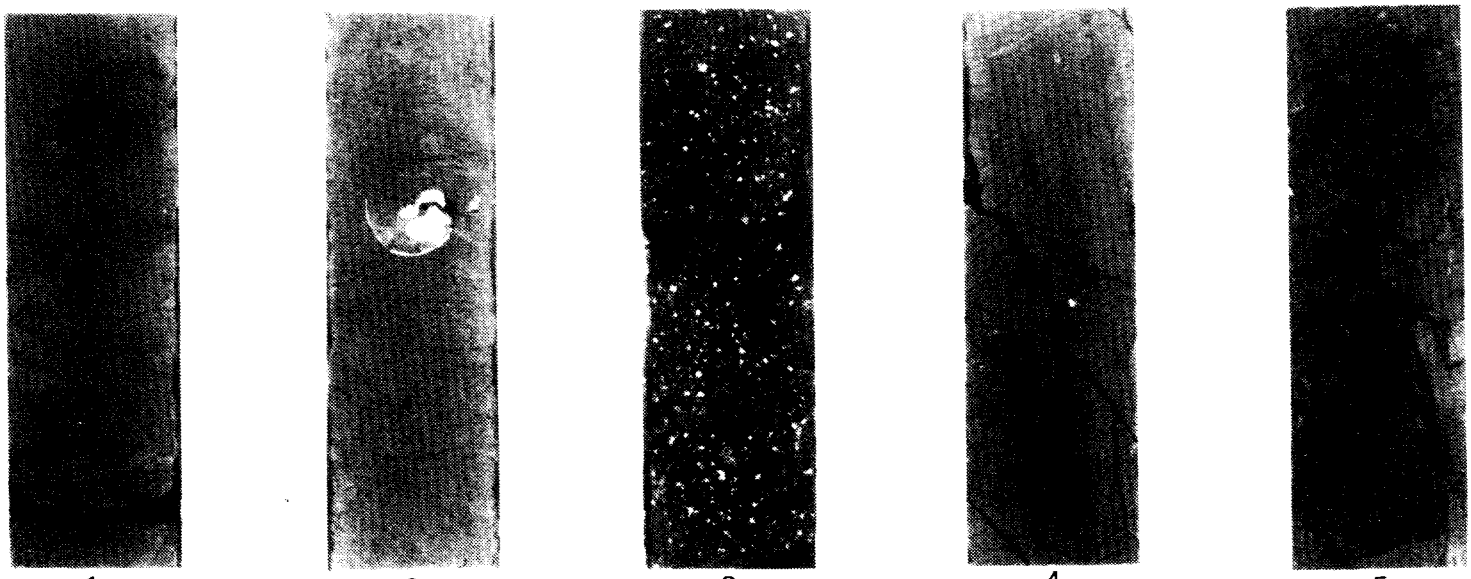
INITIAL CORE DESCRIPTIONS

DEEP SEA DRILLING PROJECT

LEG 57

JAPAN TRENCH TRANSECT



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Prepared for the
NATIONAL SCIENCE FOUNDATION
National Ocean Sediment Coring Program
Under Contract C-482
By the
UNIVERSITY OF CALIFORNIA
Scripps Institution of Oceanography
Prime Contractor for the Project

MGG 1505 5027

Captions to Cover Photos

1. 438A-1, 40-60 cm:
Diatomaceous mudstone typical of sediments of Miocene through Pleistocene age deposited in the outer forearc basin (present Deep Sea terrace). Bioturbation is common.

2. 439-26-6, 60-80 cm:
Muddy sand and silt of Oligocene(?) age deposited above conglomerates shown in adjacent photograph. These sediments typically contain articulated molluscs and were deposited in water less than 500 meters deep as indicated by benthic foraminiferal faunas.

3. 439-32-2, 55-75 cm:
"Dacite" boulder recovered from Oligocene(?) conglomerates near bottom of Site 439. Radiometric ages cluster near 23 m.y.B.P. for boulders in this suite of compositions ranging from rhyolite to andesite. The conglomerate is interpreted as a subaerial sedimentary deposit. The position of volcanism near to the site as indicated by the constituents of this conglomerate (proximal) is anomalous with respect to the trench and active volcanic arc.

4. 440B-31-5, 40-60 cm:
Highly fractured but rehealed green-gray mudstones recovered from the mid-slope terrace at about 425 meters depth in the deformed sedimentary sequence. Open fractures break sub-parallel to rehealed high angle fractures.

5. 441A-H2-1, 70-90 cm:
Recovery in this hole on the inner slope of the trench was poor. The brittle and highly fractured green-gray vitric diatomaceous mudstones and mudstones are interpreted as slope deposits involved in deformation related to convergence. This sample is typical of the material recovered.

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Dear Colleague:

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Thank you for your interest in the Deep Sea Drilling Project.

Sincerely,

David G. Moore
Chief Scientist
Deep Sea Drilling Project

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INITIAL CORE DESCRIPTIONS

DEEP SEA DRILLING PROJECT

LEG 57

18 October — 3 December 1977

A Project Planned by and Carried Out With the Advice of the
JOINT OCEANOGRAPHIC INSTITUTIONS FOR DEEP EARTH SAMPLING (JOIDES)

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INITIAL CORE DESCRIPTIONS – LEG 57

INTRODUCTION

The Japan Trench transect is the first of three IPOD transects across active margins. These transects are designed to study the effects of plate convergence at continental and island arc margins through geophysical techniques and *Glomar Challenger* sampling. Leg 57 completed the Japan Trench transect (begun on Leg 56) that was designed to sample reference sections on each side of the zone of accretion, and sites in the zone (Figure 1). At one reference site east and seaward of the trench, material entering the zone of convergence from the seaward side on oceanic crust was sampled (Site 436*), and at two others, we sampled material from the landward side in the fore-arc basin (Sites 438, 439). Four sites were drilled in the vicinity of the zone of accretion on the trench inner slope (Sites 434*, 435*, 440, 441). Core recovery data is shown in Table 1.

The Japan Trench transect crosses a portion of the fore-arc area on the Pacific side of an island arc system in which the insular continental crust rifted from the Asian mainland, creating a back-arc basin between Asia and Japan. In preparation for IPOD drilling, two 24-channel seismic reflection records across the area most favorable for study were made by JAPEX under contract to the Japan Petroleum Development Corporation. In addition, a multichannel record was donated by the Shell Oil Company. Single channel seismic reflection surveys were made by the Ocean Research Institute, University of Tokyo, and by the Geological Survey of Japan.

Seismic records along the transect indicate that the non-folded Paleogene sedimentary sequence inferred from samples near shore (Honza, et al., 1978) rests unconformably on acoustic basement, and extends from the shore to the vicinity of the trench inner slope (Ishiwada and Ogawa, 1976, Figure 1). The Paleogene sequence is in turn overlain by a Neogene sequence that extends even farther across the trench slope. Seaward of the non-folded sequence are deformed strata in the zone of presumed accretion, adjacent to the trench.

Leg 57 drilling began at a reference site (Sites 438, 439) where a complete biostratigraphic zonation and the terrigenous lithology could be established. Sites 438 and 439 are essentially a single site just landward of the trench inner slope on the deep-sea terrace in a section that has been little affected by the compressional stress of convergence as indicated by a series of extensional faults. The remaining Leg 57 sites are on the trench inner slope in a zone presumably stressed by convergence. This zone should contain the boundary between tectonically accreted oceanic material and non-accreted slope material of the present convergent tectonic epoch. Site 440 is on the relatively narrow mid-slope structural terrace. The midslope terrace is underlain by a short sequence of gently dipping unfolded weak reflections similar in character to the reflective sequence landward. Below, at great depth, the terrace is underlain by a strong reflection from igneous crust of the downgoing oceanic plate. Site 441, down the trench slope from Site 440, is on rough terrain of the zone of accretion. The zone of accretion is recorded as many diffractions and some sparse, lower tilted reflections that are overlain by short or discontinuous reflections subparallel to the sea floor. The upper sequence of reflections is much less faulted than the oceanic basement suggesting rapid slope sedimentation or downslope mass movement.

LITHOLOGY

SITES 438 AND 439

Drilling at Sites 438 and 439, on a broad faulted arch near the edge of the deep-sea terrace, reached the acoustic basement. The four holes drilled here penetrated a nearly continuous section of Holocene through upper Oligocene beds unconformably overlying hard, folded rocks of Late Cretaceous age (Figure 2). The sampled section is divided into four lithological units (see Table 2).

Unit 1 differs in thickness between the four holes and is of late Pliocene through Holocene age. It is 52 to 107 meters thick and consists of diatomaceous sandy silty clay, silt, and numerous ash layers.

Unit 2 is 765 meters thick and consists from top to bottom of: a) lower through upper Pliocene, homogeneous to

*Sites drilled on Leg 56.

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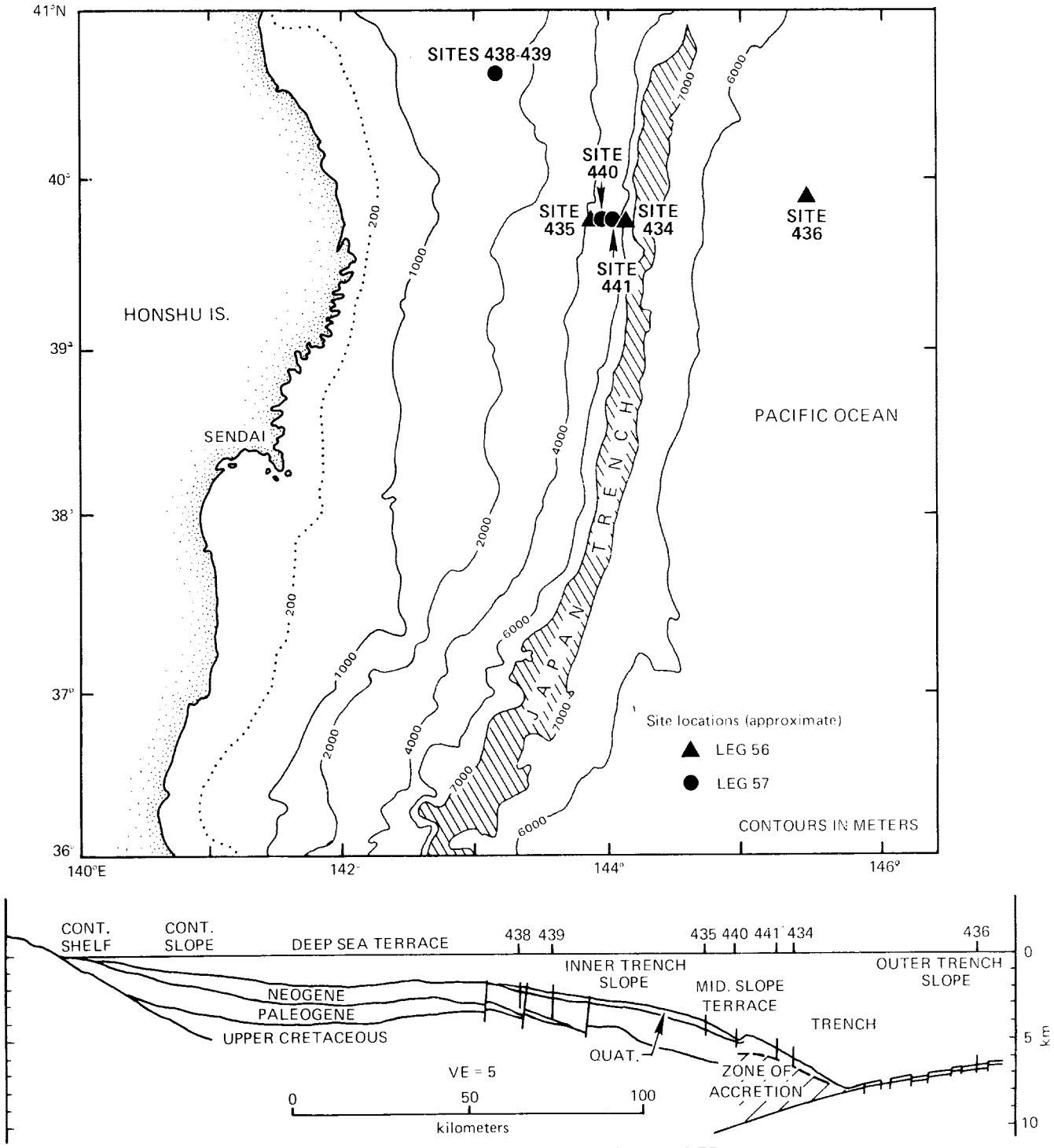

Figure 1. Location of sites drilled on the Japan Trench transect (above) and schematic section showing drill sites. Section based on Ishiwada and Ogawa and JPDC multichannel data.

TABLE 1. Leg 57 Coring Summary

HOLE	DATES (1977)	LATITUDE	LONGITUDE	WATER DEPTH (m)	PENETRATION (m)	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERY
438	19 October	40° 37.75'N	143° 13.90'E	1547.5	109.5	12	109.5	81.9	75
438A	22-27 October	40° 37.79'N	143° 14.15'E	1558.0	878.0	86	878.0	555.3	63
438B	27 October - 2 November	40° 37.80'N	143° 14.80'E	1564.5	1040.7	24	215.9	192.6	45
439	3-8 November	40° 37.61'N	143° 18.63'E	1656.0	1157.5	39	342.0	163.1	48
440	10 November	39° 44.13'N	143° 55.74'E	4507.0	73.0	8	73.0	50.4	69
440A	11 November	39° 44.13'N	143° 55.74'E	4507.0	139.5	7	66.5	33.5	50
440B	12-19 November	39° 44.13'N	143° 55.74'E	4507.0	814.0	71	814.0	401.9	49
441	21-22 November	39° 45.05'N	144° 04.59'E	5655.0	273.0	9	79.0	16.6	21
441A	23-27 November	39° 45.05'N	144° 04.59'E	5646.0	662.0	15	138.5	19.7	14
441B	30 November	39° 45.08'N	144° 04.60'E	5640.0	687.0	2	18.0	5.5	30
						273	2734.4	1520.5	

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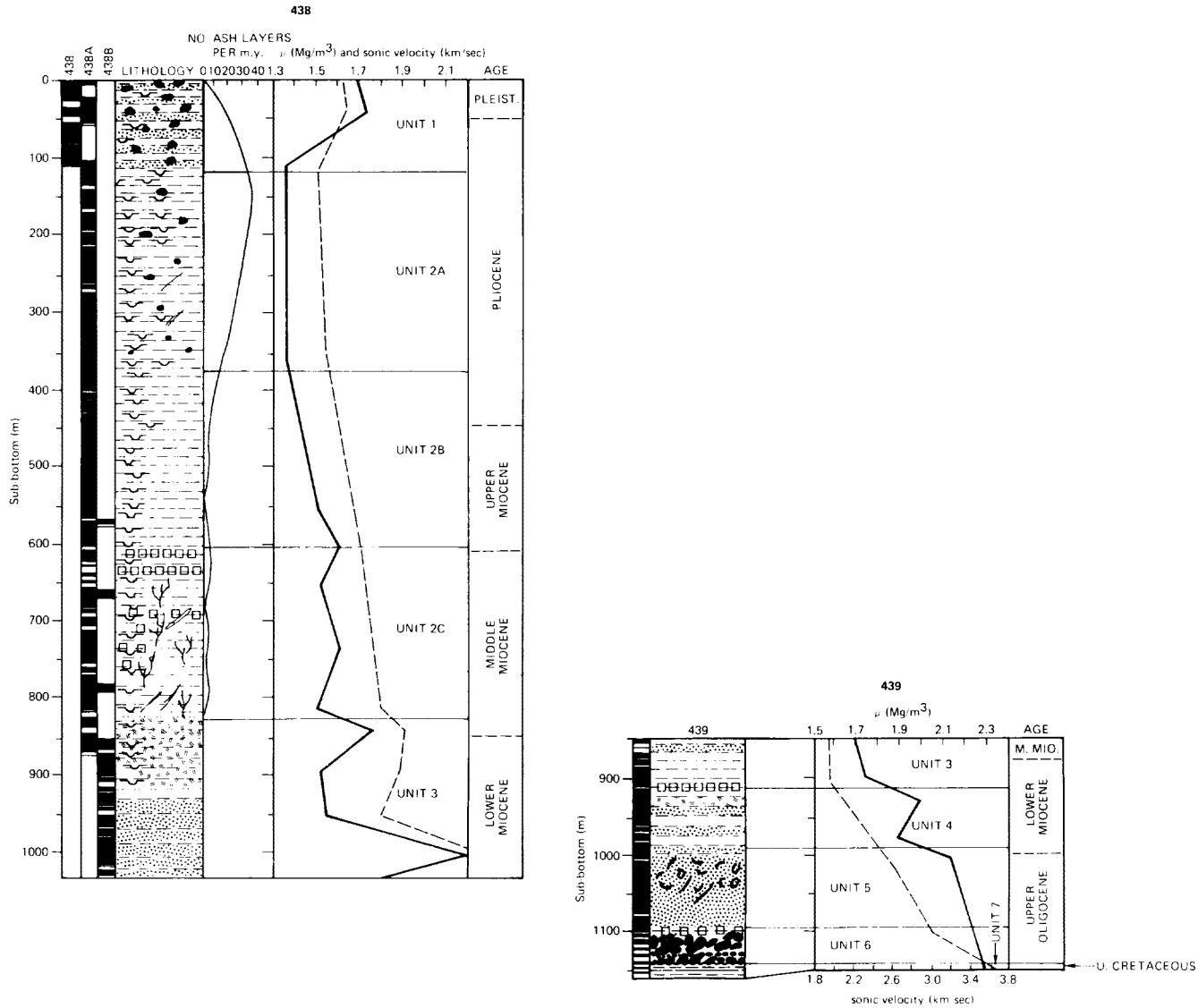

Figure 2a. Summary of lithology, ash layers, and downhole logging at sites drilled on Leg 57.

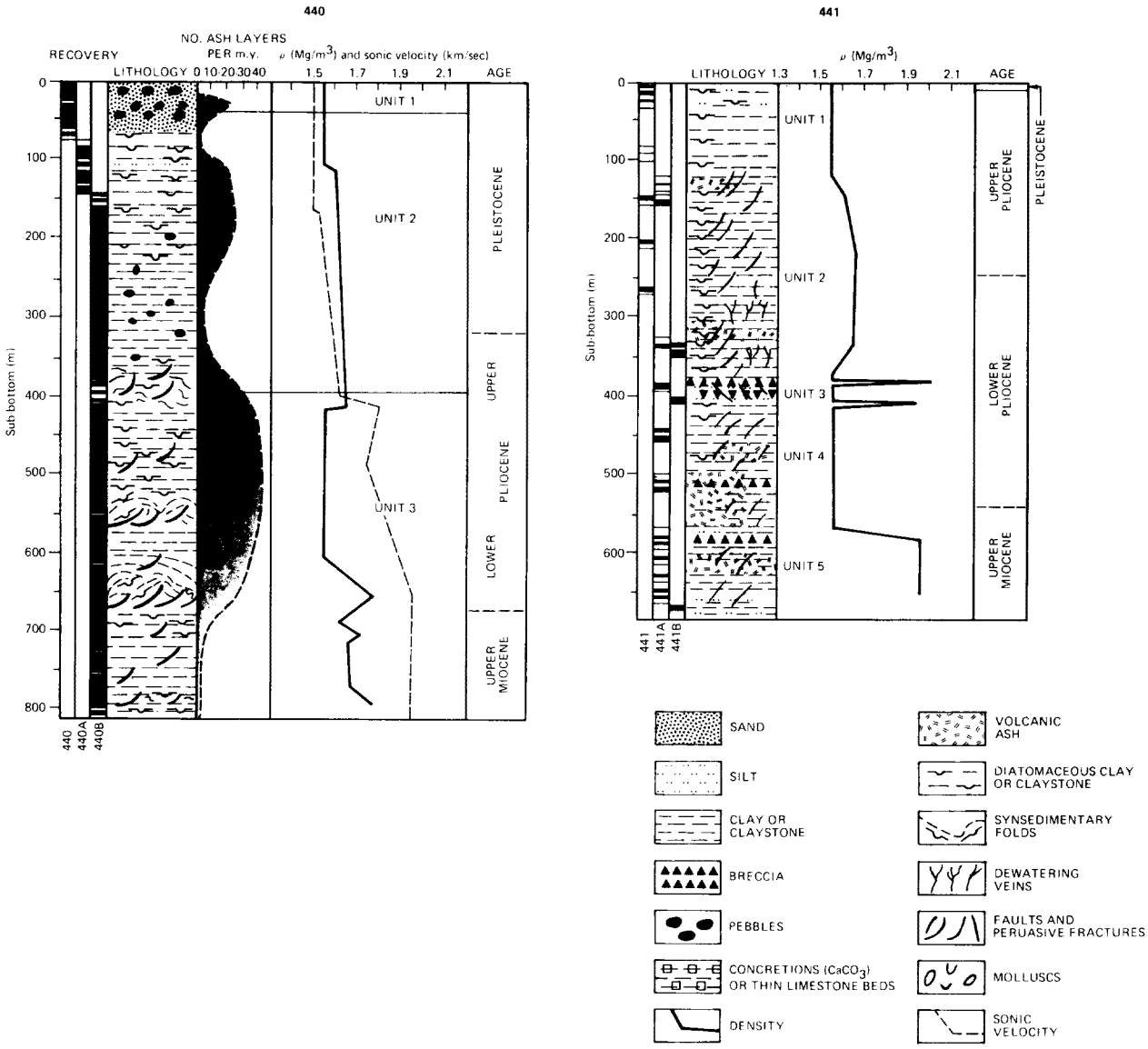

Figure 2b. Summary of lithology, ash layers, and downhole logging at sites drilled on Leg 57.

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TABLE 2. Lithology

Hole	Lithologic Unit	Core Numbers	Depth (m)	Age	Lithology
438	Unit 1 (107.0 m)	1 to 12	0.0-107.0	Upper Pliocene through Pleistocene	Diatomaceous sandy, silty clay and silt, pebbly (pumice and black graywacke[?]), dark gray, olive gray, and dark olive gray (5Y 4/2-3/2, 3/1); numerous ash layers.
438A	Unit 1 (51.5 m)	1 to 4	0.0-51.5	Pleistocene	Diatomaceous sandy, silty, pebbly clay, olive gray to dark olive gray (5Y 3/2-4/2) in part; numerous ash layers.
	Unit 2 Subunit 2A (312.5 m)	5 to 80 5 to 32	51.5-817.0 51.5-363.0	Lower Pliocene through upper Pliocene	Homogeneous to burrow-mottled (lower part) clayey diatom ooze, diatom ooze, and diatomaceous clay (soft to firm), mostly olive gray (5Y 4/2) with dark and very dark gray intervals (5Y 3/2, 4/1) and olive mottling in lower part (5Y 5/3); numerous ash horizons (green gray to gray), occasional pebbles (pumice), and siliceous sponge remains.
	Subunit 2B (230.0 m)	33 to 56	363.0-593.0	Upper Miocene through lower Pliocene (lowermost)	Diatomaceous claystone, clayey diatomite (silicified), burrow-mottled throughout, minor ash layers in upper portion. Most of unit is olive gray, dark olive gray, gray to very dark gray. Sponge remains occur only in upper part. Lower part of unit silicified. Rare pebbles (pumice).
	Subunit 2C (224.0 m)	57 to 80	593.0-817.0	Middle Miocene through lower upper Miocene	Mostly burrow-mottled claystone and diatomaceous claystone showing dewatering structures and some microfaults. Thin calcareous concretions and thin limestone beds common. Pebbles (pumice) and ash horizons rare. Unit 2C is predominantly dark gray, gray, and gray green (5Y 4/1-5/1, and 5GY 5/1-4/1).
	Unit 3 (61.0 m)	80 to 86	817.0-878.0	Lower Miocene to lower middle Miocene	Sandy claystone and diatomaceous claystone, vitric in part. Clayey sandstone and siltstone alternates with claystone. Burrow-mottling common. Colors mostly gray to dark gray and gray green (5YG 5/1-4/1 and 5GY 4/1).
439	Subunit 2B	1, 2	----	----	---- Overlap with Site 438
	Subunit 2C	3, 4	----	----	----
	Continuous coring begins----------				----------
	Unit 3 (766.5 m)	5 to 11	849.5-916.0	Lower to middle Miocene	Grayish olive green (5GY 3/2) and olive gray to dark olive gray (5Y 4/2-3/1) claystone and vitric claystone; intensely burrow-mottled (5Y 6/4 and 5Y 4/3), concretionary limestone layers, infrequent thin tuff layers, pumice clasts and fragments microfaults and dewatering veins, tension fractures, sharp transition to next unit below.
			~~ hiatus ~~~		
	Unit 4 (77.5 m)	12 to 22-1	916.0-993.5	Lower Miocene	Interbedded turbidites and silty claystone, greenish black (5G 2/1, 5Y 4/1) to olive gray, Bouma sequences mostly as with a few ade and acde; m. g. to f. g. sand, silt grading upward to clay, sharp basal contacts, scoured; lithic wacke composition (microcrystalline quartz lithic fragments), some mollusc fragments. A few tuff layers, mottled clayey siltstone at base–sharp transition to next unit below.

TABLE 2. (Cont'd.)

Hole	Lithologic Unit	Core Numbers	Depth (m)	Age	Lithology
	Unit 5 (104.5 m)	22-2 to 32-1	993.5-1098.0	Oligocene	Gray to olive gray (N5 to 5Y 4/1 and 2.5Y 4/0) massive sandstone and siltstone moderately well-sorted, friable, no sedimentary structures, abundant molluscan debris and articulated pelecypods; sandstone calcite-cemented in lowest part of unit. Wood chips, quartz, lithic fragments (sands are lithic arenites) common.
	Unit 6 (47.5 m)	32-2 to 37-1	1098.0-1145.5	Oligocene(?)	Boulder to pebble conglomerate and breccia, mostly mud-supported, angular to subrounded clasts in clay-size matrix; boulder and smaller clasts of dacite (blue-gray to greenish-gray) and pebbles and granules of very dark gray silicified silty claystone (similar to Unit 7). Boulders up to 65 cm diameter. Several individual conglomerate units. Basal 60 cm is olive gray (5Y 4/1) plastic clay (firm).
				~~ hiatus ~~	
	Unit 7	37-2 to 39	1145.5-1157.5	Cretaceous	Dark to very dark gray (N4 to N2) well indurated, silicified claystone and clayey siltstone with thin (<1 cm) calcareous graded silt beds; contorted into slump folds but some horizontal bedding.
440	Unit 1	1 to 5	0.0-38.0	Holocene-upper Pleistocene	Greenish black to olive gray (5G 2/1 to 5Y 4/2) clayey sand and gravel, poorly sorted, from dusky yellow green to olive gray (5GY 5/2 to 5Y 3/2) diatomaceous clay, sandy diatom ooze and grayish olive (10Y 4/2) diatomaceous silty and sandy clay; some graded bedding in coarser-grained intervals. Rounded pebbles of various igneous and sedimentary rocks common. Some thin ash layers.
	Unit 2	5 to 26	38.0-380.0	Lower Pleistocene-upper Pliocene	Mostly dark olive gray to olive gray (5Y 3/2-4/2) diatomaceous clay and (below 168 m) diatomaceous claystone. Randomly dispersed rounded pebbles common; burrow mottling increases downhole. Minor thin ash layers.
	Unit 3	27 to 71	380.0-808.0	Lower Pliocene-upper Miocene	Generally olive gray to dark olive gray (5Y 4/2-3/2) interbedded claystone and diatomaceous claystone. Zones of folded beds (due to mass movement), veins and microfaults. Thin (1 cm) ash layers common throughout.
441 441A	Unit 1	1 to 6 A1-A2	0.0-132.0	Pleistocene-upper Pliocene	Dark greenish gray (5GY 4/1) silty diatomaceous clay at top, predominantly olive gray (5Y 4/2) diatomaceous clay with minor ash layers; rounded pebbles up to 2 cm diameter consisting of basalt, dacite, pumice, and some calcareous pebbles or concretions. Minor clayey silt or sand layers. Slightly mottled throughout. One graded silty tuffite noted at base of Unit 1.
441 441A	Unit 2	7 to 9 A3-A4 H1, H2*	132.0-380.0	Upper Pliocene-lower Pliocene	Dark green gray (5GY 4/1) dark olive gray (5Y 3/2) and olive gray (5Y 4/1) diatomaceous claystone minor clayey diatomite, vitric diatomaceous claystone and a few thin tuff beds. Some calcareous mottles and concretions. Entire unit is characterized by fractures, parting, and some black veins (rehealed). Recovery is mostly in the form of <1 cm chips (fissility) and very poor.

*H signifies 2 wash core through an interval longer than the core barrel which was archived and sampled as a normal core for that interval.

TABLE 2. (Cont'd.)

Hole	Lithologic Unit	Core Numbers	Depth (m)	Age	Lithology
441A	Unit 3	A5	380.0-410.0	Lower Pliocene	Breccia of dark gray (N3) siltstone: rounded to angular siltstone fragments in more clay-rich matrix or gouge. Dewatering veins at top of unit recovered. Several graded and ungraded very fine-grained to coarse-grained sandstone interbedded with claystone (5Y 6/1). Bottom of unit chosen on basis of signature on geophysical log (FTC). Fair recovery.
441A	Unit 4	A6, A7	410.0-504.0	Lower Pliocene	Mostly olive gray (5Y 3/2) diatomaceous claystone and claystone, some siltstone, possible redeposited claystone, minor tuff layers and calcareous concretions; poor recovery and highly fractured material.
441A 441B	Unit 5	A8-A15 H4 B-1, 2 BH-1, BH-2	504.0-687.0	Lower Pliocene-upper Miocene	Heterogeneous lithology consisting of olive gray (5Y 3/2) claystone, greenish black to greenish gray (5G 2/1-6/1) silty claystone, calcareous claystone and carbonate-cemented claystone breccia, to dark greenish gray (5GY 4/1) resedimented claystone to 45° dip. Lower part of unit composed of greenish black claystone (5G 2/1-3/1) and olive gray, silty claystone (5Y 4/1) with some light olive gray (5Y 5/1) silty tuffite and (5Y 3/1) vitric silty claystone. Entire unit exhibits high fissility; intensely fractured except for breccia units.

burrow-mottled clayey diatomaceous ooze and diatomaceous clay with numerous ash horizons and occasional pebbles; b) upper Miocene through lower Pliocene, diatomaceous claystone and clayey diatomite, burrow-mottled throughout, with minor ash layers in the upper portion; c) middle to upper Miocene, burrow-mottled claystone and diatomaceous claystone with dewatering structures and some microfaults — thin calcareous concretions and thin limestone beds are common. Foraminiferal assemblages indicate lower bathyal water depths (>2000 meters).

Unit 3, of early Miocene age, is about 120 meters thick and consists of vitric sandy claystone and diatomaceous claystone. Clayey sandstone and siltstone alternates with claystone in the uppermost part. Burrow-mottling is common.

Unit 4 is of early Miocene age. It consists of 77 meters of clayey siltstone that is well-cemented, massive to slightly burrow-mottled, and has rare faint lamination. The rock of Unit 4 is intensely fractured, probably because it was intercepted by a fault zone as seen on the seismic records. The lower part of Unit 4 at Site 439 is a fine-grained turbidite-claystone sequence of earliest Miocene age with a middle bathyal (500 to 1500 meters) foraminiferal assemblage.

Unit 5 consists of a 105 meters thick massive sandstone of Oligocene age, deposited near a surf zone. The rock is moderately sorted, texturally a medium- to fine-grained sand, lacks discernible bedding or other sedimentary structures, and is compositionally a lithic arenite or lithic wacke. The unit contains numerous megafossils including articulated pelecypods (not in growth position), virtually unbroken gastropods, and upper bathyal (200 to 500 meters) benthic foraminifera.

Unit 6 consists of conglomerate and breccia made up largely of boulders of porphyritic dacite. The angular shape of some of the dacite clasts, their large size, and the nearly monolithologic composition of the unit indicate a nearby source of either hypabyssal rocks or possibly thick flows. The conglomerate might have formed subaerially, an inference based on the lack of marine fossils and an underlying clay that was possibly formed by subaerial weathering.

Unit 7, below the reflector at the top of the acoustic basement, is a hard, dark, silicified silty claystone of Late Cretaceous age. Thin silt turbidite layers define bedding and synsedimentary as well as possible tectonic folds. An erosion surface is inferred across the top of the claystone because at least 40 million years of sedimentary history is lost in the hiatus, a rough surface topography is indicated in seismic records, and because the claystone is found as clasts in the overlying conglomerates.

The series of environments interpreted from the lithologic sequence at Sites 438 and 439 begins with an emergent Oligocene terrane of black silicified Upper Cretaceous claystone and pre-upper Oligocene dacite. Clastic debris of this lithology in conglomeratic units was covered in late Oligocene time by sand transported from a nearby surf zone into more quiet marine water of less than 500 meters depth. The terrain continued to subside through early Miocene time as interbedded turbidite sand and clay layers were deposited. Distance from sources of coarse-grained eroded material apparently increased because in early Miocene time deposition of turbidite units gave way to sedimentation of mud and diatomaceous mud. The area of the sites reached upper middle bathyal depth at the beginning of early Miocene time and lower bathyal depth in late Miocene time, and it was essentially isolated from coarse-grained terrigenous material from middle Miocene until late Pleistocene time. This sequence of events can be extrapolated to either side of the site assuming that the time horizons can be extended along seismic horizons in the multichannel records across the sites. The multichannel records were joined with the section by Ishiwada and Ogawa (1976) in order to extend the horizons to shore, thereby forming a complete reconnaissance cross section of the margin. The historical development of part of the margin interpreted from the combined geophysical and geological data is shown schematically in Figure 3. The inundation of the landmass began in lower Paleogene time west of Sites 438 and 439 and progressed through early Neogene time. The subsidence of this ancient landmass, named the Oyashio ancient landmass, is puzzling in view of the prevailing ideas of tectonic accretion at convergent margins and the island arc volcanism presumed to have been active since late Oligocene time. Underthrusting of oceanic crust at the continental crust is generally throught to be associated with uplift of the outer continental margin, yet our data suggests that uplift is only local and of latest Cenozoic age.

Perhaps the most unexpected discovery at Sites 438 and 439 are the boulders of acidic igneous rocks only 90 km from the Japan Trench. The presently active arc is 300 km from the trench. A nearby source for the boulders from the Oyashio landmass is suggested by the size and angularity of the clasts, the monolithologic character of the deposit, and the difficulty of transporting these materials from Honshu or Hokkaido Islands. From this discovery it can be inferred that perhaps a magmatic or volcanic arc of a previous tectonic epoch lay near the site or about 200 km farther east than the present arc. The sites are on a southern projection of north-trending metamorphic belts on Hokkaido Island containing remnants of a volcanic arc of Cretaceous age. It is also possible that these igneous rocks represent only some type of poorly-understood anatectic melting of lower plate material. Radiometric (Ar^{39}/Ar^{40}) age dating establishes the volcanism as having occurred about 23 m.y.B.P., essentially just prior to the reworking of the igneous products into the conglomerate.

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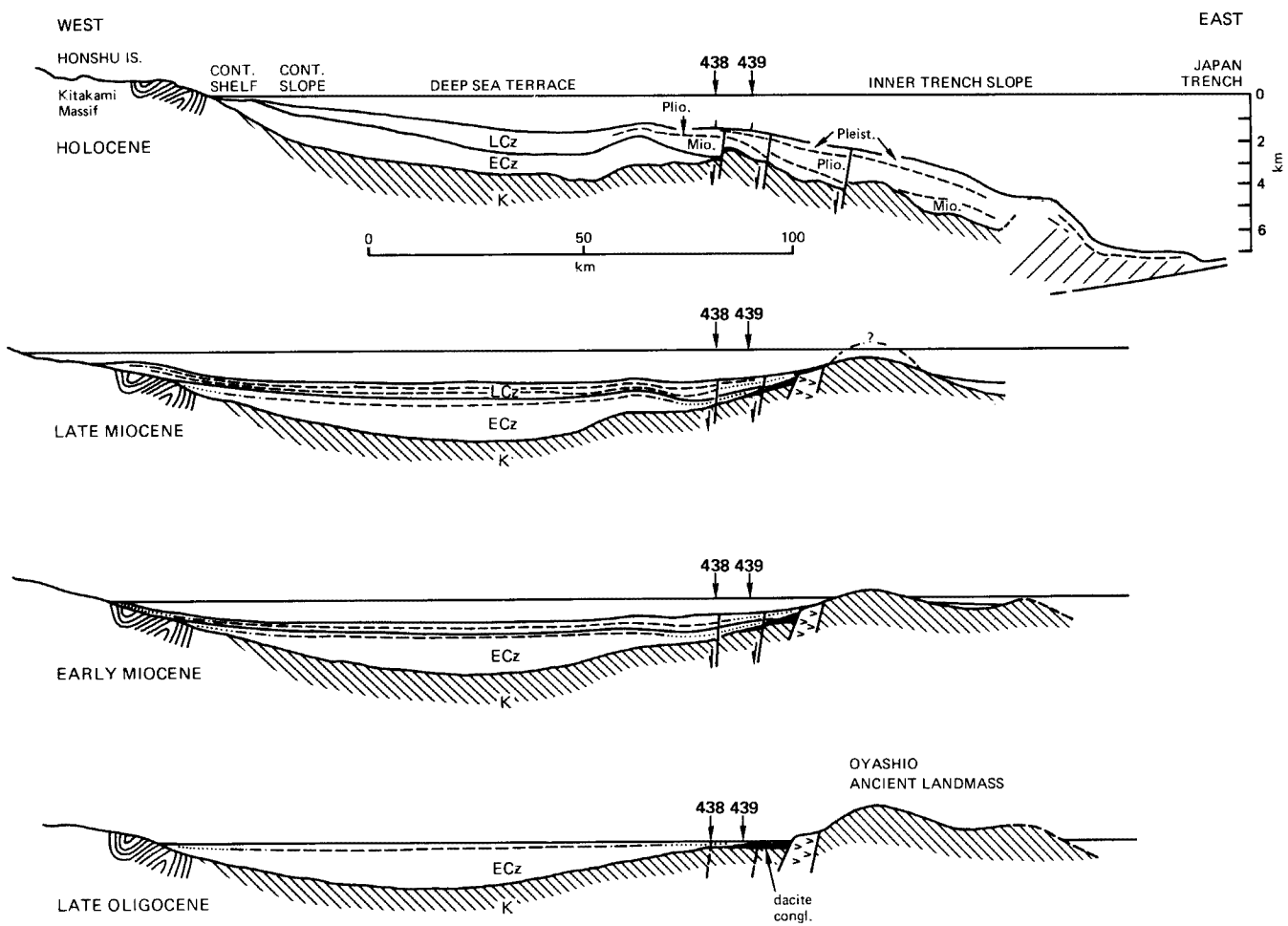

Figure 3. Diagrammatic history of subsidence of Oyashio landmass based on Leg 57 sampling, and JPDC multichannel records. K-Cretaceous, ECz-early Cenozoic (Paleogene), LCz-late Cenozoic (Neogene). Zone of accretion and oceanic igneous crust shown diagrammatically in the Holocene section.

SITE 440

Site 440 is on the relatively flat sea floor of the midslope terrace that affords a seismic window revealing a 1.6-second (2-way time) sequence of reflections dipping gently landward above a strongly diffracting acoustic horizon, much like the acoustic basement farther landward. Far below (approximately 4 km) reflections are recorded from igneous crust of the downgoing oceanic plate (Figure 1).

The composition of sediment at this site is very similar to those at Sites 439 and 439 (Figure 2, Table 2). The uppermost unit, 38 meters thick, has poorly sorted graded beds of clay, sand, and gravel between layers of diatomaceous clay and ooze. The upper half of the second unit (38 to 380 meters) is composed of diatomaceous claystone; the lower half is claystone. Mottling is slight to intense; lithification* begins at 168 meters and induration increases downward. The third unit (380 to 808 meters) is also diatomaceous claystone and claystone, but it is distinguished by several zones with syndepositional folds that appear to be thin units in downhole logs.

Ash and tuff layers are distributed much like those at Sites 438. Volcanic ash layers begin to increase in late Miocene time and remain high during the first two-thirds of Pliocene time. After a waning period, the ash layers again become numerous in late Pleistocene time. The relation of ash layers to frequency of volcanic activity will require evaluation of the effects of bioturbation and alteration.

Sediment accumulated at a constant rate in Pliocene and Miocene time (Figure 4) and deposits of these ages are of approximately equivalent thicknesses to those cored at Sites 438 and 439. The Pleistocene section, however, is 200 to 250 meters thicker than at any other site in the Japan Trench transect. This increase in thickness is probably caused by ponding of sediment on the terrace. Shelf foraminiferal assemblages are found in the upper 70 meters at this site and demonstrate that much of the sediment here has been displaced downslope. The midslope terrace was probably configured in its present form in Pleistocene time.

A large part of the section below 400 meters exhibits tectonic brecciation, a fragmentation that occurred in place after lithification allowed brittle deformation of the sediment. Rehealing of the fracture system took place after little relative displacement between the pieces of the breccia. The brecciation occurs along anastamosing and branching veins and fractures. Fracturing may have been induced along veins that originally acted as dewatering conduits.

Downhole logs record a much greater variability in density and velocity than would be expected from visual observation of the pre-Pleistocene lithology. The velocity gradient of the upper 400 meters at Site 440 is the same as Sites 438 and 439, but the average velocity is 100 to 140 m/s more at greater depth (Figure 2). The caliper log shows pronounced washouts at lithologic contacts that were not recovered. The temperature log indicates a temperature gradient of about 1°C per 100 meters, or one-third the value at the other two more landward sites (438 and 439).

From the cores, downhole logs, and seismic records, the stratified sequence beneath the midslope terrace at Site 440 is interpreted as consisting of a non-folded upper continental slope section rather than a deep ocean basin sediment accreted at the leading edge of the insular lithosphere. The sequence is more than a superficial slump block from higher on the slope. It is an orderly sequence of bedded, terrigenous sediment at least 1600 meters thick that has been rotated until it tilts landward. If the rate of sedimentation in the drilled section is assumed to continue without a hiatus in the unsampled lower part of the section, as it does at Sites 438 and 439, the estimated minimum age at the base of the sequence is early Miocene. The estimated age is a minimum one because no allowance for compaction was made. The intense fracturing is evidence that abnormal stress, probably from plate convergence, is communicated to the midslope area. The stress is superimposed on a section originally deposited in a normal continental slope environment. At the scale of resolution in seismic records, however, deformation from the stress has not yet disrupted the reflecting horizons to produce compressional folds or to mask structure with extensive diffractions.

SITE 441

At Site 441 about 680 meters of sediment was penetrated in a setting that is 15 km landward from the trench axis on the lower part of the trench inner slope (Figure 1). In seismic records across the site, igneous oceanic crust is the last prominent acoustic reflection. The oceanic crust is overlain by reflections from beds dipping steeply landward that are, at least in part, interpreted as tilted deep ocean basin deposits. These sediments are in a wedge-shaped body that is covered, in turn, by

*The cores were considered lithified when they could no longer be cut with a wire cutter and had to be sawed.

M66 1 5 0 5 5 0 2 7

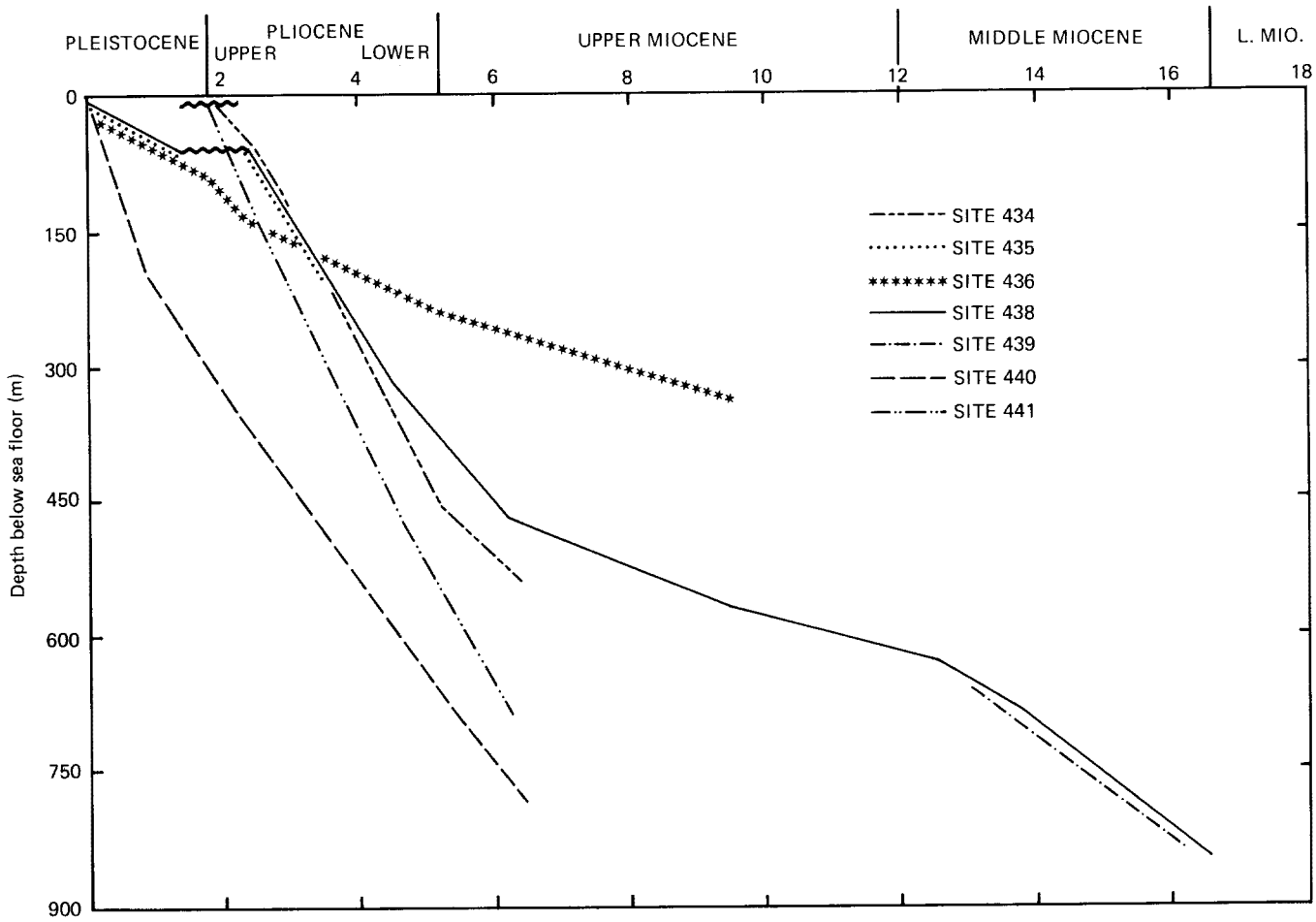

Figure 4. Rates of sediment accumulation uncorrected for compaction.

reflections subparallel to the slope, which are inferred to be terrigenous slope deposits. The slope deposits are at least 800 meters thick at the site and all sampling was in this upper layer.

The beds sampled are claystone of late Miocene to Pleistocene age with varying amounts of diatoms and volcanic ash, much the same as the other sites on this transect (Figure 2, Table 2). The intervals between paleontological datums are virtually the same as at Site 440 except for one middle Pliocene interval that is about one-third thicker than the equivalent interval farther upslope. Persistent recovery of drill cuttings composed of less than 1 cm-sized lithic chips, which readily crumble, characterizes the cores below about 140 meters from Site 441. The rare massive core pieces are cut by fractures with a variety of orientations that divide the coherent materials into blocks. Some fractures are clearly faults, but many appear to be partings or joints, and at least some may have been induced by drilling. Another type of material is in the form of sedimentary breccia consisting of mudstone chips in a mudstone matrix. In some cores the clasts were paleontologically dated as ships of lower middle Miocene rocks floating in a matrix of Pliocene age. These lithic chips must have been transported downslope. In one coherent section, the lithic chips are squeezed together with little if any apparent intervening matrix. Also sampled was tectonic breccia that apparently developed in place. The relative importance of each of these fabrics cannot be determined because the highly fragmented core material could originally have been any one of the types mentioned and because of poor recovery.

There is no evidence from the cores that a section from the oceanic plate was drilled. However, the hemipelagic section sampled here and at Site 434 (Leg 56) is more intensely fractured than any other section sampled on the Japan Trench transect. Therefore, it is thought to be stressed by tectonism associated with plate convergence and to be part of the accretionary zone, in a dynamic sense.

BIOSTRATIGRAPHY

DSDP Leg 57 sites lie within the mixing area of the cold Oyashio and warm Kurishio currents. During the Neogene, fluctuations in these currents resulted in deposition of a succession of warm water, temperate, and cold water faunal and floral assemblages. Consequently, Leg 57 sites provide an opportunity for correlation of high latitude and low latitude microfossil zonations.

Studies of DSDP cores, piston cores, and outcrop samples have established a relatively complete microfossil biostratigraphic zonation for the North Pacific. In addition, Neogene paleoclimatic events throughout the North Pacific have been identified from planktonic foraminiferal assemblages. The microfossil datums and paleoclimatic events have been tied to paleomagnetic stratigraphy and to the absolute time scale. The composite record from Holes 438A and 439 illustrates the excellent control of microfossil biostratigraphy available in beds of Pleistocene to upper Oligocene age. Microfossil control is best between 0 and 3 m.y., scant between 3 and 4.5 m.y., and moderate from 4.5 to 16.5 m.y. Only benthic foraminifera are present in the upper Oligocene and Upper Cretaceous sections. The sediment recovered from Holes 438A and 439 provide a good upper Oligocene to Holocene reference section for the northwest Pacific.

Rates of sediment accumulation for Legs 56 and 57 sites are illustrated in Figure 4; no compaction factor has been applied. Pronounced hiatuses are present in the lower Pleistocene of Sites 434, 438, and 441. Overall sediment accumulation rates are similar for all sites on the inner trench slope and deep sea terrace; however, this is misleading because no correction has been made for differences in consolidation history.

SUMMARY

IPOD geophysical data and drill sampling along the Japan Trench transect have placed limits on the volume of material tectonically accreted during the present convergent episode to a surprisingly small zone. These limits seem well established by the seaward extent of crust with continental thickness and lithologies, and by the age and thickness of a terrigenous slope apron covering the presumed but unsampled accreted oceanic material.

The evidence for crust of continental affinities is anchored in part to the geologic history on land and, as presently interpreted, the geologic history at Site 439 correlates in general with the history of Honshu Island. The Cretaceous unconformity, widely recognized on land, has now been observed 130 km east from the coast at Site 439. In outcrop and sampled sections, the unconformity cuts across an ancient landmass and, therefore, the former extent of the landmass is probably indicated by the extent of the unconformity in seismic records. In addition, there is possible evidence that the landmass extended much farther east than Site 439 because a volcanic arc like the one inferred to be near Site 439 is usually associated with a

trench 100 to 200 km farther seaward. If this is true, a pre-Oligocene fore-arc area once extended hundreds of km seaward of Site 439.

Ishiwada and Ogawa (1976) traced the unconformity from the Kitakami Massif on land, across the inner part of the continental margin. It can be continued seaward in the JPDC multichannel seismic records across Sites 438 and 439, where it is clearly recorded, and farther seaward at least to the middle of the inner trench slope where it is presently at a depth of 6 km. Therefore, it is likely that remnants of the Oyashio landmass, which was probably crust of continental thickness during a previous tectonic episode, extends at least to the seaward limit of the unconformity as recorded by the seismic reflection surveys.

The seaward limit of the unconformity is unclear because it becomes difficult to follow about 15 km upslope from the midslope terrace in the seismic record across Sites 440 and 441. However, the overlying slope deposits extend farther seaward and merge into the zone of accretion. Therefore, the sedimentary environments reflecting subsidence of the Oyashio landmass and deposition of terrigenous material on a deep sea terrace and trench slope extend to the midslope terrace at Site 440. There is no folding of this section in the multichannel records. The accretionary zone, characterized by highly diffracted reflections and a series of dipping reflections, begins immediately seaward. Therefore, the acoustically definable accretionary zone extends approximately 25 km landward of the trench axis to the vicinity of the midslope terrace. The base of the section beneath Site 440, which is virtually in contact with the oldest part of the zone of accretion, is estimated to be no younger than early Miocene age. This minimum age estimate is close to the late Oligocene age of initial volcanism associated with the present episode of convergence. At Site 441 accretion can be no younger than the upper Miocene age of the trench slope deposits.

The term accretion should probably be used in a broader sense here and not be restricted only to materials scraped off the oceanic plate. Along the Japan Trench, a great deal of terrigenous material moving down the slope never reaches the trench or oceanic plate before it is involved in compressional tectonic environment, for instance, the over-compacted sediment at Site 440. Even at sites closer to the trench, no definite material from the oceanic plate was recognized, and yet a much greater amount of sediment has accumulated here than at the reference sections landward and seaward. Although some of this greater thickness of sediment may be due to local differences in rates of sedimentation, there is evidence in cores and downhole logs of tectonic stresses that may thicken the section, and therefore accretion in the dynamic sense of the term must here include trench slope deposits.

Imbrication is the accretionary process most commonly associated with covergent margins and some imbricate faulting is interpreted from the seismic records (Leg 56, Geotimes). In addition, downslope mass movement is indicated by hiatuses at the Pliocene-Pleistocene boundary of sites on the trench slope, by evidence of some intervals of transported material, by syndepositional folding, and by scars and other evidence of slumping in the seismic records. Not so easily recognized, but perhaps an important mechanism in tectonic thickening, is tectonic consolidation, which is a process that is as yet poorly defined and understood (Moore and Karig, 1976). Our preliminary findings indicate that dewatering and development of pervasive fracturing are two important processes in the initial stage of tectonic consolidation of the mudstone encountered in Leg 57 cores.

Preliminary calculations indicate that the zone of accretion associated with the Japan Trench is not large enough to accommodate all the sediment carried there in Neogene time by the subducted plate at the convergence rate of 8 to 10 cm/yr proposed by Minster, et al. (1974) despite a liberal allowance for compaction. Nor does a great deal of the stress across the slip plane between the upper and lower plates seem to be communicated landward of the midslope terrace, at least in the upper 2 to 3 km of the continental margin. Some of the puzzling problems raised by the preliminary study of the cores from Leg 57 and geophysical data across the sites are: the fate of the subducted and accreted oceanic (and continental) material; the possible fate of the outer part of the Oyashio landmass; the mechanism whereby massive subsidence of the leading edge of the continental plate can take place during presumed addition of oceanic crust to continental crust; and the very low frictional forces that allow many thousands of km of oceanic crust to be thrust beneath the continental crust without deforming the upper plate extensively. The results from this first transect in the IPOD Active Margins drilling program suggest that much more variability in structure may exist between convergent margins than has previously been recognized.

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EXPLANATORY NOTES

INTRODUCTION

Leg 57 Initial Core Description is presented here to aid investigators in selecting samples for detailed study. Samples from Leg 57 become available to the public on 15 December 1978.

Potential investigators who desire to obtain samples should refer to the DSDP-NSF Sample Distribution Policy (p. 33). Sample request forms may be obtained from:

The Curator
Deep Sea Drilling Project, A-031
University of California, San Diego
La Jolla, California 92093

Requests must be as specific as possible: include site, core, section, interval within a section, and volume of sample required. The purpose of this publication is to aid interested investigators in understanding the (1) terminology, labeling, and numbering conventions used by the Deep Sea Drilling Project (DSDP); (2) sediment classification and biostratigraphic framework used on Leg 57; and in addition (3) present the preliminary lithologic and paleontologic data on core forms, so that sampling can be guided. However, the investigator should be aware that the data is subject to future revision.

NUMBERING OF SITES, HOLES, CORES, SAMPLES

DSDP drill sites are numbered consecutively from the first site drilled by *Glomar Challenger* in 1968. Site numbers are slightly different from hole numbers. A site number refers to one or more holes drilled while the ship was positioned over one acoustic beacon. These holes could be located within a radius as great as 900 meters from the beacon. Several holes may be drilled at a single site by pulling the drill pipe above the sea floor (out of one hole) and moving the ship 100 meters or more from the previous hole, and then begin drilling another hole.

The first (or only) hole drilled at a site takes the site number. A letter suffix distinguishes each additional hole at the same site. For example: the first hole takes only the site number; the second takes the site number with suffix A; the third takes the site number with suffix B, and so forth. It is important, for sampling purposes, to distinguish the holes drilled at a site, since recovered sediments or rocks from different holes usually do not come from equivalent positions in the stratigraphic column.

The cored interval is measured in meters below the sea floor. The depth interval of an individual core is the depth below sea floor that the coring operation began to the depth that the coring operation ended. Each coring interval is generally 9.5 meters long, which is the nominal length of a core barrel; however, the coring interval may be shorter or longer (rare). "Cored intervals" are not necessarily adjacent to each other, but may be separated by "drilled intervals". In soft sediment, the drill string can be "washed ahead" with the core barrel in place, but not recovering sediment, by pumping water down the pipe at high pressure to wash the sediment out of the way of the bit and up the space between the drill pipe and wall of the hole; however, if thin hard rock layers are present then it is possible to get "spotty" sampling of these resistant layers within the washed interval, and thus have a cored interval greater than 9.5 meters.

Cores taken from a hole are numbered serially from the top of the hole downward. Core numbers and their associated cored interval in meters below the sea floor are normally unique for a hole, however, problems may arise if an interval is cored twice. When this situation occurs, the core number is assigned a suffix, such as "S"* for supplementary.

Full recovery for a single core is normally 9.28 meters of sediment or rock, which is in a plastic liner (6.6 cm I.D.), plus about a 0.2 meter-long sample (without a plastic liner) in the Core-Catcher. The Core-Catcher is a device at the bottom of the core barrel which prevents the cored sample from sliding out when the barrel is being retrieved from the hole. The sediment-core, which is in the plastic liner, is then cut into 1.5 meter-long sections and numbered serially from the top of

*Note that this designation has been used on previous legs as a prefix to the core number for sidewall core samples.

the sediment-core (Figure 5). When we obtain full recovery, the sections are numbered from 1 through 7 with the last section possibly being shorter than 1.5 meters. The Core-Catcher sample is placed below the last section when the core is described, and labeled Core-Catcher (CC): it is treated as a separate section.

When recovery is less than 100 per cent, and if the sediment or rock is contiguous, the recovered sediment is placed in the top* of the cored interval, and then 1.5 meter-long sections are numbered serially, starting with Section 1 at the top. There will be as many sections as needed to accommodate the length of the core recovered (Figure 5); for example 3 meters of core sample in plastic liners will be divided into two 1.5 meter-long sections. Sections are cut starting at the top of the recovered sediment, and the last section may be shorter than the normal 1.5 meter length.

When recovery is less than 100 per cent, the original stratigraphic position of the sediment in the cored interval is unknown, so we employ the convention assigning the top of the sediment recovered to the top of the cored interval. This is done for convenience in data handling, and consistency. If recovery is less than 100 per cent, and core fragments are separated, and if shipboard scientists believe the sediment was not contiguous, then sections are numbered serially and the intervening sections are noted as void, whether it is contiguous or not. The Core-Catcher sample is described in the Visual Core Descriptions beneath the lowest section.

Samples are designated by centimeter distances from the top of each section to the top and bottom of the sample in that section. A full identification number for a sample consists of the following information:

Leg
Site
Hole
Core Number
Interval in centimeters from the top of section

For example, a sample identification number of "57-438B-9-3, 12-14 cm" is interpreted as follows: 12 to 14 cm designates a sample taken at 12 to 14 cm from the top of Section 3 of Core 9, from the third hole drilled at Site 438 during Leg 57. A sample from the Core-Catcher of this core is designated as "57-438B-9, CC, 12-14 cm".

The depth below the sea floor for a sample numbered "57-438B-9-3, 12-14 cm", is the summation of the following: 1) the depth to the top of the cored interval for Core 9, which is 362 meters; 2) plus 3 meters for Sections 1 and 2 (each 1.5 meters long); and plus the 12 cm depth below the top of Section 3. All of these variables add up to 365.12 meters**, which theoretically is the sample depth below the sea floor.

HANDLING OF CORES

A core was normally cut into 1.5 meter sections, sealed, and labeled; and then the sections were brought into the core laboratory for processing. The following determinations were normally made before the sections are split: gas analysis, thermal conductivity analysis (soft sediment only), and continuous wet-bulk density determinations using the Gamma Ray Attenuation Porosity Evaluation (GRAPE).

The cores were then split longitudinally into "working" and "archive" halves. Samples were extracted from the "working" half, including those for determination of grain-size distribution, mineralogy by x-ray diffraction, sonic velocity by the Hamilton Frame method, wet-bulk density by a static GRAPE technique, water content by gravimetric analysis, carbon-carbonate analysis, per cent calcium carbonate (Karbonate Bomb), geochemical analysis, paleontological studies, and others.

Smear slides from each major lithology, and most minor lithologies, were prepared and examined microscopically. The archive half was then described and photographed. Physical disturbance by the drill bit, color, texture (for uncemented lithologies), sedimentary structure and composition (±20%) of the various lithologies were noted on standard core description sheets.

** This technique differs from the labeling systems used on Legs 1 through 45, which had a designation called "zero section", but did not have a "number 7 section".

** Sample requests should refer to a specific interval within a core-section, rather than the level below sea floor.

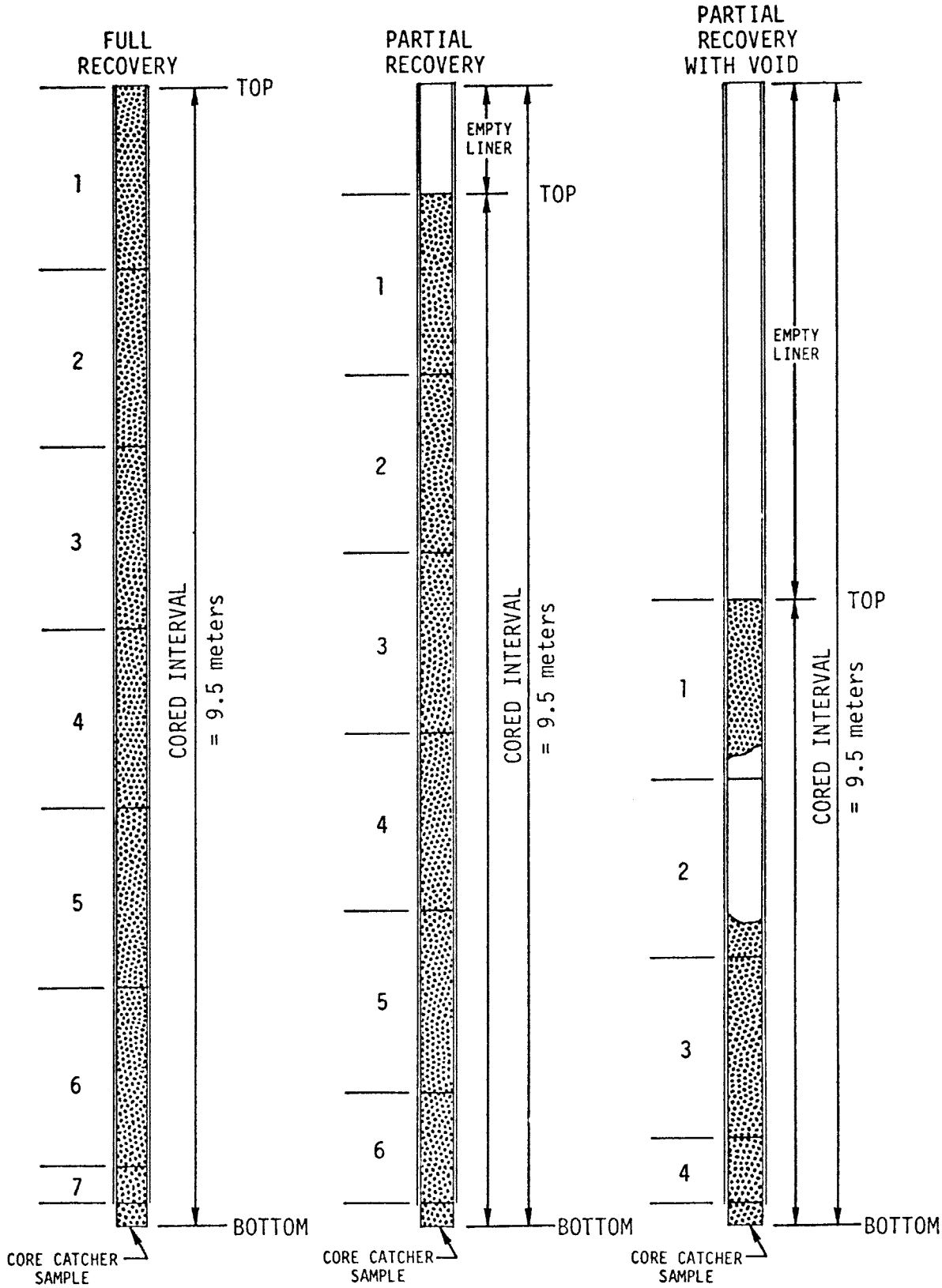

Figure 5. Diagram showing procedure in cutting and labeling of core sections.

MGC 1 5 0 5 5 8 2 2

After the cores were sampled and described, they are maintained in cold storage aboard *Glomar Challenger* until they can be transferred to the DSDP repository. Core sections which were removed for organic geochemistry study were frozen immediately onboard ship and kept frozen. All Leg 57 cores and frozen cores are presently stored at the DSDP West Coast Repository (Scripps Institution of Oceanography).

Core descriptions, smear slide descriptions, carbonate bomb determinations (% $CaCO_3$) (these data were determined aboard ship), grain size analyses, carbon-carbonate determinations (both determined at the DSDP shore-based laboratory), and x-ray diffraction data (from the labs of German Müller, Universitat Heidelberg) serve as the data for the Visual Core Descriptions in this volume. These samples, and their location in the core, are coded with a symbol on the core description sheets. The key to these codes, in order to identify the samples, is in Figure 6.

VISUAL DESCRIPTIONS

Sediment Disturbance

Recovered rocks, and particularly the soft sediments, may be extremely disturbed. This mechanical disturbance is the result of the coring technique, which uses a large 25 cm diameter bit with a small 6.0 cm diameter opening for the core sample. The following disturbance categories are used for soft and firm sediment. These categories will be indicated on the core description sheet (in a column) by coded patterns to which the key is in Figure 6. The categories are as follows:

(a) Slightly deformed: bedding contacts are slightly bent.

(b) Moderately deformed: bedding contacts have undergone extreme bowing.

(c) Very deformed: bedding is completely disturbed, sometimes showing symmetrical diapir-like structure.

(d) Soupy: water saturated intervals which have lost all aspects of original bedding.

Sedimentary Structures

In the soft, and even in some harder sedimentary cores, it may be extremely difficult to distinguish between natural structures and structures created by the coring process. Thus, the description of sedimentary structures was optional. A column on the Core Description Sheet (Figure 6) may have patterns (coded symbols) to indicate typical structures. The key to the set of structure-symbol codes is in Figure 7.

Color

Colors of the geologic material are determined with a Munsell or Geological Society of America Rock-Color Chart. Colors were determined immediately after the cores were split and while they were in a wet condition.

Graphic Lithology Column

A graphic lithologic column is presented. This graphic column is based on this lithologic classification scheme presented below. The lithologies and their corresponding symbols are in Figure 8. Often a single lithology will be represented by a single pattern. Some lithologies are represented by a grouping of two or more symbols. The symbols in this grouping may correspond to end member sediment constituents, such as clay and nannofossil ooze. Normally the symbol for the dominant constituent is placed on the right-hand side of the column, and the symbol for the subordinate constituent will be on the left-hand side of the column. The percentage of one component to another may be represented

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SITE HOLE CORE CORED INTERVAL:

TIME–ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
	F = Foraminifers N = N = Nannofossils = Diatoms R = Radiolarians	First letter = Abundance Second letter = Preservation	ABUNDANCE: B = Barren R = Rare F = Few C = Common A = Abundant	PRESERVATION: P = Poor M = Moderate G = Good		1 2 3 4 5 6 7 CC	0.5 1.0		Slightly deformed — — — Moderately deformed — — — Soupy OOOOO Very deformed ~~~~~~~~	Symbols for sedimentary structures are placed here.		

GENERAL LITHOLOGIC DESCRIPTION OF CORE: Detail at the discretion of the sedimentologist for a particular Site (Hole).

TOTAL C – ORGANIC C – CARBONATE (%)
2, 45 cm (0.8, 0.6, 2)

CARBONATE BOMB
2, 11-12 cm - 90%

GRAIN SIZE (%)

	Sand	Silt	Clay
2-50	3	59	38
4-50	1	47	52

SMEAR SLIDES (%)
D indicates dominant lithology
M indicates minor lithology

in graphic lithology:
Clast lithologies
V = volcanic
S = sedimentary
I = Igneous
● = siliceous sponge remains
F = mollusc fragment

Sample Code:

17 = Smear Slide (location in cms in each section)

Figure 6. This is a typical core description sheet, with the sediment deformation symbols, sample codes, and other general information.

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Symbol	Sedimentary Structure
	parallel-stratification
	cross-stratification
	grain-size graded (coarser at base)
	convolute-stratification
	curved-stratification
	contorted-stratification
	microfaulting
	mottles
	burrows
	bioturbation
	healed veins or sinous fracture
	mollusc fragment

Figure 7. Key to sedimentary structure symbols.

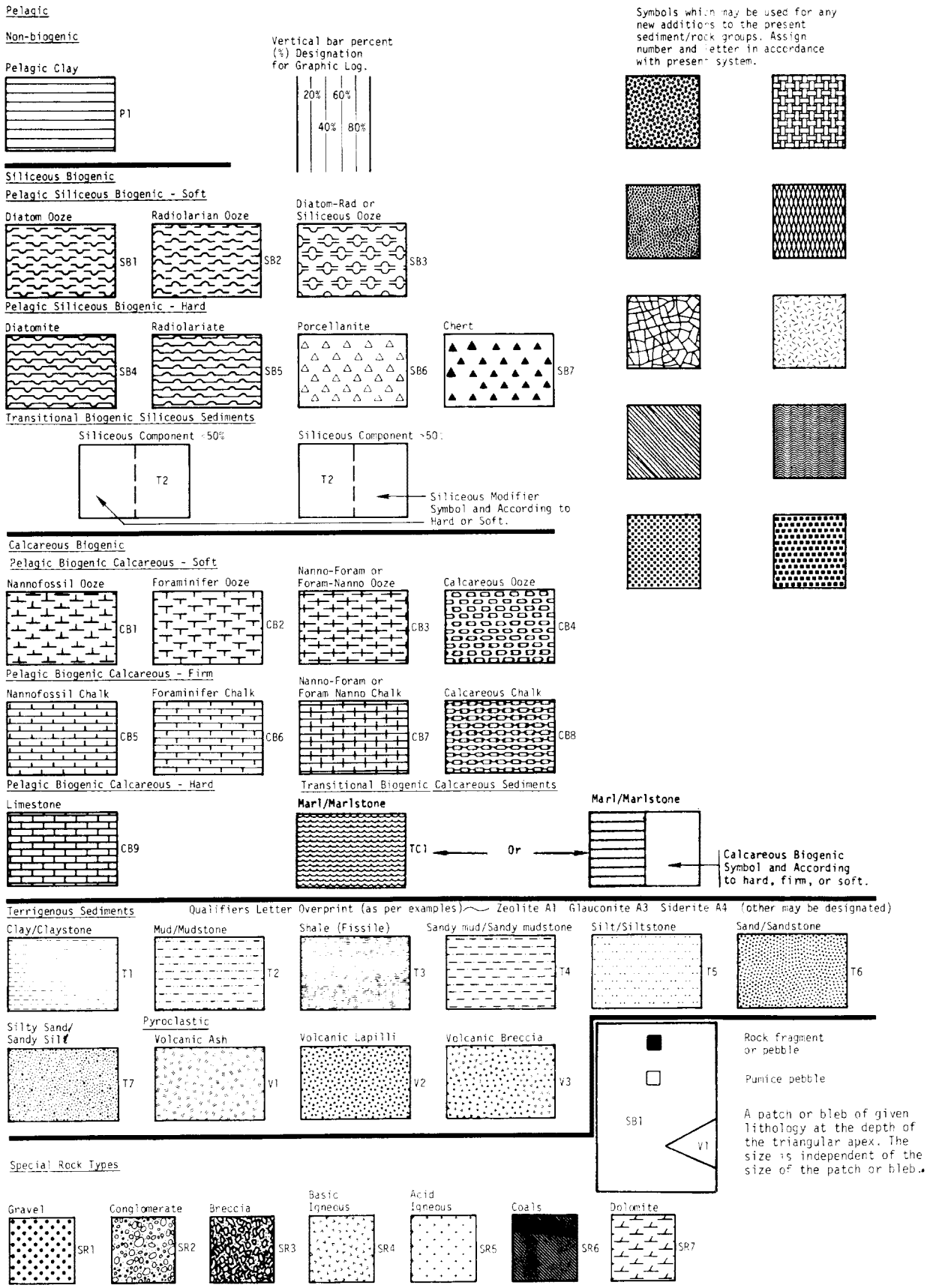

Figure 8. Graphic symbols corresponding to the lithologic classification.

in the graphic column by the symbols being presented in proportion to their percentages. For example the left 20% of the column may have a clay symbol while the right 80% of the column may have a nannofossil ooze symbol. This would mean that the sample was approximately 80% nannofossils and 20% clay. The vertical lines which separate the symbols are shown in Figure 6 with their corresponding percentages and positions in the column.

Because of the difference in the length-to-width ratio between the actual sediment core and the graphic lithologic column, it is not possible to reproduce structures as they appeared in the core. They become highly flattened and distorted. The same is true for erratic pebbles and changes of lithology in the cores.

Text of Core Description

Format, style, and terminology of the descriptive portion of the Core Description Sheets (Figure 6) are not controlled by the "Mandatory Graphic Lithologic Column Scheme", beyond the minimal name assignment which is derived from the lithologic classification (described below). Colors and additional information such as structure and textures, are normally included in the text portion of the core description.

LITHOLOGIC CLASSIFICATION

The basic classification system used here was devised by the JOIDES Panel on Sedimentary Petrology and Physical Properties (SPPP) and adopted for use by the JOIDES Planning Committee in March 1974. For the sake of continuity the Leg 57 shipboard scientists have used this basic classification with some modification. Since Legs 56 and 57 drilled in the same region and recovered sediment of similar lithology and age, the two legs have come to aggrement on a uniform lithologic classification to facilitate comparison of sediment from different drill holes. We will point out our differences from the SPPP classification when those topics are discussed.

GENERAL PRINCIPLES

This classification is not comprehensive, therefore, a category of "Special Rock Types" will create additional definitions and terminology of rock types not covered. The classification is descriptive and genetic implications are not intended. These divisions are naturally artificial, and the proposed classification is only a rough grouping of what we really find in nature. The classification, as used in this volume, will use data which was primarily estimated or measured aboard the ship.

DESCRIPTIVE DATA

Sediment and rock names are defined solely on the basis of composition and texture. Composition is most important for description of those deposits more characteristic of open marine conditions, with texture becoming more important for the classification of hemipelagic and nearshore facies. These data are primarily determined onboard the ship by (1) visual estimates 'in smear slides" with the aid of a microscope.

FIRMNESS

We use three classes of firmness for biogenic calcareous rocks, which have a calcium carbonate content greater than 60%, and only two classes of firmness for all other lithologic types. Criteria for different classes of firmness are those of Gealey, et al. (1971).

1. Biogenic-calcareous-sediment, with greater than 60% $CaCO_3$, have 3 classes of firmness as follows:

    a. Soft: Sediment which have little strength and are readily deformed under the finer or broad blade of the spatula are soft and are termed ooze.

b. Firm: Partly lithified ooze or friable limestone are called chalk. Chalks are readily deformed under the fingernail or the edge of a spatula blade. More lithified chalks are termed limestones (see below).

c. Hard: Limestone is a term which is restricted to nonfriable cemented rock.

2. Only two classes of firmness are used for transitional carbonates with less than 60% $CaCO_3$, biogenic siliceous sediment, pelagic clay, and terrigenous sediments as follows:

a. Soft: A sediment is soft if the sediment core may be split with a wire cutter. The following sediment terms are used for soft sediment:

1) Soft biogenic-siliceous-sediment (with greater than 30% siliceous fossils) are termed ooze; for example, radiolarian ooze, diatomaceous ooze, or siliceous ooze.

2) Soft terrigenous sediment, pelagic clay, and transitional calcareous-biogenic-sediments are termed as follows: sand, silt, caly, mud, or marl.

b. Hard: The core is hard if it must be cut with a band saw or diamond saw.

1) Hard siliceous-biogenic sediment (greater than 30% siliceous) are termed radiolarite, diatomite, chert or porcellanite.

2) Hard terrigenous sediment, transitional calcareous-biogenic-sediment, and pelagic clay are termed as follows: a suffix -stone is added to the soft-sediment name, for example: sandstone, siltstone, claystone, mudstone (shale, if fissile), or marlstone.

BASIC SEDIMENT TYPE

Pelagic Clay

Pelagic clay is principally authigenic pelagic deposits that accumulate at very slow rates. The class is often termed brown clay, or red clay, but since these terms are confusing, they are not used.

1. Boundary of pelagic clay with terrigenous sediments is where authigenic components (Fe/Mn micronodules, zeolites), fish debris, etc., become common (> 10%) in smear slides indicating pelagic clay. The accumulation rates of pelagic clay and terrigenous sediments are very different, therefore transitional deposits are exceptional.

2. Boundary of pelagic clay with siliceous-biogenic-sediments is where there is less than 30% siliceous remains.

3. Boundary of pelagic clay with calcareous-biogenic-sediment is uncommon. Generally this facies passes from pelagic clay through siliceous ooze to calcareous ooze, with one important exception: at the base of many oceanic sections, black, brown, or red clays occur directly on basalt, overlain by or grading up into calcareous sediments. Most of the basal clayey sediments are rich in iron, manganese and other metallic trace elements. For proper identification they require more elaborate geochemical work than is available onboard ship. These sediments would be placed in the Special Rock Category.

PELAGIC-SILICEOUS-BIOGENIC-SEDIMENT

Pelagic-siliceous-biogenic-sediment is distinguished from pelagic clay because the siliceous-biogenic-sediment has more than 30% siliceous microfossils. Siliceous-biogenic-sediments are distinguished from a calcareous category by a calcium carbonate content of less than 30%.

For a pelagic-biogenic-siliceous-sediment with ~30 to 100% siliceous fossils, the following terminology is used:

1. Soft: Siliceous ooze (radiolarian ooze, diatomaceous ooze, etc. depending on the dominant fossil component).

2. Hard: Radiolarite, diatomite, chert, or porcellanite. The term "chert" in the past has been used in a very broad sense to designate almost any form of recrystallized silica. The term porcellanite (which had a very broad usage in the past) will be used here to refer to "low density, more or less porous and dull-lustered varieties of 'chert' made of opaline silica or cristobalite..." (Lancelot, 1971). Chert used here will have a narrower scope than that of past usage, and will refer to "hard nodules and sometimes beds, that are largely quartz and/or chalcedony, and show a conchoidal fracture and a vitrous luster..." (Lancelot, 1971).

3. Compositional Qualifiers. Diatoms and radiolaria may be the principle components, thus one or two qualifiers may be used, for example;

Indeterminate siliceous fossils:	Siliceous ooze, Chert, or Porcellanite
Radiolaria only:	Radiolarian ooze, or Radiolarite
Diatoms only:	Diatomaceous ooze, or Diatomite
Diatom < radiolarians:	Diatomaceous radiolarian ooze, or Diatomaceous radiolarite
Diatom > radiolarians:	Radiolarian diatomaceous ooze, or Radiolarian diatomite

The order of the two modifiers in the terms is dependent on the dominant fossil type. The most dominant component is listed last and the minor component is listed first.

Terminology for the pelagic clay transition with diatom-sediments is as follows:

% BIOGENIC SILICEOUS FOSSIL PARTICLES	% CLAY	LITHOLOGIC TYPE	
<10	>90	clay:	soft
		claystone:	hard
30 to 10	70 to 90	diatomaceous mud:	soft
		diatomaceous mudstone:	hard
60 to 30	40 to 70	muddy diatomaceous ooze:	soft
		muddy diatomite:	hard
100 to 60	0 to 40	diatomaceous ooze:	soft
		diatomite:	hard

Other terms may be substituted for the terms diatomaceous and diatomite, respectively, as follows: 1) radiolarian and radiolarite if radiolarians are predominante, or 2) siliceous or chert if the fossil type is indeterminate.

We have divided the component frequencies into four major groups:

<30%
10-30%
30-60%
>60%

These boundaries have been used for both calcareous and siliceous components, and thus depart slightly from the SPPP panel's classification, which employs only one major subdivision (50%) in the biogenic siliceous sediments:

<50% siliceous fossils = siliceous mud
>50% siliceous fossils = siliceous ooze

To be consistent we choose to subdivide both siliceous and calcareous pelagic facies in the same way.

PELAGIC-BIOGENIC-CALCAREOUS-SEDIMENT

Pelagic-calcareous-sediment is distinguished by a biogenic $CaCO_3$ content in excess of 30%. There are two classes: 1) Pelagic-Biogenic-Calcareous-Sediments which contain 60 to 100% biogenic $CaCO_3$ and 2) Transitional-Biogenic-Calcareous-Sediments which contain 30 to 60% $CaCO_3$.

1. For the Pelagic-Biogenic-Calcareous-Sediment with 60 to 100% $CaCO_3$ the following terminology is used:

   a. Soft: Calcareous ooze

   b. Firm: Chalk

   c. Hard and cemented: Limestone

   d. Compositional Qualifiers: If nannofossils and foraminifers are the principal components, then one or two qualifiers may be used, as in the following examples:

   Indeterminate carbonate fossils:
   Calcareous ooze,
   Calcareous chalk, or
   Calcareous limestone

   Foraminifers (0-10%) - nannofossils (90-100%):
   Nannofossil ooze,
   Nannofossil chalk, or
   Nannofossil limestone

   Foraminifers (10-25%) - nannofossil (75-90%):
   Foraminiferal-nannofossil ooze,
   Foraminiferal-nannofossil chalk, or
   Foraminiferal-nannofossil limestone

   Foraminifers (25-50%) - nannofossils (50-75%):
   Nannofossil-foraminiferal ooze,
   Nannofossil-foraminiferal chalk, or
   Nannofossil-foraminiferal limestone

2. The Transitional-Biogenic-Calcareous-Sediments with 30 to 60% $CaCO_3$ are termed marl or marlstone as follows:

a. Soft: Calcareous marl,
Foraminiferal marl, or
Nannofossil marl

b. Hard: Calcareous marlstone,
Foraminiferal marlstone, or
Nannofossil marlstone

Note that the use of the terms marl or marlstone differ from the SPPP panel's classification. The panel's classification used marly as an adjective to ooze, chalk, or limestone (e.g. marly limestone) to denote sediments which had 30 to 60% biogenic carbonate.

Terminology for the pelagic clay transition with the nannofossil sediments is as follows:

% BIOGENIC CALCAREOUS PARTICLES	% CLAY	LITHOLOGIC TYPE	
0 to 10	90 to 100	clay:	soft
		claystone:	hard
30 to 10	70 to 90	nannofossil mud:	soft
		nannofossil mudstone:	hard
60 to 30	40 to 70	nannofossil marl:	soft
		nannofossil marlstone:	hard
100 to 60	0 to 10	nannofossil ooze:	soft
		nannofossil chalk:	firm
		nannofossil limestone:	hard

Other terms may be substituted for nannofossil, such as: 1) foraminiferal, nannofossil-foraminiferal, foraminiferal-nannofossil, if foraminifers are present in the percentages as discussed, or 2) calcareous if the fossil type is indeterminate.

Terrigenous Sediments

Terrigenous sediments are distinguished by a terrigenous component in excess of 30%, and siliceous and authigenic components, each less than 10%.

Sediments in this category are subdivided into textural groups (by smear slide estimation or grain size analysis on the basis of the relative proportions of sand, silt, and clay. The size limits are those defined by Wentworth (1922). Textural classification follows the triangular diagram of Shepard (1954) (Figure 9).

The transition between pelagic and terrigenous sediments are termed hemipelagic. This is the dominant type of sediment encountered during continental margin drilling. As such it is treated separately.

Hemipelagic Sediments

Hemipelagic sediments are distinguished by a terrigenous component in excess of 30%, a total non-biogenic component in excess of 40%, and a biogenic silica content in excess of 10%. Besides the terrigenous component, hemipelagic sediments

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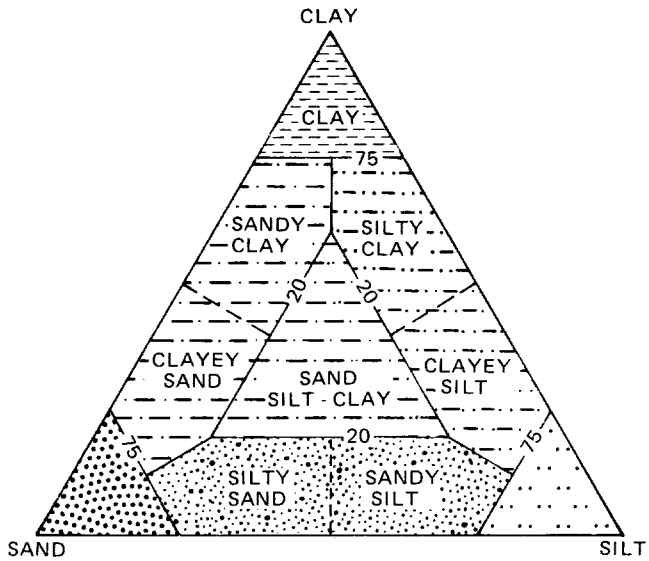

Figure 9. Textural classification of clastic sediments (after Shepard, 1954).

are usually rich in biogenic silica (usually diatoms because of coastal upwelling) and volcanic ash (predominately along active margins). The classification of these sediments in terms of the dominant components can be represented by a pyramid in which the peak and each corner represents 100% of a specific component: 100% sand at the peak; 100% silt and 100% clay at diagonal corners of the base; and 100% biogenic silica and 100% ash at the other diagonal corners of the base. As such, Shepards textural classification (1954, and Figure 9) would be represented by the plane passing through the points for 100% sand, 100% silt, and 100% clay.

The plane of the base of the pyramid (Figure 10) shows the classification of sediments with less than a 10% sand component. Such sediments are the dominant type found on most continental margins and thus the classification in Figure 10 is broadly applicable. The percentage silt and clay used in the diagram (Figure 10) refers to only terrigenous components. Authigenic minerals, ash, and biogenic particles are not included.

For biogenic opal contents greater than 10%, the dominant siliceous biogenic component should be used in the name. Since diatoms predominate in these sediments, we have used the terms "diatomaceous" and "diatomite" in the diagram (Figure). However, where other biogenic siliceous components dominate the terms radiolarian, radiolarite, spicular, etc., may be used.

Components such as sand, diatoms, radiolarians, spicules, ash, etc., may be used as qualifiers to the original sediment description if their abundance is 10 to 30% of the sediment, for example:

Clayey Vitric Diatomaceous Ooze
Diatomaceous Sandy Silty Claystone
Diatomaceous Vitric Silty Clay

The textural part of the classification should always be grouped. For example one should not use:

Vitric Clayey Diatomaceous Ooze
Sandy Diatomaceous Silty Claystone

Within the textural group and the component group the modifiers are listed in order of increasing sedimentary abundance.

Volcanogenic Sediments

Pyroclastic rocks are described according to the textural and compositional scheme of Wentworth and Williams (1932). The textural groups are:

>32 mm - Volcanic breccia
32 mm - 4 mm - Volcanic lapilli
< 4 mm - Volcanic ash (tuff when indurated)

The composition of these pyroclastic rocks are described as vitric (glass), crystalline, or lithic.

Sediments rich in ash are described in the following manner:

% Ash	Soft-Sediment	Indurated
0-10	Mud	Mudstone
10-30	Vitric mud	Vitric mudstone
30-60	Muddy ash	Tuffite
>60	Ash	Tuff

QUALIFIERS

In general, sediments containing various constituents in the 10 to 30% range may be identified in the name of sediment such as vitric diatomaceous mud or vitric muddy diatomaceous ooze. If more than one such qualifier is used, they are listed in order of increasing abundance in the sediment.

CARBONATE BOMB

Percent $CaCO_3$ was also determined onboard ship by the "Karbonate Bomb" technique (Müller and Gastner, 1971). In this simple procedure, a sample is powdered and treated with HC1 in a closed cylinder. Any resulting CO_2 pressure is

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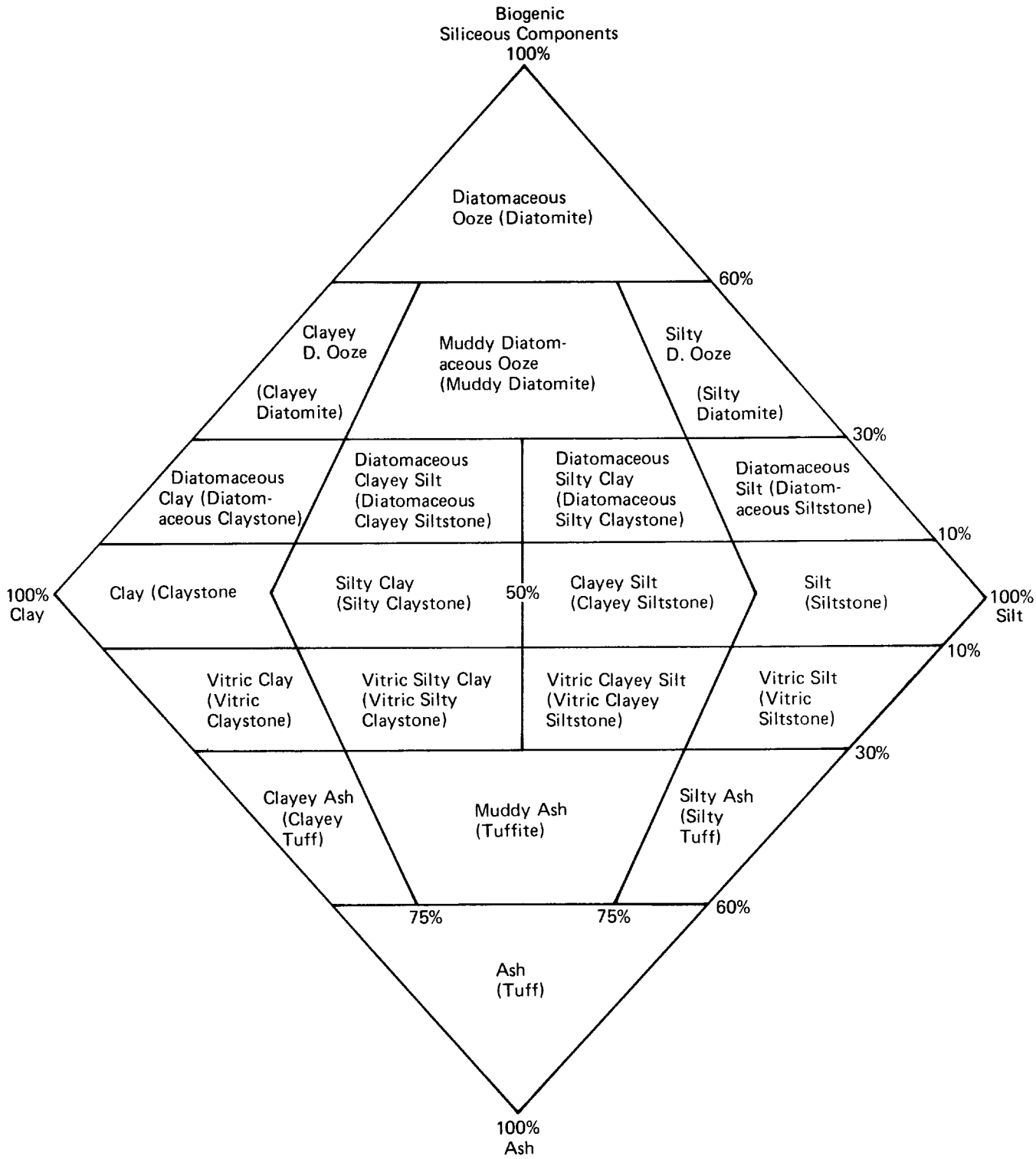

Figure 10. Hemipelagic sediment classification for use on Legs 56 and 57.

proportional to the $CaCO_3$ content of the sample. Application of the calibration factor to the manometer reading (X 100) yields per cent $CaCO_3$. Per cent error can be as low as 1% for sediments high in $CaCO_3$, and in general an accurary of ±2 to 5% can be obtained.

These data are presented on the Core Forms. The sample interval is designated by twonumbers: the section number, followed by the top of the sample interval, for example: a sample from Section 2 from 11 to 12 cm with 90% calcium carbonate will be present on the core form as follows:

CARBONATE BOMB
2, 11-12 cm = 90%

CARBON-CARBONATE ANALYSIS

Following the cruise, sediment samples were analyzed at the DSDP sediment laboratory on a LECO WR-12 Carbon Analyzer. Sample preparation procedures are identical to those used with the old LECO 70 Analyzer as outlined in Boyce and Bode (1972) and Bode (1973). Discussions of the LECO WR-12 Analyzer are in Bode (in press). Accuracy and precision of the results are as follows:

Total carbon	=	±0.3% (absolute)
Organic carbon	=	±0.06% (absolute)
$CaCO_3$	=	±3% (absolute)

The carbon-carbonate data are presented on the Core Forms. The sample interval is designated by two numbers: the section number, followed by the top of the sample interval, for example: a sample from Section 2 at 45 cm with 0.8% total carbon, 0.6% organic carbon, and 2% calcium carbonate will be presented on the Core Forms as follows:

TOTAL C – ORGANIC C – CARBONATE (%)
2, 45 cm (0.8, 0.6, 2)

GRAIN-SIZE ANALYSIS

Distribution of sand-size, silt-size, and clay-size particles was determined from 10cc sediment samples at the DSDP sediment laboratory by standard sieve and pipette methods (Appendix III, of Volume IV, Initial Reports of the Deep Sea Drilling Project, p. 745 with modified settling times as in Boyce, 1972). The sand, silt, and clay boundaries are based on the Wentworth (1922) scale. Thus the particle size of the sand, silt, and clay fractions ranges from 2000 to 62.5 μm, and less than 3.91 μm, respectively.

Grain size data are presented on the Core Forms. On the Core Forms the sample interval is designated by two numbers: the section number and the top of the sample interval within that section, for example a sample from Section 2 from 11 to 13 cm with a grain-size distribution of 20% sand-size, 30% silt-size, and 50% clay-size will be presented on the Core Form as follows:

SMEAR SLIDE SUMMARY

	2-11
Sand	20
Silt	30
Clay	50
etc.	etc.

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BIOSTRATIGRAPHY

Biostratigraphic studies of Leg 57 material were still in progress when the Leg 57 Initial Core Descriptions were compiled. Consequently, biostratigraphic boundaries given herein are tentative; although no major changes in age assignments are anticipated, some boundaries are likely to be adjusted prior to publication of the Initial Reports for Leg 57.

