7. SITE 12

The Shipboard Scientific Party[1]

SITE REPORT

Objectives

Site 12 of this report formerly was designated 14 by the Atlantic Advisory Panel. It was drilled in the Cape Verde Basin (latitude 19° 40'N, longitude 26° 01'W), which is underlain by 2000 to 2100 feet (0.9 to 1.1 seconds reflection time) of sediment. The bottom topography of the basin is fairly smooth but not to the degree of an abyssal plain. Basement topography is variable but generally smooth in the immediate area of the site (Figure 1). The lower sediments are conformable with the basement, but tend to subdue its topographic relief. Seismic reflection profiler records from Site 12 show five weak reflectors in the upper 1025 feet (312.4 meters) of sediment and a strong reflector at about 1500 feet (457.2 meters). The sediment in piston cores collected from this area by *Vema* is extremely soft.

Site 12 was selected to provide material for paleontological investigations. The biostratigraphic subdivision of the Cretaceous and Tertiary strata based on planktonic foraminifera have been established in the Caribbean region (Bolli, 1957a, b, c, d; Blow, 1959), whereas the stratotype sections of the chronostratigraphic units (stages) have been erected in Western and Southern Europe. Paleontologic-stratigraphic studies at Site 12 were designed to provide a link with other sites across the Atlantic, in demonstrating the relationship between these biostratigraphic zones and the chronostratigraphic units established in Europe.

Upper Jurassic microfossils have been found in sediments from the Cape Verde Islands (Colon, 1955). Deep penetration at this site may yield sediments as old as the Jurassic.

[1]M. N. A. Peterson, Scripps Institution of Oceanography, La Jolla, California; N. T. Edgar, Scripps Institution of Oceanography, La Jolla, California; C. von der Borch, Scripps Institution of Oceanography, La Jolla, California; M. B. Cita, University of Milano, Milan, Italy; S. Gartner, Institute of Marine Sciences, Miami, Florida; R. Goll, Scripps Institution of Oceanography, La Jolla, California; and, C. Nigrini, Scripps Institution of Oceanography, La Jolla, California.

At first the intention at Site 12 was to core continuously the entire sedimentary column. Although 14 days were scheduled originally, only six days remained following arrival on location. The revised plan was to attempt continuous coring of as much of the upper section as time permitted.

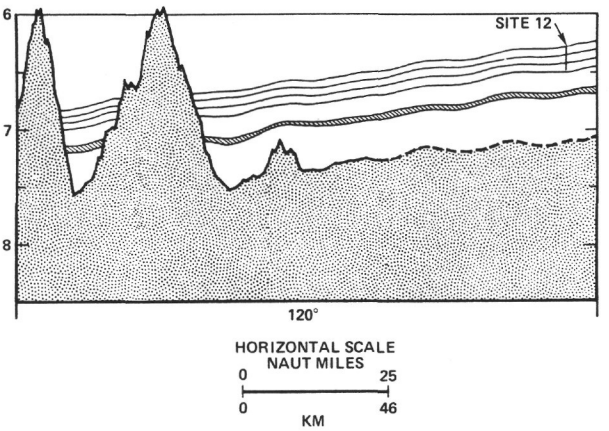

Figure 1. *Line drawing of profiler record made by* Glomar Challenger *on approach to Site 12.*

Drilling and Coring Log

The reader is referred to Table 2 for a summary of the coring operations at Site 12. Final positioning for Site 12 was accomplished in 14,898 feet (4542 meters) (corrected) of water at a location defined by the coordinates: latitude 19° 41.73'N and longitude 26° 00.03'W (Figure 2). Figure 3 is a line drawing of a profiler record made on the *Glomar Challenger* while on the site. The drill string included a Hycalog full-face diamond bit, 14 drill collars, and 2 bumper subs. While the drill string was being assembled, the ship was offset 1000 feet (304.8 meters) north and 1000 feet west from the beacon. Two attempts to core the uppermost sediment were unsuccessful, and the hole was abandoned. The drill string was completely disassembled, and both the bit and outer core barrel were found to be missing.

For Hole 12A, the drill string included a Hycalog full-face tungsten carbide bit, 14 drill collars, and 2 bumper subs. Hole 12A was aborted immediately after being spudded in; no core was recovered and the bit, outer drill barrel and two drill collars were lost.

For Hole 12B, the drill string included a Hycalog blade bit with tungsten carbide studs, 11 drill collars, and 2 bumper subs. The decision was made to drill down to a depth at which all the vulnerable joints of the lower drill string assembly were below the sea floor. The driller noted relatively firm sediment at 335 feet (102.1 meters) below the sea floor, and drilling stopped at 363 feet (110.6 meters). A piece of plastic tubing with serrated margins was used to supplement the core catcher. Thirty feet (9.1 meters) of sediment were cut for Core 1, and a length of two feet (0.6 meters) of unfossiliferous silty clay was recovered. This core contained much water, which was stored in plastic bags. The water retention indicated that the plastic tubing (core catcher assembly) functioned satisfactorily. Drilling was resumed to 511 feet (155.8 meters) below the sea floor. For the second core, a flapper-valve core catcher was used, and a 25 foot (7.6 meter) length of core was cut and a 6-foot (1.8 meter) length of silty clay was recovered. The soft sediment is unfossiliferous, but the chert fragments yielded a sparse radiolarian fauna of early Eocene Age. Drilling was resumed to a depth of 675 feet (205.7 meters) below the sea floor. The drilling rate slowed appreciably, as several hard intervals were encountered. A length of 29 feet (8.8 meters) of sediment was cut for Core 3. One foot (0.3 meter) of dolomitic clay was recovered, as well as large fragments of hard chert. Two hours of drilling resulted in only 11 feet (3.3 meters) of penetration. On the fourth attempt, a length of 2 feet (0.6 meter) of core was cut in two hours, but no sample was recovered. Hole 12B was abandoned.

It was decided to stay at this location and spend the remainder of the time scheduled for Leg 2 coring the upper several hundred feet of soft calcareous sediments. At 12C, a total length of 377 feet (114.9 meters) of sediment was continuously cored and a 30 foot (3.9 meter) core was cut for each of the 13 core barrels. At Hole 12D, the upper 120 foot section of the sedimentary column was cored in seven cores; all but the last core overlaps the lower part of the previously cored interval to insure recovery of a complete stratigraphic section. This was accomplished by drilling from the ocean floor to the objective interval in each case. During coring of these soft surface sediments, the newly developed plastic sleeve adaptation to the core catcher was used in Hole 12D. Its success is evident from the remarkably increased core recovery rate as compared to all previous attempts to core soft sediment (see drilling summaries).

At Holes 12B, 12C and 12D, a total length of 238 feet (72.5 meters) of core was recovered and average rate of recovery was 35.6 per cent. The maximum penetration beneath the sea floor was 717 feet (218.5 meters). The depths of the cored intervals in Holes 12B, 12C and 12D are presented diagrammatically in Figures 4 and 5.

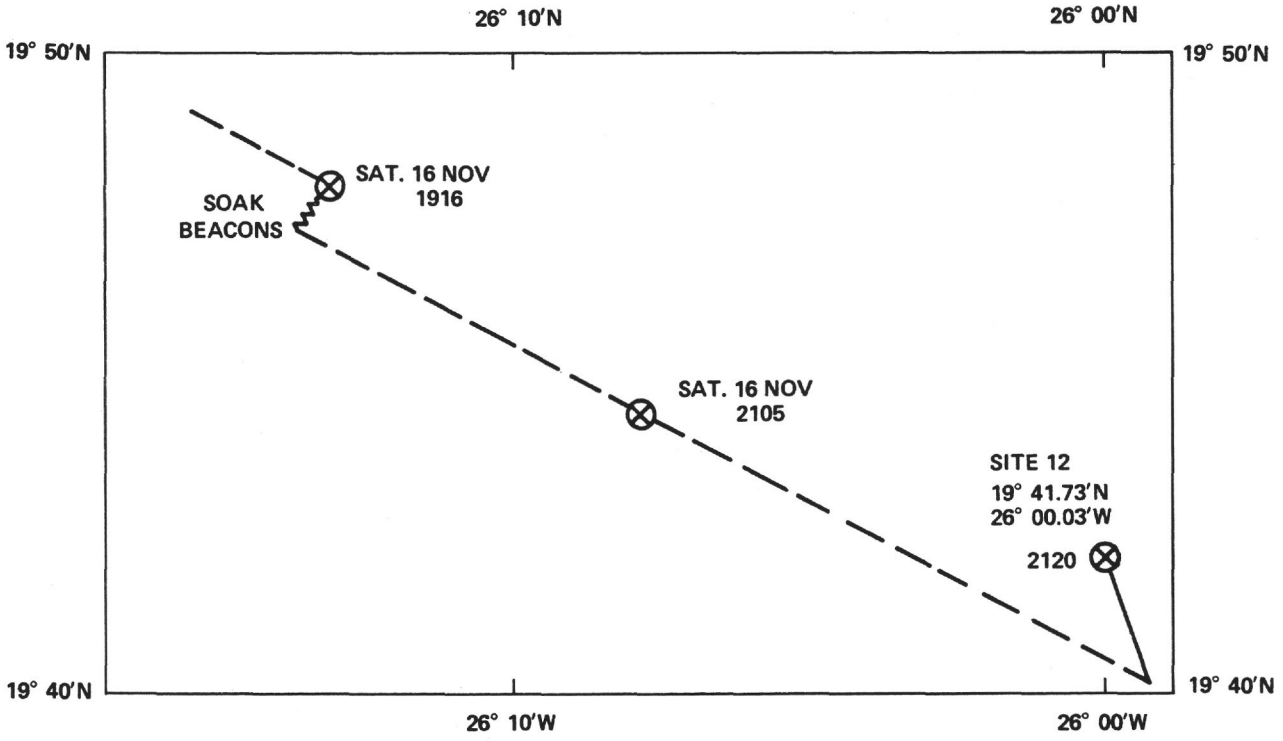

Figure 2. *Chart showing Glomar Challenger's approach to Site 12.*

TABLE 1
Drilling Summary

Hole 12B
(lat. 19° 41.73′N., long. 26° 00.03′W.; depth 4557 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	Depth Below Sea Floor ft	Depth Below Sea Surface m	Depth Below Sea Surface ft	Core Cut m	Core Cut ft	Core Recov. m	Core Recov. ft	% Core Recov.	No. of Sec.
2320		110.0	361	4667	15,311						
19 Nov	1	119.2	391	4676	15,341	9.14	30	.61	2	7	1-4[a]
0800		155.8	511	4712	15,461						
20 Nov	2	163.4	536	4720	15,486	7.62	25	1.83	6	24	2
1840		205.7	675	4762	15,625						
20 Nov	3	214.6	704	4771	15,654	8.84	29	.30	1	34	1
0045		217.9	715	4775	15,665						
21 Nov	4	218.5	717	4775	15,667	.61	2	0	0	0	0
						26.21	86	2.74	9	10.5	

Hole 12C
(lat. 19° 41.73′N., long. 26° 00.03′W.; depth 4557 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	Depth Below Sea Floor ft	Depth Below Sea Surface m	Depth Below Sea Surface ft	Core Cut m	Core Cut ft	Core Recov. m	Core Recov. ft	% Core Recov.	No. of Sec.
0645		0	0	4557	14,950						
21 Nov	1	9.1	30	4566	14,980	9.14	30	5.79	19	63	4
0825		11.3	37	4568	14,987						
21 Nov	2	20.4	67	4577	15,017	9.14	30	0	0	0	0[b]
1020		14.3	47	4571	14,997						
21 Nov	2R	23.5	77	4580	15,027	9.14	30	6.09	20	67	4
1145		23.5	77	4580	15,027						
21 Nov	3	32.6	107	4589	15,057	9.14	30	0	0	0	0[c]
1400		32.6	107	4598	15,057						
21 Nov	4	41.8	137	4598	15,087	9.14	30	4.27	14	47	3[c]
1545		41.8	137	4598	15,087						
21 Nov	5	50.9	167	4608	15,117	9.14	30	3.66	12	40	3[c]
1745		50.9	167	4608	15,117						
21 Nov	6	60.1	197	4617	15,147	9.14	30	2.13	7	23	2[d]
1940		60.1	197	4617	15,147						
21 Nov	7	69.2	227	4626	15,177	9.14	30	2.13	7	23	2[e]
2150		69.2	227	4626	15,177						
21 Nov	8	78.4	257	4635	15,207	9.14	30	.91	3	10	1

TABLE 1 - *Continued*

Hole 12C
(lat. 19° 41.73′N., long 26° 00.03′W.; depth 4557 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	Depth Below Sea Floor ft	Depth Below Sea Surface m	Depth Below Sea Surface ft	Core Cut m	Core Cut ft	Core Recov. m	Core Recov. ft	% Core Recov.	No. of Sec.
2350		78.4	257	4635	15,207						
21 Nov	9	87.5	287	4644	14,237	9.14	30	2.13	7	23	2[f]
0130		87.5	287	4644	15,237						
22 Nov	10	96.6	317	4654	15,267	9.14	30	.61	2	7	1
0330		96.6	317	4654	15,267						
22 Nov	11	105.8	347	4663	15,297	9.14	30	1.22	4	10	1
0545		105.8	347	4663	15,297						
22 Nov	12	114.9	377	4672	15,327	9.14	30	1.52	5	15	1
						118.87	390	30.48	100	25.6	

Hole 12D
(lat. 19° 41.73′N., long 26° 00.03′W.; depth 4557 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	Depth Below Sea Floor ft	Depth Below Sea Surface m	Depth Below Sea Surface ft	Core Cut m	Core Cut ft	Core Recov. m	Core Recov. ft	% Core Recov.	No. of Sec.
0700		0	0	4557	14,950						
22 Nov	1	10.1	33	4568	14,983	10.06	33	9.14	30	100	7
0900		6.1	20	4564	14,970						
22 Nov	2	15.8	52	4574	15,002	9.75	32	2.13	7	23	2
		12.2	40	4570	14,990						
22 Nov	2R	22.9	75	4581	15,025	10.67	35	4.88	16	53	4
		(-8.8)	-29	4549	14,921						
22 Nov	1R	0.3	1	4557	14,951	.30	1	0	0	0	0[g]
1525		12.2	40	4569	14,990						
22 Nov	3	21.3	70	4579	15,020	9.14	30	9.14	30	100	6
1730		18.3	60	4576	15,010						
22 Nov	4	27.4	90	4585	15,040	9.14	30	5.79	19	63	4
0900		27.4	90	4585	15,040						
23 Nov	5	36.6	120	4594	15,070	9.14	30	8.23	27	90	6
						58.22	191	39.32	129	67.5	

Note: T.D. = 15,667 feet.

Footnotes to Table 1.

[a]Core 1 - Much of the watery mud contained in the plastic liners (Sec. 2, 3, 4) was put in a 3 foot plastic bag; Section 4, about 1 foot–firm; no Sections 2, 3.

[b]Core 2 - No samples; drew pipe above mud line and re-cored Core 2; labelled Core 2R (repeat); Two freezer boxes of core catcher material.

[c]Cores 3, 4, 5 - One freezer box of core catcher sample for each core.

[d]Core 6 - Section 2 liner broke into two pieces; two freezer boxes for catcher sample.

[e]Core 7 - Three freezer boxes, one for catcher and two for material from between catcher and lower section.

[f]Core 9 - Two freezer boxes for core catcher sample.

[g]Core 1R - This core was to have been taken at 40-70 feet again, but a miscalculation put the core at -30 to +1 foot; one freezer box.

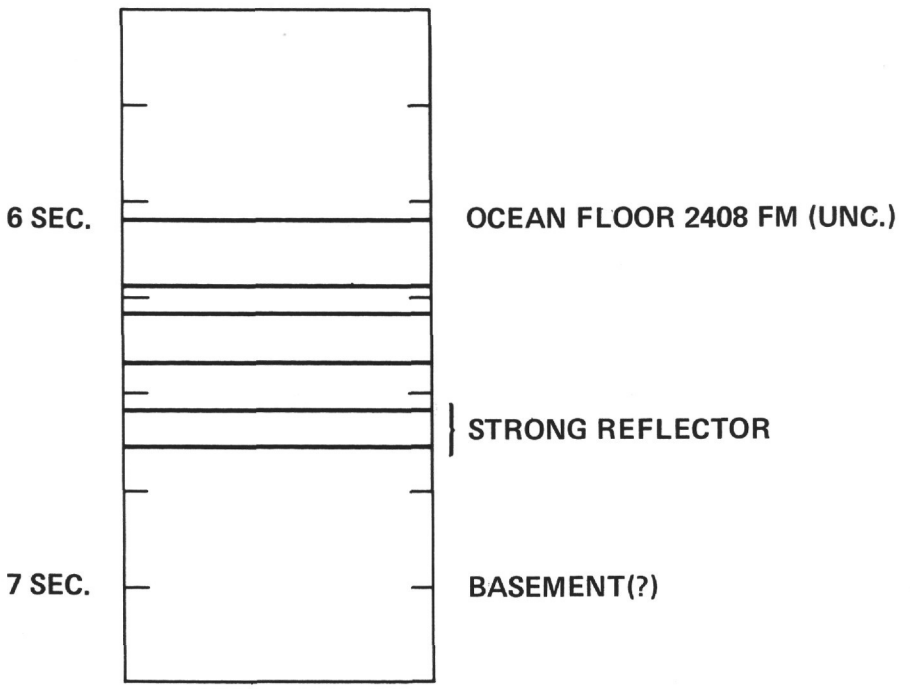

Figure 3. *Line drawing of profiler record made on station by Glomar Challenger at Site 12.*

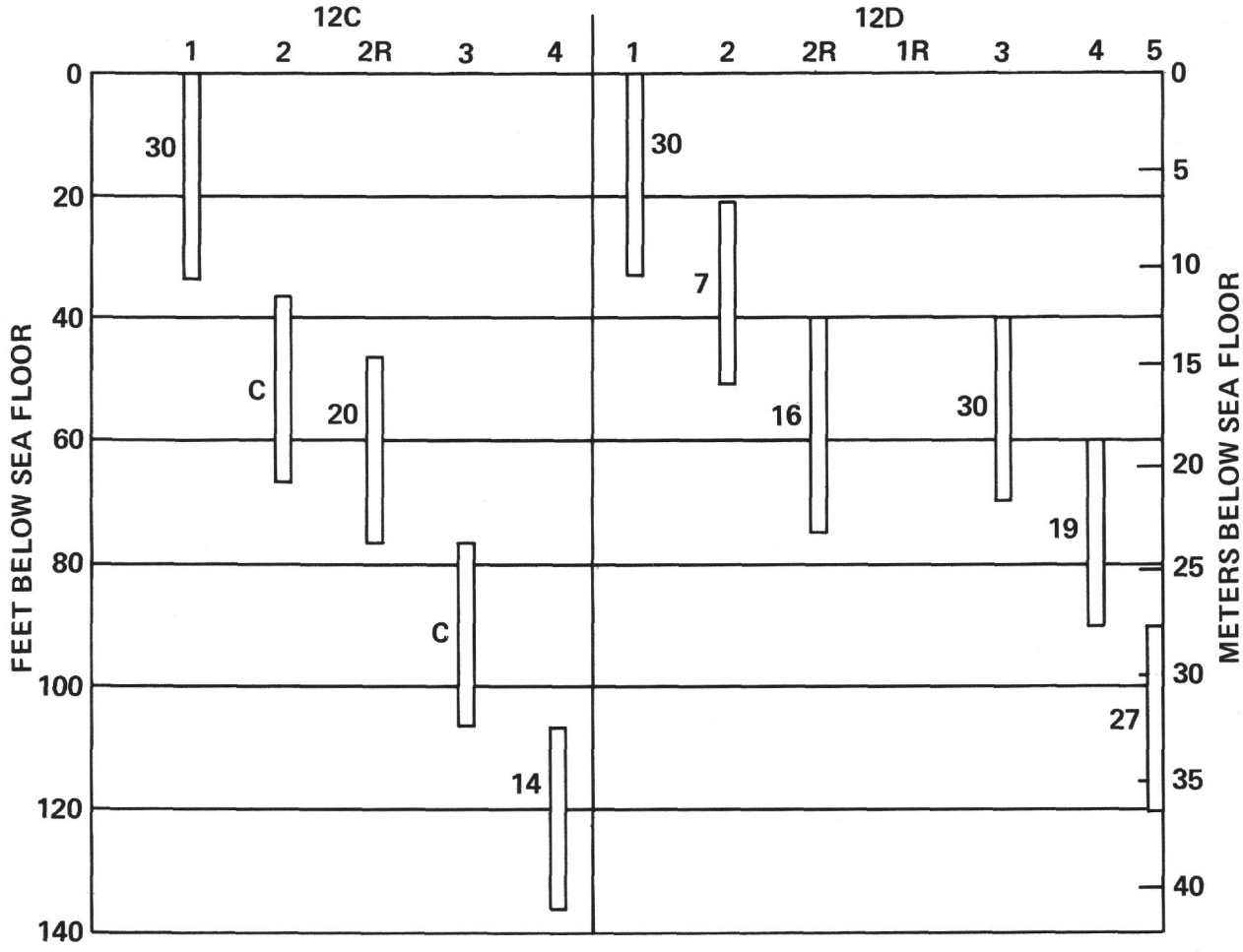

Figure 5. *Depths below the sea floor of the cored interval for each barrel of Holes 12C and 12D. Number to left of column is the recovery in feet. The location of the recovered sediment in the interval cut is not clearly known and is therefore not indicated.*

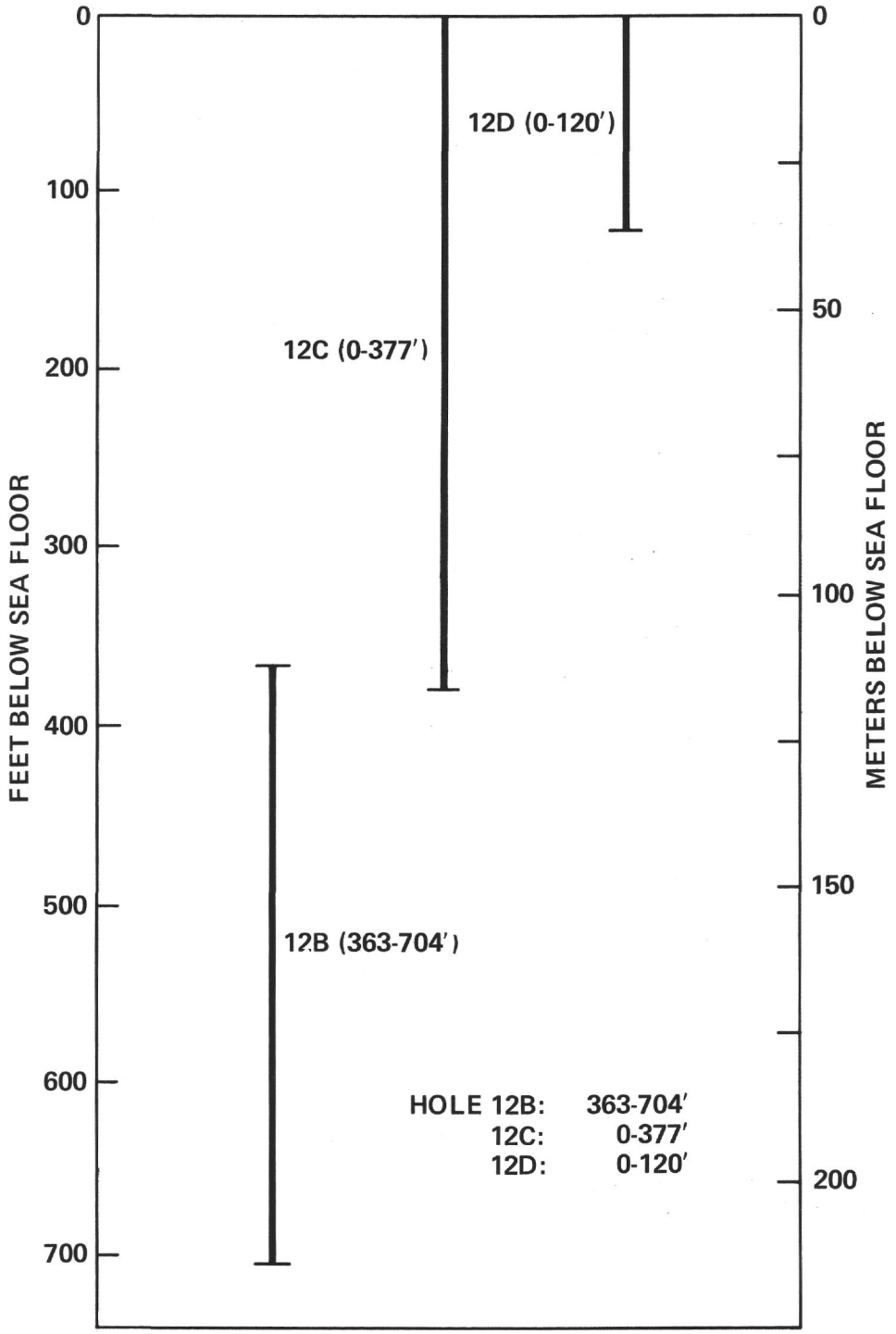

Figure 4. *Depths below the sea floor of cored intervals of Holes 12B, 12C, and 12D.*

Summary of Drilling and Coring at Site 12.

