3. SITE 77

The Shipboard Scientific Party[1]

MAIN RESULTS

Four holes were drilled at this site and 481 meters of sediment continuously cored. The bit was stopped at its deepest penetration by basalt which is immediately overlain by three inches of baked, brecciated limestone that, in turn, is overlain by 18 meters of dusky brown iron-manganese rich clay of upper Eocene age. The estimated age of basement at this site is 36 ±1 million years B.P. The average rate of accumulation at this site is 13 m/m.y. The rates of accumulation progressively increase from the base of the column to the top. With the exception of the lower 18 meters, the sediments consist of alternating siliceous calcareous oozes and calcareous siliceous oozes that grade downward into chalks. Abundant foraminifera, Radiolaria, coccoliths and diatoms are present throughout the section above the basal 18 meters. If hiatuses occur in the sequence at this site they are probably of short duration.

INTRODUCTION

Background and Objectives

Site 77 is located on the southern flank of the thick accumulation of sediment underlying the tropical Pacific. It lies just to the south of the crest of this sediment accumulation and just to the north of the Equator (Figure 1). The objectives of drilling this site as stated by the Pacific Advisory Panel were to core as complete a sediment section as possible for paleontologic and stratigraphic studies and recover samples of basement rock. In addition, the scientific staff of Leg 8 had delineated a series of lithologic units by their north-south line of sites along 140° West longitude. Our Site 77, therefore, gained importance as a connection between the north-south traverse of Leg 8 and our east-west traverse.

In the perspective of current ideas of sea floor spreading, Site 77–being the westernmost of the scheduled Leg 9 sites–should be underlain by a sequence of sediments containing at their base older sediments than any of the other proposed sites. In the light of these considerations it seemed appropriate to continuously core this site to obtain as temporally long a continuous section as possible which could serve as a standard for the later Leg 9 sites and as a basis of comparison with Leg 8.

The pre-site survey by the *Argo* showed that the area of Site 77 is characterized by water depths of between 2250 and 2290 fathoms (uncorrected), a relief of low hills ranging from 25 to 50 fathoms and two to five miles wide. These hills are a direct reflection of irregularities in the basement surface. Basement here is indicated by a strong reflector beneath which there is no stratification. Overall sediment thickness is about one-half second of reflection time.

Operations

Site Survey

Upon arrival at the prescribed location of Site 77, the *Glomar Challenger* survey began by making a square, two miles on a side. The sediment in the area consists of an upper, highly stratified section, averaging about 0.37 second (reflection time) and a lower, more transparent layer, of approximately 0.13 second of reflection time (Figure 2). The thickness of the upper stratified layer is relatively uniform throughout the area, but the thickness of the lower transparent layer is irregular. Its thickness is controlled, primarily, by basement relief, thinning over basement highs and thickening in basement depressions. During the site survey the position of the thickest, lowest transparent layer was marked. At the conclusion of the survey, the location with the thickest, lowest transparent layer and therefore the thickest total sediment was selected as the drilling site.

Coring

When the chosen site was reached a Burnett beacon was dropped. Upon reaching the bottom the repetition rate of this beacon slowed slightly to a repetition rate of 2.3 pulses per second, which is too slow to be accepted by the computer. Since the beacon was signalling and there was no way of silencing it, it was necessary to move the ship out of the range of this beacon and to drop a second beacon. Accordingly, the ship was moved in a northerly direction which our site

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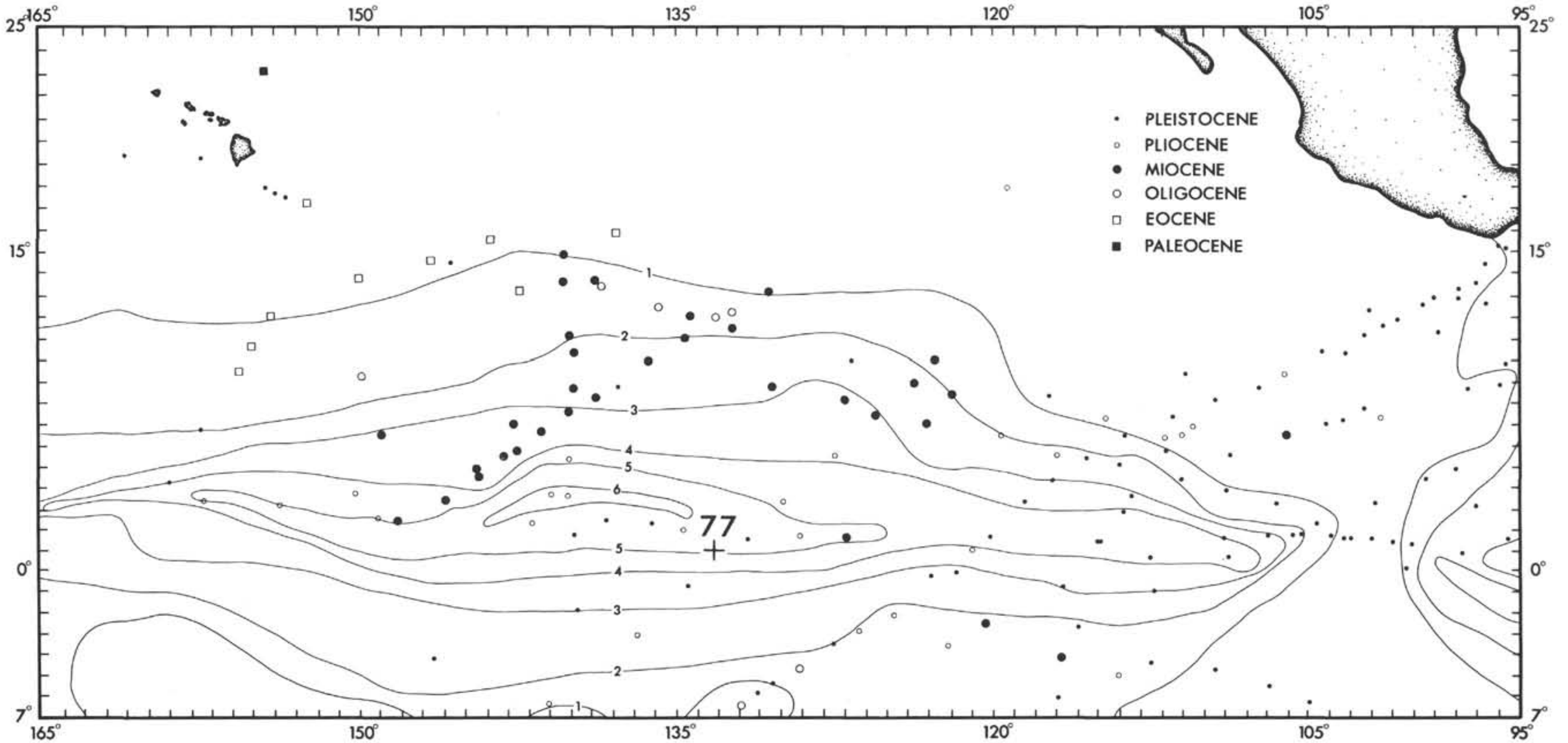

Figure 1. *Location of Site 77; sediment isopachs in hundreds of meters after Ewing et al. (1968); distribution of piston core ages after Hays et al. (1969).*

survey and the survey of the *Argo* suggested was the trend of the basement ridges and valleys, thereby maintaining the same general geologic setting of our original site, and the same sediment thickness. The ship was moved two miles to the north and a second Burnett beacon was dropped. This one had a repetition rate within the tolerance of the computer and we proceeded to assemble the drill string.

Since Leg 8 had encountered cherts just to the west of our site we decided to use the three cone Smith button roller bit in case chert was encountered, since this bit was certainly most suitable for drilling cherts. The drill string was run down and encountered the sea floor at a depth of 4291 meters below sea level. Coring was started at the sea floor by punching the bit into the sediment without rotating. Pertinent data concerning the coring operations are presented in Tables 1 and 2. The first core recovered only 1.4 meters of sediment, suggesting that this core recovered the sediment at the sea floor. The bit was pulled above the sea floor and respudded (Core 77A-1), this time recovering a full barrel. Core 77A-2 was difficult to retrieve; the sand line returned to the drill floor twice without recovering the inner core barrel. Strong circulation was applied hoping to wash out any sediment that may have accumulated above the inner core barrel. On the third attempt the inner core barrel was returned to the drill rig floor. Inspection of the core barrel showed that the large check valve failed to seat; the large checkvalve ball and seat were missing; and, the liner had started to collapse in six places. Because of the strong circulation which had been applied to retrieve the core barrel the bit was raised above the mud line and respudded at a fresh locality (Hole 77B) and coring continued. In general, coring was accomplished without difficulty except for Core 35 in which there was no recovery because the core catcher was reversed. The drilling rate in the 18 meters of stiff clay that overlies basement at this site was considerably slower than the rate in the overlying oozes and chalks (Table 2). About a foot of basalt was recovered in four hours of drilling below the stiff clay.

Throughout most of our stay at this site, the ship maintained its position within a couple of hundred meters. The maximum excursion occurred between Cores 42B and 43B when the ship moved more than 300 meters from the epicentral position. This loss of position was due to a burned out relay in the computer.

