5. SITE 5[1]

The Shipboard Scientific Party[2]

SITE REPORT

Setting and Purpose

Holes 5 and 5A were drilled at Site 5, which lies about 20 miles north-northeast of Site 4 along the easterly edge of the oldest outcrop region (Figure 1) as described in the section on Setting and Purpose for Holes 4 and 4A.

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Since a thick sequence of cherts which destroyed the drill bits had been encountered at Holes 4 and 4A, this site was chosen as a place where Layer B could be much nearer the surface, and hence, the thick sequence of cherts could be expected either to be much thinner or to have outcropped to the east of Site 5. Unfortunately, the profiling gear on the *Glomar Challenger* failed to function at this time, so the site had to be located on the basis of satellite navigation and precision depth recorder records only. The resulting location was a little farther east than originally planned, and since the section thickened to the eastward, Holes 5 and 5A were in a thicker section than desired. Figure 2 shows the profiler section on *Vema* Cruise 22 close by.

Mechanical difficulties with the drill string—which were encountered when the third core was taken on Hole 5—made it necessary to recover the drill string to clear the difficulty. Hole 5A was drilled at the same location.

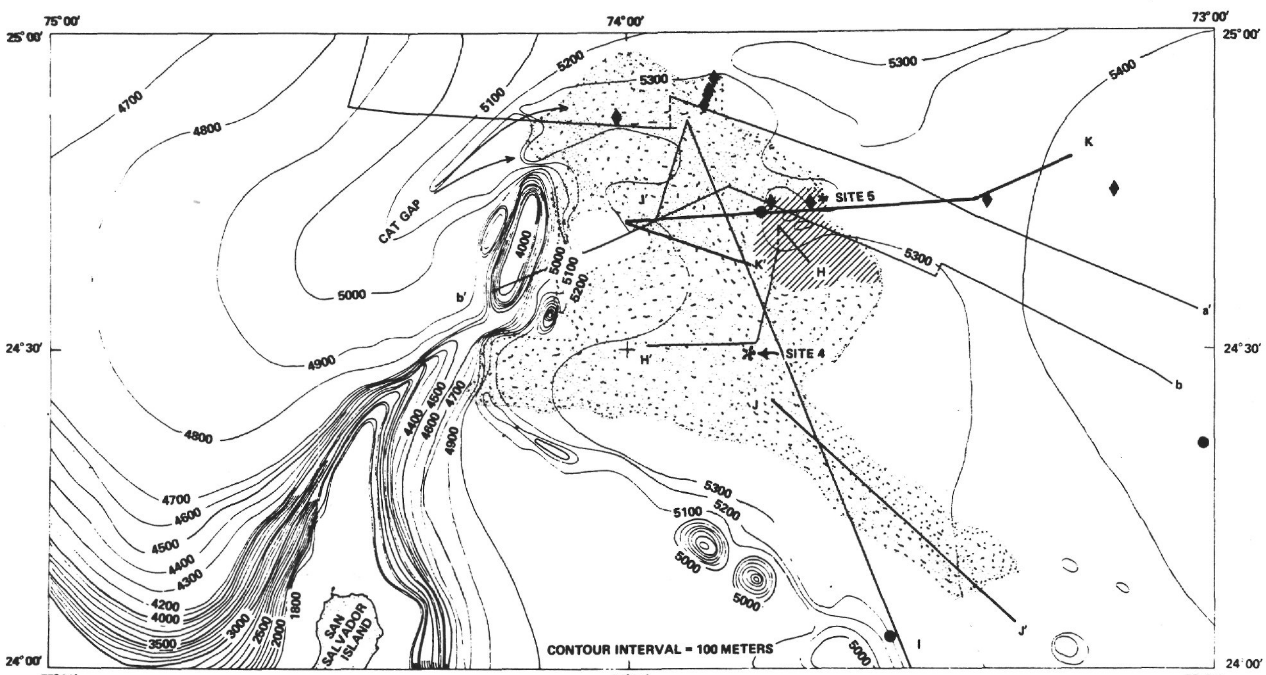


Figure 1. *Bathymetric chart of the seismic Horizon β outcrop area showing Sites 4 and 5 and the results obtained by piston coring. Outcrop of β is stippled and the oldest outcropped sediments are indicated by hachures. Solid diamonds indicate Cretaceous cores (after Windisch* et al., *1968).*

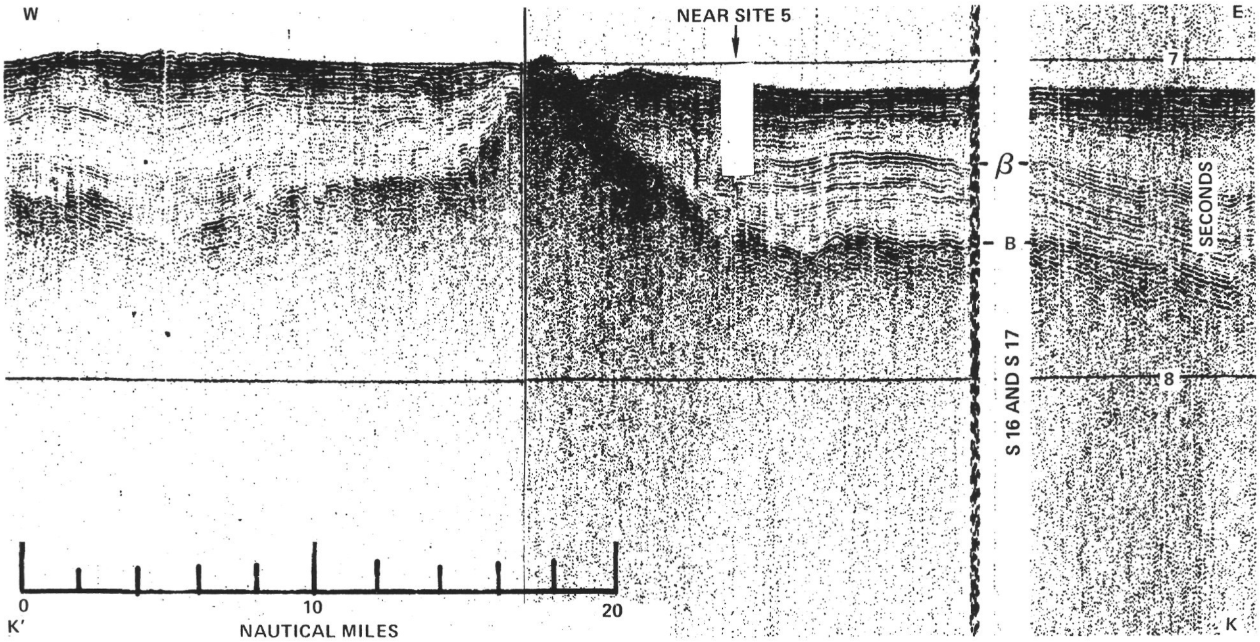


Figure 2. *Profiler section near Site 5. Locations shown in Figure 1.*

The same diamond bit was used for both holes. After penetrating to a depth of 278.5 meters (914 feet), no further progress could be made even though penetration through the full depth of section which had been indicated by the profiler was not achieved. When recovered, the diamond bit was found to be completely destroyed, presumably by the chert layers encountered. No further drilling could be attempted because notice was received of curtailment of Leg 1.

Holes 5 and 5A were located at 24°43.59′N, 73°38.46′ W, in a water depth of 5361 meters (17,589 feet) (corrected for sound velocity in the water and the depth of the transducer on the Hull).

Detailed information about the setting of this site must await results of the site survey during *Vema* Cruise 26 in April, 1969.

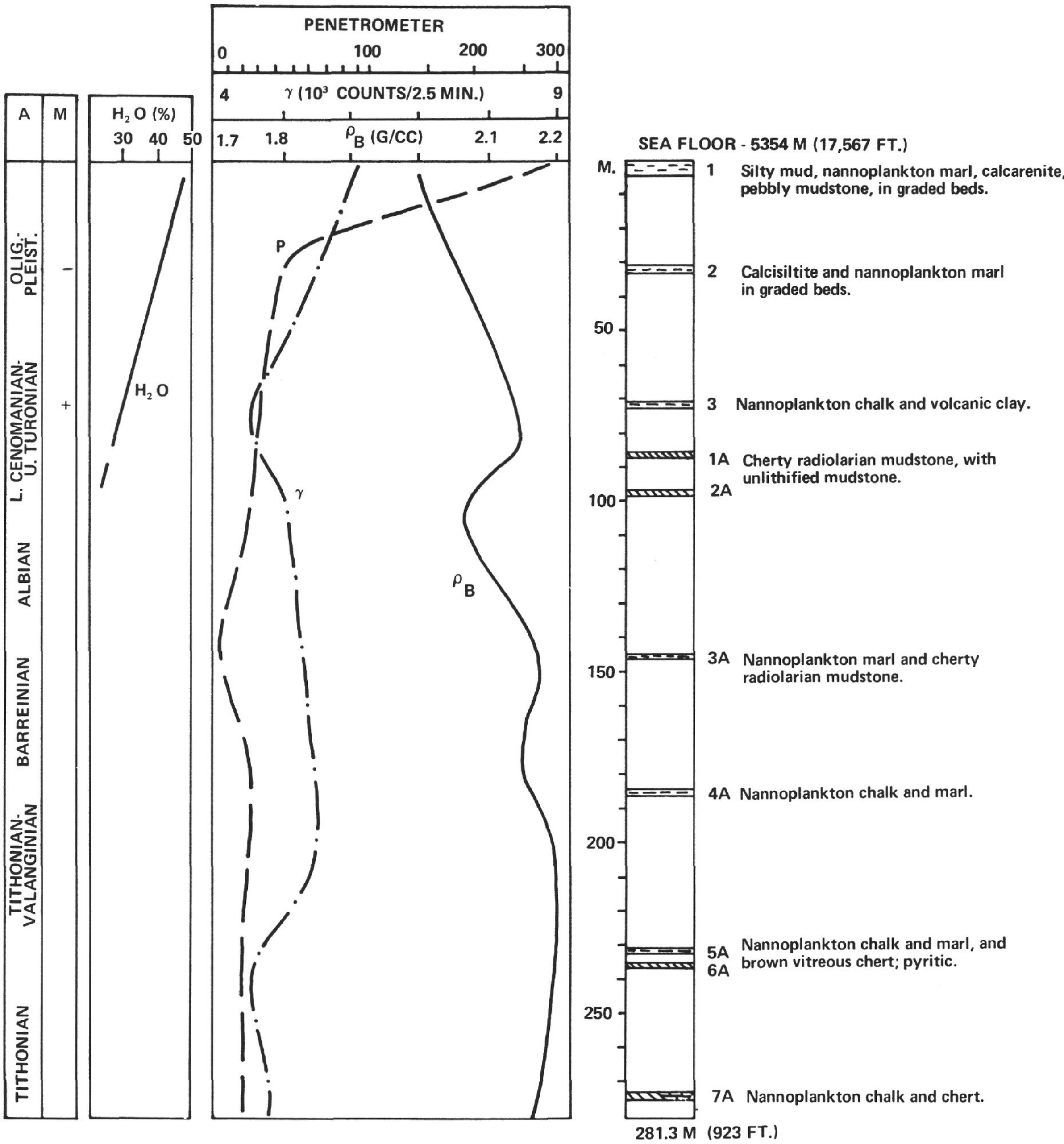


Figure 3. *Summary of drilling and coring at Site 5.*

The Cores Recovered from Site 5

Figures 4 through 13 are graphic summaries of the cores recovered at Site 5.

These figures show, for each core:

(1) The stratigraphic age.
(2) The paleomagnetic results–normal (+) or reversed (-).
(3) The natural gamma radiation (full line).
(4) The bulk density as determined by the GRAPE (Gamma Ray Attenuation Porosity Evaluator) equipment (broken line).
(5) The length of the core in meters measured from the top of the core and the subbottom depth of the top of the cored interval.
(6) The lithology (see key with Site 1 report).
(7) The positions of the tops of each core section.
(8) Some notes on the lithology.

