3. SITE 3[1]

The Shipboard Scientific Party[2]

SITE REPORT

Setting and Purpose

A general description of the deep basin of the Gulf of Mexico is given in the preceding section on Site 2, in the Setting and Purpose, and the reader is referred to that material for a preamble to the following discussion of Site 3.

The study of thirty-three cores in 1953 led Ewing, Worzel, Ericson, and Heezen (1955) from a consideration of the nature of the sediments cored, the topography of the Mississippi Cone, and the flat floor of the Sigsbee Deep, to the conclusion that the distribution of sediments in the Gulf of Mexico was profoundly influenced by turbidity currents. These authors also concluded, from seismic refraction measurements, that the crust was oceanic in character.

In 1954 a detailed topographic study, supplemented by 124 piston cores taken in the Gulf (Ewing, Ericson, and Heezen, 1958), led to the conclusion that silty sediments–supplied in quantity by the Pleistocene Mississippi River and distributed by a turbidity current process–covered the floor of the Gulf. The situation of the Sigsbee Knolls in an abyssal plain and the character of the sediments cored from them made it probable that these small elevations had received only pelagic deposition, at least since early Pleistocene time.

After examination aboard the *Glomar Challenger* of the cores taken from Hole 2 and the resulting lack of evidence of turbidity current deposits within the cored section, it was decided that cores from the nearby abyssal plain would provide comparative sedimentation rates for a region of similar pelagic deposition, which was in addition subjected to the influence of turbidity currents. This idea had originally contributed to the search for and discovery of the Sigsbee Knolls.

After a search of the profiler records taken in the vicinity, the site indicated by the arrow in Figure 1, (a profiler track from *Vema* Cruise 24) was chosen. This site was chosen because:

(1) It was well clear of the diapir zone.
(2) Profiler records taken in this part of Gulf showed many layers which had been interpreted as turbidite layers.
(3) It was possible to expect penetration through the zone of overlap of the horizontal layers on the sloping layers.
(4) It required negligible additional travel for the ship.

This site is located about twenty-one nautical miles southeast of Hole 2, and about the same distance northwest of the Sigsbee escarpment.

Hole 3 was drilled at 23° 01.8′N, 92° 02.6′W. The water depth was 3746 meters (12,294 feet), corrected for sound velocity and transponder depth. The hole was drilled to a depth of 627.6 meters (2059 feet) subbottom. It confirmed the hypothesis that the beds dipping toward the northeast contain turbidite layers which are good seismic reflectors.

A detailed description of the geological setting of Site 3 awaits the results of a site survey of *Vema* Cruise 26 in March, 1969.

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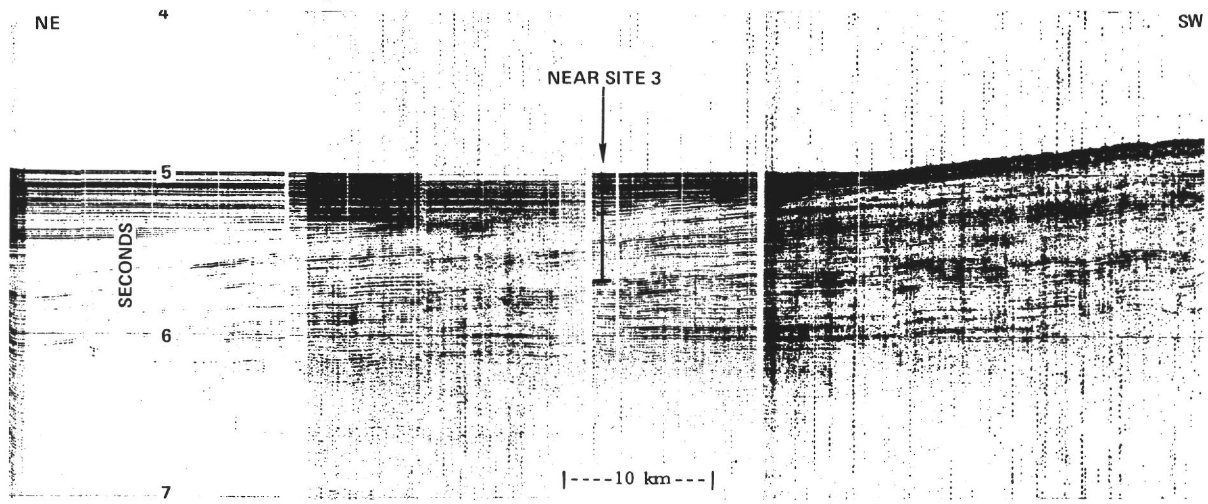


Figure 1. *Profiler traverse near Site 3 showing depth of penetration* Vema-24, *6 February 1967, 0330-0930.*

Interpretation of Down-Hole Logs

Due to loss of the hole, only a resistivity curve was obtained during logging. In view of the limited coverage of the logged interval, the resultant log has proved of limited use. The section covered (see Figure 2) has been interpreted as consisting of approximately four segments, and is based on relationships as derived from the cores.

An obscure change in curve character at a depth of 197 meters has been chosen as a possible representation of change in sediment type, primarily because of lack of evidence in the uncored and unlogged interval between Cores 2 and 3. Assuming that this interpretation is valid, the next interval lies between 197 meters and 280 meters and represents a transition from approximately 1.2 ohmmeters to 1.0 ohmmeters. On the basis of cored sediment, this corresponds to a basically carbonate pelagic ooze lithology.

A resistivity maximum occurs between depths of 280 meters and 395 meters with an average resistivity maximum of approximately 1.2 ohmmeters. This sequence corresponds well with the main interval of carbonate turbidites and laminites as determined by cores. This high resistivity unit is underlain by a sequence with an average uniform resistivity of approximately 1.0 ohmmeter. This later sequence, on the basis of cored sediment, appears to consist dominantly of pelagic, clay-rich carbonate ooze.

Absolute values of resistivity in boreholes of unknown variation in diameter and unobtainable drilling fluid resistivity are difficult to extrapolate. Nevertheless, resistivity values at Site 3 are consistently lower than those obtained at Site 1 and no large resistivity variations are observed. If it can be assumed that drilling fluid differences are minimal, then it might further be assumed that the basic differences in borehole formation temperature can explain at least part of the absolute difference in resistivity. This makes for interesting speculation as to thermal flux for the central abyssal plain of the Gulf of Mexico as compared with the continental margins. Unfortunately, until down-hole measurements are obtained, this must remain purely a speculation. It is perhaps just as likely that enlargement of the borehole at Site 3 persisted rather uniformly throughout the entire interval logged. This seems less plausible, however, when considering the semi-consolidated to consolidated condition of the carbonate turbidite-laminite-pelagite sequence opposite the maximum resistivity interval. Whatever the explanation, it must account for the rather low resistivity values obtained, especially in a zone of semi-consolidated to consolidated carbonate sands, which should—on the basis of the authors' experience—yield higher values than those obtained from Site 1 in semi-consolidated mud.

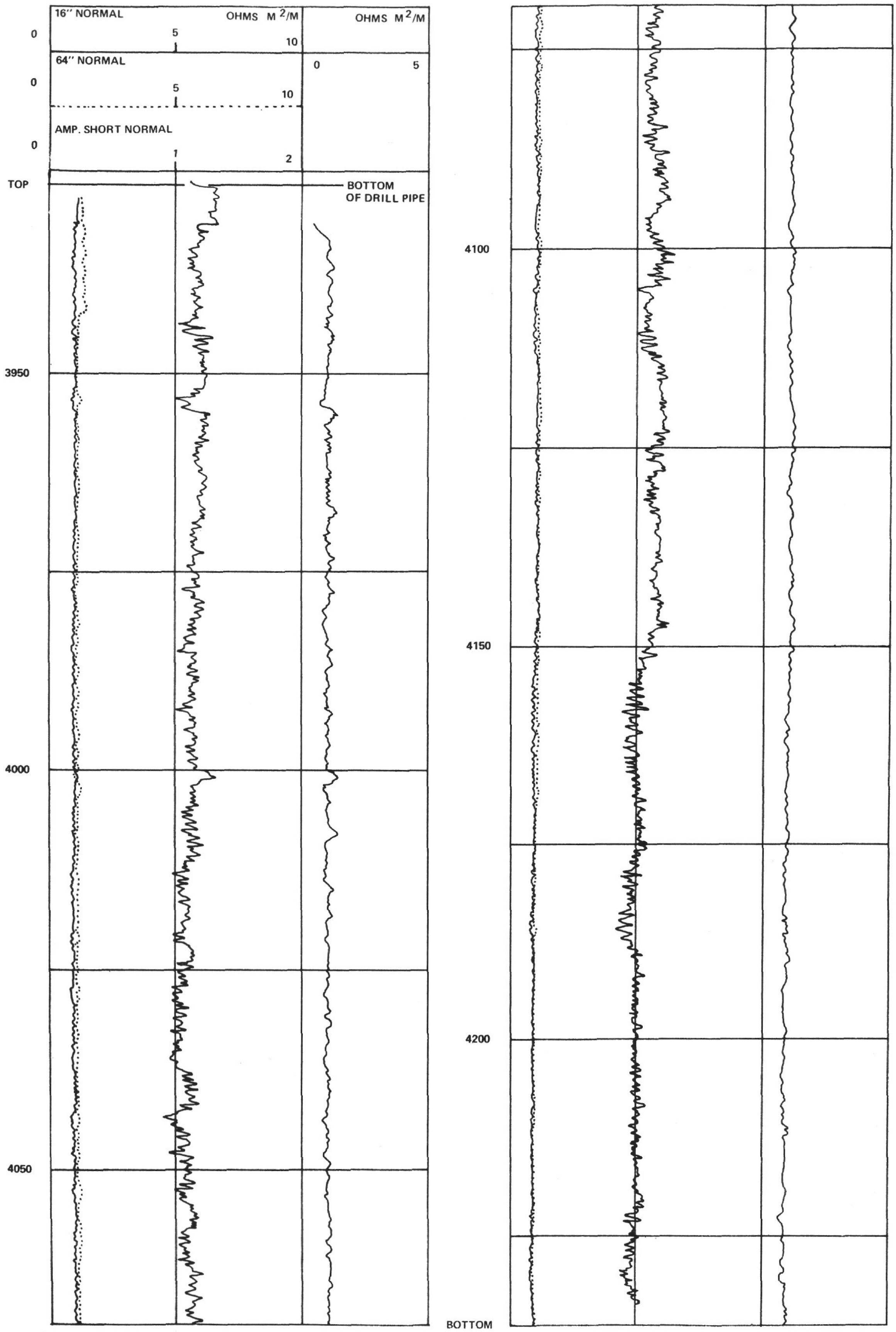


Figure 2. *Electric logs obtained at Site 3.*

Summary of Drilling and Coring at Site 3

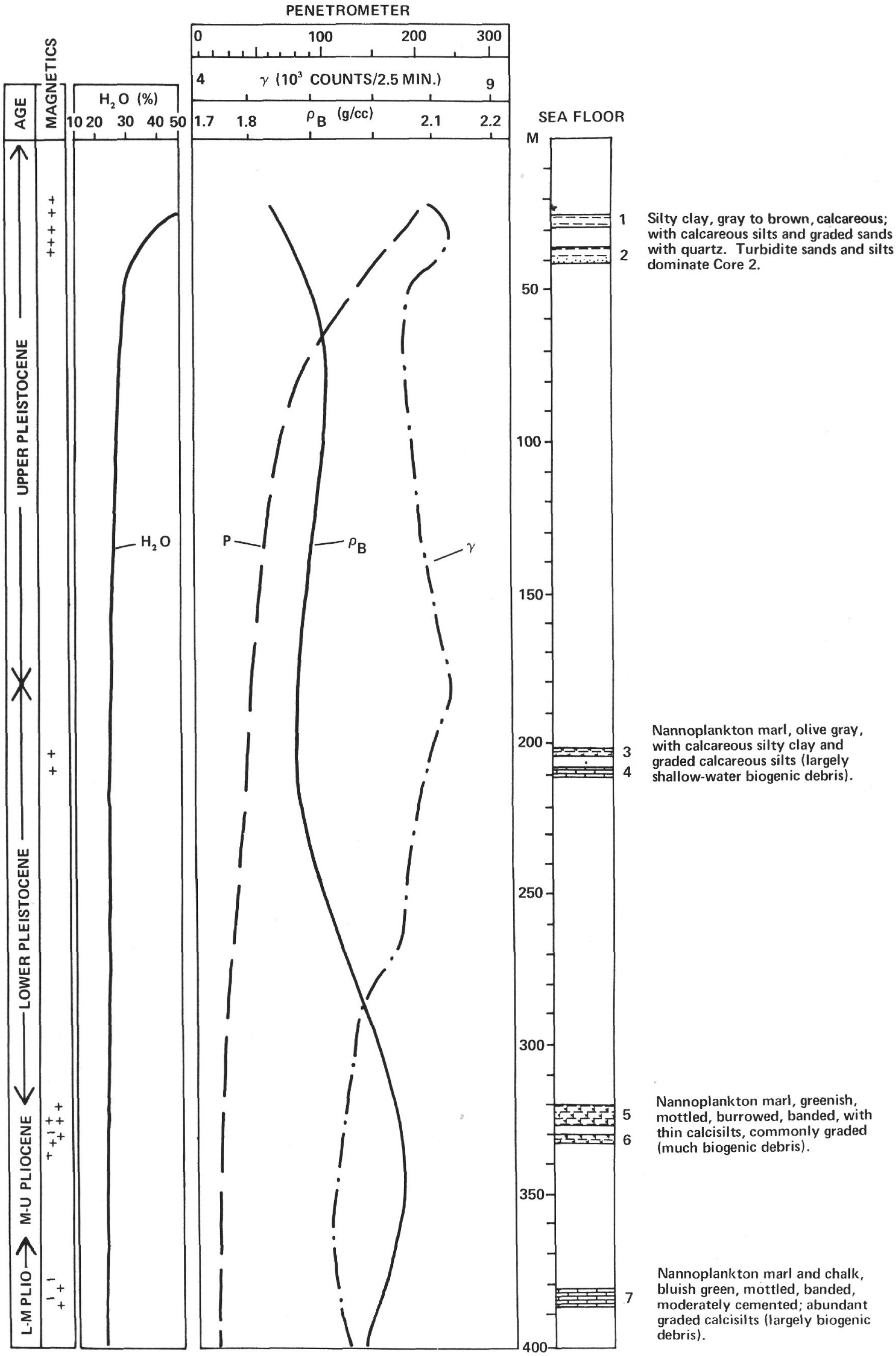


Figure 3. *Summary of drilling and coring at Site 3.*

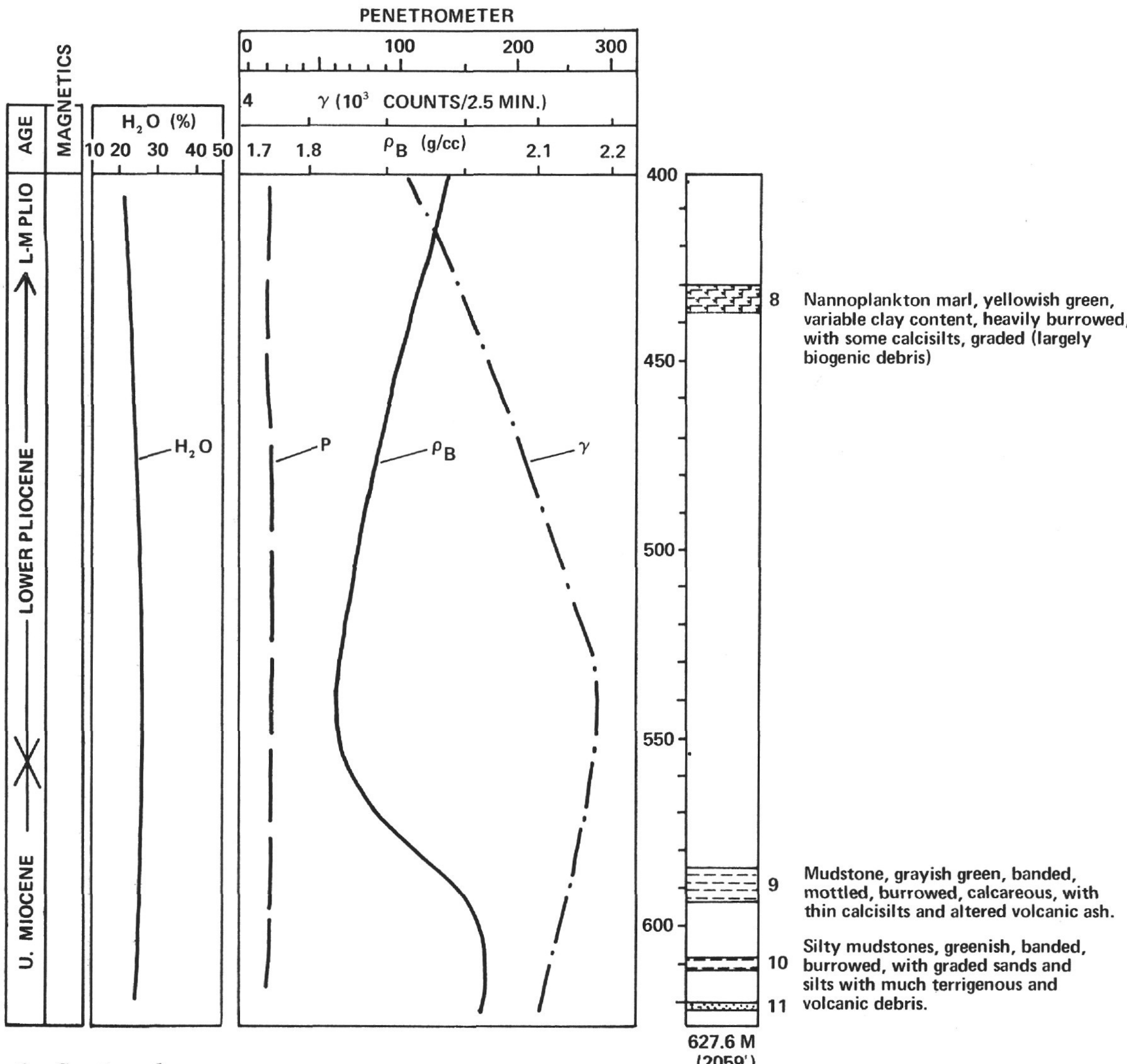


Figure 3. *Continued.*

The Cores Recovered from Site 3

Figures 4 through 14 are the graphic summaries of the cores recovered at Site 3.

These figures show for each core:

