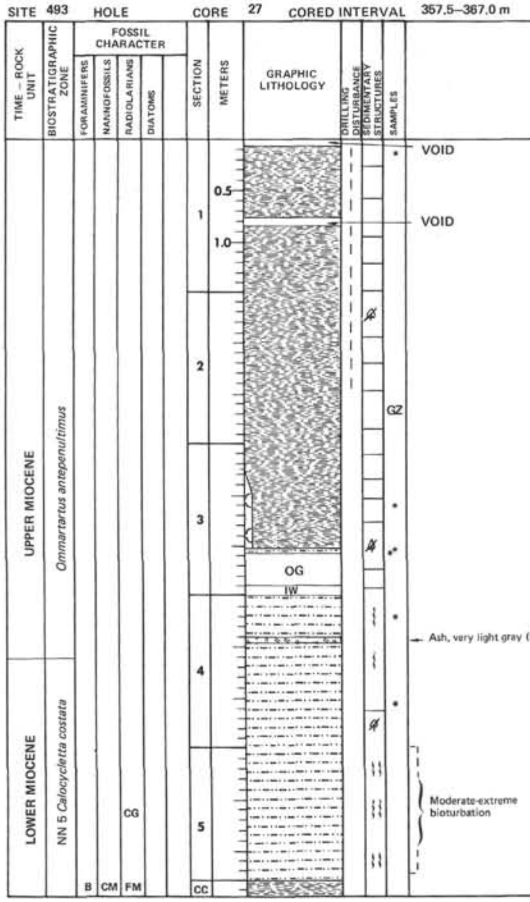
LITHOLOGIC DESCRIPTION

MUDSTONE, olive gray (5Y 3/2). Below Section 2, 75 cm, vague horizontal laminations, sub-parallel horizontal fractures locally. Deviation 3.0°.

SMEAR SLIDES

	Mud 2-6 (D)	Mud 2-82 (D)
TEXTURE:		
Sand	2	–
Silt	30	20
Clay	68	80
COMPOSITION:		
Quartz	24	13
Feldspar	4	5
Mica	1	TR
Pyrite	1	2
Clay	65	80
Carb. unspec.	1	–
Foraminifers	1	–
Nannofossils	TR	–
Radiolarians	TR	–
Diatoms	TR	TR
Sponge spicules	3	TR
Silicoflagellates	–	TR

SITE 493 HOLE CORE 27 CORED INTERVAL 357.5–367.0 m



LITHOLOGIC DESCRIPTION

MUDSTONE, olive gray (5Y 3/2), locally siliceous, parallel laminations in places to Section 3, 102 cm. Organic (woody) fragments as shown. Drilling biscuits common. MUDDY SILTSTONE, grayish olive (10Y 4/2), slightly bioturbated, occasional sponges and fragments from Section 3, 102 cm to Section 5, 132 cm. MUDSTONE, grayish olive (10Y 4/2), structureless in Core-Catcher.

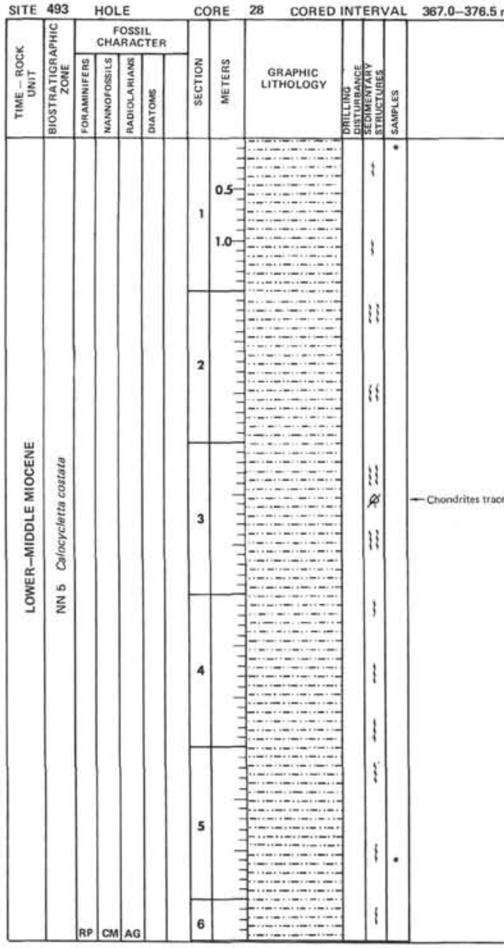
SMEAR SLIDES

	Mud 1-17 (D)	Mud 3-62 (D)	Siliceous mud 3-103 (M)	Muddy silt 3-106 (M)	Muddy silt 4-27 (D)	Muddy silt 4-108 (D)
TEXTURE:						
Sand	1	1	2	10	5	10
Silt	40	40	40	70	65	65
Clay	59	59	58	20	30	25
COMPOSITION:						
Quartz	35	33	26	63	55	61
Feldspar	4	4	5	7	8	6
Mica	1	TR	TR	2	3	3
Heavy minerals	–	–	–	1	TR	1
Pyrite	1	1	1	TR	1	TR
Clay	55	55	55	20	30	25
Glass	–	–	–	TR	–	TR
Carb. unspec.	1	TR	1	1	2	1
Foraminifers	1	–	1	–	TR	–
Radiolarians	TR	TR	TR	–	TR	TR
Diatoms	TR	1	1	TR	TR	3
Sponge spicules	3	6	10	–	TR	TR
Silicoflagellates	–	TR	TR	–	–	–

GRAIN SIZE

	2-118
Sand	0.3
Silt	39.5
Clay	60.2

SITE 493 HOLE CORE 28 CORED INTERVAL 367.0–376.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, grayish olive (10Y 4/2), fissile, bioturbated in places, drilling biscuits. Organic (woody) material as shown. Section 5 downward, fractures increase, straight, open steep and vertical fractures, offset by drilling laminations in several places.

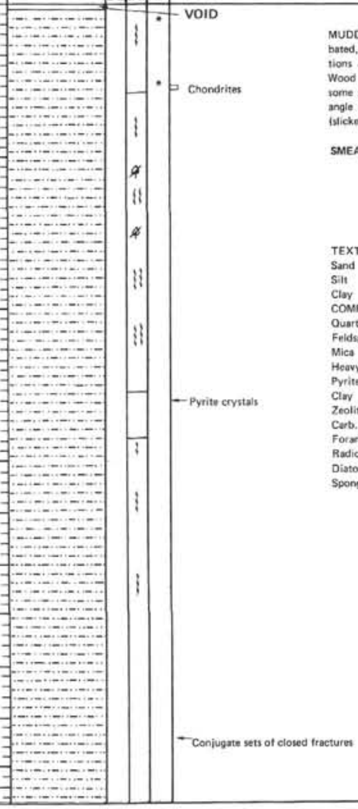
SMEAR SLIDES

	Muddy silt 1-10 (D)	Muddy silt 5-111 (D)
TEXTURE:		
Sand	12	4
Silt	58	61
Clay	30	35
COMPOSITION:		
Quartz	58	58
Feldspar	4	6
Mica	2	3
Pyrite	1	
Clay	30	30
Glass	TR	TR
Glauconite	TR?	–
Carb. unspec.	2	–
Foraminifers	–	TR
Nannofossils	TR	TR
Radiolarians	TR	TR
Diatoms	4	TR
Sponge spicules	TR	2
Silicoflagellates	TR	TR

SITE 493 HOLE CORE 29 CORED INTERVAL 376.5–386.0 m

TIME – ROCK UNIT: LOWER–MIDDLE MIOCENE
BIOSTRATIGRAPHIC ZONE: NN 5 *Calocycletta costata*
FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS AM; RADIOLARIANS AG; DIATOMS
SECTION: 1, 2, 3, 4, 5, 6, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, grayish olive (10Y 4/2), bioturbated, occasional beds of different shades, drilling laminations and biscuits. Fractures, slightly inclined (0–18°). Wood debris and sponges as shown. Fractures increase, some slickensided (steeper fractures don't have them, low angle ones do). In Section 4, fractures dip 10–20° true (slickensides) or 0–63° true (without slickensides).

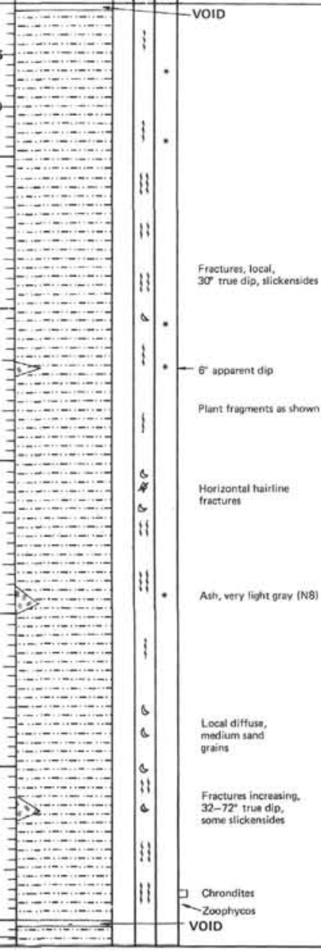
SMEAR SLIDES

	Muddy silt 1-19 (D)	Muddy silt (fine) 1-80 (M)
TEXTURE:		
Sand	3	–
Silt	67	80
Clay	30	20
COMPOSITION:		
Quartz	60	67
Feldspar	5	7
Mica	2	3
Heavy minerals	TR	TR
Pyrite	TR	2
Clay	30	20
Zeolite	–	TR
Carb. unspec.	2	1
Foraminifers	TR	–
Radiolarians	TR	–
Diatoms	TR	–
Sponge spicules	TR	–

SITE 493 HOLE CORE 30 CORED INTERVAL 386.0–395.5 m

TIME – ROCK UNIT: LOWER MIOCENE
BIOSTRATIGRAPHIC ZONE: NN 4 *Calocycletta costata*
FOSSIL CHARACTER: FORAMINIFERS RP; NANNOFOSSILS CG; RADIOLARIANS CG; DIATOMS
SECTION: 1, 2, 3, 4, 5, 6, 7, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

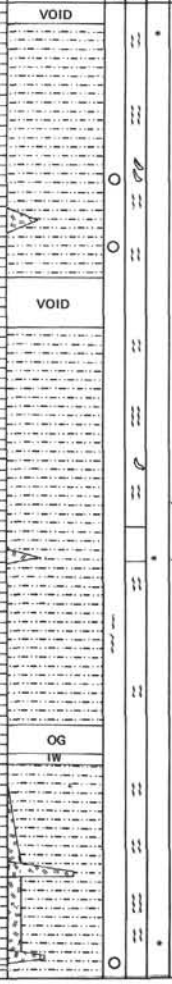
MUDDY SILTSTONE, grayish olive (10Y 4/2), local bioturbation, drilling laminations and a few drilling biscuits. Local ASH layers, lighter gray (N8) and pockets of MUD (Smear Slide identification only).

SMEAR SLIDES

	Mud 1-67 (D)	Muddy silt 1-134 (D)	Mud 3-12 (M)	Ash 3-58 (M)	Muddy silt 4-134 (D)	Ash 4-137 (M)
TEXTURE:						
Sand	2	5	8	–	5	–
Silt	40	55	30	85	60	–
Clay	58	40	62	15	35	–
COMPOSITION:						
Quartz	34	56	32	4	55	5
Feldspar	5	4	15	1	6	3
Mica	4	2	1	TR	4	TR
Heavy minerals	TR	TR	TR	TR	TR	–
Pyrite	1	TR	TR	TR	TR	TR
Clay	50	35	50	15	35	–
Glass	–	–	TR	78	TR	92
Carb. unspec.	3	3	2	2	–	–
Foraminifers	–	TR	TR	–	TR	–
Nannofossils	1	TR	TR	TR	TR	TR
Radiolarians	2	TR	TR	–	TR	TR
Diatoms	TR	TR	TR	–	TR	TR
Sponge spicules	TR	TR	TR	–	TR	–

SITE 493 HOLE CORE 31 CORED INTERVAL 395.5–405.0 m

TIME – ROCK UNIT: LOWER MIOCENE
BIOSTRATIGRAPHIC ZONE: NN 4 *Calocycletta costata*
FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS CM; RADIOLARIANS FG; DIATOMS
SECTION: 1, 2, 3, 4, 5, 6, 7, CC
METERS: 0.5, 1.0
GRAPHIC LITHOLOGY: VOID (Section 1 top); VOID (Section 2/3); OG, IW (Section 5)



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Horizontal fractures, minor slickensides, 10° apparent dip

17° apparent dip, dispersed micro-cross sand grains

Muddy siltstone becomes vitric

Fractures dip 12°, slickensided

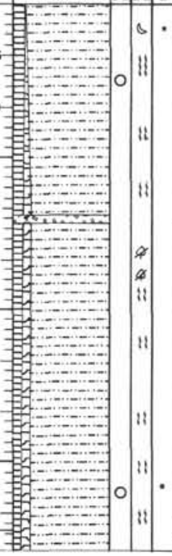
MUDDY SILTSTONE, grayish olive (10Y 4/2), bioturbated, extensive drilling biscuits with minor TUFF beds very light gray (N8). Shell fragments as shown. Below Section 3, 100 cm, fractures, 85° apparent dips, subhorizontal slickensides on these planes (Section 3 only). Section 5, vertical and horizontal fractures, minor slickensides on horizontal ones.

SMEAR SLIDES

	Muddy silt	Sand medium and coarse	Vitric muddy silt
	1-30 (D)	4-99 (M)	7-22 (D)
TEXTURE:			
Sand	2	85	1
Silt	58	10	59
Clay	40	5	40
COMPOSITION:			
Quartz	38	76	42
Feldspar	5	10	4
Mica	2	1	1
Heavy minerals	TR	TR	TR
Pyrite	1	10	TR
Clay	40	5	40
Glass	TR	–	10
Glauconite	–	TR	–
Carb. unspec.	4	1	2
Nannofossils	2	–	1
Radiolarians	5	–	–
Diatoms	TR	TR	–
Sponge spicules	3	–	–

SITE 493 HOLE CORE 32 CORED INTERVAL 405.0–414.5 m

TIME – ROCK UNIT: LOWER MIOCENE
BIOSTRATIGRAPHIC ZONE: NN 4 *Calocycletta costata*
FOSSIL CHARACTER: FORAMINIFERS CM; NANNOFOSSILS CM; RADIOLARIANS AG; DIATOMS
SECTION: 1, 2, 3, 4, CC
METERS: 0.5, 1.0
GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

12° apparent dip

26° apparent dip

30° apparent dip

MUDDY SILTSTONE, calcareous at the top, becoming radiolarian-rich with depth. Grayish olive (10Y 4/2), bioturbated, open fractures throughout, with some slickensides, 0–56° fracture planes, reverse throw on one fracture. Laminated tuff, light gray (N7) in Section 2. Local drilling laminations, biscuits and fissile zones throughout. In Core-Catcher, coarse sand concentration.

SECTION 2:

SMEAR SLIDES

	Calcareous muddy silt	Radiolarian muddy silt
	1-24 (D)	4-29 (D)
TEXTURE:		
Sand	3	2
Silt	57	68
Clay	40	30
COMPOSITION:		
Quartz	39	41
Feldspar	5	4
Mica	3	2
Heavy minerals	TR	TR
Pyrite	TR	1
Clay	40	30
Carb. unspec.	10	8
Foraminifers	TR	TR
Nannofossils	1	1
Radiolarians	1	10
Diatoms	–	TR
Sponge spicules	1	2
Silicoflagellates	–	1

SITE 493 HOLE CORE 33 CORED INTERVAL 414.5–424.0 m

TIME – ROCK UNIT: LOWER MIOCENE

BIOSTRATIGRAPHIC ZONE: *Calocycletta costata*

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

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

10° dip

Shell fragments as shown

Minor vertical irregular hairline fractures

Fine sand laminations

MUDDY SILTSTONE, radiolarian-rich above Section 1, 135 cm, grayish olive (10Y 4/2), bioturbated with TUFF, very light gray (N7). Local calcareous, well-indurated bands. Section 2 and below, drilling laminations and biscuits. Woody fragments as shown. At Section 4, 135 cm and Section 5, 15 cm, dispersed fine sand grains.

SMEAR SLIDES

	Radiolarian muddy silt	Ash	Muddy silt	Mud
	1-26 (D)	1-117 (M)	1-137 (D)	1-137 (M)
TEXTURE:				
Sand	3	20	5	–
Silt	67	75	65	40
Clay	30	5	30	60
COMPOSITION:				
Quartz	40	25	53	33
Feldspar	4	5	4	4
Mica	4	3	1	TR
Pyrite	TR	TR	1	TR
Clay	30	5	30	60
Glass	–	60	5	2
Carb. unspec.	1	2	1	–
Foraminifers	TR	–	–	–
Nannofossils	TR	–	–	–
Radiolarians	20	TR	4	TR
Diatoms	TR	–	–	TR
Sponge spicules	1	–	1	TR
Silicoflagellates	TR	–	–	–

SITE 493 HOLE CORE 34 CORED INTERVAL 424.0–433.5 m

TIME – ROCK UNIT: LOWER MIOCENE

BIOSTRATIGRAPHIC ZONE: *Calocycletta costata*

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

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

32° apparent dip fracture, oblique slip on slickensides
52° true dip fracture, normal slip on slickensides

6° apparent dip beds

MUDDY SILTSTONE, grayish olive (10Y 4/2), bioturbated, some bedding traces, rare drilling laminations (local only). A few very shallow inclination planes, no slickensides. True dips range from 3–17°.

7° apparent dip beds

3° apparent dip beds

6° apparent dip beds

SMEAR SLIDES

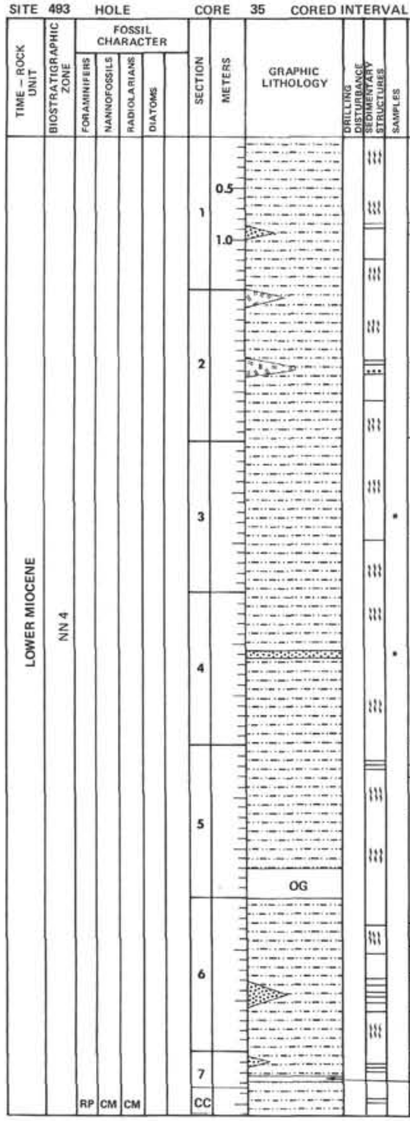
	Muddy so?t	Devitrified ash	Muddy silt	Silt
	1-12 (D)	4-148 (M)	5-95 (D)	6-52 (M)
TEXTURE:				
Sand	1	–	7	20
Silt	59	80	63	70
Clay	40	20	30	10
COMPOSITION:				
Quartz	44	2	62	69
Feldspar	5	TR	8	15
Mica	3	3	TR	4
Heavy minerals	–	–	TR	1
Pyrite	TR	–	TR	1
Clay	40	20	30	10
Glass	3	75	TR	TR
Zeolite	–	–	TR	–
Carb. unspec.	TR	–	TR	TR
Radiolarians	4	–	TR	–
Sponge spicules	1	–	TR	–
Silicoflagellates	TR	–	TR	–

Tuff, very light gray (N8)

Devitrified tuff, light olive gray (5Y 6/1)

0–20° apparent dip

SITE 493 HOLE CORE 35 CORED INTERVAL 433.5–443.0 m



LITHOLOGIC DESCRIPTION

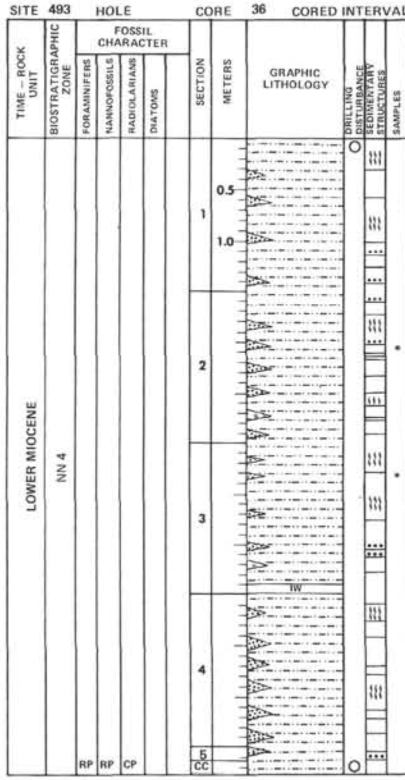
- 13° true dip
- 25° dipping fracture, dip slip
- Fine sand layers
- 11° true dip
- Devitrified tuff
- Devitrified tuff, graded and parallel laminated
- Fine sand layer
- 6° true dip
- 9° true dip
- Fine sand layer
- 9° true dip Muddy fine sand
- 8° true dip
- Fine sand layers
- 2° true dip
- 5° true dip
- Fine sand layers
- Fine sand layers
- VOID
- Fine sand layers

MUDDY SILTSTONE, dark greenish gray (5GY 4/1). Intensely bioturbated, occasional drilling lamination and biscuits, diffuse fine sand and muddy fine sand.

SMEAR SLIDES

	Muddy silt	Fine muddy sand
	3-72 (D)	4-60 (M)
TEXTURE:		
Sand	2	60
Silt	55	35
Clay	45	5
COMPOSITION:		
Quartz	50	75
Feldspar	6	10
Mica	3	5
Heavy minerals	TR	2
Pyrite	1	5
Clay	40	3
Glass	TR	–
Glauconite	TR	–
Carb. unspec.	TR	–
Nannofossils	TR	–
Diatoms	TR	–
Sponge spicules	TR	–

SITE 493 HOLE CORE 36 CORED INTERVAL 443.0–452.5 m



LITHOLOGIC DESCRIPTION

- Chondrites
- 12° true dip
- 8° true dip
- 9° true dip
- Chondrites
- Divitrified tuff
- Devitrified tuff
- 9° true dip
- Devitrified tuff
- Carbonate rich area
- 4° true dip

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), with thin layers (up to 1 cm) of fine sand. Intense bioturbation, sand mixed with matrix. Rare inclined fractures. At Section 2, 35–108 cm, drilling biscuits. Fine sand layers spaced 7–10 cm apart in Section 2. Section 3, fine sand layers as shown. Sections 4 and 5, fine sands interbedded every 10 cm.

SMEAR SLIDES

	Muddy silt	Muddy silt
	2-58 (D)	3-32 (M)
TEXTURE:		
Sand	5	35
Silt	60	40
Clay	35	25
COMPOSITION:		
Quartz	52	62
Feldspar	4	5
Mica	3	5
Heavy minerals	TR	1
Pyrite	1	2
Clay	40	25
Carb. unspec.	TR	TR
Nannofossils	TR	–
Sponge spicules	TR	–

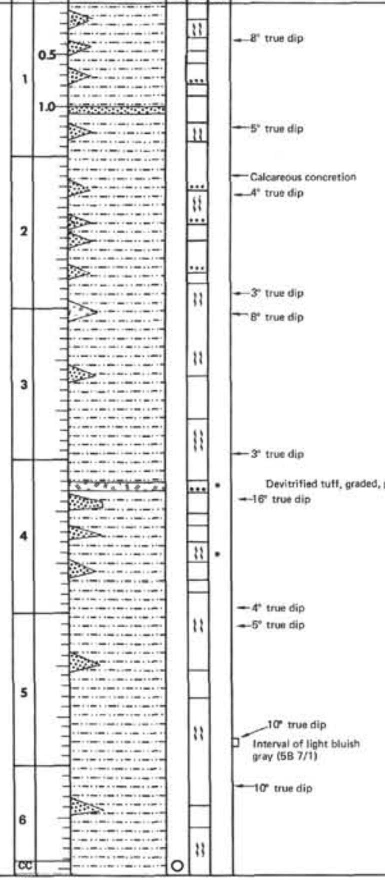
SITE 493 HOLE CORE 37 CORED INTERVAL 452.5–462.0 m

TIME – ROCK UNIT: LOWER MIOCENE

BIOSTRATIGRAPHIC ZONE: NN 4

FOSSIL CHARACTER (CC): Foraminifers RP, Nannofossils CP, Radiolarians CP

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



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), bioturbated, overprints primary parallel laminations, rare inclined, slickensided fractures with fine SAND beds and devitrified tuff layers. Section 1, fine sand beds every 10 cm, some graded. Section 2, fine sands as shown. Section 3, sands rare. Section 4, sands every 20 cm. Section 5, sands sparse. Section 6, sands sparse. Hole deviation 3.2°.

