4. SITE 488[1]

Shipboard Scientific Party[2]

HOLE 488

Date occupied: 27 March 1979

Date departed: 02 April 1979

Time on hole: 155.9 hours

Position: 15°57.10′N; 99°01.66′N

Water depth (sea level; corrected m, echo-sounding): 4254

Water depth (rig floor; corrected m, echo-sounding): 4264

Bottom felt (m, drill pipe): 4265

Penetration (m): 429

Number of cores: 46

Total length of cored section (m): 428.5

Total core recovered (m): 160.4

Core recovery (%): 37

Oldest sediment cored:
Depth sub-bottom (m): 428.5
Nature: Sand
Age: Early middle Quaternary

Principal results: At Site 488 we penetrated 429 meters and recovered 46 cores comprising two lithologic units (Table 1, Fig. 1). Unit 1 consists of 313 meters of lower middle to upper Quaternary muddy silt and mud with local thin silt and muddy sand beds in its lower portion. Lower middle Quaternary muddy silt–siltstone, sand, and granular gravel of Unit 2 extends from 313 to 428.5 meters. In spite of poor recovery, variations in drilling rates suggest several thick (8–9 m) sand beds near the top of Unit 2 with thinner sand beds at greater depth. Unit 1 probably accumulated as a slope sequence mantling Unit 2, which is interpreted as uplifted trench deposits.

The upper 210 meters at Site 488 display nearly horizontal bedding except where deformed by drilling. Dips averaging 30° to 45° are common in Unit 1 from 210 to 265 meters. Sediments from 210 to 248 meters are characterized by healed fractures that truncate bedding, producing wispy discontinuous blebs and stringers of silt within a matrix of muddy silt. Dips in Unit 2 average about 30° and are more consistent than those of Unit 1. Cores show no evidence of overturned bedding at Site 488, but top indicators are rare. Paleomagnetically oriented cores in Unit 2 indicate that bedding dips northeastward, but more steeply than seismic reflectors at the same depth. Although density and hydrocarbon anomalies in a zone of complex deformation between 200 to 250 meters suggest faulting, seismic evidence is ambiguous. Conversely, correlation of seismic reflection and drilling results suggests that a thrust fault was penetrated at about 120 meters below the mudline but without resolvable change in lithology, paleontology, or physical properties.

BACKGROUND AND OBJECTIVES

Site 488 lies on a crest of the first high landward of the Middle America Trench at 15°57.10′N and 99° 01.66′W (Figs. 2, 3). Seismic data show that the site overlies a zone of landward-dipping reflectors (Fig. 4), which have been interpreted as offscraped deep sea sediments (Shipley et al., 1980).

Models of the offscraping and accretion process abound, but the geologic data from modern subduction zones constraining these various conceptual scenarios are meager. Drilling data are available from the Aleutian, Japan, and Marianas trenches, the Nankai Trough, and the subduction zone off Oregon and Washington. Deformed trench sediments were recovered from the Aleutian Trench (Kulm, von Huene, et al., 1973) and Nankai Trough (Karig, Ingle, et al., 1975). Drilling in the Japan and Marianas trenches bottomed in trench-slope sediments without penetrating material scraped off the oceanic plate (Hussong, Uyeda, et al., in press; Scientific Party, 1980). Slope sediments and possibly a short section of accreted deep sea deposits were recovered during drilling off Oregon (Kulm, von Huene, et al., 1973). Given these few drilling penetrations in modern trench slopes, a prime objective at Site 488, and indeed of much of Leg 66, was to provide more geologic information on the lithologic environments of deposition and on the structural configurations of the deposits underlying this trench slope, and to test conceptual models of trench-slope evolution.

Recognizing the original environment of deposition constitutes one of the most fundamental problems in interpreting subduction complexes. This determination is not only of sedimentologic importance, but it also places concrete limits on the kinematics or particle trajectories associated with the accretion process. The material cored at Site 488 could be offscraped pelagic, hemipelagic, or trench deposits with overlying and/or structurally incorporated slope sediments. Hence interpreting core data from Site 488 requires lithologic comparisons to reference sections in the trench (Site 486), in the pelagic and hemipelagic apron (Site 487), and in the slope (shallow

[1] *Initial Reports of the Deep Sea Drilling Project*, Volume 66.

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Table 1. Coring summary, Hole 488.

Core	Cored Interval below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)
1	0.0-1.0	1.0	0.55	55
2	1.0-10.5	9.5	5.86	62
3	10.5-20.0	9.5	3.69	39
4	20.0-29.5	9.5	7.32	77
5	29.5-39.0	9.5	7.62	80
6	39.0-48.5	9.5	7.58	80
7	48.5-58.0	9.5	4.75	50
8	58.0-67.5	9.5	0.65	7
9	67.5-77.0	9.5	4.04	43
10	77.0-86.5	9.5	5.25	55
11	86.5-96.0	9.5	4.26	45
12	96.0-105.5	9.5	0.0	0
13	105.5-115.0	9.5	2.5	26
14	115.0-124.5	9.5	1.63	17
15	124.5-134.0	9.5	1.69	18
16	134.0-143.5	9.5	3.90	41
17	143.5-153.0	9.5	0.32	3
18	153.0-162.5	9.5	3.82	40
19	162.5-172.0	9.5	2.33	25
20	172.0-181.5	9.5	3.97	42
21	181.5-191.0	9.5	5.25	55
22	191.0-200.5	9.5	3.06	32
23	200.5-210.0	9.5	1.57	17
24	210.0-219.5	9.5	1.64	17
25	219.5-229.0	9.5	1.43	15
26	229.0-238.5	9.5	9.17	97
27	238.5-248.0	9.5	1.55	16
28	248.0-257.5	9.5	tr	0
29	257.5-264.5	7.0	6.45	92
30	264.5-276.0	11.5	9.22	80
31	276.0-285.0	9.0	4.64	52
32	285.0-294.0	9.0	5.85	65
33	294.0-303.0	9.0	9.51	105
34	303.0-312.0	9.0	8.57	95
35	312.0-321.0	9.0	1.45	16
36	321.0-333.5	12.5	0.15	1
37	333.5-343.0	9.5	2.05	22
38	343.0-352.5	9.5	0.52	5
39	352.5-362.0	9.5	0.98	10
40	362.0-371.5	9.5	1.81	19
41	371.5-381.0	9.5	0.38	4
42	381.0-390.5	9.5	3.8	40
43	390.5-400.0	9.5	1.82	19
44	400.0-409.5	9.5	2.25	24
45	409.5-419.0	9.5	3.85	41
46	419.0-428.5	9.5	1.70	18

cores, Site 488) (piston cores, McMillen and Haines, this volume).

An imbricate stack of landward-dipping thrust faults constitutes one of the most popular structural models for the lower trench slope (e.g., Karig, 1974; Seely, et al., 1974). The data supporting this model consist primarily of landward-dipping reflectors, which are exceptionally well shown in the seismic reflection line through Site 488 (Fig. 4; Shipley, this volume). Packages of these reflectors are commonly interpreted as thrust slices, yet their true nature has not been documented by drilling. Consequently, a fundamental objective at Site 488 was penetration of these tilted reflectors in search of stratigraphic age inversions, structural features, and physical property variations indicative of faulting.

Subaerially exposed subduction complexes generally show intense deformation. The origin of this deformation is variously attributed to slumping before accretion and/or shear and flattening during accretion and subsequent uplift. At Site 488, we hope to appraise the deformation of both slope and deep sea deposits at an initial stage of uplift and thereby provide some information on an early stage of progressive structural evolution in a subduction complex.

OPERATIONS AND SITE SURVEY

Because electrical and hydraulic problems delayed spudding after dropping the beacon at Site 488, we surveyed the site in detail using the beacon for a positioning. The navigational accuracy of the survey (maximum error 0.4 km) permitted preparation of a map (Fig. 3) of the major tectonic features of the trench floor and adjacent lower slope. *Glomar Challenger* reflection profiles accurately depict the surface expressions of structural features that can be traced at depth on the multichannel reflection profile through the site (Fig. 4).

With the survey data we mapped the extent of the trench floor, folds in the trench fill, the base of the slope, a lower slope high and basin, and a prominent fault scarp located seaward of the lower slope high. The anticline on the trench floor closest to the base of the slope is more continuous and of greater amplitude, than the other anticline located farther seaward. Both folds mirror the sinuous shape of the base of the slope, apparently in response to the molding of weak sediment against the buttress of the lower slope. The underthrusting direction of the oceanic plate (038°) is approximately normal to the local trend of the lower slope, minimizing the development of en echelon fold patterns due to oblique convergence.

The lower slope high and basin are well defined near Site 488 and to the southeast but become much less prominent to the northwest. A scarp (Fig. 4) lies less than 0.5 km seaward of the lower slope high adjacent to and southwest of Site 488; to the northwest the scarp could not be resolved, though it may be present. The continuity and length of the scarp suggest that it may be due to faulting (thrust or reverse?) rather than to surficial slumping.

The site survey was completed coincidentally with the repair of the electrical and hydraulic systems. Following the pipe trip, the "mudline" core established the water depth at 4265 meters, 1 meter deeper than the PDR reading. Low core recovery and penetration rates plagued the coring operation almost from the beginning. Quaternary clays and silty clays were cored to depth of 313 meters below the mudline, where loose sand was encountered. Drilling rates suggest this principal sand interval totals about 20 meters in thickness, but thinner sand strata occur, interbedded with clay and claystone to total depth. Hole-cleaning problems began when the bit plugged on the retrieval of Core 43 from 400 meters below the mudline. We cleaned the bit by working the pipe in the hole; an abnormally large batch of bentonite mud was circulated to clean the hole. Another core was cut, but the inner core barrel stuck and was freed only

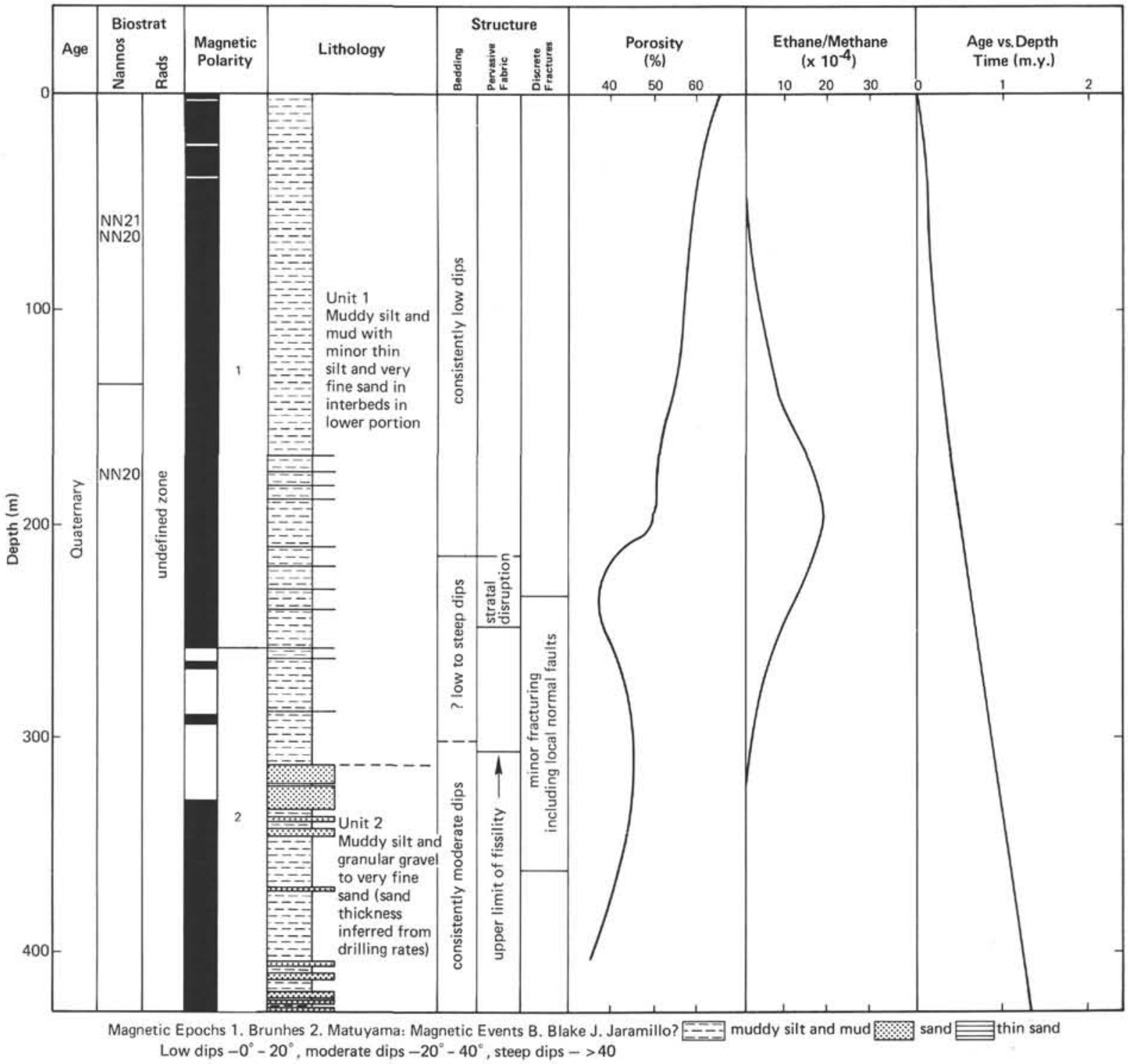

Figure 1. Site summary diagram.

with great difficulty on the third sandline attempt. Another attempt was made to clean the hole with slugs of bentonite and high-viscosity cross-linked guar gum. The core barrel stuck again temporarily following Core 45, and drilling was terminated after Core 46. Prior to core retrieval we slugged the drill pipe with 30 barrels of weighted mud to prevent backflow, but the barrel again stuck. The safety shear pin sheared on the first sandline run, and, on the second attempt to free the barrel, the sandline parted about 40 meters above the sinker bars. Chances of fishing the short length of broken line and then freeing the stuck barrel were considered extremely slim. As the core barrel annulus was packed off with sand, it was impossible to circulate mud or cement to plug the hole. It was also necessary to cancel plans for logging.

The drill string was retrieved and the inner barrel, with core, was extricated with great difficulty. The *Challenger* departed Site 488 at 1645 hours, April 2.

LITHOLOGIC SUMMARY

Site 488 is located at the base of the lower slope on the crest of the first ridge landward of the Middle America Trench. We began drilling at a water depth of 4265 meters and penetrated 428 meters of Quaternary sediments. Because Site 488 was not logged, lithostratigraphic units (Fig. 5, Chart 1, back pocket) are defined on the basis of major lithologic changes in the cores, though in Unit 2, variations in drilling rate (Fig. 6) are used to enter the extent of sand beds.

Unit 1, Quaternary (Cores 1–35, 0–313 m sub-bottom), is predominantly dark greenish gray (5GY4/1) to greenish black (5G2/1) muddy silt and mud, with occasional thin silt and muddy sand interbeds between 153 and 265 meters. Diatomaceous or siliceous mud or muddy silt occurs at 29.5 to 39, 58 to 73.3, and 143.5 to 143.8 meters. Parallel lamination is common above and infrequent below 40 meters. Moderate to intense mot-

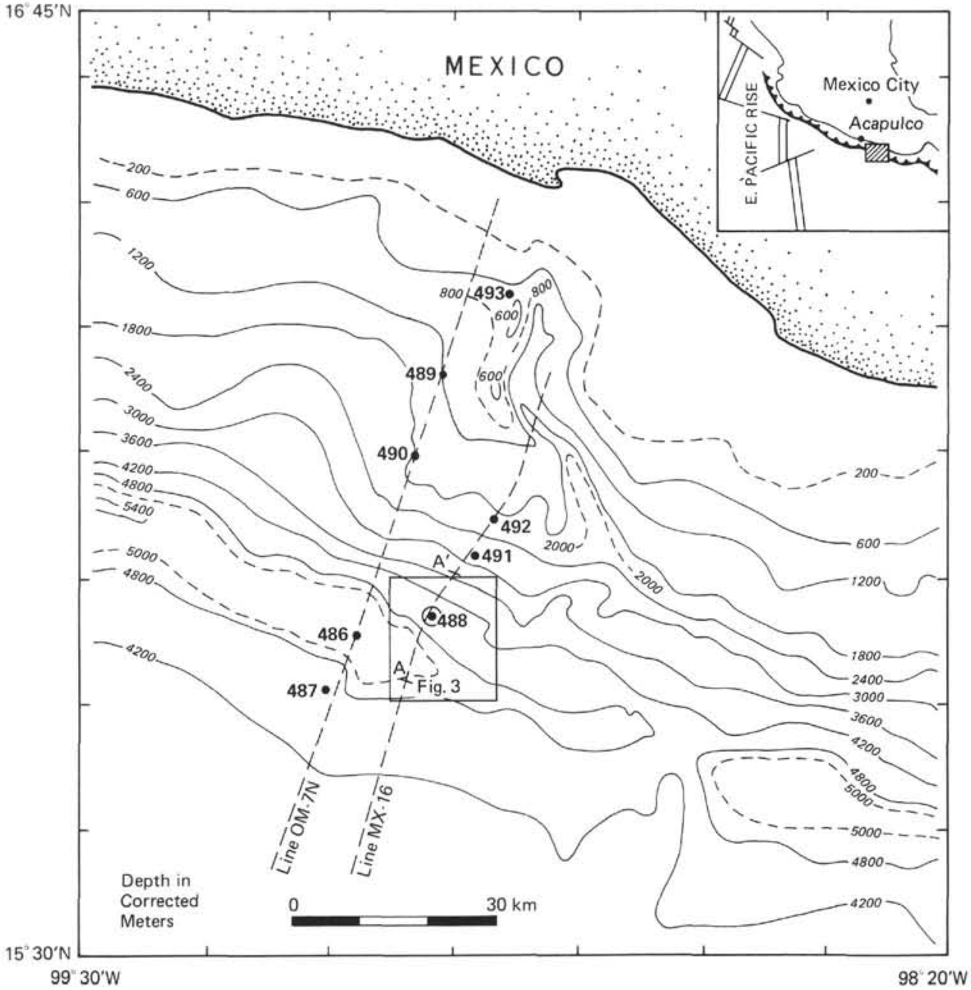

Figure 2. Generalized location map for Site 488. Detailed bathymetry adjacent to site shown in Figure 3. Section A-A′ is shown in Figure 4.

tling is infrequent, despite the fact that the basal 30 meters of this unit are moderately to intensely bioturbated. Graded bedding appears only in minor silt beds between 211 and 237 meters.

The dominant lithology is muddy silt, except for an interval of mud at 20 to 59 meters. Dominant minerals are quartz (30%–75%) and/or clay minerals and irresolvable clay-size material (5%–50%), with feldspar ranging from 1% to 15%. Mica flakes and plant fragments range from 1% to 5% and 1 to 4%, respectively, and heavy minerals generally comprise no more than 1%. Volcanic glass is very abundant (30%–40%) in the uppermost meter, which is vitric clay to clayey ash, but decreases in abundance rapidly down-section, where it comprises no more than 5% of the sediment, except in infrequent thin ash layers. Diatoms, sponge spicules, and other siliceous biogenic material comprise up to 22% of the sediment in diatomaceous mud/muddy silt intervals and generally range from 1% to 5% elsewhere. Calcareous biogenic material is never more than a trace component. Thin, discontinuous layers of authigenic mineral grains (zeolite?) occur at 109.2, 270.8, and 297.2 meters.

Unit 2, Quaternary (Cores 35–46), 313–428.5 m sub-bottom), contains significant amounts of pebbly to fine sand, in addition to muddy silt similar to that of Unit 1. Loose sand caused poor recovery below 313 meters and forced early termination of the hole. The recovered sediment is sufficient to characterize this unit, and the location and thickness of major sand intervals have been estimated from accelerated drilling rates (Fig. 6). Each inferred sand interval is represented partially by cored sand or by an interval of recovery in the cores. The sand to mud ratio appears generally to increase upward through Unit 2 (Fig. 5).

The recovered sands range from medium light gray (N6) coarse granular gravel to pebbly sand (granules up to 7 mm) (Fig. 7), through medium light to medium dark gray (N6 to N4) medium to coarse sand, to medium to dark greenish gray (5G 5/1 to 5GY 4/1) fine to medium sand. The two major sand intervals, 55 cm at 313 meters (Core 35) and 3.5 meters at 409.5 meters (Core 45), are graded, probably as a result of settling of loose sand in the core barrel. In fact, the 3.5 meters of sand at 409.5 meters may represent material caved from higher in the hole.

Of the two thinner sands recovered, a 10-cm bed at 401.7 meters displays a sharp base and slightly gradational top but no grading, and a 15-cm bed at 19.35 meters is slightly finer-grained in the top 3 cm. Smear

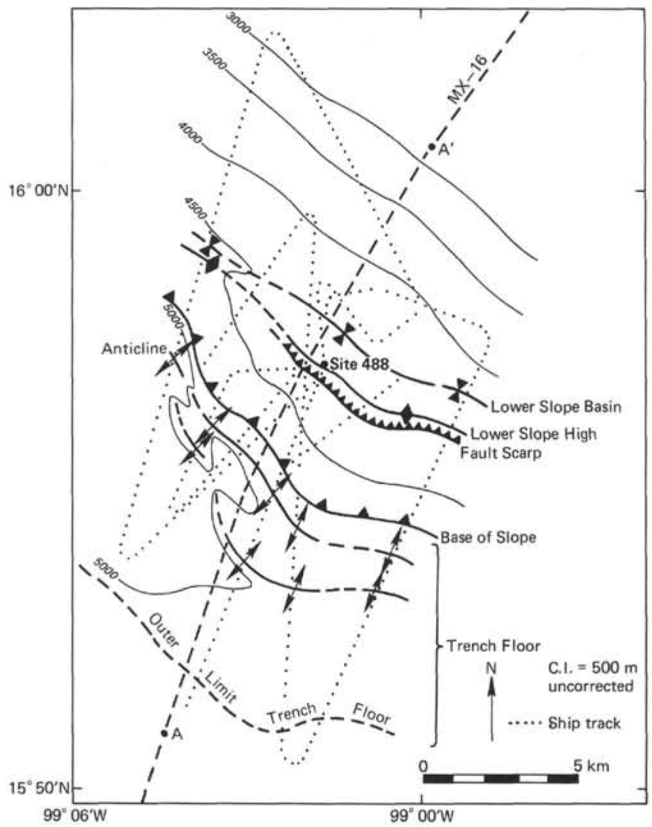

Figure 3. Tectonic features of trench and lower slope in vicinity of Site 488. Dashed line (Line MX-16) adjacent to Site 488 represents multichannel reflection profile (Fig. 4). Dotted lines show *Glomar Challenger* ship track during site survey.

slides indicate that finer portions of the sand beds are approximately 95% quartz with minor feldspar and traces of mica and heavy minerals. Macroscopically the coarser sand fraction appears more heterogeneous than the fine sand, with a higher content of lithic fragments.

The sands of Unit 2 occur as interbeds in grayish olive green (5GY 3/2) to olive black (5Y 2/1) muddy silt to muddy siltstone, with minor mud intervals and thin (0.5-3 cm) layers of silt to coarse sand. Parallel lamination is infrequent, and occasional beds are graded or moderately bioturbated. Compositionally the fine-grained sediment of Unit 2 is characterized by quartz (45% to 90%) and/or clay minerals plus irresolvable clay size material (40%), with minor feldspar (5%-10%), mica (3%-5%), and plant fragments (2%-10%). Heavy minerals make up no more than 1% of the total, volcanic glass and siliceous biogenic material are present only in trace amounts, and calcareous biogenic material is absent.

Deformation

The upper 210 meters of Unit 1 display nearly horizontal bedding where not deformed by drilling. Beds between 210 and 240 meters are tilted, without apparent regularity, with apparent dips ranging up to 61° (see Fig. 5, back pocket). No conclusive evidence of overturned bedding has been found at any point in the section, but top indicators are rare.