Most of the cores in the upper 100 meters of the section at this site are highly disturbed. One possible cause of this disturbance is the large diameter of the bit face compared with the size of the opening that the sediment passes through going into the inner core barrel. A possible way to eliminate the effect of the large diameter cutting surface is to add an extension to the lower end of the inner core barrel that will extend through the bit opening a foot or so below the bit so that the cutting edge of this extension encounters sediments undisturbed by the bit. Such an extension was made on the ship and attached to the inner core barrel. On the completion of the basalt drilling, the bit was lifted above the mud line and the inner core barrel with the extension was dropped. We chose to recore Core 77B-10 since this core contains well-defined laminations. Unfortunately, the disturbance in the core recovered with this modified core barrel was comparable with the disturbance encountered with the normal core barrel. After the cutting of this last core (77C-1) the drill string was recovered. When the bit reached the drilling platform it showed very little wear. One button was broken and several were torn, but otherwise the bit was in excellent condition.

LITHOLOGY

These sediments are divided into three lithologically distinct formations, two of which are subdivided into formal units (Figures 3 through 8): the Clipperton Oceanic Formation (0 to 172.5 meters) which consists of a cyclic unit (0 to 42.4 meters) of interbedded light orange calcareous and dusky brown siliceous ooze, and a varicolored unit (42.4 to 172.5 meters) of purple and gray calcareous ooze; the Marquesas Oceanic Formation (172.5 to 470.8 meters) of light brown and gray calcareous ooze; and the Line Islands Oceanic Formation (470.8 to 481 meters) of dusky brown, amorphous iron/manganese-rich, calcareous mudstone. Basement at this site is basalt of probably intrusive origin.

Clipperton Oceanic Formation

The Clipperton Oceanic Formation was named by Leg 8 personnel after the Clipperton Fracture Zone.

Cyclic Unit (0 to 42.4 meters)

This unit is lithologically and stratigraphically correlative with the cyclic unit of the Leg 8 Clipperton Oceanic Formation. The best example of this unit is at Site 82, Core 1, Section 1 (Figure 41, Site 82). It is very widespread and is recognized at Sites 77, 78, 79, 81, 82, 83 and in Sites 70 through 74 of Leg 8.

The cyclic unit is one of the most distinctive stratigraphic intervals in the equatorial Pacific because of its thin-bedded cyclic colors and lithology. It is characterized by the repeated interbedding of brown siliceous oozes and orange calcareous oozes, and a moderately high silica clay and iron oxide content (Figure 150).

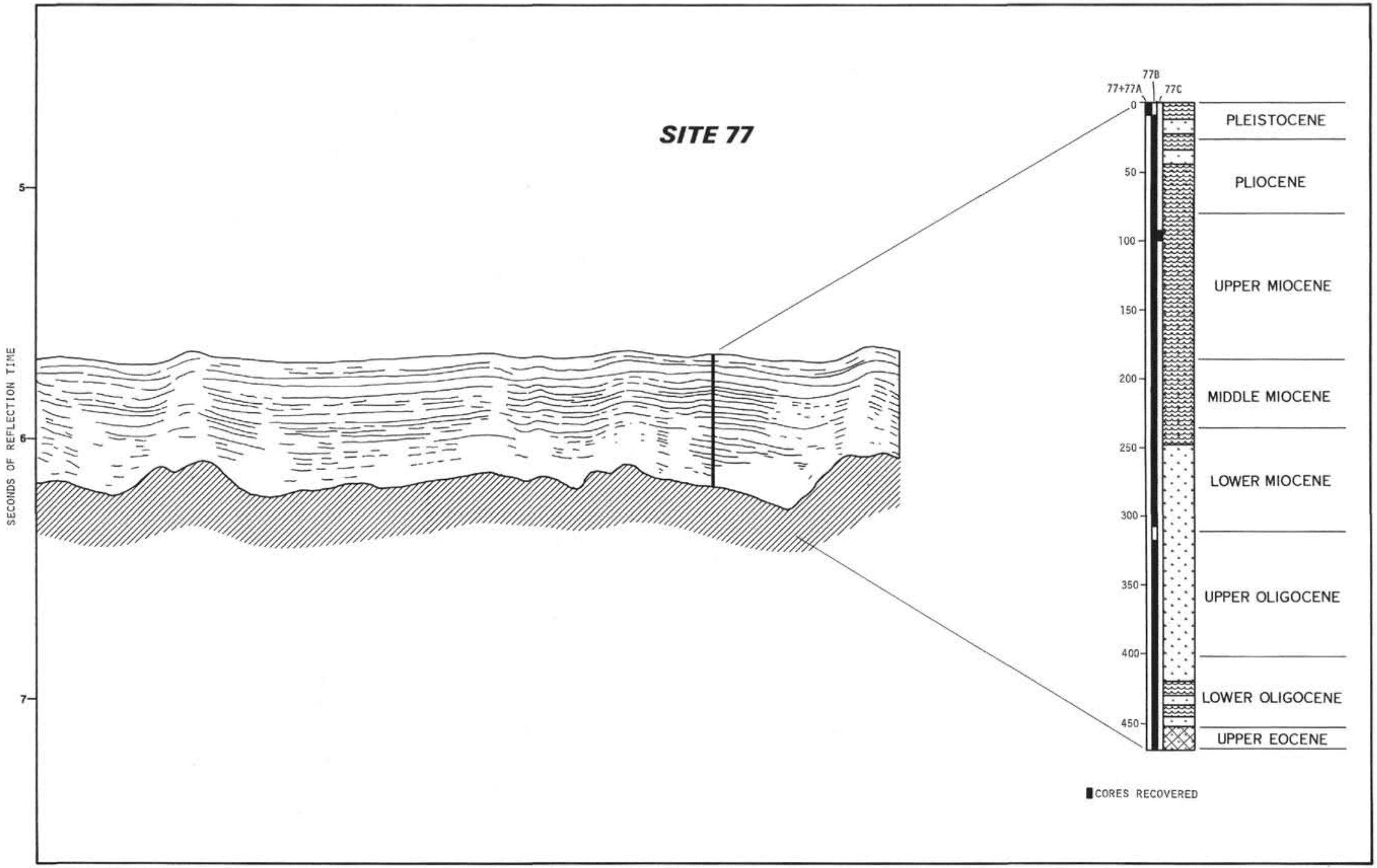

Figure 2. *Sketch of seismic reflection record in vicinity of Site 77 showing interval cored in each hole.*