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

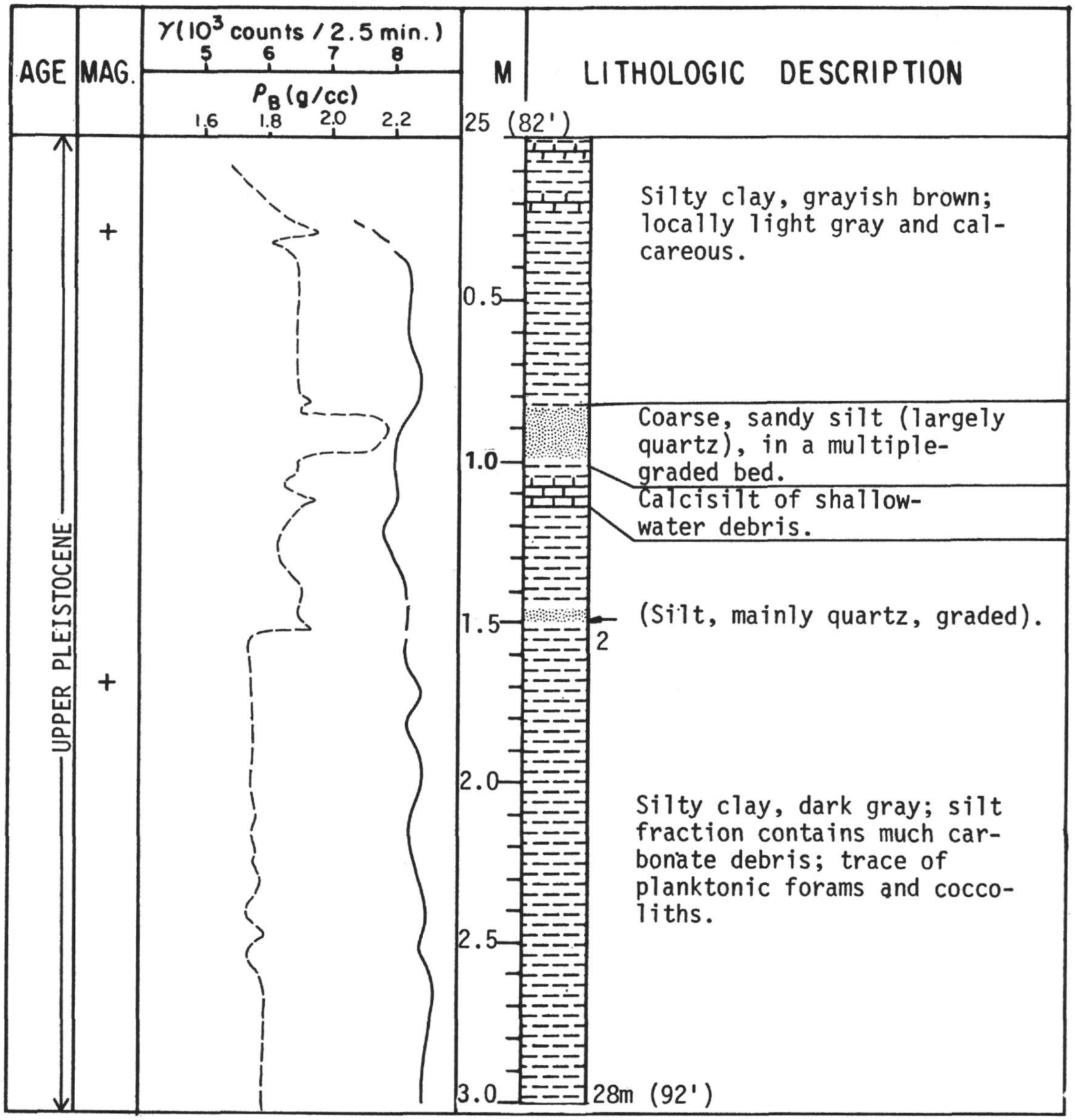


Figure 4. *Hole 3, Core 1.*

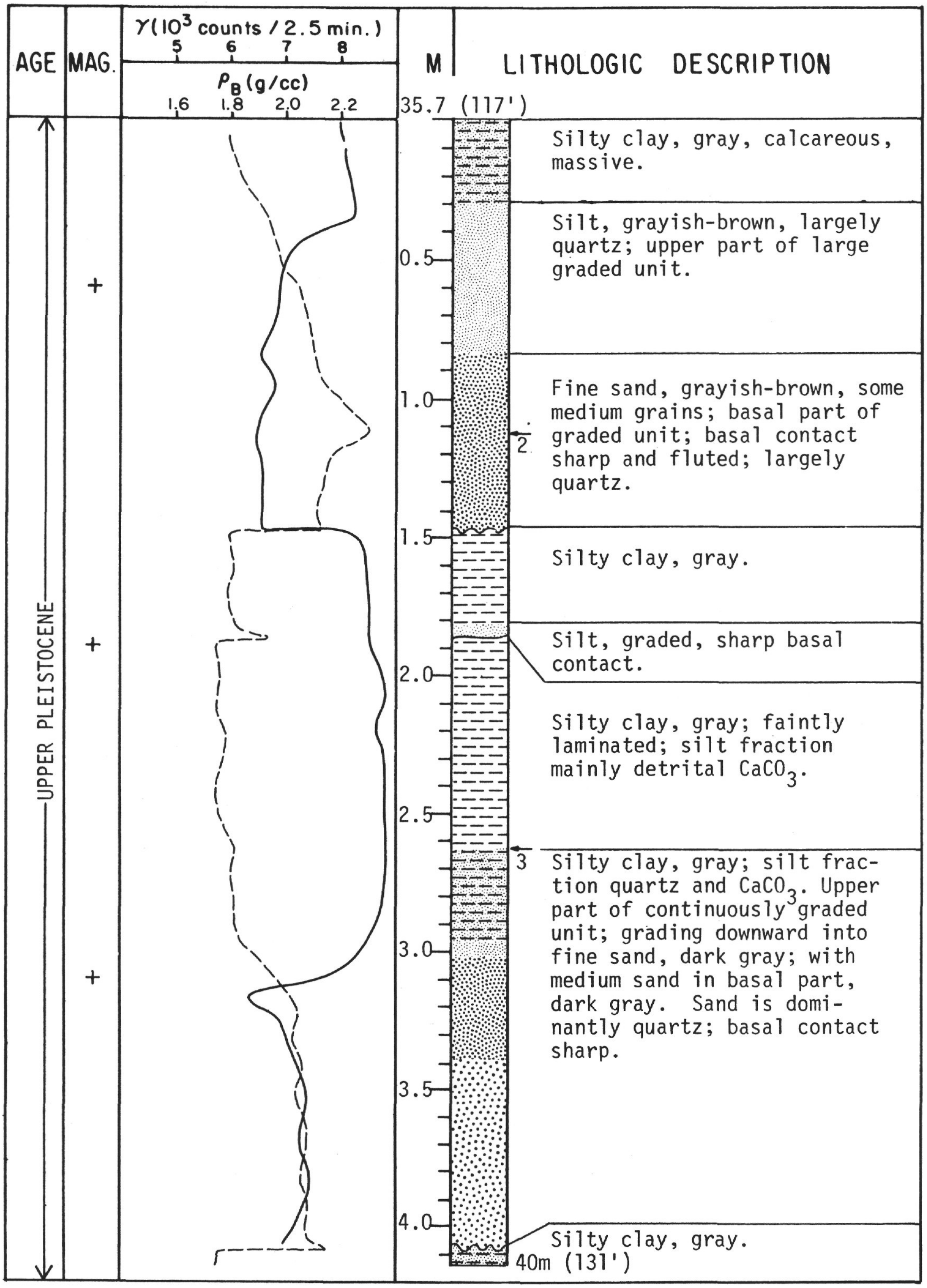


Figure 5. *Hole 3, Core 2.*

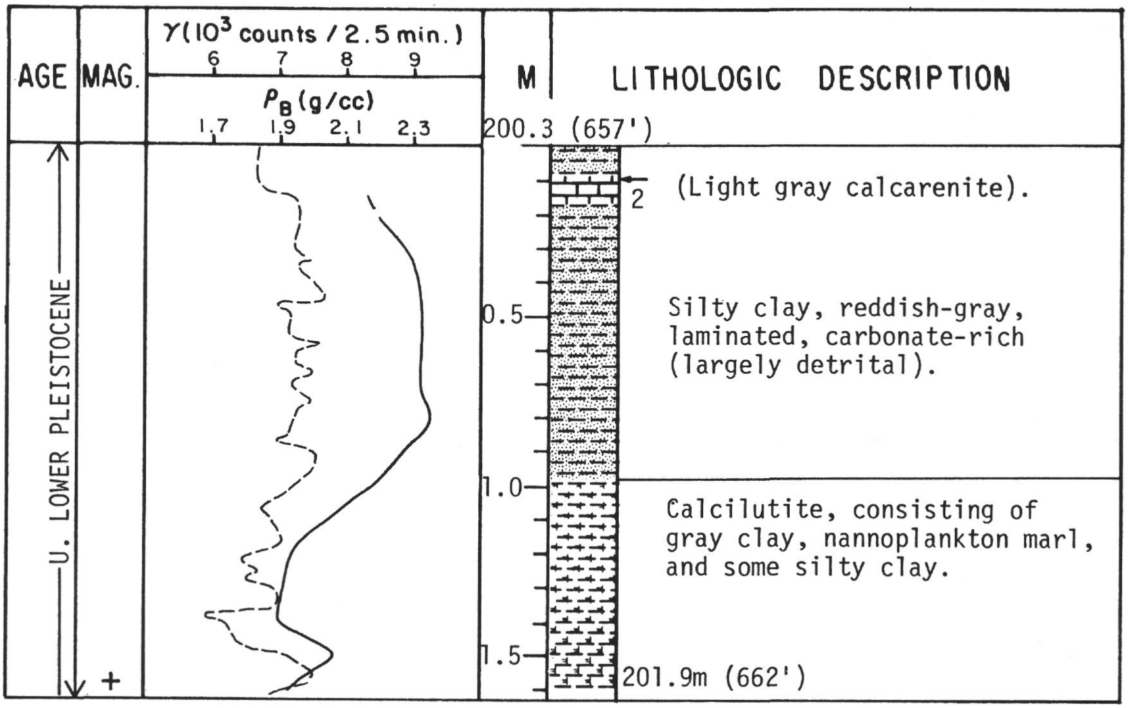


Figure 6. *Hole 3, Core 3.*

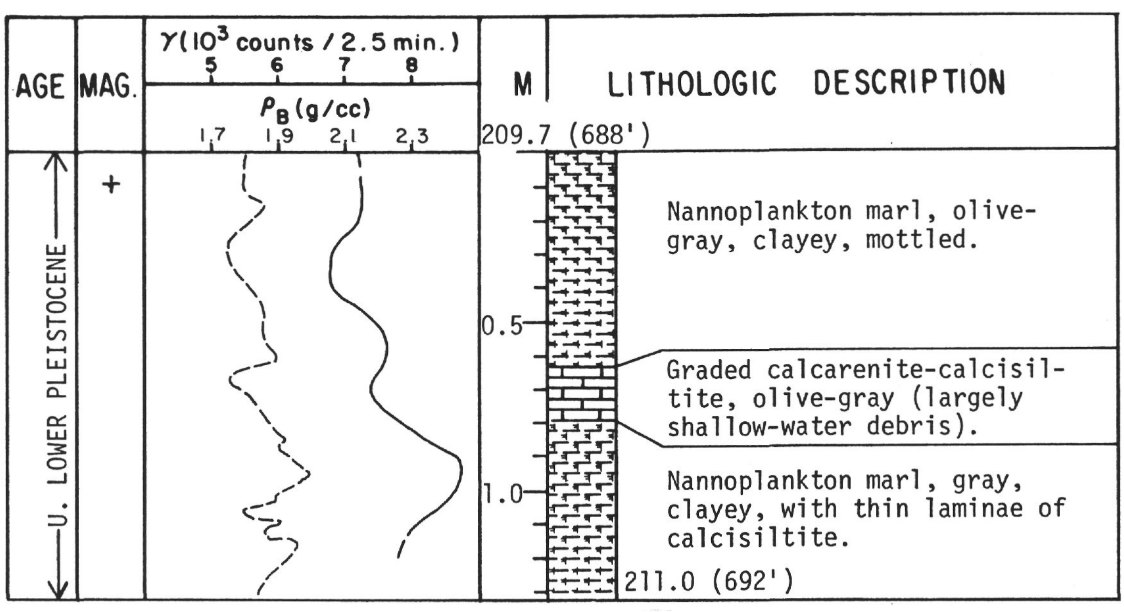


Figure 7. *Hole 3, Core 4.*

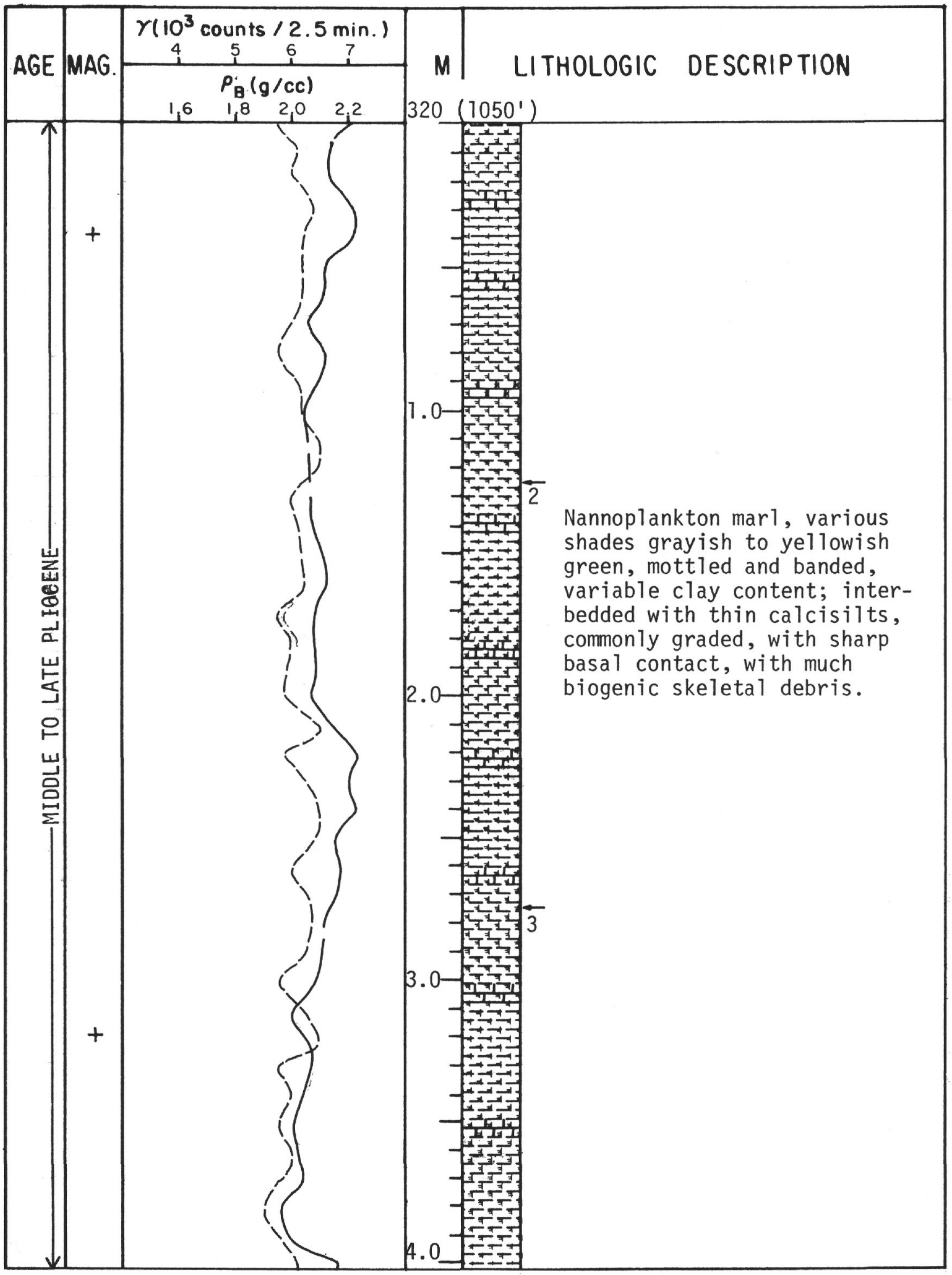


Figure 8. *Hole 3, Core 5.*

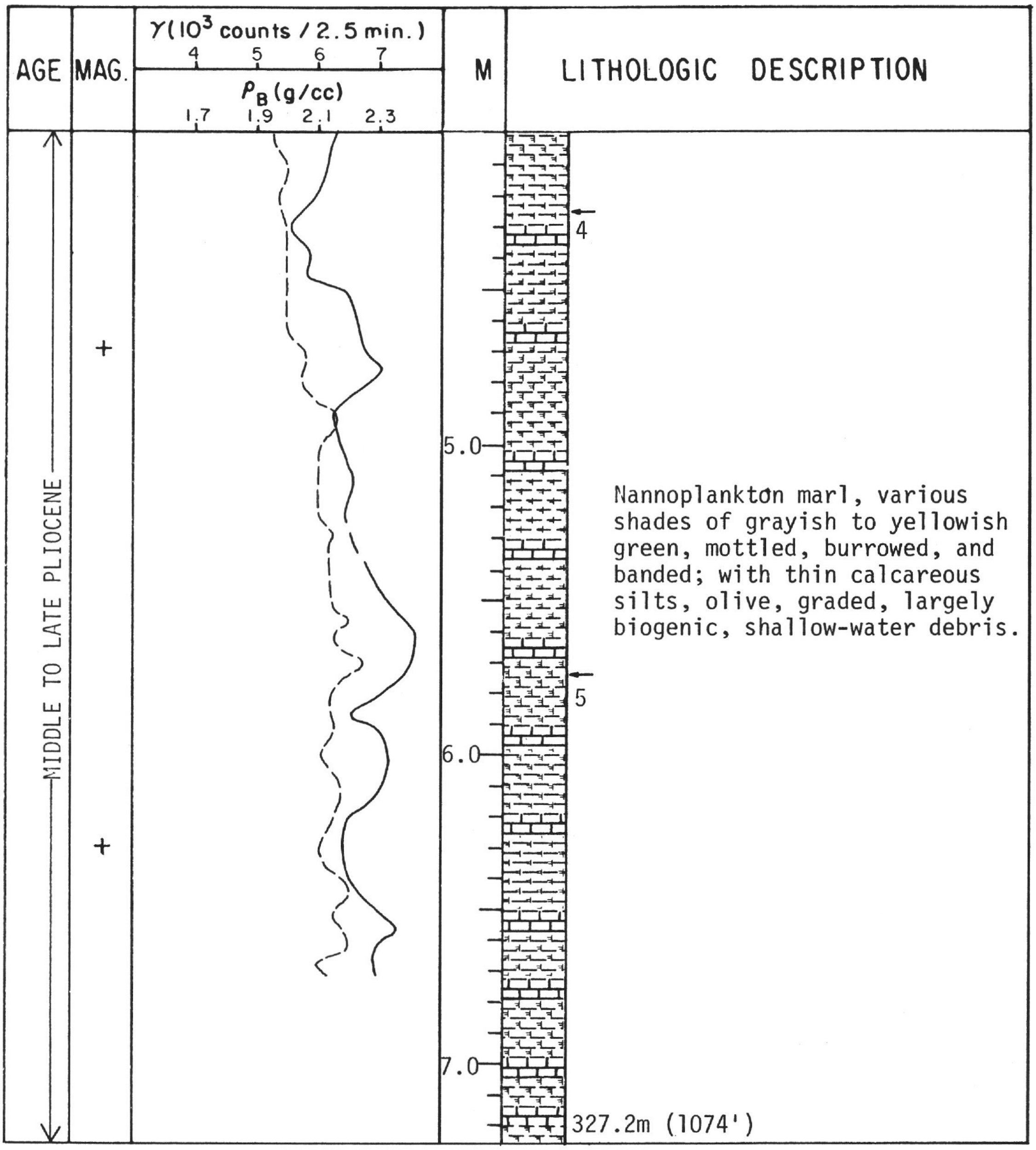


Figure 8. *Continued.*

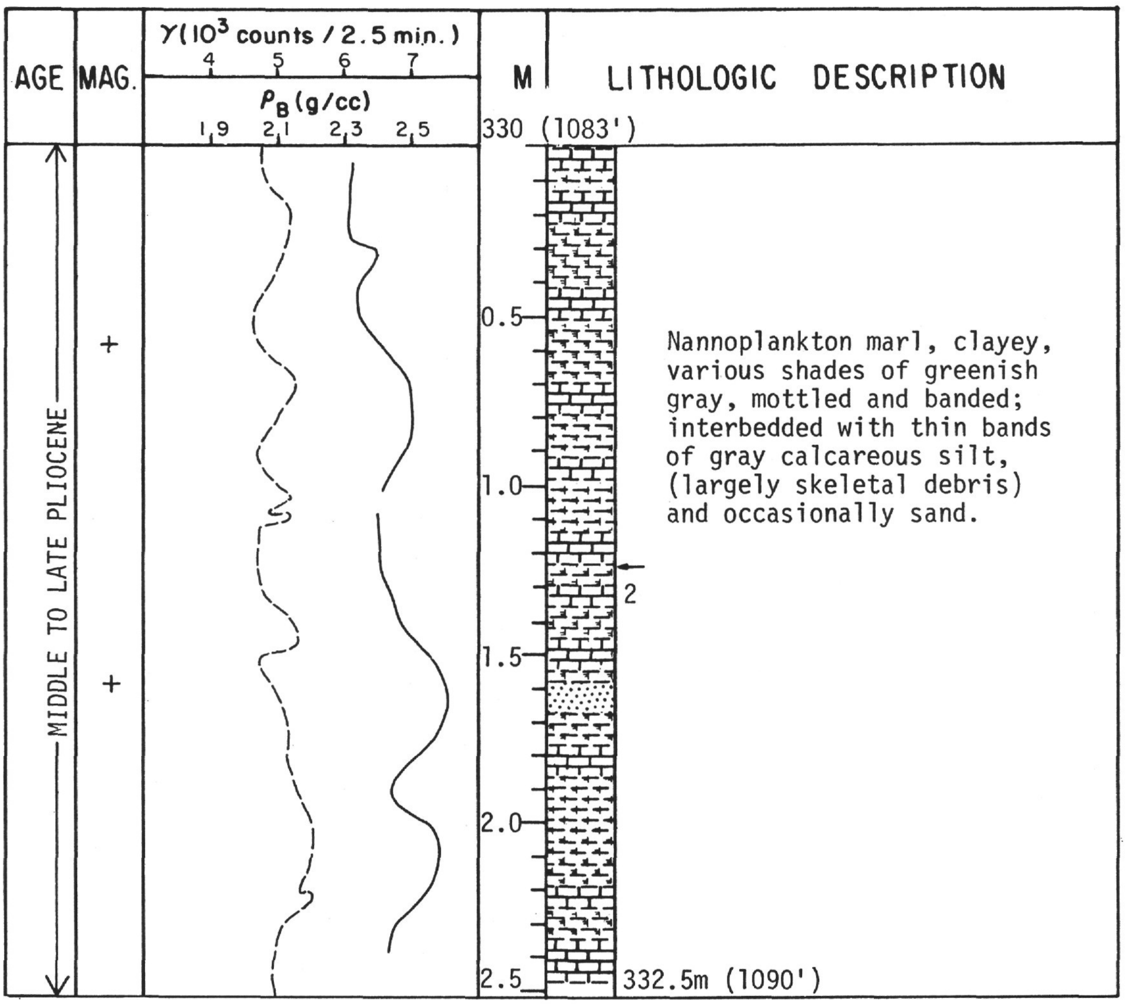


Figure 9. *Hole 3, Core 6.*

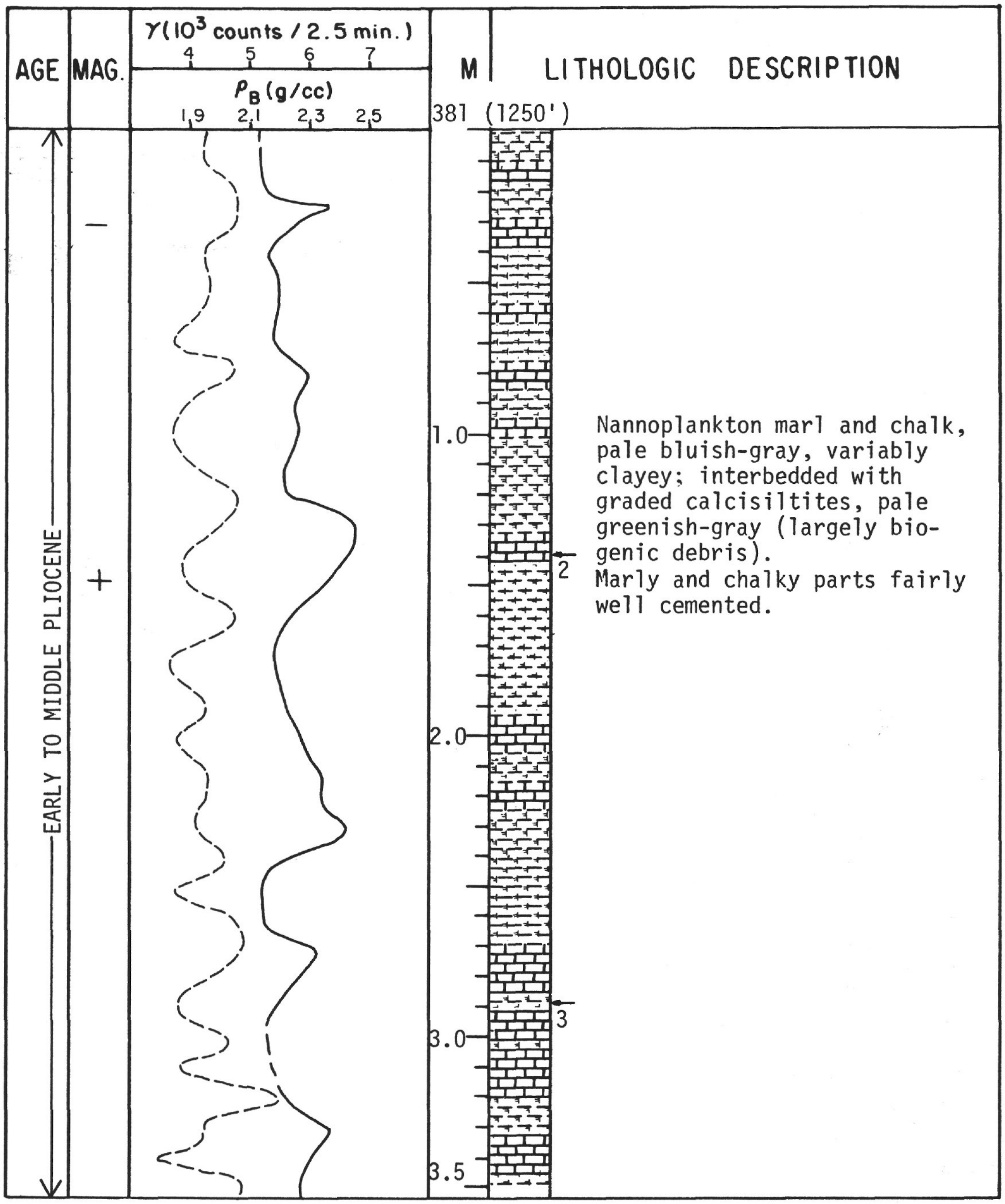


Figure 10. *Hole 3, Core 7.*

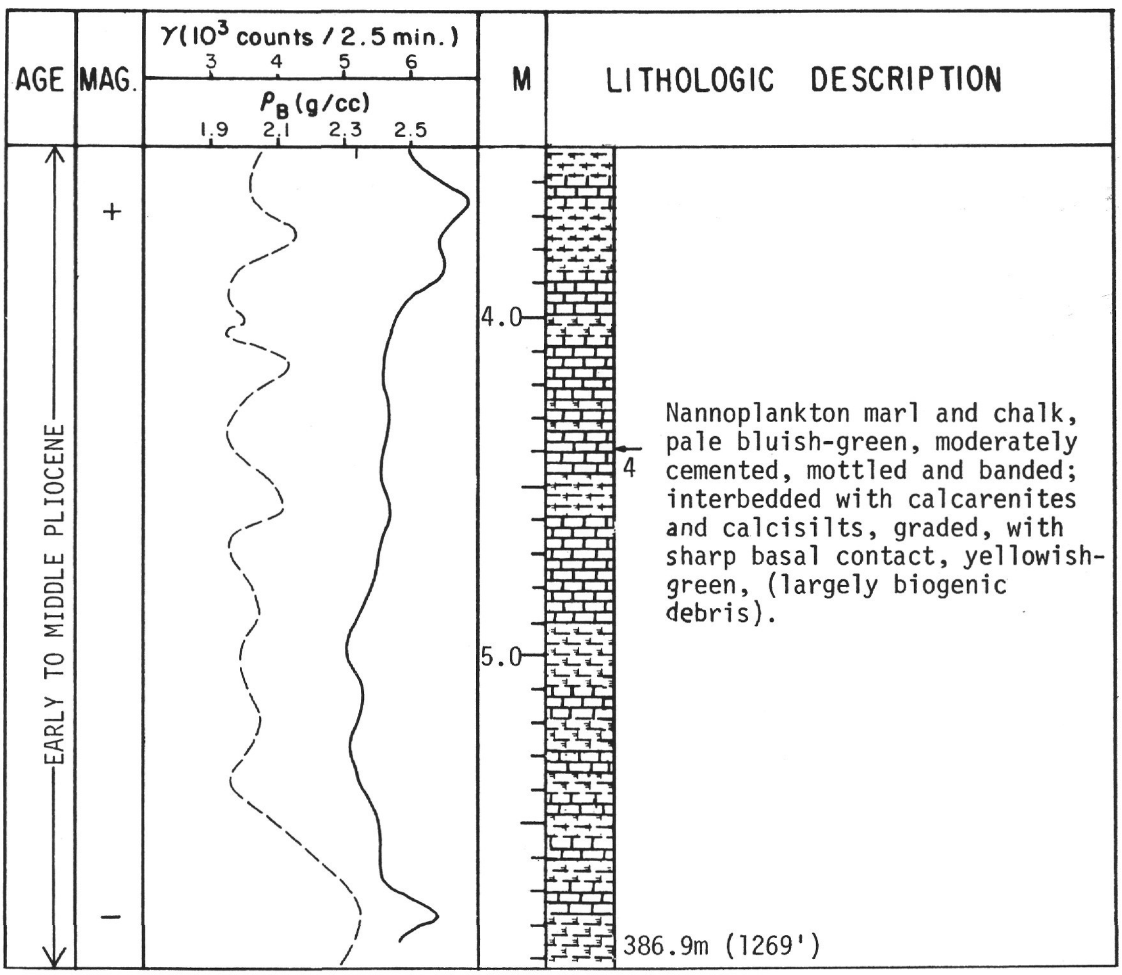


Figure 10. *Continued.*

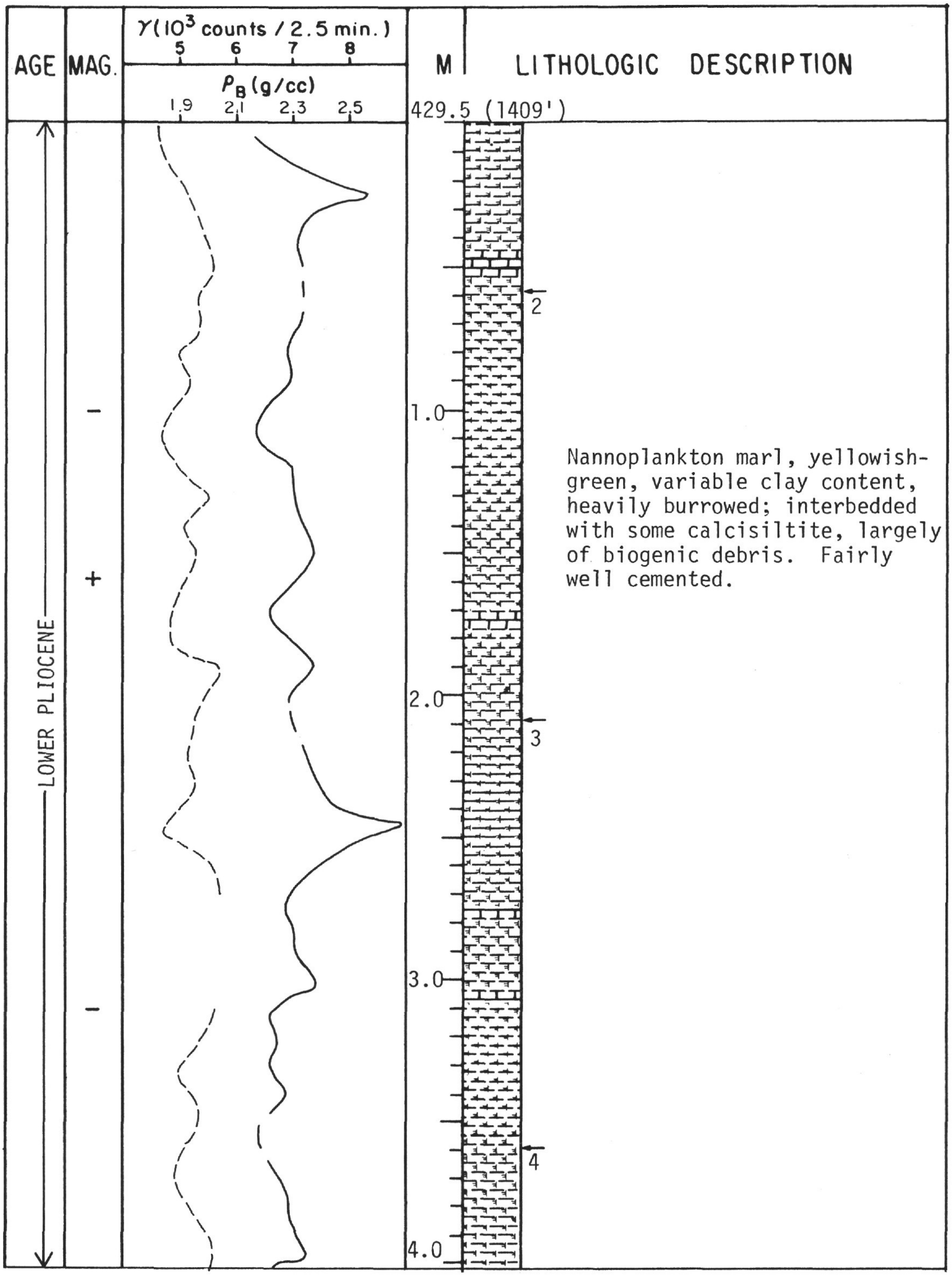


Figure 11. *Hole 3, Core 8.*

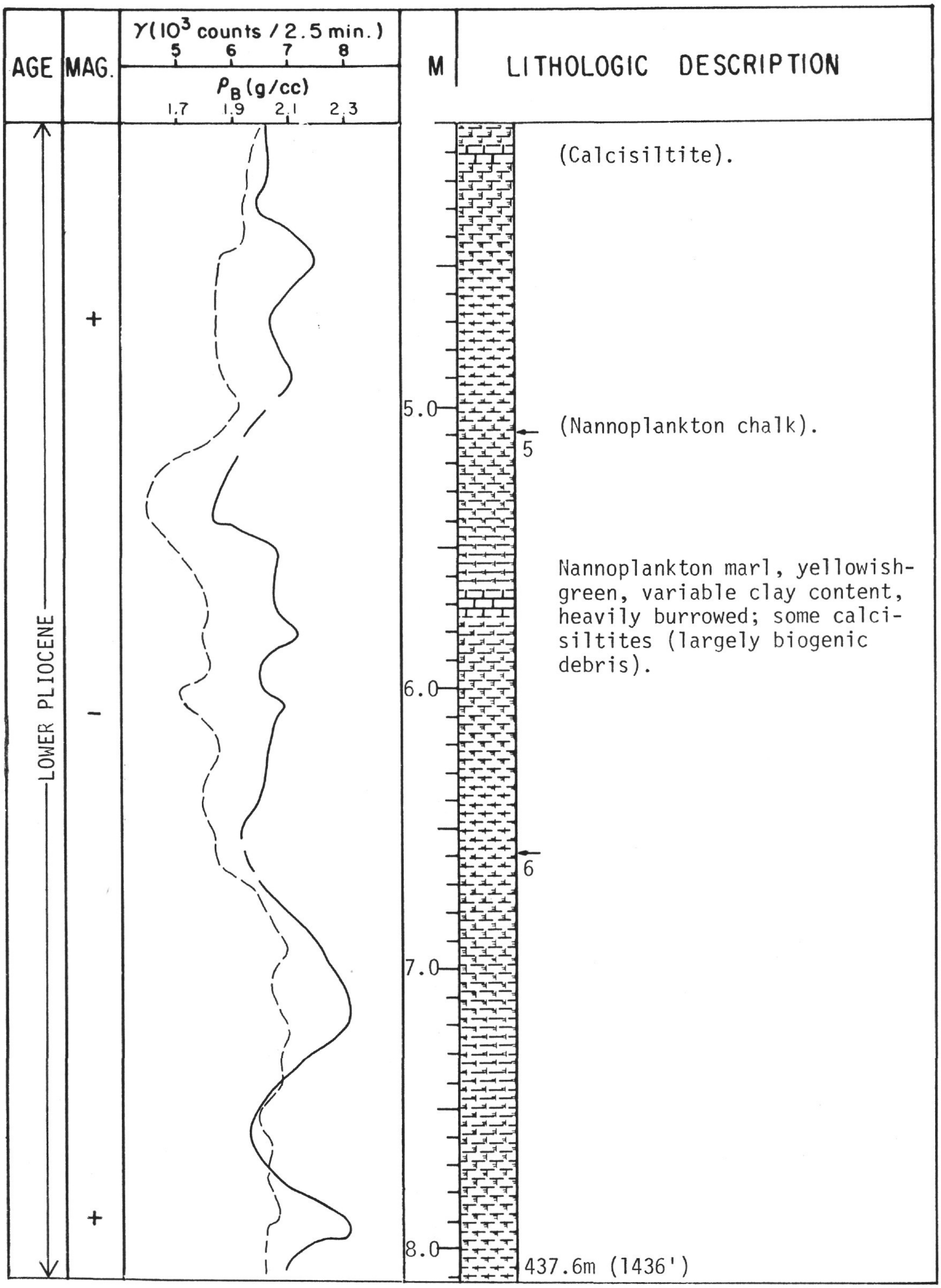


Figure 11. *Continued.*

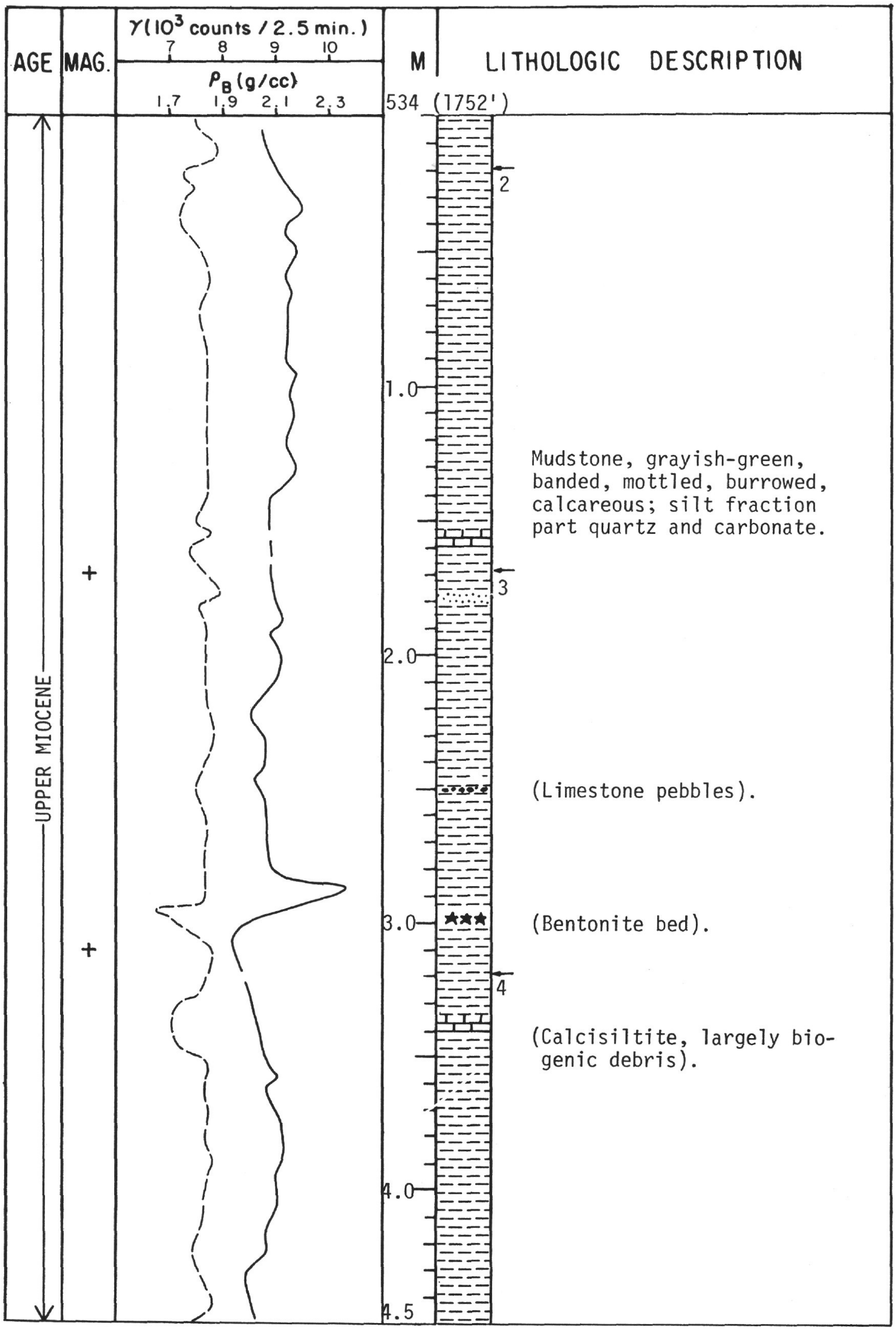


Figure 12. *Hole 3, Core 9.*

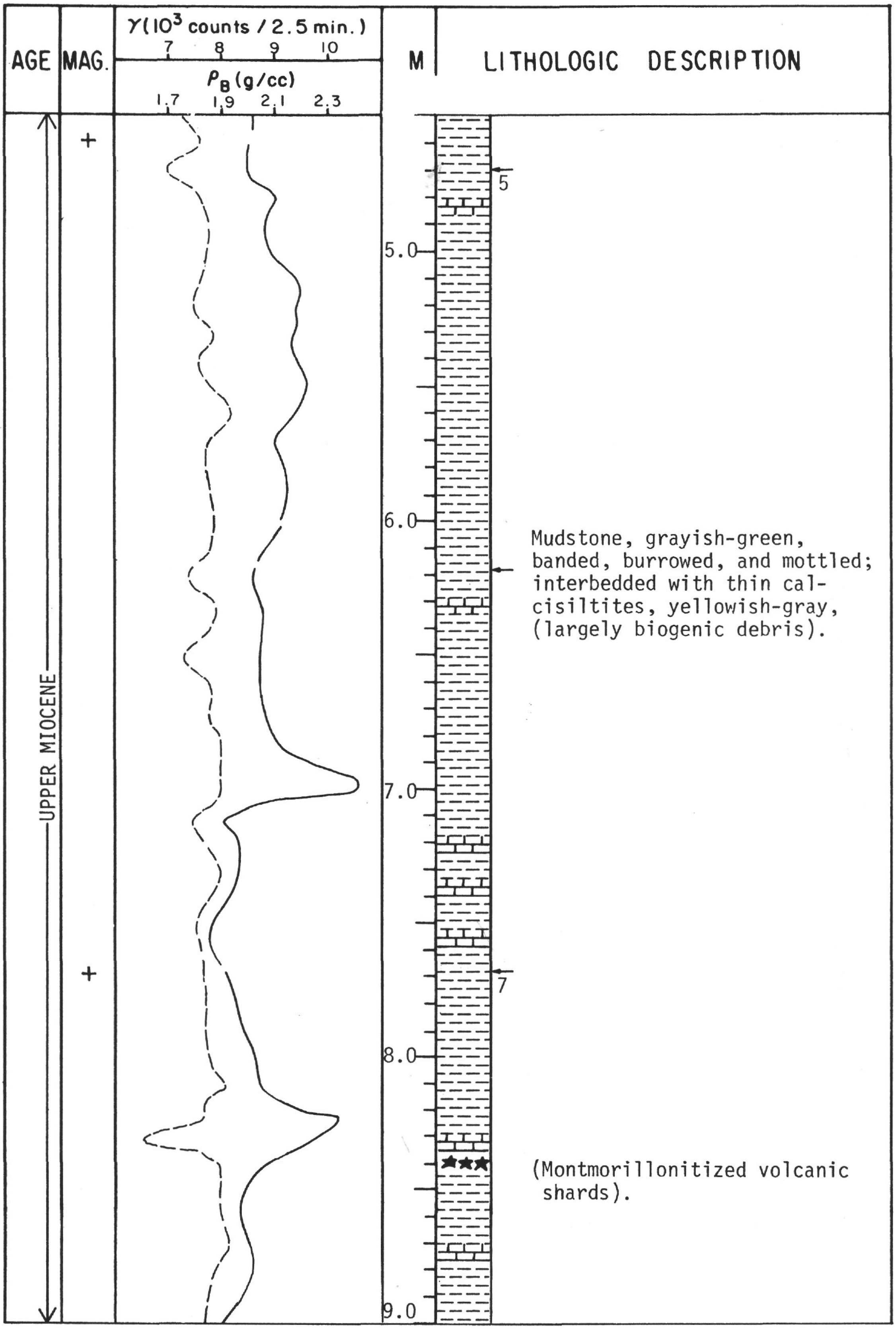


Figure 12. *Continued.*

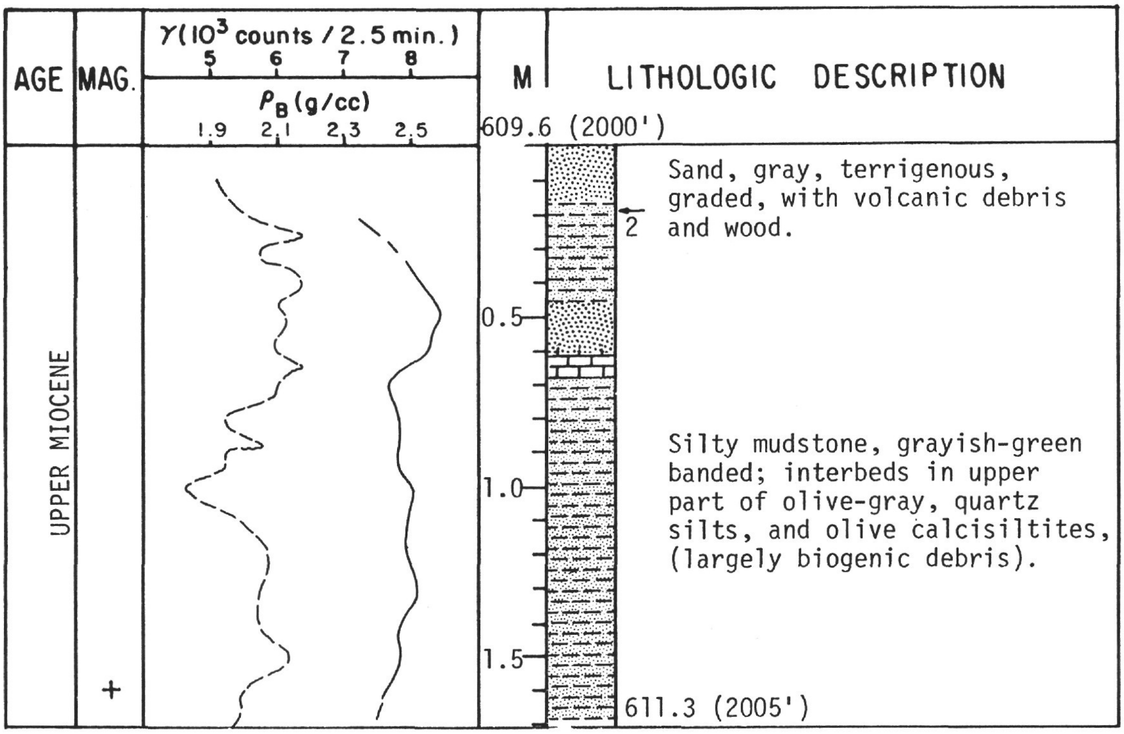


Figure 13. *Hole 3, Core 10.*

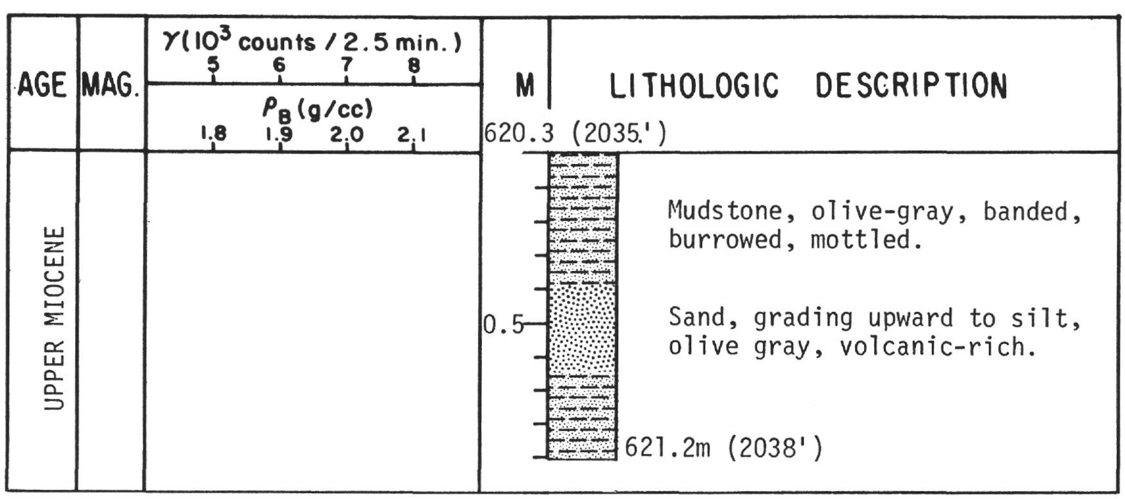


Figure 14. *Hole 3, Core 11.*

Figures 15 through 49 show details of the individual core sections of the cores from Site 3.