Sediments from 220 to 240 meters exhibit deformation characterized by healed fractures that truncate bedding, producing wispy, discontinuous blebs and stringers of silt within a matrix of muddy silt (Lundberg and

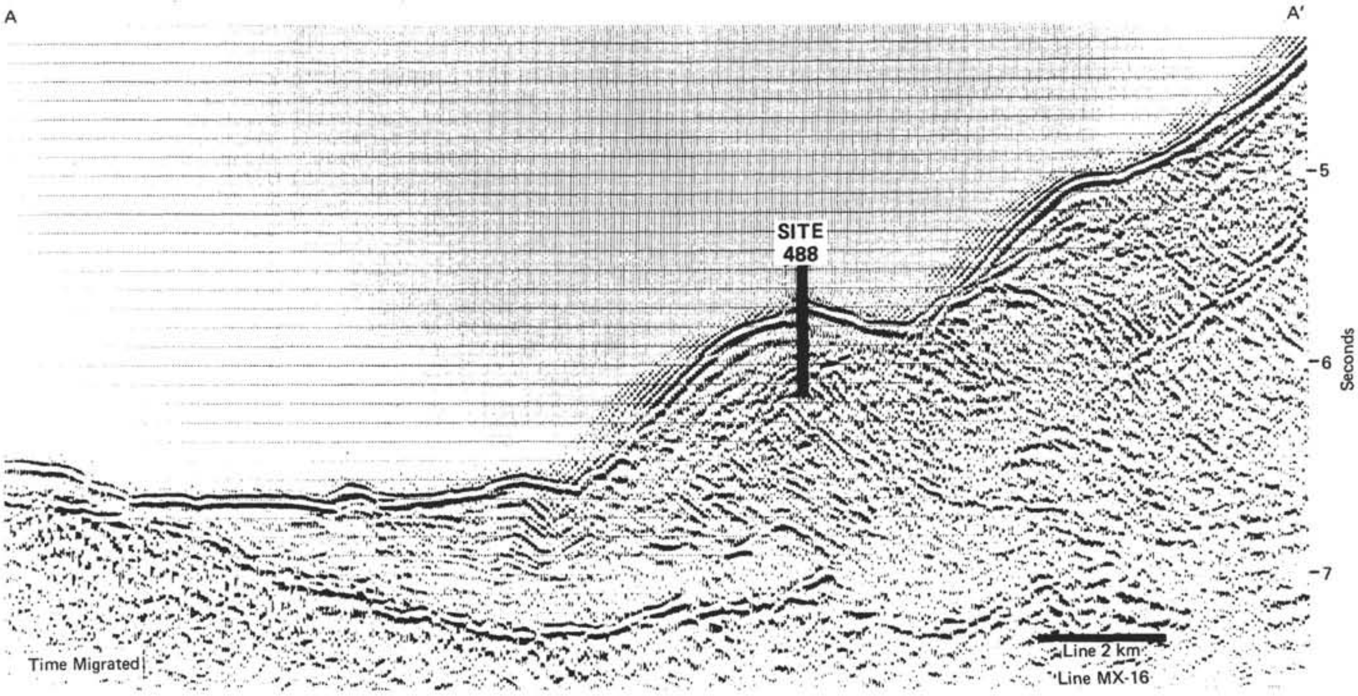

Figure 4. Multichannel reflection profile (migrated time section, Line MX-16, A-A′) adjacent to Site 488. See Figure 2 for location (after Shipley, this volume).

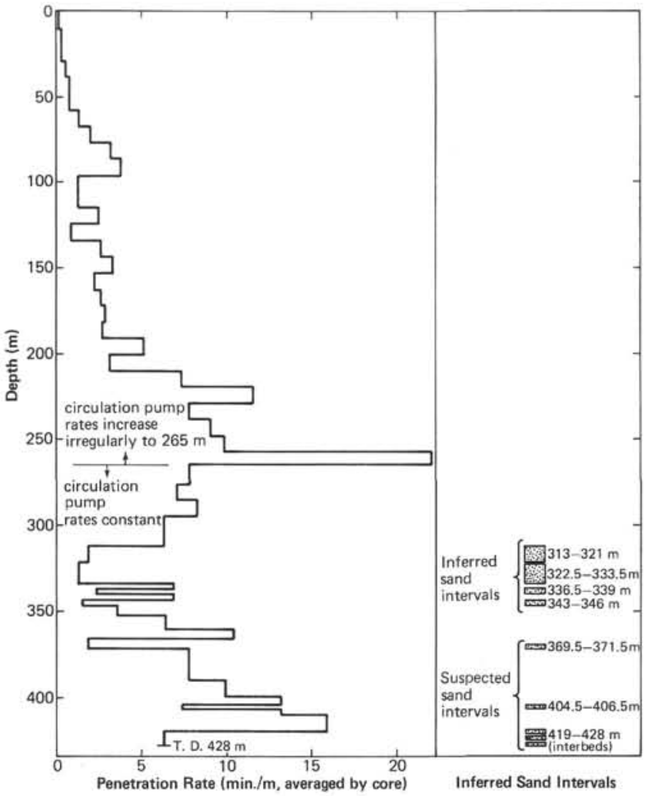

Figure 6. Penetration rate, Site 488 (sand intervals inferred from drilling rates).

Moore, this volume) (Fig. 8). Nearly horizontal thin dark laminations occur at 210 to 220 meters and probably reflect only rotation during drilling, but fractures below 220 meters are distinctly inclined and probably represent primary deformation of poorly consolidated sediments. This zone of deformation corresponds to a rapid increase in bulk density and a decrease in porosity.

A breccia composed of loose angular chips of indurated muddy siltstone at 260 to 262 meters may be a drilling artifact. However, these are cemented locally, suggesting a primary origin for the breccia.

Bedding planes in Unit 2 are tilted up to 47° (Fig. 5). back pocket). Shipboard paleomagnetic work indicates that tilted beds at 382.56, 383.05, and 391.86 meters dip northeast, as do seismic reflectors at this depth (Fig. 4). Microfaults offset bedding below 363 meters, and an incipient fissility subparallel to bedding is developed in firm muds and muddy silts below 381 meters.

Conclusions

Unit 1 generally lacks evidence of deposition by turbidity currents and is interpreted as a hemipelagic sediment blanket. The abundance of quartz-rich silt, clay, and fine sand suggest derivation from the continental crystalline basement complex of southwestern Mexico.

Unit 2 may represent uplifted trench deposits or coarse-grained channel-related deposits of the trench slope. No present-day channel exists on the slope which

Figure 7. Very coarse sand-granular gravel from Unit 2, Sample 488-45-3, 35–55 cm (413 m sub-bottom). This sediment type is among those interpreted as uplifted trench deposit.

Figure 8. Stratal disruption in silt layers in matrix of muddy silt, Unit 1 at 238 meters (Sample 488-26-6, 130–150 cm). Stratal disruption shown here occurs in interval with anomalously low water content and high ethane concentration suggestive of faulting. Drilling laminations locally cut across the fabric of stratal disruption, suggesting the latter is of natural origin. See Lundberg and Moore (this volume) for a petrographic description of this deformational fabric.

could transport coarse detritus to the site location (Figs. 2, 3). In fact, a prominent ridge 30 km north-northeast of Site 488 (Fig. 2) effectively protects Site 488 from any coarse material funneled into the major canyon of the area. Although we cannot totally preclude the possibility of a slope channel through the site, the simplest explanation is that the thick, coarse sand and muddy silt beds of Unit 2 were deposited in the trench, then uplifted to their present position. The Quaternary hemipelagic slope apron sediments of the lower portion of Unit 1, which are dewatered and deformed and include a few sand beds, probably represent a transitional zone between the slope blanket and the underlying zone of dipping reflectors.

BIOSTRATIGRAPHY

A summary of Site 488 biostratigraphy is shown in Figure 1. The extinction level of the radiolarian *Axoprunum angelinum* (0.4 m.y. old) occurs at 160 meters. The presence of *Gephyrocapsa oceanica* to the base of the hole indicates a maximum age of middle Quaternary. The benthic foraminiferal data suggest that downslope transportation of shelf and slope faunas has occurred at Site 488. These redeposited shelf faunas are dwarfed. The partial dissolution of larger planktonic foraminifers is caused by deposition below the CCD (calcite compensation depth), but the good preservation of smaller planktonic and benthic material shows that rapid burial also occurs.

Radiolarians

Radiolarians are common in Cores 1 to 13. Below Core 13, they decrease in abundance because of terrigenous sediment dilution, and in Cores 24 through 29 they are virtually absent. Cores 30 to 33 have a common, well-preserved assemblage, but from Core 34 to the base of the hole in Core 45, only a few poorly preserved radiolarians occur.

No sediments older than Quaternary have been identified at Site 488. Only one recognizable datum—the *Axoprunum angelinum* extinction at 0.4 m.y.—occurs between Cores 18 and 19. Nigrini's (1971) tropical zonation cannot be applied at Site 488 because of the very low abundance of the shallow-water collosphaerid indicator species *Collosphaera tuberosa* and the absence of *Buccinosphaera invaginata*. On the other hand, Hays's (1970) north Pacific zonations are usable because of the abundance of *A. angelinum* below Core 18. *Eucyrtidium matuyami* also seems to be present, although only reworked specimens are noted. Nigrini's zonation works well for the middle Quaternary because *C. tuberosa* is present.

Reworked radiolarians present at Site 488 include late Miocene and Pliocene *Ommatartus hughesi* and *O. penultimus*.

Foraminifers

At Site 488, the greenish gray laminated silty mud facies (Cores 1–36) contains scarce foraminifers only, as in the case of Sites 486 and 487. The sand fraction in core catcher samples consists mainly of terrigenous material. It includes abundant organic matter such as plant fragments and some molluscan debris as well as pyritized tube-like burrows and pyrite grains.

Planktonic Foraminifers

Rare planktonic foraminifers, recovered in core catcher samples of Cores 1 through 25, indicate a Quaternary age. Cores 26 through 46 are barren of planktonic species. Typical representative species include: *Neogloboquadrina dutertrei, Globorotalia tumida, G. mendardii, Globigerinoides ruber, G. triloba, Globigerina bulloides, G. falconensis*, and *Globigerinita glutinata.*

Depositional Environment

The planktonic foraminiferal assemblage indicates tropical and subtropical water masses. Some large planktonic species such as *Globorotalia menardii* and *G. tumida* are often partially dissolved, suggesting deposition below the CCD. On the other hand, well-preserved, small, and solution-susceptible species such as *Globigerinoides ruber* may indicate redeposition and burial below the CCD of shelf-living species. A similar process of redeposition of calcareous microfossils below the CCD occurs in Alpine flysch basins (Butt, in press).

Benthic Foraminifers

Small thin-walled benthic foraminifers sporadically occurring in samples 488-1,CC through 488-29,CC and in 488-32,CC, 488-40,CC, and 488-42,CC represent a displaced dwarfed assemblage. They include *Bolivinia, Gavelinella, Cassidulina, Gyroidina, Eponides, Nonion, Polymorphina*, and miliolids. Upper and middle slope reworked species include *Oridosalis umbonatus, Melonis pompilioides, Cibicidoides, Uvigerina peregrina, U. proboscidea*, and *U.* aff. *senticosa*. Absence of *in situ* benthic foraminifers in the sediments, however, may be due to sediment dilution or to relatively stagnant bottom conditions.

Calcareous Nannoplankton

Quaternary sediments of Cores 1 to 46, which are characterized by high contents of mud, muddy silt, sand, and organic debris, contain a very low percentage of nannofossils. *Gephyrocapsa oceanica* occurs from Cores 1 to 46, with *G. omega, Helicosphaera carteri, Cyclococcolithus leptoporus*, and *Syracosphaera pulchra.* Very small coccoliths in Cores 1 to 4 are tentatively considered to be *Emiliania huxleyi*. Thus Cores 1 to 4 are tentatively assigned to nannoplankton zone NN21 (late Quaternary). Cores 5 to 46 containing *G. oceanica*, and no *E. annula* (= *Pseudoemiliania lacunosa*) are tentatively assigned to nannoplankton zone NN20 (middle to late Quaternary). *Ceratolithus cristatus* occurs in Core 16. The presence of *G. oceanica* at the base of Hole 488 indicate that the NN19 zone (earliest Quaternary) was not penetrated.

Silicoflagellates

Assemblages of rare silicoflagellates in Cores 13 and 16, mainly *Dictyocha fibula, D. aculeata, D. stapedia*, and *Actiniscus pentasterias* (= *Gymnaster pentasterias*), are assigned to the *D. aculeata aculeata* Zone (upper Quaternary).

Sponges

The remains of glass sponges, agglomerations of thousands of siliceous sponge spicules of uniform design, occur as white inclusions in the sediment several millimeters wide and one to three millimeters thick. These sponges are in place, killed by a subsequent influx of terrigenous sediment.

Tunicates

In Core 15,CC a single specimen of *Micrascidites* sp. proves the existence of tunicates in the Quaternary of Site 488.

Higher Plants

We observed organic matter, with cellular patterns still recognizable, as well as pollen grains and phytolitharians. Opal phytoliths, which are deposited in the interstitial spaces of grass blades, are sometimes found in their original assemblage. A palynological study might be useful in establishing other datum planes because pollen and spores are observed in smear slides.

SEDIMENT ACCUMULATION RATES

Sedimentation rates (Fig. 9) can be inferred from biostratigraphic and paleomagnetic data. One biostratigraphic level is the *Axoprunum angelinum* extinction (0.4 Ma) at a depth of about 160 meters. A paleomagnetic reversal at about 255 meters is probably the Brunhes/Matuyama boundary (0.70 Ma). Other paleomagnetic datum levels farther down Site 488 have not been used because of the structural complexity of the site and lack of biostratigraphic control. The rate of sediment accumulation, uncorrected for compaction or structural dip, is 420 m/m.y. Undetected repetitions of thrust faulted or slumped horizons may have increased this rate.

UPLIFT RATE

The rate of vertical section uplift (Fig. 10) is inferred from facies evidence only. The sands cored below 312 meters are presumed to have been deposited in the trench because of their similarity to modern trench sands recovered in this area in piston cores (McMillen and Haines, this volume) and at Site 486. Removal of the accumulated sediment above these sands results in vertical movement of 400 m/m.y. to bring these sand to their present level.

PALEOMAGNETISM

Paleomagnetic analyses at Site 488 established magnetostratigraphy, checked reliability of paleomagnetism in drilled sediments, and determined dips of certain beds. The paleomagnetic results are summarized here and documented in detail in a separate report (Niitsuma, this volume). Cores from the upper 50 meters of Site 488 were disturbed by drilling, with laminations concave down-

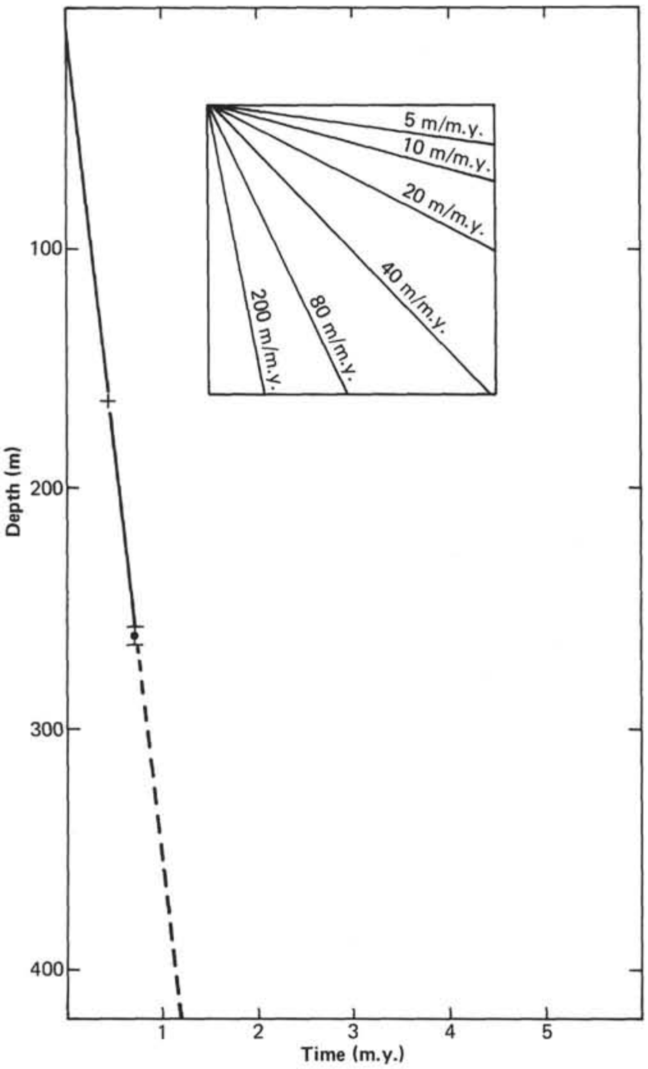

Figure 9. Sediment accumulation rate for Site 488. Rate uncorrected for either consolidation or tectonic tilt. Dashed portion is extrapolated.

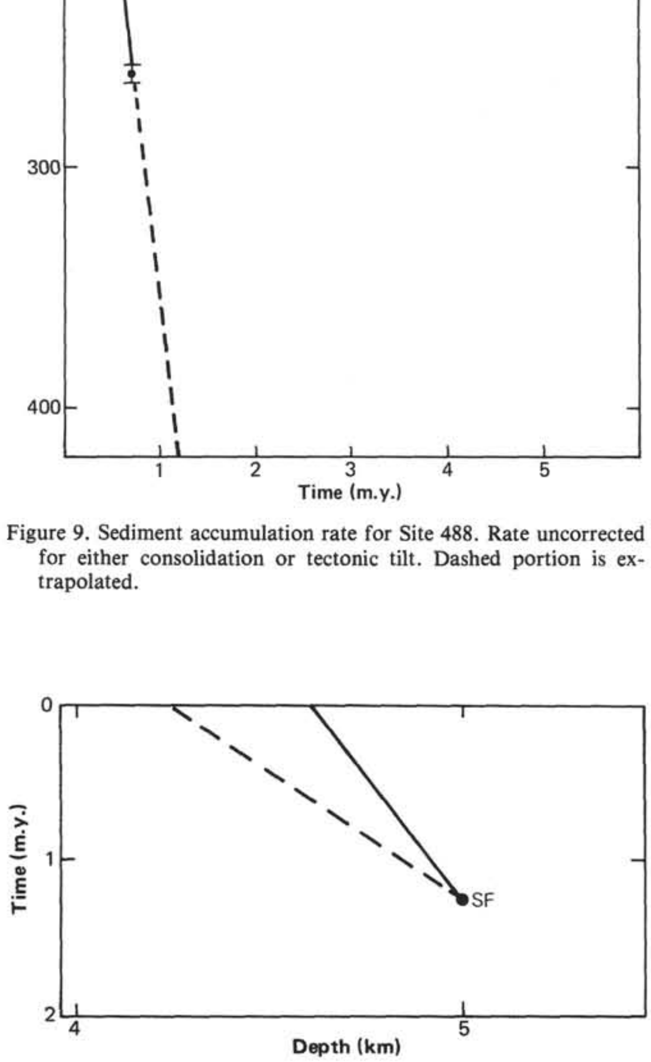

Figure 10. Paleobathymetry (dashed line) and vertical tectonics (solid line) for Site 488. Control point indicated is SF for sandy facies interpreted to be trench deposits. Curve for vertical uplift is derived from the paleobathymetry by removing the sediment accumulation at any given time.

ward along core tube margins. Cores from lower in the hole were less disturbed and generally showed original bedding. Dipping beds were observed in some areas. Seventy-four oriented samples were collected from less disturbed parts of cores. Stepwise AF demagnetization results of two selected samples of different sedimentary facies (black muddy silt and laminated muddy silt) show that both have stable direction of remanent magnetization during AF demagnetization (Niitsuma, this volume). All samples were cleaned with 15 mT AF demagnetization for elimination of unstable components. Noise level of the magnetometer was 0.05 to 0.10 $\times$ 10^{-6} emu/cc. Intensity of RM ranges from 0.05 to 111.4 $\times$ 10^{-6} emu/cc. Inclination values have been corrected for dips.

Changes in inclination suggest three magnetozones (Fig. 1). The upper magnetozone exhibits mainly positive inclination over its range (0–258 m). The upper part of the zone has three horizons in which inclination is negative; detailed sampling and measurements were made around those horizons. The thicknesses of the negative inclination intervals were limited to 2 cm, 4 cm, and 11 cm, respectively. Mean value and standard deviation of positive inclination are 33.53 $\pm$ 15.96°. The middle magnetozone exhibits negative inclination over its range (258–328 m). Mean inclination and standard deviation are $-27.48 \pm 21.54°$. In this zone there are two horizons of positive inclination, at 267 and 294 meters. The lower magnetozone shows positive inclination over its range (328 m to the hole bottom at 428 m) of 20.17 $\pm$ 7.27°.

The upper magnetozone correlates with the Brunhes normal polarity epoch and three short reversed polarity intervals with short events, established in Lake Biwa sediments (B, H, and I; K and L of Yaskawa et al., 1973). K and L of Yaskawa et al. (1973) correlates with the Blake Event; the middle magnetozone can be correlated with the later part of the Matuyama reversed polarity epoch. These correlations are supported by nannofossil data. The lower magnetozone could be the Jaramillo Event of the later part of the Matuyama Epoch.

In drilled sediments we can calculate the strike of a bed provided that the core axis is vertical, the bed not overturned, and the magnetic declination measurable. At Site 488 we made several such calculations. The lower part of the sedimentary sequence in Site 488 dipped 20° to 45° and did not appear overturned. The horizons of 383 meters and 392 meters were selected for orientation. Strike of bedding was N22.5 $\pm$ 4.2°W and dipped east-northeast. The eastward dip is consistent with seismic reflection data.

In the horizon of 383 meters, a conjugate minor fault set was found. The fault planes could be oriented as N54°W 68°NE and N40°W 61°SW. The stress field associated with the conjugate set can be calculated using the fault plane data and displacement along the faults. The compressional axis is almost vertical, the intermediate axis parallel to the Middle America Trench axis of N63°W, and the tension axis perpendicular to the trench axis.

ORGANIC GEOCHEMISTRY

At Site 488 the shipboard organic geochemistry program consisted of monitoring gases released in core liners, degasification of selected sediment samples, visual inspection for fluorescence in the split core, and carbon, nitrogen, hydrogen, and carbonate analyses of selected core samples.

Gases

Only minor amounts of gas occurred at depths greater than 10.5 meters. Gas was released in the core liners in moderate quantities, forming gas pockets and indicating that pore fluids were above gas saturation at ambient conditions. Degasification of sediments by high-speed blending and analysis of released adsorbed gases have a gas-generating ratio of 1.8×10^{-2} to 3.4×10^{-2} (vol. gas/vol. sediment), although a major part of the gas had probably been released earlier within the core liner.

Sampling and analysis of the core liner gas indicated the presence of air, methane, and CO_2. No H_2S or hydrocarbons heavier than C_2 were detected in significant concentrations. The composition of the gases varied with depth (Fig. 11), showing a methane content from 95.5% to 99.62% and a CO_2 content from 0.61% to 4.5% on an air-free basis. The air content varied from 18.2% to 78.8% and may have been affected by atmospheric contamination and indigenous nitrogen. The variations of CH_4 and CO_2 content with depth are roughly parallel, showing two relative maxima, at about 40 meters and below 260 meters (Fig. 11).

A detailed gas analysis on a Hewlett Packard 3750 gas chromatograph indicated trace amounts of hydrocarbons in the C_2 to C_5 range; ethane (C_2) is most abundant, occurring in concentrations up to 12.1 ppm by volume with the heavier hydrocarbons (C_3–C_5) near the detection limit. The ethane concentration varies with depth, reaching a maximum in the 180 to 240 meter zone (Fig. 11).

The overall gas composition suggests a biogenic origin and a mild geothermal history. The ethane maximum at 180 to 240 meters coincides with deformed sediments and a water content minimum in the 200 to 250 meter interval. The ethane peak may be displaced to shallower depths because of the ease of migration of the hydrocarbons along a fault in or near the deformed sediment sequence.

Fluorescence

Split cores showed no evidence of crude oil and/or bitumen impregnation. Sporadic fluorescent (white) droplets and superficial fluorescent stains observed on the surface of the cores and the core liners were probably due to contaminants from drilling fluids.