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SAMPLE DISTRIBUTION POLICY

Deep Sea Drilling Project/International Phase of Ocean Drilling

Distribution of Deep Sea Drilling samples for investigation will be undertaken in order to (1) provide supplementary data to support GLOMAR CHALLENGER scientists in achieving the scientific objectives of their particular cruise, and in addition to serve as a mechanism for contributions to the INITIAL REPORTS; (2) provide individual investigators with materials to conduct detailed studies beyond the scope of the Initial Reports; and (3) provide the reference centers where paleontologic materials are stored with samples for reference and comparison purposes.

The National Science Foundation has established a Sample Distribution Panel to advise on the distribution of core materials. This panel is chosen in accordance with usual Foundation practices, in a manner that will assure advice in the various disiplines leading to a complete and adequate study of the cores and their contents. Funding for the proposed research must be secured separately by the investigator. It cannot be provided through the Deep Sea Drilling Project.

The Deep Sea Drilling Project's Curator is responsible for distributing the samples and controlling their quality, as well as preserving and conserving core material. He also is responsible for maintaining a record of all samples that have been distributed, shipboard and subsequent, indicating the recipient, and the natures of the proposed investigation. This information is made available to all investigators of DSDP materials as well as other interested researchers on request.

The distribution of samples is made directly from one of the two existing repositories, Lamont-Doherty Geological Observatory and Scripps Institution of Oceanography, by the Curator or his designated representative.

1. Distribution of Samples for Research Leading to Contributions to Initial Reports

Any investigator who wishes to contribute a paper to a given volume of the Initial Reports may write to the Chief Scientist, Deep Sea Drilling Project (A-031), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, U.S.A., requesting samples from a forthcoming cruise. Requests for a specific cruise should be received by the Chief Scientist TWO MONTHS in advance of the departure of the cruise in order to allow time for the review and consideration of all requests and to establish a suitable shipboard sampling program. The request should include a statement of the nature of the study proposed, size and approximate number of samples required to complete the study, and any particular sampling technique or equipment that might be required. The requests will be reviewed by the Chief Scientist of the Project and the cruise co-chief scientists; approval will be given in accordance with the scientific requirements of the cruise as determined by the appropriate JOIDES Advisory Panel(s). If approved, the requested samples will be taken, either by the shipboard party if the workload permits, or by the curatorial staff shortly following the return of the cores to the repository. Proposals must be of a scope to ensure that samples can be processed and a contribution completed in time for publication in the Initial Reports. Except for rare, specific instances involving ephemeral properties, sampling will not exceed one-quarter of the volume of core recovered, with no interval being depleted and one-half of all core being retained as an archive. Shipboard sampling shall not exceed approximately 100 igneous samples per investigator; in all cases co-chief scientists are requested to keep sampling to a minimum.

The co-chief scientists may elect to have special studies of selected core samples made by other investigators. In this event the names of these investigators and complete listings of all materials loaned or distributed must be forwarded, if possible, prior to the cruise or, as soon as possible following the cruise, to the Chief Scientist through the DSDP Staff Science Representative for that particular cruise. In such cases, all requirements of the Sample Distribution Policy shall also apply.

If a dispute arises or if a decision cannot be reached in the manner prescribed, the NSF Sample Distribution Panel will conduct the final arbitration.

Any publication of results other than in the Initial Reports within twelve (12) months of the completion of the cruise must be approved and authored by the whole shipboard party and, where appropriate, shore-based investigators. After twelve months, individual investigators may submit related papers for open publication provided they have submitted their contributions to the Initial Reports. Investigations not completed in time for inclusion in the Initial Reports for a specific cruise may not be published in other journals until final publication of that Initial Report for which it was intended. Notice of submission to other journals and a copy of the article should be sent to the DSDP Chief Science Editor.

2. Distribution of Samples for Research Leading to Publication other than in Initial Reports

A. Researchers intending to request samples for studies beyond the scope of the Initial Reports should first obtain sample request forms from the Curator, Deep Sea Drilling Project (A-031), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, U.S.A. On the forms the researcher is requested to specify the quantities and intervals of the core required, make a clear statement of the proposed research, state time required to complete and submit results for publication, specify the status of funding and the availability of equipment and space foreseen for the research.

In order to ensure that all requests for highly desirable but limited samples can be considered, approval of requests and distribution of samples will not be made prior to 2 months after publication of the Initial Core Descriptions (I.C.D.). ICD's required to be published within 10 months following each cruise. The only exceptions to this policy will be for specific instances involving ephemeral properties. Requests for samples can be based on the Initial Core Descriptions, copies of which are on file at various institutions throughout the world. Copies of original core logs and data are kept on file at DSDP and at the Repository at Lamont-Doherty Geological Observatory, Palisades, New York. Requests for samples from researchers in industrial laboratories will be handled in the same manner as these from academic organizations, with the same obligation to publish results promptly.

B. (1) The DSDP Curator is authorized to distribute samples up to 50 ml per meter of core. Requests for volumes of material in excess of this amount will be referred to the NSF Sample Distribution Panel for review and approval. Experience has shown that most investigations can be accomplished with 10ml sized samples or less. All investigators are encouraged to be as judicious as possible with regard to sample size and, especially, frequency within any given core interval. The Curator will not automatically distribute any parts of the cores which appear to be in particularly high demand; requests for such parts will be referred to the Sample Distribution Panel for review. Requests for samples from thin layers or important stratigraphic boundaries will also require Panel review.

(2) If investigators wish to study certain properties which may deteriorate prior to the normal availability of his samples, they may request that the normal waiting period not apply. All such requests must be reviewed by the curators and approved by the NSF Sample Distribution Panel.

C. Samples will not be provided prior to assurance that funding for sample studies either exists or is not needed. However, neither formal approval of sample requests nor distribution of samples will be made until the appropriate time (Item A). If a sample request is dependent, either wholly or in part, on proposed funding, the organization to whom the funding proposal has been submitted any information on the availability (or potential availability) of samples that it may request.

D. Investigators receiving samples are responsible for:

(1) publishing significant results; however contributions shall not be submitted for publication prior to 12 months following the termination of the appropriate leg;

(2) acknowledging, in publications, that samples were supplied through the assistance of the U.S. National Science Foundation and others as appropriate;

(3) submitting five (5) copies (for distribution to the Curator's file, the DSDP Repositories, the GLOMAR CHALLENGER's Library, and the National Science Foundation) of all reprints of published results to the Curator, Deep Sea Drilling Project (A-012), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, U.S.A.;

(4) returning, in good condition, the remainders of samples after termination of research, if requested by the Curator.

E. Cores are made available at repositories for investigators to examine and to specify exact samples in such instances as may be necessary for the scientific purposes of the sampling, subject to the limitations of B (1 and 2) and D, above, with specific permission of the Curator or his delegate.

F. Shipboard-produced smear slides of sediments and thin sections of indurated sediments, igneous and metamorphic rocks, will be returned to the appropriate repository at the end of each cruise or at the publication of the Initial Reports for that cruise. These smear slides and thin sections will form a reference collection of the cores stored at each repository and may be viewed at the respective repositories as an aid in the selection of core samples.

G. The Deep Sea Drilling Project routinely processes by computer most of the quantitative data presented in the Initial Reports. Space limitations in the Initial Reports preclude the detailed presentation of all such data. However, copies of the computer readout are available for those who wish the data for further analysis or as an aid in selecting samples. A charge will be made to recover expenses in excess of $50.00 incurred in filling requests.

3. Other Records

Magnetics, seismic reflection, downhole logging, and bathymetric data collected by the GLOMAR CHALLENGER will also be available for distribution at the same time samples become available.

Requests for data may be made to:

Associate Chief Scientist,
Science Services
Deep Sea Drilling Project (A-031)
Scripps Institution of
Oceanography
University of California
at San Diego
La Jolla, California 92093

A charge will be made to recover the expenses in excess of $50.00 in filling individual requests. If required, estimated charges can be furnished before the request is processed.

4. Reference Centers

As a separate and special category samples will be distributed for the purpose of establishing up to five reference centers where paleontologic materials will be available for reference and comparison purposes. The first of these reference centers has been approved at Basel, Switzerland.
Revised 9/28/76

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SITE SUMMARY SHEET

SITE 438

Date occupied	October 19, 1977
Date departed	October 19, 1977
Time on hole	1 day
Position: latitude	40° 37.75'N
longitude	143° 13.90'E
Water depth (sea level)	1552 corrected meters, echo sounding
Water depth (rig floor)	1562 corrected meters, echo sounding
Bottom felt at	1557.5 meters, drill pipe
Penetration	109.5 meters
Number of holes	1
Number of cores	12
Total length of cored section	109.5 meters
Total core recovery	81.9 meters
Percentage core recovery	75%

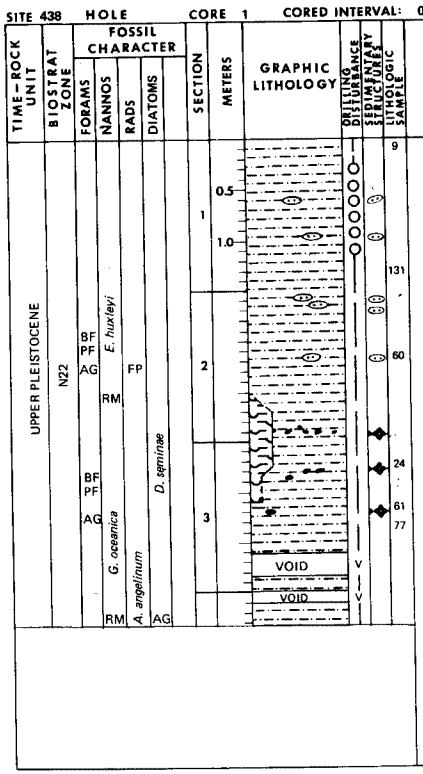
Oldest Sediment Cored

Depth sub-bottom	109.5 meters
Nature	Olive greenish mud
Age	Lower Pliocene
Measured velocity	1.6 to 1.8 km/s

Principal Results:

See 438B Site Summary Sheet.

SITE 438 HOLE CORE 1 CORED INTERVAL: 0.0-5.0 m



Coarse sandy mud, grain size increase downward, possibly drilling induced(?)

LITHOLOGIC DESCRIPTION

Dark gray and olive gray (5Y 4/1-4/2) sandy mud (vitric, diatomaceous) medium- to coarse-grained sand in mud, poorly sorted. No recognizable bedding or bioturbation.

Occasional pockets or pods of medium- to coarse-grained sand (original layers probably disrupted by drilling).

Pebbles in lower part, isolated, subrounded, maximum diameter 5 mm; pumice (light gray to white with biotite flakes).

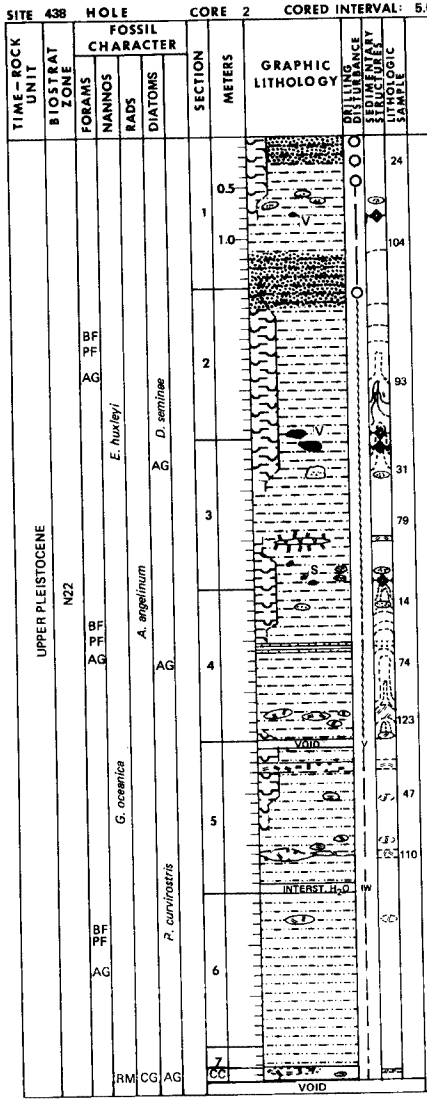
TOTAL C – ORGANIC C – CARBONATE (%)
2, 45 cm (0.8, 0.6, 2)

CARBONATE BOMB
3, 61-63 cm = 1.5%

SMEAR SLIDE SUMMARY

	Vitric, diatomaceous silty mud (D)	Diatomaceous sandy mud (D)	Vitric, diatomaceous sandy, silty clay (D)	Diatomaceous clayey sand (D)	Vitric, sandy silty mud (D)
	1-9	1-131	2-60	3-24	3-77
Sand	15	40	26	70	25
Silt	30	20	26	10	30
Clay	55	40	98	20	45
Quartz	7	40	14	42	20
Feldspar	1	15	2	10	10
Mica	4	–	3	–	–
Heavy minerals	8	3	11	2	10
Clay	49	18	31	20	32
Volcanic glass	15	5	16	5	20
Carb. unspec.	<1	2	–	–	–
Pyrite	1	–	5	–	5
Foraminifers	1	5	1	TR	TR
Carbonate	2	–	4	1	–
Diatoms	10	10	11	15	1
Radiolarians	TR	2	1	2	1
Sponge spicules	1	TR	2	3	1

SITE 438 HOLE CORE 2 CORED INTERVAL: 5.0-14.5 m



sandy mud

slight increase in sand content

lt. gy. pumic fragments, streaked, glassy w/biotite & dk. streaks, ~3 cm diameter, subangular (glacial erratics?) lower 1 cm diameter

pod of volcanic ash white/lt. gray-green

white/gray ash pockets

sandy, silty ash layers and pockets, lt. gray white

LITHOLOGIC DESCRIPTION

Section 1, 0-120 cm: Soupy, fine-grained muddy sand and silty, sandy mud (vitric, diatomaceous) olive gray (5Y 4/2). Occasional pebbles (isolated, subrounded, 5 mm maximum diameter) pumice (maximum 1 cm diameter).

Section 1, 120 cm - Section 2, 20 cm: Coarse muddy sand (poorly sorted) grains subrounded to subangular (slightly graded – drilling disturbance?).

Section 2, 60-150 cm: Fine-grained sandy/silty (vitric, diatomaceous) mud, sand content decreases downward. Highly disturbed faint bedding due to variations in sand content.

Section 3: Olive gray (5Y 4/2) silty/sandy (diatomaceous) mud occasional pockets and fine-grained sand.

Section 4, 0-20 cm: Dark olive gray (5Y 3/2) sandy mud (fine-grained sand).

Section 4, 20-60 cm: Olive gray (5Y 4/2) mud (slightly silty) occasional lamination (faint), two fine-grained sand layers (<1 cm), dark gray black.

Section 4, 60-150 cm: Highly deformed mud to sandy, silty mud (diatomaceous).

Section 5, 5 cm thru CC: Dark olive gray (5Y 3/2) homogeneous mud to slightly silty mud, H_2S odor, pyrite blebs, occasional ash layers or pockets as indicated.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 111 cm (1.5, 1.0, 5)
4, 35 cm (1.9, 1.1, 7)

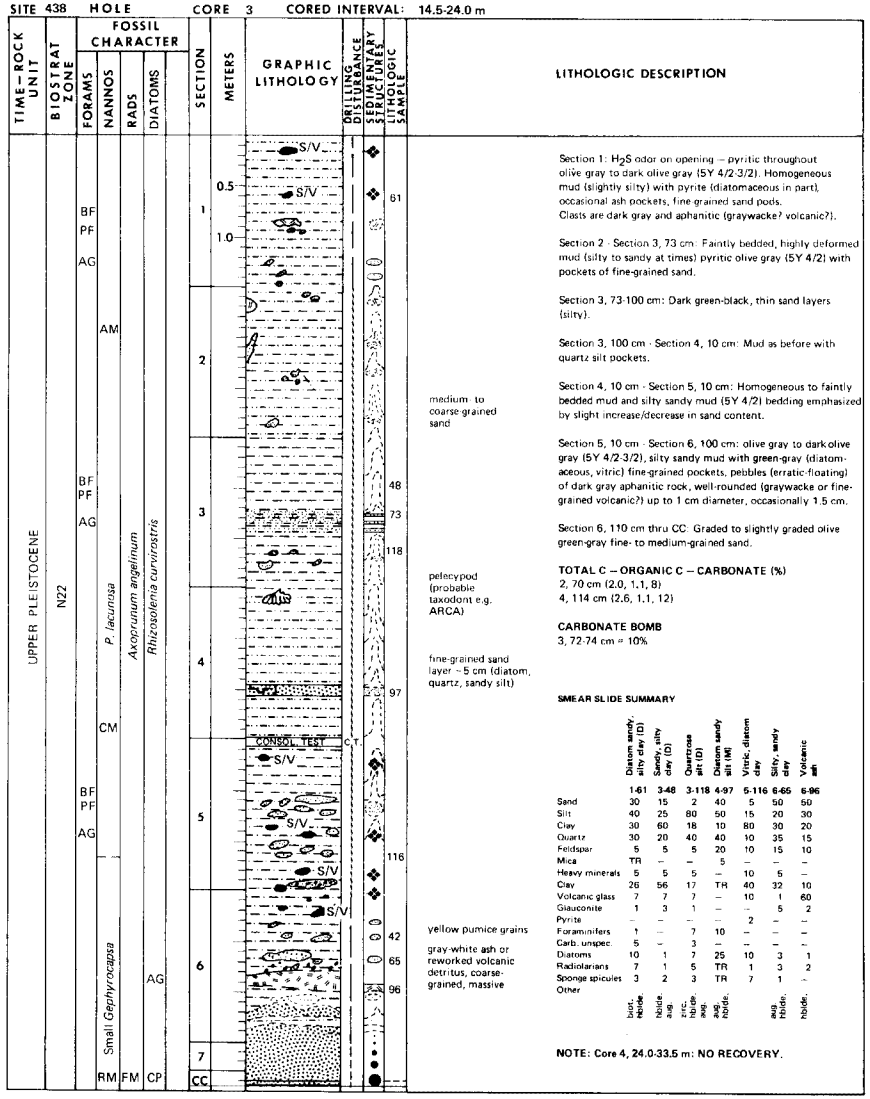
CARBONATE BOMB
3, 31-33 cm = 1.2%

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Vitric, diatomaceous sandy, silty mud (D)	Vitric, diatom silty mud (D)	Diatom, silty, sandy clay (D)	Diatomaceous clay (D)	Diatomaceous clayey silt (D)	Vitric silty clay mud (D)	Vitric, diatomaceous clay (D)	Volcanic ash (M)	Volcanic ash (M)
	1-24	1-104	2-93	3-79	4-14	4-78	4-123	5-47	5-110	CC
Sand	5	20	4	30	15	3	15	5	–	–
Silt	35	40	28	25	10	60	25	15	–	–
Clay	60	40	68	45	75	37	60	80	–	–
Quartz	31	30	1	25	20	25	20	20	8	4
Feldspar	5	20	3	7	20	7	15	3	10	–
Mica	–	–	TR	TR	–	TR	–	TR	–	–
Heavy minerals	3	10	3	5	7	3	2	2	2	–
Clay	30	10	45	30	20	37	38	40	–	–
Volcanic glass	5	10	12	3	15	5	10	10	80	96
Glauconite	2	–	1*	1	–	1	–	TR	–	–
Pyrite	–	2	2							
Foraminifers	1	–	2	7	–	1	TR	1	–	
Carb. unspec.	1	–	–	5	–	1	3	1		
Diatoms	15	10	25	10	15	12	5	15	–	
Radiolarians	5	TR	TR	5	–	5	5	5	–	–
Sponge spicules	2	5	3	2	2	3	2	3	–	–
Other special	hbldy. augite	hemat. hbldy.	volcc. rock frag.	bent sag. hbldy.			zeol.	zirc.	hbldy.	

*Volcanic rock fragments (S)

SITE 438 HOLE CORE 3 CORED INTERVAL: 14.5-24.0 m



medium- to coarse-grained sand

pelecypod (probable taxodont e.g. ARCA)

fine-grained sand layer ~5 cm (diatom, quartz, sandy silt)

yellow pumice grains

gray-white ash or reworked volcanic detritus, coarse-grained, massive

LITHOLOGIC DESCRIPTION

Section 1: H_2S odor on opening – pyritic throughout olive gray to dark olive gray (5Y 4/2-3/2). Homogeneous mud (slightly silty) with pyrite (diatomaceous in part), occasional ash pockets, fine-grained sand pods. Clasts are dark gray and aphanitic (graywacke? volcanic?).

Section 2 - Section 3, 73 cm: Faintly bedded, highly deformed mud (silty to sandy at times) pyritic olive gray (5Y 4/2) with pockets of fine-grained sand.

Section 3, 73-100 cm: Dark green-black, thin sand layers (silty).

Section 3, 100 cm - Section 4, 10 cm: Mud as before with quartz silt pockets.

Section 4, 10 cm - Section 5, 10 cm: Homogeneous to faintly bedded mud and silty sandy mud (5Y 4/2) bedding emphasized by slight increase/decrease in sand content.

Section 5, 10 cm - Section 6, 100 cm: olive gray to dark olive gray (5Y 4/2-3/2), silty sandy mud with green-gray (diatomaceous, vitric) fine-grained pockets, pebbles (erratic-floating) of dark gray aphanitic rock, well-rounded (graywacke or fine-grained volcanic?) up to 1 cm diameter, occasionally 1.5 cm.

Section 6, 110 cm thru CC: Graded to slightly graded olive green-gray fine- to medium-grained sand.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 70 cm (2.0, 1.1, 8)
4, 114 cm (2.6, 1.1, 12)

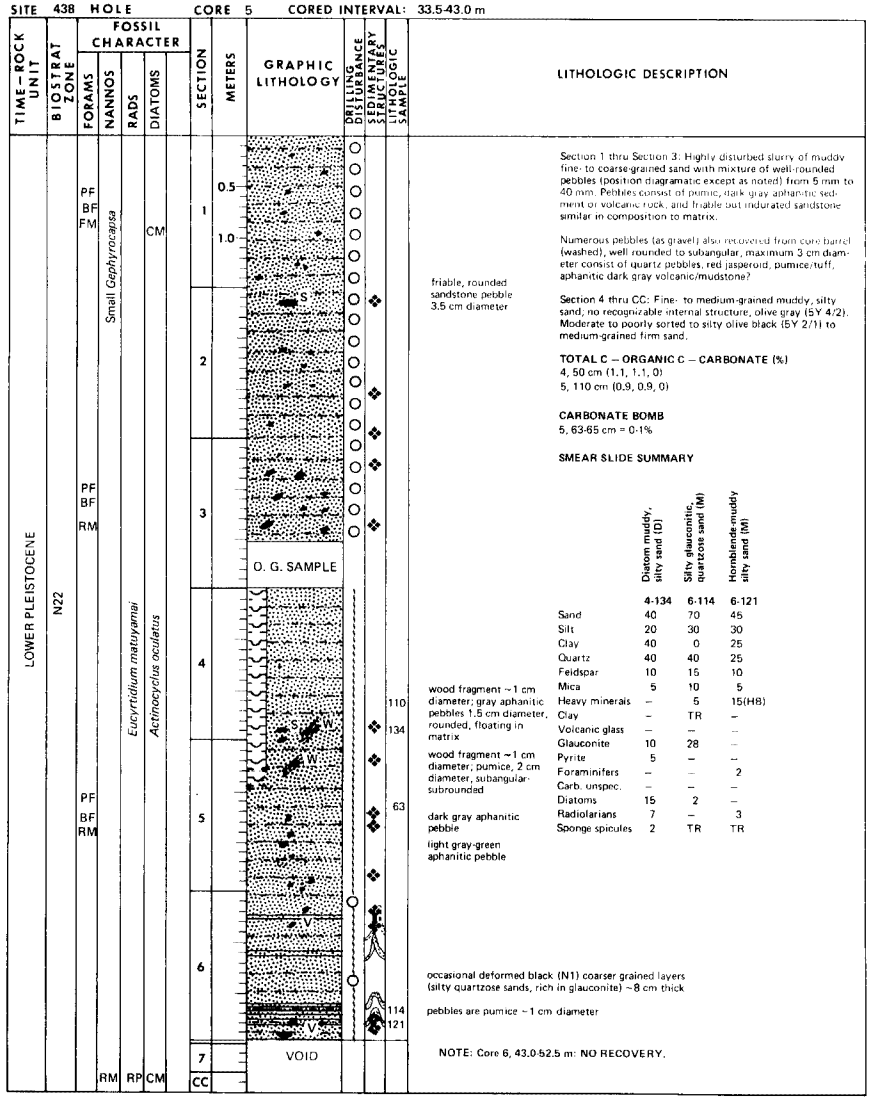
CARBONATE BOMB
3, 72-74 cm = 10%

SMEAR SLIDE SUMMARY

	Diatom sandy, silty clay (D)	Sandy, silty clay (D)	Quartzose silt (D)	Diatom sandy silt (M)	Vitric, diatom clay	Silty, sandy clay	Volcanic ash
	1-61	3-48	3-118	4-97	5-116	6-65	6-96
Sand	30	15	2	40	5	50	50
Silt	40	25	80	50	15	20	30
Clay	30	60	18	10	80	30	20
Quartz	30	20	40	40	10	35	15
Feldspar	5	5	5	20	10	15	10
Mica	TR	–	–	5	–	–	–
Heavy minerals	5	5	5	–	10	5	–
Clay	26	56	17	TR	40	32	10
Volcanic glass	7	7	7	–	10	1	60
Glauconite	1	3	1	–	–	5	2
Pyrite	–	–	–	–	2	–	–
Foraminifers	1	–	7	10	–	–	–
Carb. unspec.	5	–	3	–	–	–	–
Diatoms	10	1	7	25	10	3	1
Radiolarians	7	1	5	TR	1	3	2
Sponge spicules	3	2	3	TR	7	1	–
Other	biot. hbide.	hbide. aug.	zric. hbide. aug.	aug. hbide.		aug. hbide.	hbide.

NOTE: Core 4, 24.0-33.5 m: NO RECOVERY.

SITE 438 HOLE CORE 5 CORED INTERVAL: 33.5-43.0 m



friable, rounded sandstone pebble 3.5 cm diameter

wood fragment ~1 cm diameter; gray aphanitic pebbles 1.5 cm diameter, rounded, floating in matrix

wood fragment ~1 cm diameter; pumice, 2 cm diameter, subangular subrounded

dark gray aphanitic pebble

light gray-green aphanitic pebble

occasional deformed black (N1) coarser grained layers (silty quartzose sands, rich in glauconite) ~8 cm thick

pebbles are pumice ~1 cm diameter

LITHOLOGIC DESCRIPTION

Section 1 thru Section 3: Highly disturbed slurry of muddy fine- to coarse-grained sand with mixture of well-rounded pebbles (position diagramatic except as noted) from 5 mm to 40 mm. Pebbles consist of pumice, dark gray aphanitic sediment or volcanic rock, and friable but indurated sandstone similar in composition to matrix.

Numerous pebbles (as gravel) also recovered from core barrel (washed), well rounded to subangular, maximum 3 cm diameter consist of quartz pebbles, red jasperoid, pumice/tuff, aphanitic dark gray volcanic/mudstone?

Section 4 thru CC: Fine- to medium-grained muddy, silty sand; no recognizable internal structure, olive gray (5Y 4/2). Moderate to poorly sorted to silty olive black (5Y 2/1) to medium-grained firm sand.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 50 cm (1.1, 1.1, 0)
5, 110 cm (0.9, 0.9, 0)

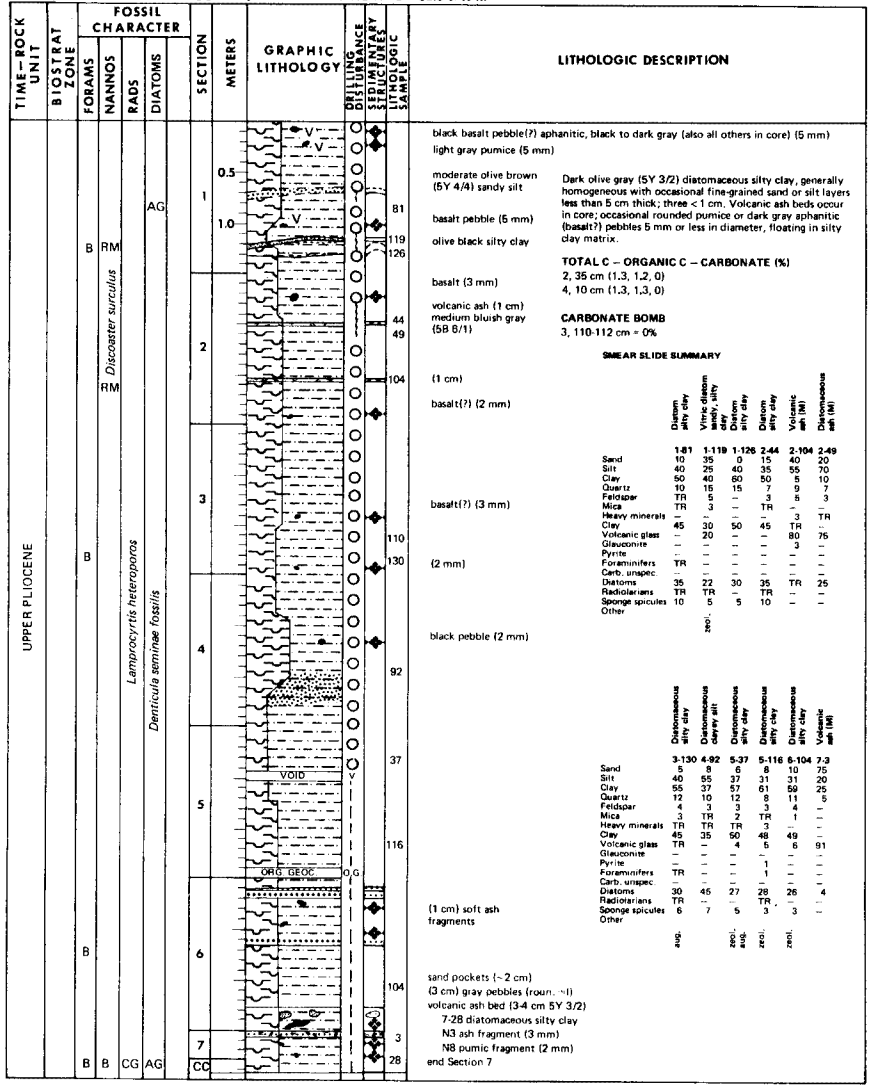
CARBONATE BOMB
5, 63-65 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatom muddy, silty sand (D)	Silty glauconitic, quartzose sand (M)	Hornblende-muddy silty sand (M)
	4-134	6-114	6-121
Sand	40	70	45
Silt	20	30	30
Clay	40	0	25
Quartz	40	40	25
Feldspar	10	15	10
Mica	5	10	5
Heavy minerals	–	5	15(HB)
Clay	–	TR	–
Volcanic glass	–	–	–
Glauconite	10	28	–
Pyrite	5	–	–
Foraminifers	–	–	2
Carb. unspec.	–	–	–
Diatoms	15	2	–
Radiolarians	7	–	3
Sponge spicules	2	TR	TR

NOTE: Core 6, 43.0-52.5 m: NO RECOVERY.

SITE 438 HOLE CORE 7 CORED INTERVAL: 52.5-62.0 m



LITHOLOGIC DESCRIPTION

black basalt pebble(?) aphanitic, black to dark gray (also all others in core) (5 mm)
light gray pumice (5 mm)
moderate olive brown (5Y 4/4) sandy silt
basalt pebble (5 mm)
olive black silty clay
basalt (3 mm)
volcanic ash (1 cm)
medium bluish gray (5B 6/1)
(1 cm)
basalt(?) (2 mm)
basalt(?) (3 mm)
(2 mm)
black pebble (2 mm)
(1 cm) soft ash fragments
sand pockets (~2 cm)
(3 cm) gray pebbles (roun. ~1)
volcanic ash bed (3-4 cm 5Y 3/2)
7-28 diatomaceous silty clay
N3 ash fragment (3 mm)
N8 pumic fragment (2 mm)
end Section 7

Dark olive gray (5Y 3/2) diatomaceous silty clay, generally homogeneous with occasional fine-grained sand or silt layers less than 5 cm thick; three < 1 cm. Volcanic ash beds occur in core; occasional rounded pumice or dark gray aphanitic (basalt?) pebbles 5 mm or less in diameter, floating in silty clay matrix.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 35 cm (1.3, 1.2, 0)
4, 10 cm (1.3, 1.3, 0)

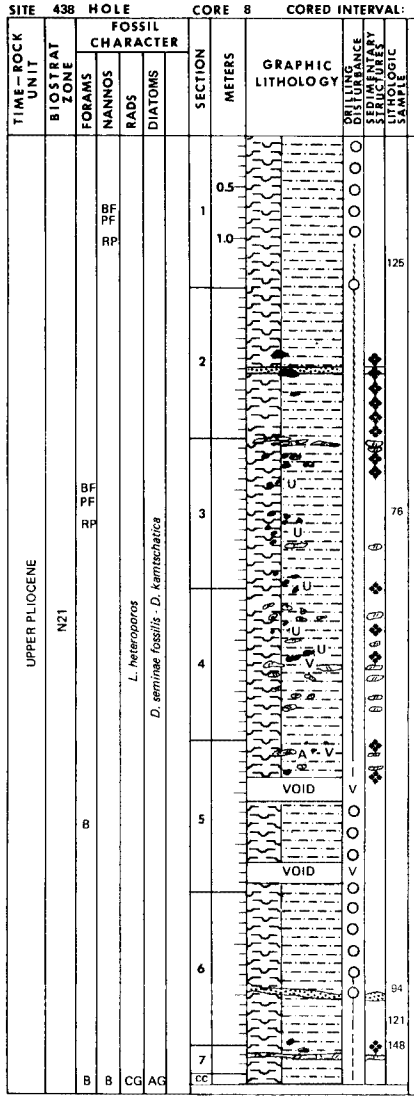
CARBONATE BOMB
3, 110-112 cm = 0%

SMEAR SLIDE SUMMARY

	Diatom silty clay 1-81	Vitric diatom sandy, silty clay 1-119	Diatom silty clay 1-126	Diatom silty clay 2-44	Volcanic ash (M) 2-104	Diatomaceous ash (M) 2-49
Sand	10	35	0	15	40	20
Silt	40	25	40	35	55	70
Clay	50	40	60	50	5	10
Quartz	10	15	15	7	9	7
Feldspar	TR	5	–	3	5	3
Mica	TR	3	–	TR	–	–
Heavy minerals	–	–	–	–	3	TR
Clay	45	30	50	45	TR	–
Volcanic glass	–	20	–	–	80	75
Glauconite	–	–	–	–	3	–
Pyrite	–	–	–	–	–	–
Foraminifers	TR	–	–	–	–	–
Carb. unspec.	–	–	–	–	–	–
Diatoms	35	22	30	35	TR	25
Radiolarians	TR	TR	–	TR	–	–
Sponge spicules	10	5	5	10	–	–
Other		zeol.				

	Diatomaceous silty clay 3-130	Diatomaceous clayey silt 4-92	Diatomaceous silty clay 5-37	Diatomaceous silty clay 5-116	Diatomaceous silty clay 6-104	Volcanic ash (M) 7-3
Sand	5	8	6	8	10	75
Silt	40	55	37	31	31	20
Clay	55	37	57	61	59	25
Quartz	12	10	12	8	11	5
Feldspar	4	3	3	3	4	–
Mica	3	TR	2	TR	1	–
Heavy minerals	TR	TR	TR	3	–	–
Clay	45	35	50	48	49	–
Volcanic glass	TR	–	4	5	6	91
Glauconite	–	–	–	–	–	–
Pyrite	–	–	–	1	–	–
Foraminifers	TR	–	–	1	1	–
Carb. unspec.	–	–	–	–	–	–
Diatoms	30	45	27	28	26	4
Radiolarians	TR	–	–	TR	–	–
Sponge spicules	6	7	5	3	3	–
Other	aug.		zeol., aug.	zeol.	zeol.	

SITE 438 HOLE CORE 8 CORED INTERVAL: 62.0-71.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) throughout core; homogeneous diatomaceous silty mud with some disrupted black and white ash layers, rare fine- to medium-grained sand or silt layers and abundant rounded, 1 cm diameter or less, black and white pebbles (basalt?, graywacke, lapilli).

TOTAL C – ORGANIC C – CARBONATE (%)
3, 80 cm (1.0, 1.0, 0)
4, 100 cm (0.8, 0.9, 0)

CARBONATE BOMB
3, 76-78 cm = 0%

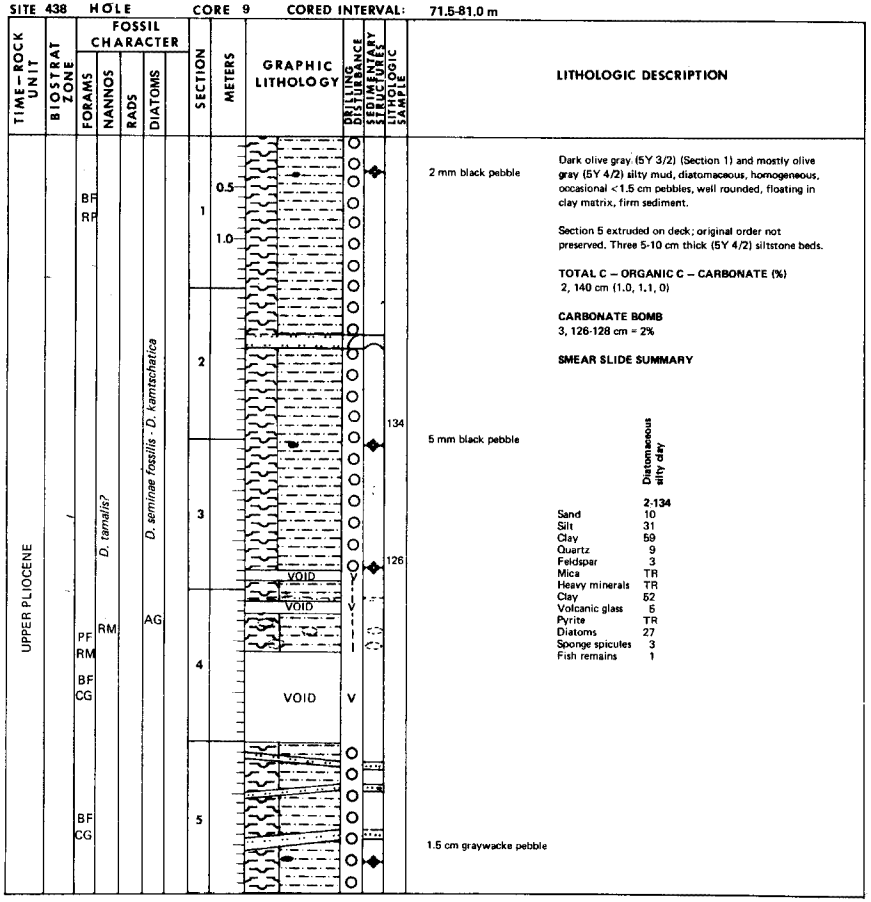
SMEAR SLIDE SUMMARY

graywacke pebble (1 cm)
graywacke pebble (1 cm) in olive black (5Y 2/2) medium sand
graywacke pebble (2 mm)
black ash pockets
white ash pockets
black ash pockets
black ash pocket
black ash pockets
8 mm unidentified pebble
black ash pockets
light gray/white ash pockets
volcanic
2 cm olive black medium grained micaceous, quartzose sand
2 mm quartz grain
2 cm gray (N6-N4) gray ash, fine-grained

	Diatomaceous silty clay (D) 1-125	Diatomaceous silty clay (D) 6-121	Micaceous quartz sand (M) 6-94	Diatomaceous silty clay (D) 6-148
Sand	10	10	55	10
Silt	30	28	25	30
Clay	60	62	20	60
Quartz	10	6	30	10
Feldspar	2	2	6	2
Mica	TR	TR	20	TR
Heavy minerals	1	–	14	TR
Clay	55	56	20	53
Volcanic glass	TR	3	10	2
Glauconite	–	–	–	–
Pyrite	1	TR	–	–
Foraminifers	–	–	TR	–
Carb. unspec.	–	–	–	–
Diatoms	27	29	–	29
Radiolarians	1	–	–	–
Sponge spicules	3	4	–	4
Other	–	–	–	–

NOTE:
U = 3-5 mm pebbles unidentified
V = 5 mm diameter lapilli as clasts
A = gray ash pockets

SITE 438 HOLE CORE 9 CORED INTERVAL: 71.5-81.0 m



Dark olive gray (5Y 3/2) (Section 1) and mostly olive gray (5Y 4/2) silty mud, diatomaceous, homogeneous, occasional <1.5 cm pebbles, well rounded, floating in clay matrix, firm sediment.

Section 5 extruded on deck; original order not preserved. Three 5-10 cm thick (5Y 4/2) siltstone beds.

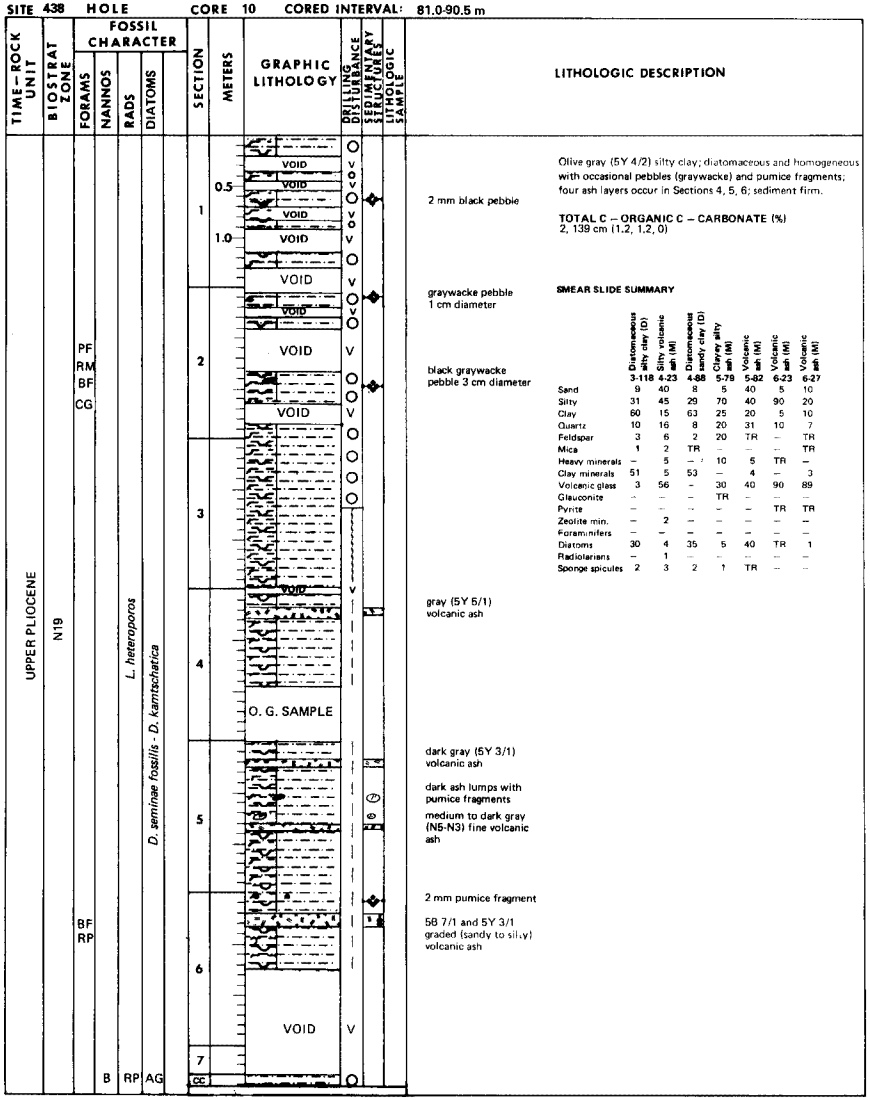
TOTAL C – ORGANIC C – CARBONATE (%)
2, 140 cm (1.0, 1.1, 0)

CARBONATE BOMB
3, 126-128 cm = 2%

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay
	2-134
Sand	10
Silt	31
Clay	59
Quartz	9
Feldspar	3
Mica	TR
Heavy minerals	TR
Clay	52
Volcanic glass	5
Pyrite	TR
Diatoms	27
Sponge spicules	3
Fish remains	1

SITE 438 HOLE CORE 10 CORED INTERVAL: 81.0-90.5 m



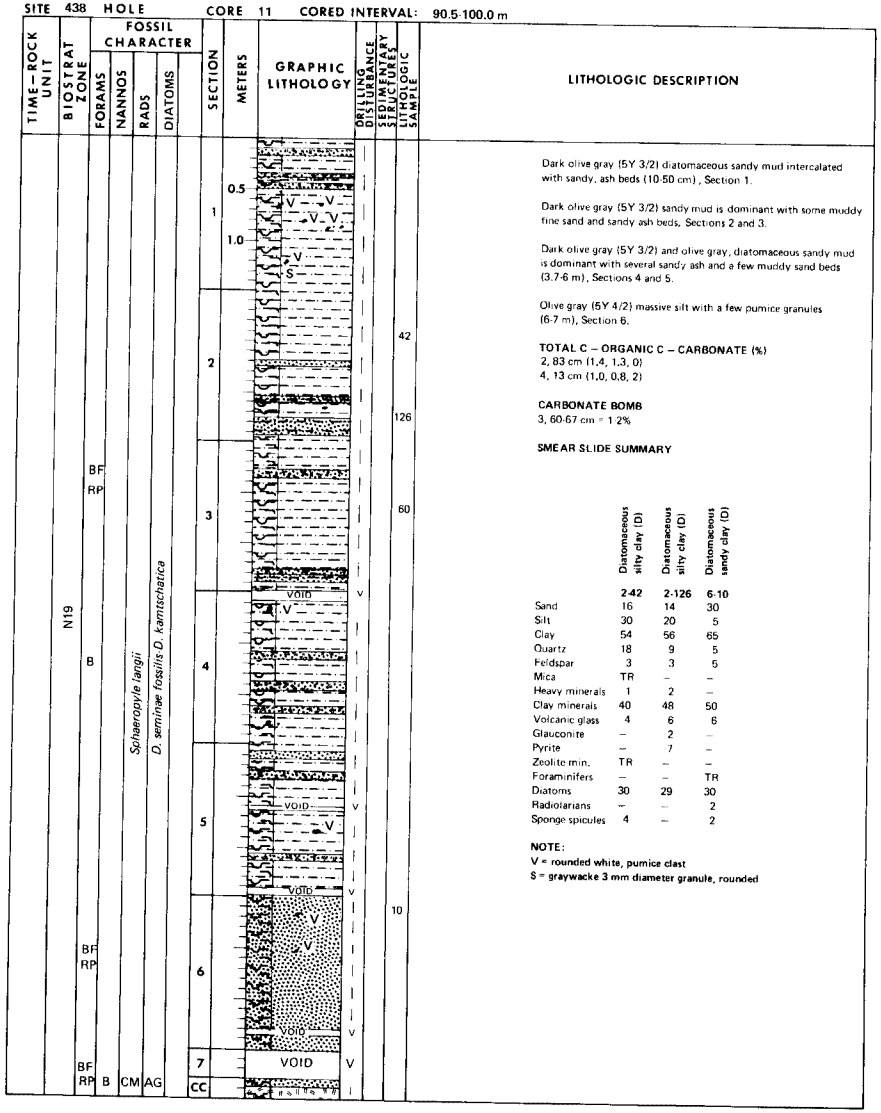
Olive gray (5Y 4/2) silty clay; diatomaceous and homogeneous with occasional pebbles (graywacke) and pumice fragments; four ash layers occur in Sections 4, 5, 6; sediment firm.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 139 cm (1.2, 1.2, 0)

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D) 3-118	Silty volcanic ash (M) 4-23	Diatomaceous sandy clay (D) 4-88	Clayey silty ash (M) 5-79	Volcanic ash (M) 5-82	Volcanic ash (M) 6-23	Volcanic ash (M) 6-27
Sand	9	40	8	5	40	5	10
Silty	31	45	29	70	40	90	20
Clay	60	15	63	25	20	5	10
Quartz	10	16	8	20	31	10	7
Feldspar	3	6	2	20	TR	–	TR
Mica	1	2	TR	–	–	–	TR
Heavy minerals	–	5	–	10	5	TR	–
Clay minerals	51	5	53	–	4	–	3
Volcanic glass	3	56	–	30	40	90	89
Glauconite	–	–	–	TR	–	–	–
Pyrite	–	–	–	–	–	TR	TR
Zeolite min.	–	2	–	–	–	–	–
Foraminifers	–	–	–	–	–	–	–
Diatoms	30	4	35	5	40	TR	1
Radiolarians	–	1	–	–	–	–	–
Sponge spicules	2	3	2	1	TR	–	–

SITE 438 HOLE CORE 11 CORED INTERVAL: 90.5-100.0 m



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/2) diatomaceous sandy mud intercalated with sandy, ash beds (10-50 cm), Section 1.

Dark olive gray (5Y 3/2) sandy mud is dominant with some muddy fine sand and sandy ash beds, Sections 2 and 3.

Dark olive gray (5Y 3/2) and olive gray, diatomaceous sandy mud is dominant with several sandy ash and a few muddy sand beds (3.7-6 m), Sections 4 and 5.

Olive gray (5Y 4/2) massive silt with a few pumice granules (6-7 m), Section 6.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 83 cm (1.4, 1.3, 0)
4, 13 cm (1.0, 0.8, 2)

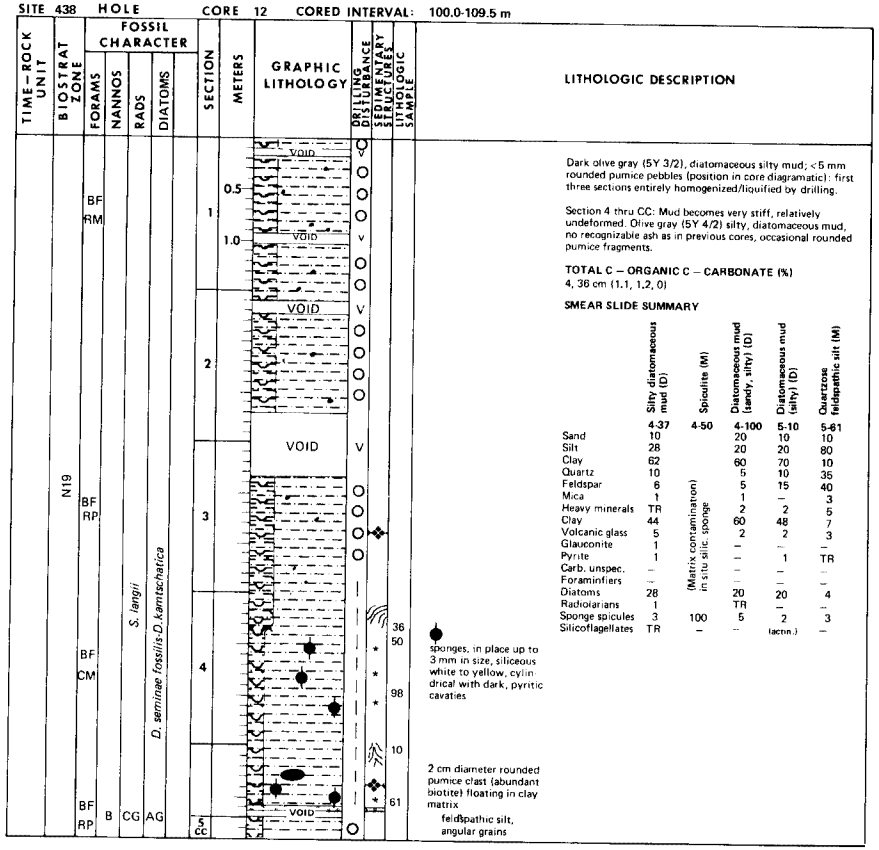
CARBONATE BOMB
3, 60-67 cm = 1.2%

SMEAR SLIDE SUMMARY

	Diatomaceous silty clay (D)	Diatomaceous silty clay (D)	Diatomaceous sandy clay (D)
	2-42	2-126	6-10
Sand	16	14	30
Silt	30	20	5
Clay	54	56	65
Quartz	18	9	5
Feldspar	3	3	5
Mica	TR	–	–
Heavy minerals	1	2	–
Clay minerals	40	48	50
Volcanic glass	4	6	6
Glauconite	–	2	–
Pyrite	–	7	–
Zeolite min.	TR	–	–
Foraminifers	–	–	TR
Diatoms	30	29	30
Radiolarians	–	–	2
Sponge spicules	4	–	2

NOTE:
V = rounded white, pumice clast
S = graywacke 3 mm diameter granule, rounded

SITE 438 HOLE CORE 12 CORED INTERVAL: 100.0-109.5 m



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/2), diatomaceous silty mud; <5 mm rounded pumice pebbles (position in core diagramatic): first three sections entirely homogenized/liquified by drilling.

Section 4 thru CC: Mud becomes very stiff, relatively undeformed. Olive gray (5Y 4/2) silty, diatomaceous mud, no recognizable ash as in previous cores, occasional rounded pumice fragments.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 36 cm (1.1, 1.2, 0)

SMEAR SLIDE SUMMARY

	Silty diatomaceous mud (D)	Spiculite (M)	Diatomaceous mud (sandy, silty) (D)	Diatomaceous mud (silty) (D)	Quartzose feldspathic silt (M)
	4-37	4-50	4-100	5-10	5-61
Sand	10		20	10	10
Silt	28		20	20	80
Clay	62		60	70	10
Quartz	10		5	10	35
Feldspar	6		5	15	40
Mica	1		1	–	3
Heavy minerals	TR		2	2	5
Clay	44		60	48	7
Volcanic glass	5		2	2	3
Glauconite	1		–	–	–
Pyrite	1		–	1	TR
Carb. unspec.	–		–	–	–
Foraminifers	–		–	–	–
Diatoms	28		20	20	4
Radiolarians	1		TR	–	–
Sponge spicules	3	100	5	2	3
Silicoflagellates	TR	–	–	(acnn.)	–

(Matrix contamination) in situ silic. sponge

sponges, in place up to 3 mm in size, siliceous white to yellow, cylindrical with dark, pyritic cavaties

2 cm diameter rounded pumice clast (abundant biotite) floating in clay matrix

feldspathic silt, angular grains

MGG 1505 5027

MGG 1505 5027

SITE SUMMARY SHEET

HOLE 438A

Date occupied	October 22, 1977
Date departed	October 27, 1977
Time on hole	6 days
Position: latitude	40° 37.79'N
longitude	143° 14.15'E
Water depth (sea level)	1558 corrected meters, echo sounding
Water depth (rig floor)	1568 corrected meters, echo sounding
Bottom felt at	1568 meters, drill pipe
Penetration	878.0 meters
Number of holes	1
Number of cores	86
Total length of cored section	878.0 meters
Total core recovery	555.3 meters
Percentage core recovery	63%

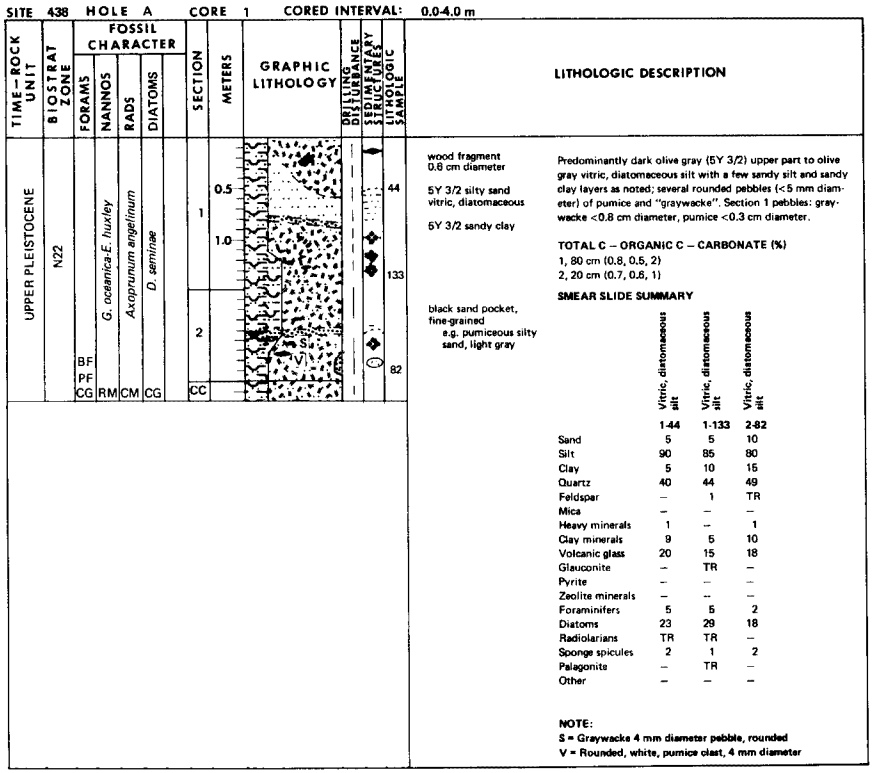
Oldest Sediment Cored

Depth sub-bottom	868.5 meters
Nature	Claystone
Age	Lowest middle Miocene
Measured velocity	1.95 km/s

Principal Results:

See 438B Site Summary Sheet.

SITE 438 HOLE A CORE 1 CORED INTERVAL: 0.0-4.0 m



Predominantly dark olive gray (5Y 3/2) upper part to olive gray vitric, diatomaceous silt with a few sandy silt and sandy clay layers as noted; several rounded pebbles (<5 mm diameter) of pumice and "graywacke". Section 1 pebbles: graywacke <0.8 cm diameter, pumice <0.3 cm diameter.

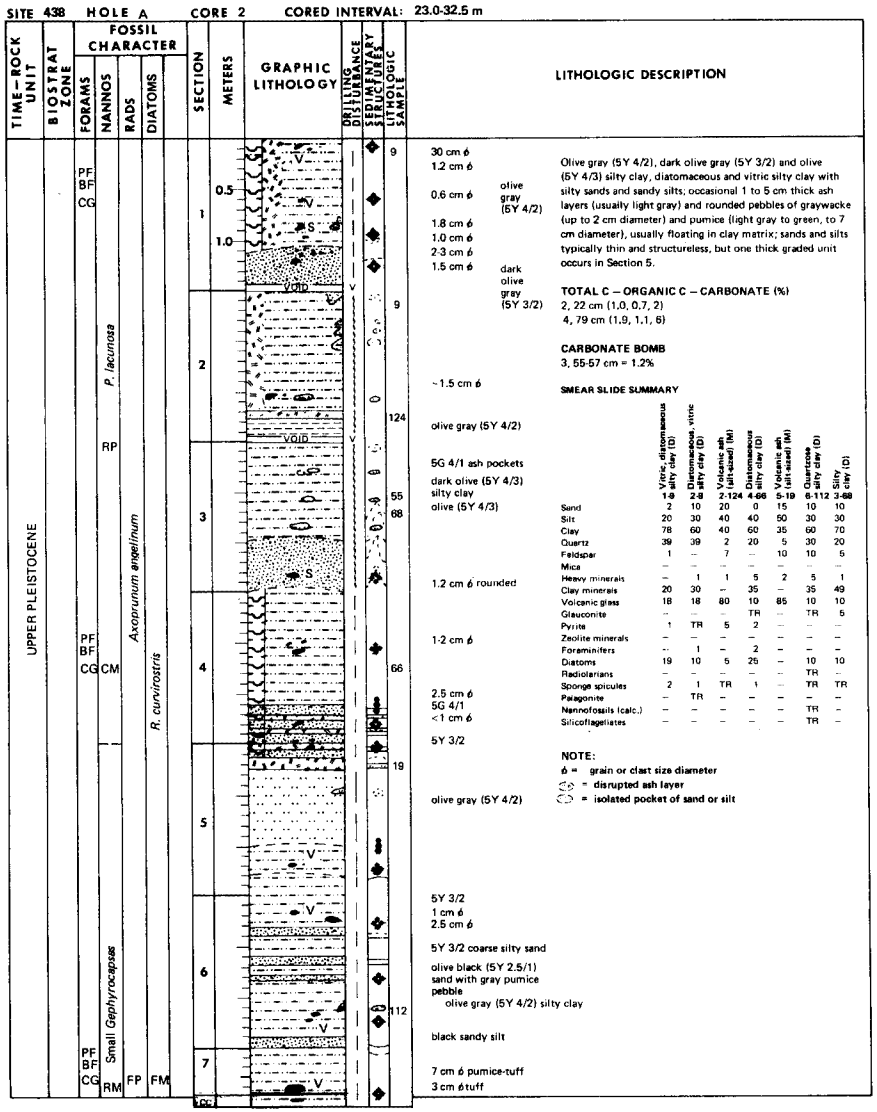
TOTAL C – ORGANIC C – CARBONATE (%)
1, 80 cm (0.8, 0.5, 2)
2, 20 cm (0.7, 0.8, 1)

SMEAR SLIDE SUMMARY

	Vitric, diatomaceous silt 1-44	Vitric, diatomaceous silt 1-133	Vitric, diatomaceous silt 2-82
Sand	5	5	10
Silt	90	85	80
Clay	5	10	15
Quartz	40	44	49
Feldspar	–	1	TR
Mica	–	–	–
Heavy minerals	1	–	1
Clay minerals	9	5	10
Volcanic glass	20	15	18
Glauconite	–	TR	–
Pyrite	–	–	–
Zeolite minerals	–	–	–
Foraminifers	5	5	2
Diatoms	23	29	18
Radiolarians	TR	TR	–
Sponge spicules	2	1	2
Palagonite	–	TR	–
Other	–	–	–

NOTE:
S = Graywacke 4 mm diameter pebble, rounded
V = Rounded, white, pumice clast, 4 mm diameter

SITE 438 HOLE A CORE 2 CORED INTERVAL: 23.0-32.5 m



Olive gray (5Y 4/2), dark olive gray (5Y 3/2) and olive (5Y 4/3) silty clay, diatomaceous and vitric silty clay with silty sands and sandy silts; occasional 1 to 5 cm thick ash layers (usually light gray) and rounded pebbles of graywacke (up to 2 cm diameter) and pumice (light gray to green, to 7 cm diameter), usually floating in clay matrix; sands and silts typically thin and structureless, but one thick graded unit occurs in Section 5.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 22 cm (1.0, 0.7, 2)
4, 79 cm (1.9, 1.1, 6)

CARBONATE BOMB
3, 55-57 cm = 1.2%

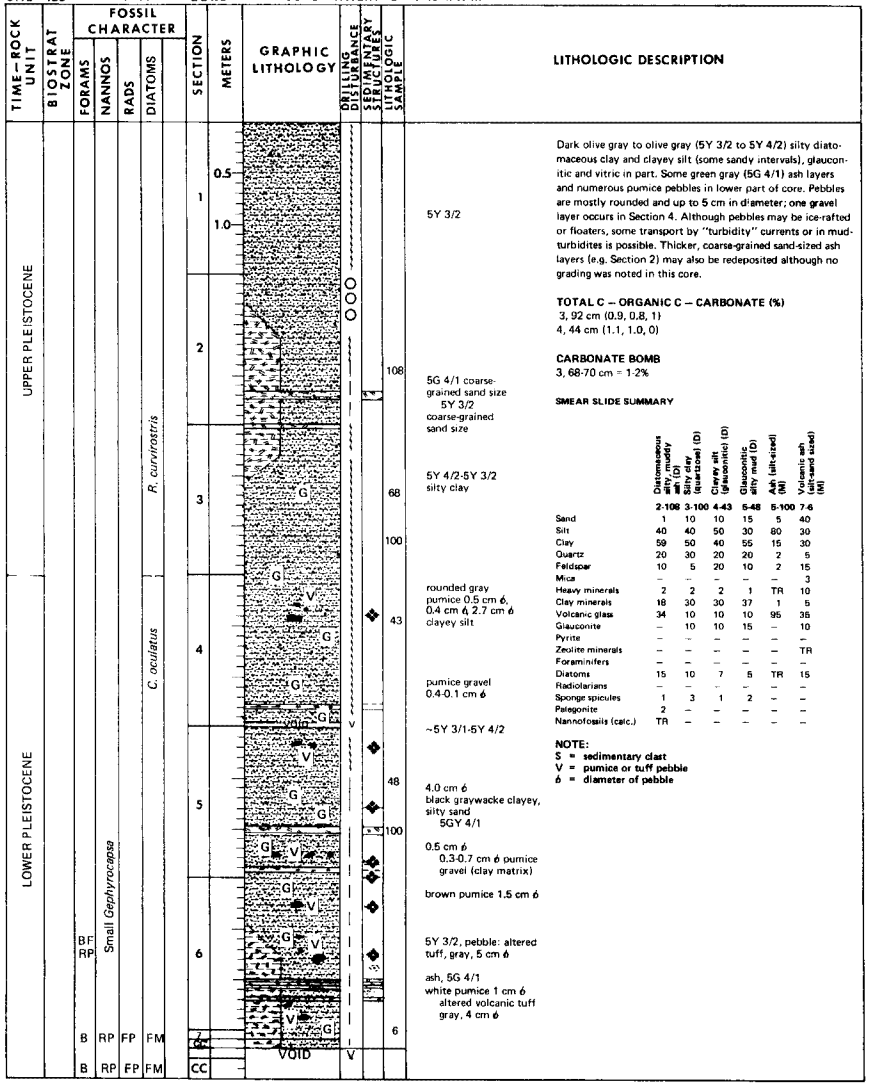
SMEAR SLIDE SUMMARY

	Vitric, diatomaceous silty clay (D) 1-9	Diatomaceous, vitric silty clay (D) 2-9	Volcanic ash (silt-based) (M) 2-124	Diatomaceous silty clay (D) 4-68	Volcanic ash (silt-based) (M) 5-19	Quartzose silty clay (D) 6-112	Silty clay (D) 3-48
Sand	2	10	20	0	15	10	10
Silt	20	30	40	40	50	30	30
Clay	78	60	40	60	35	60	70
Quartz	39	39	2	20	5	30	20
Feldspar	1	–	7	–	10	10	5
Mica	–	–	–	–	–	–	–
Heavy minerals	–	1	1	5	2	5	1
Clay minerals	20	30	–	35	–	35	49
Volcanic glass	18	18	80	10	85	10	10
Glauconite	–	–	–	TR	–	TR	5
Pyrite	1	TR	5	2	–	–	–
Zeolite minerals	–	–	–	–	–	–	–
Foraminifers	–	1	–	2	–	–	–
Diatoms	19	10	5	25	–	10	10
Radiolarians	–	–	–	–	–	TR	–
Sponge spicules	2	1	TR	1	–	TR	TR
Palagonite	–	TR	–	–	–	–	–
Nannofossils (calc.)	–	–	–	–	–	TR	–
Silicoflagellates	–	–	–	–	–	TR	–

NOTE:
ó = grain or clast size diameter
= disrupted ash layer
= isolated pocket of sand or silt

MGG 1505027

SITE 438 HOLE A CORE 3 CORED INTERVAL: 32.5-42.0 m



LITHOLOGIC DESCRIPTION

Dark olive gray to olive gray (5Y 3/2 to 5Y 4/2) silty diatomaceous clay and clayey silt (some sandy intervals), glauconitic and vitric in part. Some green gray (5G 4/1) ash layers and numerous pumice pebbles in lower part of core. Pebbles are mostly rounded and up to 5 cm in diameter; one gravel layer occurs in Section 4. Although pebbles may be ice-rafted or floaters, some transport by "turbidity" currents or in mud-turbidites is possible. Thicker, coarse-grained sand-sized ash layers (e.g. Section 2) may also be redeposited although no grading was noted in this core.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 92 cm (0.9, 0.8, 1)
4, 44 cm (1.1, 1.0, 0)

CARBONATE BOMB
3, 68-70 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous silty mudy ash (D)	Silty clay (quartzose) (D)	Clayey silt (glauconitic) (D)	Glauconitic silty mud (D)	Ash (silt-sized) (M)	Volcanic ash (silt-sand sized) (M)
	2-108	3-100	4-43	5-48	5-100	7-6
Sand	1	10	10	15	5	40
Silt	40	40	50	30	80	30
Clay	59	50	40	55	15	30
Quartz	20	30	20	20	2	5
Feldspar	10	5	20	10	2	15
Mica	–	–	–	–	–	3
Heavy minerals	2	2	2	1	TR	10
Clay minerals	18	30	30	37	1	5
Volcanic glass	34	10	10	10	95	35
Glauconite	–	10	10	15	–	10
Pyrite	–	–	–	–	–	–
Zeolite minerals	–	–	–	–	–	TR
Foraminifers	–	–	–	–	–	–
Diatoms	15	10	7	5	TR	15
Radiolarians	–	–	–	–	–	–
Sponge spicules	1	3	1	2	–	–
Palagonite	2	–	–	–	–	–
Nannofossils (calc.)	TR	–	–	–	–	–

NOTE:
S = sedimentary clast
V = pumice or tuff pebble
ϕ = diameter of pebble

5Y 3/2

5G 4/1 coarse-grained sand size
5Y 3/2 coarse-grained sand size

5Y 4/2-5Y 3/2 silty clay

rounded gray pumice 0.5 cm ϕ, 0.4 cm ϕ, 2.7 cm ϕ
clayey silt

pumice gravel 0.4-0.1 cm ϕ

~5Y 3/1-5Y 4/2

4.0 cm ϕ black graywacke clayey, silty sand 5GY 4/1

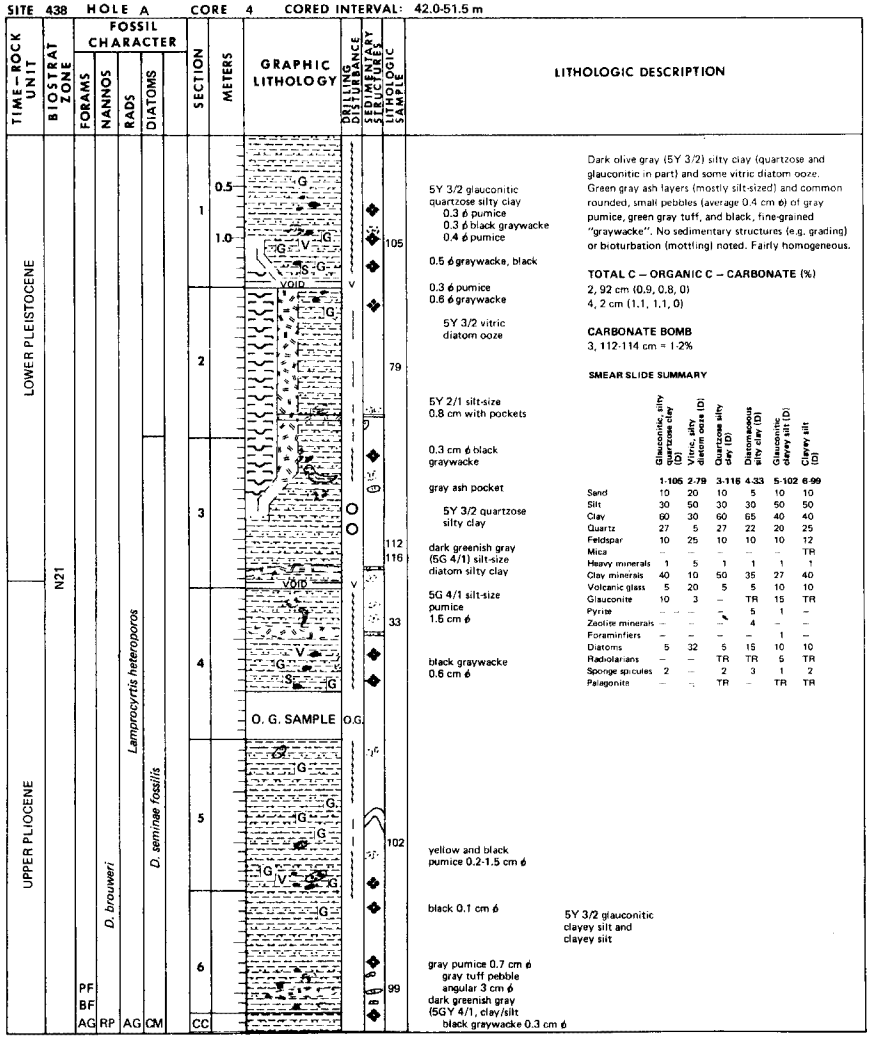
0.5 cm ϕ
0.3-0.7 cm ϕ pumice gravel (clay matrix)

brown pumice 1.5 cm ϕ

5Y 3/2, pebble: altered tuff, gray, 5 cm ϕ

ash, 5G 4/1
white pumice 1 cm ϕ
altered volcanic tuff gray, 4 cm ϕ

SITE 438 HOLE A CORE 4 CORED INTERVAL: 42.0-51.5 m



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/2) silty clay (quartzose and glauconitic in part) and some vitric diatom ooze. Green gray ash layers (mostly silt-sized) and common rounded, small pebbles (average 0.4 cm ϕ) of gray pumice, green gray tuff, and black, fine-grained "graywacke". No sedimentary structures (e.g. grading) or bioturbation (mottling) noted. Fairly homogeneous.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 92 cm (0.9, 0.8, 0)
4, 2 cm (1.1, 1.1, 0)

CARBONATE BOMB
3, 112-114 cm = 1-2%

SMEAR SLIDE SUMMARY

	Glauconitic, silty quartzose clay (D)	Vitric, silty diatom ooze (D)	Quartzose silty clay (D)	Diatomaceous silty clay (D)	Glauconitic clayey silt (D)	Clayey, silt (D)
	1-105	2-79	3-118	4-33	5-102	6-99
Sand	10	20	10	5	10	10
Silt	30	50	30	30	50	50
Clay	60	30	60	65	40	40
Quartz	27	5	27	22	20	25
Feldspar	10	25	10	10	10	12
Mica	–	–	–	–	–	TR
Heavy minerals	1	5	1	1	1	1
Clay minerals	40	10	50	35	27	40
Volcanic glass	5	20	5	5	10	10
Glauconite	10	3	–	TR	15	TR
Pyrite	–	–	–	5	1	–
Zeolite minerals	–	–	–	4	–	–
Foraminfiers	–	–	–	–	1	–
Diatoms	5	32	5	15	10	10
Radiolarians	–	–	TR	TR	5	TR
Sponge spicules	2	–	2	3	1	2
Palagonite	–	–	TR	–	TR	TR

5Y 3/2 glauconitic quartzose silty clay
0.3 ϕ pumice
0.3 ϕ black graywacke
0.4 ϕ pumice

0.5 ϕ graywacke, black

0.3 ϕ pumice
0.6 ϕ graywacke

5Y 3/2 vitric diatom ooze

5Y 2/1 silt-size
0.8 cm with pockets

0.3 cm ϕ black graywacke

gray ash pocket

5Y 3/2 quartzose silty clay

dark greenish gray (5G 4/1) silt-size diatom silty clay

5G 4/1 silt-size pumice
1.5 cm ϕ

black graywacke
0.6 cm ϕ

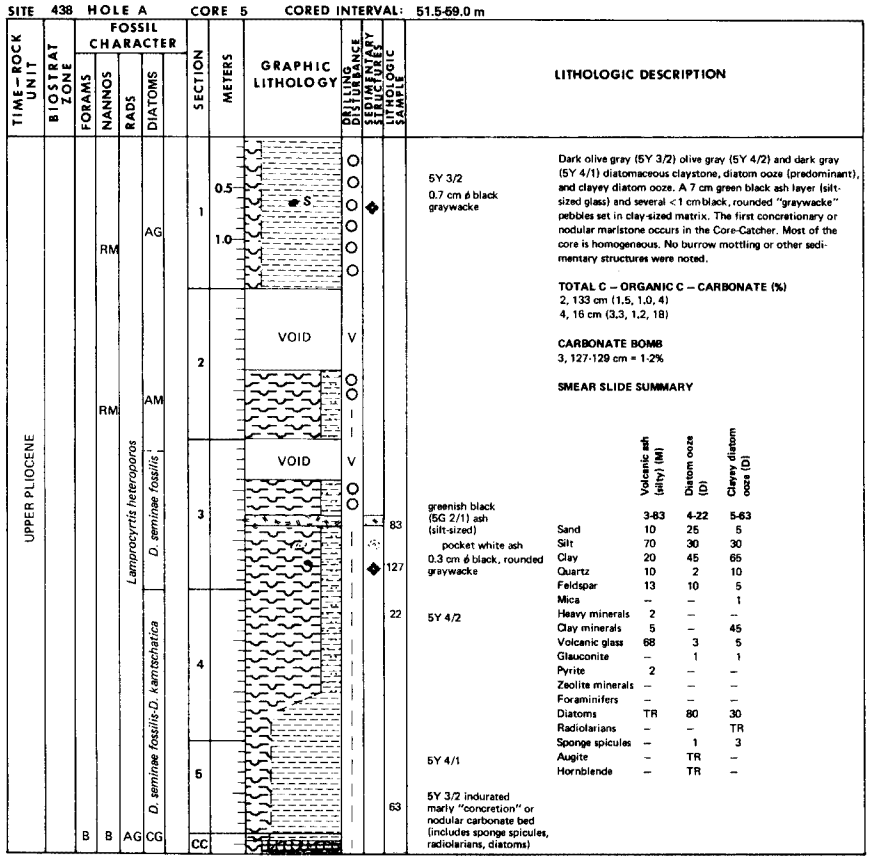
yellow and black pumice 0.2-1.5 cm ϕ

black 0.1 cm ϕ

5Y 3/2 glauconitic clayey silt and clayey silt

gray pumice 0.7 cm ϕ
gray tuff pebble
angular 3 cm ϕ
dark greenish gray (5GY 4/1, clay/silt
black graywacke 0.3 cm ϕ

SITE 438 HOLE A CORE 5 CORED INTERVAL: 51.5-59.0 m



LITHOLOGIC DESCRIPTION

5Y 3/2
0.7 cm ø black graywacke

greenish black (5G 2/1) ash (silt-sized)
pocket white ash
0.3 cm ø black, rounded graywacke

5Y 4/2

5Y 4/1

5Y 3/2 indurated marly "concretion" or nodular carbonate bed (includes sponge spicules, radiolarians, diatoms)

Dark olive gray (5Y 3/2) olive gray (5Y 4/2) and dark gray (5Y 4/1) diatomaceous claystone, diatom ooze (predominant), and clayey diatom ooze. A 7 cm green black ash layer (silt-sized glass) and several <1 cm black, rounded "graywacke" pebbles set in clay-sized matrix. The first concretionary or nodular marlstone occurs in the Core-Catcher. Most of the core is homogeneous. No burrow mottling or other sedimentary structures were noted.

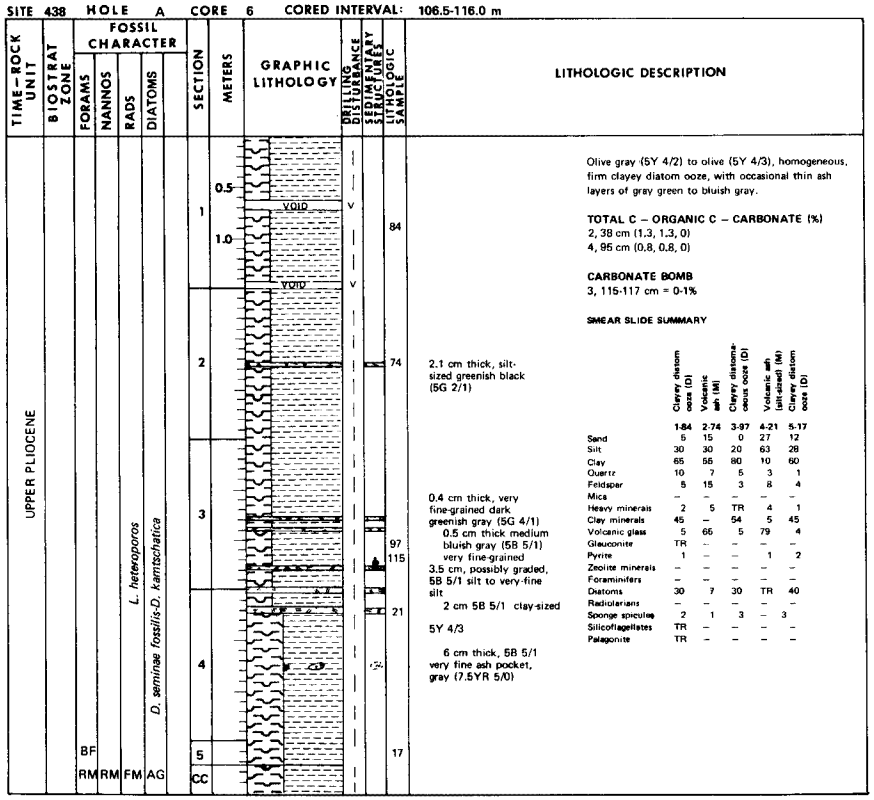
TOTAL C – ORGANIC C – CARBONATE (%)
2, 133 cm (1.5, 1.0, 4)
4, 16 cm (3.3, 1.2, 18)

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

SMEAR SLIDE SUMMARY

	Volcanic ash (silty) (M)	Diatom ooze (D)	Clayey diatom ooze (D)
	3-83	4-22	5-63
Sand	10	25	5
Silt	70	30	30
Clay	20	45	65
Quartz	10	2	10
Feldspar	13	10	5
Mica	–	–	1
Heavy minerals	2	–	–
Clay minerals	5	–	45
Volcanic glass	68	3	5
Glauconite	–	1	1
Pyrite	2	–	–
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	TR	80	30
Radiolarians	–	–	TR
Sponge spicules	–	1	3
Augite	–	TR	–
Hornblende	–	TR	–

SITE 438 HOLE A CORE 6 CORED INTERVAL: 106.5-116.0 m



LITHOLOGIC DESCRIPTION

2.1 cm thick, silt-sized greenish black (5G 2/1)

0.4 cm thick, very fine-grained dark greenish gray (5G 4/1)
0.5 cm thick medium bluish gray (5B 5/1) very fine-grained
3.5 cm, possibly graded, 5B 5/1 silt to very-fine silt
2 cm 5B 5/1 clay-sized
5Y 4/3

6 cm thick, 5B 5/1 very fine ash pocket, gray (7.5YR 5/0)

Olive gray (5Y 4/2) to olive (5Y 4/3), homogeneous, firm clayey diatom ooze, with occasional thin ash layers of gray green to bluish gray.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 38 cm (1.3, 1.3, 0)
4, 95 cm (0.8, 0.8, 0)

CARBONATE BOMB
3, 115-117 cm = 0-1%

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D)	Volcanic ash (M)	Clayey diatomaceous ooze (D)	Volcanic ash (silt-sized) (M)	Clayey diatom ooze (D)
	1-84	2-74	3-97	4-21	5-17
Sand	5	15	0	27	12
Silt	30	30	20	63	28
Clay	65	55	80	10	60
Quartz	10	7	5	3	1
Feldspar	5	15	3	8	4
Mica	–	–	–	–	–
Heavy minerals	2	5	TR	4	1
Clay minerals	45	–	54	5	45
Volcanic glass	5	65	5	79	4
Glauconite	TR	–	–	–	–
Pyrite	1	–	–	1	2
Zeolite minerals	–	–	–	–	–
Foraminifers	–	–	–	–	–
Diatoms	30	7	30	TR	40
Radiolarians	–	–	–	–	–
Sponge spicules	2	1	3	–	3
Silicoflagellates	TR	–	–	–	–
Palagonite	TR	–	–	–	–

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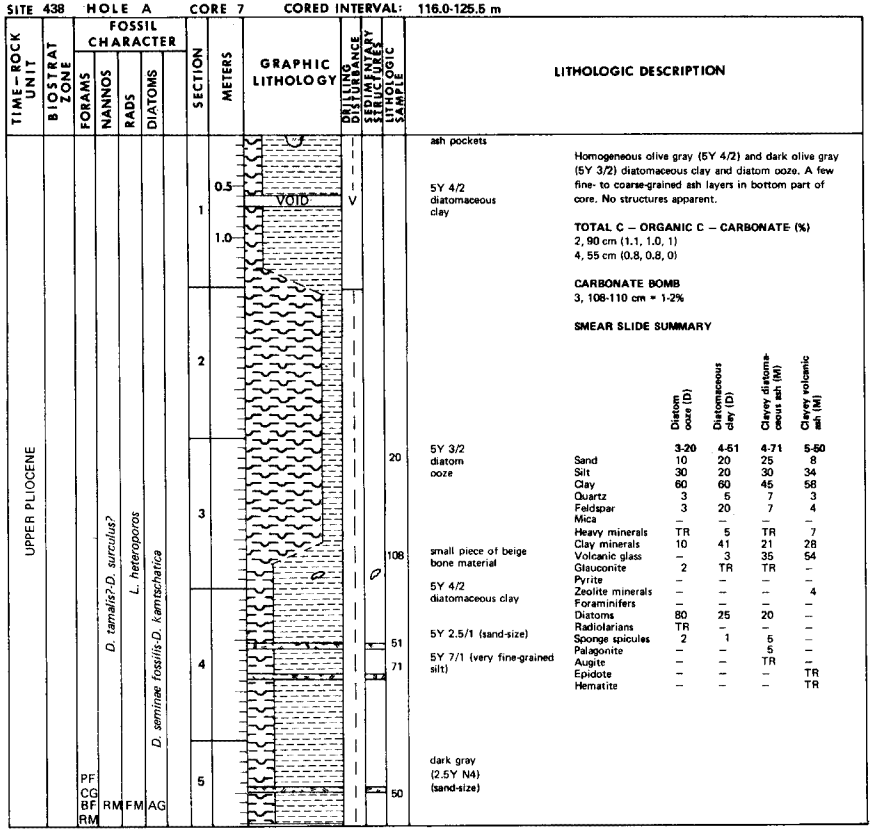
SITE 438 HOLE A CORE 7 CORED INTERVAL: 116.0-125.5 m



Homogeneous olive gray (5Y 4/2) and dark olive gray (5Y 3/2) diatomaceous clay and diatom ooze. A few fine- to coarse-grained ash layers in bottom part of core. No structures apparent.

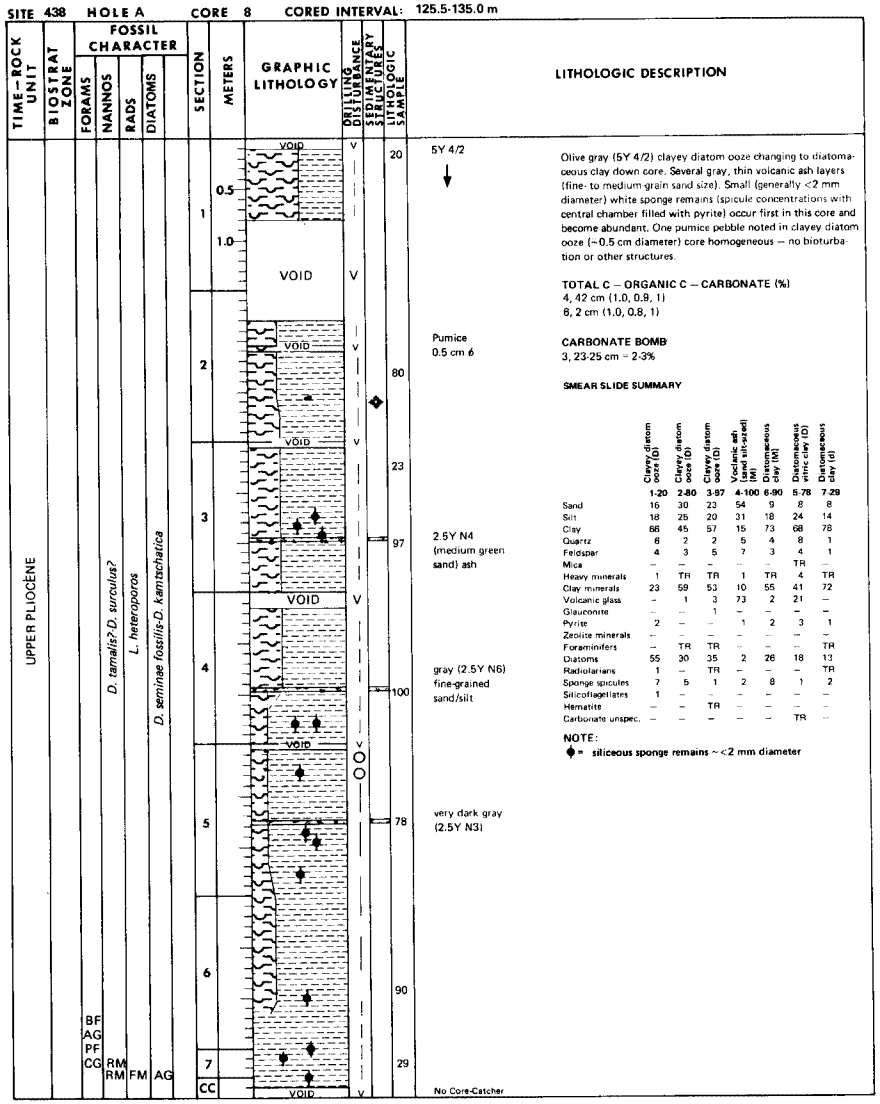
TOTAL C – ORGANIC C – CARBONATE (%)
2, 90 cm (1.1, 1.0, 1)
4, 55 cm (0.8, 0.8, 0)

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

SMEAR SLIDE SUMMARY

	Diatom ooze (D)	Diatomaceous clay (D)	Clayey diatomaceous ash (M)	Clayey volcanic ash (M)
	3-20	4-51	4-71	5-50
Sand	10	20	25	8
Silt	30	20	30	34
Clay	60	60	45	58
Quartz	3	5	7	3
Feldspar	3	20	7	4
Mica	–	–	–	–
Heavy minerals	TR	5	TR	7
Clay minerals	10	41	21	28
Volcanic glass	–	3	35	54
Glauconite	2	TR	TR	–
Pyrite	–	–	–	–
Zeolite minerals	–	–	–	4
Foraminifers	–	–	–	–
Diatoms	80	25	20	–
Radiolarians	TR	–	–	–
Sponge spicules	2	1	5	–
Palagonite	–	–	5	–
Augite	–	–	TR	–
Epidote	–	–	–	TR
Hematite	–	–	–	TR

SITE 438 HOLE A CORE 8 CORED INTERVAL: 125.5-135.0 m



Olive gray (5Y 4/2) clayey diatom ooze changing to diatomaceous clay down core. Several gray, thin volcanic ash layers (fine- to medium-grain sand size). Small (generally <2 mm diameter) white sponge remains (spicule concentrations with central chamber filled with pyrite) occur first in this core and become abundant. One pumice pebble noted in clayey diatom ooze (~0.5 cm diameter) core homogeneous – no bioturbation or other structures.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 42 cm (1.0, 0.9, 1)
6, 2 cm (1.0, 0.8, 1)

CARBONATE BOMB
3, 23-25 cm = 2-3%

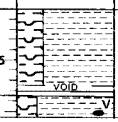
SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D)	Clayey diatom ooze (D)	Clayey diatom ooze (D)	Volcanic ash (sand-silt-pebbl) (M)	Diatomaceous clay (M)	Diatomaceous vitric clay (D)	Diatomaceous clay (d)
	1-20	2-80	3-97	4-100	6-90	5-78	7-29
Sand	16	30	23	54	9	8	8
Silt	18	25	20	31	18	24	14
Clay	66	45	57	15	73	68	78
Quartz	6	2	2	5	4	8	1
Feldspar	4	3	5	7	3	4	1
Mica	–	–	–	–	–	TR	–
Heavy minerals	1	TR	TR	1	TR	4	TR
Clay minerals	23	59	53	10	55	41	72
Volcanic glass	–	1	3	73	2	21	–
Glauconite	–	–	1	–	–	–	–
Pyrite	2	–	–	1	2	3	1
Zeolite minerals	–	–	–	–	–	–	–
Foraminifers	–	TR	TR	–	–	–	TR
Diatoms	55	30	35	2	26	18	13
Radiolarians	1	–	TR	–	–	–	TR
Sponge spicules	7	5	1	2	8	1	2
Silicoflagellates	1	–	–	–	–	–	–
Hematite	–	–	TR	–	–	–	–
Carbonate unspec.	–	–	–	–	–	TR	–

NOTE:
ϕ = siliceous sponge remains ~<2 mm diameter

SITE 438 HOLE A CORE 9 CORED INTERVAL: 135.0-144.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLIOCENE		RF RP BF FM	RM		AG	1 CC	0.5	VOID	V		70 10 18



D. seminae fossilis-D. kamtschatica

LITHOLOGIC DESCRIPTION

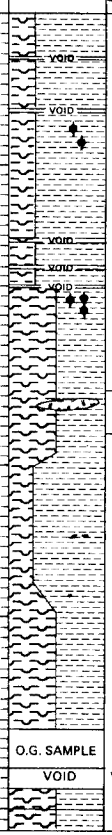
Dark olive gray to olive gray (5Y 3/2-4/2) homogeneous diatom ooze and diatomaceous clay, spicules of sponges very common (9-12% in smear slides) one pumice fragment present.