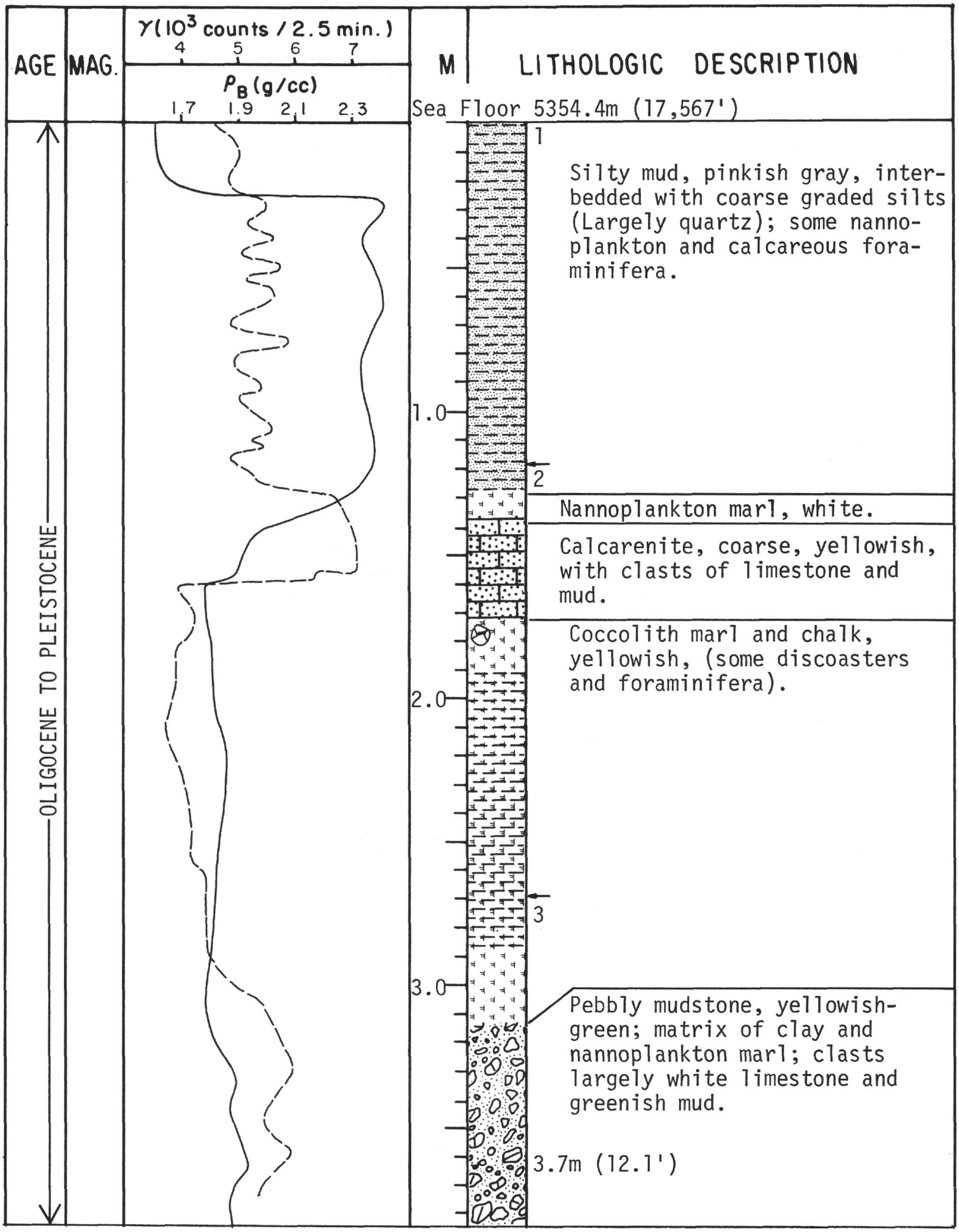


Figure 4. *Hole 5, Core 1.*

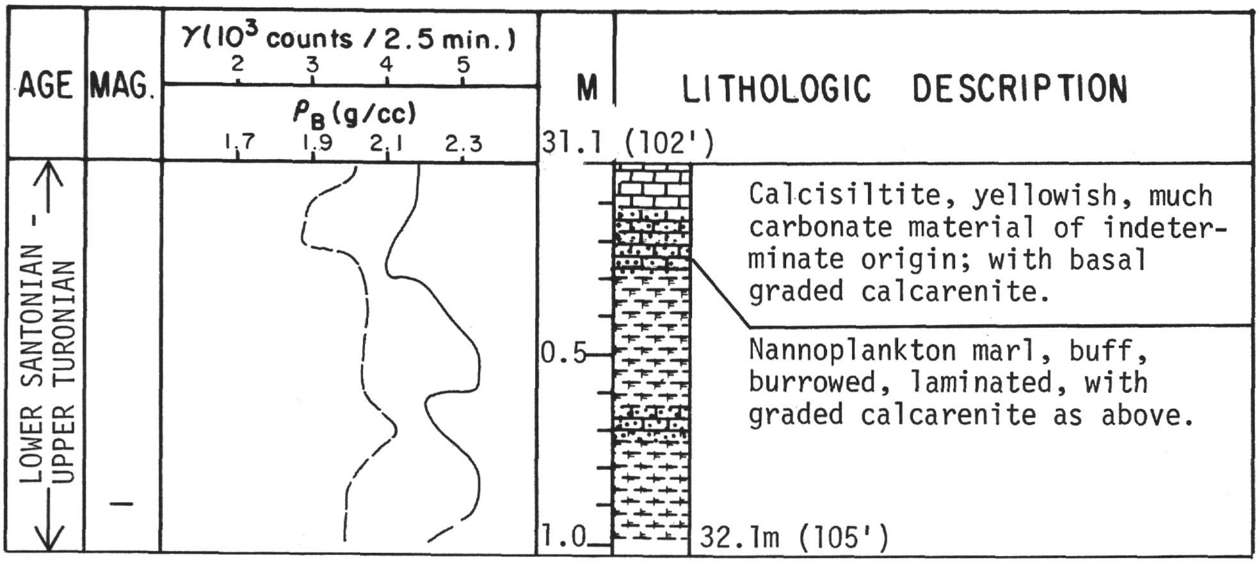


Figure 5. *Hole 5, Core 2.*

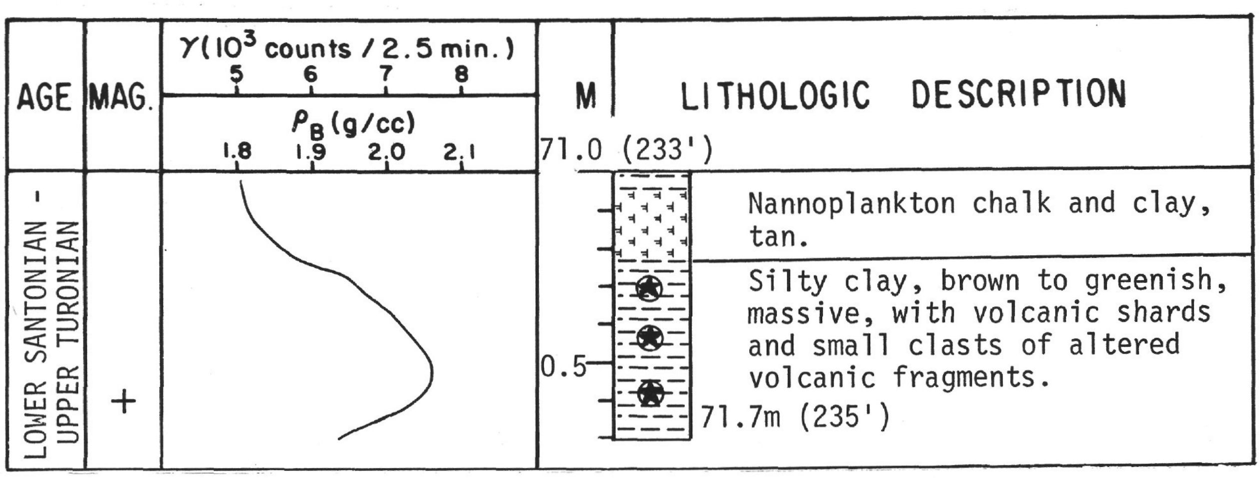


Figure 6. *Hole 5, Core 3.*

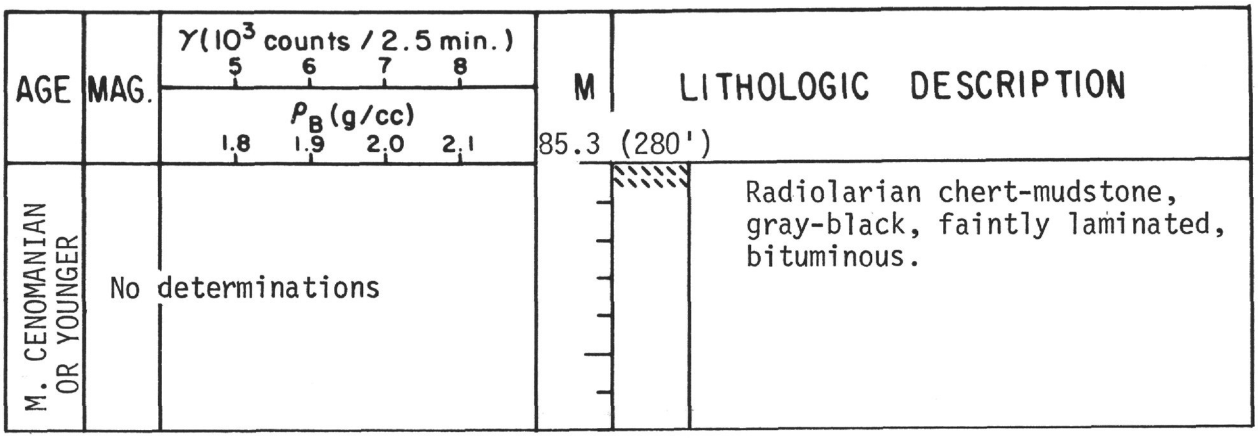


Figure 7. *Hole 5A, Core 1.*

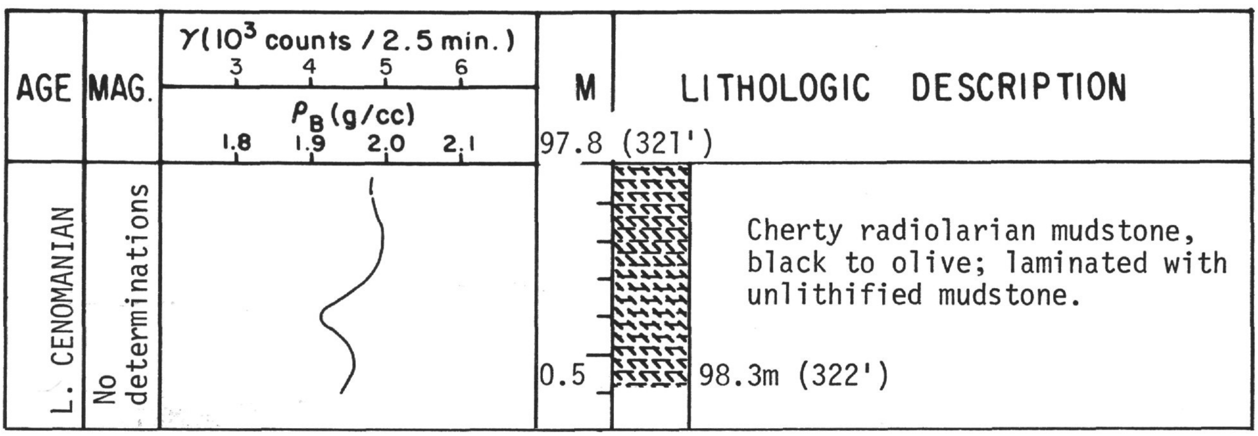


Figure 8. *Hole 5A, Core 2.*

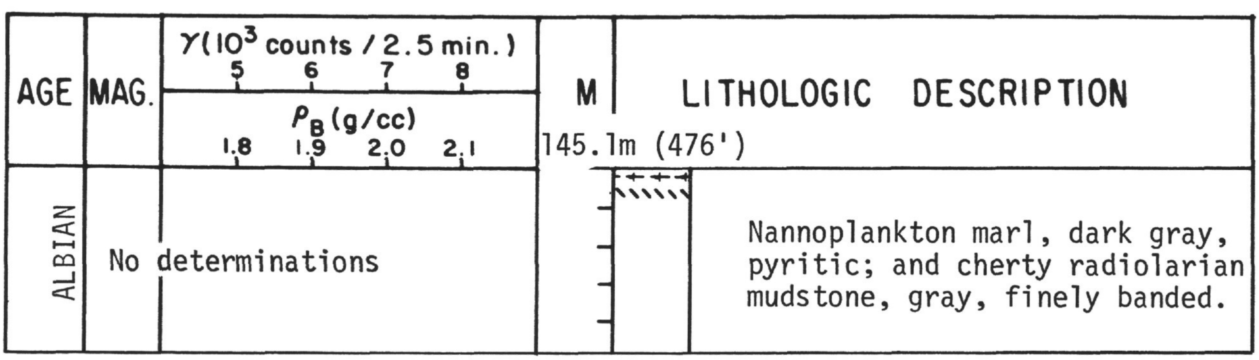


Figure 9. *Hole 5A, Core 3.*

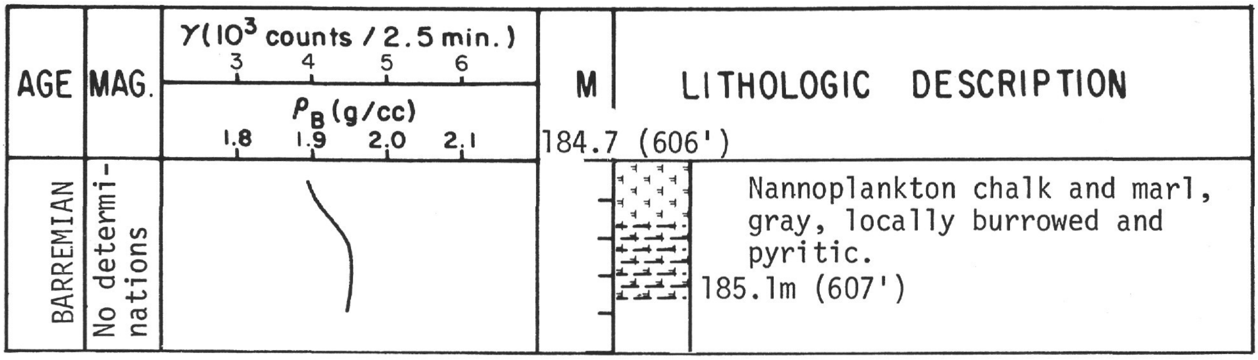


Figure 10. *Hole 5A, Core 4.*

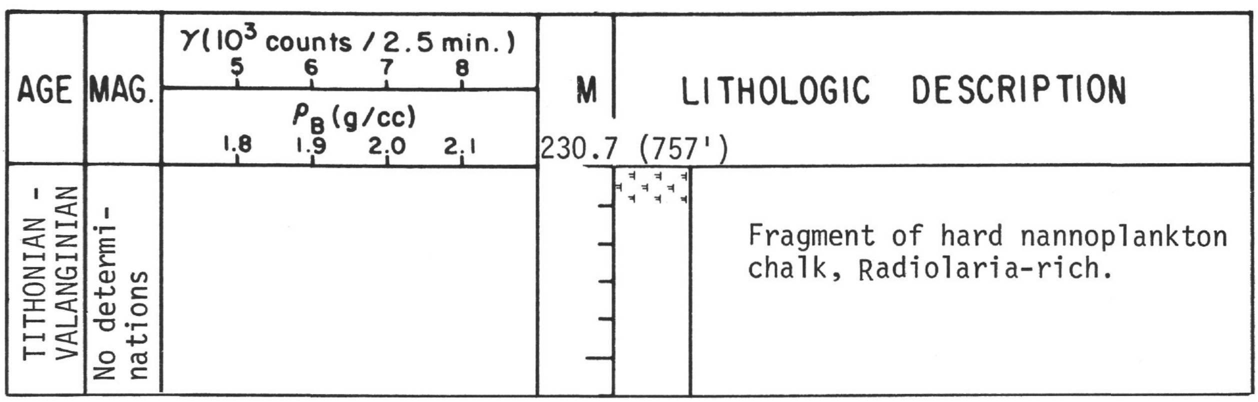


Figure 11. *Hole 5A, Core 5.*

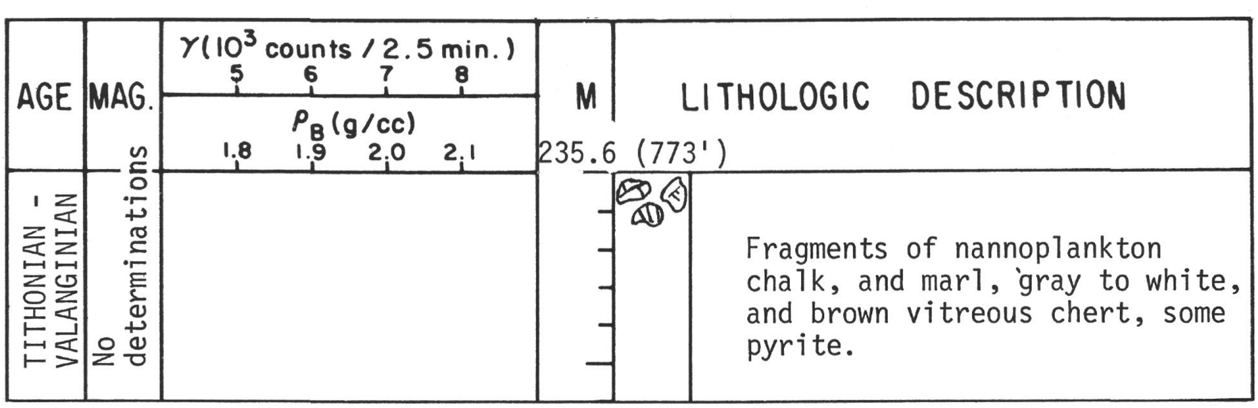


Figure 12. *Hole 5A, Core 6.*

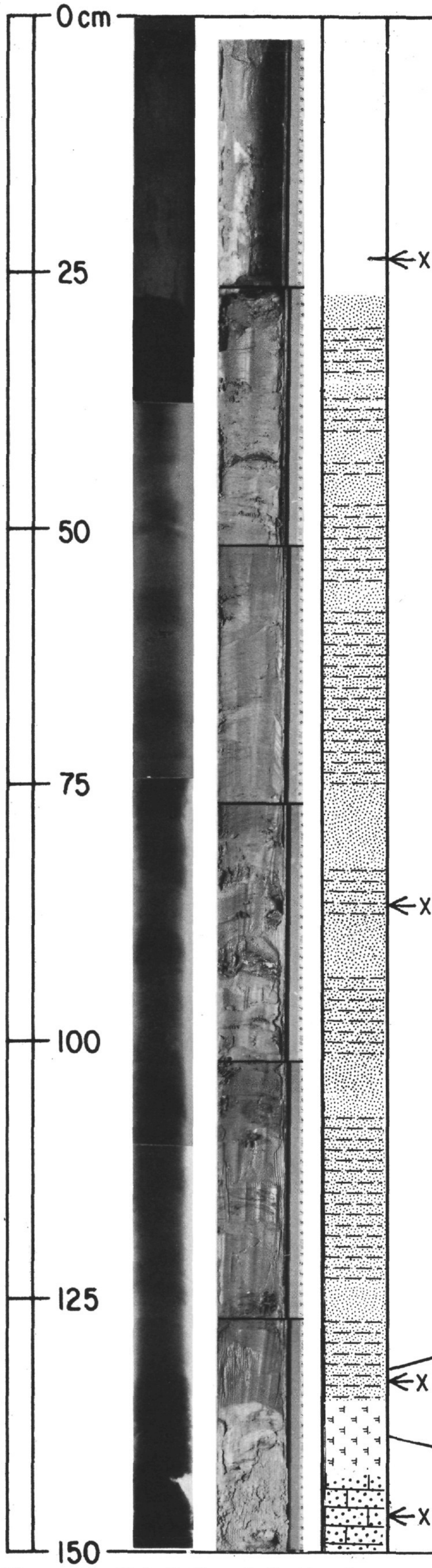
AGE	MAG.	γ (10^3 counts / 2.5 min.) 5 6 7 8 ρ_B (g/cc) 1.8 1.9 2.0 2.1	M		LITHOLOGIC DESCRIPTION
			274.3 (900')		
TITHONIAN	No determinations				Fragments of nannoplankton chalk white and grayish-green, and brownish gray chert with many Radiolaria.

Figure 13. *Hole 5A, Core 7.*

Figures 14 through 25 show details of the individual core sections of the cores from Site 5.

Each figure shows:

(1) A scale of centimeters from the top of each section.
(2) An X radiograph of the core section.
(3) A photograph of the core section.
(4) The lithology (see key with Site 1 report).
(5) The positions of smear slides (x).
(6) Notes on the lithology, carbon content, expressed as a percentage of total sediment (see Chapter 11), the water content (see Chapter 10) and the grain size (see Chapter 9). Colors are given with reference to the GSA Rock Color Chart.



