5. SITE 10

The Shipboard Scientific Party[1]

SITE REPORT

Objectives

It was the decision of the Atlantic Advisory Panel that Site 10 should be located on the lower western flank of the Mid-Atlantic Ridge (lat 32° 37′N, long 52° 20′W). This site is located on an exceptionally shallow point of an area typified by abyssal hills of low relief that vary in depth below sea level from 2550 to 2650 fathoms (4664 to 4847 meters). To the northeast of Site 10, the bottom deepens rapidly into a fairly flat trough that is probably an eastern tongue of the Sohm Abyssal Plain. A greater percentage of carbonate sediments on the top of a rise, such as where Site 10 is located, is inferred by the increased thickness of the sedimentary blanket there by comparison with the deeper surrounding slopes.

Two primary objectives influenced the selection of Site 10. One objective was to test the theory of sea floor spreading as discussed in Chapter 1. Site 10 is the westernmost member of a series of proposed sites distributed across the axis of the Mid-Atlantic Ridge. Determinations based on the age of and the sediment directly overlying acoustical basement at these sites would provide a check on the spreading concept. The second objective is related to the results of seismic reflection profiler studies in this region (Figure 1). To the east of the southern Sohm Abyssal Plain, on the lower flank of the Mid-Atlantic Ridge, there are pockets of acoustically transparent sediment between the steep peaks of basement rock. On portions of the flank that are deeper than 4400 meters below sea level, a single strong reflector is recorded in some of these pockets. It was considered that the determination of the age and nature of this reflector would contribute to our understanding of the sedimentary and tectonic history of the lower flanks of the ridge. At Site 10, a very weak reflector was noted on seismic records a few hundred feet beneath the sea floor with a stronger reflector at about 600 feet (182.9 meters). The remaining sediment is acoustically transparent, overlying a typically strong basement reflector at about 1500 feet (457.3 meters) below the sea floor. Because calcareous microfossils were found to be sparse in the sediments cored at Sites 8 and 9, a location having a sediment-water interface topographically above the estimated calcium carbonate compensation depth was also a factor in determining the exact location of Site 10 in order to assure its usefulness for biostratigraphic purposes.

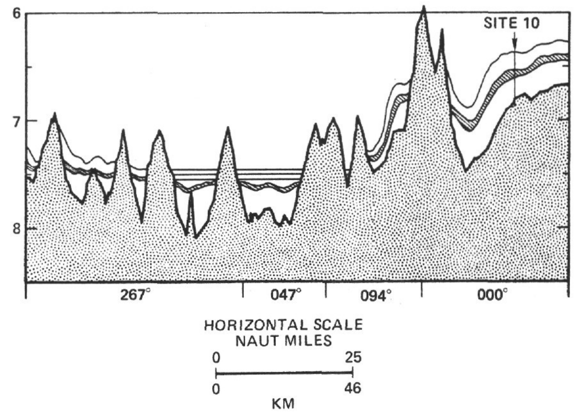

Figure 1. *Line drawing of profiler record made by* Vema *of Lamont-Doherty Geological Observatory showing typical acoustical subbottom features in the region of Site 10.*

Therefore, the following drilling prospectus was proposed:

1) Cut two cores at 300 feet (91.4 meters) below the sea floor.
2) Cut two cores at 550 feet (167.6 meters), or at the first resistant formation between 500 and 550 feet (152.4 and 167.6 meters) below the sea floor.
3) Attempt continuous coring of the interval between 1200 feet (365.8 meters) below the sea floor and the basement.
4) Recover five feet (1.5 meters) of basement rock.
5) Take one punch core at the surface of the sea floor as the drill string is retrieved from the hole.

In addition to the available well logging procedures measurement of hole inclination was to be attempted.

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Drilling and Coring Log

At 1330 hours, November 2, final positioning for Site 10 was accomplished in 15,406 feet (4697 meters) (corrected depth) of water at a location defined by the co-ordinates: latitude 32° 51.73'N and longitude 52° 12.92'W (Figure 2). The drill string included a Hycalog tungsten carbide bit, 14 drill collars, and 1 bumpersub. The reader is referred to Tables 1 and 2 for a summary of the coring operations. Figure 3 is a tracing of the on station profiling record showing the reflection time to significant subbottom horizons and basement. Drilling commenced immediately and at a depth of 98 feet (29.9 meters) below the sea floor, sediments were encountered that were considered to be adequately firm for coring. On the first coring attempt, a 30 foot (9.1 meter) core was cut at a rate of 300 feet (91.4 meters) per hour. During retrieval of the inner core barrel, the winch stopped, and the inner core barrel remained suspended in the drill pipe for six hours. At 1730 hours, November 3, Core 1 was recovered, and drilling was resumed immediately. Core 1 contained seven feet (2.1 meters) of nannofossil chalk ooze of early and middle Pliocene age. Assuming that the late Tertiary section was relatively complete, the sedimentation rate, based on Core 1, was extraordinarily low. Therefore, it was concluded that the late Tertiary section might be condensed here and should be continuously cored. Drilling was stopped at 138 feet (42.1 meters) below the sea floor; on the second attempt, a 25 foot (7.6 meter) core was cut at 250 feet (76.2 meters) per hour. At 2020 hours, November 2, Core 2 was recovered, and it contained 16 feet (4.9 meters) of nannofossil chalk ooze and clay. The sediment was obviously disturbed and was Middle and late Miocene in age. On the third attempt, a 30 foot (9.1 meter) core was cut at 300 feet (91.4 meters) per hour. At 2250 hours, November 3, Core 3 was recovered, and it contained 19 feet (5.8 meters) of nannofossil chalk ooze that was Oligocene in age. On the fourth attempt, a 30 foot (9.1 meter) core was cut at 300 feet (91.4 meters) per hour. At 0045 hours, November 4, the inner core barrel was recovered, but the core catcher was missing and there was no core in the liner. The core catcher was retrieved from the bottom of the drill string on the second spearing attempt, but the bit penetrated 16 feet (4.9 meters) of sediment before coring continued. Cores 5, 6 and 7 were all cut at 300 feet (91.4 meters) per hour. A 30 foot (9.1 meter length of core was cut for each of Cores 5 and 6. Core 5 was recovered at 0520 hours, November 4, and it contained 22 feet (6.7 meters) of nannofossil chalk ooze of Oligocene and late Eocene Ages. Cores 6 was recovered at 0700 hours, November 4, and it was found to be empty, except for scrapings on the inner wall of the liner. These scrapings were located at a position of 90 to 110 centimeters above the base of the liner, and they are evidence that the liner had been filled, but that the core catcher did not retain the sediment. On the seventh attempt, a 34 foot (10.4 meter) core was cut at 300 feet (91.4 meters) per hour. At 0840 hours, November 4, Core 7 was recovered, and it contained 18 feet (5.5 meters) of nannofossil chalk ooze of late Middle Eocene Age. The sediment accumulation calculated for Core 7 was faster than in previous cores and it was concluded that the interval of slow sedimentation was adequately sampled; drilling was resumed at a depth of 328 feet (100 meters) below the sea floor.

In order to sample the strong reflector discussed earlier, drilling stopped at a depth of 548 feet (167 meters) below the sea floor. On the eighth attempt, a 30 foot (9.1 meter) core was cut at 300 feet (91.4 meters) per hour. At 1200 hours, November 4, Core 8 was recovered, and it contained one foot (0.3 meter) of chert. A 30 foot (9.1 meter) length was cut for Core 9, directly below Core 8, at a rate of 100 feet (30.5 meters) per hour. Core 9 was recovered at 1415 hours, November 4, and it contained 15 feet (4.6 meters) of nannofossil-radiolarian chalk ooze of early Eocene Age. A bed of chert 10 centimeters thick was present 35 centimeters below the top of the core. Drilling resumed to a depth of 955 feet (291.1 meters) below the sea floor. The tenth core was attempted at this point, and a 25 foot (7.6 meter) length of core was cut at 83 feet (25.3 meters) per hour. During the recovery of Core 10, the sand line reel motor and the power sub failed and were repaired. At 0200 hours, November 5, Core 10 was recovered, and it contained 23 feet (7 meters) of foraminiferal-nannofossil ooze of late Maestrichtian Age. Because of the time lost due to mechanical malfunctions, it was decided to drill down to a depth near the basement. At 1239 feet (377.6 meters) below the sea floor, continuous coring was resumed until contact with the basement occurred. In this sequence, a total length of 267 feet (81.4 meters) of core was cut. Thirty foot (9.1 meter) lengths were cut for each of Cores 11 to 18 at rates of 100 feet (30.5 meters) to 150 feet (45.7 meters) per hour. The sediment recovered in these cores is predominantly nannofossil-foraminiferal chalk ooze and ranges in age from early Maestrichtian to Campanian. Contact with the basement occurred in Core 19, in which 19 feet (5.8 meter) were cut in 45 minutes. At 2315 hours, November 5, Core 19 was recovered, and it contained one foot (0.3 meter) of marble above two feet (0.6 meters) of igneous rock. For Core 20, an 8 foot (2.4 meter) length was cut in four hours and a 7 foot (2.1 meter) section of igneous rock was recovered. After well logging operations, Site 10 was abandoned at 0600 hours, November 7. The total time spent at Site 10 was 122.5 hours, and a depth of 1506 feet (459 meters) below the sea floor was reached. A total length of 251 feet (76.5 meters) of core was recovered, and the average recovery rate was 44.7 per cent.

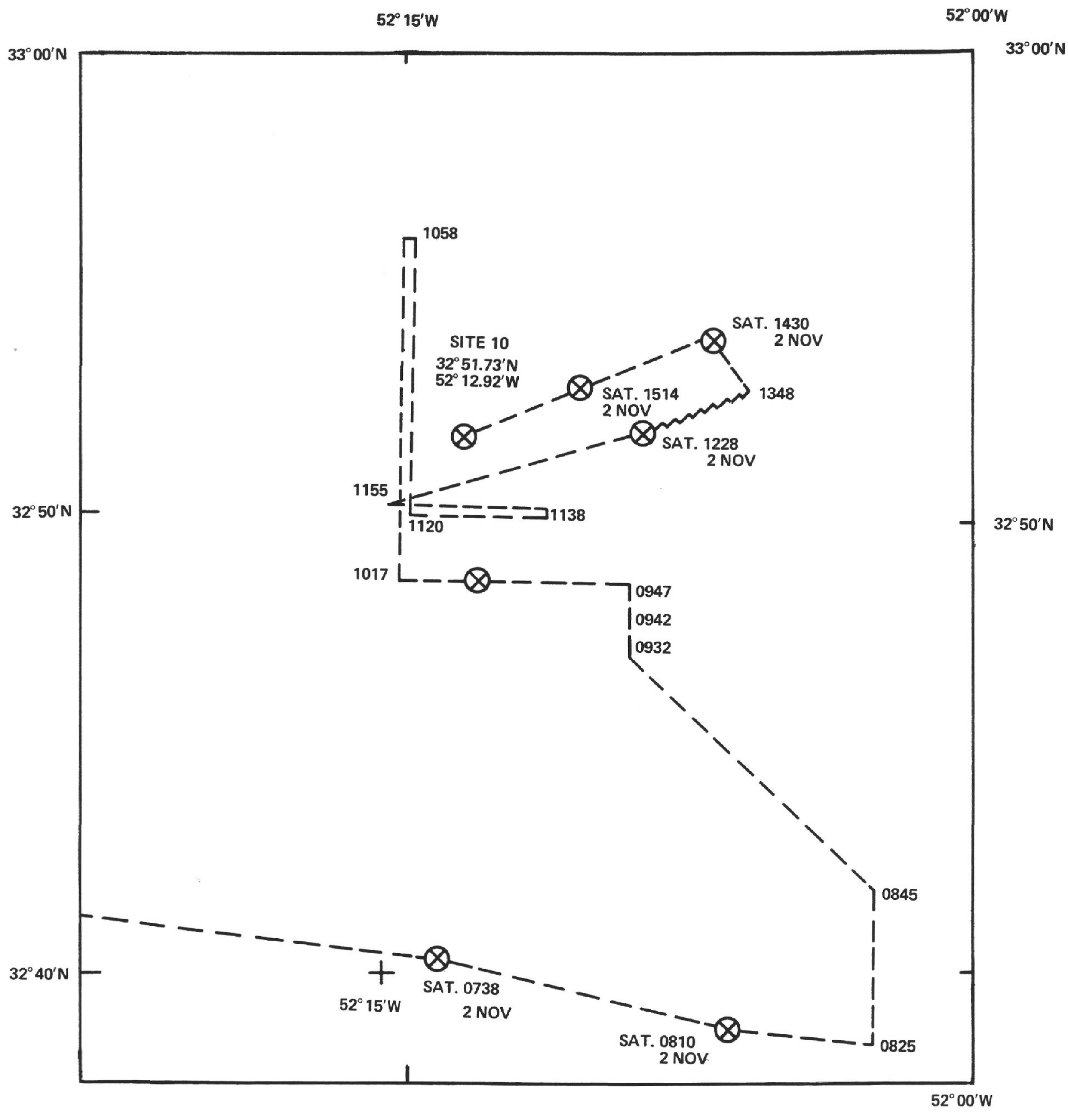


Figure 2. *Chart showing* Glomar Challenger's *approach to Site 10.*

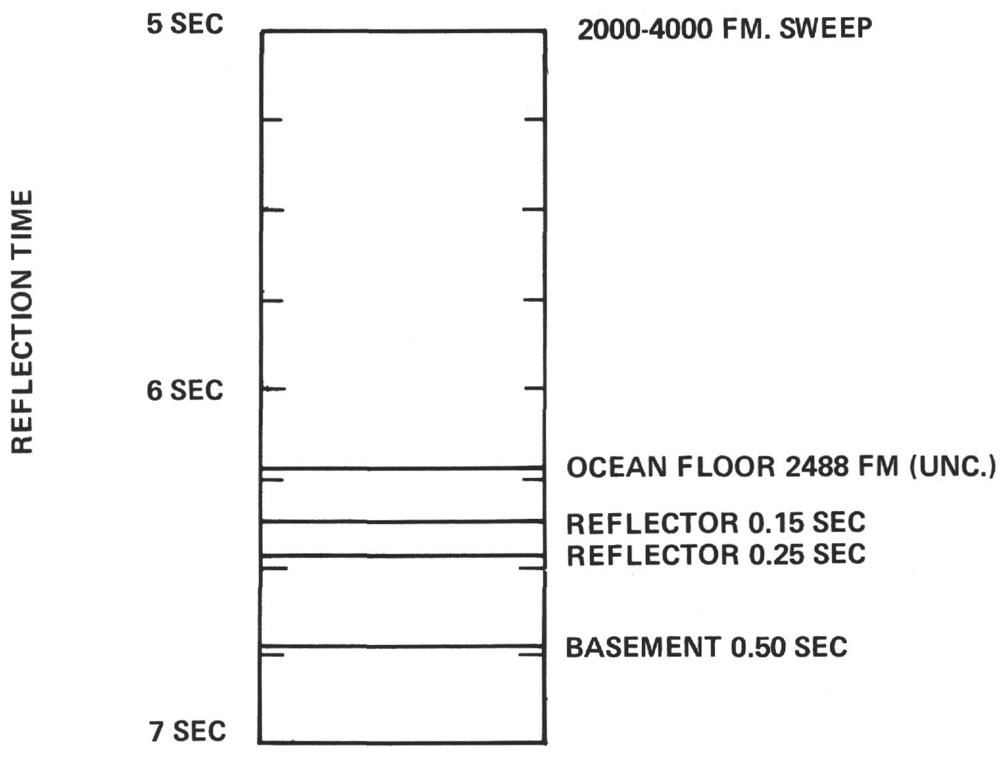


Figure 3. *Line drawing of profiler record made on station by Glomar Challenger at Site 10.*

TABLE 1
Drilling Summary

Hole 10
(lat. 32° 51.73′N., long. 52° 12.92′W., depth 4612 meters)

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	ft	Depth Below Sea Surface m	ft	Core Cut m	ft	Core Recov. m	ft	% Core Recov.	No. of Sec.
1730		29.9	98	4742	15,556						
3 Nov	1	40.0	128	4751	15,586	9.14	30	2.13	7	23	2
2020		40.2	133	4753	15,591						
3 Nov	2	48.2	158	4760	15,616	7.62	25	4.88	16	64	4
2250		48.2	158	4760	15,616						
3 Nov	3	57.3	188	4769	15,646	9.14	30	5.79	19	63	4
0045		57.3	188	4769	15,646						
4 Nov	4	66.4	218	4778	15,676	9.14	30	0	0	0	0[a]
0520		71.3	234	4784	15,692						
4 Nov	5	80.4	264	4793	15,722	9.14	30	6.71	22	73	5
0700		80.4	264	4793	15,722						
4 Nov	6	89.5	294	4802	15,752	9.14	30	0	0	0	0[b]
0840		89.5	294	4802	15,752						
4 Nov	7	100.0	328	4812	15,786	10.36	34	5.49	18	53	4
1220		167.1	548	4879	16,006						
4 Nov	8	176.2	578	4888	16,036	9.14	30	.30	1	3	1[c]
1415		176.2	578	4888	16,036						
4 Nov	9	185.3	608	4897	16,066	9.14	30	4.57	15	50	3
0200		291.2	955	5003	16,413						
5 Nov	10	298.8	980	5011	16,438	7.62	25	7.01	23	92	5
0840		377.7	1239	5090	16,697						
5 Nov	11	386.8	1269	5099	16,727	9.14	30	4.88	16	55	4[d]
1000		386.8	1269	5099	16,727						
5 Nov.	12	395.9	1299	5108	15,757	9.14	30	4.88	16	55	4[e]
1140		395.9	1299	5108	16,757						
5 Nov	13	405.0	1329	5117	16,787	9.14	30	5.18	17	60	4[f]
1250		405.0	1329	5117	16,787						
5 Nov	14	414.1	1359	5127	16,817	9.14	30	4.26	14	47	3
1405		414.1	1359	5127	16,817						
5 Nov	15	423.2	1389	5136	15,847	9.14	30	2.13	7	23	2
1615		423.2	1389	5136	16,847						
5 Nov	16	432.3	1419	5145	16,877	9.14	30	3.96	13	43	3

TABLE 1 - *Continued*

Hour/Date Recov.	Core No.	Depth Below Sea Floor m	ft	Depth Below Sea Surface m	ft	Core Cut m	ft	Core Recov. m	ft	% Core Recov.	No. of Sec.
1905		432.3	1419	5145	16,877						
5 Nov	17	441.4	1449	5154	16,907	9.14	30	3.66	12	40	3
2110		441.4	1449	5154	16,907						
5 Nov	18	450.5	1479	5163	16,937	9.14	30	7.62	25	83	5
2315		450.5	1479	5163	16,937						
5 Nov	19	456.7	1498	5169	16,956	5.79	19	.91	3	16	1
0530		456.7	1498	5169	16,956						
6 Nov	20	459.0	1506	5171	16,964	2.44	8	2.13	7	90	2

Note: Hole inclination: @ 200′ = 4° @ T.D. = 4° TD = 16,964 feet.

[a]Core 4 - Retrieved without catcher which had apparently unscrewed; very thin smear slide.

[b]Core 6 - Core catcher scraping saved; scrapings from liner at 90 to 110 cm above catcher; an almost full core was lost; the liner scrapings were put in vial in catcher freezer box.

[c]Core 8 - No liner; broken fragments were put in freezer box.

[d]Core 11 - Core catcher in 2 freezer boxes.

[e]Core 12 - Core catcher in 1 freezer box.

[f]Core 13 - Core catcher in 1 freezer box.

TABLE 2
Coring Rates

Core No.	Drilling Time (hr)	Depth Cored (ft)	Av. Coring Rate (ft/hr)	Remarks
1	0.1	30	300	
2	0.1	25	250	
3	0.1	30	300	
4	0.1	30	300	
5	0.1	30	300	
6	0.1	30	300	
7	0.1	30	300	
8	0.1	30	300	Chert in core catcher
9	0.3	30	100	Eocene Radiolaria, thin chert probably reflector
10	0.3	25	83	Upper Cretaceous
11	0.2	30	150	Upper Cretaceous
12	0.2	30	150	Upper Cretaceous
13	0.2	30	150	Upper Cretaceous
14	0.2	30	150	Upper Cretaceous
15	0.2	30	150	Upper Cretaceous
16	0.2	30	150	Upper Cretaceous
17	0.2	30	150	Upper Cretaceous
18	0.3	30	100	Upper Cretaceous
19	0.8	19	24	Basement
20	4.0	8	4	Basement

Summary of Drilling and Coring at Site 10

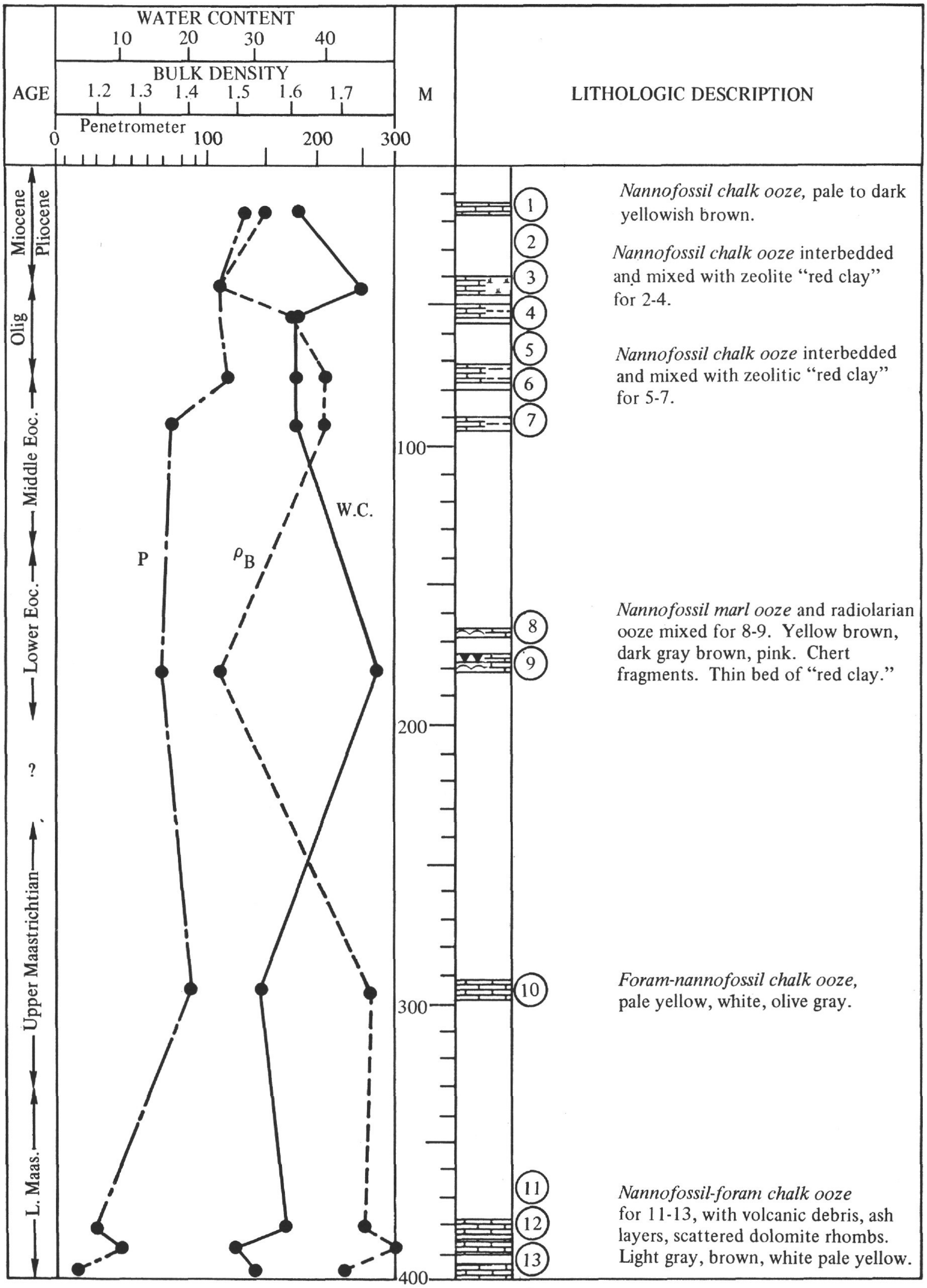


Figure 4. *Summary of drilling and coring at Site 10.*

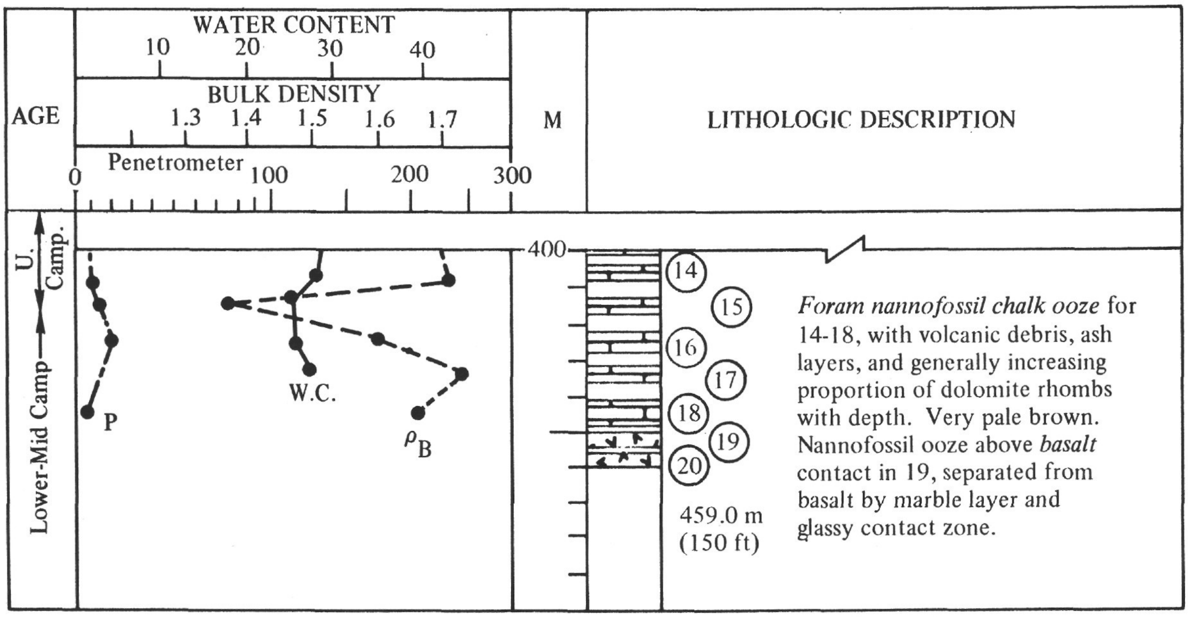


Figure 4. *Continued.*

The Cores Recovered from Site 10

Figures 5 through 21 are the graphic summaries of the cores recovered at Site 10.

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.