SMEAR SLIDE SUMMARY

	Soicular, clayey diatom ooze (M) 1-70	Spicular, clayey diatom ooze (D) CC-10	Diatomaceous clay (D) CC-18
Sand	4	4	2
Silt	20	14	16
Clay	76	82	82
Quartz	2	2	1
Feldspar	3	3	2
Mica	TR	–	–
Heavy minerals	2	1	–
Clay minerals	35	50	55
Volcanic glass	3	–	3
Glauconite	–	–	–
Pyrite	TR	2	2
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	43	32	28
Radiolarians	–	TR	TR
Sponge spicules	12	10	9
Silicoflagellates	–	TR	–

SITE 438 HOLE A CORE 10 CORED INTERVAL: 144.5-154.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLIOCENE		PF RM BF CG	RM	FM	AG	1 2 3 4 5 6 CC	0.5 1.0	VOID VOID VOID VOID VOID O.G. SAMPLE VOID	V V V V V V		54 87 94 127 64 23



R. pseudoumbilica *L. heteroporos* *D. seminae fossilis-D. kamtschatica*

5Y 4/2

black (2.5Y N2.5) ash pocket?

small pumice fragments

LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) homogeneous clayey diatom ooze; a few small siliceous sponges as before, very minor ash and pumice content.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 6 cm (0.9, 0.8, 1)
5, 71 cm (1.3, 0.9, 3)

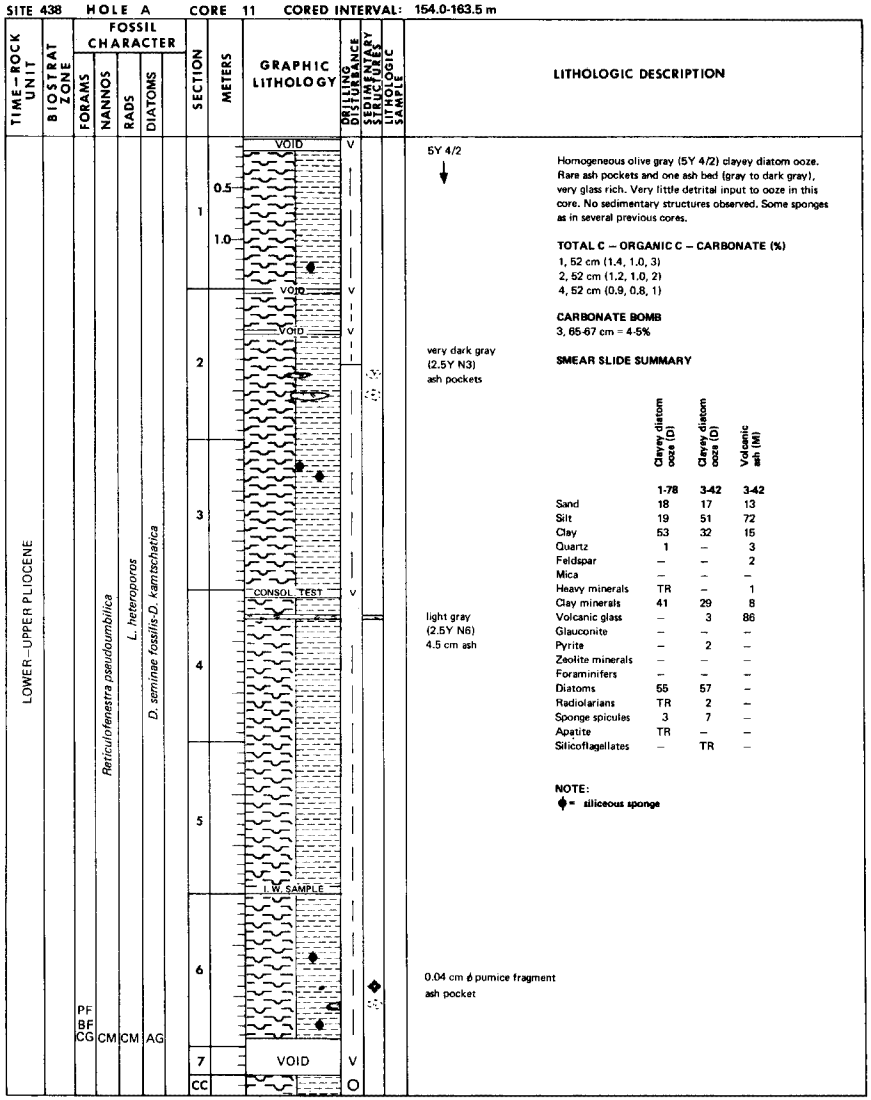
CARBONATE BOMB
3, 94-96 cm = 1-2%
3, 127-129 cm = 0-1%

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D) 2-54	Clayey diatom ooze (M) 3-87	Clayey diatom ooze (D) 4-64	Clayey diatom ooze (D) 5-23
Sand	15	18	27	28
Silt	25	27	20	27
Clay	60	55	53	45
Quartz	7	1	5	TR
Feldspar	7	–	5	–
Mica	–	–	–	TR
Heavy minerals	TR	1	TR	TR
Clay minerals	51	43	45	38
Volcanic glass	3	3	5	?
Glauconite	–	–	TR	–
Pyrite	–	4	–	2
Zeolite minerals	TR	TR?	–	–
Foraminifers	–	–	TR	–
Diatoms	30	45	30	56
Radiolarians	–	–	–	–
Sponge spicules	2	3	10	4

NOTE:
♦ = siliceous sponge remains

SITE 438 HOLE A CORE 11 CORED INTERVAL: 154.0-163.5 m



Homogeneous olive gray (5Y 4/2) clayey diatom ooze. Rare ash pockets and one ash bed (gray to dark gray), very glass rich. Very little detrital input to ooze in this core. No sedimentary structures observed. Some sponges as in several previous cores.

TOTAL C – ORGANIC C – CARBONATE (%)

1, 52 cm (1.4, 1.0, 3)
2, 52 cm (1.2, 1.0, 2)
4, 52 cm (0.9, 0.8, 1)

CARBONATE BOMB

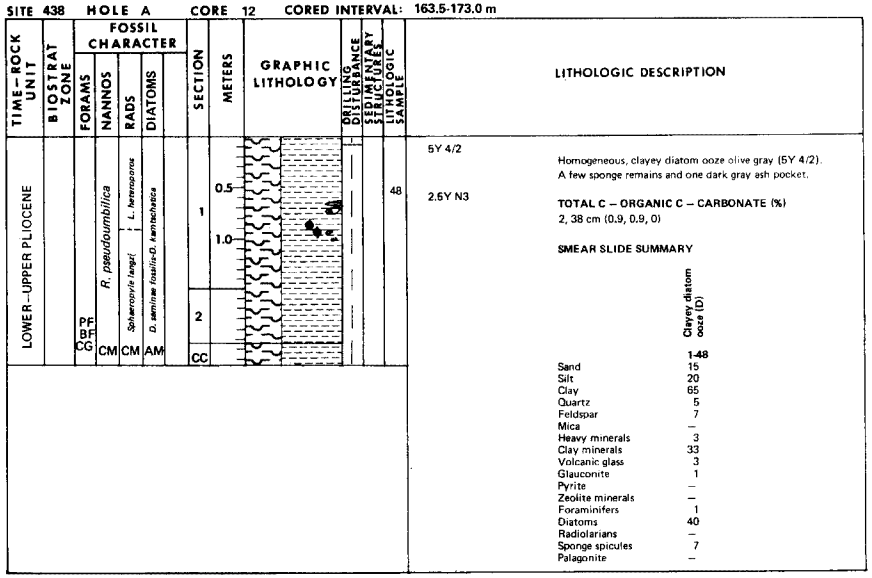
3, 65-67 cm = 4-5%

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D)	Clayey diatom ooze (D)	Volcanic ash (M)
	1-78	3-42	3-42
Sand	18	17	13
Silt	19	51	72
Clay	53	32	15
Quartz	1	–	3
Feldspar	–	–	2
Mica	–	–	–
Heavy minerals	TR	–	1
Clay minerals	41	29	8
Volcanic glass	–	3	86
Glauconite	–	–	–
Pyrite	–	2	–
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	55	57	–
Radiolarians	TR	2	–
Sponge spicules	3	7	–
Apatite	TR	–	–
Silicoflagellates	–	TR	–

NOTE:
ϕ = siliceous sponge

SITE 438 HOLE A CORE 12 CORED INTERVAL: 163.5-173.0 m



Homogeneous, clayey diatom ooze olive gray (5Y 4/2). A few sponge remains and one dark gray ash pocket.

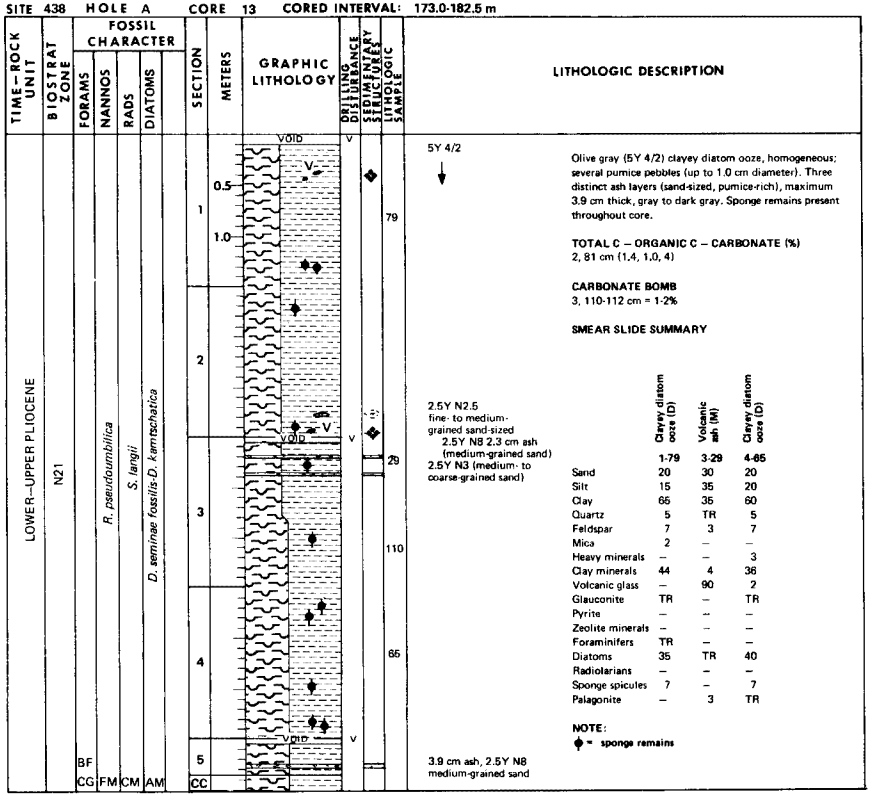
TOTAL C – ORGANIC C – CARBONATE (%)

2, 38 cm (0.9, 0.9, 0)

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D)
	1-48
Sand	15
Silt	20
Clay	65
Quartz	5
Feldspar	7
Mica	–
Heavy minerals	3
Clay minerals	33
Volcanic glass	3
Glauconite	1
Pyrite	–
Zeolite minerals	–
Foraminifers	1
Diatoms	40
Radiolarians	–
Sponge spicules	7
Palagonite	–

SITE 438 HOLE A CORE 13 CORED INTERVAL: 173.0-182.5 m



Olive gray (5Y 4/2) clayey diatom ooze, homogeneous; several pumice pebbles (up to 1.0 cm diameter). Three distinct ash layers (sand-sized, pumice-rich), maximum 3.9 cm thick, gray to dark gray. Sponge remains present throughout core.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 81 cm (1.4, 1.0, 4)

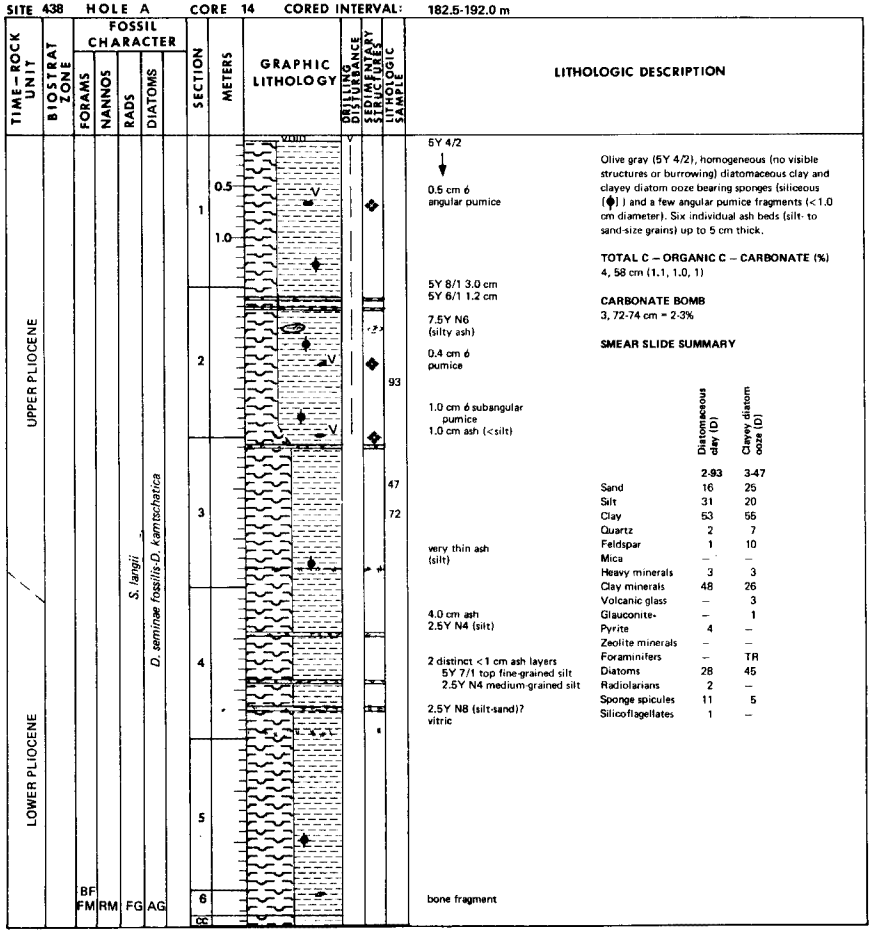
CARBONATE BOMB
3, 110-112 cm = 1-2%

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D)	Volcanic ash (M)	Clayey diatom ooze (D)
	1-79	3-29	4-65
Sand	20	30	20
Silt	15	35	20
Clay	65	35	60
Quartz	5	TR	5
Feldspar	7	3	7
Mica	2	–	–
Heavy minerals	–	–	3
Clay minerals	44	4	36
Volcanic glass	–	90	2
Glauconite	TR	–	TR
Pyrite	–	–	–
Zeolite minerals	–	–	–
Foraminifers	TR	–	–
Diatoms	35	TR	40
Radiolarians	–	–	–
Sponge spicules	7	–	7
Palagonite	–	3	TR

NOTE:
♦ = sponge remains

SITE 438 HOLE A CORE 14 CORED INTERVAL: 182.5-192.0 m



Olive gray (5Y 4/2), homogeneous (no visible structures or burrowing) diatomaceous clay and clayey diatom ooze bearing sponges (siliceous [♦]) and a few angular pumice fragments (<1.0 cm diameter). Six individual ash beds (silt- to sand-size grains) up to 5 cm thick.

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

CARBONATE BOMB
3, 72-74 cm = 2-3%

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)	Clayey diatom ooze (D)
	2-93	3-47
Sand	16	25
Silt	31	20
Clay	53	55
Quartz	2	7
Feldspar	1	10
Mica	–	–
Heavy minerals	3	3
Clay minerals	48	26
Volcanic glass	–	3
Glauconite	–	1
Pyrite	4	–
Zeolite minerals	–	–
Foraminifers	–	TR
Diatoms	28	45
Radiolarians	2	–
Sponge spicules	11	5
Silicoflagellates	1	–

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SITE 438 HOLE A CORE 15 CORED INTERVAL: 192.0-201.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	N19	PF RM BF CG	RM	FM	AG	1, 0.5, CC, 1.0						Clayey diatom ooze (5Y 4/2) homogeneous, sponge-bearing (◆).

S. langii; *D. seminae fossilis-D. kamtschatica*

SITE 438 HOLE A CORE 16 CORED INTERVAL: 201.5-211.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		BF FM	RM	CG	AG	1, 2, 3, 4, 5, CC	0.5, 1.0	VOID, VOID	V, V		28, 21, 145, 42, 88	5Y 4/2 ↓ Olive gray (5Y 4/2) clayey diatom ooze, homogeneous occasional sponge remains (◆), a few pumice pebbles (maximum diameter 1.2 cm) and several gray volcanic ash horizons (maximum 3 cm thick).

S. langii; *D. seminae fossilis-D. kamtschatica*

TOTAL C – ORGANIC C – CARBONATE (%)
5, 62 cm (1.1, 0.8, 3)

CARBONATE BOMB
3, 21-23 cm = 1-2%

SMEAR SLIDE SUMMARY

	Clayey diatom ooze (D)	Volcanic ash (M)	Clayey diatom ooze (D)	Clayey diatom ooze (D)
	2-28	3-145	4-42	5-88
Sand	25	10	30	25
Silt	15	40	22	25
Clay	60	50	48	50
Quartz	7	3	2	2
Feldspar	10	5	2	2
Mica	–	–	–	–
Heavy minerals	3	3	2	–
Clay minerals	27	–	37	44
Volcanic glass	5	85	–	TR
Glauconite	TR	–	–	–
Pyrite	–	–	–	–
Zeolite minerals	–	–	–	–
Foraminifers	–	–	–	TR
Diatoms	45	4	50	35
Radiolarians	–	–	–	–
Sponge spicules	3	–	7	7
Nannofossils (calc.)	–	–	–	10

subangular pumice, maximum 1.2 cm 6

0.7 cm pumice

2.5Y N7/1 pumice (silt) ash

2.5Y N2.5 (silt) ash

5Y 6/2 color mottling above 2.5Y N8 (silt) ash

5Y 7/1 ash (fine-grained silt) pumiceous

SITE 438 HOLE A CORE 17 CORED INTERVAL: 211.0-220.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		PF RM BF CG	RM	CG	AG	1, 2, 3, CC	0.5, 1.0	VOID	V		74, 24, 41, 63, 101	5Y 3/2 ↓ Dark olive gray to olive gray (5Y 3/2-5Y 4/2) clayey diatom ooze with olive to olive gray (5Y 4/2 or slightly lighter) mottles, slightly more carbonate rich (up to 20% nannos and/or unspecified carbonate). Several gray ash beds (silt-size) up to 3 cm thick, abundant sponge remains (◆) and one nodular or concretionary layer (Section 2) more carbonate-rich (eff. in HCL). Olive (5Y 4/2) mottles more nanno rich, carbonate-rich (Section 2, 24 cm).

S. langii; *D. seminae fossilis-D. kamtschatica*

silt, medium to light gray (2.5Y N4) ash

silt-ash mottles 2.5Y N7 2.5Y N4 ash (irregular)

5Y 4/2

ash (very fine-grained silt) possibly graded

gray (2.5Y N4) silt

dark gray (2.5Y N7) ash grading into green (5Y 4/2) mottling at top and bottom

TOTAL C – ORGANIC C – CARBONATE (%)
2, 76 cm (0.9, 1.0, 0)

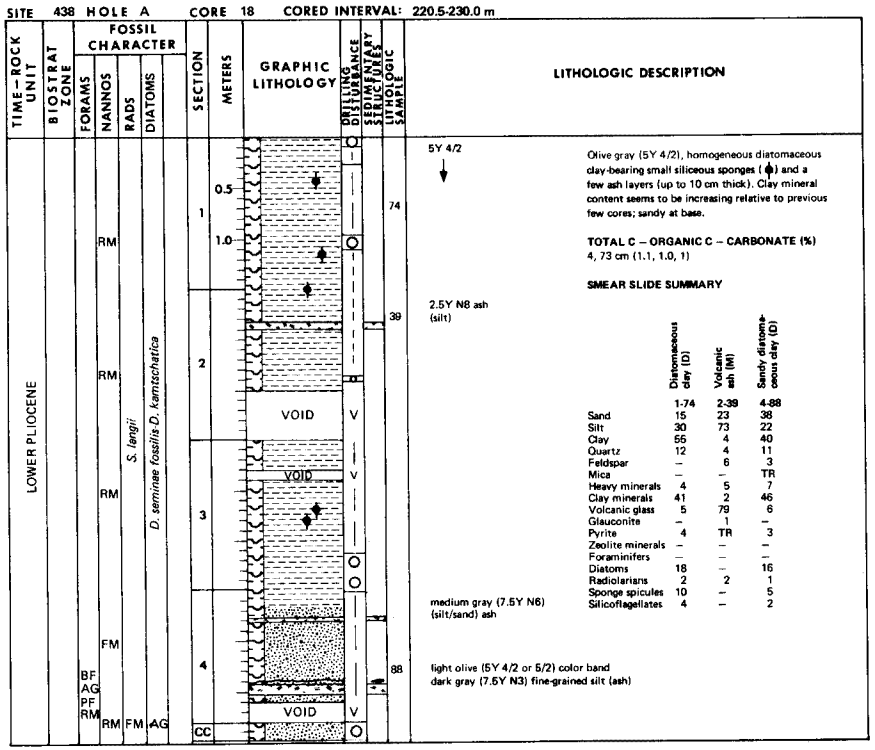
CARBONATE BOMB
3, 63-65 cm = 4%

SMEAR SLIDE SUMMARY

	Diatomaceous clayey ash (M)	Clayey diatom ooze (D)	Calcareous diatomaceous clay (M)	Sandy vitric diatomaceous clay (M)
	1-74	2-41	2-24	3-101
Sand	25	30	17	39
Silt	35	20	20	21
Clay	40	50	63	40
Quartz	5	5	1	6
Feldspar	10	5	2	5
Mica	–	–	–	–
Heavy minerals	3	2	–	8
Clay minerals	20	27	44	33
Volcanic glass	50	5	2	18
Glauconite	1	1	–	–
Pyrite	–	–	–	8
Zeolite minerals	–	–	–	–
Foraminifers	–	–	–	–
Diatoms	10	50	25	14
Radiolarians	–	–	TR	2
Sponge spicules	1	5	7	6
Carbonate unspec.	–	–	20	1

NOTE:
= **Irregular rounded concretions cemented, same color as rest of unit - $CaCO_3$-rich relatively.**

SITE 438 HOLE A CORE 18 CORED INTERVAL: 220.5-230.0 m



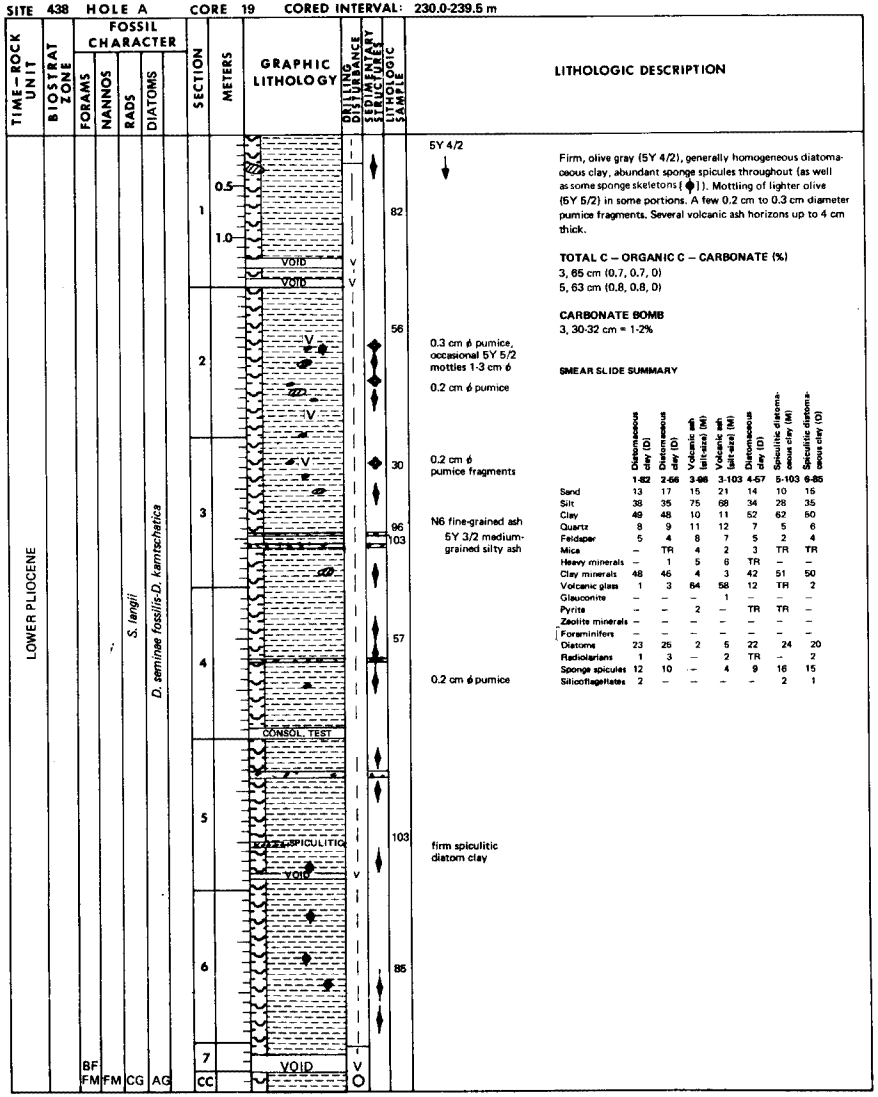
Olive gray (5Y 4/2), homogeneous diatomaceous clay-bearing small siliceous sponges ( ) and a few ash layers (up to 10 cm thick). Clay mineral content seems to be increasing relative to previous few cores; sandy at base.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 73 cm (1.1, 1.0, 1)

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)	Volcanic ash (M)	Sandy diatomaceous clay (D)
	1-74	2-39	4-88
Sand	15	23	38
Silt	30	73	22
Clay	55	4	40
Quartz	12	4	11
Feldspar	–	6	3
Mica	–	–	TR
Heavy minerals	4	5	7
Clay minerals	41	2	46
Volcanic glass	5	79	6
Glauconite	–	1	–
Pyrite	4	TR	3
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	18	–	16
Radiolarians	2	2	1
Sponge spicules	10	–	5
Silicoflagellates	4	–	2

SITE 438 HOLE A CORE 19 CORED INTERVAL: 230.0-239.5 m



Firm, olive gray (5Y 4/2), generally homogeneous diatomaceous clay, abundant sponge spicules throughout (as well as some sponge skeletons [ ]). Mottling of lighter olive (5Y 5/2) in some portions. A few 0.2 cm to 0.3 cm diameter pumice fragments. Several volcanic ash horizons up to 4 cm thick.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 65 cm (0.7, 0.7, 0)
5, 63 cm (0.8, 0.8, 0)

CARBONATE BOMB
3, 30-32 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)	Diatomaceous clay (D)	Volcanic ash (silt-size) (M)	Volcanic ash (silt-size) (M)	Diatomaceous clay (D)	Spiculitic diatomaceous clay (M)	Spiculitic diatomaceous clay (D)
	1-82	2-56	3-96	3-103	4-57	5-103	6-85
Sand	13	17	15	21	14	10	16
Silt	38	35	75	68	34	28	35
Clay	49	48	10	11	52	62	50
Quartz	8	9	11	12	7	5	6
Feldspar	5	4	8	7	5	2	4
Mica	–	TR	4	2	3	TR	TR
Heavy minerals	–	1	5	6	TR	–	–
Clay minerals	48	46	4	3	42	51	50
Volcanic glass	1	3	64	58	12	TR	2
Glauconite	–	–	–	1	–	–	–
Pyrite	–	–	2	–	TR	TR	–
Zeolite minerals	–	–	–	–	–	–	–
Foraminifers	–	–	–	–	–	–	–
Diatoms	23	25	2	5	22	24	20
Radiolarians	1	3	–	2	TR	–	2
Sponge spicules	12	10	–	4	9	16	15
Silicoflagellates	2	–	–	–	–	2	1

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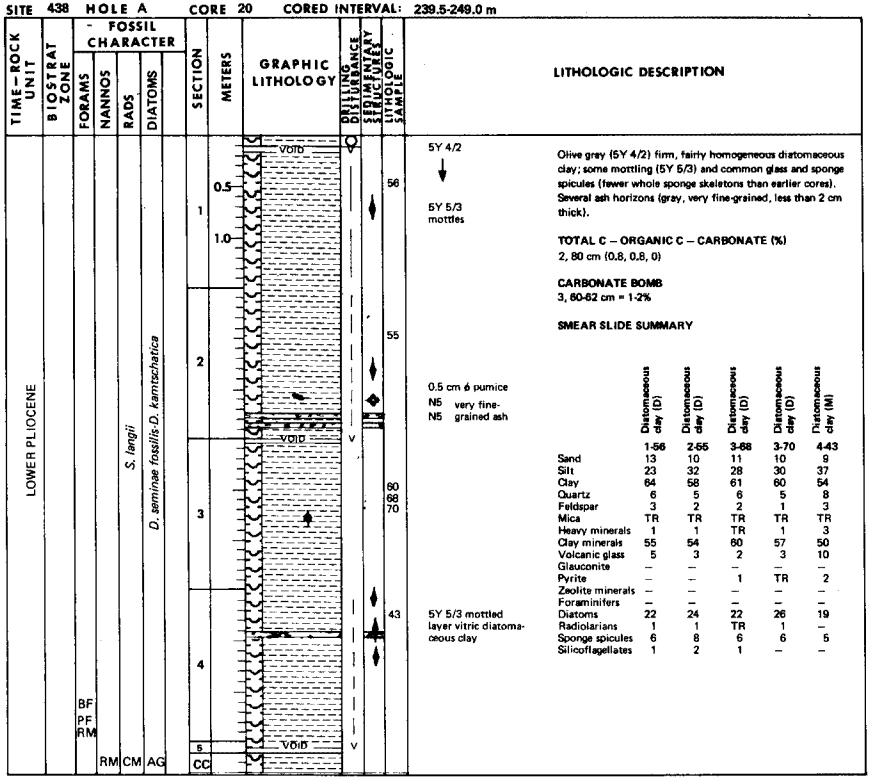
SITE 438 HOLE A CORE 20 CORED INTERVAL: 239.5-249.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) firm, fairly homogeneous diatomaceous clay; some mottling (5Y 5/3) and common glass and sponge spicules (fewer whole sponge skeletons than earlier cores). Several ash horizons (gray, very fine-grained, less than 2 cm thick).

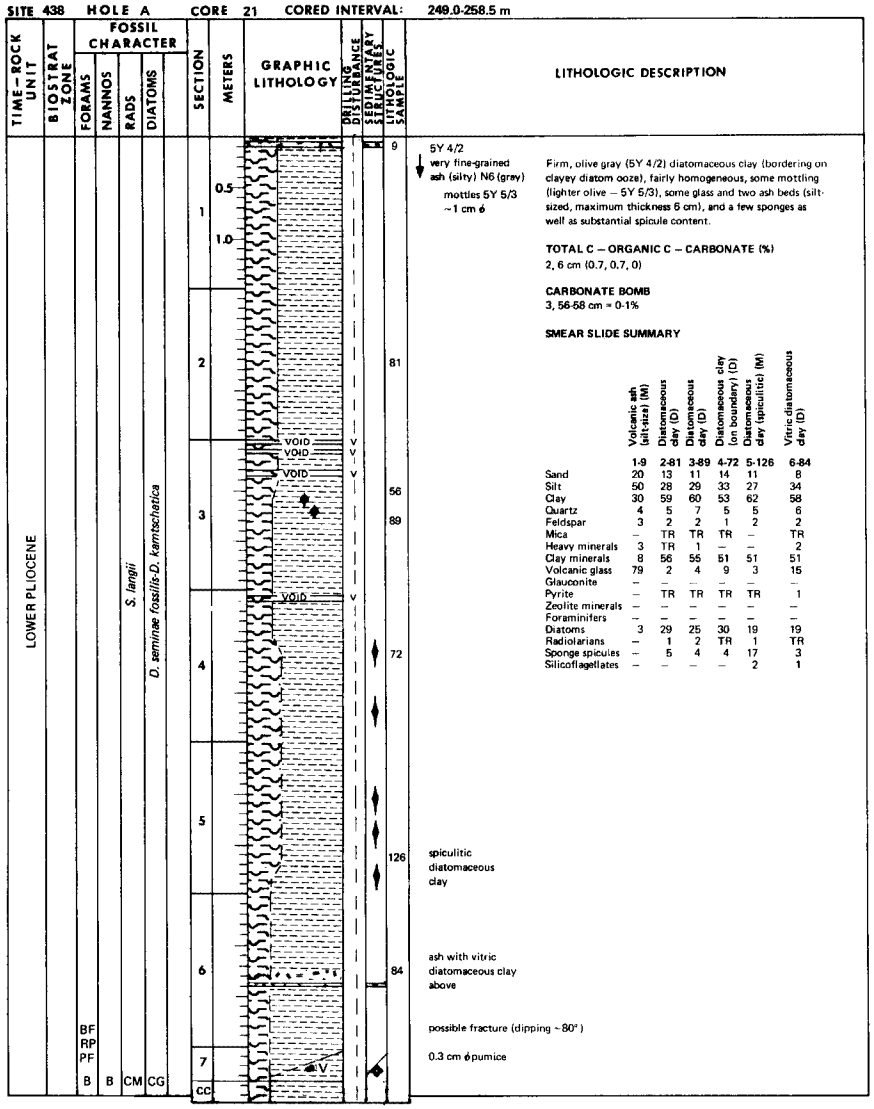
TOTAL C – ORGANIC C – CARBONATE (%)
2, 80 cm (0.8, 0.8, 0)

CARBONATE BOMB
3, 60-62 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D) 1-56	Diatomaceous clay (D) 2-55	Diatomaceous clay (D) 3-68	Diatomaceous clay (D) 3-70	Diatomaceous clay (M) 4-43
Sand	13	10	11	10	9
Silt	23	32	28	30	37
Clay	64	58	61	60	54
Quartz	6	5	6	5	8
Feldspar	3	2	2	1	3
Mica	TR	TR	TR	TR	TR
Heavy minerals	1	1	TR	1	3
Clay minerals	55	54	60	57	50
Volcanic glass	5	3	2	3	10
Glauconite	–	–	–	–	–
Pyrite	–	–	1	TR	2
Zeolite minerals	–	–	–	–	–
Foraminifers	–	–	–	–	–
Diatoms	22	24	22	26	19
Radiolarians	1	1	TR	1	–
Sponge spicules	6	8	6	6	5
Silicoflagellates	1	2	1	–	–

SITE 438 HOLE A CORE 21 CORED INTERVAL: 249.0-258.5 m



LITHOLOGIC DESCRIPTION

Firm, olive gray (5Y 4/2) diatomaceous clay (bordering on clayey diatom ooze), fairly homogeneous, some mottling (lighter olive – 5Y 5/3), some glass and two ash beds (silt-sized, maximum thickness 6 cm), and a few sponges as well as substantial spicule content.

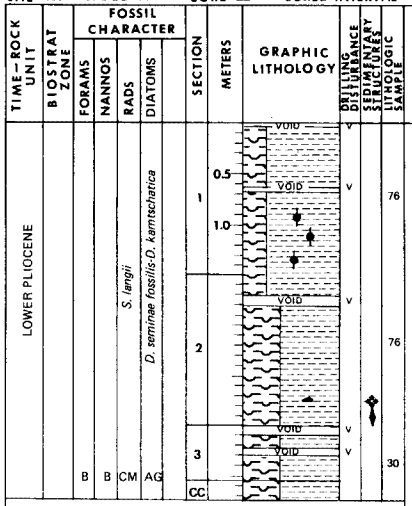
TOTAL C – ORGANIC C – CARBONATE (%)
2, 6 cm (0.7, 0.7, 0)

CARBONATE BOMB
3, 56-58 cm = 0-1%

SMEAR SLIDE SUMMARY

	Volcanic ash (silt-size) (M) 1-9	Diatomaceous clay (D) 2-81	Diatomaceous clay (D) 3-89	Diatomaceous clay (D) 4-72	Diatomaceous clay (ion boundary) (D) 5-126	Diatomaceous clay (spiculitic) (M) 6-84	Vitric diatomaceous clay (D)
Sand	20	13	11	14	11	8	
Silt	50	28	29	33	27	34	
Clay	30	59	60	53	62	58	
Quartz	4	5	7	5	5	6	
Feldspar	3	2	2	1	2	2	
Mica	–	TR	TR	TR	–	TR	
Heavy minerals	3	TR	1	–	–	2	
Clay minerals	8	56	55	51	51	51	
Volcanic glass	79	2	4	9	3	15	
Glauconite	–	–	–	–	–	–	
Pyrite	–	TR	TR	TR	TR	1	
Zeolite minerals	–	–	–	–	–	–	
Foraminifers	–	–	–	–	–	–	
Diatoms	3	29	25	30	19	19	
Radiolarians	–	1	2	TR	1	TR	
Sponge spicules	–	5	4	4	17	3	
Silicoflagellates	–	–	–	–	2	1	

SITE 438 HOLE A CORE 22 CORED INTERVAL: 258.5-268.0 m



5Y 4/2

Spicular

0.4 cm pumic fragment
5Y 5/2 mottle

LITHOLOGIC DESCRIPTION

Firm, olive gray (5Y 4/2) diatomaceous claystone changing to clayey diatom ooze down core. Abundant sponge spicules and sponge skeletons ( ). One pumice fragment and no ash. Sediment is homogeneous.

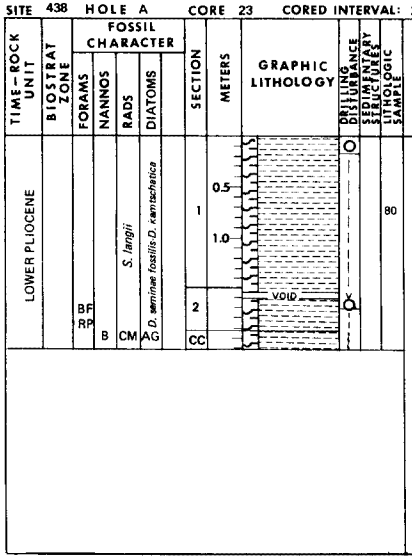
TOTAL C – ORGANIC C – CARBONATE (%)
1, 48 cm (2.5, 0.7, 14)
2, 60 cm (0.8, 0.9, 0)

CARBONATE BOMB
3, 30-32 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)	Spicular clayey diatom ooze (D)
	1-76	2-76
Sand	10	16
Silt	29	46
Clay	61	38
Quartz	7	7
Feldspar	2	4
Mica	1	1
Heavy minerals	–	–
Clay minerals	59	35
Volcanic glass	3	3
Glauconite	–	TR
Pyrite	TR	–
Zeolite minerals	–	–
Foraminifers	–	–
Diatoms	23	35
Radiolarians	–	1
Sponge spicules	5	11
Silicoflagellates	TR	3

SITE 438 HOLE A CORE 23 CORED INTERVAL: 268.0-277.5 m



LITHOLOGIC DESCRIPTION

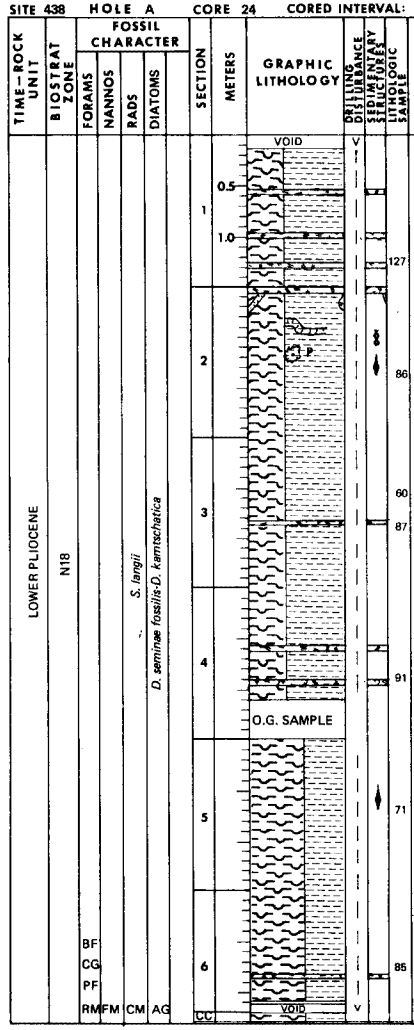
Firm, olive gray (5Y 4/2), homogeneous diatomaceous clay.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 71 cm (0.6, 0.7, 0)

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)
	1-80
Sand	11
Silt	29
Clay	60
Quartz	6
Feldspar	1
Mica	TR
Heavy minerals	TR
Clay minerals	60
Volcanic glass	3
Glauconite	–
Pyrite	TR
Zeolite minerals	–
Foraminifers	–
Diatoms	23
Radiolarians	1
Sponge spicules	5
Silicoflagellates	1

SITE 438 HOLE A CORE 24 CORED INTERVAL: 277.5-287.0 m



5Y 4/2

5Y 3/2 very fine silty ash (silt/clay)

N5 very fine ash (silt/clay)

N4

5Y 3/2 very fine sandy ash

burrow with partly cemented filling

pyrite concretion

N5 very fine ash

58 8/1 ash (silt-size)

spiculitic diatom ooze

LITHOLOGIC DESCRIPTION

Firm, olive gray (5Y 4/2) clayey diatom ooze becoming more diatom-rich down core; mottled in part; numerous ash layers up to 6 cm. Sediment rich in spicules but no individual sponges noted.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 120 cm (0.6, 0.7, 0)
4, 46 cm (1.5, 0.9, 5)

CARBONATE BOMB
3, 60-62 cm = 0-1%

SMEAR SLIDE SUMMARY

	Volcanic ash (M)	Clayey diatom ooze (D)	Clayey diatom ooze (D)	Clayey diatom ooze (M)	Clayey diatom ooze (D)	Silty volcanic ash (M)
	1-127	2-86	3-87	4-91	5-71	6-85
Sand	11	13	10	21	15	16
Silt	43	35	34	32	36	47
Clay	46	52	56	47	49	35
Quartz	9	4	5	5	5	11
Feldspar	5	3	1	1	2	9
Mica	–	1	TR	TR	TR	TR
Heavy minerals	3	TR	–	TR	1	4
Clay minerals	–	51	53	44	39	4
Volcanic glass	83	1	2	2	3	69
Glauconite	–	–	–	–	–	–
Pyrite	–	–	–	1	–	–
Zeolite minerals	–	–	–	–	–	–
Foraminifers	–	–	–	–	–	–
Diatoms	TR	32	31	33	58	2
Radiolarians	–	1	–	TR	TR	–
Sponge spicules	–	6	7	13	7	1
Silicoflagellates	–	1	1	1	2	–

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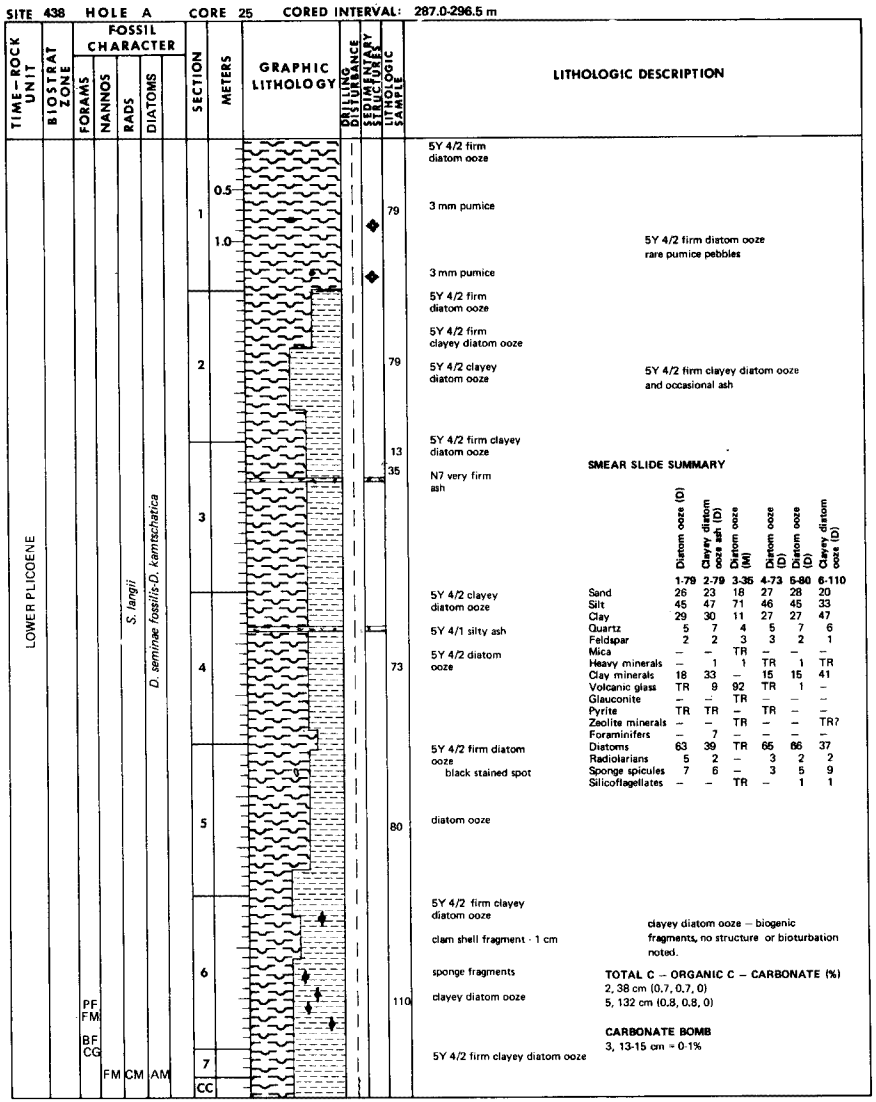
SITE 438 HOLE A CORE 25 CORED INTERVAL: 287.0-296.5 m



5Y 4/2 firm diatom ooze

3 mm pumice

5Y 4/2 firm diatom ooze
rare pumice pebbles

3 mm pumice

5Y 4/2 firm diatom ooze

5Y 4/2 firm clayey diatom ooze

5Y 4/2 clayey diatom ooze

5Y 4/2 firm clayey diatom ooze and occasional ash

5Y 4/2 firm clayey diatom ooze

N7 very firm ash

5Y 4/2 clayey diatom ooze

5Y 4/1 silty ash

5Y 4/2 diatom ooze

5Y 4/2 firm diatom ooze
black stained spot

diatom ooze

5Y 4/2 firm clayey diatom ooze

clam shell fragment - 1 cm

sponge fragments

clayey diatom ooze

clayey diatom ooze – biogenic fragments, no structure or bioturbation noted.

5Y 4/2 firm clayey diatom ooze

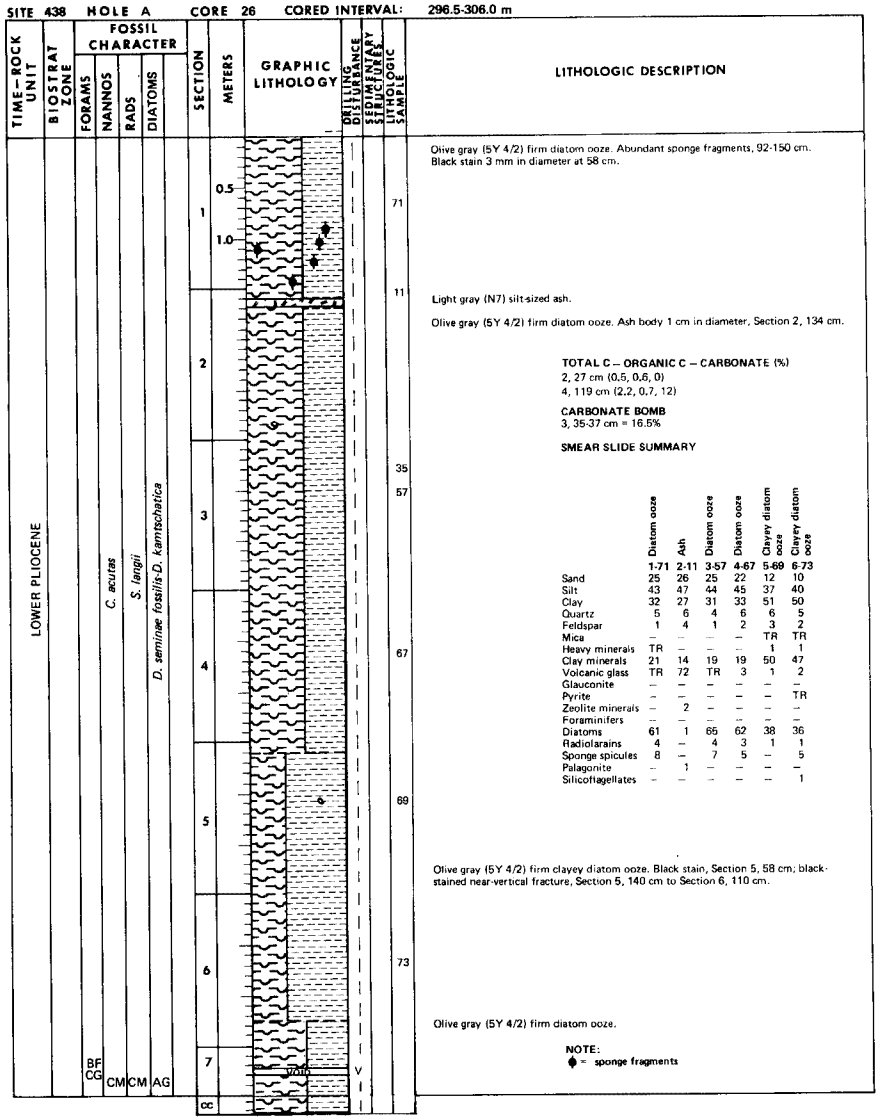
SMEAR SLIDE SUMMARY

	Diatom ooze (D) 1-79	Clayey diatom ooze ash (D) 2-79	Diatom ooze (M) 3-35	Diatom ooze (D) 4-73	Diatom ooze (D) 5-80	Clayey diatom ooze (D) 6-110
Sand	26	23	18	27	28	20
Silt	45	47	71	46	45	33
Clay	29	30	11	27	27	47
Quartz	5	7	4	5	7	6
Feldspar	2	2	3	3	2	1
Mica	–	–	TR	–	–	–
Heavy minerals	–	1	1	TR	1	TR
Clay minerals	18	33	–	15	15	41
Volcanic glass	TR	9	92	TR	1	–
Glauconite	–	–	TR	–	–	–
Pyrite	TR	TR	–	TR	–	–
Zeolite minerals	–	–	TR	–	–	TR?
Foraminifers	–	7	–	–	–	–
Diatoms	63	39	TR	65	66	37
Radiolarians	5	2	–	3	2	2
Sponge spicules	7	6	–	3	5	9
Silicoflagellates	–	–	TR	–	1	1

TOTAL C – ORGANIC C – CARBONATE (%)
2, 38 cm (0.7, 0.7, 0)
5, 132 cm (0.8, 0.8, 0)

CARBONATE BOMB
3, 13-15 cm = 0.1%

SITE 438 HOLE A CORE 26 CORED INTERVAL: 296.5-306.0 m



Olive gray (5Y 4/2) firm diatom ooze. Abundant sponge fragments, 92-150 cm. Black stain 3 mm in diameter at 58 cm.

Light gray (N7) silt-sized ash.

Olive gray (5Y 4/2) firm diatom ooze. Ash body 1 cm in diameter, Section 2, 134 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 27 cm (0.5, 0.6, 0)
4, 119 cm (2.2, 0.7, 12)

CARBONATE BOMB
3, 35-37 cm = 16.5%

SMEAR SLIDE SUMMARY

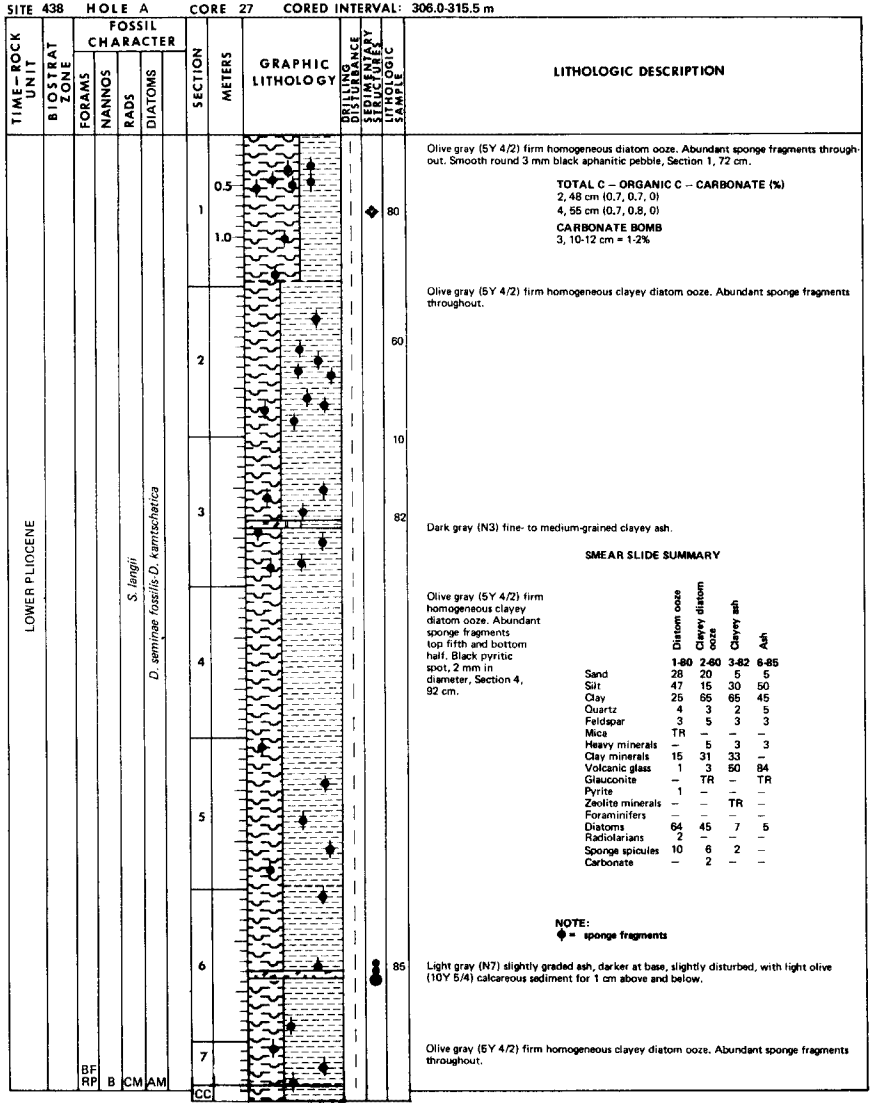
	Diatom ooze 1-71	Ash 2-11	Diatom ooze 3-57	Diatom ooze 4-67	Clayey diatom ooze 5-69	Clayey diatom ooze 6-73
Sand	25	26	25	22	12	10
Silt	43	47	44	45	37	40
Clay	32	27	31	33	51	50
Quartz	5	6	4	6	6	5
Feldspar	1	4	1	2	3	2
Mica	–	–	–	–	TR	TR
Heavy minerals	TR	–	–	–	1	1
Clay minerals	21	14	19	19	50	47
Volcanic glass	TR	72	TR	3	1	2
Glauconite	–	–	–	–	–	–
Pyrite	–	–	–	–	–	TR
Zeolite minerals	–	2	–	–	–	–
Foraminifers	–	–	–	–	–	–
Diatoms	61	1	65	62	38	36
Radiolarains	4	–	4	3	1	1
Sponge spicules	8	–	7	5	–	5
Palagonite	–	1	–	–	–	–
Silicoflagellates	–	–	–	–	–	1

Olive gray (5Y 4/2) firm clayey diatom ooze. Black stain, Section 5, 58 cm; black-stained near-vertical fracture, Section 5, 140 cm to Section 6, 110 cm.

Olive gray (5Y 4/2) firm diatom ooze.

NOTE:
♦ = sponge fragments

SITE 438 HOLE A CORE 27 CORED INTERVAL: 306.0-315.5 m



Olive gray (5Y 4/2) firm homogeneous diatom ooze. Abundant sponge fragments throughout. Smooth round 3 mm black aphanitic pebble, Section 1, 72 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 48 cm (0.7, 0.7, 0)
4, 55 cm (0.7, 0.8, 0)

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

Olive gray (5Y 4/2) firm homogeneous clayey diatom ooze. Abundant sponge fragments throughout.

Dark gray (N3) fine- to medium-grained clayey ash.

SMEAR SLIDE SUMMARY

Olive gray (5Y 4/2) firm homogeneous clayey diatom ooze. Abundant sponge fragments top fifth and bottom half. Black pyritic spot, 2 mm in diameter, Section 4, 92 cm.

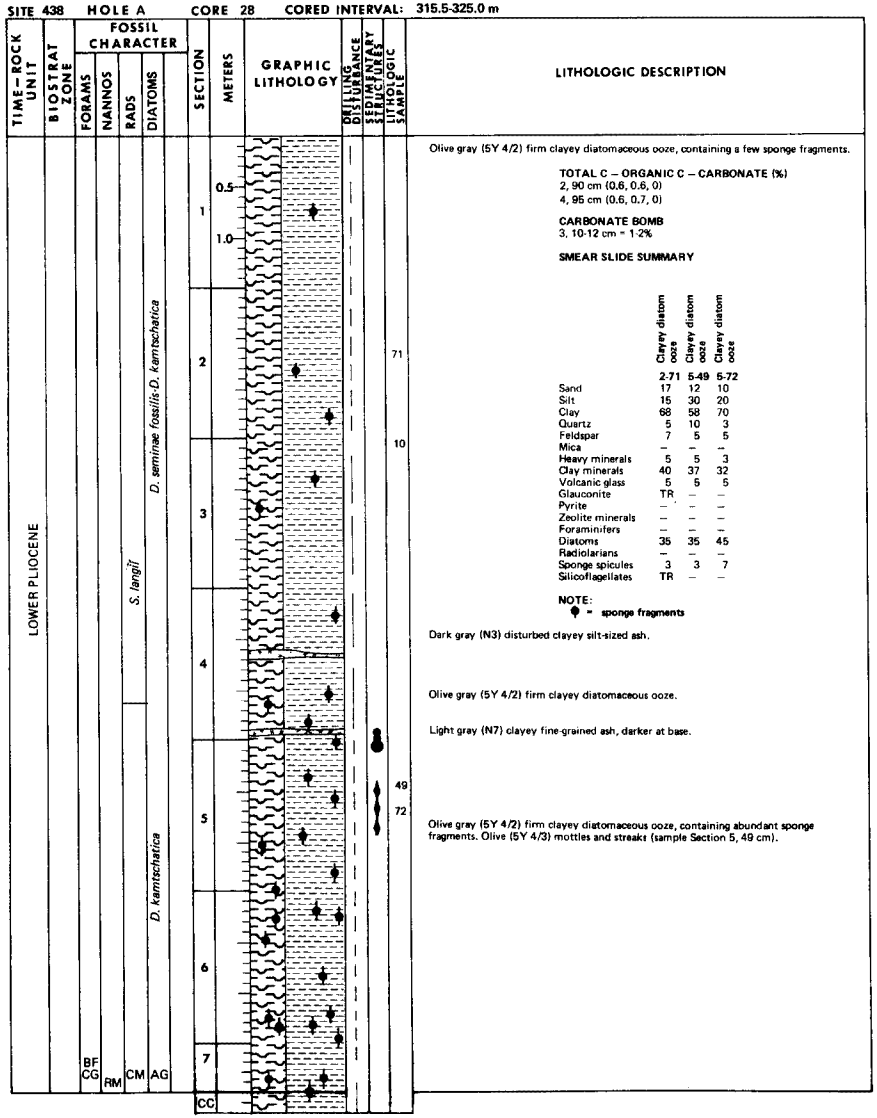
	Diatom ooze	Clayey diatom ooze	Clayey ash	Ash
	1-80	2-60	3-82	6-85
Sand	28	20	5	5
Silt	47	15	30	50
Clay	25	65	65	45
Quartz	4	3	2	5
Feldspar	3	5	3	3
Mica	TR	–	–	–
Heavy minerals	–	5	3	3
Clay minerals	15	31	33	–
Volcanic glass	1	3	50	84
Glauconite	–	TR	–	TR
Pyrite	1	–	–	–
Zeolite minerals	–	–	TR	–
Foraminifers	–	–	–	–
Diatoms	64	45	7	5
Radiolarians	2	–	–	–
Sponge spicules	10	6	2	–
Carbonate	–	2	–	–

NOTE:
♦ = sponge fragments

Light gray (N7) slightly graded ash, darker at base, slightly disturbed, with light olive (10Y 5/4) calcareous sediment for 1 cm above and below.

Olive gray (5Y 4/2) firm homogeneous clayey diatom ooze. Abundant sponge fragments throughout.

SITE 438 HOLE A CORE 28 CORED INTERVAL: 315.5-325.0 m



Olive gray (5Y 4/2) firm clayey diatomaceous ooze, containing a few sponge fragments.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 90 cm (0.6, 0.6, 0)
4, 95 cm (0.6, 0.7, 0)

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

SMEAR SLIDE SUMMARY

	Clayey diatom ooze	Clayey diatom ooze	Clayey diatom ooze
	2-71	5-49	5-72
Sand	17	12	10
Silt	15	30	20
Clay	68	58	70
Quartz	5	10	3
Feldspar	7	5	5
Mica	–	–	–
Heavy minerals	5	5	3
Clay minerals	40	37	32
Volcanic glass	5	5	5
Glauconite	TR	–	–
Pyrite	–	–	–
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	35	35	45
Radiolarians	–	–	–
Sponge spicules	3	3	7
Silicoflagellates	TR	–	–

NOTE:
♦ = sponge fragments

Dark gray (N3) disturbed clayey silt-sized ash.

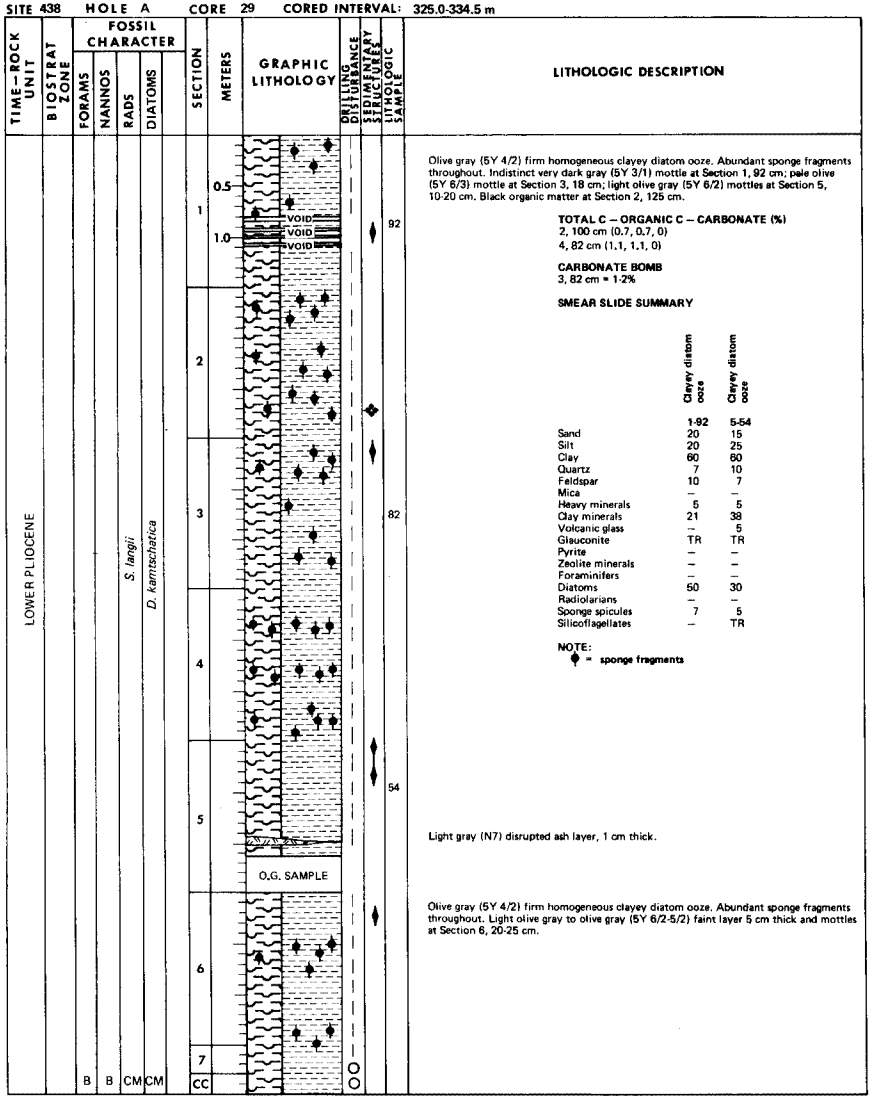
Olive gray (5Y 4/2) firm clayey diatomaceous ooze.

Light gray (N7) clayey fine-grained ash, darker at base.

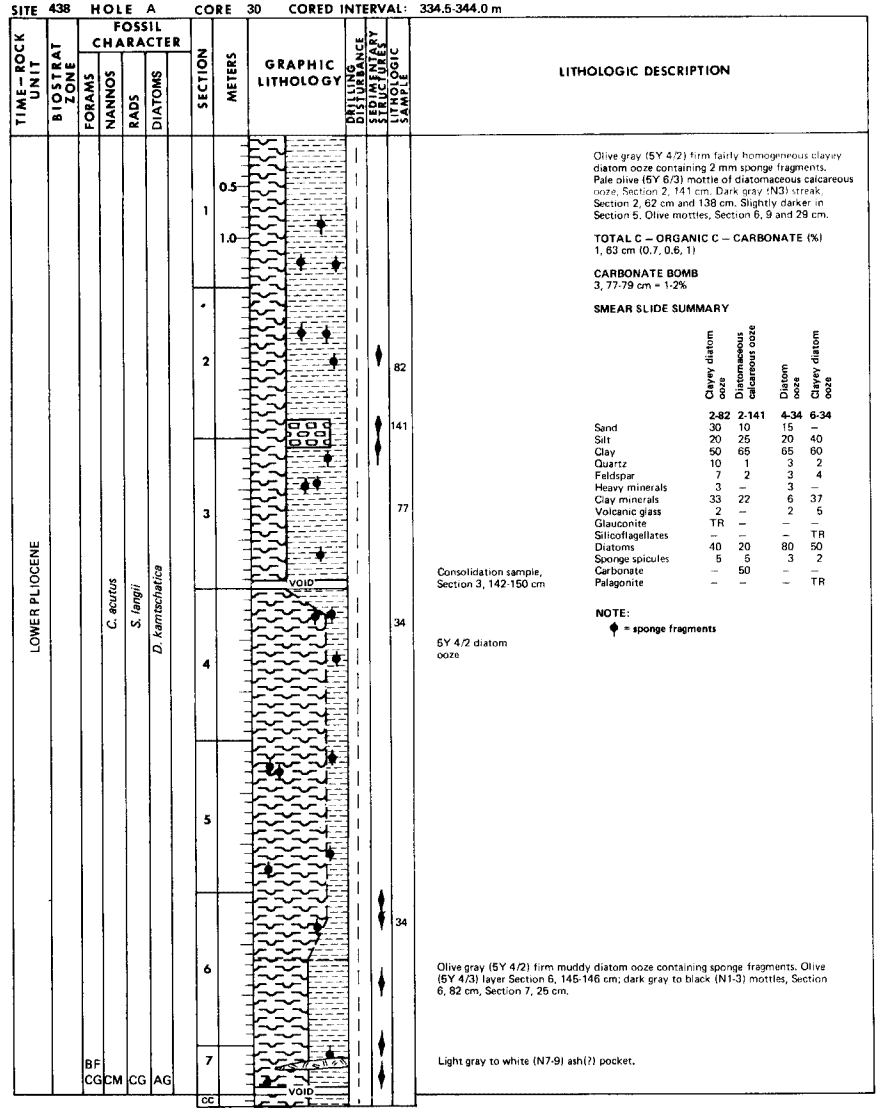
Olive gray (5Y 4/2) firm clayey diatomaceous ooze, containing abundant sponge fragments. Olive (5Y 4/3) mottles and streaks (sample Section 5, 49 cm).

MGG 1505 5027

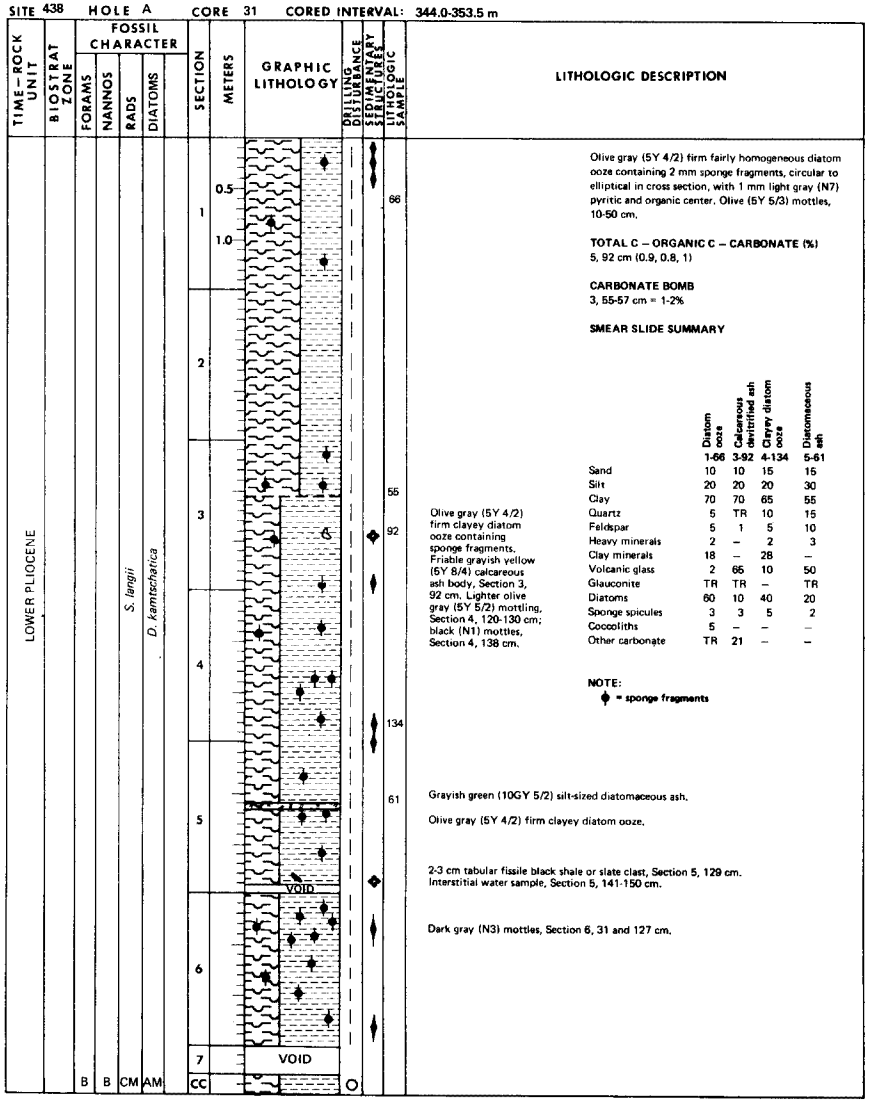
SITE 438 HOLE A CORE 29 CORED INTERVAL: 325.0-334.5 m



SITE 438 HOLE A CORE 30 CORED INTERVAL: 334.5-344.0 m



SITE 438 HOLE A CORE 31 CORED INTERVAL: 344.0-353.5 m



Olive gray (5Y 4/2) firm fairly homogeneous diatom ooze containing 2 mm sponge fragments, circular to elliptical in cross section, with 1 mm light gray (N7) pyritic and organic center. Olive (5Y 5/3) mottles, 10-50 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
5, 92 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 55-57 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatom ooze 1-66	Calcareous devitrified ash 3-92	Clayey diatom ooze 4-134	Diatomaceous ash 5-61
Sand	10	10	15	15
Silt	20	20	20	30
Clay	70	70	65	55
Quartz	5	TR	10	15
Feldspar	5	1	5	10
Heavy minerals	2	–	2	3
Clay minerals	18	–	28	–
Volcanic glass	2	65	10	50
Glauconite	TR	TR	–	TR
Diatoms	60	10	40	20
Sponge spicules	3	3	5	2
Coccoliths	5	–	–	–
Other carbonate	TR	21	–	–

NOTE:
◆ = sponge fragments

Olive gray (5Y 4/2) firm clayey diatom ooze containing sponge fragments. Friable grayish yellow (5Y 8/4) calcareous ash body, Section 3, 92 cm. Lighter olive gray (5Y 5/2) mottling, Section 4, 120-130 cm; black (N1) mottles, Section 4, 138 cm.

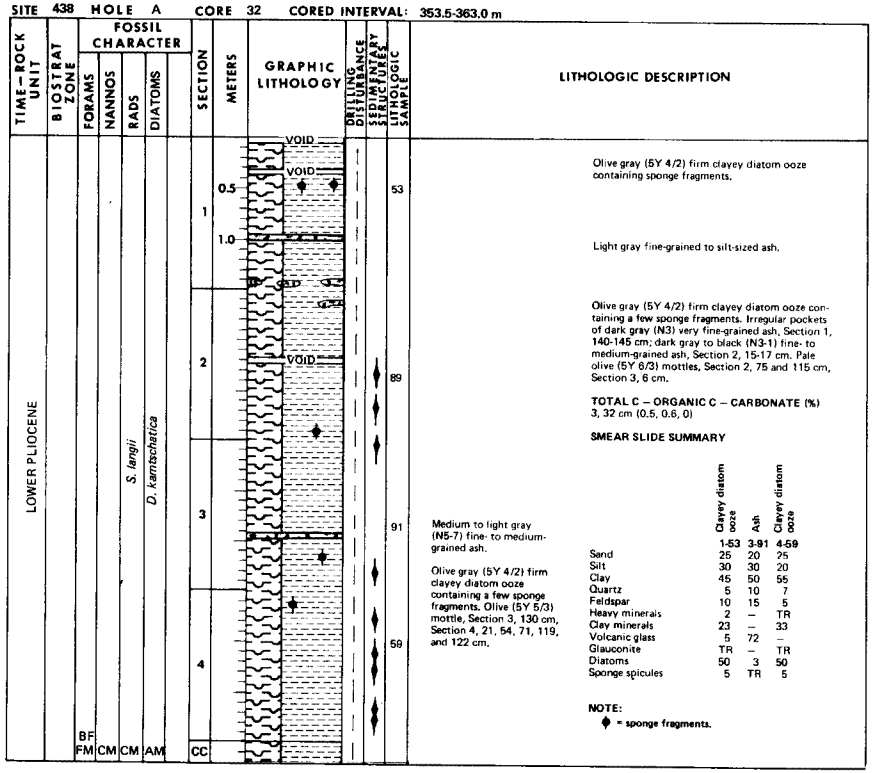
Grayish green (10GY 5/2) silt-sized diatomaceous ash.

Olive gray (5Y 4/2) firm clayey diatom ooze.

2-3 cm tabular fissile black shale or slate clast, Section 5, 129 cm. Interstitial water sample, Section 5, 141-150 cm.

Dark gray (N3) mottles, Section 6, 31 and 127 cm.

SITE 438 HOLE A CORE 32 CORED INTERVAL: 353.5-363.0 m



Olive gray (5Y 4/2) firm clayey diatom ooze containing sponge fragments.

Light gray fine-grained to silt-sized ash.

Olive gray (5Y 4/2) firm clayey diatom ooze containing a few sponge fragments. Irregular pockets of dark gray (N3) very fine-grained ash, Section 1, 140-145 cm; dark gray to black (N3-1) fine- to medium-grained ash, Section 2, 15-17 cm. Pale olive (5Y 6/3) mottles, Section 2, 75 and 115 cm, Section 3, 6 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 32 cm (0.5, 0.6, 0)

SMEAR SLIDE SUMMARY

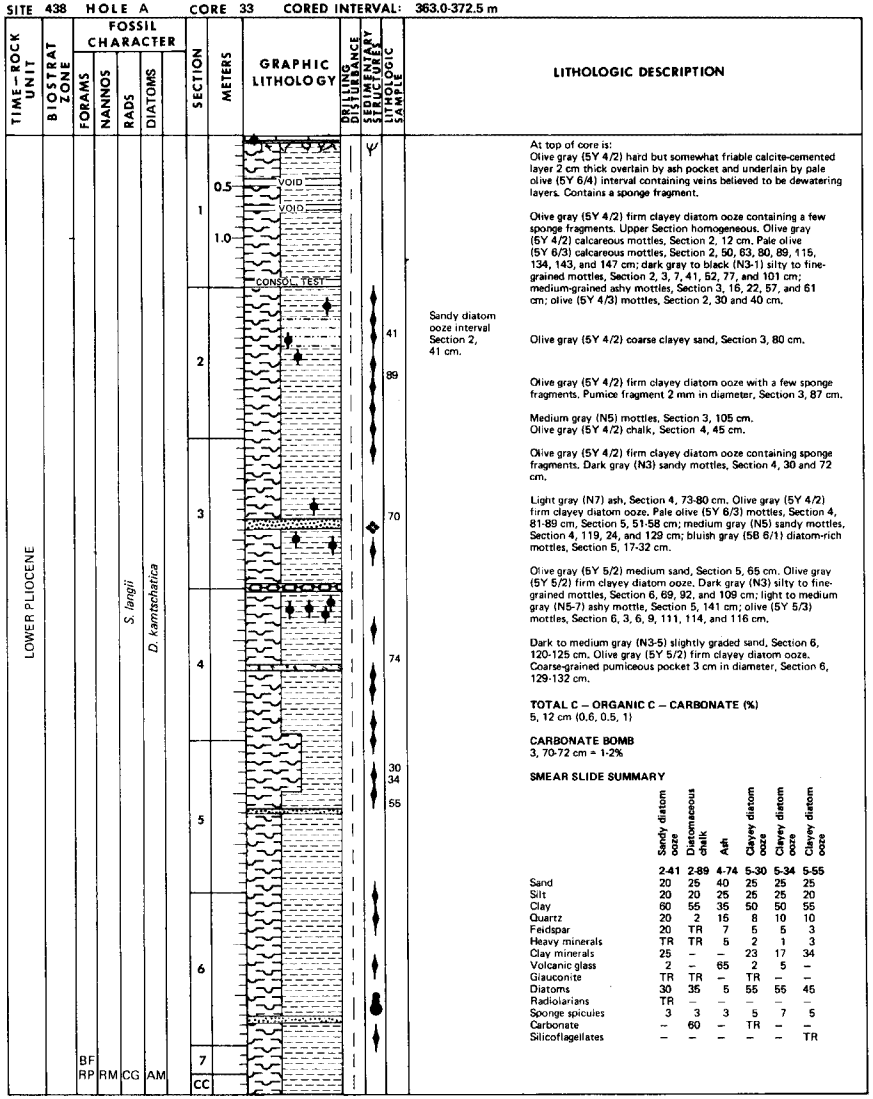
	Clayey diatom ooze 1-53	Ash 3-91	Clayey diatom ooze 4-59
Sand	25	20	25
Silt	30	30	20
Clay	45	50	55
Quartz	5	10	7
Feldspar	10	15	5
Heavy minerals	2	–	TR
Clay minerals	23	–	33
Volcanic glass	5	72	–
Glauconite	TR	–	TR
Diatoms	50	3	50
Sponge spicules	5	TR	5

NOTE:
◆ = sponge fragments.

Medium to light gray (N5-7) fine- to medium-grained ash.

Olive gray (5Y 4/2) firm clayey diatom ooze containing a few sponge fragments. Olive (5Y 5/3) mottle, Section 3, 130 cm, Section 4, 21, 54, 71, 119, and 122 cm.

SITE 438 HOLE A CORE 33 CORED INTERVAL: 363.0-372.5 m



LITHOLOGIC DESCRIPTION

At top of core is:
Olive gray (5Y 4/2) hard but somewhat friable calcite-cemented layer 2 cm thick overlain by ash pocket and underlain by pale olive (5Y 6/4) interval containing veins believed to be dewatering layers. Contains a sponge fragment.

Olive gray (5Y 4/2) firm clayey diatom ooze containing a few sponge fragments. Upper Section homogeneous. Olive gray (5Y 4/2) calcareous mottles, Section 2, 12 cm. Pale olive (5Y 6/3) calcareous mottles, Section 2, 50, 63, 80, 89, 115, 134, 143, and 147 cm; dark gray to black (N3-1) silty to fine-grained mottles, Section 2, 3, 7, 41, 52, 77, and 101 cm; medium-grained ashy mottles, Section 3, 16, 22, 57, and 61 cm; olive (5Y 4/3) mottles, Section 2, 30 and 40 cm.

Sandy diatom ooze interval Section 2, 41 cm.

Olive gray (5Y 4/2) coarse clayey sand, Section 3, 80 cm.

Olive gray (5Y 4/2) firm clayey diatom ooze with a few sponge fragments. Pumice fragment 2 mm in diameter, Section 3, 87 cm.

Medium gray (N5) mottles, Section 3, 105 cm.
Olive gray (5Y 4/2) chalk, Section 4, 45 cm.

Olive gray (5Y 4/2) firm clayey diatom ooze containing sponge fragments. Dark gray (N3) sandy mottles, Section 4, 30 and 72 cm.

Light gray (N7) ash, Section 4, 73-80 cm. Olive gray (5Y 4/2) firm clayey diatom ooze. Pale olive (5Y 6/3) mottles, Section 4, 81-89 cm, Section 5, 51-58 cm; medium gray (N5) sandy mottles, Section 4, 119, 24, and 129 cm; bluish gray (5B 6/1) diatom-rich mottles, Section 5, 17-32 cm.

Olive gray (5Y 5/2) medium sand, Section 5, 65 cm. Olive gray (5Y 5/2) firm clayey diatom ooze. Dark gray (N3) silty to fine-grained mottles, Section 6, 69, 92, and 109 cm; light to medium gray (N5-7) ashy mottle, Section 5, 141 cm; olive (5Y 5/3) mottles, Section 6, 3, 6, 9, 111, 114, and 116 cm.

Dark to medium gray (N3-5) slightly graded sand, Section 6, 120-125 cm. Olive gray (5Y 5/2) firm clayey diatom ooze. Coarse-grained pumiceous pocket 3 cm in diameter, Section 6, 129-132 cm.

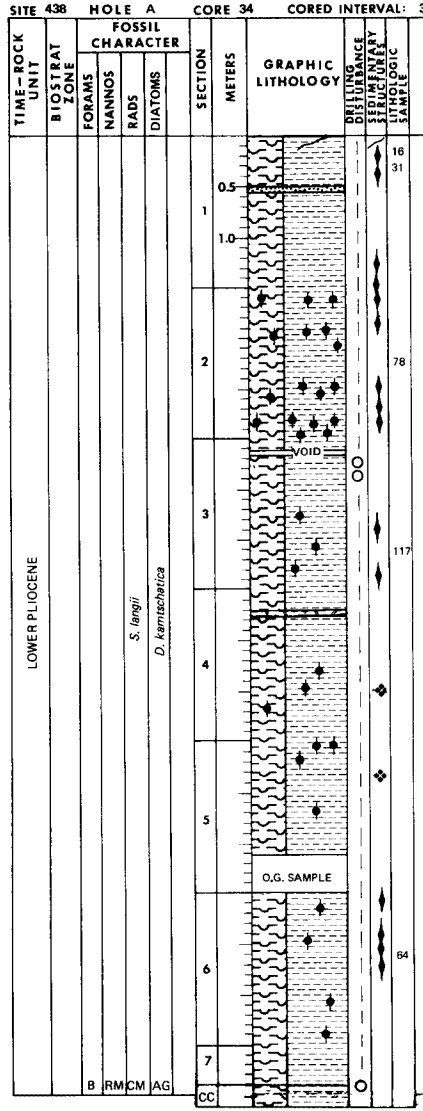
TOTAL C – ORGANIC C – CARBONATE (%)
5, 12 cm (0.6, 0.5, 1)

CARBONATE BOMB
3, 70-72 cm = 1-2%

SMEAR SLIDE SUMMARY

	Sandy diatom ooze	Diatomaceous chalk	Ash	Clayey diatom ooze	Clayey diatom ooze	Clayey diatom ooze
	2-41	2-89	4-74	5-30	5-34	5-55
Sand	20	25	40	25	25	25
Silt	20	20	25	25	25	20
Clay	60	55	35	50	50	55
Quartz	20	2	16	8	10	10
Feldspar	20	TR	7	5	5	3
Heavy minerals	TR	TR	5	2	1	3
Clay minerals	25	–	–	23	17	34
Volcanic glass	2	–	65	2	5	–
Glauconite	TR	TR	–	TR	–	–
Diatoms	30	35	5	55	55	45
Radiolarians	TR	–	–	–	–	–
Sponge spicules	3	3	3	5	7	5
Carbonate	–	60	–	TR	–	–
Silicoflagellates	–	–	–	–	–	TR

SITE 438 HOLE A CORE 34 CORED INTERVAL: 372.5-382.0 m



LITHOLOGIC DESCRIPTION

Light gray (N7) medium- to coarse-sand.

Olive gray (5Y 4/2) firm clayey diatom ooze. Possible fracture near top. Dark gray to black (N1-3) sandy vein, 15-17 cm; light olive gray (5Y 6/2) better indurated layer, 20-30 cm.

Olive gray (5Y 4/2) firm clayey diatom ooze containing sponge fragments. Dark gray (N3) silty mottles, Section 1, 70 and 90 cm; light gray (N7) hard ash pocket, Section 3, 86 cm; olive (5Y 5/3) mottles, Section 2, 20, 31, 39, 92, 111, 128 cm, Section 3, 126 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
5, 27 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 117-119 cm = 1-2%

SMEAR SLIDE SUMMARY

	Sandy diatom ooze	Clayey diatom ooze	Clayey diatom ooze	Clayey diatom ooze
	1-16	1-31	2-78	6-64
Sand	30	25	20	20
Silt	20	25	40	30
Clay	50	50	40	50
Quartz	15	5	5	10
Feldspar	8	7	8	5
Heavy minerals	5	3	3	1
Clay minerals	10	22	29	32
Volcanic glass	5	3	2	
Glauconite	2	TR	TR	TR
Foraminifers	–	2	–	TR
Diatoms	50	50	45	45
Radiolarians	–	1	–	TR
Sponge spicules	5	7	7	7
Silicoflagellates	TR	–	TR	TR
Coccoliths	–	–	–	TR

Medium gray (N5) silt-sized ash.

Olive gray (5Y 4/2) firm clayey diatom ooze containing sponge fragments. Rounded 2-3 cm pumice pebbles, Section 4, 95 cm, Section 5, 22 cm; pale olive gray (5Y 6/2) mottles, Section 6, 6, 36, 42, and 54 cm.

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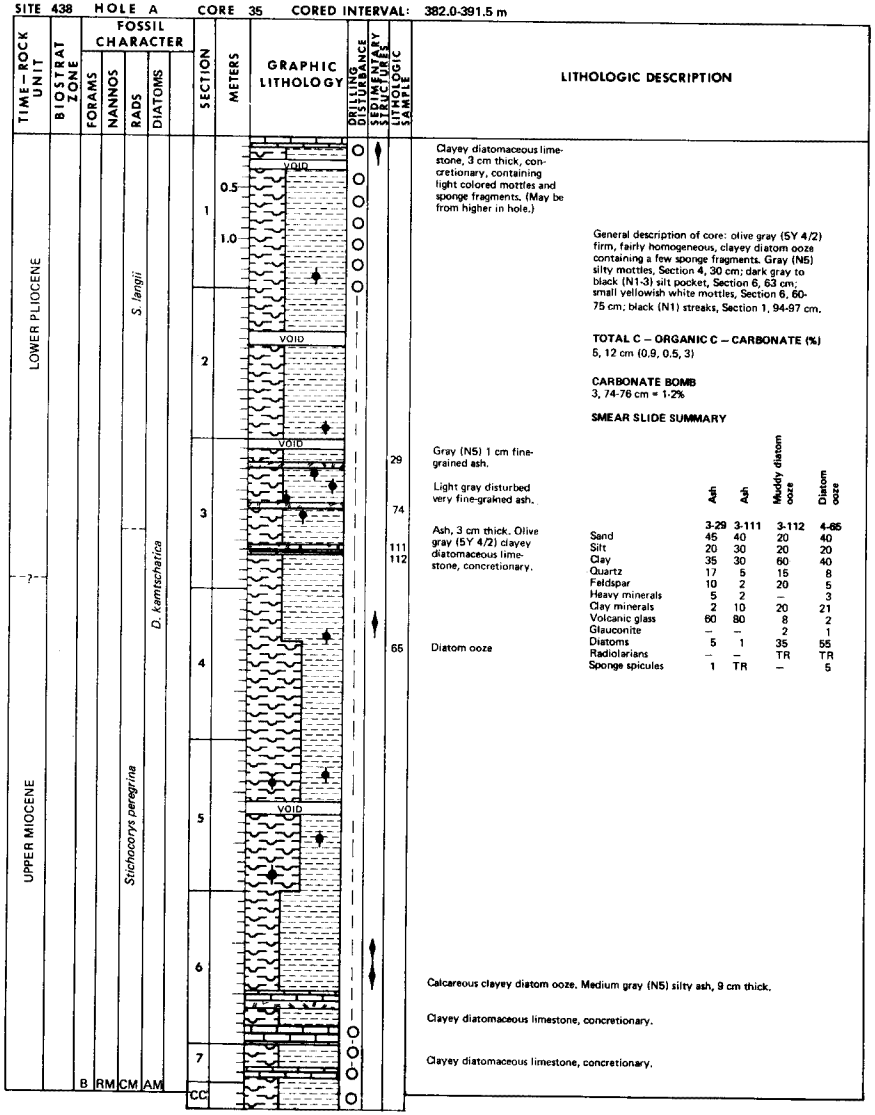
SITE 438 HOLE A CORE 35 CORED INTERVAL: 382.0-391.5 m



Clayey diatomaceous limestone, 3 cm thick, concretionary, containing light colored mottles and sponge fragments. (May be from higher in hole.)

General description of core: olive gray (5Y 4/2) firm, fairly homogeneous, clayey diatom ooze containing a few sponge fragments. Gray (N5) silty mottles, Section 4, 30 cm; dark gray to black (N1-3) silt pocket, Section 6, 63 cm; small yellowish white mottles, Section 6, 60-75 cm; black (N1) streaks, Section 1, 94-97 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
5, 12 cm (0.9, 0.5, 3)

CARBONATE BOMB
3, 74-76 cm = 1-2%

SMEAR SLIDE SUMMARY

Gray (N5) 1 cm fine-grained ash.

Light gray disturbed very fine-grained ash.

Ash, 3 cm thick. Olive gray (5Y 4/2) clayey diatomaceous limestone, concretionary.

Diatom ooze

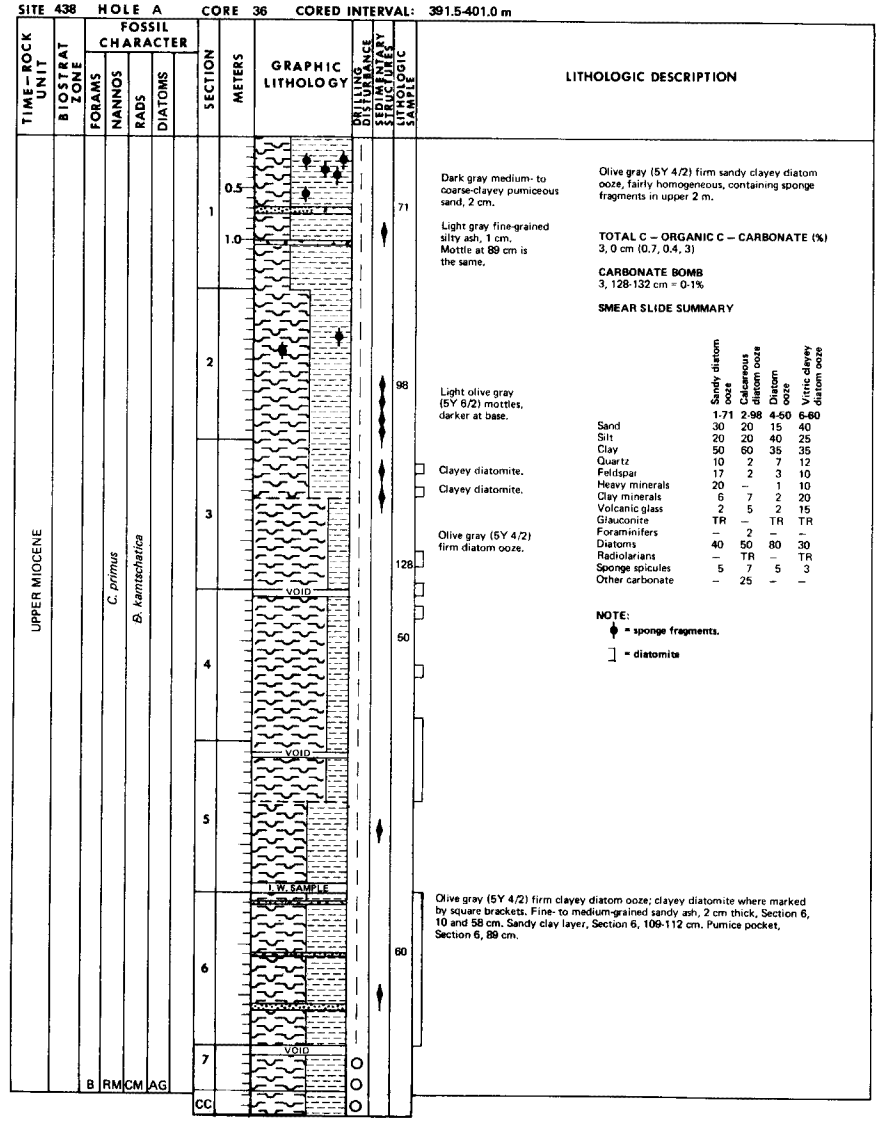
	Ash	Ash	Muddy diatom ooze	Diatom ooze
	3-29	3-111	3-112	4-65
Sand	45	40	20	40
Silt	20	30	20	20
Clay	35	30	60	40
Quartz	17	5	15	8
Feldspar	10	2	20	5
Heavy minerals	5	2	–	3
Clay minerals	2	10	20	21
Volcanic glass	60	80	8	2
Glauconite	–	–	2	1
Diatoms	5	1	35	55
Radiolarians	–	–	TR	TR
Sponge spicules	1	TR	–	5

Calcareous clayey diatom ooze. Medium gray (N5) silty ash, 9 cm thick.

Clayey diatomaceous limestone, concretionary.

Clayey diatomaceous limestone, concretionary.

SITE 438 HOLE A CORE 36 CORED INTERVAL: 391.5-401.0 m



Dark gray medium- to coarse-clayey pumiceous sand, 2 cm.

Light gray fine-grained silty ash, 1 cm. Mottle at 89 cm is the same.

Light olive gray (5Y 6/2) mottles, darker at base.

Clayey diatomite.

Clayey diatomite.

Olive gray (5Y 4/2) firm diatom ooze.

Olive gray (5Y 4/2) firm clayey diatom ooze; clayey diatomite where marked by square brackets. Fine- to medium-grained sandy ash, 2 cm thick, Section 6, 10 and 58 cm. Sandy clay layer, Section 6, 109-112 cm. Pumice pocket, Section 6, 89 cm.