Total C 1.0; Org. C 0.1; $CaCO_3$ 7.3.
Water content 28.9.
Sand 4.8; silt 46.5; clay 48.7.

Silty mud, pinkish-gray (7.5YR 6/2), interbedded with coarse, graded silts of some color; thin bands of darker brown (7.5YR 6/4 to 7/4), some yellow (10YR 6/6). Some of silts highly convoluted or burrowed. Some nannoplankton and calcareous forams. Silts are mainly quartz.

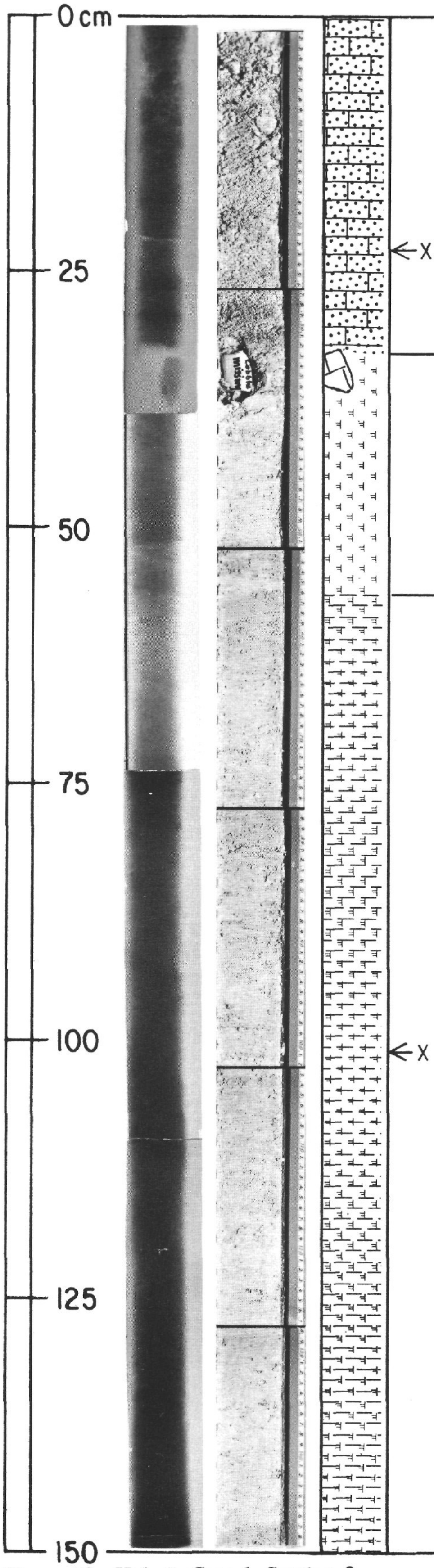
Note the grading of silt beds shown in the X-radiograph (darker portions).

(Longitudinal streaks in upper part of radiograph and photograph are merely mud-smears on empty core-liner.)

Nannoplankton marl, white, burrowed; nannofossils (coccoliths, discoasters), some forams.

Calcarenite, muddy, with fragments of limestone, forams, and clasts of mud.

Figure 14. *Hole 5, Core 1, Section 1.*



Calcarenite, coarse, mainly of white to light gray limestone chips and pebbles < 1.5 cm, fine, dense, sub-rounded to rounded; also some darker dolomite clasts, some reworked forams (*Amphistegina*, etc.).
Sand 86.9; silt 6.9; clay 6.2.
overall color pale yellow (5Y 7/3) to white (5Y 8/1); finely laminated. Note resolution of granules and pebbles in X-radiograph.

Coccolith chalk, white (5Y 8/2), base faintly layered. In top part a 4 cm cobble of white algal banded limestone.

Sand 2.0; silt 33.2; clay 64.8.

Coccolith marl, pale yellow (5Y 7/3), massive. Coccoliths and discoasters, trace foraminifera.

Total C 6.1; Org. C 0.1; $CaCO_3$ 49.7.
Water content 53.0.

