6. SITE 11

The Shipboard Scientific Party[1]

SITE REPORT

Objectives

Because of insufficient time, the locality originally designated for Site 11 by the Atlantic Advisory Panel was not drilled. Instead, Site 11 of this report—formerly designated as 12—is located on the upper portion of the western flank of the Mid-Atlantic Ridge, (lat. 29° 29′N; long 45° 07′W). The general topography of this location is that of a northwest-southeast trending plateau that is bordered by a moderate scarp on the north and a scarp of considerable relief (600 fathoms or 1100 meters) on the south. The southern scarp is believed to be one of many east-west trending fracture zones of a transform fault system. It appears that the scarp is offset slightly northeast-southwest at two or three points within the survey area. The surface of the plateau is formed by numerous sediment pockets that are separated by steep peaks of the basement (Figure 1). Site 11 is located on one of these pockets which contains about 800 feet of acoustically transparent sediment. Piston core samples from this region show high carbonate percentages. The sediment column at Site 11 shows no evidence on seismic records of strong reflectors. The major objective of Site 11 was to provide an additional evidence pertaining to the concept of sea floor spreading. Therefore, the section that includes the sediment directly above the basement, the contact of the igneous and sedimentary rocks, and five to ten feet of basement rock were of primary concern. The shipboard paleontologists were interested in coring the Pliocene-Pleistocene boundary. In addition to these programs, the mechanical functioning of the von Herzen heat-flow probe was to be tested in the core barrel.

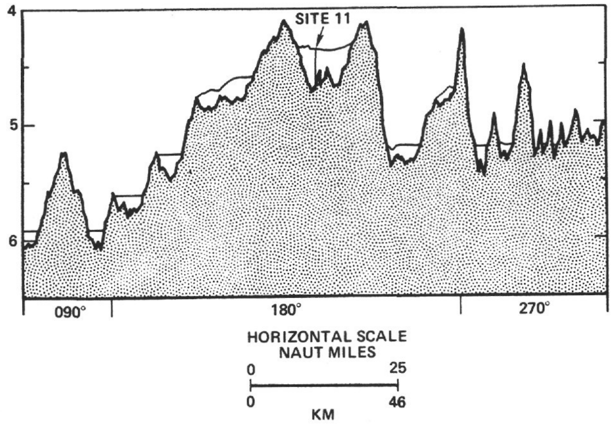

Figure 1. *Line drawing of profiler record made by* Vema *of Lamont-Doherty Geological Observatory showing typical acoustical subbottom features in the region of Site 11.*

The following drilling prospectus was formulated:

(1) With heat probe and core barrel in place, the drilling was to proceed to a depth of 50 feet (15.2 meters) below the sea floor. The core was to be punched for several feet in order to release the heat probe mechanism. Core 25 feet (7.6 meters).

(2) Replace the center bit and drill to 700 feet (213.4 meters) below the sea floor.

(3) Attempt continuous coring until the basement is reached, then continue coring for 45-60 minutes.

(4) Core the basement rock for 4 to 5 hours in a separate barrel.

(5) Pull out of Hole 11 and initiate coring at Hole 11A within the upper 700 feet (213.4 meters) of sediment, and test the heat probe again on the last core.

No well logging was planned.

Drilling and Coring Log

At 0400 hours, November 9, final positioning for Hole 11 was accomplished in 11,664 feet (3556 meters) (corrected) of water at a location defined by the coordinates: latitude 29° 56.58′N and longitude 44° 44.80′ W (Figure 2). Figure 3 shows a tracing of the seismic profile made by *Glomar Challenger* across the drilling site. The drill string included a

(1) Hycalog tungsten carbide, blade bit,

(2) 14 drill collars and

(3) 1 bumpersub.

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The reader is referred to Table 2 for a summary of the coring operations. The upper 46-foot (14 meter) section of sediment was penetrated without the center bit. On the first coring attempt, the inner core barrel contained the experimental heat-flow probe casing, and a 30-foot (9 meter) core was cut at a rate of 300 feet (91.4 meters) per hour. At 1230 hours, November 9, Core 1 was recovered and it contained 20 feet (6.1 meters) of Pliocene and Pleistocene calcareous mud. The heat-flow probe had operated properly; but the plastic liner was broken at the final position of the core liner was severed at the final position of the probe. The center bit was dropped down the drill pipe and drilling progressed to a depth of 920 feet (280.4 meters) below the sea floor. It had been the intent to cut another core at this depth, but the center bit could not be extracted. The decision was made to continue drilling until the exact depth to the basement was determined and then to abandon the hole. After drilling only an additional few feet, basement was encountered and the drill string was disassembled.

At Hole 11A, drilling progressed to a depth of 760 feet (231.6 meters) below the sea floor. At this depth, preparations were made to drill continuously to the basement. A 30-foot (9 meter) core was cut at 300 feet (91.4 meters) per hour for each of Cores 1 and 2. At 0300 hours, November 11, Core 1 was recovered and it contained no core or traces of sediment in the liner or core catcher. At 0400 hours, November 11, Core 2 was recovered and it contained one foot (.3 meter) of Miocene calcareous sediment. A 30-foot (9 meter) core was cut at 150 feet (45.7 meters) per hour for each of Cores 3, 4, and 5. At 0600 hours, November 11, Core 3 was recovered, and it was in the same condition as Core 1. At 0730 hours, Core 4 was recovered, and it contained 20 feet (6.1 meters) of Miocene calcareous sediment. At 0910 hours, November 11, Core 5 was recovered, and it was found to be empty; so also for Core 6 at 1115 hours. Therefore, the sediment-basement contact was not sampled. For Core 7, a 13-foot (4 meter) length of core was cut in 174 minutes, and one foot (0.3 meter) of basalt with an interbed of Miocene calcareous sediment was recovered. For Core 8, one foot (0.3 meter) of core was cut in two hours, but no further basalt was recovered.

At Holes 11 and 11A and a maximum penetration of 932 feet (284.1 meters) below the sea floor was reached. A total length of 22 feet (6.7 meters) of core was recovered, and the average recovery rate was 13 per cent.

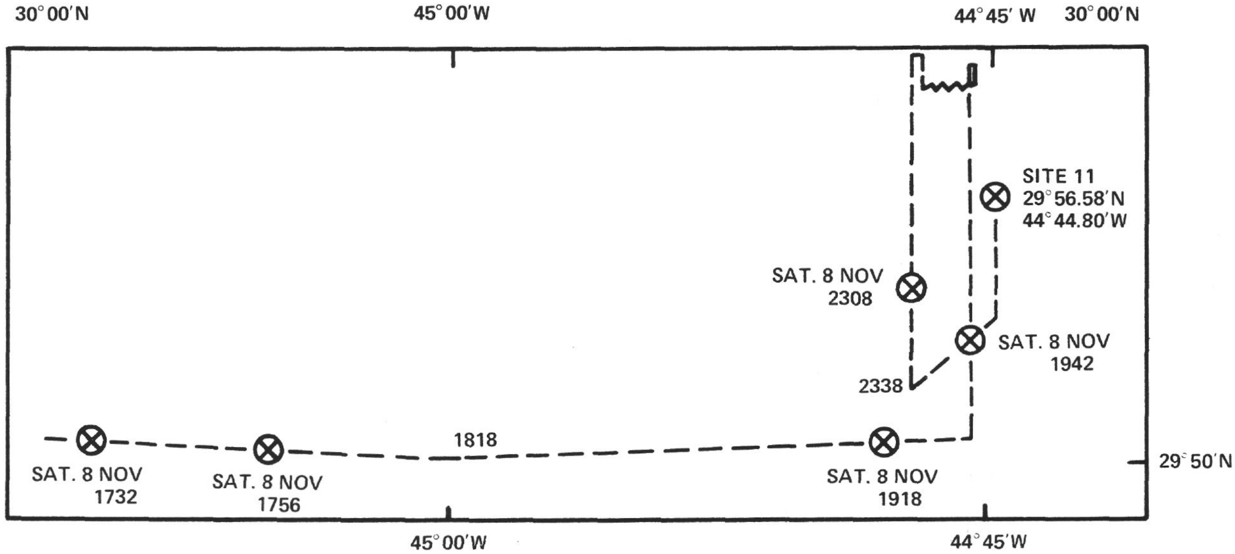


Figure 2. *Chart showing* Glomar Challenger's *approach to Site 11.*

TABLE 1
Drilling Summary

Hole 11
(lat 29° 56.58′N.; long 44° 44.80′W.; depth 3571 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	ft	Depth Below Sea Surface m	ft	Core Cut ft	m	Core Recov. ft	m	% Core Recov.	No. of Sections
1230		14.0	46	3585	11,762						
9 Nov	1	23.2	76	3595	11,792	30	9.14	20		66	4

Hole 11A
(lat. 29° 56.58′N., long 44° 44.80′W.; depth 3571 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	ft	Depth Below Sea Surface m	ft	Core Cut ft	m	Core Recov. ft	m	%Core Recov.	No. of Sections
0300		231.7	760	3803	12,476						
11 Nov	1	240.8	790	3812	12,506	30	9.14	0	1.0	0	0
0420		240.8	790	3812	12,506						
11 Nov	2	249.9	820	3821	12,536	30	9.14	1	0.30	3	0[a]
0600		249.9	820	3821	12,536						
11 Nov	3	259.0	850	3831	12,566	30	9.14	0	0	0	0
0730		259.0	850	3831	12,566						
11 Nov	4	268.2	880	3840	12,596	30	9.14	20	6.10	66	4
0910		268.2	880	3840	12,596						
11 Nov	5	277.4	910	3849	12,626	20	6.10	0	0	0	0[b]
1115		277.4	910	3849	12,626						
11 Nov	6	279.8	918	3851	12,634	8	2.44	0	0	0	0
1600		279.8	918	3851	12,634						
11 Nov	7	283.8	931	3855	12,647	13	3.96	1	0.30	8	1[c]
1900		283.8	931	3855	12,647						
22 Nov	8	284.1	932	3855	12,648	1	0.30	0	0.0	0	0
						162	49.36	22	6.70	13	

[a]Core 2 - Catcher sample only.
[b]Core 5 - Smear only.
[c]Core 7 - Basalt in liner

TD = 12,648 ft

TABLE 2
CORING RATES

Core No.	Drilling Time (hr)	Depth Cored (ft)	Av. Coring Rate (ft/hr)
Hole 11			
1	0.1	30	300.0
Hole 11A			
1	0.1	30	300.0
2	0.1	30	300.0
3	0.2	30	150.0
4	0.2	30	150.0
5	0.2	20	100.0
6	1.1	8	73.0
7	2.9	13	4.4
8	2.0	1	0.5