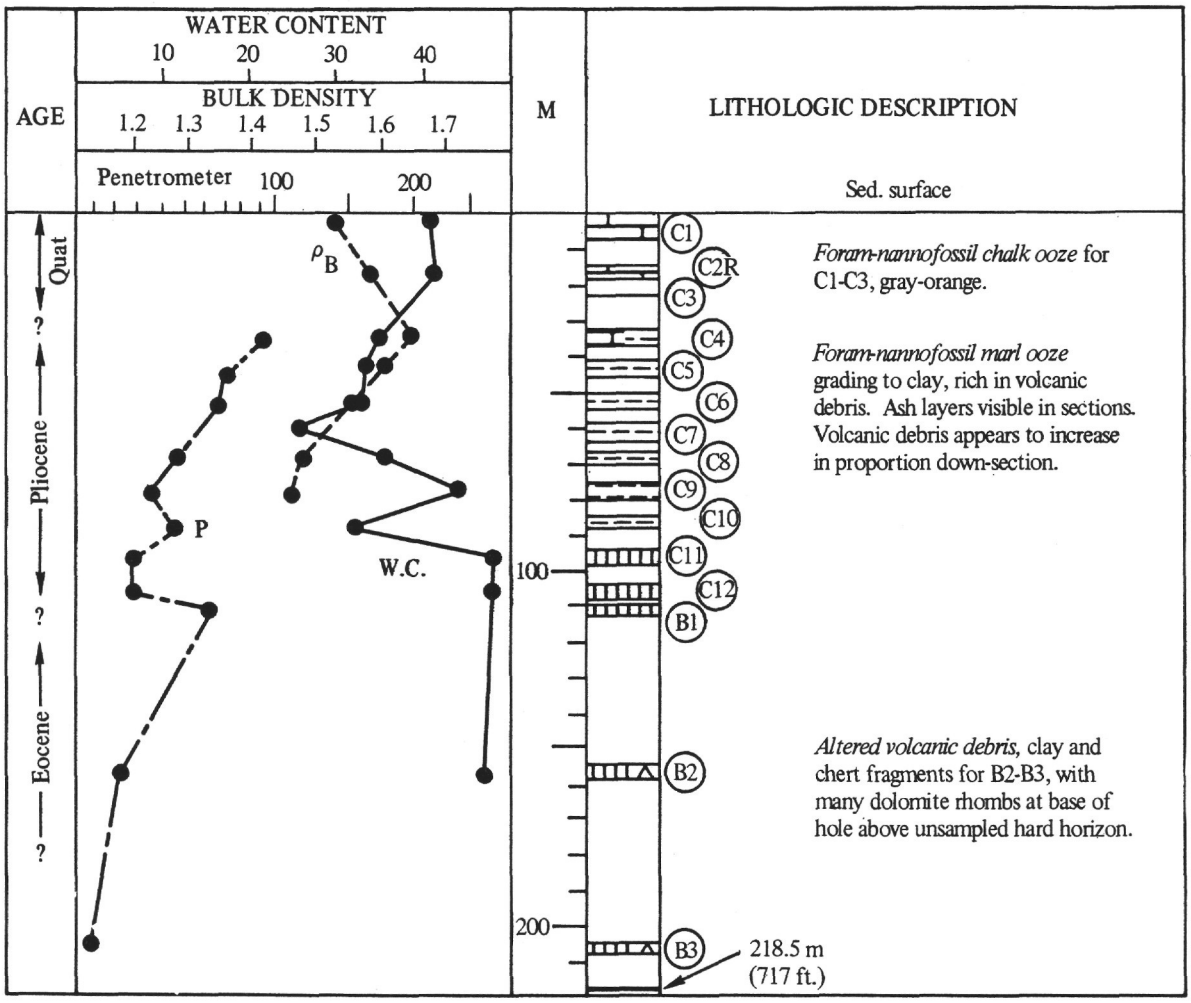

Figure 6. *Summary of drilling and coring at Site 12.*
No descriptions are available for cores taken from Hole 12D. These cores were presented unopened.

The Cores Recovered from Site 12

Figures 7 through 20 are the graphic summaries of the cores recovered at Site 12.

These figures show, for each core:

(1) The stratigraphic age.
(2) The natural gamma radiation
(3) The bulk density was 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.