Each figure shows:

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

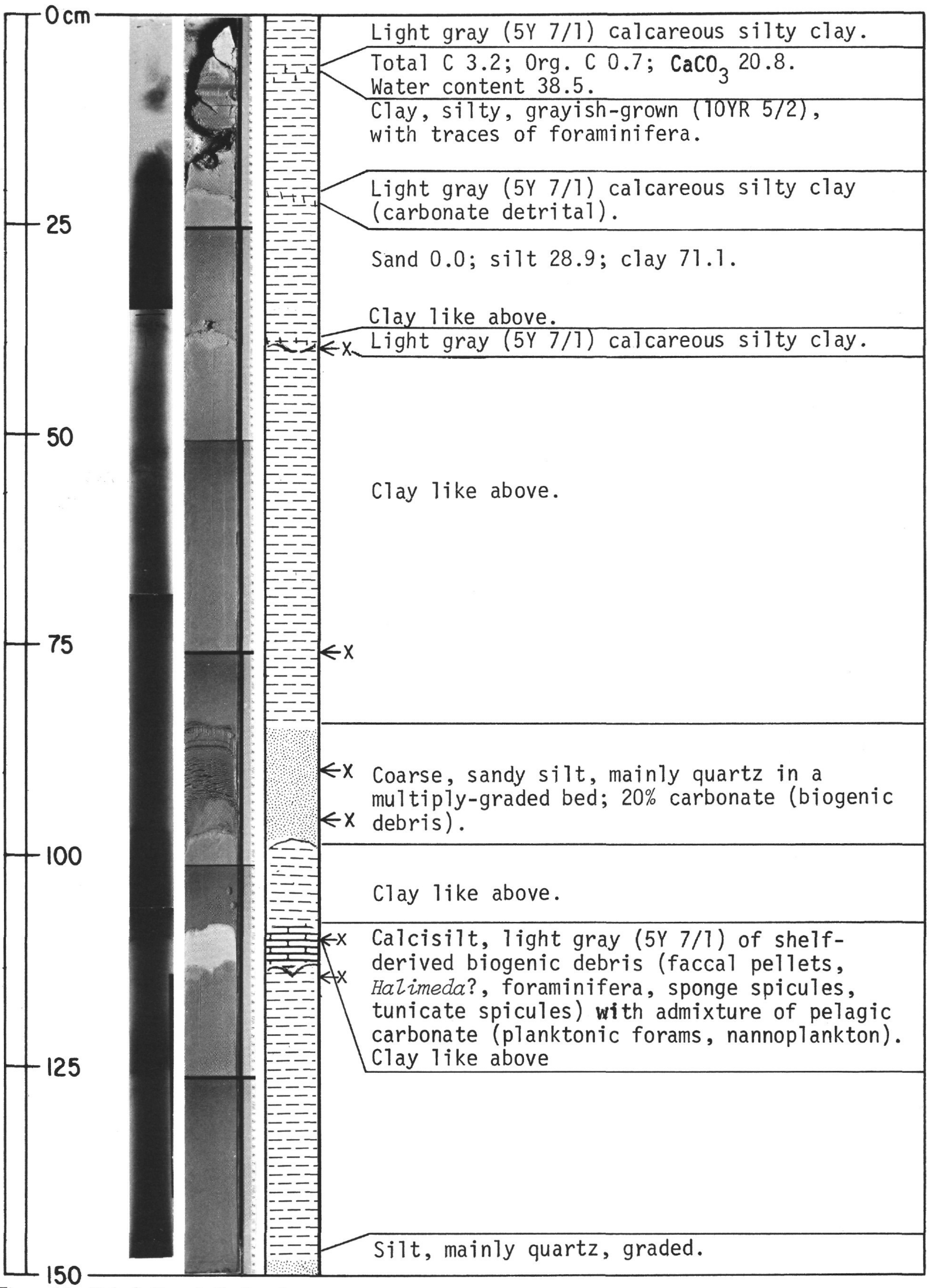
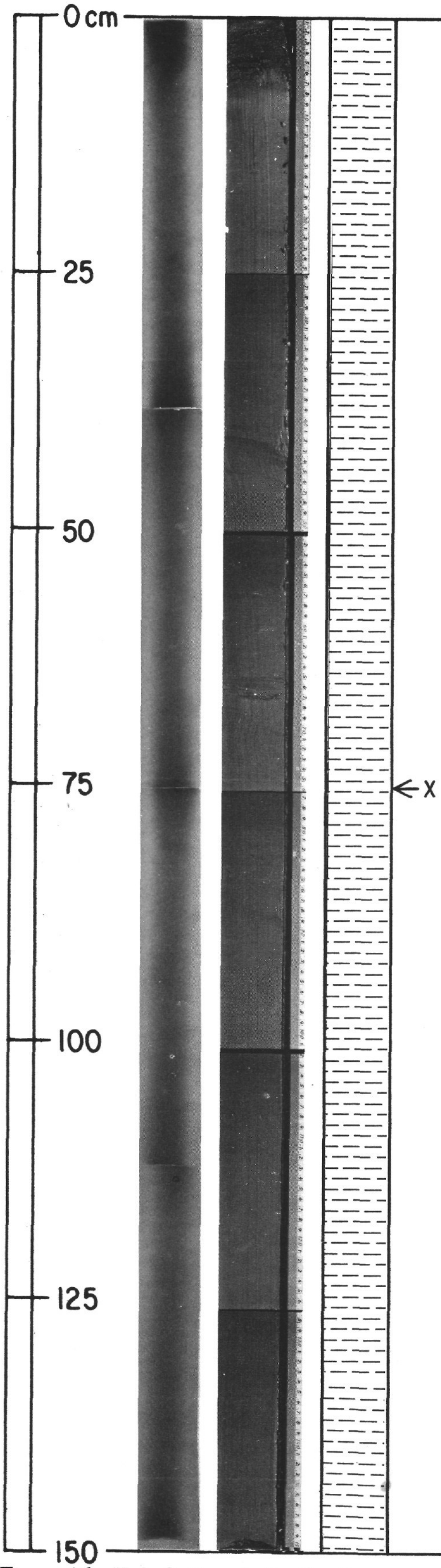


Figure 15. *Hole 3, Core 1, Section 1.*



Total C 2.3; Org. C 0.8; $CaCO_3$ 11.7.
Water content 36.6.

Sand 0.0; silt 21.0; clay 79.0.

Clay, silty, dark gray (5Y 4/1), with trace planktonic forams and coccoliths (in part reworked cretaceous); structureless: bands in photo are shadows.
Silt fraction contains much detrital carbonate.

Figure 16. *Hole 3, Core 1, Section 2.*

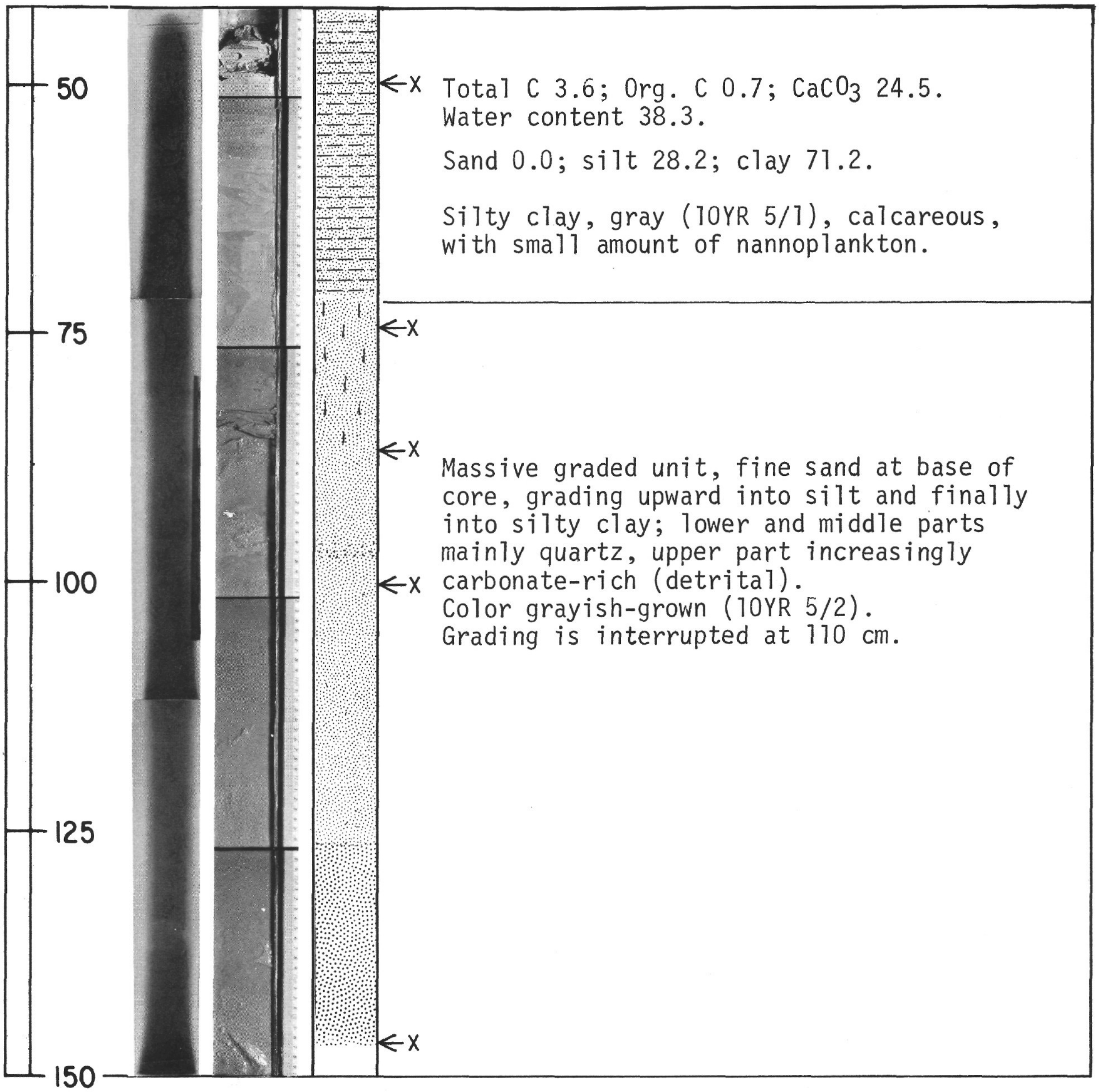
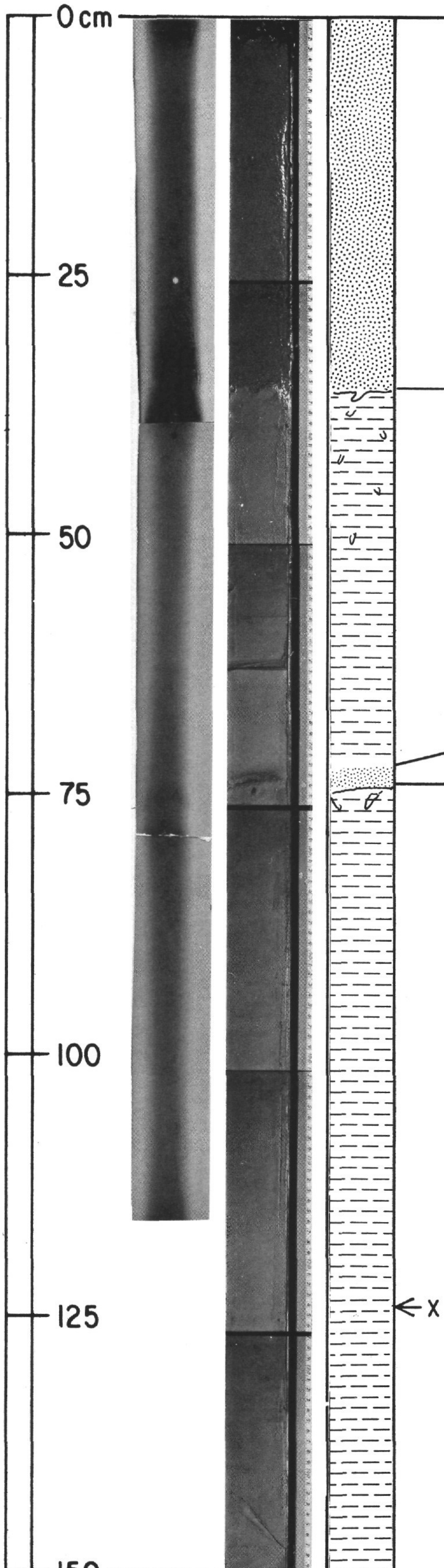


Figure 17. *Hole 3, Core 2, Section 1.*



Sand, fine with some medium grains, dominantly quartz; grayish-brown (10YR 5/2), basal part of graded unit; sharp and fluted (?) basal contact.

Total C 2.5; Org. C 0.7; $CaCO_3$ 14.8.
Water content 30.3.
Sand 4.7; silt 25.6; clay 69.7.

Silty clay, gray (10YR 5/1), upper part faintly mottled.

Silt, graded, with sharp basal contact (10YR 5/1).

Silty clay, silt fracton mainly detrital carbonate (10YR 5/1), top 2 cm mottled (burrowed?) blackish (2.5Y 2/1).

Clay like above, faintly laminated.

