3. SITES 604 AND 605[1]

Shipboard Scientific Party[2]

SITE 604 (HOLE 604)

Date occupied: 0616 hr., 8 June 1983

Date departed: 0157 hr., 10 June 1983

Time on hole: 1 day, 19 hr., 41 min.

Position: 38°42.79′N; 72°32.95′W

Water depth (sea level; corrected m, echo-sounding): 2361

Water depth (rig floor; corrected m, echo-sounding): 2371

Bottom felt (m, drill pipe): 2374.0

Penetration (m): 294.5

Number of cores: 31

Total length of cored section (m): 294.5

Total core recovered (m): 117.58

Core recovery (%): 40

Oldest sediment cored:
Depth sub-bottom (m): 284.9
Nature: Glauconitic claystone, silt, sand, and conglomerate
Age: late Miocene
Measured velocity (km/s): 1.46 (very disturbed material, extremely difficult to sample)

Basement: Not reached

SITE 604 (HOLE 604A)

Date occupied: 0157 hr., 10 June 1983

Date departed: 2340 hr., 10 June 1983

Time on hole: 21 hr., 43 min.

Position: 38°43.08′N; 72°33.64′W

Water depth (sea level; corrected m, echo-sounding): 2328

Water depth (rig floor; corrected m, echo-sounding): 2338

Bottom felt (m, drill pipe): 2350

Penetration (m): 284.4

Number of cores: 4

Total length of cored section (m): 34.8

Total core recovered (m): 2.17

Core recovery (%): 6

Oldest sediment cored:
Depth sub-bottom (m): 294.5
Nature: Glauconitic claystone, silt, sand, and conglomerate
Age: late Miocene
Measured velocity (km/s): N/A

Basement: Not reached

Principal results: Site 604, on the uppermost continental rise off New Jersey, lies at the seaward end of a set of DSDP holes which, when completed and joined with existing wells, will form a shelf–slope–rise transect. Two holes at the site, offset 1.2 km apart along a multichannel seismic line, together provide fairly good coverage of the reasonably continuous Holocene to upper Miocene section. Drilling at Site 604 calibrated the seismic stratigraphy and lithostratigraphy of this site and also intersected a massive upper Miocene debris flow: a major discovery that had been predicted by shipboard seismic facies interpretation. Both holes had to be abandoned at approximately the same stratigraphic level, where they encountered loose sands not drillable by *Glomar Challenger*.

The section consists of three lithologic units, outlined here with thicknesses taken from Hole 604.

Unit I consists of 84 m of Pleistocene dark gray, interbedded clay and silt with some slumped Eocene material near the top and internal slump structures toward the base.

Unit II is composed of 155 m of lower Pleistocene, Pliocene, and upper Miocene greenish gray clay with variable amounts of glauconitic shelf sand turbidites and biogenic silica.

Unit III consists of 56 m of upper Miocene glauconitic, biosiliceous silty claystone, silt, sand, and conglomerate with quartz pebbles and displaced blocks of middle Eocene chalk up to 50 cm across. Reworked middle Miocene fossils are common. We interpret Unit III as debris flows and turbidites emplaced as a result of a major low stand in sea level which occurred during the late Miocene. This interpretation is compatible with the onshore and nearshore geology of this region, where upper Miocene sediments are largely missing.

SITE 605

Date occupied: 0013 hr., 11 June 1983

Date departed: 1915 hr., 16 June 1983

Time on hole: 5 days, 19 hr., 2 min.

Position: 38°44.53′N; 72°36.55′W

Water depth (sea level; corrected m, echo-sounding): 2194

Water depth (rig floor; corrected m, echo-sounding): 2204

Bottom felt (m, drill pipe): 2207

Penetration (m): 816.7

Number of cores: 71

Total length of cored section (m): 662.4

Total core recovered (m): 532.08

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[1] van Hinte, J. E., Wise, S. W., Jr., et al., *Init. Repts. DSDP*, 93: Washington (U.S. Govt. Printing Office).

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Core recovery (%): 80

Oldest sediment cored:
Depth sub-bottom (m): 816.7
Nature: Olive gray marly limestone
Age: late Maestrichtian
Measured velocity (km/s): 2.243 (vertical) 2.334 (horizontal)

Basement: Not reached

Principal results: Site 605, 6 km west-northwest of Site 604 on the upper continental rise off New Jersey, was chosen as the last viable alternative for achieving the objectives for the lower half of the New Jersey Transect that eluded us at Site 604, namely a deep penetration to the Maestrichtian to study unconformities, sea level changes, seismic stratigraphy, and litho- and biofacies changes. With the aid of a last-minute 24-hr. time extension for the leg, most of our objectives were achieved in one 816.7-m hole that penetrated to the upper Maestrichtian, captured an excellent Cretaceous/Tertiary boundary sequence, and allowed us to calibrate the seismic stratigraphy.

The section consisted of five lithologic units.

Subunit IA: 198 m of Pleistocene gray silty clay; the hole was washed to 154.3 m, and continuously cored thereafter.

Subunit IB: only 30 cm of Pleistocene, green, biosiliceous calcareous clay with some reworked siliceous microfossils from Unit II.

Unit II: 152 m of lower middle Eocene, greenish gray, biosiliceous nannofossil chalk.

Unit III: 214 m of lower Eocene, greenish gray, nannofossil limestone, formed in the same environment as Unit II, but considerably altered by diagenesis; the preservation of microfossils is poor.

Unit IV: an unusually long upper Paleocene section (176 m) consisting of dark greenish gray, clayey nannofossil limestone.

Unit V: 77 m of lower Paleocene to upper Maestrichtian, olive gray marly limestone. It is subdivided into two subunits at approximately the Cretaceous/Tertiary boundary, based on a significant increase in the amounts of terrestrial silt and glauconite which appear above that point.

The presence of detrital material in the lower Danian sediments is attributed to the effects of the Cretaceous/Tertiary boundary event. The boundary section itself at Site 605 is reasonably complete and expanded for a deep-sea section, a function of the continental margin setting where sedimentation rates are relatively higher than at other DSDP sites. The boundary separates the foraminiferal *Guembelitria cretacea* Zone (P0) and the coccolith *Zygodiscus sigmoides* Zone (CP1) above from (respectively) the *Abathomphalus mayaroensis* and *Nephrolithus frequens* zones below. The core, however, fractured right at the boundary, and no "boundary clay" was observed. We fear that it was washed out during the drilling process.

The Paleogene section is, in general, highly bioturbated and shows evidence of cyclic sedimentation at selected intervals in Units III and IV. The unusually high biosiliceous productivity which persisted during the Eocene (Unit II and III) is attributed to possible high trophic levels associated with upwelling, perhaps due to the incursion of a precursor Labrador Current into this area. The cored section at Sites 604 and 605 dates oceanic reflection Horizons A^{c} (49.5 Ma), A^{*} (60 Ma), and G(P) (2.8 Ma). The section also dates other Eocene and Paleocene sequence boundaries, which are unconformities on the continental slope, and documents this portion of the Vail et al. (1980) standard cycle chart.

INTRODUCTION

Sites 604 and 605 consist of three drill holes located along a 6.2-km section of U.S. Geological Survey seismic line 25, on the uppermost continental rise off New Jersey. Holes 604A and 605 were offset from Hole 604 in an attempt to achieve penetration deeper than a Miocene debris-flow deposit that terminated rotary drilling in Hole 604. The seismic profile indicated that this Miocene deposit pinched-out slightly upslope from Hole 604; Hole 604A was drilled at the maximum possible distance upslope from Hole 604, but this hole was also terminated in the undrillable Miocene deposit.

Because acoustic beacons transmitting on the operating frequencies for *Glomar Challenger* had been deployed at Site 604, Site 605 was located just far enough upslope to avoid reception of the signals from the Site 604 beacons. Consequently, both Sites 604 and 605 had identical objectives (to analyze the strata of the uppermost continental rise), and the combined results from both sites provide a good record of Maestrichtian–late Pleistocene sedimentation. Therefore, the results from both Site 604 and Site 605 are combined in this chapter.

BACKGROUND AND OBJECTIVES

General: The New Jersey Transect

Site 604 is part of the "New Jersey Transect," which was originally proposed as four coreholes (Table 1) located along a single seismic reflection profile (U.S. Geological Survey multichannel line 25) trending southeastward across the continental slope and rise off New Jersey (Fig. 1). The transect lines up with numerous wells on the coastal plain (Brown et al., 1972; Olsson, 1978), with wells on the continental shelf (Hathaway et al., 1979; Poag, 1979, 1980; Mattick and Hennessy, 1980; Scholle, 1980), and with DSDP Sites 106, 603, 388, and 105, at the base of the continental rise (Fig. 2). It is intended to complete the first comprehensive, dipwise transect of an entire passive margin from the coastal plain to the abyssal plain.

The New Jersey Transect also lies within a closely spaced network of seismic reflection profiles (Grow et al., 1979; Klitgord and Grow, 1980; Schlee et al., 1976; Schlee, 1981), so the transect sites provide an optimum set of targets for calibrating seismic stratigraphy to the sedimentary record cored in these sites. U.S.G.S. line 25 is a dip-line recorded in a joint program of the U.S. Geological Survey and the German Bundesanstalt für Geowissenschaften und Rohstoffe, which collected more than 6000 km of multichannel, high-resolution seismic reflection profiles.

The principal DSDP sites proposed for the New Jersey margin (NJ-1 to NJ-4) were located on or near line 25 in order to maximize the accuracy of seismic correlations in all present and future coring sites along the transect. The major scientific objectives in coring the New Jersey Transect holes were:

1. To document the presence of unconformities and to determine their nature, the duration of hiatuses, their

Table 1. Planned New Jersey Transect holes.

Hole	Bathymetric location	Water depth (m)	Shot Point no.[a]	Drilled as	
				Leg	Site
NJ-1	Upper slope	827	2900	—	—
NJ-2	Middle slope	1500	3060	95	612
NJ-3	Uppermost rise	2200	3340	93	605
NJ-4	Upper rise	2387	3500	93, 95	604, 613

[a] Shot points on U.S. Geological Survey seismic line 25 (see Fig. 1).

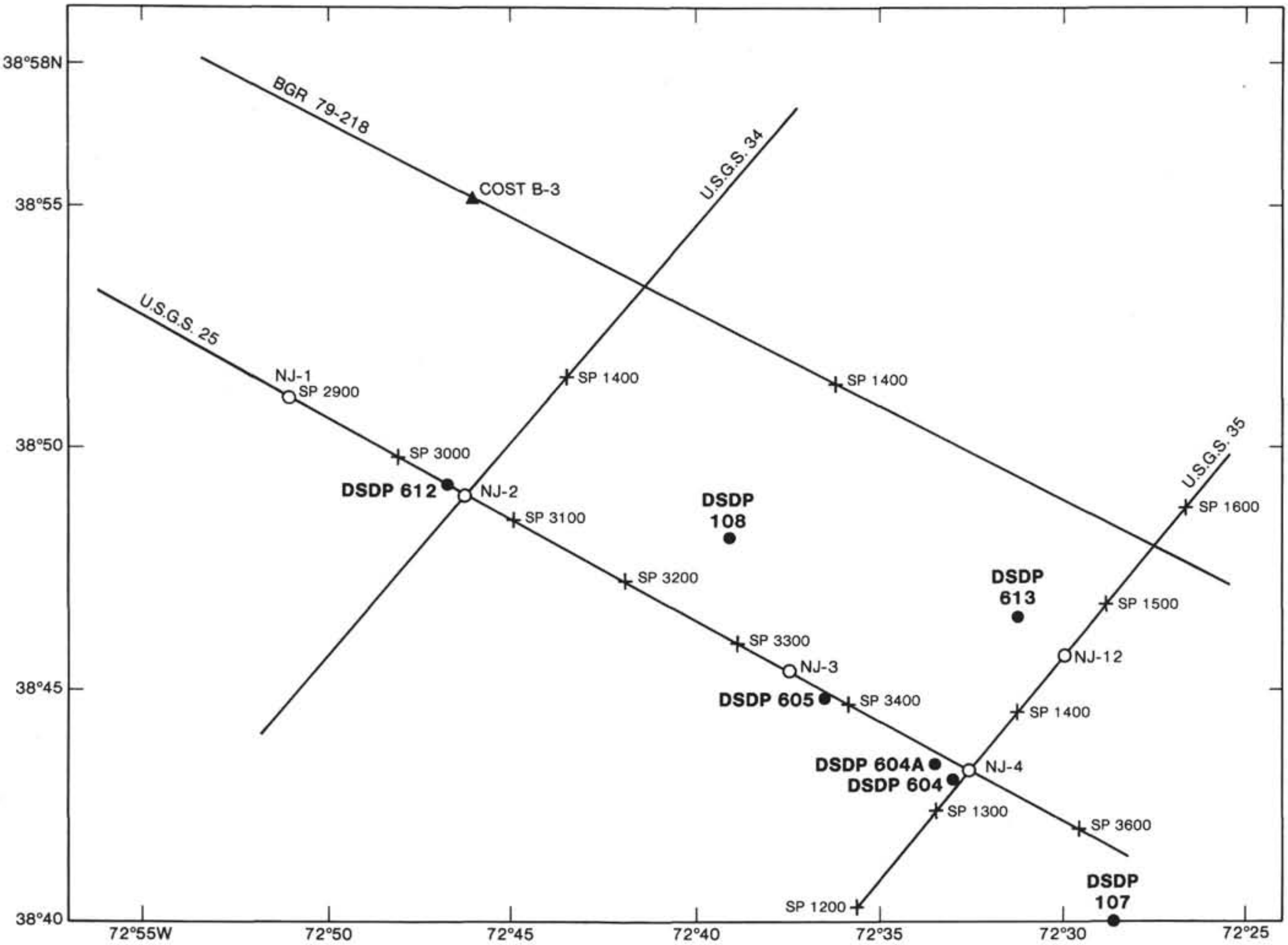


Figure 1. Location of proposed New Jersey Transect holes NJ-1 through NJ-4, with previously drilled DSDP sites, and the 3 final locations of sites drilled on Legs 93 (Holes 604, 604A, and 605) and 95 (Holes 612, 613). Tracks of reference seismic reflection profiles, U.S.G.S. lines 25 and 35 and BGR line 79-218, are also shown. SP = shot point.

correlation with seismic sequence boundaries or discontinuities (seen clearly on line 25), and their relationships to sea level fluctuations;

2. To examine the relationship between the faunal and lithic compositions and the variable character of seismic sequences seen on line 25;

3. To describe and correlate the lithofacies and biofacies sequentially from the upper slope (827 m water depth) to the upper rise (2387 m water depth);

4. To document the microfossil zones and evolutionary events of the Cenozoic and latest Cretaceous on a western Atlantic passive continental margin;

5. By virtue of the foregoing, to document the upbuilding, outbuilding, and subsidence history of this passive margin.

General objectives of drilling the New Jersey Transect were to find unconformities and other evidence for ancient sea level changes. The locations of the transect holes were considered optimal to record through lithology the influence of sea level changes on sedimentation regimes on the continental shelf and slope. With the high-resolution biostratigraphy expected from well-preserved, diverse microfossil assemblages, it should be possible to determine precisely the ages of unconformities and the changes in the sedimentary record and thus test the validity of substantial portions of the sea level curve of Vail et al. (1980) and perhaps document and determine the age of some of the presumed rapid changes in sea level.

Another objective of drilling and sampling the New Jersey Transect was to gain a better understanding of passive continental margin sedimentary processes and facies distribution; this can be achieved by the sequential description and correlation of the lithofacies and biofacies from the upper slope to the upper rise. Correlation of cored sections of known relative position and subsidence history will also make it possible to improve paleontologic criteria for paleobathymetric reconstruction as well as to establish a multiple biochronostratigraphic framework across depth zones.

The successful completion of the New Jersey Transect drilling by Legs 93 and 95 made it possible to calibrate a significant portion of the seismic reflection stratigraphy of the western Atlantic passive margin. This involved determining the age of seismic sequence boundaries; determining whether seismic sequence boundaries repre-

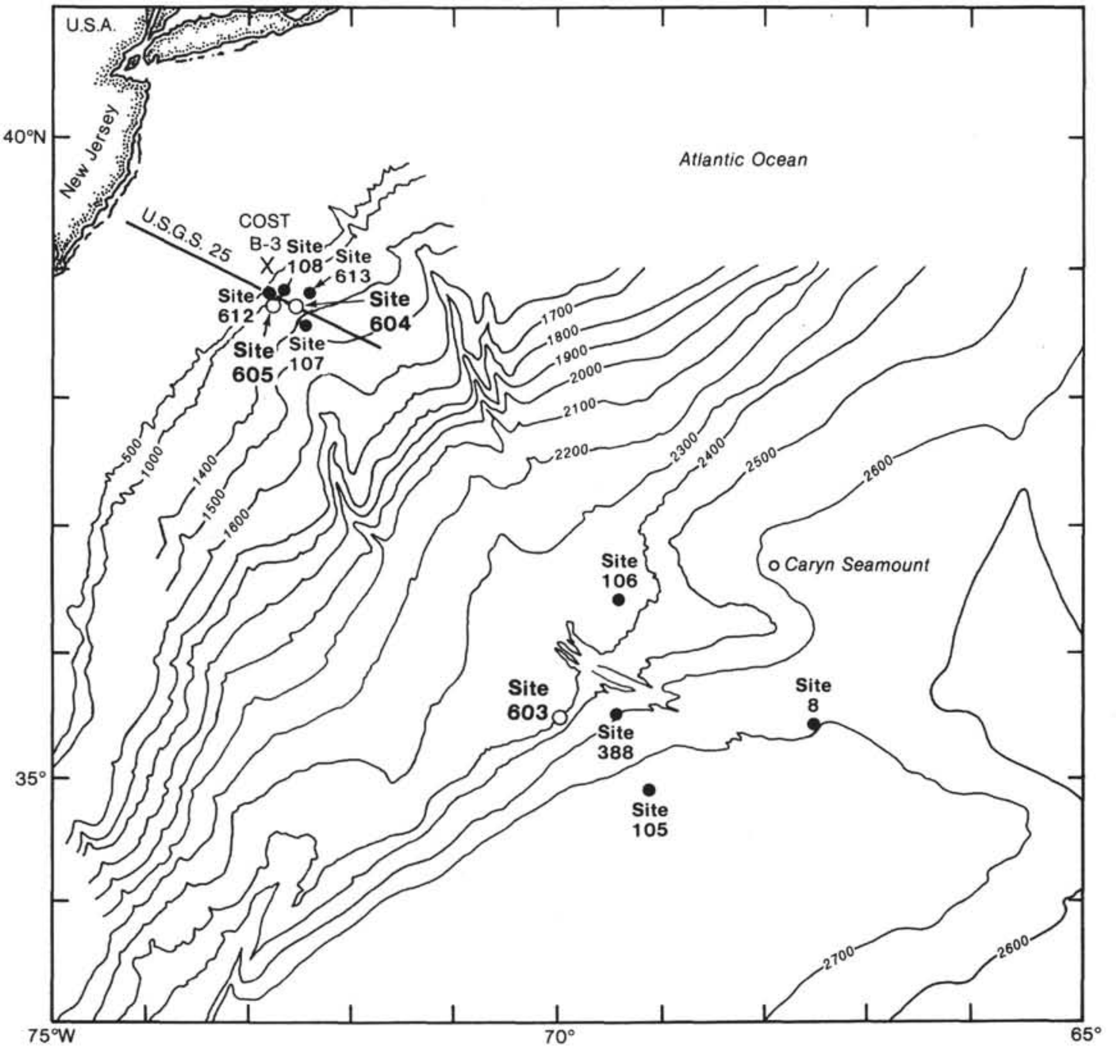


Figure 2. Map showing bathymetry of the continental slope and rise southeast of New Jersey, the location of DSDP sites and the COST B-3 well, and U.S.G.S. line 25. Bathymetry in fathoms.

sent depositional patterns, facies changes, or hiatuses; calculating estimates for the duration of possible hiatuses and for rate changes in sediment accumulation at the unconformities or their conformable extensions; and determining the sedimentary facies of different internal reflection configurations of the reflection units (seismic sequences). Part of this work is reported in this volume.

It was early clear that no single drill site could accomplish all of the tasks outlined above. The onlap pattern of the section along U.S.G.S. line 25 (Figs. 3 and 4) suggested the presence of major hiatuses, and it might not be possible accurately to date the events that caused these unconformities. At the deeper-water location of Site 603, however, it seemed most likely that there was preserved a record of conformable facies changes that correlated with lesser unconformities upslope. Furthermore, slumping and mass movements on the slope might have severely affected the sedimentary record, particularly at the deepest Site 604 (NJ-4). Therefore, all of the New Jersey Transect sites must eventually be considered together if a complete picture is to emerge from the drilling on Legs 93 and 95. By documenting the upbuilding, outbuilding, and subsidence history of this passive margin, we can develop criteria for the geohistorical analysis of lesser-known margins.

Site 604

DSDP Site 604 (NJ-4) was drilled near the intersection of U.S.G.S. seismic lines 25 and 35 (Fig. 1) to be the farthest seaward hole on the New Jersey Transect. Its location (shot point 3500 on U.S.G.S. line 25) was planned to sample a shallow (300–400 m sub-bottom) buried channel leading downslope (southeast), a few kilometers wide, within subsurface relief of 100–200 m. This channel is shown on Figure 4 as a hachured area between two seismic reflection horizons. The position for Hole 604 (Fig. 1) was determined by steaming northeast along U.S.G.S. line 35 from shot point 700 (southwest of the proposed NJ-4), using the *Glomar Challenger's* seismic profiling system to locate the buried channel.

Technical problems (see Operations Summary) made it impossible to penetrate this channel-fill deposit in either Hole 604 or in Hole 604A, offset 1.2 km to the northwest (Figs. 1, 3, and 4).

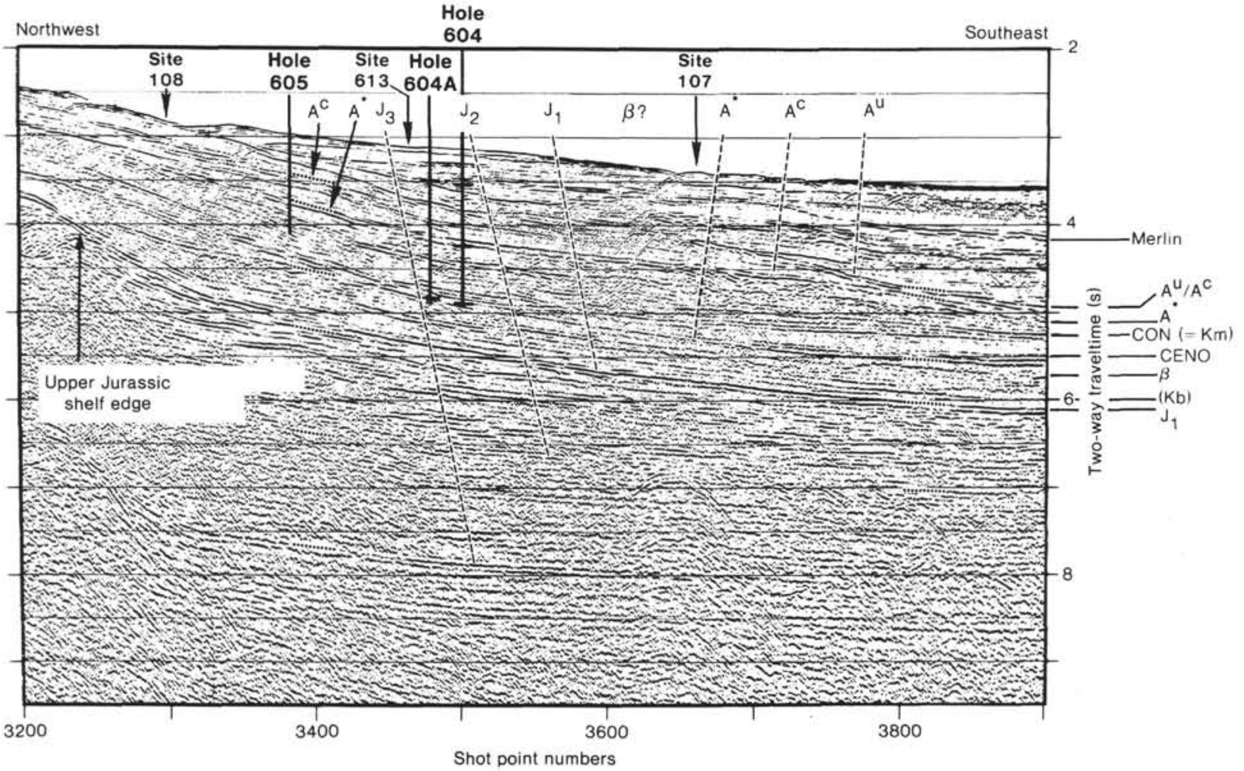


Figure 3. Upper continental rise portion of U.S.G.S. seismic reflection line 25 (between shot points 3200 and 3900) after Klitgord and Grow (1980), showing their interpretation of the seismic reflectors. The planned penetration of Site 604 is indicated to show the great depth of Horizon A* in the Klitgord and Grow interpretation (lower mark on corehole lines). The interpretation of line 25 by Schlee and Grow (1980) is indicated to the right of the figure; this interpretation is favored by Leg 93 scientists who added Kb. Km and Kb are reflection horizons defined at Site 603. Upper mark on corehole lines indicates actual penetration. Also shown are projected locations of Sites 107, 108, and 613.

Site 605

Site 605 was offset approximately 6.2 km northwest of Hole 604 (Fig. 1), along U.S.G.S. line 25. This location was chosen in a successful attempt to avoid the undrillable channel-fill deposit, by drilling upslope of its farthest extent shoreward (Fig. 4). The final location of Site 605 is only 2.5 km away from that which had been proposed for NJ-3 (Fig. 1, Table 1), so this hole fulfilled both the NJ-4 objective of sampling strata older than the channel-fill material and the objective of drilling near the NJ-3 location.

OPERATIONS

Site 604

During the northwesterly transit from Site 603 to the proposed location for Site 604 (NJ-4), the weather deteriorated rapidly, and winds reached 40 knots in squalls which persisted for most of June 7, but cleared by that evening. Upon arrival at shot point 700 on U.S.G.S. seismic line 35, *Challenger* changed course to approach the proposed NJ-4 location from the southwest by retracing U.S.G.S. line 35. The site location had been targeted as a buried channel near the intersection of U.S.G.S. lines 25 and 35 (shot point 3500 on line 25, see Table 1), trending northwest–southwest, with a subsurface relief of 100–200 m, at a sub-bottom depth of 300–400 m. NJ-4 at a predicted water depth of 3287 m, was placed on U.S.G.S. line 35 (Fig. 1), using *Glomar Challenger's* seismic reflection system to locate this buried channel. The initial pass over the proposed NJ-4 location revealed a buried channel at 3.7 s two-way traveltime (Fig. 5), in the predicted water depth. A slow Williamson turn to the left was made to return *Glomar Challenger* to the location of NJ-4, and the positioning beacon was launched at 0616 hr. (local time) on 8 June 1983 (Fig. 6).

A standard rotary coring bottom-hole assembly (BHA) was assembled because operational reports from Site 107 nearby indicated that Pleistocene sediments in this area might be too stiff to penetrate to any appreciable depth with the hydraulic piston corer (HPC). Based on a PDR reading of 2366 m, the bit was lowered to 2371.9 m for a seafloor punch core, but no sediment was recovered. At 1500 hr., 8 June, the rig weight indicator registered solid bottom at about 2374 m. This was used for the official water depth although the core barrel contained only 5.3 m after reaching a depth of 2380.5 m (Table 2). Unusually firm Pleistocene clay made coring operations slow and tedious for the first 65 m, as only very light weight could be applied with the unsupported BHA while rotation and strong circulation were required to achieve penetration.

Coring continued through Pleistocene and Pliocene clay and sandy clay with only fair core recovery but good hole conditions. At about 260 m, BSF, the drill encountered soft glauconitic sand in an apparent Miocene slump deposit (Fig. 6). Two additional cores (without recovery)

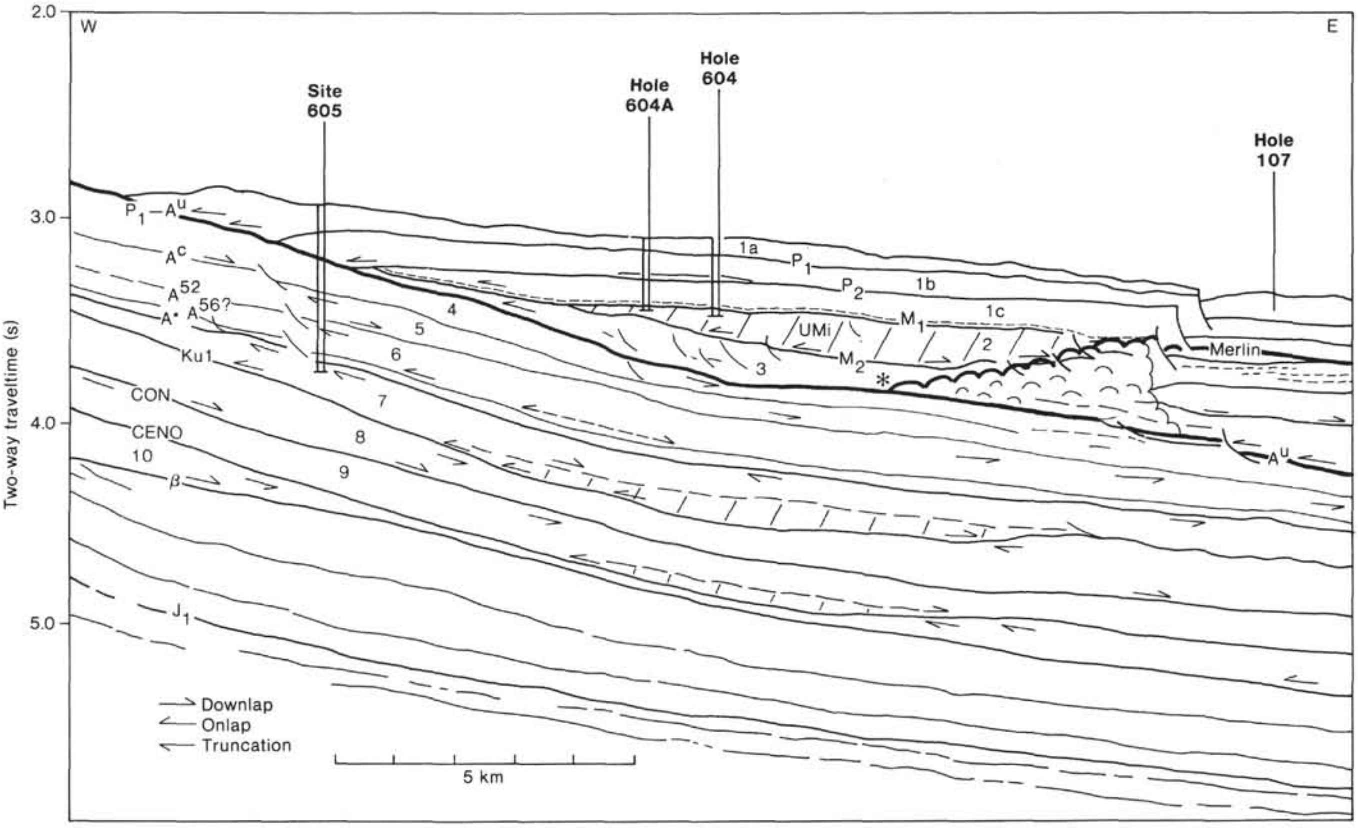


Figure 4. Line drawing interpretation of U.S.G.S. line 25 (Fig. 3), showing local reflection horizons and units and the position of Holes 604, 604A, and 605. The cross-hatched regions indicate debris-flow deposits that terminated drilling in both Holes 604 and 604A. Asterisk marks point where Merlin cuts into A^{u}.

were attempted before the sand began packing off and sticking the BHA, despite mud flushes and all attempts to stabilize the hole. As the bottom of the sand stratum had not been reached, prospects of successfully deepening the hole appeared dim. The hole was then filled with weighted mud, and the core bit was pulled clear of the seafloor.

Hole 604A

Study of the New Jersey Transect reference profile disclosed that the sand body appeared to pinch out rapidly to the northwest (Figs. 3 and 4). An optimum relocation site was chosen by the scientists about 2.5 km northwest of Hole 604. The profile indicated that the sand body could be avoided at this location while all other target strata could be cored. Unfortunately a move of 2.5 km was not technically feasible because a second positioning beacon had been dropped during Hole 604 operations to replace the malfunctioning original beacon. With beacons transmitting on both operating frequencies, about 6 km is considered to be a minimum distance to avoid interference with the new beacon. The only option open for a second attempt to core Site NJ-4 was therefore a maximum offset to the northwest to the approximate location of the edge of the sand body. The vessel was consequently offset about 1.2 km northwest along U.S.G.S. seismic line 25 as depth was monitored on the PDR.

Hole 604A was spudded at 0515 hr., 10 June. A firm seafloor was again "felt" with the weight indicator at 2350 m, as compared with a PDR reading of 2338 m. The previously cored clay section was washed to 249.6 m (Table 2) before coring commenced (Fig. 6). Only three cores were cut before the bit again broke into upper Miocene sand. The sand succeeded in sticking the drill string more quickly this time, and 15 min. were required to work the pipe loose after the first full core interval in the sand. Another core was attempted after the hole had been cleaned to total depth and a mud flush had been circulated. The pipe became stuck again, however, 6 m had been penetrated. Freeing the pipe was more difficult the second time, and it was apparent that the site was not drillable with *Challenger's* drilling system.

This hole was also filled with weighted mud in accordance with hydrocarbon safety policy. The vessel departed Site 604 shortly thereafter to move to a more suitable location along U.S.G.S. seismic line 25, out of the range of the beacons at Site 604.

Hole 605

The vessel, under way at slow speed, with the drill string suspended well above the seafloor, was moved 5 km further to the west-northwest along the reference profile (U.S.G.S. seismic line 25) to a total distance of about 6 km from the closest Site 604 beacon. LORAN C, the PDR, and the positioning system were monitored during the move, and a new beacon was launched at 0013 hr., 11 June (Fig. 6).

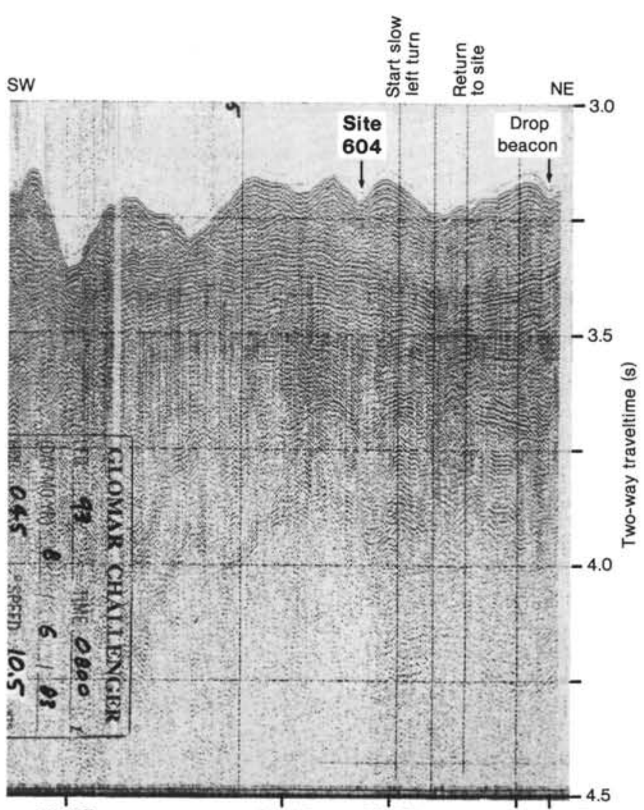


Figure 5. *Glomar Challenger* underway seismic profile near Site 604. This profile parallels U.S.G.S. line 35 (see Fig. 1). Note the buried channel near 3.7 s two-way traveltime at the proposed site location.

Water depth by PDR was 2202 m, and Hole 605 was spudded at 0708 hr., the same morning. The seafloor was detected by the weight indicator at 2207 m. The heave compensator was used, as at Site 604, to maintain a steady weight on the bit during the touchy spudding-in operation in the stiff clay.

The Pleistocene clay layer was drilled to 154.3 m BSF before coring began (Table 3). After another 48 m of clay, soft Eocene chalk was encountered. The chalk was cored with excellent rate of penetration (Fig. 6) and recovered for about 150 m before it became much harder, with properties approaching those of limestone. Drilling in the Eocene limestone continued, with phenomenal recovery to about 565 m sub-bottom, where Paleocene calcareous claystone was reached. Recovery remained very high, but the continued low penetration rate caused the "target" Cretaceous strata to remain tantalizingly out of reach as operation time ran out.

Upper Paleocene rock was still being cored at the time scheduled for termination of the operation. A last-minute phone call to DSDP in La Jolla resulted in a cruise extension of one day to attempt to penetrate through the lowermost Tertiary strata. Coring continued through the evening with little apparent change in the age or nature of the sediment. Then, around midnight, the drill suddenly reached lowermost Paleocene and soon after Cretaceous rocks. The final site objectives were fulfilled with only a few hours remaining.

The hole was then filled with barite-weighted mud and *Glomar Challenger* departed Site 605 at 1915 hr., June 16. A brief PDR profile was made to the west-northwest across the next proposed site on the New Jersey transect (Site NJ-3) and along U.S.G.S. seismic line 25. At 1935 hr., course was set for Norfolk, Virginia. As most of the return trip was to be made across the shallow waters of the continental shelf and heavy traffic was anticipated, the geophysical gear was not deployed. Leg 93 came to its official end at 1610 hr., 17 June 1983, when the ship docked at Norfolk.

LITHOLOGY

Site 604

The lithologic column of Site 604 was subdivided into three units: Unit I (0.0–84.0 m sub-bottom depth), gray to dark greenish gray alternations of clay and silt; Unit II (84.0–238.9 m sub-bottom depth), greenish gray clay with glauconite-rich intervals and variable amounts of biogenic silica; and Unit III (238.9–294.5 m sub-bottom depth), glauconite- and biogenic-silica-rich sandy siltstone with conglomerate and debris-flow intervals. Hole 604 was terminated in Unit III.

Units I and II were further subdivided as explained in the following descriptions. Hole 604A was washed to 249.6 m, then cored to 278.4 m (Cores 604-2 to -4); all the cored interval was in Unit III. The units, lithology, and recovery from Holes 604 and 604A are summarized in Table 4 and Figure 7.

Unit I: Pleistocene Interbedded Clay and Silt, Core 604-1 through Sample 604-10-1, 7 cm; Sub-bottom Depth 0–84.0 m

The unit is composed of a continuum from clay through silty clay through silt. The clay to silt lithologies have variable minor components of nannofossils, clastic carbonate, and glauconite. This unit has been subdivided into two subunits on the basis of heavy mineral content, carbonate content, and evidence of sedimentary slump structures. It is differentiated from the underlying Unit II, which is characterized by abundant glauconite sand and siliceous microfossils.

Subunit IA (Core 604-1 to top of Core 604-5; 0.0 to 35.3 m sub-bottom) is interbedded clay and silt layers. The sediments range in color from medium gray (N5) to predominantly dark greenish gray (5G 4/1–5Y 4/1) and in lithology from nannofossil-bearing (to-rich), carbonate-bearing (to-rich), silt-bearing (to-rich) clay, clayey silt, and sand-rich clay or silt. Fine-grained and slightly coarser grained layers alternate without any apparent gradation.

The total detrital content of these sediments is quite high. Quartz content ranges from 2 to 59% by smear-slide analysis. Mica composes up to 10%, feldspar and heavy minerals up to 5% of the total composition. Pyrite and other opaque minerals are present only in very small quantities (up to 3%).

The carbonate content (as specified carbonate) of the dominant lithologies ranges from 5 up to 35%, based on smear-slide analysis. Nannofossils are noted in trace

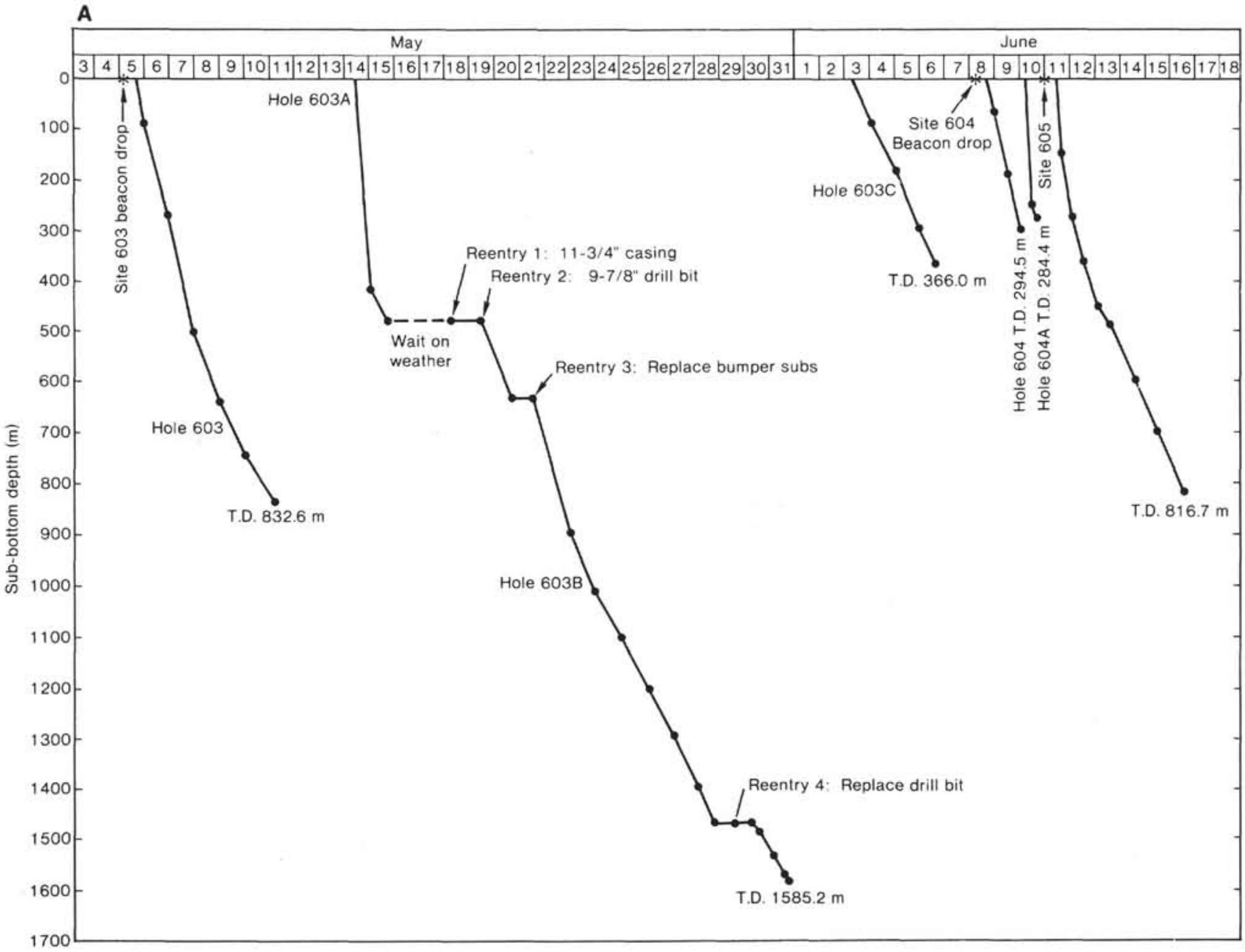


Figure 6. Leg 93 station activity summary diagram.

quantities up to 2%. Foraminifers are absent. Siliceous biogenic components appear in Core 603-3, in trace amounts up to 4%. Fish remains and plant debris occur sporadically in trace quantities up to 2%.

An unusual minor lithology of a mid-Eocene, biogenic-silica-rich nannofossil ooze occurs in Sample 604-1-1, 123–133 cm. This pale yellow (5Y 8/3) ooze contains diatoms (10%), radiolarians (10%), sponge spicules (5%), clay (5%), and foraminifers (3%), in addition to 67% nannofossils. This is interpreted as a displaced block from its lithology and the middle Eocene age of the microfossils.

Subunit IA is distinguished from Subunit IB by an increase in the heavy minerals and the strong evidence of slump structures in Subunit IB.

Subunit IB (top of Core 604-5 to 604-10-1, 7 cm; 35.3–84.0 m sub-bottom) is gray and dark greenish gray clay and silt with slump structures. The sediments range in color from light brown gray (5GY 4/1–5G 4/1) to gray (N5) at the base of the unit. The lithology ranges from carbonate-bearing (to -rich), silt bearing (to -rich), nannofossil-bearing, glauconite-bearing clay to silt.

The sedimentary structures are revealed by color patterns of shades of yellowish brown, pinkish gray (2.5YR 4/1), and reddish yellow (5YR 6/6), which appear as swirls or convoluted layers (Fig. 8) and contorted lenses in a gray or light brown matrix. The distortion of these layers/bands is probably due to slumping, and not to drilling deformation (pers. comm., Operations Manager Glen Foss, 1983).

The quartz content of the dominant lithologies is Subunit IB ranges from 2 to 7% based upon smear-slide analysis. Mica occurs in quantities of 1 to 15%, with feldspar appearing sporadically from trace quantities up to 2%. Heavy minerals increase in abundance from Subunits IA to IB and range from 1 to 10%. Glauconite, pyrite, and opaque minerals occur more frequently in this subunit than in Subunit IA.

The total carbonate content (both detrital and biogenic) decreases from the top of Subunit IB (4–21% total carbonate) to its base (4–10% total carbonate). Calcareous nannofossils occur only in trace amounts in Cores 604-8 and -9.

Subunit IB is distinguished from Unit II by the presence of common to abundant glauconite sand, siliceous microfossils, and an abundance of calcareous microfossils. This subunit is differentiated from the overlying subunit by·the evidence of slumping.

Table 2. Coring summary, Site 604.

Core no.	Date (June 1983)	Time	Depth from drill floor (m) Top Bottom	Depth below seafloor (m) Top Bottom	Length cored (m)	Length recovered (m)	Percentage recovered
Hole 604							
1	8	1550	2374.0-2380.5	0.0-6.5	6.5	5.29	81
2	8	1700	2380.5-2390.1	6.5-16.1	9.6	2.14	22
3	8	1842	2390.1-2399.7	16.1-25.7	9.6	1.71	18
4	8	2005	2399.7-2409.3	25.7-35.3	9.6	0.10	1
5	8	2117	2409.3-2418.9	35.3-44.9	9.6	3.10	32
6	8	2228	2418.9-2428.5	44.9-54.5	9.6	6.58	69
7	9	0008	2428.5-2438.1	54.5-64.1	9.6	0.30	3
8	9	0108	2438.1-2447.7	64.1-73.7	9.6	2.41	25
9	9	0210	2447.7-2457.3	73.7-83.3	9.6	3.11	32
10	9	0305	2457.3-2466.9	83.3-92.9	9.6	6.63	69
11	9	0355	2466.9-2476.5	92.9-102.5	9.6	8.14	85
12	9	0451	2476.5-2486.1	102.5-112.1	9.6	1.96	20
13	9	0543	2486.1-2495.7	112.1-121.7	9.6	5.64	59
14	9	0635	2495.7-2505.3	121.7-131.3	9.6	7.74	81
15	9	0725	2505.3-2514.9	131.3-140.9	9.6	3.75	39
16	9	0813	2514.9-2524.5	140.9-150.5	9.6	5.77	60
17	9	0930	2524.5-2534.1	150.5-160.1	9.6	5.66	59
18	9	1020	2534.1-2543.7	160.1-169.7	9.6	6.20	65
19	9	1115	2543.7-2553.3	169.7-179.3	9.6	6.90	72
20	9	1214	2553.3-2562.9	179.3-188.9	9.6	2.86	30
21	9	1403	2562.9-2572.5	188.9-198.5	9.6	5.62	59
22	9	1503	2572.5-2582.1	198.5-208.1	9.6	7.91	82
23	9	1612	2582.1-2591.7	208.1-217.7	9.6	5.64	59
24	9	1713	2591.7-2601.3	217.7-227.3	9.6	0.33	3
25	9	1810	2601.3-2610.9	227.3-236.9	9.6	4.89	51
26	9	1902	2610.9-2620.5	236.9-246.5	9.6	4.05	42
27	9	1955	2620.5-2630.1	246.5-256.1	9.6	1.50	16
28	9	2052	2630.1-2639.7	256.1-265.7	9.6	1.05	+ 100
29	9	2143	2639.7-2649.3	265.7-275.3	9.6	0.00	0
30	9	2247	2649.3-2658.9	275.3-284.9	9.6	0.60	6
31	10	0020	2658.9-2668.5	284.9-294.5	9.6	0.00	0
Total					294.5	117.58	40
Hole 604A							
1M	10	1244	2350.0-2599.6	0.0-249.6	—	—	Wash
2	10	1343	2599.6-2609.2	249.6-259.2	9.6	0.17	2
3	10	1453	2609.2-2618.8	259.2-268.8	9.6	1.91	20
4	10	1602	2618.8-2628.4	268.8-278.4	9.6	0.04	1
5	10	2200	2628.4-2634.4	278.4-284.4	6.0	0.05	1
Total					34.8	2.17	6

Unit II: Lower Pleistocene–Uppermost Miocene Greenish Gray Clay with Glauconite-Rich Intervals, Sample 604-10-1, 7 cm through 604-26-2, 46 cm; Sub-bottom Depth 84.0–238.9 m

Unit II is characterized by intervals rich in glauconitic sand and by variable amounts of biogenic silica within the dominant lithology of greenish gray clay (Fig. 7). The unit was subdivided into four subunits (Table 4) by the presence or absence of these two characteristics.

Subunit IIA (Cores 10–13; 84.0 to 121.7 m sub-bottom) has glauconite-rich sand layers in a biogenic-silica-rich to silica-bearing clay. The glauconite-rich (10–35%) intervals of sandy to clayey silt are generally dark greenish gray (5Y 4/1) to olive gray (5Y3/2) and contain abundant quartz silt (10–15%), nannofossils (5–25%), and biogenic silica (typically 15%, generally with similar amounts of diatoms, radiolarians, and sponge spicules). These redeposited sands, 30 cm to 3 m thick, are dominant in Core 604-10, and decrease in abundance in the underlying cores. The interbedded clay is lighter in color (greenish gray, 5GY 5/1, to gray, N5–N6) with a lower abundance of biogenic silica (2–12%). The clay has variable quantities of quartz silt (8–30%) and nannofossils (1–15%), with sporadically important amounts of foraminifers, skeletal carbonate, siderite, pyrite, and glauconite. There is no typical composition. There is continuum between the clay and glauconite-rich silt. No evidence of turbidite structures or graded beds was noted, although the contacts between silt and clay intervals are often sharp. The disturbance of these cores during drilling may have obscured details of primary sedimentary structures.

Subunit IIB (Cores 14–19; 121.7–179.3 m sub-bottom) is very similar to Subunit IIA in having interbedded clay and glauconite-rich silt but is distinguished by the virtual absence of biogenic silica (less than 3%). The glauconite-rich (8–24%) silts and silty clays are very minor components except in Core 604-19, where they comprise about 30% of the core. They increase in abundance from Cores 604-18 upward to Core 604-14. Possible grading and distinct lower contacts of some of these dark

Table 3. Coring summary, Site 605.

Core no.	Date (June 1983)	Time	Depth from drill floor (m) Top Bottom	Depth below seafloor (m) Top Bottom	Length cored (m)	Length recovered (m)	Percentage recovered
1M	11	1241	2207.0–2361.3	0.0–154.3	—	9.21	Wash
2	11	1342	2361.3–2370.9	154.3–163.9	9.6	tr	0
3	11	1459	2370.9–2380.5	163.9–173.5	9.6	4.23	44
4	11	1601	2380.5–2390.1	173.5–183.1	9.6	4.73	49
5	11	1750	2390.1–2399.7	183.1–192.7	9.6	3.55	37
6	11	1906	2399.7–2409.3	192.7–202.3	9.6	5.46	57
7	11	2000	2409.3–2418.9	202.3–211.9	9.6	9.62	+100
8	11	2050	2418.9–2428.5	211.9–221.5	9.6	0.05	1
9	11	2138	2428.5–2438.1	221.5–231.1	9.6	6.35	66
10	11	2224	2438.1–2447.7	231.1–240.7	9.6	9.17	96
11	11	2310	2447.7–2457.3	240.7–250.3	9.6	9.53	99
12	11	2359	2457.3–2466.9	250.3–259.9	9.6	9.65	+100
13	12	0056	2466.9–2476.5	259.9–269.5	9.6	9.64	+100
14	12	0200	2476.5–2486.1	269.5–279.1	9.6	9.13	95
15	12	0255	2486.1–2495.7	279.1–288.7	9.6	9.51	99
16	12	0343	2495.7–2505.3	288.7–298.3	9.6	9.66	+100
17	12	0436	2505.3–2514.9	298.3–307.9	9.6	9.66	+100
18	12	0545	2514.9–2524.5	307.9–317.5	9.6	4.55	47
19	12	0640	2524.5–2534.1	317.5–327.1	9.6	9.67	+100
20	12	0745	2534.1–2543.7	327.1–336.7	9.6	4.29	45
21	12	0840	2543.7–2553.3	336.7–346.3	9.6	8.01	83
22	12	0955	2553.3–2562.9	346.3–355.9	9.6	9.68	+100
23	12	1125	2562.9–2572.5	355.9–365.5	9.6	9.63	+100
24	12	1250	2572.5–2582.1	365.5–375.1	9.6	9.72	+100
25	12	1413	2582.1–2591.7	375.1–384.7	9.6	9.20	96
26	12	1635	2591.7–2601.3	384.7–394.3	9.6	8.50	89
27	12	1823	2601.3–2610.9	394.3–403.9	9.6	9.55	99
28	12	2010	2610.9–2620.5	403.9–413.5	9.6	5.33	56
29	12	2150	2620.5–2630.1	413.5–423.1	9.6	7.39	77
30	12	2347	2630.1–2639.7	423.1–432.7	9.6	5.98	62
31	13	0210	2639.7–2649.3	432.7–442.3	9.6	9.63	+100
32	13	0430	2649.3–2658.9	442.3–451.9	9.6	9.70	+100
33	13	0647	2658.9–2668.5	451.9–461.5	9.6	7.50	78
34	13	0855	2668.5–2678.1	461.5–471.1	9.6	9.77	+100
35	13	1045	2678.1–2687.7	471.1–480.7	9.6	7.93	83
36	13	1240	2687.7–2697.3	480.7–490.3	9.6	4.03	42
37	13	1430	2697.3–2706.9	490.3–499.9	9.6	8.98	94
38	13	1615	2706.9–2716.5	499.9–509.5	9.6	9.69	+100
39	13	1800	2716.5–2726.1	509.5–519.1	9.6	9.46	99
40	13	2040	2726.1–2735.7	519.1–528.7	9.6	5.38	56
41	14	0020	2735.7–2745.3	528.7–538.3	9.6	8.96	93
42	14	0308	2745.3–2754.9	538.3–547.9	9.6	9.66	+100
43	14	0503	2754.9–2764.5	547.9–557.5	9.6	9.64	+100
44	14	0645	2764.5–2774.1	557.5–567.1	9.6	8.83	92
45	14	0830	2774.1–2783.7	567.1–576.7	9.6	8.15	85
46	14	1020	2783.7–2793.3	576.7–586.3	9.6	9.14	95
47	14	1200	2793.3–2802.9	586.3–595.9	9.6	8.93	93
48	14	1435	2802.9–2812.5	595.9–605.5	9.6	6.63	69
49	14	1700	2812.5–2822.1	605.5–615.1	9.6	8.77	91
50	14	1850	2822.1–2831.7	615.1–624.7	9.6	9.52	99
51	14	2110	2831.7–2841.3	624.7–634.3	9.6	4.68	49
52	14	2240	2841.3–2850.9	634.3–643.9	9.6	9.74	+100
53	15	0055	2850.9–2855.4	643.9–648.4	4.5	2.38	53
54	15	0258	2855.4–2860.5	648.4–653.5	5.1	1.55	30
55	15	0500	2860.5–2870.1	653.5–663.1	9.6	7.89	82
56	15	0645	2870.1–2879.7	663.1–672.7	9.6	9.66	+100
57	15	0847	2879.7–2889.3	672.7–682.3	9.6	8.82	92
58	15	1000	2889.3–2898.9	682.3–691.9	9.6	0.00	0
59	15	1229	2898.9–2908.5	691.9–701.5	9.6	9.70	+100
60	15	1430	2908.5–2918.1	701.5–711.1	9.6	9.66	+100
61	15	1655	2918.1–2927.7	711.1–720.7	9.6	8.21	86
62	15	1850	2927.7–2937.3	720.7–730.3	9.6	8.90	93
63	15	2045	2937.3–2946.9	730.3–739.9	9.6	8.32	87
64	15	2226	2946.9–2956.5	739.9–749.5	9.6	9.61	+100
65	15	2353	2956.5–2966.1	749.5–759.1	9.6	2.28	24
66	16	0140	2966.1–2975.7	759.1–768.7	9.6	6.03	63
67	16	0327	2975.7–2985.3	768.7–778.3	9.6	6.66	69
68	16	0540	2985.3–2994.9	778.3–787.9	9.6	9.63	+100
69	16	0730	2994.9–3004.5	787.9–797.5	9.6	7.88	82
70	16	0929	3004.5–3014.1	797.5–807.1	9.6	9.12	95
71	16	1105	3014.1–3023.7	807.1–816.7	9.6	9.62	+100
Total					662.4	532.08	80

Table 4. Site 604 lithostratigraphy.

Unit/Subunit	Lithology	Core-Section	Sub-bottom depth (m)	Age
I	Gray to dark greenish gray alternations of clay and silt	604-1 to 604-10-1, 7 cm	0.0-84.0	late Pleistocene
IA	Interbedded clay and silt layers	604-1 to 604-5, 0 cm	0.0-35.3	late Pleistocene
IB	Gray and dark greenish gray clay and silt with slump structures	604-5, 0 cm to 604-10-1, 7 cm	35.3-84.0	late Pleistocene
II	Greenish gray clay with glauconite-rich intervals (variable amounts of biogenic silica)	604-10, 7 cm to 604-26-2, 46 cm	84.0-238.9	Pleistocene late Miocene
IIA	Greenish gray clay with glauconite-rich sand and biogenic silica	604-10-1, 7 cm through 604-13,CC	84.0-121.7	Pleistocene
IIB	Greenish gray clay with glauconite-rich sand	604-14 through 604-19,CC	121.7-179.3	Pleistocene-late Pliocene
IIC	Greenish gray clay with biogenic silica	604-20 through 604-24,CC	179.3-227.3	Pliocene-late Miocene
IID	Greenish gray clay with glauconite-rich sand and biogenic silica	604-25 through 604-26-2, 46 cm	227.3-238.9	late Miocene
III	Glauconite- and biogenic-silica-rich silty claystone and conglomerates	604-26-2, 46 cm to 604-31 and 604A-2 through 604-4,CC	238.9-294.5	late Miocene

greenish gray (10GY 3/2–5GY 3/2), muddy sand layers were noted, especially in the abundant 2- to 5-cm-thick sands of Core 604-14. In addition to glauconite, the silt layers are rich in quartz (4–20%), detrital and bioclastic carbonate (10%), and foraminifers (10% in an interval in Core 604-14). The dominant silt-rich clay contains typically 5–15% quartz, 5–10% detrital carbonate, siderite, or skeletal carbonate, and minor quantities of nannofossils and foraminifers (1–5%).

Subunit IIB cores contained a large amount of gas (methane), which had to be vented before splitting the cores—a feature unique to this subunit. Conspicuous pale red (2.5 YR 6/2) silty clay occurs from Sections 604-16-1 to 604-16-3 (and also at the base of Subunit IIA in Sections 604-13-2 and 604-13-4). Foraminiferal sandy laminae and layers are found in Core 604-17.

Subunit IIC (Cores 604-20 to -24; 179.3 to 227.3 m sub-bottom) is homogeneous biogenic-silica-bearing clay (4–10% radiolarians and sponge spicules) of grayish olive green color (5GY 3/2, 5GY 4/1). The clay is silt-bearing (typically 4–8% quartz and 2–5% unspecified carbonate); it is nannofossil-bearing (4–8% nannofossils) in Cores 604-20 and -21 to nannofossil-rich (15–40%) in Cores 604-22 through -24. In this subunit, and throughout Unit II, the abundances of calcareous and siliceous microfossils and nannofossils appear to be positively correlated. There are rare occurrences of pyrite nodules and grain clusters and of tiny white concentrations of quartz silt. The homogeneous clay may be moderately bioturbated, but such features were obscured during wire-splitting of the cores.

Subunit IID (Core 604-25 through Sample 604-26-2, 46 cm; 227.3 to 238.9 m sub-bottom) is a greenish gray clay characterized by the abundance of glauconite-rich intervals and biogenic silica. Midway in Core 604-25, the induration of the clay necessitated the change from wire splitting to saw cutting of cores, so the lithologies changed from clay and silt to claystone and siltstone. Many structures of the clay–claystone, such as vaguely defined, moderate bioturbation and the very irregular contacts between glauconite-rich siltstone and claystone, were visible on the smooth, cut surface. Such structures are obscured in the overlying subunits by the wire-splitting process. The glauconite-rich clayey siltstones are dark greenish gray (5G 3/1–5Y 4/1), silt-rich (18% quartz, 4% mica in Sample 604-25-3, 110 cm), and diatom-bearing (4%). The interbedded claystone is dark grayish olive green (5GY 3/2, 5GY 4/1) and biogenic-silica-rich (2–15% diatoms, 1–3% radiolarians, 1–5% sponge spicules, and 1% silicoflagellates). Other components of the claystone are quartz (typically 10%), mica (4%), pyrite (3%), and nannofossils (0–30%). The base of Subunit IID is placed at the top of the uppermost conglomeratic bed, the distinguishing characteristic of Unit III. The lowest 2 m of the subunit (upper portion of Core 604-26) appears to be normally graded from a glauconite-rich, diatom-rich silty claystone to biogenic-silica-rich claystone. The contacts between the glauconite-rich siltstone and the underlying claystone exposed on the cut surfaces of Sections 604-25-3 and 604-25-4 are very complex and possibly involve a combination of bioturbation, current reworking, and/or distortion by slumping.

Unit III: Upper Miocene Glauconite- and Biogenic-Silica-Rich Silty Claystone and Conglomerate (debris flow deposit), Sample 604-26-2, 46 cm to Core 604-31 and Cores 604A-1 through 604A-4; Sub-bottom Depth 238.9–294.5 m

The unit is composed primarily of grayish olive green (5GY 3/2) claystone with varying amounts of silt, biogenic silica, and glauconite. The drilling characteristics indicated abundant sand intervals, but this lithology was poorly recovered. Intervals of gray (5Y 5/1), matrix-supported conglomerates occur throughout the unit. The conglomerates contain rounded quartz pebbles and the following types of clasts: dark gray (5Y 4/1), homoge-

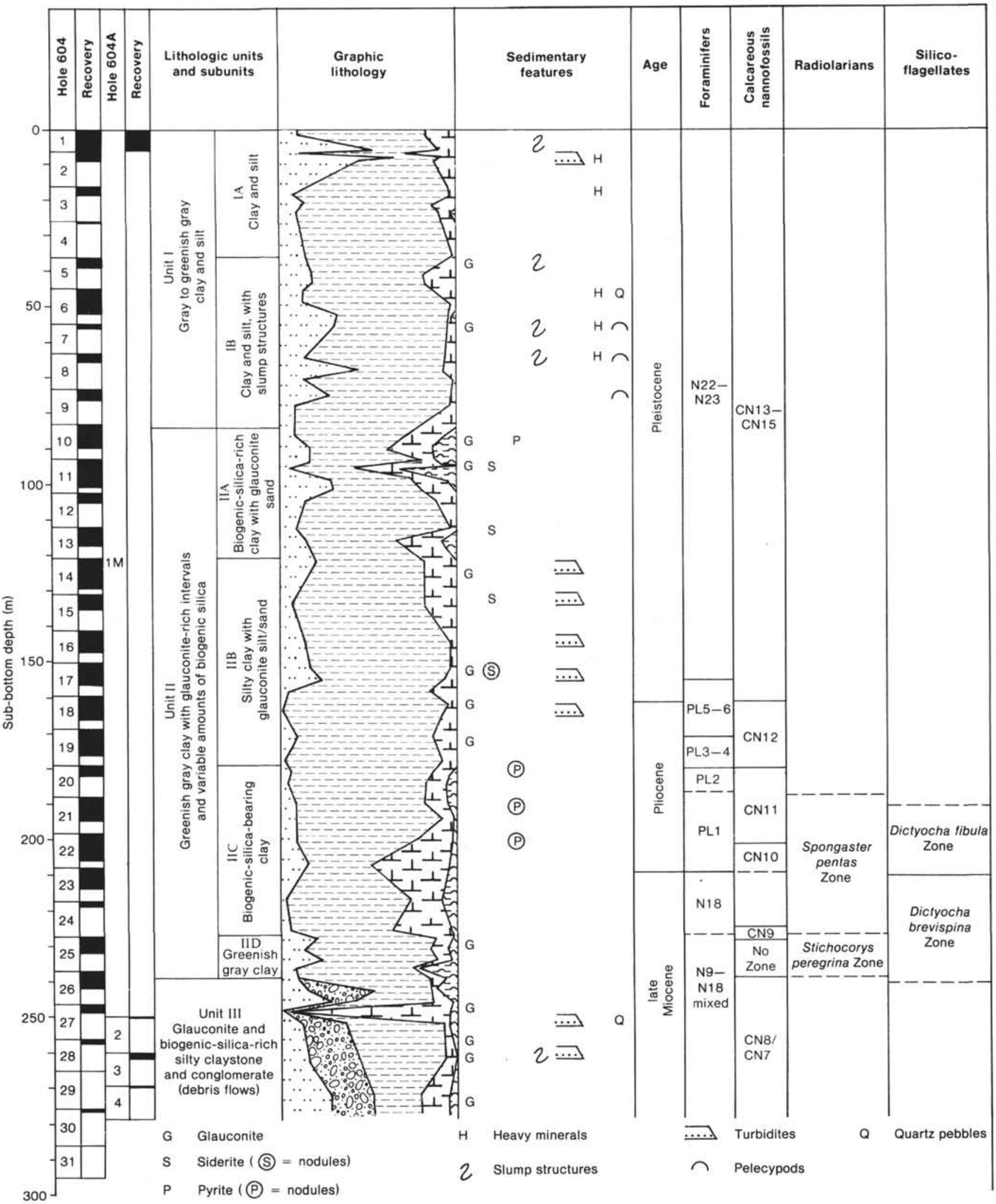


Figure 7. Stratigraphic summary for Holes 604 and 604A, indicating cored intervals, core recovery, lithology, age, and biostratigraphy of recovered sediments.

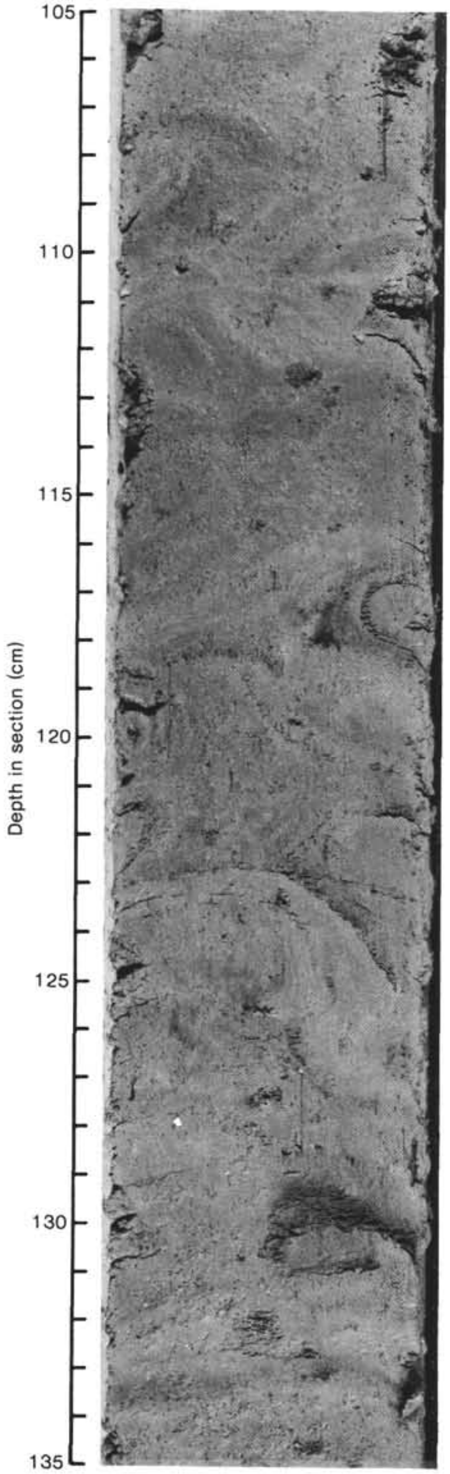


Figure 8. Contorted beds, interpreted as being due to slumping. Sample 604-8-1, 105–135 cm.

neous, biogenic-silica- and silt-bearing claystone; pale greenish yellow (10Y 8/2), clay-rich, biogenic-silica-rich nannofossil chalk; olive black (5Y 2/1) biogenic-silica-rich claystone; fragments of grayish green (5GY 3/2–5GY 4/1) limestone; and rare fragments of shells. These clasts and quartz pebbles are embedded in a silty claystone or clayey sandy siltstone matrix.

In Section 604-26-2 at 66 cm, an erosive contact at the base of a conglomerate is visible. Also in 604-26-2, from 90–150 cm, there is a concentration of glauconite grains surrounding a clast of dark gray biogenic-silica- and silt-bearing claystone (Fig. 9). These glauconite grains are arranged in a band partly encompassing the clast and appear to have been caught up as a contorted layer, possibly during a debris flow.

In the remainder of the unit are some carbonate layers, such as nannofossil chalk at 604-27-1, 35–85 cm (50 cm thick), carbonate ooze in the top of Core 604-28, and a foraminifer- and nannofossil-bearing, siliceous-biogenic- and clay-rich chalk at 604-30-1, 34–36 cm. These carbonate intervals appear to be blocks or slumped masses related to debris flows.

Glauconite is a common component of the matrix of the conglomerates; it also occurs in the normal background sediment of biogenic-silica- and silt-bearing/silty claystone.

Both Holes 604 and 604A were terminated because the unconsolidated glauconitic sand could not be penetrated by rotary drilling.

Site 605

Site 605 was washed to a sub-bottom depth of 154.3 m, because the equivalent, more complete Pleistocene record was continuously cored at Site 604. From 154.3 m down to the total depth of 816.7 m, Hole 605 was continuously cored. The lithologic column was subdivided into five units (see Table 5). The hole was terminated at 816.7 m still in Unit V, because the Leg 93 operating time had expired.

A graphic summary of the lithology and sedimentary structures is given in Figure 10. Figure 11 compares the lithologic units cored at site 604 and 605. Lithologic Unit I of Site 605 approximates Unit I of Site 604. Unit III of Site 604 is not present in Site 605, which was deliberately placed to avoid drilling this lithologic unit. It is important to note that the Site 605 lithologic units were numbered sequentially and are *not* equivalent to the Site 604 lithologic units (e.g., Unit III of Site 605 is not the same as Unit III of Site 604; see Fig. 11).

Unit I: Pleistocene Gray Silt-Rich Clay, Core 605-1M to 605-6-4, 149 cm; Sub-bottom Depth 0–198.7 m

This unit was poorly cored: only five cores were taken and the upper 150 m were washed, since Site 604 had already provided the Pliocene–Pleistocene record. Subunit IA (gray silt-rich clay) comprises the upper 198.5 m of the unit. A separate Subunit IB was identified in 605-6-4 from 125 to 149 cm; this 24-cm-thick layer is green in color and has significant amounts of glauconite and biogenic silica (Fig. 10). The correlation of the washed Core 1M (0–154.3 m) with the Pleistocene section of Site 604 is difficult. This core contains medium gray, biogenic-silica- and carbonate-bearing, silt-rich clay with layers of coarse sand more than 150 cm thick. Unit I at Site 604 was deposited in deeper water and is devoid of sand layers. Core 605-1M also contains a slumped bed of mid-Eocene light greenish gray biogenic silica and clay-rich nannofossil ooze–chalk (similar to Core 604-9).

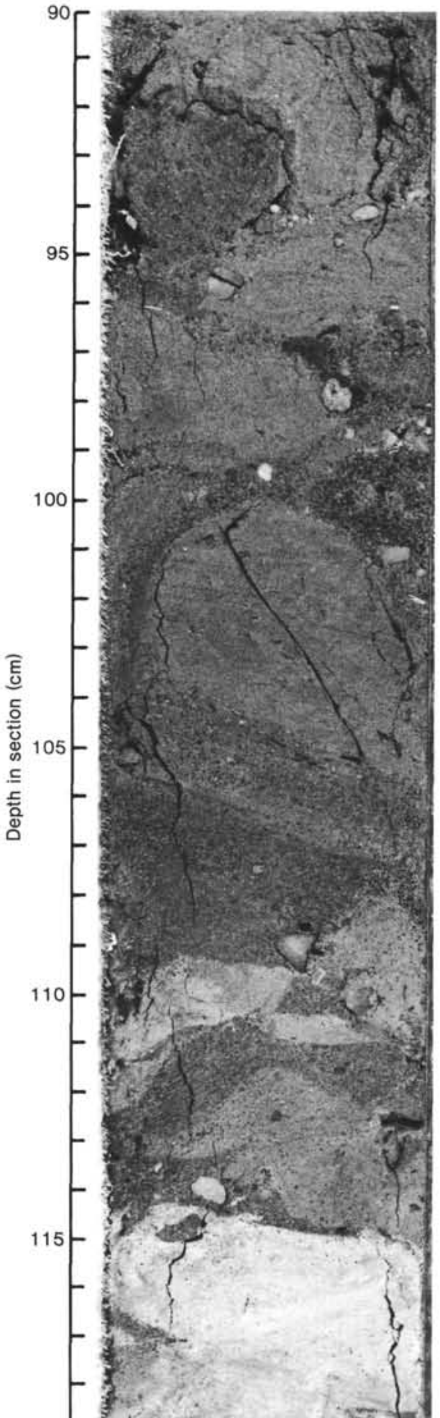


Figure 9. Contact between a clast of dark gray biogenic-silica- and silt-bearing claystone (115–120 cm) and overlying conglomerate of glauconite grains, quartz pebbles, and claystone clasts (90–115 cm). Sample 604-26-2, 90–120 cm (lithologic Unit III). Unit III is characterized by these glauconitic debris-flow conglomerates.

Cores 605-3 through 605-6-4, 149 cm correlate roughly with Subunit IB of Site 604. They contain glauconite- and nannofossil-bearing clay (texturally, sandy silty clay) and dark to medium gray, calcareous-silt- and quartz-silt-bearing clay of mid-Pleistocene age. This sediment contains abundant unspecified biogenic calcite fragments (mollusks, etc.); locally, it contains glauconite and nannofossils. Small pyrite nodules and tiny light gray spots (burrow fills?) with quartz silt are common. In general, the content of terrigenous quartz, feldspar, mica, and heavy minerals is very high (5–23%) and the carbonate content very low (less than 26%; see Fig. 10). The quartz silt lenses contain reworked Miocene and Eocene nannofossil assemblages. Section 605-6-1 to Sample 605-6-4, 125 cm contains mostly middle Pleistocene calcareous and terrigenous-silt-rich clay which grades downward into the clay and ooze of Subunit IB (see Fig. 10). The lithologic transition between the dark gray clay of Subunit IA and the slightly siliceous clay of Subunit IB occurs in Section 605-6-4 between 121 and 125 cm; it is marked by the upper extent of siliceous organisms and of glauconite as significant components of the sediment and by a change in color from green (Subunit IB) to gray (Subunit IA).

Subunit IB consists of a 24-cm-thick layer of homogeneous, structureless, biogenic-silica-bearing, calcareous-material-rich clay. It contains siliceous organisms in amounts of 7.8% (mainly radiolarians, diatoms, and sponge spicules), various carbonate components, including nannofossils (10%), foraminifers (1%), and unknown carbonate phases (up to 15%) that might be either detrital or authigenic (siderite). The detrital component is also significant (quartz, mica, feldspar), reaching a total of 5%. Subunit IB contains 5% glauconite and 2% pyrite in the sediments. The percentage of glauconite decreases upward dramatically in the lower 5 cm of the unit (Sample 605-6-4, 144–149 cm).

The lower boundary of Unit I coincides with a significant biostratigraphic break corresponding to the entire Pliocene, Miocene, Oligocene, and part of the Eocene. The contact between Units I and II, which occurs between Samples 605-6-4, 149 cm and 605-6,CC, and has the characteristics of a major unconformity, is an abrupt lithologic change associated with an upward increase in glauconite content and a dramatic upward decrease in biogenic silica.

Unit II: Lower Middle Eocene Greenish Gray, Biogenic-Silica-Rich, Nannofossil Chalk, Sample 605-6-4, 149 cm to 605-22-3, 50 cm; Sub-bottom Depth 198.7–349.8 m

The upper boundary of Unit II occurs between Samples 605-6-4, 149 cm and 605-6,CC, as a sharp contact between the Pleistocene green clay of Unit I and a layer of biogenic silica ooze of early middle Eocene age representing the topmost horizon of Unit II (Fig. 10). The contact between the two units represents an abrupt lithologic change and hiatus between Eocene and Pleistocene sediments. The lower boundary of Unit II is marked by an abrupt change in color from light greenish gray (Unit III) to darker greenish gray (Unit II), and by a dramatic upward increase of opal-A (preserved) biogenic silica microfossils. From smear-slide estimates, the transition is rapid and occurs between 605-22-1, 6 cm and 605-22-3, 50 cm, where well-preserved opaline microfossils are present only in trace amounts.

Table 5. Site 605 lithostratigraphy.

Unit/Subunit	Lithology	Core/Section	Sub-bottom depth (m)	Age
I				
IA	Gray silt-rich clay and green biogenic-silica-bearing, calcareous-material-rich clay	605-1 to 605-6-4, 125 cm	0–198.5	Pleistocene
IB	Green biogenic-silica-bearing calcareous-material-rich clay	605-6-4, 125–149 cm	198.50–198.7	Pleistocene
II	Greenish gray biogenic-silica-rich nannofossil chalk	605-6-4, 149 cm to 605-22-3, 50 cm	198.7–349.8	early middle Eocene
III	Greenish gray nannofossil limestone with varying amounts of foraminiferids and calcified radiolarians	605-22-3, 50 cm to 605-44-5, 33 cm	349.8–563.8	early middle Eocene to early Eocene
IV	Dark greenish gray clay-rich to clayey nannofossil limestone (marl)	605-44-5, 33 cm to 605-64-1, 54 cm	563.8–740.4	late Paleocene to early Paleocene
V	Olive gray, silt-rich or foraminifer-rich, clayey nannofossil limestone	605-64-1, 54 cm through 605-71,CC	740.4–816.7	early Paleocene to middle Maestrichtian
VA	Dark greenish gray, glauconite-bearing and silt-rich nannofossil clayey limestone	605-64-1, 54 cm to 605-66-1, 120 cm	740.4–760.2	early Paleocene
VB	Olive gray, clay-rich foraminifer–nannofossil limestone	605-66-1, 120 cm to 605-71,CC	760.2–816.7	Maestrichtian

Unit II is a monotonous sequence of homogeneous, biogenic-silica-rich nannofossil chalk, in places foraminifer-bearing (about 3–5% in Cores 605-16 to -18). The color is light greenish gray (5GY 7/1). The biogenic silica content is constantly high, on average around 12 and 15%, exceptionally reaching values up to 30% (Sample 605-11-2, 100 cm). The clay content is negligible for most of the unit down to Core 605-14. It is present in significant amounts (6–8%) from Core 605-15 to the top of Core 605-19.

Clay and biogenic silica contents are extremely high (45 and 50%, respectively) at the top of Unit II, immediately below the contact with Unit I, where a layer of clayey, biogenic-silica ooze occurs. This layer might represent a dissolution of "residual" facies of the underlying chalk. A significant amount of carbonate of unknown origin is also present in addition to the biogenic fraction (mostly nannofossils and foraminifers, percentages of 2–3%). This unknown carbonate phase could be either authigenic or detrital, as suggested by the positive correlation with clay content (Fig. 10). Pyrite is the most significant minor component, occurring as scattered clusters, small nodules up to 5 mm, and lenses. Dark gray pyrite-rich haloes are frequently present around burrows, and pyrite-bearing to pyrite-rich, biogenic-silica-rich nannofossil chalk, as well as pyrite concretions, occur as burrow fills. Black cm-thick bands and zones (burrows?) containing well-preserved pyritized radiolarians and diatoms (up to 7%) occur in Sample 605-12-1, 17 cm and Section 605-13-1.