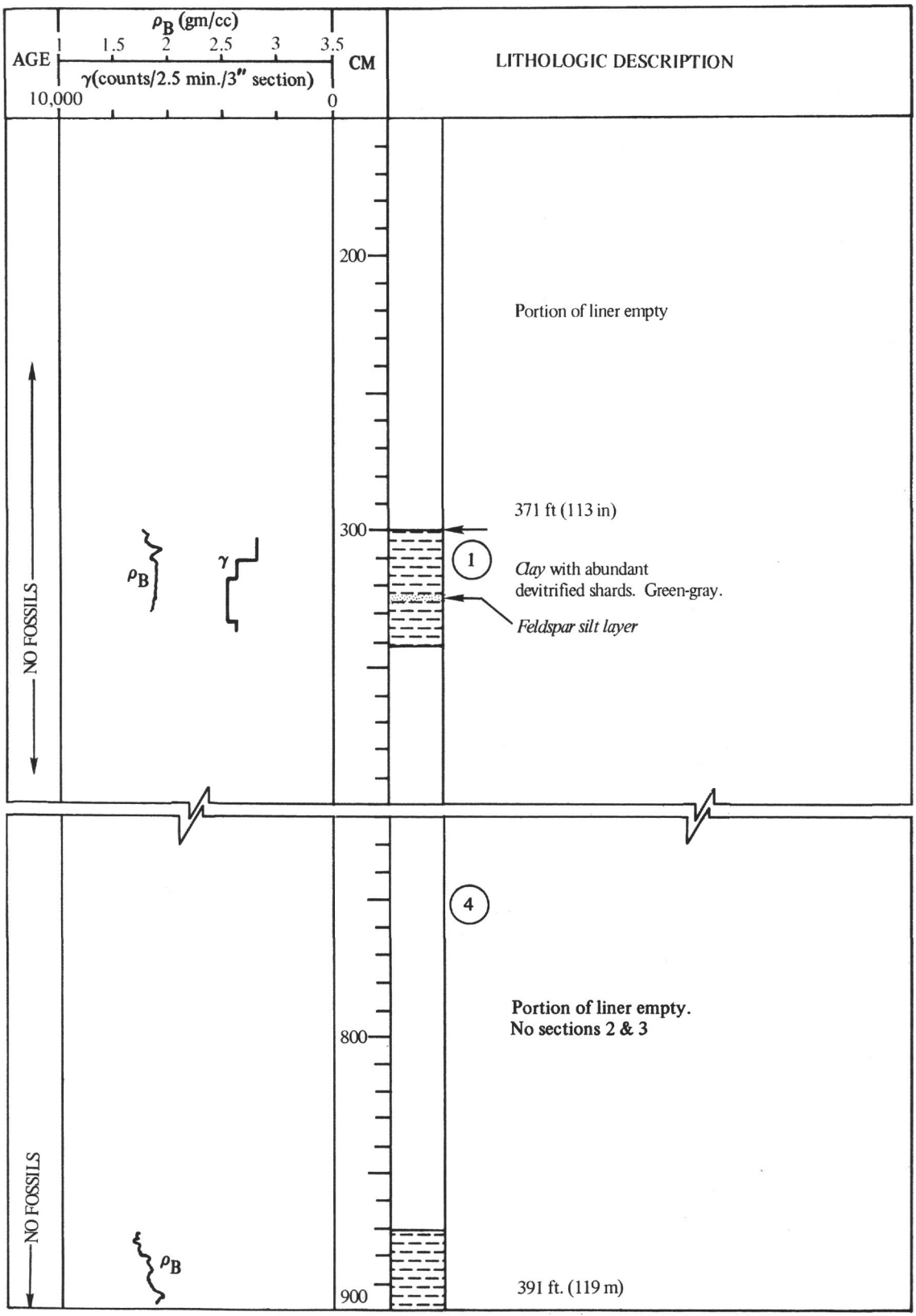

Figure 7. *Hole 12B Core 1.*

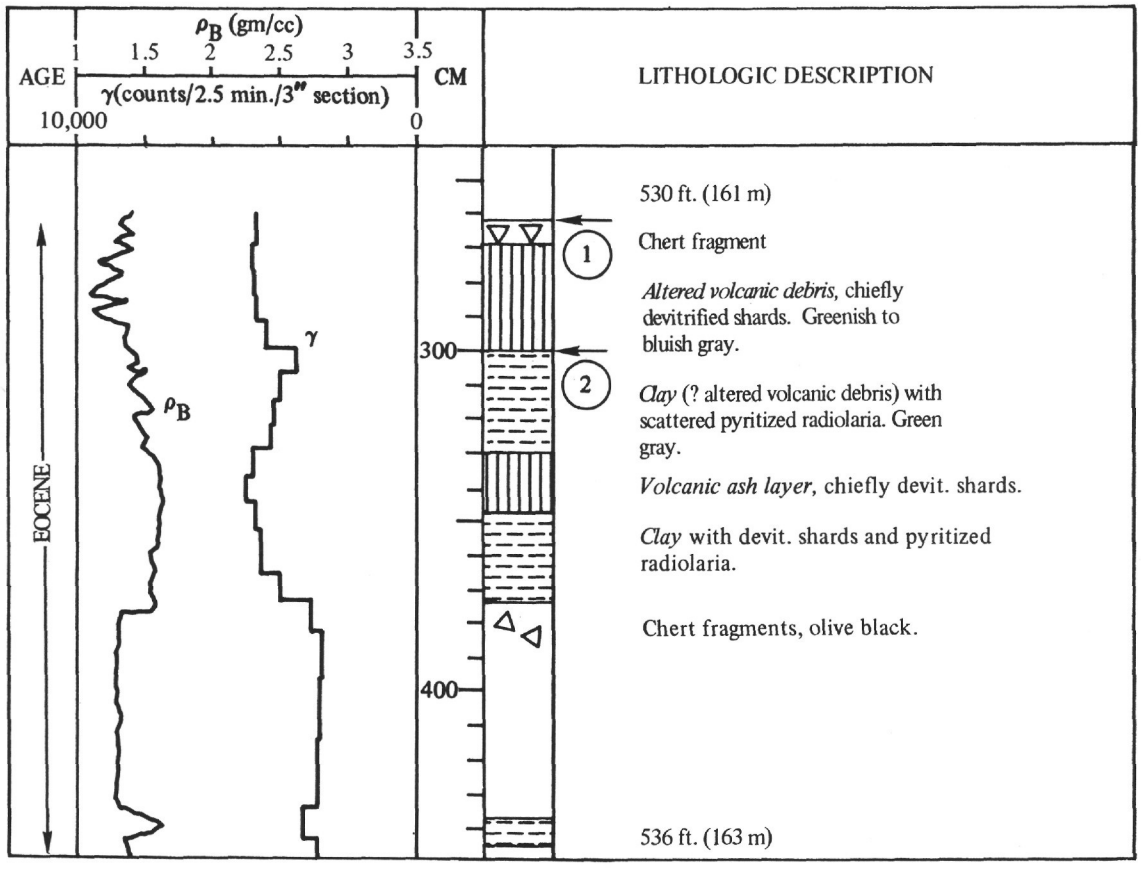

Figure 8. *Hole 12B Core 2.*

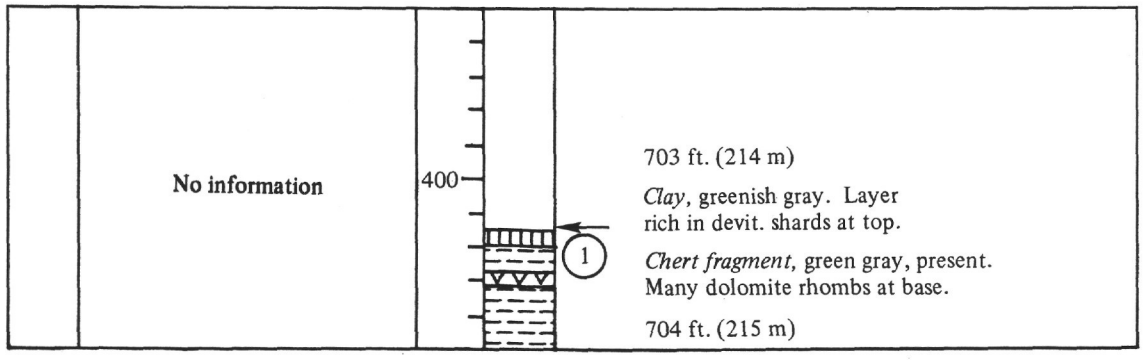

Figure 9. *Hole 12B Core 3.*

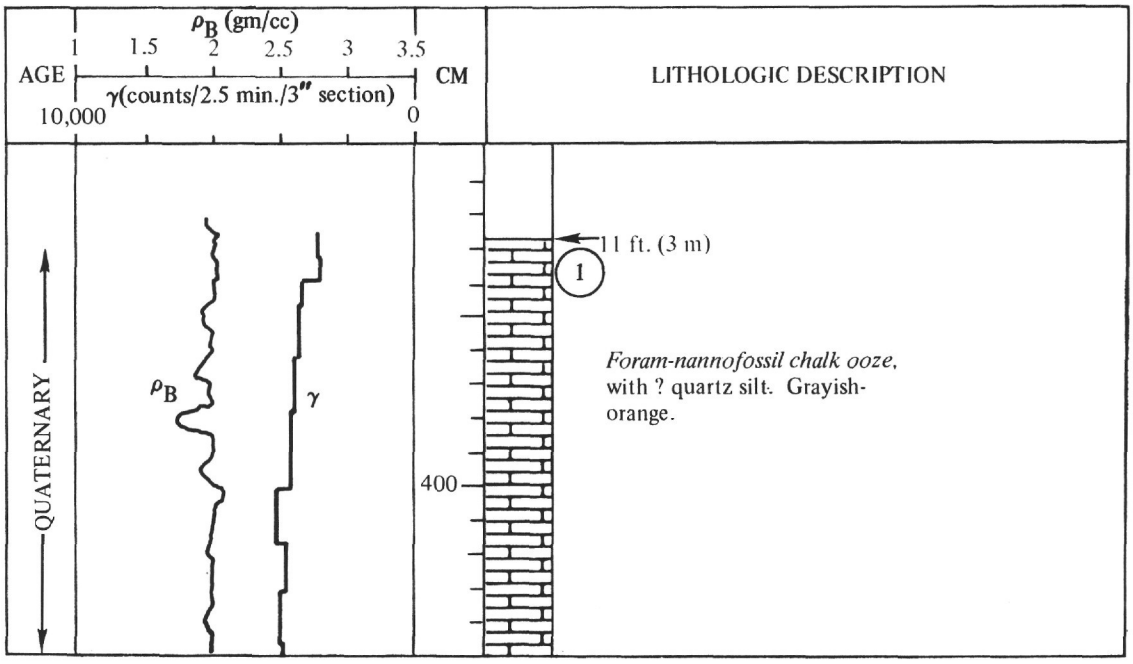

Figure 10. *Hole 12C Core 1*

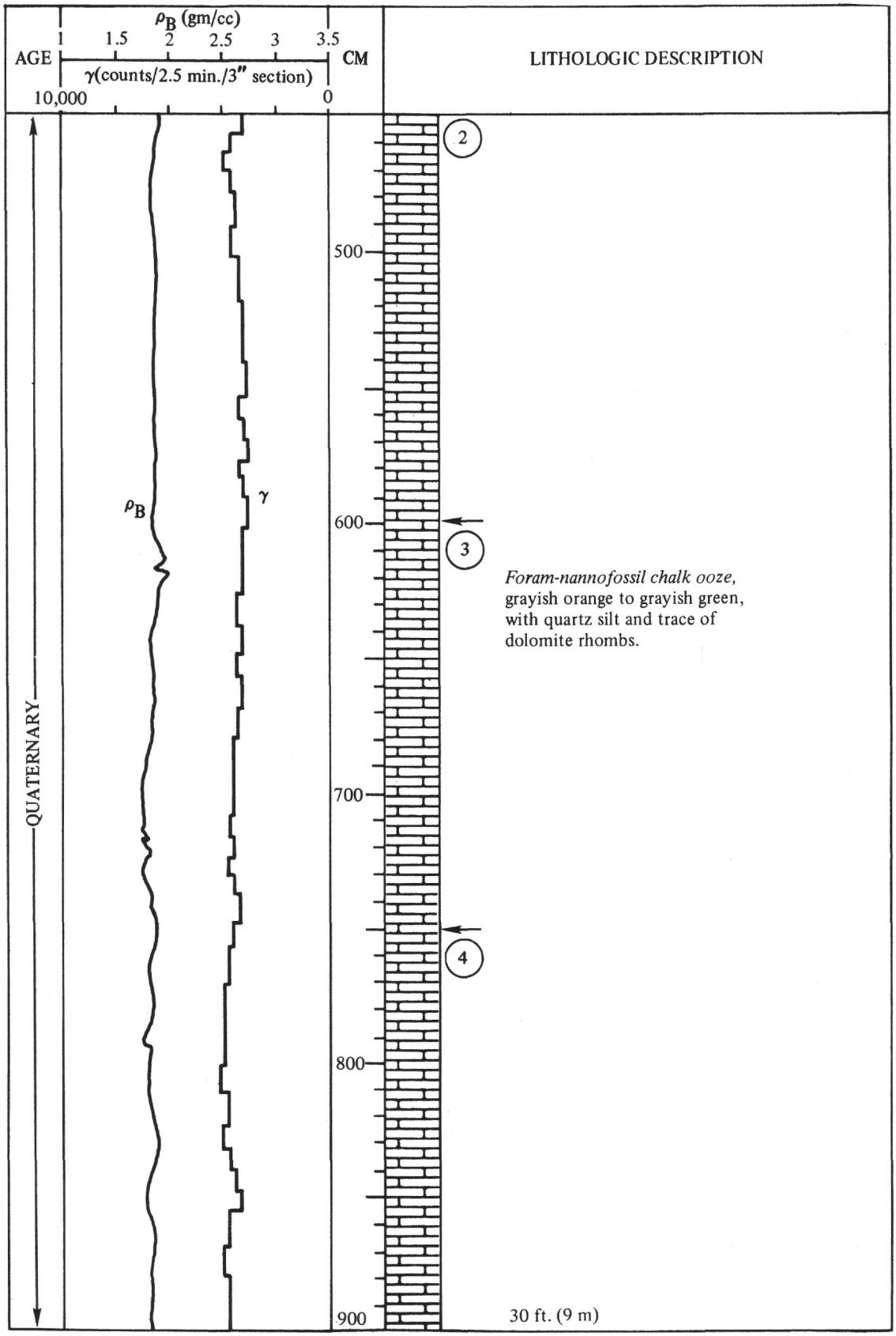

Figure 10. *(Continued).*

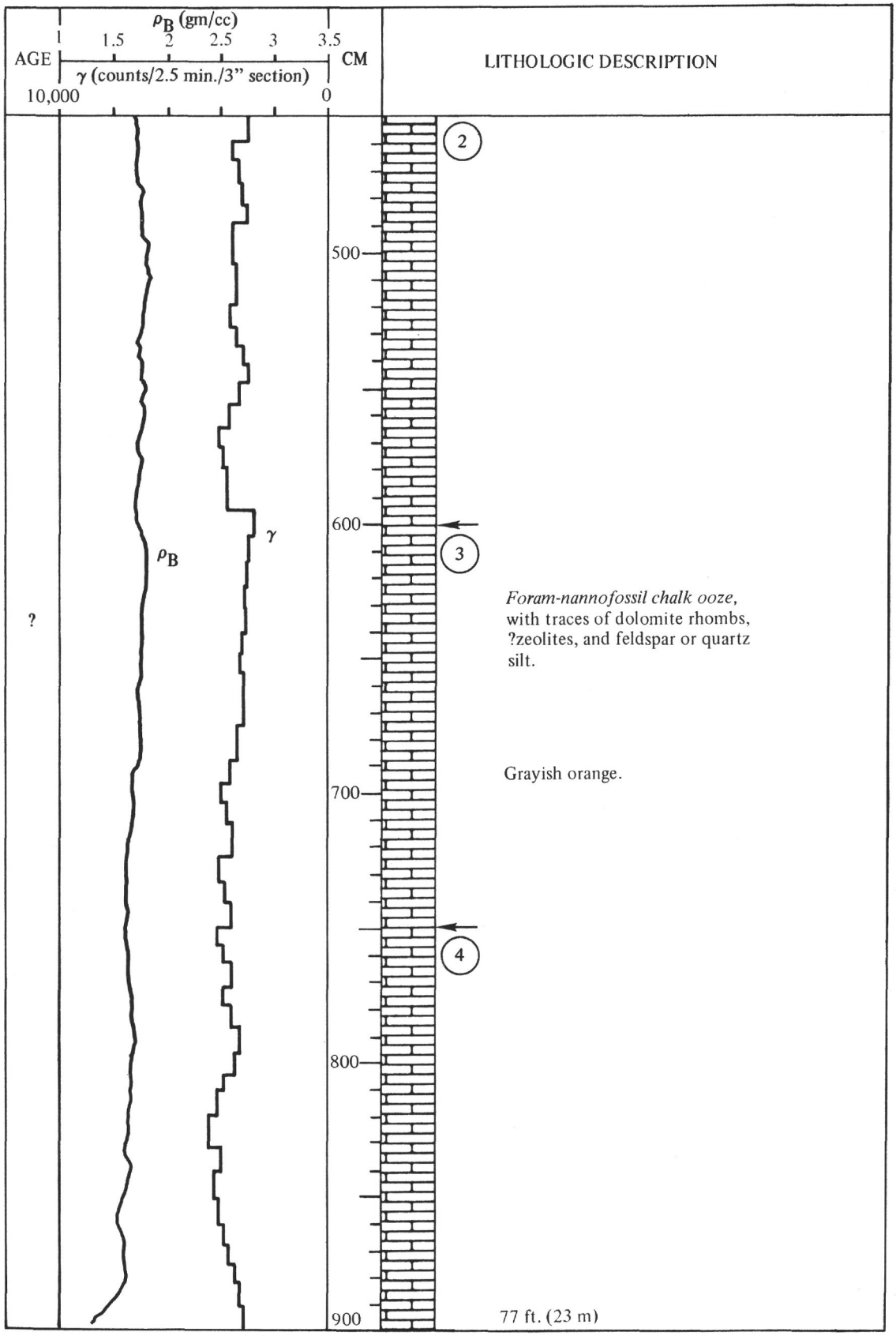

Figure 11. *(Continued).*

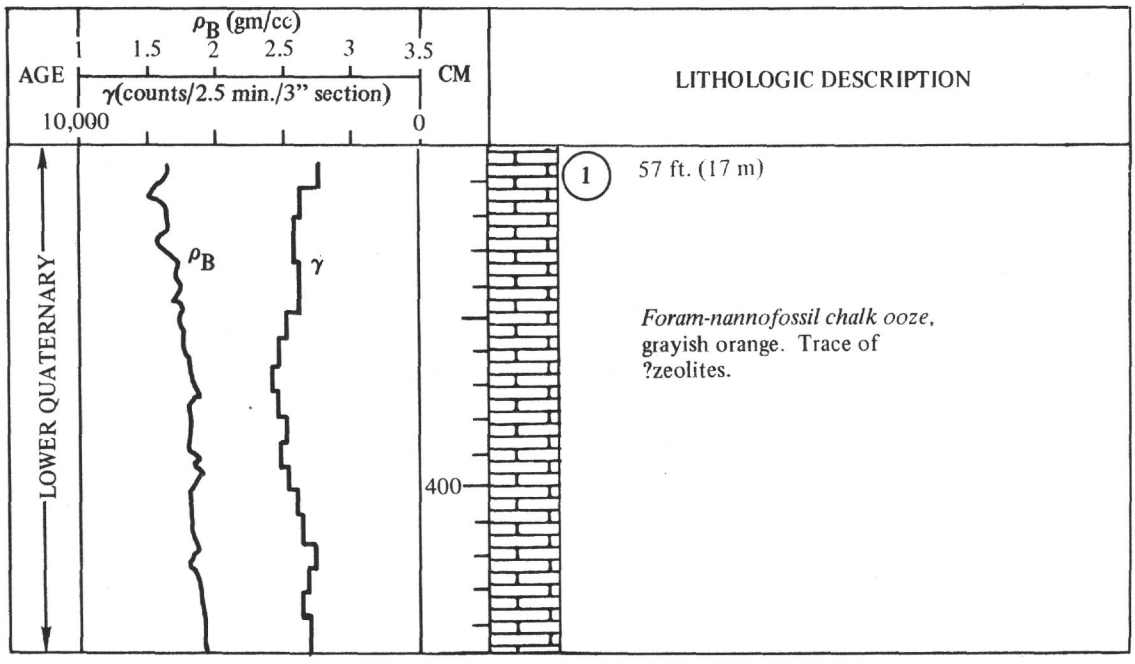

Figure 11. *Hole 12C Core 2R*

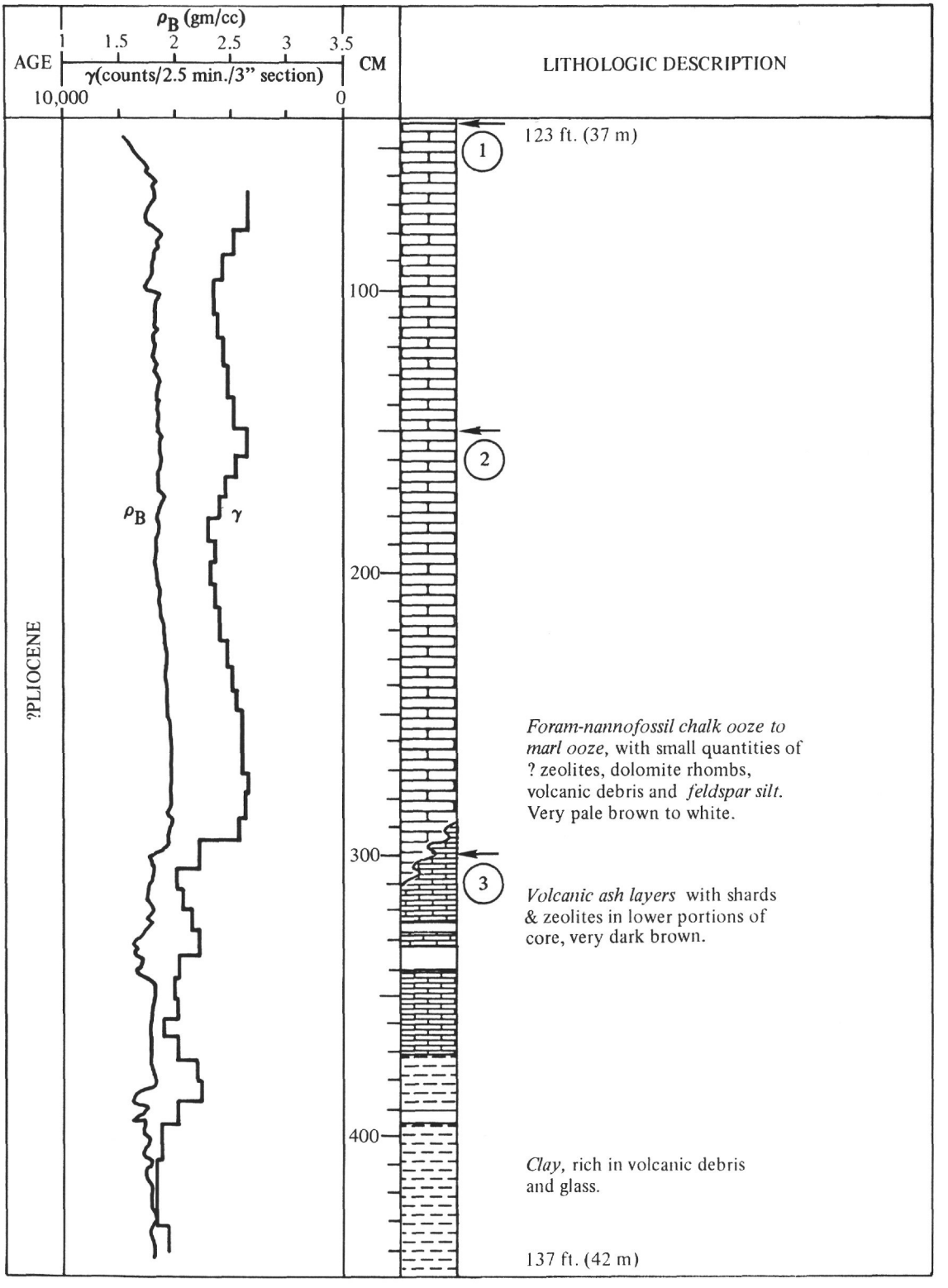

Figure 12. *Hole 12C Core 4.*

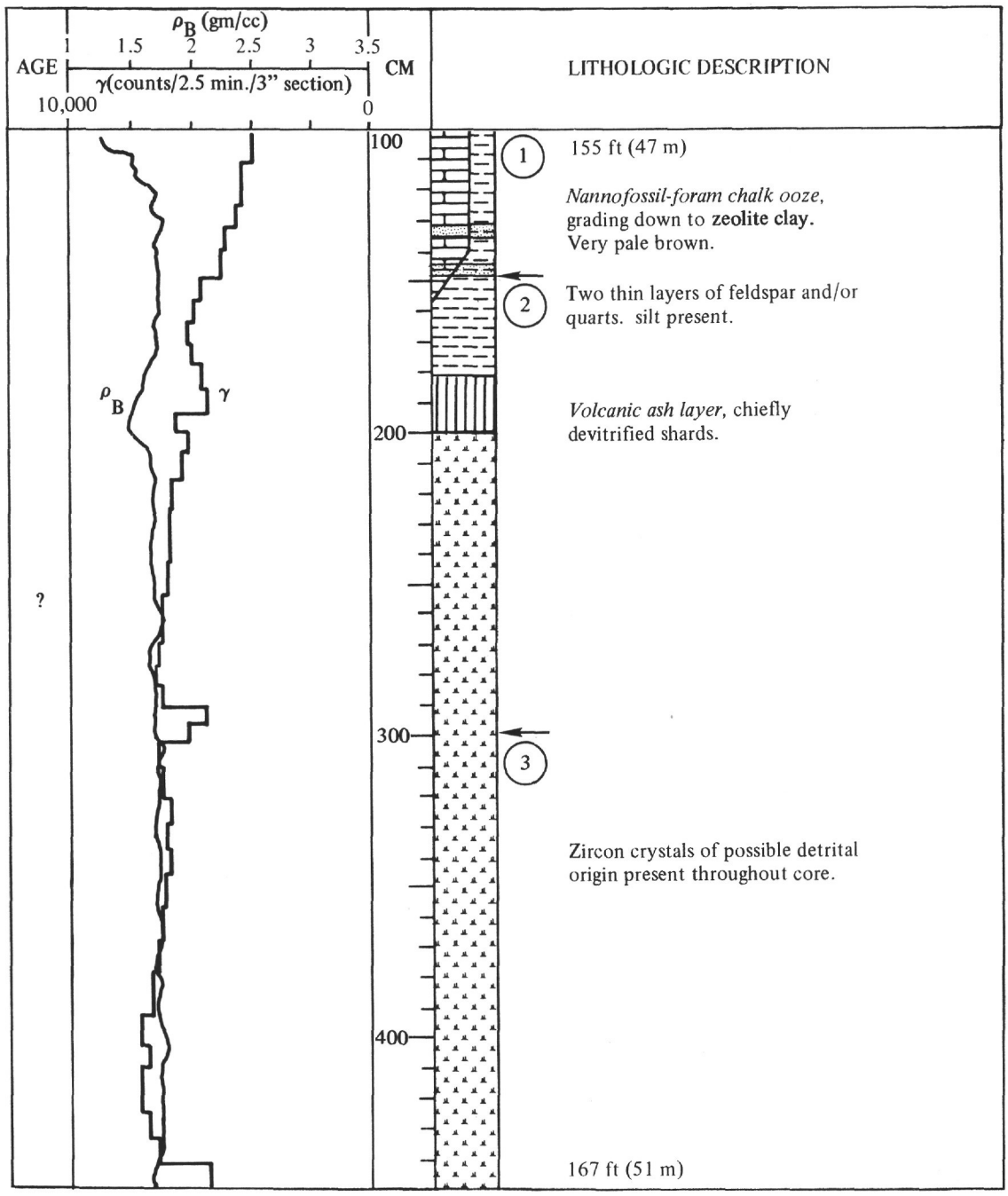

Figure 13. *Hole 12C Core 5.*

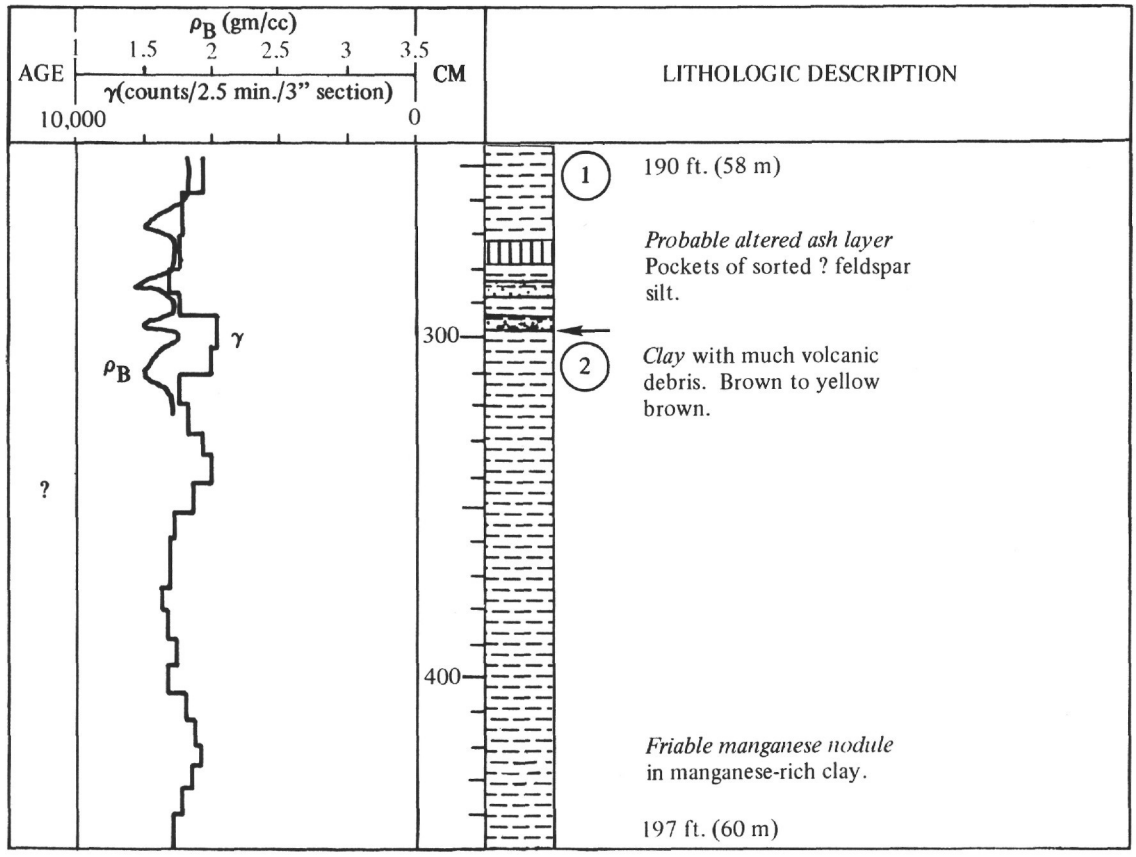

Figure 14. *Hole 12C Core 6.*

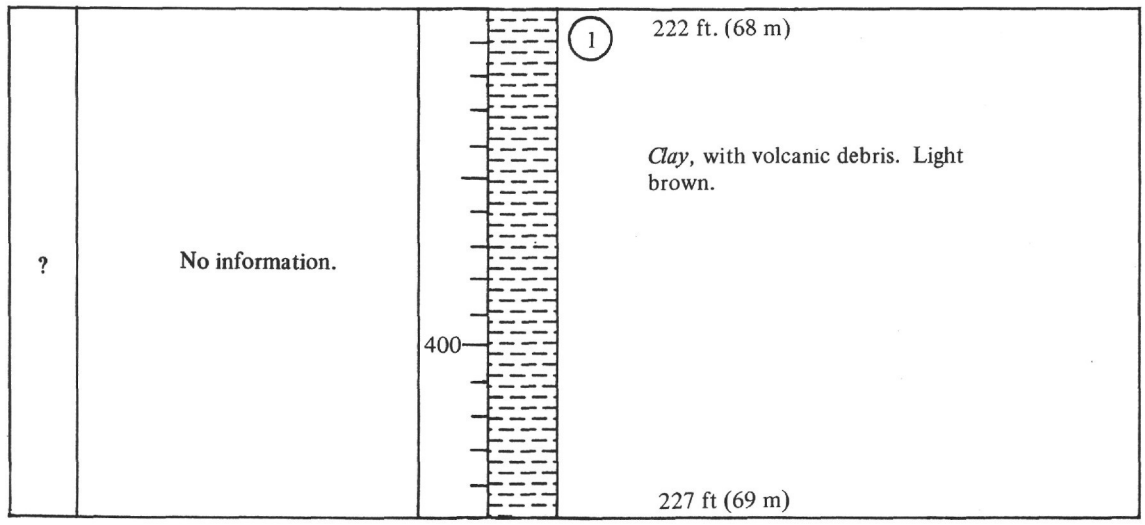

Figure 15. *Hole 12C Core 7.*

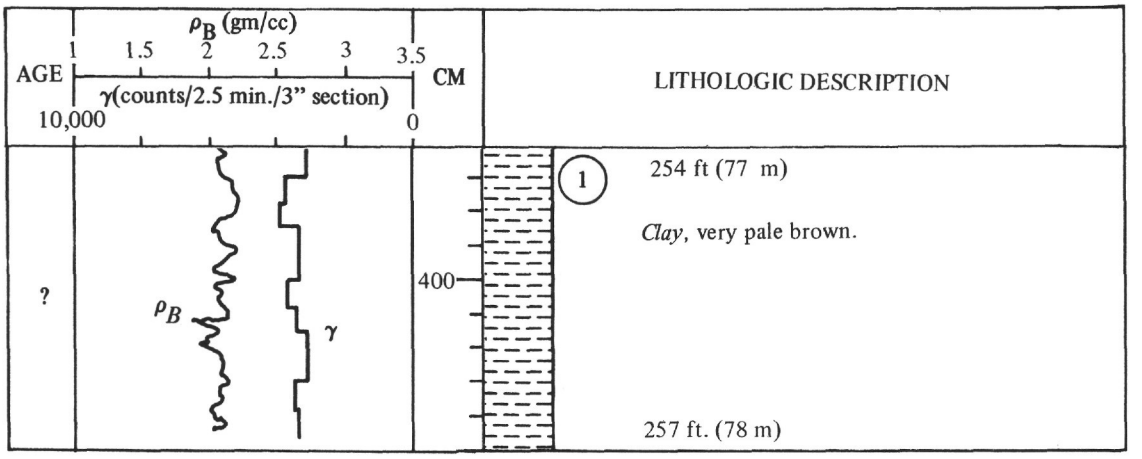

Figure 16. *Hole 12C Core 8.*

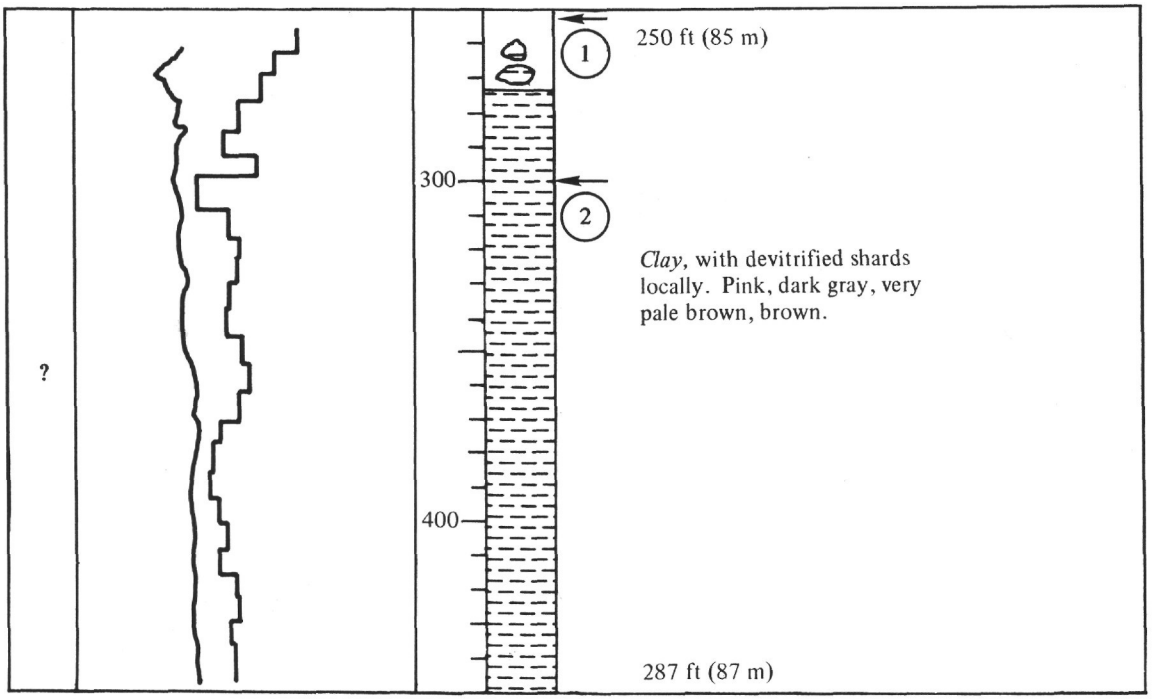

Figure 17. *Hole 12C Core 9.*

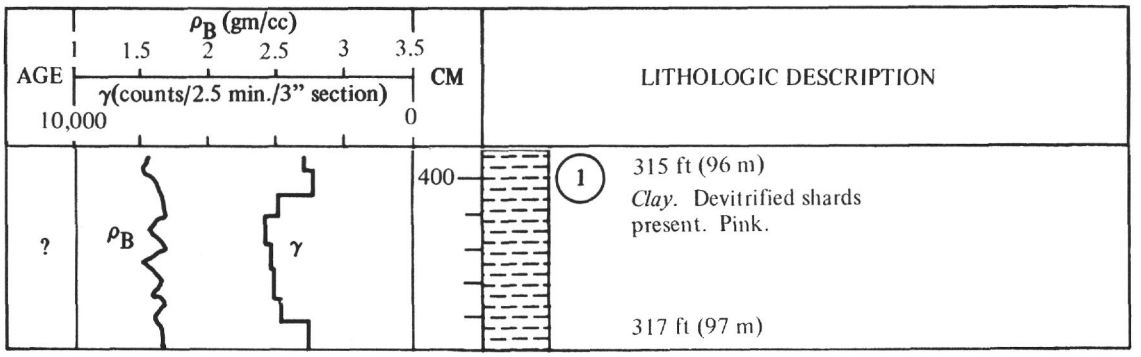

Figure 18. *Hole 12C Core 10.*

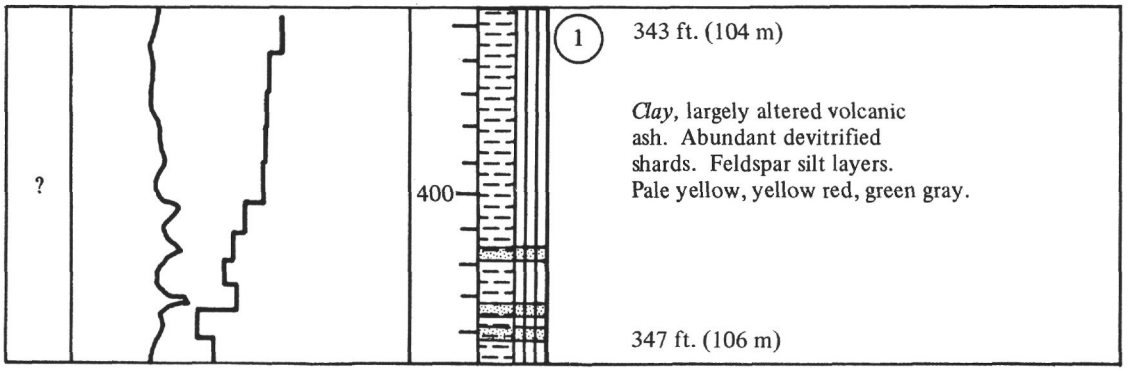

Figure 19. *Hole 12C Core 11.*

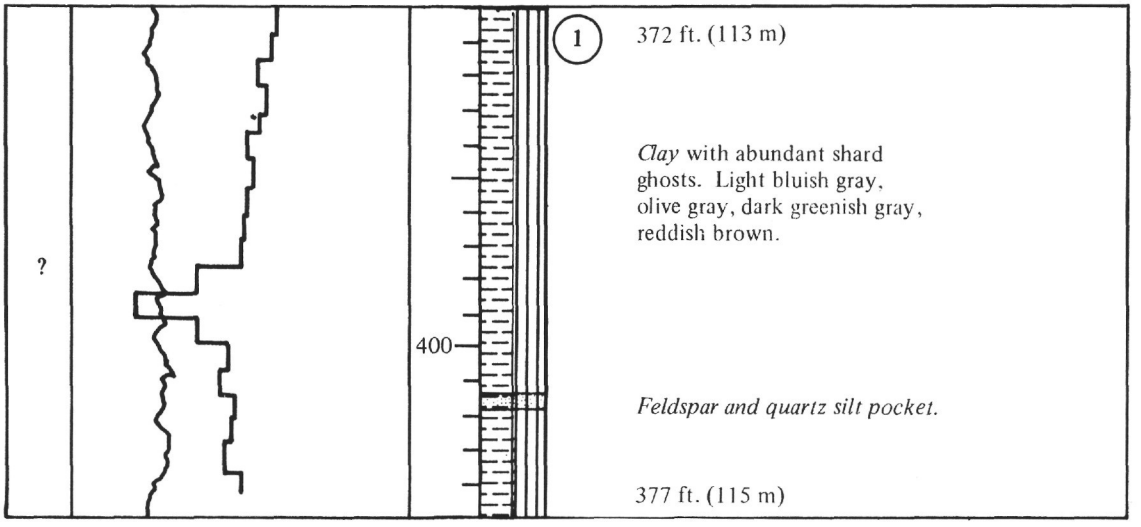

Figure 20. *Hole 12C Core 12.*

The Cores Recovered from Site 12

Figures 21 through 48 show details of the individual core sections of the cores from Site 12.

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.

