4. SITE 440: JAPAN TRENCH MIDSLOPE TERRACE, LEG 57

Shipboard Scientific Party[1]

HOLE 440

Date Occupied: 10 November 1977

Date Departed: 10 November 1977

Time on Hole: 1 day

Position: 39°44.33′N; 143°55.74′E

Water Depth (sea level): 4509 corrected meters, echo sounding

Water Depth (rig floor): 4519 corrected meters, echo sounding

Bottom Felt: 4517 meters, drill pipe

Penetration: 73.0 meters

Number of Cores: 8

Total Length of Cored Section: 73.0 meters

Total Core Recovery: 50.4 meters

Core Recovery: 69 per cent

Oldest Sediment Cored:
Depth sub-bottom: 73.0 meters
Nature: Diatomaceous silty clay
Age: Pleistocene
Measured velocity: 1.5 km/s

HOLE 440A

Date Occupied: 11 November 1977

Date Departed: 11 November 1977

Time on Hole: 1 day

Position: 39°44.13′N; 143°55.74′E

Water Depth (sea level): 4509 corrected meters, echo sounding

Water Depth (rig floor): 4519 corrected meters, echo sounding

Bottom Felt: 4517 meters, drill pipe

Penetration: 139.5 meters

Number of Cores: 7

Total Length of Cored Section: 66.5 meters

Total Core Recovery: 33.5 meters

Core Recovery: 50 per cent

Oldest Sediment Cored:
Depth sub-bottom: 139.5 meters
Nature: Diatomaceous clay
Age: Pleistocene
Measured velocity: 1.5 km/s

HOLE 440B

Date Occupied: 12 November 1977

Date Departed: 19 November 1977

Time on Hole: 8 days

Position: 39°44.13′N; 143°55.74′E

Water Depth (sea level): 4509 corrected meters, echo sounding

Water Depth (rig floor): 4519 corrected meters, echo sounding

Bottom Felt: 4517 meters, drill pipe

Penetration: 814.0 meters

Number of Cores: 71

Total Length of Cored Section: 814.0 meters

Total Core Recovery: 401.9 meters

Core Recovery: 49 per cent

Oldest Sediment Cored:
Depth sub-bottom: 814.0 meters
Nature: Diatomaceous claystone
Age: Late Miocene
Measured velocity: 2.1 km/s

Principal results:

Site 440 is on the Japan Trench inner slope, 28 km from its axis and on the midslope terrace. The core recovery and biostratigraphic zonation were good, and a suite of downhole logs contributed greatly to interpretation of lithology and structure. Beneath the midslope terrace is a flat-lying nonfolded continental-slope section which is probably not material accreted at the leading edge of the upper plate. The sediment section is of fairly uniform hemipelagic mudstone similar in composition to that at sites farther upslope. Over 800 meters were penetrated; sediment ranges in age from late Miocene through late Pleistocene.

The only breaks in continuous sedimentation are three or more periods of slumping in the Miocene and Pliocene. Ponding of turbidites and a twofold increase in sedimentation rate in the Pleistocene are consistent with the present topography of the midslope terrace.

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The section was deposited at bathyal depths near or below the carbonate compensation depth (CCD). A stress environment possibly of pre-Pleistocene age has tectonically brecciated the section at depths where the rock deforms brittlely. Although microfaulting was observed at other sites in the transect, it was not as intense and pervasive at relatively shallow depths. The reflective section above acoustic basement is at least 1600 meters thick. The estimated sediment age at this depth is lower Miocene, if sedimentation continued without hiatus and at a nearly constant rate during the early Neogene, as it did at sites upslope.

The fractured but nonfolded block 1.6 km thick and at least 6 km wide may have slumped from upslope. The seismic records and cores show a continuous Neogene continental slope section from Site 440 landward across the deep sea terrace almost to the shore. Therefore active Neogene accretion seems to have been restricted to the lower trench slope.

BACKGROUND AND OBJECTIVES

A principal objective of the Japan Trench Transect was sampling of the accretionary wedge in two or three places to establish trends of diagenesis and changes in the physical state of off-scraped sediments. Two sites had been drilled on Leg 56 to make such observations (Figure 1). At the Leg 56 Site 435 on the upper trench inner slope, undeformed Pliocene slope sediment was recovered, and the site was interpreted to be on a large slump block from farther up the slope. At Site 434 on the lower slope, deformed sediment was encountered. However, weather and unstable hole conditions forced termination of drilling at 600 meters, when the drill stem became stuck in a highly fractured Miocene diatomaceous mudstone section. Thus there was no evidence that an accreted section of oceanic sediment had been sampled.

Site 440 was placed between the two Leg 56 sites on a midslope terrace of the Japan Trench inner slope at a depth of 4500 meters. A series of faint subhorizontal reflections below the flat sea floor of the terrace indicated a relatively less deformed section and possibly more favorable hole conditions than those at Site 434. At the base of the faint reflections is a low frequency event that is similar to the acoustic basement reflection at Site 439. Thus the reflection might be a continuation of the unconformity between Cretaceous and Tertiary rock. On the other hand, this reflection was interpreted by the Leg 56 scientific staff to be oceanic crust uplifted by imbrication. This acoustic basement was the target objective at Site 440, although it was recognized that it was probably beyond the reach of a single bit hole and possibly within reach of a multiple re-entry hole. The decision on re-entry was deferred until the results of the single bit pilot hole could be evaluated, indicating whether the rocks encountered were part of an accretionary sequence. A primary consideration was whether deep penetration could be achieved, because previous experience showed caving of highly fractured material rather than drill bit life to be the primary cause of hole termination.

OPERATIONS

The 100-km transit from Site 439 to Site 440 was made during a gathering storm. The *Challenger* turned onto a course of 090° about 12 km west of the site. As was to be expected in these latitudes, the navigation aids at night were insufficient to correct for a set from a beam sea and strong wind, so there was no assurance that the ship was making the desired track after an hour of steaming along a dead-reckoned course. In addition, the seismic system and the 3.5-kHz records were essentially only noise because of sea conditions, so the beacon was not dropped during the first pass over the midslope terrace (Figure 2). A satellite position was not available during the following 4-hour period, and with sea conditions beyond the point where drill pipe would be lowered we decided to wait for a more opportune time to drop the beacon. This occurred about 5½ hours later, when the ship had been brought to a heading that provided a lee wind for personnel during beacon-dropping operations. At the time of the drop the position was recognized to be slightly south of the seismic record track line, and we planned to offset north of the beacon, essentially to the desired position.

After the ship had hove to and pipe was run, the first beacon signal became intermittent and the partially buried bottom hole assembly had to be pulled to the mudline, after only 8 cores had been recovered, until the ship's position-keeping ability could be improved. This was soon accomplished, and Hole 440A was spudded in; but after only 7 cores had been recovered, the weather became too rough to drill with incomplete burial of the bottom hole assembly and this hole was also abandoned. Hole 440B was washed down to the previously attained depth and then cored until yet another storm forced termination after 70 cores had been recovered. However, the ship's position held well enough through the storm to keep pipe in the upper 200 meters of the hole. After about 24 hours, coring was resumed until the bit released unintentionally. A decision to log and abandon this site had already been made because of the desire to drill at least one more site during this leg, and partial logging was accomplished in the less than ideal conditions during a short interval between two storms.

LITHOSTRATIGRAPHY

Site 440 was drilled at a water depth of 4515 meters, 28 km west of the Japan Trench, on the trench inner slope. The site lies on a prominent midslope structural terrace that is about 5 km wide and extends parallel with the trench more than 50 km without structural offset. In seismic reflection records the site is underlain by nearly flat-lying reflectors that are only slightly deformed, whereas the outer edge of the midslope terrace marks the edge of an apparently much more deformed and seismically diffractive area that extends down to the trench floor.

Three holes were drilled at Sites 440 (Holes 440, 440A, and 440B) (Figures 1 and 2). Except in their intervals of overlap, the holes were cored continuously, and together the samples from them provide a relatively con-

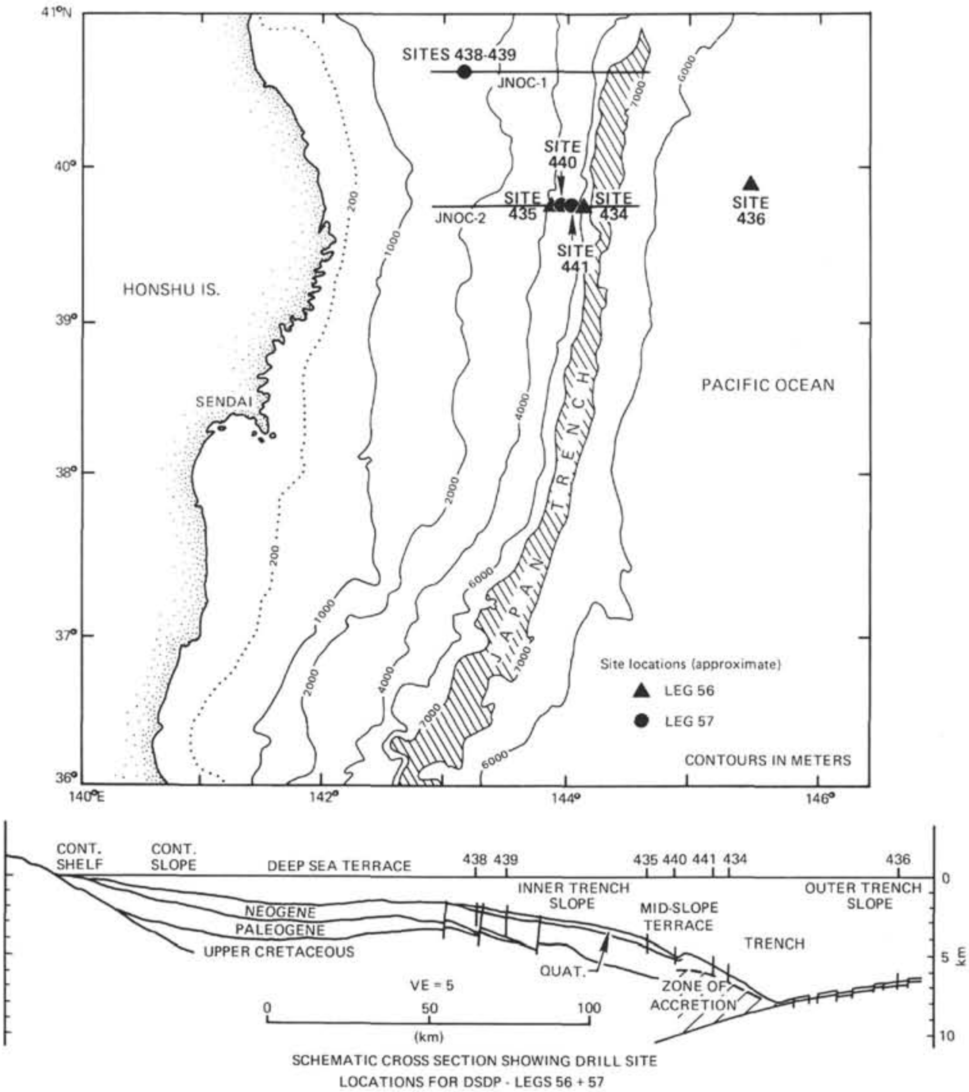

Figure 1. *Location map showing position of sites drilled on Legs 56 and 57 and of JNOC multichannel seismic reflection profiles. Diagrammatic cross section of continental margin shown below (based largely on Ishiwada and Ogawa, 1976).*

tinuous record of the stratigraphy and structural deformation of strata from the sea floor to the base of the lowest core in Hole 440B, which was taken from a sub-bottom depth of 808 meters.

The rocks have been divided into three units on the basis of their lithology (see Figure 3; Sites 435/440 Summary Chart [back pocket]; and Table 1). Unit 1 (0–38 m sub-bottom) consists of graded beds of silt, sand, and gravel with interbeds of clayey diatom ooze. Unit 2 (38–380 m) consists of claystone and diatomaceous claystone containing several zones of randomly dispersed pebbles. Unit 3 (380–808 m) consists of highly fractured claystone and diatomaceous claystone containing some folded beds deformed during mass movement.

Lithostratigraphic Unit 1 (Cores 440-1–440-5-2, 0–38 m sub-bottom, Holocene to upper Pleistocene)

The top 15 meters of Unit 1 consist of interbedded poorly sorted greenish-black to olive-gray (5G 2/1–5Y 4/2, wet) clayey sand and gravel, and firm dusky-yellow-green to olive-gray (5GY 5/2–5Y 3/2) diatomaceous clay and sandy diatom ooze. The remainder of the unit consists of grayish-olive (10Y 4/2) diatomaceous silty and sandy clay. Both parts contain graded beds. In the sand and gravel, these beds consist of matrix-supported units up to 80 cm thick, in which the largest clasts are 5 cm in diameter. In the sandy diatomaceous clay and ooze, the graded units are sand and silt beds about 2 cm thick that are spaced about 1 meter apart on the average. These show characteristics which are typical of turbidity current deposits.

The pebbles consist of subrounded to well-rounded clasts of light-colored plutonic rocks, andesite or dacite porphyry, mafic porphyry, altered metamorphic rocks, reddish-brown chert, pumice and concretionary claystone containing diatoms of earliest Pleistocene age. The diatoms in the claystone clasts are of the same time interval, represented at Site 438 (and Site 435) by a

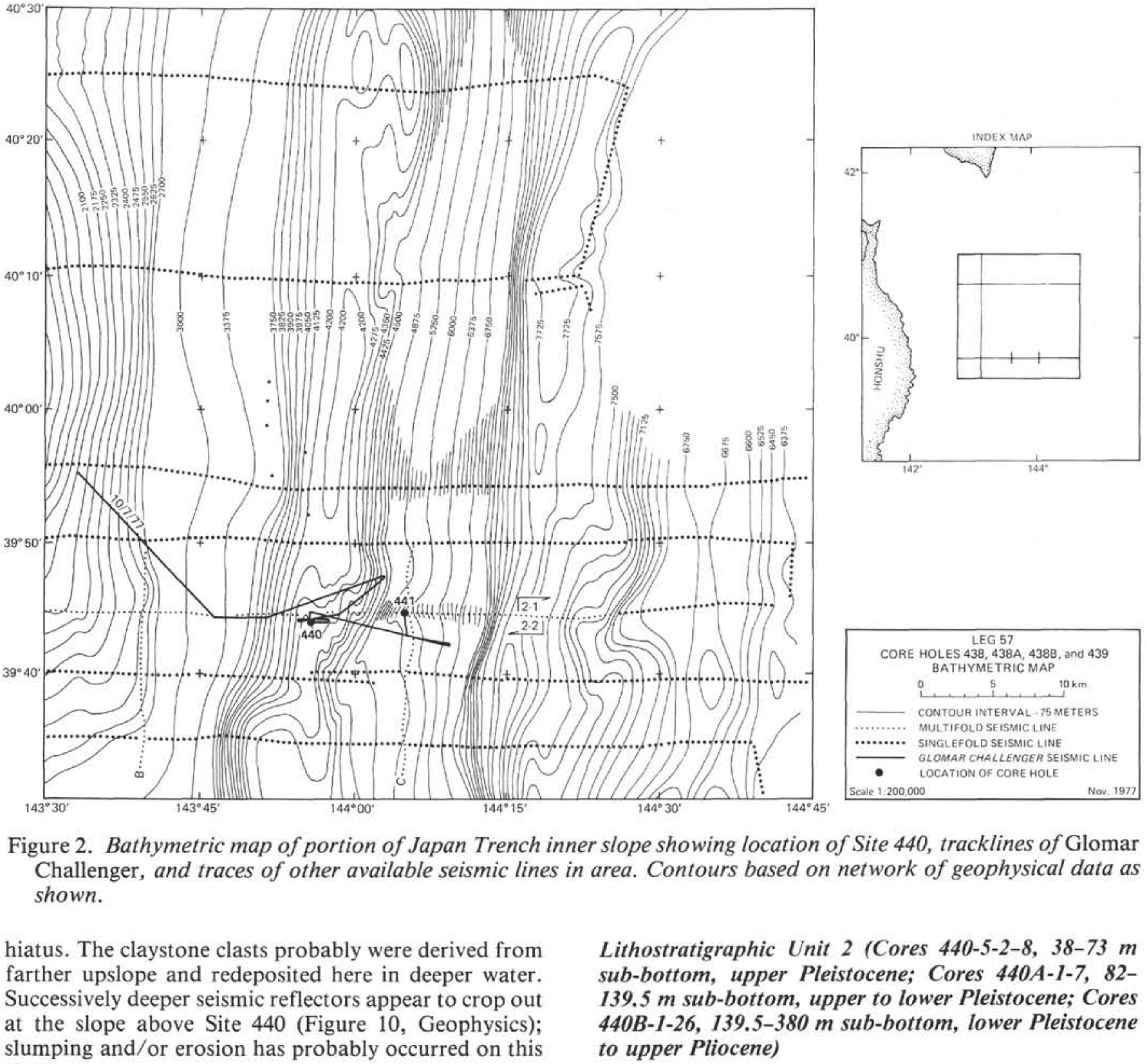

Figure 2. *Bathymetric map of portion of Japan Trench inner slope showing location of Site 440, tracklines of* Glomar Challenger, *and traces of other available seismic lines in area. Contours based on network of geophysical data as shown.*

hiatus. The claystone clasts probably were derived from farther upslope and redeposited here in deeper water. Successively deeper seismic reflectors appear to crop out at the slope above Site 440 (Figure 10, Geophysics); slumping and/or erosion has probably occurred on this slope.

Within the finer-grained beds of Unit 1, clay minerals average about 30 per cent, diatoms 21 per cent, quartz plus feldspar 20 per cent, sponge spicules 8 per cent, volcanic glass 6 per cent, heavy minerals 2 per cent, glauconite 2 per cent, and authigenic pyrite 0.5 per cent (Site Summary Chart, back pocket). Beginning in Core 4 at about 25 meters and extending into Unit 2 to a depth of 161 meters, the deposits are stained black by an ephemeral mineral, possibly the iron sulfide mackinawite. After a few hours of exposure to air, the black stain disappears.

Lithostratigraphic Unit 2 (Cores 440-5-2-8, 38–73 m sub-bottom, upper Pleistocene; Cores 440A-1-7, 82–139.5 m sub-bottom, upper to lower Pleistocene; Cores 440B-1-26, 139.5–380 m sub-bottom, lower Pleistocene to upper Pliocene)

Unit 2 is generally dark olive gray to olive gray (5Y 3/2-4/2). The upper half of the unit consists of diatomaceous clay and claystone, the lower half claystone. Its age is early Pleistocene and late Pliocene. At a sub-bottom depth of 168 meters, the cores could no longer be split with a wire, and material below that depth, cut with a power saw, by convention is considered to have been lithified into rock.

Randomly dispersed rounded pebbles, probably ice-rafted dropstones, occur at three intervals within Unit 2: at 91 to 96 meters, at 202 to 211 meters, and at 275 to

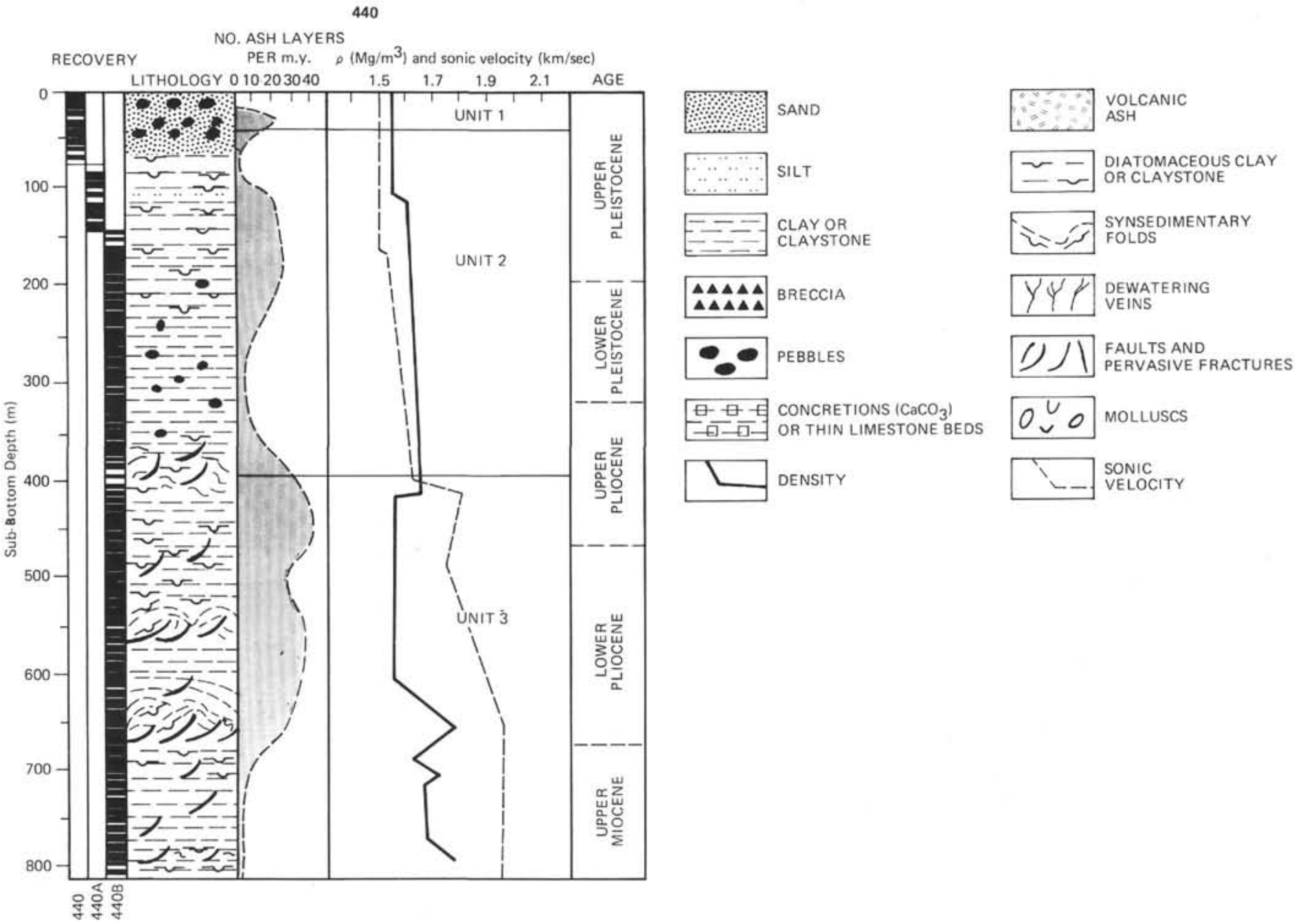

Figure 3. *General lithology, lithologic units, core recovery, ash layer frequency, and physical properties from geophysical logs for Site 440.*

TABLE 1
Lithologic Units, Coring Summary, Ages, and Description of Sequence at Site 440

Hole	Lithologic Unit	Core Numbers	Depth (m)	Age	Lithology
440	1	1 to 5	0.0–38.0	Holocene–upper Pleistocene	Greenish black to olive gray (5G 2/1-5Y 4/2) clayey sand and gravel, poorly sorted, from dusky yellow green to olive gray (5GY 5/2-5Y 3/2) diatomaceous clay, sandy diatom ooze, and grayish olive (10Y 4/2) diatomaceous silty and sandy clay; some graded bedding in coarser-grained intervals. Rounded pebbles of various igneous and sedimentary rocks common. Some thin ash layers.
440 440A 440B	2 2 2	5 to 8 1 to 7 1 to 26	38.0–480.0	Lower Pleistocene–upper Pliocene	Mostly dark olive gray to olive gray (5Y 3/2–4/2) diatomaceous clay and (below 168 m) diatomaceous claystone. Randomly dispersed rounded pebbles common; burrow mottling increases downhole. Minor thin ash layers.
440B	3	27 to 71	380.0–808.0	Lower Pliocene–upper Miocene	Generally olive gray to dark olive gray (5Y 4/2–3/2) interbedded claystone and diatomaceous claystone. Zones of folded beds (due to mass movement), veins, and microfaults. Thin (1-cm) ash layers common throughout.

352 meters. The clasts are of rock types similar to those that are concentrated near the top of Unit 1. The pebble intervals of Units 1 and 2 correspond roughly with strata containing cold-water planktic foraminiferal assemblages (see Keller, this volume). They may record past glaciations; if so, several are recorded here, the oldest in the late Pliocene.

In typical beds of Unit 2, clay minerals average about 60 per cent, quartz plus feldspar 15 per cent, diatoms 10 per cent, volcanic glass 6 per cent, sponge spicules 3 per cent, heavy minerals 1 per cent, glauconite 1 per cent, and pyrite 1 per cent (Site Summary Chart, back pocket).

Unit 2 is slightly to intensely mottled, the average level of mottling being moderate. Bedding disturbances identifiable as burrows increase toward the base of the unit. This may in part be due to the method of core-slicing. Sawing and careful cleaning exhibits structures much more clearly. Sponge fragments are seen in most cores.

Lithostratigraphic Unit 3 (Cores 440B-27-440B-71, 380-808 m sub-bottom, lower Pliocene to upper Miocene)

Unit 3 is generally olive gray to dark olive gray (5Y 4/2-5Y 3/2) and consists of interbedded claystone and diatomaceous claystone. A distinguishing feature of this unit is the presence of several zones of folded beds that may have been caused by mass movement. A typical example occurs in Core 43 (541-544 m sub-bottom), which is characterized by a series of recumbent folds. These folds are all associated with veins and faults that were clearly formed after lithification of the rock, suggesting that more than one episode of deformation may have occurred along certain zones within the unit. Veins, fractures, and faults occur nearly throughout Unit 3 to the bottom of the hole. Most of these features are rehealed, but many open fractures in cores tend to parallel the directions of the healed fractures (see Arthur, Carson, and von Huene this volume).

In typical beds of Unit 3, clay minerals average 70 per cent, quartz plus feldspar 12 per cent, diatoms 11 per cent, volcanic glass 4 per cent, sponge spicules 4 per cent, heavy minerals 0.5 per cent, glauconite 0.5 per cent, and pyrite 0.5 per cent (Site Summary Chart, back pocket).

Mottling is commonly intense in Unit 3, and burrows occur throughout the unit. Sponge fragments occur in most cores near the top of the unit; they are somewhat less common near the base.

Ash and Tuff Layers

Core recovery was sufficiently good at Site 440 that the number of ash and tuff layers per million years can be plotted with reasonable accuracy (Figure 4; see also Cadet and Fujioka, this volume) despite the effects of bioturbation on disruption of layers and diagenesis deeper in the hole. The record of volcanogenic deposition is roughly similar to that which has been noted at previous drilling sites in this area (see Kennett et al., 1977). Volcanic activity increased near the end of the Miocene and continued at a high level through the first two thirds of the Pliocene. The activity waned during the last part of the Pliocene and in the early Pleistocene. Renewed activity apparently characterizes the remainder of the Pleistocene.

Ash and tuff layers are rarely more than 1 cm thick at this site. Most of the ash probably settled through the water column after having been transported to the area through the atmosphere. Some graded beds, however, are intimately mixed with terrigenous material and were probably transported and redeposited as turbidites.

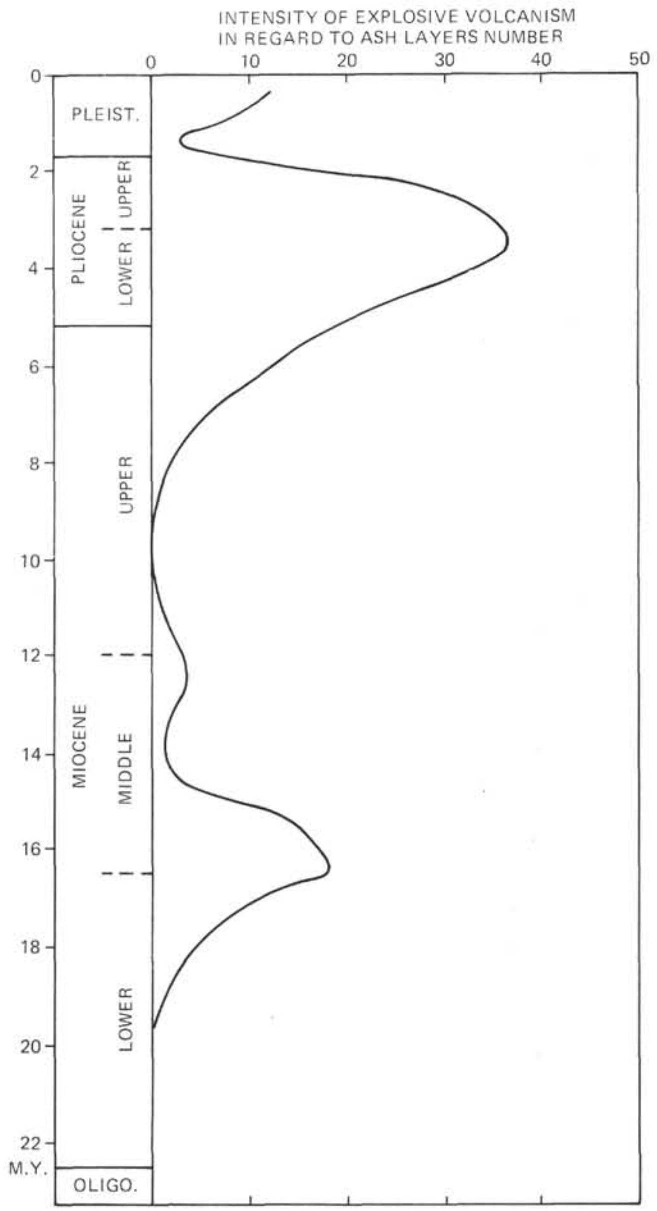

Figure 4. *Ash layer frequency through time at Leg 57 sites (see Cadet and Fujioka, this volume).*

Pumice clasts, which presumably first floated to this area, became waterlogged, and subsequently sank are dispersed throughout the section. Their abundance roughly mirrors the frequency of eruptions as recorded by the ash and tuff layers.

Structural Geology

In addition to the previously discussed synsedimentary small-scale folding that has affected the rocks of Unit 3, that unit has also been extensively faulted and fractured (see Arthur et al., this volume). Several different types of displacement have taken place at different times. One of the most characteristic types consists of healed microfaults, along which mottles and thin beds are offset from 1 mm to a few centimeters. In places where this type of faulting, along with other types, has been especially intensive, there is some brecciation of the rock.

Closely associated with the healed microfaults are black-stained veins. Some of these veins are older than the microfaults, and the older ones, which are probably dewatering conduits, are joint-like and lack discernible displacement. Other black-stained veins contain gouge and follow fractures that offset the microfaults. Both types of veins branch, and many of them are sinuous.

A third set of fractures consists of offsets along which parting occurs. These seem to be the youngest structures, and they usually result in systematically broken core fragments. They commonly exhibit faint slickensides. Normal, reverse, and strike-slip movement occurs along the microfaults, black veins, and slickensided faults with inclinations ranging from horizontal to vertical.

The faults and synsedimentary folds tend to be concentrated in several thick zones within Unit 3. Core recovery is poorer within these intervals. Anomalously high levels of ethane from 250 to 400 meters across the uppermost zone of fracturing may indicate that the fractures are interconnected (see Whelan, Hydrocarbons, this volume).

Sedimentation History and Depositonal Environments

The gross lithology and stratigraphic succession at Site 440 is very similar to that of the other sites along the Japan Trench margin transect; hemipelagic sediment predominates. Diatoms compose a volumetrically important portion of sediment from the upper Pliocene through the Pleistocene but generally decline in importance downhole. According to biostratigraphic and paleomagnetic data, there is a continuous stratigraphic sequence from late Miocene through Pleistocene (~8 m.y.B.P. to recent; only an uppermost Miocene hiatus breaks the continuity). There is no evidence for tectonic repetition of units, and a series of subhorizontal seismic reflectors underlying the midslope terrace is evident in the multichannel seismic records.

The sedimentation rate during the late Miocene–Pliocene interval at Site 440 is comparable to that at Site 438 on the deep sea terrace (~110 m/m.y.); however, during the Pleistocene the sedimentation rate at Site 440 exceeds 230 m/m.y. which is much greater than that at any other site along the transect. In fact, upper Pliocene-lower Pleistocene hiatuses are found at Sites 438, 435, 441, and 434. Possibly the high sedimentation rates on the midslope terrace during the Pleistocene represent ponding of sediment behind a growing ridge. However, coarse turbidite sands occur only in the upper 38 meters of the section at Site 440. Redeposition of sediment from upslope is suggested by claystone clasts in some upper Plesitocene intervals bearing diatom floras of the late Pliocene–early Pleistocene. The presence of a few synsedimentary slump folds indicates some redeposition from upslope during the early to late Pliocene.

The tectonically induced fractures, faults, and veins found below about 370 meters in the section apparently represent a tectonic jostling of the strata, but, as previously stated, the intense brecciation has not disrupted the stratigraphic continuity of the sequence.

BIOSTRATIGRAPHY

Introduction

An essentially continuous sequence of Quaternary through upper Miocene sediment was cored at Site 440 (Holes 440, 440A, and 440B). Microfossil assemblages provide excellent biostratigraphic control — comparable to that at Site 438. Diatoms are the most abundant microfossil group present; radiolarians range from very common to very rare; foraminifers are common above the upper Pliocene but rare to absent in the lower Pliocene and upper Miocene; and nannofossils range from abundant to rare in Pleistocene, upper Pliocene, and upper Miocene.

The relationship between the zonal assignments made for the different microfossil groups observed at Site 440 is shown in Figure 5.

The average sediment accumulation rate curve for Site 440 is shown in Figure 6. Sediment accumulation is greater above the 0.9 million year datum (~230 meters/million years) than before that datum (as low as ~100 meters/million years) and may reflect, in part, compaction of sediments.

No major hiatuses are recognized, although diatom evidence suggests a brief upper miocene hiatus between Cores 60, CC and 61, CC of Hole 440B.

Benthic foraminiferal assemblages indicate bathyal depths (greater than 2000 m) throughout the Pleistocene to upper Miocene sequence. The sparsity and generally poor state of preservation of calcareous plankton suggest deposition at or below the CCD, presently at approximately 3500 meters.

Diatoms

The *Denticula seminae* Zone (0–0.26 m.y.B.P.) is present down to Sample 440-5,CC. Reworking of earlier Pleistocene forms such as *Nitzschia fossilis, N. reinholdii, Rhizosolenia barboi, R. curvirostris, and Thalassiosira nidulus* is common in Samples 440-1,CC and 440-2,CC.

The *Rhizosolenia curvirostris* Zone (0.26-0.9 m.y. B.P.) occurs from Samples 440-6, CC through 440B-6, CC. The last occurrence of *Nitzschia reinholdii,* which marks the top of Subzone *a* and the base of Subzone *b,* is in Sample 440B-2,CC and has an estimated age of 0.63 m.y.B.P. (Burckle, 1977). The last occurrence of the silicoflagellate *Mesocenica elliptica,* which is estimated at 0.79 m.y.B.P. by Burckle (1977), occurs in Sample 440B-5,CC.

The *Actinocyclus oculatus* Zone (0.9–~1.4 m.y.B.P.) corresponds to Samples 440B-7,CC through 440B-7,CC. Following the criteria of Haq et al. (1977), the Pliocene/Pleistocene boundary is approximated by the base of this zone (Barron, this volume).

The *Denticula seminae* var. *fossilis* Zone (~1.7–2.43 m.y.B.P.) occurs from Samples 440B-18,CC through about 440B-25,CC. The base of this zone is placed at the

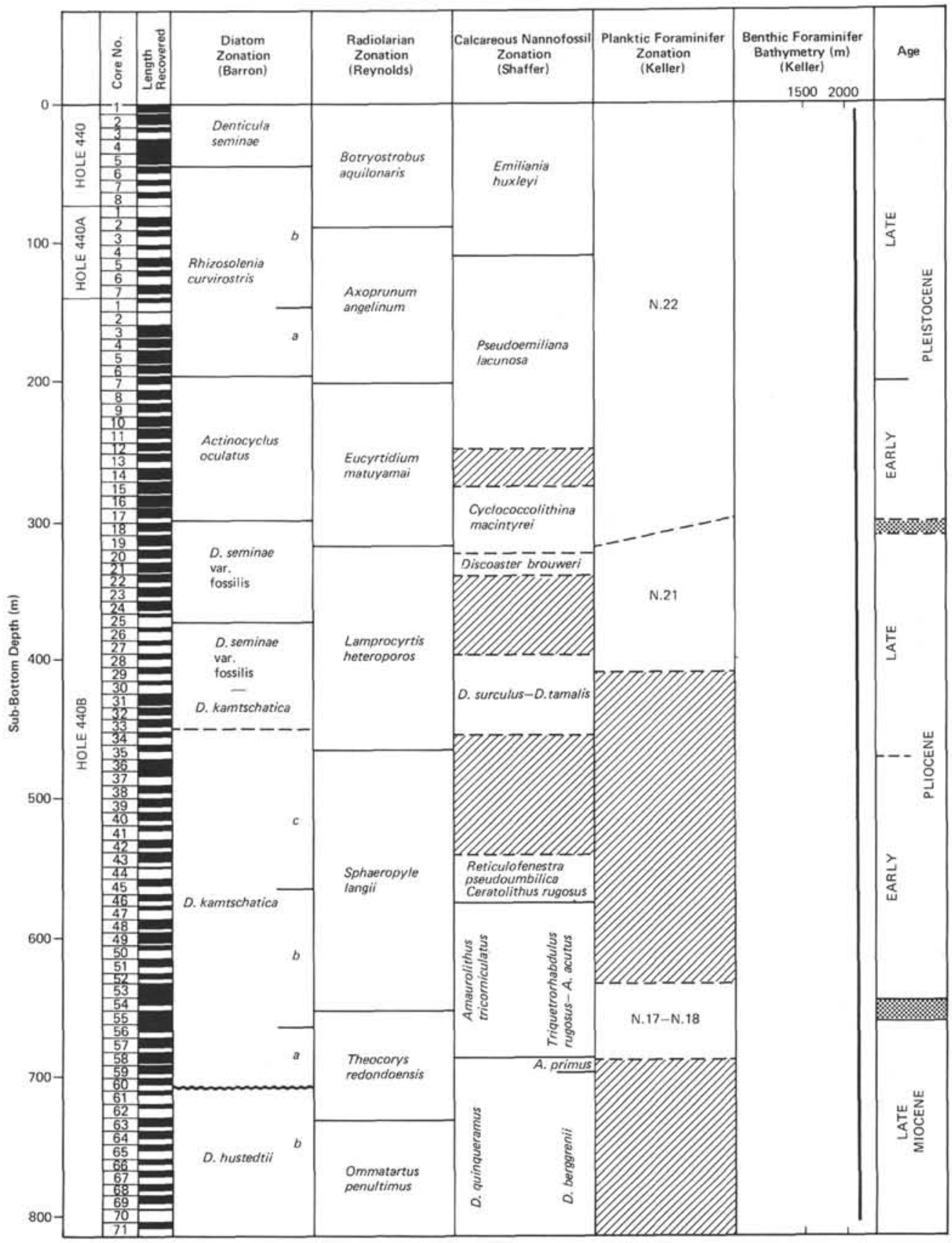

Figure 5. *Planktic biostratigraphy and generalized paleobathymetry at Site 440.*

last common *D. kamtschatica;* reworked *D. kamtschatica* is present throughout the uppermost Pliocene.

The *D. seminae* var. *fossilis–D. kamtschatica* Zone (2.43–~3.0 m.y.B.P.) is present from Samples 440B-25,CC through 440B-33, CC. The last occurrence of *Nitzschia jouseae* in Sample 440B-29,CC is assigned an absolute age of approximately 2.5 m.y.B.P. following Burckle's and Opdyke's (1977) correlation of this datum level with the uppermost part of the Gauss Magnetic Epoch. The last occurrence of *Thalassiosira nativa* in Sample 440B-33, CC coresponds to the base of the zone, and because it correlates well with its last occurrence in Hole 438A, it can be used to approximate the base of the *Denticula seminae* var. *fossilis–D. kamtschatica* Zone (Barron, this volume).

The *D. kamtschatica* Zone occurs from Samples 440B-34,CC through 440B-60,CC (4.4–6.2 m.y.B.P.). The same three subzones identified in Hole 438A occur in the proper sequence. The Miocene/Pliocene boundary (~5.1–5.2 m.y.B.P.) is approximated by the last *Rouxia californica* (top of Subzone *a*) in Sample 440B-56,CC. The first *Thalassiosira oestrupii* in Sample 440B-56,CC lends support to this assignment (Barron, this volume).

The uppermost Miocene (Messinian event?) hiatus recognized in Core 42 of Hole 438A seems to be present

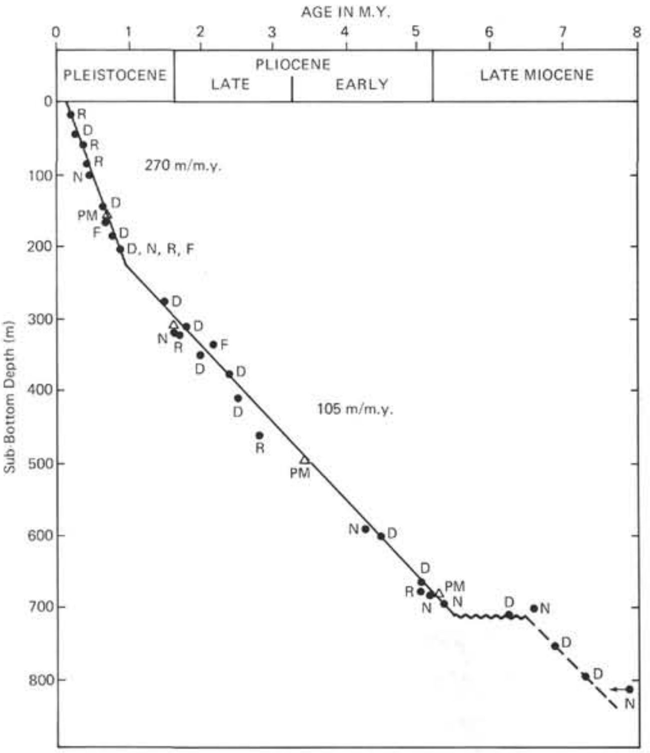

Figure 6. *Sedimentation rates for Site 440, uncorrected for compaction, based on diatom (D), nannofossil (N), radiolarian (R), planktic foraminifer (F), and paleomagnetic (PM) data. Paleomagnetic data represent the top of the Olduvai Event, the Gauss/Gilbert boundary, and the Gilbert/Epoch 5 boundary (Smetzer and Hall, this volume).*

also between Samples 440B-60,CC and 440B-61,CC. The first occurrences of *Nitzschia reinholdii* and *Denticula kamtschatica* s.str. are in Sample 440B-60,CC, and specimens of *Denticula* cf. *kamtschatica* below that level are primitive in morphology.

Assemblages from Samples 440B-61,CC through 440B-71,CC (base of hole) are correlated with Subzone *b* of the *Denticula hustedtii* Zone (Barron, this volume). The last occurrences of *Thalassionema hirosakiensis* in Sample 440B-66-3, 8–11 cm, and of *Distephanus pseudofibula* in Sample 440B-70,CC are supportive.

Preservation is good to moderate down to Sample 440B-38,CC; poor to moderate between Samples 440B-39,CC and 440B-60,CC; and poor to the base of the hole. Diatoms are common to abundant down to Sample 440B-38,CC, few to common from Samples 440B-39,CC to 440B-63,CC, and generally rare below that level.

Radiolaria

The expanded upper Miocene to Recent section of Site 440 contains common to rare radiolarian assemblages with good to poor preservation. Preservation as well as radiolarian abundance decreases with depth as noted herein:

Preservation

good — 1 (Section 440-1-1) to 409 (Section 440B-29-3) meters
good to moderate — 415 (Section 440B-30-1(to 516 (Section 440B-40-5) meters
moderate to poor — 521 (Section 440B-4-1) to 602 (Section 440B-49-5) meters
poor — 606 (Section 440B-50-1) to 814 (Section 440B-71,CC) meters

Abundance

common — 1 (Section 440-1-1) to 333 (Section 440B-21-3) meters
common to few — 336 (Section 440B-21-5) to 521 (Section 440B-41-1) meters
few — 530 (Section 440B-42-1) to 716 (Section 440B-68-1) meters
rare to few — 780 (Section 440B-68-3) to 814 (Section 440B-71,CC) meters

Radiolarian zones recognized from the cores taken at Site 440 are represented by the following intervals: 440-1-1 to 440-2-5 (*Botryostrobus aquilonaris*), 440A-3-1 to 440B-7-3 (*Axoprunum angelinum*), 440B-20-1 to 440B-35-1 (*Lamprocyrtis heteroporos*), 440B-35-3 to 440B-55-1 (*Sphaeropyle langii*), 440B-55-3 to 440B-63-1 (*Stichocorys peregrina*), and 440B-63-3 to 440B-71,CC (*Ommatartus penultimus*). The Pleistocene/Pliocene boundary occurs between Sections 440B-19-3 and 440B-20-1, and the Pliocene/Miocene boundary between Sections 440B-16-5 and 440B-17-1.

Calcareous Nannofossils

The three holes that make up Site 440 represent an apparently complete late Neogene stratigraphic sequence. Nannofossils are moderately to poorly preserved and abundances range from very rare to abundant. The generally low species diversities probably reflect extratropical environmental influences and selective dissolution. Sporadic occurrences throughout much of the Pliocene and a portion of the lower Pleistocene may indicate sedimentation within the calcite compensation range during these times. Because of these poor to barren intervals, a continuous zonation based on nannofossils was not possible, and zone and stage boundaries sometimes could not be delineated. However, nannofossil recovery was enhanced by selective sampling of light-colored calcareous mottles occurring occasionally in otherwise barren matrices. Approximately 25 per cent of these mottles, probably because of bioturbation, yielded adequate, sometimes abundant nannofossil assemblages.

All of Hole 449 (Cores 1-8) and Cores 1-3,CC of Hole 440A lie above the *Pseudoemiliania lacunosa* datum (*Emiliania huxleyi* Zone). Core 1 of Hole 440 contains common lower to middle Pleistocene nannofloras mixed with those of the late Pleistocene age. This is attributed to reworking or to mixing due to slumping. The interval between Core 4,CC in Hole 440A to Core 14,CC in Hole 440B encompasses the *Pseudoemiliania lacunosa* zone. The lower boundary of this zone is not delineated, because the samples between

Cores 8 and 14 (Hole 440B) are either barren or contain rare occurrences. The *Gephyrocapsid* assemblage in Core 7,CC is characterized by small individuals and may correspond to the upper portion of Gartner's (1977) small *Gephyrocapsa* Zone. Because of the (rare) occurrences of that taxa, we estimate that Core 15,CC (Hole 440B) is within the lower Pleistocene *Cyclococcolithina macintyrei* Zone. Samples between Cores 12,CC and 20-4 are barren or show rare, sporadic occurrences. The presence of *Gephyrocapsa caribbeanica* down to Core 19,CC suggests a Pleistocene age at least down to that level.

Cores 20 and 21 are assigned to the uppermost Pliocene *Discoaster brouweri* Zone; Cores 22 through 27 are barren or contain very rare, nondiagnostic nannofloras; and Cores 28 to 30 are within the *Discoaster surculus–D. tamalis* Zones. The top of the *Reticulofenestra pseudoumbilica* and *Sphenolithus abies* have apparent last occurrences. This may not represent the true top of the zone, as samples between Cores 35 and 42 were mostly barren. Ceratoliths, which are instrumental for lower Pliocene zonations, were too poorly represented to permit zonal assessments of Cores 47 through 57. This interval is characterized by rare to barren nannofossil occurrences. It was not possible to determine the Miocene/Pliocene boundary precisely, although the uppermost Miocene *Discoaster quinqueramus* zone top (5.6 m.y.) is well documented in Core 58-5. *D. berggrenii*, which characterizes the lower portion of the zone, is present throughout Cores 63 to 71. Hole 440B terminated near the lower boundary of the *D. quinqueramus* zone (about 7.0 m.y.), as indicated by the projected sediment accumulation rates.

No significant hiatuses could be determined from the biostratigraphic composite of Site 440 holes, and there were no repeated zones or anomalous thickening as a result of imbrication.

Foraminifera

Foraminifers at Site 440 are common to few in upper Pliocene to Pleistocene cores and absent throughout the lower Pliocene to upper Miocene, with the exception of rare occurrences in Hole 440B, Cores 54 to 64 and 68. Holes 440, 440A, and 440B contain very similar planktonic foraminiferal assemblages from the late Pleistocene. Similar to Site 438, the Plio/Pleistocene boundary falls within a dissolution interval between Cores 17,CC and 18,CC, Hole 440B. Well preserved late Pliocene faunas are present in Hole 440B, Cores 19-3 to 23,CC. Planktonic foraminifers are rare to absent in early Pliocene to late Miocene sediments because of dissolution. Samples 53-3 and 58-3 contain rare upper Miocene (N.17) forms of *Neogloboquadrina continuosa, N. pachyderma,* and *Globigerina praebulloides*.

Benthic foraminiferal faunas of Site 440 are similar to those of Site 438 but include a number of deeper-water species reflecting the deeper-water location of Site 440. Throughout this late Miocene to Pleistocene sequence the depositional environment appears to have been in lower bathyal depths (2000 meters+). A number of shallow-water species present in these samples indicate that downslope transport occurred throughout this sequence.

GEOCHEMISTRY

Shipboard geochemical studies at Site 440 consisted of analysis of interstitial water, characterization of hydrocarbon gases, and evaluation of organic richness as it relates to hydrocarbon potential. The methods of extraction and analysis were the same as those used at Sites 438 and 439.

The holes at Site 440 were drilled on the midslope terrace of the trench inner slope of the Japan Trench at a depth of 4515 meters. The strata range in age from late Miocene to Holocene and consist of 808 meters, chiefly claystone and diatomaceous claystone, in which the diatom content averages about 11 per cent. The rock is fractured and brecciated below about 350 meters. The rate of deposition in the upper 230 meters (Quaternary) is 230 m/m.y., and below this level to the bottom it is 100 m/m.y. Such rapid sedimentation at this site would minimize sea floor oxidation of organic matter and maximize the availability of the more easily decomposed fraction of the organic compounds. This labile fraction is the one most utilized during anaerobic processes.

A strong hydrogen sulfide odor was detected in the shallowest samples of this site, and a maximum H_2S analysis of 140 parts per million was measured in the gas from the first cores. In the depth interval from 26 to 160 meters, the deposits are stained black by an iron sulfide mineral, probably mackinawite, whose color disappears after exposure to air for several hours. The authigenic-pyrite content of the core ranges from 0.5 to 1 per cent.

Interstitial Water Analysis

Water samples at this site (Figure 7) do not show the strong decline in salinity and chloride-ion content that was measured at Sites 438 and 439 on the Japan Deep Sea Terrace. Site 440 seems to be too far seaward to have been influenced by the fresh-water artesian system inferred to have been associated with the Oyashio ancient landmass to which the anomalous previous analyses were ascribed.

Values of *p*H are higher at this site, and the alkalinity is exceptionally high (Figure 8). The alkalinity for the section as a whole at Site 440 is higher than that of any other site studied by the Deep Sea Drilling Project. A value of 91.8 milliequivalents per liter in diatomaceous claystone at a sub-bottom depth of 89 meters, which is nearly 100 times the commonly measured values, was exceeded only by a single previous sample, 92.9 meg/l at Site 262 in the Timor Trough (Heirtzler, Veevers, and others, 1974), and the values there declined more rapidly above and below this record value than they do at Site 440. The very high alkalinity at Site 440 probably results from unusually favorable conditions for bacterial sulfate reduction and attendant bicarbonate production, as is also attested to by the very high levels of near-bottom H_2S and by the black staining of the strata. The high sedimentation rate, which guarantees burial protection of reactive organic constituents, is clearly an important factor in creating the favorable conditions.