SMEAR SLIDES	Devitrified ash	Muddy silt
	4-25 (M)	4-90 (D)
TEXTURE:		
Sand	4	5
Silt	96	65
Clay	–	30
COMPOSITION:		
Quartz	3	60
Feldspar	–	5
Mica	1	2
Pyrite	–	TR
Clay	–	30
Glass	96	–
Carb. unspec.	–	2
Nannofossils	–	TR
Radiolarians	–	1

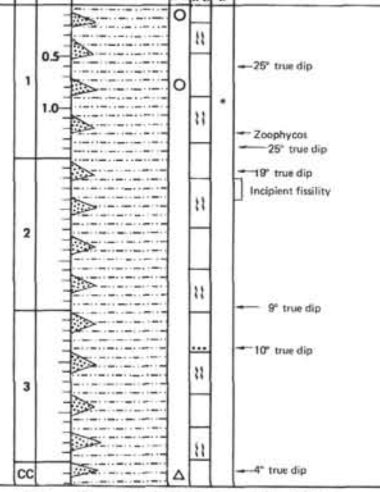
SITE 493 HOLE CORE 38 CORED INTERVAL 462.0–471.5 m

TIME – ROCK UNIT: LOWER MIOCENE

BIOSTRATIGRAPHIC ZONE: NN 4

FOSSIL CHARACTER (CC): Foraminifers RP, Nannofossils FP, Radiolarians CP

SECTION: 1, 2, 3, CC



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), moderate bioturbation, vague parallel laminations, fine sand layers interbedded, up to 1 cm thick, discrete inclined, slickensided fractures. Sands every 20–30 cm throughout. Section 2, fractures 18–56°, both dip slip and oblique slip motion. Section 3, fractures 50–78°, dip slip, one is strike slip (dips 78°).

SMEAR SLIDES	Muddy silt
	1-99 (D)
TEXTURE:	
Sand	2
Silt	63
Clay	35
COMPOSITION:	
Quartz	58
Feldspar	3
Mica	2
Heavy minerals	TR
Pyrite	TR?
Clay	35
Carb. unspec.	2
Nannofossils	TR
Sponge spicules	TR

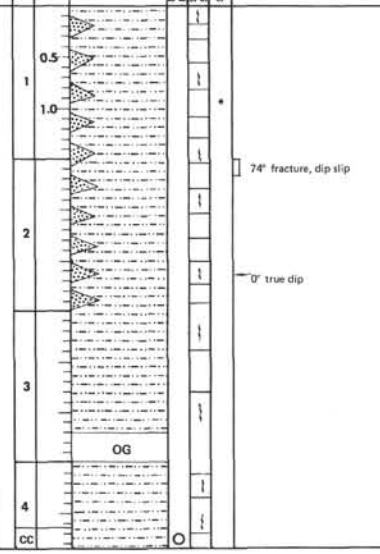
SITE 493 HOLE CORE 39 CORED INTERVAL 471.5–481.0 m

TIME – ROCK UNIT: LOWER MIOCENE

BIOSTRATIGRAPHIC ZONE: NN 4

FOSSIL CHARACTER (CC): Foraminifers CP, Nannofossils RP, Radiolarians CP

SECTION: 1, 2, 3, 4, CC

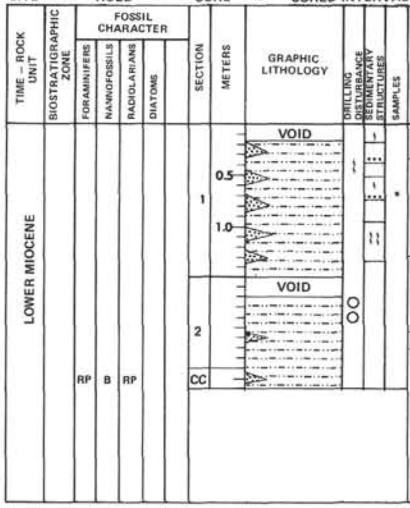


LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), bioturbated, vague bedding, occasional inclined, slickensided fractures. Sections 1 and 2, thin fine sands every 20 cm. Section 1, one vertical fracture, dip slip motion. Local drilling biscuits. Extensive drilling biscuits the rest of core. Section 3, bedding subhorizontal.

SMEAR SLIDES	Muddy silt
	1-99 (D)
TEXTURE:	
Sand	2
Silt	68
Clay	30
COMPOSITION:	
Quartz	60
Feldspar	5
Mica	2
Pyrite	1
Clay	30
Carb. unspec.	2
Nannofossils	TR
Diatoms	TR
Sponge spicules	TR

SITE 493 HOLE CORE 40 CORED INTERVAL 481.0–490.5 m



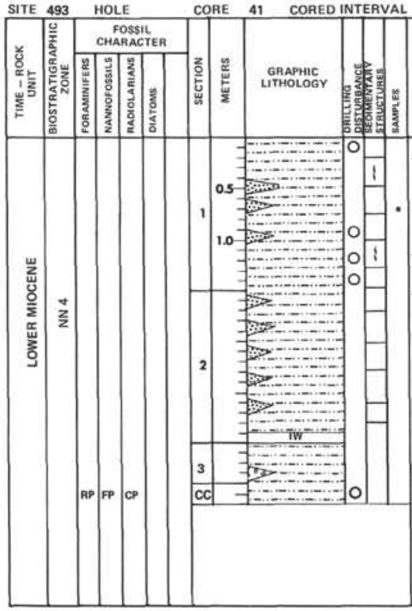
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), slight to moderate bioturbation, vague banding, common to abundant (to 2 cm) fine sand layers, some graded. Sands every 20 cm.

SMEAR SLIDES

	Muddy silt
	1-70 (D)
TEXTURE:	
Sand	3
Silt	67
Clay	30
COMPOSITION:	
Quartz	62
Feldspar	4
Mica	3
Heavy minerals	TR
Pyrite	1
Clay	30
Carb. unspec.	TR
Nannofossils	TR

SITE 493 HOLE CORE 41 CORED INTERVAL 490.5–500.0 m



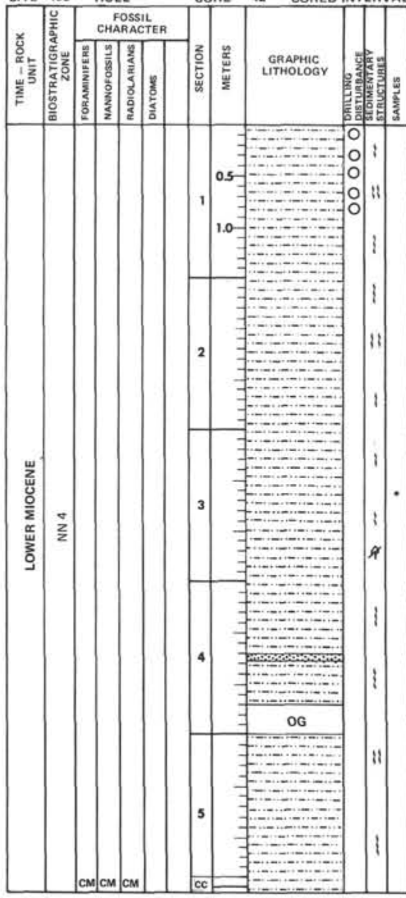
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), slightly bioturbated, parallel laminated, sparse to common thin, fine SAND layers and devitrified TUFF (light olive gray, 5Y 6/1). Common inclined, slickensided fractures. At Section 1, 80–100 cm, 115–150 cm, very fractured area – fault zone? Bedding tilted to 40°, fissility. Section 2, local drilling biscuits. Sand 5–10% of core.

SMEAR SLIDES

	Fine sand
	1-70 (M)
TEXTURE:	
Sand	80
Silt	10
Clay	10
COMPOSITION:	
Quartz	78
Feldspar	5
Mica	4
Heavy minerals	2
Clay	10
Carb. unspec.	1

SITE 493 HOLE CORE 42 CORED INTERVAL 500.0–509.5 m



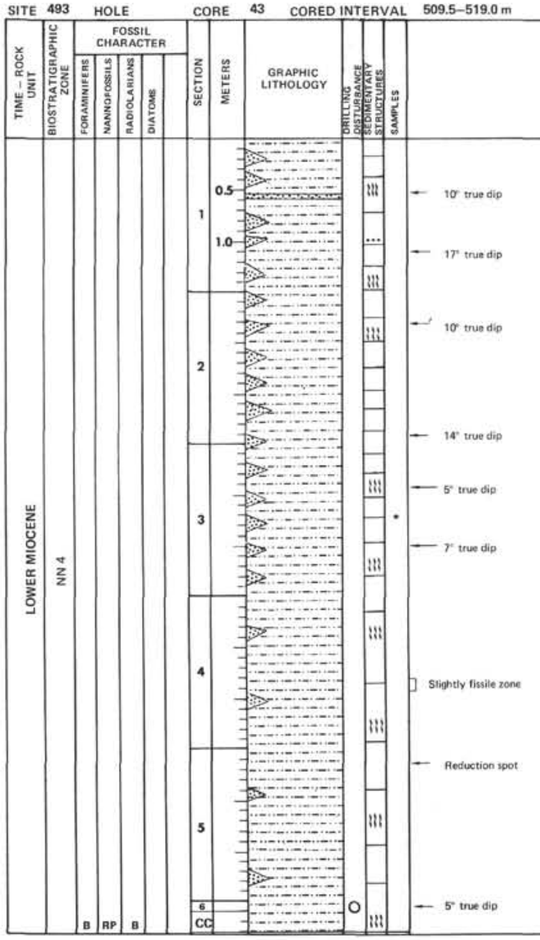
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, olive gray (5Y 3/2), slight to moderate bioturbation, vague bedding with bands of muddy siltstone, light bluish gray (5B 7/1), locally up to half of core area. Bands are 2–4 cm. One fine sand layer. Rare to common inclined, slickensided fractures.

SMEAR SLIDES

	Muddy silt
	3-66 (D)
Sand	2
Silt	58
Clay	40
COMPOSITION:	
Quartz	62
Feldspar	3
Mica	2
Pyrite	1
Clay	40
Carb. unspec.	1
Nannofossils	TR
Diatoms	1

SITE 493 HOLE CORE 43 CORED INTERVAL 509.5–519.0 m



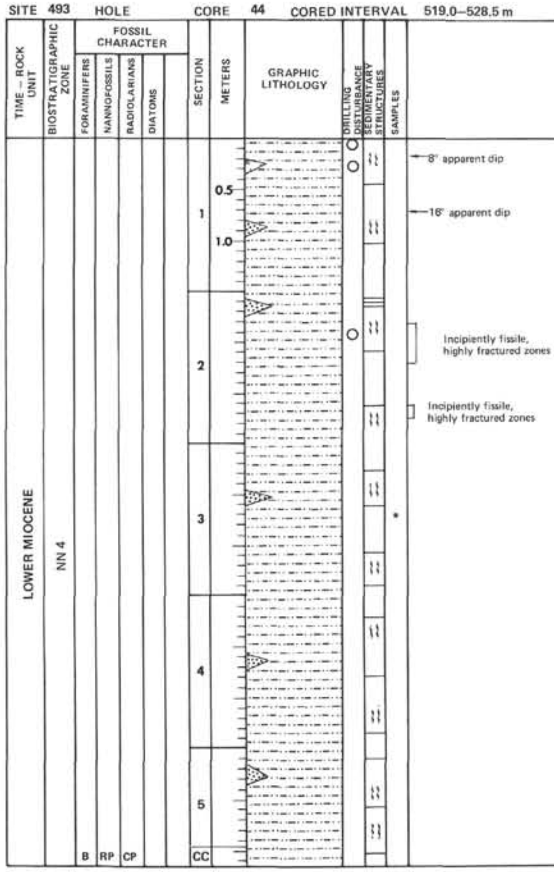
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), intense bioturbation, banded (mostly horizontal burrows), sparse inclined, slickensided fractures. Thin (up to 2 cm) fine SAND layers. In Sections 1, 2, and 3, sands every 10 cm but in Sections 4 and 5, sand beds are sparse. Section 2, 75° fracture, dip slip and 43° fracture, strike slip. Section 4, fractures dip 21–74°, dip slip. At Section 5, very fractured, inclined to vertical.

SMEAR SLIDES

	Muddy silt 3-75 (D)
TEXTURE:	
Sand	3
Silt	57
Clay	40
COMPOSITION:	
Quartz	54
Feldspar	3
Mica	2
Heavy minerals	TR
Pyrite	TR
Clay	40
Carb. unspec.	1
Diatoms	TR

SITE 493 HOLE CORE 44 CORED INTERVAL 519.0–528.5 m



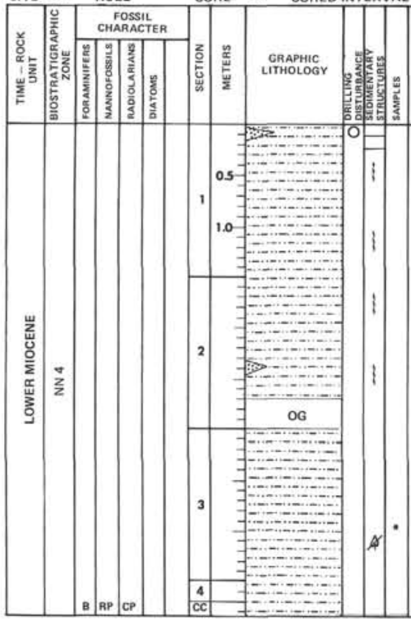
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), moderate bioturbation, vague horizontal laminations, drilling biscuits, common inclined and slickensided fractures with ash, greenish gray (5G 8/1) and sparse thin (up to 1 cm) fine sand layers. Section 2, vertical fracture, dip slip.

SMEAR SLIDES

	Muddy silt 3-70 (D)
TEXTURE:	
Sand	2
Silt	63
Clay	35
COMPOSITION:	
Quartz	58
Feldspar	3
Mica	1
Pyrite	1
Clay	35
Carb. unspec.	2
Nannofossils	TR
Diatoms	TR

SITE 493 HOLE CORE 45 CORED INTERVAL 528.5–538.0 m



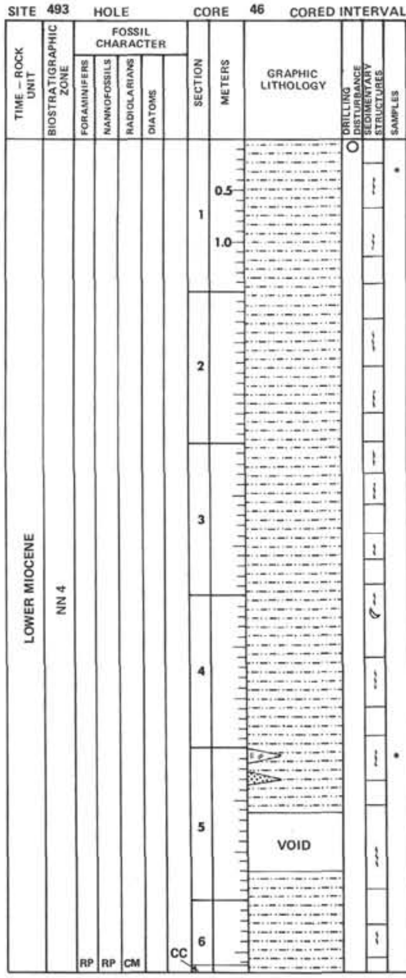
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, grayish olive (10Y 4/2), slight bioturbation locally, abundant drilling biscuits. Minor fine sand beds and pods, very thin. Section 2, open fractures, 0–60° dip, slickensides, normal slip on one. Section 3, 105–150 cm and Section 4, 0–21 cm, straight and irregular fractures, 0–27° apparent dip, some slickensides.

SMEAR SLIDES

	Muddy silt
	3-95 (D)
TEXTURE:	
Sand	12
Silt	63
Clay	15
COMPOSITION:	
Quartz	73
Feldspar	6
Mica	4
Heavy minerals	1
Pyrite	1
Clay	15
Glass	TR?
Carb. unspec.	TR
Nannofossils	TR
Radiolarians	TR

SITE 493 HOLE CORE 46 CORED INTERVAL 538.0–547.5 m



LITHOLOGIC DESCRIPTION

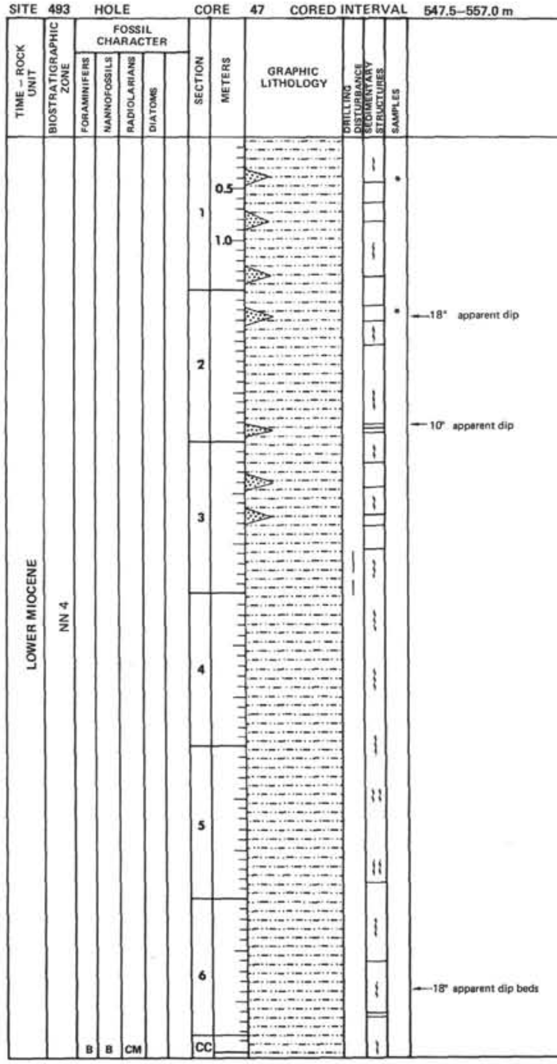
MUDDY SILTSTONE, dark greenish gray (5GY 4/1), slight bioturbation, vague subhorizontal bedding laminations, incipient fissility, drilling biscuits with devitrified ASH layer and fine SAND pod. Section 1, fracture 54° true dip, vertical slickensides. Sections 2 and 3, hairline fractures, common discrete fractures. One inclined, straight, slickensided – 50° true dip, normal slip. Sections 4 and 5, hairline fractures, some straight fractures (0–64° dip).

SMEAR SLIDES

	Muddy silt	Devitrified ash
	1-30 (D)	5-10 (M)
TEXTURE:		
Sand	4	–
Silt	78	90
Clay	18	10
COMPOSITION:		
Quartz	71	TR
Feldspar	6	TR
Mica	4	TR
Heavy minerals	TR	TR
Pyrite	TR	–
Clay	18	–
Glass	–	100
Carb. unspec.	1	–

Shell fragments as shown

SITE 493 HOLE CORE 47 CORED INTERVAL 547.5–557.0 m



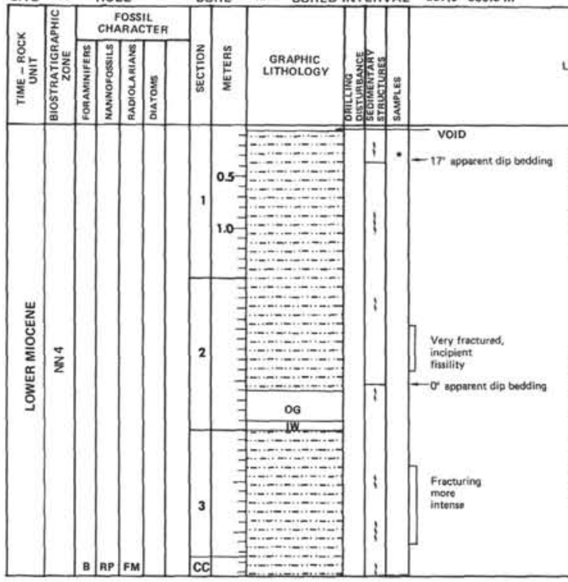
LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5G 4/1), slight bioturbation, local drilling biscuits and laminations. Very fine to fine sand pods and laminations in first three sections. At Section 1, 38 cm and 42 cm, pyritic fine sand pods, olive black (5Y 2/1). Section 1, up to 23° apparent dip bedding. Compact, minor fractures, often parallel to bedding, local fissility. At Section 1, 94–119 cm, numerous inclined fractures (up to 60° true dip) with slickensides. Sections 2 and 3, few fractures, mostly steep (up to 75° true dip), some slickensides. Sections 4 and 5, some low angle fractures, healed irregular hairline fractures. Section 6, hairline fractures, 0–78° apparent dip.

SMEAR SLIDES

	Pyritic fine sand	Muddy silt
	1-42 (M)	2-20 (D)
TEXTURE:		
Sand	80	5
Silt	15	75
Clay	5	20
COMPOSITION:		
Quartz	72	68
Feldspar	5	6
Mica	2	4
Heavy minerals	1	1
Pyrite	20	1
Clay	–	20
Glass	–	TR
Radiolarians	–	TR

SITE 493 HOLE CORE 48 CORED INTERVAL 557.0–566.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, dark greenish gray (5G 4/1), compact, open fractures throughout, slight bioturbation. Section 1, most fractures have slickensides (one reverse fault), 18–85° true dips. At Section 2, 49–86 cm, very fractured, incipient fissility. Section 3, fractures subhorizontal to subvertical, variable orientation, local slickensides.

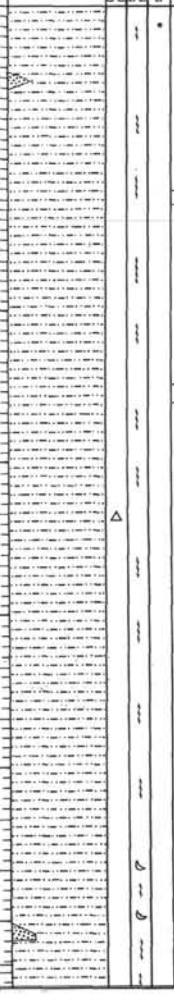
SMEAR SLIDES

	Muddy silt
	1-30 (D)
TEXTURE:	
Sand	5
Silt	75
Clay	20
COMPOSITION:	
Quartz	71
Feldspar	5
Mica	3
Heavy minerals	1
Pyrite	TR
Clay	20

SITE 493 HOLE CORE 49 CORED INTERVAL 566.5–576.0 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER MIOCENE	NN 3	B	RP	CP		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Fissile zone

Incipient fissility

60–30° conjugate fracture set suggests vertical compression

8° apparent dip bedding

Shell fragments as shown

Irregular pod of coarse granular-bearing sand (quartz and metamorphic clasts)

MUDDY SILTSTONE, dark greenish gray (5G 4/1) and minor admixture medium bluish gray (5B 5/1). Slight to moderate bioturbation, bedding traces throughout. Below Section 1, 57 cm, fine sand component with two fine sand pods. Section 1, apparent dips 0–15° on fractures. Section 2, common open fractures, dips 0–68° true, most with slickensides. Section 3, 0–75 cm, profusion gently dipping open fractures with slickensides. Sections 4, 5, and 6, fractures have variable orientations, dips. Many are slickensided.

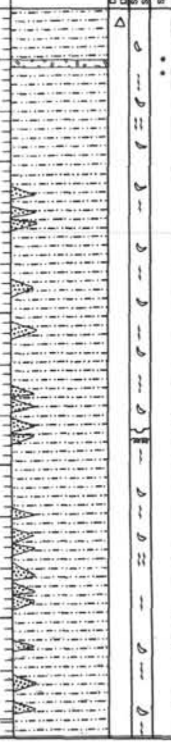
SMEAR SLIDES

	Muddy silt 1-20 (D)
TEXTURE:	
Sand	4
Silt	81
Clay	15
COMPOSITION:	
Quartz	73
Feldspar	8
Mica	3
Heavy minerals	1
Pyrite	TR
Clay	15
Glass	TR

SITE 493 HOLE CORE 50 CORED INTERVAL 576.0–585.5 m

TIME-ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER MIOCENE	NN 3	RP	CM	CP		1, 2, 3, 4, 5, CC	0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

12° apparent dip bedding

Loading and convolute structures, possibly due to liquifaction in part

Closely fractured, 0–90° dip

25° apparent dip bedding

MUDDY SILTSTONE, dark greenish gray (5GY 4/1), slight to moderate bioturbation with one layer of devitrified TUFF, medium light gray (N6) and medium and coarse granular-bearing SAND pods. Fractures, most with slickensides, dip from 0° to very steep. Throughout core, <1 mm to several mm white shell fragments.