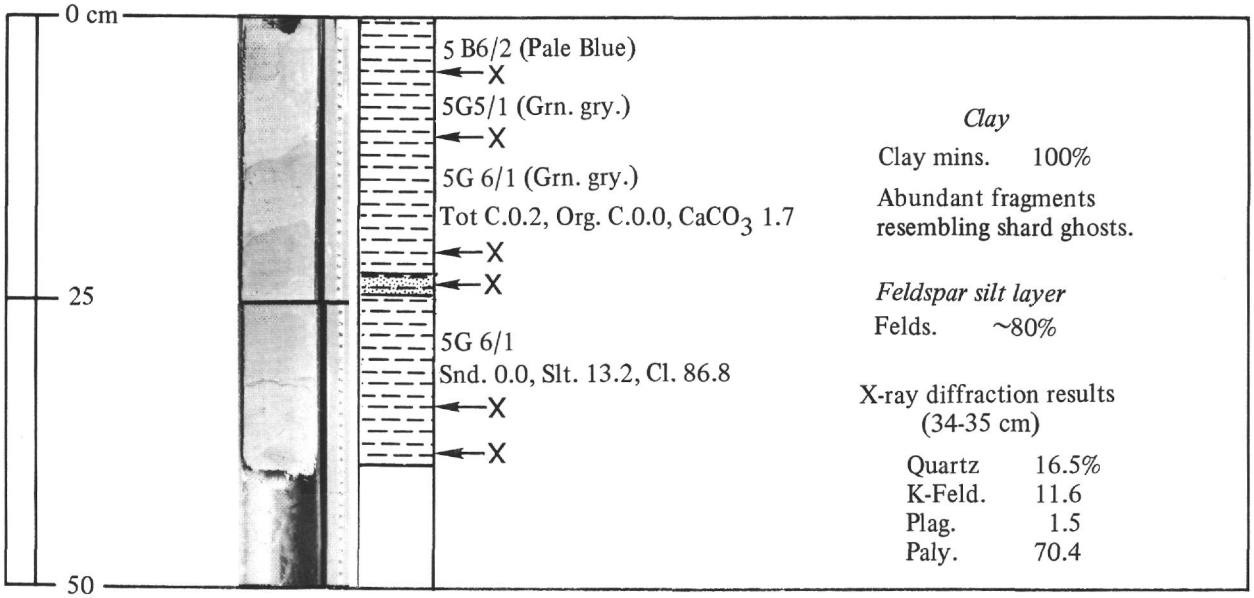

Figure 21. *Hole 12B Core 1 Section 1*

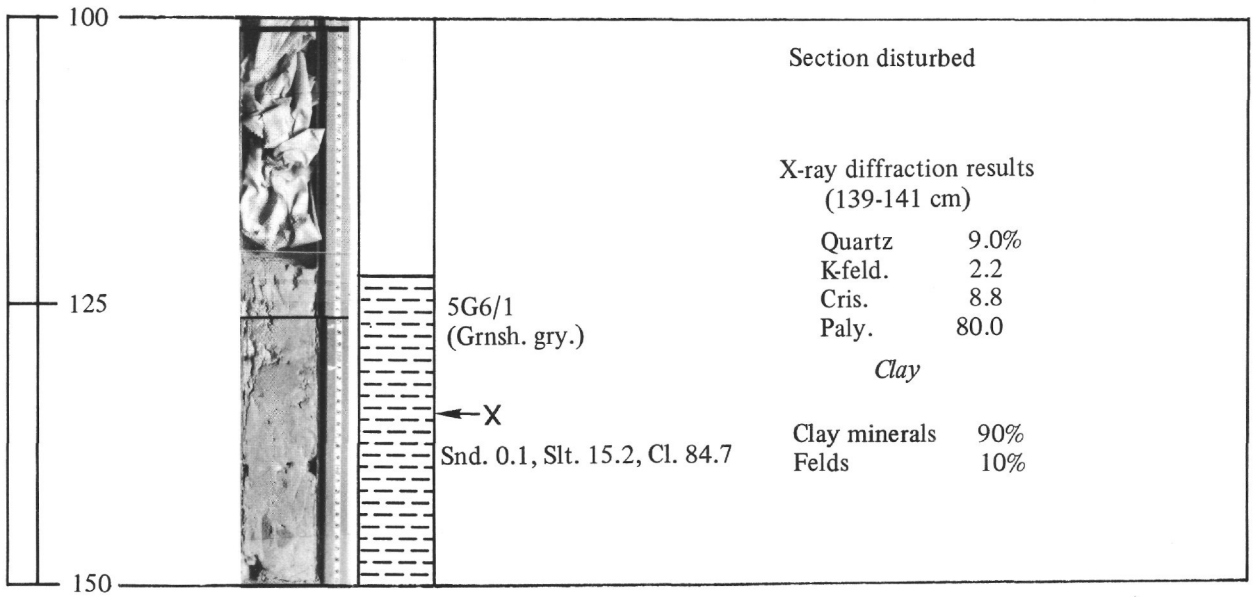

Figure 22. *Hole 12B Core 1.*

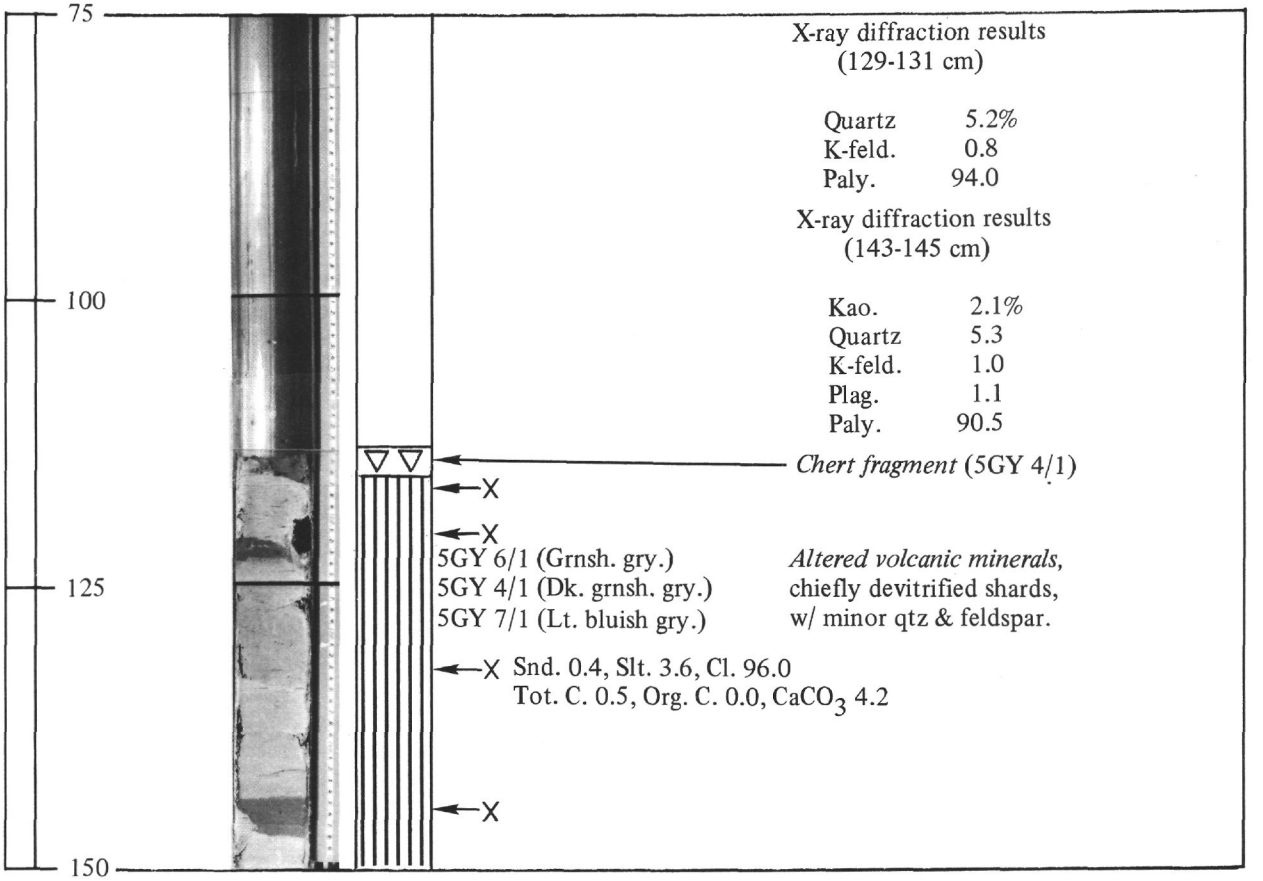

Figure 23. *Hole 12B Core 2 Section 1.*

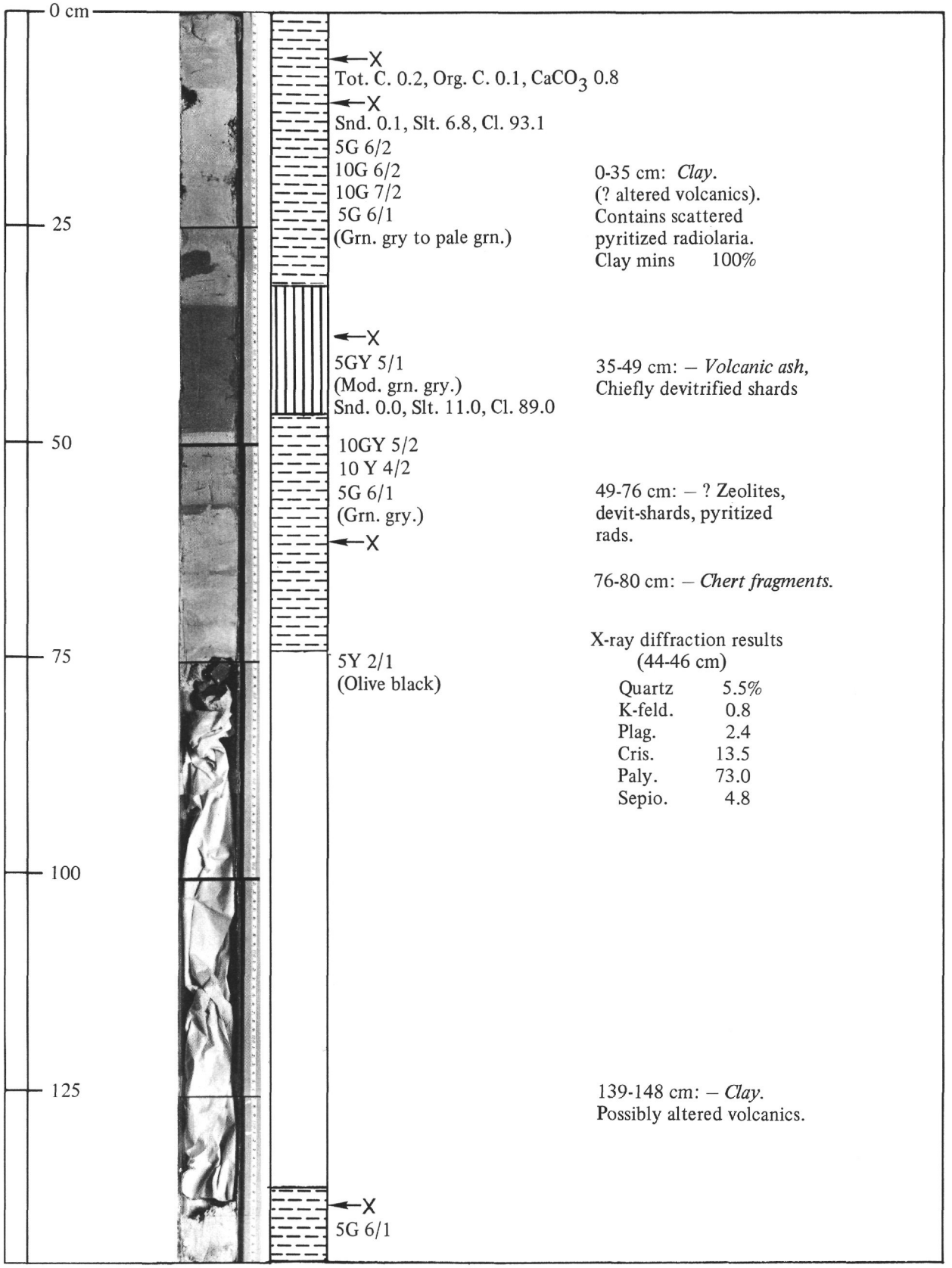

Figure 24. *Hole 12B Core 2 Section 2.*

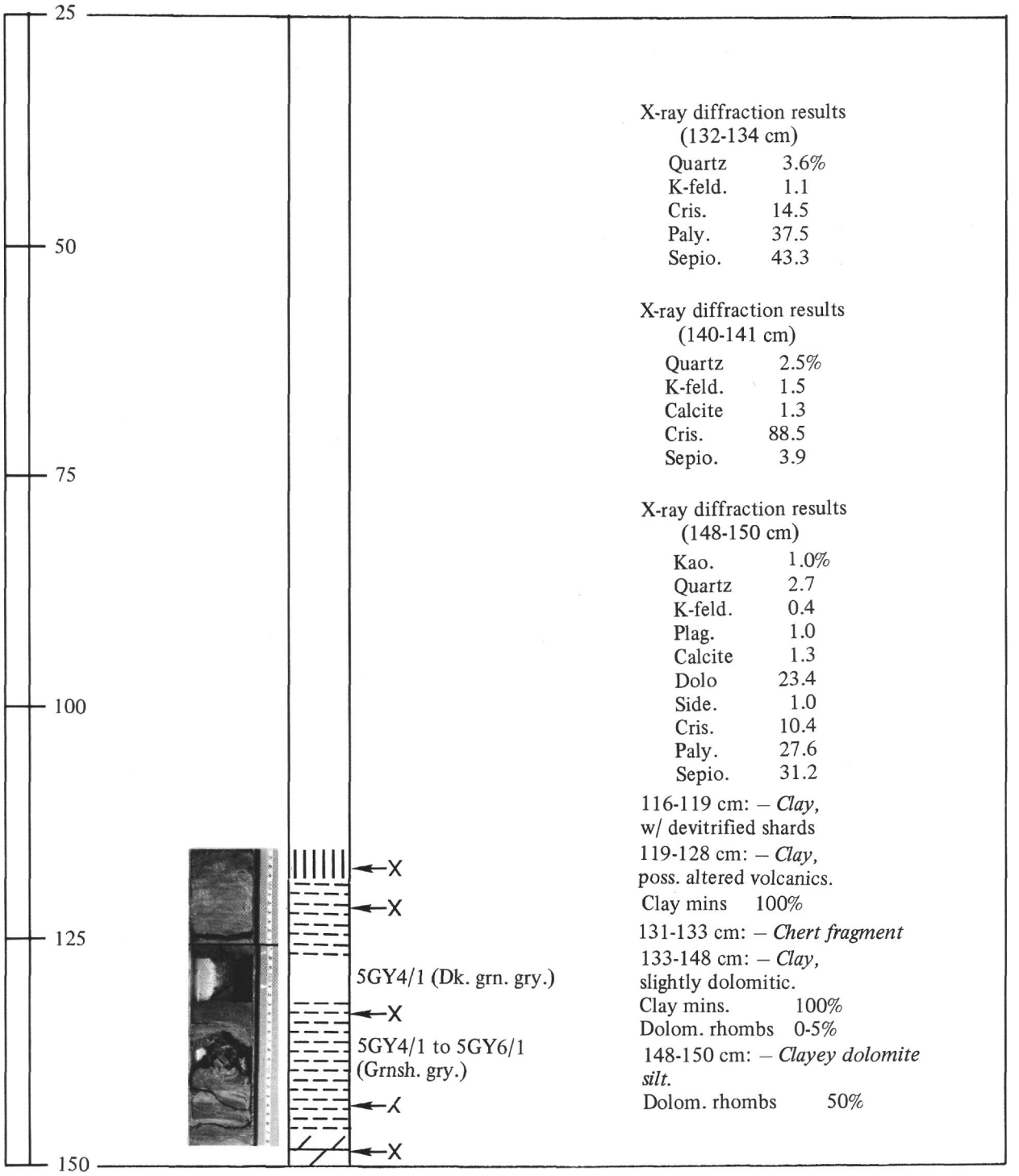

Figure 25. *Hole 12B Core 3 Section 1.*

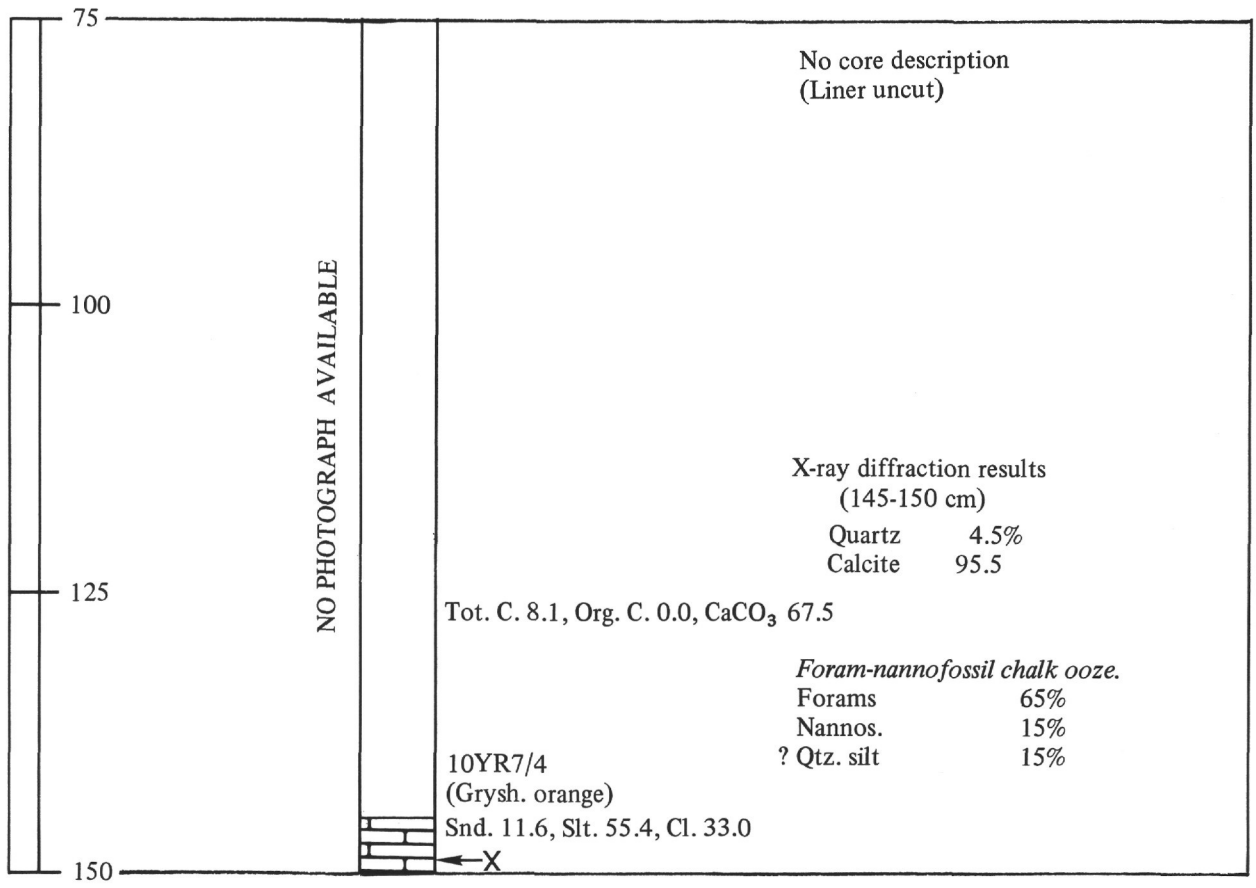

Figure 26. *Hole 12C Core 1 Section 1.*

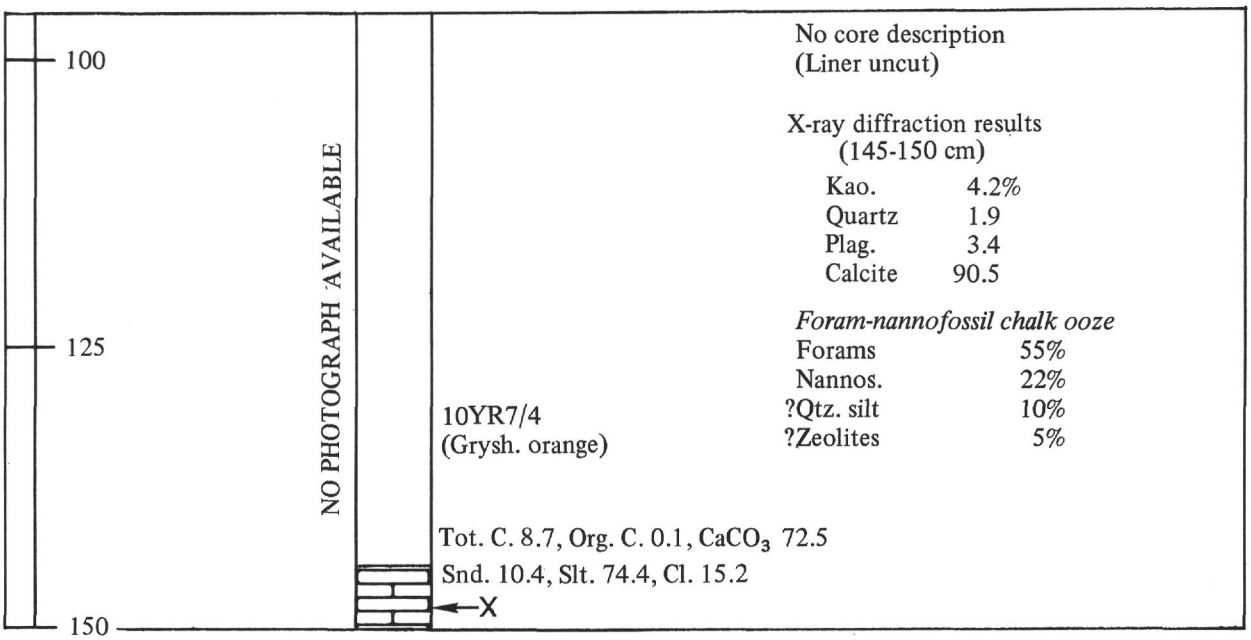

Figure 27. *Hole 12C Core 1 Section 2.*

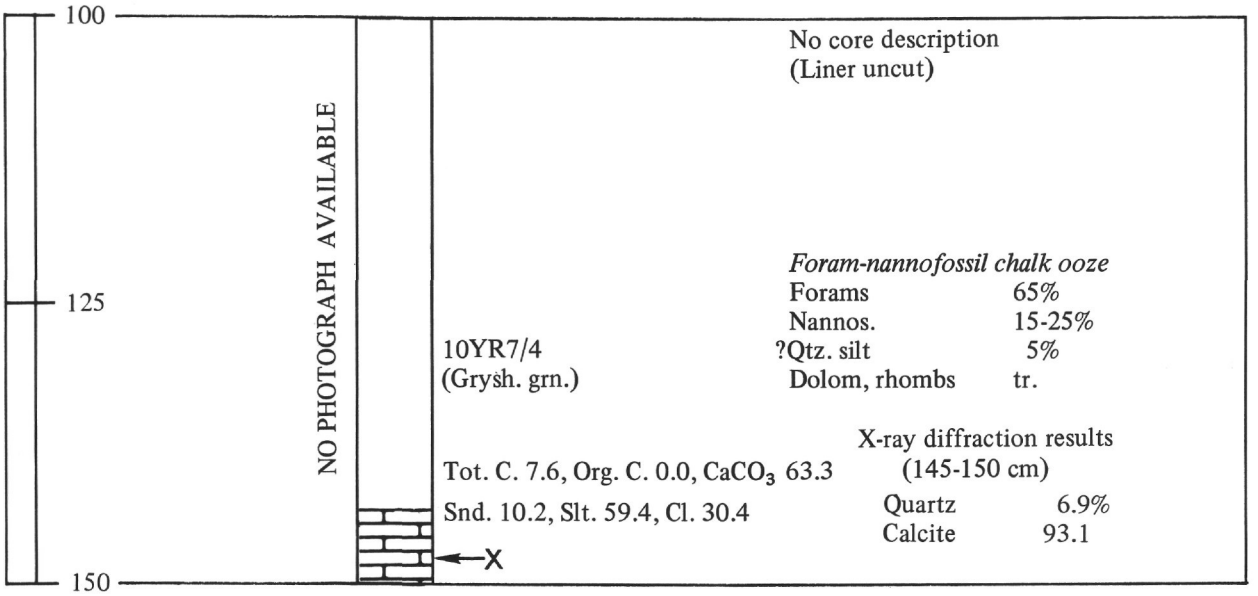

Figure 28. *Hole 12C Core 1 Section 3.*

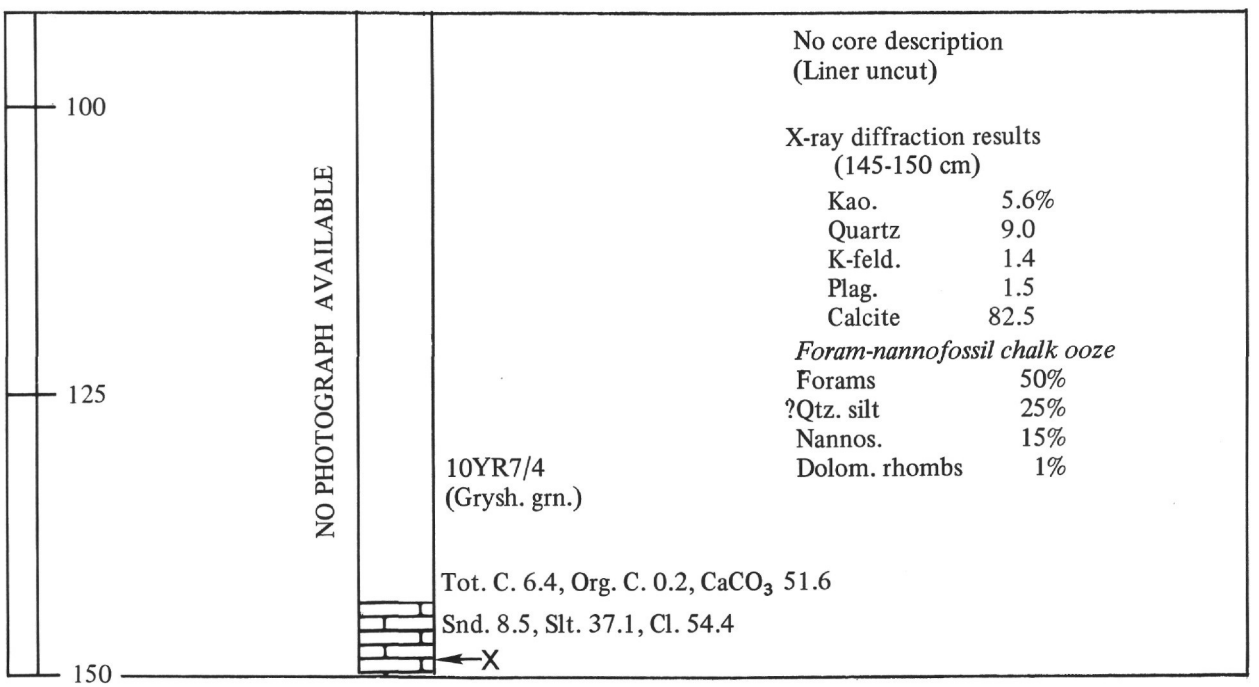

Figure 29. *Hole 12C Core 1 Section 4.*

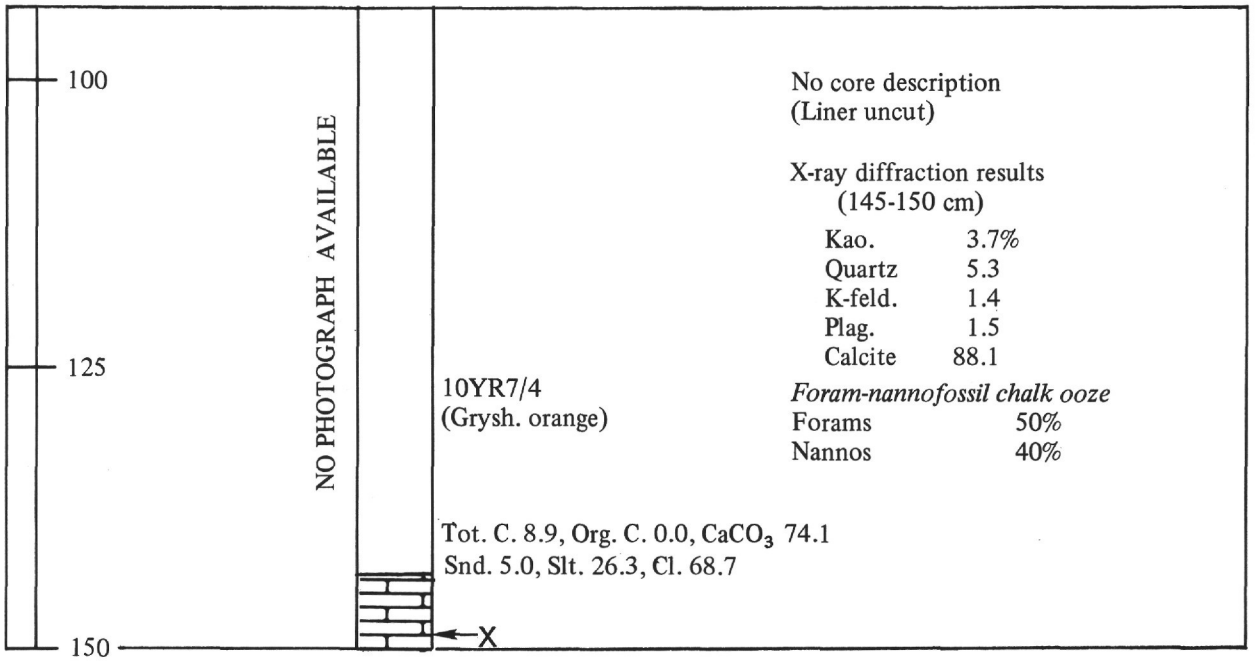

Figure 30. *Hole 12C Core 2R Section 1.*

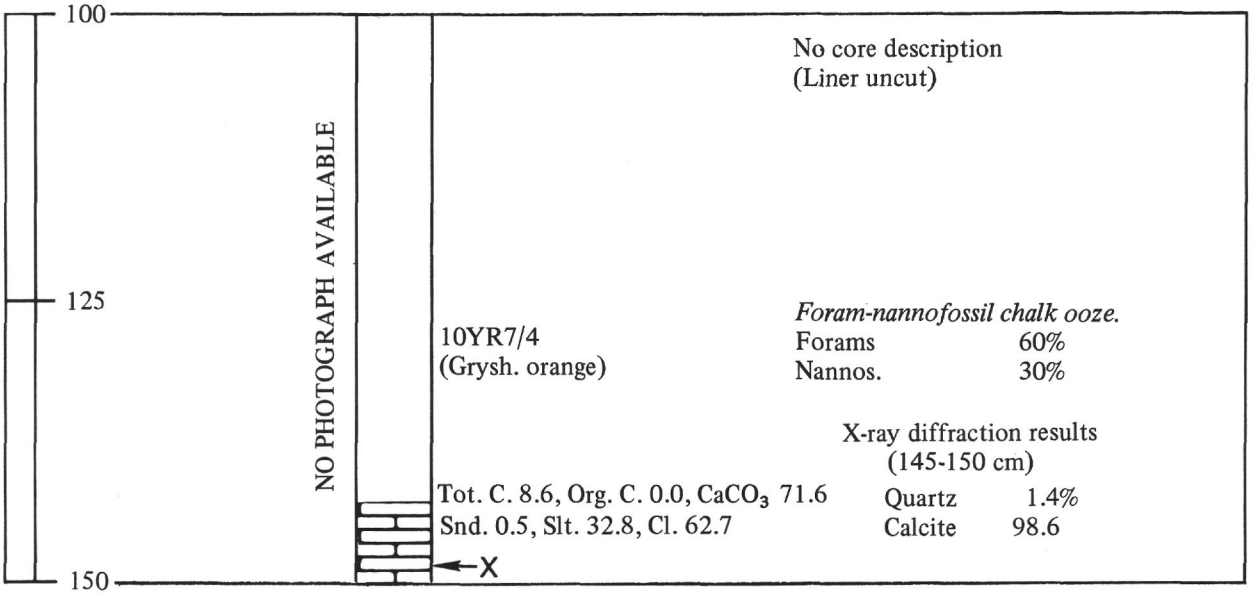

Figure 31. *Hole 12C Core 2R Section 2.*

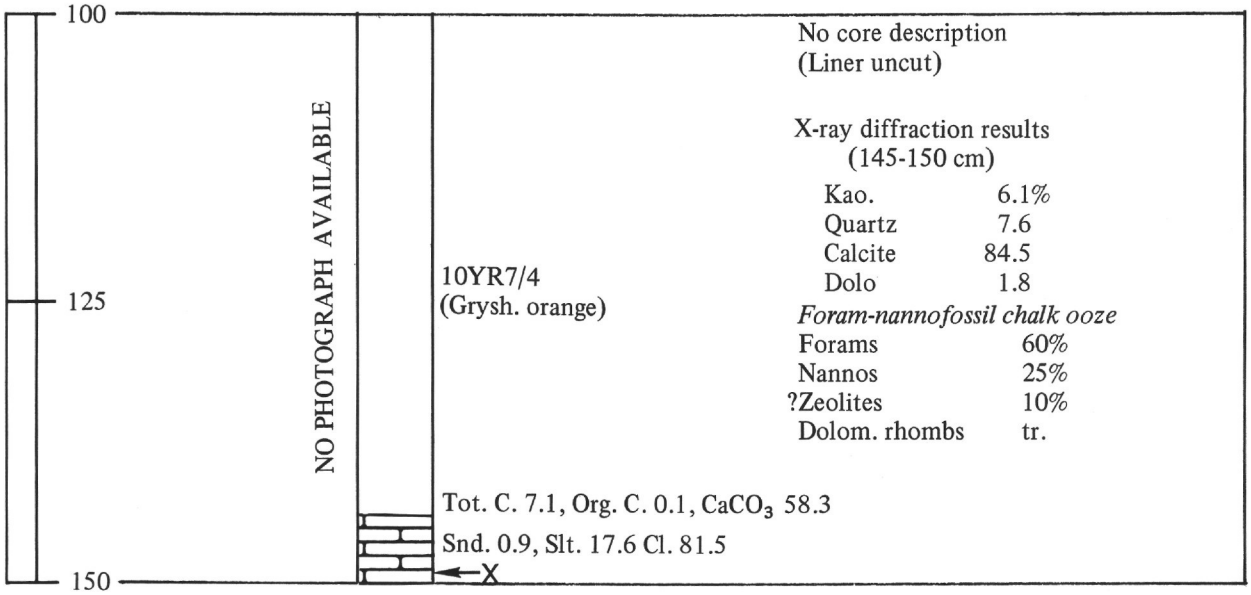

Figure 32. *Hole 12C Core 2R Section 3.*

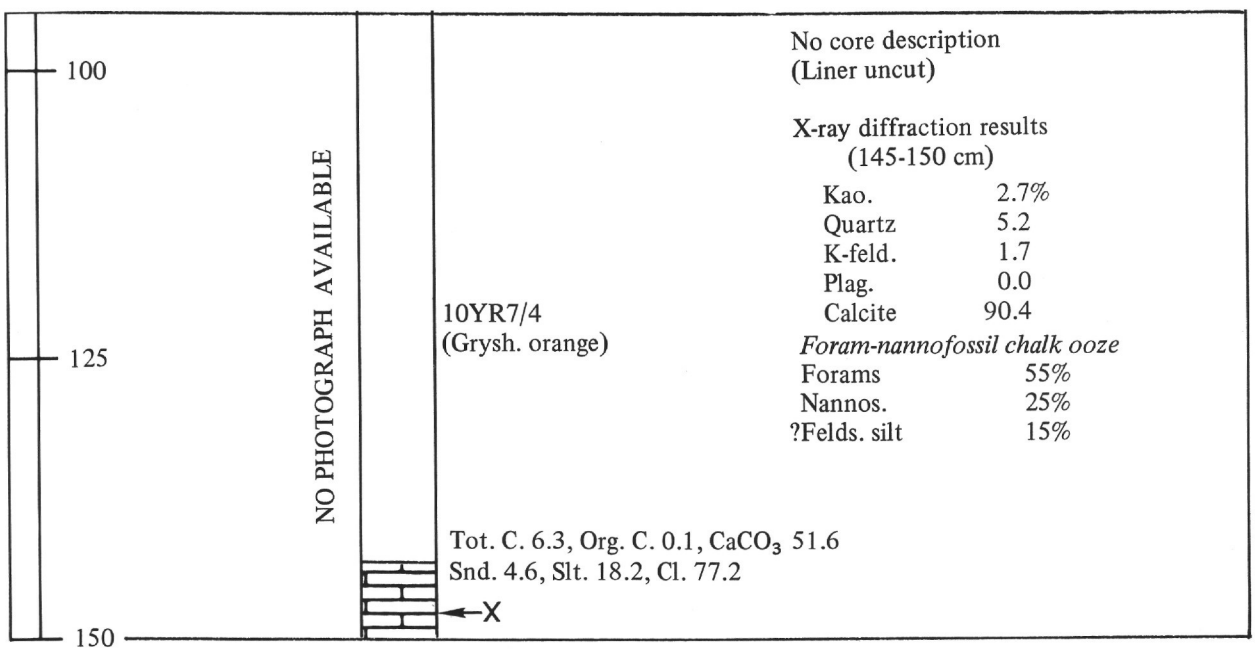

Figure 33. *Hole 12C Core 2RSection 4*

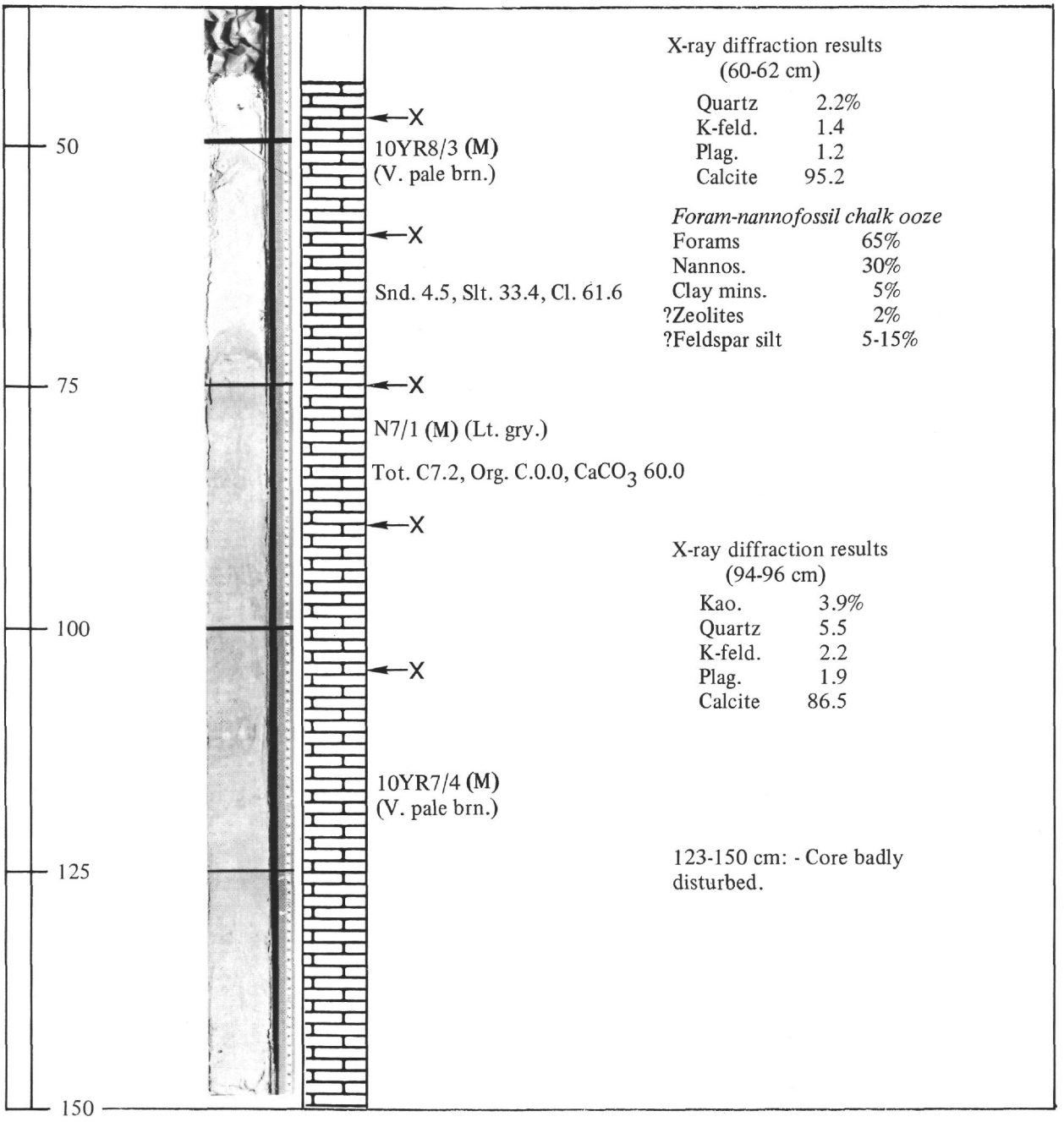

Figure 34. *Hole 12C Core 4 Section 1.*

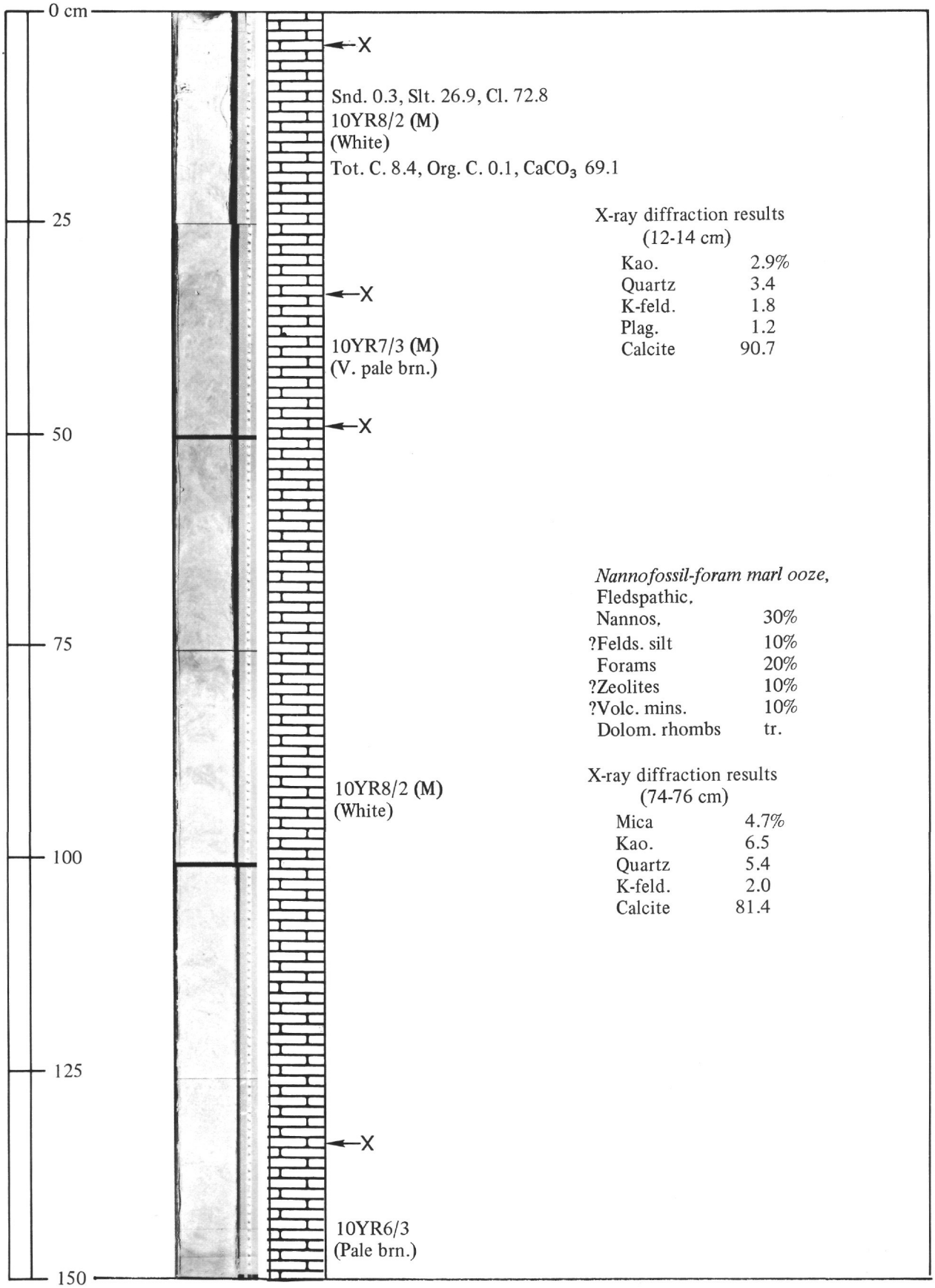

Figure 35. *Hole 12C Core 4 Section 2.*

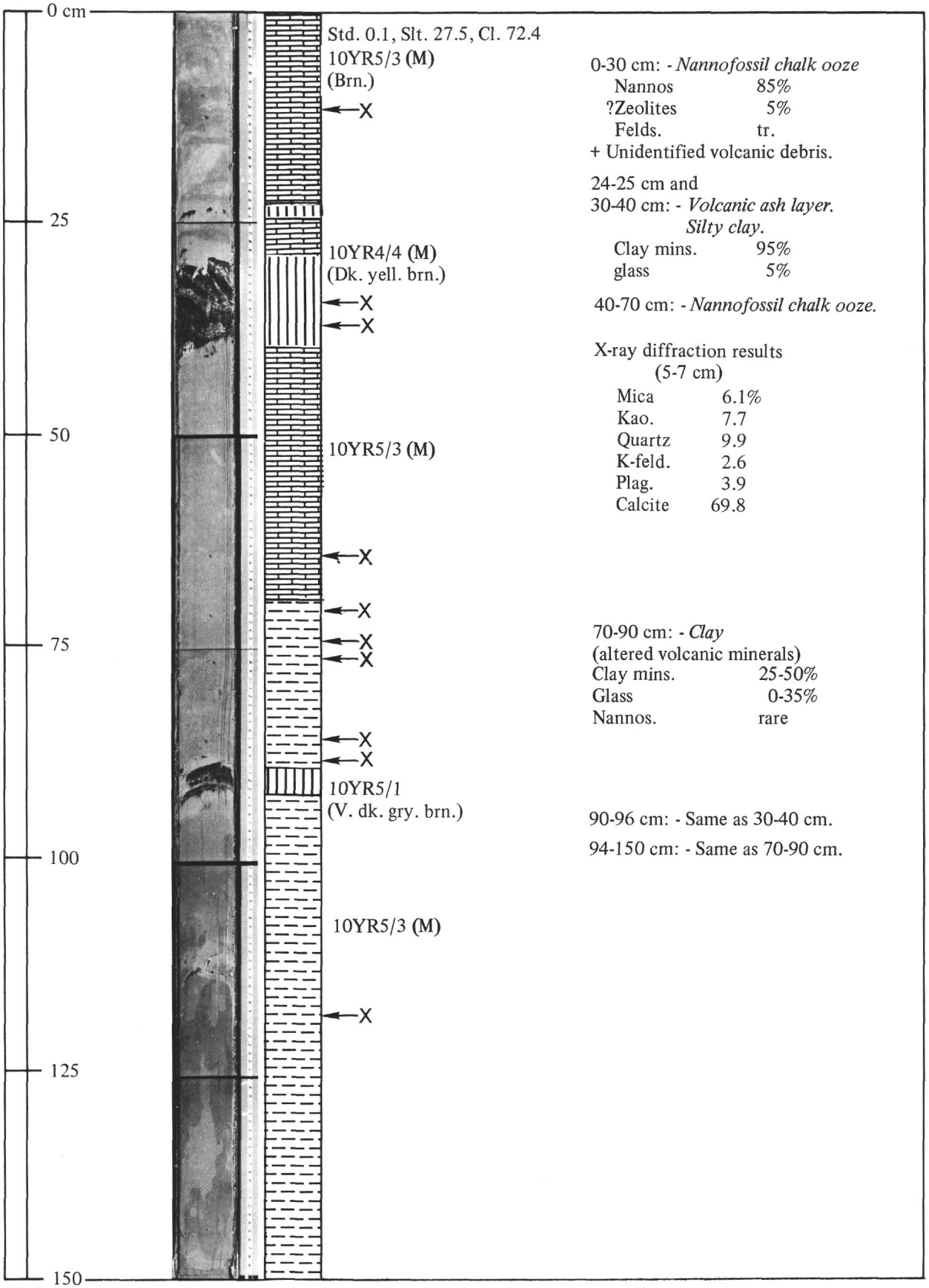

Figure 36. *Hole 12C Core 4 Section 3.*

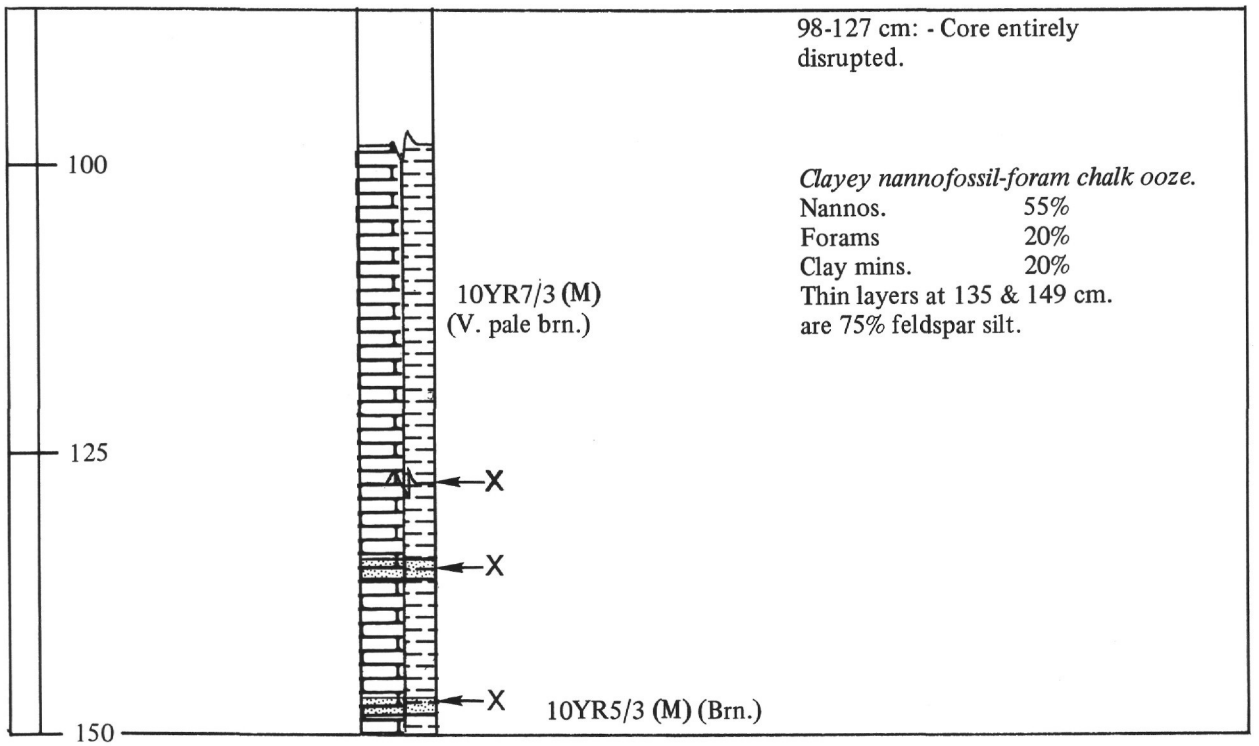

Figure 37. *Hole 12 Core 5 Section 1.*

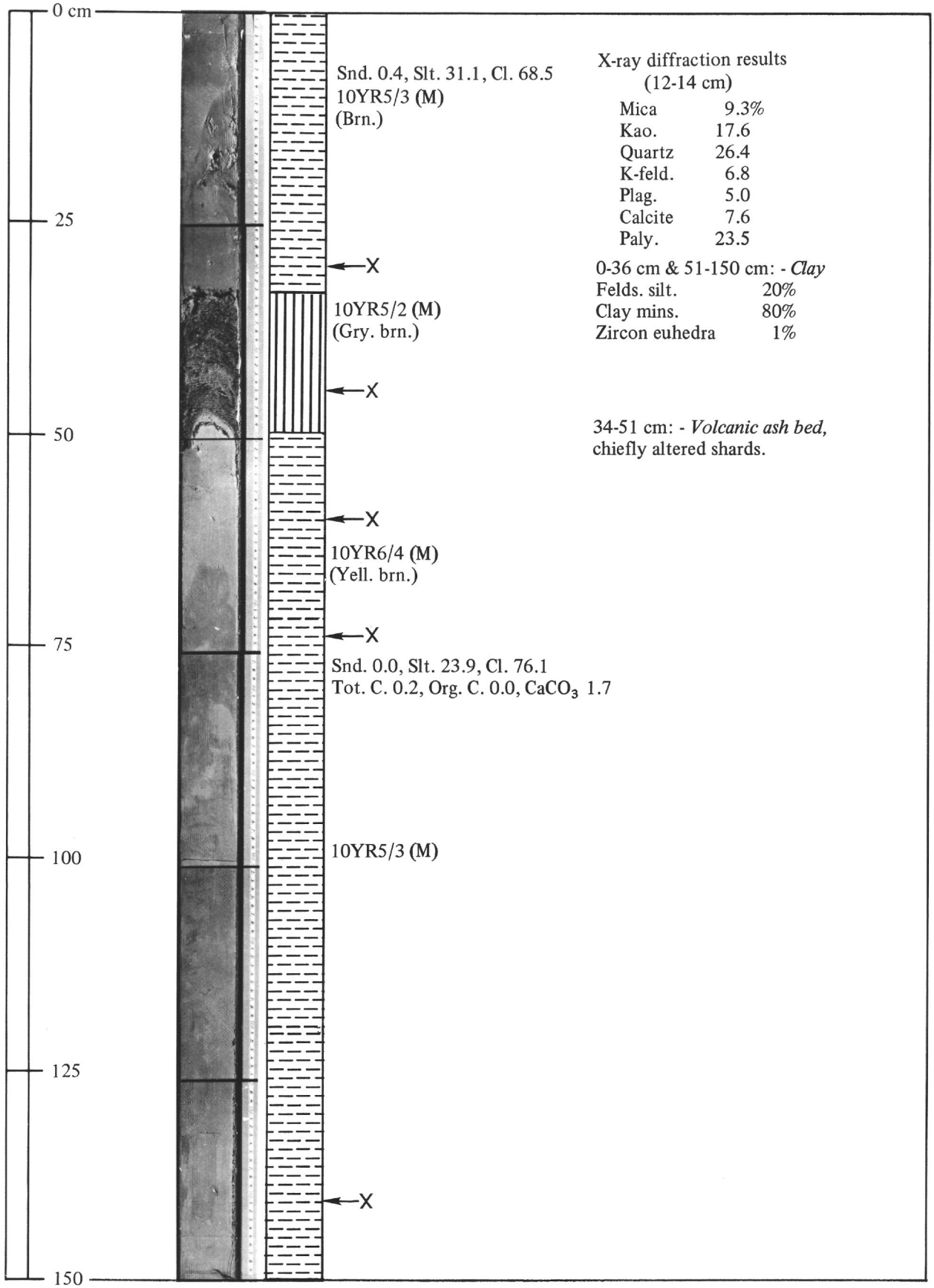

Figure 38. *Hole 12C Core 5 Section 2.*

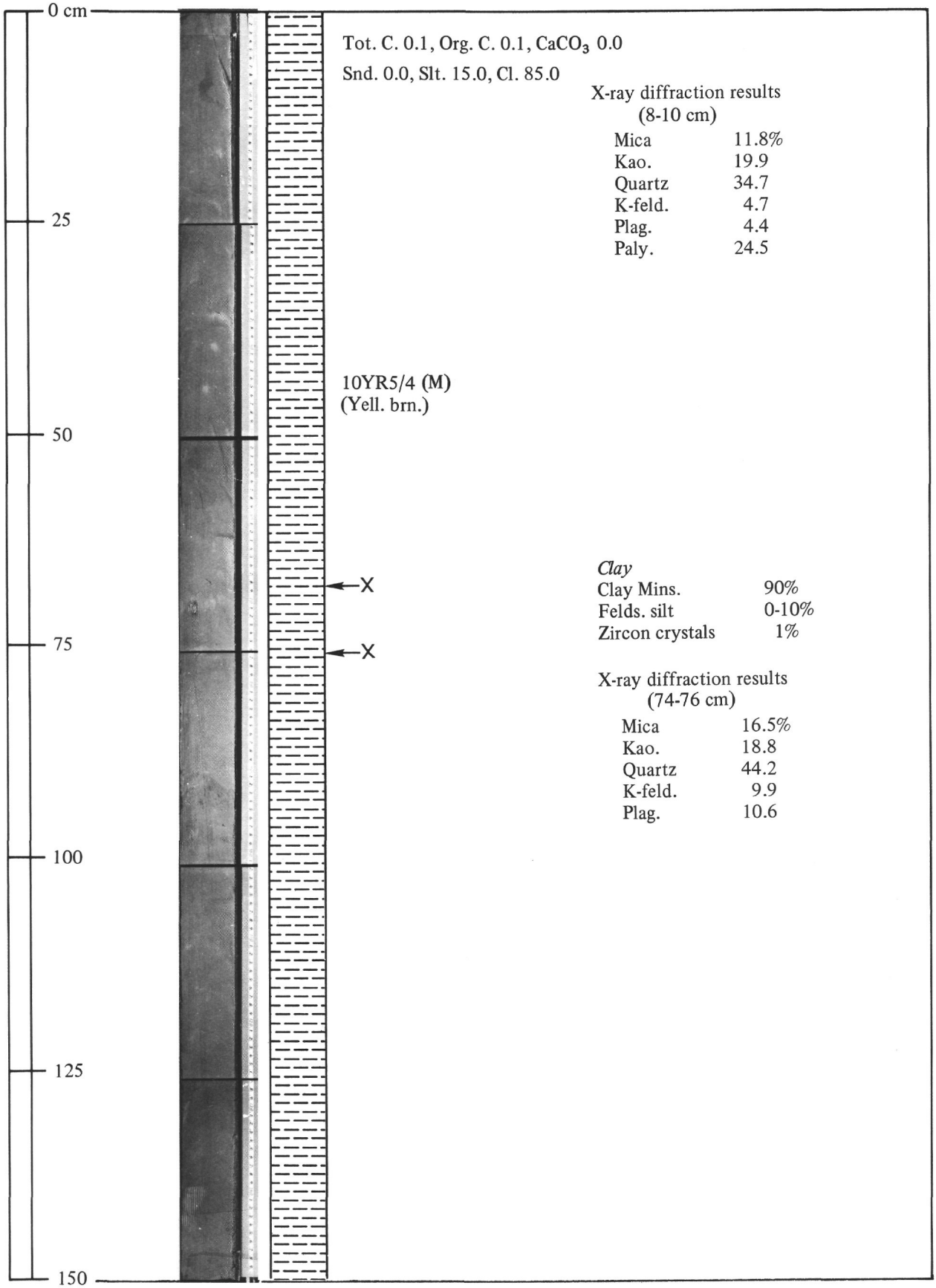

Figure 39. *Hole 12C Core 5 Section 3.*

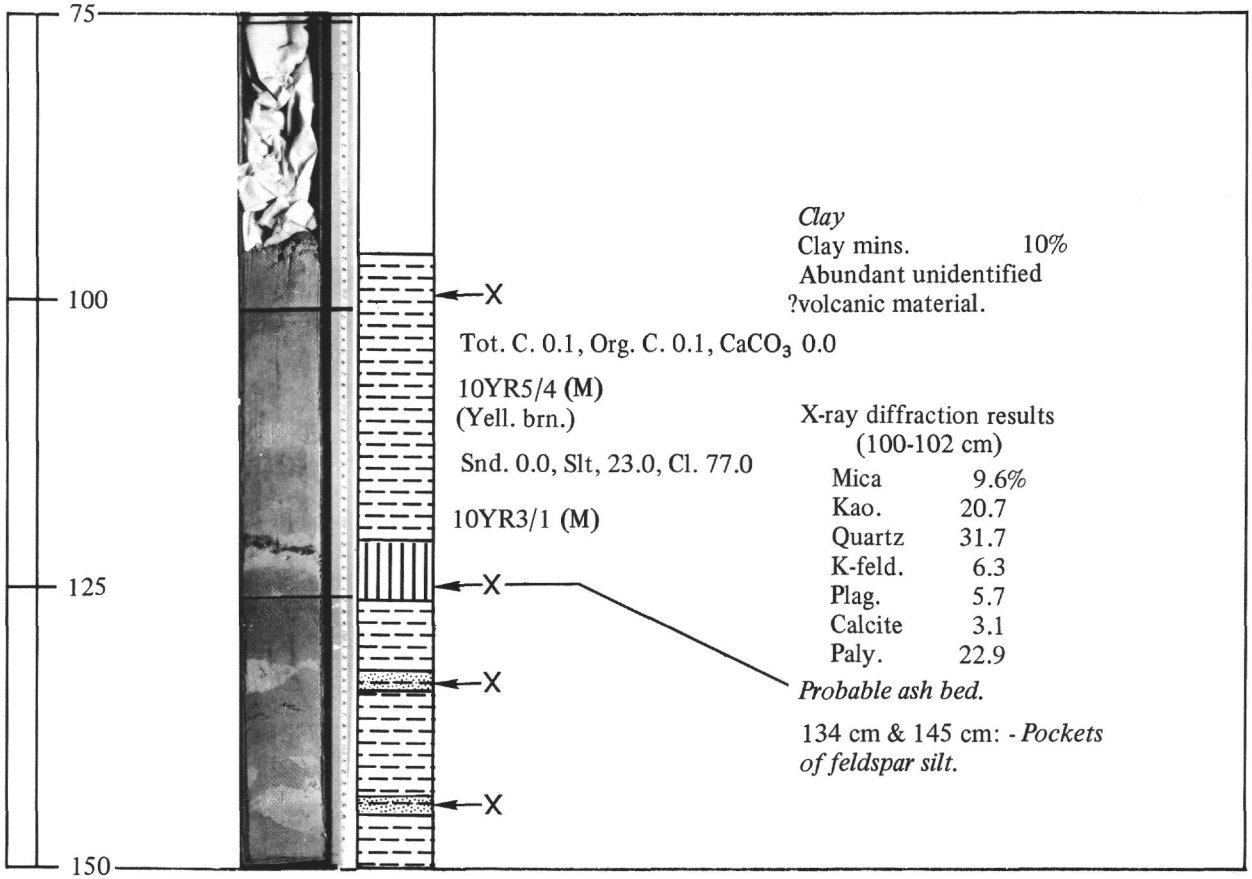

Figure 40. *Hole 12C Core 6 Section 1.*

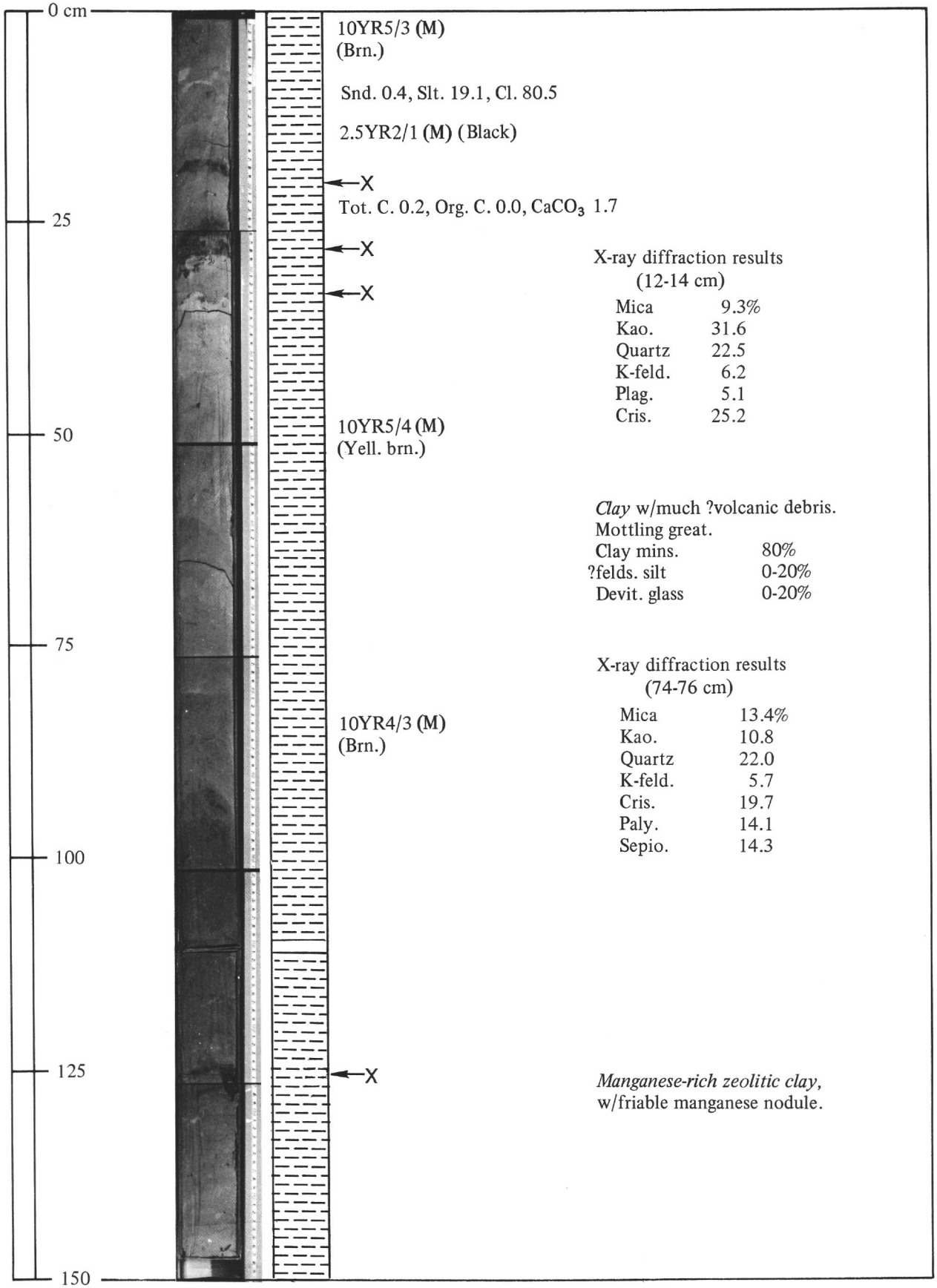

Figure 41. *Hole 12C Core 6 Section 2.*

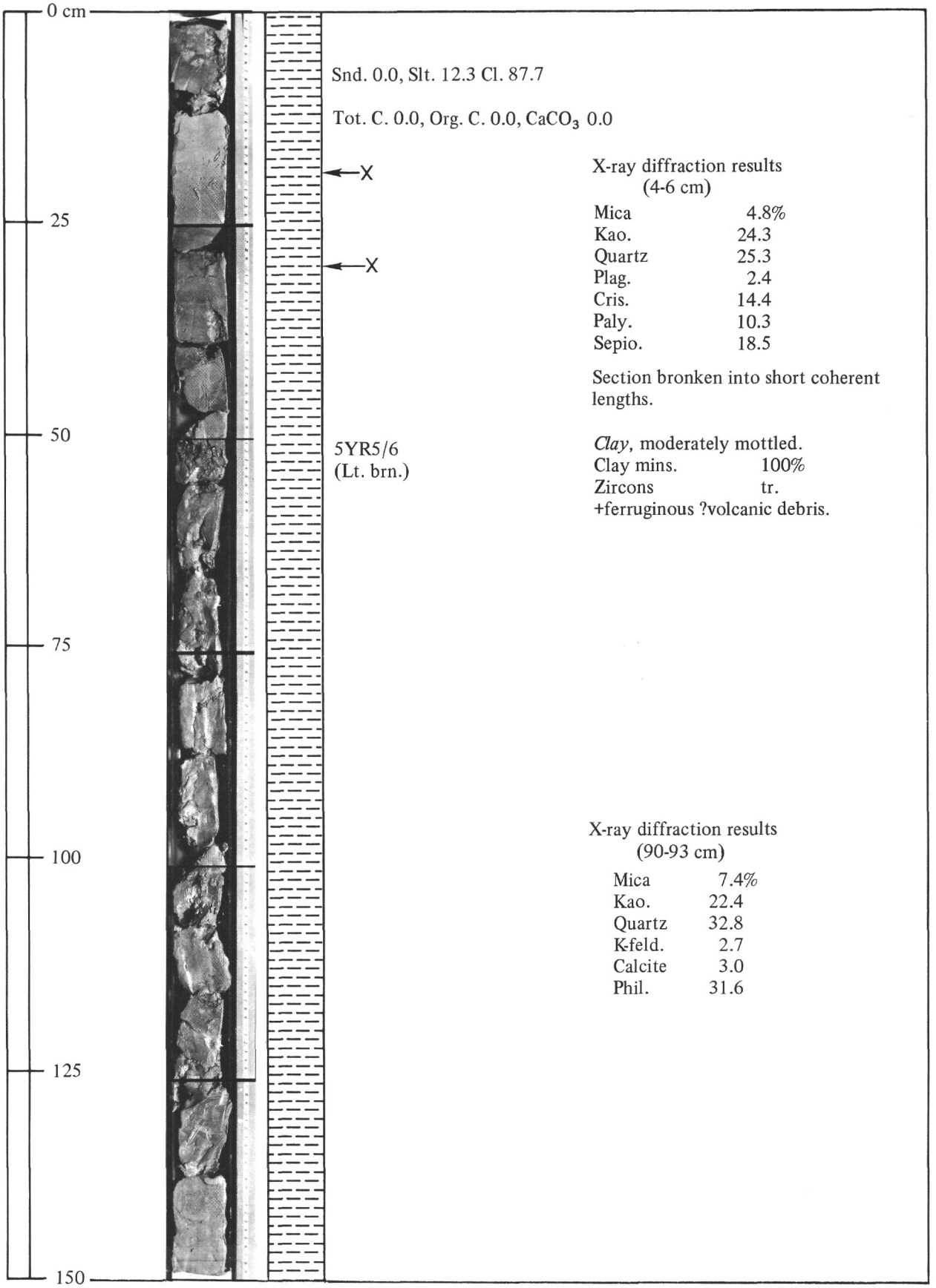

Figure 42. *Hole 12C Core 7 Section 1.*

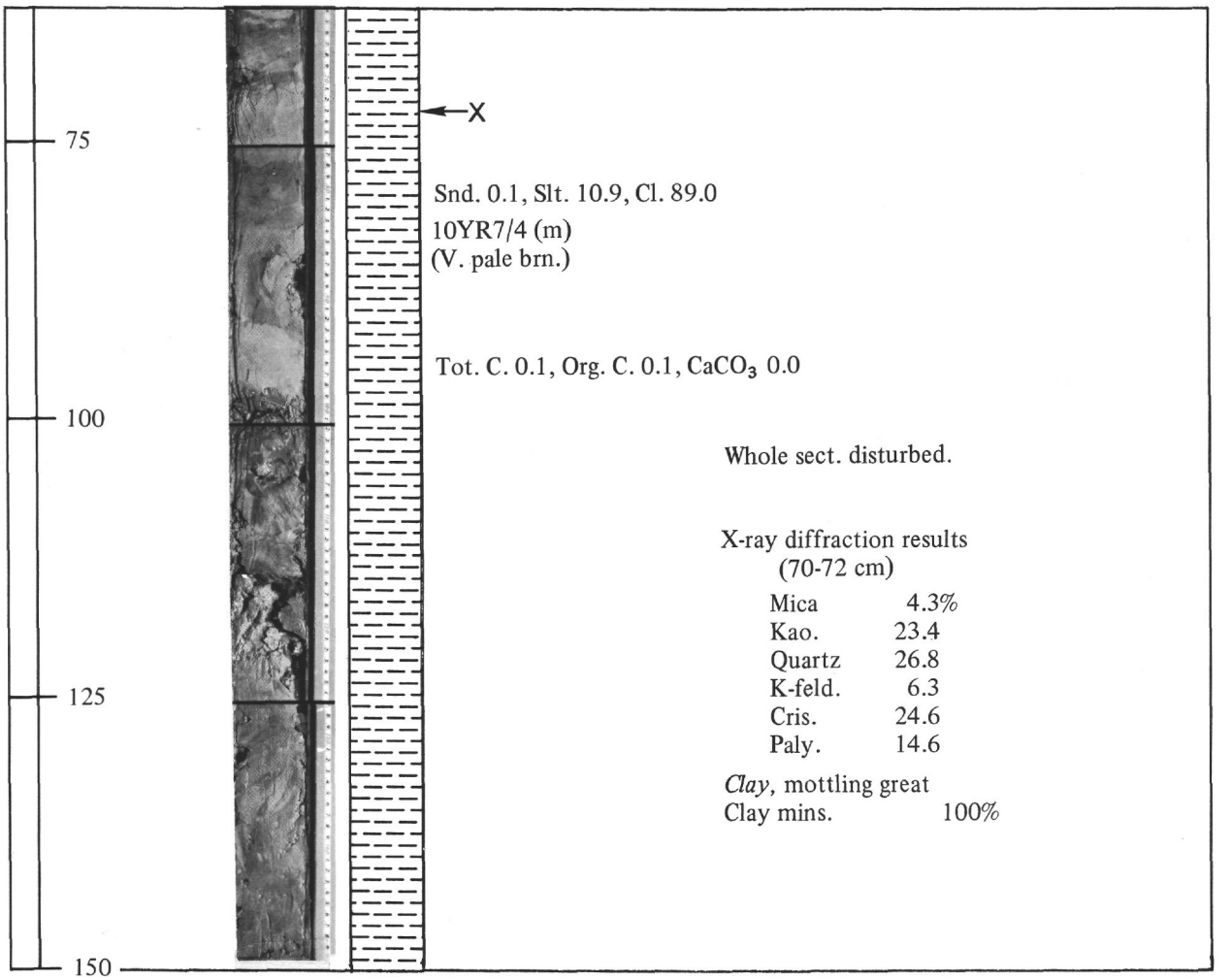

Figure 43. *Hole 12C Core 8 Section 1.*

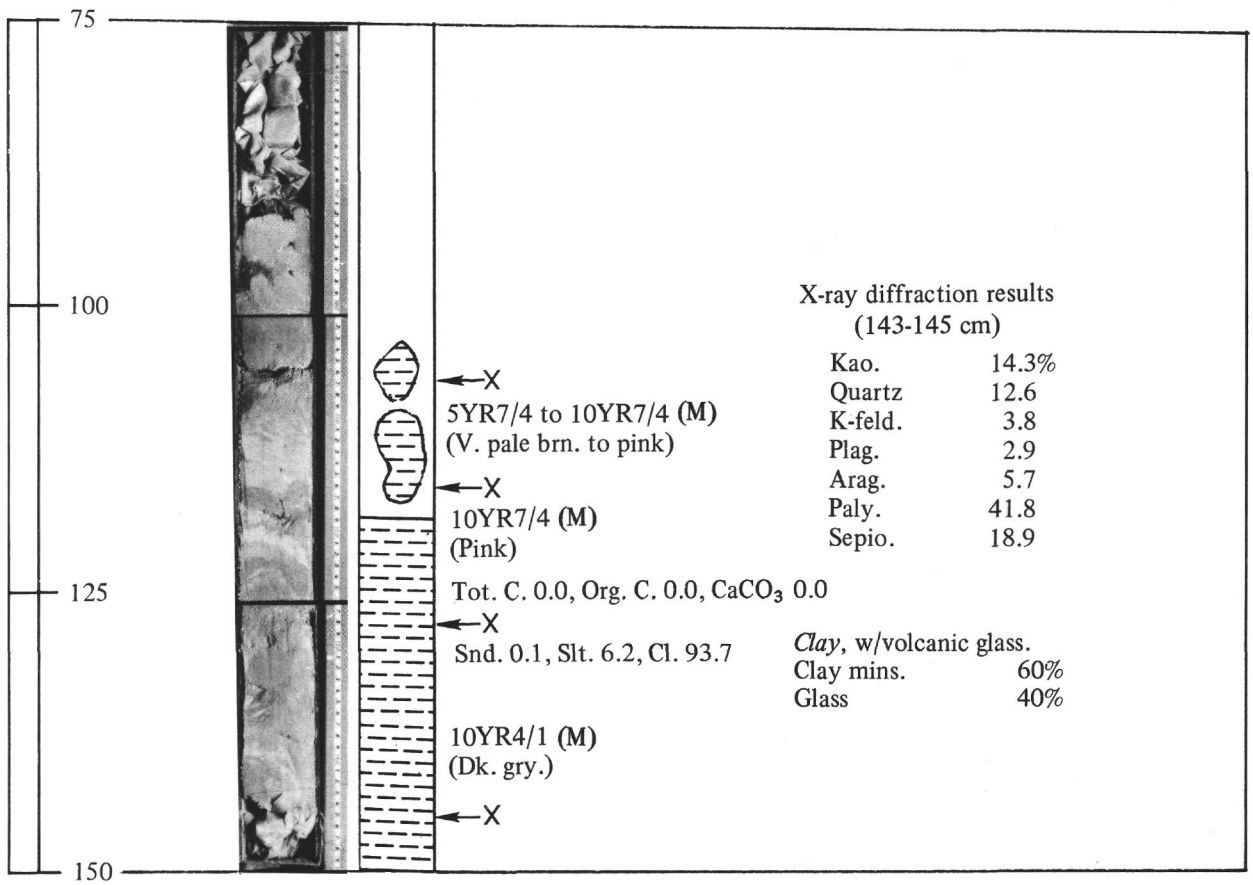

Figure 44. *Hole 12C Core 9 Section 1.*

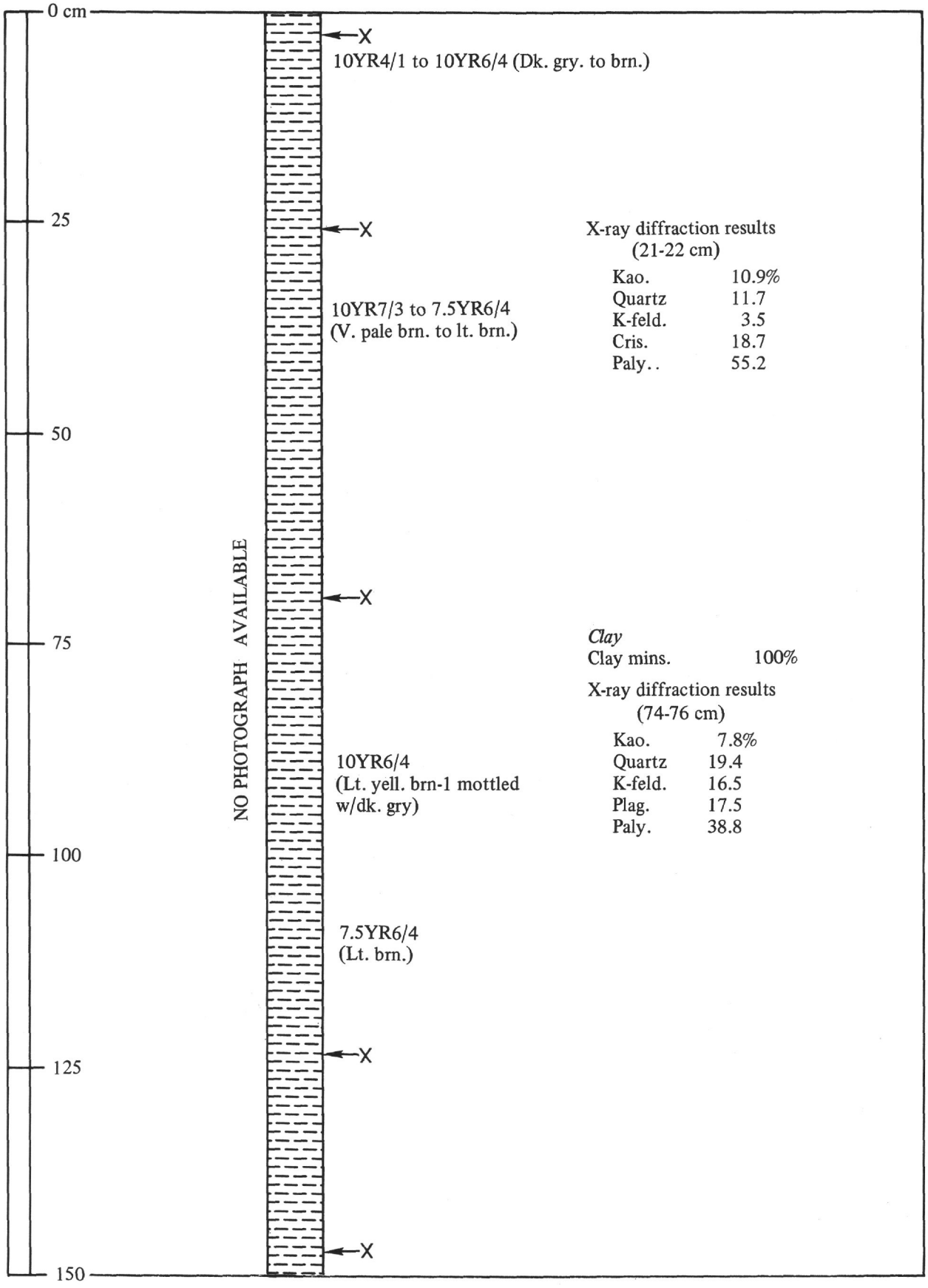

Figure 45. *Hole 12C Core 9 Section 2.*

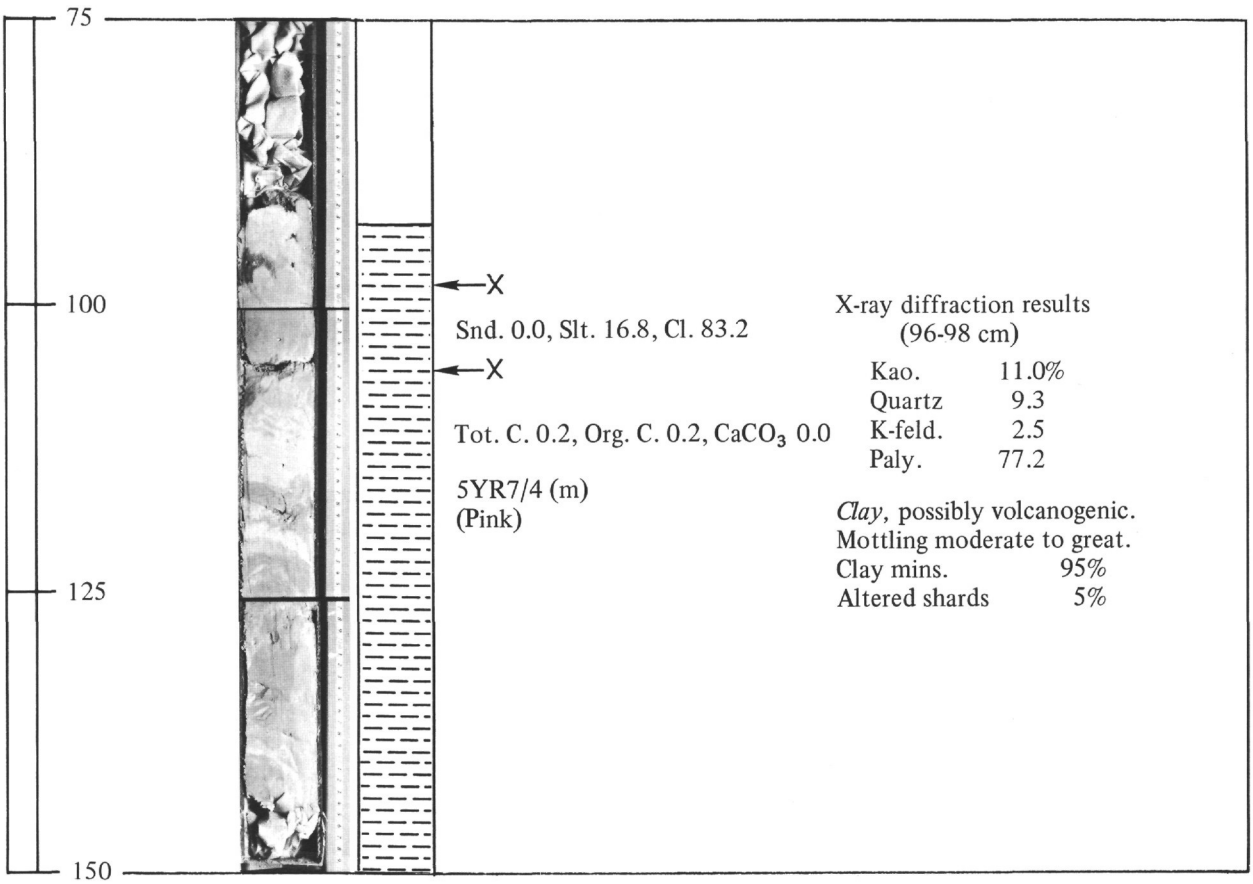

Figure 46. *Hole 12C Core 10 Section 1.*

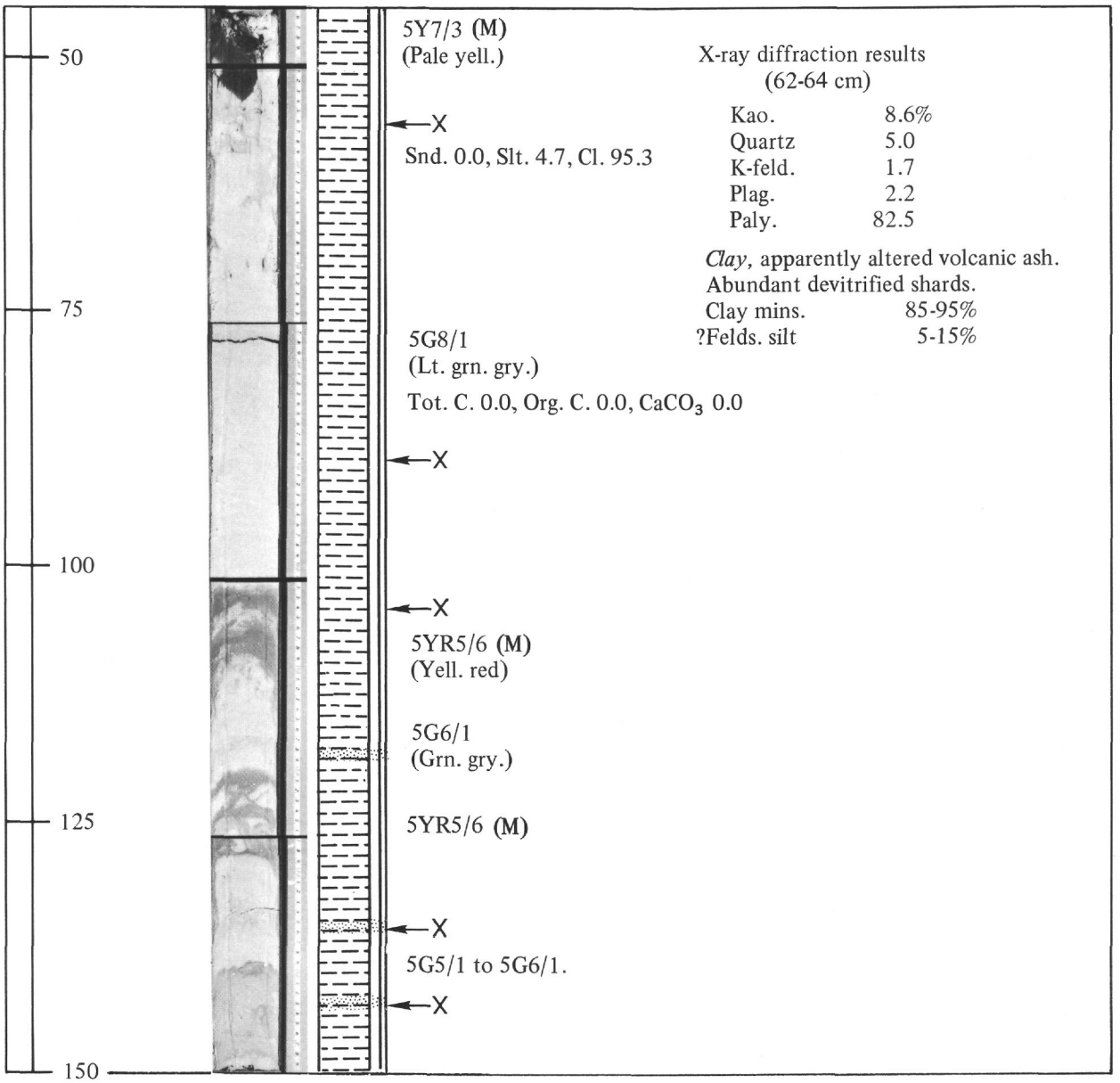

Figure 47. *Hole 12C Core 11 Section 1.*

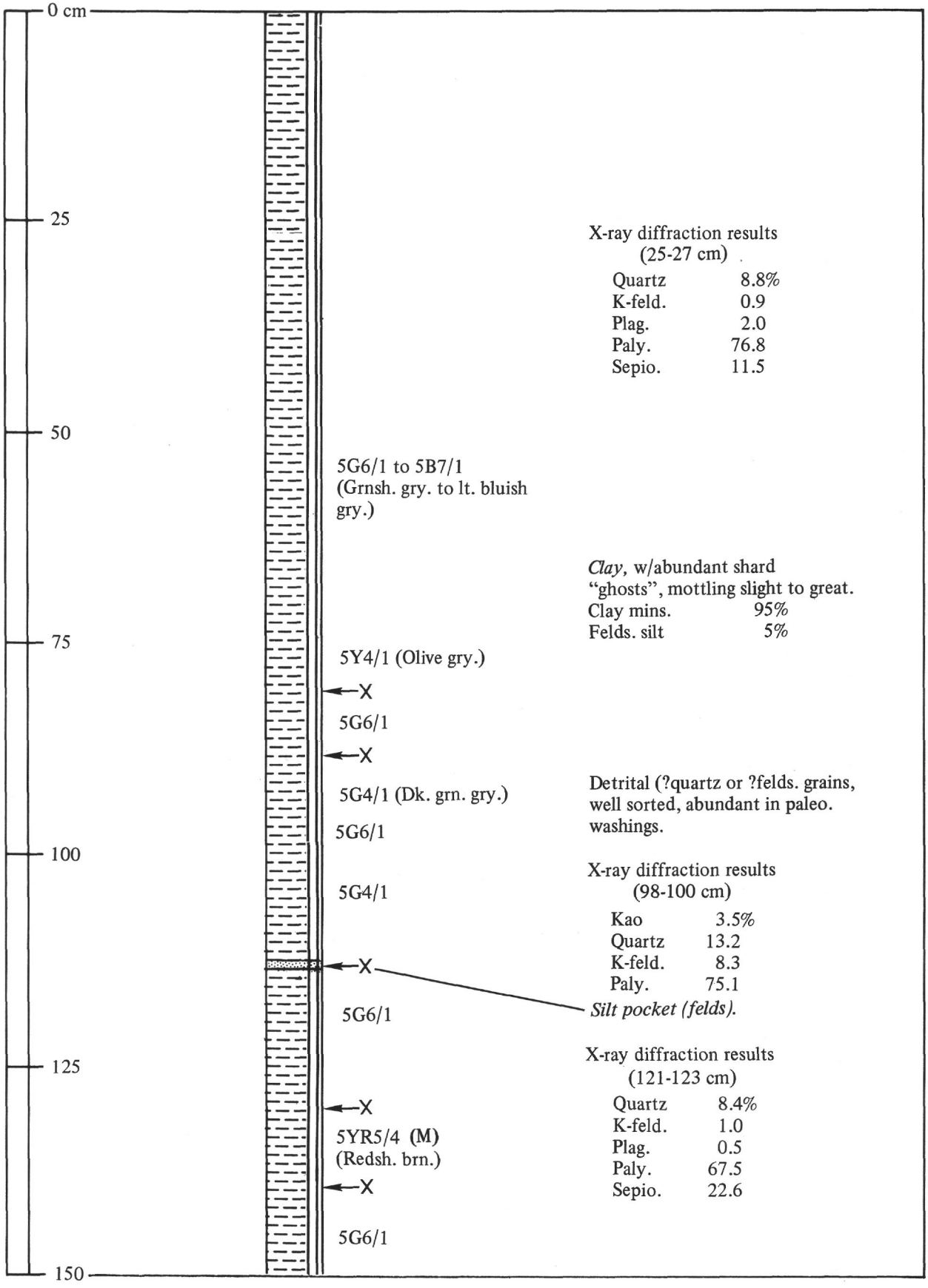

Figure 48. *Hole 12C Core 12 Section 1.*

Lithology

At Site 12, continuous coring in a combination of holes (12B, 12C, and 12D) provided a fairly representative section of the sediment from the sea floor to a sediment depth of 717 feet (218.5 meters). The following lithologic summary is based on Holes 12B and 12C. from which a total amount of 109 feet (33.2 meters) of core was recovered. Two major lithologies are represented in the cores taken, these being foraminiferal-nannofossil chalk ooze and clay containing abundant palygorskite (attapulgite) and sepiolite.

The Pliocene to Quaternary section, from the sea floor to a sediment depth of about 137 feet (41.8 meters), consists of foraminiferal-nannofossil chalk ooze, containing minor admixtures of silt-sized detrital minerals such as quartz and feldspar. Small quantities of dolomite are also present.

At about 110 feet (33.5 meters), below a thin zone of mixed calcareous and clayey sediments, there overlies a highly magnesian clay which is associated with minor feldspar, devitrified shards and scattered layers rich in disseminated manganese. This clay mixes easily with either sea water or fresh water to produce a stable and thixotropic suspension similar to drilling mud. Occurring with this essentially unfossiliferous material, are discrete, dark-colored layers of altered volcanic ash, composed largely of feldspar crystals and devitrified shards. Such layers are particularly noticeable at the transition zone between the calcareous and clayey sediments.

At a depth of about 530 feet (161.5 meters), localized radiolarian-bearing Eocene sediments occur, containing pyritized Radiolaria and thin beds of chert. Recovery of sediments below the chert to the bottom of the hole was poor, but the recovered samples indicate that the dominant lithology is clay to silty clay composed dominantly of palygorskite (attapulgite) and sepiolite.

The hole was terminated by an extremely hard layer from which no sample was recovered. Immediately above this layer a sample of dolomite of unknown thickness was cored, composed predominantly of well formed rhombohedral crystals measuring about 12 microns on edge.

Physical Measurements

Ship Laboratory Measurements

Natural Gamma-Radiation

Natural gamma-ray readings for Site 12 vary from about 1800 cpm above background for the clays rich in volcanic derivatives including feldspar, down to 280 cpm for pure foraminiferal-nannofossil chalk oozes. The highest values in the clay are considerably below those obtained in what appears to be comparable material from Site 9. This is undoubtedly because of the smaller proportions of potassium in these highly magnesian clays.

X-Radiography

Beds of volcanic ash and altered volcanic material are readily discernable on X-radiographs of the core from Site 12. The remaining intervals are featureless on the X-radiographs.

Gamma Ray Attenuation Porosity Evaluation (GRAPE)