Figure 18. *Hole 3, Core 2, Section 2.*

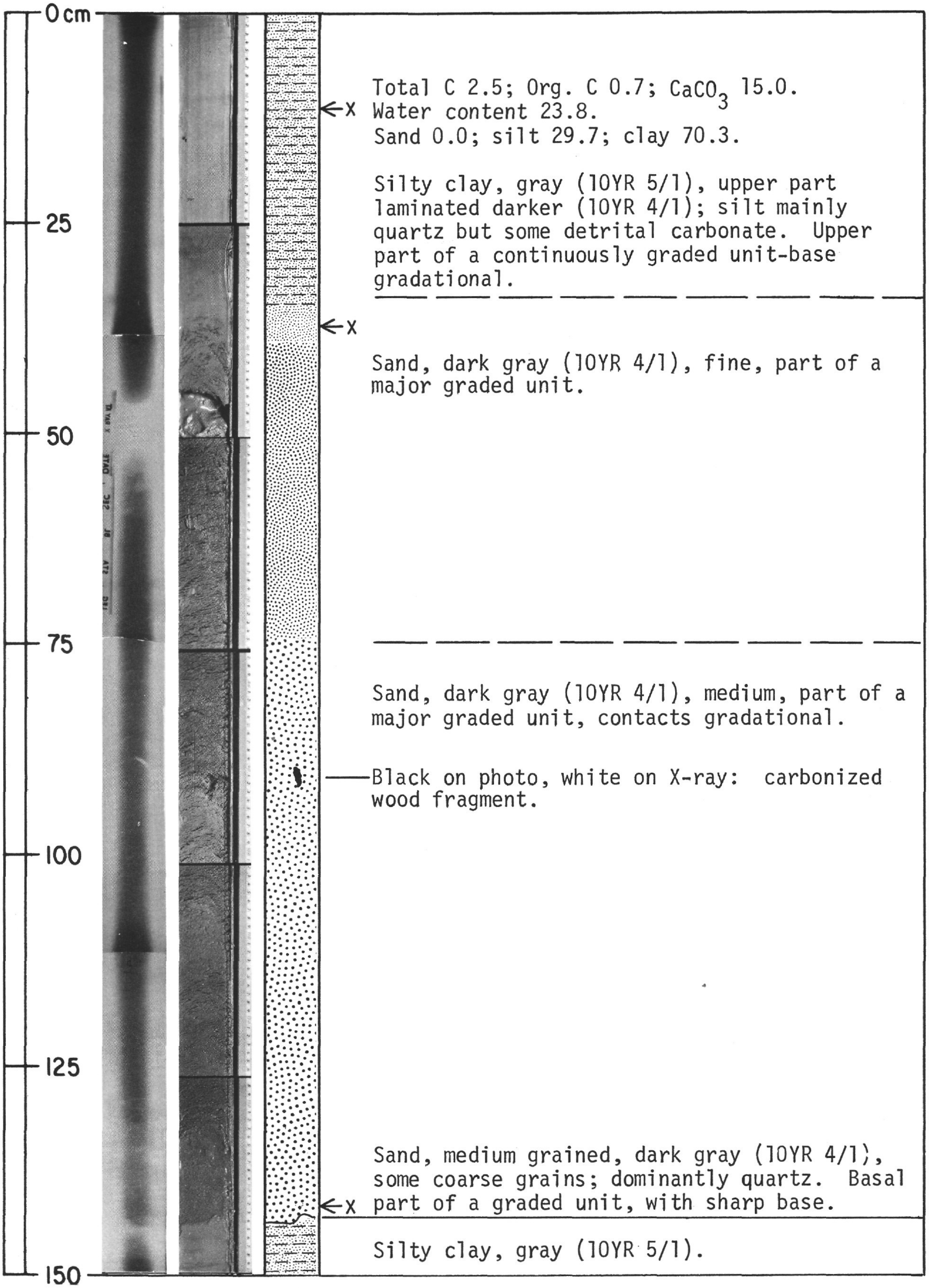


Figure 19. *Hole 3, Core 2, Section 3.*

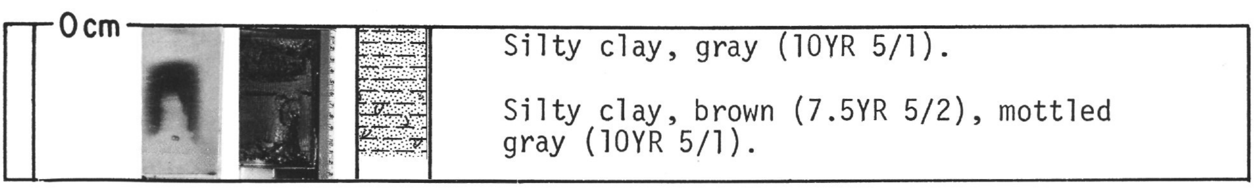


Figure 20. *Hole 3, Core 3, Section 1.*

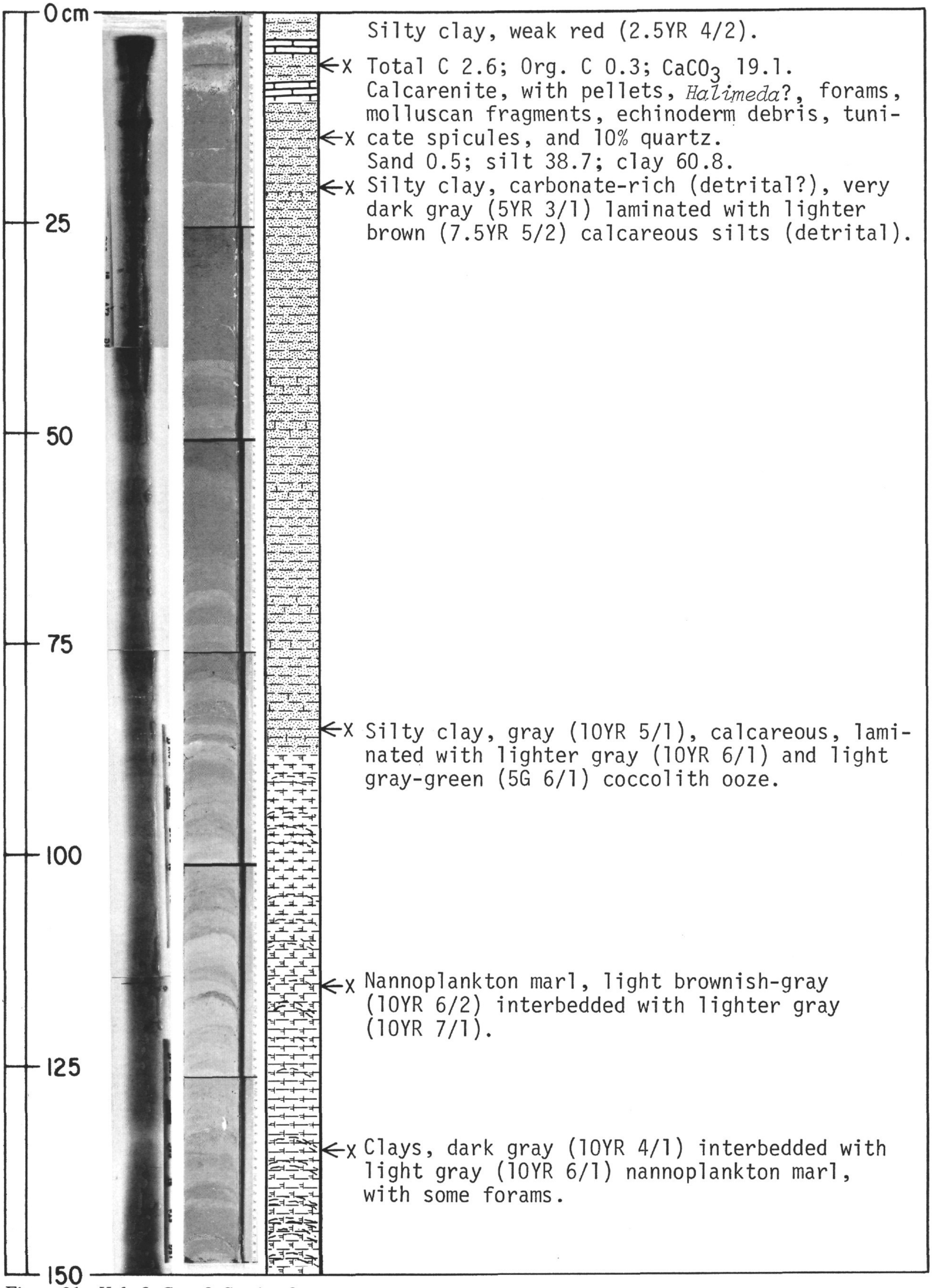
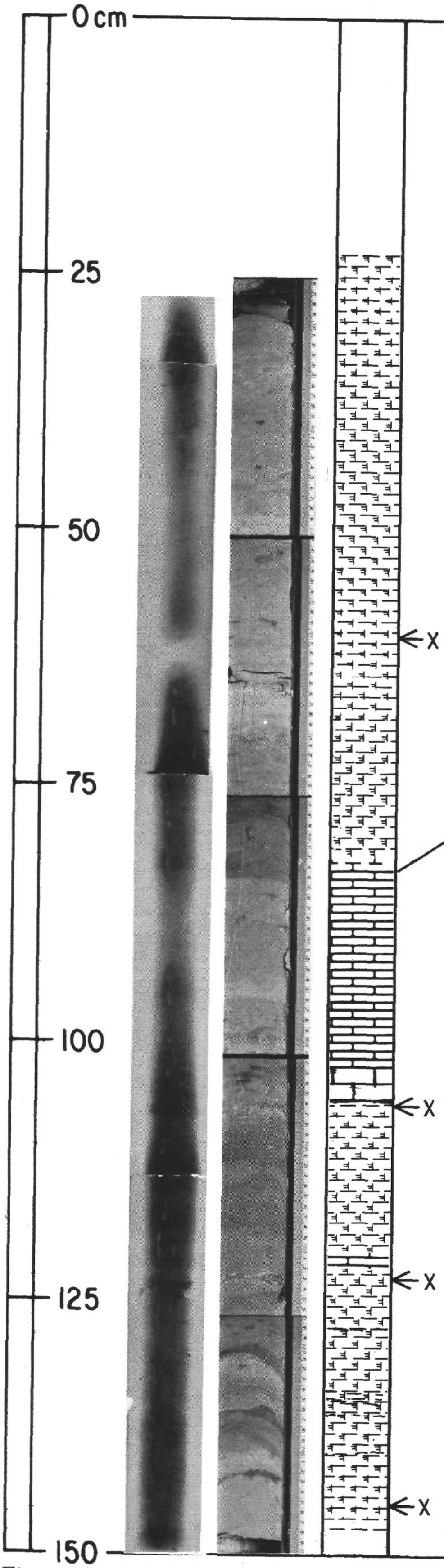


Figure 21. *Hole 3, Core 3, Section 2.*



Sand 0.8; silt 31.9; clay 67.4.

Total C 3.2; Org. C 0.4; $CaCO_3$ 23.8.
Water content 24.2.

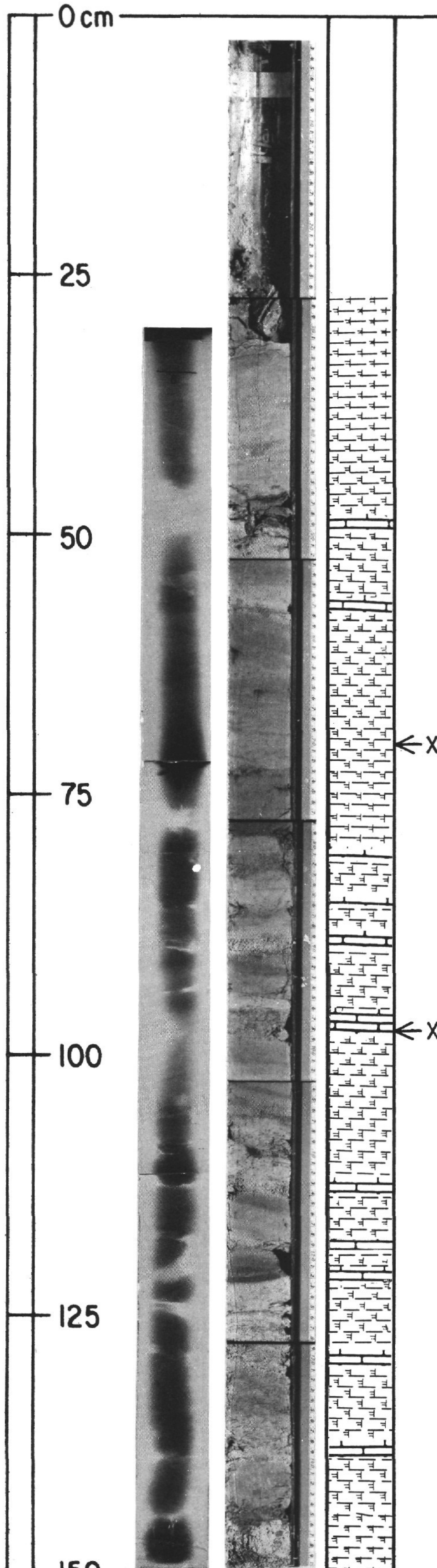
Nannoplankton marl, clayey, light olive-gray (5Y 6/2), mottled with sparse burrows; sand fraction consists of forams. Clay fraction varies, probably reflected in color.

Graded calcarenite-calcisilt, light olive-gray (5Y 6/2); base dominantly forams, sand grade, also includes pellets and molluscan fragments, basal contact sharp; grades upward into silt-grade carbonate; upper contact with coccolith chalk gradational.
Note grading shown on X-radiograph.

Nannoplankton marl, clayey, dark gray (5YR 4/1), layered with olive-gray (5Y 5/2).

Nannoplankton marl, gray (5YR 6/1), interlayered with brown (7.5YR 5/2); foraminifera form a minor fraction. Contains thin laminae of calcarenite/calcisiltite, of foraminifera and mollusk fragments.

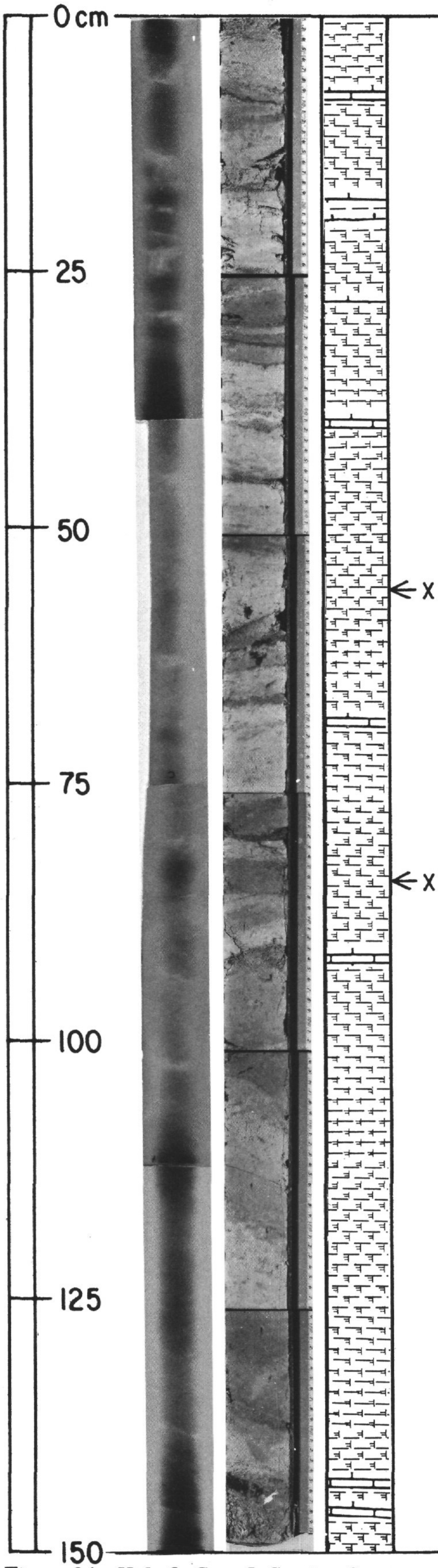
Figure 22. *Hole 3, Core 4, Section 1.*



Sand 2.8; silt 23.7; clay 73.5.
Total C 4.3; Org. C 0.2; $CaCO_3$ 34.6.

Nannoplankton marl, clayey, light green (5G 6/1), mottled and banded with lighter, darker, and more yellowish (5GY 6/1) shades. Contains thin beds of carbonate silt of foraminifera (benthic and pelagic) pellets, *Halimeda*?, tunicate spicules, mollusk fragments and nannoplankton in order of abundance.

Figure 23. *Hole 3, Core 5, Section 1.*

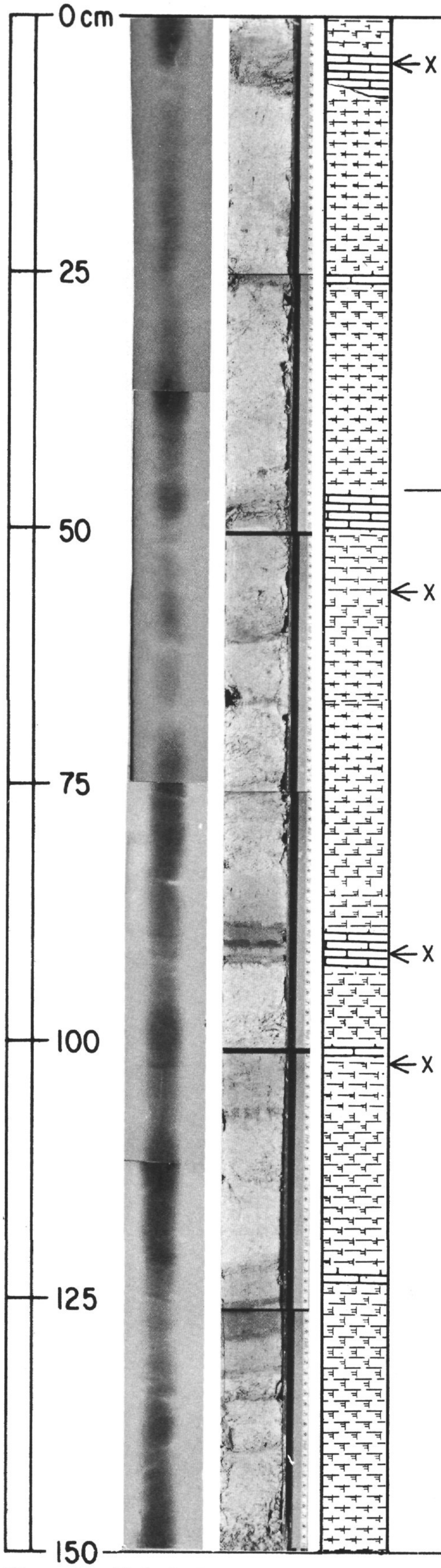


Total C 4.1; Org. C 0.2; $CaCO_3$ 32.3.
Water content 23.3.

Sand 2.7; silt 29.1; clay 68.2.

Nannoplankton marl with variable clay content, containing much fine skeletal debris including tunicate spicules; light green (5G 6/1) banded with darker (5G 8/1) and more yellow (5GY 6/1) shades. Burrow-mottled. Interbedded with thin calcisilts, pale olive to pale greenish-yellow (10Y 6/2 to 10Y 7/2), of skeletal debris, pellets, tunicate spicules, forams.

Figure 24. *Hole 3, Core 5, Section 2.*



Calcarenite (10Y 5/2).

Total C 5.4; Org. C 0.3; $CaCO_3$ 42.2.
Water content 30.6.
Sand 3.8; silt 23.8; clay 72.4.

Nannoplankton marl, greenish-gray (5G 7/1), burrowed; with variable clay content, interbedded with thin calcarenites/silts, pale yellowish-gray (5Y 8/1) to olive (10Y 5/2), graded, with sharp base and gradational top.

Calcarenite (10Y 5/2).
Carbonate sands/silts consist of skeletal fragments (algae?, mollusks, etc.), foraminifera (benthonic and pelagic), and nannoplankton; only main calcarenite/silt beds are shown.

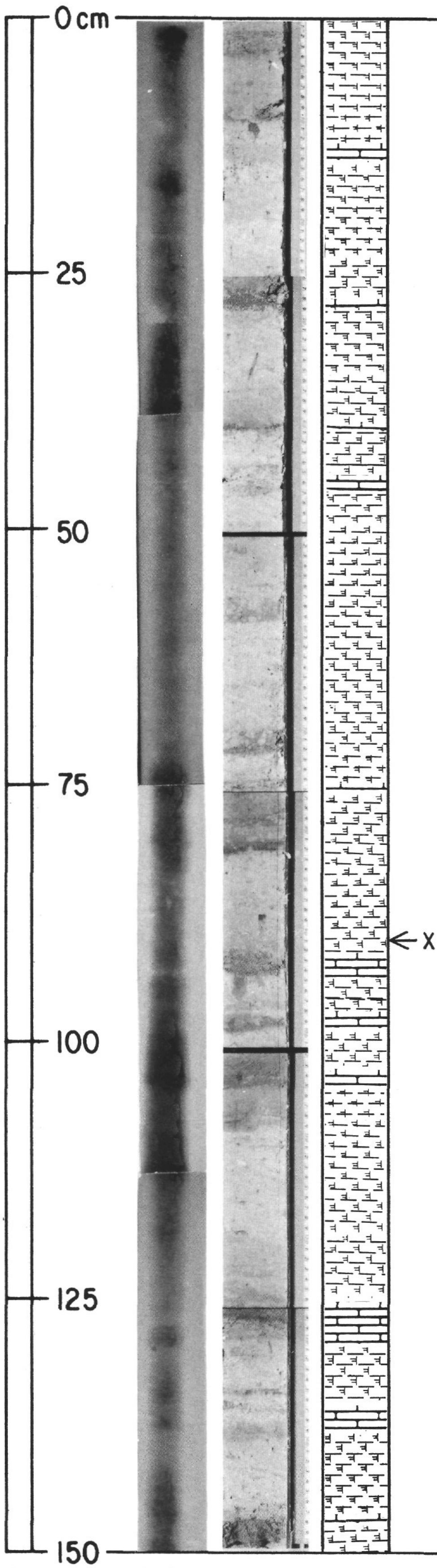
Coccolith chalk contains minor quantities of similar skeletal debris.

Calcarenite (5Y 8/1).

Calcarenite (5Y 8/1).

Calcarenite (5Y 8/1).

Figure 25. *Hole 3, Core 5, Section 3.*



Total C 4.5; Org. C 0.2; $CaCO_3$ 35.9.
Water content 25.1.

Sand 1.0; silt 20.0; clay 79.0.

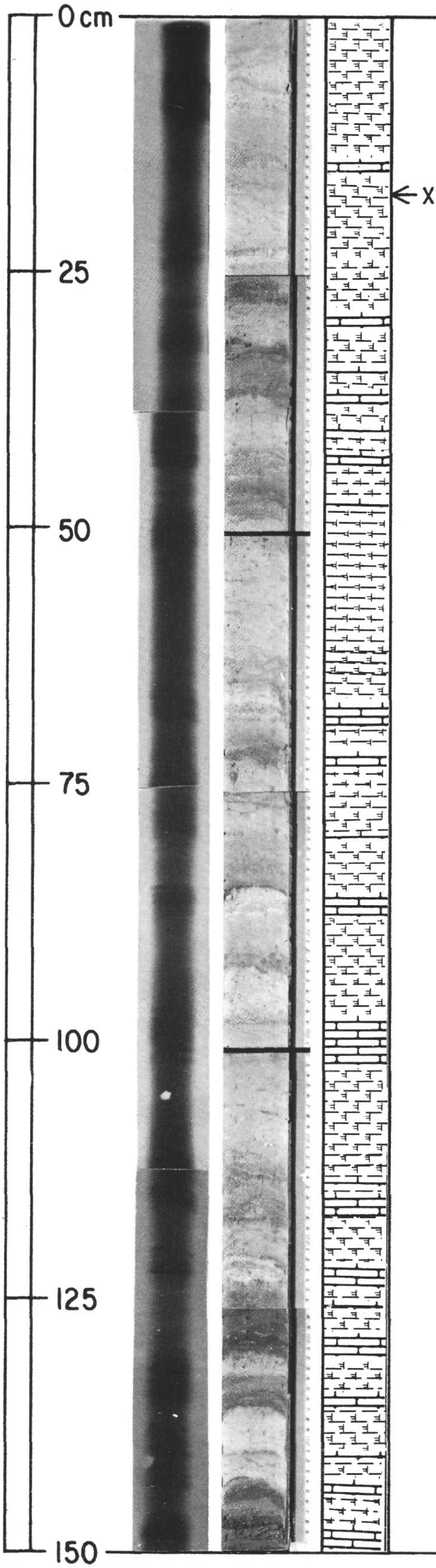
Nannoplankton marl, greenish-gray (5G 7/1), with variable clay content, mottled with burrows, interbedded with thin calcarenites/silts, graded, with sharp base, pale olive (10Y 5/2) to olive-gray (5Y 5/2 and 5/1).

Calcarenites/silts much like those in section 3, skeletal debris.

Marl contains small quantities of similar skeletal debris.

Note grading shown on X-radiograph.

Figure 26. *Hole 3, Core 5, Section 4.*

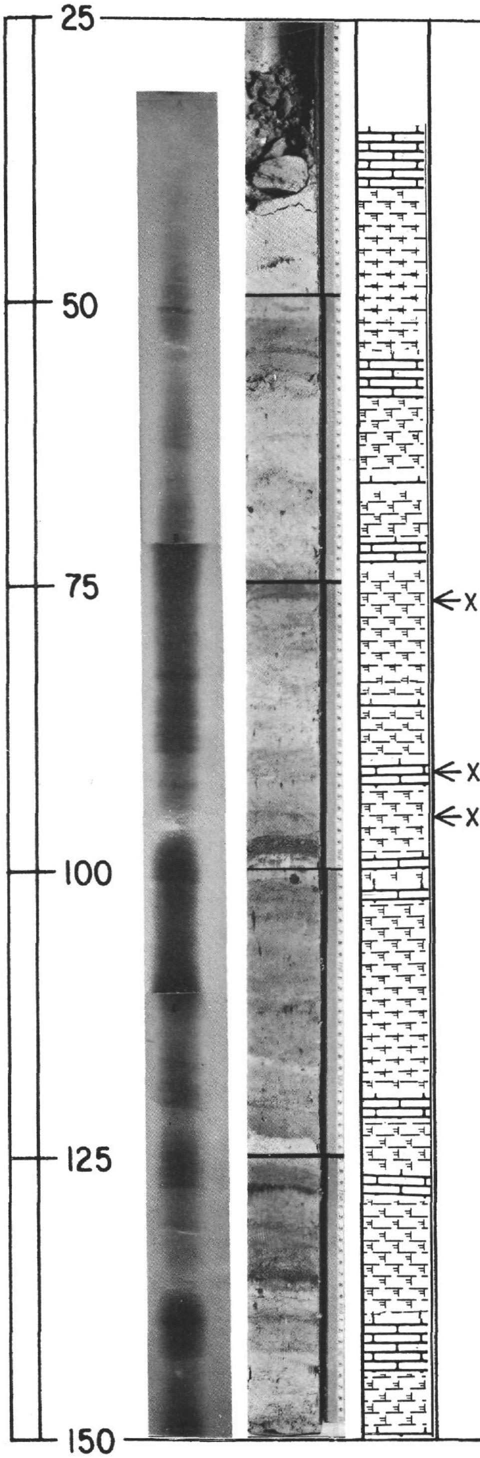


Sand 0.1; silt 38.7; clay 61.2.

Total C 5.6; Org. C 0.3; $CaCO_3$ 43.9.
Water content 24.5.

Coccolith chalk, variably clayey, greenish-gray (5G 6/1), banded with lighter (5G 8/1) and more olive (5GY 6/1), burrowed, mottled interbedded with thin calcarenites/siltites, graded, olive (10Y 6/2 - 7/2), of skeletal debris. Coccolith chalk contains small percentage of similar skeletal debris. Some dolomite rhombs present. Note grading shown on X-radiograph.