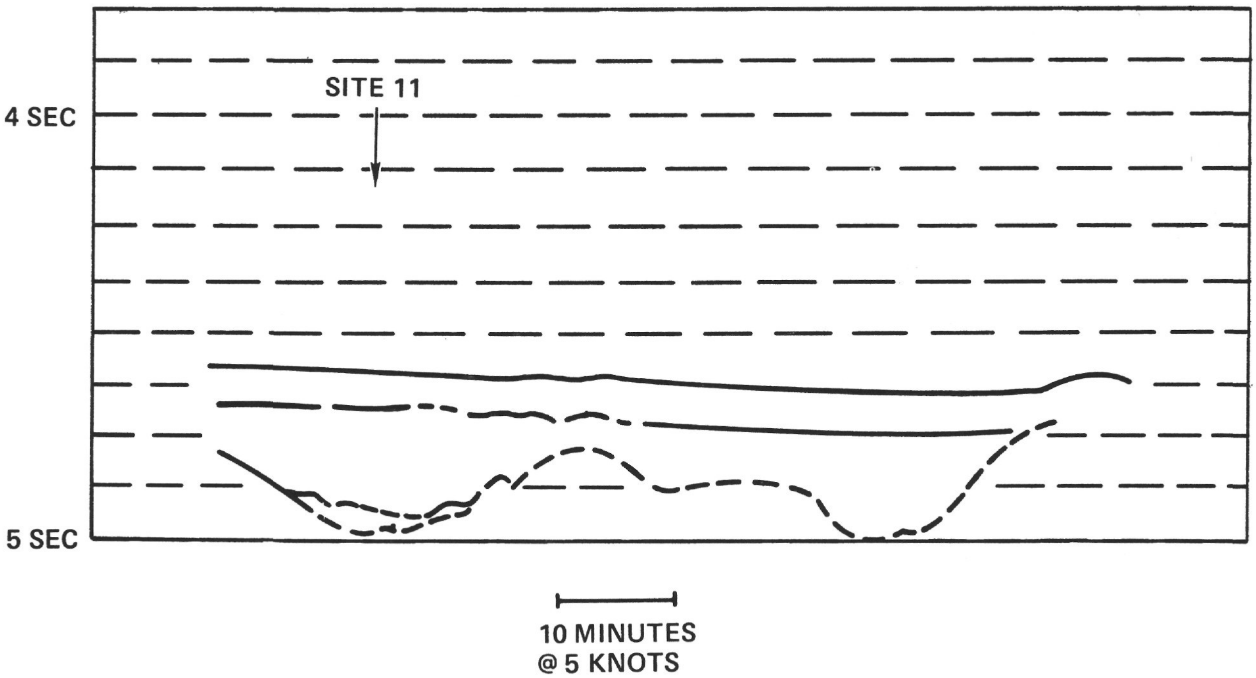


Figure 3. *Line drawing of profiler record made across Site 11 by Glomar Challenger.*

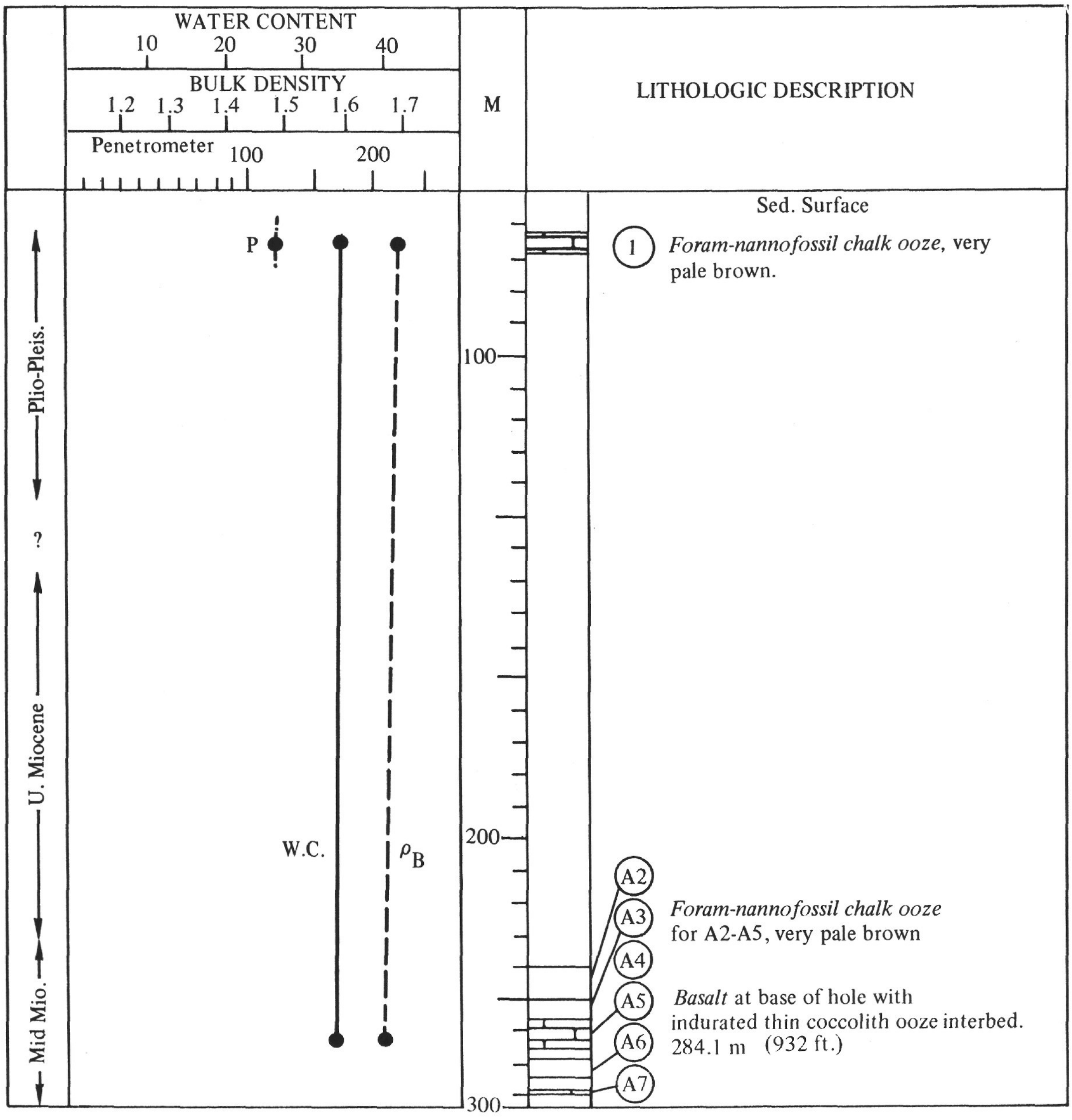


Figure 4. *Summary of drilling and coring at Site 11.*

The Cores Recovered from Site 11

Figures 5 through 7 are the graphic summaries of the cores recovered at Site 11.

These figures show, for each core:

(1) The stratigraphic age.
(2) The natural gamma radiation
(3) The bulk density determined by the GRAPE (Gamma Ray Attenuation Porosity Evaluation) equipment
(4) 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.
(5) The lithology (see key with Chapter 3).
(6) The positions of the tops of each core section.
(7) Some notes on the lithology.