SMEAR SLIDES

	Devitrified tuff 1-57 (M)	Muddy silt 1-64 (D)
TEXTURE:		
Sand	–	3
Silt	90	77
Clay	10	20
COMPOSITION:		
Quartz	TR	75
Feldspar	TR	4
Mica	–	4
Pyrite	–	2
Clay	–	15
Glass	100	–
Radiolarians	–	TR

SITE 493 **HOLE** **CORE** 51 **CORED INTERVAL** 585.5–595.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER MIOCENE	NN 3/NN 2	RP	CM	B		1	0.5, 1.0
						CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

— 10° apparent dip bedding

LITHOLOGIC DESCRIPTION

MUDDY SILTSTONE, olive gray (5Y 3/2), prominent and common diffuse concentrations and pods of fine to coarse granular-bearing sands. Slight bioturbation. Shell fragments and wood fragments as shown. Hole deviation 2.6°.

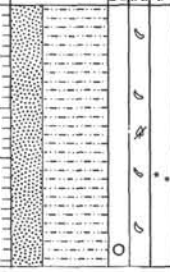
SMEAR SLIDES

	Muddy silt
	1-24
TEXTURE:	(D)
Sand	10
Silt	75
Clay	15
COMPOSITION:	
Quartz	58
Feldspar	15
Mica	4
Heavy minerals	2
Pyrite	1
Clay	15
Glass	TR
Carb. unspec. and shell frags.	5
Foraminifers	TR
Nannofossils	TR

SITE 493 **HOLE** **CORE** 52 **CORED INTERVAL** 595.0–604.5 m

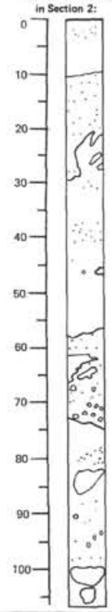
TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
LOWER MIOCENE	NN 2	RP	CP	FM		1	0.5, 1.0
						2	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

Example of mixing in Section 2:



Complex mixture of MUDDY SILTSTONE and SANDSTONE, olive gray (5Y 3/2), rich in quartzose granules and shell fragments. Granules angular to moderately well-rounded. Mixture may be due to loading and/or slumping. Sandstone cemented by calcite. Common straight fractures, 0–90° dip, slickensided, variable orientation.

SMEAR SLIDES

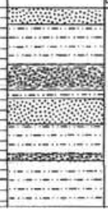
	Sand	Muddy silt
	2-20	2-22
	(M)	(D)
TEXTURE:		
Sand	60	5
Silt	30	70
Clay	10	25
COMPOSITION:		
Quartz	66	65
Feldspar	7	6
Mica	4	4
Heavy minerals	1	1
Pyrite	1	1
Clay	15	20
Carb. unspec.	5	2
Foraminifers	1	TR
Nannofossils	TR	1

Thin Section Description: 1-120 to 122 cm

Calcareous sandstone
80% sand, 20% silt
COMPOSITION:
40% Quartz
40% Feldspar (mostly microcline)
10% Carbonate
10% Foraminifers
Calcite cement

SITE 493 HOLE CORE 53 CORED INTERVAL 604.5–614.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	NN 1?	RP	CM	B		1, 2, CC	0.5, 1.0				*	Interbedded SANDSTONE, calcareous, coarse to very coarse, with shell fragments, and MUDDY SILTSTONE with coarse sand grains. Olive gray (5Y 3/2). Muddy siltstone fissile locally. Sandstone is often muddy.



SMEAR SLIDES

	Muddy silt 1-45 (D)
TEXTURE:	
Sand	30
Silt	55
Clay	15
COMPOSITION:	
Quartz	73
Feldspar	6
Mica	1
Heavy minerals	TR
Pyrite	1
Clay	15
Carb. unspec.	3
Nannofossils	1

SITE 493 HOLE CORE 54 CORED INTERVAL 614.0–623.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	NN 1?	RP	CM	B		1, 2, 3, 4, 5, CC	0.5, 1.0	OG, IW			*	MUDDY SILTSTONE, olive gray (5Y 3/2), fissile subparallel to bedding, bedding faint, bioturbation faint with fine SAND layers. MUDDY SANDSTONE, olive gray (5Y 3/2), calcareous, medium to coarse in Section 5. Section 1, fissility and bedding dip 15–30° true. Section 2, fine sand layers common, bedding up to 22° true, fractures dip 57–85°, dip slip. At Section 2, 115 cm and 130 cm, calcareous coarse SANDSTONE, shell fragments, granitic lithic fragments. Section 3, fissility slightly steeper than bedding. Fractures dip 16° and 72–78°, dip slip. 35 apparent dip bedding. Section 4, fractures dip 9° and 40–74°, dip slip. Section 5, 12° true dip, 19° apparent dip bedding.

← 46° true dip bedding

SMEAR SLIDES

	Muddy silt 1-30 (D)
TEXTURE:	
Sand	35
Silt	50
Clay	15
COMPOSITION:	
Quartz	74
Feldspar	5
Mica	3
Heavy minerals	1
Pyrite	1
Clay	15
Carb. unspec.	1

SITE 493 HOLE CORE 55 CORED INTERVAL 623.5–633.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	Unzoned					CC			O			SAND on side of Core-Catcher – only recovery.

SITE 493 HOLE CORE 56 CORED INTERVAL 633.0–642.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	Unzoned					CC						Small fragment of medium to coarse SANDSTONE, medium light gray (N6) in Core-Catcher, calcite-cemented.

SITE 493 HOLE CORE 57 CORED INTERVAL 642.5–652.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	Unzoned					CC						Small fragment SANDSTONE in Core-Catcher, coarse, calcite-cement.

SITE 493 HOLE CORE 58 CORED INTERVAL 652.0–652.2 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	Unzoned					1					*	FINE SAND, loose, quartzose, possibly washed down the hole from upper section.

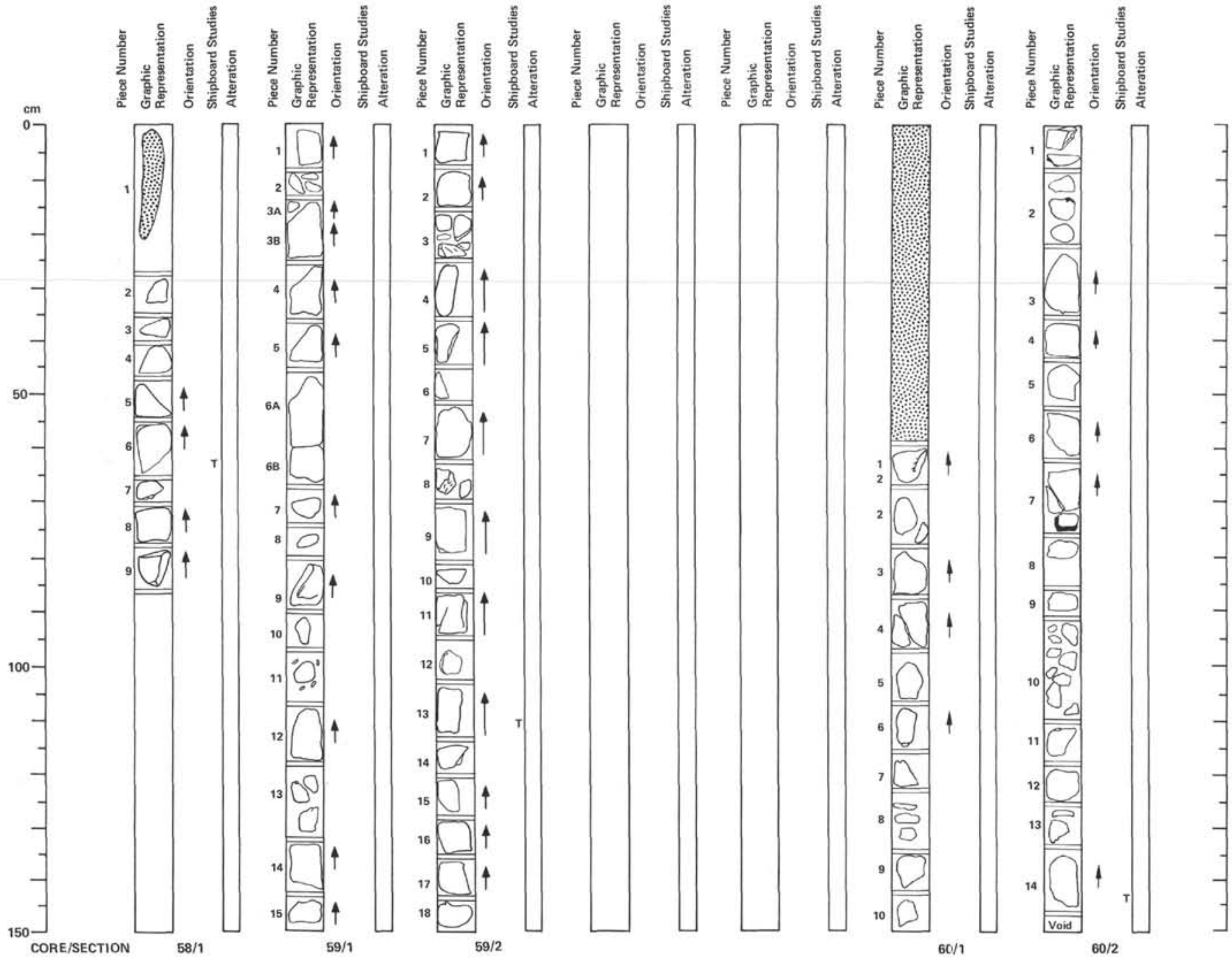
SMEAR SLIDES

	Fine sand, moderately well-sorted
	1-1 (D)
TEXTURE:	
Sand	95
Silt	5
Clay	–
COMPOSITION:	
Quartz	91
Feldspar	6
Mica	1
Heavy minerals	1
Pyrite	1

Core 59: See page 379

SITE 493 HOLE CORE 60 CORED INTERVAL 661.5–662.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
PRE-NEOGENE						1	0.5					Fine to medium sand, greenish gray (5GY 6/1), caved from hole above (originally surrounding pieces of plutonic rock when core opened).



SITE 493, CORE 58, SECTION 1, 652.2–652.8 m

Macroscopic Description
DIORITE, medium light gray (N6). 1–3 mm equant crystals of plagioclase, quartz, hornblende, biotite, and sulfides (pyrite and chalcopyrite).

SITE 493, CORE 59, SECTION 1, 656.5–658.0 m

Macroscopic Description
DIORITE, medium light gray (N6) (average color), up to 3 mm equant crystals of plagioclase, quartz, hornblende, biotite, and sulfides (pyrite and chalcopyrite). Occasional fracturing and veining.

SITE 493, CORE 59, SECTION 2, 658.0–659.5 m

Macroscopic Description
Same as Core 59, Section 1.

SITE 493, CORE 60, SECTION 1, 662.1–663.0 m

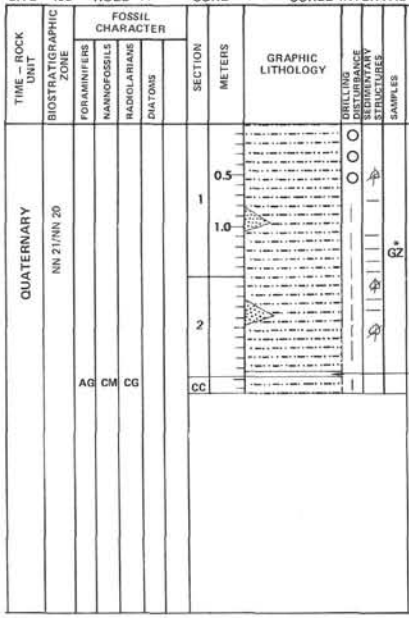
Macroscopic Description
DIORITE, medium light gray (N6).

SITE 493, CORE 60, SECTION 2, 663.0–664.5 m

Macroscopic Description
Same as Core 60, Section 1.

Thin Section Description
Section 2, 139–141 cm: equant crystals up to 2 cm of: 4% quartz, 68% plagioclase, > 1% microcline, 7% biotite, and 20% green amphibole-hornblende.

SITE 493 HOLE A CORE 1 CORED INTERVAL 0.0–2.5 m



VOID

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soft, parallel laminations. Very fine sandy layers (mostly foraminifers), <0.5 cm. Plant debris. Light bluish gray (5B 7/1) laminations.

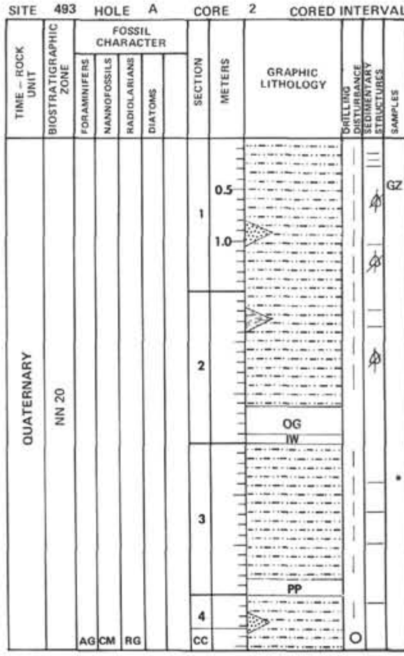
SMEAR SLIDES

	Muddy silt 1-120 (D)
TEXTURE:	
Sand	3
Silt	62
Clay	35
COMPOSITION:	
Quartz	52
Feldspar	4
Mica	2
Heavy minerals	TR
Clay	35
Carb. unspec.	1
Foraminifers	TR
Nannofossils	1
Radiolarians	TR
Diatoms	1
Sponge spicules	2

GRAIN SIZE

	1-130
Sand	1.5
Silt	52.2
Clay	46.4

SITE 493 HOLE A CORE 2 CORED INTERVAL 2.5–12.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soft, parallel laminations, light bluish gray (5B 7/1) laminations. Very thin SAND layers (foraminifers mostly). MUD layer as shown (moderate olive brown – 5Y 4/4).

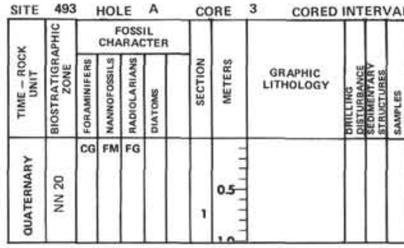
SMEAR SLIDES

	Muddy silt 3-35 (D)
TEXTURE:	
Sand	2
Silt	60
Clay	38
COMPOSITION:	
Quartz	47
Feldspar	3
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	38
Carb. unspec.	1
Foraminifers	1
Nannofossils	1
Radiolarians	1
Diatoms	2
Sponge spicules	2

GRAIN SIZE

	1-50
Sand	5.8
Silt	49.4
Clay	44.8

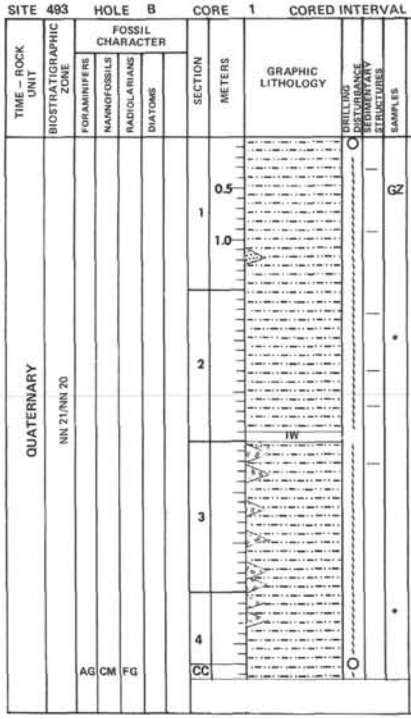
SITE 493 HOLE A CORE 3 CORED INTERVAL 12.0–21.5 m



LITHOLOGIC DESCRIPTION

Trace recovery MUDDY SILT in Core-Catcher.

SITE 493 HOLE B CORE 1 CORED INTERVAL 12.0–21.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, soft, olive gray (5Y 3/2), streaks of different color shade. Very thin SAND layers throughout. ASH and mixed ASH and MUD, light bluish gray (5Y 7/1), in Section 3.

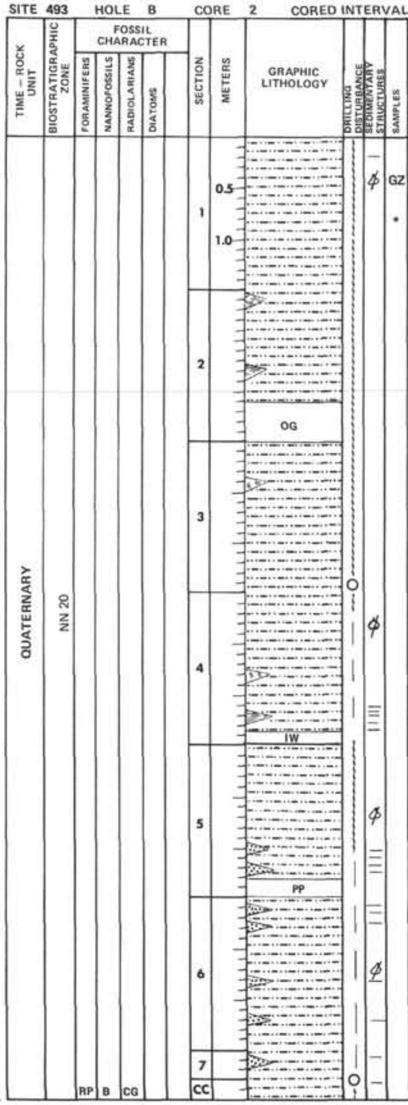
SMEAR SLIDES

	Muddy silt	Ash
	2-50 (D)	4-20 (M)
TEXTURE:		
Sand	3	–
Silt	57	95
Clay	40	5
COMPOSITION:		
Quartz	45	2
Feldspar	3	–
Mica	2	–
Heavy minerals	TR	–
Pyrite	2	5
Clay	40	5
Glass	–	88
Carb. unspec.	1	–
Foraminifers	2	–
Nannofossils	1	–
Radiolarians	TR	–
Diatoms	2	–
Sponge spicules	2	–
Silicoflagellates	TR	–

GRAIN SIZE

	1-50
Sand	3.6
Silt	59.9
Clay	36.5

SITE 493 HOLE B CORE 2 CORED INTERVAL 21.5–31.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2), subvertical faint streaks (deformed by drilling). Very thin occasional mud laminations, light bluish gray (5B 7/1) with ASH, light bluish gray (5B 7/1), in pods. At 3, 80–150 cm, mottled texturally, lumps of soft medium silt in very soft medium silt. At 4, 115–140 cm, very thin layers of FORAMINIFER SANDY MUD. Below Section 5, 90 cm, abundant thin FORAMINIFER SANDS.

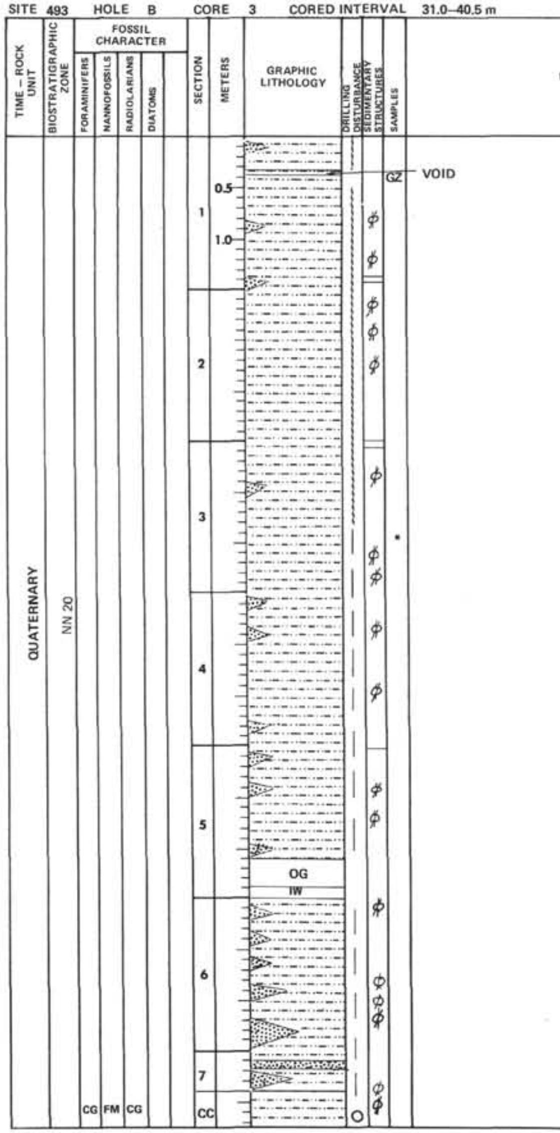
SMEAR SLIDES

	Muddy silt
	1-80 (M)
TEXTURE:	
Sand	5
Silt	60
Clay	35
COMPOSITION:	
Quartz	44
Feldspar	3
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	35
Carb. unspec.	3
Foraminifers	5
Nannofossils	1
Radiolarians	1
Diatoms	2
Sponge spicules	2

GRAIN SIZE

	1-40
Sand	8.9
Silt	56.2
Clay	34.9

SITE 493 HOLE B CORE 3 CORED INTERVAL 31.0–40.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soft, gas expansion cracks, small pods and layers of fine SAND, some with shell fragments. Sand locally foraminifera-rich. Shell fragments in fine sands becomes locally abundant in Sections 6 and 7.

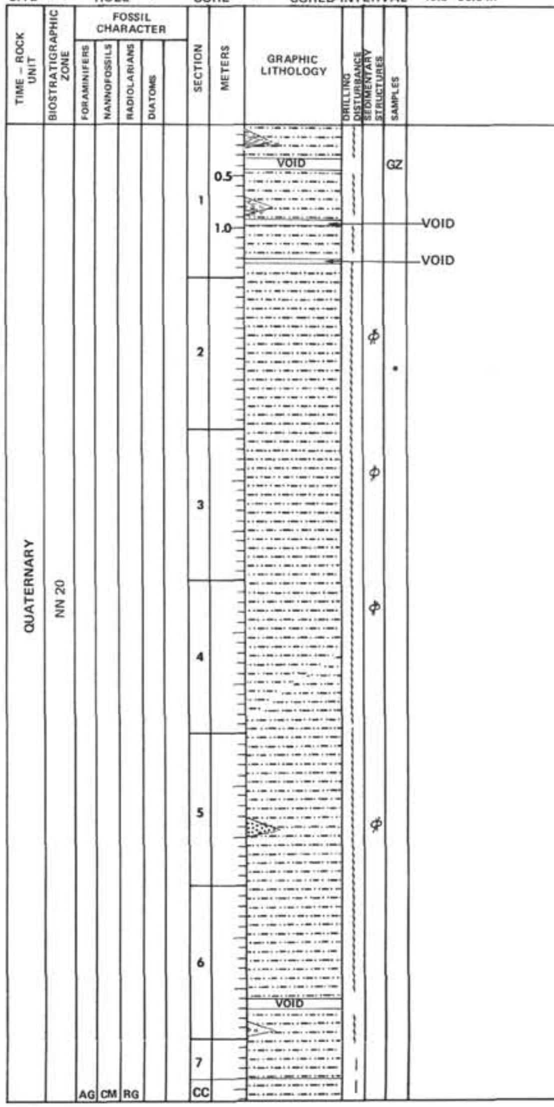
SMEAR SLIDES

	Muddy silt
	3-100 (D)
TEXTURE:	
Sand	7
Silt	63
Clay	30
COMPOSITION:	
Quartz	51
Feldspar	5
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	30
Carb. unspec.	1
Foraminifers	1
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	2

GRAIN SIZE

	1-40
Sand	6.8
Silt	63.1
Clay	30.1

SITE 493 HOLE B CORE 4 CORED INTERVAL 40.5–50.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soft to firm, gas expansion cracks, shell debris throughout. At 1, 0–60 cm, mottled with light olive gray (5Y 5/2) MUD and MUDSTONE clasts. ASH, 5 mm, light bluish gray (5B 7/1) in Section 6.

SMEAR SLIDES

	Muddy silt
	2-90 (D)
TEXTURE:	
Sand	1
Silt	59
Clay	40
COMPOSITION:	
Quartz	50
Feldspar	3
Mica	2
Pyrite	2
Clay	40
Carb. unspec.	1
Foraminifers	1
Nannofossils	1
Radiolarians	TR
Diatoms	TR
Sponge spicules	TR

GRAIN SIZE

	1-40
Sand	4.0
Silt	55.7
Clay	40.3

SITE 493 HOLE B CORE 5 CORED INTERVAL 50.0–59.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
QUATERNARY/PLIOCENE?	Unzoned		RP			1
			B			2
		CM	RP	FM		3, CC

Graphic lithology: VOID; IW. Samples: GZ (Section 1).