Figure 27. *Hole 3, Core 5, Section 5.*



Total C 6.4; Org. C 0.2; $CaCO_3$ 1.8.
Water content 27.2.

Sand 3.6; silt 23.8; clay 72.6.

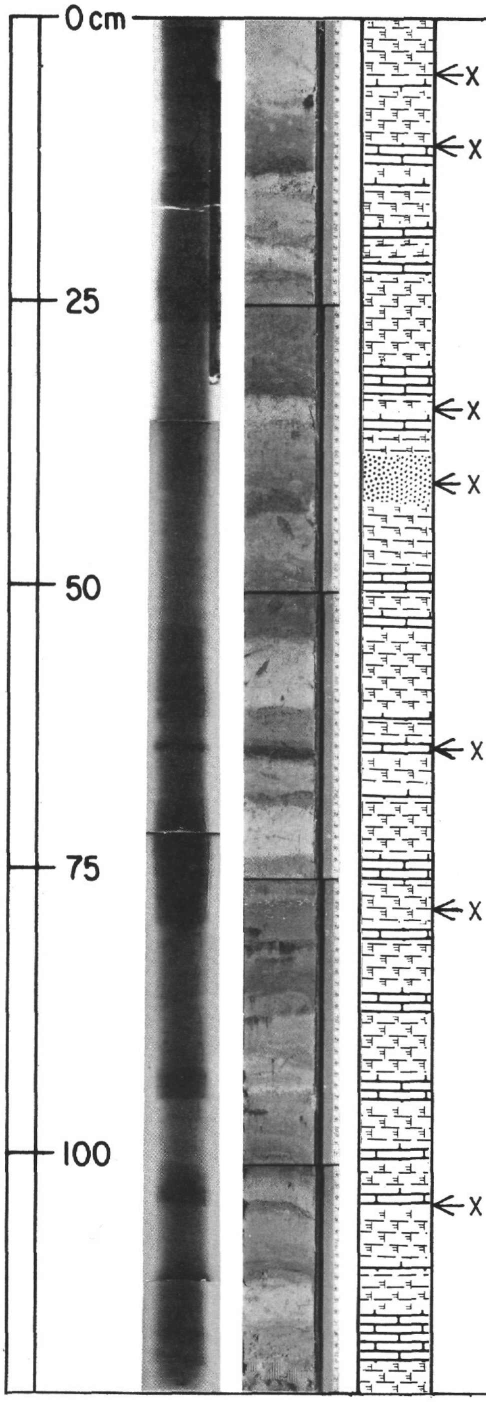
Nannoplankton marl, variably clayey, greenish-gray (5G 6/1), banded with lighter (5G 8/1) and more olive (5GY 6/1) bands; burrow-mottled throughout.

Interbedded with thin calcarenites/siltites, graded, cream to greenish-yellow (10Y 6/2 to 10Y 7/2), composed of peloids and skeletal debris including benthonic and planktonic foraminifera, molluscan fragments, echinoderm debris, and tunicate spicules.

Marl also contains minor admixture of such debris, and dolomite rhombs.

Note grading in calcarenites expressed in X-radiograph.

Figure 28. *Hole 3, Core 6, Section 1.*



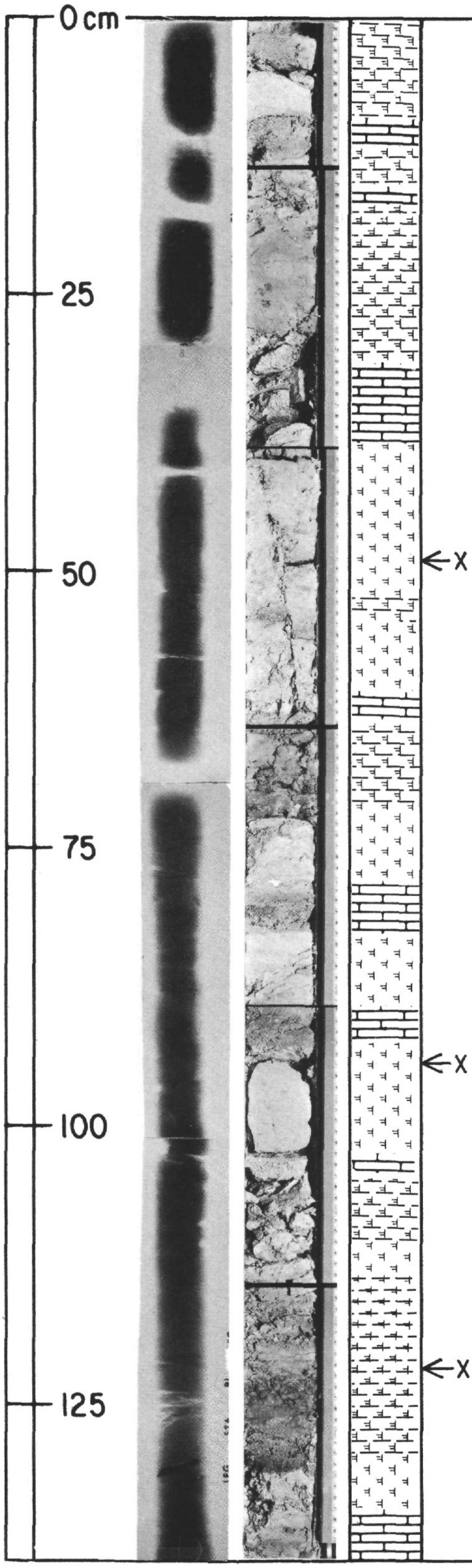
Total C 5.7; Org. C 0.3; $CaCO_3$ 44.6.
Water content 18.4.

Sand 2.4; silt 26.6; clay 71.0.

Nannoplankton marl, tan gray (5Y 8/1) to light gray (5G 7/1) to medium green-gray (5G 6/1) and green-gray (5G 5/1), with varying admixtures of clay interbedded with graded sands and silts, graded-mainly of skeletal debris (peloids, algae?, benthonic and planktonic foraminifera, molluscan fragments, and echinoderm debris, with minor admixture of quartz);in part, however, dominantly terrigenous (quartz etc.). Colors of sand/silt vary from dark gray (5Y 5/1) to olive-gray (5GY 6/1) and tan gray (5Y 8/1).

Note reflection of grading on X-radiograph.

Figure 29. *Hole 3, Core 6, Section 2.*

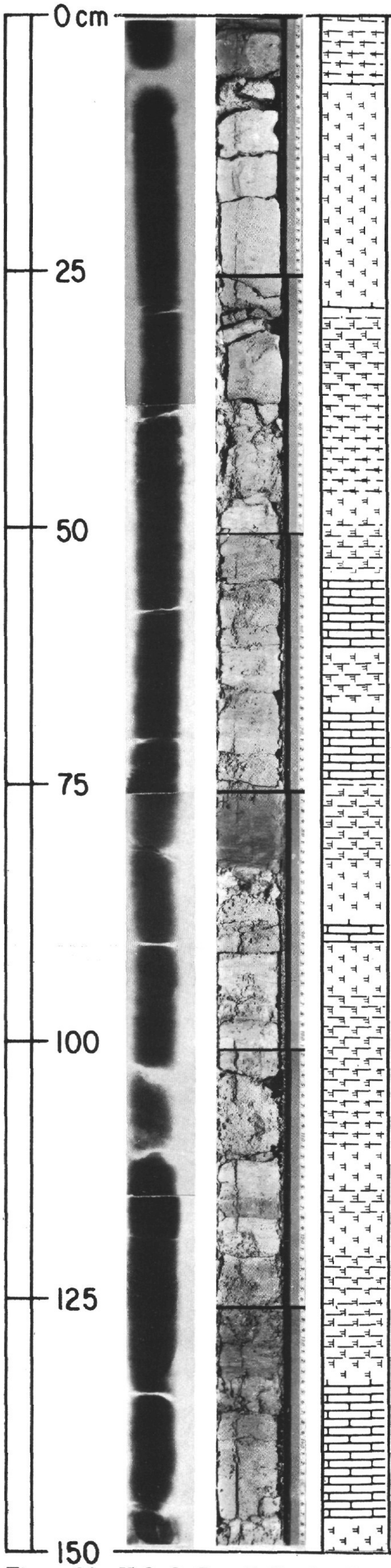


Total C 4.7; Org. C 0.2; $CaCO_3$ 37.2.
Sand 2.1; silt 24.4. clay 73.5.

Nannoplankton marl and chalk, pale blue-gray (5B 6/1 - 7/1) with a few gray-green bands (5G 4/1), burrowed; interbedded with calcarenites/silts, pale greenish-gray (5GY 8/1), consisting of foraminifera (benthonic and planktonic), peloids, sponge spicules, shell debris, and coccoliths; graded.

Marly-chalky parts rather firmly cemented.

Figure 30. *Hole 3, Core 7, Section 1.*

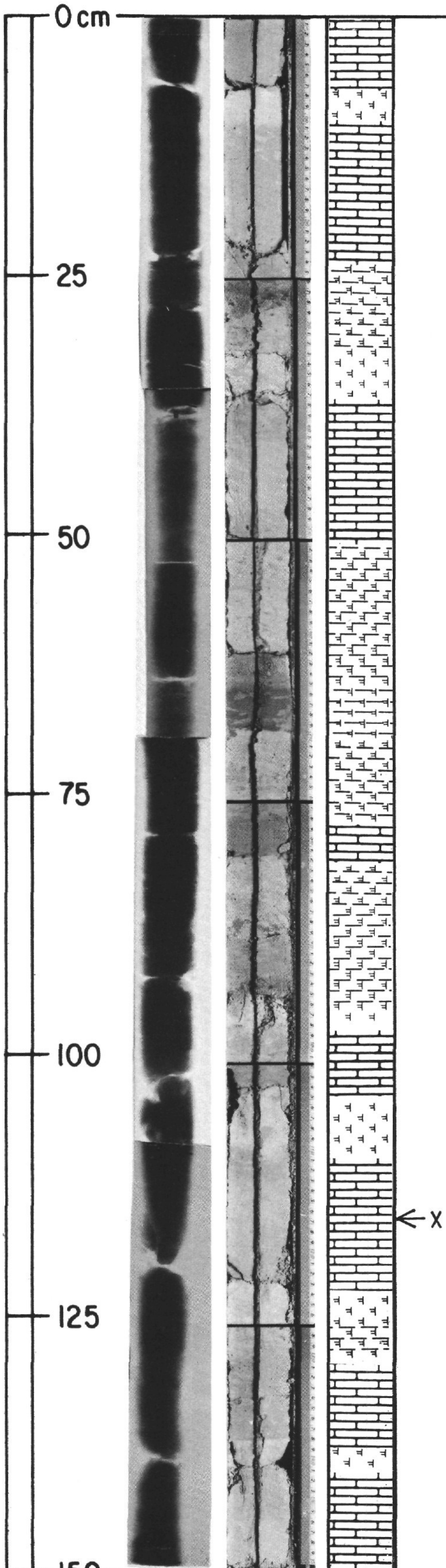


Sand 0.2; silt 18.3; clay 81.5.
Total C 4.1; Org. C 0.2; $CaCO_3$ 33.1.
Water content 17.7.

Nannoplankton marl and chalk, pale to very pale blue-gray (5B 6/1 - 8/1), burrowed clay content variable; interbedded with graded units of calcisiltite. Sandy, composed of skeletal debris, benthonic and planktonic foraminifera; grayish yellow-green (GY 7/1).

Marly-chalky parts rather firmly cemented.

Figure 31. *Hole 3, Core 7, Section 2.*



Total C 3.2; Org. C 0.2; $CaCO_3$ 25.2.
Water content 25.8.
Nannoplankton marl and chalk, pale blue-gray (5B 8/1), with darker, strongly burrowed, probably clayey bands; interbedded with graded calcisiltites and calcarenites, of foraminifera (benthonic, planktonic), peloids, and skeletal debris of mollusks and other organism.

The calcarenites/silts are graded, with sharp base, and normally are well laminated in lower part.

Marly-chalky parts rather firmly cemented.

Sand 0.9; silt 30.8; clay 68.3.

Figure 32. *Hole 3, Core 7, Section 3.*

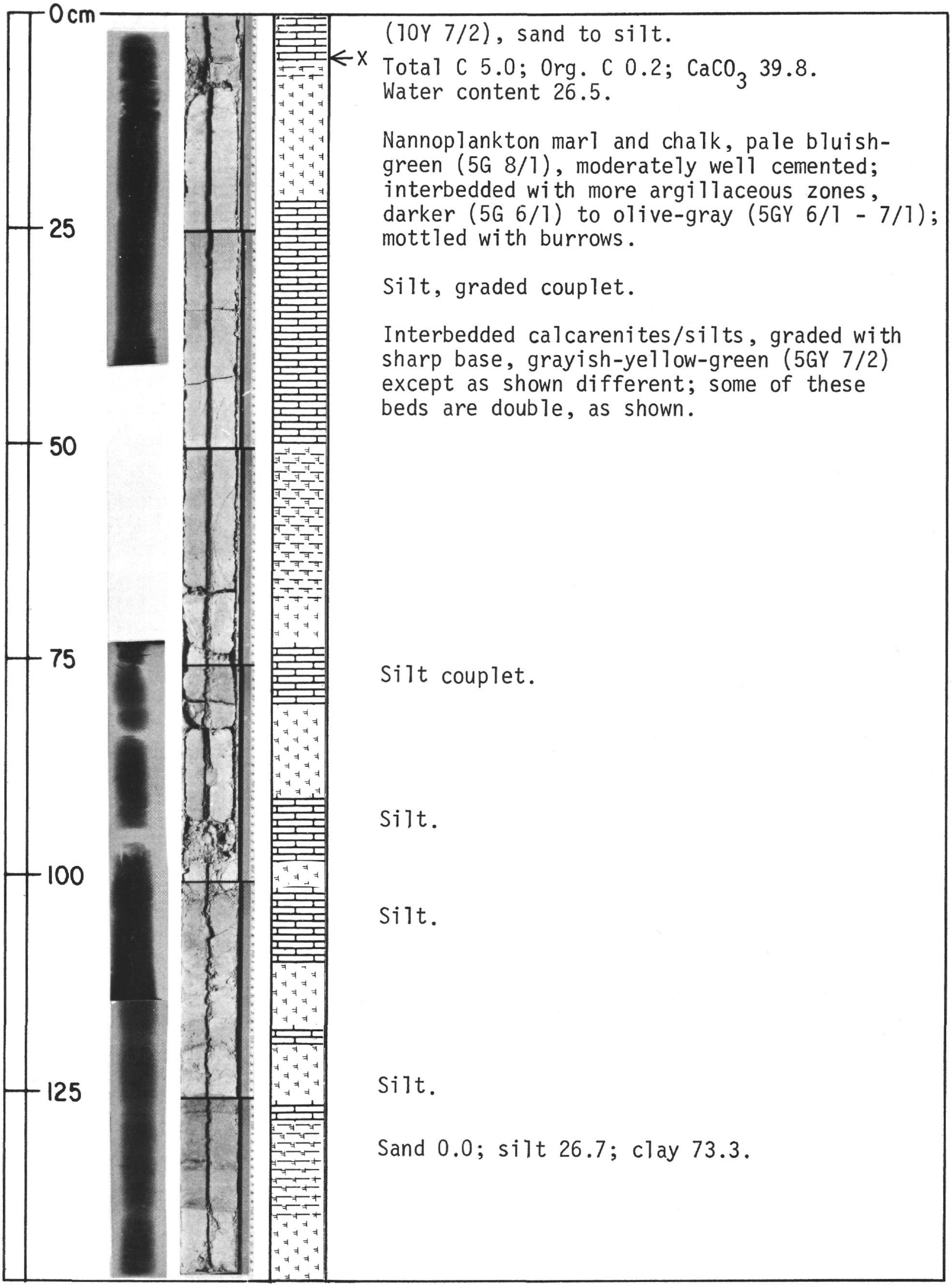
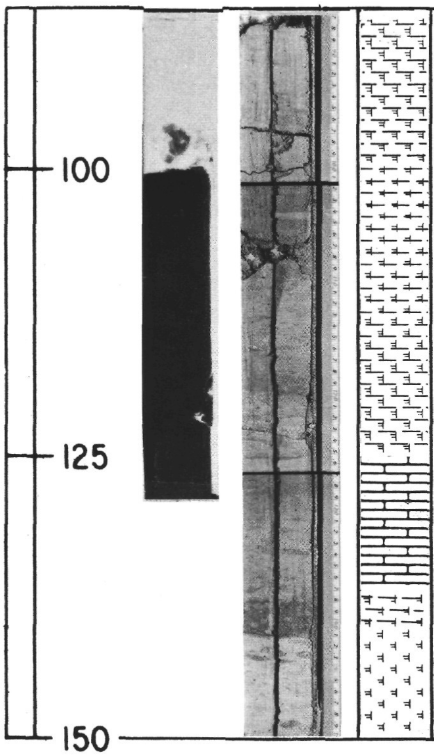


Figure 33. *Hole 3, Core 7, Section 4.*



Total C 4.5; Org. C 0.2; $CaCO_3$ 35.5.
Water content 28.0.
Sand 0.1; silt 15.3; clay 84.6.

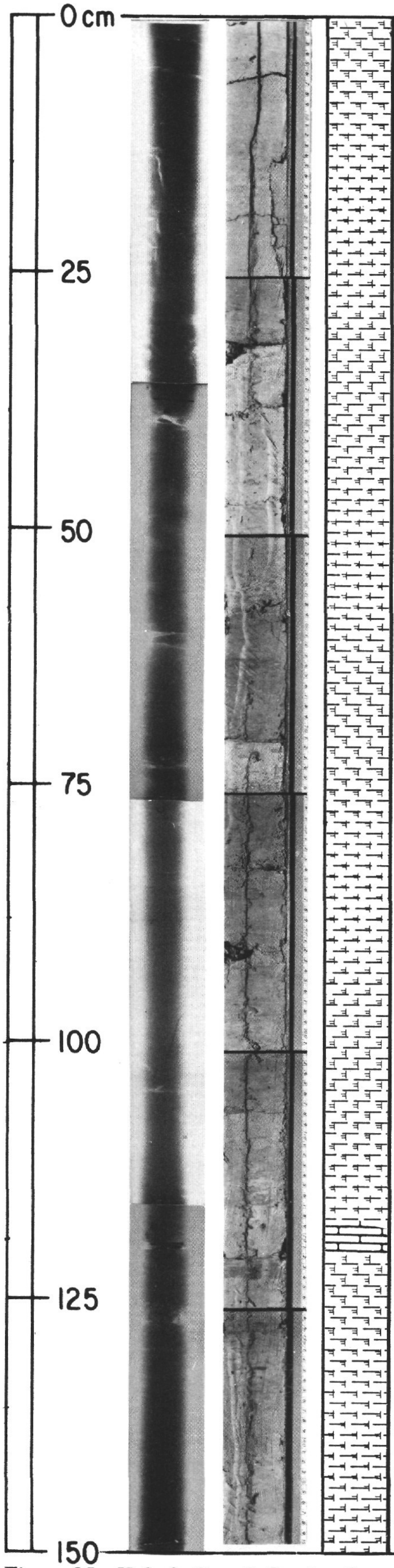
Nannoplankton marl, light greenish (5G 6/1), burrow-mottled very light (5G 8/1), with mm-laminations of (5GY 5/1 - 7/1).

Same, silty.

Darker, argillaceous zone, (5GY 6/1), heavily burrow-mottled (5G 8/1).

Light, cemented nannoplankton chalk, (5GY 7/1), burrow-mottled (5G 5/1).

Figure 34. *Hole 3, Core 8, Section 1.*



(10GY 5/2)

Total C 4.6; Org. C 0.3; $CaCO_3$ 35.8.
Water content 24.5.
Sand 0.2; silt 10.5; clay 89.3.

Nannoplankton marl, with variable clay content; shades of yellowish-green; heavily burrowed throughout with some large horizontal to oblique stuffed burrows, and small, sharply defined chondrites-type burrows. Fairly firmly cemented.
(5GY 6/2).

(10GY 5/2).

(5GY 6/2).

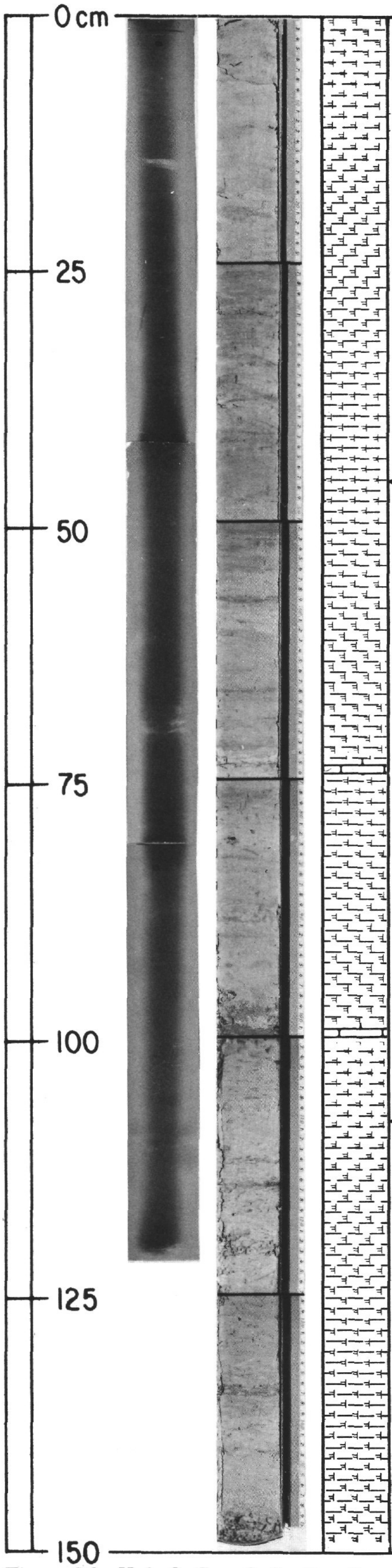
(10GY 5/2).

(5GY 6/2).

(5Y 4/1) Calcisiltite of indeterminate skeletal debris, peloids, tunicate spicules, foraminifera, and nannoplankton.

(10GY 5/2).

Figure 35. *Hole 3, Core 8, Section 2.*



Total C 3.6; Org. C 0.2; $CaCO_3$ 28.6.
Water content 23.0.
Sand 0.3; silt 55.7; clay 44.0.

Nannoplankton marl, in thin irregularly interbedded lighter and darker (more clay-rich) units; grayish-green (5G 5/1 - 6/1), abundantly burrowed with larger and small (clustered *Chondrites*-type) burrows.

←X Silt fraction contains some quartz, as well as planktonic foraminifera, coccoliths, discoasters.

Calcisiltite, pale green (5G 8/1).

Calcisiltite, dark dusky green (5G 3/1).

←X

Figure 36. *Hole 3, Core 8, Section 3.*

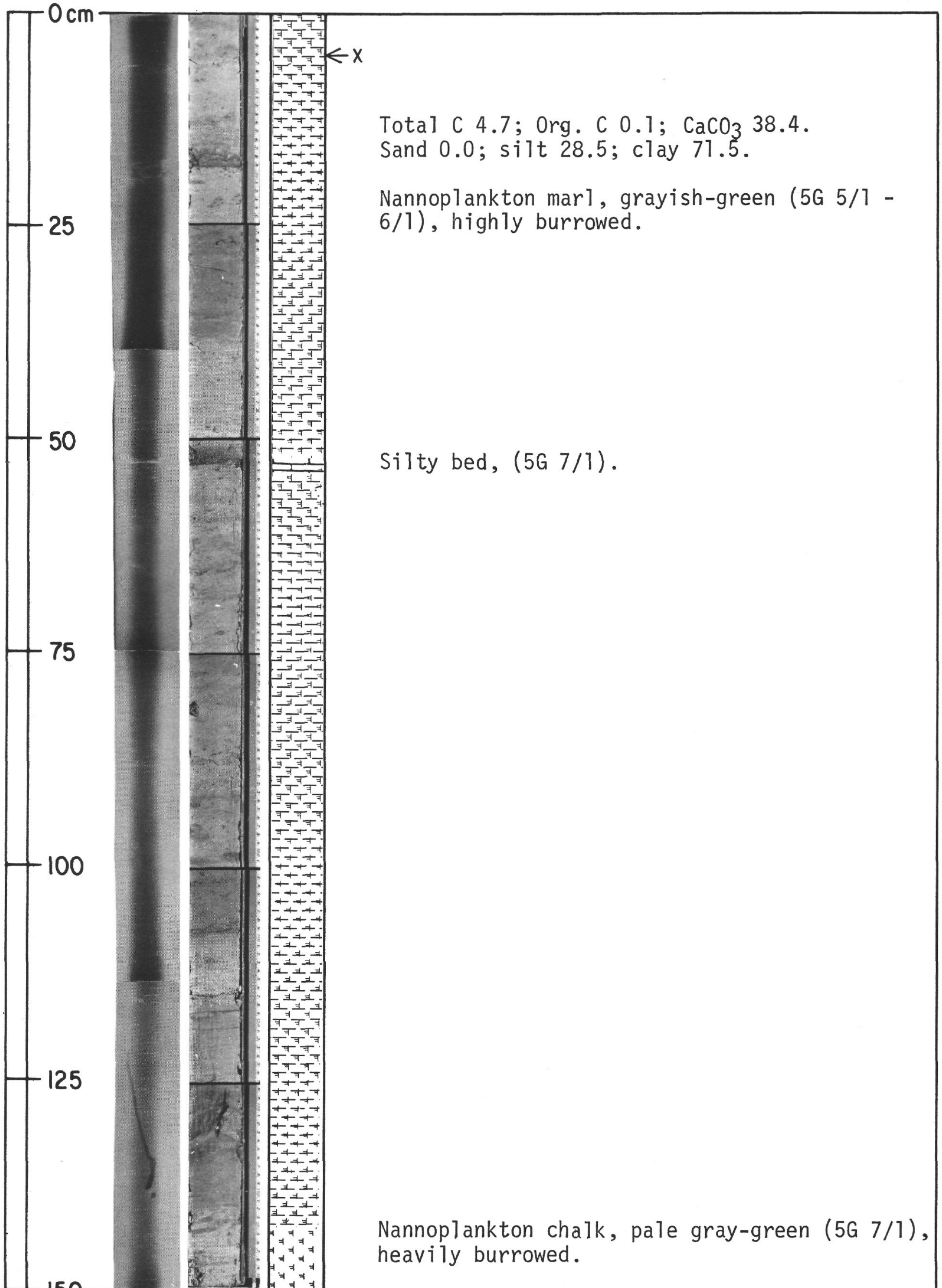
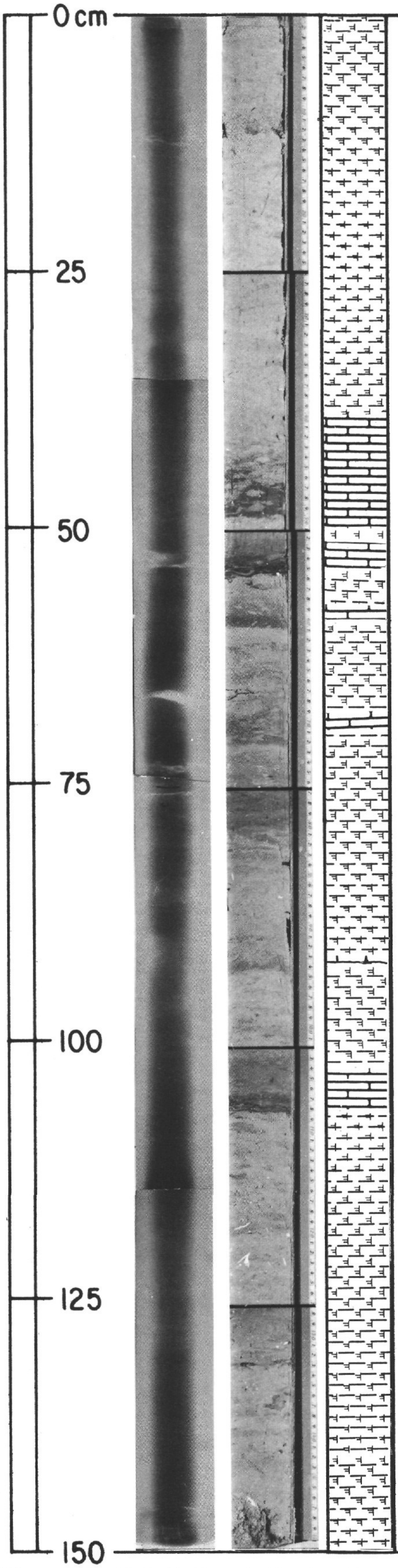


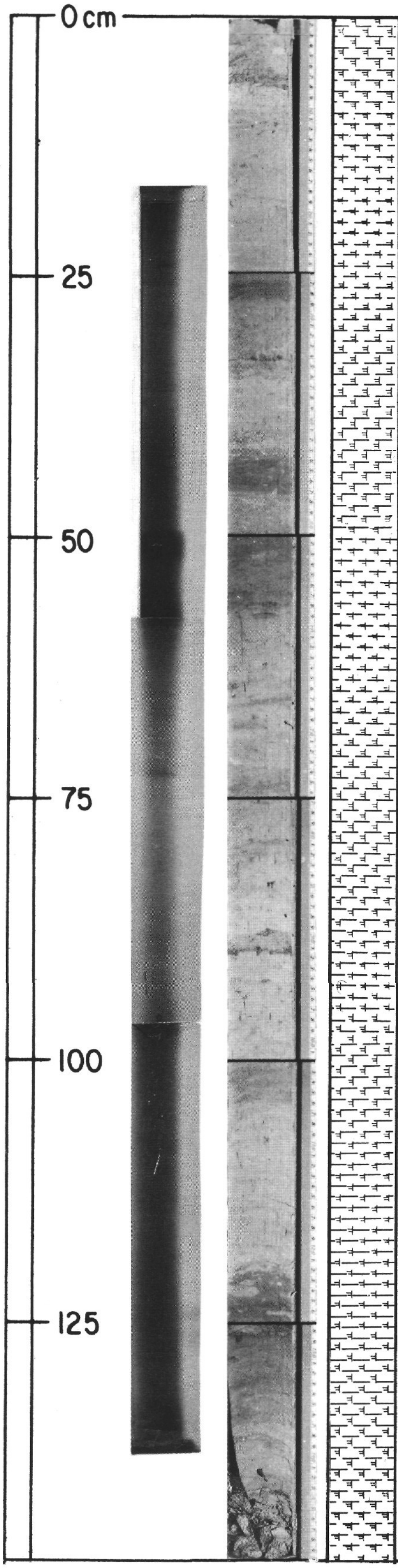
Figure 37. *Hole 3, Core 8, Section 4.*



Total C 4.6; Org. C 0.1; $CaCO_3$ 37.0.
Water content 18.0.
Sand 0.3; silt 14.3; clay 85.4.