Figure 15. *Hole 5, Core 1, Section 2.*

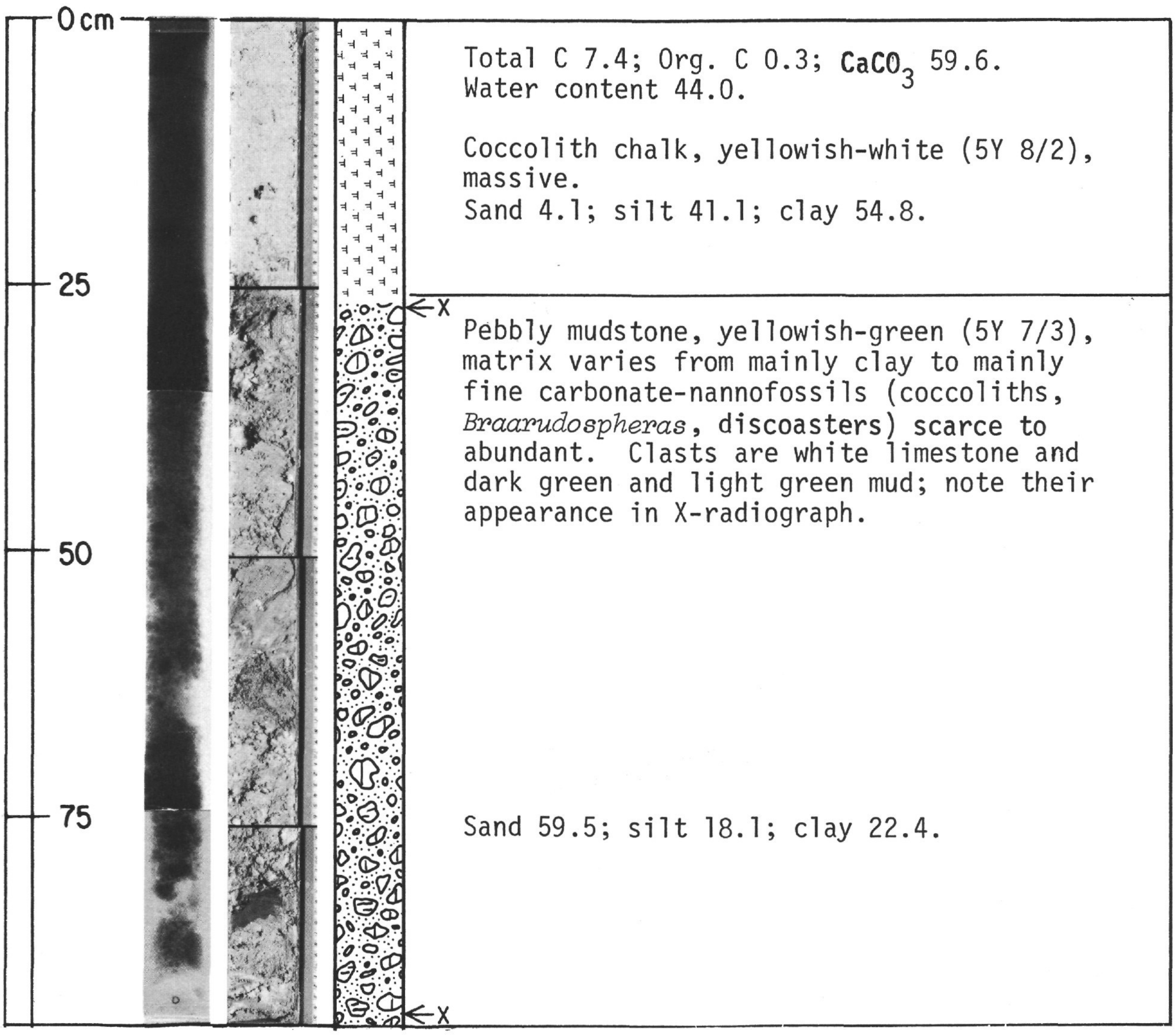
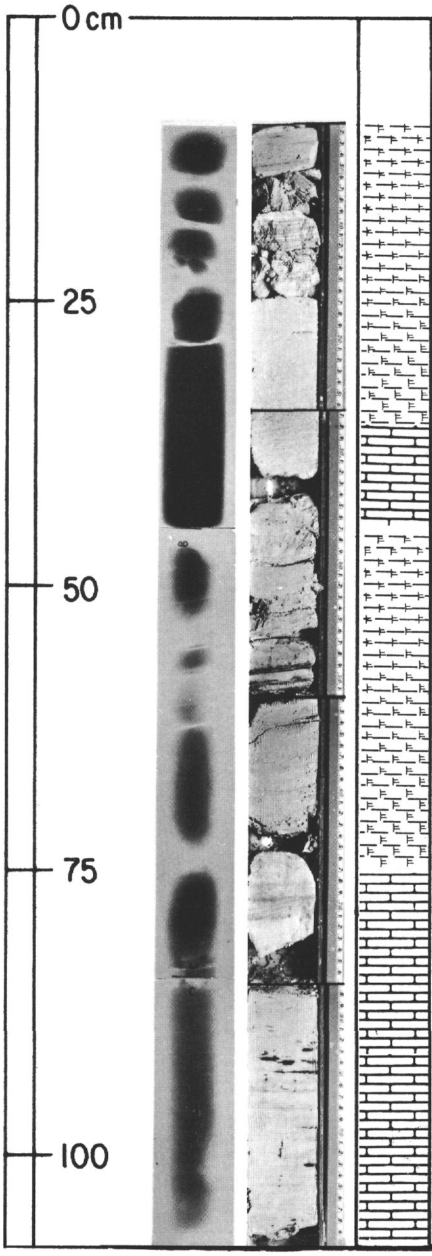


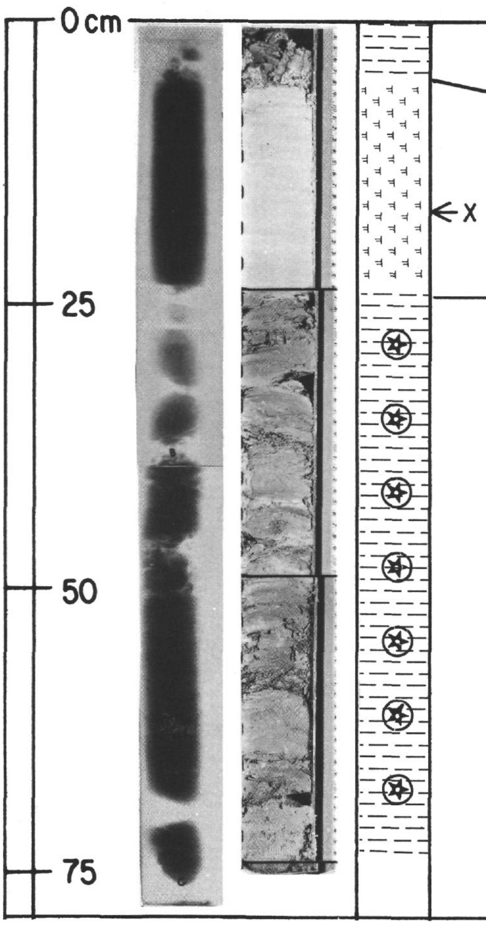
Figure 16. *Hole 5, Core 1, Section 3.*



Calcisiltite, clayey, abundant indeterminate carbonate particles in silt to sand range, some of these are micritized benthonic foraminifera; 0 - 12 finely laminated, pale yellow (2.5Y 7/2); 8 - 18 cross laminated, white. Upper part of graded sequence. 18 - 34 calcarenite, well-sorted, of indeterminate carbonate aggregates (peloids?, micritized skeletal debris?), micritized foraminifera, echinoderm debris, and cement (euhedral scalenohedra of calcite, rhombs of dolomite). Base of graded sequence. 34 - 65 nannoplankton marl, buff (2.5Y 7/4), with dark grayish brown (2.5Y laminations. 65 - 73 graded calcarenite, white white-gray. 73 - 101 coccolith marl as above, with limonite-stained and ?

Sand 0.1; silt 41.5; clay 58.4.
Total C 7.4; Org. C 0.7; $CaCO_3$ 55.8.
Water content 23.4.

Figure 17. *Hole 5, Core 2, Section 1.*



Clay, brown (10YR 6/4); fragment of dense white limestone (a clast?).

Coccolith-rich chalk, pale tan (10YR 8/3), slightly laminated.

Clay, silty, brown (10YR 6/4), massive, with relicts of shards and small clasts of altered volcanic fragments.

Bands of green (10G 7/2) chloritic clay.

Total C 0.3; Org. C 0.1; $CaCO_3$ 1.9.
Water content 31.5.

Sand 4.4; silt 38.4; clay 57.2.

Green, chloritic, silty clay (5G 5/2) with dark shard relicts and chlorite in large aggregates.