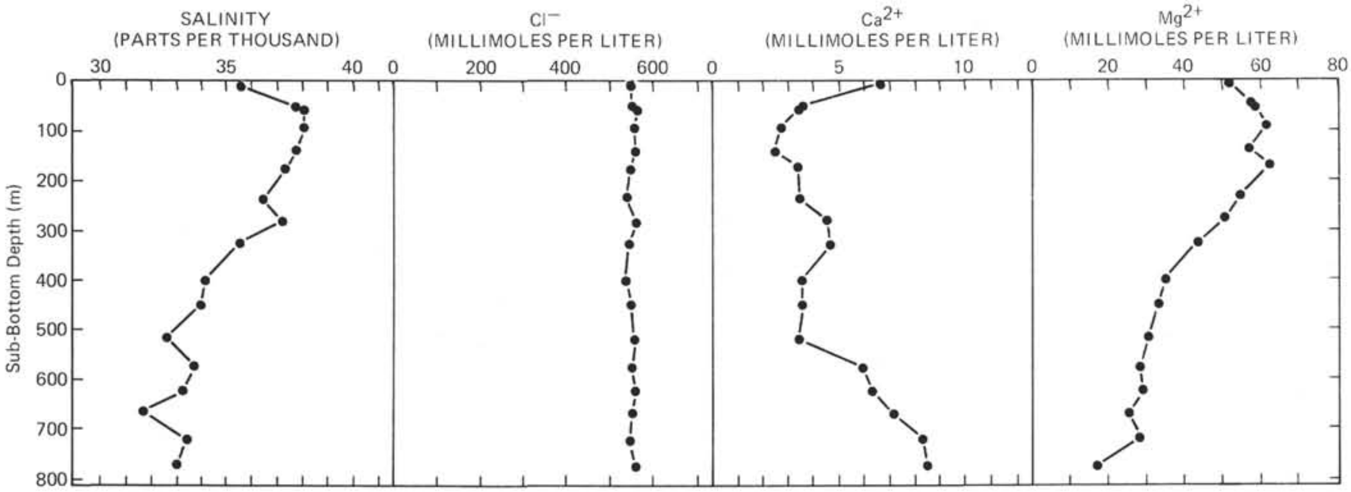

Figure 7. *Relationship between sub-bottom depth and salinity, Cl^-, Ca^{2+}, and Mg^{2+} of interstitial water, Site 440.*

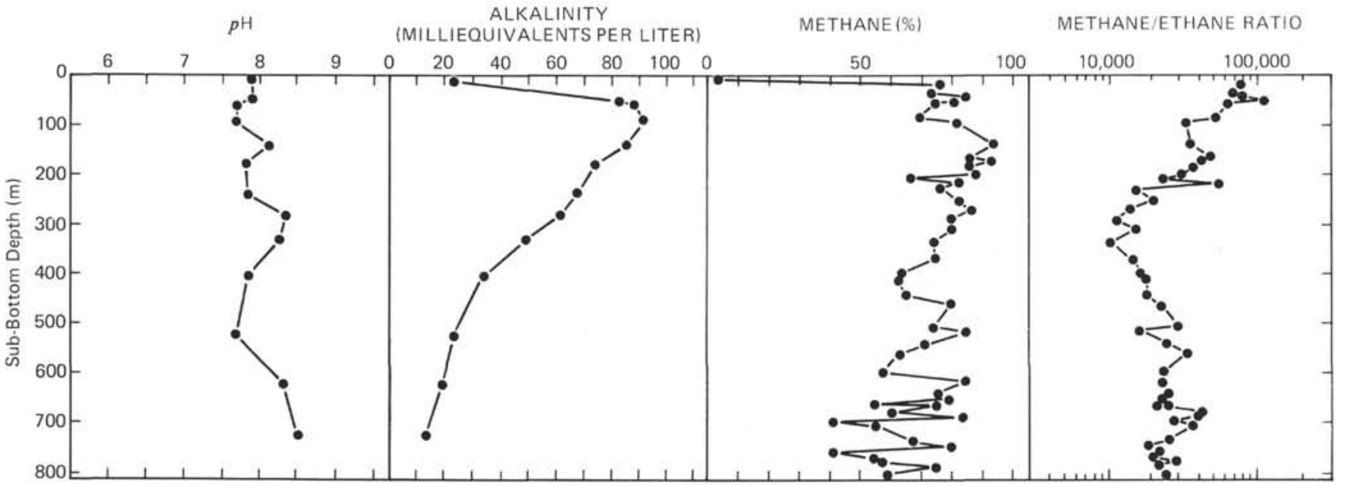

Figure 8. *Relationship between sub-bottom depth,* pH, *and alkalinity of interstitial water, and methane and methane/ethane ratio of core gas, Site 440.*

Organic Carbon and Hydrocarbon Gas Analysis

Results of organic-geochemical analyses at this site support the evidence for preservation of organic matter by rapid sedimentation, because the organic carbon content of the sediment is relatively high. But, despite the high organic carbon content, low pyrolysis-fluorescence values were obtained, and the intercept of the plot (Figure 9) indicates that about 0.5 per cent of the carbonaceous matter is free of hydrocarbons. Based on 0.28 to 1.17 per cent organic carbon and 0.2 to 13 per cent pyrolysis-fluorescence, the sediment at this site would be considered low in hydrocarbon richness with respect to oil generation. Moreover, extrapolation from the temperature log measurement of 9°C at 498 meters, 26 hours after circulation of the drilling fluid ceased, suggests that the equilibrium temperature at that depth is about 9°C. Combined with a sea floor temperature of 1°C, this gives a gradient of 1.6°C per 100 meters and a temperature of 14°C at 808 meters, indicating that the cores at this site have not been exposed to temperatures required for petroleum generation.

At about 20 meters depth the methane content reaches 77 per cent, and it is relatively constant through the remaining cores below. As indicated by changes in the methane/ethane ratio (Figure 8), the ethane content first increases with depth, as is normal (Claypool and others, 1976), but then decreases below a depth of about 350 meters. This is approximately the depth at which faults and fractures become common in the cores and also the depth at which a 1°C step occurs in the high-resolution temperature log. We believe that the older accumulations of diagenetic gas in this zone have partly escaped along fractures and that subsequently produced biogenic methane has not been subjected to diagenetic processes long enough to restore the more usual amounts of ethane.

A characteristic feature of this site is an unusually high content of propane, butane, and pentane, especially in the depth range of 20 to 140 meters (Sato and

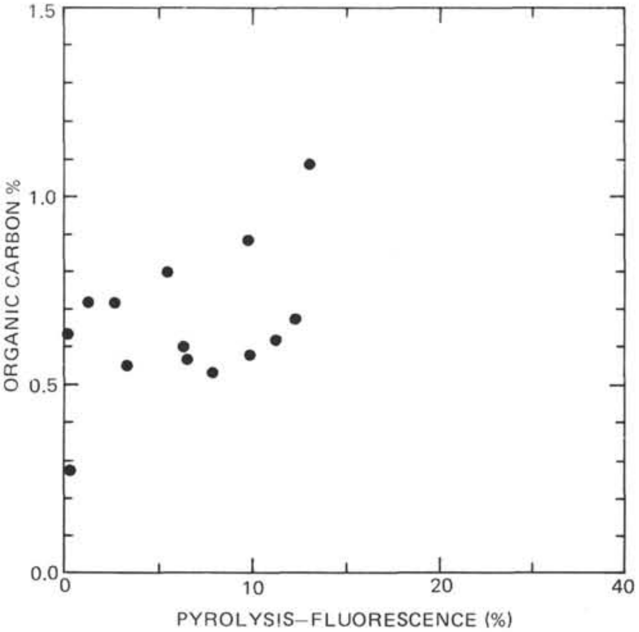

Figure 9. *Relationship between organic-carbon content and pyrolysis-fluorescence of core samples from Site 440.*

Whelan, this volume). Maximum volumetric values for these gases in the methane are measured at 94 meters, where propane, butane, and pentane, respectively, are 3.89, 4.56, and 1.68 parts per million. It is especially noteworthy that the isobutane/normal butane and isopentane/normal pentane ratios are high and that neopentane was not detected at these levels. This suggests that gas may have migrated into this zone from below or from another structural block, a possibility that is also suggested by the fact that the ethane gradient in the upper part of the hole is higher than that of Site 438, which has a higher geothermal gradient. Neopentane does first appear at a depth of 225 meters. The neopentane is not believed to be related to thermochemical processes of petroleum generation but to originate through normal diagenetic reactions.

PHYSICAL PROPERTIES

As is evident from the seismic reflection records, the sediments sampled at Site 440, predominantly diatomaceous claystones and claystones, have accumulated continuously with a nearly horizontal attitude. The structural configuration and uniform sedimentation rates suggest orderly accumulation and burial of these deposits until at least the Pleistocene. The faulting, veining, and brecciation observed in the lower half of the column, however, imply that a regional tectonic stress may have been superimposed on normal compaction and consolidation (Arthur, Carson, and von Huene, this volume). Previous studies (Lee, et al., 1973; Bouma and Moore, 1975; Carson, 1977) suggest that such a tectonic overprint may be reflected in the physical properties of the sediments.

Wet bulk density, porosity, water content, shear strength, thermal conductivity, and sonic velocity were measured on sediments recovered at Site 440. Hole 440B was logged for sonic velocity and formation (bulk) density. The data are plotted on Site Summary Chart 435/440 (back pocket) and discussed more fully in Carson and Bruns (this volume).

Sonic Velocity

Velocities range from about 1.5 km/s at the surface to 2.0 km/s at 800 meters. Near-surface (< 250 meters) sonic velocities are approximately the same (~ 1.60 km/s) as those at Site 438 (although control is very poor above 180 meters owing to signal attenuation in gas-rich sediment). At depths greater than 250 meters, however (and particularly below 400 meters), velocities are significantly higher at Site 440 than at Site 438.

Both the *in situ* sonic log and the laboratory determinations indicate gradually increasing velocities from the surface to a depth of 390 to 400 meters (Lithologic Units 1 and 2). At this point there is a marked increase in velocity from 1.65 km/s to 1.78 km/s. Below 400 meters (Lithologic Unit 3) velocities decrease slightly to minimum values (~ 1.75 km/s, *in situ*; 1.53-1.70 km/s, laboratory) at 485 meters and then increase regularly to the base of the hole.

The 390- to 400-meter depth marks the top of the brecciated zone at Site 440 as well as a section (~ 380-420 m) of apparent sediment influx by mass movement (possibly as slump deposits). The velocity increase at 400 meters may reflect either a local lithologic (textural?) variation associated with the slump unit or a general change in fabric related to brecciation, or both. The fact that relatively high velocities (>1.70 km/s) as well as brecciation persist to the base of the hole, however, implies a general change in the consolidation state below 400 meters. It may be that this depth marks a front of consolidation or induration above which stress is accommodated by plastic deformation and below by brittle fracture.

Bulk Density, Water Content, and Porosity

The bulk density profile consists of three distinct sections: 0 to 410 meters; 410 to 620 meters; and 620 meters to the bottom of the hole. The uppermost section (encompassing Lithologic Units 1 and 2) is characterized by densities which range from ~ 1.55 Mg/m^3 (surface) to ~ 1.70 Mg/m^3 (410 m), with a high degree of small-scale variability. There is a density high, defined by a lack of low values, rather than exceptionally high densities (~ 1.75 Mg/m^3; 90-140 m, laboratory determinations, Hole 440A; 113-140 m, *in situ*, Hole 440B) within this section, which reflects the occurrence of a silty, diatomaceous clay unit. Thinner intervals of higher density within this section correlate primarily with carbonate cementation (e.g., 220-227 m; 257-265 m). Between 260 meters and 400 meters, the *in situ* log defines a regular decrease in bulk density (from 1.7 Mg/m^3 to 1.58 Mg/m^3, which is not recorded in laboratory — GRAPE and gravimetric — determinations. The cause of this discrepancy is unknown, although it may indicate the presence of fracturing on a scale (> 1 m?) which affects the log but is too large to be resolved by the laboratory methods.

The second section, 410 to 620 meters (upper Lithologic Unit 3), encompasses the upper half of the observed brecciated zone. The density within this section is nearly uniform from top to bottom and averages 1.55 Mg/m^3. It forms a low-density zone beneath the upper section. Both the *in situ* log and laboratory determinations show a low degree of variability.

Below 620 meters (lower Lithologic Unit 3), the density increases sharply and is apparently lithologically as well as depth-controlled. Two density maxima (648 m, 1.80 Mg/m^3, and 704 m, 1.75 Mg/m^3) reflect more vitric and/or calcareous deposits. The upper maximum coincides with a slump deposit. The lower maximum may indicate partial carbonate cementation.

Unlike Sites 438 and 439, Site 440 shows no consistent relationship between density and sonic velocity sections. In particular, the section above 390 meters contains density maxima which are not reflected in the velocity profile (see, for example, the section from 113 m to 138 m). The borehole diameter, lithology, and the bulk density do not appear to contribute to the sonic maxima. Furthermore, the density minimum from 410 meters to 620 meters, in the zone of brittle fracture, is characterized by constant but relatively high ($\sim$1.77 km/s) velocity. It is inferred that the extensive fracturing in this zone contributes to these divergent properties.

The sediment porosity at Site 440 shows a profile which mirrors that defined by bulk density. In the upper 400 meters (Lithologic Units 1 and 2) porosities decrease fairly regularly, from $\sim$67 per cent at the surface to $\sim$63 per cent at the top of the brecciated zone. From 400 meters to 590 meters the porosity remains relatively constant at about 60 per cent, suggesting that fractures and veins maintain a constant (apparent) porosity whereas true intergranular porosity, within breccia clasts, may continue to decrease with depth (under increasing load). Below 590 meters, porosities again decline with increasing depth to about 54 per cent at the bottom of the hole. This zone, like the overlying section, is brecciated. The porosity and density data, however, suggest that either the fractures are progressively annealed with increasing depth in this lowermost section or lithologic variations exert a dominant control on void volume reduction.

Water content decreases from the surface ($\sim$47 per cent) to the bottom of the site ($\sim$30 per cent) in a fashion analogous to the decrease in porosity.

Shear Strength

The shear strength of the sediment cored at Site 440 increases rapidly and nonlinearly with depth, from average surface values of $\sim$15 kPa to 50 kPa at 130 meters. An enveloping curve (which covers all values) is defined by a surface value of $\sim$24 kPa and increases to 44 kPa at 50 meters and to >85 kPa at 100 meters. These latter values are considerably greater than those given for typical hemipelagic-terrigenous sediments by Bouma and Moore (1975). It is unclear at this time whether the shear strengths at Site 440 are anomalously high and reflect tectonic loading of the near-surface sediments or are normal and simply expand the enveloping curve defined by Bouma and Moore (1975) for diatomaceous clays.

GEOPHYSICS

Seismic Reflection

Site 440 was positioned along JNOC multichannel record section 2, between Sites 434 and 435 on the trench slope (Figure 1) drilled previously during Leg 56. Site 440 was selected for drilling to define the landward edge of the accretionary prism. This boundary had been presumed to occur at the midslope terrace by Honza and others (1977). At Site 435, on the upper inner slope of the Japan Trench, the cores were interpreted as slumped terrigenous sediment. The cores from Site 434, on the lower trench inner slope, were interpreted during Leg 56 as an imbricated section, repeated along at least two faults. This interpretation strengthened the argument of Honza and others (1977), because the boundary was inferred to lie between these sites. The midslope terrace is the most persistent topographic feature of the slope and it might therefore correspond to the continental/oceanic boundary.

Drilling at most sites, particularly at Site 434 (see Langseth et al., this volume) had terminated because of hole-caving and stuck pipe. The highly fractured claystone encountered below 300 meters was generally difficult to hold open. Because reflections at the midslope terrace appeared to be less faulted than at other places along the trench inner slope, this site looked attractive.

The relatively flat topography of the midslope terrace is a seismic window in which the reflected seismic signal is not scattered or defracted by surface roughness on the sea floor (Figure 10). Therefore the subsurface reflections in this area are stronger than elsewhere along the trench inner slope. The terrace is bounded on either side by pronounced zones of defractions in the seismic record which obscure the structural relations of the terrace to the upper and to the lower slopes.

The *Challenger* single-channel record shows possible ponding of the sediment on the midslope terrace to 0.15 sec (110 m) at Site 440. Below this level no structural indication of ponding is recorded. Upslope from the pond, a short sequence of landward dipping reflections was recorded on the single channel record which are obscured in the multichannel record.

The midslope terrace reflections are of low amplitude and have a fragile continuity. This is particularly true of the reflections above 350 meters. Nevertheless, they outline a sequence of subparallel horizons that dip slightly landward. The faint reflective character is consistent with the uniform lithology of the section recovered here, and the upper 350 meters may correspond to the less lithified part of the section. The base of the sequence is a diffracted reflection of lower frequency and higher amplitude than the overlying sequence. The basal reflection may continue west — it is implied to be continuous in Figure 10 — but its continuity is somewhat uncertain. Parts of this reflection may originate from beds to the side of the plane of the section.

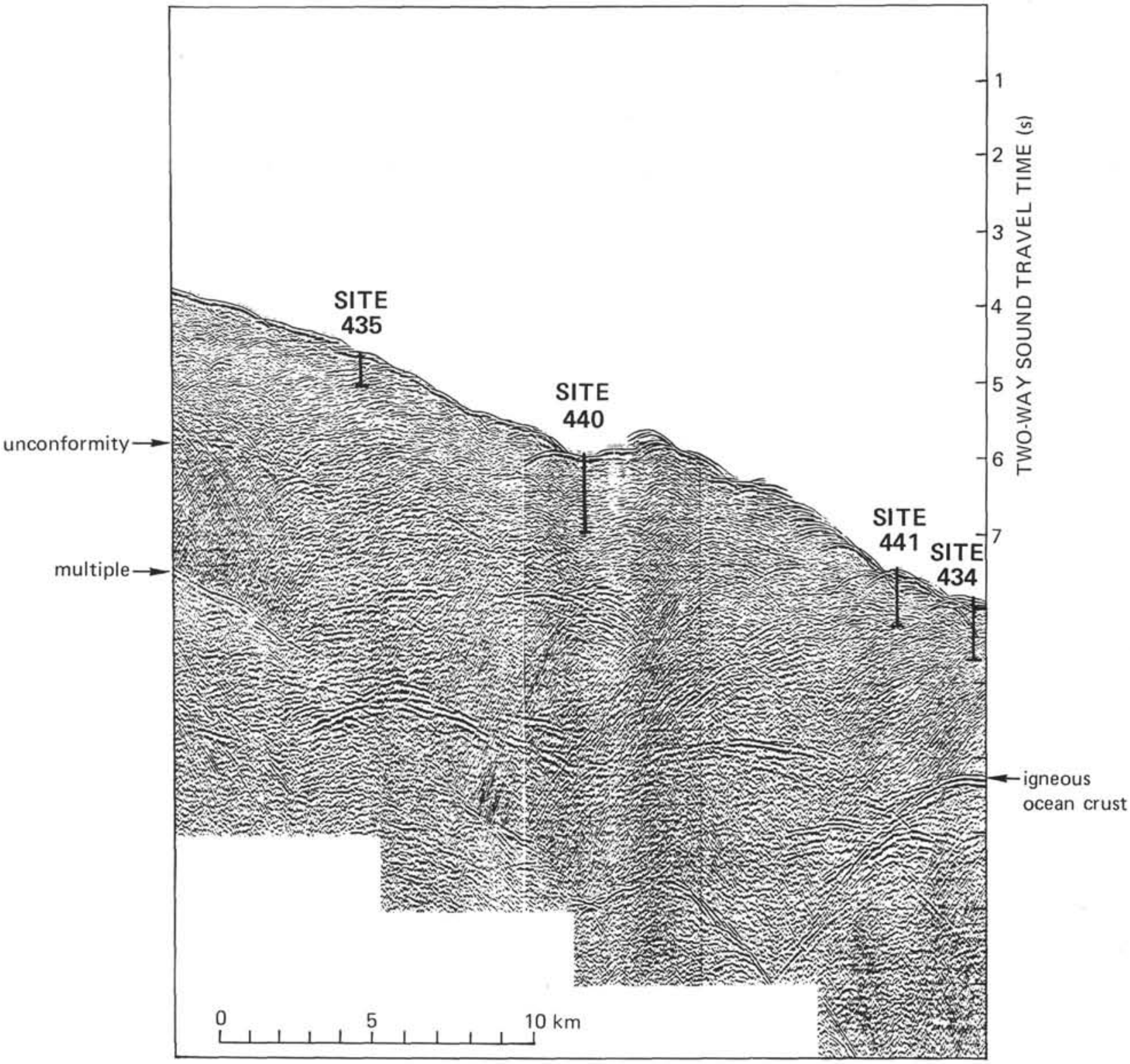

Figure 10. *Section of JNOC-2 multichannel seismic reflection record showing midslope terrace and reflective sequence penetrated at Site 440.*

According to a projection of the velocity gradient determined by downhole logging, the estimated depth of the reflective section is about 1600 meters. The estimated age of the base, assuming no hiatus, is 16 m.y. if the rate of sedimentation in the late Miocene is projected to this depth.

The interpretation (Figure 11) of how the reflective sequence in the midslope seismic window relates to other parts of the continental slope is not clearly indicated in the seismic records. Because the midslope terrace is part of a convergent margin, compressional structures would be expected. Most faults within the midslope terrace reflective sequence are steep seaward-dipping apparent reverse faults that have about 10 to 30 meters of vertical displacement. Using the same criterion, there are also some apparent steep normal faults. But the landward-dipping thrust faults indicated in this position in many convergent margin models are absent. A tectonic mechanism, which is not clear from the seismic data, is needed to bring the section found at Site 435 more than 1000 meters down to the elevation of Site 440. Because folding appears unlikely, faults or large slumps, including the rotation of bedding attitude, are inferred in the areas obscured by diffractions.

Logging

Except for the laterolog, Site 440 was logged with the same set of tools used at previous sites. Conditions were less than desirable because the large swells that caused the ship to heave superimposed this motion in turn as an oscillating motion during the logging run. The ship had held position through a storm with gale winds, and both the logging and the retrieval of the drill stem had to be accomplished in the brief period prior to another rapid-

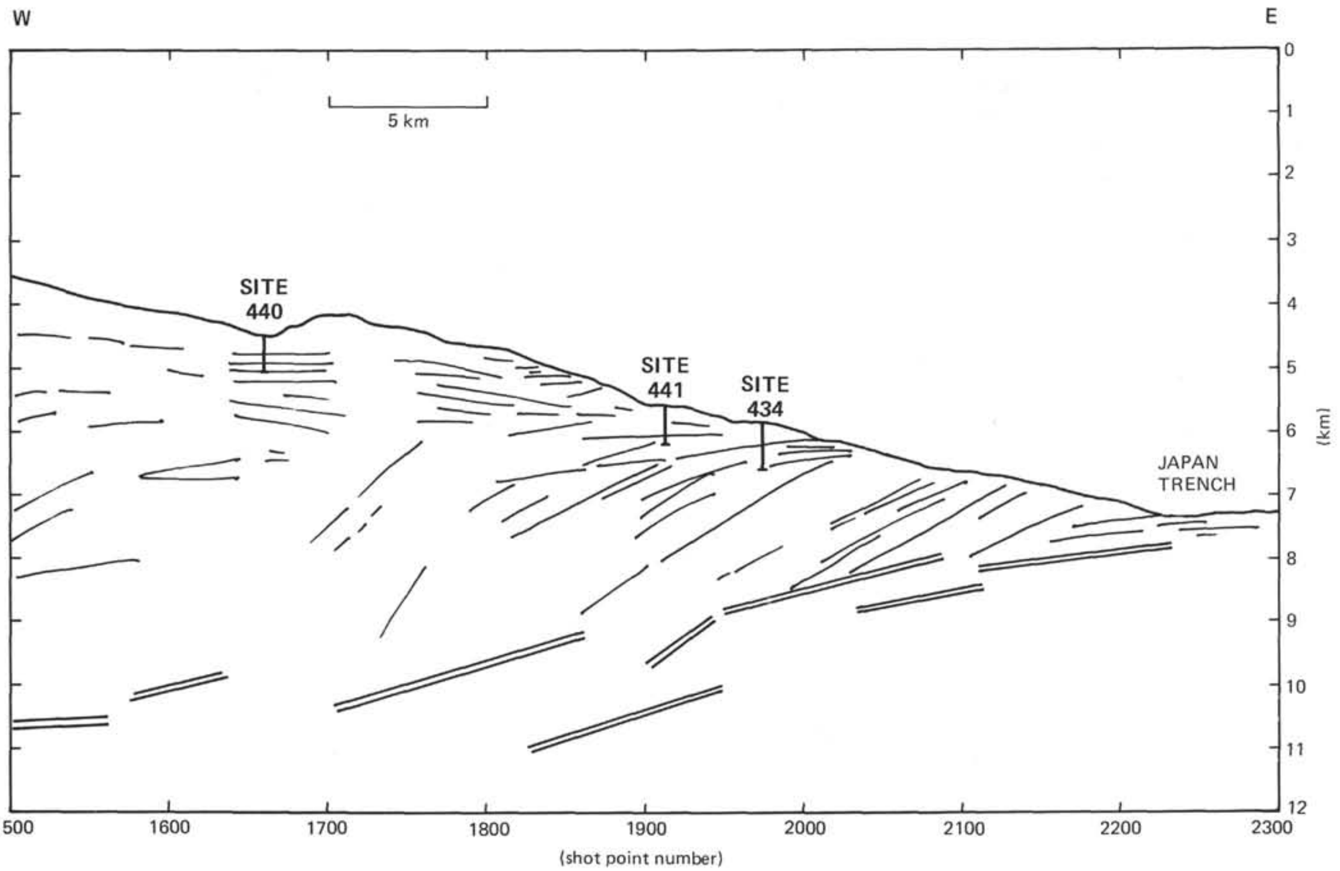

Figure 11. *Interpretive depth-section of JNOC-2 multichannel seismic reflection profile normal to trench inner slope. Vertical exaggeration 2:1. Double lines show reflection from oceanic crust.*

ly approaching storm. During logging the ship lay in the troughs, because it had to head into a current stronger than either the wind or the sea. This precarious situation did not allow sufficient time for full logging.

Temperature. The high resolution temperature (HRT) tool was run last, 24¾ hours after circulation of mud in the hole. Table 2 gives measurements of the three maximum reading thermometers included in logging runs, and it shows that the bottom hole temperatures were less than those of surface sea water. Unfortunately the hole had bridged just before the HRT run, so that only the upper 500 meters were open. Readings were taken on the way down, and jumps in the trace suggest that because of hole deviation the tool was probably riding against the side of the hole in the lower area. However, we cannot explain a sudden rise in temperature at 383 meters. Two stationary readings, five minutes apart, were made at the bottom.

TABLE 2
HRT Temperature Data, Hole 440B

	Run	Depth below Rig Floor (m)	Total Sub-bottom Depth (m)	Temperature (F°)	Time since Mud Circulation (hr.)
1	1st BHC	5280	763	< 60 (15.5C)	6¾
2	FDC-CNP	5275	758	< 60	11¾
3	2nd BHC	5250	733	< 60	17¾
4	HRT	5015	498	< 60	24¾

The uncorrected temperature gradient, about 1°C/100 meters, is one-third of the previously run gradients, and the bottom hole temperature is at least 8°C less than the reading at an equivalent depth in Hole 439. The low temperature gradient confirms the low heat flow reported at accreting margins from sea floor heat probe measurements.

Gamma Ray Log. Two runs were made with the gamma-ray tool. Comparison of the two traces shows many small differences which may reflect the effects of motion from the heave. Features with wavelengths greater than about 10 meters are reproducible. Areas washed out show increased gamma-ray values.

Caliper. This tool showed that hole conditions were good. Local "washouts" correspond well to lithologic boundaries.

Formation Density Log (FDC-CNP). The trace has much character; however, some of it may be caused by motion from heave. Because the low values above 325 meters may be incorrect, the high values should be favored. The heave frequency is very clearly superimposed on the trace in some places.

Sonic Log (BHC). This log is particularly noisy from 250 meters to 325 meters. The general velocity gradient is comparable to the log from Site 439 except that the velocity increases below 400 meters to values 100 to 140 m/s greater.

Taken together, the logs show changes corresponding to lithologic changes, noted visually, particularly with regard to the zone of mass movement. Velocity and density jumps corresponding to folded areas are the most obvious large features of the log traces. Washouts show the locations of contacts and provide an explanation for their absence in the cores. In a gross sense the logs show a distinct upper section to 400 meters, a uniform section from 400 meters to 600 meters, and a lower section to the total depth (see Physical Properties). Numerous smaller features in lithology that were not observed visually because of lack of core recovery may nevertheless be reflected in the logs.

SUMMARY AND CONCLUSIONS

Summary

Site 440 is on the midslope terrace of the Japan Trench inner slope, a persistent tectonic structure that extends parallel with the trench for 360 km with some intermittent short breaks. In the area of Site 440, it is about 5 km wide in water 4500 meters deep. The terrace is the most notable topographic feature of the trench inner slope, as is typical of many other trench slopes. For that reason, it was selected for sampling by the JOIDES Active Margins Panel and the Japan IPOD Committee.

During the Japan Trench transect, the first two sites of Leg 56 were on the lower and upper trench inner slope. From the shipboard study of samples during that leg, the lower-slope site was inferred to be on either a thrust-faulted or a slumped terrigenous slope deposit and the upper-slope site on a large block of downslope terrigenous sediment. Thus the imbricate wedge and the apron of downslope terrigenous sediment must have a common boundary between the sites, and this boundary may be the midslope terrace. In addition, because the failure of holes due to caving of fractured rock had occasionally stopped drilling during both Legs 56 and 57, the absence on seismic records of large folds or faults below the terrace increased the attractiveness of the deep drilling originally planned there.

The predrilling site survey and positioning of the beacon at Site 440 were made during a storm. Intermittent stormy weather persisted during much of the 10 days on site, twice causing abandonment of holes. Because yet another storm was approaching and because we felt that many of the original objectives at Site 440 had been accomplished, it was abandoned at 814 meters, or at about 60 per cent of the targeted penetration, despite a good hole and bit. Logging and retrieval of the drill string were accomplished in a short break between storms. Logging was possible only because of the skill and persistent efforts of the Global Marine crew and the Cruise Operations Manager in holding the ship's position through the last storm.

The relatively flat sea floor of the midslope terrace affords a seismic window that reveals a 1.6-s sequence of straight reflections dipping gently landward above a defracting acoustic basement. This section ends on either side in overlapping defractions that obscure indications of the structural relation between the midslope terrace section and the strata upslope and downslope. The uniform sequence of reflections are of low amplitude and fragile continuity, particularly above a 350-meter depth, consistent with the uniform lithology cored and the results of the downhole logging. A single-channel record made during the predrilling site survey indicates ponded sediment in the upper 110 meters of the section near the drill site. Projection of velocities below the bottom of the downhole acoustic log indicates a stratified section at least 1600 meters thick.

Downhole logging was carried out under the adverse condition of strong ship's heave, but despite degradation from the heave, the logs record a much greater variability in density and velocity than is apparent in visual observation of the lithology. The velocity gradient at Site 440 is the same as at 438 and 439 in the upper 400 meters but is 100 to 140 m/s more at greater depth. This may be caused partly by a sparser diatom content and greater compaction. Probably the velocity increase and peculiar intervals of corresponding density decrease have a diagenetic or tectonic origin that may involve overpressuring of interstitial fluids. The caliper log showed pronounced washouts at lithologic contacts that were not recovered. The gamma-ray trace reflected the uniformity of the sediment composition. A significant result came from the temperature log, which indicates bottom hole temperatures 8°C below those at equivalent depths of the outer two sites and a gradient of only 1°C/100 meters.

Physical properties measurements in conjunction with downhole logs indicate a normal increase of density, porosity, and water content to 400 meters; a constancy of these properties for the next 200 meters; and then an increase below 600 meters. This is thought to be related to the microfracturing that begins at about 400 meters and continues to the total depth. Apparently the section dewaters normally above that depth and then develops water-filled fractures that may not dewater until 600 meters, where they are gradually forced closed by the lithostatic pressure.

Biostratigraphic study gave much the same zonation as at Sites 438 and 439, documenting a continuous sequence of Quaternary through upper Miocene sediment to rocks with an age somewhere between 6 and 7 m.y. at the deepest penetration. Diatoms are again the most abundant microfossil group; radiolarians range from common to rare; foraminifers are common above the upper Pliocene; and nannofossils are more abundant than at the other sites. Sediment accumulation occurred at a very constant rate in the Pliocene and is comparable to Sites 438, 439, and 435 without a correction for water content. The Pleistocene section, however is 200 to 250 meters thicker than at any other site in the Japan Trench transect. This is probably because of ponding of sediment on the terrace. Displaced shelf foraminiferal assemblages in the upper 70 meters are consistent with the ponded structure noted in seismic records and suggest that partial closure first developed here in the upper Pleistocene.

Foraminiferal assemblages indicate bathyal depth and deposition below the local CCD. They also reflect the same climatic changes observed at other North Pacific sites. The cyclic recurrence of the diatom *Denticula seminae fossilis* in the Pliocene might also reflect climatic cycles.

The lithologies cored at Site 440 are similar to those at most of the other sites on the Japan Trench transect. Below thin graded beds interspersed with clayey diatom ooze is claystone and diatomaceous claystone which in its lower part is marked by intervals folded during local mass movement. The uppermost unit, 38 meters thick has poorly sorted graded beds of clay, sand, and gravel between layers of diatomaceous clay and ooze. Ice-rafted dropstones are common. The second unit (38–380 m) is composed in the upper half of diatomaceous claystone and in the lower half of claystone. Mottling is slight to intense; lithification begins at 168 meters and increases downward. The third unit (380–808 m) is also diatomaceous claystone and claystone, but it is distinguished by several zones with syndepositional folds that probably resulted from local mass movement. Mottling is commonly intense.

The zones of mass movement can be matched to jumps in the downhole log traces, which can in turn be matched to reflections. The downhole logs indicate that mass movement occurred in zones 5 to 10 meters thick. The amplitudes of reflections change laterally, consistent with the interpretation that the mass movement is a local intraformational feature.

Ash and tuff layers afford a record of volcanism much like that at Site 438. Volcanic ash begins to increase in the late Miocene and remains high during the first two-thirds of the Pliocene. After a waning period, the ash layers again become numerous in the late Pleistocene.

A primary objective at Site 440 was to examine structural geology in the seaward portion of an accreting margin. The general impression obtained from examination of the sediment is that this sequence has been stressed more than the section at Site 438, which is on the deep sea terrace 50 km farther landward. From shipboard observations, the first major change in the cored section is the appearance of brittle deformation in the form of fractures or joints at a sub-bottom depth of 386 meters (Core 27). Below this point, many healed microfractures, joints, and veins are observed; microfaulting is common, and fault planes of all inclinations have both normal and reversed senses of displacement. A large part of the section below 400 meters exhibits tectonic brecciation. This brecciation occurred in place after some degree of lithification of the original sediment. Rehealing occurred after small relative displacements between the pieces of the breccia. The brecciated appearance seems due to the rather random, anastomosing, and branching nature of veins and fractures. However, not all fracturing is interpreted to have resulted solely from tectonic stress. Some of it could have been induced along anastomosing veins which originally acted as dewatering conduits; these could then have propagated preferentially in a direction favorable to the ambient stress field and become planes of strain release that evolved into a series of closely spaced joints and microfaults. In turn, some dewatering must have continued along existing joints and fractures. The orientation of fractures seems generally random, and although a preferential steep trend would be expected, this cannot be established from the core without additional information on core orientation. The overall impression is that at the scale of a DSDP core, the section was subjected to mild stress fields of various orientations or to tectonic jostling without a prolonged single strong orientation of any one stress field. Possibly this is one of an initial stage of tectonic consolidation at a converging margin. However, the consolidation is much less intense and systematic than one might expect, just 28 km from the trench axis.

Conclusions

The stratified sequence beneath the midslope terrace at Site 440 consists of a nonfolded upper continental slope block rather than of material accreted at the leading edge of the continental plate. The sediment section is uniform hemipelagic mudstone containing few turbidites except in the upper Pleistocene. The basic sediment composition is similar to that at Sites 435, 438, and 439 farther upslope. A uniform hemipelagic lithology is defined well by cores, by downhole logs, and by seismic reflection records; its character is consistent with the very uniform rate of sedimentation from the late Miocene through the early Pleistocene. The block is more than a superficial slump, because it is at least 1600 meters thick, and if the rate of sedimentation is assumed to have continued without hiatus from an earlier period through the late Miocene, as it did at Sites 438 and 439, the estimated age of the sediment at the acoustic basement is early Miocene. Thus it can be inferred that the small sediment wedge seaward of the midslope terrace represents all the accretion that has occurred here since the late Neogene.

The only breaks in continuous hemipelagic deposition are three or more periods of local slumping in the Miocene and Pliocene. In the late Pleistocene, ponding of turbidites, consistent with the present topography of the midslope terrace, is recorded by the litho- and biostratigraphic histories. The sampled section has been at bathyal depths (greater than 2000 m) and near or below the CCD since at least the late Miocene. No tectonic event that would change sediment source or dispersal paths is obvious from the history recorded here. However, a stress environment of unknown age has tectonically brecciated the section at depths where the rock deforms brittlely. Although microfracturing was observed at other sites on the transect, it was not as intense and pervasive at the relatively shallow depths at which microbrecciation was observed here except at Sites 434 and 441. Fault and joint planes generally have a random orientation, and systematic study would be required to see if there was a dominant or preferred stress direction.

The tectonic history during which a continental slope block has remained coherent so far down the trench inner slope of a convergent margin is not fully apparent from the seismic records or the drill cores. Multichannel seismic records show that the deep sea terrace ends at a broad arch. The seaward flank of this arch is the trench upper slope above the midslope terrace. The uniformly thick section on the deep sea terrace continues over the arch, begins to descend the slope, and then is cut into four major segments. Between each segment is a zone of defractions that might mark a fault zone. Two faults have sea floor expression, indicating continuing activity. Within blocks, most of the clear reflections have been tilted landward from their original seaward dip. This pattern is suggestive of large back-rotated slump blocks, which seem very anomalous on a trench slope, or of steep imbricate faults. The slump interpretation rather than accreted sediment and brecciation rather than imbricate slices and isoclinal folding are consistent with the occurrence of continental slope deposits far down the trench wall. This seems the simplest explanation of the present data, although it is not the usual one in convergent margin models. It appears that the intense convergent stress at this particular margin is communicated for only a short distance from the trench in the upper plate.

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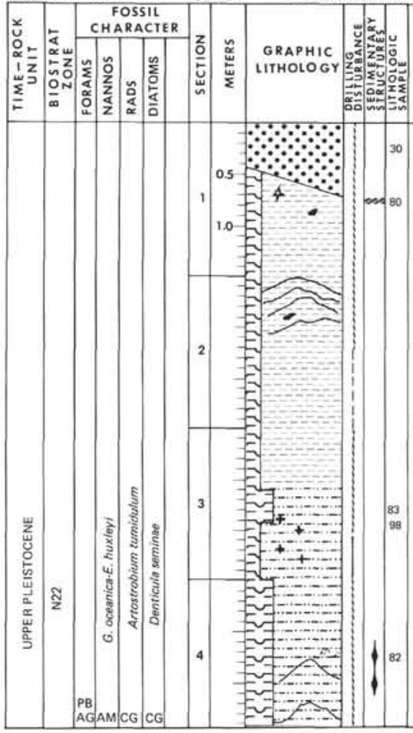
SITE 440 HOLE CORE 1 CORED INTERVAL: 0.0-6.5 m



LITHOLOGIC DESCRIPTION

Pyritized burrow

Grayish olive (10Y 4/2) but with faint color changes defining bedding to intensely deformed bedding or lamination from 5 mm to 10 mm.

Dusky yellow green (5GY 5/2) calcareous diatomaceous sandy silty clay

Firm grayish olive (10Y 4/2) silty clayey diatomaceous with streak and thin layers of lighter color dusky yellow green (5GY 5/2) bedding severely deformed.

Dark gray silty mottles (N3)

No Core-Catcher

Greenish black (5G 2/1) clayey gravel, poorly-sorted. Various pebbles of:
a. Quartz diorite-granite (*ave. 0.5 cm fine-grained*).
b. Dark gray frothy glass-pumice.
c. Metamorphic rock - altered.
d. Vesicular altered (vesicles filled) volcanic rock (basalt).
e. Porphyritic igneous rock with mafic phenocrysts aphanitic ground mass.
(all pebbles rounded).

Firm. Dusky yellow green (5GY 5/2) diatomaceous clay.

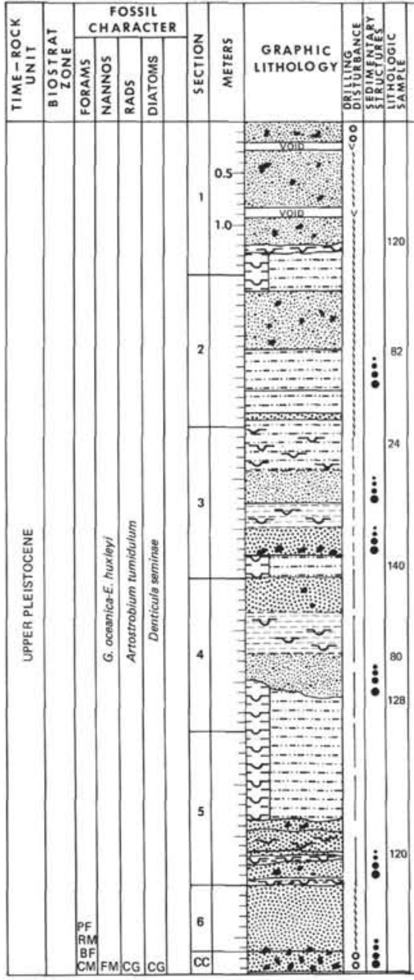
TOTAL C – ORGANIC C – CARBONATE (%)
2, 107 cm (1.4, 1.1, 3)
4, 0 cm (2.0, 1.0, 8)

CARBONATE BOMB
3, 117-119 cm = 12%

SMEAR SLIDE SUMMARY

	Diatomaceous glauconite sand (M)	Diatomaceous clay (D)	Diatomaceous clay (D)	Calcareous diatomaceous sandy silty clay (D)	Spicular diatomaceous silty clay (D)
	1-30	**1-80**	**3-83**	**3-98**	**4-82**
Sand	70	22	15	22	14
Silt	10	20	25	32	28
Clay	20	58	60	46	58
Quartz	10	9	8	14	12
Feldspar	12	11	9	8	5
Heavy minerals	5	6	1	2	2
Clay minerals	7	39	42	26	32
Volcanic glass	4	5	6	4	7
Palagonite		2	1	1	2
Glauconite	40	1	1	1	2
Foraminifers				5	TR
Diatoms	15	18	22	16	23
Radiolarians	1	–	–	TR	1
Sponge spicules	1	9	9	8	10
Carb. unspec.			1	15	4

SITE 440 HOLE CORE 2 CORED INTERVAL: 6.5-16.0 m



LITHOLOGIC DESCRIPTION

Silty clayey diatomaceous ooze.

Graded clayey sand

Sandy mottles in 10Y 4/2

Olive gray (5Y 3/2-4/2)

Sandy-clayey diatomaceous ooze

Graded unit, poorly sorted, clayey coarse-grained granular sand at base grading to medium-grained sand at top (N4) abundant pumice grains.

Poorly sorted, clayey graded sand unit. Gravel coarse-grained pebbly granule rich at base.

Clayey diatom ooze

Silty sand

5Y 4/1

Graded poorly sorted granule to pebbly sand.

Grayish olive (10Y 4/2) poorly sorted, gravelly, clayey, silty sand. Pebbles rounded, up to 4 cm diameter, average ~ 1.5 cm. *All rounded:*
1. fine-grained to medium-grained quartz diorite or granodiorite dark greenish gray.
2. Dark gray andesitic or dacitic porphyritic igneous rock.
3. Highly brecciated dense (N3) claystone or clayey limestone fractures filled with white calcite.
4. Moderate red brown (10RY 1/6) chert with tension fractures fillings of crystalline quartz.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 136 cm (1.4, 1.1, 3)

CARBONATE BOMB
3, 4-6 cm = 4-5%

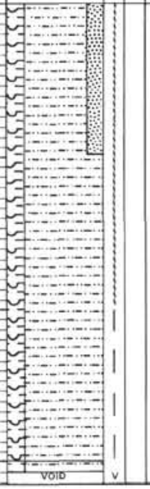
SMEAR SLIDE SUMMARY

	Spicular diatomaceous silty clay (D)	Spicular diatomaceous sandy silty clay (D)	Sandy clayey diatomaceous ooze (D)	Calcareous diatomaceous silty clay (D)	Silty sand (M)	Spicular calcareous diatomaceous clayey silty sand (D)	Clayey spicular diatom ooze (M)
	1-120	**2-82**	**3-24**	**3-140**	**4-80**	**4-128**	**5-120**
Sand	18	30	27	17	54	45	15
Silt	26	23	18	32	26	30	20
Clay	56	47	55	51	20	25	65
Quartz	16	12	17	16	17	10	6
Feldspar	5	7	5	4	33	5	8
Lithic fragments	–	–	–	–	8	–	–
Heavy minerals	3	1	TR	1	13	TR	TR
Clay minerals	25	32	13	29	14	19	23
Volcanic glass	4	7	4	4	4	4	2
Palagonite	1	2	1	1	–	1	–
Glauconite	1	1	2	1	1	2	–
Pyrite	–	–	–	1	–	TR	–
Foraminifers	TR	–	TR	TR	–	5	
Diatoms	28	24	32	26	7	28	38
Radiolarians	TR	TR	TR	–	TR	1	TR
Sponge spicules	14	11	10	7	3	11	23
Carb. unspec.	3	3	5	11	–	12	–
Silicoflagellates	–	–	1	–	–	–	TR

SITE 440 **HOLE** **CORE** 3 **CORED INTERVAL:** 16.0-25.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE		PB CG	RM	*Artostrobium tumidulum* CG	*Denticula seminae* CM	1 2 3 CC	0.5 1.0	87 96

GRAPHIC LITHOLOGY / **DRILLING DISTURBANCE** / **SEDIMENTARY STRUCTURES**



LITHOLOGIC DESCRIPTION

Diatomaceous sandy silty clay

Diatomaceous silty clay

More firm diatomaceous silty clay

Homogeneous gas cracked grayish olive (10Y 4/2) diatomaceous silty clay.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 25 cm (0.9, 0.9, 1)

CARBONATE BOMB
3, 27-29 cm = 6-7%

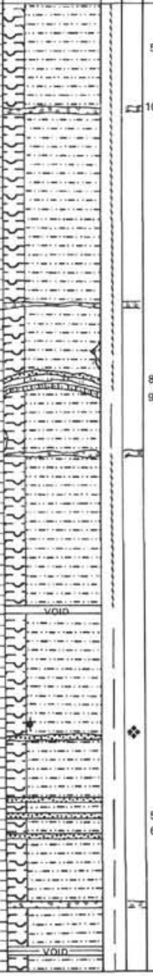
SMEAR SLIDE SUMMARY

	Diatomaceous sandy silty clay (D)	Diatomaceous silty clay (D)
	1-87	2-96
Sand	24	18
Silt	30	30
Clay	46	52
Quartz	16	19
Feldspar	10	8
Heavy minerals	2	1
Clay minerals	33	34
Volcanic glass	5	8
Glauconite	1	1
Pyrite	1	
Foraminifers	TR	
Diatoms	23	20
Radiolarians	1	
Sponge spicules	7	8
Palagonite	1	1

SITE 440 **HOLE** **CORE** 4 **CORED INTERVAL:** 25.5-35.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE		PB CG	RM	*A. tumidulum* CG	*Denticula seminae* AG	1 2 3 4 5 6 7 CC	0.5 1.0	50 106 89 91 52 69

GRAPHIC LITHOLOGY / **DRILLING DISTURBANCE** / **SEDIMENTARY STRUCTURES**



LITHOLOGIC DESCRIPTION

Gas cracked diatomaceous silty clay

Silty ash graded dark gray (N3) to pale olive (10Y 6/2) at top

Diatomaceous silty clay graded silty ash

Ash pocket

Sand layer, medium dark gray (N4)
Clayey sand (N4) underlain by calcareous silty clay, dusky yellow green (5GY 5/2)

Medium dark gray ash layer

Sponge skeleton clayey sand

Diatomaceous silty clay and diatomaceous sandysilty clay layers

3 cm ash graded N4 at base to bluish white (5B 9/1) at top

Homogeneous olive gray (10Y 4/2) diatomaceous clay, silty or sandy.

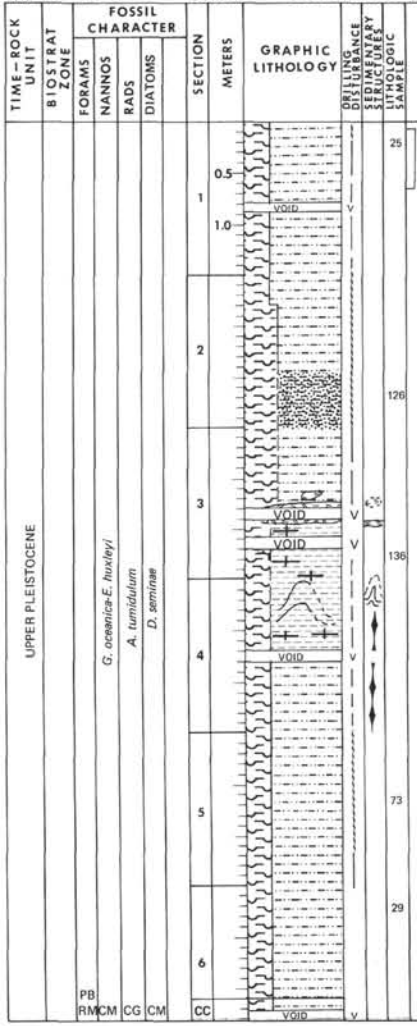
TOTAL C – ORGANIC C – CARBONATE (%)
2, 112 cm (1.3, 1.2, 1)
4, 92 cm (1.0, 0.7, 2)

CARBONATE BOMB
3, 68-70 cm = 5-6%

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Silty ash (M)	Diatomaceous silty clay (D)	Clayey sand (M)	Calcareous silty clay (M)	Diatomaceous silty clay (M)	Diatomaceous sandy silty clay (D)
	1-50	1-106	2-140	3-89	3-91	6-52	6-69
Sand	11	36	12	55	10	8	22
Silt	29	44	30	15	20	30	28
Clay	60	20	58	30	70	62	50
Quartz	15	7	12	40	7	12	15
Feldspar	11	8	8	10	3	6	7
Heavy minerals	3	1	1	11	2	1	3
Clay minerals	33	8	53	18	52	55	34
Volcanic glass	4	65	2	8	5	4	5
Glauconite	2	TR	1	2	1	–	1
Pyrite	–	–	1	–	–	–	–
Diatoms	18	3	12	1	4	15	23
Radiolarians	TR	–	TR	–	–	–	–
Sponge spicules	6	1	6	TR	3	4	8
Palagonite	1	3	1	4	–	1	1
Carb. unspec.	7	4	3	6	23	2	3

SITE 440 HOLE CORE 5 CORED INTERVAL: 35.0-44.5 m



LITHOLOGIC DESCRIPTION

N2 streaks
& layers
in 10Y 4/2

10Y 4/2
homogeneous
silty diatomaceous
clay

10Y 4/2
sandy
diatomaceous
clay

light gray (N6)
5 cm thick ash

olive gray (5Y 3/2)
calcareous diatomaceous
clay

dark grayish olive
green (5GY 2/2)
silty diatomaceous
clay with somewhat
lighter streaks
and mottles

Mostly grayish olive (10Y 4/2) diatomaceous silty clay with some variability–diatomaceous ooze (sandy, silty, clayey); one ash layer (~5 cm thick); grayish black (N2) streaks, mottles, and layers common as noted. Dark color fades with time; probably due to unstable iron sulfides which rapidly oxidize on contact with air. Color of claystone darkens down core to olive gray (5Y 3/2) dark grayish olive green (5GY 2/2) and dark olive gray (5Y 3/1).