Organic Carbon, Hydrogen, Nitrogen, and Carbonates

A sample from each core was taken for CHN analysis and analyzed as described in the Site 487 Site Chapter. The organic carbon content varies from 1.03% to 2.61% and the total nitrogen content from 0.05% to 0.24% (Fig. 11). The organic potential of the sediments ranges from good for the upper sedimentary unit to intermediate for the lower sedimentary unit and may be explained in part by the high sedimentation rates (420 m/m.y.). Both carbon and nitrogen content decrease with depth. The C/N ratio varies from 11.2 to 24.1, which is in the range for organic matter associated with recent sediments (Fairbridge, 1972) and suggests a low degree of geothermal maturity. The C/N ratio remains

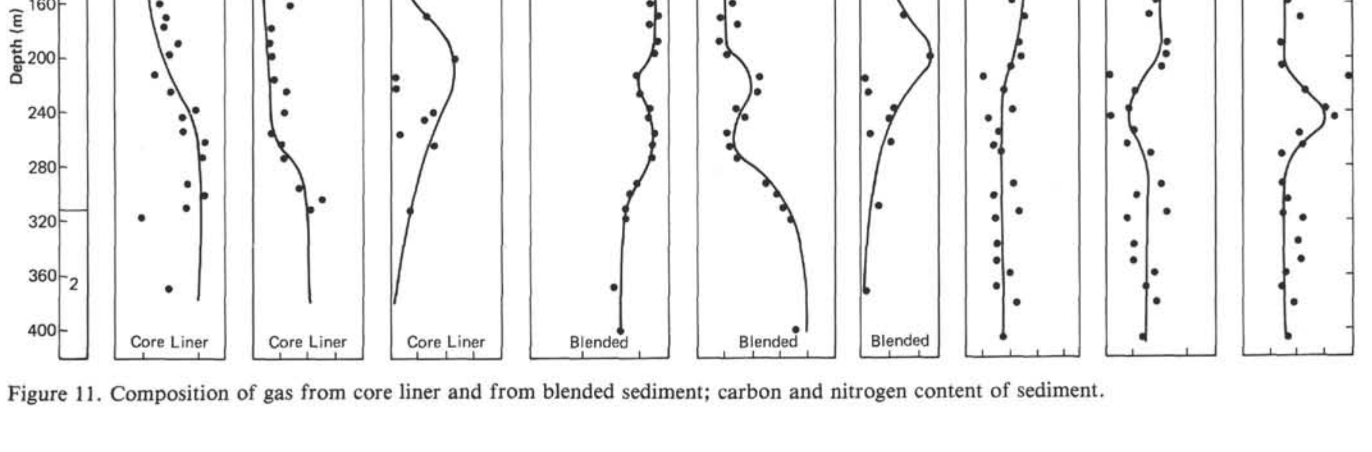

Figure 11. Composition of gas from core liner and from blended sediment; carbon and nitrogen content of sediment.

fairly constant with depth at about 12 meters except for a distinct maximum in the 200 to 250 meter interval, correlating with anomalies in ethane concentration, physical properties, and deformation. The carbonate content varies from 0 to 6% ($CaCO_3$ equivalent) and shows carbonate-free sections at 200 and 290 meters.

Conclusions

Hydrocarbon gases, probably of biogenic origin, causing low to moderate degasing of cores, occur throughout the cored sequence. There is no evidence of petroleum impregnation and/or fluorescence. The organic potential of the cored sediments varies from intermediate to good, and the C/N ratio of the organic matter suggests a low degree of geothermal maturation. Anomalies in ethane content occur at about 200 to 250 meters and correlate with an interval of deformed sediments and low water content.

PHYSICAL PROPERTIES

Site 488 physical property analyses included porosity, water content, bulk density, and undrained shear strength (Fig. 12) (see Boyce (1976) for a description of procedures). Attenuation of the sonic signal by gas precluded compressional sound velocity measurements.

Site 488 physical properties appear uniformly gradational to 200 meters sub-bottom. No significant anomalies occur that can be correlated with the thrust fault apparent on the site survey seismic profile (Shipley, this volume). However, below 200 meters abrupt changes in these properties suggest sediment deformation by either tectonic or mass movement processes (Fig. 12). Both processes result in rapid dewatering with attendant variations in bulk density and porosity (Moore and Karig, 1976; Woodbury et al., 1978). General trends in these properties, based on gravimetric data only, are summarized in the following section. To be consistent with other DSDP reports, we present GRAPE data as well as gravimetric data (Fig. 12), although we have less confidence in the former. The porosity profile presented in the Site 488 summary diagram (Fig. 1) represents a visual best fit line using porosities determined gravimetrically.

Porosity, Water Content, and Bulk Density

Porosity decreases from 65% at 12 meters to 48% at 200 meters (Fig. 12). Below 200 meters, porosity fluctuates, decreasing (36% at 235 m), gradually increasing (44% at 310 m), then finally decreasing (38% at 400 m). Water content decreases from 47% at 12 meters to 14.5% at 235 meters sub-bottom. Below 235 meters water content increases at 33% at 300 meters, then decreases to 15% at 400 meters. Bulk density increases from 1.53 Mg/m^3 at 12 meters to 1.75 Mg/m^3 at 200 meters sub-bottom (Fig. 12). Below 200 meters density abruptly increases to a maximum of 2.05 Mg/m^3 at 235

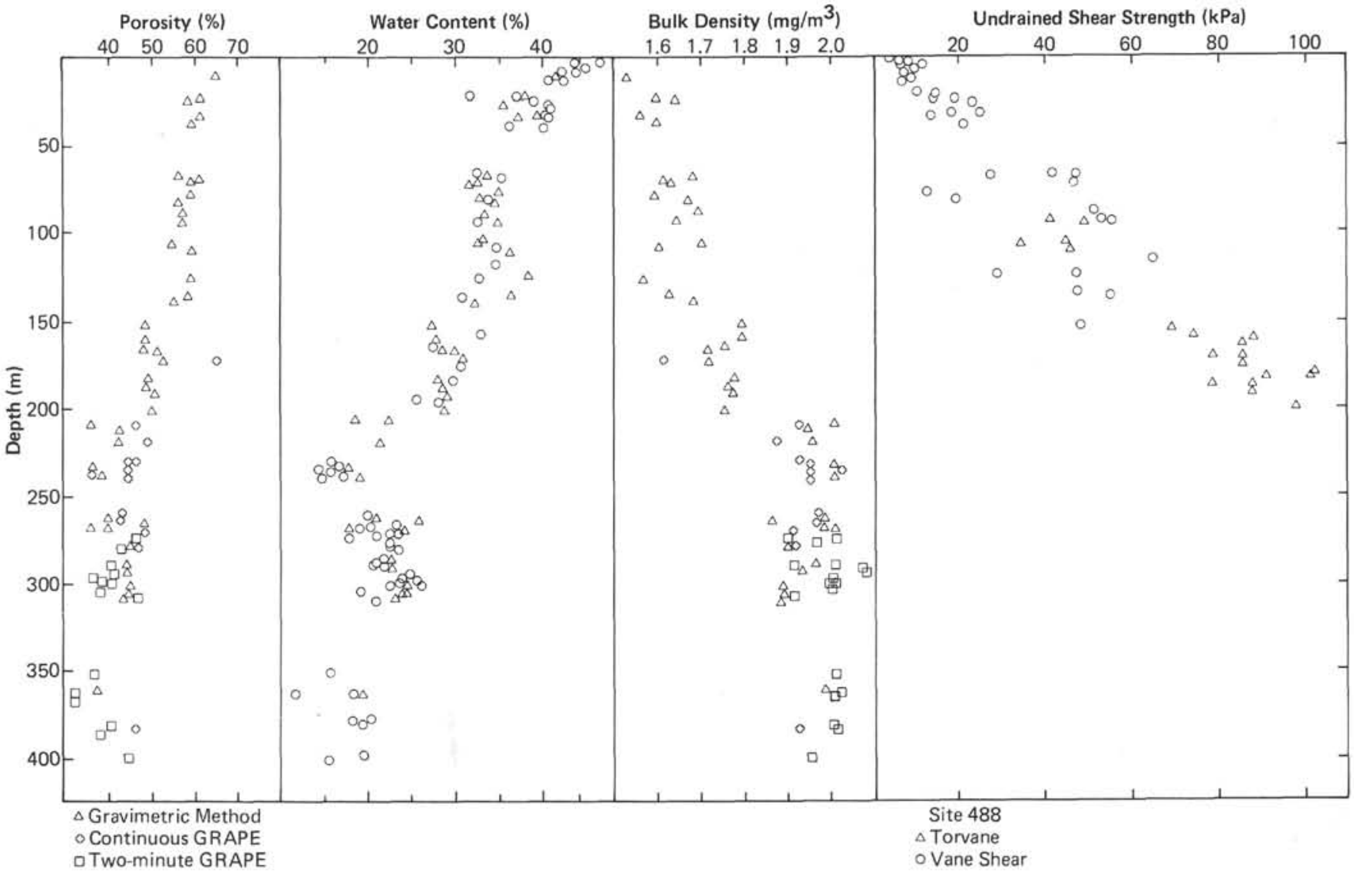

Figure 12. Physical properties summary profiles, Site 488.

meters, decreases to 1.88 Mg/m^3 at 310 meters, and then increases to 1.98 Mg/m^3 at 400 meters. Increased scatter in these profiles below 200 meters reflects varying amounts of silt and fissility.

Shear Strength

Shear strength increases uniformly from 4.4 kPa at 3.3 meters to 98 kPa at 202 meters (Fig. 12). Failure by cracking below 202 meters prevented further shear strength measurements.

Inhole Temperature Measurements

The possible occurrence of gas hydrates in the Mexican Middle America Trench transect (Shipley et al., 1979) makes it desirable to measure the thermal gradient. When compared to the known temperature conditions of hydrate stability, these data will help evaluate the possibility of gas hydrates occurring offshore Mexico. Langseth and Von Herzen's (1970) $5° \times 5°$ averages of the world ocean heat flow show a thermal gradient of about 1.4°C/100 m for this area. Shipley and others (1979) have estimated the minimum thermal gradient at 2.1°C/100 m, derived from the depth to the base of the suspected hydrate zone and the temperature and pressure relationships of hydrate stability. We had three temperature measurements in Hole 488 in an attempt to determine the actual thermal gradient, using the Uyeda Probe (see Shipley and Shephard, this volume).

Only the second run, at 162.5 meters sub-bottom, was successful, because the probe malfunctioned once and once failed to seat into bottom sediments. A gradient of 3.9°C/100 m was calculated from this run. Thermal conductivity was not measured on any core because of the gassy conditions in the upper part of the hole and sandy and often disturbed conditions in the lower part of the hole.

CORRELATIONS OF SEISMIC REFLECTION DATA AND DRILLING RESULTS

Site 488 lies along the crest of a lower slope high just landward of a fault scarp exposed at the surface (Fig. 4). Although poorly determined, the minimum average velocity of the drilled section is probably no less than 1600 m/s. Thus the 429 meters of sediment penetrated at Site 488 equals about 0.54 s of two-way travel time. The minimum penetration depth is shown in Figure 4, a seismic profile approximately 300 meters to the northwest of the site. An interpretation (Fig. 13) of this seismic profile suggests that the first two or three reflections result from source reverberations. An obviously coherent, nearly horizontal reflection occurs at 0.30 s sub-bottom (about 232 m). This reflection correlates well with the decrease in water content observed at about 225 meters (Shephard, this volume) and with the peak in ethane concentration although its geologic significance is unknown.

At about 0.4 s (320 m) an indistinct boundary separates landward-dipping reflections below from an area of incoherent reflections above. This seismic boundary correlates with the first occurrence of thick sand beds at 313 meters. The upper limit of landward-dipping reflections may approximate the boundary between accreted trench deposits and deformed and undeformed slope deposits above.

A thrust(?) fault identified by the geometry of reflections and surface offset of 50 meters was penetrated at about 0.15 s (120 m). The fault does not have a seismic expression at the location of the drilled section, and there is no obvious break in lithology or physical properties.

SUMMARY AND CONCLUSIONS

At Site 488 on the lower slope of the Middle America Trench we penetrated 429 meters and recovered 46 cores comprising two lithologic units. Unit 1 consists of 313 meters of lower-middle to upper Quaternary muddy silt and mud with local thin silt and muddy sand beds in its lower portion. Lower-middle Quaternary muddy silt-siltstone, sand, and granular gravel of Unit 2 extends from 313 to 428 meters. In spite of poor recovery, variations in drilling rates suggest several thick (8–9 m) sand beds near the top of Unit 2 with thinner sand beds at greater depth. Methane, ethane, and carbon dioxide were detected throughout both units, causing mild to moderate degassing of the cores.

The coarse sands of Unit 2 must have accumulated in a major turbidite channel or depositional basin. In view of the similarity between these sands and deposits cored at Site 486 in the trench and the absence of a large turbidite channel or basin near the site, we interpret Unit 2 as an uplifted trench sequence. Furthermore, the virtual absence of significant sand beds in slope cores from the entire site survey area (McMillen and Haines, this volume) as well as the probable topographic diversion of downslope sand transport from the site, argue against accumulation of Unit 2 sands on the slope. Deposition of these sands on the slope would require major alterations in geomorphology within the last one million years.

The uniform hemipelagic muds of the upper portion of Unit 1 probably accumulated at about their present position on the lower slope. The thin silt and sand beds of the lower portion of Unit 1 require a nearby conduit intermittently supplying relatively coarse material. As such, the lower portion of Unit 1 probably accumulated when the underlying Unit 2 was slightly elevated from the trench floor but still received fine-grained turbidites.

Whereas the uplifted trench sediments at Site 488 provide general information on the kinematics of this subduction zone, specific data on deformation of slope and trench sediments may be gleaned from the recovered cores. The upper 210 meters at Site 488 display nearly horizontal bedding except where deformed by drilling. Dips averaging 30° to 45° are common in Unit 1 from 210 to 265 meters. Sediments from 210 to 240 meters are characterized by variable dips and by healed fractures that truncate bedding, producing wispy, discontinuous blebs and stringers of silt within a matrix of muddy silt. Dips in Unit 2 average about 30° and are more consistent than those in Unit 1. Cores showed no evidence of overturned bedding at Site 488, but top indicators are rare.

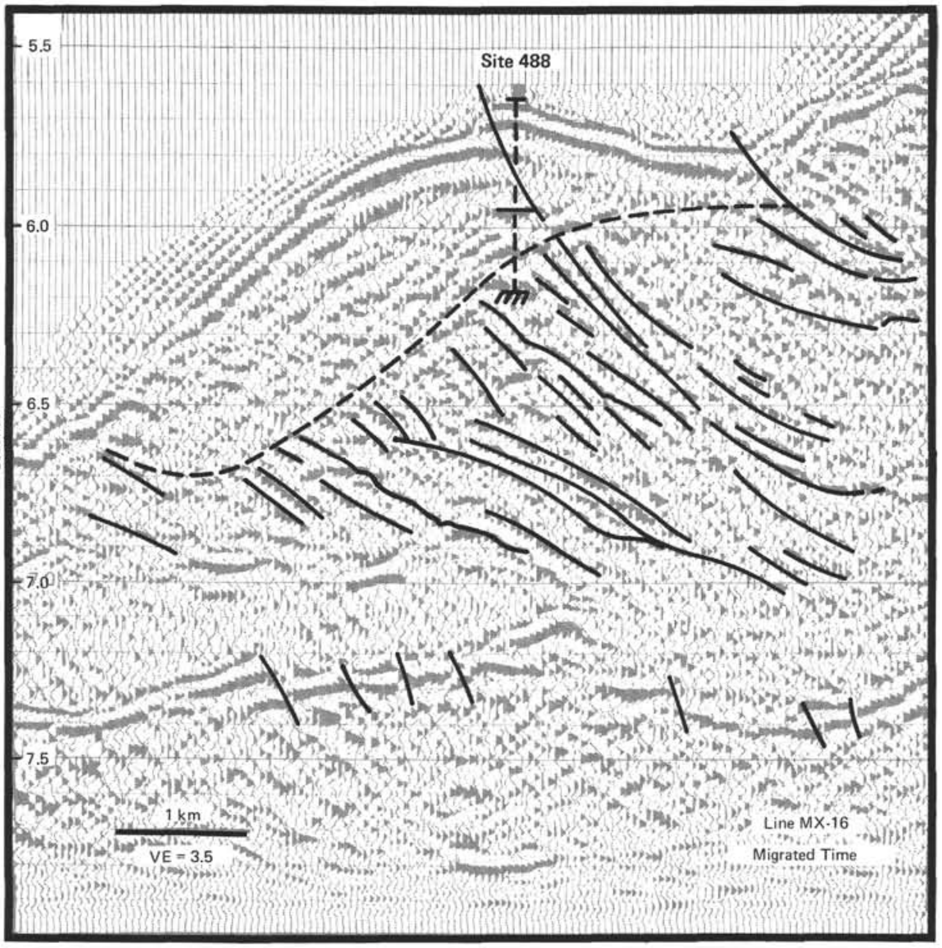

Figure 13. Highly interpreted version of Line MX-16 near Site 488.

In places, the lower portion of Unit 1 is as deformed as Unit 2, judging from the dipping beds and small-scale features. The similar structural development of these two units is consistent with the deposition of the lower portion of Unit 1 over modestly folded and elevated trench deposits near the base of the trench slope. The gradual decrease in deformation up-section in Unit 1 is due to decreasing age of the sediments and possibly to lessened intensity of deformation landward of the trench.

Correlation of seismic reflection profiles and drilling results suggest that Unit 2 is composed of a series of landward-dipping reflectors (Fig. 13). Dips measured in the cores are steeper than the dip of the landward-dipping reflectors, although these reflectors may be due in part to the thick sand and mudstone beds whose bedding attitudes are not resolved in the cores. If this is the case, the steeper dips in the cores would have to represent small-scale acoustically irresolvable deformation that is disharmonic with respect to the overall structural fabric.

The continuity of the scarp seaward of Site 488 and its parallelism to the lower slope high suggest tectonic origin and argue against the influence of localized slumping. The seismic data suggest this surface scarp may project at depth as a thrust fault and intersect the drilled section at about 120 meters below the mudline. However, we determine no resolvable biostratigraphic or lithologic change at this depth; hence, if faulting is present it is of small displacement and masked by the high sedimentation rates and monotonous lithology of the young slope deposits.

Although we have geophysical but no drilling data supporting faulting at 120 meters, between 200 and 250 meters anomalies in porosity, ethane concentration, and small-scale deformation suggest faulting. These features correlate with a strong horizontal reflector that is not obviously related to any of the inferred fault system of the seismic reflection profiles.

We have with reasonable confidence differentiated trench and slope sequences at Site 488. Both the uplift of these trench deposits and their association with landward-tilted reflectors agree generally with the accretionary model of trench slope evolution (Karig, 1974; Seely et al., 1974).

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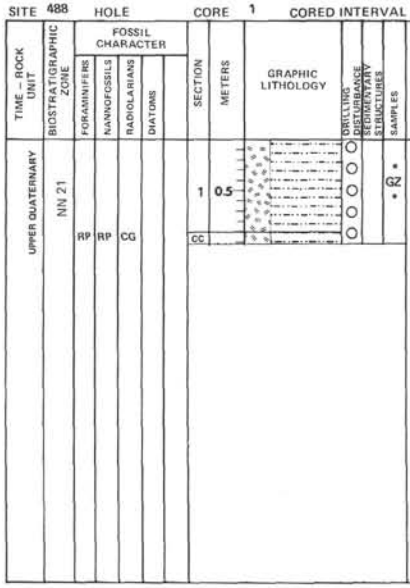
SITE 488 HOLE CORE 1 CORED INTERVAL 0.0–1.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT and MUDDY ASH, olive black (5Y 2/1).

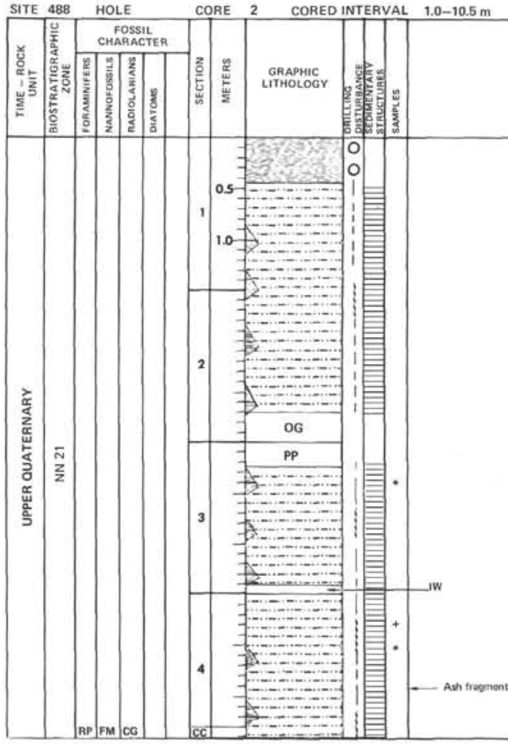
SMEAR SLIDES

	Clayey ash	Vitric clay
	1-30 (D)	1-60 (D)
TEXTURE:		
Sand	1	2
Silt	9	38
Clay	90	60
COMPOSITION:		
Quartz	10	18
Feldspar	–	5
Mica	2	2
Heavy minerals	–	TR
Pyrite	46	45
Glass	40	30
Nannofossils	TR	TR
Radiolarians	TR	1
Diatoms	TR	1
Sponge spicules	–	1
Plant fragments	2	–

GRAIN SIZE

	1-40
Sand	3.1
Silt	64.3
Clay	32.6

SITE 488 HOLE CORE 2 CORED INTERVAL 1.0–10.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, greenish black (5G 2/1) with thin (0.5–1.0 cm) parallel laminations of olive black or black (N1) mud throughout core. Black mud is rich in carbonized plant debris. Interbedding is shown diagrammatically; roughly two-thirds of the core is muddy silt, in laminations of 1.0–2.0 cm; one-third is mud in thinner laminations (0.5–1.0 cm).

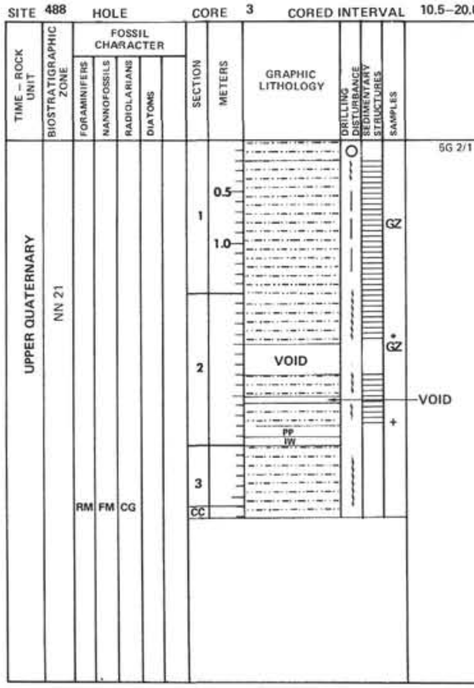
SMEAR SLIDES

	Mud	Muddy silt
	3-40 (M)	4-53 (D)
TEXTURE:		
Sand	–	1
Silt	20	59
Clay	80	40
COMPOSITION:		
Quartz	10	60
Feldspar	1	5
Mica	TR	TR
Heavy minerals	–	TR
Clay	49	20
Glass	15	11
Radiolarians	TR	TR
Diatoms	–	1
Sponge spicules	TR	1
Plant fragments	–	2

ORGANIC CARBON AND CARBONATE

	4-30
% Organic Carbon	1.7
% $CaCO_3$	3.0

SITE 488 HOLE CORE 3 CORED INTERVAL 10.5–20.0 m



LITHOLOGIC DESCRIPTION

5G 2/1

Dusky green MUD with 0.25–1.0 cm black (N1) parallel mud laminations. Soupy, greenish black (5G 2/1) muddy silt at top.

SMEAR SLIDES

	Mud 2-50 (D)
TEXTURE:	
Sand	+
Silt	35
Clay	65
COMPOSITION:	
Quartz	35
Feldspar	2
Mica	TR
Heavy minerals	TR
Clay	50
Glass	10
Nannofossils	TR
Radiolarins	TR
Diatoms	TR
Plant fragments	2
Sponge spicules	1

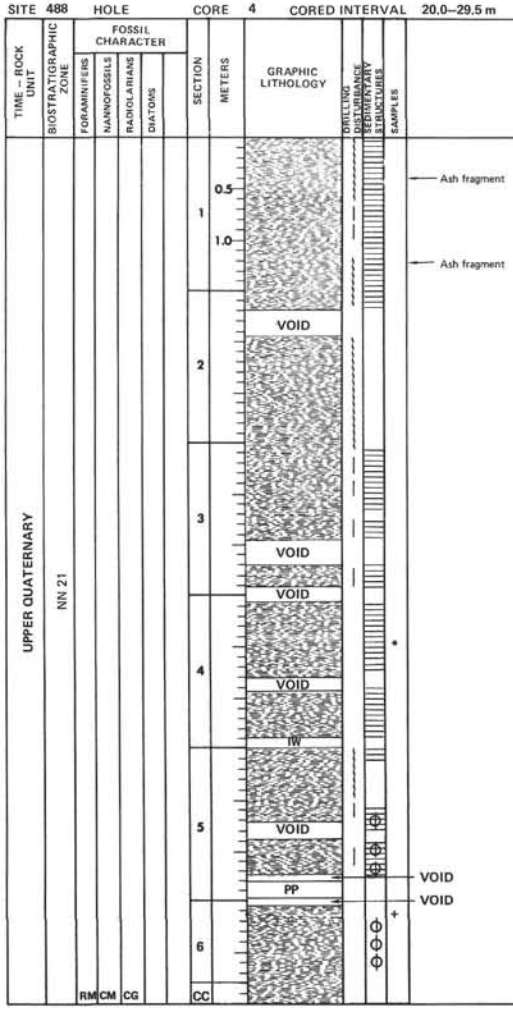
GRAIN SIZE

	1-80	2-49
Sand	2.9	2.6
Silt	48.5	65.1
Clay	48.7	32.3

ORGANIC CARBON AND CARBONATE

	2-124
% Organic Carbon	1.8
% $CaCO_3$	2.0

SITE 488 HOLE CORE 4 CORED INTERVAL 20.0–29.5 m



LITHOLOGIC DESCRIPTION

Greenish black (5GY 2/1) mud with 0.5–2.0 cm black (N1) MUD parallel laminations. Abundant gas expansion cracks, and voids. Section 6 and Core-Catcher: dusky green (5G 3/2) MUD without laminations. Sponge spicules concentrations common at base of core.