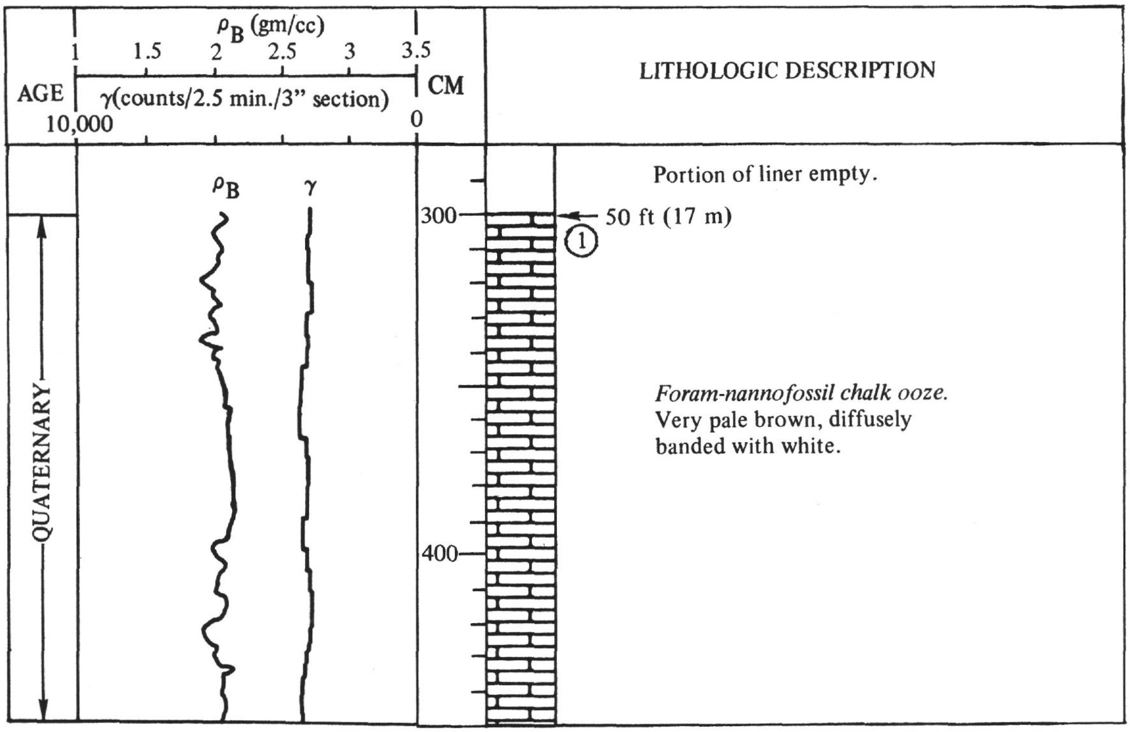


Figure 5. *Hole 11 Core 1.*

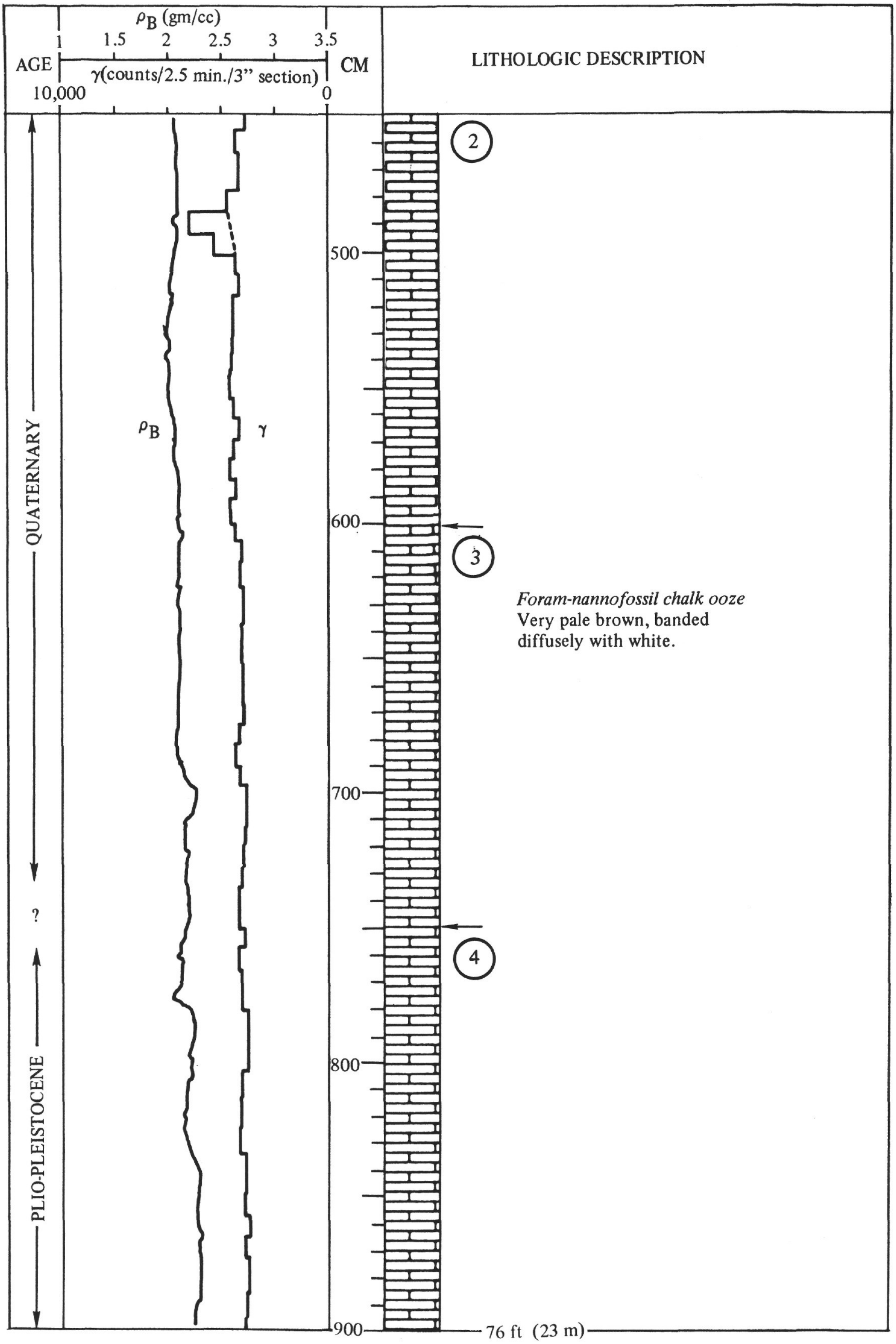


Figure 5. *(Continued).*

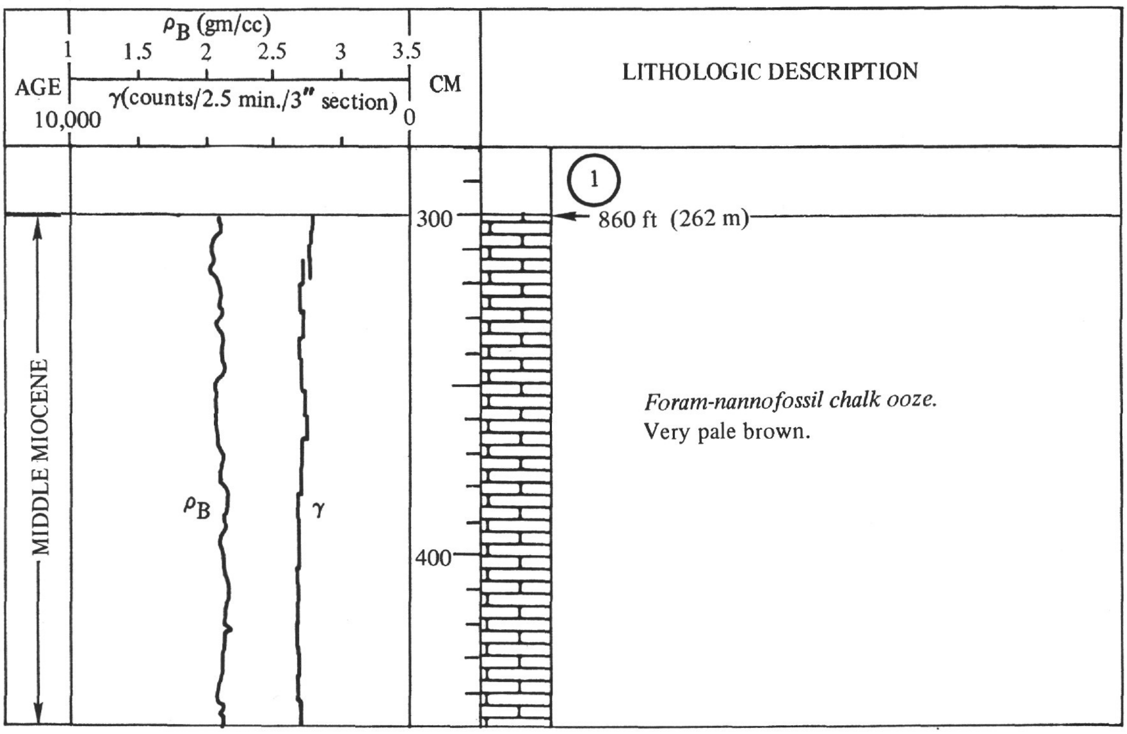


Figure 6. *Hole 11A Core 4.*

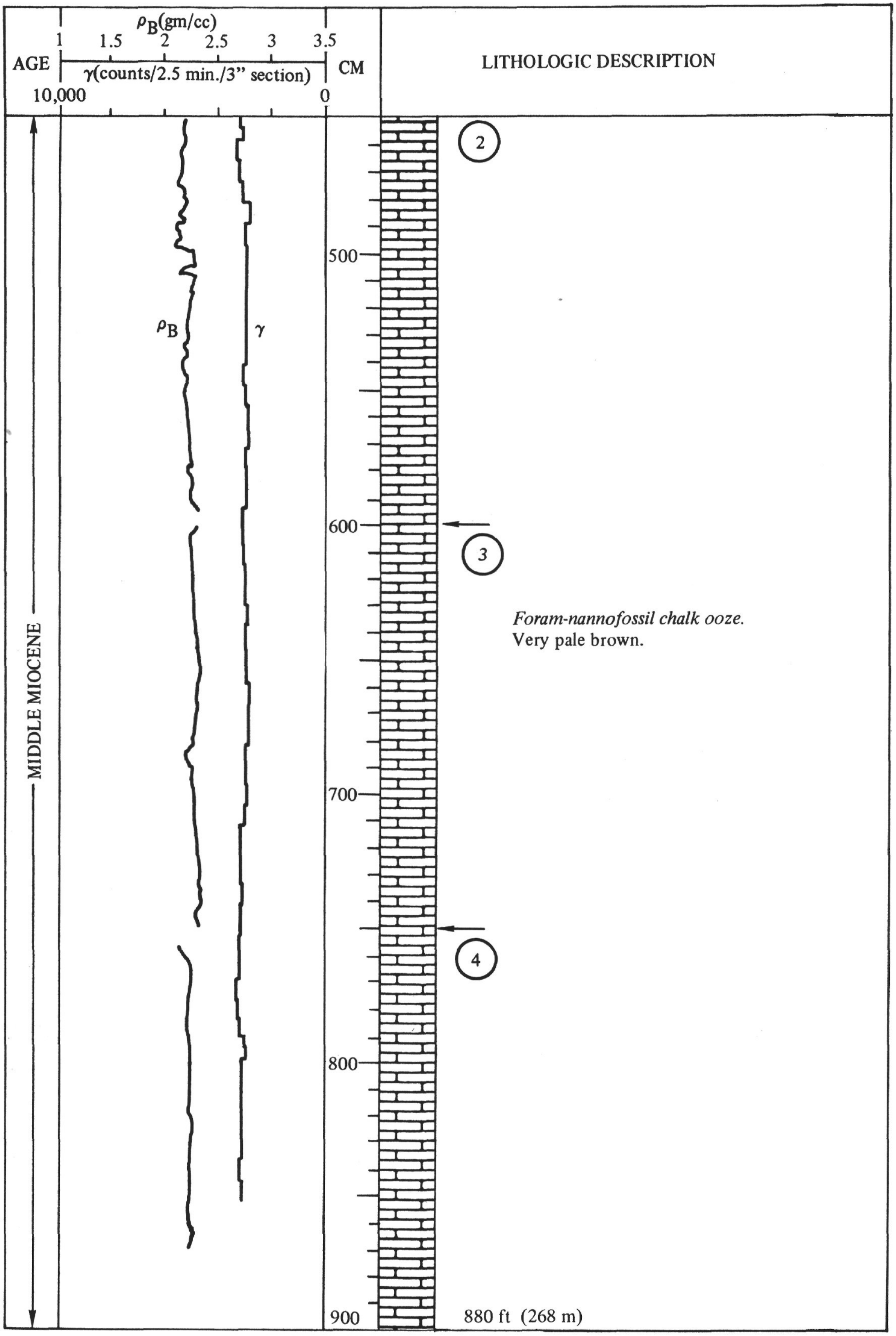
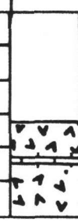


Figure 6. *(Continued).*

AGE	ρ_B (gm/cc) 1 1.5 2 2.5 3 3.5 / γ(counts/2.5 min./3" section) 10,000 0	CM		LITHOLOGIC DESCRIPTION
	No information.	400		Portion of Liner empty. *Basalt*, with thin interbed of indurated nannofossil ooze. Thin glass layer at top of sediment.