Figure 18. *Hole 5, Core 3, Section 1.*

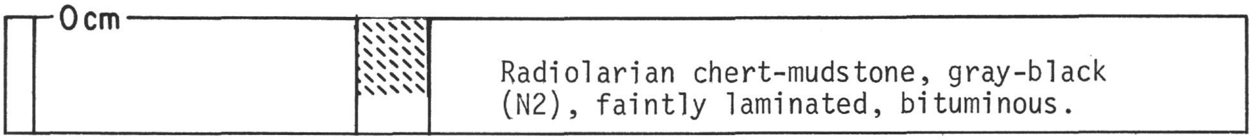


Figure 19. *Hole 5, Core 1A, Section 1.*

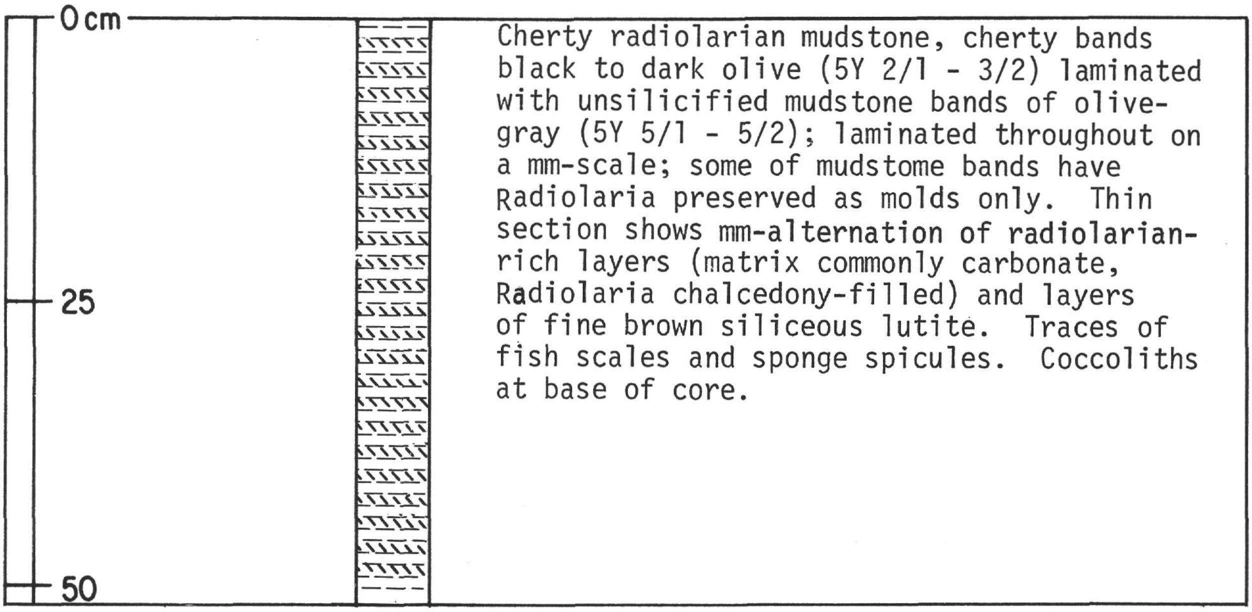


Figure 20. *Hole 5A, Core 2, Section 1.*

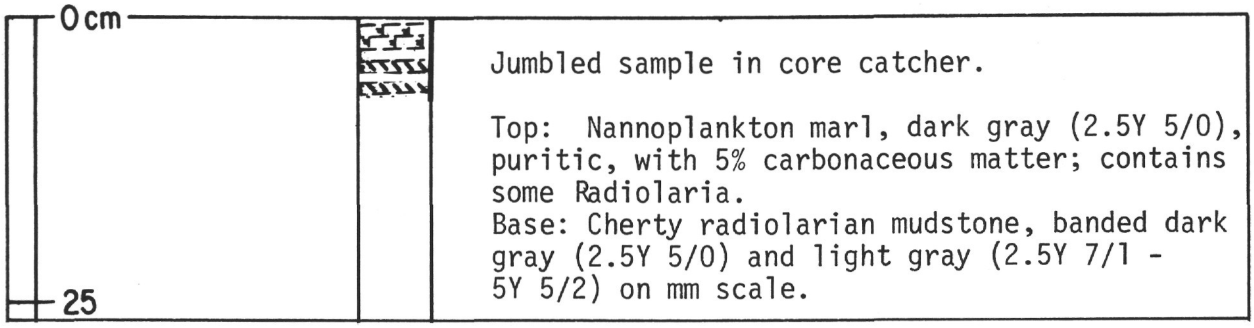


Figure 21. *Hole 5A, Core 3, Core Catcher.*

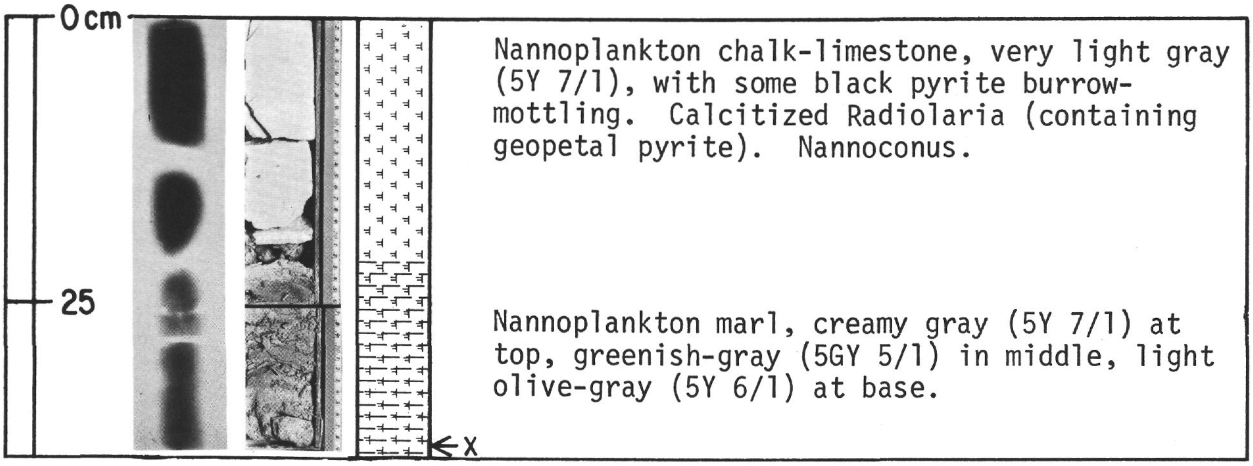
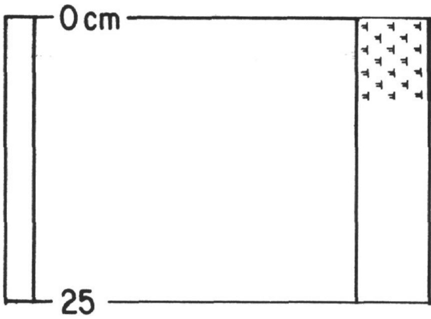


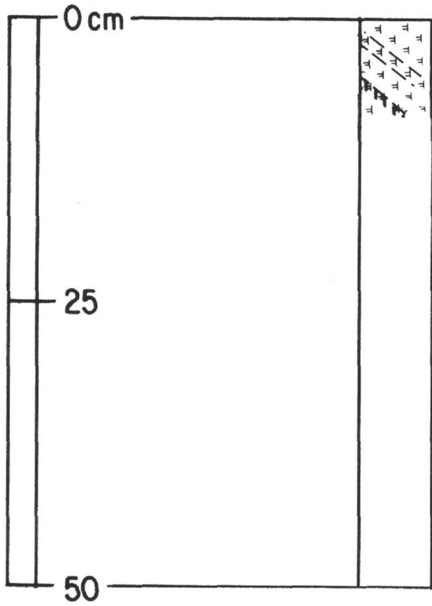
Figure 22. *Hole 5A, Core 4, Section 1.*



Core catcher sample:

Nannoplankton chalk, very hard (limestone), white to cream (5Y 8/1); rich in calcitized and in part pyritized Radiolaria. Specks of organic matter represent, in part, spores.

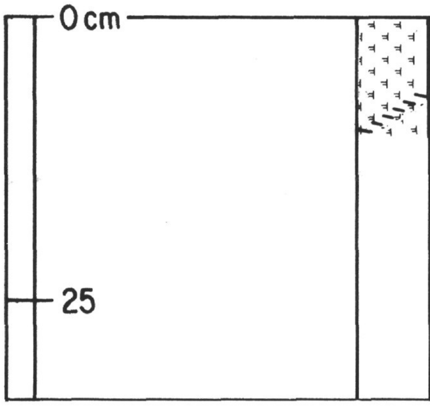
Figure 23. *Hole 5A, Core 5, Core Catcher.*



Core catcher sample, containing four rock types:

Nannoplankton chalk, white, very hard, radiolarian-rich.
Nannoplankton chalk, yellowish-gray (2.5Y 7/1), laminated (8/1 to 6/1) on a mm scale, speckled with black organic matter.
Nannoplankton marl, gray (10YR 6/1).
Chert, brown, vitreous, laminated on mm scale, appears graded.
Also a pyrite nodule.

Figure 24. *Hole 5A, Core 6, Core Catcher.*



Core catcher sample showing three rock types:

Nannoplankton chalk, very hard, white, radiolarian-rich; some of Radiolaria pyritized.
Nannoplankton chalk, light greenish-gray (5Y 7/1), with lighter and darker mm - laminations, with specks and shreds of organic matter; contains *Lamellaptychus* sp.
Chert, brownish-gray (5Y 4/1), contains abundant Radiolaria and many specks and streaks of organic matter.

Figure 25. *Hole 5A, Core 7, Core Catcher.*

Nature of the Sediments

Introduction

In view of the close proximity of Sites 4, 4A, 5, and 5A, and considering the sequences involved, it was decided to combine the discussion of these sites in order to give a more comprehensive interpretation of the total section. Other reports have cited the major stratigraphic and biostratigraphic differences between the two sites. This report will interpret the overall sequence which is revealed when the core samples are placed in their proper biostratigraphic position (see paleontological section).

Due to difficulty in recovering the cores, only part of the samples were suitable for measurement of natural gamma-radiation, GRAPE density and penetrability. Sedimentological interpretations have taken into consideration the limited core recovery. The apparent absence of Cenomanian siliceous mudstone at Site 4 has been reported. This complication will not be examined in detail here, other than to discuss depositional processes which would tend to account for such a gap.

General Description of the Sediments

The main rock types encountered at Sites 4 and 5 may be described and discussed in stratigraphic order, as follows:

(1) The oldest part of the sequence drilled consists of late Jurassic (Tithonian) and early Cretaceous (Neocomian) nannoplankton chalks and marls (Chapter 24, Plate 6, D), which vary with depth and age from compact to very compact (essentially soft limestone). The oldest of these—the Tithonian-Valanginian—contain abundant calcitized Radiolaria and are rather pyritic. Dolomite, occurring in euhedral rhombs, is a normal minor constituent throughout the section. Some of the chalks are finely laminated and speckled with organic matter. Some chert was recovered. Drilling problems, as well as poor core recoveries, suggest that it is present throughout this section. These cherts are brown to gray and vitreous. One (from Hole 5A, Core 7) contains abundant Radiolaria; another chert (from Hole 4, Core 4) retains ghosts of carbonate grains, and is seen to be a silicified graded calcarenite.

(2) Albanian and Cenomanian times brought the accumulation of nannoplankton (now forming muddier marls) alternating with the deposition of dark, finely laminated radiolarian mudstones, which had been partly silicified to radiolarian chert (Chapter 24, Plate 18). At Site 4 this section also contains massive pebbly mudstones with a matrix of clay or nannoplankton marl and terrigenous clasts of limestone. The limestone granules, pebbles and cobbles range from extremely compact calcilutites, containing scattered miliolids, to coarsely bioclastic limestones containing fragments of corals and rudistids. The Cenomanian radiolarian-rich sequence at Site 5 is absent at Site 4, as the result of a disconformity (Figure 31).

(3) At Site 5 the Turonian is characterized by green chloritic clays with shard remnants and clasts of altered volcanic debris (X radiograph, Chapter 24, Plate 4C). This would seem to indicate volcanic activity. At Site 4 it contains pebbly mudstones similar to those of the preceding episode (Chapter 24, Plate 5D), and associated graded (turbidite) calcarenites containing similar limestone clasts.

(4) The late Cretaceous is represented by an alteration of nannoplankton chalks—in part laminated and speckled with organic matter—and graded calcarenites-calcisilts composed of resedimented skeletal materials. These calcarenites may be 1.5 meters thick, may have multiple grading, and generally show lamination, and in some cases cross-lamination in their upper parts. The constituents include altered (micritized) benthonic and planktonic foraminifera, molluscan debris and echinoderm fragments. These calcarenites are generally somewhat cemented by secondary calcite, usually forming a thin crust of rim-cement (Chapter 24, Plate 17, C-F), but including millimeter-size scalenohedra. Dolomite rhombs are in a normal minor constituent (Chapter 24, Plate 18, A & B).

(5) No Paleocene or Eocene sediments were cored, but Core 1 at Hole 5 may be representative of the Tertiary section. It recovered a lower Oligocene pebbly mudstone, overlain by Lower Miocene coccolith chalk, overlain directly by Upper Miocene nannoplankton marl with the Middle Miocene missing, overlain in turn by lower Pleistocene clays and sands—a section of remnants of various sediment types separated by erosion gaps. The clasts in the Oligocene and Pleistocene include the same rock types found as clasts in the Cretaceous pebbly mudstones, and, in addition, the Pleistocene contains fragments of gray-brown sugary dolomites (of the type found in the Cretaceous and Tertiary of the Florida-Bahama platform), an abundance of resedimented larger foraminifera (Orbitoids, Nummulites, *Amphistegina, Gypsina*) of Paleogene age, bits of pink chert and clasts of brown mud.

Notable is the appearance of brown deep-sea clays near the top of Sites 4 and 5 (Chapter 24, Plate 1, A & B). At Site 5 this is limited to the Pleistocene, but at Site 4 the greater thickness of brown clay suggests that it includes Pliocene and perhaps Miocene sediment.

The brown clay contains ferruginous nodules and limonitized lumps of pumice. Nannoplankton and foraminifera are only locally present in disturbed patches.

Discussion

The Tithonian-Neocomian sediments appear to represent mainly pelagic sedimentation on the deep-sea floor, far from shore. Yet, even here there is some evidence of resedimentation: X radiographs (Chapter 24, Plate 2D) show some graded bedding, and graded calcarenites occur as shown by the above-mentioned chert. Except for their lesser degree of induration and for the lack of calpionellids, these sediments closely resemble the "Aptychus limestones" (Oberalm limestone, Majolica, Biancone, etc.) of equivalent age, in the Alps and Mediterranean mountain belts as well as in the Near East and in Cuba (Garrison, 1967; Garrison and Fischer, 1969).

The cherts are diagenetic replacement phenomena, and the silica within them is presumably derived from siliceous skeletons, such as the calcitized radiolarians.

The preservation of organic matter and fine laminations in some of these chalks shows that, at times, the bottom was not habitable by scavenger organisms—more specifically, the bottom waters were at times anaerobic.

The muddy marls and radiolarian mudstones of Albian and Cenomanian times are indicative of more complicated depositional conditions. The darkness of many of these sediments suggests continued episodes of anoxia on the sea floor. The appearance of radiolarian mudstones suggests that the area hovered at this time at the carbonate compensation depth. The pebbly mudstones of Site 4 contain limestone clasts which seem to represent the backreef and reef facies, respectively, and their induration shows diagenesis—probably fresh-water induced—prior to resedimentation. This suggests that there was tectonic activity which elevated shelf areas with only slightly older limestones, and directed mudflow activity off these areas. The edge of the Bahama Banks may have been only a few tens of miles away, and this would appear to be the nearest source for these clasts.

The disconformity (Figure 31) which cuts out part of the Cenomanian in Site 4 appears to coincide with the site of pebbly mudstone emplacement over a long geological timespan, suggesting that Site 4 coincides with a topographic depression which served as a channel for mudflows and turbidity currents.

In late Cretaceous time conditions were quieter. The preservation of fine laminations in some of the Campanian-Maestrichtian chalks indicates that there were stagnant bottom conditions. The graded calcarenite beds in this sequence are interpreted as turbidites derived from near-by shelf areas. Alteration of skeletal debris and cementation show that diagenetic stabilization processes operated on what was presumably deep-sea floor—out of reach of fresh waters.

Through mid-Tertiary time sedimentation was sporadic and the succession was broken up by many disconformities and erosional gaps. Carbonate sediments continued to be deposited from time to time, but by late Tertiary times the succession was dominated by brown deep-sea clays. The sea floor now lies definitely below the carbonate compensation depth, and such calcareous sediments, as are preserved in the clay sequences, were presumably brought in en masse by slumping or turbidity currents.