A thin (2 cm) dark gray ash layer of rhyolitic composition, containing transparent, unaltered glass shards, bubble wall shards, quartz, and biotite, occurs at 605-21-2, 146 cm (Fig. 12).

Bioturbation is the most conspicuous feature of the biosiliceous nannofossil chalk of Unit II. The sediments are constantly reworked, sometimes completely burrowed, especially in the lower half of the unit. Bedding is rarely preserved (Samples 605-11-3, 30–50 cm and 605-11-4, 140–150 cm). Frequently "streaked-out" burrows mimic horizontal layering.

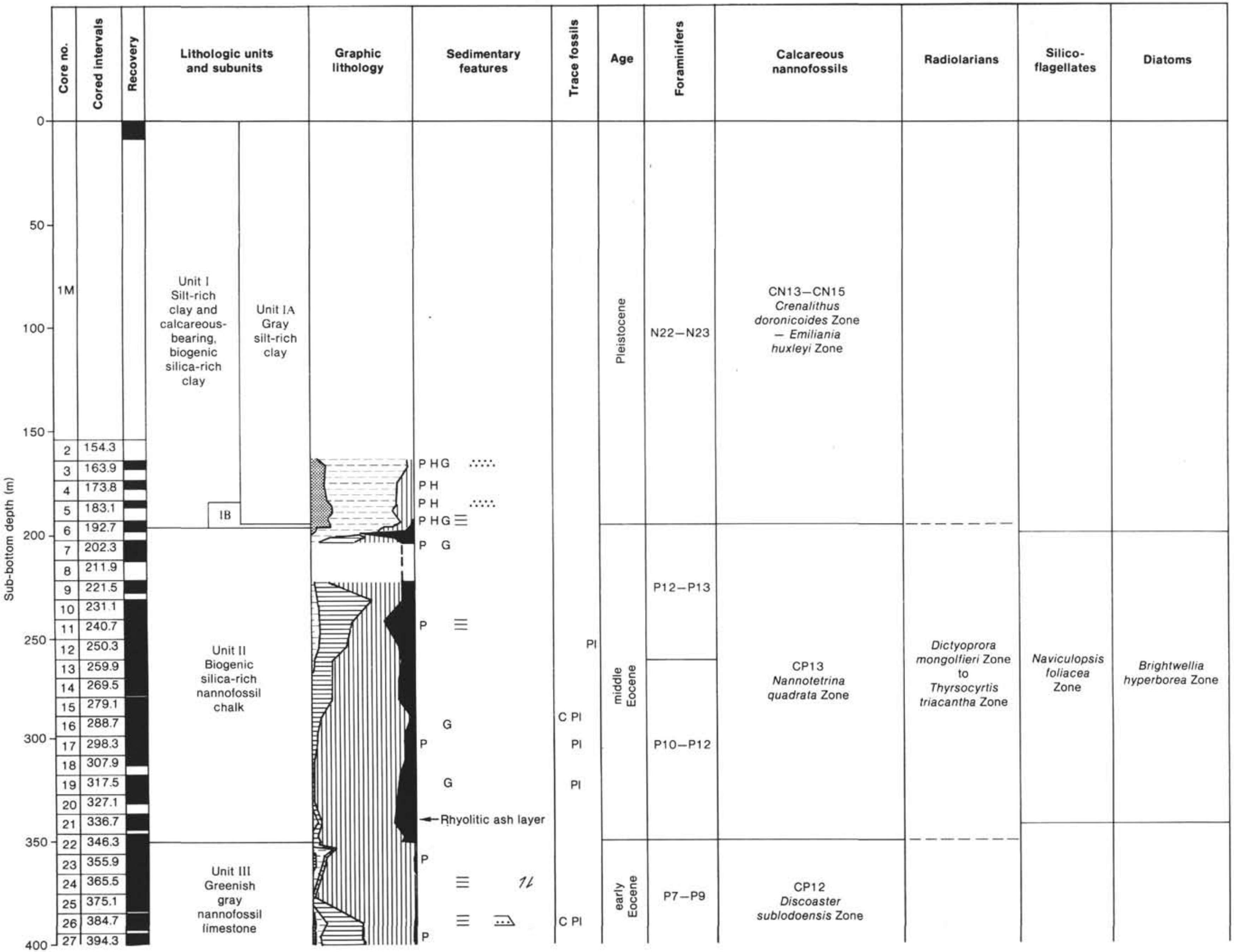
Unit II shows a wide variety of burrow structures, ranging in diameter from 1 to 2 mm (Chondrites-type) up to several cm, with burrow lengths up to 10 cm (Fig. 13). Planolites-type horizontal ovals (Figs. 13A, 13B), and Chondrites-type tubules (Figs. 13A, 13C) are by far most common feature. Large vertical or oblique tubes with crenulated outlines (Figs. 13A, 13D), horizontal burrows with backfill structures (Muensteria, Fig. 13D), and inverted funnel-shaped escape burrows (Figs. 12, 13E) are also common.

Burrow fills usually have a composition similar to the surrounding sediment. Darker color shading, from light brownish gray (5Y 7/1 to 6/1) to light brownish olive (5YR 6/1) to pale olive (5Y 5/3, 6/3) and grayish green (5G 5/2), usually indicates higher clay contents. Dark gray (N4) to grayish black are associated with pyrite.

Unit III: Upper Lower Eocene Greenish Gray Nannofossil Limestone, Sample 605-22-3, 50 cm to 605-44-5, 33 cm; Sub-bottom Depth 349.8–563.8 m

The upper boundary of Unit III was placed at 605-22-3, 50 cm, corresponding with the sudden upward increase in the biogenic silica content and the decrease in the clay content. The lower boundary of Unit III is a sharp contact between the light greenish nannofossil limestone of Unit III and the underlying dark clayey nannofossil limestone (marl) of Unit IV, in Sample 605-44-5, 33 cm.

Unit III consists of a monotonous nannofossil limestone containing various amounts of foraminifers and clay, which frequently occurs in rather high percentages (10–30%). The color is dominantly greenish gray (5GY 6/1) to light greenish gray (5GY 7/1), changing to grayish green (10GY 5/1, 5/2) and pale grayish green (10GY 6/2) in the lower half of the unit, from Core 605-34 downward.


Core no.
Cored intervals
Recovery
Lithologic units and subunits
Graphic lithology
Sedimentary features
Trace fossils
Age
Foraminifers
Calcareous nannofossils
Radiolarians
Silico-flagellates
Diatoms
Sub-bottom depth (m)
0
50
100
150
200
250
300
350
400
1M
2 154.3
3 163.9
4 173.8
5 183.1
6 192.7
7 202.3
8 211.9
9 221.5
10 231.1
11 240.7
12 250.3
13 259.9
14 269.5
15 279.1
16 288.7
17 298.3
18 307.9
19 317.5
20 327.1
21 336.7
22 346.3
23 355.9
24 365.5
25 375.1
26 384.7
27 394.3
Unit I Silt-rich clay and calcareous-bearing, biogenic silica-rich clay
Unit IA Gray silt-rich clay
IB
Unit II Biogenic silica-rich nannofossil chalk
Unit III Greenish gray nannofossil limestone
P H G
P H
P H
P H G
P G
P
G
P
G
Rhyolitic ash layer
P
P
Pl
C Pl
Pl
Pl
C Pl
Pleistocene
middle Eocene
early Eocene
N22–N23
P12–P13
P10–P12
P7–P9
CN13–CN15 Crenalithus doronicoides Zone – Emiliania huxleyi Zone
CP13 Nannotetrina quadrata Zone
CP12 Discoaster sublodoensis Zone
Dictyoprora mongolfieri Zone to Thyrsocyrtis triacantha Zone
Naviculopsis foliacea Zone
Brightwellia hyperborea Zone

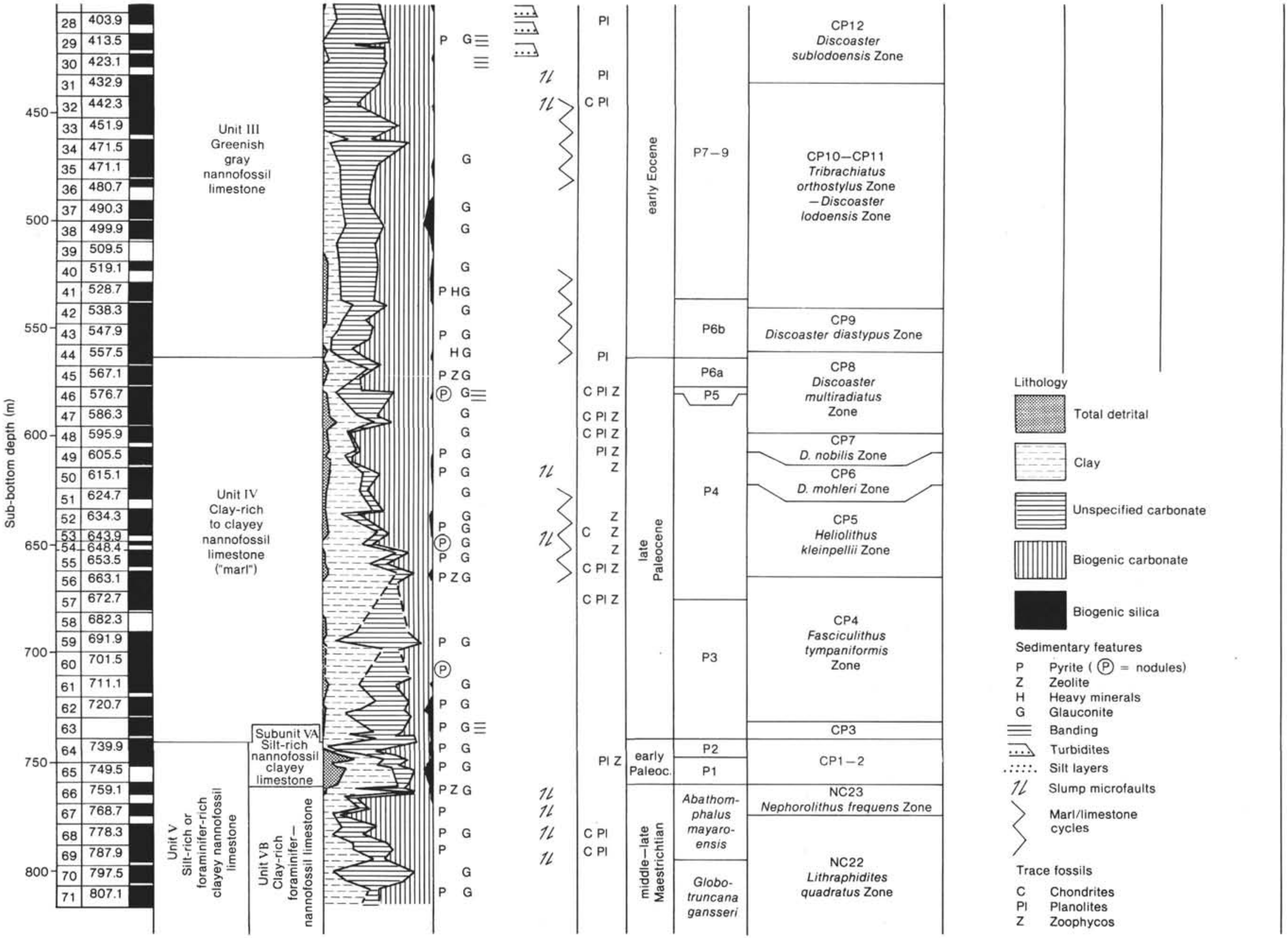


Figure 10. Stratigraphic summary for Site 605, indicating cored intervals, core recovery, lithology, age, and biostratigraphy of recovered sediments and sedimentary rocks.

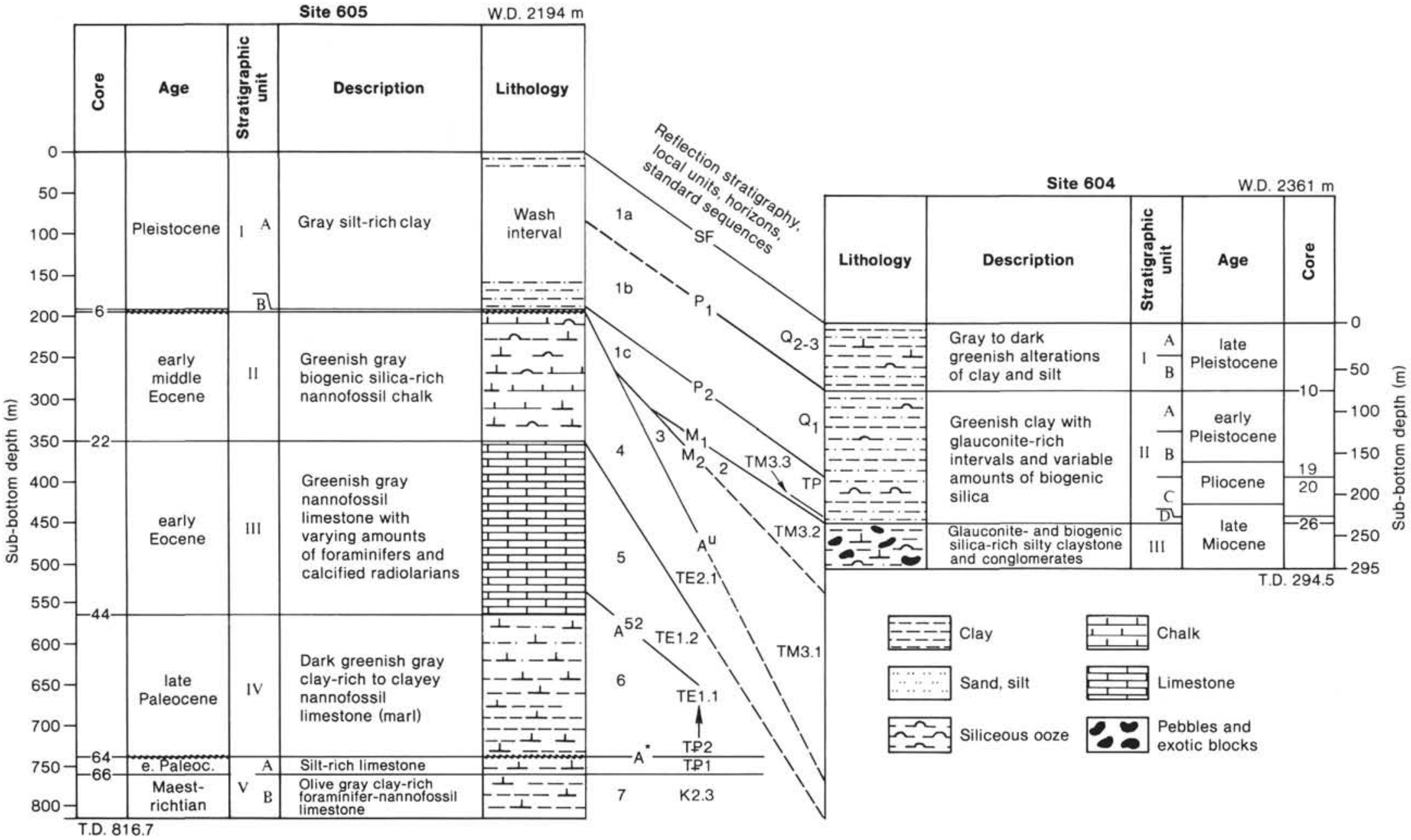


Figure 11. Comparison of lithologic units cored in Site 604 with those cored in Site 605. Seismic reflection stratigraphy correlating the two sites is also shown (revised by JvH, August 1986).

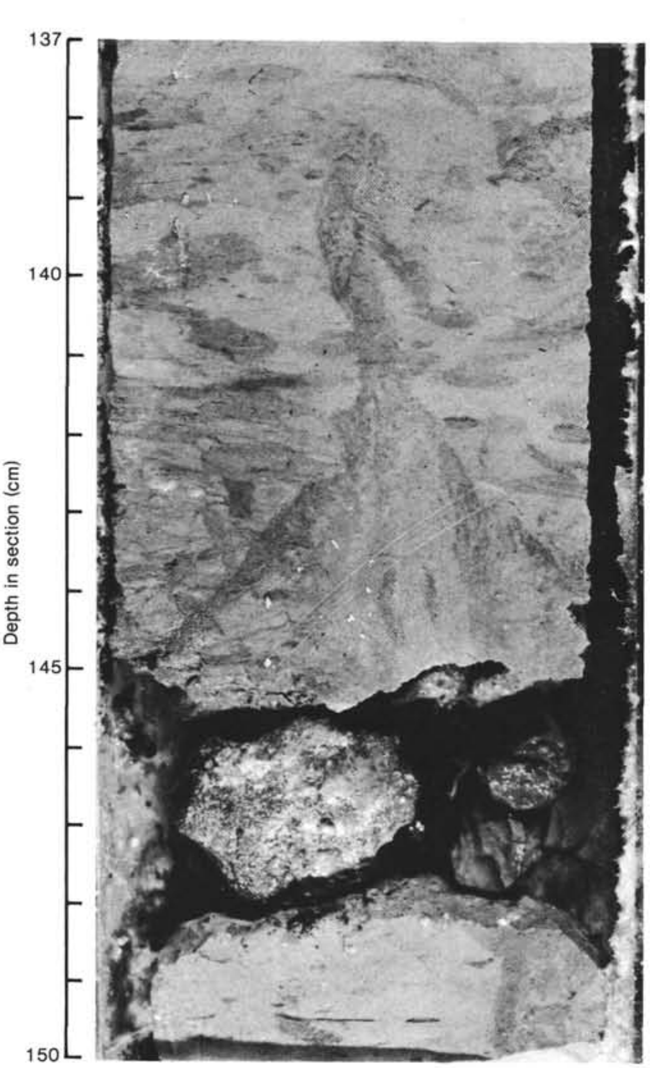


Figure 12. Rhyolitic ash layer at 605-21-1, 146 cm, overlain by an inverted funnel-shaped burrow (escape structure?). Sample 605-21-2, 137–150 cm.

Foraminifers are present in amounts ranging from 1 to 8%. At the bottom of the unit, from Sections 605-42-1 to 605-44-3, the foraminifers reach percentages of 10 to 15%. Discrete foraminiferal sand layers, 1 to 2 cm thick, are frequent from 605-26-5, 70 cm down to 605-29-5, 60 cm (Fig. 14). In some cases they show a sharp base and gradational upper contact and are therefore interpreted as thin turbiditic layers or winnowed deposits.

Biogenic silica occurs in trace amounts, in some cases reaching values of 2% (Sample 605-23-3, 26–27 cm). Higher values of biogenic silica (up to 8%) from Cores 605-37 to -38 qualify the sediments as biogenic-silica-bearing. In these cores, "ghosts" of dissolved radiolarians infilled with authigenic opal-CT are found.

Clay is present in amounts ranging from 4 to 10% between Cores 605-23 and -28; it is almost absent between Cores 605-29 and -33, and is present with average values of 15 to 20% from Core 605-34 to the bottom of the unit. The basal sediments of the unit have a significant amount of detrital materials (quartz, mica, heavy minerals). Pyrite occurs mostly as scattered tiny nodules; iron-sulfide-enriched zones occur at several levels as black streaks (Cores 605-30, -36, and -42) and as haloes around burrows, frequently associated with pyrite concretions.

An interesting, but so far unexplained feature of Unit III sediments is that certain blocks of the more clayey limestones ("marls") and even entire core sections developed concave-upward surfaces after cutting and desiccation in the core laboratory. Limestones in Cores 32 through 35 and Cores 40 through 43 developed these "bowed-upward" cut surfaces.

The bioturbation is very intense throughout Unit III. The degree of reworking and the trace fossil assemblages are different between Units II and III: there are fewer distinct, individual, trace fossils in Unit III. Most of the trace fossils in Unit III are Planolites and Chondrites (Fig. 14), but some other unusual burrow structures are also found in this unit. Sample 605-32-1, 95–98 cm, has a distinct, comet-shaped, nearly vertical burrow (Cylindrichnus?) cut by a microfault (Fig. 13F), and in Sample 605-26-2, 72–77 cm there is a contorted burrow with a three-dimensional structure, cylindrical cross section (8–15 mm diameter), and meniscate backfill structures (Fig. 13G). Sedimentary structures such as lamination or banding are occasionally preserved (Cores 605-24 to -30). In the less bioturbated horizons, "streaked-out" burrows frequently mimic horizontal layering.

From Cores 605-33 to -35 and in Core 605-40, alternation of intensely bioturbated, faintly laminated, and homogeneous undisturbed horizons gives rise to a clearly cyclic pattern. Variation in the clay content and color changes (clay-rich and clay-bearing nannofossil limestone are respectively grayish green, 10GY 5/2, and a lighter grayish yellowish green, 10GY 6/2 to 7/2) enhance the cyclicity in Core 605-44, at the bottom of the unit. Cycles are usually on a scale of 10–40 cm, with an average wave length of 7–8 cycles per 9-m core (Fig. 10).

Unit IV: Upper Paleocene Dark Greenish Gray, Clay-Rich to Clayey Nannofossil Limestone ("marl"), Samples 605-44-5, 33 cm to 605-64-1, 54 cm; Sub-bottom Depth 563.8–740.4 m

The upper boundary of Unit IV is placed at a distinct color and lithology change at 605-44-5, 33 cm; the greenish gray (5GY 5/2 to 7/2) limestone of early Eocene age (Unit III) is underlain by a dark greenish gray (5GY 4/1 to 5/1) marl of Paleocene age (Fig. 15). The lower boundary of Unit IV is difficult to define and somewhat arbitrary; it is placed at 605-64-1, 54 cm.

The main sediment type is a dark greenish gray (5GY 4/1) clayey nannofossil limestone ("marl") which alternates with a greenish gray (5GY 5/1) or gray (N5 to 5Y 5/1), clay-rich, nannofossil limestone ("marly limestone"). Some varieties are rich in terrigenous silt (up to 10% quartz and 2% mica), but usually terrigenous silt- and sand-sized material comprises less than 5%. There is, however, a distinct increase of terrigenous silt content from the almost purely pelagic early Eocene Unit V.

Figure 10 shows that the carbonate content (as estimated from smear slides) varies widely, from 30 to 90%. A significant trend is seen below Core 56, where "un-

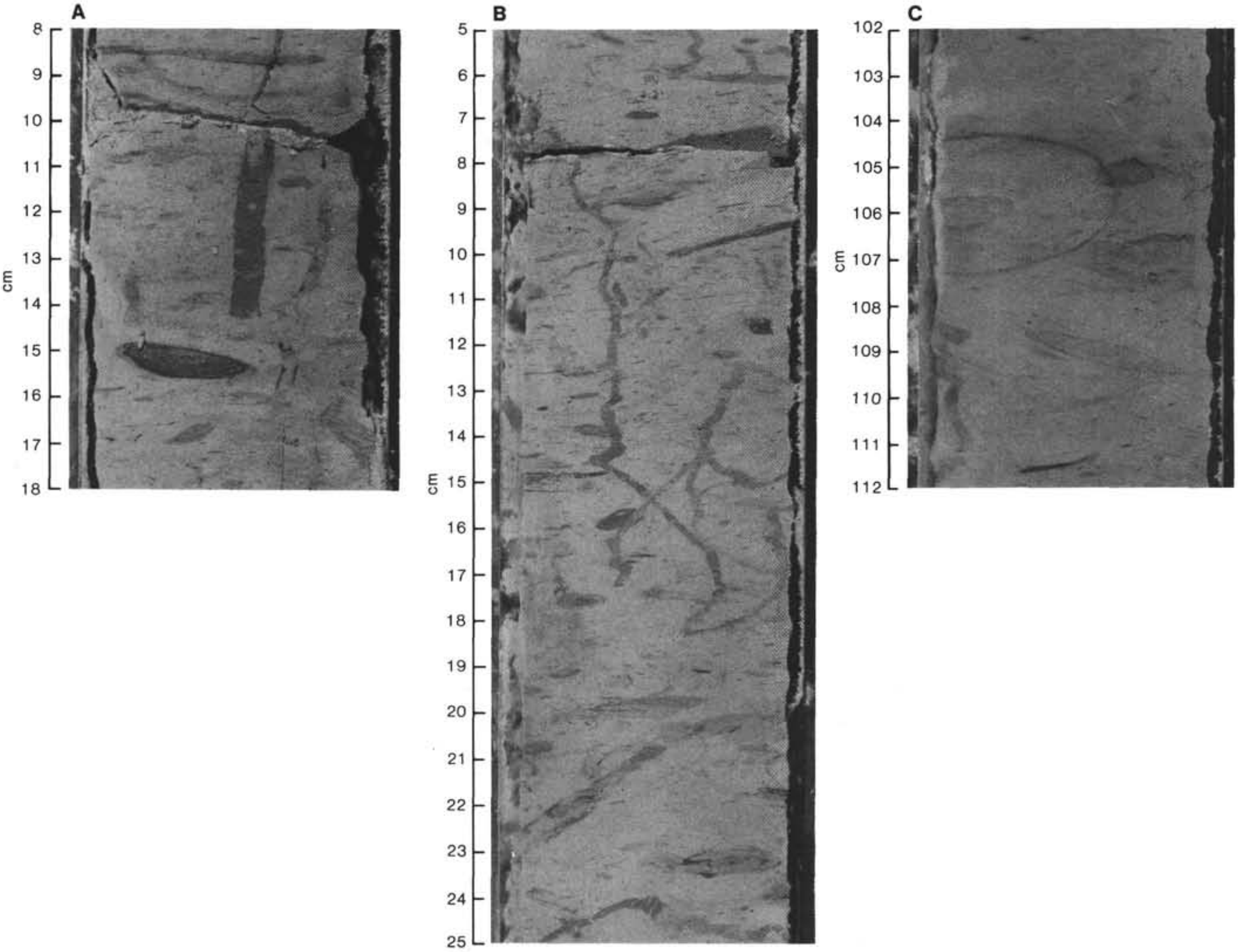


Figure 13. Burrow types in lithologic Units II and III. A. Sample 605-16-4, 8-18 cm shows mm-scale Chondrites, horizontal ovoid Planolites (at 15 cm), and vertical burrow at 10-14 cm (Skolithos?). B. Complex vertical array of interfingering burrows with meniscate structure at 8-18 cm, Planolites burrows at 20 and 23 cm, and nearly vertical burrow with backfill structures (Teichichnus) from 21-23 cm. Sample 605-19-4, 5-25 cm. C. Planolites (105 and 109 cm), Chondrites, and a "halo burrow" between 104 and 107 cm. Sample 605-16-4, 102-112 cm. D. Horizontal burrows with meniscate structure (Muensteria), Planolites burrows, and a vertical burrow between 27 and 29 cm. Sample 605-17-1, 20-35 cm. E. Inverted funnel-shaped escape burrow, Sample 605-17-5, 120-135 cm. Also seen in the figures are Planolites ovoids and mm-scale Chondrites burrows. F. nearly vertical tapered Cylindrichnus burrow cut by a microfault (reverse faulting). Section also shows Chondrites burrows and several small, horizontal Planolites burrows. Sample 605-32-1, 93-103 cm. G. Three-dimensional burrow with cylindrical cross-section and backfill structures (72-78 cm), plus an assortment of Chondrites and Planolites burrows. Sample 605-26-2, 58-78 cm.

specified carbonate" (mostly silt- and clay-sized micritic calcite, some biogenic fragments) increases downhole at the expense of calcareous nannofossils. This is probably due to diagenetic recrystallization in the more carbonate rich sediments at burial depths below 650 m. Above this burial depth, nannofossils constitute 70 to 90% of the total carbonate content. In general, foraminifers are very rare (less than 3%) and very poorly preserved. Only Core 605-56 contains 5% foraminifers (foraminifer-bearing limestone).

Siliceous organisms are rare, except for poorly preserved radiolarians in the form of opal-CT filled "ghosts," and calcified radiolarians are found in some levels. Pyrite (framboids or fragments of pyritized radiolarians) occurs in trace amounts to 2%. Glauconite is rare to absent, as is zeolite (except up to 1% in Cores 605-48, -49, and -56).

Unit IV is characterized by a high diversity of burrow structures which usually penetrate the sediment in a horizontal direction, giving the appearance of a banded structure similar to that seen in Unit II. The burrow fills are usually greenish black (5G 3/1). Some burrows are filled by pyrite concretions. Often nannofossils and foraminifers are better preserved in the burrow fills than in the adjacent sediment, producing a more silty-sandy appearance in the burrows. The most common burrow types are Chondrites and Planolites, but Unit IV is remarkable for its abundance of well-preserved Zoophycos burrow structures, some of which extend 20-30 cm vertically (Fig. 16).

Except for some faint color banding and "speckly lamination" (caused by flattened, horizontal burrows), no bedding or lamination is preserved. A compacted shell layer was recognized in Sample 605-50-6, 82-83 cm.

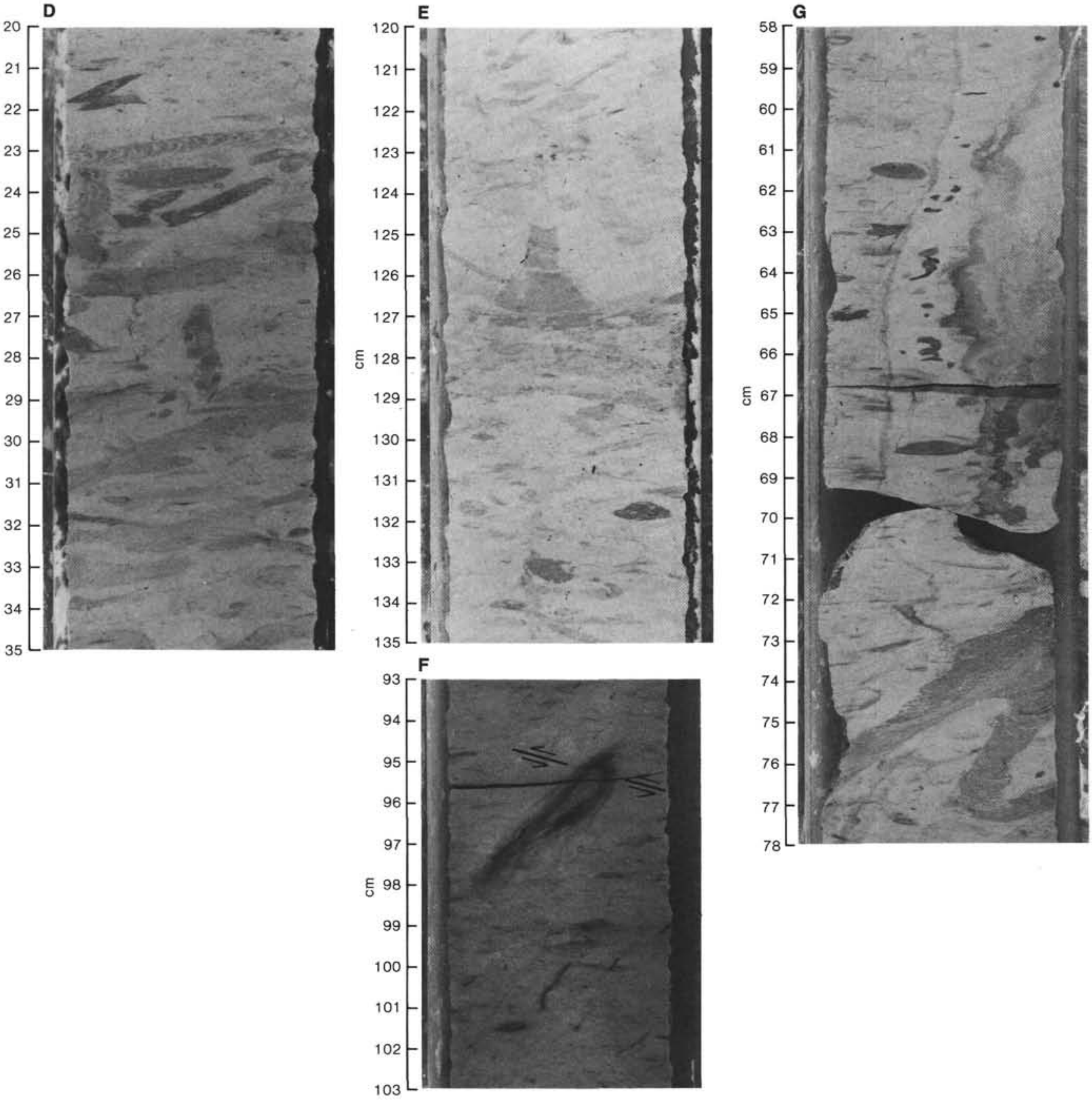


Figure 13 (continued).

Marl–limestone cycles (shown by a faint to distinct color zonation) are well developed in Units III and IV (especially in Cores 605-51 to -55, and -58 to -62; see Fig. 10). Usually, the dark-colored intervals (5GY 5/1 to 5GY 4/1) consist of clayey nannofossil limestone ("marl") to nannofossil claystone ("clayey marl"), whereas the lighter-colored zones (5GY 6/1) are a clay-bearing to -rich nannofossil limestone ("marly limestone"). The thickness of the dark or light-colored intervals varies from 10 to 60 cm. Since the color boundaries are very gradational, the wavelength of the cycles is difficult to estimate. In general, the wavelength tends to decrease from Cores 605-51 (4 cycles/core) to Core 605-57 (8) to Core 605-60 (14). The "cycles" are partially due to the concentration of dark burrows (more bioturbated areas are darker). Also different "cycles" may overlap each other.

Unit V: Lower Paleocene to Middle Maestrichtian Olive Gray, Foraminifer–Nannofossil Clayey Limestone, Samples 605-64-1, 54 cm through 605-71,CC; Sub-bottom Depth 740.4–816.7 m

Unit V is distinguished from the overlying Unit IV by an abundance of foraminifers and terrigenous silt (Fig. 17). The general lithology is olive gray (5Y 5/1), moderately bioturbated, foraminifer–nannofossil clayey limestone ("marly limestone"), though two major subunits

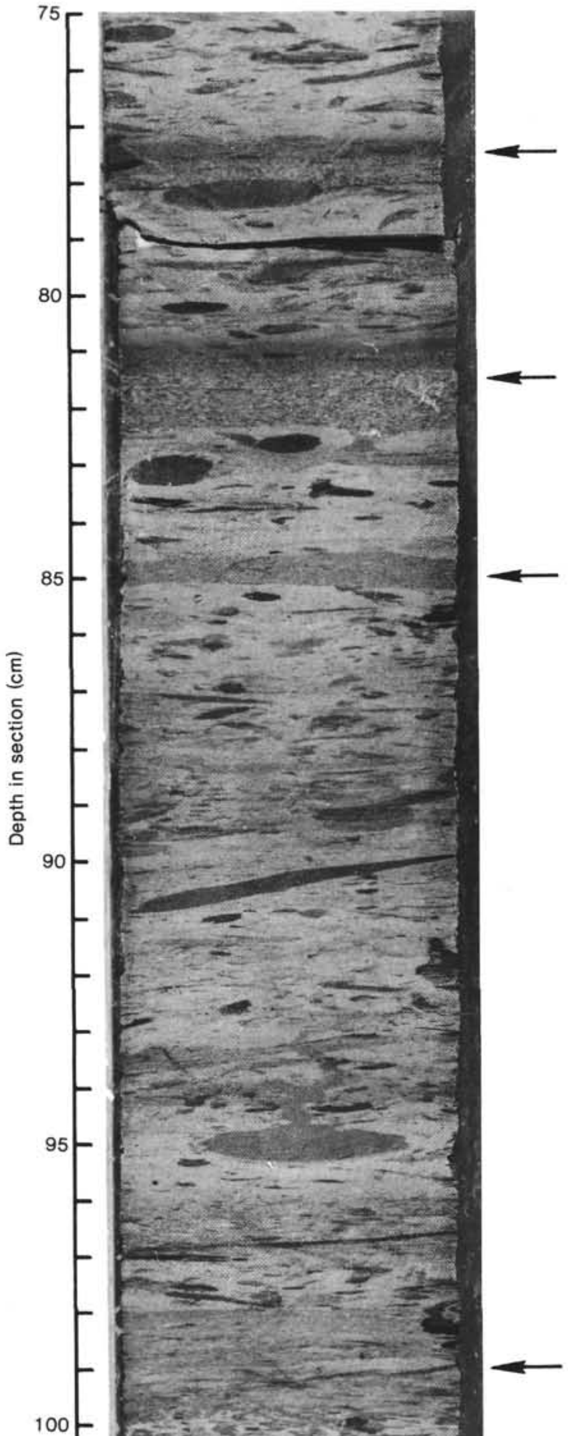


Figure 14. Lithologic Unit III at Site 605 contains foraminiferal sand layers (seen here at 77.5, 81–82, 85, and 98–100 cm). Sample 605-26-5, 75–101 cm also shows Chondrites and Planolites burrows.

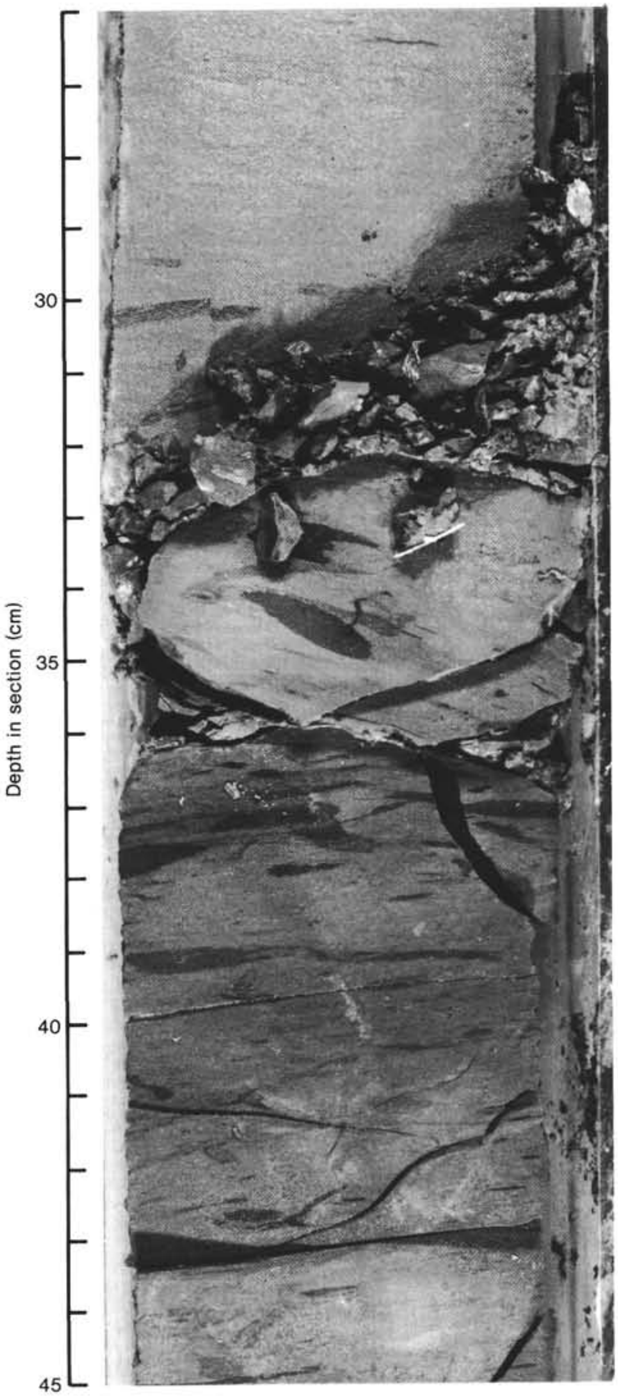


Figure 15. The contact between lithologic Unit III (lower Eocene nannofossil limestone) and Unit IV (Paleocene clay-rich nannofossil limestone) of Site 605 occurs at 33 cm. The contact is marked both by a lithologic change and by a color change, with greenish gray (5GY7/2 to 5/2) sediments overlying dark greenish gray (5GY5/1 to 4/1) sediments. Unit IV limestones are also more heavily bioturbated than the overlying Unit III limestones. Samples 605-44-5, 26–45 cm.

can be made on the basis of the variable importance of terrigenous silt versus foraminifers (Table 5). Subunit VA (terrigenous-silt-rich) has a fairly narrow transition to Subunit VB (foraminifer-rich) in Sections 605-66-1. The transition between the subunits contains the Cretaceous/Tertiary boundary.

The base of Subunit VB is 816.7 m sub-bottom, the total depth of Site 605.

The top of Unit V is difficult to define, and is somewhat arbitrarily placed at 605-64-1, 54 cm. Above this level are found dark greenish gray, clayey nannofossil

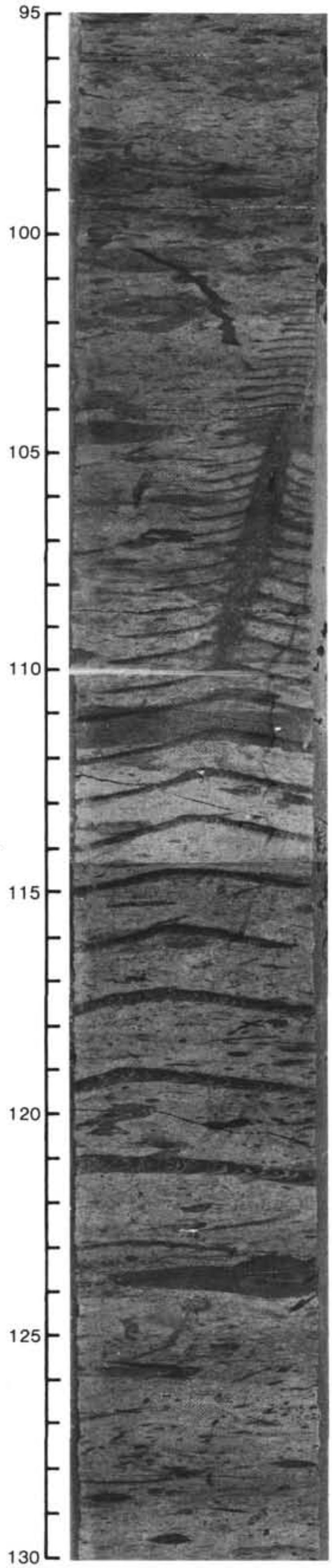


Figure 16. Unit IV of Site 605 is marked by remarkable preservation of Zoophycos burrows, such as the one extending from 101-122 cm. This core also shows Chondrites and Planolites burrows. Sample 605-57-1, 95-130 cm.

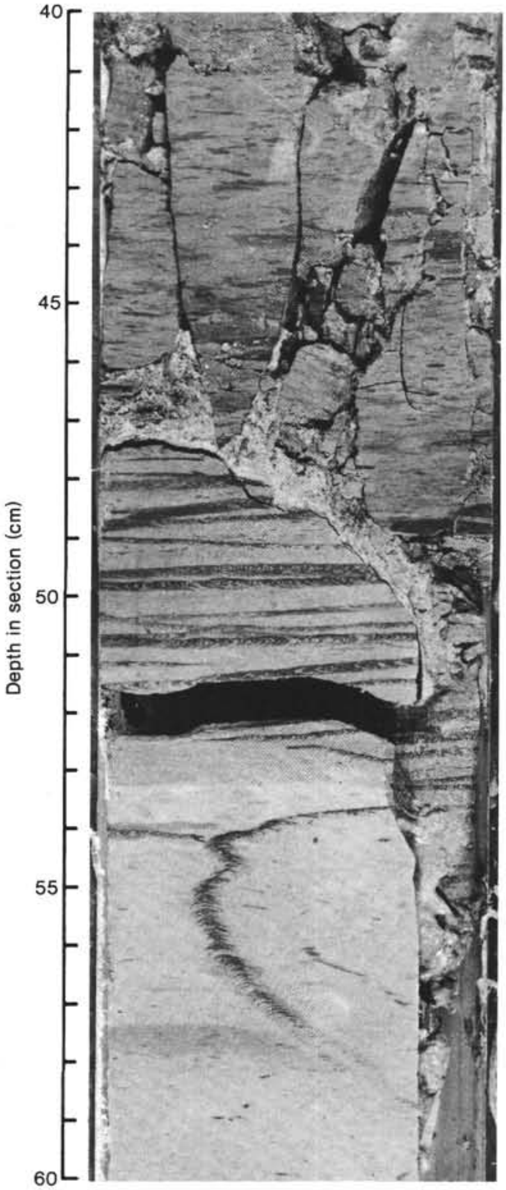


Figure 17. Contact between lithologic Units IV and V, in Sample 605-64-1, 40-60 cm, is placed at a color change at 53.2 cm. This color change is overlain by a severely bioturbated zone from 47-53 cm, so the lithologic contact has been somewhat arbitrarily defined. The interval between 47 and 54 cm is interpreted as the burrowed zone underneath an unconformity. This level coincide with reflection Horizon A*.

limestones of Unit IV, which have insignificant amounts of terrigenous silt and foraminifers. Sample 605-64-1, 47-54 cm is interpreted as being an unconformity, with a sharp basal color change topped by an interval with moderate to severe bioturbation by Zoophycos burrows, which appear to have penetrated from the overlying unit (Fig. 17; cf. Bruins et al., Lang and Wise; both this volume). The top of Unit V is arbitrarily placed at the sharp color change at 54 cm in Section 605-64-1, although it is possible that the contact may be anywhere within the bioturbated interval (47-54 cm).

Subunit VA (605-64-1, 54 cm to 605-66-1, 120 cm) is Paleocene silt-rich glauconite-bearing, clayey nannofossil limestone ("marly limestone") dark greenish gray (5G4/1 to 5G4.5/1), with moderate bioturbation. The uppermost 6 m of Subunit VA is a unique interval in which the silt and clay content decrease rapidly upward, distinct darker-sediment-filled burrows vanish, and the lithology changes from clayey nannofossil limestone to a very dense, light greenish gray (5GY 7/1) limestone with 99% carbonate. The uppermost 7 cm of this interval constitute the presumed unconformity discussed earlier. The transition between Subunits VA and VB is gradational, and the boundary has been arbitrarily placed at 605-66-1, 120 cm.

Smear-slide estimates of the composition of Subunit VA below the uppermost 6 m have a relatively narrow range: terrigenous silt of quartz and mica (10–32%, typically 15–20%), glauconite (2–3%), recrystallized radiolarians (2–3%), diatoms, fish debris (1-2%), and clay (20–60%, typically 35%). The total carbonate (20–45%, typically 40%) is composed of nannofossils (10–20% range), foraminifers (0–10%; typically 4%, with an increase in abundance in the basal transition zone of Section 605-66-1), and unidentifiable carbonate fragments or detritus (typically 15%). The ratio of silt plus clay to total carbonate is approximately 1:1, indicating that this lithology could also be called a calcareous mudstone.

Abundant burrows in this subunit are commonly filled by darker material, which is presumably slightly more clay-rich. The burrows are generally of subhorizontal types, though rare Zoophycos were recovered in Core 605-65. There is a vague indication of "cyclic" changes in the abundance of burrows and the darkness of the sediment.

The lowermost meter of Subunit VA is noteworthy in that this section contains the Cretaceous/Tertiary boundary. Shipboard analysis of the nannofossil content of smear slides indicated that the Maestrichtian/Danian contact in Site 605 occurs in Section 605-66-1, somewhere within a brecciated zone between 43 and 71 cm depth (Fig. 18). Because this contact is brecciated, it appears likely that, any "boundary clay", if originally present, was washed away by the drilling process. Basal Danian sediments in Section 605-66-1, are moderately burrowed, and contain more foraminiferal sand and glauconite silt than do the uppermost Maestrichtian sediments. There is also a slight color change at the boundary, from dark gray (5Y4.5/1), clay-rich, Maestrichtian nannofossil limestones to dark greenish gray (5G5/1), clayey Danian nannofossil limestones.

Section 605-66-1 also contains the gradational transition between Subunits VA and VB. Subunit VB (Samples 605-66-1, 120 cm through 605-71,CC) is olive gray (5Y 5/1, NS) clay-rich Maestrichtian, foraminifer-nannofossil limestone. The microfacies is a clay-rich pelagic foraminiferal packstone. Subunit VB differs in composition from Subunit VA in that VB sediments are richer in foraminifers and contain less terrigenous silt. The decrease in foraminiferal content and increase in silt is gradual, with transition occurring in Section 605-66-1. The Subunit VA/VB transition zone contains the Cretaceous/Tertiary boundary, as discussed earlier. The boundary between these two subunits has been arbitrarily placed at 605-66-1, 120 cm, at the approximate midpoint of a

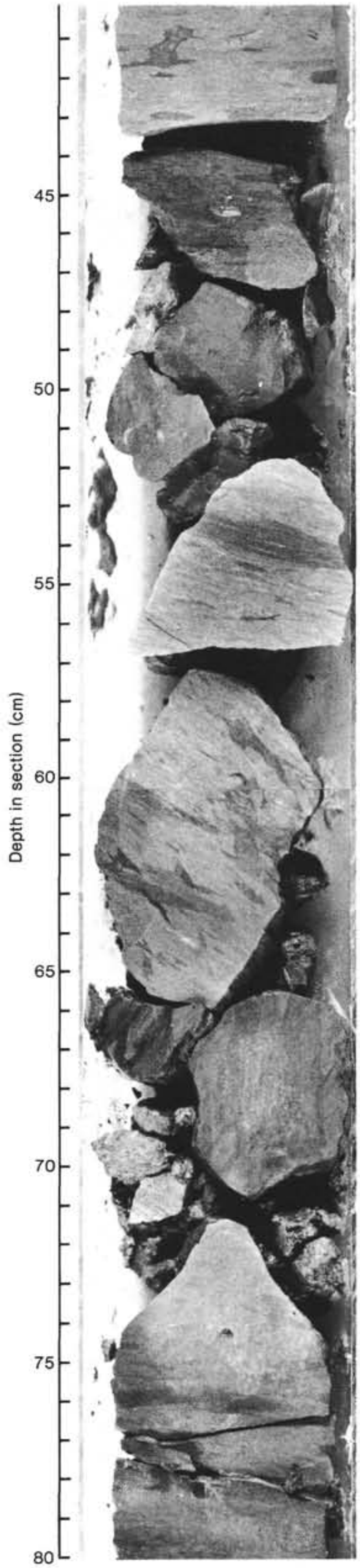


Figure 18. The Cretaceous/Tertiary boundary at Site 605 occurs in Section 605-66-1, somewhere in a brecciated interval between 43 and 71 cm. The sediments below 71 cm contain Maestrichtian nannofossils but the fragment between 65 and 71 cm contains Danian nannofossils, as did all other fragments in the brecciated interval. If a "boundary clay" lamina was originally present, it has apparently been lost in the drilling process.

brecciated zone. Below this poorly defined transition, the average composition has a typical range of clay (15-30%), foraminifers (10-25%), nannofossils (25-35%), and unspecified carbonate (15-30%). The total carbonate content (60-80%) in Subunit VB is approximately twice as much as in the overlying silt-rich Subunit VA, and the abundance of foraminifers and absence of terrigenous silt (maximum of 5%) are the distinguishing characteristics of VB. In addition, there are trace amounts of recrystallized radiolarians, glauconite, and pyrite.

As in Subunit VA, there is moderate bioturbation with a darker infilling of the burrows. Both vertical and horizontal burrows are abundant (Figs. 19, 20). Core 605-68 has beautifully preserved burrows including Planolites,

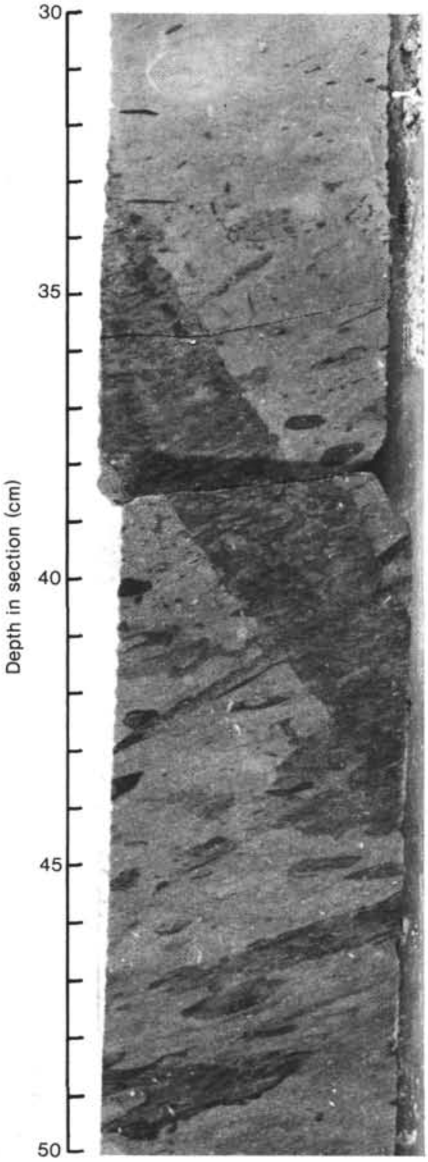


Figure 19. Subunit VB cores contain a number of burrow structures, including Chondrites, Planolites, and horizontal burrows with backfill structure (Muensteria). The subvertical burrow between 34 and 45 cm has subsequently been cut by at least two additional generations of burrows. Sample 605-68-6, 30-50 cm.

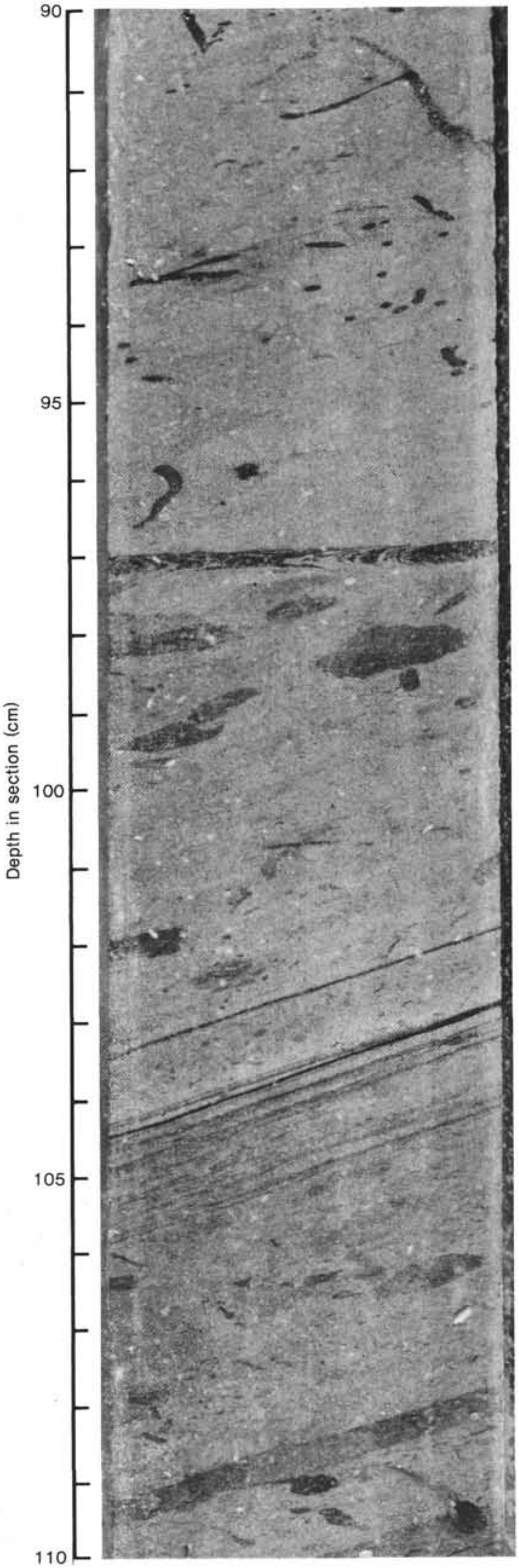


Figure 20. Subunit VB cores contain laminations with an apparent 10-15° dip (102 and 110 cm). Note clear Chondrites burrows (92-95 cm), Planolites (98-99 cm), and horizontal Muensteria burrows at 97 and 108 cm. Sample 605-69-2, 90-110 cm.

Chondrites, horizontal burrows with backfill structures (Muensteria?), and a large (2 × 4 cm) subvertical burrow which has been reworked by at least two additional generations of younger burrows (Fig. 19).

The uppermost cores (Cores 605-66 to -69) display "cycles" of lighter-colored, less bioturbated intervals alternating with darker, more heavily bioturbated intervals. In Core 605-68 there were 16 cycles, but below this core the "cycles" are much broader and are indistinct.

Core 605-69 has levels with lamination and cross-lamination (Fig. 20), which display an apparent 10–15° dip. Cores 605-70 and -71 have a similar apparent dip, estimated from the general tilt of subhorizontal burrows. Scattered microfaults occur throughout Subunit VB, as demonstrated by offset sediment laminae and offset burrows (Fig. 21).

BIOSTRATIGRAPHY[3]

Site 604 Summary

At Site 604, *Glomar Challenger* recovered sediment in 29 of 31 cores drilled by rotary drilling to a depth of 294.5 m in Hole 604, and four cores from a total penetration of 284.4 m in Hole 604A (Table 2). Calcareous nannofossils, diatoms, radiolarians, foraminifers, and silicoflagellates are present in each of the three lithologic units of these holes. Figure 7 summarizes Site 604 biostratigraphy.

Unit I extends from the sediment/water interface to 84 m sub-bottom (Core 604-1, top, to Sample 604-10-1, 7 cm). These sediments are late Pleistocene to middle Pleistocene in age, as is indicated by both the foraminifers and nannofossils. The foraminifers in Unit I are rare to abundant and show moderate preservation. Low P/B ratios, intervals that are barren of foraminifers, and the common occurrence of the benthic foraminifer genus *Elphidium* and other inner neritic forms indicate displacement from a littoral environment. The planktonic foraminiferal assemblage in Cores 604-3, -4, -7, and -8 is a cool-water assemblage. Reworked Eocene foraminifers are present in Core 604-2.

Nannofossils, which are relatively common and well preserved in Cores 604-1 through -5, decrease in abundance in Cores 604-5 through -9 and become rare in Core 604-10. Preservation in Cores 1 through 10 is moderate to poor. A light green clast of silty clay in Core 604-9 yielded abundant, well-preserved, Eocene calcareous nannofossils. Reworked mid-Eocene nannofossils are present throughout Cores 604-1 through -10.

Radiolarians are absent from Unit I or are present only as rare amounts of reworked Eocene specimens. Samples 604-2,CC and 604-6,CC contain Eocene radiolarians, possibly transported from Eocene material further up the continental slope from Site 604.

Unit II extends from 84.0 to 238.9 m sub-bottom (Sample 604-10-1, 7 cm to Sample 604-26-2, 46 cm) and is early Pleistocene to latest Miocene in age. The Pliocene/Pleistocene boundary is placed between Samples 604-18-2, 50–54 cm, and 604-18-3, 30–32 cm based on the last appearance datum (LAD) of *Discoaster brouweri*, or between Samples 604-17-2, 90–94 cm and 604-17-3, 90–96 cm based on foraminifers (Moullade, this volume). The nannofossil Miocene/Pliocene boundary occurs at the top of Core 25 based on the LAD of *Discoaster quinqueramus* and *D. berggrenii*. The Miocene/Pliocene boundary based on foraminifers occurs between Samples 604-23-3, 90–94 cm and 604-23-4, 90–94 cm (Moullade, this volume).

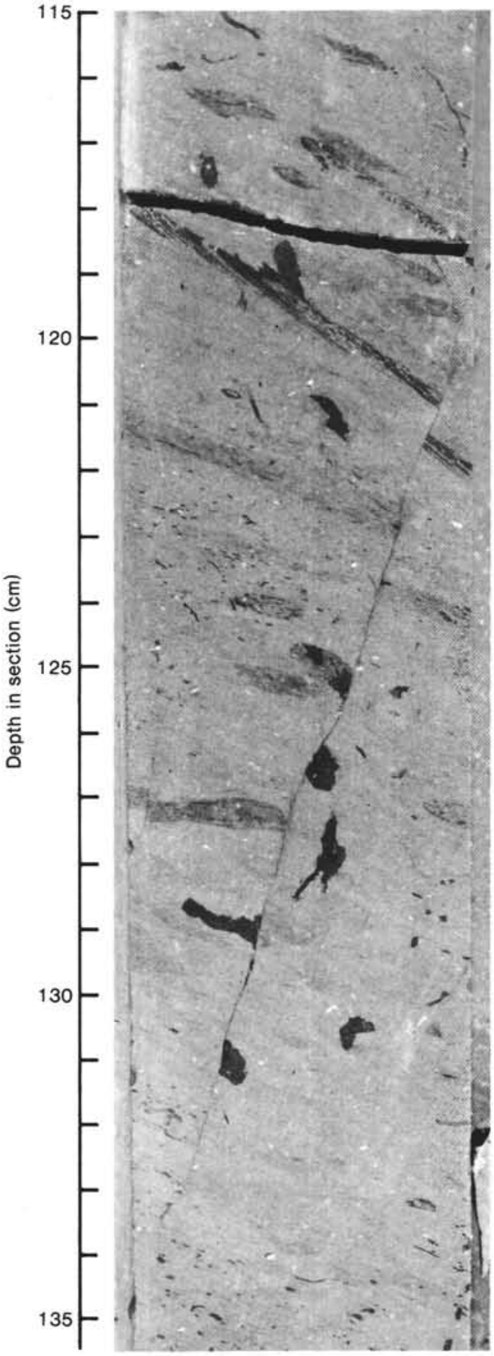


Figure 21. Microfaulted Maestrichtian limestones of Subunit VB, Site 605. Chondrites, Planolites, and Muensteria burrows are also seen in Sample 605-69-4, 115–135 cm.

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[3] For convenient cross-reference between chrono-, bio-, and seismostratigraphy we used the time scale of Vail and Mitchum (1979), unless otherwise stated.

Temporal control is good in Cores 604-11 through -20 using nannofossils. In Cores 604-21 through -26, it is not so accurate: calcareous microfossils are more poorly preserved and in lesser abundance because of an increase in the siliceous sediment component.

Foraminifers are sometimes absent or nondiagnostic in Cores 604-15 through -20. In general, the planktonic foraminiferal assemblage throughout Unit II is a cold-water assemblage.

The uppermost part of Unit II (Cores 604-10 to -13) is barren of radiolarians, except for reworked Eocene specimens in Samples 604-10,CC and 604-11,CC. Cores 604-14 to 604-24 are Pliocene, and the radiolarian Miocene/Pliocene boundary occurs between Cores 604-24,CC and 604-25,CC, as approximated by the base of the *Spongaster pentas* Zone. The lowermost part of Unit II contains upper Miocene Radiolaria.

The debris flows which comprise Unit III extend from 238.9 to 294.5 m sub-bottom (Sample 604-26-2, 46 cm through Core 604-31). The pelagic sediments of Unit III that could be interpreted as being *in situ* are late Miocene in age, the oldest being assigned to the Tortonian (calcareous nannofossil Zone CN7), the youngest possibly to the late Messinian–early Zanclean (radiolarian *Stichocorys peregrina* Zone, 604A-4,CC), but certainly not older than foraminiferal zone N17 (latest Tortonian–Messinian), which is identified in Core 604A-3. All elements of the debris flow will be either displaced or reworked. Reworked Eocene nannofossils, radiolarians, and foraminifers persist throughout this unit. The late Miocene microfossil assemblage contains sparse to few, poorly preserved to moderately preserved nannofossils, poorly preserved radiolarians and silicoflagellates, and poorly preserved foraminifers.

Site 605 Summary

Site 605 is located on the upper continental rise 6 km upslope of Site 604 on U.S.G.S. seismic profile 25. Site 605 was washed to a sub-bottom depth of 154.3 m (Core 1M), then continuously cored from 154.3 m to a total sub-bottom depth of 816.7 m (Table 3). The lithologic column was subdivided into five units. The biostratigraphic zonation for Site 605 is shown in Figure 10.

Unit I, Core 605-1 to Sample 605-6-4, 149 cm (0–198.5 m sub-bottom), is composed of gray silt-rich clay, Pleistocene in age. The foraminifers are dominated by a cold-water planktonic assemblage (no keeled globorotaliids). Displaced inner- to middle-shelf benthics are common, and at some levels reworked Eocene and Neogene plankton are found. The nannofossils in Cores 605-1 through Section 605-6-4 are middle Pleistocene in age. Nannofossils are rare to few in abundance; preservation ranges from poor to good. These cores contain intervals of reworked Eocene nannofossils. Radiolarians are absent in Unit I with the exception of Core 1, which contains a reworked Eocene assemblage.

Unit II is lower middle Eocene, greenish gray, biogenic-silica-rich nannofossil chalk (Samples 605-6-40, 149 cm to 605-22-3, 50 cm). The contact between Units I and II represents an abrupt lithologic change and stratigraphic hiatus. The foraminifers in Unit II are characteristic of a subtropical planktonic-rich assemblage which actually persists through Core 605-44. Benthics are rare or absent in most cores. Preservation is poor, in that many of the foraminifers are filled and coated with secondary calcite. Foraminifer Zone P13 to P10 are probably present. The nannofossils in Unit II illustrate the expanded nature of this lithologic unit, which was deposited within the time represented by the *Nannotetrina quadrata* Zone, spanning ~4 Ma. Nannofossils are relatively abundant in Unit II and preservation is moderate to good. The radiolarian assemblage is also representative of the middle Eocene. Radiolarian abundances are relatively common and preservation is moderate. The percentage of diatoms and silicoflagellates in the unit is also high. Diatoms are abundant and well preserved in Cores 605-7 through -21. Abundance decreases rapidly and preservation becomes poorer as the biogenic silica component of siliceous microfossils decreases toward the bottom of the section (Cores 605-22).

Unit III (Sample 605-22-3, 50 cm to 605-44-5, 33 cm) is composed of a rather monotonous, sometimes cyclic sequence of nannofossil limestone and chalk containing variable amounts of foraminifers and clay. Excellent temporal control is provided by the nannofossil assemblages, which indicate a middle early Eocene through early Eocene age for this unit. The foraminiferal assemblage in Unit III is rich in planktonics and representative of subtropical paleoenvironments. Abundances peak in the lower part of the interval, but in no case are foraminifers common. Preservation is poor as a result of diagenesis. The nannofossil assemblage in Unit III ranges from abundant to few and preservation ranges from good to poor. Abundance appears to be low in the top part of this section (Cores 605-22 through -28), increases through Core 605-35, decreases through Core 605-39, and again becomes abundant in Cores 605-40 through Core -44. Once again, the short time intervals represented between the nannofossil datums illustrate the expanded nature of this Eocene unit. Radiolarians are rare and poorly preserved throughout the entire unit. Except in a very few cases, they are not identifiable.

The Paleocene/Eocene boundary was placed between 605-44-1, 50–52 cm and 605-44-2, 50–52 cm, which probably lies within a continuous sequence in the lowermost part of lithologic Unit III. The early Eocene *Tribrachiatus contortus* nannofossil sedimentary subzone overlies the Paleocene *Discoaster multiradiatus* Zone. Unit IV (Sample 605-44-5, 33 cm to 605-64-1, 54 cm) is an upper Paleocene clayey nannofossil limestone. The entire upper Paleocene is represented by the foraminiferal and nannofossil assemblages of Unit IV, a fact which illustrates the expanded nature of the upper Paleocene sediments at Site 605. To the contrary, the lower Paleocene is thin and incomplete and we reached the K/T boundary by surprise. Benthic foraminifers dominate (up to 80%) in the lower portion of the section where the fauna is poorly preserved. The nannofossils are generally common to abundant and moderately preserved down through Core 605-63, but are poor in portions of the next two cores. Radiolarians are rare and poorly preserved from Cores 605-44 through -51. They are absent from Core 605-51 to the bottom of the hole.

Unit V is clay-rich foraminiferal–nannofossil limestone which ranges in age from early Paleocene through late Maestrichtian (Samples 605-64-1, 54 cm, through 605-71,CC). A reasonably complete Cretaceous/Tertiary boundary was recovered in Core 605-66, except that the core shattered at that point and the "boundary clay," if present, was washed away during drilling. At the contact, the foraminiferal *Globigerina eugubina* Zone (P1a) and the coccolith *Zygodiscus sigmoides* Zone (CP1) overlie the *Abathomphalus mayaroensis* and *Nephrolithus frequens* zones respectively. Foraminifers in Unit V are rather abundant, but preservation is poor as a result of diagenesis. The plankton-rich assemblage (90–95%) is dominated by forms representative of tropical/subtropical paleoenvironments. The nannofossils are relatively abundant and preservation is mostly moderate to good in Cores 605-64 through -71. Radiolaria are absent from Unit V sediments.

Foraminifers

Hole 604

The Quaternary and most of the Neogene were continuously cored in Hole 604. The foraminiferal content of the >160 μm size-fraction of all 29 cores was examined aboard ship. The foraminiferal content in the cores containing calcareous microfossils varied from rare to abundant, with moderate preservation. The percentage of planktonic foraminifers in core-catcher samples was also highly variable, ranging from 5 to 97% of the total fauna. No evidence of strong dissolution was observed in these cores. Any absence of foraminifers from Hole 604 cores is attributed to dilution by terrigenous materials, especially in those cores containing debris-flow deposits. For the planktonic foraminiferal distribution see Moullade (this volume).

Mud and water extracted from the liner and lying on the top of Core 604-1 yielded a relatively warm water, presumably Holocene and/or Recent foraminiferal association characterized by a very high percentage of planktonics. Among those, keeled species such as *Globorotalia tumida, G. menardii, G. truncatulinoides*, and *G. hirsuta* are present. Below this uppermost level, the planktonic populations from the Quaternary Cores 604-1 to -16 are mainly dominated by temperate to cold-water forms such as *G. inflata, Neogloboquadrina pachyderma*, and *Globigerina bulloides*. The warmer-water and biostratigraphically more significant forms are extremely rare or more often absent because of climatic conditions in the Quaternary, and a detailed subdivision of the 150-m-thick Quaternary sequence represented in Hole 604 has not been possible. However, we may assume that Cores 604-1 to -9 are of late Pleistocene age, based on the occurrence of pink specimens of *Globigerinoides ruber* (cf. Moullade, 1983) in these cores.

The Pliocene/Pleistocene boundary cannot be precisely located in Hole 604 by the distribution of foraminifers. However, the location of this boundary in Core 604-17 according to nannofossil data is consistent with the extinctions of *G.* gr. *obliquus* and *Neogloboquadrina humerosa* in Sample 604-13,CC and the first appearance of *N. dutertrei* in Sample 604-17,CC. *Globorotalia truncatulinoides*, a Pleistocene marker, is unfortunately (for climatic reasons) much too scarcely present in this hole, and its apparent absence in Cores 604-17 to -14 cannot be strictly interpreted in terms of biostratigraphic significance.

Shipboard examination of core-catcher samples indicates that the Quaternary strata, which are enriched in benthic foraminiferal content, are lithologically characterized by greater amounts of detrital material (quartz and micas) and glauconite; they also contain greater percentages of colder-water planktonic foraminifers. Furthermore, in these intervals the benthic foraminifer content is dominated by shallow-water genera, such as *Elphidium*, a fact which contradicts paleodepth estimates based on the present sub-bottom depth of the hole. Thus we are led to consider that these periodic enrichments in shallow-water benthics may result from inner-shelf transportation and redeposition in a bathyal environment by turbidity currents or downslope slumping. These periods of redeposition, in turn, coincide with colder climatic episodes.

The interval from the lower part of Core 604-17 to the upper part of Core 604-23 has been tentatively assigned a Pliocene age, based on the previously discussed foraminifer evidence for the Pliocene/Pleistocene boundary. The Miocene/Pliocene boundary occurs somewhere between Samples 604-23,CC and 604-22,CC based on the LAD of *Globigerina praebulloides* in 604-23,CC, the presence of *Sphaeroidinellopsis paenedehiscens* in Samples 604-23,CC and 604-22,CC, and the presence of *Globorotalia margaritae* in 604-22,CC. However, the presence or absence of the early Pliocene marker species *G. margaritae* should be evaluated with caution: because of climatic factors, this species is found only in Sample 604-22,CC (see Moullade, this volume).

The Pliocene sequence of Hole 604 has been subdivided into early Pliocene (foraminiferal Zones PL1–PL2), middle Pliocene (Zones PL3–PL4), and late Pliocene (Zones PL5–PL6), based on the occurrence of the late Pliocene marker species *Globorotalia tosaensis* and *G. miocenica*, the LADs of *Globoquadrina altispira* and *Sphaeroidinellopsis seminulina*, and the occurrence of the early Pliocene marker species *Globigerina nepenthes*.

Precise age estimates of Cores 604-24 to -31 are difficult to obtain, because the foraminiferal faunas in these cores are impoverished. Samples from several cores were barren, and in fossiliferous samples there is an apparent mixing of middle and late Miocene species, including *Catapsydrax* sp., *Globorotalia conoidea, Neogloboquadrina continuosa, G. mayeri, Globoquadrina dehiscens, G. baroemoenensis*, and *Globigerina praebulloides*. At the present stage of the investigation it is not yet possible to discern whether the deepest part of Hole 604 is effectively of middle Miocene age or if middle Miocene species have been reworked in strata of late Miocene age.

Hole 604A

Only one wash core and three rotary cores were taken at Hole 604A. Core 604A-1M corresponds to a drilled interval of about 250 m below the seafloor. Sample 604A-1M-1, 2–4 cm yielded a late Pleistocene to Holocene, mostly planktonic association, dispersed in an enormous amount of detrital quartz. Planktonics are here quantitatively dominated by *Globorotalia inflata*, with rare *Neogloboquadrina pachyderma* and *Globigerina bulloides*. Very rare *Globorotalia tumida, G. hirsuta*, and pink tests of *Globigerinoides ruber* were also present. Sample 604-1-2, 90–94 cm contained a few moderately well preserved foraminifers, including *Globigerina nepenthes, Sphaeroidinellopsis seminulina*, and possibly *G. praebulloides*. This is a rather nondiagnostic upper Miocene to lower Pliocene(?) microfauna. Sample 604-1,CC and Core 604-3 yielded a more significant late Miocene (foraminiferal Zone N17) assemblage, including *G. nepenthes, G. praebulloides, Globorotalia* gr. *cibaoensis–juanai, G. plesiotumida, G. conoidea, Globoquadrina dehiscens*, and *Orbulina suturalis*. This upper Miocene microfauna was characterized by a relatively important percentage of benthics, and was found in a strong detrital matrix with abundant quartz, glauconite, and clayey pebbles. Sample 604A-4,CC revealed only very rare and poorly preserved mid–late Miocene foraminifers, including *Globoquadrina dehiscens* and *Orbulina suturalis*, but no N17 zonal markers. The stratigraphic distribution of the planktonic foraminifers is shown in Figure 22A.

Site 605

Neogene–Quaternary

Neogene and Quaternary sediments were not the primary objective of drilling Hole 605 and, as a result, the uppermost 154.3 m of silty clays were washed before coring. The top of wash Core 605-1M yielded a Holocene to late Pleistocene foraminiferal assemblage dominated by the cold-water species *Globorotalia inflata* and *Globigerina bulloides*, with rare specimens of *Globorotalia tumida, G. menardii, G. truncatulinoides*, and pink tests of *Globigerinoides ruber*.

Cores 605-1 to -6 contain a relatively nondiagnostic late Pliocene–Pleistocene foraminiferal fauna dominated by cold-water, stratigraphically less significant species. The percentages of planktonic foraminifers in these cores are low, and most species are rare. Section 605-1-17 contains an anomalous fauna in which 90% of the planktonic foraminifers are reworked Eocene species with a few late Neogene to Quaternary species (*Globorotalia inflata, Neogloboquadrina pachyderma*).

Core 605-6 represents the basal Pleistocene, as shown by the presence of rare specimens of *Globigerinoides* sp. gr. *obliquus, Neogloboquadrina humerosa*, and *N. dutertrei*. An Eocene/Pleistocene unconformity is present in this core, marked by a change in color and lithology at Sample 605-6-4, 149 cm. Sample 605-6,CC contains an *in situ* middle Eocene foraminiferal fauna, as discussed below.

These data indicate that Site 605 was washed and cored through a 198.7-m-thick Quaternary sequence, unconformably overlying the Eocene (Fig. 22B).

Paleogene

Eocene

The lithologic composition of Units II (siliceous chalks) and III (limestones) made it very difficult to extract foraminifers from such a strongly recrystallized material. Foraminifers appeared to be recrystallized, filled and coated with calcite. Their abundance reached a maximum, together with a slightly better preservation, near the top and the bottom of the Eocene sequence.

The upper part of Unit II (Sample 605-6,CC to Core 605-12) yielded common to abundant, moderately to poorly preserved foraminifers, with predominant planktonics, including *Globorotalia bullbrooki, Truncorotaloides topilensis. T. rohri*, and *Globigerina frontosa*. Such an assemblage can be referred to the P12–P13 foraminiferal zones (early middle Eocene).

The lower part of lithologic Unit II (Cores 605-13 to -22) contained rare and poorly preserved foraminifers, mostly planktonics, with predominant *Globorotalia bullbrooki* and *Globigerina frontosa*. These relatively long ranging species characterize an interval which includes foraminiferal Zones P10 to P13 (early middle Eocene).

The majority of lithologic Unit III (Cores 605-23 to -41), yielded such badly preserved foraminifers, particularly the planktonics, that their identification was made practically impossible. However, *Globorotalia formosa formosa* was recognized in Sample 605-32,CC and *G. caucasica* and *G. quetra* in Sample 605-38,CC. These taxonomic attributions point to a P7–P9 zonal assignment (early Eocene) for Cores 605-32 to -38.

Cores 605-42 to Section 605-44-4 yielded more abundant and still poorly preserved but more easily identifiable foraminifers. *Globorotalia aequa, G. subbotinae, G. pseudotopilensis, G. formosa gracilis, G. marginodentata, G. wilcoxensis*, and *G. broedermanni* were the most representative planktonics in these cores. This assemblage is representative of foraminiferal Subzone P6b (earliest early Eocene).

More detailed shore-based investigation of the benthic foraminifers of lithologic Units II and III is given by Hulsbos (this volume).

Paleocene

Sediments from lithologic Units IV and V (Sample 605-44,CC to Section 605-66-1) contain rare to sometimes common, still poorly preserved but more easily identifiable planktonic and benthic foraminifers. For this section, preliminary shipboard results have been combined with the initial results of more detailed shore-based studies conducted by P. Saint-Marc and M. Moullade for the Paleocene and by H. Janssen and D. Kroon for the Cretaceous/Tertiary boundary. As a result, almost all the Paleocene foraminiferal zones were individually recognized and delineated in the sequence which was cored in Hole 605 (see Saint-Marc, this volume). Section

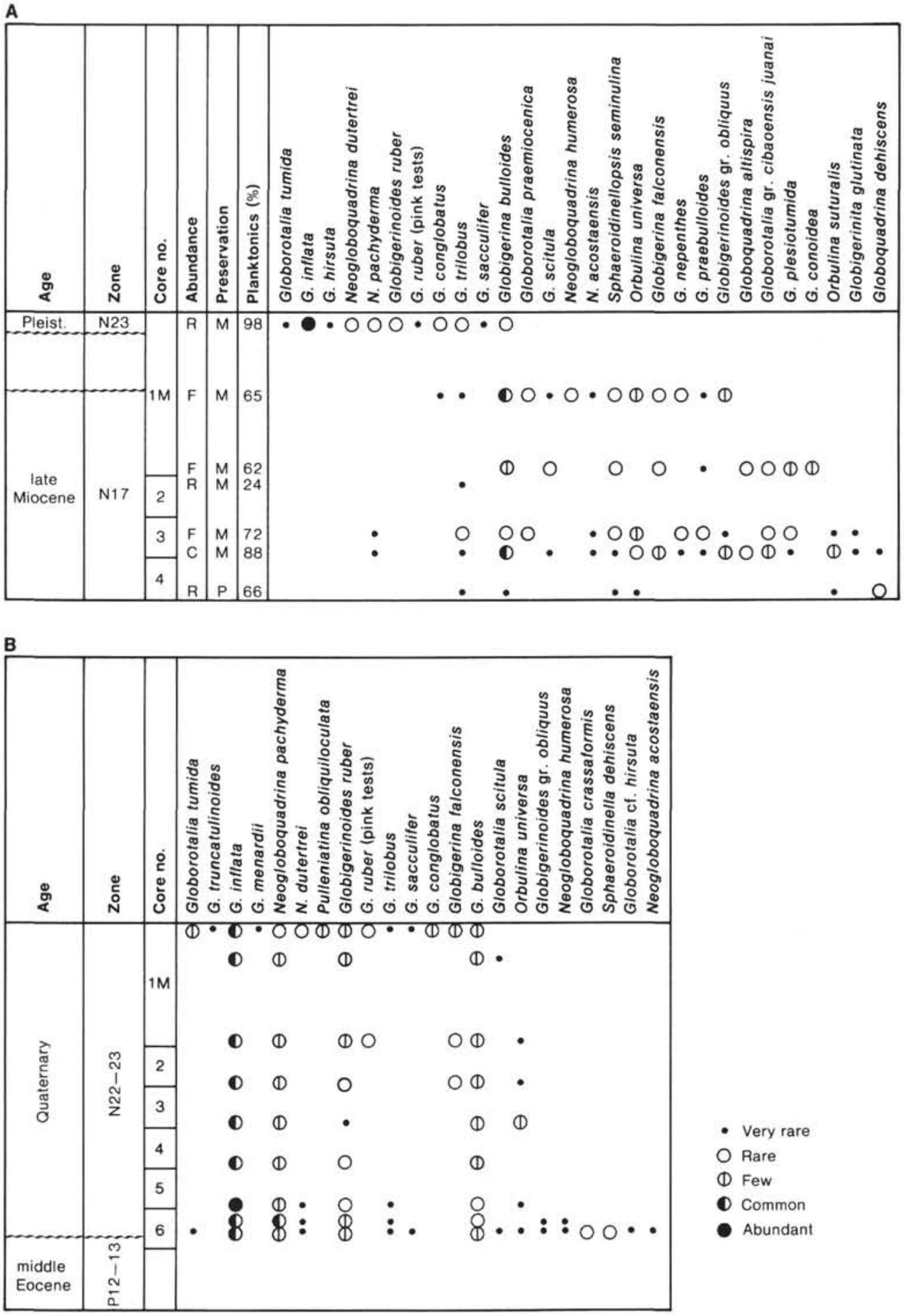


Figure 22. Distribution of planktonic foraminifers in (A) Hole 604A, (B) Hole 605. No vertical scale.