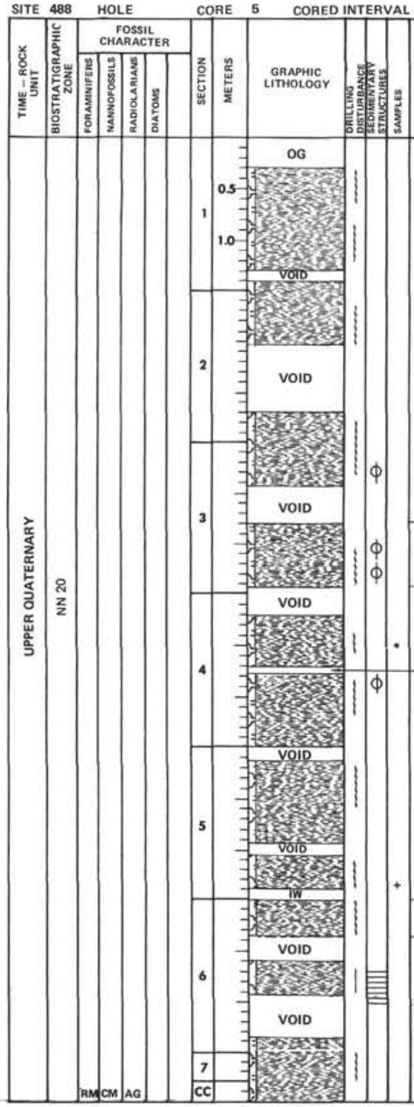
SMEAR SLIDES

	Mud 4-50 (D)
TEXTURE:	
Sand	1
Silt	29
Clay	60
COMPOSITION:	
Quartz	26
Mica	3
Heavy minerals	TR
Clay	60
Radiolarians	TR
Diatoms	1
Plant fragments	TR
Sponge spicules	TR

ORGANIC CARBON AND CARBONATE

	6-16
% Organic Carbon	2.6
% $CaCO_3$	3.0

SITE 488 HOLE CORE 5 CORED INTERVAL 29.5–39.0 m



LITHOLOGIC DESCRIPTION

In Sections 1, 2, and 3: SILICEOUS MUD, greenish black (5GY 2/1) with highly deformed black (N1) laminations. In Sections 4 through Core-Catcher: SILICEOUS MUD, black (5G 2/1) with 0.25–0.5 cm highly deformed laminations of lighter colored (greenish black, 5GY 2/1) siliceous mud.

Grayish black (N2) mottled siliceous mud

VOID

Short section of greenish black (5G 2/1) siliceous mud free of laminations

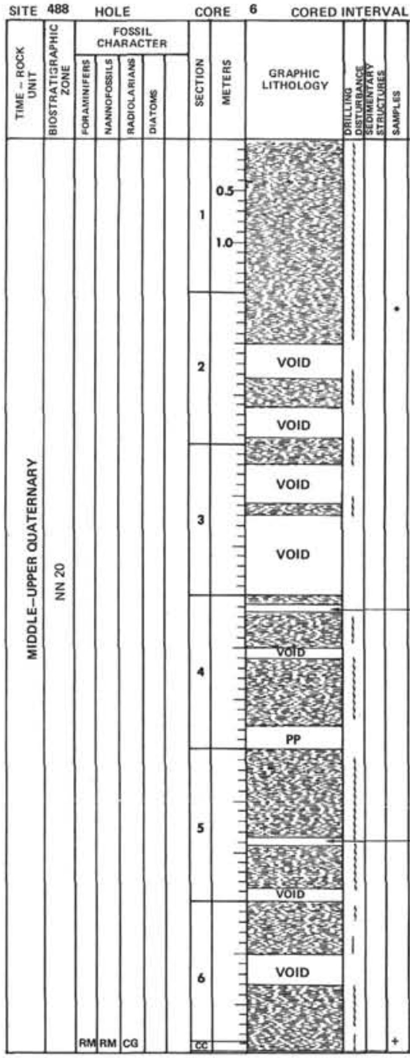
SMEAR SLIDES

	Siliceous mud 4-50 (D)
TEXTURE:	
Sand	2
Silt	33
Clay	65
COMPOSITION:	
Quartz	18
Mica	2
Pyrite	TR
Clay	65
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	7
Sponge spicules	3
Plant fragments	2

ORGANIC CARBON AND CARBONATE

	5-134
% Organic Carbon	2.1
% $CaCO_3$	6.0

SITE 488 HOLE CORE 6 CORED INTERVAL 39.0–48.5 m



LITHOLOGIC DESCRIPTION

VOID

VOID

Sections 1 and 2: MUD, black with highly deformed thin laminations of olive black (5Y 2/1) mud. Section 3: greenish black (5Y 2/1) mud with thin laminations. Section 4, 0–50 cm: grayish black (N2) mud with highly deformed thin laminations. Section 4, 60–150 cm: slightly mottled black (N1) mud. Sections 5 and 6. slightly mottled grayish black (N2) mud with grayish black (N2) mud with highly deformed thin laminations of greenish black (5G 2/1) mud below 95 cm in Section 5.

SMEAR SLIDES

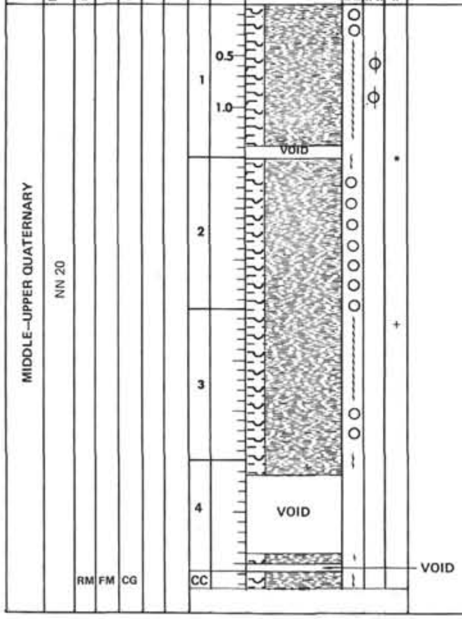
	Mud 2-20 (D)
TEXTURE:	
Sand	3
Silt	22
Clay	75
COMPOSITION:	
Quartz	15
Feldspar	3
Mica	2
Heavy minerals	TR
Clay	75
Radiolarians	TR
Diatoms	3
Sponge spicules	TR
Plant fragments	2

ORGANIC CARBON AND CARBONATE

	6-138
% Organic Carbon	2.5
% $CaCO_3$	6.0

SITE 488 HOLE CORE 7 CORED INTERVAL 48.5–58.0 m

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



Section 1: DIATOMACEOUS MUD, black (N2) highly disturbed by drilling, slight mottling which may have been bedding; small scale gas expansion cracks throughout. Section 2: DIATOMACEOUS MUD, greenish black, highly disturbed by drilling, mottled with olive black (5Y 2/1) diatomaceous mud. Section 3 and Section 4, 0–15 cm: DIATOMACEOUS MUD, greenish black (5G 2/1), mottled with grayish black (N2) diatomaceous mud; mottling may have originated as laminations, disturbed by drilling. Section 4, 88 cm–Core-Catcher: firm greenish black (5G 2/1) and grayish black (5YR 2/1) DIATOMACEOUS MUD.

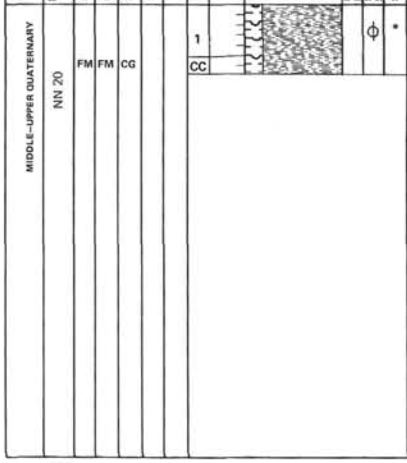
SMEAR SLIDES	Diatomaceous mud
	2-5 (D)
TEXTURE:	
Sand	2
Silt	35
Clay	63
COMPOSITION:	
Quartz	30
Feldspar	15
Mica	5
Heavy minerals	1
Pyrite	3
Clay	25
Glass	5
Foraminifers	TR
Nannofossils	TR
Radiolarians	3
Diatoms	15
Sponge spicules	4
Plant fragments	4

ORGANIC CARBON AND CARBONATE

	3-19
% Organic Carbon	2.1
% $CaCO_3$	5.0

SITE 488 HOLE CORE 8 CORED INTERVAL 58.0–67.5 m

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

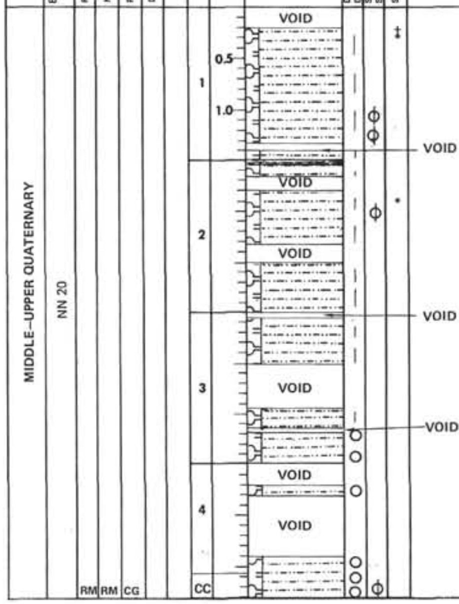


DIATOMACEOUS MUD, grayish black (N2); very slight mottling, mica flakes evident. Sponge spicule concentration at Section 1, 23 cm.

SMEAR SLIDES	Diatomaceous mud
	1-27 (D)
TEXTURE:	
Sand	10
Silt	30
Clay	60
COMPOSITION:	
Quartz	45
Feldspar	5
Mica	5
Heavy minerals	1
Pyrite	3
Clay	15
Glass	5
Nannofossils	TR
Radiolarians	2
Diatoms	15
Sponge spicules	4
Silicoflagellates	TR
Plant fragments	TR

SITE 488 HOLE CORE 9 CORED INTERVAL 67.5–77.0 m

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



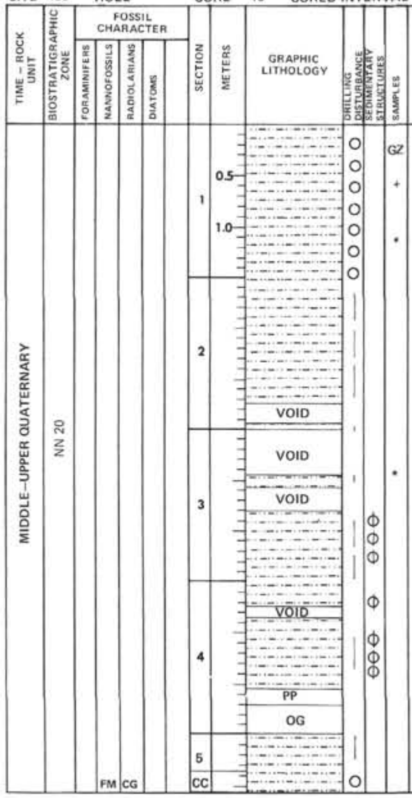
Section 1, 20–50 cm: DIATOMACEOUS MUDDY SILT, firm greenish black (5G 2/1) with faint 1.0 cm laminations. Gas expansion cracks and voids common. Section 1, 50 cm–Core-Catcher: firm olive black (5Y 2/1) SILICEOUS MUDDY SILT. Occasional sponge spicule concentrations.

SMEAR SLIDES	Diatomaceous mud	Siliceous mud
	1-27 (D)	2-40 (D)
TEXTURE:		
Sand	5	2
Silt	20	38
Clay	75	60
COMPOSITION:		
Quartz	35	16
Feldspar	12	5
Mica	8	2
Heavy minerals	3	–
Pyrite	5	–
Clay	15	60
Glass	5	–
Foraminifers	TR	TR
Nannofossils	TR	1
Radiolarians	3	1
Diatoms	12	5
Sponge spicules	2	10
Silicoflagellates	TR	–
Plant fragments	TR	–

ORGANIC CARBON AND CARBONATE

	1-20
% Organic Carbon	2.0
% $CaCO_3$	5.0

SITE 488 HOLE CORE 10 CORED INTERVAL 77.0–86.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, firm olive black (5Y 2/1). Gas expansion cracks are common. Common bluish white (5B 9/1) sponge spicule concentrations, generally 1–2 cm in maximum dimension.

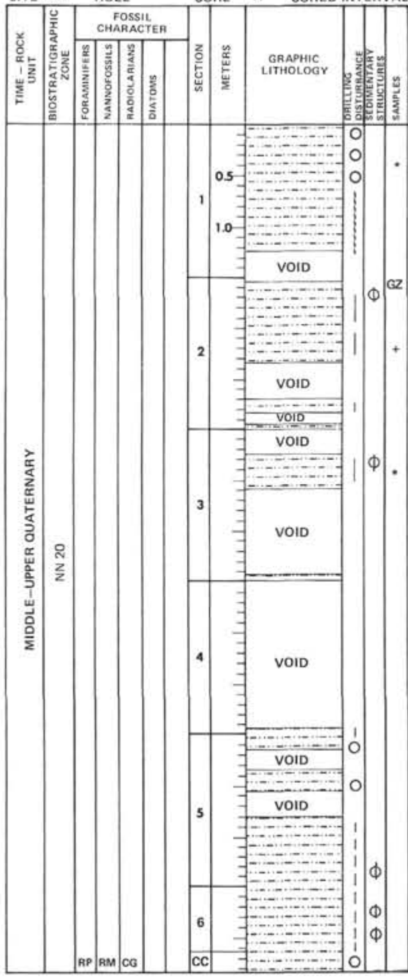
SMEAR SLIDES

	Muddy silt 1-118 (D)	Muddy silt 3-45 (D)
TEDXTURE:		
Sand	5	3
Silt	80	80
Clay	15	17
COMPOSITION:		
Quartz	66	72
Feldspar	15	15
Mica	5	3
Heavy minerals	TR	–
Clay	5	5
Glass	TR?	TR?
Foaminifers	TR	TR
Nannofossils	TR	TR
Radiolarians	–	TR
Diatoms	1	1
Sponge spicules	1	1
Plant fragments	2	2
Zeolites	TR	–
Carb. unspec.	–	1

ORGANIC CARBON AND CARBONATE

	1-60
% Organic Carbon	2.1
% $CaCO_3$	2.0

SITE 488 HOLE CORE 11 CORED INTERVAL 86.5–96.0 m



LITHOLOGIC DESCRIPTION

Ash, greenish gray (5GY 6/1)

MUDDY SILT, soft to firm, olive black (5Y 2/1), with vague diffuse black mm-scale vertical and sub-vertical streaks. Horizontal and sub-horizontal gas expanion cracks common. Common bluish white (5B 9/1) sponge spicule concentrations.

SMEAR SLIDES

	Ash 1-45 (M)	Muddy silt 3-45 (D)
TEXTURE:		
Sand	1	3
Silt	94	67
Clay	5	30
COMPOSITION:		
Quartz	7	72
Feldspar	2	15
Mica	3	3
Clay	2	5
Glass	84	TR?
Foraminifers	TR	TR
Radiolarians	TR	TR
Diatoms	TR	1
Sponge spicules	TR	1
Plant fragments	2	3
Fish debris	–	TR

GRAIN SIZE

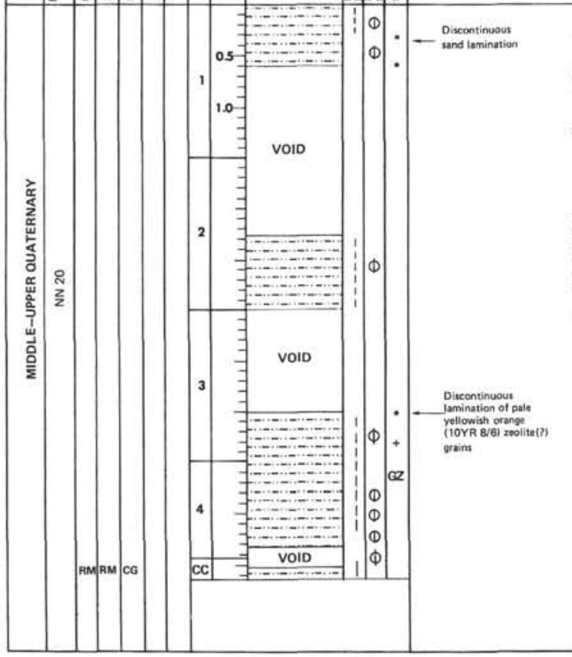
	2-9
Sand	11.1
Silt	59.0
Clay	29.9

ORGANIC CARBON AND CARBONATE

	2-70
% Organic Carbon	1.7
% $CaCO_3$	2.0

SITE 488 HOLE CORE 13 CORED INTERVAL 105.5–115.0 m

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



Site 488, Core 12', 105.5–115.0 m: NO RECOVERY.

MUDDY SILT, greenish black (5G 2/1) to dark greenish gray (5G 4/1). Gas expansion cracks common. Common sponge spicule concentrations (bluish white, 5B 9/1).

SMEAR SLIDES

	Fine sand 1-35 (M)	Muddy silt 1-60 (D)	Zeolite sand 3-103 (M)
TEXTURE:			
Sand	90	1	–
Silt	5	58	–
Clay	5	40	–
COMPOSITION:			
Quartz	77	69	–
Feldspar	10	15	–
Mica	3	3	–
Heavy minerals	1	1	–
Clay	5	10	–
Glass	1	1	–
Foraminifers	–	TR	–
Nannofossils	–	TR	–
Radiolarians	TR	TR	–
Diatoms	TR	TR	–
Sponge spicules	TR	TR	–
Silicoflagellates	–	TR	–
Plant fragments	2	1	–
Zeolites	–	–	100

GRAIN SIZE

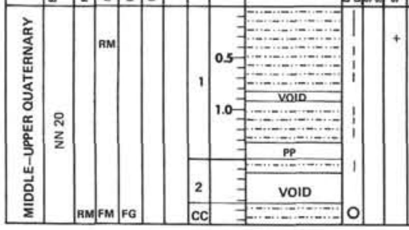
	4-14
Sand	8.6
Silt	63.4
Clay	28.0

ORGANIC CARBON AND CARBONATE

	3-130
% Organic Carbon	1.9
% $CaCO_3$	5.0

SITE 488 HOLE CORE 14 CORED INTERVAL 115.0–124.5 m

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



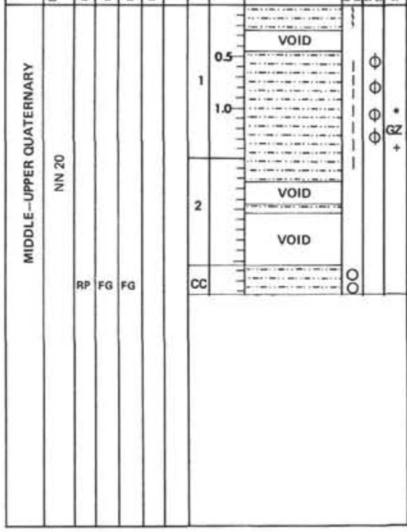
MUDDY SILT, dark greenish gray (5GY 4/1).

ORGANIC CARBON

	1-34
% Organic Carbon	1.8
% $CaCO_3$	2.0

SITE 488 HOLE CORE 15 CORED INTERVAL 124.5–134.0 m

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



MUDDY SILT, dark greenish gray (5GY 4/1). Common sponge spicule concentrations (bluish white, 5B 9/1).

SMEAR SLIDES

	Muddy silt 1-105 (D)
TEXTURE:	
Sand	7
Silt	63
Clay	30
COMPOSITION:	
Quartz	64
Feldspar	15
Mica	5
Heavy minerals	1
Clay	10
Glass	1
Foraminifers	TR
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	1
Silicoflagellates	TR
Plant fragments	3

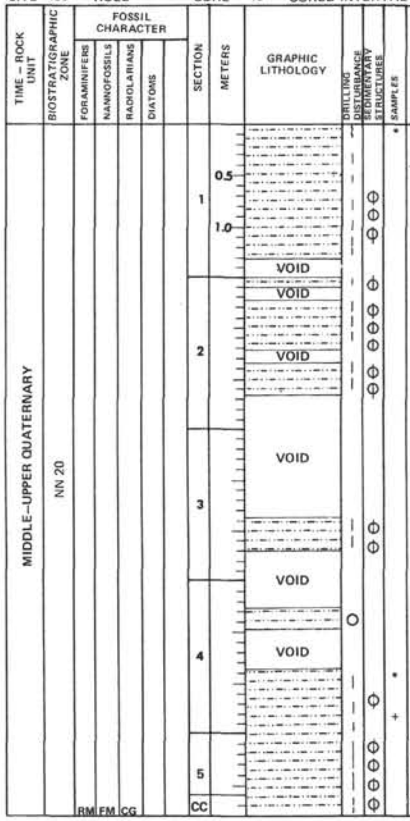
GRAIN SIZE

	1-120
Sand	8.9
Silt	62.9
Clay	28.3

ORGANIC CARBON AND CARBONATE

	1-140
% Organic Carbon	1.7
% $CaCO_3$	3.0

SITE 488 HOLE CORE 16 CORED INTERVAL 134.0–143.5 m



LITHOLOGIC DESCRIPTION

Dark yellowish orange (10YR 6/6) zeolite grains

MUDDY SILT, dark greenish gray (5GY 4/1) with minor beds of MUD. Sponge spicule concentrations (bluish white, 5B 9/1) common. Gas expansion cracks common.

Forcibly extruded from core

10YR 6/6 zeolite grains

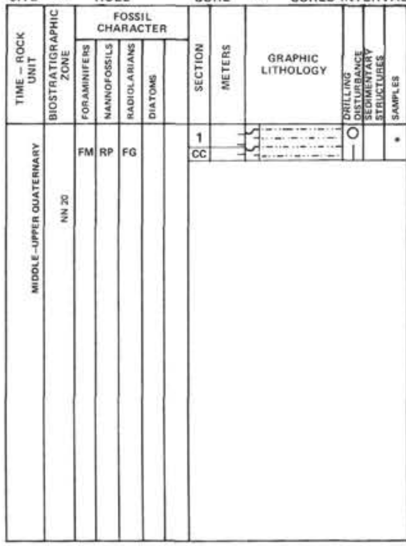
SMEAR SLIDES

	Mud	Muddy silt
	1-5 (M)	4-99 (D)
TEXTURE:		
Sand	1	3
Silt	39	62
Clay	60	35
COMPOSITION:		
Quartz	69	74
Feldspar	10	10
Mica	3	5
Heavy minerals	1	1
Clay	10	5
Glass	TR	TR
Foraminifers	TR	TR
Nannofossils	TR	TR
Radiolarians	1	TR
Diatoms	1	1
Sponge spicules	1	1
Silicoflagellates	1	1
Plant fragments	3	3

ORGANIC CARBON AND CARBONATE

	4-134
% Organic Carbon	2.1
% $CaCO_3$	5.0

SITE 488 HOLE CORE 17 CORED INTERVAL 143.5–153.0 m



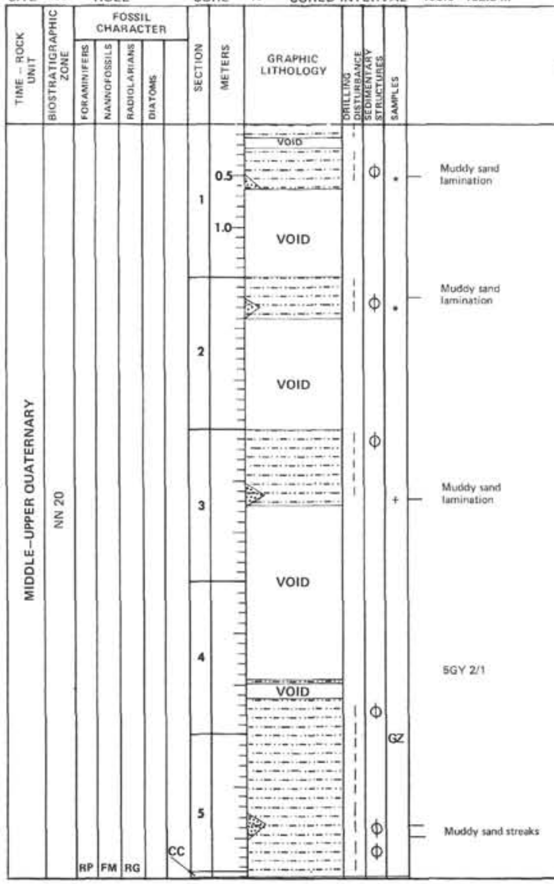
LITHOLOGIC DESCRIPTION

MUDDY SILT, dusky brown (5YR 2/2).