TOTAL C – ORGANIC C – CARBONATE (%)
2, 27 cm (0.9, 0.8, 0)
4, 91 cm (1.8, 1.6, 2)

CARBONATE BOMB
4, 144-146 cm = 6-7%

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Sandy, clayey, silty diatom ooze (D)	Diatomaceous clay (sandy, silty) (D)	Calcareous diatomaceous clay (D)	Diatomaceous silty clay (M)
	1-25	**2-126**	**5-73**	**3-136**	**6-29**
Sand	11	25	23	22	10
Silt	29	45	27	20	28
Clay	60	30	50	58	62
Quartz	16	20	14	13	17
Feldspar	6	8	6	4	7
Mica	–	–	–	TR	–
Heavy minerals	1	1	2	2	2
Clay minerals	36	20	35	33	38
Volcanic glass	4	4	8	6	9
Glauconite	2	2	2	1	TR
Foraminifers	–	TR	1	TR	TR
Diatoms	22	34	23	23	18
Radiolarians	–	TR	TR	1	–
Sponge spicules	6	5	4	5	4
Palagonite	1	–	–	2	–
Carb. unspec.	6	6	5	10	5

Mostly dark olive gray to very dark gray (5Y 3/2-3/1) diatomaceous silty clay with some olive gray (5Y 5/2-4/2) layers

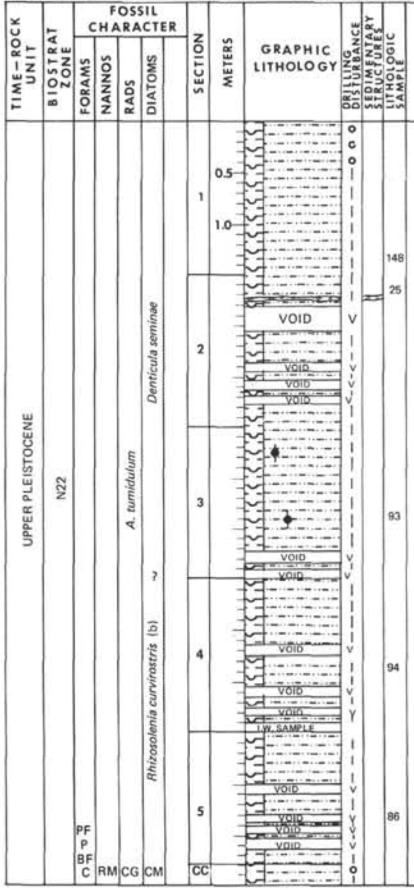
5Y 5/2

5Y 2.5/1
black at base to bottom of core with occasional 5Y 4/2 layers mottled with 5Y 2.5/1

5Y 4/2

5Y 4/2

SITE 440 HOLE CORE 6 CORED INTERVAL: 44.5-54.0 m



LITHOLOGIC DESCRIPTION

Cuttings and
down hole slumping

Dark olive gray
(5Y 3/2) firm
diatomaceous
silty clay with
Black (N1) layers
and spots
Black (N1)

5Y 3/2 as before N7
silty ash – 1.5 cm thick
↓

Black (N1) layer

Mostly dark olive gray (5Y 3/2), firm, diatomaceous silty clay with black (N1) layers (1-3 cm thick) and (1-3 mm) black spots, probably unstable iron sulfides. Color fades with time. One 1.5 cm light gray silty ash layer noted.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 100 cm (0.9, 0.7, 1)
4, 15 cm (0.9, 0.7, 1)

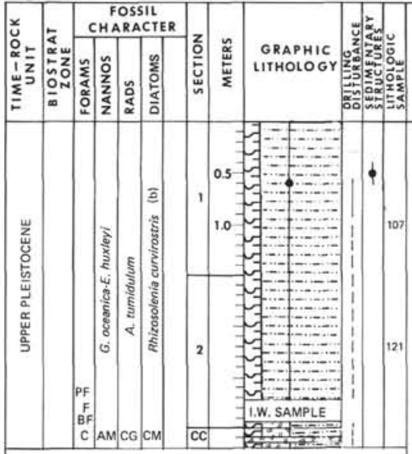
CARBONATE BOMB
3, 45-47 cm = 6-7%

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Silty ash (M)	Calcareous diatomaceous silty clay (D)	Diatomaceous silty clay (D)	Diatomaceous clay (M)
	1-148	**2-25**	**3-93**	**4-94**	**5-86**
Sand	8	3	14	12	11
Silt	30	67	32	34	21
Clay	62	30	54	54	68
Quartz	13	6	16	16	4
Feldspar	7	8	6	6	2
Heavy minerals	2	5	2	2	1
Clay minerals	48	4	39	39	67
Volcanic glass	8	75	8	8	2
Pyrite	–	2	1	1	–
Diatoms	16	TR	17	17	19
Radiolarians	–	–	3	3	TR
Sponge spicules	2	–	2	2	1
Carb. unspec.	4	–	6	6	4

NOTE:
⧫ = sponge spicules

SITE 440 **HOLE** **CORE** 7 **CORED INTERVAL:** 54.0-63.5 m



LITHOLOGIC DESCRIPTION

Drilling cut

Sponge spicule

Olive gray (5Y 3/2) diatomaceous silty clay with grayish blacks (N2) patches and black (N1) spots throughout core.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 100 cm (0.9, 0.7, 1)

CARBONATE BOMB
2, 110-112 cm = 2-3%

SMEAR SLIDE SUMMARY

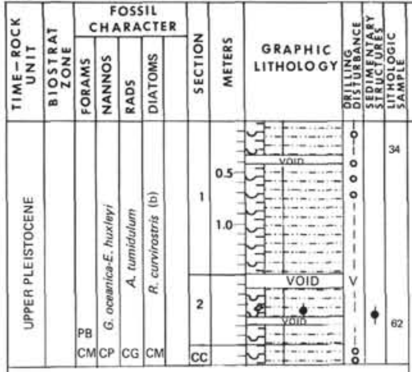
5Y 3/2

Olive gray (5Y 3/2) diatomaceous silty clay

Medium gray (N5) very fine-grained sand-sized ash

	Diatomaceous silty clay (D)	Diatomaceous silty clay (M)	Sandy silty ash (M)
	1-107	2-121	CC
Sand	3	5	13
Silt	20	29	67
Clay	77	66	20
Quartz	11	5	5
Feldspar	5	2	4
Heavy minerals	3	1	2
Clay minerals	50	64	12
Volcanic glass	4	3	70
Glauconite	2		2
Zeolite minerals			2
Diatoms	15	18	3
Radiolarians	3	TR	
Sponge spicules	1	2	
Carb. unspec	6	5	

SITE 440 **HOLE** **CORE** 8 **CORED INTERVAL:** 63.5-73.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) homogeneous diatomaceous clay throughout core.

CARBONATE BOMB
2, 25-27 cm = 5-6%

SMEAR SLIDE SUMMARY

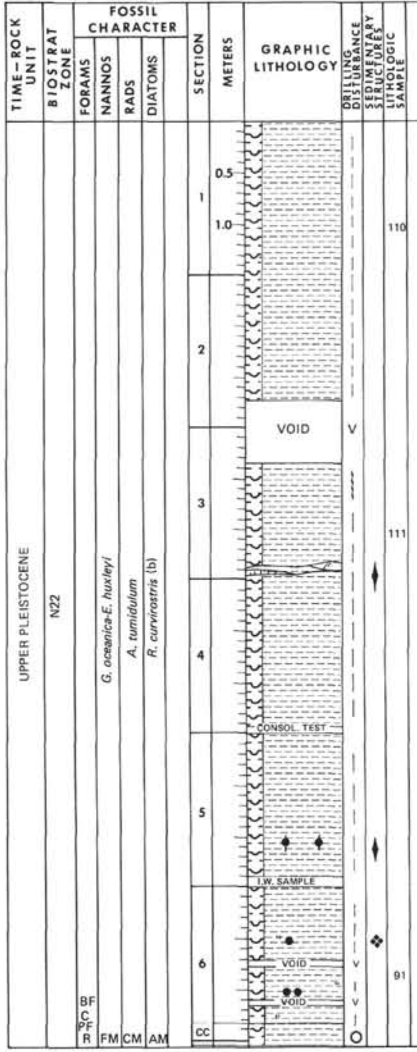
5Y 3/2

Sponge fragments

Olive gray (5Y 3/2) homogeneous diatomaceous claystone

	Diatomaceous clay (D)	Diatomaceous silty clay (D)
	1-34	2-62
Sand	4	5
Silt	19	20
Clay	77	75
Quartz	11	10
Feldspar	6	5
Heavy minerals	3	2
Clay minerals	52	56
Volcanic glass	3	3
Glauconite	1	
Pyrite		1
Diatoms	17	18
Radiolarians	2	1
Sponge spicules	1	1
Carb. unspec.	4	3

SITE 440 HOLE A CORE 2 CORED INTERVAL: 82.5-92.0 m



LITHOLOGIC DESCRIPTION

NOTE: Site 440A, Core 1, 73.0-82.5 m: NO RECOVERY

Olive gray (10Y 4/2) homogeneous diatomaceous clay, containing pyrite specks in Sections 1 and 4.

Olive gray (10Y 4/2) diatomaceous clay, homogeneous.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 117 cm (1.4, 1.0, 3)

SMEAR SLIDE SUMMARY

Ash mottled, dark gray (N3) silt mottle.

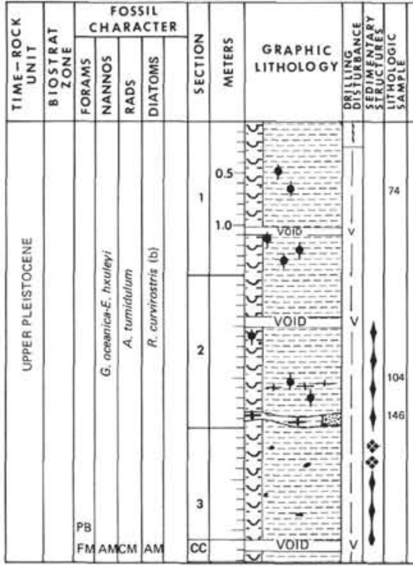
Sponge fragments (◆), and dark gray (N3) silty mottles 4 mm in diameter.

Black smooth, rounded, 3 mm, claystone(?) pebble.

Rounded 2-3 mm clasts of pumice and claystone(?).

	Diatomaceous claystone	Diatomaceous clay	Diatomaceous clay
	1-110	3-111	6-91
Sand	6	6	8
Silt	22	20	20
Clay	72	74	72
Quartz	11	9	12
Feldspar	4	4	8
Heavy minerals	1	1	2
Clay minerals	51	55	49
Volcanic glass	3	3	6
Palagonite	1	TR	1
Glauconite	1	1	1
Pyrite	TR	–	–
Foraminfiers	TR	TR	–
Diatoms	16	10	13
Radiolarians	1	–	–
Sponge spicules	5	8	4
Silicoflagellates	TR	–	–
Other carbonate	6	9	4

SITE 440 HOLE A CORE 3 CORED INTERVAL: 92.0-101.5 m



LITHOLOGIC DESCRIPTION

Sponge fragments

Diatomaceous silty clay

Small layers and mottles, irregular, grayish black (N2)

Calcareous diatomaceous clay

Calcareous sandy silty clay, 10Y 4/2

1.5 cm black pebble (basalt?)

3 cm smooth black pebble

2 mm black granule pyrite concretion

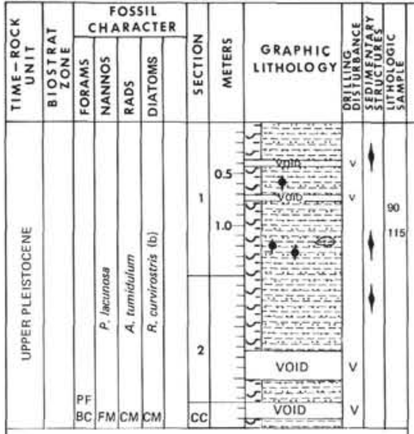
Grayish olive (10Y 4/2) very faintly mottled to homogeneous diatomaceous silty clay with dark gray to grayish black stained horizons and mottles.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 54 cm (1.2, 0.7, 4)

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Calcareous diatomaceous clay (M)	Calcareous sandy silty clay (M)
	1-74	2-104	2-146
Sand	5	12	22
Silt	18	28	35
Clay	77	60	43
Quartz	15	11	16
Feldspar	4	3	9
Heavy minerals	1		6
Clay minerals	53	44	35
Volcanic glass	3	3	5
Glauconite	1	1	1
Pyrite	TR		
Foraminifers	TR	3	4
Diatoms	13	19	2
Radiolarians		TR	
Sponge spicules	3	5	4
Carb. unspec.	7	11	16
Palagonite			2

SITE 440 HOLE A CORE 4 CORED INTERVAL: 101.5-110.0 m



LITHOLOGIC DESCRIPTION

Vitric diatomaceous silty clay

Mottle of clayey silty sand, lithic fragments

Pyrite silty mottles

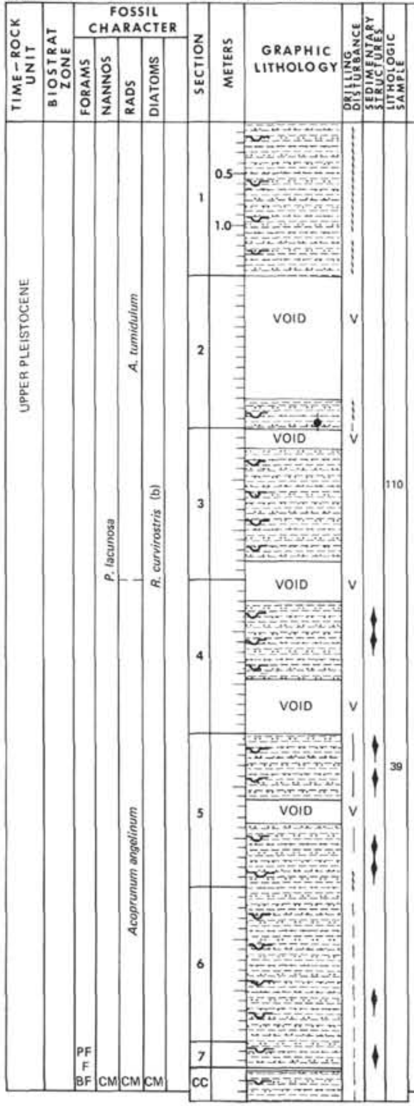
Grayish olive (10Y 4/2) very firm diatomaceous silty clay with few mottles.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 104 cm (0.6, 0.5, 1)

SMEAR SLIDE SUMMARY

	Vitric diatomaceous silty clay (D)	Clayey silty sand (M)
	1-90	1-115
Sand	9	50
Silt	25	25
Clay	66	25
Quartz	15	20
Feldspar	7	11
Heavy minerals	1	9
Clay minerals	43	24
Volcanic glass	10	4
Glaucorite	1	1
Pyrite		3
Lithic fragments		15
Diatoms	13	1
Sponge spicules	4	2
Carb. unspec.	5	7
Palagonite	1	3
Mica		TR

SITE 440 HOLE A CORE 5 CORED INTERVAL: 110.0-120.5 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) homogeneous diatomaceous silty clay with some dark gray mottles (N3) and sponge remains.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 78 cm (0.9, 0.7, 1)

SMEAR SLIDE SUMMARY

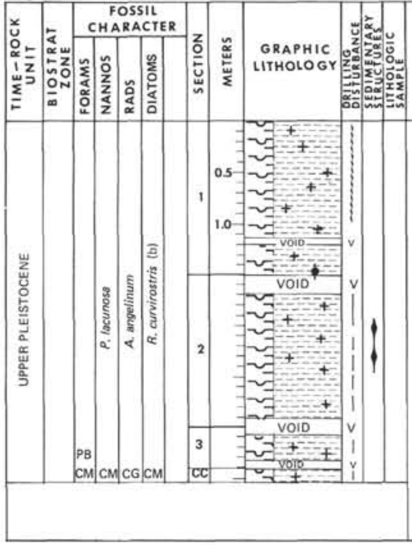
	Diatomaceous silty clay (D)	Diatomaceous silty clay (D)
	3-110	**5-39**
Sand	7	15
Silt	30	35
Clay	63	50
Quartz	15	15
Feldspar	7	10
Heavy minerals	4	2
Clay minerals	46	45
Volcanic glass	6	6
Palagonite	2	1
Glauconite	2	1
Pyrite	–	TR
Foraminfiers	TR	–
Diatoms	11	13
Radiolarians	TR	TR
Sponge spicules	4	–
Carb. unspec.	3	4

Dark gray (N3) mottles

NOTE: Core was accientally drilled without a core barrel and was inserted after recovery.

Mottle of very fine silt

SITE 440 HOLE A CORE 6 CORED INTERVAL: 120.5-130.0 m



LITHOLOGIC DESCRIPTION

Olive gray (10Y 4/2) calcareous clayey diatom ooze homogeneous; sponge fragment (◆ 1-145 cm) and mottles containing fine volcanic ash (2, 55-65 cm).

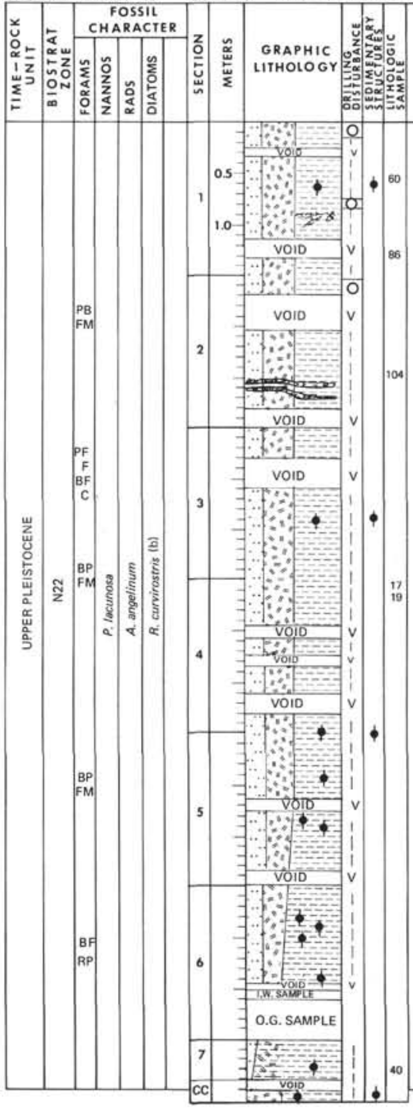
TOTAL C – ORGANIC C – CARBONATE (%)
2, 115 cm (1.7, 1.0, 6)

SMEAR SLIDE SUMMARY

Light olive (5Y 5/2) ash mottles

	Calcareous clayey diatom ooze (D)	Calcareous clayey diatom ooze (D)
	1-128	**2-94**
Sand	22	23
Silt	30	27
Clay	48	50
Quartz	10	9
Feldspar	7	6
Heavy minerals	1	1
Clay minerals	26	25
Volcanic glass	2	2
Palagonite	–	TR
Glauconite	1	1
Foraminifers	–	1
Diatoms	32	35
Radiolarians	1	1
Sponge spicules	8	6
Carb. unspec.	11	13

SITE 440 HOLE A CORE 7 CORED INTERVAL: 130.0-139.5 m



LITHOLOGIC DESCRIPTION

5Y 3/2

Sponge fragment

Very light gray (N8) ash, contorted or burrowed or drill disturbed

Olive gray (5Y 3/2) firm homogeneous diatomaceous silty clay intercalated with a few silt beds in Section 2 and with patches of sponge fragments throughout core.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 71 cm (1.3, 0.9, 3)
3, 94 cm (1.4, 1.2, 2)

5Y 3/2

Dark gray (N3) sandy silt beds with 0.5-1.0 cm thick

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Silty ash (M)	Sandy silt (M)	Silty clayey ash (M)	Sandy silt ash (M)	Diatomaceous silty clay (D)
	1-60	**1-86**	**2-104**	**4-17**	**4-19**	**7-40**
Sand	15	2	35	3	24	8
Silt	30	86	52	40	54	29
Clay	55	13	15	57	22	63
Quartz	10	5	56	6	13	9
Feldspar	6	2	12	2	5	5
Heavy minerals	2	3	6	1	6	1
Clay minerals	50	4	12	5	5	55
Volcanic glass	3	84	5	77	66	2
Glauconite	2	2	2			1
Pyrite	1		4	2	5	1
Diatoms	11					12
Radiolarians	2					2
Sponge spicules	4					3
Carb. unspec.	9					9
Zeolite		TR			TR	
Lithic fragment			15			

5Y 3/2

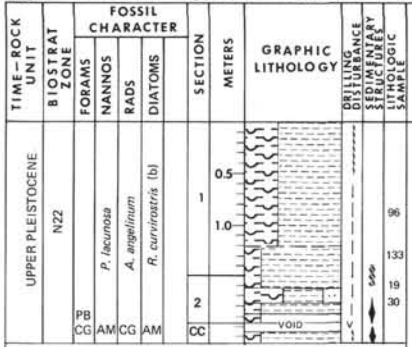
5Y 3/2

5Y 3/2

5Y 3/2

5Y 3/2 Olive gray firm homogeneous diatomaceous clay.

SITE 440 HOLE B CORE 1 CORED INTERVAL: 139.5-149.0 m



LITHOLOGIC DESCRIPTION

Dusky yellow green (5GY 5/2) firm clayey diatom ooze, containing pyritic specks.

Greenish gray (5G 6/1) diatomaceous clay, calcitized worm burrow, olive (5Y 4/4).
Light olive (10Y 5/2) calcareous silty diatom ooze.
Black (N1) diatomaceous clay.
Olive gray (5GY 4/2) diatomaceous clay, grayish olive (10Y 4/2) mottles.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 3 cm (1.1, 1.1., 0)

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (M)	Diatomaceous clay	Calcareous silty diatom ooze	Diatomaceous clay (M)
	1-96	1-133	2-19	2-30
Sand	22	13	23	19
Silt	35	30	40	40
Clay	43	57	37	41
Quartz	7	10	16	8
Feldspar	5	5	8	5
Heavy minerals	2	2	2	1
Clay minerals	34	48	16	34
Volcanic glass	4	9	5	5
Palagonite	–	–	1	1
Glauconite	2	1	2	1
Pyrite	3	–	TR	2
Foraminifers	–	–	1	2
Diatoms	34	18	34	28
Radiolarians	1	TR	1	TR
Sponge spicules	6	5	3	4
Other carbonate	2	2	11	9

SITE 440 HOLE B CORE 2 CORED INTERVAL: 149.0-158.5 m

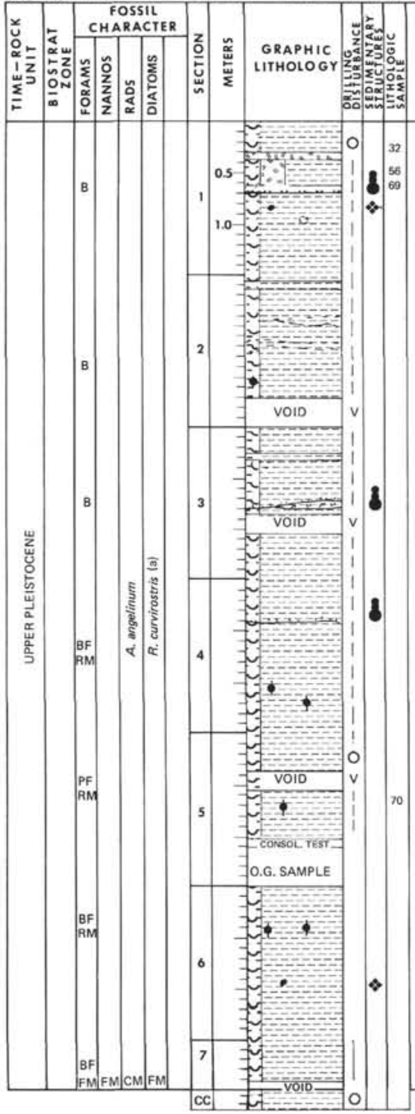
LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) firm calcareous diatomaceous clay. Contains light olive gray (5Y 5/2) 3 cm hard limestone fragment.

SMEAR SLIDE SUMMARY

	Calcareous diatomaceous clay
	CC-17
Sand	8
Silt	25
Clay	67
Quartz	11
Feldspar	4
Heavy minerals	1
Clay minerals	50
Volcanic glass	3
Pyrite	2
Diatoms	15
Radiolarians	1
Sponge spicules	2
Carbonate	11

SITE 440 HOLE B CORE 3 CORED INTERVAL: 158.5-168.0 m



LITHOLOGIC DESCRIPTION

Light olive gray (5Y 6/2) silt-sized ash.
Vitric, grayish black clay (sample 69) overlain by coarse silt.
Dark gray (N3) subrounded fine-grained 5 mm graywacke pebble.
Grayish black (N2) spot.

Olive gray (5Y 4/2) firm homogeneous diatomaceous clay, slightly calcitic.

Grayish black layer.
Grayish black spot.

Grayish black layer.

Grayish black (N2) patches.

Silty at base.
Ash body

5Y 3/2
5Y 4/2

Very fine sand over clay.

Pumice clast 2 mm in diameter

Vertical fractures.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 38 cm (2.3, 1.8, 4)
4, 102 cm (0.8, 0.8, 0)
6, 110 cm (1.0, 1.0, 0)

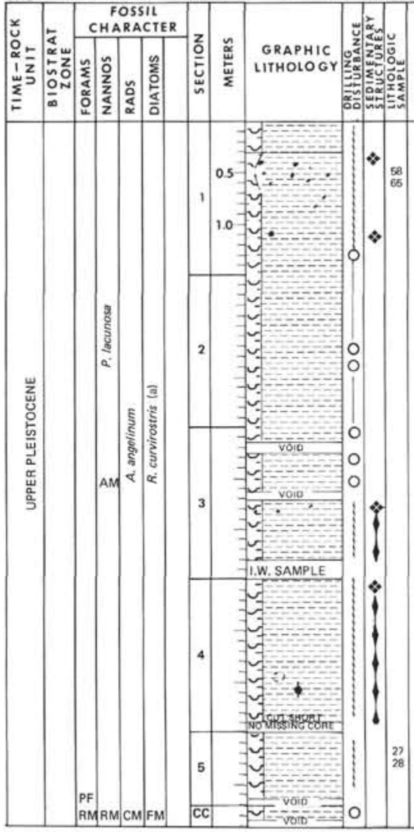
SMEAR SLIDE SUMMARY

	Ash (M)	Diatomaceous vitric clay	Diatomaceous clay (M)	Diatomaceous clay
	1-32	1-56	1-69	5-70
Sand	2	4	–	5
Silt	30	38	22	36
Clay	68	58	78	59
Quartz	9	10	3	8
Feldspar	3	7	1	4
Heavy minerals	2	2	1	2
Clay minerals	5	48	72	57
Volcanic glass	76	12	1	4
Glauconite	–	2	1	–
Pyrite	3	–	–	–
Diatoms	2	11	12	13
Radiolarians	–	1	2	1
Sponge spicules	–	2	3	3
Carbonate	TR	5	4	8

NOTE:

◆ = sponge fragments

SITE 440 HOLE B CORE 4 CORED INTERVAL: 168.0-177.5 m



LITHOLOGIC DESCRIPTION

Pumice pebbles 1 cm in diameter.
Pumice grains, 3 mm.

Core cut partly by hacksaw.
Pumice clast, 4 mm.

Core cut by power saw.

Drilling slurry

Pumice clasts, 3 mm.

Core sheared at 3.0 cm intervals during each revolution of the drill bit (biscuits).

Pumice clasts, 5 mm.

2 cm mottle.
Sponge fragment.
5Y 3/2 claystone

Olive gray (5Y 4/2) very firm homogeneous diatomaceous clay.

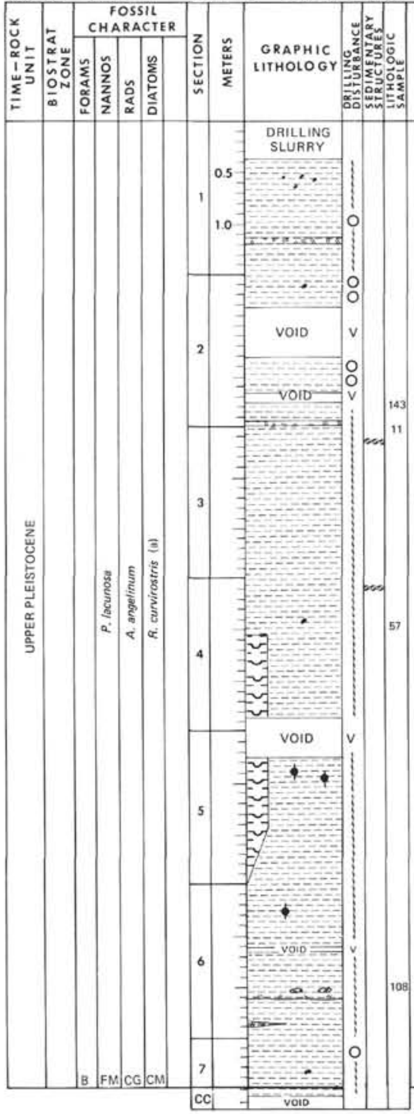
Olive gray (5Y 4/2) homogeneous diatomaceous claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 134 cm (1.3, 1.0, 2)
4, 120 cm (1.0, 0.9, 1)

SMEAR SLIDE SUMMARY

	Claystone	Diatomaceous claystone	Claystone (M)	Claystone
	1-58	1-65	5-27	5-28
Sand	4	4	3	4
Silt	32	33	30	31
Clay	64	63	67	65
Quartz	11	10	11	10
Feldspar	4	4	4	4
Heavy minerals	2	2	1	1
Clay minerals	59	60	58	61
Volcanic glass	5	5	5	4
Pyrite	2	1	2	3
Diatoms	9	13	9	8
Radiolarians	–	–	2	TR
Sponge spicules	4	2	3	5
Carbonate	4	3	5	4

SITE 440 HOLE B CORE 5 CORED INTERVAL: 177.5-187.0 m



LITHOLOGIC DESCRIPTION

5Y 3/2 homogeneous claystone
5 mm pumice pebble

Ash layer with 3 mm pumice pebble 5Y 8/1

Drilling biscuits, 1 cm pumice pebble

Slightly mottled
N8 ash (silt-size)
5Y 5/1 mottles 5 mm calcitic

fine mottled

Pumice pebble 5 mm

5Y 4/1
diatomaceous
claystone

5Y 4/1 diatomaceous
claystone with
sponge fragments

5Y 3/2 claystone

N7 silt-sized
5 mm bodies
Vitric claystone
color grades down to 5Y 5/1

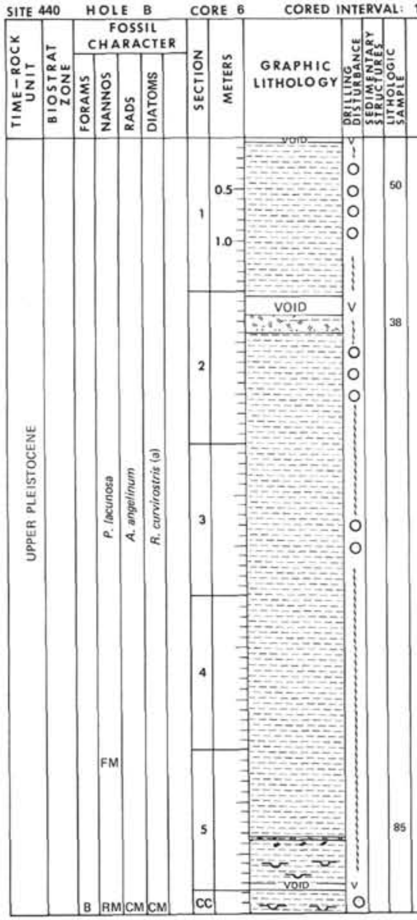
Dark gray pumice clast 5 mm

TOTAL C – ORGANIC C – CARBONATE (%)
1, 66 cm (1.2, 1.0, 2)
3, 139 cm (0.7, 0.8, 0)
5, 82 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	Ash (M)	Claystone (M)	Diatomaceous claystone	Vitric claystone (M)
	2-143	3-11	4-57	6-108
Sand	–	3	5	12
Silt	58	22	35	39
Clay	42	75	60	49
Quartz	3	5	11	9
Feldspar	5	3	5	6
Mica				
Heavy minerals	1	–	2	2
Clay minerals	5	67	58	48
Volcanic glass	84	6	3	20
Pyrite	2	5	2	2
Foraminifers	–	–	–	1
Diatoms	–	7	11	8
Radiolarians	–	1	1	–
Sponge spicules	–	1	2	1
Other carbonate	–	5	5	3
Zeolite mineral	TR	–	–	–

SITE 440 HOLE B CORE 6 CORED INTERVAL: 187.0-196.5 m



LITHOLOGIC DESCRIPTION

5Y 4/2 homogeneous claystone

at base silty 5Y 4/2 clayey ash

5Y 4/2 claystone
5Y 5/2

5Y 4/2 homogeneous
Drilling biscuits.

5Y 5/3 vitric siltstone.
3 mm pyrite bearing
pumice fragments.

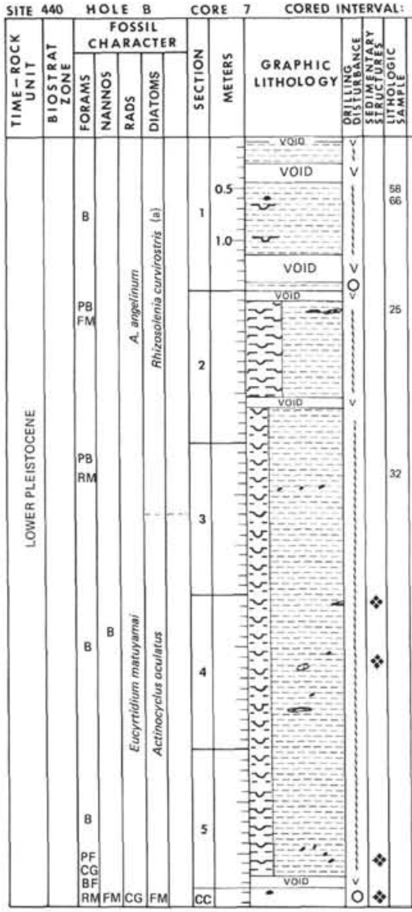
5Y 3/2 diatomaceous
claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 143 cm (0.9, 0.8, 1)
3, 9 cm (0.9, 0.8, 1)
5, 53 cm (0.8, 0.8, 0)

SMEAR SLIDE SUMMARY

	Claystone	Clayey tuffite (M)	Vitric siltstone (M)
	1-50	2-38	5-85
Sand	5	6	10
Silt	31	49	60
Clay	64	45	30
Quartz	12	5	35
Feldspar	5	5	11
Mica	–	–	1
Heavy minerals	1	1	5
Clay minerals	60	30	8
Volcanic glass	4	51	25
Glauconite	–	–	1
Pyrite	1	2	4
Diatoms	9	4	4
Radiolarians	2	2	1
Sponge spicules	2	–	1
Carbonate	4	–	–
Rock fragments	–	–	4

SITE 440 HOLE B CORE 7 CORED INTERVAL: 196.5-206.0 m



LITHOLOGIC DESCRIPTION

5Y 3/2
diatomaceous claystone

Pyritic spot

Ash pocket, silt-size
5Y 3/2 clayey diatomite

5Y 3/2 homogeneous
diatomaceous claystone

3 mm pumice pebble

Ash body, very fine-grained
(N5) clast, claystone.

Black stain

Claystone clast

Ash pocket

5Y 3/2 homogeneous
fractured zone

Sheared into 3.0 cm
segment

1 mm rock fragment

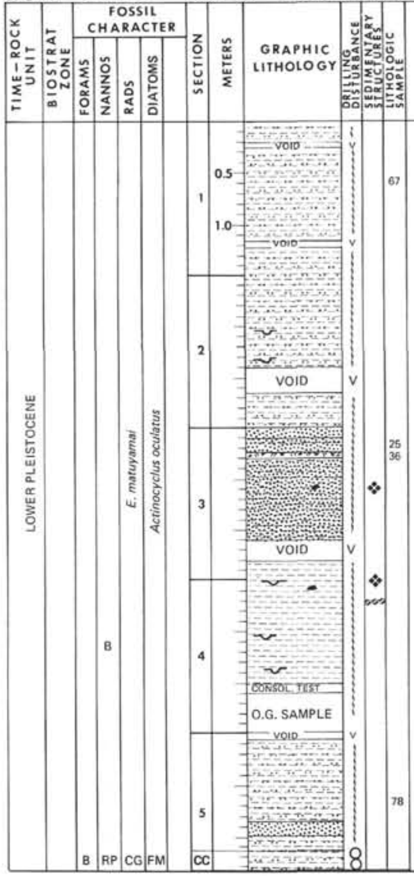
5 mm andesite pebble

TOTAL C – ORGANIC C – CARBONATE (%)
2, 11 cm (1.0, 0.7, 2)
4, 108 cm (0.5, 0.5, 0)
5, 72 cm (1.1, 1.1, 0)

SMEAR SLIDE SUMMARY

	Pyritic claystone (M)	Diatomaceous claystone	Clayey diatomite	Diatomaceous claystone
	1-58	1-66	2-25	3-32
Sand	5	8	5	7
Silt	31	30	33	30
Clay	64	62	62	63
Quartz	6	13	10	10
Feldspar	3	5	5	4
Mica	–	1	–	–
Heavy minerals	3	2	1	2
Clay minerals	39	53	40	50
Volcanic glass	2	5	2	2
Glauconite	1	1	1	1
Pyrite	36	2	–	–
Diatoms	9	11	31	27
Radiolarians	1	1	2	2
Sponge spicules	–	3	5	5
Carbonate	–	3	3	2

SITE 440 HOLE B CORE 8 CORED INTERVAL: 206.0-215.5 m



LITHOLOGIC DESCRIPTION

Drilling "biscuits" throughout.

Homogeneous to faintly streaked and mottled grayish olive (10Y 4/2) silty claystone to silty diatomaceous claystone with sandy spots (quartz). (Sand disseminated as coarse white angular quartz grains.)

Faintly streaked and mottled grayish olive (10Y 4/2) diatomaceous claystone. Noticeable sand content.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 27 cm (0.7, 0.7, 1)

Soft sandy silty claystone (10Y 4/2) Whole section angular granules to sand grains disseminated in matrix.

Angular clayey gravel of white pumice fragments 0.3-0.5 cm. Subround fragment of 0.7 cm diameter granitic rock.

Slightly streaked and mottled grayish olive (10Y 4/2) diatomaceous clay. 1 cm angular fragment of 10R 2/8 very dusky metasediment or altered sediment with angular quartz granules.

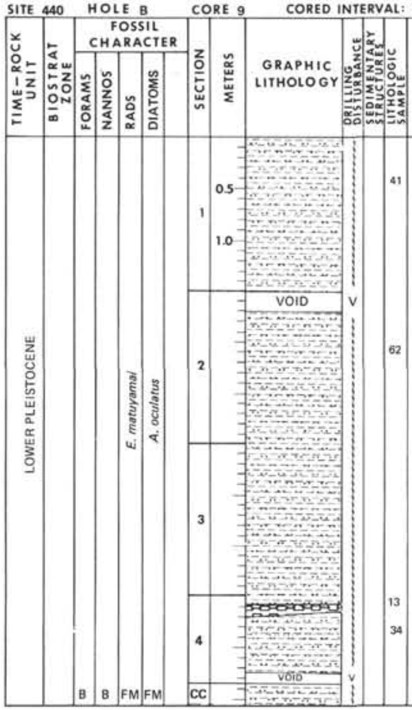
Faintly streaked and mottled grayish olive (10Y 4/2) silty claystone.

Siltier sandier interval.

SMEAR SLIDE SUMMARY

	Silty claystone	Pumice (M)	Sandy clayey siltstone	Silty claystone
	1-67	3-25	3-36	5-78
Sand	12	2	28	8
Silt	40	98	42	42
Clay	48	–	30	50
Quartz	28	2	24	28
Feldspar	5	2	15	6
Heavy minerals	2	1	4	1
Clay minerals	46	–	30	43
Volcanic glass	7	94	7	8
Palagonite	1	–	1	1
Glauconite	1	–	1	1
Pyrite	–	–	2	2
Diatoms	5	1	9	5
Radiolarians	–	–	TR	TR
Sponge spicules	2	–	4	4
Carbonate	3	–	3	1

SITE 440 HOLE B CORE 9 CORED INTERVAL: 215.5-225.0 m



LITHOLOGIC DESCRIPTION

Drilling biscuits throughout. Grayish olive (10Y 4/2) burrow mottled claystone (silty).

TOTAL C – ORGANIC C – CARBONATE (%)
2,79 cm (0.9, 0.7, 2)
4, 58 cm (0.9, 0.7, 2)

Grayish olive (10Y 4/2) silty claystone faintly mottled.

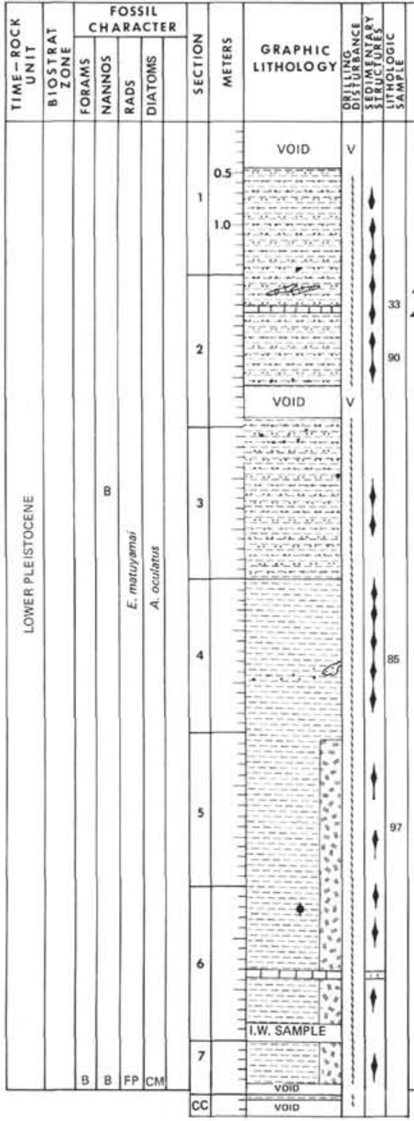
SMEAR SLIDE SUMMARY

	Silty claystone (D)	Silty claystone (D)	Chalk (M)	Vitric clayey siltstone (M)
	1-41	2-62	4-13	4-34
Sand	4	4	6	22
Silt	30	28	23	42
Clay	66	68	71	36
Quartz	25	16	2	27
Feldspar	6	11	1	8
Heavy minerals	1	3	–	4
Clay minerals	51	43	–	32
Volcanic glass	4	8	4	11
Palagonite	1	–	1	1
Glauconite	1	1	–	1
Diatoms	6	8	5	6
Radiolarians	TR	–	TR	TR
Sponge spicules	3	4	2	3
Carbonate	2	1	85	7
Rock fragments	–	5	–	–

Light yellow gray olive (5Y 6/2) calcareous chalk

2 cm laminations vitric clayey siltstone

SITE 440 HOLE B CORE 10 CORED INTERVAL: 225.0-234.5 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) silty claystone and claystone faintly mottled and streaked.

3 mm pyrite bleb
Ashy mottles deformed
yellowish gray (5Y 7/2)
vitric chalk

Gradation from light olive gray (5Y 5/2) claystone to 10Y 4/2 silty claystone

0.3 cm pumice granules

Granules of N8 pumice.

Drilling biscuits

Intensely mottled

Chondrites
Burrow systems common
Pocket of granular pumiceous sand

Vitric claystone

Sponge fragment

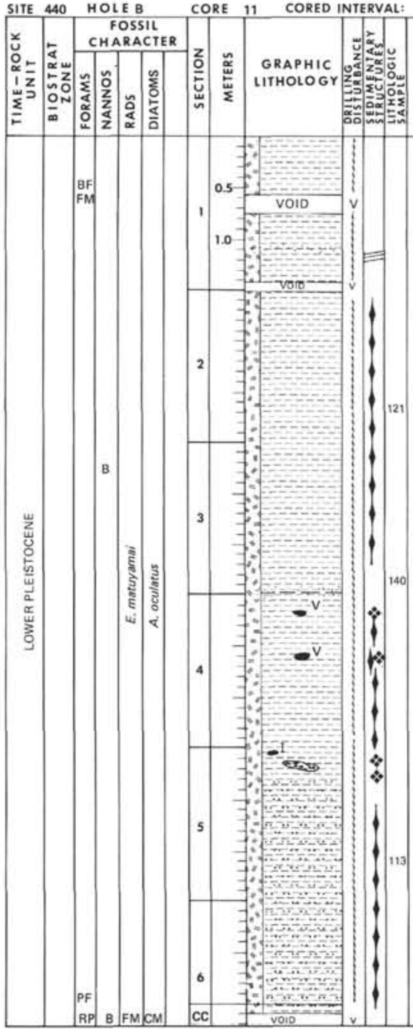
Light olive gray (5Y 6/2) calcareous chalk

TOTAL C – ORGANIC C – CARBONATE (%)
1, 104 cm (0.7, 0.6, 1)
4, 92 cm (0.9, 0.8, 0)

SMEAR SLIDE SUMMARY

	Vitric chalk (M)	Silty claystone	Claystone	Vitric claystone
	2-33	2-90	4-85	5-97
Sand	12	5	3	12
Silt	28	28	27	25
Clay	60	67	70	63
Quartz	1	17	7	10
Feldspar	2	10	5	4
Heavy minerals	TR	2	TR	1
Clay minerals	–	56	65	54
Volcanic glass	34	4	7	18
Palagonite	–	1	–	1
Glauconite	–	TR	1	TR
Pyrite	–	TR	1	2
Diatoms	1	4	8	7
Radiolarians	–	TR	–	–
Sponge spicules	–	4	–	–
Carbonate	62	2	6	3

SITE 440 HOLE B CORE 11 CORED INTERVAL: 234.5-244.0 m



LITHOLOGIC DESCRIPTION

Dark greenish gray (5GY 4/1) claystone, vitric silty claystone and vitric silty sandy claystone with fine (N3-N4) mottles and streaks of dark gray and some light olive gray (5Y 6/2); rare pebbles (< 1 cm diameter) rounded, consisting of white pumice or granite; drilling "biscuits" throughout (2 to 3 cm spacing).

In situ pore water sampler tip recovered here

Dark silt interlamination with clay (4 cm thick interval)

Disseminated glauconitic grains

Faintly mottled

0.6 cm diameter pumice

Chondrites

0.9 cm diameter pumice

Moderately bioturbated

1.0 cm diameter granite
Pumice granule gravel white (N9)
0-39 cm light olive gray (5Y 6/2) mottles

Medium dark to dark gray (N3-N4) throughout.

Chondrites systems dark gray (N3) mottling

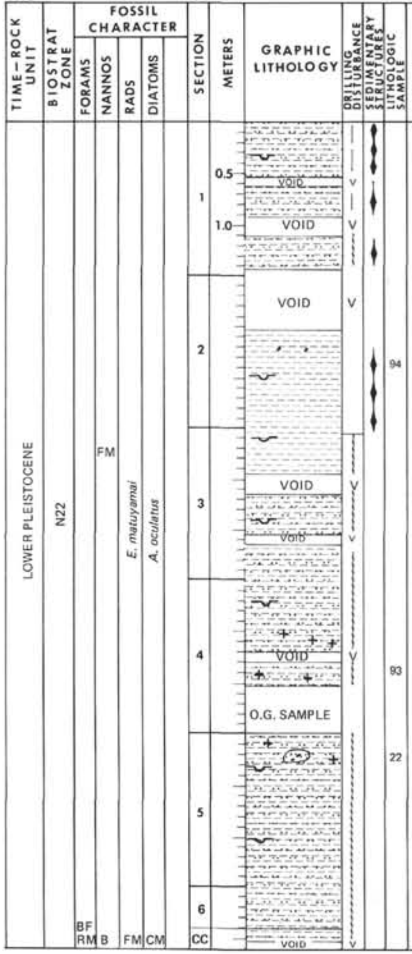
TOTAL C – ORGANIC C – CARBONATE (%)
2, 60 cm (0.5, 0.5, 1)
4, 55 cm (0.6, 0.6, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)	Vitric silty, sandy claystone (M)	Vitric silty claystone (D)
	2-121	3-140	5-113
Sand	4	25	5
Silt	23	23	36
Clay	73	52	50
Quartz	7	18	22
Feldspar	8	13	8
Heavy minerals	1	6	2
Clay minerals	67	34	45
Volcanic glass	8	15	10
Palagonite	–	–	1
Glauconite	1	1	–
Diatoms	4	7	4
Radiolarians	–	TR	TR
Sponge spicules	2	3	3
Carb. unspec.	2	3	5

NOTE:
V = volcanic clast
I = igneous clast

SITE 440 HOLE B CORE 12 CORED INTERVAL: 244.0-253.5 m



LITHOLOGIC DESCRIPTION

Intensely mottled gray-black (N2) chondrites burrow systems

faintly mottled

3 mm diameter pumice granules

homogeneous

Tuff pocket medium gray (N5) with pumice granules

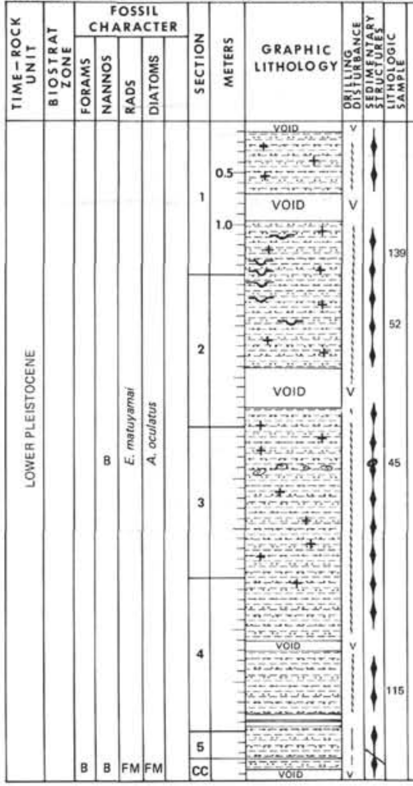
Dark greenish gray (5G 4/1-4/2) claystone and some calcareous silty claystone; rare pumice fragments (2, 70-72) and tuff pockets (5, 20-23). Intensely mottled with gray black (N2) in upper part (chondrites common) gradational to homogeneous in lower part of core.
Drilling biscuits throughout

TOTAL C – ORGANIC C – CARBONATE (%)
2, 106 cm (1.2, 1.2, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)	Tuff (M)	Calcareous silty claystone (D)
	2-94	5-22	4-93
Sand	6	45	14
Silt	28	35	36
Clay	66	20	50
Quartz	12	13	17
Feldspar	4	16	3
Heavy minerals	2	9	1
Clay minerals	58	–	46
Volcanic glass	6	62	9
Glauconite	1	–	1
Pyrite	–	–	TR
Foraminifers	–	–	TR
Diatoms	9	–	9
Radiolarians	TR	–	TR
Sponge spicules	4	–	2
Carb. unspec.	4	–	12
Calc. nannos	–	–	TR

SITE 440 HOLE B CORE 13 CORED INTERVAL: 253.5-263.0 m



LITHOLOGIC DESCRIPTION

Dark greenish gray (5GY 4/1)
↓
Intensely mottled chondrites burrow systems

Calcareous silty claystone

Very light gray (N8) tuff mottles

Silty claystone

Olive gray (5Y 4/2)

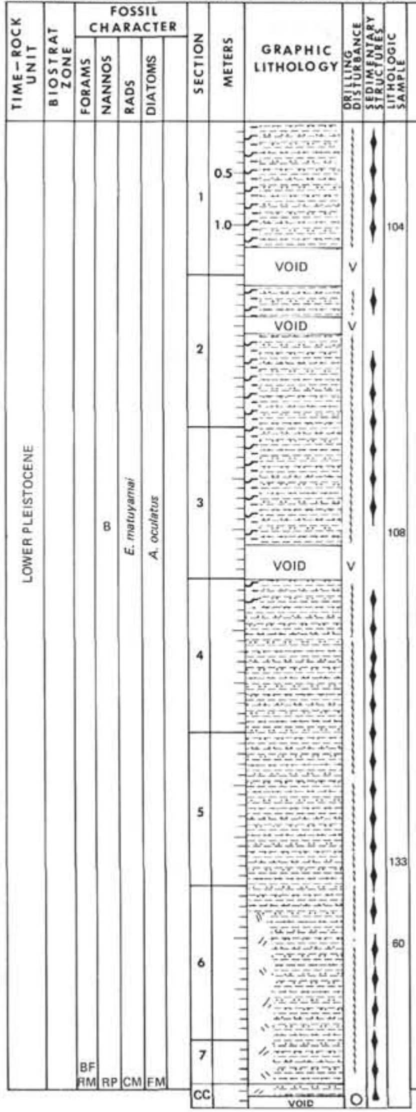
Mostly dark greenish gray (5GY 4/1) silty claystone, diatomaceous and calcareous in part. Intensely mottled with gray black (N2), numerous chondrites burrow systems.
Drilling "biscuits" throughout.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 40 cm (0.7, 0.7, 0)
4, 93 cm (0.7, 0.6, 0)

SMEAR SLIDE SUMMARY

	Diatomaceous silty claystone (D)	Calcareous silty claystone (D)	Tuff (M)	Silty claystone (D)
	1-139	2-52	3-45	4-115
Sand	8	4	2	4
Silt	38	26	55	38
Clay	54	70	43	58
Quartz	21	18	2	20
Feldspar	6	11	2	8
Heavy minerals	1	TR	–	TR
Clay minerals	42	43	–	31
Volcanic glass	7	7	96	8
Palagonite	1	–	–	–
Glauconite	2	–	–	TR
Foraminifers	1	–	–	–
Diatoms	10	8	–	7
Radiolarians	TR	TR	–	–
Sponge spicules	3	3	–	3
Carb. unspec.	6	10	–	9
Microcrystalline quartz	–	–	–	14

SITE 440 HOLE B CORE 14 CORED INTERVAL: 263.0-272.5 m



LITHOLOGIC DESCRIPTION

Dark greenish gray (5GY 4/1)

↓

Moderately mottled

Color changing gradually to olive gray (5Y 4/1)

Faintly mottled

Moderately mottled

Moderately to slightly mottled

Intensely mottled

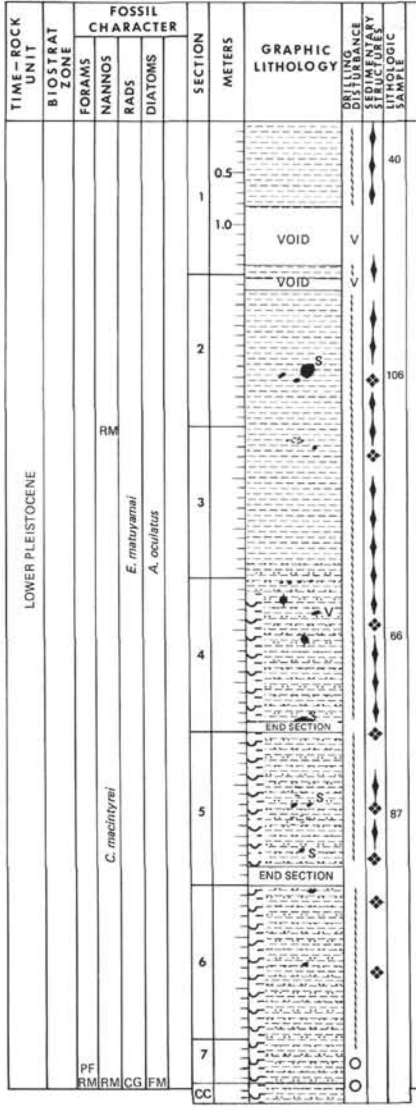
Dark greenish gray (5GY 4/1) diatomaceous silty claystone upper part changing to olive gray (5Y 4/1) diatomaceous silty claystone, silty claystone, and vitric silty claystone. Faintly to intensely mottled. Drilling "biscuits" throughout.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 86 cm (0.4, 0.4, 0)
4, 31 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	Diatomaceous silty claystone (D)	Diatomaceous silty claystone (D)	Silty claystone (D)	Vitric silty claystone (D)
	1-104	3-108	5-133	6-60
Sand	5	6	8	12
Silt	30	28	27	43
Clay	65	67	65	45
Quartz	12	14	13	22
Feldspar	6	5	8	8
Heavy minerals	2	2	2	TR
Clay minerals	51	52	54	40
Volcanic glass	4	6	5	10
Palagonite	1	–	1	–
Glauconite	–	–	1	–
Foraminifers	–	–	TR	2
Diatoms	15	11	5	7
Radiolarians	TR	TR	1	1
Sponge spicules	6	4	6	3
Carb. unspec.	3	6	4	7
Silicoflagellates	TR	–	–	–

SITE 440 HOLE B CORE 15 CORED INTERVAL: 272.5-282.0 m



LITHOLOGIC DESCRIPTION

Overall olive gray (5Y 4/2) moderately mottled
Pale olive (5Y 6/3) mottles calcareous chalk

↓

Note: pipe dope contaminant

Claystone

(0.9 and 1.6 cm diameter) clasts of calcite cemented claystone with silty, pyritic mottles light olive gray (5Y 5/2) overall

pale olive (5Y 6/3) calcareous mottles
Small sand pocket or mottle pumice fragment (2 mm)

White pumice fragments (2 mm)

Faintly but intensely mottled

Black pebble, 1 cm diameter

Medium dark gray (N4) mottle of sandy siltstone 1 cm diameter
Rounded, 2 mm diameter black pebbles

Light olive gray (5Y 5/2) calcareous mottles (vitric).