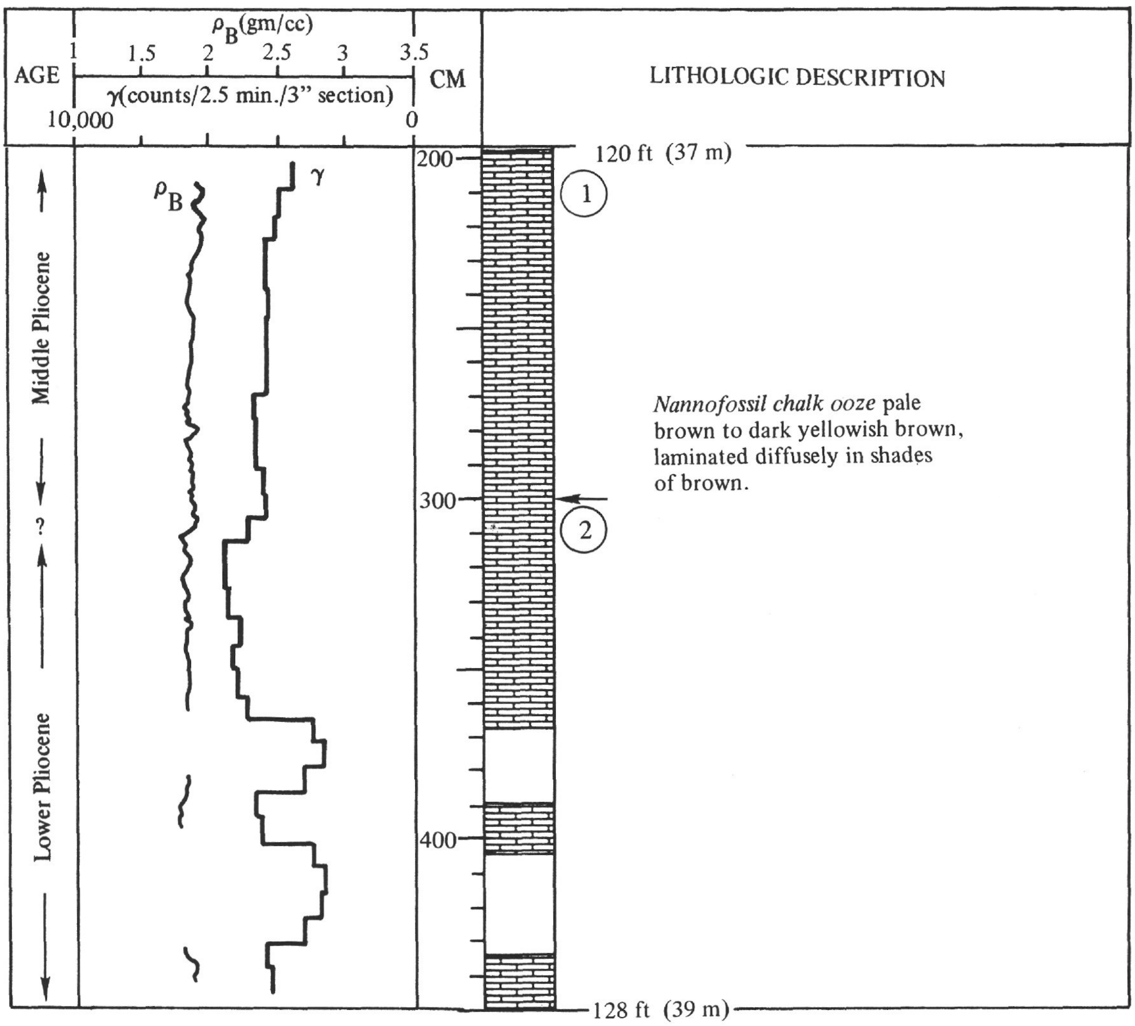


Figure 5. *Hole 10 Core 1.*

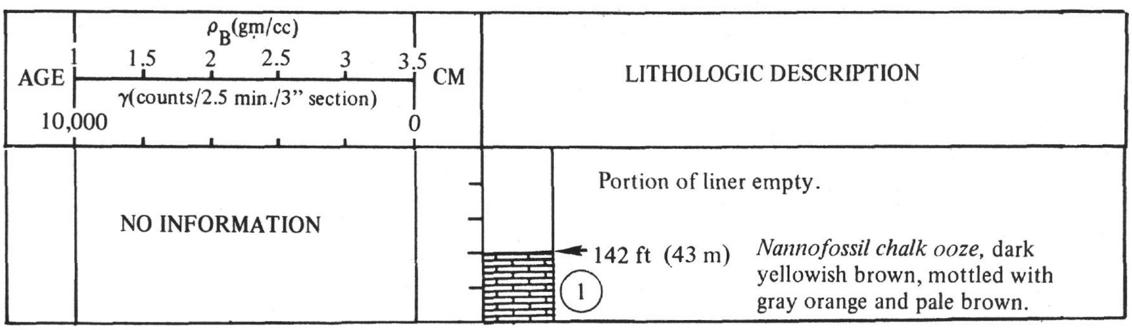


Figure 6. *Hole 10 Core 2.*

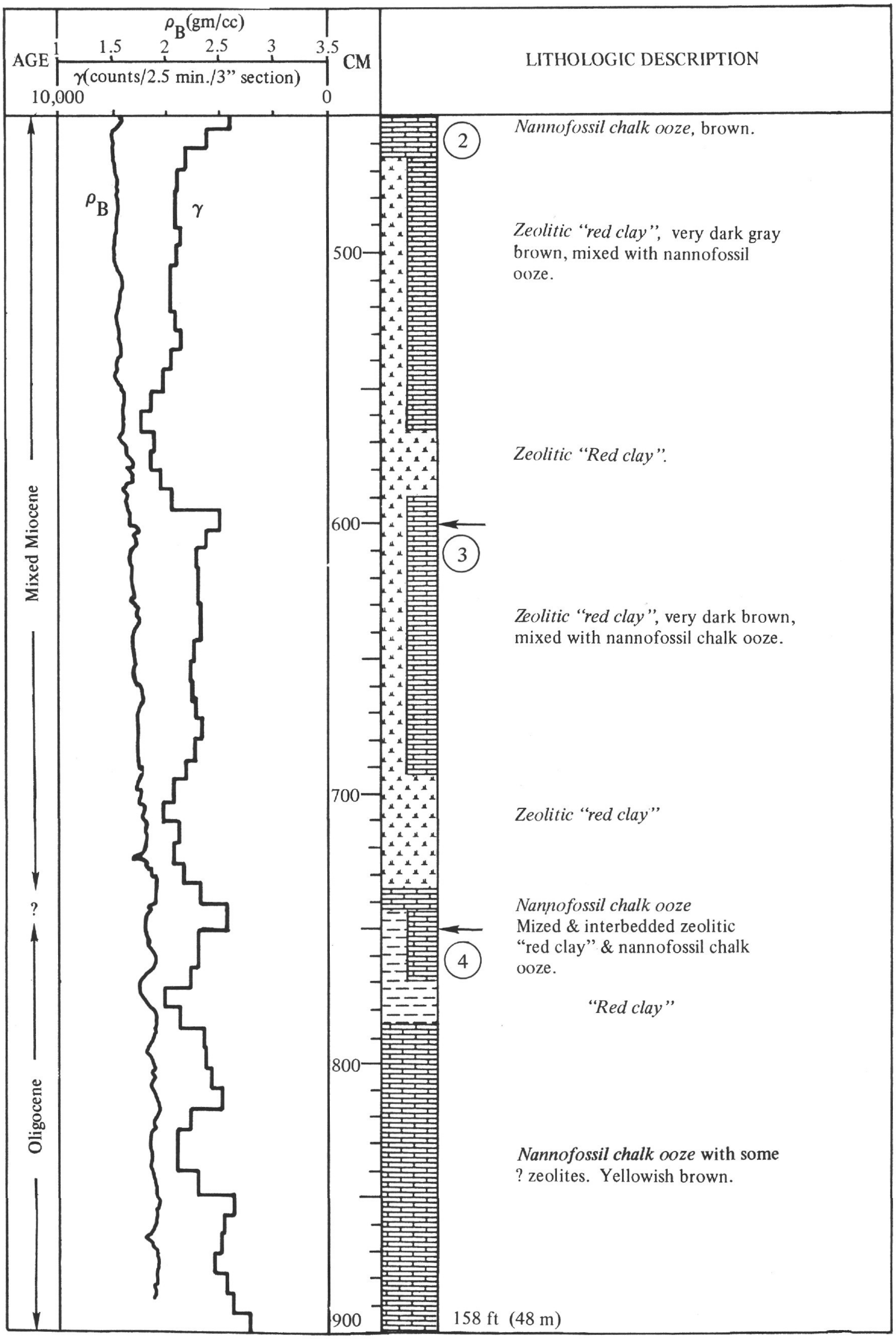


Figure 6. *Continued.*

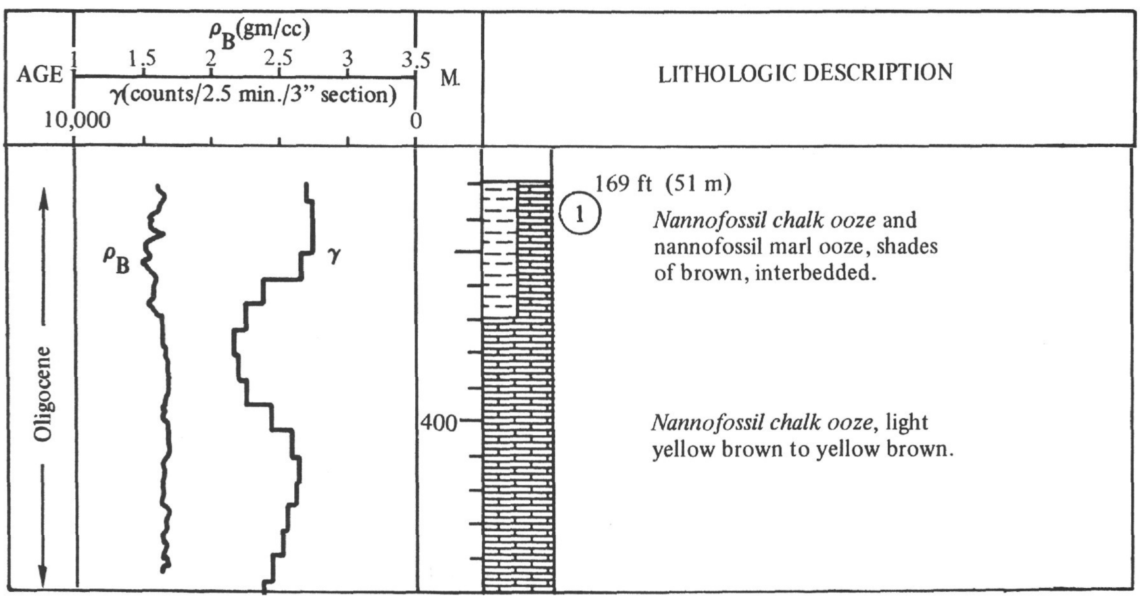


Figure 7. *Hole 10 Core 3.*

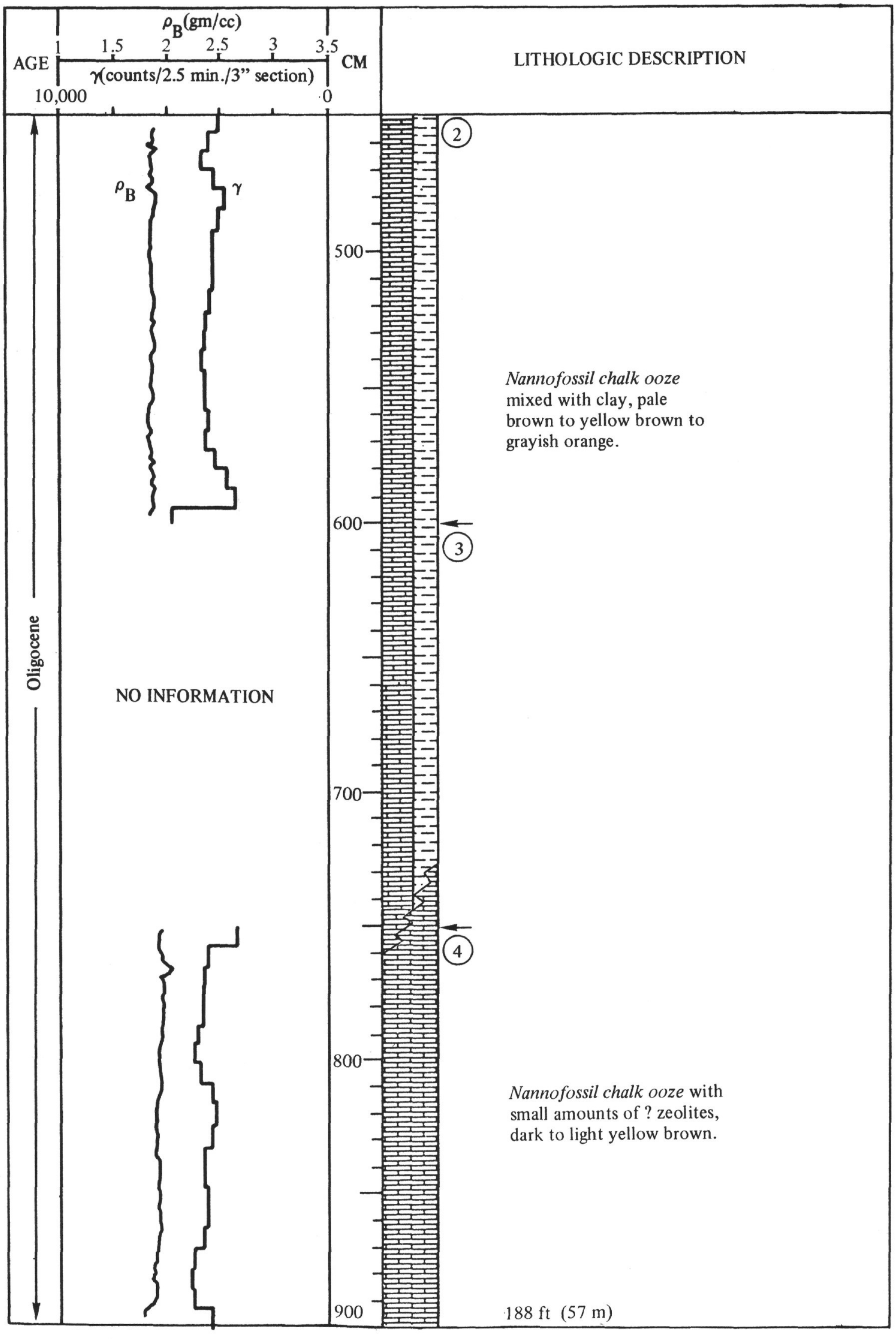


Figure 7. *Continued.*

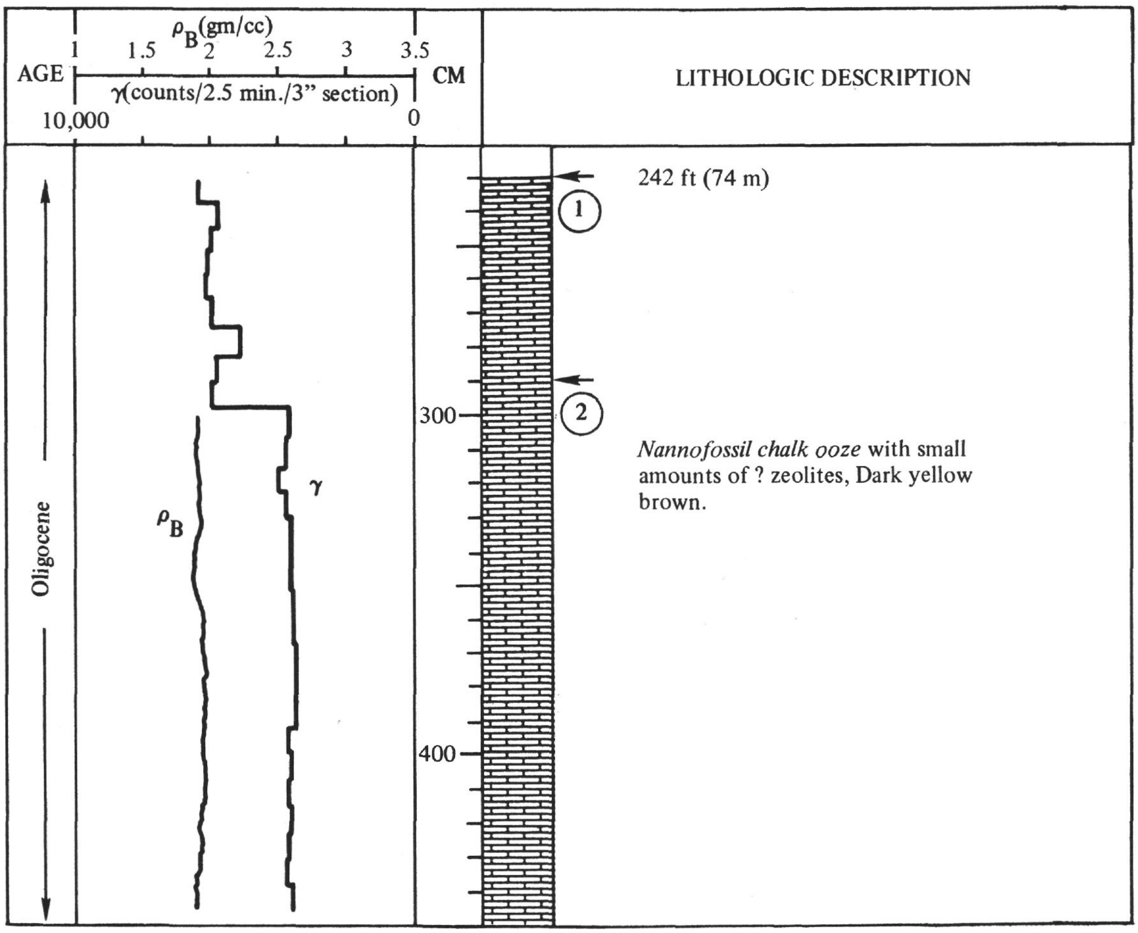


Figure 8. *Hole 10 Core 5.*

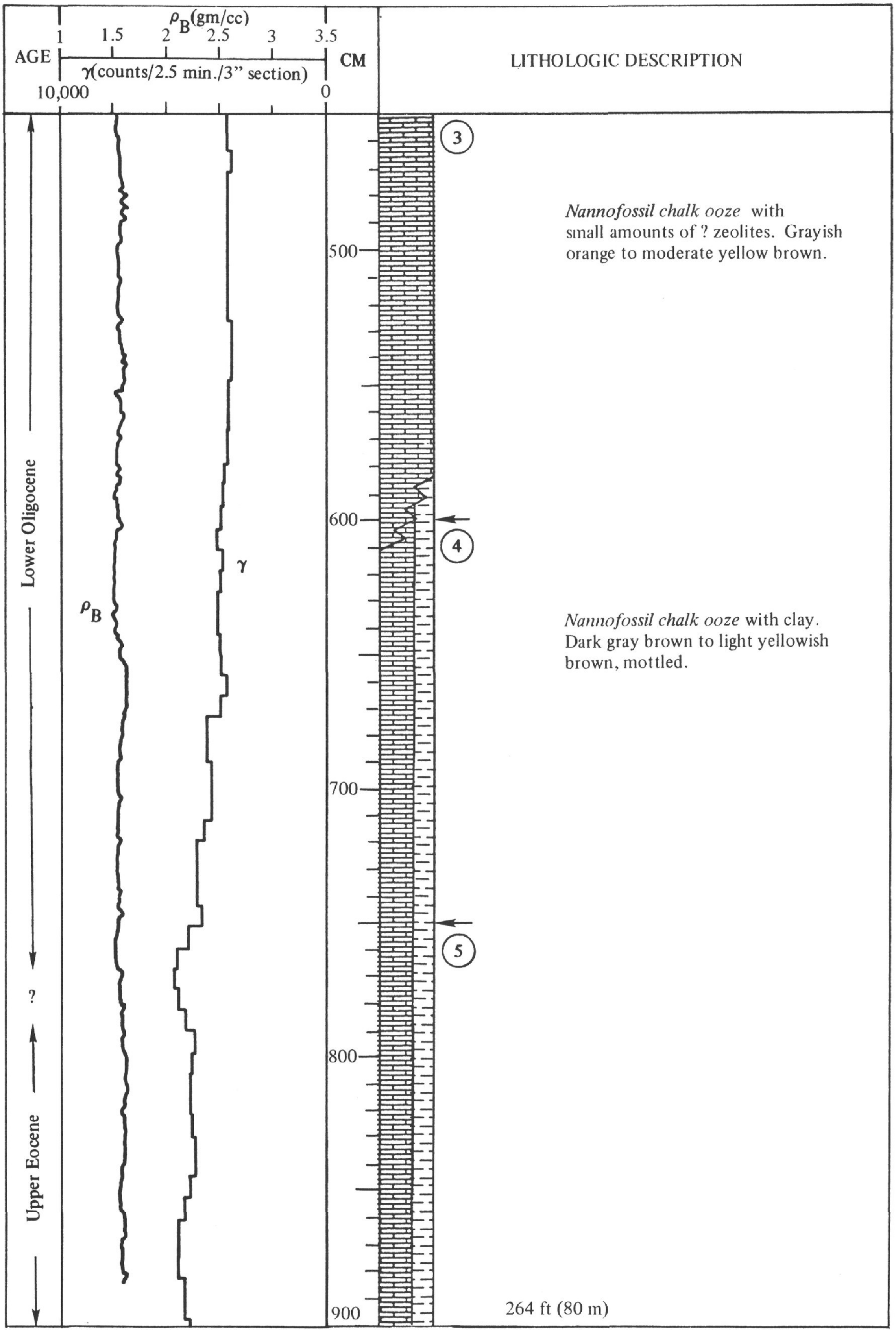


Figure 8. *Continued.*

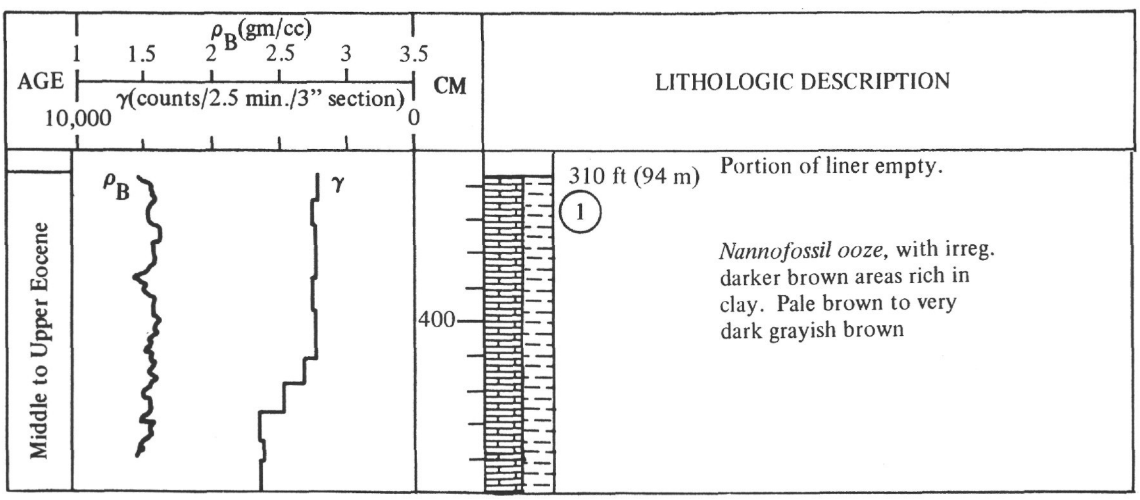


Figure 9. *Hole 10 Core 7.*

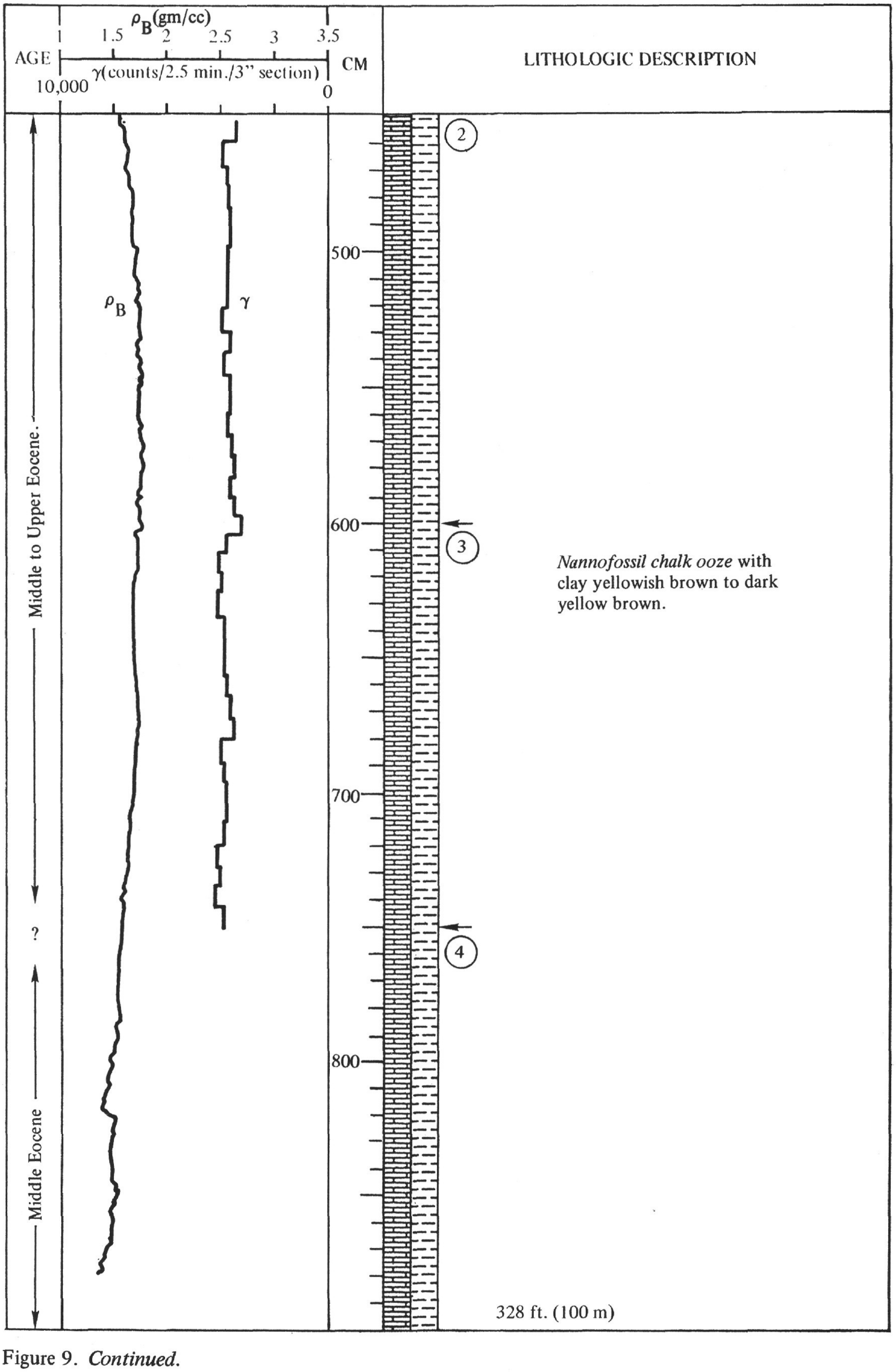


Figure 9. *Continued.*

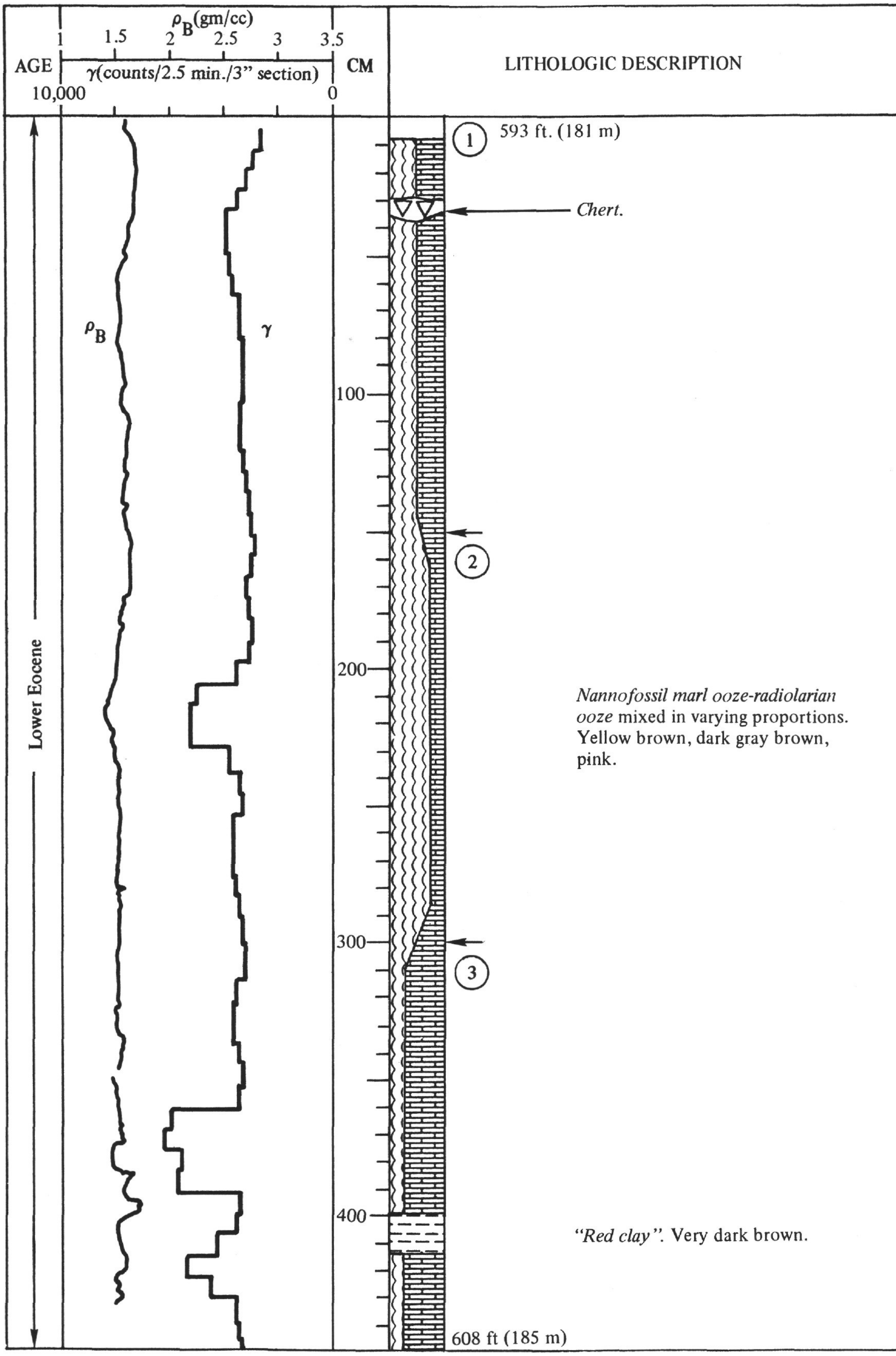


Figure 10. *Hole 10 Core 9.*

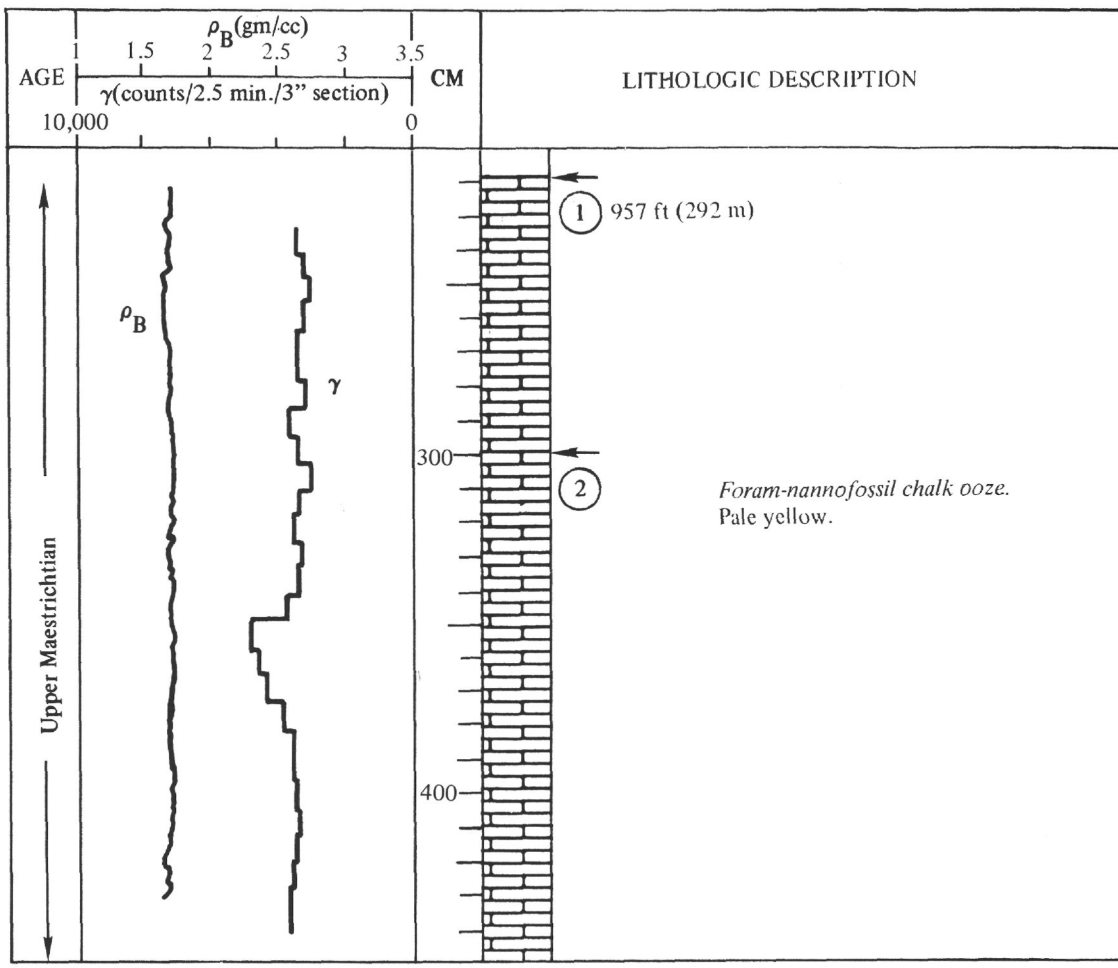
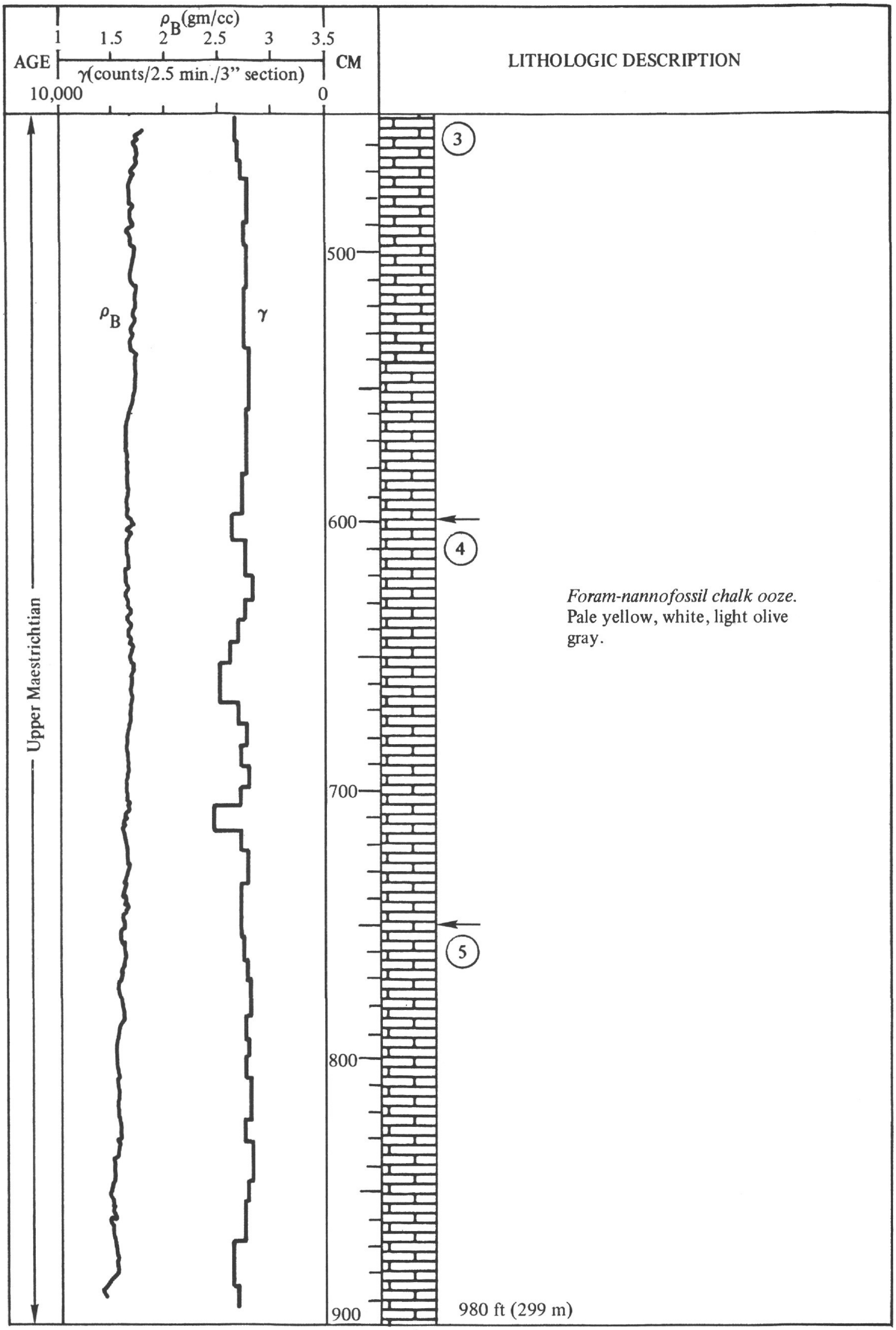


Figure 11. *Hole 10 Core 10.*



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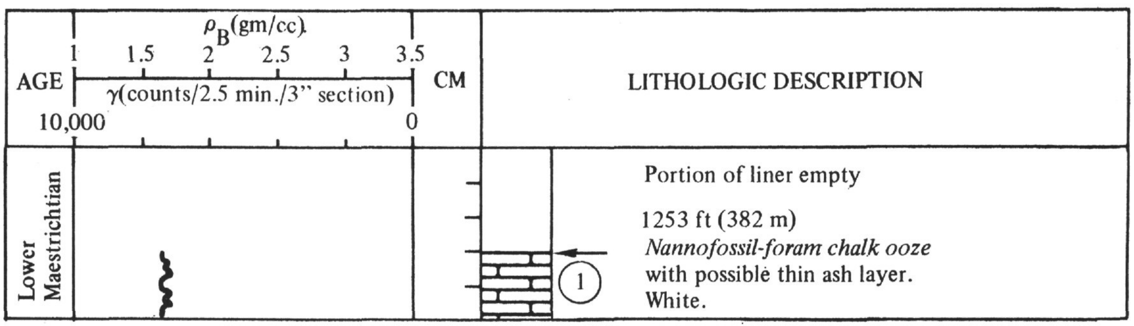