The Cores Recovered from Site 11

Figures 8 through 16 show details of the individual core sections of the cores from Holes 11 and 11A.

Each figure shows:

(1) A scale of centimeters from the top of each section.
(2) A photograph of the core section.
(3) The lithology (see key with Chapter 3).
(4) The positions of smear slides (x).
(5) Notes on the lithology, X-ray mineralogy, carbon content, expressed as a percentage of total sediment (see Chapter 9), the water content and the grain size (see Chapter 8). Colors are given with reference to the GSA Rock Color Chart.

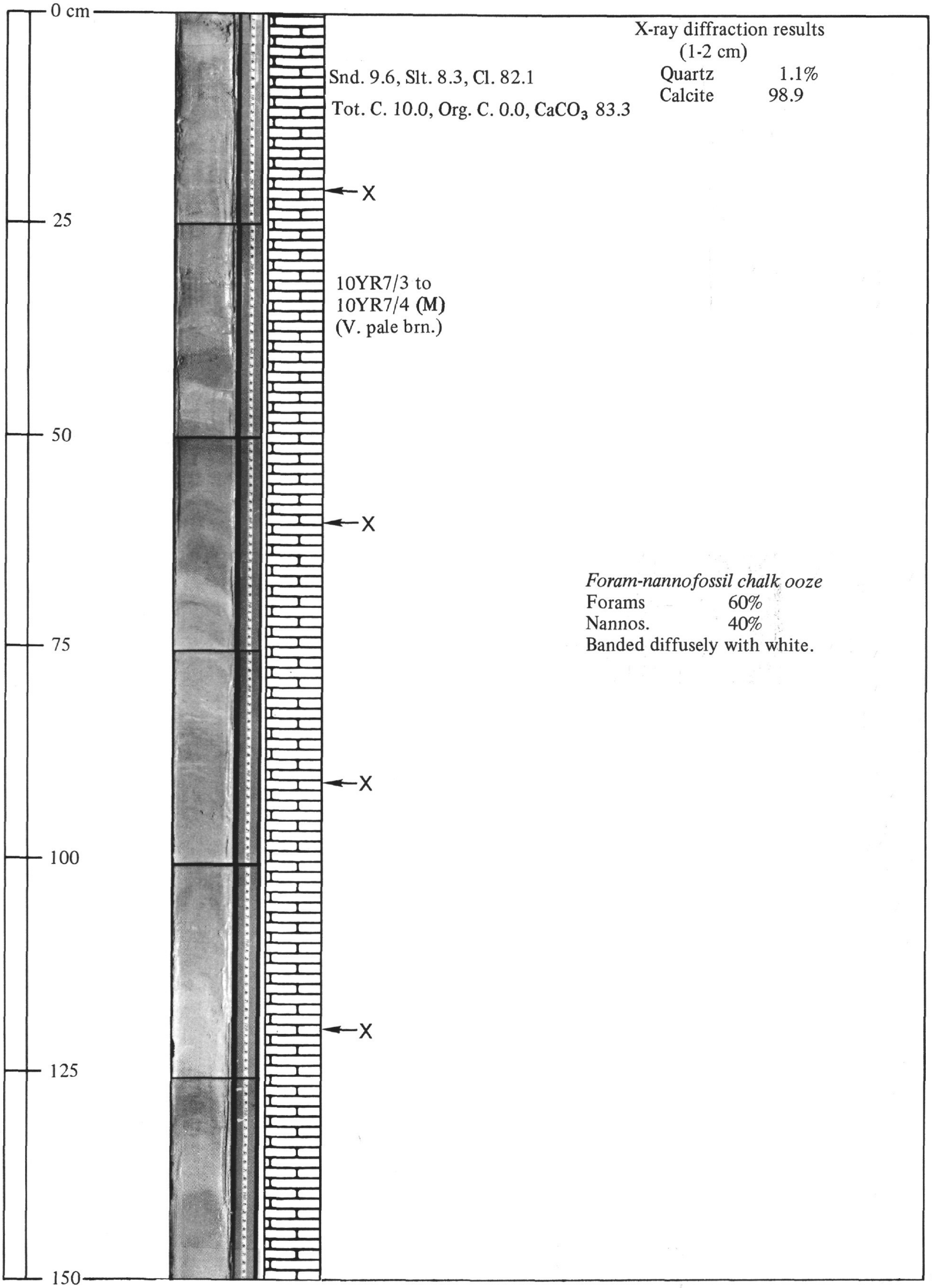


Figure 8. *Hole 11 Core 1 Section 1.*

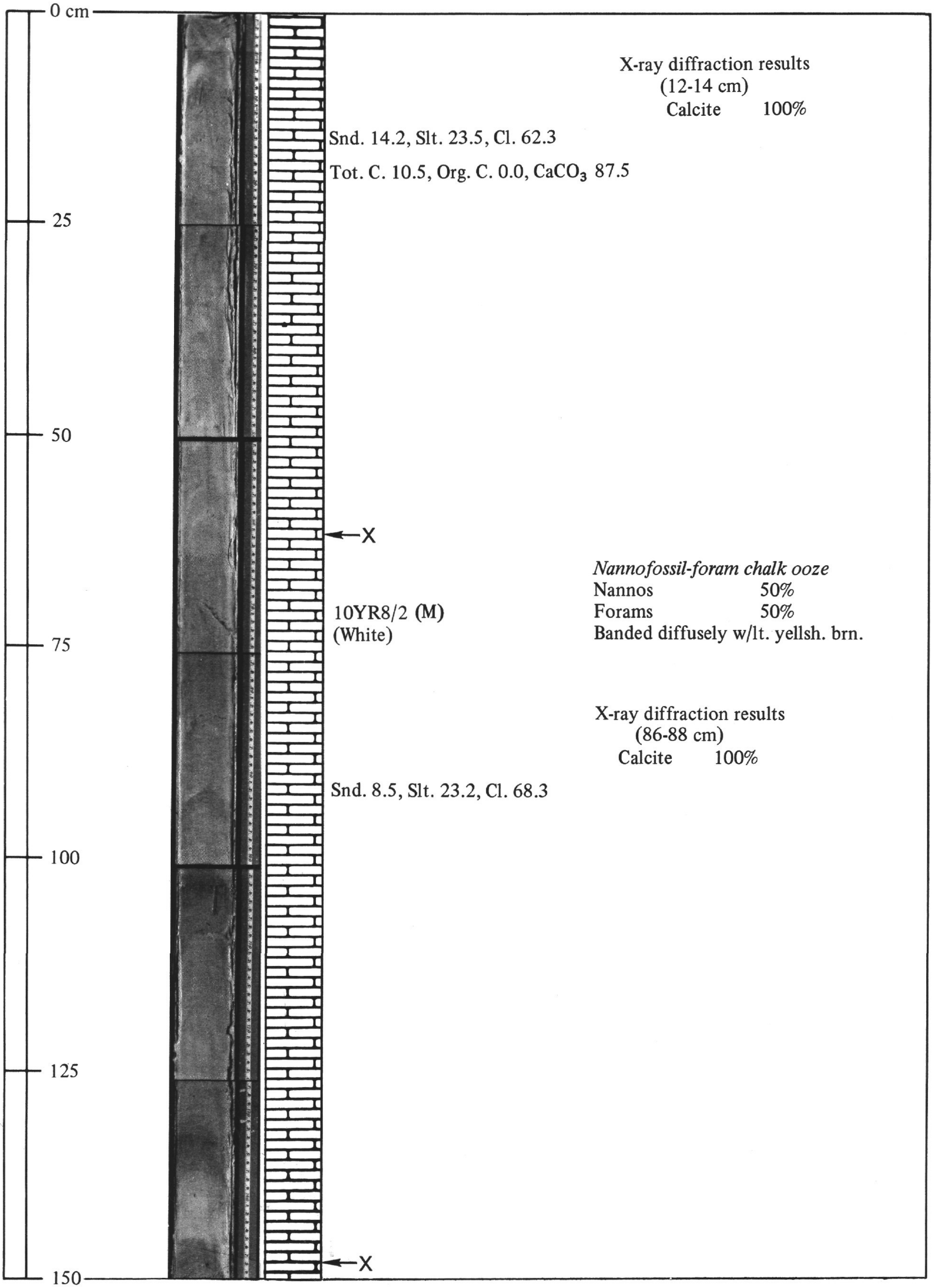


Figure 9. *Hole 11 Core 1 Section 2.*

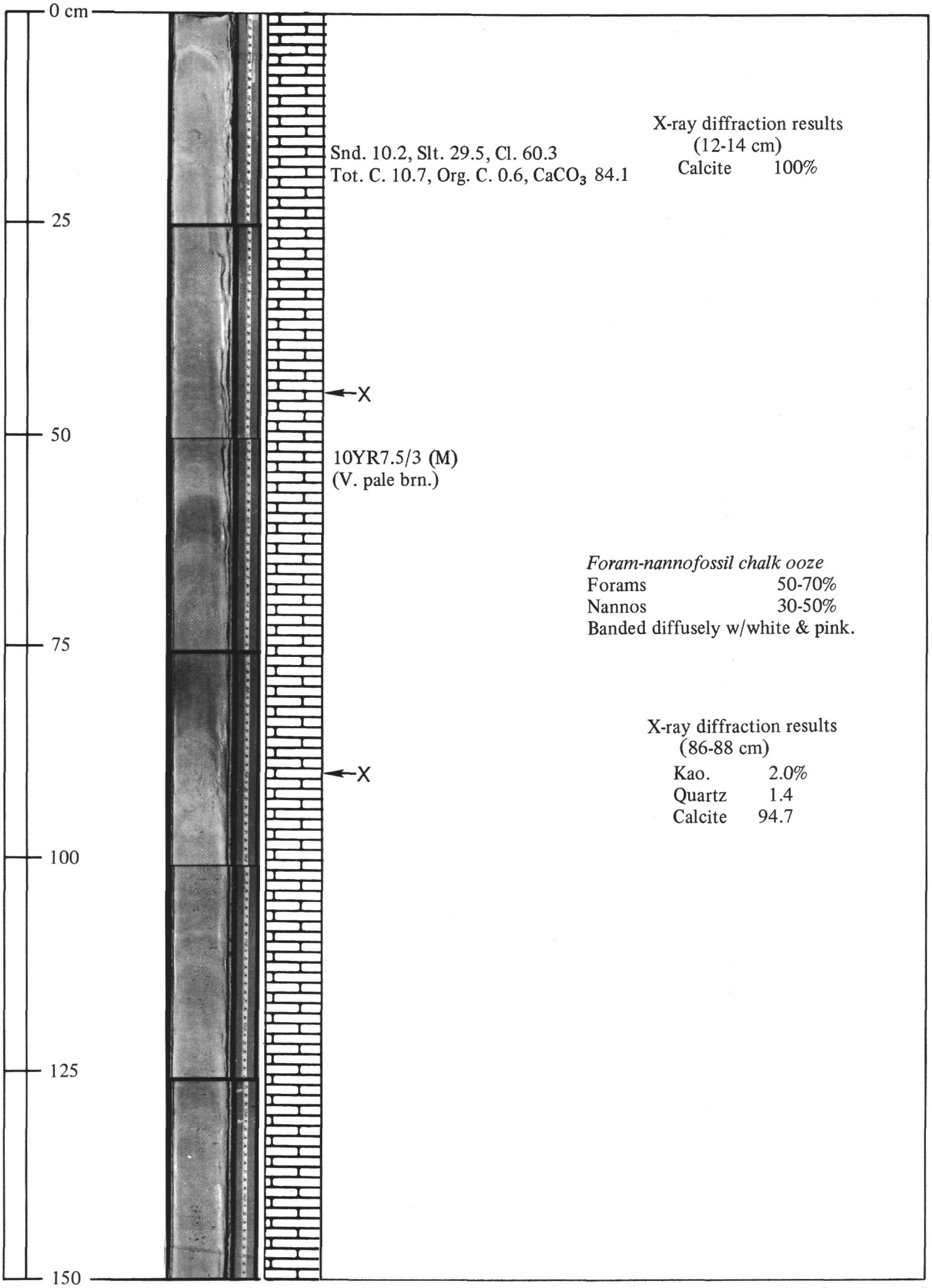


Figure 10. *Hole 11 Core 1 Section 3.*

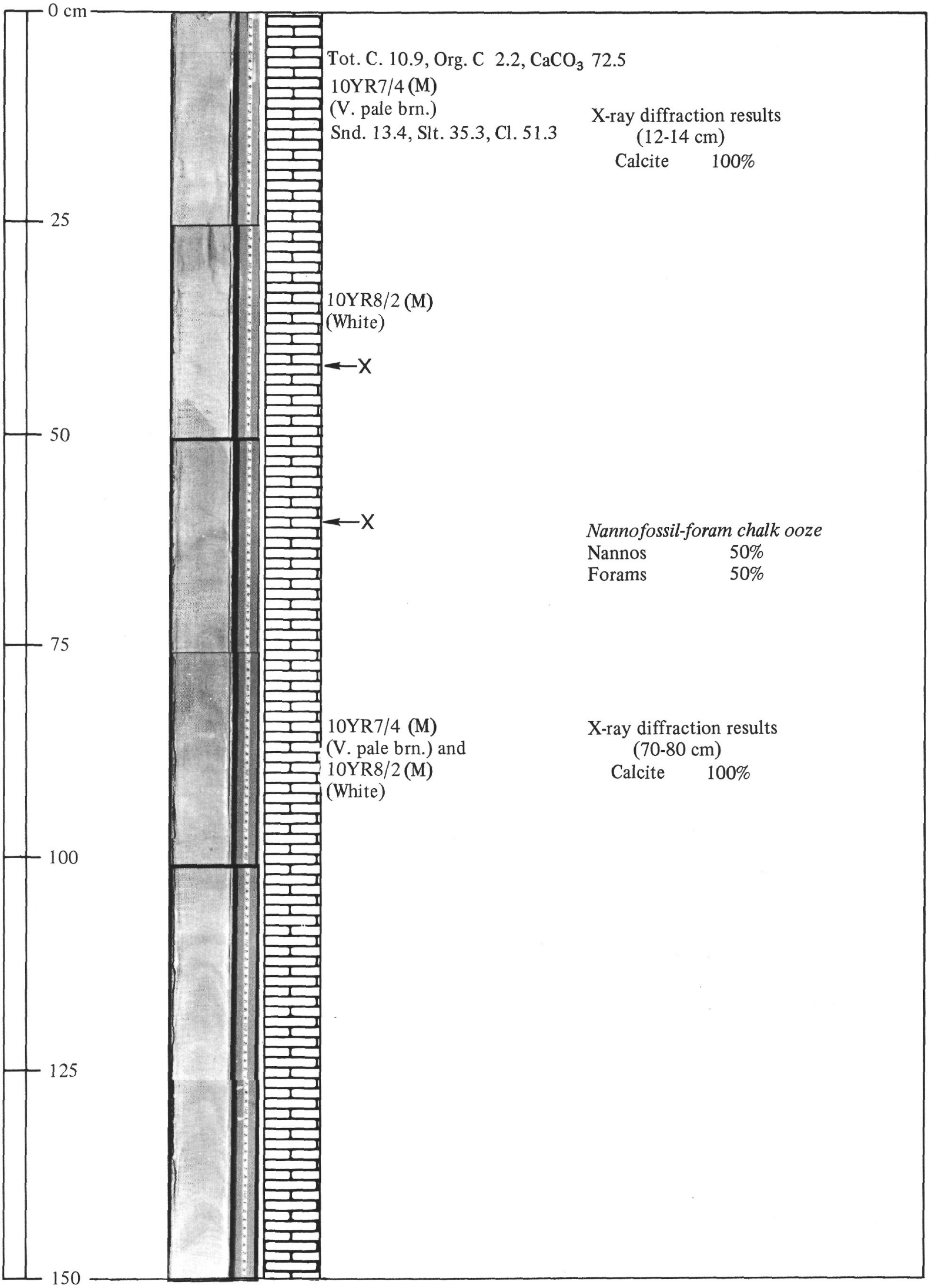


Figure 11. *Hole 11 Core 1 Section 4.*

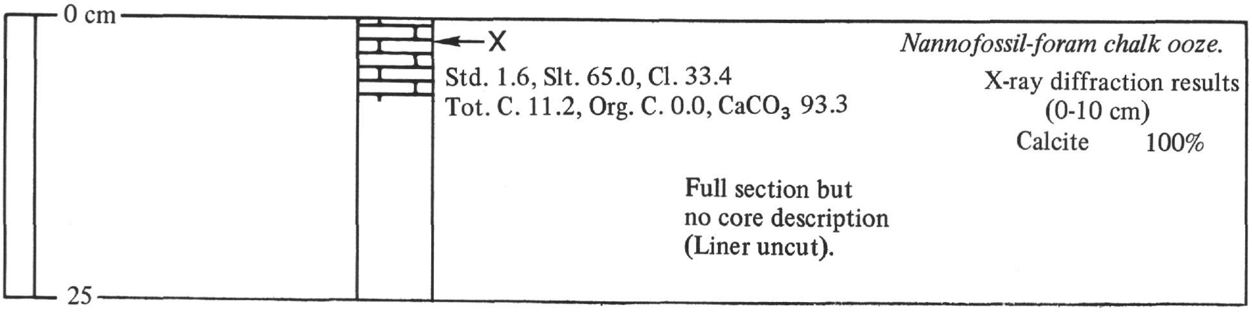


Figure 12. *Hole 11A Core 4 Section 1.*

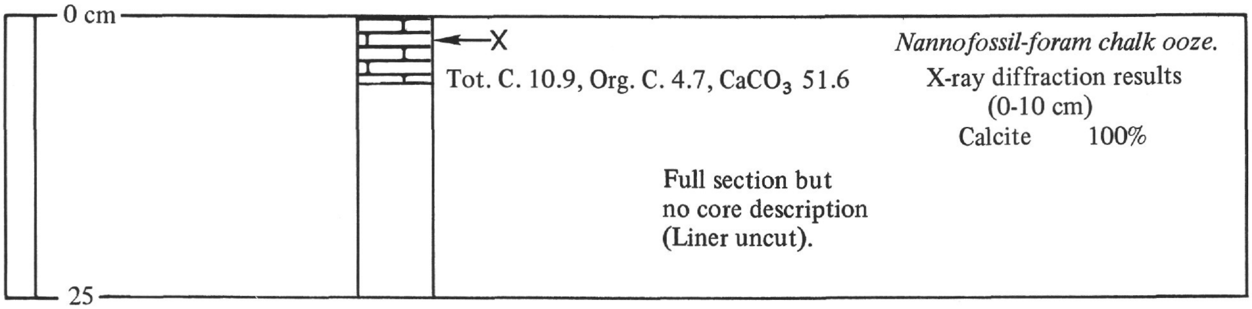


Figure 13. *Hole 11A Core 4 Section 2.*

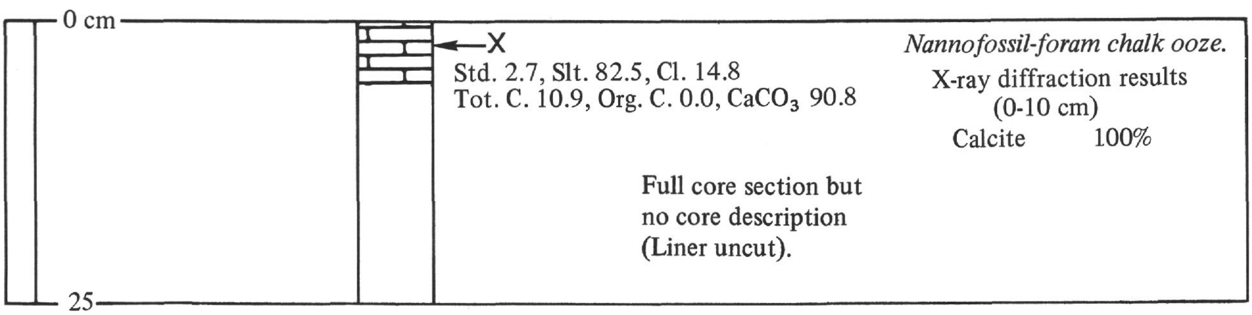


Figure 14. *Hole 11A Core 4 Section 3.*

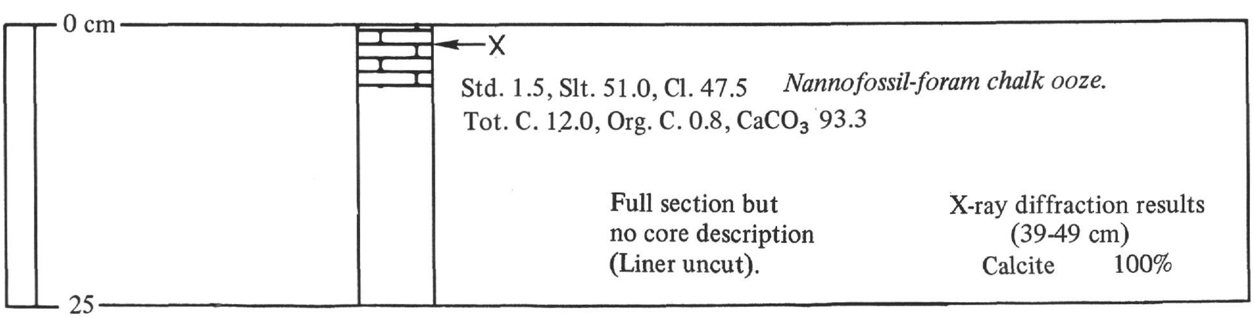


Figure 15. *Hole 11A Core 4 Section 4.*

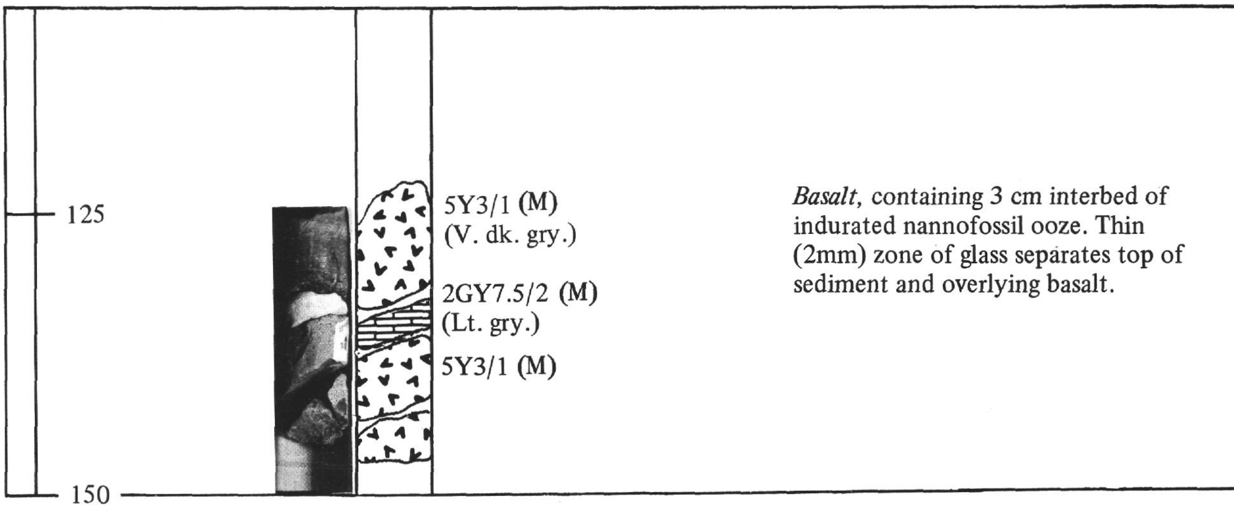


Figure 16. *Hole 11A Core 7 Section 1.*

Lithology

At Holes 11 and 11A, a total of 44 feet (13.4 meters) of core was recovered. A 20 foot (6.1 meter) section was taken from the interval 40 to 70 feet (12.2 to 21.3 meters), and the remaining 24 feet (7.3 meters) were from the interval between 820 feet (259.1 meters) and basement at 932 feet (284 meters).

The recovered sediment is all foraminiferal-nannofossil chalk ooze, ranging in age from Quaternary to Plio-Pleistocene at Hole 11 and to Miocene at Hole 11A. The ooze varies from very pale brown to white. Sparse grey mottles of unknown origin are present as well as a diffuse banding due to color variation.

Basement is a dense basaltic rock. The upper contact between basalt and sediment was not cored, although a 3 to 4 centimeter interbed of thermally metamorphosed calcareous sediment was collected. This indurated sediment layer contains remains of foraminiferal tests and coccoliths. The dip of the contacts above and below the sediment layer are both about 45 degrees. At its contact with the "baked" sediment, the overlying basalt has a 2 millimeter glass zone overlain by a 5 millimeter layer of a coarsely crystalline ferromagnesian mineral. Volcanogenic minerals and dolomite rhombs were not noted in any of the samples.

Physical Measurements

Ship Laboratory Measurements

The highly calcareous cores of Site 11 have had many of their physical properties grossly affected by coring. The sediments are exceedingly soft, both at the surface and at depth. There is little evidence of mixing here; the main disturbance being the downward dragging of sedimentary layers along the liner wall, this being more pronounced in the lower portions of Core 1.