Black, rounded pebble

Light olive gray (5Y 5/2) mottles (2-3 mm) calcareous

Olive gray (5Y 4/2) claystone and diatomaceous silty claystone, moderately to intensely mottled; some pale olive (5Y 6/3) hard, calcareous mottled intervals. Rare sponges and some rounded pebbles of indurated claystone (black) as well as white pumice. Drilling "biscuits".

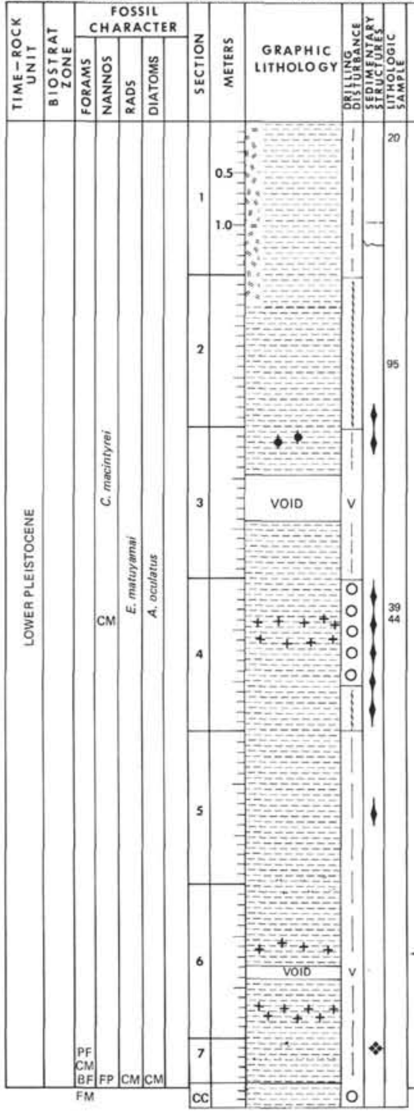
TOTAL C – ORGANIC C – CARBONATE (%)
2, 122 cm (0.6, 0.6, 1)
4, 54 cm (1.0, 1.0, 0)

SMEAR SLIDE SUMMARY

	Calcareous chalk (burrow) (M)	Claystone (D)	Diatomaceous silty claystone (D)	Clayey sandy siltstone (M)
	1-40	2-106	4-66	5-87
Sand	0	3	5	30
Silt	13	17	45	50
Clay	87	80	50	20
Quartz	1	13	28	30
Feldspar	2	4	5	10
Heavy minerals	1	TR	TR	5
Clay minerals	–	64	42	7
Volcanic glass	2	7	5	5
Palagonite	TR	–	TR	TR
Glauconite	TR	–	TR	–
Pyrite	–	–	2	–
Rock fragments	–	–	–	40
Diatoms	2	4	11	2
Radiolarians	–	–	TR	–
Sponge spicules	–	4	7	1
Carb. unspec.	88	4	–	–
Silicoflagellates	4	–	–	–

NOTE:
◆ = sponge fragments

SITE 440 HOLE B CORE 16 CORED INTERVAL: 282.0-291.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2)

↓

15 cm interval has moderate olive brown (5Y 4/4) at top, 5Y 5/2 silty claystone at base with sharp basal contact.

Olive gray (5Y 4/2) homogeneous claystone spiculitic in part

Mottled
Dark olive gray (5Y 3/2) claystone homogeneous

Moderately mottled

Olive (5Y 5/3) nannofossil marlstone layers 5 to 7 cm thick

Fairly homogeneous

Olive (5Y 5/3) composite burrows

Silty claystone
Olive gray (5Y 4/2) claystone

5Y 5/3 nanno marlstone

5Y 5/3 nanno marlstone

2 mm black rounded pebble
Silty claystone, 1 cm layer

Olive gray and dark olive gray (5Y 4/2, 3/2) claystone, vitric claystone, spiculitic in part, conspicuous mottles of olive nannofossil marlstone (5Y 5/3), and several thin (5 to 7 cm) layers of nannofossil marlstone. Claystone is homogeneous to moderately mottled.

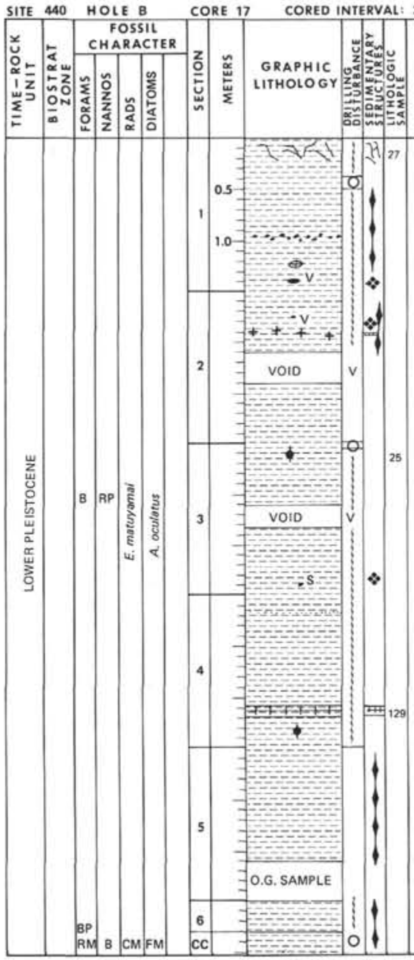
TOTAL C – ORGANIC C – CARBONATE (%)
2, 121 cm (1.4, 0.9, 5)
4, 45 cm (4.1, 0.8, 27)

SMEAR SLIDE SUMMARY

	Vitric claystone (M)	Spiculitic claystone (D)	Claystone (D)	Nannofossil marlstone (M)
	1-20	2-95	4-39	4-44
Sand	1	0	2	2
Silt	30	15	15	10
Clay	69	85	83	88
Quartz	15	5	10	2
Feldspar	–	–	5	–
Heavy minerals	–	TR	TR	–
Clay minerals	62	76	73	54
Volcanic glass	20	–	5	3
Palagonite	–	–	TR	–
Glauconite	–	TR	TR	–
Pyrite	1	TR	TR	–
Diatoms	2	9	5	5
Radiolarians	–	–	–	1
Sponge spicules	TR	10	2	5
Calc. nannos	–	–	–	30

NOTE:
◆ = sponge fragments

SITE 440 HOLE B CORE 17 CORED INTERVAL: 291.5-301.0 m



LITHOLOGIC DESCRIPTION

Dark veins, possible dewatering structures

Gravel of white pumice (~5 mm diameter)

Olive (5Y 5/3) mottle, calcite-cemented
Pumice fragments

Olive (5Y 5/3) calcareous hard layer

5Y 4/2 continued

↓

1 mm black pebble

Olive (5Y 5/3) calcareous chalk (8 cm thick)

Moderate burrowing gray black (N2) mottles and systems of chondrites type

Olive gray (5Y 4/2) claystone, slight mottling.

Olive gray (5Y 4/2) calystone, silty. In part, slight to moderate burrowing in some intervals; chondrites burrow systems with gray black (N2) mottles; pumice pebbles and black indurated sedimentary clasts rare. A few thin olive (5Y 5/3) calcareous layers.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 136 cm (1.0, 0.8, 1)
4, 140 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)	Claystone (D)
	1-27	3-25	4-129
Sand	1	1	1
Silt	20	19	9
Clay	79	80	90
Quartz	15	10	5
Feldspar	5	2	3
Heavy minerals	–	1	–
Clay minerals	72	78	81
Volcanic glass	3	5	5
Palagonite	TR	TR	TR
Glauconite	TR	TR	TR
Diatoms	5	3	5
Radiolarians	TR	TR	–
Sponge spicules	2	1	1
Plant debris	–	TR	–

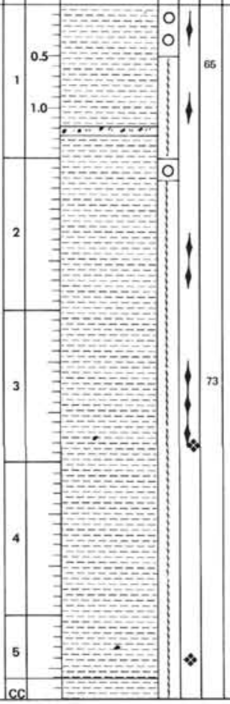
NOTE:
◆ = sponge fragments

SITE 440 HOLE B CORE 18 CORED INTERVAL: 301.0-310.5 m

TIME-ROCK UNIT: LOWER PLEISTOCENE

FOSSIL CHARACTER: FORAMS: B; NANNOS: RM; RADS: *E. matuyamai*; DIATOMS: *A. oculatus*, *Denticula seminae fossilis*

CC: FORAMS B, NANNOS CG, RADS CM, DIATOMS CM



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/2)

↓

Black (N1) mottles

N7 to N8 pumice gravel

Chondrites

gray black (N2) mottles

2 mm black pebble
Olive gray (5Y 4/2)

3 mm black pebble

Fairly homogeneous dark olive gray to olive gray (5Y 3/2-4/2) claystone; black chondrites burrow systems. One vitric pumice gravel about 5 cm thick. Rare, small granules or pebbles of black claystone(?) isolated in olive gray claystone matrix.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 83 cm (0.7, 0.6, 0)
3, 103 cm (0.8, 0.8, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)
	1-65	**3-73**
Sand	1	2
Silt	10	10
Clay	89	88
Quartz	5	5
Feldspar	3	2
Clay minerals	82	83
Volcanic glass	4	5
Palagonite	–	1
Glauconite	TR	1
Pyrite	–	TR
Diatoms	3	2
Radiolarians	–	TR
Sponge spicules	3	1

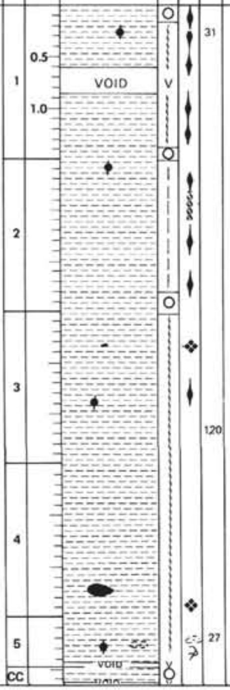
SITE 440 HOLE B CORE 19 CORED INTERVAL: 310.5-320.0 m

TIME-ROCK UNIT: UPPER PLIOCENE

BIOSTRAT ZONE: N22, N21

FOSSIL CHARACTER: FORAMS: PB CM; NANNOS: RP; RADS: *E. matuyamai*; DIATOMS: *D. seminae fossilis*

CC: NANNOS RM, RADS CG, DIATOMS CM



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2)
claystone slight to
moderately mottled

Olive gray (5Y 5/2)
calcareous burrow-fillings

Teichichnus
burrow

Homogeneous
(drilling biscuits)
1 mm diameter
black, hard, granule

3 cm diameter
rounded diorite
pebble

Tuff pocket
medium light gray (N6)
~0.7 cm diameter
2 mm composite burrows

Olive gray (5Y 4/2) homogeneous to somewhat moderately mottled claystone. Drilling disturbance interferes with analysis of sedimentary structure. Sponge remains (⧫) present; one mottle of medium light gray tuff. Large, 3 cm rounded pebble of diorite.

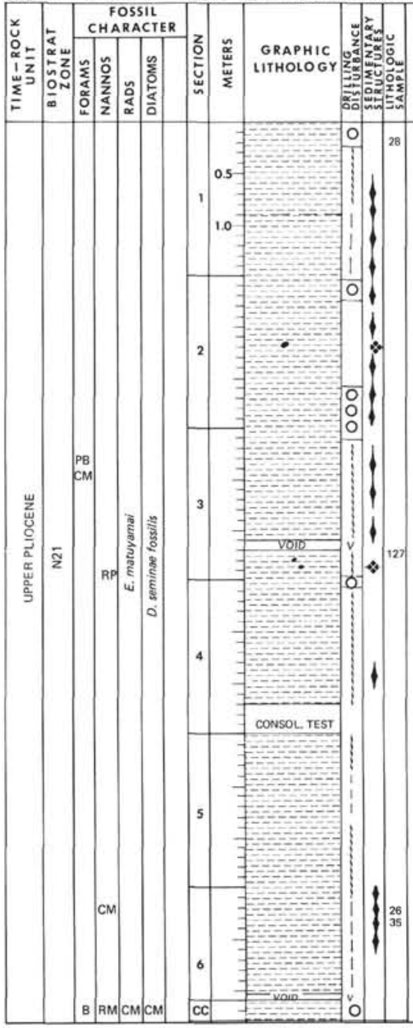
TOTAL C – ORGANIC C – CARBONATE (%)
2, 57 cm (0.8, 0.7, 1)
4, 47 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)	Tuff (M)
	1-31	**3-120**	**5-27**
Sand	3	1	5
Silt	15	15	75
Clay	82	84	20
Quartz	8	5	5
Feldspar	2	2	5
Mica	–	–	TR
Clay minerals	76	79	14
Volcanic glass	5	3	75
Palagonite	–	–	TR
Glauconite	3	1	TR
Diatoms	4	8	1
Radiolarians	TR	–	–
Sponge spicules	2	2	–
Plant debris	–	TR	–

NOTE:
⧫ = sponge fragments

SITE 440 HOLE B CORE 20 CORED INTERVAL: 320.0-329.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) claystone slightly mottled

Olive gray (5Y 5/2) calcareous mottles

Moderate mottling

Black, rounded pebble, 0.5 cm diameter

Intense mottling olive (5Y 4/3) calcareous burrow fillings 0.1-0.3 cm diameter, some larger up to 1 cm

<2 mm diameter rounded black pebbles

Slight mottling

Fairly homogeneous

Moderately mottled with slightly lighter 5Y 4/2-4/3 calcareous

Olive gray (5Y 4/2) claystone, homogeneous to slightly mottled, intensely mottled in parts with olive (5Y 4/3) calcareous burrow fillings. A few, small rounded black granules or pebbles, isolated in clay matrix.

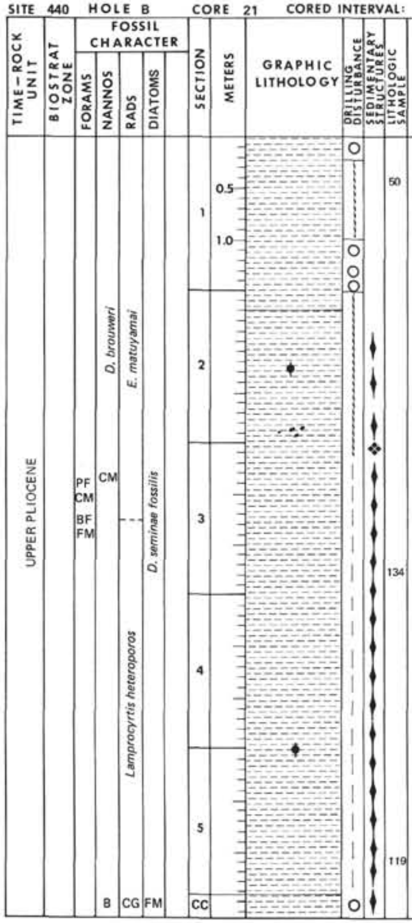
TOTAL C – ORGANIC C – CARBONATE (%)

1, 36 cm (0.0, 0.4, 0)
5, 125 cm (1.1, 1.1, 1)

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)	Vitric nannofossil claystone (M)	Claystone (microcrystalline quartz present) (D)
	1-28	3-127	6-26	6-33
Sand	2	1	3	2
Silt	16	15	20	15
Clay	82	84	77	83
Quartz	5	7	8	15
Feldspar	2	3	2	3
Heavy minerals	–	TR	–	–
Clay minerals	78	79	65	74
Volcanic glass	9	5	10	3
Palagonite	–	–	–	TR
Glauconite	–	TR	TR	TR
Pyrite	1	–	–	–
Diatoms	3	5	3	3
Radiolarians	–	TR	TR	–
Sponge spicules	2	1	2	2
Calc. nannos	–	–	10	–
Plant debris	–	–	TR	–

SITE 440 HOLE B CORE 21 CORED INTERVAL: 329.5-339.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) homogeneous claystone

↓

Dark gray (5Y 4/1) slightly mottled claystone Mottles olive (5Y 4/3), calcareous

Pumice pebbles 5 mm diameter
Moderately mottled olvie (5Y 4/3) calcareous burrow fillings

Intensely mottled Chondrites burrows

Moderately mottled and burrowed

TOTAL C – ORGANIC C – CARBONATE (%)

1, 59 cm (0.9, 0.9, 0)
4, 100 (0.5, 0.5, 0)
5, 40 cm (0.5, 0.5, 0)

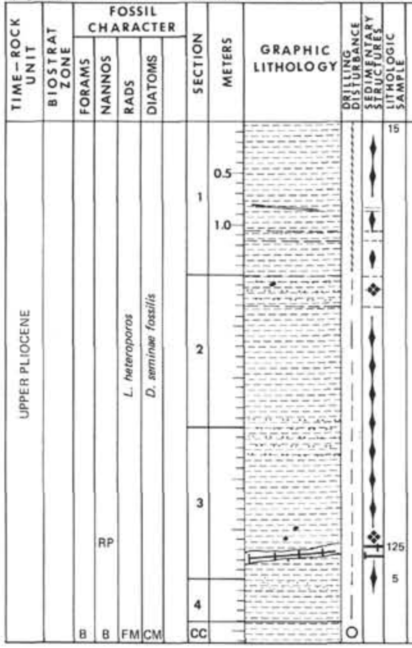
SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)	Claystone (D)
	1-50	3-134	5-119
Sand	3	0	2
Silt	15	23	28
Clay	82	77	70
Quartz	8	11	18
Feldspar	5	4	4
Heavy minerals	–	–	1
Clay minerals	75	66	65
Volcanic glass	7	5	2
Palagonite	–	–	1
Glauconite	–	–	TR
Foraminifers	–	TR	–
Diatoms	–	2	4
Sponge spicules	5	4	3
Carb. unspec.	–	8	2

NOTE:

◆ = sponge fragments

SITE 440 HOLE B CORE 22 CORED INTERVAL: 339.0-348.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) claystone, slightly mottled with very dark gray (5Y 3/1)

Black (N1) <1 cm thick claystone layer
Black sand grains disseminated in clay

Sandy claystone with 3 mm diameter very dark gray (5Y 3/1) claystone
Slightly mottled with olive gray (5Y 4/2) calcareous fillings

Moderately mottled black sand grains upper 30 cm
Mixed 5Y 4/1 and 5Y 3/1

3 mm black pebbles

Olive (5Y 5/3) calcareous chalk

Dark gray black (5Y 4/1) grains upper 20 cm silty claystone

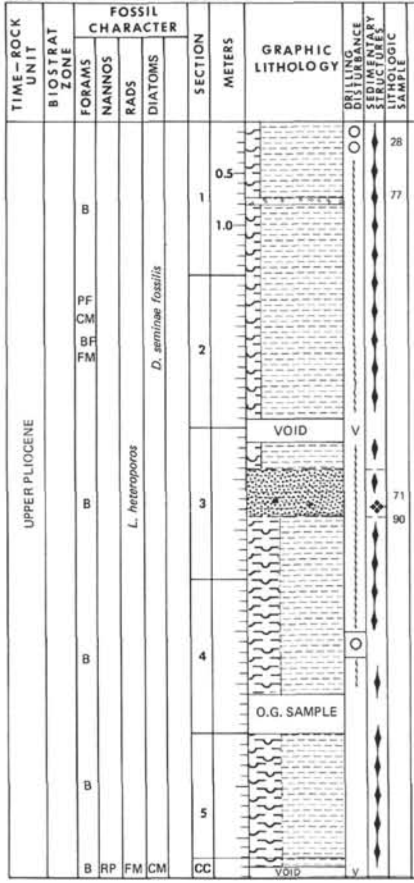
Dark gray, very dark gray and olive gray (5Y 4/2, 4/1, 3/1) claystone and silty claystone, moderately mottled.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 105 cm (0.5, 0.5, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)	Calcareous chalk (M)	Silty claystone (D)
	1-15	3-125	4-5
Sand	4	0	10
Silt	20	4	28
Clay	76	96	62
Quartz	8	2	22
Feldspar	5	1	6
Heavy minerals	1	–	2
Clay minerals	69	–	54
Volcanic glass	3	3	7
Palagonite	1	1	1
Glauconite	TR	–	–
Diatoms	3	–	2
Sponge spicules	5	3	2
Carb. unspec.	–	90	4

SITE 440 HOLE B CORE 23 CORED INTERVAL: 348.5-358.0 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) diatomaceous claystone intensely but faintly mottled

Very light gray (N8) ash
Gradation to medium greenish gray (5GY 5/1) claystone mottled slightly with pale olive (10Y 7/2)

Moderately mottled

10Y 4/2 diatomaceous claystone

5GY 5/1 silty claystone

2, 1 cm dark brown-black rock fragments and sand grains disseminated in clay

10Y 4/2 diatomaceous claystone

White (N9) ash mottles

Intensely mottled

Drilling biscuits throughout.

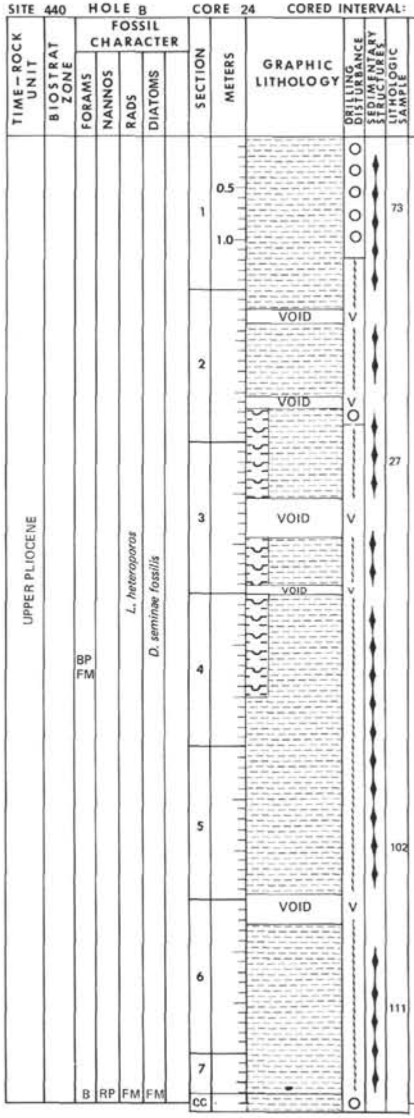
Grayish olive (10Y 4/2) diatomaceous claystone with minor medium green gray (5GY 5/1) silty claystone. One 4 cm ash layer (Section 1).

TOTAL C – ORGANIC C – CARBONATE (%)
2, 59 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	Diatomaceous silty claystone (D)	Tuff (M)	Silty claystone (D)	Diatomaceous claystone (D)
	1-28	1-77	3-71	3-90
Sand	4	–	3	8
Silt	28	68	35	38
Clay	68	32	62	54
Quartz	22	12	18	8
Feldspar	4	10	14	6
Heavy minerals	TR	2	1	TR
Clay minerals	45	–	49	48
Volcanic glass	3	76	6	3
Palagonite	1	–	TR	TR
Glauconite	1	–	–	TR
Foraminifers	–	–	–	TR
Diatoms	11	–	8	28
Radiolarians	–	–	–	TR
Sponge spicules	4	–	TR	5
Carb. unspec.	9	–	4	2

SITE 440 HOLE B CORE 24 CORED INTERVAL: 358.0-367.5 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) claystone moderately mottled, very well indurated

↓

Drilling biscuits and other drilling deformation throughout.

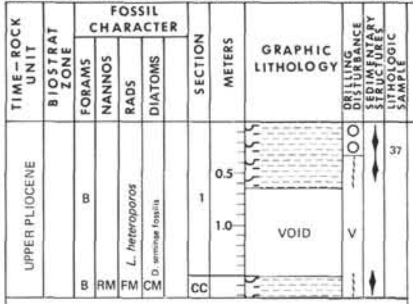
TOTAL C – ORGANIC C – CARBONATE (%)
2, 104 cm (1.0, 0.9, 1)

SMEAR SLIDE SUMMARY

	Claystone (D)	Diatomaceous silty claystone (D)	Claystone (D)	Claystone (D)
	1-73	3-27	5-102	6-111
Sand	5	10	3	6
Silt	23	38	23	28
Clay	72	52	74	66
Quartz	9	7	11	13
Feldspar	4	7	4	6
Heavy minerals	TR	1	TR	TR
Clay minerals	67	50	–	58
Lithic fragments	–	7	–	–
Volcanic glass	7	5	7	5
Palagonite	–	1	1	1
Glauconite	–	1	1	TR
Pyrite	TR	TR	–	–
Diatoms	7	15	9	9
Radiolarians	–	TR	TR	–
Sponge spicules	3	4	3	4
Carb. *unspec.*	3	2	1	4

8 mm rounded pumice

SITE 440 HOLE B CORE 25 CORED INTERVAL: 367.5-377.0 m



LITHOLOGIC DESCRIPTION

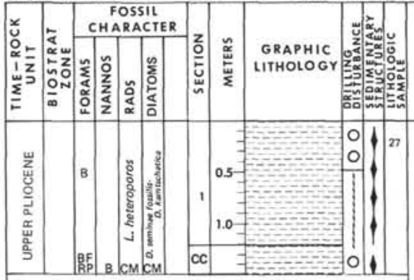
Grayish olive (10Y 4/2) diatomaceous claystone (brittle), moderately mottled highly deformed in drilling.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 62 cm (1.1, 1.1, 0)

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)
	1-37
Sand	
Silt	28
Clay	72
Quartz	12
Feldspar	5
Heavy minerals	TR
Clay minerals	59
Volcanic glass	4
Palagonite	1
Glauconite	1
Diatoms	11
Radiolarians	TR
Sponge spicules	4
Carb. unspec.	3

SITE 440 HOLE B CORE 26 CORED INTERVAL: 377.0-386.5 m



LITHOLOGIC DESCRIPTION

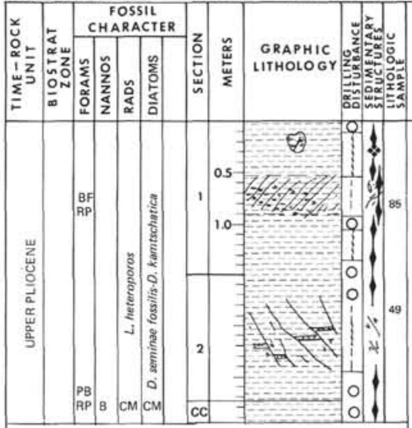
Grayish olive (10Y 4/2) claystone moderately mottled with occasional gray-black (N2) streaks.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 28 cm (0.7, 0.7, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)
	1-27
Sand	6
Silt	33
Clay	61
Quartz	14
Feldspar	4
Heavy minerals	1
Clay minerals	61
Volcanic glass	4
Glauconite	1
Diatoms	9
Radiolarians	TR
Sponge spicules	5
Carb. unspec.	1

SITE 440 HOLE B CORE 27 CORED INTERVAL: 386.5-396.0 m



LITHOLOGIC DESCRIPTION

Clast of claystone (10Y 4/2)
(5 cm diameter) with microfault

Very well-indurated (10Y 4/2) claystone, intensely mottled, intensely veined (dark anastomosing, branching structures) and microfaulted. Lamination and burrow patterns inclined 30°
1-2 mm reverse offset on closely-spaced (<1 cm apart) fault planes inclined ~70°

Near vertical fault planes with both normal and reversed sense of offset amounting to as much as 1 to 2 cm per fault. Faint bedding inclined 25°

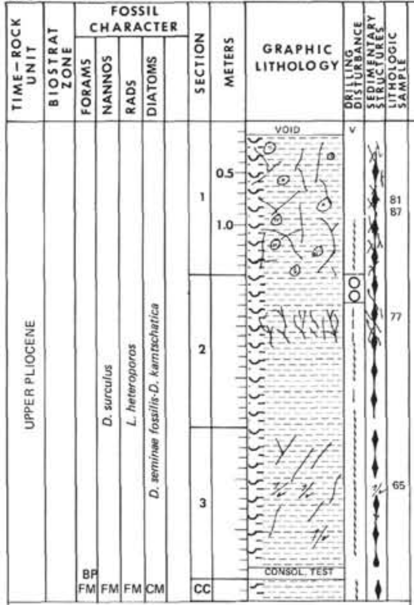
Mostly intensely mottled grayish olive (10Y 4/2) claystone with intervals of intense veining and faulting. Bedding (faint) inclined approximately 25°; faults, high angle normal and reverse.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 31 cm (1.0, 1.0, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)
	1-85	2-49
Sand	2	2
Silt	24	28
Clay	74	70
Quartz	8	5
Feldspar	2	3
Heavy minerals	TR	1
Clay minerals	72	70
Volcanic glass	1	2
Palagonite	1	1
Glauconite	–	1
Diatoms	8	9
Radiolarians	–	TR
Sponge spicules	7	5
Carb. unspec.	1	3

SITE 440 HOLE B CORE 28 CORED INTERVAL: 396.0-405.5 m



LITHOLOGIC DESCRIPTION

Light olive gray (5Y 5/2) diatomaceous claystone white pumice grains disseminated through Section 1. Intensely fractured/veined with random orientations. Intensely mottled with greenish gray (5GY 5/1) and medium dark gray (N4); occasional silty mottles (quartz and glass-rich).

Olive gray (5Y 4/2) diatomaceous claystone, intensely mottled, branching fracture systems noted in better-preserved parts of cores (much of core brecciated in drilling).

Black (N2) mottles

Moderately mottled grayish black (N2) and pale greenish yellow (10Y 8/2) burrow-mottles.
Moderately fractured, some faults with slight offset. High angle reverse.

Lower 15 cm Section 3 is consolidation test.

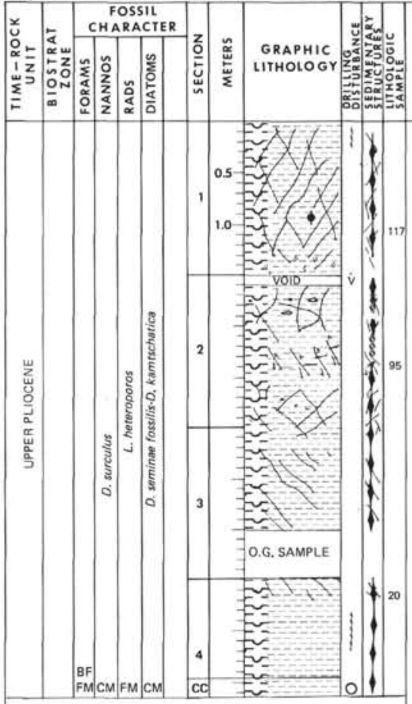
Rock holds together well despite intense veining and fracture systems. Lithologic change from previous cores. Mostly olive gray (5Y 5/2, 4/2). Diatomaceous claystone, vitric in upper part, moderately to intensely mottled with gray, greenish gray, and pale greenish yellow (5GY 5/1, N2-N4, 10Y 8/2) fracture/vein systems.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 56 cm (1.0, 0.9, 1)

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Diatomaceous claystone (D)
	1-81	1-87	2-47	3-65
Sand	6	12	8	10
Silt	38	30	36	32
Clay	56	58	56	58
Quartz	10	9	13	10
Feldspar	4	3	5	5
Heavy minerals	1	1	1	TR
Clay minerals	53	57	52	58
Voclanic glass	11	5	8	6
Palagonite	1	TR	TR	TR
Glauconite	–	1	1	1
Pyrite	TR	TR	–	–
Diatoms	11	13	10	13
Radiolarians	TR	TR	TR	TR
Sponge spicules	6	7	4	3
Carb. unspec.	3	4	6	4

SITE 440 HOLE B CORE 29 CORED INTERVAL: 405.5-415.0 m



LITHOLOGIC DESCRIPTION

Olive gray to dark olive gray (5Y 3/2-4/2) diatomaceous claystone intensely mottled fine network of veins (very fine dark, irregular branching and anastomosing veins) conjugate system in part (dip approximately 50°) resembles a rehealed "breccia".

Olive gray and grayish olive (5Y 3/2, 4/2 and 10Y 4/2) diatomaceous claystone; intensely mottled; fracture/vein systems and some faulting common.

Disseminated numerous white pumice grains (<2 mm diameter)

Intensely mottled and burrowed with moderate dusky yellow (5Y 5/4).

70° ≥ reverse faults with 0.5 cm offsets intensely mottled with moderate olive brown (5Y 4/4) irregular large mottles up to 1.5 cm

Grayish olive (10Y 4/2) diatomaceous claystone intensely mottled with slightly lighter shades of olive gray; fracture pattern ≥ 60°, no offsets noted.

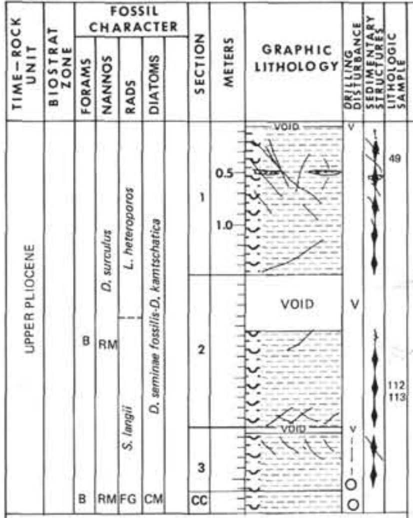
TOTAL C – ORGANIC C – CARBONATE (%)
2, 48 cm (0.8, 0.7, 1)
4, 17 cm (1.1, 1.0, 1)

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Diatomaceous claystone (D)
	1-117	2-95	4-20
Sand	14	11	4
Silt	30	28	33
Clay	56	61	63
Quartz	10	12	9
Feldspar	6	3	6
Heavy minerals	TR	1	1
Clay minerals	55	59	54
Volcanic glass	2	7	4
Palagonite	TR	1	2
Glauconite	1	–	1
Diatoms	17	12	15
Radiolarians	TR	TR	TR
Sponge spicules	3	3	3
Carb, unspec.	6	2	5

NOTE:
◆ = sponge fragments

SITE 440 HOLE B CORE 30 CORED INTERVAL: 415.0-424.5 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) diatomaceous claystone intensely mottled.

Intensely mottled grayish olive (10Y 4/2) diatomaceous claystone with faint veins and fractures.

Vitric diatomaceous claystone
Fine black vein system, (healed) some larger fractures with minor offsets. (Post drilling open fracture orientation approximately 75° (do not follow earlier healed fracture pattern).

TOTAL C – ORGANIC C – CARBONATE (%)
1, 70 cm (1.2, 0.8, 3)

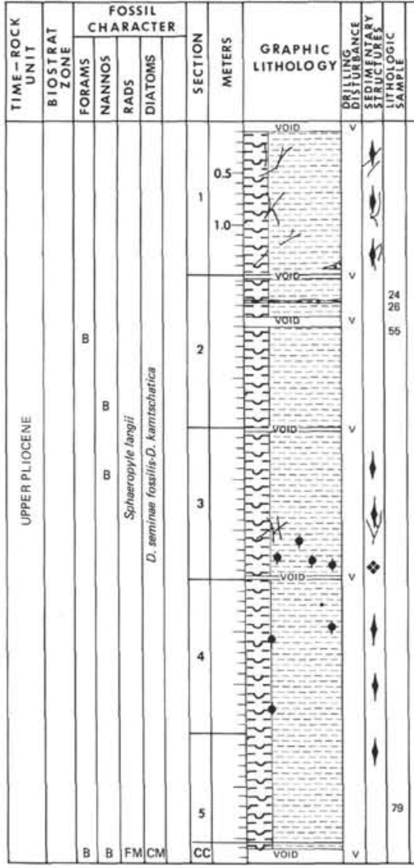
SMEAR SLIDE SUMMARY

Faint veining.

2 mm offset on fractures

	Vitric diatomaceous claystone (M)	Diatomaceous claystone (D)	Diatomaceous claystone (M)
	1-49	2-112	2-113
Sand	7	4	5
Silt	36	30	32
Clay	57	66	63
Quartz	9	8	7
Feldspar	5	3	2
Heavy minerals	1	2	1
Clay minerals	54	66	60
Volcanic glass	10	2	2
Palagonite	–	TR	–
Pyrite	1	–	–
Diatoms	11	11	15
Radiolarians	TR	1	2
Sponge spicules	5	3	5
Carb. unspec.	–	–	6

SITE 440 HOLE B CORE 31 CORED INTERVAL: 424.5-434.0 m



LITHOLOGIC DESCRIPTION

Faint veins (black)
some with offset

Ash body (medium gray,
silt-size)

Diatomaceous claystone
Olive (5Y 5/3) vitric
diatomaceous claystone bed

Prominent mottles

Black veins, very faint

Sponge fragments

Pumice grain

Very faint
veining

Olive gray (5Y 4/2) diatomaceous claystone moderately mottled.

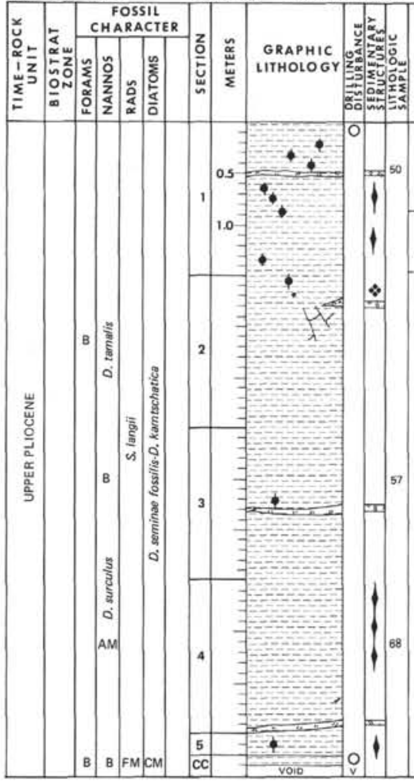
TOTAL C – ORGANIC C – CARBONATE (%)
1, 80 cm (1.2, 1.0, 1)
3, 107 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 92-95 cm = 1.2%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Vitric diatomaceous claystone (M)	Diatomaceous claystone (D)	Pumice (M)
	2-24	2-26	2-55	5-79
Sand	6	4	3	10
Silt	30	35	30	60
Clay	64	61	67	40
Quartz	11	5	7	2
Feldspar	3	3	3	9
Heavy minerals	2	1	1	2
Clay minerals	64	49	65	13
Volcanic glass	2	11	3	71
Glauconite	–	–	1	–
Diatoms	10	17	12	2
Radiolarians	1	1	1	–
Sponge spicules	3	6	3	1
Carb. unspec.	4	7	4	–

SITE 440 HOLE B CORE 32 CORED INTERVAL: 434.0-443.5 m



LITHOLOGIC DESCRIPTION

Sponge fragment

Tuff

Systematic open fractures
with inclination of 74°

Pumice fragment
Tuff, gray (5Y 6/1)
Open unstained fractures
with offsets, closely-
spaced partings throughout
71° inclination

Claystone
Gray (5Y 6/1) tuff

Intense mottling

Prominent mottle
(pale olive, 5Y 6/3):
nanno chalk

Medium gray tuff

Olive gray (5Y 4/2) claystone, slight mottling; fractured.

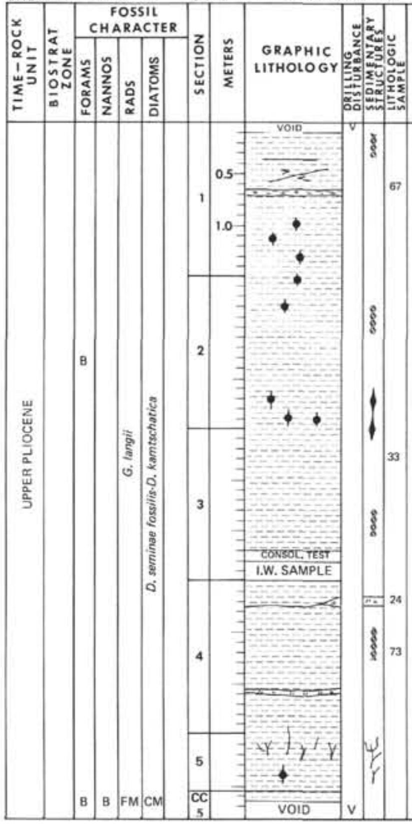
TOTAL C – ORGANIC C – CARBONATE (%)
1, 55 cm (0.9, 0.8, 1)
3, 84 cm (0.6, 0.5, 0)

CARBONATE BOMB
2, 89-91 cm = 1%

SMEAR SLIDE SUMMARY

	Tuff (M)	Claystone (D)	Nanno-chalk (M)
	1-50	3-57	4-68
Sand	4	11	–
Silt	39	30	25
Clay	57	59	75
Quartz	8	12	3
Feldspar	5	5	2
Heavy minerals	1	1	–
Clay minerals	15	57	51
Volcanic glass	63	5	3
Glauconite	1	–	–
Pyrite	2	1	1
Calc. nannos	–	–	31
Diatoms	3	8	5
Radiolarians	TR	1	–
Sponge spicules	TR	5	4
Zeolite	2	–	–
Carb. unspec.	–	5	–

SITE 440 HOLE B CORE 33 CORED INTERVAL: 443.5-453.0 m



LITHOLOGIC DESCRIPTION

Reverse fault with slickensides, dip-slip motion, plane dips 28°.
Silty claystone, dip 3° (hole deviation 2.8°)

Sponge fragments

Moderate mottling

Claystone

Horizontal burrows

Tuff

Light gray tuff

Faint veins

Olive gray (5Y 4/2) claystone.

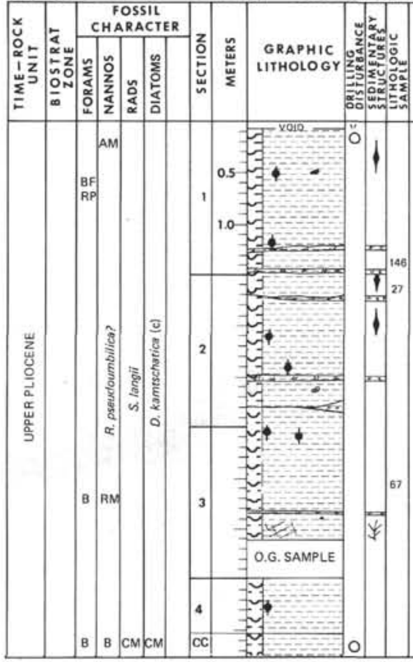
TOTAL C – ORGANIC C – CARBONATE (%)
2, 49 cm (0.7, 0.7, 0)
4, 107 cm (1.0, 0.8, 2)

CARBONATE BOMB
3, 42-44 cm = 0-1%

SMEAR SLIDE SUMMARY

	Silty claystone (M)	Claystone (D)	Tuff (M)	Diatomaceous claystone (D)
	1-67	3-33	4-24	4-73
Sand	10	4	2	9
Silt	40	43	44	30
Clay	50	53	54	61
Quartz	23	14	5	13
Feldspar	8	6	3	5
Heavy minerals	2	1	–	1
Clay minerals	48	50	12	59
Volcanic glass	7	7	73	2
Pyrite	–	1	4	2
Diatoms	8	9	3	10
Radiolarians	–	1	–	1
Sponge spicules	2	5	–	3
Carb. unspec.	2	6	–	4

SITE 440 HOLE B CORE 34 CORED INTERVAL: 453.0-462.5 m



LITHOLOGIC DESCRIPTION

3 mm pumice clast

Light gray silt-size tuff

Light gray (N7) tuff layer silt-size
Apparent dip ±3°
Light gray very fine-grained tuff

Sponge fragments

Very light gray (N8) silt-sized tuff
Ash pocket
Light gray (N7) fine-grained tuff

Diatomaceous claystone
Tuff layer (5 mm thick)
Pumice fragment

Dewatering veins

Dark olive (5Y 3/2) diatomaceous claystone with persistent ±75° partings throughout.

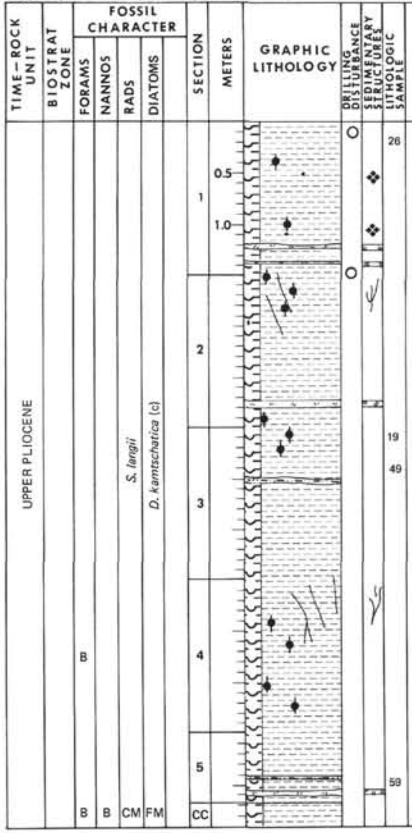
TOTAL C – ORGANIC C – CARBONATE (%)
1, 114 cm (0.7, 0.7, 0)
2, 98 cm (0.8, 0.8, 0)

CARBONATE BOMB
3, 3-5 cm = 1-2%

SMEAR SLIDE SUMMARY

	Tuff (M)	Silty tuff (M)	Diatomaceous claystone (D)
	1-146	2-27	3-67
Sand	0	15	5
Silt	22	35	32
Clay	78	52	63
Quartz	2	5	10
Feldspar	4	12	4
Heavy minerals	5	–	1
Clay minerals	–	10	51
Volcanic glass	89	58	2
Pyrite	–	6	2
Diatoms	–	4	18
Radiolarians	–	–	2
Sponge spicules	–	–	5
Carb. unspec.	–	2	5
Zeolite	–	3	–

SITE 440 HOLE B CORE 35 CORED INTERVAL: 462.5-472.0 m



LITHOLOGIC DESCRIPTION

Drill cuttings
Diatomaceous claystone
Sponge fragment
5 mm pumice clast

Pumice clast
Tuff bed

Tuff bed

Fain veins

Silty tuff

Diatomaceous claystone

Siltstone

Intense near vertical fracturing

Black veining

Dark gray very fine siltstone
Light gray (N7) silt-sized tuff

Olive gray (5Y 4/2) diatomaceous claystone.

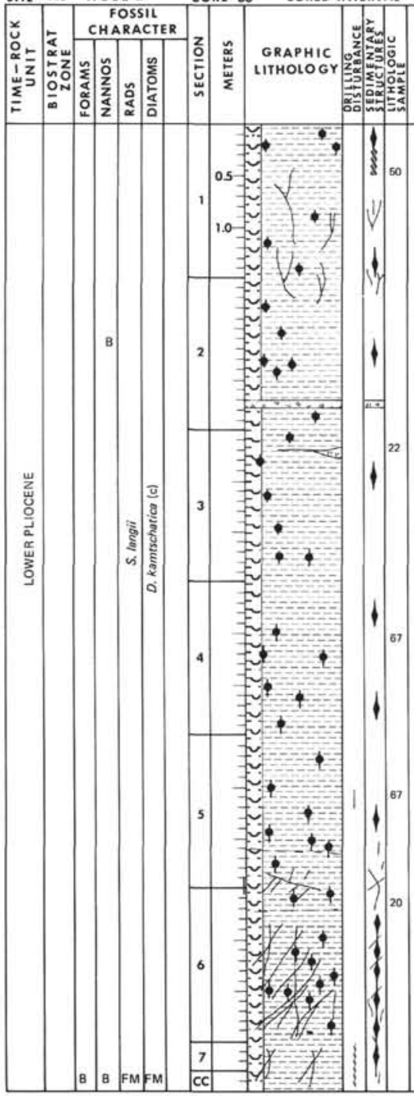
TOTAL C – ORGANIC C – CARBONATE (%)
1, 82 cm (0.6, 0.6, 0)
3, 107 cm (0.9, 0.9, 0)

CARBONATE BOMB
3, 72-74 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Siltstone (M)	Tuff (M)
	1-26	3-19	3-49	5-59
Sand	4	4	15	5
Silt	30	37	60	52
Clay	66	59	25	43
Quartz	9	6	33	6
Feldspar	4	3	14	2
Mica	–	–	TR	–
Heavy minerals	1	1	5	5
Clay minerals	55	54	19	10
Volcanic glass	1	2	6	72
Glauconite	–	2	7	–
Pyrite	–	–	5	–
Diatoms	20	25	6	5
Radiolarians	1	1	1	–
Sponge spicules	4	4	2	–
Lithic fragments	2	–	–	–
Carb. unspec.	3	2	2	–

SITE 440 HOLE B CORE 36 CORED INTERVAL: 472.0-481.5 m



LITHOLOGIC DESCRIPTION

Burrowed (0.5 cm x 3-5 cm)

Diatomaceous claystone

Black dewatering veins throughout

Sponge fragments

Very light gray silt-sized tuff

Light gray (N7) silt-sized tuff

Sponge fragments

Diatomaceous claystone

Diatomaceous claystone

Silty lamination

Dark silty claystone lamination

Intensely mottled and highly fractured (main trend vertical and 60°)

Anastomosing fractures

Olive gray (5Y 4/2) diatomaceous claystone slightly mottled; common sponge remains, healed veins and fractures.

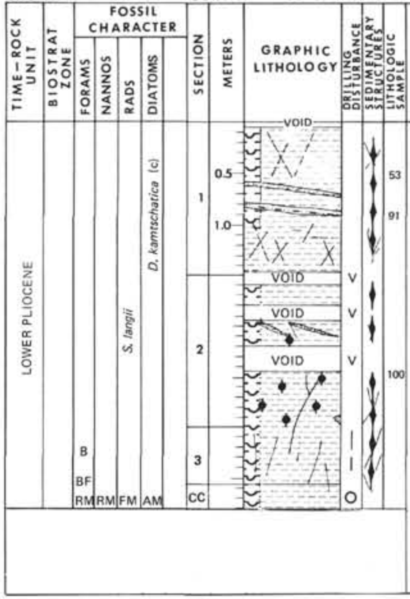
TOTAL C – ORGANIC C – CARBONATE (%)
1, 108 cm (1.2, 1.2, 0)
3, 60 cm (1.0, 0.9, 0)
5, 100 cm (1.1, 1.0, 1)

CARBONATE BOMB
3, 4-6 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Tuff (M)	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Silty claystone (M)
	1-50	3-22	4-67	5-67	6-20
Sand	3	3	3	3	18
Silt	34	52	32	30	40
Clay	63	45	65	67	42
Quartz	5	4	5	5	15
Feldspar	3	5	2	3	25
Heavy minerals	1	1	1	1	2
Clay minerals	58	8	64	63	40
Volcanic glass	4	79	3	2	8
Palagonite	–	–	–	–	1
Glauconite	TR	–	–	–	–
Pyrite	1	1	1	1	–
Diatoms	22	2	18	19	6
Radiolarians	1	–	1	–	–
Sponge spicules	3	–	3	3	3
Carb. unspec.	2	–	2	3	–

SITE 440 HOLE B CORE 37 CORED INTERVAL: 481.5-491.0 m



LITHOLOGIC DESCRIPTION

Diatomaceous claystone

Vitric clayey siltstone

Numerous fractures
Normal and reverse offset

About 8 cm offset on reverse fault

Diatomaceous claystone

Silty mottle

Olive gray (5Y 4/2) diatomaceous claystone intensely mottled, moderately fractured, silty in part.