The most notable fact concerning density and porosity measurements made by the GRAPE is the correlation with ash beds. The ash layers show abrupt increases in porosity and corresponding decreases in bulk density.

Penetrometer

Holes 12B and 12C exhibit a normal pattern of decreasing penetrability with depth, as determined by penetrometer measurements.

Sonic Velocity

Sonic velocity, determined on core sections in the ship's laboratory, shows a general increase with depth at Site 12. Velocities range from 1500 to 1565 km/sec.

Paleontology and Biostratigraphy

One of the aims of drilling at Site 12 was to recover, if possible, a continuous section of pelagic sediments. This section could then serve as a means of correlating the Tertiary planktonic zonation, determined largely in the Caribbean area, to the Tertiary of the Mediterranean area. Initial difficulties in obtaining cores from near the surface forced the coring effort to be directed several hundred feet below the sediment surface (see operations report). This in turn led to the discovery that only barren clay and chert containing Radiolaria are present at these depths, and that calcareous sediments are found only as a relatively thin veneer near the surface of the ocean floor.

Drilling beneath the calcareous sediments had to be suspended when the coring bit was worn down on chert; and, for the time remaining, only soft sediments could be cored. The very gentle slope of the bottom and the high water content of the calcareous ooze led to the hope that a complete and continuous Pleistocene section may be present at this site, and preparations were made to attempt recovery of this section. The interval from the sea floor to the contact between the clayey and calcareous sediments is about 125 feet thick, and this interval was cored in duplicate. Also, in order to give complete coverage, adjoining cores overlap one another.

Radiolaria

The only Radiolaria recovered at Site 12 were from Core 2 of Hole 12B. Rare, dirty or silicified forms were found in the core catcher sample, but their preservation is such that specific identification is impossible. An equally sparse but better preserved fauna of Lower Eocene Age was extracted from a chert fragment found near the top of Core 2. Species include *Lithochytris* sp. with well developed 3-bladed feet, *Anthocyrtidium hispidum*, and several other forms the names of which are unknown–at least to the present authors–but which have been found in Lower Eocene assemblages from other sites.

Nannofossils and Foraminifera

As the upper part of Site 12 was cored twice and the cores are partially overlapping, the following descriptions are presented in stratigraphic succession, only insofar as this is possible without treating individual sections of every core separately. Only gross descriptions of the faunal successions are presented because the cores were not cut on board ship. Instead, they were frozen and will be shipped to a shore based laboratory for opening and detailed examination and sampling. Shipboard samples were taken from one end of each section.

Nannofossils	Foraminifera
Hole 12C, Core 1: Sections 2, 3 and 4: The rich calcareous nannofossil assemblage indicates an early to middle Quaternary age and includes the following forms: cf. *Coccolithus cricotus, Umbilicosphaera mirabilis, Gephyrocapsa, Cyclococcolithus loptoporus, Rhabdosphaera claviger, Helicopontosphaera carteri, "Discolithus phaseolus"* and *Ceratolithus* sp.	Hole 12, Core 1: and well preserved assemblage. Among the most significant species are: *Globorotalia truncatulinoides, G. menardii* (left coiling), *G. tumida, G. inflata, G. crassaformis, Hastigerina siphonifera, Globigerinoides ruber* (also with pink tests), *G. conglobatus, G. sacculifer, Globigerina eggeri, Pulleniatina obliquiloculata, P. obliquiloculata finalis,* and highly evoluted *Sphaeroidinella dehiscens (excavata).* Benthonic foraminifera are quite subordinate both in number of species and of specimens and include single *Lagena, Uvigerina, Eponides, Cibices,* etc. Also noticed were a single Ostracod and a corroded test of *Quinqueloculina.* The assemblage indicates a late Quaternary Age and may probably be referred to Zone N.23 of Blow. Other samples were investigated from the uncut sections of this barrel, all of them indicating a late Quaternary Age.
Hole 12C, Core 2R: Section 1: A sample from the base of this section contains a latest Pliocene-early Pleistocene nannofossil assemblage, including: cf. *Coccolithus cricotus, Cyclococcolithus leptoporus, Coccolithus pelagicus, Discolithus phaseolus, Rhabdosphaera claviger, Discoaster brouweri* and *Ceratolithus rugosus.* Section 2: The nannofossils from the base of this section are of Pliocene Age and include: *Discoaster pentaradiatus, D. brouweri,* cf. *Coccolithus cricotus, Cyclococcolithus leptoporus* and *Coccolithus pelagicus.* Sections 3,4: The nannofossils from these two sections are of Quaternary Age and include *Gephyrocapsa, Rhabdosphaera claviger, Cyclococcolithus leptoporus,* cf. *Coccolithus cricotus, C. pelagicus, Umbilicosphaera mirabilis* and *Helicopontosphaera carteri.*	Hole 12C, Core 2R: Sections 1, 3 and 4 of this core yielded rich, diversified and well preserved foraminiferal faunas of lower Pleistocene Age, referable to Zone N.22 of Blow, including: left coiling *Globorotalia menardii, G. tumida, G. flexuosa, G. truncatulinoides, G. scitula, G. inflata, G. crassaformis, Globigerina eggeri, Pulleniatina obliquiloculata, Globigerinoides conglobatus, G. elongatus, G. ruber,* etc. Section 2 of Core 2R contains two different faunal assemblages mixed together; one of them of lower Pleistocene Age, the other one of Upper Pliocene Age (Zone N.21 of Blow). The Pliocene fauna is numerically dominant and includes right coiling *Globorotalia menardii, G. exilis, G. miocenica, G. multicamerata.* For further details see correlation between the sites, (Chapter 19).