Figure 12. *Hole 10 Core 11.*

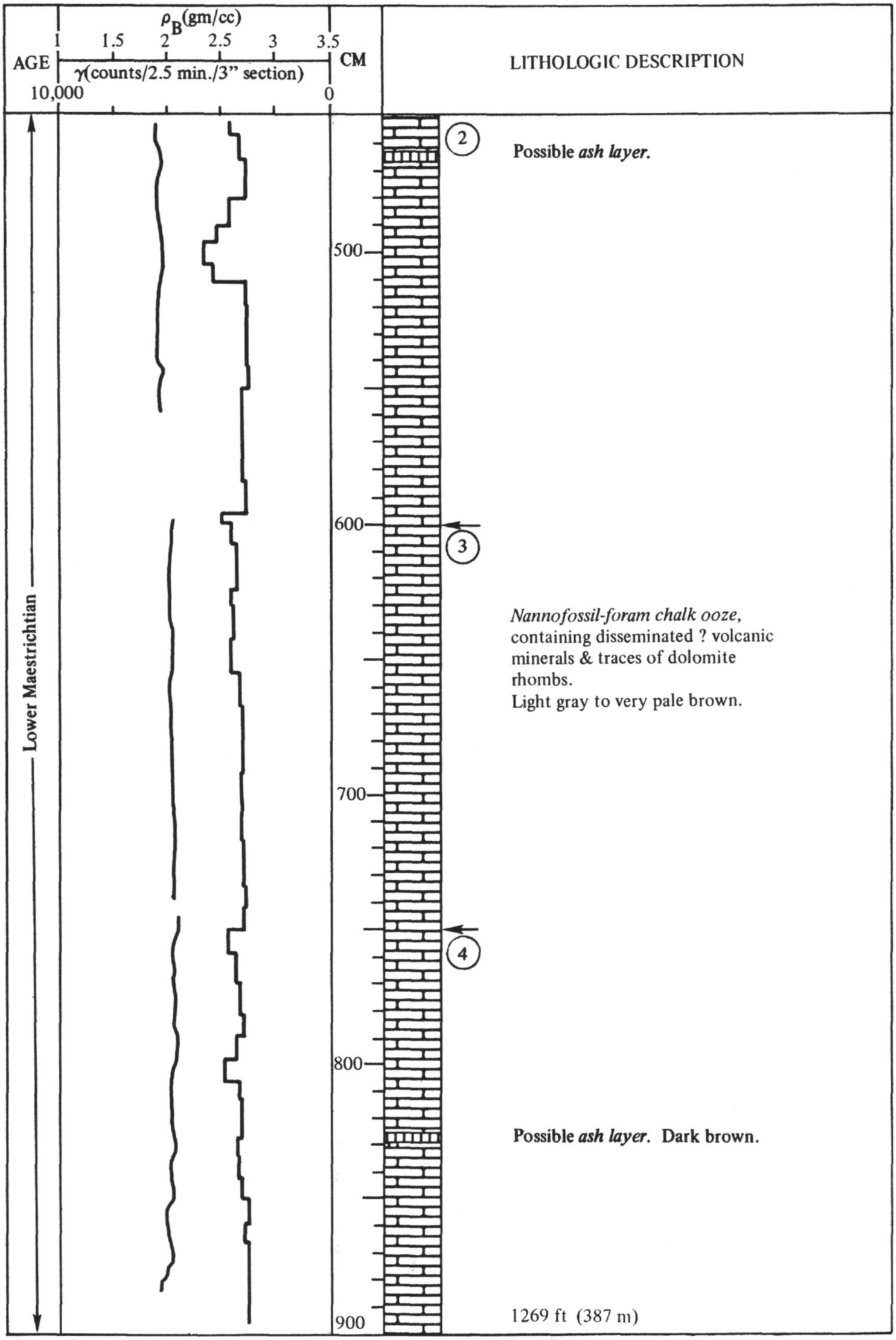


Figure 12. *Continued.*

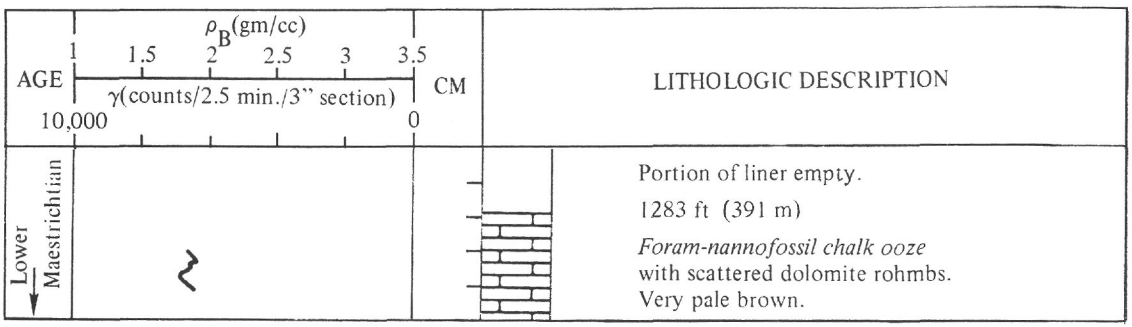


Figure 13. *Hole 10 Core 12.*

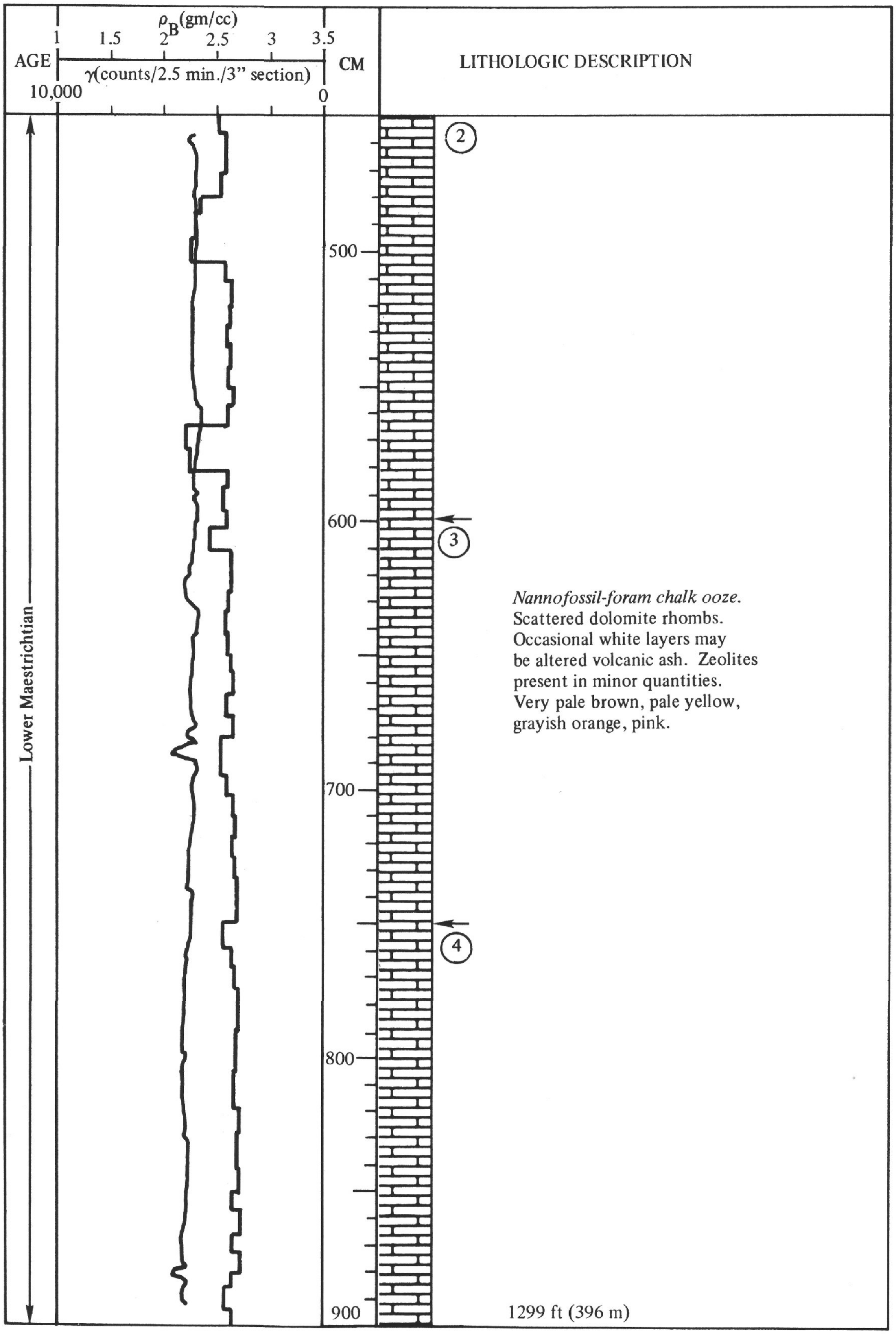


Figure 13. *Continued.*

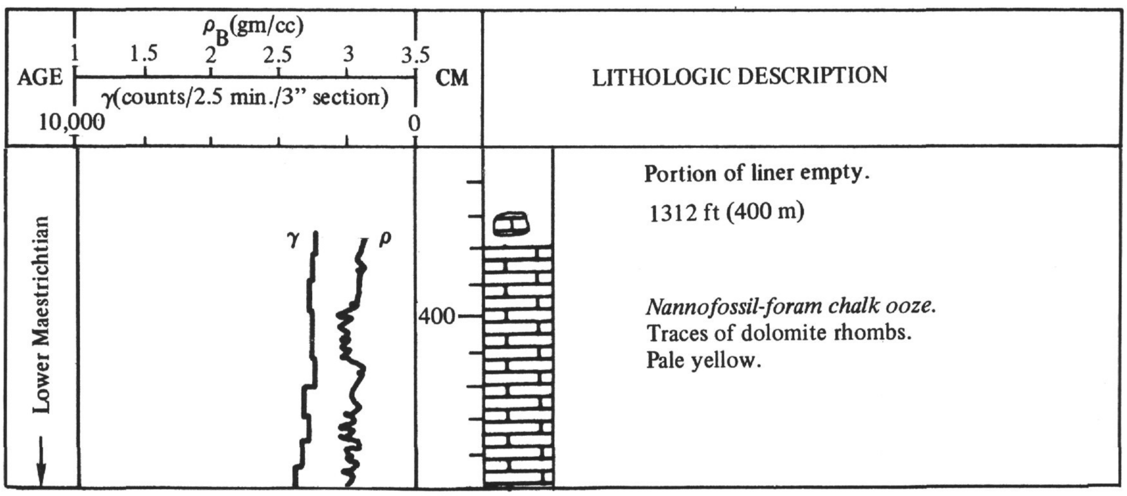


Figure 14. *Hole 10 Core 13.*

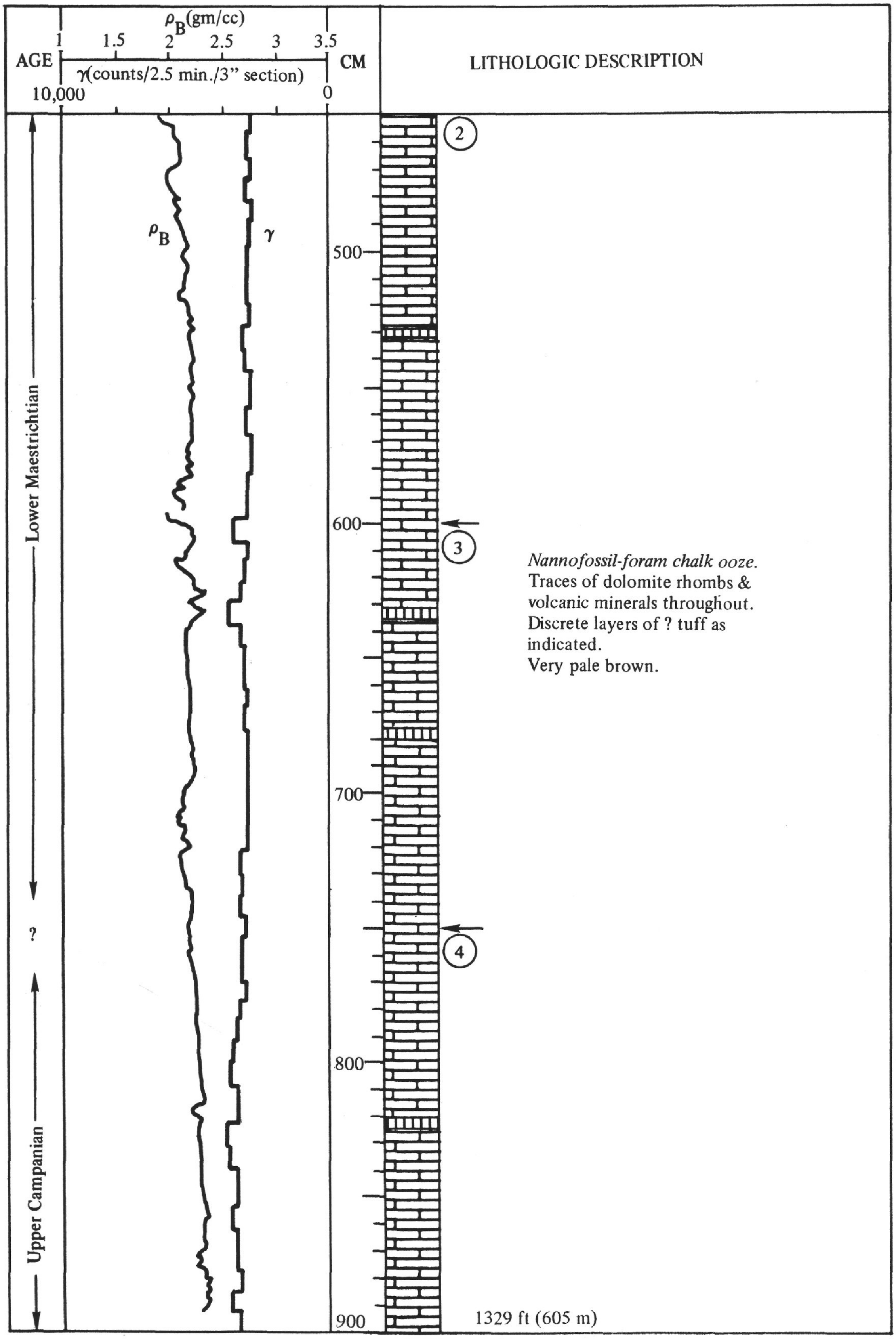


Figure 14. *Continued.*

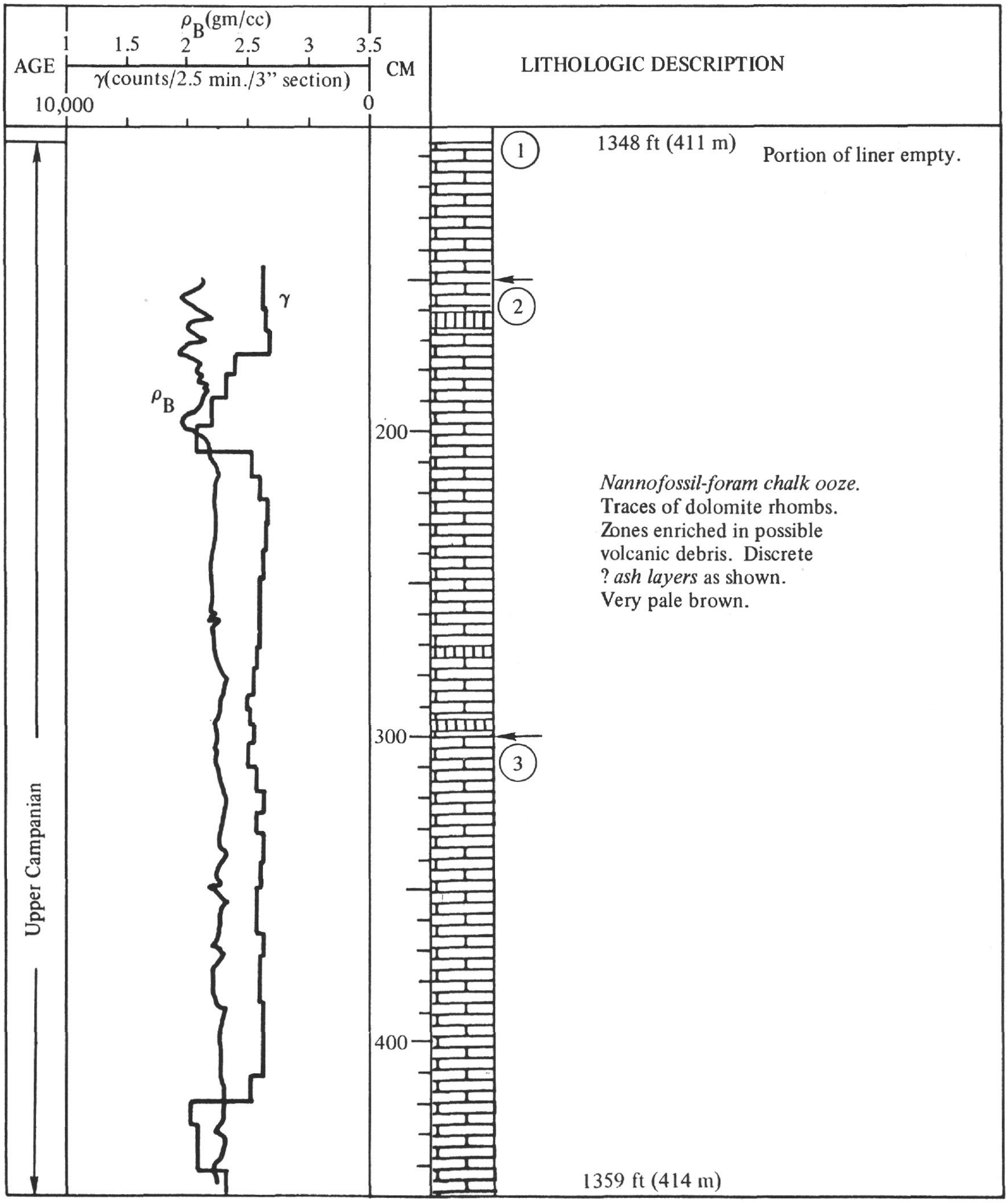


Figure 15. *Hole 10 Core 14.*

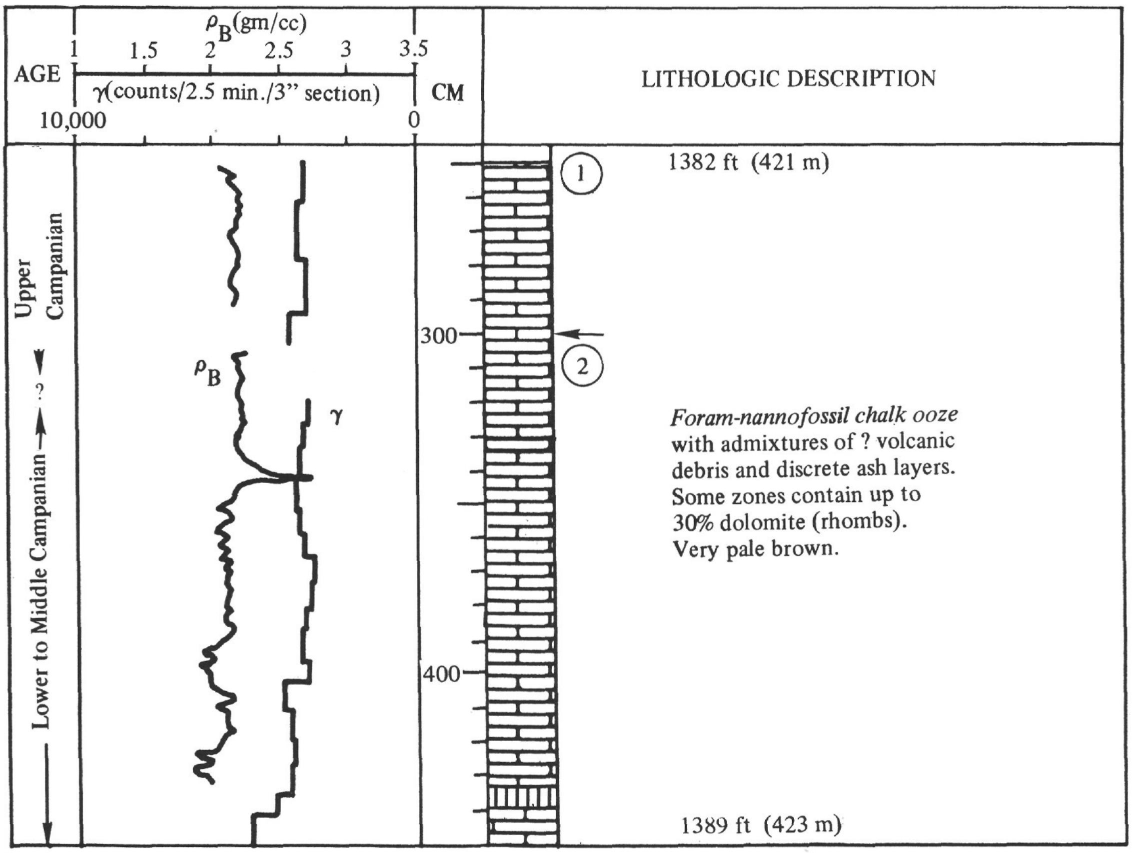


Figure 16. *Hole 10 Core 15.*

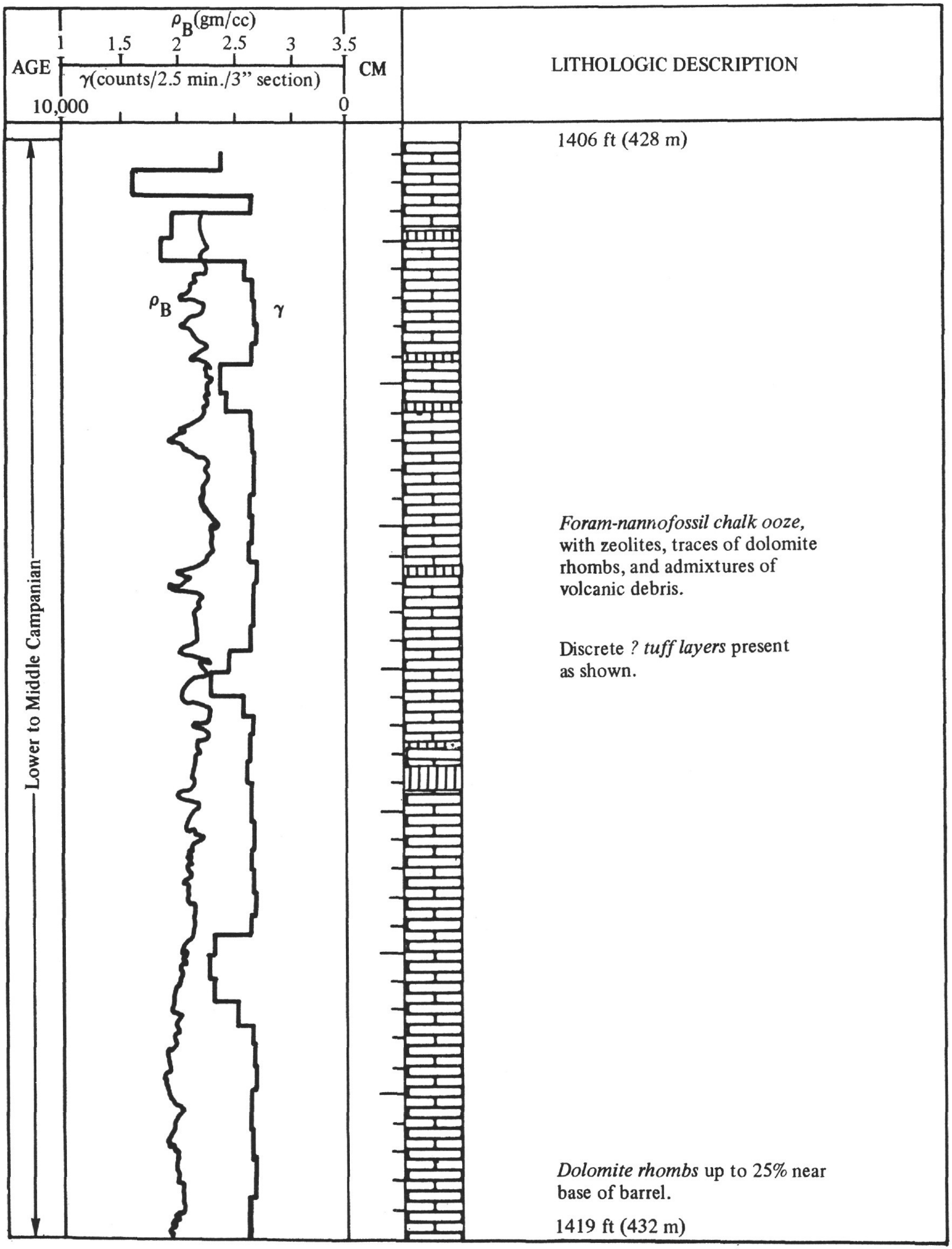


Figure 17. *Hole 10 Core 16.*

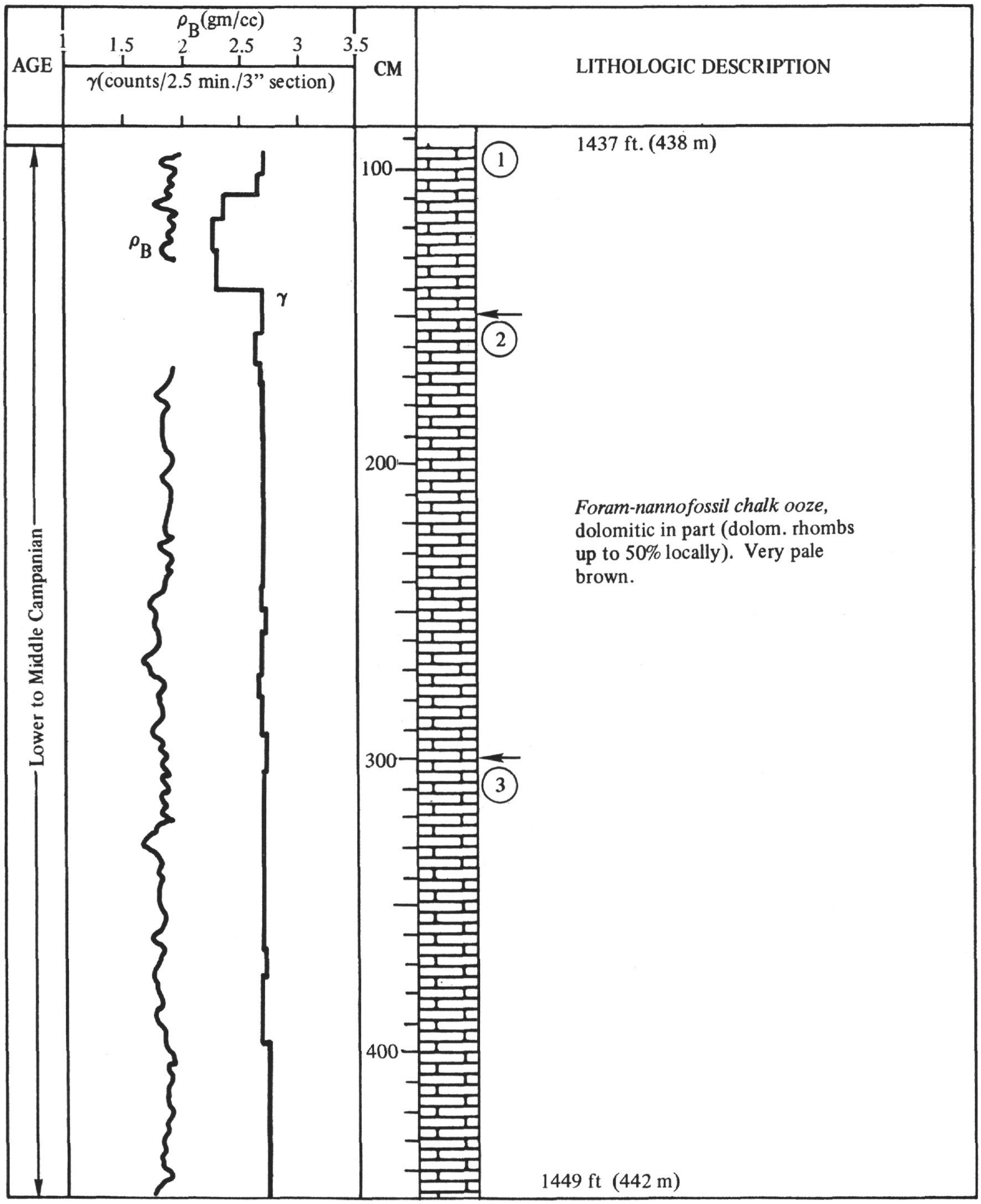


Figure 18. *Hole 10 Core 17.*

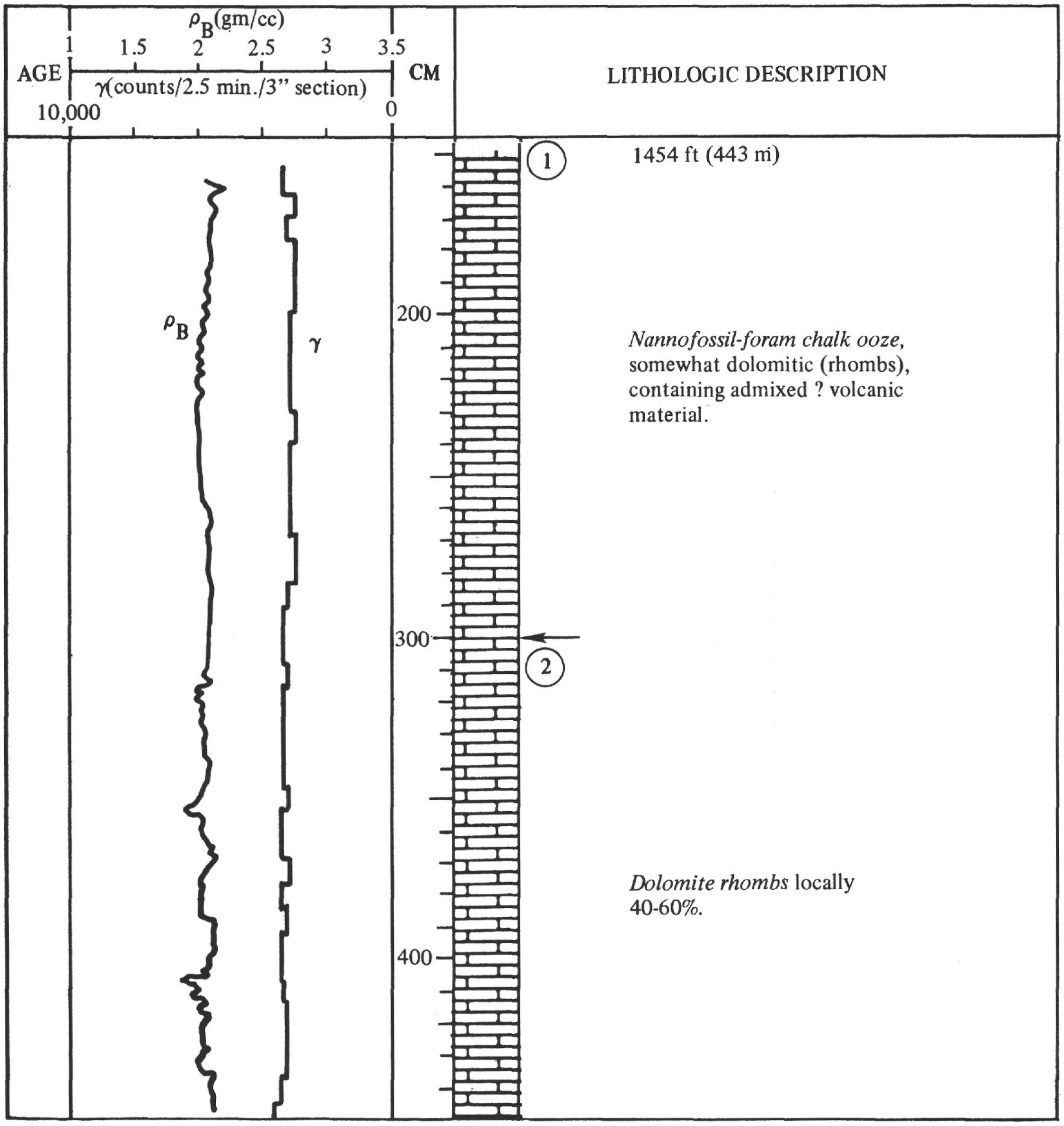


Figure 19. *Hole 10 Core 18.*

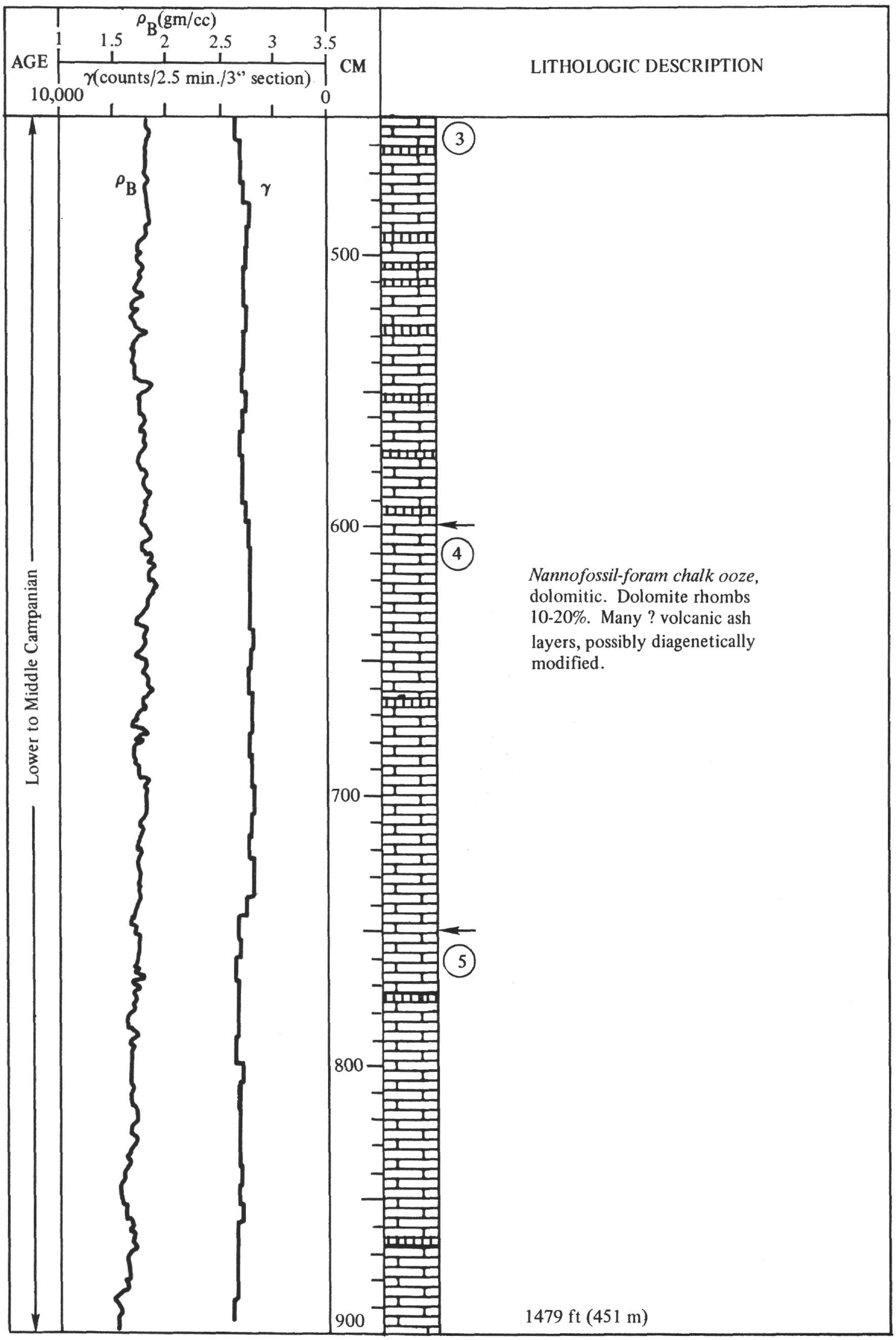


Figure 19. *Continued.*

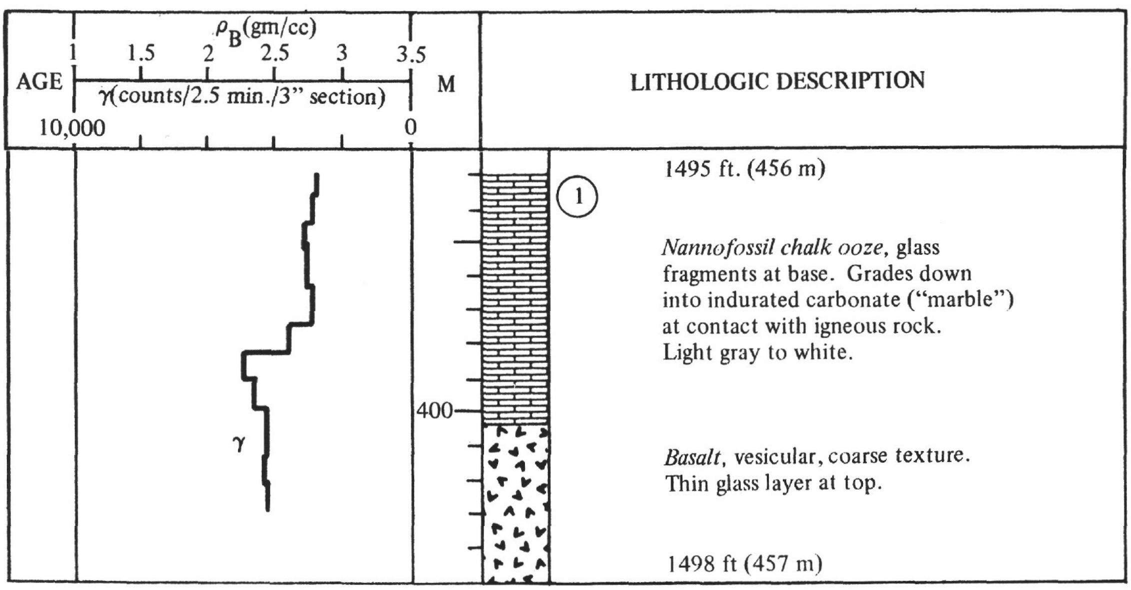


Figure 20. *Hole 10 Core 19.*

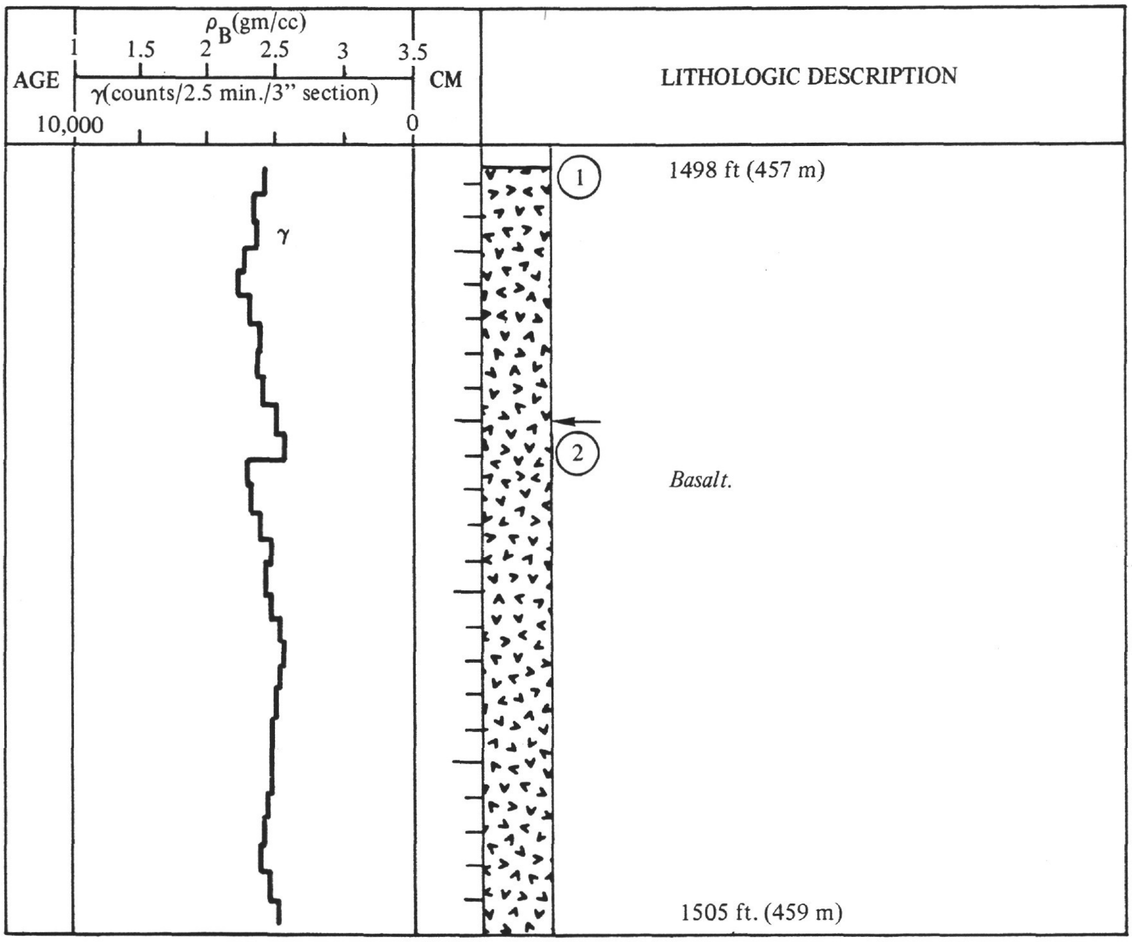


Figure 21. *Hole 10 Core 20.*

The Cores Recovered from Site 10

Figures 22 through 79 show details of the individual core sections of the cores from Site 10.

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.

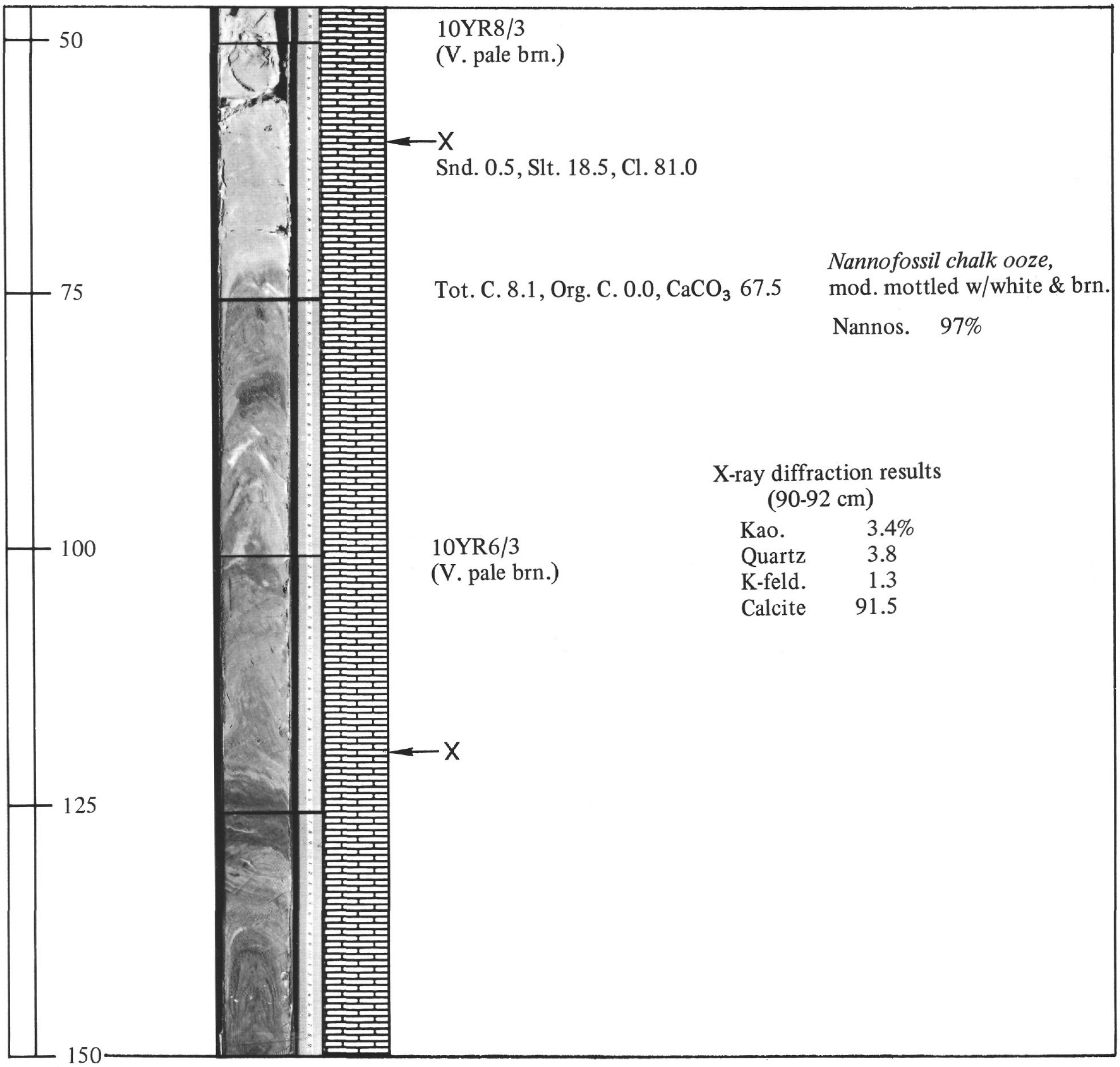


Figure 22. *Hole 10 Core 1 Section 1.*

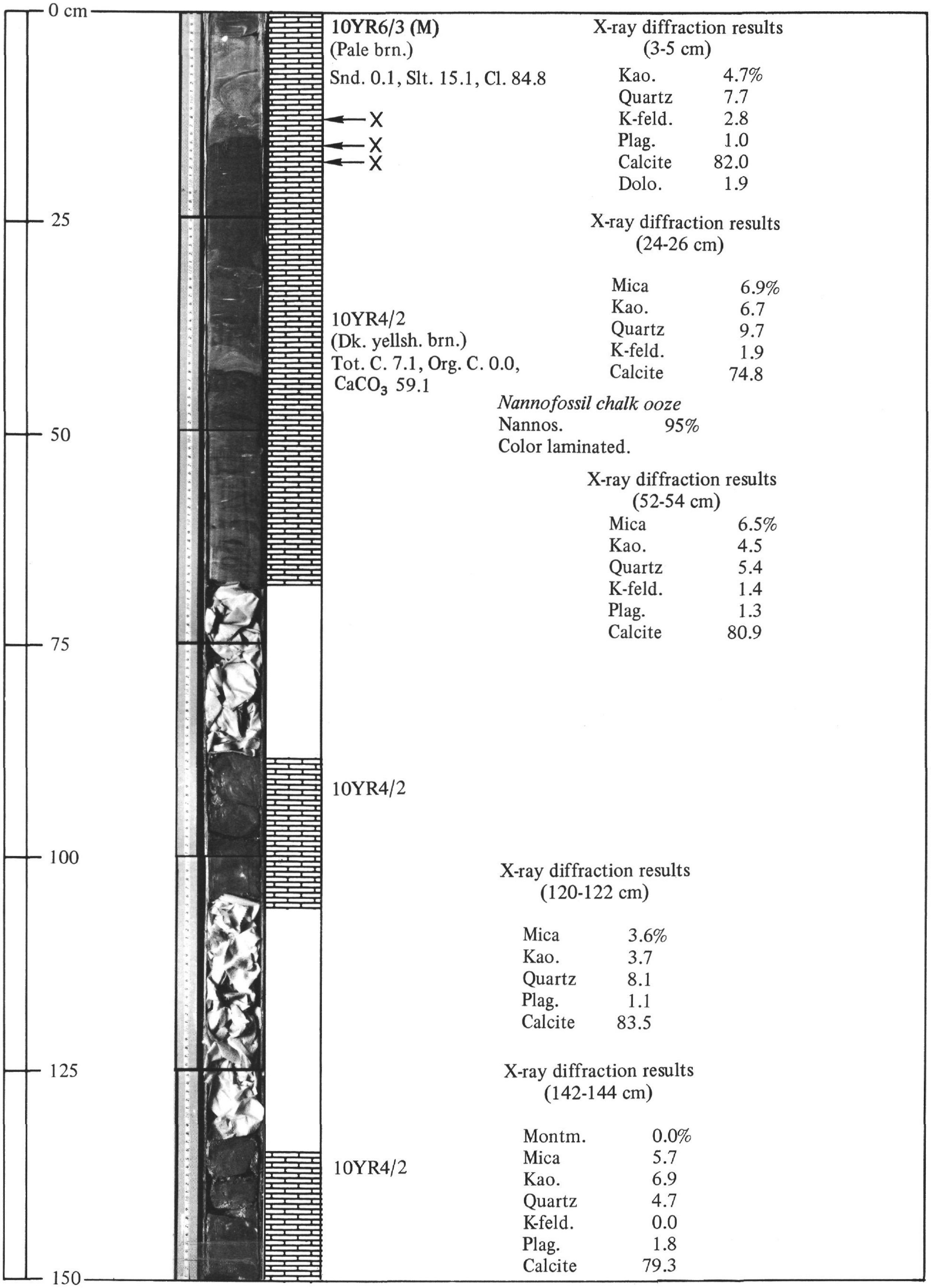


Figure 23. *Hole 10 Core 1 Section 2.*

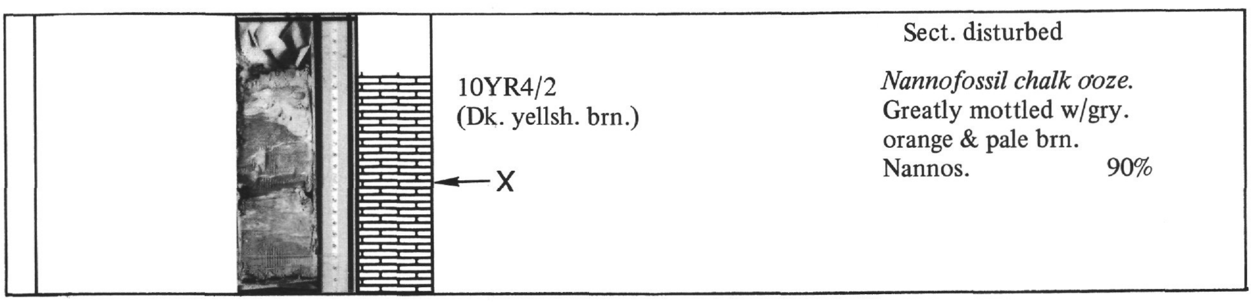
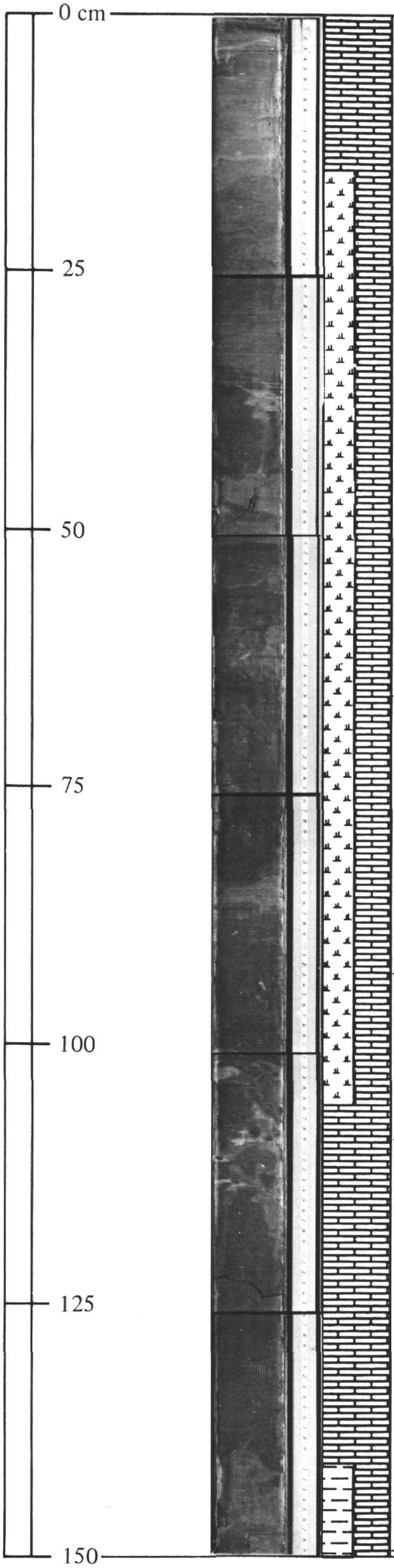


Figure 24. *Hole 10 Core 2 Section 1.*



10YR4/3
(Brn.)

X
Tot. C. 3.0, Org. C. 0.1, $CaCO_3$ 24.2
Snd. 0.2, Slt. 16.3, Cl. 83.5

X-ray diffraction results
(39-41 cm)

Montm.	0.0%
Mica	13.7
Kao.	19.5
Quartz	24.0
K-feld.	6.3
Plag.	7.3
Calcite	29.2

10YR3/2 (M)
(V. dark grysh. brn.)
10YR4/2 (m)
(Dark grysh. brn.)

X

X

X

Snd. 2.2, Slt. 25.0, Cl. 72.8

10YR4/2
(Dk. grysh. brn.)

X

Sect. disturbed

0-15 cm: - *Nannofossil chalk ooze.*
Nannos. 92%

X-ray diffraction results
(17-19 cm)

Montm.	0.0%
Mica	14.0
Kao.	21.8
Quartz	32.8
K-feld.	9.4
Plag.	8.4
Calcite	13.6

15-115 cm: - *Zeolitic red clay.*
Zeolites 20%
Clay mins. 80%
Forams present in some zones.
Light-colored layers nannofossil ooze: -
Nannos. 90%

X-ray diffraction results
(69-71 cm)

Kao.	25.4%
Quartz	29.9
K-feld.	8.7
Plag.	8.0
Calcite	26.0

X-ray diffraction results
(89-91 cm)

Montm.	0.0%
Mica	2.8
Kao.	24.2
Quartz	19.8
K-feld.	4.9
Plag.	5.4
Cris.	41.2
Side.	1.7

115-140 cm: - *Zeolitic red clay.*

X-ray diffraction results
(133-135 cm)

Mica	4.8%
Kao.	4.2
Quartz	14.8
Cris.	29.8
Side.	2.0
Phil.	44.4

140-150 cm: - *Nannofossil chalk ooze* mixed w/red clay.

Figure 25. *Hole 10 Core 2 Section 2*

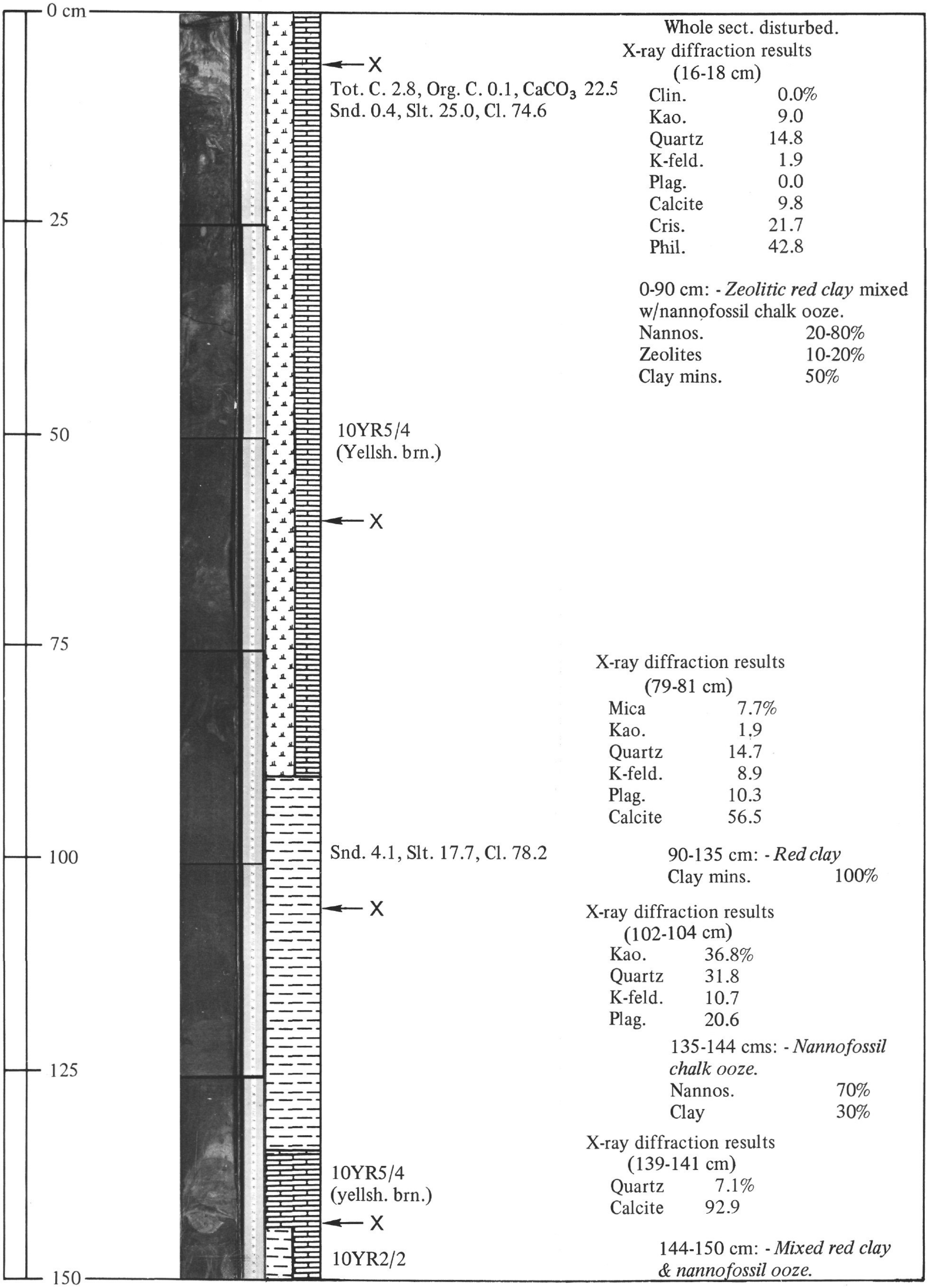
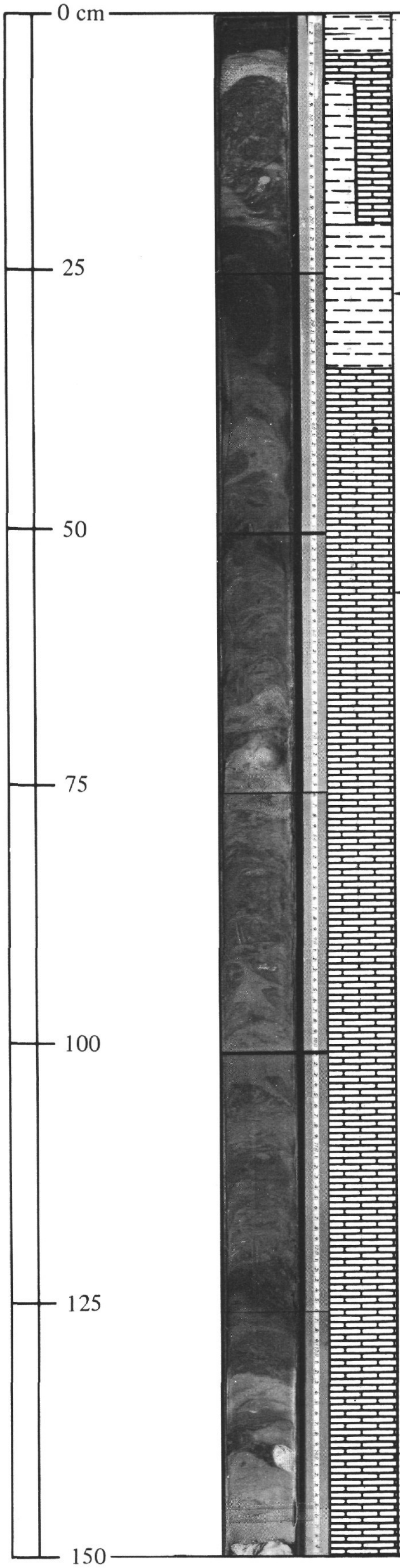


Figure 26. *Hole 10 Core 2 Section 3*



10YR3/2 (V. dk. brn.)
10YR6/4 (Lt. yell. brn.)
Snd. 0.1, Slt. 16.5, Cl. 83.4
Tot. C. 6.7, Org. C. 0.1, $CaCO_3$ 55.8
10YR5/3
(Med. brn.)
10YR3/2 (V. dk. brn.)
←X
←X
10YR5/4
(yellsh. brn.)
←X

0-3 cm: - *Calcareous red clay.*
3-6 cm: - *Nannofossil chalk ooze.*
6-20 cm: - *Mixed nannofossil chalk ooze & red clay.*
20-35 cm: - *"red clay".*

X-ray diffraction results
(24-26 cm)

Kao.	12.6%
Quartz	9.1
K-feld.	2.1
Plag.	7.4
Calcite	68.8

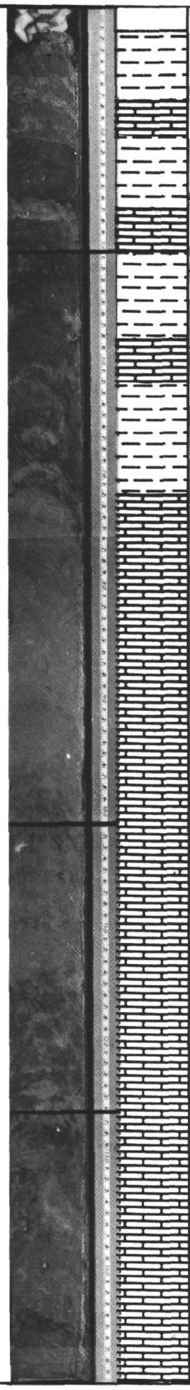
35-150 cm: - *Nannofossil chalk ooze w/clay.*

Nannofossils	90%
Clays	10%

X-ray diffraction results
(75-77 cm)

Calcite	100%

Figure 27. *Hole 10 Core 2 Section 4*



Snd. 0.1, Slt. 48.2, Cl. 51.7
10YR3/2 (M) (Dk. grysh. brn.)
10YR4/3 (M) (Brn.)
10YR6/3 (M) (Pale brn.)
10YR5/4 (M) (Yellsh. brn.)

X

50

X

X

75

Tot. C. 8.0, Org. C. 0.6, $CaCO_3$, 61.6

10YR6/4 (M)
(Lt. yell. brn.)

X

100

10YR5/4
(Yell. brn.)

125

X

150

Sect. disturbed.

32-72 cm: - *Interbedded nannofossil chalk ooze & clayey nannofossil marl ooze.*

Nannos.	20-80%
Clay mins.	0-60%

X-ray diffraction results (43-45 cm)

Kao.	10.0%
Quartz	7.5
K-feld.	2.9
Plag.	2.6
Calcite	72.9
Arag.	4.1

72-150 cm: - *Nannofossil chalk ooze.*

Nannos.	90%
Clays	10%

X-ray diffraction results (103-105 cm)

Calcite	100%

X-ray diffraction results (140-142 cm)