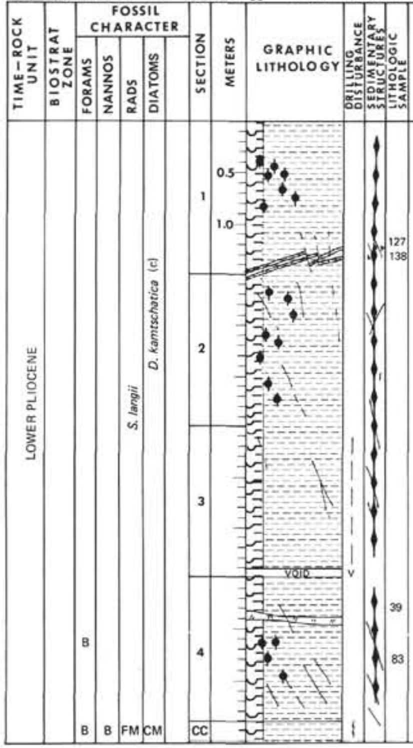
TOTAL C – ORGANIC C – CARBONATE (%)
2, 140 cm (0.8, 0.7, 1)

CARBONATE BOMB
3, 26-28 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Vitric clayey siltstone (M)	Diatomaceous claystone (D)
	1-53	1-91	2-100
Sand	18	18	5
Silt	27	46	31
Clay	55	36	64
Quartz	8	22	8
Feldspar	5	10	3
Heavy minerals	TR	1	TR
Clay minerals	55	36	66
Volcanic glass	5	12	4
Palagonite	1	–	–
Glauconite	1	8	1
Pyrite	–	–	TR
Diatoms	17	7	14
Radiolarians	1	1	–
Sponge spicules	5	3	3
Carb. unspec.	2		1

SITE 440 HOLE B CORE 38 CORED INTERVAL: 491.0-500.5 m



LITHOLOGIC DESCRIPTION

Long burrow trace

Long burrow trace
Sponge fragments

Black to olive black claystone layers, faulted
Olive (5Y 4/3-4/4) interval with faint laminations
Pale yellow white (5Y 8/2) calcareous chalk layer
30° dip at base of Section 1

Intensely mottled with various shades of olive (5Y 3/2-4/3)
Numerous fractures, some with minor offsets

Pale yellow (5Y 7/3) tuffite intensely mottled

Diatomaceous claystone

Olive gray (5Y 4/2) diatomaceous claystone intensely mottled and fractured.

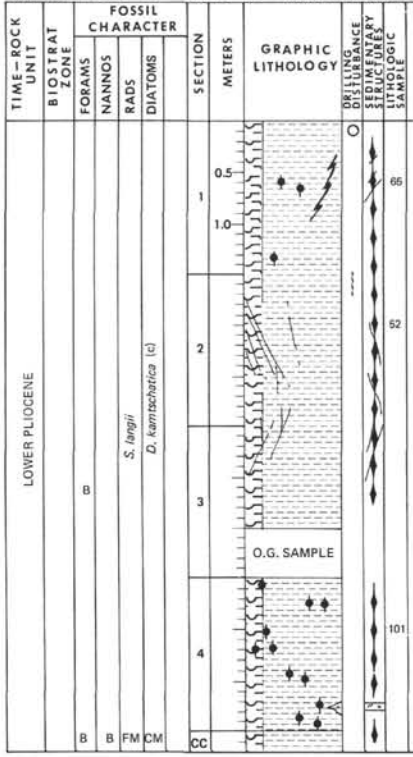
TOTAL C – ORGANIC C – CARBONATE (%)
2, 116 cm (1.0, 0.8, 2)
4, 58 cm (1.1, 1.0, 1)

CARBONATE BOMB
2, 112-113 cm = 1-2%

SMEAR SLIDE SUMMARY

	Claystone (M)	Calcareous chalk (M)	Tuffite (M)	Diatomaceous claystone (D)
	1-127	1-138	4-39	4-83
Sand	0	0	2	0
Silt	21	25	45	28
Clay	79	75	53	72
Quartz	11	1	4	6
Feldspar	4	1	1	3
Heavy minerals	TR	–	–	1
Clay minerals	79	–	53	72
Volcanic glass	1	1	35	3
Palagonite	–	TR	1	1
Glauconite	–	TR	–	TR
Diatoms	TR	3	4	10
Sponge spicules	3	3	2	4
Carb. unspec.	2	91	–	TR

SITE 440 HOLE B CORE 39 CORED INTERVAL: 500.5-510.0 m



LITHOLOGIC DESCRIPTION

2 mm wide grayish black (N2) fracture filling

Diatomaceous claystone

Network of fine fractures

Diatomaceous claystone

Coarse grayish black (N2) filling fractures, anastomosing and branching

Numerous sponge fragments

Diatomaceous claystone (dark gray, 5Y 4/1)

Grayish black (N2) ash mottle

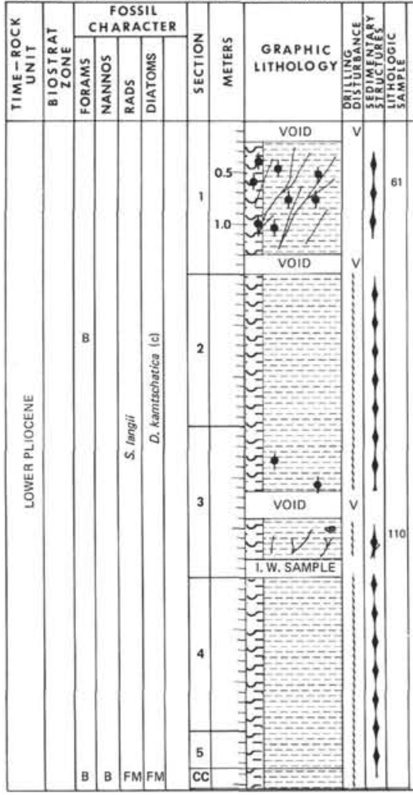
Olive gray (5Y 4/2) diatomaceous claystone intensely burrow mottled, some healed fractures.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 32 cm (1.3, 1.2, 1)
4, 110 cm (1.4, 1.5, 0)

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Diatomaceous claystone (D)
	1-65	2-52	4-101
Sand	2	3	3
Silt	26	28	27
Clay	72	69	70
Quartz	6	5	5
Feldspar	2	2	1
Mica			
Heavy minerals	1	1	TR
Clay minerals	72	69	70
Volcanic glass	4	4	4
Palagonite	TR	–	–
Glauconite	–	1	TR
Diatoms	12	13	15
Radiolarians	TR	–	TR
Sponge spicules	2	3	4
Carb. unspec.	1	2	1

SITE 440 HOLE B CORE 40 CORED INTERVAL: 510.0-519.5 m



LITHOLOGIC DESCRIPTION

Diatomaceous claystone
Intensely mottled and fractured

Sponge fragments abundant

Drilling biscuits

Pale yellow (5Y 7/4) ashy mottle (fine veins and fractures)

Highly deformed by drilling, broken into small biscuits

Olive gray (5Y 4/2) diatomaceous claystone intensely mottled ("biscuits" re-occur).

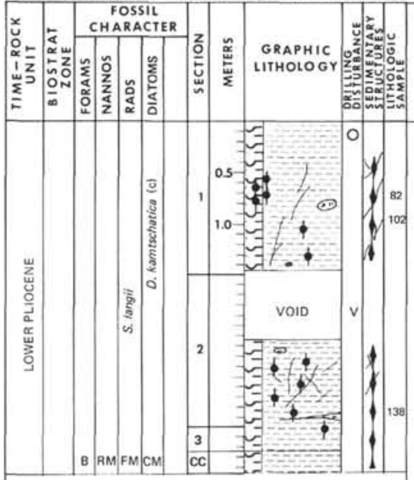
TOTAL C – ORGANIC C – CARBONATE (%)
2, 10 cm (1.4, 1.3, 1)
4, 56 cm (1.2, 1.0, 1)

CARBONATE BOMB
3, 28-30 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Diatomaceous claystone (D)	Vitric claystone (D)
	1-61	3-110	CC-5
Sand	2	2	6
Silt	31	20	36
Clay	67	70	58
Quartz	7	8	12
Feldspar	4	4	6
Heavy minerals	1	1	1
Clay minerals	67	70	58
VOlcanic glass	3	1	10
Palagonite	2	TR	1
Glauconite	–	–	1
Diatoms	11	10	8
Radiolarians	TR	TR	TR
Sponge spicules	4	4	2
Carb. unspec.	1	2	1

SITE 440 HOLE B CORE 41 CORED INTERVAL: 519.5-529.0 m



LITHOLOGIC DESCRIPTION

Dark gray mottles
Silty tuff
Diatomaceous claystone
Some fractures
Silty ash mottles (4 mm diameter).

Tuff mottle (diameter 10 mm)

Faint fractures with numerous orientations

Dark gray (N3) tuff

Olive gray (5Y 4/2) diatomaceous claystone intensely mottled.

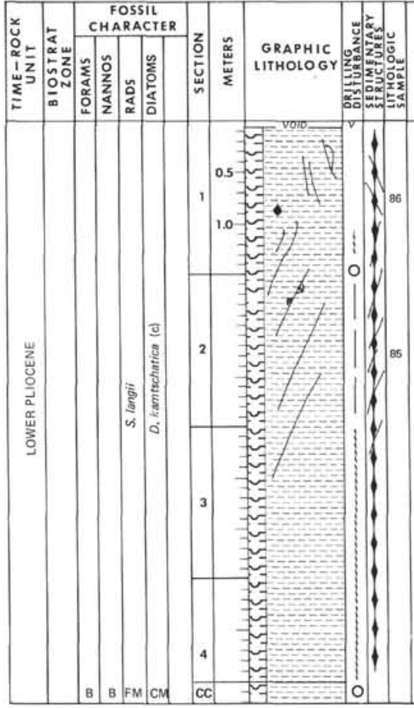
TOTAL C – ORGANIC C – CARBONATE (%)
2, 128 cm (1.0, 0.8, 1)

CARBONATE BOMB
3, 31-33 cm = 1-2%

SMEAR SLIDE SUMMARY

	Tuff (M)	Diatomaceous claystone (D)	Tuff (M)
	1-82	1-102	2-138
Sand	40	1	32
Silt	45	29	45
Clay	15	70	23
Quartz	18	8	18
Feldspar	11	2	14
Heavy minerals	1	–	3
Clay minerals	–	70	1
Volcanic glass	66	3	62
Palagonite	4	1	2
Glauconite	–	1	–
Diatoms	–	11	–
Sponge spicules	–	3	–
Carb. unspec.	–	1	–

SITE 440 HOLE B CORE 42 CORED INTERVAL: 529.0-538.5 m



LITHOLOGIC DESCRIPTION

Diatomaceous claystone

Fractures with 1 cm offset maximum

Diatomaceous claystone

Strong drilling disturbances

Olive gray (5Y 4/2) diatomaceous claystone intensely mottled with numerous fracture systems.

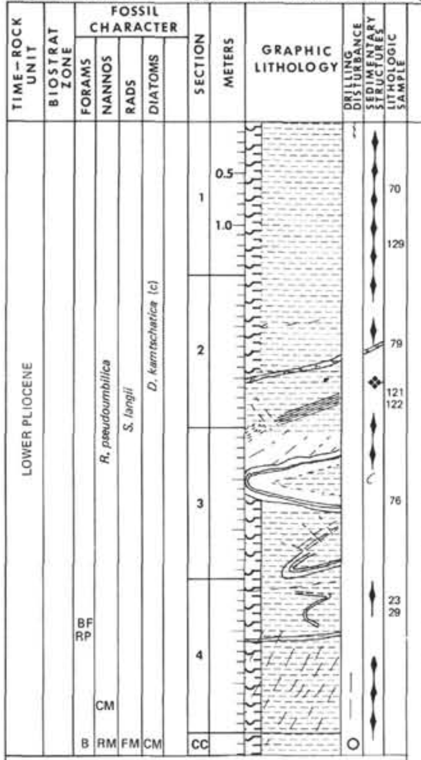
TOTAL C – ORGANIC C – CARBONATE (%)
2, 87 cm (1.2, 1.1, 1)
4, 67 cm (1.1, 1.0, 0)

CARBONATE BOMB
3, 10-12 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Diatomaceous claystone (D)
	1-86	2-85
Sand	1	0
Silt	27	35
Clay	72	65
Quartz	6	8
Feldspar	3	2
Heavy minerals	TR	1
Clay minerals	72	65
Volcanic glass	4	2
Palagonite	1	TR
Glauconite	TR	1
Diatoms	11	12
Radiolarians	–	1
Sponge spicules	2	4
Carb. unspec.	1	4

SITE 440 HOLE B CORE 43 CORED INTERVAL: 538.5-548.0 m



LITHOLOGIC DESCRIPTION

3 distinct units of claystone: lighter colored olive gray grading to darker at top. May be mud turbidites(?).

Darker
Claystone
Lighter

Sharp, irregular contact

Claystone

Faint streaks or laminations

Ash mottles

Ash layer
Wood fragment (3 cm long)

Spiculitic claystone (dark)
Vitric spiculitic claystone (light)
Reverse faulting in an irregularly laminated unit
Discordant contact, sharp and irregular
5Y 4/2
Possible overturned fold (slumping?)
5G 5/1 claystone
5Y 4/2 claystone

Zone of confused laminations complex faulting
greenish gray (5GY 5/1) claystone

5Y 4/2 diatomaceous claystone
dark olive gray (5Y 3/2) 1 cm layer
Olive bed (5Y 5/6), confusing relations, possible folding?

Thin olive (5Y 5/6) layer

Mottled and fractured but fairly uniform greenish gray (5GY 5/1) claystone.
No structure other than healed fractures observed.

Olive gray (5Y 4/2) diatomaceous claystone intensely streaked and mottled, overturned folds, some bedding at top dipping ≈ 35°.

Interval of laminated olive (5Y 4/3) and pale olive (5Y 6/4) beds, dips ≈ 40°.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 49 cm (1.5, 1.4, 1)
3, 61 cm (0.9, 0.8, 1)
4, 43 cm (0.8, 0.6, 1)

CARBONATE BOMB
3, 48-50 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Claystone (D)	Diatomaceous claystone (D)	Spiculitic claystone (M)	Vitric spiculitic claystone (M)	Claystone (D)	Diatomaceous claystone (D)	Diatomaceous claystone (M)
	1-70	1-129	2-79	2-121	2-122	3-76	4-23	4-29
Sand	2	0	2	2	1	2	7	5
Silt	29	25	22	40	52	30	35	25
Clay	69	75	76	62	47	68	58	60
Quartz	6	5	5	6	7	8	6	7
Feldspar	4	2	1	2	2	4	3	2
Mica	TR	–	–	–	–	–	–	–
Heavy minerals	–	1	–	–	–	–	1	TR
Clay minerals	69	75	76	62	47	68	52	60
Volcanic glass	4	5	2	8	18	5	6	6
Palagonite	TR	–	TR	–	–	–	TR	–
Glauconite	TR	–	–	–	–	–	TR	–
Diatoms	11	8	10	8	5	6	23	14
Radiolarians	–	TR	TR	–	–	–	TR	–
Sponge spicules	4	4	5	12	20	6	5	7
Carb. unspec.	2	–	1	2	1	3	2	4

SITE 440 HOLE B CORE 44 CORED INTERVAL: 548.0-557.5 m

TIME–ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE		BF RP	RM	FM *S. langii*	FM *D. kamtschatica* (c)	CC		○		

GRAPHIC LITHOLOGY

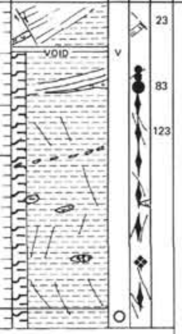
LITHOLOGIC DESCRIPTION

Diatomaceous claystone, olive gray (5Y 4/2).

SITE 440 HOLE B CORE 45 CORED INTERVAL: 557.5-567.0 m

TIME–ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE				*S. langii*	*D. kamtschatica* (c)	1	0.5 1.0	V		23 83 123
						2				
		B	B	FP	CM	CC		○		

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

Fractured (normal fault) light gray (N7) tuff layer offset > 15 cm.

Dip of layer 40°.
Small graded beds offset by fractures.
Medium dark gray (N4) disrupted vitric sandy siltstone grading to claystone.

Mottled diatomaceous claystone.
Ash lenses.

Large burrow (Zoophycus)
Medium light gray (N6) ash pockets.

Pumice fragment.

Olive gray (5Y 4/2) diatomaceous claystone intensely streaked and moderately mottled; highly fractured (healed); bedding dips 20°.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 107 cm (0.9, 0.9, 0)
2, 103 cm (0.9, 0.9, 0)

CARBONATE BOMB
1, 4-6 cm = 0%

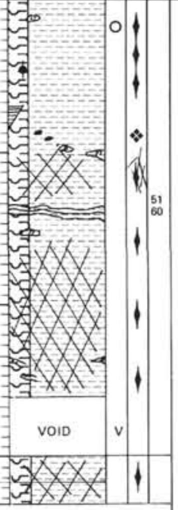
SMEAR SLIDE SUMMARY

	Tuff (M)	Vitric sandy siltstone (M)	Diatomaceous claystone (D)
	1-23	1-83	1-123
Sand	50	30	1
Silt	40	40	25
Clay	10	30	74
Quartz	5	32	5
Feldspar	10	10	2
Heavy minerals	TR	–	–
Clay minerals	10	25	72
Volcanic glass	75	25	5
Palagonite	–	TR	TR
Glauconite	–	2	–
Pyrite	–	1	
Diatoms	TR	5	15
Sponge spicules	–	–	1

SITE 440 HOLE B CORE 46 CORED INTERVAL: 567.0-576.5 m

TIME–ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE				*S. langii*	*D. kamtschatica* (b)	1	0.5 1.0	○		
						2				51 60
						3		V		
		BF				4				
		RM	CM	FP	CM	CC				

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

Silty pocket

Fine olive (5Y 5/3) and dark gray (5Y 4/1) laminations cut by fracture.
Pumice fragments.
Silty ash pocket.
Net of conjugate fractures, open, with possible horizontal slickensides(?).

Diatomaceous claystone.
Contorted olive (5Y 5/4) clayey diatomite bed.
Dark olive gray mottled claystone layer.
Ash pocket.
Highly fractured (healed fractures and open partings).

Medium gray (N5) silty pocket.

Offset of silty bed along faults.

Highly fractured, moderate mottling.

Olive gray (5Y 4/2) diatomaceous claystone moderately mottled and highly fractured (open network).

TOTAL C – ORGANIC C – CARBONATE (%)
1, 103 cm (1.2, 1.1, 1)
2, 77 cm (1.4, 1.3, 1)

CARBONATE BOMB
3, 34-37 cm = 1-2%

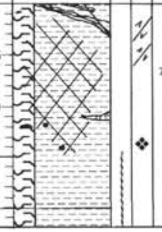
SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Clayey diatomite (M)
	2-51	2-60
Sand	0	0
Silt	25	30
Clay	75	70
Quartz	5	4
Feldspar	2	1
Clay minerals	72	52
Volcanic glass	5	3
Diatoms	15	40
Sponge spicules	1	TR

SITE 440 HOLE B CORE 47 CORED INTERVAL: 576.5-586.0 m

TIME–ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE			RM	*S. langii*	*D. kamtschatica* (b)	1	0.5 1.0			70
						2				
		B	CM	FM	CM	CC				

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

Olive (5Y 5/3) laminations cut by normal fault.

Diatomaceous claystone with 1 cm blocks with horizontal slickensides.

Ash.

Pumice fragment.

High drilling disturbance. No structure visible.

Olive gray (5Y 4/2) diatomaceous claystone, slightly mottled and highly fractured (open network) throughout.

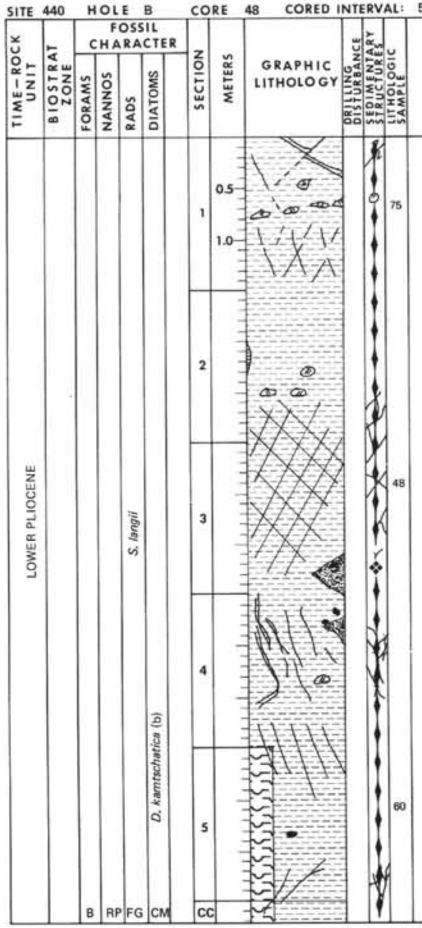
TOTAL C – ORGANIC C – CARBONATE (%)
1, 15 cm (1.2, 1.1, 1)

CARBONATE BOMB
1, 79-81 cm = 2%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (M)	Pumice clast (M)
	1-70	CC
Sand	0	–
Silt	25	25
Clay	75	70
Quartz	5	2
Feldspar	2	–
Clay minerals	71	20
Volcanic glass	5	74
Palagonite	–	TR
Pyrite	1	–
Diatoms	15	3
Sponge spicules	1	1

SITE 440 HOLE B CORE 48 CORED INTERVAL: 586.0-595.5 m



LITHOLOGIC DESCRIPTION

Fractures with offset.

Medium light gray ash pocket.

Tuff bed disrupted, medium gray (N5).

Dark gray (5Y 4/1) or olive (5Y 4/3, 5Y 4/4).
Mottles outlined by black rims and veins.

Strongly mottled and bioturbated.
Large open parting fracture surface with horizontal slickensides.

Ash pocket.
Medium dark gray (N4) ash pocket.

Strongly fractured.

Fractures, outlined by black fillings along fracture planes.

Claystone, strongly mottled (5Y 4/1, 4/3, 4/4 mottles).
No visible dip.

Pumice fragment.
Silt grains dispersed in claystone.

Pumice fragment.
Silt grains mixed with claystone.

Complex veins; probably dewatering structures, medium gray ash pocket.

Intense mottling.

Strong high angle parting.

Diatomaceous claystone.
Intensely mottled.
Pumice fragment.

Black vein network; dewatering veins.

Olive gray (5Y 4/2) claystone and diatomaceous claystone strongly mottled and partly fractured (both healed systems and open parting network).

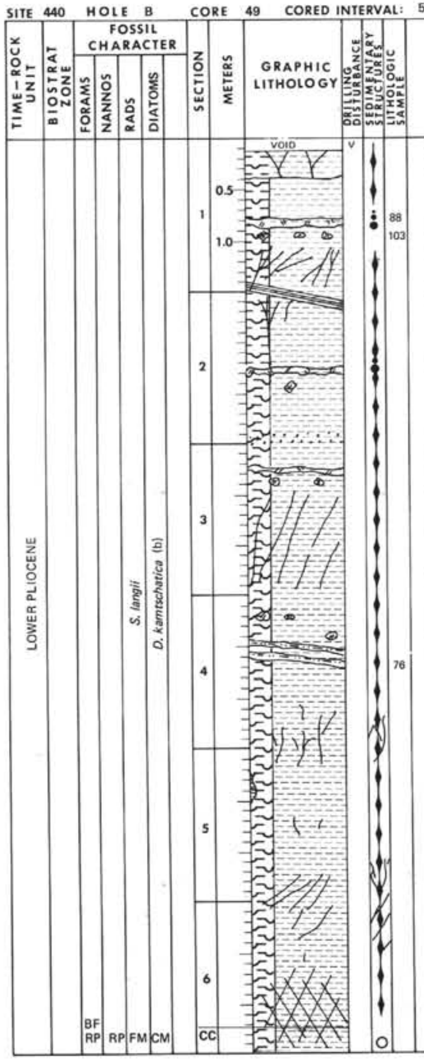
TOTAL C – ORGANIC C – CARBONATE (%)
1, 100 cm (1.1, 1.0, 1)
3, 90 cm (1.3, 1.2, 1)
5, 109 cm (1.1, 1.0, 1)

CARBONATE BOMB
3, 130-133 cm = 1-2%

SMEAR SLIDE SUMMARY

	Tuff (M)	Claystone (D)	Diatomaceous claystone
	1-75	3-48	5-60
Sand	5	0	1
Silt	60	10	20
Clay	35	90	79
Quartz	5	3	5
Feldspar	5	1	2
Heavy minerals	–	–	TR
Clay minerals	20	86	71
Volcanic glass	67	–	5
Glauconite	TR	–	–
Pyrite	2	2	–
Diatoms	1	8	15
Sponge spicules	–	TR	2

SITE 440 HOLE B CORE 49 CORED INTERVAL: 595.5-605.0 m



LITHOLOGIC DESCRIPTION

Olive gray claystone grading downward to dark olive gray.

Graded ash reworked by burrowing.

Diatomaceous claystone intensely burrowed (chondrites type).

Small laminations showing a 15° dip.
Black veins (hole deviation 5.4°).

Medium gray ash bed bioturbated and graded.

Numerous pumice granules.

Olive (5Y 4/3) claystone.
Medium gray (N5) ash bed, burrowed.
Ash pocket.

Fractures with slickensides(?) on surface.

Olive (5Y 4/3) claystone strongly mottled. Dip = 10°

Medium gray (N5) ash pocket.
Medium light gray (N6) ash pocket.
Bioturbated silty claystone bed.
Silty claystone.

Very dark gray (5Y 3/1) claystone with large mottles (>1 cm) separated by black rims and veins.

Fault surface with horizontal slickensides

Coarse mottling with limey olive (5Y 5/4, 5/6) mottles.
Fractured zone with numerous surfaces showing horizontal slickensides.

Strong parting.

Highly indurated claystone from olive gray (5Y 4/2) to very dark gray (5Y 3/1); intense mottling; fracturing moderate; persistent high angle parting.

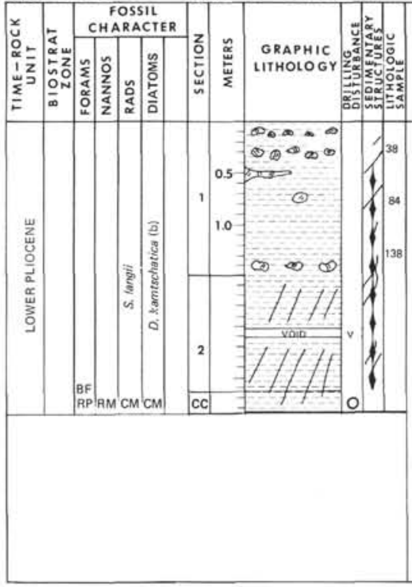
TOTAL C – ORGANIC C – CARBONATE (%)
1, 117 cm (1.1, 1.1, 0)
3, 44 cm (1.8, 1.1, 6)
5, 37 cm (1.4, 0.9, 4)

CARBONATE BOMB
3, 115-117 cm = 2-3%

SMEAR SLIDE SUMMARY

	Clayey tuff (M)	Diatomaceous claystone (D)	Silty claystone (M)
	2-88	2-103	4-76
Sand	10	–	15
Silt	55	15	30
Clay	35	85	55
Quartz	5	3	25
Feldspar	3	1	5
Heavy minerals	–	–	5
Clay minerals	32	76	54
Volcanic glass	60	5	8
Palagonite	–	–	TR
Pyrite	–	TR	1
Diatoms	TR	15	2
Radiolarians	–	–	TR
Sponge spicules	–	TR	TR

SITE 440 HOLE B CORE 50 CORED INTERVAL: 605.0-614.5 m



LITHOLOGIC DESCRIPTION

Medium gray (N5) ash layer.

Tuffite mottle

Medium gray (N5) tuffite pod

N5 ash pocket
Claystone

Medium gray tuffite layer disturbed by burrowing

Fractured dark gray (5Y 4/1) claystone

Dark gray (5Y 4/1) claystone; highly fractured and veined: strongly mottled claystone with large (2 cm) mottled angular. 5Y 5/3 calcitic-cemented or 5Y 5/2 claystone.

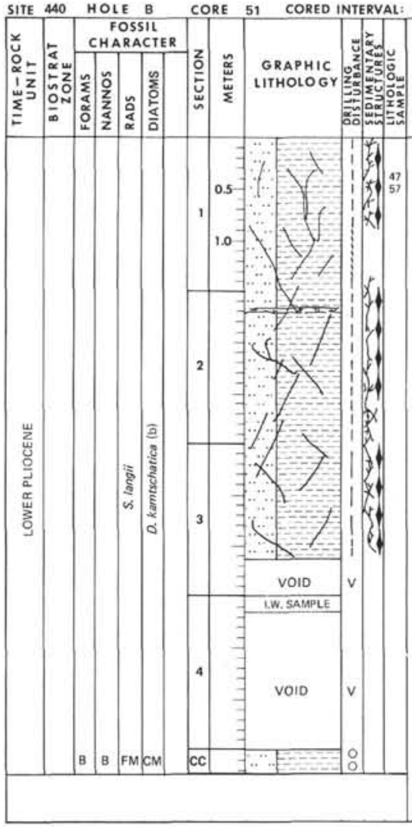
TOTAL C – ORGANIC C – CARBONATE (%)
1, 131 cm (1.4, 1.2, 1)

CARBONATE BOMB
1, 127-129 cm = 2-3%

SMEAR SLIDE SUMMARY

	Tuffite (M)	Claystone (D)	Tuffaceous claystone (M)
	1-38	1-84	1-138
Sand	2	0	2
Silt	38	32	25
Clay	60	68	73
Quartz	5	9	20
Felspar	2	4	10
Heavy minerals	–	TR	TR
Clay minerals	48	68	45
Volcanic glass	40	3	25
Palagonite	–	TR	–
Diatoms	5	9	–
Radiolarians		TR	TR
Sponge spicules	TR	3	–
Carb. unspec.	–	4	–

SITE 440 HOLE B CORE 51 CORED INTERVAL: 614.5-624.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/1) claystone, intensely mottled highly irregular, large (up to 1.5 cm diameter) mottles of olive (5Y 5/3); faults with normal offset of at least 3-5 cm. Gives impression of pseudo-breccia.
Faults probably occurred pre-lithification; persistent parting.

Very light gray (N8) ash bed

Grayish olive (10Y 4/2) claystone, intensely mottled and highly fractured numerous faults (inclined 55°-60°) offsets, average 1 cm per fault.

Irregular fracture, fairly homogeneous.

Grayish olive (10Y 4/2) claystone intensely mottled and highly faulted. Fractured intensely during drilling (open partings).

TOTAL C – ORGANIC C – CARBONATE (%)
1, 28 cm (1.1, 0.8, 3)

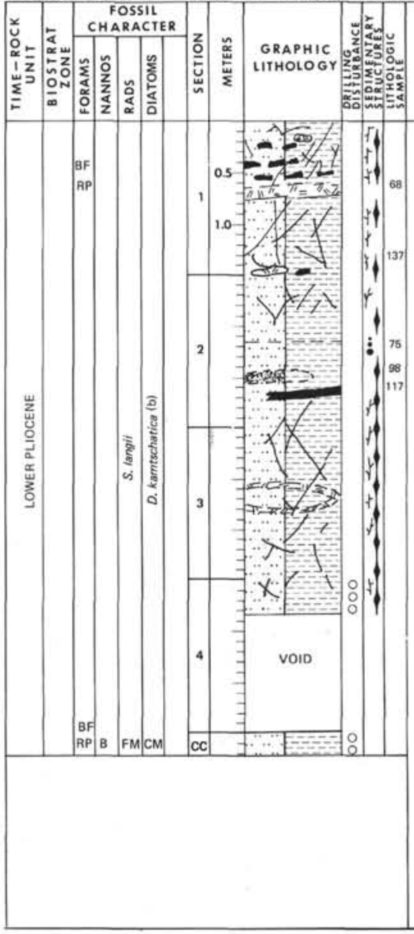
CARBONATE BOMB
2, 80-82 cm = 2-3%

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)
	1-47	1-57
Sand		1
Silt	38	22
Clay	62	77
Quartz	12	8
Feldspar	3	3
Heavy minerals		1
Clay minerals	62	77
Voclanic glass	5	3
Palagonite	TR	
Glauconite	TR	
Diatoms	8	4
Sponge spicules	2	2
Carb. unspec.	4	2
Calc. nannos	4	

Grayish olive (10Y 4/2) claystone

SITE 440 HOLE B CORE 52 CORED INTERVAL: 624.0-633.5 m



LITHOLOGIC DESCRIPTION

Persistent high angleopen partings. Light olive gray (5Y 5/2) claystone with olive gray (5Y 3/2) mottles and streaks.

Ash mottle

Dusky yellow (5Y 6/4) hard calcareous greenish gray (5GY 6/1) tuffite with streaks and mottles.

Numerous faults with 1.0-1.5 cm normal offset and dip with 60°-70°.

Grayish olive (10Y 4/2) claystone, homogeneous to mottles and faults.

Medium dark gray (N4) ash mottle. Light olive brown (5Y 5/6) calcareous mottle.

Dusky grayish olive green (5GY 4/2) claystone intensely mottled to homogeneous with some faults.

Dark gray (N3-N4) sandy claystone mottle.

Dusky yellow (5Y 6/4) calcareous patch (rich in nannofossils) surrounded by olive gray (5Y 3/2) mottles.

Grayish olive (10Y 5/2) claystone, intensely mottled and streaked.

Medium gray disrupted ash bed, folded.

Bedding dip with 25°.

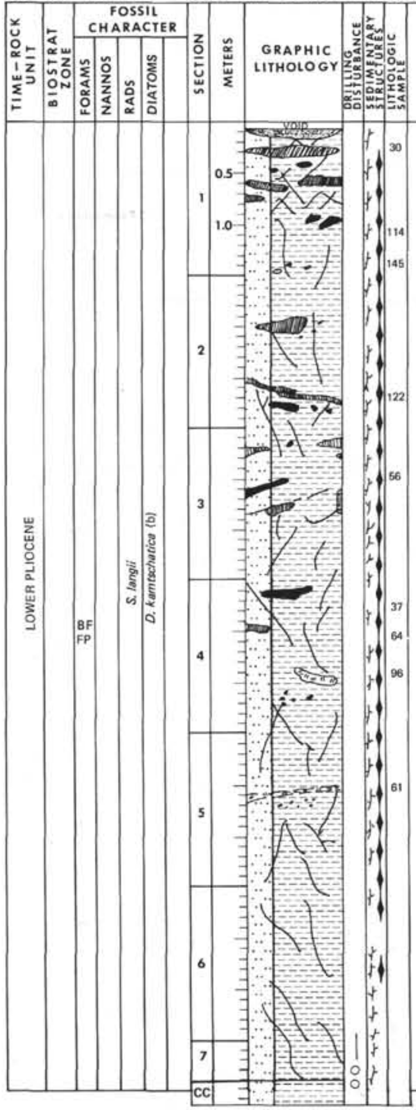
TOTAL C – ORGANIC C – CARBONATE (%)
2, 63 cm (1.0, 0.8, 1)

CARBONATE BOMB
3, 127-129 cm = 1-2%

SMEAR SLIDE SUMMARY

	Tuffite (D)	Claystone (D)	Claystone (D)	Sandy claystone (M)	Calcareous claystone (M)
	1-68	1-127	2-75	2-98	2-117
Sand	10		3	32	
Silt	42	24	34	26	28
Clay	48	76	63	42	72
Quartz	6	10	9	28	4
Feldspar	2	1	5	15	2
Heavy minerals	TR		TR	7	TR
Clay minerals	48	76	63	42	72
Volcanic glass	32	1	5	3	1
Palagonite	TR	1		1	TR
Glauconite		TR		1	
Foraminifers					TR
Diatoms	3	4	9	2	5
Radiolarians			TR		TR
Sponge spicules	5	3	4	1	2
Carb. unspec.	4	4	5		6
Calc. nannos		TR	TR		8

SITE 440 HOLE B CORE 53 CORED INTERVAL: 633.5-643.0 m



LITHOLOGIC DESCRIPTION

Pale olive (5Y 6/3) calcareous mottles.

Grayish olive (10Y 4/2) claystone with intense mottling of olive gray (5Y 3/2) veins and faulting throughout Anastomosing fracture nets 45°-60° inclinations.

Glauconite grains

Calcareous mottles and glauconite grains are commonly observed through Sections 1 to 5.

Vitric claystone pocket

TOTAL C – ORGANIC C – CARBONATE (%)
2, 35 cm: (0.8, 0.7, 1)
4, 53 cm (1.1, 0.9, 2)

Calcareous mottle.

CARBONATE BOMB
3, 49-51 cm = 1-2%

Calcareous mottle
Glauconite grains

Grayish olive to light olive gray (10Y 4/2 to 5Y 5/2)

SMEAR SLIDE SUMMARY

	Claystone (D)	Nannofossil calcareous claystone (M)	Vitric claystone (M)	Glauconite grain (M)	Claystone (D)	Claystone (D)	Claystone (M)	Tuff (M)	Silty claystone (M)
	1-114	1-30	1-145	2-122	3-56	4-37	4-64	4-96	5-61
Sand	4	2		14	4	1		14	8
Silt	26	43	43	57	22	22	33	74	31
Clay	70	55	57	29	74	77	67	12	61
Quartz	8	3	3	8	7	7	11	2	14
Feldspar	3	1	6	4	4	3	3	3	6
Heavy minerals	TR					TR			TR
Clay minerals	70	55	57	29	74		67	12	61
Volcanic glass	4	2	25	8	5	3	8	78	8
Palagonite	1				1	TR	1		TR
Glauconite	TR		8	40			TR		
Foraminifers		TR		TR					
Diatoms	8	6		5	5	4	7		5
Sponge spicules	3	2			2	2	3		3
Carb. unspec.	3	21	1	6	2	4	3	5	3
Calc. nannos	TR	10		TR		TR	TR	TR	

SITE 440 HOLE B CORE 54 CORED INTERVAL: 643.0-652.5 m

TIME-ROCK UNIT: LOWER PLIOCENE

FOSSIL CHARACTER — RADS: *S. langii*; DIATOMS: *D. kamtschatica* (b)

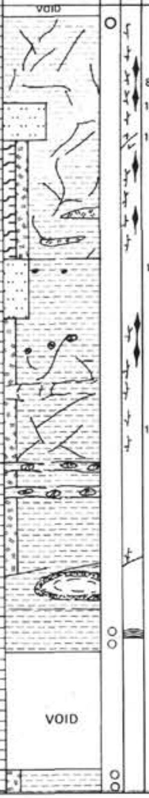
Section 4: PB, FP

Section 5: BF

CC: RP RM CG FM

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

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES



LITHOLOGIC SAMPLE: 88, 100, 136, 117, 124

LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) claystone, with mottles or homogeneous, with healed fractures throughout core; open partings parallel to fracture trend.

Bedding dips 10° to 15°.

Grayish olive (10Y 4/2) homogeneous silty claystone

Faults with reversed offsets; fault planes dip 40°-50° inclinations (125-150 cm).

Grayish olive (10Y 4/2) diatomaceous vitric claystone Dipping at steep angles associated with faults. Possible as clasts incorporated in silty unit; bedding bends and is overturned (210-250 cm).

Ash mottle

Glauconite grains

Grayish olive (110Y 4/2) silty claystone.

White pumice fragments up to 4 mm

Grayish olive (10Y 4/2) vitric claystone bedding with 25°-30°.

Vertical bedding, faulted-in sandy claystone to right of nertical, moderate olive brown (5Y 4/4) beds.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 40 cm (1.0, 0.9, 1)

CARBONATE BOMB
3, 110-113 cm = 2%

Calcareous beds and mottles in claystone.

SMEAR SLIDE SUMMARY

	Claystone (M)	Diatomaceous claystone (D)	Diatomaceous vitric silty claystone (M)	Claystone (D)	Vitric claystone (D)
	1-88	1-100	1-136	2-117	3-124
Sand	2	9	15		5
Silt	39	36	40	20	38
Clay	69	55	45	80	57
Quartz	8	12	12	4	9
Feldspar	3	5	8	1	4
Heavy minerals		TR	1	TR	1
Clay minerals	69	55	45	80	57
Volcanic glass	3	1	12	4	12
Palagonite		TR	1	1	1
Glauconite		TR	1		
Pyrite	TR				
Foraminifers				TR	
Diatoms	7	14	11	4	5
Radiolarians		TR			
Sponge spicules	4	4	3	2	5
Carb. unspec.	6	9	5	4	5
Calc. nannos			1		

Olive gray (5Y 4/2) vitric claystone

Mottled claystone capped with 5 mm vitric glauconitic silt, folded.

Laminated or streaked claystone.

Vitric claystone

SITE 440 HOLE B CORE 55 CORED INTERVAL: 652.5-662.0 m

TIME-ROCK UNIT: LOWER PLIOCENE

FOSSIL CHARACTER — DIATOMS: *D. kamtschatica* (b)

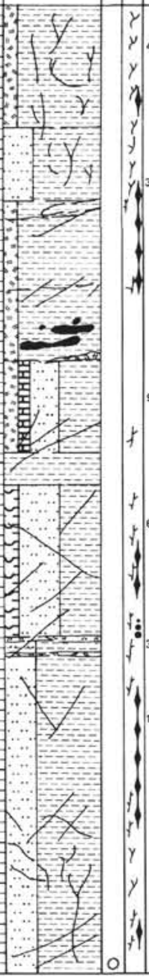
Section 5: B

Section 6: B

CC: BF, RP B FM FM

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

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES



LITHOLOGIC SAMPLE: 49, 35, 95, 62, 36, 107

LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) vitric claystone healed black veins and fractures throughout.

Greenish gray (5GY 6/1) mottle.

Olive gray (5Y 4/2) silty claystone.

Possible fold of mottled claystones in vitric claystone.

Olive gray (5Y 4/2) vitric claystone.

Glauconite grains
Ash pocket

Olive gray (5Y 4/2) glauconitic vitric claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 32 cm (0.8, 0.7, 1)
4, 65 cm (0.9, 0.8, 1)

Olive gray (5Y 4/2) calcareous clayey siltstone.

SMEAR SLIDE SUMMARY

	Vitric claystone	Claystone (D)	Vitric calcareous clayey siltstone (D)	Diatomaceous silty claystone (D)	Calcareous tuff (M)	Claystone (silty) (D)
	1-49	2-35	3-95	4-62	5-36	5-107
Sand	4	1	15	7	30	6
Silt	29	27	56	48	45	23
Clay	67	72	29	45	25	71
Quartz	8	5	25	14	3	6
Feldspar	3	4	9	4	4	1
Heavy minerals	TR	TR	TR	TR		TR
Clay minerals	67	72	29	45		71
Volcanic glass	10	3	10	5	82	3
Palagonite	1	1	1	TR		TR
Glauconite	TR		1	TR		TR
Diatoms	7	8	8	16	1	7
Radiolarians						TR
Sponge spicules	2	3	5	3		5
Carb. unspec.	2	4	12	8	10	7
Calc. nannos			TR			

Vitric claystone.

Olive gray (5Y 4/2) diatomaceous silty claystone.

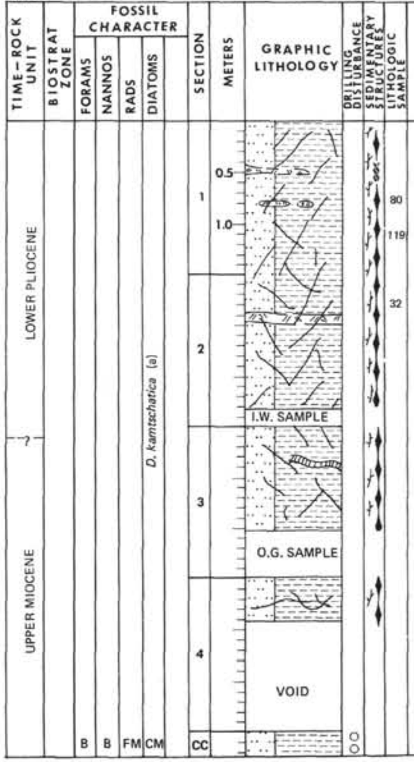
Calcareous tuff, laminated.

Olive gray (5Y 4/2) silty claystone, mottled.

CARBONATE BOMB
3, 12-13 cm = 1-2%

Olive gray (5Y 4/2) silty claystone, homogeneous.

SITE 440 HOLE B CORE 56 CORED INTERVAL: 662.0-671.5 m



LITHOLOGIC DESCRIPTION

Ash fill burrow

Olive gray (5Y 4/2) silty claystone intensely mottled and streaked. Intensely faulted and fractured; persistent high angle open parting.

White ash mottled

Greenish gray (5GY 6/1) mottled tuffite.

Olive gray (5Y 4/2) silty claystone intensely but *relatively* faintly mottled and highly faulted (healed fracture network).

TOTAL C – ORGANICS C – CARBONATE (%)
2, 50 cm (0.6, 0.6, 0)

CARBONATE BOMB
3, 78-80 cm = 0%

Burrows

SMEAR SLIDE SUMMARY

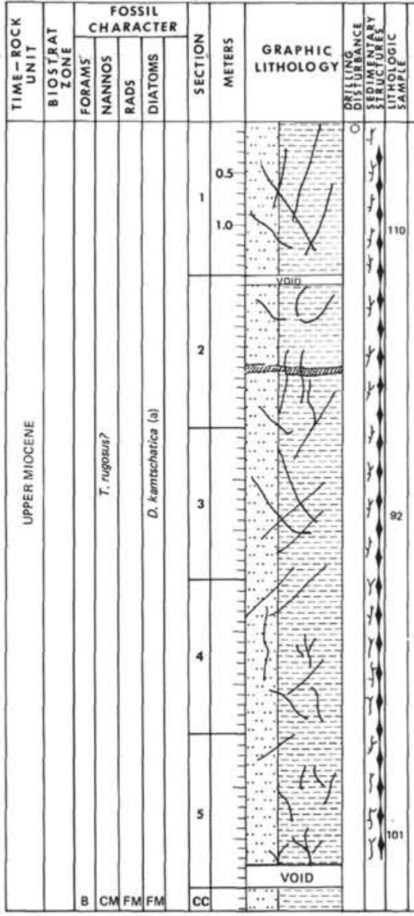
Olive gray (5Y 4/2) silty claystone intensely but faintly mottled.

	Tuffite (M)	Silty claystone (D)	Silty claystone (D)
	1-80	1-119	2-32
Sand		3	5
Silt	72	26	24
Clay	28	71	71
Quartz	5	6	10
Feldspar	3	6	5
Heavy minerals	TR	TR	TR
Clay minerals	28	71	71
Volcanic glass	58	3	2
Palagonite		TR	
Diatoms	4	9	7
Sponge spicules		4	3
Carb. unspec.	2	1	2

Olive gray (5Y 4/2) silty claystone.

Silty claystone.

SITE 440 HOLE B CORE 57 CORED INTERVAL: 671.5-681.0 m



LITHOLOGIC DESCRIPTION

Grayish olive (10Y 4/2) silty calystone intensely mottled, with greenish gray (5GY 6/1) and moderate olive brown (5Y 4/4) calcareous intervals. Healed faults and fractures of several orientations; partings parallel to some fracture orientations.

Grayish olive (10Y 4/2) silty claystone, intensely mottled.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 106 cm (0.8, 0.5, 2)
5, 54 cm (0.8, 0.7, 1)

Offset calcareous mottle.

CARBONATE BOMB
3, 130-132 cm = 1-2%

SMEAR SLIDE SUMMARY

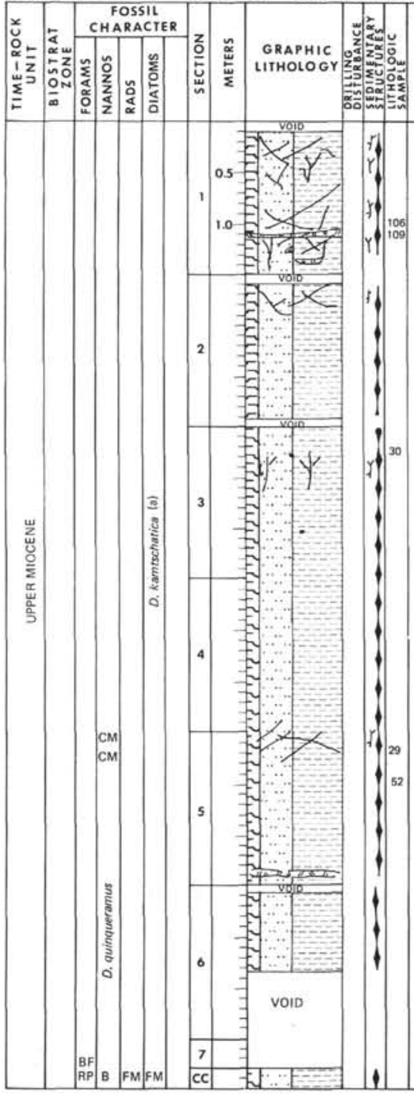
Grayish olive (10Y 4/2) silty claystone, intensely mottled.

	Silty claystone (D)	Silty claystone (D)	Calcareous claystone (M)
	1-110	3-92	5-101
Sand	5		6
Silt	27	31	25
Clay	68	69	69
Quartz	7	8	4
Feldspar	5	2	2
Heavy minerals	TR	1	TR
Clay minerals	68	69	
Volcanic glass	3	2	5
Palagonite		TR	1
Glauconite	TR		TR
Foraminifers	TR		
Diatoms	6	9	5
Radiolarians			TR
Sponge spicules	2	3	3
Carb. unspec.	9	6	11
Calc. nannos	TR		TR

Grayish olive (10Y 4/2) silty claystone, intensely mottled.

Grayish olive (10Y 4/2) silty claystone, intensely mottled.

SITE 440 **HOLE** B **CORE** 58 **CORED INTERVAL:** 681.0-690.5 m



LITHOLOGIC DESCRIPTION

Silty bed.
Sponge fragment.
Medium light gray tuff pocket.

Olive gray (5Y 3/2) diatomaceous silty claystone, intensely mottled.

Pumice clast with 3 mm diameter.

Pumice clast with 3 mm diameter.

Olive gray (5Y 3/2) diatomaceous silty claystone.

Olive gray (5Y 3/2) diatomaceous silty clay.

Tuff bed.

Olive gray (5Y 3/2) diatomaceous silty claystone

Olive gray (5Y 3/2) diatomaceous silty claystone. Moderately mottled, with a net of black very fine dewatering veins, some mottles are offset along dark fractures.

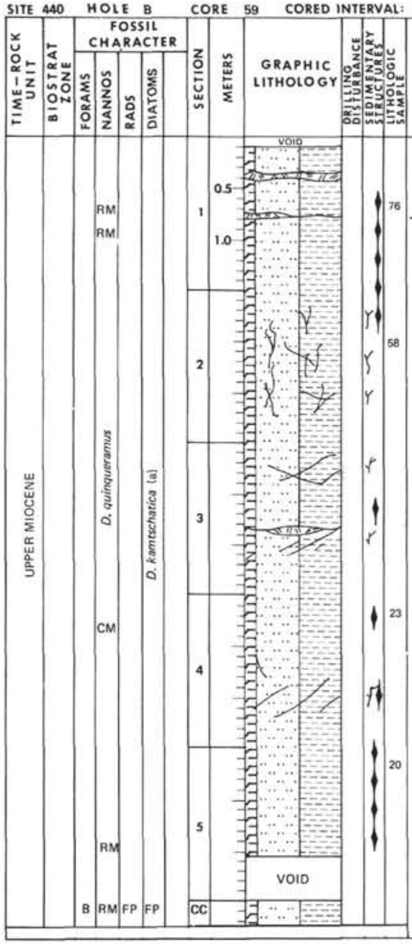
TOTAL C – ORGANIC C – CARBONATE (%)
2, 15 cm (0.7, 0.7, 1)
4, 135 cm (0.6, 0.6, 0)

CARBONATE BOMB
3, 141-144 cm = 4%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Siltstone (M)	Pumice (M)	Diatomaceous calcareous claystone (M)	Diatomaceous claystone (M)
	1-106	1-109	3-30	5-29	5-52
Sand	13	19	9	3	9
Silt	29	59	68	21	33
Clay	68	22	23	76	58
Quartz	12	40	7	5	12
Feldspar	5	15		2	3
Heavy minerals	1	9		1	1
Clay minerals	62	18	15	35	56
Voclanic glass	1	8	76	1	8
Glauconite	1				
Pyrite		4	1		1
Foraminifers		1			
Diatoms	13	4	2	19	10
Radiolarians	1			1	
Sponge spicules	4	1		6	4
Carb. unspec.				30	5
Zeolite				TR	
Calc. nannos				TR	

SITE 440 **HOLE** B **CORE** 59 **CORED INTERVAL:** 690.5-700.0 m



LITHOLOGIC DESCRIPTION

Diatomaceous silty claystone.

