# 4. SITE 78

The Shipboard Scientific Party[1]

## MAIN RESULTS

One hole was drilled at this site and continuously cored. A complete stratigraphic section from lower Oligocene to lower middle Miocene, 320 meters thick, was recovered. There is no evidence of substantial hiatuses provided by any of the fossil groups, which include foraminifera, Radiolaria, coccoliths, diatoms and silicoflagellates, except for the large hiatus at the top of the section between the lower middle Miocene and Recent. The bit was stopped by a hard layer which, judging by a few chips recovered from the roller cones, was basalt overlain by about 2.5 meters of baked limestone. The estimated age of basement at this site is about 33 ±1 million years B.P. Lithologies in this sequence are siliceous-calcareous ooze and chalk, and calcareous-siliceous ooze and chalk. The lithologic and biostratigraphic similarity of the sediments at this site and Site 77 is evidence for the regional continuity of deposition in this region from Oligocene to lower Middle Miocene. The average rate of deposition is about 14 m/m.y. The sediment accumulation rates decrease from the base of the hole to the top and abruptly drop to near zero in the Middle Miocene.

## INTRODUCTION

### Background and Objectives

The original position of Site 78 at 08° 00′N and 124° 30′W was chosen by the JOIDES Pacific Panel to determine the biostratigraphy, age of basement and rate of sea floor spreading north of the Clipperton Fracture Zone. Leg 8 had drilled sites on either side of the Clipperton Fracture Zone (Sites 70 and 71), but were stopped by chert before reaching basement thereby preventing them from determining basement age. Piston core data in the vicinity of this site show that Miocene sediments either crop out or nearly crop out over a broad area (Riedel and Funnell, 1964; Hays and others, 1969) (Figure 1). Site 78 is the northernmost of the scheduled sites of Leg 9, providing an opportunity not only to compare spreading rates on either side of the Clipperton Fracture Zone but also to compare the Tertiary history of a more northern site with that obtained from the continuous sequence of Site 77. Since the sedimentation rates varied with time at Site 77, an examination of sedimentation rates through time was an important objective of our coring at Site 78. Reasoning that the age of the basal sediments in this part of the Pacific increases westward, it was decided to move Site 78 from its originally scheduled location to latitude 07° 57.37′N, longitude 127° 21.39′W, thereby increasing the possibility of encountering older sediments and at the same time not adding appreciably to the length of our track (Figure 1). Because of its stratigraphic significance it was decided to continuously core this site.

Between Sites 77 and 78 the seismic profiler records were very poor despite the nearly constant attention of the ship's electronic technicians. What could be gleaned from the sparse data was that the sediments gradually become thinner away from Site 77, thinning to as little as 0.2 second of reflection time a few tens of miles before we reached Site 78. In the neighborhood of Site 78, the sediments thicken again to between 0.3 and 0.4 seconds reflection time. The sediments are draped conformably over the basement and have a nearly constant thickness, with minor thickening in basement valleys and thinning over basement highs (Figure 2). The relief of the sea floor is small amounting to about 50 fathoms. No region of rough topography was recorded that might indicate the position of the Clipperton Fracture Zone. However, at 0730 hours on December 24, we crossed a region with a few small seamounts and greater relief than normal. This is about the position of the Clipperton Fracture Zone as reported by Menard (1964).

### Operations

#### Site Survey

Upon reaching the location of Site 78, the *Challenger* made a survey since there had been no survey of this site by the *Argo*. The survey was made over a sequence of sediments about 0.3 to 0.4 second (reflection time) thick. *Challenger* made a square survey, the length of the sides of the square being 2 miles and the diagonals connecting the corners of the square running east-west and north-south. The thickest sediments encountered were at the western corner of the survey and have a thickness of 0.37 second. The upper 0.13 second

[1]J. D. Hays, Lamont-Doherty Geological Observatory, Palisades, New York; H. E. Cook, University of California, Riverside; D. G. Jenkins, University of Canterbury, Christchurch, New Zealand; F. M. Cook, independent; J. Fuller, Kennecott Exploration, Inc., San Diego, California; R. Goll, Lamont-Doherty Geological Observatory, Palisades, New York; E. D. Milow, Scripps Institution of Oceanography, La Jolla, California; W. Orr, University of Oregon, Eugene, Oregon.

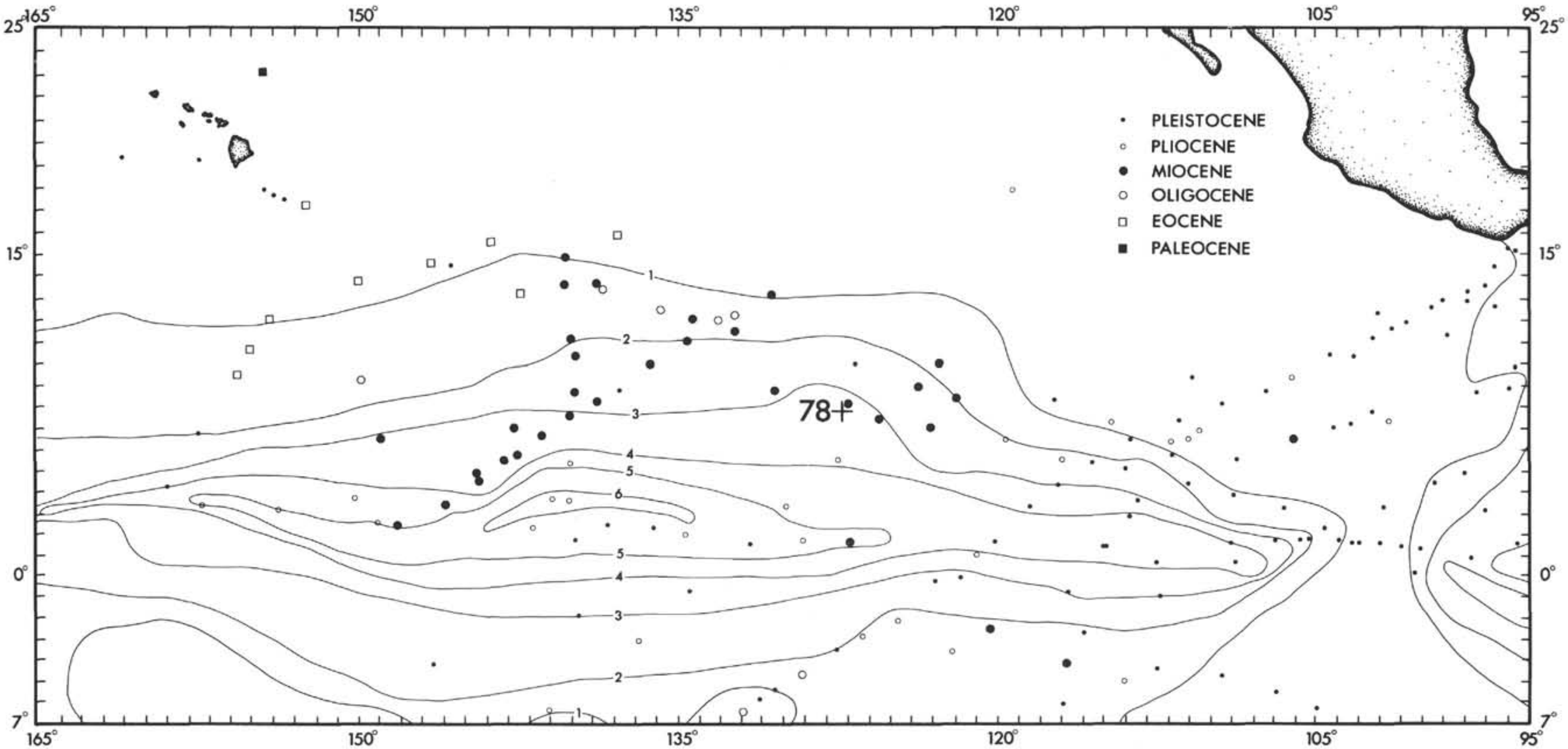



Figure 1. *Location of Site 78; sediment isopachs in hundreds of meters after Ewing* et al. *(1968); distribution of piston core ages after Hays* et al. *(1969).*

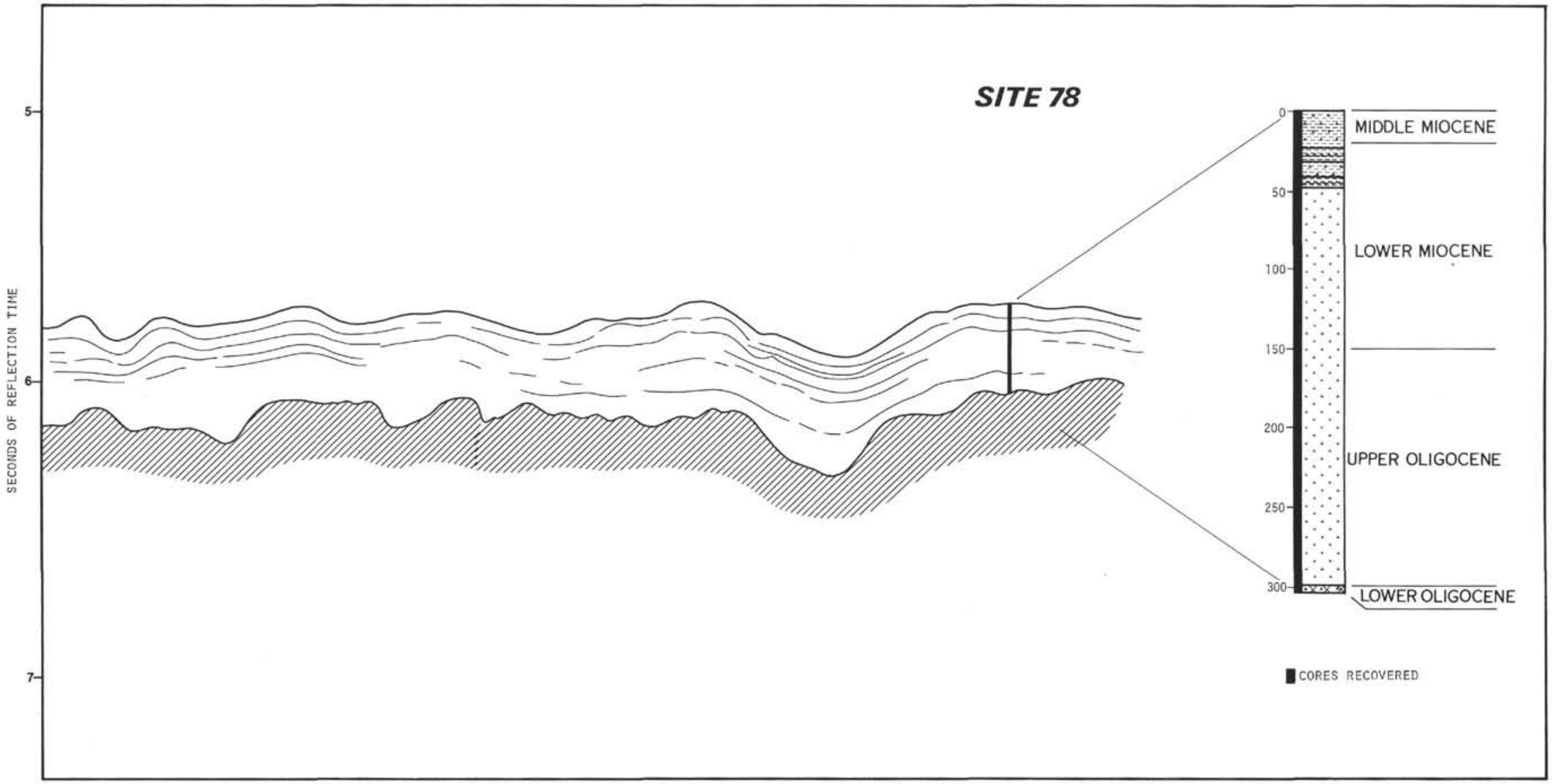



Figure 2. *Sketch of seismic reflection record in vicinity of Site 78 showing interval cored.*

contains two prominent reflectors and the remaining 0.24 second of sediment is nearly transparent.

### Coring

Upon arrival at the drilling site a Burnett beacon was dropped. Its signal was satisfactory and the drill string with the roller bit was lowered. The bit encountered the sea floor at a depth of 4363 meters and we proceeded to continuously core the hole. Pertinent data concerning the coring operation are presented in Tables 1 and 2. Coring went smoothly and quickly until a resistant layer was encountered at a depth of 315 meters below the sea floor. About 6 inches of hard limestone were cut in approximately an hour of drilling. While drilling on a hard layer, probably basalt below the limestone, the drill string began to vibrate severely. It was thought that one of the bit cones had been lost or had locked. When the bit was recovered it showed no signs of skidding but one of the cones was locked. After some effort the cone was freed but all the cones had noisy bearings and it was decided that the bit could be rebuilt but was unsuitable for further use on this leg.

## LITHOLOGY

Three formations are present at Site 78: the cyclic unit (0 to 51.7 meters) of the Clipperton Oceanic Formation which consists of interbedded orange calcareous and dusky brown siliceous oozes; the Marquesas Oceanic Formation (51.7 to 310.5 meters) which consists of gray and brown calcareous oozes and chalks; and the dark brown amorphous iron-oxide, calcareous chalks of the Line Islands Oceanic Formation (310.5 to 320.3 meters). Basement at this site is interpreted to be an intrusive basalt which has baked and hydrothermally altered the overlying chalks.

### Clipperton Oceanic Formation

#### Cyclic Unit (0 to 51.7 meters)

The cyclic unit is mainly characterized by its orange and dark brown colors; for descriptive purposes it is divided into an upper and lower part. Thin, well-bedded orange and brown lithologies are characteristic of the upper 20 meters. Individual beds range in thickness from about 5 to 25 centimeters. Within beds no laminations were seen; however, because these oozes are intensely disturbed by coring primary depositional structures are rarely preserved. The main lithologies of the upper part are:

1. Pale yellowish-brown (10YR2/2) clay (2 to 10 per cent)–calcareous nannofossil (90 per cent) chalk ooze with about 5 to 10 per cent foraminifera and radiolarians.

2. Pale orange (10YR7/2) clay (2 to 10 per cent)–calcareous nannofossil (90 per cent) chalk ooze with less than 1 per cent foraminifera and radiolarians.

3. Pale yellowish-orange (10YR8/6) clay (3 to 5 per cent)–foraminiferal (10 to 15 per cent)–radiolarian (10 to 15 per cent)–calcareous nannofossil (70 to 80 per cent) chalk ooze.

4. Dark yellowish-brown (10YR4/2) clay (5 to 10 per cent)–foraminiferal (5 to 10 per cent)–radiolarian (5 to 10 per cent)–calcareous nannofossil (70 to 85 per cent) chalk ooze.

The boundary between the upper and lower parts of the cyclic unit is gradational over a 1.5-meter interval. This boundary is recognized by the presence of cyclic, interbedded, high and low siliceous chalk oozes starting at about 20 meters from the top of the hole.

The lower part of this unit is similar to the upper part in overall color, but its cyclic bedding of high and low siliceous oozes serves to set it apart. It is distinguished by the 20 to 100 centimeter-thick interbeds of very pale orange calcareous chalk oozes and dark yellowish-brown siliceous chalk oozes (Figure 99):

1. Very pale orange (10YR8/2) radiolarian (10 to 15 per cent)–foraminiferal (10 to 15 per cent)–calcareous nannofossil (65 to 75 per cent) chalk ooze.

2. Dark yellowish-brown (10YR4/2) clay (10 to 15 per cent)–calcareous nannofossil (30 to 50 per cent)–radiolarian (30 to 50 per cent) chalk ooze.

3. Pale orange (10YR7/2) calcareous nannofossil (90 per cent) chalk ooze with 10 per cent foraminifera and radiolarians.

4. Very dark yellowish-brown (10YR3/2) clay (5 per cent)–calcareous nannofossil (40 to 50 per cent)–radiolarian (50 to 60 per cent) chalk ooze.

5. Very pale orange (10YR8/2) calcareous nannofossil (30 to 40 per cent)–radiolarian (40 to 60 per cent) chalk ooze.

6. Pale yellowish-brown (10YR6/2) clay (1 to 5 per cent)–radiolarian (10 to 15 per cent)–calcareous nannofossil (80 per cent) chalk ooze.

7. Very pale yellowish-brown (10YR7/2) clay (5 per cent)–radiolarian (15 per cent)–calcareous nannofossil (80 per cent) chalk ooze.

This part of the cyclic unit grades into the underlying Marquesas Oceanic Formation over a 2.5-meter interval from pale yellowish-brown calcareous and siliceous sediments to very pale orange calcareous sediments.

### Marquesas Oceanic Formation

#### Brown Unit (51.7 to 101.1 meters)

Distinguishing characteristics of this unit include its very pale orange color, massive bedding with no

**TABLE 1**
**Site Operational Summary**

Site 78

Latitude 07° 57.00'N; Longitude 127° 21.35'W.

Time of arrival: 0438 hours, 12/25/69; Time of departure: 2115 hours, 12/28/69.

Time on site: 3 days, 16 hours, 37 minutes.

Water depth: 4363 meters.

Sediment thickness determined by drilling: 320.3 meters.

Acoustical thickness: 0.3 second.

Average sound velocity of sediments: 2.1 km/sec.

| Hole | Penetration (m) | Cores Attempted | Cores Recovered | Per Cent Cored | Recovery Meters | Per Cent Recovered |
|---|---|---|---|---|---|---|
| 78 | 320.3 | 37 | 36 | 100 | 301.7 | 94.2 |

apparent laminations, and high carbonate content:

1. Very pale orange (10YR8/2) radiolarian (10 to 15 per cent)–foraminiferal (40 to 50 per cent)–calcareous nannofossil (50 to 60 per cent) ooze.

2. Very, very pale orange (10YR9/2) radiolarian (10 to 15 per cent)–foraminiferal (15 to 20 per cent)–calcareous nannofossil (70 to 80 per cent) ooze.

3. Very pale orange (10YR8/2) radiolarian (10 to 20 per cent)–calcareous nannofossil (30 to 50 per cent)–foraminiferal (40 to 50 per cent) ooze.

4. Grayish-orange (10YR7/4) clay (2 to 3 per cent)–radiolarian (10 to 15 per cent) calcareous nannofossil (80 to 85 per cent) chalk ooze.

The oranges of this unit grade into pastel shades of gray and light blue and green of the underlying gray unit of the Marquesas Oceanic Formation over a 1-meter interval.

**Gray Unit (101.1 to 272.4 meters)**

This unit is easily recognized because of its light gray, green and blue colors with occasional dusky purple laminations. Individual colors usually persist over long intervals with no apparent laminations which results in massive-appearing beds.

1. Dominant light greenish-gray (5G8/1) foraminiferal (10 to 15 per cent) radiolarian (10 to 15 per cent)–calcareous nannofossil (70 to 80 per cent) chalk and ooze chalk.

2. Common bluish-white (5B9/1) foraminiferal (10 to 15 per cent)–radiolarian (10 to 15 per cent)–calcareous nannofossil (70 to 80 per cent) chalk.

3. Rare pale yellowish-orange (10YR6/2) foraminiferal (15 to 20 per cent)–radiolarian (15 to 20 per cent)–calcareous nannofossil (60 to 70 per cent) ooze chalk.

4. Rare very dusky purple (5P2/2) manganese (?) (5 to 10 per cent)–foraminiferal (10 to 20 per cent)–radiolarian (30 to 40 per cent) calcareous nannofossil (40 to 60 per cent) ooze.

5. Common light greenish-gray (5G8/1) foraminiferal (15 to 25 per cent)–calcareous nannofossil (70 to 80 per cent) chalk with less than 5 to 10 per cent Radiolaria.

6. Common bluish-white (5B9/1) to light greenish-gray (5G8/1) foraminiferal (15 to 25 per cent)–calcareous nannofossil (70 to 80 per cent) chalk.

This unit grades into another brown unit of the Marquesas Oceanic Formation over a 1 to 2 centimeter-thick transitional color change from light gray to very pale orange.

**Brown Unit (272.4 to 310.5 meters)**

These sediments are massive with no apparent laminations. The dominant lithologies are:

1. Dominant very pale yellowish-orange (10YR9/6) foraminiferal (15 to 20 per cent)–calcareous nannofossil (80 to 85 per cent) chalk, with radiolarians about 5 to 10 per cent.

2. Common very pale orange (10YR8/2) foraminiferal (20 to 30 per cent)–calcareous nannofossil (70 to 80 per cent) chalk, with about 1 to 3 per cent radiolarians.

**TABLE 2**
**Hole Drilling Summary, Site 78**
**(Latitude 07° 57.00′N, Longitude 127° 21.35′W; 4363 meters depth)**

**Hole 78**

| Interval Below Sea Floor (m) | (ft) | Drilled | Core | Core Cut (m) | (ft) | Core Recovered (m) | (ft) | Drill Stem Rotated | Pump Circ | Drilling Rate (ft/min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-9.1 | 0-30.0 | | 1 | 9.10 | 30.0 | 9.10 | 30.0 | – | – | 3.3 |
| 9.1-18.3 | 30.0-60.0 | | 2 | 9.10 | 30.0 | 9.10 | 30.0 | – | – | 1.7 |
| 18.3-27.4 | 60.0-90.0 | | 3 | 9.10 | 30.0 | 9.10 | 30.0 | – | – | 2.3 |
| 27.4-36.6 | 90.0-120.0 | | 4 | 9.10 | 30.0 | 9.10 | 30.0 | – | – | 3.0 |
| 36.6-45.7 | 120.0-150.0 | | 5 | 9.10 | 30.0 | 9.10 | 30.0 | – | – | 3.0 |
| 45.7-54.9 | 150.0-180.0 | | 6 | 9.10 | 30.0 | 9.10 | 30.0 | – | – | 2.5 |
| 54.9-64.0 | 180.0-210.0 | | 7 | 9.10 | 30.0 | 8.80 | 29.0 | – | – | 3.0 |
| 64.0-73.2 | 210.0-240.0 | | 8 | 9.10 | 30.0 | 2.40 | 8.0 | – | – | 2.5 |
| 73.2-82.3 | 240.0-270.0 | | 9 | 9.10 | 30.0 | 8.80 | 29.0 | – | – | 1.0 |
| 82.3-91.4 | 270.0-300.0 | | 10 | 9.10 | 30.0 | 9.10 | 30.0 | | – | 1.1 |
| 91.4-100.6 | 300.0-330.0 | | 11 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.0 |
| 100.6-109.8 | 330.0-360.0 | | 12 | 9.10 | 30.0 | 8.20 | 27.0 | | Int | 2.1 |
| 109.8-118.9 | 360.0-390.0 | | 13 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 3.3 |
| 118.9-128.0 | 390.0-420.0 | | 14 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 2.0 |
| 128.0-137.2 | 420.0-450.0 | | 15 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 2.5 |
| 137.2-146.3 | 450.0-480.0 | | 16 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | ? |
| 146.3-155.5 | 480.0-510.0 | | 17 | 9.10 | 30.0 | 7.30 | 24.0 | | Int | 1.9 |
| 155.5-164.6 | 510.0-540.0 | | 18 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | ? |
| 164.6-173.7 | 540.0-570.0 | | 19 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.5 |
| 173.7-182.9 | 570.0-600.0 | | 20 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.1 |
| 182.9-192.0 | 600.0-630.0 | | 21 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.0 |
| 192.0-201.2 | 630.0-660.0 | | 22 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.0 |
| 201.2-210.3 | 660.0-690.0 | | 23 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.1 |
| 210.3-219.5 | 690.0-720.0 | | 24 | 9.10 | 30.0 | 2.70 | 9.0 | | Int | 1.0 |
| 219.5-228.6 | 720.0-750.0 | | 25 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 0.8 |
| 228.6-237.7 | 750.0-780.0 | | 26 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.1 |
| 237.7-246.9 | 780.0-810.0 | | 27 | 9.10 | 30.0 | 8.50 | 28.0 | | Int | 1.5 |
| 246.9-256.0 | 810.0-840.0 | | 28 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.2 |
| 256.0-265.2 | 840.0-870.0 | | 29 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.5 |
| 265.2-274.3 | 870.0-900.0 | | 30 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 1.1 |
| 274.3-283.5 | 900.0-930.0 | | 31 | 9.10 | 30.0 | 9.10 | 30.0 | | Cont | 0.9 |
| 283.5-292.6 | 930.0-960.0 | | 32 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 0.8 |
| 292.6-301.8 | 960.0-990.0 | | 33 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 0.8 |

TABLE 2 – *Continued*

**Hole 78** – *Continued*

| Interval Below Sea Floor (m) | (ft) | Drilled | Core | Core Cut (m) | (ft) | Core Recovered (m) | (ft) | Drill Stem Rotated | Pump Circ | Drilling Rate (ft/min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 301.8-310.9 | 990.0-1020.0 | | 34 | 9.10 | 30.0 | 9.10 | 30.0 | | Int | 0.9 |
| 310.9-320.1 | 1020.0-1050.0 | | 35 | 9.10 | 30.0 | 7.60 | 25.0 | | Cont | 3.8 |
| 320.1-320.3 | 1050.0-1050.5 | | 36 | 0.15 | 0.5 | 0.15 | 0.5 | | Cont | 3.0 |
| 320.3-320.3 | 1050.5-1050.5 | | 37 | 0.00 | 0.0 | 0.00 | 0.0 | | Cont | ? |
| Total 320.3 | 1050.5 | | 37 | 320.35 | 1050.5 | 301.75 | 989.5 | | | |

This unit grades into the Line Islands Oceanic Formation over a 30-centimeter interval. This change is marked by a darkening of color from very pale orange to grayish orange.

### Line Islands Oceanic Formation

As at other sites, these brown sediments have varying amounts of reddish brown amorphous iron and (?) manganese oxides which lie directly above basaltic basement. No crystalline phases of iron or manganese oxide were detected in the samples submitted for X-ray analyses (Cook and Zemmels, 1971). At this site, the Line Islands Oceanic Formation is characterized by its orange and light brown color, massive bedding, and well-indurated nature:

1. Grayish-orange (10YR7/4) clay (1 to 3 per cent)–radiolarian (15 to 20 per cent)–calcareous nannofossil (80 to 85 per cent) chalk, with about 1 to 2 per cent foraminifera.

2. The basal few inches are a white (N9) to very pale orange (10YR8/2) calcareous nannofossil (25 to 50 per cent)–foraminiferal (50 to 75 per cent) packstone limestone.

The contact with the underlying basalt is baked. This baked zone exhibits partial replacement of foraminifera and nannofossils by opaque euhedral iron oxides and moderate greenish-yellow (10YR7/4) clay both of which are probably hydrothermal in origin.

### Basaltic Basement

A basement core was not recovered, but basalt chips were on the bit at a depth directly below the baked limestone. The chips are a black (N1), very fine-grained basalt.

## PHYSICAL PROPERTIES

### Natural Gamma

Natural gamma readings ranged from 784 counts to 1000 counts/75 sec except in Cores 1, 4 and 33 where small increases up to 1079 counts were noted.

The cyclic unit of the Clipperton Oceanic Formation yielded counts from 813 to 1079. The top two thirds of the cyclic unit is irregularly marked by counts of about 1000, whereas the bottom third of the cyclic unit yields average readings of about 900 counts. Within the upper two thirds of the cyclic unit potassic mica and montmorillonite are present, and probably are responsible for the higher readings.

The Marquesas Oceanic Formation yielded counts of 785 to 950 with the exception of Core 33 where one reading of 1016 was noted. No reason for this slight increase in Core 33 is apparent.

The Line Islands Oceanic Formation yielded counts from 807 to 951.

The lower third of the cyclic unit of the Clipperton Oceanic Formation, the Marquesas Oceanic Formation, and the Line Islands Oceanic Formation are not distinguishable from one another at this site on the basis of natural gamma radiation.

### Porosity

Porosity at Site 78 ranges from 48 to 80 per cent. There may be an overall porosity decrease with depth, but if there is, it is less than 10 per cent (Figures 4 and 6). Porosity fluctuates irregularly and does not seem to correspond to lithology at this site. Rough seas increased drilling disturbance in the cores and made true measurements of porosity difficult.

## Sonic Velocity

Sound velocities range from 1415 to 1708 m/sec. The velocities tend to increase downhole, as would be expected due to sediment compaction; however, the velocities fluctuate irregularly at the bottom of the hole. This fluctuation probably reflects the interbedded unconsolidated oozes and consolidated chalks. Whether these different degrees of consolidation over 5 to 20-centimeter intervals are natural or were artificially created by drilling procedures is uncertain. No distinct changes in velocity are directly attributable to a change in lithologic type.

## Bulk Density

At Site 78 the bulk densities range from 1,408 g/cc at the top to 1,686 g/cc at the bottom and show a slight increase with depth. However, this trend is broken by sharp fluctuations in the readings some of which are probably due to water injected into the sediments during drilling. In Core 4 the lower density readings are possible due to an abundance of Radiolaria forming a more open framework.

## Penetrometer

The general trend of the readings decrease downhole even though on a detailed scale the readings fluctuate erratically from 0.1 centimeter to over 3 centimeters. The sea was rough at this site and the vertical movement of the ship probably forced sea water into the core barrel. This resulted in sediments being mixed with sea water throughout much of the hole. Probably the highest reliable reading was 2 centimeters which occurs at the top of the hole. Any minor fluctuations in the penetrometer readings due to cementation, compaction, and/or lithologic variation are obliterated by coring disturbances.

# BIOSTRATIGRAPHY

## Foraminifera

The record for this site is anomalous compared to the other sites because the youngest sediments cored were middle Miocene.

Except for a few Pliocene-Recent specimens of *Globorotalia tumida* and *G. tumida flexuosa* in the first core recovered, no evidence was found to indicate the occurrence of younger sediments.

In the cored interval from the middle Miocene *Globorotalia fohsi-G. peripheroacuta* Zone to the lower Oligocene *Pseudohastigerina barbadoensis* Zone, sedimentation was very rapid at certain intervals when compared to similar intervals at Site 77. In particular, the *Globorotalia kugleri* and *Globigerina ampliapertura* Zones comprise over half of the total cored interval for the hole. Coring was nearly continuous at the site and unlike Site 77, no continuous intervals were encountered without abundant well-preserved foraminiferal specimens. Diversity fluctuations occurred in the faunas but these were found to be far more subtle than similar fluctuations at Site 77. Low diversity intervals in Hole 78 appear somewhat lower in the section, e.g., *Globorotalia opima* Zone, than those of Site 77. As at Site 77, these fluctuations in the faunal diversity cannot be correlated to any apparent solution or accelerated sedimentation.

A short interval of hard limestone immediately above the basalt yielded a typical lower Oligocene fauna including the zonal species *Pseudohastigerina barbadoensis.*

## Radiolaria

Radiolaria are abundant and well preserved in all of the 35 sediment cores from Site 78. In this respect, Site 78 differs from Sites 77, 80 and 81, in which Radiolaria were either absent or rare in the ten meters of sediment directly overlying basement rock. The section at Site 78 differs from the section of equivalent age at Site 77 in the general scarcity of orosphaerid Radiolaria and the presence of diatoms throughout the recovered intervals.

Down-section reworking of younger material appears to have occurred to variable degrees throughout the cores. This contamination may reach ten per cent in Cores 9 through 20, and extreme care must be exercised in determining stratigraphic ranges.

The radiolarian assemblages at Site 78 range from the *Theocyrtis tuberosa* Zone to the *Cannartus laticonus* Zone. The discussion in the Site Report for Site 77 regarding the stratigraphic ranges of *Artophormis gracilis* and *Cannartus prismaticus* also applies to Site 78. Several discrepancies exist between the stratigraphic ranges of the same radiolarian species in these two sites. In Site 78, *Cannartus tubarius* first appears simultaneously with *Lychnocanium bipes*, whereas in Site 77, *C. tubarius* first appears 15 meters above the first appearance of *L. bipes* and after the first appearance of *Brachiospyris simplex* and *Tympanidium binoctonum.* In Core 14 of Site 78, *Dipodospyris forcipata, Tympanidium binoctonum, Liriospyris mutuaria* and *Cyrtocapsella tetrapera* first appear simultaneously, whereas approximately 13 meters of sediment exist between the first appearances of *L. mutuaria* and *D. forcipata* in Site 77. These two discrepancies may be the result of minor hiatuses in the sections.

Three other inconsistencies exist which cannot be explained by unconformities. In Site 78, *Cannartus violina* first appears above the first appearance of

*Giraffospyris annulispina*, whereas the opposite is true in Site 77. *Cyclampterium* (?) *tanythorax* and *Lithopera renzae* first appear above the first appearance of *Brachiospyris alata* in Site 78, whereas the former two species occur in the *Calocycletta costata* Zone in Site 77. In Cores 1 and 2 of Site 78, the polar columns of specimens belonging to *Cannartus* are generally absent. Consequently, the true stratigraphic range of *Cannartus laticonus* may be lower than is indicated on the Biostratigraphic Chart. Except for these three inconsistencies there is good agreement between the radiolarian stratigraphic ranges in Sites 78 and 77, and with the other sites.

## DISCUSSION AND INTERPRETATION

The sediments at this site are similar in lithology to those recovered at Site 77 but the upper part of the section from the middle of the Middle Miocene to Recent is missing. There is some reworking of Pleistocene foraminifera into the Middle Miocene faunas of the top several cores suggesting that a very thin veneer of Quaternary might be present but was not recovered. The total absence of sediments younger than middle Miocene could be accounted for if sediments of this age were not deposited at this site or if they had been subsequently eroded. A number of facts favor the former interpretation. First, the sediments at this site are not appreciably more consolidated than they were at the previous site (Site 77), and much less consolidated in their upper 100 meters than sediments of equivalent age at Site 77. Second, studies of piston cores (Riedel and Funnell, 1967; and, Hays *et al.*, 1969) from this region have shown that sediments of Miocene age outcrop over a broad area so the results at this site are probably representative for the region, indicating an extensive area of outcropping Miocene sediments that is clearly not the result of local slumping or erosion. Regional erosion that would remove a thickness of sediment equivalent to the upper Miocene through Quaternary of Site 77 (200 meters) is improbable. Also the rates of accumulation decrease rapidly toward the top of our section at Site 78, suggesting that the absence of sediment younger than Middle Miocene in age is due to the fact that it was not deposited rather than eroded away.

Important to the problem of the missing section are the accumulation rates (Table 3). At Site 77 the rates are 18 m/m.y. down to the top of the Lower Miocene and average 10 m/m.y. above this. At Site 78 the rates in the Oligocene and lower Miocene up to the *G. dissimilis* Zone are 16 m/m.y. above which they fall off rapidly approaching zero above the middle Miocene. The foraminiferal diversity is reduced in the middle Miocene as compared to the Oligocene and lower Miocene probably due to solution. Also, there is evidence of etching of coccoliths probably indicating solution resulting from slower sedimentation rates.

The sediment types at this site are generally similar to those at Site 77. The upper part of both is the cyclic unit of the Clipperton Oceanic Formation. Also present are the well indurated chalks of the Marquesas Oceanic Formation and the brown iron-manganese rich clays of the Line Islands Oceanic Formation.

Penetration was slowed at the bottom of this hole as the bit encountered hard limestone. This limestone contained euhedral magnetite and shows signs of being baked. It also contains well-preserved foraminifera, indicating that its genesis is tied to some kind of contact metamorphism. Six inches of this material were recovered. After the limestone was recovered the bit was lowered again and drilling continued for 1.5 hours with no appreciable penetration. When the bit was recovered, small pieces of basalt were removed from the cones indicating that basalt immediately underlies the limestone. This evidence of baking indicates that the basalt is a sill.

Radiolaria, nannofossils and planktonic foraminifera are all present in samples from near the base of this site, but the only zonal boundary close to the base of the section is the upper boundary of the *Pseudohastigerina barbadoensis* planktonic foraminiferal zone. The top of this zone has an estimated age of 33.5 ±1 million years and falls within a few centimeters of the base of the hole. Therefore the best estimate for the basement age at this site is 33.5 ±1 million years.

## REFERENCES


Cook, H. E. and Zemmels, I., 1971. X-ray mineralogy studies–Leg 9. **In** Hays, J. D. *et al., Initial Reports of the Deep Sea Drilling Project, Volume IX.* Washington (U. S. Government Printing Office), in press.

Hays, J. D., Saito, T. Opdyke, N. D. and Burckle, L. H., 1969. Pliocene-Pleistocene sediments of the Equatorial Pacific: Their paleomagnetic, biostratigraphic, and climatic record. *Bull. Geol. Soc. Am.* **80**, 1481.

Menard, H. W., 1964. *Marine Geology of the Pacific.* New York (McGraw-Hill), 260 p.

Riedel, W. R. and Funnell, B. M., 1964. Tertiary sediment cores and microfossils from the Pacific Ocean floor. *Quart. J. Geol. Soc. London.* **120**, 305.

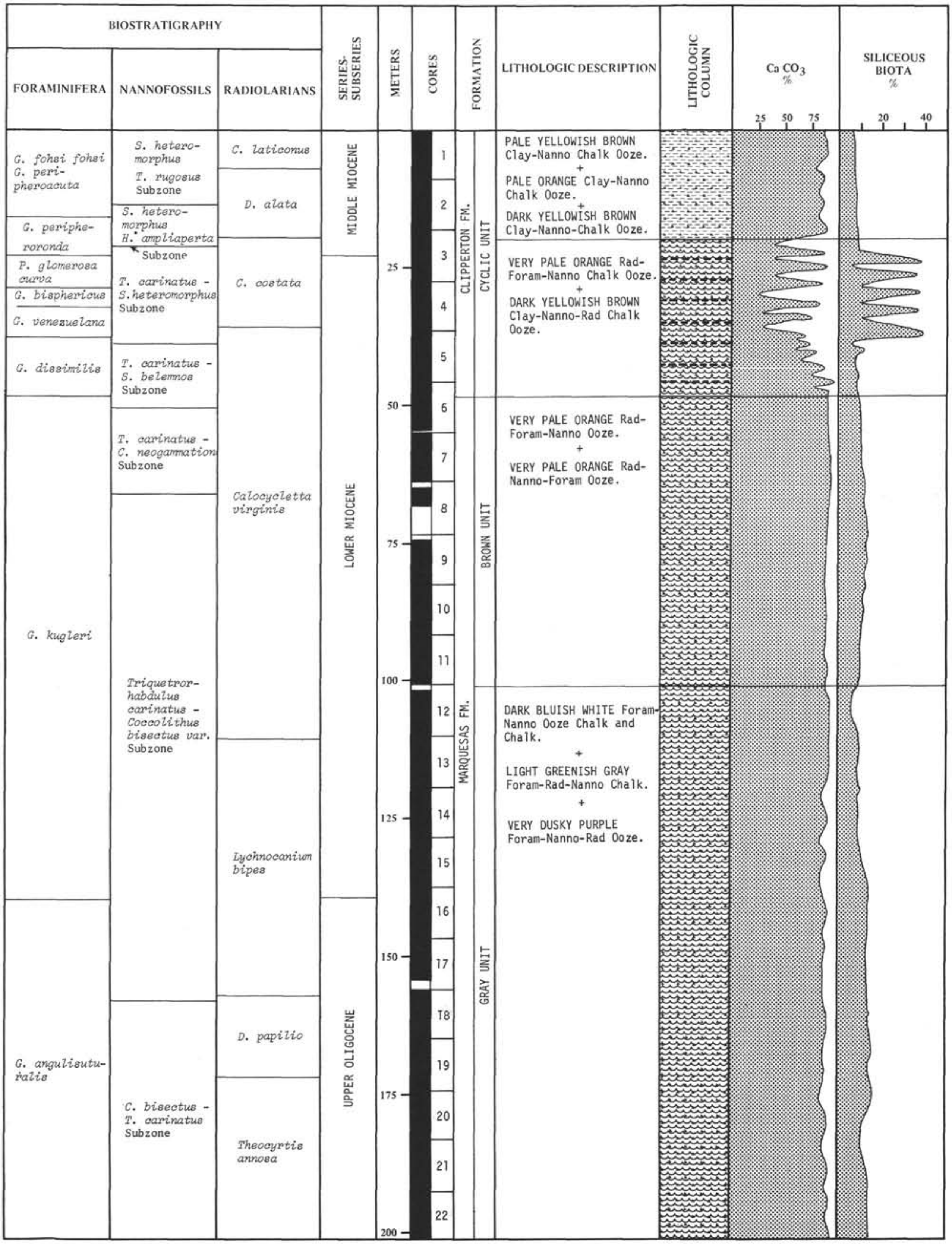



Figure 3. *Site 78 summary.*

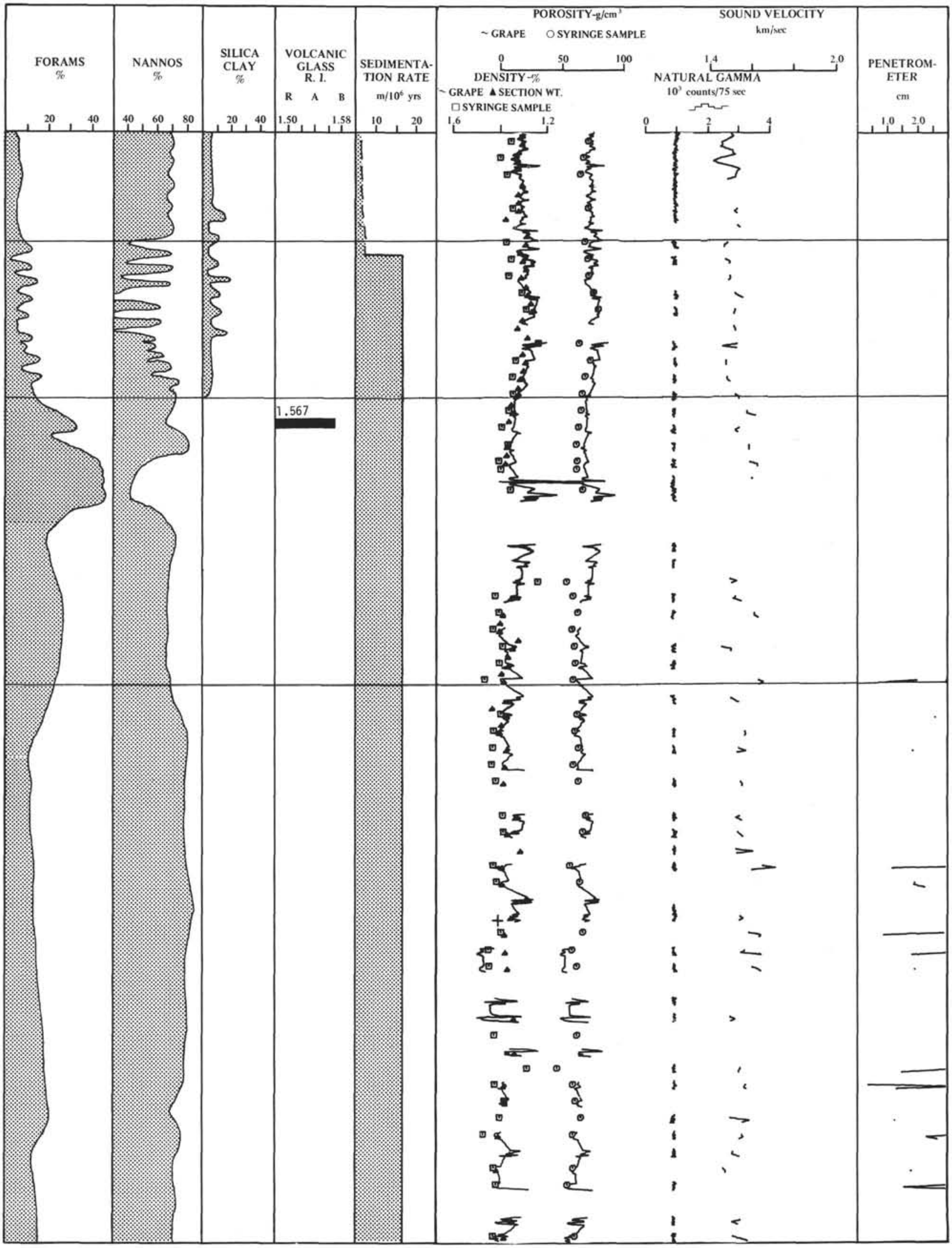



Figure 4. *Site 78 summary.*

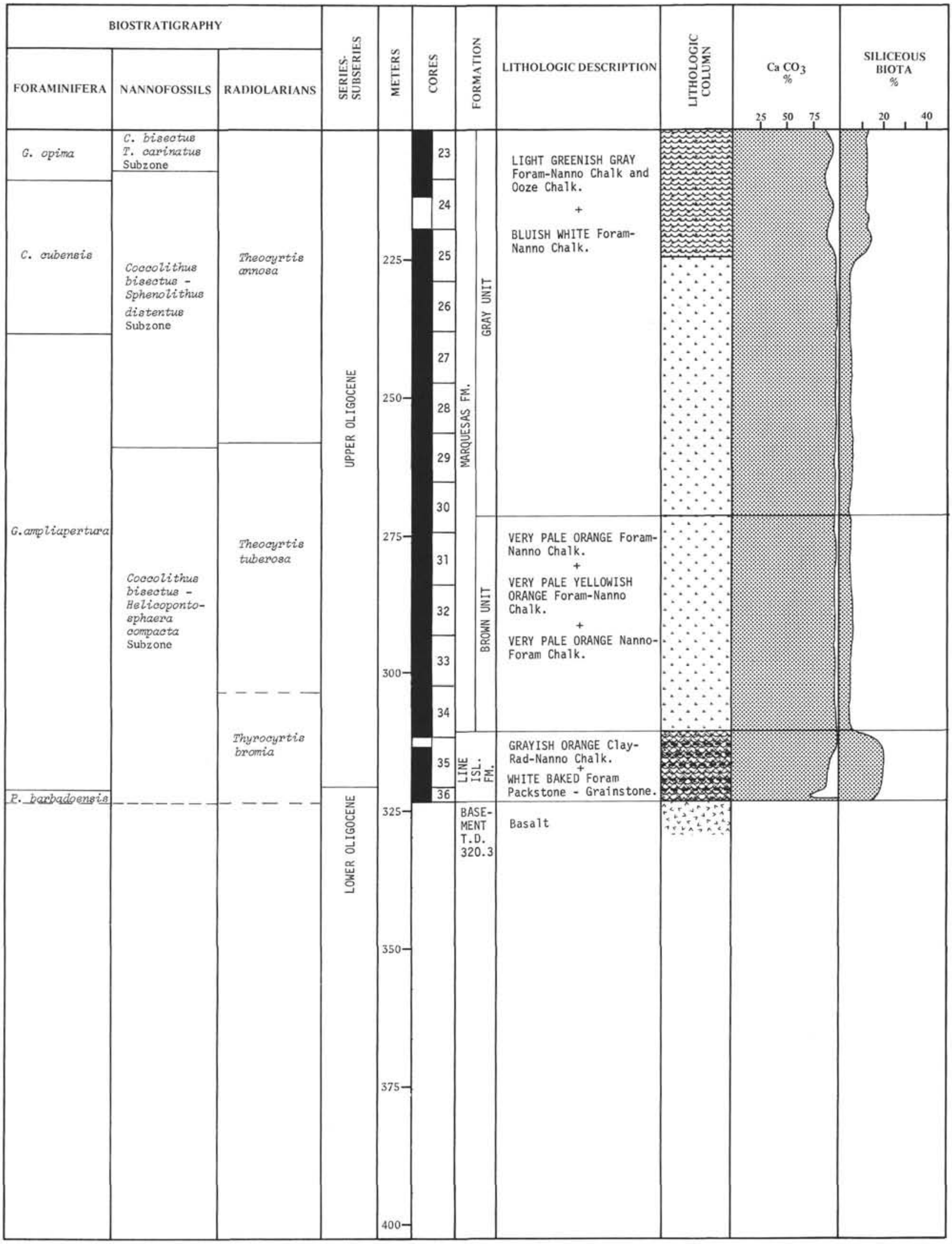



Figure 5. *Site 78 summary (continued).*

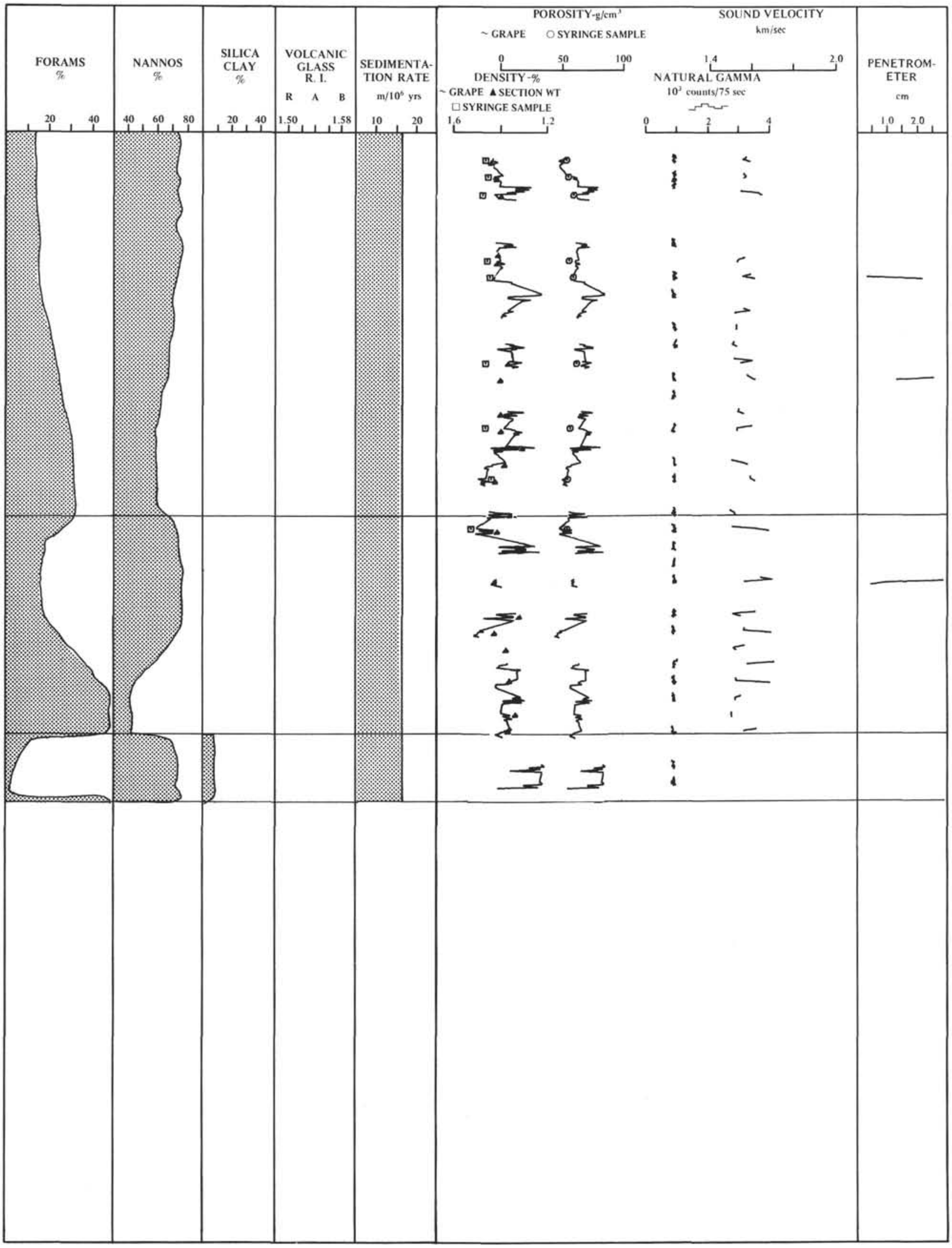



Figure 6. *Site 78 summary (continued).*

**TABLE 3**
**Rates of Sedimentation, Site 78**

| Geologic Interval | Duration Geologic Interval (m.y.) | Sediment Thickness (meters) | Accumulation Rate ($m/10^6$ yrs) |
|---|---|---|---|
| Pleistocene | 1.8 | 0 | 0 |
| Pliocene | 3.2 | 0 | 0 |
| Upper Miocene | 5.0 | 0 | 0 |
| Middle Miocene | 4.0 | 18 | 4.5 |
| Lower Miocene | 8.5 | 132 | 15.5 |