605-44-6 to Core 605-45 contain *Globorotalia velascoensis*, *G.* cf. *occlusa*, *G. aequa*, *G. subbotinae*, and (in the upper part only) *G. pseudotopilensis*, and thus belong to the late Paleocene P6a Subzone. Then a short interval, represented by the upper part of Core 605-46, yielded most of the species cited above, with the exception of *G. subbotinae*, and therefore corresponds to the P5 Zone. A thick interval from the lower part of Core 605-46 to Core 605-56 corresponds to the stratigraphic range of *Globorotalia pseudomenardii*, index marker of foraminiferal Zone P4, accompanied by *G. pusilla pusilla*, *G. chapmani*, *G. acuta*, *Globigerina velascoensis*, and *G. mckannai*. In addition, *Globorotalia velascoensis*, *G.* cf. *occlusa*, *G. aequa*, and *Globigerina nitida* first appear in the middle part of this zone, and *Globorotalia conicotruncana* and *Globigerina triloculinoides* become extinct about 20 to 30 m below the top of Zone P4.

Cores 605-57 to -62 were attributed to foraminiferal Zone P3, on the basis of the co-occurrence of *Globorotalia pusilla pusilla, G.* cf. *angulata, G. conicotruncana, G. chapmani*, and *G.* cf. *compressa*.

The interval including Core 605-63 and the upper part of Core 605-64 seems to correspond to Zone P2, for Sample 605-64-2, 90–92 cm contains *Globorotalia* cf. *uncinata*, the zonal marker, plus *G. pseudobulloides, G.* cf. *inconstans*, and *G. trinidadensis*. However, the attribution of the upper part of this interval, devoid of foraminifers, to Zone P2 remains questionable.

Sample 605-64,CC contains the same assemblage as Sample 605-64-2, 90–92 cm, with the exception of *G.* cf. *uncinata*, and is thus attributed to the upper part of Zone P1 (= *G. trinidadensis* Subzone). Sample 605-64-4, 90–92 cm was devoid of planktonic foraminifers and showed only strongly dissolved benthics. Core 605-65 can be attributed to the middle part of Zone P1 (= *G. pseudobulloides* Subzone) because the zonal marker occurs; *Globigerina daubjergensis, G. triloculinoides*, and *G.* cf. *fringa* were also found in this interval.

The uppermost 75 cm of Section 605-66-1 were studied in more detail by Smit and Van Kempen (this volume). Most of this interval belongs to the *Globorotalia pseudobulloides* Subzone P1c of Smit and Romein (1985). Their zonal subdivisions P1b and P1a have not yet been identified in the 605 sequence, but one chip of sediment (Sample 605-66-1, 73–74 cm; see Fig. 18) located just above the Cretaceous/Tertiary boundary (as defined on the basis of shipboard observations) yielded foraminifers from the P0 *(Guembelitria cretacea)* Zone.

The relatively precise biostratigraphic control for the Paleocene sequence cored in Hole 605 permitted us better to discern some variations in the sedimentation rates. Considering the usually accepted duration of the Paleocene foraminiferal zones, the sedimentation rate seems to have been at a maximum during the middle part of the Paleocene (Zones P3 and P4), with an approximate accumulation rate of 50 m/Ma. In Zones P1 and P2, the sedimentation rate dropped to 6 m/Ma. On the other hand, a condensed sedimentary section or even a hiatus may be suspected in the upper Paleocene, as indicated by the reduced thickness of foraminiferal Zone P5 sediments.

Cretaceous

Completing the preliminary shipboard observations, data obtained by shore-based investigations conducted by H. Jansen and D. Kroon (this volume) have been included in this site chapter. Samples taken from Sections 605-66-2 to 605-69-4 contain rare specimens of *Abathomphalus mayaroensis*, together with *Rugoglobigerina scotti* and *Planoglobulina fructicosa*, which indicates that this interval is part of the late Maestrichtian *A. mayaroensis* Zone (UC 17). Thus the remaining interval from Section 605-69-5 to the bottom of Hole 605 (Sample 605-71,CC) should be assigned to the Maestrichtian *Globotruncana stuarti* Zone (UC 15). In this interpretation, the occurrence of rare and isolated specimens of *A. mayaroensis* in Sample 605-71,CC is considered to result from downhole contamination.

Calcareous Nannofossils

Site 604

Drilling in Hole 604 recovered 29 sediment cores containing few to abundant nannofossils of late Miocene to Quaternary age but was terminated prematurely after the drill bit had penetrated 55.6 m into a series of debris flows estimated to be some 200 m thick. The first 18 cores contain common Pleistocene nannofossils with a few scattered layers of reworked or redeposited Eocene sediment. In Cores 604-18 to -22, the dominant assemblage is Pliocene, but sporadic Pleistocene forms are also present. Cores 604-25 to -28 contain upper Miocene coccolith assemblages with a significant reworked component, particularly in the debris flows below Sample 604-26-2, 46 cm. Assuming that the lowermost sample from the debris flows, Sample 604-30-1, 79–80 cm, represents a true *in situ* assemblage, it is assigned to the *Discoaster hamatus* Zone (CN7; lower Tortonian).

The upper part of Core 604-1 down to Sample 604-1-1, 84–87 cm contains Quaternary forms, such as *Syracosphaera pulchra, Gephyrocapsa oceanica, G. caribbeanica, Calcidiscus leptoporus, Ceratolithus cristatus*, and *Pontosphaera japonica*. This interval is assigned to the *G. oceanica* or *huxleyi* zones. Future examination of prepared samples with the scanning electron microscope should confirm or deny the presence of the late Holocene marker, *Emiliania huxleyi*.

Samples 604-1-1, 110–112 cm and 604-1-1, 130 cm contain a well-developed Eocene assemblage in an allochthonous nannofossil ooze, which probably represents transported Eocene sediments exposed further up the continental slope from Site 604. Nannoliths observed from this interval include *Discoaster barbadiensis, D. saipanensis, Reticulofenestra umbilica, R. reticulata, Coccolithus formosus, Isthmolithus recurvus, Campylosphaera dela, Rhabdosphaera tenuis, Chiasmolithus grandis, Discolithina pulcher*, and *Zygolithus dubius*. Core 5 also contains an interval of redeposited Eocene sediments. Samples 604-5-2, 50–54 cm through 604-5-2, 110–112 cm contain Eocene forms similar to the ones mentioned above from Core 1.

The highest occurring Pliocene forms were observed in Core 18. Sample 604-18-3, 30–32 cm contains *Discoaster brouweri* in its six-rayed form. Sample 604-18-4, 50–54 cm contains numerous triradiate forms of *D. brouweri*. It has been suggested that this may indicate a useful horizon to establish the Pliocene/Pleistocene boundary (Backman and Shackleton, 1983), particularly where reworking is a problem. In our section, however, it has been possible to subdivide the *D. brouweri* Zone, which extends down to Sample 604-19-5, 50 cm, into at least three subzones. Species most often encountered include *D. brouweri, D. surculus, D. pentaradiatus*, and *Calcidiscus macintyrei*. Cores 604-20 and -21 contain assemblages that include the forms above with the addition of *Reticulofenestra pseudoumbilica* and *D. asymmetricus* are assigned to the *R. pseudoumbilica* Zone (CN11).

Cores 604-22 through -24 yielded a diverse but rare assemblage of amauroliths and are assigned to the *Amaurolithus tricorniculatus* Zone (CN10). The assemblage includes *Discoaster intercalaris, A. primus, D. surculus, C. macintyrei, R. pseudoumbilica*, and *A. delicatus*. A few reworked Eocene species are also present.

Samples from Core 25 lack amauroliths and contain only rare discoasters such as *D. surculus* and *D. berggrenii* and are assigned to the *D. quinqueramus* Zone (CN9).

Sample 604-26-2, 120 cm, from an Eocene chalk cobble within a debris flow, contains an Eocene assemblage of the *Isthmolithus recurvus* Subzone (CP15b). Eocene species include *I. recurvus, Chiasmolithus oamaruensis, D. barbadiensis, Coccolithus formosa, D. tani*, and *R. reticulata*. The underlying sample, 604-26-2, 146 cm, contains what is believed to be an *in situ* Miocene assemblage of the *D. neohamatus* Zone (CN8). Species in this population include *D. bollii, D. neohamatus*, and *D. calcaris*. Another Eocene clast sampled at 604-26-3, 18 cm is underlain by more sediment assigned to CN8 (down to Sample 604-27-1, 138 cm). The samples examined from Cores 604-28 and -30 (there was no recovery in Core 29) are early Tortonian in age (CN7).

The difficulties in dating the upper Miocene section are considerable. Virtually every sample shows evidence of either reworking or redeposition. Recovery was especially poor, except for Cores 604-25 and -26. If our late Miocene dates are correct and if the samples dated indeed contain mostly *in situ* coccolith assemblages, then the debris flows we penetrated at Site 604 are early Tortonian in age.

Four cores cut in Hole 604A recovered short segments of the lower Pliocene–upper Miocene section before the hole was abandoned because of the poor drilling conditions. The lowest core dated (Core 604A-3) contained coccoliths of the *D. neohamatus* Zone (CN8).

Site 605

In Hole 605, calcareous nannofossils are common to abundant in the Paleogene chalks below Section 605-6-4. Preservation throughout the cored interval fluctuated from moderate to poor, with a distinct decrease in the quality of preservation in samples from the lower Eocene interval.

Quaternary forms are typical from the top of the hole down to 605-6-4, 127 cm. Sample 605-6-4, 150 cm contains middle Eocene nannofossils of the *Chiasmolithus gigas* Subzone (CP13b) of the *Nannotetrina quadrata* Zone (CP13). Species present in Zone CP13 down to 605-22-3, 110–111 cm include *Chiasmolithus grandis, C. solitus, Coccolithus pelagicus, C. formosus, Discoaster barbadiensis, D. saipanensis*, and *Zygrhablithus bijugatus*. Preservation in this interval is poor to moderate. Many of the discoasters are overgrown and placoliths are often etched. The *D. sublodoensis* Zone (CP12) spans the interval from 605-22-4, 20–21 cm to 605-31-4, 50–52 cm. Species common in this zone include *Chiasmolithus grandis, C. solitus, Coccolithus pelagicus, C. formosus, D. barbadiensis, D. sublodoensis, Neococcolithus dubius*, and *Sphenolithus radians*. Preservation in this interval is poor to moderate. The *D. lodoensis* Zone (CP11) spans the interval from 605-31-5, 50–52 cm to 605-36-2, 50–52 cm. The first occurrence of *C. formosus* is used to approximate the base of CP11. The interval from 605-36-2, 50–52 cm to 605-42-1, 50–52 cm is assigned to the *Tribrachiatus orthostylus* Zone (CP10). Species observed within this zone include *Chiasmolithus consuetus, Coccolithus pelagicus, D. lodoensis, D. barbadiensis*, and *T. orthostylus*. The lowermost Eocene zone, the *D. diastypus* Zone (CP9), spans the interval from 605-42-2, 50–52 cm to 605-44-1, 50–52 cm. Preservation is poor to moderate, and common species in this interval include *Chiasmolithus consuetus, Coccolithus pelagicus, D. barbadiensis, D. binodosus, D. diastypus, Tribrachiatus orthostylus*, and *Zygrhablithus bijugatus*.

The Paleocene/Eocene boundary is coincident with the boundary between this and the underlying *D. multiradiatus* Zone (CP8), and lies between 605-44-1, 50–52 cm and 605-44-2, 50–52 cm. Nannofossils of the upper Paleocene *D. multiradiatus* Zone persist in samples from 605-44-2, 50–52 cm to 605-48-4, 110–112 cm. Species present in this interval include *Discoaster multiradiatus, D. nobilis, Campylosphaera eodela, Chiasmolithus bidens, C. consuetus, Coccolithus pelagicus*, and *Toweius eminens*. Samples from 605-48,CC through 605-49-2, 110–112 cm lack *D. multiradiatus* and are placed in the *D. nobilis* Zone (CP7). Save for the lack of *D. multiradiatus* and *Campylosphaera eodela*, the assemblage in this zone is similar to that of the overlying interval. The boundary between the *D. nobilis* Zone (CP7) and the *D. mohleri* Zone (CP6) at this site falls between 605-49-2, 110–112 cm and 605-49-3, 50–52 cm. The *D. mohleri* Zone spans the interval from Sample 605-49-3, 50–52 cm to Sample 605-50-5, 50–52 cm. Sediments of the underlying *Heliolithus kleinpellii* Zone (CP5) are first encountered in 605-50-6, 110–112 cm. An assemblage characteristic of this zone persists down to 605-56-2, 50–52 cm. Species composing this assemblage include *Fasciculithus tympaniformis, Chiasmolithus consuetus, Cruciplacolithus tenuis, Zygodiscus sigmoides*, and numerous specimens of *H. kleinpellii*. The *F. tympaniformis* Zone (CP4) encompasses samples from 605-55-4, 50–52 cm to 605-63-2, 50–52 cm. The population is the same as that of the overlying *H. kleinpellii* Zone except that *H. kleinpellii* is absent. The interval from 605-63-4, 50–52 cm to 605-64-4, 50–52 cm is placed within the combined *Ellipsolithus macellus/Chiasmolithus danicus* zones (CP3–CP2). Preservation within this interval is typically poor, and the occurrence of *E. macellus*, a delicate form highly susceptible to dissolution, is thus heavily influenced by secondary alteration. The earliest Paleocene *Cruciplacolithus tenuis* Subzone (CP1b) spans the interval from below 605-64-5, 110–112 cm to 605-66-1, 21–23 cm.

The highest occurrence of definitively Cretaceous nannofossils occurs in 605-66-1, 70–71 cm. The interval from this sample to the top of Section 605-66-1 contains rare Cretaceous and Paleocene forms and a large number of thoracosphaerids.

Samples from 605-66-1, 70–71 cm through 605-67-3, 126–127 cm contain the latest Cretaceous marker species, *Nephrolithus frequens*, and are assigned to the zone of the same name. Samples from the interval below 605-67-3, 126–127 cm to the termination of drilling are assigned to the *Lithraphidites quadratus* Zone.

Radiolarians

Site 604

Core-catcher samples (or, in some cases, the deepest material in the core liner) were studied aboard ship for all cores taken at Site 604. All 31 core-catcher samples from Hole 604 were examined. A water sample taken from the top of Core 1, while the liner was still in the coring device, contained a few Pliocene to Recent radiolarians with moderate preservation, including *Didymocyrtis tetrathalamus, Dictyophimus crisiae*, and *Phormocyrtis* sp.

In general, radiolarians are absent or rare in the uppermost 13 cores of this hole. Samples 604-2,CC, 604-6,CC, 604-10,CC and 604-11,CC, contain reworked Eocene radiolarian assemblages with *Thyrsocyrtis rhizodon, Podocyrtis diamesa, Theocampe* sp., and *Euchitonia* sp.

Sample 604-14,CC contains common radiolarians with moderate preservation, and is of Pliocene to Recent age. This sample contains *Spongaster tetras, Anthocyrtidium* sp., and *Didymocyrtis tetrathalamus* along with reworked Eocene radiolarians.

Cores 604-15 to -20 have common radiolarian assemblages with good to moderate preservation. Samples 604-21,CC to 604-24,CC are of early Pliocene age, and contain *S. pentas, Stichocorys peregrina*, and *Lamprocyrtis heteroporos*. Based on these identifications, Cores 604-21 to -24 are placed in the *Spongaster pentas* Zone. These samples also contain reworked Eocene (*Podocyrtis papalis, Phormocyrtis striata, Theocampe* sp., *Periphaena* sp.), and Miocene (*Cyrtocapsella tetrapera*) radiolarians.

The first appearance of *S. pentas* marks the base of the *S. pentas* Zone, and approximates the Miocene/Pliocene boundary. This event occurs somewhere between Samples 604-24,CC and 604-25,CC. Samples 604-25,CC and 604-26-1, 54–56 cm are in the late Miocene *Stichocorys peregrina* Zone, as indicated by the presence of *S. peregrina, Stichocorys* sp., and *Acrobotrys* sp. These samples also contain reworked late Miocene radiolarians (*Diartus hughesi* and *Didymocyrtis antepenultima*).

Sample 604-26,CC is effectively barren of Radiolaria, and 604-27-1, 55–57 cm contains only a few reworked Eocene radiolarians, including *Dictyoprora mongolfieri, Liriospyris geniculosa, Podocyrtis papalis*, and *P. sinuosa*, with moderate preservation of the individual specimens. All deeper samples in Hole 604 (604-27,CC, 604-28,CC, and 604-30,CC) were barren.

Hole 604A

Four core-catcher samples from Hole 604A were examined for Radiolaria. Core 1 of this hole was a wash core obtained by drilling from the seafloor to 249.6 m sub-bottom; this sample contained abundant early Pliocene Radiolaria, including six-rayed *Spongaster pentas, S. tetrathalamus, Anthocyrtidium* sp., and *Stichocorys peregrina*. Based on these species, this material would be in the *Spongaster pentas* Zone. However, the sample also contained reworked late Miocene (*Didymocyrtis antepenultima, D. penultima*) and Eocene (*Podocyrtis papalis*) radiolarians.

The trace of material recovered by drilling Core 2 from 249.6 to 259.2 m sub-bottom is also from the early Pliocene *Spongaster pentas* Zone. Sample 604A-3,CC contained only reworked Eocene radiolarians.

604A-4,CC is of late Miocene age, and contains common but poorly preserved radiolarians belonging to the *Stichocorys peregrina* Zone. These include *S. peregrina, Stichocorys* sp., and circular specimens of *Spongaster* sp. Sample 604A-4,CC also contains reworked Eocene specimens of *Podocyrtis papalis, Lychnocanoma babylonis*, and *L. bellum*.

Site 605

Strewn slides of 65 core-catcher samples of Cenozoic sediment in Site 605 were examined for their radiolarian content. In general, this site has very poorly preserved siliceous microfossils. Core-catcher samples from Cores 1 to 5 of Site 605 are barren.

Cores 6 to 21 contain common to abundant radiolarian assemblages with good to moderate preservation. Radiolaria in these cores include *Dictyoprora mongolfieri, D. amphora, Thyrsocyrtis triacantha, T. hirsuta hirsuta, T. hirsuta robusta, Podocyrtis diamesa*, and *P. papalis*. Based on these species, these sediments are latest early Eocene (*D. montgolfieri* Zone) to earliest middle Eocene (*T. triacantha* Zone) in age. Differentiation between these two zones is not possible because *Eusyringium lagena* or *Theocorys anaclasta* are missing in these samples. Despite this difficulty, it appears that there was a major peak in the accumulation of siliceous sediments at Site 605 during the early to middle Eocene.

All Cenozoic sediments below this material (Cores 22 to 65) are either barren or contain rare, poorly preserved spumellarian radiolarians that are not age-diagnostic. Samples 605-27,CC and 605-28,CC may be tentatively identified as being early Eocene in age, based on the presence of *Dorcadospyris angisca* (Goll, 1968).

Silicoflagellates and Ebridians

Site 604

Silicoflagellates were examined from Cores 604-21 to -26, where forms were generally sparse, except in Section 604-25-4, which contained common silicoflagellates. Samples from Sections 604-21-1 through 604-23-2 were assigned to the Pliocene *Dictyocha fibula* Zone; samples from Section 604-23-3 through 604-26,CC, were assigned to the late Miocene *Dictyocha brevispina* Zone.

Site 605

Silicoflagellates were present in rather small numbers in the biosiliceous nannofossil chalks between Cores 605-7 and -21. In general, ebridians, strongly dominated by *Ebriopsis antigua antigua*, were more numerous than silicoflagellates. Silicoflagellates were generally dominated by *Naviculopsis foliacea* with *Corbisema tricantha* common to abundant between Cores 605-10 and -14. Cores 605-7 through -21 can be assigned to the Eocene *Naviculopsis foliacea* Zone of Bukry (1981).

Diatoms

Hole 604

Diatoms in Hole 604 are sparse and mostly reworked from older strata except for some forms toward the base of the hole. Diatoms in the Pleistocene sediments of Cores 604-4 to -11 are all reworked from the upper and middle Miocene. Diatoms in the Pleistocene to upper Miocene sediments of Cores 604-13 to -25 are characteristic of the middle to upper Miocene and Eocene. Cores 604-25 to -30 contain forms no older than middle Miocene, except for species obviously reworked from the Eocene.

Hole 605

Diatoms were observed in 30 samples from Hole 605. In the interval between 202.61 m and 349.51 m sub-bottom depth (Cores 605-7 to -22), diatoms are abundant and moderately to well preserved except for Core 22, where abundance and preservation drastically diminish. The age of the interval is early middle Eocene; it can be assigned to the *Brightwellia hyperborea* Zone of Gombos (1983). The *B. hyperborea* Zone in Hole 390A (Blake Plateau) has been correlated with foraminifer Zones P11 and P10 and Martini's (1971) nannofossil Zone NP15. No indication of stratigraphic breaks was indicated by the distribution of diatoms in Hole 605.

At present, no formal diatom zonation has been established for the Eocene.

SEDIMENT ACCUMULATION RATES

Site 604

The Site 604 sediment accumulation diagram (Fig. 23) is based on selected nannofossil biohorizons. Numeric ages are based on the scale of Vail and Mitchum (1979). Accumulation rates are difficult to determine for this site because reworked material is present throughout the entire drilled interval. Accumulation rates for the entire Pleistocene (i.e., sediment/water interface to 162 m sub-bottom) average 9 cm/10^3 years. Pliocene sedimentation rates average 1.9 cm/10^3 years, and extrapolating these rates to the top of the debris flow at 239 m (dashed line in Fig. 22) gives an age of 5.9 Ma for this deposit. Using the foraminiferal dates for the top of Zone N18, the calculated estimate for the age of the top of Unit III would be 6.6 Ma. See Moullade (this volume) for detailed curve based on foraminiferal datums.

Site 605

The sediment accumulation rates for Site 605 are calculated using the time scale of Vail and Mitchum (1979). The average rate of accumulation of the Pleistocene is about 10 cm/10^3 years, using selected nannofossil biohorizons or the fact that basal Pleistocene foraminifers occur above the unconformity. An unconformity has removed the late Eocene to Pliocene sedimentary record at this site. Estimating, from shipboard nannofossil and foraminifer data, that we entered the Eocene below the top of the Lutetian (at ~46 Ma), the average rate at which the 150 m of middle Eocene sediment accumulated is 5 cm/10^3 years. The lower Eocene between 350 and 565 m accumulated at an average rate of 4.8 cm/10^3 years. See Bruins et al. (this volume) for a discussion of the Paleocene and Cretaceous accumulation rates at Site 605.

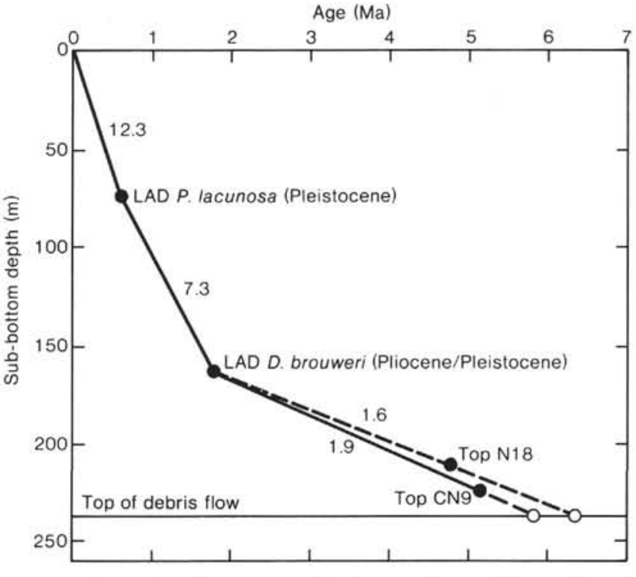


Figure 23. Site 604 sediment accumulation rates (in cm/10^3 years) based on nannofossil biostratigraphy.

GEOCHEMISTRY

Site 604

Shipboard geochemical measurements were made of interstitial gases, organic carbon concentrations and C/N ratios in organic matter, calcium carbonate concentrations, and geochemical properties of interstitial water samples.

Interstitial Gases

Concentrations of interstitial gases were low. Core sections were not sampled until they had been warmed in the core lab in order to obtain enough gas to allow analysis. The composition of the interstitial gases was almost totally CH_4 and CO_2, and no H_2S odor was noticeable. These biogenic gases could not be accurately quantified because of their low volumes and the way in which they were sampled.

Organic Carbon and Nitrogen

Concentrations of organic carbon in sediments from Site 604 average 0.65% and vary between 0.06 and 2.11% (Appendix II). Little relationship exists between these concentrations and sub-bottom depth, except for the interval between ~170 and 240 m (Cores 604-19 to -26), where relatively high values of 0.94 to 2.11% consistently appear. C/N ratios range between 7.8 and 23.5 and, like organic carbon concentrations, are not related to sediment depth. The C/N values average 13.8 and indicate that the organic matter in these sediments is a mixture of continental and/or marine material. The variability in concentrations of organic carbon and in C/N ratios suggests that the proportions of terrigenous and aquatic sediments in Cores 604-1 to -26 have fluctuated over the period of time represented by this 250-m-thick sequence of sediment.

Carbonate Carbon

Concentrations of calcium carbonate generally vary between 2 and 19% in Site 604 sediments, but one exceptionally high value of 59% is recorded in Sample 604-27-1, 75–78 cm (Appendix II). For the most part, carbonates are minor constituents of these sediments, even though this site has always been above the CCD.

Interstitial Water

Five samples of interstitial water were squeezed from sediments from Site 604. Values of pH, alkalinity, chlorinity, and concentrations of Ca^{++} and Mg^{++} are shown in Figure 24. Neither pH nor chlorinity deviate significantly with depth from values typical of seawater. Alkalinity is unexplainably higher than expected, and both calcium and magnesium are lower than expected. The concentrations of Ca^{++} and Mg^{++} begin to increase and decrease, respectively, in response to the diagenetic changes common in marine sediments (cf. Gieskes et al., 1982).

Site 605

Geochemical measurements at Site 605 were not done aboard ship because of the limited amount of time between this site and the end of the cruise. Samples were collected, however, for subsequent shore-based analyses of carbonate and organic carbon contents of sediments. Furthermore, none of the core sections at Site 605 gave evidence of abundant biogenic or thermogenic gases. We encountered no hydrogen sulfide odor, no extensive gas pockets, nor extrusion of cores when they warmed to ambient temperature.

Organic Carbon and Nitrogen

Concentrations of organic carbon are low in most Site 605 samples (Appendix II). The range of values of the 108 samples analyzed on shore is from 0.08 to 0.60 wt.%, and the mean is 0.22 ± 0.10%, slightly below the mean of 0.3% calculated by McIver (1975) for DSDP Legs 1 through 31. Although organic carbon concentrations are generally variable throughout Site 605 sediments, those in the upper six cores are consistently greater than the mean value. A similar trend toward decreasing concentrations over the topmost sediment sections also exists at Site 603 (site chapter, this volume) and has been described for Leg 58 sediments from the western North Pacific (Waples and Sloan, 1980). Such downhole decreases are attributed to continued microbial degradation of organic matter after its burial in the seafloor.

Atomic C/N ratios of the organic matter contents of Site 605 sediments average 25.4 ± 14.6 for the 105 samples which had measurable nitrogen contents. This value is higher than those found in sediments of similar age at Sites 603 and 604 (site chapter, this volume) and is characteristic of land-plant organic material (Müller, 1977). C/N values, however, are quite variable at Site 605, ranging from 4.5 to over 100. This variability in C/N ratios, when combined with the general variability of organic carbon concentrations, suggests fluctuations in the proportions of marine and continental contributions of organic matter to the sediments at this continental margin site.

PHYSICAL PROPERTIES

Site 604

The following physical properties were studied at Sites 604 and 605: sonic velocity, shear strength, bulk physical properties, GRAPE. No heat flow experiments were conducted as the time required was not deemed worthwhile. No physical properties were measured for Hole

Figure 24. Values of pH, alkalinity, chlorinity, and dissolved calcium and magnesium from interstitial waters squeezed from sediments from Site 604.

604A. All methods were the same as at Holes 603B and 603C. Only vertical velocity was measured. Bulk physical properties were all determined by the Boyce (1976) cylinder technique. Following good results at Hole 603C, both Torvane and pocket penetrometer measurements of shear strength were made.

All measured and calculated data are shown in Figure 25. The measurements are affected by gas exsolving within the sediments. Fracturing of the core causes (apparent) porosity to increase with depth; wet-bulk density and sonic velocity are consequently decreased. Further, the Boyce gravimetric chunk technique assumes a saturated sample; exsolved gas displaces pore water and further lowers the measurement of density. Error arising from sample damage causes similar trends in the bulk physical properties, simply because they are determined from the same sample. Such disturbance reduces the value of any deductions concerning *in situ* properties. However, if all trends were dominated by gas it might be reasonable to expect shear strength to decrease; this was not the case. Therefore, if breaks in the physical properties are to be considered significant they would be indicated primarily by shear strength and carbonate content and only secondarily by sonic velocity and bulk physical properties (the latter being considered as a whole).

The most prominent break, at 174 m, represents a sharp increase in shear strength and a peak in carbonate content.

Lower-amplitude breaks occur at 112, 151, 163, 190, 212, and 235 m. Low recovery between 0 and 85 m hinders analysis. Shear strength increases slowly with depth and levels off at approximately 20 kPa at 112 m. Between 112 and 151 m carbonate content is variable (7–15%). Between 190 and 212 m carbonate content, porosity, and water content show a transitional increase. As a result of low recovery, no measurements were possible between 212 and 235 m. Below 235 m all measurements are variable, reflecting the heterogenous lithology (upper Miocene slump, facies).

Seismic Reflectors and Physical Properties at Site 604

Three high-amplitude reflectors were penetrated at Site 604. The quality of the data is generally poor, as stated earlier. The reflectors at Site 604 are P_1 (84 m, Core 19), P_2 (179 m, Cores 20 and 19) and M_1 (239 m, Core 26).

Horizon P_1 is tentatively correlated with a layer of transitional properties between 80 and 100 m; over this interval, shear strength increases slightly and bulk density increases. There is no break on the velocity log at 80 m although carbonate content is elevated (18%). The most prominent break in physical properties is at 173.5 m (Section 604-19-3), where the shear strength rises from 20 kPa to 40 kPa between 150 and 180 m sub-bottom. Grain density decreases slightly below this depth. It is likely that this break is responsible for Reflector P_2, whose predicted depth prior to drilling was 162 m sub-bottom. Lithologically, this depth marks the boundary, within greenish gray clay between biogenic silica as an accessory constituent below and glauconite sand above (Subunits IIC/IIB). The other clear break at Site 604 is at 235 m, which approximately correlates with the predicted depth of Horizon M1. Lithologically, this is the top of the Miocene conglomerates and clays. Data are insufficient to comment further.

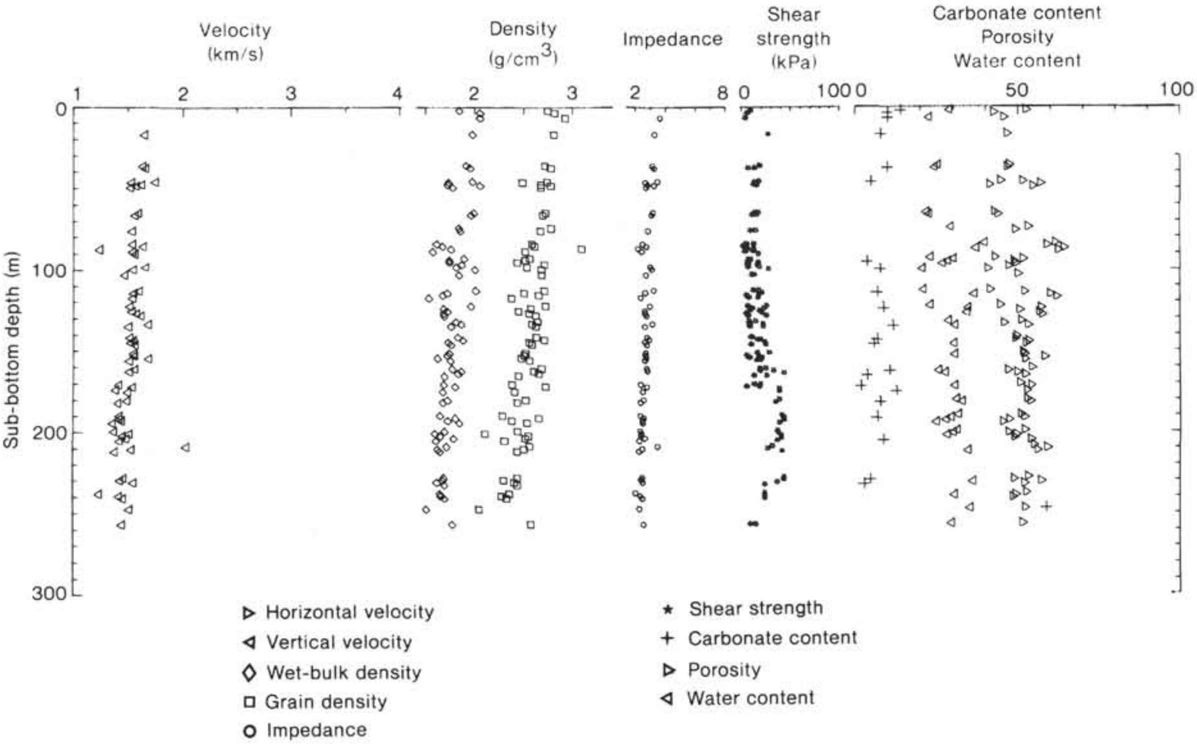


Figure 25. Summary of physical properties of Hole 604.

The depths of reflectors were based on a velocity of 1.7 km/s. It is likely that the true velocity is nearer 1.5 km/s for much of the upper part of the section, so predictions of the reflector depths are too deep. More detailed modeling is necessary to improve the correlation of physical properties and seismic reflections.

Site 605

Compressional sound wave velocity was measured both parallel and perpendicular to bedding in Site 605, at intervals of approximately 1.5 m (once per section, five samples per core) (see Fig. 26). Shear strength was measured between 165 and 206 m; below this interval it exceeded our ability to measure. Wet-bulk density, grain density, porosity, and water content were determined from the same samples as taken for the sonic velocity measurement (Fig. 26).

On the basis of physical properties, the following 13 units may be delineated:

Unit 1 (0–203 m): High density and low porosity reflecting the lithology—nonindurated gray clays. Horizontal velocity could not be measured.

Unit 2 (203–270 m): densities markedly lower and velocities higher than Unit 1, porosity and water content slightly lower than above. The contrast in densities is very marked, indicating an important change in composition.

Unit 3 (270–293 m): properties are broadly similar to those above, with the exception of density, which is higher. Again, compositional change is the cause. Base of unit is defined by a marked increase downward in horizontal and vertical velocity.

Unit 4 (293–350 m): bulk density increases with decreasing porosity and water content, resulting in a denser structure and, therefore, increasing sonic velocities.

Unit 5 (350–428 m): top defined by large increase in bulk density and sonic velocities resulting from sharp decreases in porosity and water content. These trends are maintained throughout this unit.

Unit 6 (428–455 m): top of unit marked by sharp increases in bulk density, grain density, and sonic velocity. At 428 m occurs the most prominent of all breaks in physical properties.

Unit 7 (455–552 m): slight decrease in bulk density; the remaining physical properties maintain established trends.

Unit 8 (552–565 m): sharp increase in bulk density, grain density, and velocities, resulting from a decrease in porosity and water content.

Unit 9 (565–600 m): bulk density decreases, resulting from a slight increase in porosity and water content; other properties remain the same.

Unit 10 (600–716 m); all physical properties exhibit a greater variability than those of the overlying unit.

Unit 11 (716–740 m): bulk density is lower because porosity is higher.

Unit 12 (740–760 m): wet-bulk density is higher; values are similar to those of Unit 10, although grain density is higher. Porosity and water content are lower than in Unit 11.

Unit 13 (760+ m): wet-bulk density and, to a lesser extent, grain density increase. Velocity is significantly higher.

Seismic Reflectors and Physical Properties at Site 605

The reflectors penetrated at Site 605 were A^u (192 m, Cores 5/6), A^c (~350 m, Core 20/22), A^{52} (~525 m, Core 44), and A* (740 m, Core 64).

Horizon A^u represents the unconformity caused by increased current activity during late Eocene to early Miocene times (Tucholke, 1979). This is consistent with the base of lithologic Unit I, 198.14 m. Lithologically, the boundary is important, separating green clay from underlying nannofossil chalk. The bulk physical properties show the change well; most noticeably, porosity rises to over 60%. Sonic velocity does not show the change well because the lowered density cancels the effect of increased porosity. The nannofossil chalks transmit sound well despite their low density. Thus the reflectivity of Horizon A^u at Site 605 is due to density variation alone.

Horizon A^c correlates with the top of physical properties Unit 5 (350 m, top of lithologic Unit III). Bulk density increases markedly with sonic velocity, because porosity and water content are abruptly reduced below this depth. Grain density rises slightly below the horizon, as a result of the higher carbonate content. Mobilization of silica (radiolarian tests replaced by calcite) shows that cementation is advanced, and greater rigidity of the sedimentary frame explains the higher velocity. Porosity is reduced by cement overgrowth and the collapse of tests weakened by dissolution. The precise cause for Reflector A^c is not obvious. It is possible that this reflector is due to chalk/limestone transition, but the physical properties do not demonstrate the transitional trend predicted by such a hypothesis.

Horizon A^{52} (523 m predicted depth) lies within physical properties Unit 7. This unit is characterized by a transitional decrease downward in porosity and water content. Wet-bulk density shows a similar trend, and grain density suggests that physical properties Unit 7 may be further divided into three sub-units; the top of the lowest of these, then, equates with Horizon A^{52}. Horizontal velocity is slightly elevated over this subunit, compared to those above. Lithologic Unit III has variable composition, and therefore it is likely that a minor change in lithology is responsible for this reflector.

Elsewhere in the North American Basin, Horizon A* is a hard limestone of Maestrichtian age (Tucholke, 1979). Correlation at Site 605 is complicated by the proximity of two physical property breaks to the predicted depth. Grain density exhibits a very marked increase at 740 m, which is approximately the boundary between lithologic Units IV and V, that is, between lower and upper Paleocene sediments. Bulk density and sonic velocity (particularly vertical velocity) show a more marked break at 760 m. Reflectivity is normally considered to be controlled by impedance (the product of these latter two properties). Although both horizons will cause reflections, exact correlation must await further study.

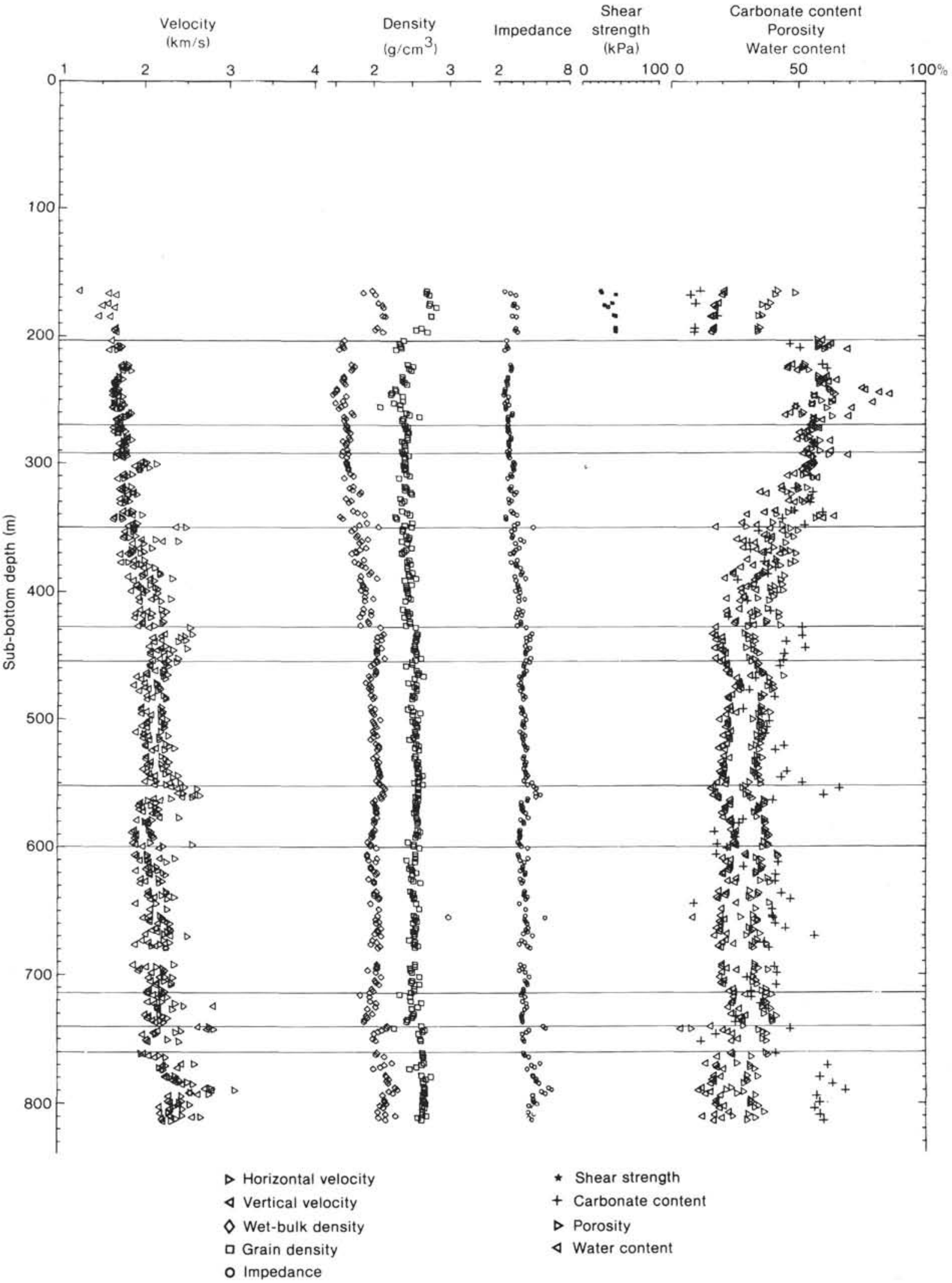


Figure 26. Summary of physical properties of Hole 605.

SEISMIC STRATIGRAPHY

After completion of Hole 603C on the lower continental rise, *Glomar Challenger* moved to the upper rise to drill Site 604 (= location NJ-4 of the New Jersey Transect). Site 604 is located at the intersection of two U.S.G.S. multichannel seismic profiles, lines 25 and 35 (Fig. 1). The portion of line 25 between shot points 3200 and 3900 published by Klitgord and Grow (1980, p. 1670) was interpreted to prepare for drilling (Fig. 3). We applied the analytical methods outlined by Vail et al. (1977) and use their descriptive terminology.

To assign age and facies predictions to the profile and make a drilling pronosis for Site 604 (Fig. 27) and later for Hole 604A and Site 605, we used (1) the interpretation of line 25 by Schlee and Grow (1980), which closely compared with the drilling prognosis provided to us by TELEX from DSDP (Fig. 27); (2) Poag's (1980) correla-

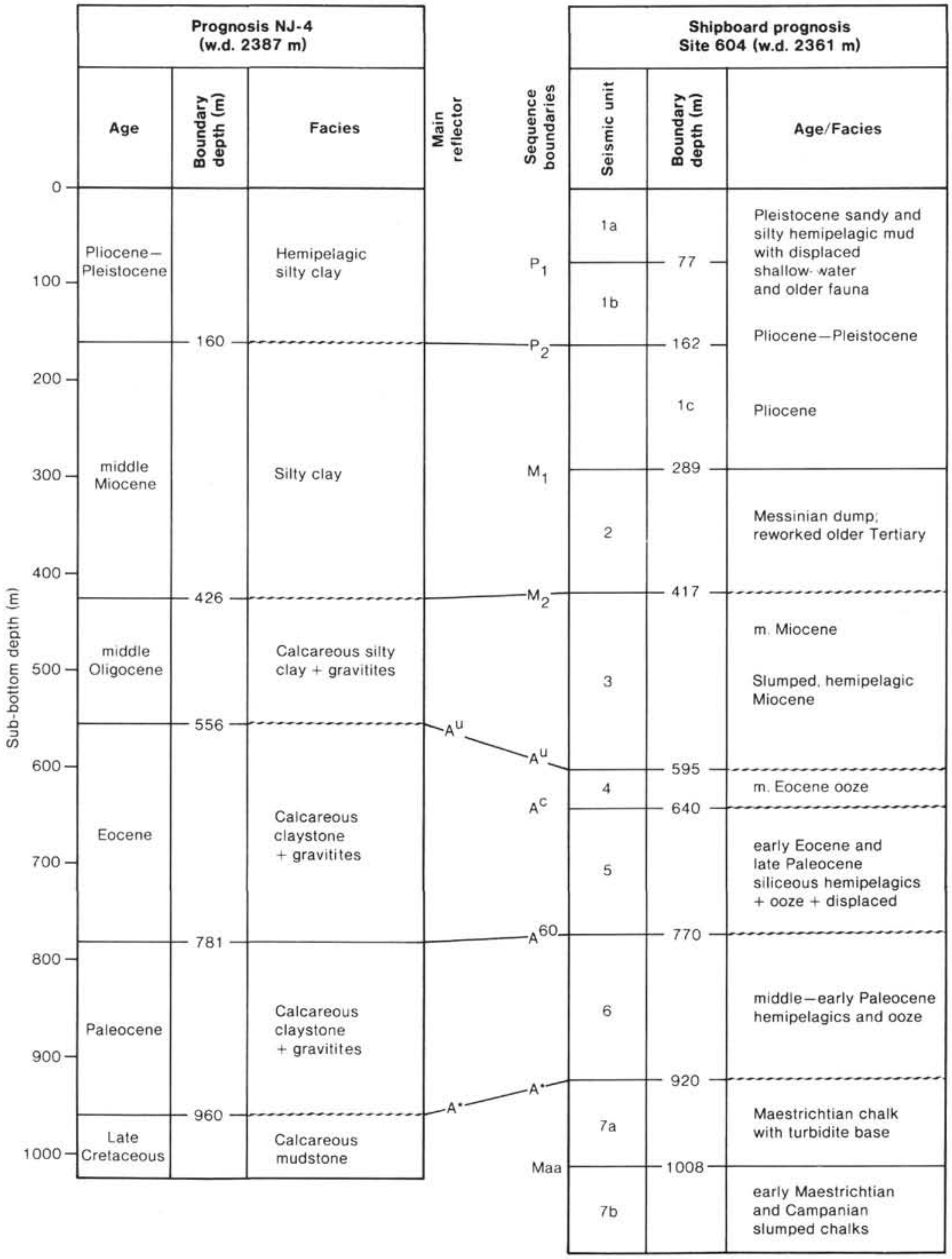


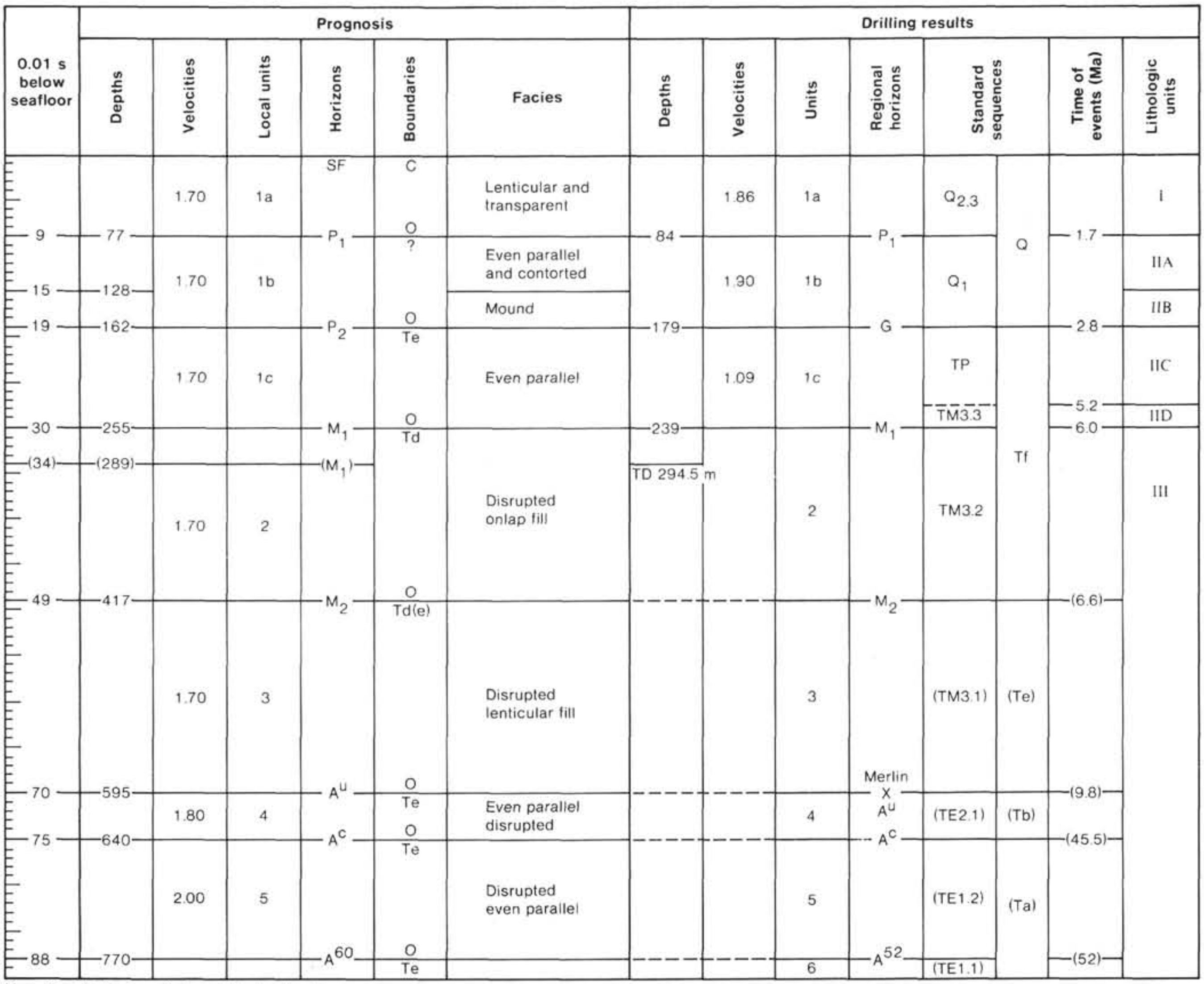
Figure 27. Drilling prognoses for Site 604. See Figures 11, 28, and 29 for drilling results. w. d. = water depths (m).

tion of the upper continental slope well COST-B3 with line 25; (3) the predictions of Vail et al. (1977) on the nature and age of North Atlantic "reflectors"; (4) the results of drilling Site 603; and (5) DSDP drilling results at Sites 107 and 108.

The latter provided good stratigraphic calibration points (see Fig. 1 for location). Site 108 projects on line 25 near shot point 3250 and dates the "outcropping" seismic sequence as middle Eocene (Cores 108-1 and -2, 39–75 m sub-bottom; Hollister, Ewing, et al., 1972b; i.e., below reflection Horizon A_T and above A_c of Tucholke [1979]). In our interpretaion of the profile this implied that there was no upper Eocene and no (or very little) middle Eocene at Site 604. On the other hand, we did expect a well-developed lower Eocene and Paleocene section. Hole 107 bottomed at 78 m in Pleistocene sandy, silty mud with displaced inner neritic Pleistocene and reworked Paleogene fauna, thus giving an indication of the age and nature of reflection Unit 1 at Site 604.

In the following discussion, correlation with standard sequences refers to the depositional cycles and supercycles of Vail and Mitchum (1979). We followed general stratigraphic practice and identified local units and their boundaries, that is, reflection units and reflection horizons. Thus an objective description of the local succession of acoustic images of rock strata is obtained. This can then be correlated with a standard, either by speculation when the succession has not been drilled, or by conventional stratigraphic methods when the rocks have been sampled.

The reflection stratigraphy at Sites 604 and 605 is summarized in Figures 28 and 29, which also show the drilling results. (Note that our shipboard reading in milliseconds may not be accurate, because we had only a photographic reproduction of the published line to work with.) We distinguished 13 local seismic sequences, labeled reflection Units 1–10, and Subunits 1a–c and 6a, b. Units 8–10 were not reached by the drill. Figure 30 shows the



( ) = Post-drilling prediction with standard sequences

Figure 28. Summary of reflection stratigraphy at Hole 604 location. Depths are in meters, velocities in km/s, time in Ma. Standard sequences are cycles and supercycles of Vail and Mitchum (1979). Boundary descriptions are: C = concordance, O = onlap, Td = depositional truncation, Te = erosional truncation.

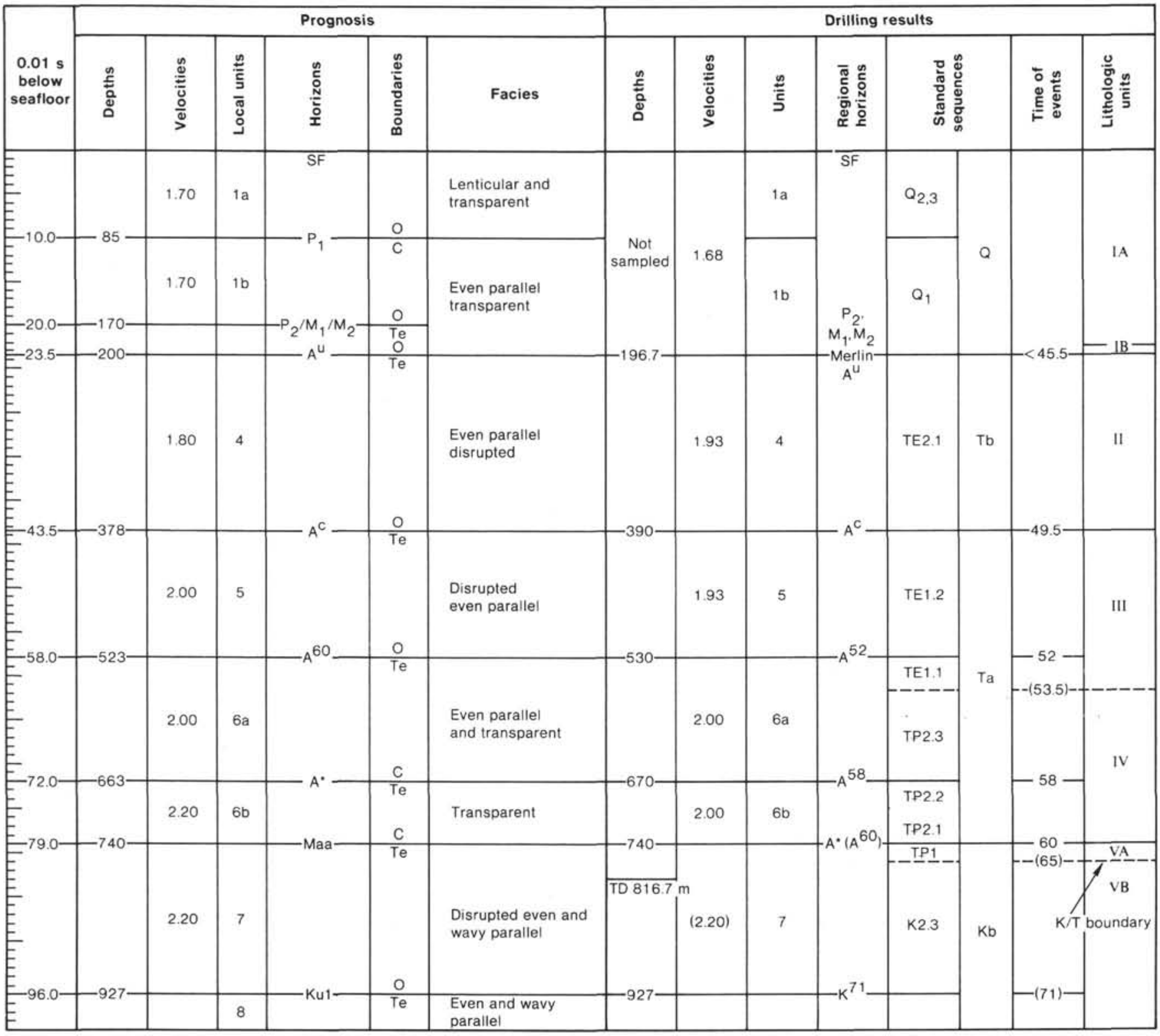


Figure 29. Summary of reflection stratigraphy at Site 605 location, For explanation see Figure 28. Note that at the location of Site 605 sequence boundaries P_2, M_1, M_2, Merlin and A^u have merged (cf. Fig. 4).

correlation of these units with the ones defined at Site 603 and with the Vail et al. (1977) standard sequence chart.

Reflection Unit 1

The internal reflection configuration of reflection Unit 1 shows transparent portions and parallel, fairly even reflectors. It consists of turbidites and hemipelagic mud like the section cored at Site 107. A short, high-amplitude reflector above the base of Subunit 1b, which was thought to mark a possibly gas-filled, sand turbidite mound, indeed proved to be the top of a sandy turbiditic section but was without gas (lithologic Subunit IIB).

The prominent reflectors separating Subunits 1a, 1b, and 1c are referred to as reflection Horizons P_1 and P_2. Both surfaces show onlap; P_2 truncates underlying sections to the west of Site 604. The two sequence boundaries coincide with lithologic boundaries (IIA/I and IIC/IIB respectively) which both separate more quiet, biogenic-silica-bearing sediments below from sandier, slumped sediments above in which displaced shallow-water material has increased. A sharp downhole increase in shear strength marks the level of P_2.

Good age determination with planktonic foraminifers (Moullade, this volume) and calcareous nannofossils (Lang and Wise, this volume) confirm that the horizons result from the onset of the first two major glacial sea-level low stands as they correlate with standard sequence boundaries Tb/Q and O_1/Q_2. The P_2 event is clearly expressed in the isotope record as a major cooling event (Ganssen, this volume) and on that basis alone can be correlated with Horizon G at Site 603.

Reflection Unit 2

This unit rests on the irregular top surface of Unit 3. Its skewed plano-convex body, with a flat top and a convex base, pinches out to the west (updip) as well as to the east (downdip). We do not consider this feature to represent a downslope channel cut and fill, because it appears on a dip-line and does not show the strong erosion at its base a valley cut would. In our interpretation, its internal, disrupted, onlap-fill reflection pattern represents gravitite fill (mass flow, debris flow, grain flow, turbidites) behind a slump mound to its east. This interpretation has twice been confirmed by the drill (Hole 604 and 604A, lithologic Unit III), and by postcruise examination of a strike line over Site 604. The unit shows as a sheet on strike line U.S.G.S. line 35, where it should have had a V-shaped channel form if it were in fact a channel. The bounding reflection horizons of Unit 2 were work-labeled as M_1 and M_2 (Fig. 4). This was a mistake (it creates confusion, as they do not necessarily correlate with Hoizons M_1 and M_2 at Site 603) that cannot now be restored because the denotation found postcruise use among shipboard scientists and was used in preliminary reports.

Aboard ship M_1 was originally drawn at 0.34 s below seafloor on an interrupted, high-amplitude reflector. We now draw the sequence boundary at 0.30 s at the base of the first continuous, low-amplitude reflector above it. If we had done this on board we might not have risked drilling Hole 604A because the predicted thickness of the impenetrable debris flow of lithologic Unit III would have increased.

Horizon M_2 merges just west of Hole 604A with M_1, terminating Unit 2. To the east, M_2 follows a slump mound; either it merges with M_1 over the top of the mound or spills over its obstruction and continues as a stringer. The age of Unit 2 is a matter of debate; it is most unfortunate that neither Leg 93 nor Leg 95 could sample its base with Unit 3 present underneath it. The age of its top can, thanks to shore-based paleontologic analysis, be determined as Messinian, as will be discussed in the following. Sample 604-24,CC, at the base of lithologic Subunit IIC, is of earliest Pliocene age based on nannofossils (base of Zone CN10; Lang and Wise, this volume) and on foraminifers (Zone N18 with *Globorotalia tumida* present; Moullade, this volume). In the absence of a hiatus the upper part of lithologic Subunit IID is of late Messinian age because it contains nannofossil Zone CN9 (Cores 604-25, Sections 1 and 2; Lang and Wise, this volume). The lower part of Subunit IID (Section 604-25-3 through Sample 604-26-2, 46 cm) is barren of calcareous fossils but yielded radiolarians of the *Stichocorys peregrina* Zone (Okamura, this chapter) of Messinian–early Zanclean age (Berggren et al., 1985). We conclude that lithologic Subunit IID is of late Messinian age, the time of the Mediterranean salinity crisis, and that this unit equates with standard sequence TM3.3. The unit is too thin to stand out on the seismic record, but will be recorded in the first continuous reflection cycle that drapes the irregular pattern of reflection Unit 2. In Figure 4 this cycle is indicated by a dashed line; it dashed line; it could drape as far west as the point where it is cut off by reflection Horizon P_2.

The conglomerate breccia of lithologic Unit III consists of displaced shelf and reworked slope and upper rise sediments. At some levels, Eocene or Neogene nannofossils, foraminifers, and radiolarians abound. The time of deposition of the debris flow at Site 604 must be later than that of its youngest component. These are radiolarians of the Messinian–early Zanclean *S. peregrina* Zone and foraminifers of the latest Tortonian–Messinian Zone N17 (both elements are common in samples from lithologic Unit III from Hole 604A; see earlier this chapter). One has to conclude, therefore, that the drilled upper part of Unit 2 belongs to the lower Messinian. Considering its internal reflection pattern and its geometry, which levels the slope behind a mound (overlying units are more or less horizontal, underlying units dip downslope), we expect the entire unit to be made of rapidly emplaced gravitites, and conclude that reflection Unit 2 is of early Messinian age, representing standard sequence TM3.2.

Reflection Unit 3

One of the objectives for drilling location NJ-4 of the New Jersey transect was to drill through one of a post-Eocene generation of large channels, seen on strike lines as cutting deeply into the older section of the continental rise. U.S.G.S. line 35 shows a large channel at Site 604 that appears as our Unit 3 on U.S.G.S. dip-line 25 over that location. Downdip the channel seems to have been diverted by a slump mound that predates the channel fill but that probably formed during the devastatingly erosive times of channel cut. The disruptive lenticular fill pattern (more chaotic in the east, more parallel onlap in the west) suggests turbidite facies. Two attempts to sample this unit failed (Holes 604 and 604A), depriving us of the opportunity to directly determine the nature of the fill and the age of the channel-cutting event by coring the section.

The sequence boundary associated with the channels has been labeled Horizon Merlin by Mountain and Tucholke (1985). At Site 604, Horizon Merlin cut into and merged with Horizon A^u. East of the site one could bring the base of Unit 3 over the slump mound (or include the slump in it?) well above Horizon A^u. Further east Horizon Merlin cuts down again into the underlying section (beyond Fig. 4; see Fig. 3).

Although Unit 3 was not drilled, its age can be reliably estimated by the drilling results obtained at Site 604. Both drilling prognoses (Fig. 27) were proven wrong for this unit. We correlate Unit 3 with the Tortonian standard sequence TM3.1, which implies an age of 9.8 Ma for the event that created Horizon Merlin. A speculative correlation could be based on the following general reasons: Unit 3 naturally underlies TM3.2 (Unit 2) and therefore is likely to represent the next older sequence; at the slump mound Horizon Merlin moves upsection to continue to the east, well above Horizon A^u, and therefore must postdate that event considerably; we found the same sequence at Site 603. However, the compelling reason for our correlation is formed by the fact that reworked middle and upper Eocene and Tortonian fossils are dominant in Unit 2 (Lang and Wise, this volume). This implies that, during Unit 2 time, sediments of those particular ages would have to be exposed at the seafloor, updip from the debris-flow deposit, in order to be picked up by the flow, exactly as they would be today if the post-Unit 2 section were removed (and provided that Unit 3 is of Tortonian age; (see Fig. 4). Unit 3 could hardly be anything else but standard sequence TM3.1.

Reflection Units 4 through 7

The Neogene section of this continental rise that we just described is separated from the older, underlying section by a very distinct unconformity that outcrops at the seafloor (western edge of Fig. 4). From dredge samples of the exposed top of this section, and especially from the results of drilling at DSDP Site 108, the section below the unconformity is known to consist of Eocene chalk and limestone. Schlee and Grow (1980) and others assigned several oceanic reflection horizon nominators to the unconformity and sequence boundaries in the presumed limestones underneath (Fig. 3). We used their nomenclature in delineating our local reflection units and horizons (see Fig. 29, under "prognosis").

The internal reflections of these units show an even, parallel pattern that mostly is moderately to strongly disrupted. The disruptions, sometimes chaotic patterns, and numerous small normal faults all indicate that the succession has been creeping downslope during various periods of its existence and in various stages of consolidation. (See, for instance, Figs. 20 and 21 for its small-scale effect. These photographs are from Unit 7, which showed the strongest deformation.) Units 6a and 7 show onlap fill patterns at a break in slope of their underlying reflection horizon, indicating that downslope transport also occurred during sedimentation. This portion of Unit 7 even shows a fan complex pattern with high-amplitude parallel reflectors suggesting turbidite deposition. The presumed turbidites are ponded behind a slump mound that, curiously, lies at the same location as the mound behind which reflection Units 3 and 2 accumulated. Units 4 through 6 and the top of 7 were drilled and cored at Site 605. We recovered an exceptionally complete and in parts expanded middle Eocene to upper Maestrichtian section. "Classical" reflection Horizons A^c and A* were precisely dated in terms of nannofossil and, more broadly, foraminiferal zones. As is apparent from Figure 29, we had to revise our prognosis, the Paleocene being 100 m thicker than expected. As a consequence, the erosional truncation which we expected at the Cretaceous/Tertiary boundary was, in fact, at the basal Thanetian, as predicted by Vail et al. (1980), and we had the good fortune to drill a complete boundary section. Our drilling confirmed the ages of sequence boundaries as they appear on the Vail et al. chart, with one notable exception in the Paleocene.

We see a distinct sequence boundary, initially labeled A*, at 0.72 s below the seafloor at Site 605. The sequence boundary below it (at 0.79 s) has been well dated and correlates with the TⱣ1/TⱣ2.1 standard sequence boundary. Above, at 0.58 s, is another well-established boundary that equates with the TE1.1/TE1.2 standard sequence boundary at 52 Ma. To correlate our boundary at 0.72 s we can choose either TⱣ2.2/2.3 at 56 Ma, or TⱣ2.1/2.2 at 59 Ma. Neither of them makes sense. If we choose the first, the boundary will lie at 580 m below seafloor (top *Planorotalites pseudomenardii* Zone): The consequent sonic velocities would be 0.71 km/s for Subunit 6 and 4.57 km/s for Subunit 6b, and the respective rates of sediment accumulation would be 1.25 and 4.00 cm/10^3 years. If we choose 59 Ma as the sequence boundary age, the boundary will lie at 725 m (base *Morozovella pusilla pusilla* Zone). The velocities for 6a and 6b would then be 2.78 and 0.43 km/s, their accumulation rates 2.79 and 1.5 cm/10^3 years. Since we are dealing with a continuous, homogeneous section these numbers make no sense. We propose that one of the standard sequence boundaries changes age, and, specifically, that it be placed at the top of the *M. pusilla pusilla* Zone. That 58-Ma level lies at 670 m at Site 605, which leads to a normally expected sonic velocity of 2.00 km/s for both Subunits 6a and 6b. Since the ages of the Vail et al. sequence boundaries have not been documented in publication, we do not know which boundary should be moved on their chart, if any can be moved at all.

We would also like to propose (on much weaker ground) that a cycle boundary be considered for the late Campanian. The Maestrichtian section accumulated at an approximate rate of 3 cm/10^3 years using the zonation given by Jansen and Kroon (this volume) and the time scale of van Hinte (1976). Downward extrapolation of this rate gives a calculated estimate of 71.23 Ma for the age of reflection Horizon Ku1 at a predicted depth of 927 m in Hole 605.

Reflection Units 8 through 10

None of these units were drilled and they will not be discussed here. Figure 30 shows our estimated correlation of these units with Site 603 and with the Vail et al. (1977) chart.

SUMMARY AND CONCLUSIONS

Hole 604 is located in 2364 m of water on the uppermost continental rise, 160 km southeast of Atlantic City, New Jersey. As the seaward end member of the New Jersey Transect, the section here could be expected to show the strongest influence of open marine conditions. Several strong reflectors and sequence boundaries, visible on the multichannel seismic profile, were used to predict the section. These profiles showed upper units wedging out updip against more continuous Eocene beds which were cored at Site 108 some 13 km to the north.

The hole was rotary cored continuously from the surface with fair core recovery and good hole conditions. At about 260 m sub-bottom, the drill string encountered soft glauconitic sand in an apparent upper Miocene debris flow. The sand began packing off and sticking the BHA despite mud flushes and all attempts to stabilize the hole. Our copy of U.S. Geological Survey seismic line 25 (photographically enlarged by the shipboard photographer from a journal reprint since no other copies of Line 25 were on board) indicated that the sand-bearing unit would continue another 150 m. Prospects of successfully deepening the hole appeared nil and the hole was abandoned.

On the reference profile the sandy unit appeared to pinch out rapidly to the northwest. An optimum relocation site was chosen about 2.5 km northwest of Hole 604. The profile indicated that the sand body could be avoided at this location while all other target strata (middle Miocene or Oligocene) could be cored. Unfortunately, a move of 2.5 km was not technically feasible because positioning beacons on the only two usable operating frequencies had been dropped at Hole 604. A move of at least 6 km would be necessary to avoid interference from the old beacons. The only option open, therefore, was for a second attempt to core Site 604 at a maximum offset from the old beacons. This would put us approximately at the feather edge of the sandy unit, which we hoped would be sufficient to avoid any significant hole problems. The vessel was consequently offset about 1.2 km northwest along the seismic line.

Hole 604A, at a water depth of 2340 m, was washed to 249.6 m and continuously cored thereafter. After three cores the bit again broke into upper Miocene sand, which quickly packed off and stuck the pipe. Fifteen minutes were required to work the pipe free and another core was attempted after the hole had been cleaned and a mud flush circulated. After 6 m penetration the pipe became stuck again. Freeing it the second time was even more difficult, and it was apparent that the site was not drillable with *Challenger's* drilling system.

With the loss of Site 604, the scientific options for the leg became quite limited, considering the mission and time remaining. We were now constrained to relocate west–northwest along the reference profile at least 6 km from the Site 604 beacons. However, the Miocene strata of interest (reflection Unit 3) appeared to pinch out less than a kilometer past that point, if not sooner. Within another 4 km, Eocene siliceous chalks, too firm to be spudded, cropped out. We therefore elected to try the minimum offset of 6 km and again set our target on the Maestrichtian, which was thought to lie at about 663 m.

Hole 605 was spudded in 2197 m of water, washed to 154.3 m BSF, and continuously cored to 816.7 m. The hole was terminated after the expiration of time allotted for the cruise, which had already been extended by DSDP one day to allow the Cretaceous/Tertiary boundary to be reached.

Stratigraphy

Site 604

The lithologic units penetrated at Site 604 between 0 and 295 m are outlined in Table 4 and depicted in Figures 7 and 11. From top to bottom they are:

Unit I: 84 m of Holocene(?) to Pleistocene gray to dark greenish gray clays and silts in alternating sequences. The unit contains Eocene and Neogene fossils and some slumped or redeposited Eocene biosiliceous chalk in the upper 35 m (Subunit IA) and exhibits internal slump structures in the lower part (Subunit IB). Displaced shallow-water foraminifers and shell fragments are common.

Unit II: 155 m of lower Pleistocene to upper Miocene greenish gray clay with variable amounts of glauconitic shelf sand turbidites and biogenic silica. It is divided into four subunits based on the presence or absence of sand and biogenic silica.

Unit III: 56 m of upper Miocene glauconitic, biosiliceous silty claystone, sand, and conglomerate. The sands are inferred from the drilling characteristics. The conglomerates contain rounded quartz pebbles up to 1 cm long, clasts of claystone, chalk, and limestone up to 10 cm in diameter, and rare shell fragments. Elsewhere in the unit are found exotic blocks of nannofossil chalk up to 50 cm thick. These and the conglomerates appear to represent debris flows, whereas some of the sands could be turbiditic.

Site 605

Lithologic units penetrated at Site 605 between 0 and 816.7 m are outlined in Table 5, depicted in Figure 10, and correlated with units of Site 604 in Figure 11.

Unit I: Unit I is divided into two subunits. Subunit IA consists of 198 m of Pleistocene gray silt-rich clay with common displaced and reworked (Eocene) faunal elements and a high percentage of land-plant organic material. Subunit IB is only 24 cm of Pleistocene green biosiliceous and calcareous clay. It is separated by a disconformity from the underlying unit and contains some reworked siliceous microfossils from that unit.

Unit II: 152 m of lower middle Eocene, biosiliceous nannofossil chalk rich in radiolarians and diatoms.

Unit III: 214 m of lower Eocene, greenish gray, nannofossil limestone, with varying amounts of foraminifers and calcified radiolarians.

Unit IV: 176 m of upper Paleocene, dark greenish gray, clayey nannofossil limestone (marl).

Unit V: 77 m of lower Paleocene to middle Maestrichtian, olive gray, marly limestone.

All of the Paleogene to Maestrichtian units are strongly bioturbated. Preservation of trace fossils is excellent, and several examples of whole Zoophycos burrows are noted. The preservation of siliceous and calcareous microfossils is generally good in Unit II (except for foraminifers), poor in Unit III, and much improved in Units IV and V. Excellent recovery throughout most of the section, particularly the long (200 m) Paleocene interval, will allow detailed correlations of biozones with the magnetostratigraphy of the cores.

Seismic Stratigraphy

Drilling at Sites 604 and 605 was highly successful in delineating unconformities and calibrating the seismic stratigraphy. Figure 4 shows the interpretation of the seismic stratigraphy of U.S.G.S. line 25, based on the results of drilling at Sites 604 and 605. Figure 28 summarizes the seismostratigraphy of Site 604, and Figure 29 that of Site 605. All units that were penetrated have been dated and can be related to supercycles and cycles of Vail et al. (1979) (Fig. 11) with one problem. We cannot properly relate the Vail standard with the Site 605 mid-Paleocene sequence boundaries without implying odd sonic velocities or odd variations in sediment accumulation rates in an otherwise homogeneous section. The age determinations on which Vail based his cycle chart are not known; we cannot, therefore, assess their reliability. The Site 605 control point is excellent and certainly indicates that the Paleocene portion of the standard needs adjustment and that a sequence boundary event occurred at 58 Ma.

The cored sections at Sites 604 and 605 date oceanic reflection Horizons A^c (49.5 Ma) and A* (60 Ma), confirming the prediction of Vail et al. (1980). The results complement very well our findings at Site 603 (Fig. 29). Local reflection Horizons P_2 (= G at Site 603) and M_2 (= M at Site 603) are well dated at both sites. They are demonstrated to be reliable time-stratigraphic markers in both oceanic and continental margin acoustic stratigraphy. We expect that the same holds for Horizons that were dated at one site only: Merlin (= M_2 at Site 603), CON (= Km at Site 603) CENO (unnamed, but present at Site 603), and Kb (well dated at Site 603), as well as the more poorly dated Horizon Ku1, for which we propose a preliminary age of 71 Ma. The section drilled and sampled at Sites 604/605 determines with great precision the ages of Eocene and Paleocene unconformities on the continental slope, documents the Vail et al. (1980) cycle chart, refines its age assignments, and calibrates internal reflection patterns.

Depositional History

The oldest sediment cored at Sites 604 and 605 was middle to upper Maestrichtian clayey limestone (Hole 605, Subunit VB). The terrigenous silt content of this material is quite low, averaging about 3%, whereas the carbonate content is high, usually greater than 60%. The sediment contains only trace amounts of glauconite. These sediments show clear signs of mass downslope movements (creep) (Figs. 20 and 21).

Going upsection it is evident that we had penetrated a reasonably complete Cretaceous/Tertiary boundary sequence in an expanded section. The expanded Maestrichtian/Danian boundary sequence is a function of the continental margin environment of deposition, where sedimentation rates are generally higher than in the deep sea.

At the contact, the foraminiferal *Guembelitria cretacea* Zone (PO) and the coccolith *Zygodiscus sigmoides* Zone (CP1) overlie the foraminiferal *Abathomphalus mayaroensis* and coccolith *Nephrolithus frequens* zones, but other lower Danian foraminiferal zones (P1a and P1b) have not been recognized in the fragmented core (Fig. 18). Unfortunately, the core shattered just above the Cretaceous/Tertiary boundary, and thus it appears that the "boundary clay," if originally present, was washed away during coring. There is no visual lithologic discontinuity between upper Maestrichtian and lower Paleocene sediments which, on the other hand, are disconformably overlain by an unusually thick upper Paleocene section.

Unlike the Maestrichtian limestone below, the lowest Danian sediments (Subunit VA) show a marked rise in the percentage of terrigenous silt (15–20%) and glauconite (2–4%). Assuming that these micaceous silts and glauconites are land- and shelf-derived, this may indicate a drop in sea level at the time of the Cretaceous/Tertiary boundary event. The silt and glauconite contents decrease rapidly in the top of Subunit VA, where the lithology becomes a foraminifer-bearing nannofossil limestone. This rapid decline may reflect a subsequent sea level rise. To some shipboard scientists this suggested that a terminal Cretaceous meteorite (Alvarez et al., 1980; Smit and Hertogen, 1980) did strike the ocean and cloud the Earth. However, the existence of a near-complete Cretaceous/Tertiary boundary section in the New Jersey coastal plain (Koch and Olsson, 1977) suggests that there was no appreciable drop in sea level associated with the boundary event. The silt and glauconite in Sub-unit VA, therefore, may possibly reflect exceptional current-wave (tsunami) activity induced by the impact, an explanation which would also account for the deep-water, current-bedded Cretaceous/Tertiary sand with spherules at Site 603 (see Site 603 site chapter). Another possibility could be that the effects of the impact decimated plant life, which resulted in increased hinterland erosion and terrigenous riverine output.

Marl–limestone cycles (shown by a faint to distinct color zonation) are well developed in Units III and IV at Site 605, especially in Cores 605-52 to -55, and 605-58 to -62. Since pelagic carbonate dissolution at this shallow site would not have been a factor in the genesis of these cycles, their cause could have been fluctuations in carbonate input related to productivity or to fluctuations in the input of terrigenous clay, which would tend to cause cyclic dilution of carbonate content during periods of continuous carbonate sedimentation (sea level fluctuations, climate). Another type of cyclicity is manifested in Cores 605-33 to -35 and 605-40, where intensely bioturbated and faintly laminated, undisturbed horizons alternate. These cycles may represent fluctuations in bottom-water oxygen content.

In general, the Maestrichtian–Eocene sequence at Site 605 (lithologic Units II to V) is heavily bioturbated, indicating steady input of nutrients (either via surface productivity or terrestrial influx) into the sediments. Beginning with Unit II deposition during the early middle Eocene, there is a sharp increase in biosiliceous material (diatoms, radiolarians, and silicoflagellates). Although this contrast may have been further accentuated by silica diagenesis, this is not likely to be a significant factor.