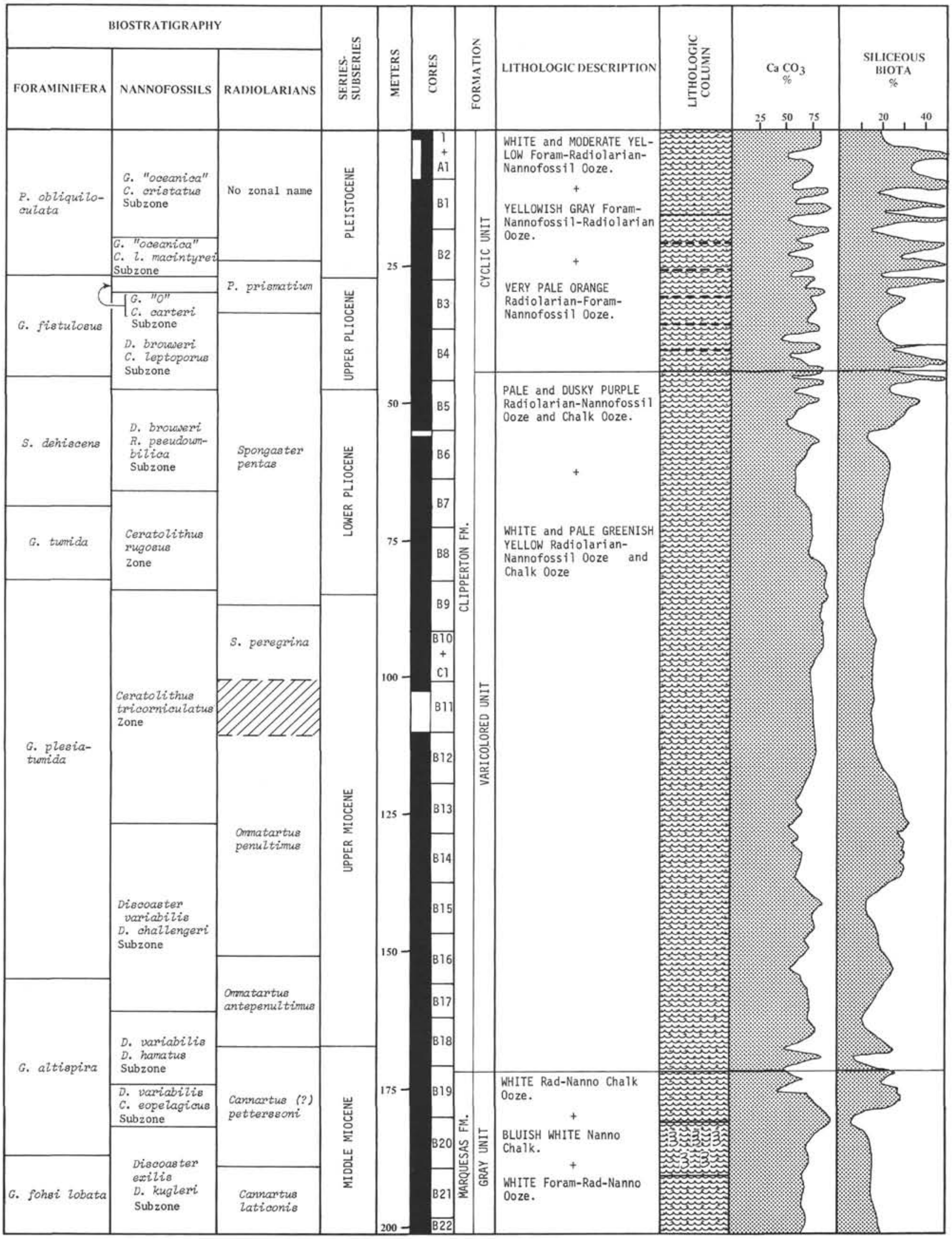

Figure 3. *Site 77 summary.*

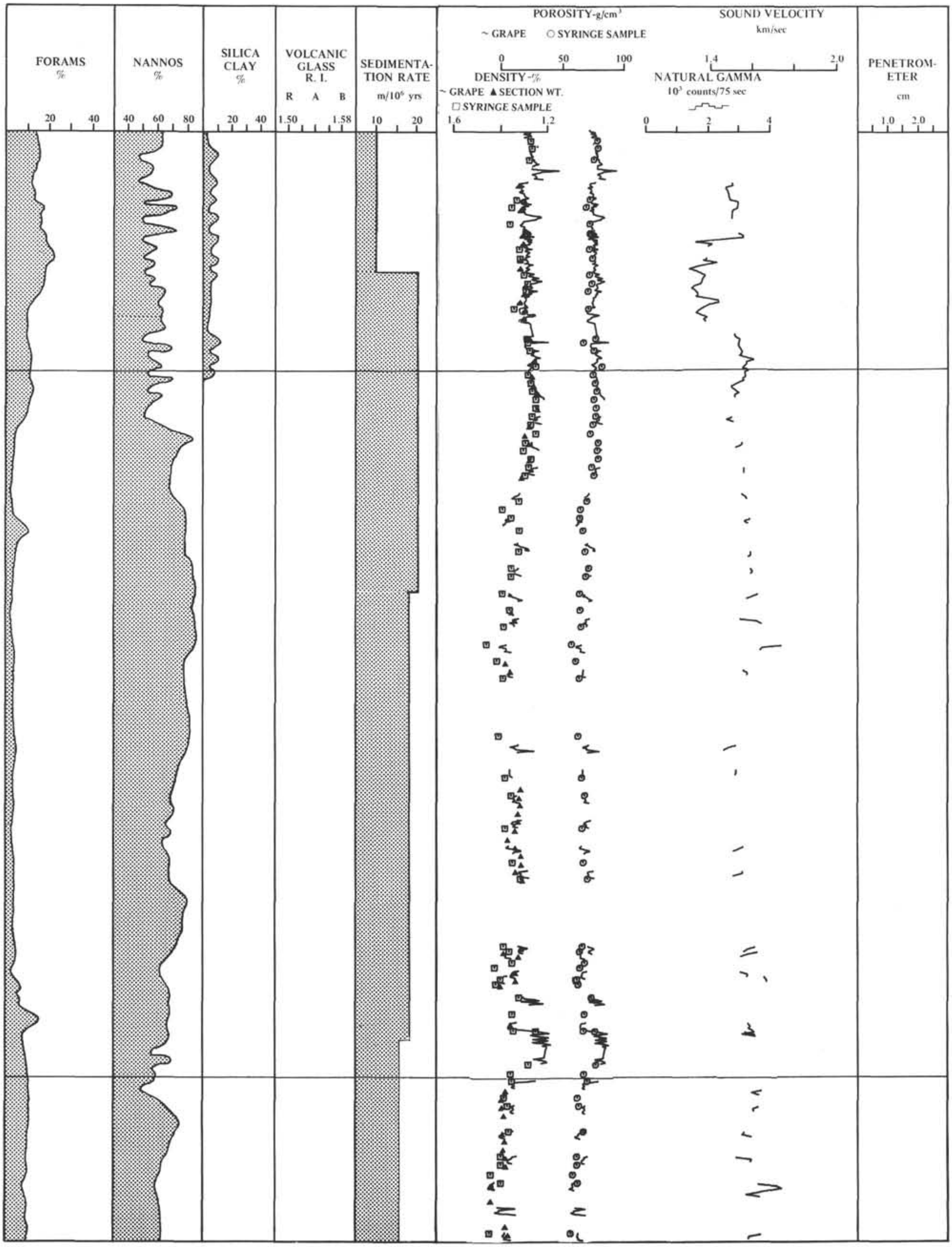

Figure 4. *Site 77 summary.*

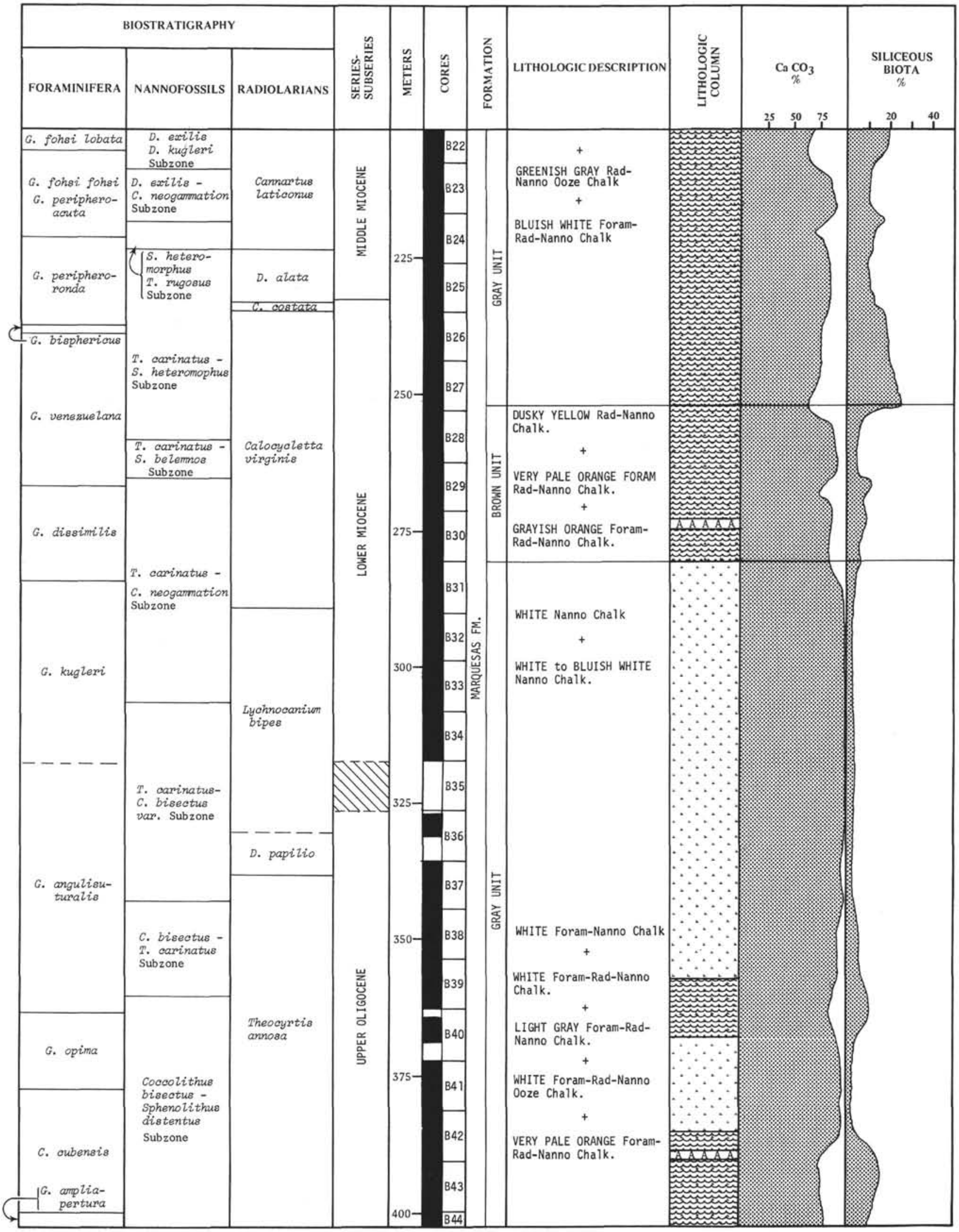

Figure 5. *Site 77 summary (continued).*

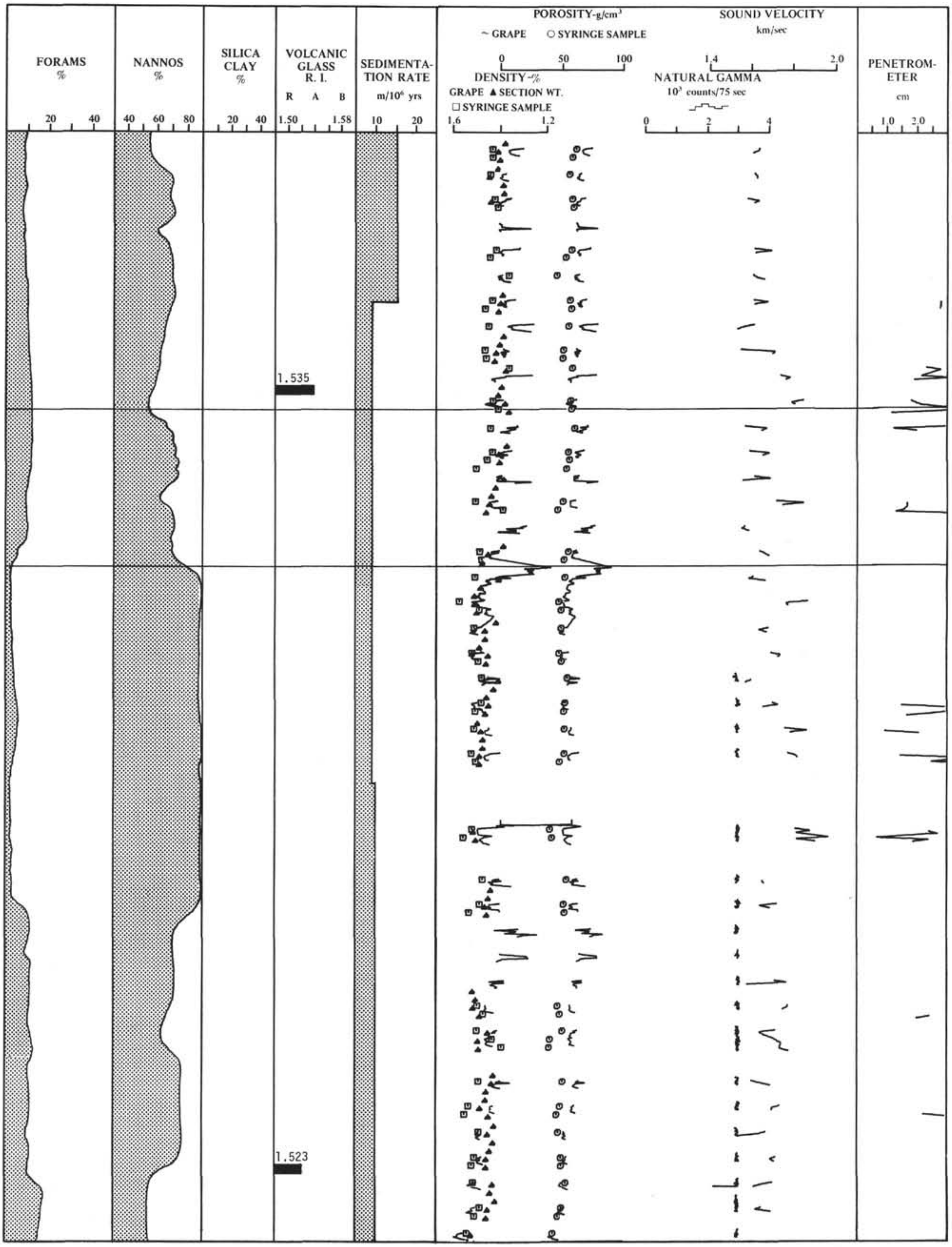

Figure 6. *Site 77 summary (continued).*

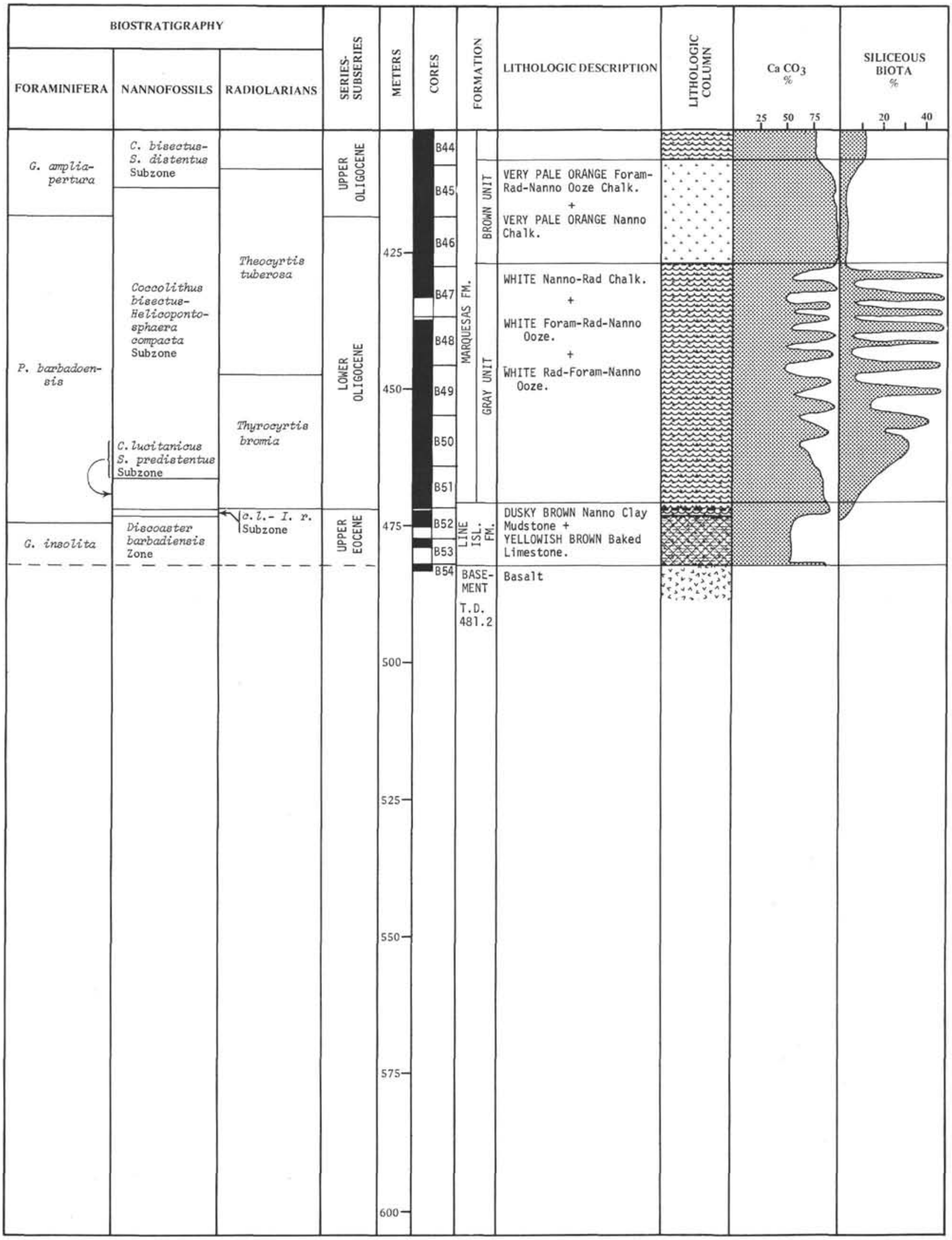

Figure 7. *Site 77 summary (continued).*

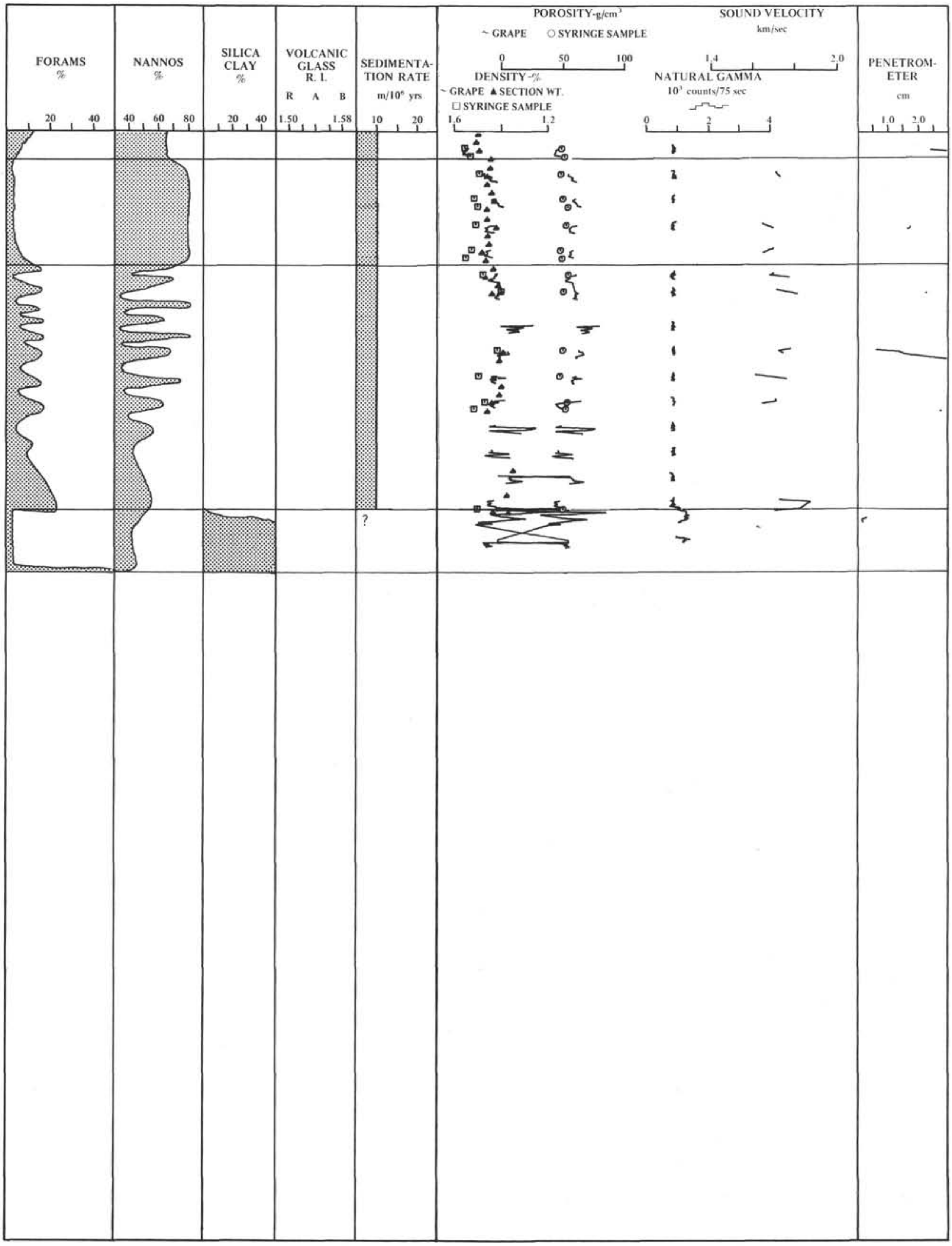

Figure 8. *Site 77 summary (continued).*

TABLE 1
Site Operational Summary

Site 77

Latitude 00° 28.90'N; Longitude 133° 13.70'.

Time of arrival: 1731 hours, 12/15/69; Time of departure: 0200 hours, 12/22/69.

Time on site: 6 days, 8 hours, 29 minutes.

Water depth: 4291 meters.

Sediment thickness determined by drilling: 469.5 meters.

Acoustical thickness: 0.51 second.

Average sound velocity of sediments: 1.8 km/sec.

Hole	Penetration (m)	Cores Attempted	Cores Recovered	Per Cent Cored	Recovery (m)	Per Cent Recovered
77	9.1	1	1	100.0	0.3	3.3
77A	18.3	2	1	100.0	9.1	50.0
77B	481.4	54	54	98.1	437.5	92.6
77C	100.6	1	1	9.0	9.1	83.5
Totals	481.4	58	57	100.0	456.0	89.7

Beds range from about 1 to 25 centimeters in thickness and exhibit horizontal, sharp contacts. The dominant lithologies are:

1. Very pale orange (10YR8/2) and moderate yellowish-brown (10YR5/4) foraminiferal (10 to 20 per cent)–radiolarian (10 to 30 per cent)–calcareous nannofossil (40 to 60 per cent) ooze.

2. Grayish orange (10YR7/4) to moderate brown (5YR4/4) clay (1 to 10 per cent–calcareous nannofossil (30 to 50 per cent)–radiolarian (40 to 60 per cent) ooze.

3. Light olive gray (5YR5/2) clay (5 to 10 per cent)–foraminiferal (5 to 10 per cent)–radiolarian (20 to 30 per cent)–calcareous nannofossil (40 to 50 per cent) ooze.

4. Yellowish gray (5YR7/2) foraminiferal (10 to 20 per cent)–calcareous nannofossil (30 to 40 per cent)–radiolarian (40 to 60 per cent) ooze.

The cyclic unit is conformably underlain by the varicolored unit. This contact is gradational over a 3 meter interval with the browns and oranges of the cyclic unit gradually being dominated by the blues and greens of the pastel-colored varicolored unit.

Varicolored Unit (42.4 to 172.5 meters)

This unit is stratigraphically and lithologically correlative with the varicolored unit of the Leg 8 Clipperton Oceanic Formation. It is quite widespread in the equatorial Pacific, as it is recognized at Sites 77, 79, 80, 81 and at Leg 8 Sites 71, 72 and 73.