Olive gray (5Y 4/2) firm sandy clayey diatom ooze, fairly homogeneous, containing sponge fragments in upper 2 m.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 0 cm (0.7, 0.4, 3)

CARBONATE BOMB
3, 128-132 cm = 0-1%

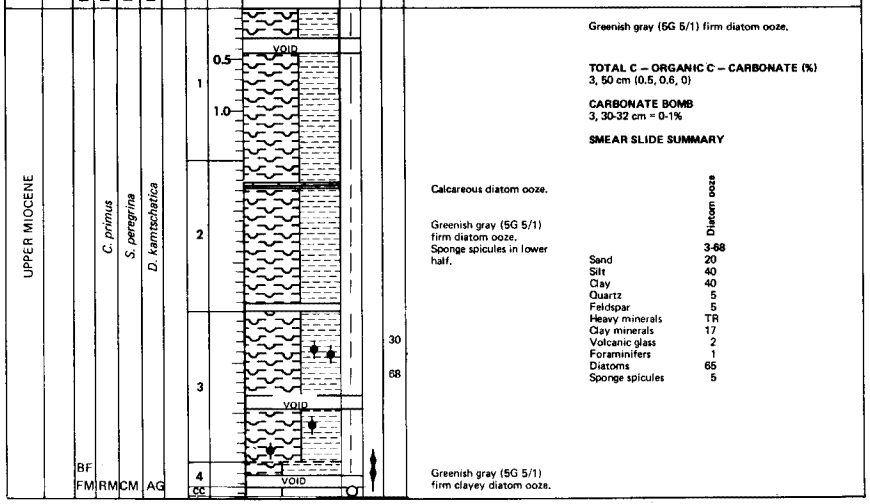
SMEAR SLIDE SUMMARY

	Sandy diatom ooze	Calcareous diatom ooze	Diatom ooze	Vitric clayey diatom ooze
	1-71	2-98	4-50	6-60
Sand	30	20	15	40
Silt	20	20	40	25
Clay	50	60	35	35
Quartz	10	2	7	12
Feldspar	17	2	3	10
Heavy minerals	20	–	1	10
Clay minerals	6	7	2	20
Volcanic glass	2	5	2	15
Glauconite	TR	–	TR	TR
Foraminifers	–	2	–	–
Diatoms	40	50	80	30
Radiolarians	–	TR	–	TR
Sponge spicules	5	7	5	3
Other carbonate	–	25	–	–

NOTE:
♦ = sponge fragments.
] = diatomite

MGG 1503 5 5 0 3 7 6

SITE 438 HOLE A CORE 37 CORED INTERVAL: 401.0-410.5 m



LITHOLOGIC DESCRIPTION

Greenish gray (5G 5/1) firm diatom ooze.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 50 cm (0.5, 0.6, 0)

CARBONATE BOMB
3, 30-32 cm = 0-1%

SMEAR SLIDE SUMMARY

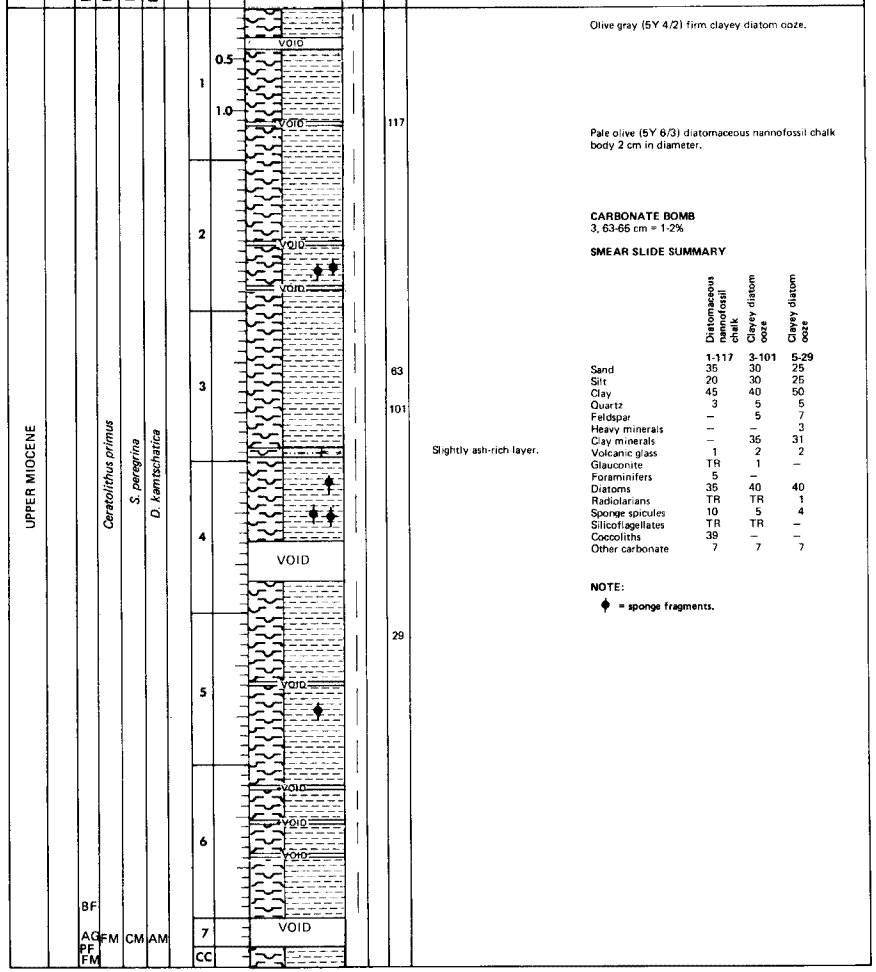
	Diatom ooze
	3-68
Sand	20
Silt	40
Clay	40
Quartz	5
Feldspar	5
Heavy minerals	TR
Clay minerals	17
Volcanic glass	2
Foraminifers	1
Diatoms	65
Sponge spicules	5

Calcareous diatom ooze.

Greenish gray (5G 5/1) firm diatom ooze. Sponge spicules in lower half.

Greenish gray (5G 5/1) firm clayey diatom ooze.

SITE 438 HOLE A CORE 38 CORED INTERVAL: 410.5-420.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) firm clayey diatom ooze.

Pale olive (5Y 6/3) diatomaceous nannofossil chalk body 2 cm in diameter.

CARBONATE BOMB
3, 63-66 cm = 1-2%

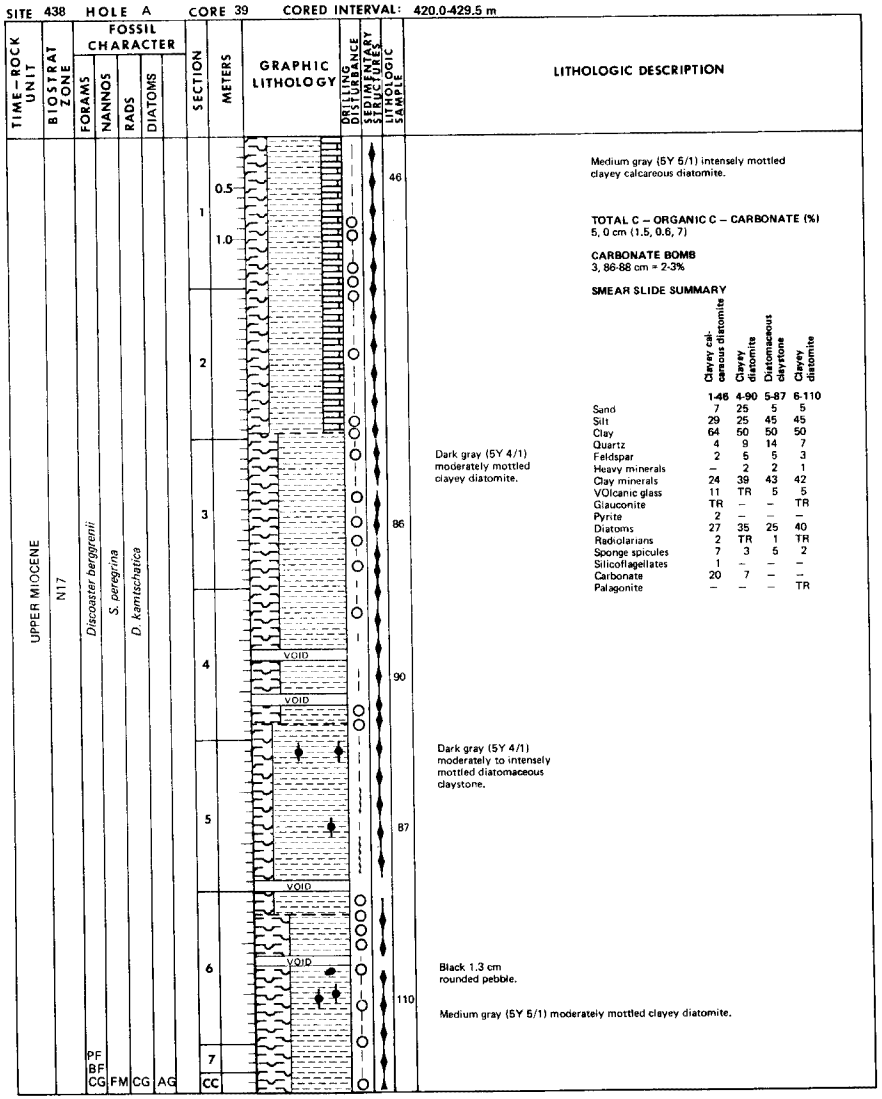
SMEAR SLIDE SUMMARY

	Diatomaceous nannofossil chalk	Clayey diatom ooze	Clayey diatom ooze
	1-117	3-101	5-29
Sand	35	30	25
Silt	20	30	25
Clay	45	40	50
Quartz	3	5	5
Feldspar	–	5	7
Heavy minerals	–	–	3
Clay minerals	–	36	31
Volcanic glass	1	2	2
Glauconite	TR	1	–
Foraminifers	5	–	–
Diatoms	35	40	40
Radiolarians	TR	TR	1
Sponge spicules	10	5	4
Silicoflagellates	TR	TR	–
Coccoliths	39	–	–
Other carbonate	7	7	7

Slightly ash-rich layer.

NOTE:
♦ = sponge fragments.

SITE 438 HOLE A CORE 39 CORED INTERVAL: 420.0-429.5 m



Medium gray (5Y 5/1) intensely mottled clayey calcareous diatomite.

TOTAL C – ORGANIC C – CARBONATE (%)
5, 0 cm (1.5, 0.6, 7)

CARBONATE BOMB
3, 86-88 cm = 2-3%

SMEAR SLIDE SUMMARY

	Clayey calcareous diatomite	Clayey diatomite	Diatomaceous claystone	Clayey diatomite
	1-46	4-90	5-87	6-110
Sand	7	25	5	5
Silt	29	25	45	45
Clay	64	50	50	50
Quartz	4	9	14	7
Feldspar	2	5	5	3
Heavy minerals	–	2	2	1
Clay minerals	24	39	43	42
VOlcanic glass	11	TR	5	5
Glauconite	TR	–	–	TR
Pyrite	2	–	–	–
Diatoms	27	35	25	40
Radiolarians	2	TR	1	TR
Sponge spicules	7	3	5	2
Silicoflagellates	1	–	–	–
Carbonate	20	7	–	–
Palagonite	–	–	–	TR

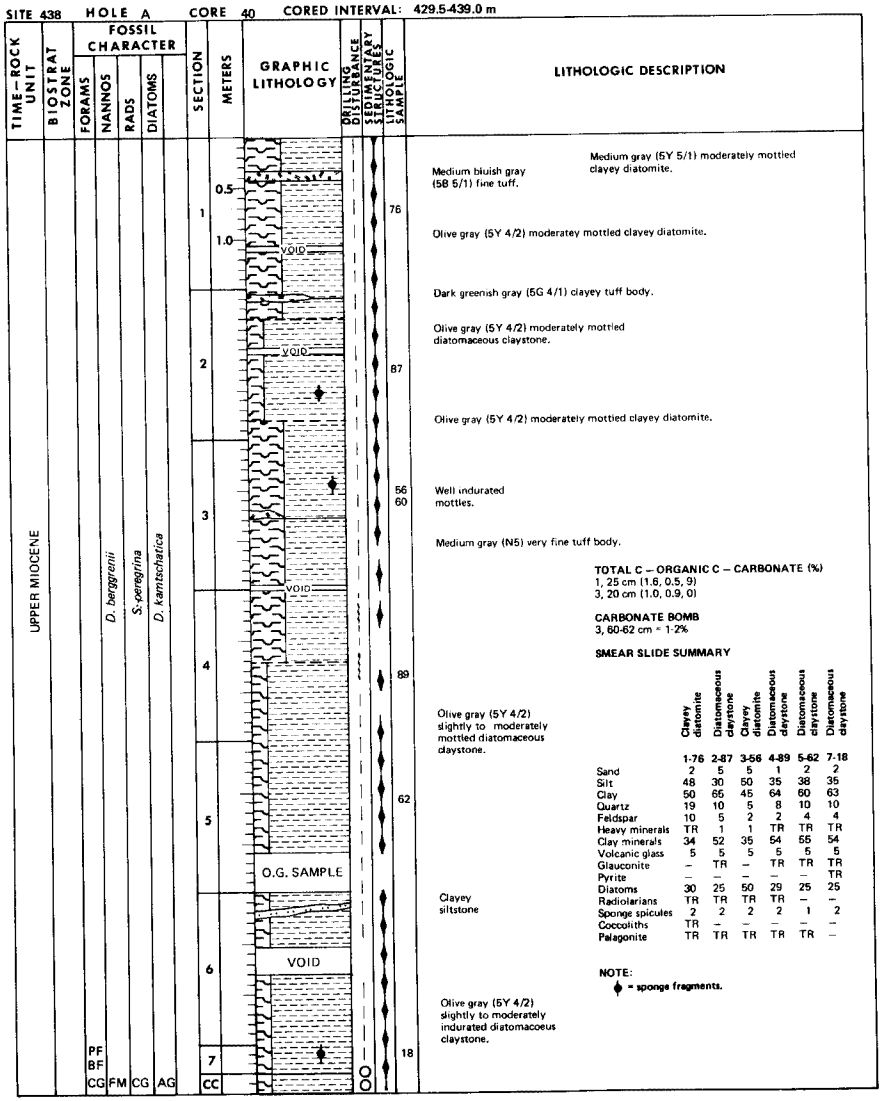
Dark gray (5Y 4/1) moderately mottled clayey diatomite.

Dark gray (5Y 4/1) moderately to intensely mottled diatomaceous claystone.

Black 1.3 cm rounded pebble.

Medium gray (5Y 5/1) moderately mottled clayey diatomite.

SITE 438 HOLE A CORE 40 CORED INTERVAL: 429.5-439.0 m



Medium bluish gray (5B 5/1) fine tuff.

Medium gray (5Y 5/1) moderately mottled clayey diatomite.

Olive gray (5Y 4/2) moderately mottled clayey diatomite.

Dark greenish gray (5G 4/1) clayey tuff body.

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

Olive gray (5Y 4/2) moderately mottled clayey diatomite.

Well indurated mottles.

Medium gray (N5) very fine tuff body.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 25 cm (1.6, 0.5, 9)
3, 20 cm (1.0, 0.9, 0)

CARBONATE BOMB
3, 60-62 cm = 1-2%

SMEAR SLIDE SUMMARY

	Clayey diatomite	Diatomaceous claystone	Clayey diatom	Diatomaceous claystone	Diatomaceous claystone	Diatomaceous claystone
	1-76	2-87	3-56	4-89	5-62	7-18
Sand	2	5	5	1	2	2
Silt	48	30	50	35	38	35
Clay	50	65	45	64	60	63
Quartz	19	10	5	8	10	10
Feldspar	10	5	2	2	4	4
Heavy minerals	TR	1	1	TR	TR	TR
Clay minerals	34	52	35	54	55	54
Volcanic glass	5	5	5	5	5	5
Glauconite	–	TR	–	TR	TR	TR
Pyrite	–	–	–	–	–	TR
Diatoms	30	25	50	29	25	25
Radiolarians	TR	TR	TR	TR	–	–
Sponge spicules	2	2	2	2	1	2
Coccoliths	TR	–	–	–	–	–
Palagonite	TR	TR	TR	TR	TR	–

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

Clayey siltstone

Olive gray (5Y 4/2) slightly to moderately indurated diatomaceous claystone.

NOTE:
♦ = sponge fragments.

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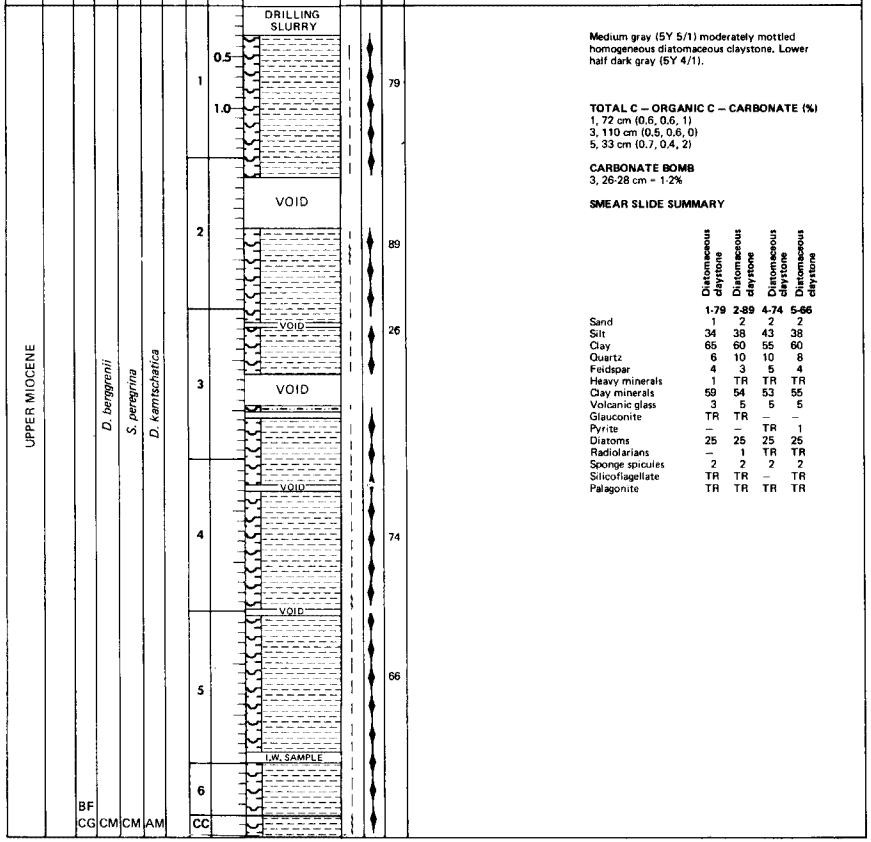
SITE 438 HOLE A CORE 41 CORED INTERVAL: 439.0-448.5 m



LITHOLOGIC DESCRIPTION

Medium gray (5Y 5/1) moderately mottled homogeneous diatomaceous claystone. Lower half dark gray (5Y 4/1).

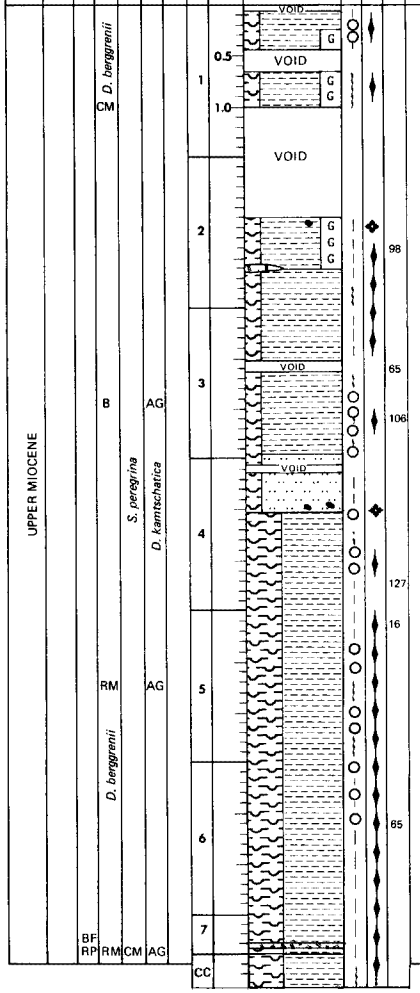
TOTAL C – ORGANIC C – CARBONATE (%)
1, 72 cm (0.6, 0.6, 1)
3, 110 cm (0.5, 0.6, 0)
5, 33 cm (0.7, 0.4, 2)

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

SMEAR SLIDE SUMMARY

	1-79 Diatomaceous claystone	2-89 Diatomaceous claystone	4-74 Diatomaceous claystone	5-66 Diatomaceous claystone
Sand	1	2	2	2
Silt	34	38	43	38
Clay	65	60	55	60
Quartz	6	10	10	8
Feldspar	4	3	5	4
Heavy minerals	1	TR	TR	TR
Clay minerals	59	54	53	55
Volcanic glass	3	5	5	5
Glauconite	TR	TR	–	–
Pyrite	–	–	TR	1
Diatoms	25	25	25	25
Radiolarians	–	1	TR	TR
Sponge spicules	2	2	2	2
Silicoflagellate	TR	TR	–	TR
Palagonite	TR	TR	TR	TR

SITE 438 HOLE A CORE 42 CORED INTERVAL: 448.5-458.0 m



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/2) homogeneous diatomaceous claystone. Slightly to moderately mottled. Glauconitic, Section 1, 25 cm, to Section 2, 110 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 120 cm (0.4, 0.5, 0)
5, 65 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 65-67 cm = 0-1%

SMEAR SLIDE SUMMARY

	2-98 Glauconitic diatomaceous claystone	3-106 Diatomaceous claystone	4-127 Clayey diatomite	5-16 Clayey diatomite	6-65 Clayey diatomite
Sand	2	2	5	5	2
Silt	43	33	45	45	43
Clay	55	65	50	50	55
Quartz	10	10	5	10	10
Feldspar	4	4	2	5	4
Heavy minerals	TR	TR	TR	2	1
Clay minerals	49	54	43	37	41
Volcanic glass	5	5	5	9	5
Glauconite	10	5	5	TR	–
Pyrite	TR	–	–	–	–
Diatoms	20	20	35	35	35
Radiolarians	–	TR	3	–	TR
Sponge spicules	2	2	2	2	2
Silicoflagellates	–	TR	–	–	–
Palagonite	TR	–	TR	–	2

Yellowish pumice pebble.

Olive gray (5Y 5/3) silt body.

Silty laminae

Very dark gray (5Y 3/1) diatomaceous siltstone.

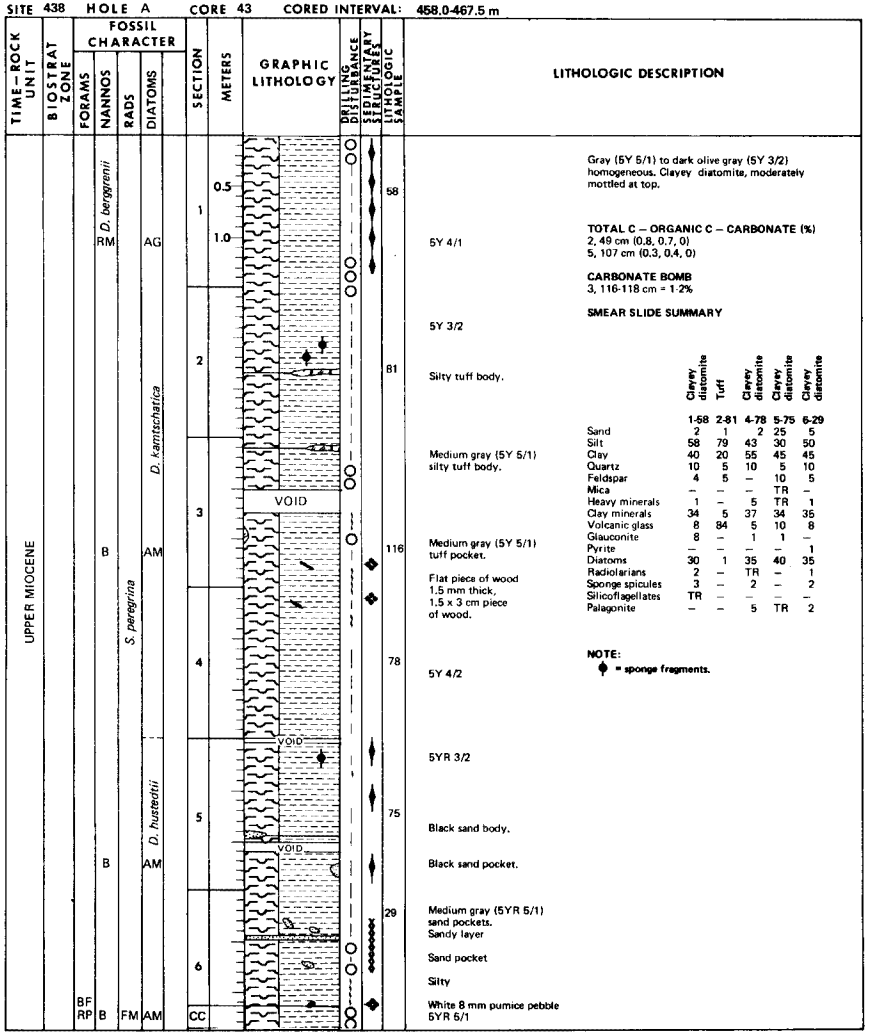
Pumice pebbles.

Silty

Clayey diatomite ranging from very dark gray (5Y 3/1) at top to olive gray (5Y 4/2) at base. Moderately mottled.

White clay-sized tuff 3 mm thick.

SITE 438 HOLE A CORE 43 CORED INTERVAL: 458.0-467.5 m



Gray (5Y 5/1) to dark olive gray (5Y 3/2) homogeneous. Clayey diatomite, moderately mottled at top.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 49 cm (0.8, 0.7, 0)
5, 107 cm (0.3, 0.4, 0)

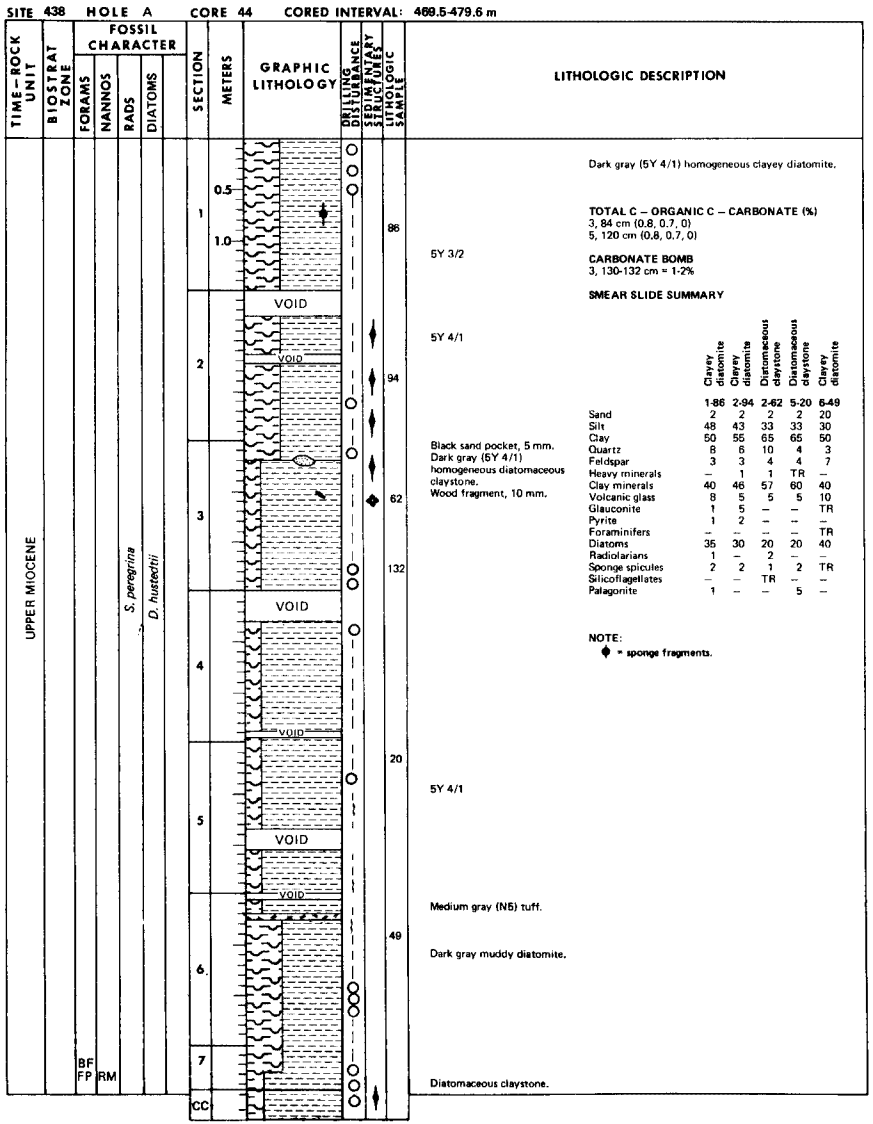
CARBONATE BOMB
3, 116-118 cm = 1-2%

SMEAR SLIDE SUMMARY

	1-58 Clayey diatomite	2-81 Tuff	4-78 Clayey diatomite	5-75 Clayey diatomite	6-29 Clayey diatomite
Sand	2	1	2	25	5
Silt	58	79	43	30	50
Clay	40	20	55	45	45
Quartz	10	5	10	5	10
Feldspar	4	5	–	10	5
Mica	–	–	–	TR	–
Heavy minerals	1	–	5	TR	1
Clay minerals	34	5	37	34	35
Volcanic glass	8	84	5	10	8
Glauconite	8	–	1	1	–
Pyrite	–	–	–	–	1
Diatoms	30	1	35	40	35
Radiolarians	2	–	TR	–	1
Sponge spicules	3	–	2	–	2
Silicoflagellates	TR	–	–	–	–
Palagonite	–	–	5	TR	2

NOTE:
♦ = sponge fragments.

SITE 438 HOLE A CORE 44 CORED INTERVAL: 469.5-479.6 m



TOTAL C – ORGANIC C – CARBONATE (%)
3, 84 cm (0.8, 0.7, 0)
5, 120 cm (0.8, 0.7, 0)

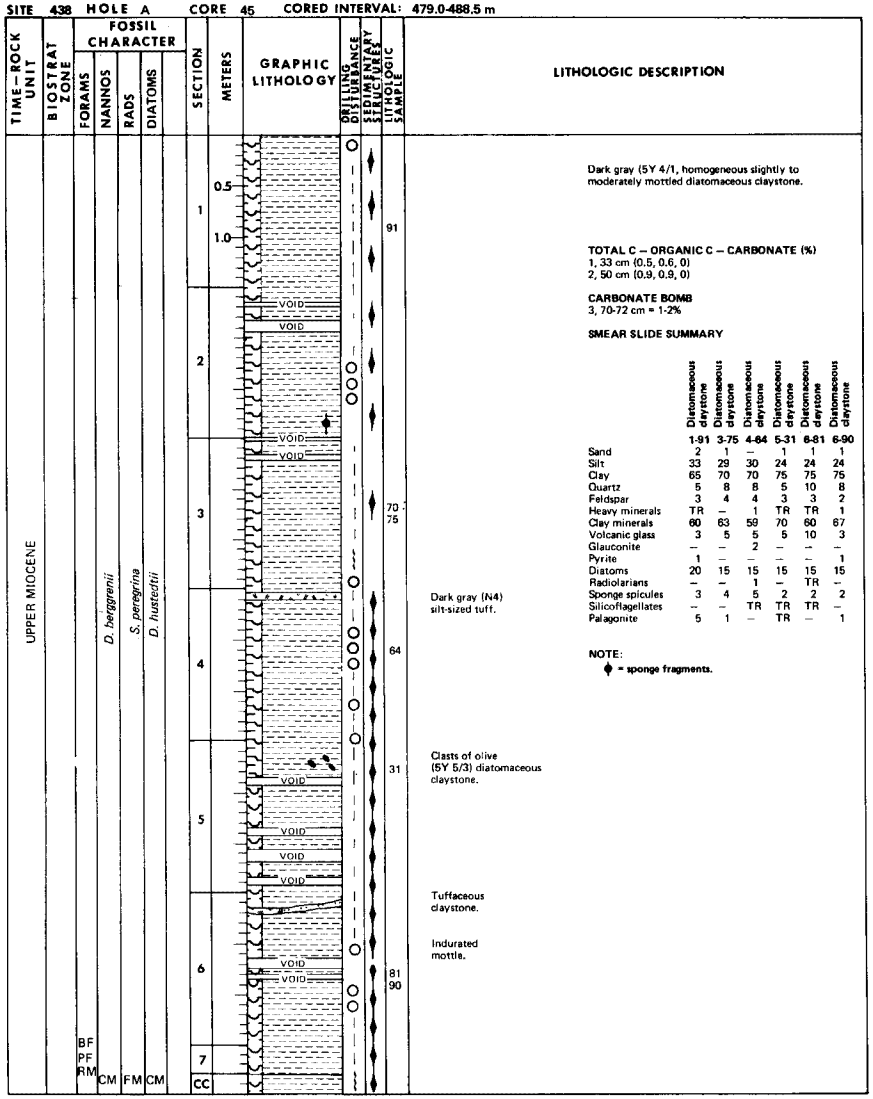
CARBONATE BOMB
3, 130-132 cm = 1-2%

SMEAR SLIDE SUMMARY

	1-86 Clayey diatomite	2-94 Clayey diatomite	2-62 Diatomaceous claystone	5-20 Diatomaceous claystone	6-49 Clayey diatomite
Sand	2	2	2	2	20
Silt	48	43	33	33	30
Clay	50	55	65	65	50
Quartz	8	6	10	4	3
Feldspar	3	3	4	4	7
Heavy minerals	–	1	1	TR	–
Clay minerals	40	46	57	60	40
Volcanic glass	8	5	5	5	10
Glauconite	1	5	–	–	TR
Pyrite	1	2	–	–	–
Foraminifers	–	–	–	–	TR
Diatoms	35	30	20	20	40
Radiolarians	1	–	2	–	–
Sponge spicules	2	2	1	2	TR
Silicoflagellates	–	–	TR	–	–
Palagonite	1	–	–	5	–

NOTE:
♦ = sponge fragments.

SITE 438 HOLE A CORE 45 CORED INTERVAL: 479.0-488.5 m



Dark gray (5Y 4/1, homogeneous slightly to moderately mottled diatomaceous claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 33 cm (0.5, 0.6, 0)
2, 50 cm (0.9, 0.9, 0)

CARBONATE BOMB
3, 70-72 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous ooze	Diatomaceous ooze	Diatomaceous ooze	Diatomaceous ooze	Diatomaceous ooze	Diatomaceous ooze
	1-91	3-75	4-64	5-31	6-81	6-90
Sand	2	1	–	1	1	1
Silt	33	29	30	24	24	24
Clay	65	70	70	75	75	75
Quartz	5	8	8	5	10	8
Feldspar	3	4	4	3	3	2
Heavy minerals	TR	–	1	TR	TR	1
Clay minerals	60	63	59	70	60	67
Volcanic glass	3	5	5	5	10	3
Glauconite	–	–	2	–	–	–
Pyrite	1	–	–	–	–	1
Diatoms	20	15	15	15	15	15
Radiolarians	–	–	1	–	TR	–
Sponge spicules	3	4	5	2	2	2
Silicoflagellates	–	–	TR	TR	TR	–
Palagonite	5	1	–	TR	–	1

NOTE:
♦ = sponge fragments.

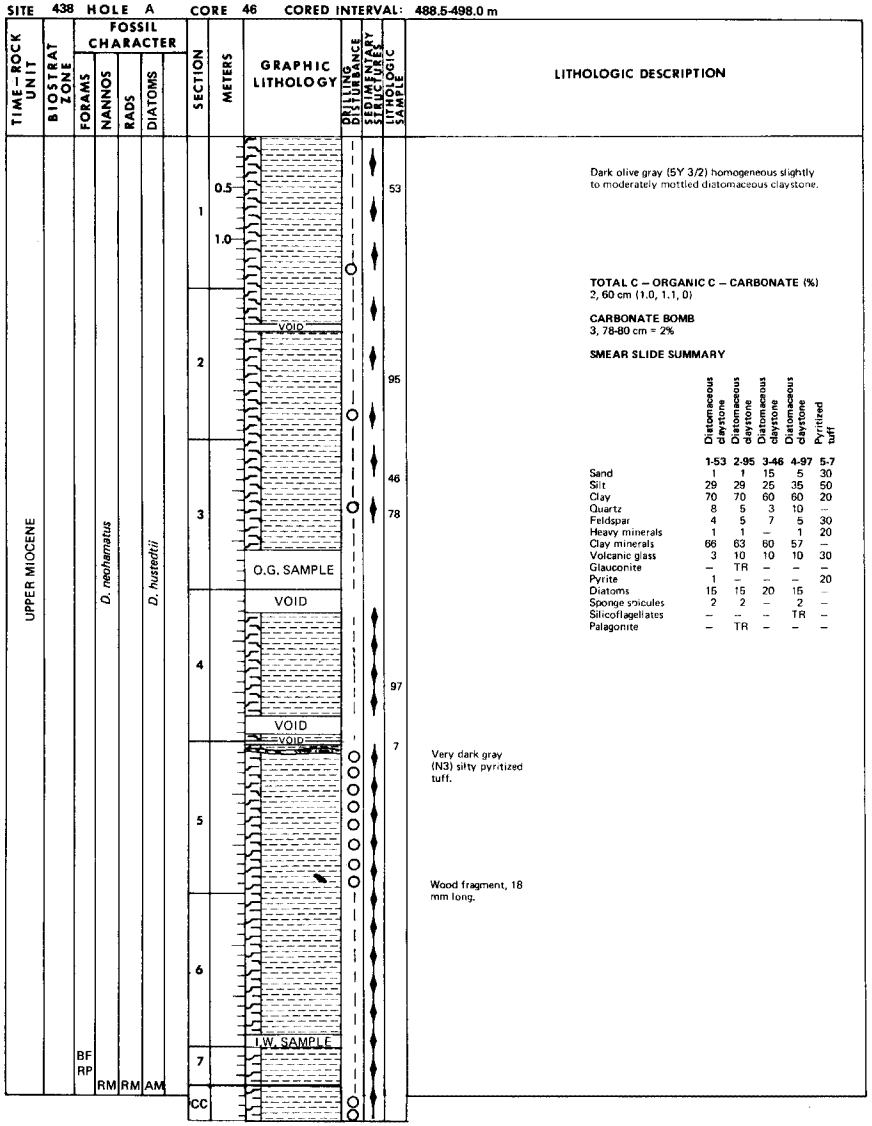
Dark gray (N4) silt-sized tuff.

Clasts of olive (5Y 5/3) diatomaceous claystone.

Tuffaceous claystone.

Indurated mottle.

SITE 438 HOLE A CORE 46 CORED INTERVAL: 488.5-498.0 m



Dark olive gray (5Y 3/2) homogeneous slightly to moderately mottled diatomaceous claystone.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 60 cm (1.0, 1.1, 0)

CARBONATE BOMB
3, 78-80 cm = 2%

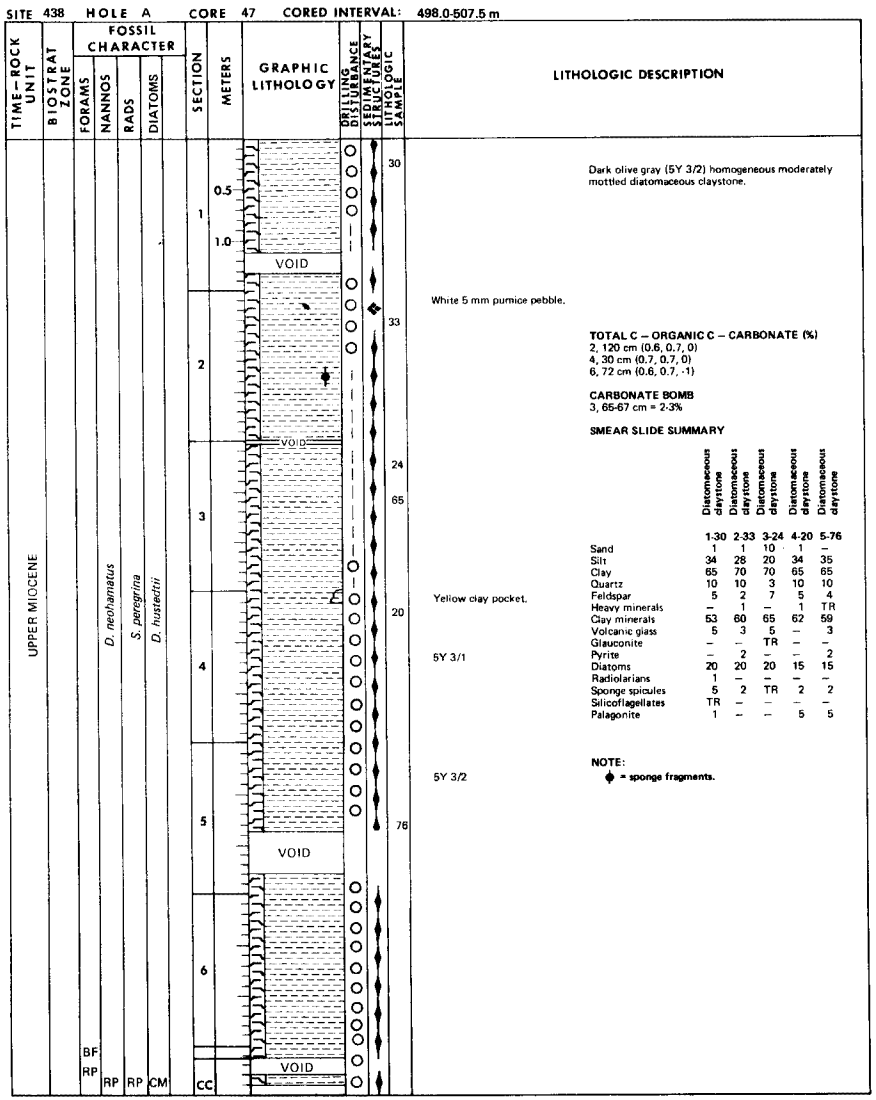
SMEAR SLIDE SUMMARY

	Diatomaceous ooze	Diatomaceous ooze	Diatomaceous ooze	Diatomaceous ooze	Pyritized tuff
	1-53	2-95	3-46	4-97	5-7
Sand	1	1	15	5	30
Silt	29	29	25	35	50
Clay	70	70	60	60	20
Quartz	8	5	3	10	–
Feldspar	4	5	7	5	30
Heavy minerals	1	1	–	1	20
Clay minerals	66	63	60	57	–
Volcanic glass	3	10	10	10	30
Glauconite	–	TR	–	–	–
Pyrite	1	–	–	–	20
Diatoms	15	15	20	15	–
Sponge spicules	2	2	–	2	–
Silicoflagellates	–	–	–	TR	–
Palagonite	–	TR	–	–	–

Very dark gray (N3) silty pyritized tuff.

Wood fragment, 18 mm long.

SITE 438 HOLE A CORE 47 CORED INTERVAL: 498.0-507.5 m



TOTAL C – ORGANIC C – CARBONATE (%)
2, 120 cm (0.6, 0.7, 0)
4, 30 cm (0.7, 0.7, 0)
6, 72 cm (0.6, 0.7, -1)

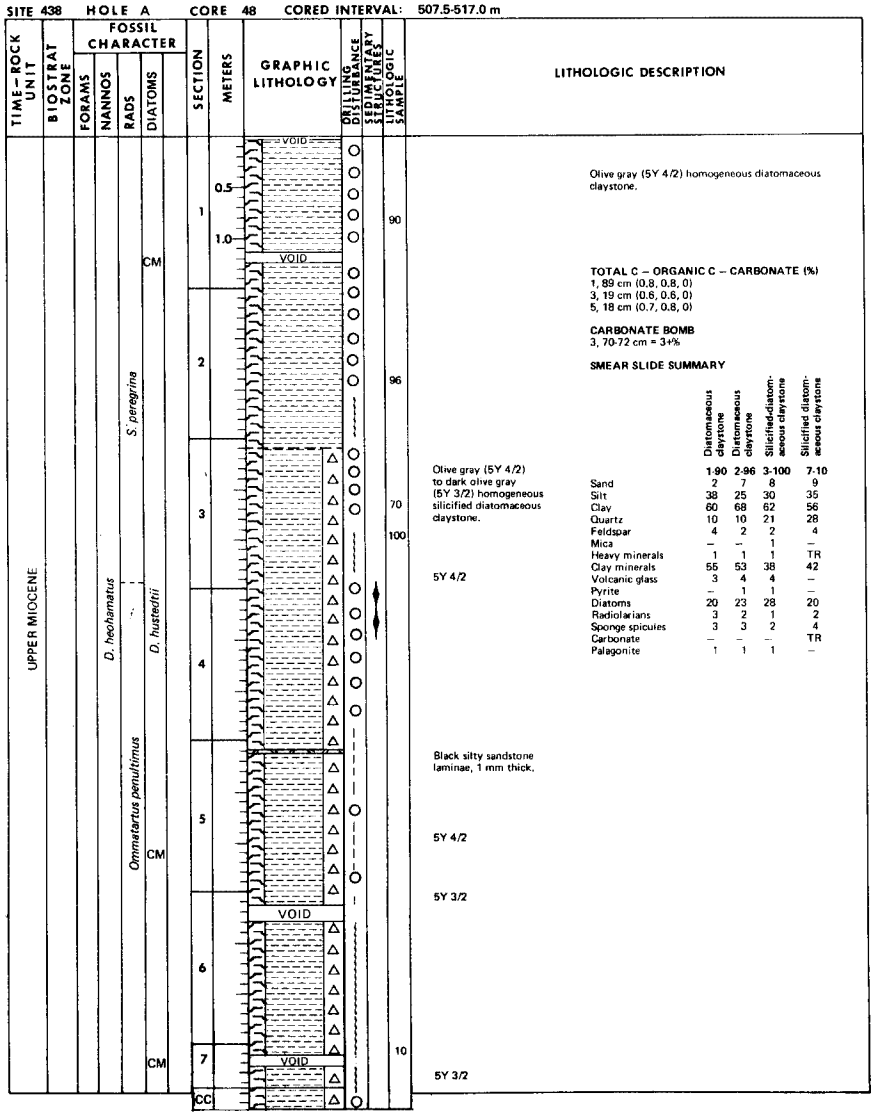
CARBONATE BOMB
3, 65-67 cm = 2-3%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-30	Diatomaceous claystone 2-33	Diatomaceous claystone 3-24	Diatomaceous claystone 4-20	Diatomaceous claystone 5-76
Sand	1	1	10	1	–
Silt	34	28	20	34	35
Clay	65	70	70	65	65
Quartz	10	10	3	10	10
Feldspar	5	2	7	5	4
Heavy minerals	–	1	–	1	TR
Clay minerals	53	60	65	62	59
Volcanic glass	5	3	5	–	3
Glauconite	–	–	TR	–	–
Pyrite	–	2	–	–	2
Diatoms	20	20	20	15	15
Radiolarians	1	–	–	–	–
Sponge spicules	5	2	TR	2	2
Silicoflagellates	TR	–	–	–	–
Palagonite	1	–	–	5	5

NOTE:
♦ = sponge fragments.

SITE 438 HOLE A CORE 48 CORED INTERVAL: 507.5-517.0 m



TOTAL C – ORGANIC C – CARBONATE (%)
1, 89 cm (0.8, 0.8, 0)
3, 19 cm (0.6, 0.6, 0)
5, 18 cm (0.7, 0.8, 0)

CARBONATE BOMB
3, 70-72 cm = 3+%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-90	Diatomaceous claystone 2-96	Silicified diatomaceous claystone 3-100	Silicified diatomaceous claystone 7-10
Sand	2	7	8	9
Silt	38	25	30	35
Clay	60	68	62	56
Quartz	10	10	21	28
Feldspar	4	2	2	4
Mica	–	–	1	–
Heavy minerals	1	1	1	TR
Clay minerals	55	53	38	42
Volcanic glass	3	4	4	–
Pyrite	–	1	1	–
Diatoms	20	23	28	20
Radiolarians	3	2	1	2
Sponge spicules	3	3	2	4
Carbonate	–	–	–	TR
Palagonite	1	1	1	–

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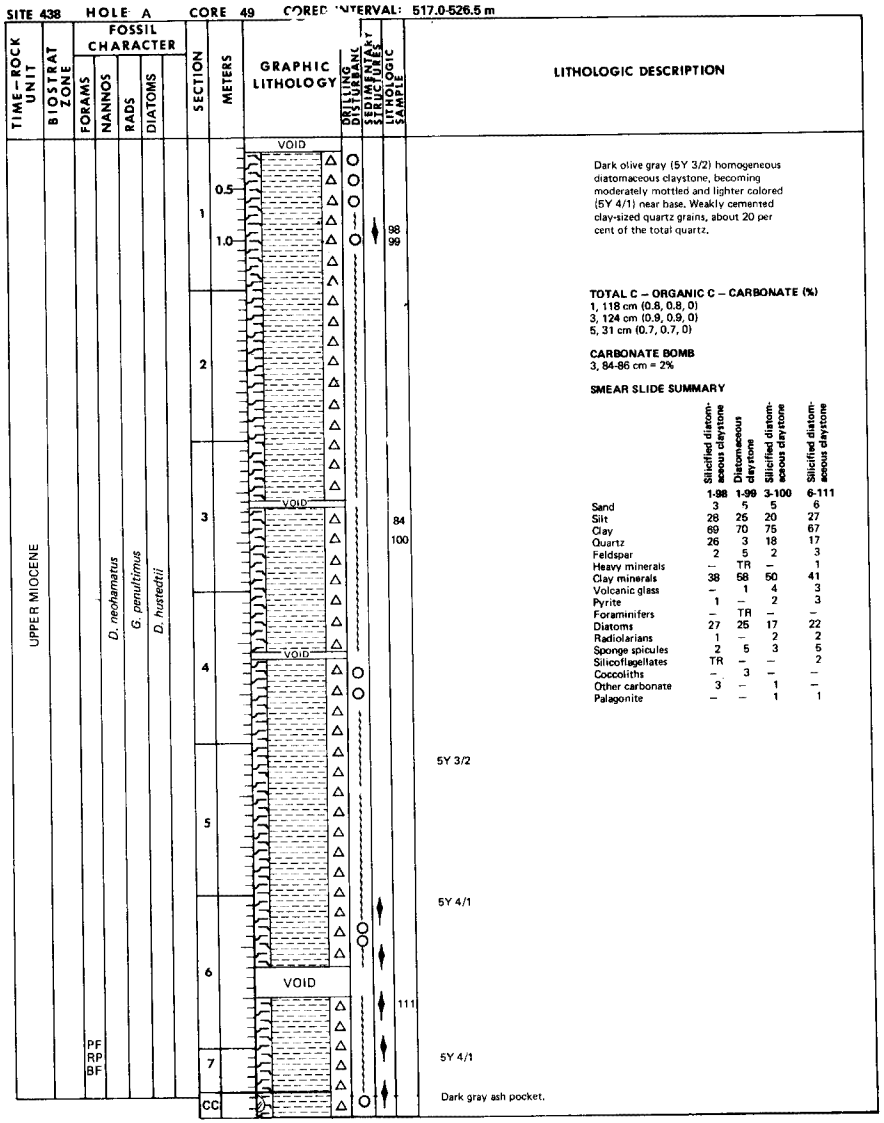
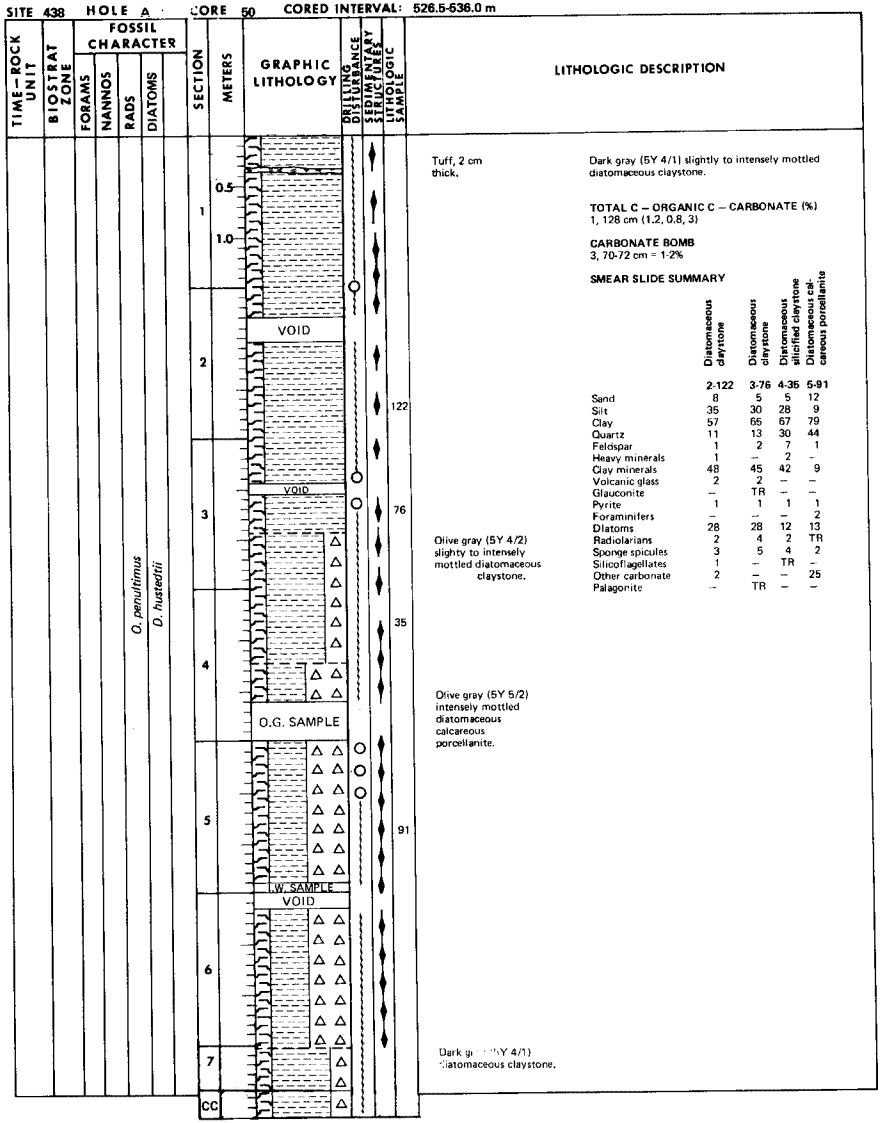
SITE 438 HOLE A CORE 49 CORED INTERVAL: 517.0-526.5 m



	Silicified diatomaceous claystone 1-98	Diatomaceous claystone 1-99	Silicified diatomaceous claystone 3-100	Silicified diatomaceous claystone 6-111
Sand	3	5	5	6
Silt	28	25	20	27
Clay	69	70	75	67
Quartz	26	3	18	17
Feldspar	2	5	2	3
Heavy minerals	–	TR	–	1
Clay minerals	38	58	50	41
Volcanic glass	–	1	4	3
Pyrite	1	–	2	3
Foraminifers	–	TR	–	–
Diatoms	27	25	17	22
Radiolarians	1	–	2	2
Sponge spicules	2	5	3	5
Silicoflagellates	TR	–	–	2
Coccoliths	–	3	–	–
Other carbonate	3	–	1	–
Palagonite	–	–	1	1

SITE 438 HOLE A CORE 50 CORED INTERVAL: 526.5-536.0 m



	Diatomaceous claystone 2-122	Diatomaceous claystone 3-76	Diatomaceous silicified claystone 4-35	Diatomaceous calcareous porcellanite 5-91
Sand	8	5	5	12
Silt	35	30	28	9
Clay	57	66	67	79
Quartz	11	13	30	44
Feldspar	1	2	7	1
Heavy minerals	1	–	2	–
Clay minerals	48	45	42	9
Volcanic glass	2	2	–	–
Glauconite	–	TR	–	–
Pyrite	1	1	1	1
Foraminifers	–	–	–	2
Diatoms	28	28	12	13
Radiolarians	2	4	2	TR
Sponge spicules	3	5	4	2
Silicoflagellates	1	–	TR	–
Other carbonate	2	–	–	25
Palagonite	–	TR	–	–

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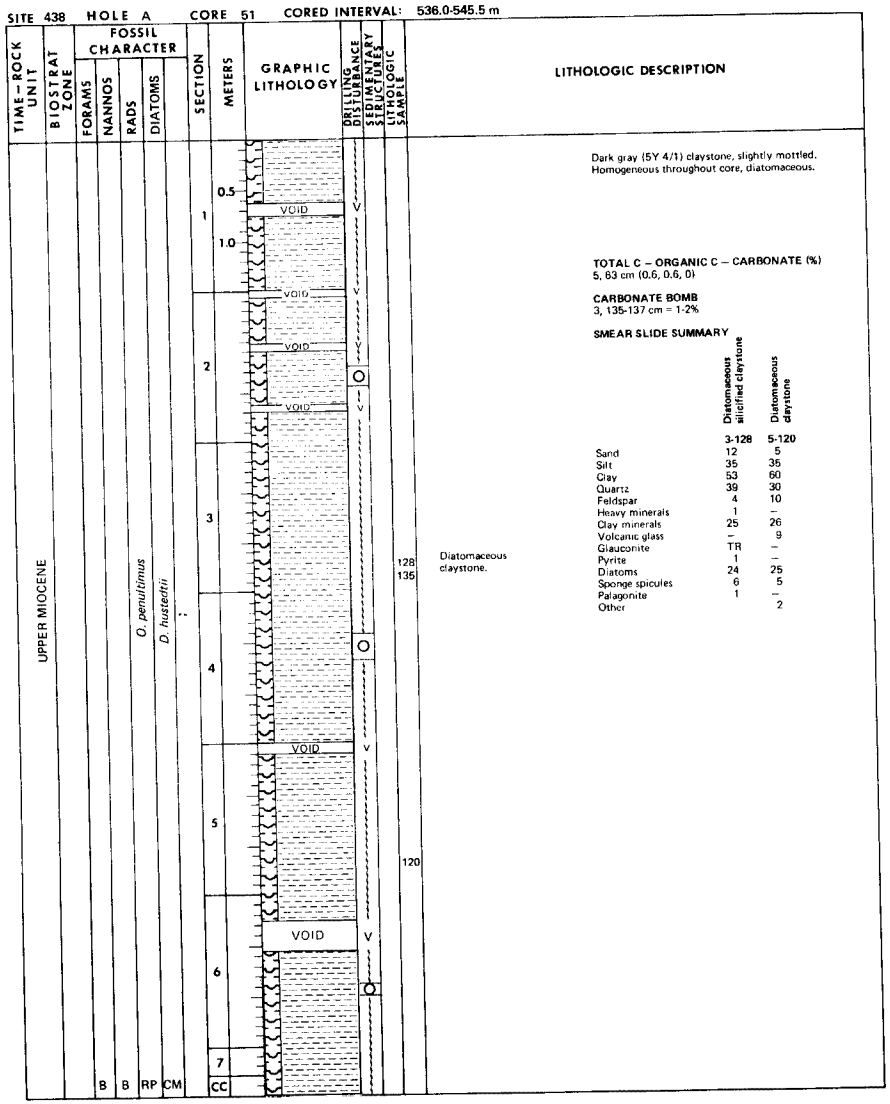
SITE 438 HOLE A CORE 51 CORED INTERVAL: 536.0-545.5 m



Dark gray (5Y 4/1) claystone, slightly mottled. Homogeneous throughout core, diatomaceous.

TOTAL C – ORGANIC C – CARBONATE (%)
5, 83 cm (0.6, 0.6, 0)

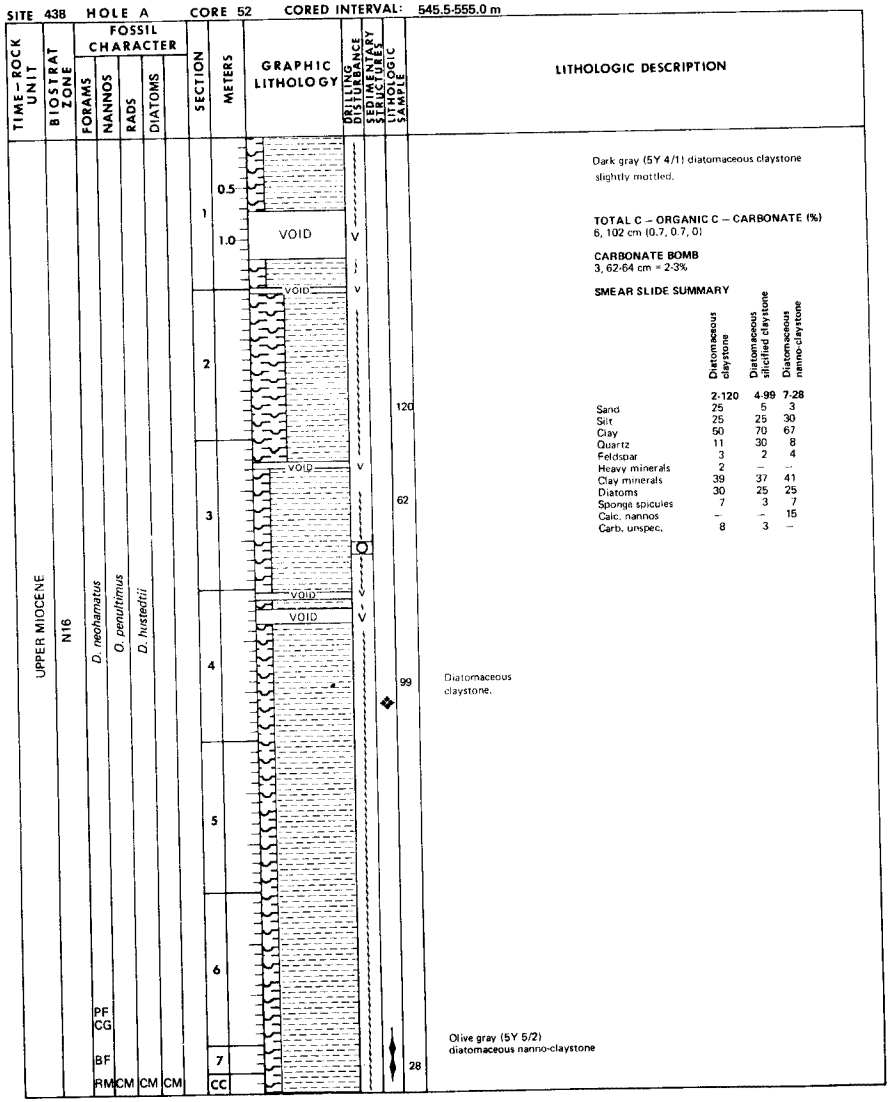
CARBONATE BOMB
3, 135-137 cm = 1-2%

SMEAR SLIDE SUMMARY

	3-128 Diatomaceous silicified claystone	5-120 Diatomaceous claystone
Sand	12	5
Silt	35	35
Clay	53	60
Quartz	39	30
Feldspar	4	10
Heavy minerals	1	–
Clay minerals	25	26
Volcanic glass	–	9
Glauconite	TR	–
Pyrite	1	–
Diatoms	24	25
Sponge spicules	6	5
Palagonite	1	–
Other		2

Diatomaceous claystone.

SITE 438 HOLE A CORE 52 CORED INTERVAL: 545.5-555.0 m



Dark gray (5Y 4/1) diatomaceous claystone slightly mottled.

TOTAL C – ORGANIC C – CARBONATE (%)
6, 102 cm (0.7, 0.7, 0)

CARBONATE BOMB
3, 62-64 cm = 2-3%

SMEAR SLIDE SUMMARY

	2-120 Diatomaceous claystone	4-99 Diatomaceous silicified claystone	7-28 Diatomaceous nanno-claystone
Sand	25	5	3
Silt	25	25	30
Clay	50	70	67
Quartz	11	30	8
Feldspar	3	2	4
Heavy minerals	2	–	–
Clay minerals	39	37	41
Diatoms	30	25	25
Sponge spicules	7	3	7
Calc. nannos	–	–	15
Carb. unspec.	8	3	–

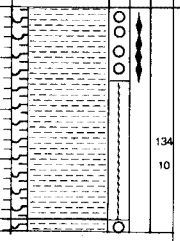
Diatomaceous claystone.

Olive gray (5Y 5/2) diatomaceous nanno-claystone

MGG 1505027

SITE 438 HOLE A CORE 53 CORED INTERVAL: 555.0-564.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE		B	FM	FM	CM	1, CC	0.5, 1.0				134, 10



LITHOLOGIC DESCRIPTION

Diatomaceous claystone

Dark gray (5Y 4/1) diatomaceous claystone.

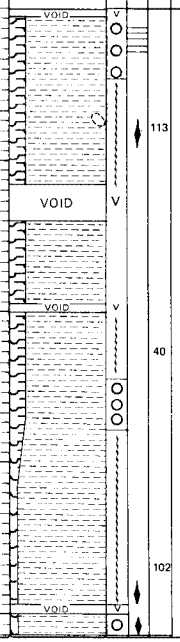
TOTAL C – ORGANIC C – CARBONATE (%)
1, 20 (1.1, 0.9, 2)

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-134	Diatomaceous silicified claystone 2-10
Sand	5	5
Silt	10	28
Clay	85	67
Quartz	20	20
Feldspar	20	2
Mica	–	
Heavy minerals	–	2
Clay minerals	40	39
Volcanic glass	3	
Pyrite	1	1
Zeolite minerals	–	7
Diatoms	15	25
Sponge spicules	1	5

SITE 438 HOLE A CORE 54 CORED INTERVAL: 564.5-574.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE		BF, RP	B	RP	CM	1, 2, 3, 4, CC	0.5, 1.0	VOID	V		113, 40, 102



LITHOLOGIC DESCRIPTION

Thin darker beds

Olive gray (5Y 5/2) mottled nannofossil bearing diatomaceous claystone

5Y 4/1 claystone

Dark gray (5Y 4/1) diatomaceous claystone homogeneous throughout core.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 125 cm (0.7, 0.7, 0)

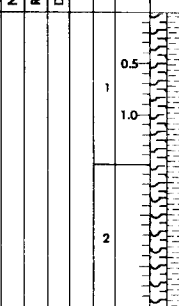
CARBONATE BOMB
3, 40-42 cm = 1-2%

SMEAR SLIDE SUMMARY

	Nannofossil diatomaceous claystone 1-113	Claystone 4-102
Sand	5	5
Silt	30	25
Clay	65	70
Quartz	8	20
Feldspar	4	10
Clay minerals	42	61
Volcanic glass	5	–
Pyrite	–	1
Diatoms	23	7
Sponge spicules	8	1
Calc. nannos	10	–

SITE 438 HOLE A CORE 55 CORED INTERVAL: 574.0-583.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE		PF, BF, RM	B	FM	AM	1, 2, 3, 4, 5, 6, CC	0.5, 1.0	VOID	V		114, 60, 25



LITHOLOGIC DESCRIPTION

Dark gray (5Y 4/1) and olive gray (5Y 4/2) diatomaceous claystone slightly mottled.

5Y 4/1

Diatomaceous claystone,

5Y 4/2

Sponge spicules pocket

5Y 4/2 diatomaceous claystone

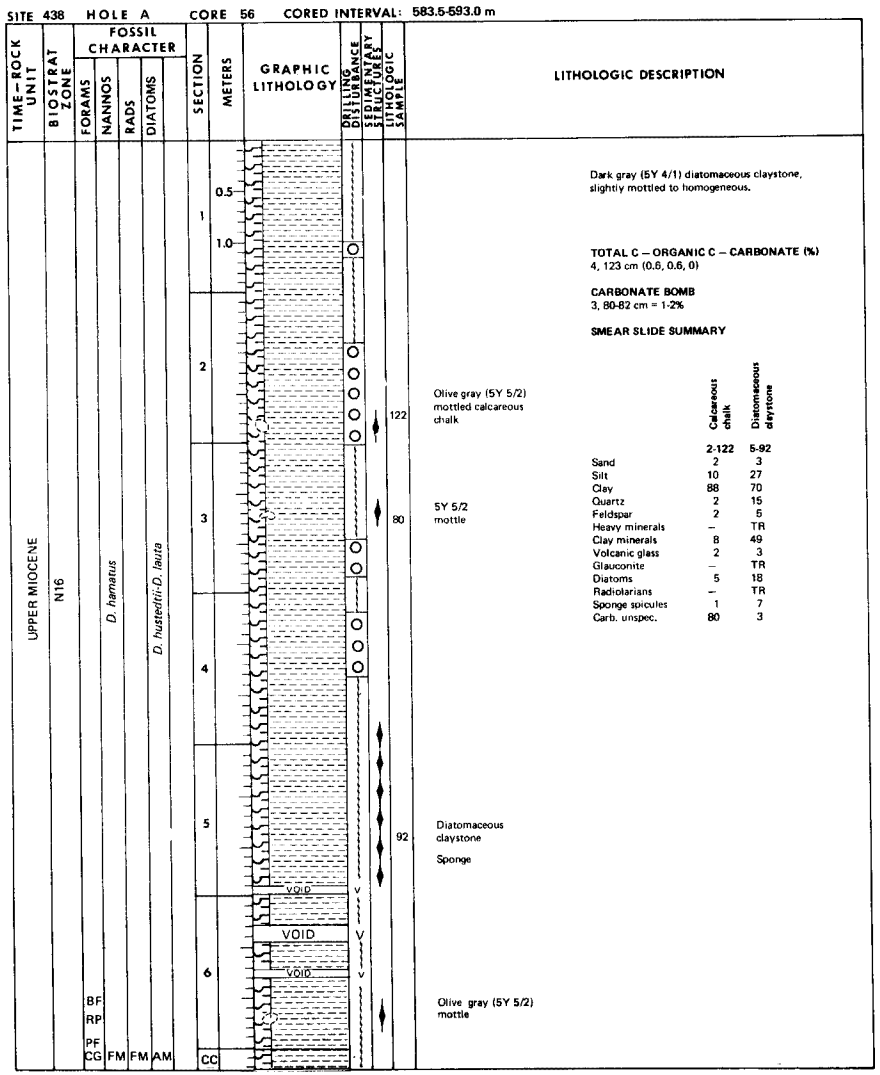
TOTAL C – ORGANIC C – CARBONATE (%)
4, 90 cm (0.8, 0.7, 1)

CARBONATE BOMB
3, 60-62 cm = 1-2%

SMEAR SLIDE SUMMARY

	Diatomaceous silicified claystone 2-114	Diatomaceous claystone 5-25
Sand	3	7
Silt	25	23
Clay	72	70
Quartz	21	10
Feldspar	4	8
Heavy minerals	–	1
Clay minerals	47	39
Volcanic glass	–	2
Diatoms	23	25
Sponge spicules	5	8
Carb. unspec.	–	5
Calc. nannos	–	1

SITE 438 HOLE A CORE 56 CORED INTERVAL: 583.5-593.0 m



Dark gray (5Y 4/1) diatomaceous claystone, slightly mottled to homogeneous.

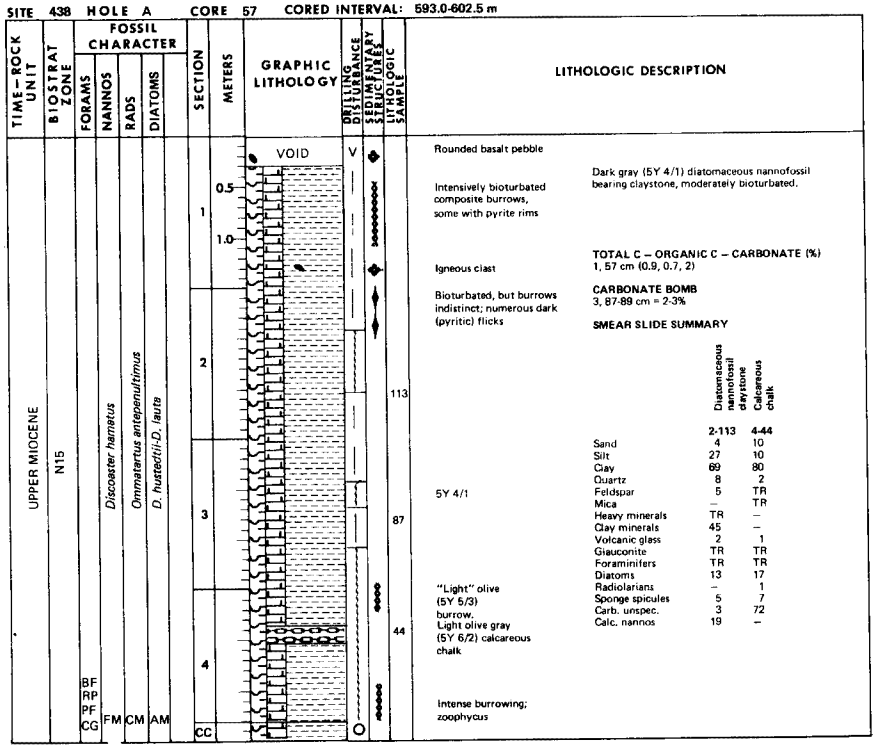
TOTAL C – ORGANIC C – CARBONATE (%)
4, 123 cm (0.6, 0.6, 0)

CARBONATE BOMB
3, 80-82 cm = 1-2%

SMEAR SLIDE SUMMARY

	Calcareous chalk 2-122	Diatomaceous claystone 5-92
Sand	2	3
Silt	10	27
Clay	88	70
Quartz	2	15
Feldspar	2	5
Heavy minerals	–	TR
Clay minerals	8	49
Volcanic glass	2	3
Glauconite	–	TR
Diatoms	5	18
Radiolarians	–	TR
Sponge spicules	1	7
Carb. unspec.	80	3

SITE 438 HOLE A CORE 57 CORED INTERVAL: 593.0-602.5 m



Dark gray (5Y 4/1) diatomaceous nannofossil bearing claystone, moderately bioturbated.

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

CARBONATE BOMB
3, 87-89 cm = 2-3%

SMEAR SLIDE SUMMARY

	Diatomaceous nannofossil claystone 2-113	Calcareous chalk 4-44
Sand	4	10
Silt	27	10
Clay	69	80
Quartz	8	2
Feldspar	5	TR
Mica	–	TR
Heavy minerals	TR	–
Clay minerals	45	–
Volcanic glass	2	1
Glauconite	TR	TR
Foraminifers	TR	TR
Diatoms	13	17
Radiolarians	–	1
Sponge spicules	5	7
Carb. unspec.	3	72
Calc. nannos	19	–

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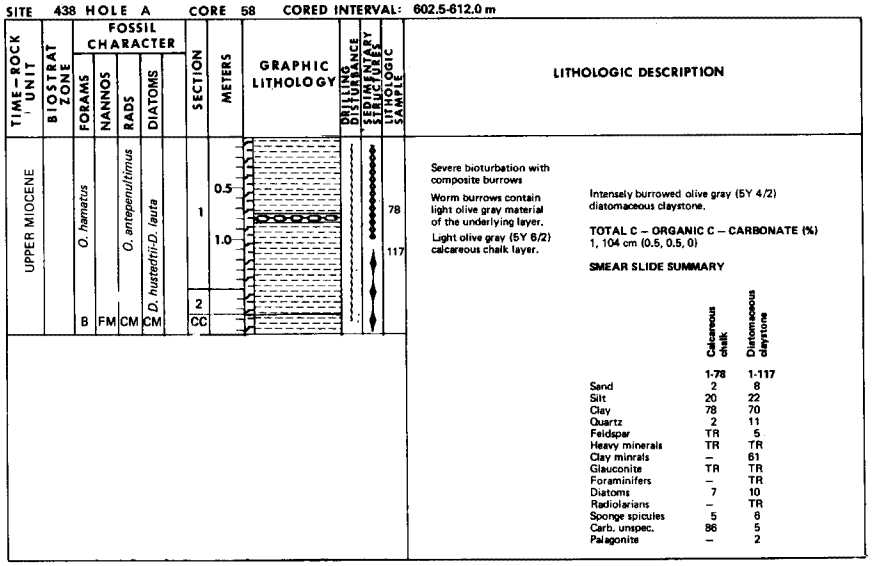
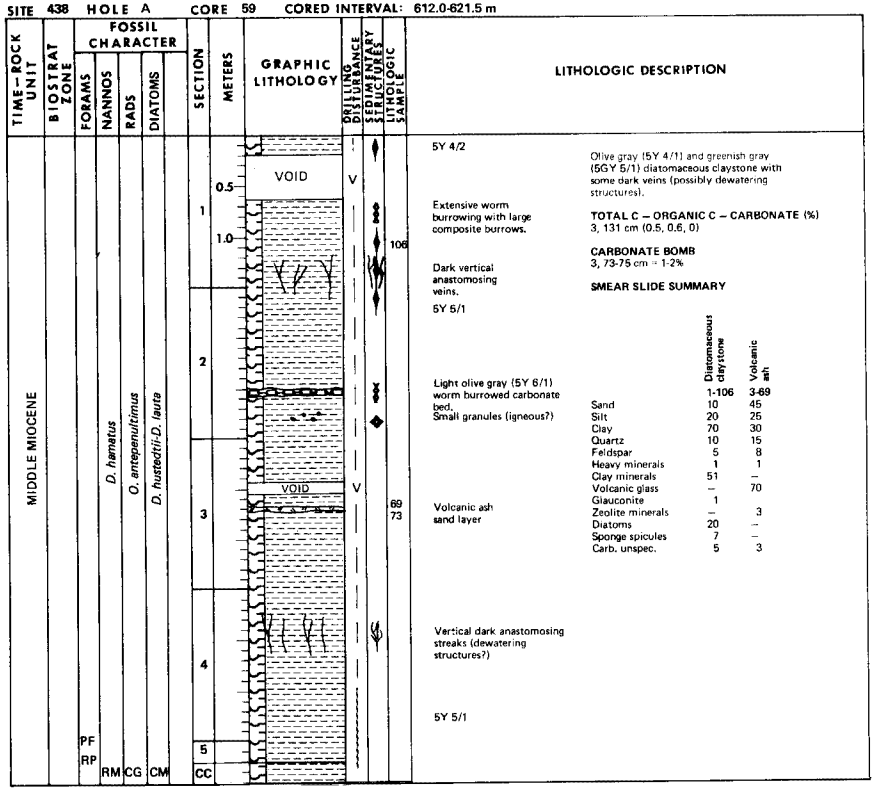
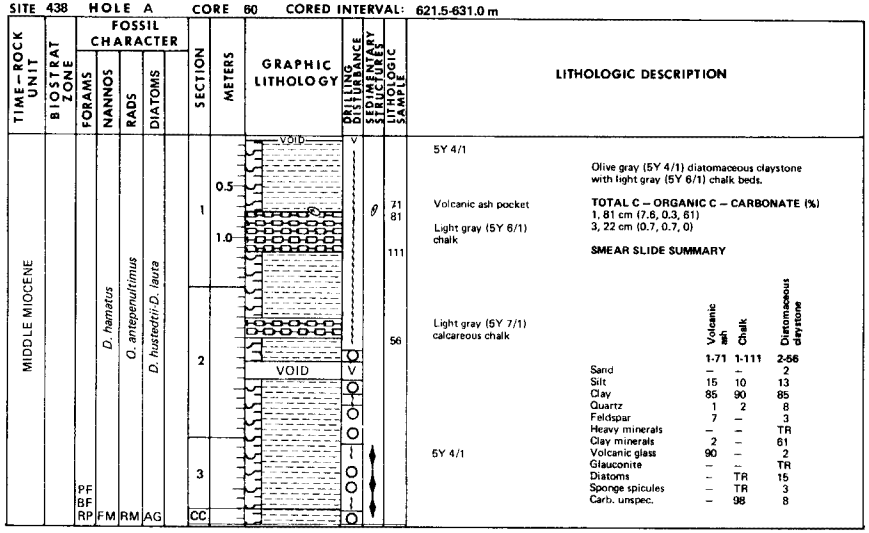
SITE 438 HOLE A CORE 58 CORED INTERVAL: 602.5-612.0 m



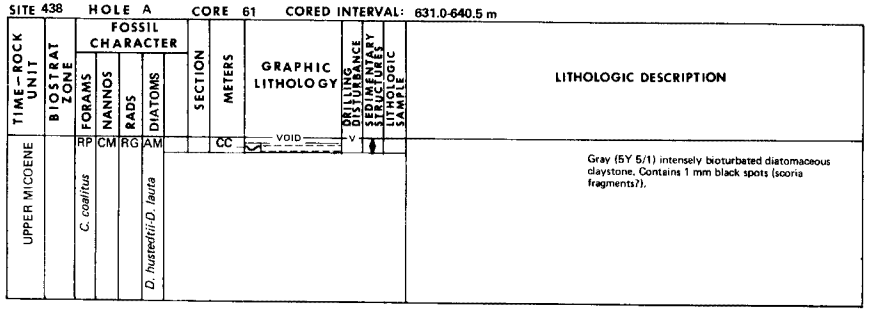
SITE 438 HOLE A CORE 59 CORED INTERVAL: 612.0-621.5 m



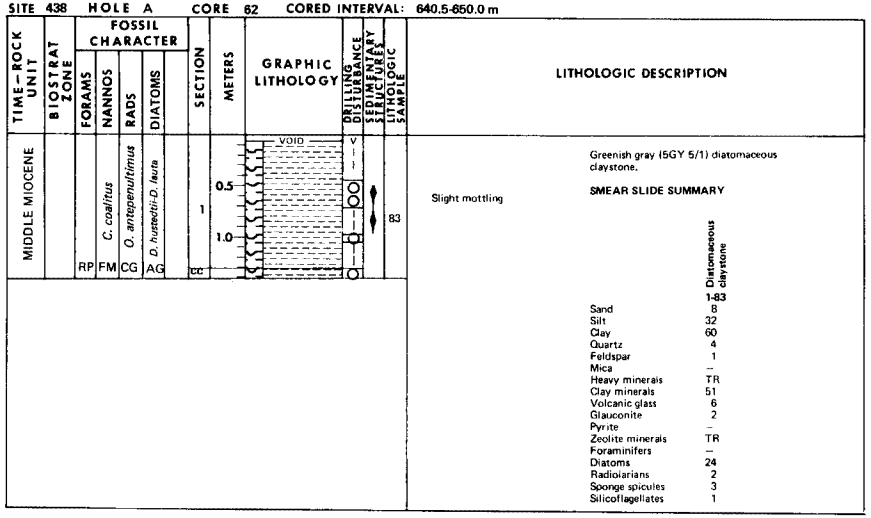
SITE 438 HOLE A CORE 60 CORED INTERVAL: 621.5-631.0 m



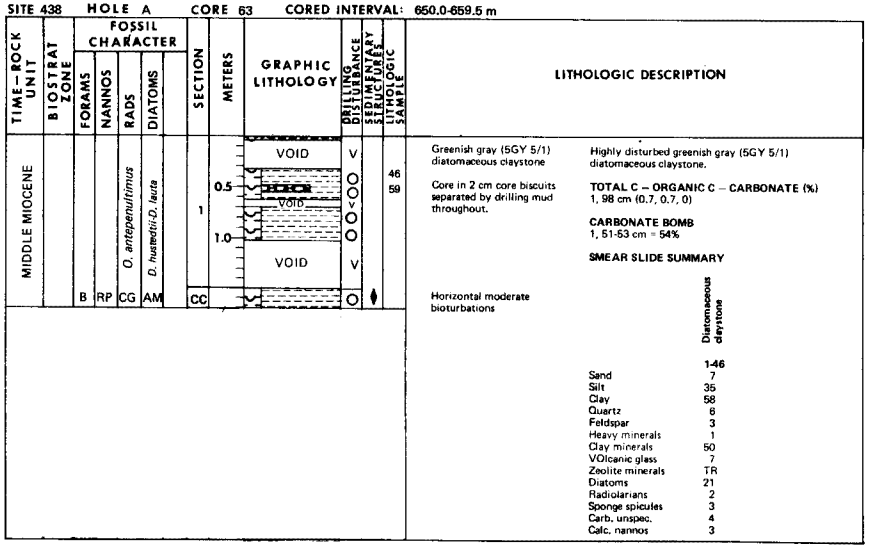
SITE 438 HOLE A CORE 61 CORED INTERVAL: 631.0-640.5 m



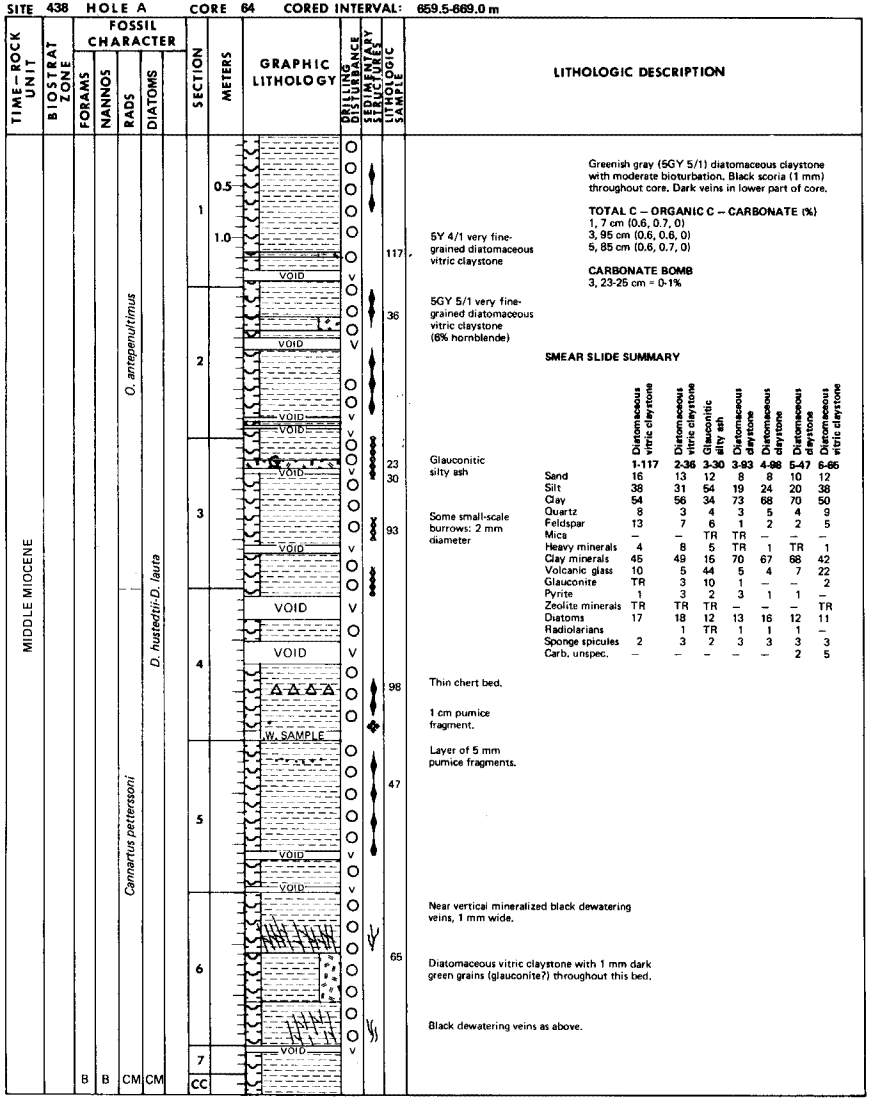
SITE 438 HOLE A CORE 62 CORED INTERVAL: 640.5-650.0 m



SITE 438 HOLE A CORE 63 CORED INTERVAL: 650.0-659.5 m



SITE 438 HOLE A CORE 64 CORED INTERVAL: 659.5-669.0 m



Greenish gray (5GY 5/1) diatomaceous claystone with moderate bioturbation. Black scoria (1 mm) throughout core. Dark veins in lower part of core.

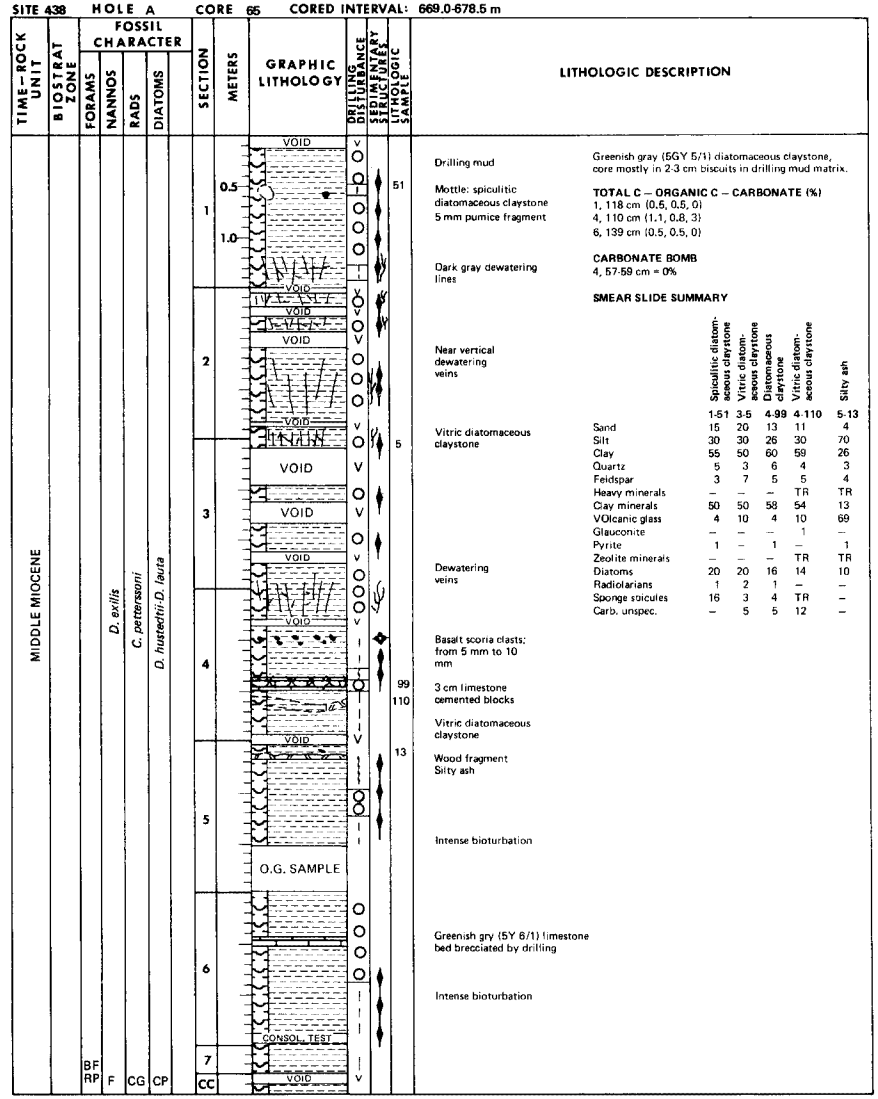
TOTAL C – ORGANIC C – CARBONATE (%)
1, 7 cm (0.6, 0.7, 0)
3, 95 cm (0.6, 0.6, 0)
5, 85 cm (0.6, 0.7, 0)

CARBONATE BOMB
3, 23-25 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous vitric claystone	Diatomaceous vitric claystone	Glauconitic silty ash	Diatomaceous claystone	Diatomaceous claystone	Diatomaceous claystone	Diatomaceous vitric claystone
	1-117	2-36	3-30	3-93	4-98	5-47	6-65
Sand	16	13	12	8	8	10	12
Silt	38	31	54	19	24	20	38
Clay	54	56	34	73	68	70	50
Quartz	8	3	4	3	5	4	9
Feldspar	13	7	6	1	2	2	5
Mica	–	–	TR	TR	–	–	–
Heavy minerals	4	8	5	TR	1	TR	1
Clay minerals	45	49	15	70	67	68	42
Volcanic glass	10	5	44	5	4	7	22
Glauconite	TR	3	10	1	–	–	2
Pyrite	1	3	2	3	1	1	–
Zeolite minerals	TR	TR	TR	–	–	–	TR
Diatoms	17	18	12	13	16	12	11
Radiolarians		1	TR	1	1	1	–
Sponge spicules	2	3	2	3	3	3	3
Carb. unspec.	–	–	–	–	–	2	5

SITE 438 HOLE A CORE 65 CORED INTERVAL: 669.0-678.5 m



Greenish gray (5GY 5/1) diatomaceous claystone, core mostly in 2-3 cm biscuits in drilling mud matrix.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 118 cm (0.5, 0.5, 0)
4, 110 cm (1.1, 0.8, 3)
6, 139 cm (0.5, 0.5, 0)

CARBONATE BOMB
4, 57-59 cm = 0%

SMEAR SLIDE SUMMARY

	Spiculitic diatomaceous claystone	Vitric diatomaceous claystone	Diatomaceous claystone	Vitric diatomaceous claystone	Silty ash
	1-51	3-5	4-99	4-110	5-13
Sand	15	20	13	11	4
Silt	30	30	26	30	70
Clay	55	50	60	59	26
Quartz	5	3	6	4	3
Feldspar	3	7	5	5	4
Heavy minerals	–	–	–	TR	TR
Clay minerals	50	50	58	54	13
VOlcanic glass	4	10	4	10	69
Glauconite	–	–	–	1	–
Pyrite	1	–	1	–	1
Zeolite minerals	–	–	–	TR	TR
Diatoms	20	20	16	14	10
Radiolarians	1	2	1	–	–
Sponge spicules	16	3	4	TR	–
Carb. unspec.	–	5	5	12	–

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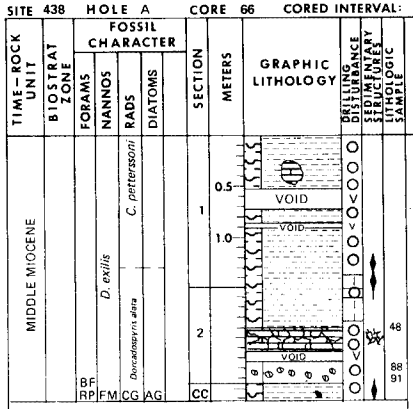
SITE 438 HOLE A CORE 66 CORED INTERVAL: 678.5-688.0 m



Drilling mud

Limestone block with "vertical" bedding (set in drilling mud)

Cemented limestone breccia greenish gray (5GY 6/1)

Breccia: dark matrix: calcareous (13%) diatomaceous claystone
Light blocks: limestone in 1-4 mm grains of irregular shape
5 mm pumice clast

Greenish gray (5GY 5/1) diatomaceous claystone with calcareous interval and recemented breccia.

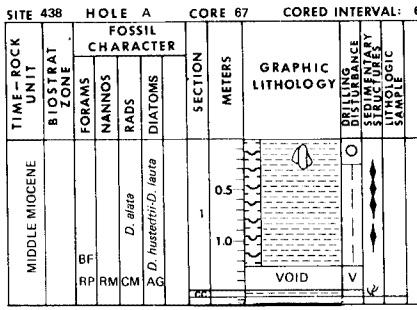
TOTAL C – ORGANIC C – CARBONATE (%)
1, 120 cm (0.6, 0.5, 0)

CARBONATE BOMB
2, 48-50 cm = 69%

SMEAR SLIDE SUMMARY

	Calcareous diatomaceous claystone 2-88	Limestone 2-91
Sand	6	–
Silt	25	5
Clay	69	95
Quartz	5	–
Feldspar	3	–
Heavy minerals	1	–
Clay minerals	55	–
Volcanic glass	3	5
Diatoms	13	2
Radiolarians	1	–
Sponge spicules	6	3
Carb. unspec.	13	85

SITE 438 HOLE A CORE 67 CORED INTERVAL: 688.0-697.5 m



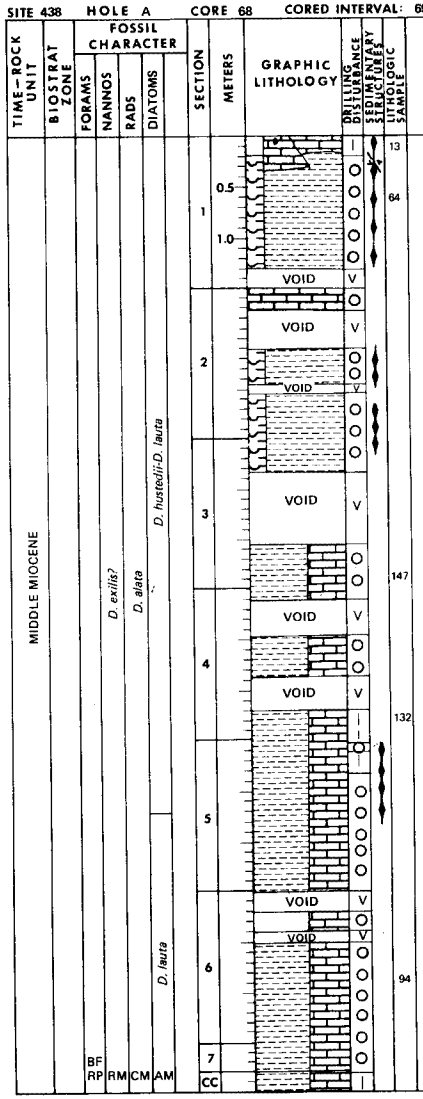
Drilling slurry vertical block of limestone and claystone

Intense mottling

Greenish gray (5GY 5/1) diatomaceous claystone.