Because of drilling problems at Site 604, we obtained no direct information on the Oligocene–middle Miocene interval, nor do we know the nature and age of the lower 150 m of our seismic Unit 2 (the continuance of our lithologic Unit III). Reworked upper Eocene and middle Miocene microfossils in the upper Miocene sediments of Site 604 indicate that those units are present in the area. To date, no reworked Oligocene material has been identified, and at Site 605 these sediments were missing. There, Pleistocene sediments were separated from the middle Eocene by a pronounced disconformity which can be traced at seismic reflection Horizon A^u.

The upper Miocene glauconitic, biosiliceous silty claystone, silt, sand, and conglomerate with quartz pebbles and displaced blocks of middle Eocene chalk in Unit III (Hole 604) clearly represent debris and turbidite flows from upslope. Their emplacement followed canyon cutting centered about a time when glaciation on the Antarctic continent apparently induced significant eustatic lowering of sea level. Upper Miocene sediments are almost absent in offshore boreholes along the east coast of the United States and have not been identified in land outcrops of the coastal plain. During periods of lowered sea levels, the shoreline migrated toward the shelf break where river deltas spilled their loads. The debris flows and turbidites we drilled at Site 604 apparently result from such a period of deposition in an unstable shelf-edge environment. Diatomaceous sediments associated with these deposits indicate further upwelling in this area, perhaps again related to incursions of the Labrador Current system. Glauconitic sands, shallow-water foraminifers and shell fragments, and occasional displaced Eocene material in Units I and II reflect further unstable sea level and current conditions into the Pliocene and Pleistocene particularly since the initiation of glacial times.

Highly contorted and convolute patterns in the Pleistocene Subunit IB at Site 604 are interpreted as internal slump structures, features which indicate unstable slope conditions as well. Slumping within Quaternary deposits has been widely observed on the continental slope in this area in detailed seismic surveys, for example, by Robb et al. (1981).

Seismic profile records and drilling at Site 108 reveal large areas upslope where post-Eocene sediments have been removed by erosion and slumping, thereby leaving a belt of Eocene chalk cropping out along strike at the surface. The incorporation of this material, along with middle Miocene microfossils, in the upper Miocene and Plio-Pleistocene indicates that denudation of the Eocene units was not limited to the Oligocene A^u Event. In our area, a major loss of material apparently occurred during the late Miocene (Tortonian and Messinian) in conjunction with profound sea-level drops (Vail cycles TM3.1 and TM3.2).

REFERENCES

Alvarez, L. W., Alvarez, W., Asaro, F., and Michel, H. V., 1980. Extraterrestrial cause for the Cretaceous-Tertiary extinction. *Science*, 208:1095-1108.

Backman, J., and Shackleton, N. J., 1983. Quantitative biochronology of Pliocene and early Pleistocene calcareous nannofossils from the Atlantic, Indian, and Pacific oceans. *Mar. Micropaleontol.*, 8: 141-170.

Berggren, W. A., 1985. Neogene planktonic foraminiferal biostratigraphy and biogeography: Atlantic, Mediterranean, and Indo-Pacific regions. *In* Tsuchi, R. (Ed.), *Pacific Neogene Datum Planes.* IGCP Project 114: Tokyo: University of Tokyo Press.

Berggren, W. A., Kent, D. V., Flynn, J. J., and Van Couvering, J. A., 1985. Cenozoic geochronology. *Geol. Soc. Am. Bull.*, 96:1407-1418.

Boyce, R. E., 1976. Definitions and laboratory techniques of compressional sound velocity parameters and wet-water content, wet-bulk density, and porosity parameters by gravimetric and gamma ray attenuation techniques. *In* Jackson, E. D., Schlanger, S. O., et al., *Init. Repts. DSDP*, 33: Washington (U.S. Govt. Printing Office), 931-958.

Brown, P. M., Miller, J. A., and Swain, F. M., 1972. *Structural and Stratigraphic Framework and Spatial Distribution of Permeability of the Atlantic Coastal Plain, North Carolina to New York.* U.S. Geol. Survey Prof. Pap., 796.

Bukry, D., 1981. Synthesis of silicoflagellate stratigraphy for Maestrichtian to Quaternary marine sediment. *In* Warme, J. E., Douglas, R. G., and Winterer, E. L. (Eds.), *The Deep Sea Drilling Project. A Decade of Progress.* Soc. Econ. Paleontol. Mineral. Spec. Publ., 32:433-444.

Gieskes, J. M., Elderfield, H., Lawrence, J. R., Johnson, J., Meyers, B., and Campbell, A., 1982. Geochemistry of interstitial waters and sediments, Leg 64, Gulf of California. *In* Curray, J. R., Moore, D. G., et al., *Init. Repts. DSDP*, 64, Pt. 1: Washington (U.S. Govt. Printing Office), 675-694.

Goll, R. M., 1968. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in Pacific and Caribbean basins, Part I. *J. Paleontol.*, 42(6):1409-1432.

Gombos, A. M., Jr., 1983. Early and middle Eocene diatom evolutionary event. *Bacillaria*, 5:225-242.

Grow, J. A., Mattick, R. E., and Schlee, J. S., 1979. Multichannel seismic depth sections and interval velocities over outer continental shelf and upper continental slope between Cape Hatteras and Cape Cod. *In* Watkins, J. S., Montadert, L., and Dickerson, P. W. (Eds.), *Geophysical and Geological Investigations of Continental Margins.* Am. Assoc. Pet. Geol. Mem., 29:65-83.

Hathaway, J. C., Poag, C. W., Valentine, P. C., Miller, R. E., Schultz, D. M., Manheim, F. T., Kohout, F. A., Bothner, M. H., and Sangrey, D. A., 1979. U.S. Geological Survey core drilling on the U.S. Atlantic Shelf. *Science*, 206(4418):515-527.

Hinte, J. E. van, 1976. A Jurrasic time scale. *Am. Assoc. Pet. Geol. Bull.*, 60:489-497.

Hollister, C. D., Ewing, J. I., et al., 1972a. Site 107—upper continental rise. *In* Hollister, C. D., Ewing, J. I., et al., *Init. Repts. DSDP*, 11: Washington (U.S. Govt. Printing Office), 351-356.

________, 1972b. Site 108—continental slope. *In* Hollister, C. D., Ewing, J. I., et al., *Init. Repts. DSDP*, 11: Washington (U.S. Govt. Printing Office), 357-364.

Klitgord, K. D., and Grow, J. A., 1980. Jurassic seismic stratigraphy and basement structure of western Atlantic magnetic quiet zone. *Am. Assoc. Pet. Geol. Bull.*, 64:1658-1680.

Koch, R. C., and Olsson, R. K., 1977. Dinoflagellate and planktonic foraminiferal biostratigraphy of the uppermost Cretaceous of New Jersey. *J. Paleontol.*, 51:480-491.

McIver, R., 1975. Hydrocarbon occurrences from JOIDES Deep Sea Drilling Project. *Proc. 9th World Hydrocarbon Congr.*, pp. 269-280.

Martini, E., 1971. Neogene silicoflagellates from the equatorial Pacific. *In* Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1695-1708.

Mattick, R. E., Hennessy, J. L. (Eds.), 1980. *Structural Framework, Stratigraphy, and Petroleum Geology of the Area of Oil and Gas Lease Sale No. 49 on the U.S. Atlantic Continental Shelf and Slope.* U.S. Geol. Surv. Circular, 812.

Moullade, M., 1983. Upper Neogene and Quaternary planktonic foraminifers from the Blake Outer Ridge and Blake Bahama Basin (Western North Atlantic), Deep Sea Drilling Project Leg 76, Sites 533 and 534. *In* Sheridan, R. E., Gradstein, F. M., et al., *Init. Repts. DSDP*, 76: Washington (U.S. Govt. Printing Office), 511-535.

Mountain, G. S., and Tucholke, B. E., 1985. Mesozoic and Cenozoic stratigraphy of the United States Atlantic continental slope and rise. *In* Poag, C. W. (Ed.), *Geologic Evolution of the United States Atlantic Margin:* New York (Van Nostrand-Reinhold), pp. 293-341.

Müller, P. J., 1977. C/N ratios in Pacific deep-sea sediments: Effect of inorganic ammonium and organic nitrogen compounds sorbed by clays. *Geochim. Cosmochim. Acta*, 41:765-776.

Olsson, R. K., 1978. Summary of lithostratigraphy and biostratigraphy of Atlantic Coastal Plain (northern part). *In* Benson, W. E., Sheridan, R. E., et al., *Init. Repts. DSDP*, 44: Washington (U.S. Govt. Printing Office), 941-947.

Poag, C. W., 1979. Stratigraphy and depositional environments of Baltimore Canyon Trough. *Am. Assoc. Pet. Geol, Bull.*, 63:1452-1466.

________, 1980. Foraminiferal stratigraphy, paleoenvironments, and depositional cycles in the outer Baltimore Canyon Trough. *In* Scholle, P. A. (Ed.), *Geological Studies of the COST No. B-3 Well, United*

States Mid-Atlantic Continental Slope Area. U.S. Geol. Surv. Circular, 833:44–66.

Robb, J. M., Hampson, J. C., Jr., and Twichell, D. C., 1981. Geomorphology and sediment stability of a segment of the United States continental slope off New Jersey. *Science*, 211:935–937.

Schlee, J. S., 1981. Seismic stratigraphy of Baltimore Canyon Trough. *Am. Assoc. Pet. Geol. Bull.*, 65:26–53.

Schlee, J. S., Behrendt, J. C., Grow, J. A., Robb, J. M., Mattick, R. E., Taylor, P. T., and Lawson, B. J., 1976. Regional framework off northeastern United States. *Am. Assoc. Pet. Geol. Bull.*, 60:926–951.

Schlee, J. S., Dillon, W. P., and Grow, J. A., 1979. Structure of the continental slope off the eastern United States. *In* Doyle, L. J., and Pilkey, O. H. (Eds.), *Geology of Continental Slopes*. Soc. Econ. Paleontol. Mineral., Spec Publ., 27:95–117.

Schlee, J. S., and Grow, J. A., 1980. Seismic stratigraphy in the vicinity of the COST No. B-3 Well. *In* Scholle, P. A. (Ed.), *Geological Studies of the COST No. B-3 Well, United States Mid-Atlantic Continental Slope Area.* U.S. Geol. Surv. Circular, 833:111–116.

Scholle, P. A. (Ed.), 1980. *Geological Studies of the COST No. B-3 Well, United States Mid-Atlantic Continental Slope Area.* U.S. Geol. Surv. Circular, 833.

Smit, J., and Hertogen, J., 1980. An extraterrestrial event at the Cretaceous–Tertiary boundary. *Nature*, 285:198–200.

Smit, J., and Romein, A. J. T., 1985. A sequence of events across the Cretaceous–Tertiary boundary. *Earth Planet. Sci. Lett.*, 74:157–170.

Taylor, D. J., and Anderson, R. C., 1980. Geophysical studies. *In* Scholle, P. A. (Ed.), 1980. *Geological Studies of the COST No. B-3 Well, United States Mid-Atlantic Continental Slope Area.* U.S. Geol. Surv. Circular, 833:105–110.

Tucholke, B. E., 1979. Relationships between acoustic stratigraphy and lithostratigraphy in the western North Atlantic Basin. *In* Tucholke, B. E., Vogt, P. R., et al., *Init. Repts. DSDP*, 43: Washington (U.S. Govt. Printing Office), 827–846.

Vail, P. R., and Mitchum, R. M., 1979. Global cycles of relative changes in sea level from seismic stratigraphy. *In* Watkins, J. S., Montadert, L., and Dickerson, P. W. (Eds.), *Geological and Geophysical Investigations of Continental Margins.* Am. Assoc. Pet. Geol. Mem., 29:469–472.

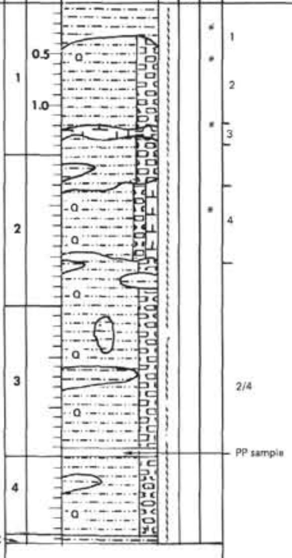
Vail, P. R., Mitchum, R. M., Jr., Todd, R. G., Widmier, J. M., Thompson, S. III, Sangree, J. B., Bubb, J. N., and Hatlelid, W. G., 1977. Seismic stratigraphy and global changes of sea level. *In* Payton, C. E. (Ed.), *Seismic Stratigraphy: Applications to Hydrocarbon Exploration.* Am. Assoc. Pet. Geol. Mem., 26:49–212.

Vail, P. R., Mitchum, R. M., Jr., Shipley, T. H., and Buffler, R. T., 1980. Unconformities of the North Atlantic. *Phil. Trans. R. Soc. London, A*, 294:137–155.

Waples, D. W., and Sloan, J. R., 1980. Carbon and nitrogen diagenesis in deep sea sediments. *Geochim. Cosmochim. Acta*, 44:1463–1470.

SITE 604 HOLE CORE 1 CORED INTERVAL 0–6.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
Late Pleistocene		N23	CN14–15	Barren	



LITHOLOGIC DESCRIPTION

1) NANNOFOSSIL-BEARING, (QUARTZ-RICH) SILTY CLAY
olive gray (5Y5/2)

2) QUARTZ-BEARING, CARBONATE-RICH CLAY, dark greenish gray (5G 4/1).

3) BIOGENIC SILICA-RICH NANNOFOSSIL OOZE, pale yellow (5Y 8/3) (apparently allochthonous–middle Eocene fossils).

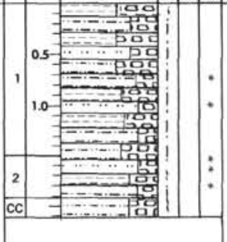
4) NANNOFOSSIL-SKELETAL CARBONATE AND QUARTZ-RICH CLAY (sandy-silty clay = texture) grayish olive green ("forest green"; 5GY3/2)

SMEAR SLIDE SUMMARY (%)

	1, 11 M	1, 53 D	1, 130 M	2, 60 M	3,CC D
Texture:					
Sand	–	–	–	25	25
Silt	40	30	80	25	40
Clay	60	70	20	50	35
Composition:					
Quartz	30	10	–	20	45
Feldspar	–	TR	–	–	1
Mica	–	TR	TR	2	2
Heavy minerals	–	TR	–	–	3
Clay minerals	60	70	5	48	35
Glauconite	TR	TR	–	1	1
Pyrite + opaques	TR	TR	–	3	3
Carbonate unspec.	–	20	–	15	8
Foraminifers	2	–	3	2	–
Calc. nannofossils	5	TR	67	10	–
Diatoms	1	–	10	–	–
Radiolarians	2	–	10	–	–
Sponge spicules	–	–	5	–	–
Fish remains	–	TR	–	–	TR
Plant debris	–	–	–	TR	2

SITE 604 HOLE CORE 2 CORED INTERVAL 6.5–16.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
Late Pleistocene		N23	CN14–15		



LITHOLOGIC DESCRIPTION

CALCAREOUS-RICH QUARTZOSE SILTY CLAY, SILT-BEARING CALCAREOUS CLAY, SAND-RICH CALCAREOUS-RICH SILT, and CLAYEY SILT.
Dark gray (5Y3/1) with only slight darkness variations. Banded on the five-centimeter scale with fine/coarse grained alternations. These alternations are on centimeter scale in lower part of Sec. 1. In Sect. 2 are some light (5Y4/1) gray 1 cm fine-grained bands within the fine-grained dark gray intervals. The coarse/fine layers appear to have normal grading, but core is too disturbed to verify this.

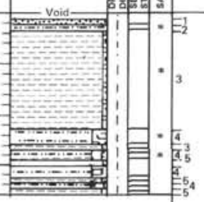
Drawing of Graphic Lithology is entirely schematic

SMEAR SLIDE SUMMARY (%)

	1, 74 M	1, 97 D	2, 2 D	2, 8 D	2, 33 M
Texture:					
Sand	–	–	15	5	–
Silt	90	45	75	40	40
Clay	10	55	10	55	60
Composition:					
Quartz	54	6	59	29	5
Feldspar	6	1	3	5	–
Mica	4	3	10	5	–
Heavy minerals	25	–	5	5	4
Clay	10	55	10	50	50
Glauconite	–	–	1	–	–
Pyrite	–	–	–	2	1
Carbonate unspec.	1	35	20	10	40
Calc. nannofossils	–	–	1	2	–
Other opaques	–	–	1	1	–

SITE 604 HOLE CORE 3 CORED INTERVAL 16.1–25.7 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	FOSSIL CHARACTER NANNOFOSSILS	FOSSIL CHARACTER RADIOLARIANS	FOSSIL CHARACTER DIATOMS	SECTION	METERS
Late Pleistocene		N23	CN14–15	Barren		1 2	0.5 1.0



LITHOLOGIC DESCRIPTION

1) SILT, dark greenish gray (5YR4/1)
2) SILT-RICH CLAY, medium gray (N5)
3) CALCAREOUS-BEARING CLAY, medium dark gray (N4)
4) CALCAREOUS- and SILT-RICH CLAY, medium gray (N5).
5) CALCAREOUS- and SILT-BEARING CLAY, dark gray (5Y 4/1).

Silt, underlain by silt-rich clay, then alternating layers of calcareous-bearing clay and calcareous & silt rich clay. The base of Section 1 and all of Section 2 are alternating 5-10 cm layers of calcareous & silt rich clay and calcareous & silt bearing clay.

SMEAR SLIDE SUMMARY (%)

	1, 14 D	1, 55 D	1, 121 D	1, 140 D
Texture:				
Silt	25	15	30	20
Clay	75	85	70	80
Composition:				
Quartz	5	2	5	3
Feldspar	1	–	1	–
Mica	10	4	3	5
Heavy minerals	2	1	4	1
Clay	74	85	68	77
Glauconite	–	–	–	1
Pyrite	–	–	–	TR
Carbonate unspec.	5	5	15	5
Foraminifers	–	TR	–	–
Calc. nannofossils	TR	1	2	2
Diatoms	–	–	–	1
Radiolarians	–	–	TR	3
Sponge spicules	–	–	–	TR
Fish remains	–	–	–	1
Plant debris	1	–	–	–
Other opaques	2	1	2	1

SITE 604 HOLE CORE 4 CORED INTERVAL 25.7–35.3 m

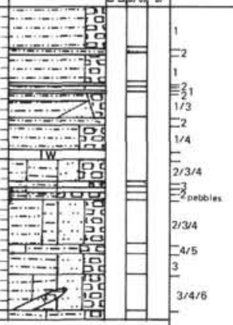
TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	FOSSIL CHARACTER NANNOFOSSILS	FOSSIL CHARACTER RADIOLARIANS	FOSSIL CHARACTER DIATOMS	SECTION	METERS
Late Pleistocene		N23	CN14–CN15	Barren		CC	

LITHOLOGIC DESCRIPTION

CALCAREOUS- and SILT-RICH to -BEARING CLAY. Dark greenish gray (5GY4/1), with greenish gray (5GY5/1) at base. Two silt-rich intervals. Only 10 cm recovered. Clam shell at base (1x1½ cm).

SITE 604 HOLE CORE 5 CORED INTERVAL 35.3–44.9 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER FORAMINIFERS	FOSSIL CHARACTER NANNOFOSSILS	FOSSIL CHARACTER RADIOLARIANS	FOSSIL CHARACTER DIATOMS	SECTION	METERS
Late Pleistocene		N23	CN14–15	Barren		1 2 CC	0.5 1.0



LITHOLOGIC DESCRIPTION

1) SILT- and CALCAREOUS-RICH CLAY, light brownish gray (5YR 6/1).
2) SILT-RICH CLAY, medium dark gray (N4).
3) CALCAREOUS-RICH CLAYEY SILT, dark greenish gray (5GY 4/1).
4) SILT-RICH CALCAREOUS CLAY, light brownish gray (5YR 6/1).
5) SILICEOUS BIOGENIC and FORAMINIFER-BEARING NANNOFOSSIL OOZE, beige (5Y 8/2).
6) GLAUCONITE- and NANNOFOSSIL-BEARING, CALCAREOUS- and SILT-RICH CLAY.

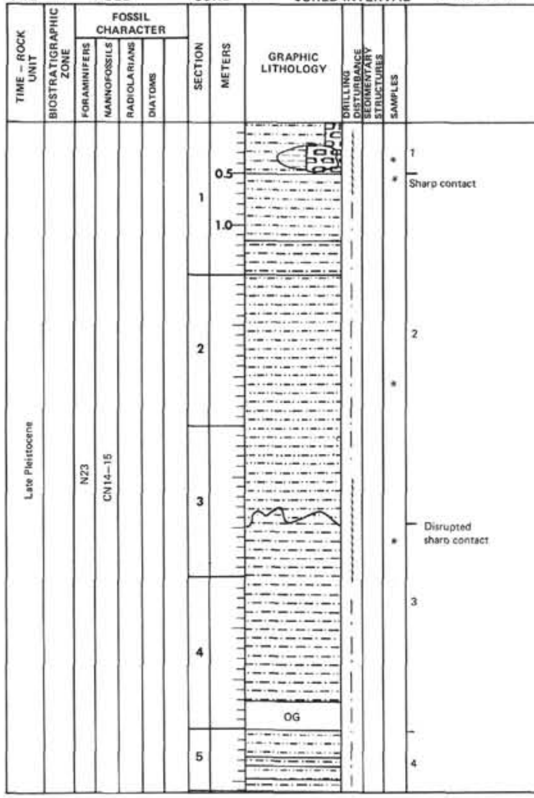
Irregular bands and swirls of silt- and calcareous-rich clay. Bands of silt-rich clay are interspersed and not deformed. Base of Section 1 has silt-rich calcareous clay. Erratics of chert and claystone occur in a band; a lens of siliceous biogenic- and foraminifer-bearing nannofossil ooze is also swirled through silt-rich clay in Section 2. Base of section is composed of glauconite- and nannofossil-bearing, calcareous-silt-rich clay.

The swirled intervals are interpreted as SLUMPS.

SMEAR SLIDE SUMMARY (%)

	1, 18 M	1, 44 D	1, 102 M	1, 134 D	2, 85 M	2, 89 M	2, 141 D
Texture:							
Sand	2	–	10	–	–	–	5
Silt	23	20	45	35	100	20	40
Clay	75	80	45	65	–	80	55
Composition:							
Quartz	2	5	20	10	1	5	10
Feldspar	1	2	–	1	–	–	–
Mica	10	5	15	3	–	5	5
Heavy minerals	2	2	5	3	–	2	3
Clay	74	80	44	60	–	80	55
Glauconite	–	–	2	–	–	–	5
Pyrite	1	–	1	–	–	TR	–
Carbonate unspec.	18	4	10	21	–	5	10
Foraminifers	–	–	–	–	9	–	1
Calc. nannofossils	1	–	–	TR	81	2	8
Diatoms	–	–	1	–	1	–	–
Radiolarians	–	–	–	–	4	–	–
Sponge spicules	–	–	–	–	2	–	–
Fish remains	–	–	–	–	1	–	TR
Plant debris	–	1	–	1	–	–	1
Other opaques	1	1	2	1	1	1	1

SITE 604 HOLE CORE 6 CORED INTERVAL 44.9–54.5 m



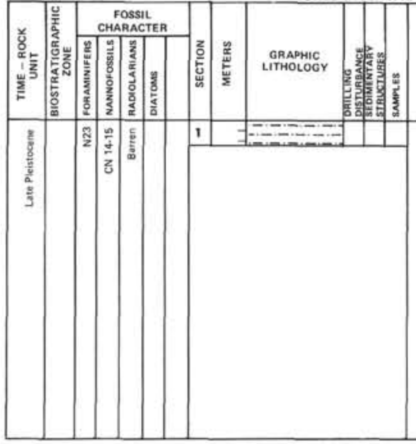
LITHOLOGIC DESCRIPTION

1) SILT- and CALCAREOUS-RICH CLAY, weak reddish gray to gray (2.5YR 4/1–N3) with interbedded swirls of CALCAREOUS CLAY, weak pinkish gray (10R 5/1).
2) SILT-RICH CLAY, dark greenish gray (5GY 4/1, 5G 4/1) with silty clay intervals. Some of the swirling bands may be produced by slumping; especially in the silty clay interval of lower Section 1. Rare claystone pieces and black spots.
3) SILTY CLAY, grayish green (5GY 4/2). Heavy mineral-rich.
4) SILT-RICH CLAY with SILTY CLAY intervals. Dark greenish gray (5GY 4/1, 5Y 4/1). Contains a shell fragment (pelecypod?) at Section 5, 35 cm and rare very fine quartz pebbles.

SMEAR SLIDE SUMMARY (%)

	1, 39	1, 50	2, 100	3, 110
	M	D	D	D
Texture:				
Silt	38	28	20	42
Clay	62	72	80	58
Composition:				
Quartz	1	3	4	7
Feldspar	TR	TR	TR	–
Mica	–	3	2	–
Heavy minerals	–	7	6	25
Clay	62	72	80	58
Palagonite	TR	–	–	–
Glauconite	–	TR	TR	1
Carbonate unspec.	35	15	3	–
Foraminifers	–	–	TR	3
Calc. nannofossils	–	–	1	–
Diatoms	–	–	TR	2
Sponge spicules	–	–	–	1
Silicoflagellates	–	–	–	TR
Plant debris (Organics)	1	–	–	–
Other opaques	1	–	3	3

SITE 604 HOLE CORE 7 CORED INTERVAL 54.5–64.1 m



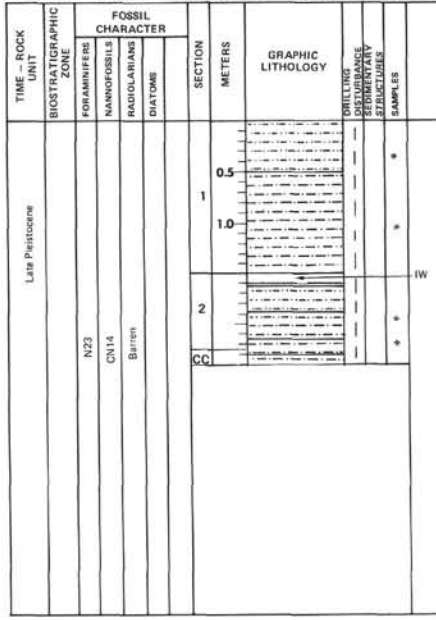
LITHOLOGIC DESCRIPTION

SILTY CLAY, medium gray (N4) with a faint swirl pattern from slumping. At 21 cm is a thin band/lens of PYRITE & GLAUCONITE GRAINS. Grains are silt, and mostly sand size.

SMEAR SLIDE SUMMARY (%)

	CC, 10	CC, 22
	D	M
Texture:		
Sand	–	50
Silt	40	48
Clay	60	2
Composition:		
Quartz	10	5
Mica	15	–
Heavy minerals	5	1
Clay	60	1
Glauconite	TR	60
Pyrite	2	30
Carbonate unspec.	8	2
Calc. nannofossils	–	1

SITE 604 HOLE CORE 8 CORED INTERVAL 64.1–73.7 m



LITHOLOGIC DESCRIPTION

1) CALCAREOUS-BEARING SILTY CLAY to CLAYEY SILT, dark greenish gray (5GY 4/1).

2) CALCAREOUS-BEARING SILT-RICH CLAY, medium gray (N5) or medium dark gray (N4) layers. Difference between these shades is undetermined.

Lower half of Section 1 and top of Section 2 display swirls of silt-poor and silt-rich with suggestions of slump origin.

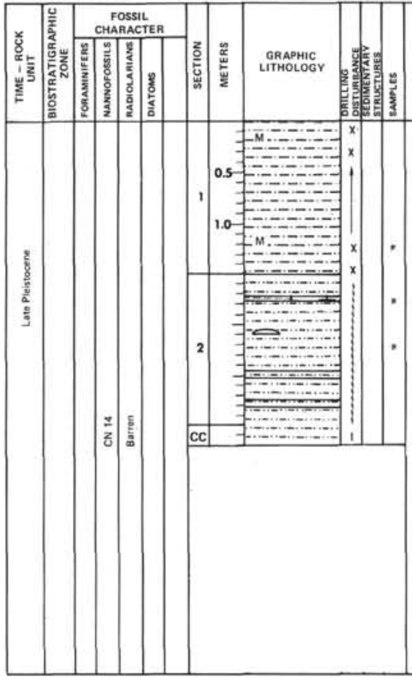
At Section 2, 47 cm is a 3–4 mm band of pinkish gray (5YR 6/2), silt-bearing clay.

At Sect. CC, 13 cm is a shell fragment (1 cm diameter; pelecypod?)

SMEAR SLIDE SUMMARY (%)

	1, 32	1, 100	2, 47	2, 72
	D	D	M	D
Texture:				
Silt	24	54	14	18
Clay	76	46	86	82
Composition:				
Quartz	6	25	5	5
Feldspar	TR	2	TR	–
Mica	2	5	TR	1
Heavy minerals	6	10	4	6
Clay	76	46	86	82
Pyrite/Micronodules	1	–	TR	–
Carbonate unspec.	9	10	4	6
Calc. nannofossils	–	TR	1	–
Other opaques	–	2	–	–

SITE 604 HOLE CORE 9 CORED INTERVAL 73.7–83.3 m



LITHOLOGIC DESCRIPTION

TERRIGENOUS SILT-BEARING CLAY, medium gray (N5) with mottling of CALCAREOUS-BEARING SILTY CLAY greenish-gray (5GY 4/1), with minor laminae of: BIOGENIC SILICA-BEARING, CLAY-RICH NANNOFOSSIL OOZE, light greenish gray (5GY 7/1) – 2 mm thick layer in Section 2, 25 cm.

TERRIGENOUS SILT-BEARING CLAY, reddish yellow (5Y 6/6), 2 mm thick layers in Section 3, 100 and 130 cm.

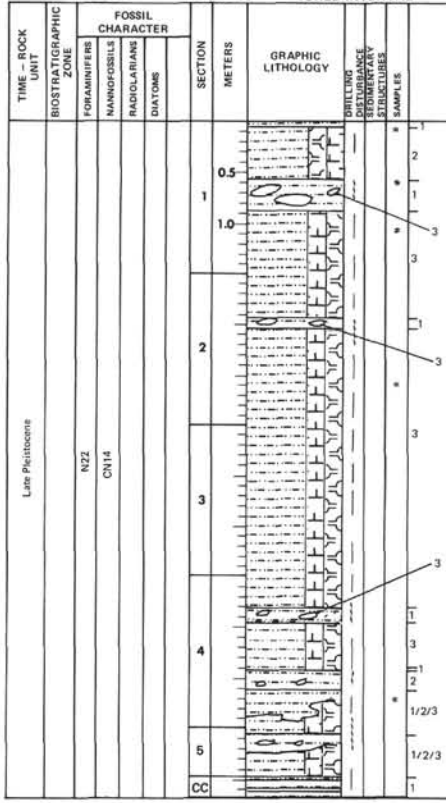
A pelecypod shell occurs at Section 2, 58 cm.

Pelecypod shell ⌒

SMEAR SLIDE SUMMARY (%)

	125, 1 D	71, 2 D	23, 2 M	130, 2 M
Texture:				
Sand	–	–	2	–
Silt	32	15	68	11
Clay	68	85	30	89
Composition:				
Quartz	4	2	–	5
Mica	20	6	–	TR
Heavy minerals	4	1	–	TR
Clay mins	67	85	30	89
Glauconite	TR	–	–	TR
Carbonate unspec.	4	4	15	5
Foraminifers	–	–	2	–
Calc. nannofossils	–	1	43	1
Diatoms	–	–	1	–
Radiolarians	–	–	3	TR
Sponge spicules	–	–	4	–
Silicoflagellates	–	–	TR	–
Fish remains	TR	–	–	–
Plant debris	1	1	–	–

SITE 604 HOLE CORE 10 CORED INTERVAL 83.3–92.9 m



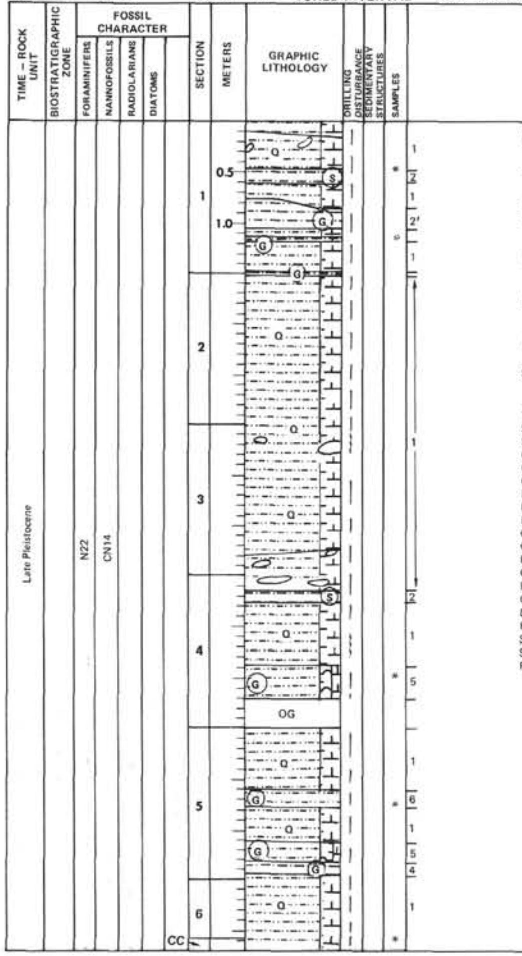
LITHOLOGIC DESCRIPTION

1) QUARTZ- and CARBONATE-RICH CLAY, gray (N5) and greenish gray (5GY 5/1).
2) QUARTZ-, GLAUCONITE-, PYRITE-BEARING BIOGENIC-SILICA and NANNOFOSSIL-RICH CLAY, dark greenish gray (5Y 4/1), structureless.
3) BIOGENIC SILICA-, QUARTZ-CLAY-RICH to CLAYEY GLAUCONITE SAND-SILT (SANDY-CLAYEY SILT), dark olive green gray (5Y 3/2) with black mottles to black with dark olive mottles. Structureless. It is included in (1) as "intraclasts" due to drilling disturbance.

SMEAR SLIDE SUMMARY (%)

	6, 1 M	51, 1	114, 1	114, 2	120, 4 D
Texture:					
Sand	–	–	20	10	–
Silt	20	40	48	55	22
Clay	80	60	32	35	78
Composition:					
Quartz	5	7	15	15	10
Mica	tr	1	–	tr	21
Heavy minerals	tr	1	2	2	–
Clay	79	50	32	21	78
Glauconite	–	5	10	35	–
Pyrite	3	4	–	5	–
Zeolite	–	–	–	–	10
Carbonate unspec. (skel)	10	3	3	2	–
Foraminifers	3	2	2	tr	–
Calc. nannofossils	tr	15	20	5	tr
Diatoms	–	5	6	5	tr
Radiolarians	tr	5	8	5	tr
Sponge spicules	tr	2	2	5	–
Silicoflagellates	–	tr	tr	tr	–
Other Ech. Spines	–	–	–	tr	–

SITE 604 HOLE CORE 11 CORED INTERVAL 92.9–102.5 m



LITHOLOGIC DESCRIPTION

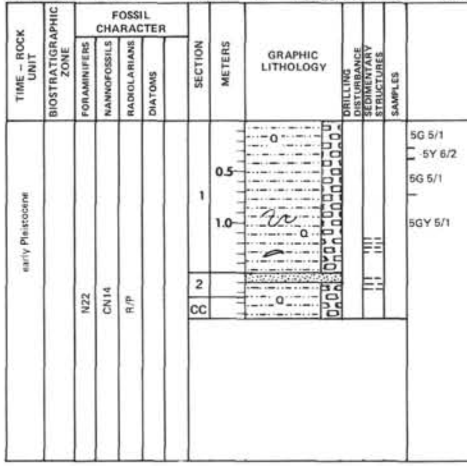
Alternation of the following lithologies:

1) QUARTZ- and NANNOFOSSIL-RICH CLAY, gray to light gray (N5–N6).
2) Terrigenous QUARTZ SAND and SIDERITE SILT-RICH CLAY, light olive gray (5Y 6/2).
2') GLAUCONITIC SILICEOUS SAND, black.
3) GLAUCONITE-BEARING, CLAY-RICH BIOGENIC SILICA and NANNOFOSSIL OOZE, olive gray (5G 4/3).
4) GLAUCONITE- and UNSPECIFIED CARBONATE-BEARING, QUARTZ-SAND-RICH SILTY CLAY, dark gray (5Y 5/1).
5) MICA-, GLAUCONITE-, PYRITE-, FORAM-BIOGENIC SILICA-SIDERITE-BEARING, QUARTZ-RICH CLAY, olive gray (5Y 5/2).
6) GLAUCONITE-, PYRITE-BEARING, QUARTZ AND SIDERITE-RICH CLAY, reddish gray (5YR 5/2).

SMEAR SLIDE SUMMARY (%)

	50, 1 M	112, 1 M	92, 4 D	75, 5 M	7, CC D
Texture:					
Sand	15	20	–	–	53
Silt	25	40	40	40	–
Clay	60	40	60	60	47
Composition:					
Quartz	15	30	20	20	30
Feldspar	TR	TR	–	TR	–
Mica	3	3	8	3	–
Heavy minerals	–	TR	TR	TR	TR
Clay	59	54	37	59	47
Glauconite	–	8	5	3	–
Pyrite	5	–	5	5	1
Carbonate unspec.	15	5	10	10	TR
Foraminifers	TR	–	5	TR	TR
Calc. nannofossils	3	TR	3	–	20
Diatoms	–	–	3	–	1
Radiolarians	TR	–	2	–	1
Sponge spicules	–	–	2	–	–
Silicoflagellates	–	–	TR	–	–
Plant debris	TR	–	–	–	TR

SITE 604 HOLE CORE 12 CORED INTERVAL 102.5–112.1 m



LITHOLOGIC DESCRIPTION

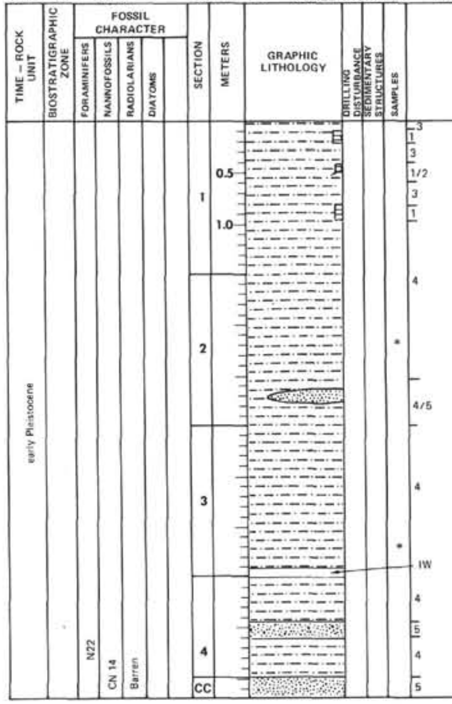
QUARTZ and CARBONATE-RICH CLAY, greenish gray (5G 5/1), light olive gray (5Y 6/2), and greenish-gray (5GY 5/1) colored.

In Section 2, 0–10 cm is a layer of SANDY SILT.

SMEAR SLIDE SUMMARY (%)

	CC, 7 D
Texture:	
Silt	30
Clay	70
Composition:	
Quartz	10
Mica	5
Clay	67
Pyrite	3
Carbonate unspec.	15
Calc. nannofossils	TR
Plant debris	TR

SITE 604 HOLE CORE 13 CORED INTERVAL 112.1–121.7 m



LITHOLOGIC DESCRIPTION

Interbedded

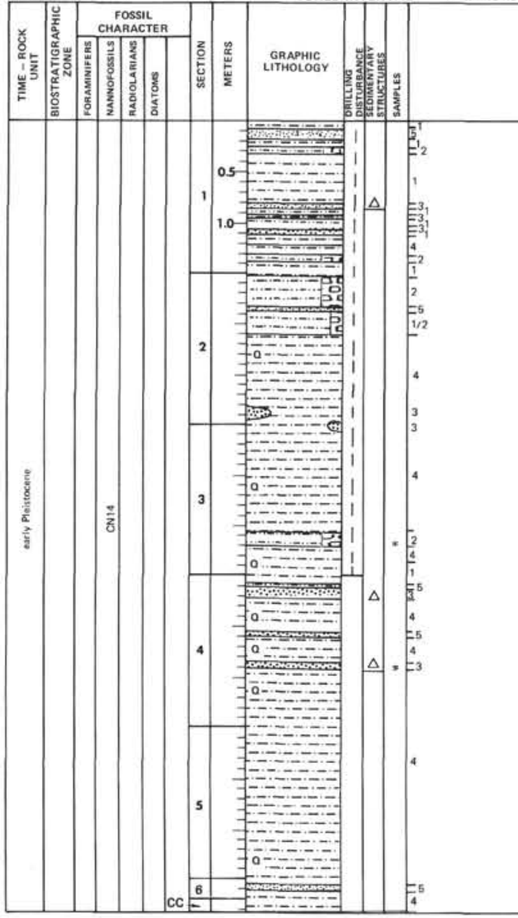
1) CALCAREOUS-BEARING SILTY CLAY, greenish-gray (5GY4/1)
2) SILTY CLAY, pale red to reddish gray (5YR5/2)
3) MICA-GLAUCONITE-PYRITE-FORAMINIFERA BEARING, QUARTZ-RICH SILTY CLAY, gray
4) QUARTZ-MICA-SIDERITE-BEARING SILTY CLAY, similar to (1), but more greenish-gray and stiffer (close to claystone!).
5) SANDY and CLAYEY SILT, GLAUCONITE-RICH, greenish gray.

Color banding and gradation between (1) and (2)

SMEAR SLIDE SUMMARY (%)

	2, 71 D	3, 132 D
Texture:		
Sand	–	10
Silt	20	40
Clay	80	50
Composition:		
Quartz	8	15
Mica	2	–
Heavy minerals	–	TR
Clay	83	44
Glauconite	2	3
Pyrite	–	5
Carbonate unspec.	5	10
Foraminifers	–	13
Calc. nannofossils	TR	2
Diatoms	–	5
Radiolarians	TR	3
Sponge spicules	–	2
Silicoflagellates	–	TR
Plant debris	TR	–

SITE 604 HOLE CORE 14 CORED INTERVAL 121.7–131.3 m



LITHOLOGIC DESCRIPTION

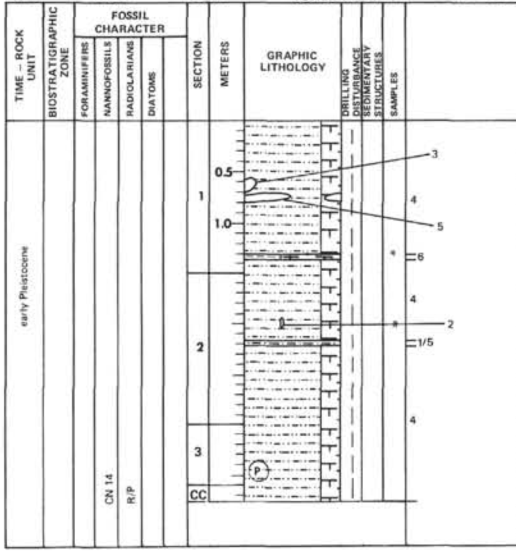
Interbedded are the following lithologies (all in different shades of dark greenish-gray)

1) SILTY CLAY, gray
2) GLAUCONITE-FORAMINIFERA-SKELETAL CARBONATE-BEARING QUARTZ-RICH CLAY, more olive shade
3) QUARTZ-BEARING, SKELETAL CARBONATE-RICH GLAUCONITE SAND (sandy silt to silty sand texture), dark greenish gray
4) SILTY CLAY, ± siliceous organisms, greenish gray
5) SANDY AND CLAYEY SILT

SMEAR SLIDE SUMMARY (%)

	4, 89 M	3, 113 D
Texture:		
Sand	100	–
Silt	–	20
Clay	–	80
Composition:		
Quartz	10	20
Feldspar	–	TR
Heavy minerals	–	TR
Clay	–	52
Glauconite	50	8
Carbonate unspec.	20	10
Foraminifers	–	10
Radiolarians	TR	–

SITE 604 HOLE CORE 15 CORED INTERVAL 131.3–140.9 m



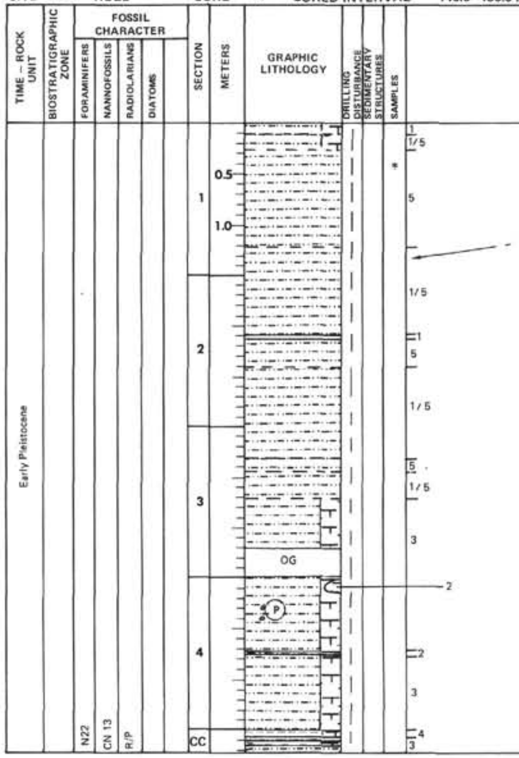
LITHOLOGIC DESCRIPTION

Alternation of:
1) SILTY CLAY, gray
2) SANDY SILTY CLAY, olive gray
3) SANDY SILT and/or SILTY SAND, GLAUCONITE-RICH, dark gray to greenish black (turbiditic layers)
4) SILTY CLAY, FORAM- and UNSPECIFIED CARBONATE-RICH, greenish gray
5) SANDY SILT layers (5 turbidites)
6) FORAM-RICH SILTY SAND layers (turbidites)

SMEAR SLIDE SUMMARY (%)

	2, 44 D	1, 132 M
Texture:		
Sand	–	50
Silt	25	30
Clay	75	20
Composition:		
Quartz	5	5
Feldspar	–	TR
Mica	2	TR
Heavy minerals	TR	TR
Clay minerals	73	35
Glauconite	2	TR
Pyrite	2	–
Carbonate unspec.	10	30
Foraminifers	5	30
Diatoms	TR	–
Radiolarians	1	–

SITE 604 HOLE CORE 16 CORED INTERVAL 140.9–150.5 m



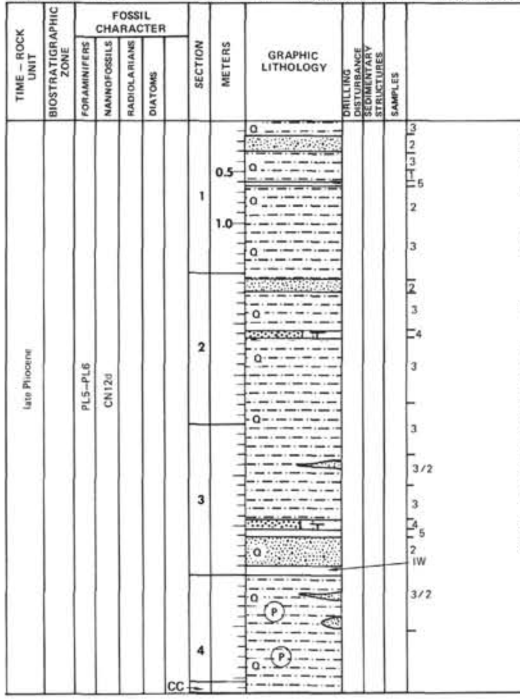
LITHOLOGIC DESCRIPTION

Alternation of:
1) SILTY CLAY, gray (N4)
2) SANDY SILTY CLAY, olive gray
3) SILTY CLAY, FORAM- and CARBONATE-RICH, greenish gray
4) FORAM-RICH SILTY SAND layers (= turbidites)
5) SILTY CLAY (same as [3]), pale red (2.5YR 6/2)
3/5) Greenish gray–dark greenish gray, pale red mottled or pale red, greenish gray mottled

SMEAR SLIDE SUMMARY (%)

	1, 49 D
Texture:	
Silt	25
Clay	75
Composition:	
Quartz	15
Mica	tr
Clay	75
Glauconite	tr
Fe-Ox	5
Carbonate unspec.	5
Calc. nannofossils	tr

SITE 604 HOLE CORE 17 CORED INTERVAL 150.5–160.1 m



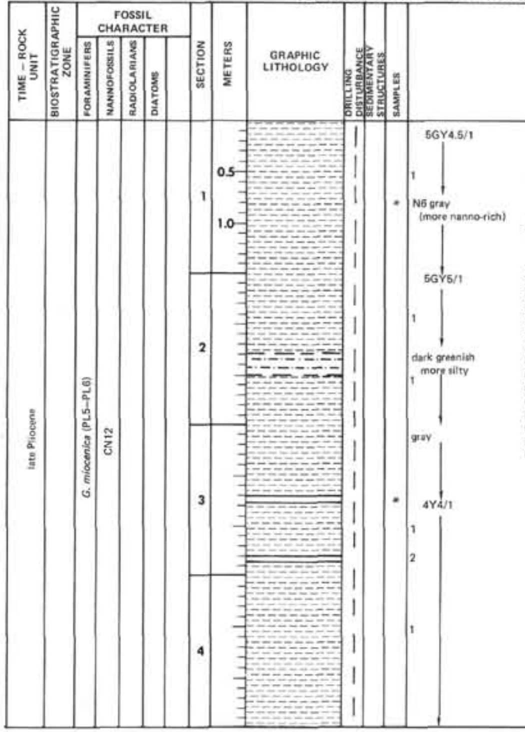
LITHOLOGIC DESCRIPTION

Interbedded
1) Gray SILTY CLAY
2) SANDY-SILTY CLAY, olive gray (QUARTZ-RICH CLAY)
3) CARBONATE-BEARING QUARTZ-SILT RICH CLAY to QUARTZ GLAUCONITE-FORAM-BEARING CARBONATE-RICH CLAY, greenish gray
4) SILTY SAND, rich in foraminifers (turbidites)
5) QUARTZ and CLAY MINERAL-RICH CARBONATE (?SIDERITE) SILT, ~8 cm thick light colored layer with 2 mm pure siderite lamina

SMEAR SLIDE SUMMARY (%)

	1, 64 D	1, 46 D	1, 54 M	4, 80 D
Texture:				
Silt	30	25	85	30
Clay	70	75	15	70
Composition:				
Quartz	5	15	15	20
Feldspar	TR	–	–	–
Mica	–	3	3	2
Heavy minerals	–	–	TR	1
Clay minerals	68	73	11	66
Glauconite	4	TR	–	3
Pyrite	–	3	5	–
Carbonate unspec. (? siderite)	10	5	60	3
Foraminifers	5	1	5	2
Calc. nannofossils	2	TR	–	TR
Sponge spicules	–	–	1	3

SITE 604 HOLE CORE 18 CORED INTERVAL 160.1–169.7 m



LITHOLOGIC DESCRIPTION

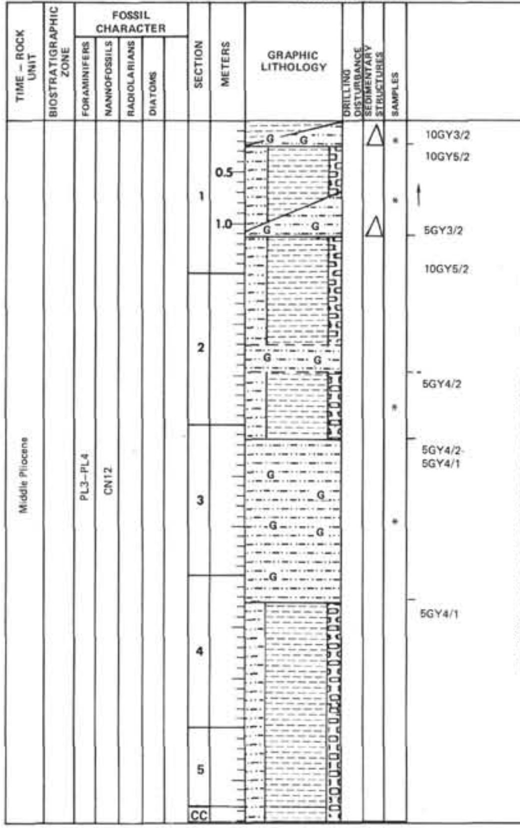
1) Mainly QUARTZ-, CARBONATE- and NANNO-BEARING CLAY, in places quartz silt-rich or silty and nanno-rich.

2) GLAUCONITE-RICH SAND layer (cm-thick), massive, dark green to black occur.

SMEAR SLIDE SUMMARY (%)

	1, 80 D	3, 76 D
Texture:		
Silt	4	13
Clay	96	87
Composition:		
Quartz	2	3
Feldspar	tr	–
Mica	1	–
Heavy minerals	tr	–
Clay	96	87
Glauconite	–	tr
Carbonate unspec.	3	10
Foraminifers	tr	–
Calc. nannofossils	2	tr
Radiolarians	–	tr
Fish remains	tr	–

SITE 604 HOLE CORE 19 CORED INTERVAL 169.7–179.3 m



LITHOLOGIC DESCRIPTION

Alternations of two main textures:

(1) SILT-BEARING to NANNOFOSSIL- and SILT-BEARING CLAY, grayish green (10GY 5/2, 5GY 4/2 – grayish olive green).

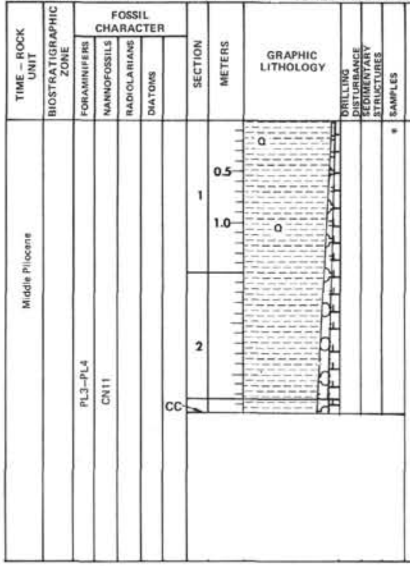
(2) BIOGENIC SILICA-BEARING, SILT-RICH CLAY to CALCAREOUS-BEARING GLAUCONITE (SAND)-RICH CLAY, dark grayish green (10GY 3/2 to 5GY 3/2).

Grading of Glauconite-rich to silt-bearing CLAY in Section 1.

SMEAR SLIDE SUMMARY (%)

	1, 23 M	1, 68 D	2, 130 D	3, 19 D
Texture:				
Sand	–	–	–	20
Silt	41	23	26	16
Clay	59	77	74	64
Composition:				
Quartz	17	7	4	4
Feldspar	1	TR	–	–
Mica	1	1	–	–
Heavy minerals	4	2	3	–
Clay	59	73	74	64
Palagonite	TR	–	TR	–
Glauconite	1	TR	–	20
Pyrite	–	–	4	2
Zeolite	–	1	2	–
Carbonate unspec.	7	4	10	9
Foraminifers	1	2	TR	–
Calc. nannofossils	TR	8	3	–
Diatoms	1	–	–	–
Radiolarians	3	1	TR	1
Sponge spicules	4	TR	–	–
Silicoflagellates	TR	–	–	–
Fish remains	–	–	TR	–
Plant debris	1	1	–	–

SITE 604 HOLE CORE 20 CORED INTERVAL 179.3–188.9 m



LITHOLOGIC DESCRIPTION

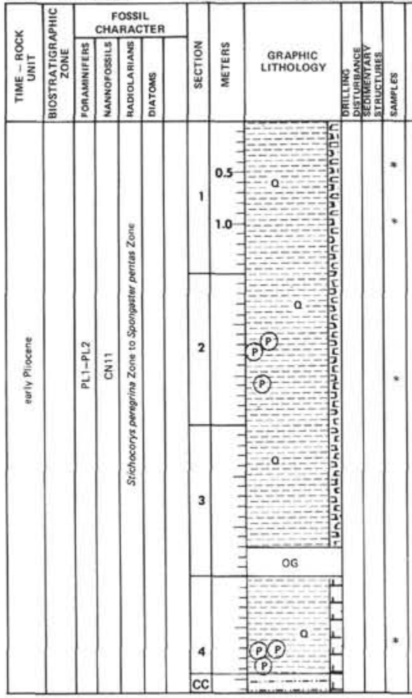
BIOGENIC SILICA-, QUARTZ-, and NANNOFOSSIL-BEARING CLAY, grayish olive green (5GY 3/2) with no apparent structure. Section 1.

BIOGENIC SILICA, NANNOFOSSIL-BEARING CLAY, grayish olive green (5GY3/2) with no apparent structure Section 1 & 2.

SMEAR SLIDE SUMMARY (%)

	1, 10 D	2, 60 D
Texture:		
Sand	3	–
Silt	22	76
Clay	75	24
Composition:		
Quartz	4	4
Mica	2	1
Heavy minerals	1	TR
Clay	75	76
Glauconite	1	2
Pyrite	2	–
Carbonate unspec.	3	4
Foraminifers	1	–
Calc. nannofossils	6	6
Diatoms	1	1
Radiolarians	1	3
Sponge spicules	2	2
Plant debris	TR	1
Other opaques	1	–

SITE 604 HOLE CORE 21 CORED INTERVAL 188.9–198.5 m



LITHOLOGIC DESCRIPTION

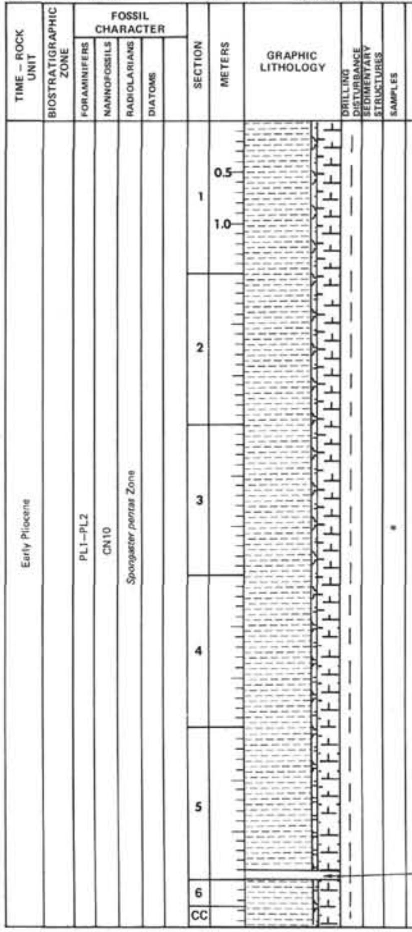
NANNOFOSSIL- and SILT-BEARING CLAY to CALCAREOUS-, BIOGENIC SILICA-, and QUARTZ SILT-BEARING CLAY, dark greenish gray (5GY 4/1 and 5GY 3/2); homogeneous with rare white spots of quartz silt clusters and rare pyrite nodules and clusters (dark grayish brown, 2.5Y 4/2).

Sect. 3, 85-105 is a (?) Pyrite-rich zone with abundant fine black grains.

SMEAR SLIDE SUMMARY (%)

	1, 37 M	1, 100 D	2, 105 M	4, 60 D
Texture:				
Silt	100	31	100	21
Clay	–	69	–	79
Composition:				
Quartz	100	9	–	8
Feldspar	–	–	–	2
Mica	–	1	–	–
Heavy minerals	–	TR	–	–
Clay	–	69	–	79
Glauconite	–	1	–	TR
Pyrite	–	2	96	1
Zeolite	–	1	–	–
Carbonate unspec.	–	6	2	–
Foraminifers	–	1	–	–
Calc. nannofossils	–	4	2	8
Diatoms	–	1	–	–
Radiolarians	–	2	–	1
Sponge spicules	–	2	–	1
Plant debris	–	1	–	–

SITE 604 HOLE CORE 22 CORED INTERVAL 198.5-208.1 m



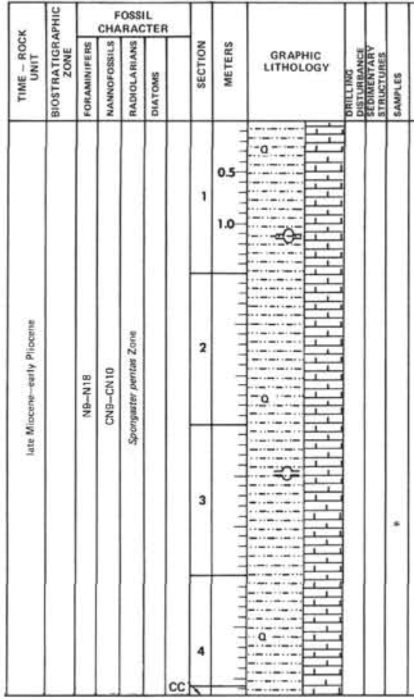
LITHOLOGIC DESCRIPTION

QUARTZ-, MICA-, BIOGENIC SILICA-BEARING NANNOFOSSIL-RICH CLAY; dark greenish gray (5GY 4/1), structureless and homogeneous.

SMEAR SLIDE SUMMARY (%)

	1, 100
	D
Texture:	
Silt	35
Clay	65
Composition:	
Quartz	8
Mica	2
Clay	63
Glauconite	tr
Pyrite	1
Zeolite	tr
Carbonate unspec.	2
Foraminifers	tr
Calc. nannofossils	20
Diatoms	tr
Radiolarians	1
Sponge spicules	3

SITE 604 HOLE CORE 23 CORED INTERVAL 208.1–217.7 m



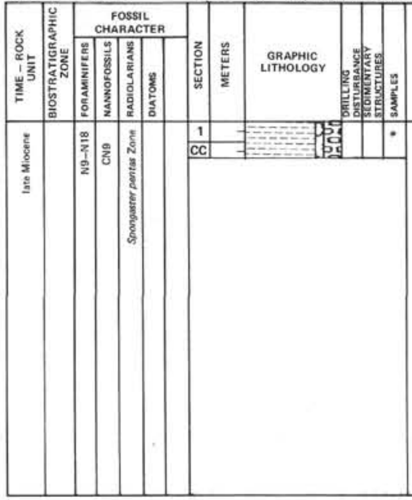
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-, FORAMINIFERA-, and PYRITE-BEARING, QUARTZ- and CLAY-RICH NANNOFOSSIL CHALK, dark greenish gray (5GY 5/1 to 4/1), homogeneous, no bedding, faintly mottled.

SMEAR SLIDE SUMMARY (%)

	3, 100
Texture:	
Silt	60
Clay	40
Composition:	
Quartz	15
Mica	1
Clay	25
Glauconite	3
Pyrite	5
Carbonate unspec.	3
Foraminifers	3
Calc. nannofossils	40
Diatoms	TR
Radiolarians	2
Sponge spicules	3
Plant debris	TR

SITE 604 HOLE CORE 24 CORED INTERVAL 217.7–227.3 m



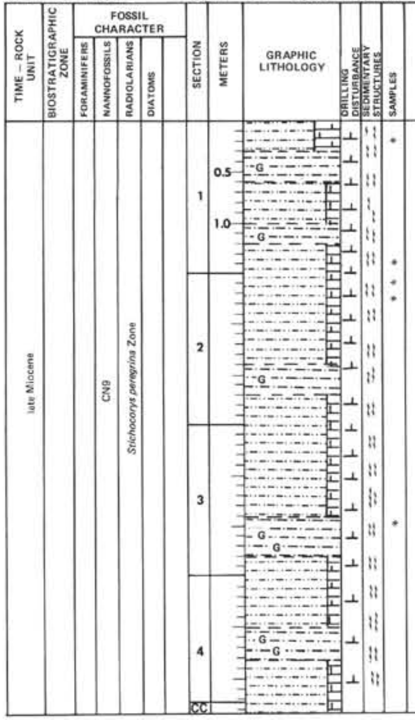
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-BEARING, NANNOFOSSIL-RICH CLAY grayish olive green (5GY3/2) with no apparent structure

SMEAR SLIDE SUMMARY (%)

	1, 10
	D
Texture:	
Sand	3
Silt	27
Clay	70
Composition:	
Quartz	2
Mica	1
Heavy minerals	TR
Clay	67
Glauconite	2
Pyrite	1
Carbonate unspec.	2
Foraminifers	TR
Calc. nannofossils	15
Diatoms	1
Radiolarians + Silicified	7
Sponge spicules	2
Plant debris	TR

SITE 604 HOLE CORE 25 CORED INTERVAL 227.3–236.9 m



LITHOLOGIC DESCRIPTION

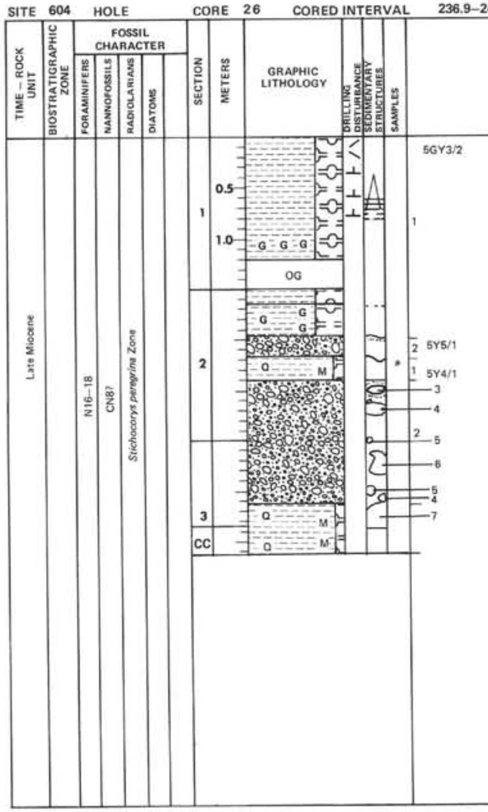
BIOGENIC SILICA-BEARING NANNOFOSSIL-RICH CLAYSTONE, dark grayish olive green (5GY 3/2 and 5GY 4/1). Intervals which are silt-rich appear dark greenish gray (5G 3/1) due to abundance of greenish black grains (GLAUCONITE); these silt-rich intervals are a complex bioturbated and (?) current reworked mixture of glauconite-rich and clay-rich stringers and burrow fills. Moderate to heavy bioturbation throughout. Rare tiny white, quartz-silt concentrations.

Sections 1 & 2 wire-split, Sections 3 & 4 saw cut – implying CLAY → CLAYSTONE change in induration.

SMEAR SLIDE SUMMARY (%)

	1, 20 D	1, 140 D	2, 8 D	2, 28 M	3, 110 D
Texture:					
Silt	45	38	34	32	42
Clay	55	62	66	68	58
Composition:					
Quartz	5	15	10	3	18
Feldspar	–	2	TR	–	1
Mica	–	3	3	–	4
Clay	54	62	66	68	58
Glauconite	–	1	1	15	10
Pyrite/Micronodules	3	4	2	2	–
Carbonate unspec.	2	2	2	–	4
Foraminifers	1	–	–	–	–
Calc. nannofossils	30	6	8	3	–
Diatoms	TR	–	2	TR	4
Radiolarians	3	3	2	6	1
Sponge spicules	2	1	2	2	TR
Silicoflagellates	–	TR	1	–	–
Plant debris	–	1	1	1	–

SITE 604 HOLE CORE 26 CORED INTERVAL 236.9–246.5 m



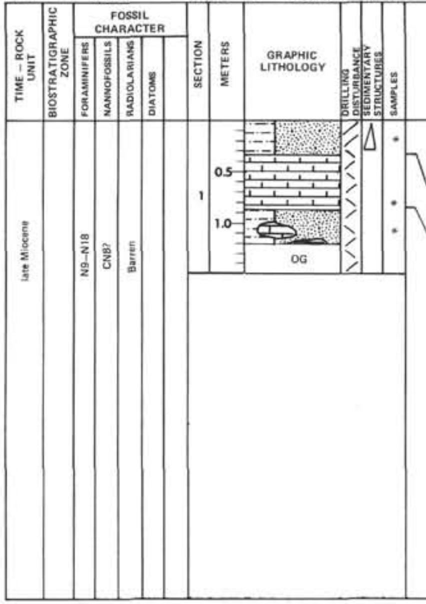
LITHOLOGIC DESCRIPTION

1) BIOGENIC SILICA-RICH CLAYSTONE, (5GY 3/2) grayish olive green. Faint laminations (65-73 cm) frame concentrations of glauconite sand. Remainder of Section 1 has the addition of *glauconite-rich* to the name. Section 2, is 1 up to 17 cm with addition of GLAUCONITE RICH to the name from 17-49 cm. Gradational contact at 49 cm.
2) CONGLOMERATE, gray (5Y 5/1) containing clasts (3 cm) of claystone, pebbles of quartz with common glauconitic grains in clay matrix. Erosive contact at base
3) BIOGENIC SILICA & SILT BEARING CLAYSTONE, dark gray (5Y 4/1), homogenous Section 2, 90-150 cm, & Section 3, 0-60 cm similar to (2) but a concentration of glauconite grains surround a clast of (3). Evidence of debris flow?
4) CLAY-RICH BIOGENIC SILICA-RICH NANNOFOSSIL CHALK (pale greenish yellow, 10Y 8/2).
5) CHALK with quartz & glauconite is another cobble.
6) Cobble again composed of SILT & BIOGENIC SILICA-RICH CLAYSTONE (olive black 5Y 2/1)
7) BIOGENIC SILICA & SILT BEARING CLAYSTONE of olive gray (5Y 4/1). Base of Section 3 & CC.

SMEAR SLIDE SUMMARY (%)

	1, 56 D	2, 76 D	3, 57 M	3, 29 D	3, 9 M
Texture:					
Sand	–	–	2	–	5
Silt	35	30	83	34	5
Clay	65	70	15	66	90
Composition:					
Quartz	2	5	–	10	5
Mica	4	4	–	4	–
Heavy minerals	1	–	–	–	–
Clay	63	67	15	66	–
Glauconite	2	1	–	1	5
Pyrite	1	4	–	3	–
Carbonate upspec.	–	5	40	2	90
Foraminifers	–	–	5	–	–
Calc. nannofossils	2	4	30	–	–
Diatoms	15	5	–	8	–
Radiolarians	3	3	5	3	–
Sponge spicules	5	1	5	2	–
Silicoflagellates	1	–	–	1	–
Fish remains	1	–	–	–	–
Plant debris	–	1	–	–	–

SITE 604 HOLE CORE 27 CORED INTERVAL 246.5–256.1 m



LITHOLOGIC DESCRIPTION

CLAYEY SANDY SILTSTONE with fine pebbles of quartz; grayish olive green (5GY3/2); contains glauconite-rich intervals. Between 22 and 25 cm is a layer of greenish gray (5G: 6/1) NANNOFOSSIL-RICH CHALK

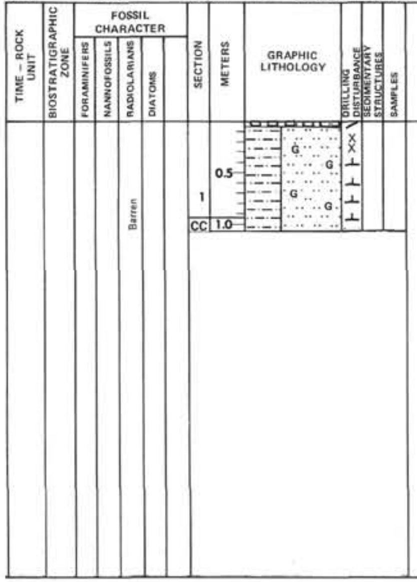
NANNOFOSSIL CHALK, light greenish gray (5GY7/1) with irregular banding in a slightly browner shade. Allochthonous block?

Fragments of LIMESTONE (grayish green, 5GY3/2 + 5GY4/1) in CLAYEY SANDY SILTSTONE (dark greenish gray, 5GY3/1; glauconite-rich.

SMEAR SLIDE SUMMARY (%)

	1, 20 D	1, 85 D	1, 110 M
Texture:			
Sand	15	–	–
Silt	33	95	97
Clay	58	5	3
Composition:			
Quartz	20	–	–
Mica	8	–	–
Heavy minerals	2	–	–
Clay	58	5	3
Glauconite	5	–	–
Pyrite	–	–	1
Carbonate unspec.	–	–	96
Foraminifers	2	1	–
Calc. nannofossils	3	91	–
Diatoms	–	1	–
Radiolarians	1	1	–
Sponge spicules	1	1	–

SITE 604 HOLE CORE 28 CORED INTERVAL 256.1–265.7 m



LITHOLOGIC DESCRIPTION

0–5 cm CALCAREOUS OOZE, light gray (5Y 7/1)

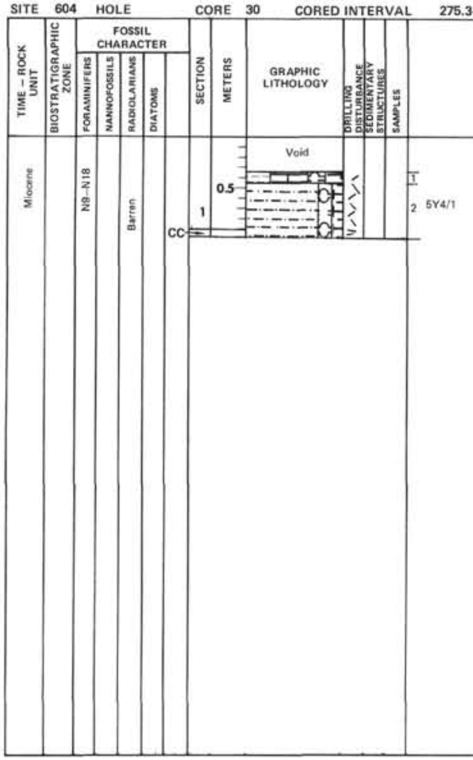
GLAUCONITE-RICH CLAYEY SILTSTONE with rare quartz pebbles (rounded) and large sand grains and rare shell fragments, dark olive gray (5Y 4/1).

SMEAR SLIDE SUMMARY (%)

	1, 3 M
Texture:	
Silt	10
Clay	90
Composition:	
Quartz	3
Mica	2
Heavy minerals	1
Clay	10
Carbonate unspec.	80
Foraminifers	1
Radiolarians	2
Other Opaques	1

Core 29, 265.7–275.3 m: no recovery.

SITE 604 HOLE CORE 30 CORED INTERVAL 275.3–284.9 m



LITHOLOGIC DESCRIPTION

1) FORAMINIFER- and NANNOFOSSIL-BEARING, BIOGENIC SILICA- and CLAY-RICH CHALK, light gray (N7) with 1 cm band of light medium gray (N6) at base of rock (34–46 cm).

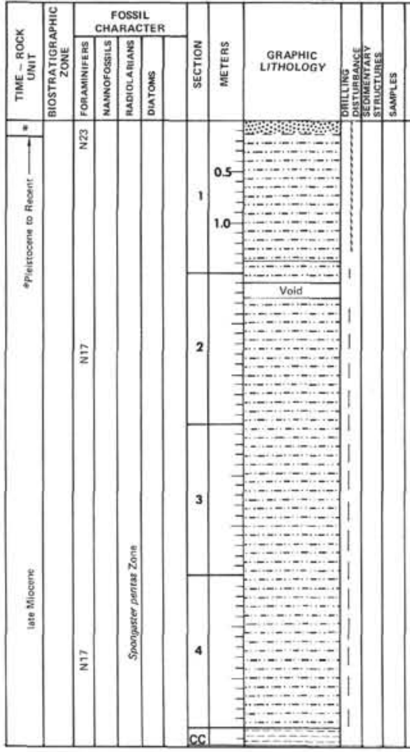
2) BIOGENIC SILICA AND NANNOFOSSIL BEARING SILTY CLAYSTONE, dark gray (5Y4/1) with black fragments of plant debris visible from 46-50 cm. One small clast (3 mm length, 2 mm thick) – green, composed of CLAY BIOGENIC SILICA OOZE within the claystone.

SMEAR SLIDE SUMMARY (%)

	1, 42 M	1, 65 D	1, 80 M
Texture:			
Sand	–	15	–
Silt	60	45	65
Clay	40	40	35
Composition:			
Quartz	–	16	–
Feldspar	–	2	–
Mica	–	6	–
Heavy minerals	–	3	–
Clay	28	40	35
Glauconite	–	2	–
Pyrite	–	4	–
Carbonate unspec.	40	5	–
Foraminifers	5	2	–
Calc. nannofossils	10	8	5
Diatoms	3	3	10
Radiolarians	6	3	30
Sponge spicules	8	3	20
Fish remains	–	1	–
Plant debris	–	1	–

Core 31, 284.9–294.0 m: no recovery.

SITE 604 HOLE A CORE 1M CORED INTERVAL 0.0–249.6 m



LITHOLOGIC DESCRIPTION

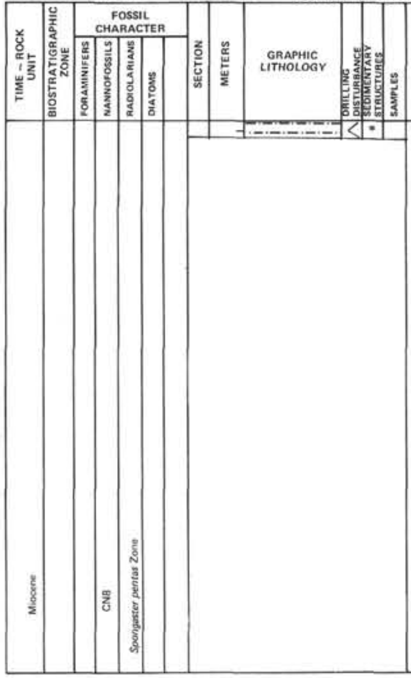
WASH CORE.
Soupy QUARTZOSE COARSE SAND, gray (N4) in uppermost 15 cm.

Soupy CLAY, gray (N5) in Section 1, 15–138 cm.

Rest of core is SILTY CLAYSTONE, dark greenish gray (5GY 4/1), stiff.

Dark greenish gray (5GY 4/1), stiff.

SITE 604 HOLE A CORE 2 CORED INTERVAL 249.6–259.2 m



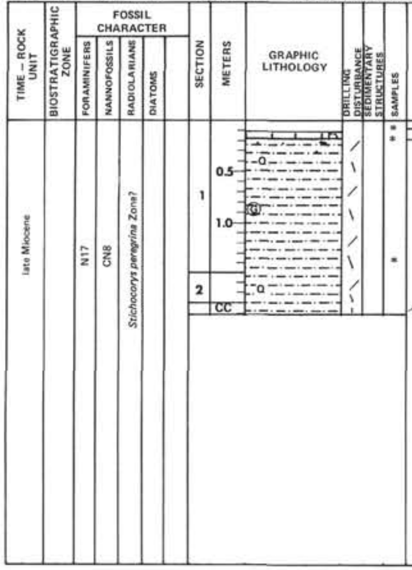
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-GLAUCONITE-PYRITE-UNSPECIFIED CARBONATE-BEARING, QUARTZ-RICH CLAYSTONE,
dark greenish gray (5GY 4/1).

SMEAR SLIDE SUMMARY (%):

	1,5 D
Texture:	
Sand	10
Silt	20
Clay	70
Composition:	
Quartz	10
Feldspar	2
Mica	2
Heavy Minerals	TR
Clay	72
Glauconite	3
Pyrite	2
Carbonate unspec.	5
Calc. nannofossils	TR
Diatoms	TR
Radiolarians	3
Sponge spicules	1

SITE 604 HOLE A CORE 3 CORED INTERVAL 259.2–268.8 m



LITHOLOGIC DESCRIPTION

Several layers of silicified? micritic limestone in loose sandy and pebbly mud (quartz pebbles up to 1 cm)

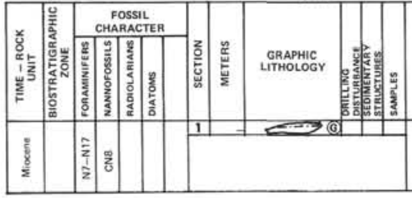
BIOGENIC SILICA- and FORAMINIFERA-RICH NANNOFOSSIL CHALK, light greenish gray (5G 8/1).

PYRITE-BEARING, GLAUCONITE-, NANNOFOSSIL-, QUARTZ-RICH CLAY (glauconitic mudstone), dark greenish gray (5GY 4/1). Dark green crystalline rock fragments (up to 5 mm).