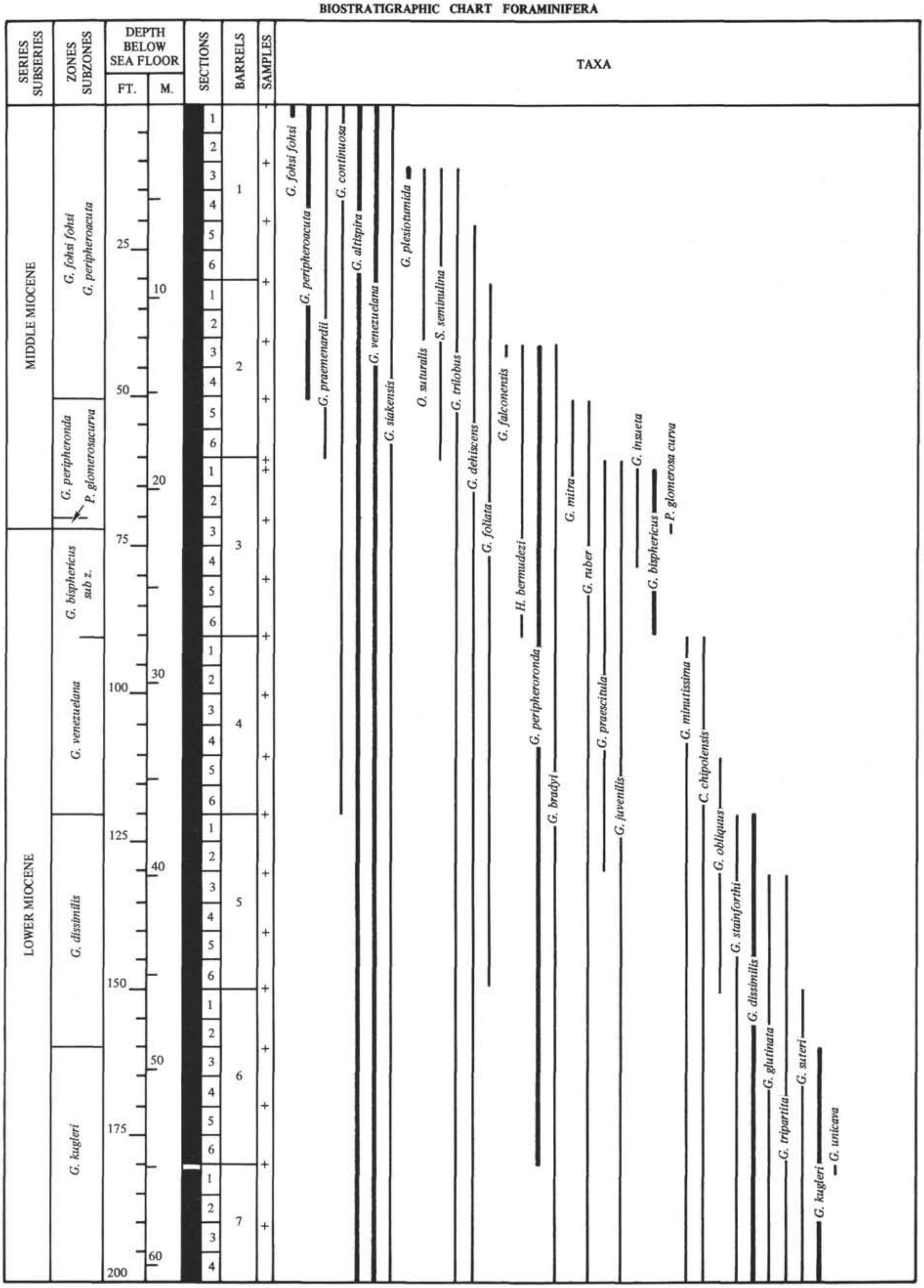



Figure 7. *Site 78 Biostratigraphic Chart Foraminifera (0 to 200 feet).*

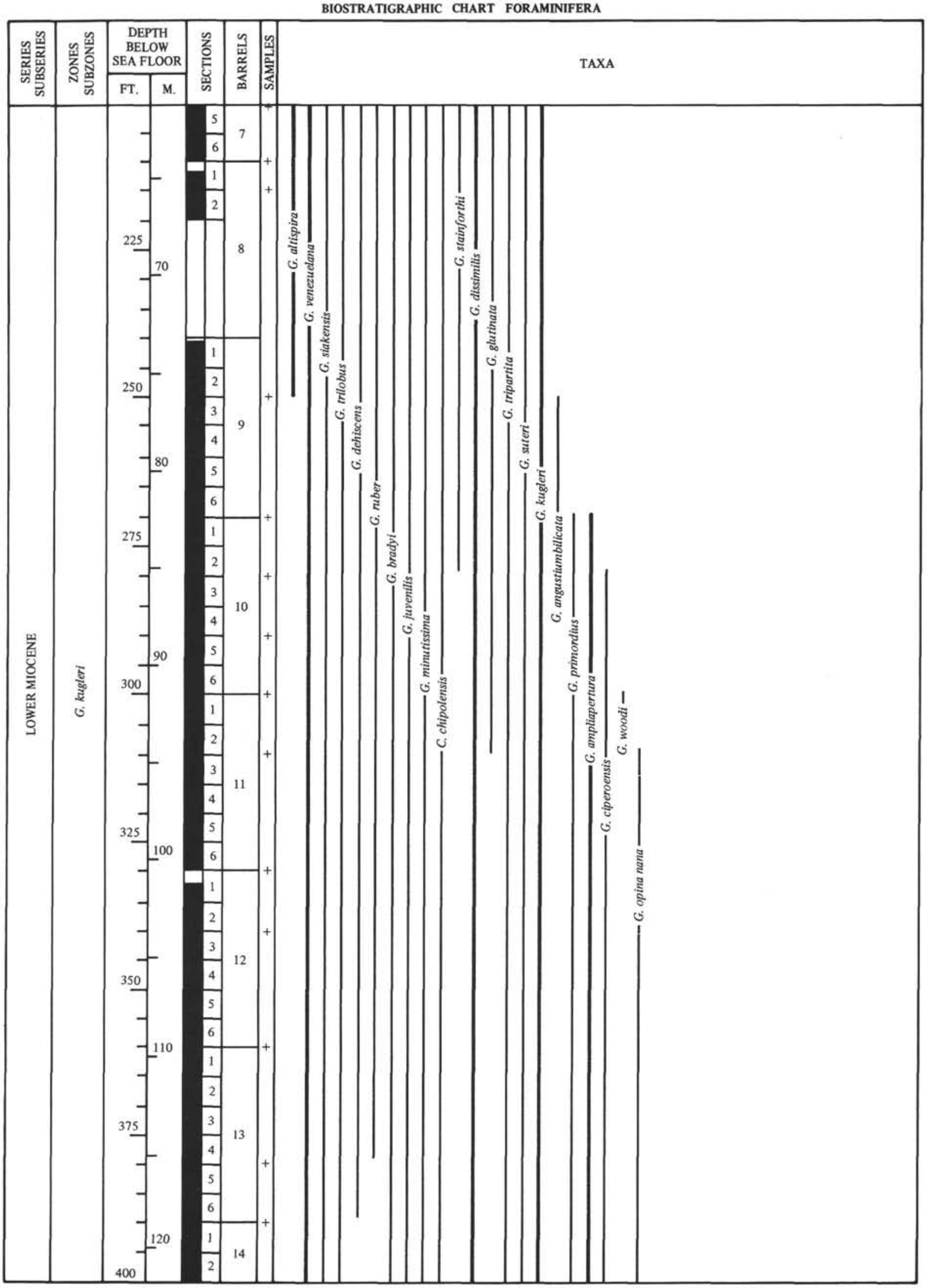



Figure 8. *Site 78 Biostratigraphic Chart Foraminifera (200 to 400 feet).*

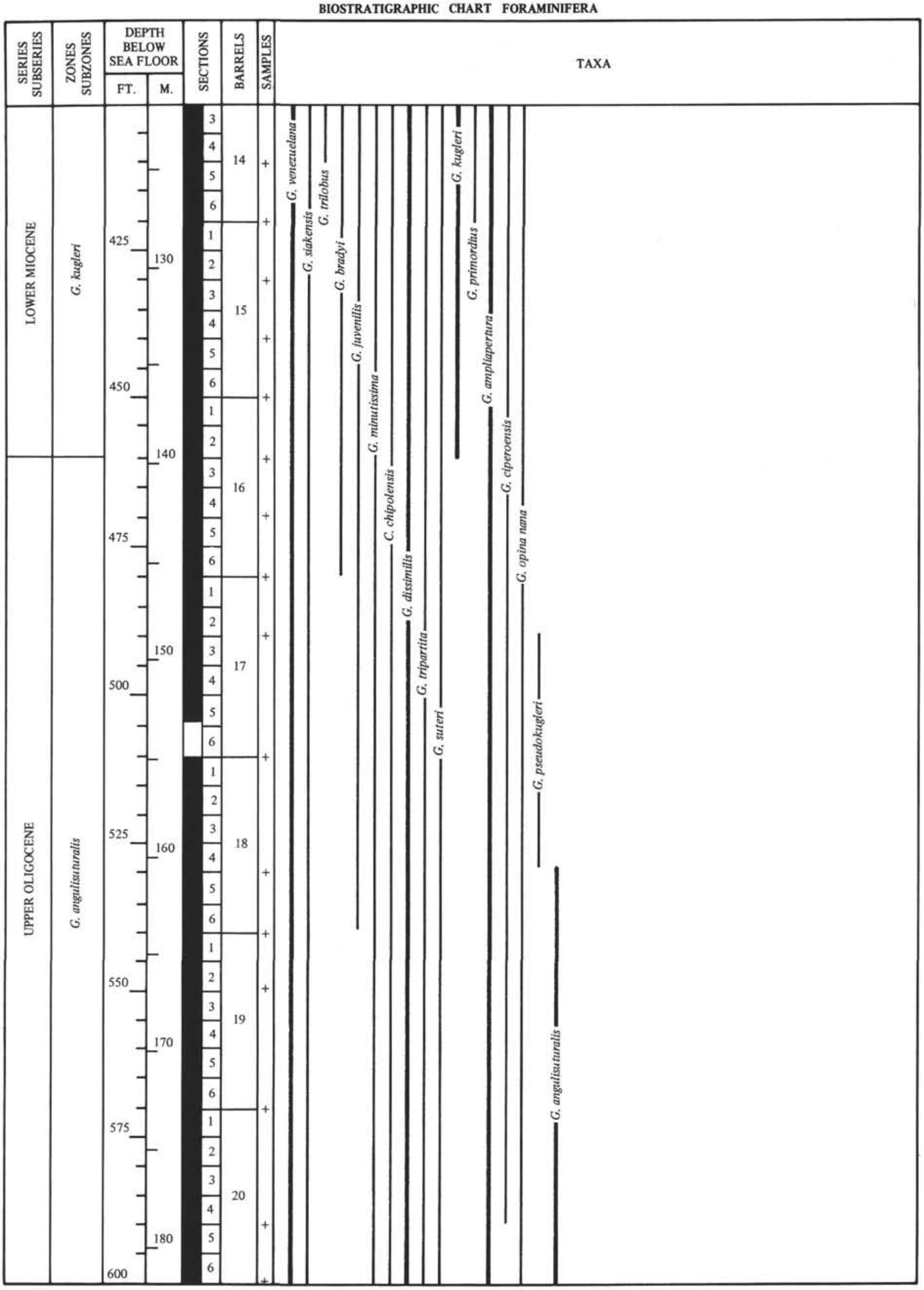



Figure 9. *Site 78 Biostratigraphic Chart Foraminifera (400 to 600 feet).*

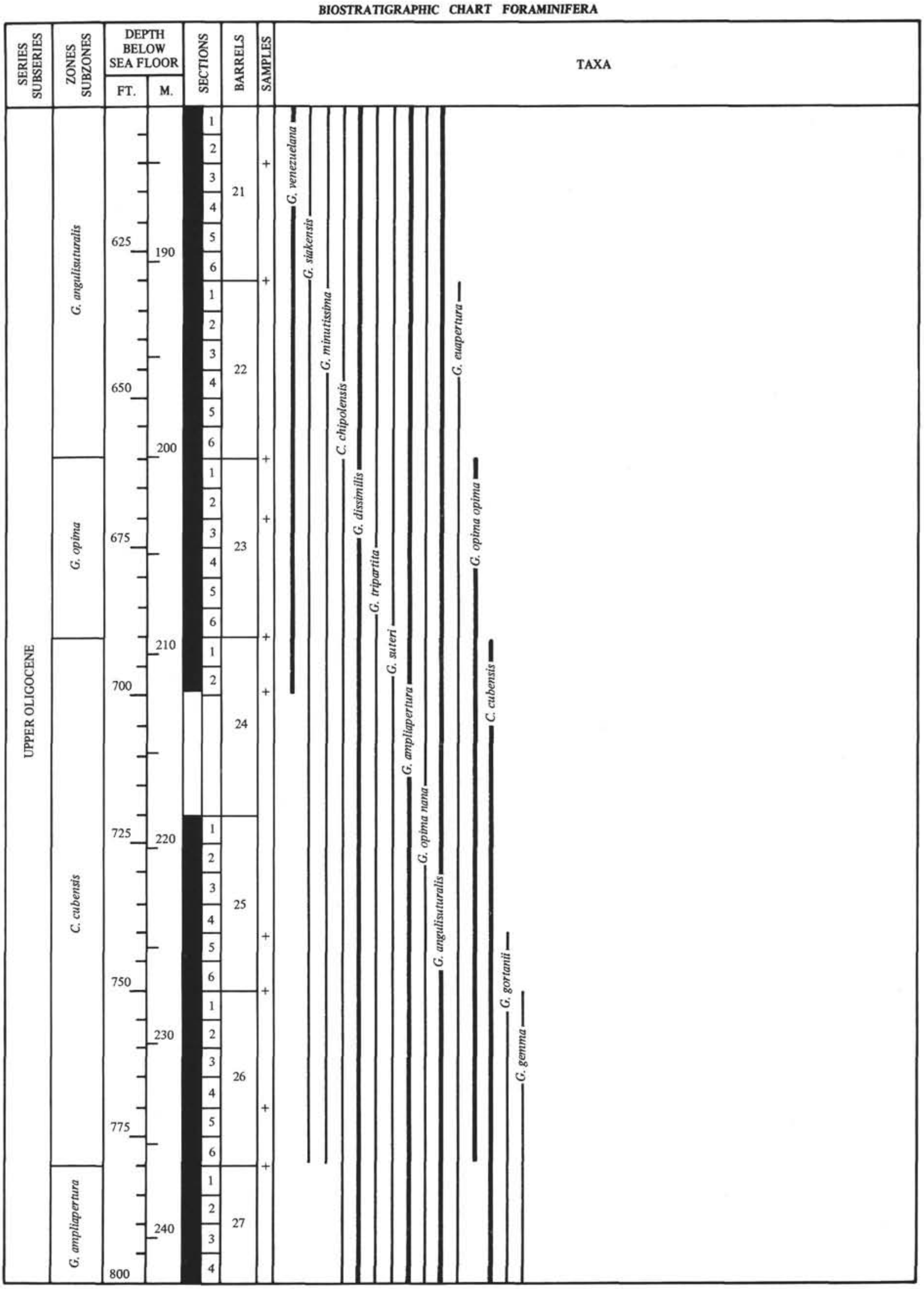



Figure 10. *Site 78 Biostratigraphic Chart Foraminifera (600 to 800 feet).*

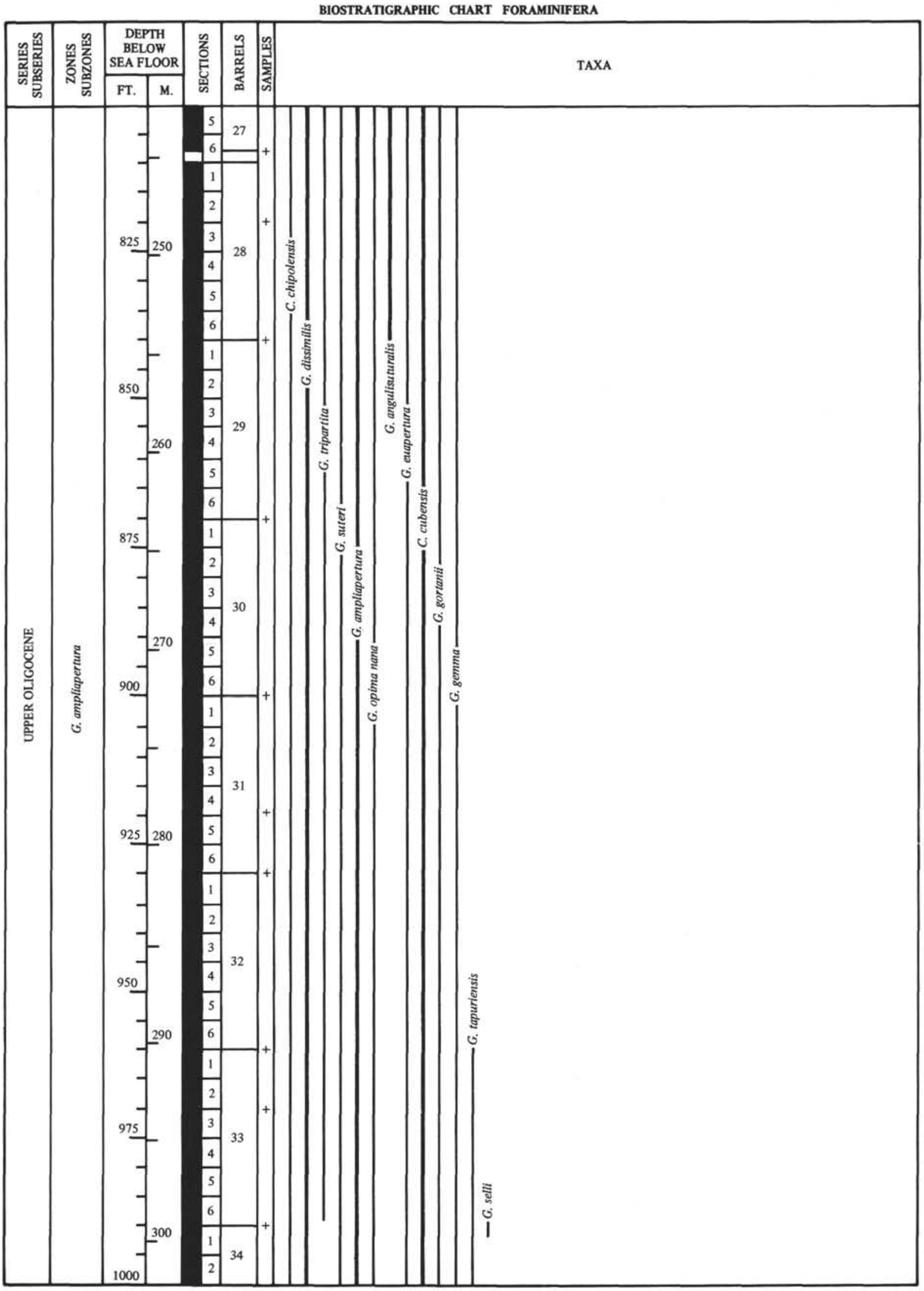



Figure 11. *Site 78 Biostratigraphic Chart Foraminifera (800 to 1000 feet).*

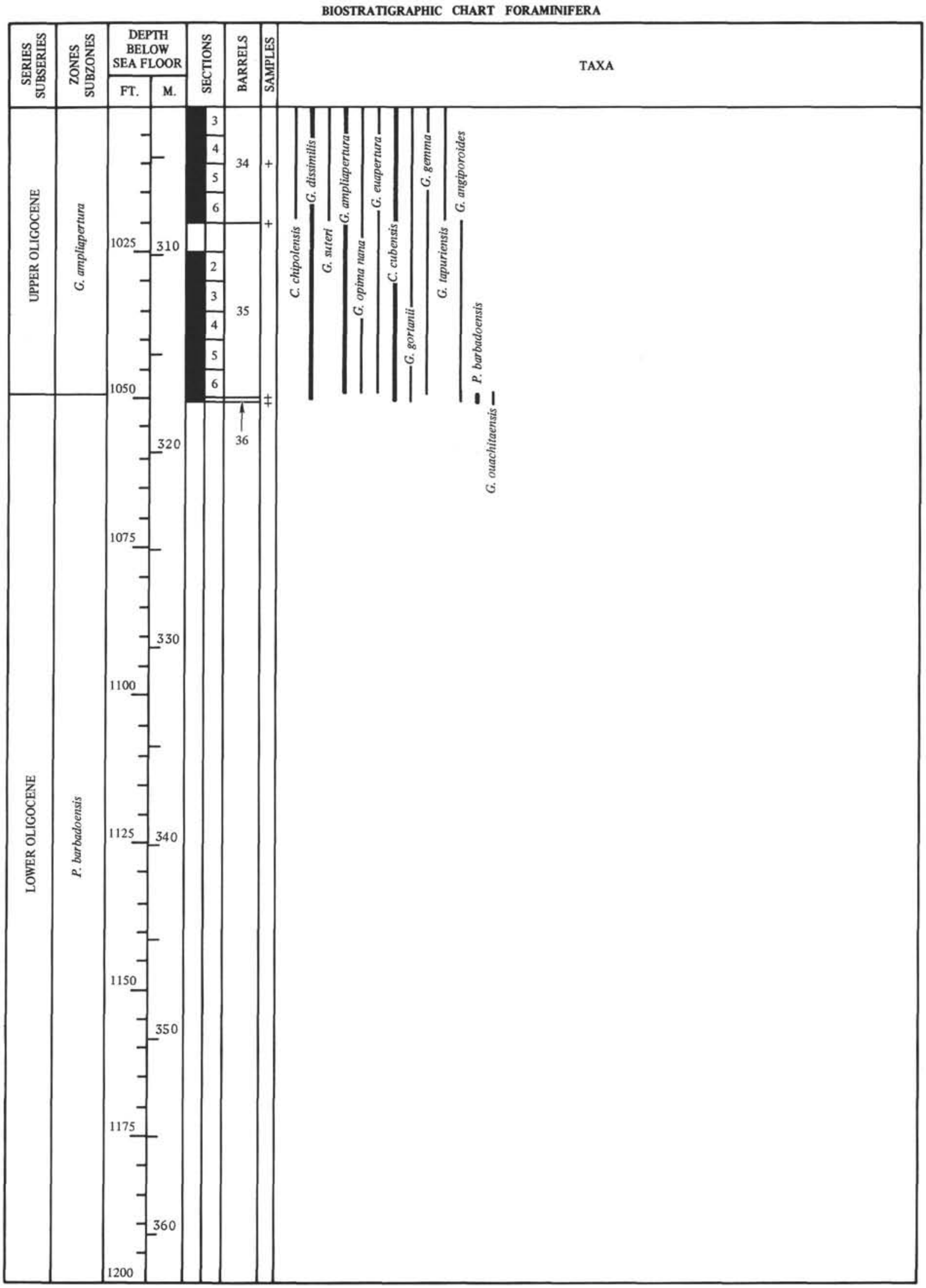



Figure 12. *Site 78 Biostratigraphic Chart Foraminifera (1000 to 1200 feet).*

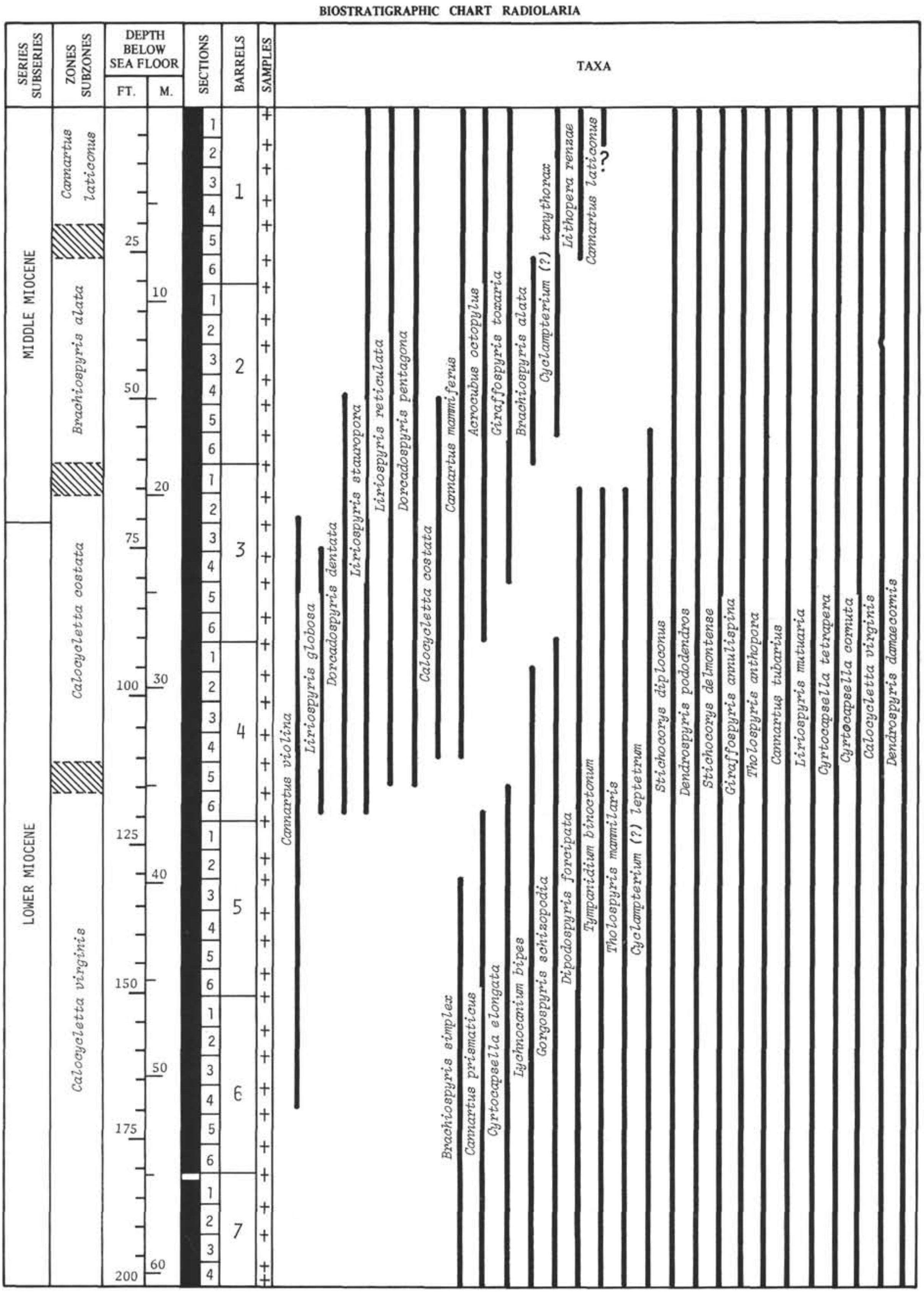



Figure 13. *Site 78 Biostratigraphic Chart Radiolaria (0 to 200 feet).*

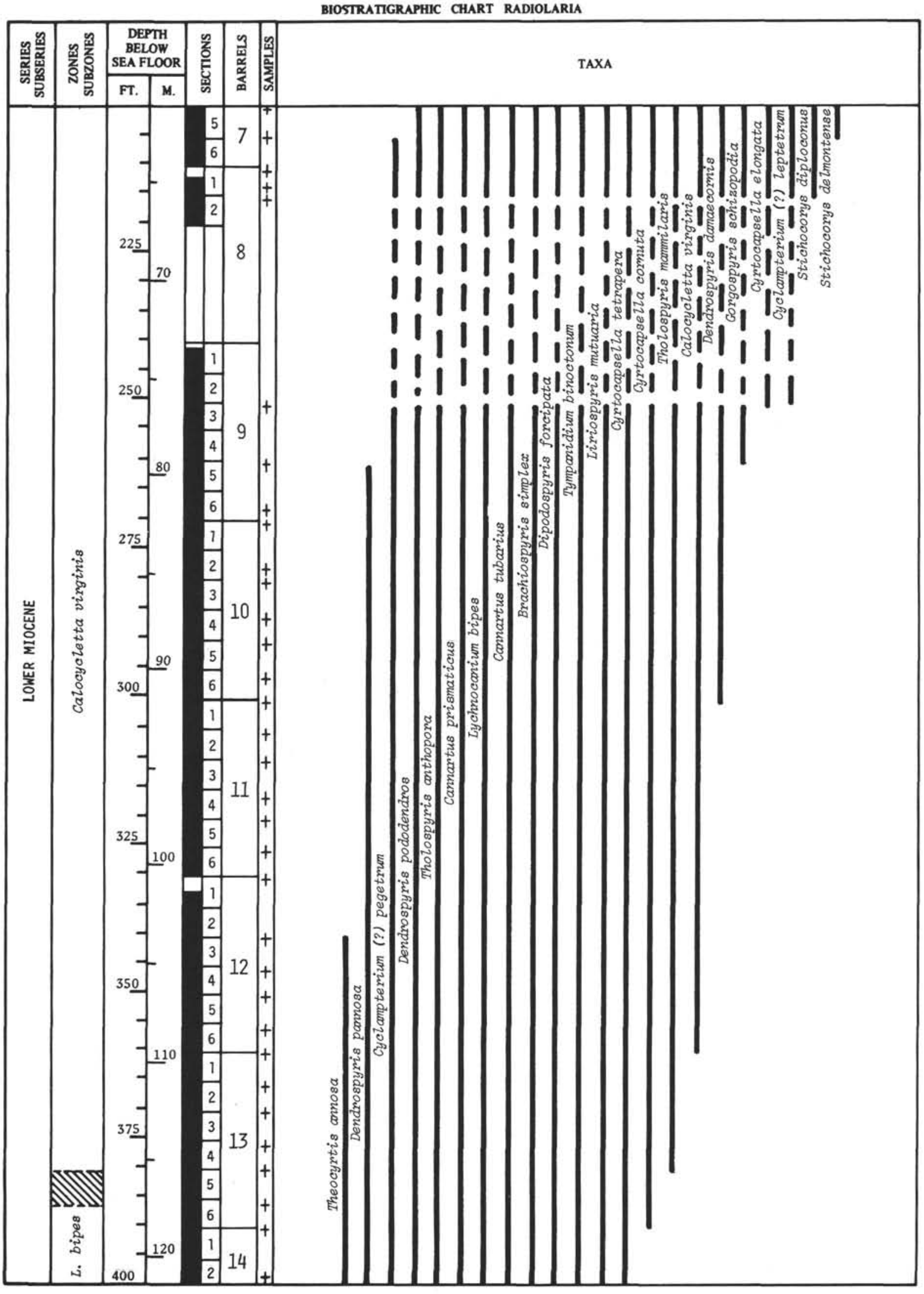



Figure 14. *Site 78 Biostratigraphic Chart Radiolaria (200 to 400 feet).*

BIOSTRATIGRAPHIC CHART RADIOLARIA

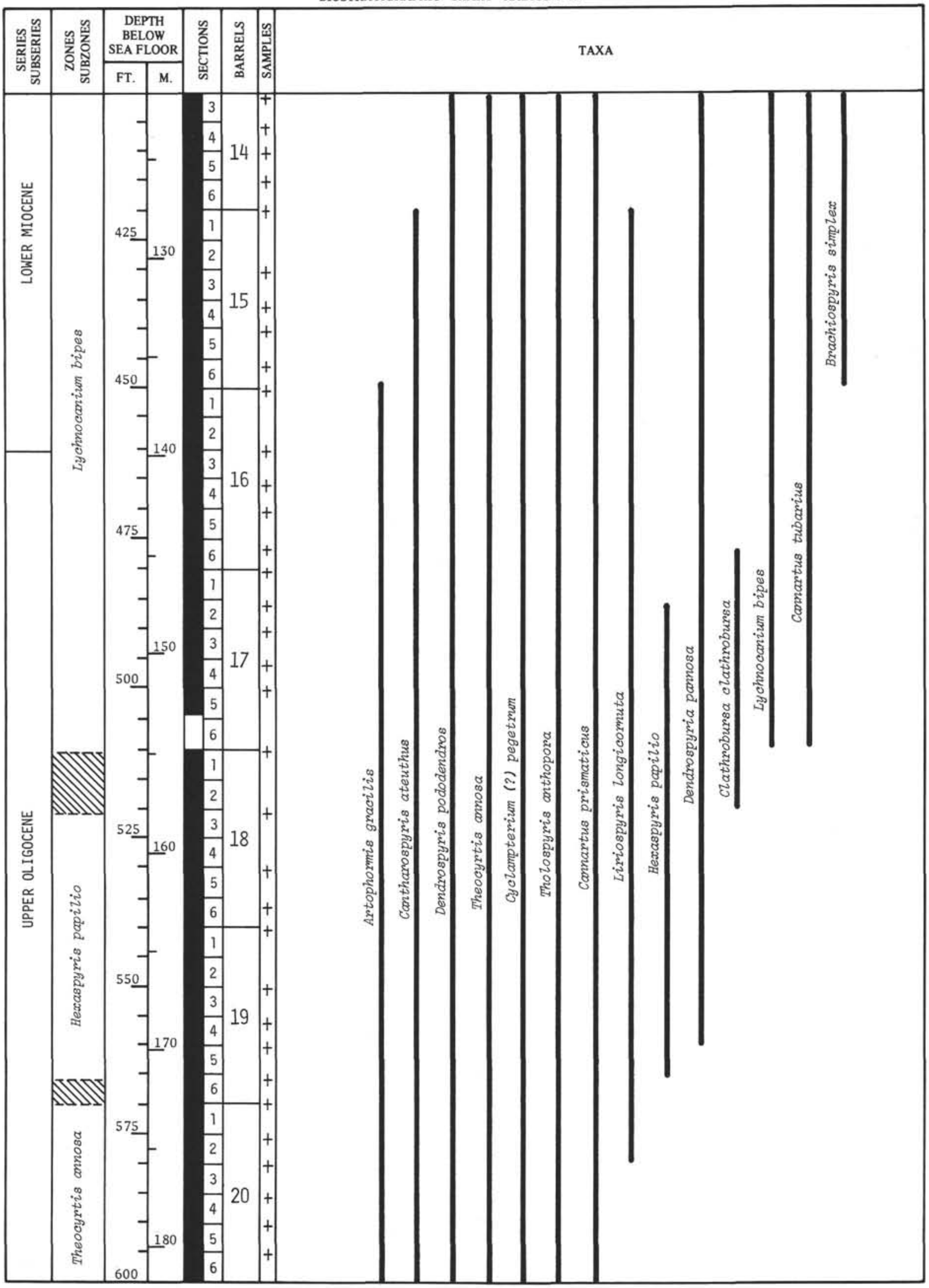



Figure 15. *Site 78 Biostratigraphic Chart Radiolaria (400 to 600 feet).*

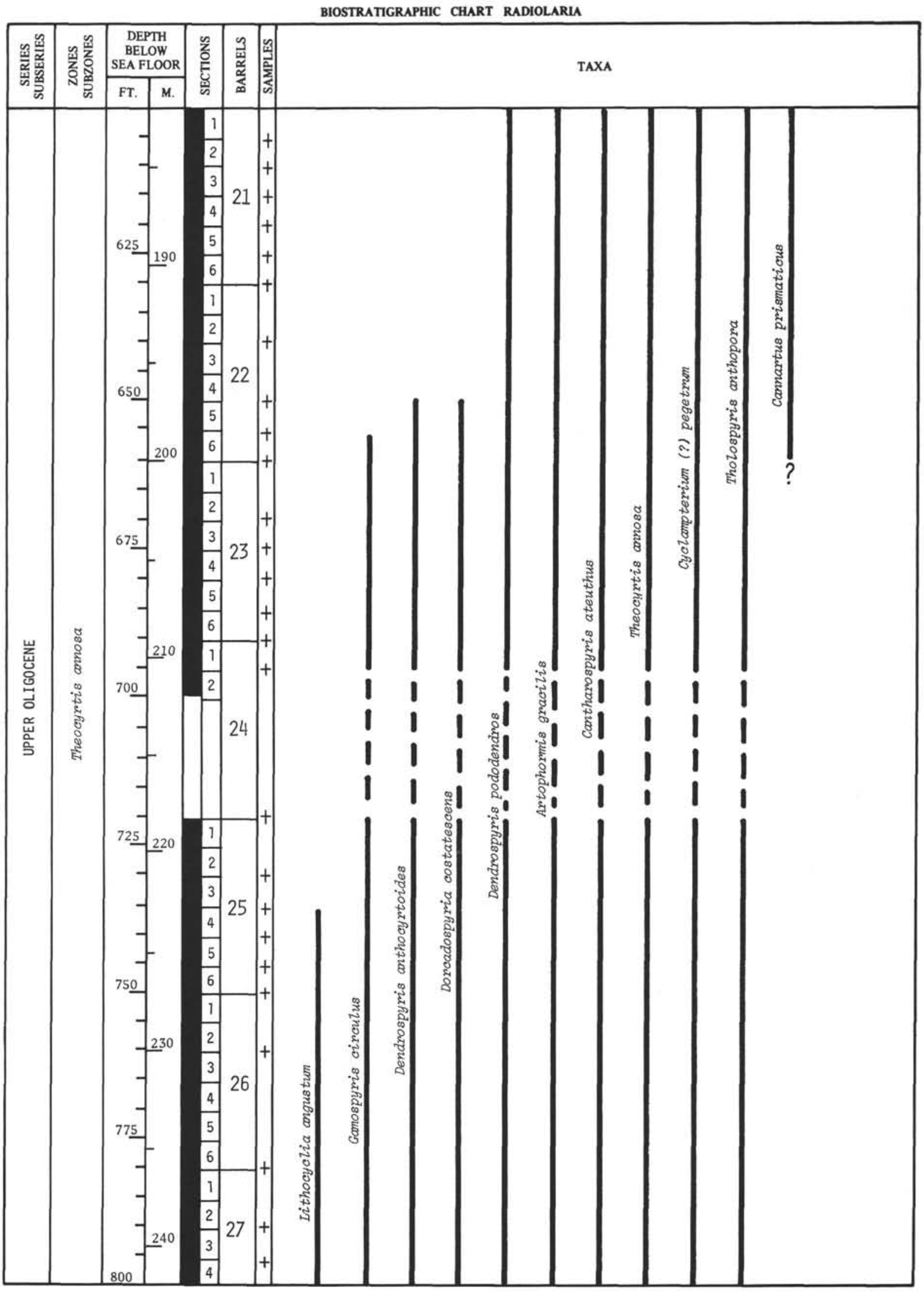



Figure 16. *Site 78 Biostratigraphic Chart Radiolaria (600 to 800 feet).*

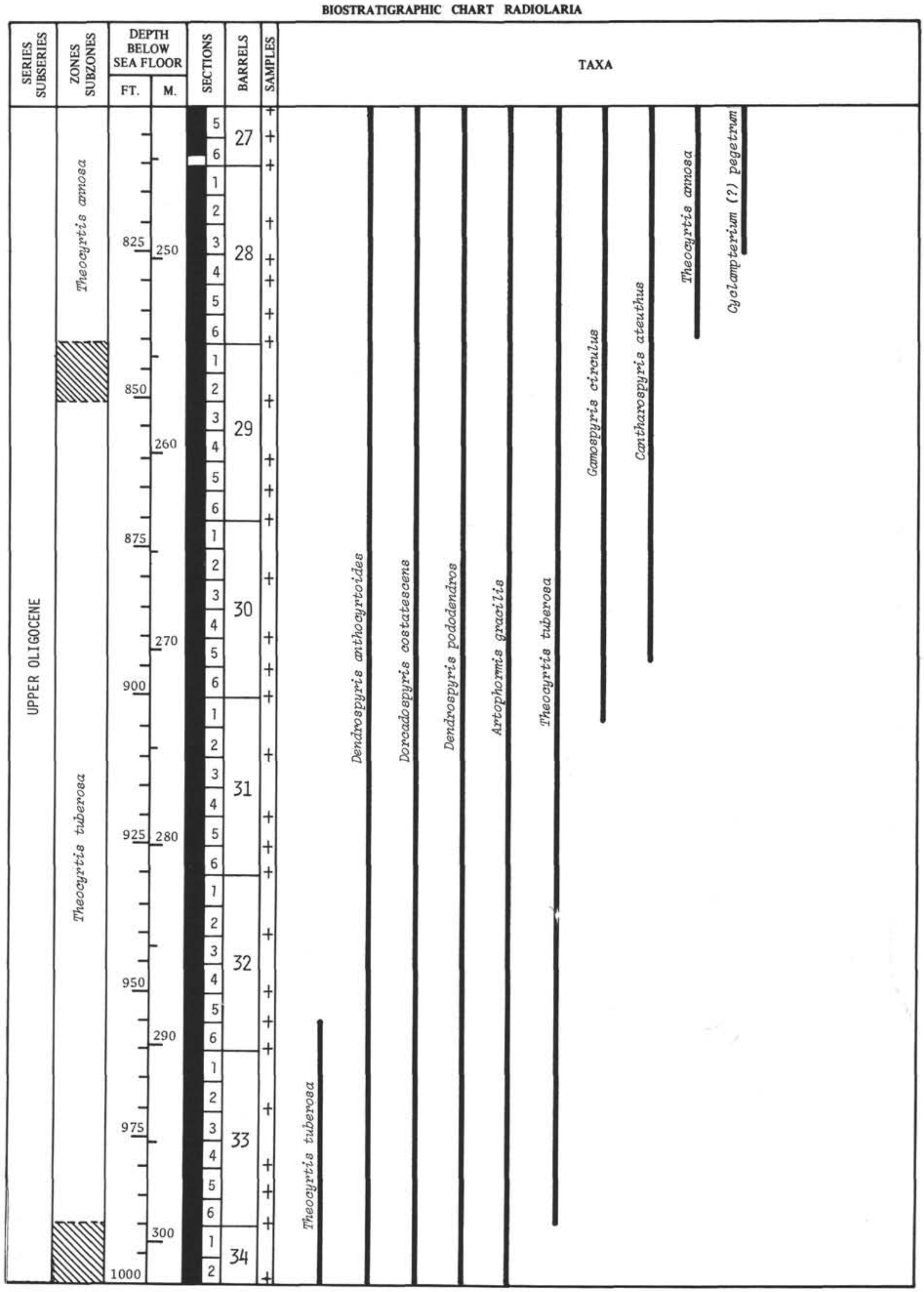



Figure 17. *Site 78 Biostratigraphic Chart Radiolaria (800 to 1000 feet).*

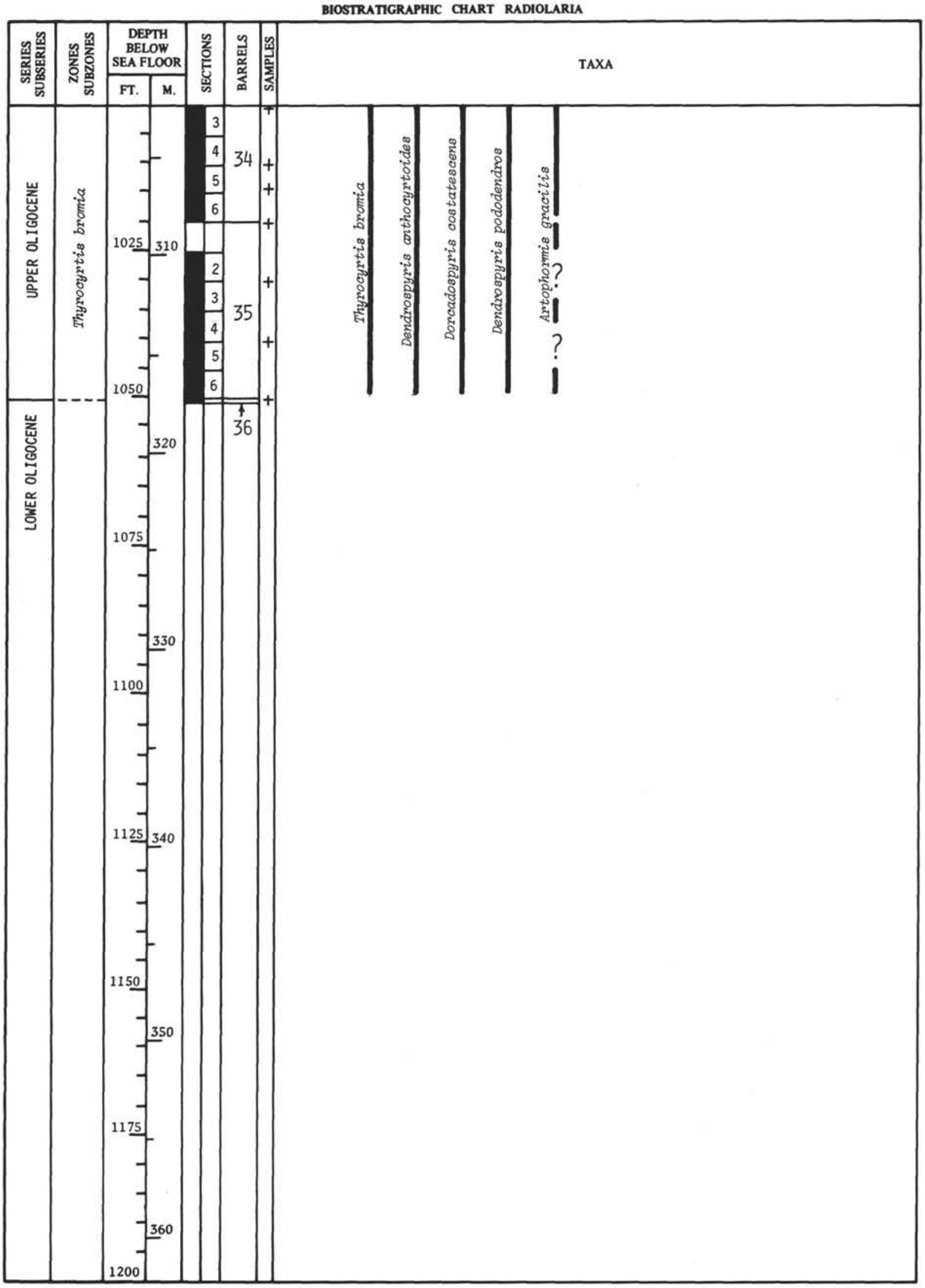
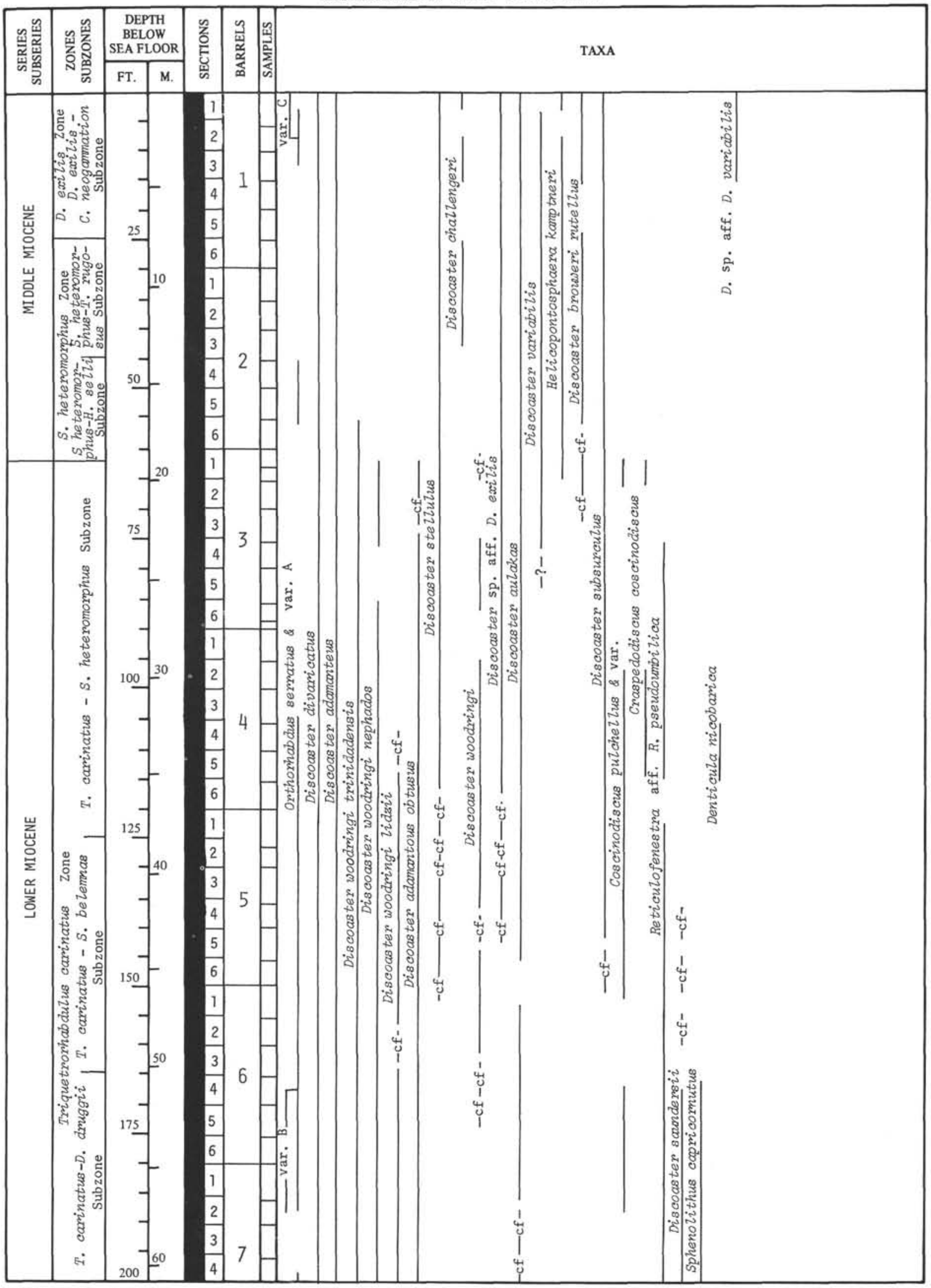



Figure 18. *Site 78 Biostratigraphic Chart Radiolaria (1000 to 1200 feet).*

BIOSTRATIGRAPHIC CHART NANNOFOSSILS




NANNOFOSSIL LEGEND: —— Rare to infrequent occurrence. —— Frequent occurrence. ▬▬ Greater than frequent occurrence.