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), firm, faint parallel laminations. Minor areas of light bluish gray (5B 7/1).

SMEAR SLIDES

	Muddy silt 1-10 (D)
TEXTURE:	
Sand	7
Silt	63
Clay	30
COMPOSITION:	
Quartz	60
Feldspar	4
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	30
Carb. unspec.	1
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	TR

GRAIN SIZE

	1-40
Sand	1.1
Silt	59.1
Clay	39.8

SITE 493 HOLE B CORE 6 CORED INTERVAL 59.5–69.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
PLIOCENE?	Unzoned	AG	CM	B		1, 2, 3, 4, CC

Graphic lithology: VOID (top of Section 1); OG; PP. Samples: GZ (Section 2).

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soft, gas expansion cracks, structureless. Below Section 2: parallel laminated, near horizontal bedding, sparse thin SAND beds. Foraminifer concentration in Section 3.

SMEAR SLIDES

	Muddy silt 3-60 (D)
TEXTURE:	
Sand	10
Silt	50
Clay	40
COMPOSITION:	
Quartz	43
Feldspar	4
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	40
Carb. unspec.	1
Foraminifers	7
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1

GRAIN SIZE

	2-90
Sand	2.6
Silt	59.6
Clay	37.7

SITE 493 HOLE B CORE 7 CORED INTERVAL 69.0–78.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
PLIOCENE?	Unzoned	RP	B	RM		1, 2, 3

Graphic lithology: VOID (top of Section 2); IW; VOID; VOID. Samples: GZ (Section 2).

Non-carbonized wood twig, several cm long

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), firm, parallel laminations, occasional layers light bluish gray (5B 7/1).

SMEAR SLIDES

	Muddy silt 2-70 (D)
TEXTURE:	
Sand	3
Silt	57
Clay	40
COMPOSITION:	
Quartz	50
Feldspar	5
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	40
Carb. unspec.	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1

GRAIN SIZE

	2-70
Sand	1.5
Silt	50.0
Clay	48.5

SITE 493 HOLE B CORE 8 CORED INTERVAL 78.5–88.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION
UPPER PLIOCENE?	Unzoned	RP	B	FM		1, 2, CC

Graphic lithology: VOID (Section 2). Samples: GZ (Section 1).

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soupy to firm, mottled with grayish olive (10Y 4/2). Foraminifera-rich SAND at 1, 23–38 cm.

SMEAR SLIDES

	Muddy silt 1-100 (D)
TEXTURE:	
Sand	2
Silt	53
Clay	45
COMPOSITION:	
Quartz	46
Feldspar	5
Mica	1
Pyrite	2
Clay	45
Carb. unspec.	TR
Nannofossils	TR
Sponge spicules	1
Plant fragments	TR

GRAIN SIZE

	1-88
Sand	3.7
Silt	55.0
Clay	41.3

SITE 493 HOLE B CORE 9 CORED INTERVAL 88.0–97.5 m

TIME – ROCK UNIT: PLIOCENE?
BIOSTRATIGRAPHIC ZONE: Unzoned
FOSSIL CHARACTER: FORAMINIFERS RM; NANNOFOSSILS CM; RADIOLARIANS RM; DIATOMS
SECTION: 1, CC
METERS: 0.5, 1.0

LITHOLOGIC DESCRIPTION

MUD, olive gray (5Y 3/2), soupy to firm with some streaks light bluish gray (5B 7/1) mud. One bed of ASH, light bluish gray (5B 7/1).

SMEAR SLIDES

	Ash	Mud
	1-100 (M)	1-130 (D)
TEXTURE:		
Sand	5	3
Silt	90	42
Clay	5	55
COMPOSITION:		
Quartz	5	35
Feldspar	–	2
Mica	1	1
Pyrite	2	2
Clay	5	55
Glass	87	–
Carb. unspec.	–	2
Foraminifers	–	1
Nannofossils	–	1
Radiolarians	–	TR
Sponge spicules	–	1

SITE 493 HOLE B CORE 10 CORED INTERVAL 97.5–107.0 m

TIME – ROCK UNIT: PLIOCENE?
BIOSTRATIGRAPHIC ZONE: Unzoned
FOSSIL CHARACTER: FORAMINIFERS RM; NANNOFOSSILS CM; RADIOLARIANS B; DIATOMS
SECTION: 1, CC
METERS: 0.5, 1.0
SAMPLES: GZ

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), very firm with MUDSTONE clasts and CHALK, light olive gray (5Y 5/2).

SMEAR SLIDES

	Mud
	1-80 (D)
TEXTURE:	
Sand	2
Silt	38
Clay	60
COMPOSITION:	
Quartz	34
Feldspar	2
Mica	1
Pyrite	2
Clay	60
Carb. unspec.	1
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Sponge spicules	TR

GRAIN SIZE

	1-74
Sand	0.4
Silt	63.5
Clay	36.1

SITE 493 HOLE B CORE 11 CORED INTERVAL 107.0–116.5 m

TIME – ROCK UNIT: PLIOCENE?
BIOSTRATIGRAPHIC ZONE: Unzoned
FOSSIL CHARACTER: FORAMINIFERS RM; NANNOFOSSILS CP; RADIOLARIANS CG; DIATOMS
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0
GRAPHIC LITHOLOGY: VOID; OG; IW
SAMPLES: GZ

Local silt pod

VOID

Calcareous nodule

LITHOLOGIC DESCRIPTION

MUDDY SILT, olive gray (5Y 3/2), soft but firmer below Section 1.

SMEAR SLIDES

	Muddy silt
	3-80 (D)
TEXTURE:	
Sand	1
Silt	60
Clay	39
COMPOSITION:	
Quartz	52
Feldspar	4
Mica	2
Heavy minerals	TR
Pyrite	2
Clay	35
Carb. unspec.	2
Foraminifers	1
Nannofossils	2
Sponge spicules	TR

GRAIN SIZE

	2-30
Sand	0.2
Silt	62.4
Clay	37.4

SITE 493 HOLE B CORE 12 CORED INTERVAL 116.5–126.0 m

TIME – ROCK UNIT: PLIOCENE ?
BIOSTRATIGRAPHIC ZONE: Unzoned
FOSSIL CHARACTER: FORAMINIFERS RM; NANNOFOSSILS CM; RADIOLARIANS FM; DIATOMS
SECTION: 1, 2, CC
METERS: 0.5, 1.0
GRAPHIC LITHOLOGY: VOID
SAMPLES: GZ

VOID

VOID

LITHOLOGIC DESCRIPTION

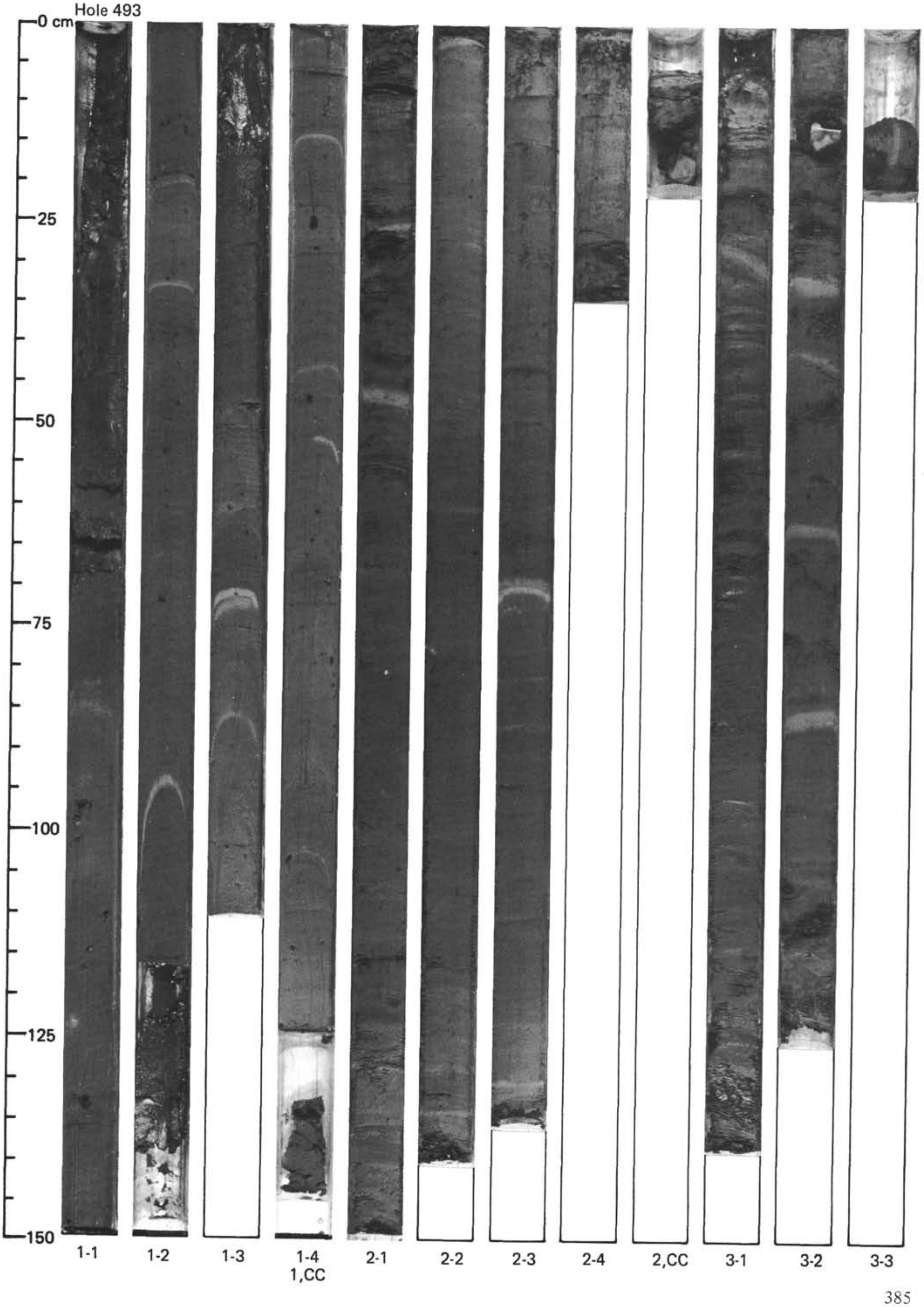
MUDDY SILT, olive gray (5Y 3/2), soft, soupy in places.

SMEAR SLIDES

	Muddy silt
	2-90 (D)
TEXTURE:	
Sand	1
Silt	54
Clay	45
COMPOSITION:	
Quartz	48
Feldspar	4
Mica	3
Heavy minerals	TR
Pyrite	1
Clay	40
Carb. unspec.	2
Sponge spicules	1
Plant fragments	1