SMEAR SLIDES

	Diatomaceous mud
	1-20 (D)
TEXTURE:	
Sand	2
Silt	35
Clay	63
COMPOSITION:	
Quartz	40
Feldspar	15
Mica	10
Heavy minerals	1
Pyrite	1
Clay	12
Glass	5
Nannofossils	TR
Radiolarians	1
Diatoms	10
Sponge spicules	5
Silicoflagellates	TR
Plant fragments	TR

SITE 488 HOLE CORE 18 CORED INTERVAL 153.0–162.5 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, dusky brown (5YR 2/2) with fine-grained MUDDY SAND lamination (dark greenish gray, 5GY 4/1) and dusky brown (5YR 2/2) SANDY MUD. Olive black (5Y 2/1) MUDDY SILT with interbeds of dark greenish gray (5GY 4/1) MUDDY SAND. MUD, greenish black (5GY 2/1) with thin (<0.5 cm) streaks of MUDDY SAND.

SMEAR SLIDES

	Muddy sand	Mud
	1-55 (M)	2-34 (D)
TEXTURE:		
Sand	55	7
Silt	20	33
Clay	25	60
COMPOSITION:		
Quartz	65	25
Feldspar	10	5
Mica	10	2
Heavy minerals	1	TR
Clay	11	60
Glass	TR	–
Radiolarians	–	TR
Diatoms	1	4
Sponge spicules	2	3
Plant fragments	–	1

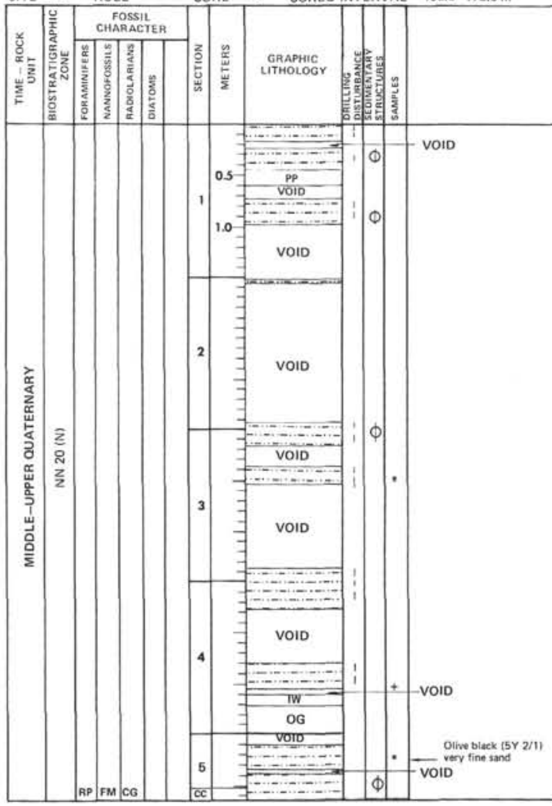
GRAIN SIZE

	5-8
Sand	13.7
Silt	55.4
Clay	30.9

ORGANIC CARBON AND CARBONATE

	3-70
% Organic Carbon	1.5
% $CaCO_3$	5.0

SITE 488 HOLE CORE 19 CORED INTERVAL 162.5–172.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, olive black (5Y 2/1) to greenish black (5G 2/1) and intense mottling.

SMEAR SLIDES

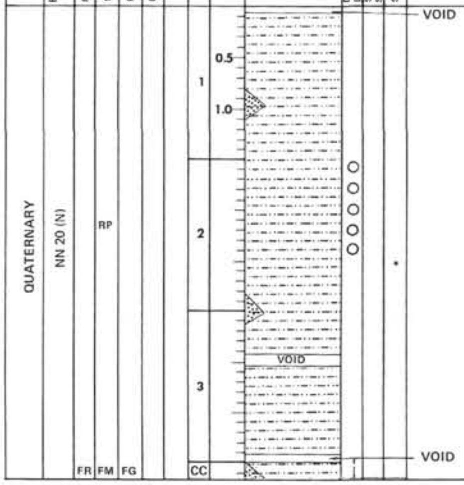
	Mud	Very fine sand
	3-50 (D)	5-27 (M)
TEXTURE:		
Sand	10	90
Silt	30	7
Clay	60	3
COMPOSITION:		
Quartz	25	75
Feldspar	5	10
Mica	2	–
Heavy minerals	TR	5
Clay	60	3
Nannofossils	TR	–
Radiolarians	1	–
Diatoms	1	1
Sponge spicules	4	1
Plant fragments	2	5

ORGANIC CARBON AND CARBONATE

	4-103
% Organic Carbon	1.7
% $CaCO_3$	2.0

SITE 488 HOLE CORE 20 CORED INTERVAL 172.0–181.5 m

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



LITHOLOGIC DESCRIPTION

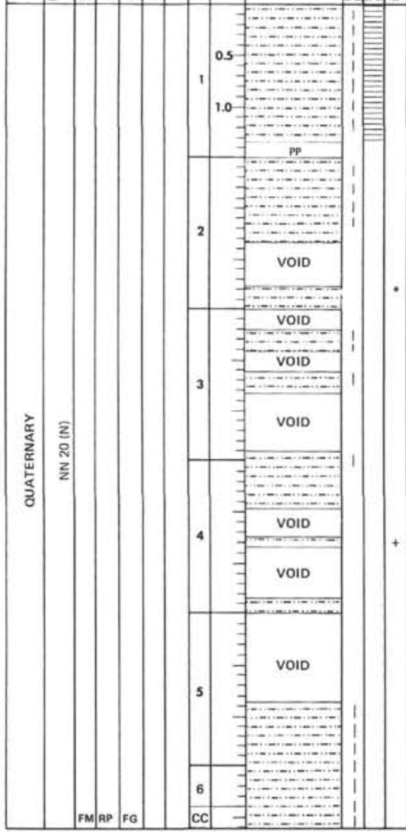
MUDDY SILT, stiff, homogeneous olive gray (5Y 3/2) with sparse thin fine-grained SAND laminations. Interbedding shown dragrammatically; sand beds are 1–3 mm thick. Scattered sponge remains.

SMEAR SLIDES

	Mud 2-103 (D)
TEXTURE:	
Sand	7
Silt	28
Clay	65
COMPOSITION:	
Quartz	50
Feldspar	15
Mica	13
Heavy minerals	1
Pyrite	TR
Clay	10
Glass	3
Nannofossils	1
Diatoms	5
Sponge spicules	2
Plant fragments	TR

SITE 488 HOLE CORE 21 CORED INTERVAL 181.5–191.0 m

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



LITHOLOGIC DESCRIPTION

MUDDY SILT, alternating laminations (0.5–4.0 cm) of olive black (5Y 2/1) and greenish black (5G 2/1). Occasional silt beds. Mottling in upper half of Section 2. Scattered sponge remains. Possible 5° apparent dip at base of Section 2.

SMEAR SLIDES

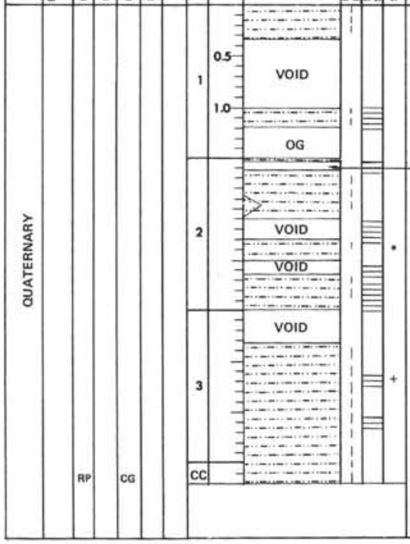
	Muddy silt 2-135 (D)
TEXTURE:	
Sand	3
Silt	60
Clay	37
COMPOSITION:	
Quartz	45
Feldspar	5
Mica	5
Clay	37
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	5
Plant fragments	2

ORGANIC CARBON AND CARBONATE

	4-80
% Organic Carbon	1.6
% $CaCO_3$	1.0

SITE 488 HOLE CORE 22 CORED INTERVAL 191.0–200.5 m

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



Section 1, 0–35 cm: MUDDY SILT, moderately mottled greenish black (5GY 2/1). Section 1, 98–120 cm: MUDDY SILT; thinly laminated (0.5–1.5 cm); equal parts greenish black (5GY 2/1) and darker greenish black (5G 2/1). Sections 2 and 3: MUDDY SILT, thinly laminated (1.0–2.0 cm) olive black (5Y 2/1) and greenish black (5GY 2/1). Occasional thin (0.5–1.0 cm) silt beds. Gradational color change at Section 3, 120 cm to olive gray (5Y 3/2) muddy silt.

SMEAR SLIDES

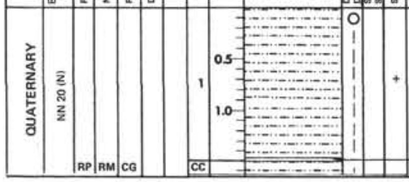
	Muddy silt 2-90 (D)
TEXTURE:	
Sand	8
Silt	62
Clay	30
COMPOSITION:	
Quartz	55
Felspar	5
Mica	5
Clay	30
Nannofossils	TR
Radiolarians	TR
Diatoms	1
Sponge spicules	2
Plant fragments	2

ORGANIC CARBON AND CARBONATE

	3-70
% Organic Carbon	1.7
% $CaCO_3$	0.0

SITE 488 HOLE CORE 23 CORED INTERVAL 200.5–210.0 m

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



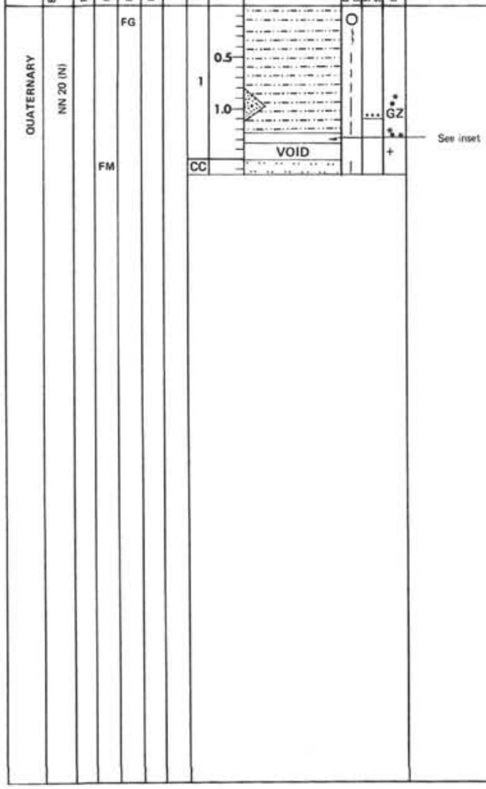
MUDDY SILT, grayish olive green (5GY 3/2).

ORGANIC CARBON AND CARBONATE

	1-70
% Organic Carbon	1.3
% $CaCO_3$	0.0

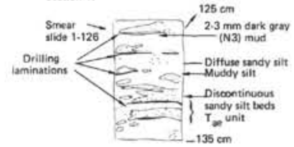
SITE 488 HOLE CORE 24 CORED INTERVAL 210.0–219.5 m

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



MUDDY SILT, grayish olive green (5GY 3/2). Several gas expansion cracks. Occasional silt interbeds. There is one graded (5 cm-thick) bed of sandy silt to silt (light gray, N7) at 100–105 cm. Silt and sandy silt, deformed, in Core-Catcher. Silt beds are truncated and apparent deformation is caused by horizontal dark drilling laminations, horizons along which rotation occurred during drilling.

Section 1:



SMEAR SLIDES

	Silt 1-95 (M)	Silt (sandy) 1-102 (M)	Silt (sandy) 1-103 (M)	Muddy silt 1-126 (M)	1-126.5 (D)
TEXTURE:					
Sand	5	35	40	2	1
Silt	85	60	50	20	54
Clay	10	5	10	78	45
COMPOSITION:					
Quartz	90	90	77	64	61
Feldspar	1	2	15	3	5
Mica	1	3	2	2	2
Heavy minerals	–	1	1	–	–
Clay	–	3	2	30	30
Glass	5	–	–	–	–
Sponge spicules	TR	TR	1	–	–
Plant fragments	3	–	2	1	2
Carb. unspec.	–	1	–	–	–

GRAIN SIZE

	1-97
Sand	45.2
Silt	40.0
Clay	14.9

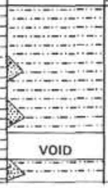
ORGANIC CARBON AND CARBONATE

	1-130
% Organic Carbon	1.0
% $CaCO_3$	4.0

SITE 488 HOLE CORE 25 CORED INTERVAL 219.5–229.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)					1	0.5, 1.0
		RP	RM	RG		CC	

GRAPHIC LITHOLOGY



VOID

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

MUDDY SILT, dark greenish gray (5GY 4/1). Three 1 cm SANDY SILT beds at 70 cm with an apparent dip of 45°. Diffuse traces of deformed sandy silt beds below 100 cm – fairly well developed early stages of deformation resulting in wispy beds of sandy silt. Matrix sediment of Core-Catcher is mud.

SMEAR SLIDES

	Muddy silt 1-113 (M)	Mud CC-5 (D)
TEXTURE:		
Sand	10	2
Silt	60	18
Clay	30	80
COMPOSITION:		
Quartz	66	44
Feldspar	10	10
Mica	2	3
Heavy minerals	1	1
Clay	20	40
Radiolarians	–	TR
Diatoms	–	TR
Sponge spicules	–	TR
Plant fragments	1	2

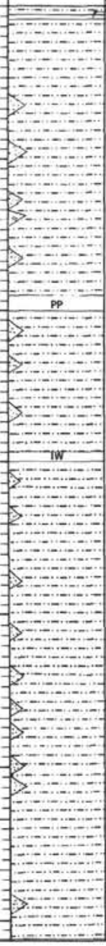
ORGANIC CARBON AND CARBONATE

	1-80	1-80
% Organic Carbon	1.4	1.2
% $CaCO_3$	4.0	–

SITE 488 HOLE CORE 26 CORED INTERVAL 229.0–238.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)					1	0.5, 1.0
						2	
						3	
						4	
						5	
						6	
		RP				CC	

GRAPHIC LITHOLOGY



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DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

VOID

Sections 1–4: MUDDY SILT olive black (5Y 2/1) to greenish black (5GY 2/1) with silt interbeds. Some wispy deformation; other areas apparently through-going beds. Section 5–Core-Catcher: MUDDY SILT, dusky green (5GY 3/2), healed fractures that truncate bedding give appearance of wispy bedding; probably deformation of poorly consolidated sediments.

- Apparent dip 45°
- Apparent dip 45°
- 5GY 2/1
- Silt interbeds, to 4 cm thick, apparent dip of 28°
- Ash
- 52° apparent dip, possible normal grading but top and base gradational
- 47° apparent dip
- 40° apparent dip
- 3 cm silt bed, possibly normal grading
- 26° apparent dip
- Fracture, core may have rotated (45 cm)
- 1 cm silt bed, 61° apparent dip, sharper contact toward top of core
- 2.0–3.0 cm silt-normal grading
- 13° apparent dip
- 21° apparent dip
- 28° apparent dip

SMEAR SLIDES

	Muddy silt 4-105 (D)	Mud 6-65 (M)
TEXTURE:		
Sand	5	1
Silt	75	20
Clay	20	79
COMPOSITION:		
Quartz	65	55
Feldspar	3	20
Mica	5	8
Heavy minerals	–	3
Clay	20	15
Radiolarians	TR	–
Diatoms	3	–
Sponge spicules	1	TR
Plant fragments	3	4

ORGANIC CARBON AND CARBONATE

	3-128
% Organic Carbon	1.0
% $CaCO_3$	5.0

SITE 488 HOLE CORE 27 CORED INTERVAL 238.5–248.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	NN 20	RP				1, CC	0.5, 1.0	VOID			+, •

LITHOLOGIC DESCRIPTION

MUDDY SILT, greenish black (5GY 2/1) with common silt interbeds – up to 1.5 cm thick; thin silt beds generally truncated and wispy. Two thin parallel (horizontal) dark fine-grained laminations (1–2 mm thick, 3 cm apart) surrounded and separated by "wispy" deformed silt and muddy silt, at Section 1, 144–147 cm. Laminations probably produced by drilling rotation.

SMEAR SLIDES

	Muddy silt 1-80 (D)
TEXTURE:	
Sand	1
Silt	59
Clay	40
COMPOSITION:	
Quartz	60
Feldspar	20
Mica	10
Heavy minerals	2
Clay	3
Diatoms	TR
Sponge spicules	TR
Plant fragments	5

ORGANIC CARBON AND CARBONATE

	1-64
% Organic Carbon	1.1
% $CaCO_3$	1.0

SITE 488 HOLE CORE 28 CORED INTERVAL 248.0–257.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	NN 20 (N)	RP				CC					

LITHOLOGIC DESCRIPTION

Very poor recovery – only a few cm of sediment in Core-Catcher.

SITE 488 HOLE CORE 29 CORED INTERVAL 257.5–264.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
QUATERNARY	NN 20 (N)	FG				1, 2, 3, 4, 5, CC	0.5, 1.0	VOID, VOID			•, • GZ, +

LITHOLOGIC DESCRIPTION

13–14 couplets of greenish black muddy silt (1–2.5 cm) and grayish black (N2) MUD (2–4 mm)

Diffuse olive gray (5Y 4/1) slightly SANDY SILT lamination; 37° apparent dip

Very firm, muddy silt, apparently structureless

20% darker blebs

MUDDY SILT, firm to very firm, greenish black (5G 2/1) and MUD, grayish black (N2), homogeneous soft to firm. Thin dark laminations probably formed by drilling disturbance. Drilling breccia. Indurated greenish black muddy siltstone in angular chips (average size several mm, maximum 5x3 cm). Core-Catcher: mm-scale parallel drilling *laminations visible in firm muddy silt broken into discrete* blocks by drilling.

SMEAR SLIDES

	Mud 1-90 (M)	Muddy silt 2-12 (D)
TEXTURE:		
Sand	–	30
Silt	40	50
Clay	60	20
COMPOSITION:		
Quartz	48	73
Feldspar	15	15
Mica	4	3
Heavy minerals	1	1
Clay	30	5
Radiolarians	TR	–
Diatoms	TR	–
Sponge spicules	TR	–
Plant fragments	2	3

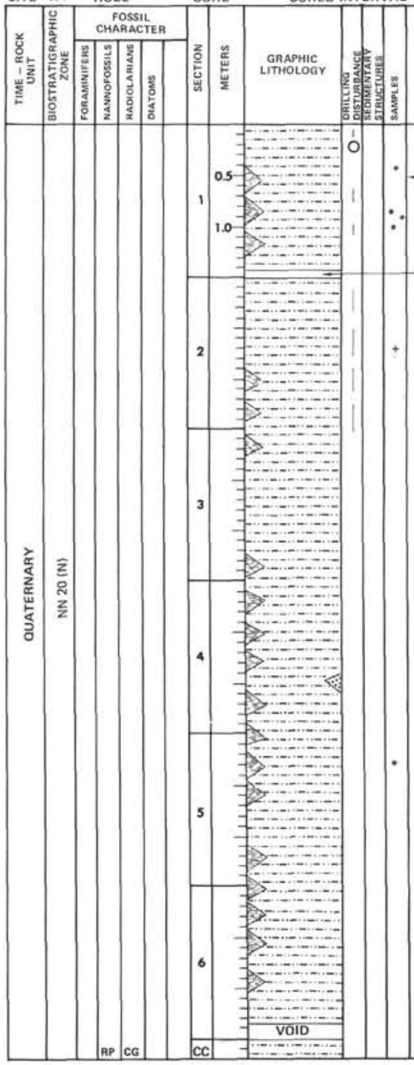
GRAIN SIZE

	2-20
Sand	59.2
Silt	30.9
Clay	9.9

ORGANIC CARBON AN CARBONATE

	2-142
% Organic Carbon	1.3
% $CaCO_3$	1.0

SITE 488 HOLE CORE 30 CORED INTERVAL 264.5–276.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, dark greenish gray (5GY 4/1) with thick beds medium dark gray (N4) MUD (interbedding shown diagrammatically). Very uniform appearance and thickness of drilling laminations. Concentrations of zeolite grains at Section 5, 31 cm with scattered sponge remains.

Section 1:

Section 4, 90–100 cm: Apparent fold probably caused by drilling rotation

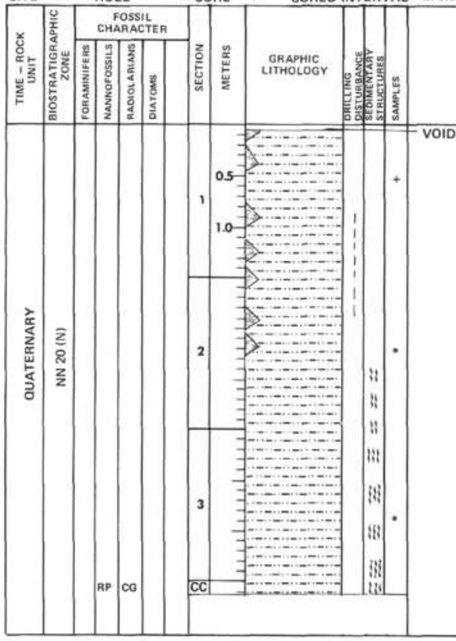
SMEAR SLIDES

	Silt	Mud	Muddy silt	Muddy silt	Zeolite sand
	1-49 (M)	1-93.5 (M)	1-94 (D)	1-101 (M)	5-31 (D)
TEXTURE:					
Sand	40	1	–	20	100
Silt	50	14	60	60	–
Clay	10	85	40	20	–
COMPOSITION:					
Quartz	81	75	61	79	–
Feldspar	10	15	15	10	
Mica	2	4	5	3	–
Heavy minerals	1	1	1	1	–
Clay	5	3	15	5	–
Nannofossils	–	–	TR	TR	–
Radiolarians	–	TR	TR	TR	–
Diatoms	–	TR	TR	TR	–
Sponge spicules	TR	TR	TR	TR	–
Silicoflagellates	–	–	–	TR	–
Plant fragments	1	2	3	2	–
Zeolite	–	–	–	–	100

ORGANIC CARBON AND CARBONATE

	2-83
% Organic Carbon	1.2
% $CaCO_3$	1.0

SITE 488 HOLE CORE 31 CORED INTERVAL 276.0–285.0 m



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2) with thin (1 mm) laminations of greenish black (5GY 2/1) MUD every ~ 2 cm. Drilling laminations shown diagrammatically. Moderate bioturbation. Laminations not continuous across core. Intensely mottled – probably intensely bioturbated.

SMEAR SLIDES

	Muddy silt	Muddy silt
	2-75 (D)	3-90 (D)
TEXTURE:		
Sand	2	1
Silt	68	59
Clay	30	40
COMPOSITION:		
Quartz	55	67
Feldspar	10	15
Mica	3	5
Heavy minerals	TR	1
Clay	30	10
Nannofossils	TR	–
Radiolarians	TR	TR
Diatoms	TR	TR
Sponge spicules	TR	TR
Silicoflagellates	–	TR
Plant fragments	2	2

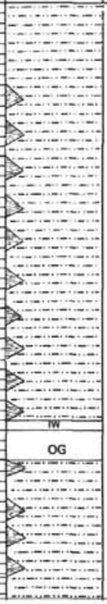
ORGANIC CARBON AND CARBONATE

	1-56
% Organic Carbon	1.4
% $CaCO_3$	1.0

SITE 488 HOLE CORE 32 CORED INTERVAL 285.0–294.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)	FM	RP	CG		1, 2, 3, 4, CC	0.5, 1.0

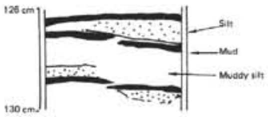
GRAPHIC LITHOLOGY



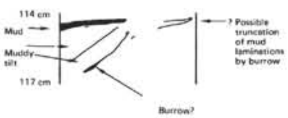
LITHOLOGIC DESCRIPTION

Grayish olive green (5GY 3/2) MUDDY SILT with mottling of greenish black (5GY 2/1) MUD. Moderately mottled, probably bioturbated, no drilling biscuits and laminations in Section 1. In rest of core drilling laminations common. Drilling laminations shown diagrammatically. Scattered sponge remains.