Small block with dewatering veins

SITE 438 HOLE A CORE 68 CORED INTERVAL: 697.5-707.0 m



Black spot (13): clayey limestone bioturbated bed of muddy limestone (5GY 7/1) offset by a 3 cm synsedimentary structure.

Diatomaceous claystone

Greenish gray (5GY 7/1) limestone

Greenish gray (5GY 5/1) diatomaceous claystone

Diatomaceous claystone

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

Calcareous claystone in 3 cm drilling biscuits

Calcareous claystone (5GY 4/1)

Greenish gray (5GY 5/1) diatomaceous claystone until Section 3; calcareous claystone after.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 26 cm (1.0, 0.6, 3)
2, 125 cm (0.5, 0.5, 0)

CARBONATE BOMB
3, 147-149 cm = 3.4%

SMEAR SLIDE SUMMARY

	Clayey limestone 1-13	Diatomaceous claystone 1-64	Calcareous claystone 4-132	Calcareous claystone 6-94
Sand	8	12	5	6
Silt	30	27	30	33
Clay	62	61	65	61
Quartz	3	4	6	3
Feldspar	1	3	2	1
Heavy minerals	–	–	1	–
Clay minerals	27	58	50	50
Volcanic glass	1	5	2	1
Pyrite	–	1	–	–
Diatoms	4	19	6	6
Radiolarians	1	1	–	1
Sponge spicules	4	3	4	4
Carb. unspec.	59	6	29	34

MGS 1 0 5 5 0 2 7

SITE 438 HOLE A CORE 69 CORED INTERVAL: 707.0-716.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		BF RP	RM	CG *D. alata*	CM *D. lauta*	1	CC		O			Calcareous claystone, dark greenish gray (5GY 4/1) highly disturbed in drilling.

SITE 438 HOLE A CORE 70 CORED INTERVAL: 716.5-726.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE				*D. alata*	*D. lauta*	1	0.5 1.0		I O		48	Dark greenish gray (5GY 4/1) limestone Calcareous claystone
						2		VOID	V O		67	Claystone Intense bioturbations
						3		VOID	V O		77	2-3 cm drilling biscuits
						4		O.G. SAMPLE	V O		20	Diatomaceous claystone 3 cm drilling biscuits
						5		W. SAMPLE	O			
						6		VOID VOID	V I O O I O O			
						7		VOID VOID	V V			
		B	RM	FM	AM	CC			O			

Homogeneous to slightly mottled dark greenish (5GY 4/1) claystone, calcareous or diatomaceous.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 92 cm (0.5, 0.5, 0)
5, 57 cm (0.9, 0.9, 0)

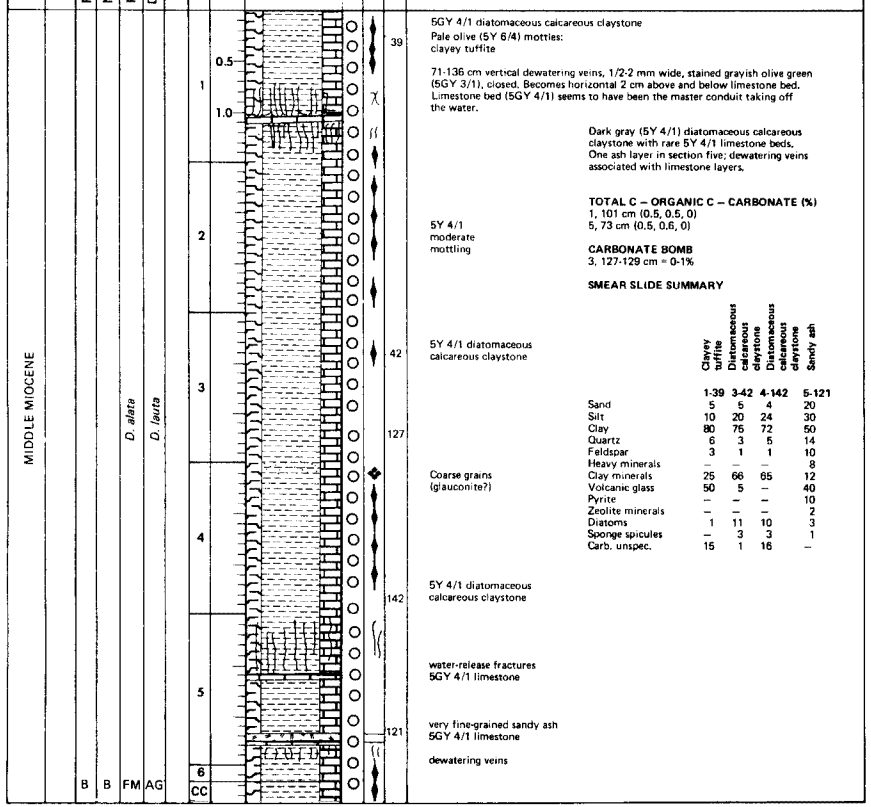
CARBONATE BOMB
3, 77-80 cm = 1%

SMEAR SLIDE SUMMARY

	Calcareous claystoen	Claystone	Diatomaceous claystone
	1-48	2-67	4-20
Sand	5	3	5
Silt	26	20	25
Clay	69	77	70
Quartz	6	4	6
Feldspar	3	2	2
Heavy minerals	–	–	1
Clay minerals	61	74	66
Volcanic glass	1	–	–
Glauconite	1	3	–
Pyrite	1	–	–
Diatoms	7	6	12
Radiolarians	–	1	1
Sponge spicules	3	2	3
Carb. unspec.	17	8	9

MGG 1505 0 2

SITE 438 HOLE A CORE 71 CORED INTERVAL: 726.0-735.5 m



Dark gray (5Y 4/1) diatomaceous calcareous claystone with rare 5Y 4/1 limestone beds. One ash layer in section five; dewatering veins associated with limestone layers.

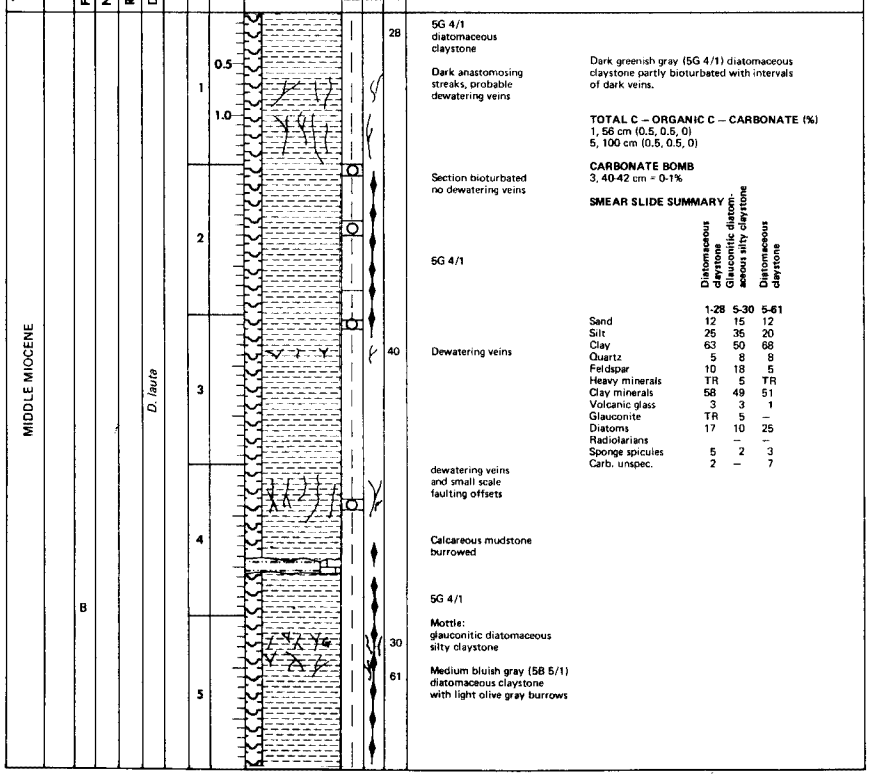
TOTAL C – ORGANIC C – CARBONATE (%)
1, 101 cm (0.5, 0.5, 0)
5, 73 cm (0.5, 0.6, 0)

CARBONATE BOMB
3, 127-129 cm = 0-1%

SMEAR SLIDE SUMMARY

	Clayey tuffite 1-39	Diatomaceous calcareous claystone 3-42	Diatomaceous calcareous claystone 4-142	Sandy ash 5-121
Sand	5	5	4	20
Silt	10	20	24	30
Clay	80	75	72	50
Quartz	6	3	5	14
Feldspar	3	1	1	10
Heavy minerals	—	—	—	8
Clay minerals	25	66	65	12
Volcanic glass	50	5	—	40
Pyrite	—	—	—	10
Zeolite minerals	—	—	—	2
Diatoms	1	11	10	3
Sponge spicules	—	3	3	1
Carb. unspec.	15	1	16	—

SITE 438 HOLE A CORE 72 CORED INTERVAL: 735.5-745.0 m



Dark greenish gray (5G 4/1) diatomaceous claystone partly bioturbated with intervals of dark veins.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 56 cm (0.5, 0.5, 0)
5, 100 cm (0.5, 0.5, 0)

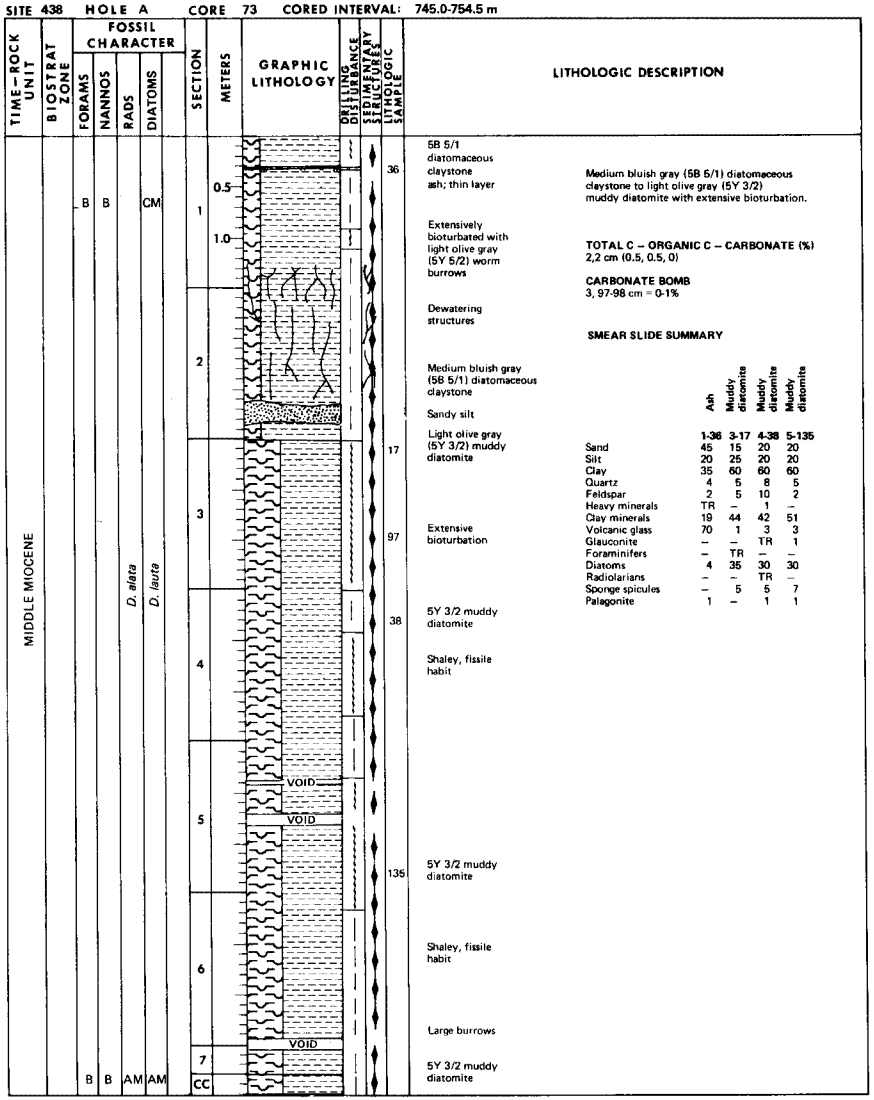
CARBONATE BOMB
3, 40-42 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-28	Glauconitic diatomaceous silty claystone 5-30	Diatomaceous claystone 5-61
Sand	12	15	12
Silt	25	35	20
Clay	63	50	68
Quartz	5	8	8
Feldspar	10	18	5
Heavy minerals	TR	5	TR
Clay minerals	58	49	51
Volcanic glass	3	3	1
Glauconite	TR	5	—
Diatoms	17	10	25
Radiolarians		—	—
Sponge spicules	5	2	3
Carb. unspec.	2	—	7

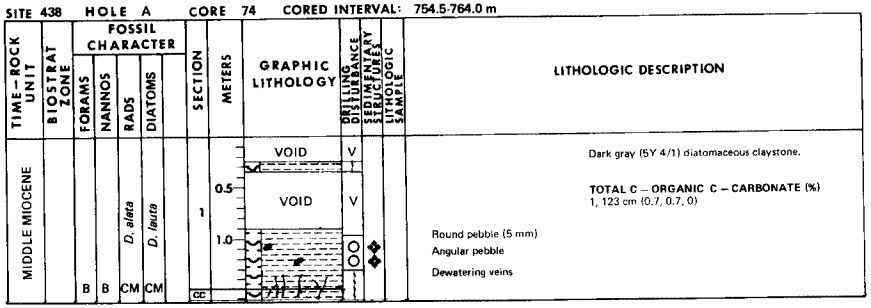
MGG 1505 502

SITE 438 HOLE A CORE 73 CORED INTERVAL: 745.0-754.5 m

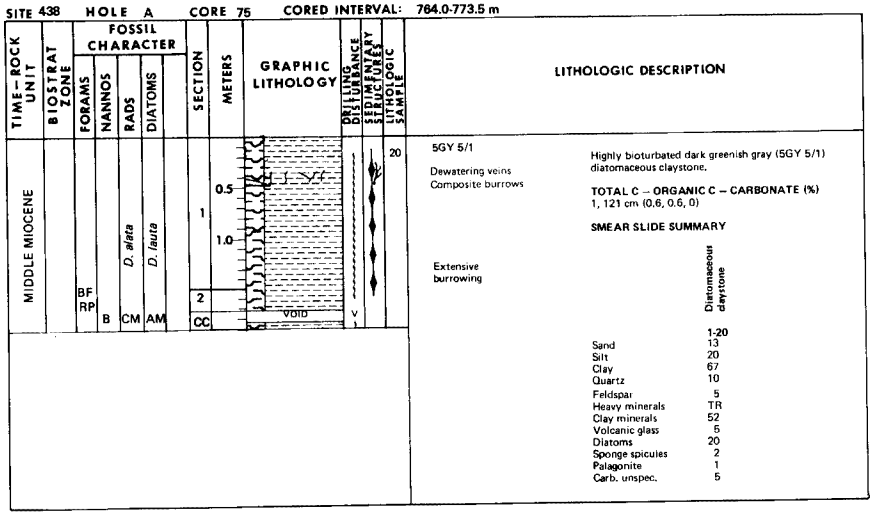


	Ash 1-36	Muddy diatomite 3-17	Muddy diatomite 4-38	Muddy diatomite 5-135
Sand	45	15	20	20
Silt	20	25	20	20
Clay	35	60	60	60
Quartz	4	5	8	5
Feldspar	2	5	10	2
Heavy minerals	TR	–	1	–
Clay minerals	19	44	42	51
Volcanic glass	70	1	3	3
Glauconite	–	–	TR	1
Foraminifers	–	TR	–	–
Diatoms	4	35	30	30
Radiolarians	–	–	TR	–
Sponge spicules	–	5	5	7
Palagonite	1	–	1	1

SITE 438 HOLE A CORE 74 CORED INTERVAL: 754.5-764.0 m

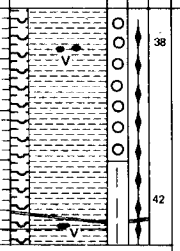


SITE 438 HOLE A CORE 75 CORED INTERVAL: 764.0-773.5 m



	Diatomaceous claystone 1-20
Sand	13
Silt	20
Clay	67
Quartz	10
Feldspar	5
Heavy minerals	TR
Clay minerals	52
Volcanic glass	5
Diatoms	20
Sponge spicules	2
Palagonite	1
Carb. unspec.	5

SITE 438 HOLE A CORE 76 CORED INTERVAL: 773.5-783.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		B	B	FM *D. alata*	CM *D. lauta*	1, 2, CC	0.5, 1.0				38, 42	5GY 5/1; 5GY 5/1; Burrow

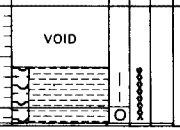
Medium greenish gray (5GY 5/1) diatomaceous claystone with bioturbation throughout core, rare ash pockets.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 113 cm (0.8, 0.8, 0)

SMEAR SLIDE SUMMARY

	Tuff (M) 1-38	Diatomaceous claystone (D) 2-42
Sand	10	7
Silt	20	23
Clay	70	70
Quartz	3	10
Feldspar	2	5
Heavy minerals	TR	TR
Clay minerals	10	43
Volcanic glass	75	12
Diatoms	10	20
Radiolaria	TR	
Sponge spicules	TR	5
Glauconite		TR
Carb. unspec.		5

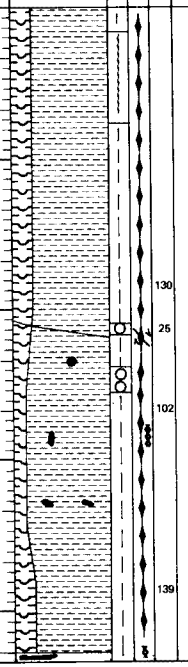
SITE 438 HOLE A CORE 77 CORED INTERVAL: 783.0-792.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		B	B	CM *D. alata*	AM *D. lauta*	1, CC	0.5	VOID 				5Y 5/1

Medium olive gray (5Y 5/1) diatomaceous claystone with burrows.

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

SITE 438 HOLE A CORE 78 CORED INTERVAL: 792.5-802.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		BF RP	B	CM *D. alata*	CM *D. lauta*	1, 2, 3, 4, 5, CC	0.5, 1.0				130, 25, 102, 139	5GY 5/1; 5GY 5/1; Minor fault which cuts bioturbated bed; Tuff; 5GY 5/1; Burrow; Tuff; 5GY 5/1; Calcite filled burrow in the Core-Catcher

Medium greenish gray (5GY 5/1) diatomaceous claystone throughout core with bioturbation (color light olive gray – 5Y 6/1) throughout; A few pockets of tuff are observed in the lower part of the core.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 68 cm (0.8, 0.7, 0)

CARBONATE BOMB
3, 102-104 cm = 1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D) 2-130	Diatomaceous claystone (D) 3-25	Diatomaceous claystone (D) 4-139
Sand	2	1	7
Silt	17	10	20
Clay	81	89	73
Quartz	7	8	5
Feldspar	2	5	2
Heavy minerals	TR	TR	TR
Clay minerals	51	59	53
Volcanic glass	10	10	8
Diatoms	22	15	27
Sponge spicules	7	3	5

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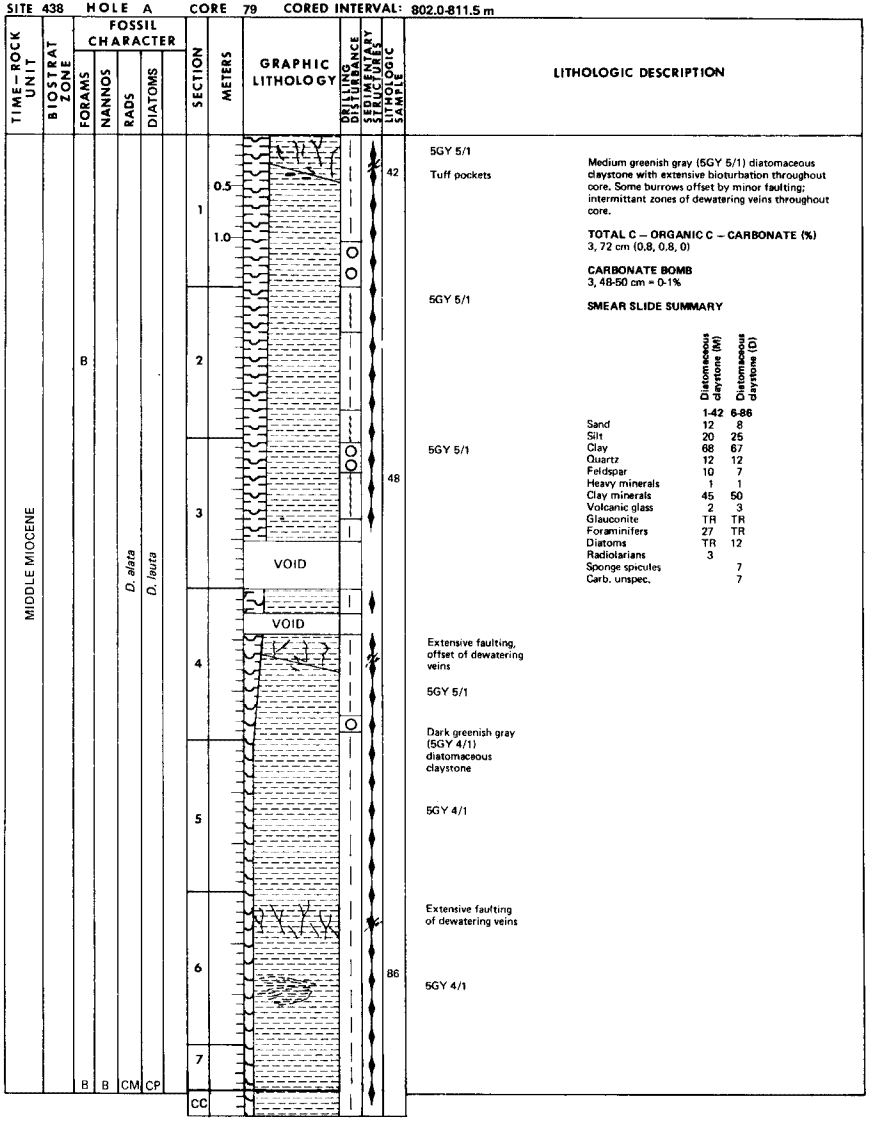
SITE 438 HOLE A CORE 79 CORED INTERVAL: 802.0-811.5 m



Medium greenish gray (5GY 5/1) diatomaceous claystone with extensive bioturbation throughout core. Some burrows offset by minor faulting; intermittant zones of dewatering veins throughout core.

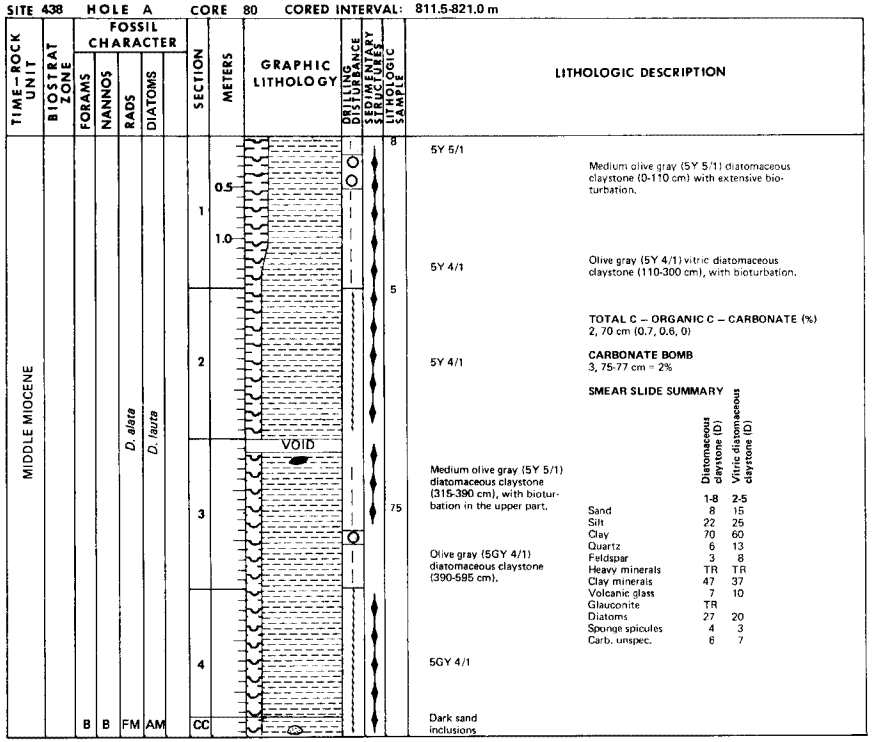
TOTAL C – ORGANIC C – CARBONATE (%)
3, 72 cm (0.8, 0.8, 0)

CARBONATE BOMB
3, 48-50 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (M)	Diatomaceous claystone (D)
	1-42	6-86
Sand	12	8
Silt	20	25
Clay	68	67
Quartz	12	12
Feldspar	10	7
Heavy minerals	1	1
Clay minerals	45	50
Volcanic glass	2	3
Glauconite	TR	TR
Foraminifers	27	TR
Diatoms	TR	12
Radiolarians	3	
Sponge spicules		7
Carb. unspec.		7

SITE 438 HOLE A CORE 80 CORED INTERVAL: 811.5-821.0 m



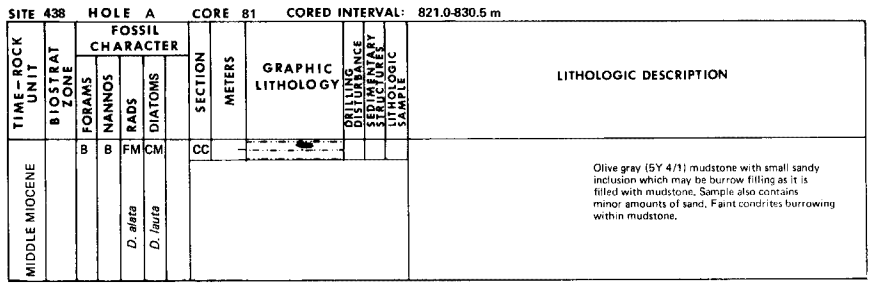
TOTAL C – ORGANIC C – CARBONATE (%)
2, 70 cm (0.7, 0.6, 0)

CARBONATE BOMB
3, 75-77 cm = 2%

SMEAR SLIDE SUMMARY

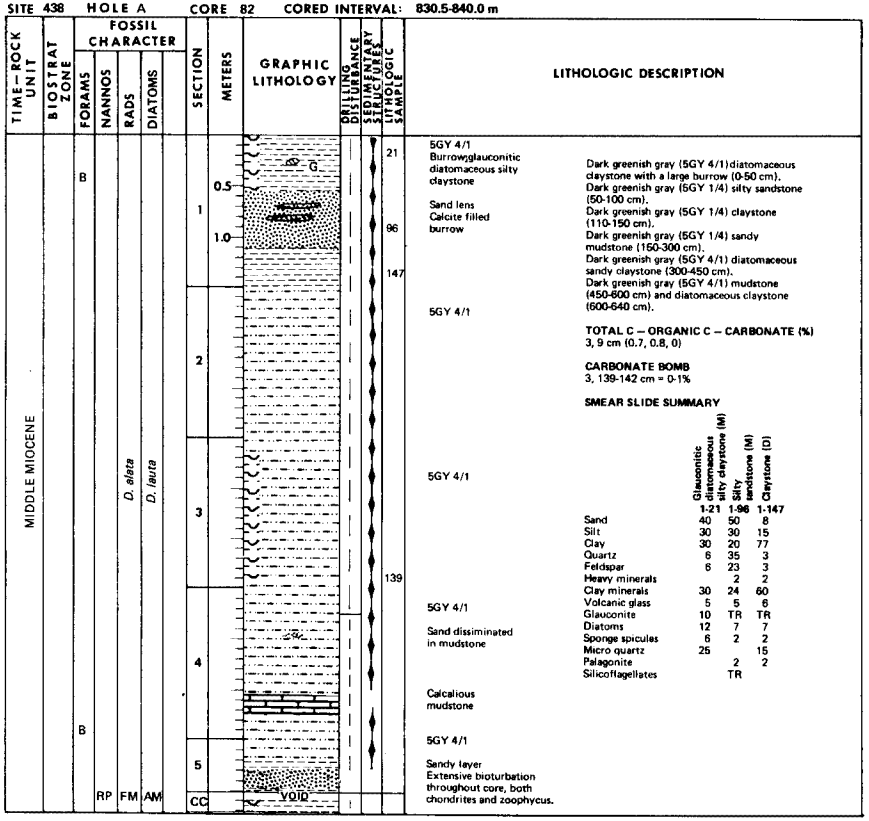
	Diatomaceous claystone (D)	Vitric diatomaceous claystone (D)
	1-8	2-5
Sand	8	15
Silt	22	25
Clay	70	60
Quartz	6	13
Feldspar	3	8
Heavy minerals	TR	TR
Clay minerals	47	37
Volcanic glass	7	10
Glauconite	TR	
Diatoms	27	20
Sponge spicules	4	3
Carb. unspec.	6	7

SITE 438 HOLE A CORE 81 CORED INTERVAL: 821.0-830.5 m

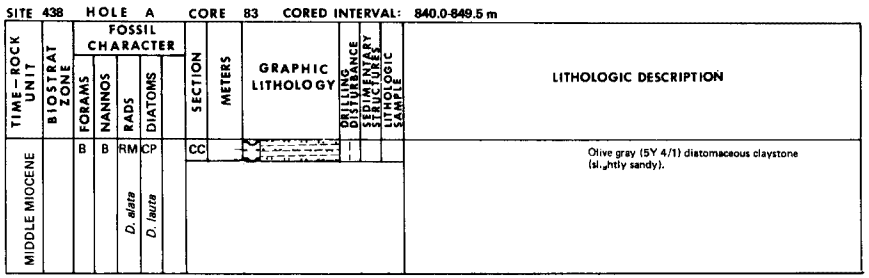


Olive gray (5Y 4/1) mudstone with small sandy inclusion which may be burrow filling as it is filled with mudstone. Sample also contains minor amounts of sand. Faint condrites burrowing within mudstone.

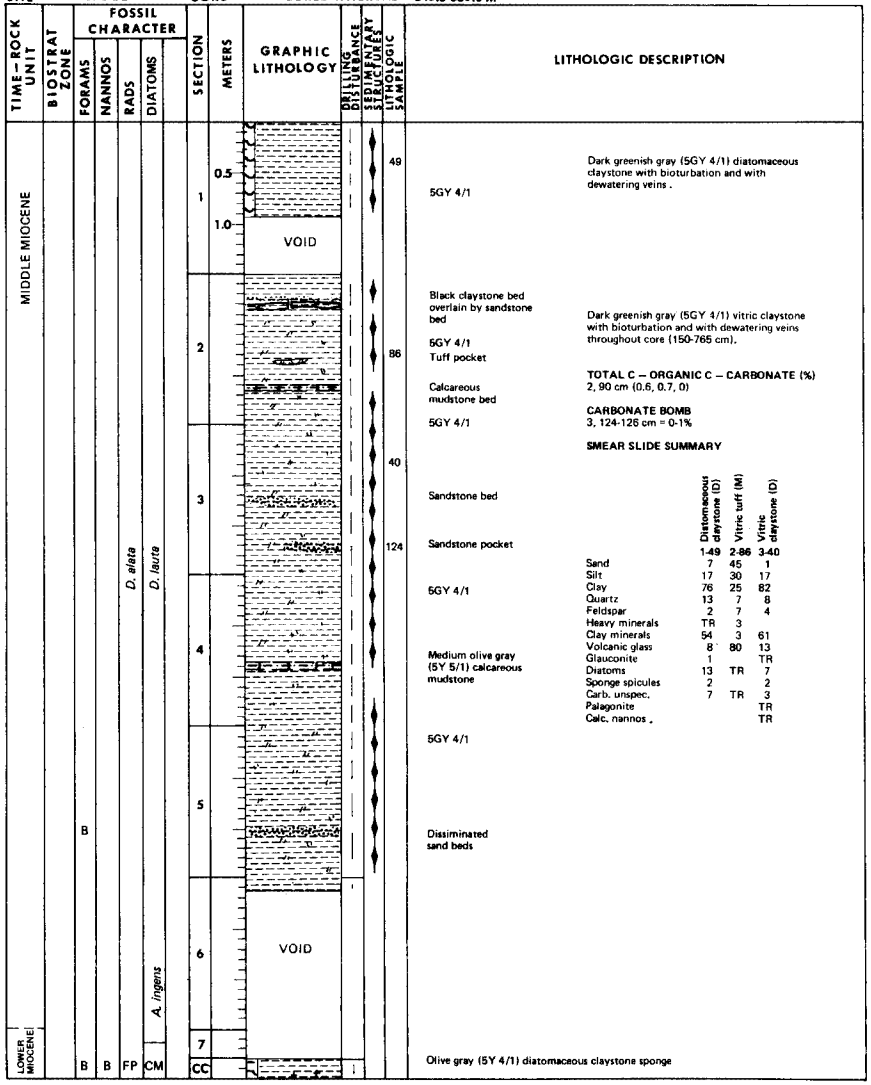
SITE 438 HOLE A CORE 82 CORED INTERVAL: 830.5-840.0 m



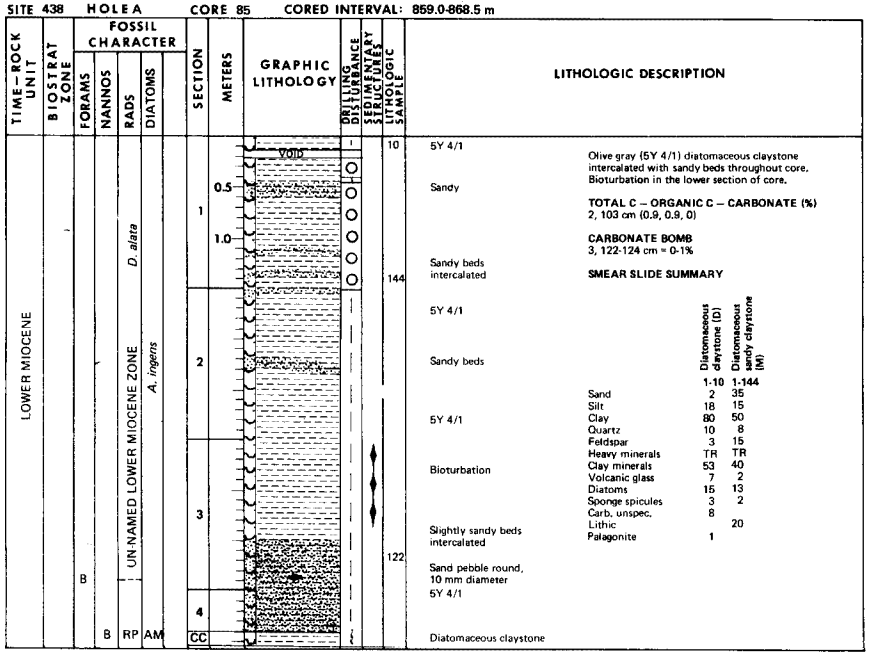
SITE 438 HOLE A CORE 83 CORED INTERVAL: 840.0-849.5 m



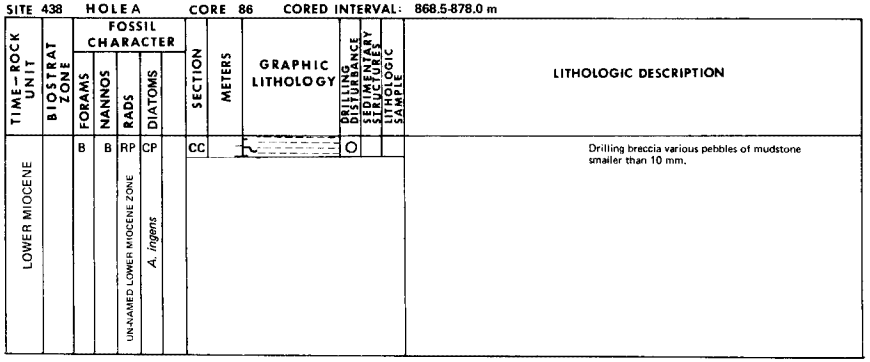
SITE 438 HOLE A CORE 84 CORED INTERVAL: 849.5-859.0 m



SITE 438 HOLE A CORE 85 CORED INTERVAL: 859.0-868.5 m



SITE 438 HOLE A CORE 86 CORED INTERVAL: 868.5-878.0 m



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SITE SUMMARY SHEET

HOLE 438B

Date occupied	October 27, 1977
Date departed	November 2, 1977
Time on hole	7 days
Position: latitude	40° 37.80'N
longitude	143° 14.80'E
Water depth (sea level)	1564.5 corrected meters, echo sounding
Water depth (rig floor)	1574.5 corrected meters, echo sounding
Bottom felt at	1574.5 meters, drill pipe
Penetration	1040.7 meters
Number of holes	1
Number of cores	24
Total length of cored section	215.9 meters
Total core recovery	192.6 meters
Percentage core recovery	45%

Oldest Sediment Cored

Depth sub-bottom	1040.7 meters
Nature	Clayey siltstone
Age	Lower Miocene
Measured velocity	2.0 to 3.5 km/s
	Average 2.2 km/s

Principal Results:

At Site 438 three holes were drilled, the deepest to 1040 meters, and 122 cores were recovered. At maximum depth, rocks are of lower Miocene age, and the Pliocene and Pleistocene boundaries are at 380 and 52 meters respectively. Hole 438 penetrated sandy, silty clay with erratic pebbles and the hole was ended at 110 meters because of a medical emergency. Hole 438A was cored and logged to 868 meters through a generally uniform diatomaceous silt and clay section divided as follows: from diatomaceous clay to diatom ooze with numerous ash layers and uniformly straight log traces; 364 to 593 meters, mostly upper Miocene diatomaceous claystone to clayey diatomite of variable induration which gave highly variable log traces; 593 to 818 meters, largely middle Miocene claystone, diatomaceous claystone and calcareous claystone with some thin limestone beds; 818 to 878 meters, largely lower Miocene sandy and diatomaceous claystone, in part vitric, marked by a pronounced shift in all log traces. Hole 438B was a re-entry hole washed to 850 meters and cored to 1040 meters prior to hole failure in highly fractured claystone. The section consists of lower Miocene diatomaceous claystone with highly vitric sandy-silty claystones to 976 meters. From 976 meters to 1040 meters, samples consist of highly-fractured, well indurated, dark clayey siltstone. This section is similar to other Neogene sections drilled on northeastern Pacific margins. Hole 438B ended 250 meters short of the main objective at this site, an acoustic basement that may establish the boundary of oceanic and continental crust between the Japan trench and the continental shelf. This objective was attained at Site 439, 5 km east.

SITE 438 HOLE B CORE 1 CORED INTERVAL: 571.5-581.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE	*Discoaster neohamatus* / *Denticula hustedtii*	B	CM	FM	CM	1, 2, 3, 4, CC	0.5, 1.0	DRILLING SLURRY; VOID	O; V			Drilling slurry of olive gray silty clay. Bioturbated olive gray clay.

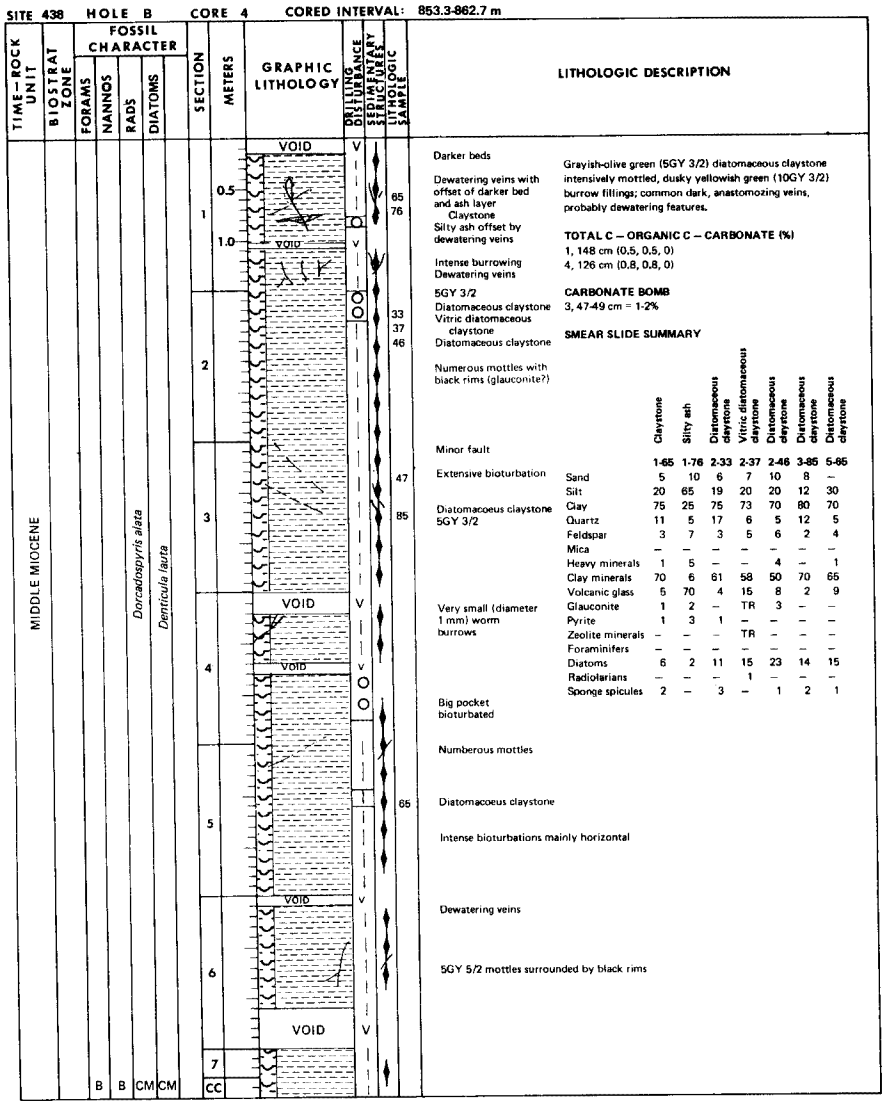
SITE 438 HOLE B CORE 2 CORED INTERVAL: 661.5-671.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	*Catinaster coalitus* / *Ommatartus antepenultimus* / *D. lauta*	B	RM	CM	CM	1, 2, 3, 4, 5, CC	0.5, 1.0	DRILLING SLURRY	O			Drilling slurry of olive gray mud.

SITE 438 HOLE B CORE 3 CORED INTERVAL: 786.0-795.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE	*Dorcadospyris alata* / *Denticula lauta*	B	B	FM	CP	1, 2, 3	0.5, 1.0					Grayish olive to dark grayish olive (10Y4/2-3/2), moderately mottled diatomaceous claystone with some intervals of light colored burrow-mottling which is totally $CaCO_3$ unspecified and very well cemented. Small blue-gray calcareous burrow filling (hard). Colored calcareous filled burrows. Dark gray veining, irregular; dewatering veins? Light colored burrowed interval (cemented $CaCO_3$). Hackly fractures in core mostly vertical orientation (probable drilling disturbance)

SITE 438 HOLE B CORE 4 CORED INTERVAL: 853.3-862.7 m



LITHOLOGIC DESCRIPTION

Darker beds

Dewatering veins with offset of darker bed and ash layer

Claystone

Silty ash offset by dewatering veins

Intense burrowing

Dewatering veins

5GY 3/2

Diatomaceous claystone

Vitric diatomaceous claystone

Diatomaceous claystone

Numerous mottles with black rims (glauconite?)

Minor fault

Extensive bioturbation

Diatomaceous claystone 5GY 3/2

Very small (diameter 1 mm) worm burrows

Big pocket bioturbated

Numberous mottles

Diatomaceous claystone

Intense bioturbations mainly horizontal

Dewatering veins

5GY 5/2 mottles surrounded by black rims

Grayish-olive green (5GY 3/2) diatomaceous claystone intensively mottled, dusky yellowish green (10GY 3/2) burrow fillings; common dark, anastomozing veins, probably dewatering features.

TOTAL C – ORGANIC C – CARBONATE (%)

1, 148 cm (0.5, 0.5, 0)
4, 126 cm (0.8, 0.8, 0)

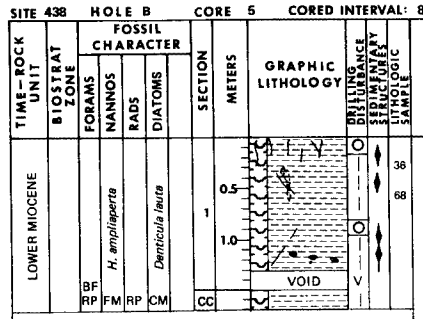
CARBONATE BOMB

3, 47-49 cm = 1-2%

SMEAR SLIDE SUMMARY

	Claystone 1-65	Silty ash 1-76	Diatomaceous claystone 2-33	Vitric diatomaceous claystone 2-37	Diatomaceous claystone 2-46	Diatomaceous claystone 3-85	Diatomaceous claystone 5-65
Sand	5	10	6	7	10	8	–
Silt	20	65	19	20	20	12	30
Clay	75	25	75	73	70	80	70
Quartz	11	5	17	6	5	12	5
Feldspar	3	7	3	5	6	2	4
Mica	–	–	–	–	–	–	–
Heavy minerals	1	5	–	–	4	–	1
Clay minerals	70	6	61	58	50	70	65
Volcanic glass	5	70	4	15	8	2	9
Glauconite	1	2	–	TR	3	–	–
Pyrite	1	3	1	–	–	–	–
Zeolite minerals	–	–	–	TR	–	–	–
Foraminifers	–	–	–	–	–	–	–
Diatoms	6	2	11	15	23	14	15
Radiolarians	–	–	–	1	–	–	–
Sponge spicules	2	–	3	–	1	2	1

SITE 438 HOLE B CORE 5 CORED INTERVAL: 862.3-872.1 m



LITHOLOGIC DESCRIPTION

Dewatering veins

Black

Burrow fills with diatomaceous clayey tuff, offset by fault (dewatering veins)

Diatomaceous claystone

Minor fault

Small pockets of tuff (black)

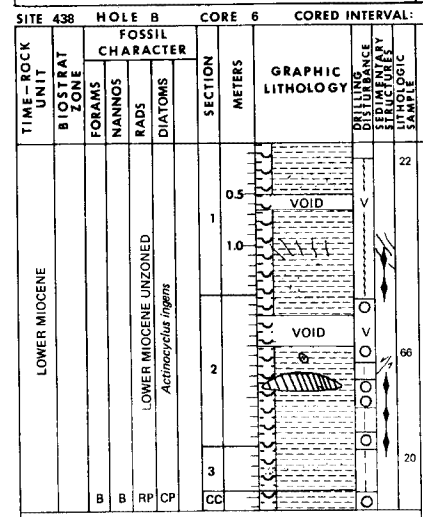
Black spots (glauconite or grains of tuff?)

Grayish-olive green (5GY 3/2) diatomaceous claystone slightly mottled (5GY 5/2) with common dark veins and some microfaults.

SMEAR SLIDE SUMMARY

	Diatomaceous clayey tuff 1-36	Diatomaceous claystone 1-68
Sand	40	–
Silt	30	20
Clay	30	80
Quartz	7	7
Feldspar	10	5
Mica	–	–
Heavy minerals	5	–
Clay minerals	30	71
Volcanic glass	30	5
Glauconite	–	–
Pyrite	1	1
Zeolite minerals	TR	1
Foraminifers	–	–
Diatoms	15	10
Radiolarians	1	
Sponge spicules	1	TR

SITE 438 HOLE B CORE 6 CORED INTERVAL: 872.1-881.5 m



LITHOLOGIC DESCRIPTION

Drilling mud

Diatomaceous claystone (10% diatoms)

Disseminated black grains throughout section

Small fractures

Moderate mottling with dark yellowish orange (10YR 6/6) burrows

Drilling breccia

Ash pocket (diameter 1.5 cm) medium bluish gray (5B 5/1) fault surface with slickensides (45°) on cut

Distinctive burrows filled with dark yellowish orange (10YR 6/6) carbonate cemented sediment

Black grains throughout

Drilling breccia

Grayish-olive green (5GY 3/2) diatomaceous claystone with moderate bioturbation and some faults and veins.

TOTAL C – ORGANIC C – CARBONATE (%)

1, 125 cm (0.5, 0.5, 0)

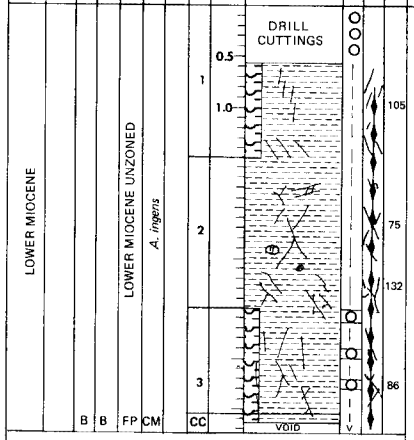
CARBONATE BOMB

3, 20-22 cm = 0%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-22	Silty ash 2-66
Sand	5	13
Silt	20	60
Clay	75	27
Quartz	5	8
Feldspar	5	5
Mica	–	–
Heavy minerals	1	3
Clay minerals	69	10
Volcanic glass	8	70
Glauconite	–	
Pyrite	1	
Zeolite minerals	–	
Foraminifers	–	
Diatoms	10	2
Radiolarians	–	
Sponge spicules	1	
Palagonite	–	2

SITE 438 HOLE B CORE 7 CORED INTERVAL: 881.5-890.9 m



LITHOLOGIC DESCRIPTION

Drill cuttings

Dark stained fractures
Diatomaceous claystone (10% diatom)

Extensive bioturbations throughout Sections 2 and 3 with dusky yellow green (5GY 5/2) carbonate burrow fillings
Microfractures
Claystone

Tuffs pockets (3-10 mm of diameter)

Extensive bioturbations and microfaults and fractures (thin, planar surfaces)

Grayish-olive green (5GY 3/2) diatomaceous claystone and claystone with dusky yellow green (5GY 5/2) bioturbated pockets; extensively veined, fractured, and faulted.

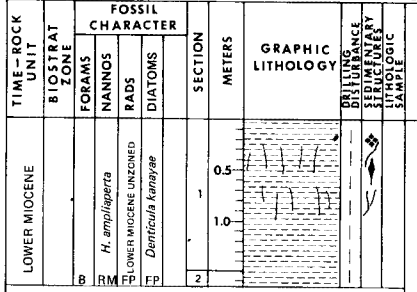
TOTAL C – ORGANIC C – CARBONATE (%)
1, 136 cm (0.8, 0.8, 0)

CARBONATE BOMB
2, 132 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-105	Claystone 2-75	Diatomaceous claystone 3-86
Sand	–	–	
Silt	20	20	25
Clay	80	80	75
Quartz	4	5	10
Feldspar	4	2	4
Mica	–	–	–
Heavy minerals	1	1	1
Clay minerals	76	76	66
Volcanic glass	5	8	8
Glauconite	–	–	TR
Pyrite	–	–	–
Zeolite minerals	–	–	–
Foraminifers	–	–	
Diatoms	10	8	10
Radiolarians	–	–	–
Sponge spicules	TR	TR	–
Palagonite	–	–	1

SITE 438 HOLE B CORE 8 CORED INTERVAL: 890.9-900.3 m



LITHOLOGIC DESCRIPTION

2 cm bit-rounded limestone clast
Claystone, pale olive (5Y 6/4)
calcareous mottle

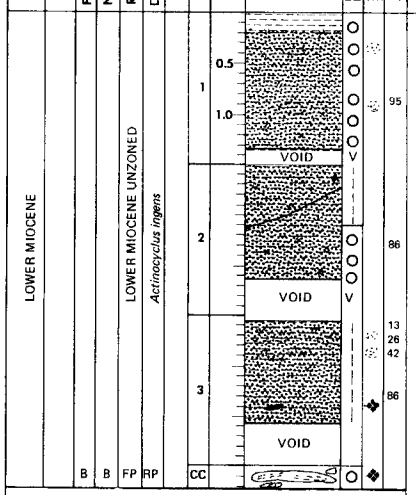
Near vertical dewatering veins

Olive gray (5Y 4/2) claystone. Core is small in diameter, owing to bit problem, persistent veining.

SMEAR SLIDE SUMMARY

	Claystone 1-44
Sand	
Silt	15
Clay	85
Quartz	5
Feldspar	3
Mica	–
Heavy minerals	1
Clay minerals	70
Volcanic glass	5
Glauconite	
Pyrite	
Zeolite minerals	
Foraminifers	
Diatoms	5
Radiolarians	
Sponge spicules	1
Carb. unspec.	10

SITE 438 HOLE B CORE 9 CORED INTERVAL: 900.3-909.7 m



LITHOLOGIC DESCRIPTION

mottle

mottle

5Y 4/2 dewatering veins

calcite cemented mottle (1 cm diameter)

mottles or burrows containing coarse sand

wood fragment 5 mm length

Dark gray (5Y 4/1) subrounded calcite pebble
Dark, medium olive gray (5Y 3/2, 5Y 4/2) highly burrowed silty claystone

Olive gray (5Y 4/2) claystone 10-15 cm

Olive gray (5Y 4/2) medium- to coarse-grained clayey sandstone, poorly sorted. Pumice, hornblende and plagioclase grains prominent in coarsest fraction.

Olive gray (5Y 4/2) sandy silty claystone, poorly sorted. White very coarse-grained sands with composition of glass and feldspar.

Olive gray (5Y 4/2) vitric silty sandy claystone. Moderately mottled. Somewhat faulted and brecciated containing some coarse fragments.

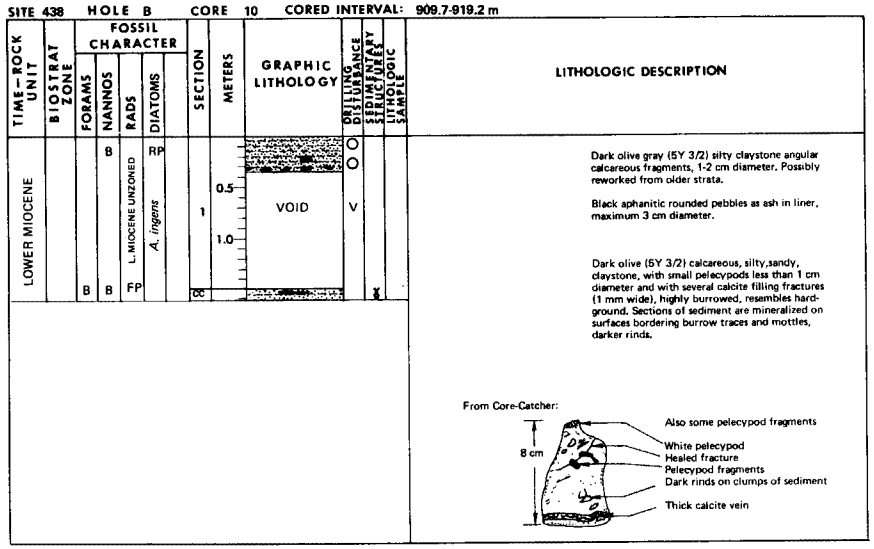
TOTAL C – ORGANIC C – CARBONATE (%)
3, 88 cm (0.4, 0.5, 0)

CARBONATE BOMB
3, 42-45 cm = 2%

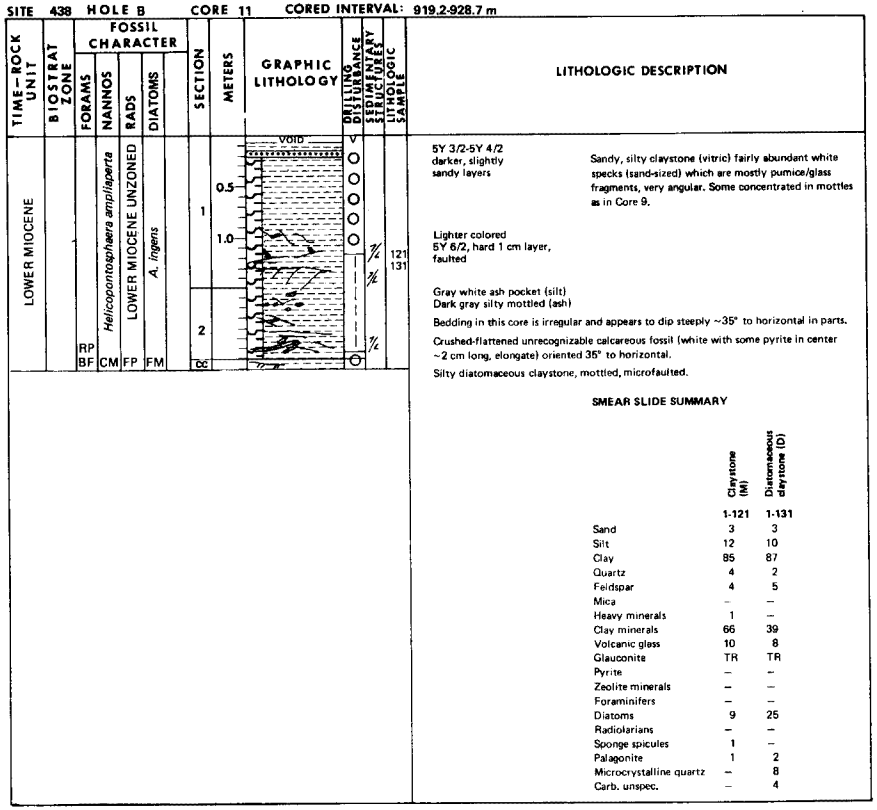
SMEAR SLIDE SUMMARY

	Sandy claystone (D) 1-95	Vitric silty claystone (D) 2-86	Vitric clayey sandstone (D) 3-15	Sandy silty muddy tuff (M) 3-26	Vitric sandy claystone (D) 3-86
Sand	40	15	55	30	35
Silt	10	30	15	25	20
Clay	50	55	30	45	45
Quartz	5	8	20	4	5
Feldspar	7	15	25	8	10
Mica	–	–	–	TR	–
Heavy minerals	–	6	7	3	3
Clay minerals	65	46	25	49	33
Volcanic glass	13	20	15	30	25
Glauconite	TR	TR	–	TR	5
Pyrite	–	–	–	–	–
Zeolite minerals	TR	–	–	–	–
Foraminifers	–	–	–	–	–
Diatoms	5	3	5	2	7
Radiolarians	–	–	–	–	–
Sponge spicules	TR	TR	–	–	–
Microcrystalline quartz	–	–	–	–	10
Palagonite	–	–	3	3	2

SITE 438 HOLE B CORE 10 CORED INTERVAL: 909.7-919.2 m



SITE 438 HOLE B CORE 11 CORED INTERVAL: 919.2-928.7 m



SMEAR SLIDE SUMMARY

	Claystone (M)	Diatomaceous claystone (D)
	1-121	1-131
Sand	3	3
Silt	12	10
Clay	85	87
Quartz	4	2
Feldspar	4	5
Mica	–	–
Heavy minerals	1	–
Clay minerals	66	39
Volcanic glass	10	8
Glauconite	TR	TR
Pyrite	–	–
Zeolite minerals	–	–
Foraminifers	–	–
Diatoms	9	25
Radiolarians	–	–
Sponge spicules	1	–
Palagonite	1	2
Microcrystalline quartz	–	8
Carb. unspec.	–	4

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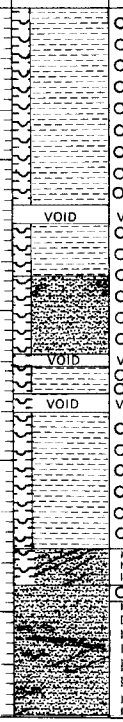
SITE 438 HOLE B CORE 12 CORED INTERVAL: 928.7-938.1 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER MIOCENE	*H. ampliaperta* / LOWER MIOCENE UNZONED / *A. ingens*	B	FM	RM	FP	1, 2, 3, 4, 5	0.5, 1.0	VOID, VOID, VOID			129, 112, 16



LITHOLOGIC DESCRIPTION

Drilling biscuits set in mud wash, 5GY 4/1. Diatomaceous vitric (silty sand) claystone.

0-112 cm soft slurry of drilling induced mud.

TOTAL C – ORGANIC C – CARBONATE (%)
4, 120 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	Calcareous diatomaceous claystone (D)	Diatomaceous claystone (D)	Claystone (D)
	2-129	4-112	5-16
Sand	10	10	8
Silt	20	22	12
Clay	70	68	80
Quartz	3	4	18
Feldspar	5	6	7
Mica	–	–	TR
Heavy minerals	1	TR	–
Clay minerals	52	44	48
Volcanic glass	8	5	6
Glauconite	TR	1	TR
Pyrite	–	–	–
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	12	20	8
Radiolarians	–	–	–
Sponge spicules	1	5	3
Palagonite	1	1	1
Microcrystalline quartz	5	6	–
Carb. unspec.	12	8	9

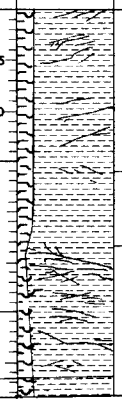
5Y 4/2 diatomaceous claystone (mottled, burrowed). Gray calcareous clay beds and clasts. Dark gray-black ashy mottles and specks. Drilling biscuits in clay slurry 5Y 4/2 diatomaceous claystone; mottled, slightly sandy.

mottled
Some slight bedding, possible steep angle low angle small offset microfaults ~30° to horizontal
5Y 4/2 microfaulted faintly mottled diatomaceous claystone layers.

5Y 5/2 of irregular thickness faulted

SITE 438 HOLE B CORE 13 CORED INTERVAL: 938.1-947.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER MIOCENE	*H. ampliaperta* / LOWER MIOCENE UNZONED / *Actinocyclus ingens*	B	FM	RM	FM	1, 2, 3, CC	0.5, 1.0				101, 33, 52



LITHOLOGIC DESCRIPTION

Faintly mottled olive gray (5Y 4/2) diatomaceous claystone, intensely microfaulted in places. Still some pumice or glass grains (white specks). A few molds of forams.

5Y 4/2 diatomaceous claystone intensely microfaulted (almost a breccia); fault planes distinct to faint, offsets not measured (no visible bedding).

5Y 4/2 claystone, intensely microfaulted.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 111 cm (1.0, 0.8, 2)

CARBONATE BOMB
3, 52-54 cm = 2%

SMEAR SLIDE SUMMARY

	Vitric calcareous diatomaceous claystone (D)	Diatomaceous claystone (D)
	1-101	3-33
Sand	20	2
Silt	20	22
Clay	60	76
Quartz	5	8
Feldspar	7	5
Mica	–	–
Heavy minerals	1	1
Clay minerals	33	60
Volcanic glass	10	6
Glauconite	TR	TR
Pyrite	–	–
Zeolite minerals	–	–
Foraminifers	–	–
Diatoms	17	11
Radiolarians	–	–
Sponge spicules	7	4
Palagonite	1	1
Microcrystalline quartz	7	–
Carb. unspec.	12	4

SITE 438 HOLE B CORE 14 CORED INTERVAL: 947.5-956.9 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	L. MIOCENE UNZONED	B	FM	FM	CP	CC			O			Dark greenish gray (5G 4/1-5/1) claystone with dark gray mottles and streaks.

H. ampliaperta — *A. ingens*

SITE 438 HOLE B CORE 15 CORED INTERVAL: 956.9-966.3 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	L. MIOCENE UNZONED	B	RM	FP	RP	1	0.5		O		55	Chunk of clayey-silt mottled 5GY 4/1 and dark gray (N4) ash; chips of gray green (5GY 4/1-5/1)
							1.0		O		91	Vitric diatomaceous claystone, mottled, with fractures, core pieces break along "healed" fractures lined with very thin dark green gray material but no slickensides seen on fracture surfaces. This core, does not seem to be as brecciated or fractured as preceeding ones. Diatom preservation poor.
						2			O		50	Silty mottled (tuff or ash—rather hard)
						CC			O			

H. ampliaperta — *Actinocyclus ingens*

TOTAL C – ORGANIC C – CARBONATE (%)
2, 57 cm (0.7, 0.6, 1)

SMEAR SLIDE SUMMARY

	Claystone (D) 1-55	Diatomaceous vitric claystone (D) 1-91	Tuff (M) 2-50
Sand	5	5	35
Silt	20	20	25
Clay	75	75	40
Quartz	5	5	10
Feldspar	6	7	12
Mica	–	–	–
Heavy minrals	1	1	–
Clay minerals	58	45	6
Volcanic glass	5	10	65
Glauconite	TR	TR	1
Pyrite	–	–	–
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	6	10	2
Radiolarians	–	–	–
Sponge spicules	2	6	3
Palagonite	2	1	–
Microcrystalline quartz	10	12	–
Carb. unspec.	5	3	1

SITE 438 HOLE B CORE 16 CORED INTERVAL: 966.3-975.7 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	L. MIOCENE UNZONED	BF				1	0.5				14	Small foram (benthic) molds, core bubbling some gas
		RP	B	FP	FP	CC	1.0		O			Broken into very angular pieces set in drilling slurry

A. ingens

5GY 4/1 vitric claystone moderately but faintly mottled, slightly vitric (silty) highly fractured (healed).

TOTAL C – ORGANIC C – CARBONATE (%)
1, 23 cm (0.9, 0.7, 1)

SMEAR SLIDE SUMMARY

	Vitric claystone (D) 1-14
Sand	7
Silt	13
Clay	80
Quartz	4
Feldspar	10
Mica	–
Heavy minerals	TR
Clay minerals	42
Volcanic glass	11
Glauconite	TR
Pyrite	–
Zeolite minerals	–
Foraminifers	–
Diatoms	5
Radiolarians	–
Sponge spicules	8
Palagonite	1
Microcrystalline quartz	12
Carb. unspec.	7

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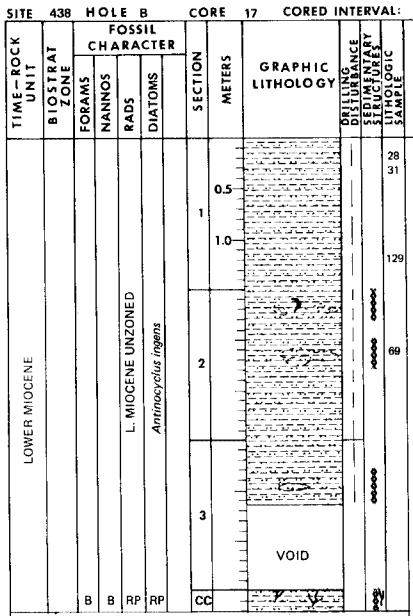
SITE 438 HOLE B CORE 17 CORED INTERVAL: 975.7-985.2 m



LITHOLOGIC DESCRIPTION

Thin section

Black (5Y 2/1) clayey siltstone, very highly indurated, massive, but some slight, faint mottling, no noticeable sedimentary structure. Pyrite and molds of benthic foraminiferas are seen on split face. Vertically broken fractures and some slickensides are observed.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 142 cm (0.9, 0.8, 1)
3, 7 cm (0.8, 0.7, 0)

Pyrite streak
Burrows

CARBONATE BOMB
2, 69-71 cm = 0%

Burrow-mottling, light gray, much finer grained material fills all burrows (appears to be mostly quartz).

SMARE SLIDE SUMMARY

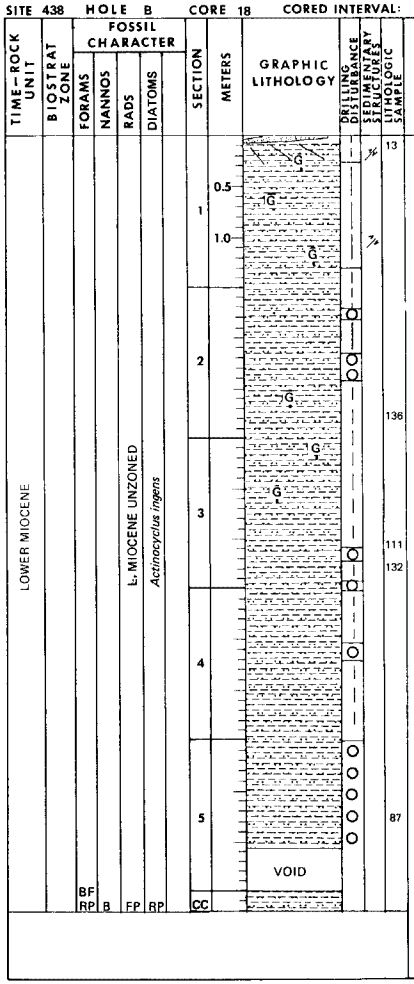
Black (5Y 2/1) clayey massive siltstone

Burrow mottles

Black clayey siltstone; Possible dewatering structure, burrow mottles; also plant material, and pollen

	Clayey (sandy) siltstone (D)
	1-128
Sand	20
Silt	45
Clay	35
Quartz	7
Feldspar	15
Mica	–
Heavy minerals	TR
Clay minerals	30
Volcanic glass	4
Glauconite	1
Pyrite	TR
Zeolite minerals	–
Foraminifers	5
Diatoms	TR
Radiolarians	–
Sponge spicules	–
Microcrystalline quartz	30
Palagonite	1
Carb. unspec.	7

SITE 438 HOLE B CORE 18 CORED INTERVAL: 985.2-994.8 m



LITHOLOGIC DESCRIPTION

(5Y 3/1) glauconitic clayey siltstone, (0-2 cm), rich in very fine-grained glauconitic sand grains, possible 7° dip. Prominant fracture set, 51°

Slickensides 47°, dip-slip movement

Very dark gray (5Y 3/1) clayey siltstone.

Very dark gray (5Y 3/1) clayey siltstone with slight mottling.

Glauconitic clayey siltstone, most glauconite grains are very fine-grained sand.

Very dark gray (5Y 3/1) clayey siltstone.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 142 cm (0.6, 0.6, 0)
2, 133 cm (0.6, 0.5, 1)

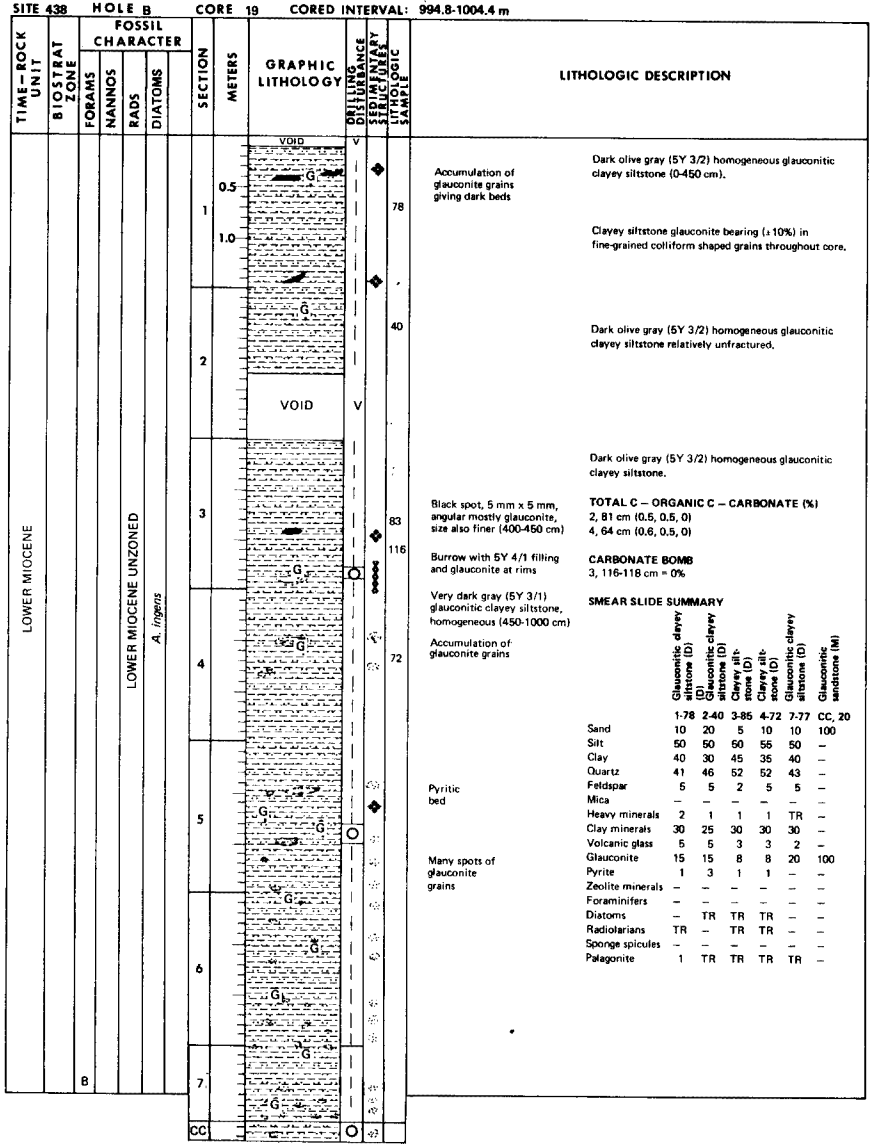
CARBONATE BOMB
3, 111-113 cm = 0%

SMEAR SLIDE SUMMARY

Very dark gray (5Y 3/1) clayey siltstone

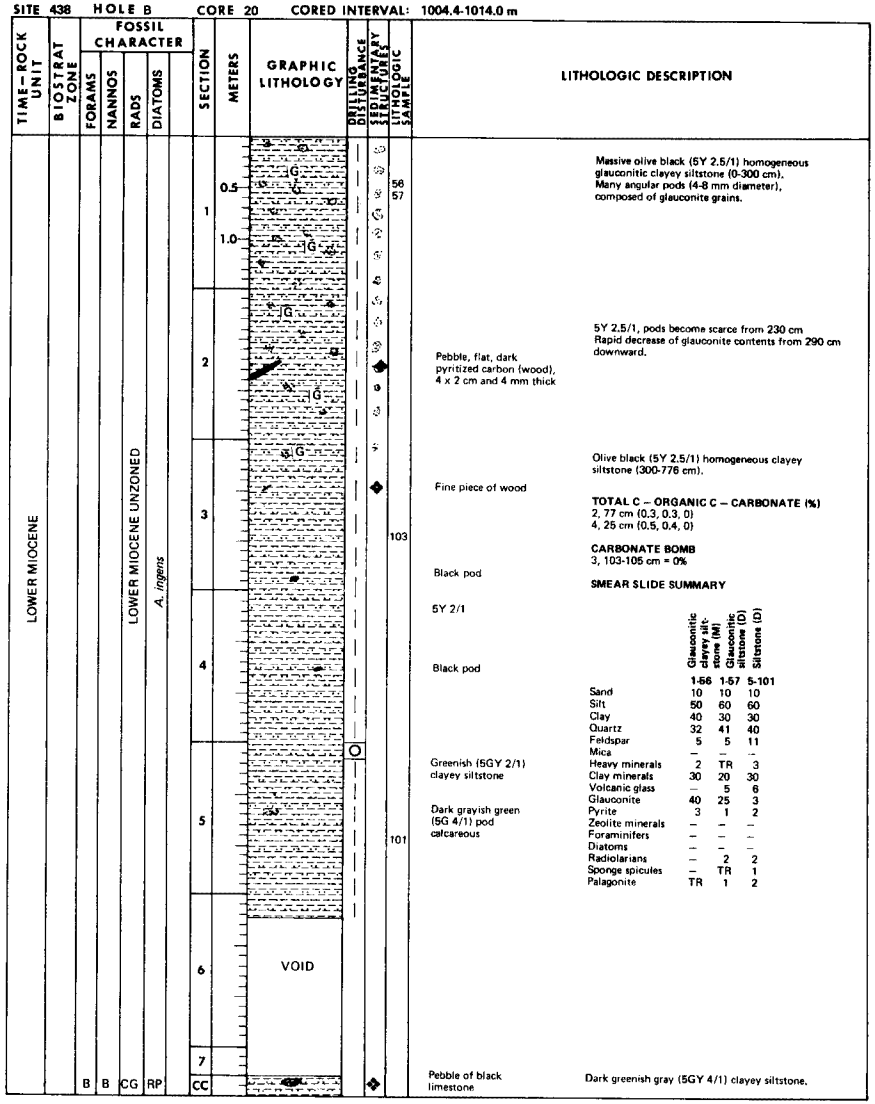
	Clayey siltstone (D)	Glauconitic clayey siltstone (D)	Claystone (D)	Silty claystone (D)
	1-13	2-136	3-132	5-87
Sand	10	10	–	1
Silt	50	40	17	35
Clay	40	40	83	54
Quartz	50	42	7	20
Feldspar	5	5	7	10
Mica	–	–	–	–
Heavy minerals	2	2	–	2
Clay minerals	35	35	75	60
Voclanic glass	5	5	5	5
Glauconite	1	10	–	1
Pyrite	1	–	–	–
Zeolite minerals	–	–	TR	TR
Foraminifers	–	–	–	–
Diatoms	–	–	–	TR
Radiolarians	–	TR	TR	–
Sponge spicules	–	–	–	–
Palagonite	1	1	–	–

SITE 438 HOLE B CORE 19 CORED INTERVAL: 994.8-1004.4 m



	Glauconitic clayey siltstone (D)	Glauconitic clayey siltstone (D)	Clayey siltstone (D)	Clayey siltstone (D)	Glauconitic clayey siltstone (D)	Glauconitic sandstone (M)
	1-78	2-40	3-85	4-72	7-77	CC, 20
Sand	10	20	5	10	10	100
Silt	50	50	50	55	50	–
Clay	40	30	45	35	40	–
Quartz	41	46	52	52	43	–
Feldspar	5	5	2	5	5	–
Mica	–	–	–	–	–	–
Heavy minerals	2	1	1	1	TR	–
Clay minerals	30	25	30	30	30	–
Volcanic glass	5	5	3	3	2	–
Glauconite	15	15	8	8	20	100
Pyrite	1	3	1	1	–	–
Zeolite minerals	–	–	–	–	–	–
Foraminifers	–	–	–	–	–	–
Diatoms	–	TR	TR	TR	–	–
Radiolarians	TR	–	TR	TR	–	–
Sponge spicules	–	–	–	–	–	–
Palagonite	1	TR	TR	TR	TR	–

SITE 438 HOLE B CORE 20 CORED INTERVAL: 1004.4-1014.0 m



	Glauconitic clayey siltstone (M)	Glauconitic siltstone (D)	Siltstone (D)
	1-56	1-57	5-101
Sand	10	10	10
Silt	50	60	60
Clay	40	30	30
Quartz	32	41	40
Feldspar	5	5	11
Mica	–	–	–
Heavy minerals	2	TR	3
Clay minerals	30	20	30
Volcanic glass	–	5	6
Glauconite	40	25	3
Pyrite	3	1	2
Zeolite minerals	–	–	–
Foraminifers	–	–	–
Diatoms	–	–	–
Radiolarians	–	2	2
Sponge spicules	–	TR	1
Palagonite	TR	1	2

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SITE 438 HOLE B CORE 21 CORED INTERVAL: 1014.0-1023.4 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	*A. ingens*	B	B	B	RP	1, 2, 3, 4, 5, CC	0.5, 1.0	VOID; VOID; VOID	V; O		102; 100; 82	Greenish black (5G 2/1) silty claystone, homogeneous (0-200 cm). Small burrows fill with the same material. Greenish black (5GY 2/1-5G 2/1) clayey siltstone (200-300 cm). Dark greenish gray (5G 4/1) burrow. Black piece of wood. Greenish black (5GY 2/1) clayey siltstone, homogeneous, with small pieces of wood, burrows (300-500 cm). Small pieces of wood. Burrow. Sandy bed. Small pieces of wood. Burrow. Greenish black (5GY 2/1) clayey siltstone. Dark greenish gray (5GY 4/1) limestone concretions (2.5-5.5 cm diameter). Greenish black (5GY 2/1) mudstone drilling breccia

TOTAL C – ORGANIC C – CARBONATE (%)
2, 116 cm (0.3, 0.4, 0)
3, 102 cm (0.5, 0.5, 0)

CARBONATE BOMB
3, 100-102 cm = 0%

SMEAR SLIDE SUMMARY

	Clayey siltstone (D) 2-102	Clayey siltstone (D) 4-82
Sand	13	11
Silt	51	56
Clay	36	33
Quartz	43	53
Feldspar	8	6
Mica	–	–
Heavy minerals	3	1
Clay minerals	31	30
Volcanic glass	–	3
Glauconite	4	4
Pyrite	2	2
Zeolite minerals	–	–
Foraminifiers	–	–
Diatoms	–	–
Radiolarians	1	1
Sponge spicules	1	–

SITE 438 HOLE B CORE 22 CORED INTERVAL: 1023.4-1032.8 m

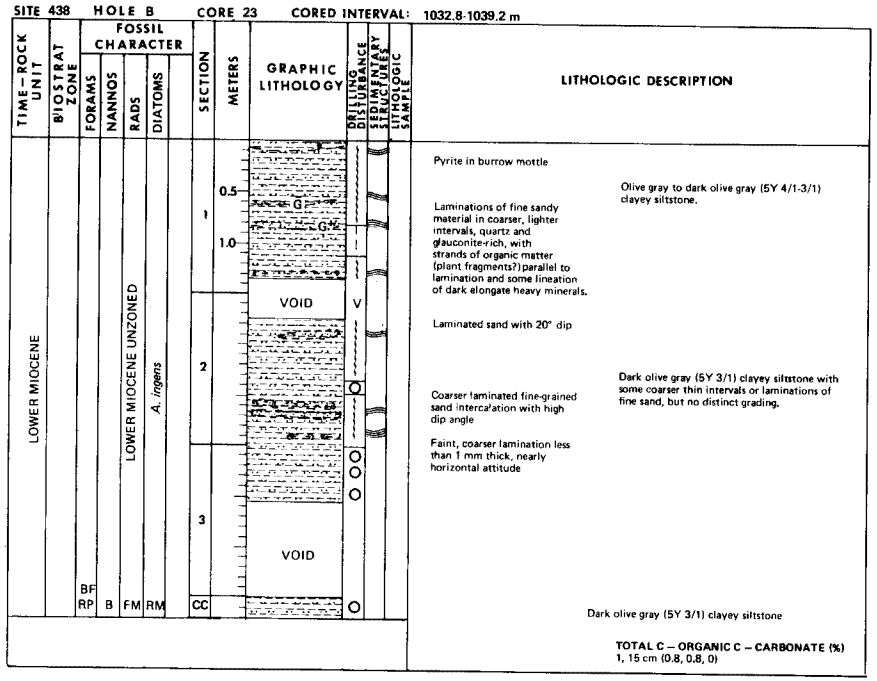
TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER MIOCENE	LOWER MIOCENE UNZONED; *A. ingens*	B	B	RM	RP	1, 2, CC	0.5, 1.0	VOID	O		101; 107; 22	Fine bioturbation. Medium dark olive gray (5Y 3/1) silty claystone and clayey siltstone. Medium greenish gray (5GY 5/1) siltstone bed; graded, sandy at bottom. Siltstone, very small pieces with plant fragments. Medium dark olive gray (5Y 3/1) claystone

CARBONATE BOMB
2, 22-24 cm = 0-1%

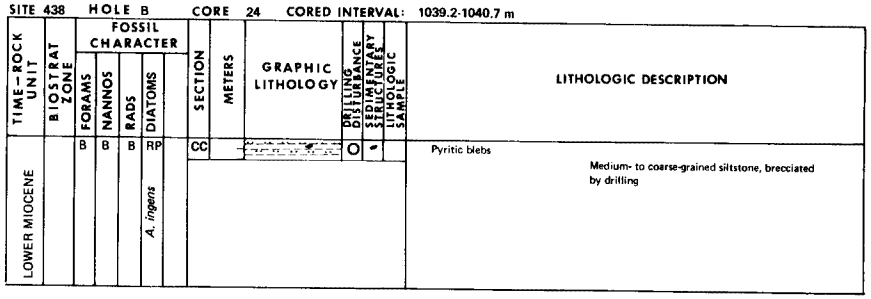
SMEAR SLIDE SUMMARY

	Claystone (silty) (D) 1-101	Siltstone (clayey) (M) 1-104
Sand	–	20
Silt	20	52
Clay	80	28
Quartz	25	40
Feldspar	10	18
Mica	–	3
Heavy minerals	2	5
Clay minerals	56	24
Volcanic glass	–	3
Glauconite	2	1
Pyrite	1	–
Zeolite minerals	–	–
Foraminifers	–	–
Diatoms	3	2
Radiolarians	–	–
Sponge spicules	1	–
Palagonite	–	1

SITE 438 HOLE B CORE 23 CORED INTERVAL: 1032.8-1039.2 m



SITE 438 HOLE B CORE 24 CORED INTERVAL: 1039.2-1040.7 m



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SITE SUMMARY SHEET

SITE 439

Date occupied	November 3, 1977
Date departed	November 8, 1977
Time on hole	6 days
Position: latitude	40° 37.61'N
longitude	143° 18.63'E
Water depth (sea level)	1656 corrected meters, echo sounding
Water depth (rig floor)	1666 corrected meters, echo sounding
Bottom felt at	1666 meters, drill pipe
Penetration	1157.5 meters
Number of holes	1
Number of cores	39
Total length of cored section	342.0 meters
Total core recovery	163.1 meters
Percentage core recovery	48%

Oldest Sediment Cored

Depth sub-bottom	1157.5 meters
Nature	Hard clayey siltstone
Age	Late Cretaceous
Measured velocity	About 4.2 maximum km/s

Basement

Depth sub-bottom	as above

Principal Results:

Core logs from Site 439, which extend from those at Site 438 to older rocks, were recovered to study the base of a more than 1000 meter thick reflective section and acoustic basement near the top of the Japan trench inner wall. This reflective sequence, largely of Neogene age, shows only mild tectonism and rests on a deep, 130 km wide, terrace. Rapid subsidence of a Paleogene continental land mass to bathyal depth by early Miocene time is indicated by the following sequence to lithologies near the bottom of the hole: Cretaceous dark silicified silty claystone cut by an erosion surface near or below the acoustic basement reflector; boulder-conglomerate and breccia, 48 meters thick, in which most of the clasts are porphyritic dacite from a nearby source and dark silty claystone; massive Oligocene sandstone, 105 meters thick, with numerous megafossils, many still articulated, and upper bathyal benthonic foraminifera. The lithology then changes abruptly to a fine-grained turbidite-claystone sequence, 78 meters thick and of early Miocene age, overlain by the approximately 850 meter thick sequence of hemipelagic diatomaceous claystone deposited at bathyal depth and studied at Site 438. The sequence of environments interpreted from these lithologies begins with an Oligocene or older emergent terrane that included the silicified claystone and dacite outcrops. Subaerial conglomerate and breccia were covered in Oligocene time by sand transported from a nearby surf zone into more quiet but shallow waters. As subsidence continued, the distance from sources of terrigenous material increased and turbidites become increasingly distal. The area of the sites reached bathyal depth at the beginning of early Miocene time and was then essentially isolated from all but some very fine-grained terrigenous materials until a renewed influx of terrigenous material in late Pliocene and Pleistocene time.

SITE 439 HOLE CORE 1 CORED INTERVAL: 498.0-506.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE	N17	BP FP	*D. hengrenii* CM	RM	*D. hustedtii* CM CM	1 CC	0.5	VOID			55

LITHOLOGIC DESCRIPTION

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

Mottle 1 cm in diameter, olive (5Y 4/3).
Small burrows.
Black (5YR 5/2) mottle

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-55
Sand	10
Silt	20
Clay	70
Quartz	3
Feldspar	1
Clay minerals	58
Volcanic glass	10
Diatoms	25
Sponge spicules	3
Palagonite	TR
Silicoflagellates	TR

SITE 439 HOLE CORE 2 CORED INTERVAL: 555.0-563.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE		BF M	RM	*Stichocorys peregrina* CM	*D. hustedtii* FM	1 CC	0.5 1.0				108

LITHOLOGIC DESCRIPTION

Black 3 mm rounded pebbles probably from higher in hole.

Medium gray (5Y 5/1) vitric diatomaceous claystone, moderately mottled.

Light olive gray (5Y 6/2) 2 cm mottle.

SMEAR SLIDE SUMMARY

	Vitric diatomaceous claystone 1-108
Sand	5
Silt	30
Clay	65
Quartz	6
Feldspar	6
Clay minerals	48
Volcanic glass	15
Glauconite	TR
Diatoms	25
Sponge spicules	TR

SITE 439 HOLE CORE 3 CORED INTERVAL: 649.0-657.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
MIDDLE MIOCENE		BR	CM *Catinaster coalitus*	CG *Cannartus petersoni*	CM *D. hustedtii-D. lauta*	CC		DRILL CUTTINGS			

LITHOLOGIC DESCRIPTION

SITE 439 HOLE CORE 4 CORED INTERVAL: 745.0-753.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
MIDDLE MIOCENE		BF RP	B	FG *Dorcadospyris alata*	RP *Denticula lauta*	1 2 3 CC	0.5 1.0				85 22 40

LITHOLOGIC DESCRIPTION

Grayish black (N2) sand (ash?) layer, with disseminated sand above and below. Dewatering veins displaced along a fracture.

Grayish olive green (5GY 3/2) diatomaceous claystone with moderate olive brown (5Y 4/4) mottles.
Closely-spaced tension fractures.
Large burrow mottles which deflects fractures and dewatering veins.

Light olive gray (5Y 5/2) calcitic concretion with slightly porous outer rind which deflects fractures and veins.

Zone of subhorizontal shearing of veins.
10Y 4/2
Woody fragment

Fracture cleavage and sigmoidal shears.
Intensely fractured, black veins; mottles sheared.

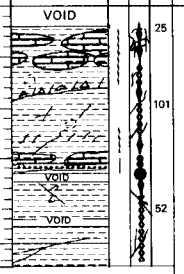
SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-85	Claystone 3-22	Claystone 3-40
Sand	10	7	5
Silt	20	10	10
Clay	70	83	85
Quartz	5	10	3
Feldspar	3	5	2
Clay minerals	70	77	89
Volcanic glass	2	2	1
Glauconite	–	–	TR
Pyrite	–	TR	–
Diatoms	15	5	3
Radiolarians	–	–	TR
Sponge spicules	5	1	2

SITE 439 HOLE CORE 5 CORED INTERVAL: 849.5-859.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS
MIDDLE MIOCENE		B			*Denticula lauta*	1	0.5, 1.0
		B	RM	RM	FP	2	
						CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE



LITHOLOGIC DESCRIPTION

Grayish olive green (5GY 3/2) claystone, intensely mottled and burrowed.
Zone cemented into locally pyritic light olive gray to pale olive (5Y 6/2-10Y 6/2) limestone, cut by several generations of fractures filled by calcite. Sheared breccia zone at 85 cm.
Sandy ash-filled mottle at 75 cm.

Concretionary limestone underlain by very fine-grained slightly graded poorly sorted sandstone.
Burrows displaced 2 cm along a fracture.
Dip to bedding 10° (equal to hole deviation).
Sheared grayish black seams; calcite-cemented burrows.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 34 cm (8.6, 0.3, 69)
2, 20 cm (0.7, 0.7, 0)

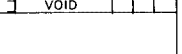
SMEAR SLIDE SUMMARY

	Limestone 1-25	Claystone 1-101	Claystone 2-52
Sand	2	5	2
Silt	40	20	22
Clay	58	75	76
Quartz	3	18	18
Feldspar	3	5	6
Heavy minerals	TR	2	TR
Clay minerals	–	44	49
Voclanic glass	5	8	8
Glauconite	–	TR	–
Diatoms	–	8	7
Sponge spicules	1	6	7
Carbonate	88	8	5
Palagonite	–	1	–

SITE 439 HOLE CORE 6 CORED INTERVAL: 859.0-868.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS
LOWER MIOCENE		B	B	B	RP *Actinocyclus ingens*	CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE



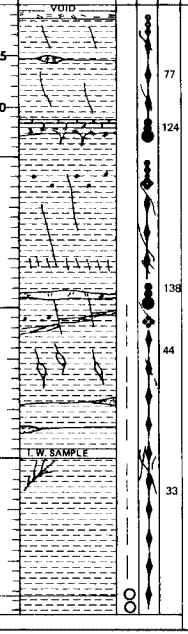
LITHOLOGIC DESCRIPTION

Dark gray (N3-4) dense silica-cemented sandstone, 2 cm thick (possibly out of place).

SITE 439 HOLE CORE 7 CORED INTERVAL: 868.5-878.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS
LOWER MIOCENE		B			*Actinocyclus ingens*	1	0.5, 1.0
		B				2	
		B				3	
		B				4	
		B	RM	RM	FP	CC	

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE



LITHOLOGIC DESCRIPTION

Dark olive gray to olive gray (5Y 3/2-4/2) vitric claystone, intensely mottled and burrowed in the top third, moderately mottled below that. Light gray 5 mm silt-sized tuff layer at 13 cm; grayish black (N2) pocket at 56 cm.

Light gray (N7) silt-sized slightly graded 5 cm tuff, with 2 cm sandstone veins below, and 2 cm clayey limestone bed 5 cm above.

Pumice fragments 3 mm in diameter.

Strata dip 26°; hole deviation ~8°.
Black stained fractures, 3 mm wide, 5 mm apart; other more widely spaced ones above are offset a few mm in places.

Medium light gray graded 3 cm tuff.

Pumice fragments, 3 mm in diameter, underlain by offset and braided veins.

Olive gray (5Y 4/2) claystone.