GRAIN SIZE

	2-65
Sand	21.1
Silt	47.6
Clay	31.4



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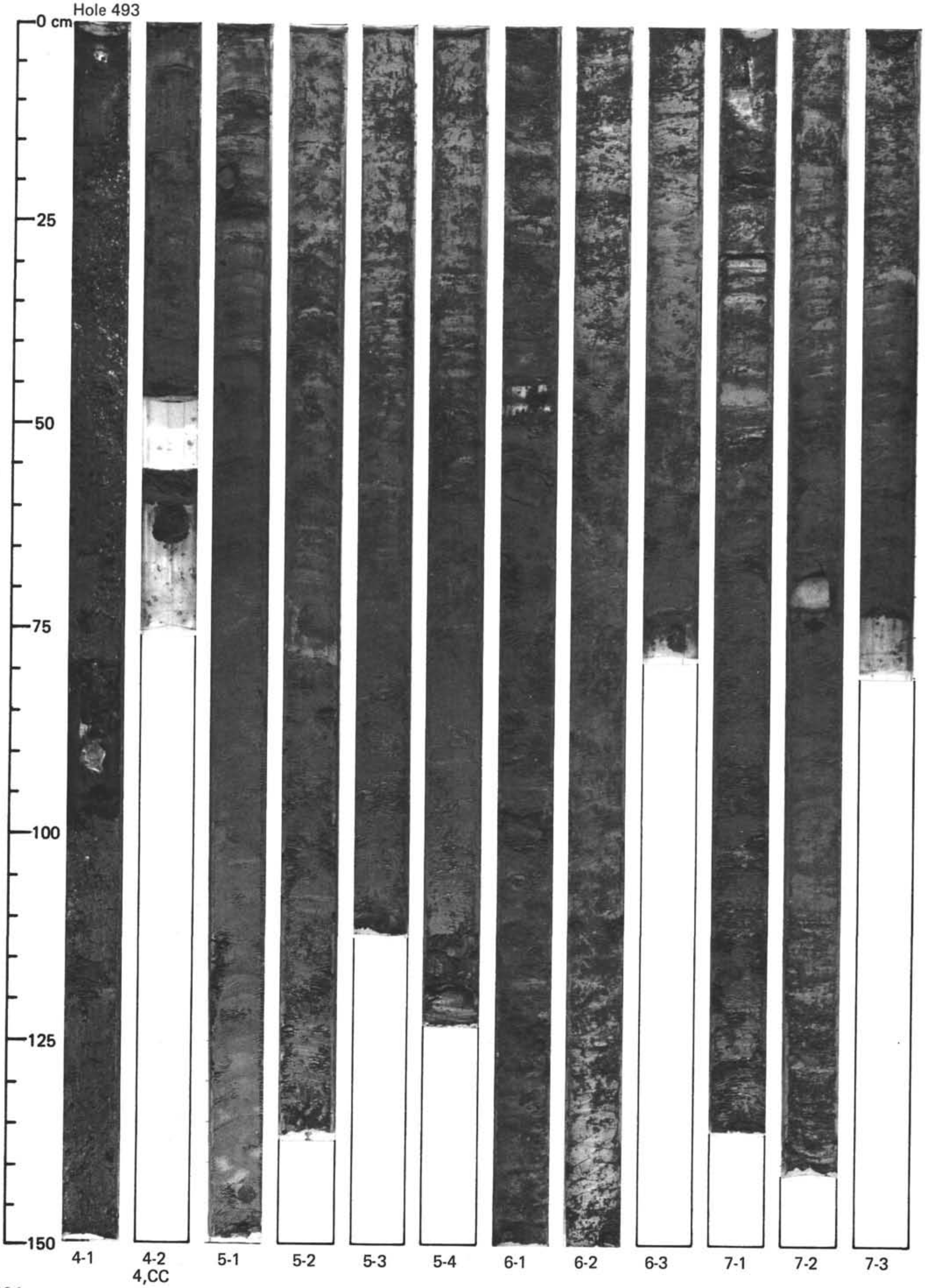
3-1
3-2
3-3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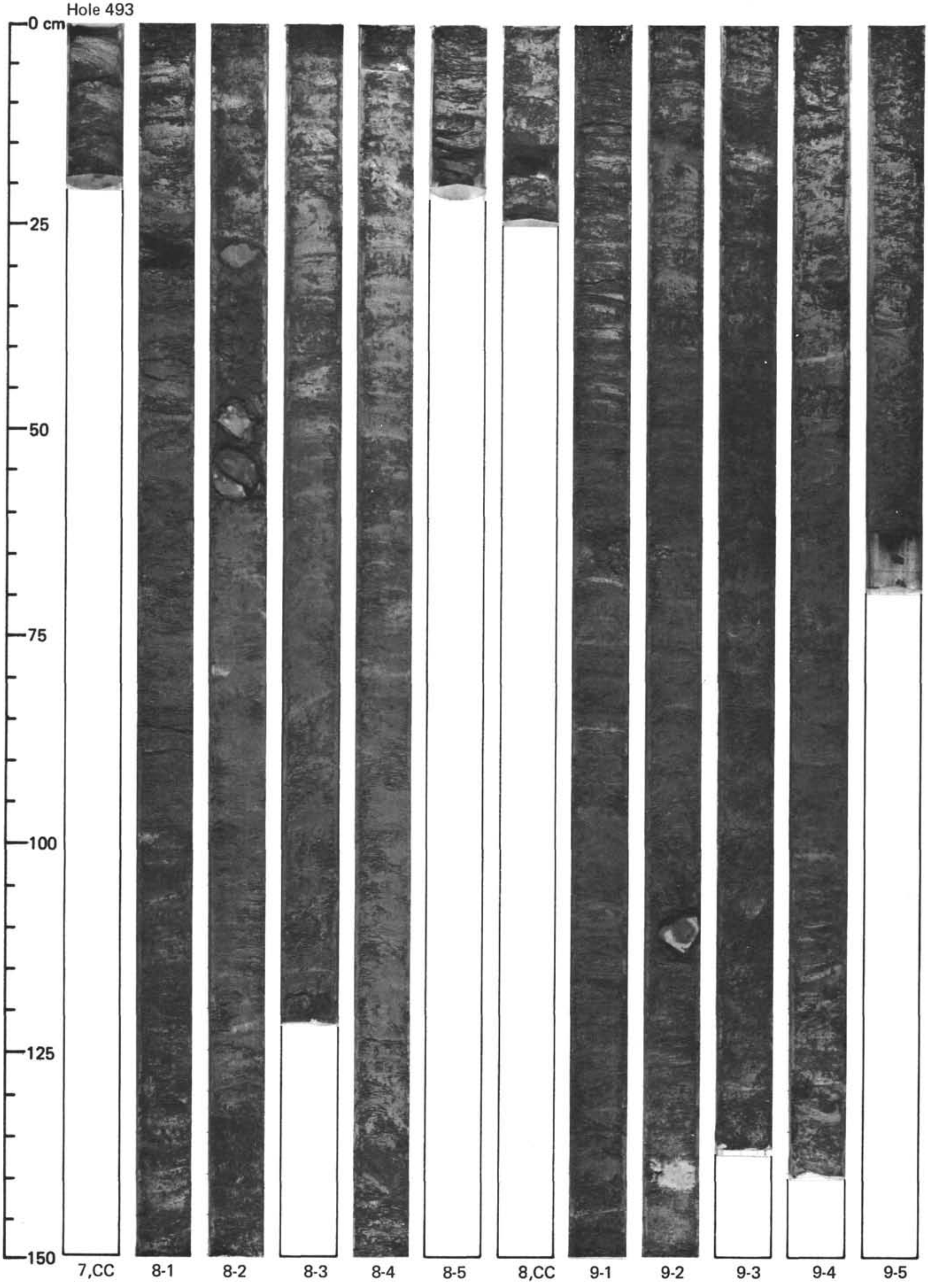
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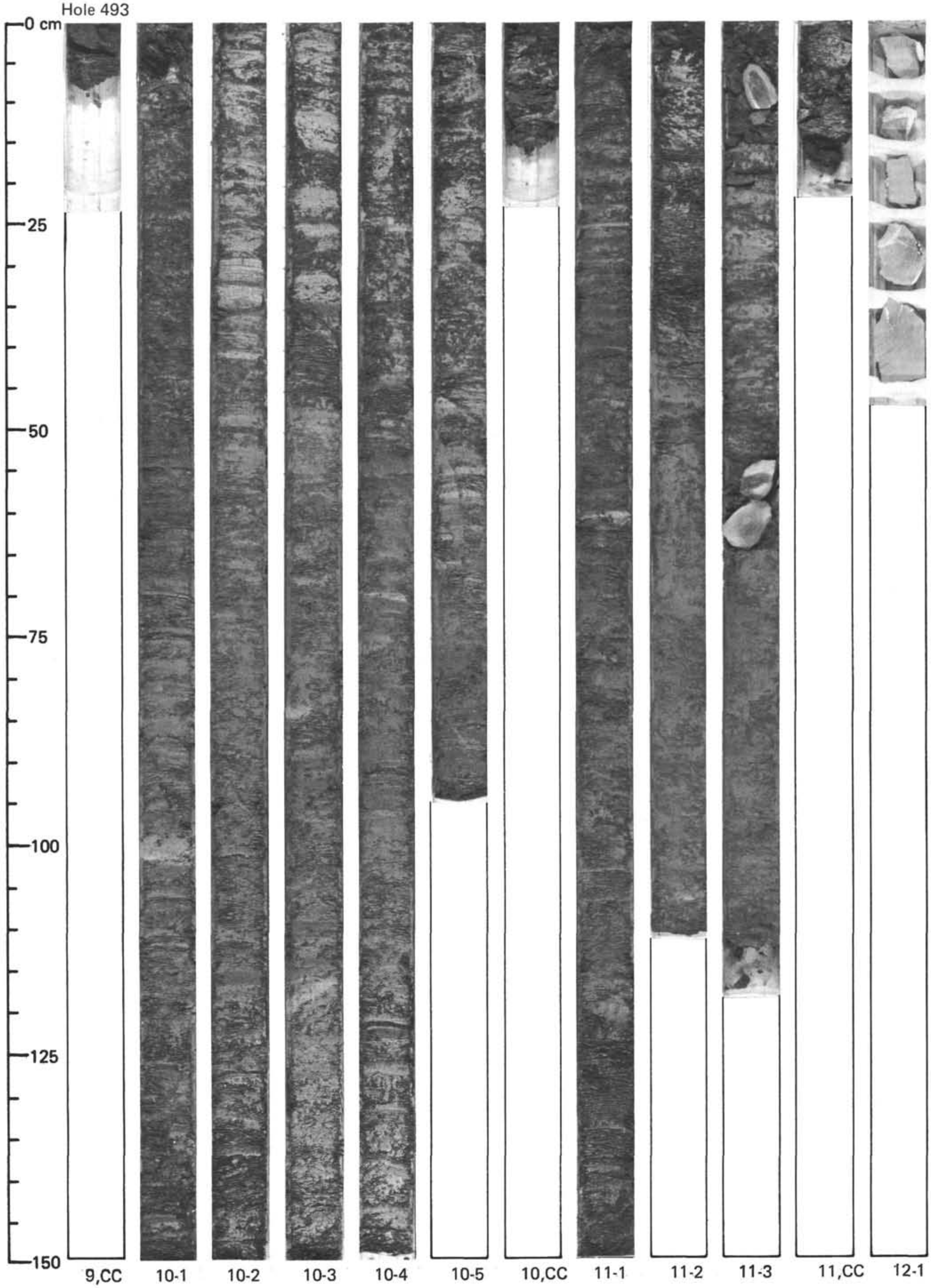
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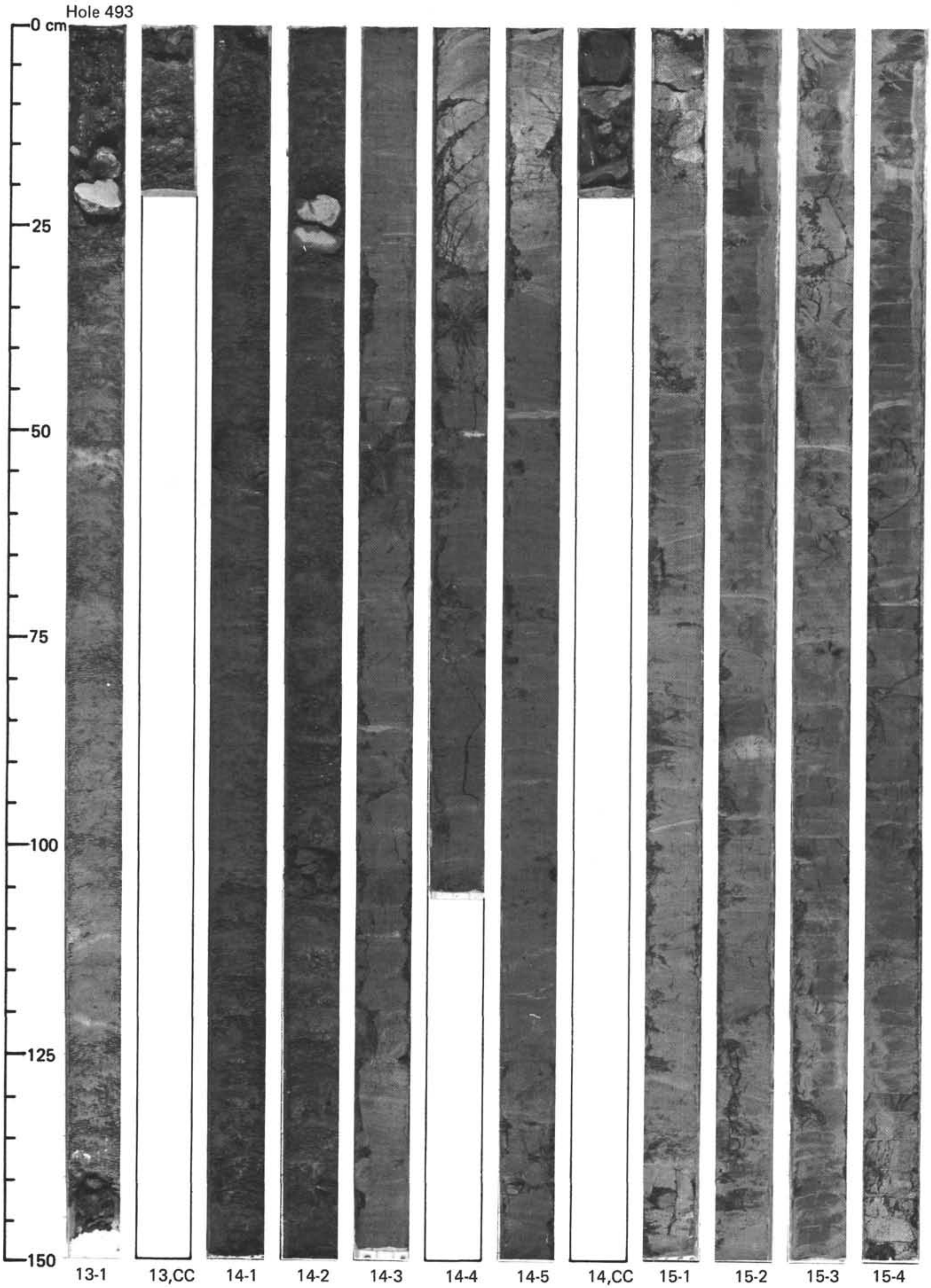
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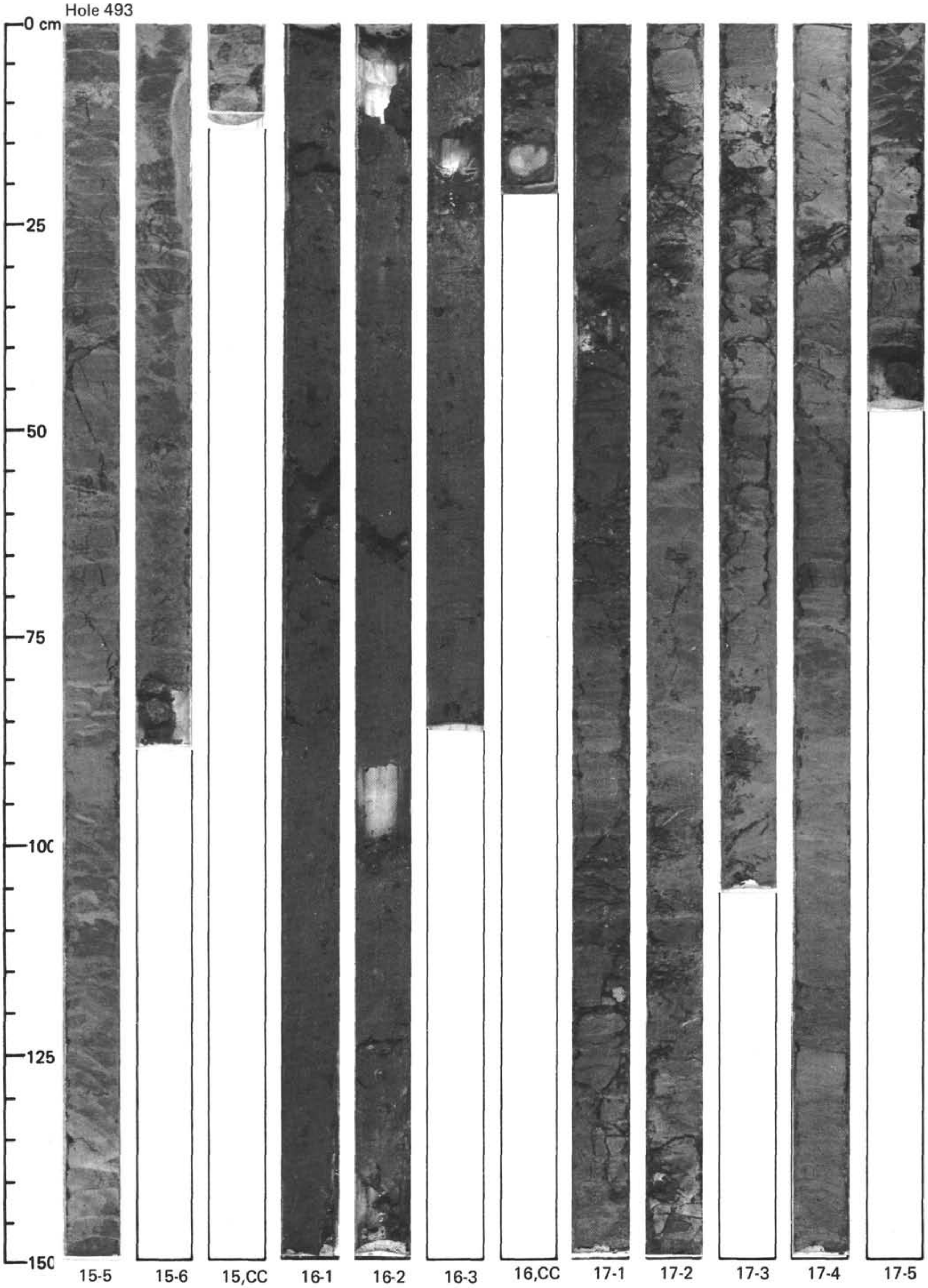
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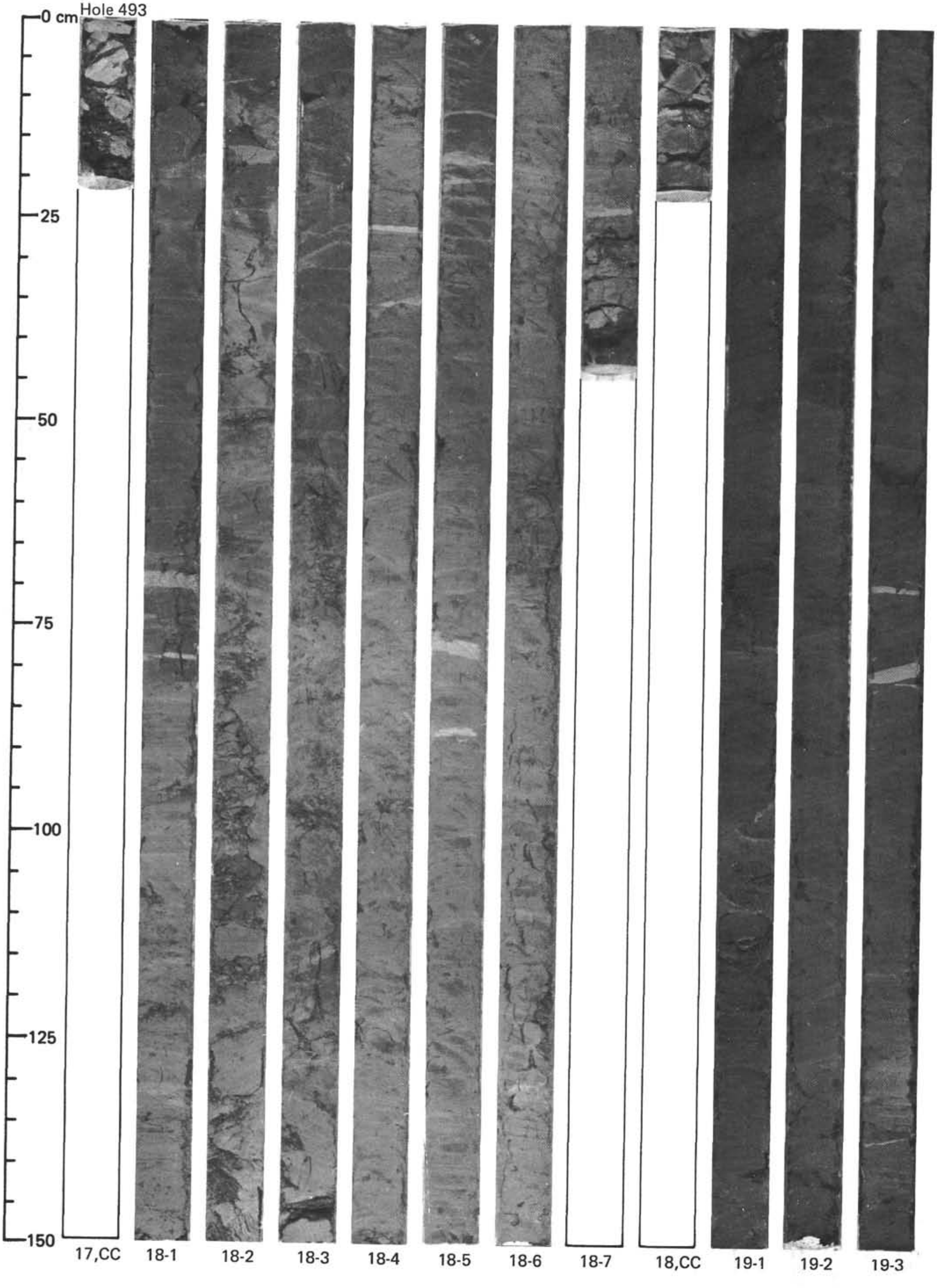
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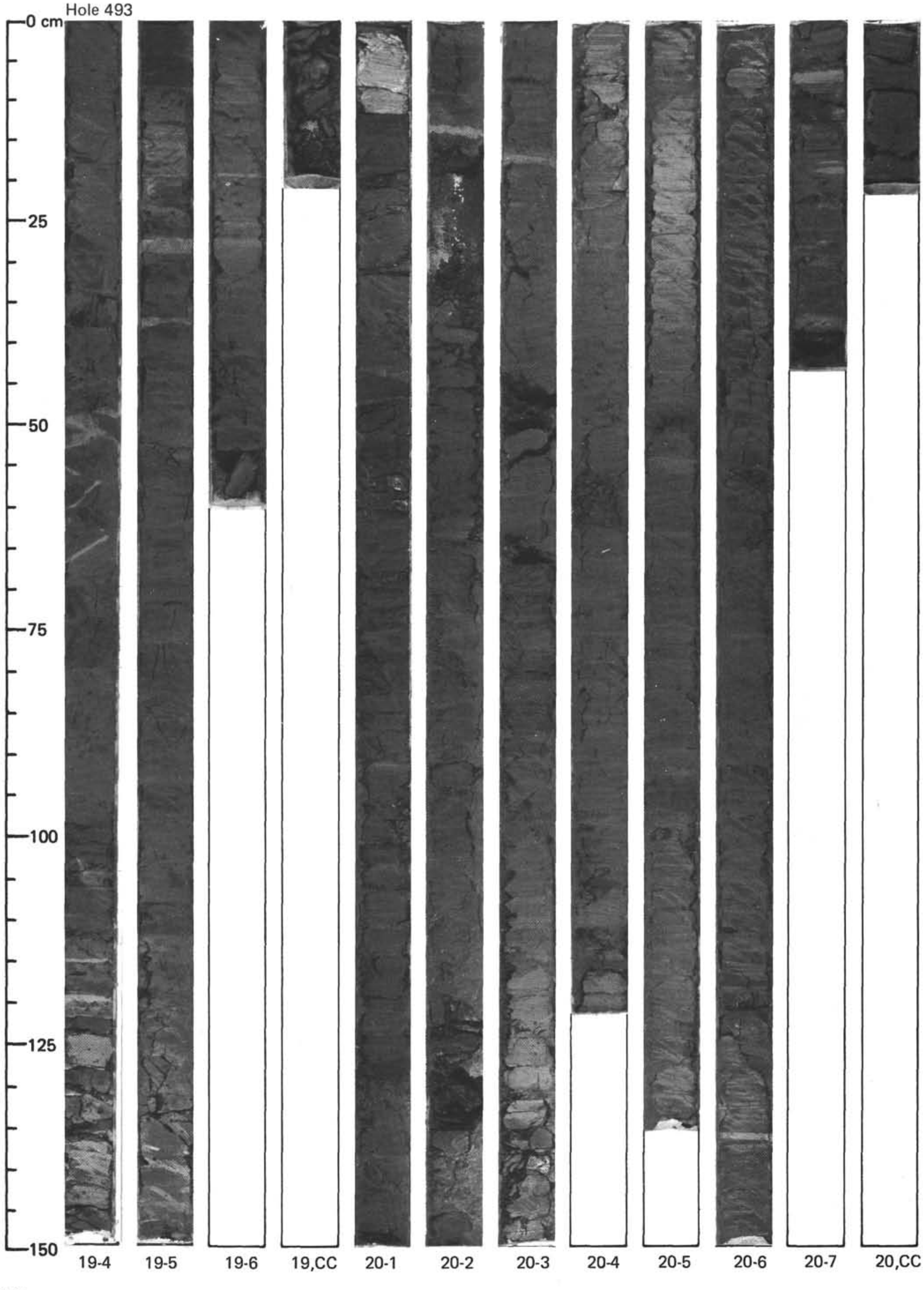
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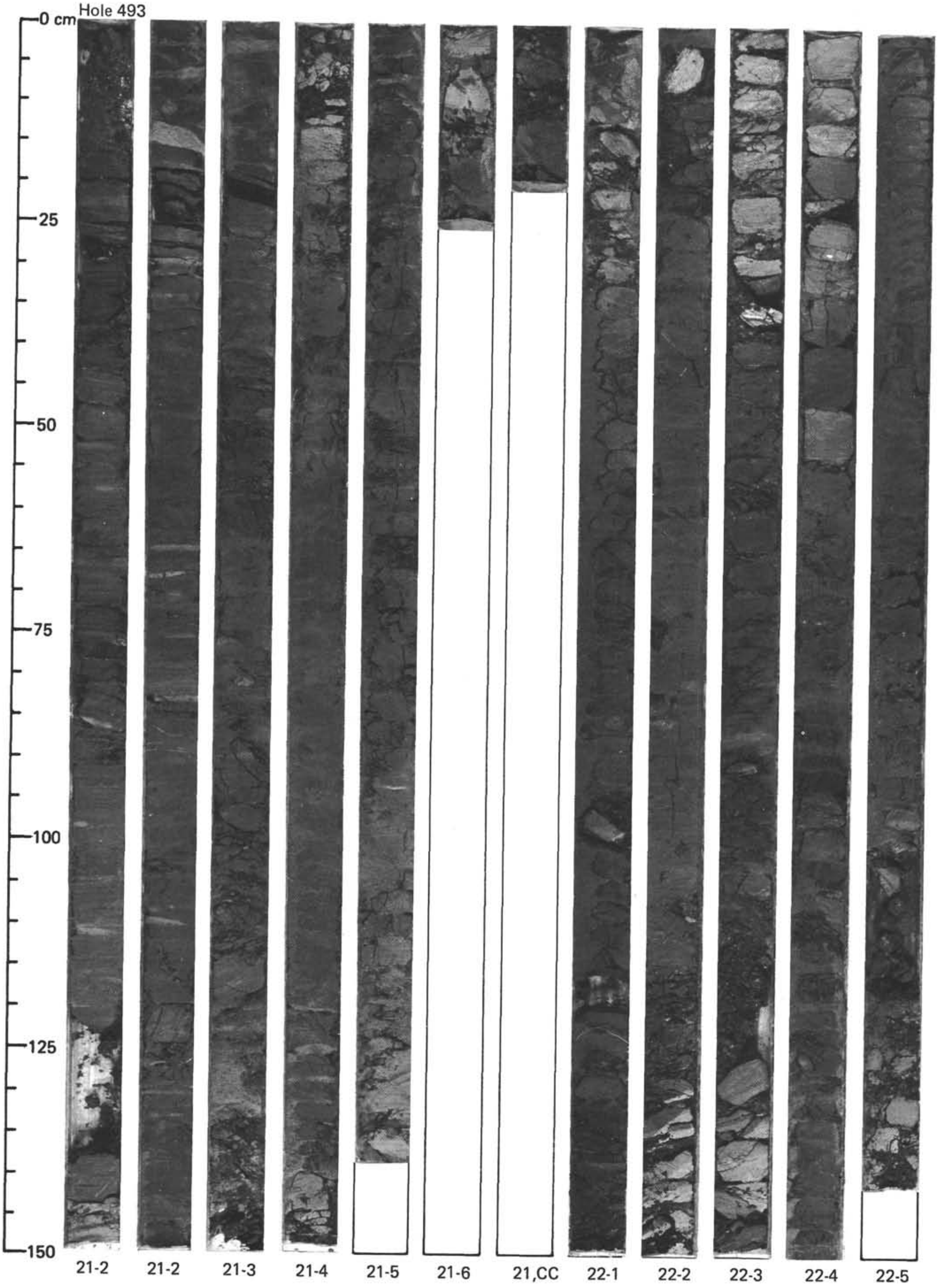
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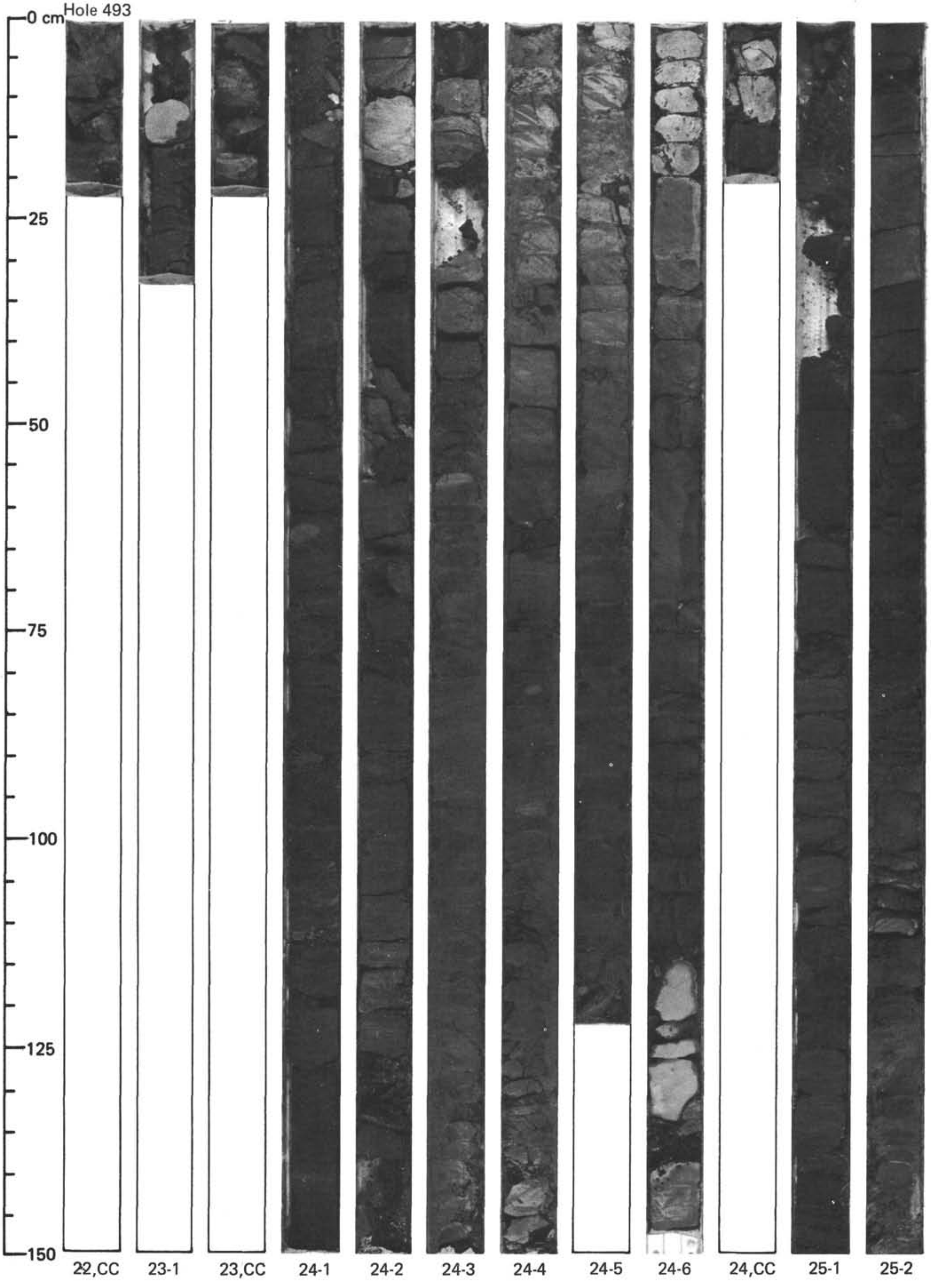
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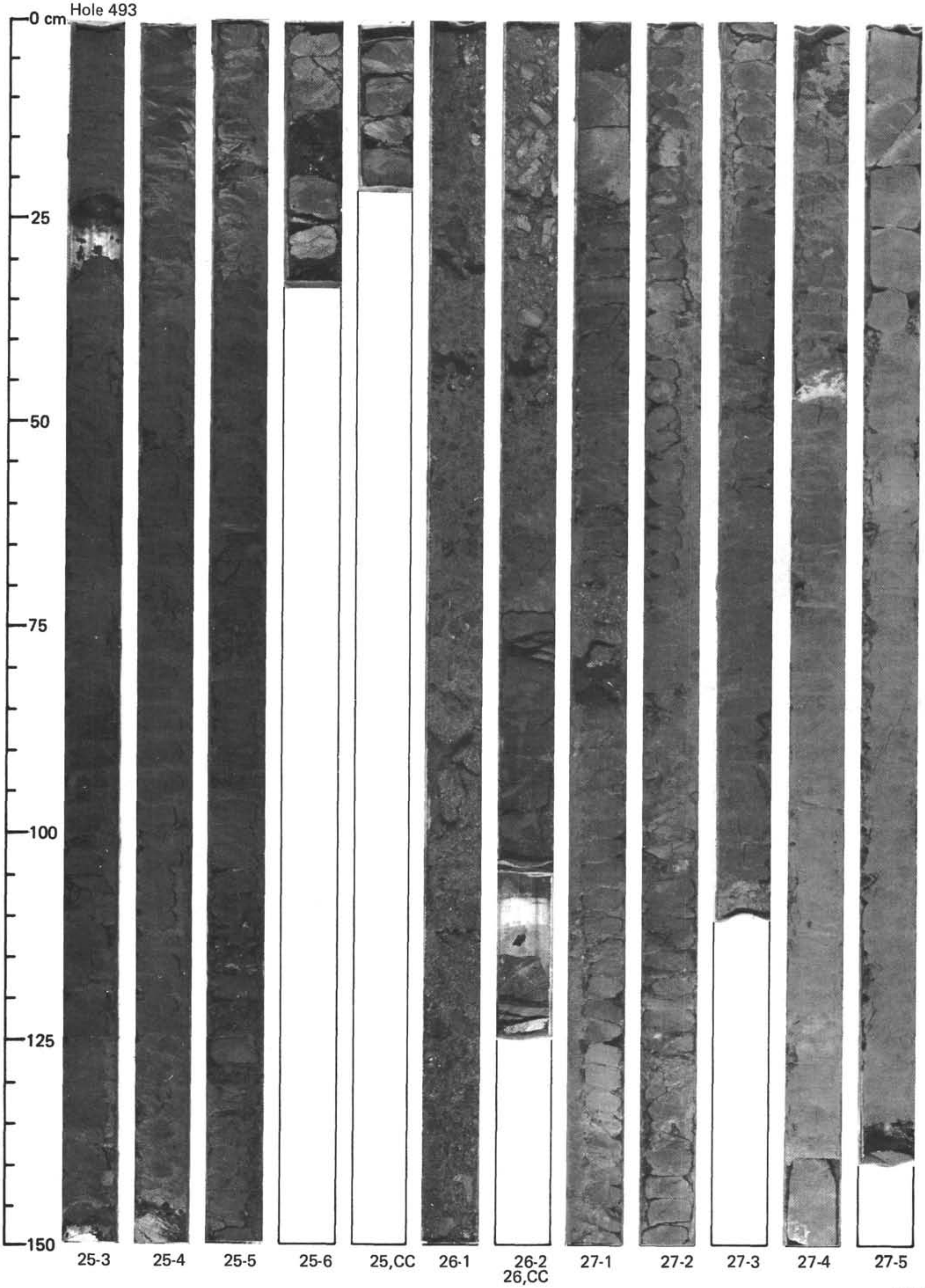
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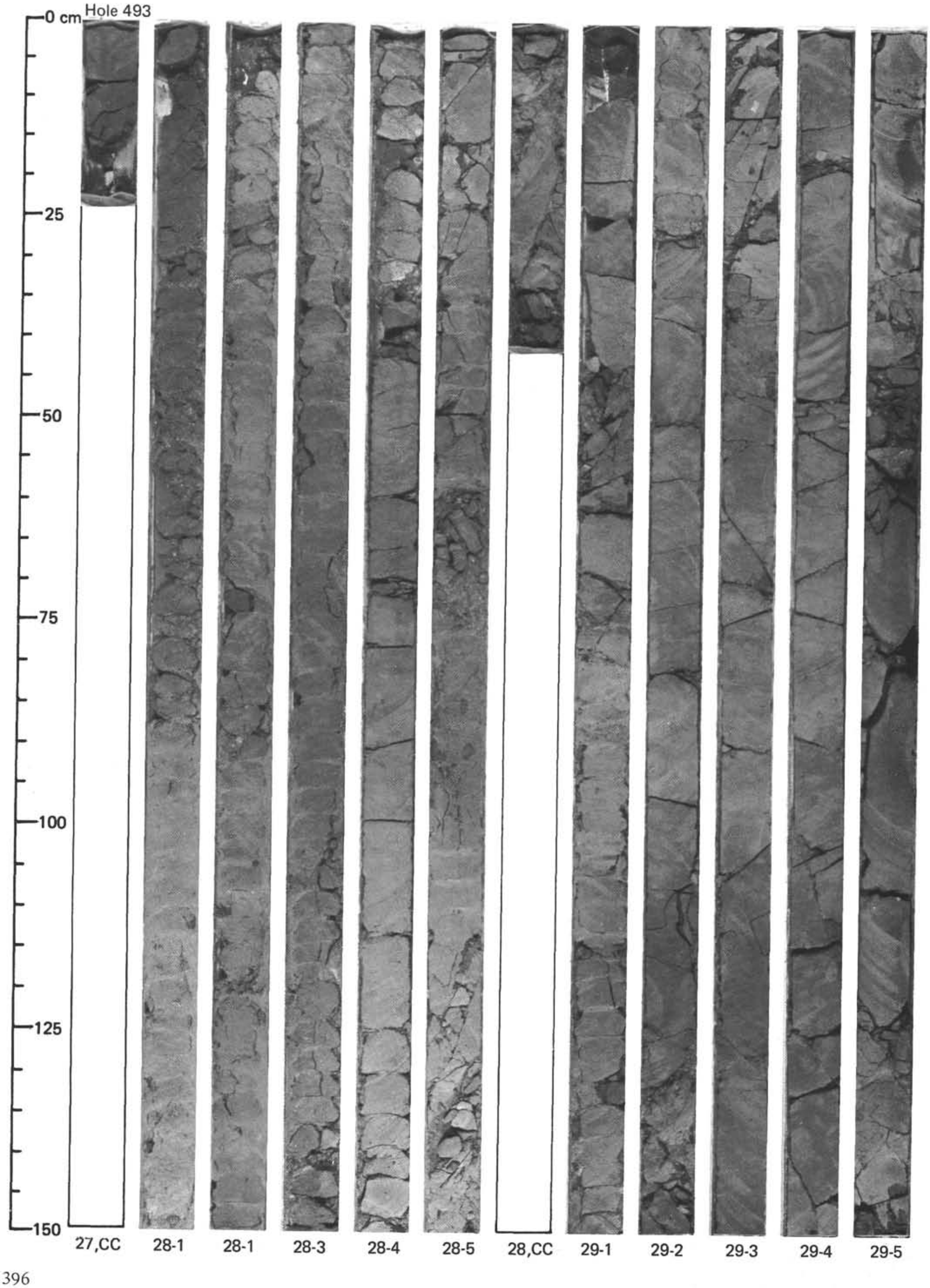
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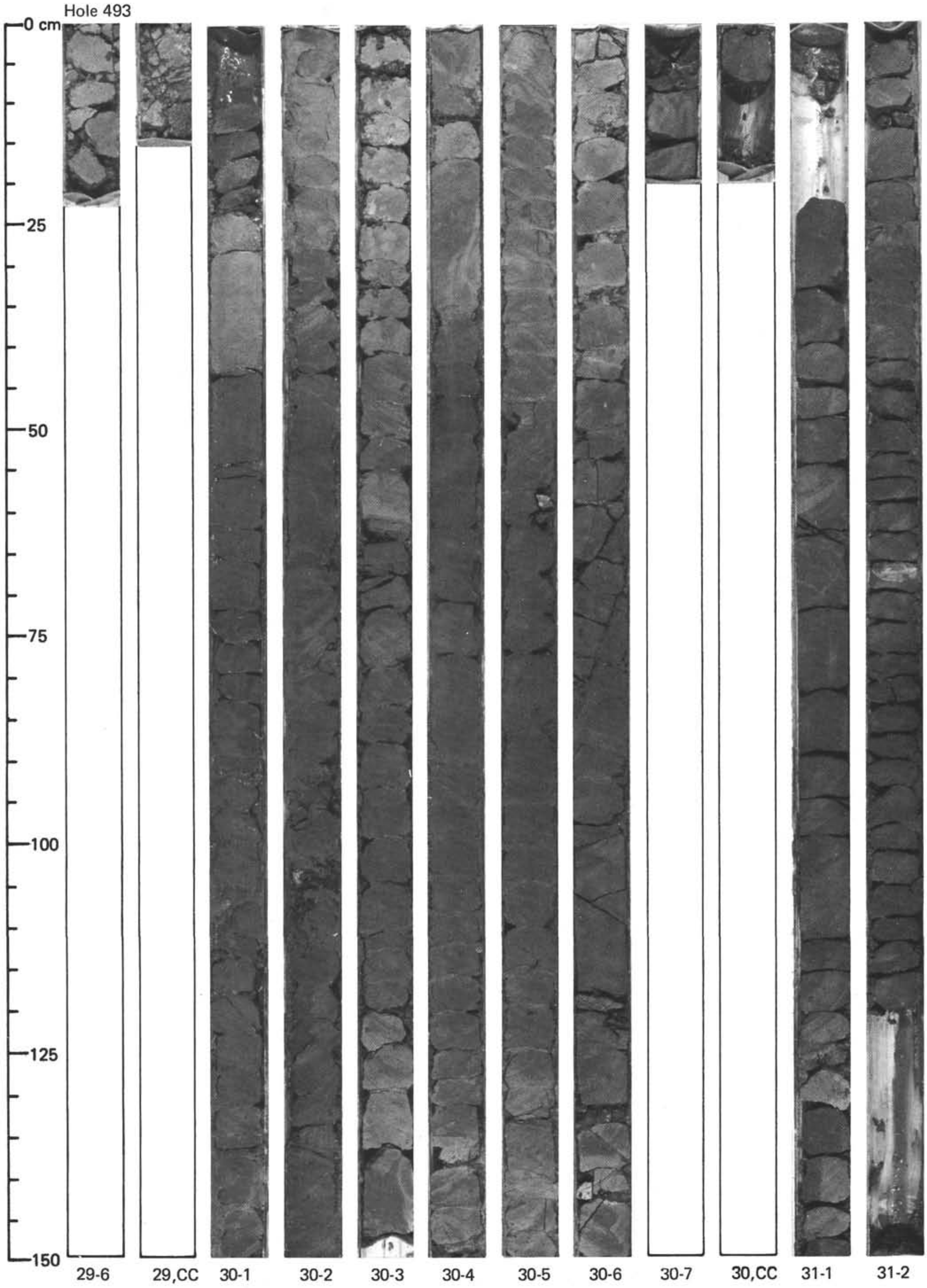
29-5