Figure 19. *Site 78 Biostratigraphic Chart Nannofossils (0 to 200 feet).*

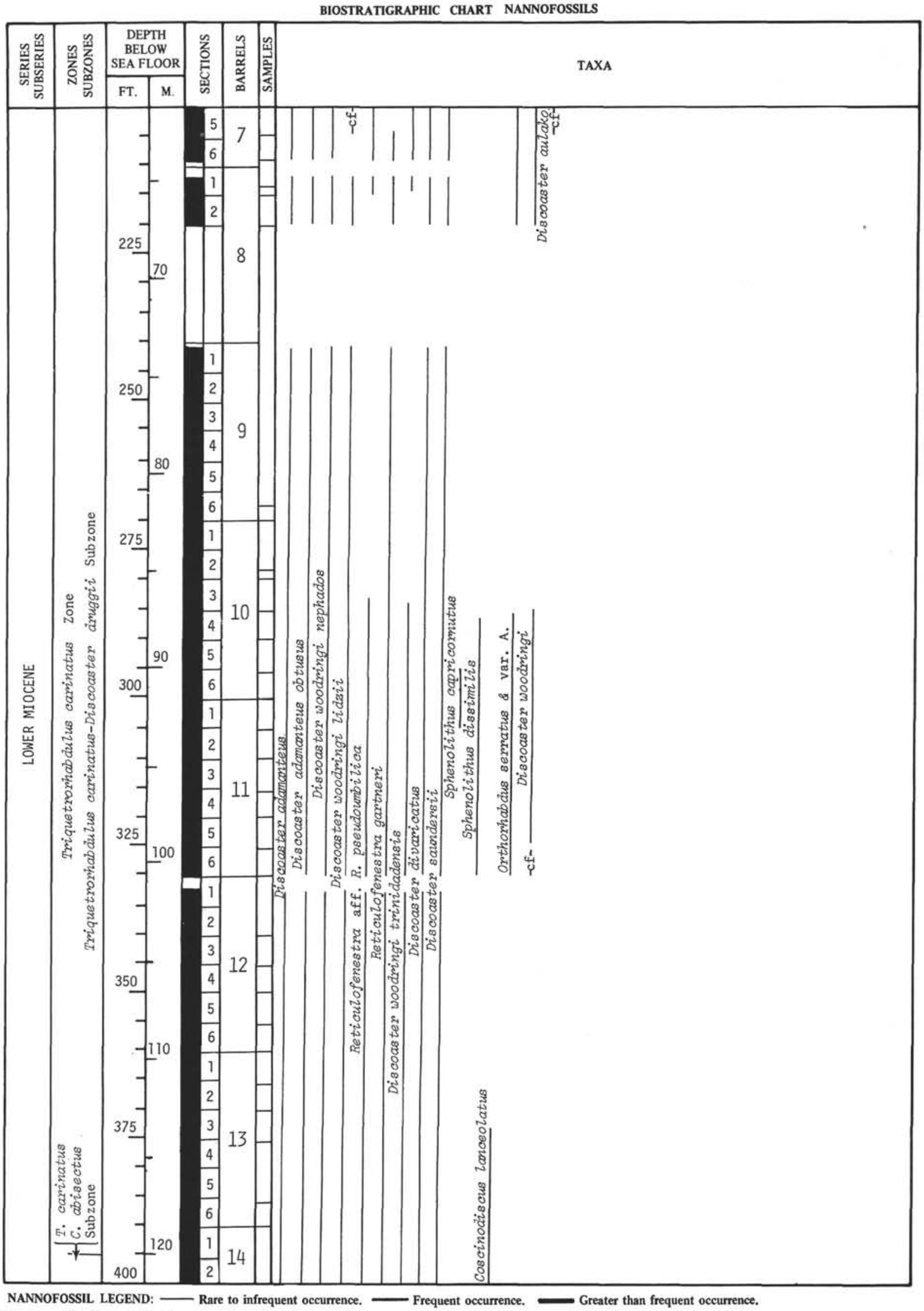
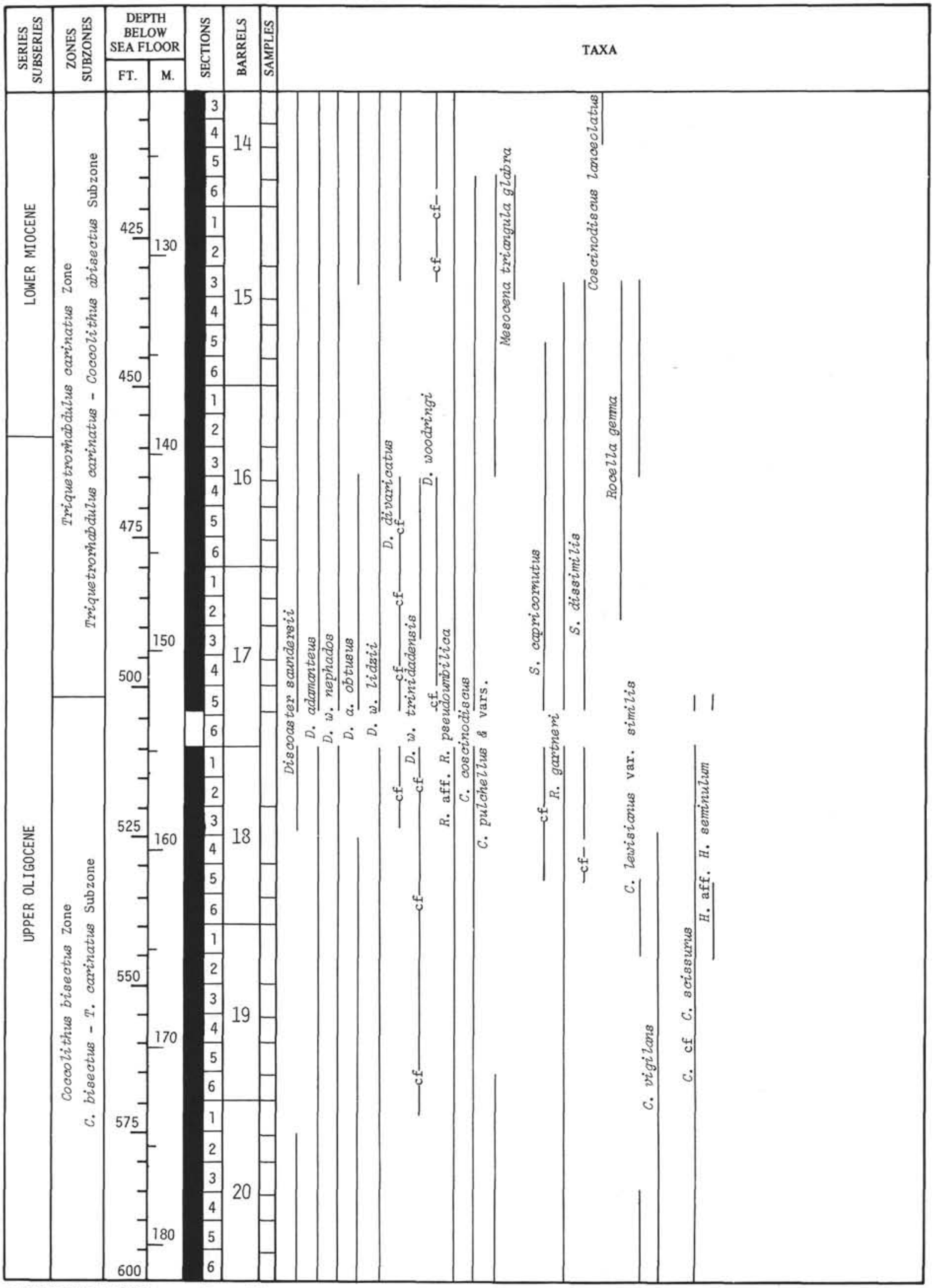



Figure 20. *Site 78 Biostratigraphic Chart Nannofossils (200 to 400 feet).*

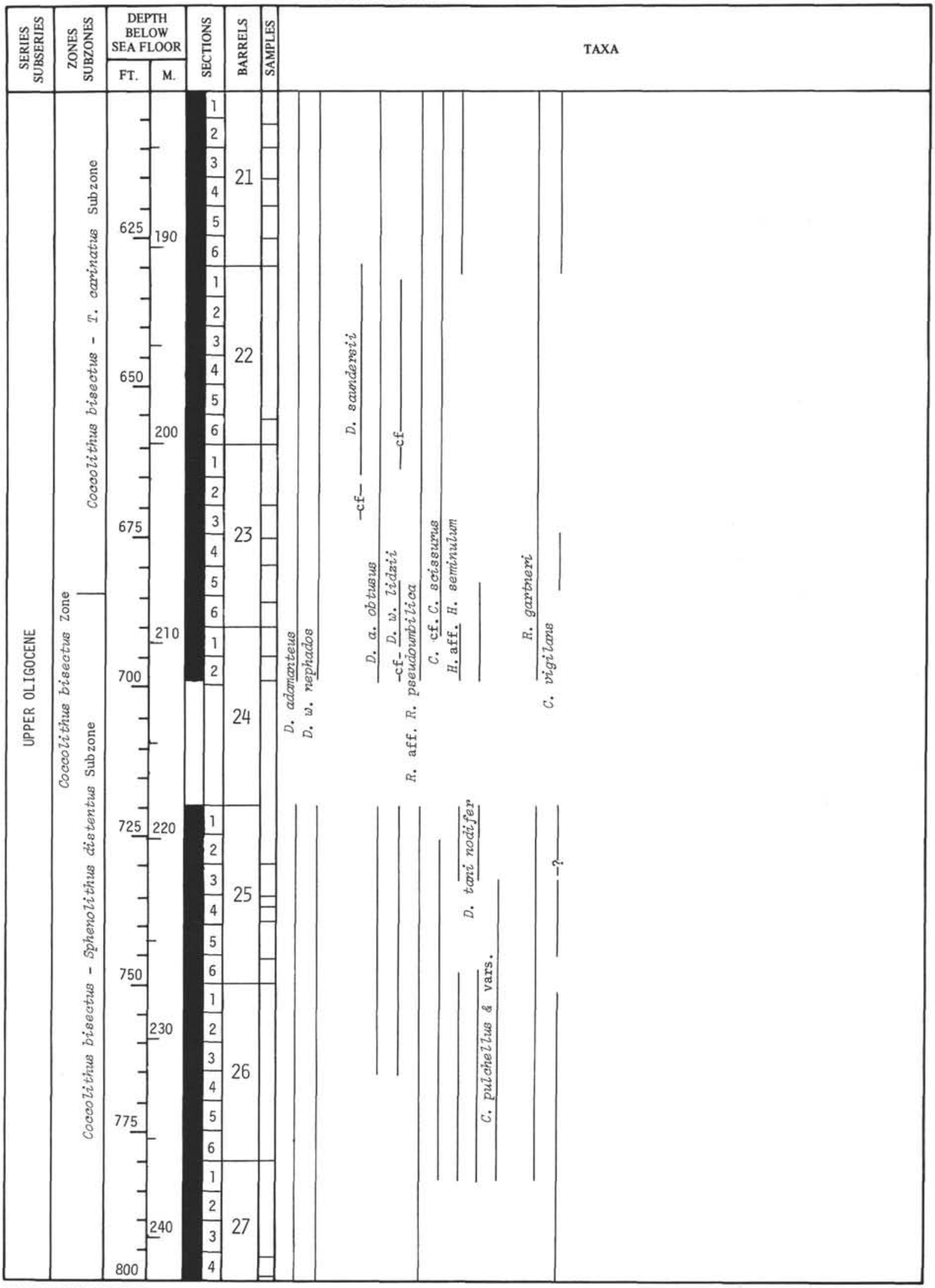
BIOSTRATIGRAPHIC CHART NANNOFOSSILS



NANNOFOSSIL LEGEND: —— Rare to infrequent occurrence. —— Frequent occurrence. ▬▬ Greater than frequent occurrence.

Figure 21. *Site 78 Biostratigraphic Chart Nannofossils (400 to 600 feet).*

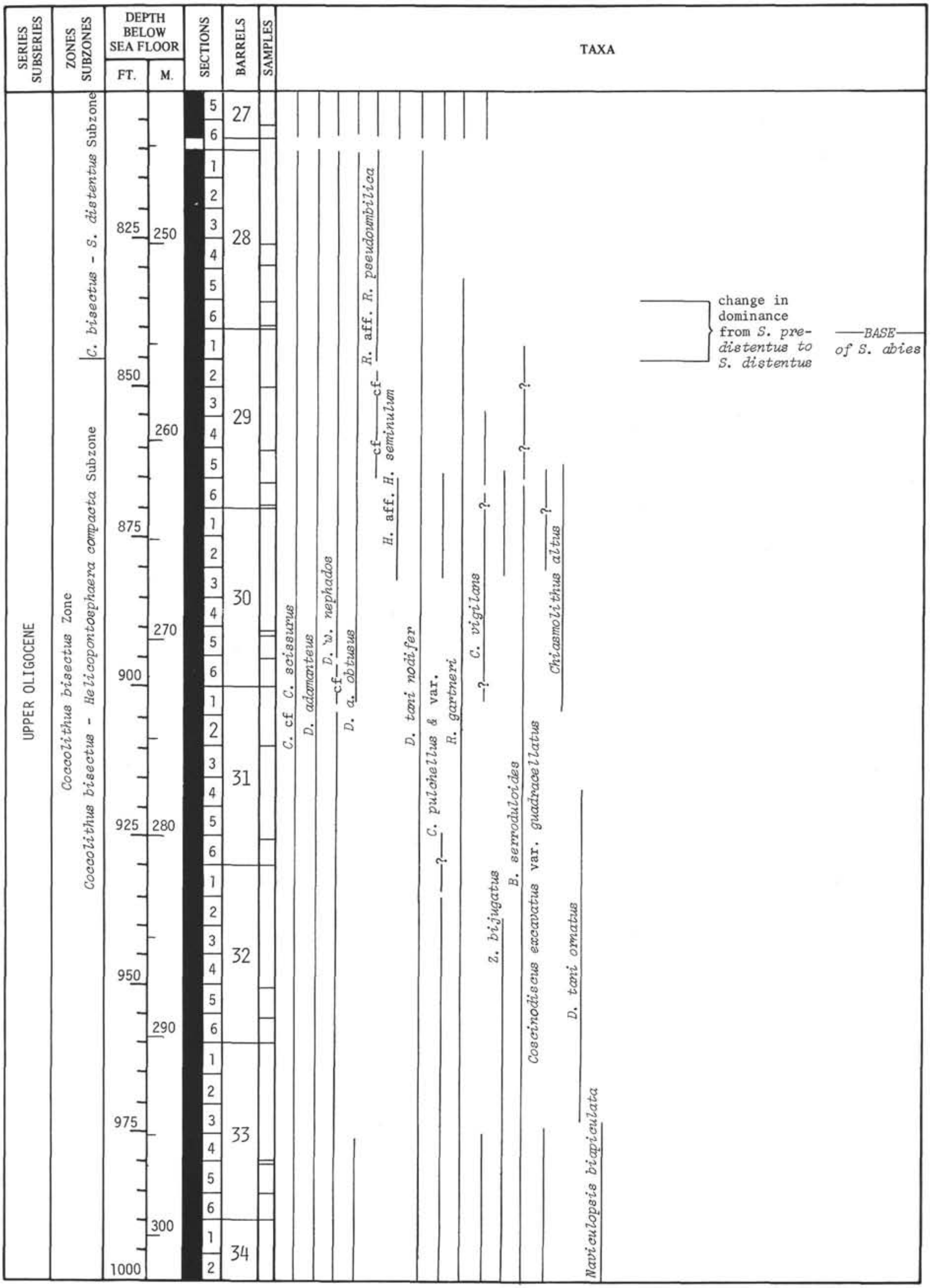
BIOSTRATIGRAPHIC CHART NANNOFOSSILS




NANNOFOSSIL LEGEND: —— Rare to infrequent occurrence. —— Frequent occurrence. ▬▬ Greater than frequent occurrence.

Figure 22. *Site 78 Biostratigraphic Chart Nannofossils (600 to 800 feet).*

BIOSTRATIGRAPHIC CHART NANNOFOSSILS




NANNOFOSSIL LEGEND: —— Rare to infrequent occurrence. —— Frequent occurrence. ▬▬ Greater than frequent occurrence.

Figure 23. *Site 78 Biostratigraphic Chart Nannofossils (800 to 1000 feet).*

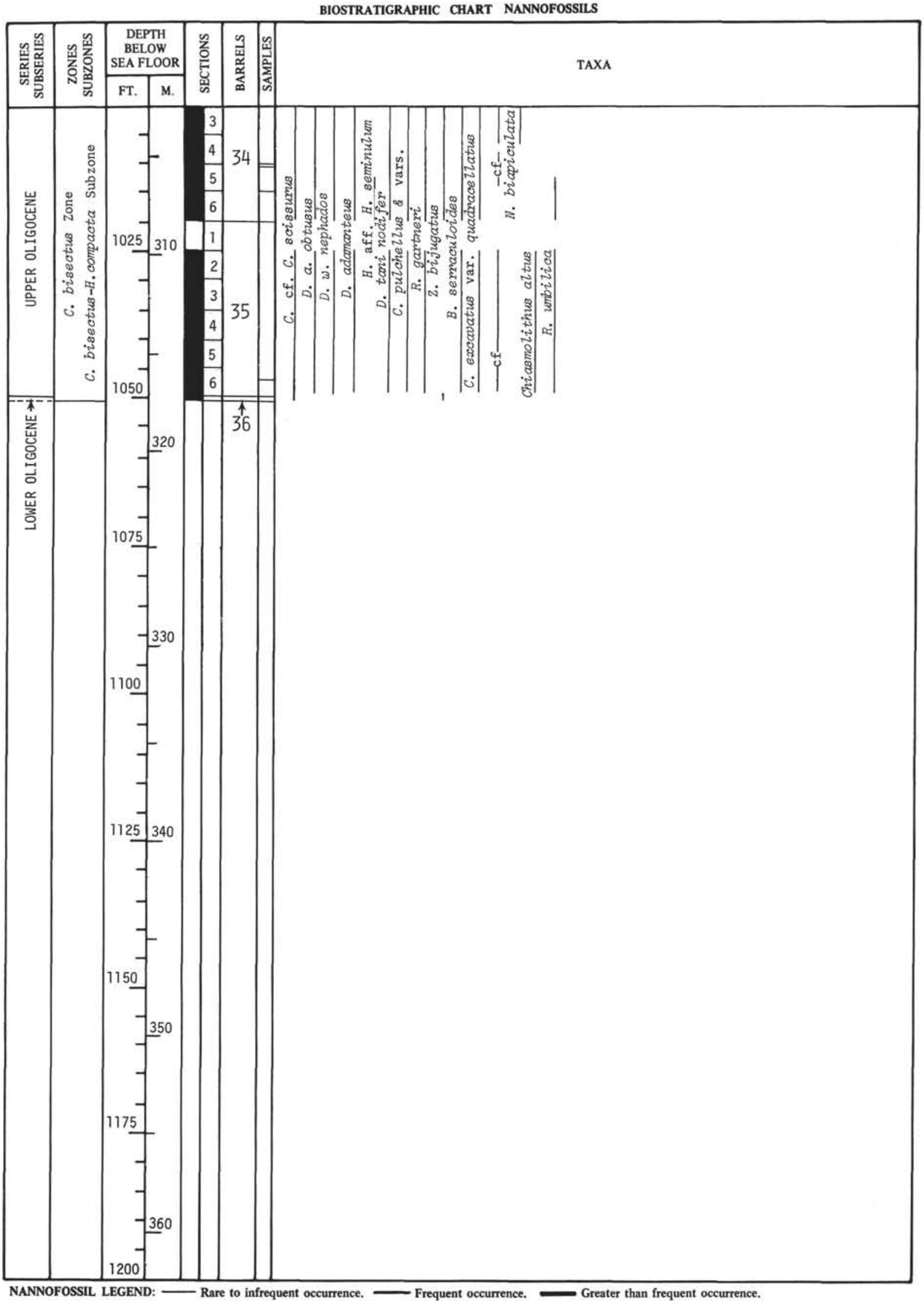



Figure 24. *Site 78 Biostratigraphic Chart Nannofossils (1000 to 1200 feet).*

BIOSTRATIGRAPHIC COMPARISON CHART

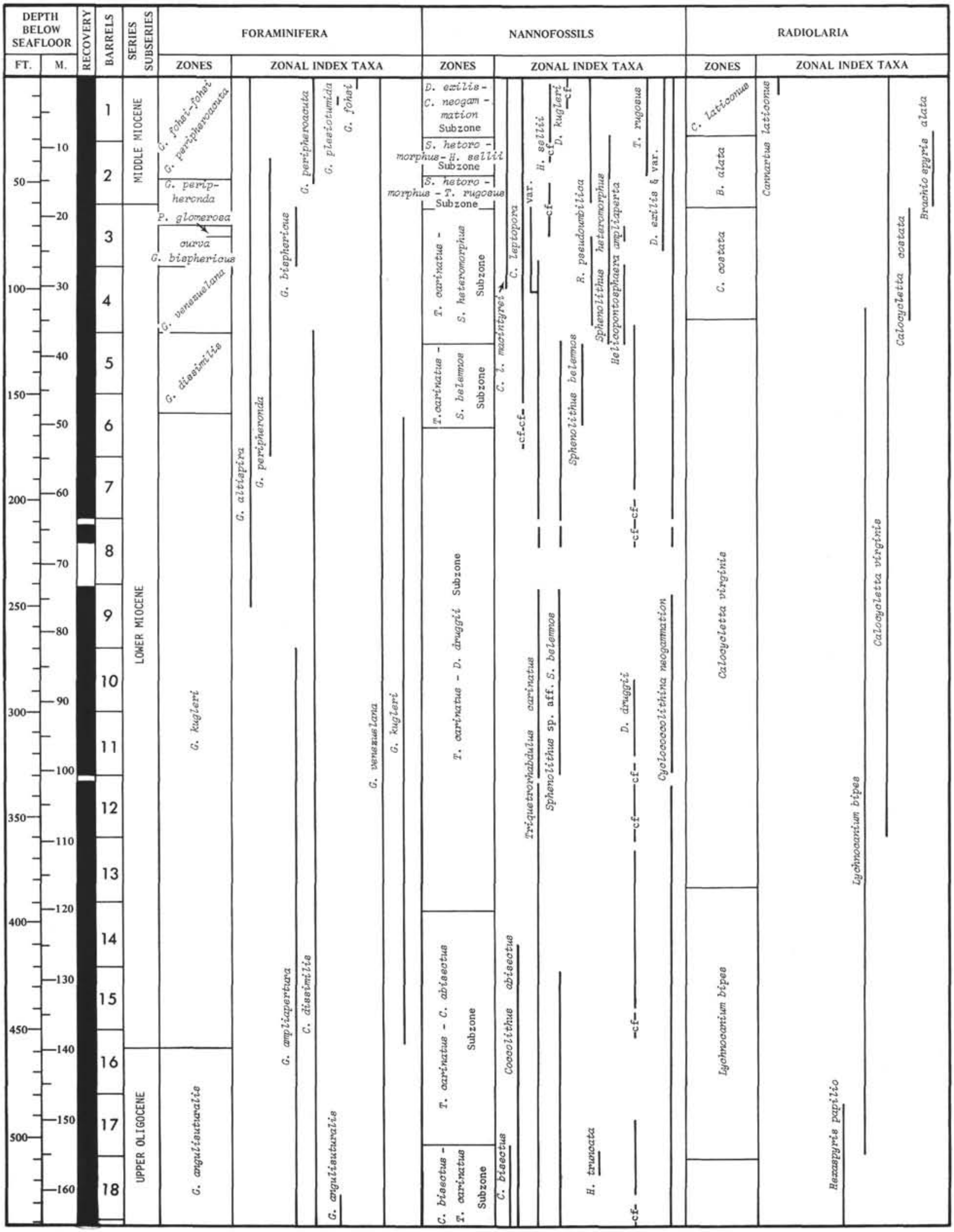



Figure 25. *Site 78 Biostratigraphic Comparison Chart.*

BIOSTRATIGRAPHIC COMPARISON CHART

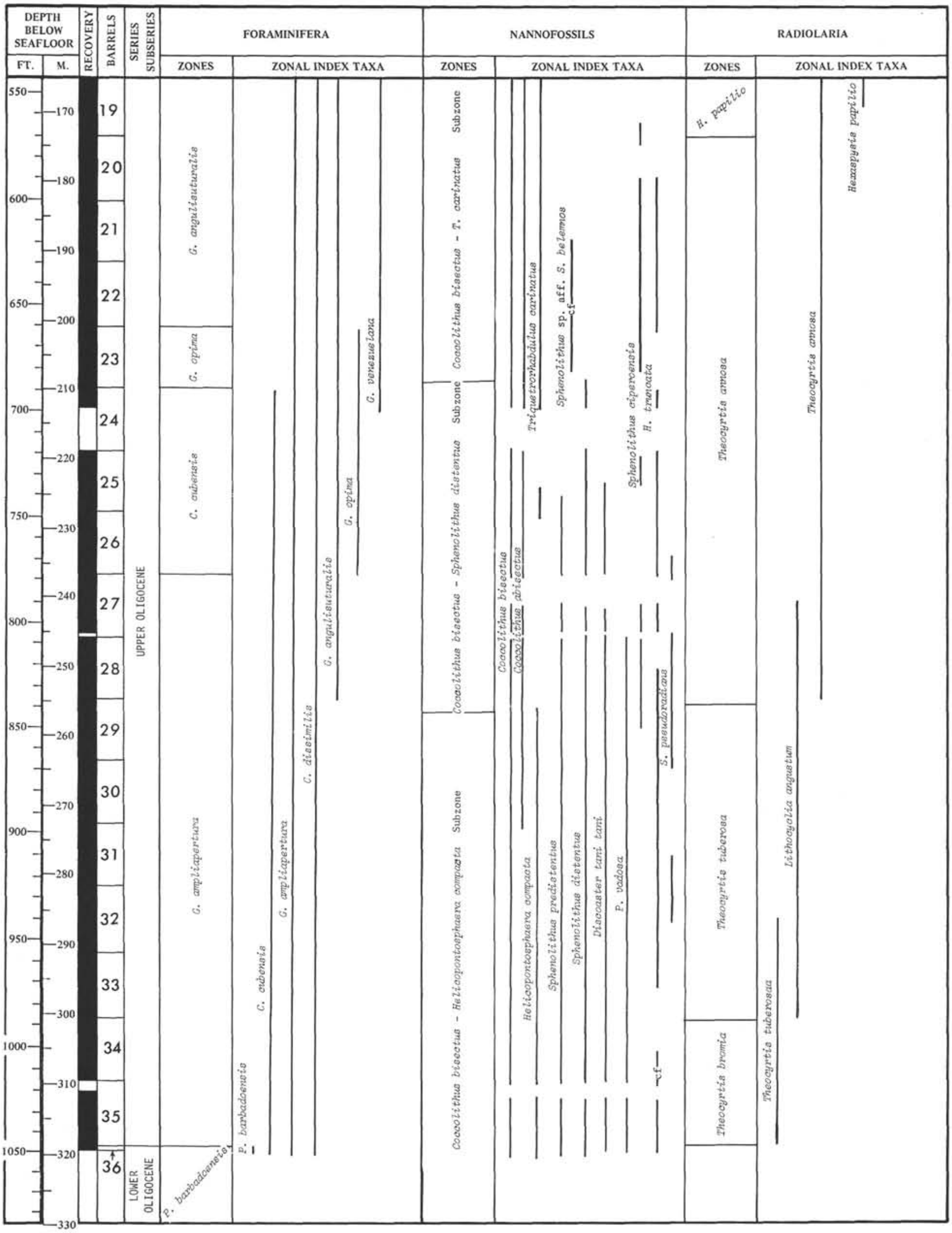



Figure 26. *Site 78 Biostratigraphic Comparison Chart (continued).*

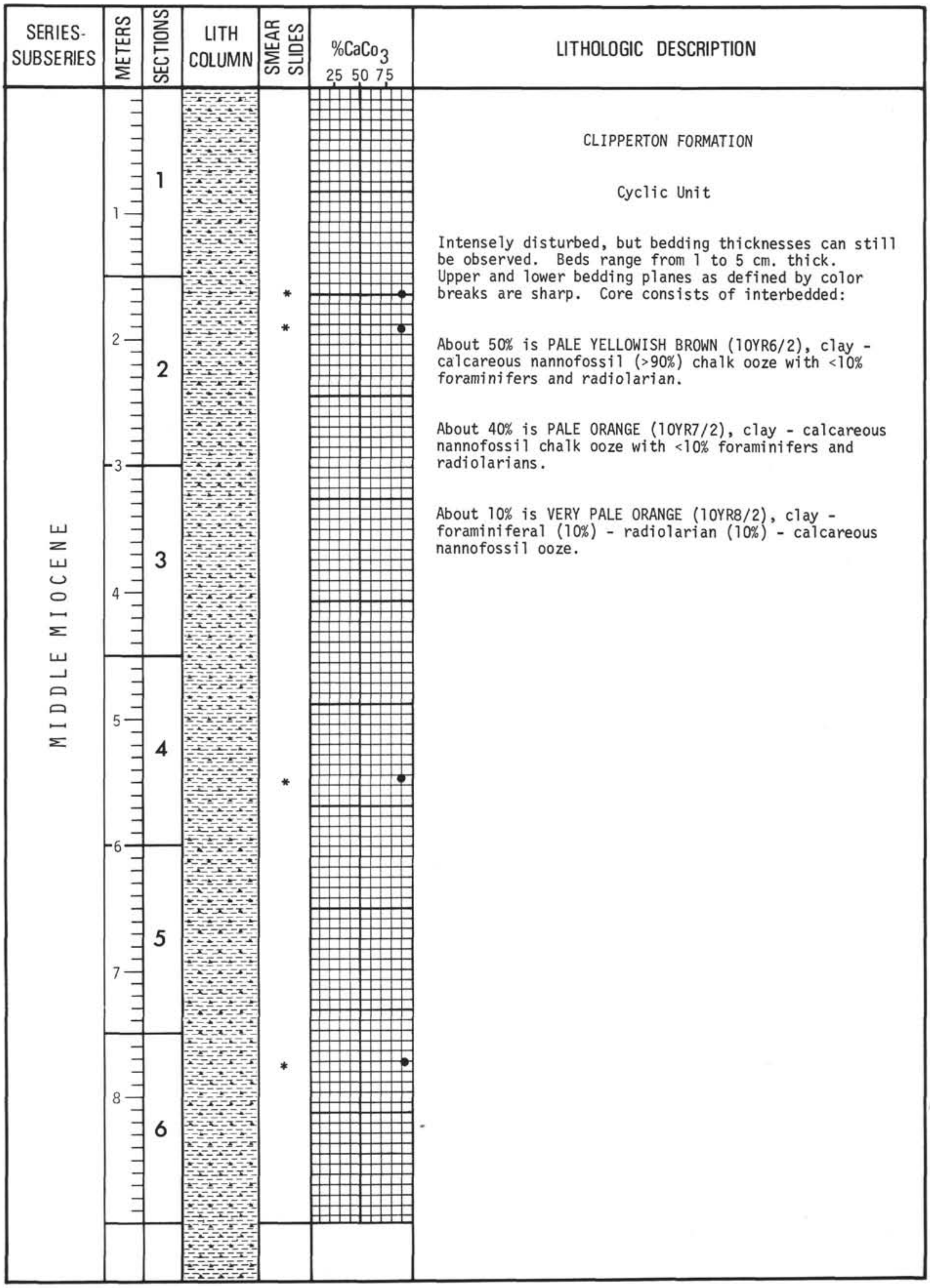



Figure 27. *Hole 78, Core 1 (0 to 9.1 m).*

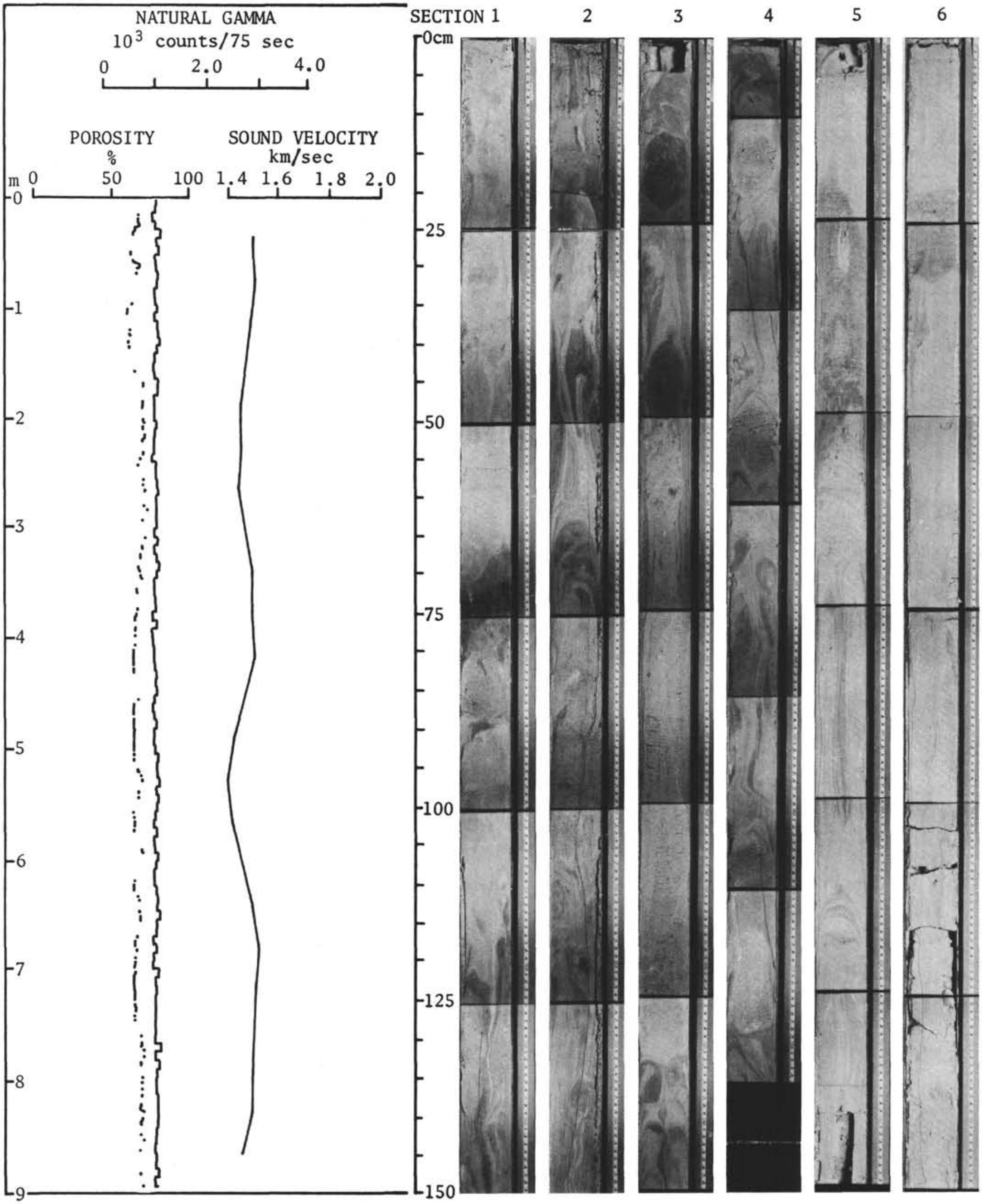
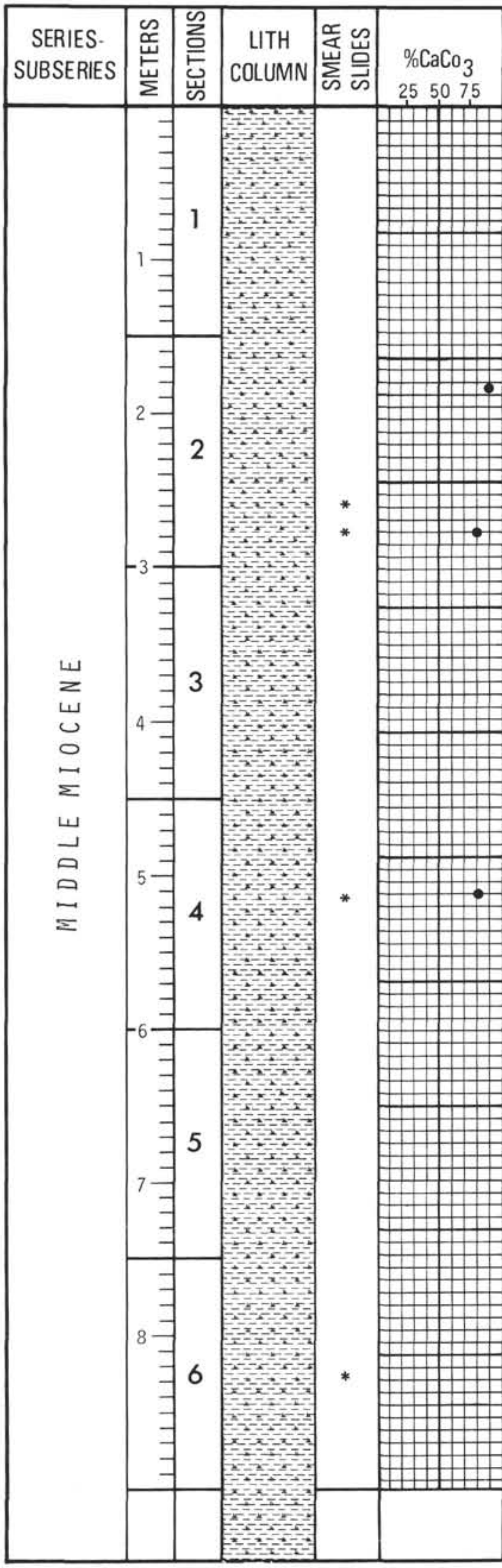



Figure 28. *Hole 78, Core 1, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Cyclic Unit

Intensely disturbed. Interbedded in 5 to 50 cm. thick beds:

About 90% is PALE ORANGE (10YR7/2), clay - calcareous nannofossil chalk ooze with less than 10% foraminifers and radiolarians.

About 5% is DARK YELLOWISH BROWN (10YR4/2), clay - calcareous nannofossil chalk ooze with 5%-10% radiolarians and 5%-10% foraminifers.

About 5% is PALE YELLOWISH ORANGE (10YR8/6), clay, foraminiferal - radiolarian - calcareous nannofossil chalk ooze.

Figure 29. *Hole 78, Core 2 (9.1 to 18.2 m).*

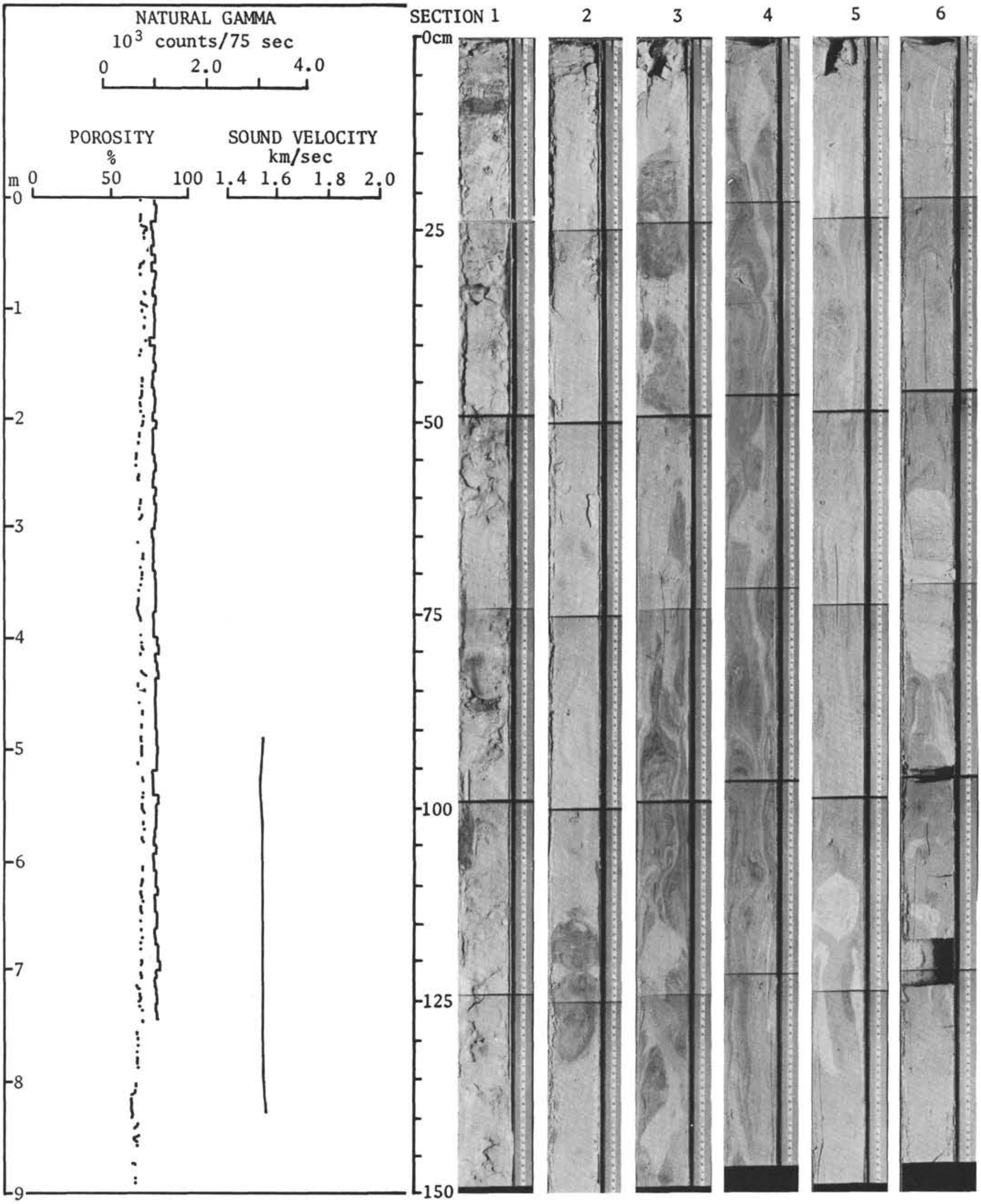



Figure 30. *Hole 78, Core 2, Sections 1-6, Physical Properties.*

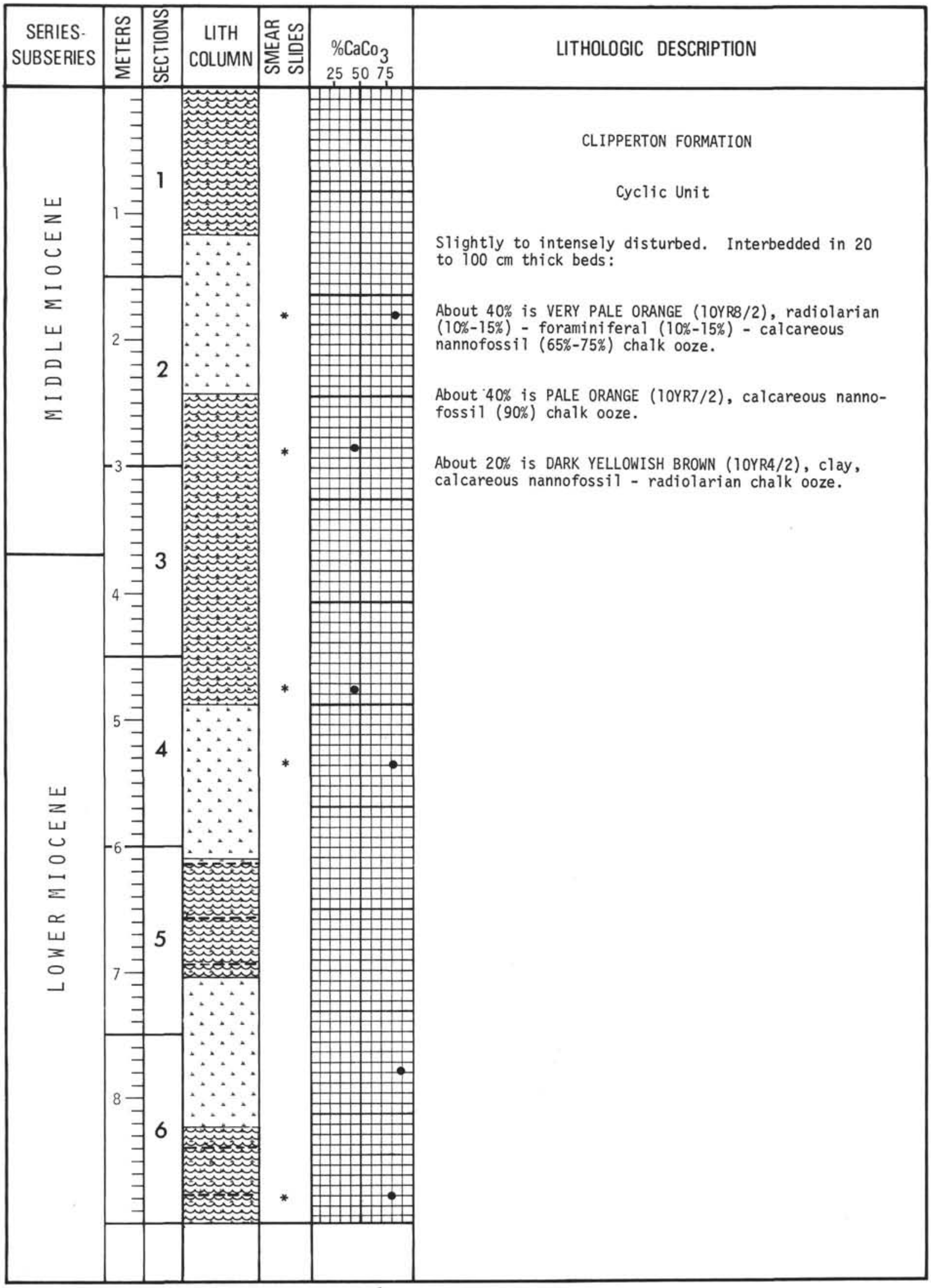



Figure 31. *Hole 78, Core 3 (18.2 to 27.4 m).*

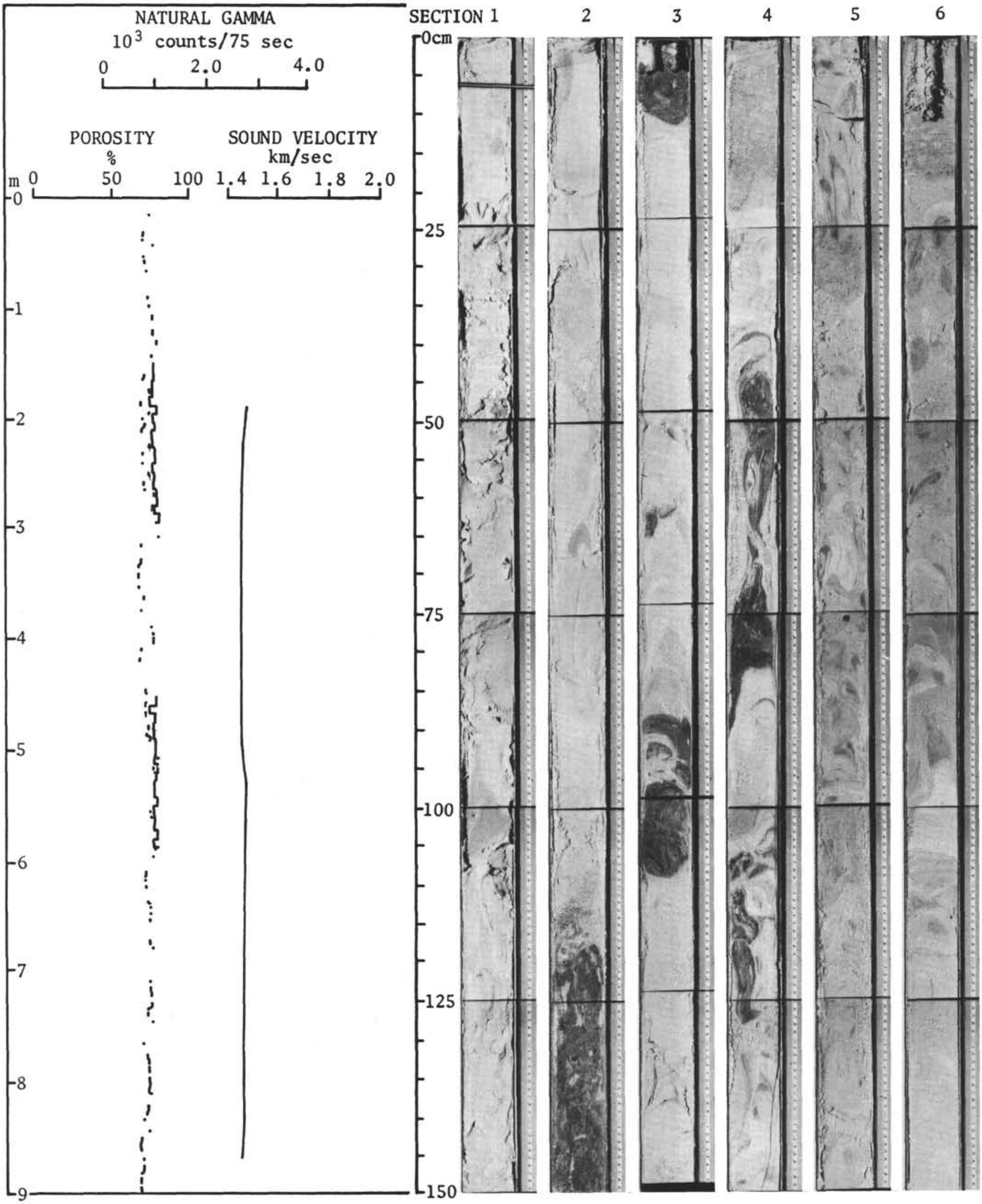
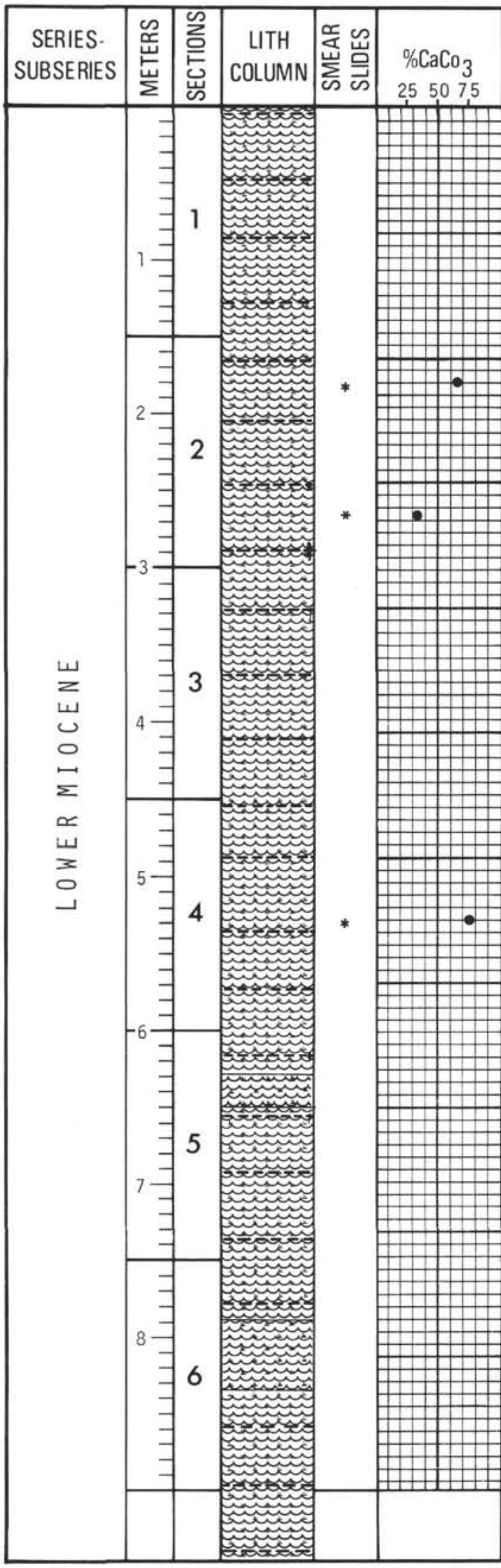



Figure 32. *Hole 78, Core 3, Sections 1-6, Physical Properties.*




## LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Cyclic Unit

Intensely disturbed. Interbedded lithologys in 1 to 20 cm. thick beds with laminations. Alternating silica rich and silica poorer beds:

About 80% is PALE YELLOWISH BROWN (10YR6/2), clay (3%-5%) - radiolarian (20%-30%) - calcareous nannofossil (60%-70%) chalk ooze.