Sandy pyritic body

Sandy body
Dark gray (N3) mottle

Black dewatering veins

Conspicuous partings

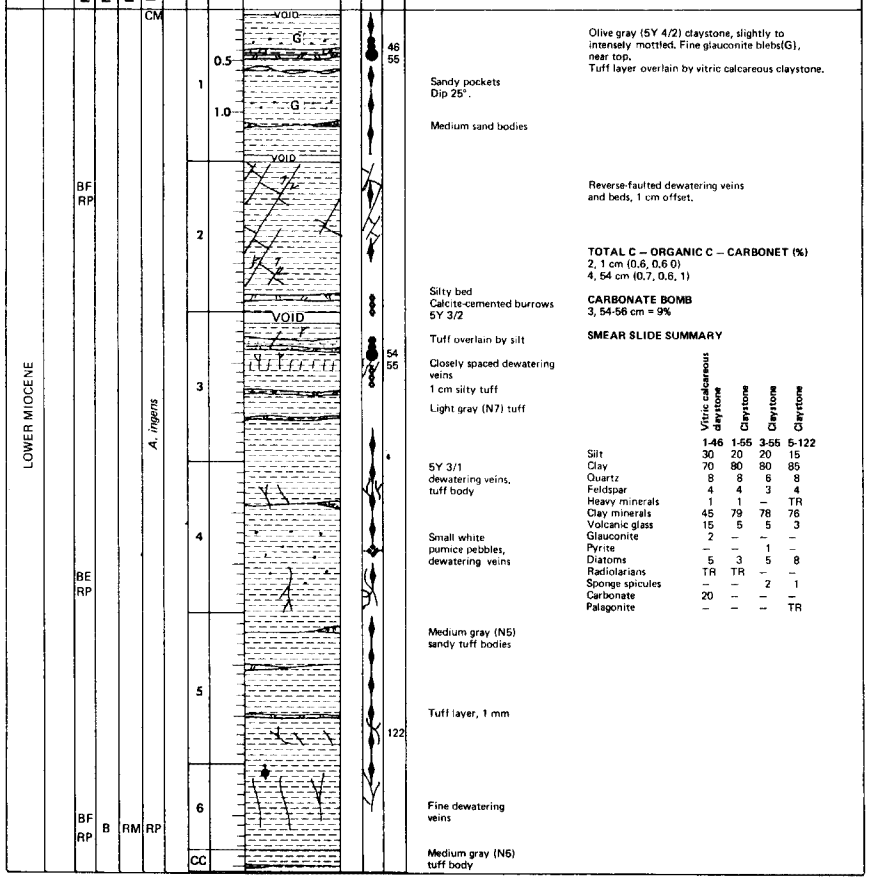
TOTAL C – ORGANIC C – CARBONATE (%)
2, 80 cm (0.5, 0.5, 0)
4, 55 cm (0.6, 0.6 0)

CARBONATE BOMB
3, 44-46 cm = 1-2%

SMEAR SLIDE SUMMARY

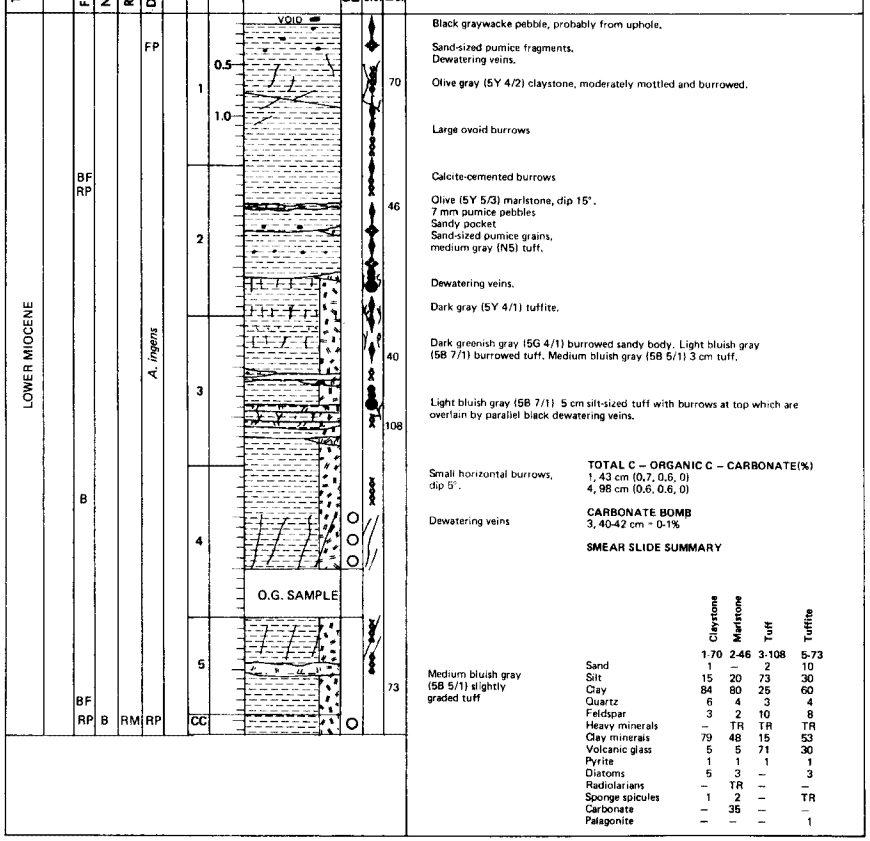
	Vitric claystone 1-77	Tuff 1-124	Tuff 2-138	Claystone 4-33
Sand	–	10	10	–
Silt	30	70	60	20
Clay	70	20	30	80
Quartz	2	5	5	8
Feldspar	4	10	10	4
Heavy minerals	TR	1	–	–
Clay minerals	67	5	20	76
Volcanic glass	18	79	61	5
Pyrite	–	–	3	2
Diatoms	8	–	1	5
Sponge spicules	1	–	–	–
Silicoflagellates	TR	–	–	–
Coccoliths	–	–	TR	–

SITE 439 HOLE CORE 8 CORED INTERVAL: 878.0-887.5 m



	Vitric calcareous claystone	Claystone	Claystone	Claystone
	1-46	1-55	3-55	5-122
Silt	30	20	20	15
Clay	70	80	80	85
Quartz	8	8	6	8
Feldspar	4	4	3	4
Heavy minerals	1	1	–	TR
Clay minerals	45	79	78	76
Volcanic glass	15	5	5	3
Glauconite	2	–	–	–
Pyrite	–	–	1	–
Diatoms	5	3	5	8
Radiolarians	TR	TR	–	–
Sponge spicules	–	–	2	1
Carbonate	20	–	–	–
Palagonite	–	–	–	TR

SITE 439 HOLE CORE 9 CORED INTERVAL: 887.5-897.0 m



	Claystone	Marlstone	Tuff	Tuffite
	1-70	2-46	3-108	5-73
Sand	1	–	2	10
Silt	15	20	73	30
Clay	84	80	25	60
Quartz	6	4	3	4
Feldspar	3	2	10	8
Heavy minerals	–	TR	TR	TR
Clay minerals	79	48	15	53
Volcanic glass	5	5	71	30
Pyrite	1	1	1	1
Diatoms	5	3	–	3
Radiolarians	–	TR	–	–
Sponge spicules	1	2	–	TR
Carbonate	–	35	–	–
Palagonite	–	–	–	1

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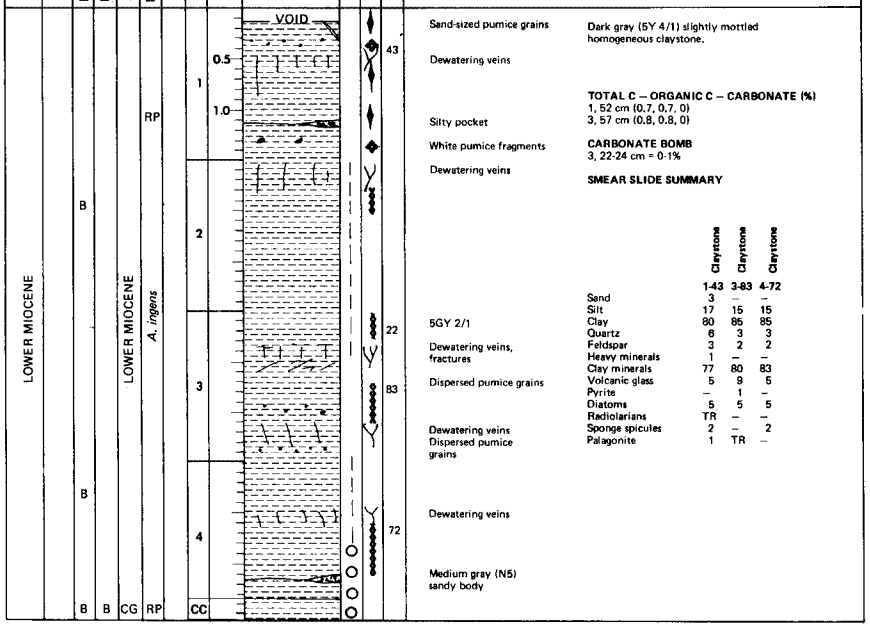
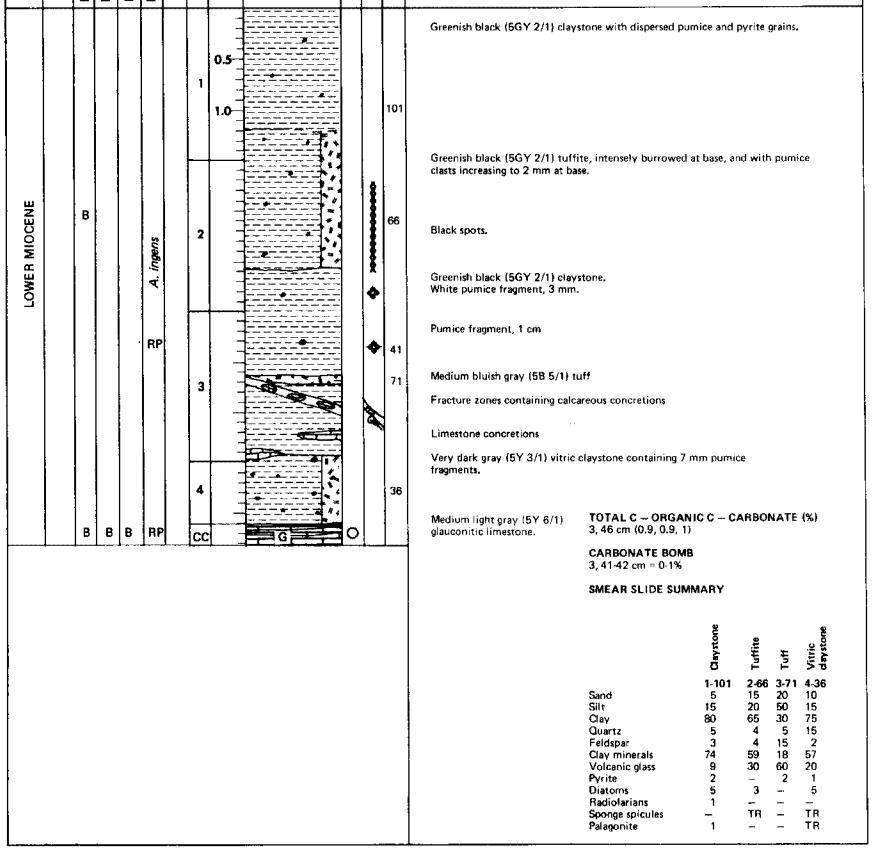
SITE 439 HOLE CORE 10 CORED INTERVAL: 897.0-906.5 m



SITE 439 HOLE CORE 11 CORED INTERVAL: 906.5-915.5 m



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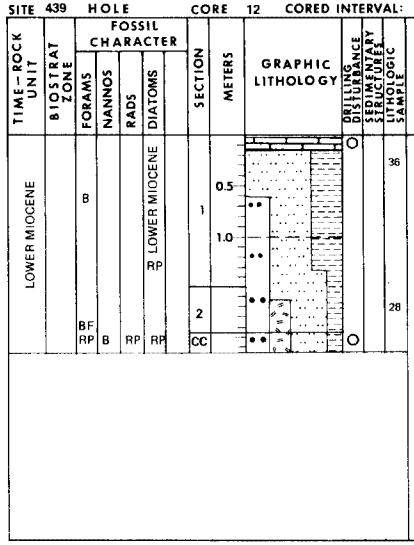
SITE 439 HOLE CORE 12 CORED INTERVAL: 916.0-925.5 m



LITHOLOGIC DESCRIPTION

Dark greenish gray (5G 4/1) limestone.

Dark gray (N3) clayey siltstone, becoming gradually coarser downward.

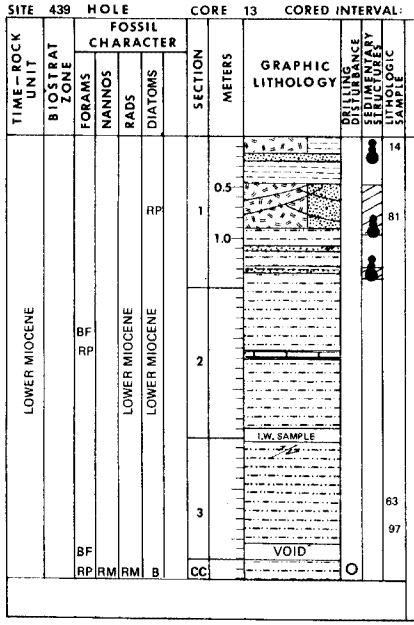
Dark gray (N3) vitric sandy siltstone.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 145 cm (0.3, 0.2, 0)

SMEAR SLIDE SUMMARY

	Clayey siltstone 1-36	Vitric sandy siltstone 2-28
Sand	10	30
Silt	50	50
Clay	40	20
Quartz	50	55
Feldspar	5	5
Heavy minerals	1	2
Clay minerals	40	10
Volcanic glass	2	25
Glauconite	2	2
Pyrite	–	1
Diatoms	–	TR

SITE 439 HOLE CORE 13 CORED INTERVAL: 925.5-932.0 m



LITHOLOGIC DESCRIPTION

Dark greenish gray (5G 4/1) muddy tuffite, silty at base.
Dark greenish gray (5G 4/1) claystone.

Dark greenish gray (5G 4/1) fine sandy tuffite, silty at top, cross laminated.

Dark greenish gray (5G 4/1) siltstone.
Sandy layer, laminated graded very fine sand

TOTAL C – ORGANIC C – CARBONATE (%)
1, 89 cm (0.9, 0.8, 0)
2, 116 cm (0.9, 0.8, 0)

CARBONATE BOMB
3, 97-98 cm = 0-1%

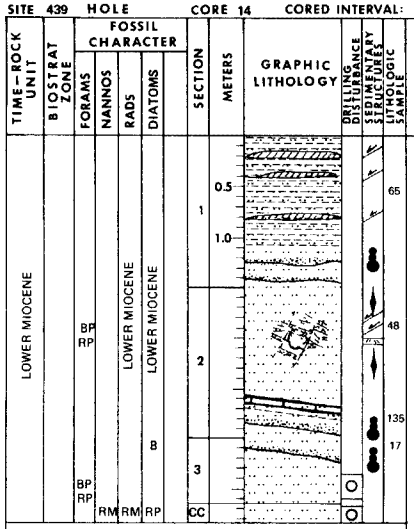
Concretionary limestone
Greenish black (5G 2/1) siltstone, homogeneous

SMEAR SLIDE SUMMARY

Fault dipping 45° with dip-slip slickensides

	Clayey tuffite 1-14	Sandy tuffite 1-81	Siltstone 3-63
Sand	–	50	10
Silt	60	40	50
Clay	40	10	40
Quartz	3	24	50
Feldspar	6	15	15
Mica	–	–	1
Heavy minerals	–	2	2
Clay minerals	29	8	20
Volcanic glass	60	50	9
Glauconite	–	1	1
Pyrite	2	–	2
Palagonite	–	–	1

SITE 439 HOLE CORE 14 CORED INTERVAL: 932.0-935.0 m



LITHOLOGIC DESCRIPTION

Faul surfaces with slickensides at 20, 40, and 80 cm

Clayey siltstone, greenish black (5G 2/1)

Fine-grained graded sequences from sandy siltstone to clayey siltstone

Small contorted burrows
minor fault (normal); cross-laminations in siltstone
Tuff
Large burrow (1 cm diameter , 6 cm long)
Dark greenish gray (5G 4/1) siltstone
Limestone (5Y 4/3) spotted with black detrital minerals
Sandy claystone (40% of quartz is micro-cristalline)
Fine sequence from sandy siltstone to claystone (and limestone at top)

Thin sequences of graded siltstone, greenish black (5G 2/1).

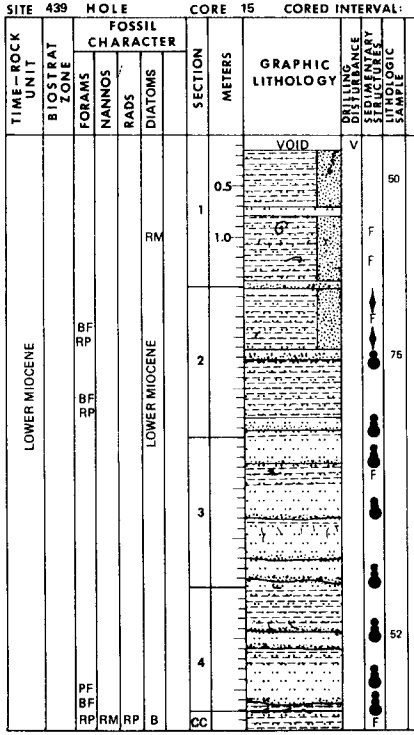
TOTAL C – ORGANIC C – CARBONATE (%)
1, 97 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 17-19 cm = 4-5%

SMEAR SLIDE SUMMARY

	Clayey siltstone (D) 1-65	Tuff (M) 2-48	Sandy claystone (M) 2-135
Sand	20	25	25
Silt	50	30	15
Clay	30	45	60
Quartz	50	15	47
Feldspar	15	3	5
Mica	1	–	–
Heavy minerals	–	2	–
Clay minerals	26	4	36
Volcanic glass	3	75	–
Glauconite	1	–	1
Pyrite	2	–	2
Zeolite minerals		1	1
Diatoms	2	–	–
Radiolarians	TR	–	–
Carb. unspec.	–	–	8

SITE 439 HOLE CORE 15 CORED INTERVAL: 935.0-944.5 m



LITHOLOGIC DESCRIPTION

Sandy, silty claystone (30% of quartz is micro-crystalline)

Fine siltstone with numerous black laminations (mainly wood fragments)
Section of gastropoda (thin shell) and pelecypods

Siltstone with fine black lamination

Clayey siltstone to silty claystone faintly burrow-mottled (0.5 cm motties), laminated siltstone, graded, sharp basal contact
Silty claystone (20% of quartz is micro-crystalline), with clay-filled burrow

Concentration of brown black organic matter
Laminated sequences, slightly graded from sand to silt, sharp contact at base
Coarse-grained sand

Silty claystone

Inclined lamination

Dewatering veins (between turbidites)
Graded thin laminated bed

Mollusc; massive silty claystone
Normal fault (1 cm offset)
Sandy siltstone (30% of quartz is micro-crystalline)

Thick graded sequence

Pelecypod fragments

Olive gray (5Y 4/1) silty claystone throughout with thin, fine-grained turbiditic sequences.

TOTAL C – ORGANIC C – CARBONATE (%)
3, 36 cm (0.9, 0.9, 1)

SMEAR SLIDE SUMMARY

	Sandy silty claystone (D) 1-50	Silty claystone (D) 2-75	Sandy siltstone (M) 4-52
Sand	28	18	45
Silt	30	20	25
Clay	42	62	30
Quartz	40	37	35
Feldspar	5	8	7
Heavy minerals	2	TR	TR
Clay minerals	30	34	25
Volcanic glass	12	6	9
Glauconite	2	2	1
Diatoms	2	4	1
Radiolarians	–		
Sponge spicules	TR	1	–
Carb. unspec.	7	7	22
Palagonite		1	

NOTE:
F = mollusc fragment

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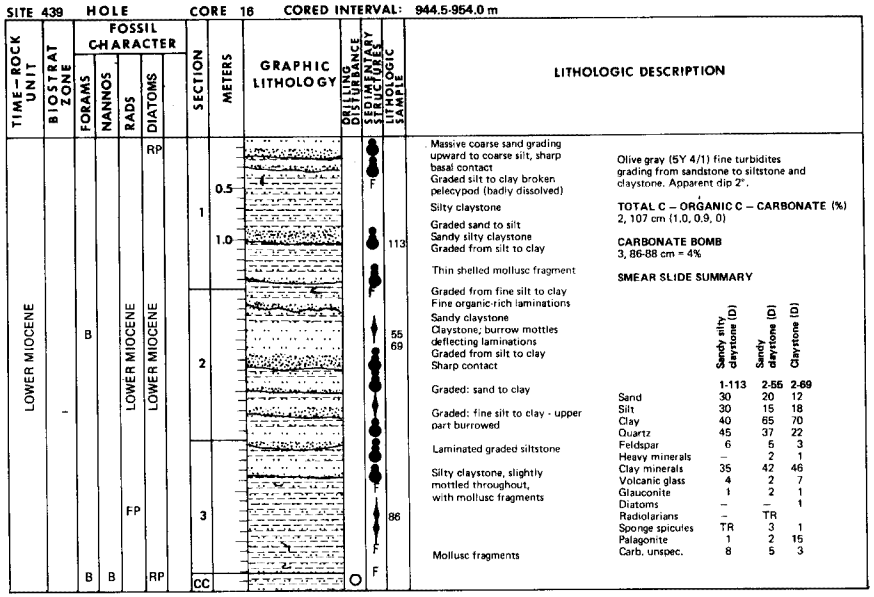
SITE 439 HOLE CORE 16 CORED INTERVAL: 944.5-954.0 m



Olive gray (5Y 4/1) fine turbidites grading from sandstone to siltstone and claystone. Apparent dip 2°.

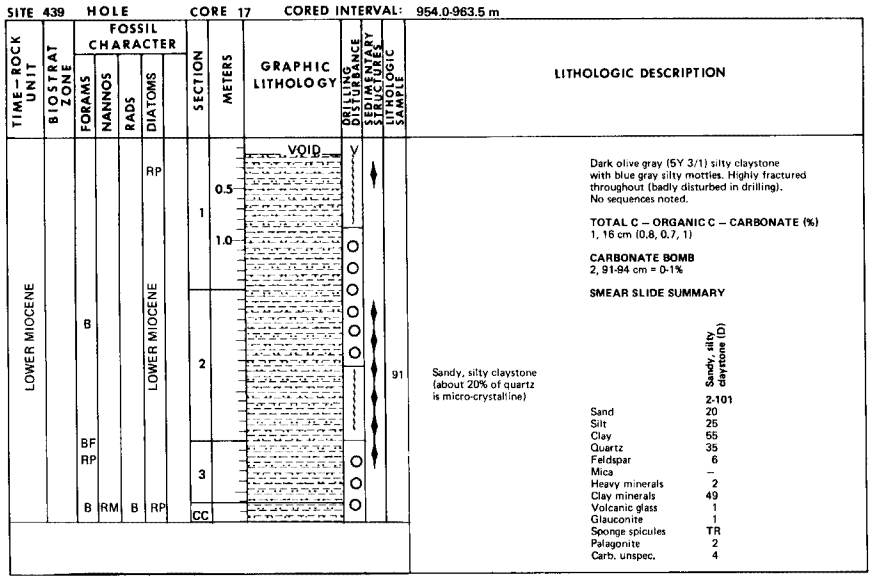
TOTAL C – ORGANIC C – CARBONATE (%)
2, 107 cm (1.0, 0.9, 0)

CARBONATE BOMB
3, 86-88 cm = 4%

SMEAR SLIDE SUMMARY

	Sandy silty claystone (D)	Sandy claystone (D)	Claystone (D)
	1-113	2-55	2-69
Sand	30	20	12
Silt	30	15	18
Clay	40	65	70
Quartz	45	37	22
Feldspar	6	5	3
Heavy minerals	–	2	1
Clay minerals	35	42	46
Volcanic glass	4	2	7
Glauconite	1	2	1
Diatoms	–	–	1
Radiolarians	–	TR	
Sponge spicules	TR	3	1
Palagonite	1	2	15
Carb. unspec.	8	5	3

SITE 439 HOLE CORE 17 CORED INTERVAL: 954.0-963.5 m



Dark olive gray (5Y 3/1) silty claystone with blue gray silty mottles. Highly fractured throughout (badly disturbed in drilling). No sequences noted.

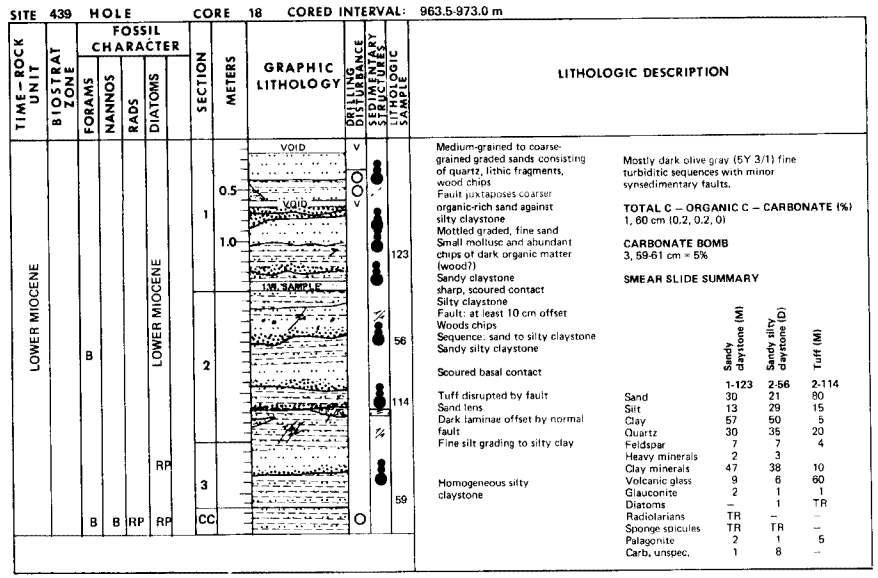
TOTAL C – ORGANIC C – CARBONATE (%)
1, 16 cm (0.8, 0.7, 1)

CARBONATE BOMB
2, 91-94 cm = 0-1%

SMEAR SLIDE SUMMARY

	Sandy, silty claystone (D)
	2-101
Sand	20
Silt	25
Clay	55
Quartz	35
Feldspar	6
Mica	–
Heavy minerals	2
Clay minerals	49
Volcanic glass	1
Glauconite	1
Sponge spicules	TR
Palagonite	2
Carb. unspec.	4

SITE 439 HOLE CORE 18 CORED INTERVAL: 963.5-973.0 m



Mostly dark olive gray (5Y 3/1) fine turbiditic sequences with minor synsedimentary faults.

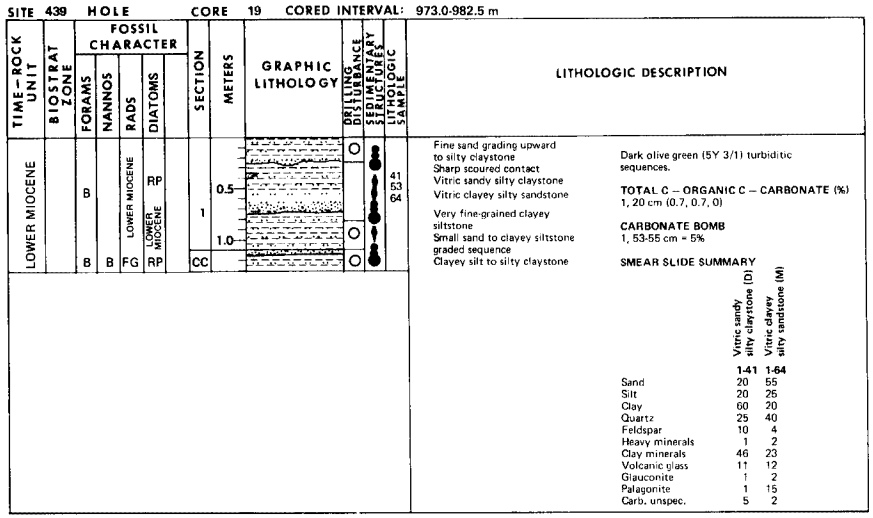
TOTAL C – ORGANIC C – CARBONATE (%)
1, 60 cm (0.2, 0.2, 0)

CARBONATE BOMB
3, 59-61 cm = 5%

SMEAR SLIDE SUMMARY

	Sandy claystone (M)	Sandy silty claystone (D)	Tuff (M)
	1-123	2-56	2-114
Sand	30	21	80
Silt	13	29	15
Clay	57	50	5
Quartz	30	35	20
Feldspar	7	7	4
Heavy minerals	2	3	
Clay minerals	47	38	10
Volcanic glass	9	6	60
Glauconite	2	1	1
Diatoms	–	1	TR
Radiolarians	TR	–	–
Sponge spicules	TR	TR	–
Palagonite	2	1	5
Carb. unspec.	1	8	–

SITE 439 HOLE CORE 19 CORED INTERVAL: 973.0-982.5 m



Dark olive green (5Y 3/1) turbiditic sequences.

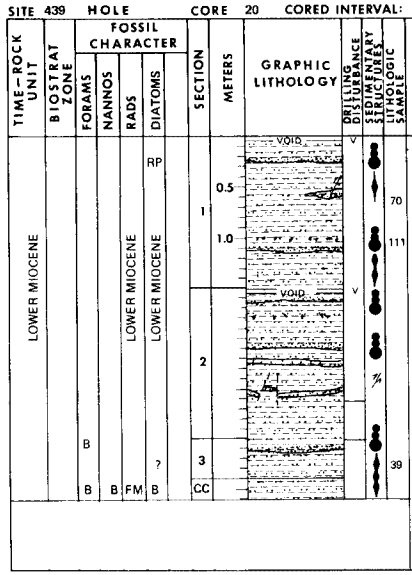
TOTAL C – ORGANIC C – CARBONATE (%)
1, 20 cm (0.7, 0.7, 0)

CARBONATE BOMB
1, 53-55 cm = 5%

SMEAR SLIDE SUMMARY

	Vitric sandy silty claystone (D)	Vitric clayey silty sandstone (M)
	1-41	1-64
Sand	20	55
Silt	20	25
Clay	60	20
Quartz	25	40
Feldspar	10	4
Heavy minerals	1	2
Clay minerals	46	23
Volcanic glass	11	12
Glauconite	1	2
Palagonite	1	15
Carb. unspec.	5	2

SITE 439 HOLE CORE 20 CORED INTERVAL: 982.5-992.0 m



LITHOLOGIC DESCRIPTION

Complete Bouma sequence
Sharp contact

Clayey siltstone
homogeneous but mottled with silt
Claystone
Concentration of wood chips
Clayey silty sandstone
Sharp, scoured basal contact
Clayey siltstone, mottled

Graded sequence
Concentration of organic matter
Silty claystone

Sandy layer; no grading

Laminated organic-rich siltstone bed offset by fault
Clayey siltstone

Small sequence: fine sand to siltstone

Clayey siltstone with mottles of coarser-grained silt

Olive gray to dark olive gray (5Y 4/1-3/1) silty claystone and clayey siltstone with graded sequences.

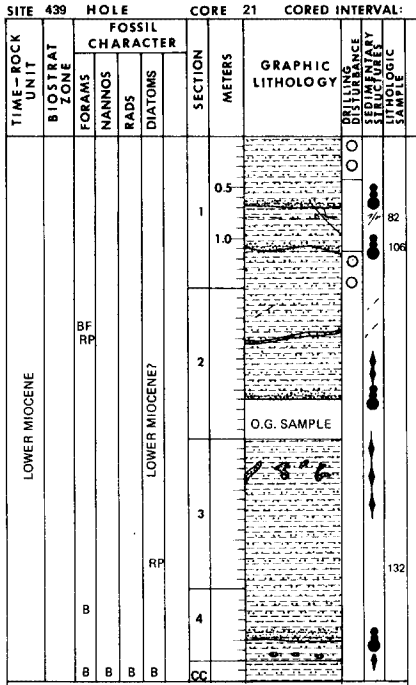
TOTAL C – ORGANIC C – CARBONATE (%)
1, 35 cm (0.7, 0.7, 0)

CARBONATE BOMB
3, 39-41 cm = 4%

SMEAR SLIDE SUMMARY

	Claystone (D)	Clayey silty sandstone (M)
	1-70	1-111
Sand	3	48
Silt	25	30
Clay	72	22
Quartz	42	28
Feldspar	4	10
Heavy minerals	1	8
Clay minerals	41	18
Volcanic glass	4	8
Glauconite	–	2
Lithic frag. (chert?)	–	25
Diatoms	1	TR
Sponge spicules	2	–
Palagonite	1	1
Carb. unspec.	4	–

SITE 439 HOLE CORE 21 CORED INTERVAL: 992.0-1001.5 m



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/1) clayey siltstone

Sandstone grading upward through massive silt to clayey siltstone
Claystone, dark silt-laminae faulted (0.5 cm offset) sand grading to clayey siltstone
Sandy clayey siltstone
Fractured silty claystone some slickensides on fracture planes; abundant silty streaks and mottles
Small synsedimentary normal fault (Note thickening of laminae over downdropped black within sand unit. Small load-cast on left side.)
Clay mottles
Fine-grained sand grading to fine silt (no basal contact)

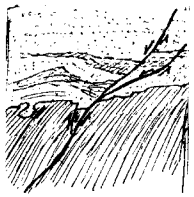
Bluish gray (5B 6/1) bioturbation (silt lenses)

Homogeneous clayey siltstone

Coarser silt grading upward rapidly to clayey siltstone

Silty mottles

Olive gray (5Y 3/1) clayey siltstone with few graded sequences.



Detail of synsedimentary fault, at 50 cm Section 2.

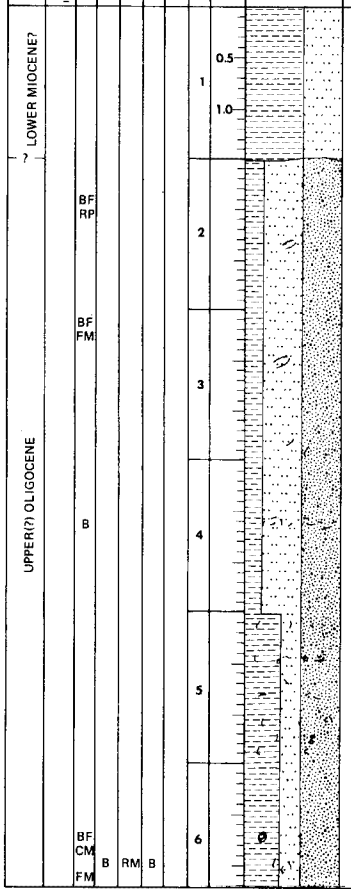
TOTAL C – ORGANIC C – CARBONATE (%)
1, 73 cm (0.5, 0.4, 1)

CARBONATE BOMB
3, 132-134 cm = 4%

SMEAR SLIDE SUMMARY

	Claystone (D)	Sandy clayey siltstone (D)
	1-82	1-106
Sand	8	25
Silt	22	45
Clay	70	30
Quartz	35	55
Feldspar	5	10
Heavy minerals	1	5
Clay minerals	49	28
Volcanic glass	2	–
Glauconite	1	1
Diatoms	TR	–
Sponge spicules	1	–
Palagonite	1	1
Carb. unspec.	5	–

SITE 439 HOLE CORE 22 CORED INTERVAL: 1001.5-1011.0 m



LITHOLOGIC DESCRIPTION

Dark olive gray (5Y 3/1) homogeneous or massive clayey siltstone

Pronounced change between Sections 1 and 2 Medium gray (N5) coarse-grained siltstone or very fine-grained sandstone, moderately friable

Articulated pelecypod Silty sandstone moderately well-sorted massive (no bedding) and without grain-size variations

Pelecypod

Pelecypod fragment

Concentration of pelecypods, some articulated

Pelecypod and scaphopod(?)-rich layer

Abundant molluscs throughout

Clayey sandstone

Entire gastropod test

Dark olive gray (5Y 3/1) clayey siltstone (Section 1) and medium gray (N5) coarse-grained siltstone to fine-grained sandstone, massive and homogeneous. Abundant molluscan debris or shells.

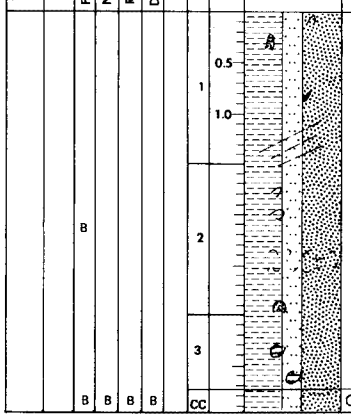
TOTAL C – ORGANIC C – CARBONATE (%)
4, 130 cm (0.8, 0.7, 1)

CARBONATE BOMB
3, 38-40 cm = 5%

SMEAR SLIDE SUMMARY

	Clayey siltstone (D) 1-82	Silty sandstone (D) 2-93	Clayey sandstone (D) 6-138
Sand	15	50	50
Silt	50	30	17
Clay	35	20	33
Quartz	45	40	50
Feldspar	8	5	11
Mica	–	–	2
Heavy minerals	2	2	2
Clay minerals	29	19	13
Glauconite	TR	1	–
Carb. unspec.	–	2	5
Lithic fragments	15	30	12
Palagonite	1	1	5

SITE 439 HOLE CORE 23 CORED INTERVAL: 1011.0-1020.5 m



LITHOLOGIC DESCRIPTION

Pelecypod

Gastropod

Well preserved high-spiral gastropod (turritella?)

Silty clayey sandstone occasional laminations suggest a 35° dip.

Pelecypod fragment

Articulated pelecypod

Mollusc fragments

Gastropod

Articulated pelecypods with dark gray (N3) filling of calcareous silt

Silty sand (drilling breccia)

Olive gray (5Y 4/1) medium-grained sand, massive, well indurated, molluscan-bearing (gastropods, pelecypods, scaphopods). No bedding structures.

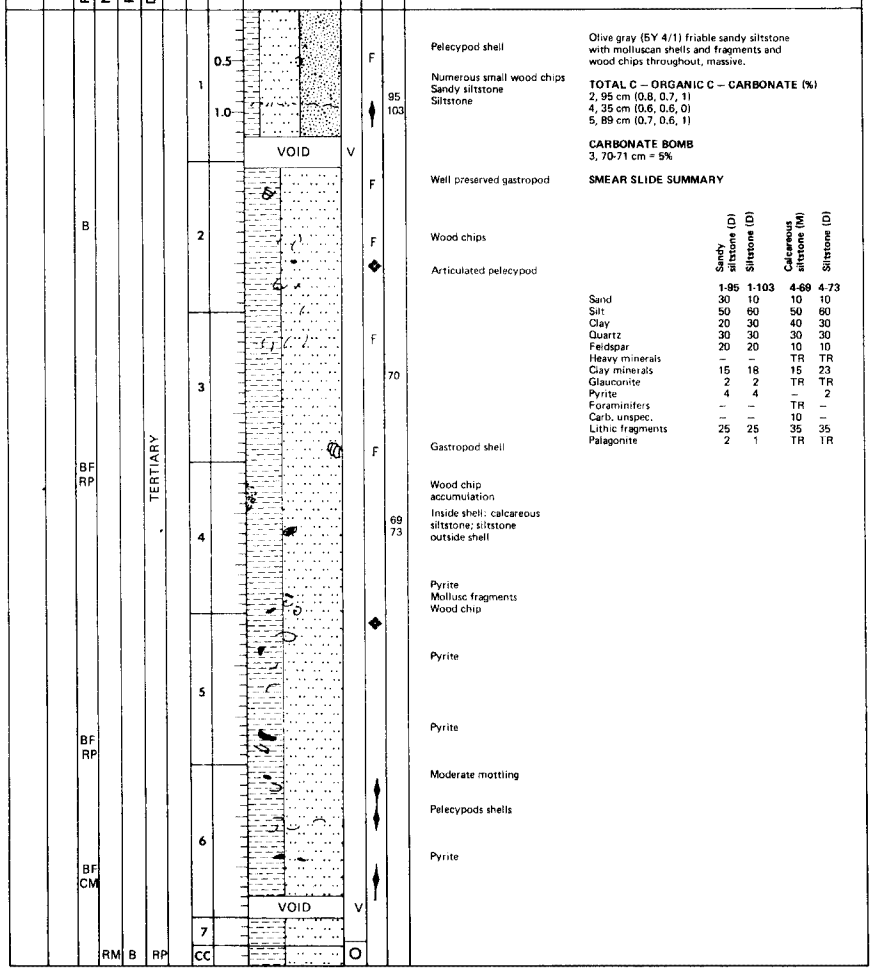
TOTAL C – ORGANIC C – CARBONATE (%)
1, 104 cm (0.7, 0.7, 0)

CARBONATE BOMB
3, 7-10 cm = 4%

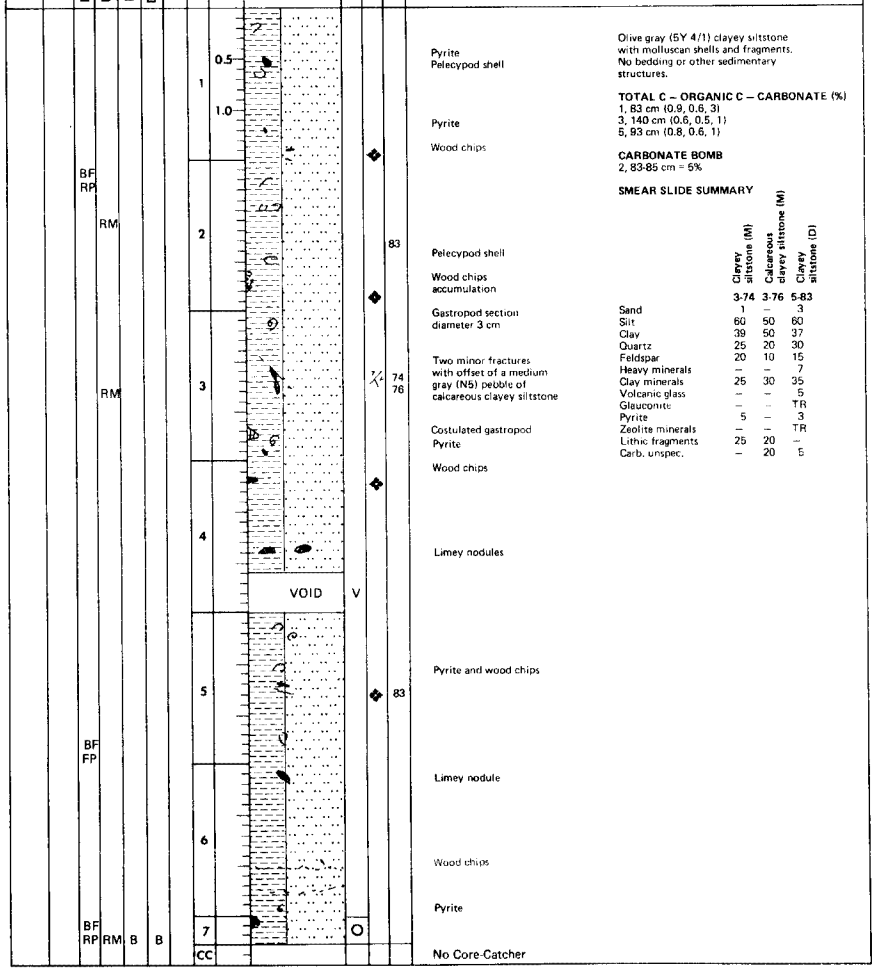
SMEAR SLIDE SUMMARY

	Silty clayey sandstone 1-118
Sand	45
Silt	25
Clay	30
Quartz	30
Feldspar	10
Clay minerals	16
Glauconite	1
Carb. unspec.	2
Lithic fragments	35
Palagonite	6

SITE 439 HOLE CORE 24 CORED INTERVAL: 1020.5-1030.0 m



SITE 439 HOLE CORE 25 CORED INTERVAL: 1030.0-1039.5 m



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SITE 439 HOLE CORE 26 CORED INTERVAL: 1039.5-1049.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
		B				1	0.5, 1.0				92	
		B				2					75	
		B				3					70	
		B				4					98	
		B				5						
		B	B	B	B	6						
						7						
						CC						

Gastropod shell

Fractures (black)

Fracture with black rims

Clayey siltstone

Two pelecypod shells filled with limestone

Wood chips

Gastropod shell

Very dark gray (N3) clayey siltstone

Articulated pelecypod shell

Pelecypod with limey filling

Gastropod shell

Wood chips

Pelecypod shells

Pelecypod shell and gastropod shell with limey filling

Sandy siltstone

Sand, very dark gray (N3) with black and gray gravel and numerous wood fragments

Olive gray (5Y 4/1) to very dark gray (N3) clayey siltstone with molluscan shell and fragments. Sand at bottom of core. Wood chips throughout.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 48 cm (0.6, 0.4, 1)
4, 96 cm (0.7, 0.6, 1)
6, 1 cm (0.7, 0.6, 1)

CARBONATE BOMB
3, 75-77 cm = 8%

SMEAR SLIDE SUMMARY

	Clayey siltstone (D)	Clayey siltstone (D)	Sandy siltstone (D)
	2-92	4-70	6-98
Sand	5	15	30
Silt	75	60	45
Clay	20	25	25
Quartz	40	45	35
Feldspar	25	26	23
Heavy minerals	3	3	3
Clay minerals	20	24	20
Volcanic glass	5	–	7
Glauconite	TR	TR	–
Pyrite and opaques	2	–	10
Carb. unspec.	5	3	2

SITE 439 HOLE CORE 27 CORED INTERVAL: 1049.0-1058.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
		B				1	0.5, 1.0				100	
		B				2					56, 133, 8	
						3		VOID				
		B	B	B	B	CC						

2.5Y 4/0

Small shell

Coarse sand with small gravel (<2 mm)

Coarse sand

Calcite cemented Woody material

2.5Y 4/0

Medium-grained siltstone

Calcite cemented concretion of 1 cm diameter

Medium dark gray (2.5Y 4/0) fine-grained sandstone

Medium dark gray friable fine-grained sandstone intercalated by coarser- and finer-grained beds throughout core.

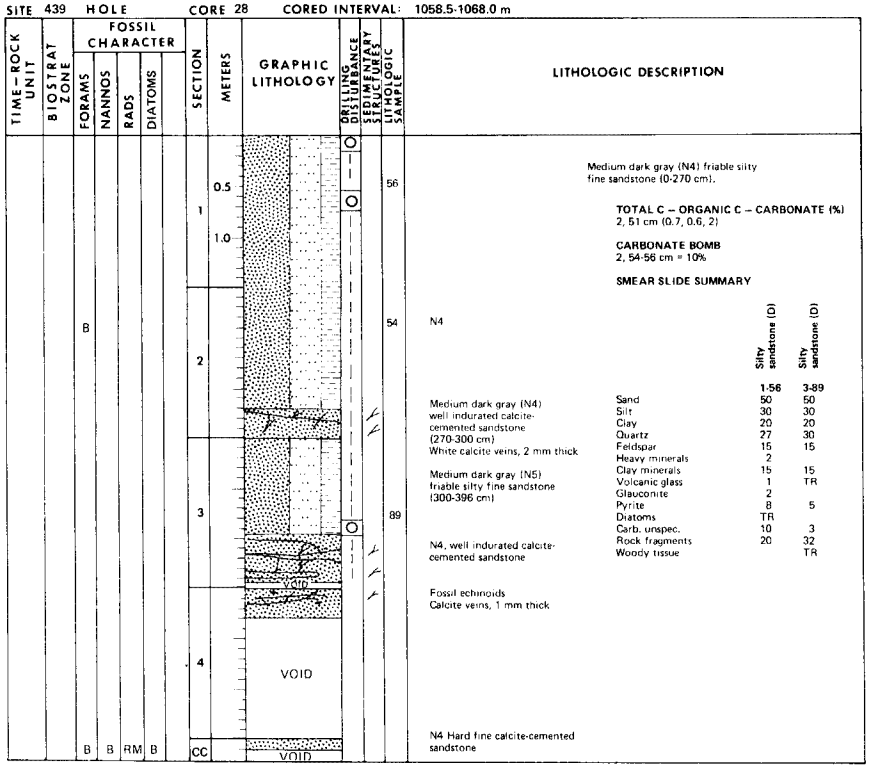
TOTAL C – ORGANIC C – CARBONATE (%)
2, 18 cm (0.9, 0.7, 1)

CARBONATE BOMB
3, 8-10 cm = 9%

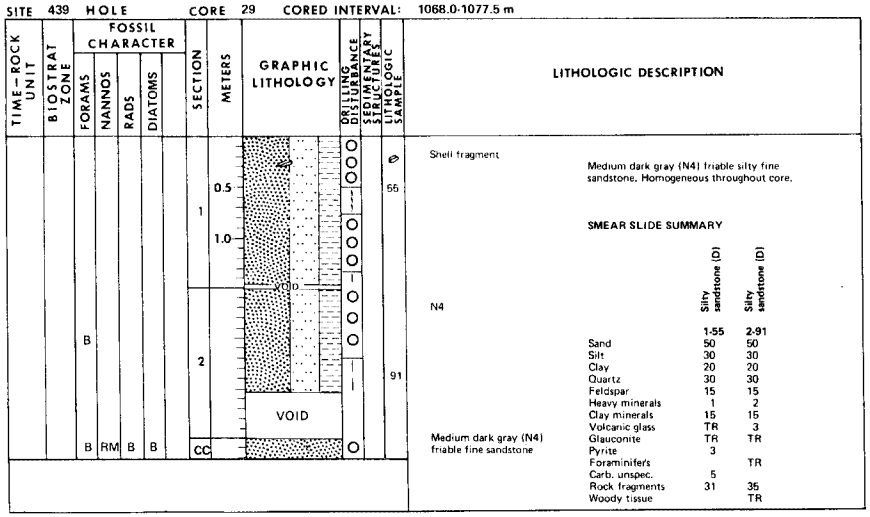
SMEAR SLIDE SUMMARY

	Quartzite or plutonic (M)	Sandy siltstone (D)	Sandy siltstone (M)
	1-100	2-56	2-133
Sand		15	20
Silt		70	75
Clay		15	5
Quartz	93	50	60
Feldspar	5	20	30
Heavy minerals	2	3	
Clay minerals		10	5
Carb. unspec.		15	TR

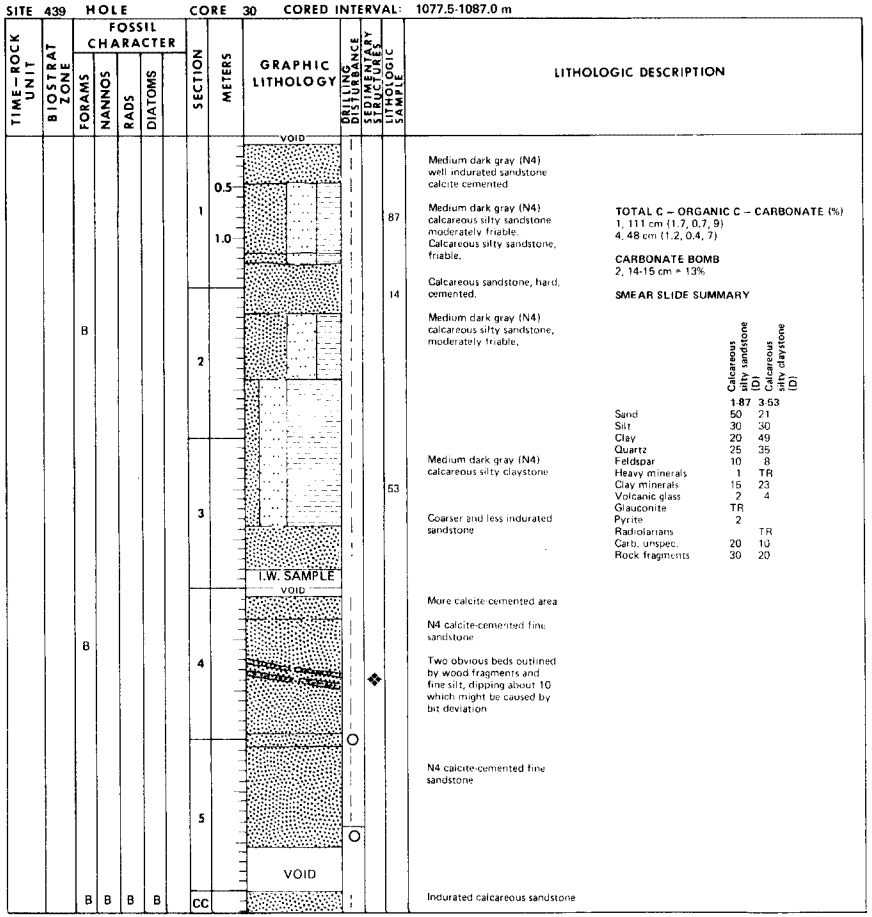
SITE 439 HOLE CORE 28 CORED INTERVAL: 1058.5-1068.0 m



SITE 439 HOLE CORE 29 CORED INTERVAL: 1068.0-1077.5 m



SITE 439 HOLE CORE 30 CORED INTERVAL: 1077.5-1087.0 m



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SITE 439 HOLE CORE 31 CORED INTERVAL: 1087.0-1096.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
					B	1	0.5, 1.0				
		B				2					45
						3					70
								VOID			
		B				4					101
						5		VOID			
		BF RP	B	RP	B	CC		VOID			

LITHOLOGIC DESCRIPTION

Medium dark gray to dark gray (N4-N3) calcite-cemented sandstone, homogeneous, and sandy claystone.

Medium dark gray (N4) calcite-cemented friable coarse sandstone, graded in whole of Section 2. Grain distribution in smear slide is erroneous, for it is crushed to see lithology.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 88 cm (1.0, 0.3, 6)
4, 41 cm (1.8, 0.3, 12)

CARBONATE BOMB
3, 70-72 cm = 7.5%

SMEAR SLIDE SUMMARY

	Sandy claystone (D) 2-45	Silty claystone (D) 4-101
Sand	35	20
Silt	20	40
Clay	45	40
Quartz	35	35
Feldspar	10	9
Heavy minerals	TR	1
Clay minerals	18	24
Volcanic glass	2	2
Glauconite	1	1
Diatoms	1	
Sponge spicules		TR
Carb. unspec.	8	8
Rock fragments	25	20

N4 calcite-cemented friable sandstone

Small shell (pelecypod)
Rounded pebble 2 cm x 1 cm (possible mesozoic chert)
Rounded pebble 1 cm diameter

Dark gray (N3) indurated sandstone

Dark gray (N3) indurated sandstone

SITE 439 HOLE CORE 32 CORED INTERVAL: 1096.5-1106.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
		B				1	0.5, 1.0				
			B			2					45 50 56 57
								VOID			
			B	B		CC					

LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) calcite-cemented moderately friable sandstone

Greenish gray (5G 6/1) angular aphanitic material

Calcite cemented fault with 3 mm wide

Thin section 58 5/1 — Thin section — Dacite boulder

Medium bluish gray (5B 5/1) angular conglomerate with coarse-grained sand to granule matrix. Grayish black (N2) mudstone, shale, chert, angular pebbles of dacite, talc, maximum diameter of 4 cm for volcanics. More aphanitic than lower part in place in core.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 114 cm (2.1, 0.3, 15)

Numerous fragments of dacite and others both aphanitic- and phenocryst-rich

THIN SECTION SUMMARY

	2, 45-50 pebble	2, 56-57 pebble
Phenocrysts:		
Plagioclase	8	5
Clinopyroxene	TR	
Biotite	TR	
Hornblende	5	
K-feldspar	1	2
Mafic		2
Groundmass:		
Plagioclase	45	40
Magnetite	4	4
Quartz	7	12
Alkali feldspar	25	30
Alteration:		
Chalcedony		3 (Gr. mass)
Chlorite	5	2 (Phenol
	DACITE	DACITE
Texture	Hyaloophitic -Intersertial	Intersertial

SITE 439 HOLE CORE 33 CORED INTERVAL: 1106.0-1115.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
					B	1	0.5, 1.0				95 96
			B	B		CC		VOID			

LITHOLOGIC DESCRIPTION

Drilling breccia

Medium bluish gray (5B 5/1) rather fine-grained dacite

Grayish black (N2) fine-grained shale gravel, medium bluish gray (5B 5/1) siltstone gravel and chert pebble (20 mm).

Thin section dacite

Dark greenish gray to greenish black (5GY 4/1-5GY 2/1) dacite boulder, moderately altered, phenocrysts up to 5 mm.

Dark greenish gray to greenish black (5GY 4/1-5GY 2/1) dacite gravels, siltstone, rounded gravels.

THIN SECTION SUMMARY

	CONSTITUENT	Section/Sample 1, 95-96 boulder
Phenocrysts and micro-phenocrysts	Plagioclase	16
	Quartz	TR
	Mafic	8
	K-feldspar	1
Ground-mass	Plagioclase	30
	Magnetite	6
	Glass	10
	Quartz	11
	Alkali feldspar	18
Alteration clay		18
		DACITE

Texture: Intersertial

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SITE 439 HOLE CORE 34 CORED INTERVAL: 1115.5-1125.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
		B			B	1	0.5, 1.0		O		31, 41, 103
						2			O		
						3		VOID	O		
		B	B	B		CC			O		

LITHOLOGIC DESCRIPTION

Dark greenish gray (5G 3/1) subangular volcanic aphanitic clast.
Grayish black to medium dark gray (N2-N4) breccia of coarse-grained sand-silt matrix angular to rounded gravels with 3 mm to 10 mm diameter aphanitic rocks of mudstone, and fine-grained volcanic rocks.
Gravels of angular to subangular fragments with maximum, 2.0 cm and average 5 mm diameter, all aphanitic. Mudstones are altered volcanics, with greenish gray (5G 6/1) clay matrix.

Boulder of total 65 cm thick dacite

Siltstone to coarse-grained sandstone granules

Reverse graded but finer again at top

Dusky green (5G 3/2-10GY 3/2) homogeneous dacite boulder, approximately 60 cm thick.

Angular to subangular dacite pebbles with mudstone and dacite clasts.

Dacite clast; angular

SMEAR SLIDE SUMMARY

	Clay stone (M)	Boulder of igneous rock (D)	Pebble of clay stone (M)
	1-31	1-41	1-103
Sand	4	55	7
Silt	20	45	20
Clay	76		73
Quartz	42	56	50
Feldspar	3	35	8
Mica			
Heavy minerals	1	9	3
Clay minerals	35		21
Volcanic glass	2		2
Glauconite	1		6
Diatoms	TR		TR
Carb. unspec.	1		
Rock fragments	15		10

SITE 439 HOLE CORE 35 CORED INTERVAL: 1125.0-1134.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
					B	1	0.5, 1.0				73, 74
						2		VOID			
		B	B	B		CC			O		

LITHOLOGIC DESCRIPTION

Thin section

Medium light bluish gray (5B 6/1) pebble medium dark gray (N4) streaks, suggesting a flow-banded volcanic.

Greenish gray (5G 6/1) dacite boulder and pebbles. Black (N1-N2) silicified mudstone breccias with maximum 3.5 cm diameter, partly indurated greenish gray (5G 6/1) dacite boulder with at least 26 cm diameter (52-78 cm).

Dark bluish gray (5B 6/1) porphyritic igneous clasts and black (N1-N2) silicified mudstone clast up to 5 cm (80-135 cm).

Greenish black (5G 2/1) porphyritic boulder of subrounded to subangular with 14 cm diameter (136-150 cm).

THIN SECTION SUMMARY

Constituent	1, 73-74 boulder
Phenocrysts:	
Plagioclase	14
Hornblende	TR
Mafic	7
Groundmass:	
Plagioclase	53
Glass	10
Quartz	9
Alkali feldspar	7
Alteration:	
Muscovite	TR
Clay	17
	DACITE

Texture: Intersertal-intergranular

TOTAL C – ORGANIC C – CARBONATE (%)
1, 100 cm (0.0, 0.0, 0)

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SITE 439 HOLE CORE 36 CORED INTERVAL: 1134.5-1144.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
		B	B	RP	RP	1	0.5, 1.0				2, 28
						2		VOID			65, 66
						CC					

LITHOLOGIC DESCRIPTION

Greenish black (5G 2/1) dacite boulders up to 20 cm thick, are commonly observed throughout core.
Medium grained sandstone clast (110-115 cm), greenish gray (5G 7/1) tuff pebble with 3x5 cm (120-130 cm).

Brownish gray (5YR 4/1) angular pelagic cherty mudstone clast (42-47 cm).

Thin section

Greenish black (5G 2/1) porphyritic clast and broken-up bed or crust of brown black (5YR 2/1) silty claystone with laminae of quartz, silt and fine-grained sand, well indurated.

THIN SECTION SUMMARY

	2, 65-66
Phenocrysts:	
Plagioclase	18
Biotite	TR
Mafic	11
Hornblende	3
K-feldspar	1
Groundmass:	
Plagioclase	30
Magnetite	5
Glass	7
Orthopyroxene	TR?
Quartz	8
Alkali feldspar	17
Alteration:	
Carbonate	TR
Clay	18

HORNBLENDE
DACITE
Texture: Intersertial-Hyalophitic

SMEAR SLIDE SUMMARY

	Pebble of claystone (M) 1-2	Sandy siltstone (M) 1-28
Sand		30
Silt	50	50
Clay	50	20
Quartz	30	25
Feldspar	15	20
Heavy minerals		8
Clay minerals	55	17
Volcanic glass		4
Glauconite		5
Rock fragments		25

SITE 439 HOLE CORE 37 CORED INTERVAL: 1144.0-1148.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
		B	B			1	0.5				
					B		1.0				
		B	B	B	B	CC		VOID			

LITHOLOGIC DESCRIPTION

Grayish black (N2) fine-grained clayey siltstone with thick calcite vein and numerous quartz-rich silty intervals. Many of the chips have shiny grooved surfaces (0-70 cm).

Olive gray (5Y 4/1) clay moderately indurated, but plastic when wet. Sandstone with small angular to subrounded granules set in and some larger clast of white calcite veined calcareous mudstone (70-135 cm).

A few 1 cm chips of grayish black (N2) silt-sized graywacke, very well indurated.

SITE 439 HOLE CORE 38 CORED INTERVAL: 1148.0-1153.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER CRETACEOUS		BF, FP	B		B	1	0.5, 1.0				114, 139
						2		VOID			
		B	B	B	B	CC					

LITHOLOGIC DESCRIPTION

Pebble of eruptive rock, clear gray with black elongate minerals.

Dark gray (N3) well indurated shale (claystone and clayey siltstone) with medium dark gray (N4) calcareous very fine-grained siltstone intercalations, which are disrupted and contorted on upper surface.

Small beds of dark gray (N3) clayey siltstone, graded, alternating with medium dark gray (N4) fine sandstone. Dips 15 -30 ; folded.

Blocks of fine alternation of dark gray (N3) clayey siltstone and medium dark gray (N4) fine siltstone

TOTAL C – ORGANIC C – CARBONATE (%)
1, 33 cm (1.0, 0.4, 4)

SMEAR SLIDE SUMMARY

	Calcareous clayey siltstone (M) 1-114	Clayey siltstone (D) 1-139
Sand	10	10
Silt	50	50
Clay	40	40
Quartz	33	35
Feldspar	3	3
Heavy minerals	2	2
Clay minerals	25	25
Volcanic glass	3	5
Glauconite	TR	
Rock fragments	24	25
Woody tissue	TR	
Carb. unspec	10	

SITE 439 HOLE CORE 39 CORED INTERVAL: 1153.5-1157.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
		BF, FP	B			1	0.5, 1.0				82, 97
								VOID			
		B	B	B	B	CC					

LITHOLOGIC DESCRIPTION

Dark gray (N3) shale (clayey siltstone) some slickensides and observed on ships, some others show fine beds of limey silt as in Core 38.

CARBONATE BOMB
1, 97-99 cm = 8%

Drilling breccia of dark gray (N3) shale

SMEAR SLIDE SUMMARY

	Clayey siltstone (D) 1-82
Sand	5
Silt	50
Clay	45
Quartz	35
Feldspar	3
Heavy minerals	2
Clay minerals	25
Volcanic glass	3
Rock fragments	32

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SITE SUMMARY SHEET

SITE 440

Date occupied	November 10, 1977
Date departed	November 10, 1977
Time on hole	1 day
Position: latitude	39° 44.13'N
longitude	143° 55.74'E
Water depth (sea level)	4509 corrected meters, echo sounding
Water depth (rig floor)	4519 corrected meters, echo sounding
Bottom felt at	4517 meters, drill pipe
Penetration	73.0 meters
Number of holes	1
Number of cores	8
Total length of cored section	73.0 meters
Total core recovery	50.4 meters
Percentage core recovery	69%

Oldest Sediment Cored

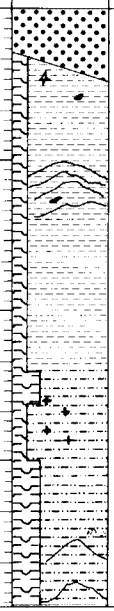
Depth sub-bottom	73.0 meters
Nature	Diatomaceous silty clay
Age	Pleistocene
Measured velocity	1.5 km/s

Principal Results:

See 440B Site Summary Sheet.

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE	N22	PB AG	AM	CG	CG	1, 2, 3, 4	0.5, 1.0				30, 80, 83, 98, 82



G. oceanica-E. huxleyi; *Artostrobium tumidulum*; *Denticula seminae*

LITHOLOGIC DESCRIPTION

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

Pyritized burrow

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

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

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

CARBONATE BOMB
3, 117-119 cm = 12%

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

SMEAR SLIDE SUMMARY

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

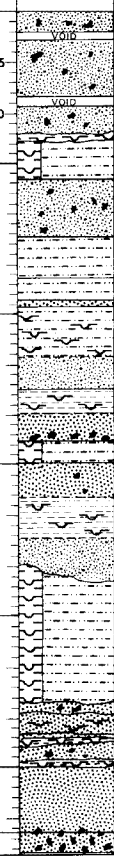
Firm grayish olive (10Y 4/2) silty clayey diatomaceous with streak and thin layers of lighter color dusky yellow green (5GY 5/2) bedding severely deformed.

Dark gray silty mottles (N3)

No Core-Catcher

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE		PF RM BF CM	FM	CG	CG	1, 2, 3, 4, 5, 6, CC	0.5, 1.0				120, 82, 24, 140, 80, 128, 120



G. oceanica-E. huxleyi; *Artostrobium tumidulum*; *Denticula seminae*

LITHOLOGIC DESCRIPTION

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

Silty clayey diatomaceous ooze.

Graded clayey sand

Sandy mottles in 10Y 4/2

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

Sandy-clayey diatomaceous ooze

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

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

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

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

Clayey diatom ooze

Silty sand

SMEAR SLIDE SUMMARY

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

5Y 4/1

Graded poorly sorted granule to pebbly sand.

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLEISTOCENE	*Artostrobium tumidulum* / *Denticula seminae*	PB, CG	RM	CG	CM	1, 2, 3, CC	0.5, 1.0	VOID	V		87, 96	Diatomaceous sandy silty clay; Diatomaceous silty clay; More firm diatomaceous silty clay

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

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

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

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLEISTOCENE	*A. tumidulum* / *Denticula seminae*	PB, CG	RM	CG	AG	1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0	VOID			50, 106, 89, 91, 52, 69	Gas cracked diatomaceous silty clay; Silty ash graded dark gray (N3) to pale olive (10Y 6/2) at top; Diatomaceous silty clay graded silty ash; Ash pocket; Sand layer, medium dark gray (N4); Clayey sand (N4) underlain by calcareous silty clay, dusky yellow green (5GY 5/2); Medium dark gray ash layer; Sponge skeleton clayey sand; Diatomaceous silty clay and diatomaceous sandy silty clay layers; 3 cm ash graded N4 at base to bluish white (5B 9/1) at top

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

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

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

SMEAR SLIDE SUMMARY

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

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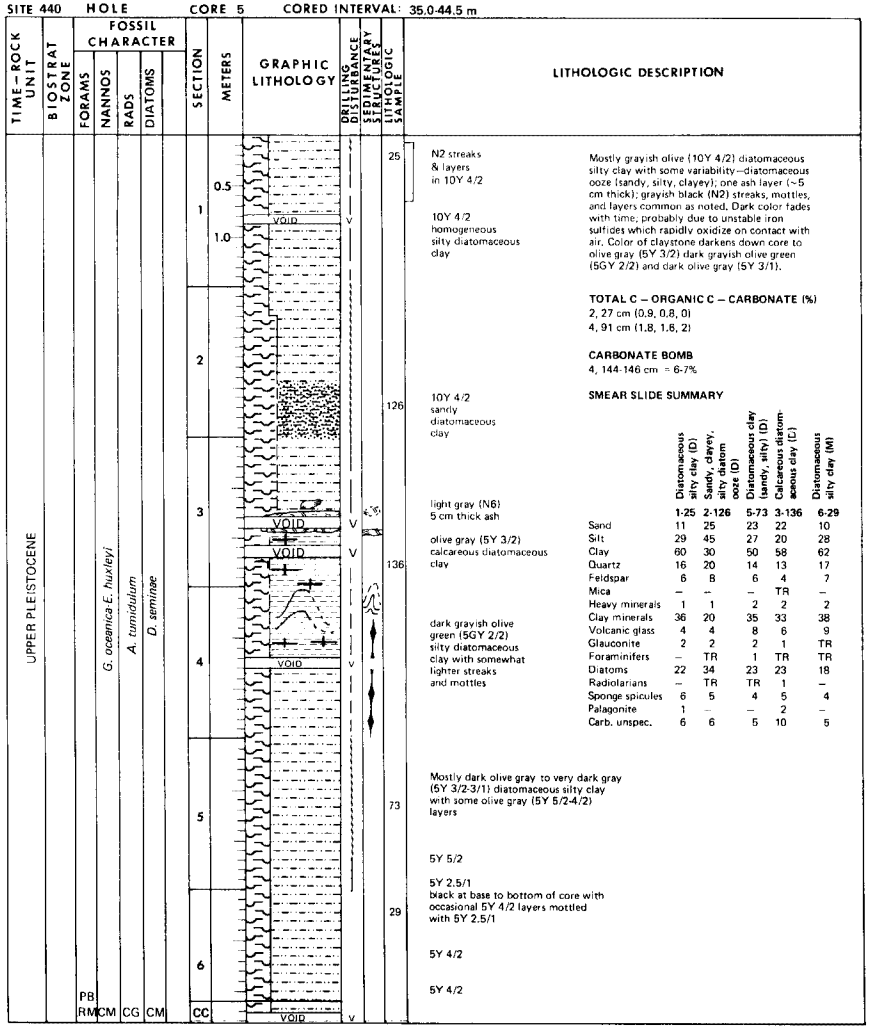
SITE 440 HOLE CORE 5 CORED INTERVAL: 35.0-44.5 m



LITHOLOGIC DESCRIPTION

N2 streaks & layers in 10Y 4/2

10Y 4/2 homogeneous silty diatomaceous clay

10Y 4/2 sandy diatomaceous clay

light gray (N6) 5 cm thick ash

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

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

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

5Y 5/2

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

5Y 4/2

5Y 4/2

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

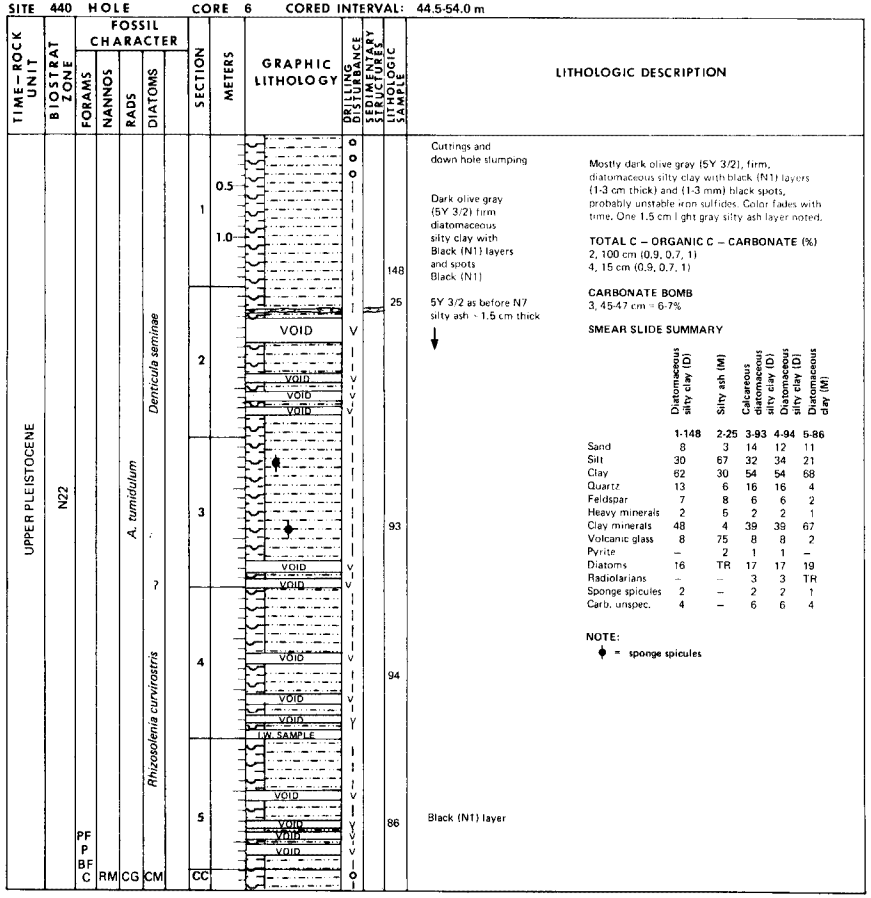
TOTAL C – ORGANIC C – CARBONATE (%)
2, 27 cm (0.9, 0.8, 0)
4, 91 cm (1.8, 1.8, 2)

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

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

Cuttings and down hole slumping

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

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

Black (N1) layer

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

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

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

SMEAR SLIDE SUMMARY

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

NOTE:
♦ = sponge spicules

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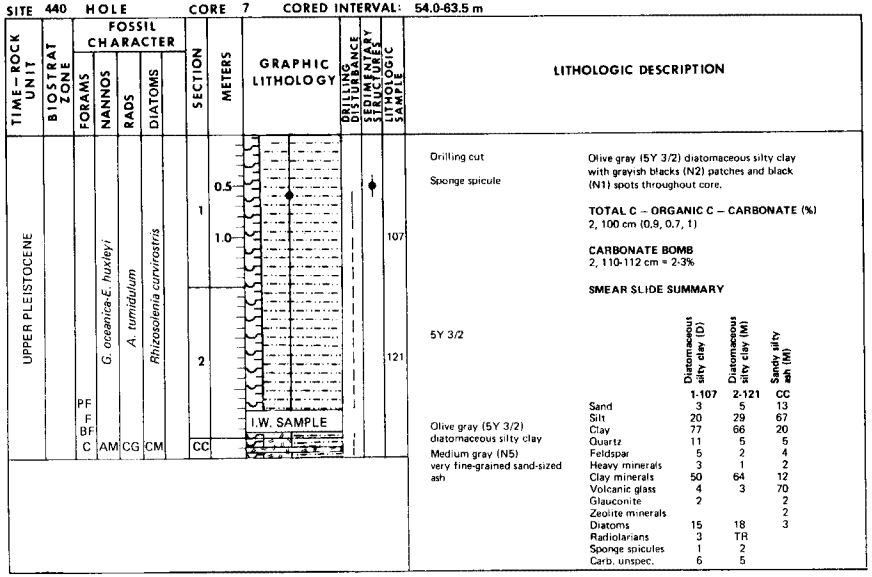
SITE 440 HOLE CORE 7 CORED INTERVAL: 54.0-63.5 m



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

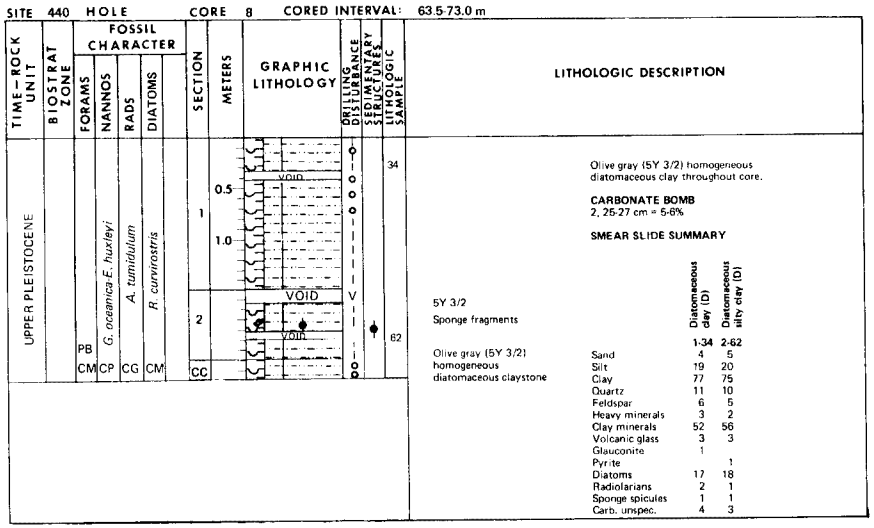
TOTAL C – ORGANIC C – CARBONATE (%)
2, 100 cm (0.9, 0.7, 1)

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

SMEAR SLIDE SUMMARY

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

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



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

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

SMEAR SLIDE SUMMARY

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

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SITE SUMMARY SHEET

HOLE 440A

Date occupied	November 11, 1977
Date departed	November 11, 1977
Time on hole	1 day
Position: latitude	39° 44.13'N
longitude	143° 55.74'E
Water depth (sea level)	4509 corrected meters, echo sounding
Water depth (rig floor)	4519 corrected meters, echo sounding
Bottom felt at	4517 meters, drill pipe
Penetration	139.5 meters
Number of holes	1
Number of cores	7
Total length of cored section	66.5 meters
Total core recovery	33.5 meters
Percentage core recovery	50%

Oldest Sediment Cored

Depth sub-bottom	139.5 meters
Nature	Diatomaceous clay
Age	Pleistocene
Measure velocity	1.5 km/s

Principal Results:

See 440B Site Summary Sheet.

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE	N22	BF, C, PF, R	FM	CM	AM	1, 2, 3, 4, 5, 6, CC	0.5, 1.0	VOID, CONSOL. TEST, J.W. SAMPLE, VOID, VOID	V, V, V, O		110, 111, 91

G. oceanica-E. huxleyi; *A. tumidulum*; *R. curvirostris*

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

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

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

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

SMEAR SLIDE SUMMARY

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

Ash mottled, dark gray (N3) silt mottle.

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

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

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE		PB, FM	AM	CM	AM	1, 2, 3, CC	0.5, 1.0	VOID, VOID, VOID	V, V, V		74, 104, 146

G. oceanica-E. huxleyi; *A. tumidulum*; *R. curvirostris*

Sponge fragments

Diatomaceous silty clay

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

Calcareous diatomaceous clay

Calcareous sandy silty clay, 10Y 4/2

1.5 cm black pebble (basalt?)

3 cm smooth black pebble

2 mm black granule pyrite concretion

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

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

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLEISTOCENE		PF, BC	FM	CM	CM	1, 2, CC	0.5, 1.0	VOID, VOID, VOID, VOID	V, V, V, V		90, 115

P. lacunosa; *A. tumidulum*; *R. curvirostris*

Vitric diatomaceous silty clay

Mottle of clayey silty sand, lithic fragments

Pyrite silty mottles

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

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

SMEAR SLIDE SUMMARY

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

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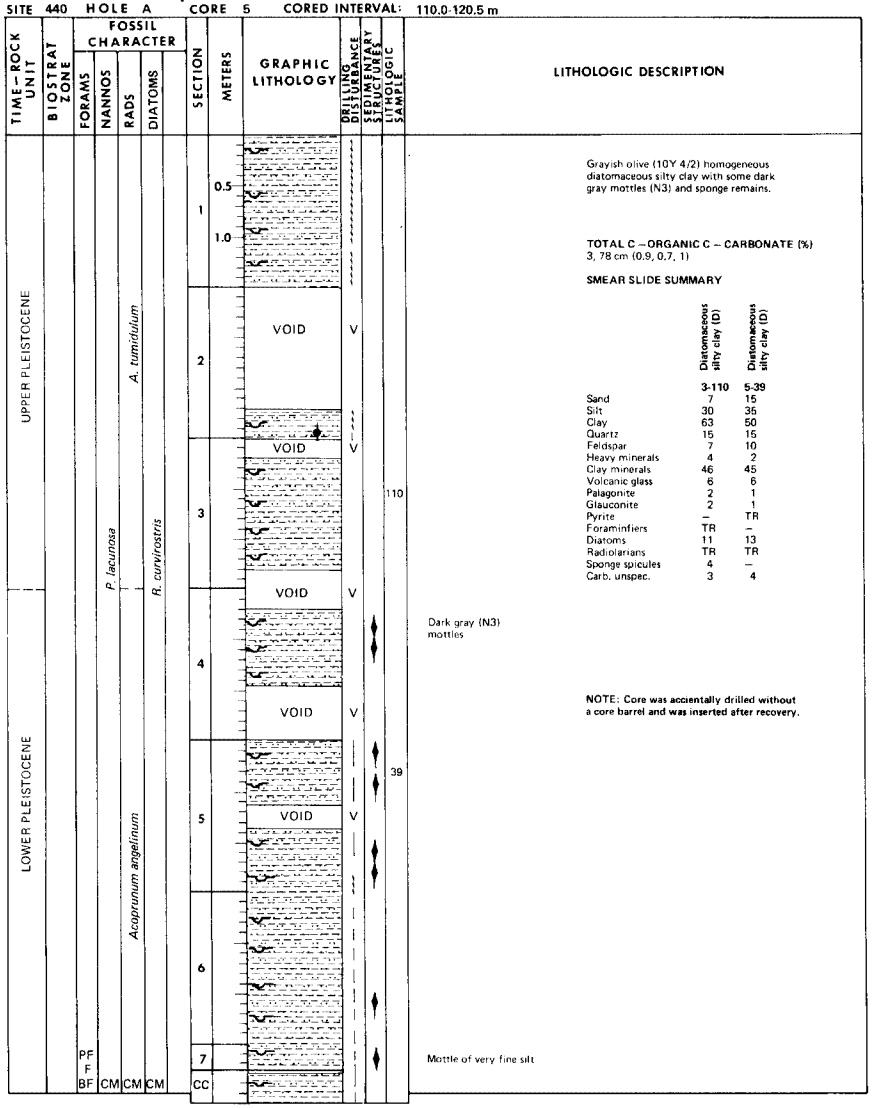
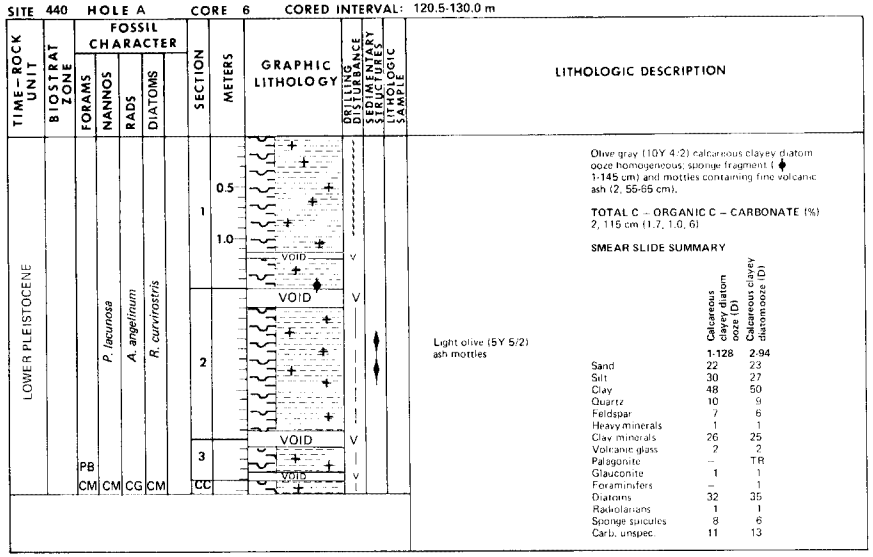
SITE 440 HOLE A CORE 5 CORED INTERVAL: 110.0-120.5 m



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



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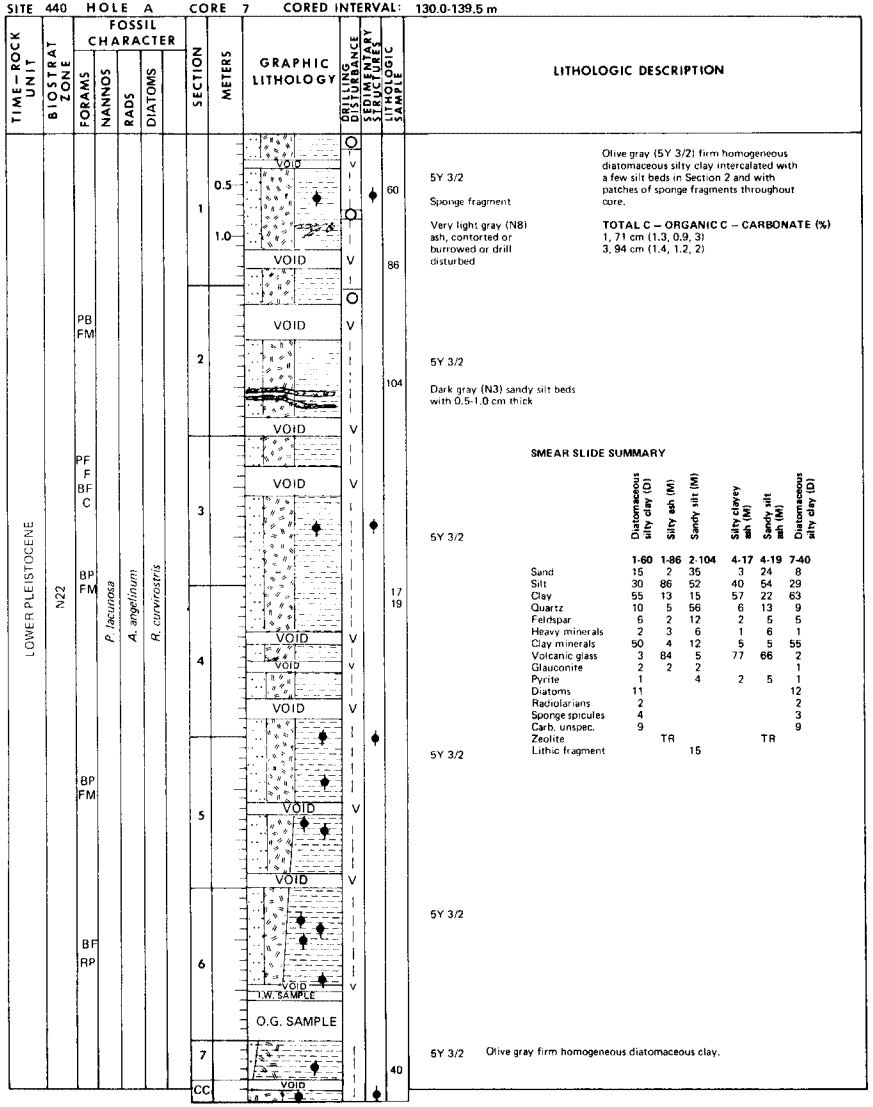
SITE 440 HOLE A CORE 7 CORED INTERVAL: 130.0-139.5 m



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SITE SUMMARY SHEET

HOLE 440B

Date occupied	November 12, 1977
Date departed	November 19, 1977
Time on hole	8 days
Position: latitude	39° 44.13'N
longitude	143° 55.74'E
Water depth (sea level)	4509 corrected meters, echo sounding
Water depth (rig floor)	4519 corrected meters, echo sounding
Bottom felt at	4517 meters, drill pipe
Penetration	814.0 meters
Number of holes	1
Number of cores	71
Total length of cored section	814.0 meters
Total core recovery	401.9 meters
Percentage core recovery	49%

Oldest Sediment Cored

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

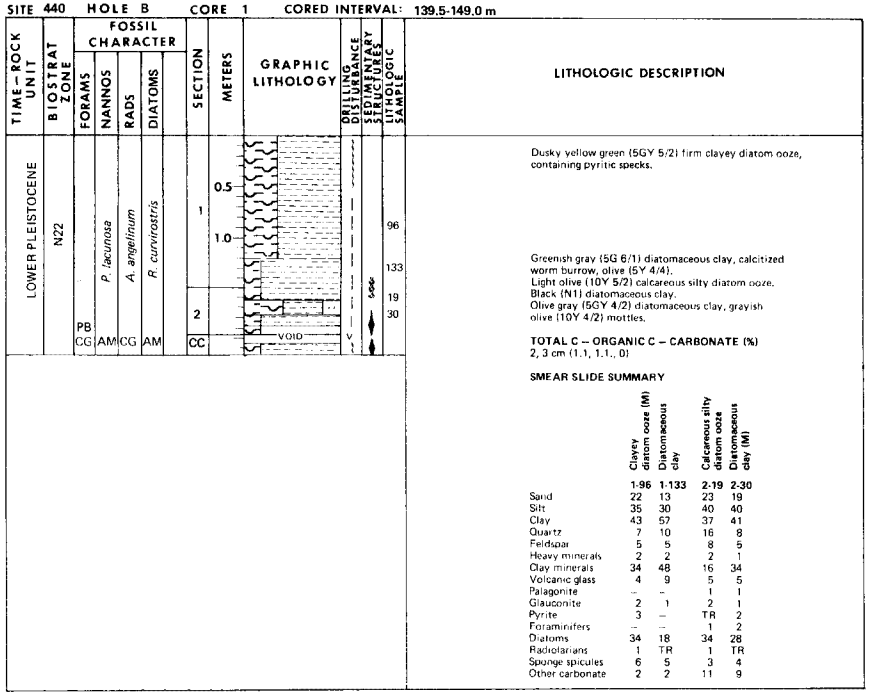
Principal Results:

Site 440 is on the Japan Trench landward slope, 28 km from its axis and on the midslope terrace. The core recovery and biostratigraphic zonation were good, and a suite of downhole logs contributed greatly to interpretation of lithology and structure. Beneath the midslope terrace is a nonfolded continental-slope section rather than material accreted at the leading edge of the upper plate. The sediment section is of uniform hemipelagic mudstone similar in composition to that at sites farther upslope, and its character is consistent with the very uniform rate of sedimentation over the nearly 800 meter section ranging in age from late Miocene through early Pleistocene.

The only breaks in continuous sedimentation are three or more periods of slumping in the Miocene and Pliocene. Ponding of turbidites, consistent with the present topography of the midslope terrace is recorded only in late Pleistocene time. The section was deposited at bathyal depths and near or below the CCD. No tectonic event that would change sediment source or dispersal paths is obvious from the history recorded here. However, a stress environment of unknown age has tectonically brecciated the section at depths where the rock deforms brittlely. Although microfaulting was observed at other sites in the transect, it was not as intense and pervasive at the relatively shallow depths that the micro-brecciation was observed here. The section is at least 1600 meters thick. The estimated sediment age at this depth is early Miocene, if sedimentation continued without hiatus and at a nearly constant rate during the Neogene, as it did at sites upslope.

The tectonic history that allowed a continental slope segment to be so far down the inner trench slope of a convergent margin is not fully apparent from the seismic records and the cores. A nonfolded block 1.6 km thick and 6 km wide is not likely to have slumped very far. The seismic records and cores show a continuous Neogene continental slope section from Site 440 landward across the deep sea terrace almost to the shore. Therefore active Neogene accretion seems to have been restricted to the lower trench slope.

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



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

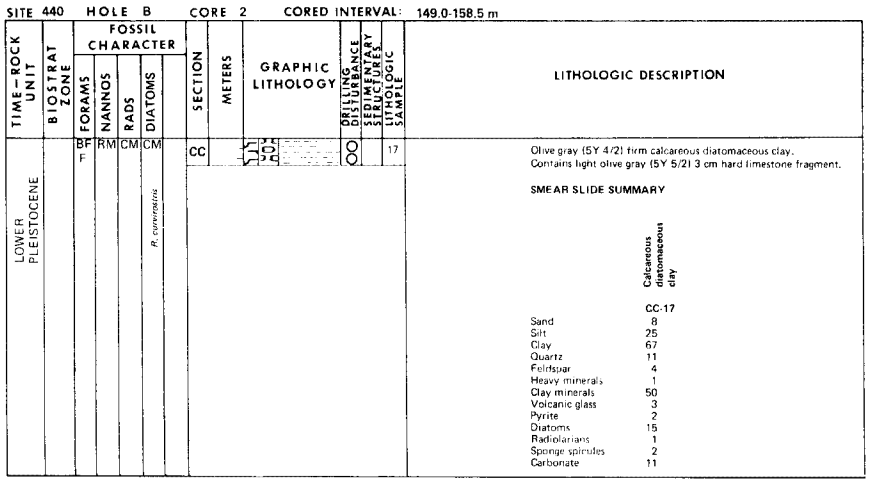
Greenish gray (5G 6/1) diatomaceous clay, calcitized worm burrow, olive (5Y 4/4).
Light olive (10Y 5/2) calcareous silty diatom ooze.
Black (N1) diatomaceous clay.
Olive gray (5GY 4/2) diatomaceous clay, grayish olive (10Y 4/2) mottles.

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

SMEAR SLIDE SUMMARY

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

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

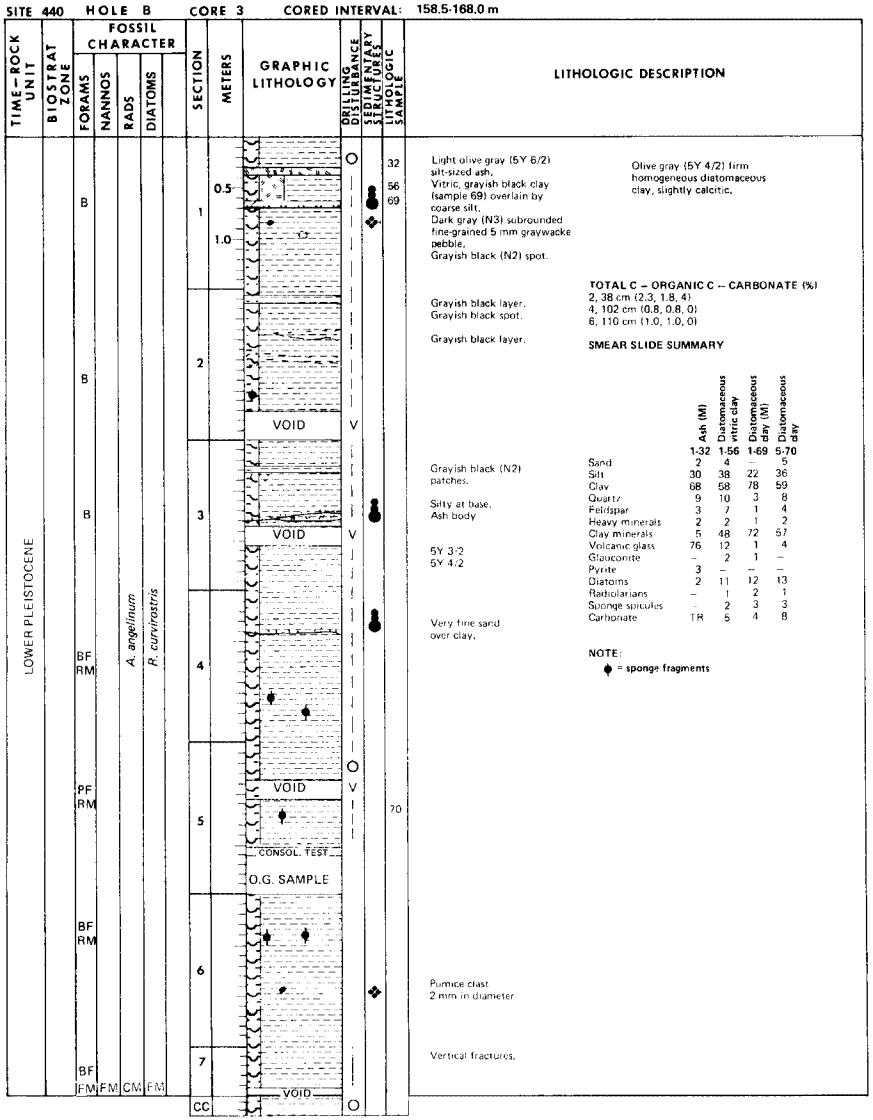


Olive gray (5Y 4/2) firm calcareous diatomaceous clay.
Contains light olive gray (5Y 5/2) 3 cm hard limestone fragment.