Hole 493
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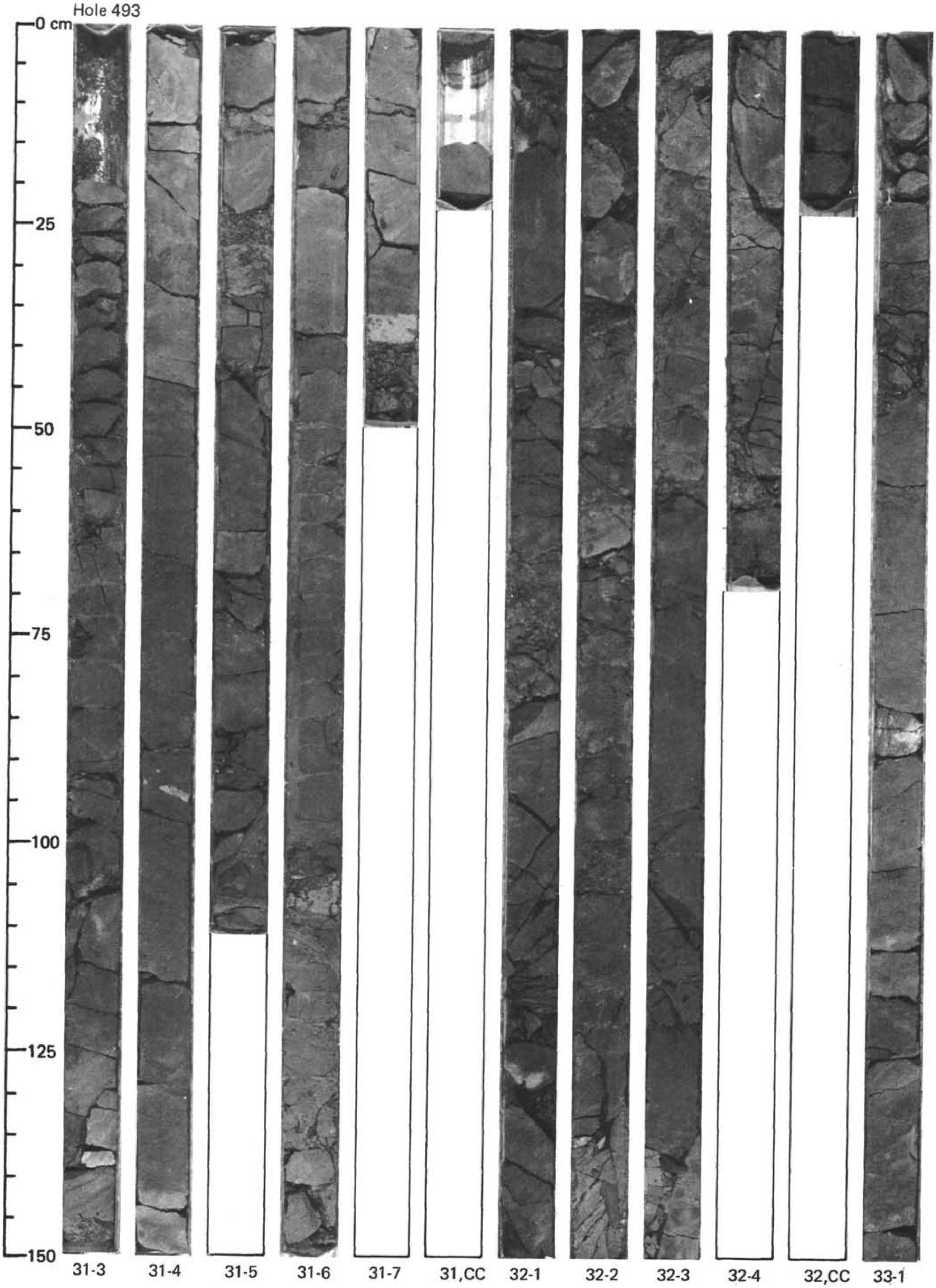
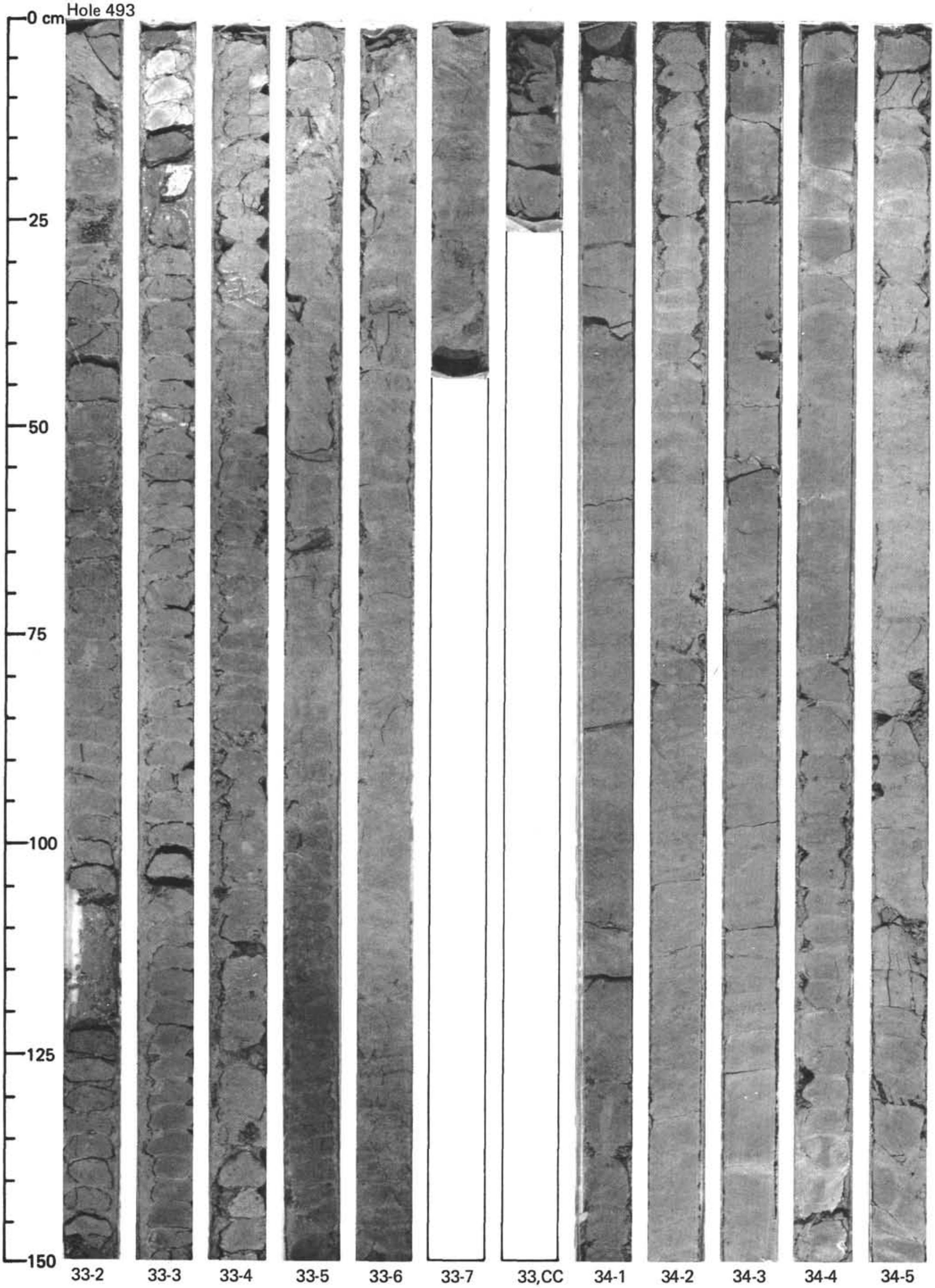
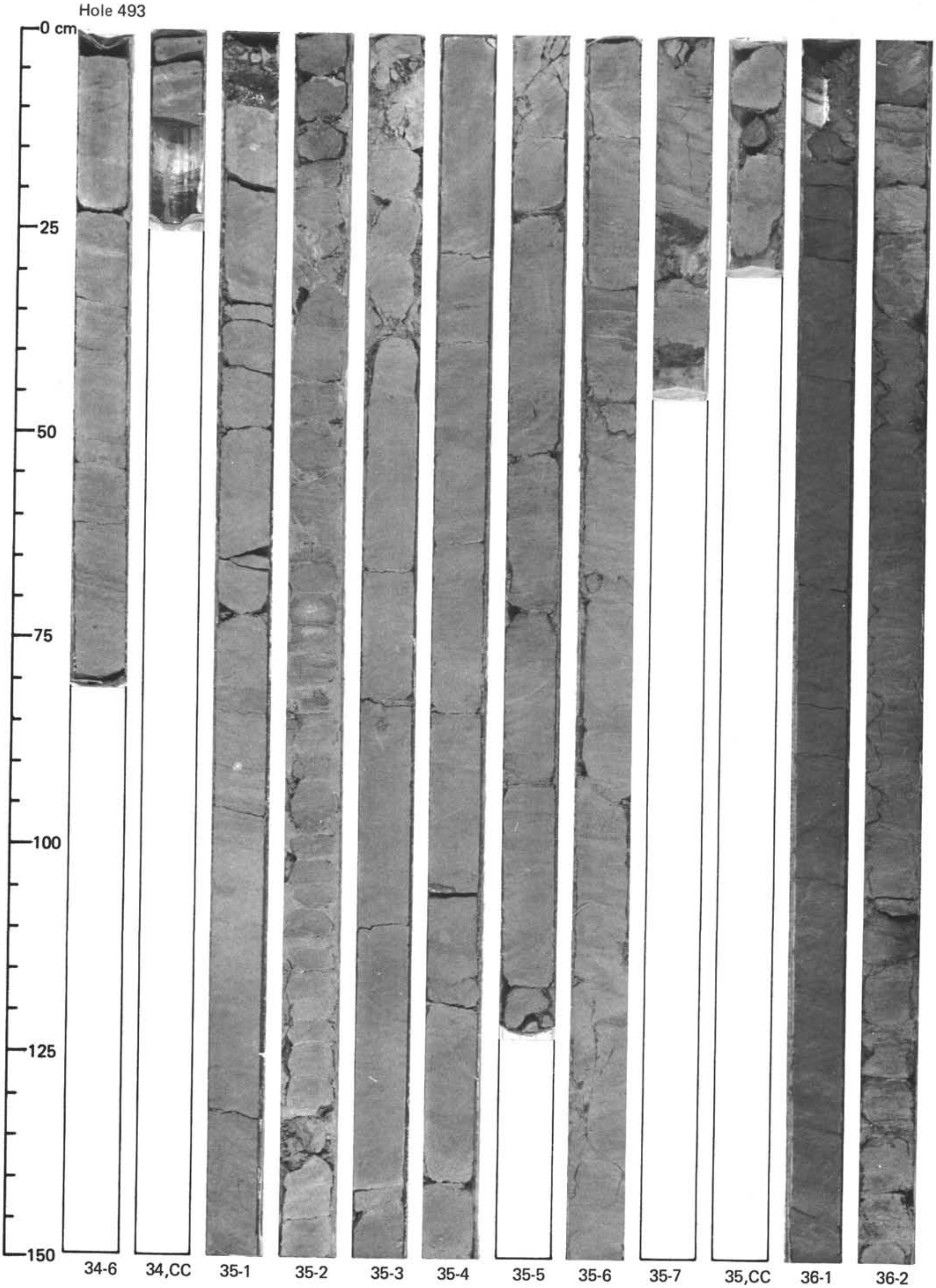
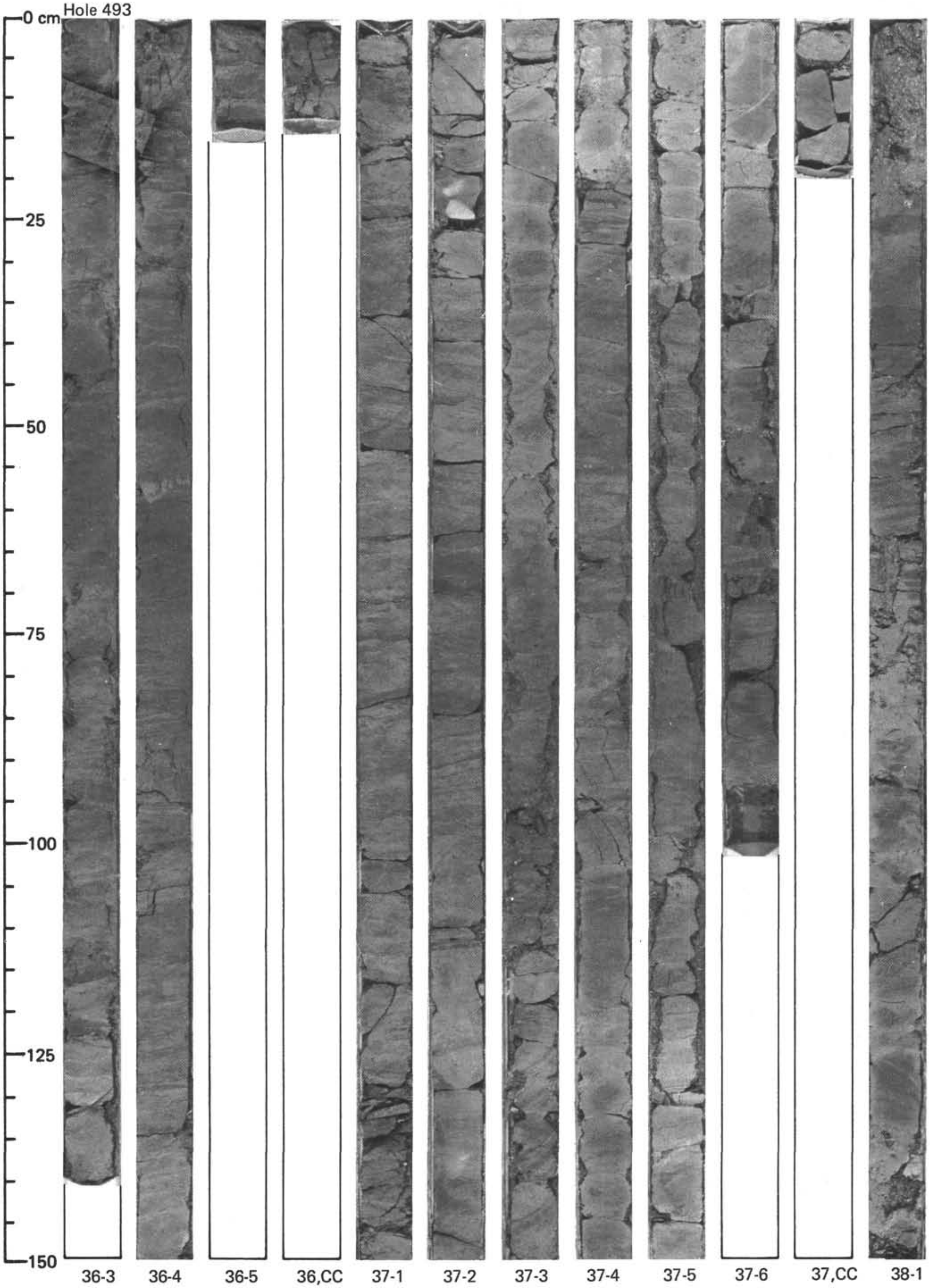
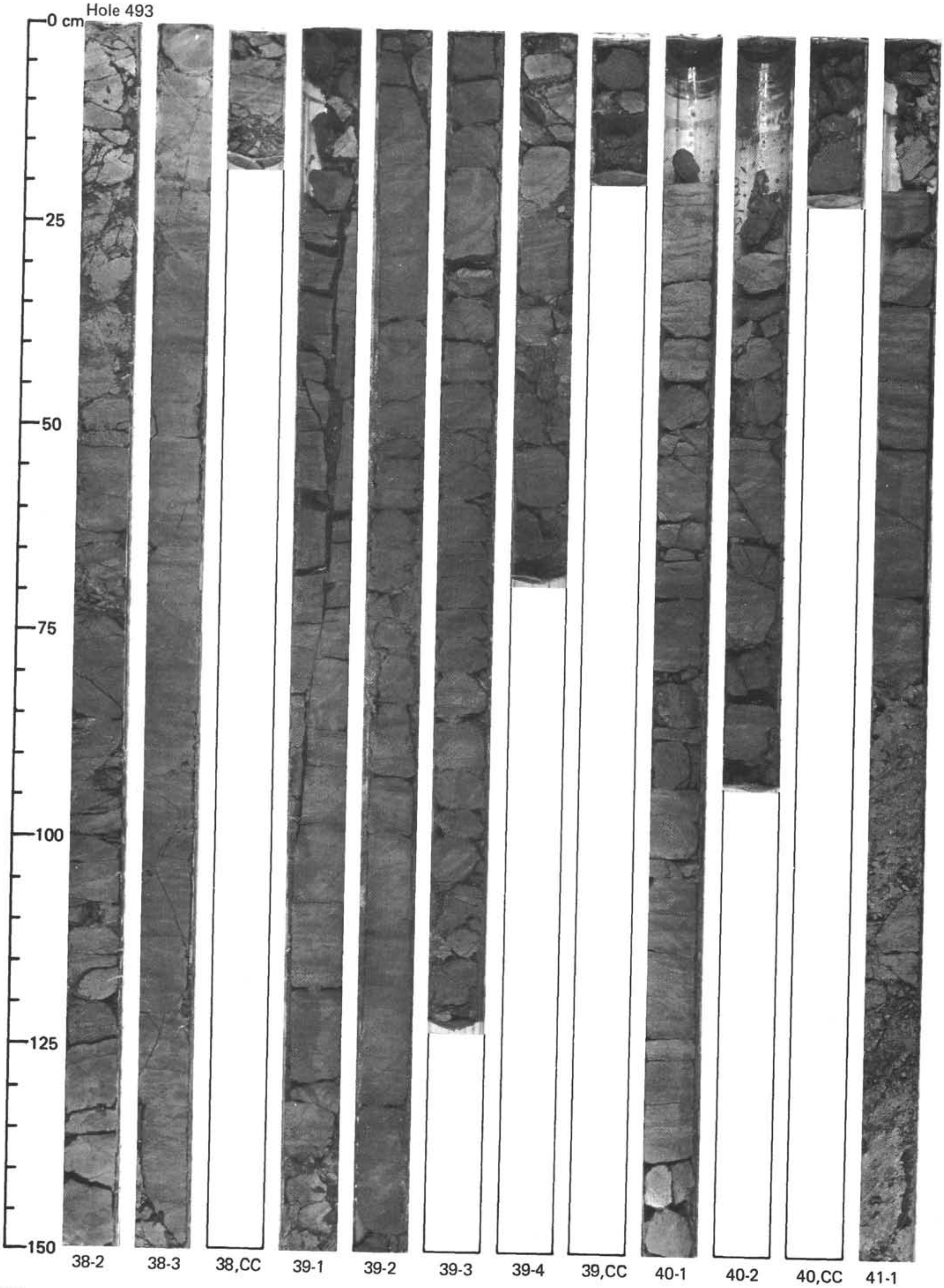
31-1
31-2