Characteristic of this unit are its striking pastel shades of blue, purple, and green, and its well bedded character. Core 6, Section 4 is characteristic of this unit (Figure 151). Although purple oozes make up less than 10 per cent of this formation, these oozes are usually distributed uniformly throughout each core in millimeter-thick laminations, giving an overall purple hue to the sediments.

The cores are generally disturbed to varying degrees; however, main bedding characteristics can still be observed. Beds range in thickness from 1 to 20 centimeters and in undisturbed slightly indurated sediments, horizontal laminations are present in all the beds. The various lithologies include:

1. Pale purple (5P6/2) foraminiferal (15 to 25 per cent)–radiolarian (15 to 25 per cent)–calcareous nannofossil (50 to 70 per cent) ooze and chalk ooze. This purple color is thought to be caused by manganese coatings on radiolarians.

2. Pale greenish-yellow (10Y8/2) radiolarian (40 to 50 per cent)–calcareous nannofossil (40 to 60 per cent) ooze and chalk ooze.

TABLE 2
Hole Drilling Summary, Site 77
(Latitude 00° 28.90′N, Longitude 133° 13.70′W; 4291 meters depth)

Hole 77A

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)
0.0-9.1	0-30		1	9.1	30	9.1	30.0	–	–	3.00
9.1-18.3	30-60		2	9.1	30	0.0	0.0	–	–	?
Total 18.3	60		2	18.3	60	9.1	30.0			

Hole 77B

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)
9.1-18.3	30-60		1	9.1	30	9.1	30.0	–	–	3.00
18.3-27.4	60-90		2	9.1	30	9.1	30.0	–	–	2.50
27.4-36.6	90-120		3	9.1	30	7.6	25.0	–	–	3.80
36.6-45.7	120-150		4	9.1	30	9.1	30.0	–	–	2.10
45.7-54.9	150-180		5	9.1	30	9.1	30.0	–	–	3.00
54.9-64.0	180-210		6	9.1	30	8.8	29.0	–	–	3.80
64.0-73.2	210-240		7	9.1	30	9.1	30.0	–	–	2.30
73.2-82.3	240-270		8	9.1	30	8.5	28.0	–	–	2.10
82.3-91.4	270-300		9	9.1	30	9.1	30.0	–	Int	2.50
91.4-100.6	300-330		10	9.1	30	9.1	30.0		–	2.50
100.6-109.8	330-360		11	9.1	30	1.5	5.0		Int	3.30
109.8-118.9	360-390		12	9.1	30	9.1	30.0		–	1.60
118.9-128.0	390-420		13	9.1	30	9.1	30.0		–	2.70
128.0-137.2	420-450		14	9.1	30	9.1	30.0		–	3.00
137.2-146.3	450-480		15	9.1	30	9.1	30.0		–	1.30
146.3-155.5	480-510		16	9.1	30	8.8	29.0		Int	3.00
155.5-161.6	510-530		17	6.4	20	9.1	30.0		Int	0.80