Kao.	3.8%
Quartz	2.1
Calcite	91.9

Figure 28. *Hole 10 Core 3 Section 1*

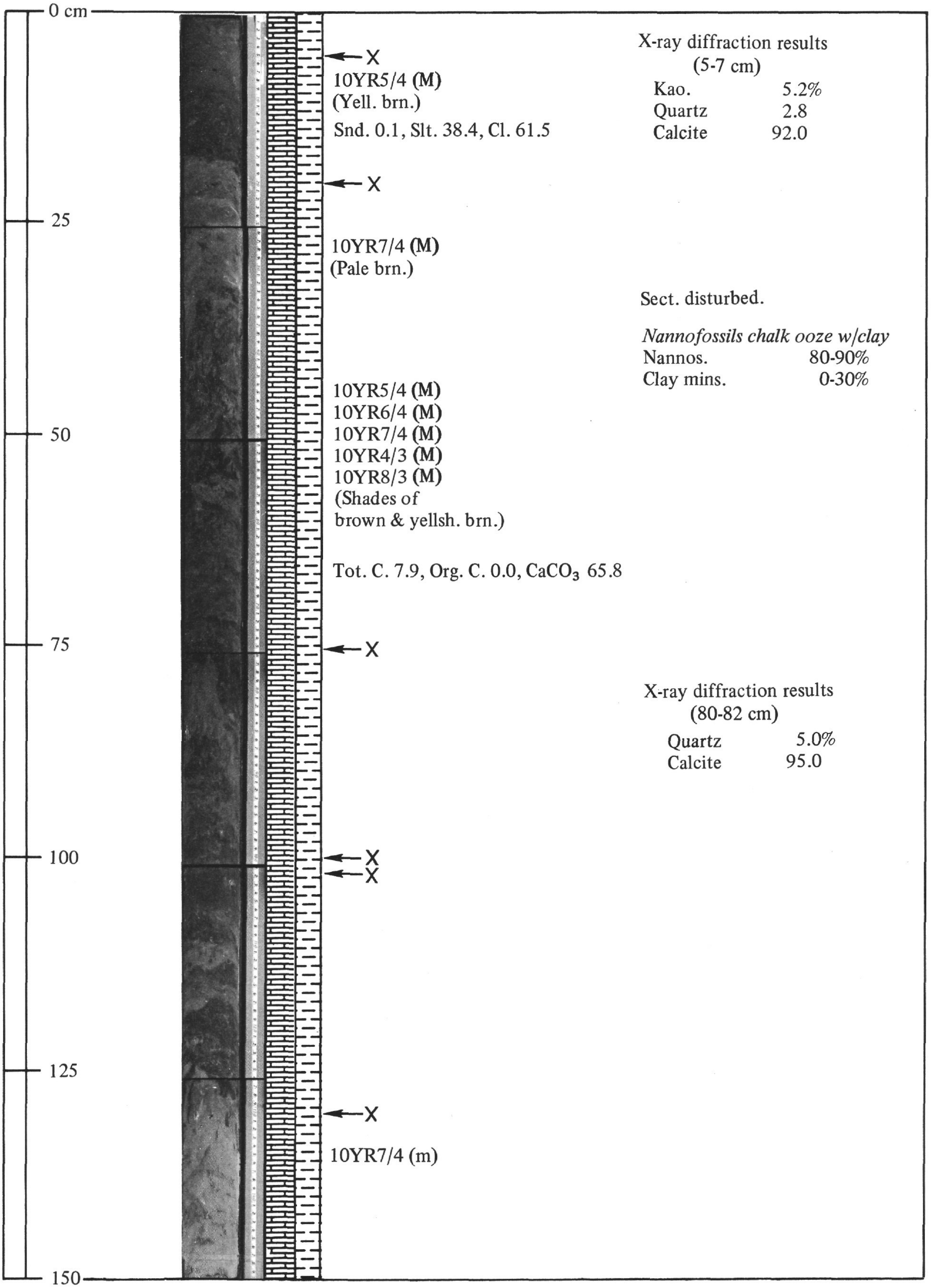


Figure 29. *Hole 10 Core 3 Section 2*

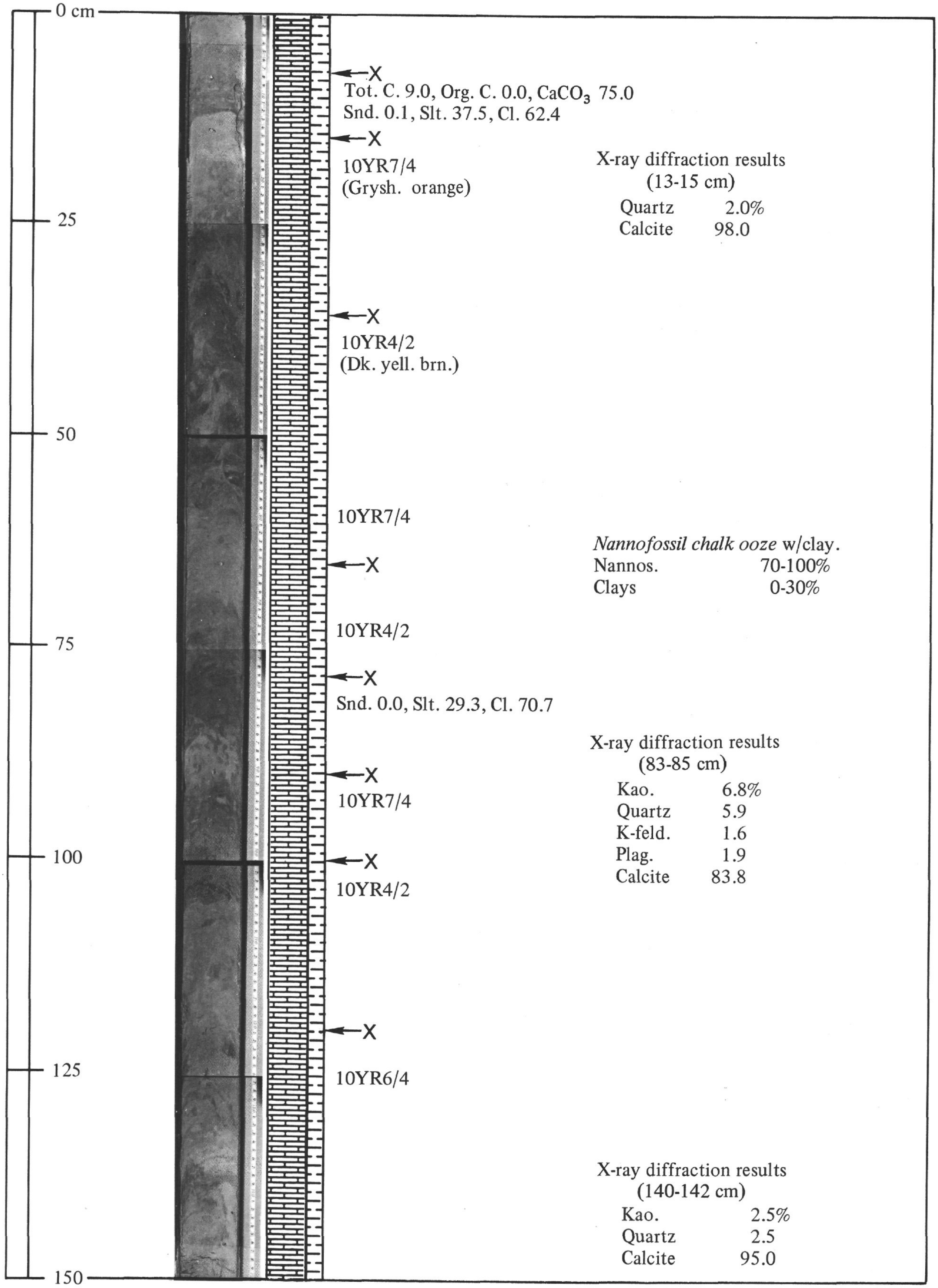


Figure 30. *Hole 10 Core 3 Section 3*

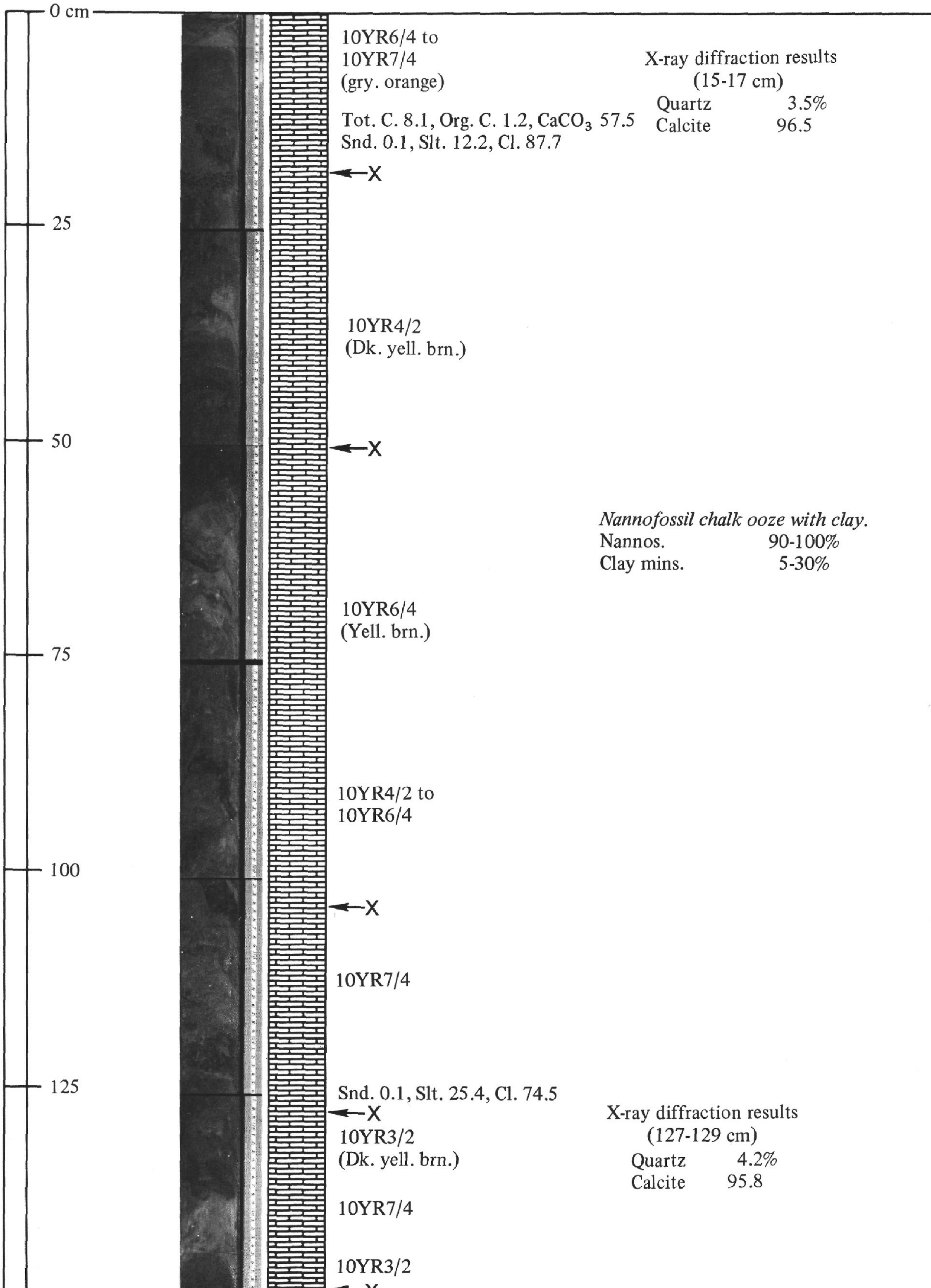


Figure 31. *Hole 10 Core 3 Section 4*

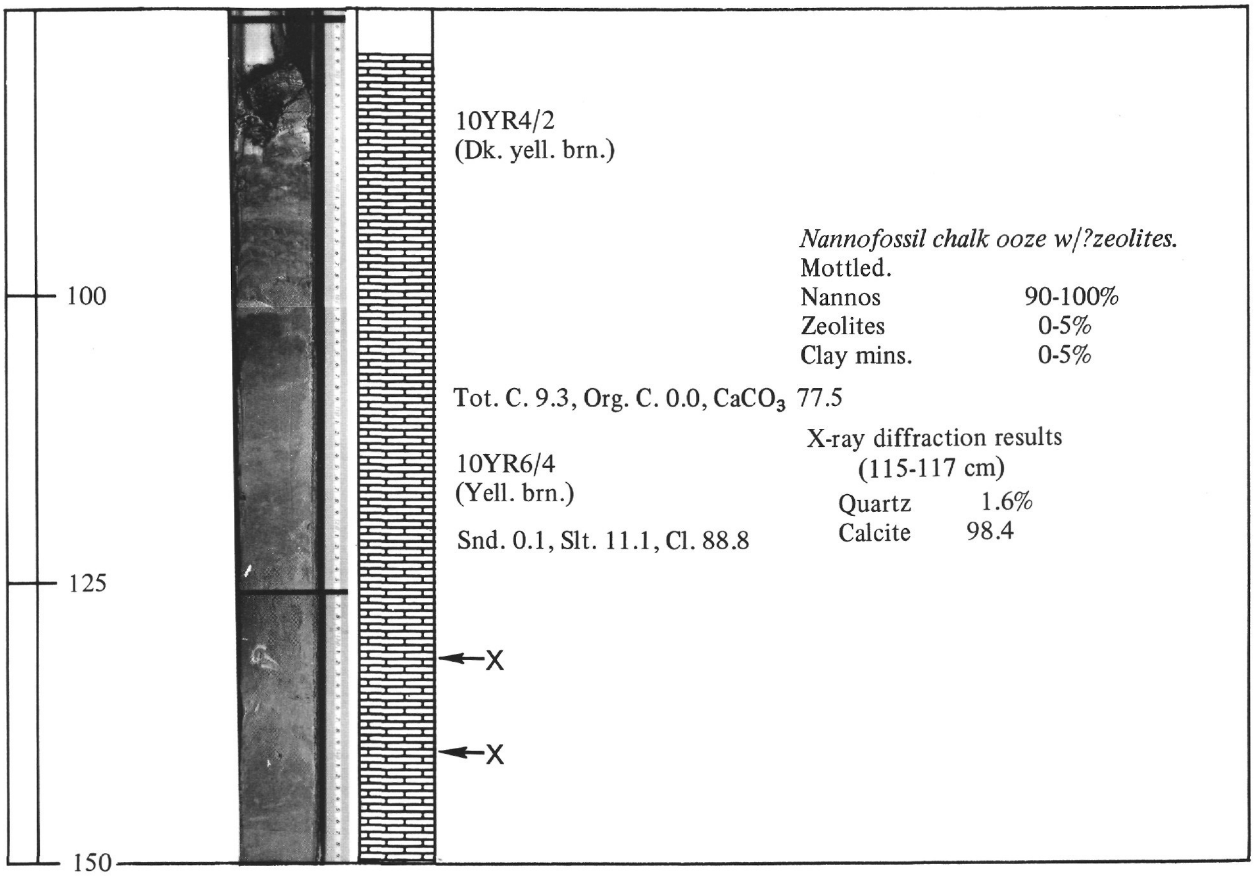


Figure 32. *Hole 10 Core 5 Section 1*

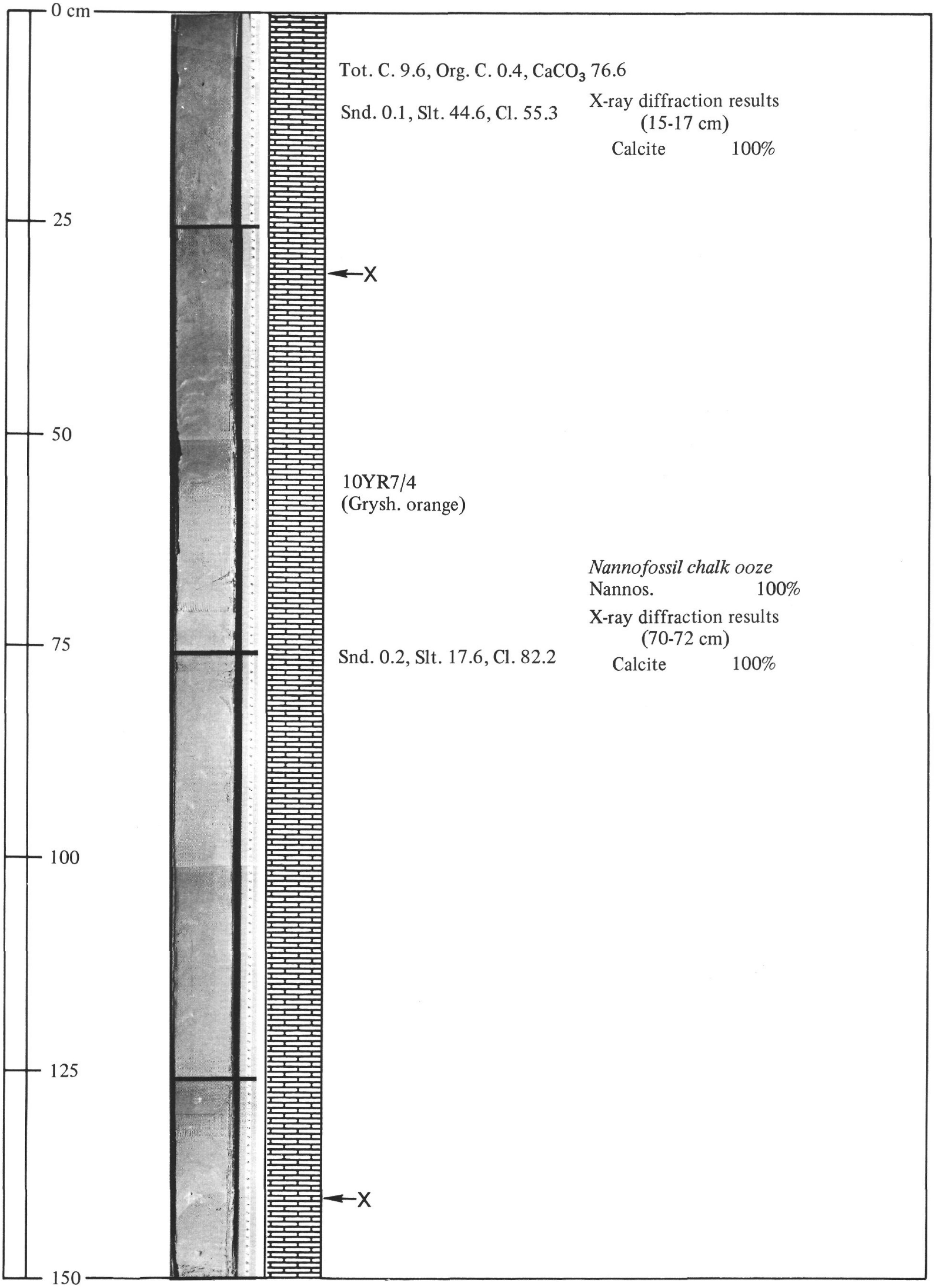


Figure 33. *Hole 10 Core 5 Section 2.*

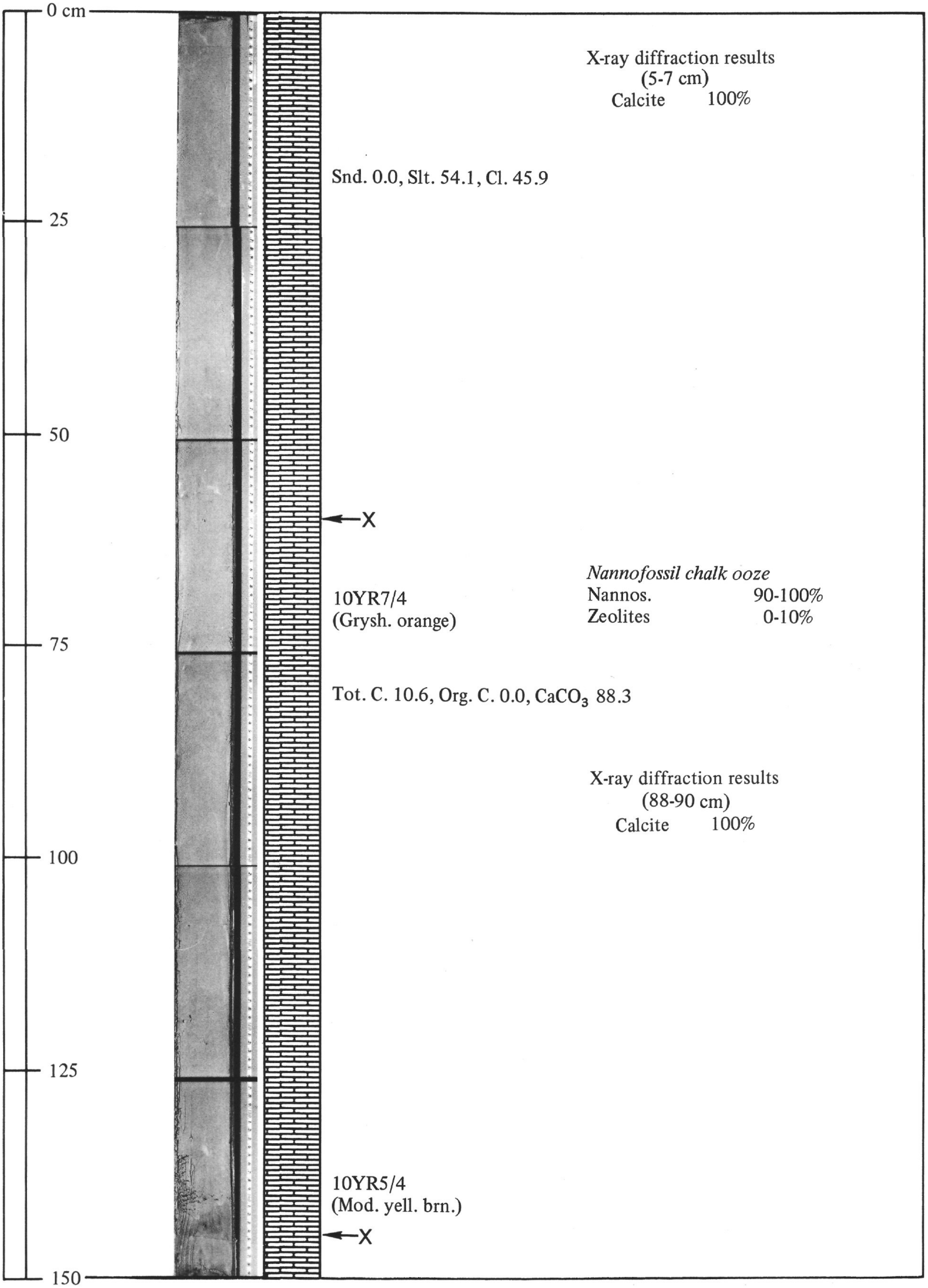


Figure 34. *Hole 10 Core 5 Section 3.*

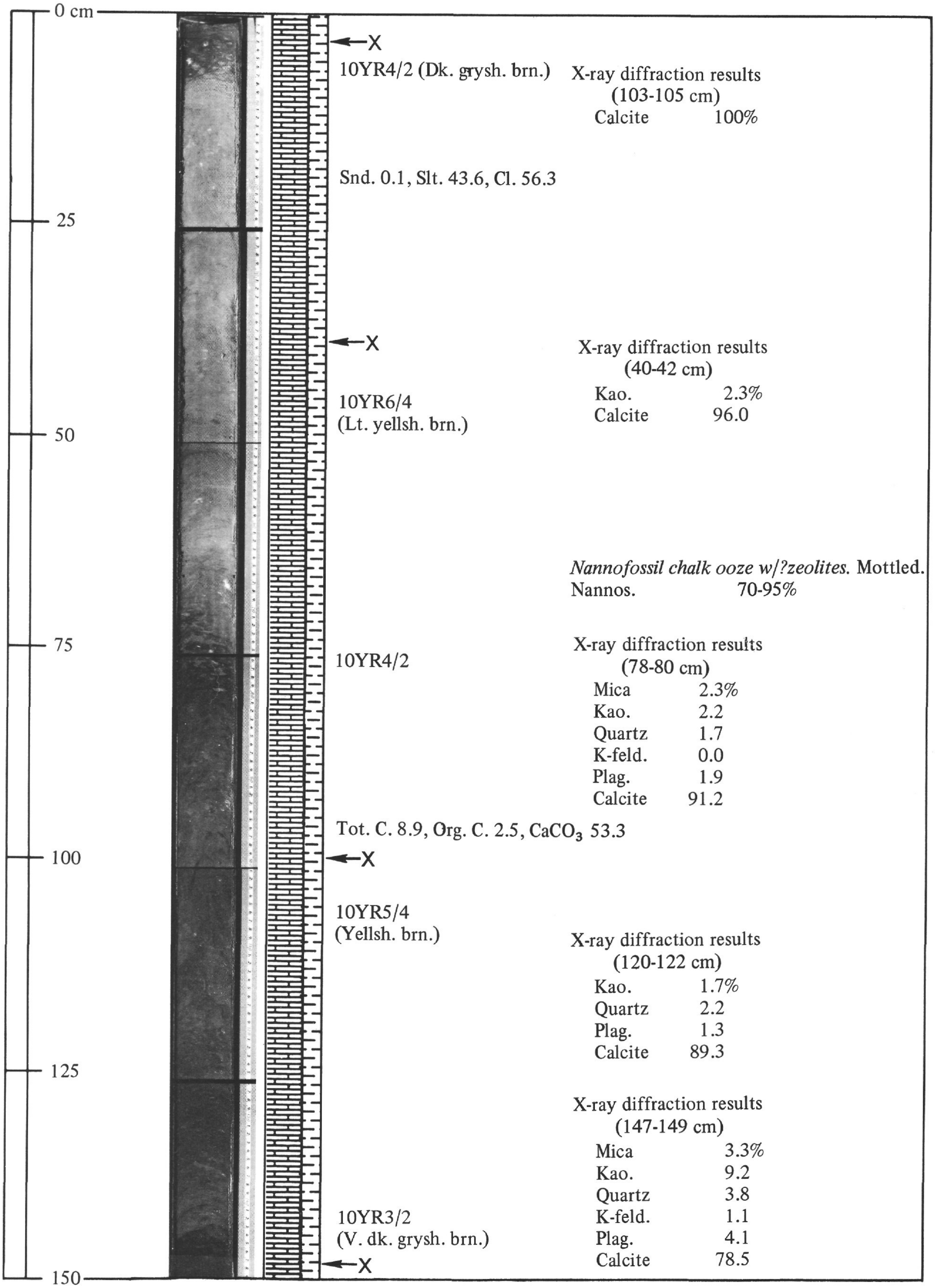


Figure 35. *Hole 10 Core 5 Section 4.*

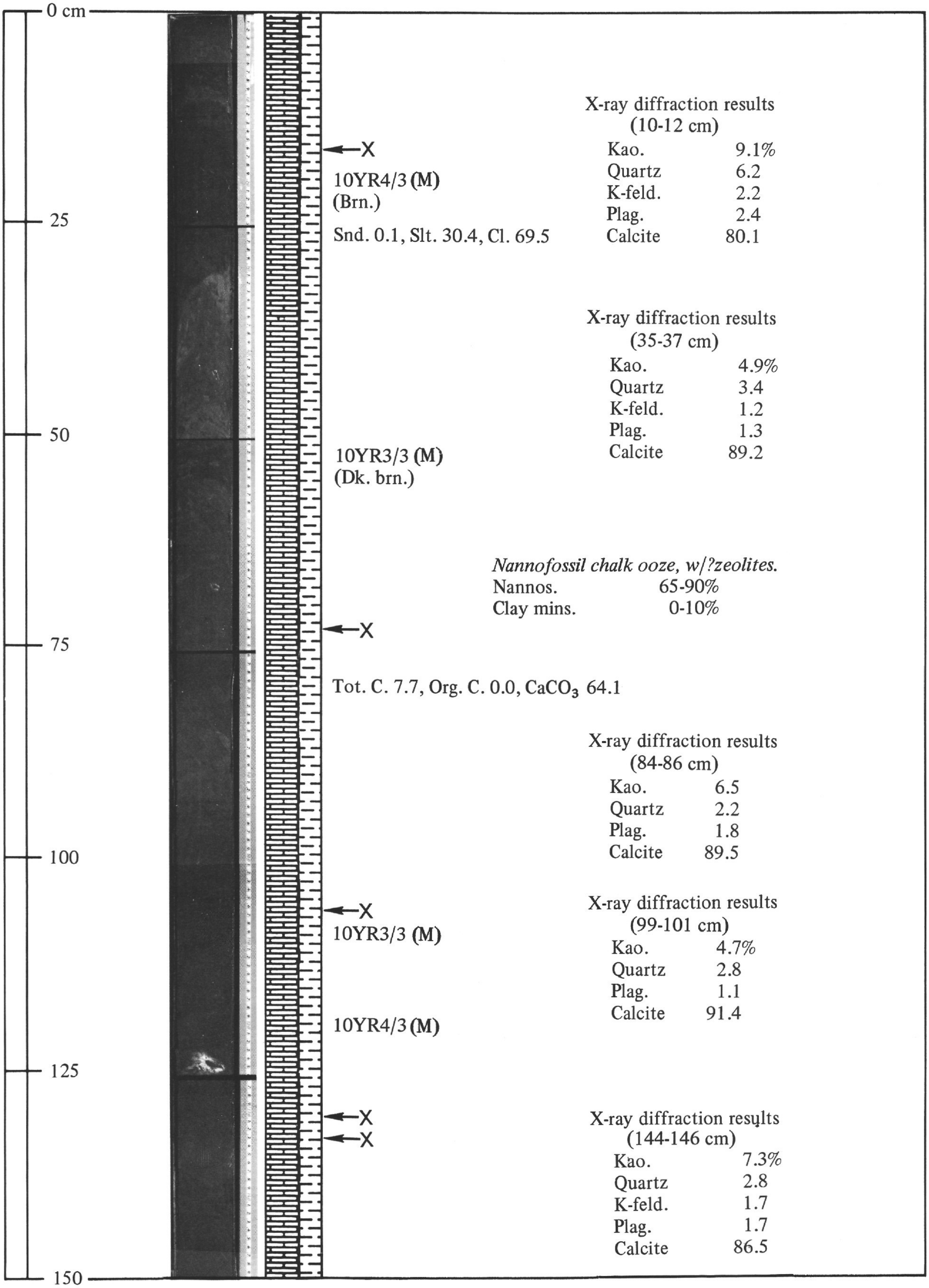


Figure 36. *Hole 10 Core 5 Section 5.*

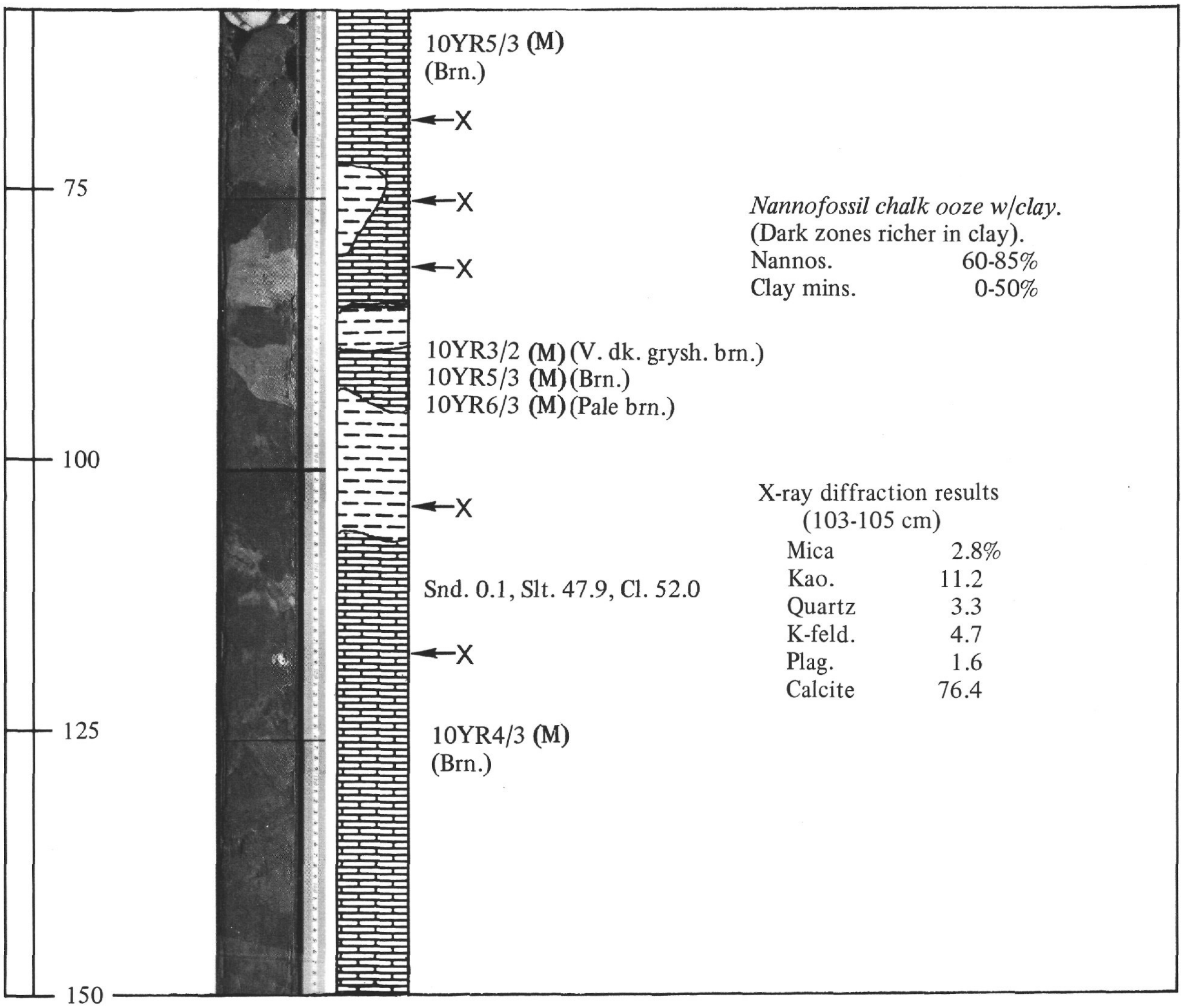


Figure 37. *Hole 10 Core 7 Section 1.*

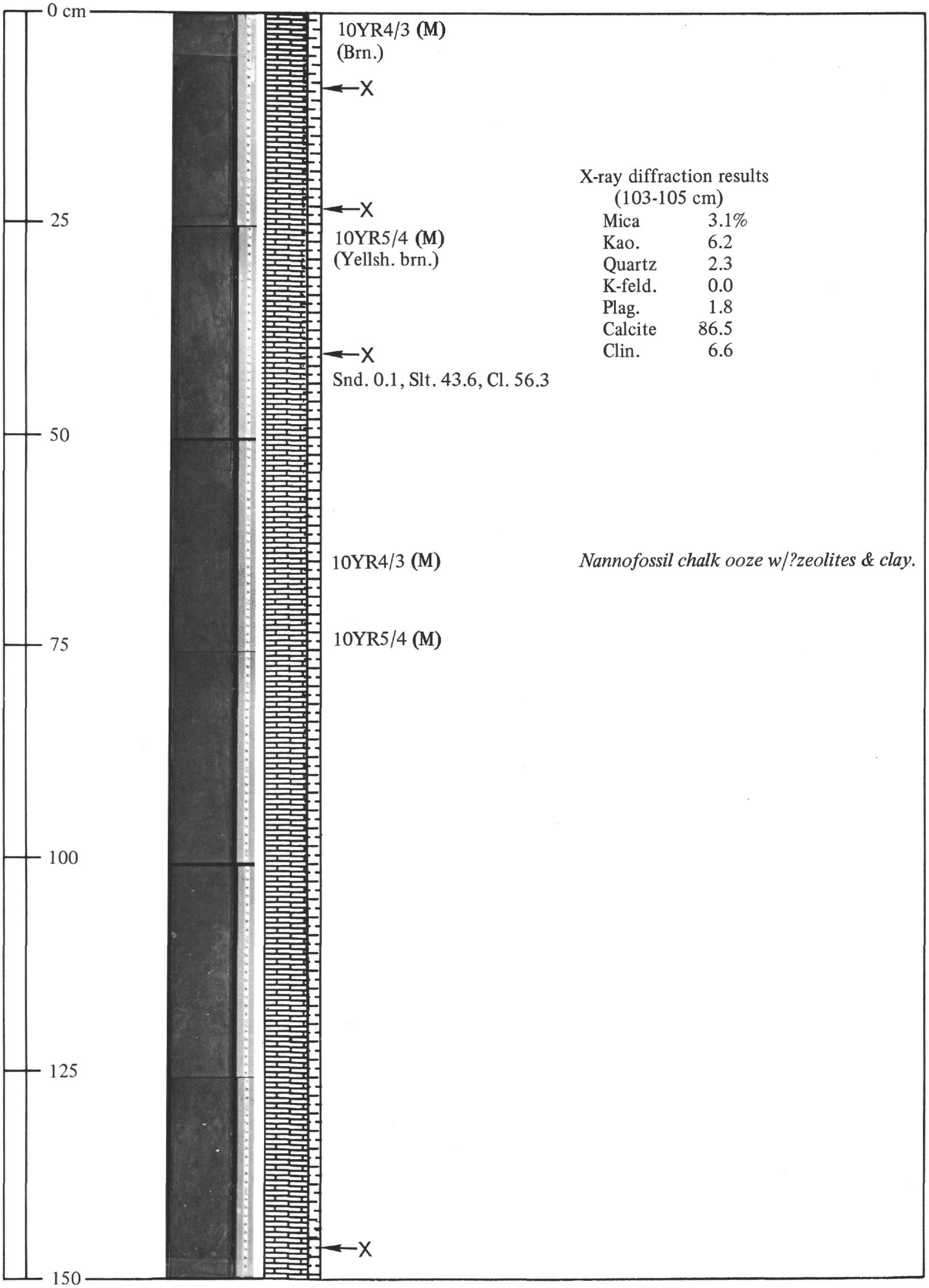


Figure 38. *Hole 10 Core 7 Section 2.*

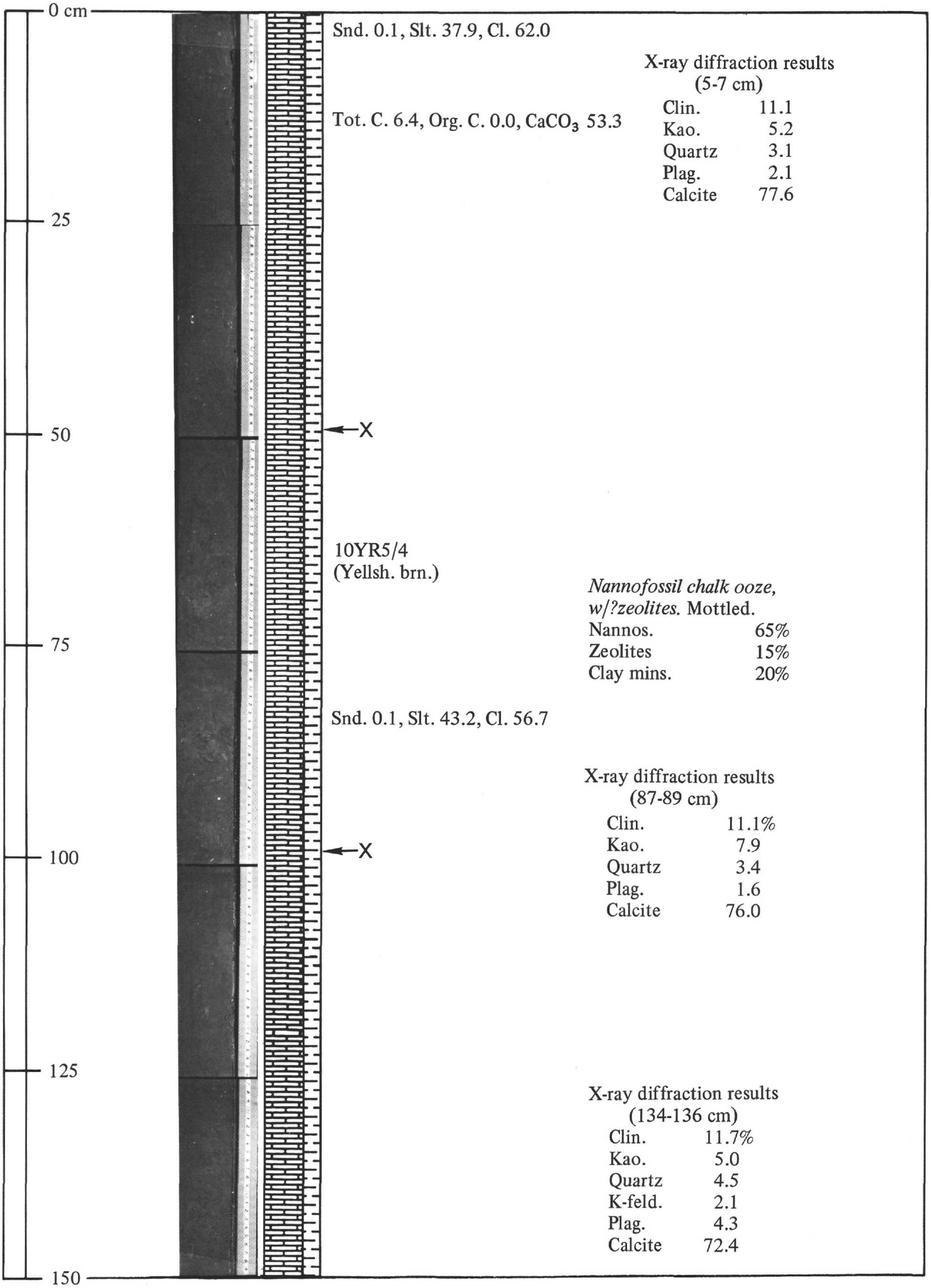


Figure 39. *Hole 10 Core 7 Section 3.*

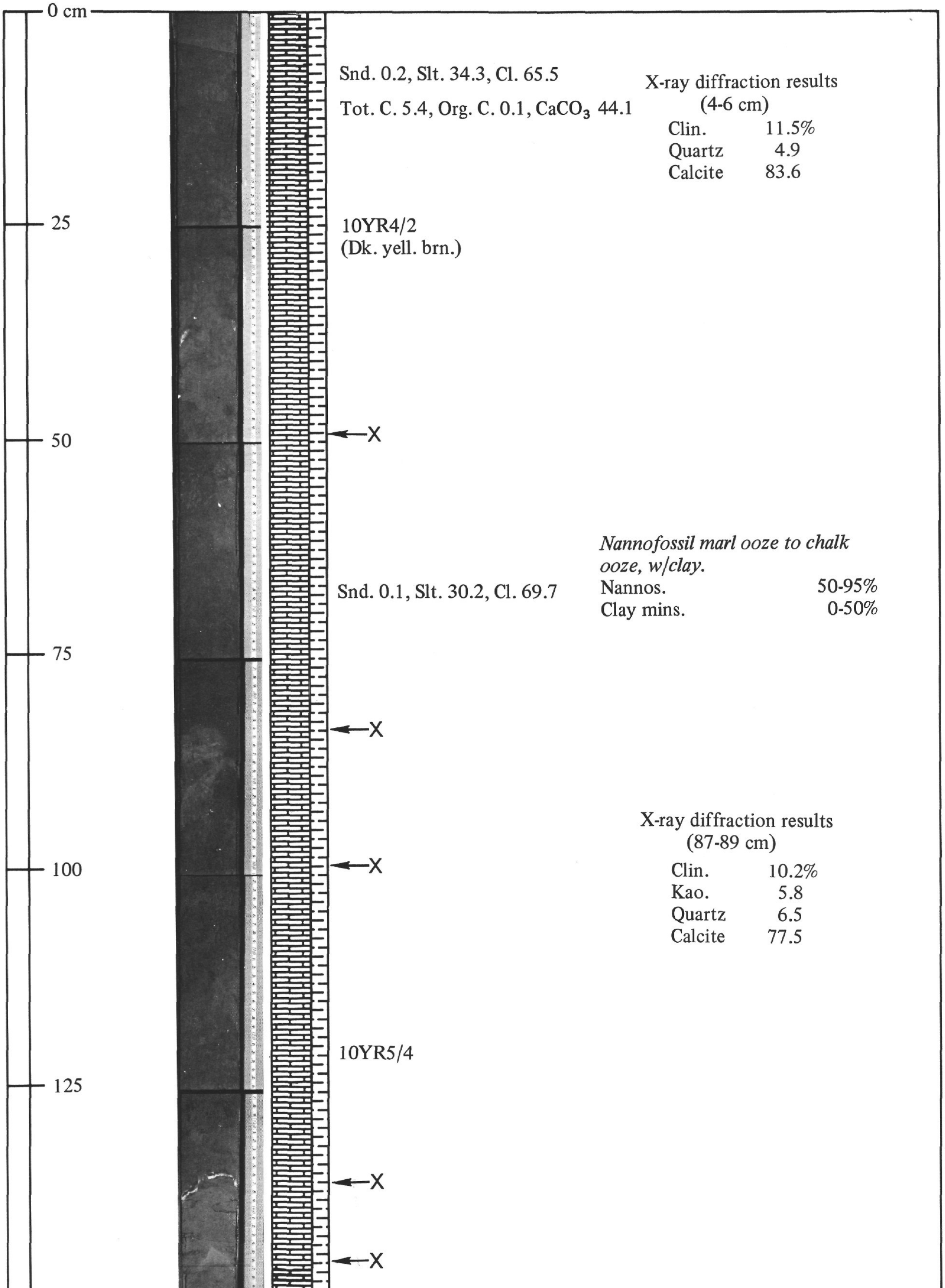


Figure 40. *Hole 10 Core 7 Section 4.*

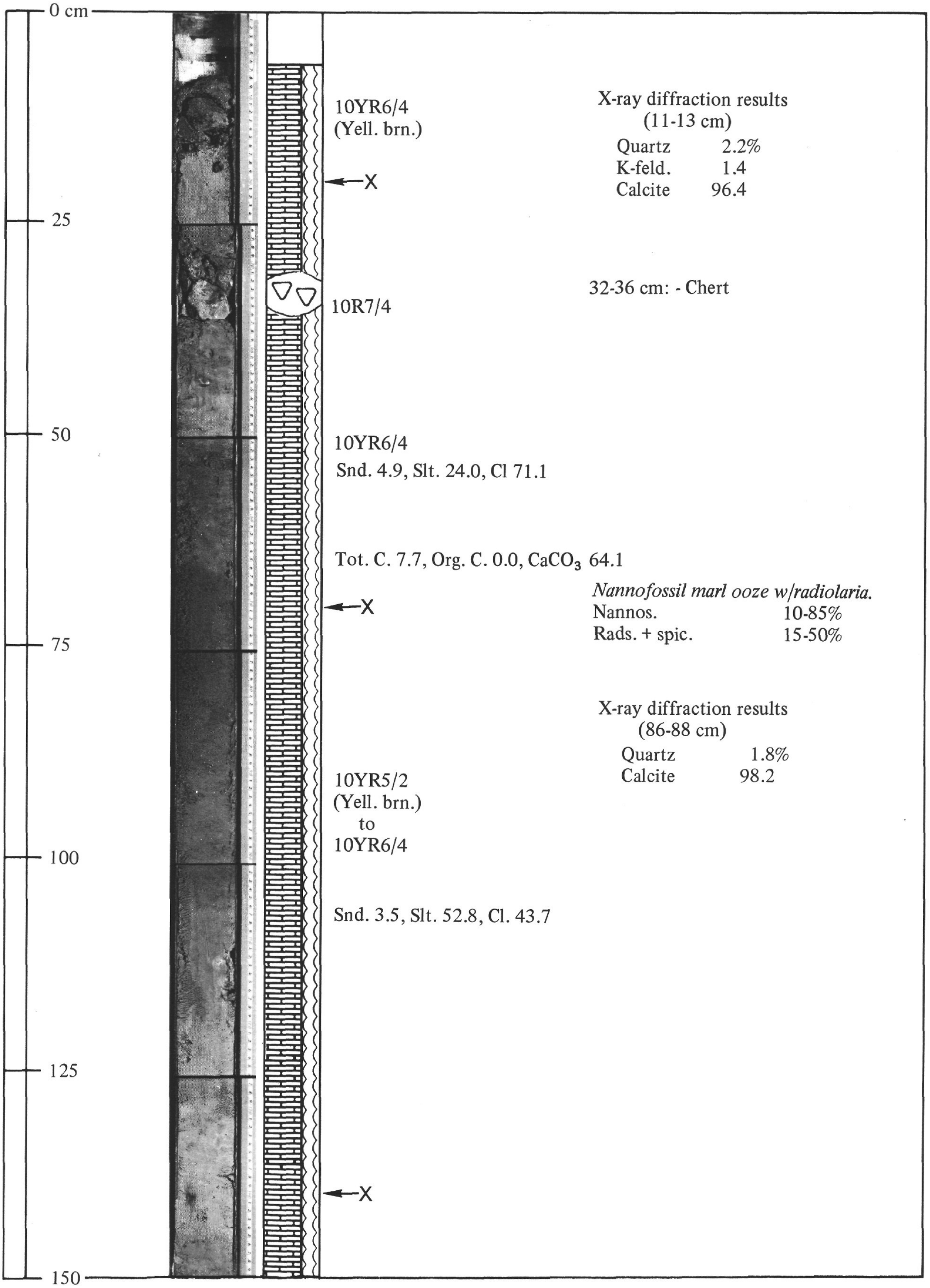


Figure 41. *Hole 10 Core 9 Section 1.*

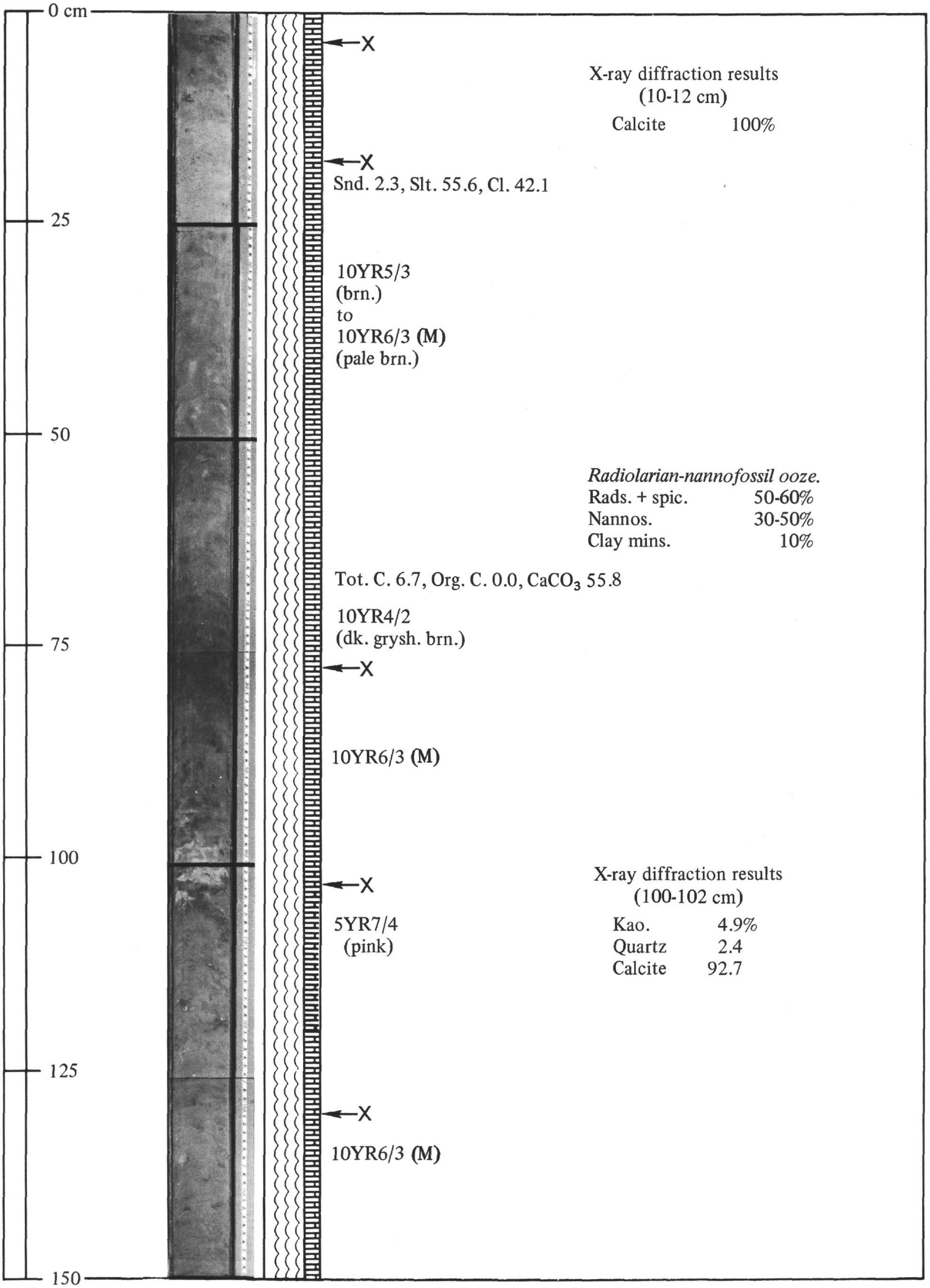


Figure 42. *Hole 10 Core 9 Section 2.*

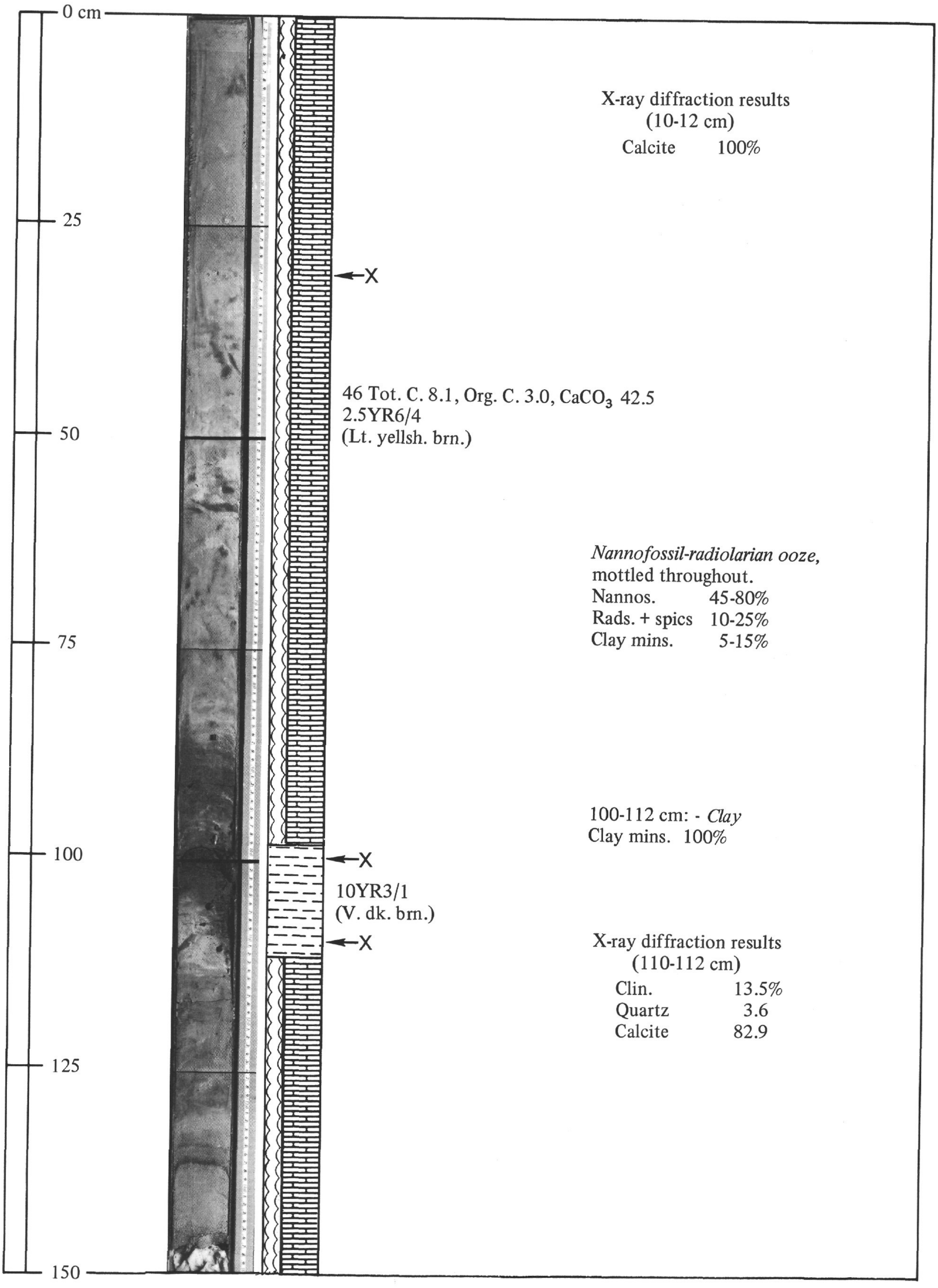


Figure 43. *Hole 10 Core 9 Section 3.*

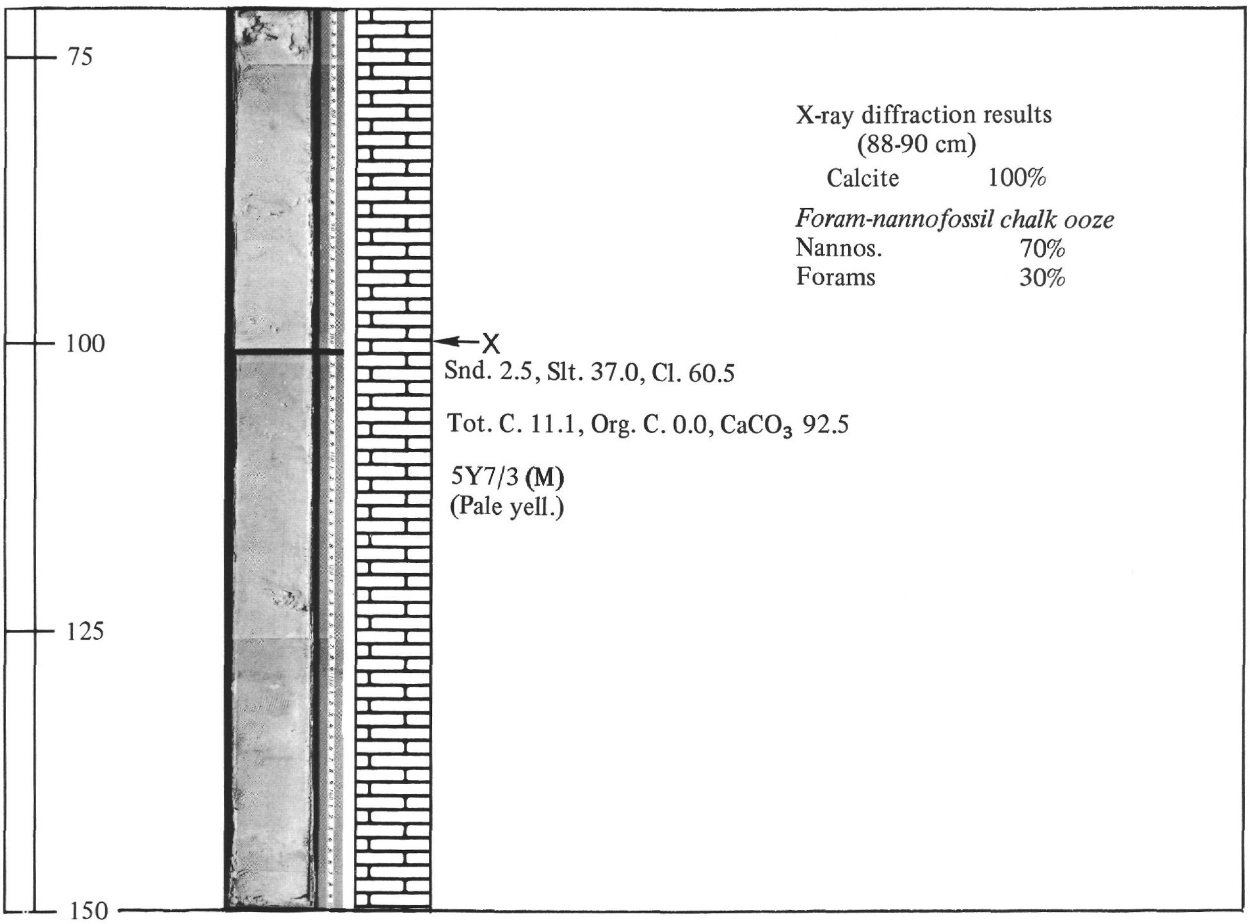


Figure 44. *Hole 10 Core 10 Section 1.*

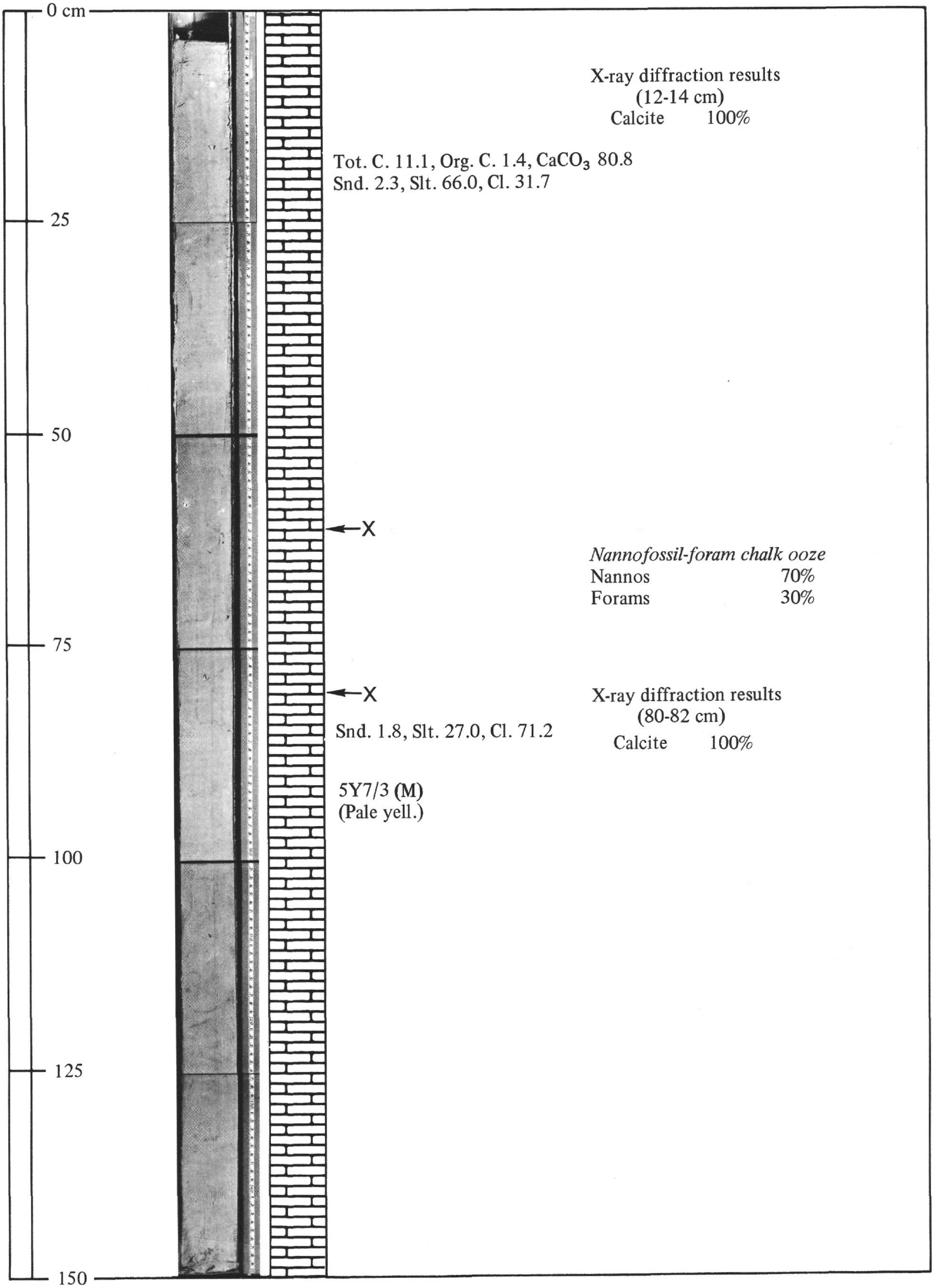


Figure 45. *Hole 10 Core 10 Section 2.*

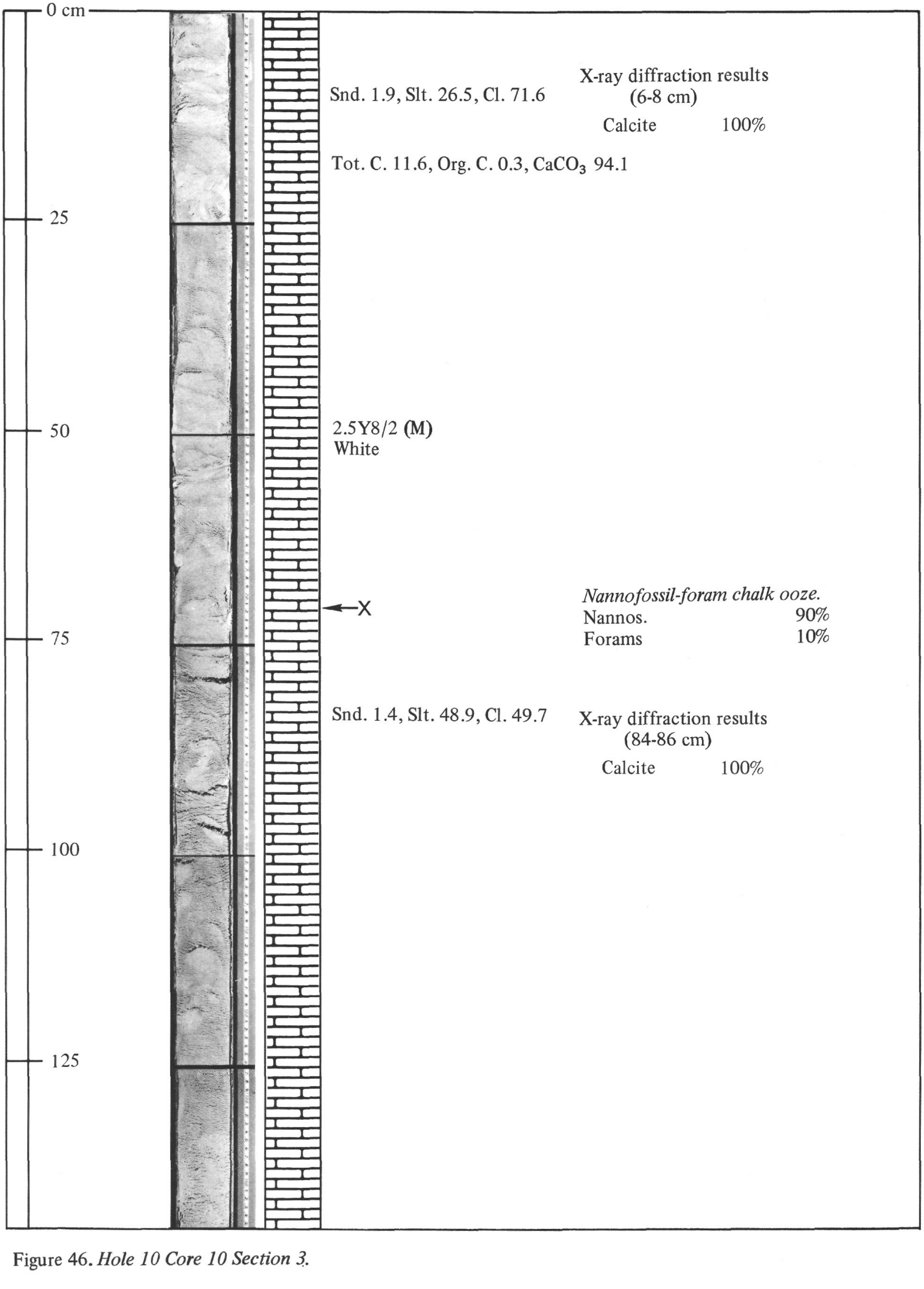


Figure 46. *Hole 10 Core 10 Section 3.*

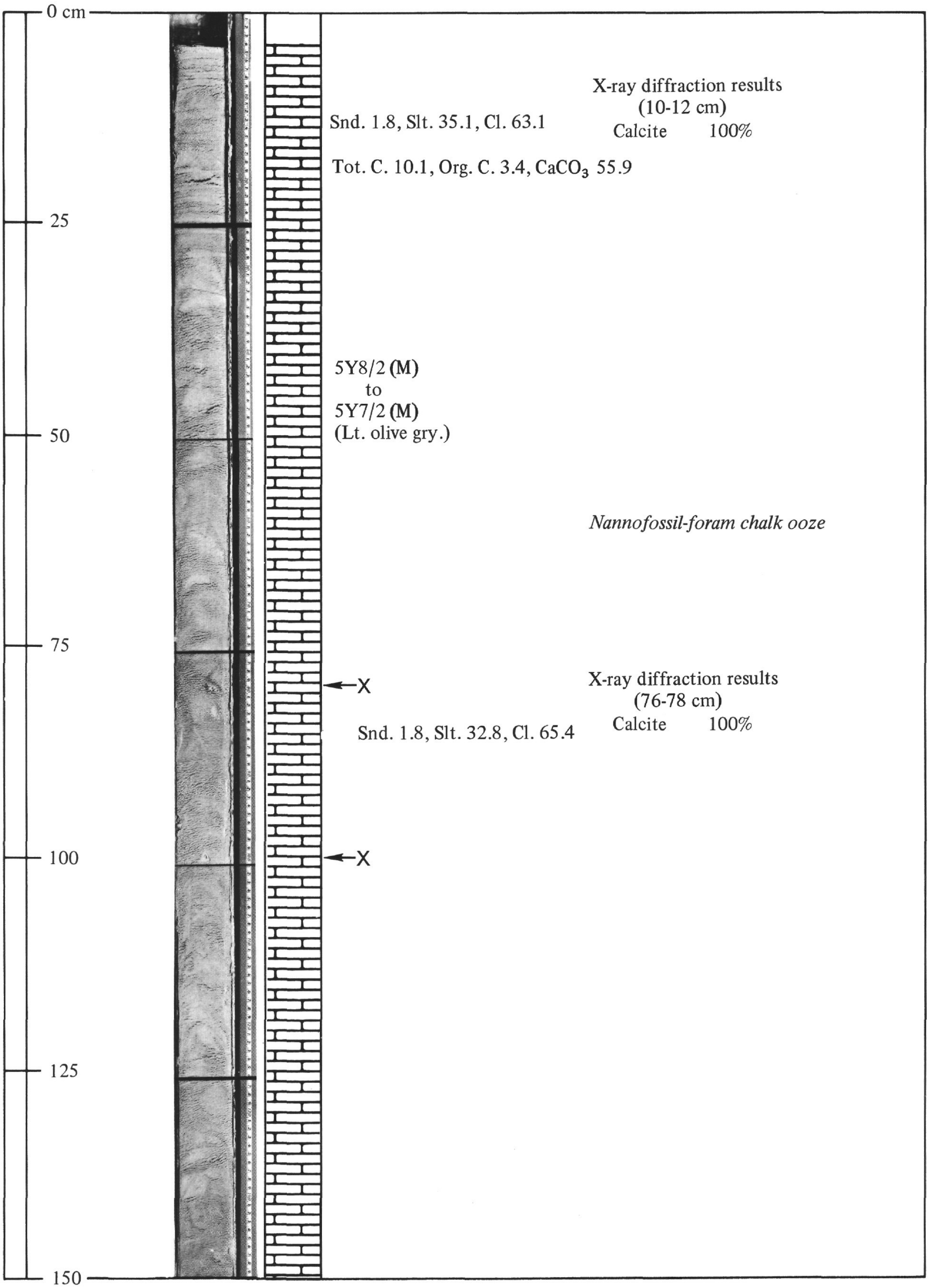


Figure 47. *Hole 10 Core 10 Section 4.*

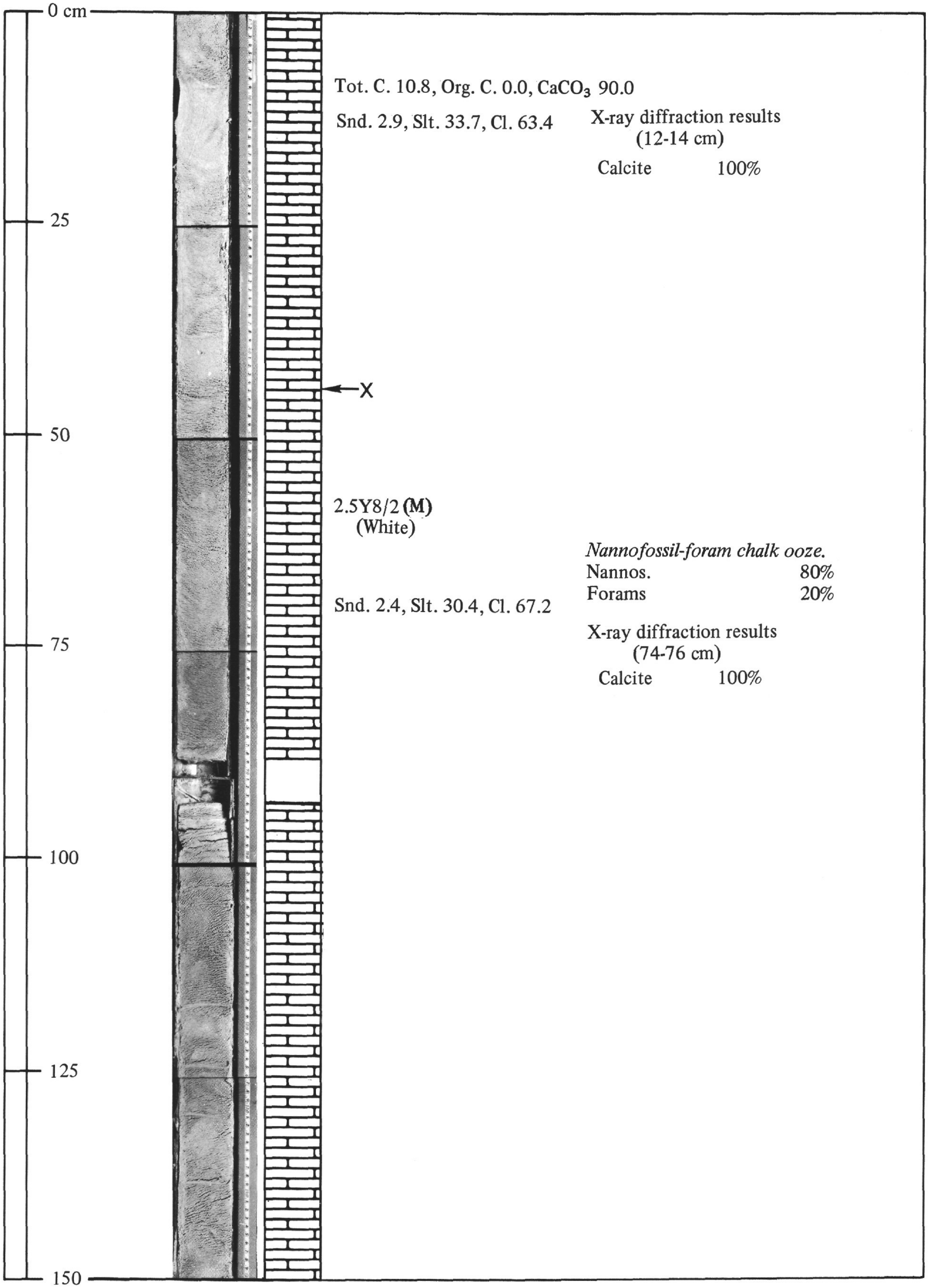


Figure 48. *Hole 10 Core 10 Section 5.*

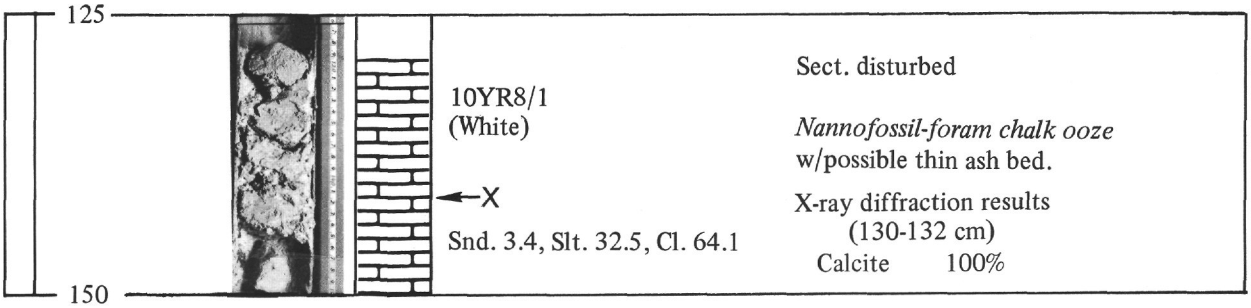


Figure 49. *Hole 10 Core 11 Section 1.*

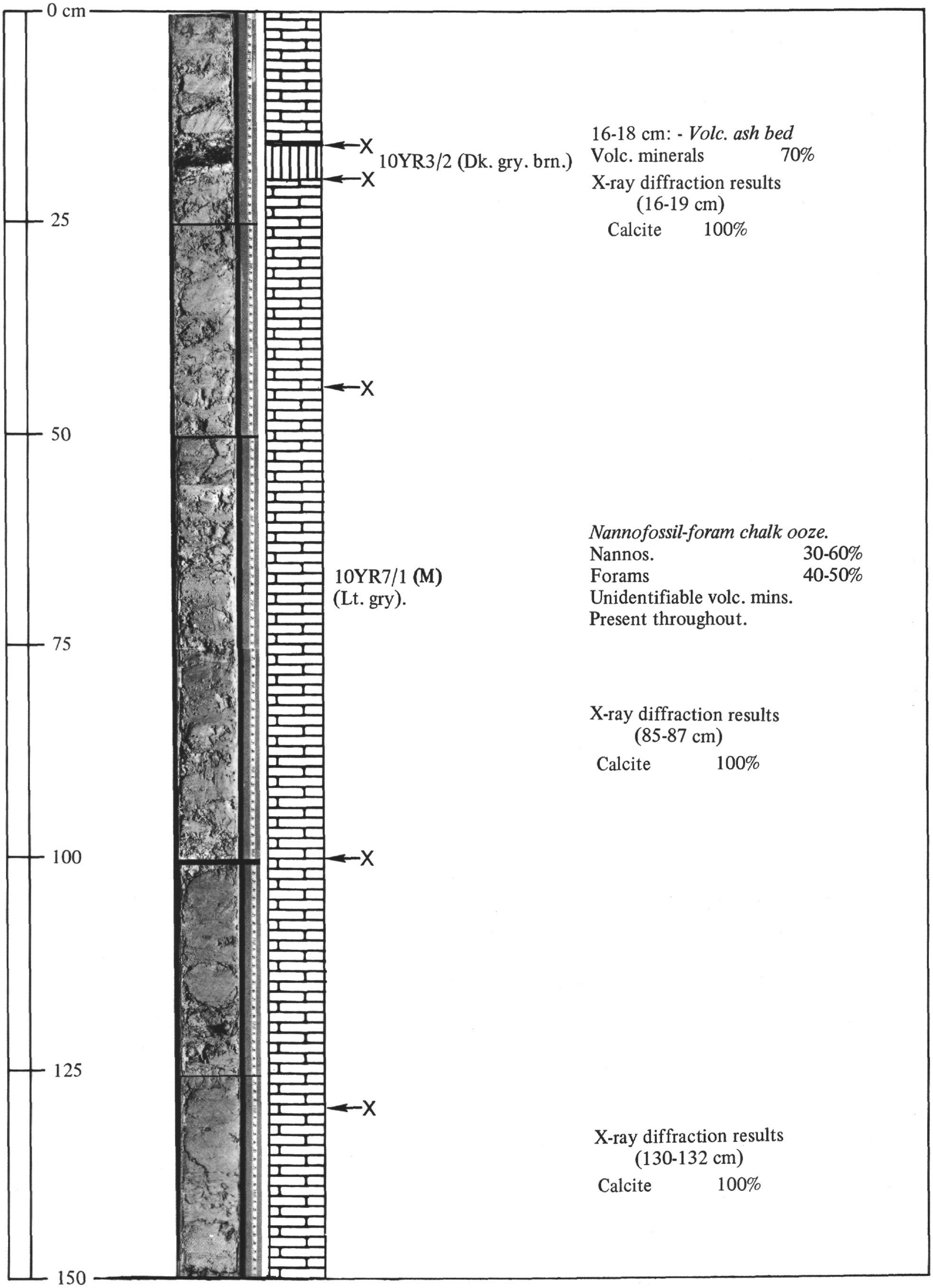


Figure 50. *Hole 10 Core 11 Section 2.*

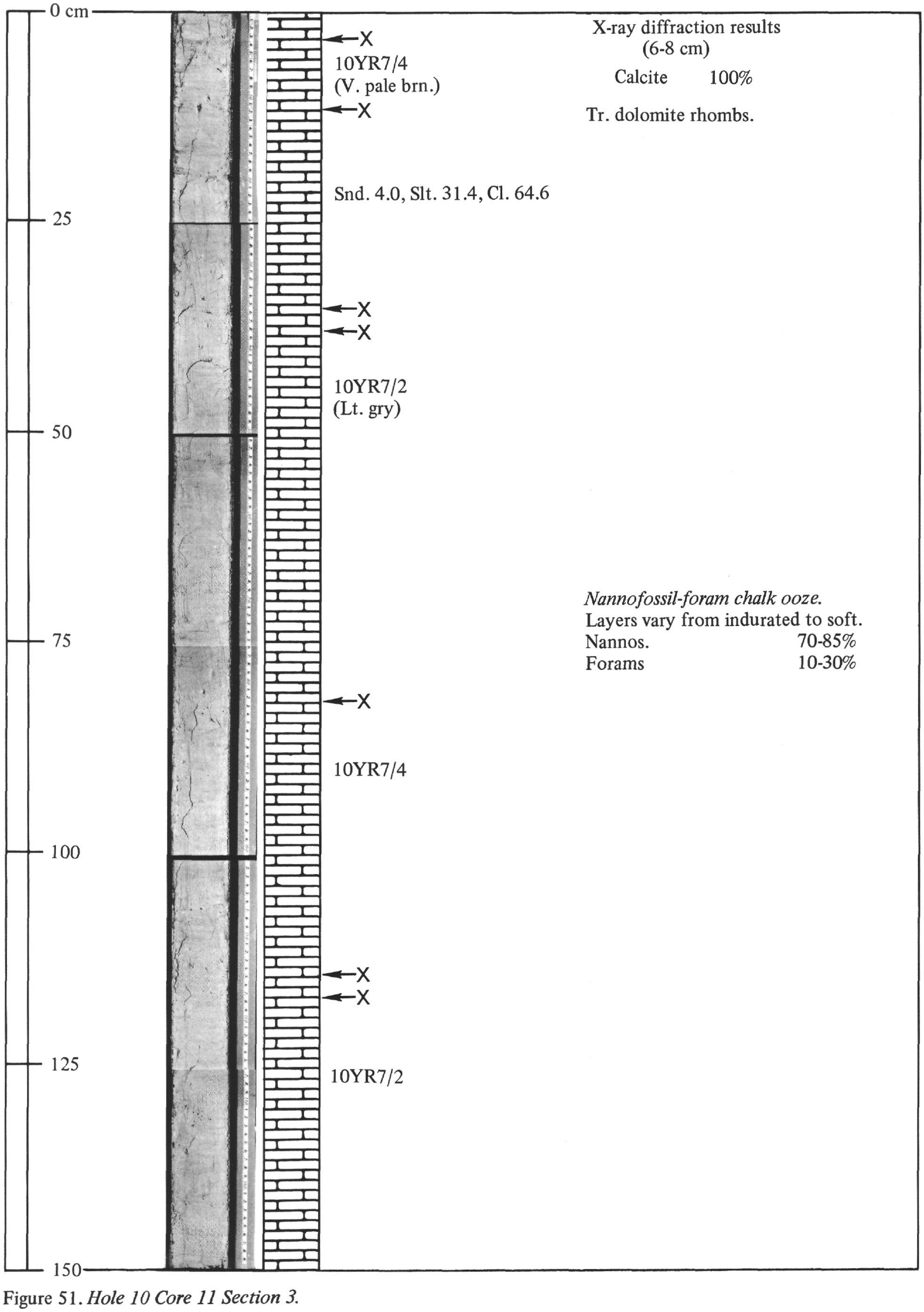


Figure 51. *Hole 10 Core 11 Section 3.*

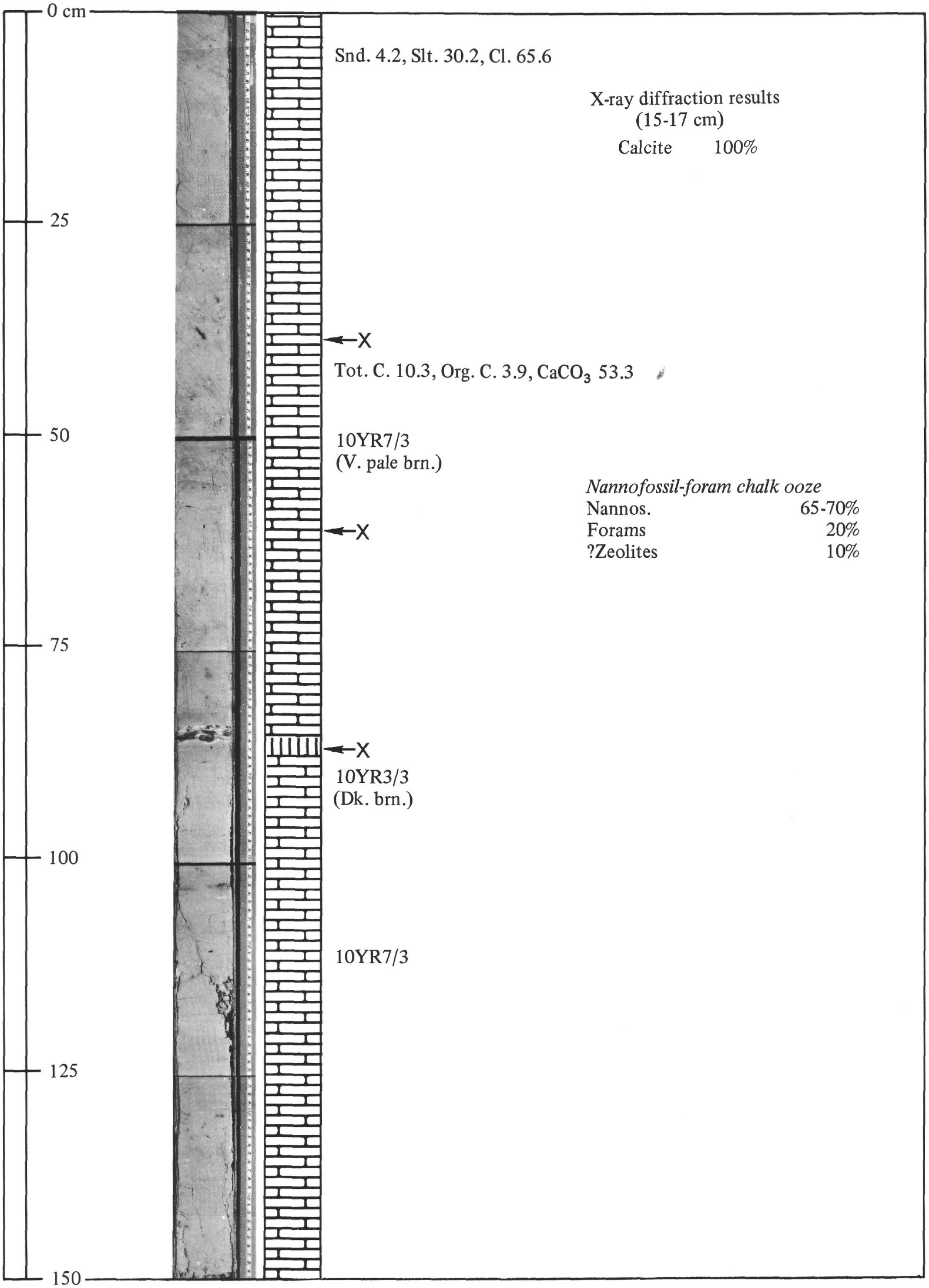


Figure 52. *Hole 10 Core 11 Section 4.*

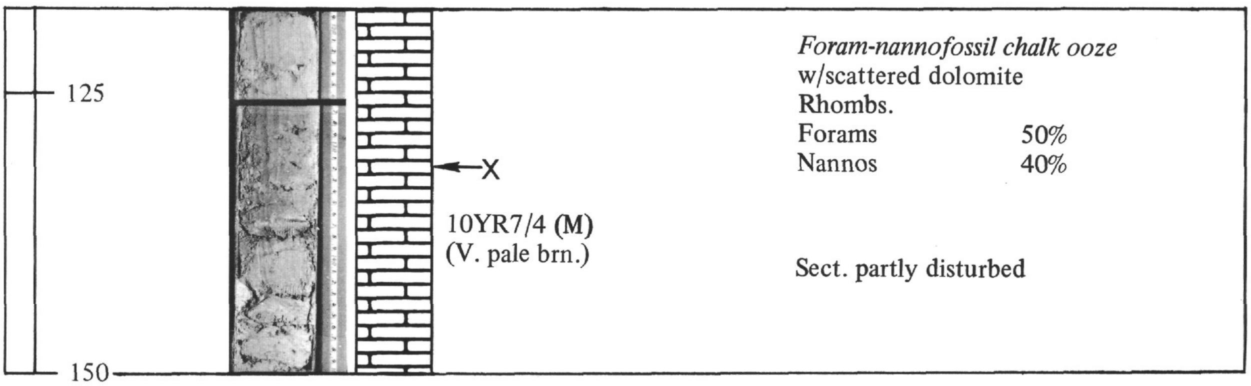


Figure 53. *Hole 10 Core 12 Section 1.*

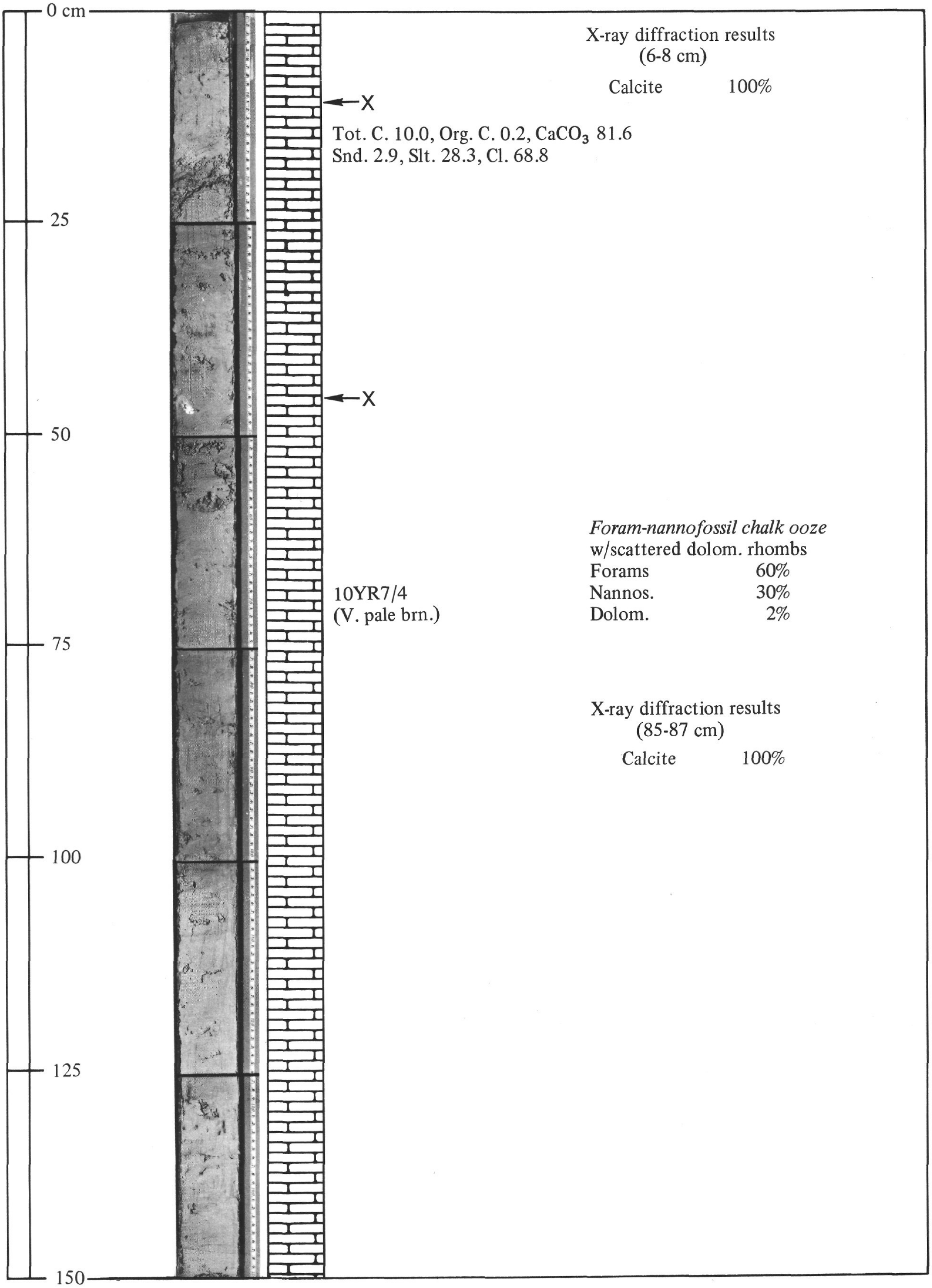


Figure 54. *Hole 10 Core 12 Section 2.*

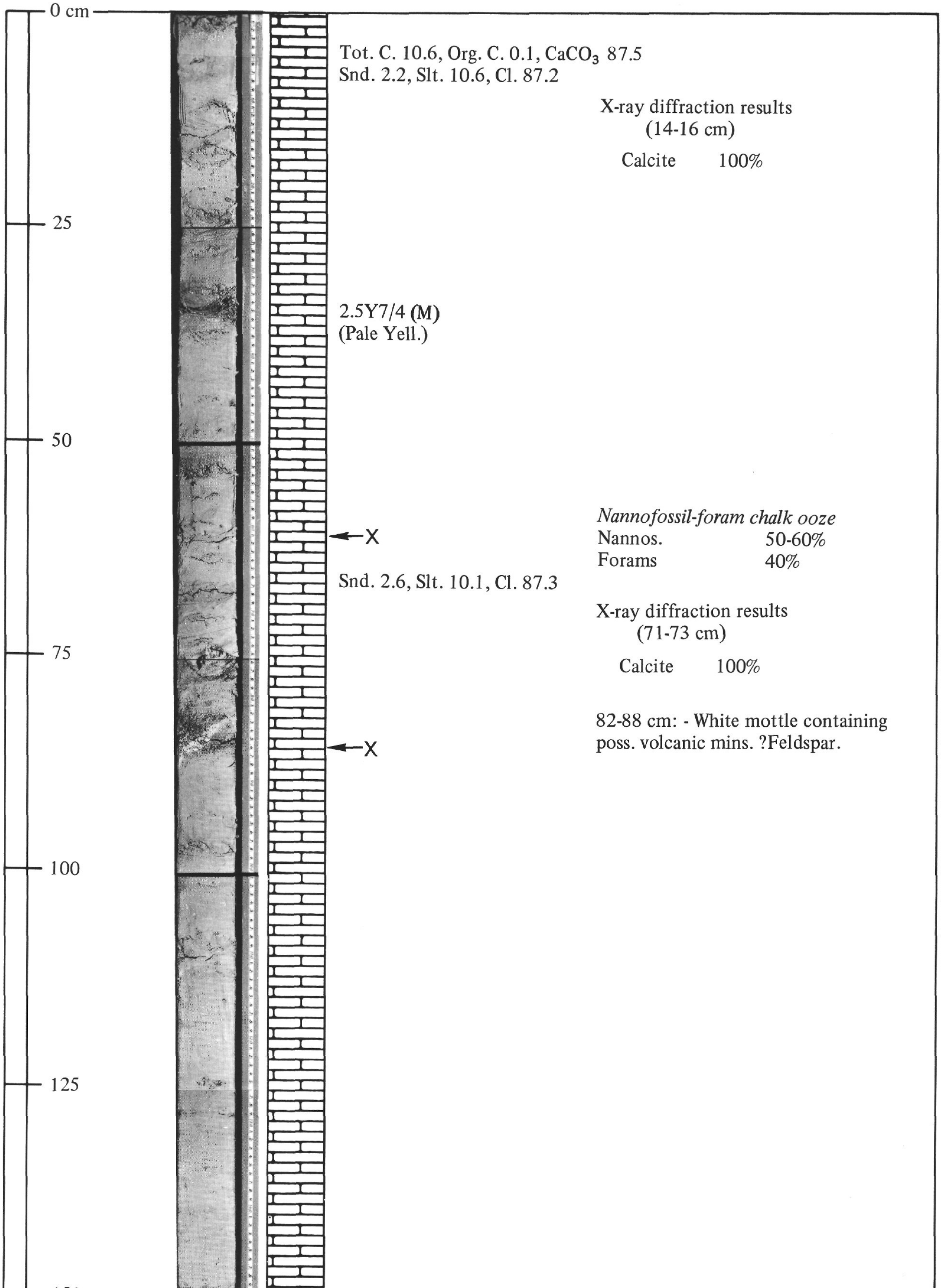


Figure 55. *Hole 10 Core 12 Section 3.*

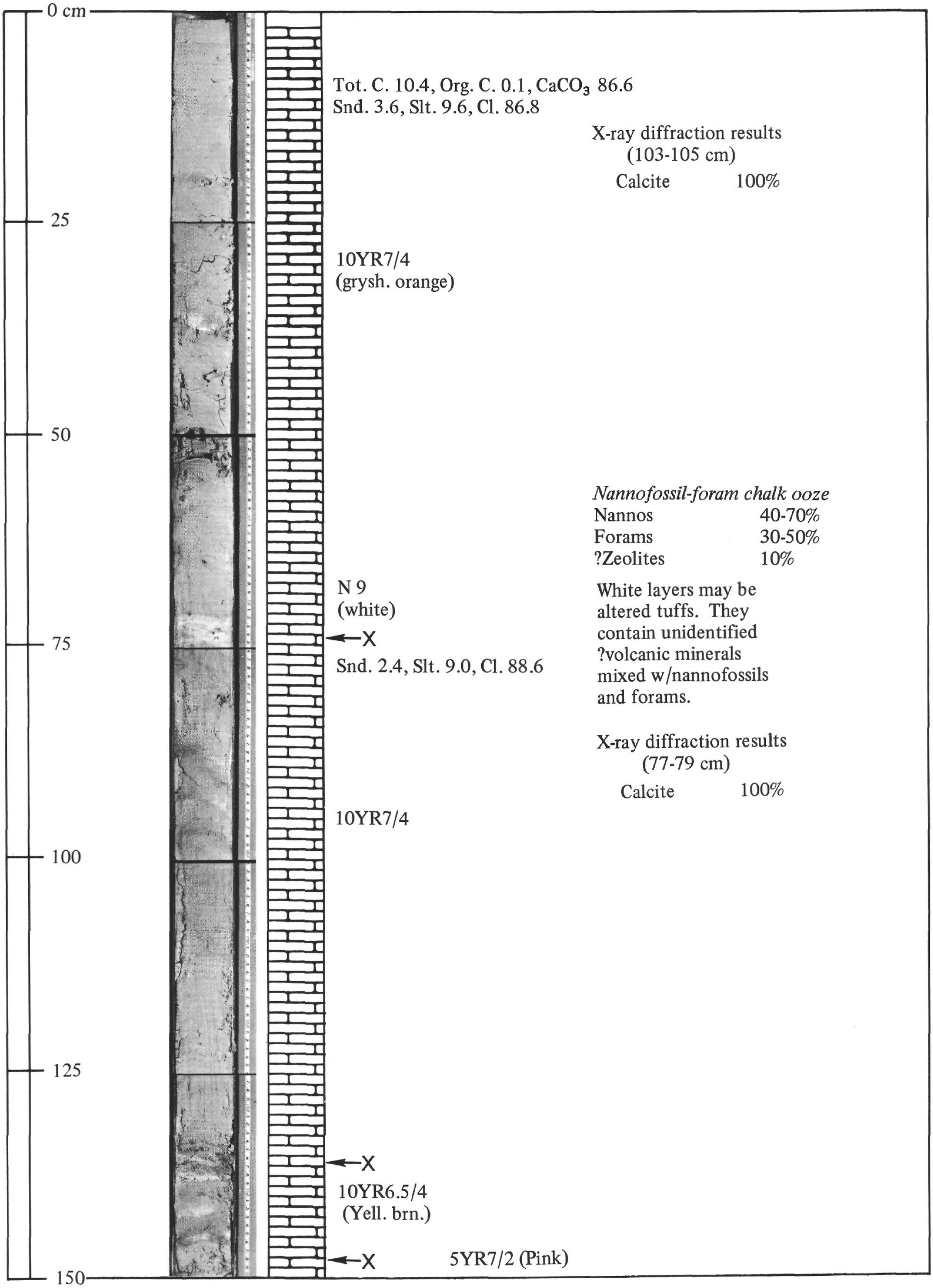


Figure 56. *Hole 10 Core 12 Section 4.*

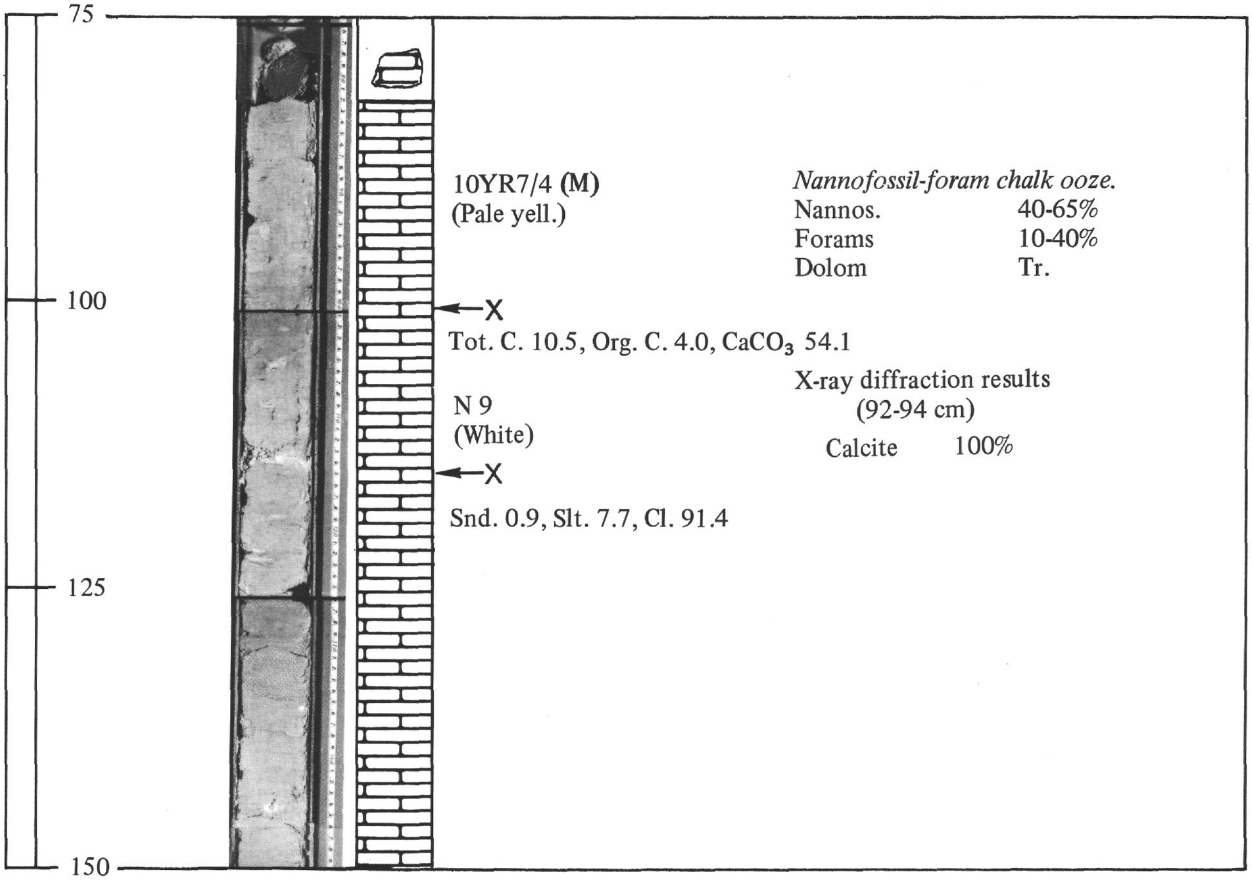


Figure 57. *Hole 10 Core 13 Section 1.*

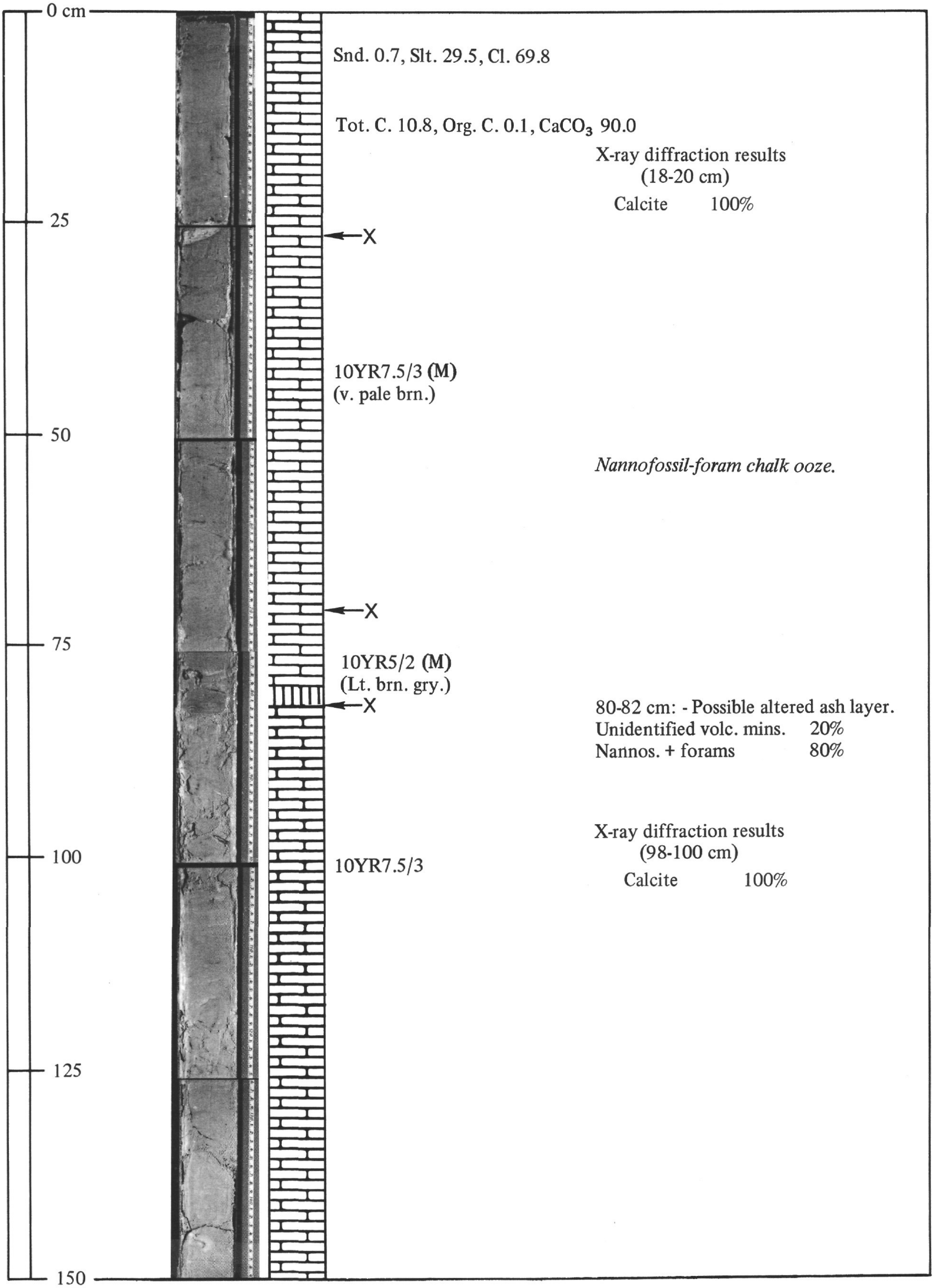


Figure 58. *Hole 10 Core 13 Section 2.*

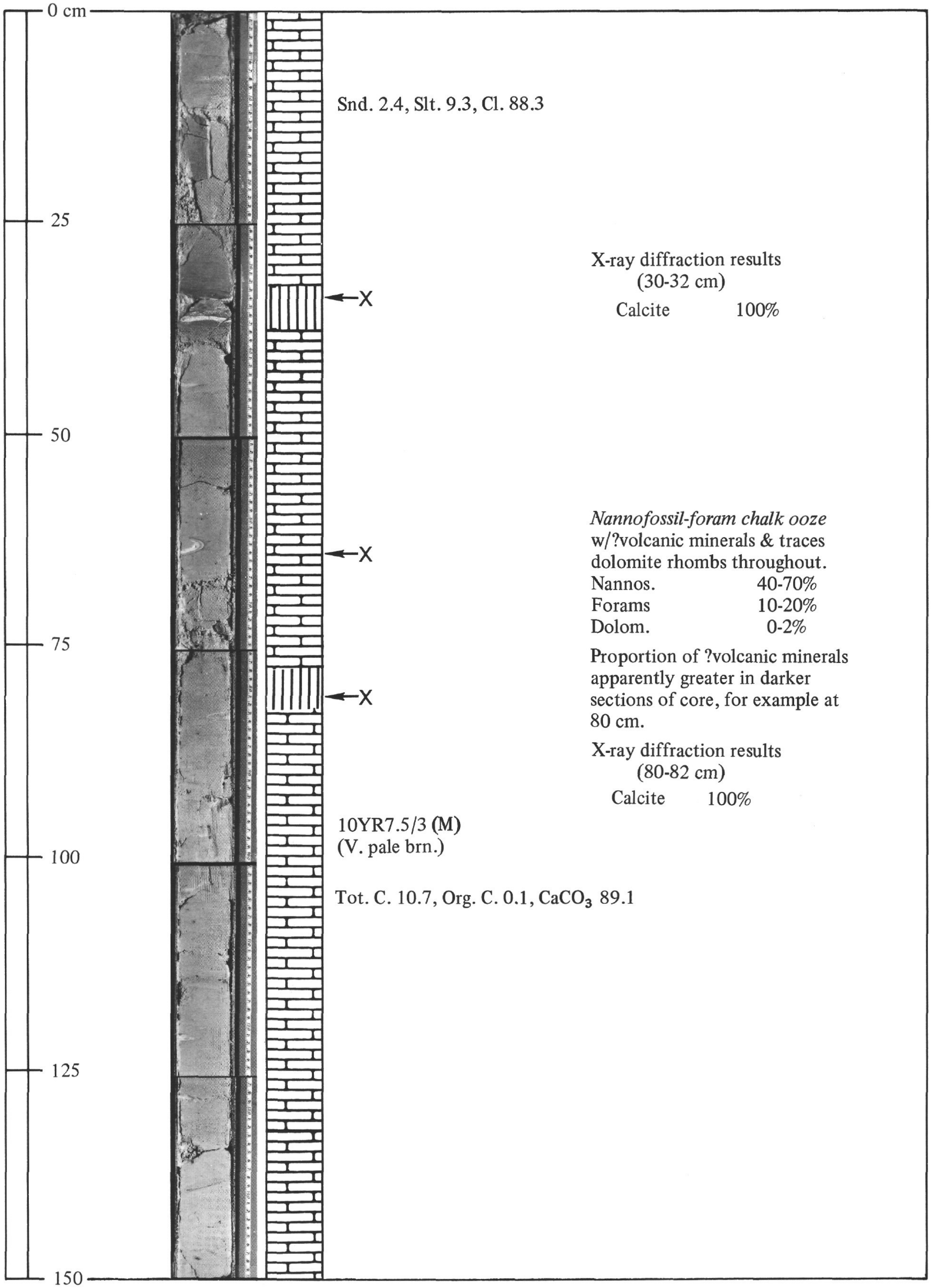


Figure 59. *Hole 10 Core 13 Section 3.*

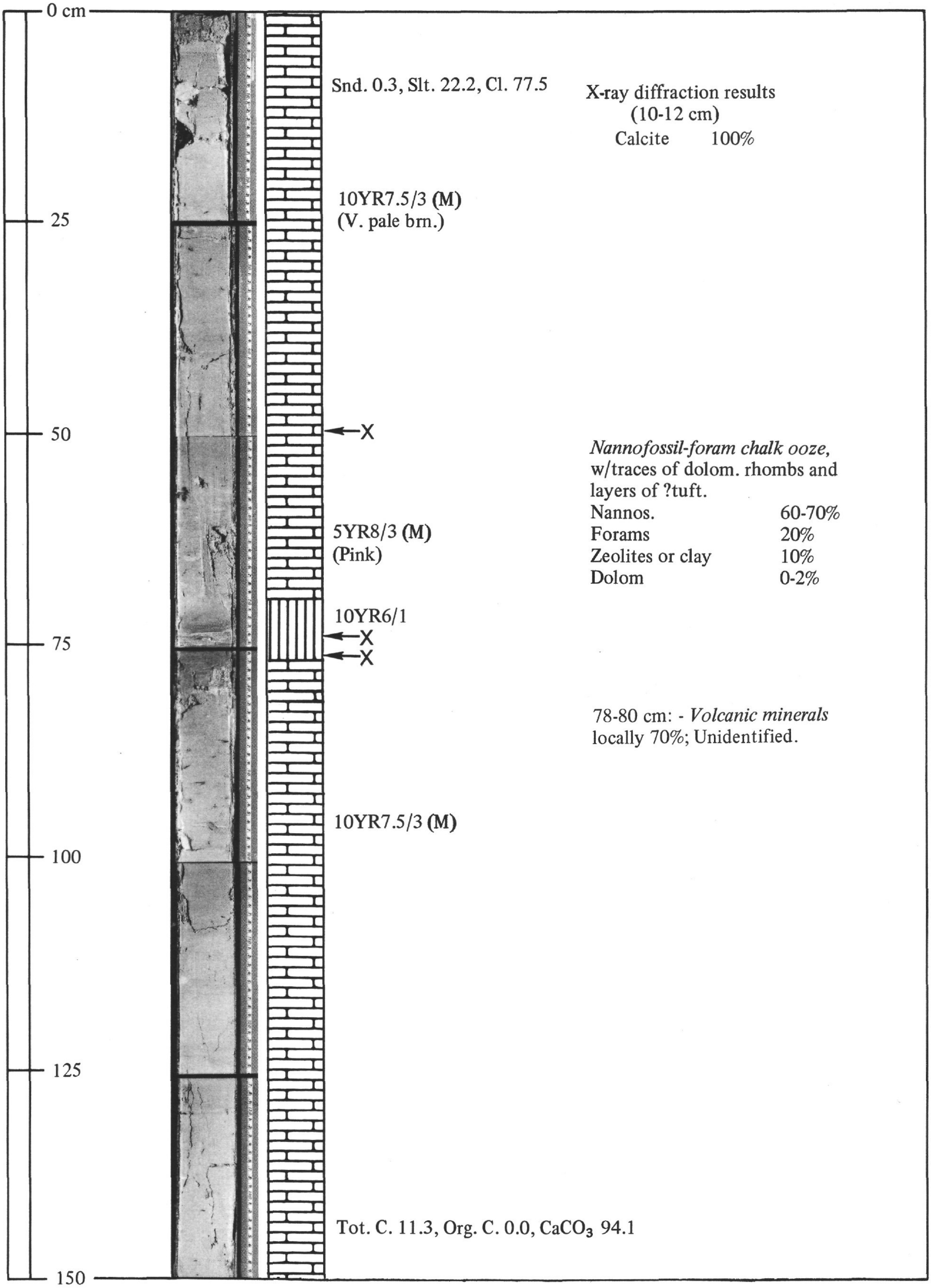


Figure 60. *Hole 10 Core 13 Section 4.*

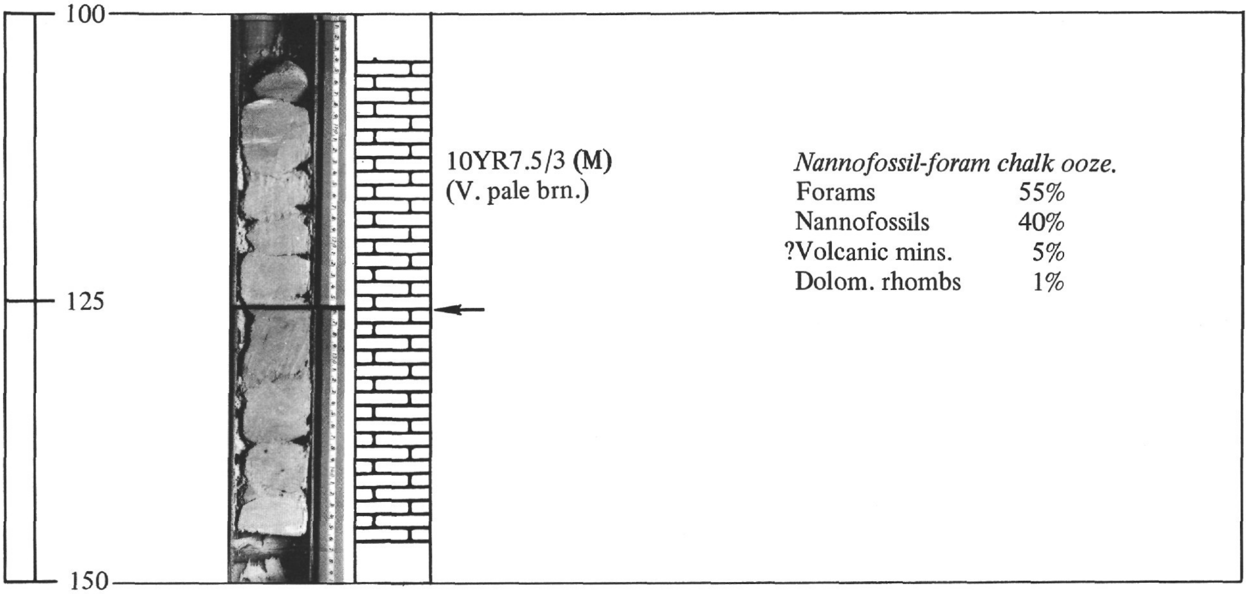


Figure 61. *Hole 10 Core 14 Section 1.*

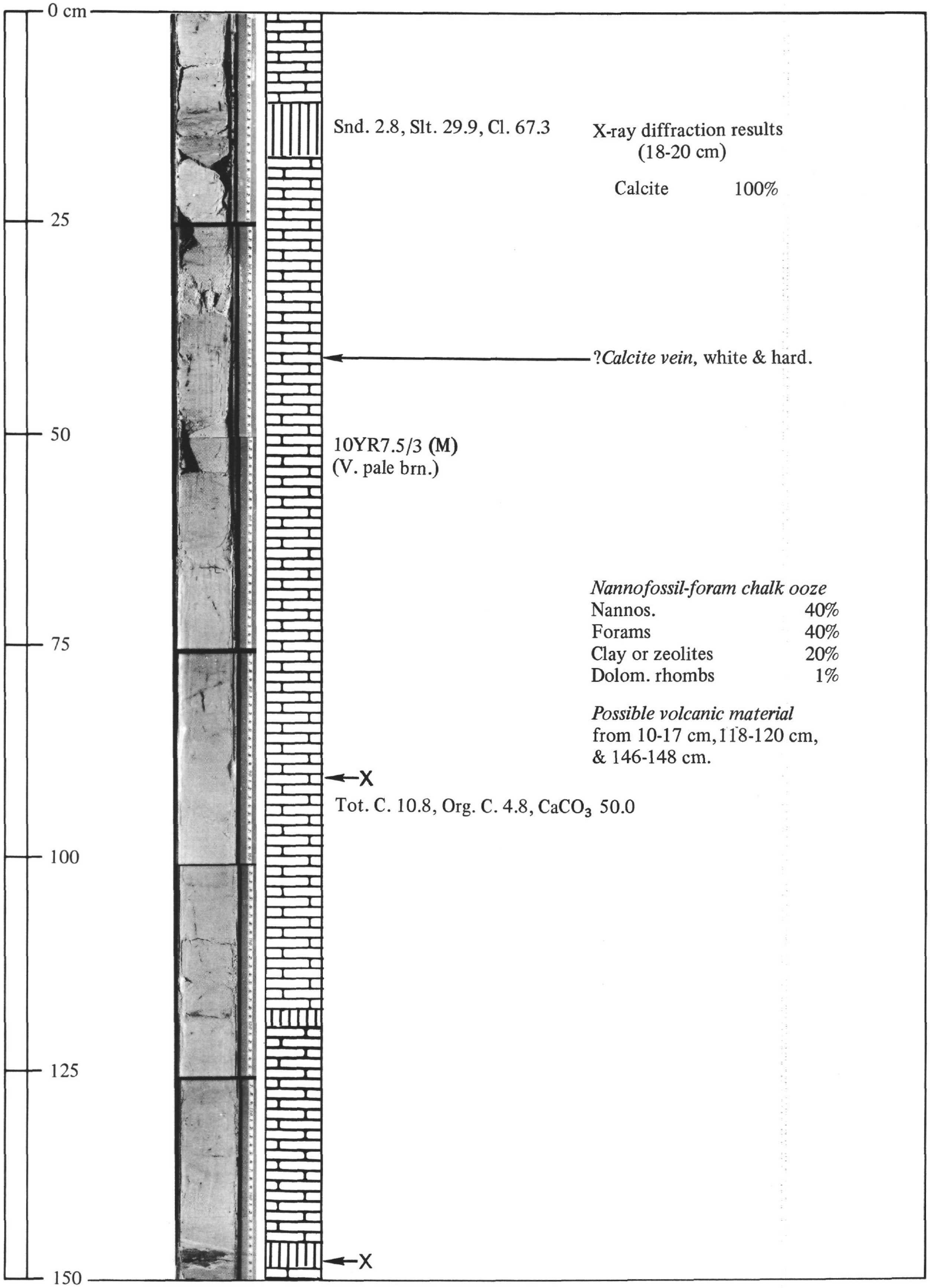


Figure 62. *Hole 10 Core 14 Section 2.*

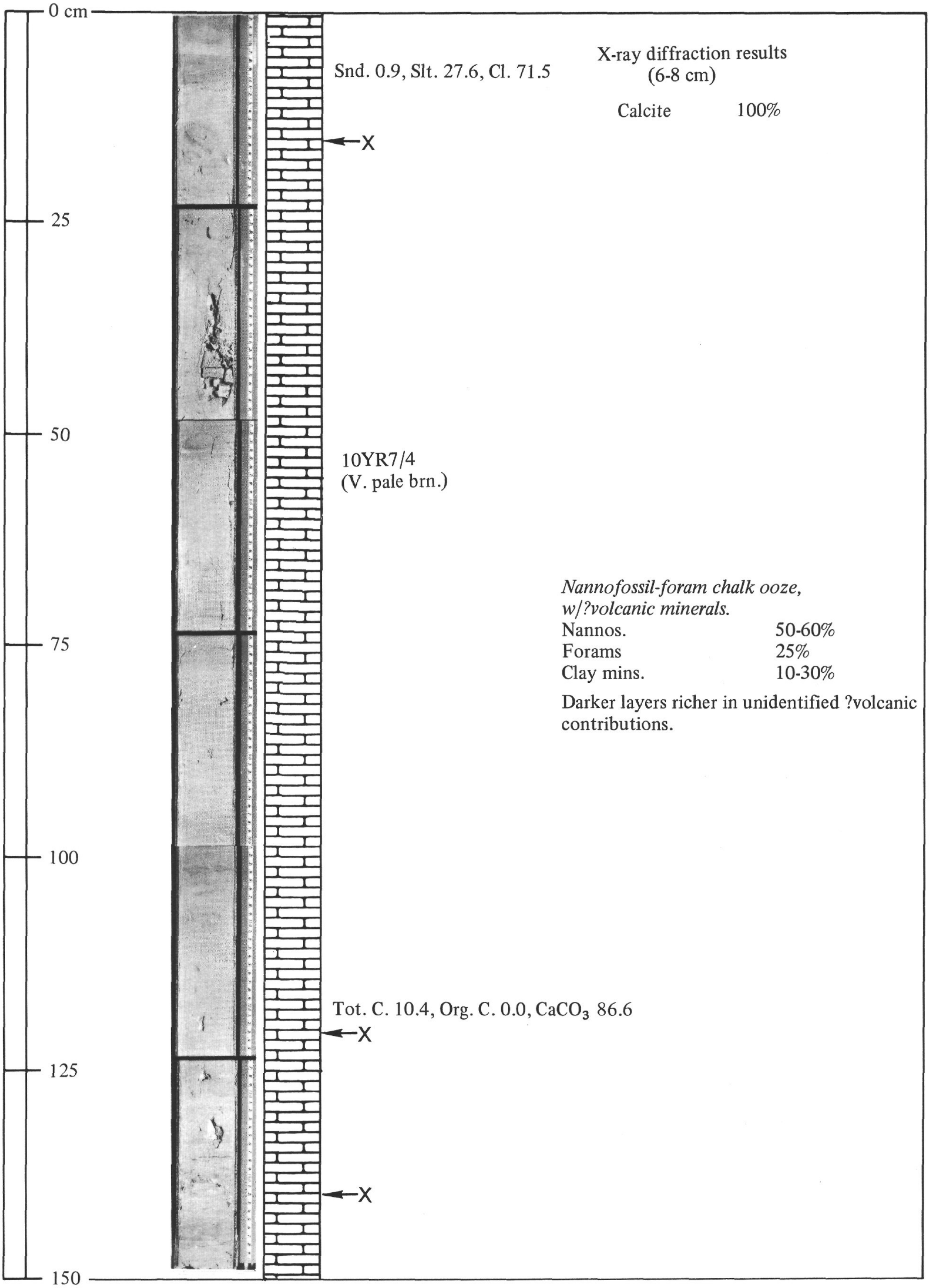


Figure 63. *Hole 10 Core 14 Section 3.*

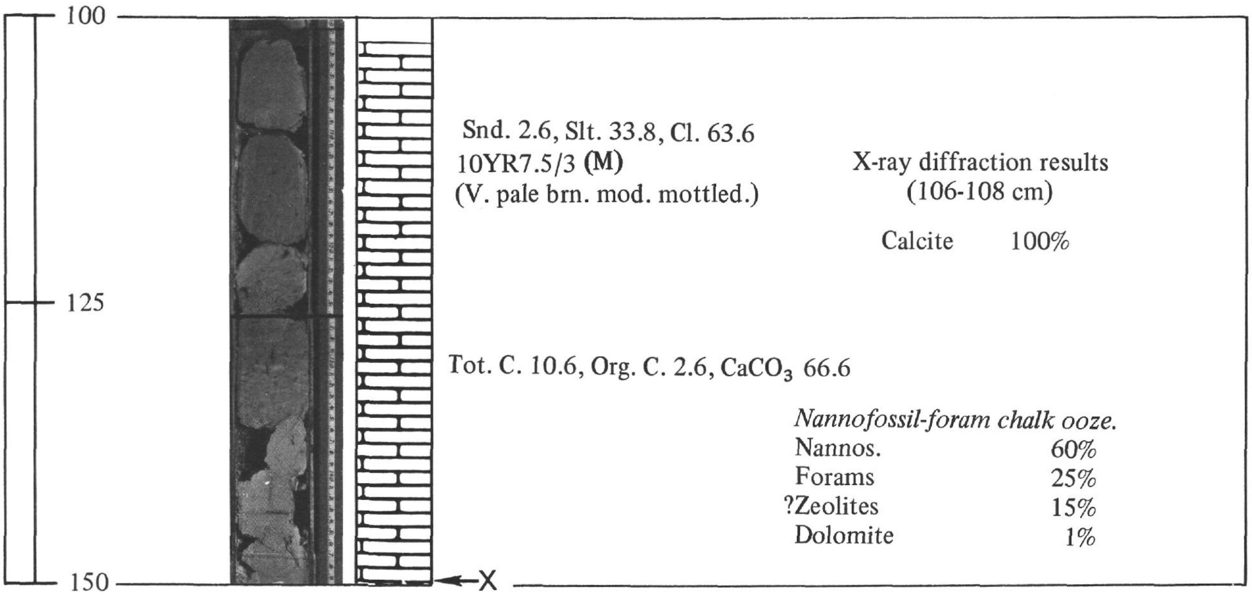


Figure 64. *Hole 10 Core 15 Section 1.*

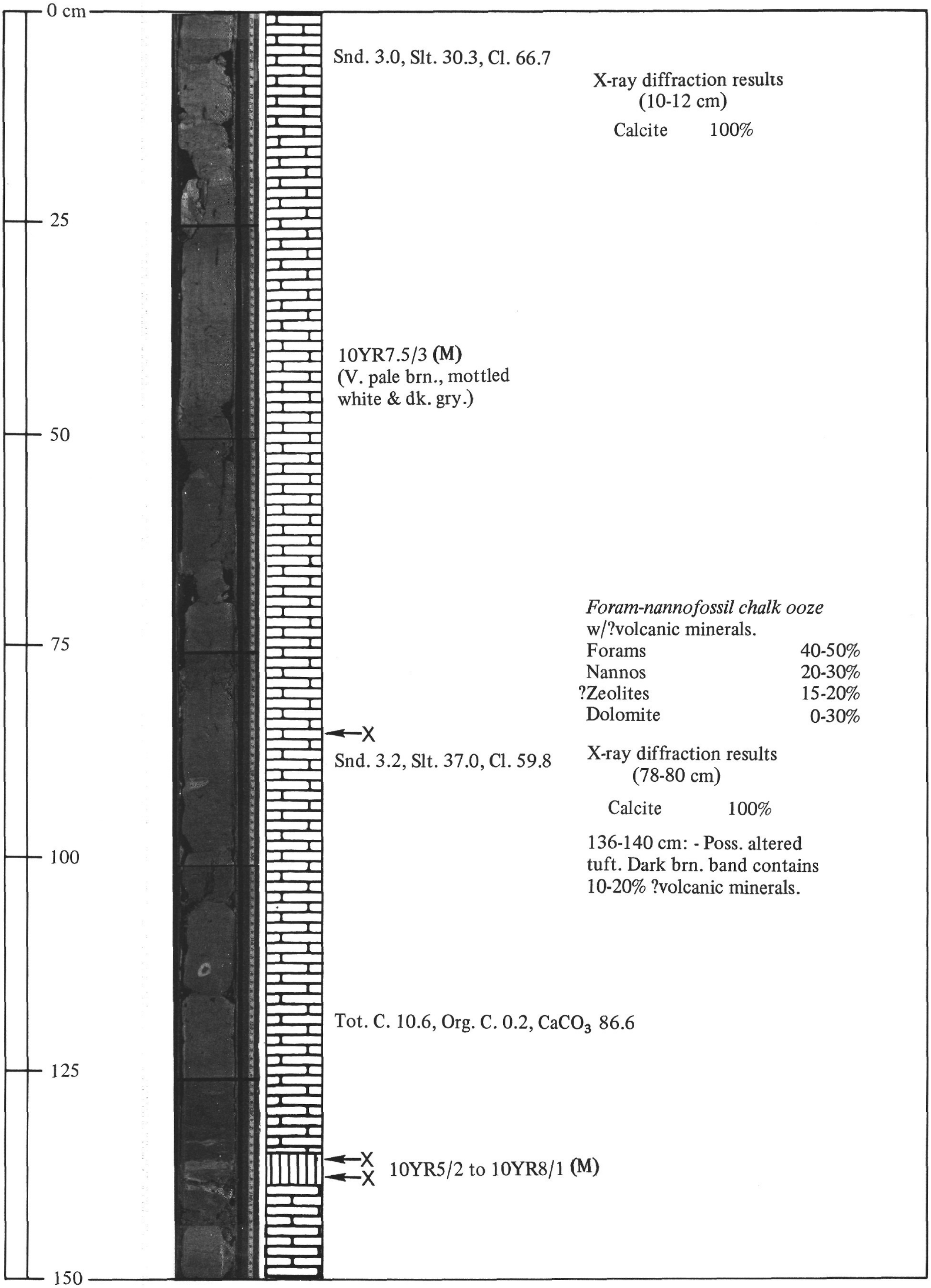


Figure 65. *Hole 10 Core 15 Section 2.*

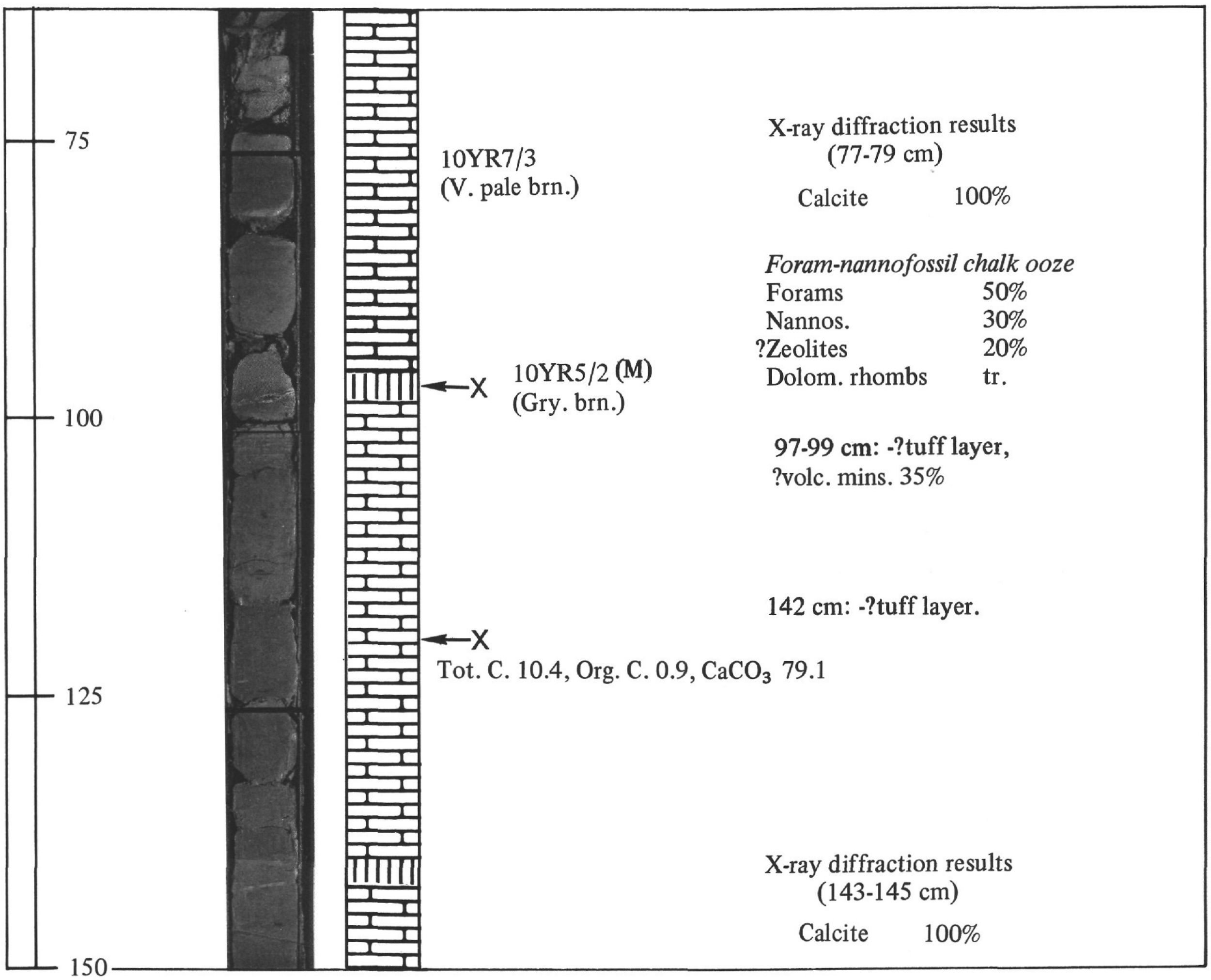


Figure 66. *Hole 10 Core 16 Section 1.*

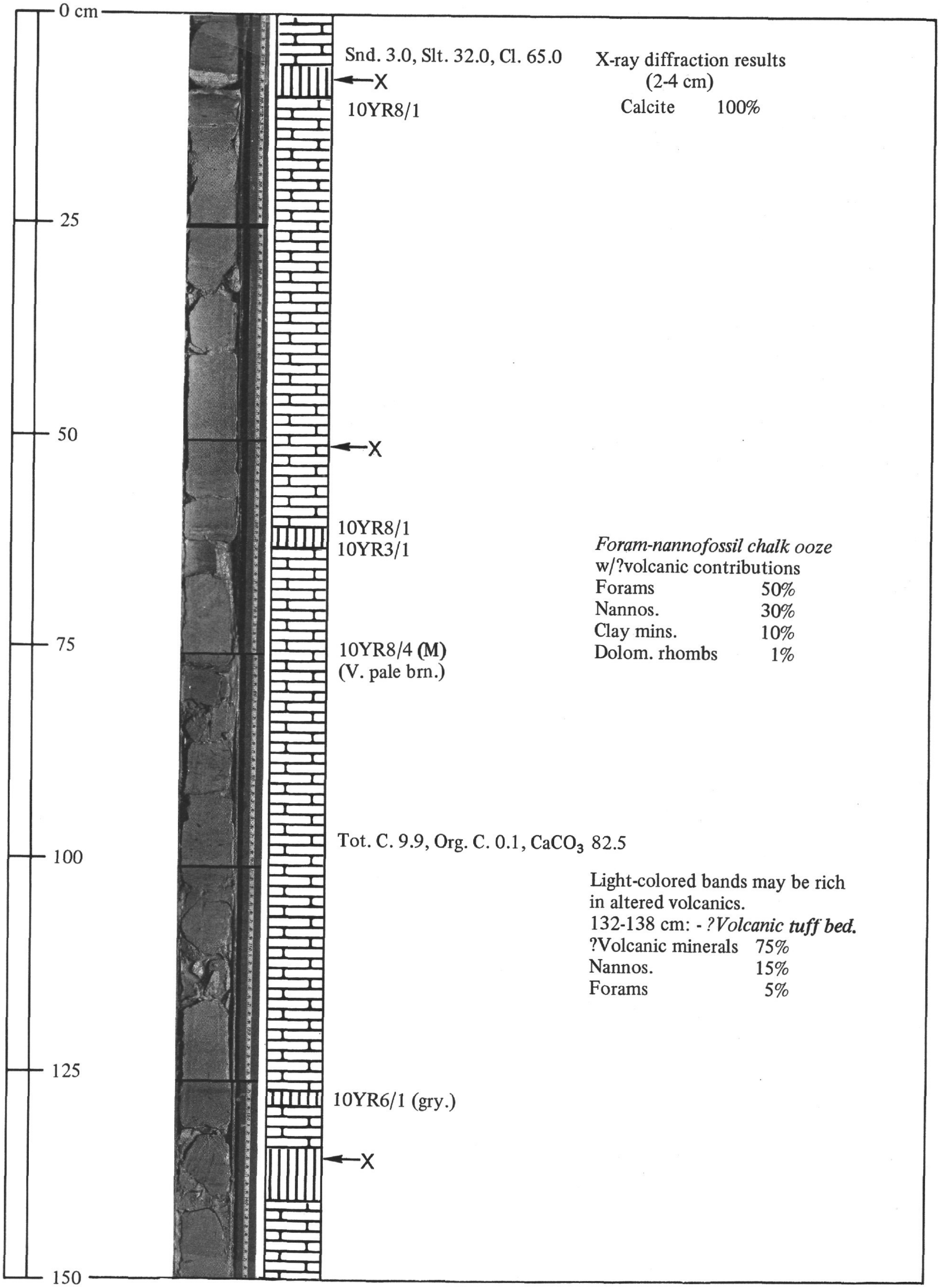


Figure 67. *Hole 10 Core 16 Section 2.*

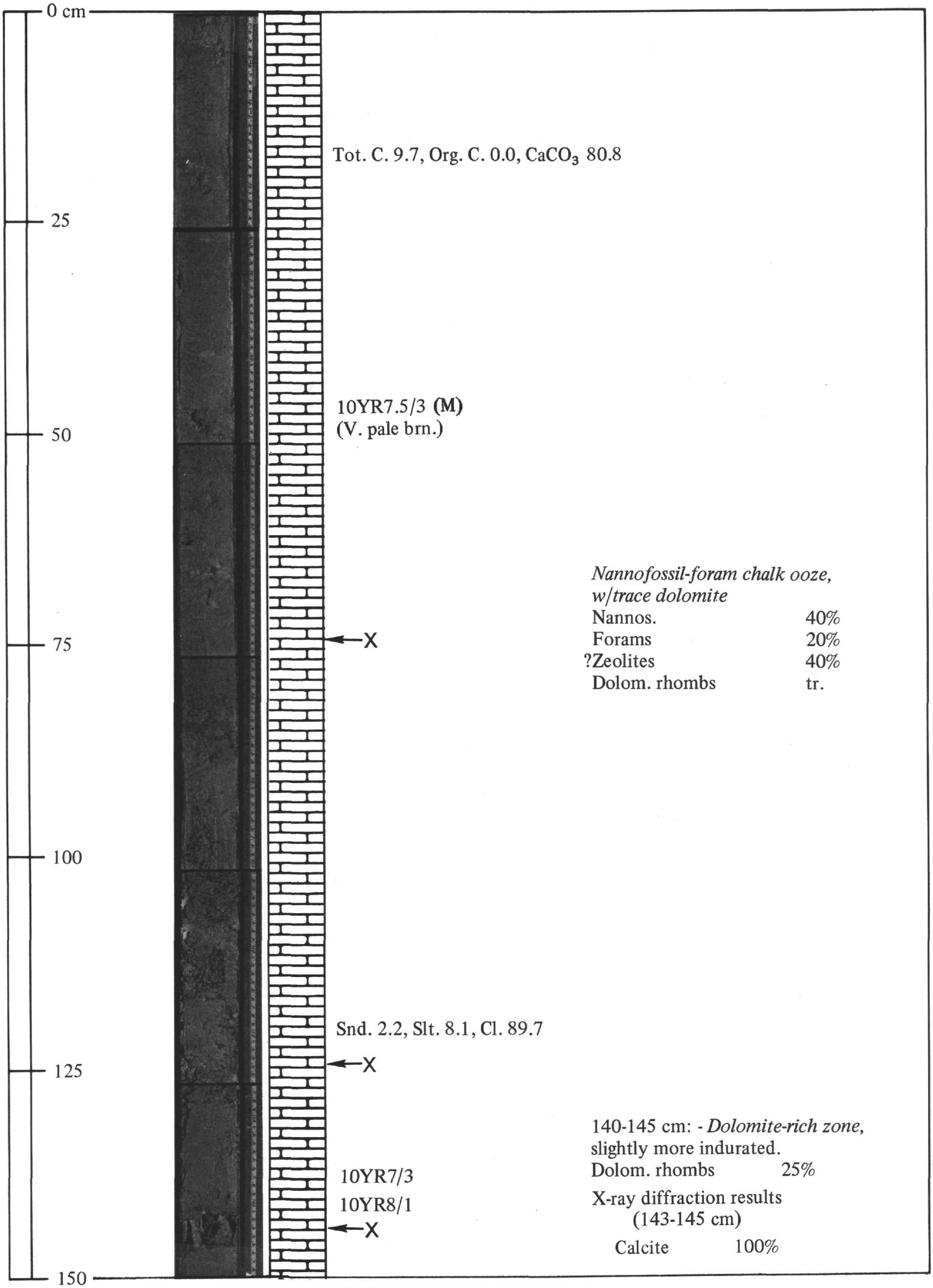


Figure 68. *Hole 10 Core 16 Section 3.*

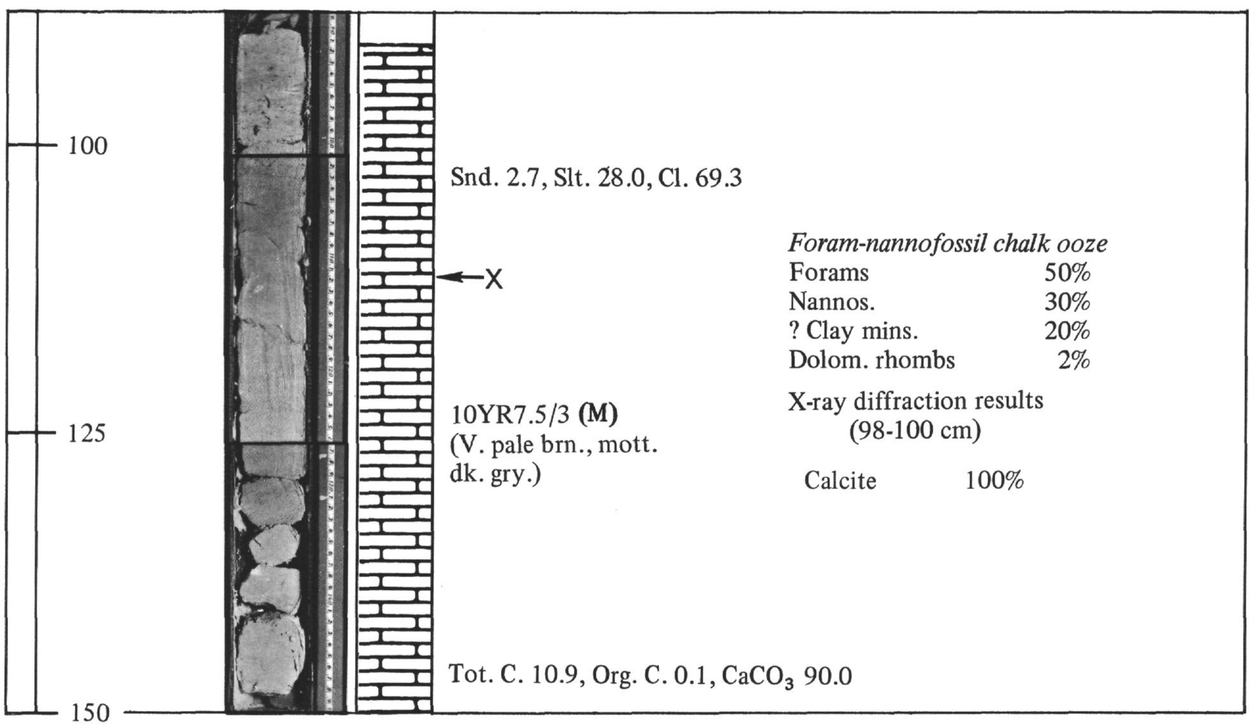


Figure 69. *Hole 10 Core 17 Section 1.*

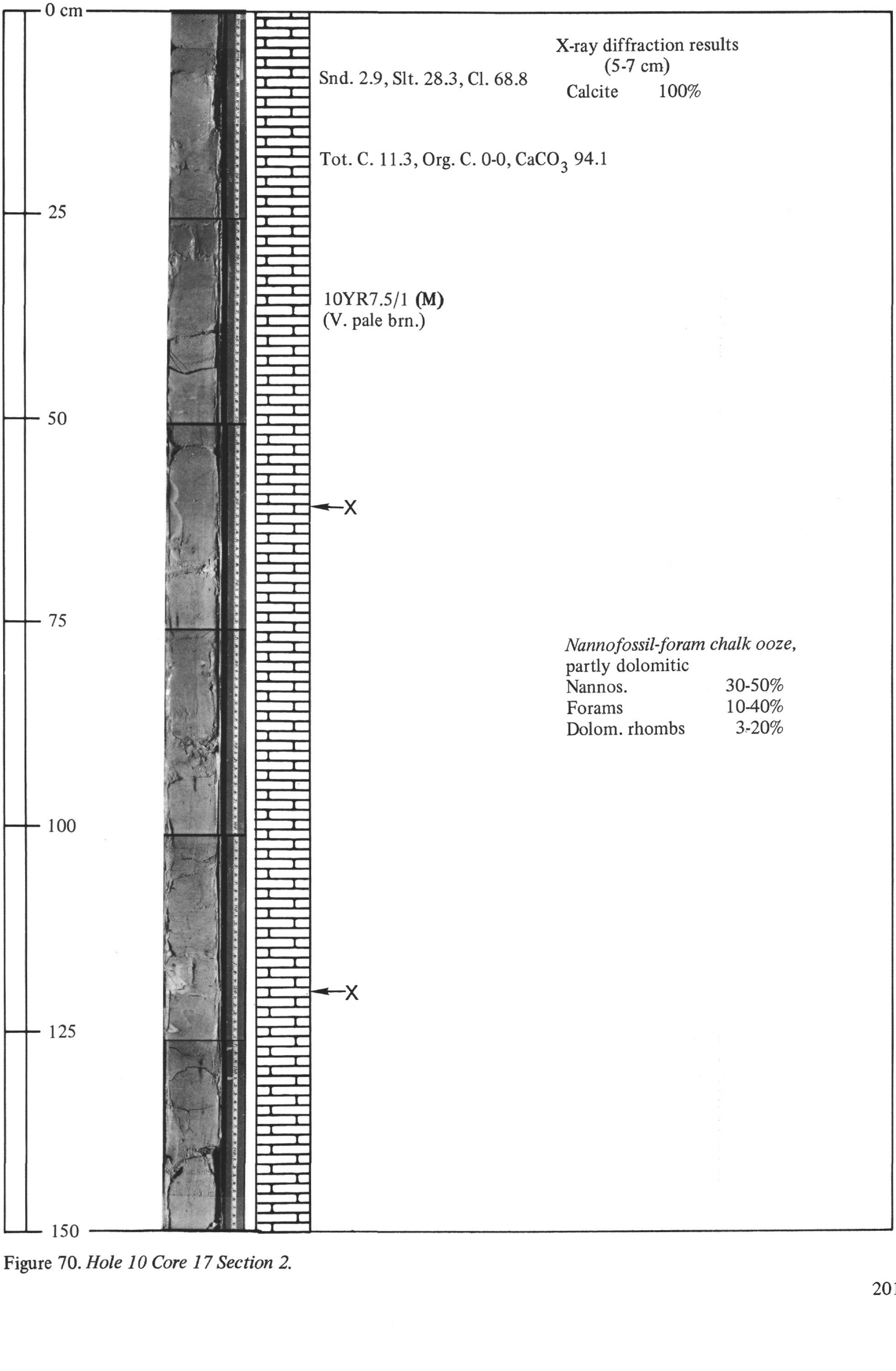


Figure 70. *Hole 10 Core 17 Section 2.*

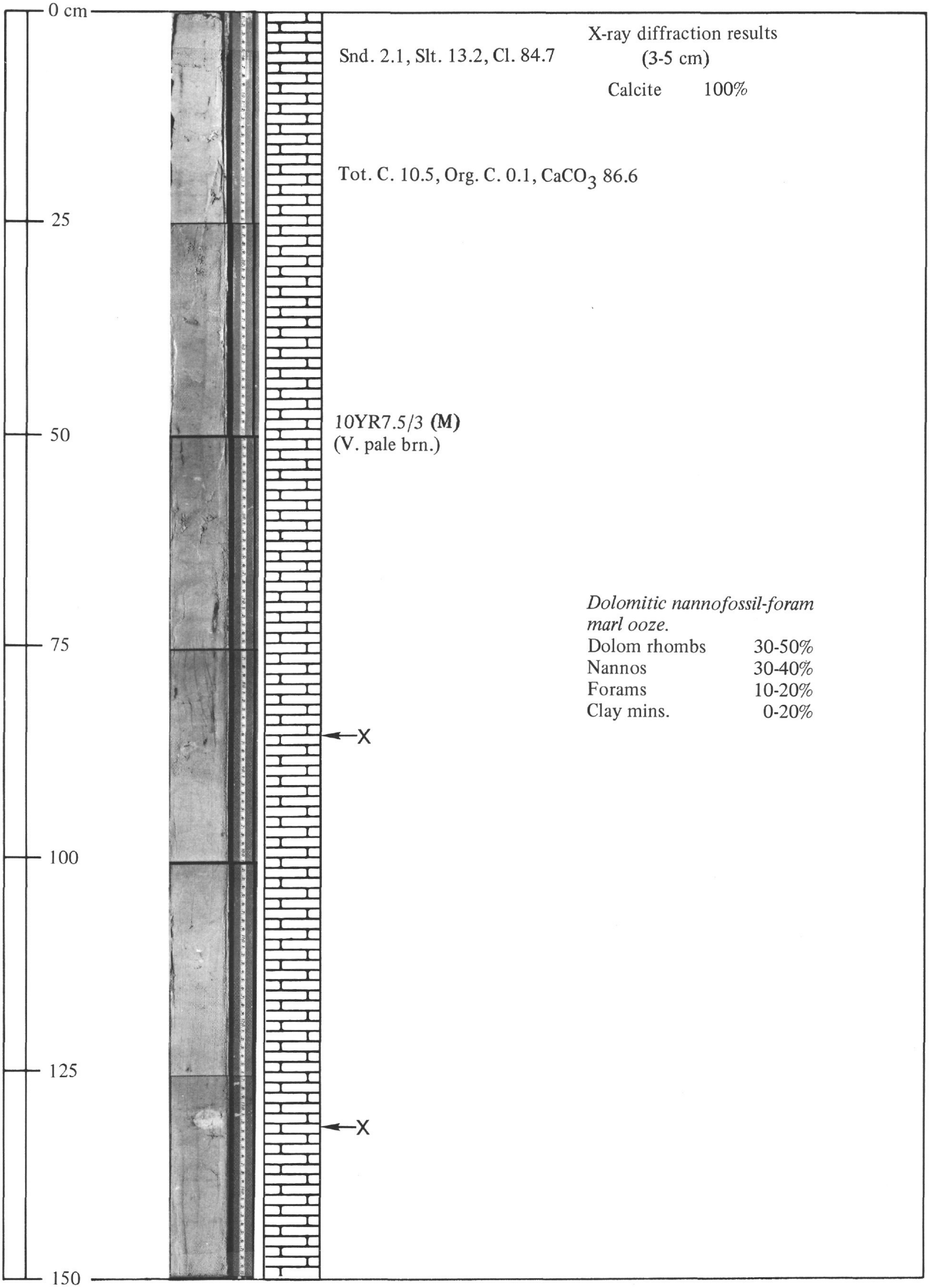
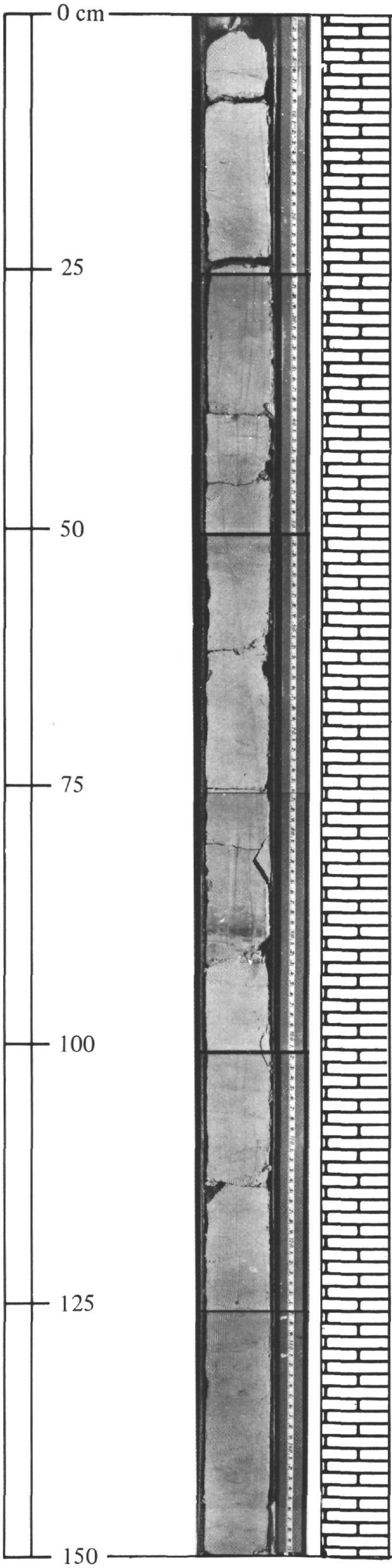


Figure 71. *Hole 10 Core 17 Section 3.*



Tot. C. 10.9, Org. C. 0.1, $CaCO_3$ 89.1
Snd. 2.4, Slt. 24.0, Cl. 73.6

X-ray diffraction results
(14-16 cm)

Calcite	100%

10YR8/3 **(M)**
(V. pale brn).

10YR5/1 **(M)**
(Gry; mottled)

Nannofossil-foram chalk ooze, dolomitic, w/local ? volcanic contributions.

Nannos.	40-70%
Forams	10-50%
Dolom. rhombs	3-10%

X-ray diffraction results
(73-75 cm)

Calcite	100%

85-90 cm:– *Layer enriched in ? volc. mins.*

Nannos.	70%
Clay mins.	15%
Forams	10%
Dolom. rhombs	3%
Opaques	3%

Figure 72. *Hole 10 Core 18 Section 1.*

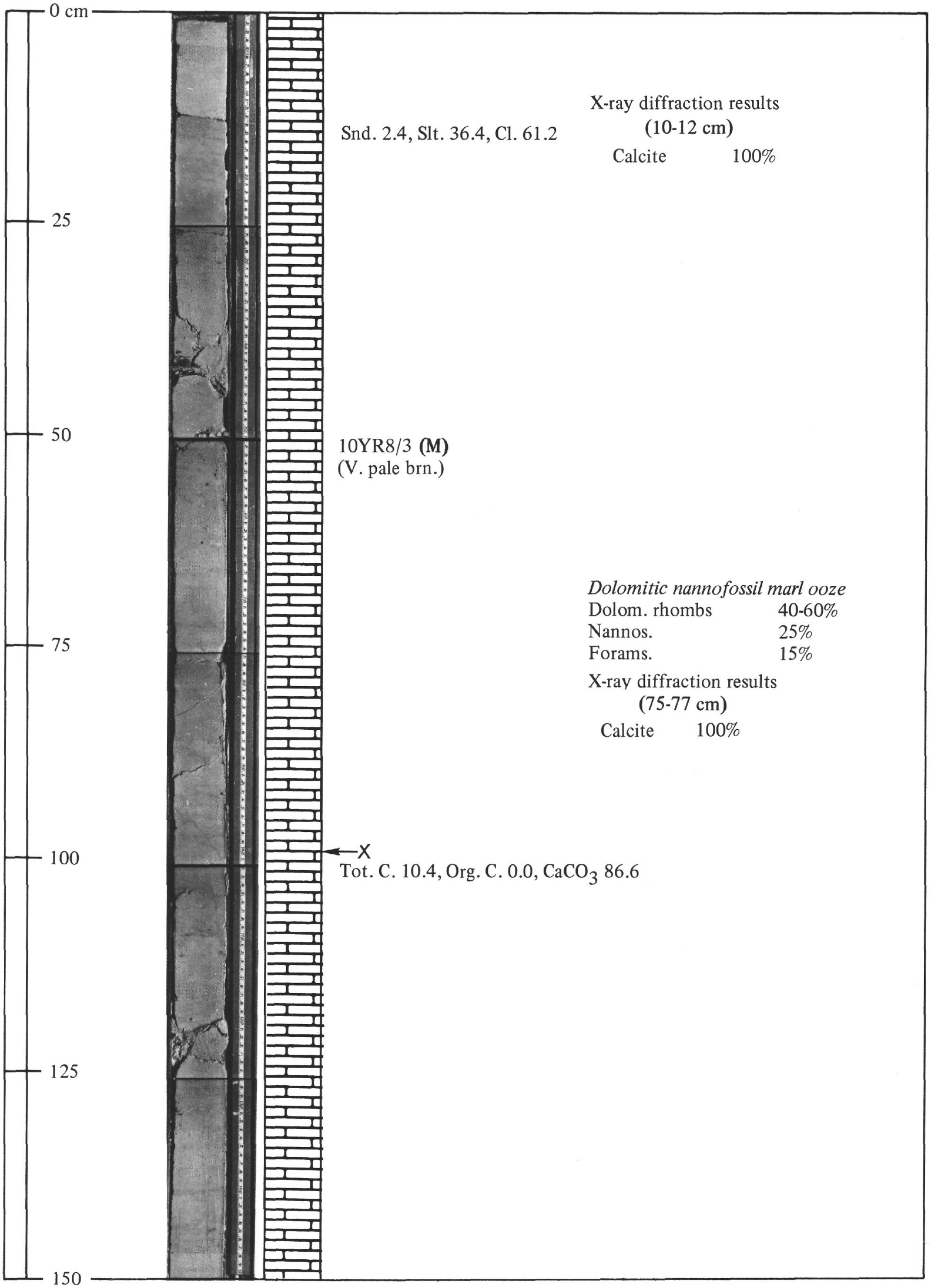


Figure 73. *Hole 10 Core 18 Section 2.*

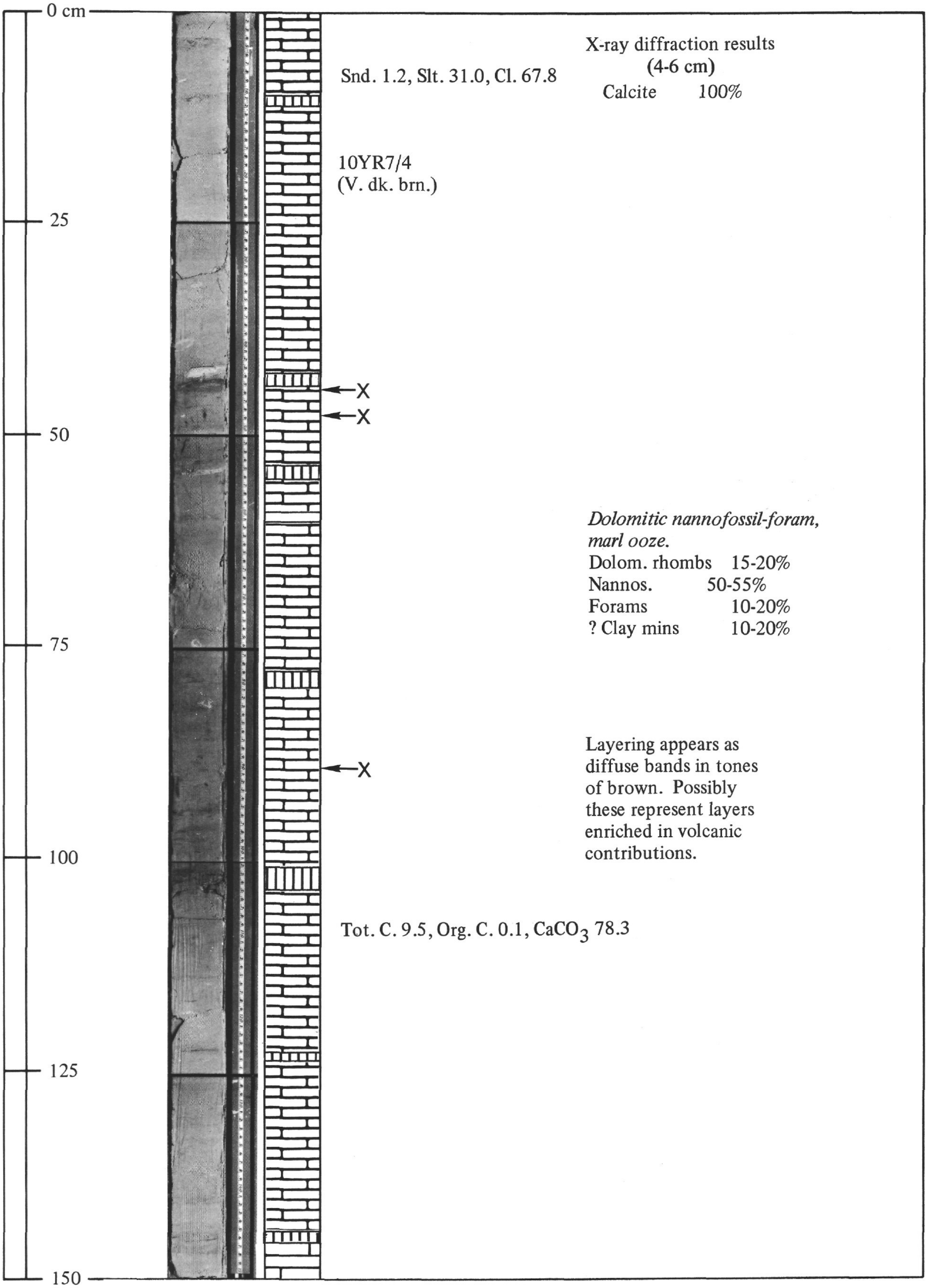
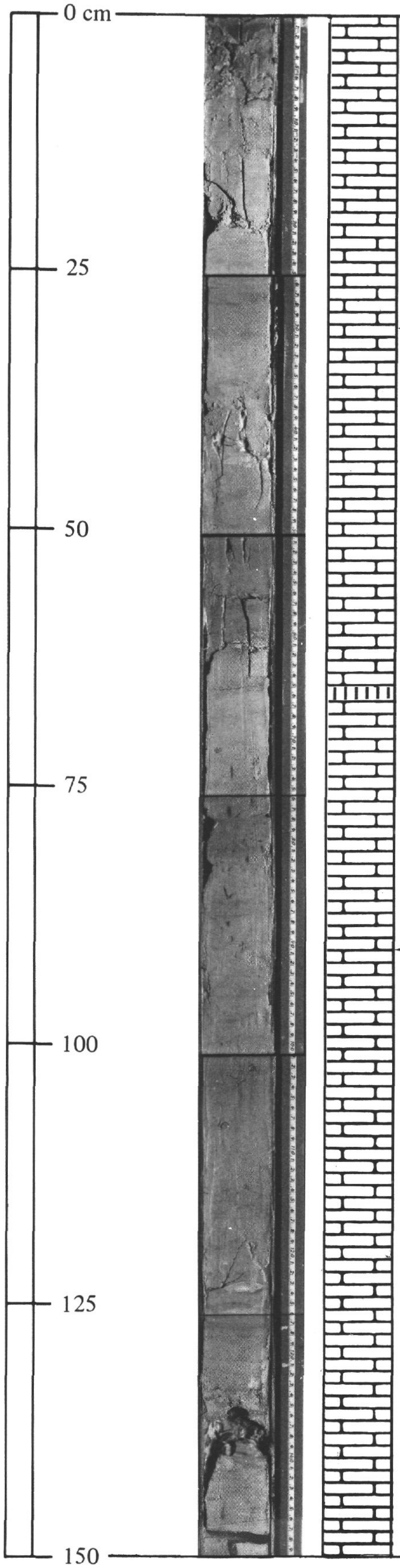


Figure 74. *Hole 10 Core 18 Section 3.*



X-ray diffraction results
(13-15 cm)

Calcite	100%

Snd. 1.8, Slt. 28.0, Cl. 70.2

Tot. C. 10.8, Org. C. 0.0, $CaCO_3$ 90.0.

←X

10YR7-5/3 **(M)**
(V. pale brn.)

Dolomitic nannofossil-foram chalk ooze.

Nannos.	70%
Dolom. rhombs	15%