About 10% is VERY DARK YELLOWISH BROWN (10YR3/2), clay (15%-20%) - calcareous nannofossil (30%-40%) - radiolarian (40%-50%) chalk ooze.

About 10% is DARK YELLOWISH BROWN (10YR4/2), clay (5%) - calcareous nannofossil (40%-50%) - radiolarian (50%-60%) chalk ooze.

Rare VERY PALE ORANGE (10YR8/2), calcareous nannofossil (30%-40%) - radiolarian (40%-60%) chalk ooze.

Beds with clay tend to be less disturbed than beds without clay.

Figure 33. *Hole 78, Core 4 (27.4 to 36.6 m).*

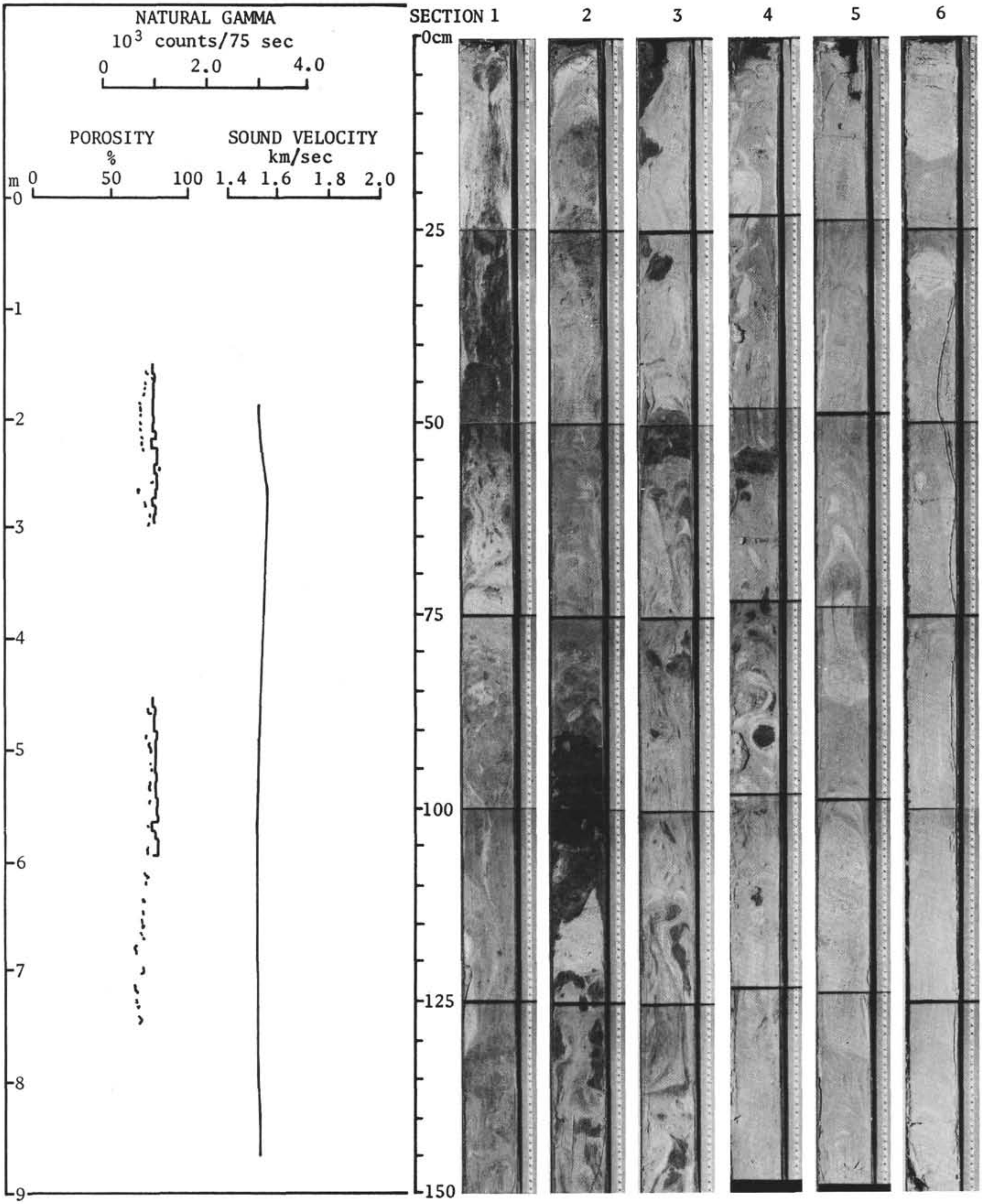
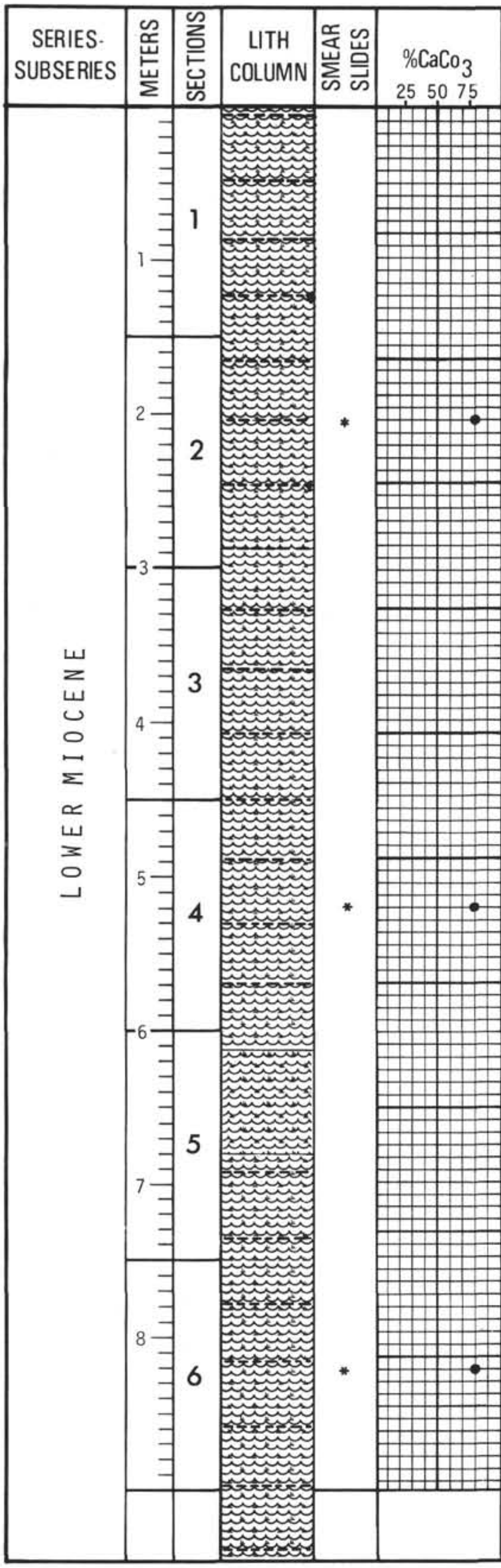



Figure 34. *Hole 78, Core 4, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Cyclic Unit

Intensely disturbed. Interbedded 1 to 5 cm. thick beds with laminations:

About 80% is PALE YELLOWISH BROWN (10YR6/2), clay (3%-5%) - radiolarian (10%-15%) - calcareous nannofossil (95%) chalk ooze.

About 20% is VERY PALE YELLOWISH BROWN (10YR7/2), clay (<5%) - radiolarian (15%) - calcareous nannofossil (80%) chalk ooze.

Rare VERY PALE ORANGE (10YR8/2), radiolarian (10%-15%) - calcareous nannofossil (80%-90%) chalk ooze.

Figure 35. *Hole 78, Core 5 (36.6 to 45.7 m).*

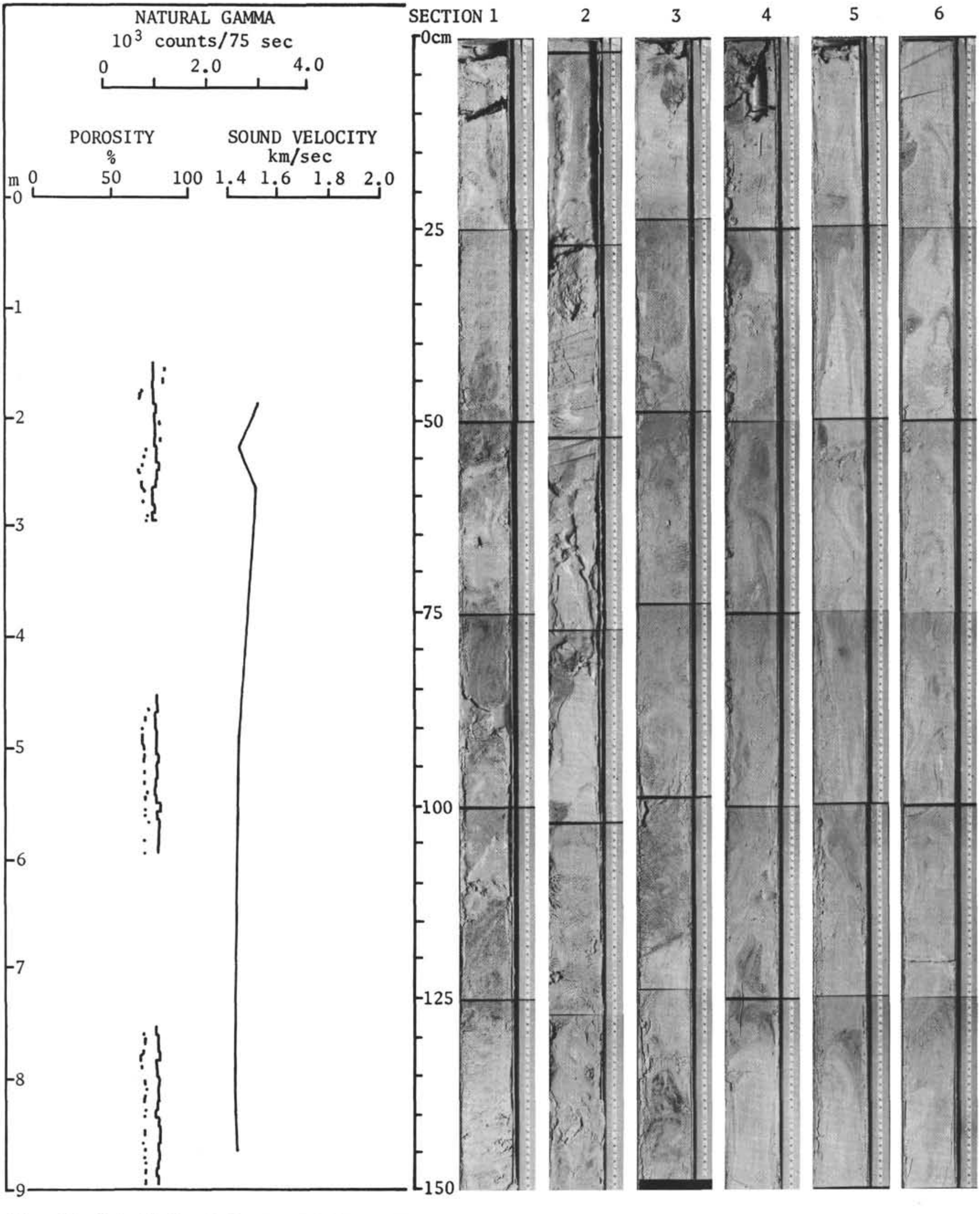



Figure 36. *Hole 78, Core 5, Sections 1-6, Physical Properties.*

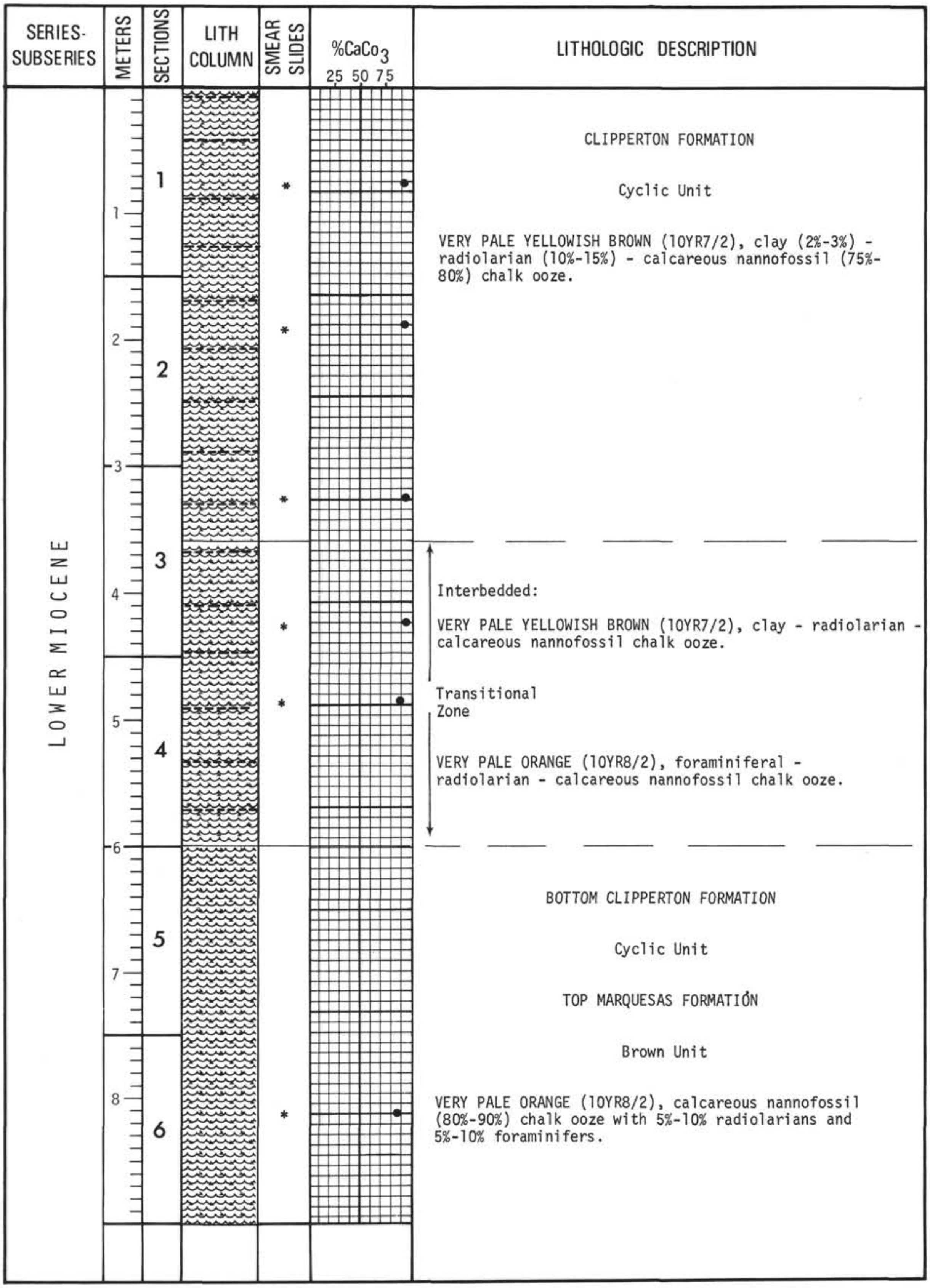



Figure 37. *Hole 78, Core 6 (45.7 to 54.9 m).*

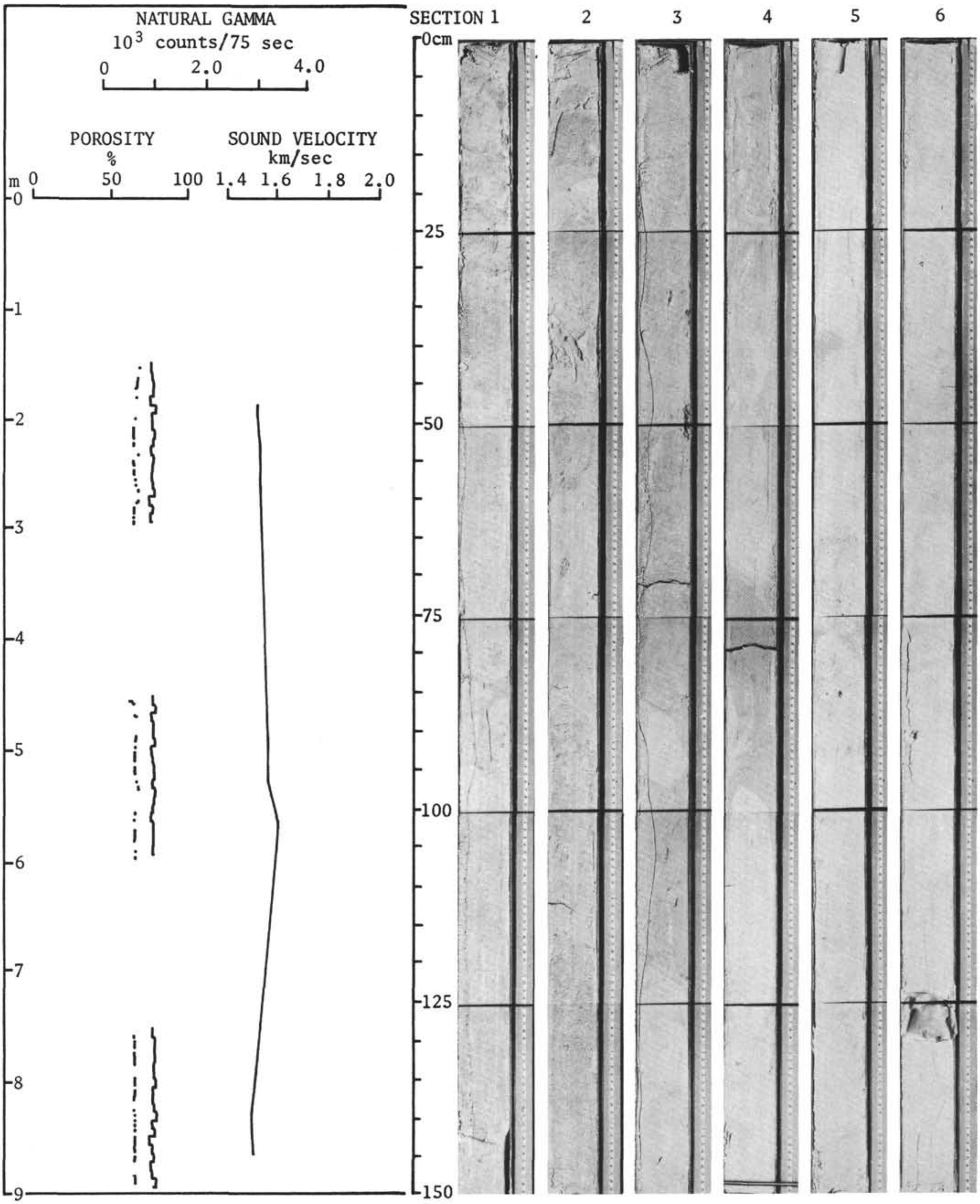
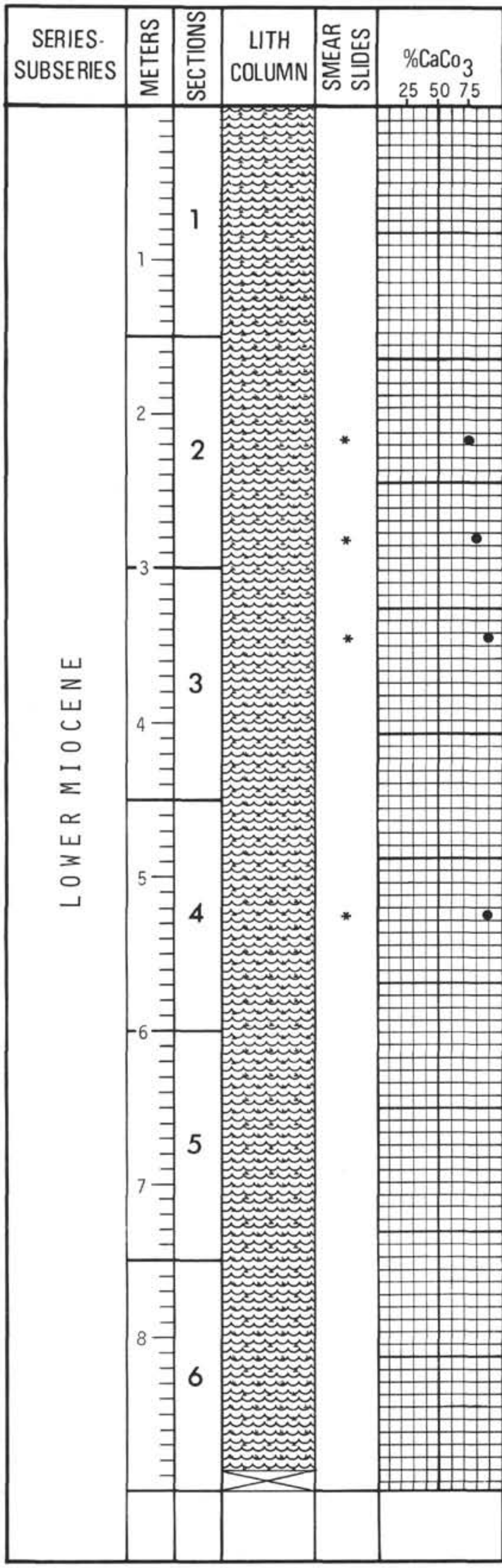



Figure 38. *Hole 78, Core 6, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Brown Unit

Moderately disturbed. Interbedded in 25 to 100 cm. thick beds:

VERY PALE ORANGE (10YR8/2), radiolarian (10%-15%) - foraminiferal (30%-50%) - calcareous nannofossil (50%-60%) ooze.

VERY PALE ORANGE (10YR8/2), radiolarian (10%-20%) - calcareous nannofossil (30%-50%) - foraminiferal (40%-50%) ooze.

VERY PALE ORANGE (10YR9/2), radiolarian (10%-15%) - foraminiferal (15%-20%) - calcareous nannofossil (70%-80%) ooze.