Nannofossils	Foraminifera
Hole 12C, Core 3: Core Catcher: Only a small sample was recovered in the core catcher of this barrel. However, the sample contains a rich assemblage of calcareous nannofossils of Pliocene Age including: *Ceratolithus rugosus, Discoaster pentaradiatus, D. brouweri, D. surculus, Coccolithus pelagicus, Helicopontosphaera carteri, Cyclococcolithus leptoporus,* cf. *Coccolithus cricotus.*	Hole 12C, Core 3: Core Catcher: Rich planktonic assemblage with *Globorotalia menardii* (right coiling), *G. miocenica, G. multicamerata, G. exilis, G. tosaensis, G. inflata, G. crassaformis, Candeina nitida, Pulleniatina obliquiloculata, Sphaeroidinella dehiscens, Globigerina eggeri,* etc., indicating an Upper Pliocene Age (lower part of Zone N.21 of Blow).
Hole 12D, Core 4: Sections 1 through 4: Calcareous nannofossils of late Pliocene Age are very abundant throughout Core 4 and include: *Discoaster brouweri, D. pentaradiatus, D. variabilis,* cf. *Coccolithus cricotus, Cyclococcolithus leptoporus, Ceratolithus rugosus, Coccolithus pelagicus, Umbilicosphaera mirabilis.* Also present throughout most of the core are specimens of *Gephyrocapsa,* although never in abundance, which probably can be attributed to contamination.	Hole 12D, Core 4: Section 1 yielded planktonic foraminifera similar to those present throughout Core 5, Hole 12D, indicating an Upper Pliocene Age (probably lower part of Zone N.21 of Blow). Sections 2 to 4 contain a mixture of Upper Pliocene species (including right coiling *Globorotalia menardii, G. exilis, G. multicamerata, G. miocenica, Globigerinoides fistulosus*) and of Pleistocene ones, including *Globorotalia truncatulinoides* and highly evoluted *Pulleniatina obliquiloculata.* In Sections 3 and 4, the Pleistocene fauna is numerically dominant.
Hole 12D, Core 5: Sections 1 through 6: All sections of Core 5 contain Pliocene calcareous nannofossils, including the following forms: *Discoaster surculus, D. brouweri, D. pentaradiatus,* cf. *Coccolithus cricotus, Umbilicosphaera mirabilis* and *Ceratolithus rugosus.* At the bottom of Section 1 *Gephyrocapsa* was recorded also, but this form probably represents contamination.	Hole 12D, Core 5: This core yielded a rich and diversified foraminiferal assemblage dominated by *Globorotalia menardii* cum var, including *G. multicamerata* and *G. miocenica,* which are particularly abundant in each section and show a distinct preference for right coiling. Also present are: *Globorotalia tumida, G. flexuosa, G. crassaformis, G. acostaensis, G. humerosa, G. tosaensis, Globigerinoides conglobatus, G. fistulosus, Pulleniatina obliquiloculata, Sphaeroidinella dehiscens,* etc. Benthonic foraminifera are quite subordinate and consist of single specimens of *Laticarinina pauperata, Lagena* sp., *Pyrgo* sp., *Globocassidulina, Eponides,* etc. The assemblage indicates an Upper Pliocene Age and may be referred to the lower part of Zone N.21 of Blow. In fact, the absence of *Sphaeroidinellopsis seminulina* and/or of *S. subdehiscens* places the present assemblage above the horizon of extinction of the aforementioned taxa. The topmost part of the Pliocene section is not documented, since *Globorotalia miocenica* and *G. multicamerata* are present throughout the sections of the core.

Nannofossils	Foraminifera
Hole 12C, Core 4: Sections 1 through 4: The nannofossils from all sections of this core are Pliocene in age, and include: *Discoaster brouweri, D. pentaradiatus, D. variabilis, D. surculus, Coccolithus pelagicus, Ceratolithus* sp. (rugose), and *Cyclococcolithus leptoporus.* In addition, cf. *Coccolithus cricotus* occurs also at the top of Sections 1 and 2, but not in Sections 3 and 4. *Reticulofenestra pseudoumbilica* occurs at the top of Section 3 and above the calcareous ooze and zeolite contact, but not at the top of Sections 1 and 2. The level at which *Reticulofenestra pseudoumbilica* gives way as the dominant placolith species to cf. *Coccolithus cricotus* is easily recognized, the interval above this level corresponding roughly to the Upper Pliocene, and the interval below this level corresponding approximately to a middle Pliocene. The absence of *Sphenolithus abies* in an otherwise normal Pliocene assemblage indicates that the lowermost Pliocene is not represented. Cores recovered at Hole 12C below Core 4 contained nannofossils apparently only as contaminators brought up during the drilling.	