161.6-170.7	530-560		18	9.1	30	9.1	30.0		Int	1.70
170.7-179.9	560-590		19	9.1	30	9.1	30.0		Int	1.70
179.9-189.0	590-620		20	9.1	30	9.1	30.0		Int	2.10
189.0-198.2	620-650		21	9.1	30	9.1	30.0		–	2.10
198.2-207.3	650-680		22	9.1	30	9.1	30.0		Int	3.00
207.3-216.5	680-710		23	9.1	30	9.1	30.0		Int	2.00
216.5-225.6	710-740		24	9.1	30	9.1	30.0		–	1.90
225.6-234.8	740-770		25	9.1	30	9.1	30.0		–	1.50
234.8-243.9	770-800		26	9.1	30	9.1	30.0		–	1.90
243.9-253.0	800-830		27	9.1	30	9.1	30.0		–	1.70

TABLE 2 – *Continued*

Hole 77B – *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)
253.0-262.2	830-860		28	9.1	30	9.1	30.0		–	2.50
262.2-271.3	860-890		29	9.1	30	9.1	30.0		Int	1.50
271.3-280.5	890-920		30	9.1	30	9.1	30.0		Int	0.90
280.5-289.6	920-950		31	9.1	30	9.1	30.0		Int	1.20
289.6-298.8	950-980		32	9.1	30	9.1	30.0		Int	1.20
298.8-307.9	980-1010		33	9.1	30	9.1	30.0		Int	1.00
307.9-317.1	1010-1040		34	9.1	30	9.1	30.0		Int	2.10
317.1-326.2	1040-1070		35	9.1	30	0.0	0.0	–	–	0.80
326.2-335.4	1070-1100		36	9.1	30	3.7	12.0		Int	0.80
335.4-344.5	1100-1130		37	9.1	30	9.1	30.0		Int	0.60
344.5-353.7	1130-1160		38	9.1	30	9.1	30.0		–	1.90
353.7-362.8	1160-1190		39	9.1	30	9.1	30.0		Int	2.10
362.8-372.0	1190-1220		40	9.1	30	4.9	16.0		–	1.70
372.0-381.1	1220-1250		41	9.1	30	9.1	30.0		Int	1.20
381.1-390.2	1250-1280		42	9.1	30	9.1	30.0		Int	1.10
390.2-399.4	1280-1310		43	9.1	30	9.1	30.0		Int	1.10
399.4-408.5	1310-1340		44	9.1	30	9.1	30.0		Int	1.20
408.5-417.7	1340-1370		45	9.1	30	9.1	30.0		Int	1.40
417.7-426.8	1370-1400		46	9.1	30	9.1	30.0		Int	3.00
426.8-436.0	1400-1430		47	9.1	30	6.4	21.0		Int	1.40
436.0-445.1	1430-1460		48	9.1	30	8.4	27.5		Int	1.00
445.1-454.3	1460-1490		49	9.1	30	9.1	30.0		Int	0.80
454.3-463.4	1490-1520		50	9.1	30	9.1	30.0		Int	0.90
463.4-471.0	1520-1545		51	7.6	25	9.1	30.0		–	0.40
471.0-476.5	1545-1563		52	5.5	18	2.4	8.0		Cont	0.10
476.5-481.1	1563-1578		53	4.6	15	1.1	3.5		Cont	0.09
481.1-481.4	1578-1579		54	0.3	1	0.3	1.0		Cont	0.02
Total 481.4	1579		54	472.3	1549	437.5	1435			

Hole 77C

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)
91.4-100.6	300-330		1	9.1	30	7.6	25.0	–	–	3.70

3. White (N9) radiolarian (20 to 30 per cent)–calcareous nannofossil (60 to 70 per cent) ooze and chalk ooze.

4. Very dusky purple (5P2/2) radiolarian (10 to 15 per cent)–calcareous nannofossil (80 to 85 per cent) ooze and chalk ooze.