SMEAR SLIDE SUMMARY (%):

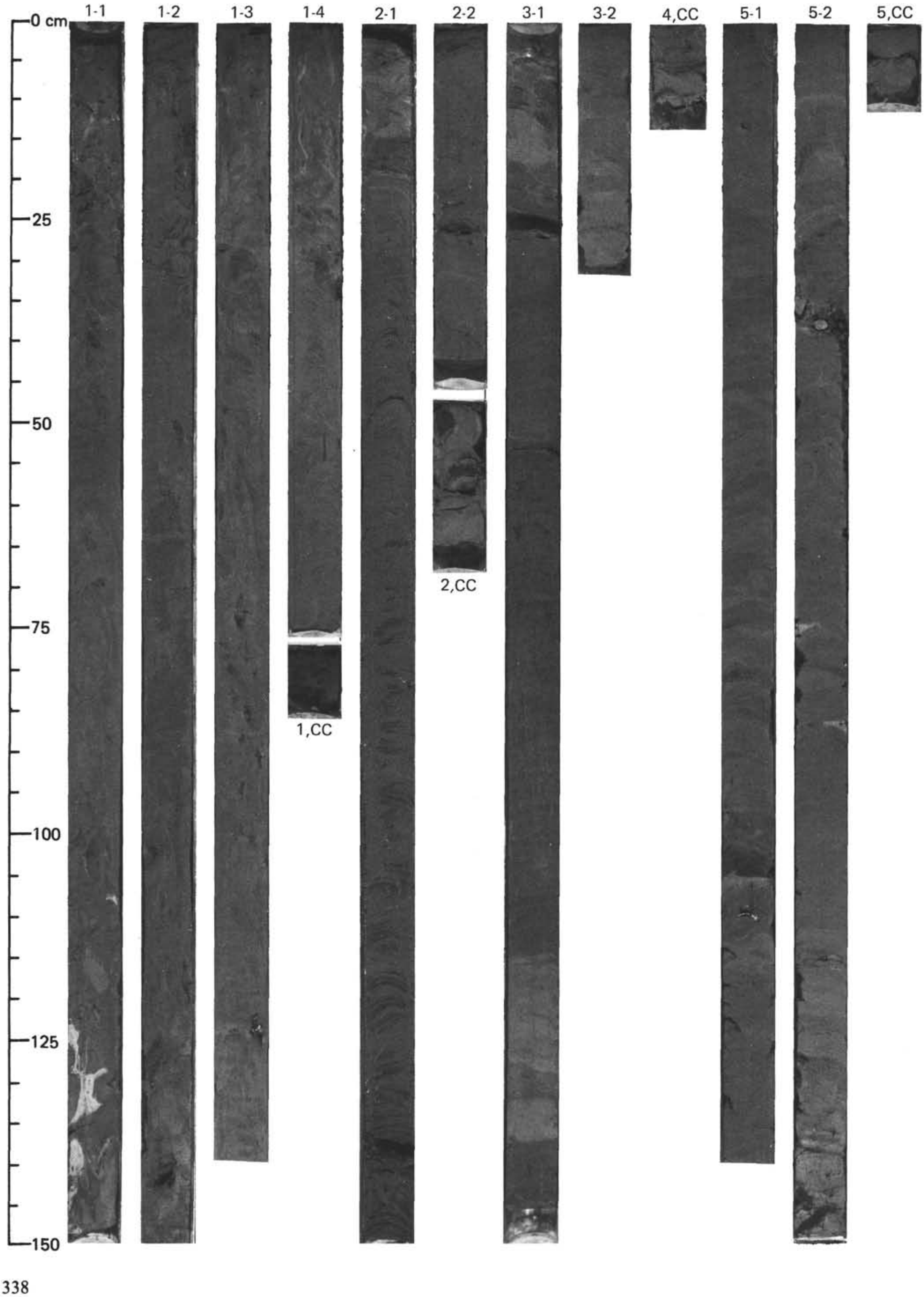
	1,140 D	1,5 M	1,14 M
Texture:			
Sand	–	–	–
Silt	45	90	50
Clay	55	10	50
Composition:			
Quartz	15	–	2
Feldspar	TR	–	–
Mica	TR	1	–
Clay	55	10	TR
Glauconite	10	TR	–
Pyrite	5	–	–
Carbonate unspec.	3	90	23
Foraminifers	1	–	10
Calc. nannofossils	10	–	50
Diatoms	–	–	5
Radiolarians	–	–	4
Sponge spicules	1	–	6
Plant debris	TR	–	–
Other Opal cement.	–	TR	–

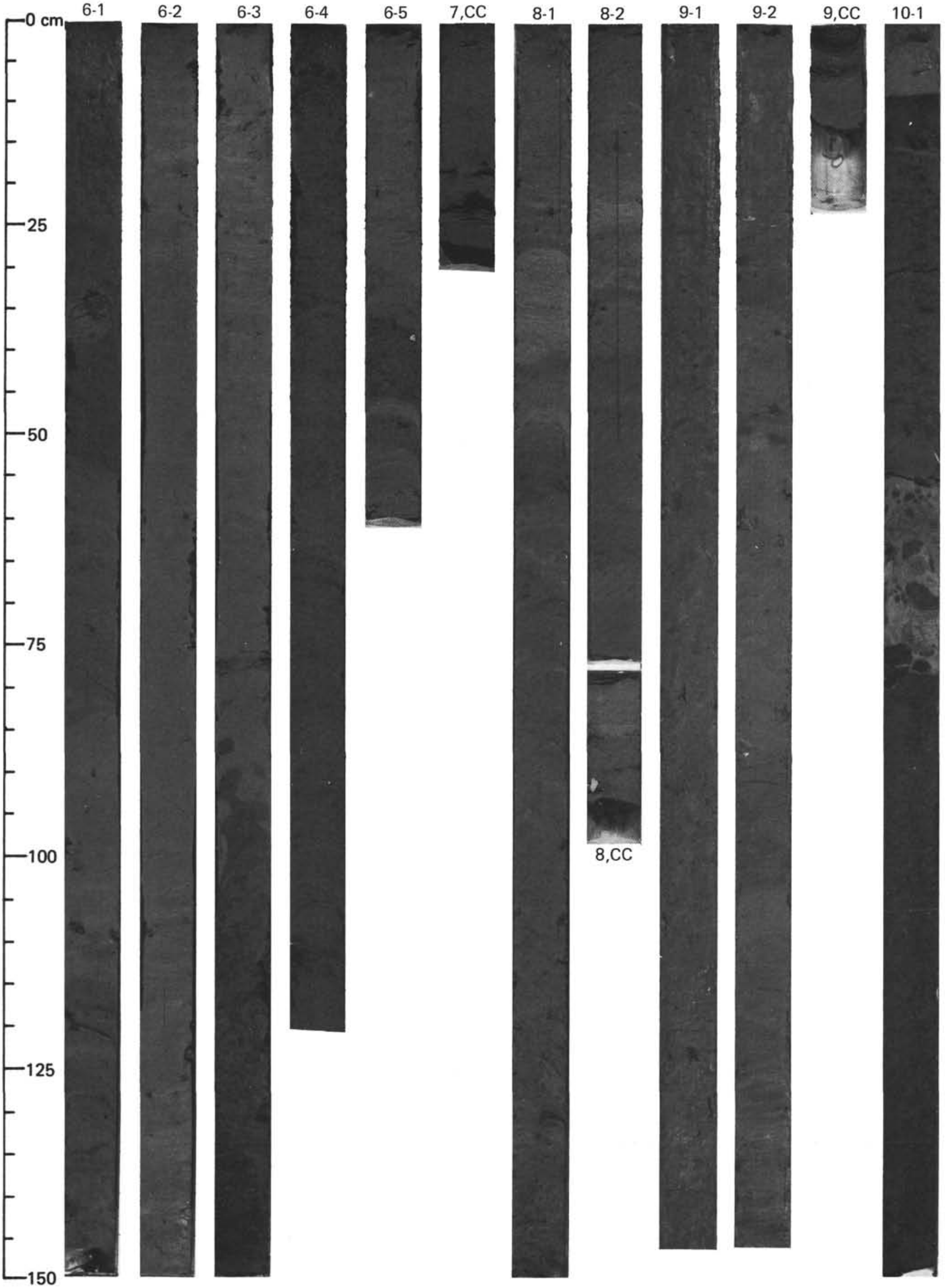
SITE 604 HOLE A CORE 4 CORED INTERVAL 268.8–278.4 m

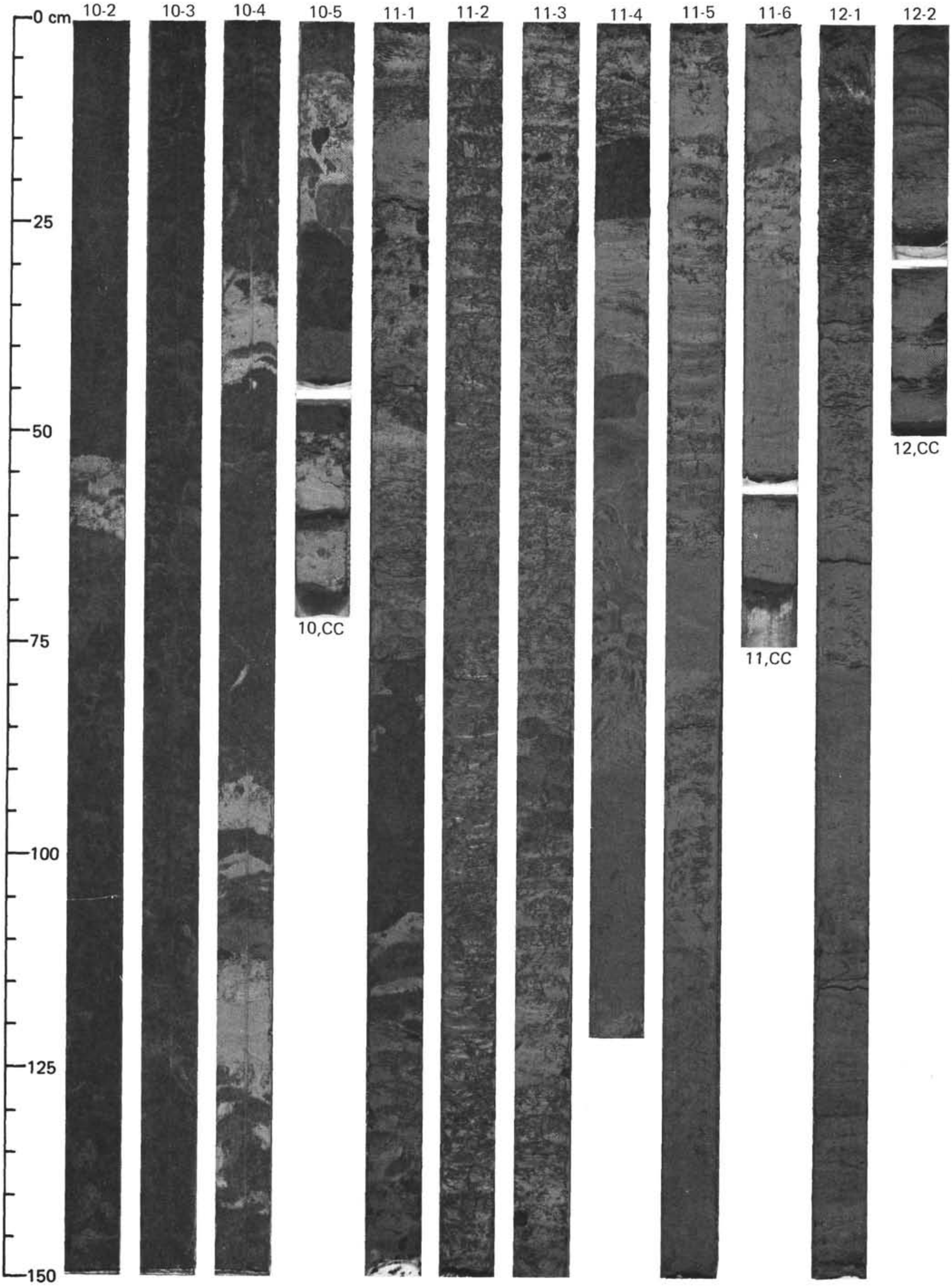


LITHOLOGIC DESCRIPTION

One fragment (5 cm in diameter) of dark gray (5Y 4/1) QUARTZOSE, GLAUCONITIC SANDY MUDSTONE (with fish debris).


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


0 cm
25
50
75
100
125
150
6-1
6-2
6-3
6-4
6-5
7,CC
8-1
8-2
8,CC
9-1
9-2
9,CC
10-1


0 cm
25
50
75
100
125
150
10-2
10-3
10-4
10-5
10,CC
11-1
11-2
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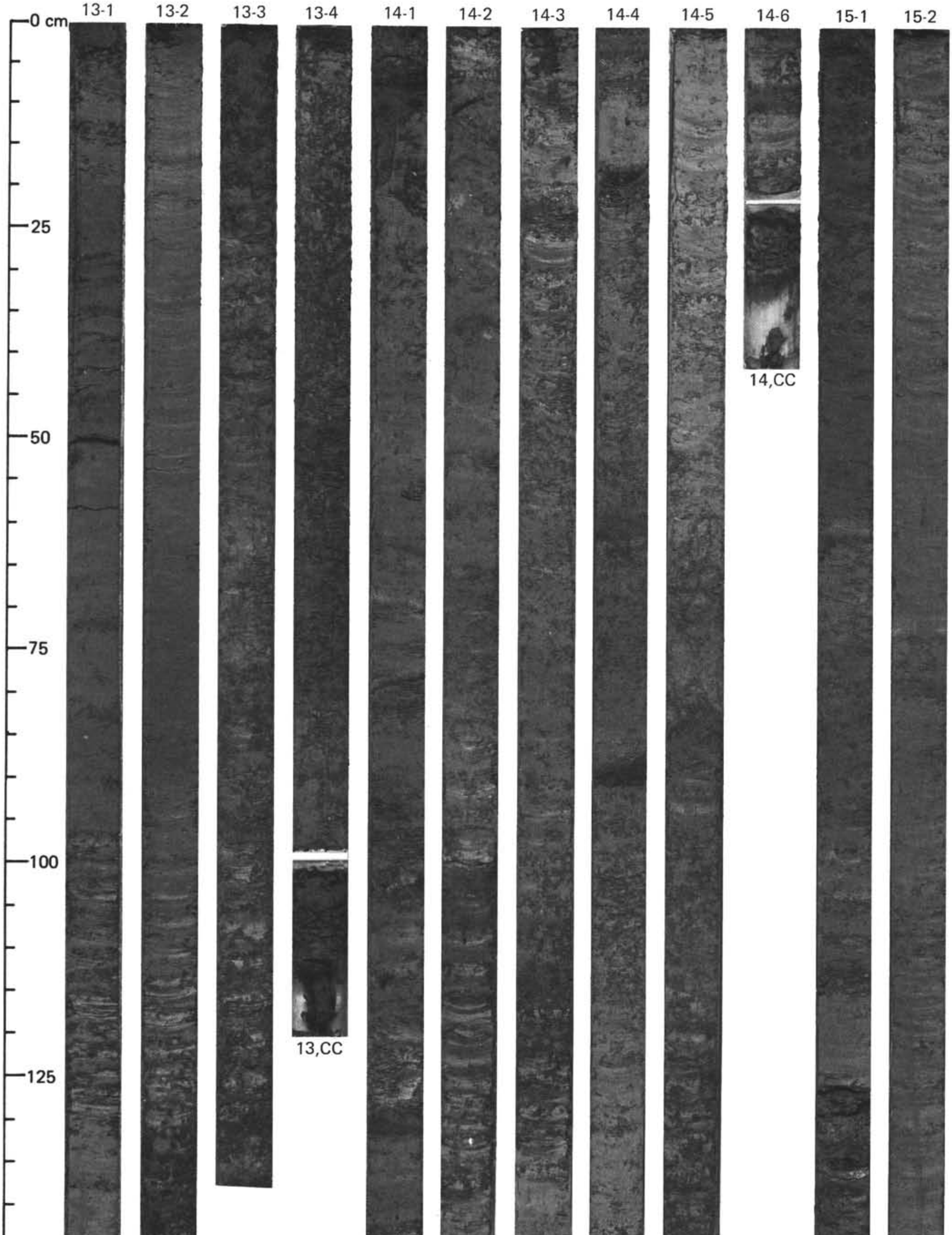
11-6
11,CC
12-1
12-2
12,CC


0 cm
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125
150
13-1
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13-4
13,CC
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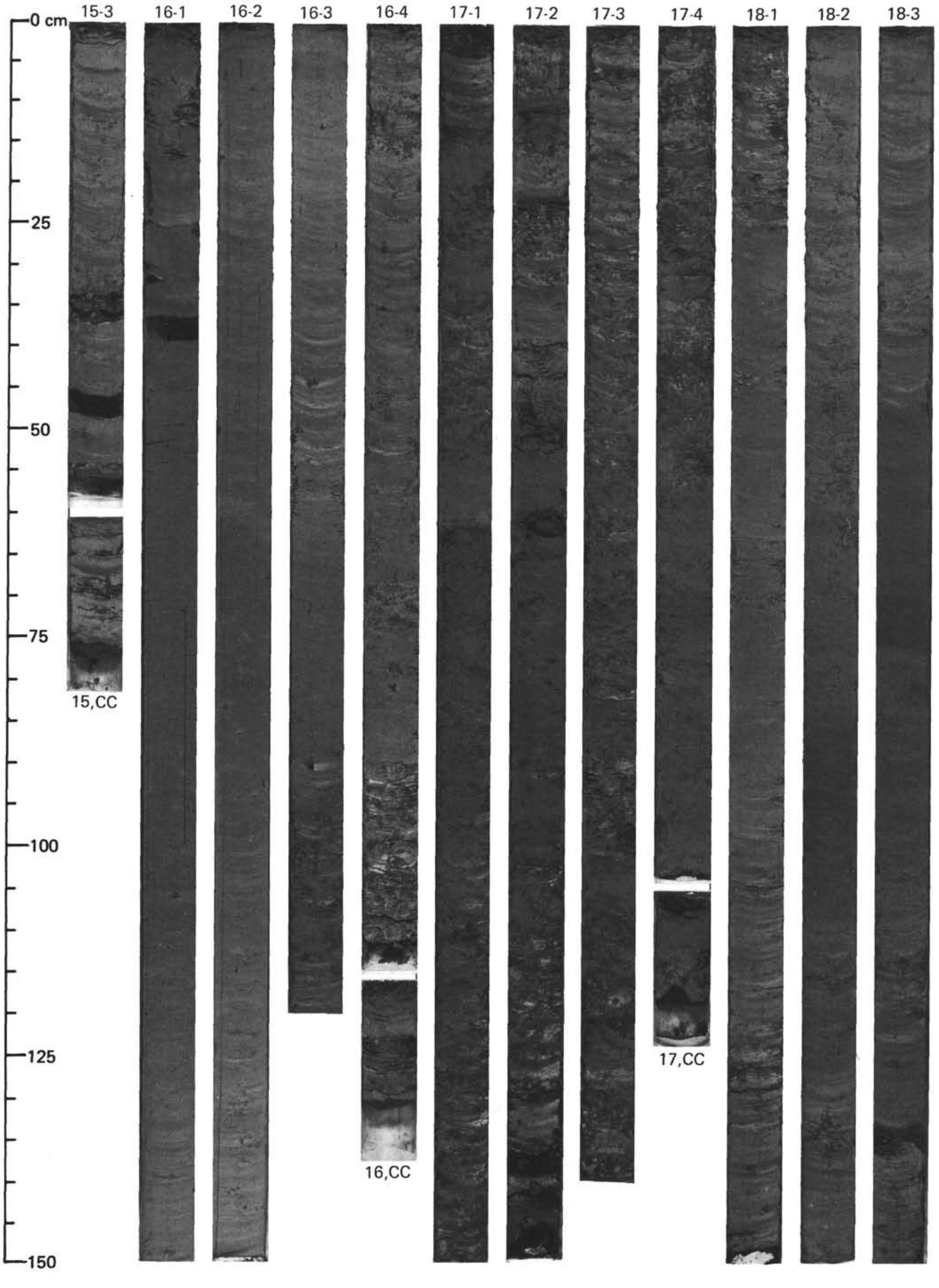
14-4
14-5
14-6
14,CC
15-1
15-2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15-3
16-1
16-2
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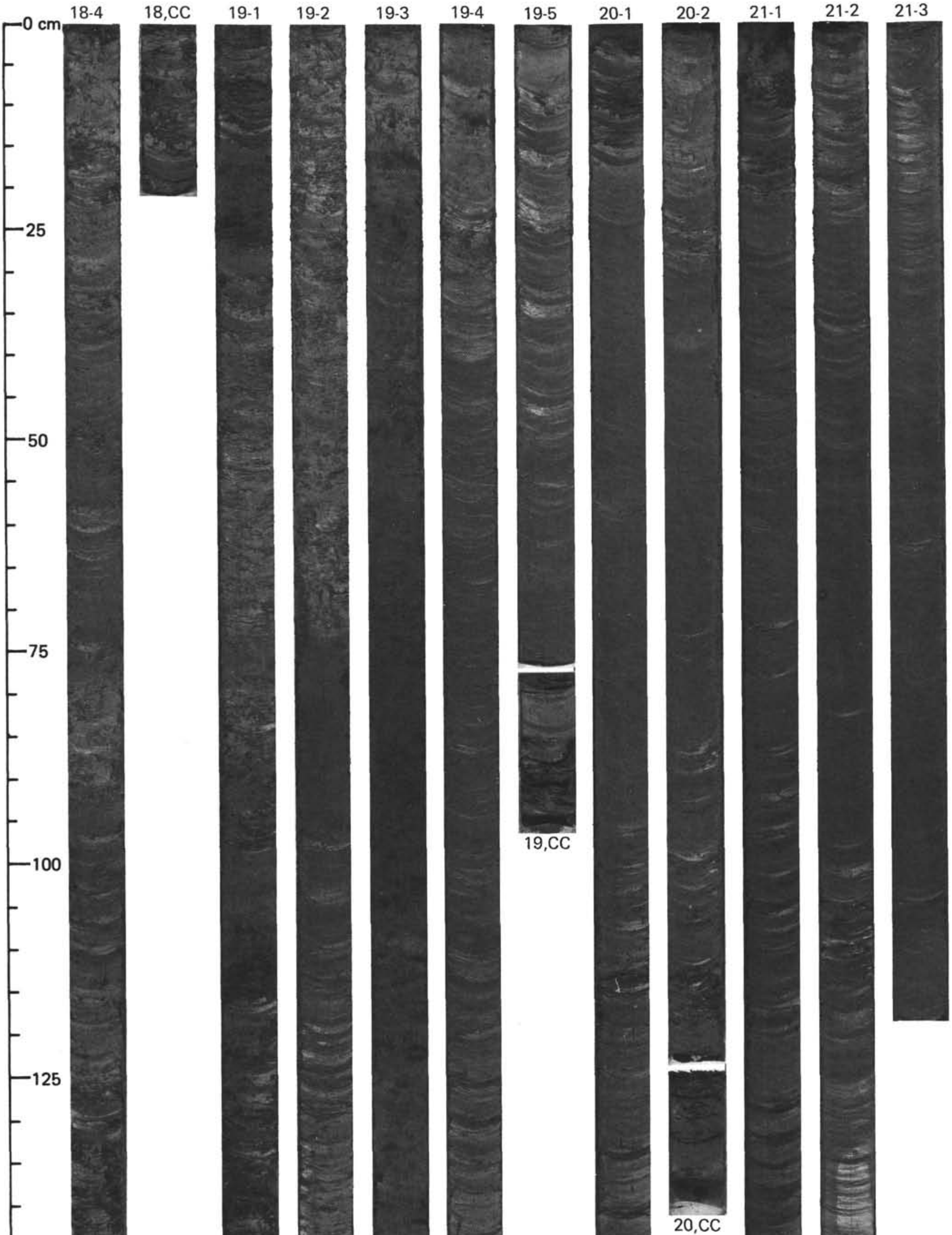
17-4
18-1
18-2
18-3
15,CC
16,CC
17,CC


18-4
18,CC
19-1
19-2
19-3
19-4
19-5
19,CC
20-1
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21-1
21-2
21-3
0 cm
25
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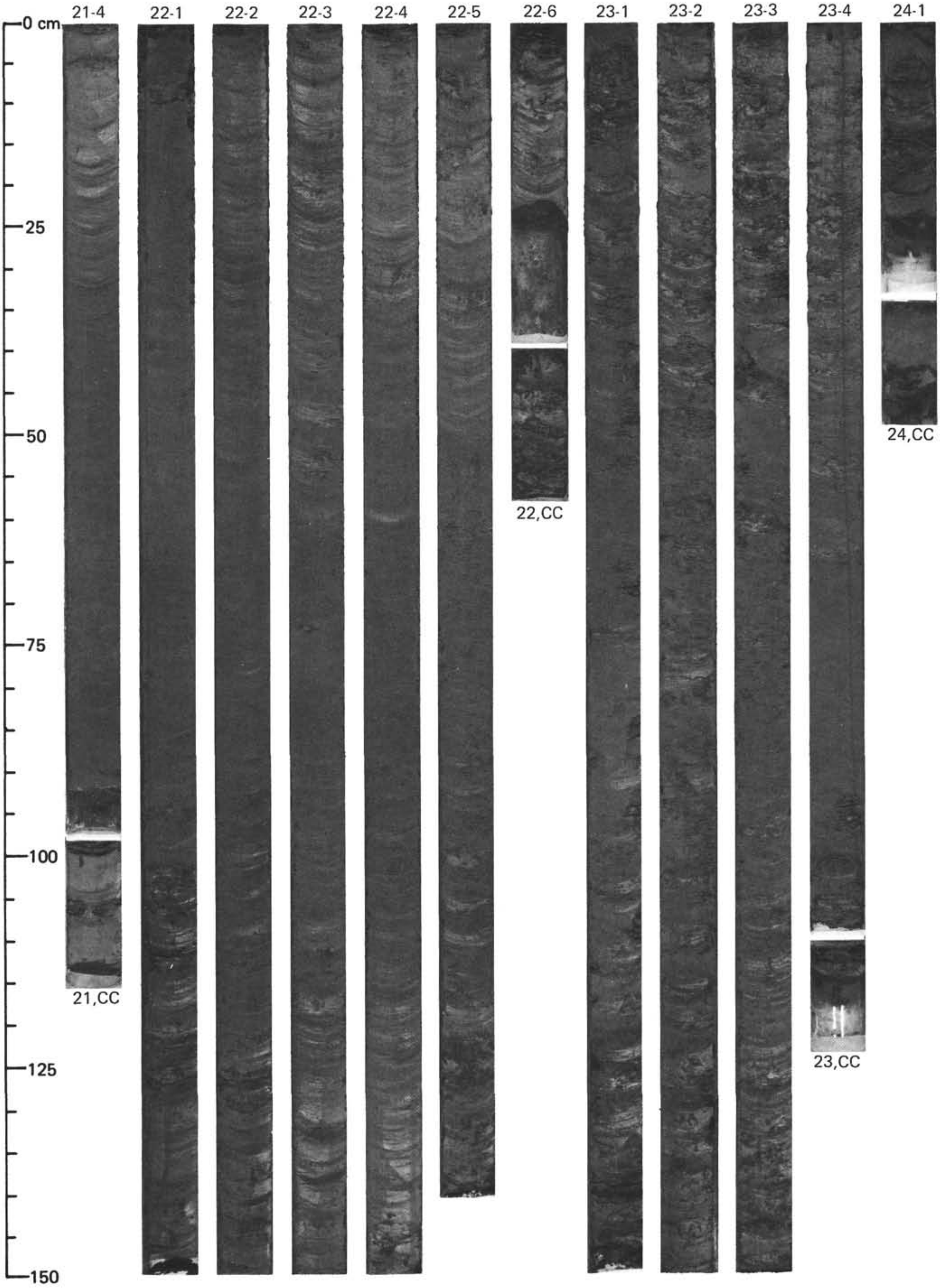
21-4
22-1
22-2
22-3
22-4
22-5
22-6
23-1
23-2
23-3
23-4
24-1
0 cm
25
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125
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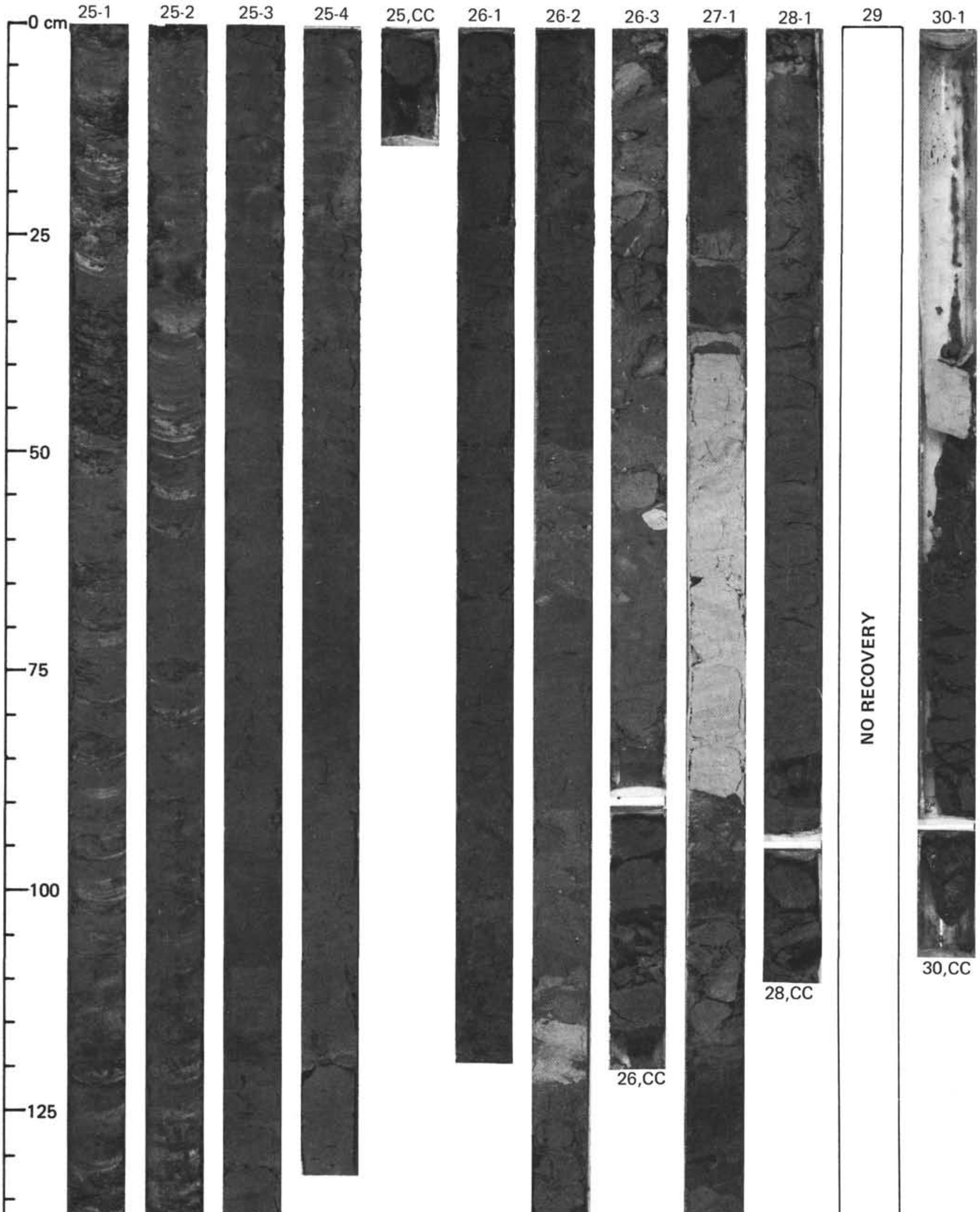
21,CC
22,CC
23,CC
24,CC


0 cm
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125
150
25-1
25-2
25-3
25-4
25,CC
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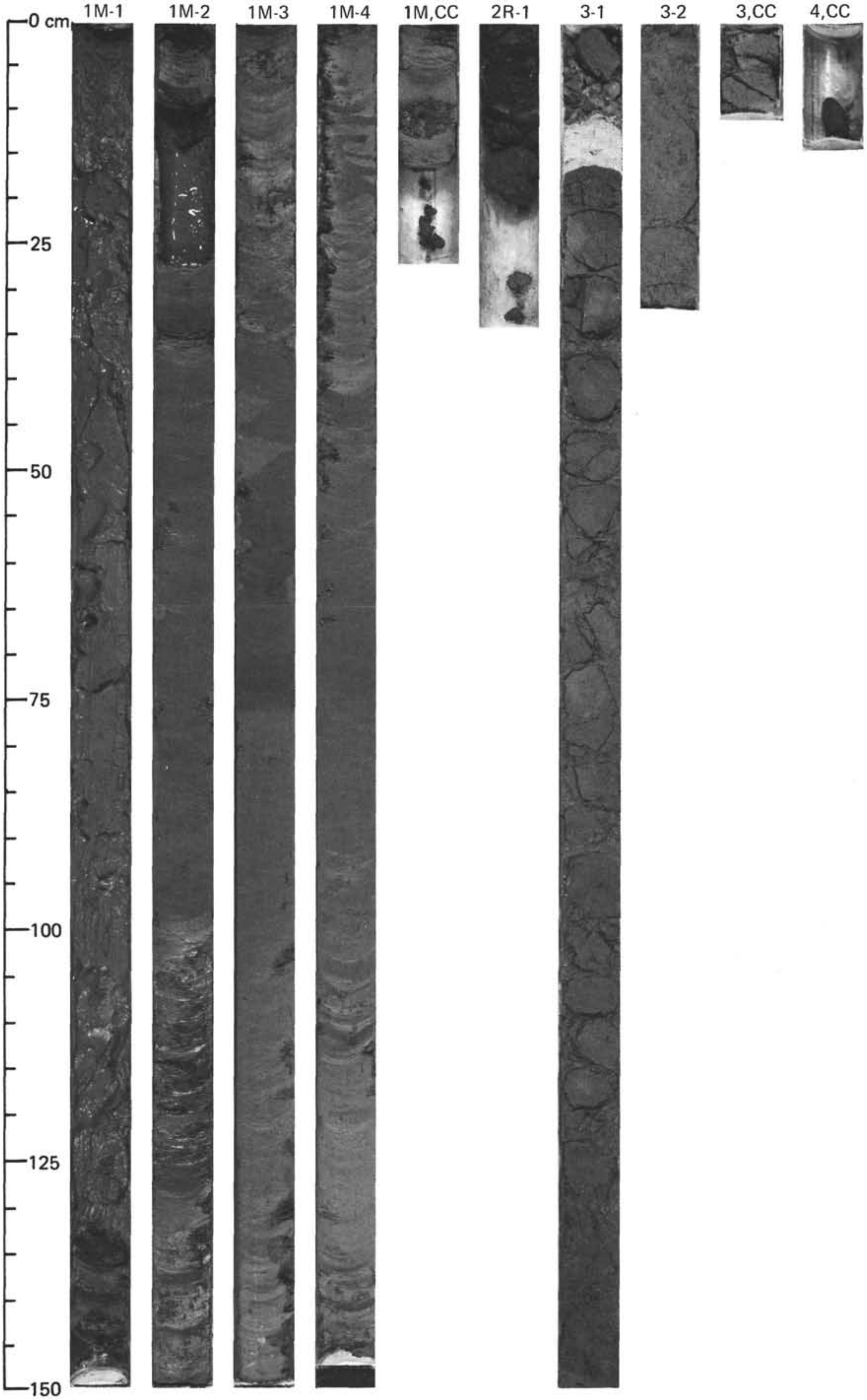
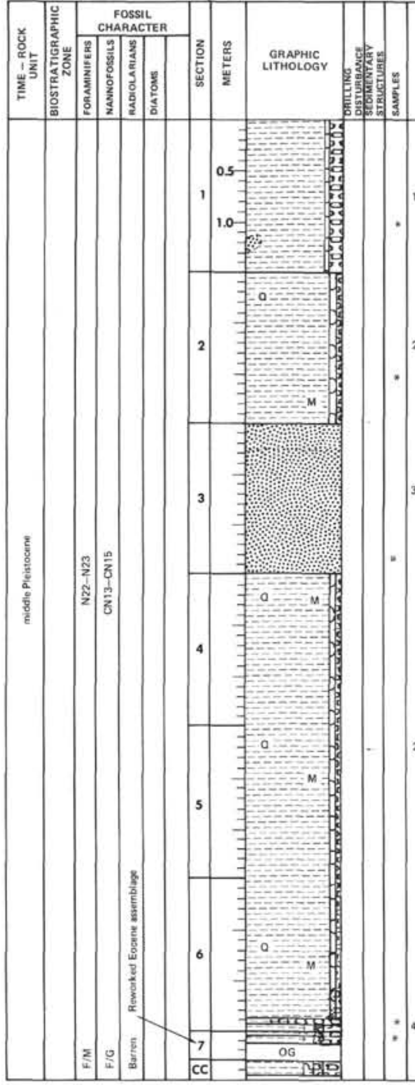
26-2
26-3
27-1
28-1
29
30-1
26,CC
28,CC
30,CC
NO RECOVERY


0 cm
25
50
75
100
125
150
1M-1
1M-2
1M-3
1M-4
1M,CC
2R-1
3-1
3-2
3,CC
4,CC

SITE 605 HOLE CORE 1 CORED INTERVAL 0-154.3 m



LITHOLOGIC DESCRIPTION

WASH CORE

1) BIOGENIC SILICA- and CARBONATE-BEARING CLAY, medium gray (N5) with small patches of sand as indicated.

2) BIOGENIC SILICA-BEARING SILT-RICH CLAY, medium gray (N5)

3) COARSE SAND, medium gray (N5)

4) BIOGENIC SILICA- and CLAY-RICH NANNOFOSSIL OOZE, light greenish gray (5G 8/1) of middle Eocene age.

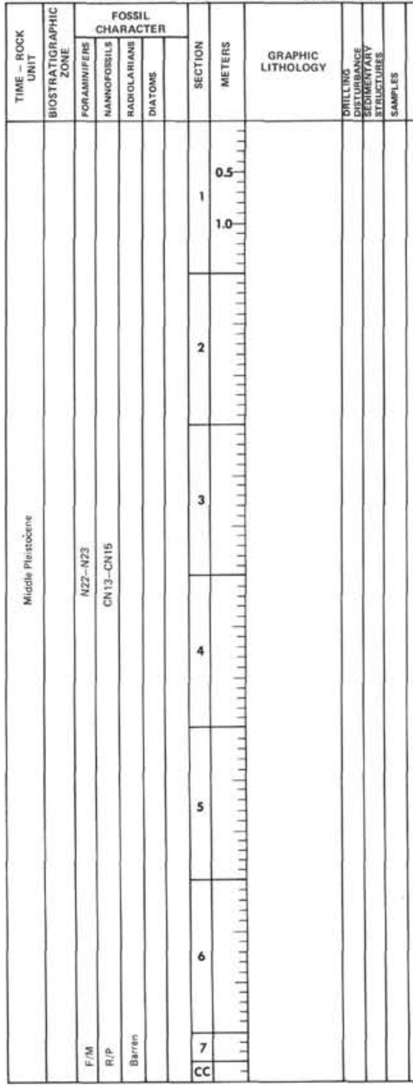
5) BIOGENIC SILICA-BEARING, SILT-BEARING NANNOFOSSIL CLAY, medium gray (N5)

Lithologies 4 and 5 alternate at the base of the core.

SMEAR SLIDE SUMMARY (%)

	1, 100 D	2, 100 D	3,130 D	6,147 M	7, 4 M
Texture:					
Sand	–	–	100	50	50
Silt	20	35	–	50	50
Clay	80	65	–	–	–
Composition:					
Quartz	1	5	80	2	–
Feldspar	–	1	5	–	–
Mica	3	9	3	5	1
Heavy minerals	1	5	2	1	–
Clay	81	63	–	49	23
Glauconite	–	2	5	–	–
Pyrite	1	1	–	1	–
Carbonate unspec.	5	5	–	5	30
Foraminifers	2	1	–	1	4
Calc. nannofossils	2	2	–	30	30
Diatoms	3	–	–	2	3
Radiolarians	1	1	–	1	3
Sponge spicules	–	3	–	2	6
Silicoflagellates	–	1	–	–	–
Plant debris	–	1	–	1	–
Other unknown	–	–	5	–	–

SITE 605 HOLE CORE 2 CORED INTERVAL 154.3–163.9 m

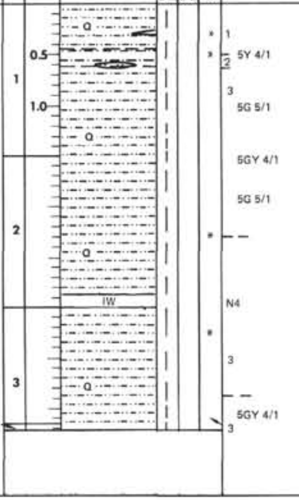


LITHOLOGIC DESCRIPTION

TRACE RECOVERY, MATERIAL GIVEN TO PALEONTOLOGISTS.

SITE 605 HOLE CORE 3 CORED INTERVAL 163.9–173.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
Middle Pleistocene		N22–N23	CN13–CN15	Barren	



LITHOLOGIC DESCRIPTION

1) Medium gray QUARTZ-RICH, CARBONATE-BEARING CLAY with fine sandy silty bands

2) GLAUCONITE- and NANNOFOSSIL-BEARING QUARTZ AND SKELETAL CARBONATE-RICH CLAY (fine sandy silty CLAY)

A lens of white silt occurs at Section 1, 60 cm, containing quartz, heavy minerals, and reworked Eocene and Miocene nannofossils.

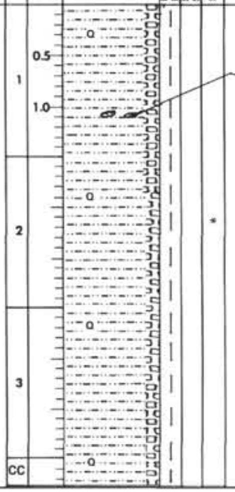
3) CARBONATE-BEARING, QUARTZ-RICH to -BEARING CLAY, with scattered pyrite nodules and mollusc fragments. Light grayish green (5G 5/1, 5GY 4/1) to Section 2, 80 cm. Below this is dark gray (N4) colored to Section 3, 88 cm, then greenish gray again.

SMEAR SLIDE SUMMARY (%)

	1, 30 M	1, 54 M	2, 80 D	3, 24 D
Texture:				
Sand	–	10	–	5
Silt	100	30	20	30
Clay	–	60	80	75
Composition:				
Quartz	89	20	9	15
Feldspar	1	tr	tr	tr
Mica	1	tr	tr	tr
Heavy minerals	5	tr	1	1
Clay	–	54	81	76
Glauconite	–	8	–	–
Pyrite	2	3	3	3
Carbonate unspec.	2	10	6	5
Foraminifers	–	tr	tr	tr
Calc. nannofossils	–	5	tr	–

SITE 605 HOLE CORE 4 CORED INTERVAL 173.5–183.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
Middle Pleistocene		*Globorotalia inflata* Zone	CN13–CN15	Barren	



LITHOLOGIC DESCRIPTION

CARBONATE- and QUARTZ SILT-RICH CLAY, dark gray (N4), mottled, in places faintly banded, with molluscs fragments scattered.

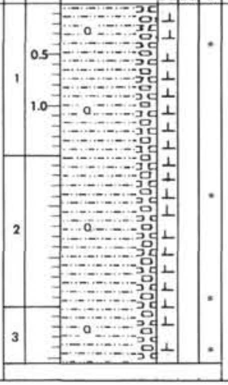
White to light gray spots of quartz-silt.

SMEAR SLIDE SUMMARY (%)

	2, 65 D
Texture:	
Silt	33
Clay	67
Composition:	
Quartz	12
Mica	9
Heavy minerals	3
Clay	67
Glauconite	tr
Pyrite	3
Carbonate unspec.	15

SITE 605 HOLE CORE 5 CORED INTERVAL 183.1–192.7 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
Middle Pleistocene		*Globorotalia inflata* Zone R/M	CN13–CN15	Barren	



LITHOLOGIC DESCRIPTION

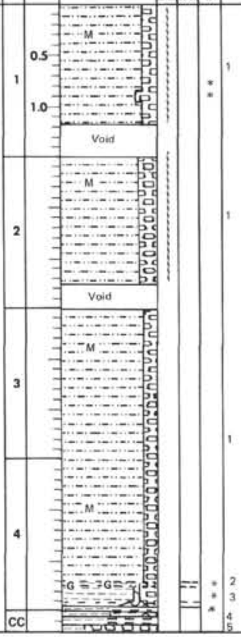
CALCAREOUS- and SILT-RICH CLAY. Section 1, 0–125 cm is dark greenish gray (5GY 4/1). Section 1, 125 cm–base is gray (N4, 5GY 3.5/1). Homogeneous with rare white specks and with silt clusters or lenses. The silt concentrations are enriched in heavy minerals and are possibly the remnants silt layers which have been washed away during drilling.

SMEAR SLIDE SUMMARY (%)

	1, 40 D	2, 40 D	3, 40 D	2, 144 M
Texture:				
Silt	35	40	44	90
Clay	65	60	56	10
Composition:				
Quartz	8	10	10	30
Feldspar	2	4	3	9
Mica	5	4	5	10
Heavy minerals	3	4	5	20
Clay	65	60	56	20
Glauconite	–	–	–	3
Pyrite	1	–	1	3
Carbonate unspec.	15	15	20	5
Foraminifers	1	–	–	TR
Calc. nannofossils	–	2	–	TR
Plant debris	–	1	–	–

SITE 605 HOLE CORE 6 CORED INTERVAL 192.7–202.3 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS
lower Pleistocene		N22 N22			
* middle Eocene		P12–P13	CP13b		
*					



LITHOLOGIC DESCRIPTION

1) CALCAREOUS & SILT-RICH CLAY, medium gray (N4), homogenous, no apparent structure

Minor lithologies in lower Section 4 and Core Catcher:

2) GLAUCONITE-BEARING, PYRITE-RICH, CALCAREOUS-RICH CLAY, is a transition zone from gray (N4) to a grayish olive green (5GY 3/2) in color (Sect. 4, 121-125 cm).

3) BIOGENIC SILICA-BEARING, CALCAREOUS RICH CLAY, grayish olive green (5GY3/2) (125-144 cm, Sec. 4). From 149 cm up to 144 cm there appears to be a "fining upward" as in a glauconite sand decrease.

4) CLAYEY BIOGENIC SILICA OOZE, grayish green (10G 4/2). Sharp contact above and below. This may be a dissolution facies from the underlying chalk. Between Sect. 4 and C.C.

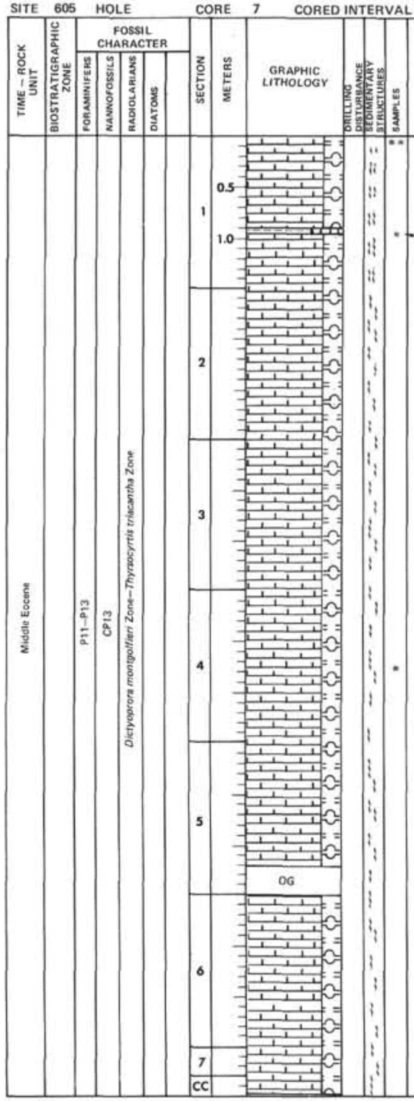
5) CLAY & BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light green gray (5GY 7/1) in C.C.

No apparent structures in the above lithologies.

SMEAR SLIDE SUMMARY (%)

	1, 95	1, 80 D	4, 125 M	4, 135 M	4, 149 M	CC, 5 D
Texture:						
Sand	–	–	5	–	–	–
Silt	39	30	45	45	50	82
Clay	61	70	50	55	50	18
Composition:						
Quartz	4	5	4	2	1	–
Feldspar	1	1	–	1	–	–
Mica	12	10	1	2	–	–
Heavy minerals	3	2	–	–	–	–
Clay	61	68	50	54	45	18
Glauconite	–	–	5	5	1	–
Pyrite	1	1	10	2	3	2
Carbonate unspec.	15	10	25	15	–	35
Foraminifers	–	–	1	2	–	–
Calc. nannofossils	2	2	–	10	–	25
Diatoms	–	–	–	1	20	10
Radiolarians	–	–	1	4	20	5
Sponge spicules	–	–	3	2	10	5
Plant debris	1	1	–	–	–	–

SITE 605 HOLE CORE 7 CORED INTERVAL 202.3–211.9 m



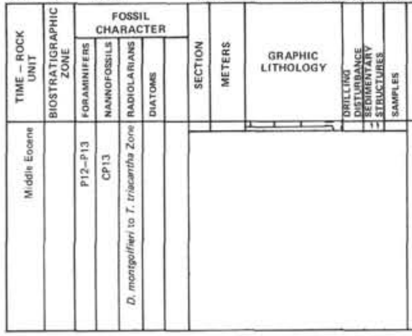
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1).
Moderate bioturbation; burrows commonly filled by light brownish gray (5Y 7/1) (contains slightly more clay) and rarely by dark gray (N4) PYRITE-BEARING BIOGENIC SILICA-RICH NANNOFOSSIL CHALK; burrow types have wide range from *Chondrites* to 10 cm long, 1 1/2 cm wide, vertical burrows.
Sect. 1, 94-97 cm – dark gray soft clay with clasts of dark greenish gray (5GY 4/1) carbonate-rich CLAYSTONE. Downhole contamination?

SMEAR SLIDE SUMMARY (%)

	1, 1 D	1, 1 M	1, 96 M	4, 82 M
Texture:				
Silt	93	94	20	90
Clay	7	6	80	10
Composition:				
Quartz	–	–	4	–
Feldspar	–	–	2	–
Clay	7	6	80	10
Pyrite	1	8	–	–
Carbonate unspec.	35	36	12	3
Foraminifers	–	TR	–	TR
Calc. nannofossils	45	35	1	70
Diatoms	3	4	–	3
Radiolarians	4	4	1	8
Sponge spicules	5	7	–	6

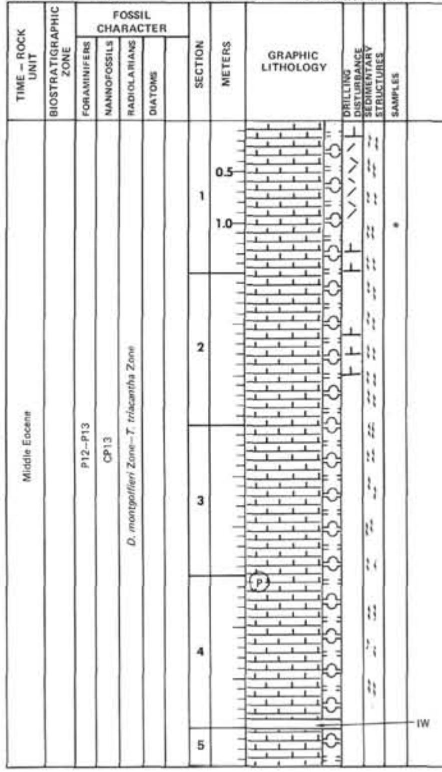
SITE 605 HOLE CORE 8 CORED INTERVAL 211.9–221.5 m



LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1).
Moderate bioturbation; burrows commonly filled by light brownish gray (5Y 7/1) [contains slightly more clay] and rarely by dark gray (N4) pyrite-bearing Si-rich Nannofossil Chalk; burrow types have wide range from *Chondrites* to 5 mm length and 3 mm in thickness.

SITE 605 HOLE CORE 9 CORED INTERVAL 221.5–231.1 m



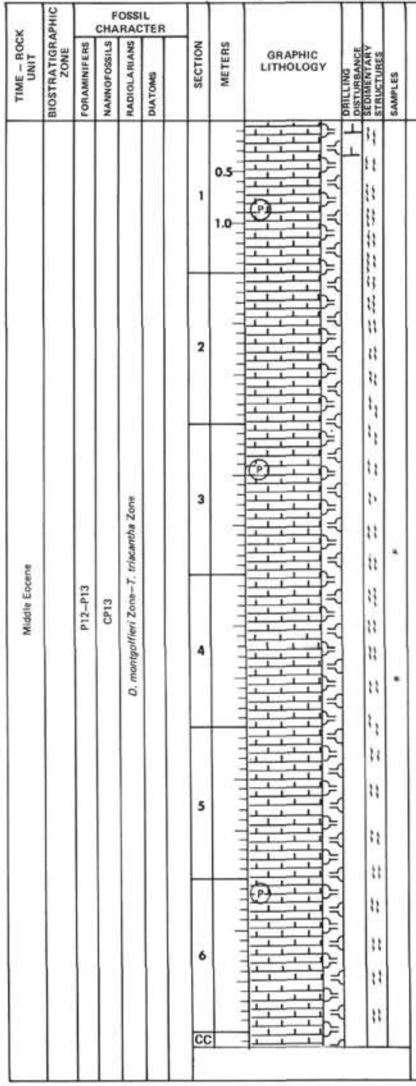
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1); moderate bioturbation with burrows commonly filled by light brownish gray (5Y 7/1–5Y 6/1). Rare pyrite clusters. Some burrows have gray (pyrite-rich?) halo or border.

SMEAR SLIDE SUMMARY (%)

	1, 100 D
Texture:	
Silt	96
Clay	4
Composition:	
Clay	4
Carbonate unspec.	10
Foraminifers	1
Calc. nannofossils	73
Diatoms	2
Radiolarians	5
Sponge spicules	4
Silicoflagellates	1

SITE 605 HOLE CORE 10 CORED INTERVAL 231.1–240.7 m



LITHOLOGIC DESCRIPTION

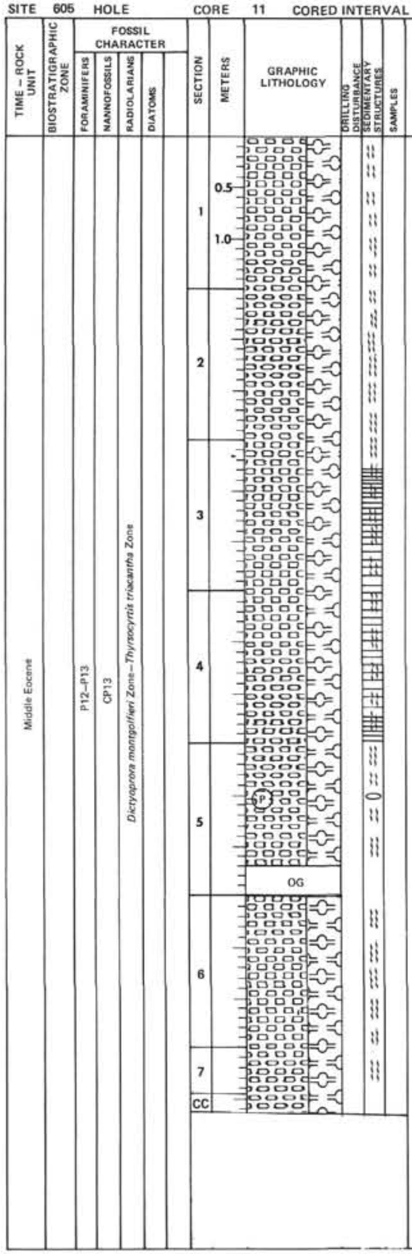
BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1); moderate bioturbation with burrows commonly filled by light brownish gray (5Y 7/1–5Y 6/1). Wide variety of burrows.

Section 3, 126–128 cm: Some burrows are infilled by grayish green (5G 5/2). Biogenic silica-rich clayey nannofossil CHALK. Rare tiny pyrite nodules throughout.

SMEAR SLIDE SUMMARY (%)

	3, 126 M	4, 100 D
Texture:		
Silt	64	94
Clay	36	6
Composition:		
Clay	36	6
Carbonate unspec.	10	52
Foraminifers	1	–
Calc. nannofossils	40	30
Diatoms	1	4
Radiolarians	6	6
Sponge spicules	5	2
Silicoflagellates	1	–

SITE 605 HOLE CORE 11 CORED INTERVAL 240.7–250.3 m



LITHOLOGIC DESCRIPTION

BIOGENIC SILICA NANNOFOSSIL CHALK, light greenish gray (5GY 7/1), with moderate bioturbation throughout the core. Burrows are filled by light brownish gray (5Y 7/1) with a higher clay content.

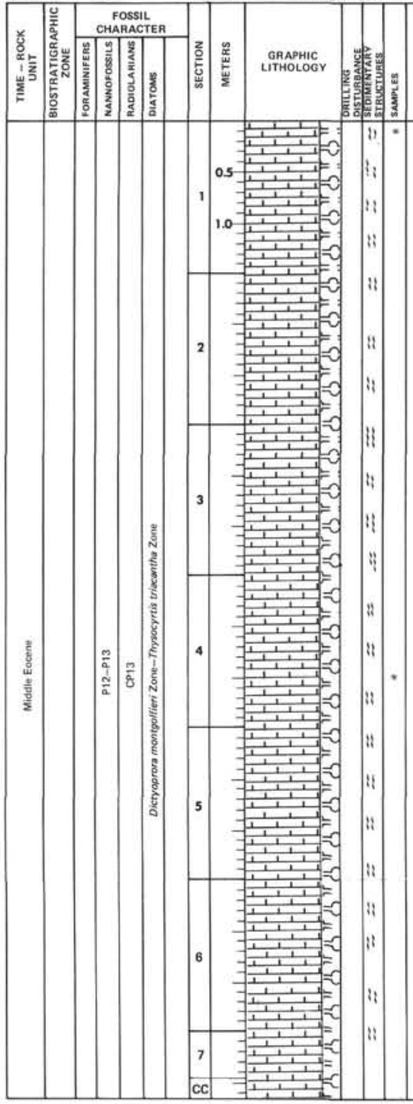
In Section 3, 32-50 cm and Section 4, the burrows are more horizontal and there is a faint laminated appearance.

In Section 5, at 52 cm is a lens of pyrite.

SMEAR SLIDE SUMMARY (%)

	2, 100
Texture:	
Silt	80
Clay	20
Composition:	
Clay	9
Pyrite	1
Carbonate unspec.	28
Foraminifers	2
Calc. nannofossils	30
Diatoms	20
Radiolarians	5
Sponge spicules	5

SITE 605 HOLE CORE 12 CORED INTERVAL 250.3–259.9 m



LITHOLOGIC DESCRIPTION

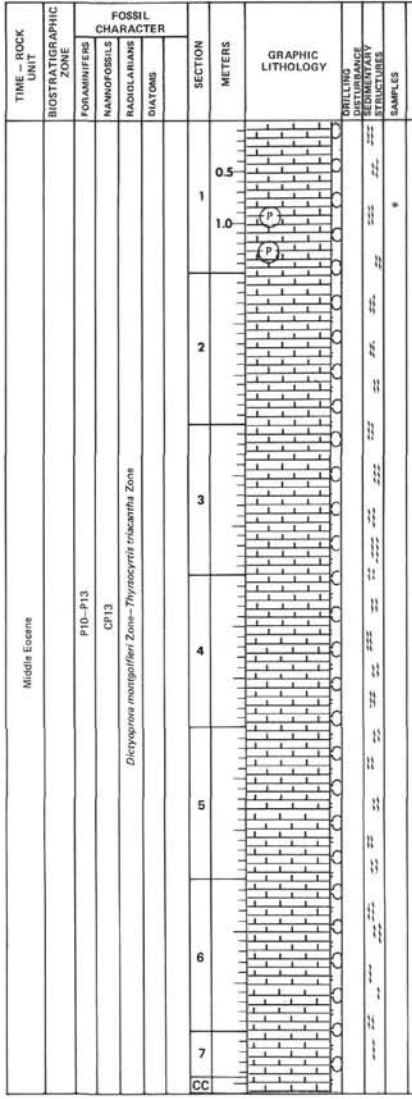
BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1). Sections 2 and 5 are slightly darker shade. Moderate bioturbation; burrows commonly filled by light brownish gray (5Y 7/1–5Y 6/1), several types including some beautiful *Planolites*; a dark gray border or halo surrounds some burrows.

Sect. 1, 17 cm – horizon of black pyrite-rich material containing well-preserved pyritized radiolarian & diatoms.

SMEAR SLIDE SUMMARY (%)

	1, 17 M	4, 100 D
Texture:		
Silt	100	92
Clay	–	8
Composition:		
Clay	–	8
Pyrite	97	–
Carbonate unspec.	–	25
Foraminifers	–	2
Calc. nannofossils	–	50
Diatoms	7	10
Radiolarians	–	4
Sponge spicules	–	1

SITE 605 HOLE CORE 13 CORED INTERVAL 259.9–269.5 m



LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1), with moderate bioturbation.

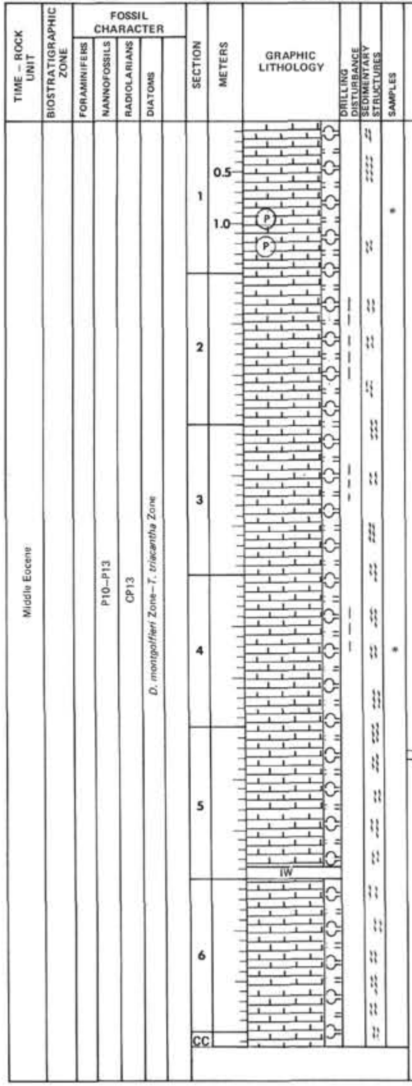
Burrow fills light brownish to light olive gray (5YR 6/1 to 5Y 6/1). Burrows are mostly *Planolites*-type, partly with horizontal spreiten burrows.

Scattered pyrite nodules and zones occur where pyritized radiolarians are common (burrow fills).

SMEAR SLIDE SUMMARY (%)

	1, 81 D
Texture:	
Silt	30
Clay	70
Composition:	
Quartz	TR
Clay	3
Pyrite	TR
Carbonate unspec.	15
Foraminifers	3
Calc. nannofossils	67
Diatoms	5
Radiolarians	3
Sponge spicules	4
Silicoflagellates	TR

SITE 605 HOLE CORE 14 CORED INTERVAL 269.5–279.1 m



LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1) color, with light brownish olive (5YR 6/1) and light olive gray (5Y 6/1), pale olive (5Y 5/3), and pale olive (5Y 6/3) burrow fills.

A great variety of trace fossils (impossible to describe properly here) occur in this core. Core is moderately burrowed. Individual burrows have diameter <1 mm (fucoids) to >10 mm (*Planolites*-type). In some cases continuous cm-thick layers of darker (5Y 5–6/3) material with burrows of light greenish gray material occur.

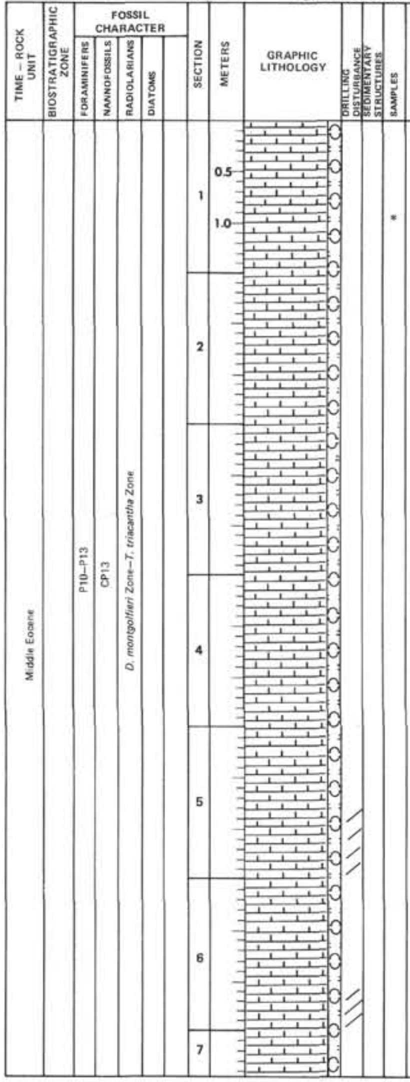
Pyrite nodules are present.

Continuous layer of 5Y 5/6

SMEAR SLIDE SUMMARY (%)

	1, 86 D	4, 70 M
Texture:		
Silt	100	95
Clay	–	5
Composition:		
Mica	–	tr
Clay	–	5
Carbonate unspec.	20	10
Foraminifers	tr	tr
Calc. nannofossils	65	70
Diatoms	2	5
Radiolarians	6	5
Sponge spicules	7	5

SITE 605 HOLE CORE 15 CORED INTERVAL 279.1–288.7 m



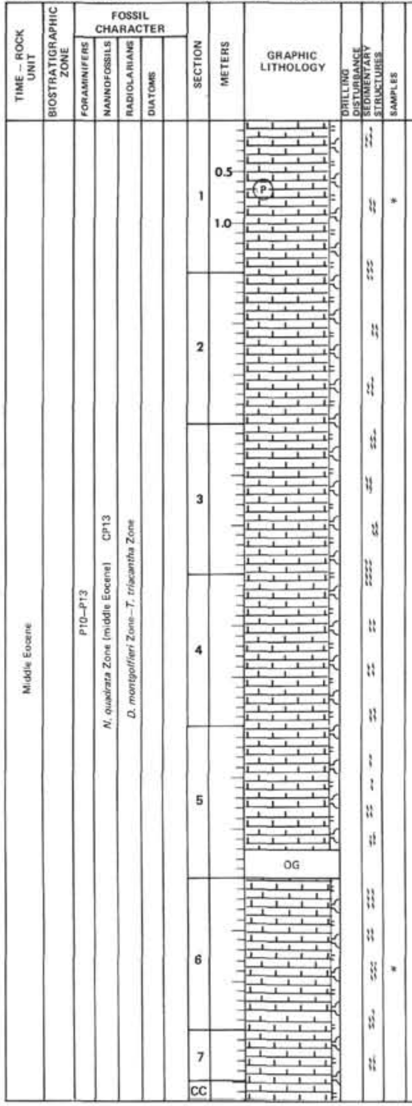
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1). Moderately to heavily bioturbated, with light brownish olive (5YR 6/1) burrows, mostly horizontal *Planolites*-type. Several vertical and horizontal large burrows up to 1 cm in diameter with "spreiten" structure (see figure):

SMEAR SLIDE SUMMARY (%)

	1, 41 D
Texture:	
Silt	100
Composition:	
Carbonate unspec.	20
Foraminifers	tr.
Calc. nannofossils	64
Diatoms	2
Radiolarians	8
Sponge spicules	6

SITE 605 HOLE CORE 16 CORED INTERVAL 288.7–298.3 m



LITHOLOGIC DESCRIPTION

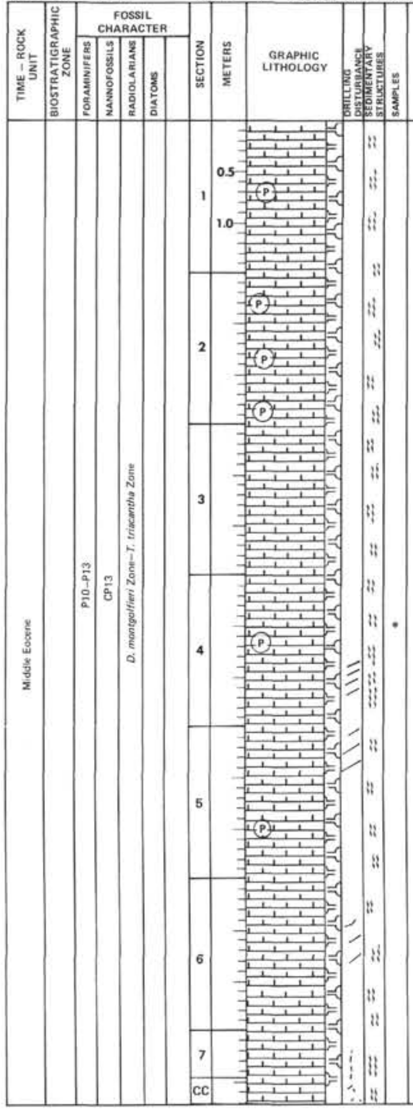
FORAMINIFERA-BEARING, BIOGENIC SILICA-BEARING to -RICH, NANNOFOSSIL CHALK, light greenish gray (5GY 7/1), heavily to moderately bioturbated (mostly horizontal *Planolites*-type + "spreiten"-structure burrow.

Scattered pyrite burrow fills.

SMEAR SLIDE SUMMARY (%)

	1, 80 D	6, 85 D
Texture:		
Silt	100	60
Clay	–	40
Composition:		
Clay	–	tr.
Glauconite	–	tr.
Carbonate unspec.	–	20
Foraminifers	7	3
Calc. nannofossils	89	68
Diatoms	tr.	3
Radiolarians	2	2
Sponge spicules	2	4

SITE 605 HOLE CORE 17 CORED INTERVAL 298.3–307.9 m



LITHOLOGIC DESCRIPTION

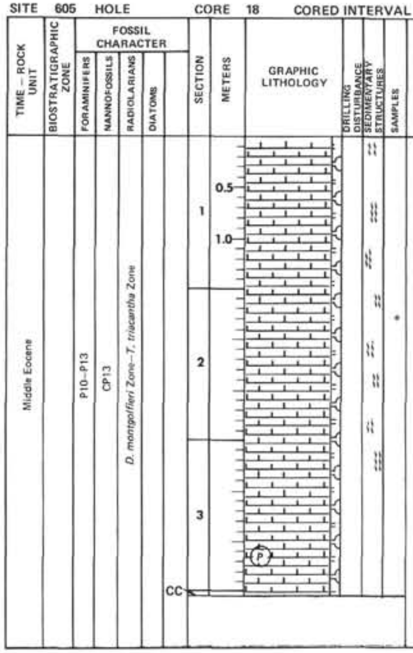
FORAMINIFERA-BEARING BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1) colored.

Moderately bioturbated with light olive brownish (5YR 6/1) burrows, as in previous cores, and scattered pyrite nodules.

SMEAR SLIDE SUMMARY (%)

	4, 59 D
Texture:	
Silt	90
Clay	10
Composition:	
Quartz	TR
Mica	TR
Clay	TR
Pyrite	1
Carbonate unspec.	10
Foraminifers	3
Calc. nannofossils	75
Diatoms	5
Radiolarians	3
Sponge spicules	3

SITE 605 HOLE CORE 18 CORED INTERVAL 307.9–317.5 m



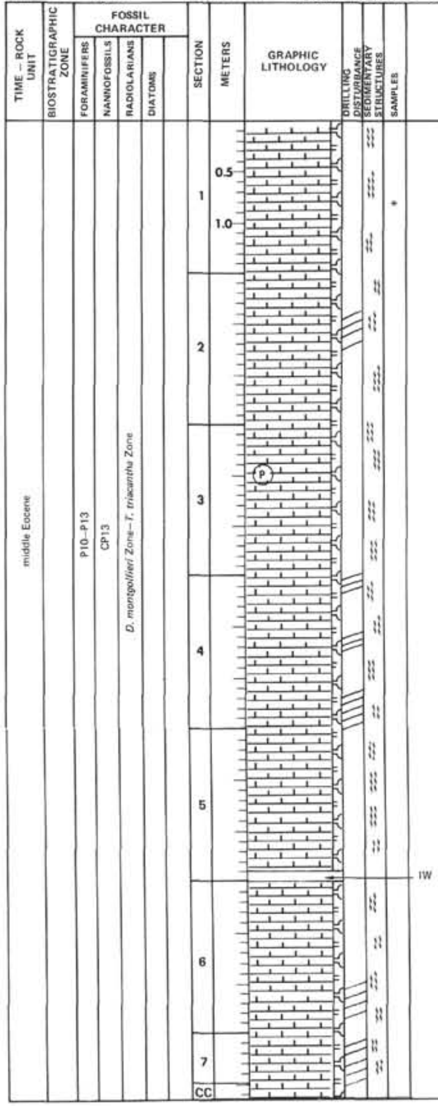
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH and FORAMINIFERA-BEARING NANNOFOSSIL CHALK, light greenish gray (5GY 7/1) colored. Moderately to intensely burrowed, including large ellipsoidal (—6 cm diameter) burrows of (echinoids or crustaceans?), as shown in figure below:

SMEAR SLIDE SUMMARY (%)

	2, 35
	D
Texture:	
Silt	80
Clay	20
Composition:	
Quartz	TR
Mica	TR
Carbonate unspec.	20
Foraminifers	4
Calc. nannofossils	67
Diatoms	2
Radiolarians	3
Sponge spicules	4

SITE 605 HOLE CORE 19 CORED INTERVAL 317.5–327.1 m



LITHOLOGIC DESCRIPTION

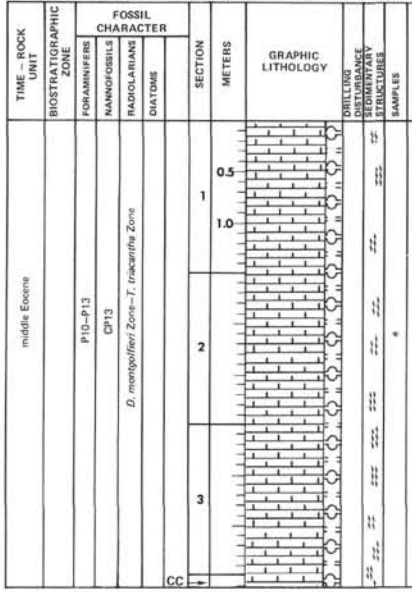
FORAMINIFER-BEARING BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1) colored.

Moderately to intensely burrowed with light brownish olive (5YR 6/1) burrow fills.

SMEAR SLIDE SUMMARY (%)

	1, 82
	D
Texture:	
Silt	100
Composition:	
Quartz	TR
Glauconite	TR
Carbonate unspec.	10
Foraminifers	5
Calc. nannofossils	70
Diatoms	4
Radiolarians	8
Sponge spicules	3

SITE 605 HOLE CORE 20 CORED INTERVAL 327.1–336.7 m



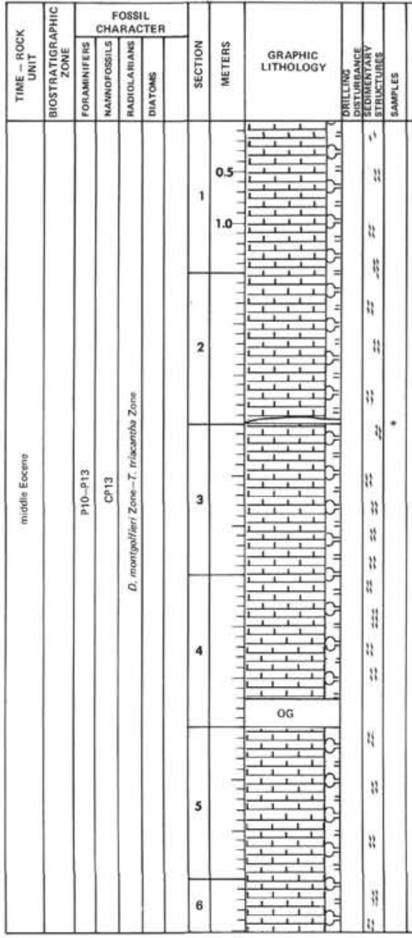
LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK' light greenish gray (5GY 7/1) colored, heavily to moderately bioturbated.

SMEAR SLIDE SUMMARY (%)

	2, 64
	D
Texture:	
Silt	100
Mica	tr.
Carbonate unspec.	10
Calc. nannofossils	73
Diatoms	5
Radiolarians	8
Sponge spicules	4
Fish remains	tr.

SITE 605 HOLE CORE 21 CORED INTERVAL 336.7–346.3 m



LITHOLOGIC DESCRIPTION

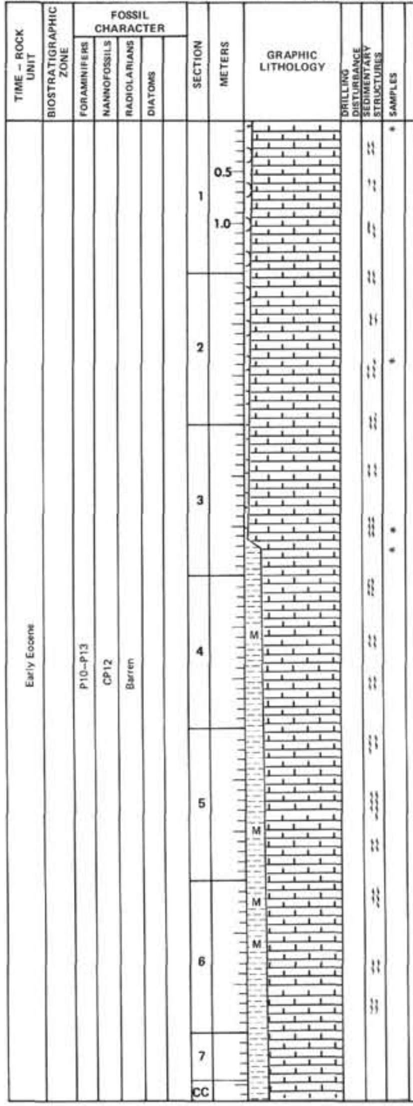
BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light greenish gray (5GY 7/1), heavily to moderately bioturbated. Burrow fills are light brownish gray (5Y 7/1) and rarely dark gray (N4) pyrite-bearing, silica-rich nannofossil chalk.

A rhyolitic ash layer with transparent clear glass shards, bubble-wall shards (from Bermuda volcanism?) dark gray, semiconsolidated, fresh (not altered) about 2–3 cm thick, occurs in Section 2 at 145 cm.

SMEAR SLIDE SUMMARY (%)

	2, 146	6,6
	M	D
Texture:		
Sand	75	–
Silt	25	93
Clay	–	7
Composition:		
Quartz	3	–
Mica	3	–
Clay	–	7
Volcanic glass	89	–
Pyrite	5	–
Carbonate unspec.	–	20
Foraminifers	–	tr.
Calc. nannofossils	–	53
Diatoms	–	5
Radiolarians	–	10
Sponge spicules	–	5

SITE 605 HOLE CORE 22R CORED INTERVAL 346.3–355.9 m



LITHOLOGIC DESCRIPTION

BIOGENIC SILICA-RICH NANNOFOSSIL CHALK, light green gray (5GY 7/1) as in previous cores changing to BIOGENIC SILICA-BEARING NANNOFOSSIL CHALK by Section 3, 50 cm.

NANNOFOSSIL LIMESTONE, light green gray (5GY 7/1) occurs from 50–111 cm, Section 3, with no siliceous organisms.

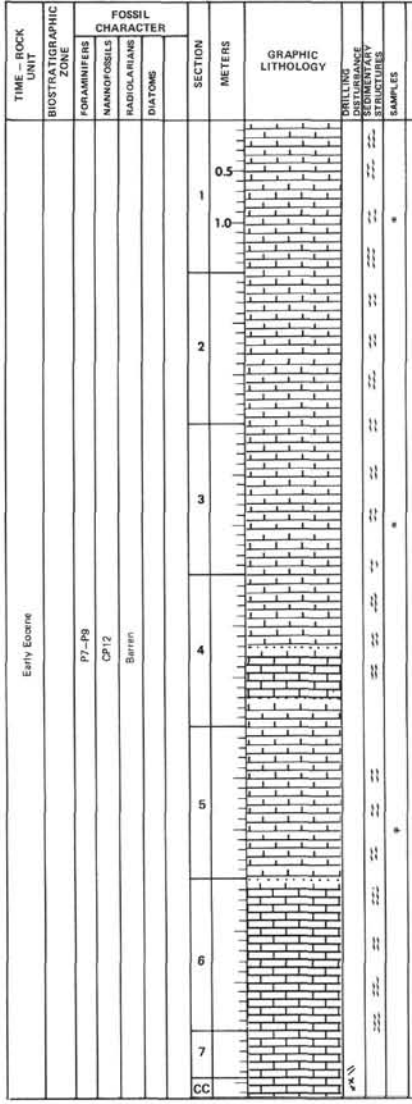
CLAY-RICH NANNOFOSSIL CHALK, green gray (5GY 6/1) begins below 111 cm in Section 3 and continues throughout the remainder of the core. No siliiceous organisms.

The overall appearance of the core is heavily to moderately bioturbated. Burrow fills are light brownish gray (5Y 7/1) and rarely dark gray (N4) pyrite-bearing, silica-rich nannofossil chalk.