Hole 12C, Core 4: This core is composed of 4 sections; core recovery was 50 per cent. The original position of the sediment recovered in the cored interval is unknown and so a possible total overlap with Core 5 of Hole 12D was taken into account. However, the paleontological study indicates that only part of Section 1 overlaps Core 5 (Hole 12D), yielding an assemblage rich in *Globorotalia multicamerata* and *G. miocenica* which can be referred to Zone N.21 of Blow (lower part). The lower part of Section 1 (below 100 centimeters) and part of Section 2 may be referred to the middle Pliocene (?) Zone N.20 of Blow and/or to his Zone N.19 (upper part). Among the most significant species are: *Sphaeroidinella dehiscens, Sphaeroidinellopsis seminulina, Globoquadrina altispira, Pulleniatina obliquiloculata, Globorotalia multicamerata, G. miozea, G. acostaensis, G. miocenica, G. menardii,* etc. Lower in Section 2 and in Section 3 the foraminiferal assemblages may be referred to the Lower Pliocene Zone N.19 of Blow. They yield *Sphaeroidinellopsis seminulina, Sphaeroidinella dehiscens, Globigerina venezuelana,* primitive *P. obliquiloculata (praecursor), Globigerinoides obliquus extremus,* various species of *Globorotalia* among which are *G. miocenica, G. multicamerata* and *G. acostaensis. Globigerina nepenthes,* a common and significant species which is known to range through most of Zone N.19, has not been recorded. This absence may indicate that the assemblages are above the *G. nepenthes* extinction datum, or that the species was lacking in this biogeographic province during the Pliocene. Most of the samples examined from Section 2 yielded assemblages consisting largely of minute fragments of foraminiferal tests, but also containing entire specimens. Dissolution by depth is considered to be the cause of this fragmentation. Section 3 contains the contact between the calcareous ooze and the zeolitic clay with the latter containing few or no fossil remains. Section 3 also contains 2 ash layers, one of which is in the calcareous ooze. Samples were examined from above and below the ash layer: both contain much volcanic material and rare benthonic and planktonic foraminifera. The presence of primitive *Sphaeroidinella* sp., *Sphaeroidinellopsis seminulina, Globorotalia menardii, G. miocenica* and *G. puncticulata* indicate a Lower Pliocene Age. The core catcher of Core 4 yielded manganese micronodules, fish teeth, plates and debris, and single, dwarfed planktonic foraminifera indicating a Neogene Age.

Nannofossils	Foraminifera
	Hole 12C, Core 5: The core catcher sample contained manganese micronodules, quartz grains, mica flakes, fish teeth and plates, and rare specimens of dwarfed planktonic foraminifera, mostly unidentifiable at a species level (*Globigerinita glutinata, Globigerina* aff. *quinqueloba*) and possibly artificially introduced.
	Hole 12C, Core 6: The core catcher sample contained manganese micronodules, fish teeth and very rare, dwarfed planktonic foraminifera.
	Hole 12C, Core 7: Similar to the core catcher of Core 6. The species *Globigerinita* cf. *quinqueloba, Globigerina ciperoensis angustumbilicata, Globigerinita* aff. *uvula. Globigerinoides ruber, Globigerina* aff. *praedigitata* were identified. Also recorded are rare specimens of *Cyclammina* sp.
	Hole 12C, Core 8: The core catcher sample yielded a very poor assemblage of manganese nodules, fish teeth, plates, otoliths and debris, a single specimen each of *Glomospira* and large *Cyclammina* coated with manganese and fairly numerous *Rhizammina* sp. No planktonic foraminifera were observed.
	Hole 12C, Cores 9 and 10: The core catcher samples of these cores yielded extremely poor assemblages consisting of rare fish teeth and questionable planktonic foraminifera indicating a Neogene Age.

SUMMARY – SITE 12

Rates of Sediment Accumulation

For Site 12 (including Holes 12C and 12D), two dates were obtained which permit calculation of partial sediment accumulation rates. As entirely different types of sediments were recovered for the two intervals in question, it does not seem useful to calculate sediment accumulation rates for the total interval penetrated.

The Pleistocene and part of the Pliocene intervals (including approximately the upper half of Zone N.19) were represented by calcareous pelagic ooze 41.8 meters in thickness. Using an estimated radiometric age of 4.5 million years for this level (based on planktonic foraminifera) the partial sediment accumulation rate for this interval is 0.93 cm/1000 years, somewhat less than that commonly assumed for calcareous pelagic oozes. It may be significant that most of the 41.8 meters represents Pleistocene sediments and that the Pliocene interval is relatively thin.

Below 41.8 meters, only non-calcareous siliceous clays were recovered. The oldest sediments recovered were from a depth of 218 meters and contained Lower Eocene Radiolaria. The equivalent radiometric age for this level is estimated to be 51 million years. Thus it is estimated that an interval of 166.2 meters represents 46.5 million years. The partial sediment accumulation rate for this interval is 0.36 cm/1000 years.