Figure 39. *Hole 78, Core 7 (54.9 to 64.0 m).*

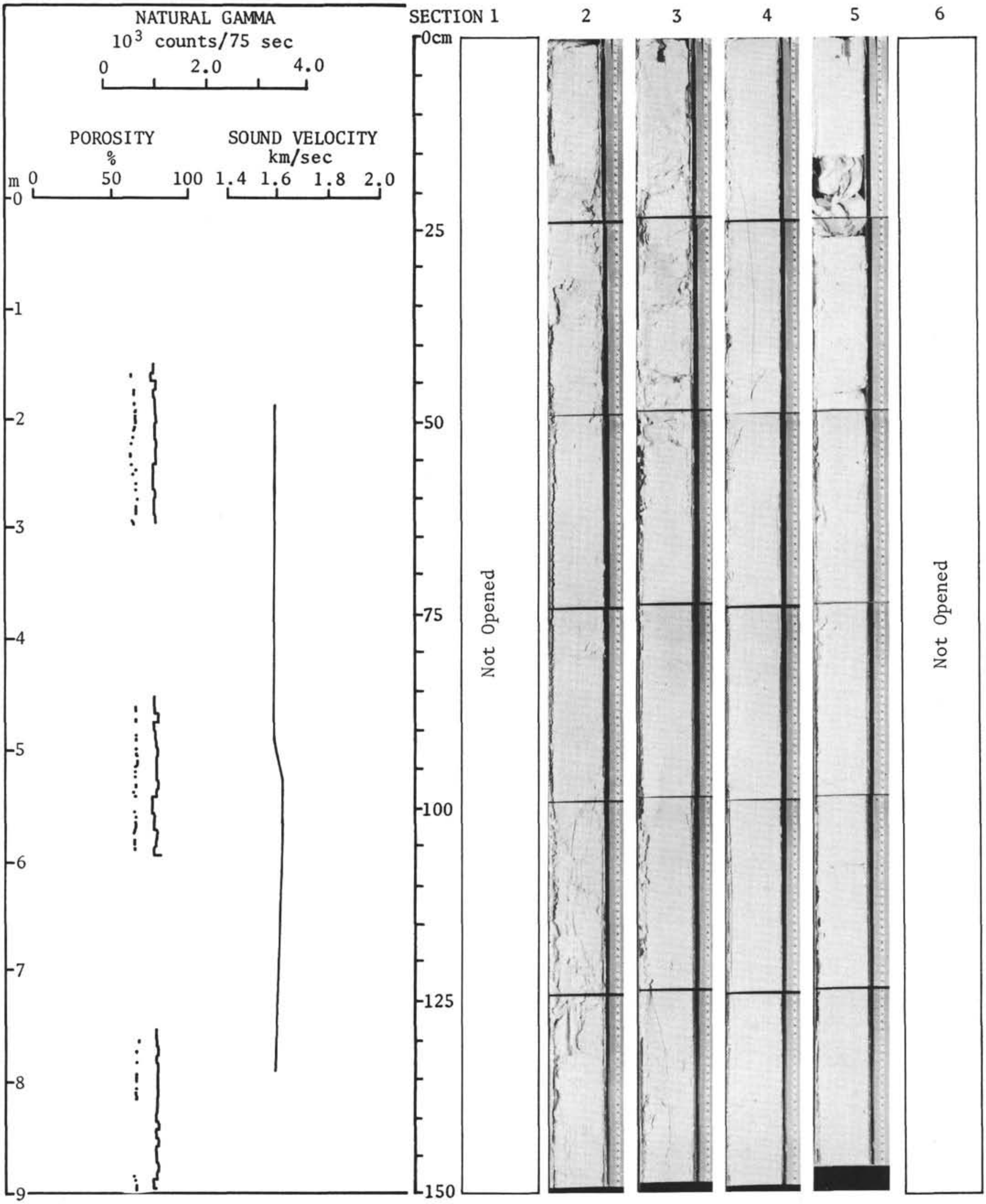



Figure 40. *Hole 78, Core 7, Sections 1-6, Physical Properties.*

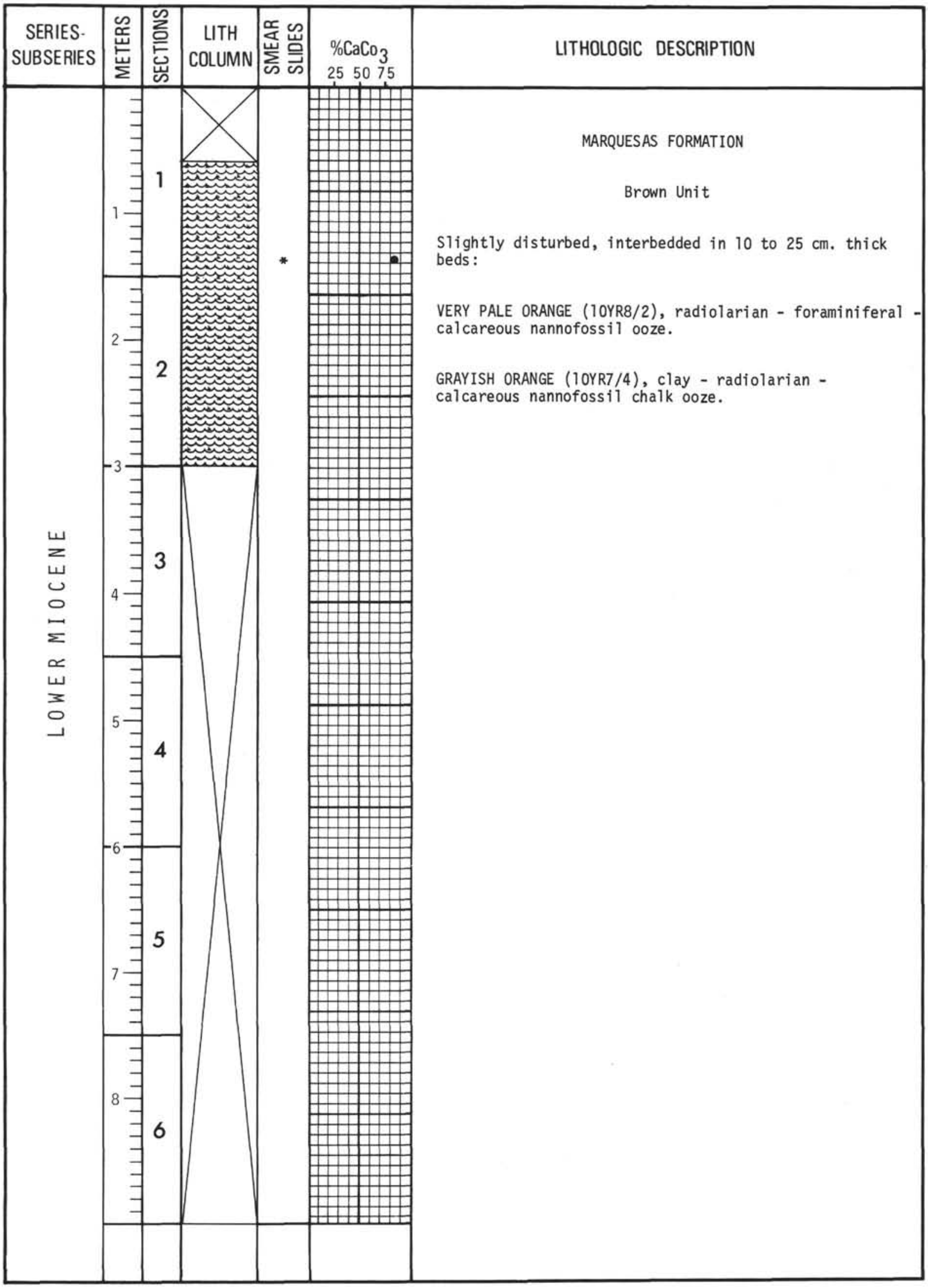



Figure 41. *Hole 78, Core 8 (64.0 to 73.1 m).*

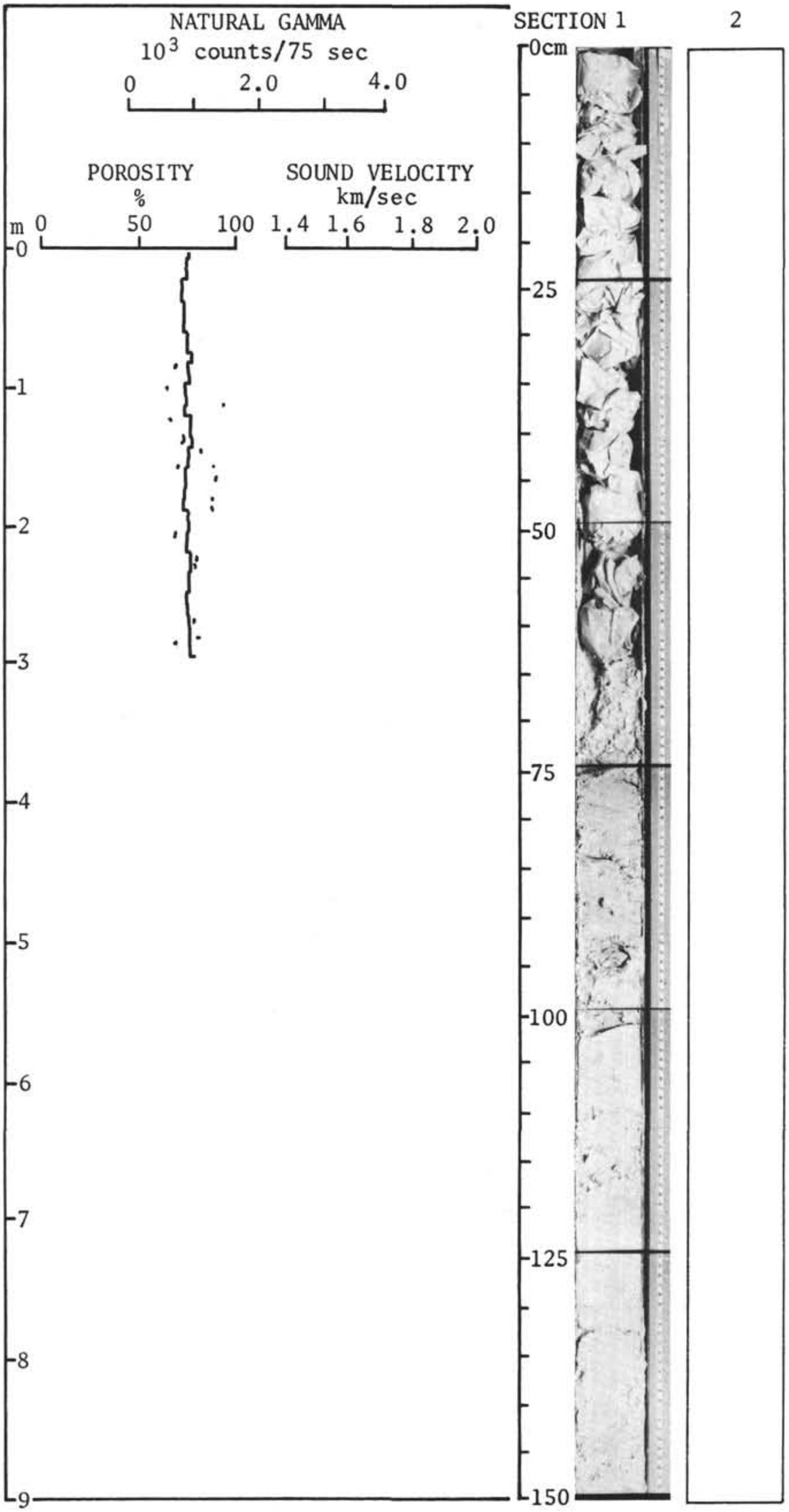



Figure 42. *Hole 78, Core 8, Sections 1 and 2, Physical Properties.*

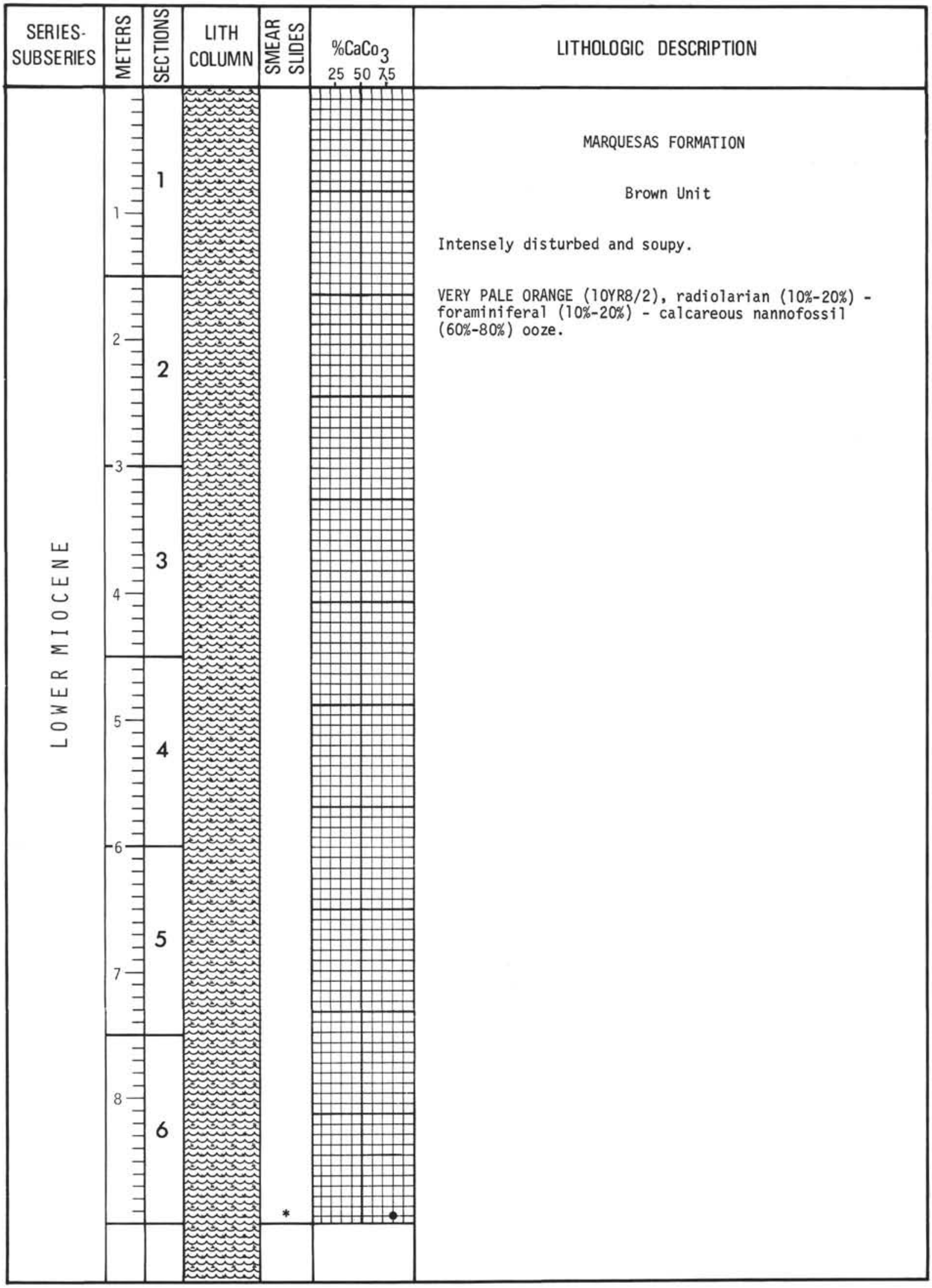



Figure 43. *Hole 78, Core 9 (73.1 to 82.3 m).*

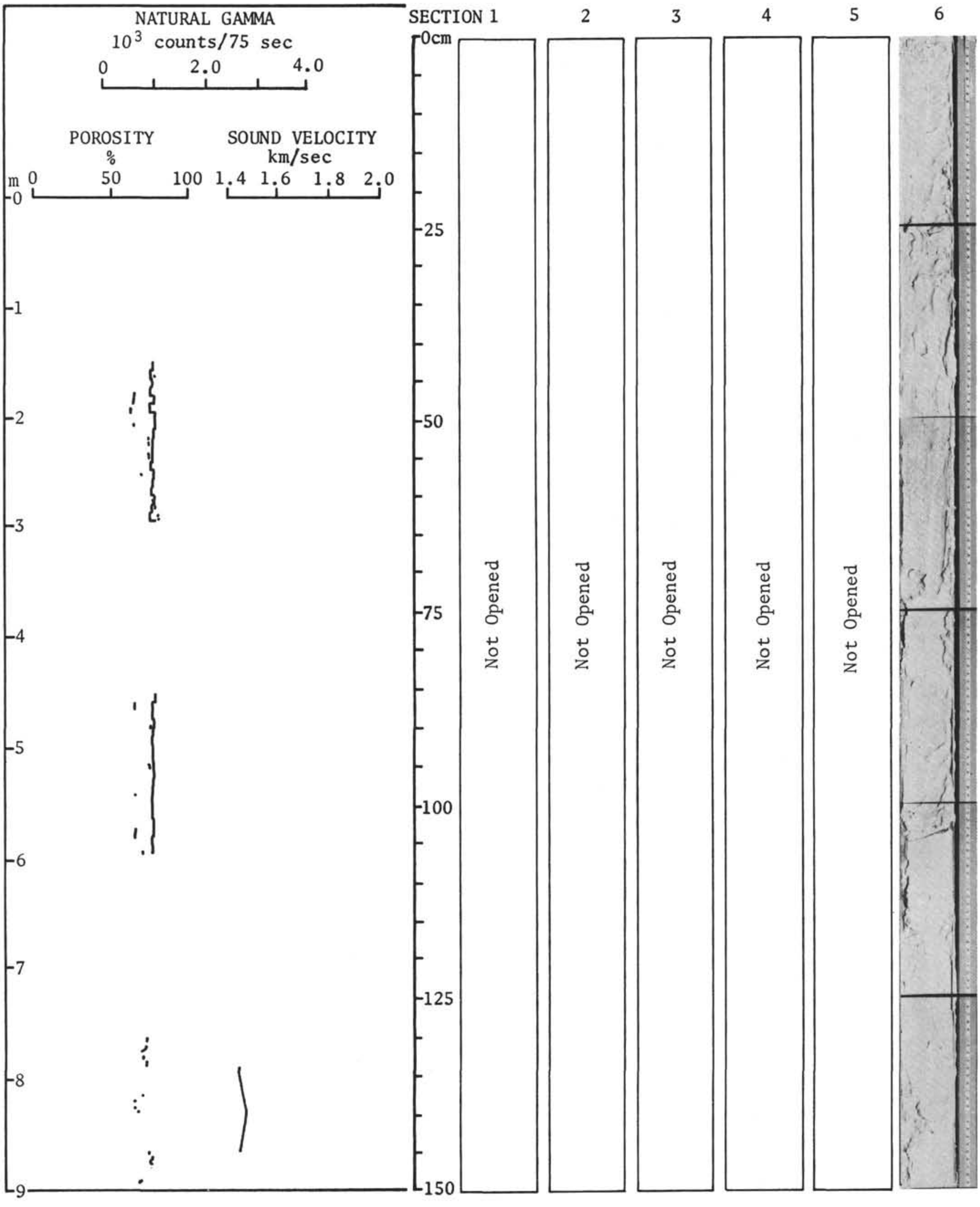



Figure 44. *Hole 78, Core 9, Sections 1-6, Physical Properties.*

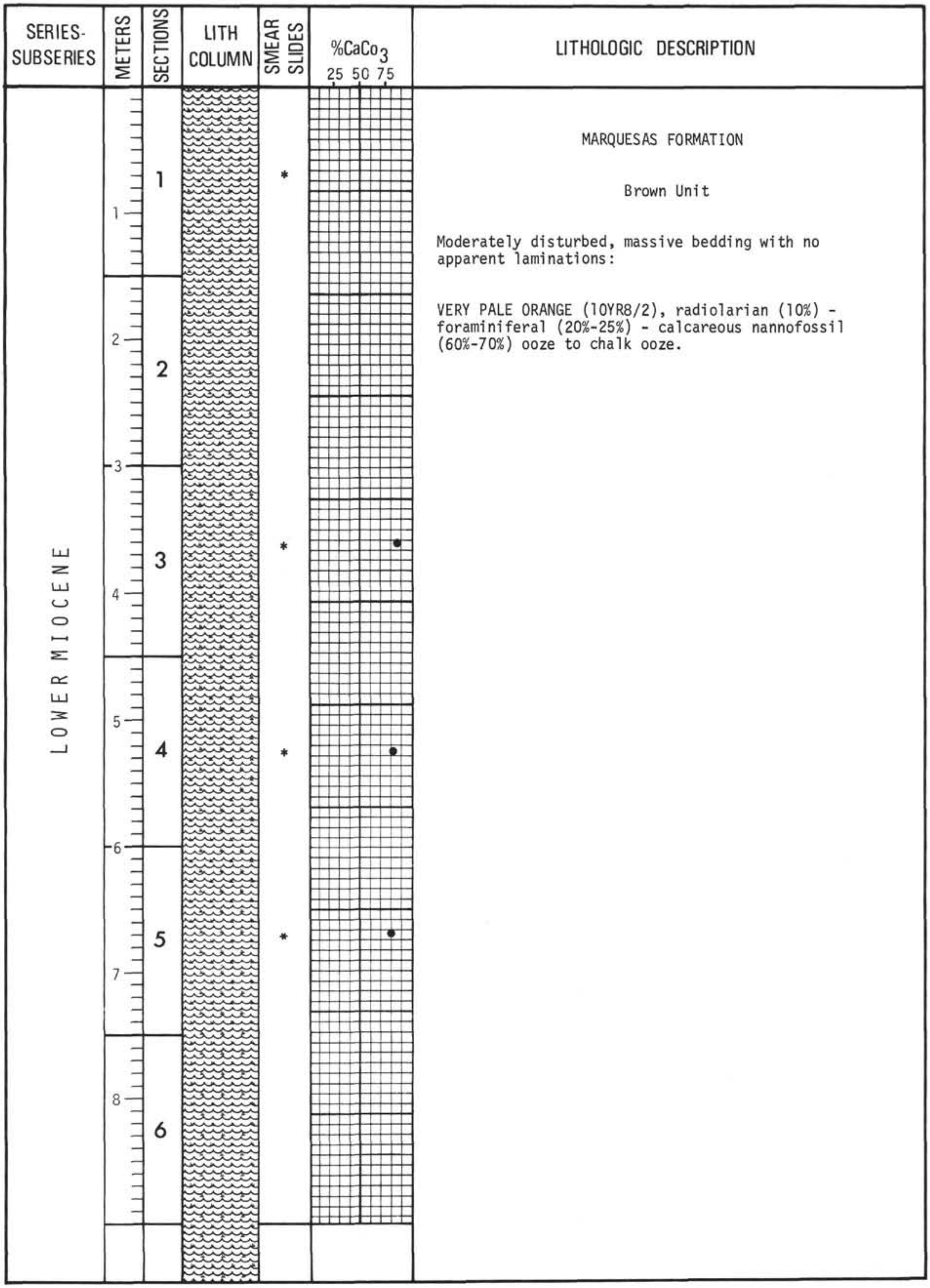



Figure 45. *Hole 78, Core 10 (82.3 to 91.4 m).*

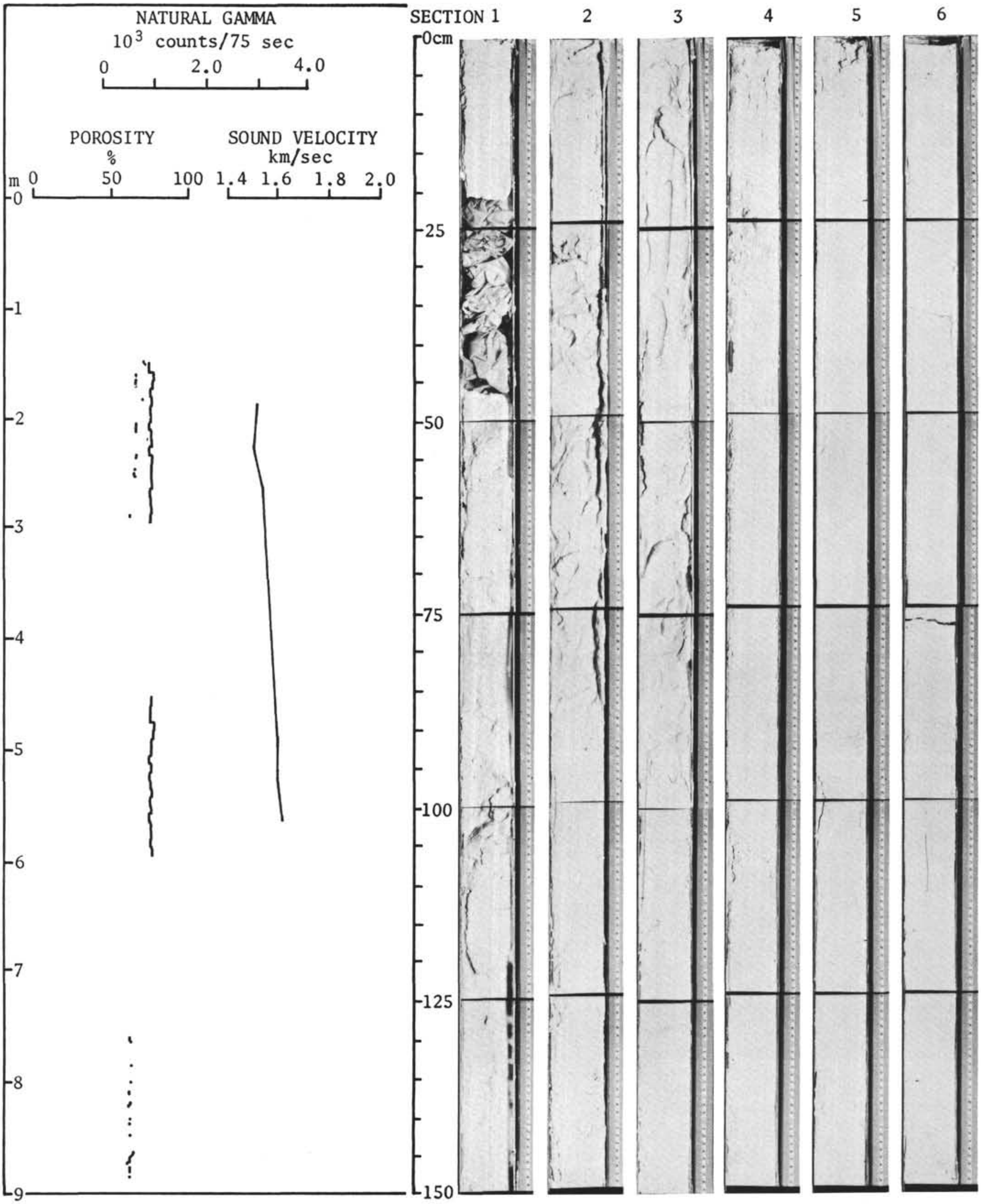



Figure 46. *Hole 78, Core 10, Sections 1-6, Physical Properties.*

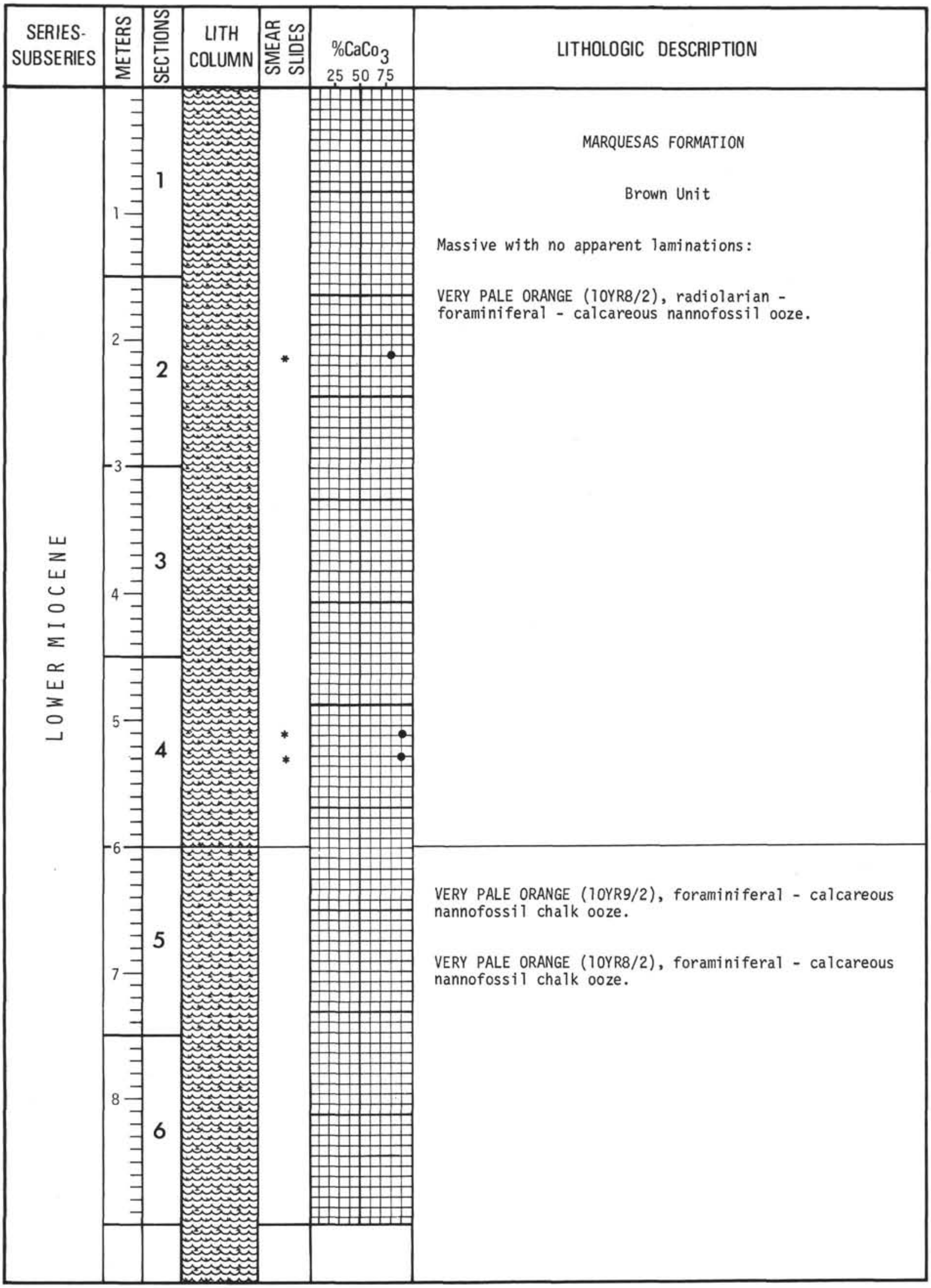



Figure 47. *Hole 78, Core 11 (91.4 to 100.6 m).*

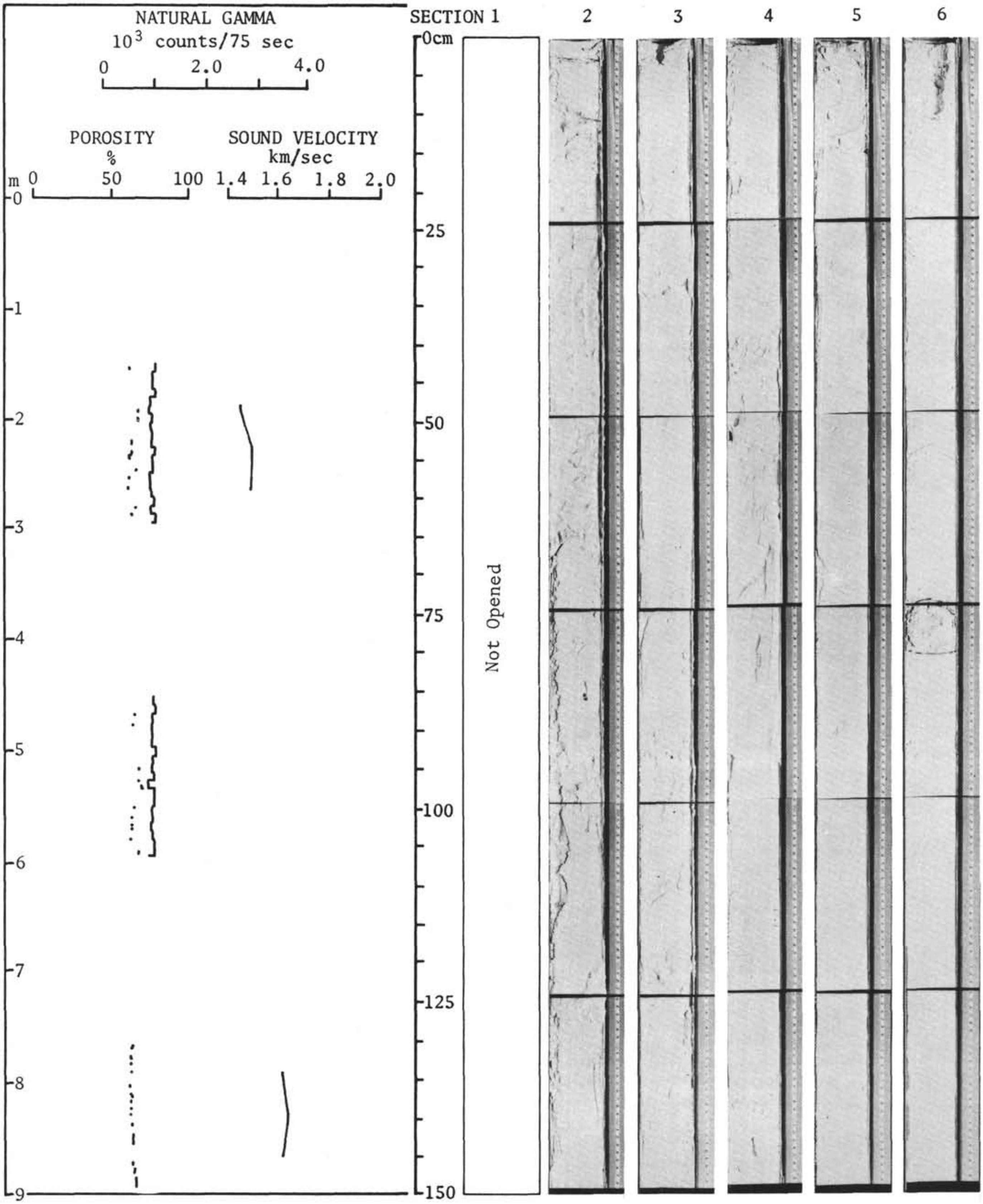



Figure 48. *Hole 78, Core 11, Sections 1-6, Physical Properties.*

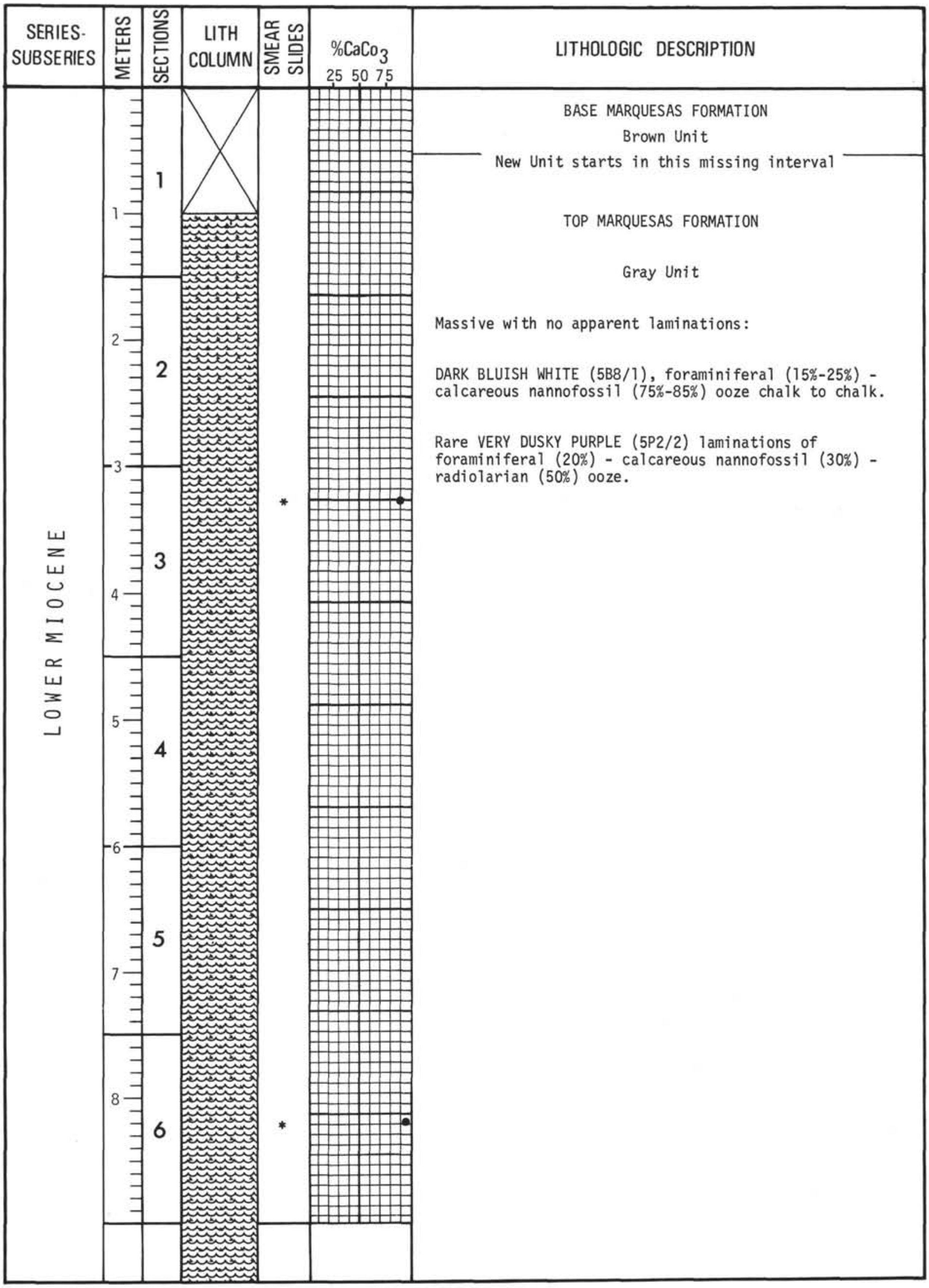



Figure 49. *Hole 78, Core 12 (100.6 to 109.7 m).*

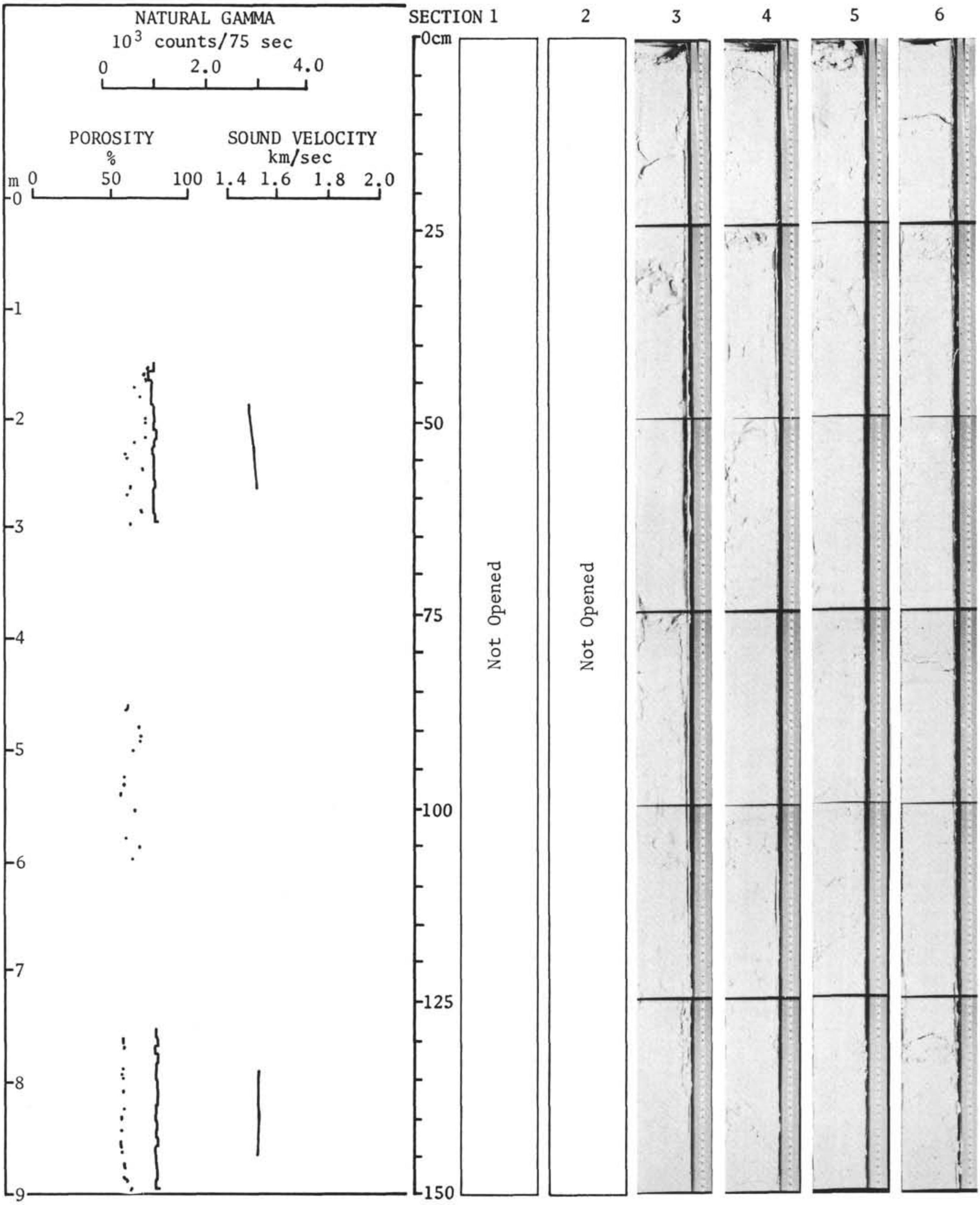



Figure 50. *Hole 78, Core 12, Sections 1-6, Physical Properties.*

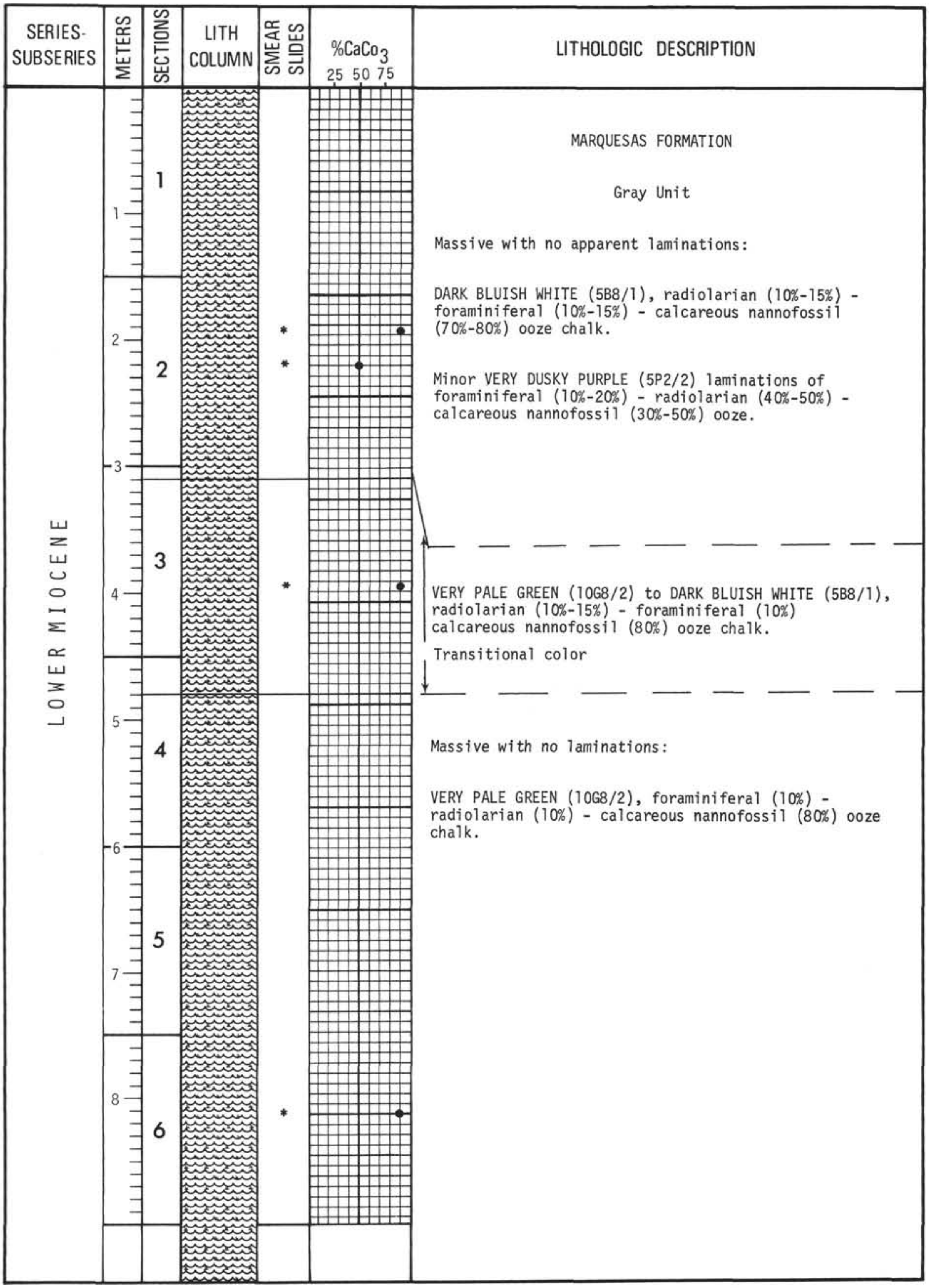



Figure 51. *Hole 78, Core 13 (109.7 to 118.9 m).*


Figure 52. *Hole 78, Core 13, Sections 1-6, Physical Properties.*

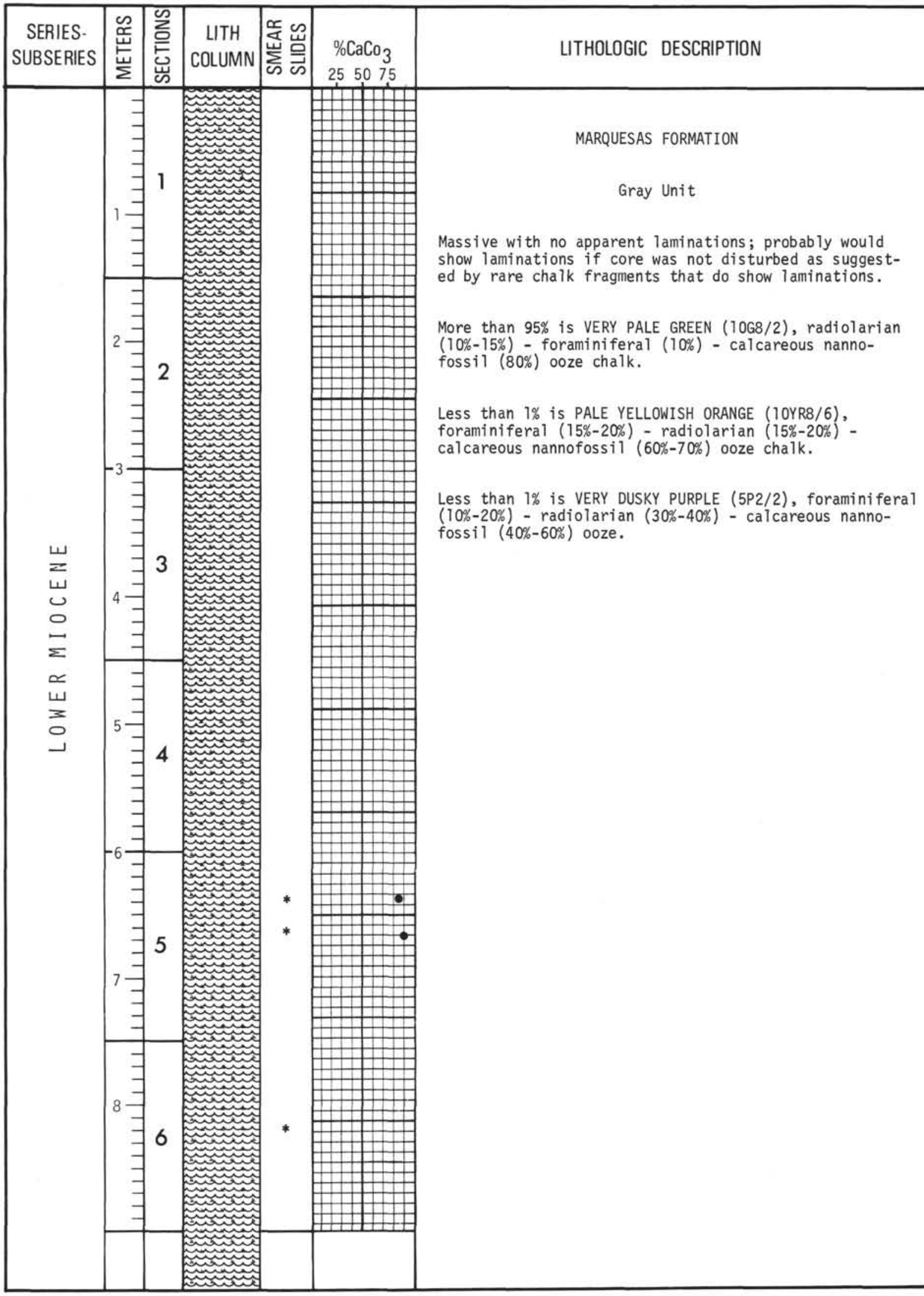



Figure 53. *Hole 78, Core 14 (118.9 to 128.0 m).*

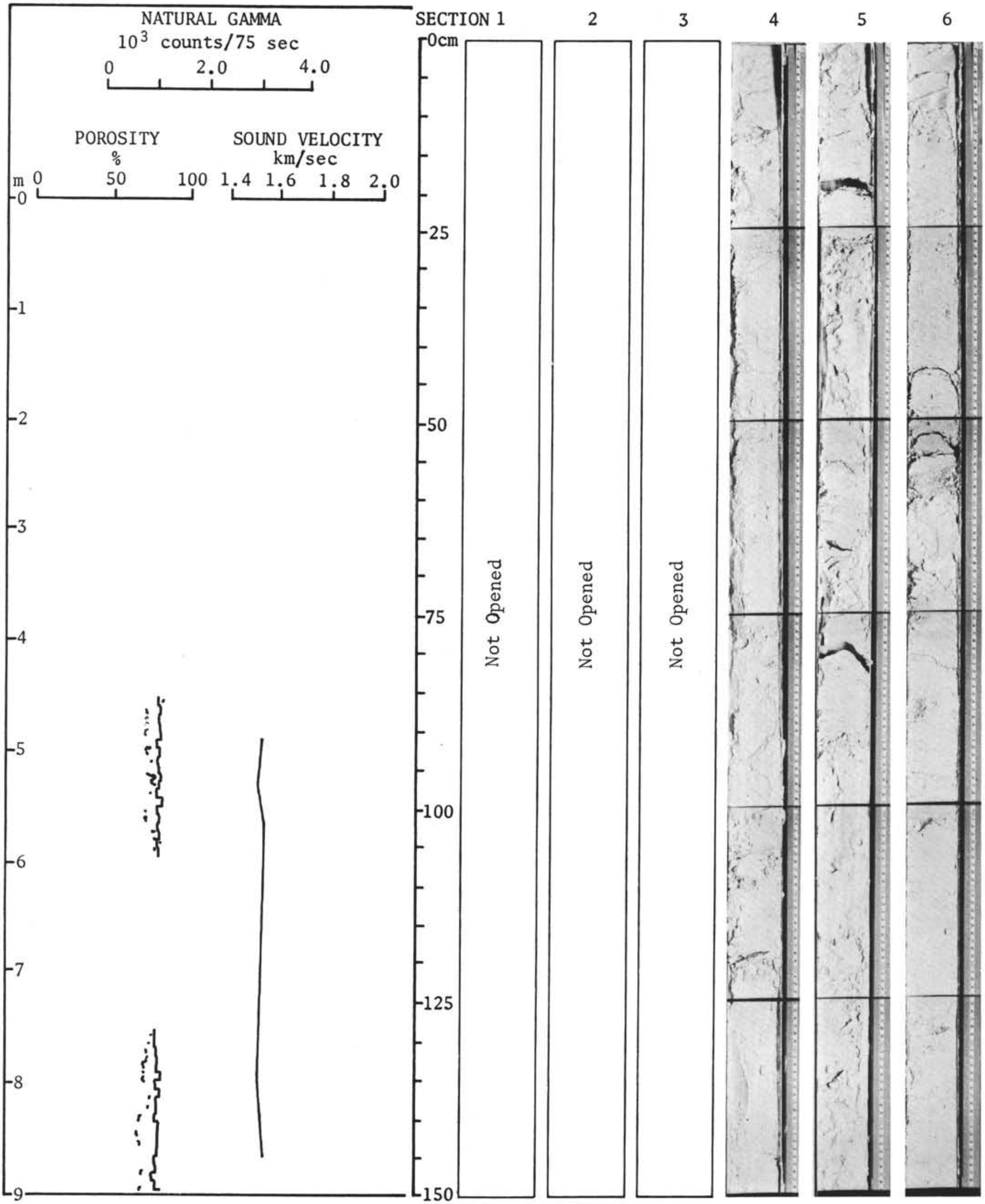



Figure 54. *Hole 78, Core 14, Sections 1-6, Physical Properties.*

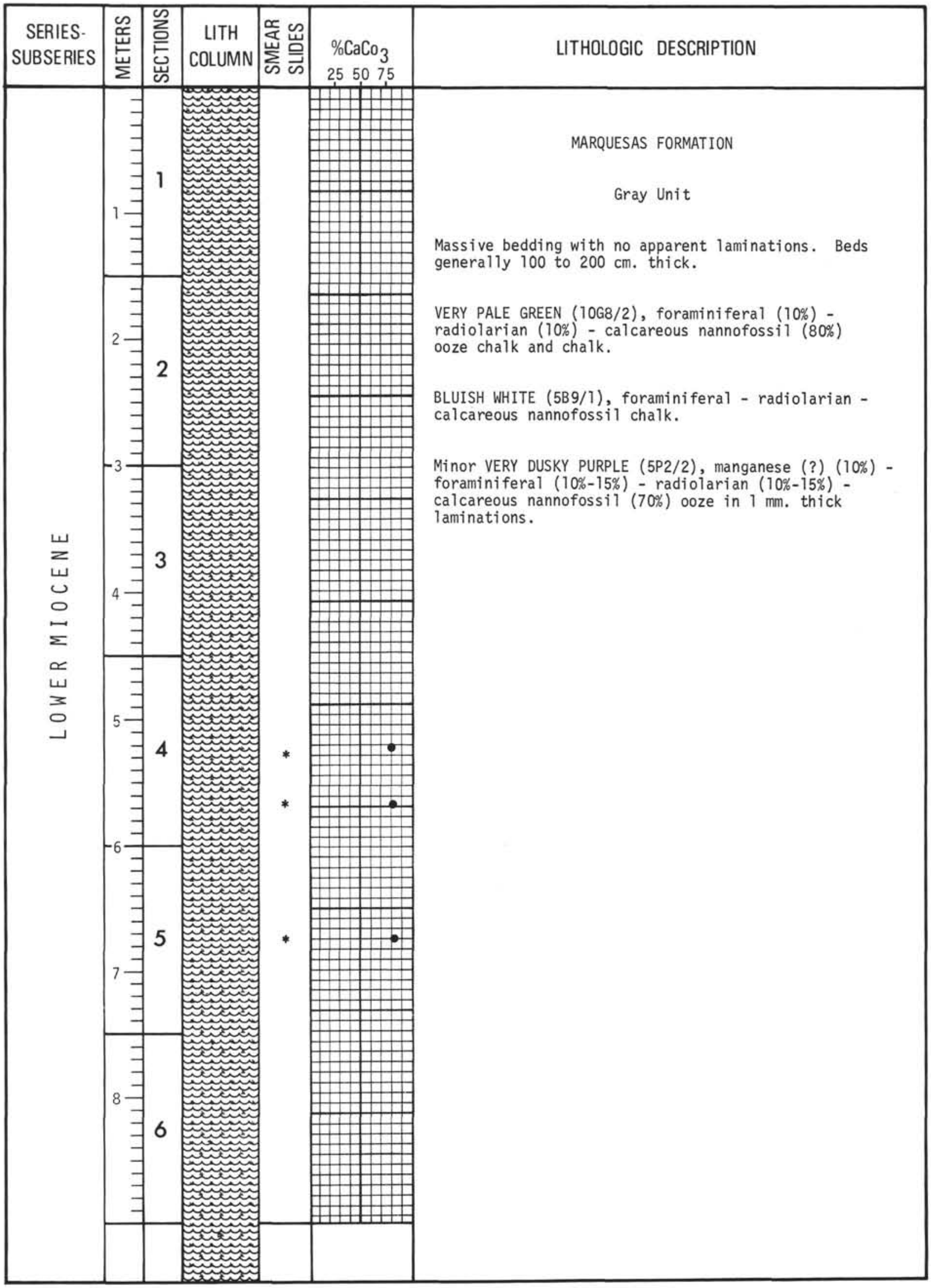



Figure 55. *Hole 78, Core 15 (128.0 to 137.1 m).*

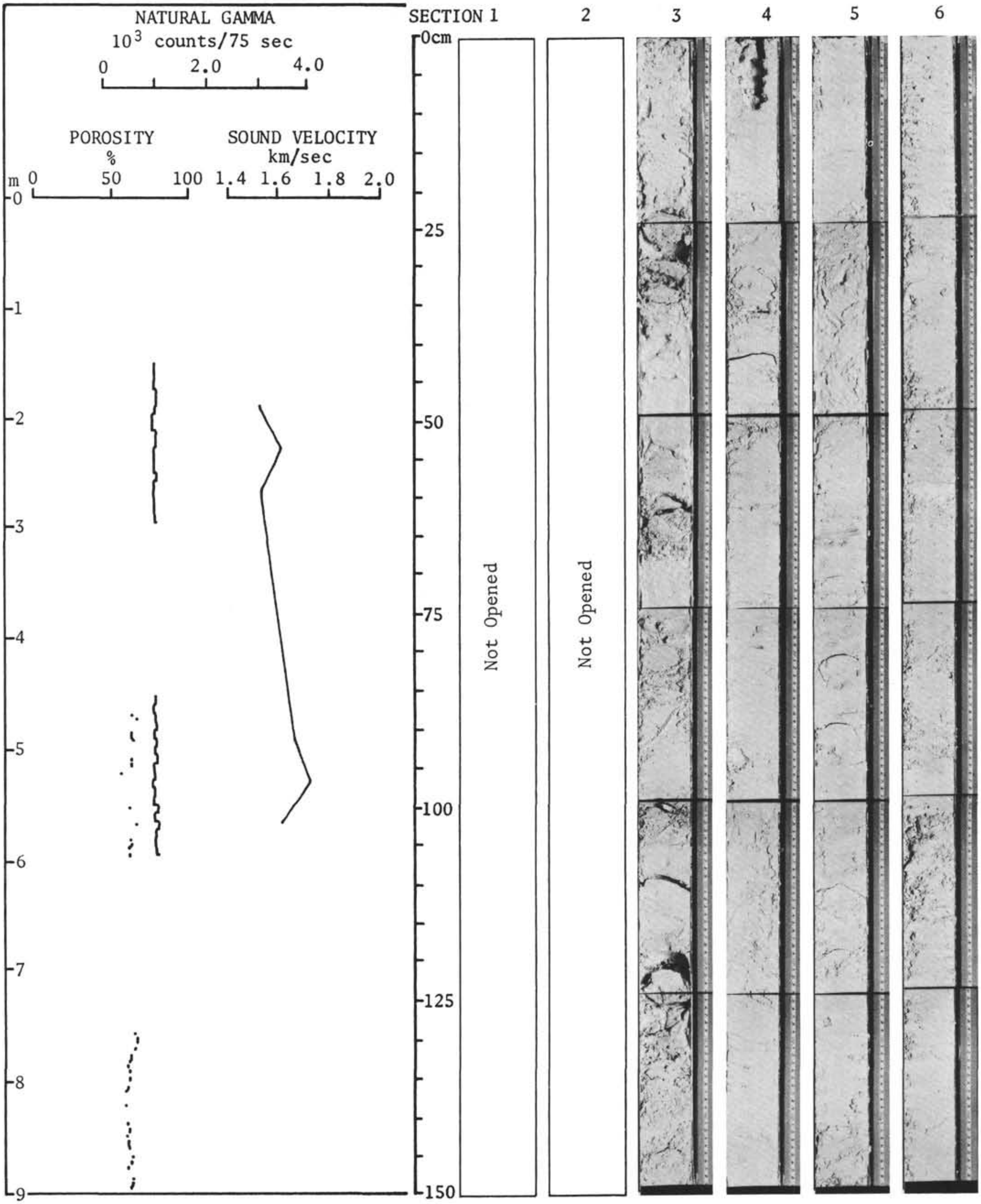
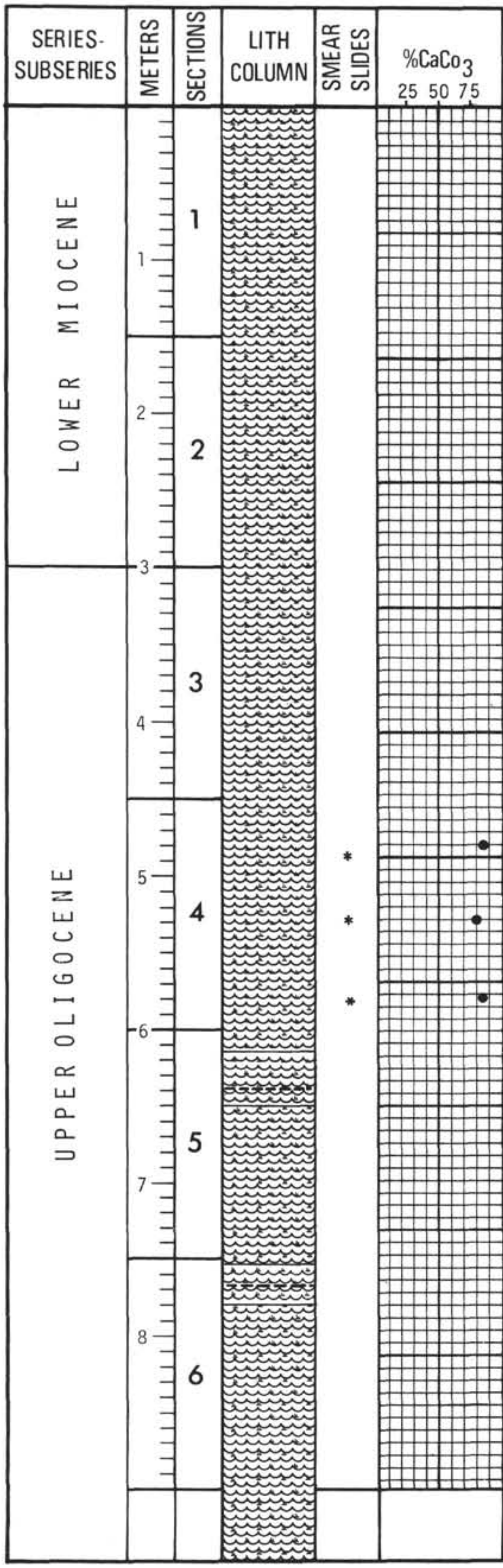



Figure 56. *Hole 78, Core 15, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Massive bedding with no obvious laminations.

VERY PALE GREEN (10G8/2), radiolarian (10%-20%) - calcareous nannofossil (70%-80%) chalk with 5%-10% foraminifers.

LIGHT GREENISH GRAY (5G8/1), foraminiferal (10%-15%) - radiolarian (15%-20%) - calcareous nannofossil (60%-70%) ooze.

Rare MODERATE YELLOWISH BROWN (10YR5/4), clay (2%-3%) - radiolarian (15%-25%) - foraminiferal (15%-25%) - calcareous nannofossil (60%-75%) ooze.