In summary, a quiescent period of pelagic carbonate sedimentation in Tithonian-Neocomian time was followed by a time when radiolarian oozes repeatedly replaced calcareous sediment (carbonate compensation depth), while mudflows brought in terrigenous pebbly mudstones. Calcareous pelagites dominated the Upper Cretaceous, while periodic turbidity currents brought in shelf sediment. The late Cenozoic was characterized by many disconformities, and continued resedimentation of older carbonates; brown clay became the normal pelagic background sediment. Throughout the Cretaceous there are signs of episodic bottom stagnation.

Physical Properties of the Sediments

As noted previously, gamma-ray and GRAPE responses correspond well with lithological variations noted in the core descriptions. Core 1 from Hole 4 is an excellent example. Note that the carbonate sand shows a high bulk density and low gamma-ray count as compared to the underlying clay unit. The mixed contact zone is also well represented by curve response of the GRAPE trace. As explained previously, gamma-ray response is integrated over a broader interval, thus fine-scale phenomena tend to be "smeared." A decrease in gamma-ray count and bulk density near the base of the core appears to correspond with a color change since no basic lithological difference was noted in the core description.

Core 2 from Hole 4 shows a somewhat different set of physical measurements derived from a graded carbonate sand and pebbly mudstone suite of lithologies overlying coccolith ooze. Whereas the graded carbonate sand shows a higher bulk density and lower gamma-ray count, there appears to be little difference between the coccolith ooze below and the pebbly mud above. This is apparently because the clay component of the pebbly mud is of the same composition and state of consolidation as the underlying pelagic coccolith ooze. This can be contrasted with Core 3, which contains a high proportion of pebbly clay. The low density segments are apparently due to mechanically disturbed intervals.

Gamma-ray counts are apparently somewhat higher due to the more clay mineral-rich nature of the matrix as compared to Core 2.

Core 1 from Hole 4A represents a less successful example of lithological discrimination on the basis of physical measurements. Subtle differences in bulk density and gamma-ray count appear to correspond with profound textural differences. Note that the carbonate sand units overlying the fine-grained interval at approximately 300 centimeters show very little variation. The high gamma-ray count at 300 centimeters is apparently due to a local, relatively high concentration of clay-minerals. The carbonate sand and calcilutite below this horizon appear more or less the same in terms of curve response, and are apparently more consolidated than overlying sediments.

Core 1 from Hole 5 contains a varied assemblage of lithologies which correspond well with curve response. The uppermost sequence of laminated brown silty clay with thin intercalations of graded quartzose silt are represented by a highly variable bulk density curve and a high gamma-ray response. This type of response was previously noted at Site 1. The "laminite" unit overlies a partially-graded carbonate pebbly calcarenite with a high bulk density and low gamma-ray count as normally expected. This unit in turn sharply overlies a low bulk density coccolith ooze with a correspondingly low gamma-ray count. The base of Core 1 contains a pebbly mud unit with higher bulk density (due to a higher clay-mineral content). The remaining cores show relationships more clearly demonstrated by examples previously discussed.

Averaged determinations of natural gamma-radiation, GRAPE and penetrometer are shown in Figure 3. Although measurements are somewhat limited or lacking for some of the cores, an idealized trend using the total sequence encountered at both Sites 4 and 5 can be generated.

Natural gamma-ray determinations show two main maxima: one at the top of the sequence and the other at the level of Core 3, Hole 5. Both maxima are thought to represent clay mineral-rich sequences as noted in the lithological descriptions. A third, less pronounced maximum is represented by Core 2, Hole 4A and Core 3, Hole 4. These intervals also have a significant amount of clay mineral and terrigenous detritus as compared to the carbonate-rich sequences which comprise the remainder of the bore hole.

Penetrometer readings show a general decrease downward, representing consolidation and cementation of the sediments. The thick chert unit in Core 1 (Hole 5A) and Core 2 (Hole 5) was not measured with the penetrometer, but is obviously quite hard and is shown as such in Figure 3. In addition to the semi-consolidated sediments present below that level, there are thin, quite hard or consolidated cherts and calcilutites which are not shown in Figure 3.

Penetrometer readings show a general tendency to be lower in the pelagic units as compared to the finer-grained segments of turbidite and fluxo-turbidite sequences. Although textural differences exist between obvious pelagic units and fine-grained interbeds of a graded sand sequence, it might be suggested that such units consolidate at different rates and by different processes. A more thorough study of these differences is suggested as a rewarding area of future investigation.

GRAPE determinations, although somewhat questionable due to the uneven coverage and general broken condition of the core, shows a general decrease in porosity and increase in bulk density with depth. The sediment interval immediately overlying Core 2, Hole 4 shows the most marked minimum, suggesting that an increase in clay-mineral component is responsible. Much of the variation shown by the GRAPE curve in the overall sequence is probably partially due to differences in grain-density between clay minerals and carbonate minerals. The gross correspondence between penetrometer value and bulk density reinforces the general interpretation of consolidation with depth regardless of lithology.

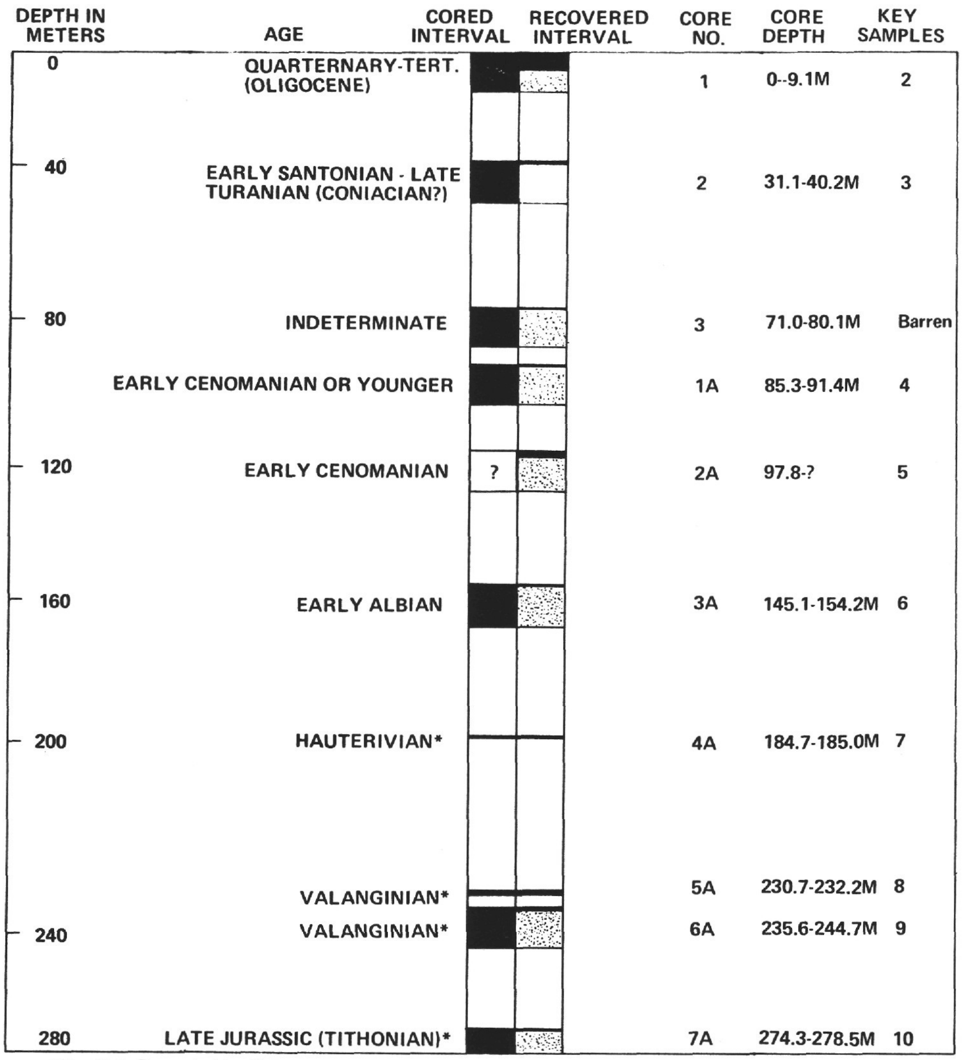
Several sonic velocity measurements were attempted on unsheathed samples of sediment from the lower portion of Hole 5A. For several reasons the results appeared to be unsatisfactory. Sonic velocities in the range of 2.8 to 3.8 kn/sec were obtained in the chert section (Core 1, Hole 5A and Core 2, Hole 5A). Repeated attempts to attain better precision resulted in loss of precision as well as accuracy, and measurements were discontinued.

Biostratigraphy

Foraminifera and Radiolaria

The biostratigraphy of Site 5, as deduced from the planktonic foraminifera and Radiolaria is shown in Figure 26. The faunas of the samples listed in Figure 26 are discussed below. As with previous sites, the faunal lists are not necessarily complete or representative, but show only the most common or significant species. In Samples 3 through 10, A equals Abundant (6 or more specimens); C equals Common (3-5 specimens); R equals Rare (1 or 2 specimens).

Sample 1 (1-5-1-1, top):
Orbulina universa, Hastigerina siphonifera, Globigerinoides conglobata, G. rubra, Globorotalia menardii, G. inflata and various rotaliids.



*See Data Presented by Bukry.

Figure 26. *Biostratigraphy of Site 5 as deduced from the foraminifera and Radiolaria.*

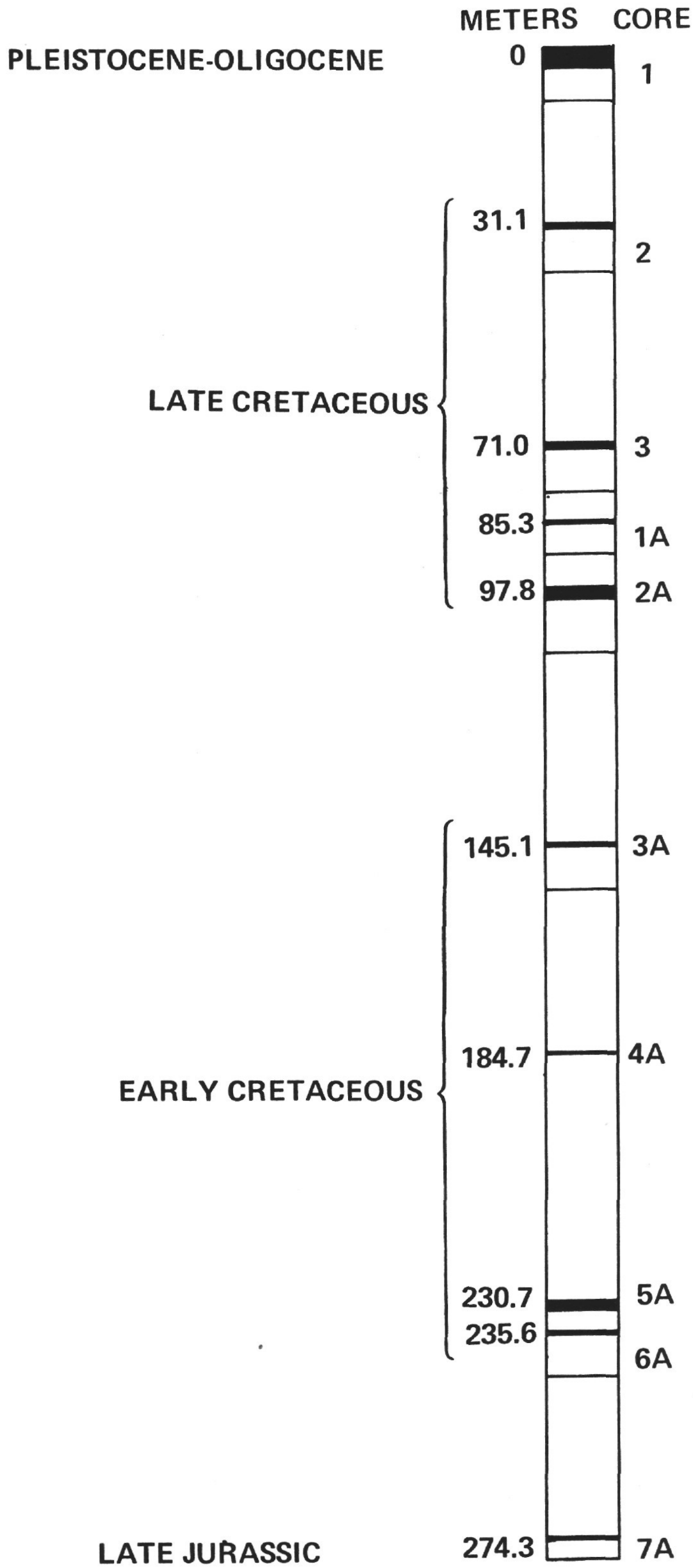


Figure 27. *Biostratigraphy of Site 5 as deduced from the calcareous nannoplankton.*

Sample 2 (1-5-1-3, core catcher):
Pseudohastigerina sp. cf., *P. naguewichiensis*, *Globigerina ouachitaensis*, *G. praebulloides*, *G. officinalis*, *G. anguliofficinalis*, *G. senilis* with *Globorotalia lensiformis* (Lower Eocene), *Globigerapsis* sp. (middle-late Eocene) with various benthonic rotaliids, *Nuttalides* sp., bolivinids, buliminids.