Section 2: slight disruption in coarser (silt) beds



Core-Catcher:



SMEAR SLIDES

	Mud 1-91 (M)	Muddy silt 2-93 (D)
TEXTURE:		
Sand	0	5
Silt	25	70
Clay	75	25
COMPOSITION:		
Quartz	20	60
Feldspar	3	8
Mica	1	5
Heavy minerals	–	TR
Clay	75	25
Radiolarians	–	TR
Diatoms	TR	TR
Sponge spicules	TR	1
Plant fragments	1	2

ORGANIC CARBON AND CARBONATE

	4-8
% Organic Carbon	1.8
% $CaCO_3$	0.0

SITE 488 HOLE CORE 33 CORED INTERVAL 294.0–303.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)		RP	CG		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0

GRAPHIC LITHOLOGY

LITHOLOGIC DESCRIPTION

Dark greenish gray (5GY 4/1) firm muddy silt. Homogeneous, but vaguely mottled with a diffuse darker colored muddy silt – probably bioturbated. Scattered sponge remains.

SMEAR SLIDES

	Zeolite sand 3-20 (M)	Muddy silt 3-110 (D)	Clay 6-127 (M)
TEXTURE:			
Sand	100	–	–
Silt	–	70	5
Clay	–	29	95
COMPOSITION:			
Quartz	–	58	3
Feldspar	–	5	–
Mica	–	3	2
Heavy minerals	–	TR	–
Clay	–	29	95
Nannofossils	–	TR	–
Radiolarians	–	TR	–
Diatoms	–	1	TR
Sponge spicules	–	2	TR
Plant fragments	–	2	TR
Zeolites	100	–	–

GRAIN SIZE

	2-8
Sand	4.9
Silt	68.8
Clay	26.3

ORGANIC CARBON AND CARBONATE

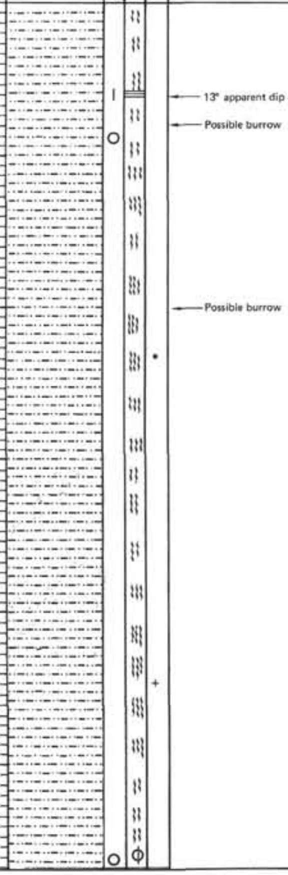
	2-144
% Organic Carbon	1.2
% $CaCO_3$	4.0

Diffuse yellowish gray (5Y 7/2) clay

SITE 488 HOLE CORE 34 CORED INTERVAL 303.0–312.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)					1	0.5, 1.0
						2	
						3	
						4	
						5	
						6	
		RP	FM			CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2) with minor thin (1 mm) mud laminations. Moderately bioturbated.

SMEAR SLIDES

	Muddy silt 3-50 (D)
TEXTURE:	
Sand	–
Silt	65
Clay	35
COMPOSITION:	
Quartz	57
Feldspar	TR
Mica	3
Clay	35
Nannofossils	TR
Radiolarians	TR
Diatoms	TR
Sponge spicules	2
Plant fragments	3

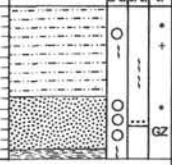
ORGANIC CARBON AND CARBONATE

	5-70
% Organic Carbon	1.7
% $CaCO_3$	3.0

SITE 488 HOLE CORE 35 CORED INTERVAL 312.0–321.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)	RP	RP			1	0.5, 1.0
						CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

MUDDY SILT, grayish olive green (5GY 3/2), possibly bioturbated. Medium to coarse SAND, medium dark gray (N4), normally graded probably due to settling in core barrel. Core-Catcher: olive black (5Y 2/1) mud. Drillers detected sand at 1 meter depth into this core.

SMEAR SLIDES

	Muddy silt 1-20 (D)	Medium to coarse sand 1-100 (D)
TEXTURE:		
Sand	2	95
Silt	70	5
Clay	28	–
COMPOSITION:		
Quartz	60	95
Feldspar	7	5
Mica	3	TR
Heavy minerals	TR	TR
Clay	28	–
Nannfoossils	TR	–
Diatoms	TR	–
Sponge spicules	TR	–
Plant fragments	2	TR

GRAIN SIZE

	1-124
Sand	95.5
Silt	2.3
Clay	2.2

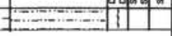
ORGANIC CARBON AND CARBONATE

	1-40
% Organic Carbon	1.3
% $CaCO_3$	1.0

SITE 488 HOLE CORE 36 CORED INTERVAL 321.0–333.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)			FM		CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES



LITHOLOGIC DESCRIPTION

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

SITE 488 HOLE CORE 37 CORED INTERVAL 333.5–343.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
QUATERNARY	NN 20 (N)			RG		1 2 CC	0.5 1.0				* +	Woody debris layers, 0.5–0.75 cm thick

MUDDY SILT, grayish olive green (5GY 3/2) with occasional 0.5 cm silt layers. Slight to moderate bioturbation.

SMEAR SLIDES

	Muddy silt/mud
	1-50 (D)
TEXTURE:	
Sand	5
Silt	45
Clay	50
COMPOSITION:	
Quartz	38
Feldspar	4
Mica	2
Heavy minerals	TR
Clay	50
Nannofossils	TR
Diatoms	TR
Sponge spicules	TR
Plant fragments	6

ORGANIC CARBON AND CARBONATE

	1-77
% Organic Carbon	1.3
% $CaCO_3$	4.0

SITE 488 HOLE CORE 38 CORED INTERVAL 343.0–352.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
QUATERNARY	NN 20 (N)		RM	RM		1 CC	0.5				* +	

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

SMEAR SLIDES

	Muddy silt
	1-15 (D)
TEXTURE:	
Sand	–
Silt	60
Clay	40
COMPOSITION:	
Quartz	45
Feldspar	5
Mica	3
Clay	40
Sponge spicules	TR
Plant fragments	7
Seed pods	TR

ORGANIC CARBON AND CARBONATE

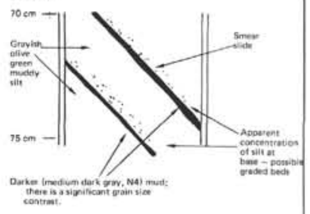
	1-18
% Organic Carbon	1.3
% $CaCO_3$	2.0

SITE 488 HOLE CORE 39 CORED INTERVAL 352.5–362.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
QUATERNARY	NN 20 (N)	RP RP				1	0.5				* * +	VOID 47° apparent dip

MUDDY SILT, grayish olive green with occasional thin (2 mm) MUD layers shown diagrammically.

Section 1:



SMEAR SLIDES

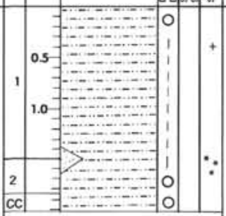
	Muddy silt	Mud
	1-63 (D)	1-72.5 (M)
TEXTURE:		
Sand	1	5
Silt	75	30
Clay	24	65
COMPOSITION:		
Quartz	65	95
Feldspar	4	–
Mica	4	1
Heavy minerals	1	–
Clay	24	2
Radiolarians	TR	–
Diatoms	TR	–
Sponge spicules	TR	–
Plant fragments	2	2

ORGANIC CARBON AND CARBONATE

	1-84
% Organic Carbon	1.6
% $CaCO_3$	6.0

SITE 488 HOLE CORE 40 CORED INTERVAL 362.0–371.5 m

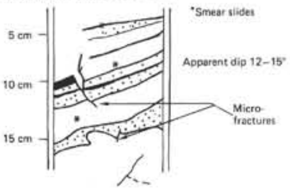
TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)	RP	RP	RP		1, 2, CC	0.5, 1.0



LITHOLOGIC DESCRIPTION

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

Section 2: Detail of upper portion. Vaguely outlined siltier, slightly lighter colored beds.



SMEAR SLIDES

	Mud	Muddy silt	Muddy silt
	2-3.5 (M)	2-8.5 (D)	2-12 (D)
TEXTURE:			
Sand	2	3	–
Silt	38	62	80
Clay	60	35	20
COMPOSITION:			
Quartz	61	81	79
Feldspar	10	10	10
Mica	5	2	3
Heavy minerals	1	1	1
Clay	20	5	5
Radiolarians	TR	TR	TR
Diatoms	TR	TR	TR
Sponge spicules	TR	TR	1
Plant fragments	3	1	1

ORGANIC CARBON AND CARBONATE

	1-40
% Organic Carbon	1.2
% $CaCO_3$	2.0

SITE 488 HOLE CORE 41 CORED INTERVAL 371.5–381.0 m

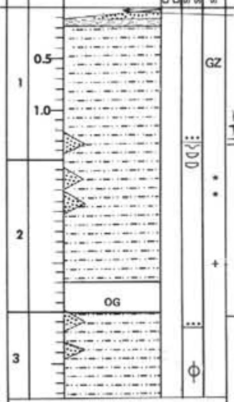
TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)		RP	RP		1, CC	

LITHOLOGIC DESCRIPTION

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

SITE 488 HOLE CORE 42 CORED INTERVAL 381.0–390.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)	RU	RP	RM		1, 2, 3	0.5, 1.0



LITHOLOGIC DESCRIPTION

VOID

Wispy, possibly tectonically broken-up sand beds

23° apparent dip

Greenish gray, fine sand laminations with 5–10° dip (true dip)

5GY 3/2 and 5GY 6/1 and N4

Section 1, 0–15 cm: FINE TO MEDIUM GRAINED SAND and FISSILE SHALE, grayish olive green (5GY 3/2). Section 1: grayish olive green (5GY 3/2) MUDDY SILT, incipiently fissile in places. Section 2: 15–20° true dips. Interbedded laminations of greenish gray (5GY 6/1) and medium dark gray (N4) FINE SAND and SILT, the latter rich in carbonized organic detritus. Interbedding shown diagrammatically. Minor normal faults at Section 2, 40 and 60 cm. Section 3: MUDDY SILT, grayish olive green (5GY 3/2) with incipient fissility along same orientation as bedding, above and below 5 cm thick graded bed of fine to very fine sand. Occasional sponge remains.

SMEAR SLIDES

	Mud	Muddy silt
	2-25 (D)	2-39 (M)
TEXTURE:		
Sand	1	15
Silt	19	65
Clay	80	20
COMPOSITION:		
Quartz	65	70
Feldspar	10	10
Mica	3	4
Heavy minerals	1	1
Clay	20	5
Radiolarians	TR	TR
Diatoms	TR	TR
Sponge spicules	TR	TR
Plant fragments	1	10

GRAIN SIZE

	1-59
Sand	15.3
Silt	62.3
Clay	22.5

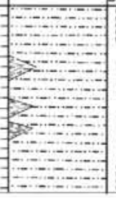
ORGANIC CARBON AND CARBONATE

	2-106
% Organic Carbon	1.7
% $CaCO_3$	3.0

SITE 488 HOLE CORE 43 CORED INTERVAL 390.5–400.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)	RP	FP			1	0.5, 1.0
						2	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

5Y 2/1

47° true dip

42° true dip

44° true dip

MUDDY SILT, olive black (5Y 2/1) with occasional thin (1–5 mm) MUD layers. Fissility developing in the muddy silt, parallel to bedding.

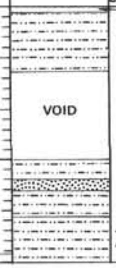
SMEAR SLIDES

	Mud 1-63 (M)	Muddy silt 1-140 (D)
TEXTURE:		
Sand	1	1
Silt	34	65
Clay	65	34
COMPOSITION:		
Quartz	23	57
Feldspar	5	5
Mica	5	3
Heavy minerals	–	TR
Clay	65	34
Radiolarians	–	TR
Diatoms	TR	TR
Sponge spicules	TR	TR
Plant fragments	2	1

SITE 488 HOLE CORE 44 CORED INTERVAL 400.0–409.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)					1	0.5, 1.0
						2	
		FP	RP			CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

VOID

40–44° apparent dip

MUDDY SILT, olive black (5Y 2/1) with occasional 0.1–1.0 cm MUD laminations and medium greenish gray fine to medium SAND; sharp base and slightly gradational top, no grading. Incipient fissility in the muddy silt. Section 2, 55–94 cm: drilling fragments, clumps and debris of muddy siltstone with occasional layering. One half-round piece can be oriented, true dip is 44°.

SMEAR SLIDES

	Fine to medium sand 2-25 (D)	Muddy silt 2-40 (D)
TEXTURE:		
Sand	100	1
Silt	–	69
Clay	–	30
COMPOSITION:		
Quartz	96	55
Feldspar	3	5
Mica	1	7
Heavy minerals	TR	TR
Clay	–	30
Glass	–	TR
Diatoms	–	TR
Sponge spicules	–	TR
Plant fragments	–	3

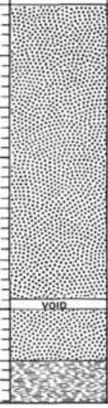
ORGANIC CARBON AND CARBONATE

	1-11
% Organic Carbon	1.4
% $CaCO_3$	4.0

SITE 488 HOLE CORE 45 CORED INTERVAL 409.5–419.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)					1	0.5, 1.0
						2	
			RP			3	
						CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

Fine and fine to medium

Medium

Medium and coarse

Coarse and pebbly

Sections 1 and 2: FINE AND FINE TO MEDIUM SAND dark greenish gray (5GY 4/1) to medium light gray (N6). Section 3, 0–38 cm: medium light gray (N6) medium to coarse SAND poorly sorted. Section 3, 38–70 cm and Core-Catcher: predominantly grayish olive green (5GY 3/2) MUD and MUDSTONE mixed with coarse to pebbly SAND.

Note: Drill string was lifted 18 meters to free the previous core, so the apparent grading seen here as well as the coarse sand are most readily explained as products of caving in of previously penetrated sands.

SITE 488 HOLE CORE 46 CORED INTERVAL 419.0–428.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS
QUATERNARY	NN 20 (N)					1	0.5, 1.0
			RP	RP		CC	