Clay mins.	15%
Forams	10%

10YR 5/1 **(M)**

Darker-toned diffuse layers possibly enriched in volcanic contributions.

←X

Figure 75. *Hole 10 Core 18 Section 4.*

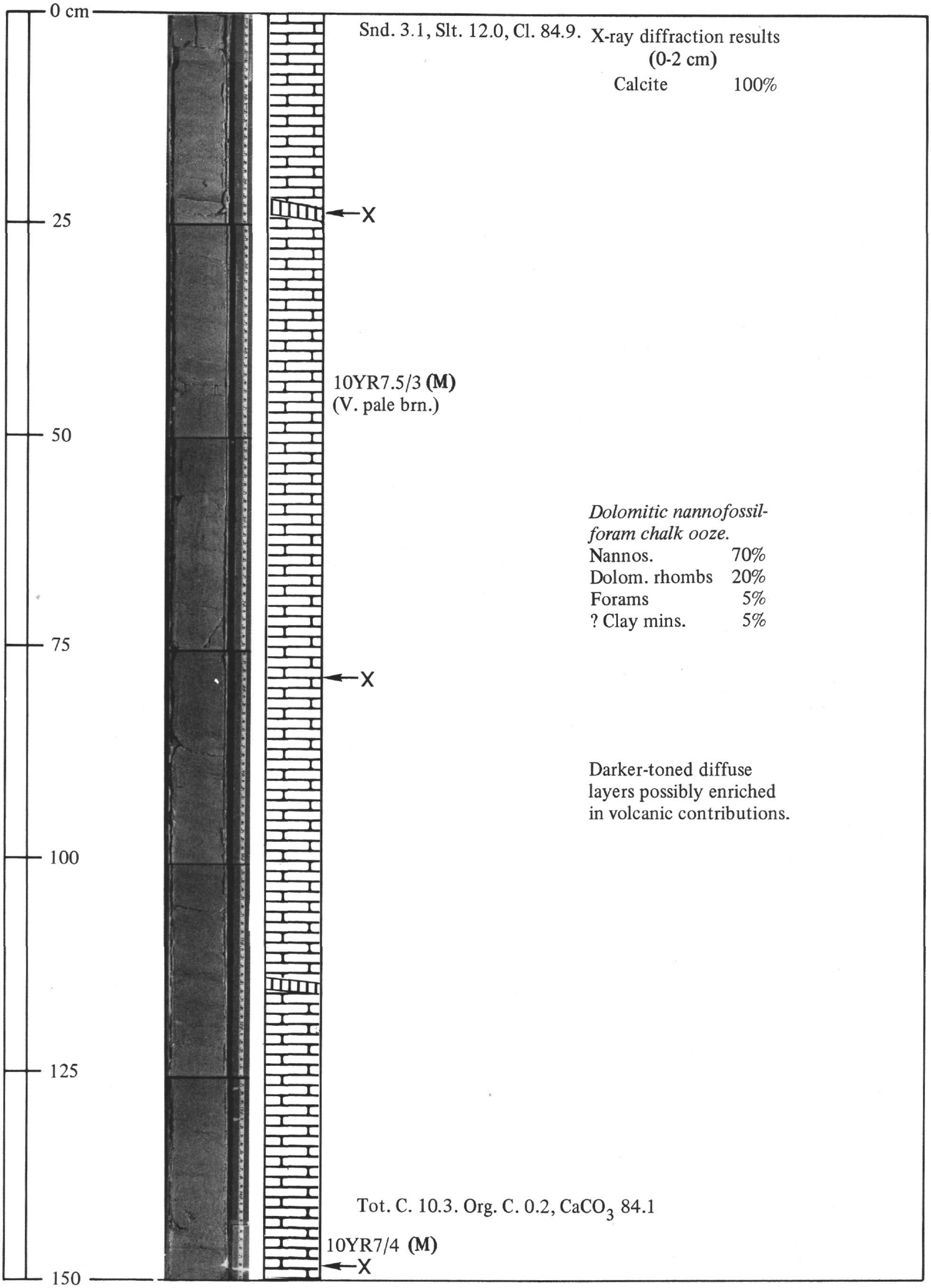
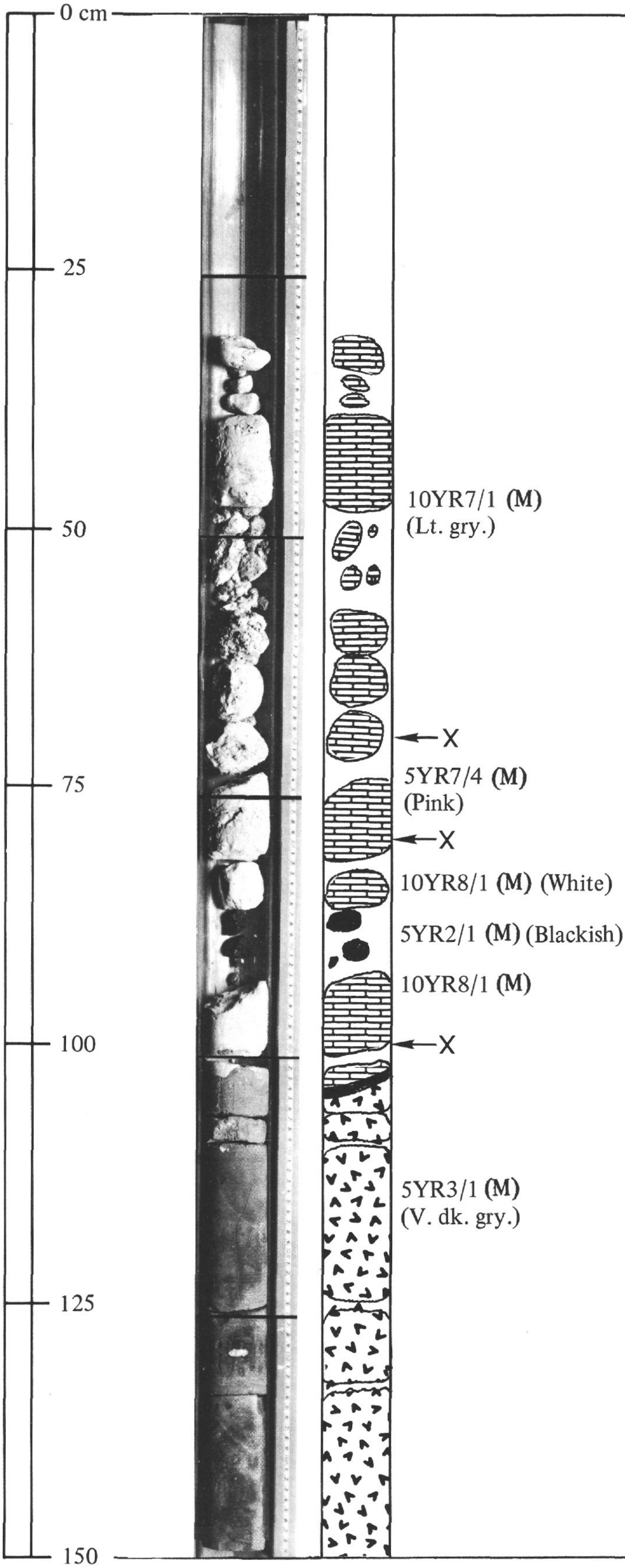


Figure 76. *Hole 10 Core 18 Section 5.*



30-73 cm: – *Nannofossil ooze,* unconsolidated. Glass fragment at base

73-83 cm: – *Indurated carbonate.*

83-86 cm: – *Cherty material* associated w/glass.

86-94 cm: – Glass fragments

94-101 cm: – *Indurated carbonate,* marble-like, separated by thin glass layer from underlying basalt.

101-150 cm: – *Basalt,* vesicular, coarse texture.

Figure 77. *Hole 10 Core 19 Section 1.*

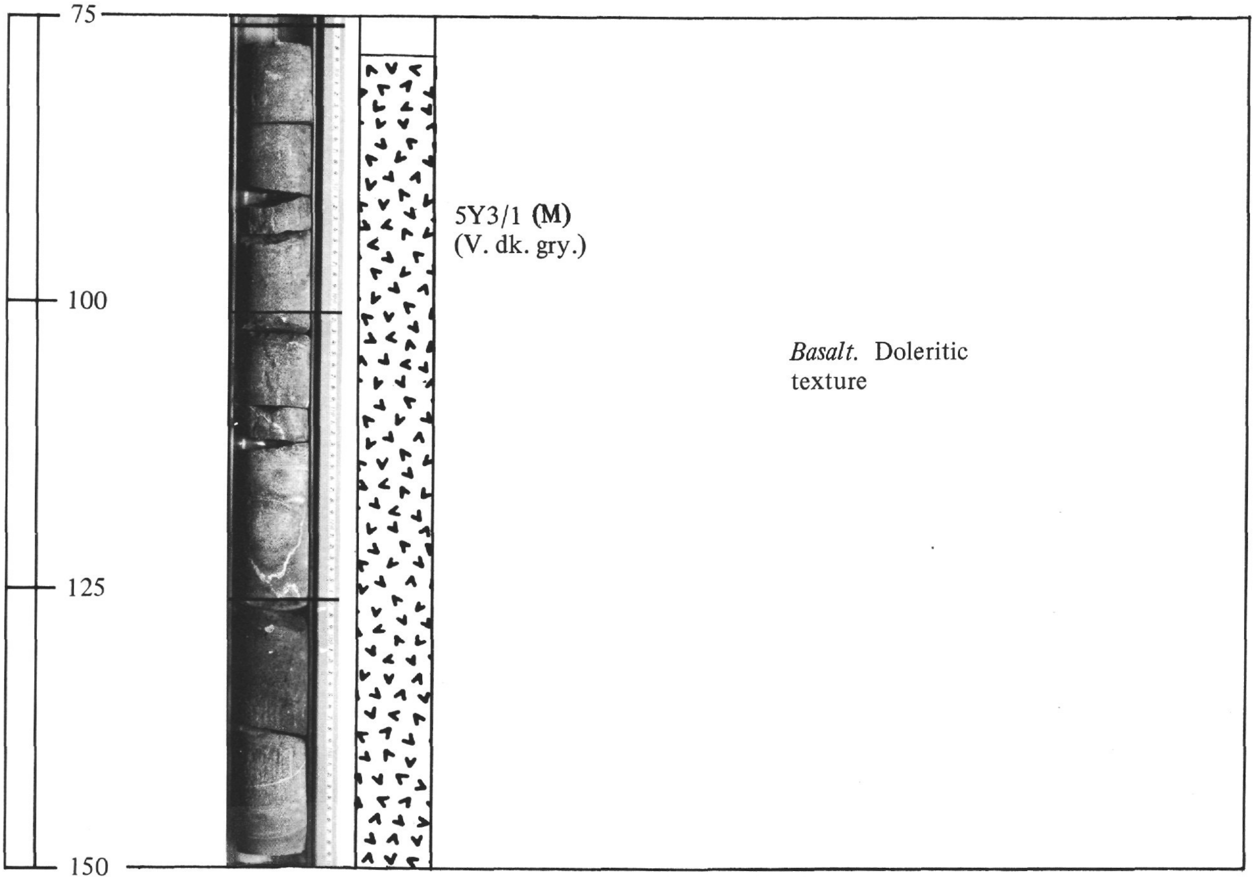


Figure 78. *Hole 10 Core 20 Section 1.*

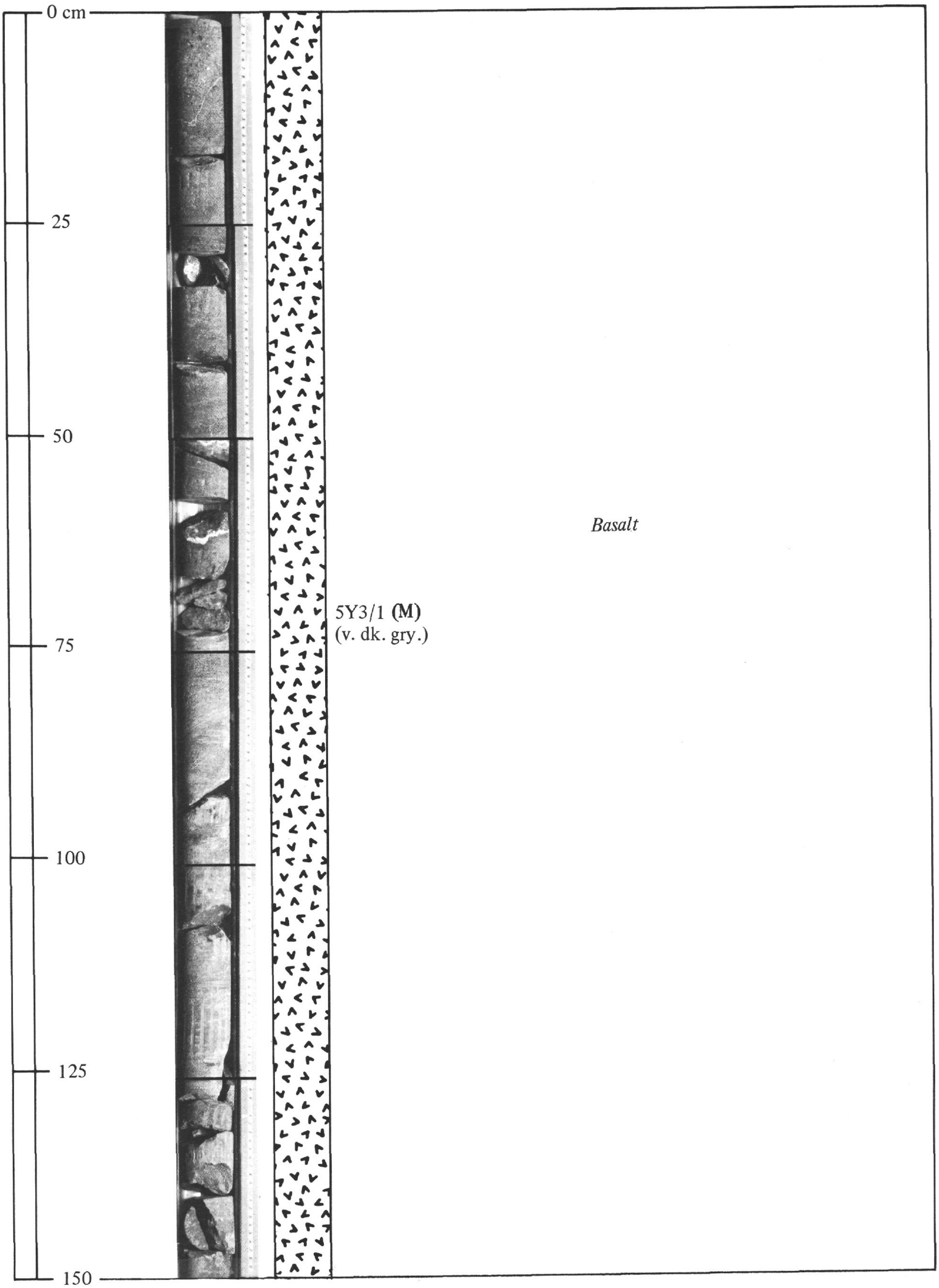


Figure 79. *Hole 10 Core 20 Section 2.*

Lithology

At Site 10, a total of 250 feet (76.2 meters) of sediment was recovered from about 100 feet below the ocean floor down to basement. Sediments of two types were present: the first, a nannofossil-foraminiferal chalk ooze; and, the second, a deep-sea clay commonly containing minor but varying amounts of nannofossils and foraminifera. The clay occurs in only one interval between 133 and 158 feet (40.5 and 48.1 meters), separating the remaining calcareous section into an Upper Pliocene-Pleistocene unit and an underlying Oligocene to Cretaceous unit. This sediment, which was dated from interbedded calcareous material, is predominantly Miocene with the lowest part being Oligocene. The uppermost 420 feet (128 meters) of the lower sequence of nannofossil-foraminiferal ooze contain significant amounts of phillipsite. Radiolaria of Lower Eocene Age, occur between 578 and 608 feet (176 and 185 meters). At least one thin chert horizon is associated with this interval. From a depth of 1000 feet (305 meters) down to basement, the incidence of thin volcanic tuff layers with volcanic minerals increases. Small scattered dolomite rhombs increase in abundance downward. The basement is a vesicular diabasic rock with a chilled glassy upper margin. A thin contact zone of carbonate sediment that has been recrystallized to marble separates the igneous rock from overlying, essentially unaltered, dolomitic nannofossil-foraminiferal ooze.

In general, the calcareous ooze varies from pale brown to grey-white. The clayey sediments contrast by being yellow-brown, brown, and dark brown.

The clays vary in composition. Some zones are composed entirely of zeolite and clay. Other zones are composed of clays admixed with calcareous microfossils. The clay sequence is typified by dark brown, clay-rich zones interbedded with pale brown, nannofossil-rich layers, generally separated by gradational boundaries. The dark brown pigment appears to be due to abundant translucent, dark red ferruginous particles in the clay-size range.

Volcanic contributions, which occur within the lowermost portion of the sediment column, are present either as thin discrete layers or are disseminated throughout the carbonate ooze. The layers are generally of the order of 2 to 5 centimeters in thickness and may be dark to light brown. Glass shards are not common, but scattered feldspar crystals occur within aggregates of minerals that may be, at least in part, altered volcanic debris.

Dolomite rhombs, averaging 12 microns in size, occur scattered throughout the nannofossil-foraminiferal ooze within the zone containing appreciable volcanic material. The proportion of dolomite increases irregularly with depth, from less than 1 per cent at a depth of 1000 feet (305 meters) to a very substantial fraction of the approximately 10 micron size fraction near basement.

The glassy upper portion of the volcanic basement lies in direct contact with a layer of white marble about 12 centimeters thick. Fragments of glass several centimeters across were recovered above this white marble, followed by a seven centimeter zone of pink, semi-indurated carbonate. Above this an unconsolidated, light grey, dolomitic, coccolithic-chalk ooze occurs which contains glass fragments at the base. The white marble and pink semi-indurated zones are associated with basaltic glass.

Physical Measurements

Ship Laboratory Measurements

Natural Gamma-Radiation

Gamma-ray activity was found to be high in sediments containing phillipsite and is considered to be a sensitive indicator of its presence. Small peaks, counting at a single 3 inch interval, correspond in several instances to visible layers containing volcanic debris. The gamma-ray activity of the Cretaceous pure-carbonate ooze was scarcely above background. The underlying basement basalts have appreciable gamma-ray activity which probably derives from the potassium-bearing minerals, some of which are alteration products.