5. Medium bluish-gray (5B5/1) foraminiferal (15 to 20 per cent)–calcareous nannofossil (40 to 50 per cent)–radiolarian (40 to 50 per cent) ooze.

6. Dusky blue green (5BG3/2) foraminiferal (10 to 15 per cent)–calcareous nannofossil (30 to 50 per cent)–radiolarian (40 to 60 per cent) ooze chalk.

The sediments of this unit are gradually replaced by the white, gray, and orange sediments of the Marquesas Oceanic Formation over a 10-centimeter interval.

Marquesas Oceanic Formation

On the basis of stratigraphic position, color, and bedding characteristics, we correlate this stratigraphic interval with the Marquesas Oceanic Formation of Leg 8. At Site 77 it is divided into five informal units.

Gray Unit (172.5 to 252.6 meters)

This unit is characteristically massive with no apparent laminations within the different colored beds. Beds range from 50 to 150 centimeters in thickness. Core 20, Section 2 is typical of this unit (Figure 152). The lithologies are:

1. Dominantly white (N9) to bluish-white (5B9/1) foraminiferal (10 to 15 per cent)–radiolarian (10 to 20 per cent)–calcareous nannofossil (60 to 70 per cent) chalk.

2. Minor greenish-gray (5GY6/1) radiolarian (10 to 20 per cent)–calcareous nannofossil (60 to 70 per cent) chalk.

3. Rare pale purple (5P6/2) radiolarian (30 to 40 per cent)–calcareous nannofossil (60 to 70 per cent) ooze.

This unit grades into the strikingly different oranges and yellows of an underlying brown unit over a 5-centimeter interval.

Brown Unit (252.6 to 280.3 meters)

This unit is characterized by its orange colors that occur in 25 to 150 centimeter thick beds with no obvious laminations. Core 28, Section 5 is typical of this unit (Figure 153). Many of the dusky yellow beds are burrowed, which give them a slightly mottled appearance. Its dominant lithologies are:

1. Dusky yellow (5Y6/4) radiolarian (20 to 30 per cent)–calcareous nannofossil (60 to 70 per cent) chalk.

2. Very pale orange (10YR8/2) foraminiferal (10 to 15 per cent)–radiolarian (20 to 30 per cent)–calcareous nannofossil (60 to 70 per cent) chalk.

3. Grayish-orange (10YR7/4) foraminiferal (10 to 15 per cent)–radiolarian (20 to 30 per cent)–calcareous nannofossil (60 to 70 per cent) chalk.

The characteristically well-bedded oranges and yellows of this unit are easily distinguishable from the underlying white massive chalks of a gray unit. This transition takes place over a one meter interval.

Gray Unit (280.3 to 408.1 meters)

This gray unit is characterized by its generally massive bedding, firm chalk texture, and dominantly white color. Core 32, Section 4 is typical of this unit (Figure 154). The upper part is massively bedded with no apparent bedding breaks or laminations. It consists of:

1. White (N9) calcareous nannofossil chalk.

2. White (N9) radiolarian (10 to 15 per cent)–calcareous nannofossil (85 to 90 per cent) chalk.

The lower part of this gray unit is also white with no apparent bedding but has a distinct increase in its foraminiferal and radiolarian content giving it a more sandy, granular appearance. Also, this part of the unit is less indurated than the upper part. It consists of:

1. White (N9) foraminiferal (10 to 15 per cent)–calcareous nannofossil (75 to 80 per cent) chalk.

2. White (N9) foraminiferal (10 to 15 per cent)–radiolarian (10 to 15 per cent)–calcareous nannofossil (70 to 80 per cent) chalk.

3. Light gray (N7) foraminiferal (10 to 15 per cent)–radiolarian (10 to 15 per cent)–calcareous nannofossil (60 to 80 per cent) chalk.

Brown Unit (408.1 to 426.6 meters)

This brown unit is massive with no apparent bedding and is distinguished from the superjacent gray unit by its pale orange colors. The dominant lithologies are:

1. Very pale orange (10YR8/2) foraminiferal (10 to 15 per cent)–radiolarian (10 to 15 per cent)–calcareous nannofossil (70 to 80 per cent) ooze chalk.

2. White (N9) foraminiferal (5 to 10 per cent)–radiolarian (5 to 10 per cent)–calcareous nannofossil (80 to 90 per cent) ooze chalk.

3. Very pale orange (10YR8/2)–calcareous nannofossil chalk.

The contact with the underlying gray unit is gradational over a 2-meter interval.

Gray Unit (426.6 to 470.8 meters)

This unit is characterized by firm chalks repeatedly interbedded with "doughy" ooze chalks (Figure 155). These two textures occur in 5 to 50 centimeter thicknesses and are easy to recognize in cut sections. This unit is similar to the cyclic unit of the Clipperton Oceanic Formation in that it has repeated, interbedded calcareous and siliceous beds. The dominant lithologies are:

1. White (N9) calcareous nannofossil (30 to 40 per cent)–radiolarian (50 to 60 per cent) chalk.

2. White (N9) foraminiferal (10 to 20 per cent)–radiolarian (10 to 20 per cent) calcareous nannofossil (60 to 80 per cent) ooze chalk.

This unit contrasts sharply with the dusky brown colors of the underlying Line Islands Oceanic Formation. This color break is transitional over a 30 to 100-centimeter interval.

Line Islands Oceanic Formation (470.8 to 481 meters)

The Line Islands Formation was named by Leg 8 scientists after the Line Islands. This formation, which lies directly above the basaltic basement, is recognized at Sites 77, 78, 80, 82 and 83. Its chief characteristic is its high "red clay" content. This "red clay" is mostly amorphous iron and manganese oxides which range from a few per cent at the top to about 40 per cent at the contact with basaltic basement. This amorphous material is responsible for the characteristic brown color. Hole 77B, Core 52, Sections 1, 2 and Hole 77B, Core 53, Section 1 are typical of this formation (Figures 156, 157 and 158). No crystalline forms of iron or manganese oxides were detected in these sediments (Cook and Zemmels, 1971).

These beds are generally very firmly indurated with a low water content and can be called a true calcareous mudstone. Laminations and partially flattened burrows are common. These burrows are distinct because their outer rims are a pale yellowish brown in contrast to their dusky brown interiors. These rims consist of macerated nannofossils, whereas the interior fillings contain well-preserved nannofossils. The dominant lithology is:

1. Dusky brown (5YR2/2) calcareous nannofossil (30 to 50 per cent)–clay (2 to 60 per cent) calcareous mudstone.

Within this calcareous mudstone is a variety of constituents which are considered to be of an authigenic hydrothermal origin such as magnetite, epidote, feldspar, chert and amorphous iron and manganese oxides.

At the base of the Line Islands Oceanic Formation is a well-indurated apparently baked limestone breccia with clasts ranging from 0.5 to 2 centimeters in maximum diameter. This rock contains poorly preserved foraminifera and nannofossils and very fine-grained magnetite (?) disseminated throughout the matrix and clasts.

Basaltic Basement

About one foot of basaltic basement was recovered. This basalt is a black, fine-grained, slightly vesicular basalt interpreted to be of intrusive origin.

PHYSICAL PROPERTIES

Natural Gamma

Natural gamma readings at Site 77 usually range from 785 to 900 counts/75 sec with sharp increases up to 1363 counts within the basal 10 meters of the hole (Figures 4, 6, 8).

The Clipperton Oceanic Formation was not tested for natural gamma emission because of technical malfunctioning of the recorder. The Marquesas Oceanic Formation yielded counts from 785 to 960. The brown and gray units of the Marquesas Oceanic Formation are not distinguishable from each other on the basis of natural gamma radiation even though there are more clay minerals in the brown units. The Line Islands Oceanic Formation can be distinguished from the Marquesas Oceanographic Formation on the basis of natural gamma radiation at this site. The Marquesas Oceanic Formation has a natural gamma radiation of 800 counts, whereas the Line Islands Oceanic Formation yields counts from 965 to 1398. Within the Line Islands Oceanic Formation potassium mica and the potassic zeolite clinoptilolite are present in the sediments (Cook and Zemmels, 1971), and probably are responsible for the high readings.