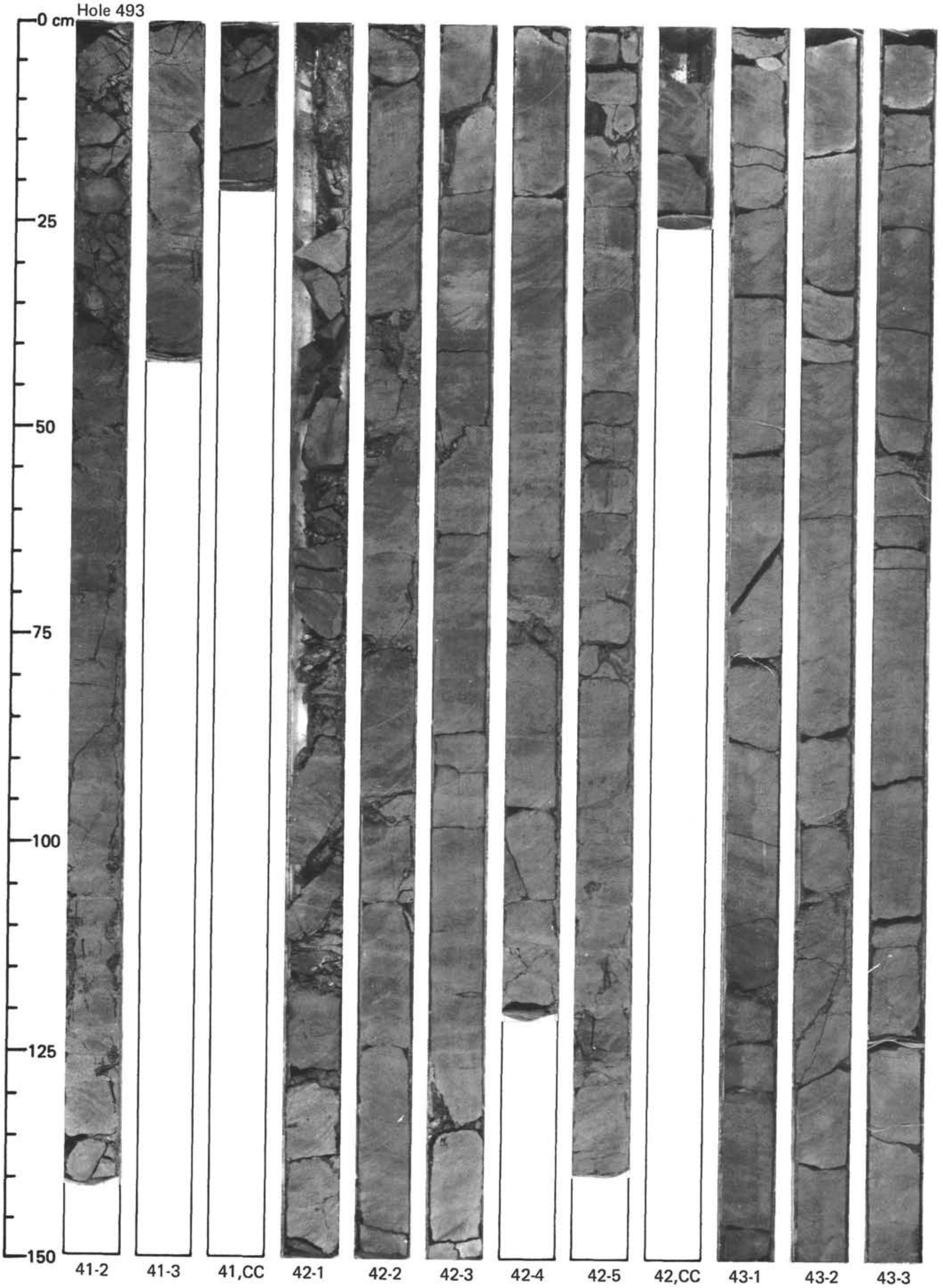

Hole 493
0 cm
25
50
75
100
125
150
31-3
31-4
31-5
31-6
31-7
31,CC
32-1
32-2
32-3
32-4
32,CC
33-1

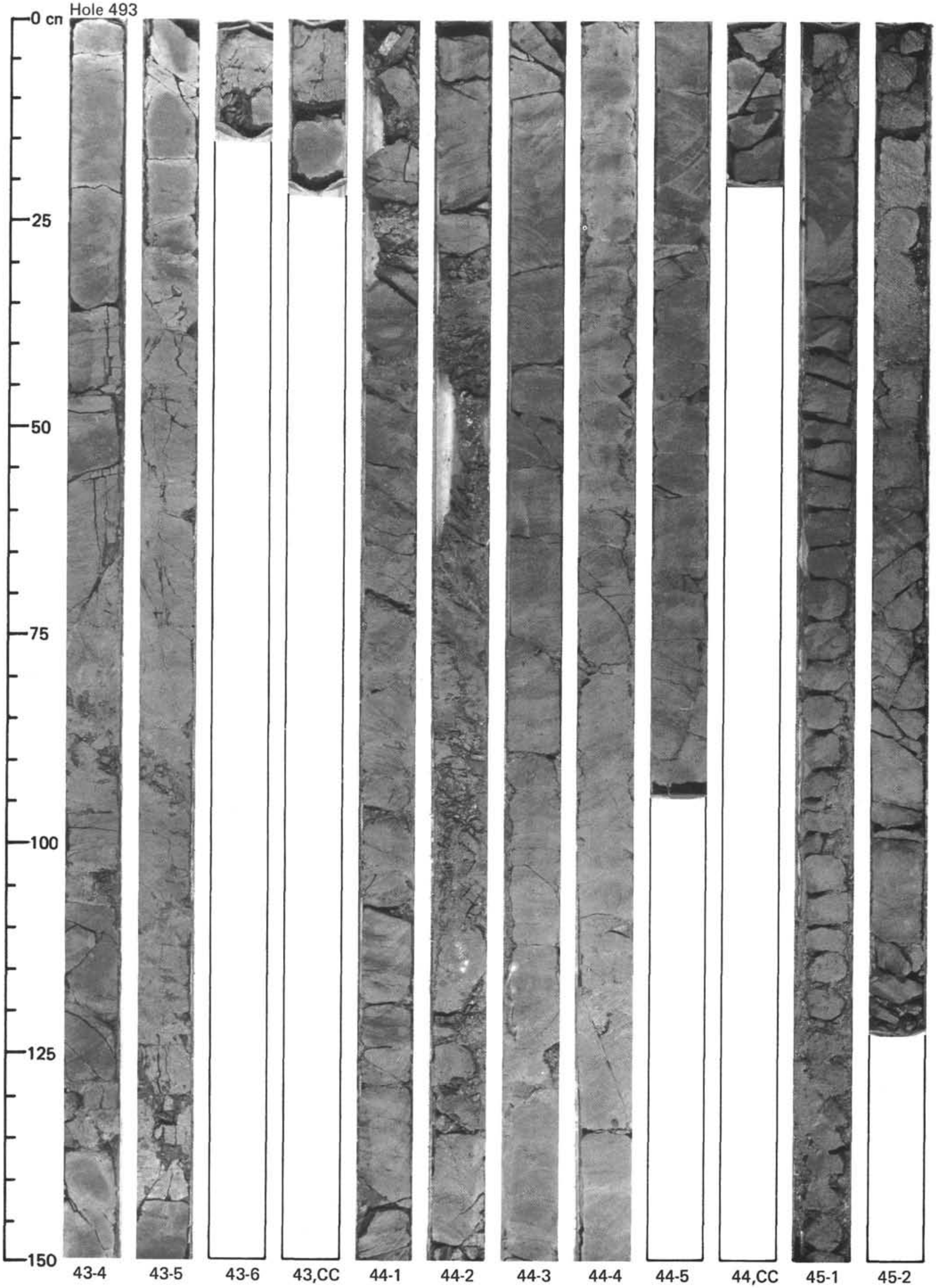

Hole 493
0 cm
25
50
75
100
125
150
33-2
33-3
33-4
33-5
33-6
33-7
33,CC
34-1
34-2
34-3
34-4
34-5

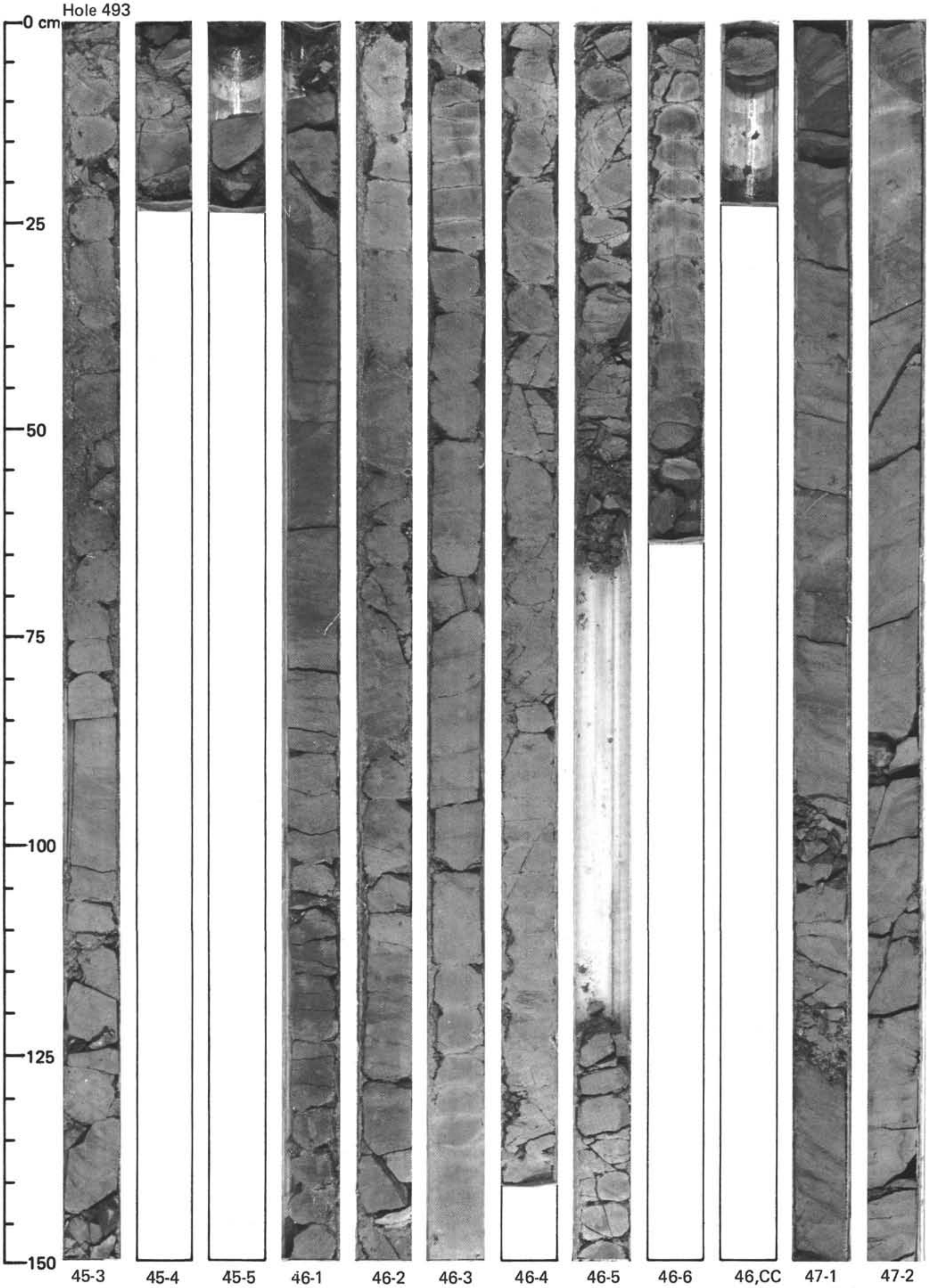

Hole 493
0 cm
25
50
75
100
125
150
34-6
34,CC
35-1
35-2
35-3
35-4
35-5
35-6
35-7
35,CC
36-1
36-2

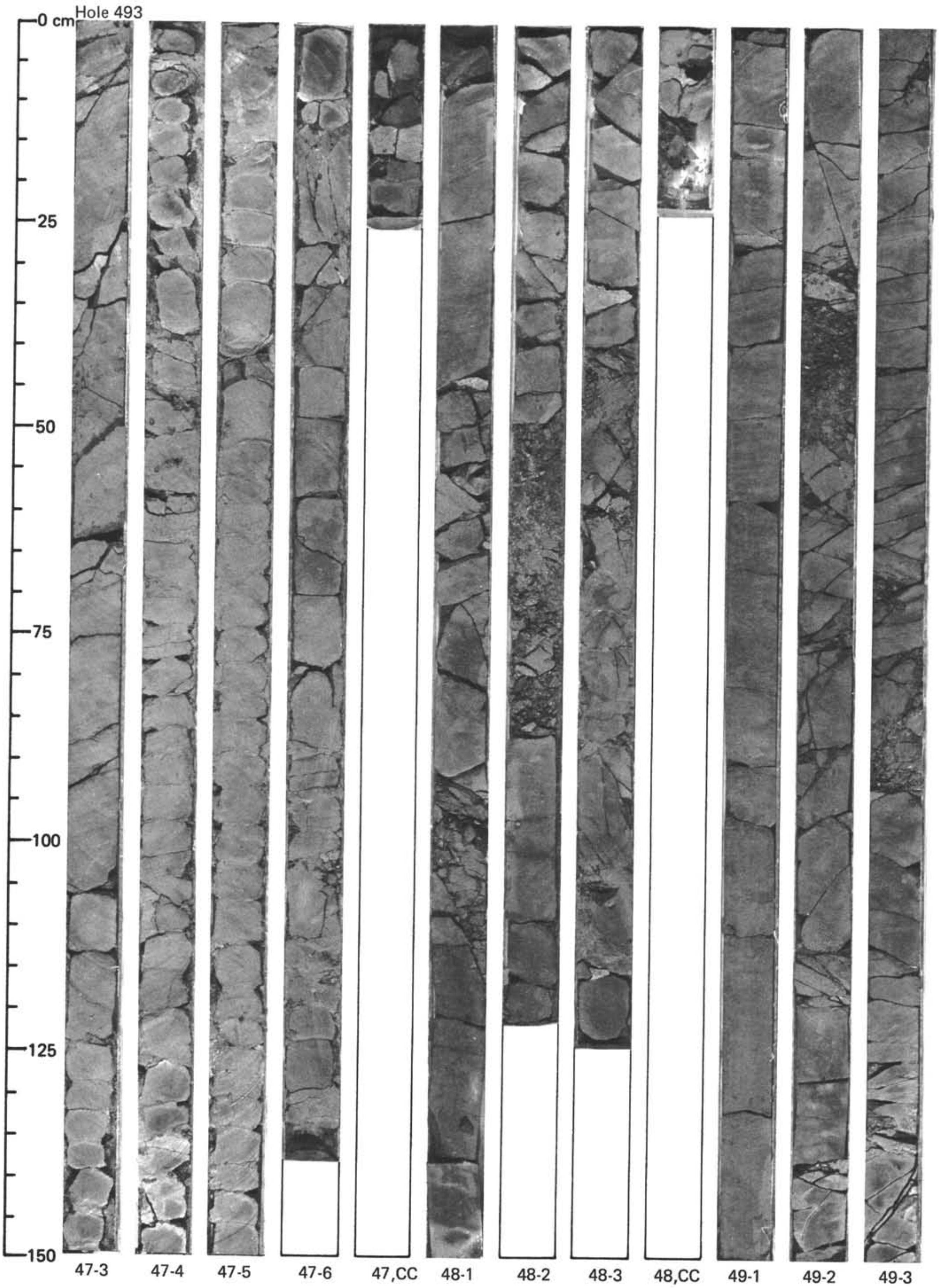

0 cm
Hole 493
25
50
75
100
125
150
36-3
36-4
36-5
36,CC
37-1
37-2
37-3
37-4
37-5
37-6
37,CC
38-1


Hole 493
0 cm
25
50
75
100
125
150
38-2
38-3
38,CC
39-1
39-2
39-3
39-4
39,CC
40-1
40-2
40,CC
41-1


Hole 493
0 cm
25
50
75
100
125
150
41-2
41-3
41,CC
42-1
42-2
42-3
42-4
42-5
42,CC
43-1
43-2
43-3


Hole 493
0 cm
25
50
75
100
125
150
43-4
43-5
43-6
43,CC
44-1
44-2
44-3
44-4
44-5
44,CC
45-1
45-2


Hole 493
0 cm
25
50
75
100
125
150
45-3
45-4
45-5
46-1
46-2
46-3
46-4
46-5
46-6
46,CC
47-1
47-2