Discussion

The sediments from Site 12 are of particular interest because of the discovery of a thick interval of palygorskite (Attapulgite) and sepiolite, both magnesium rich clays. Palygorskite is rarely found in deep-sea sediments, although it has been reported in the Atlantic (Bonatti and Joensuu, 1968; Hathaway and Schlee, 1968) and in the Red Sea (Heezen *et al.*, 1965). The occurrence of Eocene palygorskite has been reported on the African continent in eastern Senegal (Wirth, 1968) adjacent to the deep-sea deposits found in this site. It is commonly associated with evaporite sediments or the hydrothermal alteration of serpentimites. The origin of palygorskite in the deep marine environment of Site 12 is not clearly understood. A more comprehensive discussion of the problem is included in the *Cruise Synthesis.*

The abrupt transition from a lower sequence of non-fossiliferous clay to Pliocene and Pleistocene calcareous ooze occurs within one five-foot (1.5 meter) section. It is impossible to determine which of the following phenomena caused this lithologic change: a rapid lowering of the calcium carbonate compensation depth, an increase in the productivity of the surface waters, or a change in the depth of water.

The cherts appear indistinguishable from those found at Sites 8, 9, and 10. They contain and are associated with Eocene Radiolaria. Within the bounds of paleontological dating, the upper cherts cored at Site 12 and at Sites 8, 9, and 10 appear to be essentially synchronous.

Site 12 terminated on an unsampled hard layer which is directly overlain by dolomitic silt with zeolite and shard intercalations. The possibility of a relationship between the occurrence of igneous rock and the formation of dolomite in deep-sea sediments is suggested by the presences of dolomite crystals overlying the basement at Site 10. Such a relationship was also encountered by the Experimental Mohole drilling of the Guadeloups Site (Riedel *et al.*, 1961) where, of the five basalts encountered, dolomite was plentiful or dominant in the overlying sediments. From the evidence established from these two sites, it is possible that the hard layer underlying the dolomitic clay at Site 12 is basalt.

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APPENDIX - MICROPALEONTOLOGICAL DETERMINATIONS

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

Sample 12A, drill collar:
Rich and diversified planktonic assemblage including: *Globorotalia menardii* (dominant species), *G. tumida* (abundant), *G. truncatulinoides, G. inflata, G. puncticulata, G.* sp. ex gr. *G. crassaformis, G. scitula* (very rare), *Globigerinoides ruber* (with small, pink specimens large, high spired ones), *G. sacculifer, G. elongatus, G. trilobus* s.l. (including *G. quadrilobatus), Globigerina eggeri* (rare), *G. quinqueloculata* (rare), *Globigerinita glutinata, Pulleniatina obliquiloculata finalis,* etc. Very rare benthonic foraminifera including *Eponides* sp. and *Cibicides* sp.
Age determination: Recent or sub-Recent (Zone N.23 of Blow).

Sample 12B-1, core catcher (depth about 120 meters below the mud line):
Very rare planktonic foraminifera are present in the core catcher sediment, probably artificially introduced by coring operations. They include *Globorotalia truncatulinoides, Globigerinoides trilobus, G. ruber, Globigerinita glutinata, Pulleniatina obliquiloculata finalis* which indicate a young Pleistocene or Holocene Age; this, however, is not the age of the sediments at the considered depth below the mud line. The mineral content consists of abundant, fine quartz grains.
Age determination: None.

Sample 12B-2, core catcher (depth about 164 meters below the mud line):
Rare planktonic foraminifera including: *Globorotalia truncatulinoides, G. scitula, G.* aff. *puncticulata, Globigerina bulloides, Globigerinoides ruber, G. elongatus, G. trilobus, Globigerinita glutinata, Orbulina universa, Hastigerina siphonifera, Globotruncana fornicata, G. linneiana, Heterohelix* sp. The aforementioned assemblage is strongly heterogeneous, comprising Upper Cretaceous and Pleistocene species, and has nothing to do with the sediments penetrated at the considered depth—which are present in the washing as fragments of silicified chert and crystals of pyrite. It is thought that the cited foraminifera have been artificially introduced by coring operations. Some of them (the Upper Cretaceous forms) are not present in the section penetrated at Hole 12 and are derived by previously drilled sites.
Age determination: None.

Sample 12C-1-1, 150 cm (depth about 150 meters below the mud line):
Rich planktonic assemblage, highly diversified, including: *Globorotalia truncatulinoides, G. crassaformis, G. menardii* (left coiling), *G. tumida, G. inflata, G. flexuosa, G. scitula, Hastigerina siphonifera, Orbulina universa, Globigerina eggeri, G. quinqueloba, G.* cf. *calida, Sphaeroidinella dehiscens* (and forma *excavata), Pulleniatina obliquiloculata finalis, Globigerinoides elongatus, G. ruber* (also with pink tests), *G. conglobatus, G. sacculifer, G. quadrilobatus,* etc. Extremely rare benthonic foraminifera including: *Quinqueloculina seminulum, Dentalina* sp., *Nonion* sp., *Cibicides* sp. *Quinqueloculina* shows corroded tests. Also present extremely rare Ostracods.
Age determination: late Pleistocene or Holocene, probably Zone N.23 of Blow, according to the occurrence of *Sphaeroidinella dehiscens excavata, Pulleniatina obliquiloculata finalis, Globigerina* cf. *calida* and pink *Globigerinoides ruber.*

Sample 12C-1-2, 145-150 cm (depth about 3 meters below the mud line):
Rich assemblage as above.
Age determination: As above.

Sample 12C-1-3, 145-150 cm (depth about 4.5 meters below the mud line):
Rich assemblage as above, also including *Globigerina digitata, G. calida, Globorotalia pseudopima* and, among the benthonics, *Pullenia, Cibicides, Eponides, Eggerella.*
Age determination: As above.

Sample 12C-1-4, 145-150 cm (depth about 6 meters below the mud line):
Rich assemblage as above, also including *Candeina nitida* and *Globigerinita glutinata.*
Age determination: As above.

Sample 12C-1, core catcher (depth about 9.1 meters below the mud line):
Rich planktonic assemblage as above, containing a large amount of broken tests.
Age determination: As above.

Sample 12C-2, core catcher (depth about 20.4 meters below the mud line):
Rich planktonic assemblage including: *Globorotalia truncatulinoides, G. menardii* (left coiling), *G. inflata, G. crassaformis, G. scitula, Orbulina universa, Globigerina bulloides, G. eggeri, Hastigerina siphonifera, Globigerinoides quadrilobatus, G. conglobatus, G. elongatus, G. sacculifer, G. ruber* (also with pink tests), *Sphaeroidinella dehiscens excavata, Pulleniatina obliquiloculata finalis,* etc. Very rare benthonic foraminifera including: *Lagena, Uvigerina, Cibicides, Eponides,* etc. Very rare Ostracod valves.
Age determination: Pleistocene. The three last species cited in the planktonic foraminifera list speak in favor of a late Pleistocene age (Zone N.23). However, it is possible that they have been artificially introduced by coring operations and that the age of the fauna is middle to early Pleistocene (Zone N.22).

Sample 12C-2R-1, 145-150 cm (depth about 14.9 meters below the mud line):
Rich planktonic assemblage including: *Globorotalia menardii* (abundant, always left coiling), *G. tumida, G. inflata, G. truncatulinoides,* (very rare), *G. pseudopima, G. scitula* (very rare), *G. hirsuta, Globigerina eggeri, G. bulloides, Globigerinoides sacculifer, G. ruber, G. elongatus, G. quadrilobatus, Orbulina universa, Pulleniatina obliquiloculata obliquiloculata, Sphaeroidinella dehiscens,* etc. Many broken tests. Very rare benthonic foraminifera including: *Textularia, Nonion, Pyrgo.*
Age determination: Pleistocene, Zone N.22.

Sample 12C-2R-2, 145-150 cm (depth about 16.4 meters below the mud line):
Rich, heterogeneous planktonic assemblage including: *Globorotalia truncatulinoides, G. tumida, G. crassaformis, G. menardii* (both right and left coiling), *G. hirsuta, G. miocenica* (abundant), *G. multicamerata, G. exilis, G. scitula, G. obesa, Globigerinoides quadrilobatus, G. ruber, G. elongatus, G. sacculifer, G. conglobatus, Orbulina universa, Globigerina eggeri, Hastigerina siphonifera, Sphaeroidinella dehiscens.*
Age determination: lower to middle Pleistocene (Zone N.22) mixed with Upper Pliocene (Zone N.21). Species mutually exclusive are present in this assemblage, where the Pliocene species are numerically dominant.

Sample 12C-2R-3, 145-150 cm (depth about 17.9 meters below the mud line):
Rich planktonic assemblage, homogeneous, including: *Globorotalia truncatulinoides, G. tosaensis, G. menardii* (left coiling), *G. inflata, G. scitula, G. tumida, G. flexuosa, G. hirsuta, G. crassaformis, Globigerina eggeri, G. digitata, Orbulina universa, Hastigerina siphonifera, Pulleniatina obliquiloculata obliquiloculata* (very rare), *Globigerinoides elongatus, G. conglobatus, G. sacculifer, G. ruber, Sphaeroidinella dehiscens,* etc. Very rare benthonic foraminifera including: *Quinqueloculina, Dorothia, Pyrgo bulloides, Eponides umbonatus, Cibicides, Nonion,* etc.
Age determination: lower Pleistocene, lower part of Zone N.22.

Sample 12C-2R-3, 145-150 cm (depth about 19.4 meters below the mud line):
Rich assemblage as above, with many broken tests of planktonic foraminifera.
Age determination: As above.

Sample 12C-2R, core catcher (depth about 23.5 meters below the mud line):
Rich assemblage as above, including also some specimens of *Sphaeroidinella dehiscens excavata, Pulleniatina obliquiloculata finalis,* pink *Globigerinoides ruber* which would suggest a young Pleistocene or Holocene age. However, it is thought that they have been artificially introduced in the core catcher.
Age determination: As above.

Sample 12C-3, core catcher (depth about 32.6 meters below the mud line):
Rich planktonic assemblage including: *Globorotalia multicamerata, G. menardii* (right coiling), *G. crassaformis, G. inflata, G. humerosa* (highly evolute), *G. miocenica* (common), *G. tosaensis* (primitive), *G. exilis* (rare), *Globigerina eggeri, Globigerinoides elongatus, G. quadrilobatus, G. ruber, G. sacculifer, G. fistulosus, G. conglobatus, Globigerinita glutinata, Pulleniatina obliquiloculata, Sphaeroidinella dehiscens, Candeina nitida,* etc. Many broken tests of planktonic foraminifera. Very rare benthonic foraminifera including: *Lagena, Pyrgo, Cibicides, Eponides, Globocassidulina, Pullenia, Nonion, Quinqueloculina seminulum.*
Age determination: Upper Pliocene, lower part of Zone N.21.

Sample 12C-4-1, 50-52 cm (depth about 33.1 meters below the mud line):
Rich planktonic assemblage as above, also including rare specimens of *Globoquadrina altispira altispira* and *Globigerina venezuelana.*
Age determination: Upper Pliocene, lower part of Zone N.21.

Sample 12C-4-1, 80-82 cm (depth about 33.4 meters below the mud line):
Planktonic assemblage rather rich but strongly affected by solution. Many broken tests, reduced in minute fragments. Some of the entire tests show corrosion. Same taxa as above, including primitive *Globorotalia tosaensis, Globoquadrina altispira altispira, G.* cf. *obesa, Globigerina venezuelana, Globorotalia miocenica, G. multicamerata,* etc.
Age determination: Upper Pliocene, basal part of Zone N.21.

Sample 12C-4-1, 100-105 cm (depth about 33.6 meters below the mud line):
Planktonic assemblage rather rich, with many broken tests including: *Sphaeroidinella dehiscens,* rare *Sphaeroidinellopsis seminulina,* rare *S. subdehiscens, Globorotalia menardii, G. miocenica, G. puncticulata, G. crassaformis, G. multicamerata, G. scitula, G.* aff. *miozea, G. acostaensis humerosa, Orbulina universa, O. suturalis, Globigerina eggeri, G. venezuelana, Globoquadrina altispira altispira, Globoquadrina* cf. *obesa, Globigerinoides conglobatus, G. elongatus, G. quadrilobatus, G. ruber, G. sacculifer,* etc.
Age determination: middle (?) Pliocene, probably Zone N.20 or upper part of Zone N.19.

Sample 12C-4-1, 140-142 cm (depth about 34 meters below the mud line):
Planktonic assemblage as above, with many broken tests. Also present abundant and typical *Globorotalia acostaensis.* Benthonic foraminifera very rare, including: *Laticarinina pauperata, Gyroidina soldanii, Pyrgo* sp., *Eponides* sp., *Quinqueloculina* sp. Also present rare fish teeth.
Age determination: As above.

Sample 12C-4-2, 8-10 cm (depth about 34.2 meters below the mud line):
Rather poor planktonic assemblage, including: *Globorotalia multicamerata, G. acostaensis. G. menardii* (right coiling), *G.* aff. *miozea, G.* aff. *puncticulata, Globoquadrina altispira altispira, Globoquadrina* sp., *Globigerina* aff. *venezuelana, Sphaeroidinella dehiscens, Sphaeroidinellopsis subdehiscens.* Many broken tests.
Age determination: Probably Lower Pliocene. Zone N.19 of Blow.

Sample 12C-4-2, 10-15 cm (depth about 34.3 meters below the mud line):
Poor planktonic fauna as above, with many broken tests.
Age determination: As above.

Sample 12C-4-2, 56-58 cm (depth about 34.7 meters below the mud line):
Poor planktonic assemblage as above, with many broken tests.
Age determination: As above.

Sample 12C-4-2, 100-105 cm (depth about 35.2 meters below the mud line):
Fairly rich planktonic assemblage as above, also including *Globoquadrina dehiscens,* abundant *Sphaeroidinellopsis* spp. and *Pulleniatina obliquiloculata* in primitive evolutionary stages.
Age determination: Lower Pliocene, Zone N.19.

Sample 12C-4-2, 121-123 cm (depth about 35.4 meters below the mud line):
Rather poor planktonic assemblage, with many broken tests. Also present: *Sphaeroidinella dehiscens* forma *immatura, Globigerinoides obliquus extremus, Pulleniatina primalis, Pulleniatina obliquiloculata praecursor,* etc.
Age determination: As above.

Sample 12C-4-3, 28-30 cm (depth about 36 meters below the mud line):
Rare planktonic foraminifera, including: *Sphaeroidinellopsis seminulina, S. subdehiscens, Globorotalia menardii, G.* aff. *puncticulata, Globigerinoides obliquus extremus, G. trilobus, G. elongatus, G. sacculifer, Globoquadrina* sp. Rare benthonic foraminifera including: *Laticarinina pauperata, Cibicides, Nonion, Eponides,* etc. Also present were some fish teeth in the washing, which mostly consists of volcanic material.
Age determination: probably Lower Pliocene.

Sample 12C-4-3, 40-42 cm (depth about 36.1 meters below the mud line):
Extremely rare planktonic foraminifera including: *Globorotalia miocenica, Globigerina bulloides, G. ciperoensis angustiumbilicata, Sphaeroidinellopsis subdehiscens,* dwarfed *Globigerina* cf. *quinqueloba.* Very rare benthonic foraminifera including: *Eponides, Anomalina, Reussella, Eggerella.*
Age determination: probably Pliocene.

Sample 12C-4-3, 75-77 cm (depth about 36.5 meters below the mud line):
Very rare planktonic foraminifera including: *Globorotalia menardii, G.* cf. *puncticulata, Globoquadrina altispira altispira, Globigerina bulloides, Globigerinita glutinata, Orbulina universa, Globigerinoides bollii.* Very rare benthonic foraminifera including: *Globocassidulina, Cibicides, Lagena, Eponides, Pullenia.* Also present siliceous spicules and fish teeth.
Age determination: As above.

Sample 12C-4, core catcher (depth about 41.8 meters below the mud line):
Extremely rare planktonic foraminifera including *Globigerina quinqueloba, G. ciperoensis angustiumbilicata, G.* cf. *tetracamerata, Globigerinita* sp. (possibly artificially introduced) in a washing residue mostly consisting of manganese micronodules, fish teeth, plates and debris.
Age determination: probably Neogene.

Sample 12C-5-2, 51-53 cm (depth about 43.8 meters below the mud line):
No planktonic foraminifera present. Extremely rare fish teeth.
Age determination: None

Sample 12C-5-3, 40-50 cm (depth about 45.3 meters below the mud line):
No planktonic foraminifera. Extremely rare fish teeth.
Age determination: None

Sample 12C-5, core catcher (depth about 50.9 meters below the mud line):
Extremely rare planktonic foraminifera, dwarfed and possibly artificially introduced by coring operations, including *Globigerinita glutinata* and *Globigerina* aff. *quinqueloba.* Also present in the washing residue: quartz crystals, mica flakes, tourmaline crystals, fish teeth and plates.
Age determination: None.

Sample 12C-6-2, 48-50 cm (depth about 52.9 meters below the mud line):
No planktonic foraminifera. Manganese micronodules and fish teeth.
Age determination: None.

Sample 12C-6, core catcher (depth about 60.1 meters below the mud line):
Very rare planktonic foraminifera, possibly artificially introduced and including: *Globigerinoides ruber, G. trilobus, Globorotalia truncatulinoides, G.* aff. *miocenica, Globigerinita glutinata.* Also present manganese micronodules and fish teeth.
Age determination: none (the foraminiferal fauna is considered as displaced).

Sample 12C-7, core catcher (depth about 69.2 meters below the mud line):
Extremely rare planktonic foraminifera, possibly artificially introduced and including *Globigerinoides quadrilobatus, G. ruber, Globigerina* cf. *quinqueloba, G. ciperoensis angustiumbilicata, G.* cf. *praedigitata, Globigerinita* aff. *uvula.* Also present extremely rare *Cyclammina* sp. (probably in place), manganese micronodules, fish teeth, plates and otoliths.
Age determination: none (probably Neogene if the planktonic foraminifera are *in situ).*

Sample 12C-8-1, 102-105 cm (depth about 70.2 meters below the mud line):
Extremely rare, dwarfed planktonic foraminifera including: *Globigerina quinqueloba, G. ciperoensis angustiumbilicata, Hastigerina* sp. Also present manganese micronodules and fish teeth.
Age determination: probably Neogene (see above).

Sample 12C-8, core catcher (depth about 78.4 meters below the mud line):
No planktonic foraminifera. Extremely rare benthonic foraminifera including *Rhizammina* sp., one specimen of *Glomospira,* one and a half specimens of planispiral Lituolidae *(Cyclammina?)* manganese-coated. Also

present manganese micronodules, fish teeth, plates and otoliths.
Age determination: None.

Sample 12C-10-1, 124-126 cm (depth about 88.8 meters below the mud line):
No planktonic foraminifera. Some fish teeth.
Age determination: None.

Sample 12C-10, core catcher (depth about 96.6 meters below the mud line):
One specimen of *Globigerina* aff. *quinqueloba.*
Age determination (if *in situ):* probably Neogene.

Sample 12C-11, core catcher (depth about 105.8 meters below the mud line):
No planktonic foraminifera.
Age determination: None.

Sample 12C-12, core catcher (depth about 114.9 meters below the mud line):
No foraminifera present.
Age determination: None.

Sample 12D-4-1, 0-5 cm (depth about 18.3 meters below the mud line):
Rich and diversified planktonic assemblage including: *Globorotalia miocenica* (abundant), *G. multicamerata, G. exilis, G. menardii, G. tumida, G. flexuosa, G. crassaformis, G. inflata, G. tosaensis, G. acostaensis humerosa, Globigerina eggeri, Globigerinoides conglobatus, G. elongatus, G. ruber, G. sacculifer, Orbulina universa, Sphaeroidinella dehiscens,* etc. Very rare benthonic foraminifera including *Globocassidulina subglobosa.*
Age determination: Upper Pliocene, Zone N.21.

Sample 12D-4-2, 0-5 cm (depth about 19.8 meters below the mud line):
Rich heterogeneous planktonic assemblage including the taxa listed for Section 1 of the same core, and also *Globorotalia truncatulinoides, Pulleniatina obliquiloculata finalis, Sphaeroidinella dehiscens excavata,* pink *Globigerinoides ruber.*
Age determination: Upper Pliocene, Zone N.21 mixed with Pleistocene.

Sample 12D-4-3, 0-5 cm (depth about 21.3 meters below the mud line):
Rich, heterogeneous planktonic assemblage as above, also including *Globigerinoides fistulosus* and many species which are mutually exclusive.
Age determination: Upper Pliocene, Zone N.21 mixed with Pleistocene. The Pleistocene fauna is numerically dominant.

Sample 12D-4-4, 0-5 cm (depth about 22.8 meters below the mud line):
Planktonic assemblage as above, also including *Globigerina digitata* and *Globoquadrina altispira altispira.*
Age determination: As above.

Sample 12D-5-1, 145-150 cm (depth about 28.9 meters below the mud line):
Rich and diversified planktonic assemblage including *Globorotalia miocenica* (abundant), *G. multicamerata, G. exilis, G. menardii* (right coiling), *G. tumida, G. flexuosa, G. tosaensis, G. crassaformis, G. acostaensis humerosa, G. scitula, G. inflata, Globigerinoides fistulosus, G. ruber, G. conglobatus, G. quadrilobatus, G. elongatus, G. sacculifer, Globigerina eggeri, Hastigerina siphonifera, Orbulina universa, Pulleniatina obliquiloculata,* etc. Very rare benthonic foraminifera including *Laticarinina pauperata, Pyrgo, Quinqueloculina,* etc. Also present very rare Ostracod valves.
Age determination: Upper Pliocene, Zone N.21 of Blow.

Sample 12D-5-2, 145-150 cm (depth about 30.4 meters below the mud line):
Rich planktonic assemblage as above.
Age determination: As above.

Sample 12D-5-3, 145-150 cm (depth about 31.9 meters below the mud line):
Rich planktonic fauna as above. Many broken tests.
Age determination: As above.

Sample 12D-5-4, 145-150 cm (depth about 33.4 meters below the mud line):
Rich planktonic assemblage as above, with some contamination of Pleistocene species.
Age determination: As above.

Sample 12D-5-5, 145-150 cm (depth about 34.9 meters below the mud line):
Rich planktonic assemblage as above.
Age determination: As above.

Sample 12D-5-6, 145-150 cm (depth about 36.4 meters below the mud line):
Rich planktonic assemblage as above.
Age determination: As above (Upper Pliocene).

NOTE: The depth below the mud line has been calculated according to the general rule. For the real position of Core 5, Hole 12D versus Core 4, Hole 12C see discussion on the correlations between the holes.

Calcareous Nannofossil Determinations by S. Gartner

Sample 12C-1-2, bottom:
Umbilicosphaera mirabilis, Cyclococcolithus leptoporus, Helicopontosphaera kamptneri, cf. *Coccolithus cricotus, Discolithus phaseolus, Gephyrocapsa* sp., *Rhabdosphaera claviger.*
Age determination: early-middle Pleistocene

Sample 12C-1-3, bottom:
As above.
Age determination: early-middle Pleistocene.

Sample 12C-1-4, bottom:
As above.
Age determination: early-middle Pleistocene.

Sample 12C-1, core catcher:
As above.
Age determination: early-middle Pleistocene.

Sample 12C-2R-1, bottom:
cf. *Coccolithus cricotus, Rhabdosphaera claviger, Cyclococcolithus leptoporus, Discolithus phaseolus, Discoaster brouweri,* cf. *Ceratolithus rugosus, Ceratolithus cristatus.*
Age determination: late Pliocene.

Sample 12C-2R-2, bottom:
As above, plus *Discoaster pentaradiatus.*
Age determination: late Pliocene.

Sample 12C-2R-3, bottom:
Gephyrocapsa sp., cf. *Coccolithus cricotus, Umbilicosphaera mirabilis.*
Age determination: early-middle Pleistocene.

Sample 12C-2R-4, bottom:
As above.
Age determination: early-middle Pleistocene.

Sample 12C-2R, core catcher:
As above.
Age determination: early-middle Pleistocene.

Sample 12C-3, core catcher:
Ceratolithus rugosus, Discoaster pentaradiatus, D. brouweri, D. surculus, Coccolithus pelagicus, Cyclococcolithus leptoporus, cf. *Coccolithus cricotus.*
Age determination: late Pliocene.

Sample 12C-4-1, top:
As above, plus *Ceratolithus rugosus.*
Age determination: late Pliocene.

Sample 12C-4-2, 2 cm:
As above.
Age determination: late Pliocene.

Sample 12C-4-2, 50 cm:
As above, plus *Reticulofenestra pseudoumbilica.*
Age determination: middle Pliocene.

Sample 12C-4-2, 75 cm:
As above.
Age determination: middle Pliocene.

Sample 12C-4-2, 100 cm:
Discoaster pentaradiatus, D. brouweri, D. surculus, D. challangeri, Ceratolithus rugosus, Reticulofenestra pseudoumbilica, cf. *Ceratolithus tricorniculatus.*
Age determination: early-middle Pliocene.

Sample 12C-4-2, 145 cm:
As above.
Age determination: early-middle Pliocene.

Sample 12C-4-3, 2 cm:
As above.
Age determination: early-middle Pliocene.

Sample 12C-4-3, 65 cm:
As above.
Age determination: early-middle Pliocene.

Sample 12C-4-3, 92 cm:
As above.
Age determination: early-middle Pliocene.

Sample 12C-4, core catcher:
Discoaster variabilis, D. brouweri.
Age determination: probably early-middle Pliocene.

Sample 12D-4-1, top:
Discoaster brouweri, D. pentaradiatus, cf. *Coccolithus cricotus, C. pelagicus, Discolithus phaseolus, Rhabdosphaera claviger, Cyclococcolithus leptoporus, Ceratolithus rugosus, Scyphosphaera pulcherima.*
Age determination: late Pliocene.

Sample 12D-4-2, top:
As above.
Age determination: late Pliocene.

Sample 12D-4-3, top:
As above.
Age determination: late Pliocene.

Sample 12D-4-4, top:
As above.
Age determination: late Pliocene.

Sample 12D-5-1, bottom:
Discoaster surculus, D. brouweri, D. pentaradiatus, Umbilicosphaera mirabilis, cf. *Coccolithus cricotus.*
Age determination: late Pliocene.

Sample 12D-5-2, bottom:
As above.
Age determination: late Pliocene.

Sample 12D-5-3, bottom:
As above.
Age determination: late Pliocene.

Sample 12D-5-4, bottom:
As above.
Age determination: late Pliocene.

Sample 12D-5-5, bottom:
As above.
Age determination: late Pliocene.

Sample 12D-5-5, bottom:
As above.
Age determination: late Pliocene.