Light gray (N7) tuff.

Vitric diatomaceous claystone.

Medium gray (N5) tuff bed.

Olive gray (5Y 3/2) diatomaceous silty claystone.

Olive gray (5Y 3/2) diatomaceous silty claystone.

Olive gray (5Y 3/2) diatomaceous silty claystone.

Olive gray (5Y 3/2) diatomaceous silty claystone throughout core. Slightly to moderately mottled; black veins and healed fractures.

Olive gray (5Y 3/2) diatomaceous silty claystone with faint net of black veins.

Olive gray (5Y 3/2) diatomaceous silty claystone with faint veins and minor faults.

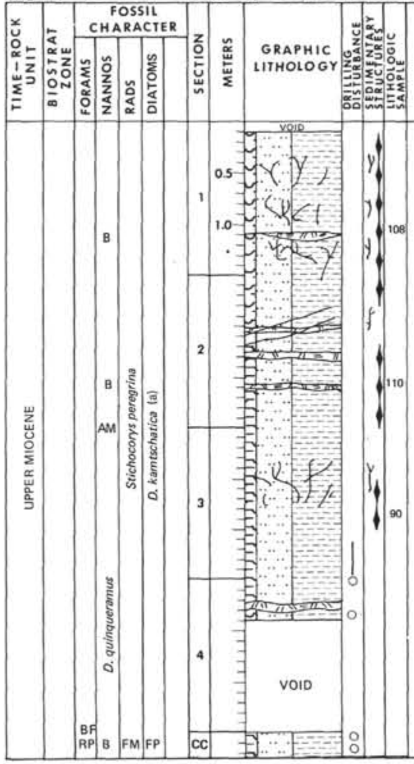
TOTAL C – ORGANIC C – CARBONATE (%)
2, 111 cm (0.9, 0.9, 0)
4, 86 cm (0.7, 0.7, 0)

CARBONATE BOMB
1, 108-110 cm = 2-3%

SMEAR SLIDE SUMMARY

	Vitric diatomaceous silty claystone (M)	Diatomaceous claystone (D)	Diatomaceous calcareous claystone (M)	Diatomaceous claystone (D)
	1-76	2-58	4-23	5-20
Sand	11	4	3	5
Silt	38	32	22	38
Clay	51	64	75	57
Quartz	7	11	5	10
Feldspar	13	5	2	5
Heavy minerals	1	1		2
Clay minerals	47	58	48	61
Volcanic glass	10	5	1	8
Glauconite	1			
Pyrite	1	2	1	2
Diatoms	10	11	11	12
Radiolarians	1	TR		1
Sponge spicules		3	4	5
Carb. unspec.	5	4	25	4
Silicoflagellates	4			
Calc. nannos			3	

SITE 440 HOLE B CORE 60 CORED INTERVAL: 700.0-709.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) diatomaceous silty claystone slightly mottled and faintly veined with many small fractures with offset throughout core.

Light gray (N7) tuff.

Moderately mottled.

Tuffite.

Olive gray (5Y 3/2) diatomaceous silty claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 98 cm (0.8, 0.7, 0)
4, 8 cm (0.8, 0.7, 0)

Intensely mottled.

CARBONATE BOMB
2, 26-28 cm = 3-4%

SMEAR SLIDE SUMMARY

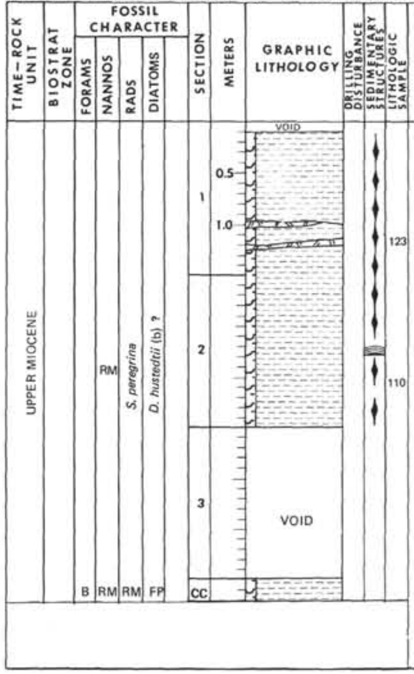
Olive gray (5Y 3/2) diatomaceous silty claystone.

	Ash (or tuff) (M)	Tuffite (clayey ash) (M)	Diatomaceous claystone (D)
	1-108	**2-110**	**3-90**
Sand	4	3	5
Silt	52	47	33
Clay	44	50	62
Quartz	12	7	13
Feldspar	4	6	3
Heavy minerals	1	1	2
Clay minerals	17	26	52
Volcanic glass	60	52	8
Pyrite	1		1
Diatoms	4	5	11
Radiolarians			1
Sponge spicules	1	1	4
Carb. unspec.			5

Light olive gray (5Y 7/1) tuff.

Olive gray (5Y 3/2) diatomaceous silty claystone.

SITE 440 HOLE B CORE 61 CORED INTERVAL: 709.5-719.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) diatomaceous claystone, moderately mottled.

Very light gray (N8) tuff

Medium dark gray (N4) tuffite

Olive gray (5Y 3/2) diatomaceous claystone, slightly mottled.

Dark gray laminae with 5 mm thick, dipping 15°

TOTAL C – ORGANIC C – CARBONATE (%)
2, 28 cm (0.8, 0.8, 0)

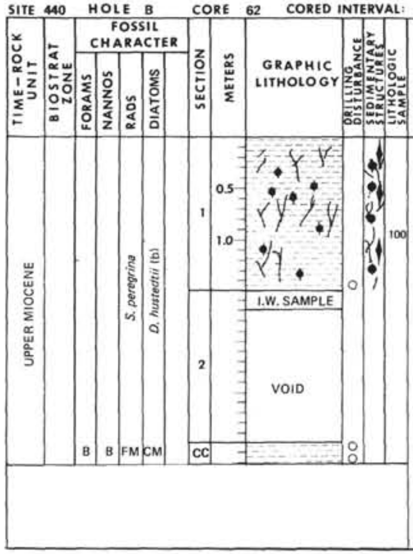
CARBONATE BOMB
1, 148-150 cm = 0-1%

SMEAR SLIDE SUMMARY

Olive gray (5Y 3/2) diatomaceous claystone.

	Vitric claystone (M)	Diatomaceous claystone (D)
	1-123	**2-110**
Sand	5	3
Silt	36	24
Clay	59	73
Quartz	13	6
Feldspar	6	3
Clay minerals	52	71
Volcanic glass	18	1
Pyrite		1
Diatoms	2	10
Sponge spicules	5	3
Carb. unspec.	4	5

SITE 440 HOLE B CORE 62 CORED INTERVAL: 719.0-728.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) claystone, Diatom rich, slightly mottled; faint black veins; high angle open parting.

Sponge fragments.

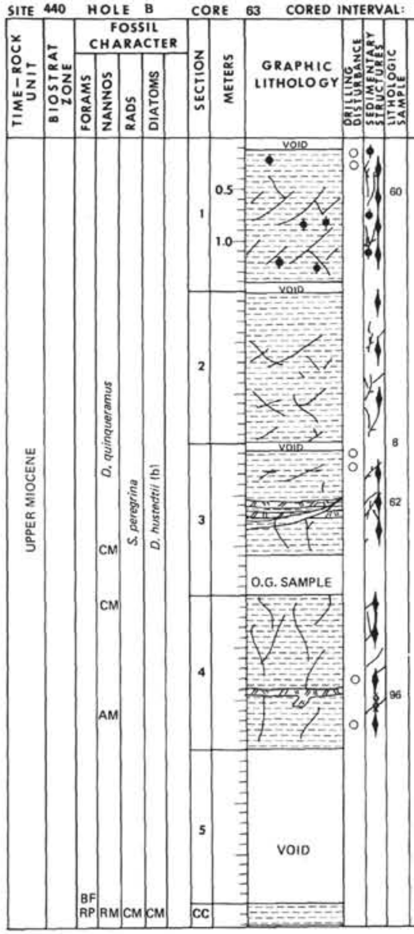
TOTAL C – ORGANIC C – CARBONATE (%)
1, 146 cm (0.8, 0.8, 0)

SMEAR SLIDE SUMMARY

	Claystone (D)
	1-100
Sand	
Silt	25
Clay	75
Quartz	5
Feldspar	2
Heavy minerals	1
Clay minerals	72
Volcanic glass	1
Glauconite	1
Diatoms	9
Radiolarians	1
Sponge spicules	3
Carb. unspec.	5

Olive gray (5Y 3/2) claystone

SITE 440 HOLE B CORE 63 CORED INTERVAL: 728.5-738.0 m



LITHOLOGIC DESCRIPTION

Sponge fragment.

Olive gray (5Y 3/2) claystone, slightly mottled and faint black veins, some healed fractures.

With sponge fragments.

Olive gray (5Y 3/2) claystone, slightly mottled and faintly veined with offset in black color.

Light gray tuff bed.

Olive gray (5Y 3/2) claystone.

Light olive gray (5Y 6/1) tuff beds.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 69 cm (0.9, 0.9, 0)
4, 35 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 37-39 cm = 2-3%

Olive gray (5Y 3/2) claystone.

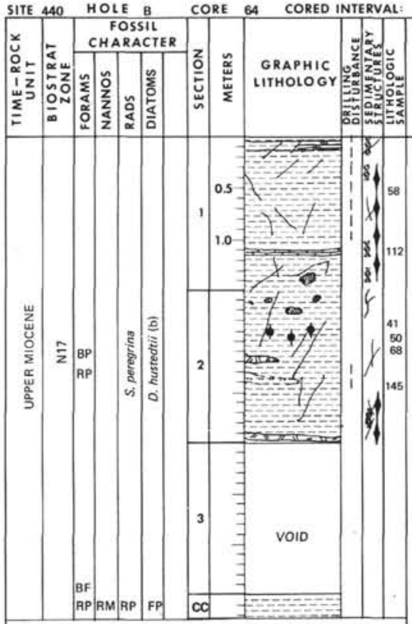
SMEAR SLIDE SUMMARY

Medium gray tuff with burrow.

	Claystone (D)	Tuff (M)	Diatomaceous tuff (M)	Ash (or tuff) (M)
	1-60	3-8	3-62	4-96
Sand		3	5	7
Silt	26	51	68	53
Clay	74	46	27	30
Quartz	6	6	6	4
Feldspar	3	4	3	12
Heavy minerals	1			2
Clay minerals	71	13	13	10
VOlcanic glass	1	75	61	69
Pyrite		1		2
Diatoms	8	1	13	1
Radiolarians	TR			
Sponge spicules	4		3	
Carb. unspec.	6	TR	2	
Zeolite				TR

Olive gray (5Y 3/2) claystone.

SITE 440 HOLE B CORE 64 CORED INTERVAL: 738.0-747.5 m



LITHOLOGIC DESCRIPTION

Dewatering veins offset by small faults.
Brecciated claystone with some minor carbonate content.
Calcareous worm burrow.

Grayish olive (10Y 4/2) claystone, intensely bioturbated; healed fracture network and veins.

Light olive gray (5Y 5/2) calcareous, possible worm burrow and bed.

Calcareous burrow.

Olive gray (5Y 4/1) claystone with light olive gray (5Y 5/2) to dusky yellow (5Y 6/4) calcareous mottles.

Sponge fragments

Tuff pocket.
Disseminated silty bed.

Intensely bioturbated.

Tuffite bed.

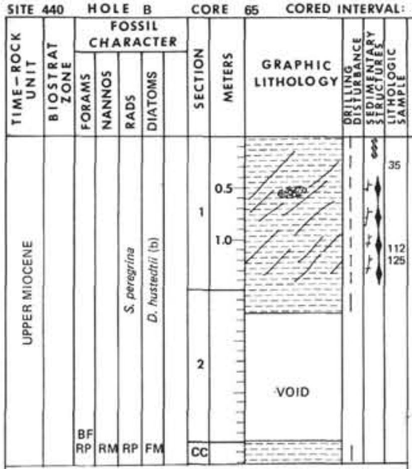
Olive gray (5Y 4/1) claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 31 cm (0.8, 0.6, 1)

SMEAR SLIDE SUMMARY

	Claystone (D)	Calcareous marlstone (M)	Spicular clayey siltstone (M)	Claystone (D)	Tuff (M)	Tuffite (M)
	1-58	1-112	2-41	2-50	2-68	2-145
Sand		2		TR	28	10
Silt	17	54	68	19	72	46
Clay	83	44	32	81		44
Quartz	4	3	20	3	10	10
Feldspar	2	1	4	1	6	7
Heavy minerals				TR		
Clay minerals	83	44	32	81		44
Volcanic glass	1	1	8	1	77	36
Palagonite			TR			
Glauconite	TR					1
Diatoms	7	4	1	9		1
Radiolarians				TR		
Sponge spicules	2	2	35	3		1
Carb. unspec.	1	45		2	7	

SITE 440 HOLE B CORE 65 CORED INTERVAL: 747.5-757.0 m



LITHOLOGIC DESCRIPTION

Burrow

Dark greenish gray (5GY 4/1) claystone

Sand pocket

Extensive olive yellow (5Y 5/4) calcareous burrows offset 1-5 mm. Offsets dominantly horizontal along vertical fault planes.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 125 cm (1.0, 0.8, 2)

CARBONATE BOMB
1, 51-52 cm = 1-2%

SMEAR SLIDE SUMMARY

Dark greenish gray (5GY 4/1) claystone.

	Claystone (M)	Claystone (D)	Claystone (D)
	1-38	1-112	1-125
Silt	28	26	19
Clay	72	74	81
Quartz	4	6	6
Feldspar	4	4	2
Heavy minerals			TR
Clay minerals	72		81
Volcanic glass	2	4	1
Palagonite	TR	TR	TR
Foraminifers	TR		
Diatoms	7	6	7
Sponge spicules	4	3	2
Carb. unspec.	7	3	1

SITE 440 **HOLE** B **CORE** 66 **CORED INTERVAL:** 757.0-766.5 m

TIME-ROCK UNIT: UPPER MIOCENE

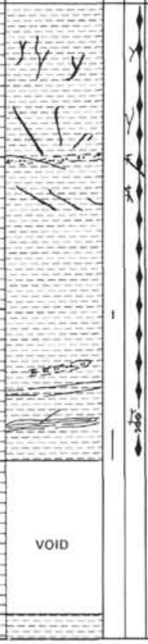
BIOSTRAT ZONE

FOSSIL CHARACTER: FORAMS B; NANNOS B; RADS *S. peregrina*; DIATOMS *D. hustedtii* (b) FP

CC: FORAMS B; NANNOS RP; RADS RP; DIATOMS RP

SECTION: 1, 2, 3, 4, CC

METERS: 0.5, 1.0



LITHOLOGIC SAMPLE: 8, 81, 52, 112, 130

LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/1) claystone with bioturbation and dewatering veins, extensively brecciated throughout core with mottles of light olive gray (5Y 5/2).

8 Vitric claystone bed offset and rotated.

Olive gray (5Y 4/1) claystone.

Dark greenish gray (5GY 4/1) claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 112 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 64-67 cm = 2-3%

52 Light gray (N7) silty mottled.

Black claystone with good fissility.

112, 130 Deformed burrows by faults.

CC Claystone.

SMEAR SLIDE SUMMARY

	Vitric clay-stone (M)	Claystone (D)	Claystone (D)	Silty claystone (M)	Vitric silty claystone (M)
	2-8	**2-81**	**3-52**	**3-112**	**3-130**
Sand	4	2			3
Silt	23	15	23	28	34
Clay	68	83	77	72	63
Quartz	4	4	4	16	13
Feldspar	5	3	2	6	5
Heavy minerals		TR	TR	1	3
Clay minerals		83	77	72	
Volcanic glass	18	5	5	2	8
Palagonite		TR	1		2
Glauconite					TR
Pyrite	TR				
Diatoms	3	2	6	TR	4
Sponge spicules	1	1	2		1
Carb. unspec.	1	1	3	3	1

SITE 440 **HOLE** B **CORE** 67 **CORED INTERVAL:** 766.5-776.0 m

TIME-ROCK UNIT: UPPER MIOCENE

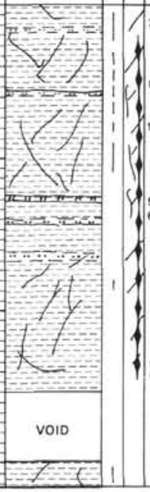
BIOSTRAT ZONE

FOSSIL CHARACTER: RADS *S. peregrina*; DIATOMS *D. hustedtii* (b)

CC: FORAMS B; NANNOS B; RADS RP; DIATOMS FP

SECTION: 1, 2, 3, CC

METERS: 0.5, 1.0



LITHOLOGIC SAMPLE: 28, 84, 126, 50, 64, 52, 65

LITHOLOGIC DESCRIPTION

28 Silt bed and tuffite (5Y 4/1).

Olive gray (5Y 4/2) claystone with bioturbation and fractures.

84 Vitric clayey siltstone (5Y 2.5/2).

Olive gray (5Y 4/1) claystone with bioturbations and healed fractures; open parting network.

50 Thin (silt) bed.

64 Vitric silty claystone graded bed.

Disseminated silt in clay matrix.

Dark greenish gray (5GY 4/1) bioturbated claystone, healed fractures.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 60 cm (0.6, 0.6, 0)

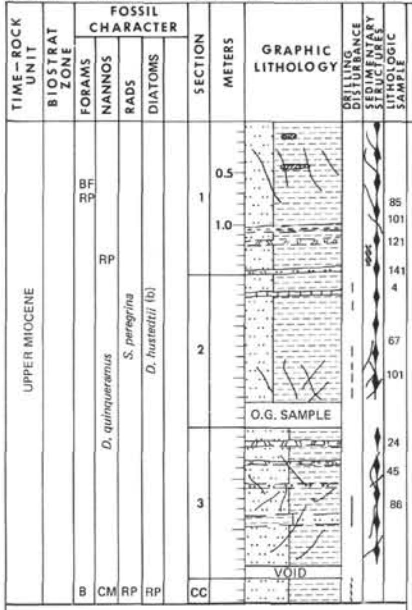
CARBONATE BOMB
3, 31-35 cm = 1-2%

CC Dark greenish gray (5GY 4/1) claystone.

SMEAR SLIDE SUMMARY

	Tuffite (M)	Vitric clayey siltstone (M)	Claystone (D)	Claystone (D)	Vitric silty claystone (M)	Silty claystone (M)	Claystone (D)
	1-28	**1-84**	**1-126**	**2-50**	**2-64**	**3-52**	**3-65**
Sand	2	15			25		
Silt	62	52	26	14	27	39	25
Clay	36	33	74	86	48	61	75
Quartz	4	18	5	3	22	18	9
Feldspar	1	8	3	2	6	7	3
Heavy minerals		4		TR	4	1	
Clay minerals	36				48		75
Volcanic glass	51	18	7	2	9	4	3
Palagonite		3		TR	3	1	1
Glauconite		8			1		
Diatoms	2	1	6	4	1	3	4
Radiolarians			TR				
Sponge spicules			3	2	1	2	4
Carb. unspec.	6		2	1	TR	3	1
Lithic		7			5		

SITE 440 HOLE B CORE 68 CORED INTERVAL: 776.0-785.6 m



LITHOLOGIC DESCRIPTION

Calcareous worm burrow (olive yellow, 5Y 6/6).

Calcareous worm burrow (olive yellow, 5Y 6/6).

Silty claystone.
Tuffite.

Yellowish gray (5Y 7/2)
chalk filled burrows.
Silt bed.

Calcareous worm burrow.

Dark greenish gray (5GY 4/1)
silty claystone.

Vitric clayey siltstone.

Dark greenish gray (5GY 4/1)
silty claystone.

Silt bed.

Clayey siltstone.

Same as
above
Section.

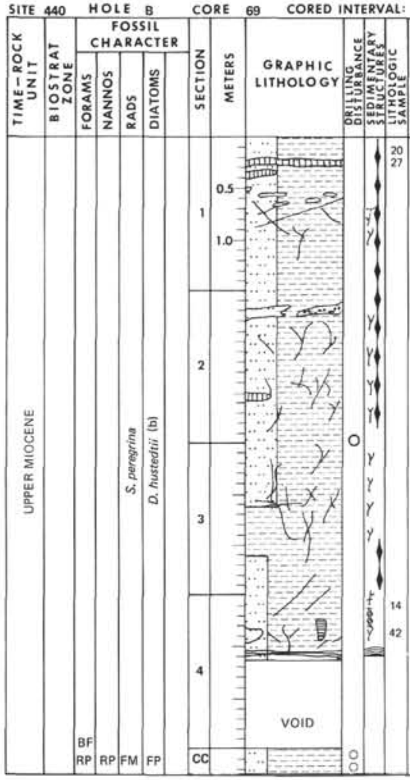
TOTAL C – ORGANIC C – CARBONATE (%)
2, 68 cm (0.5, 0.6, 0)

CARBONATE BOMB
3, 132-134 cm = 1-2%

SMEAR SLIDE SUMMARY

	Silty claystone (D)	Silty claystone (M)	Tuffite (M)	Chalk (M)	Vitric clayey siltstone (M)	Silty claystone (D)	Silty claystone (M)	Vitric clayey siltstone (M)	Silty claystone (D)	Clayey siltstone (M)
	1-85	1-101	1-21	1-141	2-4	2-67	2-101	3-24	3-46	3-86
Sand	5		18		12	12	16	15	11	18
Silt	30	34	36	5	52	26	42	48	43	46
Clay	65	66	46	95	36	62	42	37	46	36
Quartz	8	18	8		22	14	23	26	21	26
Feldspar	4	4	10		10	5	10	8	7	12
Heavy minerals	1	2	TR		6	2	3	4	3	4
Clay minerals	65		46		36			37	46	
Volcanic glass	6		32	2	6	2	4	4	5	3
Palagonite	1	3	2		4	2	4	6	3	3
Glauconite	TR	1			TR	2	1	1	1	1
Diatoms	8	3	1	1	TR	3	4		7	2
Radiolarians									TR	
Sponge spicules	5	2	TR	2	1	1	3		3	1
Carb. unspec.	2	1	1	95		2			3	
Calc. nannos				TR						
Lithic fragments					15	5	6	14		12

SITE 440 HOLE B CORE 69 CORED INTERVAL: 785.5-795.0 m



LITHOLOGIC DESCRIPTION

Light olive gray (5Y 5/2)
calcareous claystone, calcite-cemented.

Very dark gray (5Y 3/1) silty claystone,
moderately mottled; dark veins and
healed fractures; persistent low angle
parting.

Medium gray (N5) silty pocket.

Very dark gray (5Y 3/1) silty claystone.

Calcite-cemented mottle.

Very dark gray (5Y 3/1)
silty claystone, fairly
homogeneous claystone
(360-410 cm).

Worm burrow
Silty claystone
Thin lamination

Very dark gray (5Y 3/1)
silty claystone.

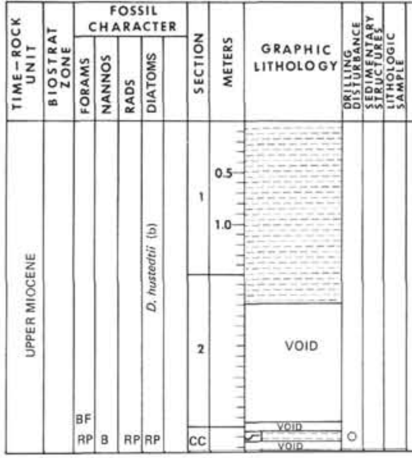
TOTAL C – ORGANIC C – CARBONATE (%)
1, 75 cm (0.7, 0.7, 0)
2, 1 cm (0.7, 0.6, 1)

CARBONATE BOMB
2, 94-97 cm = 0-1%

SMEAR SLIDE SUMMARY

	Silty claystone (D)	Calcareous claystone (M)	Chalk (M)	Claystone (D)
	1-20	1-27	4-14	4-42
Sand				2
Silt	30	20	10	20
Clay	70	80	90	78
Quartz	20	5	2	10
Feldspar	5	2		3
Clay minerals	66	45	17	71
Volcanic glass	5	5	2	5
Glauconite				1
Pyrite	1	TR	1	
Diatoms	2	1		8
Sponge spicules	2	1		2
Carb. unspec.		40	78	

SITE 440 HOLE B CORE 70 CORED INTERVAL: 795.0-804.5 m

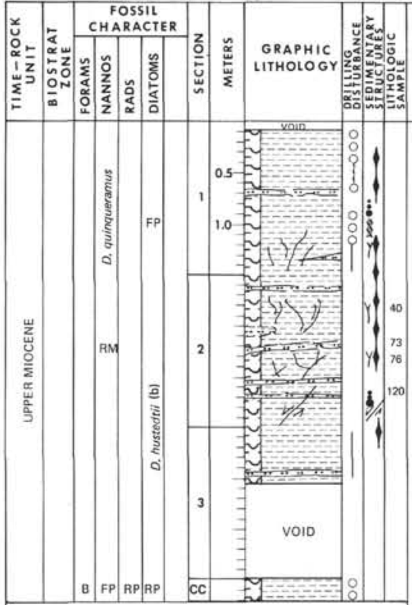


LITHOLOGIC DESCRIPTION

Drill cuttings and downhole wash, graded during wash.

Olive gray (5Y 3/2) diatomaceous claystone.

SITE 440 HOLE B CORE 71 CORED INTERVAL: 804.5-814.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) diatomaceous claystone, moderately mottled throughout core.
Some dark veins and healed fractures; persistent low angle open parting.

Dark gray (N3) very fine grained sandstone to siltstone.
Graded bed.
Worm burrow, 1 x 10 mm

Silt body or bed.

Dark gray (N3) siltstone bed.

Olive gray (5Y 3/2) diatomaceous claystone.

Vitric siltstone bed.

Siltstone.
Dark gray (N3) graded siltstone bed, healed faults.

Olive gray (5Y 3/2) diatomaceous claystone.

Medium dark gray (N4) siltstone.

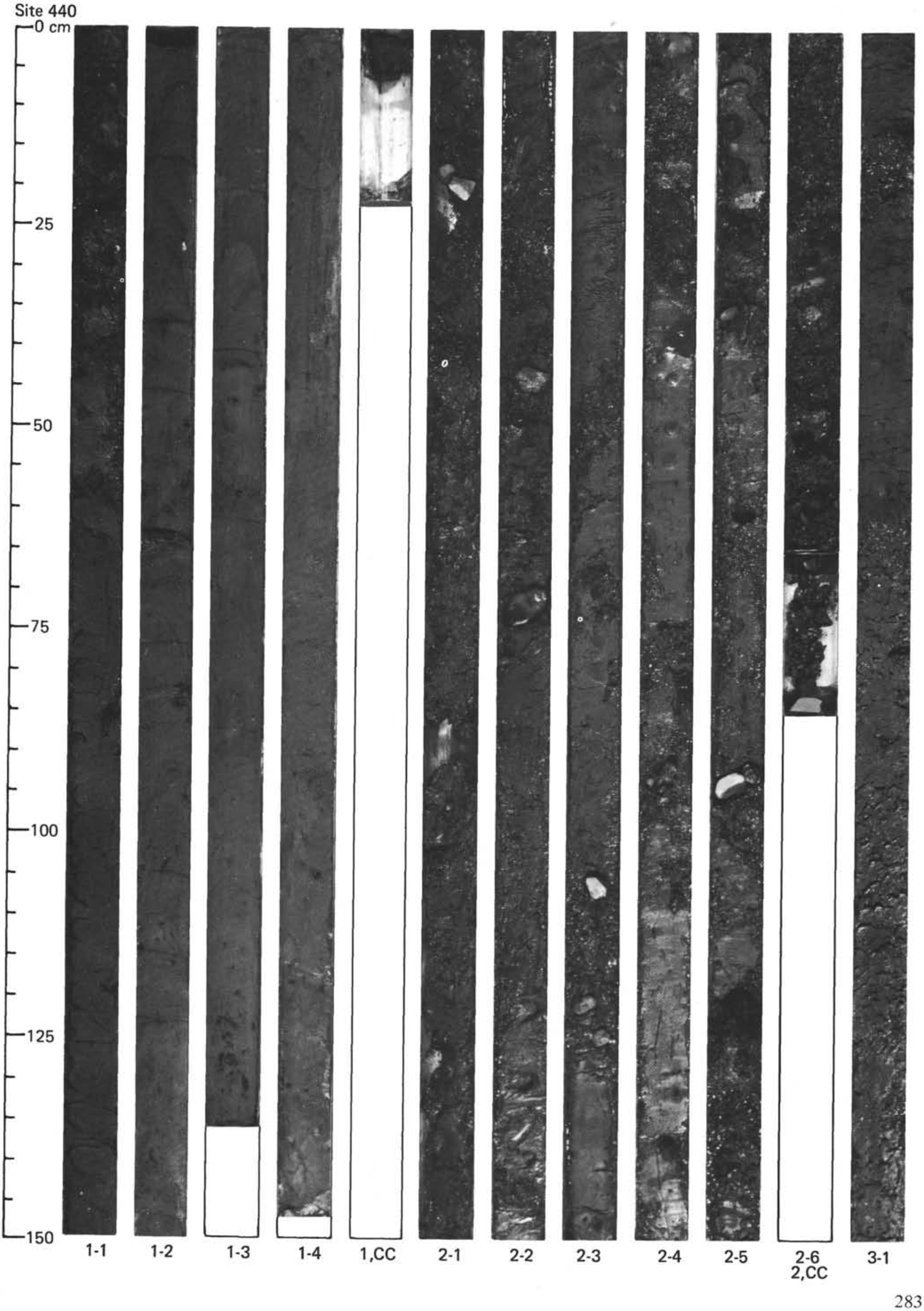
TOTAL C – ORGANIC C – CARBONATE (%)
2, 106 cm (0.7, 0.7, 1)

CARBONATE BOMB
2, 142-144 cm = 0-1%

SMEAR SLIDE SUMMARY

Olive gray (5Y 3/2) diatomaceous claystone.

	Diatomaceous claystone (D)	Vitric claystone (M)	Diatomaceous calcareous claystone (M)	Clayey siltstone (M)
	2-40	2-73	2-76	2-120
Sand	2	2	3	12
Silt	22	28	20	53
Clay	66	70	77	35
Quartz	7	5	6	45
Feldspar	4	12	3	8
Heavy minerals	1	1		4
Clay minerals	62	60	55	31
VOlcanic glass	3	17	TR	9
Pyrite	1	2	2	2
Diatoms	14	2	13	1
Radiolarians	TR		TR	
Sponge spicules	3	1	3	
Carb, unspec.	5		18	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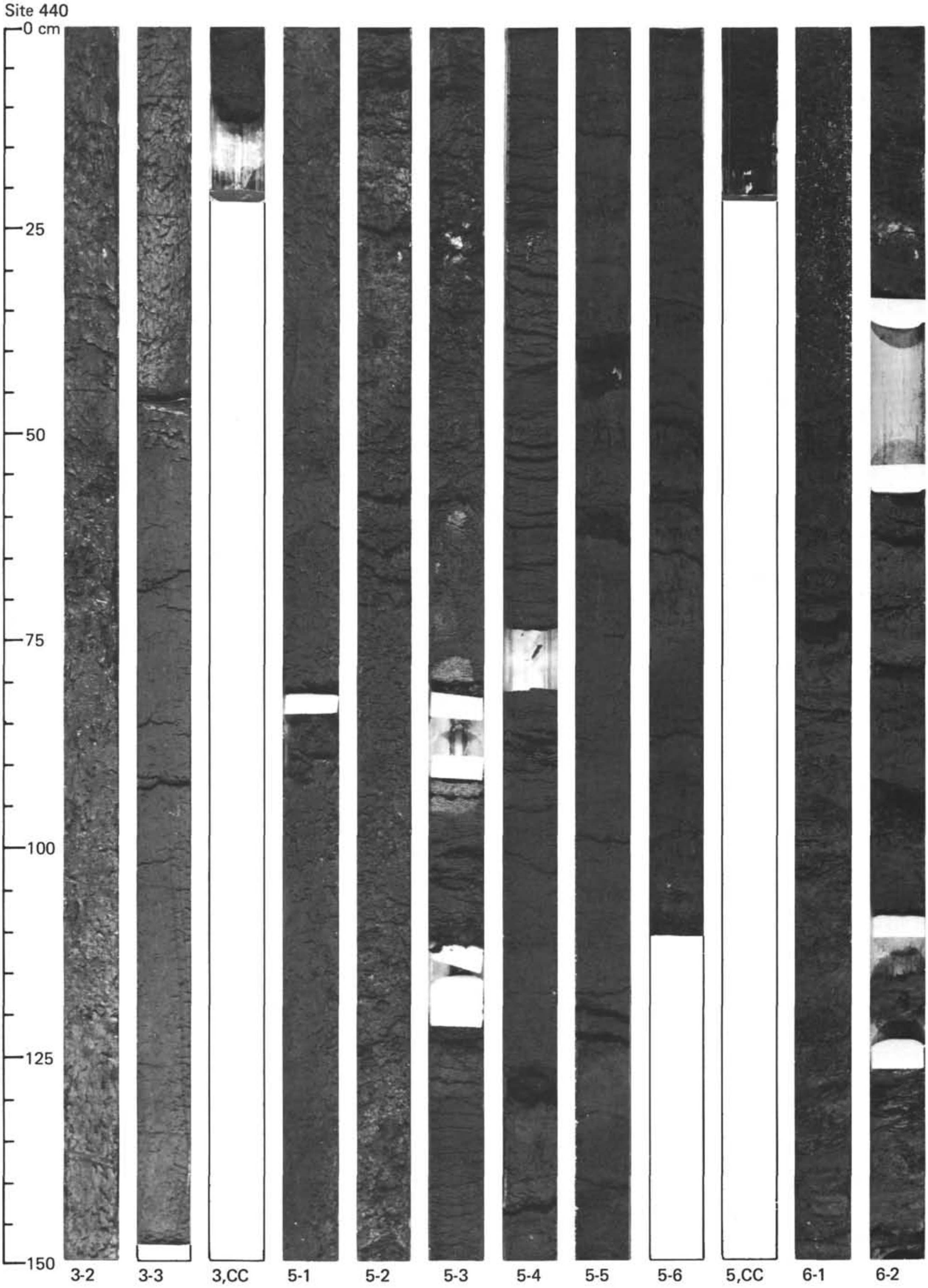
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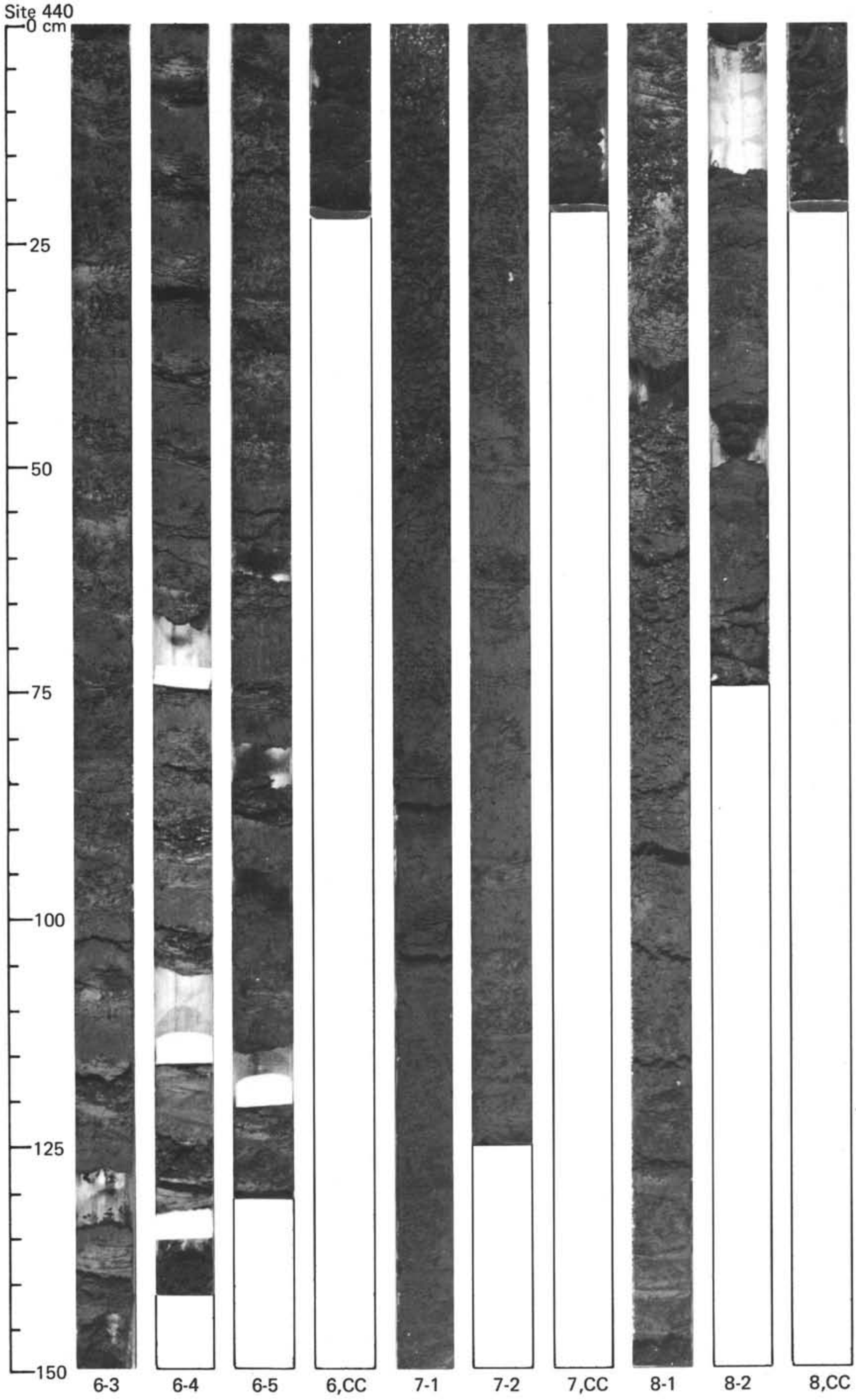
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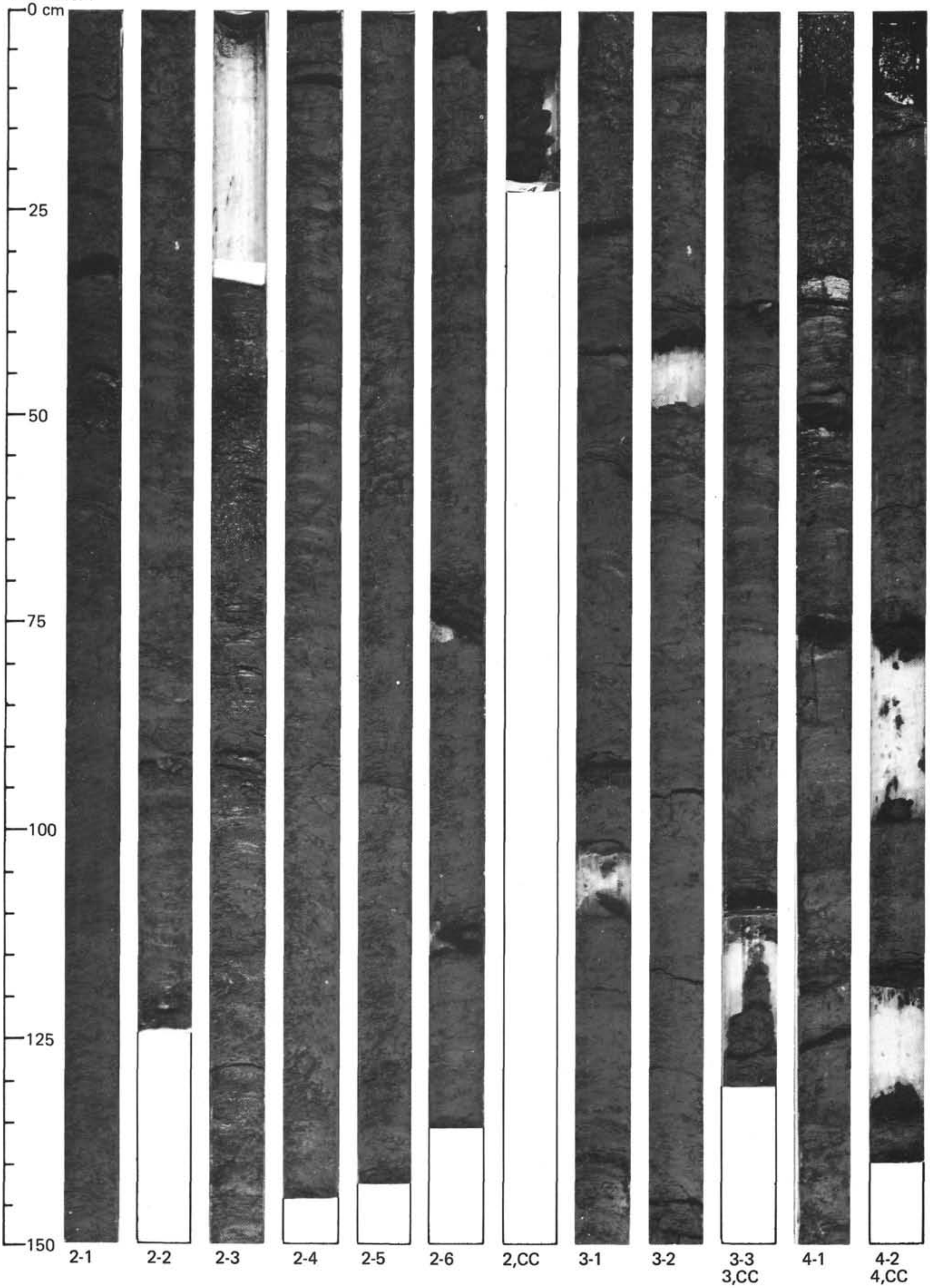
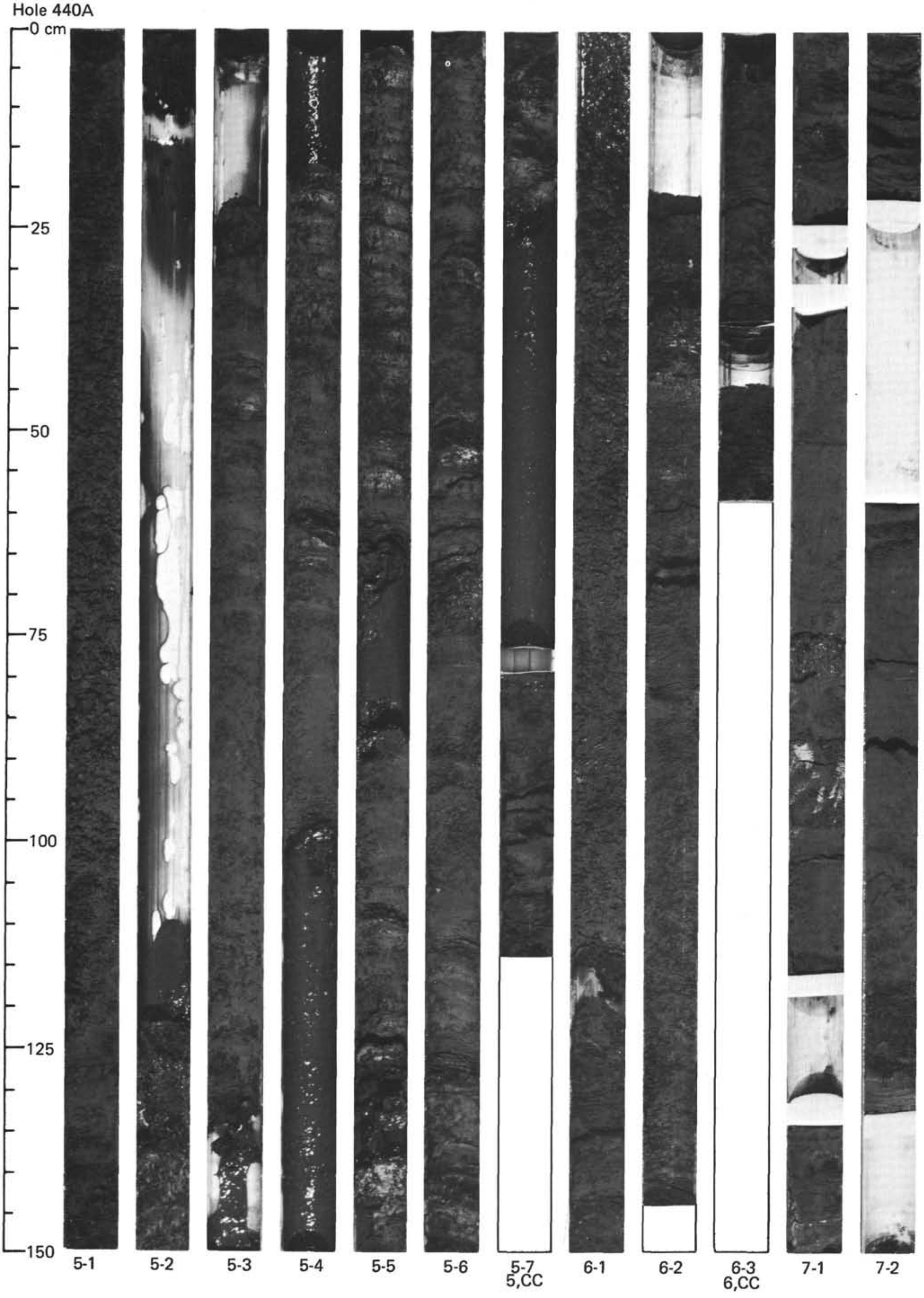
Hole 440A