Nannoplankton marl, grayish-green (5G 7/1) highly burrowed, interbedded with calcisiltites, of largely indeterminate skeletal debris, darker (5G 5/1), graded.

Figure 38. *Hole 3, Core 8, Section 5.*



Total C 5.4; Org. C 0.3; $CaCO_3$ 42.1.
Water content 23.9.

Nannoplankton marl, greenish-gray in lighter and darker shades (5G 7/1 - 6/1 - 5/1 - 4/1), heavily burrowed throughout.

Sand 0.1; silt 26.4; clay 73.5.

Figure 39. *Hole 3, Core 8, Section 6.*

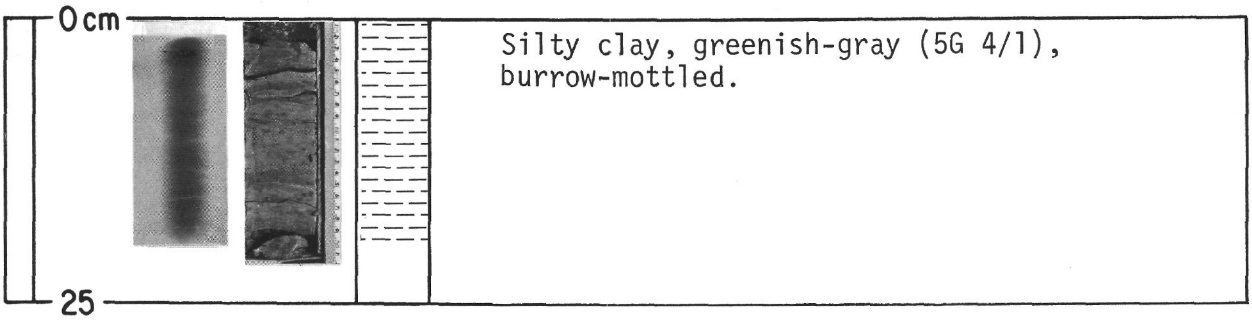
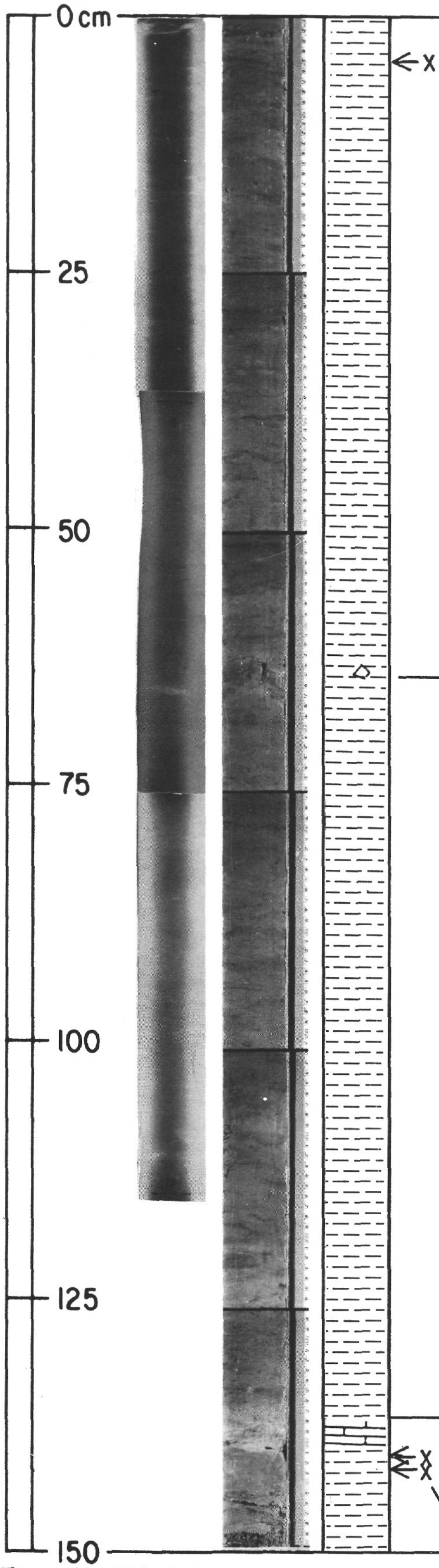


Figure 40. *Hole 3, Core 9, Section 1.*



Total C 0.6; Org. C 0.2; $CaCO_3$ 1.7.
Water content 24.4.
Sand 0.1; silt 15.4; clay 84.5.

Mudstone, dark grayish-green (5G 4/1), largely non-calcareous, burrowed and vaguely laminated. Silt fraction part quartz, part carbonate.

At 64 cm a 5 mm pebble of dolomite.

Calcisiltite, creamy gray (5Y 8/1) at base shading up into pale green (5Y 6/1), detrital skeletal fragments.

Mudstone as above, silt fraction mainly quartz.

Figure 41. *Hole 3, Core 9, Section 2.*

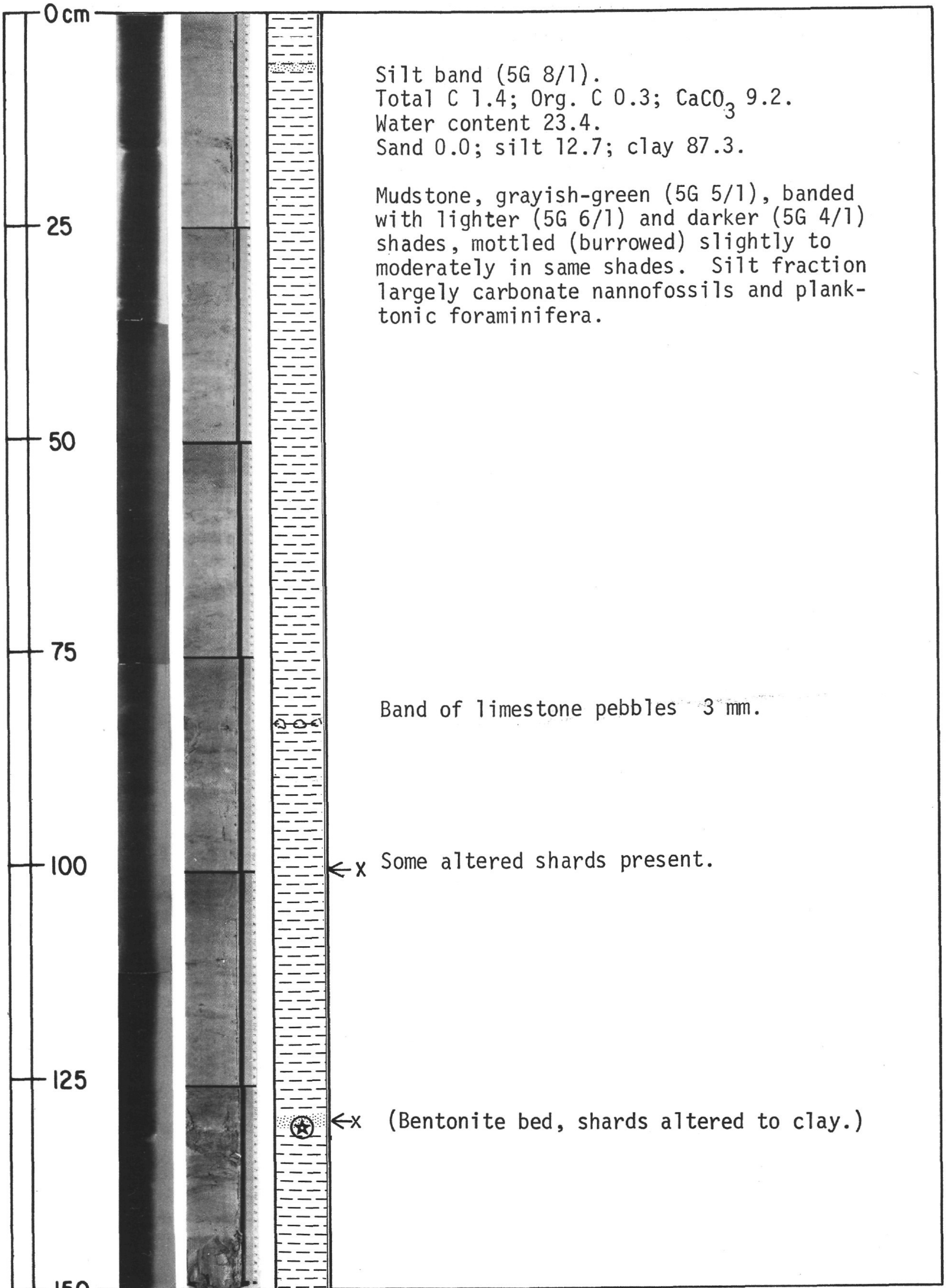


Figure 42. *Hole 3, Core 9, Section 3.*

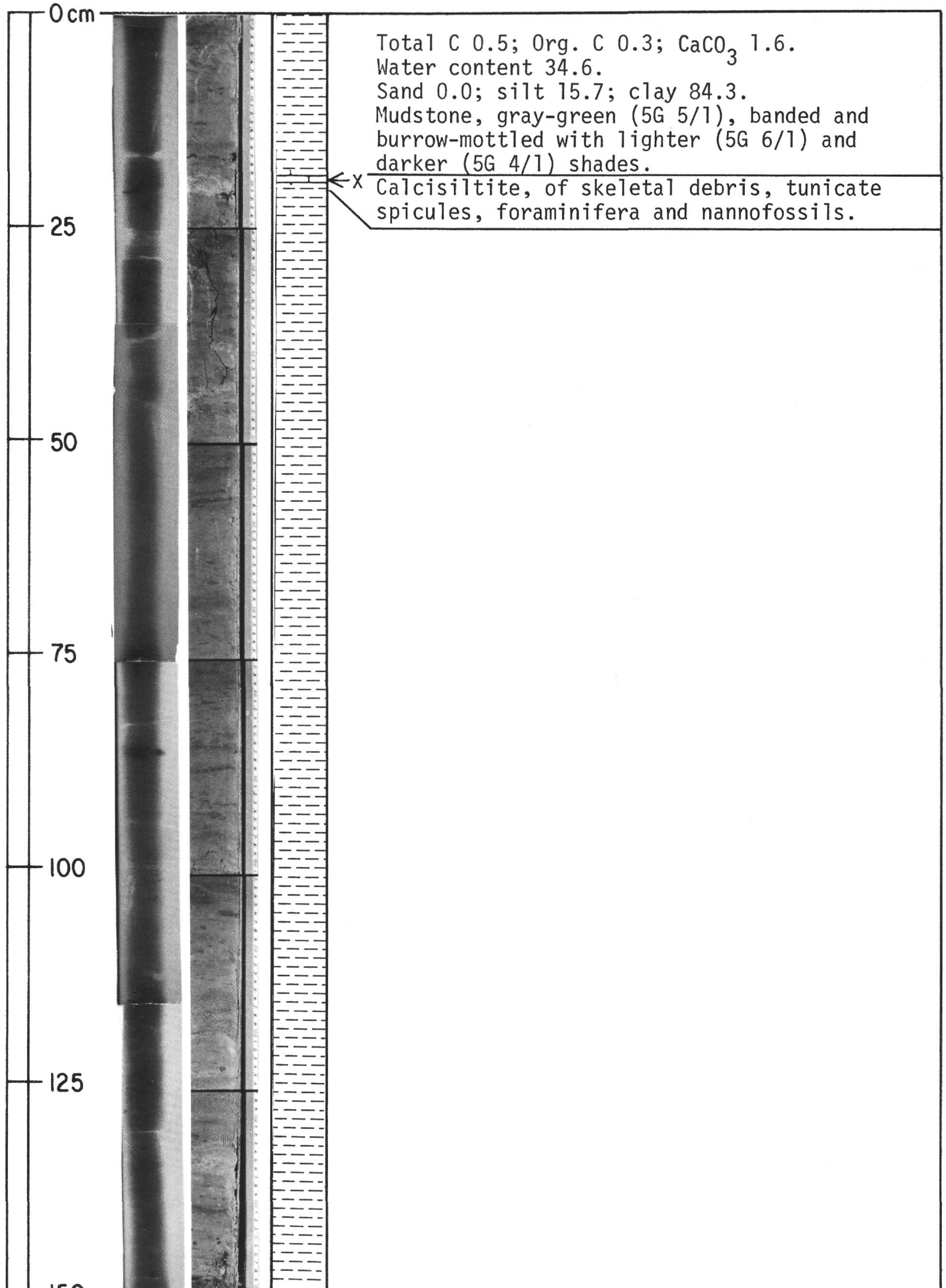
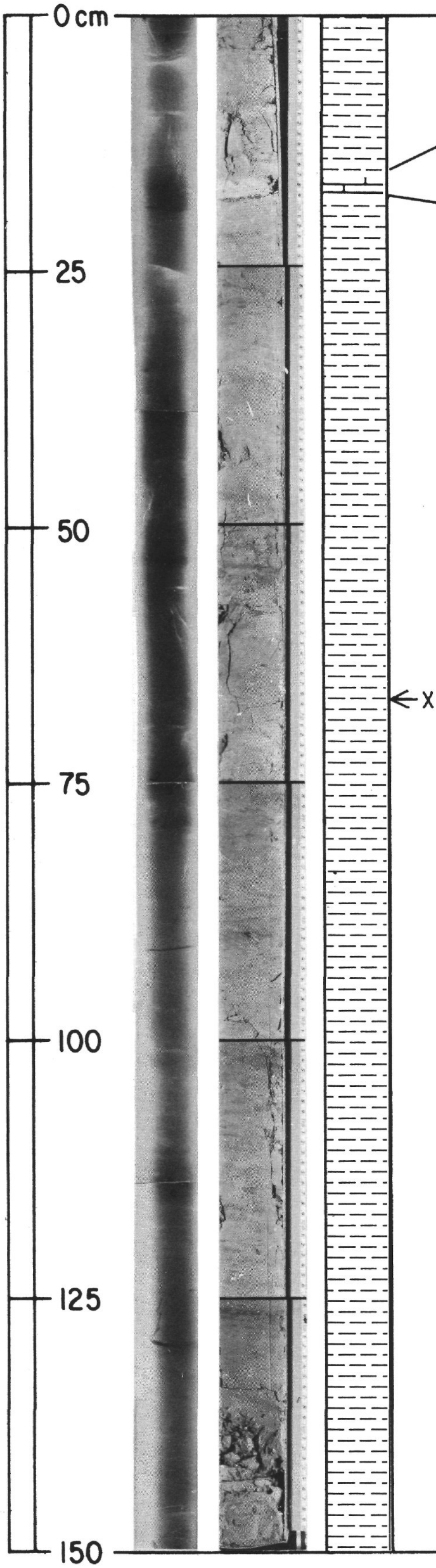


Figure 43. *Hole 3, Core 9, Section 4.*



Total C 1.1; Org. C 0.3; $CaCO_3$ 6.9.
Water content 24.9.

Calcisiltite of skeletal debris and nannofossils, graded.

Sand 0.0; silt 18.5; clay 81.5.

Mudstone, grayish-green (5G 5/1), irregularly laminated and burrow-mottled with lighter (5G 6/1) and darker (5G 4/1) shades. Silt fraction skeletal fragments, foraminifera and nannofossils.

Figure 44. *Hole 3, Core 9, Section 5.*

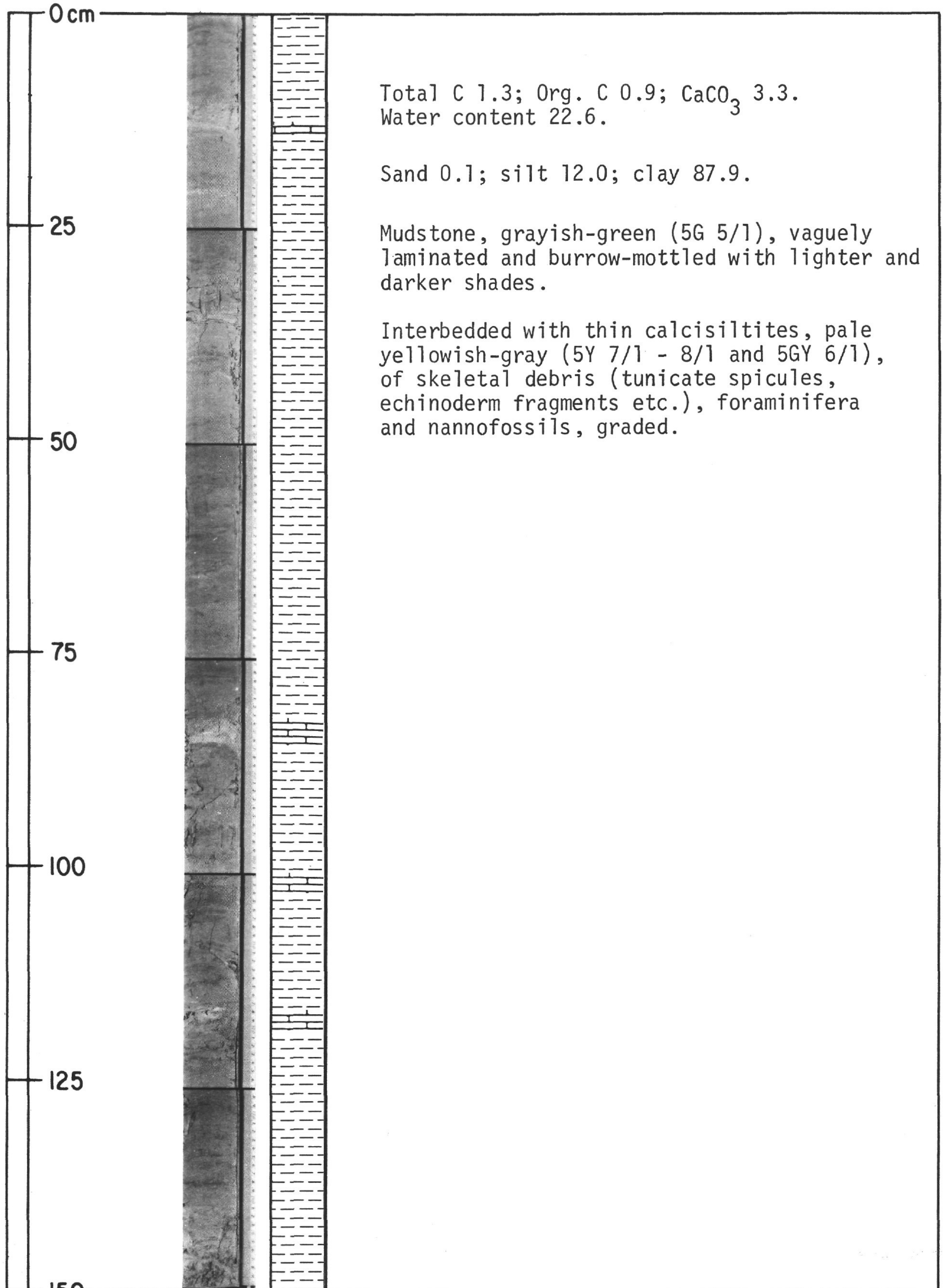
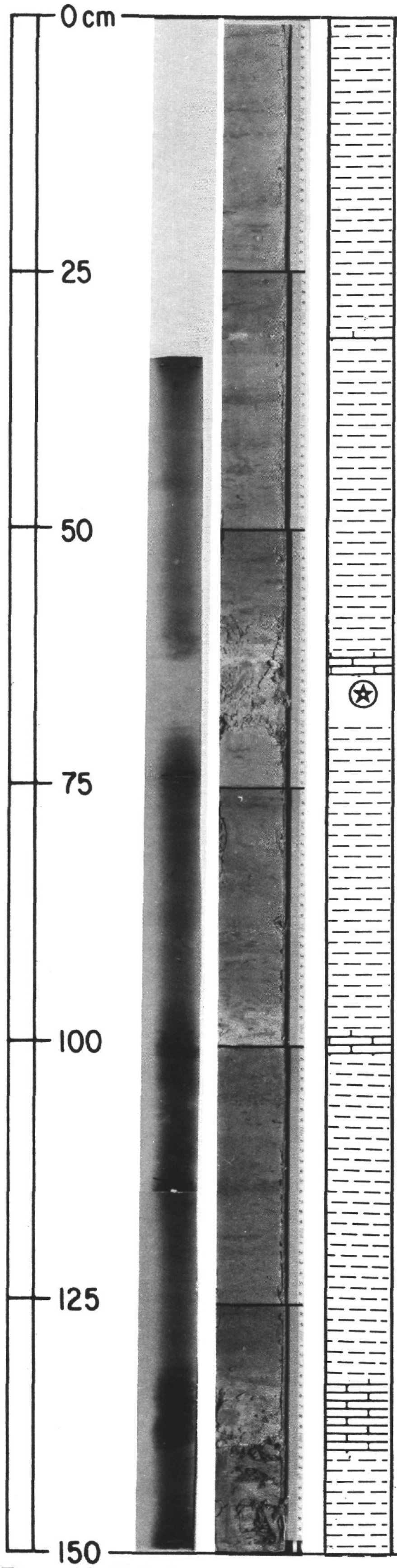


Figure 45. *Hole 3, Core 9, Section 6.*



Total C 1.4; Org. C 0.4; $CaCO_3$ 8.2.
Water content 24.4.

Sand 0.1; silt 17.3; clay 82.6.

Mudstone, gray-green (5G 5/1) with darker and lighter (5G 4/1 - 5G 7/1) bands and slight to strong burrow-mottling.

Interbedded with thin calcisiltites, of largely indeterminate skeletal debris (including peloids, tunicate spicules, molluscan debris), nannofossils and some foraminifera; some dolomite; some quartz; graded.

Bed of montmorillonitized volcanic shards; Note transparency on X-radiograph.