SMEAR SLIDE SUMMARY

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

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



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

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

Grayish black layer.
Grayish black spot.

Grayish black layer.

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

SMEAR SLIDE SUMMARY

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

Grayish black (N2) patches.

Silty at base.
Ash body

5Y 3/2
5Y 4/2

Very fine sand over clay.

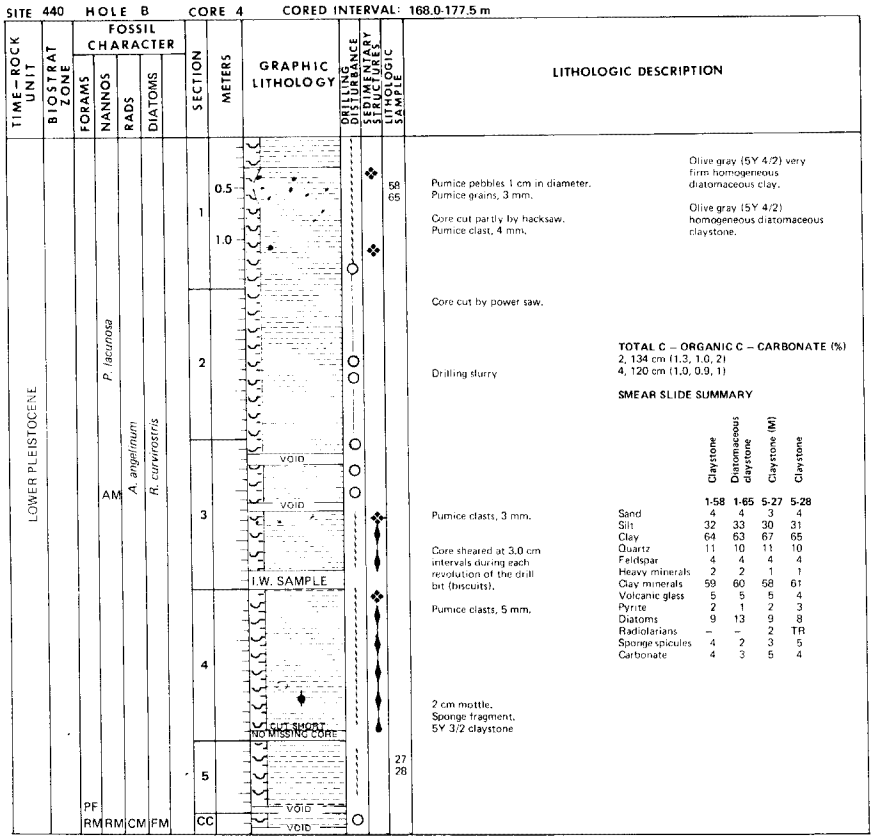
NOTE:
♦ = sponge fragments

Pumice clast 2 mm in diameter

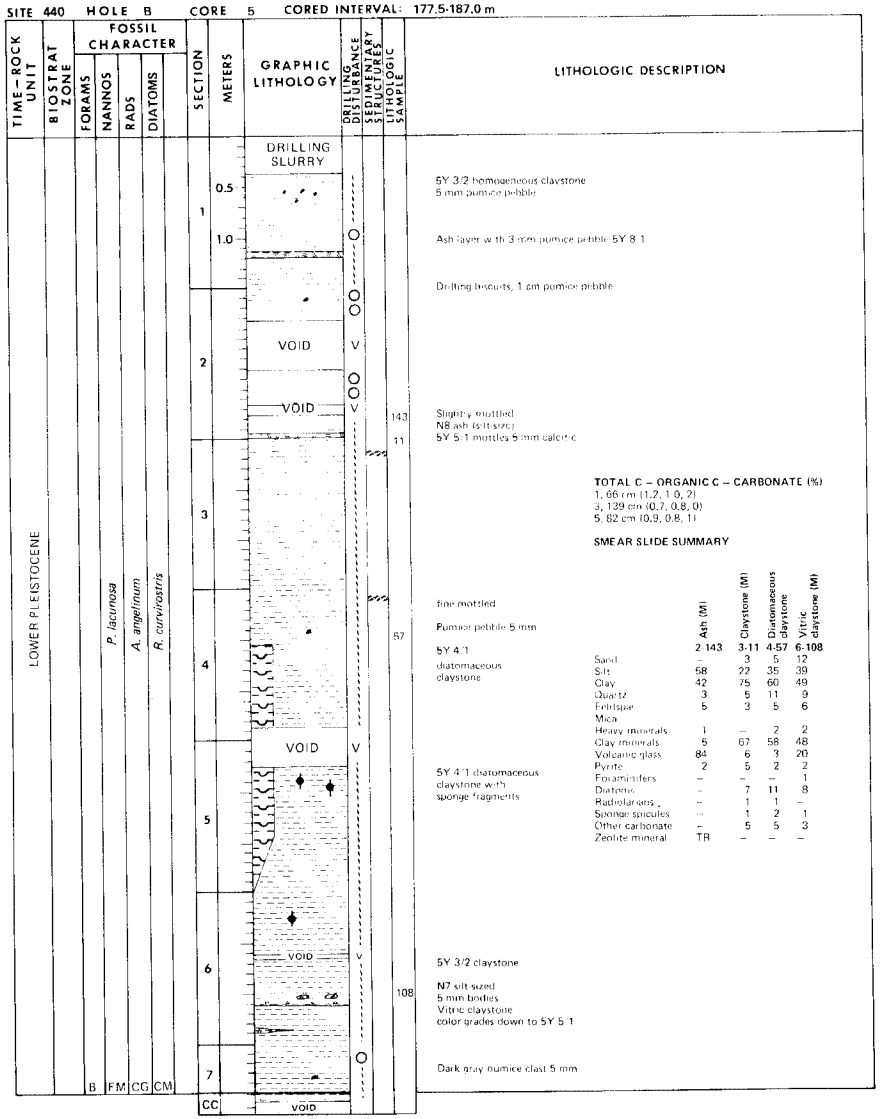
Vertical fractures.

MGG 1505502 6/6

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

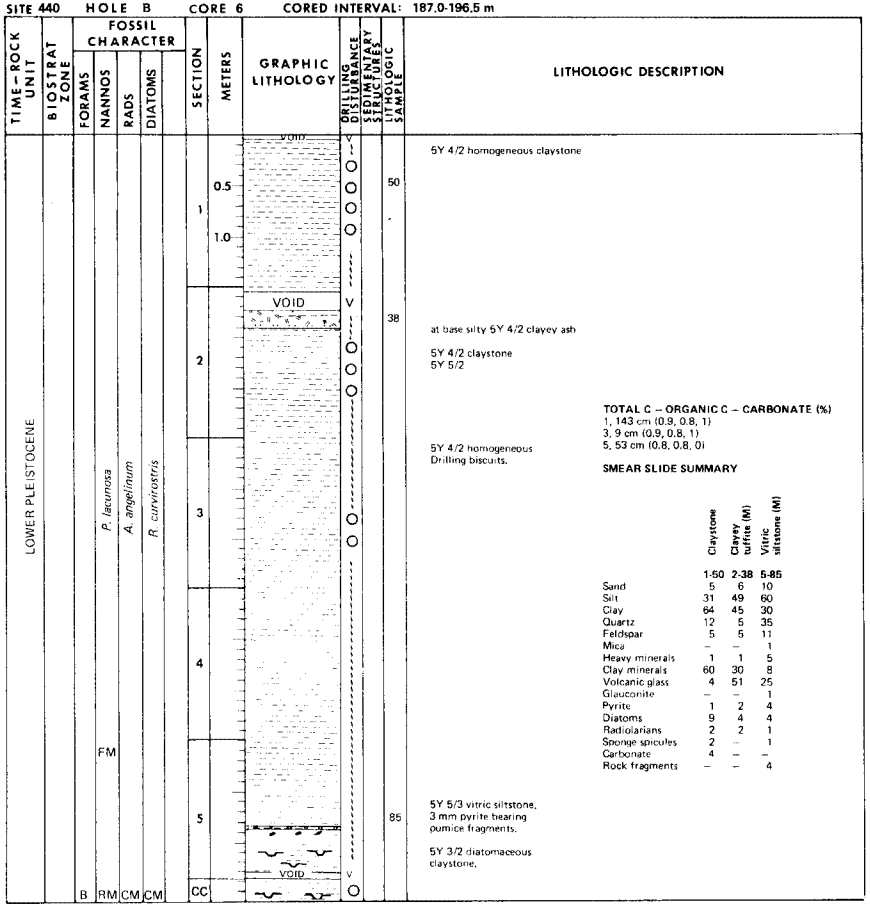


SITE 440 HOLE B CORE 5 CORED INTERVAL: 177.5-187.0 m

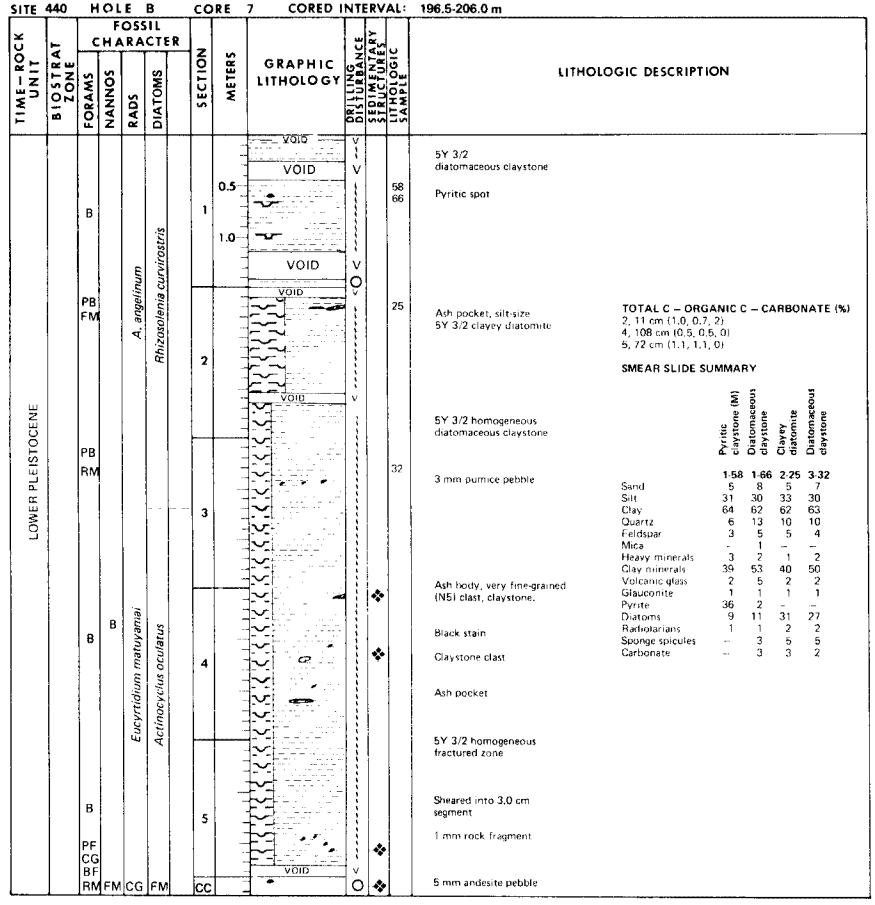


MGG 15 0 5 0 2 7

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

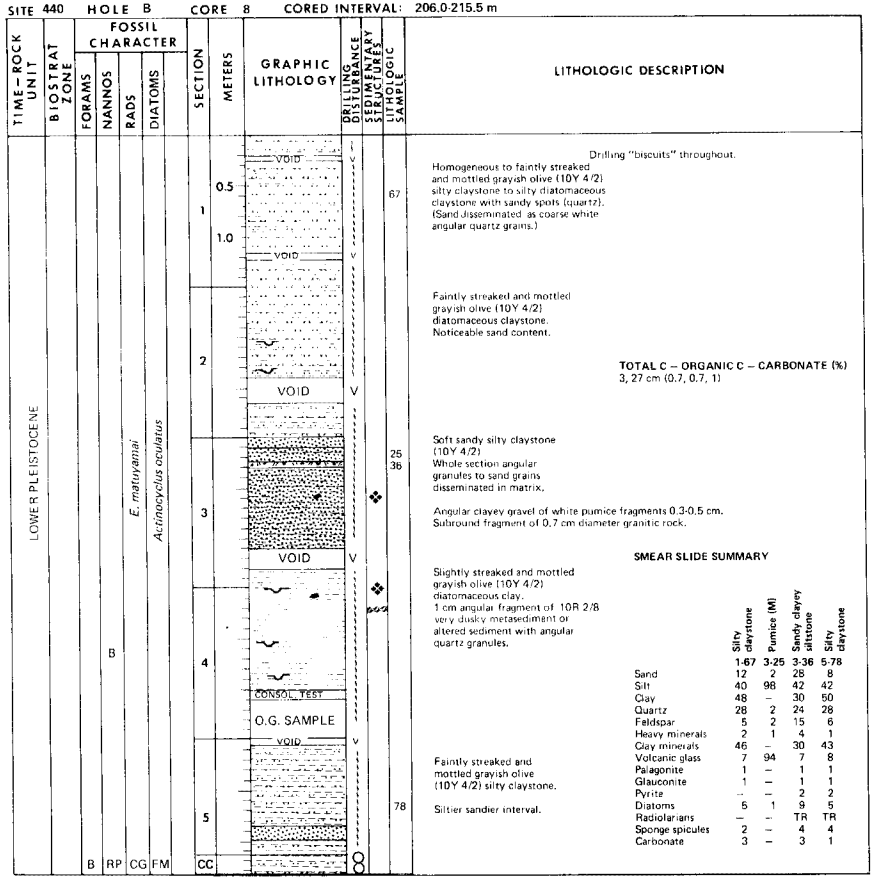


SITE 440 HOLE B CORE 7 CORED INTERVAL: 196.5-206.0 m



MGG 1505027

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



Drilling "biscuits" throughout.

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

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

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

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

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

SMEAR SLIDE SUMMARY

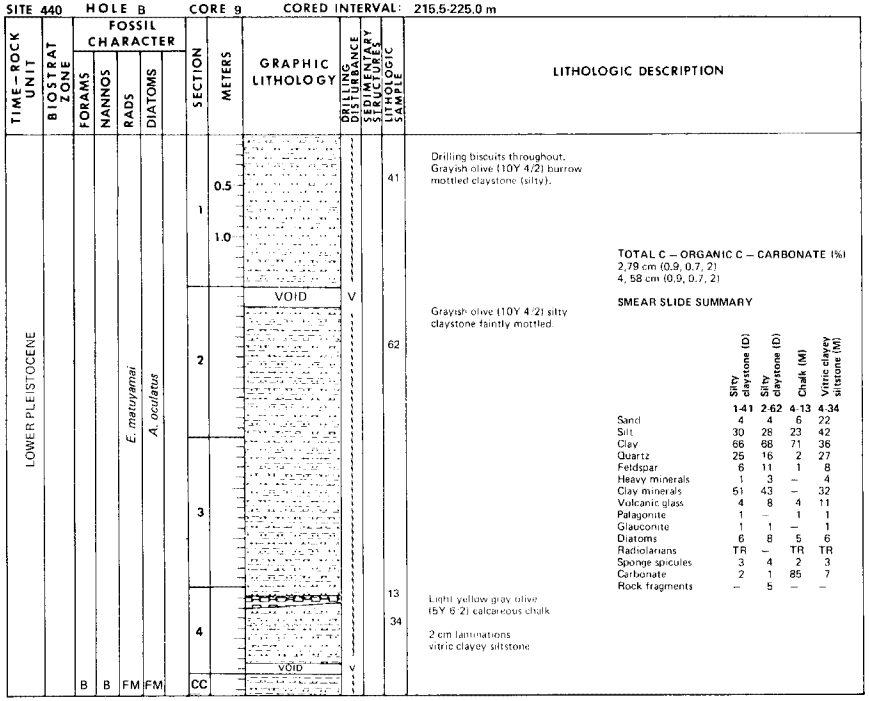
Slightly streaked and mottled grayish olive (10Y 4/2) diatomaceous clay.
1 cm angular fragment of 10R 2/8 very dusky metasediment or altered sediment with angular quartz granules.

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

Siltier sandier interval.

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

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



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

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

SMEAR SLIDE SUMMARY

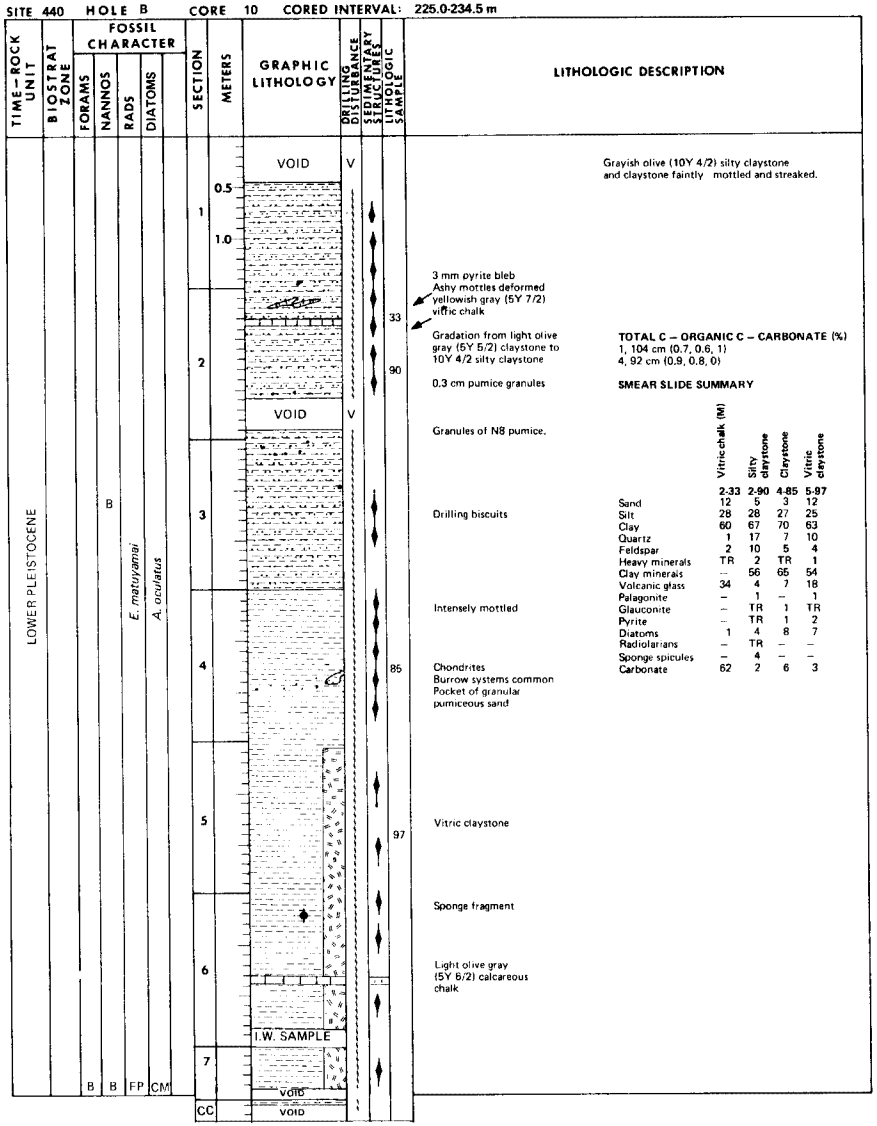
Grayish olive (10Y 4/2) silty claystone faintly mottled.

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

2 cm laminations vitric clayey siltstone

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

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

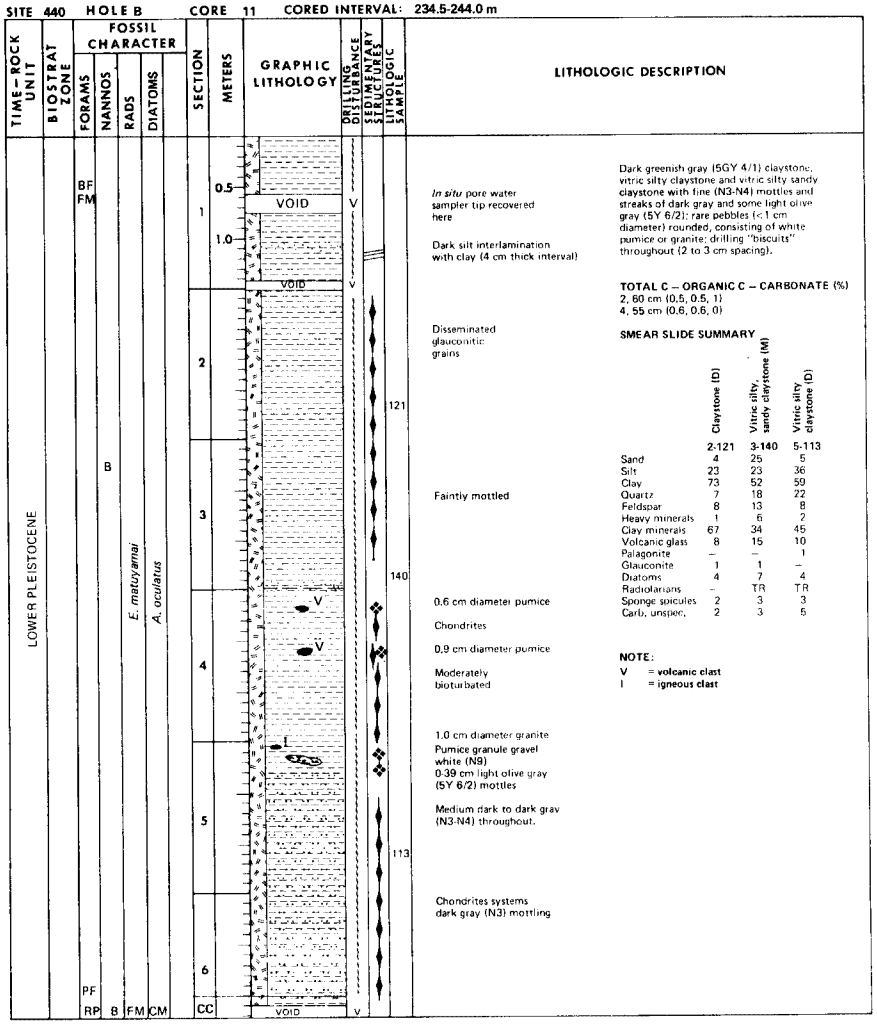


TOTAL C – ORGANIC C – CARBONATE (%)
1, 104 cm (0.7, 0.6, 1)
4, 92 cm (0.9, 0.8, 0)

SMEAR SLIDE SUMMARY

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

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



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

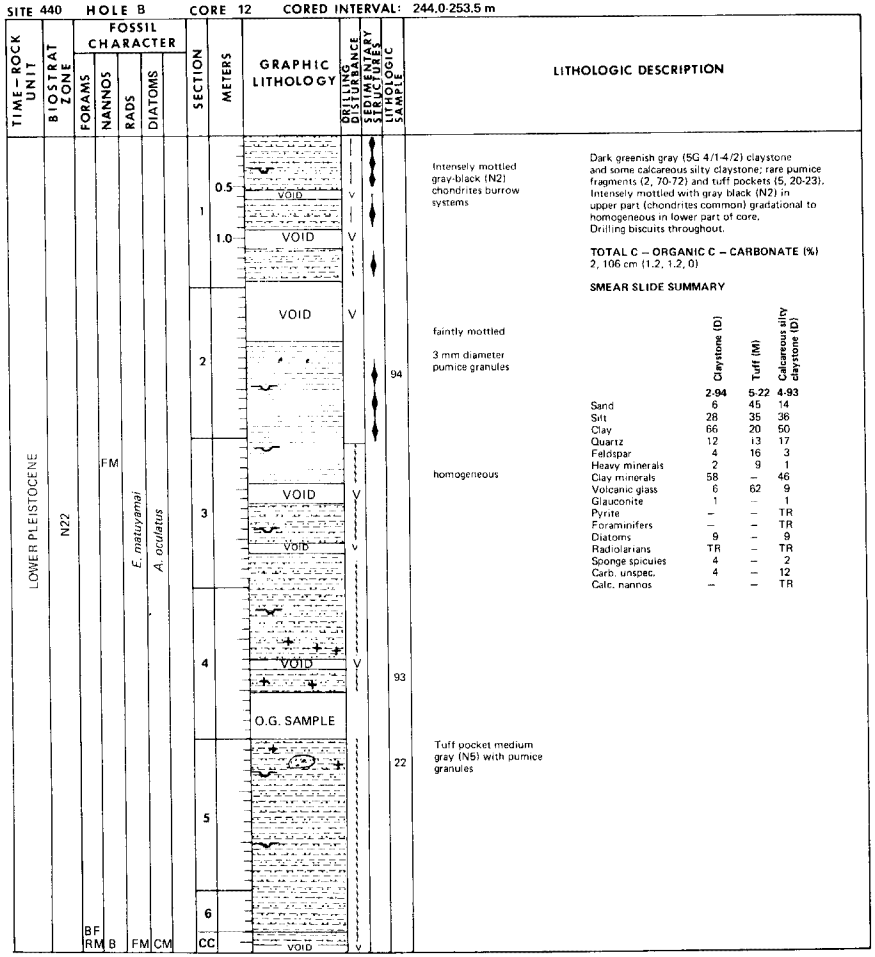
TOTAL C – ORGANIC C – CARBONATE (%)
2, 60 cm (0.5, 0.5, 1)
4, 55 cm (0.6, 0.6, 0)

SMEAR SLIDE SUMMARY

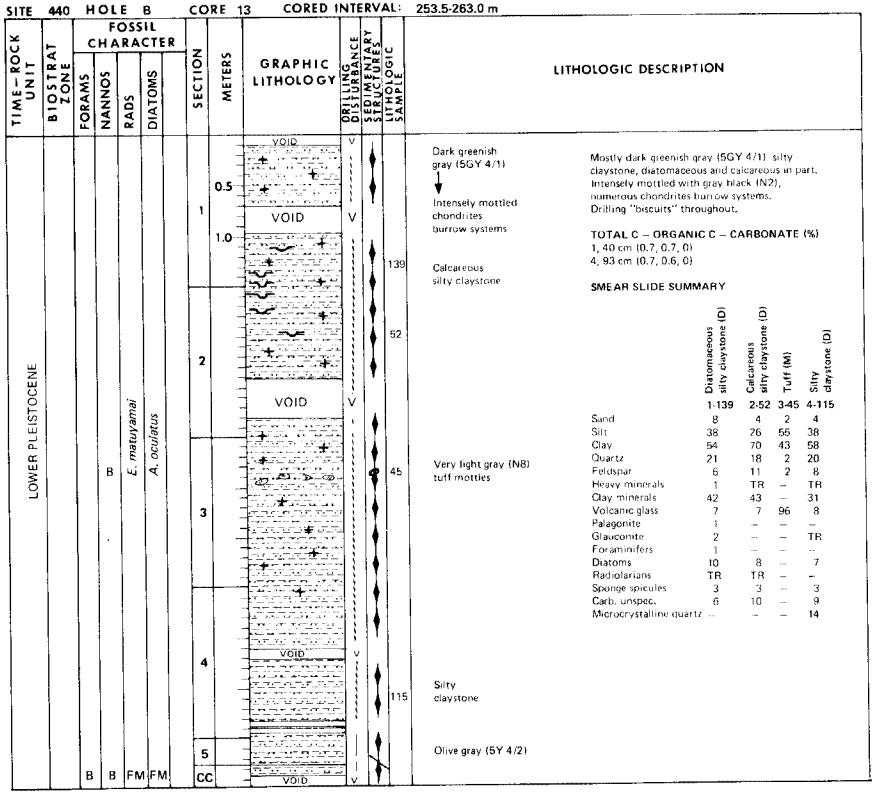
	Claystone (D)	Vitric silty, sandy claystone (M)	Vitric silty claystone (D)
	2-121	3-140	5-113
Sand	4	25	5
Silt	23	23	36
Clay	73	52	59
Quartz	7	18	22
Feldspar	8	13	8
Heavy minerals	1	6	2
Clay minerals	67	34	45
Volcanic glass	8	15	10
Palagonite	–	–	1
Glauconite	1	1	–
Diatoms	4	7	4
Radiolarians	–	TR	TR
Sponge spicules	2	3	3
Carb. unspec.	2	3	5

NOTE:
V = **volcanic clast**
I = **igneous clast**

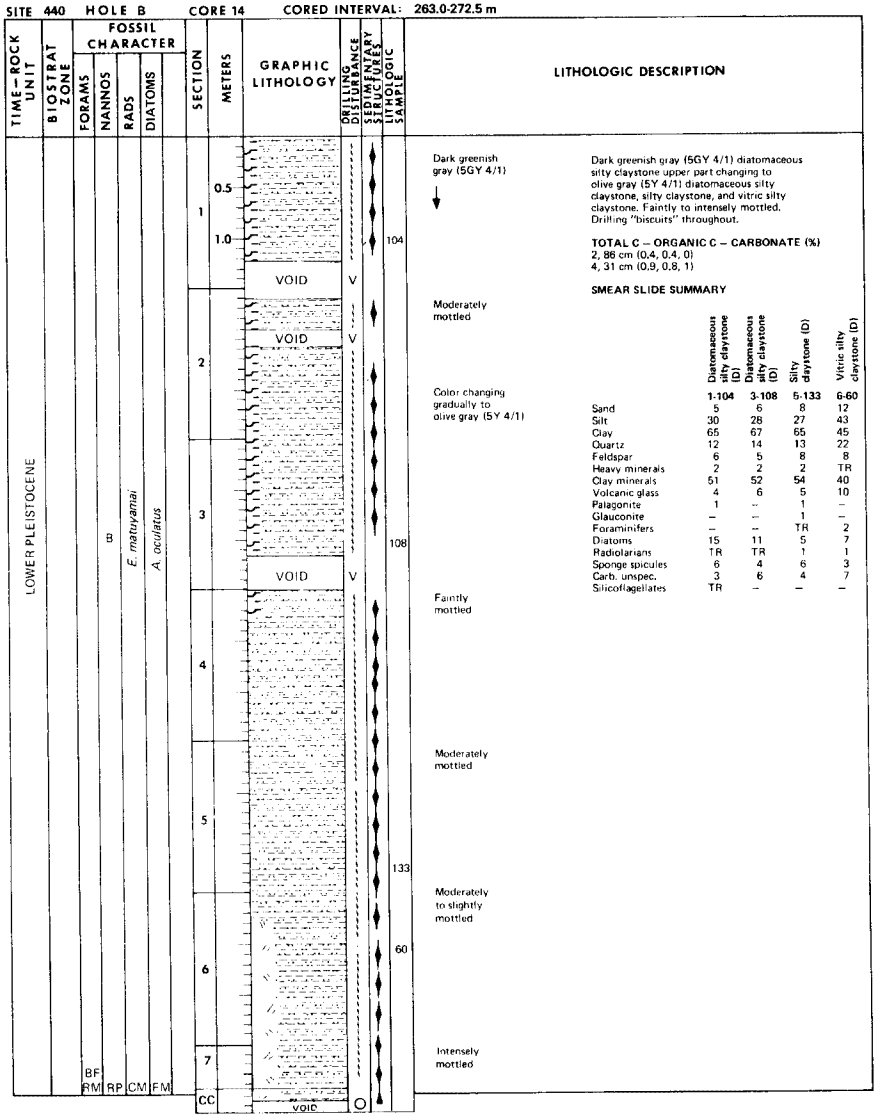
SITE 440 HOLE B CORE 12 CORED INTERVAL: 244.0-253.5 m



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

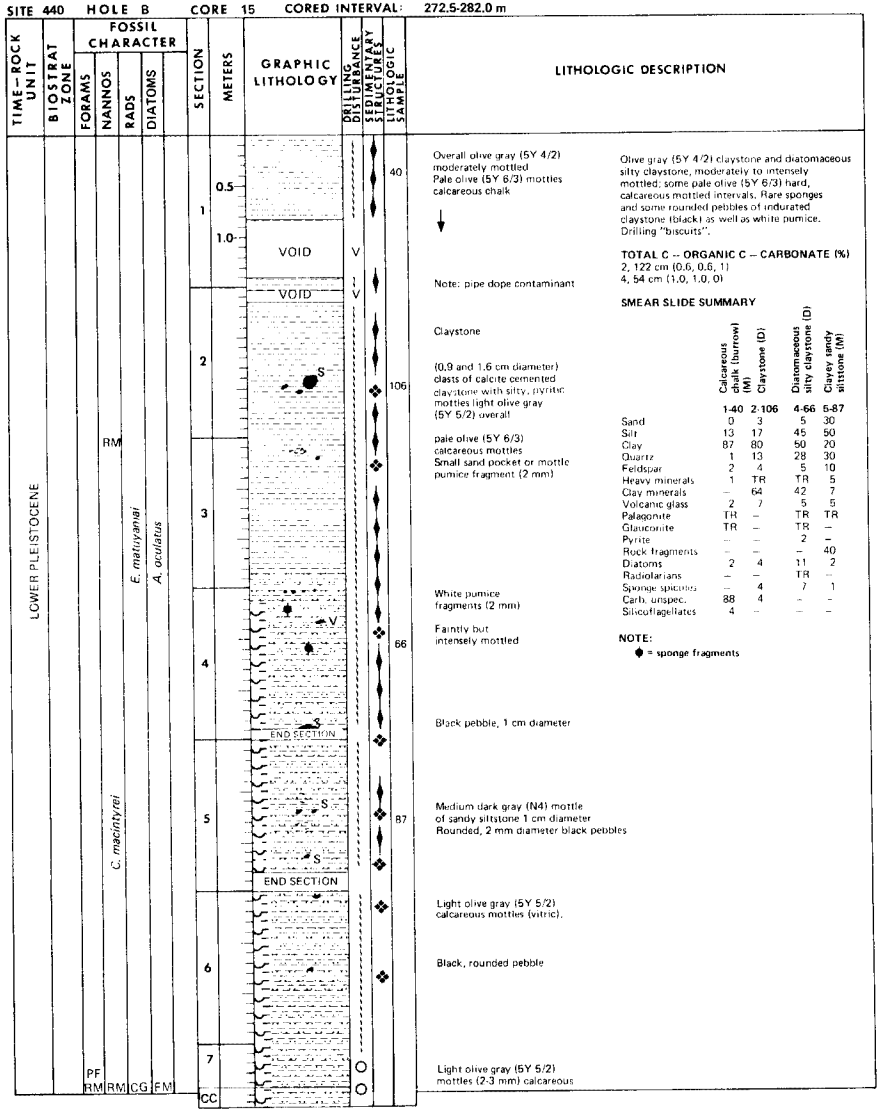


SITE 440 HOLE B CORE 14 CORED INTERVAL: 263.0-272.5 m



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

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

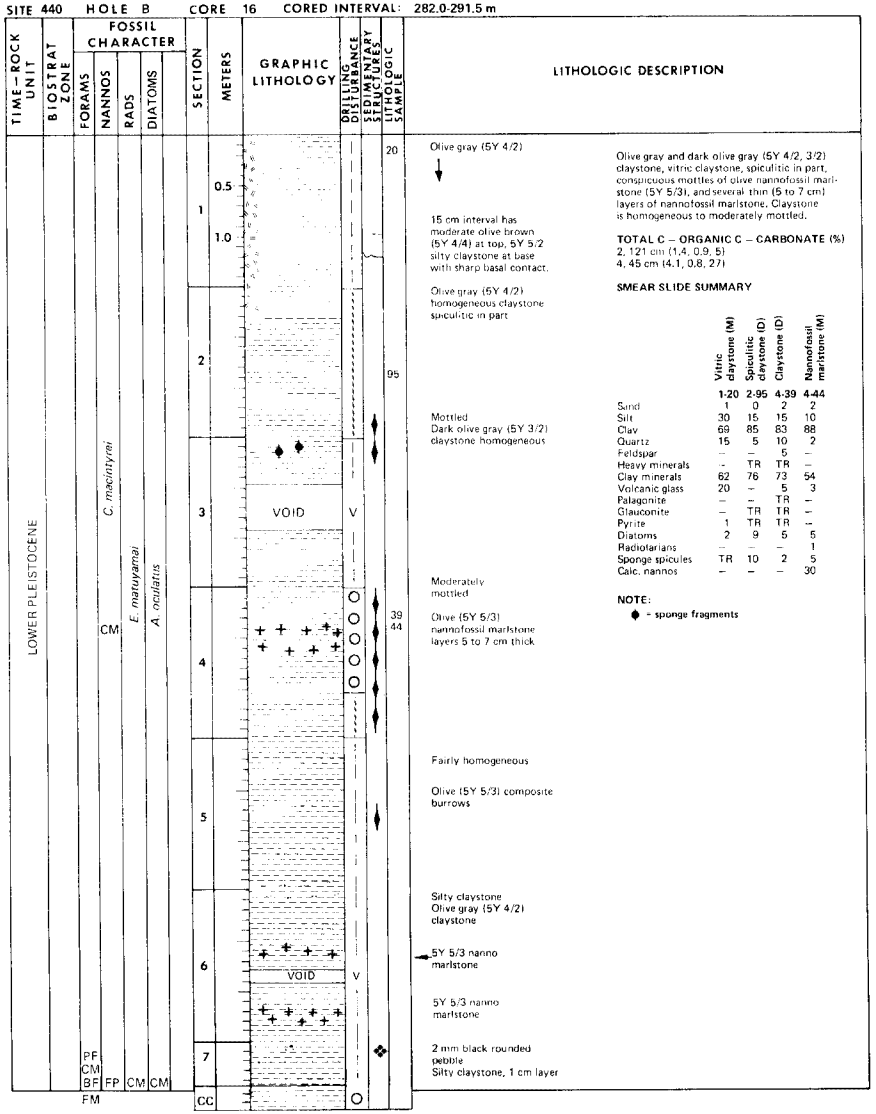


	Calcareous chalk (burrow) (M)	Claystone (D)	Diatomaceous silty claystone (D)	Clayey sandy siltstone (M)
	1-40	2-106	4-66	5-87
Sand	0	3	5	30
Silt	13	17	45	50
Clay	87	80	50	20
Quartz	1	13	28	30
Feldspar	2	4	5	10
Heavy minerals	1	TR	TR	5
Clay minerals	–	64	42	7
Volcanic glass	2	7	5	5
Palagonite	TR	–	TR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

NOTE:
♦ = sponge fragments

MGG 1505027

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



Olive gray (5Y 4/2)

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

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

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

Moderately mottled

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

Fairly homogeneous

Olive (5Y 5/3) composite burrows

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

5Y 5/3 nanno marlstone

5Y 5/3 nanno marlstone

2 mm black rounded pebble

Silty claystone, 1 cm layer

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

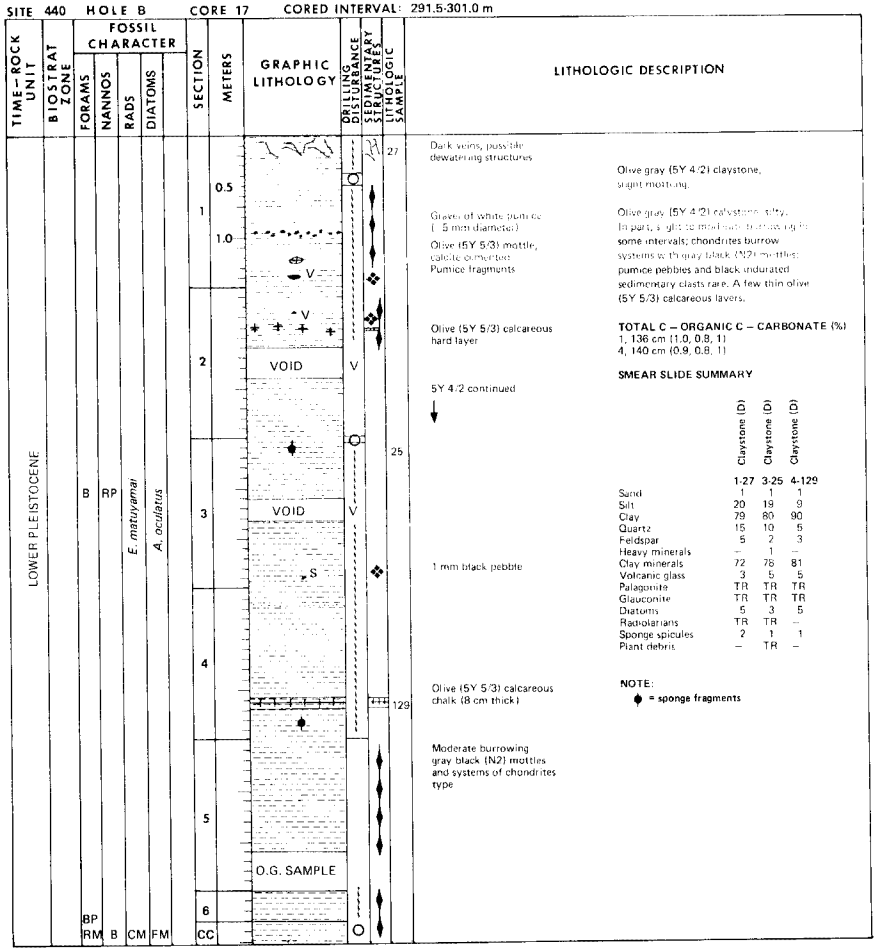
TOTAL C – ORGANIC C – CARBONATE (%)
2, 121 cm (1.4, 0.9, 5)
4, 45 cm (4.1, 0.8, 27)

SMEAR SLIDE SUMMARY

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

NOTE:
♦ = sponge fragments

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



Dark veins, possible dewatering structures

Olive (5Y 5/3) mottle, calcite cement

Pumice fragments

Olive (5Y 5/3) calcareous hard layer

5Y 4/2 continued

1 mm black pebble

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

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

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

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

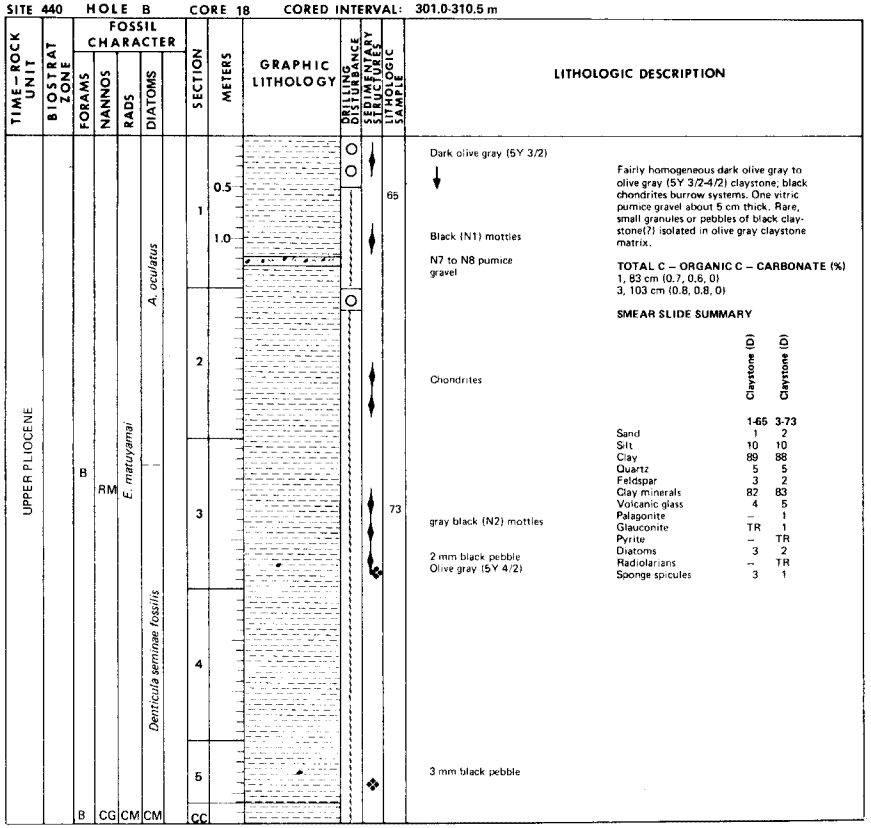
TOTAL C – ORGANIC C – CARBONATE (%)
1, 136 cm (1.0, 0.8, 1)
4, 140 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

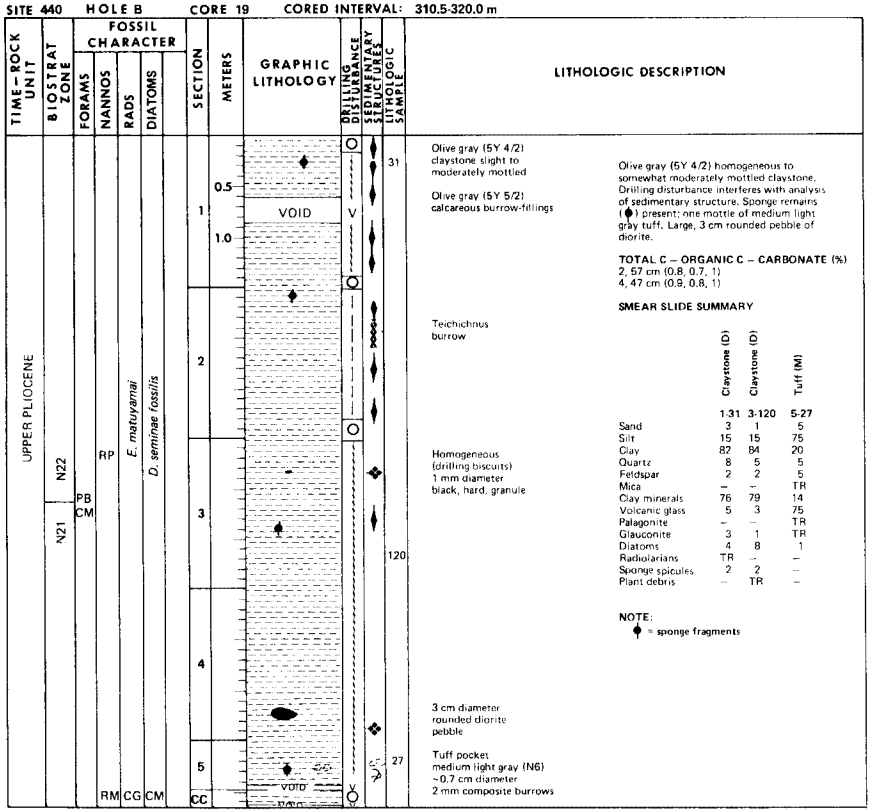
	Claystone (D)	Claystone (D)	Claystone (D)
	1-27	3-25	4-129
Sand	1	1	1
Silt	20	19	9
Clay	79	80	90
Quartz	15	10	5
Feldspar	5	2	3
Heavy minerals	–	1	–
Clay minerals	72	78	81
Volcanic glass	3	5	5
Palagonite	TR	TR	TR
Glauconite	TR	TR	TR
Diatoms	5	3	5
Radiolarians	TR	TR	–
Sponge spicules	2	1	1
Plant debris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

NOTE:
♦ = sponge fragments

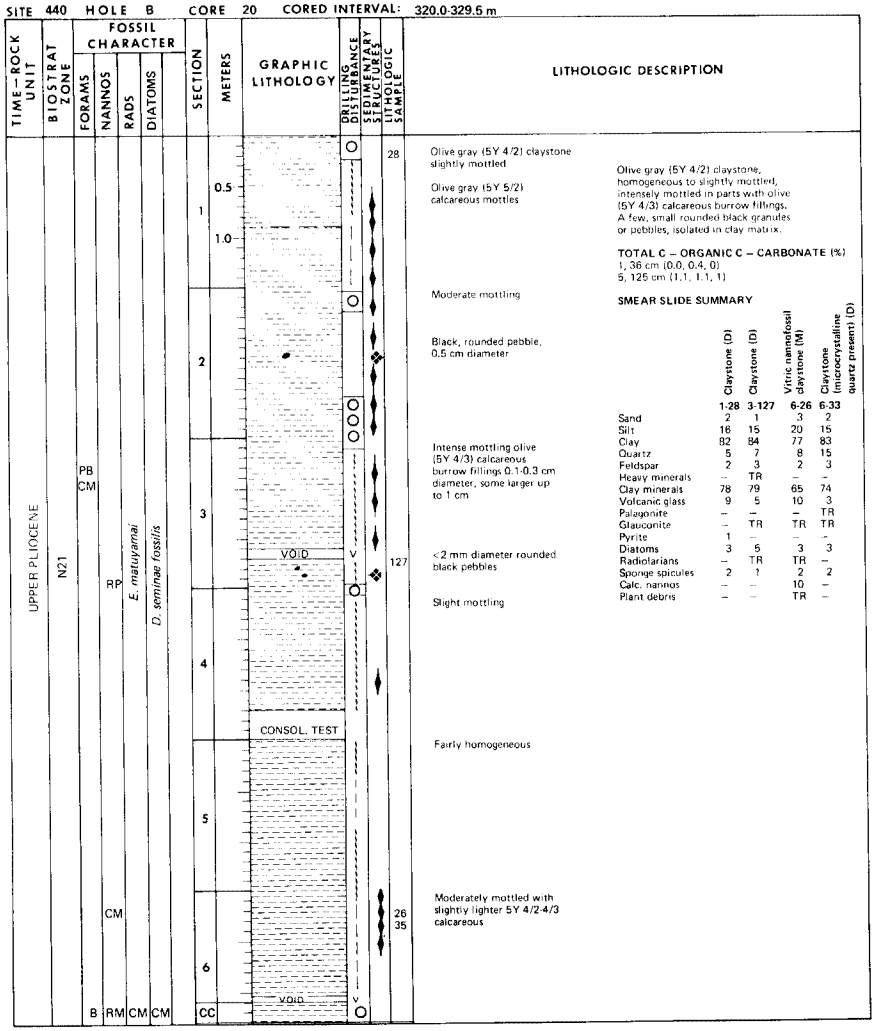
SITE 440 HOLE B CORE 18 CORED INTERVAL: 301.0-310.5 m



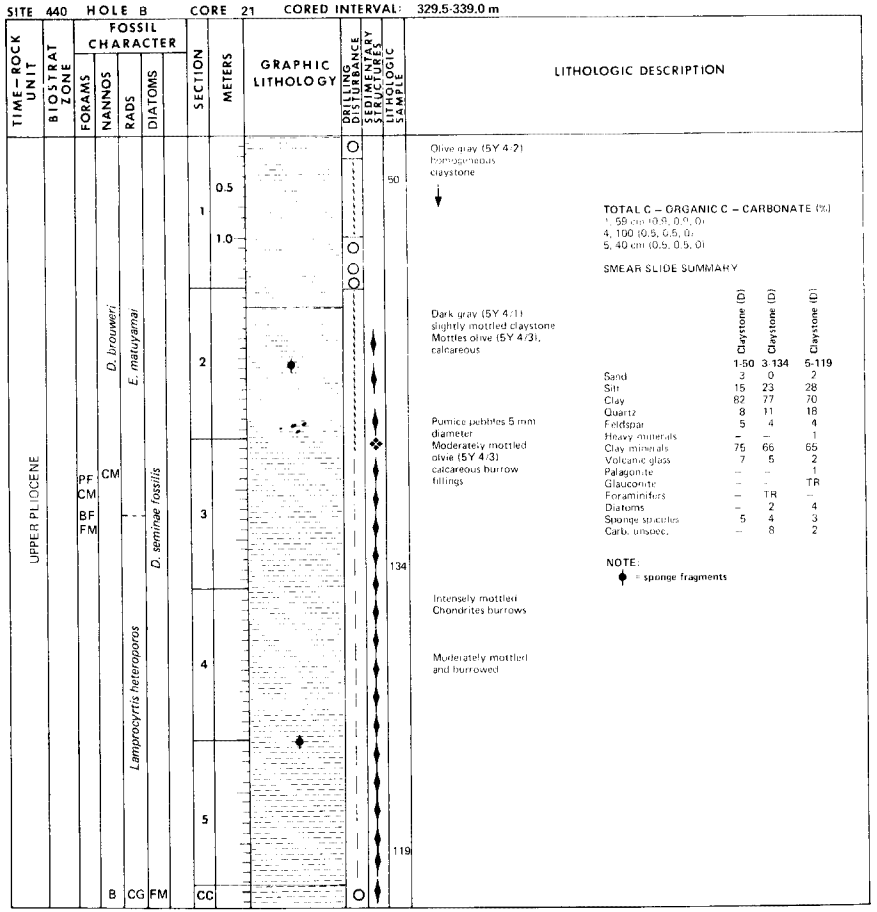
SITE 440 HOLE B CORE 19 CORED INTERVAL: 310.5-320.0 m



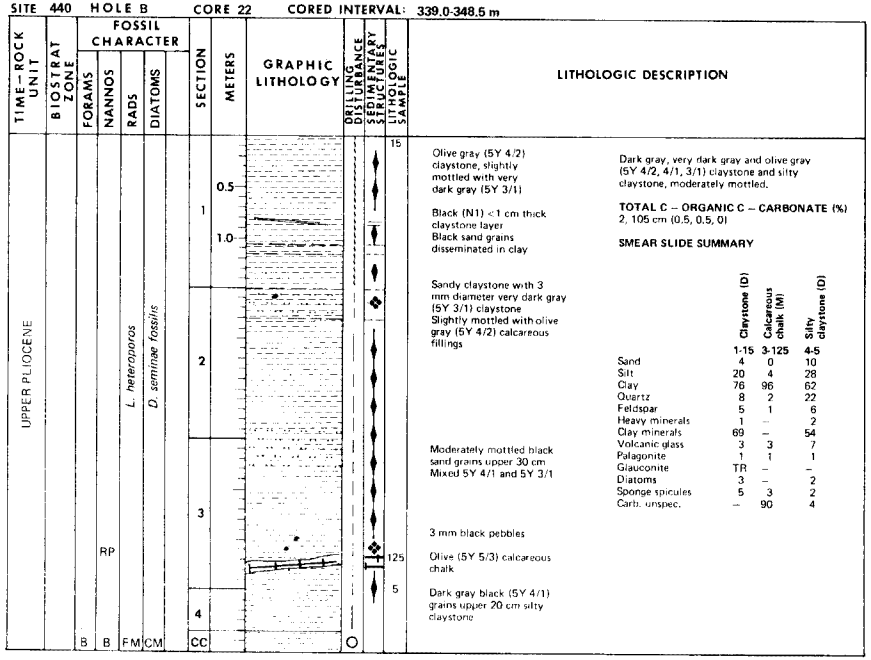
SITE 440 HOLE B CORE 20 CORED INTERVAL: 320.0-329.5 m



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



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



LITHOLOGIC DESCRIPTION

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

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

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

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

3 mm black pebbles

Olive (5Y 5/3) calcareous chalk

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

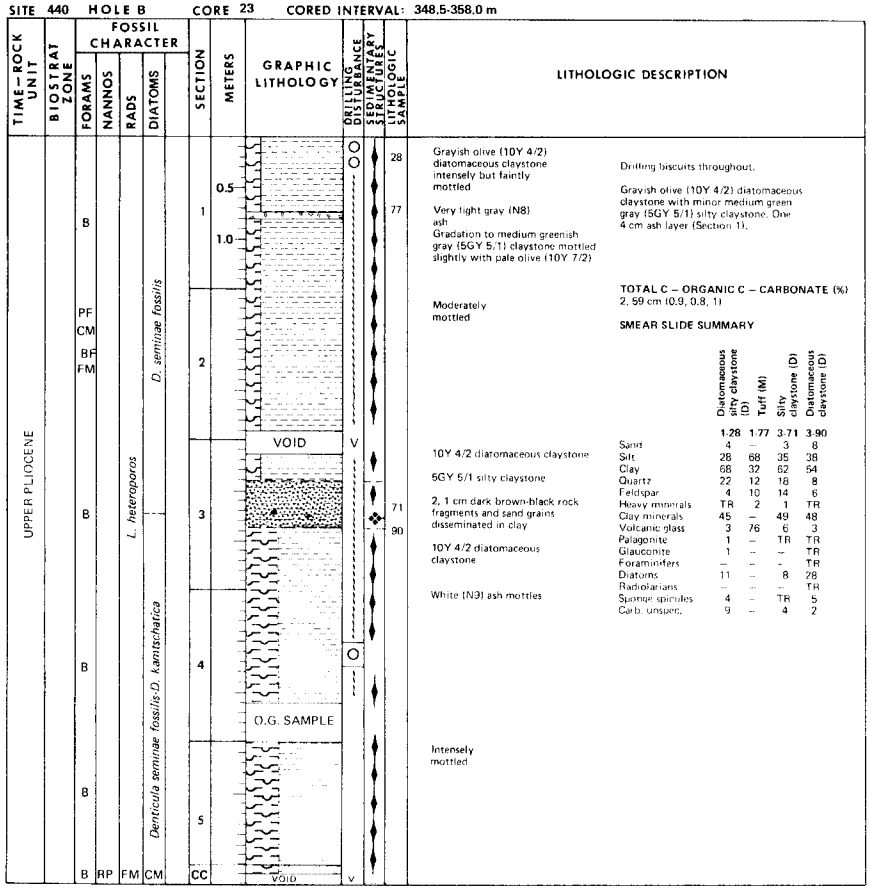
Dark gray, very dark gray and olive gray (5Y 4/2, 4/1, 3/1) claystone and silty claystone, moderately mottled.

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

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

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

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

Moderately mottled

10Y 4/2 diatomaceous claystone

5GY 5/1 silty claystone

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

10Y 4/2 diatomaceous claystone

White (N9) ash mottles

Intensely mottled

Drilling biscuits throughout.

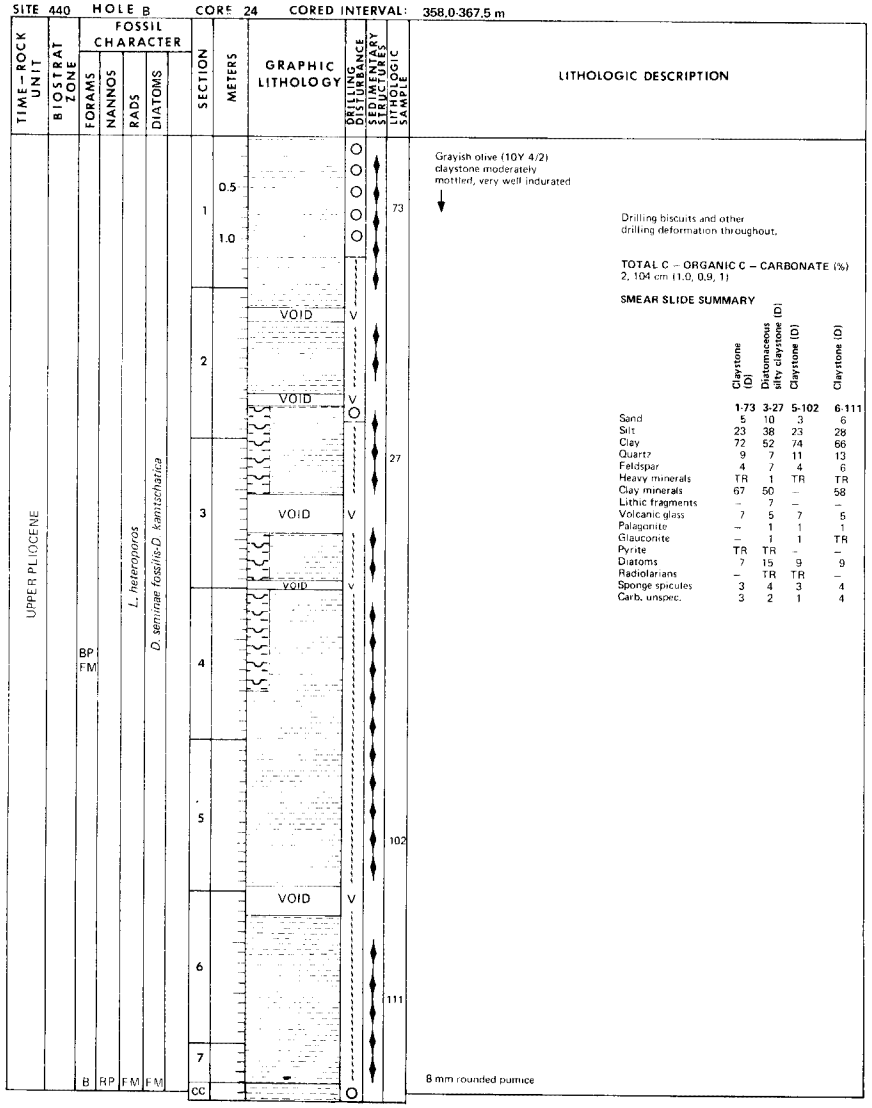
Grayish olive (10Y 4/2) diatomaceous claystone with minor medium green gray (5GY 5/1) silty claystone. One 4 cm ash layer (Section 1).

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

SMEAR SLIDE SUMMARY

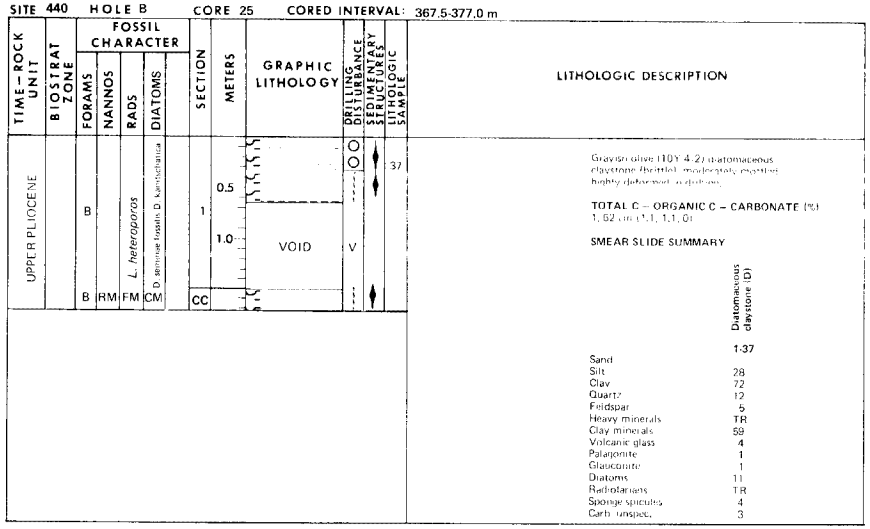
	Diatomaceous silty claystone (D) 1-28	Tuff (M) 1-77	Silty claystone (D) 3-71	Diatomaceous claystone (D) 3-90
Sand	4	–	3	8
Silt	28	68	35	38
Clay	68	32	62	54
Quartz	22	12	16	8
Feldspar	4	10	14	6
Heavy minerals	TR	2	1	TR
Clay minerals	45	–	49	48
Volcanic glass	3	76	6	3
Palagonite	1	–	TR	TR
Glauconite	1	–	–	TR
Foraminifers	–	–	–	TR
Diatoms	11	–	8	28
Radiolarians	–	–	–	TR
Sponge spicules	4	–	TR	5
Carb. unspec.	9	–	4	2

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



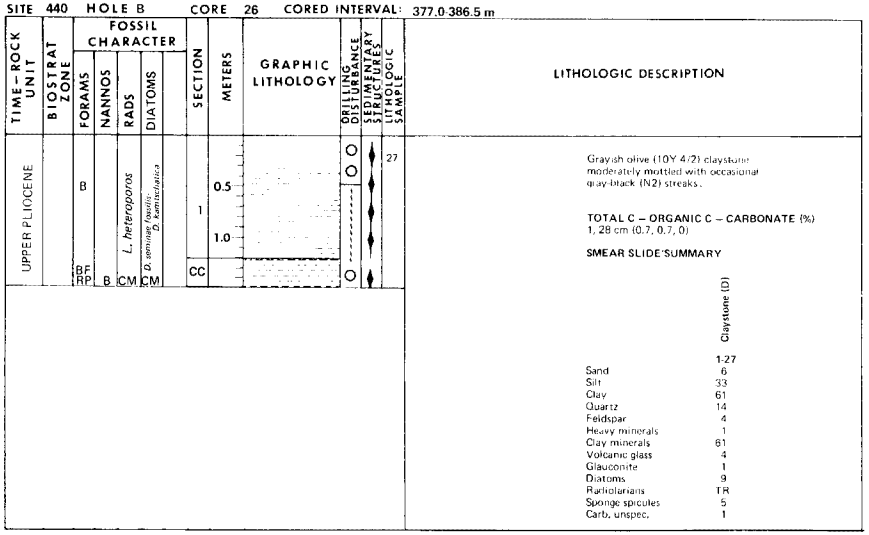
	Claystone (D)	Diatomaceous silty claystone (D)	Claystone (D)	Claystone (D)
	1-73	3-27	5-102	6-111
Sand	5	10	3	6
Silt	23	38	23	28
Clay	72	52	74	66
Quartz	9	7	11	13
Feldspar	4	7	4	6
Heavy minerals	TR	1	TR	TR
Clay minerals	67	50	–	58
Lithic fragments	–	7	–	–
Volcanic glass	7	5	7	5
Palagonite	–	1	1	1
Glauconite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

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



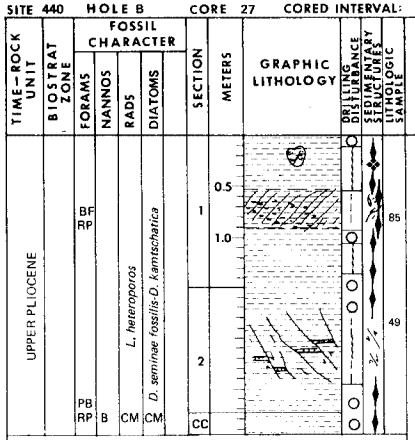
	Diatomaceous claystone (D)
	1-37
Sand	
Silt	28
Clay	72
Quartz	12
Feldspar	5
Heavy minerals	TR
Clay minerals	59
Volcanic glass	4
Palagonite	1
Glauconite	1
Diatoms	11
Radiolarians	TR
Sponge spicules	4
Carb. unspec.	3

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



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

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



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

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

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

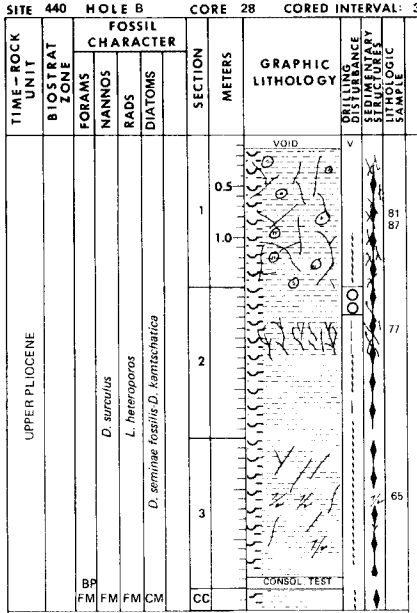
Mostly intensely mottled grayish olive (10Y 4/2) claystone with intervals of intense veining and faulting. Bedding (faint) inclined approximately 25°; faults, high angle normal and reverse.

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

SMEAR SLIDE SUMMARY

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

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



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

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

Black (N2) mottles

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

Lower 15 cm Section 3 is consolidation test.

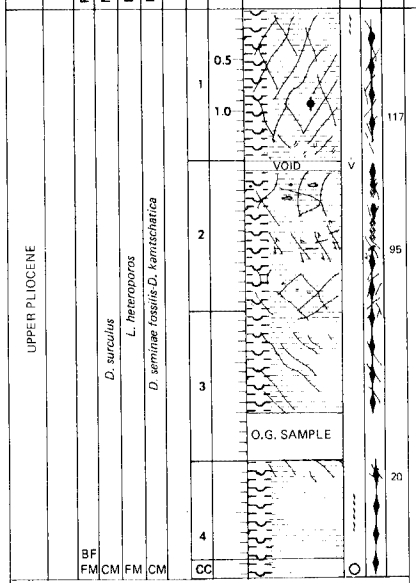
Rock holds together well despite intense veining and fracture systems. Lithologic change from previous cores. Mostly olive gray (5Y 5/2, 4/2). Diatomaceous claystone, vitric in upper part, moderately to intensely mottled with gray, greenish gray, and pale greenish yellow (5GY 5/1, N2-N4, 10Y 8/2) fracture/vein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

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

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

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

Disseminated numerous white pumice grains (<2 mm diameter)

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

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

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

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

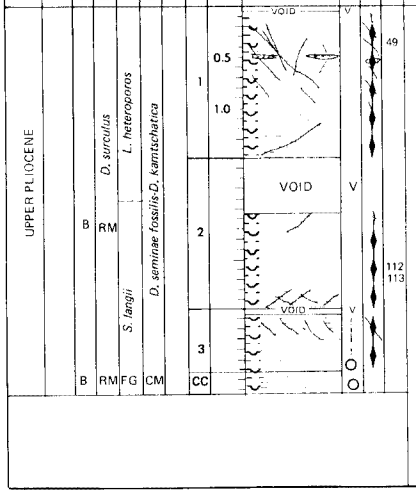
TOTAL C – ORGANIC C – CARBONATE (%)
2, 48 cm (0.8, 0.7, 1)
4, 17 cm (1.1, 1.0, 1)

SMEAR SLIDE SUMMARY

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

NOTE:
♦ = sponge fragments

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



LITHOLOGIC DESCRIPTION

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

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

V tric diatomaceous claystone
Fine black veinlets, conjugate systems, larger fractures with minor offsets. (Post drilling open fracture orientation approximately 75 (do not follow earlier healed fracture pattern).

Faint veining.

2 mm offset on fractures

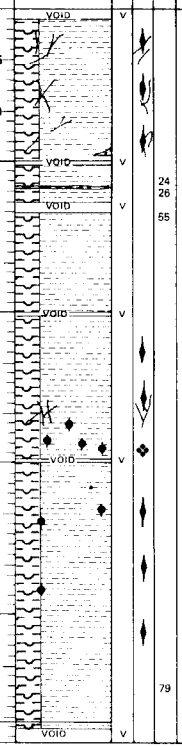
TOTAL C – ORGANIC C – CARBONATE (%)
1, 70 cm (1.2, 0.8, 3)

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLIOCENE		B	B	B	*Sphaeropyle langii* / *D. seminae fossilis-D. kamtschatica*	1, 2, 3, 4, 5, CC	0.5, 1.0	VOID	V		24, 26, 55, 79



LITHOLOGIC DESCRIPTION

Faint veins (black) some with offset

Ash body (medium gray, silt-size)

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

Prominent mottles

Black veins, very faint

Sponge fragments

Pumice grain

Very faint veining

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

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

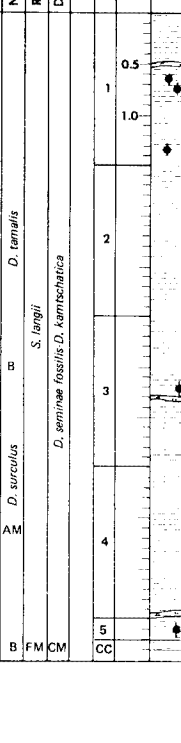
CARBONATE BOMB
3, 92-95 cm = 1.2%

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLIOCENE		B	B	B	*D. tamalis* / *S. langii* / *D. seminae fossilis-D. kamtschatica*	1, 2, 3, 4, 5, CC	0.5, 1.0	VOID	O, V		50, 57, 68



LITHOLOGIC DESCRIPTION

Sponge fragment

Tuff

Systematic open fractures with inclination of 74

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

Claystone
Gray (5Y 6/1) tuff

Intense mottling

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

Medium gray tuff

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

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

CARBONATE BOMB
2, 89-91 cm = 1%

SMEAR SLIDE SUMMARY

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

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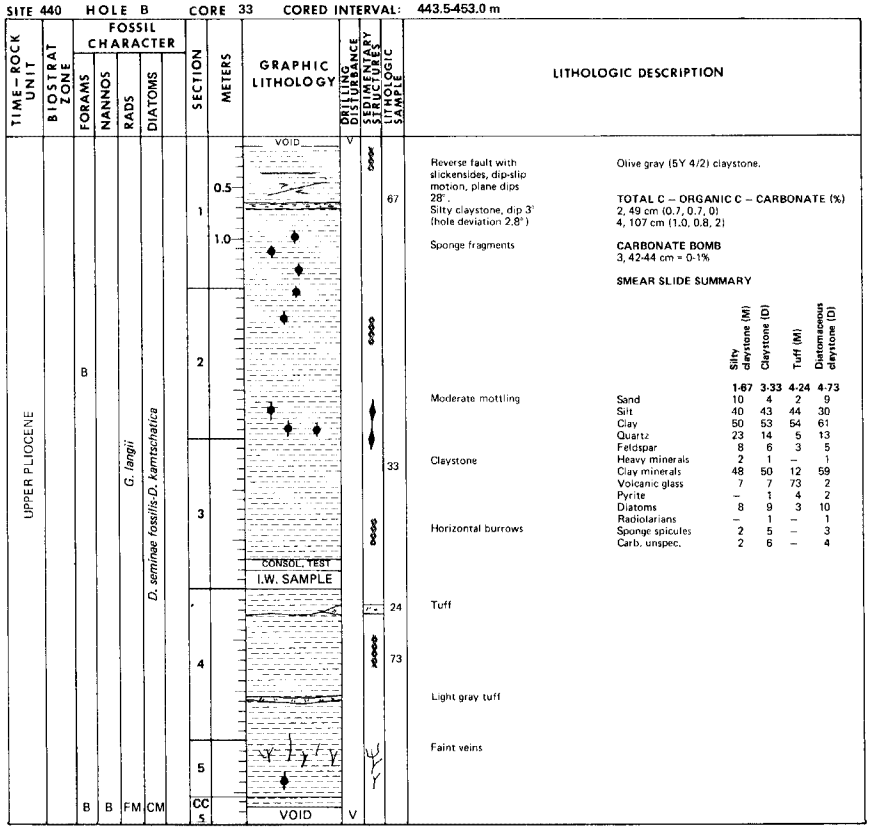
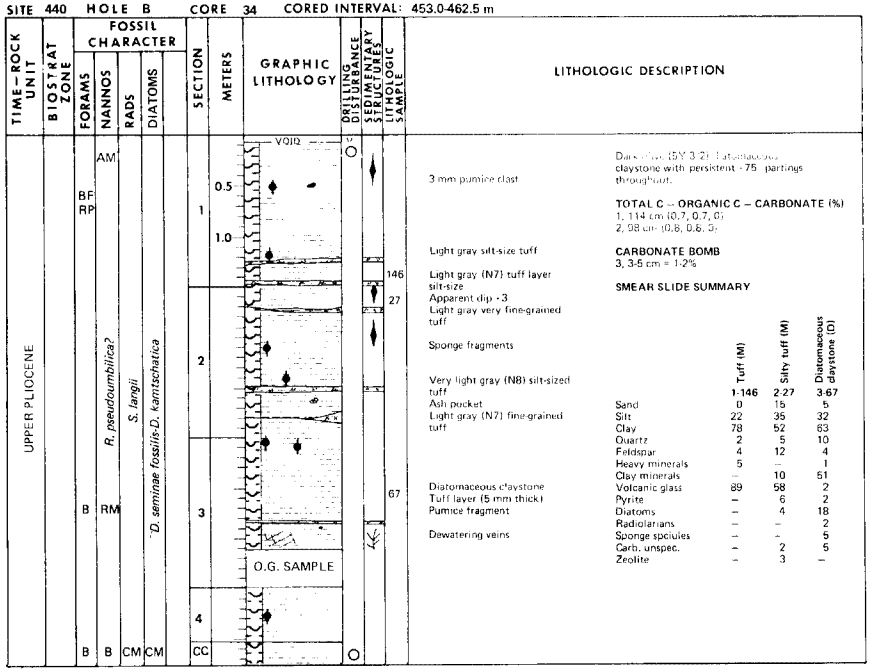
SITE 440 HOLE B CORE 33 CORED INTERVAL: 443.5-453.0 m



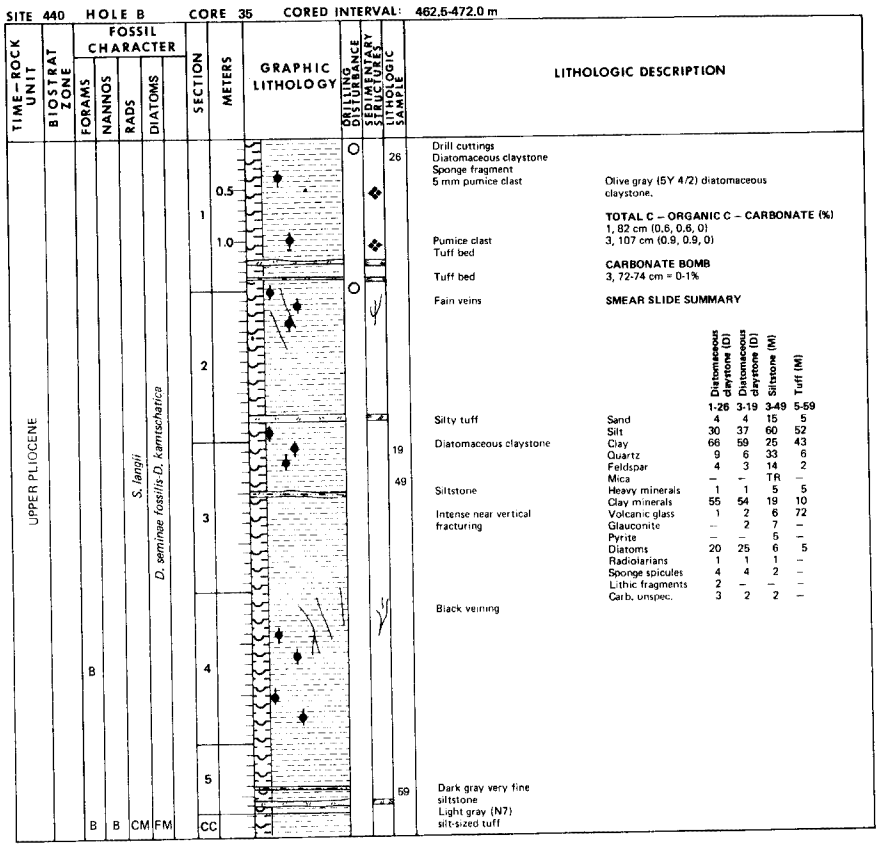
	Silty claystone (M)	Claystone (D)	Tuff (M)	Diatomaceous claystone (D)
	1-67	3-33	4-24	4-73
Sand	10	4	2	9
Silt	40	43	44	30
Clay	50	53	54	61
Quartz	23	14	5	13
Feldspar	8	6	3	5
Heavy minerals	2	1	–	1
Clay minerals	48	50	12	59
Volcanic glass	7	7	73	2
Pyrite	–	1	4	2
Diatoms	8	9	3	10
Radiolarians	–	1	–	1
Sponge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

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



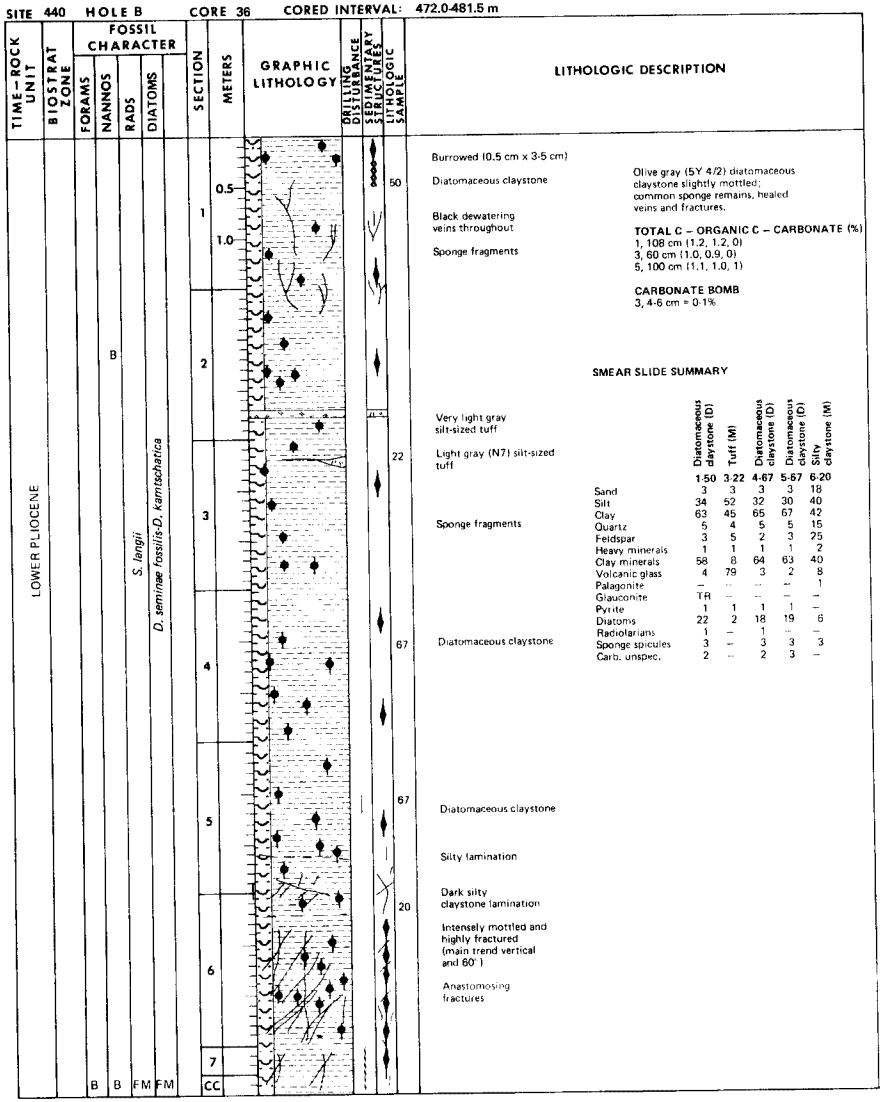
	Tuff (M)	Silty tuff (M)	Diatomaceous claystone (D)
	1-146	2-27	3-67
Sand	0	15	5
Silt	22	35	32
Clay	78	52	63
Quartz	2	5	10
Feldspar	4	12	4
Heavy minerals	5	–	1
Clay minerals	–	10	51
Volcanic glass	89	58	2
Pyrite	–	6	2
Diatoms	–	4	18
Radiolarians	–	–	2
Sponge spicules	–	–	5
Carb. unspec.	–	2	5
Zeolite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

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



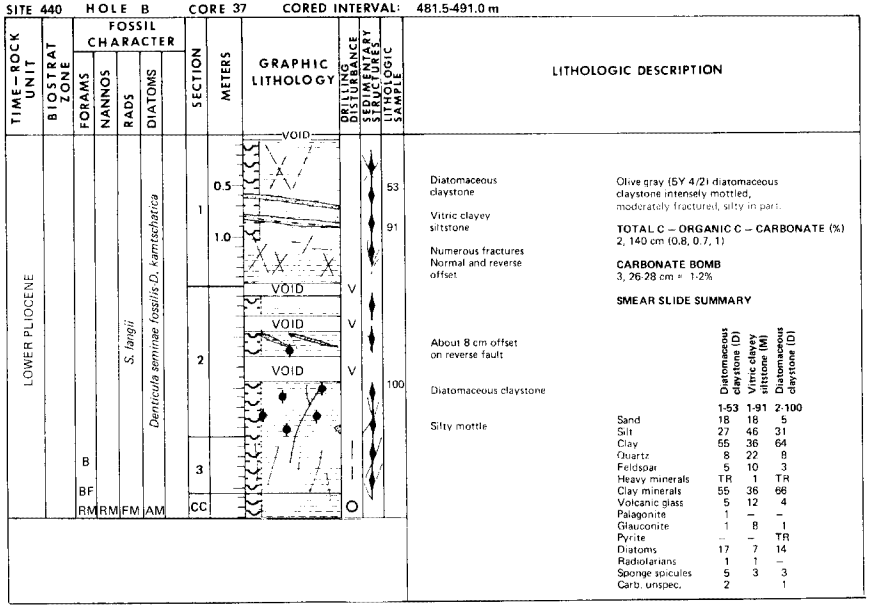
	Diatomaceous claystone (D) 1-26	Diatomaceous claystone (D) 3-19	Siltstone (M) 3-49	Tuff (M) 5-59
Sand	4	4	15	5
Silt	30	37	60	52
Clay	66	59	25	43
Quartz	9	6	33	6
Feldspar	4	3	14	2
Mica	–	–	TR	–
Heavy minerals	1	1	5	5
Clay minerals	55	54	19	10
Volcanic glass	1	2	6	72
Glauconite	–	2	7	–
Pyrite	–	–	5	–
Diatoms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

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

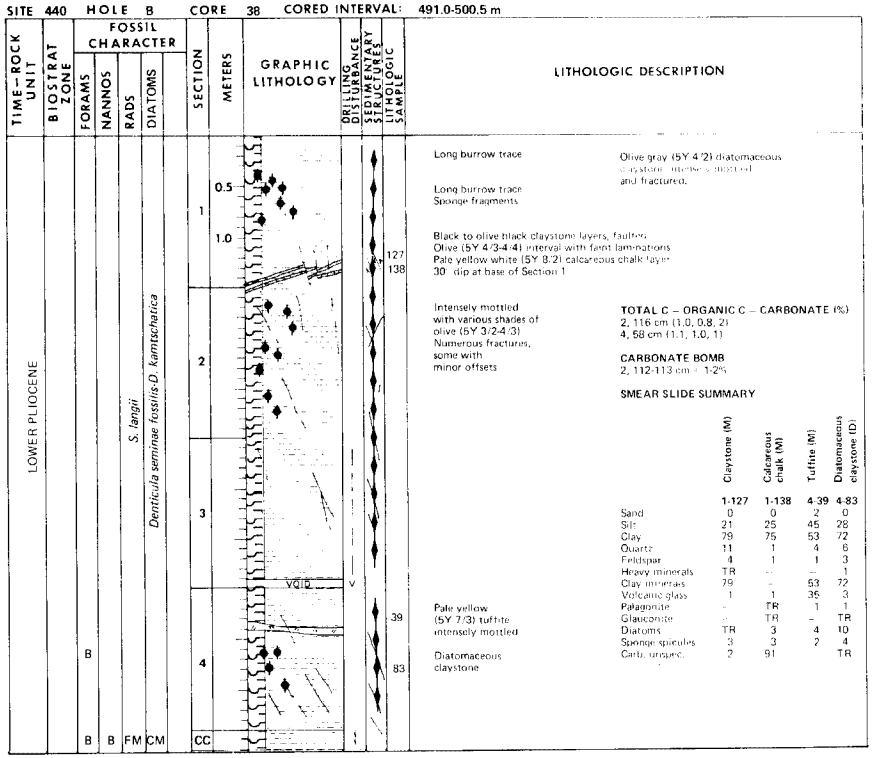


	Diatomaceous claystone (D) 1-50	Tuff (M) 3-22	Diatomaceous claystone (D) 4-67	Diatomaceous claystone (D) 5-67	Silty claystone (M) 6-20
Sand	3	3	3	3	18
Silt	34	52	32	30	40
Clay	63	45	65	67	42
Quartz	5	4	5	5	15
Feldspar	3	5	2	3	25
Heavy minerals	1	1	1	1	2
Clay minerals	58	8	64	63	40
Volcanic glass	4	79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

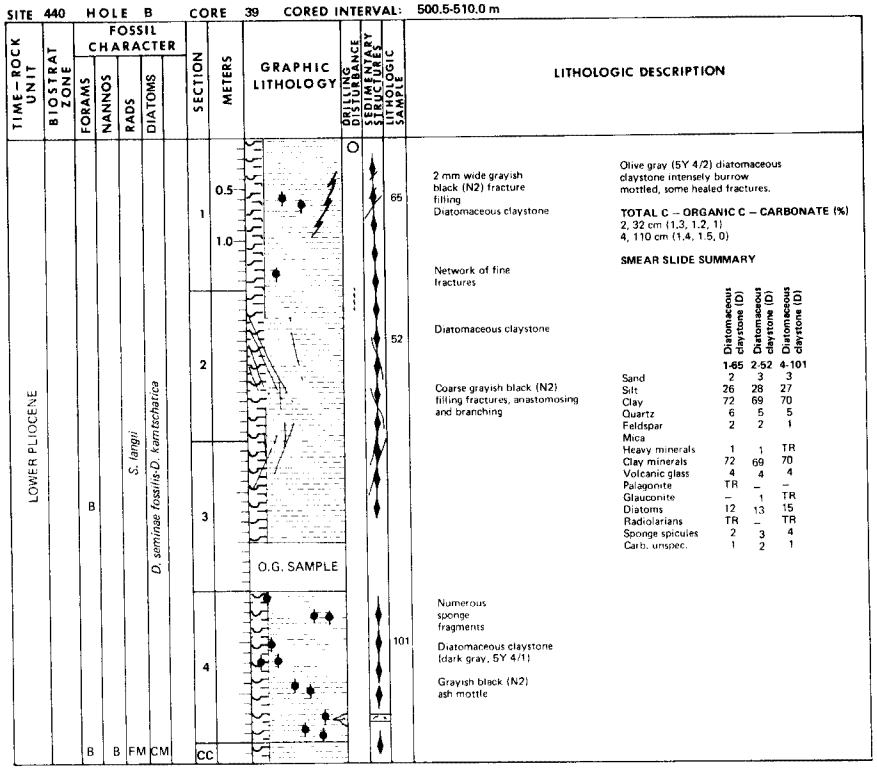
SITE 440 HOLE B CORE 37 CORED INTERVAL: 481.5-491.0 m



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

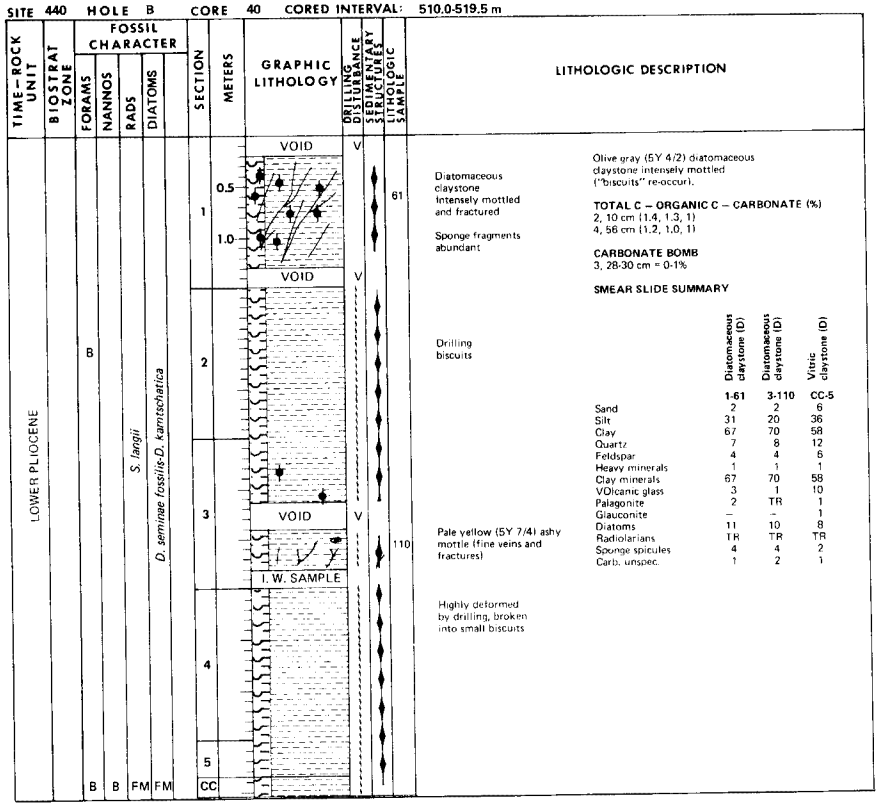


SITE 440 HOLE B CORE 39 CORED INTERVAL: 500.5-510.0 m



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

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



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

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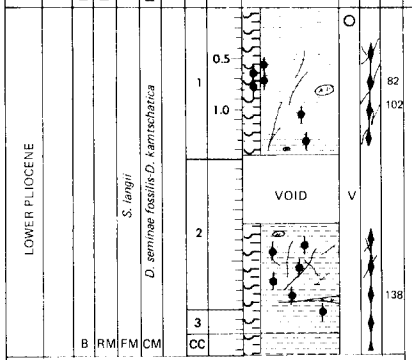
SITE 440 HOLE B CORE 41 CORED INTERVAL: 519.5-529.0 m



LITHOLOGIC DESCRIPTION

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

Tuff mottle (diameter 10 mm)

Faint fractures with numerous orientations

Dark gray (N3) tuff

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

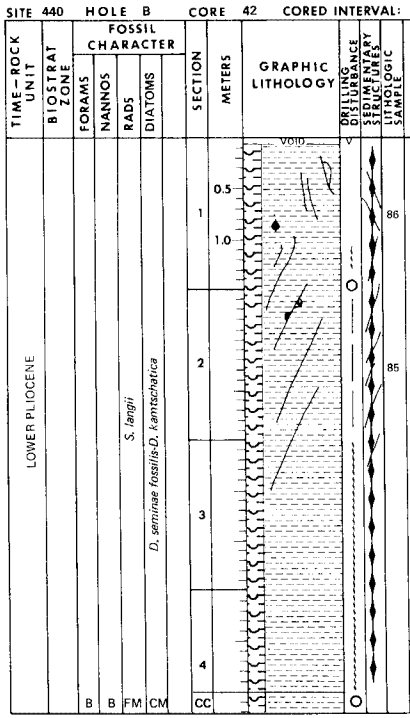
TOTAL C – ORGANIC C – CARBONATE (%)
2, 128 cm (1.0, 0.8, 1)

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

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

Diatomaceous claystone

Fractures with 1 cm offset maximum

Diatomaceous claystone

Strong drilling disturbances

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

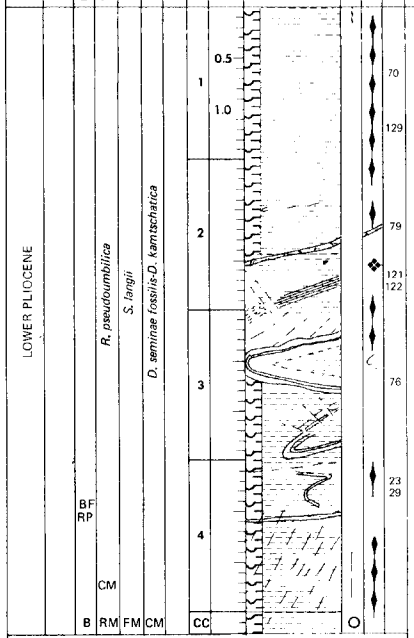
TOTAL C – ORGANIC C – CARBONATE (%)
2, 87 cm (1.2, 1.1, 1)
4, 67 cm (1.1, 1.0, 0)

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

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

3 distinct units of claystone, lighter colored olive gray, gradational at top. May be multi-stabilized?