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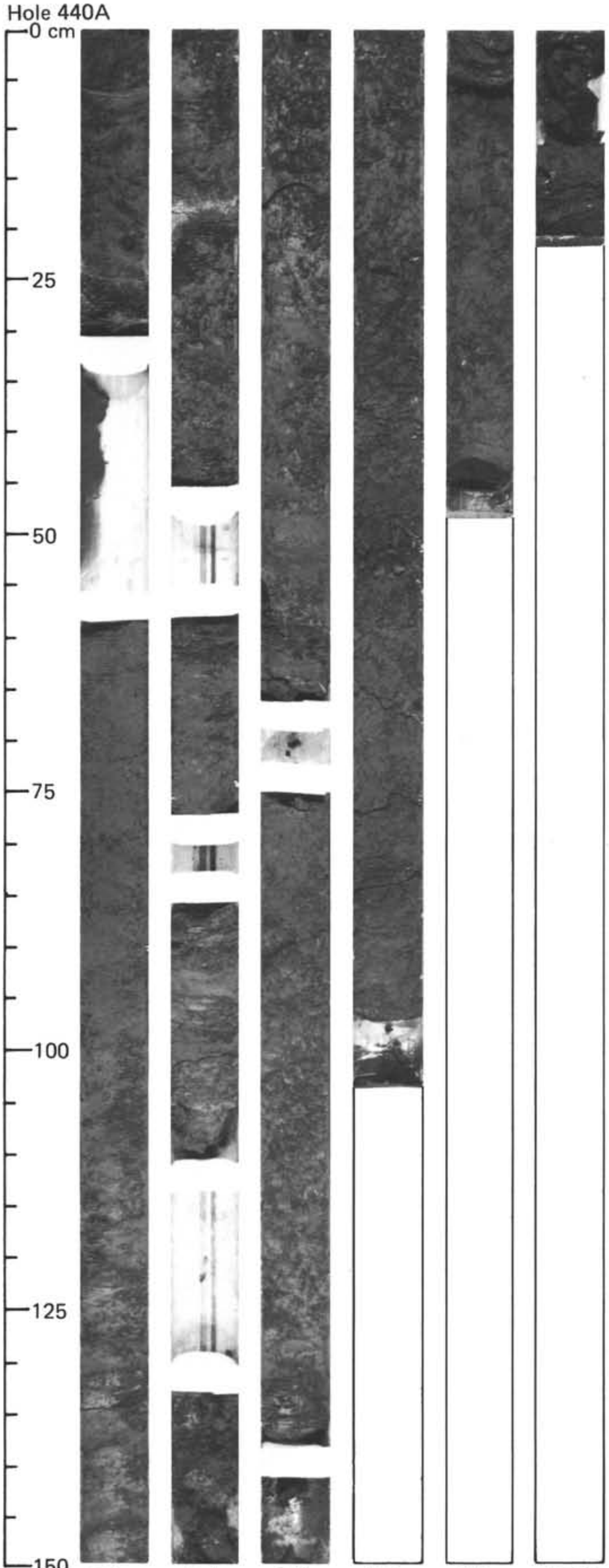
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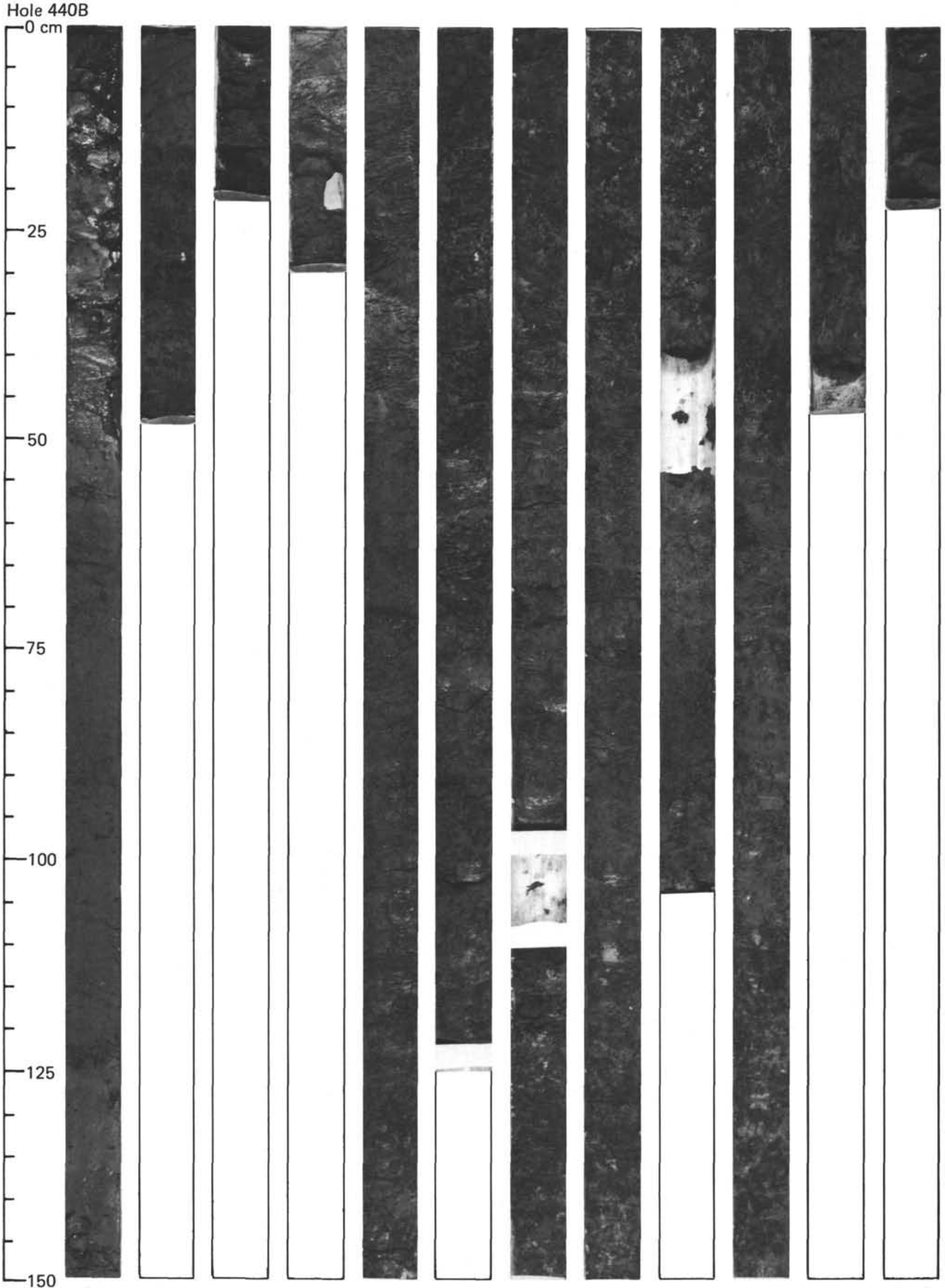
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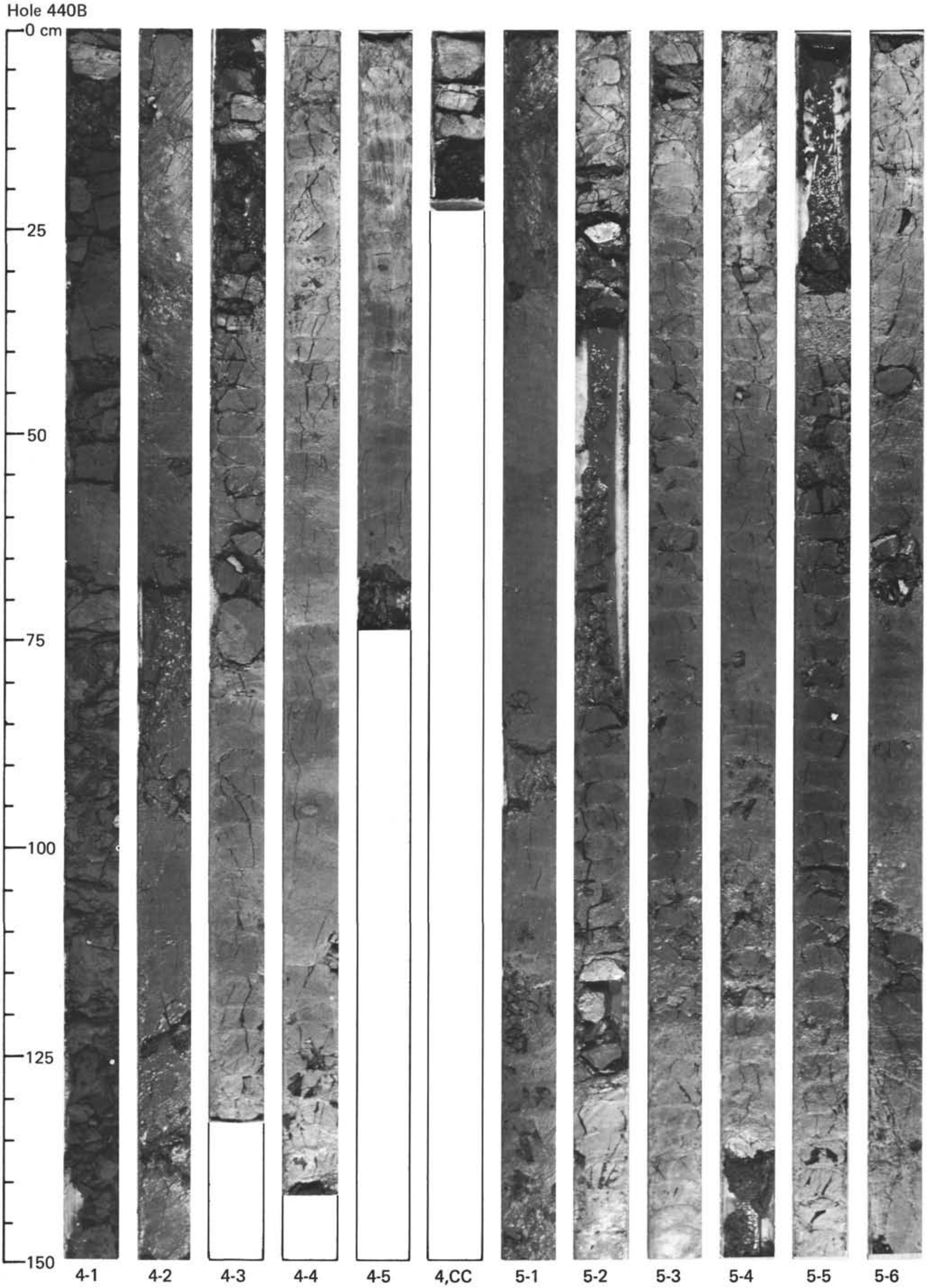
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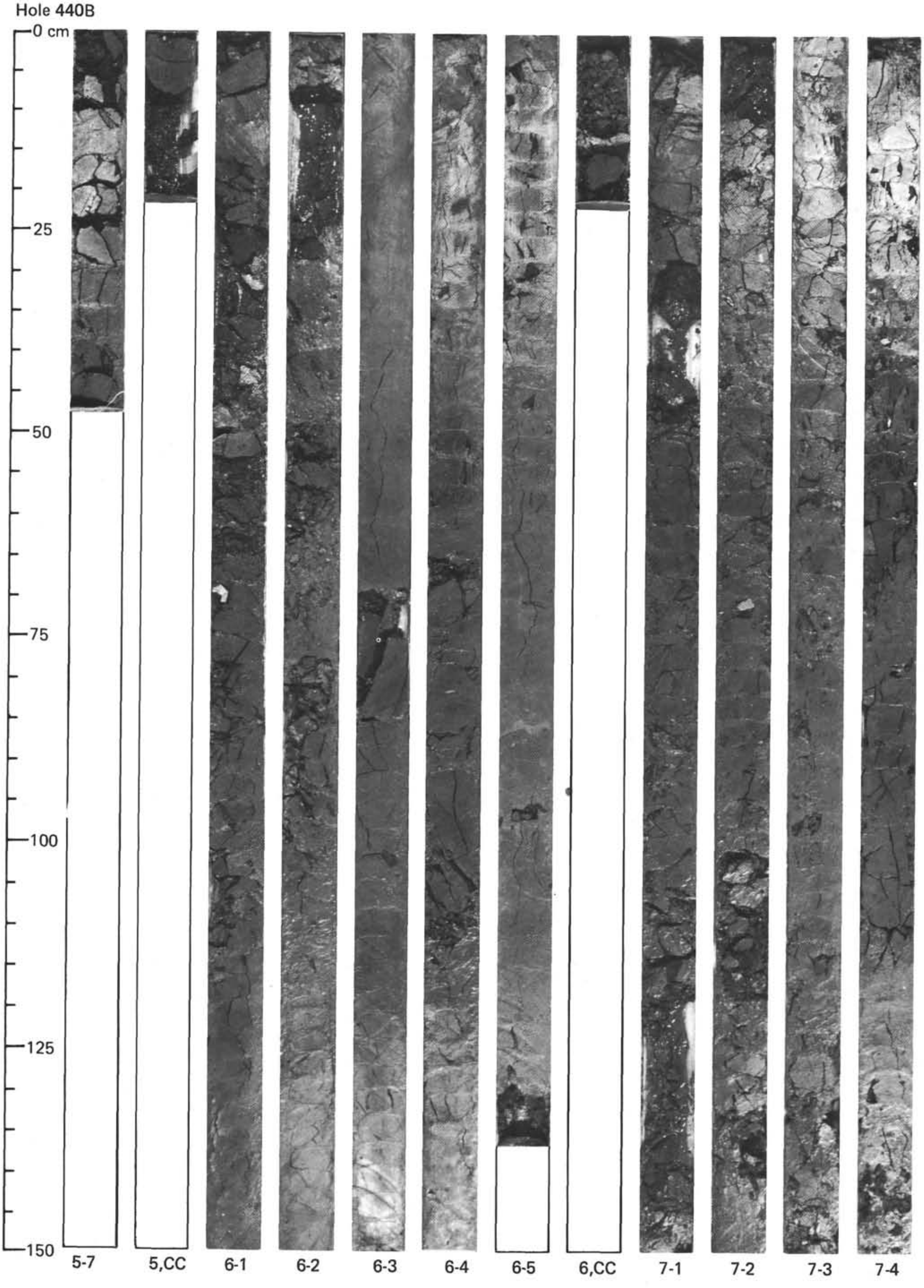
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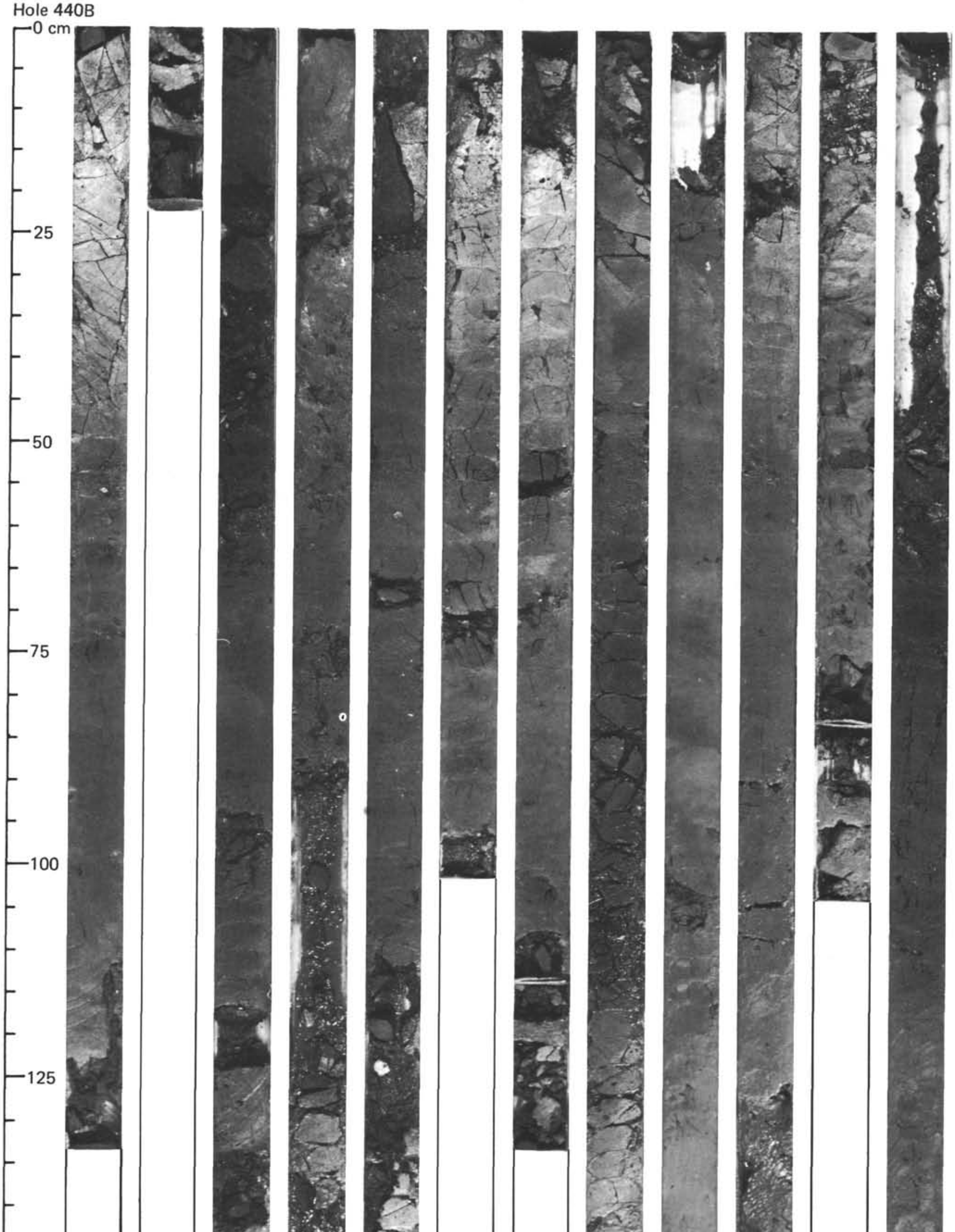
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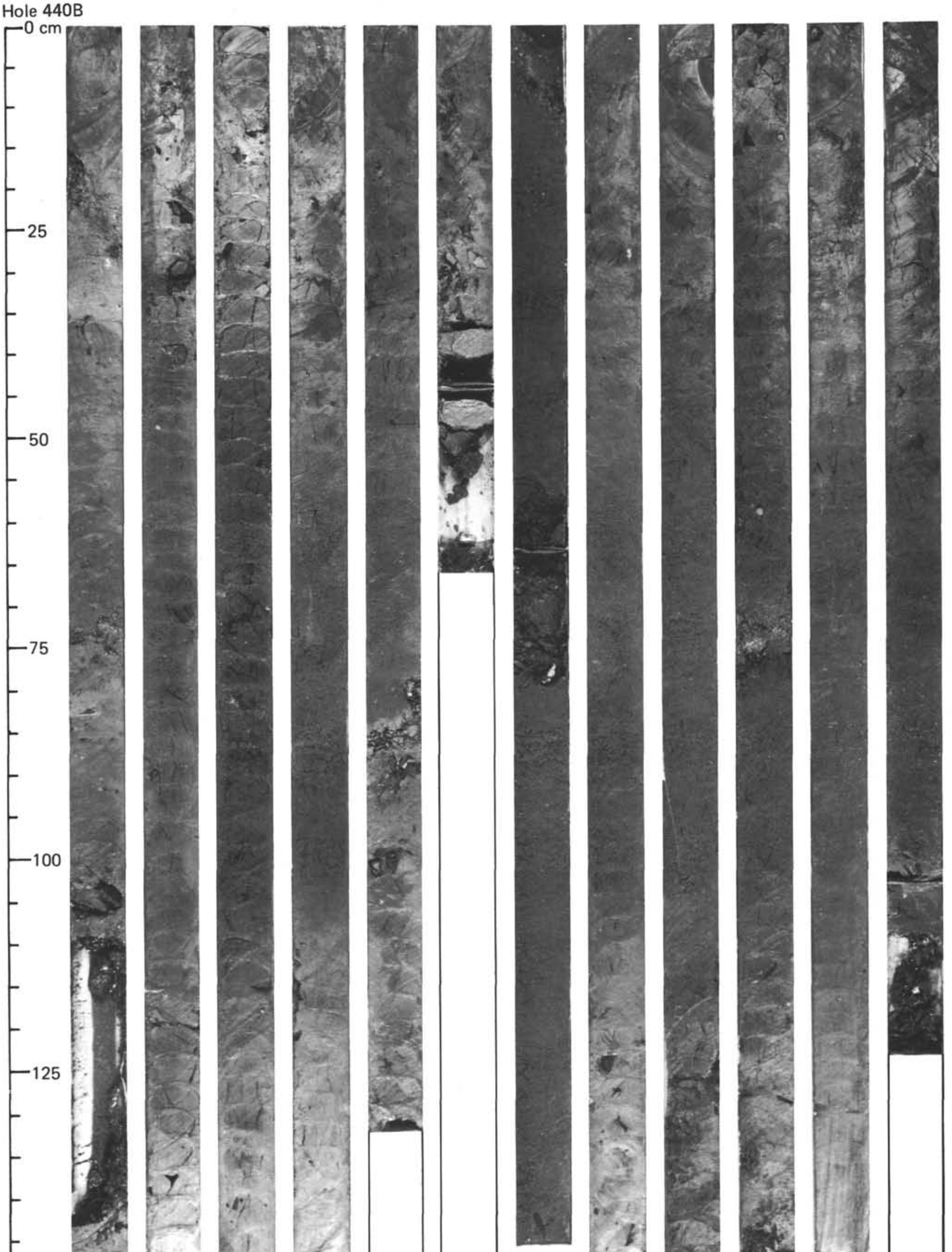
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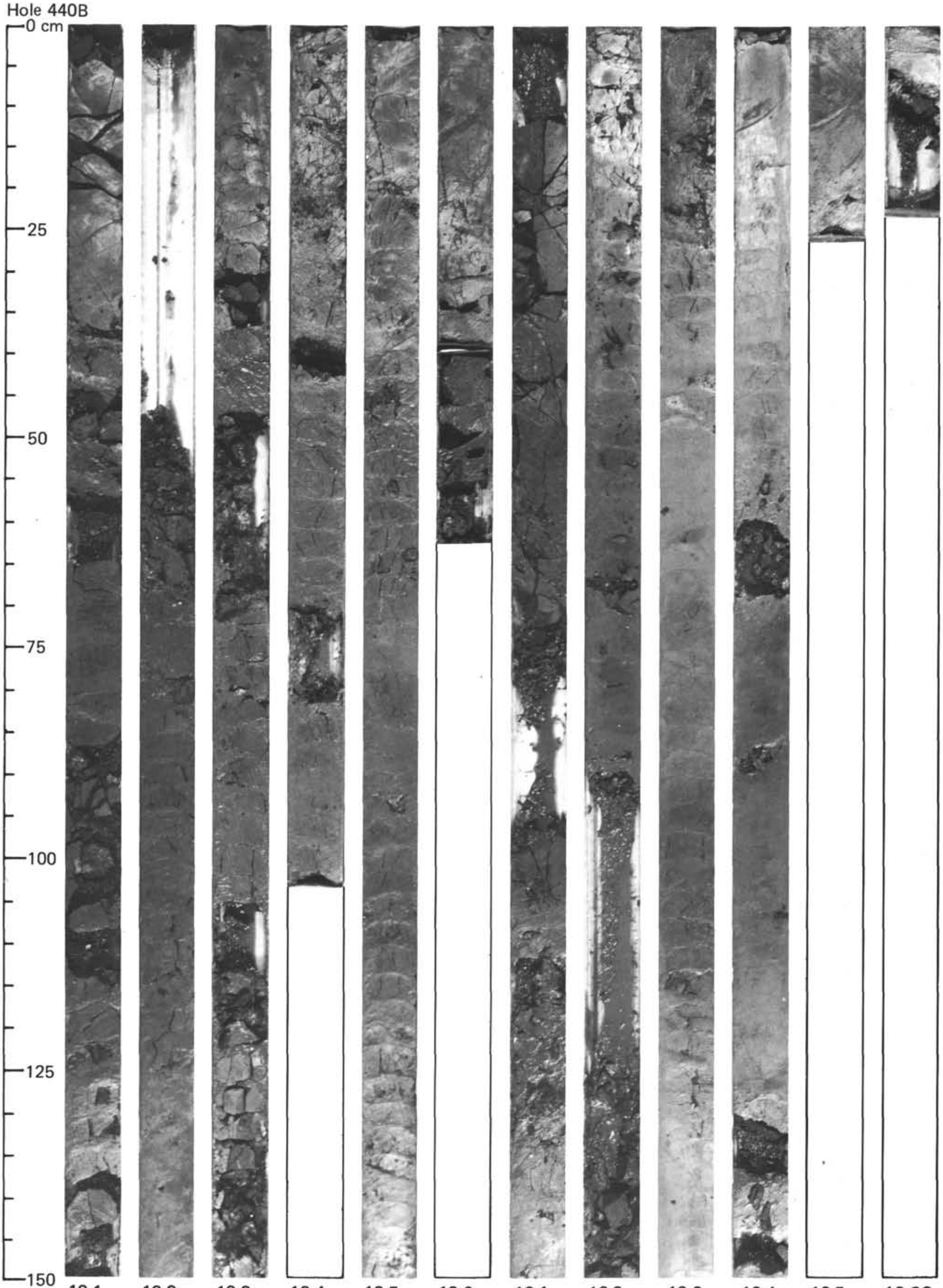
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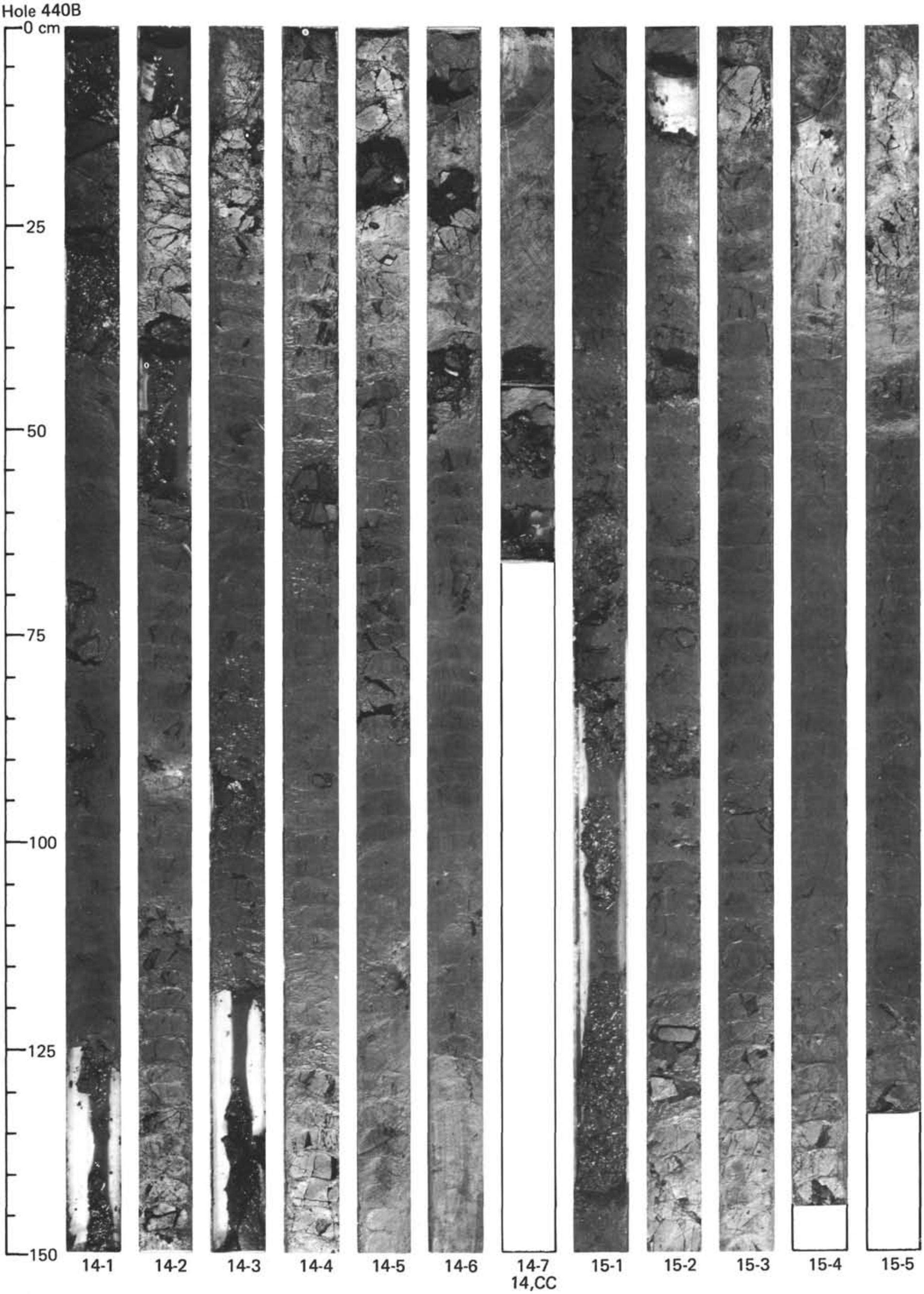
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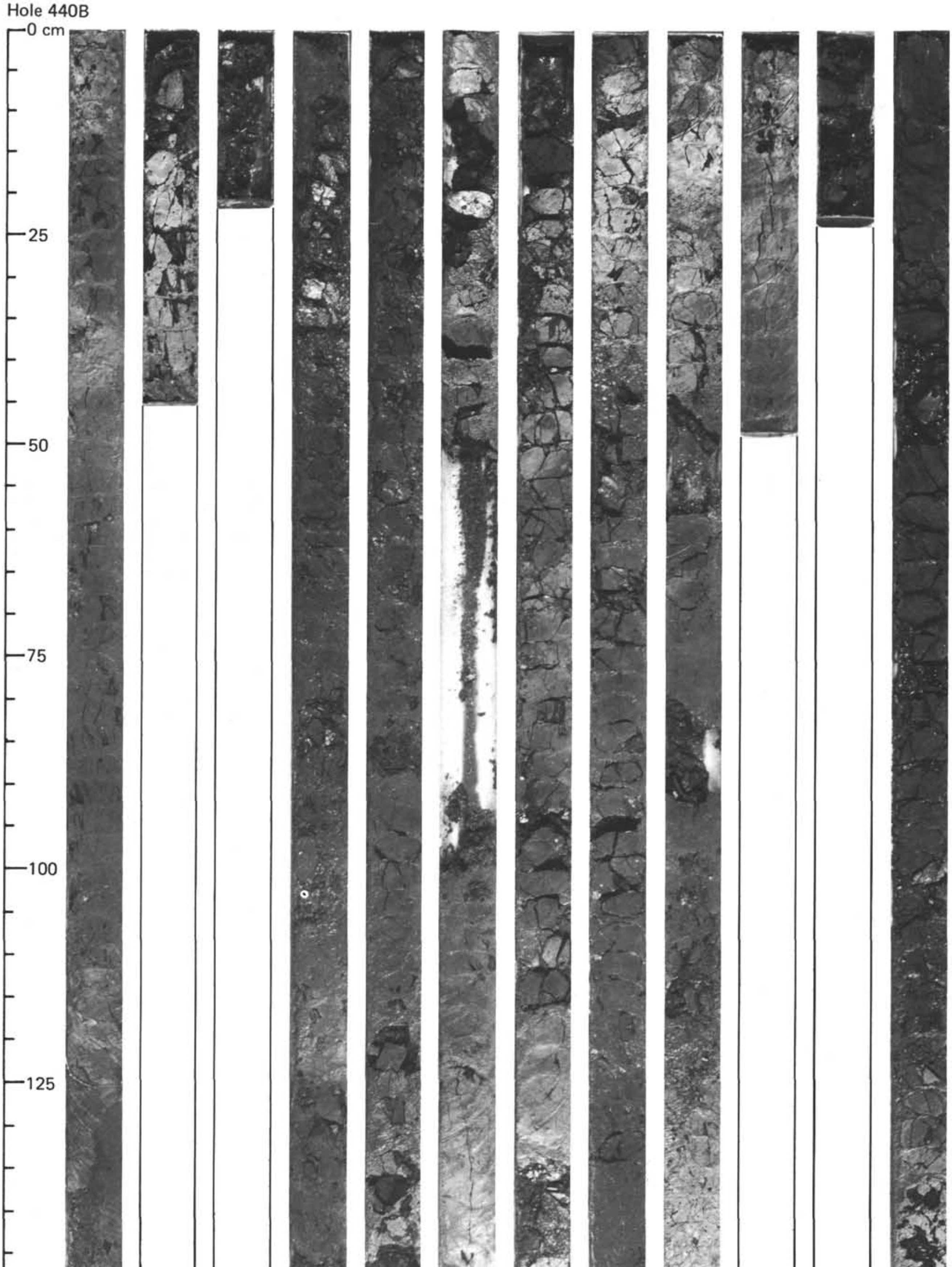
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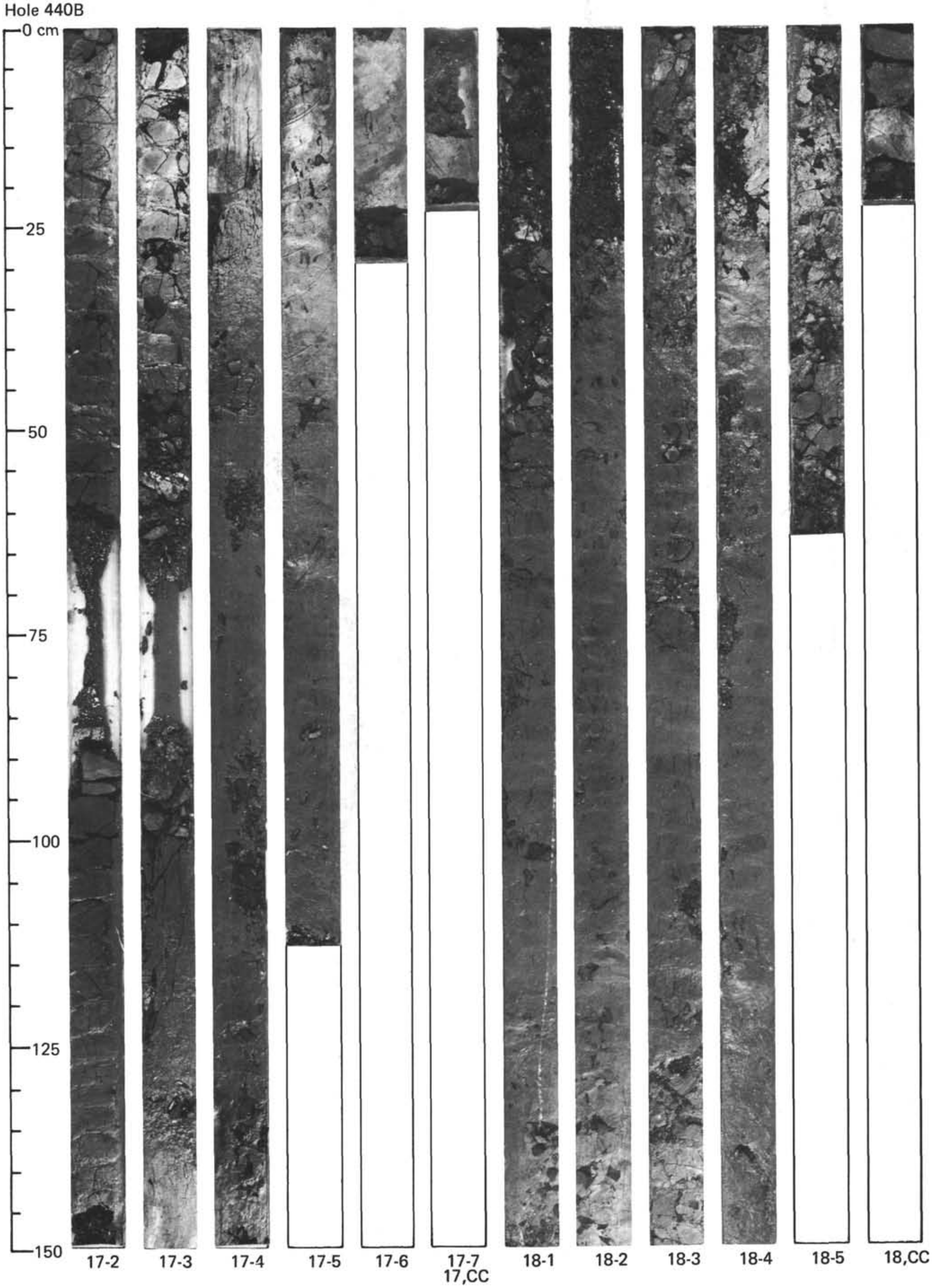
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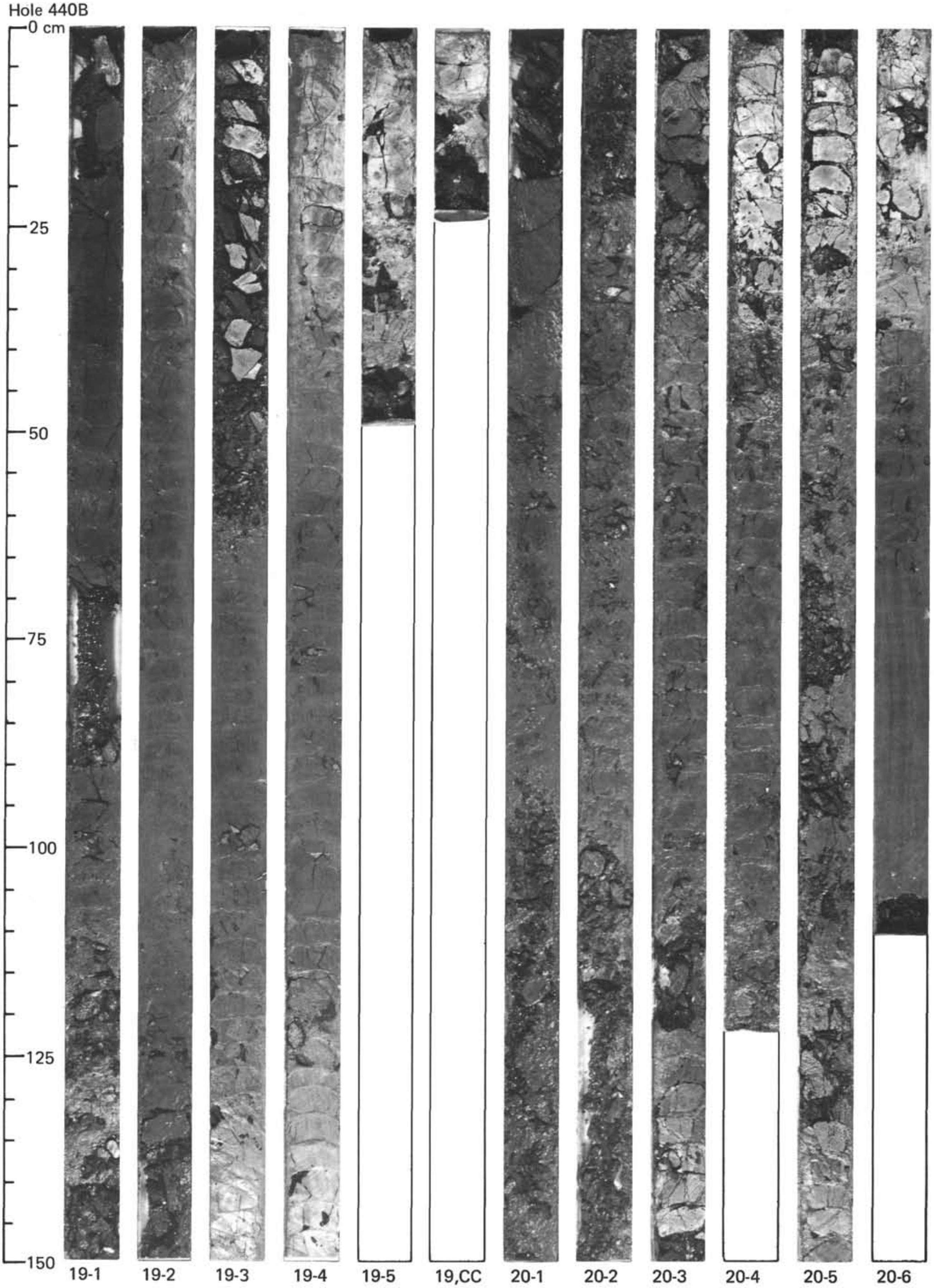
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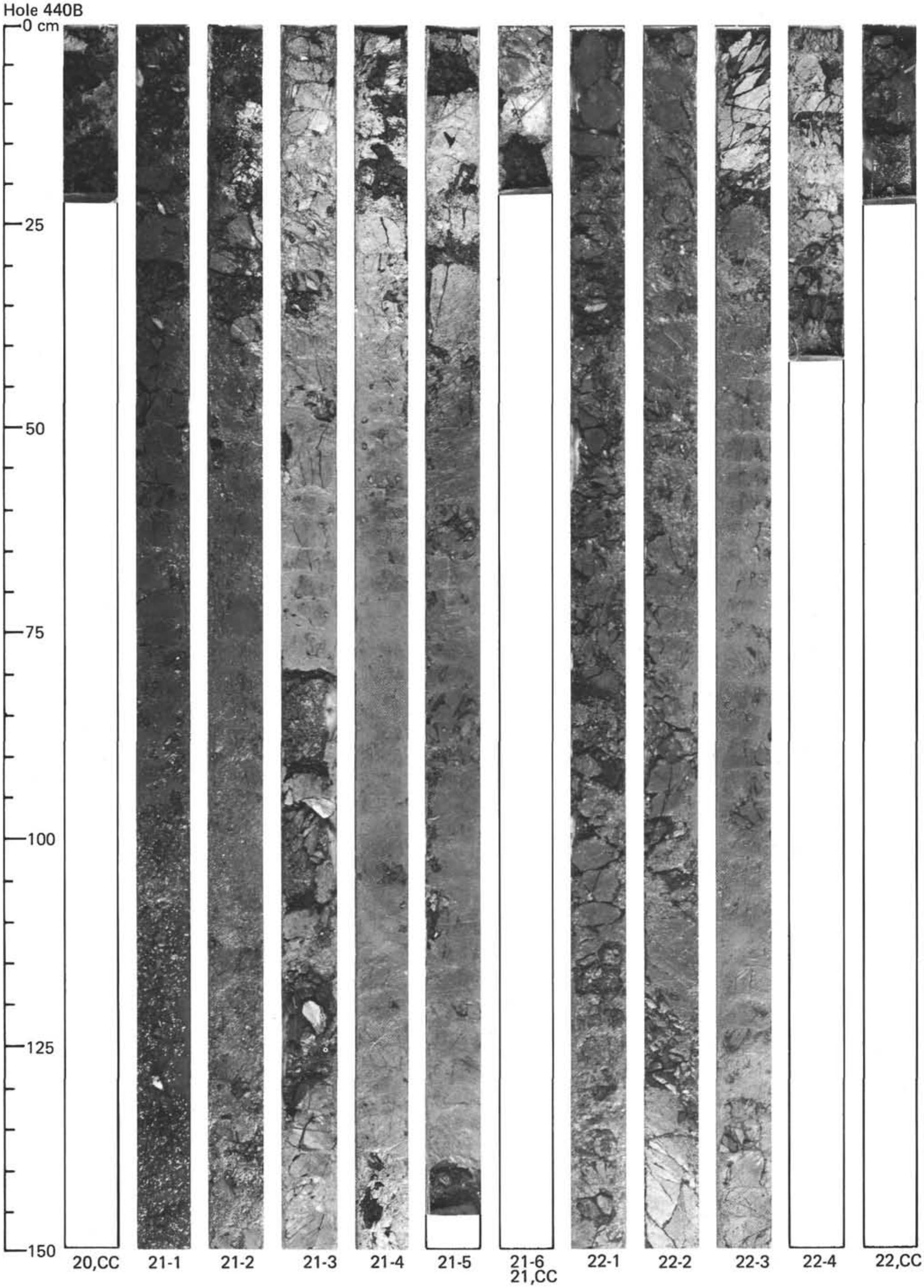
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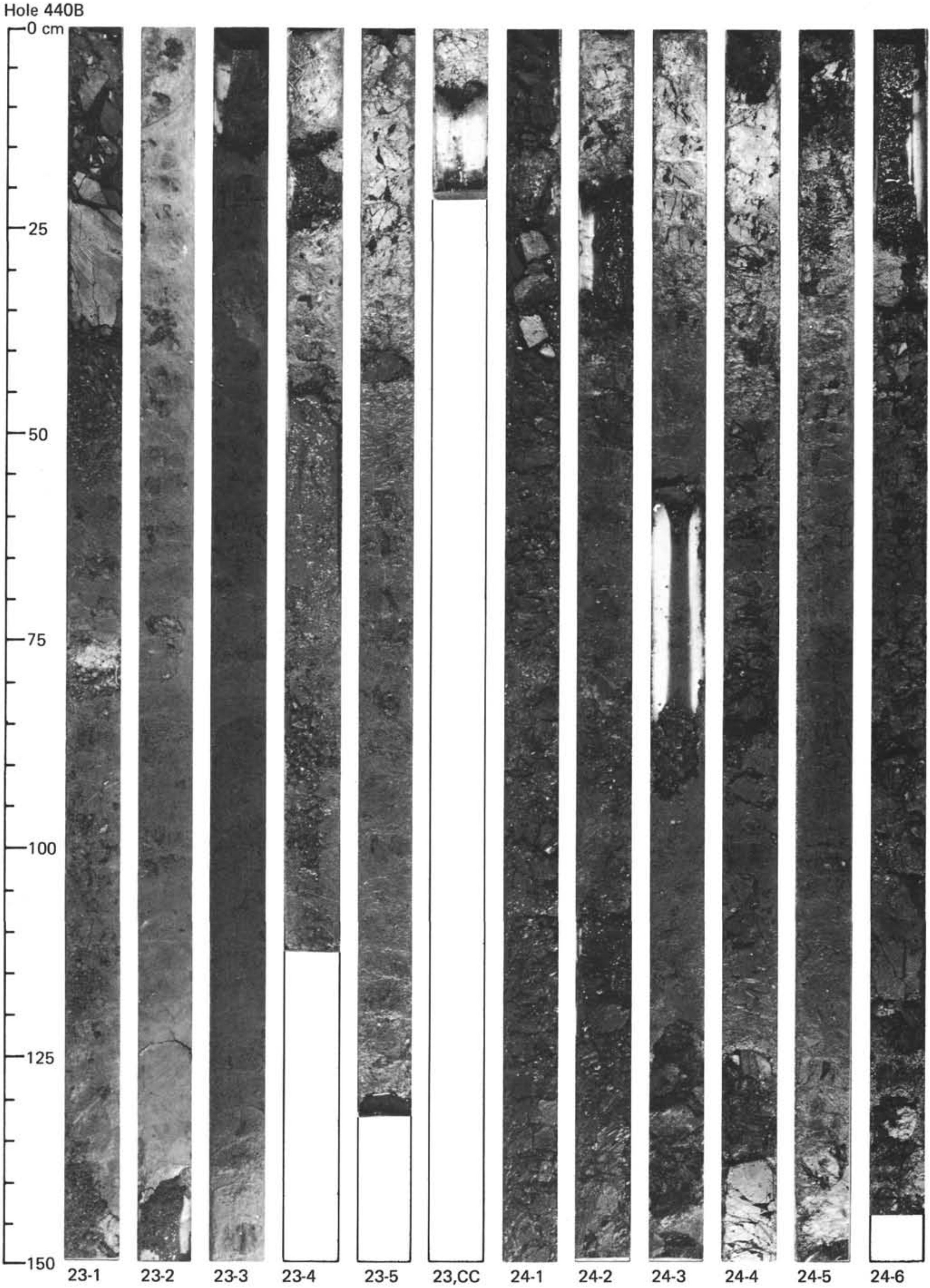
Hole 440B
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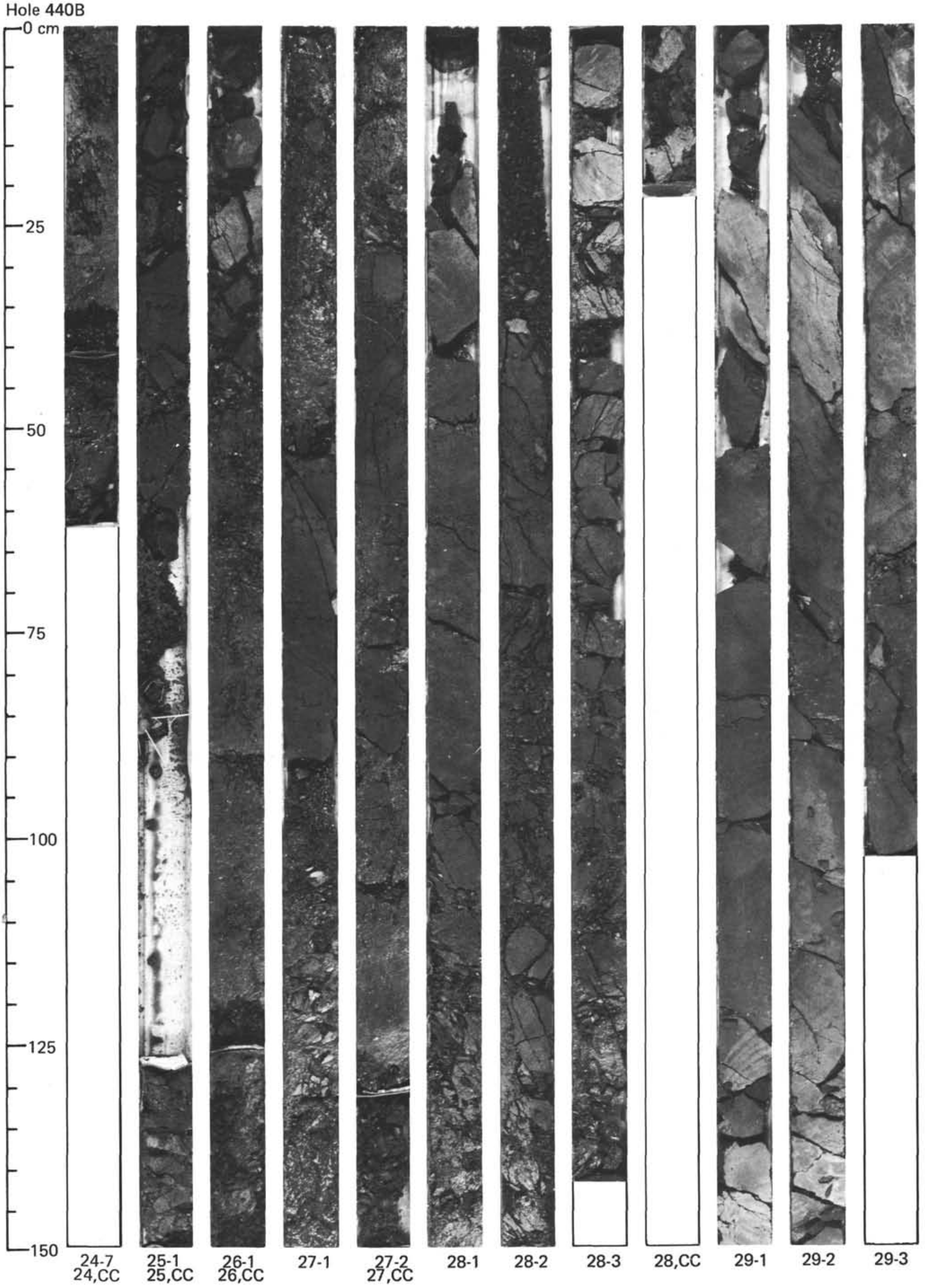
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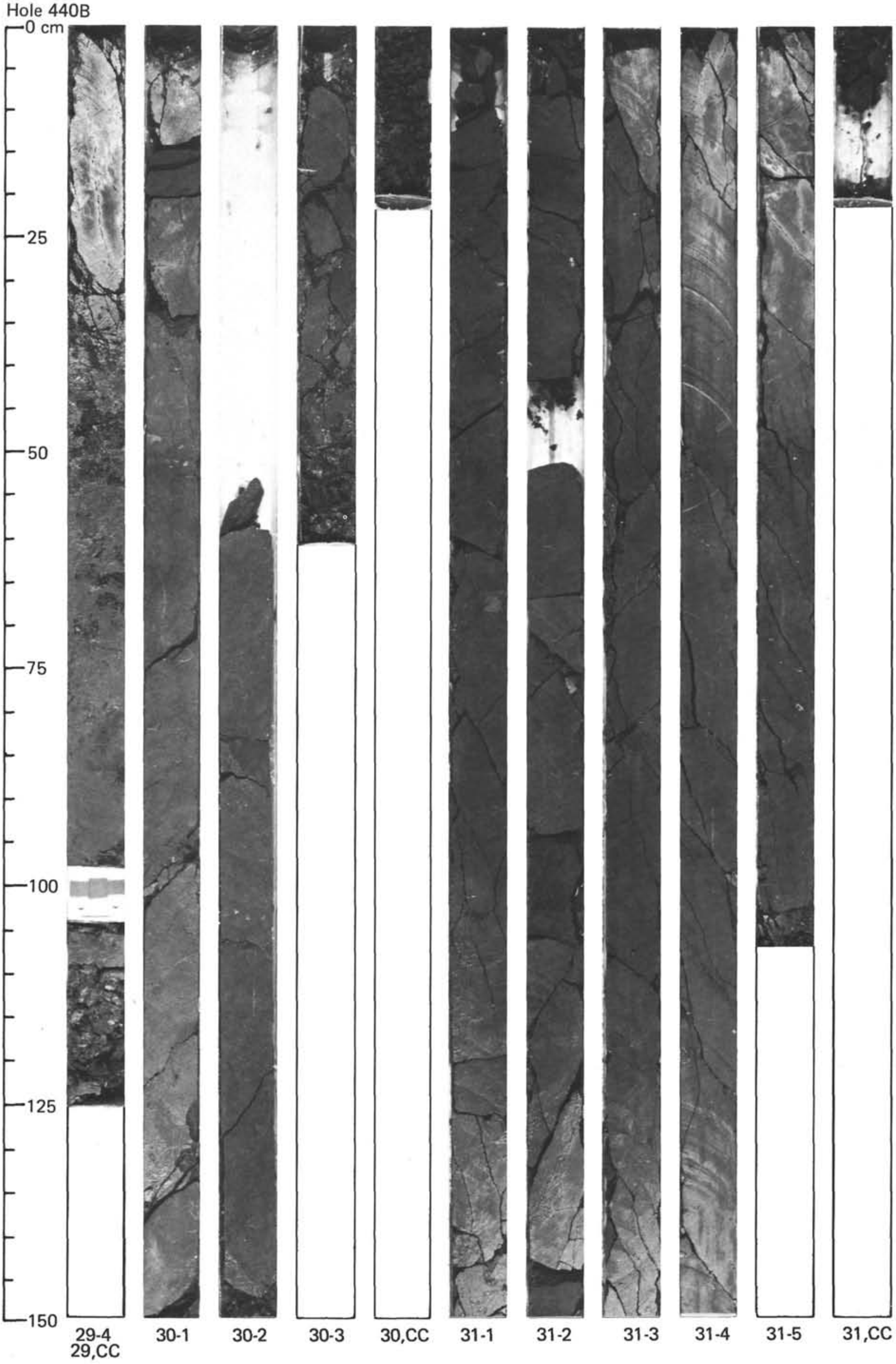
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31-2
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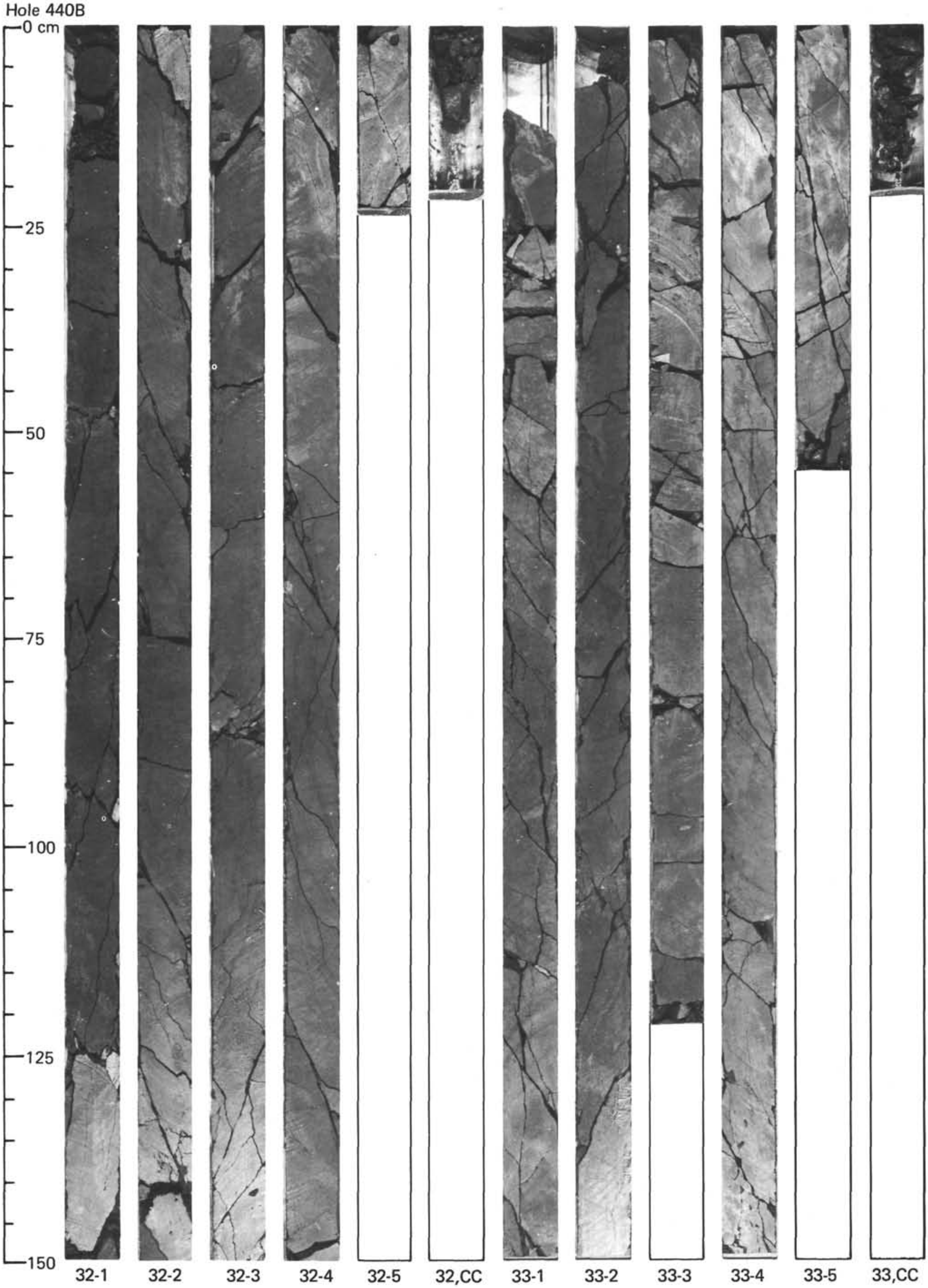
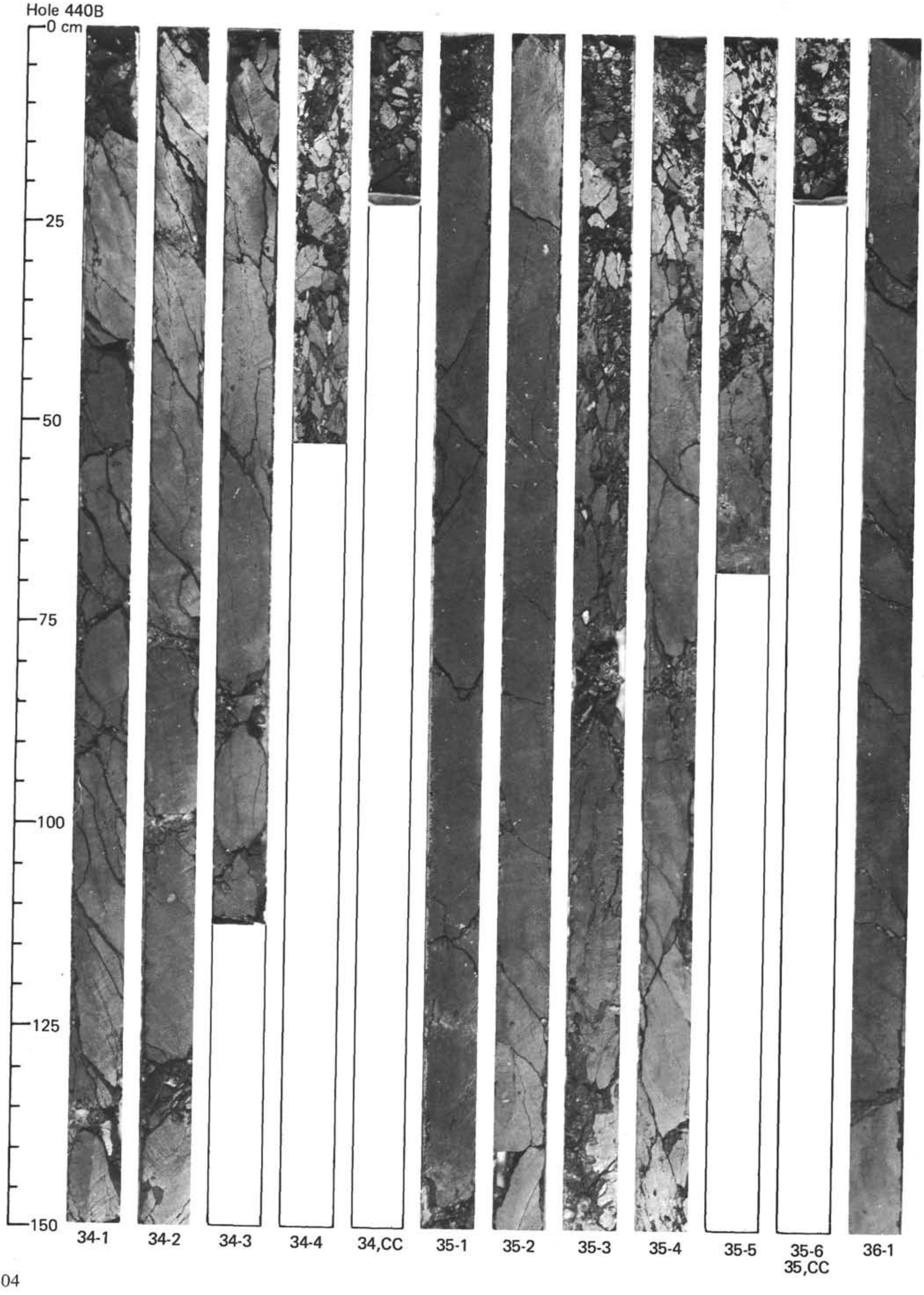
31-5
31,CC