SMEAR SLIDE SUMMARY (%)

	1, 10 D	2, 71 D	3, 111 D	3, 121 D
Texture:				
Silt	100	100	100	100
Composition:				
Mica	–	–	–	TR
Clay	–	–	–	20
Carbonate unspec.	40	60	85	20
Foraminifers	–	TR	TR	TR
Calc. nannofossils	50	28	15	60
Diatoms	2	4	–	–
Radiolarians	5	4	–	TR
Sponge spicules	3	4	–	–

SITE 605 HOLE CORE 23 CORED INTERVAL 355.9–365.5 m



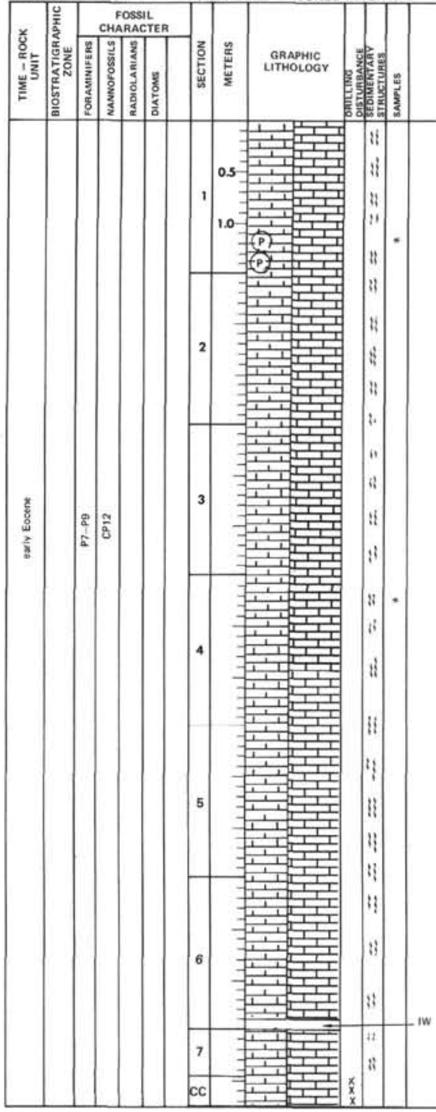
LITHOLOGIC DESCRIPTION

FORAMINIFERA-BEARING NANNOFOSSIL LIMESTONE to CHALK, greenish gray (5GY 6/1). Moderate bioturbation; burrows commonly filled by greenish brownish gray (5Y 6/1). Hardness varies between chalk and limestone within core, but apparent composition is uniform.

SMEAR SLIDE SUMMARY (%)

	1, 100 D	3, 100 D	5, 100 D
Texture:			
Silt	80	85	90
Clay	20	15	10
Composition:			
Quartz	TR	–	–
Mica	1	1	1
Clay	10	10	6
Pyrite	1	1	2
Carbonate unspec.	40	38	40
Foraminifers	3	8	4
Calc. nannofossils	44	40	45
Diatoms	–	–	TR
Radiolarians	1	2	2
Plant debris	TR	–	–

SITE 605 HOLE CORE 24 CORED INTERVAL 365.5–375.1 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE TO CHALK, greenish gray (5GY 6/1–5GY 6.5/1); moderate to heavy bioturbation, burrows commonly filled by brownish gray (5Y 5/1–5Y 6/1). Rare pyrite nodules.

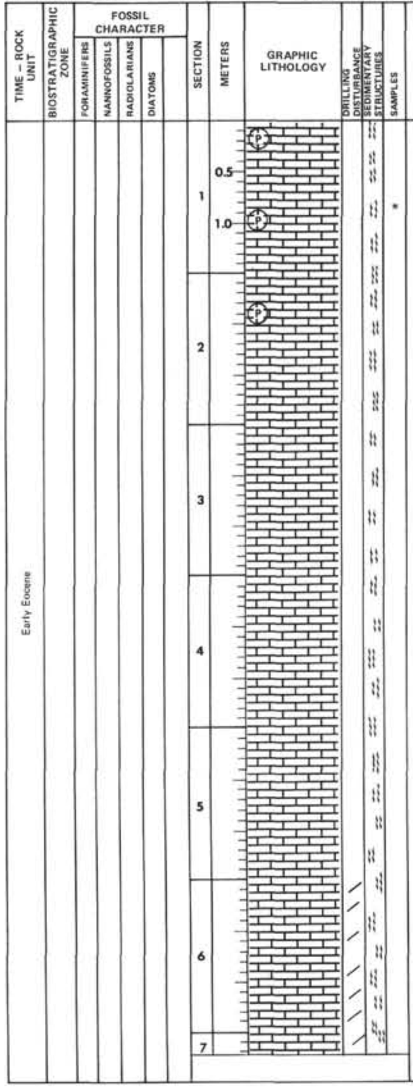
Microfaults in Sect. 3, 115-125 cm and Sect. 4, 90-100 cm.

Sect. 4, 70-90 cm is slightly laminated with one dark horizon.

SMEAR SLIDE SUMMARY (%)

	1, 117 M	4, 25 D
Texture:		
Silt	100	96
Clay	–	4
Composition:		
Clay	–	4
Pyrite	85	–
Carbonate unspec.	15	30
Foraminifers	–	1
Calc. nannofossils	–	65
Radiolarians Calcified	–	TR
Sponge spicules	–	TR

SITE 605 HOLE CORE 25 CORED INTERVAL 375.1–384.7 m



LITHOLOGIC DESCRIPTION

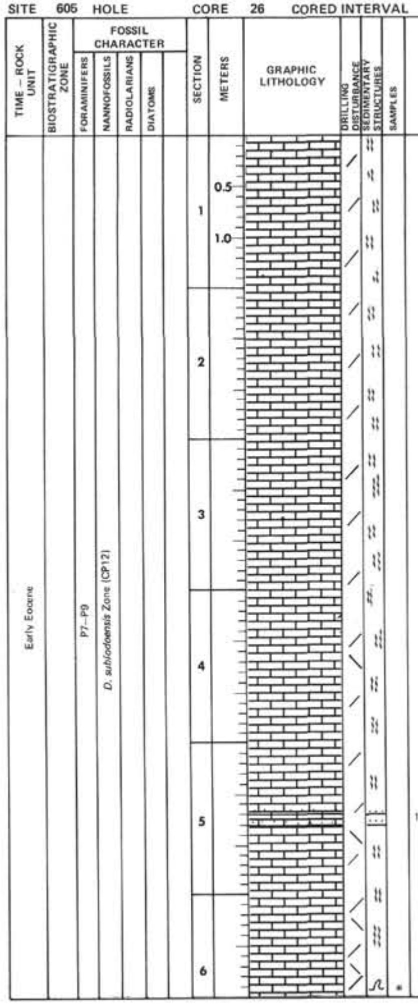
NANNOFOSSIL LIMESTONE, greenish gray (5GY 6/1–5GY 6.5/1) moderate bioturbation; burrows commonly filled by brownish gray (5Y 6/1, 5Y 5/1) faintly laminated nannofossil limestone. Core contains pyrite nodules.


Burrow structure at Sect. 1, 10

SMEAR SLIDE SUMMARY (%)

	1, 71 D
Texture:	
Composition:	
Quartz	tr.
Carbonate unspec.	95
Calc. nannofossils	5

SITE 605 HOLE CORE 26 CORED INTERVAL 384.7–394.3 m



LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL LIMESTONE, greenish gray (5GY 6/1), moderate bioturbation: burrows commonly filled by brownish gray (5Y 6/1, 5Y 5/1).

Faint banding preserved

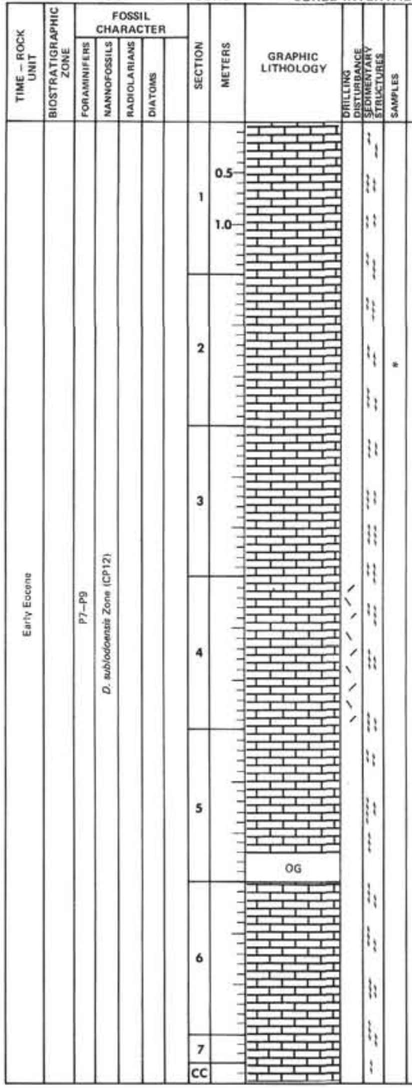
1) Pelagic turbidites (2 layers 1 cm thick): graded foraminiferal-peloidal? fine-sand, parallel laminated with slight scouring at the base.

Slump contortions at Sect. 6, 90-100 cm.

SMEAR SLIDE SUMMARY (%)

	6, 100 D
Texture:	
Sand	3
Silt	82
Clay	15
Composition:	
Quartz	1
Mica	1
Clay	13
Pyrite	1
Carbonate unspec.	40
Foraminifers	3
Calc. nannofossils	40
Radiolarians	2

SITE 605 HOLE CORE 27 CORED INTERVAL 394.3–403.9 m



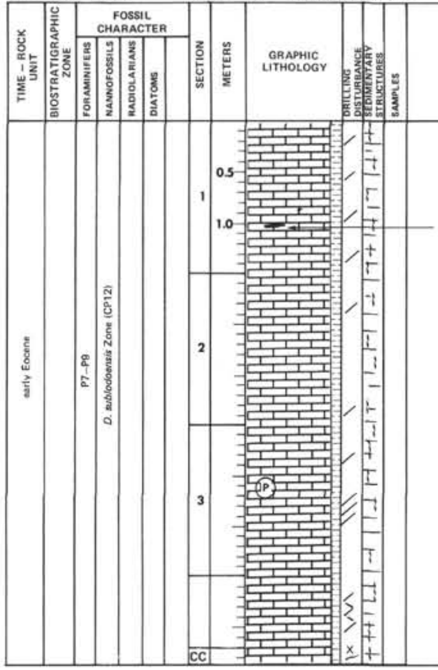
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL LIMESTONE Greenish gray (5GY 6/1); moderate to heavy bioturbation, burrows generally filled by brownish gray (5Y 5/1, 5Y 6/1), several burrow varieties including *Planolites* and *Chondrites*. Most of Sections 4-7 display vague laminations as well as some bands in the upper sections. Rare thin intervals of foraminiferal sand (Section 2, 142 cm; Section 3, 32 cm) occur.

SMEAR SLIDE SUMMARY (%)

	2, 90 D
Texture:	
Silt	85
Clay	15
Composition:	
Mica	2
Clay	6
Carbonate unspec.	55
Foraminifers	4
Calc. nannofossils	30
Radiolarians	2
Plant debris	1

SITE 605 HOLE CORE 28 CORED INTERVAL 403.9–413.5 m



LITHOLOGIC DESCRIPTION

FORAMINIFERA-BEARING CLAY-RICH NANNOFOSSIL LIMESTONE, grayish yellow green (5GY 7/2–5GY 6/1) becoming pale green (10G 6/2) in lower part of Section 4. Moderate bioturbation with vague lamination; burrow filling is commonly olive gray (5Y 5/2–5Y 5/1).

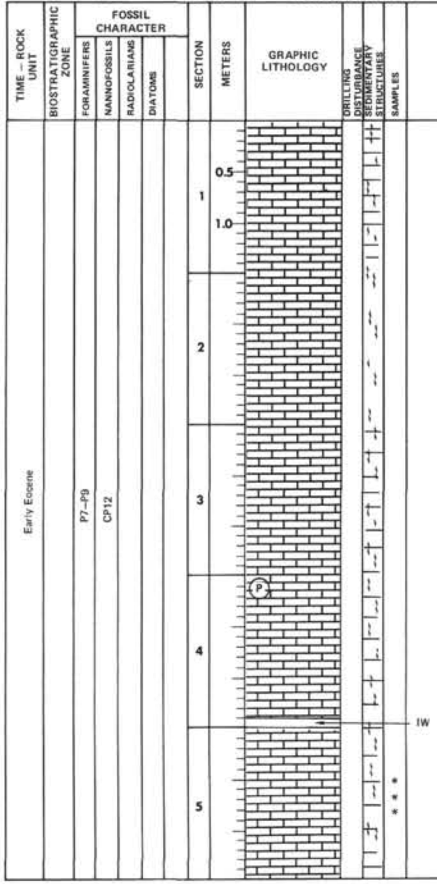
Foraminifer-rich layers at Sect. 1, 124-125 cm and Sect. 3, 35-36 cm. These have sharp lower contacts and an upward decrease in foram abundance.

Rare pyrite laminae and nodules.

SMEAR SLIDE SUMMARY (%)

	4, 65 D
Texture:	
Silt	88
Clay	12
Composition:	
Clay	12
Pyrite	TR
Carbonate unspec.	40
Foraminifers	5
Calc. nannofossils	43

SITE 605 HOLE CORE 29 CORED INTERVAL 413.5–423.1 m



LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL LIMESTONE
Grayish green (10GY 5/1) to pale green (10G 6/2). Moderate to heavy bioturbation with vague laminations (except Sect. 2). Burrows are commonly filled with light olive gray (5Y 5/2 – 5Y 5/1) and rarely with greenish gray (5GY 6/2). Abundant dark bluish gray streaks. Scattered rare pyrite nodules.

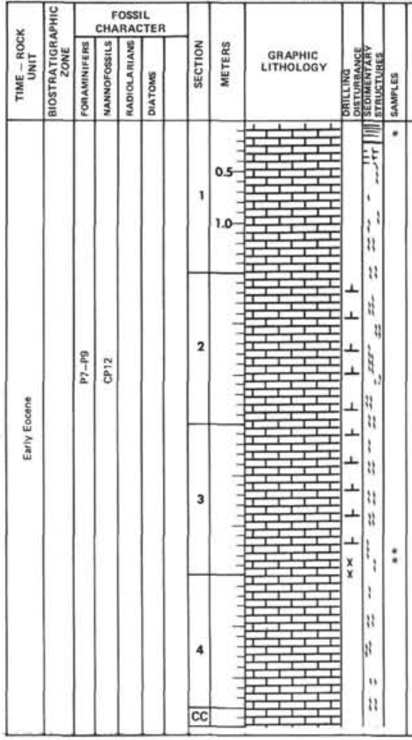
Sect. 5: 60-62 cm Foram-rich layer
- 62-65 cm Interval with no bioturbation (turbidite?)
- 65-80 cm Bioturbated interval of Nannofossil Limestone, grayish green (5G 5/2)
- 80-83 cm Interval of no bioturbation – Clay-rich Nannofossil Limestone

All the above are bound by sharp contacts.

SMEAR SLIDE SUMMARY (%)

	5, 50 D	5, 70 M	5, 82 M
Texture:			
Silt	100	100	85
Clay	–	–	15
Composition:			
Mica	TR	–	–
Clay	–	–	15
Glauconite	TR	–	–
Pyrite	–	1	–
Carbonate unspec.	40	20	55
Foraminifers	6	TR	–
Calc. nannofossils	53	79	30
Sponge spicules	TR	–	–
Plant debris, Organics	TR	TR	–

SITE 605 HOLE CORE 30 CORED INTERVAL 423.1–432.7 m



LITHOLOGIC DESCRIPTION

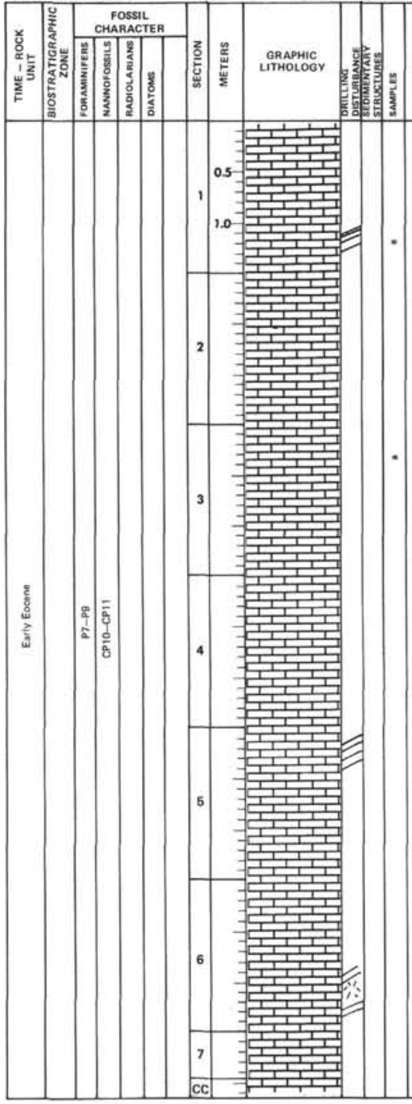
NANNOFOSSIL LIMESTONE

1) Pale green (10G 6/2) usually moderately bioturbated. In Section 1, 0-25 cm, strongly laminated with laminae<1 min. Below 25 cm the laminations gradually become faint and bioturbation is more dominant. At 15 cm (Sec. 1), is a discontinuous 3 mm layer of pyritized radiolarian-rich nannofossil limestone. Sec 2, *through Sec. 3*, 12 cm is moderately bioturbated with faint laminations.
2) Sec. 3, 12-130 cm, sharp contact at top and bottom. Color change to greenish gray (5G 5/1). Little bioturbation from 12-14 cm. The remainder of the interval is moderately bioturbated and faintly laminated.
3) Sec 3, 130-150 cm, Sec 4, + CC: Sharp contact with color change to light greenish gray (5GY 7/1) with a pyrite streak just below contact. Slight bioturbation from contact to Sec 4, 23 cm, below it is moderately bioturbated with faint laminations.

SMEAR SLIDE SUMMARY (%)

	1, 15 M	3, 128 D	3, 132 D
Texture:			
Silt	90	85	85
Clay	10	15	15
Composition:			
Clay	10	5	1
Glauconite	1	–	–
Carbonate unspec.	50	40	55
Foraminifers	1	3	3
Calc. nannofossils	20	50	40
Diatoms	TR	–	–
Radiolarians	15	1	–
Sponge spicules	3	–	–
Other Opaques	–	1	1

SITE 605 HOLE CORE 31 CORED INTERVAL 432.7–442.3 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Light greenish-gray (5GY 7/1) becoming down core (below Sect 1, 50 cm) light pale green (10G 7/1)

Moderately bioturbated
(a) Bluish-black tiny fucoid-like streaky burrows (<1 mm)
(b) Larger brownish burrows (2–5 mm diameter), indistinct boundaries, mostly parallel but also across bedding
(c) Scattered layer pyritic and hydrotroilite (black)

Small micro faults

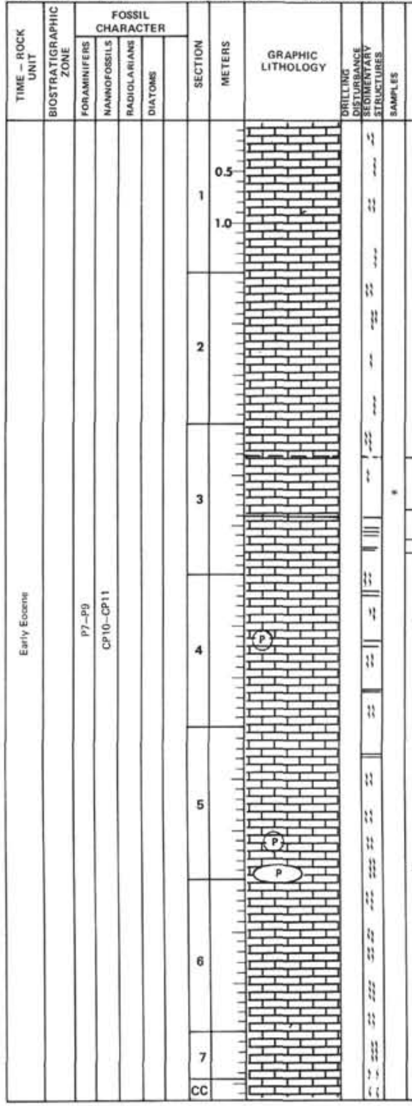
Flattened burrows give appearance of hidden lamination

SMEAR SLIDE SUMMARY (%)

	1, 114 M	3, 52 D
Texture:		
Silt	100	100
Composition:		
Mica	TR	TR
Carbonate unspec.	99	90
Calc. nannofossils	1	10

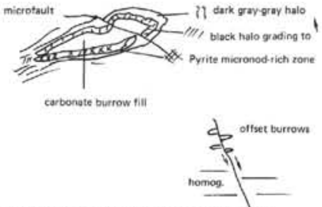
SITE 605 HOLE CORE 32 CORED INTERVAL 442.3–451.9 m

LITHOLOGIC DESCRIPTION



CLAY-BEARING, FORAMINIFER-BEARING to -RICH NANNOFOSSIL LIMESTONE, pale green (10G 7/1). Bioturbation slight to moderate. Pyrite-hydrotroilite-rich laminae + pyrite nodules.

Color ranges from pale green (10G 7/1) to greenish gray in the lower half of the core



Bioturbation decreases, lighter colored.

Not bioturbated

darker green

more bioturbation faintly banded pyrite-rich burrow fills

(5GY 6/1 to 5G 6/2), homogeneous, faintly laminated, microfaults Foraminifera and Calcified radiolarians common (as figured above).

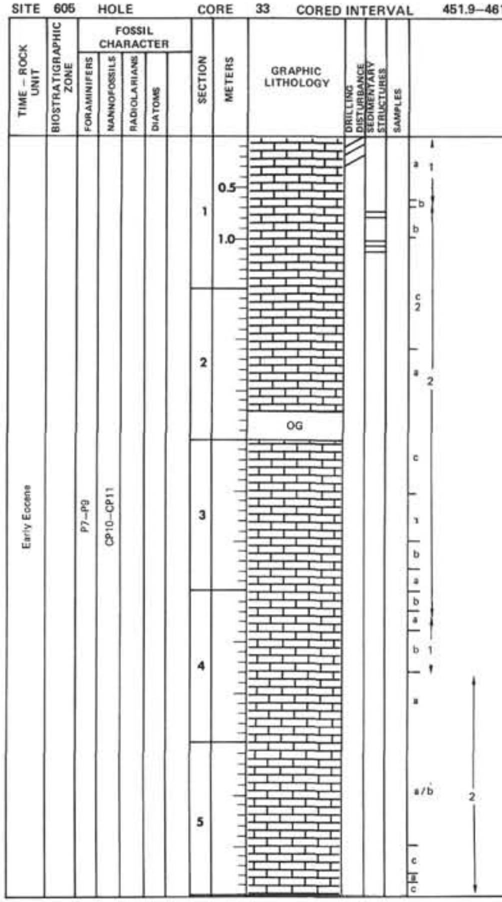
Pyrite-rich bands

SMEAR SLIDE SUMMARY (%)

	3, 70 D	2, 96 D
Texture:		
Sand	–	5
Silt	100	85
Clay	–	10
Composition:		
Mica	TR	TR
Clay	–	9
Carbonate unspec.	90	71
Foraminifers	3	5
Calc. nannofossils	5	15
Radiolarians	2	–

SITE 605 HOLE CORE 33 CORED INTERVAL 451.9–461.5 m

LITHOLOGIC DESCRIPTION



1) NANNOFOSSIL LIMESTONE light-greenish gray (5GY–5G 7/1), and
2) FORAMINIFERA- and CLAY-BEARING NANNOFOSSIL LIMESTONE, slightly darker green (5GY to G 6/1 or 6.5/1)

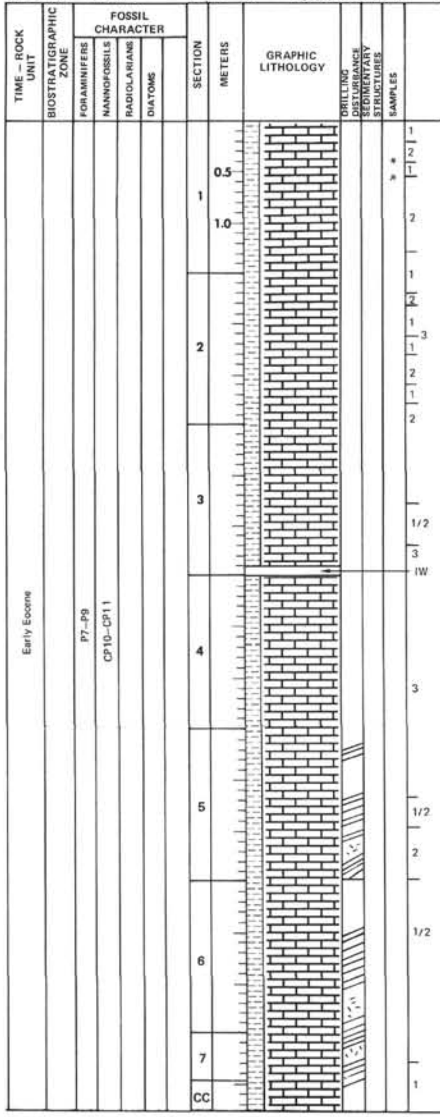
Showing gradations between:
a) Intense to moderate bioturbation and only weak/indistinct lamination
b) Laminations more distinct than bioturbation (as in (a)
c) "Homogeneous" (= no lamination + only weak bioturbation of "green" burrow fills, no black burrow fills

Fresh water causes bowing upwards of core half.

SMEAR SLIDE SUMMARY (%)

	2, 96 D	4, 11 D
Texture:		
Sand	3	–
Silt	92	100
Clay	5	–
Composition:		
Clay minerals	5	–
Carbonate unspec.	87	97
Foraminifers	3	–
Calc. nannofossils	5	3
Radiolarians	TR	–

SITE 605 HOLE CORE 34 CORED INTERVAL 461.5–471.1 m



LITHOLOGIC DESCRIPTION

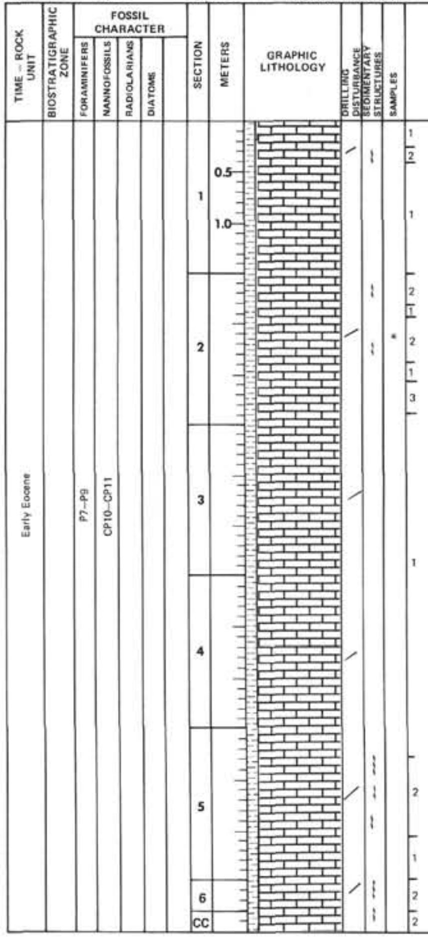
NANNOFOSSIL LIMESTONE mostly grayish-green (10GY 5–6/2).

More homogeneous-looking than Core 33 (less bioturbation and lamination very indistinct). A few bands of darker green (5GY 5/2, dusky yellow green) material (2–20 mm wide) occur. Core shows gradations between:
1) Homogeneous
2) Bioturbated + faintly laminated
3) Dark bands

SMEAR SLIDE SUMMARY (%)

	1, 46 D	1, 64 D
Texture:		
Silt	80	–
Clay	20	–
Composition:		
Mica	tr	tr
Heavy minerals	tr	–
Clay	20	5
Glauconite	tr	–
Carbonate unspec.	50	80
Calc. nannofossils	30	15
Fish remains	tr	–

SITE 605 HOLE CORE 35 CORED INTERVAL 471.1–480.7 m



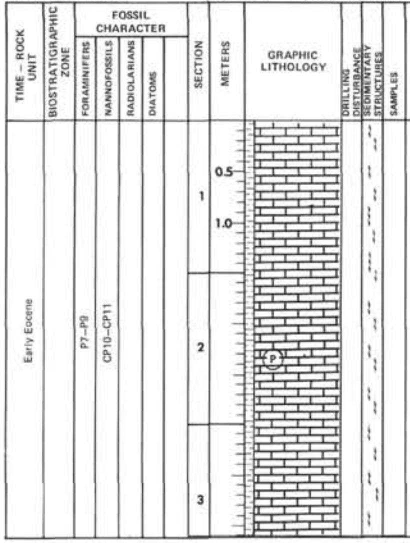
LITHOLOGIC DESCRIPTION

CLAY-RICH NANNOFOSSIL LIMESTONE, grayish green (5G 6/2), light to moderate bioturbation or homogeneous, rare intervals of faint lamination
1) Homogeneous
2) Bioturbated and/or faintly laminated
3) Interval of 10GY 5/2 grayish green

SMEAR SLIDE SUMMARY (%)

	2, 70 D
Texture:	
Silt	80
Clay	20
Composition:	
Clay	13
Carbonate unspec.	45
Foraminifers	1
Calc. nannofossils	40
Radiolarians	1

SITE 605 HOLE CORE 36 CORED INTERVAL 480.7–490.3 m



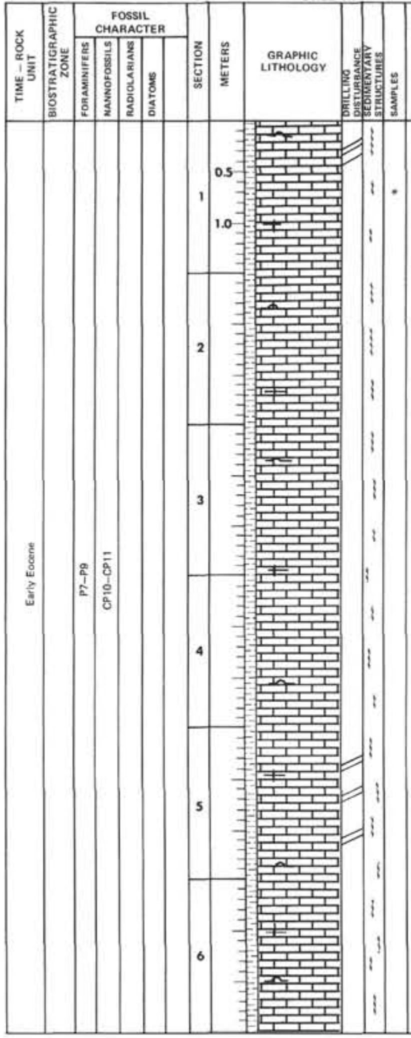
LITHOLOGIC DESCRIPTION

CLAY-RICH NANNOFOSSIL LIMESTONE, grayish green (10GY 6/2); moderate bioturbation throughout, but burrows are difficult to resolve due to filling by same color material, in Section 3 some are filled by brownish gray. Rare pyrite nodule. Blue gray (dark) streaks are abundant.

SMEAR SLIDE SUMMARY (%)

	1, 100 D
Texture:	
Silt	86
Clay	14
Composition:	
Clay	14
Glauconite	TR
Carbonate unspec.	44
Foraminifers	2
Calc. nannofossils	40

SITE 605 HOLE CORE 37 CORED INTERVAL 490.3–499.9 m



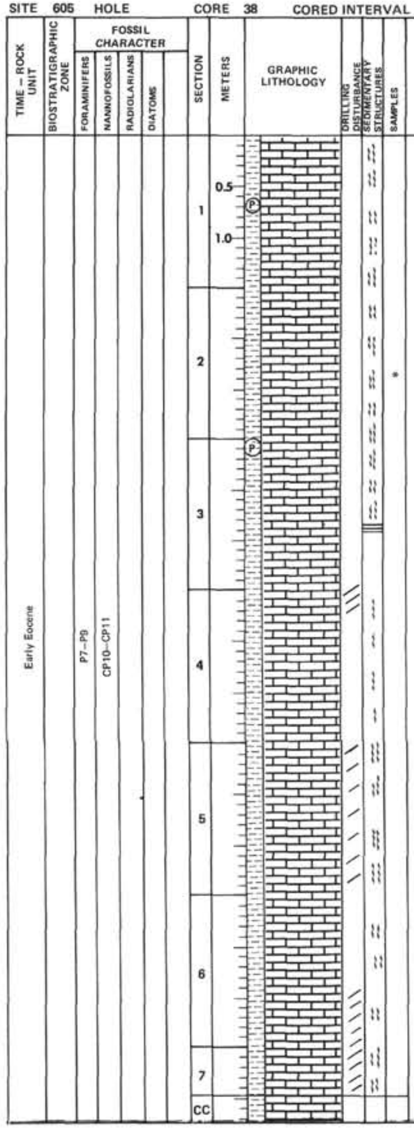
LITHOLOGIC DESCRIPTION

RADIOLARIAN-, FORAMINIFER-, and NANNOFOSSIL-BEARING CLAY-RICH LIMESTONE, gray yellow green (10GY 6/2) color. Entire core is moderately bioturbated giving the appearance of faint "streaky" lamination. A few 2–5 mm thick brownish horizontal burrows occur.

SMEAR SLIDE SUMMARY (%)

	1, 70 D
Texture:	
Sand	15
Silt	75
Clay	15
Composition:	
Quartz	TR
Mica	TR
Clay minerals	15
Glauconite	TR
Carbonate unspec.	70
Foraminifers	6
Calc. nannofossils	6
Radiolarians	3

SITE 605 HOLE CORE 38 CORED INTERVAL 499.9–509.5 m



LITHOLOGIC DESCRIPTION

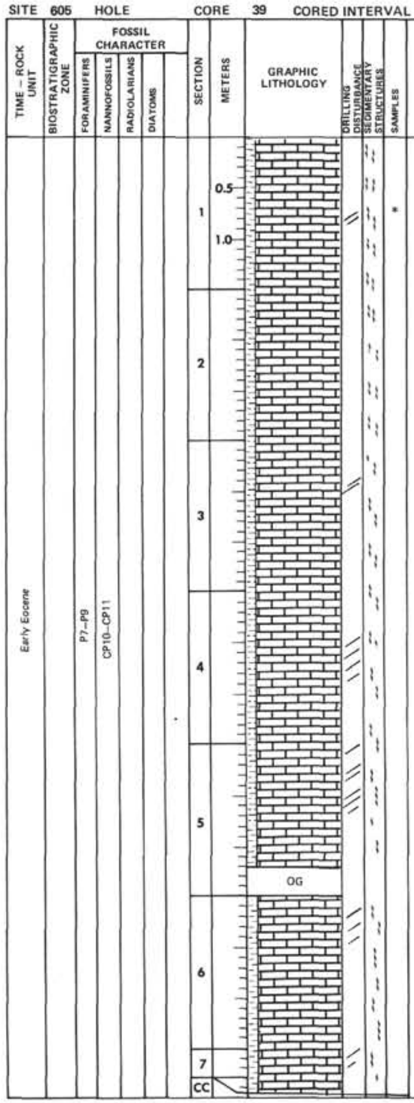
RADIOLARIAN-BEARING, CLAY-RICH NANNOFOSSIL LIMESTONE greenish gray (10GY 6/2) moderately bioturbated and faintly laminated. Burrows are compressed and streaked-out horizontally. Burrow fill is brownish gray to black and pyrite-rich.

In Section 3, at 90 cm occurs a 1cm thick horizon of black pyrite-rich, mm laminae. The remainder of the section is not bioturbated. Section 4 is slightly bioturbated with the upper portion of Section 5 returning to a moderate bioturbation. The lower portion of Section 5 is very faintly laminated.

SMEAR SLIDE SUMMARY (%)

	2, 87
	D
Texture:	
Sand	5
Silt	65
Clay	30
Composition:	
Clay	20
Carbonate unspec.	29
Foraminifers	3
Calc. nannofossils	30
Radiolarians calcified	8

SITE 605 HOLE CORE 39 CORED INTERVAL 509.5–519.1 m



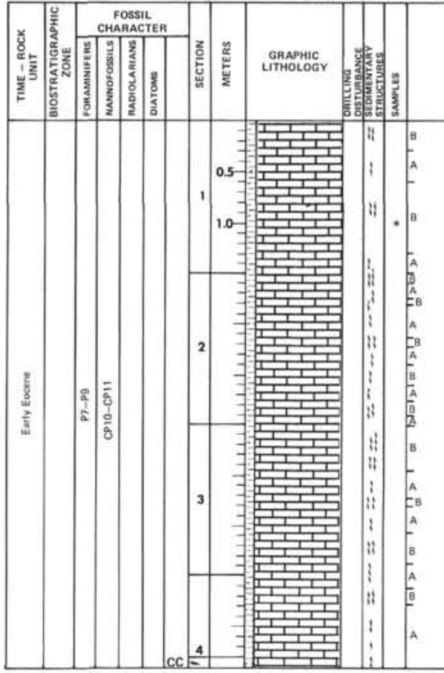
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING CLAY-RICH NANNOFOSSIL LIMESTONE, grayish green (10GY 5/2–8GY 5/2), lighter when dry. Moderate bioturbation; burrows filled by dark greenish gray (5GY 5/1, 5GY 4/1), especially in Sections 2 and 4. In general, burrows are better defined and with more subvertical forms than in Core 38 and above. Dark bluish gray streaks are abundant.

SMEAR SLIDE SUMMARY (%)

	1, 70
	D
Texture:	
Silt	89
Clay	11
Composition:	
Clay	11
Glauconite	TR
Carbonate unspec.	35
Foraminifers	7
Calc. nannofossils	46
Radiolarians Calcified	1

SITE 605 HOLE CORE 40 CORED INTERVAL 519.1–528.7 m



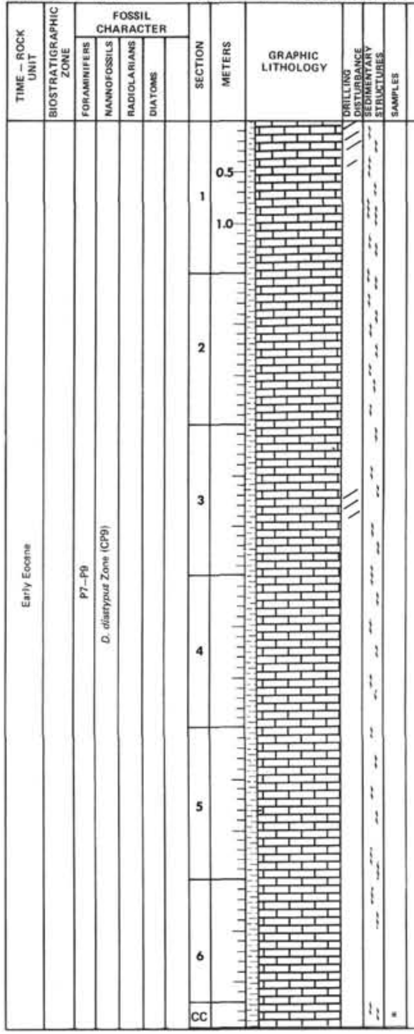
LITHOLOGIC DESCRIPTION

FORAMINIFERA-BEARING, CLAY-RICH NANNOFOSSIL LIMESTONE, pale green (10G 6/2) with slight (A) to moderate (B) bioturbation. Burrows are infilled with brownish gray, pyrite-rich material. Burrows are compressed, and streaked-out horizontally, giving the impression of faint laminations. In the moderately bioturbated areas (B) the burrows are larger and more distinct. Some burrows continue across the full width of the cut surface as an irregular band.

SMEAR SLIDE SUMMARY (%)

	1, 100 D
Texture:	
Silt	89
Clay	11
Composition:	
Quartz	1
Mica	2
Clay	11
Glauconite	TR
Carbonate unspec.	5
Foraminifers	8
Calc. nannofossils	71
Radiolarians	2

SITE 605 HOLE CORE 41 CORED INTERVAL 528.7–538.3 m



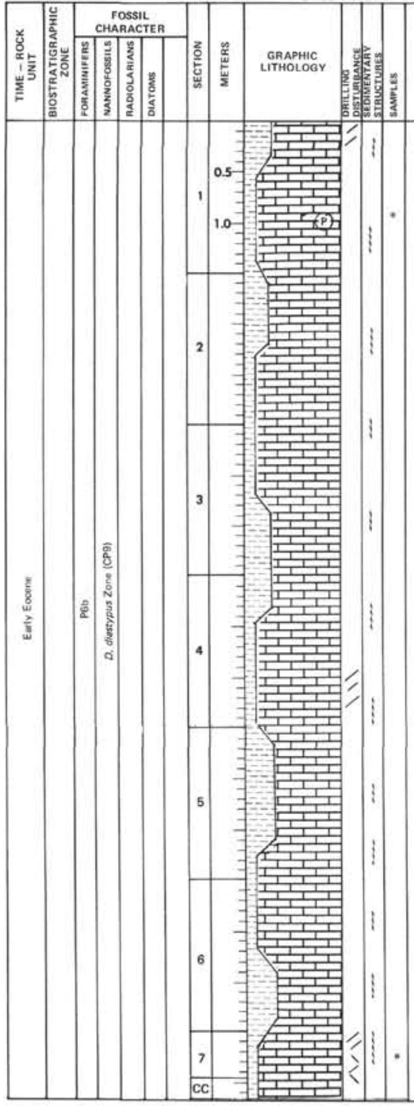
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING CLAY-RICH NANNOFOSSIL LIMESTONE, pale greenish gray (5G 6/2) to yellowish grayish green (10GY 6/2). Moderate bioturbation, burrows often filled by dark gray (5Y 4/1, 5GY 3/1; *Chondrites*-type common in Sections 5 and 6, wide variety of other types. Scattered pyrite as blue-black streaks, replaced radiolarians (esp. Section 5, 83–85 cm where there is a vague lenticular relative concentration), and rare burrow linings.

SMEAR SLIDE SUMMARY (%)

	CC, 1 M
Texture:	
Silt	85
Clay	15
Composition:	
Quartz	1
Heavy minerals	1
Clay	14
Pyrite	1
Carbonate unspec.	30
Foraminifers	5
Calc. nannofossils	45
Radiolarians	3
Fish remains	TR

SITE 605 HOLE CORE 42 CORED INTERVAL 538.3 - 547.9m



LITHOLOGIC DESCRIPTION

CLAY and FORAMINIFER-RICH, NANNOFOSSIL LIMESTONE *shading from grayish green 10GY 6/2 to greenish gray (5GY 5/1), slightly to moderately bioturbated (mostly horizontal burrows, dark gray (5Y 4/1) pyrite-rich burrow fills).*

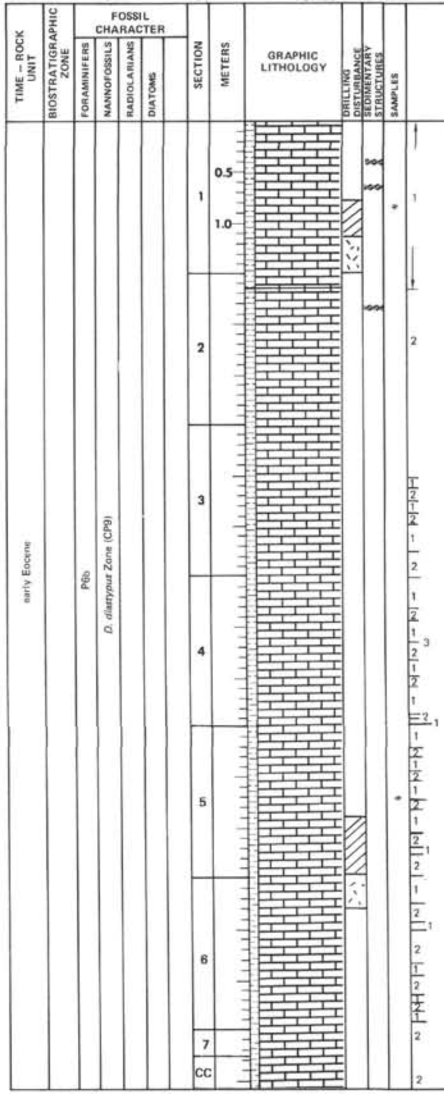
Pyrite-rich laminated bands occur.

Darker greenish gray material contains more clay and less nannofossils.

SMEAR SLIDE SUMMARY (%)

	1, 90 D	7, 34 D
Texture:		
Sand	20	20
Silt	55	65
Clay	25	15
Composition:		
Quartz	2	1
Mica	TR	TR
Clay	25	15
Glauconite	TR	—
Carbonate unspec.	30	20
Foraminifers	10	10
Calc. nannofossils	33	54
Radiolarians	TR	TR

SITE 605 HOLE CORE 43 CORED INTERVAL 547.9 - 557.5m



LITHOLOGIC DESCRIPTION

FORAMINIFER- and CLAY-RICH NANNOFOSSIL LIMESTONE *alternately banded by:*

1) dark (= grayish-green 10 GY 5/2), and
2) light-colored (= 10 GY 6 to 6/2) = (pale) grayish green) intervals – 10 to 30 cm wide.

(1) and (2) moderately bioturbated, faintly laminated/color banded.

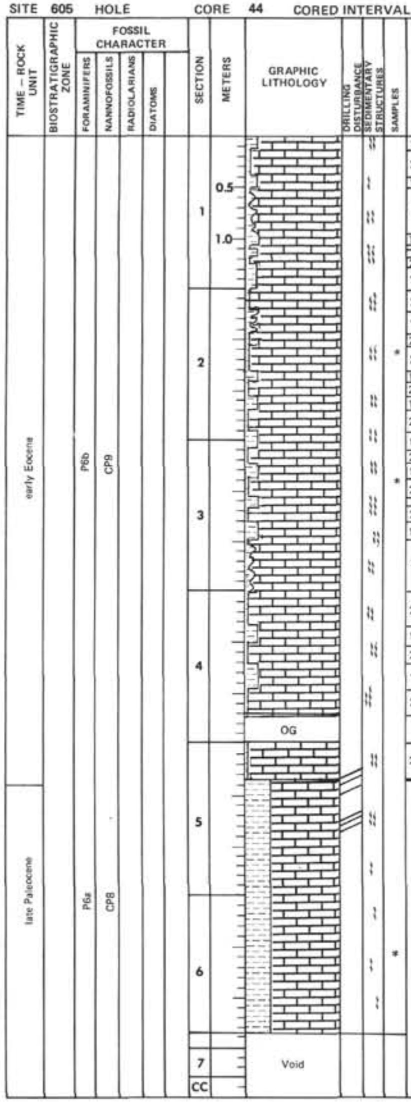
Dark gray burrow fills (hydrotroilite?), rarely with pyrite concretions in center of burrow fill occur.

Dried core bows concave upward (due to splitting in fresh water?).

SMEAR SLIDE SUMMARY (%)

	1, 92 D	5, 83 D
Texture:		
Sand	10	15
Silt	75	75
Clay	15	10
Composition:		
Quartz	TR	TR
Mica	TR	TR
Clay minerals	15	8
Glauconite	TR	—
Pyrite	1	—
Carbonate unspec.	30	35
Foraminifers	11	15
Calc. nannofossils	43	42
Radiolarians	—	TR

SITE 605 HOLE CORE 44 CORED INTERVAL 557.5 - 567.1m



LITHOLOGIC DESCRIPTION

FORAMINIFER- and CLAY-RICH NANNOFOSSIL LIMESTONE, Section 1 to Section 5, 33 cm.
Composed of cyclic alternations (10–20 cm intervals) of:
(1) dark (10GY 5/2)
(2) light-colored (5GY 7 to 6/2)
with gradational contacts.

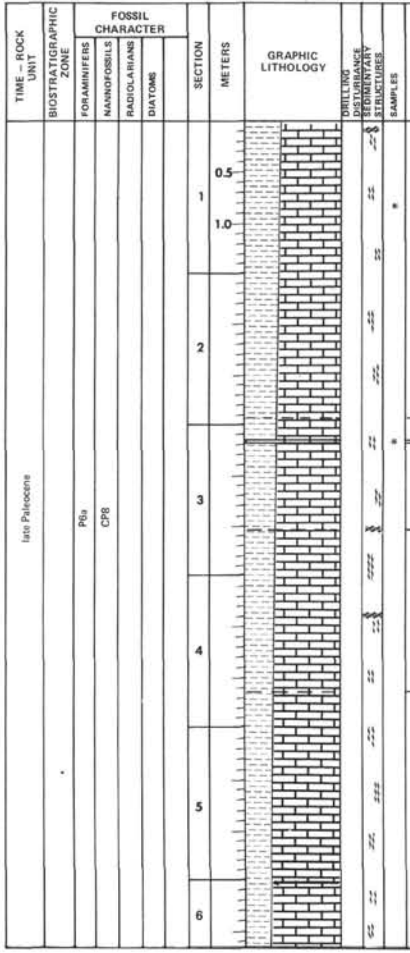
Core moderately to intensely burrowed, with distinct dark horizontal burrows (*Planolites*-type).

FORAMINIFER-BEARING CLAYEY NANNOFOSSIL LIMESTONE (MARL), (dark) greenish gray (5GY 4–5/1), occurs below Section 5, 33 cm. Core bows upward when dry. Many horizontal burrows.

SMEAR SLIDE SUMMARY (%)

	2, 72 D	3, 33 D	6, 51 D
Texture:			
Sand	5	–	–
Silt	90	85	70
Clay	5	15	30
Composition:			
Quartz	1	TR	1
Mica	TR	TR	TR
Heavy minerals	TR	TR	TR
Clay minerals	5	15	30
Glauconite	–	TR	TR
Zeolite	1	–	–
Carbonate unspec.	20	20	20
Foraminifers	10	12	4
Calc. nannofossils	63	52	45
Radiolarians calcitized	–	1	
Silicoflagellates	–	TR	–

SITE 605 HOLE CORE 45 CORED INTERVAL 567.1 - 576.7m



LITHOLOGIC DESCRIPTION

QUARTZ- and FORAMINIFER-BEARING CLAYEY NANNOFOSSIL LIMESTONE (MARL)
Dark greenish gray (5GY 4/1), in places in Sect. 1 faintly banded (cm-to dm-scale), moderately bioturbated (mainly Planolites-type + Zoophycos with dark gray (N3) to grayish black N2 filling). It lightens very gradually from Sect. 1 to 5 from dark greenish gray to greenish gray (5GY 4-5/1 → 5/1).

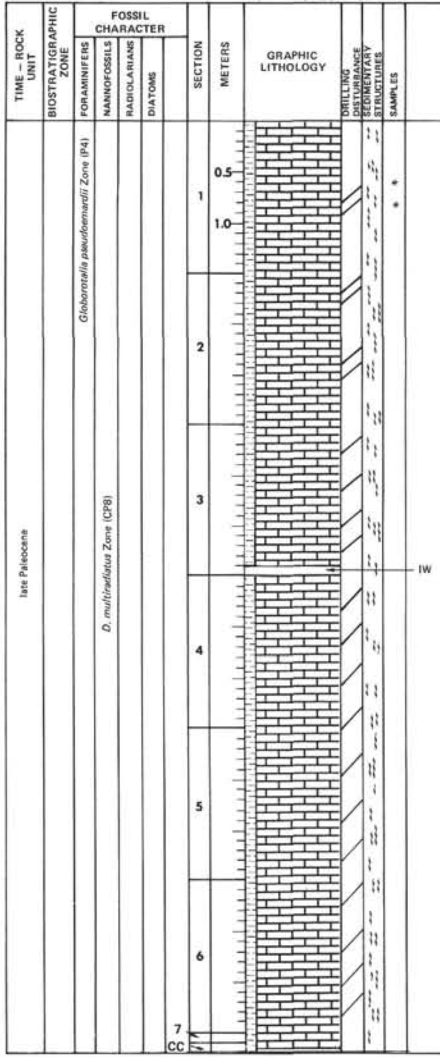
Zoophycos burrow at Section 1, 12 cm.

5GY 5/1
Pyrite layer, 1 cm thick.
5GY 4/1
5GY 4.5/1
5GY 5/1

SMEAR SLIDE SUMMARY (%)

	1, 80 D	3, 45 M	4, 135 D
Texture:			
Sand	10	10	–
Silt	50	65	70
Clay	40	25	30
Composition:			
Quartz	3	–	2
Feldspar	1	–	–
Mica	–	1	TR
Clay	38	23	30
Pyrite	1	50	–
Carbonate unspec.	5	5	1
Foraminifers	7	TR	3
Calc. nannofossils	45	12	64

SITE 605 HOLE CORE 46 CORED INTERVAL 576.7 - 586.3 m



LITHOLOGIC DESCRIPTION

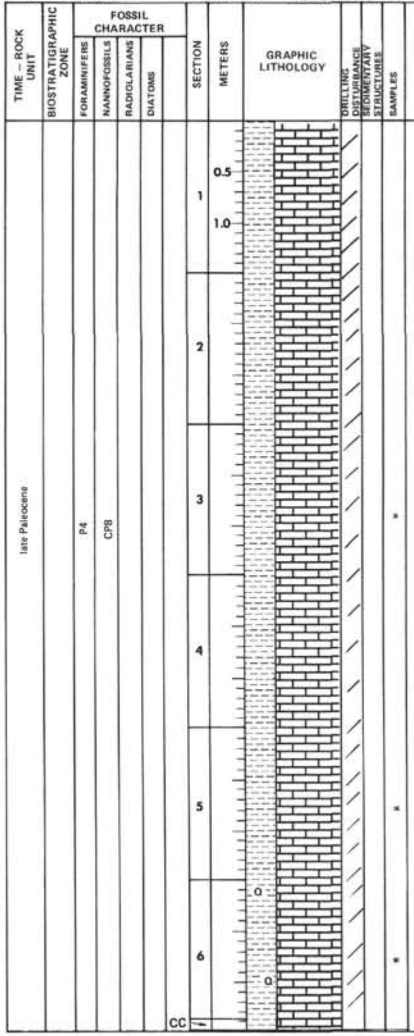
CLAY-RICH NANNOFOSSIL LIMESTONE

Dark greenish gray (5GY 4/1, 5GY 4.5/1). Moderate bioturbation including *Planolites*, *Zoophycos* (esp. Sect. 2, 136-141 cm), and *Chondrites*. Burrow fills are commonly greenish black (5G 3/1) clay-rich Nannofossil Limestone (but with more clay and nannofossils). Sect. 1 has slightly less bioturbation.

SMEAR SLIDE SUMMARY (%)

	1, 80 D	1, 62 M
Texture:		
Silt	89	85
Clay	11	15
Composition:		
Quartz	1	–
Heavy minerals	TR	–
Clay	11	15
Glauconite	TR	TR
Carbonate unspec.	52	20
Foraminifers	1	2
Calc. nannofossils	35	60
Radiolarians	–	1
Other Opaques	–	2

SITE 605 HOLE CORE 47 CORED INTERVAL 586.3 - 595.9m



LITHOLOGIC DESCRIPTION

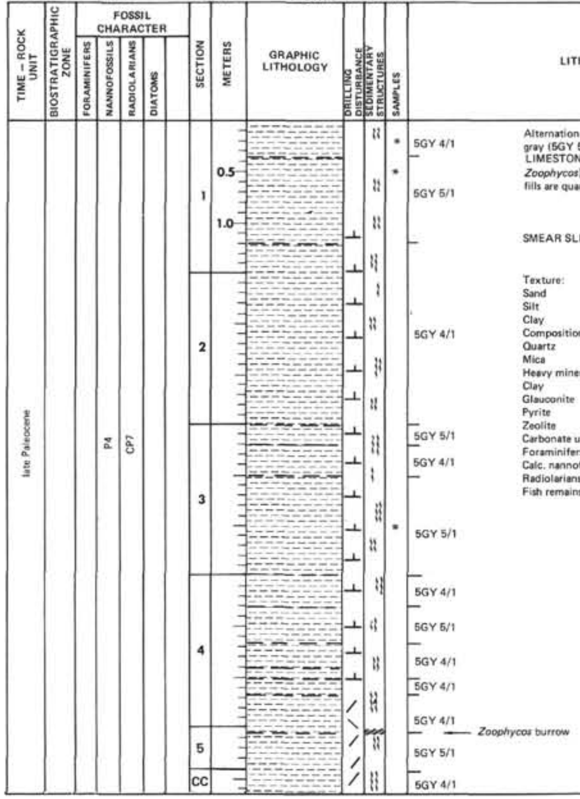
CLAYEY NANNOFOSSIL LIMESTONE, varying from dark greenish gray (5GY 4/1) to greenish gray (5GY 5/1) with moderate bioturbation *Planolites* and *Chondrites*-types are abundant. Three sets of *Zoophycos*-type burrows in this core.

SILT-BEARING CLAYEY NANNOFOSSIL LIMESTONE, greenish gray (5GY 5/1) appears similar to the lithology above listed, but contains more quartz. This occurs in Section 6.

SMEAR SLIDE SUMMARY (%)

	3, 90 D	5, 80 D	6, 90 D
Texture:			
Silt	60	65	–
Clay	40	35	–
Composition:			
Quartz	2	2	10
Mica	2	1	2
Heavy minerals	1	–	–
Clay	35	35	35
Glauconite	1	TR	1
Carbonate unspec.	17	10	15
Foraminifers	1	1	–
Calc. nannofossils	50	50	35
Radiolarians	–	TR	–
Fish remains	–	TR	
Other Opaques	1	1	2

SITE 605 HOLE CORE 48 CORED INTERVAL 595.9 - 605.5m



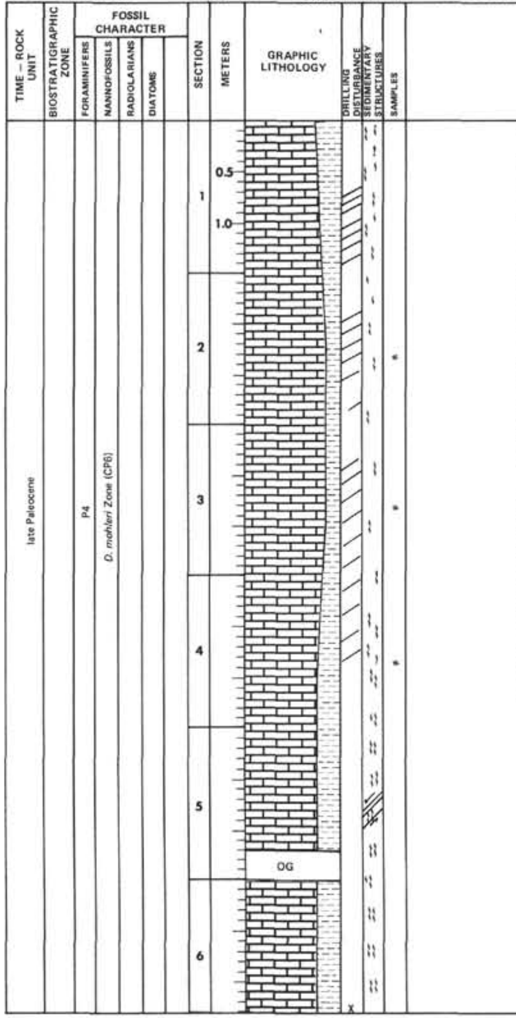
LITHOLOGIC DESCRIPTION

Alternation of dark greenish gray (5GY 4/1) and greenish gray (5GY 5/1), CLAYEY TO CLAY-RICH NANNOFOSSIL LIMESTONE, moderately bioturbated (*Planolites*-type + *Zoophycos*). Dark gray to grayish black (N3 to N2) burrow fills are quartz- and pyrite-bearing, nannofossil limestone.

SMEAR SLIDE SUMMARY (%)

	1, 20 D	1, 50 D	3, 91 M
Texture:			
Sand	–	–	–
Silt	70	80	65
Clay	30	20	35
Composition:			
Quartz	3	2	6
Mica	TR	TR	1
Heavy minerals	TR	TR	–
Clay	30	20	35
Glauconite	TR	TR	1
Pyrite	1	–	2
Zeolite	TR	–	–
Carbonate unspec.	5	–	5
Foraminifers	–	–	2
Calc. nannofossils	61	78	49
Radiolarians	TR	TR	–
Fish remains	–	TR	–

SITE 605 HOLE CORE 49 CORED INTERVAL 605.5 - 615.1 m



LITHOLOGIC DESCRIPTION

CLAY-RICH NANNOFOSSIL LIMESTONE

Sect. 1, top – Sect. 2, 30 cm – CLAYEY NANNOFOSSIL LIMESTONE, dark greenish gray (5GY 4/1), with moderate to light bioturbation of very dark brownish gray (5Y 3/1, 5Y 3/1).

Section 2, 30 cm–Section 3, 20 cm: CLAY-RICH NANNOFOSSIL LIMESTONE, greenish gray (5GY 5/1) with only small vague burrows of same color.

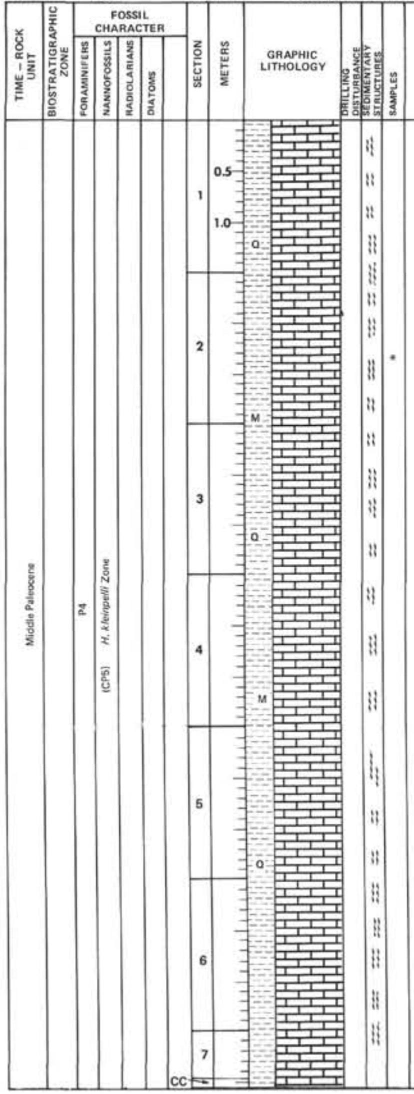
Section 3, 20 cm–Section 4, 50 cm: CLAY-RICH NANNOFOSSIL LIMESTONE, greenish gray (5GY 6/1–10GY 6/2) (lighter than above) with faint bioturbation (small size). Interval of 10GY 5/2 in Section 3, 60–73 cm with (?)clast of 5GY 6/1.

Section 4, 50 cm–base of core: SILT-BEARING CLAY-RICH NANNOFOSSIL LIMESTONE, dark greenish gray (5GY 4.5/1) with moderate to heavy bioturbation. Burrows often filled by very dark greenish gray (5GY 3/1) *Zoophycos* of large size in Section 5, 105–120 cm and Section 6, 50–70 cm. Microfaults and disturbed structure at Section 5, 70–90 cm.

SMEAR SLIDE SUMMARY (%)

	2, 80 D	3, 80 D	4, 80 D
Texture:			
Silt	74	83	83
Clay	26	17	17
Composition:			
Quartz	4	2	4
Mica	1	1	3
Heavy minerals	–	–	TR
Clay	26	17	17
Palagonite	–	–	TR
Glauconite	1	2	1
Pyrite	1	–	1
Carbonate unspec.	2	6	3
Foraminifers	–	1	10
Calc. nannofossils	65	70	60
Radiolarians	TR	1	1
Fish remains	TR	–	–

SITE 605 HOLE CORE 50 CORED INTERVAL 615.1 - 624.7m



LITHOLOGIC DESCRIPTION

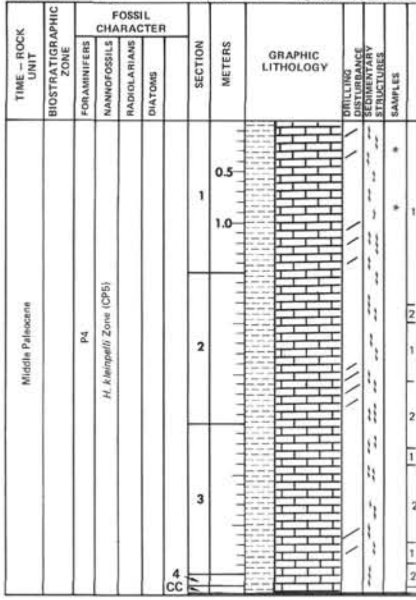
SILT BEARING, CLAYEY NANNOFOSSIL LIMESTONE, greenish gray (5GY 5/1) with dark greenish gray (5GY 4/1) burrow fill. Core is moderately bioturbated; mostly *Planolites* type. *Zoophycos*-type of burrows occurs in Sect. 1, 50-70 cm; Sect. 3, 61-69 cm; Sect. 4, 125-140 cm; Sect. 5, 35-44 cm, and 110-121 cm; Sect. 7, 21-32 cm.

A compacted shell layer occurs in Sect. 6, at 82-83 cm.

SMEAR SLIDE SUMMARY (%)

	2, 80 D
Texture:	
Silt	70
Clay	30
Composition:	
Quartz	3
Mica	3
Clay	30
Glauconite	1
Carbonate unspec.	15
Foraminifers	TR
Calc. nannofossils	47
Radiolarians recrystallized	1

SITE 605 HOLE CORE 51 CORED INTERVAL 624.7 - 634.3m



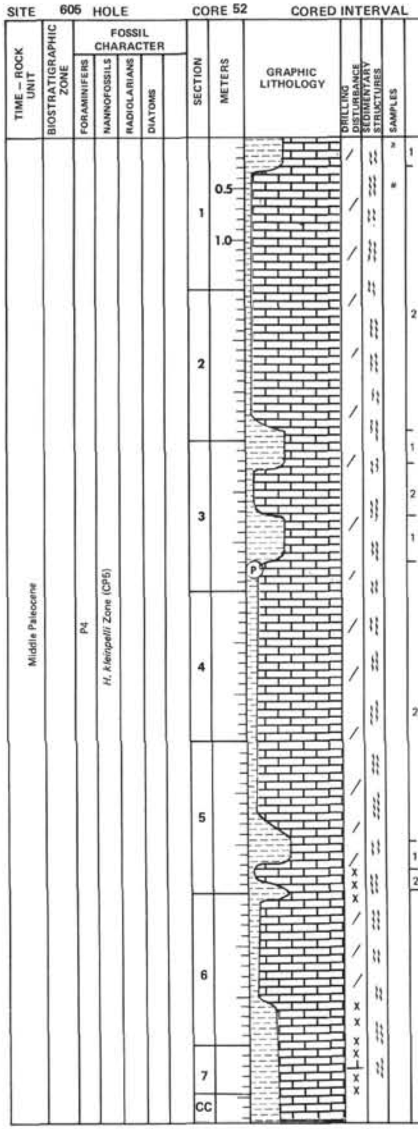
LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL LIMESTONE
Dark greenish gray (5GY 4/1) to greenish gray (5GY 5/1) – These dark/light zones are marked "1" and "2" respectively. Moderate bioturbation with burrow fillings commonly of very dark greenish gray (5GY 3/1), also of clayey nannofossil limestone.

SMEAR SLIDE SUMMARY (%)

	1, 35 D	1, 89 M
Texture:		
Silt	70	60
Clay	30	40
Composition:		
Quartz	2	1
Mica	1	1
Heavy minerals	TR	–
Clay	30	40
Glauconite	TR	–
Carbonate unspec.	7	15
Foraminifers	TR	3
Calc. nannofossils	60	40
Radiolarians	TR	TR

SITE 605 HOLE CORE 52 CORED INTERVAL 634.3 - 643.9m



LITHOLOGIC DESCRIPTION

1) CLAYEY NANNOFOSSIL LIMESTONE, greenish gray (5GY 5/1) alternating with

2) CLAY-RICH NANNOFOSSIL LIMESTONE, greenish gray (5GY 6/1). The whole core has moderate bioturbation. Small microfault occurs in Section 1, at 33–36 cm with mm offset.

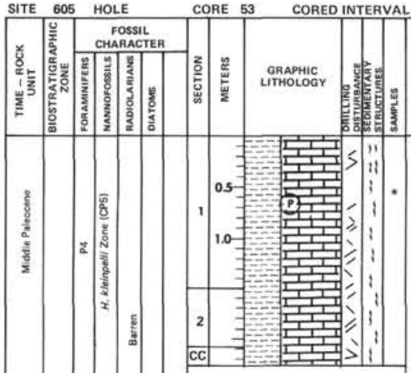
One pyrite filled burrow occurs in Section 3, 128–130 cm. *Zoophycos* type burrows occur in the following intervals: Section 2, 53-71 cm; Section 3, 23-40 cm; Section 5, 130-132 cm reburrowed by *Chrondrites*-type; Section 6, 5-26 cm, and 36-46 cm.

No sharp boundaries between lithologies.

SMEAR SLIDE SUMMARY (%)

	1, 40 D	1, 10 D
Texture:		
Silt	87	50
Clay	13	50
Composition:		
Quartz	2	1
Mica	1	–
Heavy minerals	TR	TR
Clay	13	44
Glauconite	2	
Pyrite	1	–
Carbonate unspec.	15	10
Foraminifers	4	3
Calc. nannofossils	60	40
Radiolarians recrystallized	2	1
Fish remains	1	–
Other opaques	–	1

SITE 605 HOLE CORE 53 CORED INTERVAL 643.9 - 648.4 m



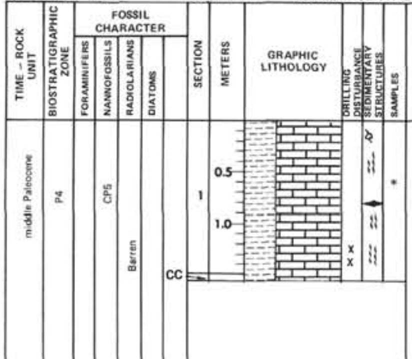
LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL LIMESTONE, dark greenish gray (5GY 4/1) becoming 5GY 4.5/1 in lower part of Sect. 1. Moderate to slight bioturbation; burrows generally filled with darker colored marly limestone. Rare pyrite nodule. Core is heavily brecciated from drilling.

SMEAR SLIDE SUMMARY (%)

	1, 55 D
Texture:	
Silt	50
Clay	50
Composition:	
Quartz	2
Mica	3
Clay	45
Glauconite	1
Carbonate unspec.	10
Foraminifers	1
Calc. nannofossils	37
Radiolarians	1
Fish remains	TR
Other Opaques	TR

SITE 605 HOLE CORE 54 CORED INTERVAL 648.4 - 653.5m



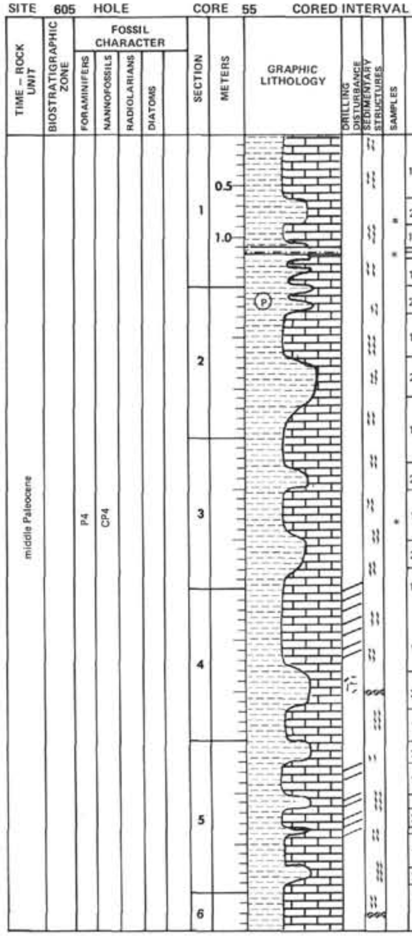
LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING CLAYEY NANNOFOSSIL LIMESTONE, gray (N5, slightly greenish), Moderately bioturbated with streaked-out burrows. *Zoophycos* burrow at Section 1, 80 cm.

SMEAR SLIDE SUMMARY (%)

	1, 65 D
Texture:	
Sand	–
Silt	65
Clay	35
Composition:	
Quartz	TR
Mica	TR
Clay	35
Glauconite	TR
Carbonate unspec.	10
Calc. nannofossils	55
Fish remains	TR

SITE 605 HOLE CORE 55 CORED INTERVAL 653.5 - 663.1m



LITHOLOGIC DESCRIPTION

Cyclic alternations of 20–30 cm wide intervals (gradational boundaries) of:

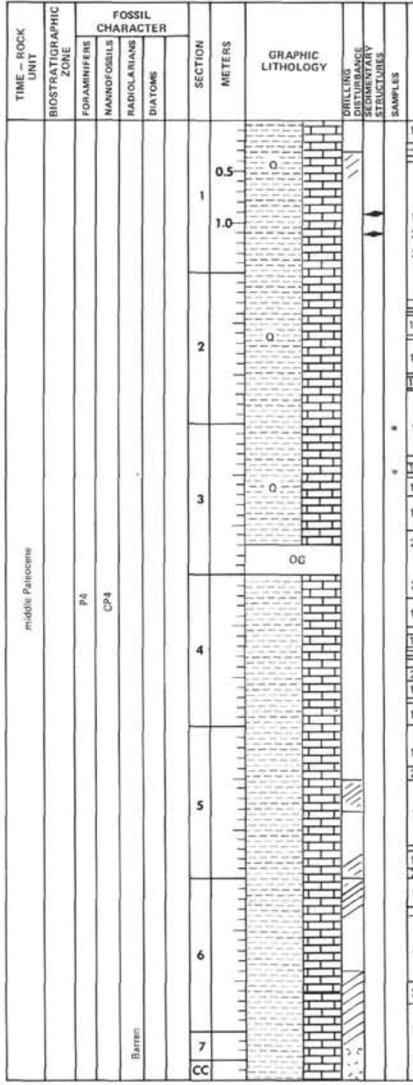
1) Gray (N5 to 5Y 5/1), slightly greenish CLAYEY NANNOFOSSIL LIMESTONE (MARL), and
2) dark gray (N4 to 5Y 4/1) quartz-bearing NANNOFOSSIL-RICH CLAYSTONE (CLAYEY MARL) moderately (to intensely) bioturbated with *Planolites*-, *Chondrites*-, and *Zoophycos*-type (expec. Sect. 4, 100–115 cm) burrows; pyrite nodules rare.
3) Local bands (2 cm thick) of dark greenish-gray (5GY 4/1) QUARTZ-RICH CLAYSTONE (texturally fine sandy and silty clay); only one band shows.

Color zonation is very indistinct.

SMEAR SLIDE SUMMARY (%)

	1, 85 D	1, 110 M	3, 82 D
Texture:			
Sand	5	10	10
Silt	30	15	50
Clay	65	75	40
Composition:			
Quartz	2	20	1
Feldspar	–	3	–
Mica	–	TR	TR
Heavy minerals	–	1	–
Clay minerals	66	75	40
Glauconite	1	–	TR
Pyrite	1	1	1
Carbonate unspec.	10	TR	15
Foraminifers	TR	–	TR
Calc. nannofossils	20	–	43
Radiolarians, calcitized	TR	–	TR

SITE 605 HOLE CORE 56 CORED INTERVAL 663.1 - 672.7m



LITHOLOGIC DESCRIPTION

Cyclic alternations of:

1) Gray (N5 to 5Y 5/1), slightly greenish FORAMINIFER-BEARING, NANNOFOSSIL CLAYSTONE (MARL) with
2) dark gray (N4 to 5Y 4/1) NANNOFOSSIL- AND QUARTZ-BEARING CALCAREOUS-RICH CLAYSTONE
3) local especially dark bands of CLAYSTONE

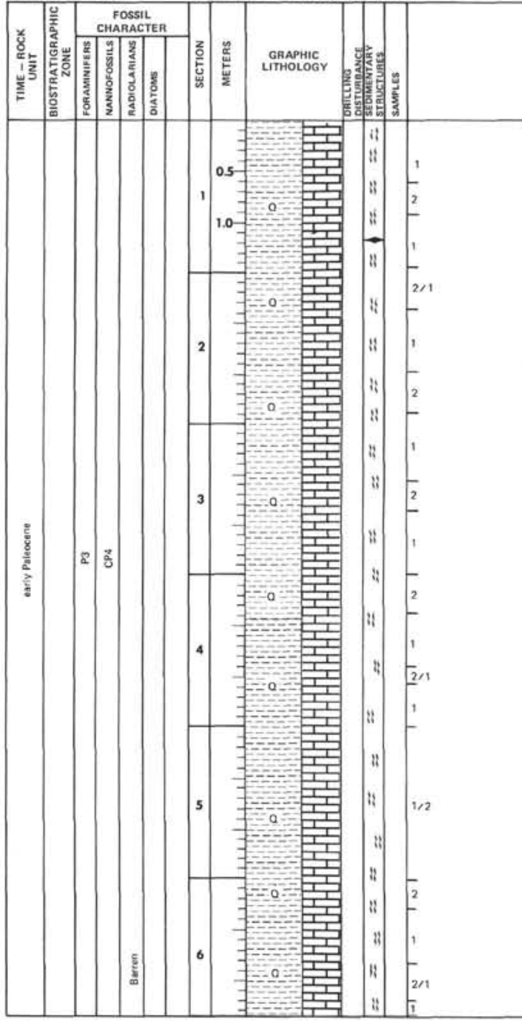
Very indistinct color zonation.

Core bows concave upward upon drying.

SMEAR SLIDE SUMMARY (%)

	3, 10 D	3, 40 D
Texture:		
Sand	10	–
Silt	25	30
Clay	65	70
Composition:		
Quartz	5	TR
Mica	TR	TR
Heavy minerals	TR	–
Clay minerals	63	60
Glauconite	–	TR
Pyrite	1	TR
Zeolite	1	
Carbonate unspec.	15	5
Foraminifers	2	5
Calc. nannofossils	10	30
Radiolarians	3	TR

SITE 605 HOLE CORE 57 CORED INTERVAL 672.7 - 682.3m



LITHOLOGIC DESCRIPTION

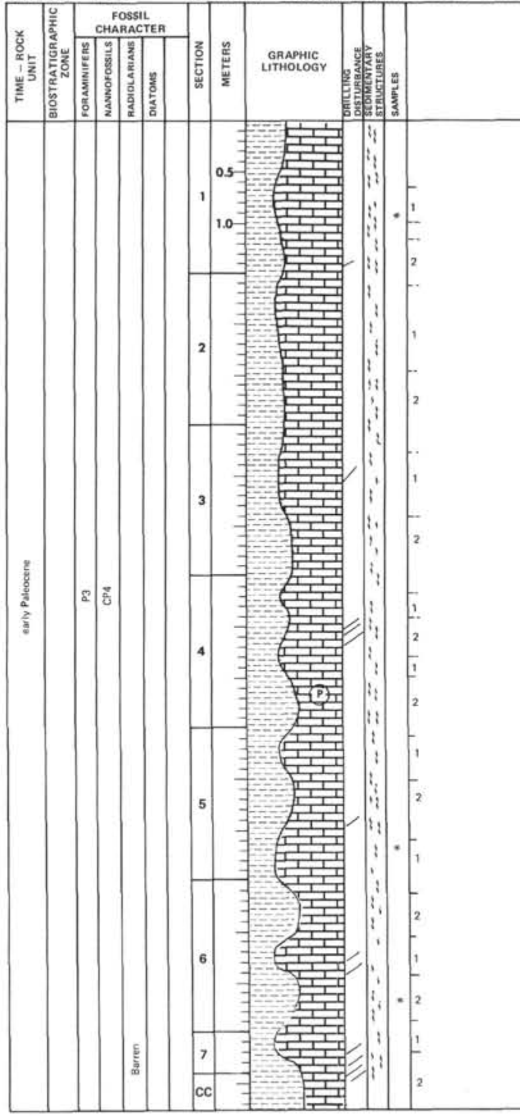
Well developed cyclic alternations of (each ca. 30–50 cm)
(1) gray (5GY 5/1 to 6/1) FORAMINIFER-BEARING NANNOFOSSIL CLAYSTONE (MARL) with
(2) dark gray (max. 5GY 4/1 to 5G 4/1) NANNOFOSSIL- AND QUARTZ-BEARING CALCAREOUS-RICH CLAYSTONE

Intensely bioturbated (*Planolites-*, *Chondrites-*, *Zoophycos-* (= espec. Sect. 1, 90-130 cm) type burrows

2-10 mm dark claystone bands (probably burrows) also in (1)

Core 58, 682.3–691.9 m: no recovery.