Darker
Claystone
Lighter

Sharp, irregular contact

Claystone

Faint streaks or laminations

Ash mottles

Ash layer
Wood fragment (3 cm long)

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

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

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

Thin olive (5Y 5/6) layer

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

Olive gray (5Y 4/2) diatomaceous claystone intensely streaked and mottled, overturned folds, some [illegible]

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

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

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

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		BF RP	RM	FM	FM	CC			O			Diatomaceous claystone, olive gray (5Y 4/2).

S. langii; *D. seminae fossilis-D. kamtschatica*

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		B	B	FP	CM	1 2 CC	0.5 1.0	VOID	V O		23 83 123	

S. langii; *D. seminae fossilis-D. kamtschatica*

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

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

Mottled diatomaceous claystone.
Ash lenses.

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

Pumice fragment.

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

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

CARBONATE BOMB
1, 4-6 cm = 0%

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		BF	RM	CM	FP	CM	1 2 3 4 CC	0.5 1.0	VOID	O V	51 60	

S. langii; *D. seminae fossilis-D. kamtschatica*

Silty pocket

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

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

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

Medium gray (N5) silty pocket.

Offset of silty bed along faults.

Highly fractured, moderate mottling.

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

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

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D) 2-51	Clayey diatomite (M) 2-60
Sand	0	0
Silt	25	30
Clay	75	70
Quartz	5	4
Feldspar	2	1
Clay minerals	72	62
Volcanic glass	5	3
Diatoms	15	40
Sponge spicules	1	TR

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		B	RM	CM	FM	CM	1 2 CC	0.5 1.0			70	

S. langii; *D. seminae fossilis-D. kamtschatica*

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

Diatomaceous claystone with 1 cm blocks with horizontal slickensides.

Ash.

Pumice fragment.

High drilling disturbance. No structure visible.

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

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

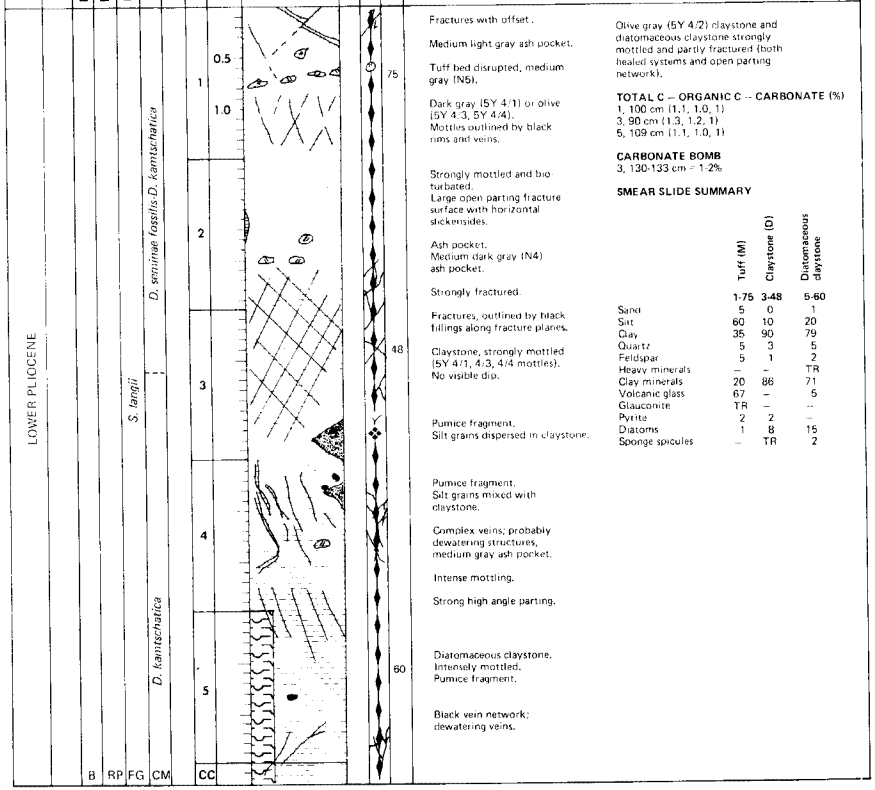
CARBONATE BOMB
1, 79-81 cm = 2%

SMEAR SLIDE SUMMARY

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

MGG 1505027

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



Fractures with offset.

Medium light gray ash pocket.

Tuff bed disrupted, medium gray (N5).

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

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

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

Strongly fractured.

Fractures, outlined by black fillings along fracture planes.

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

Pumice fragment. Silt grains dispersed in claystone.

Pumice fragment. Silt grains mixed with claystone.

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

Intense mottling.

Strong high angle parting.

Diatomaceous claystone. Intensely mottled. Pumice fragment.

Black vein network; dewatering veins.

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

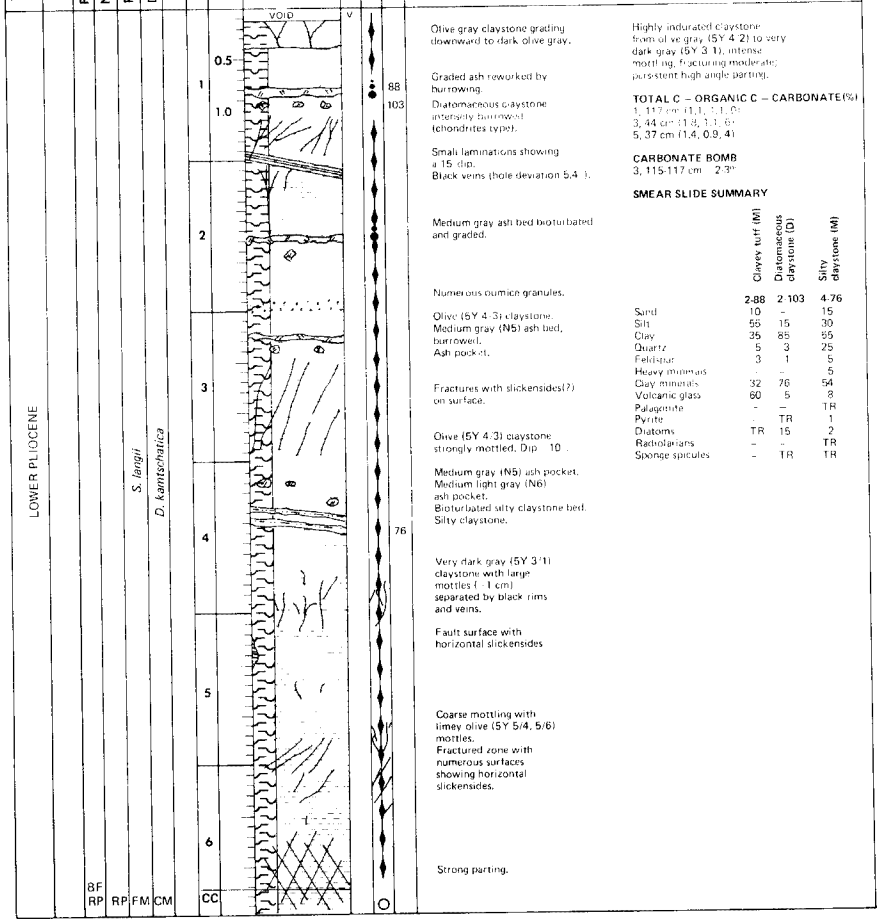
TOTAL C – ORGANIC C – CARBONATE (%)
1, 100 cm (1.1, 1.0, 1)
3, 90 cm (1.3, 1.2, 1)
5, 109 cm (1.1, 1.0, 1)

CARBONATE BOMB
3, 130-133 cm = 1·2%

SMEAR SLIDE SUMMARY

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

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



Olive gray claystone grading downward to dark olive gray.

Graded ash reworked by burrowing.

Diatomaceous claystone intensely burrowed (chondrites type).

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

Medium gray ash bed bioturbated and graded.

Numerous pumice granules.

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

Fractures with slickensides(?) on surface.

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

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

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

Fault surface with horizontal slickensides

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

Strong parting.

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

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

CARBONATE BOMB
3, 115-117 cm 2·3%

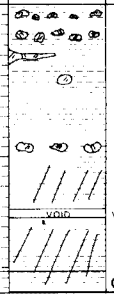
SMEAR SLIDE SUMMARY

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

MGG 15 0 5 6 0 2

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE		BF, RP	RM	CM	CM	1, 2, CC	0.5, 1.0	VOID	V, O	38, 84, 138	



S. langii — *D. kamtschatica*

LITHOLOGIC DESCRIPTION

Medium gray (N5) ash layer.

Tuffite mottle

Medium gray (N5) tuffite pod

N5 ash pocket
Claystone

Medium gray tuffite layer disturbed by burrowing

Fractured dark gray (5Y 4/1) claystone

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

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

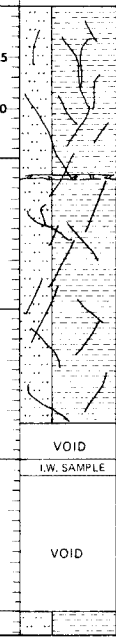
CARBONATE BOMB
1, 127-129 cm = 2-3%

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE		B	B	FM	CM	1, 2, 3, 4, CC	0.5, 1.0	VOID, I.W. SAMPLE, VOID	V, V, O, O	47, 57	



S. langii — *D. kamtschatica*

LITHOLOGIC DESCRIPTION

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

Very light gray (N8) ash bed

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

Irregular fracture, fairly homogeneous.

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

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

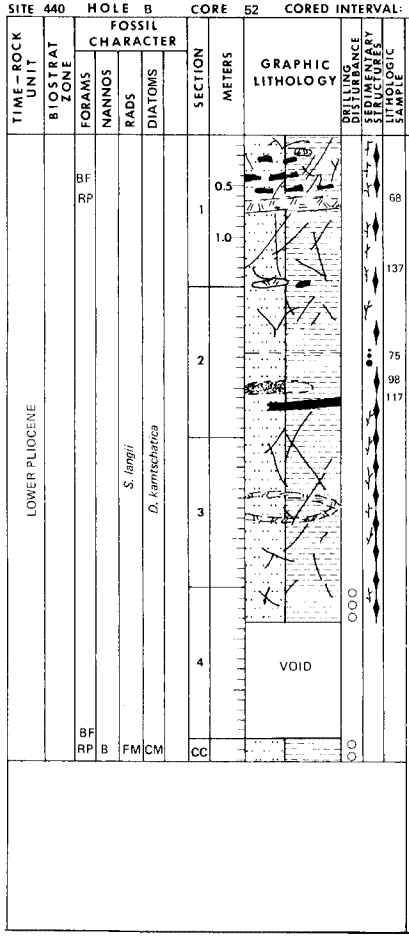
CARBONATE BOMB
2, 80-82 cm = 2-3%

SMEAR SLIDE SUMMARY

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

Grayish olive (10Y 4/2) claystone

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



LITHOLOGIC DESCRIPTION

Persistent high angle open partings. Light olive gray (5Y 5/2) claystone with olive gray (5Y 3/2) mottles and streaks.
Ash mottle
Dusky yellow (5Y 6/4) hard calcareous greenish gray (5GY 6/1) tuffite with streaks and mottles.

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

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

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

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

Dark gray (N3-N4) sandy claystone mottle.
Dusky yellow (5Y 6/4) calcareous patch (rich in nannofossils) surrounded by olive gray (5Y 3/2) mottles.

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

Medium gray disrupted ash bed, folded.

Bedding dip with 25°.

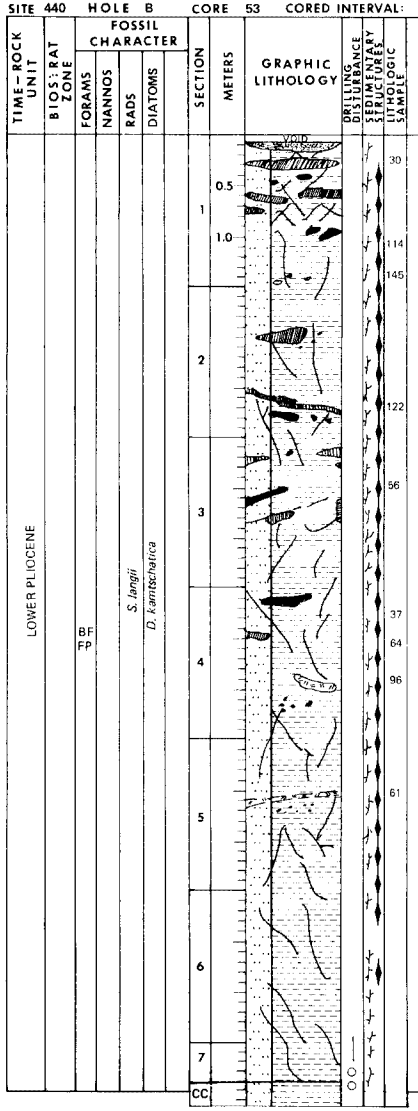
TOTAL C – ORGANIC C – CARBONATE (%)
2, 63 cm (1.0, 0.8, 1)

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

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

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

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

Glauconite grains

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

Vitric claystone pocket

Calcareous mottle.

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

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

Calcareous mottle
Glauconite grains

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

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE				*S. langii* / *D. karnitschatica*		1, 2, 3, 4, 5, CC	0.5, 1.0	VOID; VOID			88, 100, 136, 117, 124	Bedding dips 10° to 15°. Gravish olive (10Y 4/2) homogeneous silty claystone. Ash mottle. Glauconite grains. White pumice fragments up to 4 mm. Vertical bedding, faulted-in sandy claystone to right of nertical, moderate olive brown (5Y 4/4) beds. Calcareous beds and mottles in claystone. Olive gray (5Y 4/2) vitric claystone. Mottled claystone capped with 5 mm vitric glauconitic silt, folded. Laminated or streaked claystone. Vitric claystone.
		PB, FP										
		BF, RP	RM	CG	FM							

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

Faults with reversed offsets; fault planes dip 40°-60° inclinations (125-150 cm).

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

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

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

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

CARBONATE BOMB
3, 110-113 cm = 2%

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE		B			*D. karnitschatica*	1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0				49, 35, 95, 62, 36, 107	Olive gray (5Y 4/2) vitric claystone healed black veins and fractures throughout. Greenish gray (5GY 6/1) mottle. Olive gray (5Y 4/2) silty claystone. Possible fold of mottled claystones in vitric claystone. Olive gray (5Y 4/2) vitric claystone. Glauconite grains. Ash pocket. Olive gray (5Y 4/2) glauconitic vitric claystone. Olive gray (5Y 4/2) calcareous clayey siltstone. Vitric claystone. Olive gray (5Y 4/2) diatomaceous silty claystone. Calcareous tuff, laminated. Olive gray (5Y 4/2) silty claystone, mottled. Olive gray (5Y 4/2) silty claystone, homogeneous.
		BF, RP	B	FM	FM	CC						

TOTAL C – ORGANIC C – CARBONATE (%)
2, 32 cm (0.8, 0.7, 1)
4, 66 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

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

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE / UPPER MIOCENE	*D. kamtschatica*	B	B	F M	C M	1, 2, 3, 4, CC	0.5, 1.0	I.W. SAMPLE; O.G. SAMPLE; VOID			80, 119, 32	Ash fill burrow; White ash mottled; Greenish gray (5GY 6/1) mottled tuffite; Burrows; Olive gray (5Y 4/2) silty claystone intensely but faintly mottled; Olive gray (5Y 4/2) silty claystone. Silty claystone.

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

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

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

CARBONATE BOMB
3, 78-80 cm = 0%

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE		B	*T. rugosus?*	C M	F M	F M	*D. kamtschatica*	CC	1, 2, 3, 4, 5	0.5, 1.0	VOID; VOID	110, 92, 101	Grayish olive (10Y 4/2) silty claystone intensely mottled, with greenish gray (5GY 6/1) and moderate olive brown (5Y 4/4) calcareous intervals. Healed faults and fractures of several orientations; partings parallel to some fracture orientations. Grayish olive (10Y 4/2) silty claystone, intensely mottled. Offset calcareous mottle. Grayish olive (10Y 4/2) silty claystone, intensely mottled. Grayish olive (10Y 4/2) silty claystone, intensely mottled. Grayish olive (10Y 4/2) silty claystone, intensely mottled.

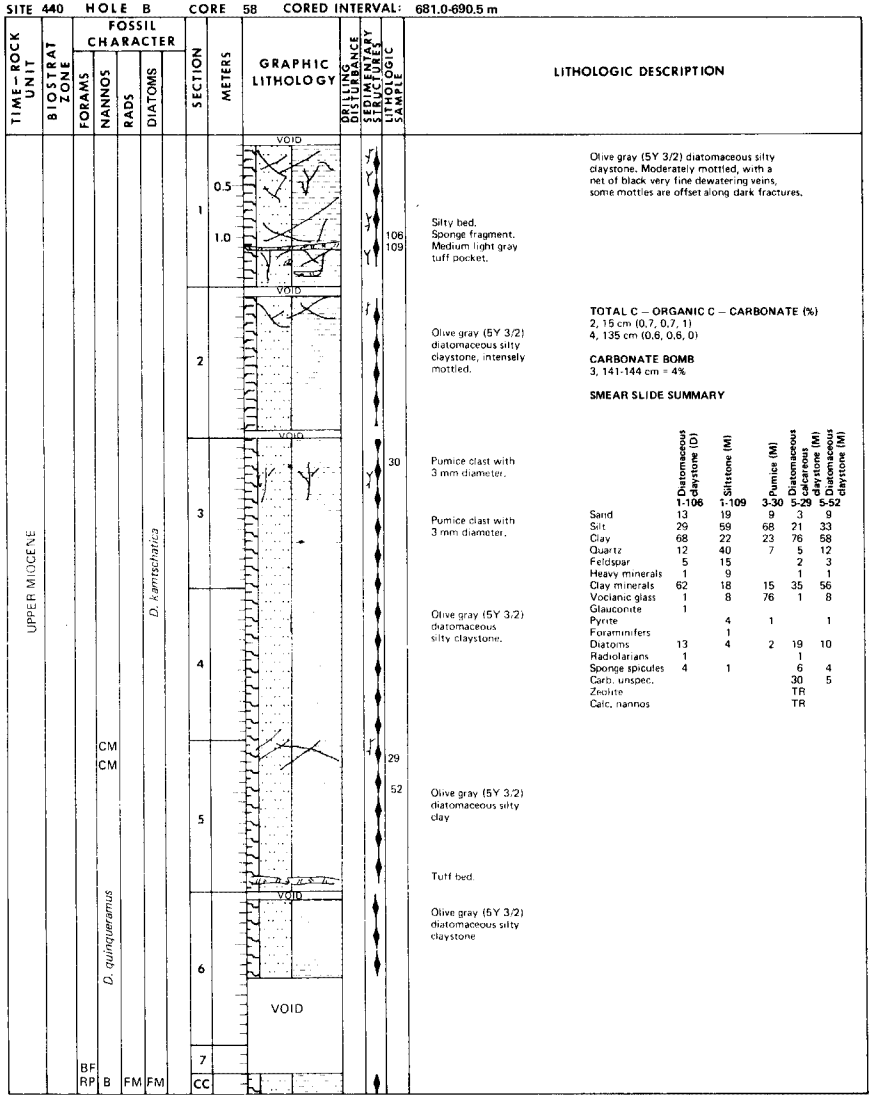
TOTAL C – ORGANIC C – CARBONATE (%)
3, 106 cm (0.8, 0.5, 2)
5, 54 cm (0.8, 0.7, 1)

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

SMEAR SLIDE SUMMARY

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

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



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

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

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

Pumice clast with 3 mm diameter.

Pumice clast with 3 mm diameter.

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

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

Tuff bed.

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

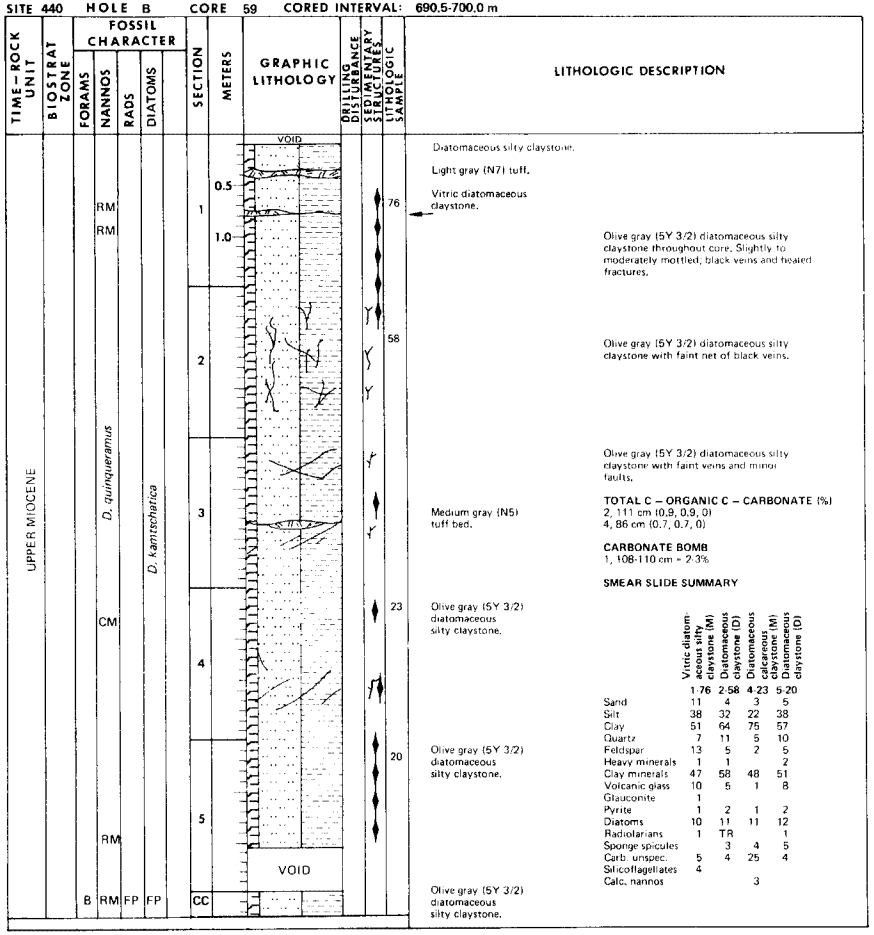
TOTAL C – ORGANIC C – CARBONATE (%)
2, 15 cm (0.7, 0.7, 1)
4, 135 cm (0.6, 0.6, 0)

CARBONATE BOMB
3, 141-144 cm = 4%

SMEAR SLIDE SUMMARY

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

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



Diatomaceous silty claystone.

Light gray (N7) tuff.

Vitric diatomaceous claystone.

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

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

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

Medium gray (N5) tuff bed.

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

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

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

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

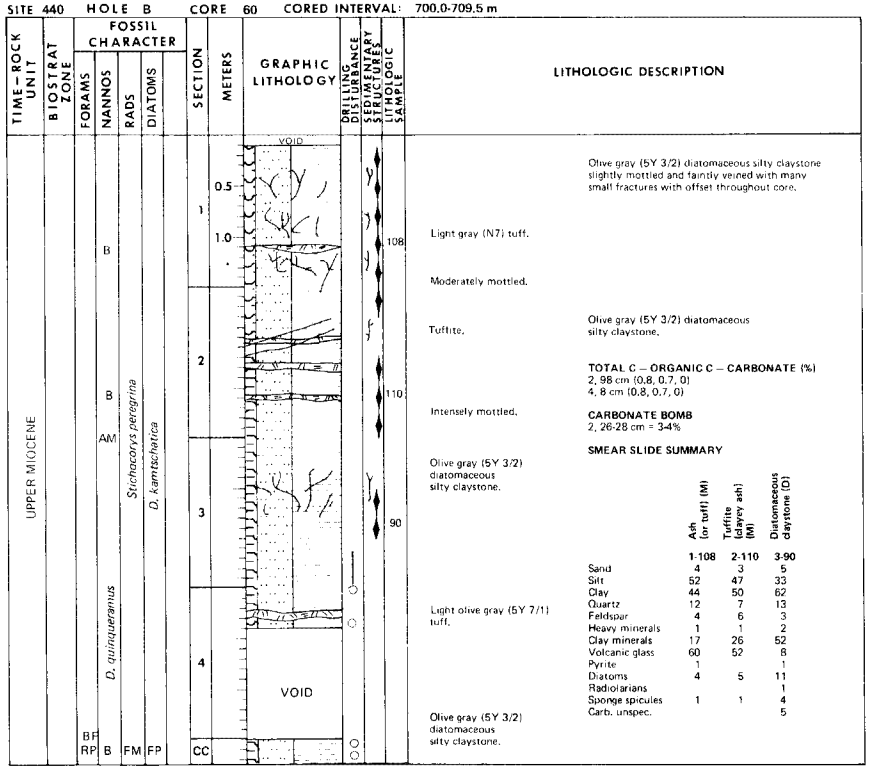
CARBONATE BOMB
1, 108-110 cm = 2.3%

SMEAR SLIDE SUMMARY

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

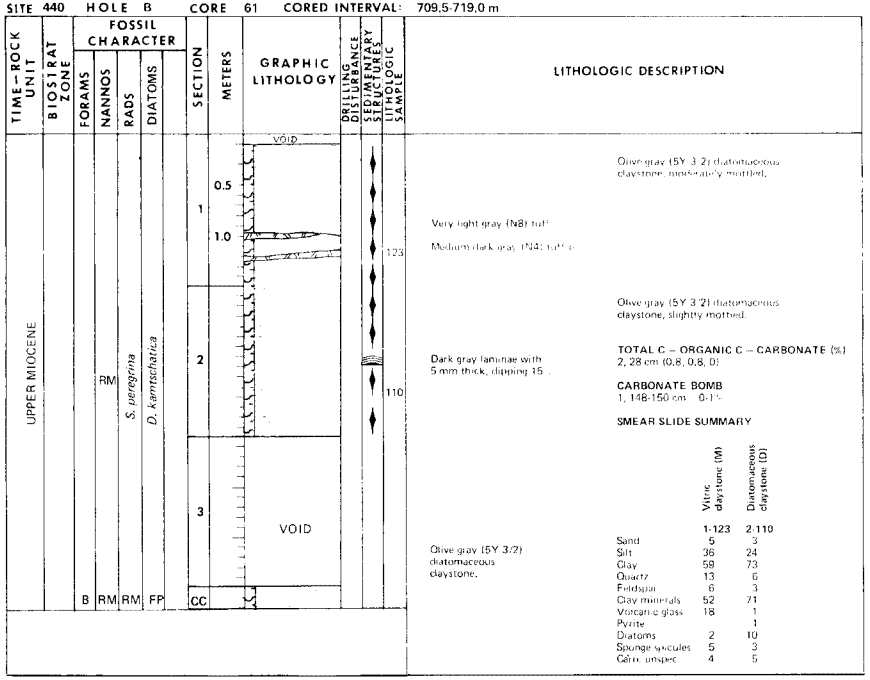
MCG 1505 5027

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



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

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



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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE				*S. peregrina* / *D. kamtschatica*		1	0.5, 1.0	VOID; I.W. SAMPLE			100	Olive gray (5Y 3/2) claystone, Diatom rich, slightly mottled; faint black veins; high angle open parting. Sponge fragments.
		B	B	FM	CM	2 / CC						Olive gray (5Y 3/2) claystone.

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

SMEAR SLIDE SUMMARY

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

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE			*D. quinqueramus*	*S. peregrina* / *D. kamtschatica*		1	0.5, 1.0	VOID			60	Sponge fragment. Olive gray (5Y 3/2) claystone, slightly mottled and faint black veins, some healed fractures. With sponge fragments.
						2		VOID				Olive gray (5Y 3/2) claystone, slightly mottled and faintly veined with offset in black color.
						3		VOID; O.G. SAMPLE			8, 62	Light gray tuff bed. Olive gray (5Y 3/2) claystone. Light olive gray (5Y 6/1) tuff beds.
			CM			4					96	Olive gray (5Y 3/2) claystone. Medium gray tuff with burrow.
			CM									
			AM			5		VOID				
		BF RP	RM	CM	CM	CC						Olive gray (5Y 3/2) claystone.

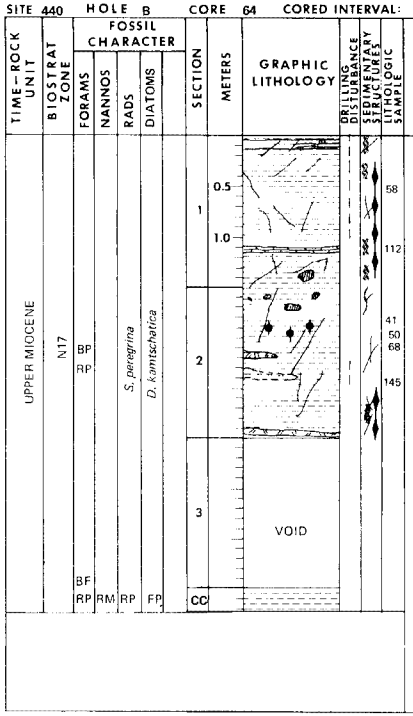
TOTAL C – ORGANIC C – CARBONATE (%)
2, 69 cm (0.9, 0.9, 0)
4, 35 cm (0.9, 0.8, 1)

CARBONATE BOMB
3, 37-39 cm - 2.3%

SMEAR SLIDE SUMMARY

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

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



LITHOLOGIC DESCRIPTION

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

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

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

Calcareous burrow.

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

Sponge fragments
Tuff pocket.
Disseminated silty bed.

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

Intensely bioturbated.

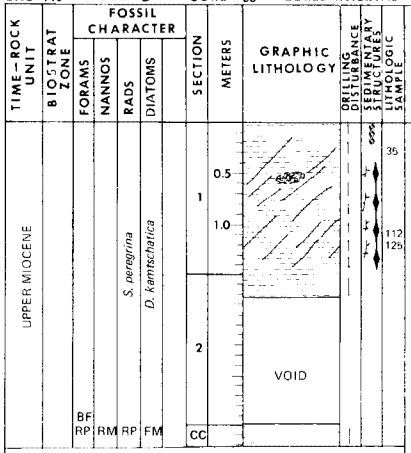
SMEAR SLIDE SUMMARY

Tuffite bed.

Olive gray (5Y 4/1) claystone.

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

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



LITHOLOGIC DESCRIPTION

Burrow

Sand pocket

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

Dark greenish gray (5GY 4/1) claystone

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

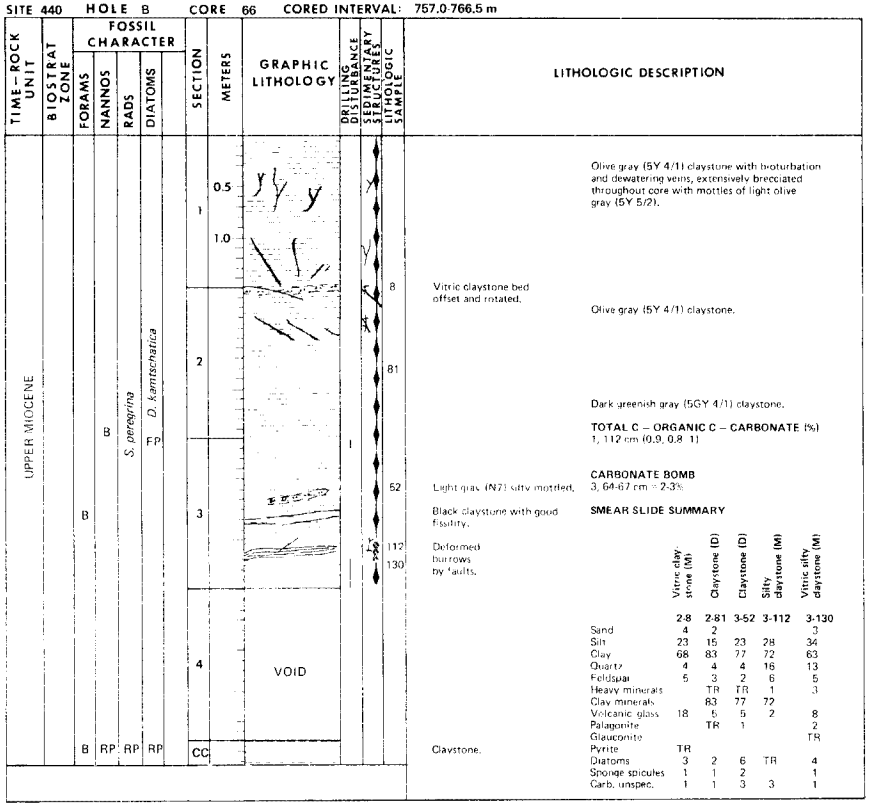
TOTAL C – ORGANIC C – CARBONATE (%)
1, 125 cm (1.0, 0.8, 2)

CARBONATE BOMB
1, 51-52 cm – 1.2%

SMEAR SLIDE SUMMARY

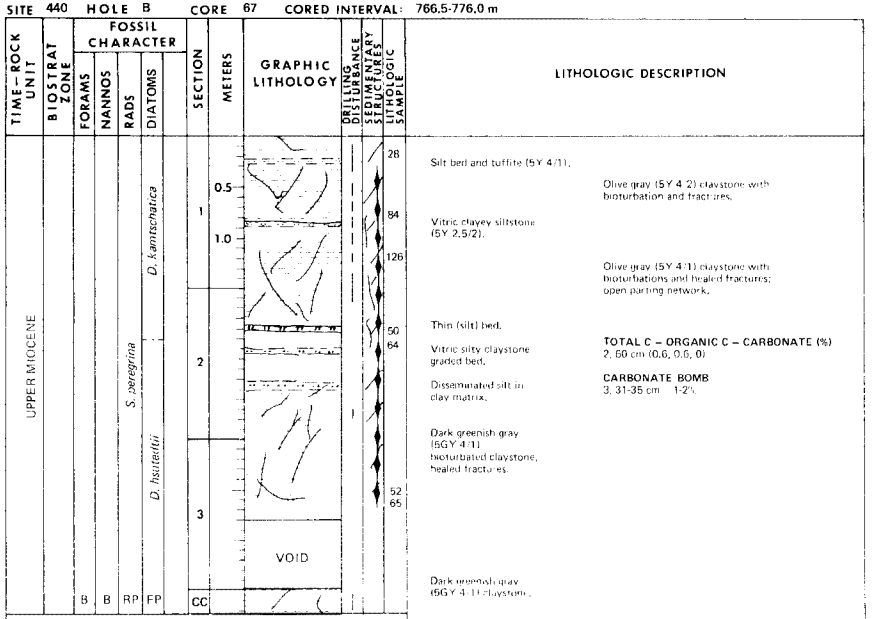
	Claystone (M) 1-38	Claystone (D) 1-112	Claystone (D) 1-125
Silt	28	26	19
Clay	72	74	81
Quartz	4	6	6
Feldspar	4	4	2
Heavy minerals			TR
Clay minerals	72		81
Volcanic glass	2	4	1
Palagonite	TR	TR	TR
Foraminifers	TR		
Diatoms	7	6	7
Sponge spicules	4	3	2
Carb. unspec.	7	3	1

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



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

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



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

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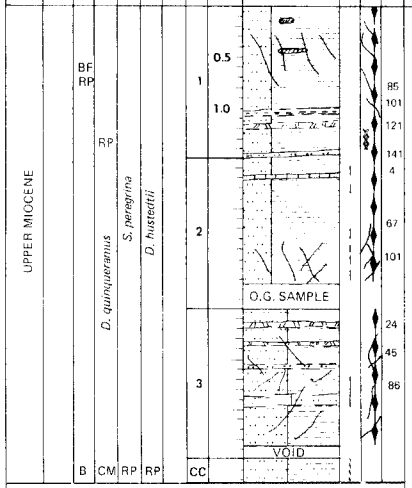
SITE 440 HOLE B CORE 68 CORED INTERVAL: 776.0-785.6 m



LITHOLOGIC DESCRIPTION

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

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

Silty claystone.
Tuffite.

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

Calcareous worm burrow.

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

Vitric clayey siltstone.

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

Silt bed.

Clayey siltstone.

Same as above Section.

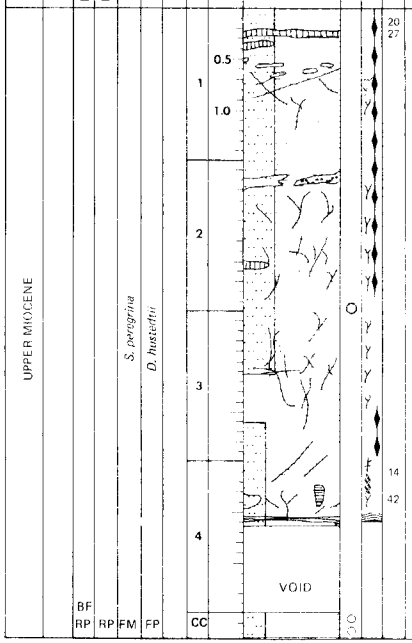
TOTAL C – ORGANIC C – CARBONATE (%)
2, 68 cm (0.5, 0.6, 0)

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

SMEAR SLIDE SUMMARY

	Silty claystone (D) 1-85	Silty claystone (M) 1-101	Tuffite (M) 1-21	Chalk (M) 1-141	Vitric clayey siltstone (M) 2-4	Silty claystone (D) 2-67	Silty claystone (M) 2-101	Vitric clayey siltstone (M) 3-24	Silty claystone (D) 3-45	Clayey siltstone (M) 3-86
Sand	5		18		12	12	16	15	11	18
Silt	30	34	36	5	52	26	42	48	43	46
Clay	65	66	46	95	36	62	42	37	46	36
Quartz	8	18	8		22	14	23	26	21	26
Feldspar	4	4	10		10	5	10	8	7	12
Heavy minerals	1	2	TR		6	2	3	4	3	4
Clay minerals	69		46		36			37	46	
Volcanic glass	6		32	2	6	2	4	4	5	3
Palagonite	1	3	2		4	2	4	6	3	3
Glauconite	TR	1			TR	2	1	1	1	1
Diatoms	8	3	1	1	TR	3	4		7	2
Radiolarians									TR	
Sponge spicules	5	2	TR	2	1	1	3		3	1
Carb. unspec.	2	1	1	95		2			3	
Calc. nannos				TR						
Lithic fragments					15	5	6	14		12

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



LITHOLOGIC DESCRIPTION

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

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

Medium gray (N5) silty pocket.

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

Calcite-cemented mottle.

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

Worm burrow
Silty claystone
Thin lamination

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

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

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

SMEAR SLIDE SUMMARY

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

MGG 1505 6047

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE					*D. hustedtii*	1	0.5, 1.0					Drill cuttings and downhole wash, graded during wash.
						2		VOID				
		BF						VOID				
		RP	B	RP	RP	CC		VOID	○			Olive gray (5Y 3/2) diatomaceous claystone.

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

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER MIOCENE			*D. quinqueramus*			1	0.5, 1.0	VOID				Olive gray (5Y 3/2) diatomaceous claystone, moderately mottled throughout core. Some dark veins and healed fractures; persistent low angle open parting.
					FP							Dark gray (N3) very fine grained sandstone to siltstone. Graded bed. Worm burrow, 1 x 10 mm
												Silt body or bed.
												Dark gray (N3) siltstone bed.
											40	Olive gray (5Y 3/2) diatomaceous claystone.
			RM			2					73, 76	Vitric siltstone bed.
											120	Siltstone. Dark gray (N3; graded siltstone bed, healed faults.
					D. hustedtii							Olive gray (5Y 3/2) diatomaceous claystone.
						3		VOID				Medium dark gray (N4) siltstone.
		B	FP	RP	RP	CC			○			Olive gray (5Y 3/2) diatomaceous claystone.

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

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

SMEAR SLIDE SUMMARY

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

NGS 1 1 0 5 5 0 2 7

SITE SUMMARY SHEET

SITE 441

Date occupied	November 21, 1977
Date departed	November 22, 1977
Time on hole	2 days
Position: latitude	39° 45.05'N
longitude	144° 04.59'E
Water depth (sea level)	5655 corrected meters, echo sounding
Water depth (rig floor)	5665 corrected meters, echo sounding
Bottom felt at	5665 meters, drill pipe
Penetration	273.0 meters
Number of holes	1
Number of cores	9
Total length of cored section	79.0 meters
Total core recovery	16.6 meters
Percentage core recovery	21%

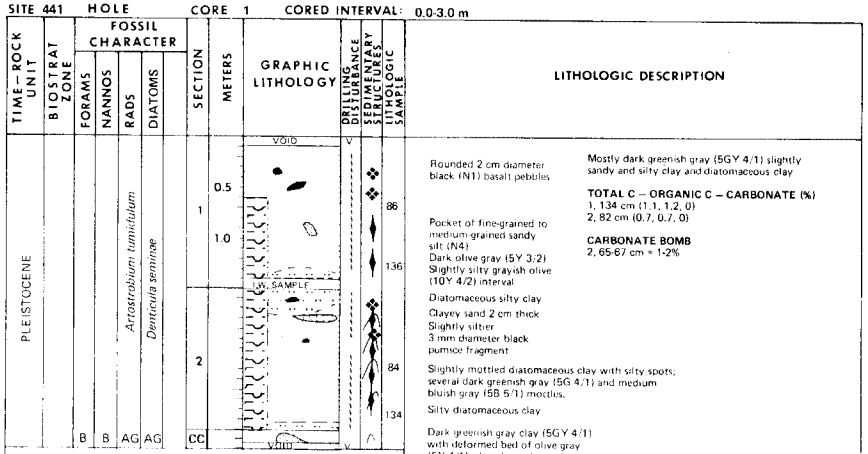
Oldest Sediment Cored

Depth sub-bottom	273.0 meters
Nature	Diatomaceous claystone
Age	Early Pliocene
Measured velocity	1.6 km/s

Principal Results:

See 441B Site Summary Sheet.

SITE 441 HOLE CORE 1 CORED INTERVAL: 0.0-3.0 m



Rounded 2 cm diameter black (N1) basalt pebbles

Pocket of fine-grained to medium-grained sandy silt (N4)
Dark olive gray (5Y 3/2)
Slightly silty grayish olive (10Y 4/2) interval

Diatomaceous silty clay

Clayey sand 2 cm thick
Slightly siltier
3 mm diameter black pumice fragment

Slightly mottled diatomaceous clay with silty spots; several dark greenish gray (5G 4/1) and medium bluish gray (5B 5/1) mottles.

Silty diatomaceous clay

Dark greenish gray clay (5GY 4/1) with deformed bed of olive gray (5Y 4/1) silty clay at base.

Mostly dark greenish gray (5GY 4/1) slightly sandy and silty clay and diatomaceous clay

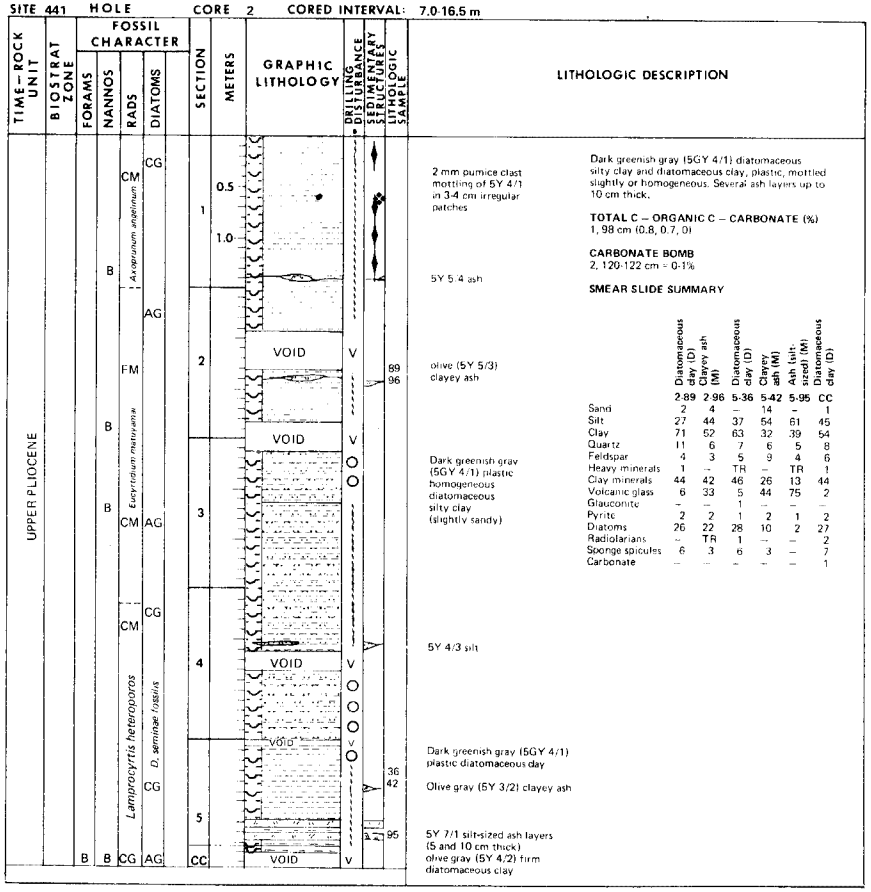
TOTAL C – ORGANIC C – CARBONATE (%)
1, 134 cm (1.1, 1.2, 0)
2, 82 cm (0.7, 0.7, 0)

CARBONATE BOMB
2, 65-67 cm = 1-2%

SMEAR SLIDE SUMMARY

	Sandy silt (M)	Diatomaceous clay (D)	Diatomaceous clay (D)	Diatomaceous clay (M)
	1-86	1-136	2-84	2-134
Sand	32	1	6	3
Silt	46	47	26	38
Clay	22	52	68	59
Quartz	16	8	7	10
Feldspar	27	12	6	13
Heavy minerals	9	2	2	2
Clay minerals	16	35	46	39
Volcanic glass	9	9	4	5
Glauconite	–	–	–	TR
Pyrite	3	–	2	TR
Foraminfiers	–	–	–	TR
Diatoms	7	26	24	23
Radiolarians	1	2	1	2
Sponge spicules	5	4	5	4
Lithic fragments	7	–	–	2
Other carbonate	–	2	3	–

SITE 441 HOLE CORE 2 CORED INTERVAL: 7.0-16.5 m



2 mm pumice clast mottling of 5Y 4/1 in 3-4 cm irregular patches

5Y 5/4 ash

olive (5Y 5/3) clayey ash

Dark greenish gray (5GY 4/1) plastic homogeneous diatomaceous silty clay (slightly sandy)

5Y 4/3 silt

Dark greenish gray (5GY 4/1) plastic diatomaceous clay

Olive gray (5Y 3/2) clayey ash

5Y 7/1 silt-sized ash layers (5 and 10 cm thick)
olive gray (5Y 4/2) firm diatomaceous clay

Dark greenish gray (5GY 4/1) diatomaceous silty clay and diatomaceous clay, plastic, mottled slightly or homogeneous. Several ash layers up to 10 cm thick.

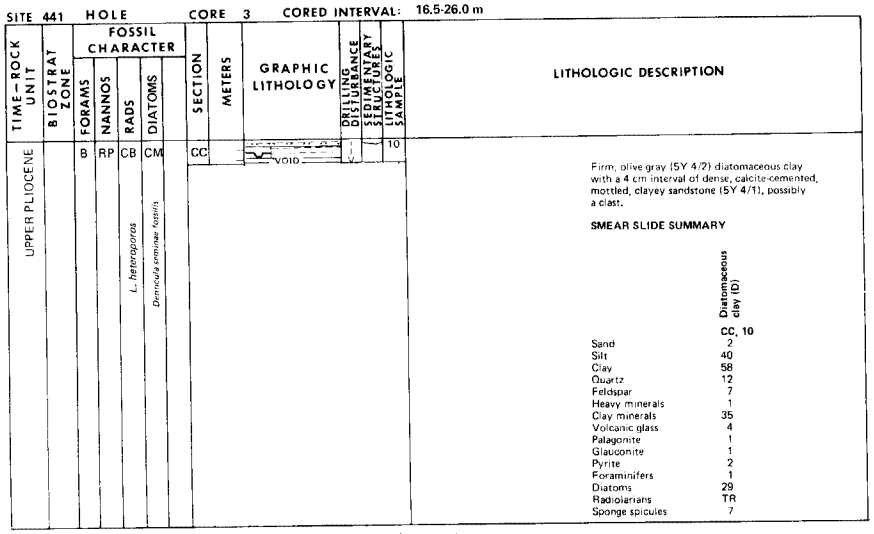
TOTAL C – ORGANIC C – CARBONATE (%)
1, 98 cm (0.8, 0.7, 0)

CARBONATE BOMB
2, 120-122 cm = 0-1%

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)	Clayey ash (M)	Diatomaceous clay (D)	Clayey ash (M)	Ash (silt-sized) (M)	Diatomaceous clay (D)
	2-89	2-96	5-36	5-42	5-95	CC
Sand	2	4	–	14	–	1
Silt	27	44	37	54	61	45
Clay	71	52	63	32	39	54
Quartz	11	6	7	6	5	8
Feldspar	4	3	5	9	4	6
Heavy minerals	1	–	TR	–	TR	1
Clay minerals	44	42	46	26	13	44
Volcanic glass	6	33	5	44	75	2
Glauconite	–	–	1	–	–	–
Pyrite	2	2	1	2	1	2
Diatoms	26	22	28	10	2	27
Radiolarians	–	TR	1	–	–	2
Sponge spicules	6	3	6	3	–	7
Carbonate	–	–	–	–	–	1

SITE 441 HOLE CORE 3 CORED INTERVAL: 16.5-26.0 m

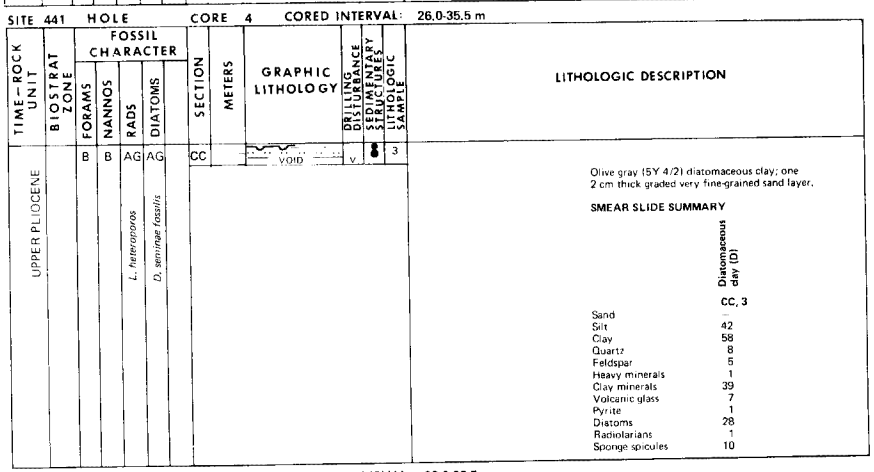


Firm, olive gray (5Y 4/2) diatomaceous clay with a 4 cm interval of dense, calcite-cemented, mottled, clayey sandstone (5Y 4/1), possibly a clast.

SMEAR SLIDE SUMMARY

	Diatomaceous clay (D)
	CC, 10
Sand	2
Silt	40
Clay	58
Quartz	12
Feldspar	7
Heavy minerals	1
Clay minerals	35
Volcanic glass	4
Palagonite	1
Glauconite	1
Pyrite	2
Foraminifers	1
Diatoms	29
Radiolarians	TR
Sponge spicules	7

SITE 441 HOLE CORE 4 CORED INTERVAL: 26.0-35.5 m

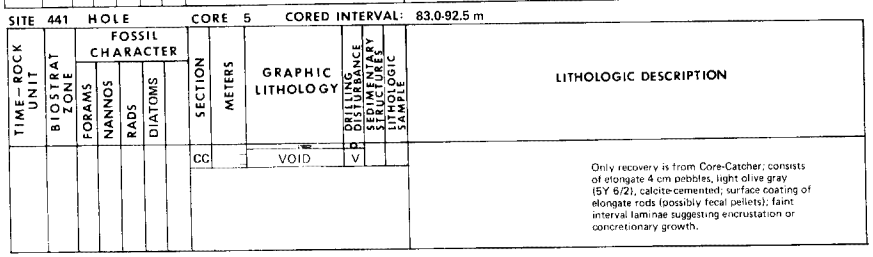


Olive gray (5Y 4/2) diatomaceous clay; one 2 cm thick graded very fine-grained sand layer.

SMEAR SLIDE SUMMARY

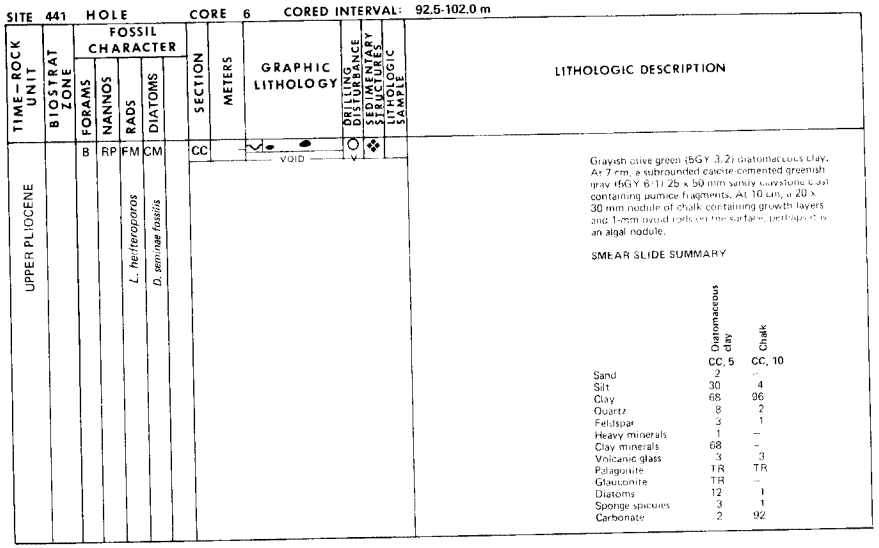
	Diatomaceous clay (D)
	CC, 3
Sand	–
Silt	42
Clay	58
Quartz	8
Feldspar	5
Heavy minerals	1
Clay minerals	39
Volcanic glass	7
Pyrite	1
Diatoms	28
Radiolarians	1
Sponge spicules	10

SITE 441 HOLE CORE 5 CORED INTERVAL: 83.0-92.5 m



Only recovery is from Core-Catcher; consists of elongate 4 cm pebbles, light olive gray (5Y 6/2), calcite-cemented; surface coating of elongate rods (possibly fecal pellets); faint interval laminae suggesting encrustation or concretionary growth.

SITE 441 HOLE CORE 6 CORED INTERVAL: 92.5-102.0 m

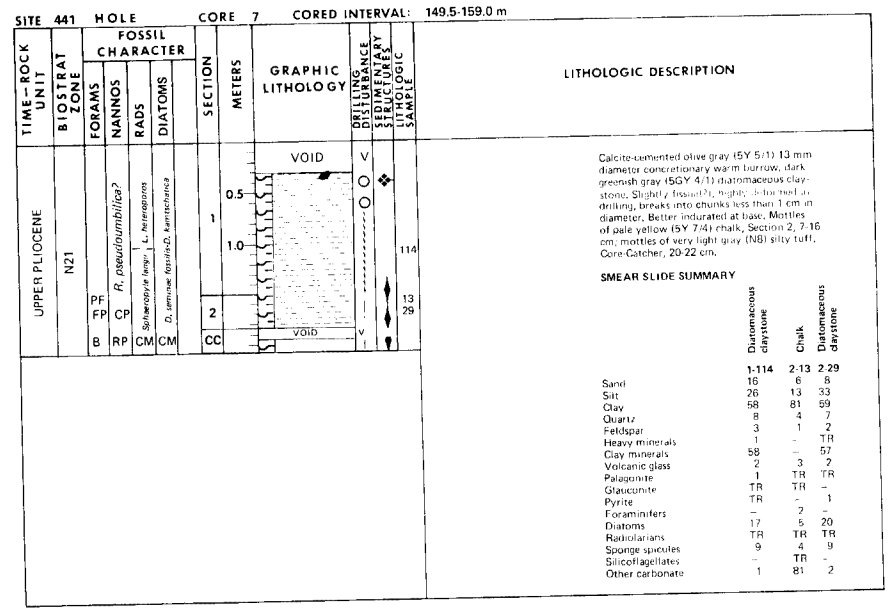


Grayish olive green (5GY 3/2) diatomaceous clay. At 7 cm, a subrounded calcite-cemented greenish gray (5GY 6/1) 25 x 50 mm sandy claystone clast containing pumice fragments. At 10 cm, a 20 x 30 mm nodule of chalk containing growth layers and 1-mm ovoid pels on the surface, perhaps it is an algal nodule.

SMEAR SLIDE SUMMARY

	Diatomaceous clay	Chalk
	CC, 5	CC, 10
Sand	2	–
Silt	30	4
Clay	68	96
Quartz	8	2
Feldspar	3	1
Heavy minerals	1	–
Clay minerals	68	–
Volcanic glass	3	3
Palagonite	TR	TR
Glauconite	TR	–
Diatoms	12	1
Sponge spicules	3	1
Carbonate	2	92

SITE 441 HOLE CORE 7 CORED INTERVAL: 149.5-159.0 m



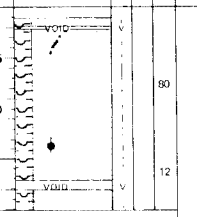
Calcite-cemented olive gray (5Y 5/1) 13 mm diameter concretionary warm burrow; dark greenish gray (5GY 4/1) diatomaceous claystone. Slightly fissile(?), highly disturbed by drilling, breaks into chunks less than 1 cm in diameter. Better indurated at base. Mottles of pale yellow (5Y 7/4) chalk, Section 2, 7-16 cm; mottles of very light gray (N8) silty tuff, Core-Catcher, 20-22 cm.

SMEAR SLIDE SUMMARY

	Diatomaceous claystone	Chalk	Diatomaceous claystone
	1-114	2-13	2-29
Sand	16	6	8
Silt	26	13	33
Clay	58	81	59
Quartz	8	4	7
Feldspar	3	1	2
Heavy minerals	1	–	TR
Clay minerals	58	–	57
Volcanic glass	2	3	2
Palagonite	1	TR	TR
Glauconite	TR	TR	–
Pyrite	TR	–	1
Foraminifers	–	2	–
Diatoms	17	5	20
Radiolarians	TR	TR	TR
Sponge spicules	9	4	9
Silicoflagellates	–	TR	–
Other carbonate	1	81	2

SITE 441 HOLE CORE 8 CORED INTERVAL: 206.5-216.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER PLIOCENE		B	B	CM	CM	1, 2, CC	0.5, 1.0	VOID, VOID	V, V		80, 12



LITHOLOGIC DESCRIPTION

Drill cuttings

Possible fault surface, time inclination 45 , reverse slickensides, rake 80 clockwise from strike of surface. (Hole deviation at 149 m, 1.2 .)

Dark olive gray (5Y 3/2) homogeneous diatomaceous claystone. Hard layers, Section 1, 13-18 cm, 30-37 cm, Core-Catcher, 29-39 cm.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 74 cm (0.9, 0.7, 1)

CARBONATE BOMB
1, 91-93 cm = 0-1%

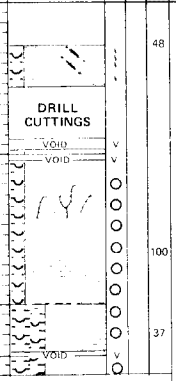
SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-80	Diatomaceous claystone 2-12
Sand	10	8
Silt	29	31
Clay	61	61
Quartz	7	9
Feldspar	3	4
Heavy minrals	1	1
Clay minerals	56	54
Volcanic glass	1	3
Pyrite	2	1
Diatoms	22	20
Radiolarians	1	1
Sponge spicules	7	6
Carbonate	TR	1

NOTE:
♦ = sponge fragments

SITE 441 HOLE CORE 9 CORED INTERVAL: 263.5-273.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE		B	B	FM	FM	1, 2, 3, CC	0.5, 1.0	DRILL CUTTINGS, VOID, VOID, VOID	V, V, O, O, O, O, O, O, O, V, O		48, 100, 37



LITHOLOGIC DESCRIPTION

Wash-resistent core fragments as below.

Possible fault, inclination 35 . Fault, inclination 35 , grooves rake 85 clockwise.

Dark olive gray (5Y 3/2) diatomaceous claystone.

Drill cuttings

This core was cut at core-cutting pump pressure from 263.5-273.0 m, but the core barrel had not been cleaned following washing at high pump pressure from 216.0 m. Some or all of the material described as core may have been cut about 263.5 m.

Fractured into 1-cm pieces.

Olive gray (5Y 4/2) clayey diatomite, homogeneous, less brittle than first two sections. Hackly fracture, Section 3, 0-25 cm.

SMEAR SLIDE SUMMARY

	Diatomaceous claystone 1-48	Diatomaceous claystone 2-100	Clayey diatomite 3-37
Sand	8	7	5
Silt	26	25	45
Clay	66	68	50
Quartz	8	9	7
Feldspar	6	6	3
Heavy minerals	2	1	TR
Clay minerals	58	65	46
Volcanic glass	4	–	3
Glauconite	1	2	–
Pyrite	1	–	–
Foraminifers	1	–	–
Diatoms	13	11	31
Radiolarians	1	TR	1
Sponge spicules	5	4	8
Other carbonate	–	2	1

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SITE SUMMARY SHEET

HOLE 441A

Date occupied	November 23, 1977
Date department	November 27, 1977
Time on hole	5 days
Position: latitude	39° 45.05'N
longitude	143° 04.59'E
Water depth (sea level)	5644 corrected meters, echo sounding
Water depth (rig floor)	5654 corrected meters, echo sounding
Bottom felt at	5656 meters, drill pipe
Penetration	662.0 meters
Number of holes	1
Number of cores	15
Total length of cored section	138.5 meters
Total core recovery	19.7 meters
Percentage core recovery	14%

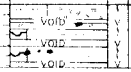
Oldest Sediment Cored

Depth sub-bottom	662.0 meters
Nature	Claystone
Age	Late Miocene
Measured velocity	2.3 km/s

Principal Results:

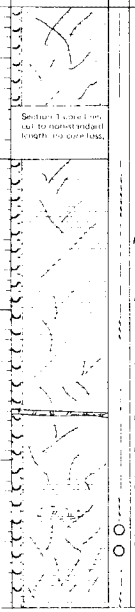
See 441B Site Summary Sheet.

SITE 441 HOLE A CORE 2 CORED INTERVAL: 130.0-139.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE		B	B	CM	CM	1 CC	0.5					NOTE: Site 441A, Core 1, 120.5-130.0 m: NO RECOVERY. Olive gray (5Y 4/1) silty tuff, graded, very fine-grained sand-size at base. Pumice clast, 3 mm, at base. Olive gray (5Y 4/2) diatomaceous claystone. Contains calcitic concretions up to 30 mm at 45 cm.

Lenticorpis heteroporus; *D. seminae fossilis*; *D. kamtchatica*

SITE 441 HOLE A CORE H1 CORED INTERVAL: 252.5-329.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE		B	B	FM	FM	1 2 3 4	0.5 1.0				31 99 101	Olive gray (5Y 4/2) homogeneous well-indurated diatomaceous claystone, intensely fractured throughout. **TOTAL C – ORGANIC C – CARBONATE (%)** 2, 68 cm (1.0, 0.9, 1) 4, 82 cm (0.9, 0.9, 0) **CARBONATE BOMB** 3, 137-140 cm = 0-1% **FRACTURE INCLINATIONS**

S. lanpii; *D. seminae fossilis D. kamtchatica*

Section 1 core 1 m cut to nominal length in core liner.

Faint black anastomosing veins

5Y 4/2

5Y 4/2

Very light gray mottled tuff with dip 15°

5Y 4/2

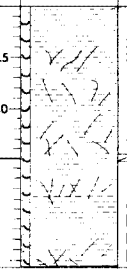
Very light gray ash slurry

Section 1	Section 2	Section 3	Section 4
7 cm 50°	6 cm 50°	65 cm 0	13 cm 35°
19 cm 2	7 cm 50°	65 cm 80	16 cm 15
28 cm 90	18 cm 25°	89 cm 13°	17 cm 80°
29 cm 10	39 cm 47°	90 cm 55°	17 cm 45
41 cm 28°	39 cm 33°	93 cm 45°	23 cm 50°
46 cm 2	54 cm 45	95 cm 32°	29 cm 35°
52 cm 52°	54 cm 43°	106 cm 55°	91 cm 10°
53 cm 45	60 cm 2°	115 cm 15	95 cm 76°
62 cm 40	70 cm 15	115 cm 68°	107 cm 53°
68 cm 35	75 cm 55	120 cm 35°	117 cm 15
80 cm 22°	82 cm 68°	137 cm 20°	117 cm 68°
86 cm 37	91 cm 36°		125 cm 78°
88 cm 60	135 cm 45		126 cm 37
92 cm 30	146 cm 15°		

SMEAR SLIDE SUMMARY

	Diatomaceous claystone (D)	Tuff (M)	Vitric diatomaceous claystone (D)
	1-31	3-99	3-101
Sand	8	36	12
Silt	26	56	29
Clay	66	8	59
Quartz	9	3	9
Feldspar	4	4	4
Mica	TR	–	–
Heavy minerals	1	–	TR
Clay minerals	66	8	59
Volcanic glass	5	83	10
Palagonite	TR	TR	TR
Glauconite	1	–	TR
Diatoms	10	2	12
Sponge spicules	3	–	6
Carbonate	1	–	–

SITE 441 HOLE A CORE H2 CORED INTERVAL: 338.0-386.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE						1 2	0.5 1.0				10 48	Olive gray (5Y 4/2) diatomaceous claystone with many fractures. Intense mottling of 1-2 mm size, and faint black veins with offsets, through Section 1. Olive gray (5Y 4/2) diatomaceous claystone with moderate mottling of small size. **FRACTURE INCLINATIONS**

D. seminae fossilis-*D. kamtchatica* or *D. kamtchatica*

Section 1	Section 2
70 cm 80°	26 cm 62°
80 cm 81	46 cm 68
85 cm 55°	96 cm 61
88 cm 70°	
104 cm 29°	
138 cm 19	

SMEAR SLIDE SUMMARY

	Vitric calcareous clayey siltstone (M)	Diatomaceous claystone (D)
	1-10	2-48
Sand	21	6
Silt	47	30
Clay	52	64
Quartz	12	5
Feldspar	26	3
Heavy minerals	4	1
Clay minerals	15	64
Volcanic glass	10	4
Palagonite	1	–
Glauconite	–	1
Pyrite	2	–
Diatoms	7	11
Radiolarians	TR	TR
Sponge spicules	6	4
Carbonate	17	7

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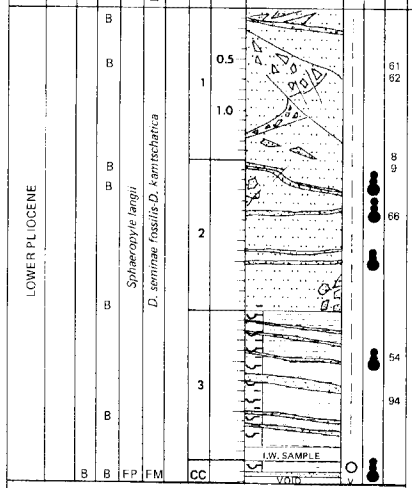
SITE 441 HOLE A CORE 5 CORED INTERVAL: 386.5-396.0 m



LITHOLOGIC DESCRIPTION

Bedding, 20° inclination
clay-sized devitrified ash(?)

Siltstone (blocks)
silty claystone (matrix)

Calcareous claystone
Clayey siltstone

Very fine graded sandstone
graded sandstone
Siltstone

Dark gray (N3) sandy siltstone
Dark gray (N3) sandy siltstone

Graded medium sandstone,
7 cm clast at base.
Diatomaceous claystone

Coarse-grained; up to 2
mm grains; 60° and 75°
fractures, normal.
Diatomaceous claystone

Medium-grained sandstone

NOTE: Site 441A, Core 3, 244.0-252.5 m and Site 441A, Core 4, 329.5-338.0 m: NO RECOVERY.

Dark gray (N3) siltstone as "tectonic breccia". Blocks are dark gray (N3), and the softer interblock matrix is medium dark gray (N4). Matrix is more clay rich. Some graded sand layers.

Dark gray (N3) diatomaceous claystone.

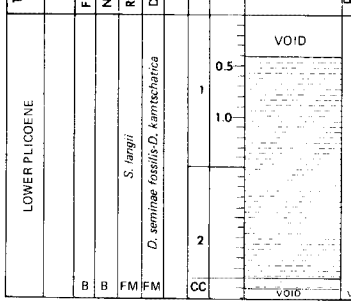
TOTAL C – ORGANIC C – CARBONATE (%)
2, 132 cm (0.7, 0.6, 1)

CARBONATE BOMB
3, 105-107 cm = 0.1%

SMEAR SLIDE SUMMARY

	Clayey siltstone (D) 1-61	Silty claystone (M) 1-62	Calcareous claystone (M) 2-8	Sandy clayey siltstone (M) 2-9	Clayey siltstone (D) 2-66	Diatomaceous claystone (M) 3-54	Diatomaceous claystone (D) 3-94
Sand	20	15	8	27	21	7	7
Silt	50	30	17	41	48	41	32
Clay	30	55	75	32	31	52	61
Quartz	50	35	7	47	45	11	14
Feldspar	13	8	5	16	17	5	6
Heavy minerals	4	1	TR	4	3	2	1
Clay minerals	25	54	61	22	30	47	48
Volcanic glass	–	1	TR	3	2	6	8
Palagonite	–	–	–	–	–	–	TR
Glauconite	–	–	–	1	–	–	–
Pyrite	2	1	–	–	–	1	1
Diatoms	–	–	1	–	TR	16	12
Sponge spicules	–	–	–	–	–	2	1
Lithic fragments	4	–	–	5	–	6	5
Carbonate	2	TR	26	2	3	4	4

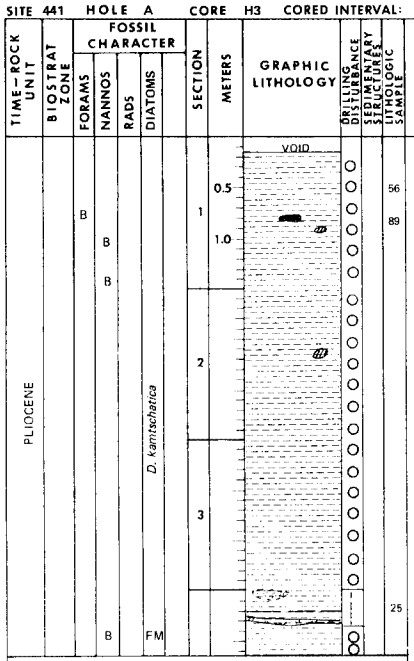
SITE 441 HOLE A CORE 6 CORED INTERVAL: 443.5-452.0 m



LITHOLOGIC DESCRIPTION

DRILL CUTTINGS THROUGHOUT

SITE 441 HOLE A CORE H3 CORED INTERVAL: 452.0-500.5 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 3/2) claystone

Wood fragment, 1.5 cm

1-2 cm chips in drilling mud matrix

Fine sand-sized 1 cm calcite-cemented concretion

Olive gray (5Y 3/2) claystone

Fine sand-sized 1 cm calcite-cemented concretion

Olive gray (5Y 3/2) claystone

Medium-grained sandstone chips

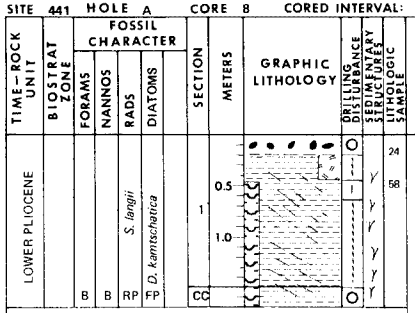
Grayish black (N2) re-sedimented shale.

Medium olive gray (5Y 5/1) silt-sized tuff

SMEAR SLIDE SUMMARY

	Claystone (D) 1-56	Marlstone (M) 1-89	Tuffite (M) 4-25
Sand	6	6	12
Silt	18	11	53
Clay	76	83	35
Quartz	7	3	7
Feldspar	3	–	6
Clay minerals	70	59	13
Volcanic glass	6	–	72
Palagonite	–	3	–
Pyrite	–	–	3
Diatoms	7	–	TR
Sponge spicules	2	–	–
Carbonate	5	35	–

SITE 441 HOLE A CORE 8 CORED INTERVAL: 510.0-519.5 m



LITHOLOGIC DESCRIPTION

Vitric claystone olive gray

45 and 65 fractures, reverse

32 35

NOTE: Site 441A, Core 7, 500.5-510.0 m: NO RECOVERY

Pebbles, rounded to subrounded, possible from uphole:
5 cm phaneritic basalt;
2.5 cm medium dark gray (N4) siltstone;
4 and 3.5 cm olive (5Y 4/3) claystone.

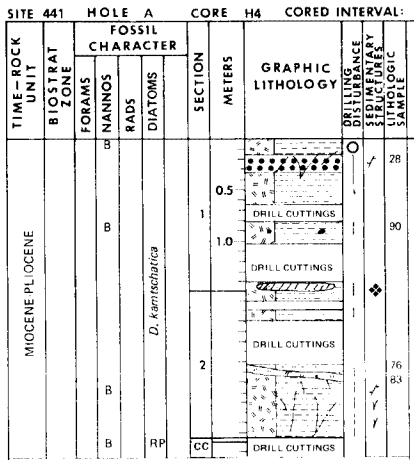
Dark olive gray (5Y 3/2) diatomaceous claystone, highly broken up during drilling into fissile chips with persistent fractures or partings (joints): 40 45 .

TOTAL C – ORGANIC C – CARBONATE (%)
1, 60 cm (1.3, 0.9, 3)

SMEAR SLIDE SUMMARY

	Vitric claystone (D) 1-24	Diatomaceous claystone (D) 1-58
Sand	7	6
Silt	36	20
Clay	57	74
Quartz	13	3
Feldspar	4	2
Heavy minerals	1	–
Clay minerals	57	74
Volcanic glass	11	1
Palagonite	1	TR
Glauconite	TR	–
Diatoms	8	14
Sponge spicules	2	3
Other carbonate	2	2
Nannofossils	1	1

SITE 441 HOLE A CORE H4 CORED INTERVAL: 519.5-568.0 m



LITHOLOGIC DESCRIPTION

3 mm rounded clasts

10 cm calcite-concretion clast

DRILL CUTTINGS
Olive gray (5Y 4/2) vitric claystone

Tuff, bedding inclination 18 ; reverse fault, 65

Hackly cleavage 35 ; bedding 21

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

Grayish black (N2) to greenish gray (5G 6/1) conglomerate, with 1 cm subangular clasts of calcareous claystone; bedding dip 15 ; fault 75 ; slickensides approximately horizontal.

SMEAR SLIDE SUMMARY

	Calcareous diatomaceous claystone (M) 1-28	Vitric claystone (D) 1-90	Silty tuff (M) 2-76	Tuff (M) 2-83
Sand	4	11	15	–
Silt	20	33	62	60
Clay	76	56	23	40
Quartz	6	7	13	5
Feldspar	3	5	3	
Heavy minerals		2	4	
Clay minerals	51	52	15	5
Volcanic glass	4	24	51	90
Palagonite		1	–	
Pyrite	–	–	–	TR
Foraminifers	1	–	–	
Diatoms	11	5	1	
Radiolarians	TR	–	–	–
Sponge spicules	3	2	1	
Other carbonate	21	2	1	
Zeolite	–	1	2	

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SITE 441 HOLE A CORE 9 CORED INTERVAL: 568.0-576.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE	*D. kamtschatica*	B	B	RM	FP	1		VOID	O		

LITHOLOGIC DESCRIPTION

5Y 3/2 claystone
Five calcitic concretionary pebbles or concretions ranging from claystone to fine sandstone; one is microbrecciated and contains pyrite veins. All are different.
No Core-Catcher sample.

SITE 441 HOLE A CORE 10 CORED INTERVAL: 576.5-586.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
LOWER PLIOCENE	*D. kamtschatica?*		B			1	0.5		O		48
							1.0		O		
			B						O		
									O		
			B			2			O		
			B						O		
			B						I		51
		B	B	RP	RP	CC			I		52
									I		7

LITHOLOGIC DESCRIPTION

Greenish black (5G 2/1).
Drill cuttings (small chips) of silty claystone.

Less than 5 mm breccia pieces; (51) is green, (52) is N4-N6. Calcite-cemented breccia; thin veinlets of calcite separating clots of dark greenish gray (5G 4/1) claystone (does not effervesce) and gray (N4-N6) calcareous chalk(?), silt-sized with dark angular sand-silt grains tightly cemented.

Dark greenish gray (5G 6/1) calcareous claystone mottled very slightly with N5, streaked.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 50 cm (6.1, 0.3, 48)

SMEAR SLIDE SUMMARY

	Silty claystone (D) 1-48	Muddy limestone (pebble) (M) 2-51	Limestone (pebble) (M) 2-52	Limestone (M) CC-7
Sand	11	–	2	–
Silt	30	85	68	65
Clay	59	15	30	35
Quartz	24	5	1	1
Feldspar	5	4	1	TR
Clay minerals	59	15	–	–
Volcanic glass	8	6	3	3
Palagonite	–	TR	–	–
Diatoms	1	–	1	–
Sponge spicules	1	–	–	–
Carbonate	2	70	94	96

SITE 441 HOLE A CORE 11 CORED INTERVAL: 586.0-595.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE			B		*D. kamtschatica?*	1	0.5		O		49
			B				1.0				70
											126
		B	B	RP	RP	CC		VOID	O		

LITHOLOGIC DESCRIPTION

Cuttings of dark greenish gray (5GY 3/1) claystone.

Cuttings of breccia unit 5Y 3/1; minor ash mottles, white (N8) in chips.

Resedimented breccia, clast-supported, dark greenish gray (5GY 4/1) overall, typically 5 mm or smaller angular clasts, some yellowish gray (5Y 8/1) calcareous marlstone, minor olive gray (5Y 4/1) claystone, and 5GY 2/1 glauconitic claystone, silty claystone, and white (N8) tuff. Entire unit indurated; many clasts appear to have been lithified upon sedimentation, while [illegible] conforming to adjacent clast shapes, as though soft when transported.

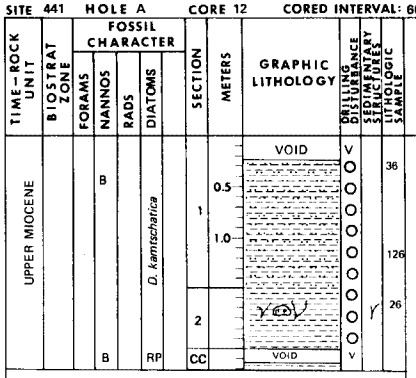
TOTAL C – ORGANIC C – CARBONATE (%)
1, 46 cm (0.9, 0.4, 5)

SMEAR SLIDE SUMMARY

	Claystone (pebble) (M) 1-49	Tuff (M) 1-70	Tuff (M) 1-126
Sand	–	–	12
Silt	33	35	58
Clay	67	65	30
Quartz	11	2	4
Feldspar	5	1	2
Clay minerals	67	–	–
Volcanic glass	5	97	94
Palagonite	1	–	–
Diatoms	4	–	TR
Sponge spicules	3	–	–
Carbonate	4	–	–

FRACTURE INCLINATIONS
Section 1
38 cm 70 , normal
38 cm 40 , reverse
53 cm 32 , reverse
53 cm 65 , reverse
63 cm 51 , reverse
72 cm 59
87 cm 3
89 cm 45
90 cm 85
93 cm 28
96 cm 29

SITE 441 HOLE A CORE 12 CORED INTERVAL: 605.0-614.5 m



LITHOLOGIC DESCRIPTION

Drill cuttings throughout, greenish black (5G 2/1-3/1) and olive gray (5Y 5/1); see smear slide summary. Chiefly clayey siltstone and claystone.

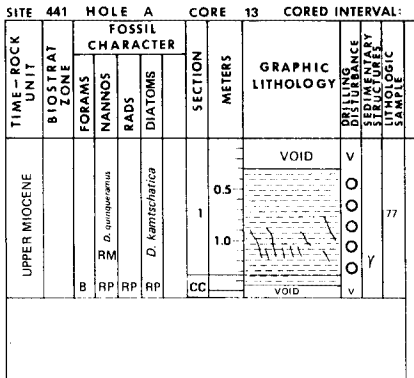
Fragment of silty tuff, light olive gray, containing numerous aligned somewhat branching non-calcareous light veins that lack offset.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 96 cm (0.5, 0.0, 0)

SMEAR SLIDE SUMMARY

	1-36 Clayey siltstone	1-126 Claystone	2-26 Silty tuff
Sand	6	–	15
Silt	54	26	46
Clay	40	74	39
Quartz	42	11	22
Feldspar	8	3	5
Heavy minerals	1	–	–
Clay minerals	40	74	39
Voclanic glass	3	5	33
Palagonite	–	–	TR
Diatoms	2	2	TR
Sponge spicules	4	3	TR
Carbonate	–	2	1

SITE 441 HOLE A CORE 13 CORED INTERVAL: 624.0-633.5 m



LITHOLOGIC DESCRIPTION

Claystone, fissile, breaks easily along partings all of several orientations. Fracture surfaces have slickensides or grooves.
Fractures dipping 65°, closely-spaced partings

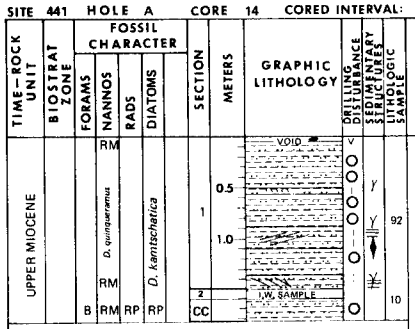
Greenish black (5G 2/1) claystone, mainly drill cuttings.

TOTAL C – ORGANIC C – CARBONATE (%)
1, 70 cm (0.9, 0.8, 1)

SMEAR SLIDE SUMMARY

	1-77 Claystone (D)
Sand	–
Silt	22
Clay	78
Quartz	8
Feldspar	3
Clay minerals	78
Volcanic glass	2
Diatoms	4
Sponge spicules	2
Carbonate	3

SITE 441 HOLE A CORE 14 CORED INTERVAL: 643.0-652.5 m



LITHOLOGIC DESCRIPTION

Pebble, N3 silt-sized sanstone, 3 cm in diameter, subrounded.

Parallel fractures, 65° inclination

A few mottles, small 5Y 4/1 silty claystone

Silty claystone with probable dewatering veins (blocks, 1 mm black streaks), very fine laminations showing at 42° inclination.

5Y 4/1 silty claystone strongly disturbed by drilling. Apparent dip, 40°.

Very fine laminations or cleavage N4-N5 show an apparent dip of about 40°.

All other parts are drill cuttings (chips).

Core-Catcher: Drill cuttings, some slickensides visible on small blocks.

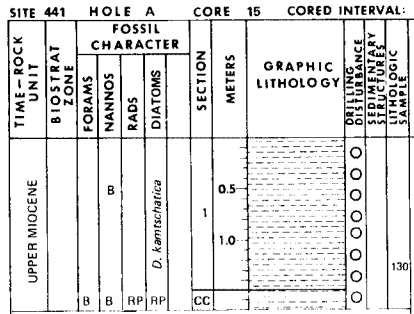
TOTAL C – ORGANIC C – CARBONATE (%)
1, 122 cm (0.6, 0.6, 1)

CARBONATE BOMB
1, 114-116 cm = 0-1%

SMEAR SLIDE SUMMARY

	1-92 Silty claystone (D)	CC 10 Silty claystone (D)
Sand	2	2
Silt	25	38
Clay	73	60
Quartz	25	25
Feldspar	2	5
Heavy minerals	–	TR
Clay minerals	64	58
Voclanic glass	8	8
Palagonite	–	1
Glauconite	TR	TR
Pyrite	TR	1
Diatoms	1	2

SITE 441 HOLE A CORE 15 CORED INTERVAL: 652.5-662.0 m



LITHOLOGIC DESCRIPTION

Drill cuttings, throughout, 5Y 3/1 claystone, with pumice pebbles (2-3 mm diameter), and black rounded basalt(?) pebbles scattered throughout. Possible caving from uphole.

SMEAR SLIDE SUMMARY

	1-130 Claystone (D)
Sand	
Silt	10
Clay	90
Quartz	6
Feldspar	2
Clay minerals	85
Volcanic glass	5
Diatoms	2

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SITE SUMMARY SHEET

HOLE 441B

Date occupied	November 30, 1977
Date departed	December 2, 1977
Time on hole	3 days
Position: latitude	39° 45.08'N
longitude	144° 04.60'E
Water depth (sea level)	5635 corrected meters, echo sounding
Water depth (rig floor)	5645 corrected meters, echo sounding
Bottom felt at	5650 meters, drill pipe
Penetration	687.0 meters
Number of holes	1
Number of cores	2
Total length of cored section	18.0 meters
Total core recovery	5.5 meters
Percentage core recovery	30%

Oldest Sediment Cored

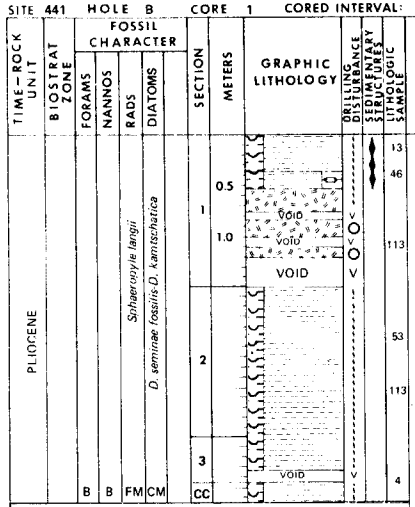
Depth sub-bottom	687.0 meters
Nature	Vitric silty claystone
Age	Late miocene
Measured velocity	Unable to measure

Principal Results:

Site 441 was selected to sample the accretionary zone associated with the Japan Trench. It is 15 km landward of the trench axis near Site 434. Three holes were attempted but periods of weather calm enough for drilling were too short to penetrate as deeply as planned or to obtain more than one logging run. The lithology sampled is hemipelagic slope sediment of late Miocene to Pleistocene age, much the same as at the other sites on this transect. The lithologic intervals are about 1/3 thicker than equivalent ones farther up slope. Uniform rates of sedimentation and lack of repeated paleontological zones argue against thickening through imbrication. More likely is a combination of repeated small slumps, particularly for intervals where reworked microfossils were recovered, and tectonic thickening along pervasive microfractures. The importance of slumping and tectonic thickening cannot be estimated from the cores because coring recovered mainly fine drill cuttings that may have been derived either from brittle intensely fractured rock, tectonic breccia, or redeposited breccia, all of which were recovered in rare coherent sections.

There is no evidence that a section from the oceanic plate was drilled. However, the hemipelagic section samples is far more intensely fractured than any other section on the Japan Trench transect. Therefore it is thought to be overstressed by tectonism associated with plate convergence and to be part of the accretionary zone particularly in a dynamic sense. Fracture development is best illustrated by interpretation of the Formation Density log. Near the surface the sediment deforms plastically, consolidates, and dewaters. At greater depth the sediment responds to stress by brittle fracture which imparts a secondary porosity and anomalously low density. Dewatering, fracturing, and microfaulting may be the principal initial mechanism in tectonic consolidation and volume reduction of the accreted sediment along the Japan Trench.

SITE 441 HOLE B CORE 1 CORED INTERVAL: 335.5-344.0 m



LITHOLOGIC DESCRIPTION

5Y 4/1

Greenish gray (5GY 5/1) vitric diatomaceous claystone with medium dark to dark gray (N3 & 4) 1-2 mm mottles. Breaks into small soft chips. Olive gray (5Y 5/1) diatomaceous calcareous claystone. Light olive gray to light gray (5Y 6/1-N7) tuff. Contains some olive gray (5Y 5/1) chips, 62-65 cm. A soft drilling wash with a high water content; structureless.

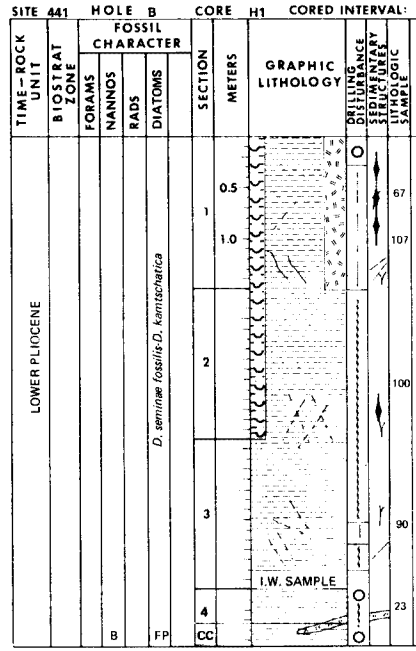
Dark greenish gray (5GY 4/1) diatomaceous claystone. Compressed drilling chips less than 1-2 mm in diameter in most part; a few drilling biscuits that crumble into chips.

TOTAL C – ORGANIC C – CARBONATE (%)
2, 68 cm (1.0, 0.9, 1)
2, 124 cm (1.2, 1.0, 1)

SMEAR SLIDE SUMMARY

	Vitric diatomaceous claystone	Diatomaceous calcareous claystone	Tuff	Diatomaceous claystone	Diatomaceous claystone	Diatomaceous claystone
	1-13	1-46	1-113	2-53	2-113	CC, 4
Sand	10	6	50	8	5	12
Silt	48	16	28	38	35	32
Clay	42	78	22	54	60	56
Quartz	12	4	9	14	9	8
Feldspar	6	3	8	4	3	3
Mica	–	–	–	–	–	–
Heavy minerals	1	TR	1	1	–	1
Clay minerals	42	42	–	54	60	56
Volcanic glass	10	6	75	5	3	3
Palagonite	1	1	4	1	–	TR
Glauconite	1	–	2	TR	–	1
Pyrite	–	–	–	–	–	–
Foraminifers	–	–	–	–	–	–
Diatoms	18	12	1	11	16	14
Radiolarians	–	–	–	–	TR	–
Sponge spicules	8	4	–	3	6	5
Carbonate	1	28	–	8	3	9

SITE 441 HOLE B CORE H1 CORED INTERVAL: 344.0-402.0 m



LITHOLOGIC DESCRIPTION

Olive gray (5Y 4/2) diatomaceous claystone and claystone, faintly fractured.

Very faint 2 mm mottles throughout

Vitric diatomaceous claystone fractured into 2-3 cm blocks

Calcareous claystone (olive calcitic mottles)

Black dewatering vein

Fractured into 1 cm blocks. Desoriented when drilling; deformation is intense

Diatomaceous claystone

Grayish green (5G 6/1) mottles inclined 35 (bedding)

Fractured in 1 cm blocks

Claystone fault 55

Light gray clayey tuff bed with 35 dip, uncertain (drilling disturbance)

FAULTS:
55 , 80 clockwise, normal
8 reverse, rake 80
80 , normal, slickensides, rake 80
18 , slickensides, 90 , normal
20 , slickensides, rake 80 , clockwise

SMEAR SLIDE SUMMARY

	1-67	1-104	2-100	3-90	4-23
Sand	3	0	2	–	2
Silt	30	18	28	23	60
Clay	67	82	70	77	38
Quartz	6	3	8	7	8
Feldspar	4	1	3	4	3
Mica	–	–	–	–	–
Heavy minerals	1	TR	1	1	–
Clay minerals	62	50	68	75	30
Volcanic glass	10	–	2	2	50
Palagonite	–	–	–	–	–
Glauconite	–	–	–	–	–
Pyrite	–	–	–	–	1
Foraminiers	–	–	–	–	–
Diatoms	11	7	11	6	2
Radiolarians	TR	–	1	–	–
Sponge spicules	3	2	3	2	–
Carbonate	3	37	3	3	–

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SITE 441 HOLE B CORE 2 CORED INTERVAL: 668.0-687.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
UPPER MIOCENE		B	B B B B	B	*D. kamtschatica?* FM RP	1 2 CC	0.5 1.0	VOID VOID	V V		78

LITHOLOGIC DESCRIPTION

Drill cuttings throughout; chips approximately 3 mm in diamter, 5Y 3/1, vitric silty claystone.

Vitric silty claystone (5GY 4/1) highly fractured, most persistently at about 75 .

5GY 4/1 vitric silty claystone and claystone; hackly somewhat braided fractures, predominantly 75 .

TOTAL C – ORGANIC C – CARBONATE (%)
1, 44 cm (0.7, 0.7, 0)

SMEAR SLIDE SUMMARY

	Vitric silty claystone (D)
	2-78
Sand	11
Silt	51
Clay	38
Quartz	22
Feldspar	8
Mica	
Heavy minerals	2
Clay minrals	34
Volcanic glass	26
Pyrite	2
Diatoms	4
Radiolarians	
Sponge spicules	1
Zeolite	2

SITE 441 HOLE B CORE H2 CORED INTERVAL: 402.0-668.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
MIOCENE-PLIOCENE			B		*D. kamtschatica?*	1 2 3 4 5 CC	0.5 1.0	I.W. SAMPLE	O O O	Y Y Y Y Y Y Y Y Y	20 105 5 92 130 50

LITHOLOGIC DESCRIPTION

Dark greenish gray to olive gray (5GY-5Y 4/1) claystone.

Olive gray (5Y 4/1) claystone, relatively homogeneous; disturbed by drilling.

Olive gray to medium dark gray (5Y 4/1-N4) claystone.

Axis of fold; plane dips 0 , the folded surfaces are made up of 1-3 mm mullions parallel with the fold axis (N4-5Y 4/1).

Olive gray (5Y 4/1) diatomaceous silty claystone.

SMEAR SLIDE SUMMARY

	Claystone (D)	Claystone (D)	Silty claystone (D)	Silty claystone (D)	Silty claystone (D)	Diatomaceous silty claystone (D)
	1-20	1-105	3-5	3-92	3-130	5-50
Sand	1	2	7	5	15	8
Silt	30	25	38	45	40	36
Clay	69	73	55	50	45	56
Quartz	6	9	14	31	21	17
Feldspar	3	4	6	12	12	7
Mica	TR	–	–	–	–	–
Heavy minerals	TR	TR	1	TR	1	2
Clay minerals	69	73	55	37	45	50
Volcanic glass	5	4	8	1	TR	6
Palagonite	1	TR	1	1	1	–
Glauconite	–	1	1	–	1	–
Hematite	–	–	–	TR	–	–
Pyrite	–	–	–	–	–	1
Diatoms	7	3	7	3	3	11
Radiolarians	–	–	TR	TR	–	TR
Sponge spicules	4	3	4	4	3	4
Other carbonate	2	3	3	4	3	2
Nannofossils	3	–	–	–	TR	–
Lithic fragments	–	–	–	7	10	–

Several concretions of calcite-cemented tuff and claystone.
Cuttings

Fracture Orientations:

Section 1	Section 2	Section 3	Section 4	Section 5
17 cm 40	55 cm 65	10 cm 15	10 cm 1	3 cm 11
21 cm 45		10 cm 75	15 cm 2	10 cm 82
77 cm 11		10 cm 35	17 cm 15	10 cm 12
105 cm 75		135 cm 70	20 cm 18	14 cm 11
		135 cm 11	101 cm 72	14 cm 27
		135 cm 45	104 cm 12	18 cm 8
				22 cm 2
				24 cm 15
				24 cm 82

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