Figure 46. *Hole 3, Core 9, Section 7.*

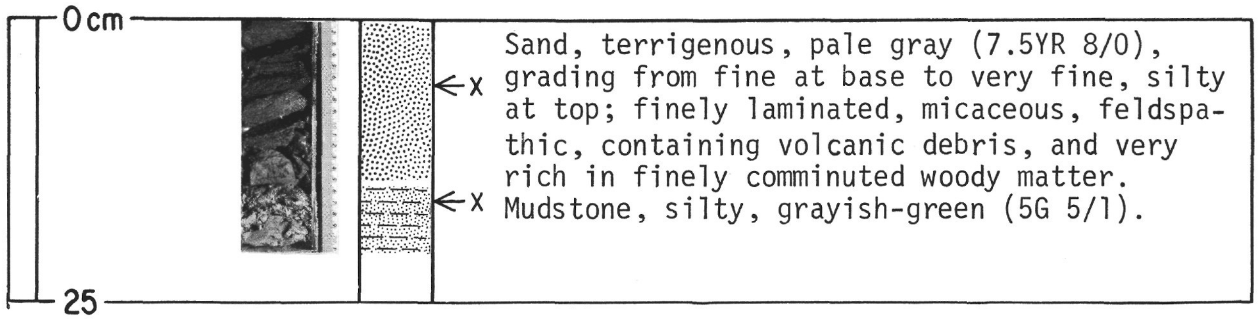


Figure 47. *Hole 3, Core 10, Section 1.*

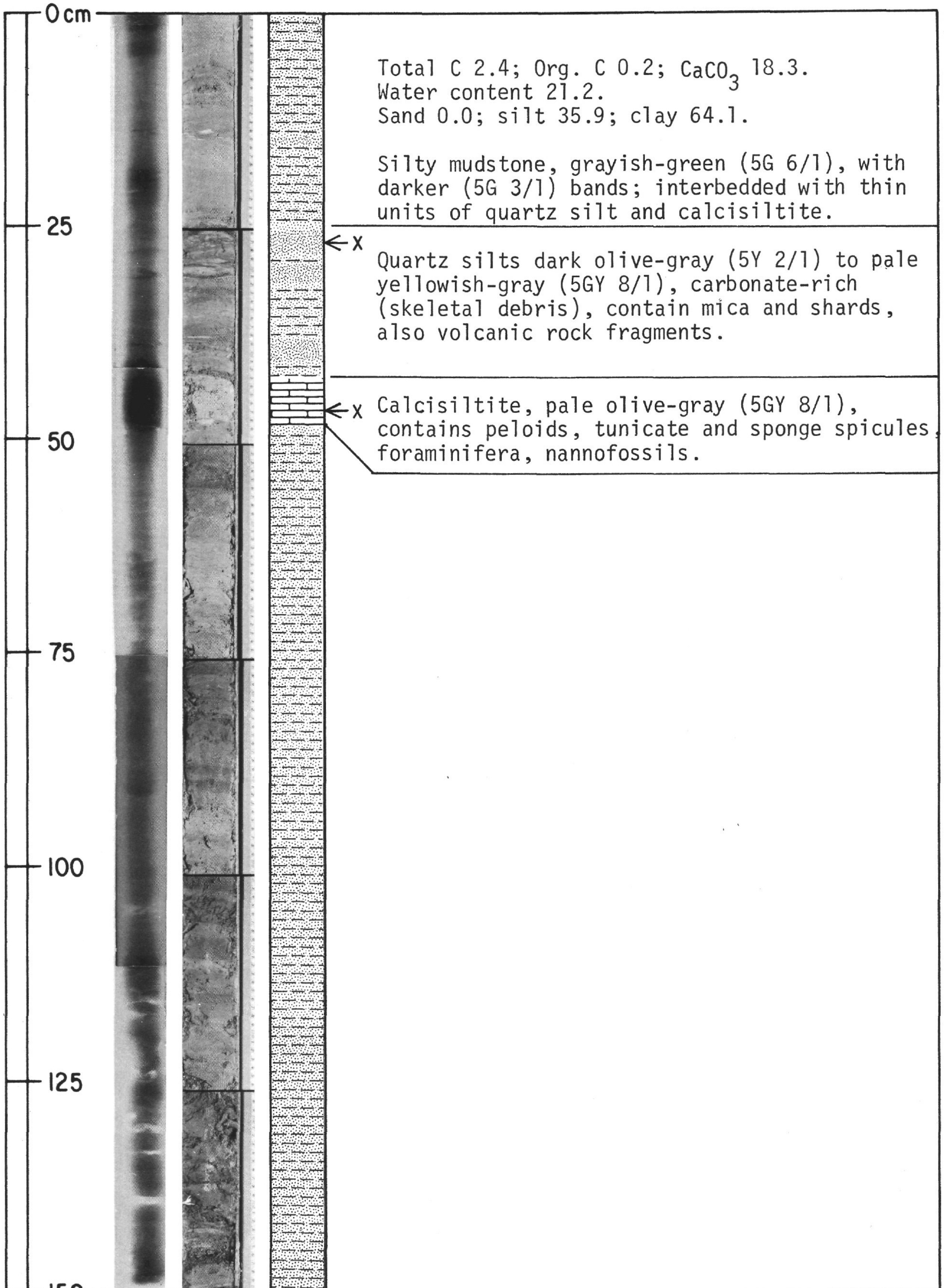


Figure 48. *Hole 3, Core 10, Section 2.*

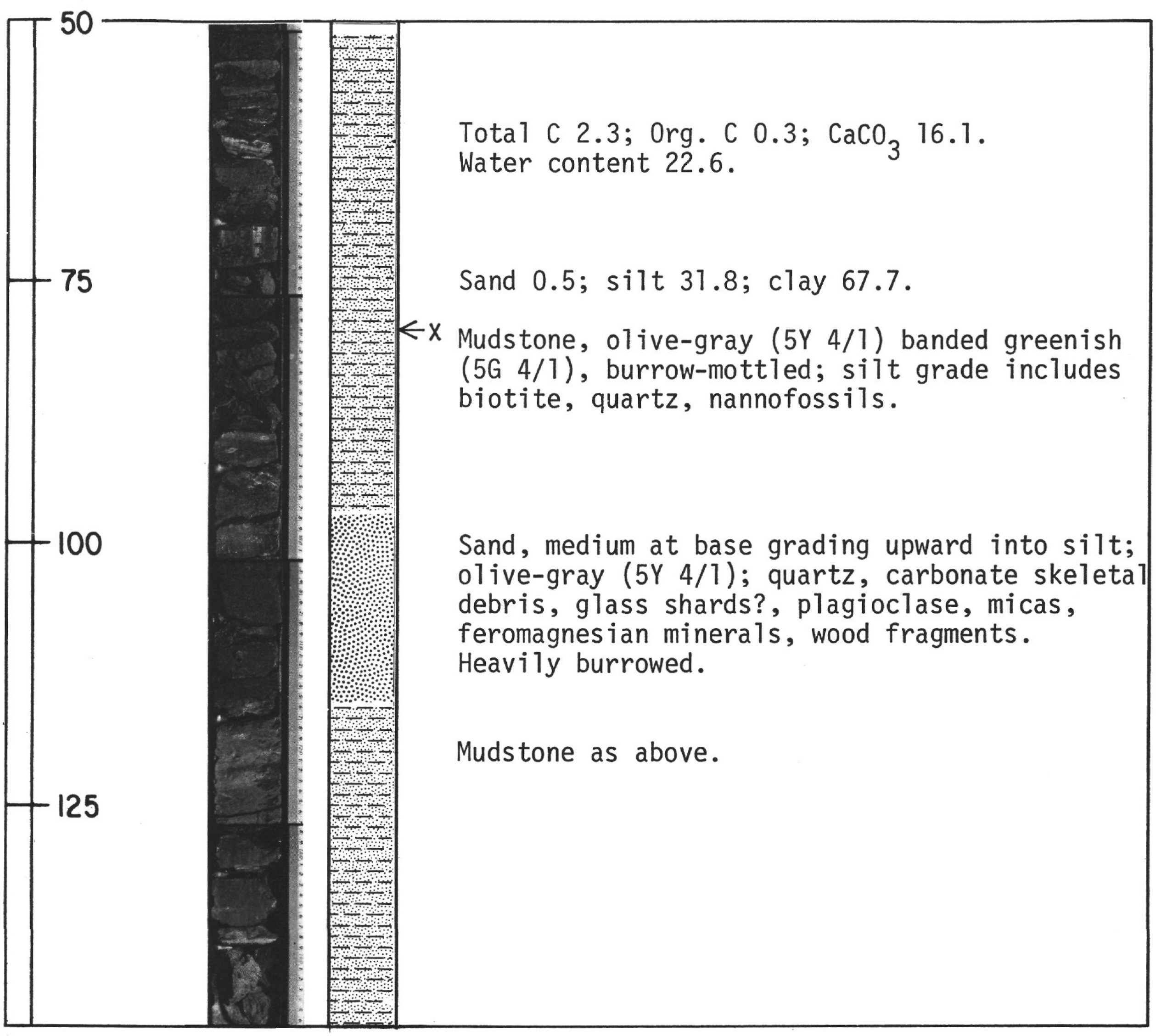


Figure 49. *Hole 3, Core 11, Section 1.*

The Nature of the Sediments

General Description of the Sediments

The sediments recovered at Site 3 consist throughout of lutites interbedded with graded (upward fining) sands and silts (Chapter 24, Plate 2 A & B).

In stratigraphic order, the main units of the cored sequence appear as follows:

(1) Cores 10 and 11 (late Miocene): These silty greenish-gray mudstones contain some nannoplankton, interbedded with terrigenous and somewhat lignitic sandstones and silts. The abundance of feldspar, mica and volcanic fragments suggests a volcanic source (Mexican highlands?) for the sands, and volcanism is documented by shard-rich montmorillonitic beds (bentonites) in the clay.

(2) Core 9 (late Miocene): This is silty grayish-green clay with only a slight admixture of nannofossils and foraminifera. There are a few, thin beds of calcisilt and one ash bed. Radiographs (Chapter 24, Plate 2D) show partly disrupted lamination and pyritized burrows.

(3) Core 3-8 (Pliocene-early Pleistocene): In these cores that are nannoplankton marls, greenish-gray, burrowed, interbedded with graded calcarenites-calcisilts and with subordinate terrigenous silts. Nannoplankton-rich chalks in Core 7 appear to belong to turbidites.

(4) Cores 1-3 (Pleistocene): Silty to very silty terrigenous clays are present with or without admixture of nannoplankton and foraminifera. These are interbedded with (a) thin quartzose silts, (b) one calcisilt of the type described above, and (c) thicker medium-to-fine-grained sands, grading upward into silty muds. One such bed, 1.5 meters thick, has been described in more detail in Chapter 24, and an X radiograph of one is shown in (Chapter 24, Plate 3D) This particular sand shows a piece of fossil wood, and structures which may represent gas bubbles. It also contains clasts of a porous white radiolarian ooze of Eocene age—indirect evidence that such sediments exist in the Gulf region; whether they outcrop on some part of the continental slope, or whether they were brought to the surface by diapirs remains uncertain. In its general character this part of the section resembles that cored at Site 1, but it is more fossiliferous, contains thicker sands, and is far thinner than the Pleistocene record obtained there.

It can be seen that the lutites vary in composition from terrigenous silty clays to nannoplankton chalks with the proportion of silicate clay presumably reflecting the rate of terrigenous influx.

The silts and sands here are of two general types. Terrigenous quartz-rich ones predominate at the bottom of the hole (late Miocene) and near the surface (Pleistocene), whereas, the middle part (late Miocene to early Pleistocene) shows a preponderance of calcisilts and calcarenites. This segregation is not absolute; subordinate terrigenous silts also occur in the mid-portion of the sequence, and a few calcareous ones occur in the lower and upper sequences. Both types show grading which is commonly multiple, and commonly a fine lamination. Irregular but sharp bases, and poor sorting (with coarser sands commonly containing 15 to 20 per cent of particles smaller than 30 microns) suggest turbidity currents as the mechanism of transport and deposition. A more detailed discussion of the terrigenous sand-silt beds is provided in Chapter 24. The terrigenous sand-silt beds cored at the bottom of Hole 3 are associated with volcanogenic material, whereas, this material is absent from the Pleistocene terrigenous sands.

The calcareous sands and silts are of particular interest, and are of comparable character throughout the section. Their grading and lamination is shown in X radiographs on Plate 2, A & B (Chapter 24), and their composition is illustrated in Plate 8 *(ibid.)*. They are composed of microfossils and skeletal debris, and recognizable grains which include the following: benthonic foraminifera of shelf origin (miliolids, peneroplids, rotaliids); benthonic foraminifera (buliminids) of deep-water origin; planktonic foraminifera; siliceous sponge spicules (tetractinellids); molluscan debris; echinoid fragments; holothurian sclerites; tunicate spicules (didemnids); finely textured, rounded carbonate grains (peloids) of uncertain origin; and, in the fine fraction, a mixture of indeterminate fine skeletal debris and nannoplankton. Quartz silt and terrigenous clay may or may not occur in appreciable quantities. The thicker calcarenites normally grade upward into chalks, commonly, rather firmly cemented, which are largely composed of nannoplankton and tunicate spicules, and with an admixture of fine skeletal debris of other origin. The planktonic foraminifera found in these chalks are mainly juveniles.

Discussion

The strange composition of the calcareous sands and silts shows them to be clearly a mixture of materials derived from a calcareous shelf and materials from the slope or even from the abyssal plain itself. The authors suggest that the shelf constituents were derived from the Campeche Bank—perhaps originating from the unstable shoulders of bank sediment formed at the outer edge which were dislodged by earthquakes and suspended into turbidity currents, and that these currents proceeded to erode and to incorporate the more planktonic sediments of the slope and of the abyssal plain. The sediments which settled out of this cloud show in their lower, coarser phase a predominance of the shelf-derived particles with an admixture of the coarser planktonic grains (foraminifera), while the overlying, finer phase of the deposit is dominated by resedimented deep-water sediment (nannoplankton and juvenile foraminifera) with an admixture of shelf-derived fines.

It would appear from this that a large part of the nannoplankton chalk or marl may be resedimented in this manner. In Core 6 the authors have estimated that 50 per cent of the thickness (mostly lutite) was resedimented in this fashion, and in Core 7 the proportion may be nearer 75 or 80 per cent; here only the dark-green, clayey, heavily burrowed nannoplankton marls appear to represent unreworked pelagic deposits.

The graded, terrigenous sands and silts also show all the characters of turbidites and are interpreted as such.

The occurrence of two major types of turbidite sands and silts—terrigenous and organogenic—indicates that several source areas were feeding this abyssal plain during late Cenozoic time. One of these was presumably the Campeche Bank; the source of the terrigenous materials is to be sought in one or more deltas. Their association with volcanic debris suggests that the Miocene sands may have come from the Mexican highlands, while the Pleistocene ones are most likely derived from the Mississippi. During Pliocene time, normal pelagic sedimentation and carbonate influx from the Campeche Bank dominated sedimentation. Assuming that turbidity currents have been the dominant agent of transport of coarser material, some of those in Pleistocene time must have traveled three hundred miles.

Physical Properties of the Sediments

Cores 1 and 2 provide excellent examples of correspondence between lithology and GRAPE/gamma-ray response. In Core 1, a thin (12 centimeters thick) quartzose turbidite sand is clearly revealed by high bulk density values. It is interesting to note that the second section of Core 1 has consistently lower readings of bulk density and higher gamma-ray values, suggesting a finer-grained clay. If these variations of bulk density are real, such broad scale differences in sediment properties might well provide variations in reflection coefficients of the magnitude necessary to give seismic reflections utilizing high frequency apparatus.

Core 2 provides a detailed exhibit of high bulk density and low gamma-ray values opposite turbidite sands as compared to low bulk density and high gamma-ray opposite intercalated muds. A detailed discussion of these relationships along with textural data is given in Chapter 24. As such sediments became more consolidated, the bulk density relationships were reversed, reflecting the more stable porosity of the sands.

Cores 3, 4, 5, 6, and 7 show a progressive decrease in clay content, as reflected by gamma-ray count along with a corresponding diminishing difference between bulk densities of muds and interstratified coarser sediment. For example, Core 3 shows a rapidly varying bulk density curve and rather large variations in gamma-ray count. As subsequent cores were examined, variation in density and gamma-ray count became more consistent over short intervals, reflecting an increasing state of consolidation and thicker lithological units. This is best shown by Core 7, where rather thick, lower density carbonate turbidite sands are interbedded with thin, higher density carbonate pelagites and laminites.

Core 9 shows rather consistent values of bulk density and gamma-ray count, if core junctions are ignored. This consistency is matched by a corresponding lithology as revealed by core description. The presence of bentonites(?) is revealed by very high gamma-ray counts at several horizons in this core. Smaller variations are probably a combination of background noise and slight variations in carbonate content.

Average values of gamma ray and GRAPE, along with penetrometer, have been used as representative of cored intervals and are shown in Figure 3. As might be expected, GRAPE bulk density determinations show a pronounced correspondence with gross sediment type, by attaining intermediate to low values in the upper and lower segments of the borehole. The semi-consolidated to consolidated carbonate-rich section—represented by Cores 5, 6, and 7—attains values greater than 2 grams/cc (corrected determination, as described in Site 1).

Correspondingly low values of natural gamma-ray count in the central carbonate-rich section (less than 7000 counts per 2.5 minutes) indicate a paucity of inorganic clay-minerals. The highest gamma-ray readings were attained in Core 9 (approaching 9000 counts per 2.5 minutes); the bentonites of Core 9 gave natural gamma-ray readings in excess of 10,000 counts per 2.5 minutes. The laminite facies near the top of the boring and near the base have intermediate gamma-ray values. The difference in average gamma-ray intensity between Cores 1 and 2 is apparently due to a higher percentage of quartz sand in Core 2, which has a corresponding lower gamma-ray count.

Penetrometer determinations more clearly reflect consolidation than other physical measurements performed on the cores. The interpolated curve shown in Figure 3 reveals a generally steady increase in consolidation toward the base of the drilled section, and there Core 11 contains mudstone which falls in the consolidated category on the proposed penetrometer scale. Several of the graded carbonate turbidites in Cores 6 and 7 gave zero readings on the penetrometer, qualifying them as consolidated sediment. Secondary cementation, either diagenetic or authigenic, appears to be responsible for such low readings.

As discussed previously, the interval of relatively high down-hole formation resistivity corresponds well with the high GRAPE bulk density and low natural gamma-ray intensity of the carbonate turbidite sequence. If this relationship is correct as described, then the limits of the sequence are approximately known. The transitional sediments above and below this zone are intermediate in terms of the physical properties described above.

Biostratigraphy

Foraminifera

As deduced from the planktonic foraminifera, the biostratigraphy of Site 3 is shown in Figure 50. The faunas of the samples listed in Figure 50 are discussed below. These faunal lists are not necessarily complete or representative, since only the most abundant or significant species are listed. The abbreviations (D) and (S) stand for dextral and sinistral, respectively.

Sample 1 (1-3-1-1, top):
No coarse fraction residue (i.e., 60 mesh). Sponge spicules, small bolivinids, miliolids, discorbids, nonionids, few juvenile *Globigerinoides* spp., *Globorotalia* spp., pelecypod embryos.
Age: Pleistocene.

Sample 2 (1-3-1-1, 114-115 cm):
Globigerinoides rubra (majority bright pink), *G. sacculifera, Globorotalia truncatulinoides* (D), *G. crassaformis, Hastigerina siphonifera, Orbulina universa* with small miliolids, bolivinids, lagenids, nonionids, rotaliids, and pteropods; *Limacina* sp., *Creseis* sp., echinoid spines, sponge spicules.
Age: Pleistocene.

Sample 3 (1-3-1-2, core catcher):
Few specimens of *Globigerinoides rubra, G. sacculifera, Globorotalia menardii, G. crassaformis, Hastigerina siphonifera* with ostracod valves, wood fibers, and a few pteropod shells.
Age: Pleistocene.

Discussion:
Core 1 is essentially a turbidite sequence. A calcareous layer was sampled at 114 centimeters in Section 1 and yielded a rich late Pleistocene planktonic-foraminiferal fauna.

Sample 4 (1-3-2-1, top):
Few specimens of *Globigerinoides rubra, G. sacculifera, Globorotalia menardii* with miliolids, bolivinids, rotaliids, wood fibers.
Age: Pleistocene.

Remarks: Sample is poorly sorted (turbidity) sand.

Sample 5 (1-3-2-3, core catcher):
Few reworked specimens of *Globigerinoides rubra, G. sacculifera, Globorotalia truncatulinoides, G. menardii, G. inflata, Globoroquadrina dutertrei.*
Age: Pleistocene.

Discussion:
Core 2 is composed of poorly sorted sands of turbidity current origin. A few specimens of planktonic foraminifera have been found in several samples, but as they have all been displaced only the faunas from two samples are listed here.

Sample 6 (1-3-3-1, top):
Globigerinoides rubra (majority pink), *G. sacculifera, Globorotalia truncatulinoides* (D), *G. inflata, Hastigerina siphonifera.*
Age: Pleistocene.

Remarks: No specimens of *Globorotalia menardii, Globoquadrina dutertrei, Sphaeroidinella, Pulleniatina* observed. Fauna is extremely restricted in terms of diversity.

Sample 7 (1-3-3-2, 104 cm):
Globigerinoides rubra (including pink variant), *G. sacculifera, Globorotalia truncatulinoides* (D), *G. menardii* (S), *G. crassaformis, Globoquadrina dutertrei.* Benthonic fauna: *Fissurina murrhina,* small bolivinids.
Age: Pleistocene.

Sample 8 (1-3-3-2, core catcher):
Globigerinoides rubra (majority pink), *G. sacculifera, Globorotalia truncatulinoides* (D), *G. menardii* (S), *G. crassaformis, G. inflata, G. scitula, Pulleniatina obliquiloculata, Globoquadrina dutertrei.*
Age: Pleistocene.

Sample 9 (1-3-4-1, 49-50 cm):
Globigerinoides rubra, Globorotalia truncatulinoides (D), *G. menardii* (S) *Globoquadrina dutertrei, Sphaeroidinella dehiscens.* Benthonic fauna: *Planulina wuellerstorfi, P. bradyi, Anomalina* sp., *Textularia* sp. cf. *T. parvula.*
Age: Pleistocene.

Sample 10 (1-3-4-1, 90 cm):
Globigerinoides rubra, G. sacculifera, Orbulina universa, Globorotalia truncatulinoides (S), *Pulleniatina obliquiloculata, Sphaeroidinella dehiscens, Globoquadrina dutertrei.* Benthonic fauna: *Fissurina murrhina,*

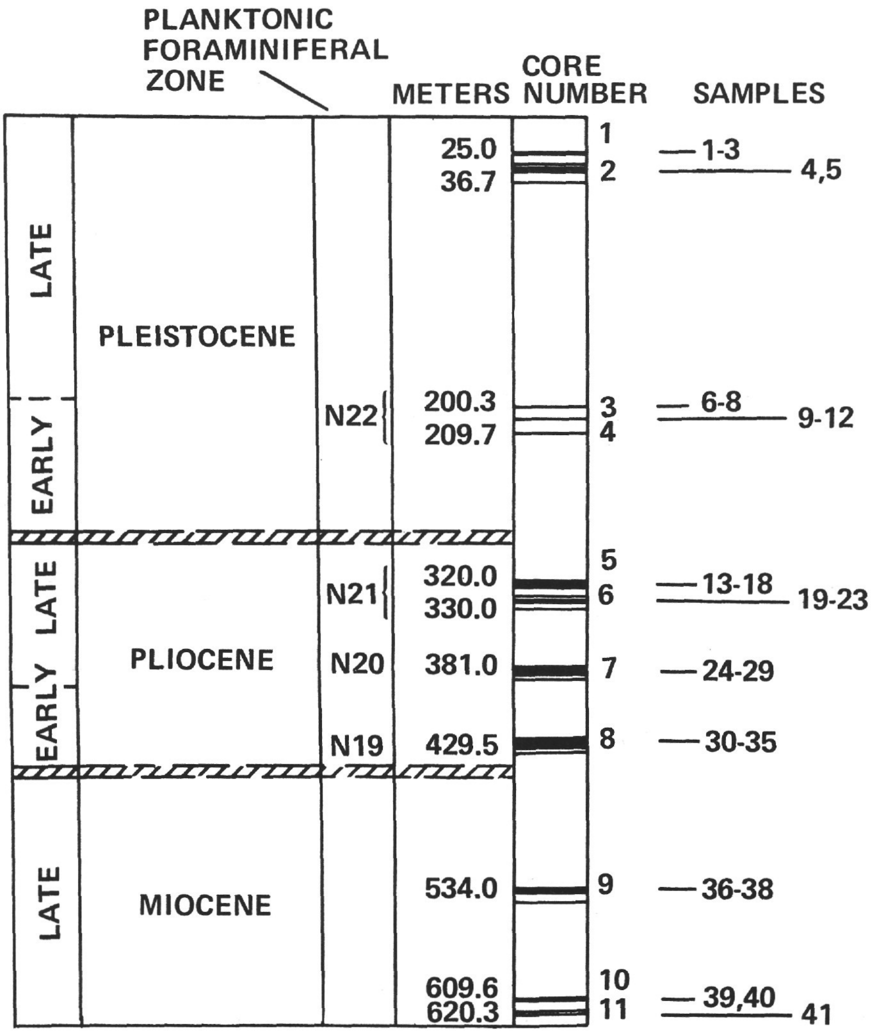


Figure 50. *Biostratigraphy of Site 3 as deduced from the foraminifera.*

Planulina bradyi, Cibicides deprimus, Eponides repandus, Cassidulinoides bradyi.
Age: Pleistocene.

Remarks: The presence of sinistrally coiled *Globorotalia truncatulinoides* and the absence of *Globorotalia menardii* may indicate cooler climatic conditions at this level than above.

Sample 11 (1-3-4-1, 98 cm):
Globigerinoides rubra, G. sacculifera, Globoquadrina dutertrei, G. pseudopima, Globorotalia exilis, G. miocenica.
Age: Pleistocene.

Remarks: Sample is in a carbonate turbidite; residue is composed of agglutinated particulate shell fragments and lutite. Fauna indicates reworking of late Pliocene material.

Sample 12 (1-3-4-1, core catcher):
Globigerinoides rubra (including pink variant), *G. sacculifera, G. conglobata, Orbulina universa, Globorotalia truncatulinoides* (50 per cent dextral), *G. crassaformis, Globoquadrina dutertrei, Sphaeroidinella dehiscens, Pulleniatina obliquiloculata* (D).
Age: Pleistocene.

Sample 13 (1-3-5-1, top):
Orbulina universa, Globigerinoides rubra, G. sacculifera, G. obliqua, Globoquadrina humerosa-dutertrei, Globorotalia miocenica. G. exilis, G. menardii (D), *G. crassaformis, G. scitula, Sphaeroidinella dehiscens.*
Age: Pliocene (late).

Sample 14 (1-3-5-1, 50 cm):
Orbulina universa, Globigerinoides rubra, G. sacculifera, G. obliqua, Globoquadrina humerosa-dutertrei, Globorotalia miocenica. G. exilis, G. menardii (D), *G. crassaformis, G. scitula, Sphaeroidinella dehiscens.*
Age: Pliocene (late).

Sample 15 (1-3-5-3, 8-9 cm):
Globorotalia miocenica (common), *G. crassaformis G. scitula, Globigerinoides rubra, G. sacculifera, G. obliqua, Globoquadrina humerosa-dutertrei, Globigerina bulloides.*
Age: Pliocene (late).

Remarks: The absence of *Globorotalia exilis* and *Sphaeroidinella dehiscens* may indicate cooler conditions here and above in Section 2 where they are also absent.

Sample 16 (1-3-5-4, 10-13 cm):
Globorotalia menardii s.l. (D), *G. exilis, G. crassaformis, Globigerinoides rubra, G. sacculifera, G. obliqua, Globoquadrina humerosa-dutertrei, Globigerina bulloides.*
Age: Pliocene (late).

Sample 17 (1-3-5-5, 0-1.5 cm):
Globorotalia menardii s.l. (D), *G. exilis, G. miocenica, G. crassaformis, G. scitula, Globigerinoides rubra, G. sacculifera, G. obliqua, Sphaeroidinella dehiscens, Globoquadrina humerosa-dutertrei, Globigerina bulloides.*
Age: Pliocene (late).

Sample 18 (1-3-5-5 core catcher):
Globorotalia menardii s.l. (D), *G. exilis, G. miocenica, G. crassaformis, G. scitula, Globigerinoides rubra, G. sacculifera, G. obliqua, Sphaeroidinella dehiscens, Globoquadrina humerosa-dutertrei, Globigerina bulloides.*
Age: Pliocene (late).

Discussion:
A relatively homogeneous planktonic foraminiferal fauna occurs in Core 5. The predominant species here include *Globigerinoides rubra* and *G. sacculifera.* Of stratigraphic importance are the occurrence of *Globorotalia exilis, G. miocenica* and *Globigerinoides obliqua. Globorotalia crassaformis* and *G. scitula* are common in this core and their presence may indicate somewhat cooler conditions in the late Pliocene of the Gulf of Mexico.

Sample 19 (1-3-6-1, top):
Globorotalia menardii s.l. (D), *G. exilis* (abundant), *G. miocenica, G. crassaformis, G. scitula, Globoquadrina humerosa-dutertrei, Globigerinoides rubra, G. sacculifera, G. obliqua, Sphaeroidinella dehiscens, Globigerina bulloides.*
Age: Pliocene (late).

Sample 20 (1-3-6-2, 0-2 cm):
Globorotalia menardii s.l., *G. exilis, G. miocenica, G. scitula, G. crassaformis, Globigerinoides rubra, G. sacculifera, G. obliqua, Sphaeroidinella dehiscens, Globoquadrina humerosa-dutertrei.*
Age: Pliocene (late).

Sample 21 (1-3-6-2, 48-49 cm):
Globorotalia menardii s.l. (D), *G. exilis, G. miocenica, G. crassaformis, G. scitula, Globigerinoides obliqua, Sphaeroidinella dehiscens.*
Age: Pliocene (late).

Sample 22 (1-3-6-2, 100 cm):
Globorotalia exilis, G. miocenica, G. crassaformis, G. scitula, Globigerinoides obliqua, Globoquadrina humerosa-dutertrei, Sphaeroidinella dehiscens.
Age: Pliocene (late).

Remarks: Typical *Globorotalia exilis* and *G. miocenica* both became common at this level for the first time in the stratigraphic sequence at this site.