Hole 493
0 cm
25
50
75
100
125
150
47-3
47-4
47-5
47-6
47,CC
48-1
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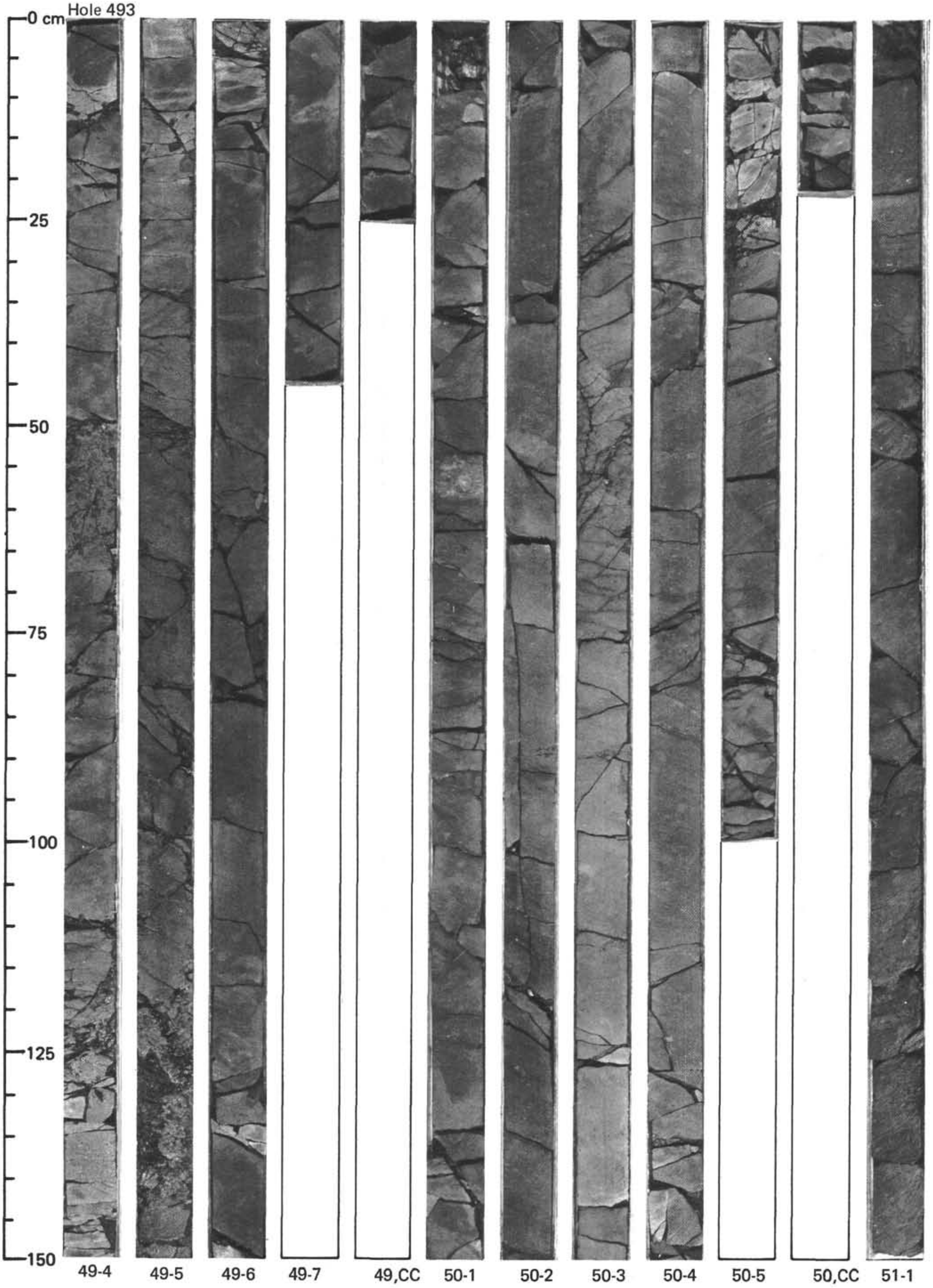
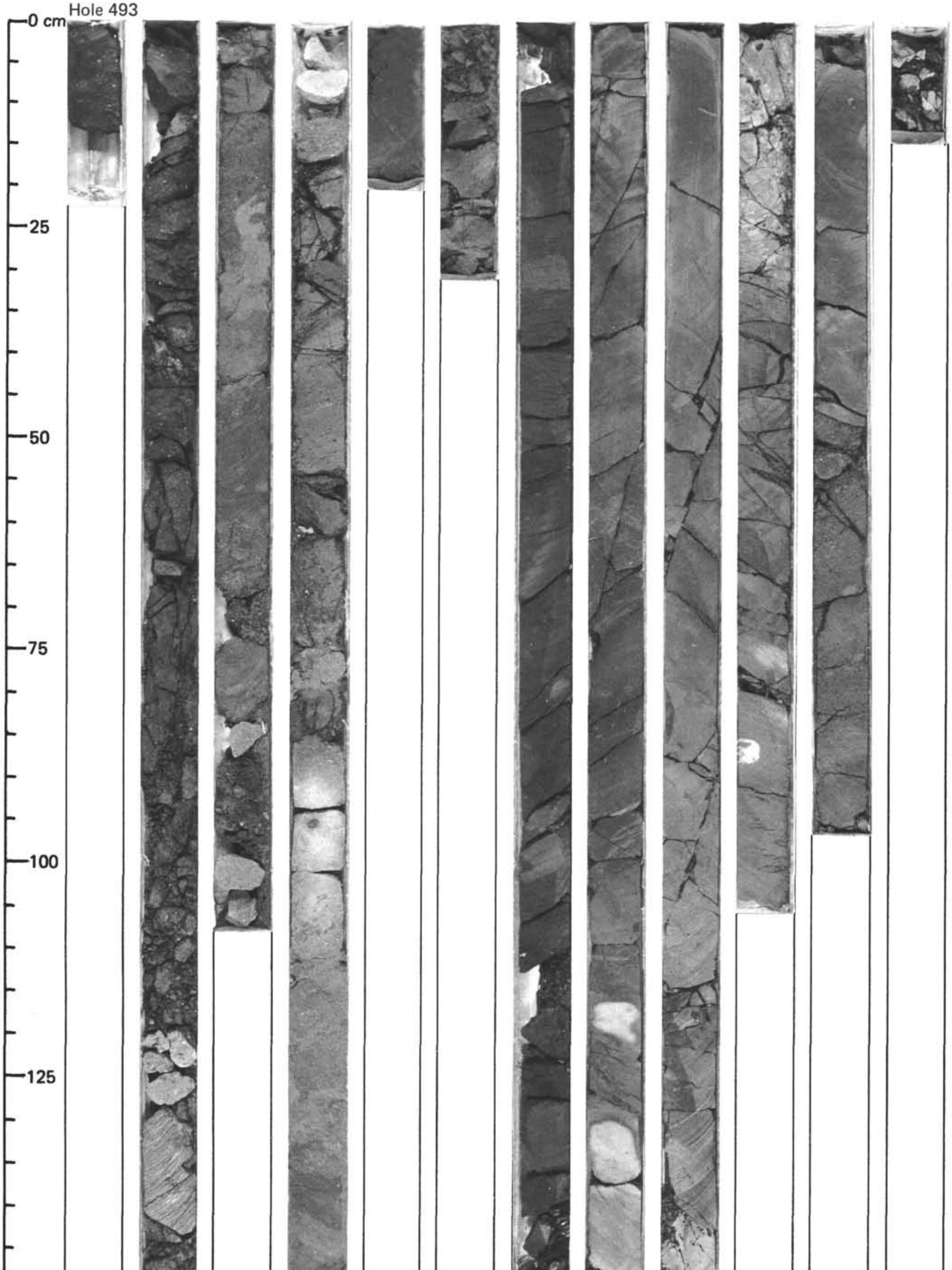
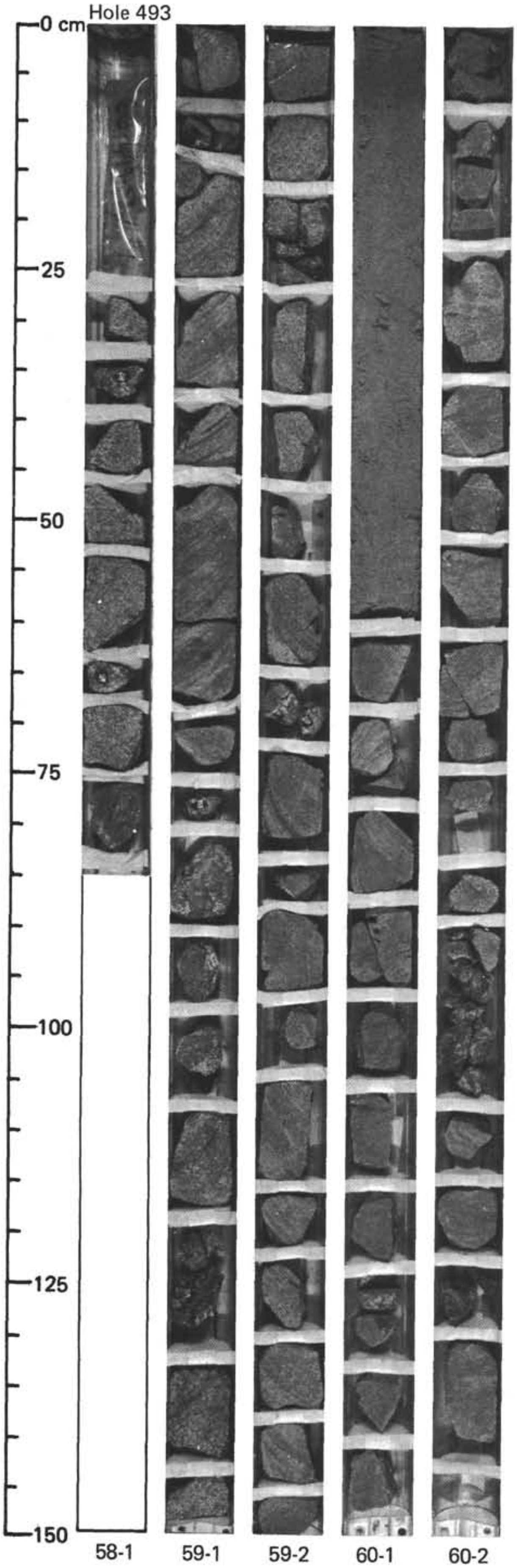
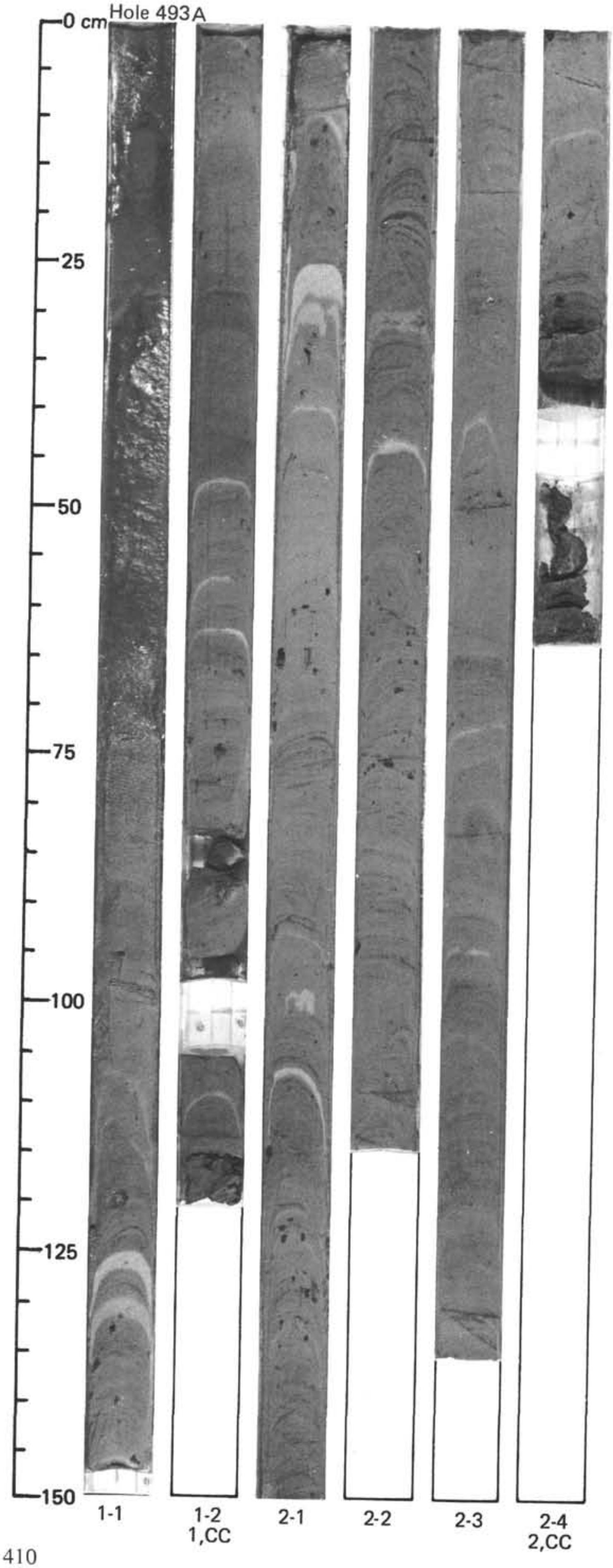
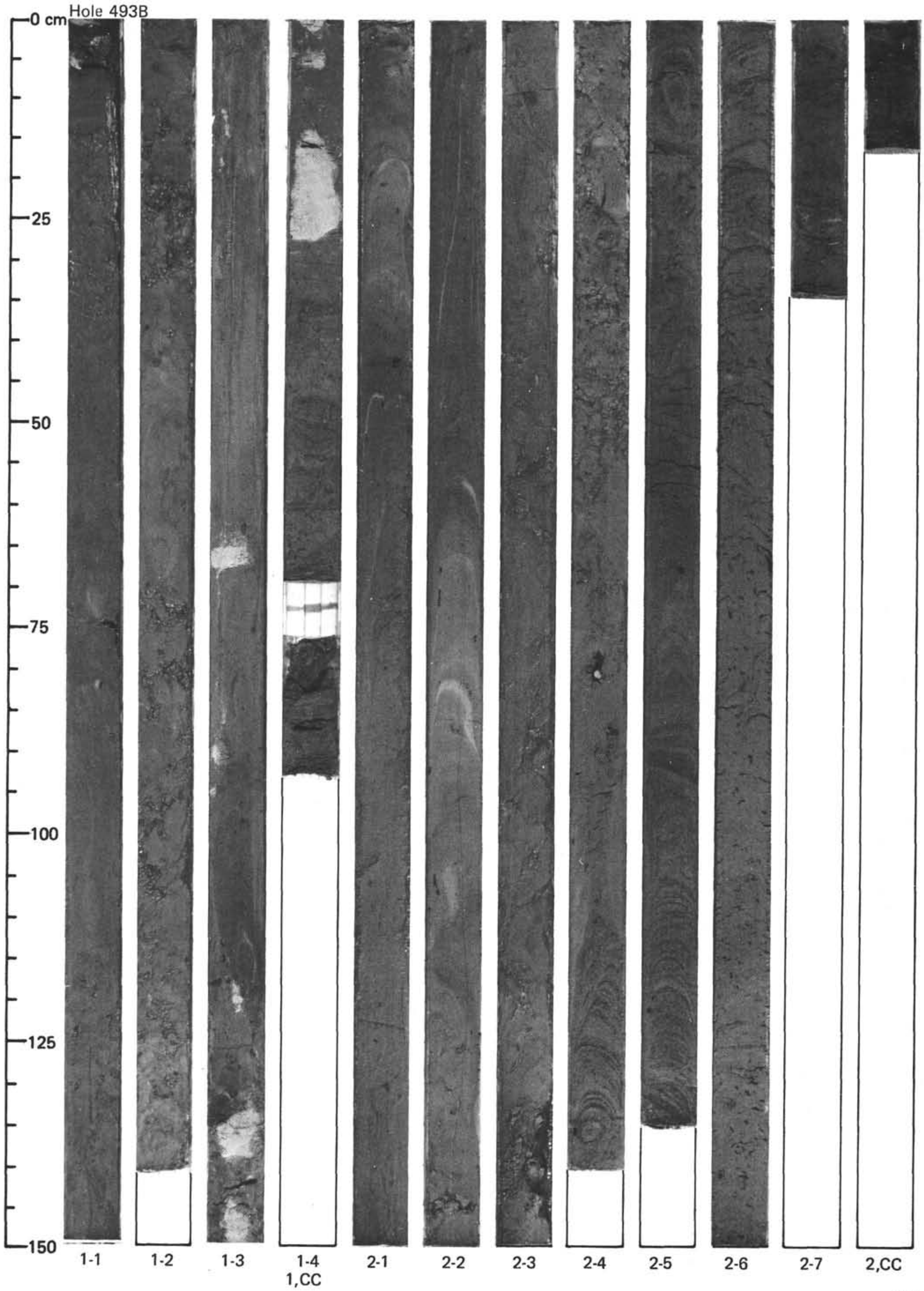
48-3
48,CC
49-1
49-2
49-3

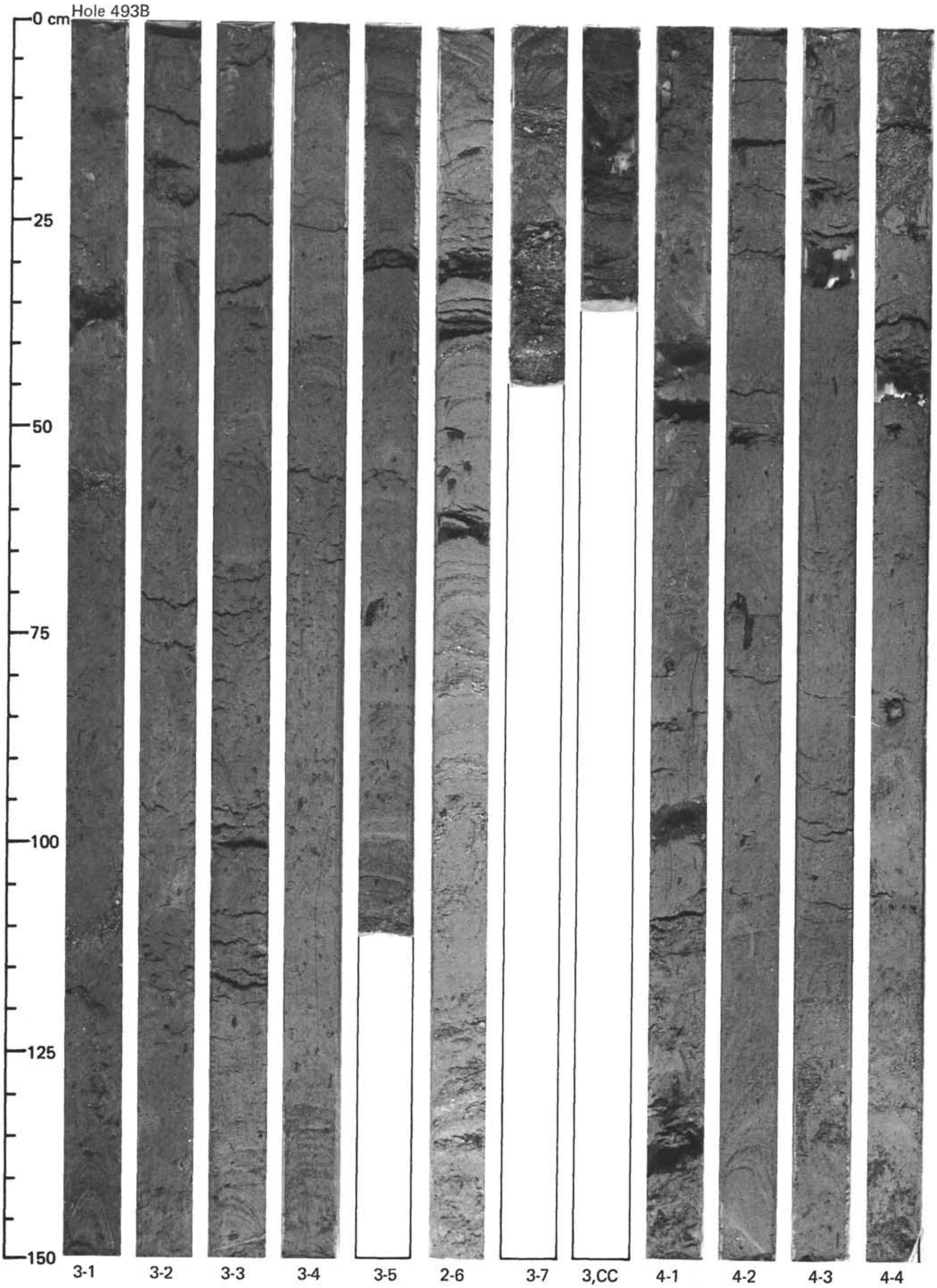

Hole 493
0 cm
25
50
75
100
125
150
49-4
49-5
49-6
49-7
49,CC
50-1
50-2
50-3
50-4
50-5
50,CC
51-1

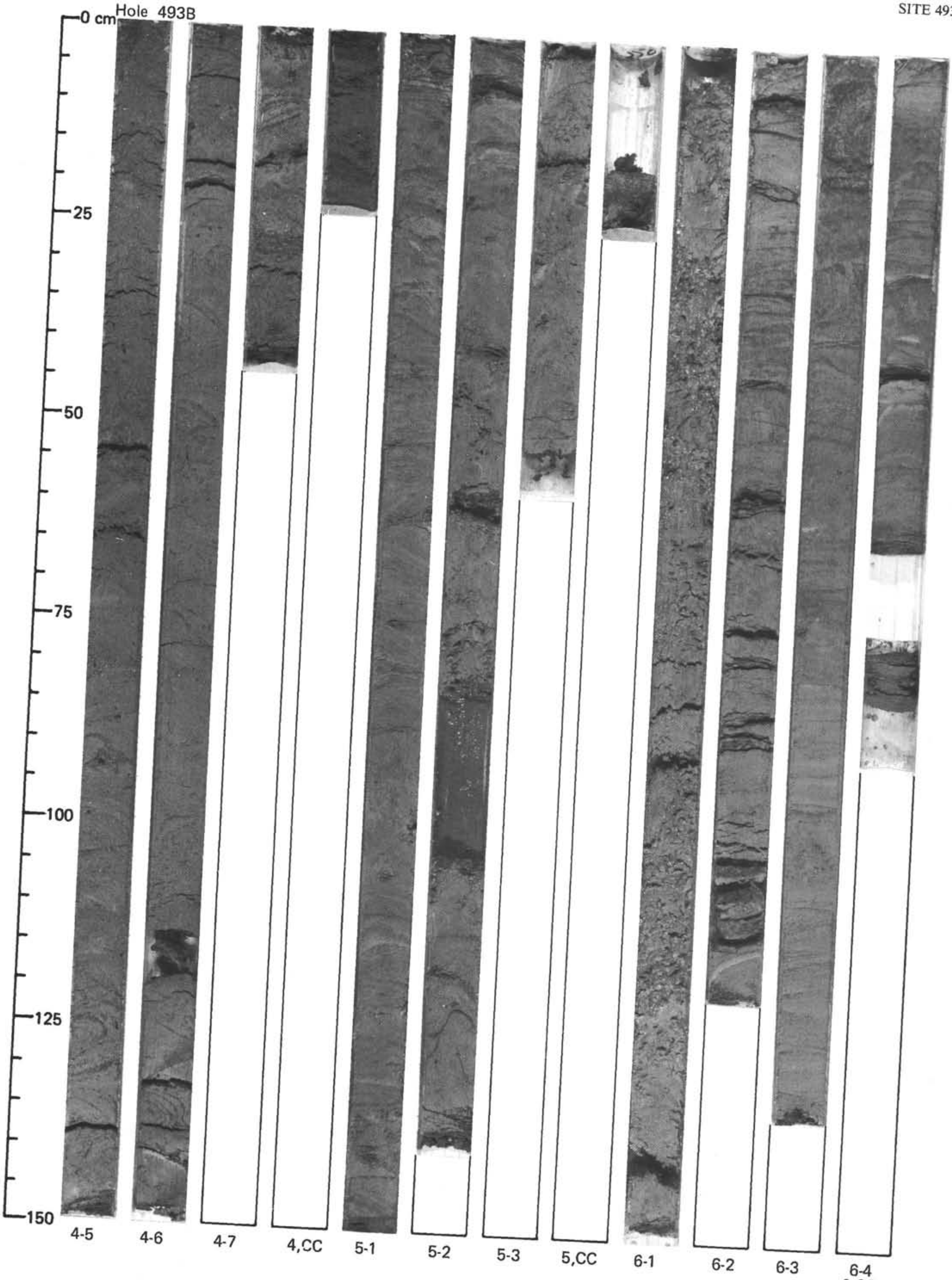

Hole 493
0 cm
25
50
75
100
125
150
51,CC
52-1
52-2
53-1
53-2
53,CC
54-1
54-2
54-3
54-4
54-5
54,CC

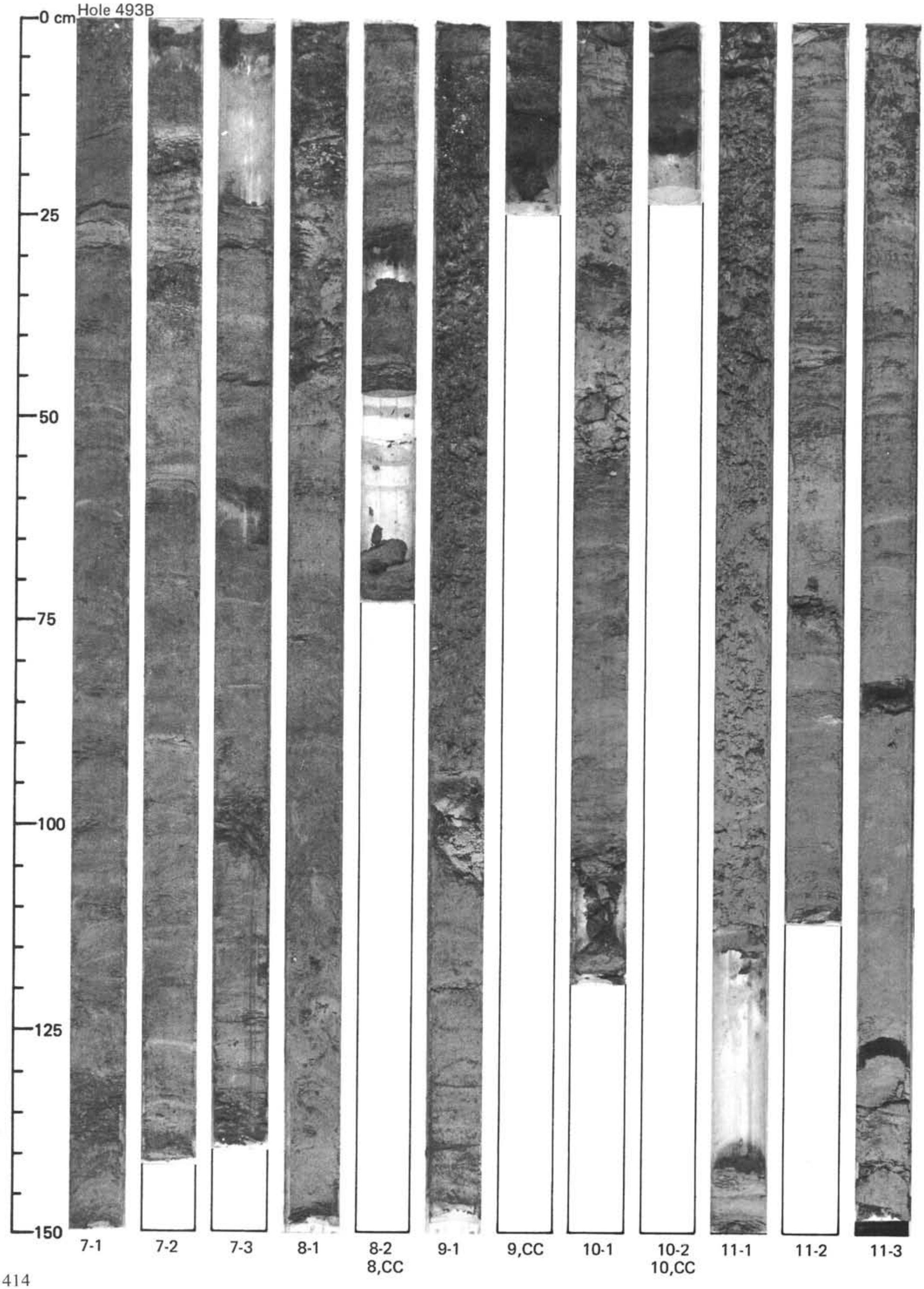

0 cm
Hole 493
25
50
75
100
125
150
58-1
59-1
59-2
60-1
60-2

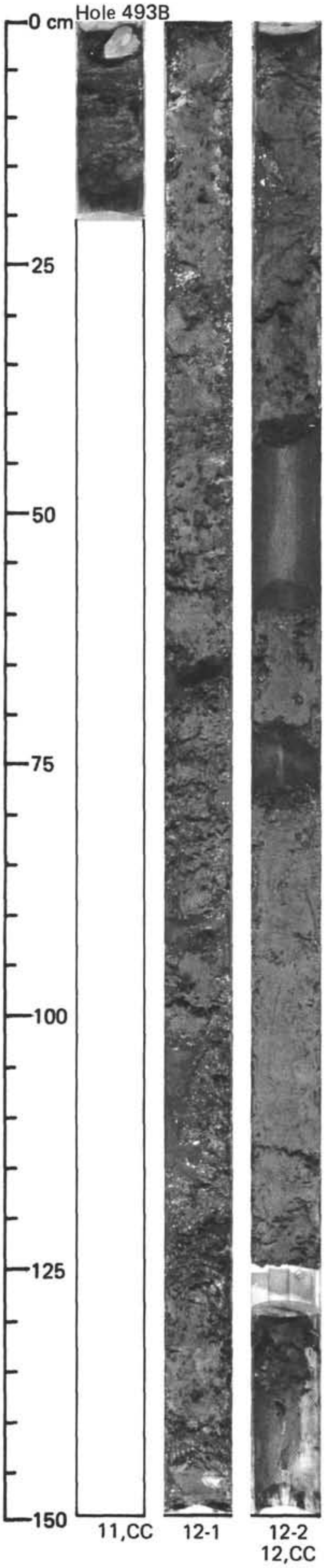

Hole 493A
0 cm
25
50
75
100
125
150
1-1
1-2
1,CC
2-1
2-2
2-3
2-4
2,CC


Hole 493B
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1-4
1,CC
2-1
2-2
2-3
2-4
2-5
2-6
2-7
2,CC


Hole 493B
0 cm
25
50
75
100
125
150
3-1
3-2
3-3
3-4
3-5
2-6
3-7
3,CC
4-1
4-2
4-3
4-4


Hole 493B
0 cm
25
50
75
100
125
150
4-5
4-6
4-7
4,CC
5-1
5-2
5-3
5,CC
6-1
6-2
6-3
6-4
6,CC


Hole 493B
0 cm
25
50
75
100
125
150
7-1
7-2
7-3
8-1
8-2
8,CC
9-1
9,CC
10-1
10-2
10,CC
11-1
11-2
11-3


0 cm
Hole 493B
25
50
75
100
125
150
11,CC
12-1
12-2
12,CC