Figure 57. *Hole 78, Core 16, (137.1 to 146.3 m).*

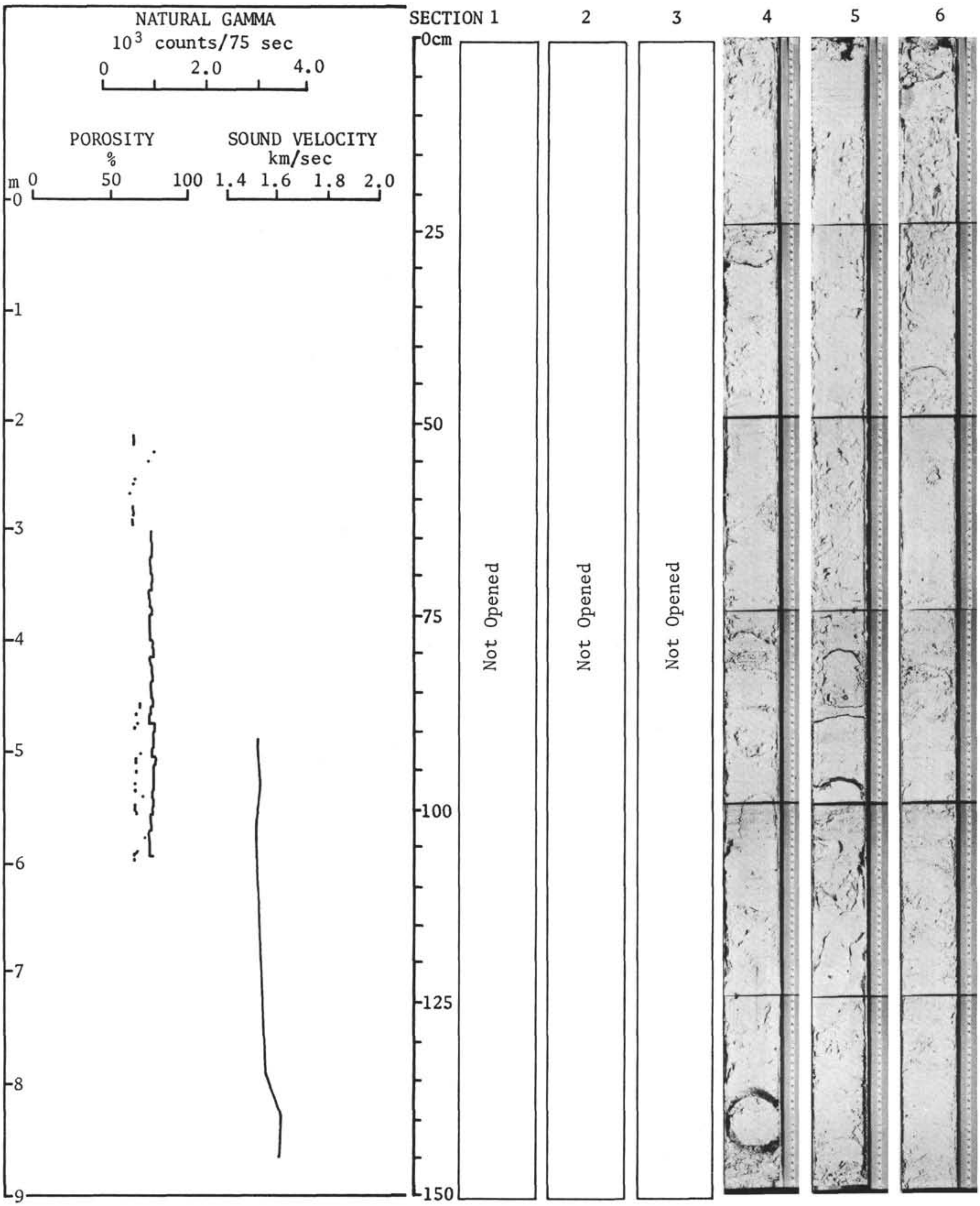



Figure 58. *Hole 78, Core 16, Sections 1-6, Physical Properties.*

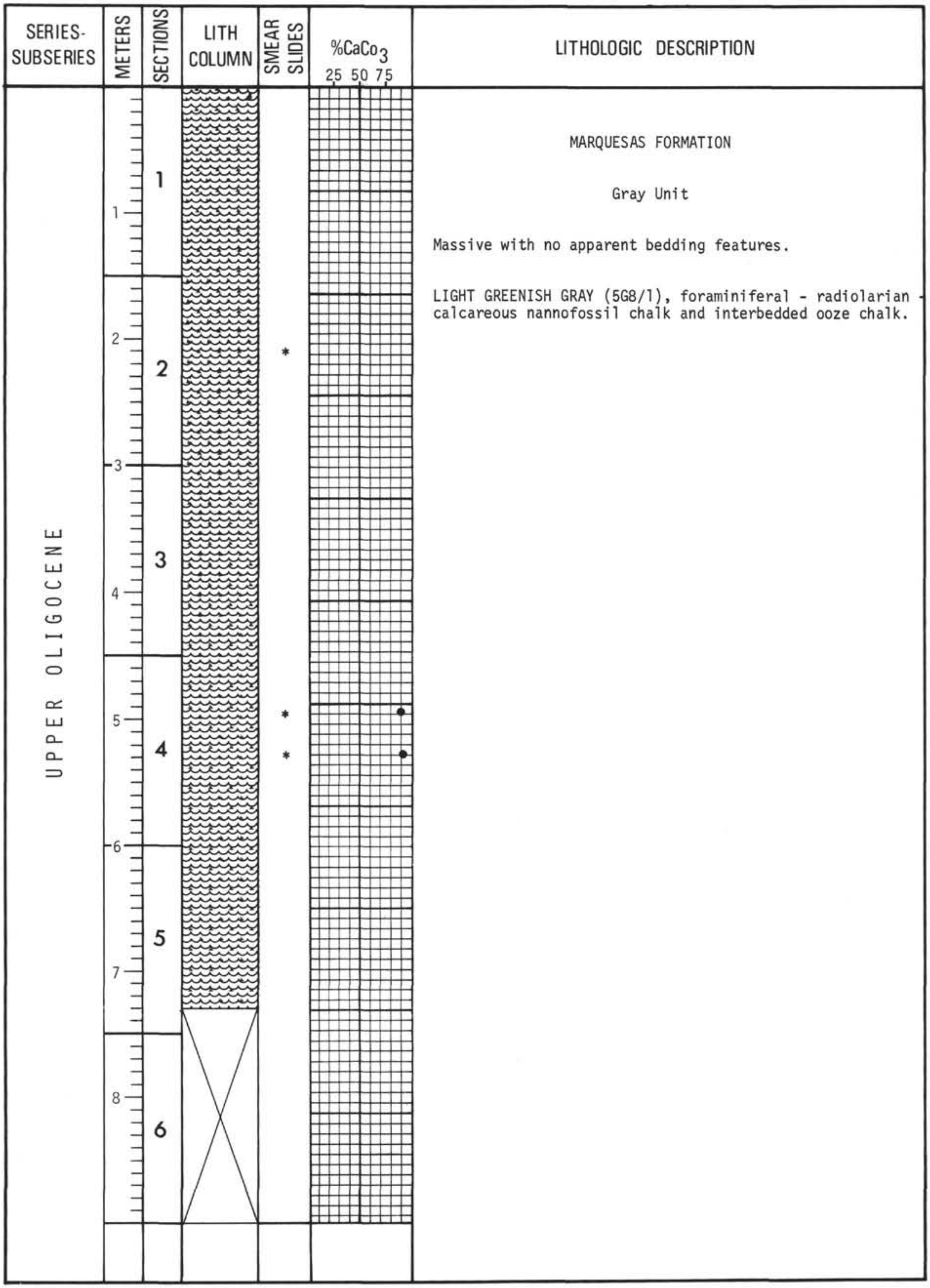



Figure 59. *Hole 78, Core 17 (146.3 to 155.4 m).*

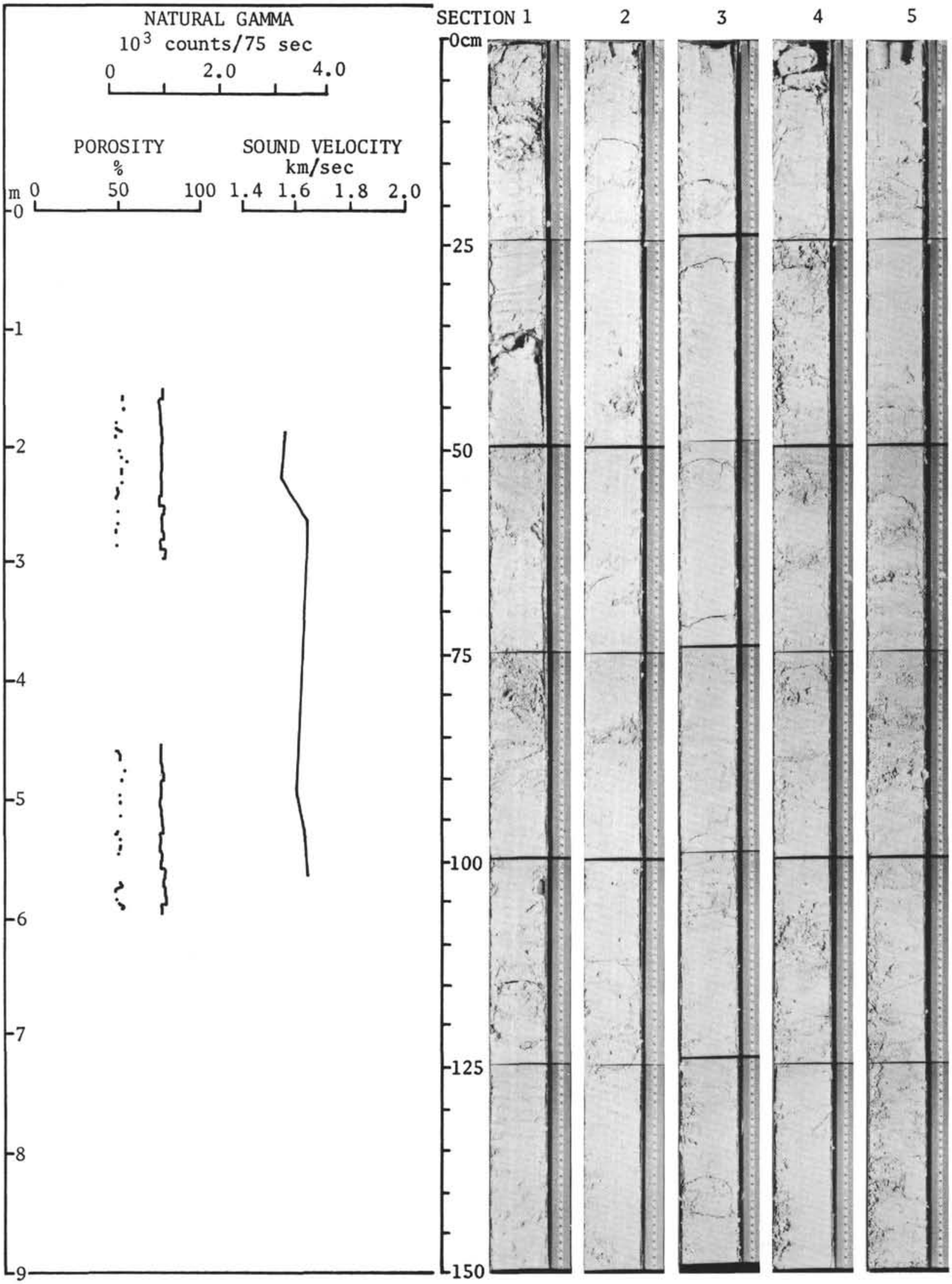



Figure 60. *Hole 78, Core 17, Sections 1-5, Physical Properties.*

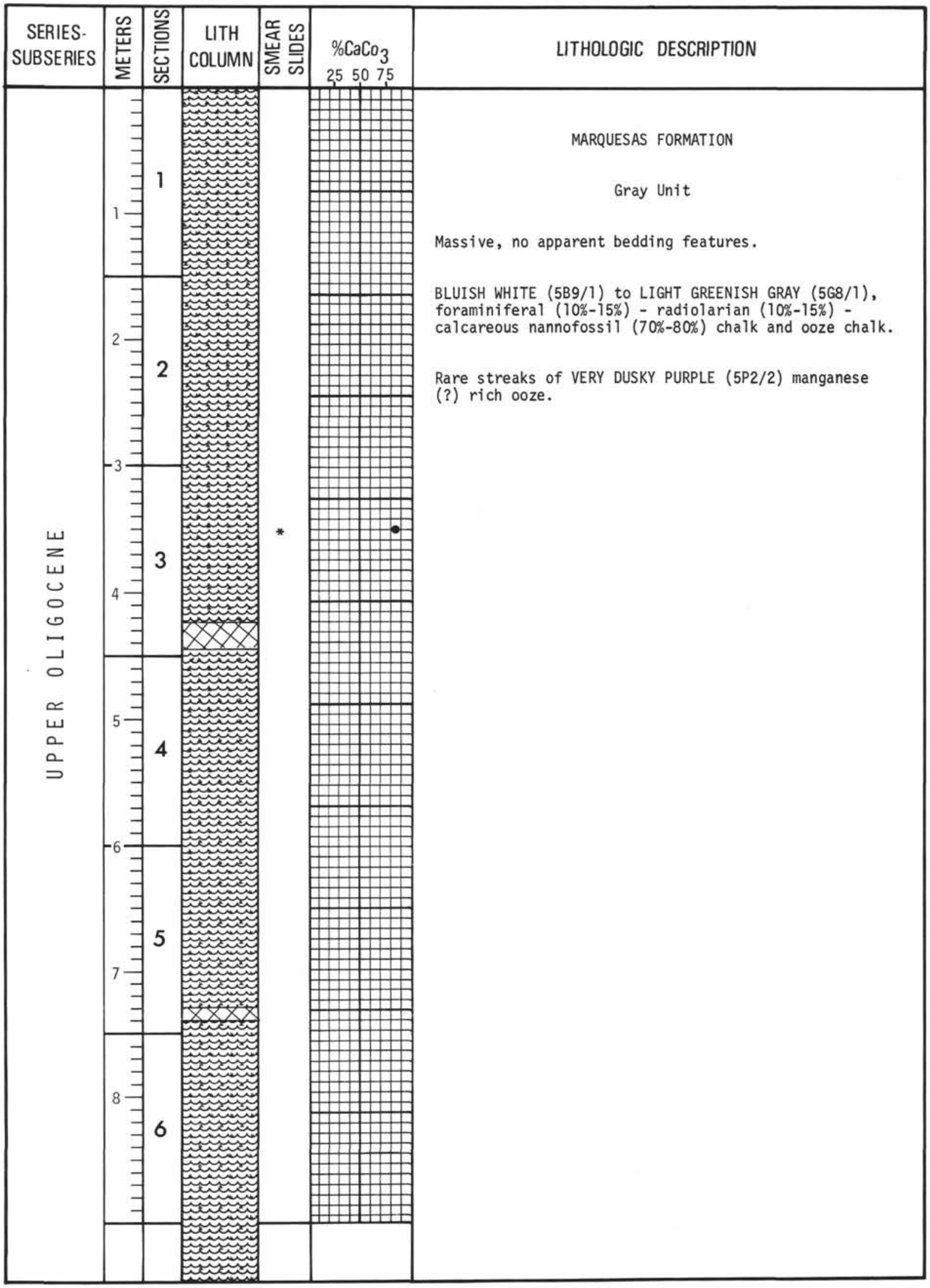



Figure 61. *Hole 78, Core 18 (155.4 to 164.6 m).*

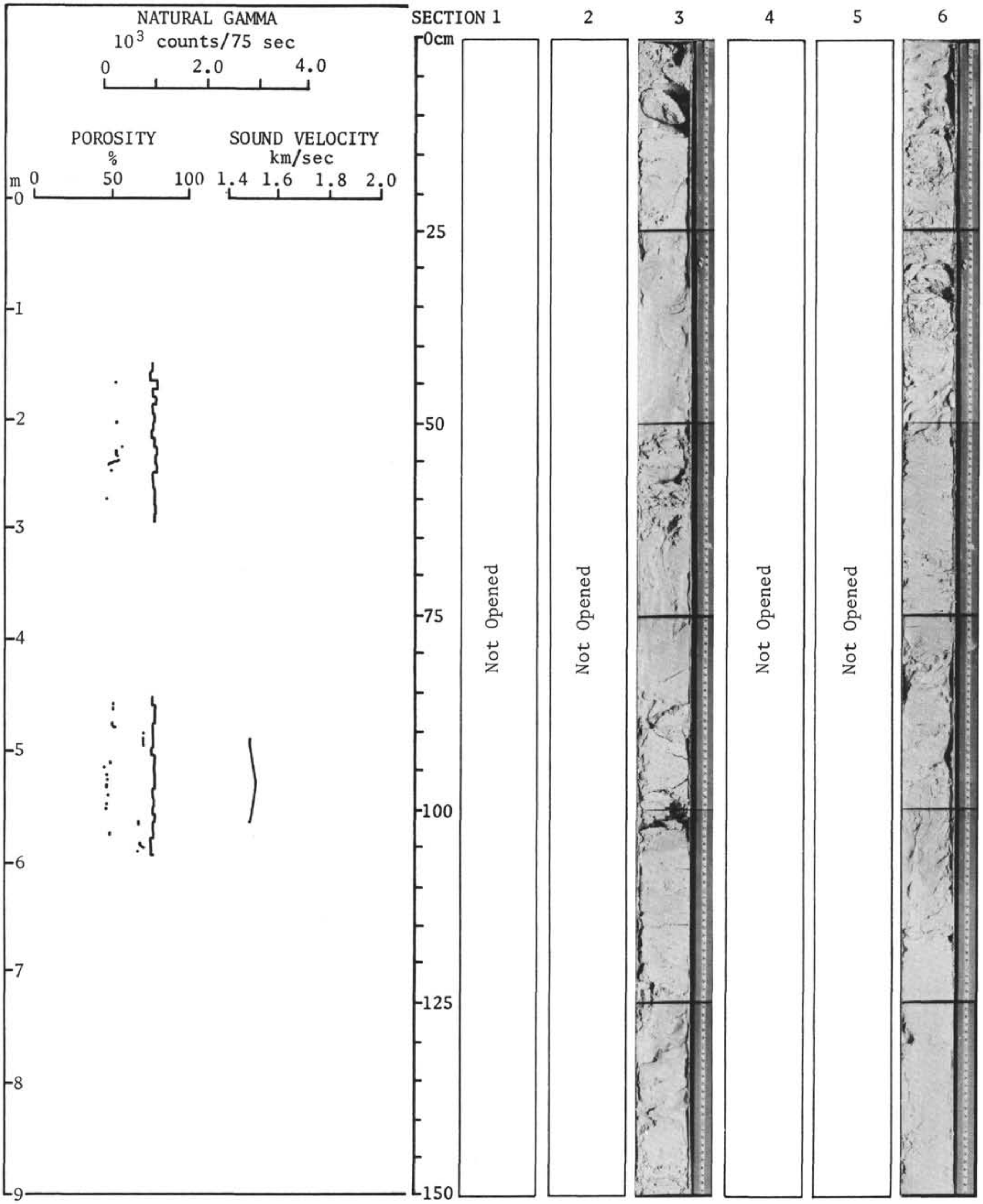
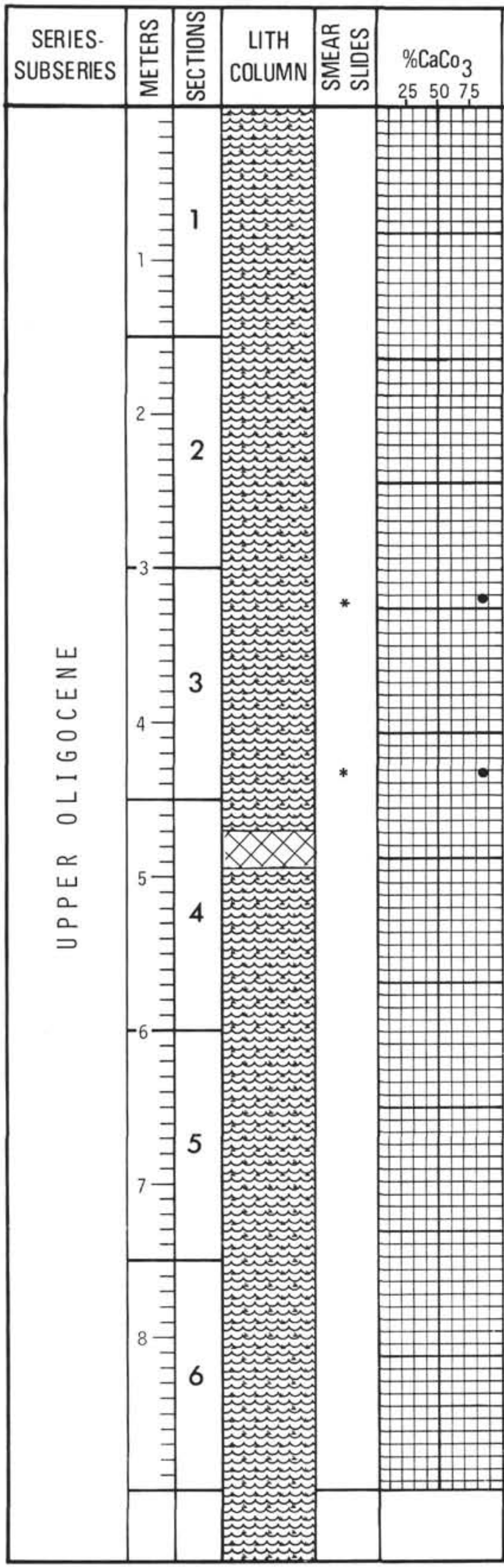



Figure 62. *Hole 78, Core 18, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Massive, no apparent bedding features.

BLUISH WHITE (5B9/1) to LIGHT GREENISH GRAY (5G8/1), foraminiferal (10%-15%) - radiolarian (10%-15%) - calcareous nannofossil (70%-80%) chalk and ooze chalk.

Rare streaks of VERY DUSKY PURPLE (5P2/2) manganese (?) rich ooze.

Figure 63. *Hole 78, Core 19 (164.6 to 173.7 m).*

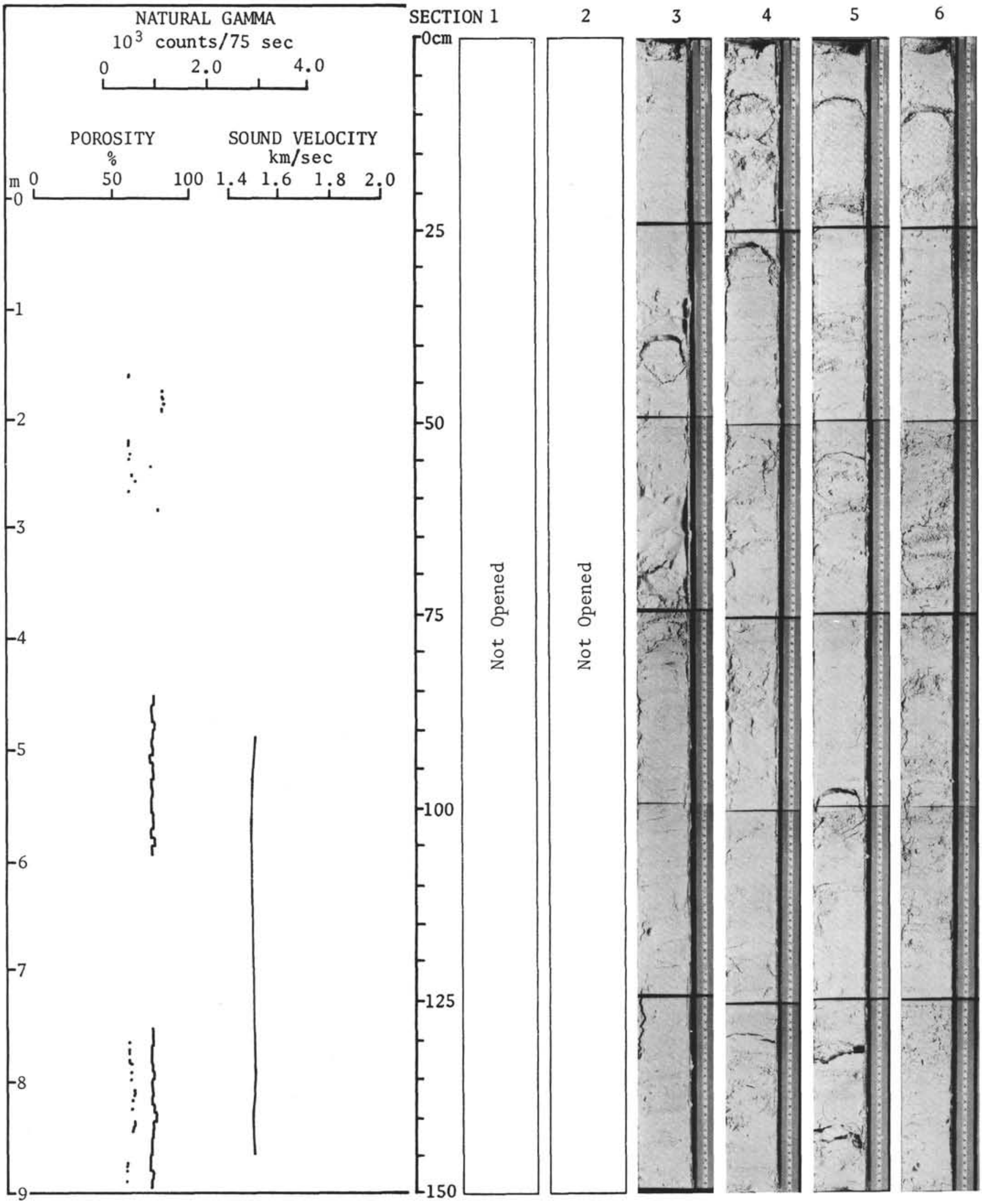



Figure 64. *Hole 78, Core 19, Sections 1-6, Physical Properties.*

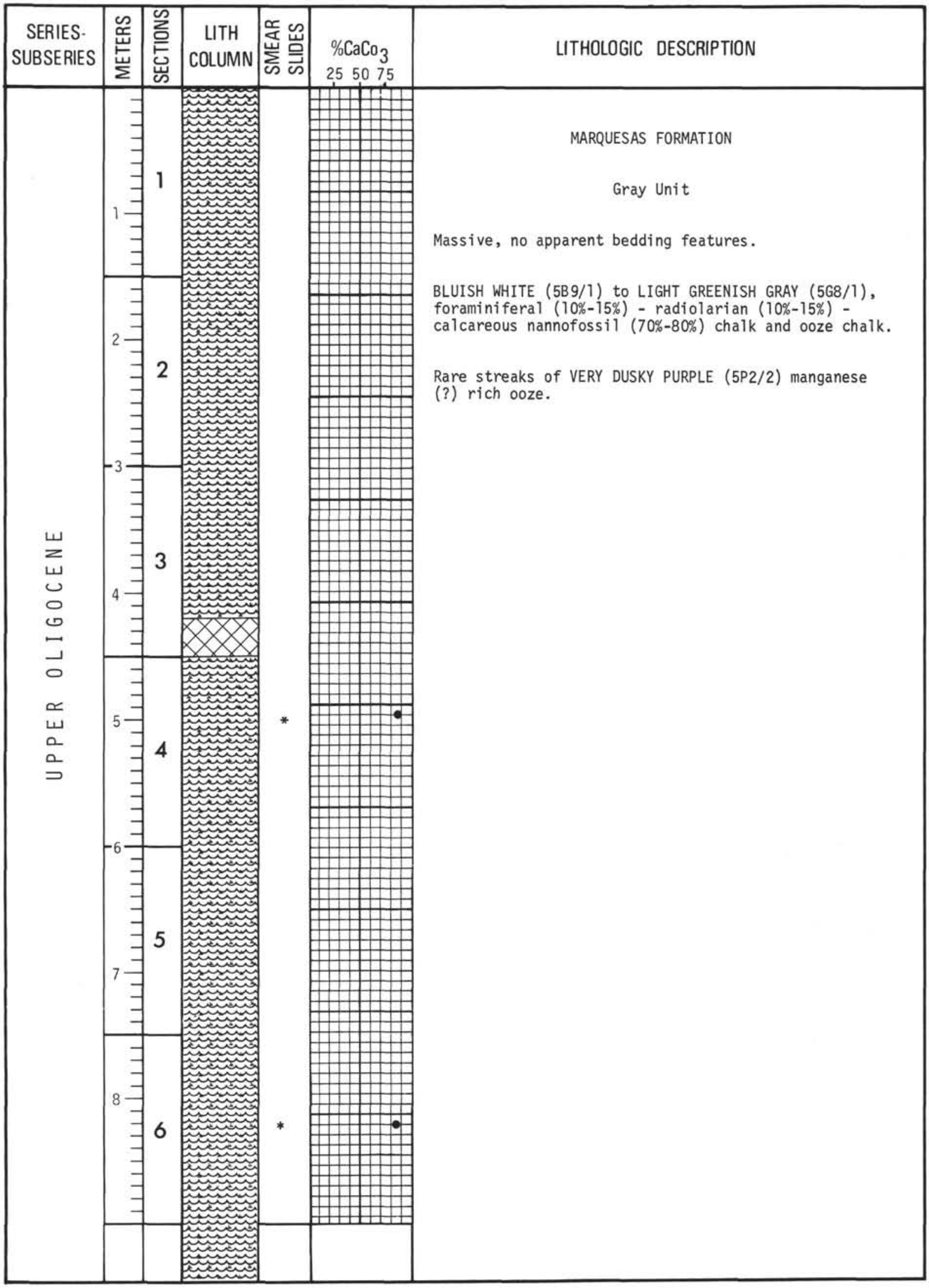



Figure 65. *Hole 78, Core 20 (173.7 to 182.9 m).*

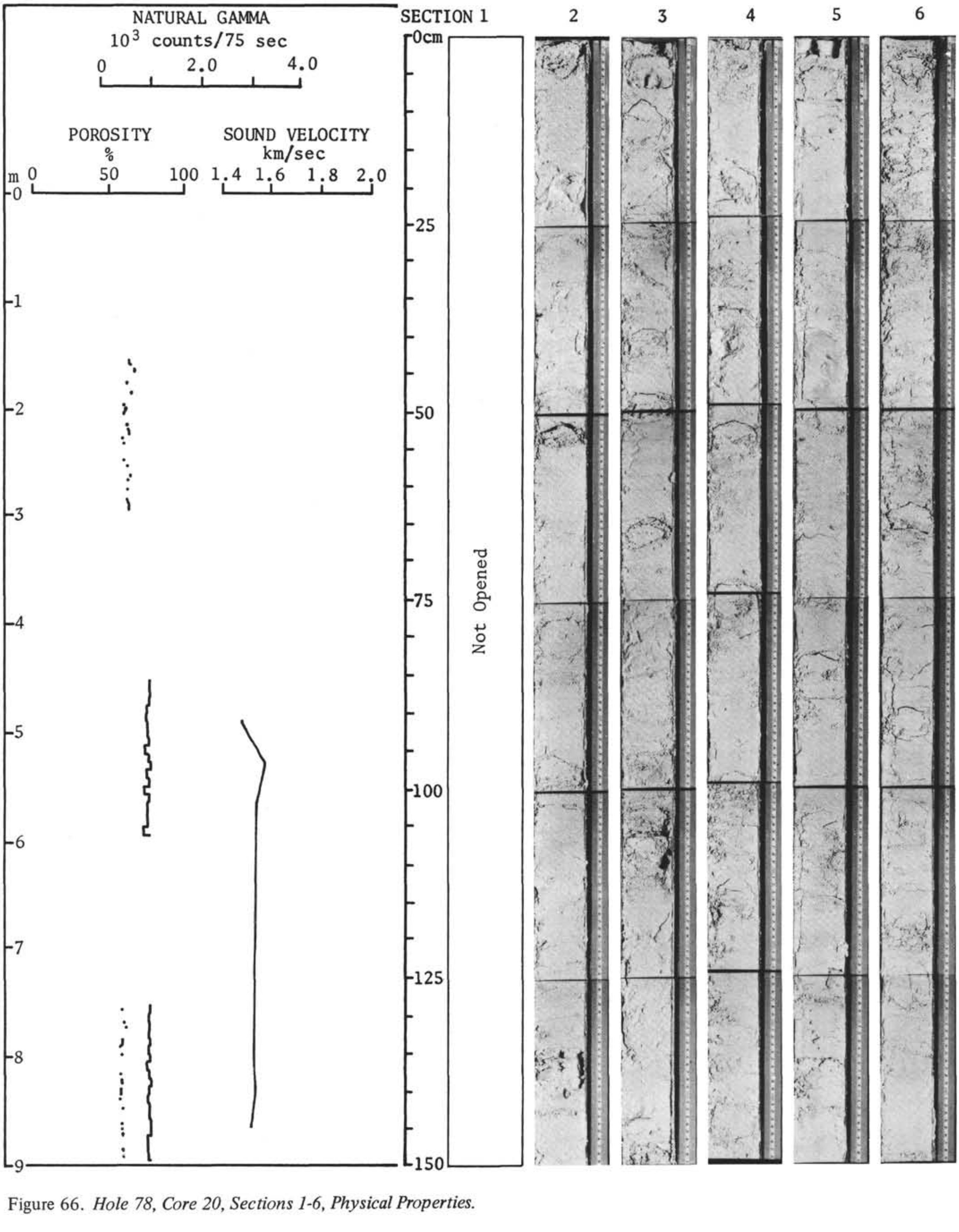



Figure 66. *Hole 78, Core 20, Sections 1-6, Physical Properties.*

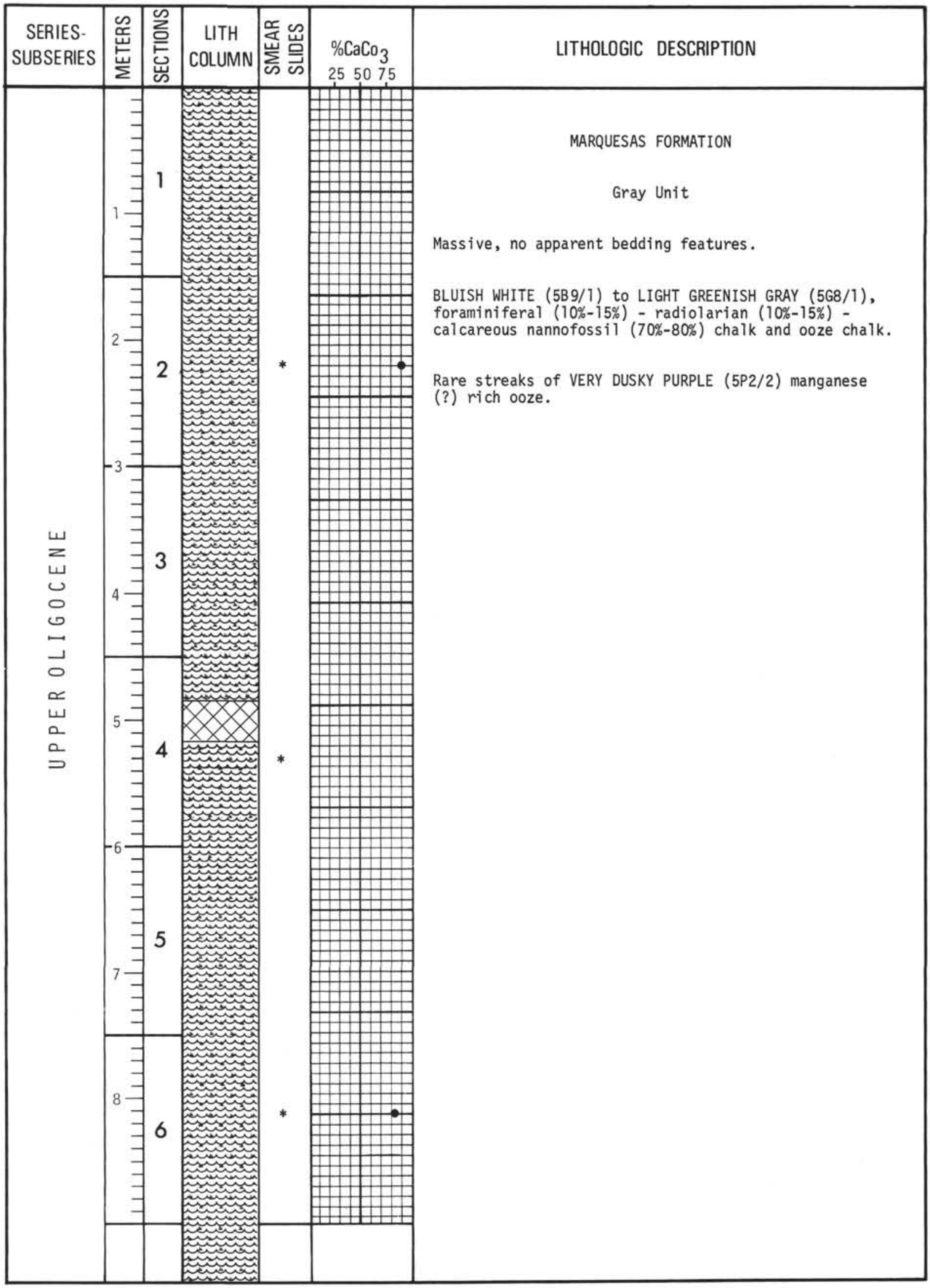



Figure 67. *Hole 78, Core 21 (182.9 to 192.2 m).*

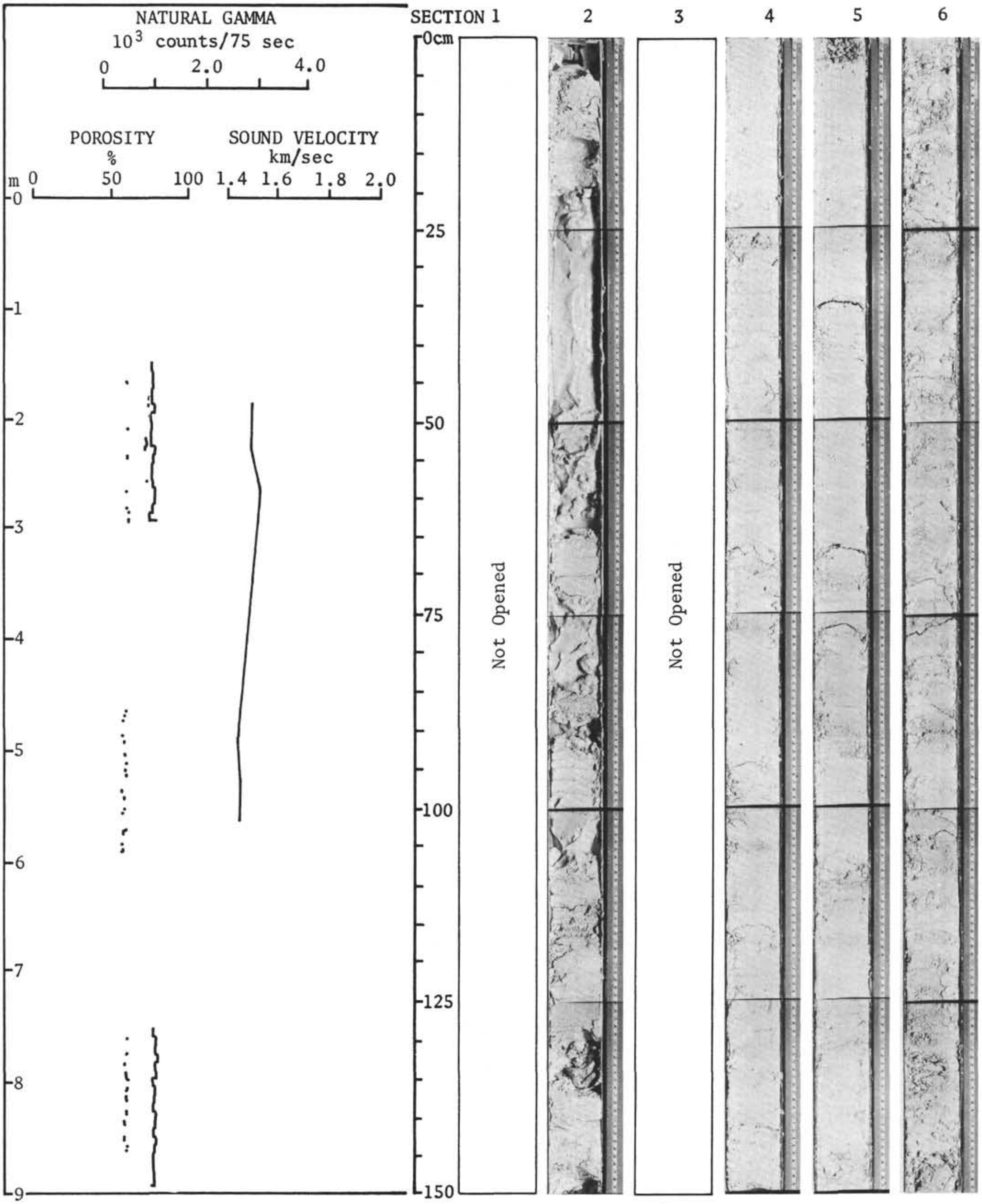
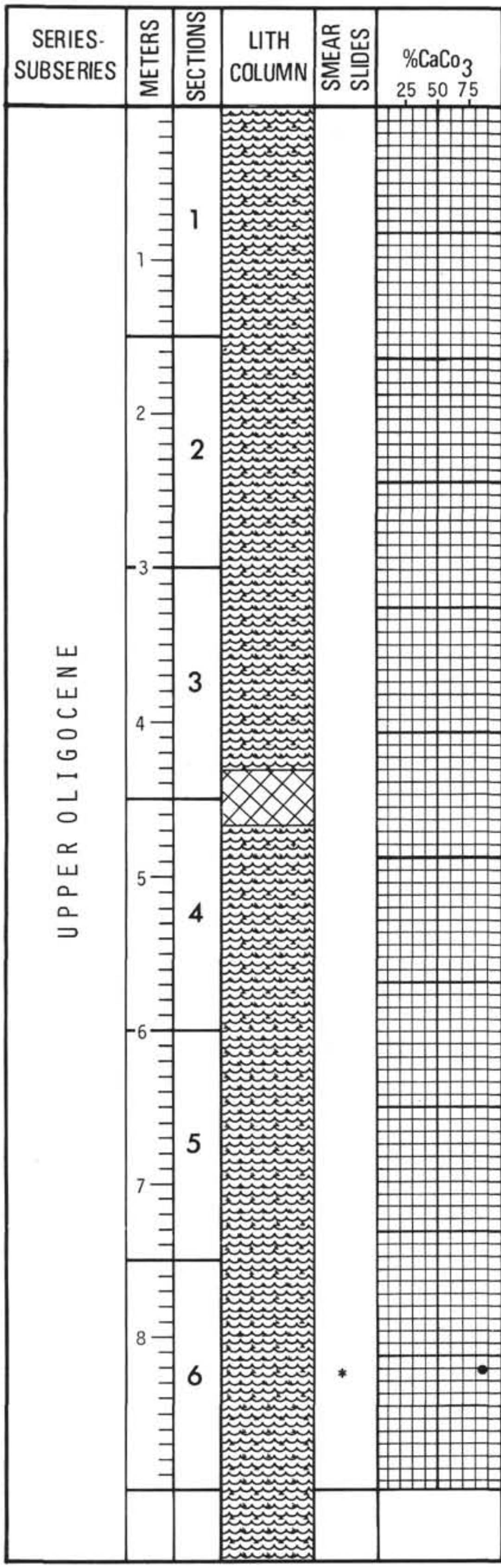



Figure 68. *Hole 78, Core 21, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Massive, no apparent bedding features.

BLUISH WHITE (5B9/1) to LIGHT GREENISH GRAY (5G8/1), foraminiferal (10%-15%) - radiolarian (10%-15%) - calcareous nannofossil (70%-80%) chalk and ooze chalk.

Rare streaks of VERY DUSKY PURPLE (5P2/2) manganese (?) rich ooze.