Natural Gamma-Radiation

The very low level of natural gamma-ray activity which was observed for Site 11 sediments is consistent with an almost pure carbonate sediment, which is low in potassium-bearing detrital authigenic volcanogenic minerals.

X-Radiography

Due to the uniformity of the sediments at Site 11, very little structure was observed on X-radiographs.

Gamma Ray Attenuation Porosity Evaluation (GRAPE)

Systematic variations of physical properties in the cores from Holes 11 and 11A indicate artificial compaction by coring. The density increases downward in Core 1 of Hole 11 from 1.6 to almost 2.0 and in Core 4 of 11A from 1.6 to 1.9. The sediment is more compacted at the base of each core as a result of the drilling operation. Concomitant variation of porosity was also recorded.

Penetrometer

The cores at Site 11 are exceedingly soft and easily penetrated. Measurements made were not considered meaningful because the needle generally penetrated to the full thickness of sediment in the core and came to rest on the liner.

Sonic Velocity

Because the cores had been seriously disturbed, the sonic velocity data are not considered very meaningful. Sonic velocities range from 1.50 km/sec to 1.54 km/sec. These values compare to approximately 1.65 km/sec, which is based on the known length of drill string required to drill to a seismic reflector, interpreted as basement (see discussion).

Down-Hole Logging

No down-hole logging was attempted for Site 11.

Paleontology and Biostratigraphy: Summary

Nannofossils	Foraminifera
Hole 11, Core 1: Calcareous nannofossils are very abundant throughout this core, and for the upper three sections indicate an early to middle Pleistocene age, the most characteristic forms being *Gephyrocapsa*, cf. *Coccolithus cricotus* and *Umbilicosphaera mirabilis.* The upper 25 centimeters of Core 1, Section 4, contain an early Pleistocene assemblage, giving way to a mixture of Pliocene and Pleistocene forms at about 55 centimeters. From 55 to 85 centimeters, characteristic late Pliocene forms are present, including cf. *Coccolithus cricotus, Discoaster brouweri, Ceratolithus rugosus* and *Cyclococcolithus aequiscutum.* There may be a hiatus between 85 and 95 centimeters as the nannofossils below 95 centimeters indicate an early Pliocene age, and include *Reticulofenestra pseudoumbilica, Cyclococcolithus aequiscutum, C. leptoporus, Discoaster brouweri, Sphenolithus abies, Ceratolithus rugosus* and *C. tricorniculatus.* The total lack of *Ceratolithus rugosus* and the presence of well developed *C. tricorniculatus* at 145 centimeters in Section 4 may indicate a latest Miocene (Messinian) age for this level.	