Sample 23 (1-3-6-2, core catcher):
Globorotalia nulticamerata, G. menardii s.l., *G.*

crassaformis, G. scitula, Globigerinoides rubra, G. sacculifera, G. obliqua, Globoquadrina altispira, Sphaeroidinella dehiscens, Globigerina bulloides.
Age: Pliocene (late).

Remarks: The bottom of Core 6 is the highest level at which *Globoquadrina altispira* is found. This level appears to mark the highest occurrence of *typical Globorotalia multicamerata* as well; atypical forms above are referred to *Globorotalia exilis.*

Discussion:
A relatively homogeneous planktonic microfauna occurs throughout Core 6. The most characteristic forms include *Globorotalia exilis* and *Globorotalia miocenica. G. exilis* is particularly abundant at the top of Core 6. The upper limit of typical *Globorotalia multicamerata* and *Globoquadrina altispira* is at the base of this core. Specimens of *Sphaeroidinella dehiscens* have a large, well-developed supplementary aperture on the spiral side and in some specimens a broad, thick marginal flange extending towards the periphery of the test (in edge view).

Sample 24 (1-3-7-1, top):
Globorotalia menardii s.l. (D), *Globorotalia multicamerata, G. miocenica, G. crassula, Globoquadrina altispira, G. venezuelana, G. humerosa, Globigerinoides rubra, G. sacculifera, G. obliqua, Sphaeroidinella dehiscens, Sphaeroidinellopsis seminulina, S. subdehiscens.*
Age: Pliocene (mid).

Sample 25 (1-3-7-1, 50 cm):
Globorotalia multicamerata, G. crassula, Globoquadrina venezuelana, G. humerosa, G. pseudopima, Globigerinoides rubra, G. sacculifera, G. obliqua, Sphaeroidinellopsis seminulina, S. subdehiscens.
Age: Pliocene (mid).

Sample 26 (1-3-7-2, 8-9 cm):
Globigerinoides obliqua, G. rubra, G. sacculifera, Globoquadrina humerosa, G. pseudopima, G. venezuelana, G. altispira, Globorotalia miocenica, G. multicamerata, G. crassula, G. menardii s.l., *Sphaeroidinella dehiscens, Sphaeroidinellopsis subdehiscens, S. seminulina.*
Age: Pliocene (mid).

Sample 27 (1-3-7-3, 100 cm):
Globigerinoides obliqua, G. rubra, G. sacculifera, Globoquadrina humerosa, G. venezuelana, G. altispira, Globorotalia miocenica, G. menardii s.l., *G. multicamerata, G. crassula, Sphaeroidinella dehiscens, Sphaeroidinellopsis subdehiscens, S. seminulina.*
Age: Pliocene (mid).

Sample 28 (1-3-7-4, 100 cm):
Globigerinoides obliqua, G. rubra, G. sacculifera, Globoquadrina humerosa, G. venezuelana, G. altispira, Globorotalia miocenica, G. menardii s.l., *G. tumida* (including *G. tumida flexuosa), G. multicamerata, G. crassula, Sphaeroidinella dehiscens, Sphaeroidinellopsis subdehiscens, S. seminulina.*
Age: Pliocene (mid).

Sample 29 (1-3-7-4, core catcher):
Globigerinoides obliqua, G. rubra, G. sacculifera, Globoquadrina humerosa, G. venezuelana, G. altispira, Globorotalia miocenica, G. menardii s.l., *G. tumida flexuosa, G. multicamerata, G. crassula, Sphaeroidinella dehiscens, S. seminulina, Sphaeroidinellopsis subdehiscens.*
Age: Pliocene (mid).

Discussion:
The fauna in Core 7 is remarkably uniform throughout. The most significant occurrences are those of *Globorotalia miocenica, G. multicamerata, G. crassula, Globoquadrina humerosa, G. pseudopima, G. altispira, G. venezuelana, Sphaeroidinella dehiscens, Sphaeroidinellopsis subdehiscens, S. seminulina* and dextrally coiling *Globorotalia tumida* s.l. (including *G. tumida flexuosa)* in the lower part of this core (Section 4).

Sample 30 (1-3-8-1, top):
Sphaeroidinellopsis subdehiscens, Sphaeroidinella dehiscens s.l. (with discrete supplementary aperture on spiral side), *Globorotalia* sp. cf. *G. plesiotumida, G. praehirsuta* with common benthonic rotaliids *(Eponides, Gyroidina, Pullenia)* and other forms, lagenids.
Age: Pliocene (basal).

Remarks: Sample has been diluted through transportation and/or solution; mostly fine fraction remains, small coarse fraction (less than 60 mesh). The presence of *S. dehiscens* (with very small supplementary aperture on spiral side in some individuals) and *Globorotalia praehirsuta* suggests that this sample is a level which is very low in the Pliocene.

Sample 31 (1-3-8-2, 50 cm):
Sphaeroidinella dehiscens s.l. (with small supplementary aperture on spiral side), *Sphaeroidinellopsis subdehiscens* s.l., *Globoquadrina acostaensis, G. humerosa, G. menardii* s.l. with benthonic rotaliids, fissurinids, lagenids.
Age: Pliocene (basal).

Sample 32 (1-3-8-3, top):
Sphaeroidinella dehiscens s.l. (including *S. dehiscens* f. *immatura), Sphaeroidinellopsis subdehiscens* s.l. (including *paenedehiscens), Globorotalia* sp. ex. gr. *G. menardii, Globoquadrina acostaensis, G. altispira, Globigerina nepenthes, Globigerinoides canimarensis, G. obliqua* with benthonic forms including various rotaliids; *Eponides, Gyroidina, Planulina,* lagenids.
Age: Pliocene (basal).

Sample 33 (1-3-8-3, 11-12 cm):
Sphaeroidinella dehiscens s.l. (with small supplementary

apertures), *Sphaeroidinellopsis subdehiscens* s.l., *S. seminulina, Globoquadrina acostaensis, G. altispira, G. venezuelana, G. humerosa, Globorotalia menardii* s.l. (D), *G. crassula.*
Age: Pliocene (basal).

Sample 34 (1-3-8-6, 89-90 cm):
Globoquadrina altispira, Globigerinoides obliqua, G. sacculifera, Globorotalia menardii s.l. (D), *G.* sp. cf. *G. miocenica, Sphaeroidinella dehiscens* s.l. (with small supplementary aperture), *Sphaeroidinellopsis subdehiscens* s.l. with benthonic forms: rotaliids, uvigerinids, buliminids.
Age: Pliocene (basal).

Sample 35 (1-2-8-6, core catcher):
Globorotalia ex. gr. *menardii* s.l., *Orbulina universa, Globigerina nepenthes, Globoquadrina acostaensis, G. altispira, G. venezuelana, G. humerosa, Globigerinoides obliqua, G. canimarensis, Sphaeroidinella dehiscens* s.l., *Sphaeroidinellopsis subdehiscens* s.l., *S. seminulina,* with benthonic fauna of various rotaliids, buliminids, uvigerinids, *Planulina, Gyroidina, Cassidulina.*
Age: Pliocene (basal).

Discussion:
The planktonic foraminiferal fauna in samples from Core 8 varies in regards to diversity and preservation. Core 8 contains numerous turbidites and their presence is reflected in the displaced benthonic faunas (the rotaliids and some other forms indicate deposition on the continental shelf or slope). In the case of several samples only a fine residue remained after sample preparation and either a very small fauna was found in the fine fraction or else the specimens were too small to allow accurate identification. Only samples having an adequate fauna for age determination have been included here.

Sample 36 (1-3-9-4, 22-23 cm):
Sphaeroidinellopsis subdehiscens, Sphaeroidinella seminulina, Globoquadrina altispira, G. venezuelana, Globigerina apertura, Globigerinoides rubra, G. sacculifera, Globorotalia ex. gr. *menardii* (S), small globigerinids, with benthonic fauna of rotaliids, bolivinids, miliolids.
Age: Miocene (late).

Remarks: Only a small residue remained after the preparation of this sample and it is almost all finer than 60 mesh.

Sample 37 (1-3-9-7, 140-142 cm):
Globoquadrina altispira, G. venezuelana, Globorotalia menardii s.l. (S), *Orbulina universa, Globigerinoides obliqua, G. sacculifera, Sphaeroidinellopsis subdehiscens,* with benthonic foraminifera: various rotaliids, buliminids bolivinids, miliolids, *Eggerella bradyi, Planulina wuellerstorfi, Cassidulina subglobosa.*
Age: Miocene (late).

Sample 38 (1-3-9-7, core catcher):
Globoquadrina altispira, G. venezuelana, Globigerina nepenthes, Globigerinoides quadrilobata, G. canimarensis, G. sacculifera, Sphaeroidinellopsis subdehiscens s.l., *S. seminulina,* with benthonic fauna: various rotaliids and *Planulina bradyi, Planulina weullerstorfi, Cassidulina subglobosa, Gyroidina neosoldanii, Gyroidina* sp., *Bulimina marginata,* and various bolivinids, fissurinids, lagenids, and several arenaceous forms.
Age: Miocene (late).

Discussion:
Only Sections 4 and 7 have yielded good microfaunal assemblages in Core 9. The sediments are predominantly lignitic siltstones with a high clay content. In most instances only a small residue remained after preparation and it was usually found to be nearly barren or to contain too few and too small specimens for determination. The dominant planktonic foraminifera in Core 9 are *Globoquadrina altispira, G. venezuelana* and *Sphaeroidinellopsis subdehiscens.* Unfortunately, no keeled globorotaliids were recovered from Core 9. A relatively rich association of benthonic foraminifers occurs in Section 7 and consists predominantly of forms which live today at bathyal depths on the continental slope and lower continental shelf.

Sample 39 (1-3-10-1, 1-10 cm):
Globigerinoides sp., *Globorotalia menardii* s.l. (S), *Globorotalia crassula, Orbulina universa, Sphaeroidinellopsis subdehiscens* with benthonic fauna including *Gyroidina neosoldanii, Vulvulina pennatula.*
Age: Miocene (late).

Remarks: The sample is a quartz-rich lignitic, micaceous silty clay and the microfauna is sparse; only a few specimens of planktonic foraminifera were recovered.

Sample 40 (1-3-10-2, core catcher):
Globigerinoides sp. with a few specimens of an indeterminable trochoidal arenaceous species, *Bathysiphon* sp., *Bulimina notovata.*

Remarks: Only a few foraminiferal specimens were recovered in this sample and they are identified, as well as is possible, above. There is no further faunal control based on foraminifera in Core 10 except these two samples.

Sample 41 (1-3-11-1, core catcher):
Globigerinoides quadrilobata, Globigerinoides sp. cf. *G. obliqua, Globigerinoides* sp. cf. *G. subquadrata, Bulimina notovata.*

Remarks: Only a few specimens of foraminifera were recovered from this sample. There is no other faunal control in Core 11 based upon foraminifera.

Calcareous Nannoplankton

The biostratigraphy of Site 3, as deduced from the calcareous nannoplankton, is summarized in Figure 51. For a detailed discussion of the faunas, see the report by Bukry and Bramlette (Chapter 15).

SUMMARY: HISTORICAL AND REGIONAL ASPECTS

The first cores from the deep parts of the Gulf of Mexico in 1953 (Ewing *et al.*, 1955) pointed up the significance of turbidity currents in the shaping of the very flat floor of the Sigsbee Deep and in the distribution of sediments in this area. The configuration of the Gulf as a whole also indicated that the origin of most young deposits was as a result of the debris provided by the Mississippi River. However, seismic reflection profiles showed an overlapping of sedimentary sequences below the abyssal plain, suggesting that older turbidites may have been derived from significantly different sources.

Site 3 was chosen in an area adjacent to but free of diapirs where seismic reflection data indicated that turbidites older than Pleistocene could be samples, and where the abyssal plain deposits could be compared with those of the Challenger Knoll at Site 2. The hole was located in 3746 meters (12,294 feet) of water, northwest of the Campeche Scarp and approximately 21 nautical miles from Site 2 (Figure 52). The penetration was 628 meters (2059 feet) below the sea floor.

Abundant microfossils indicate that complete sequence from Upper Miocene (Tortonian) to Recent is present. The sediments are generally of three distinct types. The upper Pleistocene consists of gray terrigenous silts and clays with thin quartz-rich turbidites, comparable to those in the glacial Pleistocene sequence of Site 1. The lower Pleistocene and the Pliocene sediments consist of bluish-green coccolith oozes with then calcareous turbidites, of shallow-water biogenic debris, which become thicker and more abundant in the Lower Pliocene. The Upper Miocene contains green montmorillonitic (volcanic) clays with turbidites of volcanic rock debris, quartz, much carbonaceous plant debris, and some feldspars and heavy minerals. These turbidites also increase downward in coarseness and in thickness.

These distinct lithologic groups appear to represent major changes in the provenance of the sediments and probably in the location of the source area as well. They probably also reflect major geological events

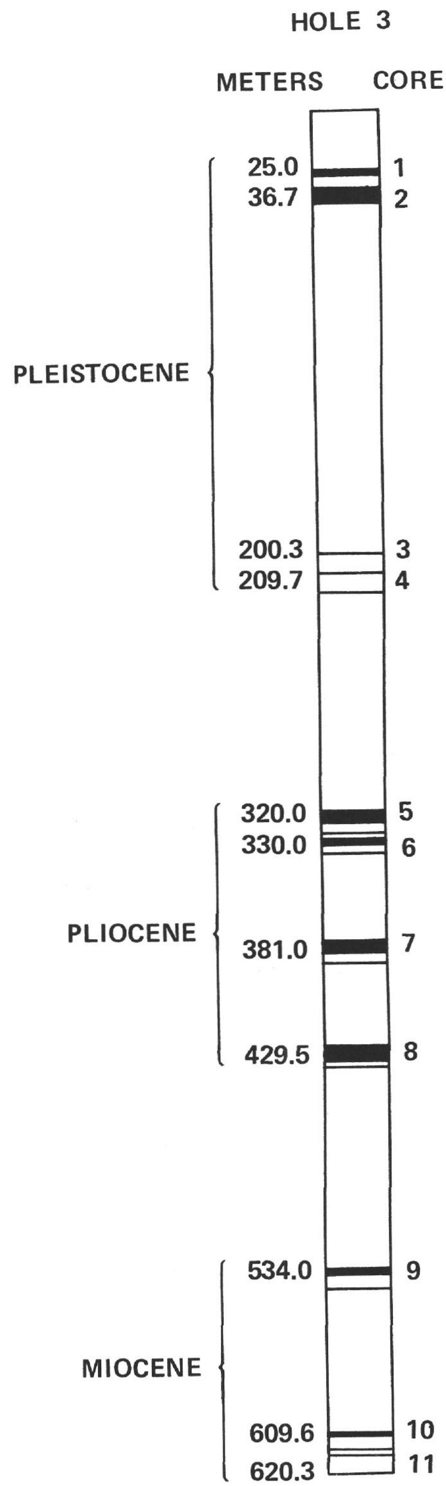


Figure 51. *Biostratigraphy of Site 3 as deduced from the calcareous nannoplankton.*

within the surrounding land areas. The upper Pleistocene and Recent surely represents the floor of detritus eroded from the United States during glaciation (Moody, 1967). The Pliocene and lower Pleistocene reflect a much lower rate of terrigenous contribution; they contain abundant pelagic organic oozes, and also shallow-water calcareous debris, probably from the Florida and Campeche shelves. The coarseness of some of the Upper Miocene turbidites suggests a nearby source, perhaps, southern or central Mexico, and an area of strong volcanism. The presence of volcanic shards, beds of ash and bentonite indicate local volcanism even in the clays of the upper part of this sequence.

It is significant that these same lithologic changes are exactly reflected in the purely pelagic deposits from the Challenger Knoll at Site 2.

Turbidites appear to make up about three-fourths of the total upper Pleistocene and Recent abyssal plain sediments of this area and somewhat more than half the Pliocene and lower Pleistocene sediments. The Upper Miocene turbidite component appears to exceed even that of the upper Pleistocene and Recent. This is also apparent in the computed rates of sedimentation, which at Site 3 range from 46 cm/10^3y in the Upper Miocene to 3.5 cm/10^3y in the Lower Pliocene. The Pleistocene at Site 3 (Figure 53) averaged 15 cm/10^3y (against 3 cm/10^3y at Site 2), and the Pliocene averaged 3.5 cm/10^3y (against 1.5 cm/10^3y at Site 2). The upper Pleistocene and Recent at Site 1 accumulated at an average rate of at least 38 cm/10^3y.

If any general pattern of abyssal plain sedimentation can be approximated from Site 3, it is that the surges of turbidite deposition gradually diminished through time in thickness and in frequency of the turbidites, and then gave way to largely pelagic deposition, which was followed by another surge of turbidites. The pelagic component in the resulting sedimentary sequence was greatly diluted.

These differences in sedimentation can be recognized in a careful examination of the seismic reflection profiles (Figure 54). Prominent horizontal reflectors

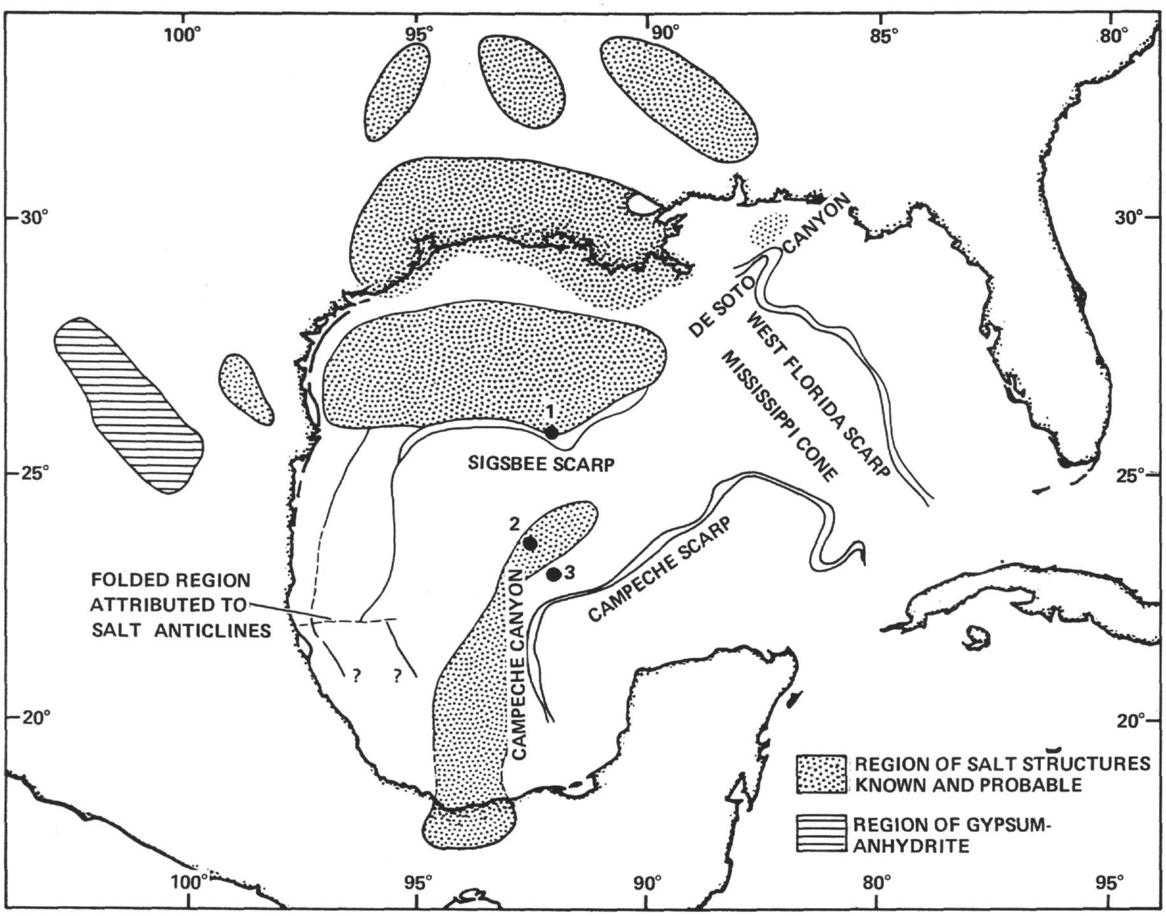


Figure 52. *Physiographic diagram of the Gulf of Mexico showing the locations of Sites 1, 2 and 3.*

in the upper Pleistocene to Recent—due to the turbidites—overlap a more acoustically transparent zone, (containing sparse turbidites of the Upper Pliocene and lower Pleistocene, which is the upper part of a sequence which dips about 1° NE and thins northeastward. Prominent reflectors appear again in the Lower Pliocene, and are sparse in the uppermost Miocene and then are prominent again at the depth of the increasingly thick and abundant Miocene turbidites. It may be feasible eventually to correlate lithologic units of known geologic ages in great detail throughout wide areas within the Gulf of Mexico and other abyssal plains by utilizing a few carefully selected coring sites and high quality seismic reflection data.

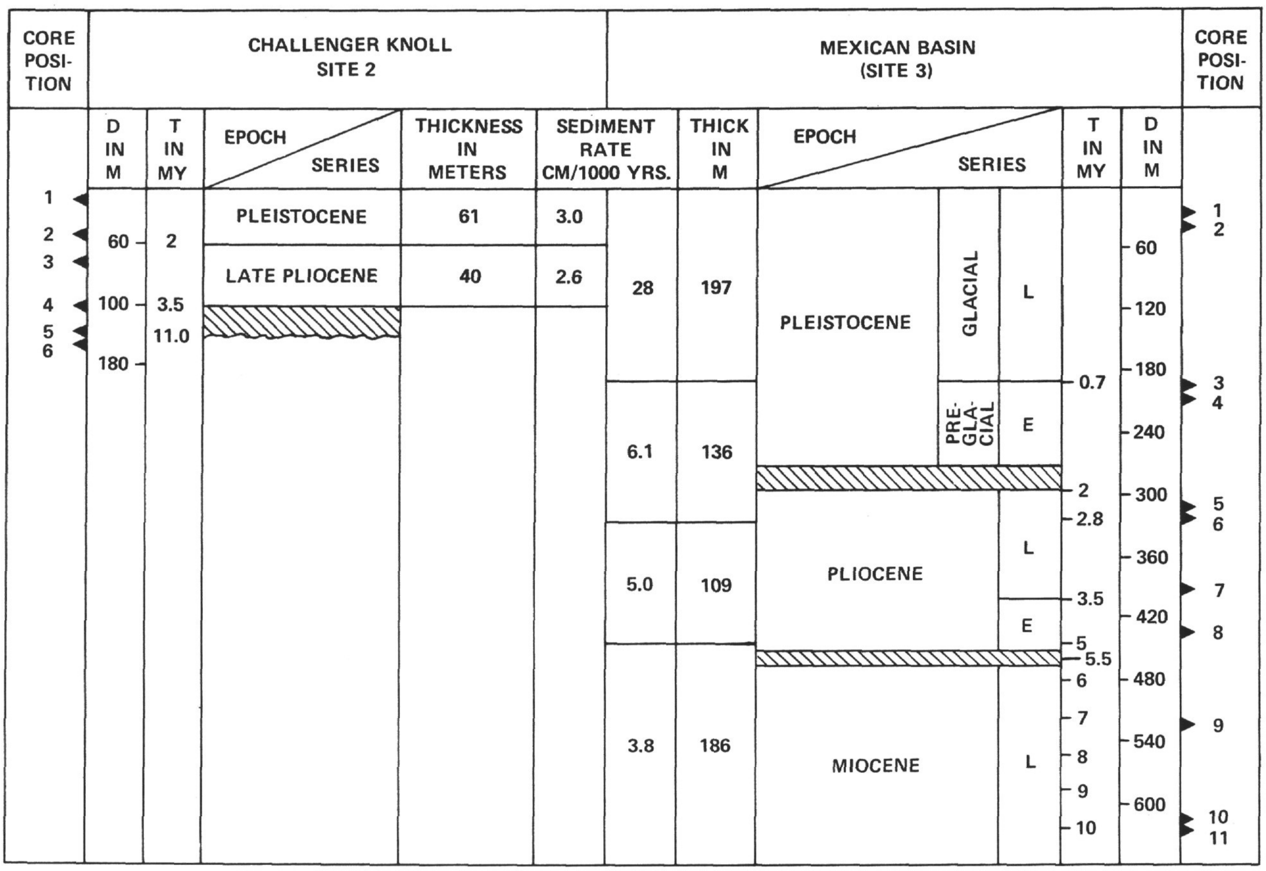


Figure 53. *Late Cenozoic sediment thickness for the Mexican Basin Plain and the Challenger Knoll (Berggren).*

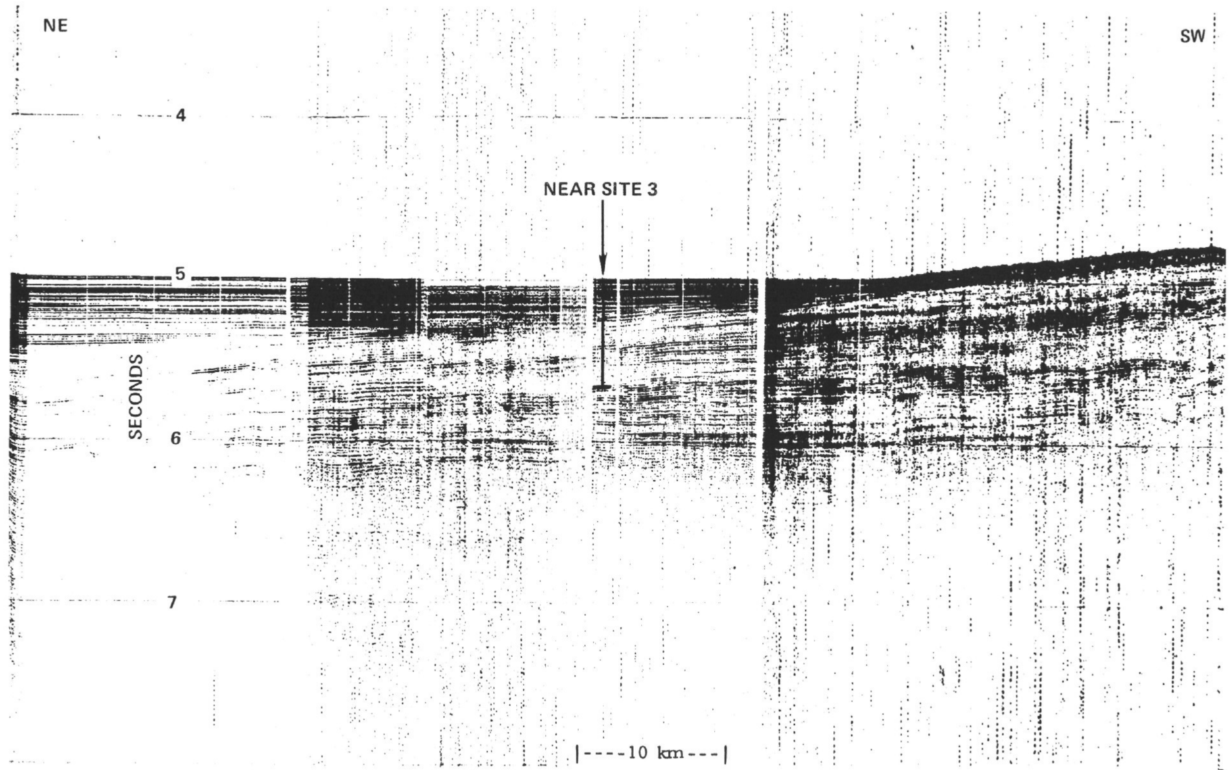


Figure 54. *Profiler traverse near Site 3. 6 February 1967, 0330-0930.*

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