Discussion:
Samples from Core 1 contain turbidite sediments with an abundant admixture of Eocene-Miocene larger foraminifera (see report by K. N. Sachs, Chapter 18). Planktonic foraminifera of Eocene, Oligocene, Miocene and Pliocene age also occur in this core. A sample at 33 to 36 centimeters in Section 2 has yielded, among other forms, *Globoquadrina dehiscens, G. praedehiscens, Globorotalia praescitula, G.* ex. gr. *praehirsuta-margaritae, Globigerina ampliapertura, Globigerapsis* sp. and various benthonic rotaliids. On the basis of the presence of *Orbulina* in this sample an age of late Miocene-Pliocene is suggested. At 133 to 152 centimeters in Section 2, a fauna including *Globoquadrina venezuelana, G. rohri, G. dehiscens, G.* sp. ex. gr. *G. larmeui-baroemoenensis, Globigerinoides* sp. cf. *G. altiapertura, Globigerinita dissimils, Globorotalia peripheroronda* and *Globigerina selli* was found. On the basis of the absence of *Orbulina* and the presence of *Globigerinoides* and *Globigerinita dissimilis* an age of early Miocene is suggested for this level.

Sample 3 (1-5-2-1, core catcher):
Marginotruncana canaliculata (Reuss) R, *Heterohelix reussi* (Cushman) R, *Globigerinelloides asperum* (Ehrenberg) R, *Marginotruncana* sp. (double keeled form with curved, raised sutures umbilically; broken).
Age determination: Early Santonian to late Turonian. *M. helvetica* Assemblage Zone, *W. archaeocretacea* Subzone to *G. bulloides* Assemblage Zone, *M. concavata* Subzone.

Sample 4 (1-5A-1-1, core catcher):
Thin-section examination: *Rotalipora reicheli* Mornod?, *Rotalipora appenninica* (O. Renz)?
Age determination: Late early Cenomanian or younger. *Rotalipora* s.s. Assemblage Zone, *R. evoluta* Subzone or younger.

Remarks: A single planoconves planktonic foraminifera resembling *R. reicheli* Mornod was observed together with a form resembling *R. appenninica* (O. Renz) in thin-section.

Sample 5 (1-5A-2-1, core catcher):
Rotalipora evoluta Sigal, *Rotalipora appenninica* (O. Renz)?, *Clavihedbergella subcretacea* (Tappan), Radiolaria of Cenomanian aspect present.
Age determination: Early Cenomanian (see data presented by Bukry and Bramlette, Chapter 15). *Rotalipora* s.s. Assemblage Zone, *R. evoluta* Subzone.

Remarks: Identifications from thin-section analysis. Preservation poor.

Sample 6 (1-5A-3-1, core catcher):
Hedbergella modesta Bolli C, *Schackoina pustulans* Bolli C, *Globigerinelloides* sp. C.
Age determination: Albian–probably early Albian.

Remarks: Abundant, well preserved Radiolaria showing little relation to those of early Cenomanian. Majority of species are new and thus undescribed. A few of the more distinctive members of this assemblage are illustrated in Plates 2 through 5 (Chapter 25).

Sample 7 (1-5A-4-1, core catcher):
Abundant, poorly preserved calcified and pyritized Radiolaria.
Age determination: Hauterivian (see Bukry and Bramlette, Chapter 15).

Sample 8 (1-5A-5-1, core catcher):
Thin-section only: Radiolarian assemblage has a Jurassic aspect.
Age determination: Valanginian-Tithonian (see Bukry and Bramlette).

Sample 9 (1-5A-6-1, core catcher):
Radiolaria common to abundant. Best preserved material pyritized; occurring in lutite facies. (See Plate 5D; Chapter 25).
Age determination: As Sample 8.

Sample 10 (1-5A-7-1, top):
Spongosaturnalis dicranocanthos (Squinabol) A, *"Theosyringium" amaliae* Parona? A, *"Lithocampe" mediodilatata* Rust?, *"Rhopalastrum" spinosum* Parona, plus other forms that are seemingly new; see Plate 1, Chapter 25.
Age determination: Jurassic. Bukry's and Bramlette's nannofossil data indicates Tithonian.

Remarks: *Spongosaturnalis dicranocanthos* (Squinabol) (Plate 1, A & B) has been recorded from the Jurassic of Italy.

Calcareous Nannoplankton

The biostratigraphy of Site 5, as deduced from the calcareous nannoplankton, is summarized in Figure 27. For a detailed account of the faunas, see the report by Bukry and Bramlette (Chapter 15).

SUMMARY: HISTORICAL AND REGIONAL ASPECTS

The background discussion for Site 4 is equally applicable to Site 5. Both sites were located in an area where the oldest known sediments in the deep ocean crop out a short distance east of the Bahama Platform. Site 5 was located about 20 miles north-northeast of Site 4 in an attempt to obtain even older sediments and to examine any lateral variations within the Tertiary and Cretaceous. Difficulties were encountered in accurately locating Site 5 due to breakdowns in the satellite navigation system and the reflection profiler, but the drilling successfully recovered sediments of uppermost Jurassic age. As at Site 4, the Cretaceous cherts again presented serious drilling problems.

Site 5 was situated approximately 60 miles northeast of the island of San Salvador, as shown in Figure 28, between the Bahama Platform and the Hatteras Abyssal Plain. Several significant records were set at this site for drilling in the oceans, including: the water depth of 5354 meters (17,567 feet) and the longest string of drill pipe used in deep water (18,523 feet), as well as the oldest rocks yet recovered from the deep ocean. The deepest penetration below the sea floor at this site was 281 meters (923 feet).

Numerous geophysical surveys by Lamont-Doherty Geological Observatory have revealed several prominent seismic reflecting horizons useful in deciphering the history of the deep oceans; these are shown in Figure 29. They have been discussed in the regional summary for Site 4, and it is adequate to note here that these have been designated Horizons A, β and B, in order of increasing depth beneath the sea floor. Piston cores in the northwest part of the area have recovered Aptian-Albian and Cenomanian sediments, an age which now appears to represent the interval below Horizon B. Two piston cores to the east recovered Maestrichtian rocks (near Horizon A), and near Site 5 recovered upper Neocomian (Hauterivian-Barremian) well below Horizon β (Windisch *et al.,* 1968). The small open circles near Site 5 mark several small hills which appear to be outcrops of Horizon β (the largest was referred to as Mt. Reproach by the shipboard scientists).

As at Site 4, the section here is abnormally thin, again due to many small hiatuses in the sequence rather than to unusually low rates of sedimentation. The details given in Figure 31 permit a comparison of the sections. A core at the sea floor recovered Oligocene to Pleistocene sediments with the Pliocene and much of the Miocene missing, but there were reworked Eocene, Oligocene, Miocene, and Pliocene fossils in the Pleistocene. Also cored were Turonian to lower Santonian sediments (coccolith ooze, chloritic clay, scattered volcanic fragments), middle and lower Cenomanian, Barremian, Valanginian and Tithonian sediments (all coccolith oozes and chalks, and radiolarian cherts). Carbonate turbidites containing both shelf-derived detritus and reworked pelagic oozes, thus dominated the Tertiary and Cretaceous. Silicified siltstones and radiolarian cherts, interbedded with unconsolidated carbonates, are notably abundant in the Lower Cretaceous and uppermost Jurassic. Turonian volcanism is also indicated.

This sequence of sediments, as at Site 4, strongly suggests that at least since latest Jurassic this area was open and deep, with water depths approximating those of today. The seismic reflection data also show that there is as much sediment below the drilled depth as the thickness already penetrated. Horizon B was not reached, but the reflection profiles point to the fact that it also may be largely or partly sedimentary. The prominent magnetic anomalies near Mt. Reproach indicate that volcanic rocks might also be involved.

The cherty Cenomanian mudstones found at Site 5 were not cored at Site 4, where only pebbly calcareous sediment was recovered. However, these samples may be of slightly different ages, rather than representing a facies change; and the known vertical variations within a single core are prominent. The recovered cores at both sites generally were meager, and different coring bits were used at the two sites.

Horizon β is marked, apparently, by the mid-Cenomanian unconformity, which also can be recognized north and east of Mt. Reproach, but it is not apparent to the southwest toward Site 4. The uplift of Mt. Reproach appears to have occurred largely later than the Horizon β unconformity; there is also some suggestion of possible earlier growth. The dip of the beds increased to 15° at the deepest penetration, and it is likely that, at most, only a part of this was due to hole deviation.

Ammonite aptychi occur in the Valanginian and Tithonian samples–similar to the aptychus limestone which is found at this time interval throughout the Tethyan area. Compared to the Alps, where these beds might be compared to the base of the coccolith-aptychus sequence, Horizon B could be radiolarian cherts and the body of B could be older sediments or ophiolites.

As at Site 4 it would appear that calcareous deposits, even organic oozes, can be preserved below the depth of carbonate compensation if they are brought into the area rapidly and in large quantities–as in turbidites.

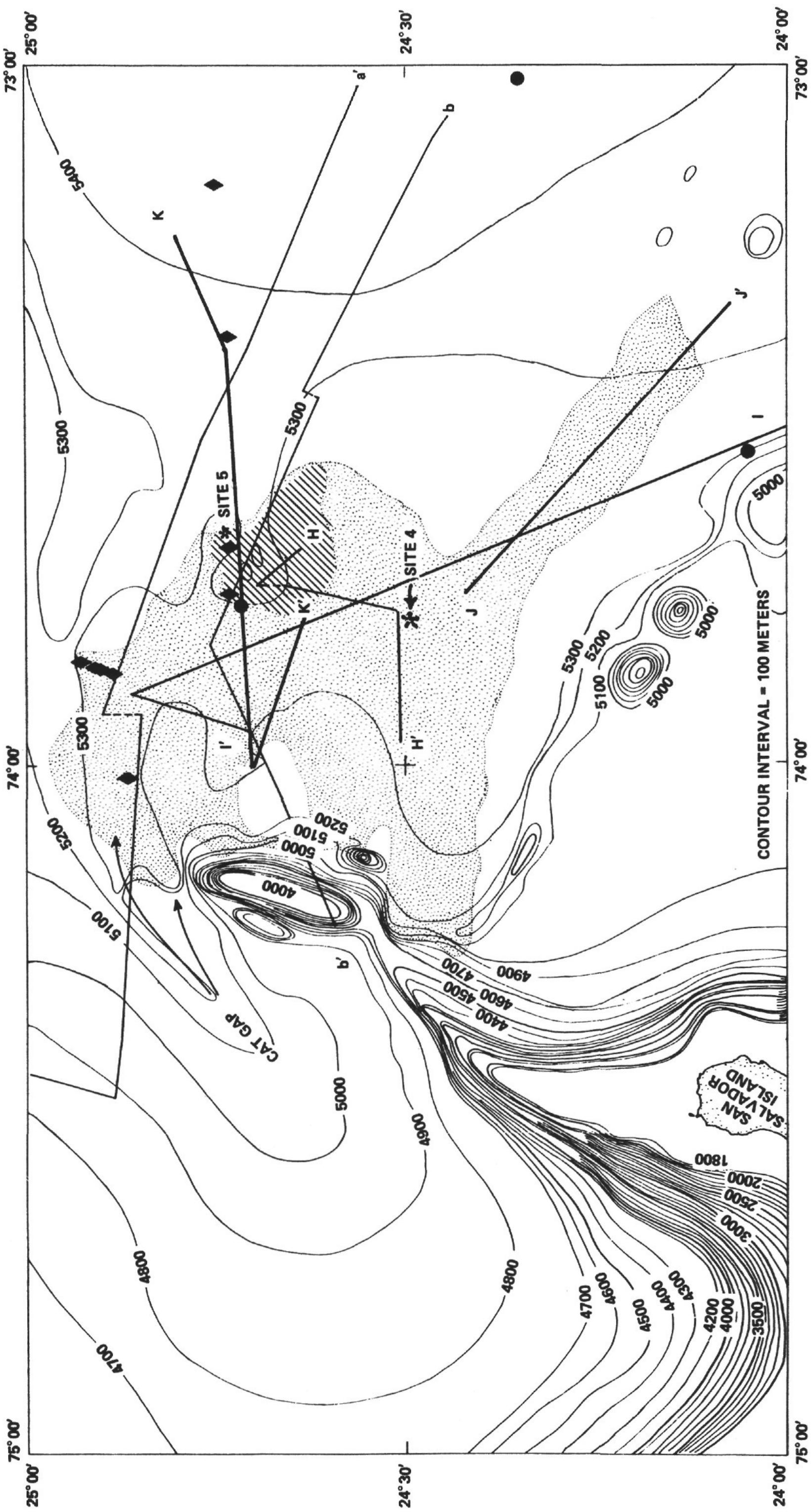
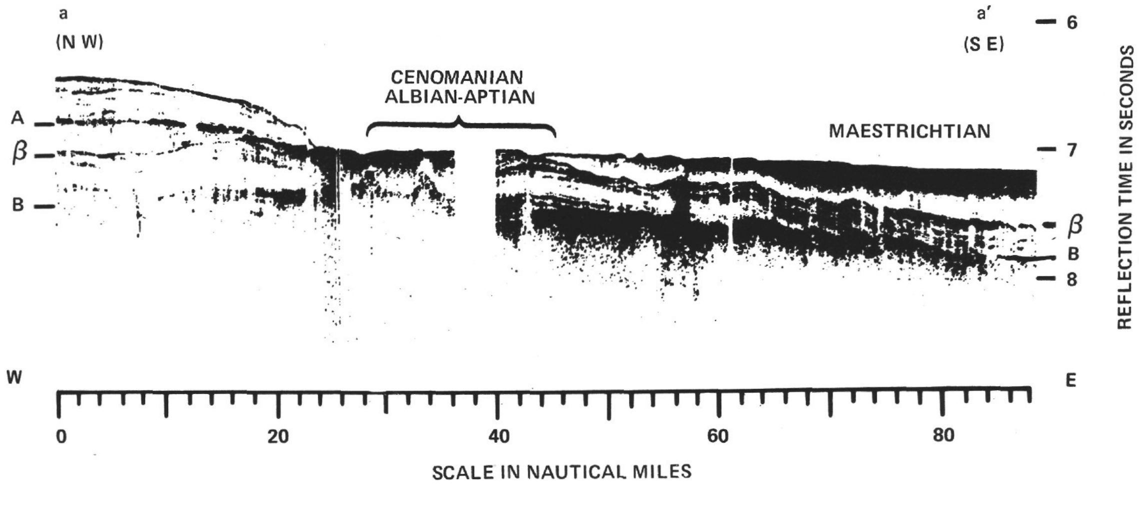