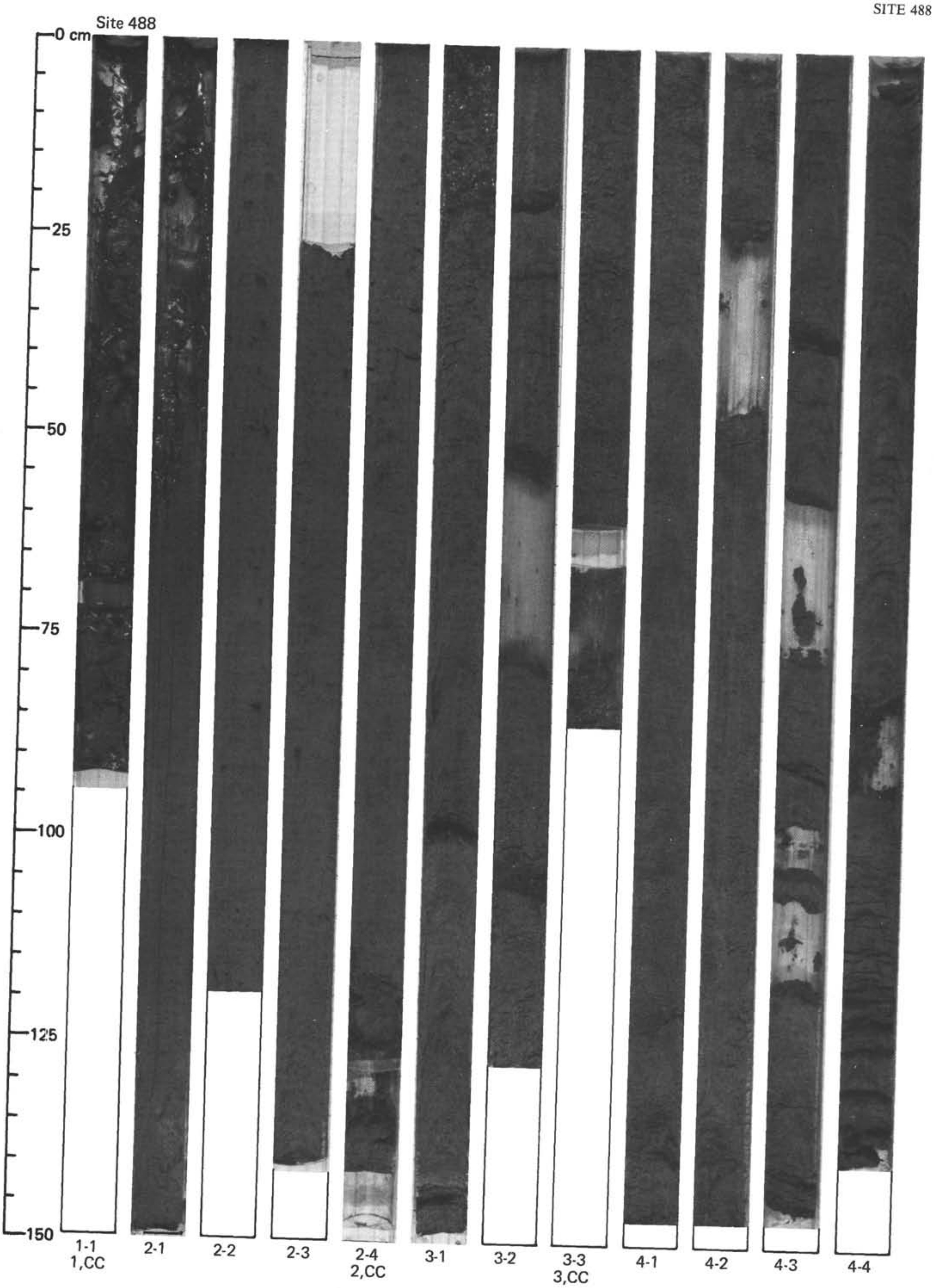
GRAPHIC LITHOLOGY

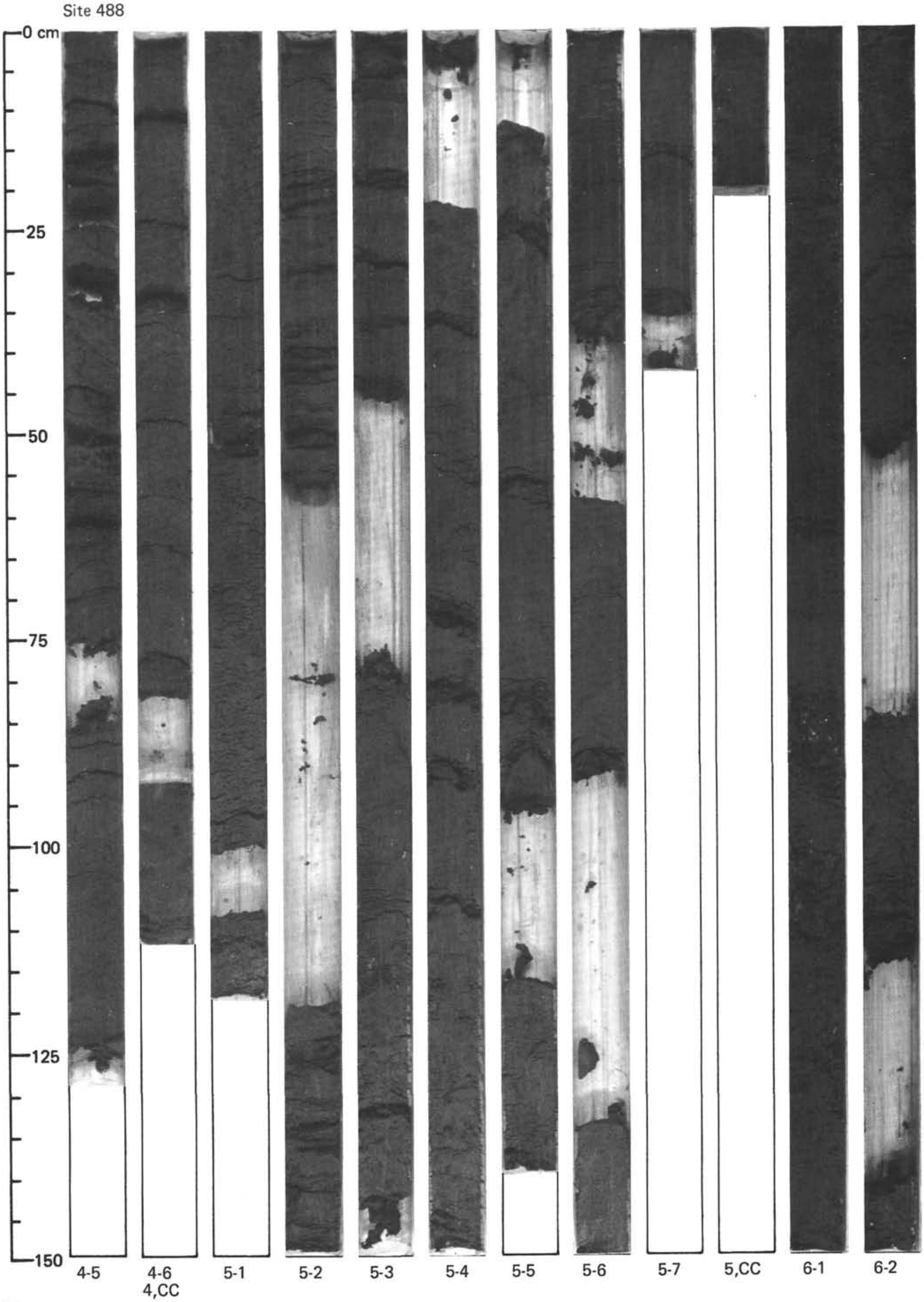
LITHOLOGIC DESCRIPTION

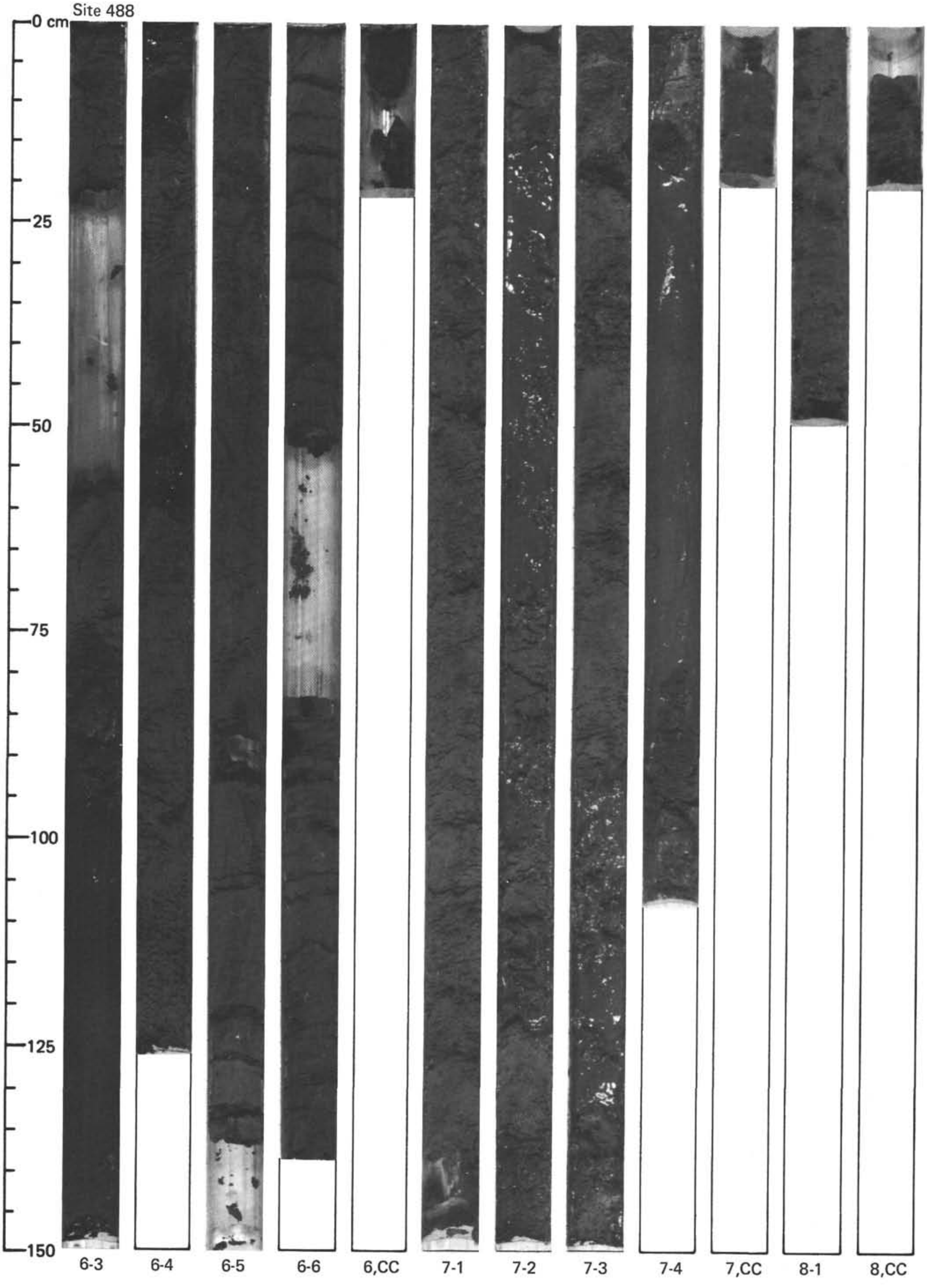
5GY 4/1

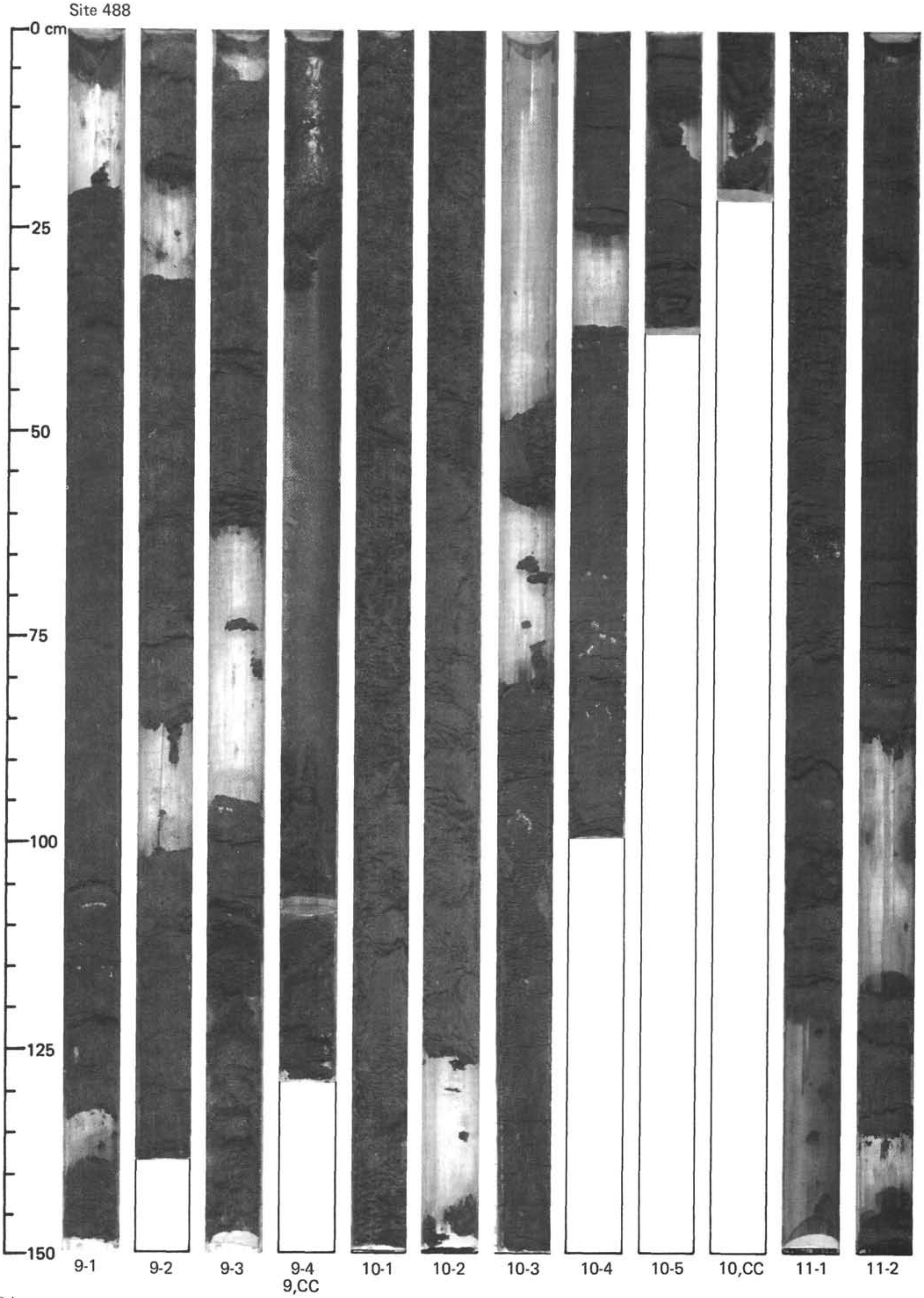
30° apparent dip

MUDDY SILT, very firm dark greenish gray (5GY 4/1). Fine to medium SAND, medium light gray (N6), slightly finer grained in top 3 cm and very firm dark greenish gray MUDDY SILT with small blebs and discontinuous stringers of fine to coarse sand, especially in Core-Catcher (probably artificial in Core-Catcher, as coarse sand was plugged between liner and pipe – stuck core barrel). Incipient fissility at base of Section 1, parallel to bedding with apparent dip of 30°.

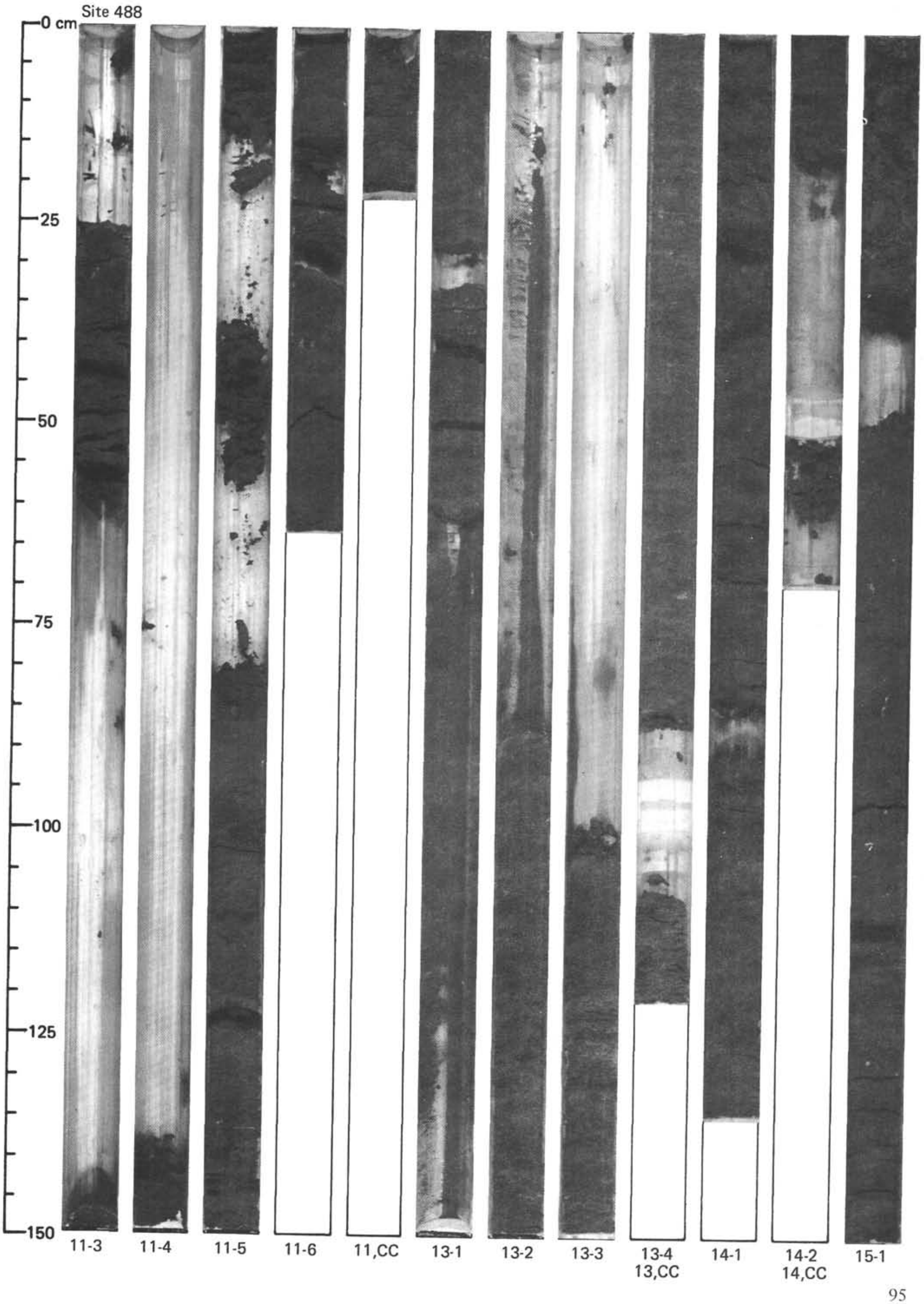

Site 488
0 cm
25
50
75
100
125
150
1-1
1,CC
2-1
2-2
2-3
2-4
2,CC
3-1
3-2
3-3
3,CC
4-1
4-2
4-3
4-4


Site 488
0 cm
25
50
75
100
125
150
4-5
4-6
4,CC
5-1
5-2
5-3
5-4
5-5
5-6
5-7
5,CC
6-1
6-2

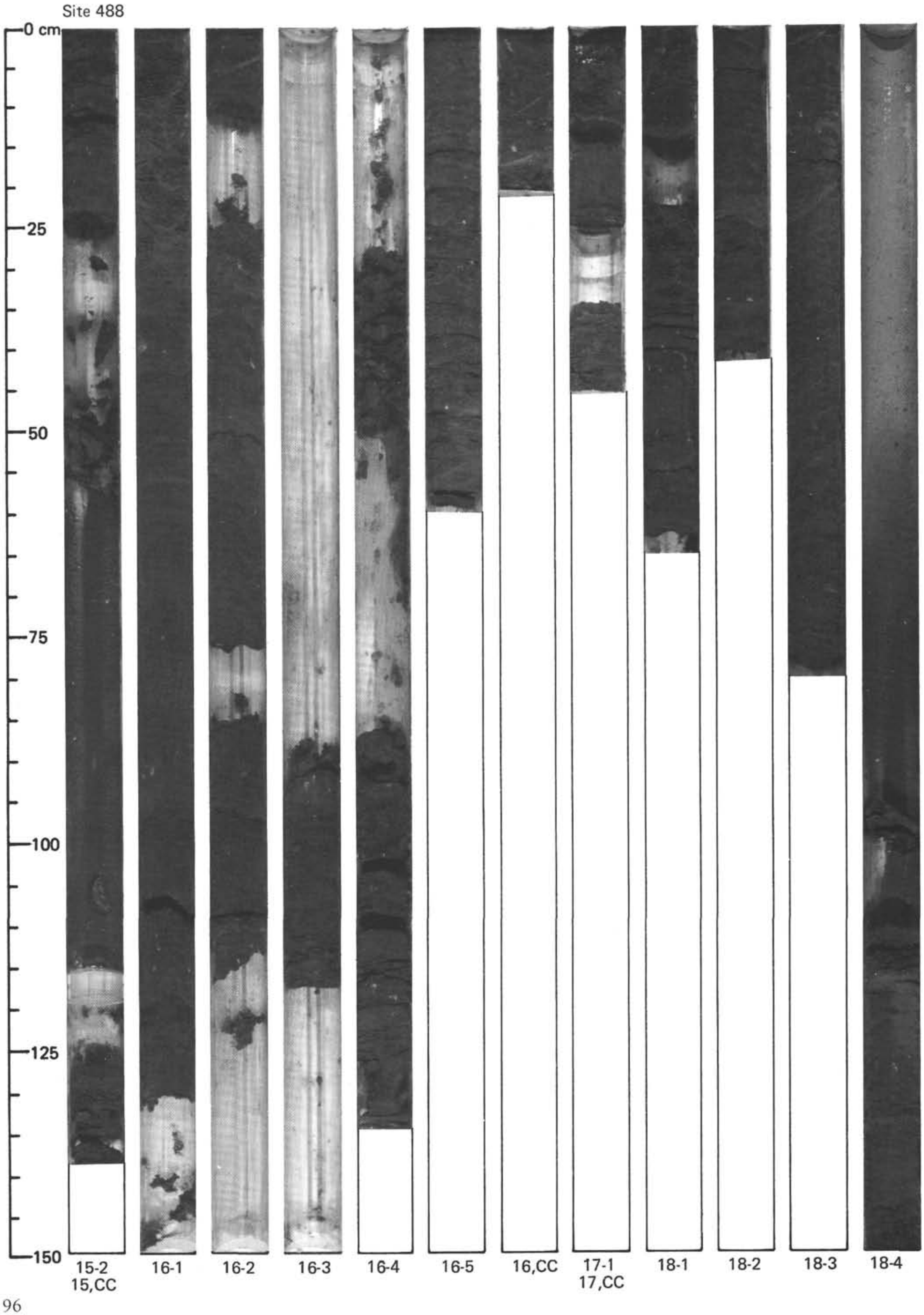

Site 488
0 cm
25
50
75
100
125
150
6-3
6-4
6-5
6-6
6,CC
7-1
7-2
7-3
7-4
7,CC
8-1
8,CC

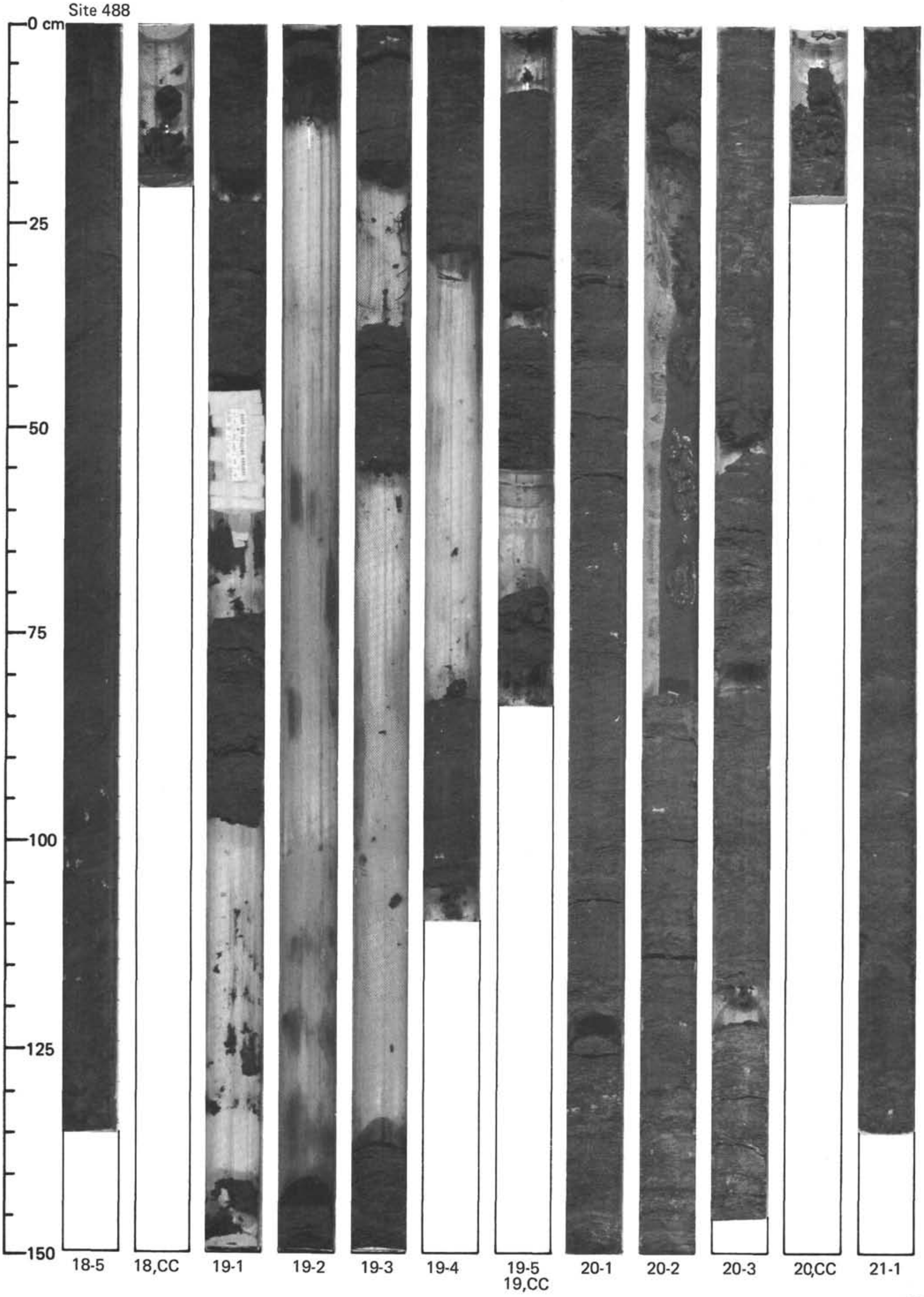


Site 488
0 cm
25
50
75
100
125
150
9-1
9-2
9-3
9-4
9,CC
10-1
10-2
10-3
10-4
10-5
10,CC
11-1
11-2



Site 488
0 cm
25
50
75
100
125
150
11-3
11-4
11-5
11-6
11,CC
13-1
13-2
13-3
13-4
13,CC
14-1
14-2
14,CC
15-1


Site 488
0 cm
25
50
75
100
125
150
15-2
15,CC
16-1
16-2
16-3
16-4
16-5
16,CC
17-1
17,CC
18-1
18-2
18-3
18-4


Site 488
0 cm
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50
75
100
125
150
18-5
18,CC
19-1
19-2
19-3
19-4
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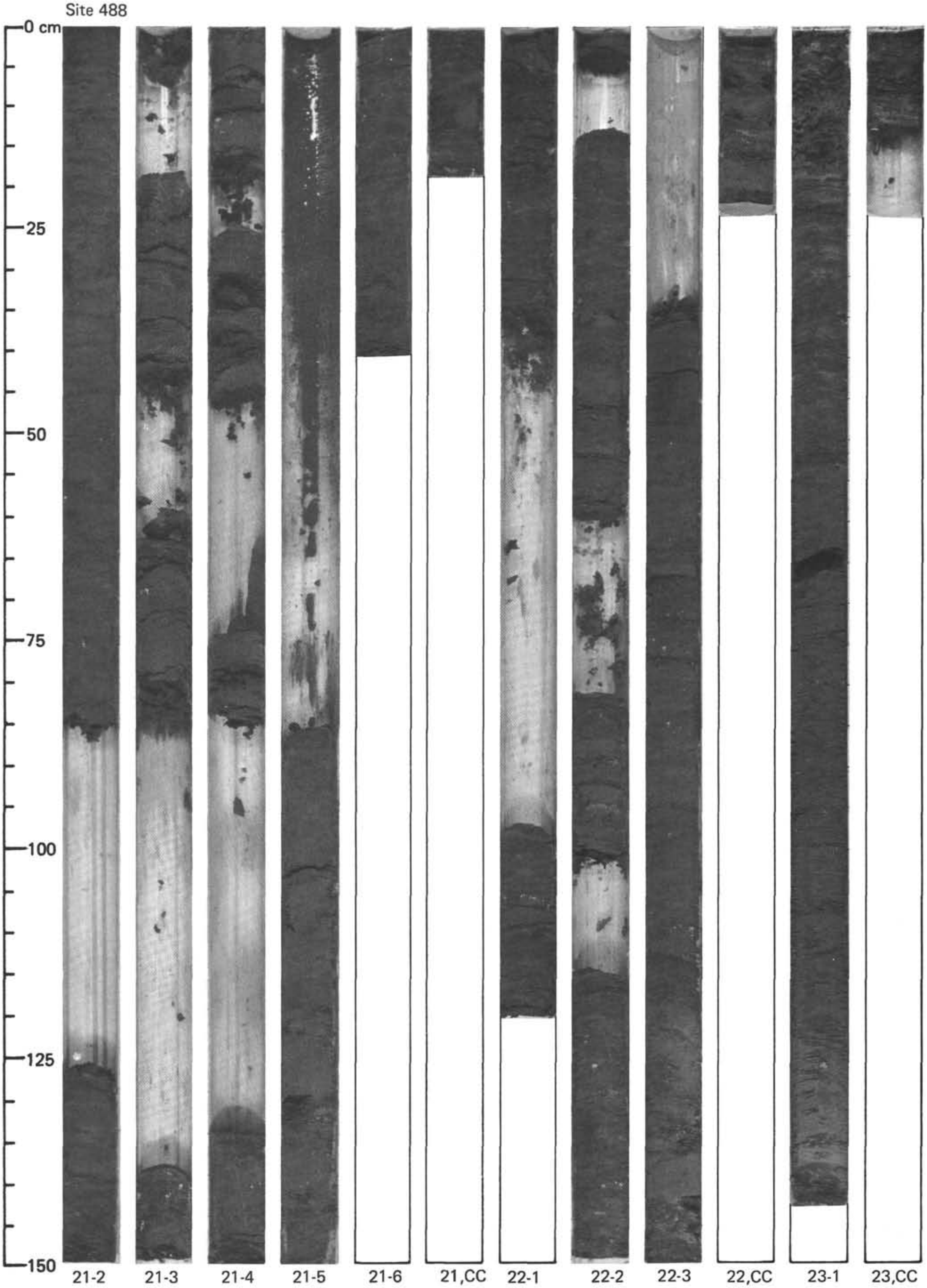
20-1
20-2
20-3
20,CC
21-1



Site 488
0 cm
25
50
75
100
125
150
21-2
21-3
21-4
21-5
21-6
21,CC
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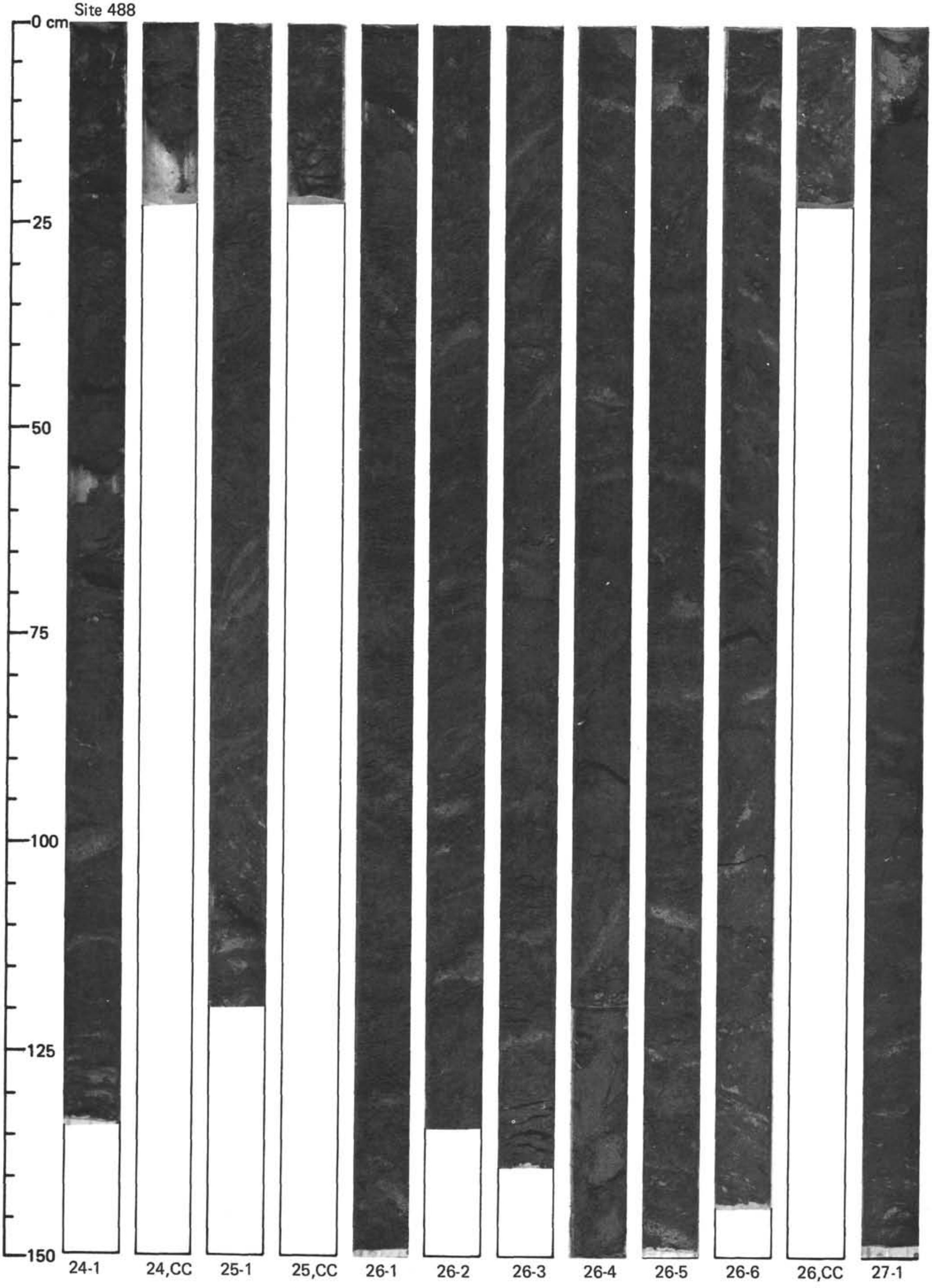
22-2
22-3
22,CC
23-1
23,CC