SITE 605 HOLE CORE 59 CORED INTERVAL 691.9 - 701.5 m



LITHOLOGIC DESCRIPTION

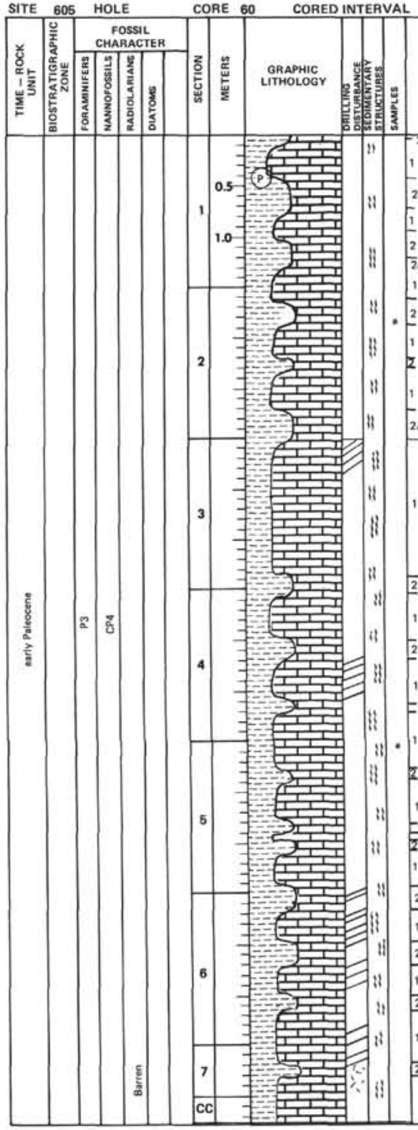
CLAYEY NANNOFOSSIL LIMESTONE to NANNOFOSSIL CLAYSTONE (Marl)
Dark greenish gray (5GY 4/1, 5Y 4/1) to greenish gray (5GY 5/1, 5Y 5/1) with well-developed cycles in lower part of core. Light /dark denoted by "1", "2" respectively. Moderate to heavy bioturbation with slightly less in lighter areas. Burrows generally filled by very dark greenish gray (5GY 3/1, 5Y 3/1).

Approximately 9 light/dark cycles very tentatively identified. Range of composition is clay-rich nannofossil limestone to nannofossil claystone (darkest areas).

SMEAR SLIDE SUMMARY (%)

	1, 84 D	5, 120 D	6, 122 D
Texture:			
Silt	65	88	40
Clay	35	12	60
Composition:			
Quartz	1	TR	1
Mica	1	TR	1
Clay	35	12	52
Glauconite	TR	–	–
Pyrite	TR	–	1
Carbonate unspec.	42	77	15
Foraminifers	1	TR	–
Calc. nannofossils	20	11	30
Radiolarians	–	TR	–

SITE 605 HOLE CORE 60 CORED INTERVAL 701.5 - 711.1m



LITHOLOGIC DESCRIPTION

Cyclic alternations (approx. 13 – 15 cycles/core) of:
1) gray (greenish-gray, 5GY 5/1 to 5Y 5.5/1) CLAY-RICH NANNOFOSSIL LIMESTONE
2) dark gray (5GY 5/1 to 5Y 5/1) CLAYEY NANNOFOSSIL LIMESTONE (MARL)

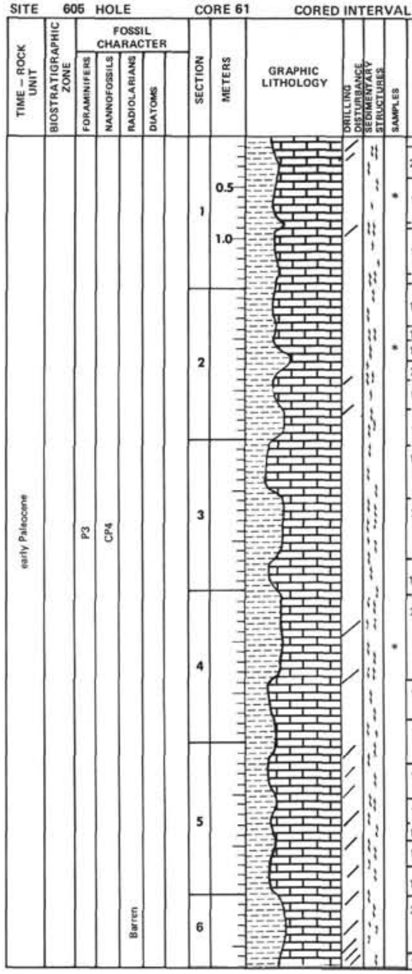
Intensely bioturbated (less in light colored Nannofossil Limestone).

Pyrite nodule occurs in Section 1, 40 cm.

SMEAR SLIDE SUMMARY (%)

	2, 34 D	5, 6 D
Texture:		
Silt	50	70
Clay	50	30
Composition:		
Quartz	TR	TR
Mica	–	TR
Clay	50	30
Glauconite	–	TR
Pyrite	1	TR
Carbonate unspec.	19	27
Foraminifers	TR	3
Calc. nannofossils	30	40
Radiolarians	TR	TR

SITE 605 HOLE CORE 61 CORED INTERVAL 711.1 - 720.7 m



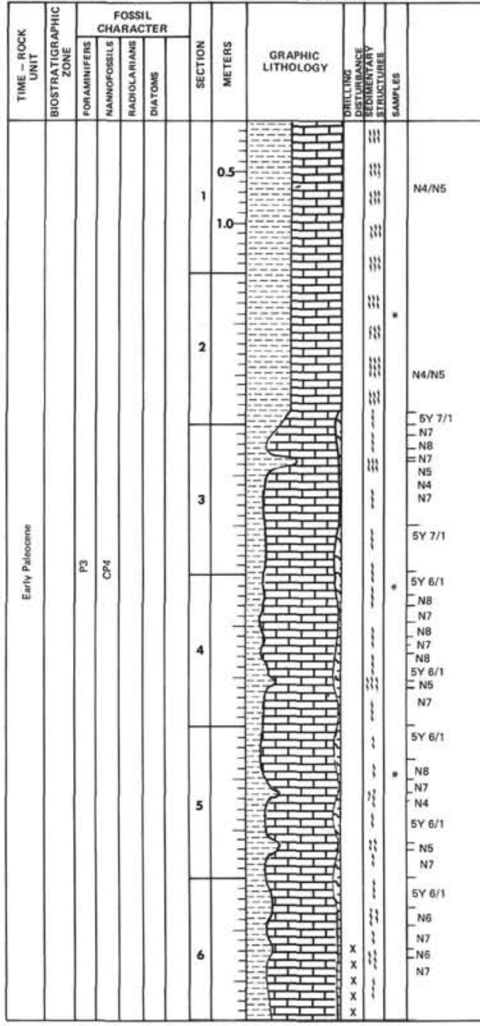
LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL LIMESTONE
Predominantly greenish gray (5GY 5/1) with darker intervals of heavy bioturbation or more clay content (dark greenish gray [5GY 4/1], gray [N4, N5] in Sect. 4). These "cycles" are denoted "1" (light), "2" (dark), or "1/2" intermediate. Moderate to light bioturbation visible from infillings of dark greenish gray (5G 4/1, 5G 3/1).

SMEAR SLIDE SUMMARY (%)

	1, 60 D	2, 50 D	4, 55 M
Texture:			
Silt	65	80	60
Clay	35	20	40
Composition:			
Quartz	2	1	1
Mica	–	3	1
Heavy minerals	–	TR	TR
Clay	35	30	40
Palagonite	–	–	TR
Glauconite	–	TR	1
Pyrite	–	–	1
Carbonate unspec.	41	31	49
Foraminifers	1	2	–
Calc. nannofossils	20	32	6
Radiolarians	–	1	–
Fish remains	1	–	–
Other Opaques	–	1	–

SITE 605 HOLE CORE 62 CORED INTERVAL 720.7 - 730.3m



LITHOLOGIC DESCRIPTION

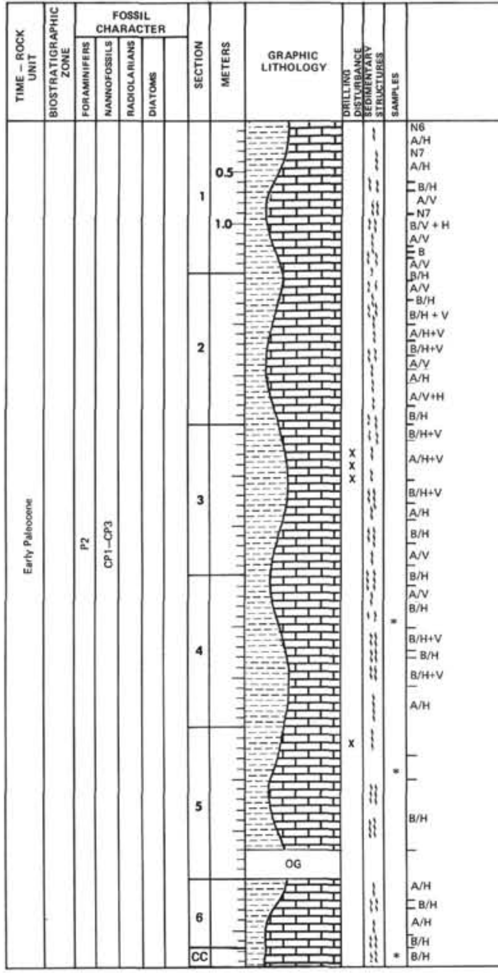
CLAYEY NANNOFOSSIL LIMESTONE, gray (N5), heavily bioturbated.
– Burrows are infilled with dark gray (N4) clayey material.
– Section 1 and 2 only.

At 140 cm in Section 2 begins bands varying in color light gray (5Y 7/1, N7), very light gray (N8), and gray (5Y 6/1) with rare bands of medium gray (N5). The darker the band the more distinct and abundant burrows. The light gray and gray N7 and N8 bands are composed of CLAY-RICH NANNOFOSSIL LIMESTONE. The grays with a yellowish tinge, 5Y 7/1 and 5Y 6/1 are composed of RADIOLARIAN-BEARING, CLAYEY NANNOFOSSIL LIMESTONE.

SMEAR SLIDE SUMMARY (%)

	2, 40 D	4, 10 D	5, 40 D
Texture:			
Silt	40	50	70
Clay	60	50	30
Composition:			
Quartz	TR	–	1
Mica	1	2	1
Heavy minerals	–	–	TR
Clay	47	35	20
Glauconite	1	–	–
Pyrite	TR	–	–
Carbonate unspec.	30	40	60
Foraminifers	1	2	1
Calc. nannofossils	20	15	15
Radiolarians	TR	6	3

SITE 605 HOLE CORE 63 CORED INTERVAL 730.3 - 739.9m



LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL LIMESTONE, with varying concentrations of clay – sometimes CLAY-RICH NANNOFOSSIL LIMESTONE, all in various shades of gray (N6, N7, N8, 5Y 6/1, & 5GY 6/1). Intervals alternate from slightly (A) to moderately (B) bioturbated.

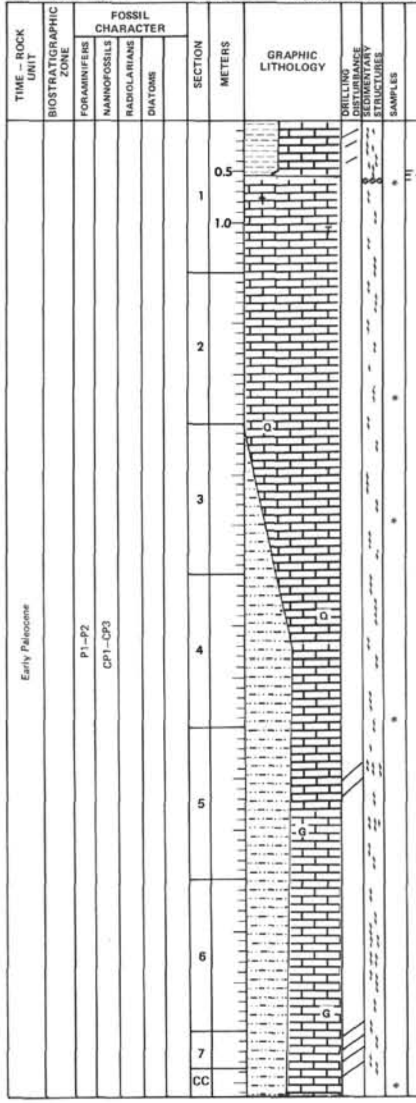
The type of burrows are predominantly horizontal (H) or vertical (V). Bioturbation evident as medium gray (N4).

Graphic lithology is schematic. Clay content increases as the color becomes a darker gray.

SMEAR SLIDE SUMMARY (%)

	4, 40 D	5, 40 D	CC, 10 D
Texture:			
Silt	40	65	40
Clay	60	35	60
Composition:			
Quartz	1	–	–
Mica	1	1	1
Heavy minerals	TR	1	TR
Clay	45	21	45
Glauconite	TR	–	1
Pyrite	1	1	1
Carbonate unspec.	25	40	35
Calc. nannofossils	25	35	15
Radiolarians	1	1	1
Fish remains	1	–	1

SITE 605 HOLE CORE 64 CORED INTERVAL 739.9 - 749.5 m



LITHOLOGIC DESCRIPTION

CLAYEY NANNOFOSSIL LIMESTONE, greenish gray (5GY 5/1); moderately bioturbated with *Planolites* and *Chondrites* having fillings of very dark greenish gray (5GY 3/1), all are horizontal.
45–54 cm: transition zone

FORAMINIFER-BEARING LIMESTONE, light greenish gray (5GY 7/1) to greenish gray (5GY 6/1), with faint light/dark "cycles;" moderately bioturbated, but these small burrows have the same color filling as the host sediment. Rock is very hard and dense. Silt content increases downward, as does nannofossil content.

QUARTZ-BEARING CLAY-RICH NANNOFOSSIL LIMESTONE, in shades of greenish gray (5GY 6/1–5GY 5/1) to dark greenish gray (5GY 4/1–5GY 3/1).

Section 3, 90 cm to Section 5, 25 cm: sediment is burrow-mottled—burrow fills generally are darker colored.

GLAUCONITE- AND FORAMINIFER-BEARING SILT-RICH CLAYEY NANNOFOSSIL LIMESTONE, greenish gray (5GY 5/1–4.5/1), burrow-mottled, Section 5, 25 cm to Core Catcher.

5GY 6/1

5GY 5/1
with
5GY 6/1
mottles

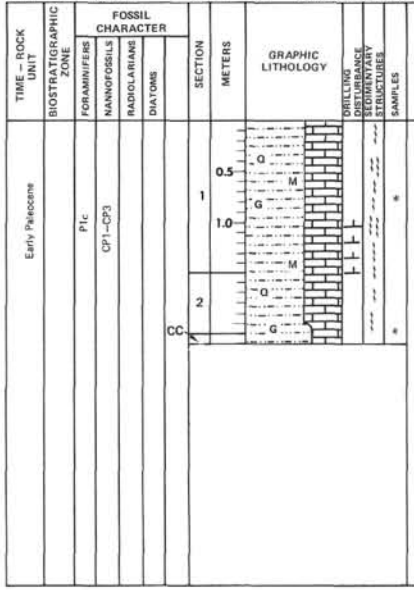
5GY 4/1
with
5GY 5/1
mottles

5GY 5/1
to
5GY 4.5/1
with
5GY 3/1
mottles

SMEAR SLIDE SUMMARY (%)

	1, 62 D	2, 125 D	3, 92 D	4, 145 D	CC, 20 D
Texture:					
Silt	100	95	80	80	60
Clay	–	5	20	20	40
Composition:					
Quartz	–	5	10	20	3
Mica	–	2	2	10	6
Heavy minerals	–	–	–	2	1
Clay	–	5	20	20	33
Glauconite	–	1	3	4	4
Carbonate unspec.	86	35	35	21	20
Foraminifers	8	10	–	–	5
Calc. nannofossils	5	40	30	21	20
Diatoms	–	–	–	–	1
Radiolarians	1	2	–	–	4
Fish remains	–	–	–	–	1
Plant debris	–	–	–	–	1
Other Opaques	–	–	–	1	–
Pyrite	–	–	–	–	1

SITE 605 HOLE CORE 65 CORED INTERVAL 749.5 - 759.1m



LITHOLOGIC DESCRIPTION

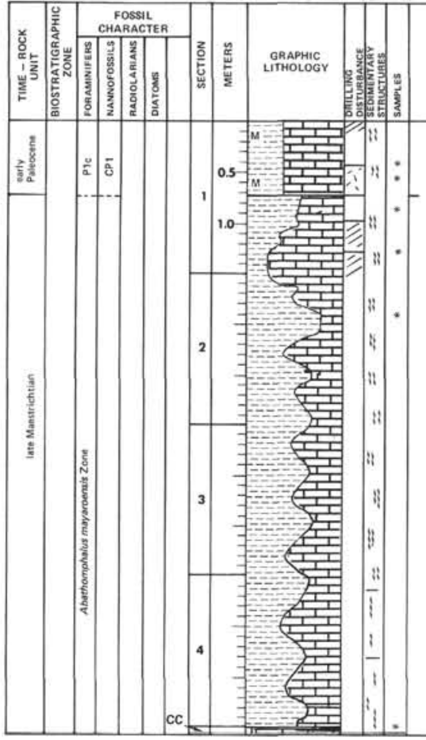
GLAUCONITE-BEARING, SILT-RICH NANNOFOSSIL MARL, dark greenish gray (5G 4/1) with varying intensity of medium dark gray (N4) burrows. *Zoophycos* occurs in Sect. 1, 5-12 cm, and Sect. 2, 32–40 cm. The burrows are generally horizontal.

FORAMINIFER-BEARING, CALCAREOUS MUDSTONE, dark greenish gray (5G 4/1) and moderately bioturbated. Burrows filled with medium dark gray (N4). Found in the base of Sect. 2, 64-71 and core catcher.

SMEAR SLIDE SUMMARY (%)

	1, 80 D	CC, 5 D
Texture:		
Silt	50	60
Clay	50	40
Composition:		
Quartz	6	15
Feldspar	1	–
Mica	5	5
Heavy minerals	1	2
Clay	40	36
Glauconite	3	2
Pyrite	1	2
Carbonate unspec.	15	15
Foraminifers	2	6
Calc. nannofossils	20	10
Diatoms	–	1
Radiolarians	3	4
Fish remains	2	2
Other Opaques	1	–

SITE 605 HOLE CORE 66 CORED INTERVAL 759.1 - 768.7m



LITHOLOGIC DESCRIPTION

FORAMINIFER-RICH CLAYEY NANNOFOSSIL LIMESTONE, SILT-RICH (mica), greenish gray (5G 5/1), moderately bioturbated, steady "lamination", partly more glauconitic silt above boundary (See special sketch on visua of 605-66-1 in site chapter).

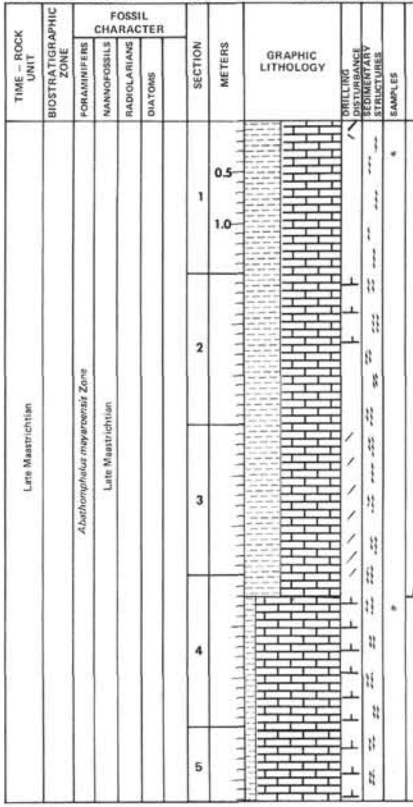
CLAY-RICH NANNOFOSSIL LIMESTONE, FORAMINIFER-BEARING, gray (5Y 5.5/1) to QUARTZ- and NANNOFOSSIL-RICH CLAYSTONE, darker colored (5Y 4.5/1).
- moderately bioturbated throughout
- slump fault (with vein calcite) at Sect. 1, 135 cm (see sketch on visual)
- small erosional contacts overlain by more foraminifer-rich "sand".

Partly it is a CLAY-RICH FORAMINIFERID-NANNOPOSSIL LIMESTONE (e.g., at 66 cc) or a QUARTZ-BEARING NANNOFOSSIL-RICH CLAYSTONE.

SMEAR SLIDE SUMMARY (%)

	1, 55	1, 85	1, 151	2, 50	CC, 1
	D	D	D	D	D
Texture:					
Sand	–	10	–	–	20
Silt	62	30	75	21	60
Clay	38	60	25	79	20
Composition:					
Quartz	2	20	2	5	1
Mica	15	TR	2	TR	1
Heavy minerals	–	TR	1	TR	–
Clay minerals	38	60	25	79	15
Glauconite	2	TR	–	TR	–
Pyrite	1	–	–	–	–
Carbonate unspec.	15	–	45	–	10
Foraminifers	10	–	4	1	30
Calc. nannofossils	15	20	20	15	40
Radiolarians	2	–	1	–	1
Fish remains	–	–	–	–	1

SITE 605 HOLE CORE 67 CORED INTERVAL 768.7–778.3 m



LITHOLOGIC DESCRIPTION

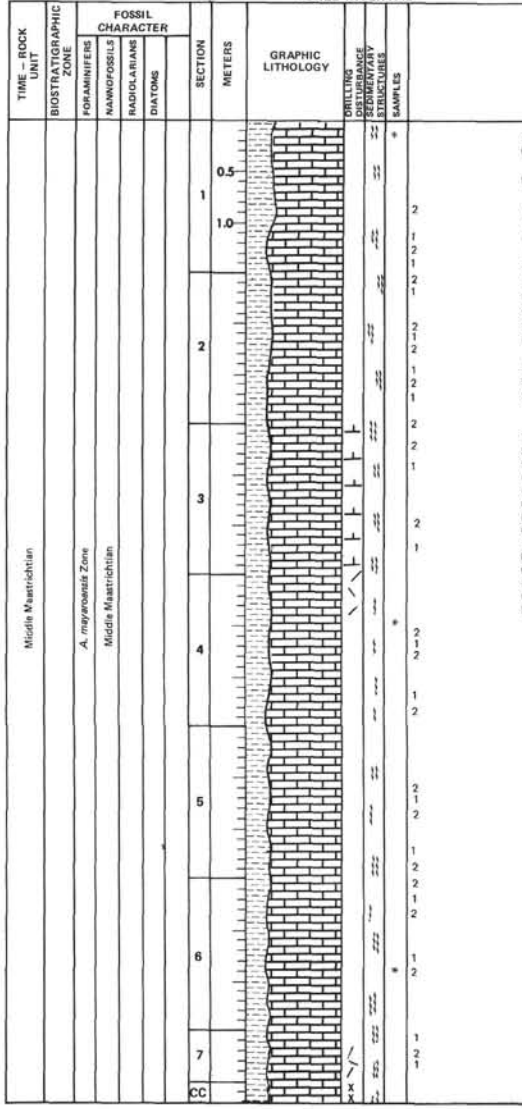
FORAMINIFER-RICH, CLAYEY NANNOFOSSIL LIMESTONE (MARL), gray (5Y 5/1) with dark gray (5Y 4/1) elongate, streaked-out *Planolites*-type burrows. Moderately to slightly bioturbated in the upper most section. Bioturbation becomes heavy downward. Microfaulting occurs in the core.

FORAMINIFER- and CLAY-RICH NANNOFOSSIL LIMESTONE, cyclic, shading from light gray (N7) to gray (5Y 5/1). Abundant *Chondrites*-type burrow in addition to the usual *Planolites*-type.

SMEAR SLIDE SUMMARY (%)

	1, 33	4, 34
	D	D
Texture:		
Sand	–	20
Silt	60	65
Clay	40	15
Composition:		
Quartz	2	1
Mica	TR	TR
Heavy minerals	–	TR
Clay minerals	35	15
Glauconite	–	TR
Pyrite	–	TR
Carbonate unspec.	5	–
Foraminifers	15	20
Calc. nannofossils	43	64

SITE 605 HOLE CORE 68 CORED INTERVAL 778.3 - 787.9 m



LITHOLOGIC DESCRIPTION

Cyclic alternation of:

(1) CLAY-BEARING, FORAMINIFER-RICH to FORAMINIFERAL NANNOFOSSIL LIMESTONE.

(2) FORAMINIFER-RICH, CLAY-RICH to CLAYEY NANNOFOSSIL LIMESTONE.

Gray (5Y 5/1) (2) and (5Y 6/1) (1) Bioturbation slight to moderate. In Sect. 4 lighter horizons are slightly to not bioturbated at all.

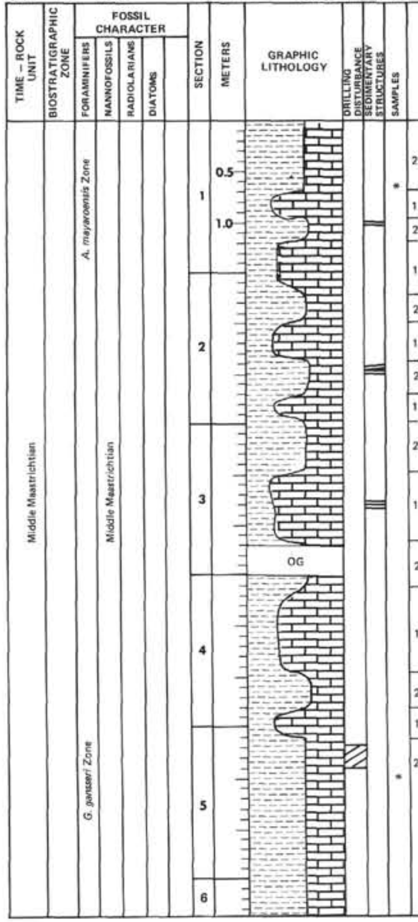
Burrow types: *Planolites*-type, *Chondrites*-type. In places up to three generations of burrows are seen. Primary burrows are large (2.5 cm diameter) and nearly vertical. Secondary burrows are smaller (1 cm diameter) and horizontal, while tertiary burrows are seen as a fine network of *Chondrites*-type branches.

Layers or bands of foraminiferal sands occur in Section 4, 52 cm.

SMEAR SLIDE SUMMARY (%)

	1, 10 D	4, 52 D	6,86 D
Texture:			
Sand	20	40	30
Silt	60	50	40
Clay	20	10	30
Composition:			
Quartz	TR	1	TR
Mica	TR	1	TR
Clay	20	9	30
Glauconite	–	TR	–
Pyrite	TR	TR	TR
Carbonate unspec.	30	26	20
Foraminifers	15	30	20
Calc. nannofossils	35	33	30
Radiolarians	TR	–	–

SITE 605 HOLE CORE 69 CORED INTERVAL 787.9 - 797.5m



LITHOLOGIC DESCRIPTION

Five indistinct cycles (about 70-100 cm wide) of:

1) FORAMINIFERID-RICH NANNOFOSSIL LIMESTONE (MARL), light gray (N7) to light olive gray (5Y 6/1), and

2) FORAMINIFERID-BEARING NANNOFOSSIL CLAYSTONE (MARL), gray (N6) to olive gray (5Y 5/1).

Moderately (1) to intensely (2) bioturbated, mainly by subhorizontal *Planolites*- and *Chondrites*-type burrows

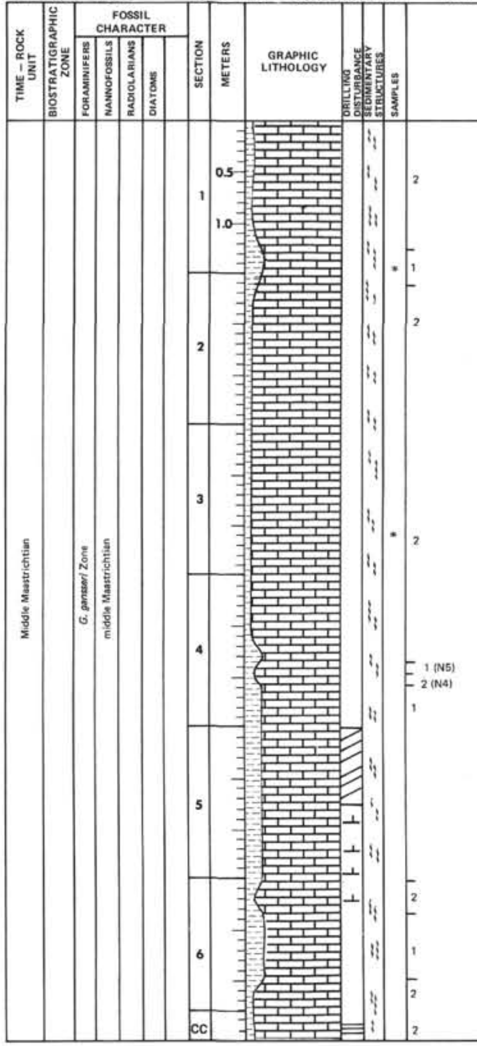
Distinct sub-mm-scale lamination (green-black laminae), partly as low-angle inclined (cross-) lamination.
Lamination indicates in-situ slope of 10-12° (maybe rotational slump fault block?)

Faults (slump faults?) show downward displacement of about 1 cm

SMEAR SLIDE SUMMARY (%)

	1, 80 D	5, 66 D
Texture:		
Silt	60	35
Clay	40	65
Composition:		
Mica	–	TR
Clay minerals	30	65
Carbonate unspec.	35	10
Foraminifers	10	8
Calc. nannofossils	25	35
Fish remains	TR	–

SITE 605 HOLE CORE 70 CORED INTERVAL 797.5–807.1 m



LITHOLOGIC DESCRIPTION

1) FORAMINIFER- and CLAY-BEARING NANNOFOSSIL LIMESTONE, gray (N6), and

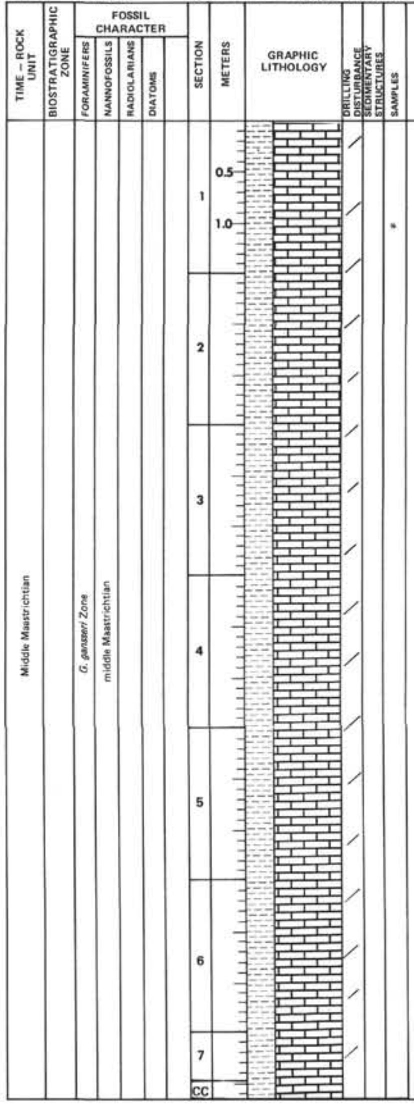
2) dark gray (5Y 4/1 to N4/N5) FORAMINIFER- and CLAY-RICH NANNOFOSSIL LIMESTONE.

Moderate bioturbation throughout core.

SMEAR SLIDE SUMMARY (%)

	1, 147 D	3, 110 D
Texture:		
Sand	5	25
Silt	75	55
Clay	20	20
Composition:		
Quartz	1	TR
Mica	TR	TR
Clay	10	20
Glauconite	TR	TR
Pyrite	–	1
Carbonate unspec.	74	44
Foraminifers	5	15
Calc. nannofossils	10	10
Other Calcitic ? macrofossils	–	10

SITE 605 HOLE CORE 71 CORED INTERVAL 807.1–816.7 m



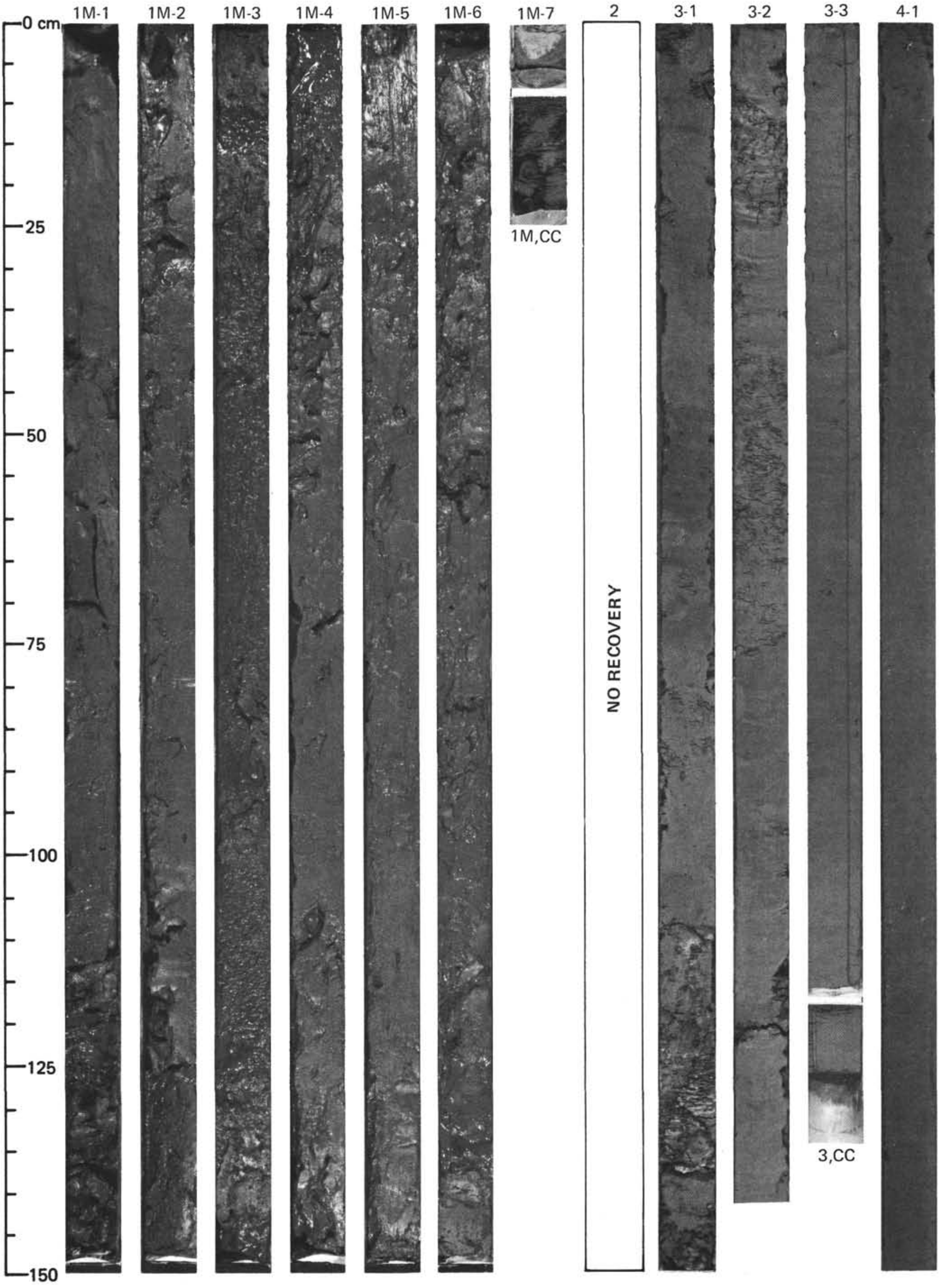
LITHOLOGIC DESCRIPTION

FORAMINIFER-RICH CLAYEY NANNOFOSSIL LIMESTONE, dark greenish gray (5Y 4/1–N4/N5), with moderate bioturbation of very dark gray (5Y 3/1–N4). Vague lighter intervals (5Y 4.5/1–N5) in Section 3, 45–130 cm and Section 4, 135 cm–Section 5, 60 cm.

Apparent 10-15° dip of burrow "lamination" is probably a real dip of beds

SMEAR SLIDE SUMMARY (%)

	1, 100 D
Texture:	
Sand	5
Silt	50
Clay	45
Composition:	
Quartz	1
Mica	1
Heavy minerals	TR
Clay	32
Glauconite	2
Pyrite	2
Carbonate unspec.	15
Foraminifers	15
Calc. nannofossils	25
Radiolarians	2
Sponge spicules	1
Fish remains	TR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1M-3
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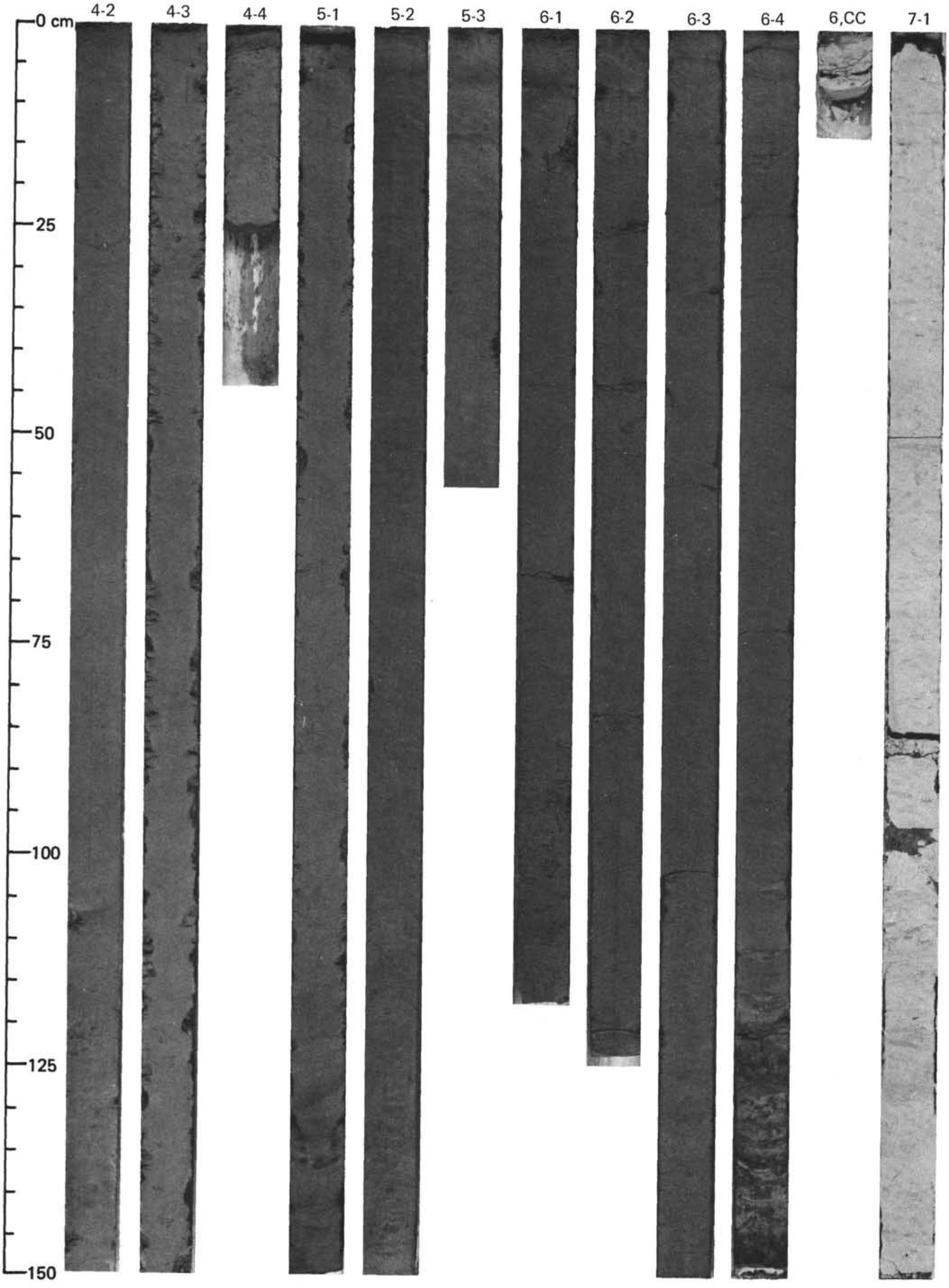
3-1
3-2
3-3
3,CC
4-1