X-Radiography

The X-ray exposure time for core sections of Site 10 systematically followed the density trend—with denser sections causing longer exposure times. The radiographs show the extent and concentrations of the volcanic layers in the lower part of the hole.

Gamma Radiation Attenuation Porosity Evaluator (GRAPE)

At this site, the usual increase in density downward by compaction is overshadowed by variations in the lithology in certain intervals. Highly calcareous oozes were found, according to the GRAPE, to have high densities and low porosities. By comparison, clays from similar depths have distinctly low densities. Radiolarian-rich sediments have the lowest densities in the sediments measured, except where they are silicified to chert.

Characteristic values, sequentially downward, are: The upper 133 feet (40.5 meters) of calcareous chalk ooze have densities up to 1.70 gm/cc and 60 per cent porosity. The intermediate layer of clay between 133 and 158 feet (40.5 and 48.2 meters) has a density range of 1.43 to 1.56 gm/cc and a porosity of about 70 per cent. The calcareous and slightly zeolitic sediments down to 324 feet (98.8 meters) are very similar to the upper calcareous oozes, but have densities ranging up to 1.73 gm/cc and porosities down to 50 to 55 per cent. The radiolarian-rich sediments near 600 feet (182.9 meters) have densities in the range of 1.35 to 1.58 gm/cc and porosities of 65 to 70 per cent. For the underlying carbonate sediment, there is a general increase in density with core depth. The maximum density range is 2.1 to 2.2 cm/cc., porosity ranges from 20 to 30 per cent. As a precaution, the samples of basement were not exposed to ionizing radiation in either the GRAPE or the X-ray radiography.

Penetrometer

Penetrometer measurements of sediment rigidity did not show a systematic increase with sediment depth, as was the case at other sites. This was due to the unusually soft Cretaceous carbonate sediments which occur at depth at Site 10.

Sonic Velocity

Sonic velocity measured directly on the cores yielded an average of about 1.56 km/sec. This compares unfavorably with 1.83 calculated from seismic profiling and drilling. This difference is probably too great to be accounted for by the effects of pressure. A more plausible explanation is disturbance of the core material during coring. It is also possible that velocities measured in the laboratory parallel to bedding may differ from values obtained vertically. Velocity measurements in the upper several hundred feet were consistent and reasonable. At greater depths, sonic velocity varies from quite high to quite low within a short depth range and in sediments of similar lithology. Throughout much of the Cretaceous carbonate section the sediment has a texture that is easily and irreversible destroyed by physically disturbing the sediment. It is very likely that the act of coring may have partially destroyed this micro-texture, which may be due to incipient cementation. A single section near the bottom yielded a sonic velocity of up to 2.13 km/sec. It may be that the incipient cementation in this zone close to the basalt was sufficient to buttress the sediment against serious deformation during coring so that its sound transmission properties were not affected. Calculations based on this highest value at the base of the Cretaceous carbonates yield an average sonic velocity, uncorrected for pressure, of about 1.70 km/sec for the entire section. This value appears to conform more closely to the *in situ* measurement.

Down-Hole Logging

Logging plans called for: in-pipe interval velocity and open-hole qualitative density, electric and natural gamma-ray measurements.

The interval velocity phones were suspended in the pipe at a depth of 3280 feet (1000 meters) beneath the ship where the system was tested using a 20 cubic-inch air gun source. No recognizable signal was noted on the records. Similar tests were made at 4920 feet (1500 meters), 6560 feet (2000 meters) and 8200 feet (2500 meters) without success. The interval velocity system failed because the hydrophones did not appear to be sufficiently sensitive to record the air gun signal, although they may be capable of recording a signal from a substantially more powerful source, such as, explosives, which are not permitted to be shot from the drilling vessel. No attempt was made to dampen hydrophone motion in the pipe, although large amplitude noise noted on the records probably resulted from a direct coupling with the ship's motion. This system does not seem to be designed to receive the relatively weak signals commonly employed in standard oceanographic seismic techniques and is, therefore, not suited for use with the air gun. The records have been preserved for future detailed analysis.