Porosity

Porosity at Site 77 ranges from 86 per cent in unconsolidated oozes to 41 per cent in lithified chalks. There may be an overall porosity decrease with depth, but if there is, it is less than 10 per cent (Figures 4, 6, 8).

Stratigraphic intervals which contain large amounts of sand-sized radiolarians and foraminifera have higher porosities than beds which are dominantly of clay-sized calcareous nannofossils. The sand-sized biogenous constituents produce a grain-supported texture with both interparticle and intragrain porosity whereas calcareous nannofossil oozes form mud supported textures with only interparticle porosity.

Locally, waters injected into the sediments because of drilling procedures confuse the overall picture.

The porosity, as evaluated by the chemist, roughly corresponds to the porosity as determined by the GRAPE.

Sonic Velocity

The sound velocities range from 1292 to 1975 m/sec. The general trend is for the velocities to increase downhole which would be expected due to compaction (Figures 4, 6, 8). Fluctuations in the velocities are attributed to changes in the water content of the sediments. Some of this water may be injected during coring and may not reflect the true connate water.

Bulk Density

At Site 77 bulk densities range from 1298 g/cc at the top to 1.856 g/cc at the bottom. The average density at the top of the hole is less than the average at the bottom of the hole; however, there are sharp fluctuations in readings throughout. There is no apparent systematic correlation of density with variations in lithology and depth.

Penetrometer

Penetrometer readings at Site 77 are the most complete of Leg 9 because of continuous coring, and they show a general downhole decrease as would be expected as a result of compaction. The readings vary from 2.8 centimeters at shallow depths to 0.1 centimeter at depths of 200 meters and greater. An anomalously high reading of 3 centimeters at about 150 meters is probably due to water injection into the sediments during drilling. The overall downhole penetrometer trend reflects some type of gradual induration whether it be compaction and/or cementation; however, in detail, and over short stratigraphic intervals, different lithologies show differences in induration.

BIOSTRATIGRAPHY

Foraminifera

Because of the age span represented by sediments at this site and the availability of continuous cores, the site was adopted as a standard foraminiferal section for Leg 9. The foraminiferal sample frequency for Site 77 is by far the highest of any of the sites of Leg 9.

A number of Cenozoic zonal foraminiferal species recorded by Blow (1969) are missing at Site 77 and this is probably not due to an hiatus. Some of these zonal species appear farther to the east at successive sites within their proper stratigraphic intervals. This apparent provincialism and problems of solution led us to establish a composite zonal scheme to suit this particular area of the equatorial eastern Pacific (see Synthesis Section–Foraminifera).

The cored interval includes sediments from the Pleistocene *Pulleniatina obliquiloculata* Zone through the Pliocene, Miocene and Oligocene without any apparent stratigraphic breaks, into the upper Eocene *Globorotalia insolita* Zone.

Planktonic foraminiferal specimens were found to be abundant and well preserved in most cored intervals. In certain of the Pleistocene and upper Pliocene intervals, there is evidence of solution of large specimens and the complete removal of thin walled and juvenile specimens. These intervals with dissolved specimens were, however, very discontinuous. Continuous sections of dissolved foraminiferal specimens were only found in three intervals in the upper Miocene, lower Miocene, and upper Eocene. Within these latter intervals, foraminiferal specimens were missing or were rarely represented by a fragment of a keel or similar thick structure of the test. These high-solution intervals were usually continuous through part of one core, but never more than two complete cores. The only microfaunal representatives within the foraminiferal size range in these high solution intervals were Radiolaria.

The diversity of planktonic foraminiferal faunas fluctuates significantly throughout the cored interval. Diversity is highest from the Pleistocene *Pulleniatina obliquiloculata* Zone through the upper Miocene *Globorotalia plesiotumida* Zone. Within the interval from the middle Miocene *Globorotalia siakensis* Zone to the upper Oligocene *Globorotalia opima* Zone, the diversity is about one-third to one-fourth of the values for the *Pulleniatina obliquiloculata-Globorotalia plesiotumida* Zones. In the upper Oligocene *Globigerina ampliapertura* Zone through the upper Eocene *Globorotalia insolita* Zone, the diversity again increases to values equivalent to or only slightly lower than those of the upper Miocene to Pleistocene. These diversity fluctuations do not appear to correspond with either intervals of rapid sedimentation or intervals where solution of calcium carbonate is prevalent.

Site 77 was terminated in basalt which slightly altered the overlying sediments and foraminiferal tests therein. Despite this alteration, the zonal species *Globorotalia insolita* as well as other species were recorded which indicated a late Eocene age for the deepest sediments penetrated.

Radiolaria

Well-preserved Radiolaria are present in all the cores at Site 77 above the top of Core 52B. Orosphaerid Radiolaria are common in Cores 40B to 52B and scarce above. Conversely, diatoms become progressively more abundant towards the top of the section. Siliceous microfossils generally constitute a minor proportion of the bulk sediment, which is largely composed of calcareous nannofossils. Consequently, clean siliceous residues can be obtained with relatively little laboratory preparation.

Site 77 has been used as a standard to which the stratigraphic ranges of Radiolaria from the remaining sites are compared. Inconsistencies between the ranges of radiolarian species at Site 77 and other sites are discussed in the remaining Site Reports. Four particular occurrences deserve discussion here. At Site 77, *Lithocyclic angustum* is not continuously present in the upper portion of the *Lithocyclia angustum* Zone. In comparison, *L. angustum* ranges approximately 30 meters above the base of the *Theocyrtis annosa* Zone at Site 78. *Brachispyris alata* also has a discontinuous occurrence at the top of its range in Site 77. This situation is unfortunate because the base and top of its range define the base and top of the *B. alata* Zone. The top of the *B. alata* Zone has been placed at the top of the continuous occurrence of *B. alata,* because it is possible that the higher occurrences of this species may be the result of reworking. Incomplete specimens which may be referrable to *Artophormis gracilis* and *Cannartus prismaticus* occur below the horizons indicated as the base of the stratigraphic ranges of these two species on the Biostratigraphic Chart. Only the ranges of complete specimens have been indicated.

DISCUSSION AND INTERPRETATION

A complete stratigraphic section from upper Eocene to upper Quaternary was continuously cored. The seismic reflection records at this site show a sequence of sediments 0.5 seconds of reflection time thick, consisting of an upper transparent layer about 0.06 seconds thick, a stratified layer from 0.06 seconds to 0.4 seconds and a lower transparent layer from 0.4 to 0.5 seconds (Figure 2). Using an average sound velocity through these sediments of 1.7 km/sec these layers would have the following thicknesses: upper transparent layer, 0 to 50 meters; stratified layer, 50 to 320 meters and the lower transparent layer, 320 meters to basement.

The lithology recovered can also be divided into three formations. The upper forty-two meters is interbedded, siliceous calcareous ooze which is the cyclic unit of the Clipperton Oceanic Formation. From 42 to 172.5 meters the sediments are interbedded white and purple, calcareous-siliceous ooze and chalk forming the varicolored unit of the Clipperton Oceanic Formation. From 172 to 470 meters, the sediments are the interbedded, white and orange, calcareous and siliceous chalk and ooze of the Marquesas Oceanic Formation. The basal 10.2 meters of highly ferro-manganese clay is defined as the Line Islands Oceanic Formation. Apparently, the low carbonate content of the cyclic unit of the Clipperton Oceanic Formation at this site provides less acoustical impedance that the more calcareous layers below; therefore, it appears as a transparent layer above the highly stratified layers below. The fossil faunas show very little or no mixing while the coccoliths show considerably more. In the upper Pliocene, in particular, there is considerable reworking of Miocene coccoliths. The sedimentation rates calculated using Berggren's (1969) ages for the series and sub-series boundaries are not uniform. But, as can be seen from Table 1, they are twice as high from the base of the Middle Miocene to the base of the Quaternary as they are from the top of the Eocene to the top of the lower Miocene. The low rate for the Quaternary, 10 m/m.y., is probably not reliable because of the difficulty in determining the exact depth of the mud line. It is interesting to note that the rate in the lower Oligocene is somewhat greater than that of the upper Oligocene and lower Miocene.

The foraminiferal diversity decreases by a factor of 2 in the lower Miocene, and although the diversity is somewhat greater in the upper Oligocene it is still considerably below the diversity in the lower Oligocene and middle Miocene. This is probably a result of increased solution associated with the lower sedimentation rates in the upper Oligocene and upper Miocene. The 18 meters of ferro-manganese clay at the base of the section overlying basalt is in striking contrast with the overlying chalk lithology. The contact between the two is gradational through about 60 centimeters. The origin of the clay is problematical. One possible explanation is that its origin is similar to the origin of the iron-manganese rich clays presently collecting on the crest of the East Pacific Rise in the area of high heat flow (Bostrom and Peterson, 1969). They suggest that these clays are a result of alteration of the organic oozes in this area by hydrothermal solutions rich in iron and manganese. In line with current theories of sea floor spreading, if this clay forms at the ridge crest, one would expect to find it forming a thin veneer above basement at all drill sites. Similar clays were encountered just above basement on Leg 8 at Sites 74 and 75. The boundary between the clay and the overlying chalk coincides with the boundary between the Eocene and Oligocene; this may be fortuitous.