Hole 11, Core 1: The foraminiferal assemblages contained in Core 1 are very rich and were investigated in some detail (15 samples from 4 sections). Sections 1 to 3 yielded rich planktonic associations with some benthonics (less than 5 per cent), including *Laticarinina pauperata,* large specimens of *Pyrgo* and *Globocassidulina, Lagena* sp., and a single *Uvigerina.* Also rare Ostracods are present as well as single specimens of shallow-water *Miliolidae* with corroded tests (e.g., Section 1, 30-32 cm; Section 3, 60-62 cm). The presence, once again, of single specimens of shallow water *Quinqueloculina, Triloculina* etc. in deep-sea deposits far away from shallow water environments speaks in favor of some mechanism for transportation of suspended empty shells. Among the planktonic foraminifera are *Globorotalia truncatulinoides, G. crassaformis, G. menardii* (rare, always left coiling), *G. tumida, Globigerina eggeri, Globigerinoides ruber* (also with pink tests in the upper portion of the core), *G. conglobatus, G. elongatus, Candeina nitida, Orbulina universa, Sphaeroidinella dehiscens, Pulleniatina obliquiloculata* are present. *Globorotalia truncatulinoides* shows fully keeled specimens, as well as specimens that are incompletely keeled and transitional to *G. tosaensis.* These assemblages may be referred to the Pleistocene Zone N.22 of Blow (1968), *(Globorotalia truncatulinoides* Zone). Section 4 shows a quite unusual succession of faunal assemblages: in the highest sample examined (30-32 centimeters) *Globorotalia truncatulinoides, G. tosaensis, G. crassaformis, G. inflata, G. pseudopima, Globigerinoides ruber, G. conglobatus, Globigerina eggeri, G. digitata, Orbulina universa, Hastigerina siphonifera* are present, indicating a lower Pleistocene (lower part of Zone N.22) age. At 74-76 centimeters an assemblage similar to the preceding one is mixed with forms indicating a lower Pliocene age *(Sphaeroidinella dehiscens, dehiscens/Globoquadrina altispira altispira* Zone N.19 of Blow, 1968) such as *Sphaeroidinella dehiscens, S. dehiscens immatura, Sphaeroidinellopsis seminulina,* etc. Lower in the section (124-126 centimeters) a pure lower Pliocene assemblage without any contamination and/or mixture with Pleistocene material was encountered, containing, among others, *Globigerina nepenthes, Globorotalia multicamerata, G. menardii* (right coiling), *G. margaritae, Hastigerina siphonifera, Sphaeroidinellopsis semulinua, S. subdehiscens.* The absence of *Sphaeroidinella dehiscens* and/or forma *immatura* suggests a pre-*Sphaeroidinella* datum age (i.e., the topmost part of the *Globorotalia tumida tumida/Sphaeroidinellopsis subdehiscens paenedehiscens* Zone N.18 of Blow, 1968). The core catcher contained a Lower Pliocene assemblage apparently slightly younger than the one examined above (with *Sphaeroidinella dehiscens* and forma *immatura)* which may be referred to Zone N.19, mixed