The open-hole measurements were even less successful. Considerable difficulty was experienced in passing the sonde through the bit. Once through the bit all signals were lost immediately; the system became stuck and the cable parted at the crown block sheave at a tension of under 9000 pounds. The 17,000 feet (5182 meters) of cable and the sonde were lost. The gamma-ray, neutron and sonic velocity tools were not operative at this time.

Paleontology and Biostratigraphy - Summary

Nannofossils	Foraminifera
Hole 10, Core 1: The core catcher of Core 1 yielded abundant nannofossils indicating early Pliocene or possibly latest Miocene (Messinian) Age. The assemblage is characterized by *Reticulofenestra pseudoumbilica, Sphenolithus abies, Ceratolithus tricorniculatus, Discoaster brouweri, D. pentaradiatus* and *D. surculus.* At the top, Core 1 is considerably younger–probably late Pliocene–the nannofossil assemblage being characterized by *Discoaster pentaradiatus, D. brouweri, D. surculus, Ceratolithus rugosus* and cf. *Cyclococcolithus cricotus.*	Hole 10, Core 1: Foraminifera, mostly planktonic, are abundant in Core 1 and were studied in some detail. They indicate a probable middle Pliocene Age for the upper part of the core (Section 1, in part), a Lower Pliocene Age for the lower part of Section 1 and for Section 2. These age assignments are based on the occurrence of *Globorotalia multicamerata* and *Globoquadrina altispira altispira* and *G. altispira globosa* throughout the core; of *Globigerina nepenthes* and *Sphaeroidinellopsis seminulina* (in Section 2) and *Sphaeroidinella dehiscens forma immatura* (in Section 2 and the lower part of Section 1). The great abundance of *Sphaeroidinellopsis* at the base of the core suggests a lowermost Pliocene Age. Reference is made to Zone N.19 of Blow for Section 2 and the lower part of Section 1, and to the upper part of Zone N. 19 (or Zone N.20?) of Blow for the upper part of Section 1. Benthonic foraminifera are scarce and some of them are probably displaced (single specimens of *Quinqueloculina* with corroded test).
Hole 10, Core 2: The core catcher sample of Core 2 yielded abundant nannofossils of probably upper Oligocene or possibly basal Miocene Age. The assemblage is dominated by *Coccolithus neogammation* and *Discoaster* sp. cf. *D. druggi.* Also present are *Sphenolithus ciperoensis, S. moriformis* and questionable *Triquetrorhabdulus carinatus.* At the top, Core 2 contains characteristic Lower Pliocene nannofossils, apparently transitional to Upper Miocene (Messinian) near the base of Core 1, Section 1; Upper Miocene (basal Tortonian) near the top of Core 2; and mixed Upper, Middle and Lower Miocene throughout most of the remainder of Core 2. Most Miocene index species are lacking, however, it is apparent that some Middle and Lower Miocene sediments are present. Doubtless there also are gaps in sedimentation and a considerable amount of vertical mixing, possibly caused by caving during the coring operation.	Hole 10, Core 2: All the samples studied from Core 2 are to some degree contaminated with Pleistocene and sub-Recent material, particularly the topmost sample. In Section 1 the planktonic fauna indicates an uppermost Miocene Age, near the Miocene-Pliocene boundary, with *Sphaeroidinellopsis seminulina, Globigerina nepenthes, Sphaeroidinellopsis subdehiscens* etc. In Section 2 samples are poor in foraminifera, but contain abundant fish debris and fish teeth, and many broken tests of planktonic foraminifera. The assemblages indicate a probable Upper Miocene Age *(Sphaeroidinellopsis seminulina, S. subdeniscens, Globigerina nepenthes,* etc.). The top of Section 3, of which the planktonic foraminiferal fauna is dominated by *Globoquadrina dehiscens* and appears strongly affected by dissolution, is probably Middle Miocene in age. Lower in Section 3 and in Section 4, samples yielded poor planktonic faunas with *Globigerina venezuelana, Globorotalia opima nana,* some atypical *Globigerina rohri,* abundant *Globigerinita unicava* and *G. dissimilis* which indicate a probable upper Oligocene (pre-*Globigerinoides* datum) age, but do not allow a precise age determination. According to foraminiferal evidence, the Miocene is practically absent at Hole 10 with an important gap, which may be located in Core 2, that is Oligocene in its lower part and topmost Miocene in its upper part.