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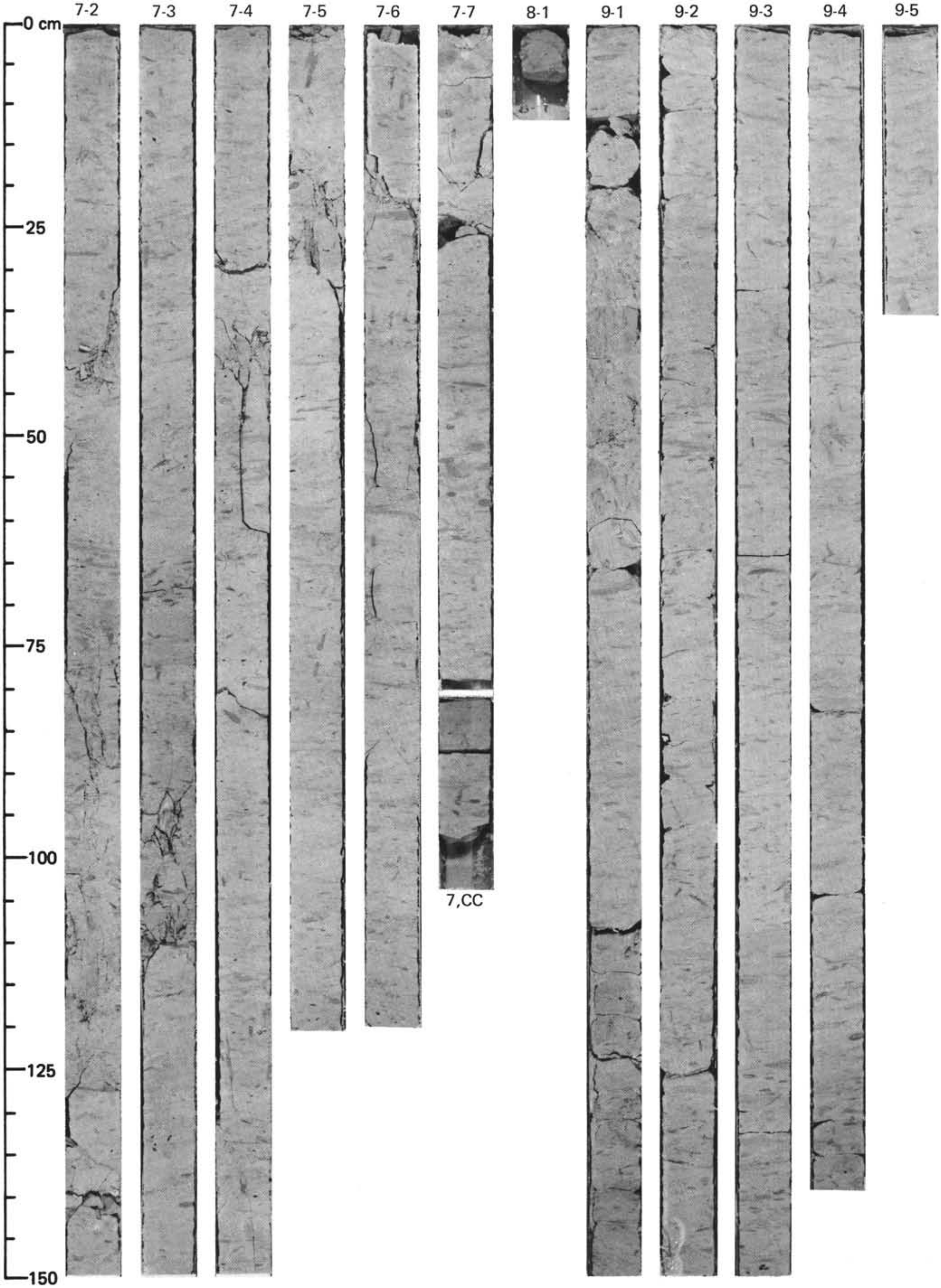
7-1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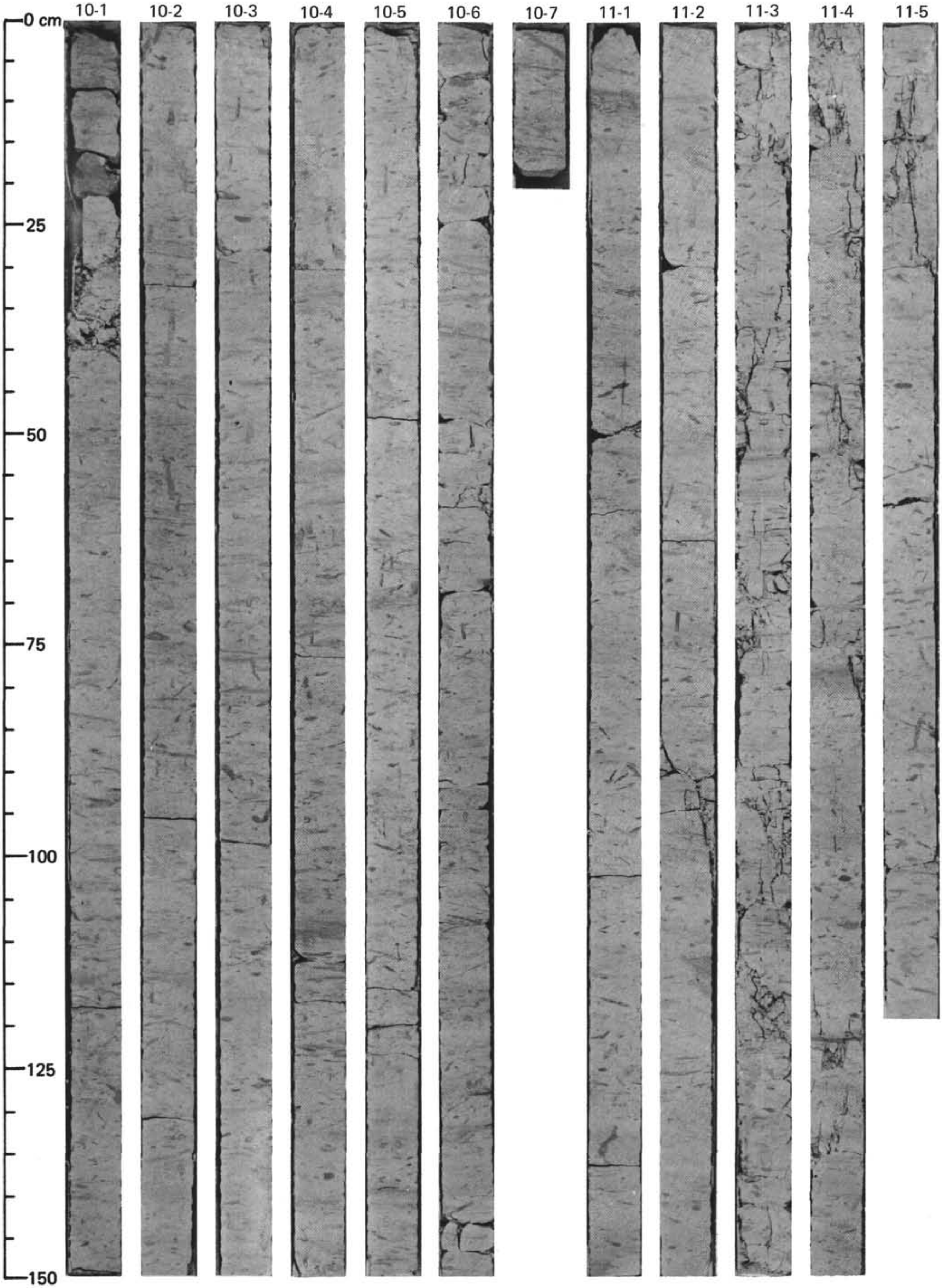
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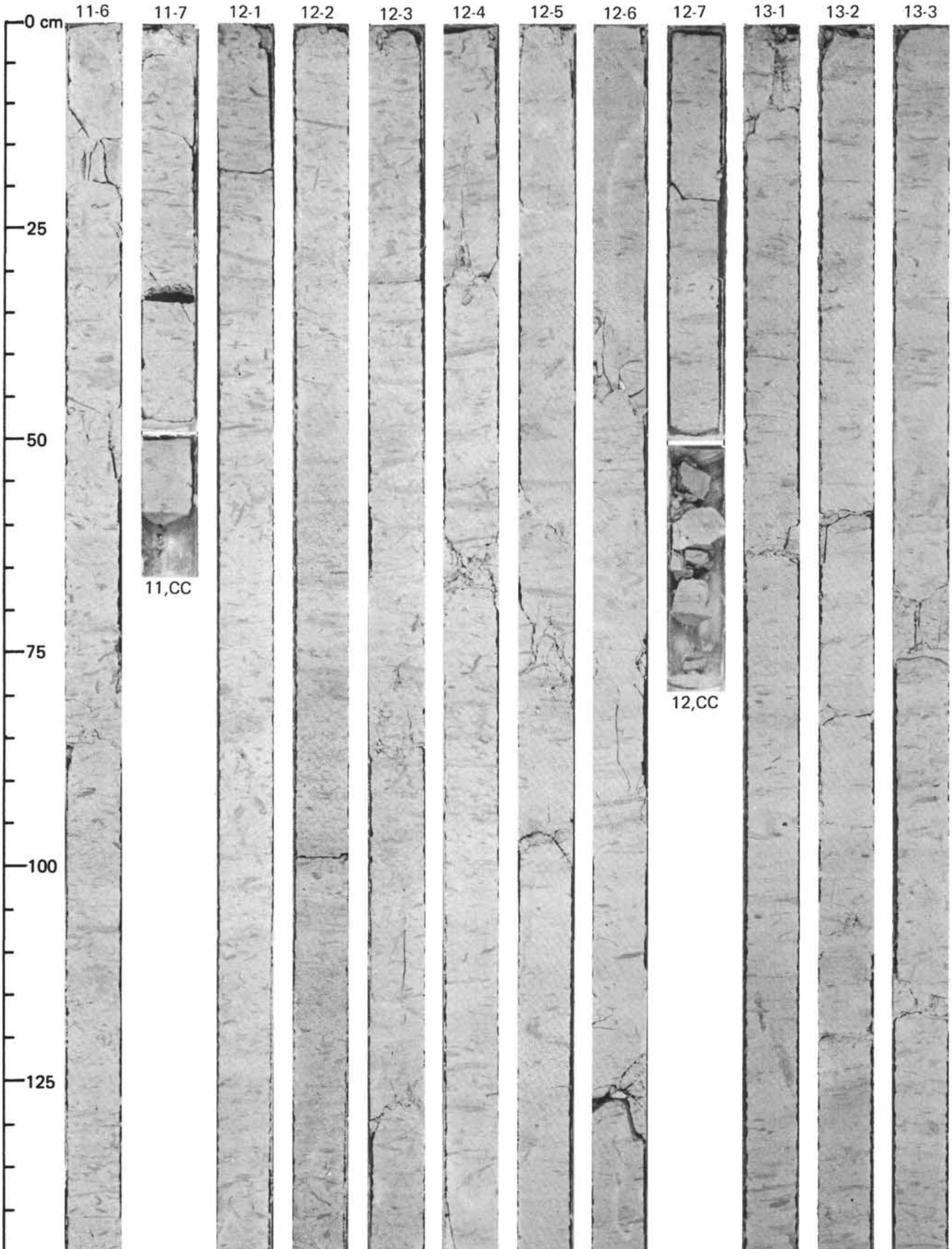
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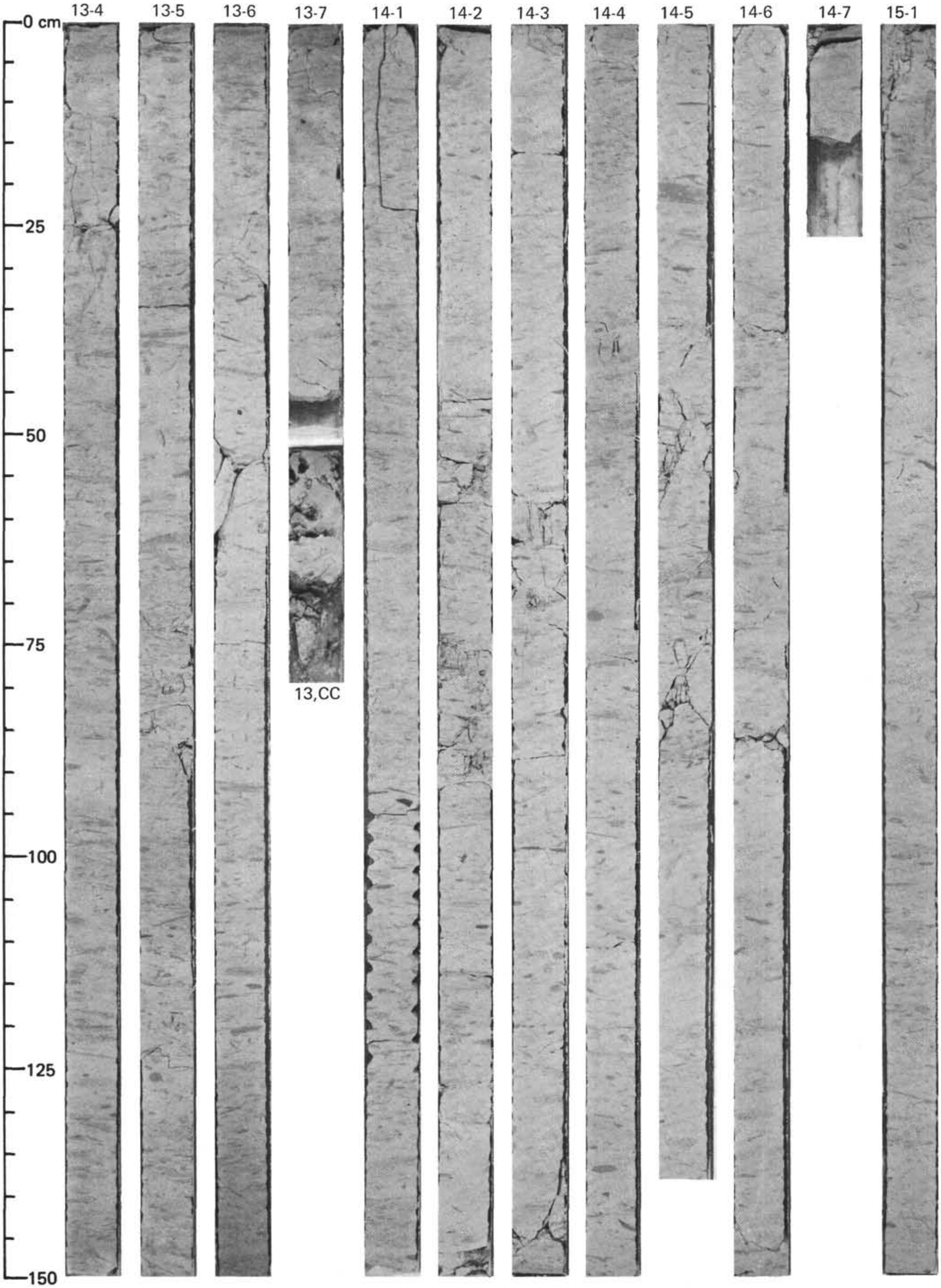
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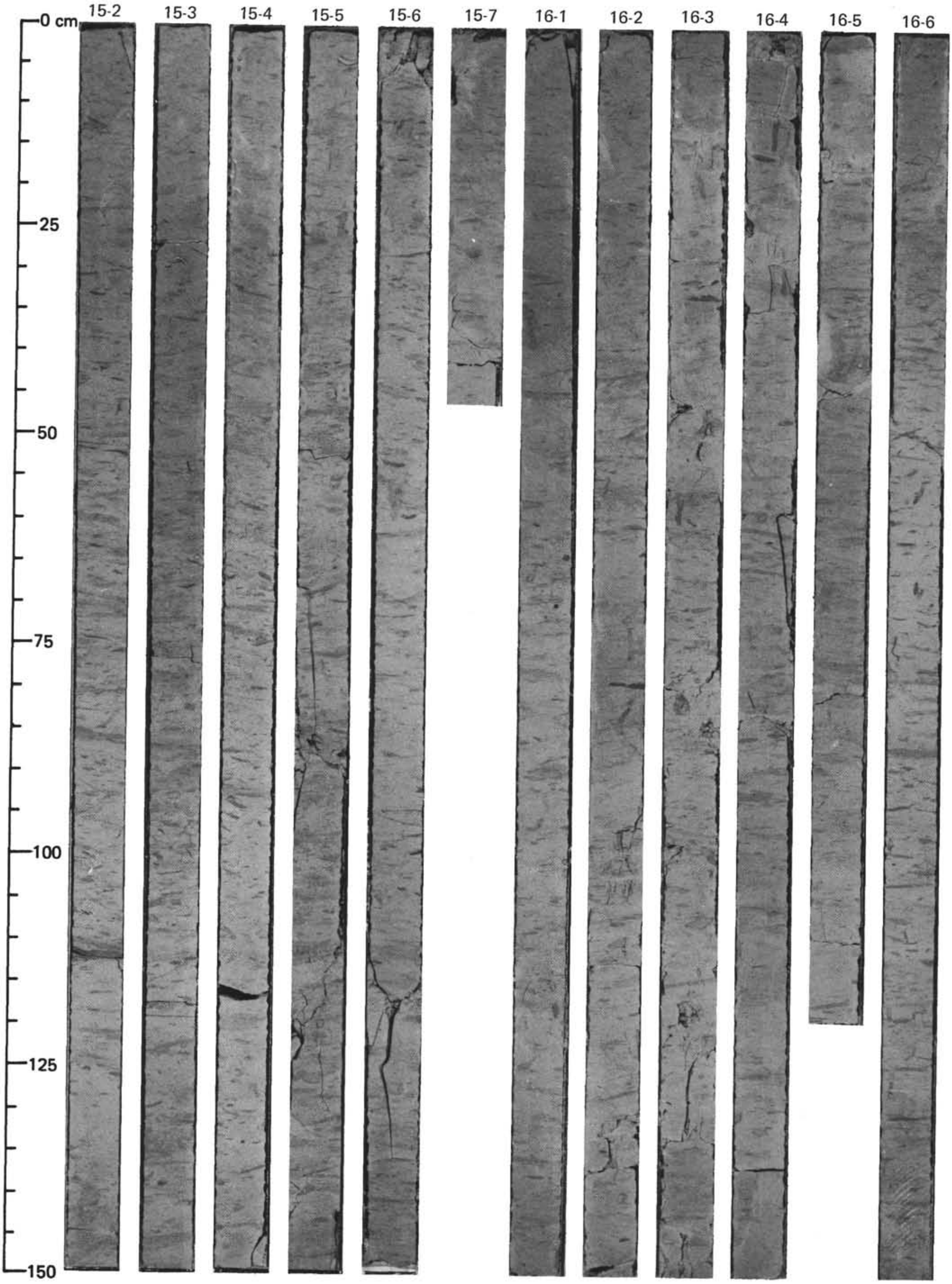
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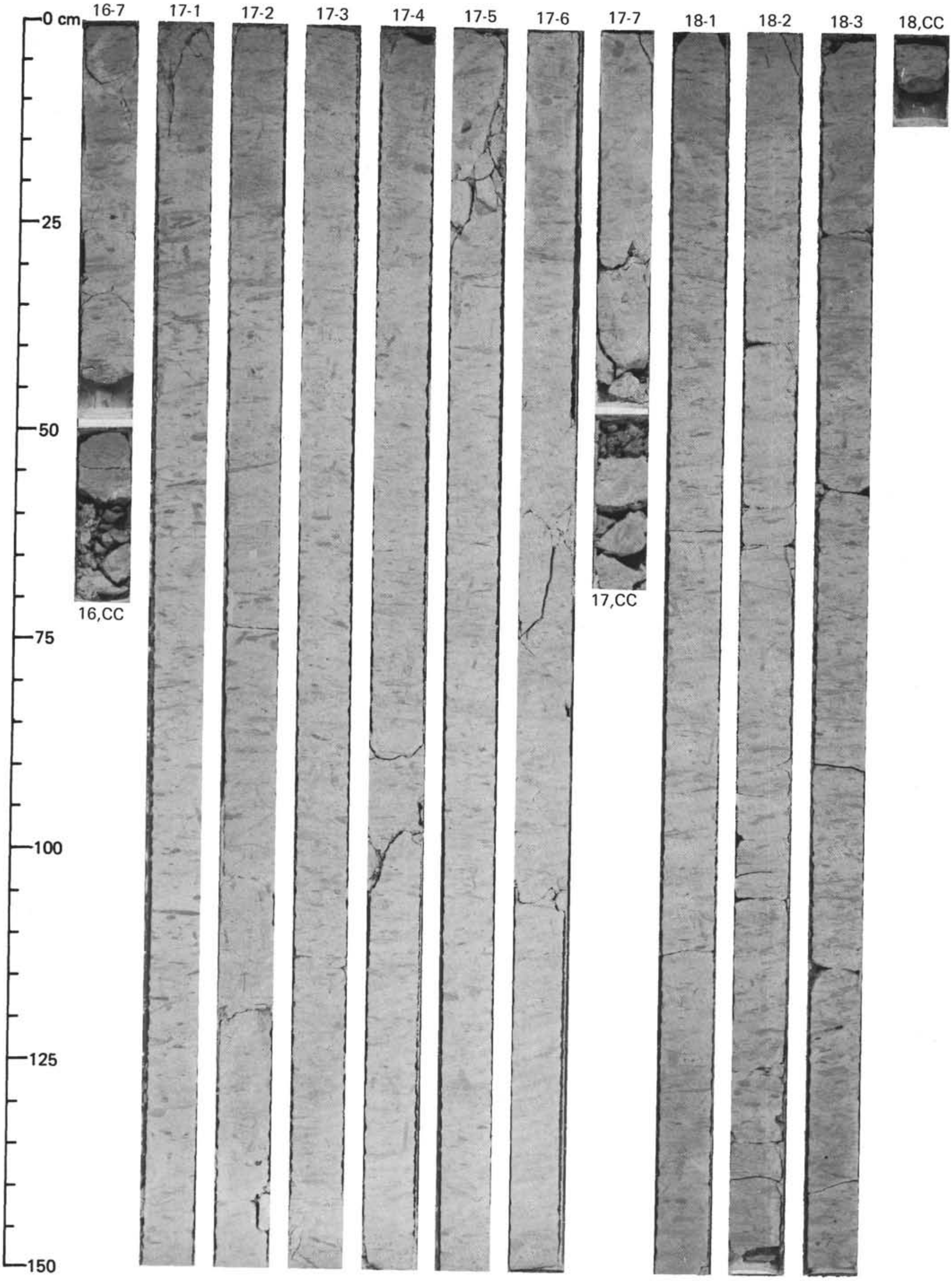
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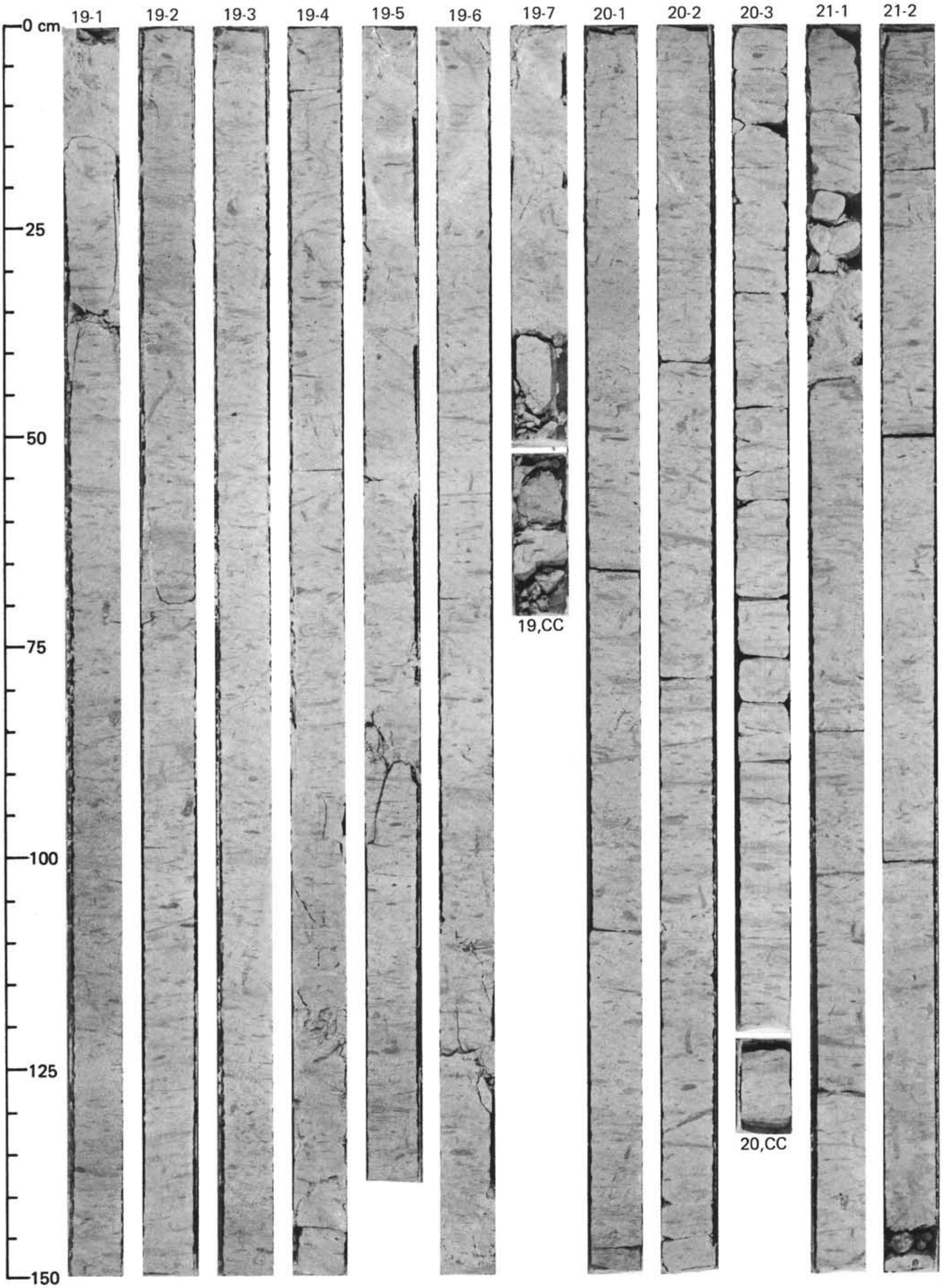
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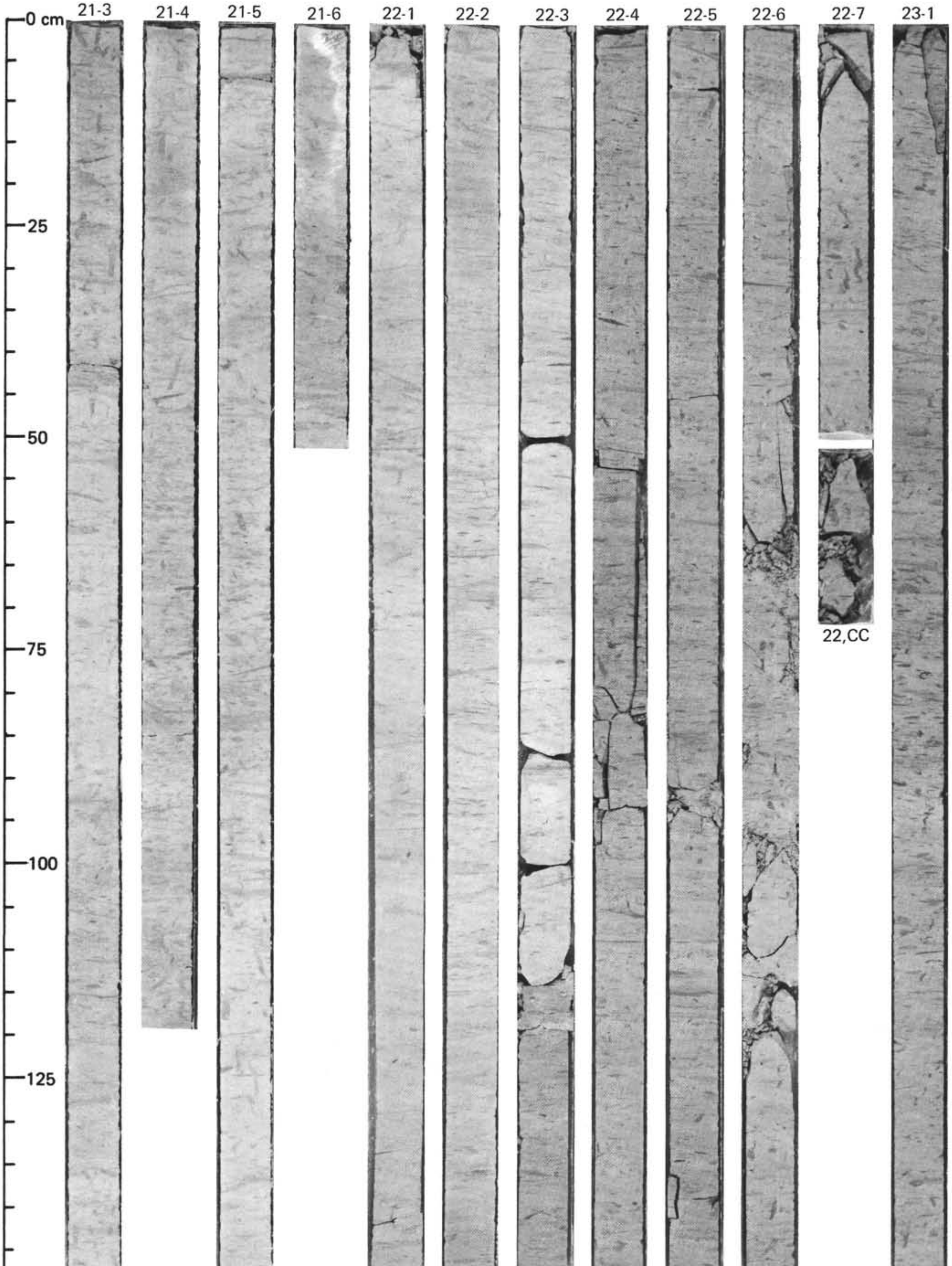
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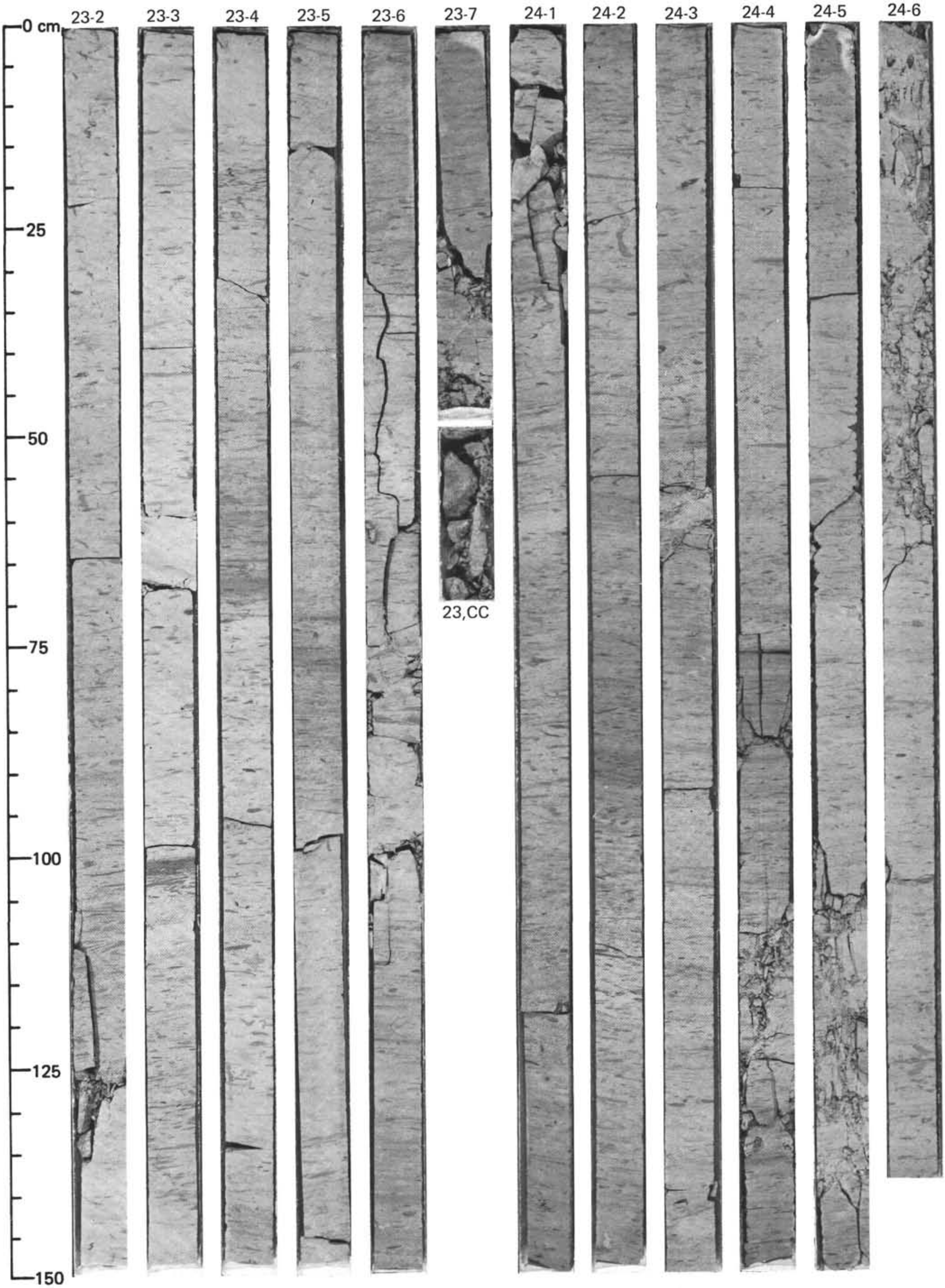
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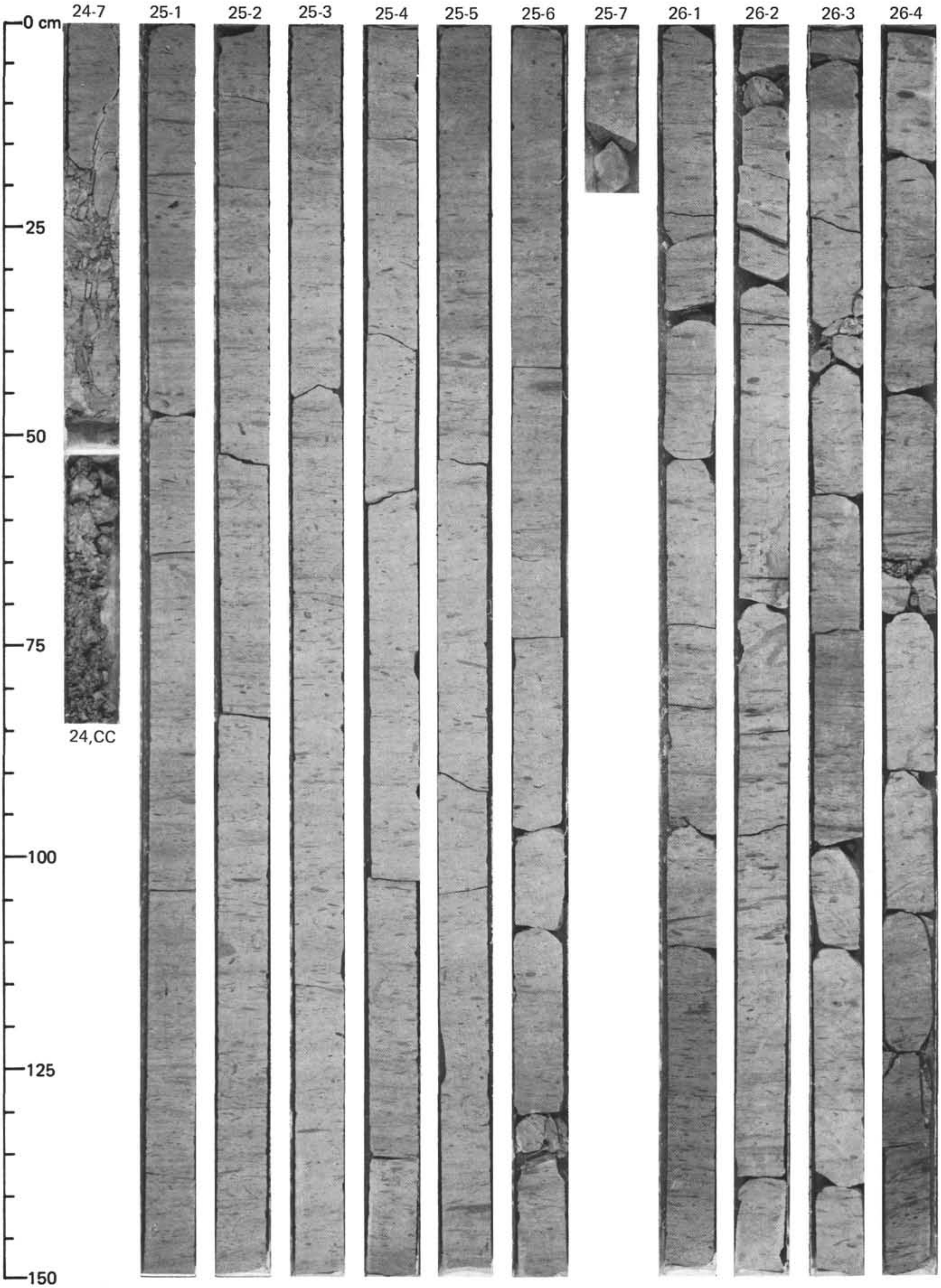
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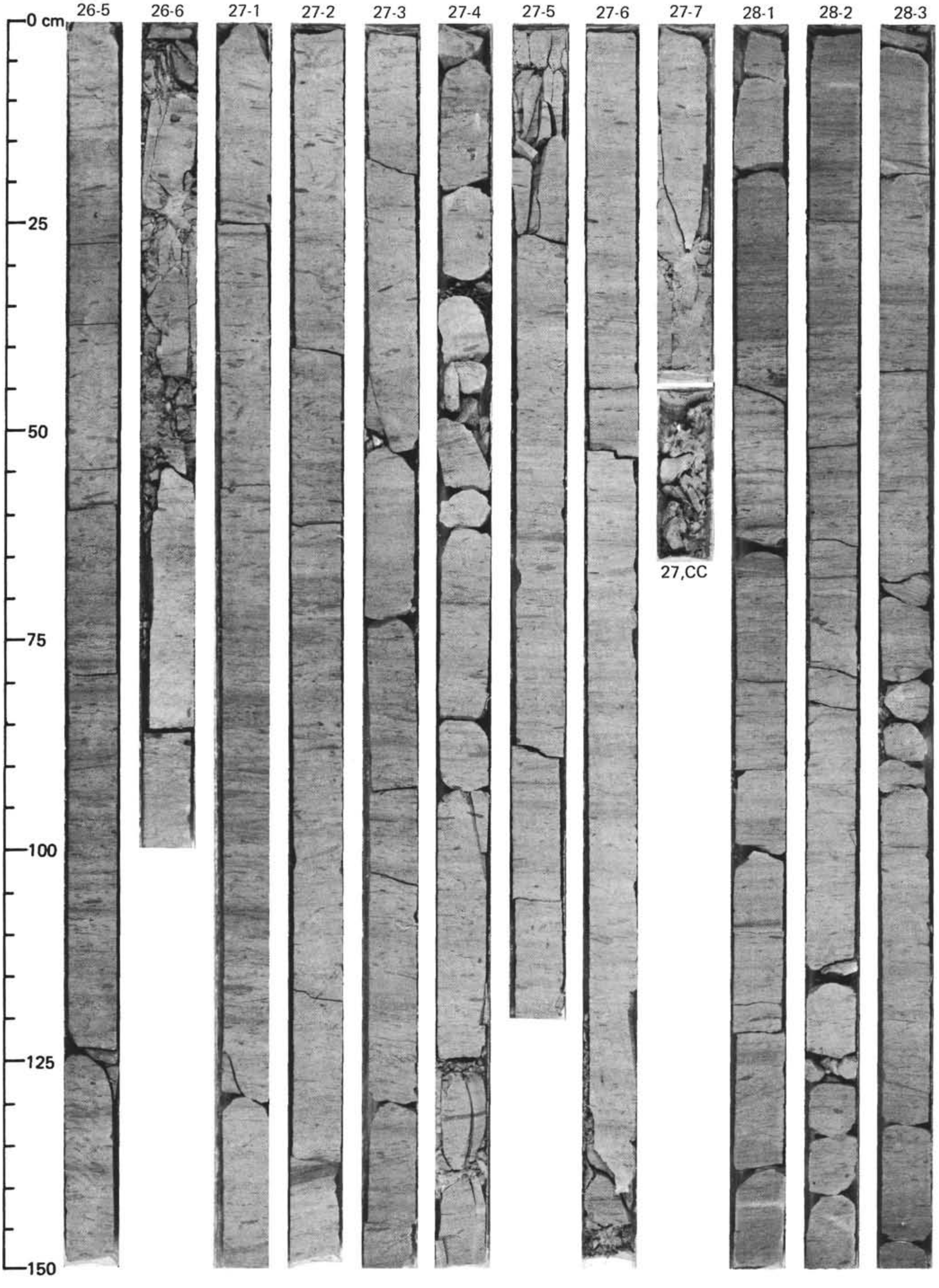
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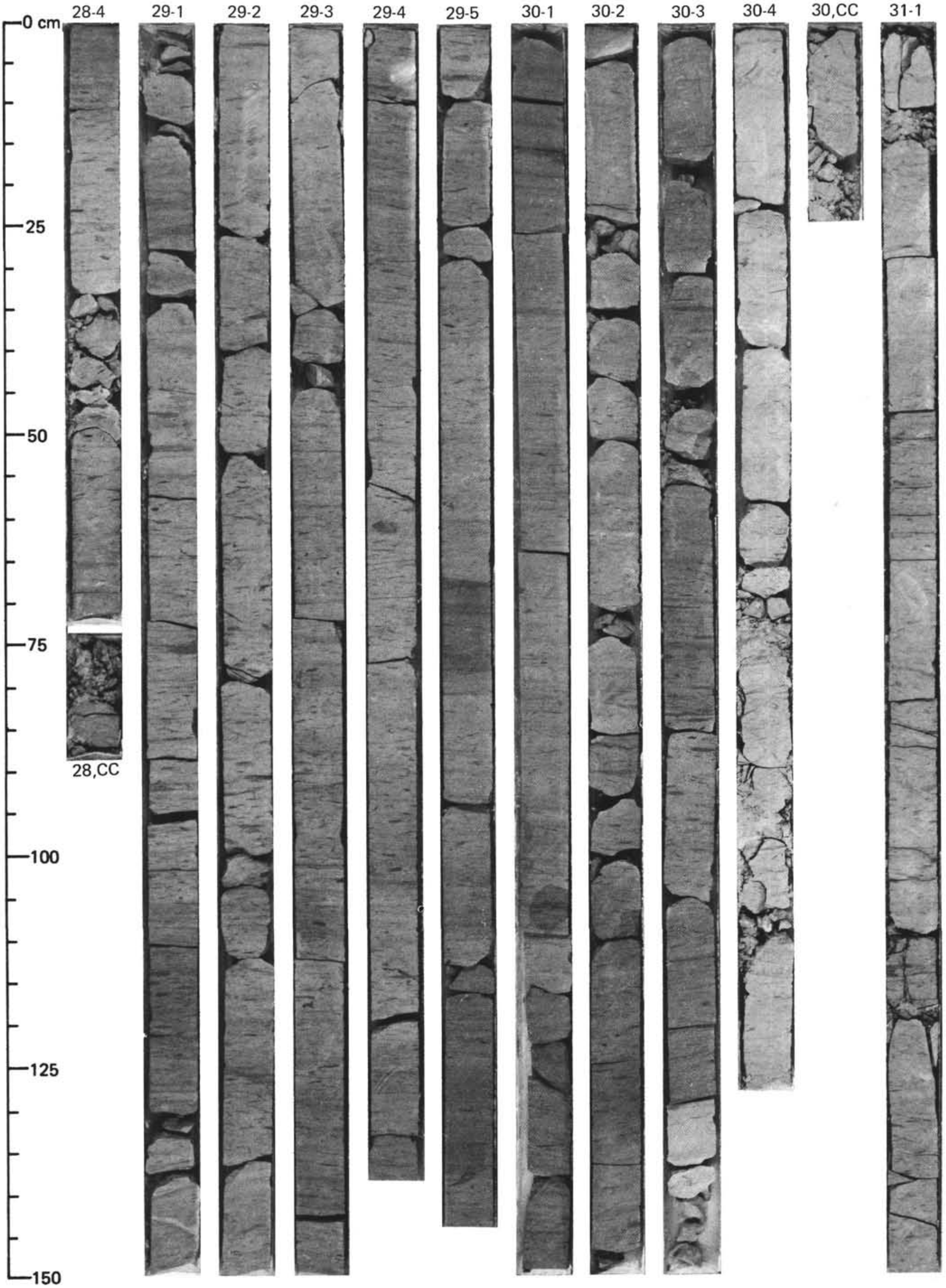
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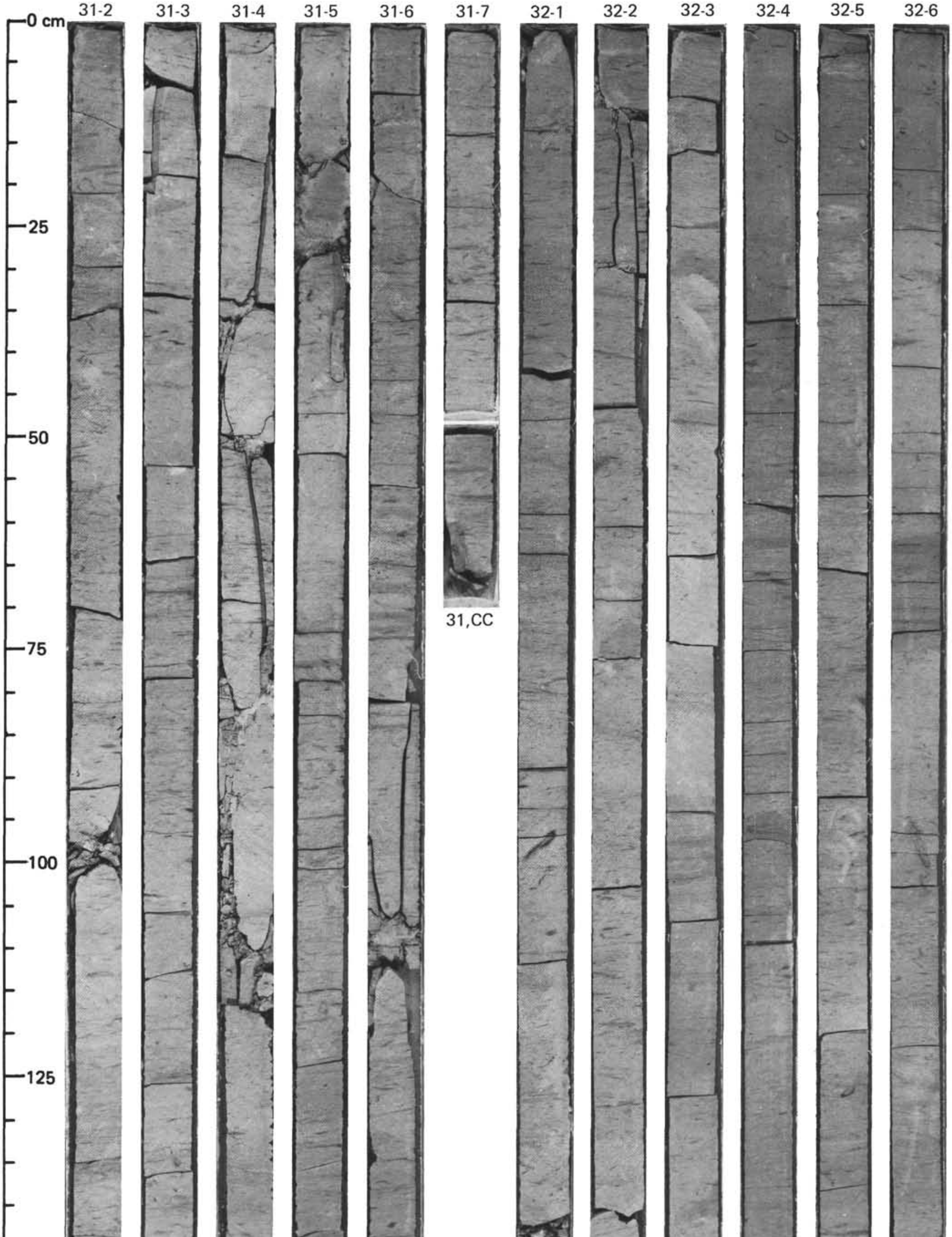
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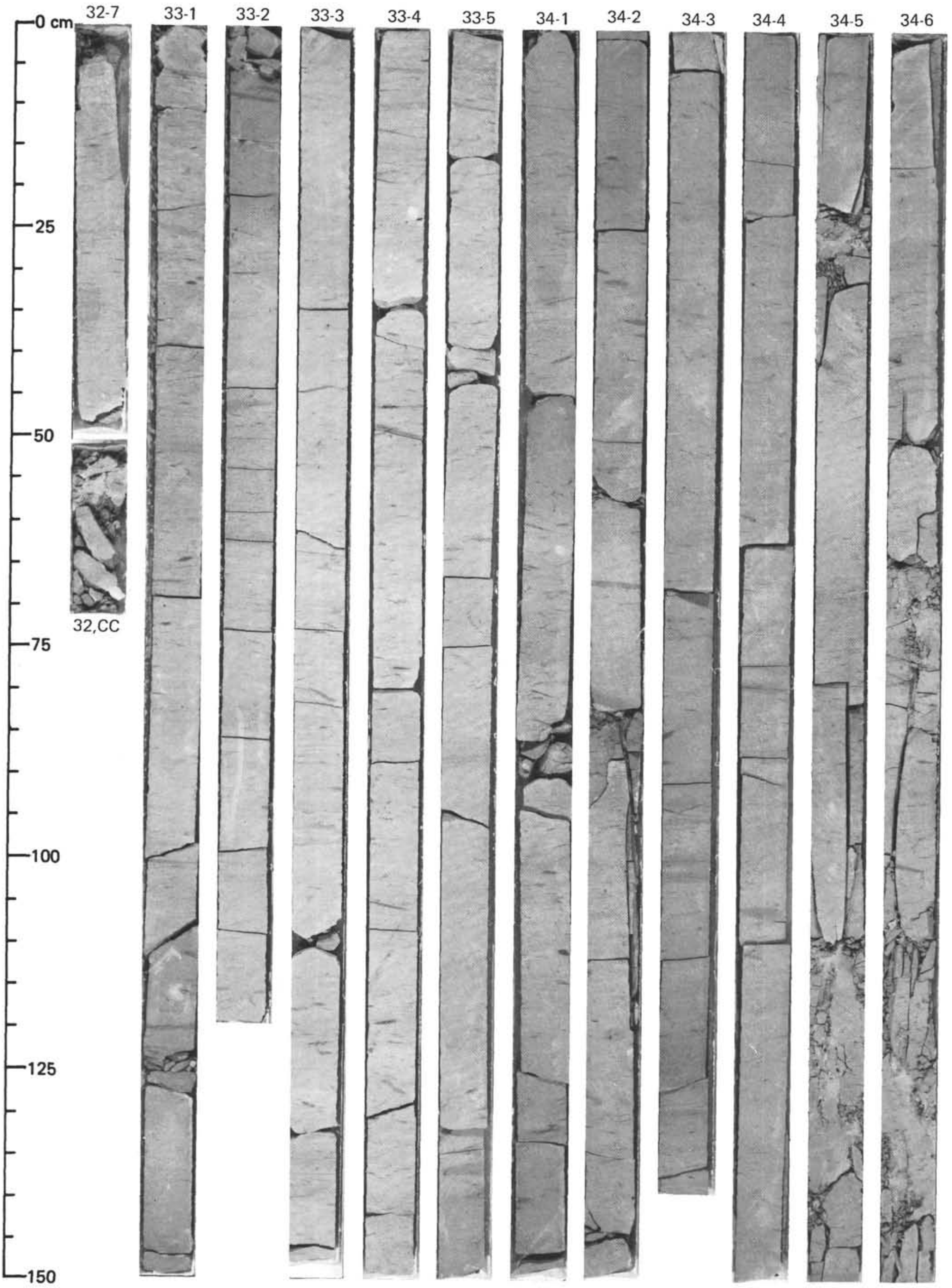
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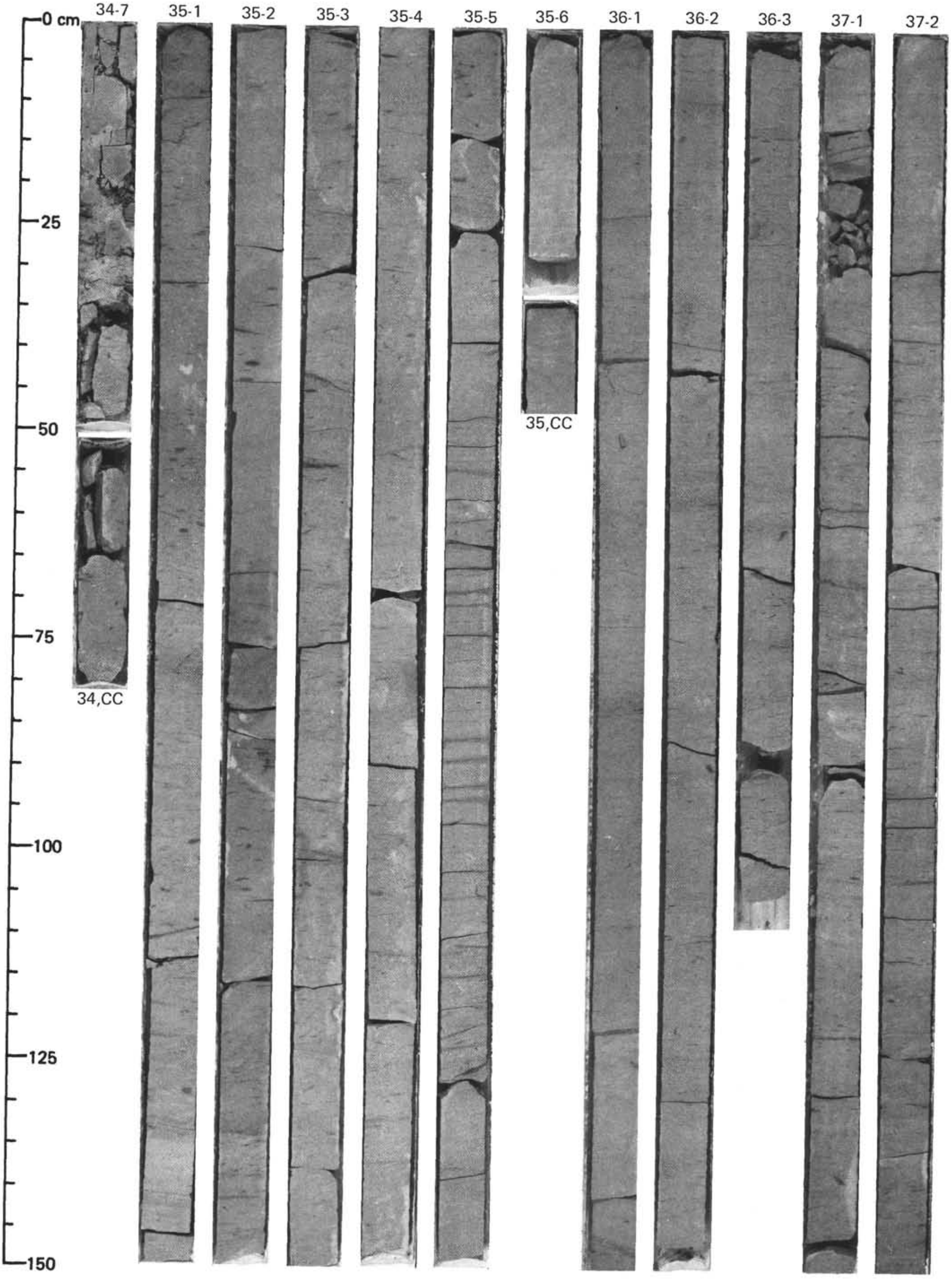
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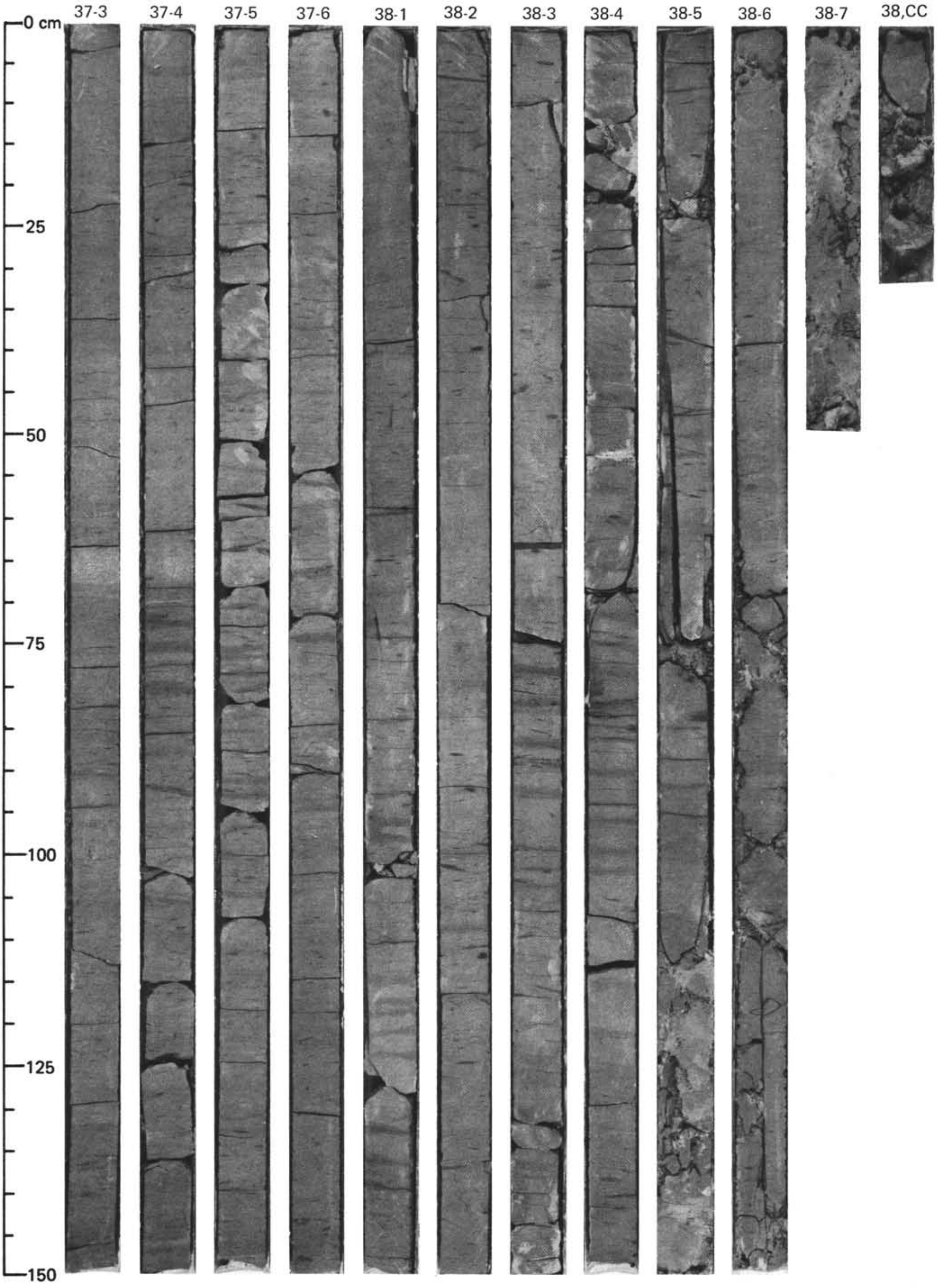
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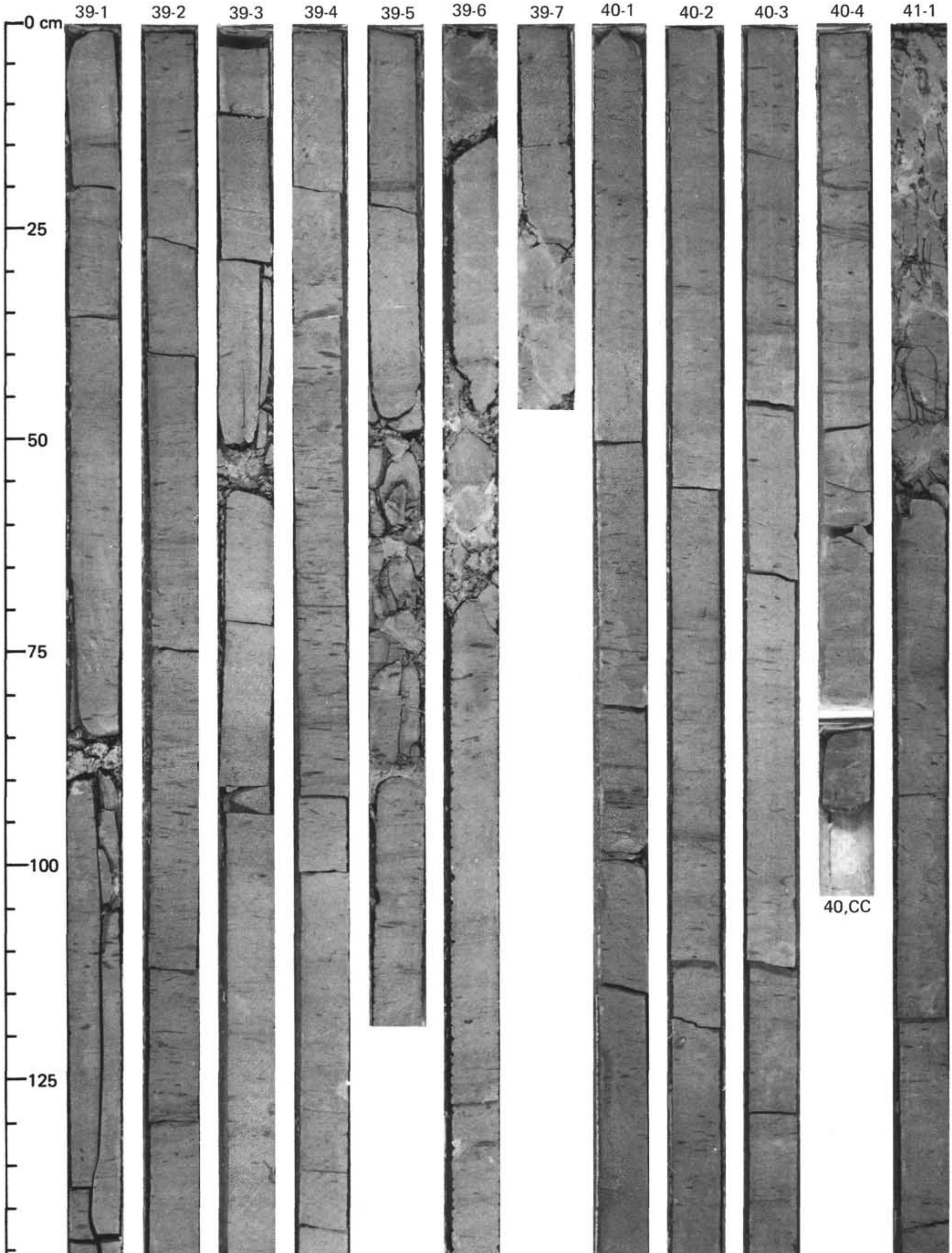
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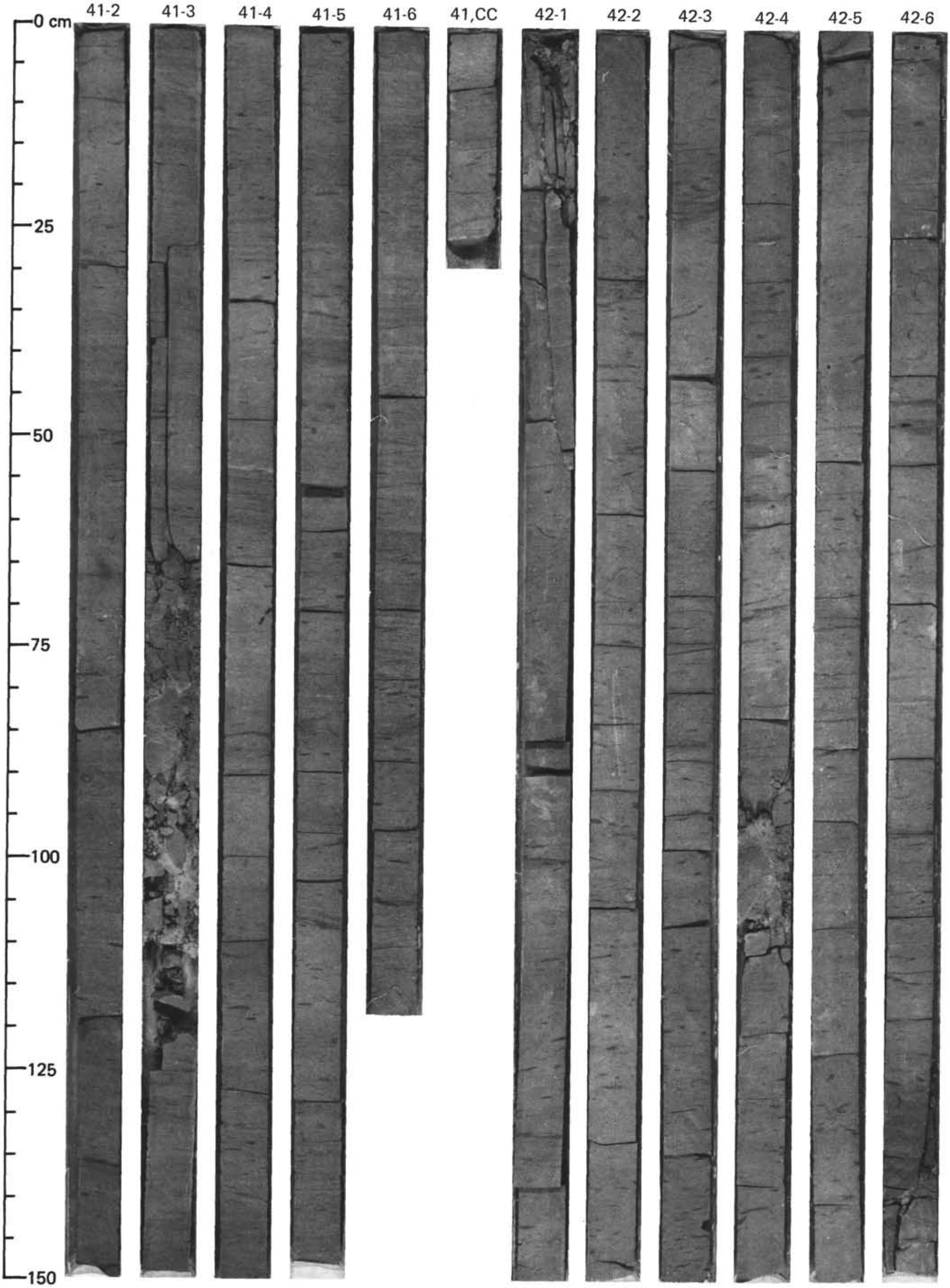
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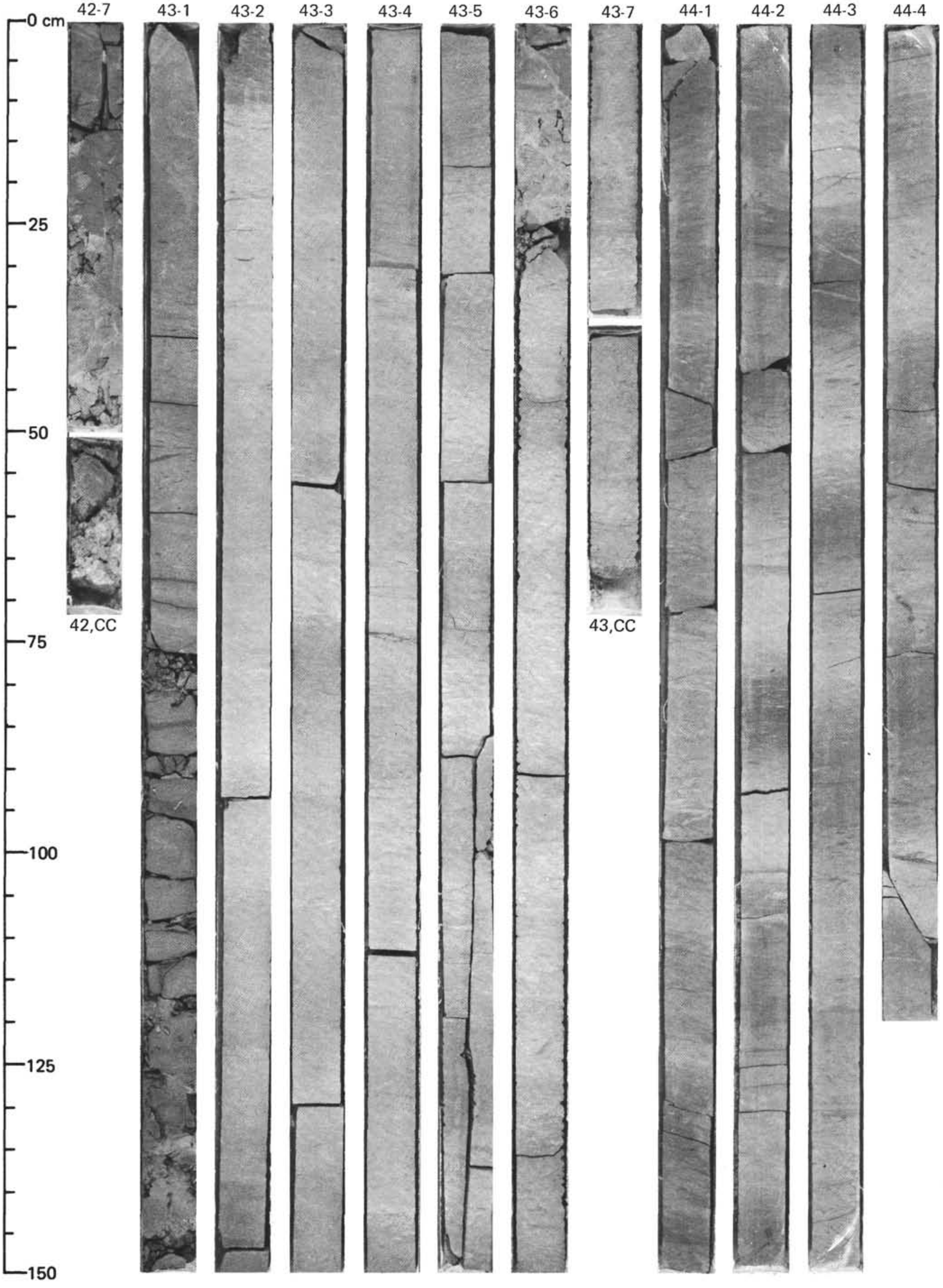
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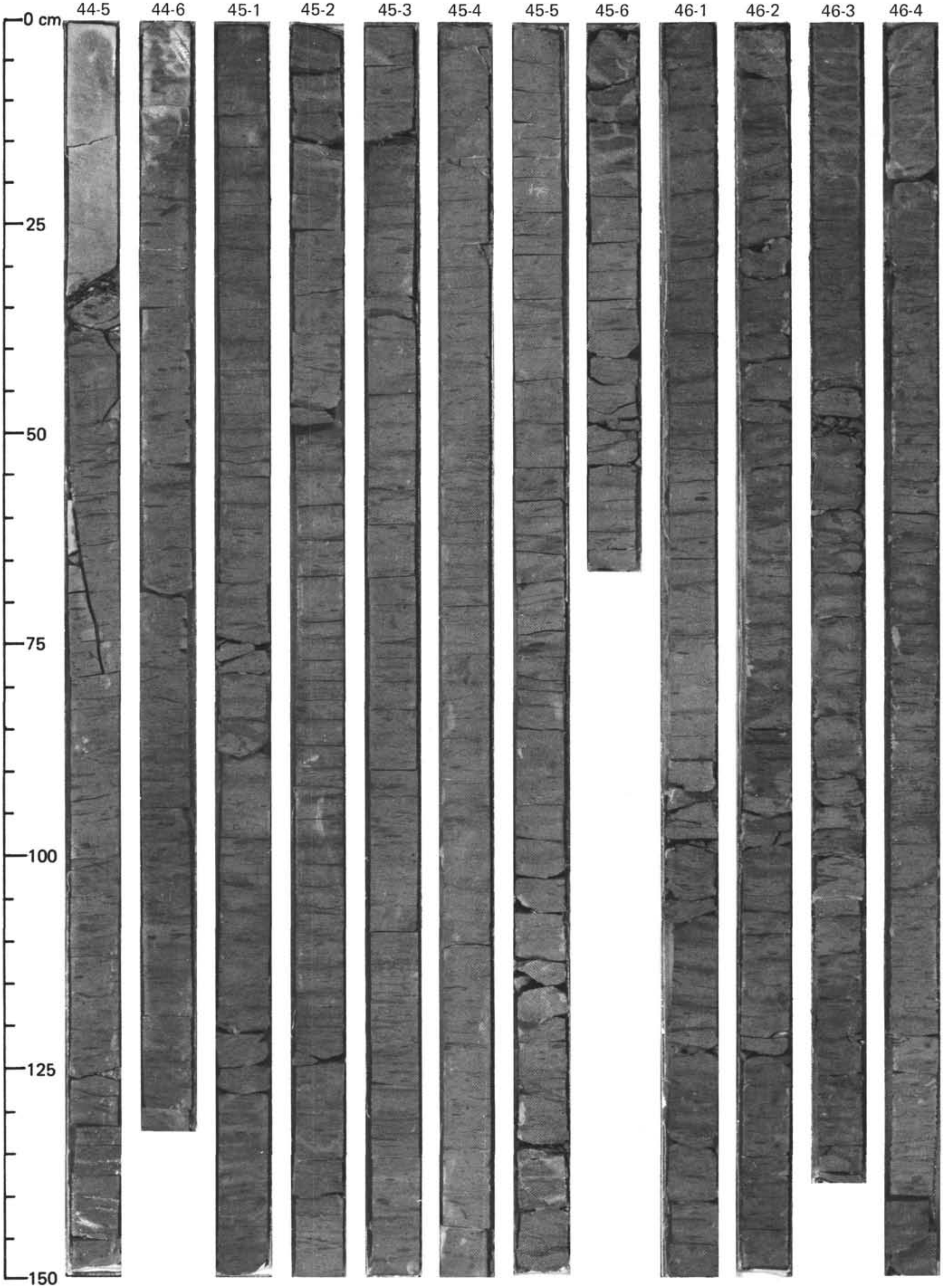
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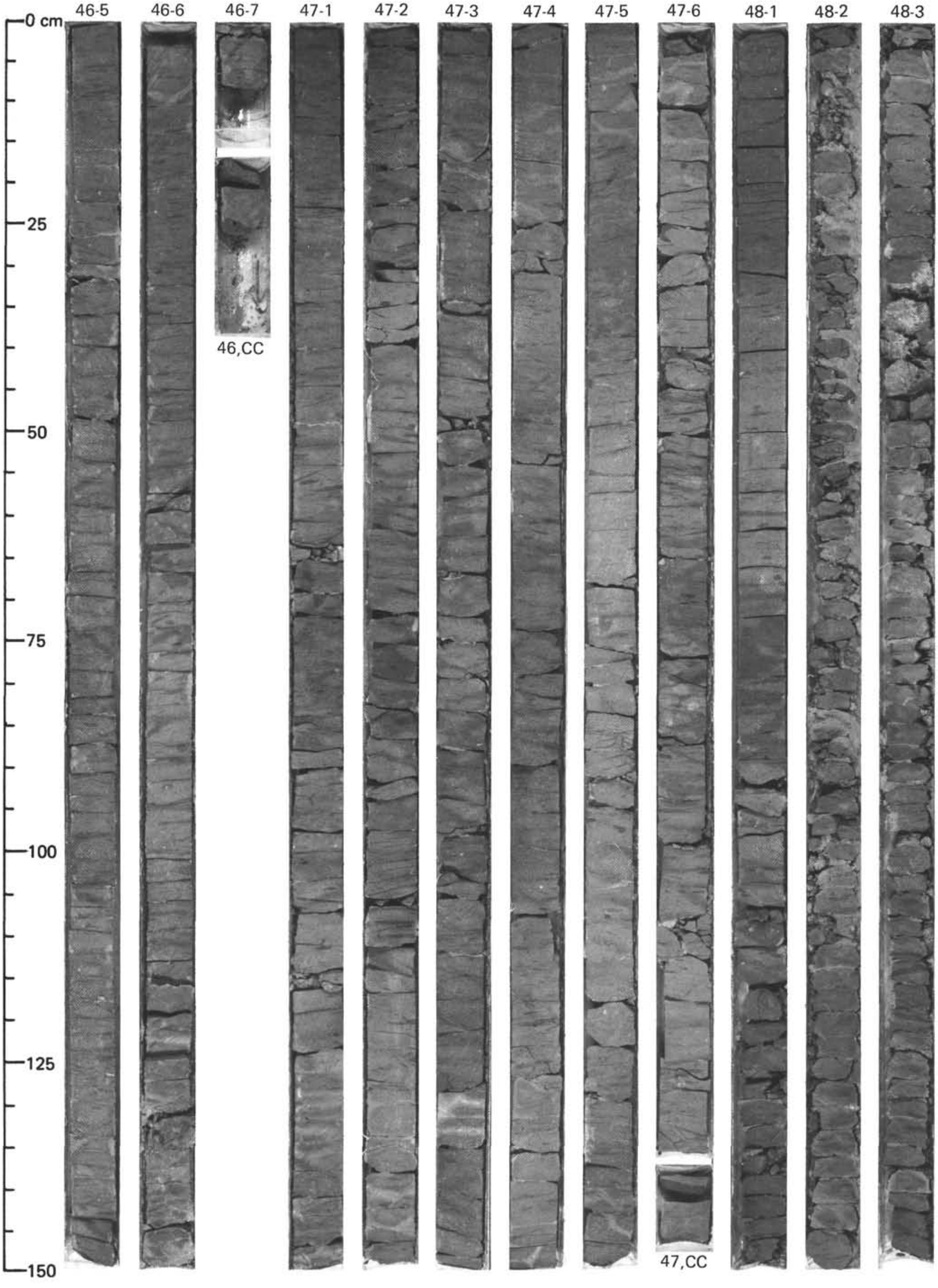
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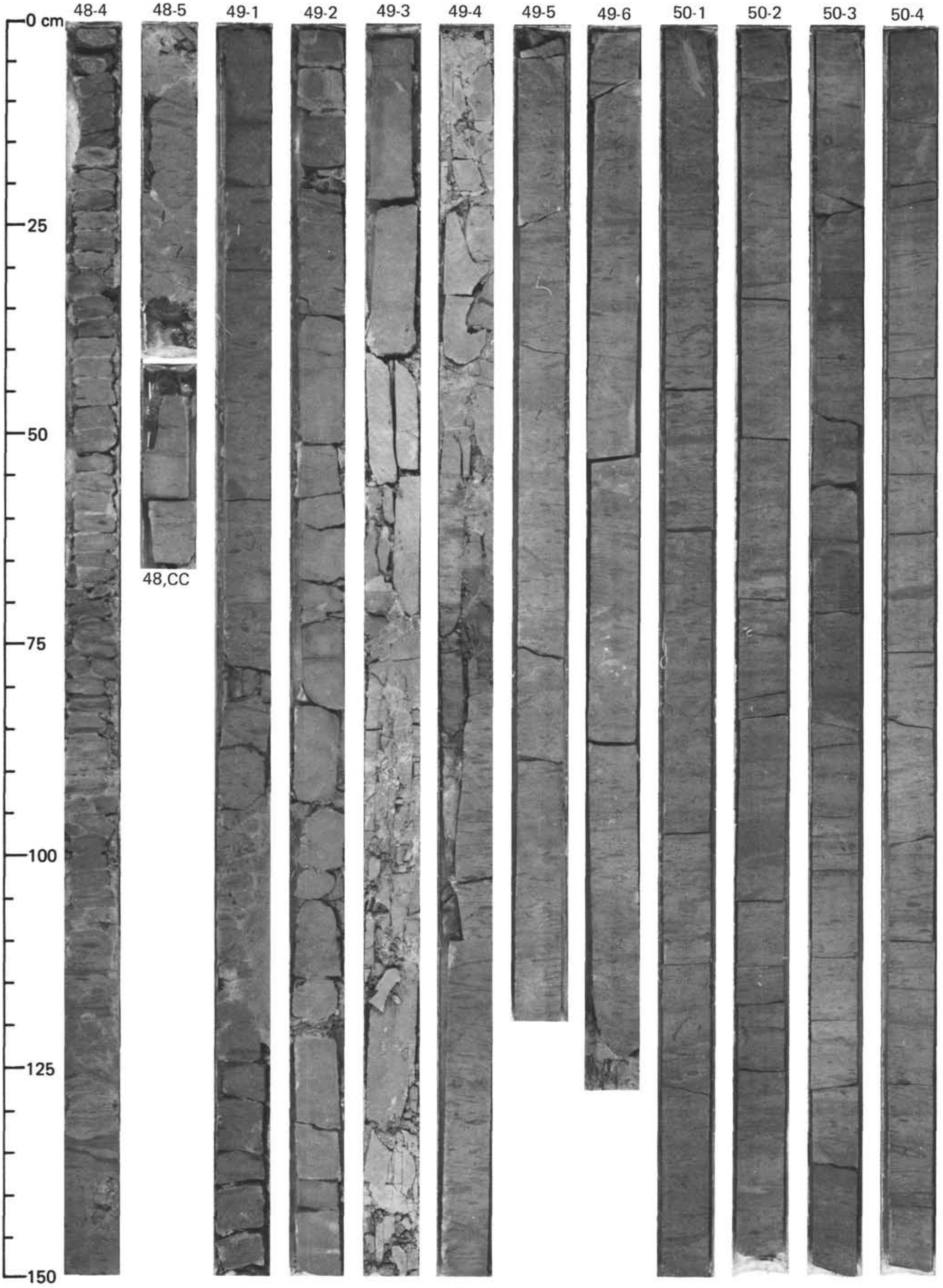
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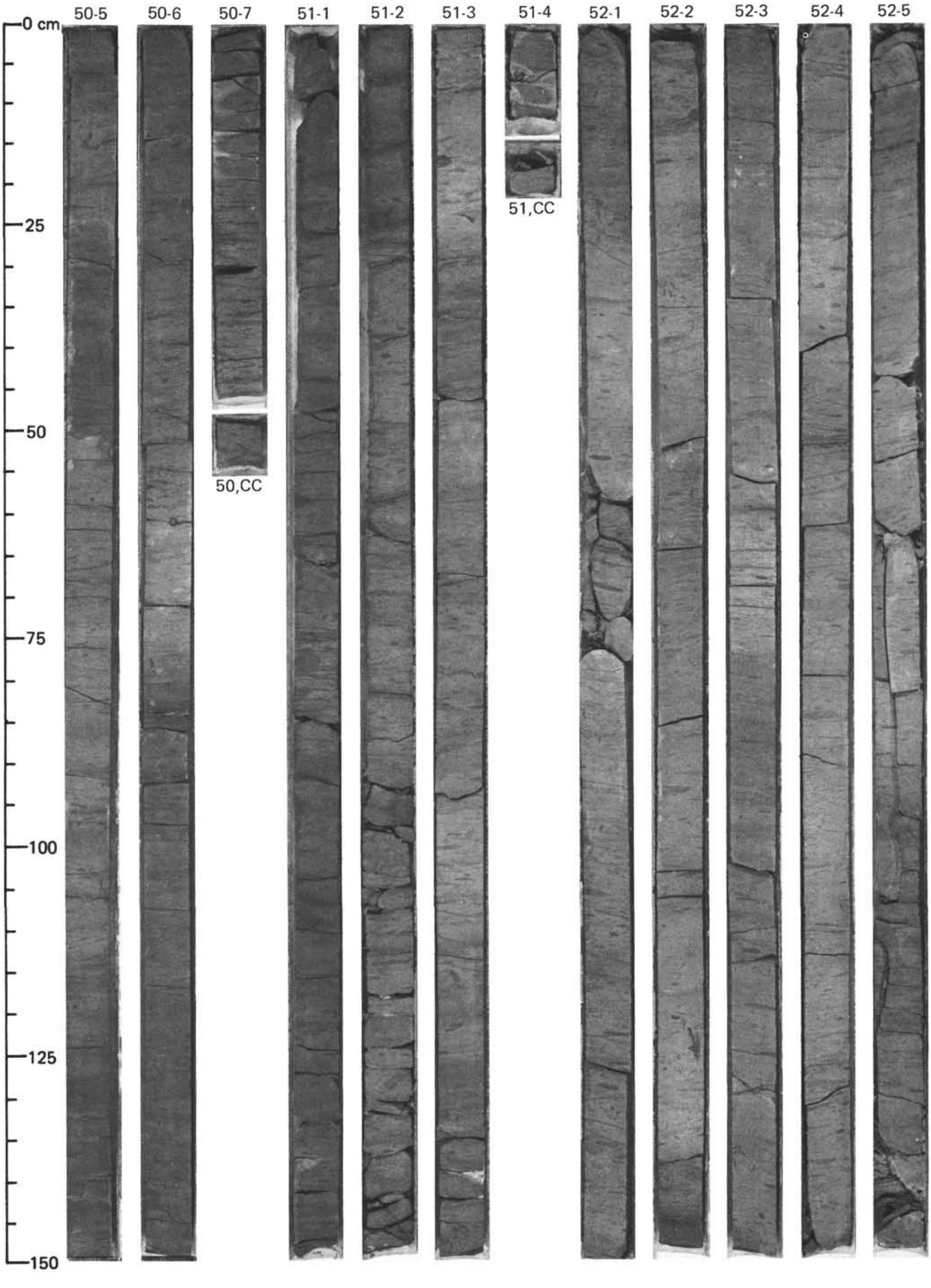
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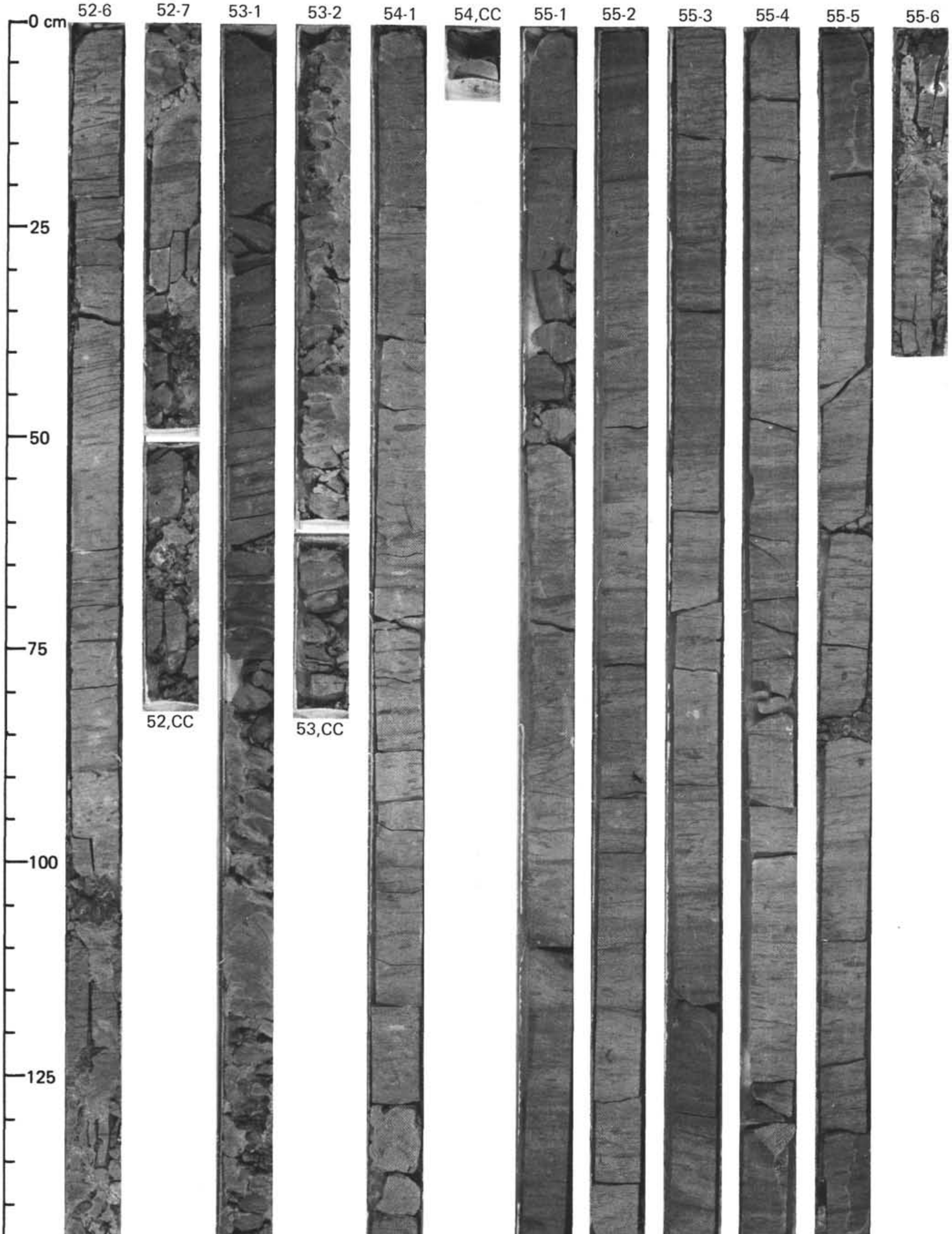
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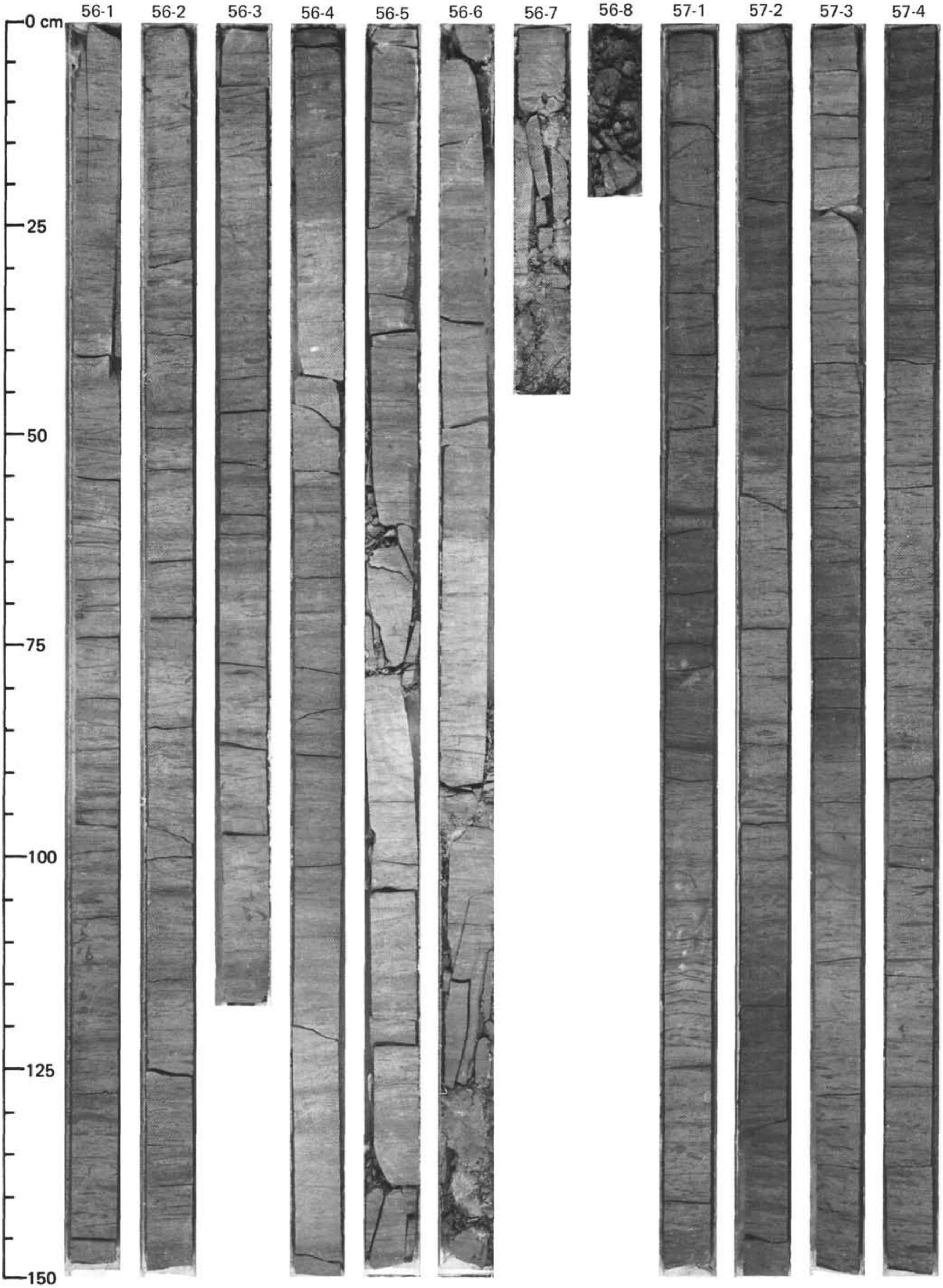
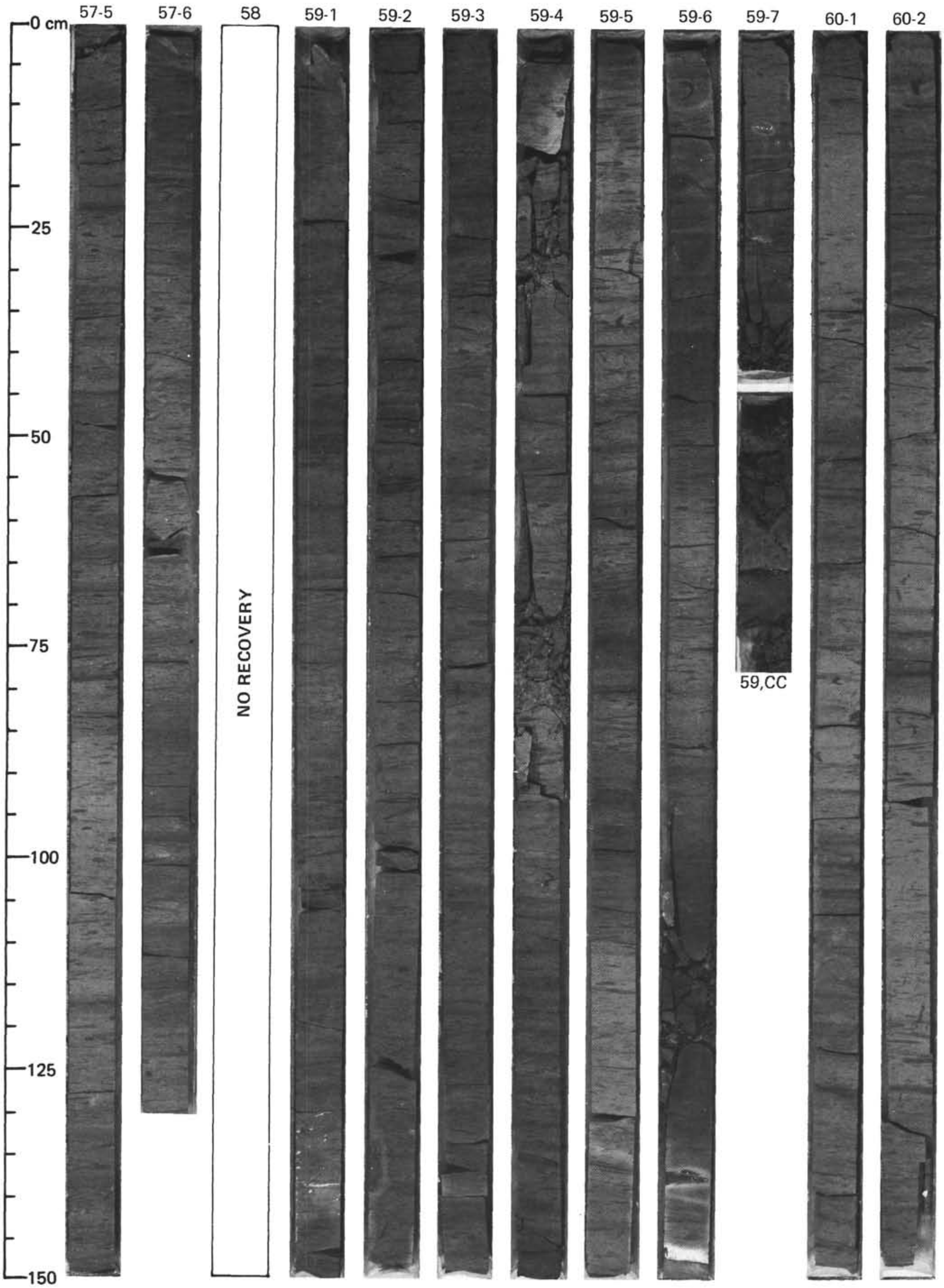
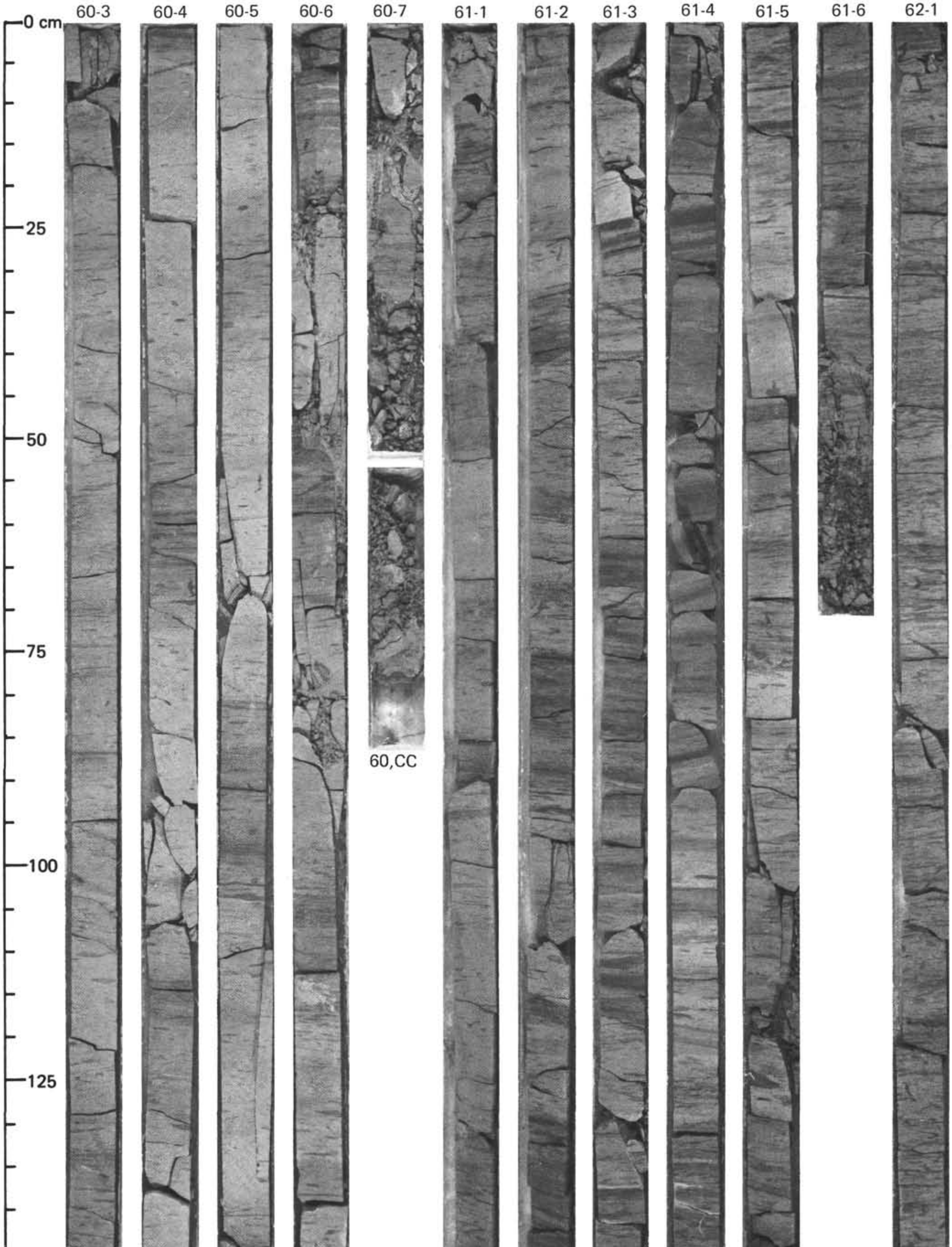
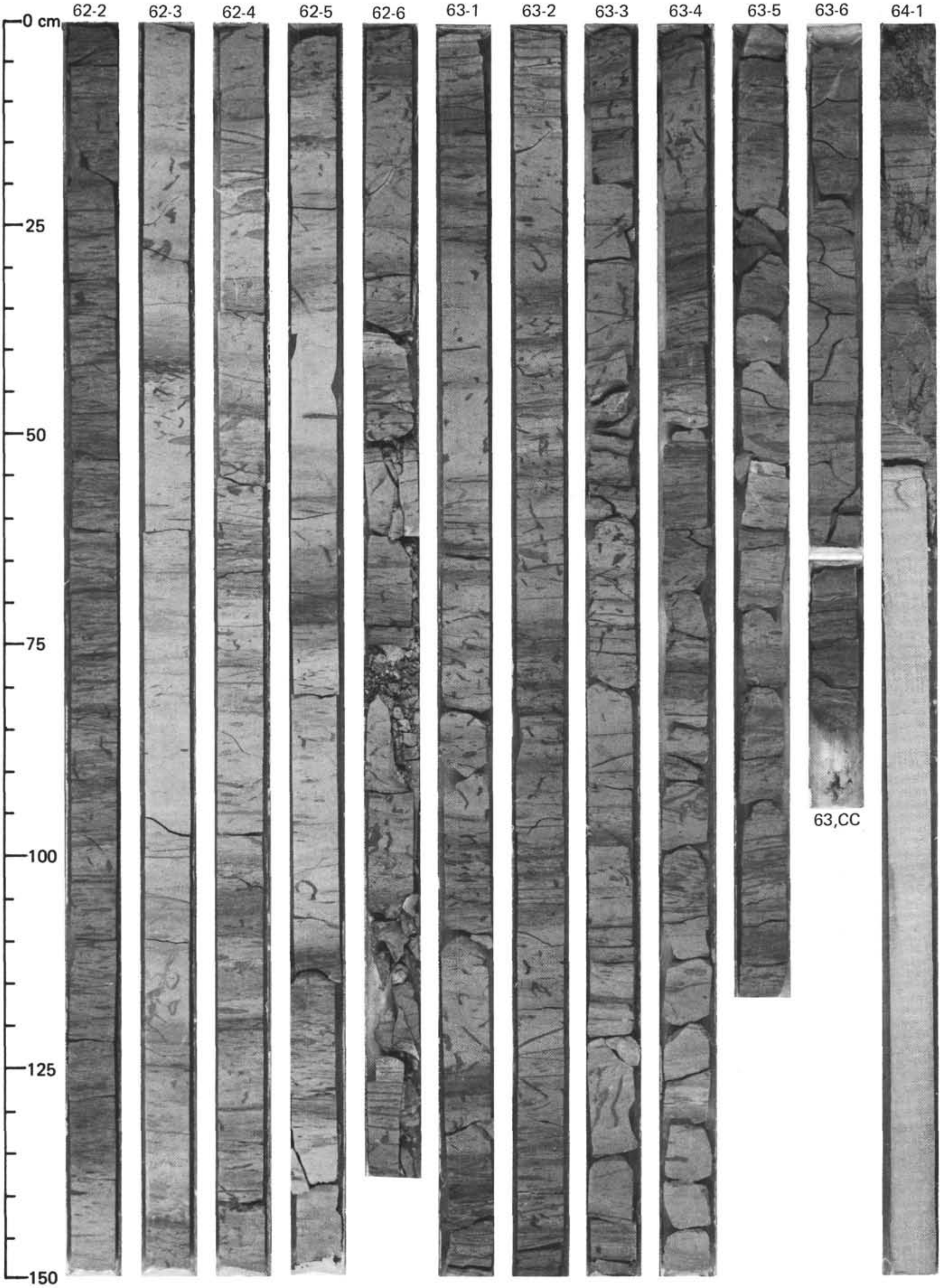
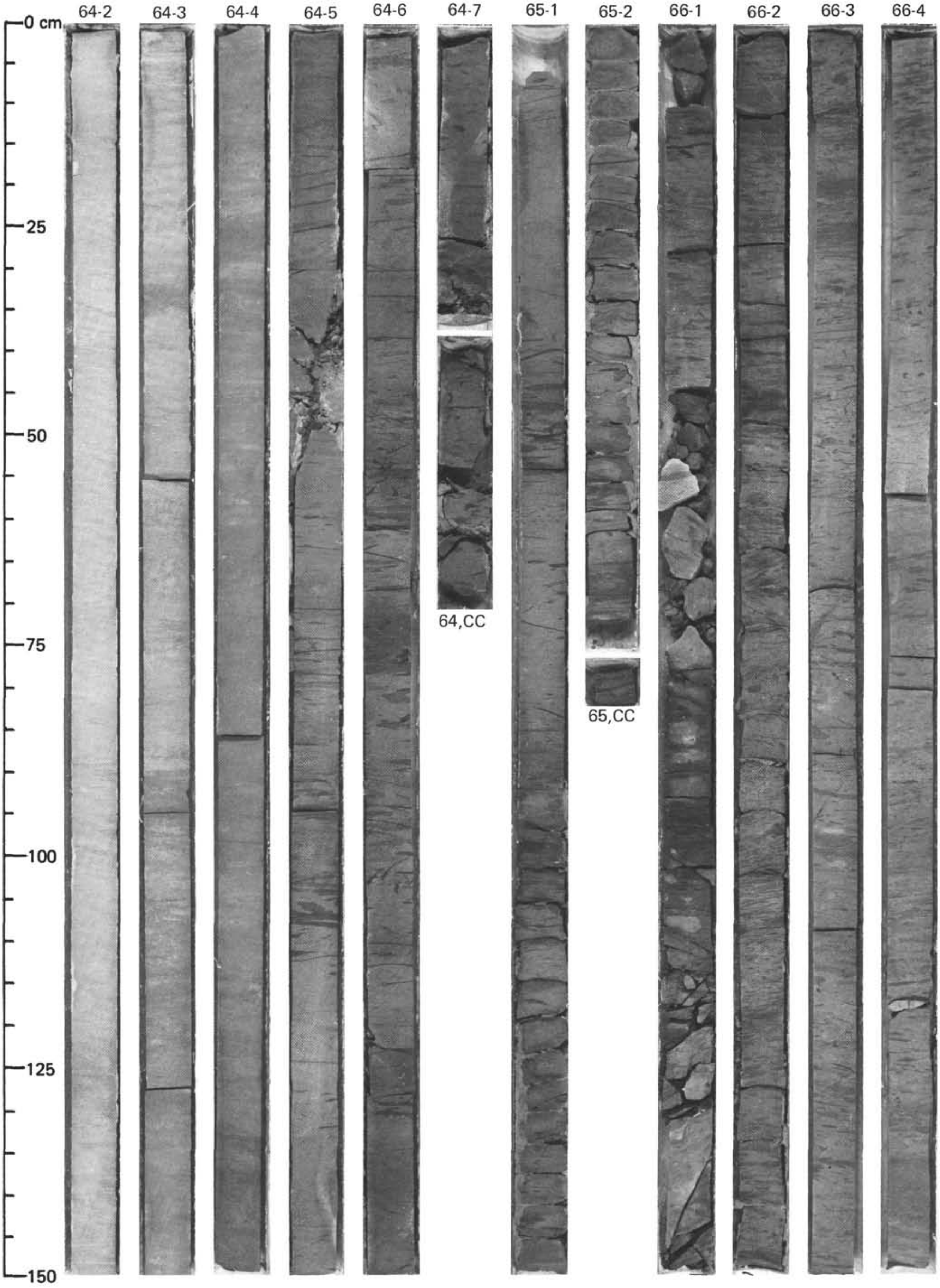
55-6

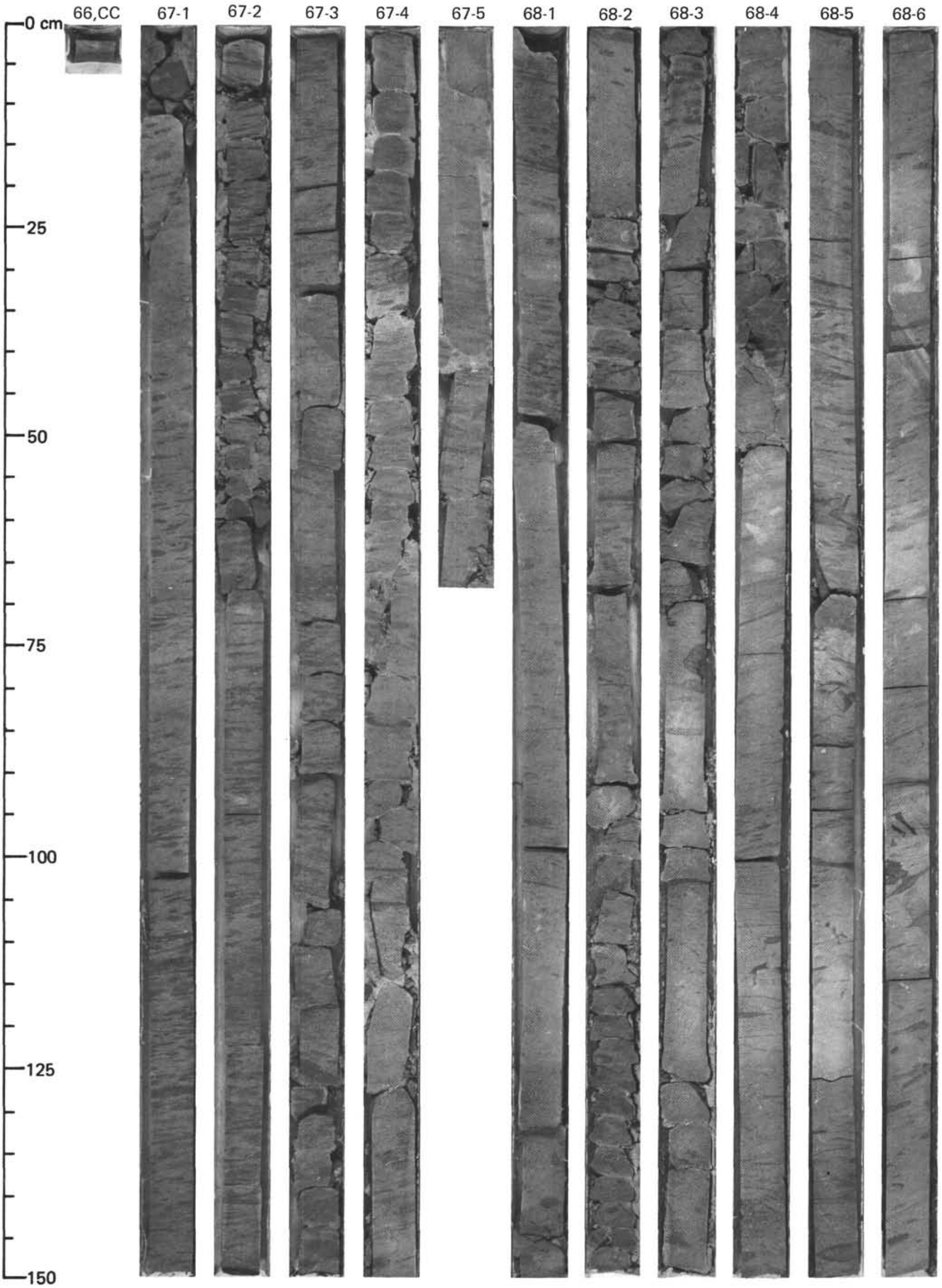

56-1
56-2
56-3
56-4
56-5
56-6
56-7
56-8
57-1
57-2
57-3
57-4
0 cm
25
50
75
100
125
150

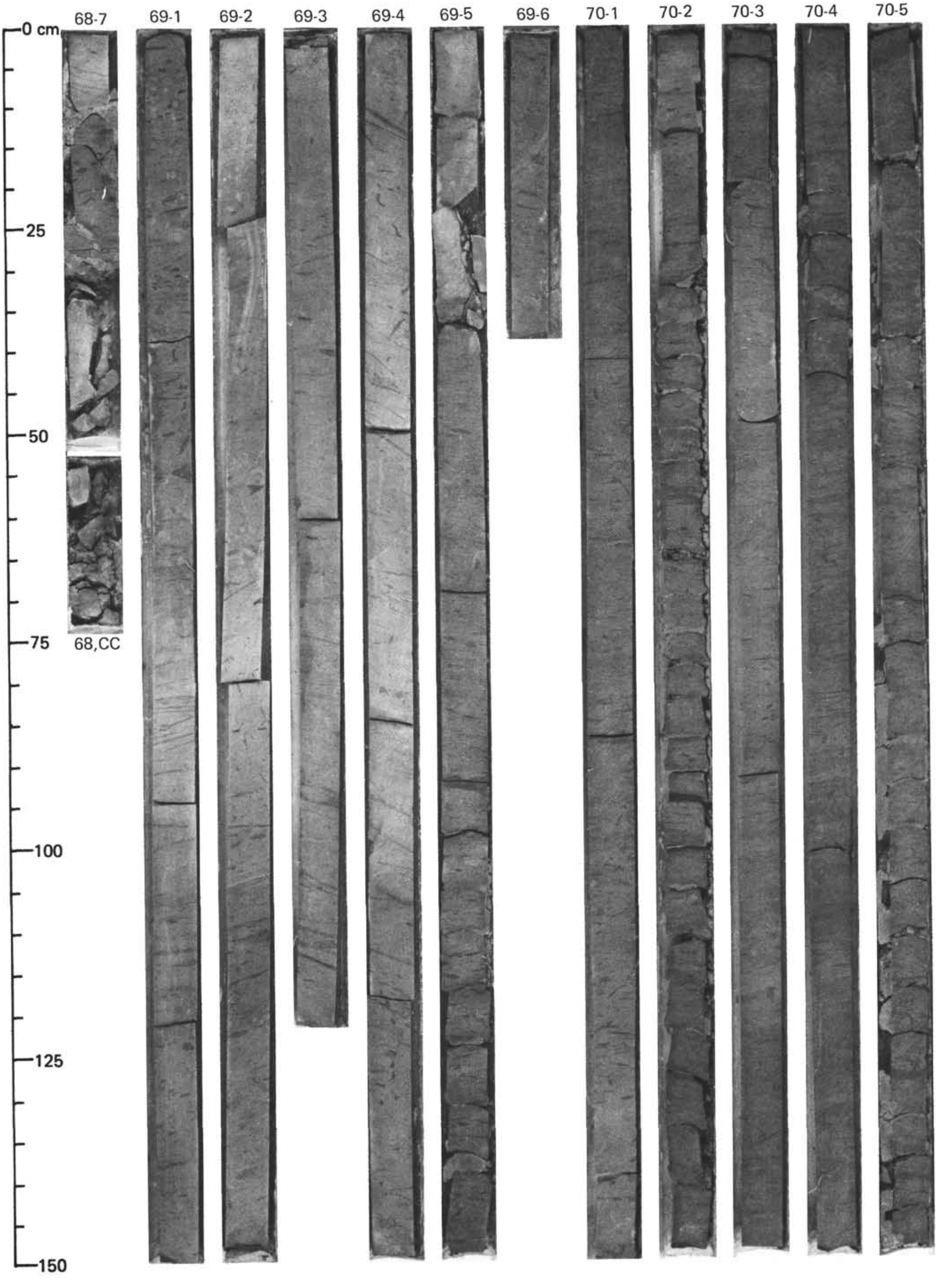

0 cm
25
50
75
100
125
150
57-5
57-6
58
NO RECOVERY
59-1
59-2
59-3
59-4
59-5
59-6
59-7
59,CC
60-1
60-2

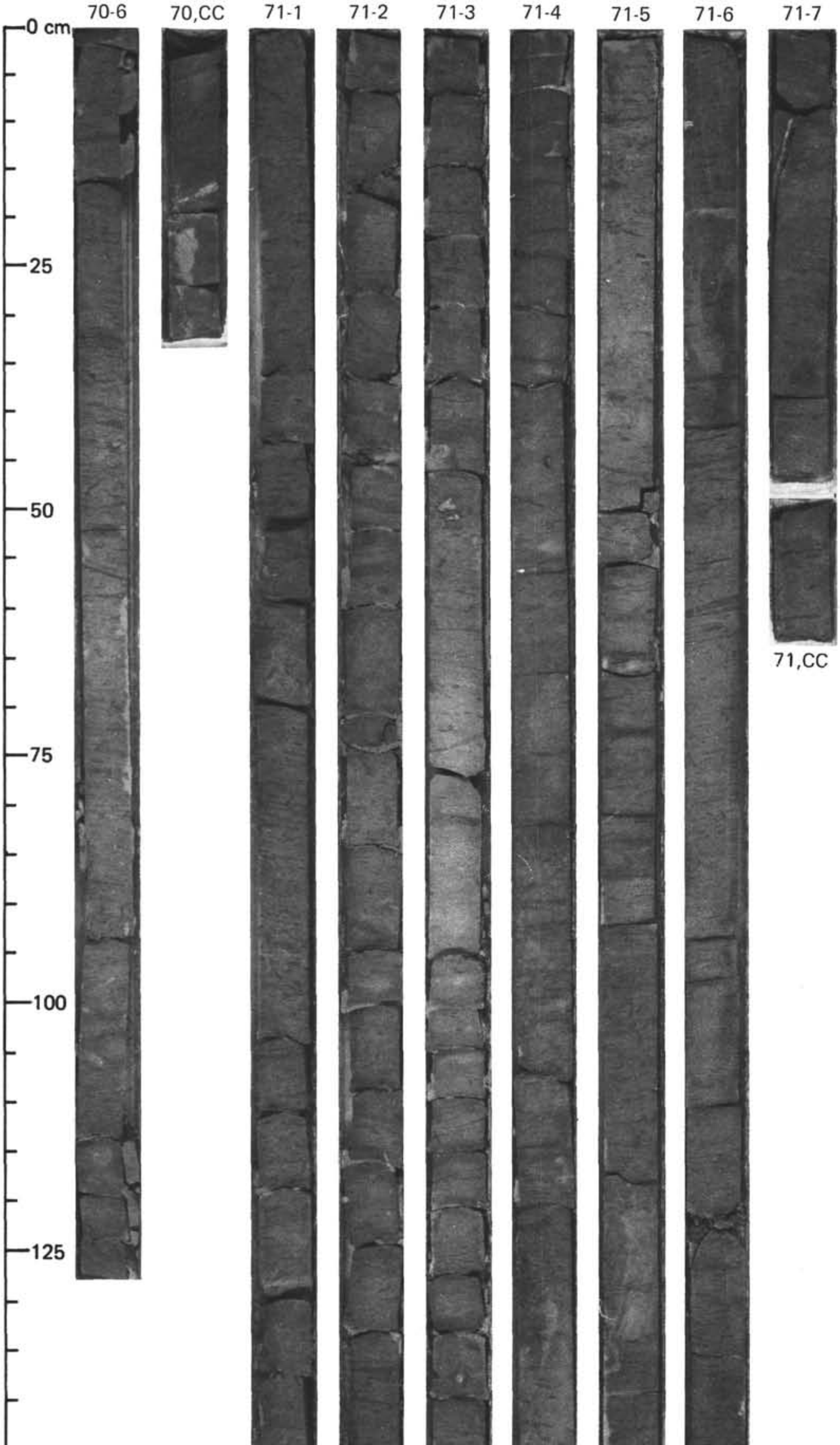

60-3
60-4
60-5
60-6
60-7
61-1
61-2
61-3
61-4
61-5
61-6
62-1
0 cm
25
50
75
100
125
150
60,CC


62-2
62-3
62-4
62-5
62-6
63-1
63-2
63-3
63-4
63-5
63-6
64-1
63,CC
0 cm
25
50
75
100
125
150


0 cm
25
50
75
100
125
150
64-2
64-3
64-4
64-5
64-6
64-7
64,CC
65-1
65-2
65,CC
66-1
66-2
66-3
66-4


66,CC
67-1
67-2
67-3
67-4
67-5
68-1
68-2
68-3
68-4
68-5
68-6
0 cm
25
50
75
100
125
150


68-7
69-1
69-2
69-3
69-4
69-5
69-6
70-1
70-2
70-3
70-4
70-5
0 cm
25
50
75
100
125
150
68,CC



70-6
70,CC
71-1
71-2
71-3
71-4
71-5
71-6
71-7
71,CC
0 cm
25
50
75
100
125
150