Nannofossils	Foraminifera
	with some Pleistocene species such as *Globorotalia truncatulinoides, Pulleniatina obliquiloculata finalis,* etc. If we assume that the observed faunal succession is natural and that it is not artificially introduced by the coring operation, which is unlikely, a possible explanation is that a submarine slide occurred in the early Pleistocene, depositing the central part of the sedimentary basin (where the drilling site was located) Lower Pliocene sediments originally deposited in some external higher portions of the basin itself.
Hole 11A, Core 2: Calcareous nannofossils are very abundant in the core catcher sample of Core 2 and include *Reticulofenestra pseudoumbilica, Cyclococcolithus leptoporus,* cf. *Discoaster brouweri, Sphenolithusabies, Discoaster aulakos,* and forms probably assignable to *Catinaster calyculus.* The assemblage indicates a late Middle Miocene Age, equivalent to assemblages from the *Globorotalia mayeri* Zone level.	Hole 11A, Core 2: The core catcher of Core 2 yielded a rich and well developed foraminiferal fauna with rare benthonic Foraminifera, including *Globocassidulina, Pleurostomella, Cibicides,* and *Planulina* and fish teeth. Planktonic foraminifera are abundant. Abundant *Globigerina nepenthes* and *Globoquadrina dehiscens, G. altispira, Globorotalia mayeri, G. menardii, G. miozea, Orbulina universa, Globigerinita glutinata, Sphaeroidinellopsis seminulina* were observed. This assemblage is clearly located above the *Globigerina nepenthes* datum plane. It corresponds to the middle or upper part of the *Globorotalia mayeri* Zone of Bolli (1957), to the *Globigerina nepenthes/Globorotalia siakensis* Zone N.14 of Blow (1968).
Hole 11A, Core 4: All sections of Core 4 contain the same assemblage of calcareous nannofossils and indicate an early Middle Miocene age. The assemblage is generalized, containing only few species, although these species are represented by large numbers of specimens. Included are the following species: *Coccolithus neogammation, Reticulofenestra pseudoumbilica, Cyclococcolithus leptoporus, Helicopontosphaera intermedia, Sphenolithus moriformis, Discoaster aulakos,* and other generalized asteroliths. The sample from the top of Section 2 is contaminated with Pliocene-Pleistocene species, but all of the other samples are not contaminated.	Hole 11A, Core 4: The sediments contained in Core 4 were so fluid that the core was not cut and samples were taken from the top of each section and from the core catcher. Samples taken from Sections 1 and 2 contain rich planktonic assemblages of Middle Miocene age *(Orbulina universa, O. suturalis, Globoquadrina dehiscens, G. altispira,* rare *Globorotalia fohsi robusta)* contaminated with Pliocene and/or younger forms *(Sphaeroidinella dehiscens, Pulleniatina obliquiloculata, Globorotalia crassaformis,* different species of *Globigerinoides,* etc.). The preservation of the test is slightly different for the Pliocene specimens, which are very common and obviously come from the upper portion of the hole, than for the Miocene ones. Sections 3 and 4 yielded rich faunas composed mostly of planktonic foraminifera, with rare benthonics *(Gyroidina, Planulina, Nonion, Vulvulina,* etc.). The species *Orbulina suturalis, O. universa, Globoquadrina dehiscens, G. altispira, Globigerina venezuelana, Globigerinita glutinata, Sphaeroidinellopsis seminulina, Globorotalia mayeri, G. miozea, G. scitula, G. siakensis, G. praemenardii, G. menardii, G. fohsi robusta* and *G. fohsi lobata* indicate a Middle Miocene, pre-*Globigerina nepenthes* and post-*Orbulina* datum planes age. They may be referred to the *Globorotalia fohsi robusta* Zone of Bolli (1957 and 1966) and/or to the N.12 *Globorotalia fohsi* Zone of Blow (1968). With reference to the stratotypes defined in Italy, these assemblages

Nannofossils	Foraminifera
	may be considered as post-Langhian and pre-Tortonian (cf. discussion) Chapter 20.
Hole 11A, Core 5: The core catcher sample from Core 5 contains a Middle Miocene nannofossil assemblage including the following species: *Sphenolithus heteromorphus, Coccolithus neogammation,* cf. *Reticulofenestra pseudoumbilica, Cyclolithella rotunda, Sphenolithus moriformis, Helicopontosphaera parallela,* rare and primitive *Cyclococcolithus leptoporus,* and generalized asteroliths. The occurrence together of *Sphenolithus heteromorphus* and *Helicopontosphaera parallela* indicates this sample to be correlative with the *Globigerinatella insueta* Zone of Bolli. This sample was the closest to the basement at Holes 11 and 11A that could be dated with calcareous nannofossils.	Hole 11A, Core 5: Insufficient material for foraminiferal examination.
Hole 11A, Core 6: Scrapings from the lithified "baked" carbonate sediment which was interbedded with the basement rock yielded only the long ranged species *Coccolithus neogammation.*	Hole 11A, Core 6: A small sample of lithified carbonate sediment underlying the topmost basement rock (basalt) recovered contains numerous planktonic foraminifera, including *Globigerina, Globorotalia* and abundant *Orbulina.* Although no specific determination is possible, the presence of abundant, perfectly spherical and internally undivided tests of *Orbulina* indicates a post-*Orbulina* datum age. The first evolutionary appearance of *Orbulina* occurs in the upper part of the *Globigerinatella insueta* Zone of Bolli (1957), in the *Praeorbulina glomerosa* Zone of Bolli (1966), and it is used to define the base of the *Orbulina suturalis/Globorotalia peripheroronda* Zone N9 of Blow (1968). The first occurrence of *Orbulina* also occurs within the stratotype of the Langhian stage of Italy (cf. discussion).

SUMMARY - SITE 11

Rates of Sediment Accumulation

The reader is referred to the Cruise Leg Synthesis for discussion of the basic assumptions involved in these calculations.

Sediment accumulation rates can be calculated from three levels at Holes 11 and 11A, although with the limited core recovery these accumulation rates may be even less reliable than those at Sites 9 and 10. A lower Pleistocene age determined for Core 1 at Hole 11 at 65 feet (20.1 meters) beneath the ocean floor yields a sediment accumulation rate of 1.4 cm/1000 years for this interval. The absolute age of this level is somewhat arbitrarily assumed to be about 1.4 million years, the error in this assumption probably being less than 10 per cent.

The next accurate age was determined from Core 4 of Hole 11A at a depth of 878 feet (267.1 meters). This is taken as the *Globorotalia fohsi* datum with an absolute age of about 16.5 million years (Berggren, 1969). At this level both the interval and cumulative sediment accumulation rates are 1.6 cm/1000 years.

Finally, the *Orbulina* datum is believed to occur approximately at the level at which basement was encountered, i.e., 926 feet (282.0 meters). This is probably the most nearly accurate datum as *Orbulina* tests were identified in lithified, "baked" carbonate enclosed by basement rock. Also, in Core 5 at Hole 11A, at 907 feet (276.2 meters) beneath the ocean floor, the *Globigerinella insueta* Zone was identified by means of calcareous nannofossils, further indicating the proximity of the *Orbulina* datum. The absolute age for this datum is determined at 18.5 million years (Berggren, 1969) yielding a cumulative sediment accumulation rate of 1.4 cm/1000 years. The accumulation rate between the *Orbulina* datum and the *Globorotalia fohsi* datum is only 0.8 cm/1000 years. However, small errors in the absolute ages introduce serious errors over the relatively short time interval involved (2 million years).

The overall values of 1.4 to 1.6 cm/1000 years are in agreement with commonly accepted values for pelagic carbonate ooze sedimentation; the Miocene to Recent interval is probably represented by a more or less complete sedimentary section at Holes 11 and 11A.

Discussion

At Holes 11 and 11A, the contact between sediment and basalt was not cored, but the recovery of sediment between the basaltic layers conforms that the age of the deepest sediments represents only a minimum age and layers. Whether or not the amount of sediment interbedded with basalt below the level cored is geologically significant is a currently unsolved problem. There was neither indication of red ferruginous staining such as that noted in the sediments overlying the basement at Site 9, nor of the presence of dolomite rhombs such as were observed at Site 10.

The sediment immediately overlying the basement proved to be extremely difficult to core using our presently available techniques. The core barrels were returned to the surface often completely clean of even traces of sediment, because of the "soupy" nature of the calcareous sediment at this site. The surface core (Hole 11), as an exception, was relatively firm, but deeper sediment, within 100 feet of the basement, would literally flow in the core liner when slightly tilted and would not support the weight of a penetrometer needle. The softness of this deeply buried sediment is of interest, and ability to flow at very low angles is pertinent in evaluating the sediment migration and distribution on the Mid-Atlantic Ridge. The water content of the sediment is not as great as might be anticipated from the softness of the sediments. The combination of high mobility with only moderate water content may be related to the fact that the major solid constituents are nannofossils.

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APPENDIX - MICROPALEONTOLOGICAL DETERMINATIONS

Lists of Selected Planktonic and Benthonic Foraminifera and Age Determinations by M. B. Cita

Sample 11-1-1, 0-5 cm (depth 14 meters below the mud line):

Rich planktonic assemblage including *Globorotalia truncatulinoides* (abundant), also with forms transitional to *G. tosaensis*, *G. crassaformis* (very abundant), *G. menardii* (left coiling), *G. tumida*, *Sphaeroidinella dehiscens*, *Pulleniatina obliquiloculata* (common), *Candeina nitida*, *Orbulina universa*, *Hastigerina siphonifera*, *Globigerinoides ruber*, *G. conglobatus*, etc. Benthonic foraminifera are very rare and include *Pyrgo* sp., *Laticarinina pauperata*, etc. Also present are arae Ostracoda.
Age determination: Pleistocene (probably lower), *Globorotalia truncatulinoides* Zone N.22 of Blow.

Sample 11-1-1, 30-32 cm (depth 14.3 meters below the mud line):

Planktonic fauna as above, also including *Globorotalia inflata*, *G. scitula*, *Globigerinoides elongatus*, *G. sacculifer*, *Orbulina bilobata*.
Age determination: As above.

Sample 11-1-1, 80-82 cm (depth 14.8 meters below the mud line):

Planktonic fauna as above. Benthonic fauna including *Lagena*, *Nonion*, *Pullenia*, *Globocassidulina*.
Age determination: As above.

Sample 11-1-1, 140-142 cm (depth 15.4 meters below the mud line):

Rich foraminiferal fauna including the same species as listed above and also *Globorotalia pseudopima*.
Age determination: As above.