Figure 69. *Hole 78, Core 22 (192.2 to 201.2 m).*

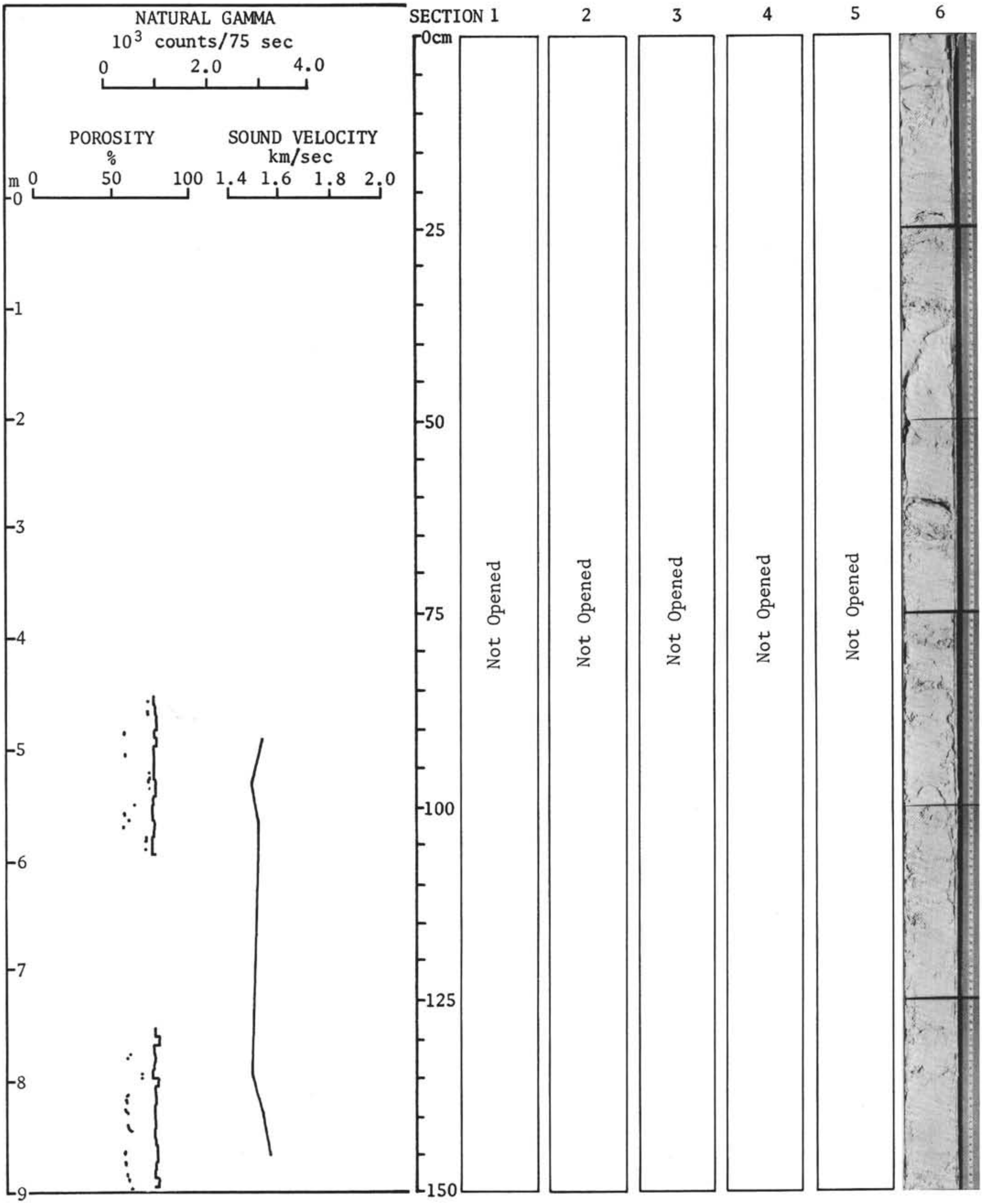



Figure 70. *Hole 78, Core 22, Sections 1-6, Physical Properties.*

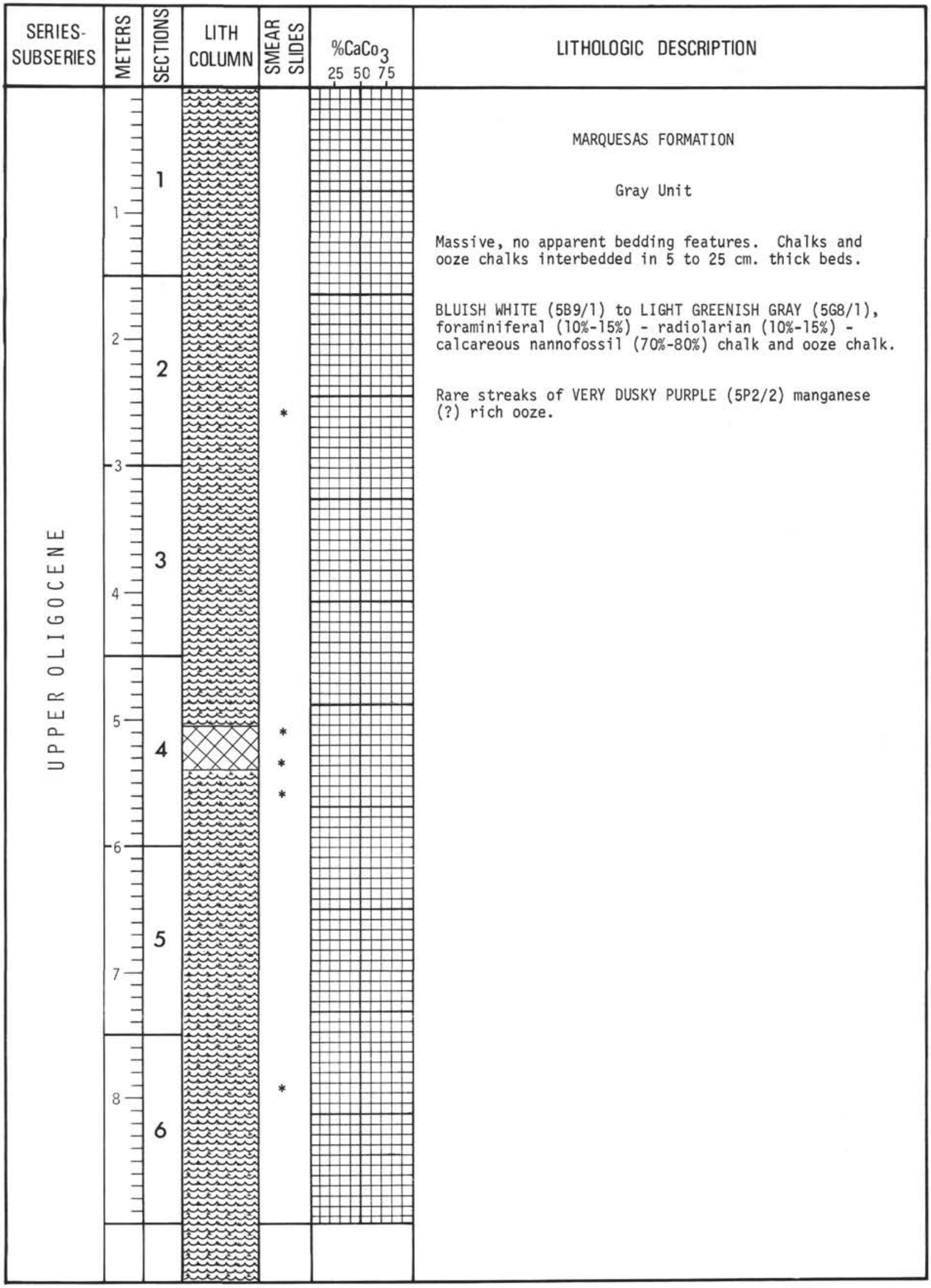



Figure 71. *Hole 78, Core 23 (201.2 to 210.3 m).*

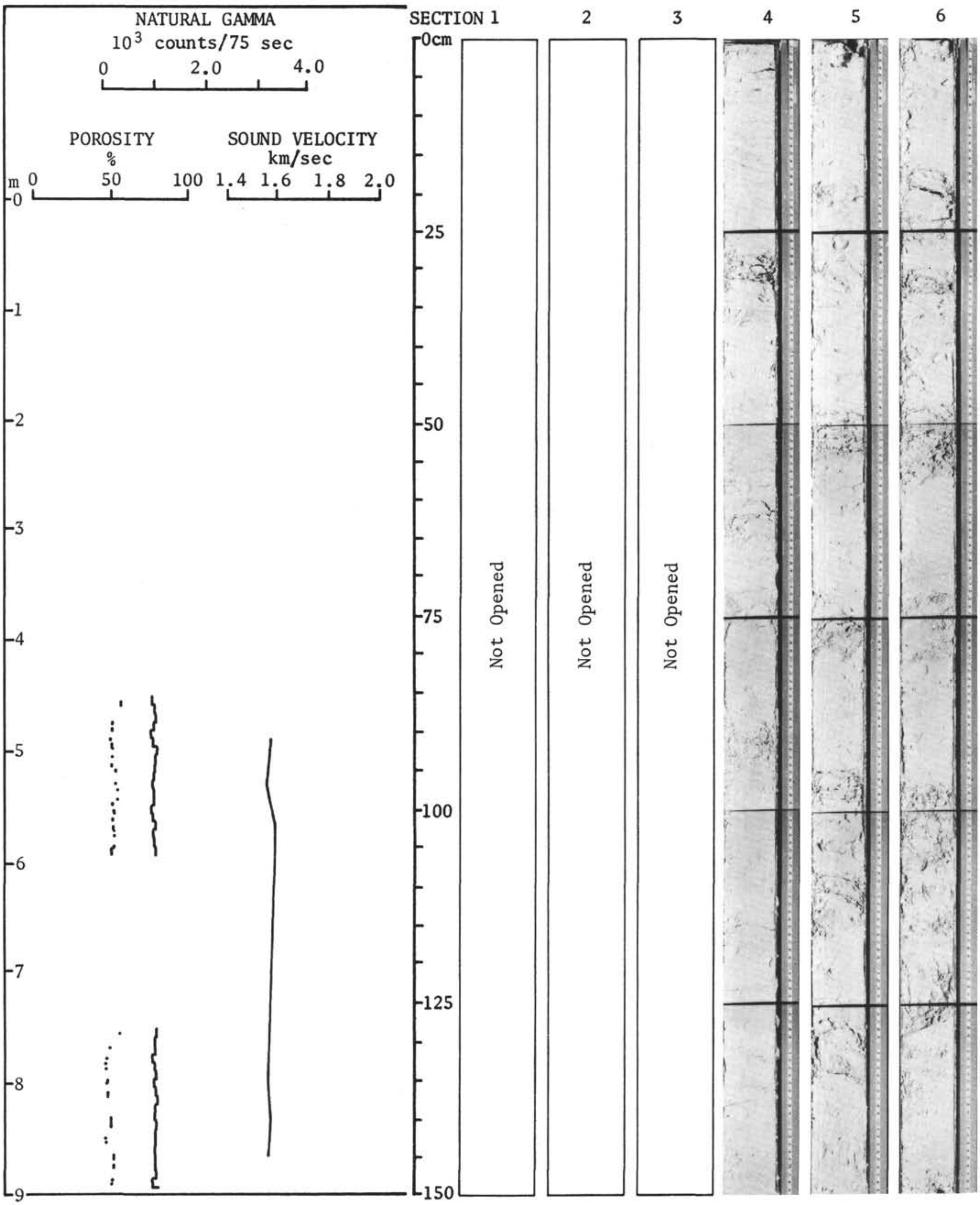



Figure 72. *Hole 78, Core 23, Sections 1-6, Physical Properties.*

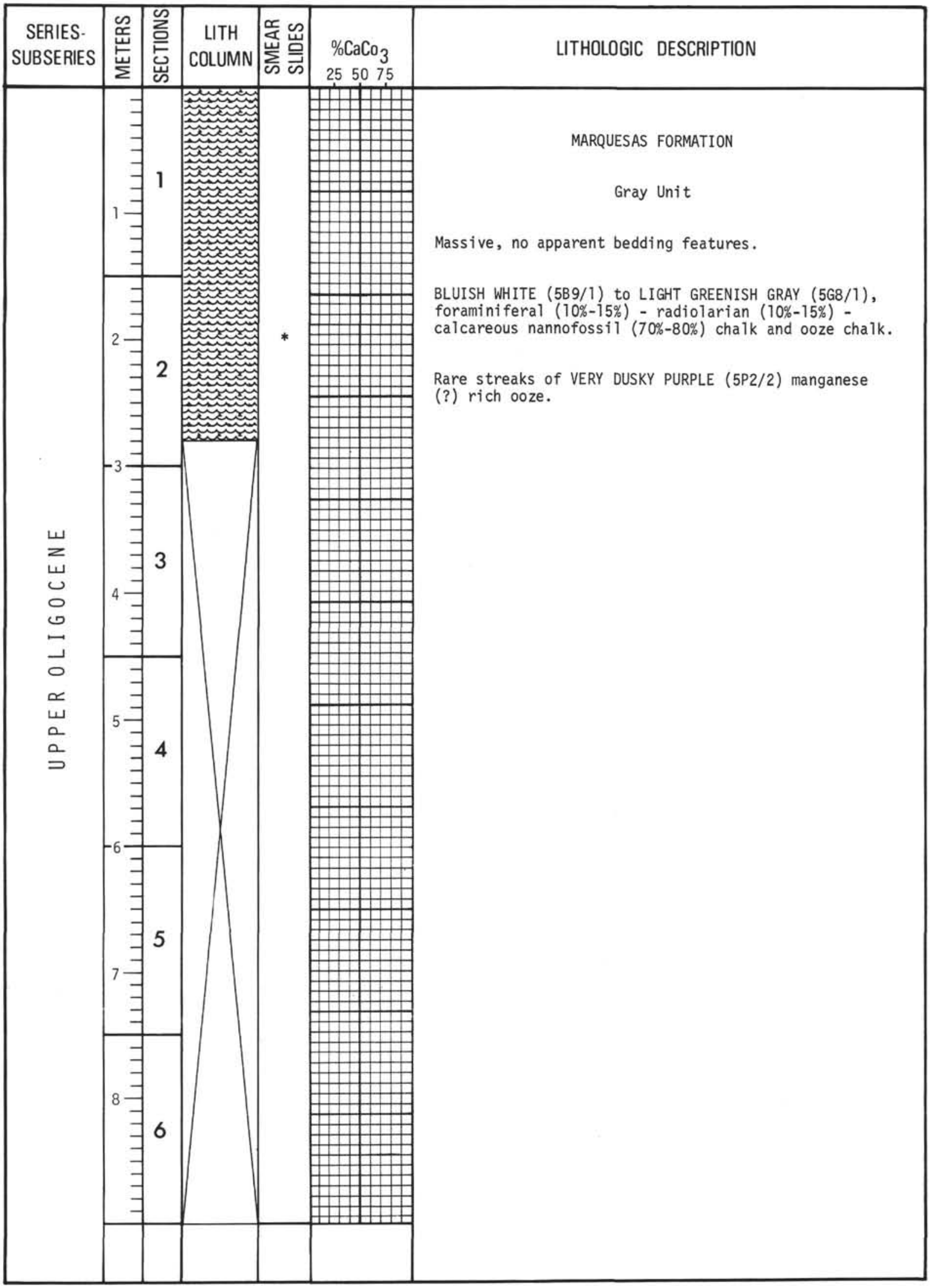



Figure 73. *Hole 78, Core 24 (210.3 to 219.4 m).*

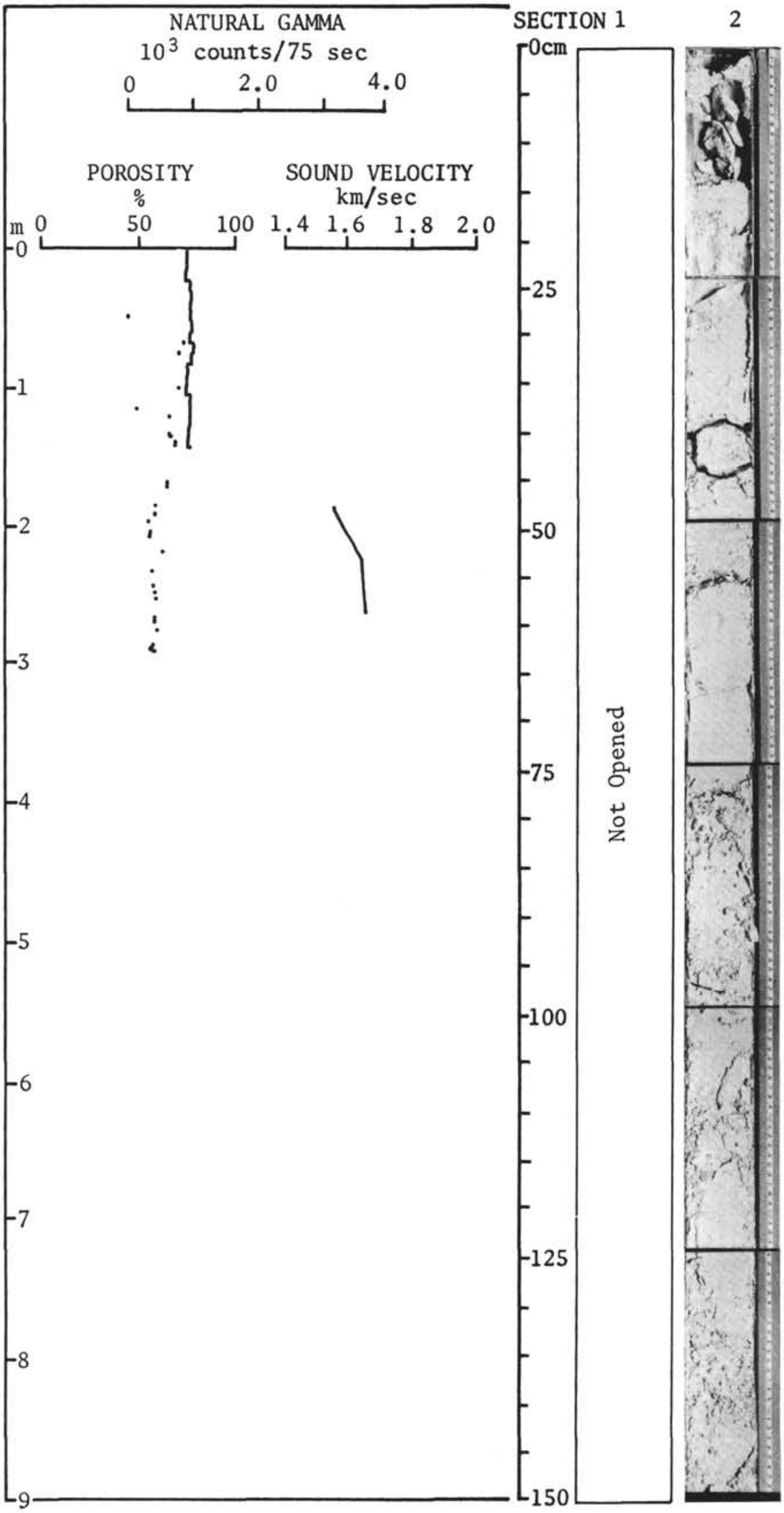
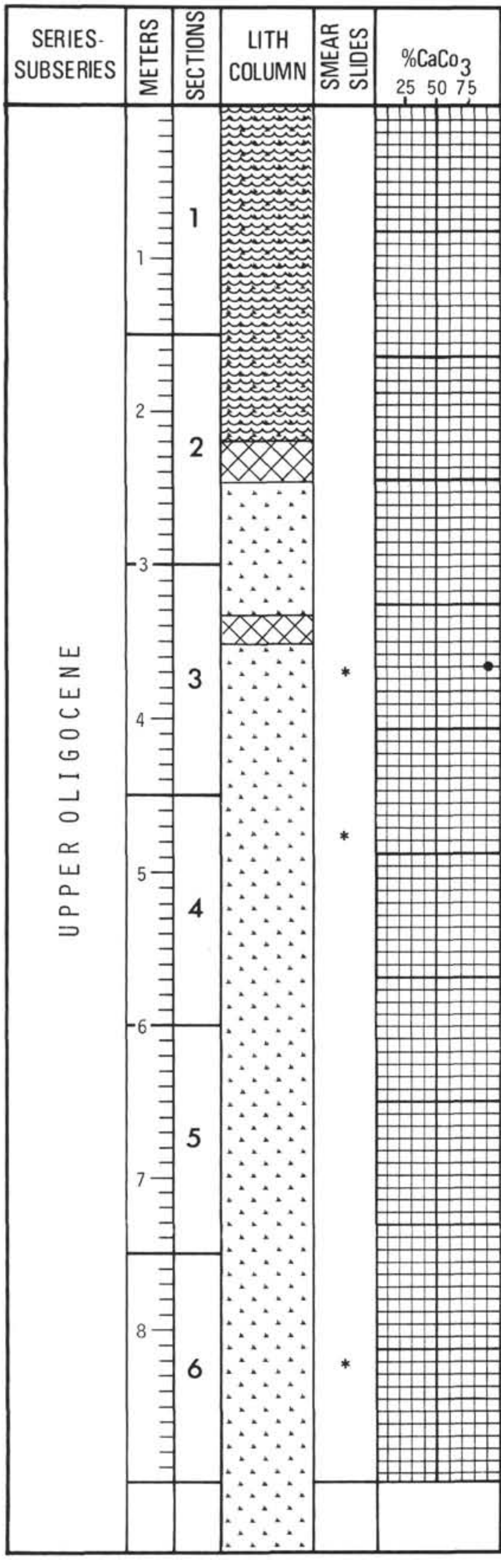



Figure 74. *Hole 78, Core 24, Sections 1 and 2, Physical Properties.*




## LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Massive, no apparent bedding features.

BLUISH WHITE (5B9/1) to LIGHT GREENISH GRAY (5G8/1), foraminiferal (10%-15%) - radiolarian (10%-15%) - calcareous nannofossil (70%-80%) chalk and ooze chalk.

Rare streaks of VERY DUSKY PURPLE (5P2/2) manganese (?) rich ooze.

LIGHT GREENISH GRAY (5G8/1), foraminiferal (15%-25%) - calcareous nannofossil (65%-80%) chalk with 5%-10% radiolarians.

At about 224 m there is an increase in the total $CaCO_3$%. This is reflected in the decrease in radiolarians and increase in the foraminifera (Figure 5). The color of the beds remains the same.

LIGHT GREENISH GRAY (5G8/1), foraminiferal (15%-25%) - calcareous nannofossil (70%-80%) chalk.