Site 488
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75
100
125
150
24-1
24,CC
25-1
25,CC
26-1
26-2
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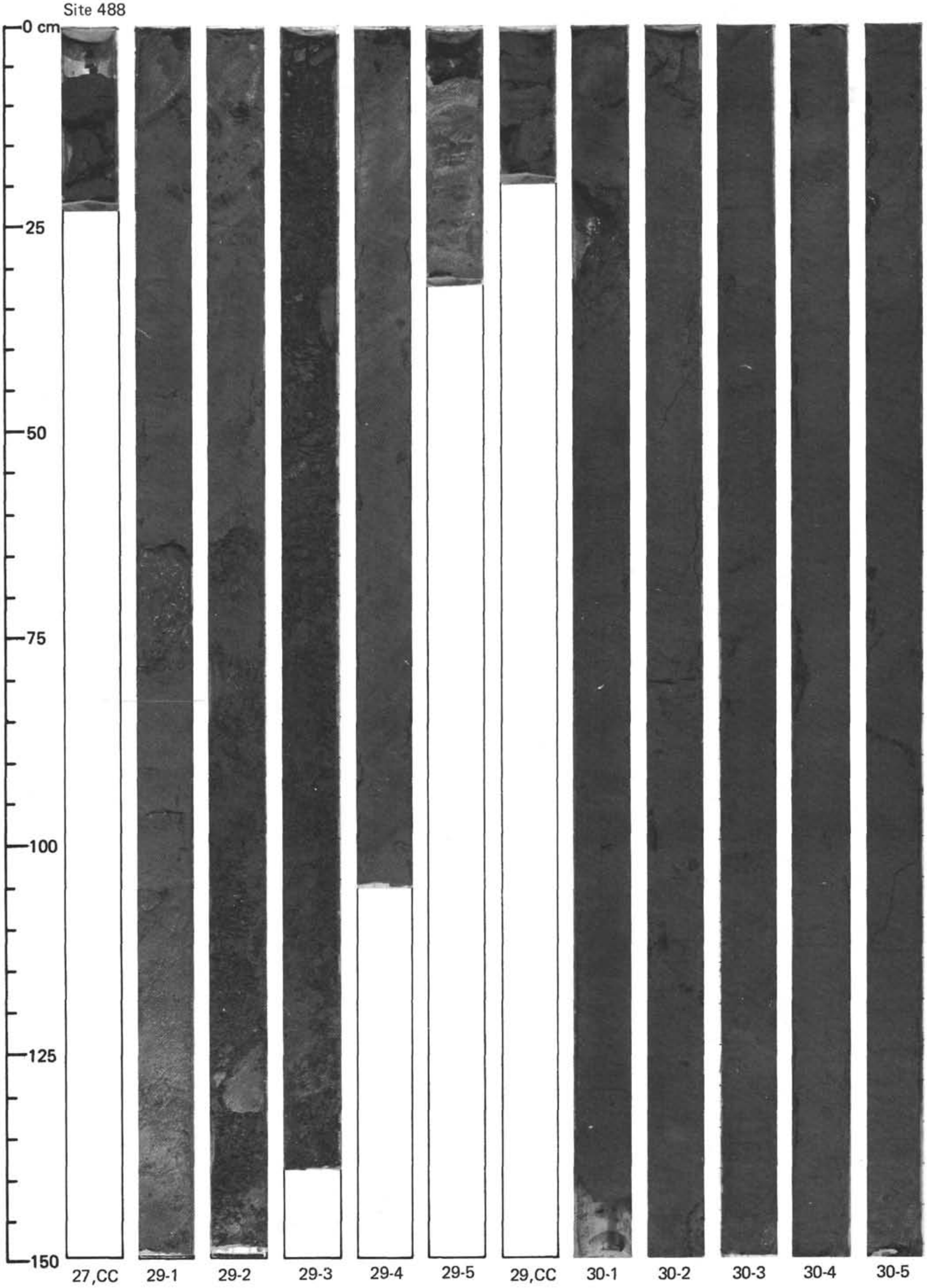
26-4
26-5
26-6
26,CC
27-1


Site 488
0 cm
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75
100
125
150
27,CC
29-1
29-2
29-3
29-4
29-5
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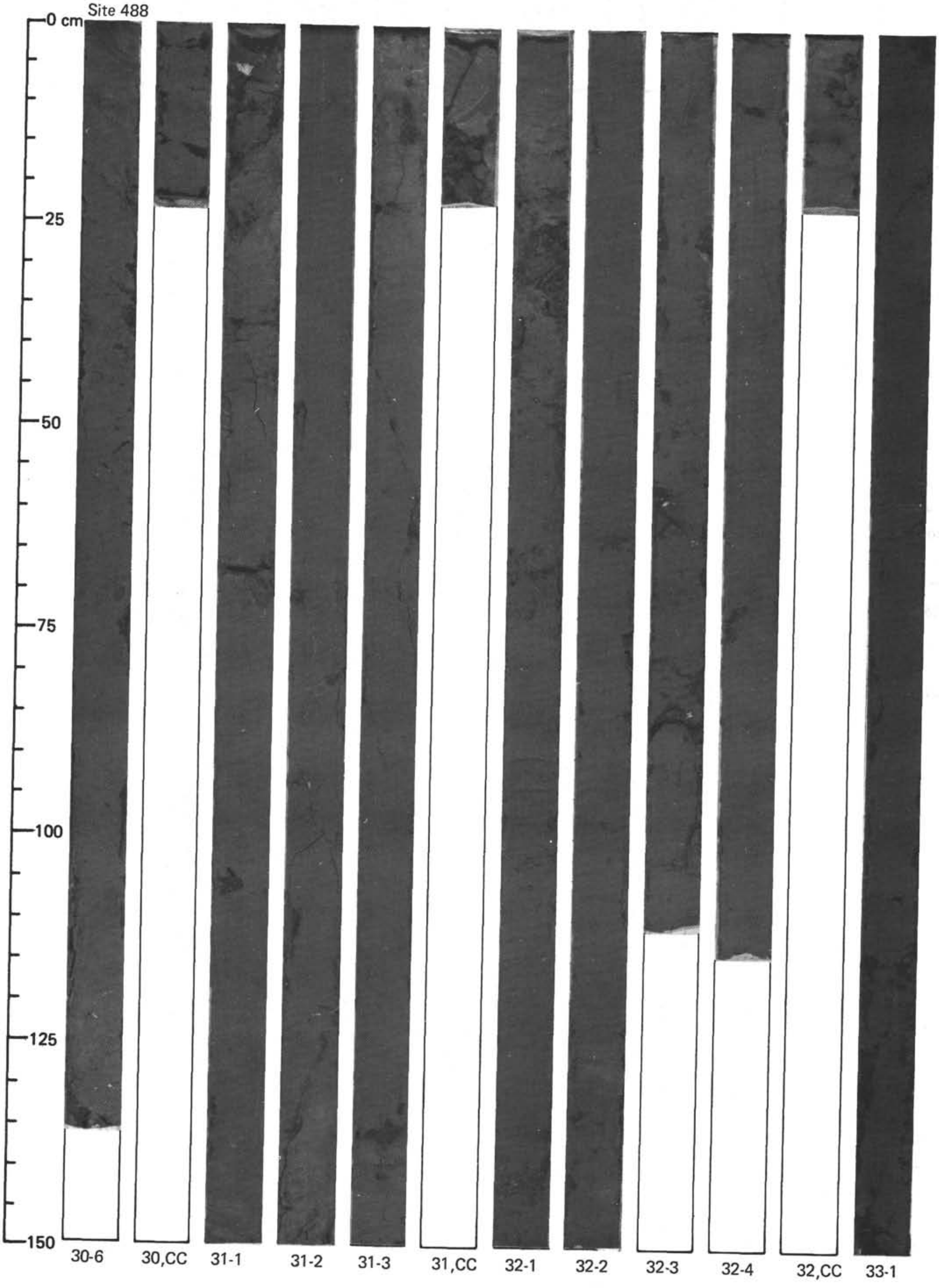
30-3
30-4
30-5


Site 488
0 cm
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50
75
100
125
150
30-6
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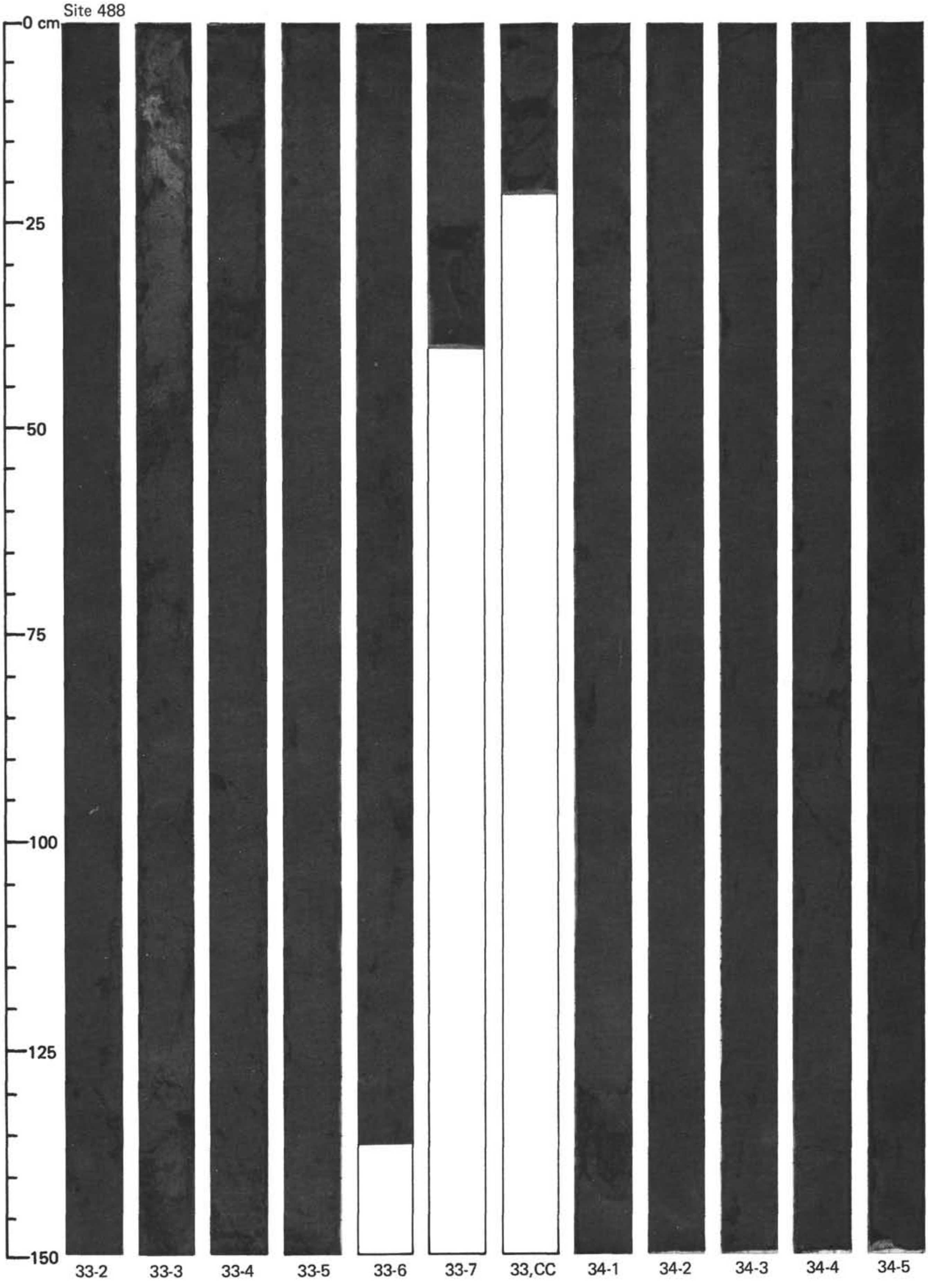
31-1
31-2
31-3
31,CC
32-1
32-2
32-3
32-4
32,CC
33-1


Site 488
0 cm
25
50
75
100
125
150
33-2
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33-4
33-5
33-6
33-7
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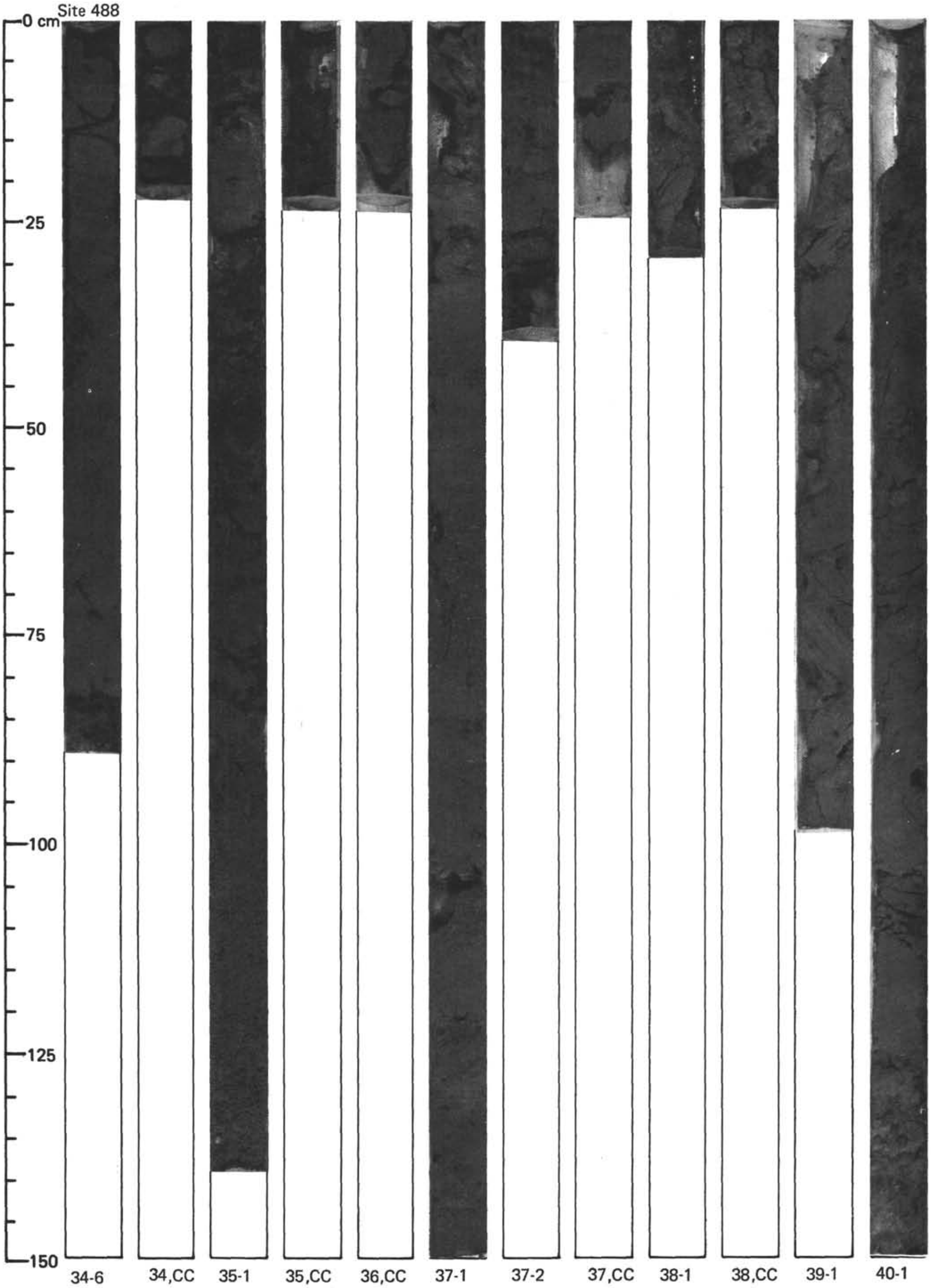
34-3
34-4
34-5


Site 488
0 cm
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100
125
150
34-6
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35-1
35,CC
36,CC
37-1
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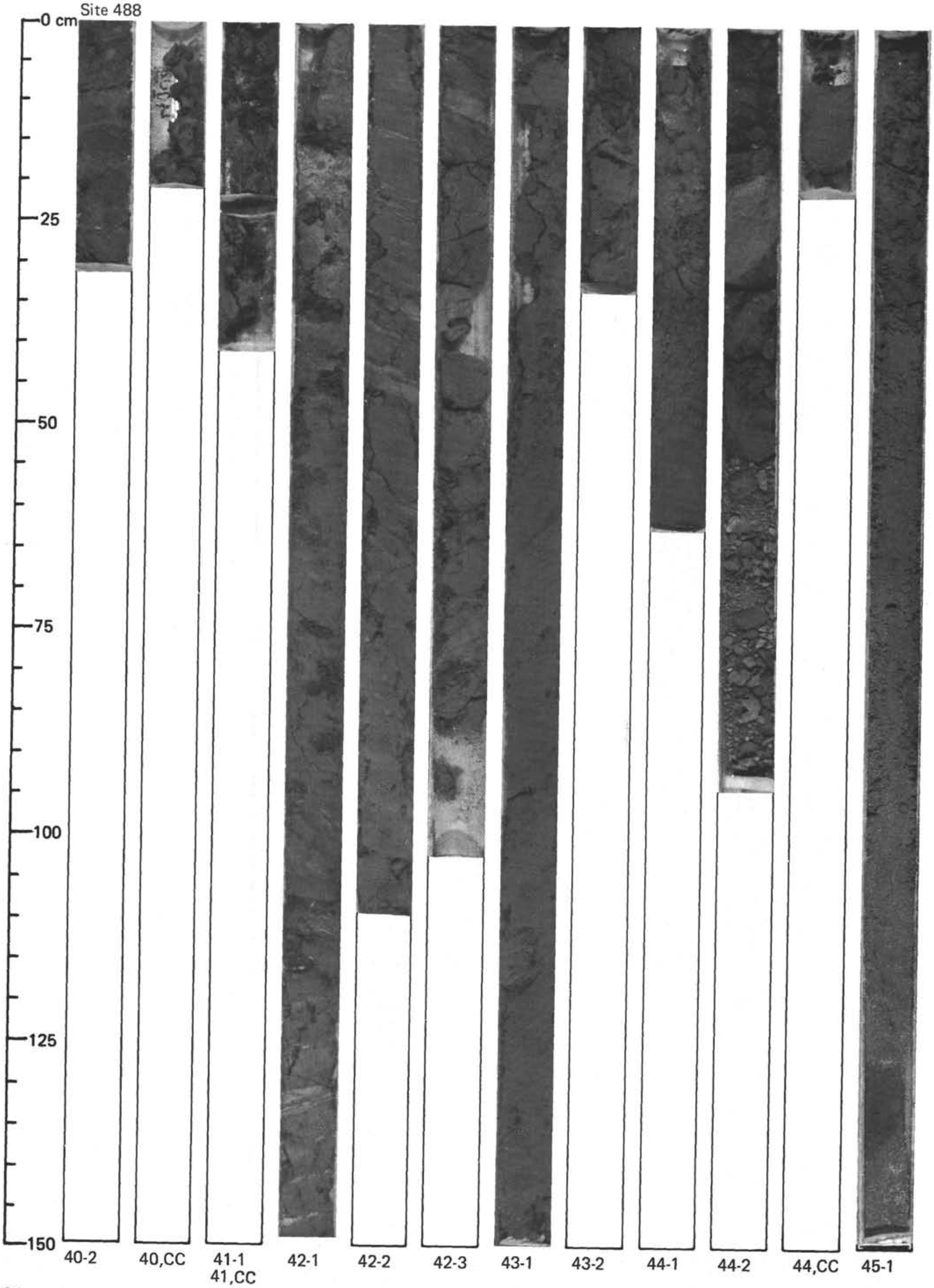
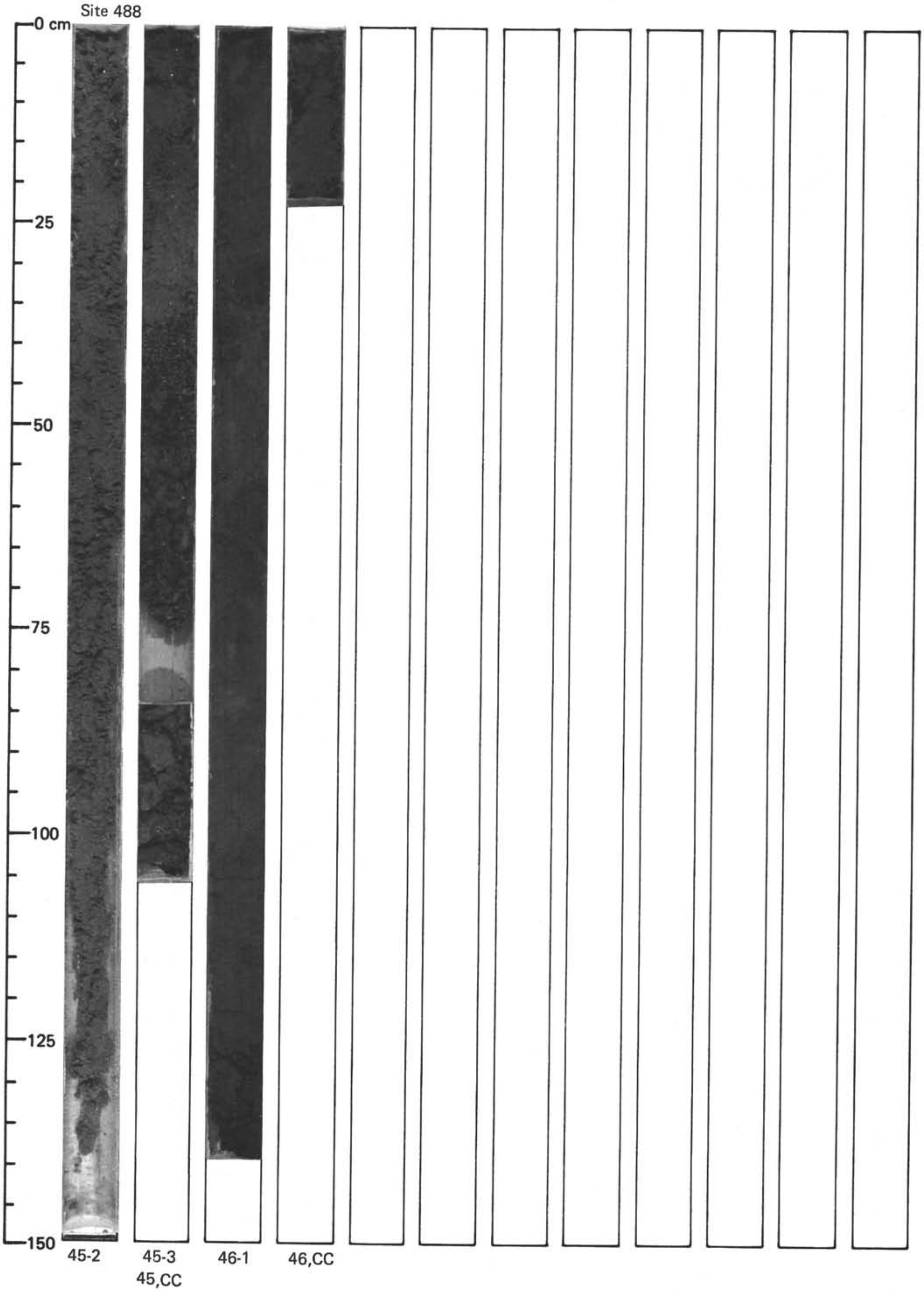
38,CC
39-1
40-1


Site 488
0 cm
25
50
75
100
125
150
40-2
40,CC
41-1
41,CC
42-1
42-2
42-3
43-1
43-2
44-1
44-2
44,CC
45-1


Site 488
0 cm
25
50
75
100
125
150
45-2
45-3
45,CC
46-1
46,CC