Sample 11-1-2, 30-32 cm (depth 15.8 meters below the mud line):

Planktonic fauna including *Globorotalia truncatulinoides* (abundant), *G. crassaformis* (abundant), *G. inflata*, *G. scitula*, *Orbulina universa*, *Pulleniatina obliquiloculata*, *Globigerina eggeri*, *Globigerinoides elongatus*, *G. conglobatus*, *G. sacculifer*, etc.
Age determination: As above.

Sample 11-1-2, 80-82 cm (depth 16.3 meters below the mud line):

Planktonic fauna as above. Rare benthonic forms including *Pyrgo*, *Globocassidulina*, *Uvigerina*. Single Ostracoda.
Age determination: As above.

Sample 11-1-2, 120-122 cm (depth 16.7 meters below the mud line):

Planktonic assemblage as above, also including *Globorotalia tosaensis* and *G. pseudopima.*

Age determination: early Pleistocene; lower part of *Globorotalia truncatulinoides* Zone N.22 of Blow (based on the occurrence of *Globorotalia tosaensis).*

Sample 11-1-3, 20-22 cm (depth 17.2 meters below the mud line):

Planktonic and benthonic assemblages quite similar to those of the overlying sections.

Age determinations: As above.

Sample 11-1-3, 60-62 cm (depth 17.6 meters below the mud line):

Rich planktonic assemblage including *Globorotalia truncatulinoides* (abundant), *G. tosaensis, G. crassaformis, G. pseudopima, G. inflata, G. scitula, Globigerina bulloides, G. eggeri, Candeina nitida, Pulleniatina obliquiloculata, Sphaeroidinella dehiscens, Orbulina universa, O. suturalis* (very rare), *Globigerinoides ruber, G. elongatus, G. trilobus, G. sacculifer, Globigerinita glutinata,* etc. Benthonic foraminifera including *Lagena, Pyrgo, Quinqueloculina, Anomalina.*

Age determination: early Pleistocene, lower part of *Globorotalia truncatulinoides* Zone N.22 of Blow.

Sample 11-1-3, 120-122 cm (depth 18.2 meters below the mud line):

Foraminifera as above.

Age determination: As above.

Sample 11-1-4, 30-32 cm (depth 18.5 meters below the mud line):

Rich planktonic assemblage including *Globorotalia truncatulinoides, G. tosaensis, G. crassaformis, G. inflata, G. pseudopima, Orbulina universa, Globigerina eggeri, G. digitata, Globigerinoides conglobatus, G. ruber, G. trilobus,* etc.

Age determination: early Pleistocene, lower part of *Globorotalia truncatulinoides* Zone N.22.

Sample 11-1-4, 74-76 cm (depth 18.95 meters below the mud line):

Rich, heterogeneous planktonic assemblage including *Globorotalia truncatulinoides, Globigerina eggeri, Sphaeroidinella dehiscens, S. dehiscens immatura, Sphaeroidinellopsis seminulina, Orbulina universa, Pulleniatina obliquiloculata, Globigerinoides ruber, G. elongatus, G. trilobus,* etc.

Age determination: early Pleistocene (Zone N.22) mixed with early Pliocene (Zone N.19 or N.18).

Sample 11-1-4, 124-126 cm (depth 19.45 meters below the mud line):

Rich planktonic assemblage including *Globigerina nepenthes, G. eggeri, Sphaeroidinellopsis seminulina, S. subdehiscens, Globorotalia margaritae, G. menardii* (right coiling), *G. multicamerata, G. scitula, G.* aff. *puncticulata, Candeina nitida, Globoquadrina altispira altispira, G. altispira globosa, Hastigerina siphonifera, Globigerinoides ruber, G. conglobatus, G. obliquus extremus,* etc.

Age determination: lowermost Pliocene (pre-*Sphaeroidinella* datum) upper part of Zone N.18 of Blow.

Sample 11-1, Core catcher (depth 23.2 meters below the mud line):

Rich, heterogeneous planktonic assemblage including *Globorotalia truncatulinoides, G. tumida, G. menardii* (right coiling), *G. inflata, G. multicamerata, G. crassaformis, Globigerina nepenthes, G. eggeri, Globigerinita glutinata, Globoquadrina altispira, Orbulina universa, Globigerinoides elongatus, G. conglobatus, G. ruber, G. trilobus, Pulleniatina obliquiloculata, Sphaeroidinella dehiscens, S. dehiscens immatura, Sphaeroidinellopsis seminulina* etc.

Age determination: early Pleistocene (Zone N.22) mixed with early Pliocene (Zone N.19 and/or N.18).

Sample 11A-2, core catcher (depth 249.9 meters below the mud line):

Rich, well preserved but not highly diversified planktonic assemblage including abundant and highly evoluted *Globigerina nepenthes, Globoquadrina dehiscens* (abundant), *G. altispira, Orbulina universa, Globorotalia menardii, G. miozea, Sphaeroidinellopsis seminulina, Globigerinita glutinata, Orbulina universa,* etc. Also present *Cibicides, Planulina, Pleurostomella, Globocassidulina* and fish teeth.

Age determination: Middle Miocene, probably Zone N.14 of Blow.

Sample 11A-4-1, 0-5 cm (depth 258 meters below the mud line):

Rich, heterogeneous planktonic assemblage including rare, evolute forms of *Globorotalia fohsi robusta, G. miozea, G. crassaformis, G. acostaensis, G. siakensis, Globigerinoides conglobatus, G. elongatus, G. obliquus extremus, G. ruber, Sphaeroidinellopsis seminulina, S. subdehiscens, Sphaeroidinella dehiscens, Orbulina universa, Globoquadrina dehiscens, G. altispira,* primitive *Globigerina nepenthes, Pulleniatina obliquiloculata,* etc.

Age determination: the oldest horizon represented in this highly heterogeneous assemblage is the Middle Miocene marker *Globorotalia fohsi robusta* (probably lower part of Zone N.13 of Blow because of the co-occurrence of the aforementioned taxon and of *Globigerina nepenthes* in an early evolutionary stage).

Sample 11A-4-2, 0-5 cm (depth 259.5 meters below the mud line):

Planktonic assemblage as above.

Age determination: As above.

Sample 11A-4-3, 0-5 cm (depth 261 meters below the mud line):

Rich, homogeneous planktonic assemblage including *Globorotalia fohsi robusta, G. fohsi lobata, G. miozea, G. siakensis, G. praemenardii, G. scitula, Orbulina universa, Globoquadrina dehiscens, G. altispira, G. larmeui, Sphaeroidinellopsis seminulina, Globigerina druryi*, etc. Rare benthonic foraminifera belonging to the genera *Globocassidulina, Anomalina, Planulina*, etc.
Age determination: Middle Miocene (Serravallian). *Globorotalia fohsi robusta* Zone or correspondent (Zone N.12 of Blow, or possible lower part of Zone N.13).

Sample 11A-4-4, 0-5 cm (depth 262.5 meters below the mud line):

Planktonic assemblage as above.
Age determination: As above.

Sample 11A-4, core catcher (depth 267.1 meters below the mud line):

Rich planktonic assemblage including *Orbulina suturalis, O. universa, Globoquadrina altispira, G. dehiscens, G. larmeui, Globigerina druryi, G. venezuelana, Sphaeroidinellopsis seminulina, Sphaeroidinellopsis* sp;, *Globorotalia mayeri, G. siakensis, G. scitula, G. praemenardii, G. miozea, G. fohsi robusta, G. fohsi lobata.*
Age determination: Middle Miocene (post-Langhian and pre-Tortonian with reference to the type-sections of the aforementioned stages, see discussion); *Globorotalia fohsi robusta* Zone or correspondent (Zone N.12 of Blow).

Sample 11A-7-1, (depth 280 meters below the mud line):

Planktonic assemblage including *Orbulina* sp., *Globorotalia* sp., *Globigerina* sp. in a lithified foraminiferal ooze in contact with basalt.
Age determination: Middle Miocene, probably Langhian (above the *Orbulina* horizon).

Calcareous Nannofossil Determinations by S. Gartner

Sample 11-1, Top:

Gephyrocapsa sp., cf. *Coccolithus cricotus, Umbilicosphaera mirabilis.*
Age determination: early-middle Pleistocene.

Sample 11-1-1, 150 cm:

Nannofossils as above.
Age determination: early-middle Pleistocene.

Sample 11-1-2, 145 cm:

Nannofossils as above.
Age determination: early-middle Pleistocene.

Sample 11-1-3, 145 cm:

Nannofossils as above.
Age determination: early-middle Pleistocene.

Sample 11-1-4, 5 cm:

Gephyrocapsa sp. (rare), cf. *Coccolithus cricotus, Scyphosphaera pulcherrima, Ceratolithus rugosus.*
Age determination: early Pleistocene.

Sample 11-1-4, 55 cm:

cf. *Coccolithus cricotus, Sphenolithus abies, Ceratolithus rugosus, Reticulofenestra pseudoumbilica, Discoaster brouweri, Gephyrocapsa* sp.
Age determination: mixed Pliocene-Pleistocene.

Sample 11-1-4, 125 cm:

Reticulofenestra pseudoumbilica, Sphenolithus abies, Cyclococcolithus aequiscutum, Cyclococcolithus leptoporus, Ceratolithus tricorniculatus (bizzar), *C. rugosus.*
Age determination: early Pliocene.

Sample 11-1-4, 145 cm:

Nannofossils above less *Ceratolithus rugosus.*
Age determination: probably late Miocene (Messinian).

Sample 11A-2, core catcher:

Reticulofenestra pseudoumbilica, Cyclococcolithus leptoporus, cf. *Discoaster brouweri, Sphenolithus abies, Discoaster aulakos,* cf. *Catinaster calyculus,* cf. *Triquetrorhabdulus rugosus.*
Age determination: late-Middle Miocene.

Sample 11A-4-1, Top:

Reticulofenestra pseudoumbilica, Cyclococcolithus leptoporus, Coccolithus neogammation, Discoaster aulakos.
Age determination: Middle Miocene.

Sample 11A-4-3, Top:

Nannofossils as above.
Age determination: Middle Miocene.

Sample 11A-4-4, Top:

Nannofossils as above.
Age determination: Middle Miocene.

Sample 11A-4, core catcher:

Nannofossils as above.
Age determination: Middle Miocene

Sample 11A-5, core catcher:

Sphenolithus heteromorphus, Coccolithus neogammation, cf. *Reticulofenestra pseudoumbilica,* aff. *Cyclococcolithus leptoporus.*
Age determination: early Miocene-early-Middle Miocene.