Figure 75. *Hole 78, Core 25 (219.4 to 228.6 m).*

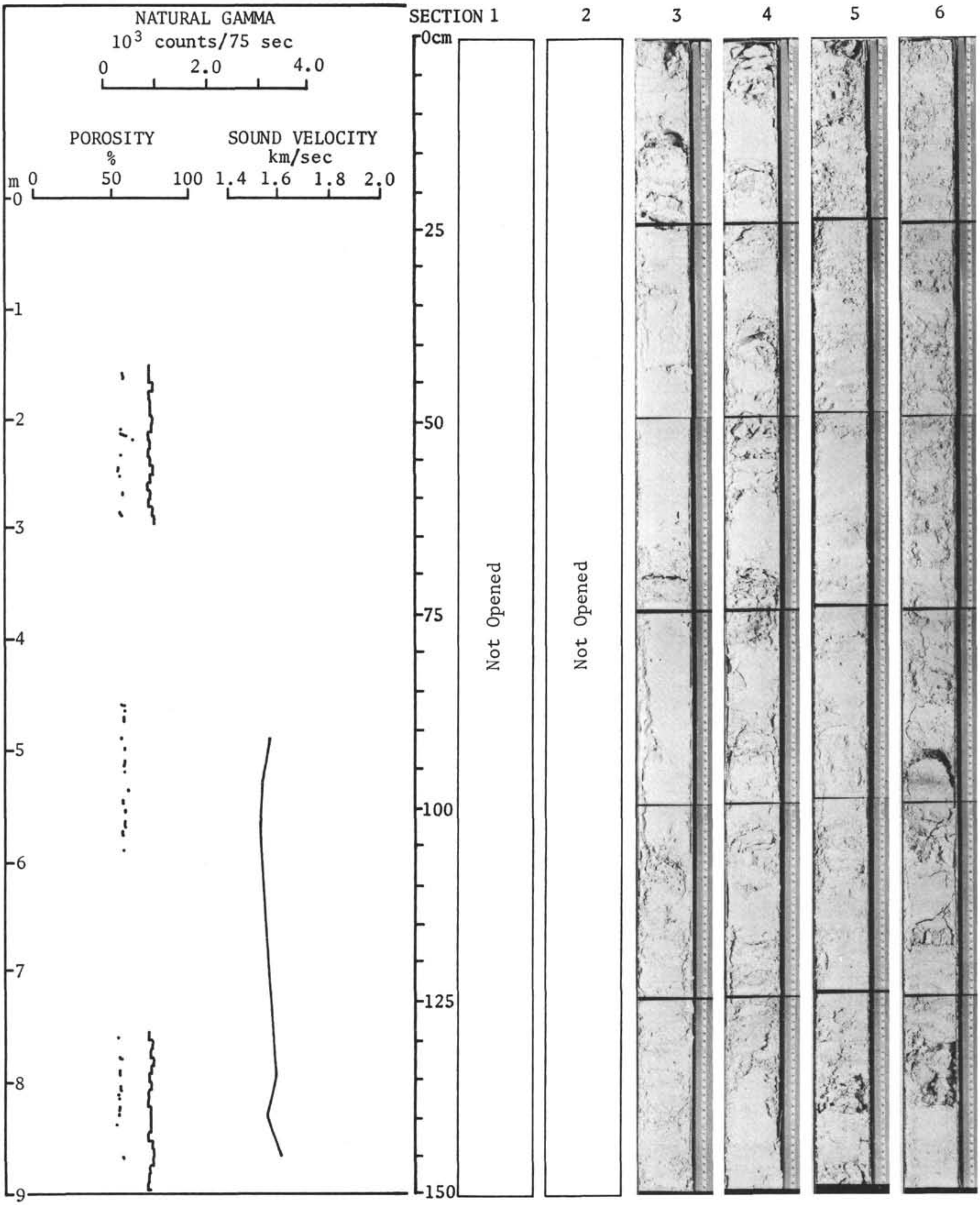



Figure 76. *Hole 78, Core 25, Sections 1-6, Physical Properties.*

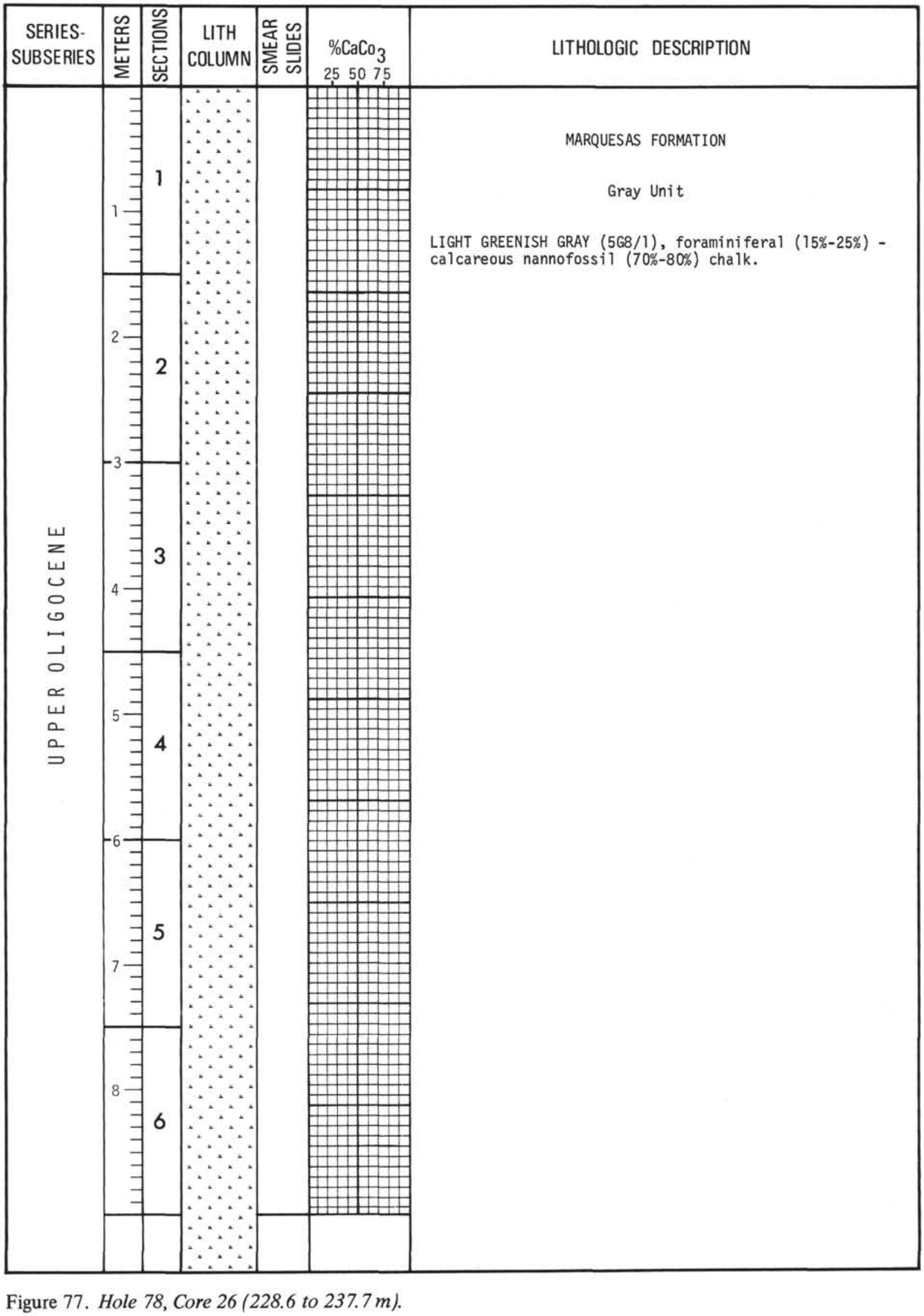



Figure 77. *Hole 78, Core 26 (228.6 to 237.7 m).*

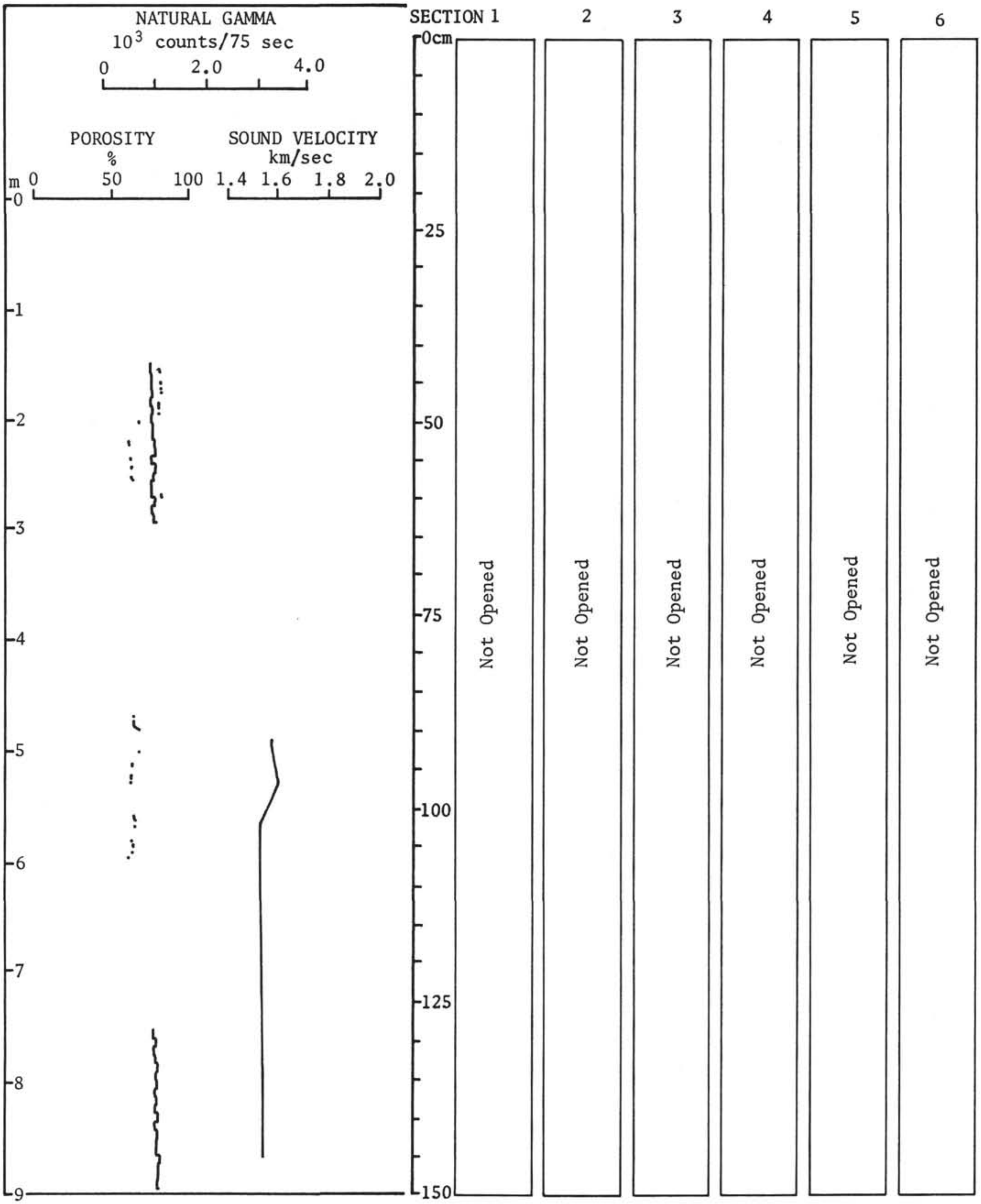



Figure 78. *Hole 78, Core 26, Sections 1-6, Physical Properties.*

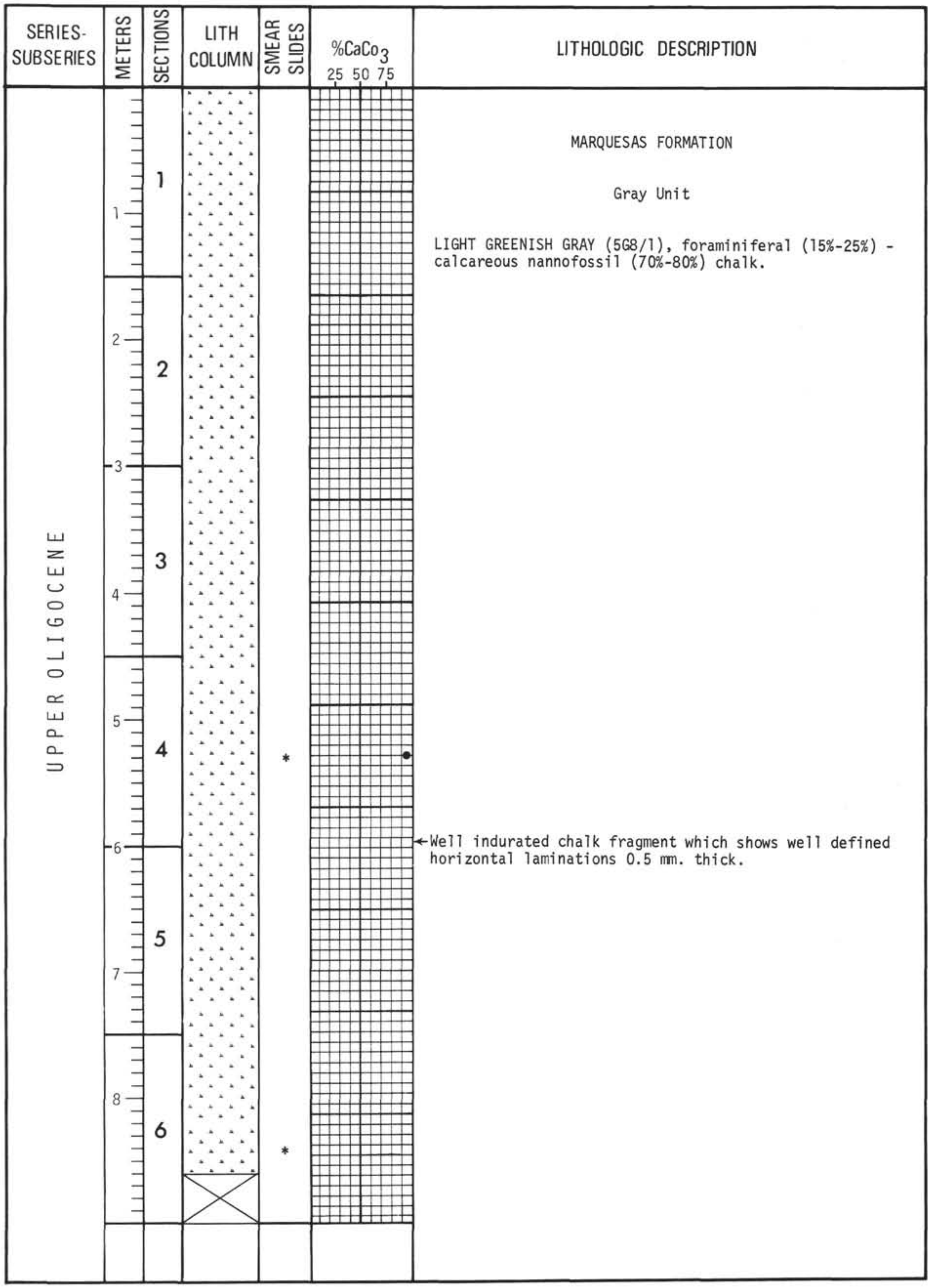



Figure 79. *Hole 78, Core 27 (237.7 to 246.9 m).*

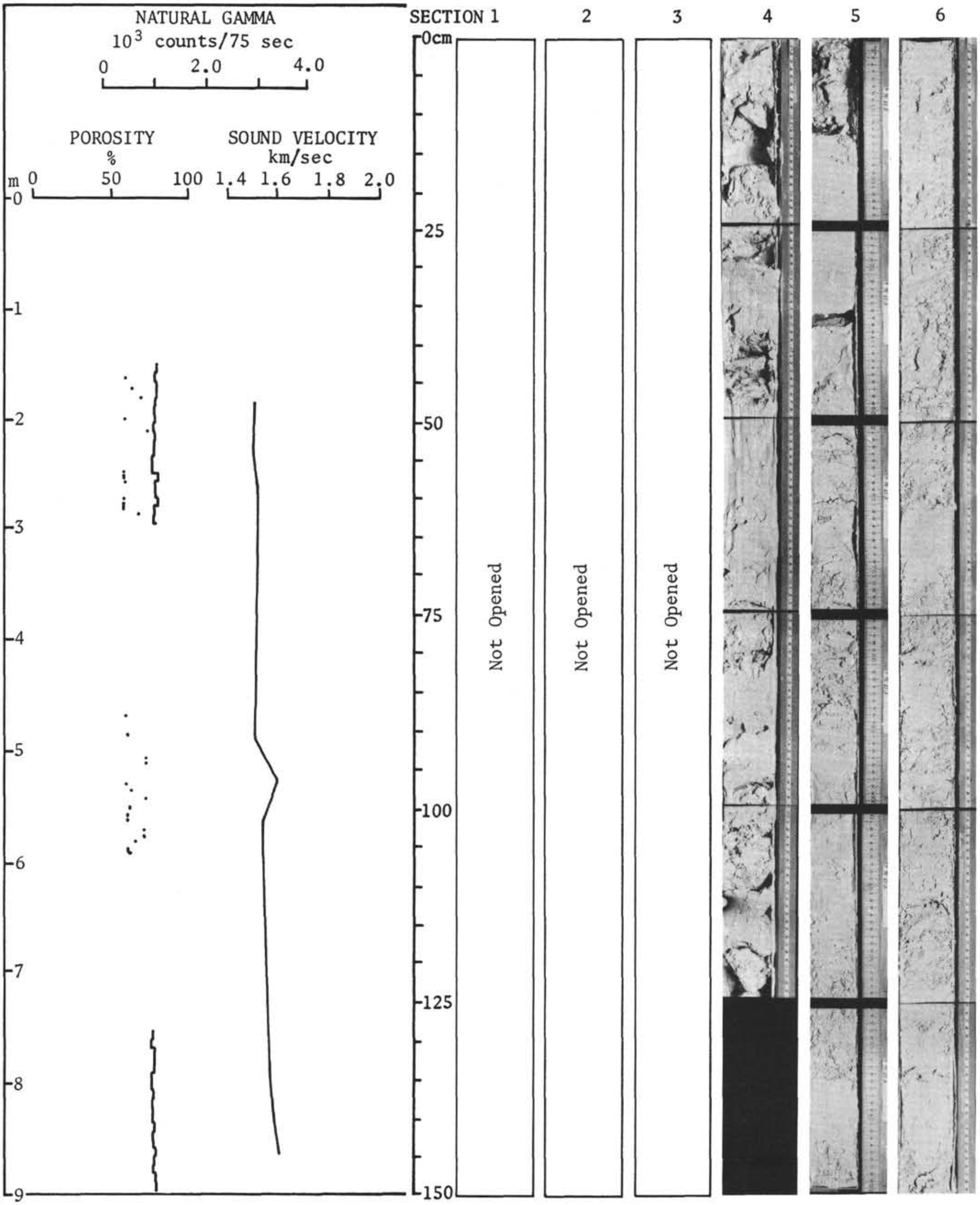



Figure 80. *Hole 78, Core 27, Sections 1-6, Physical Properties.*

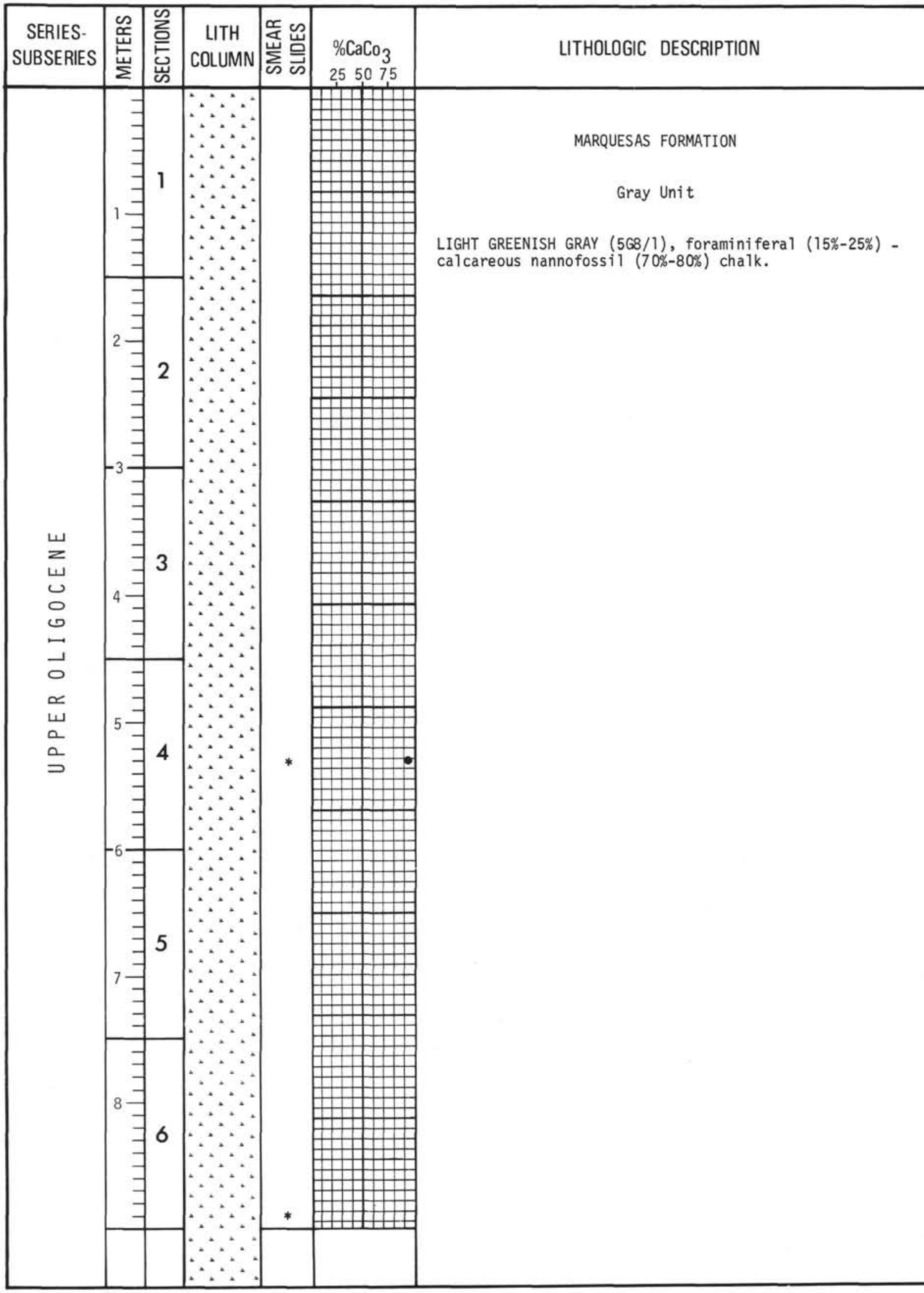



Figure 81. *Hole 78, Core 28 (246.9-256.0 m).*

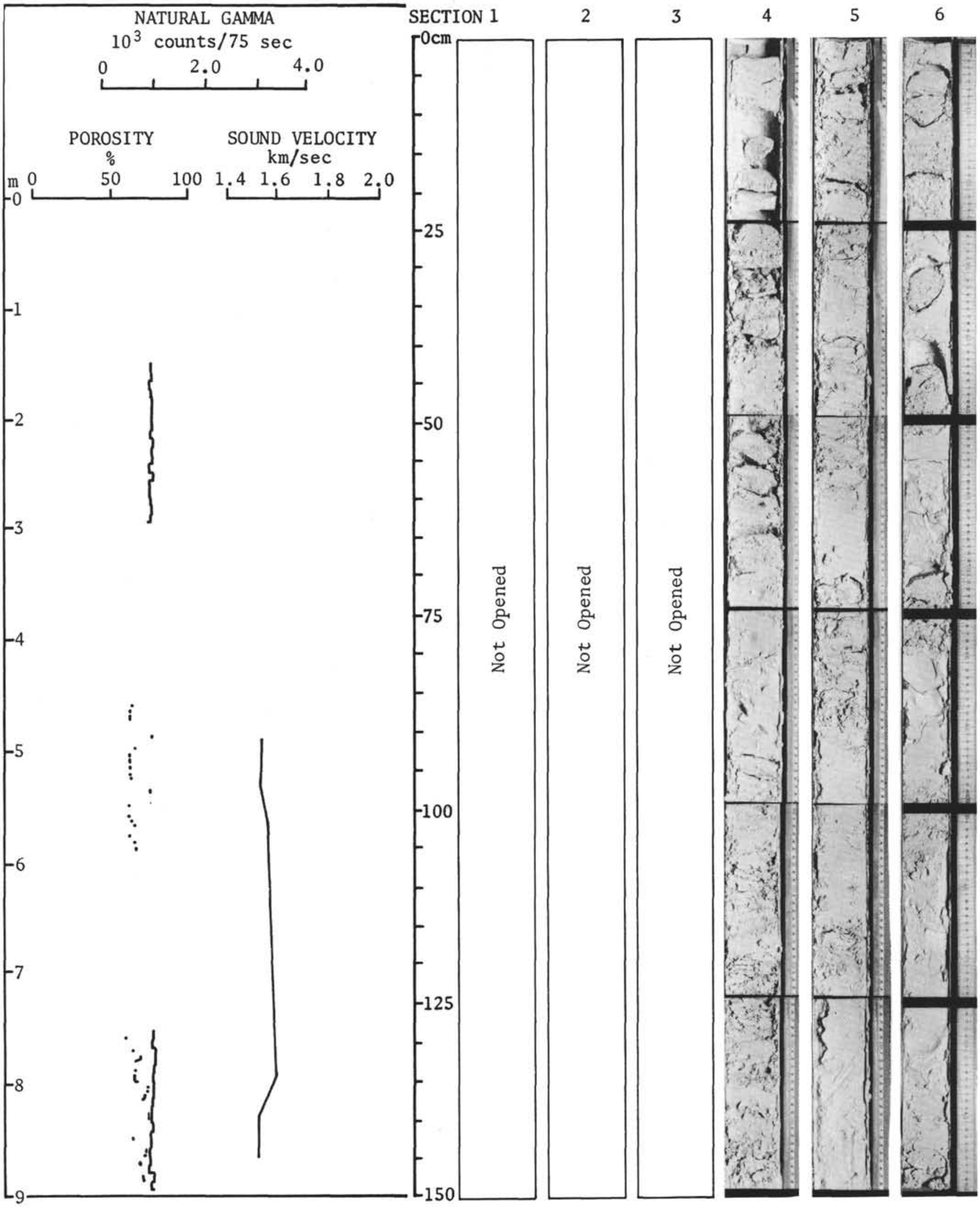



Figure 82. *Hole 78, Core 28, Sections 1-6, Physical Properties.*

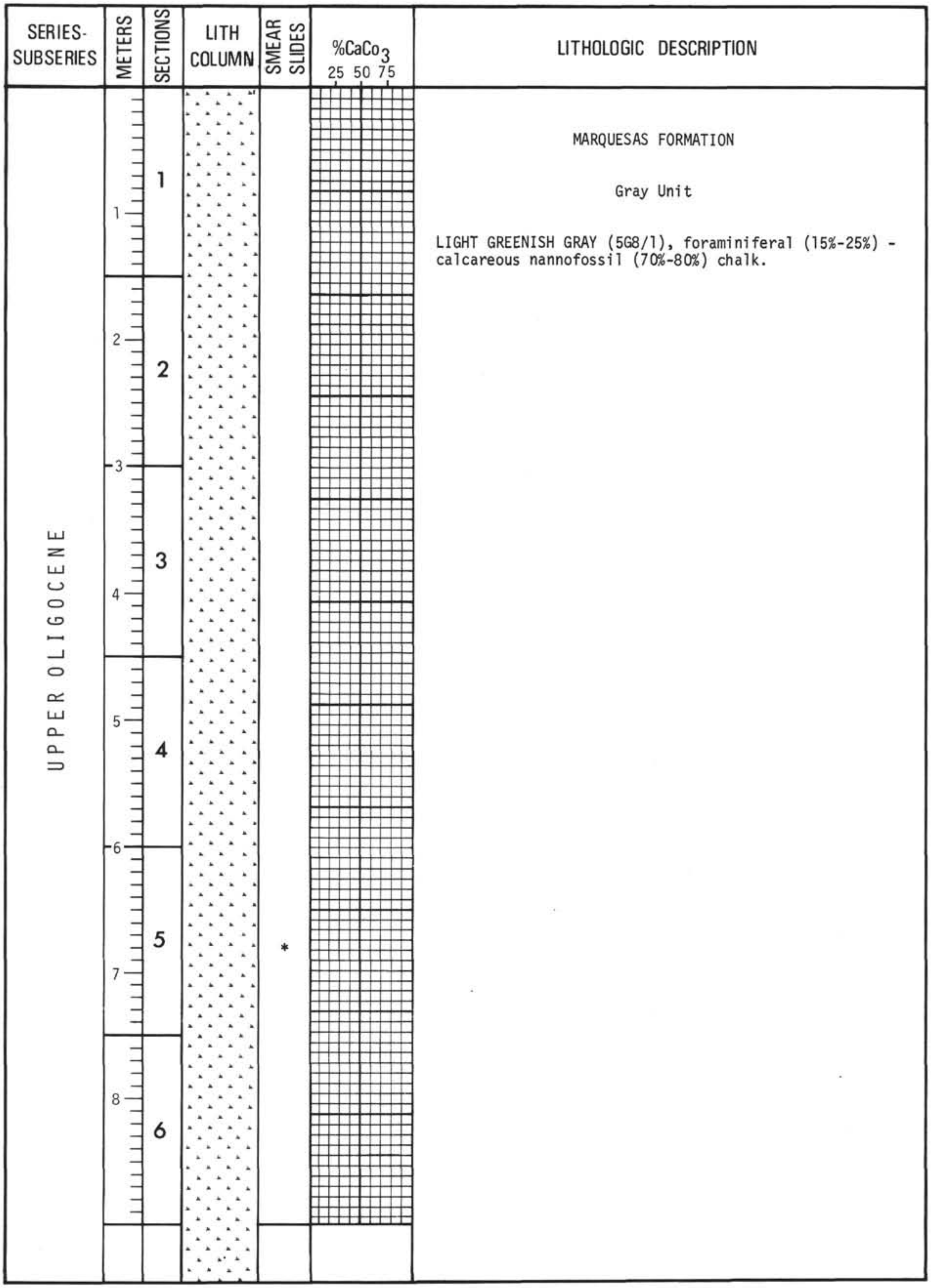



Figure 83. *Hole 78, Core 29 (256.0 to 265.1 m).*

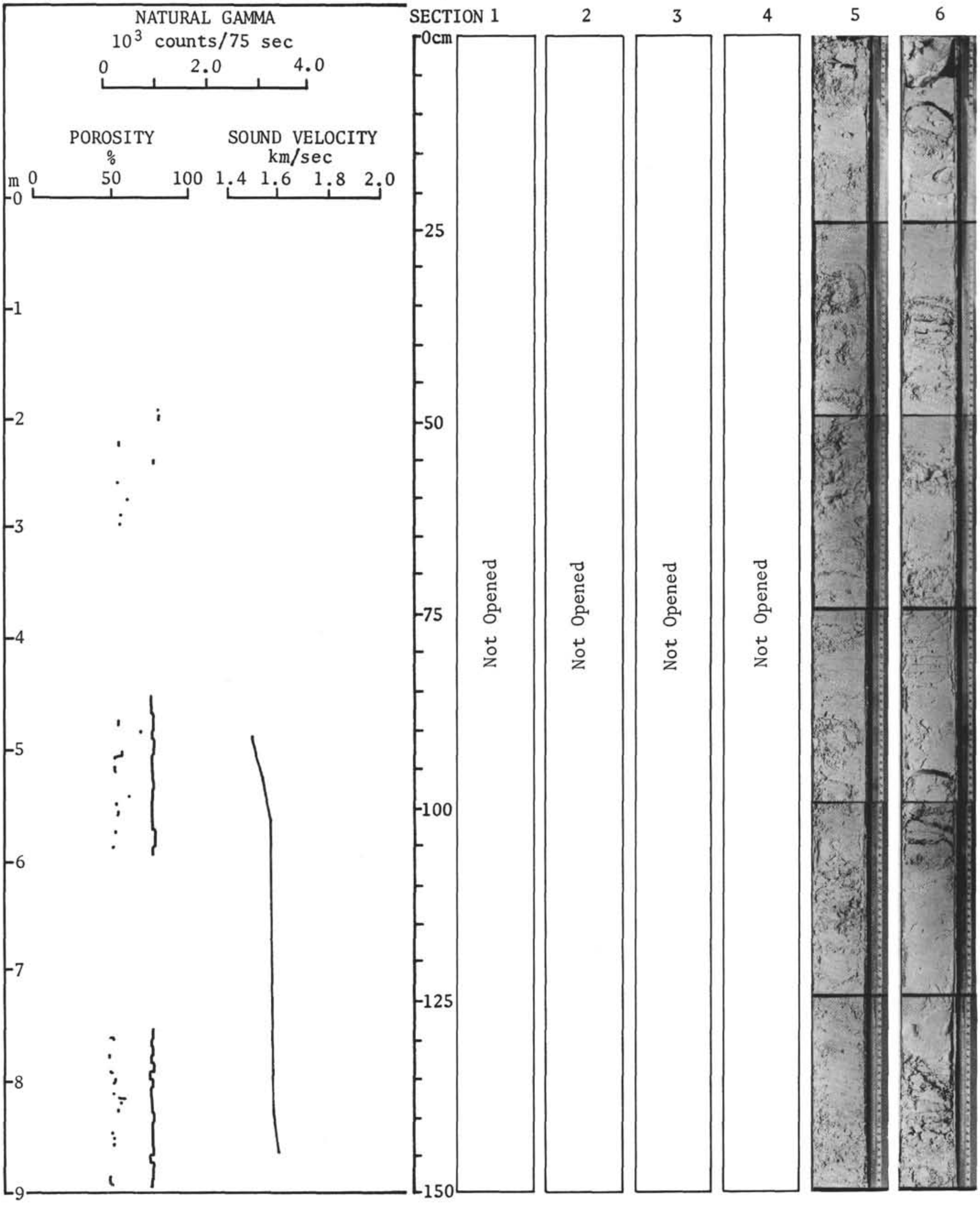



Figure 84. *Hole 78, Core 29, Sections 1-6, Physical Properties.*

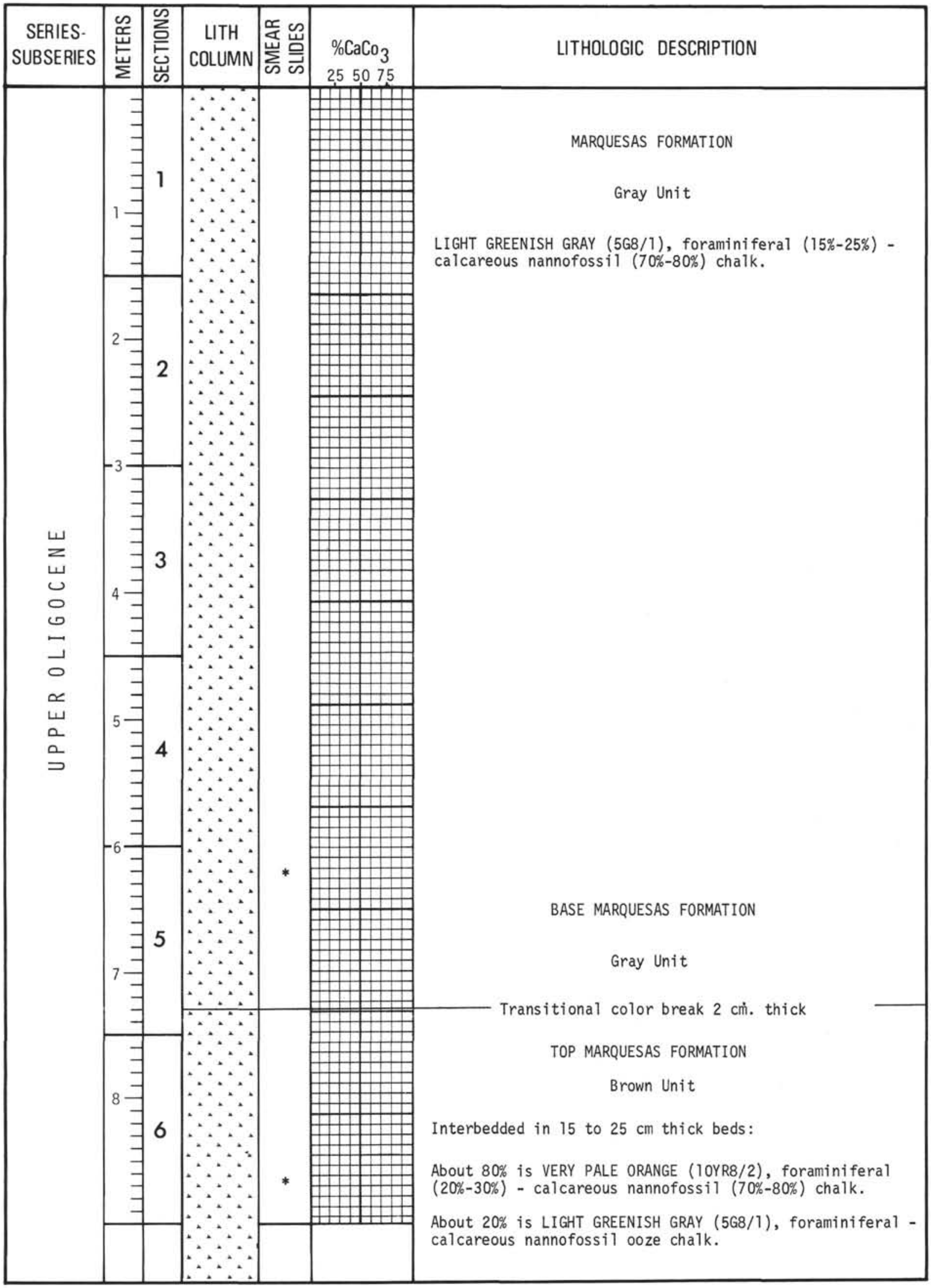



Figure 85. *Hole 78, Core 30 (265.1 to 274.3 m).*

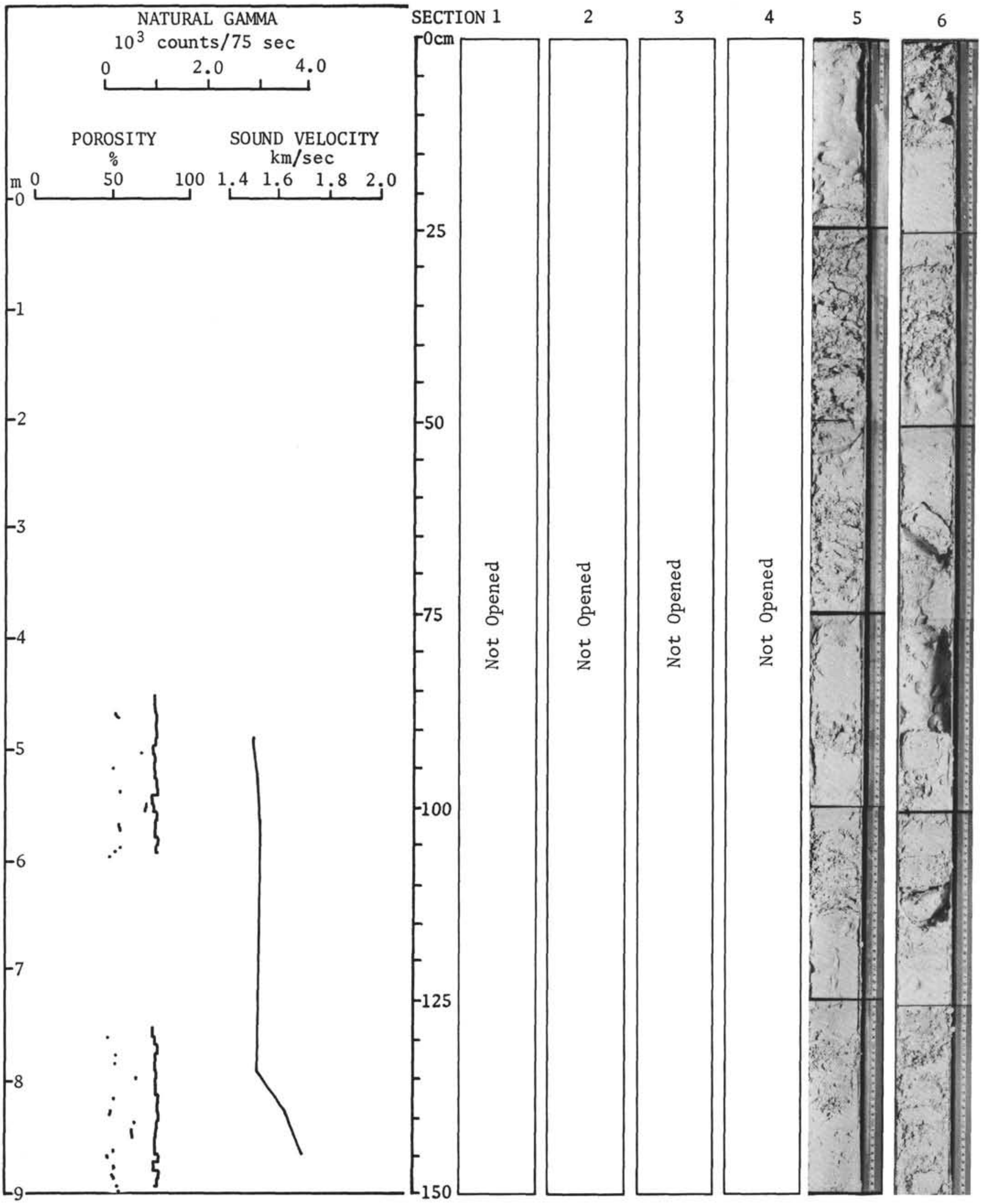



Figure 86. *Hole 78, Core 30, Sections 1-6, Physical Properties.*

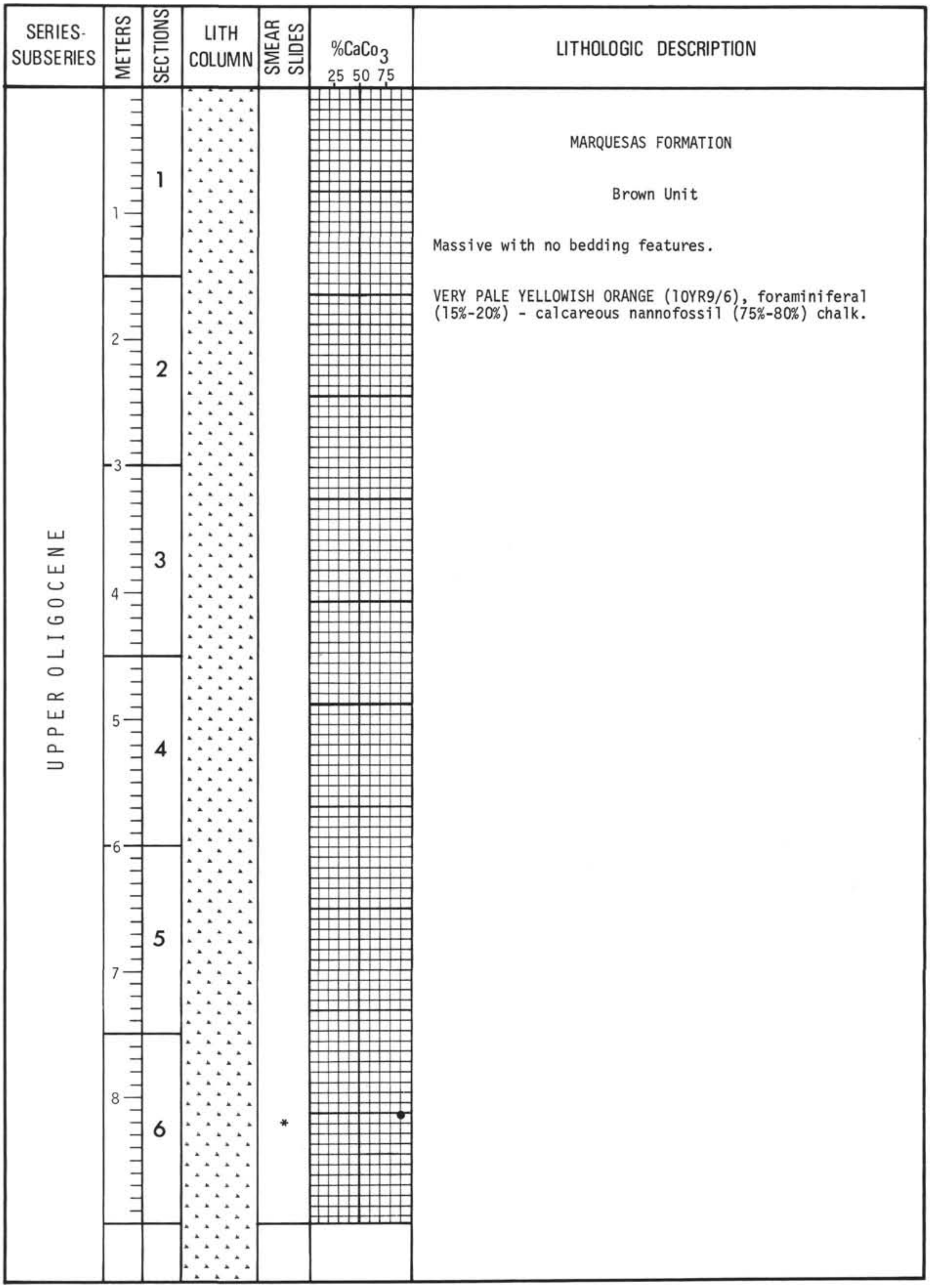



Figure 87. *Hole 78, Core 31 (274.3 to 283.5 m).*

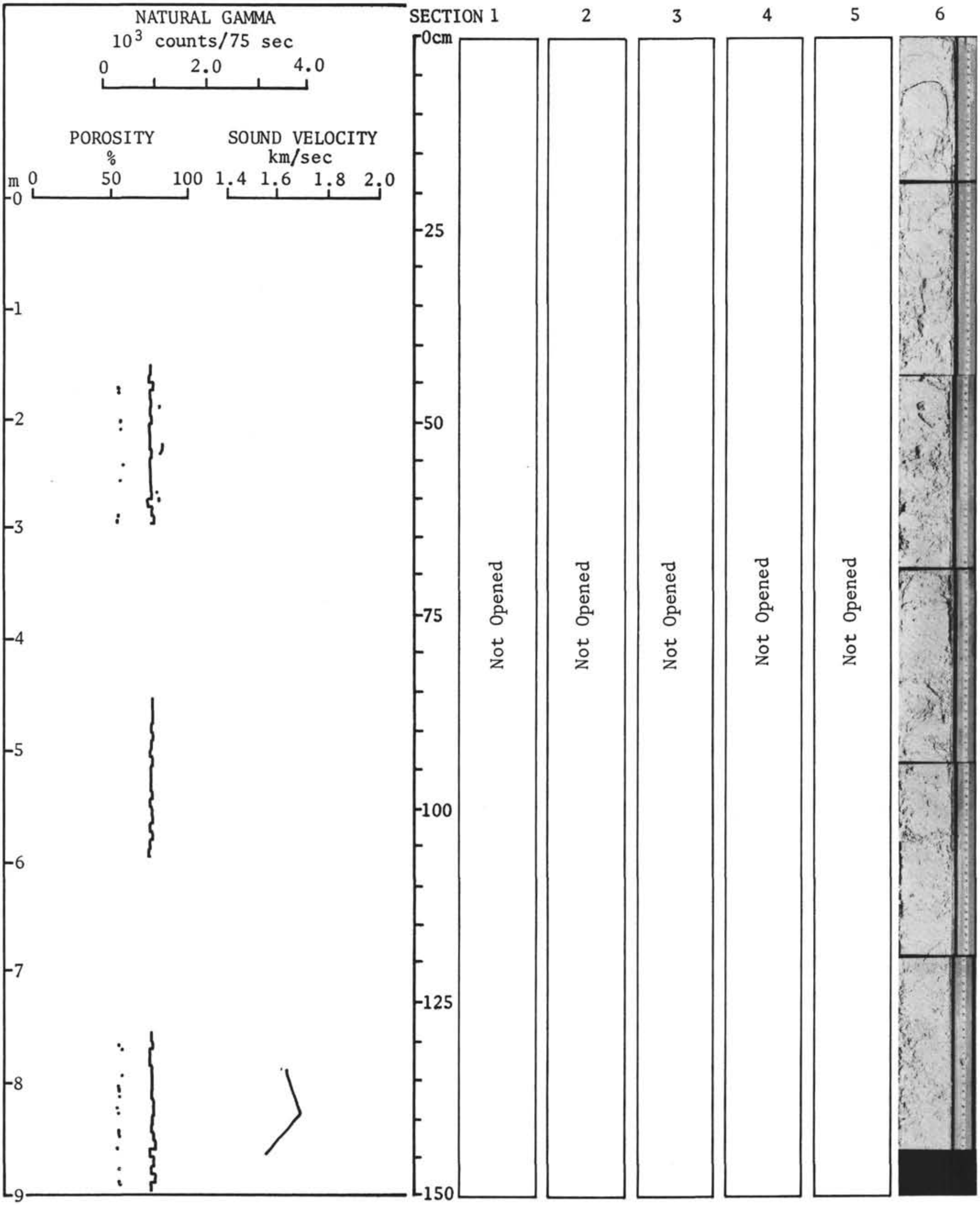



Figure 88. *Hole 78, Core 31, Sections 1-6, Physical Properties.*

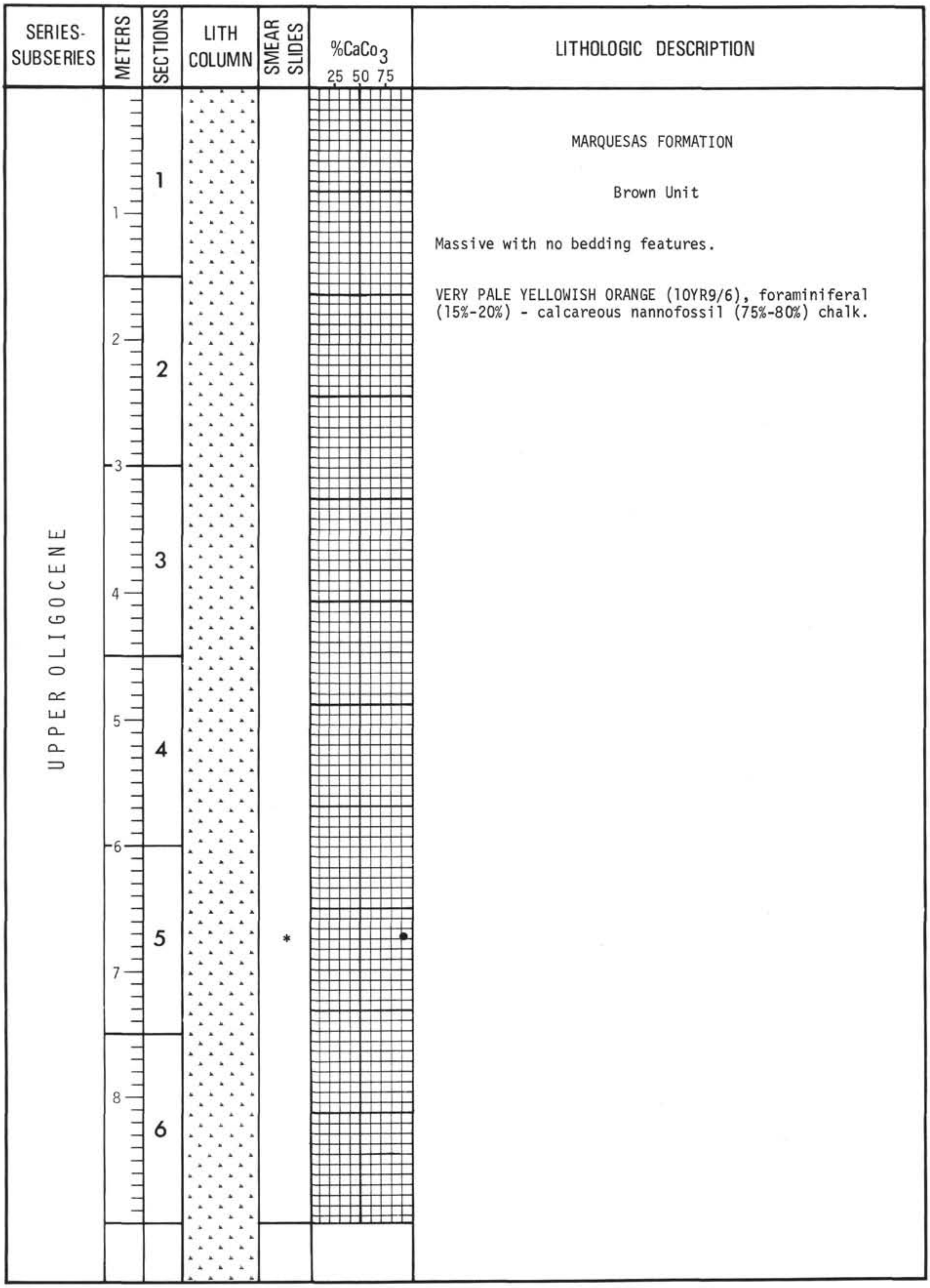



Figure 89. *Hole 78, Core 32 (283.5 to 292.6 m).*

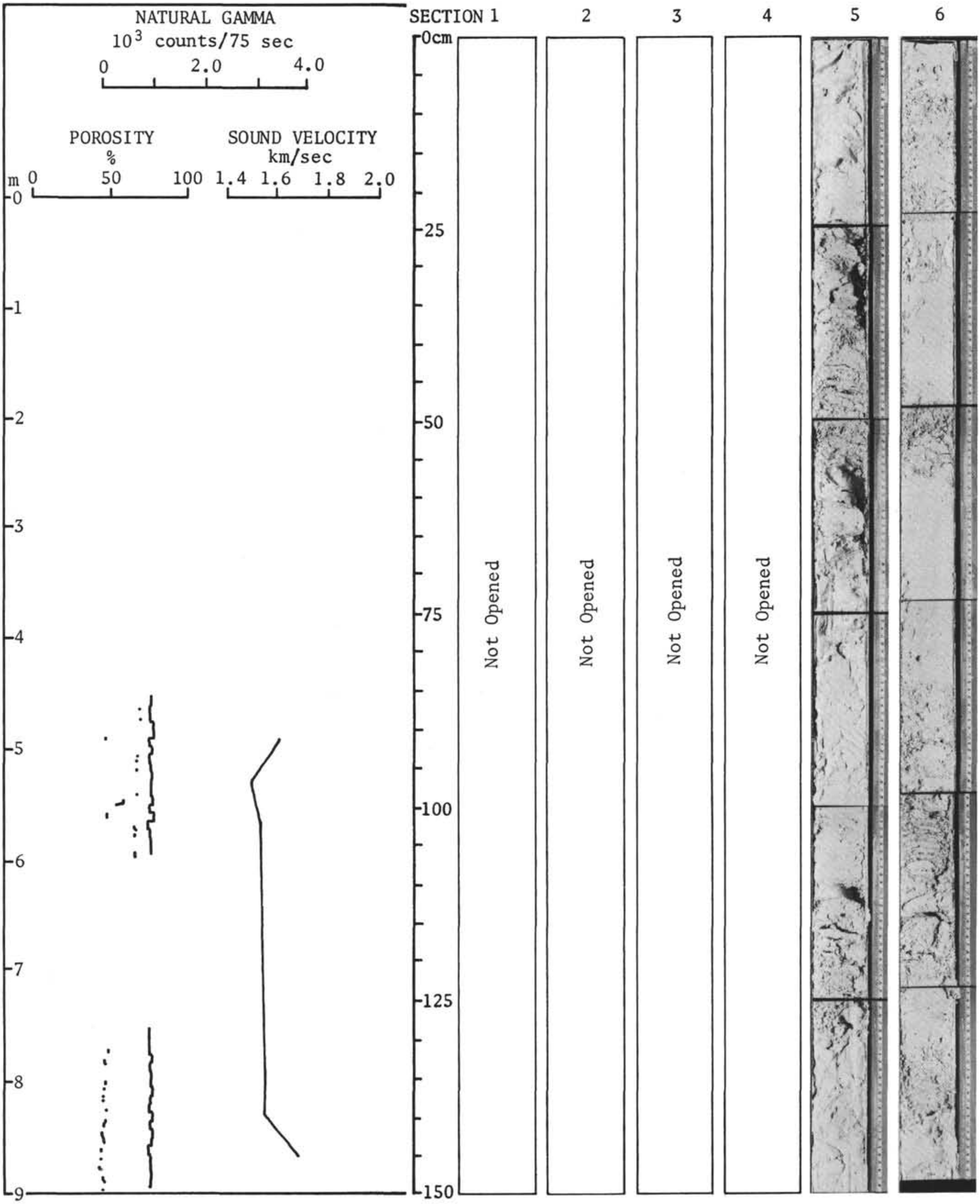
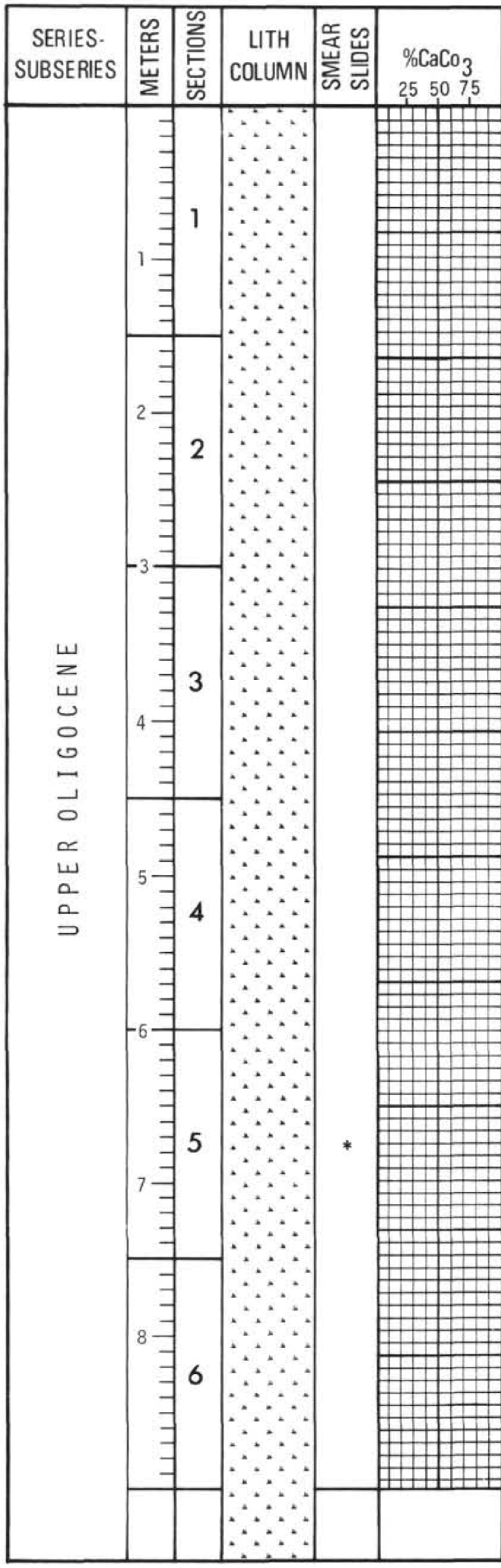



Figure 90. *Hole 78, Core 32, Sections 1-6, Physical Properties.*




LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Brown Unit

Massive with no bedding features.

VERY PALE YELLOWISH ORANGE (10YR9/6), foraminiferal (15%-20%) - calcareous nannofossil (75%-80%) chalk.

Figure 91. *Hole 78, Core 33 (292.6 to 301.7 m).*

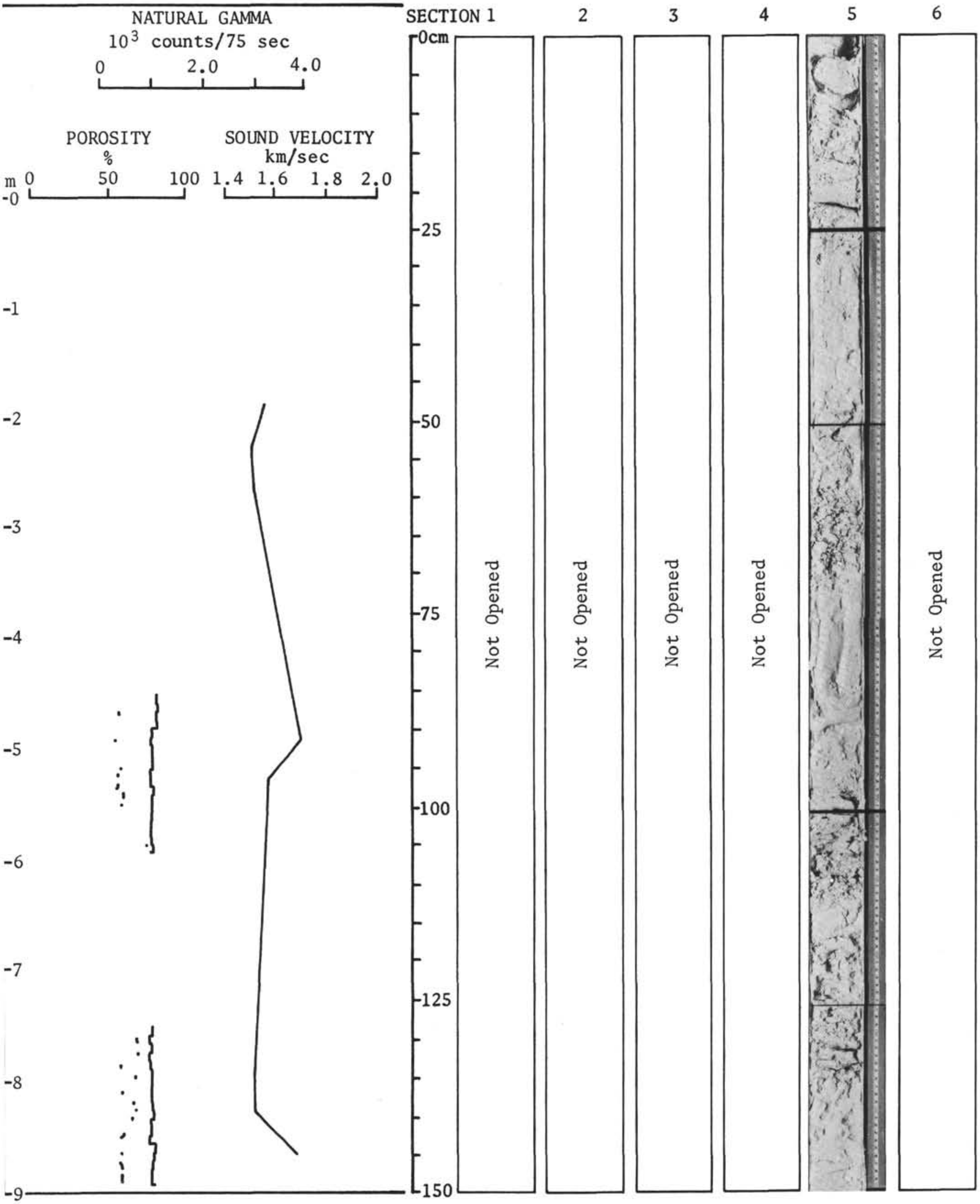


Figure 92. *Hole 78, Core 33, Sections 1-6, Physical Properties.*

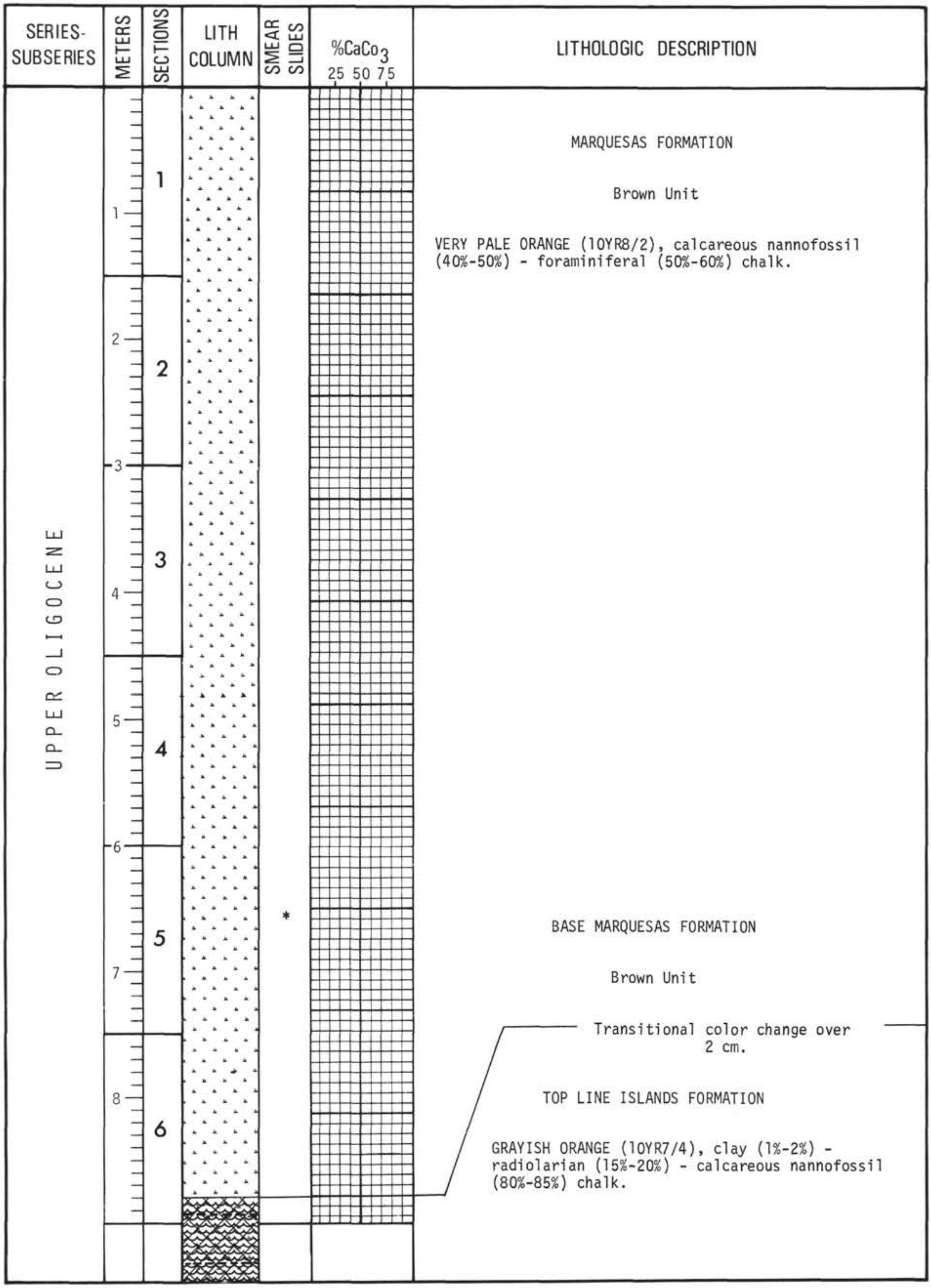



Figure 93. *Hole 78, Core 34 (301.7 to 310.9 m).*

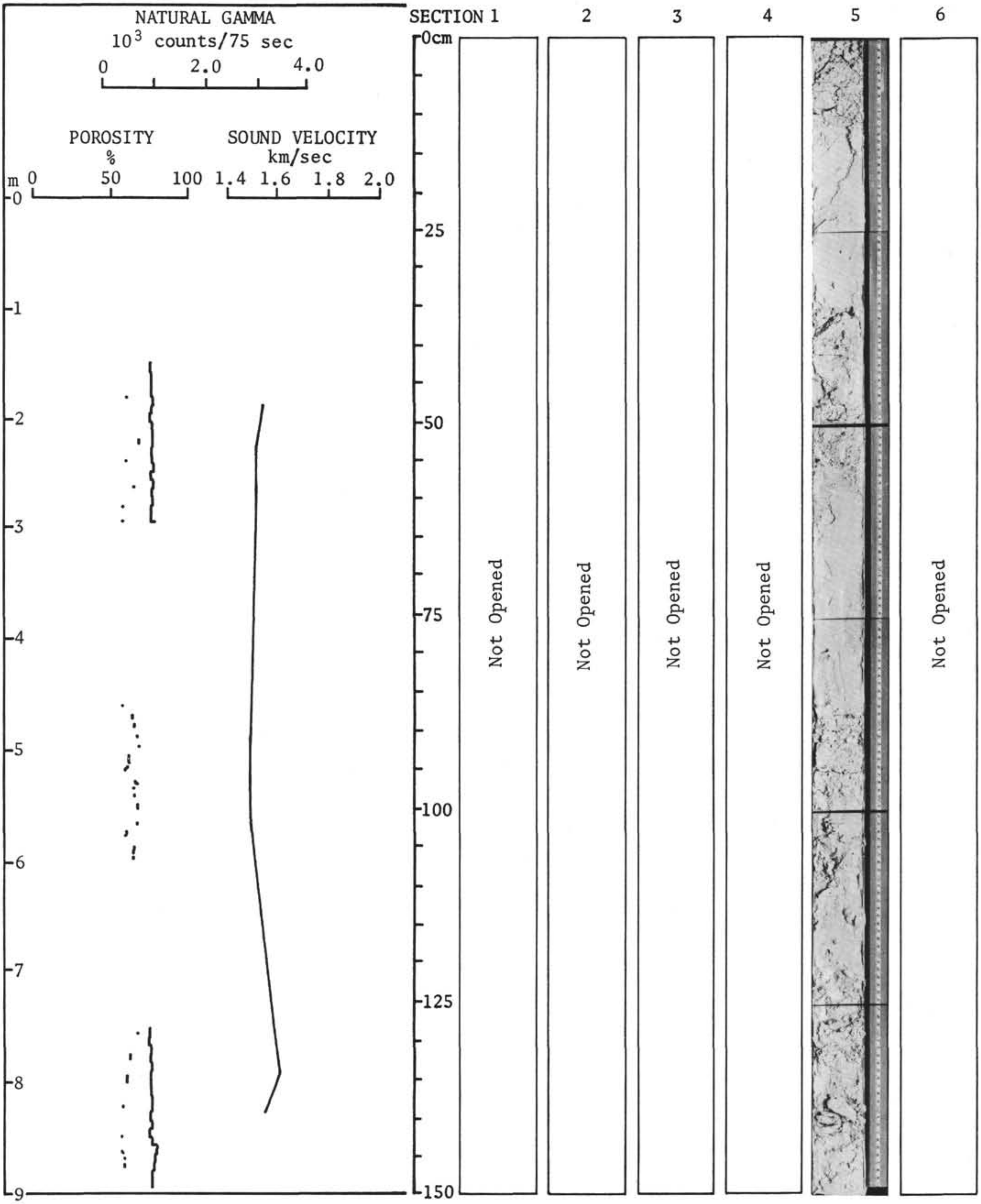



Figure 94. *Hole 78, Core 34, Sections 1-6, Physical Properties.*

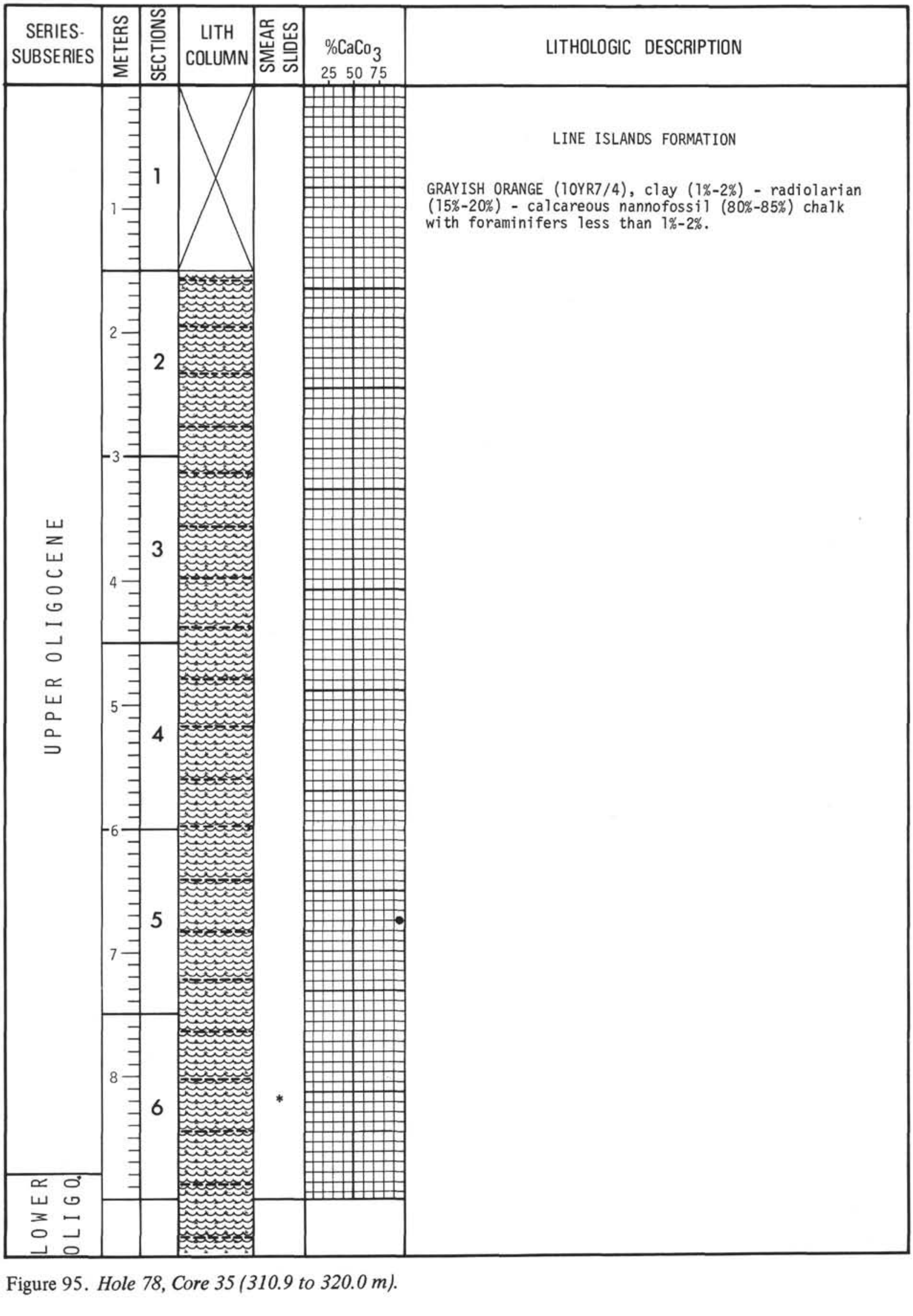



Figure 95. *Hole 78, Core 35 (310.9 to 320.0 m).*

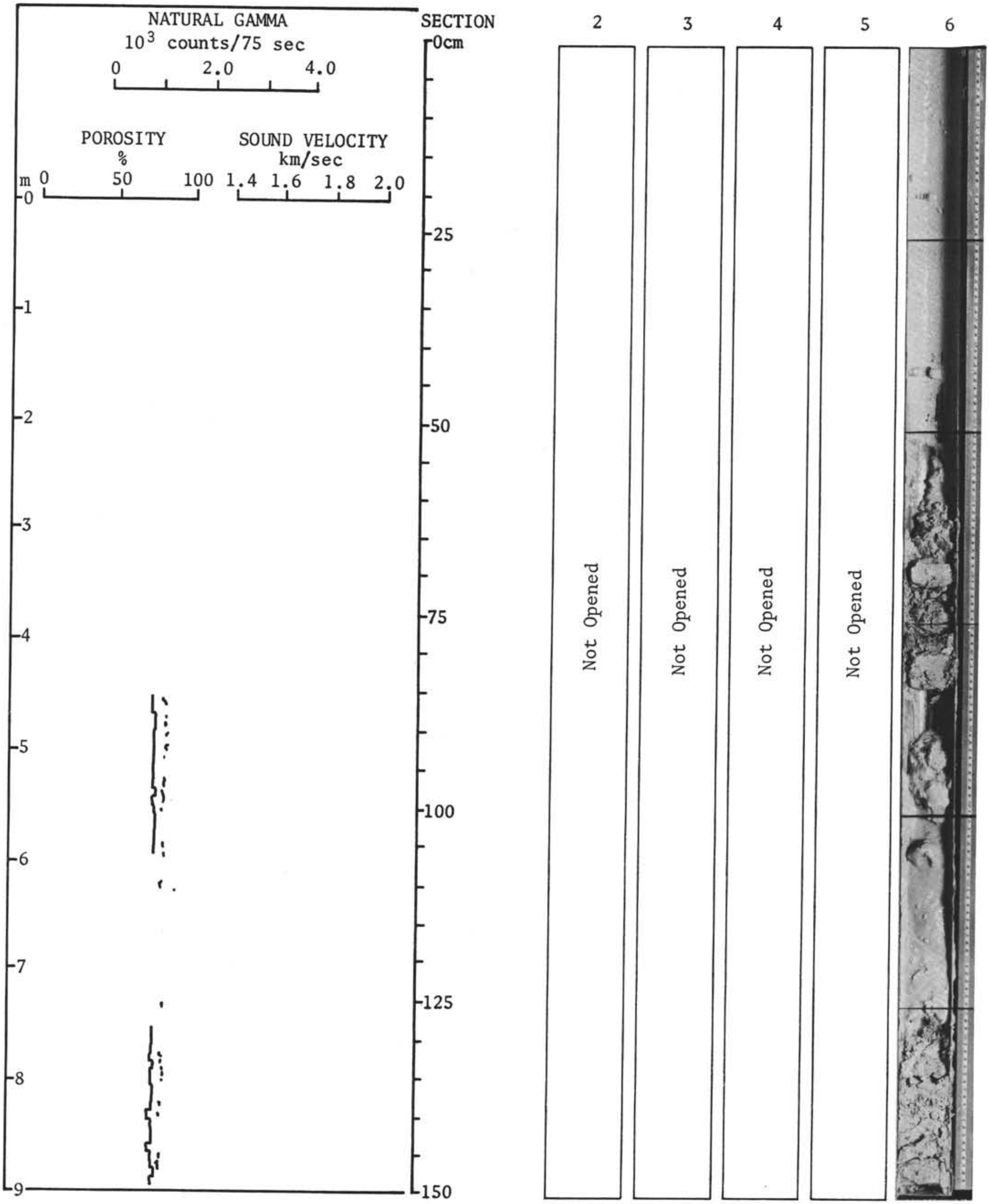



Figure 96. *Hole 78, Core 35, Sections 2-6, Physical Properties.*

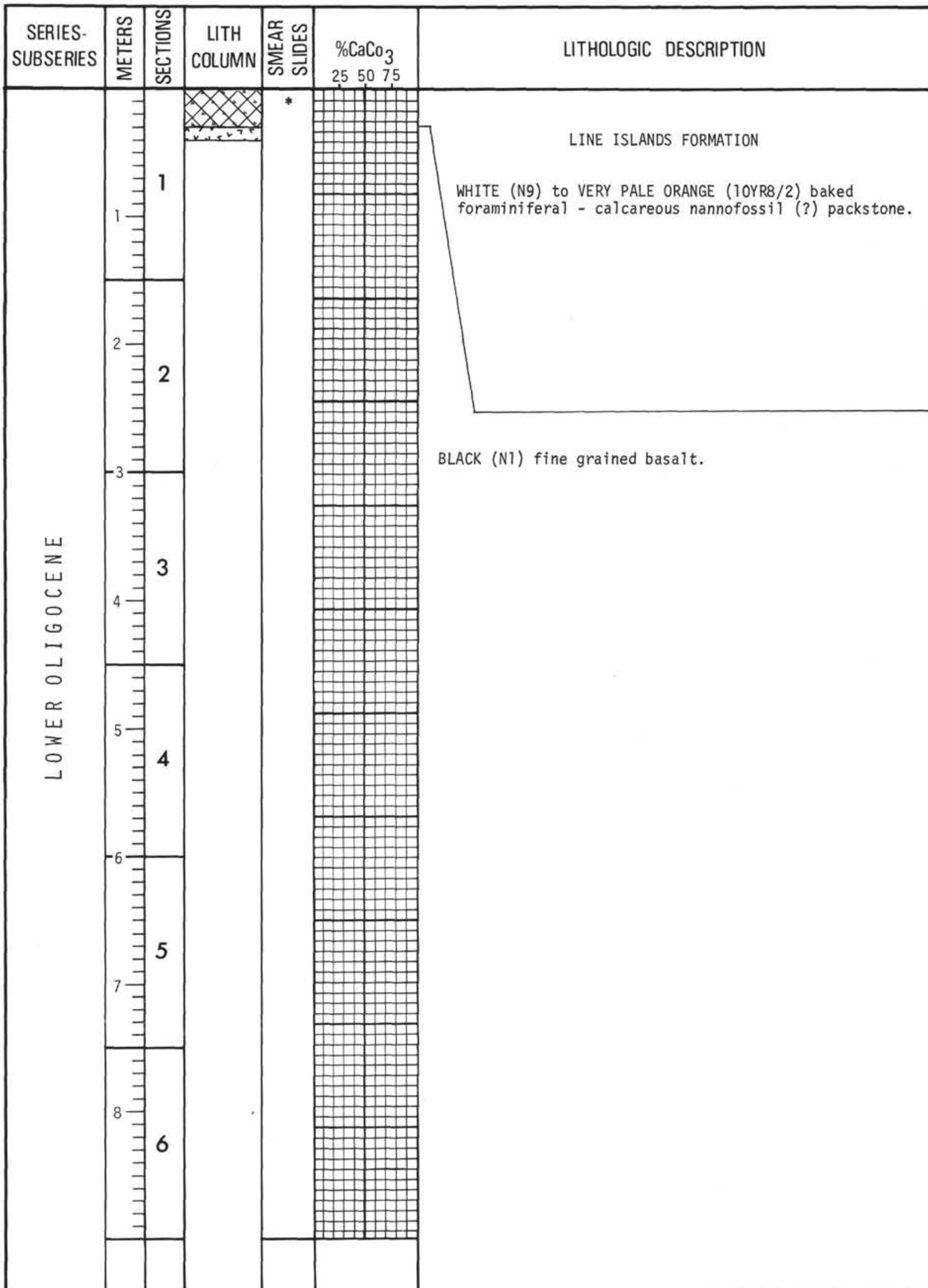



Figure 97. *Hole 78, Core 36 (320.0 to 320.3 m).*

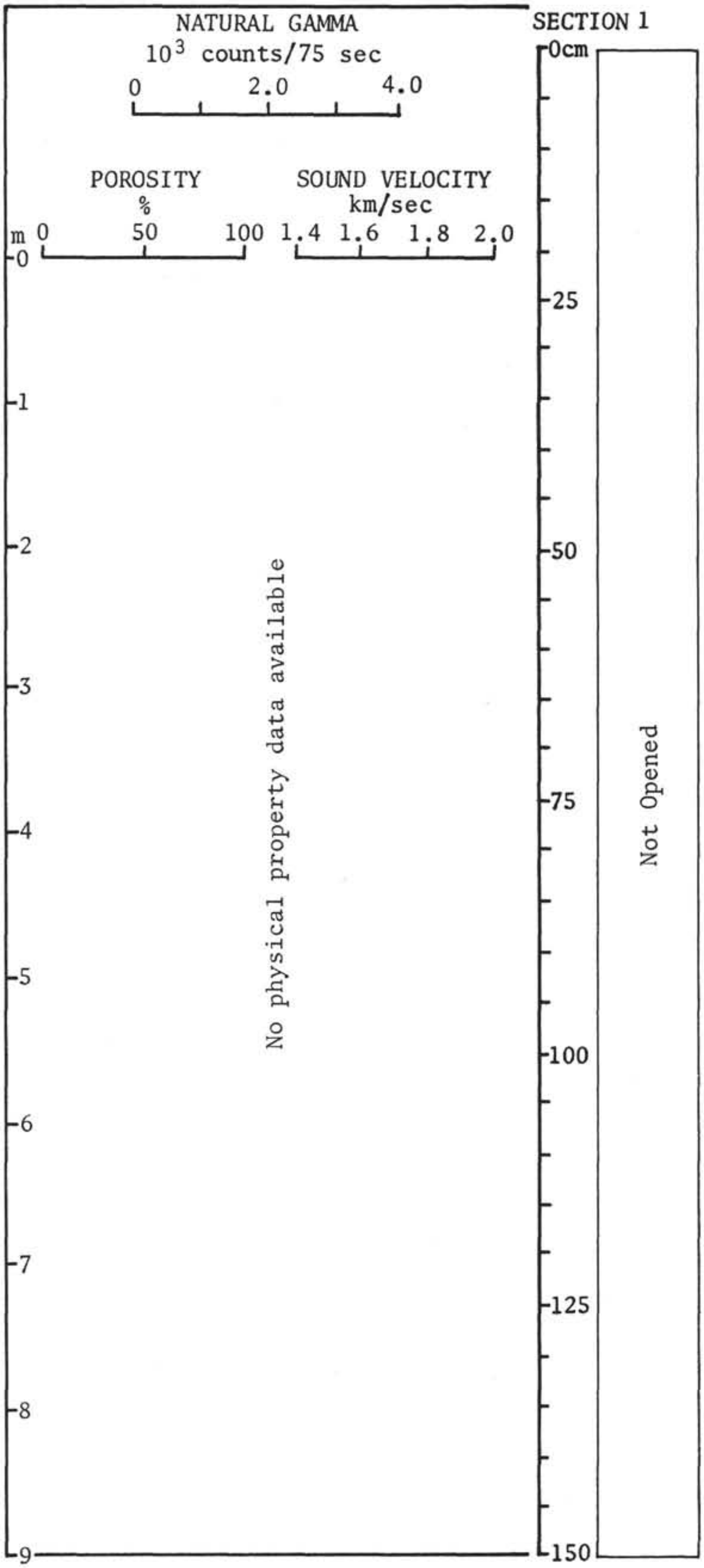



Figure 98. *Hole 78, Core 36, Section 1.*

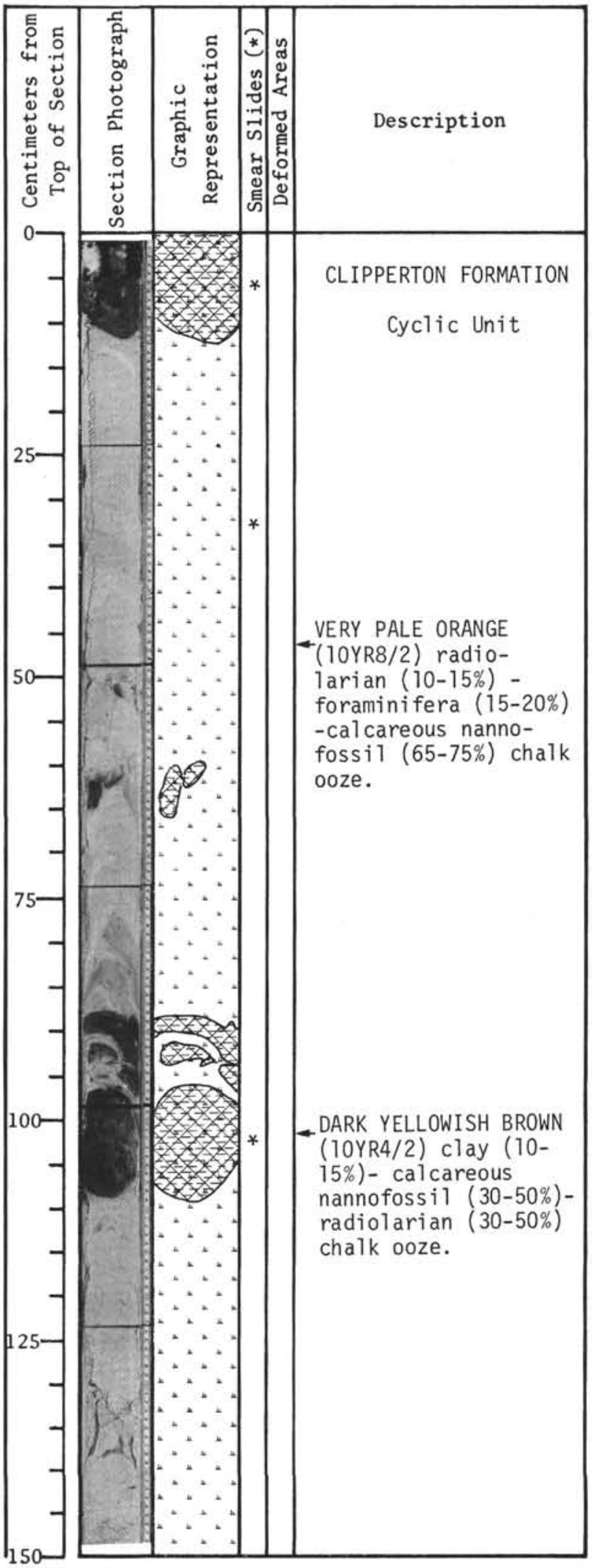



Figure 99. *Hole 78, Core 3, Section 3.*