Nannofossils	Foraminifera
Hole 10, Core 3: The core catcher sample and most of Core 3 contain a monotonous and generalized nannoflora of Oligocene Age, and are dominated by *Coccolithus neogammation,* generalized asteroliths, *Sphenolithus moriformis* and *Coccolithus pelagicus–eopelagicus* types. Also present are rare specimens of *Sphenolithus ciperoensis, S. predistentus, S. radians, Reticulofenestra scissura,* and *R. umbilica.*	Hole 10, Core 3: The foraminiferal fauna is very poor in the core catcher of Core 3 and the planktonic forms are strongly subordinate to the benthonics, which are diversified with many genera and species present but without great stratigraphic significance. Fish teeth and various fish debris are also abundant. The species *Globigerinita unicava, G. dissimilis, Globorotaloides suteri, Globigerina venezuelana, G. rohri* (below its usual size) indicate an Oligocene Age.
Hole 10, Core 4: The core catcher and all core material of Core 4 was lost. A smear slide made from inside the core barrel contained *Coccolithus neogammation, Sphenolithus moriformis,* generalized asteroliths, and large *Coccolithus eopelagicus.* This should be noted as the first instance where the sample recovered was insufficient for an age determination with nannofossils.	Hole 10, Core 4: Insufficient material for foraminiferal examination.
Hole 10, Core 5: The core catcher sample of Core 5 yielded a rich Upper Eocene nannoflora characterized by *Discoaster saipanensis, D. barbadiensis, D. tani tani, Reticulofenestra umbilica, Helicopontosphaera compacta, R. scissura, Cyclococcolithus orbis, Bramletteius serraculoides* and *Isthmolithus recurvus.* At the top, Core 5 contains an Oligocene nannoflora; and, the Oligocene-Eocene boundary is at the top of Section 5 of Core 5, marked by the last occurrence of *Discoaster saipanensis* and *D. barbadiensis. Isthmolithus recurvus* and *Bramletteius serraculoides* persist upwards into Core 4 (see Appendix: discussion of Eocene-Oligocene boundary).	Hole 10, Core 5: All the washed residues of Core 5 are very small. Samples were taken where the sediment was relatively light in color, but the content in planktonic foraminifera is highly variable. In Section 1 some specimens referable to *Globorotalia opima* suggest a middle Oligocene Age (*Globorotalia opima* Zone?). In Section 3 the presence of *Globigerina ampliapertura, G.* cf. *tapuriensis, G. tripartita, G. rohri, Globigerinita dissimilis, G. unicava* suggest a lower Oligocene Age—with the possible condensation of two zones. Since the planktonic foraminifera are scarce and not well preserved, no precise age determination is possible.
Hole 10, Core 6: The core catcher of Core 6 yielded a rich Upper Eocene nannoflora very similar to that found in the core catcher of Core 5.	Hole 10, Core 6: Insufficient material for foraminiferal examination.
Hole 10, Core 7: The core catcher of Core 7 yielded an uppermost Middle Eocene to Upper Eocene nannoflora characterized by *Reticulofenestra scissura, R. umbilica, Discoaster barbadiensis, D. saipanensis,* cf. *D. tani tani, Bramletteius serraculoides, Cyclococcolithus orbis* and cf. *Isthmolithus recurvus.*	Hole 10, Core 7: The core catcher of Core 7 yielded a poorly preserved fauna with abundant benthonic foraminifera, fish debris and planktonic foraminifera. The planktonic assemblage is unusually poor and most of the genera, such as *Globorotalia, Truncorotaloides, Hantkenina,* etc., which are common in the stratigraphic interval involved, are lacking. This notwithstanding the presence of an important zonal marker (*Porticulasphaera mexicana* vel *Orbulinoides beckmanni*) allows a precise age determination, since *O. beckmanni* is a total range zone indicating the upper part of the Middle Eocene. Also present are *Globigerapsis index, Globigerinita* sp. and numerous benthonic species with arenaceous as well as calcitic tests.

Nannofossils	Radiolaria
Hole 10, Core 8: The core catcher of Core 8 yielded a Lower Eocene nannoflora characterized by *Discoaster lodoensis, D. barbadiensis, Discoasteroides kupperi, Chiasmolithus grandis, Sphenolithus radians* and *Cruciplacolithus staurian.* At the top of Core 8 the same nannofossils were recorded. Hole 10, Core 9: The nannoflora from the core catcher sample of Core 9 is very similar to that obtained from Core 8 with the addition of a discoaster species similar to *Discoaster multiradiatus,* but with only 14 rays, and tentatively identified as *Discoaster salisburgensis.* The age of this level is Lower Eocene, probably *G. formosa formosa* or *Globorotalia aragonensis* Zone.	Hole 10, Core 8: The core catcher sample of Core 8 contains an abundant, well preserved Eocene radiolarian fauna, including *Podocyrtis papalis, Lynchnocanium bellum* and *Anthocyrtidium hispidum.* The absence of *Calocyclas turris* indicates a Lower to Middle Eocene age for the assemblage (see further paleontological notes). Hole 10, Core 9: Samples from throughout Core 9 contain an abundant and well-preserved radiolarian fauna of Lower to Middle Eocene Age (see further paleontological notes).
Hole 10, Core 10: The sediments recovered in Cores 10 to 19 contained a rich and varied Upper Cretaceous nannoflora. From the top of Core 10 the following species were identified: *Lithraphidites quadratus, Cribrosphaerella chrenbergi, Prediscosphaera Cretacea, P. spinosa, Arkhangelskiella cymbiformis, Microrhabdulus decoratus, Maslovella barnesae, Crebarhabdus conicus, Micula decussata, Eiffellithus turriseiffeli, Rhabdolithes regularis, Lithraphidites carniolensis, Kamptnerius* sp., *Tatralithus murus, Tertalithus aculeus, Cylindralithus gallicus, Zygodiscus pseudanthophorus, Microrhabdulus stradneri, Cretarhabdus? decorus* and *Rhabdolithina splendens.* The same species were also recorded from the core catcher of Core 10. *Lithrapidites quadratus* restricts this assemblage to the Maestrichtian. Cores 11 through 18 contain essentially the same assemblages except that *Lithrapidites quadratus, Cylindralithus gallicus* and *Tetralithus murus* are lacking, whereas *Arkhangelskiella parca, Tetralithus pyramidus* and a peculiar species of *Vekshinella* are present here but are lacking in Core 10. Core 19 contains most of the above but, significantly, is lacking *Rhabdolithina splendens* and *R. regularis.* These last two species are present in the Corsicana Marl and the upper part of the Taylor Marl in Texas, but are lacking near the base of the Taylor Marl (lower Campanian equivalent).	Hole 10, Core 10: Cores 10 through 18 yielded very rich and beautifully preserved Upper Cretaceous foraminiferal faunas which allowed precise age determinations. The topmost sample taken in Core 10 contains: *racemiguembelina fructicosa, Planoglobulina acervulinoides, Globotruncana conica, G. stuarti, Praeglobotruncana citae* (vel *Globotruncanella havanensis*), *Globotruncana contusa* (abundant, with large, high-spired specimens–indicating the latest evolutionary stages of the species) and many other species and is referable to the upper part of the *Globotruncana mayaroensis* Zone, where the zonal marker is often absent. This zone is the last known from the Upper Cretaceous, and is referred to as the upper Maestrichtian. The core catcher of Core 10 contains the species listed above, as well as *Globotruncana mayaroensis, Globigerinelloides messinae, Rugoglobigerina rugosa,* etc.
Hole 10, Core 11: See Core 10.	Hole 10, Core 11: The core catcher of Core 11 contains a rich and diversified planktonic foraminiferal fauna with *Globotruncana tricarinata, G. linneiana, G. fornicata, C. conica, Planoglobulina acervulinoides, Rugoglobigerina,* etc., which is referred to the *Globotruncana tricarinata* Zone (lowermost Maestrichtian).

Nannofossils	Foraminifera
Hole 10, Core 12: See Core 10.	Hole 10, Core 12: The core catcher of Core 12 yielded a foraminiferal fauna very similar to that of Core 11 and is also referred to the *Globotruncana tricarinata* Zone (lowermost Maestrichtian).
Hole 10, Core 13: See Core 10.	Hole 10, Core 13: The presence of the zonal marker *Globotruncana calcarata* places Cores 13 (pars) and 14 in the homonymous zone (upper Campanian), which–being a total range zone–is clearly defined. The last occurrence of *Globotruncana calcarata* has been noticed in Section 4 of Core 13. For the definition of the Campanian-Maestrichtian boundary, see the discussion in Chapter 20. Also present are *Globotruncana arca, G. rosetta, G. fornicata, G. linneiana, G. ventricosa, G. tricarinata, Globigerinelloides messinae, Heterohelix globulosa, Schackoina tappanae,* etc.
Hole 10, Core 14: See Core 10:	Hole 10, Core 14: As above, *Globotruncana calcarata* Zone (upper Campanian).
Hole 10, Core 15: See Core 10.	Hole 10, Core 15: Most of the species present in Core 14 are also present here, e.g., *Globotruncana arca, G. ventricosa, G. tricarinata, G. caliciformis, G. elevata, G. linneiana,* etc. *Globotruncana calcarata* is present in Section 1, but is lacking in lower sections. Several zonal names have been proposed for the pre-*Globotruncana calcarata* datum stratigraphic interval *(Globotruncana elevata* Zone, *G. stuartiformis* Zone, *G. stuarti sensulato* Zone), all of which are comparable since the upper boundary of all of them is indicated by the first occurrence of *Globotruncana.*
Hole 10, Core 16: See Core 10.	Hole 10, Core 16: Same fauna as above with *Pseudotextularia elegans, Heterohelix globulosa, Schackoina multispinata, Globigerinelloides* spp., *Globotruncana elevata, G. caliciformis, G. arca, G. linneiana, G. marginata, G. fornicata,* etc.; *Globotruncana elevata* Zone, Campanian. A good correlation with the stratotype of the Campanian Stage as described by Van Hinte (1965) is possible, but the present fauna is much more diversified.
Hole 10, Core 17: See Core 10.	Hole 10, Core 17: Assemblage similar to Core 16; Campanian, *Globotruncana elevata* Zone.
Hole 10, Core 18: See Core 10.	Hole 10, Core 18: As for Core 17, Campanian (middle to lower), *Globotruncana elevata* Zone.
Hole 10, Core 19: See Core 10.	Hole 10, Core 19: As above.

SUMMARY - SITE 10

Rates of Sediment Accumulation

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

At Site 10 six cored intervals allowed a calculation of rates of sediment accumulation. They are as follows:

1) Miocene/Pliocene boundary at 40 meters; 6 m.y.
2) Eocene/Oligocene boundary at 80 meters; 38 m.y.
3) Upper Middle Eocene (*Orbulinoides beckmanni* Zone) at 99 meters; 45 m.y.
4) Lower Eocene (*Globorotalia formosa formosa* Zone or *G. aragonensis* Zone–*Globorotalia rex* Zone) at 185 meters; 51 m.y.
5) Uppermost Maestrichtian (upper part of the *Globotruncana mayaroensis* Zone) at 295 meters; 65 m.y.
6) Lower Campanian (*Globotruncana elevata* Zone) at 475 meters; 80 m.y.

The rates of sediment accumulation for the different intervals considered are as follows:

TABLE 3
Rates of Sediment Accumulation

Interval	Cumulative
Miocene/Pliocene boundary to Recent (ocean floor to Core 2): 0.8 cm/1000 years	Miocene/Pliocene boundary to Recent: 0.8 cm/1000 years
Eocene/Oligocene boundary to Miocene/Pliocene boundary (Core 5 to Core 2): 0.12 cm/1000 years	Eocene/Oligocene boundary to Recent: 0.21 cm/1000 years
Middle Eocene to Eocene/Oligocene boundary (Core 7 to Core 5): 0.25 cm/1000 years	Middle Eocene to Recent: 0.22 cm/1000 years
Lower Eocene to Middle Eocene (Core 9 to Core 7): 1.43 cm/1000 years	Lower Eocene to Recent: 0.36 cm/1000 years
Upper Maestrichtian to Lower Eocene (Core 10 to Core 9): 0.78 cm/1000 years	Upper Maestrichtian to Recent: 0.45 cm/1000 years
Lower Campanian to upper Maestrichtian (Core 19 to Core 10): 1.2 cm/1000 years	Lower Campanian to Recent: 0.57 cm/1000 years

The sediment accumulation rate for the Pliocene-Pleistocene interval penetrated at Site 10 is approximately 0.8 cm/1000 years. This is somewhat less than the 1 to 3 cm/1000 years commonly considered an average rate for calcareous pelagic sediments (Broecker *er al.*, 1958). A middle Pliocene Age determined for Section 1 of Core 1 (see nannofossil biostratigraphy) yields a value of 0.77 cm/1000 years, and is in very close agreement with the rate of accumulation for the entire Pliocene-Pleistocene interval.

The rate of sediment accumulation from the top of the Eocene to the base of the Pliocene is 0.12 cm/1000 years, which is far below that of the interval above. This figure is obviously misleading, however, as there appears to be a gap in sedimentation in the Lower and/or Middle Miocene interval, or a greatly attenuated and mixed section, or both. In addition, the core which penetrated this interval also appears to be contaminated by down-hole caving.

The interval from the upper Middle Eocene (*Orbulinoides beckmanni* Zone) to the basement of the Oligocene is also characterized by a low sediment accumulation rate, i.e., 0.25 cm/1000 years, although for this interval no large gap in sedimentation is apparent from preliminary sampling.

The Middle Eocene to Lower Eocene interval and the Lower Eocene to uppermost Cretacous interval have a sediment accumulation rate of 1.07 cm/1000 years and 0.91 cm/1000 years, respectively. These values are not significantly different and are comparable to the 0.8 cm/1000 years estimated for the Pliocene-Pleistocene interval at this site.

The Cretaceous interval from the upper Maestrichtian to the lower Campanian yields a sediment accumulation rate of 1.2 cm/1000 years, which is only slightly higher than the apparently undisturbed intervals above.

The 1 to 3 cm/1000 years figure commonly accepted for calcareous pelagic sediments is based largely on data obtained from piston cores which usually penetrate only Pleistocene, and rarely Pliocene, sediments; and, hence, a rate of about 1.0 cm/1000 years is entirely reasonable.

Discussion

Site 10 was drilled in 15,402 feet (4697 meters)–(corrected) of water. The sediment is predominantly calcareous throughout, which suggests that this area has remained above the effective calcium carbonate compensation depth from lower Campanian times to the Recent. In contrast, the sediment at Site 7, 8 and 9 apparently was deposited on the sea floor at a level below the compensation depth.

Possible zeolites are found in the clays from the Eocene to the late Miocene—scattered throughout and forming thin beds within calcareous oozes. As discussed in the report for Site 9, these zeolites and clays may have been formed by the alteration of volcanic material possibly supplied by seamounts that lie to the north and northwest. The zeolites of Site 10 are mostly typical laths and cross twins of phillipsite.

A seismic reflector that lies in acoustically transparent sediments has been noted over a wide area of the western lower flank of the Mid-Atlantic Ridge in the North Atlantic. The reflector lies at a sediment depth of about 500 to 600 feet (152.4 to 182.9 meters), based on seismic measurements. The coring rate for Core 9 decreased markedly and a piece of radiolarian chert was recovered in that core as well as in the core catcher of Core 8. In addition, the drilling record showed a decrease in the drilling rate below Core 9. The evidence suggests that the reflector is associated with the Eocene siliceous sediment.

The deeper sediments at Site 10, immediately above volcanic basement, exhibit almost no signs of iron-enrichment. In fact, they appear to be unaltered and unconsolidated calcareous oozes right down to the basalt contact. The main changes with increasing depth are the increasing proportions of volcanogenic material and dolomite rhombs.

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APPENDIX - MICROPALEONTOLOGICAL DETERMINATIONS

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

Sample 10-1-1, 57-59 cm (depth about 30.5 meters below the mud line):
Rich planktonic assemblage including *Globoquadrina altispira altispira* (very abundant, dominant species), *G. altispira globosa, Orbulina universa, Globorotalia* sp. ex gr. *G. miozea, G.* cf. *crassaformis, G.* aff. *puncticulata, G. menardii* (right coiling), *G. multicamerata, Sphaeroidinella* sp. (also without external cortex), *Globigerinita glutinata, Globigerinoides ruber, G. conglobatus, G. elongatus, G. sacculifer* etc. The benthonic forms include *Pyrgo* spp., *Globocassidulina, Cassidulina, Cibicides, Quinqueloculina, Lagena.* Also present rare Ostracoda. Many broken tests of planktonic foraminifera.
Age determination: Pliocene, probably middle. Upper part of Zone N.19 or Zone N.20 of Blow (above the horizon of extinction of *Sphaeroidinellopsis* spp. and of *Globigerina nepenthes).*

Sample 10-1-1, 98-100 cm (depth about 30.9 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-1-1, 135-137 cm (depth about 31.25 meters below the mud line):
Many broken tests of planktonic foraminifera. Assemblage as above, but containing also rare *Sphaeroidinellopsis subdehiscens, Sphaeroidinella dehiscens immatura, Globorotalia puncticulata.* Among the benthonics are present *Cassidulina* sp., *Laticarinina pauperata, Pyrgo* spp. *Lagena,* etc.
Age determination: Lower Pliocene, Zone N.19.

Sample 10-1-2, 1-3 cm (depth about 31.40 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-1-2, 41-43 cm (depth about 31.80 meters below the mud line):
Assemblage as above, with *Globorotalia multicamerata, Sphaeroidinellopsis seminulina, Globoquadrina altispira, Globorotalia puncticulata, Globigerinoides conglobatus,* etc. Benthonic assemblage including *Globocassidulina, Cassidulina, Cibicides* spp., among which *C. pseudoungerianus, Pyrgo, Lagena, Eponides, Pullenia, Laticarinina pauperata.* Very rare Ostracodes. Assemblage very poor.
Age determination: As above.

Sample 10-1-2, 64-66 cm (depth about 32 meters below the mud line):
Assemblage as above, with *Globigerina nepenthes.* Benthonic assemblage including *Allomorphina trigona, Quinqueloculina, Gyroidina,* etc.
Age determination: Lower Pliocene, Zone N.19 of Blow.

Sample 10-1-2, 101-103 cm (depth about 32.40 meters below the mud line):
Assemblage similar to the overlying ones, with *Globigerina nepenthes, Sphaeroidinellopsis seminulina, Sphaeroidinella dehiscens* and forma *immatura, Sphaeroidinellopsis subdehiscens, Globoquadrina altispira,* single specimens of *Globorotalia margaritae,* etc. The benthonic population includes *Pyrgo, Quinqueloculina, Pullenia, Cassidulina, Gyroidina soldanii,* etc.
Age determination: Lower Pliocene, lower part of Zone N.19.

Sample 10-1, core catcher (depth about 40 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-2-1, 134-136 cm (depth about 41.55 meters below the mud line):
Rich heterogeneous planktonic assemblage including Lower Pliocene species such as *Sphaeroidinellopsis subdehiscens* and sub-Recent ones such as fully keeled *Globorotalia truncatulinoides*, pink *Globigerinoides ruber, Globigerina digitata, Pulleniatina obliquiloculata finalis*, etc.
Age determination: the oldest species indicate a Lower Pliocene or topmost Miocene Age. It is the opinion of the writer that the Quaternary species have been artificially introduced during the coring operations.

Sample 10-2-2, 1-3 cm (depth 41.7 meters below the mud line):
Planktonic assemblage including *Globigerina nepenthes, Orbulina universa, Globigerinita glutinata, Sphaeroidinellopsis seminulina, S. subdehiscens, Sphaeroidinella dehiscens immatura, Globoquadrina altispira, Globigerinoides conglobatus, G. elongatus, Hastigerina siphonifera.* Benthonic assemblage including *Laticarinina pauperata, Pyrgo, Eponides, Planulina, Ehrenbergina,* etc. Assemblage rather poor, with many broken tests (dissolution). Some contamination with sub-Recent materials.
Age determination: lowermost Pliocene (probably basal part of Zone N.19).

Sample 10-2-2, 48-50 cm (depth about 42.2 meters below the mud line):
Planktonic assemblage very poor, including *Globigerina nepenthes* (abundant), *Sphaeroidinellopsis seminulina* (rare), *Globoquadrina dehiscens, Globigerina venezuelana.* Detrital material is common, as well as fish teeth. Also present benthonic foraminifera, among which are *Laticarinina pauperata, Spiroplectammina, Gyroidina girardana, Siphonodosaria, Eggerella.*
Age determination: Middle-Upper Miocene.

Sample 10-2-2, 102-105 cm (depth about 42.7 meters below the mud line):
Planktonic assemblage including *Globoquadrina altispira, Sphaeroidinellopsis seminulina, S. subdehiscens, Globigerinoides ruber, G. conglobatus, Globorotalia acostaensis, Globigerina nepenthes, Orbulina universa,* etc. Detrital material is present as well as fish teeth and rare Ostracodes. Benthonic foraminifera include *Laticarinina pauperata, Quinqueloculina, Anomalina, Eponides, Globocassidulina,* etc. Many broken tests of planktonic foraminifera.
Age determination: Upper Miocene, Probably Tortonian.

Sample 10-2-3, 0-3 cm (depth about 43.2 meters below the mud line):
Assemblage very poor, with many broken tests of planktonic foraminifera. The fauna is dominated by *Globoquadrina dehiscens* et aff. Also present *Globigerina* cf. *bulloides, Globigerinita dissimilis, Sphaeroidinellopsis* sp. Benthonic assemblage as above, including also *Vaginulina, Ellipsonodosaria, Eggerella, Pullenia, Pleurostomella,* etc.
Age determination: Miocene, possibly Lower to Middle.

Sample 10-2-3, 82-85 cm (depth about 44 meters below the mud line):
Assemblage very poor, mostly consisting of minute fragments of the test of planktonic foraminifera. Some contamination with younger material (fragments of Pliocene to Recent keeled *Globorotalias). Globigerina venezuelana.* Also present abundant detritus, fish teeth and other fish remains, benthonic foraminifera including *Siphonodosaria verneuili, Globocassidulina, Vulvulina, Gyroidina,* etc.
Age determination: probably Miocene.

Sample 10-2-3, 142-144 cm (depth about 44.6 meters below the mud line):
Assemblage very poor, similar to the preceding one. *Globigerinita dissimilis, G. unicava* and *Globigerina* cf. *venezuelana* have been identified.
Age determination: possibly Lower Miocene or Oligocene.

Sample 10-2-4, 15-17 cm (depth about 44.85 meters below the mud line):
Assemblage poor in planktonic foraminifera, which include the taxa *Globigerinita dissimilis, G. unicava, Globorotalia opima nana, Globigerina venezuelana.* Benthonic foraminifera include *Eggerella, Textularia, Globocassidulina, Vaginulina, Nodosaria, Siphonodosaria, Cibicides, Eponides, Nonion, Pleurostomella, Pullenia.* Also present abundant fish teeth. Some contamination with Quaternary material.
Age determination: As above.

Sample 10-2-4, 40-42 cm (depth about 45.1 meters below the mud line):
Assemblage very poor, strongly affected by dissolution. Benthonic foraminifera and fish teeth as above. Many broken tests of planktonic foraminifera. Some contamination with Quaternary material.
Age determination: As above. A pre-Miocene age is probable, but is based only on negative factors (absence of *Globigerinoides* spp.).

Sample 10-2-4, 64-66 cm (depth about 45.35 meters below the Mud line):
Assemblage as above.
Age determination: As above.
Sample 10-2-4, 90-93 cm (depth about 45.60 meters below the mud line):
Assemblage as above, with many broken tests of planktonic foraminifera. Diversified, though not rich, benthonic assemblage including, among others, *Vulvulina jarvisi, Pullenia quinqueloba,* etc. Always abundant fish teeth.
Age determination: probably Oligocene (upper?).

Sample 10-2-4, 105-107 cm (depth about 45.75 meters below the mud line):
Assemblage as above. Some contamination with Quaternary material.
Age determination: As above.

Sample 10-2-4, 145-147 cm (depth about 46.15 meters below the mud line):
Assemblage containing many broken tests of planktonic foraminifera and some entire shells belonging to

the species *Globigerina rohri, G. venezuelana, Globigerinita dissimilis, G. unicava, Globorotalia opima opima, G. opima nana.* A number of small, immature tests of *Globigerinae.* Few benthonic foraminifera including *Vulvulina jarvisi, Gyroidina girardana, Pleurostomella* sp.
Age determination: Oligocene, probably *Globorotalia opima* Zone.

Sample 10-2, core catcher (depth about 48.2 meters below the mud line):
Assemblage rather poor in planktonic foraminifera, including the species *Globigerina rohri, G. venezuelana, Globigerinita dissimilis, G. unicava.* Fairly abundant benthonic foraminifera of Oligocene affinity including genera with calcareous test *(Pleurostomella, Nodosarella, Ellipsonodosaria, Siphonodosaria, Globocassidulina, Gyroidina girardana)* and arenaceous test *(Vulvulina jarvisi, Dorothia, Eggerella, Textularia,* etc.). Also present fish debris and teeth.
Age determination: As above.

Sample 10-3-2, 28-30 cm (depth about 50 meters below the mud line):
Planktonic assemblage very poor, mostly consisting of minute fragments of tests. Some (rare) tests are complete, but internally dissolved. They belong to *Globigerinita unicava.*
Age determination: probably Oligocene.

Sample 10-3, core catcher, (depth about 57.3 meters below the mud line):
Very poor planktonic assemblage including *Globorotaloides suteri, Globigerinita dissimilis, G. unicava, Globigerina* aff. *rohri, G. venezuelana,* and many broken tests. Tests internally dissolved. The benthonic assemblage includes *Textularia, Pleurostomella, Cibicides,* abundant *Globocassidulina, Caucasina* (?), *Gyroidina girardana, Gyroidina octocamerata, Eponides, Ellipsonodosaria, Nodosarella, Nonion, Eggerella, Dorothia, Pullenia quinqueloba.* Abundant fish teeth and debris.
Age determination: probably Oligocene.

Sample 10-5-1, 103-105 cm (depth about 72.3 meters below the mud line):
Very poor planktonic assemblage, mostly consisting of minute fragments of tests. Most of the entire tests are empty, internally dissolved. The assemblage is dominated by *Globigerinita unicava.* Also present *G. dissimilis, Globigerina venezuelana, G.* cf. *rohri, Globorotalia opima opima.*
Age determination: Oligocene, probably *Globorotalia opima opima* Zone.

Sample 10-5-2, 39-41 cm (depth about 73.2 meters below the mud line):
Poor planktonic assemblage, as above. Fairly abundant benthonic foraminifera and fish teeth.
Age determination: Oligocene.

Sample 10-5-3, 120-123 cm (depth about 74.6 meters below the mud line):
Many broken tests. Planktonic foraminifera are fairly abundant, but most of them under their average size. They include *Globigerinita unicava* (abundant), *G. dissimilis, Globigerina* cf. *ampliapertura, G. rohri, G.* ex gr. *G. tripartita, G.* cf. *tapuriensis.*
Age determination: Lower Oligocene, possibly Zones P.18 to P.20 of Blow, condensed (?).

Sample 10-5-4, 58-60 cm (depth about 75.5 meters below the mud line):
Planktonic assemblage very poor, including *Globigerina* sp. and *Globigerinita unicava,* with empty tests. Many fragments of tests, probably due to dissolution. The benthonic assemblage includes *Globocassidulina, Cibicides, Eponides, Pleurostomella, Ellipsonodosaria, Glomospira charoides,* etc. Numerous fish teeth.
Age determination: None, (lower Oligocene?).

Sample 10-5, core catcher (depth about 80.4 meters below the mud line):
Very poor planktonic assemblage including *Globigerina venezuelana, Globorotaloides* sp. and many broken tests. Planktonic assemblage fairly diversified, including *Cibicides* sp., *C. grimsdalei, Pullenia salisburyi, Gyroidina octocamerata, Siphonodosaria, Nodosarella, Globocassidulina, Robulus,* etc.
Age determination: None, (lower Oligocene? Upper Eocene?).

Sample 10-7-1, 83-85 cm (depth about 90.3 meters below the mud line):
Poor planktonic assemblage, mostly consisting of broken tests. *Globigerinita unicava, Globorotaloides* sp., *Globigerina ouatchitaensis, G.* cf. *tripartita.* The benthonic assemblage includes *Eponides trumpyi, Gyroidina octocamerata, Siphonodosaria, Globocassidulina,* etc.
Age determination: probably Upper Eocene.

Sample 10-7-2, 100-103 cm (depth about 92 meters below the mud line):
Very poor assemblage, similar to the preceding one.
Age determination: As above.

Sample 10-7-3, 38-41 cm (depth about 92.9 meters below the mud line):
Planktonic assemblage as above, with *Globigerapsis index.* Benthonic assemblage including *Eponides trumpyi, Cibicides grimsdalei, Pleurostomella* sp.
Age determination: As above.

Sample 10-7-4, 119-122 cm (depth about 95.2 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-7, core catcher (depth about 98.8 meters below the mud line):
Poor planktonic assemblage including *Orbulinoides beckmanni, Globigerinita* sp., *Globigerapsis index.* Many broken tests; empty tests are usual. Fairly rich benthonic assemblage including *Clavulina, Karreriella, Dorothia, Osangularia mexicana, Cibicides, Eponides,* etc.
Age determination: upper Lutetian, *Orbulinoides beckmanni* Zone (upper part of the Middle Eocene).

Sample 10-8, core catcher (depth about 176.2 meters below the mud line):
No foraminifera present.
Age determination: None.

Sample 10-9, core catcher (depth about 185.3 meters below the mud line):
No foraminifera present.
Age determination: None.

Sample 10-10-1, 76-78 cm (depth about 292 meters below the mud line):
Rich planktonic assemblage including *Globotruncana contusa* (abundant, with highly evoluted specimens), *G. conica, G. stuarti, Praeglobotruncana citae, Racemiguembelina fructicosa, Pseudotextularia elegans, Pseudoguembelina excolata, Planeglobulina acervulinoides, P. multicamerata, Rugoglobigerina* spp., *Globigerinelloides messinae*, etc.
Age determination: Maestrichtian (upper), *Globotruncana mayaroensis* Zone.

Sample 10-10-2, 100-102 cm (depth about 293.85 meters below the mud line):
Rich planktonic assemblage as above, also including *Globotruncana mayaroensis.*
Age determination: late Maestrichtian, *Globotruncana mayaroensis* Zone.

Sample 10-10-3, 100-102 cm (depth about 295.3 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-10-4, 100-102 cm (depth about 296.8 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-10, core catcher (depth about 298.8 meters below the mud line):
Rich and diversified planktonic assemblage including *Globotruncana mayaroensis, G. intermedia, G. contusa, G. conica, G. stuarti, Praeglobotruncana citae, Rugoglobigerina rugosa, R. scotti, Globigerinelloides messinae, Racemiguembelina fructicosa, Planoglobulina acervulinoides, Heterohelix* sp., etc.
Age determination: upper Maestrichtian, *Globotruncana mayaroensis* Zone.

Sample 10-11-1, 140-143 cm (depth about 379.1 meters below the mud line):
Rich and diversified planktonic assemblage including *Globotruncana arca, G. caliciformis, G. linneiana, G. stuarti, G. tricarinata, Praeglobotruncana citae, Pseudotextularia elegans, Pseudoguembelina excolata, Rugoglobigerina* spp., etc.
Age determination: lower Maestrichtian, *Globotruncana tricarinata* (or corresponding) Zone.

Sample 10-11-2, 96-98 cm (depth about 380.2 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-11-3, 100-102 cm (depth about 381.7 meters below the mud line):
Planktonic assemblage as above, with *Globotruncana fornicata, G. elevata stuartiformis,* etc.
Age determination: As above.

Sample 10-11, core catcher (depth about 386.8 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-12-1, 120-122 cm (depth about 388 meters below the mud line):
Rich and diversified planktonic assemblage including *Globotruncana arca, G. caliciformis, G. fornicata, G. linneiana, G. tricarinata, G. ventricosa* etc. Also present some benthonic foraminifera among which *Reussella szajnochae szajnochae.*
Age determination: early Maestrichtian, *Globotruncana tricarinata* (or corresponding) Zone.

Sample 10-12-1, 100-102 cm (depth about 389.3 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-12-3, 100-102 cm (depth about 390.8 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-12, core catcher (depth about 395.9 meters below the mud line):
Planktonic assemblage including *Globotruncana arca, G. caliciformis, G. fornicata, G. ventricosa, Praeglobotruncana citae, Globotruncana elevata stuartiformis, G. tricarinata, Heterohelix globulosa, Pseudotextularia elegans,* etc. Benthonic foraminifera are rather common including the genera *Aragonia, Lagena, Osangularia, Pleurostomella, Verneuilina, Gaudryina.*
Age determination: lower Maestrichtian, *Globotruncana tricarinata* Zone (or correspondent).

Sample 10-13-1, 98-100 cm (depth about 396.9 meters below the mud line):
Planktonic assemblage as above. Benthonic assemblage including *Aragonia* and *Gavelinella.*
Age determination: As above.

Sample 10-13-2, 100-102 cm (depth about 397.9 meters below the mud line):
Planktonic assemblage as above. Benthonic assemblage including *Reussella szajnochae szajnochae.*
Age determination: As above.

Sample 10-13-3, 98-100 cm (depth about 398.9 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-13, core catcher (depth about 405 meters below the mud line):
Rich and diversified planktonic assemblage including *Globotruncana calcarata* (rare), *G. arca, G. rosetta, G. fornicata, G. linneiana, G. ventricosa, G. tricarinata, Globigerinelloides messinae, Heterohelix globulosa, Schackoina tappanae,* etc. Very rare benthonic foraminifera including *Aragonia* sp.
Age determination: uppermost Campanian, *Globotruncana calcarata* Zone.

Sample 10-14-1, 120-122 cm (depth about 406.2 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-14-2, 100-102 cm (depth about 407.5 meters below the mud line):
Planktonic assemblage as above.
Age determination: As above.

Sample 10-14, core catcher (depth about 414.1 meters below the mud line):
Planktonic assemblage as above, very rich and well preserved.
Age determination: As above.

Sample 10-15-1, 120-122 cm (depth about 415.3 meters below the mud line):
Planktonic assemblage as above, with *Globotruncana calcarata,* etc.
Age determination: as above, *Globotruncana calcarata* Zone.

Sample 10-15, core catcher (depth about 423.2 meters below the mud line):
Rich planktonic assemblage including *Globotruncana elevata, G. caliciformis, G. fornicata, G. linneiana, G. ventricosa, Pseudotextularia elegans,* etc.
Age determination: Campanian, *Globotruncana elevata* Zone.

Sample 10-16-1, 130-132 cm (depth about 423.5 meters below the mud line):
Rich planktonic assemblage as above.
Age determination: As above.

Sample 10-16-2, 100-102 cm (depth 424.7 meters below the mud line):
Assemblage as above.
Age determination: As above.

Sample 10-16, core catcher (depth about 432.3 meters below the mud line):
Globotruncana arca, C. caliciformis, G. fornicata, G. linneiana, G. elevata, Heterohelix globulosa, Pseudotextularia elegans, Globigerinelloides sp., *Schackoina multispinata,* etc.
Age determination: Campanian, *Globotruncana elevata* Zone.

Sample 10-17-1, 140-142 cm (depth about 443.7 meters below the mud line):
Assemblage as above.
Age determination: As above.

Sample 10-17-2, 100-102 cm (depth about 434.8 meters below the mud line):
Assemblage as above.
Age determination: As above.

Sample 10-17, core catcher (depth 441.4 meters below the mud line):
Very rich and diversified planktonic fauna including *Globotruncana linneiana, G. elevata, G. marginata, G. fornicata, G. caliciformis, Pseudotextularia elegans, Heterohelix globulosa, Globigerinelloides* sp., etc. Rare benthonic foraminifera including *Gavelinella, Verneuilina, Gaudryina,* etc.
Age determination: lower to middle Campanian *(Globotruncana elevata* Zone).

Sample 10-18-1, 100-102 cm (depth about 442.4 meters below the mud line):
Rich assemblage as above.
Age determination: As above.

Sample 10-18-2, 110-112 cm (depth about 444 meters below the mud line):
Rich assemblage as above, including *Globotruncana arca, G. rosetta, G. linneiana, G. fornicata, G. elevata, G. caliciformis* etc.
Age determination: lower to middle Campanian.

Sample 10-18-3, 100-102 cm (depth about 445.4 meters below the mud line):
Rich assemblage as above.
Age determination: As above.

Sample 10-18-4, 120-122 cm (depth about 447.1 meters below the mud line):
Rich assemblage as above, also including *Reussella szajnochae szajnochae.*
Age determination: As above.

Sample 10-18, core catcher (depth about 450.5 meters below the mud line):
Rich assemblage as above, also including *Globotruncana marginata, G. elevata, G. caliciformis, G. fornicata, G. rosetta, Schackoina tappanae,* etc.
Age determination: *Globotruncana elevata* Zone, lower to middle Campanian.

Sample 10-19-1, 80-82 cm (depth about 451.3 meters below the mud line):
Rich assemblage as above.
Age determination: As above.

Calcareous Nannofossil Determinations by S. Gartner.

Sample 10-1, top:
Discoaster brouweri, D. pentaradiatus, D. surculus, cf. *Coccolithus cricotus.*
Age determination: late Pliocene.

Sample 10-1-1, 56 cm:
Discoaster pentaradiatus, D. brouweri (3, 4, and 6 rays) *D. surculus, Ceratolithus rugosus,* cf. *Coccolithus cri-*

cotus, Cyclococcolithus leptoporus, Scyphosphaera amphora, Discolithus phaseolus, Reticulofenestra pseudoumbilica (small).
Age determination: *middle*-late Pliocene.

Sample 10-1-1, 66 cm:
As above.
Age determination: *middle*-late Pliocene.

Sample 10-1-1, 100 cm:
As Above.
Age determination: *middle*-late Pliocene.

Sample 10-1-1, 125 cm:
As above.
Age determination: *middle*-late Pliocene.

Sample 10-1-1, 140-145 cm:
Discoaster penetaradiatus, D. brouweri, D. surculus, C. variabilis, Retifulofenestra pseudoumbilica, Cyclococcolithus leptoporus, Ceratolithus rugosus.
Age determination: middle Pliocene.

Sample 10-1-1, 150 cm:
As above.
Age determination: middle Pliocene.

Sample 10-1-2, 145 cm:
Discoaster penetaradiatus, D. brouweri, D. variabilis Reticulofenestra pseudoumbilica, Sphenolithus abies, Ceratolithus rugosus, C. tricorniculatus.
Age determination: early Pliocene.

Sample 10-1, core catcher:
As above.
Age determination: early Pliocene.

Sample 10-2-1, 134 cm:
As above.
Age determination: early Pliocene.

Sample 10-2-1, 143 cm:
Discoaster brouweri, D. pentaradiatus, D. surculus, D. variabilis, D. challangeri, Reticulofenestra pseudoumbilica, Ceratolithus tricorniculatus.
Age determination: late Miocene (Messinian) -early Pliocene.

Sample 10-2-2, 2 cm:
Discoaster variabilis, D. brouweri (primitive, with large center), *D. pentaradiatus, Reticulofenestra pseudoumbilica, Ceratolithus tricorniculatus.*
Age determination: early Pliocene.

Sample 10-2-2, 60 cm:
Discoaster exilis, D. kugleri, Coccolithus neogammation.
Age determination: Middle Miocene.

Sample 10-2-2, 140 cm:
Ceratolithus tricorniculatus, Discoaster pentaradiatus, D. brouweri, D. variabilis, cf. *D. kugleri, D. hamatus, D. exilis, D. aulakos, D. surculus, Reticulofenestra pseudoumbilica, Cyclococcolithus leptoporus.*
Age determination: mixed late Middle Miocene and late Miocene.

Sample 10-2-3, 2 cm:
Discoaster exilis, D. subsurculus, D. pentaradiatus, D. calcaris, D. brouweri, Coccolithus neogammation, Cyclococcolithus leptoporus, Sphenolithus abies.
Age determination: mixed late Middle Miocene and late Miocene.

Sample 10-2-3, 20 cm:
Discoaster exilis, D. aulakos, D. kugleri, D. deflandrei, Coccolithus neogammation, Sphenolithus moriformis.
Age determination: middle Miocene.

Sample 10-2-3, 40 cm:
Discoaster exilis, D. deflandrei, Coccolithus neogammation, Sphenolithus heteromorphus, Cyclolithella rotunda.
Age determination: middle Miocene.

Sample 10-2-3, 140 cm:
Coccolithus neogammation, Triquetrorhagdulus carinatus, Discoaster druggi, D. obtusus, Sphenolithus moriformis, Cyclolithella rotunda.
Age determination: early Miocene.

Sample 10-2-4, 140 cm:
Coccolithus neogammation, Sphenolithus ciperoensis, S. moriformis.
Age determination: Oligocene.

Sample 10-3-1, 40 cm:
Coccolithus neogammation, C. pelagicus, cf. *Discoaster druggi, Sphenolithus moriformis.*
Age determination: Oligocene.

Sample 10-3-1, 80 cm:
cf. *Reticulofenestra scissura, Sphenolithus moriformis, Coccolithus neogammation, Cyclolithella rotunda, Coccolithus eopelagicus.*
Age determination: Oligocene.

Sample 10-3-1, 100 cm:
Coccolithus neogammation, cf. *Reticulofenestra scissura, Sphenolithus ciperoensis.*
Age determination: Oligocene.

Sample 10-3-1, 140 cm:
Reticulofenestra scissura, Coccolithus neogammation, Reticulofenestra umbilica, Coccolithus eopelagicus.
Age determination: early Oligocene.

Sample 10-3, core catcher:
Coccolithus neogammation, Reticulofenestra scissura, Sphenolithus predistentus, S. ciperoensis, S. pseudoradians.
Age determination: early Oligocene.

Sample 10-5-4, 140 cm:
Reticulofenestra umbilica, R. scissura, Isthmolithus recurvus, Sphenolithus pseudoradians, Discoaster tani

tani, Bramletteius serraculoides.
Age determination: early Oligocene.

Sample 10-5-5, 20 cm:
Bramletteius serraculoides, Reticulofenestra umbilica, R. scissura, Sphenolithus pseudoradians, Cyclococcolithus orbis, Discoaster saipanensis, Isthmolithus recurvus, Hayella situliformis, Discoaster tani tani.
Age determination: late Eocene.

Sample 10-5-5, 40 cm:
As above plus *Discoaster barbadiensis.*
Age determination: late Eocene.

Sample 10-5-5, core catcher:
As above.
Age determination: late Eocene.

Sample 10-6, core catcher:
As above.
Age determination: late Eocene.

Sample 10-7, core catcher:
As above.
Age determination: late Eocene.

Sample 10-8 top:
Discoaster lodoensis, D. barbadiensis, Discoasteroides kupperi, Chiasmolithus grandis, Coccolithus gammation, Cyclococcolithus orbis, Cruciplacolithus staurion.
Age determination: early Eocene.

Sample 10-8, core catcher:
As above.
Age determination: early Eocene.

Sample 10-9, core catcher:
Discoaster lodoensis, D. salisburgensis, Discoasteroides kapperi, Sphenolithus radians, Chiasmolithus grandis, Cyclococcolithus orbis.
Age determination: early Eocene.

Sample 10-10, top:
Lithraphidites quadratus, L. carniolensis, Cribrosphaerella ehrenbergi, Prediscosphaera cretacea, P. spinosa, Microrhabdulus decoratus, M. stradneri, Maslovella barnesae, Arkhangelskiella cymbiformis, Cretarhabdus conicus, C. crenulatus, Micula decussata, Eiffellithus turriseiffeli, Rhabdolithina regularis, R. splendens, Kamptnerius sp., *Tetralithus aculens, T. murus, Cylindralithus gallicus, Zygodiscus pseudanthophorus, Cretarhabdus? decorus.*
Age determination: Maestrichtian.

Sample 10-10, core catcher:
As above.
Age determination: Maestrichtian.

Sample 10-11, core catcher:
As above less *Cylindralithus gallicus, Lithraphidites quadratus, Prediscosphaera spinosa, Tetralithus murus,* plus *Arkhangelskiella parca, Cylindralithus serratus.*
Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-12, core catcher:
As above.
Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-13, core catcher:
As above.
Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-14, core catcher:
As above.

Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-15, core catcher:
As above.
Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-16, core catcher:
As above.
Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-17, core catcher:
As above.
Age determination: late Cretaceous (Campanian-Maestrichtian).

Sample 10-18, core catcher:
As above less *Rhabdolithina regularis.*
Age determination: early Campanian.

Sample 10-19, core catcher:
As above less *Rhabdolithina splendens.*
Age determination: early Campanian.