Figure 28. *Bathymetric chart of the seismic Horizon β outcrop area showing Sites 4 & 5 and the results obtained by piston coring. Outcrop of β is stippled and the oldest outcropped sediments are indicated by hachures. Solid diamonds indicate Cretaceous cores (after Windisch* et al., *1968).*



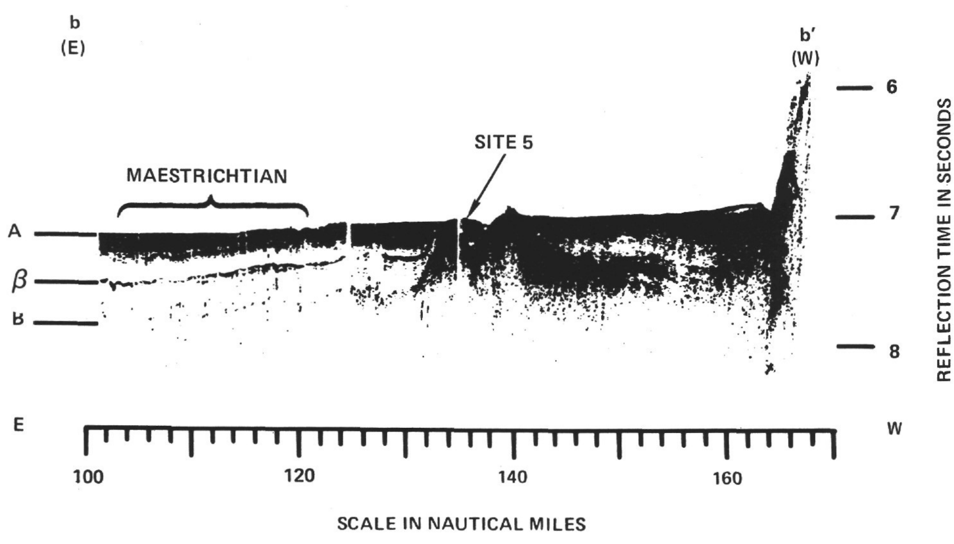


Figure 29. *Profiler sections near Site 5. Locations are indicated in Figure 28.*

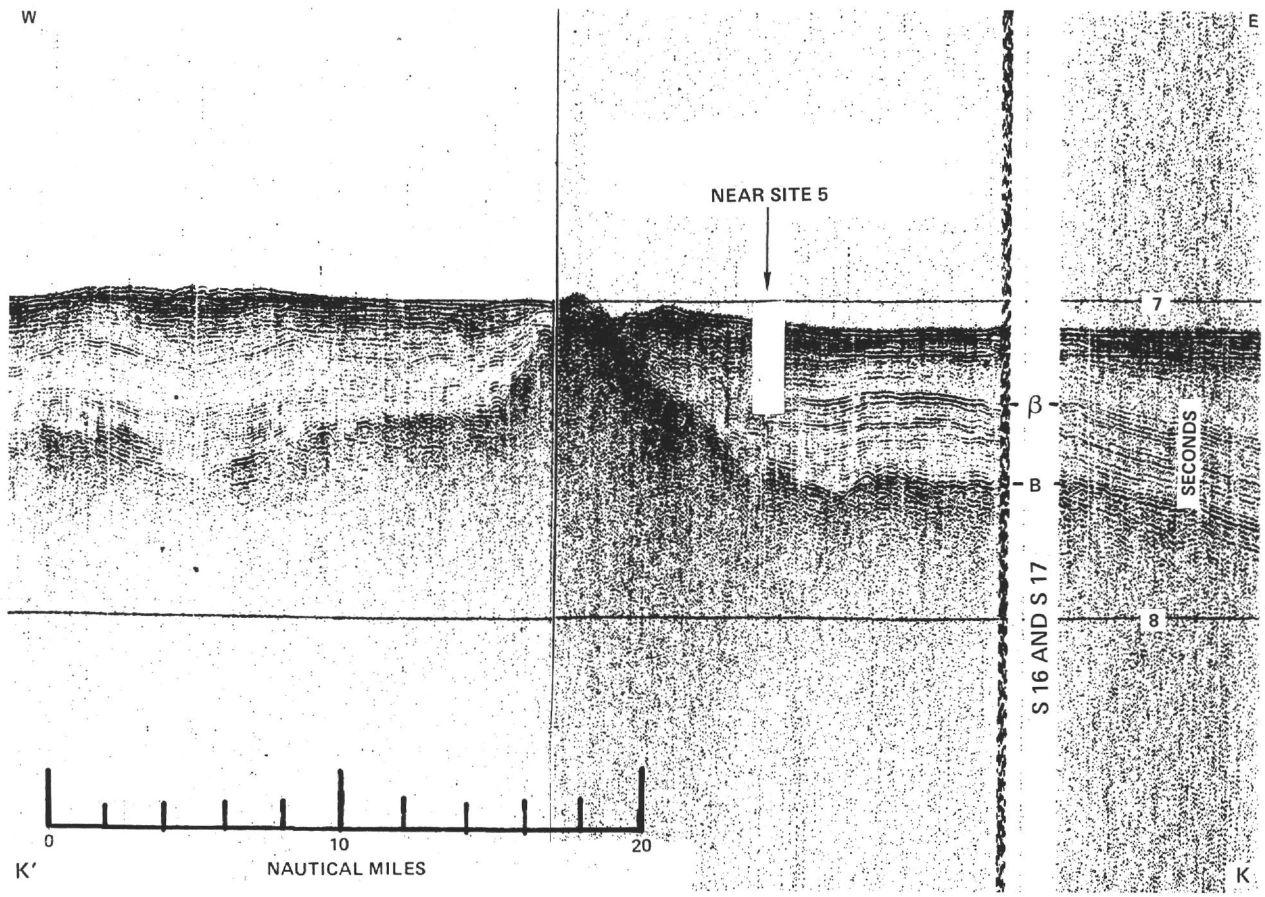


Figure 30. *Profiler traverse near Site 5. Location shown in Figure 28.*

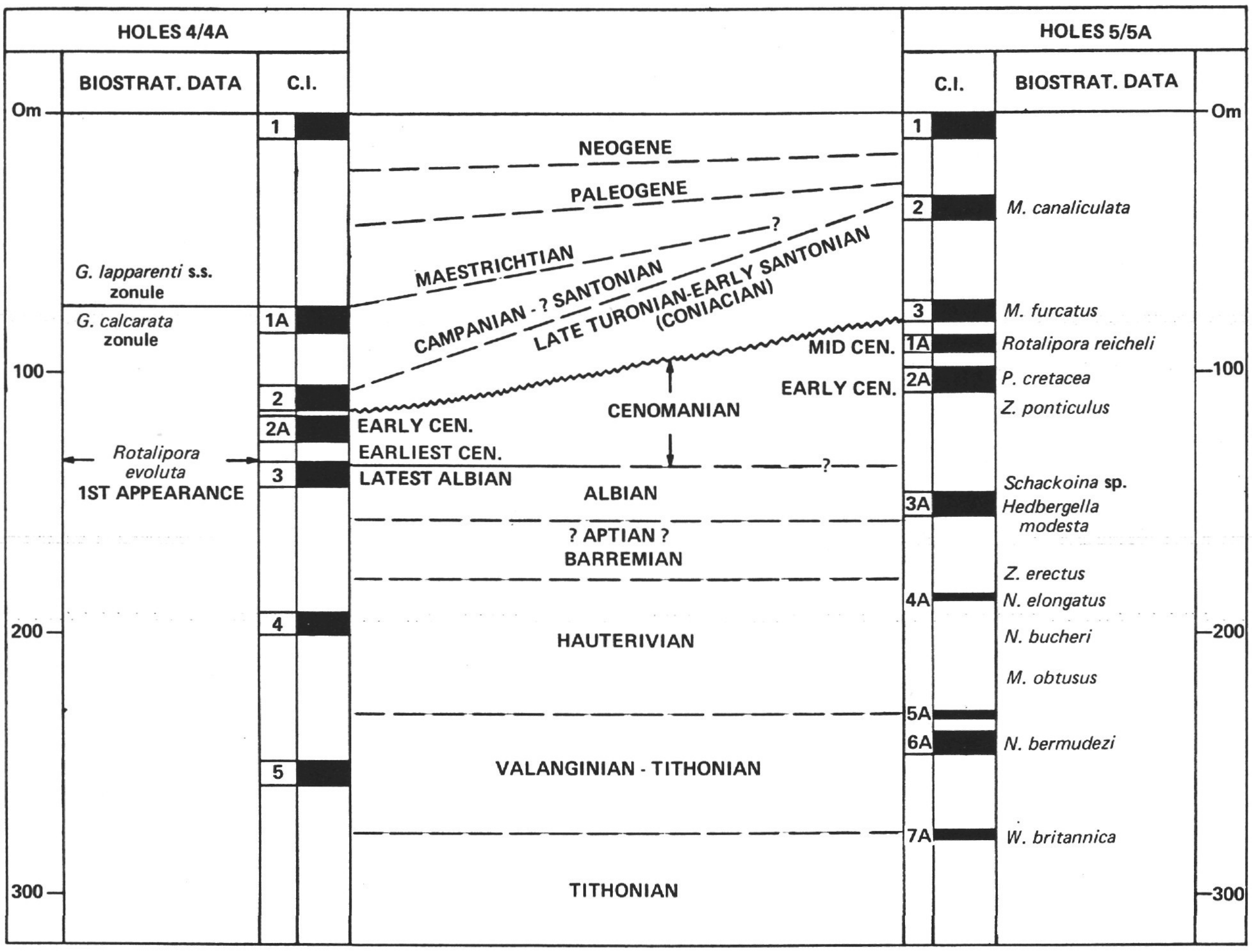


Figure 31. *Stratigraphic sections for Sites 4 and 5.*

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