Hole 440B
0 cm
25
50
75
100
125
150
32-1
32-2
32-3
32-4
32-5
32,CC
33-1
33-2
33-3
33-4
33-5
33,CC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34-1
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34,CC
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35-4
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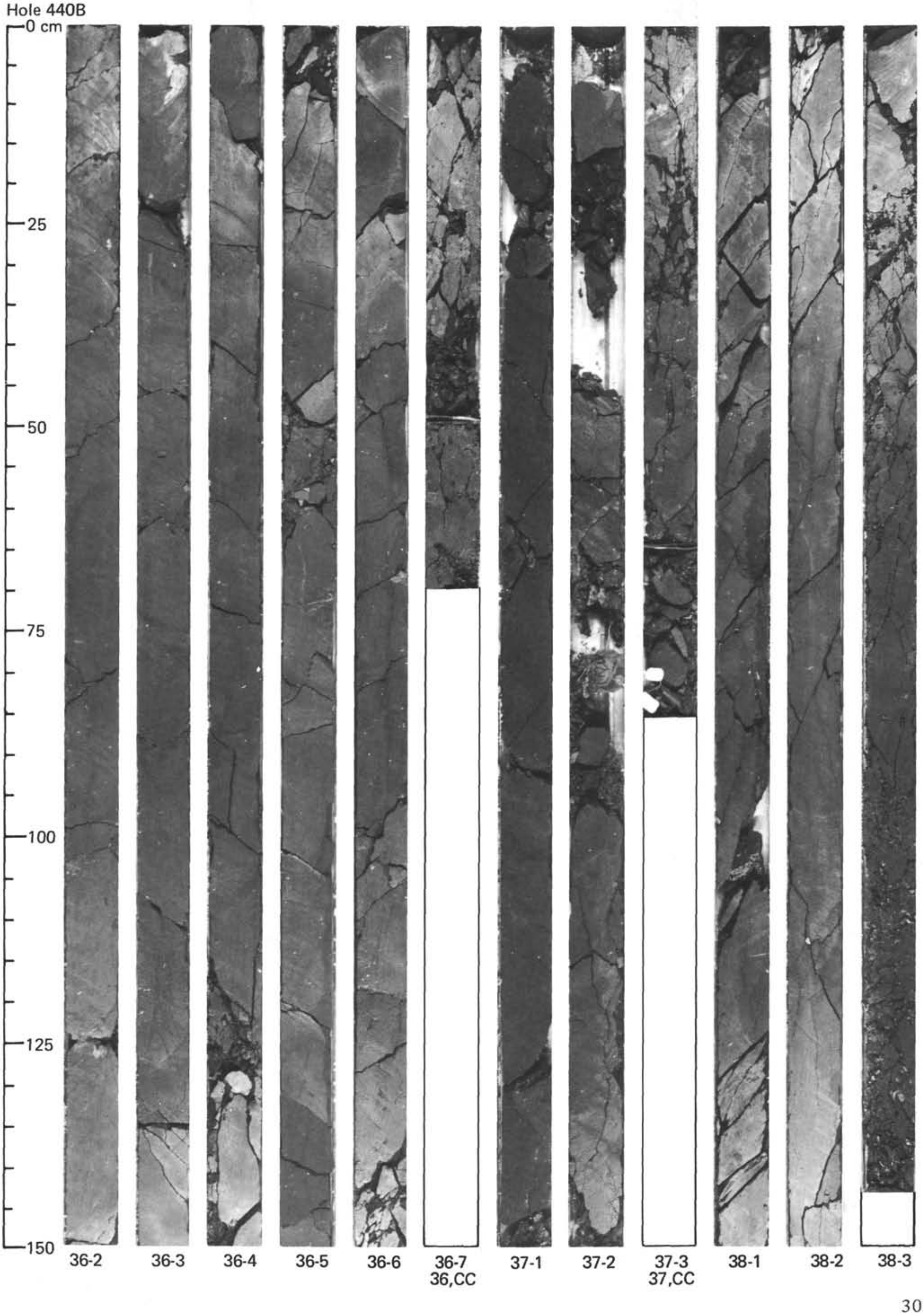
35-6
35,CC
36-1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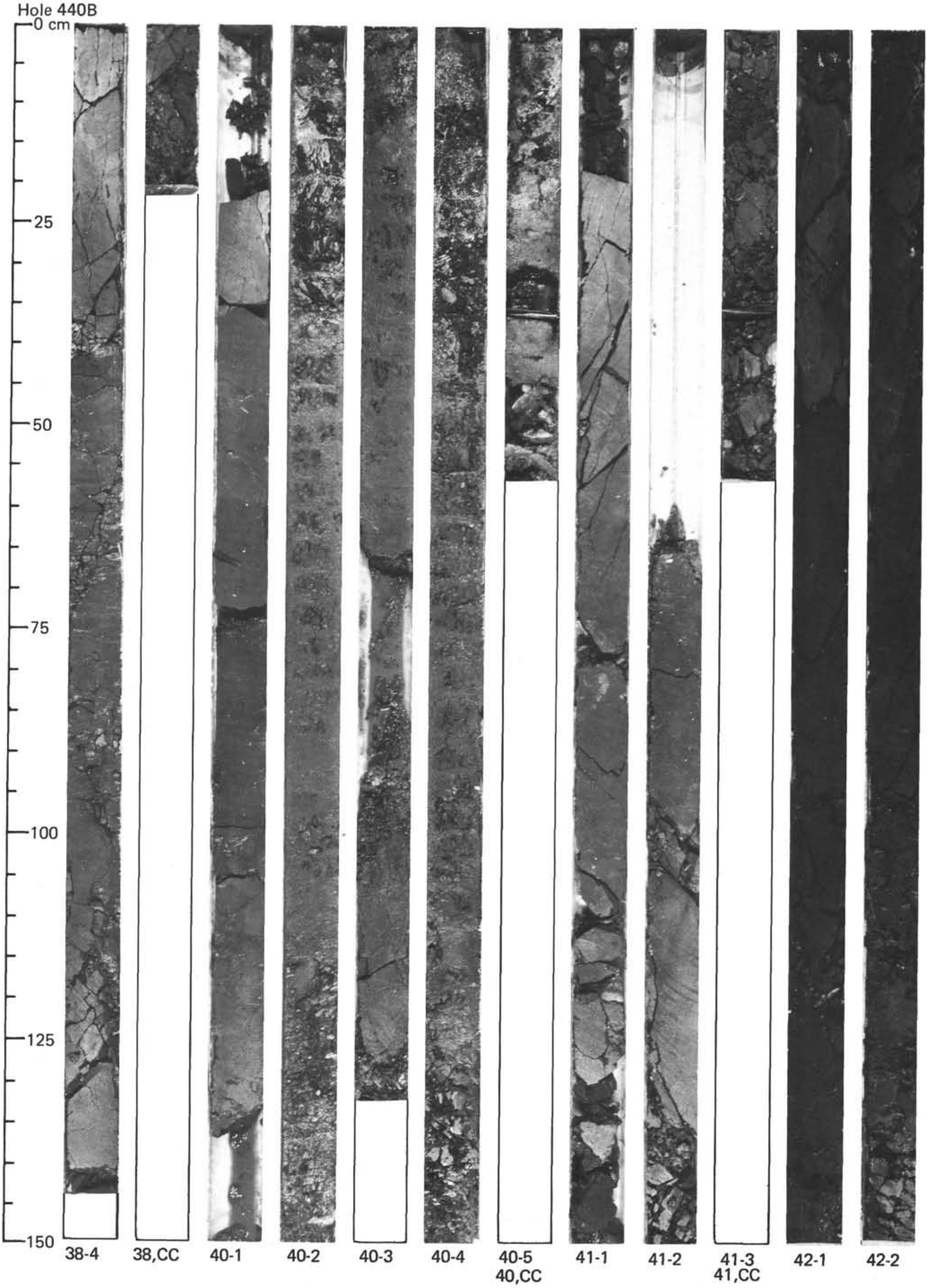
36-7
36,CC
37-1
37-2
37-3
37,CC
38-1
38-2
38-3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40-5
40,CC
41-1
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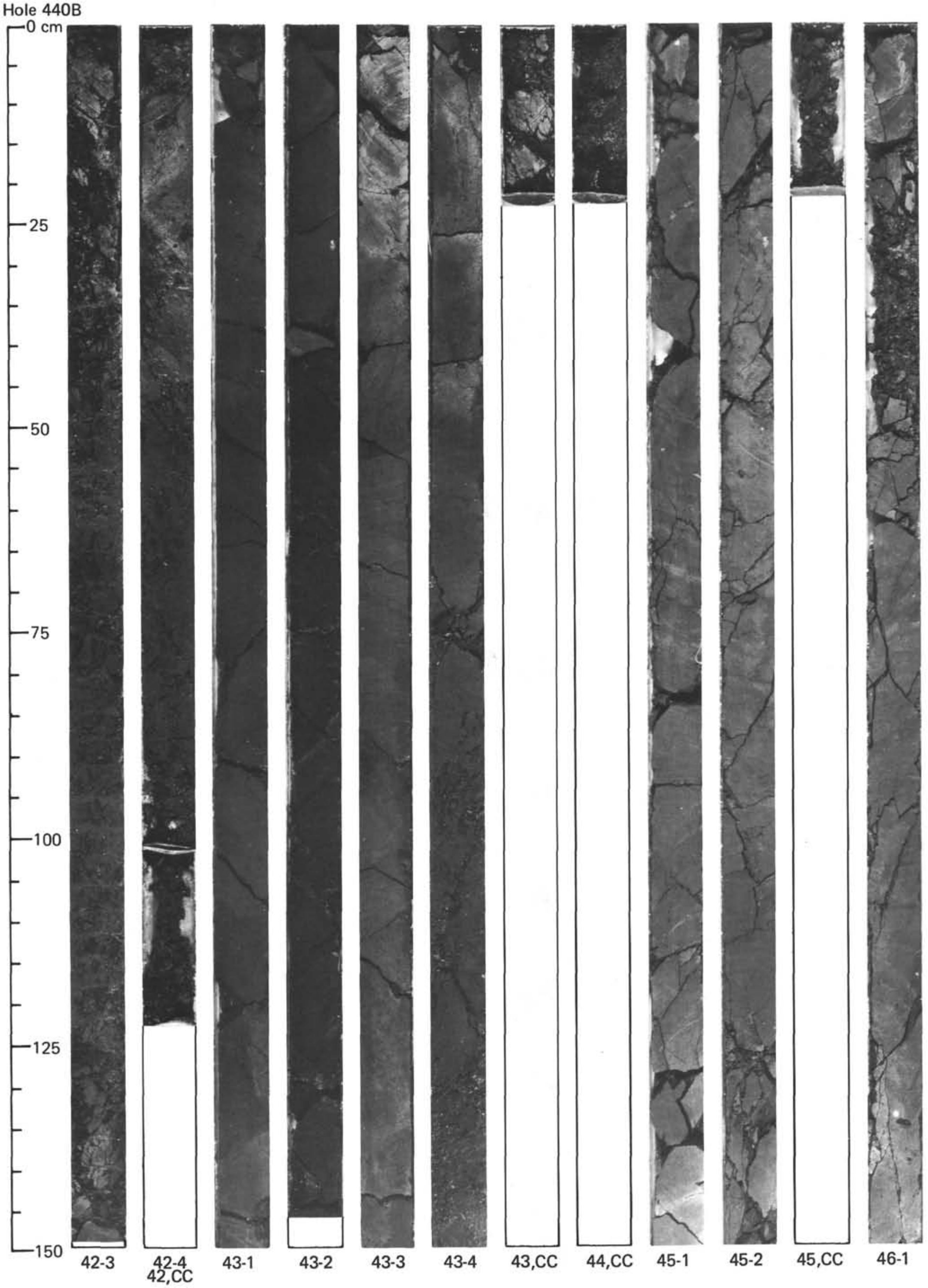
41,CC
42-1
42-2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43-2
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43-4
43,CC
44,CC
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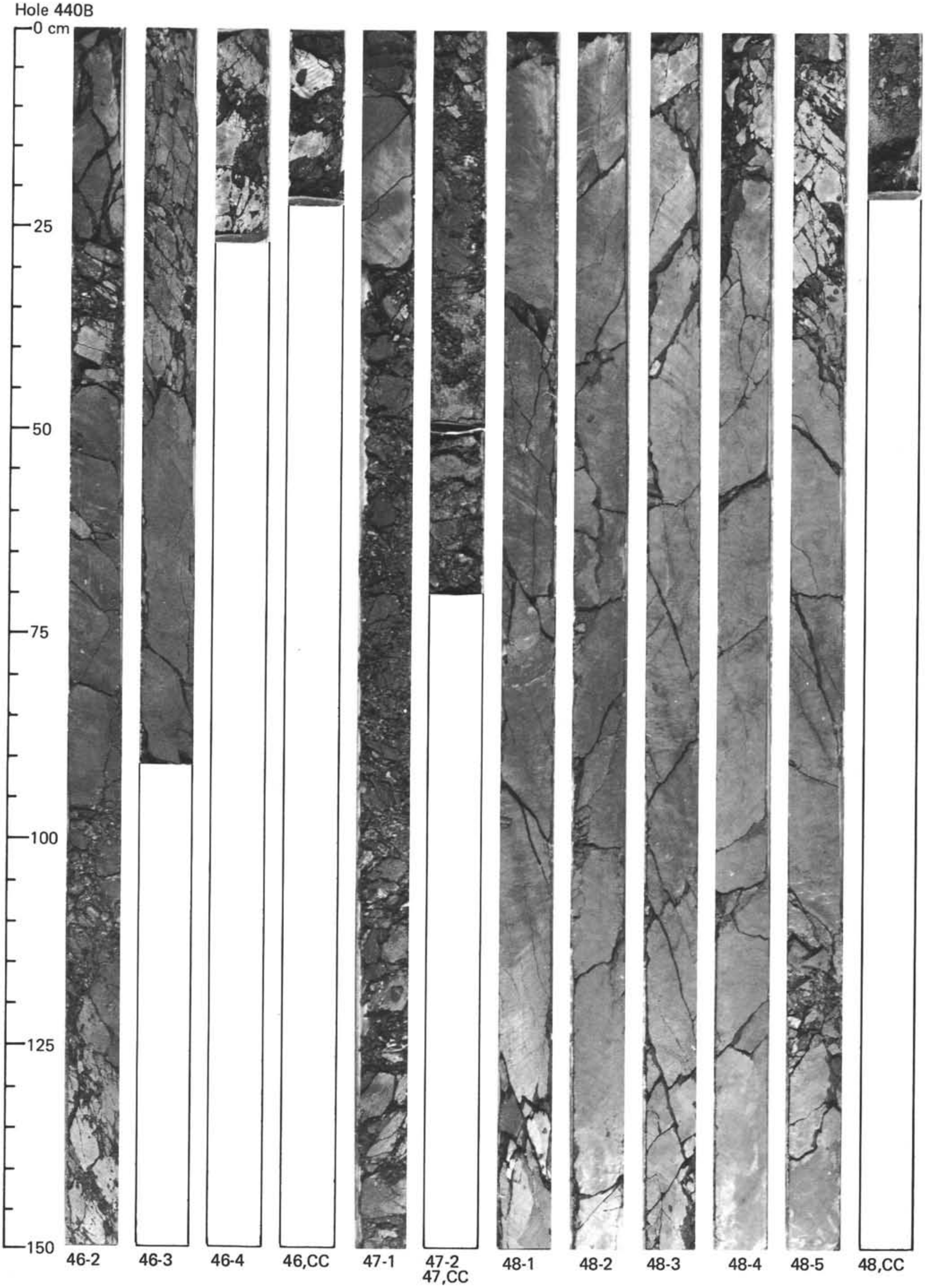
45-2
45,CC
46-1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47-1
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47,CC
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48-2
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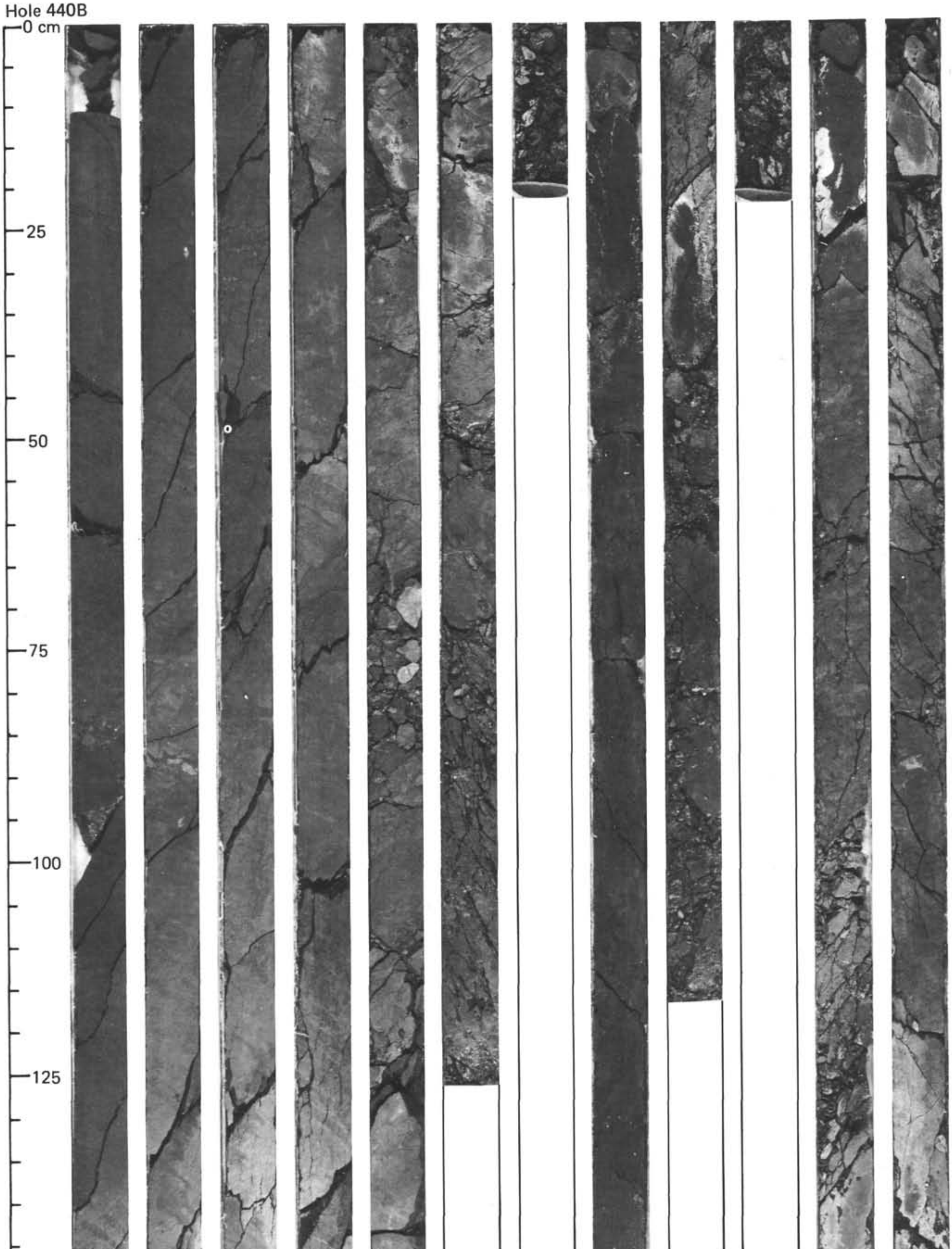
48,CC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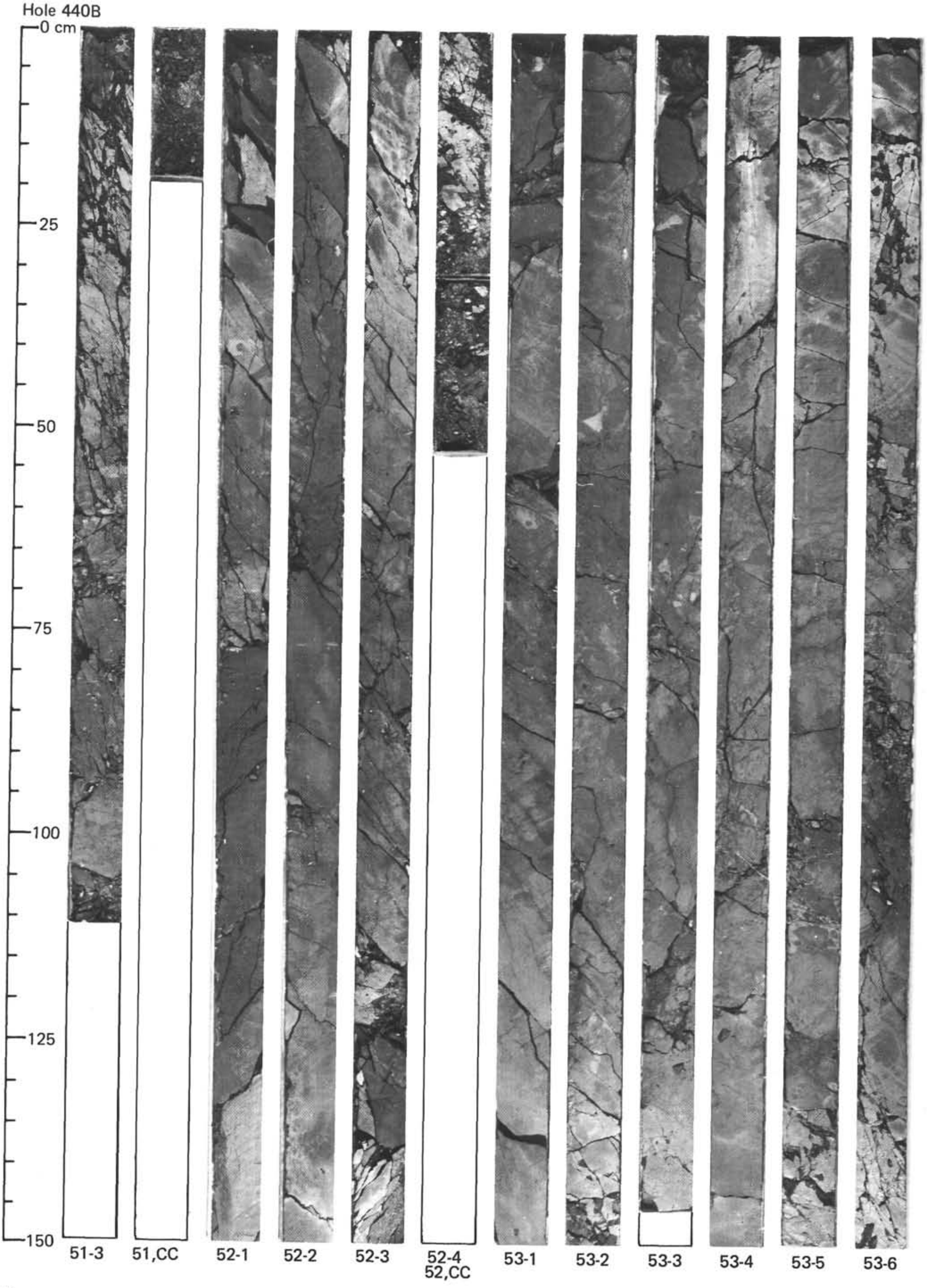
50,CC
51-1
51-2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52-3
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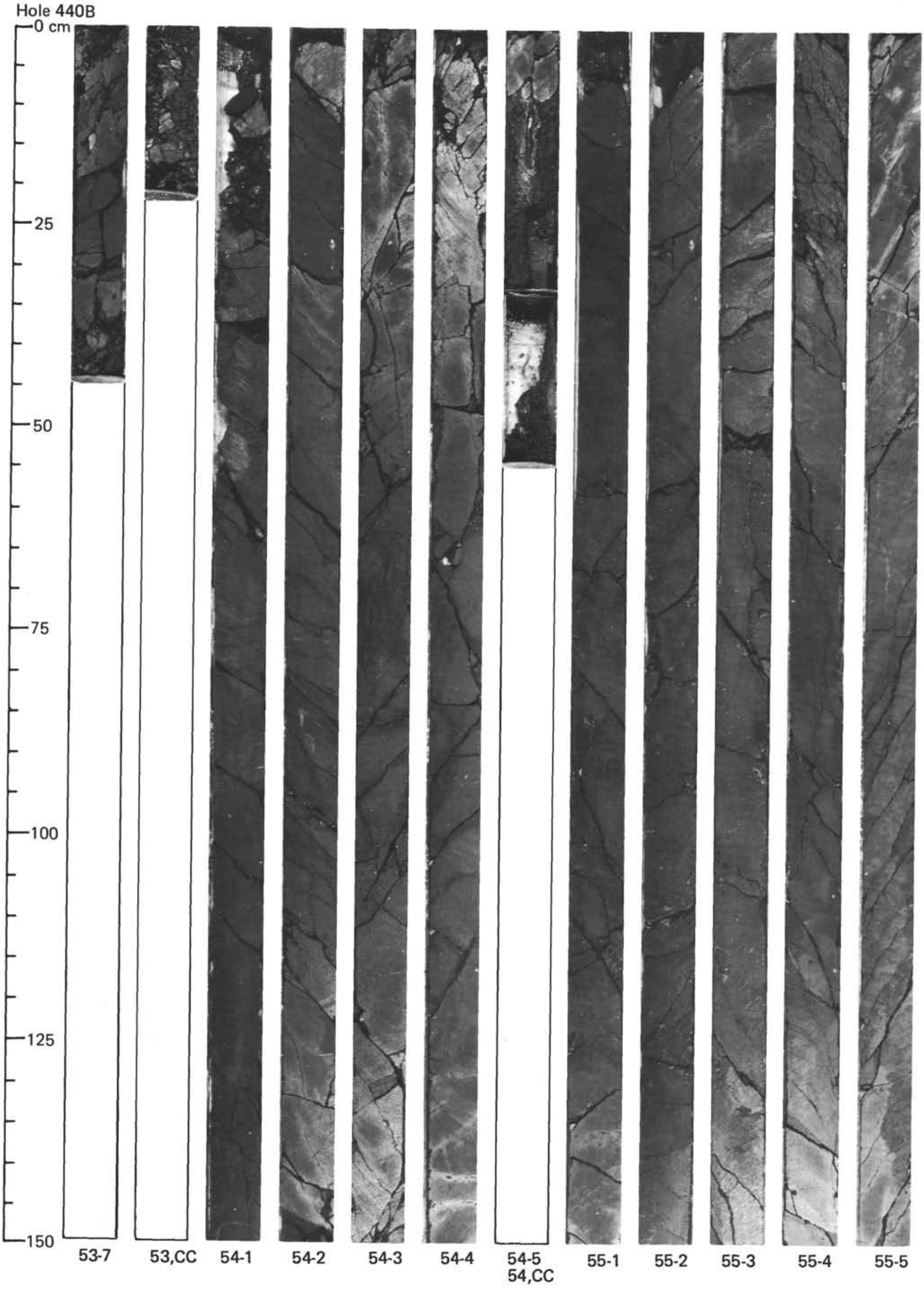
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53-7
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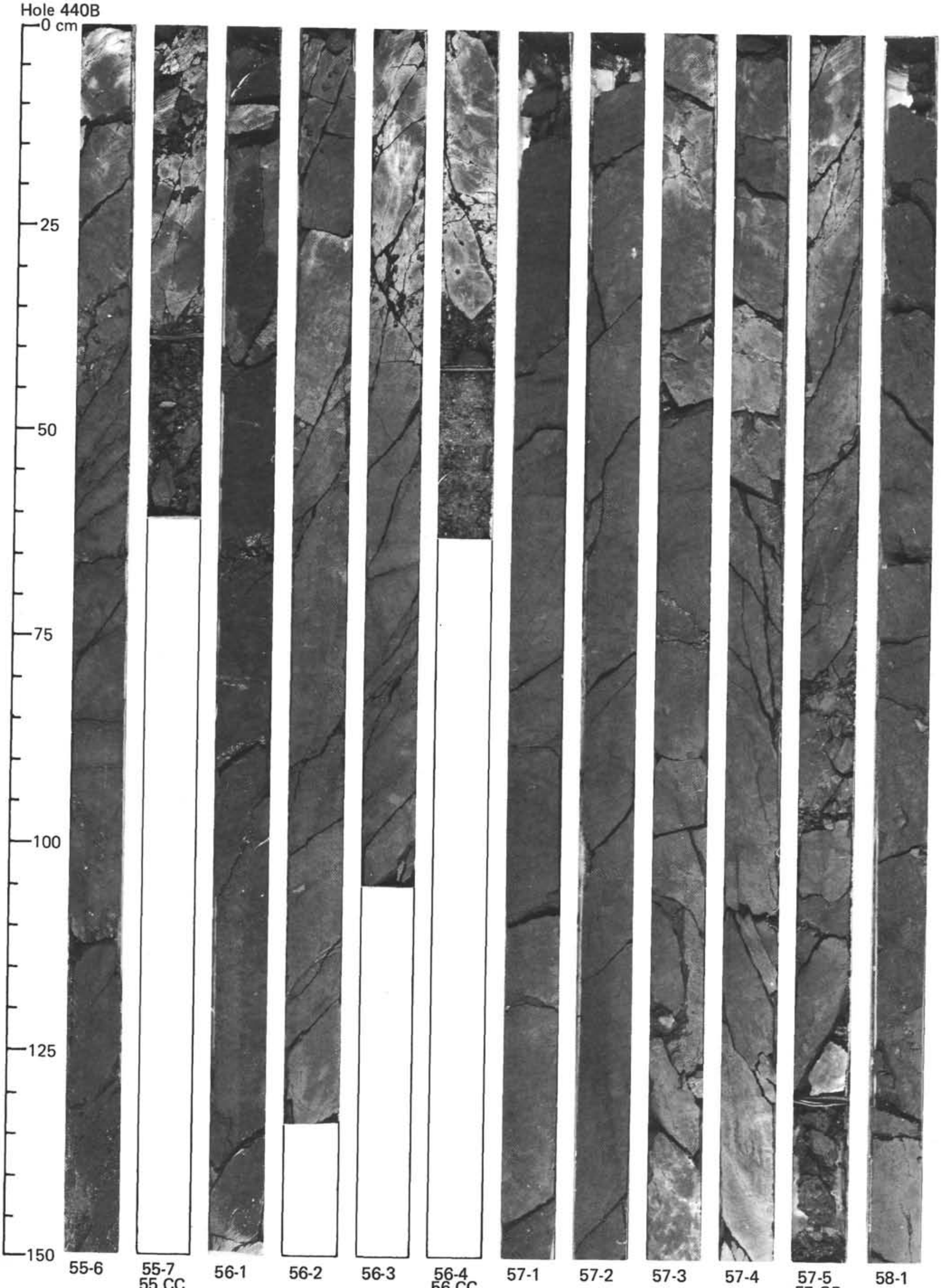
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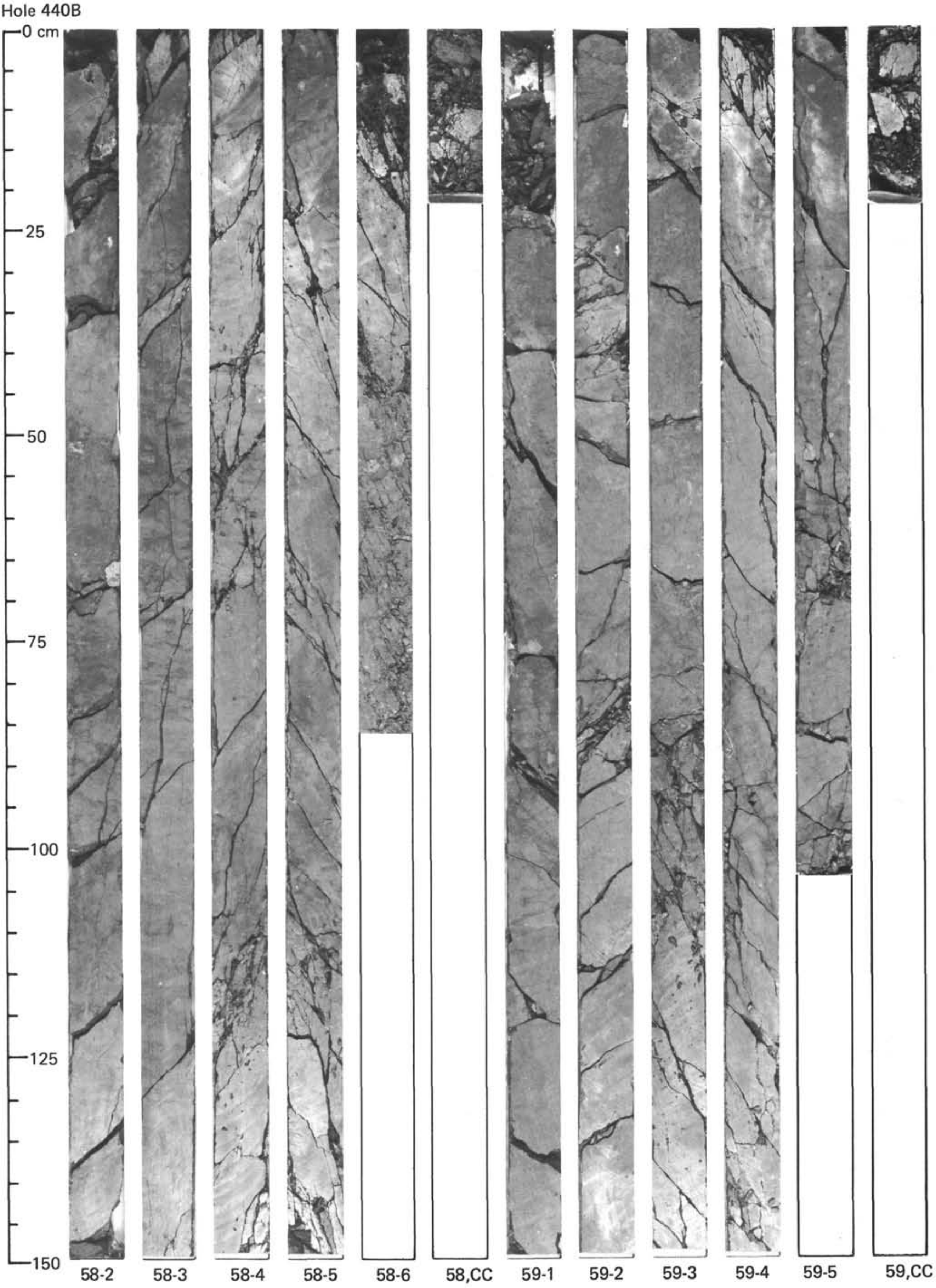
57,CC
58-1


Hole 440B
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58-6
58,CC
59-1
59-2
59-3
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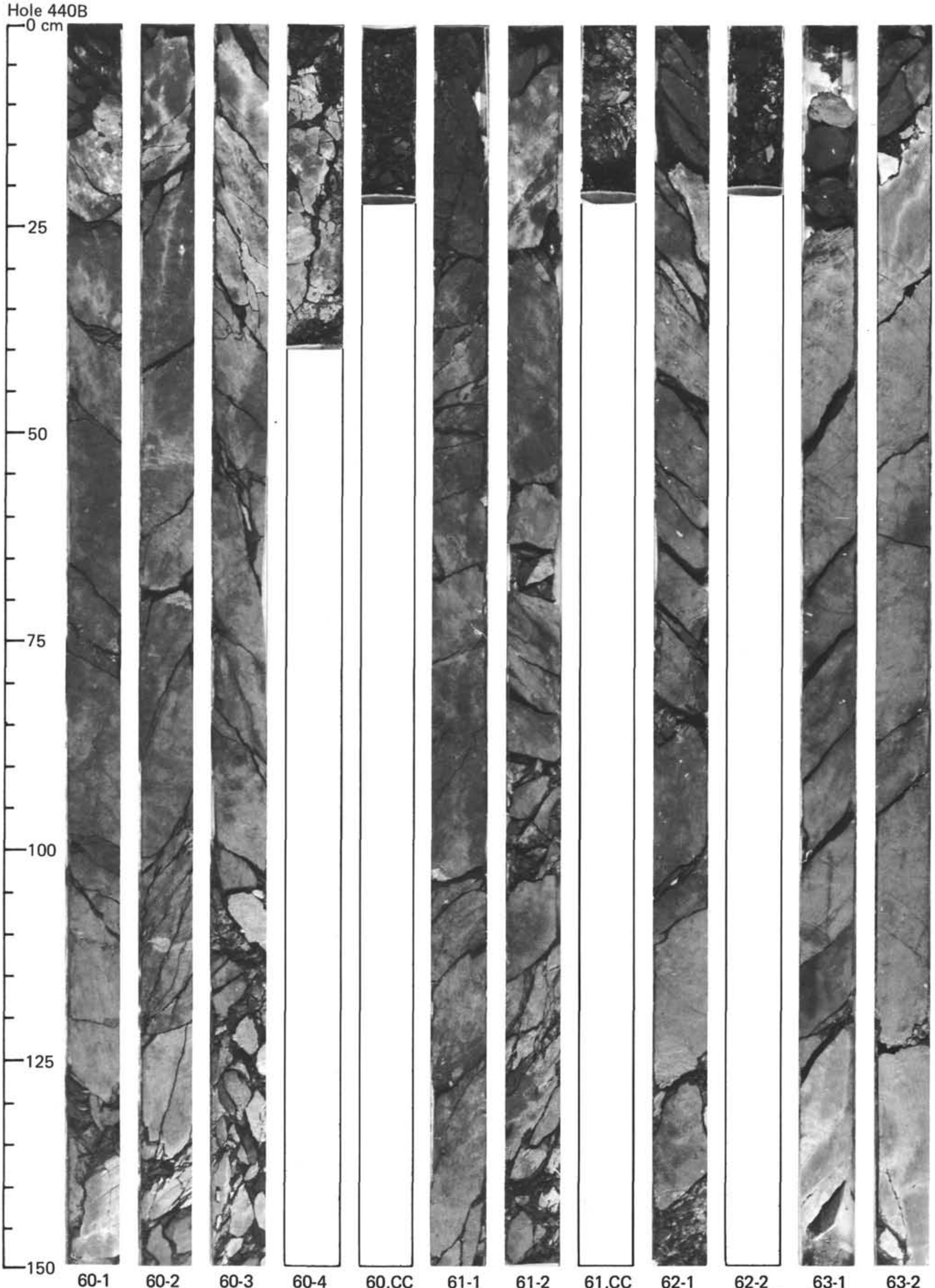
59-5
59,CC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60,CC
61-1
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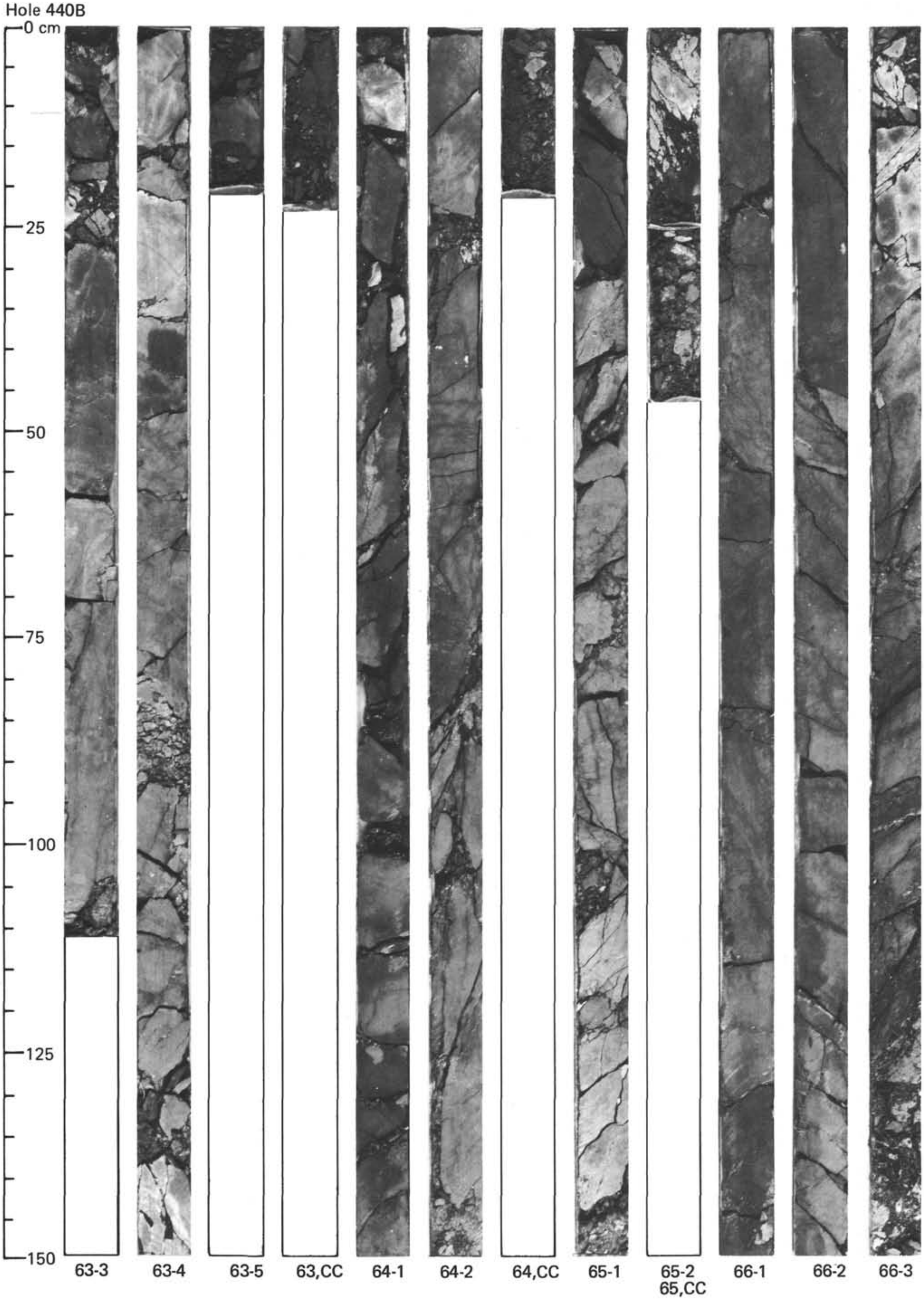
62,CC
63-1
63-2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64-1
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64,CC
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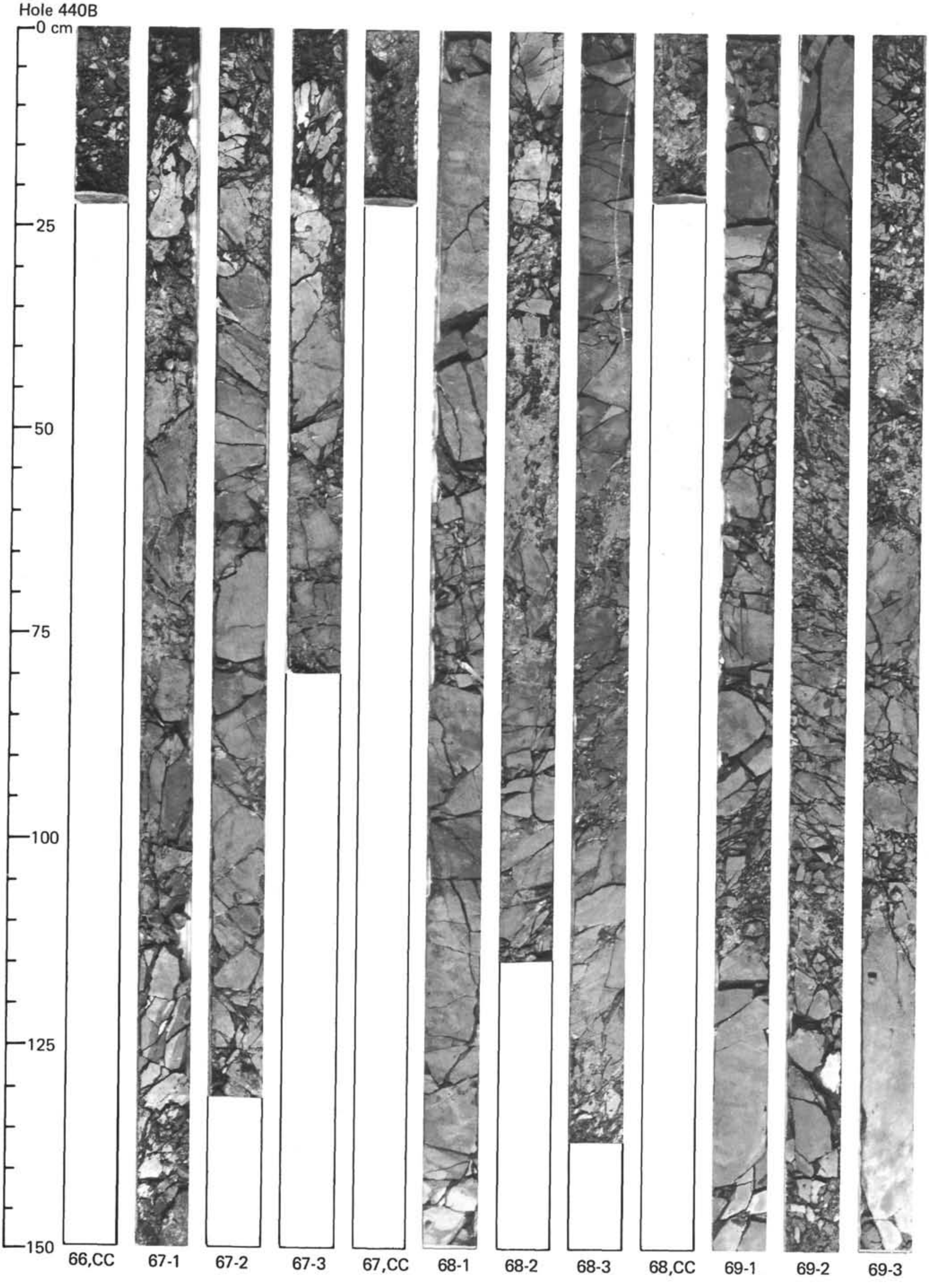
65-2
65,CC
66-1
66-2
66-3


Hole 440B
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67,CC
68-1
68-2
68-3
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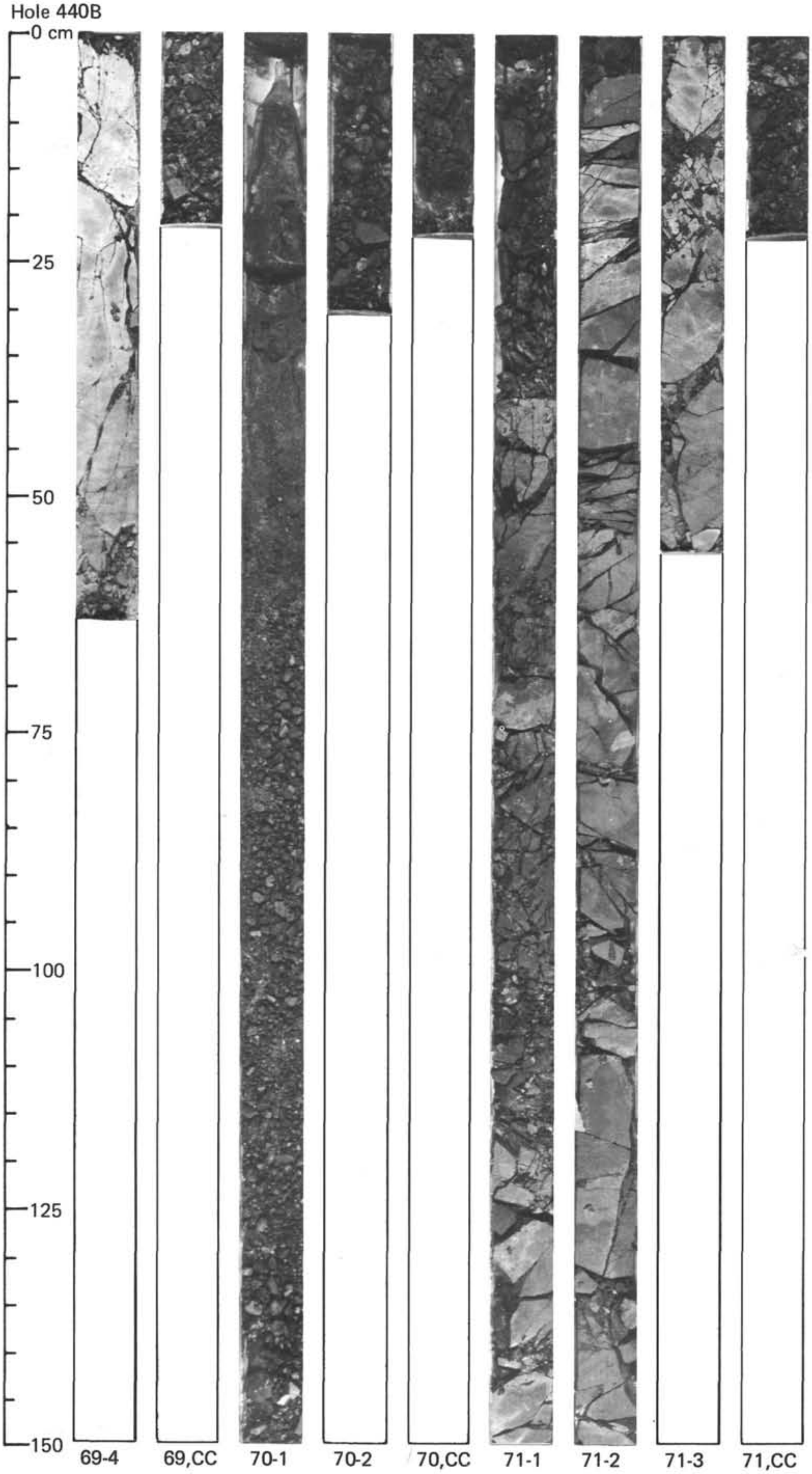
69-1
69-2
69-3


Hole 440B
0 cm
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75
100
125
150
69-4
69,CC
70-1
70-2
70,CC
71-1
71-2
71-3
71,CC