Although sediments just above the basalt at this site show evidence of baking, it was possible to recover enough of a fauna and flora sample to arrive at an estimate of their age. The first diagnostic radiolarian assemblage 9.5 meters above the base of the hole contains the index fossils of the *Theocyrtis tuberosa* Zone. The top of the *Discoaster barbadiensis* Nannofossil Zone was recorded 8.5 meters above the base of the hole, and the top of the planktonic foraminiferal *Globorotalia insolita* Zone occurs at 8 meters above the basalt.

Sedimentation rates in the lower Oligocene at this site are on the order of 13 m/m.y. (Table 3). Using this sedimentation rate and an age of 35 ±1 million years for the top of the Eocene at the base of the *Cyclococcolithus lusitanicus, Sphenolithus predistentus* Subzone at 9.5 meters above the basalt, we can calculate an age of 36 ±1 million years for the age of the oldest sediment at this site.

TABLE 3
Rates of Sedimentation, Site 77

Geologic Interval	Duration Geologic Interval (m.y.)	Sediment Thickness (meters)	Accumulation Rate ($m/10^6$ yrs)
Pleistocene	1.8	18	10
Pliocene	3.2	64	20
Upper Miocene	5.0	91	18
Middle Miocene	4.0	64	16
Lower Miocene	8.5	78	9
Oligocene	13.5	145	10

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Boström, K. and Peterson, M. N. A., 1969. The origin of aluminum-poor ferro-manganoan sediments in areas of high heat flow on the East Pacific Rise. *Marine Geol.* **7**, 427.

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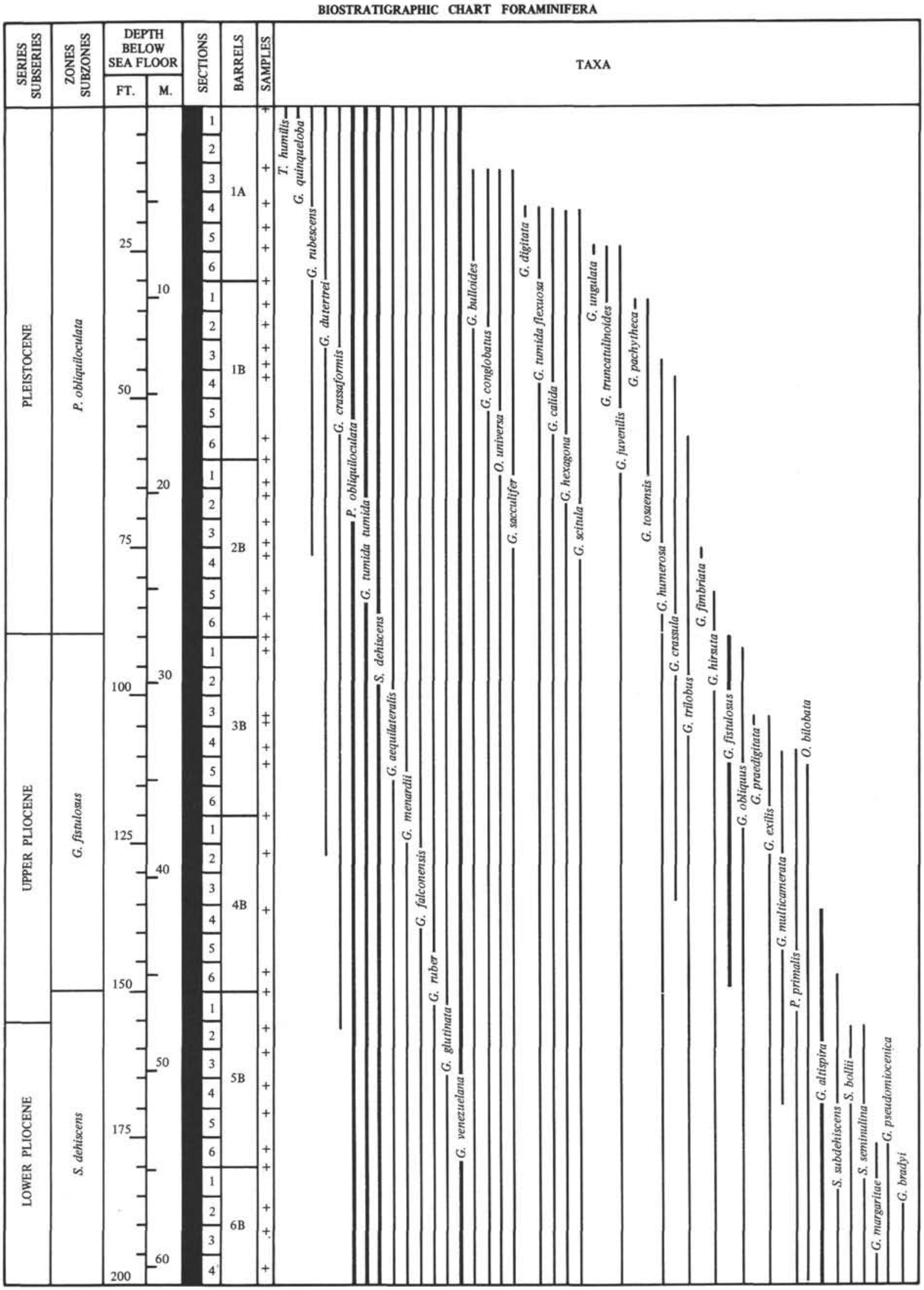


Figure 9. *Site 77 Biostratigraphic Chart Foraminifera (0 to 200 feet).*

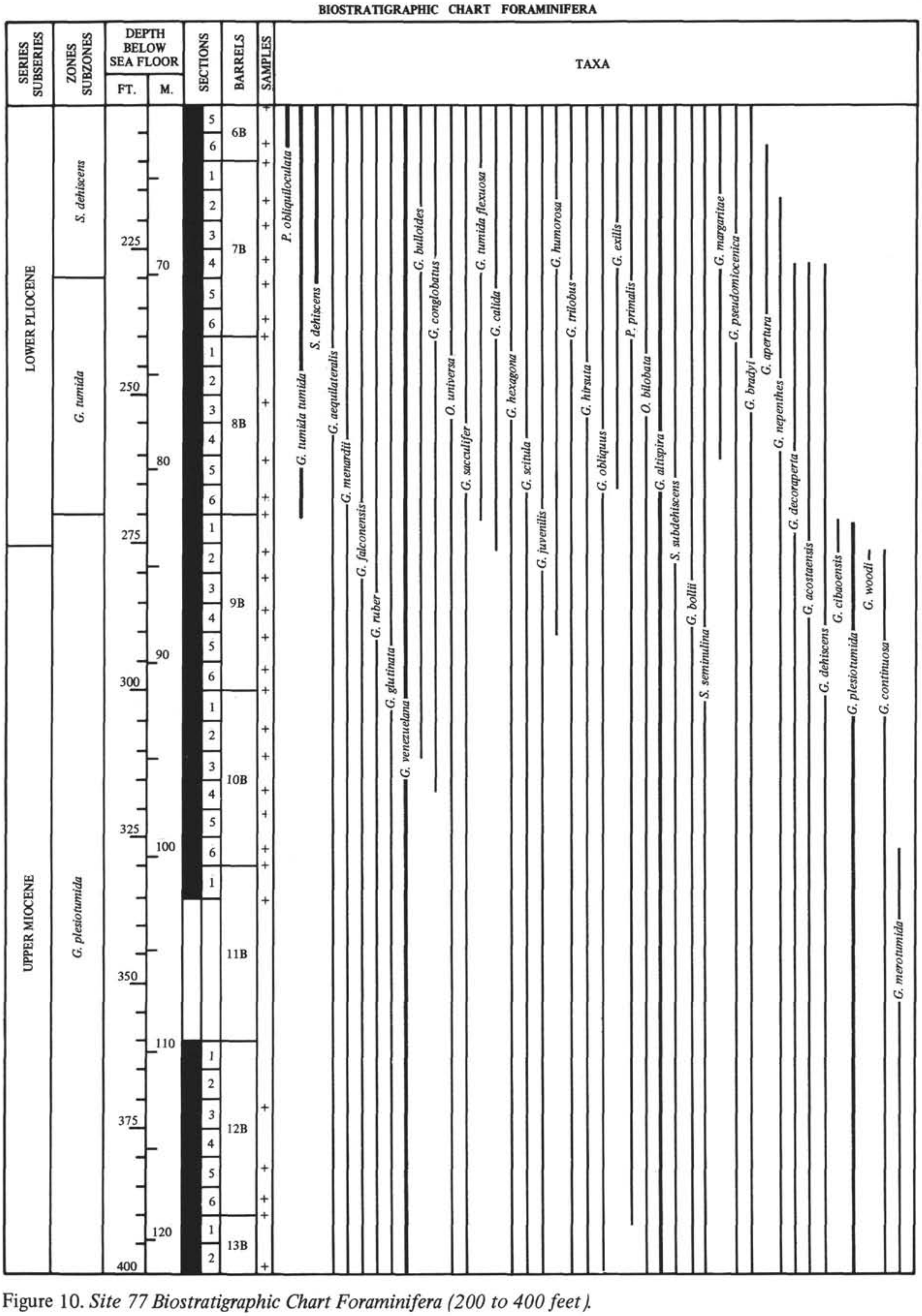


Figure 10. *Site 77 Biostratigraphic Chart Foraminifera (200 to 400 feet).*

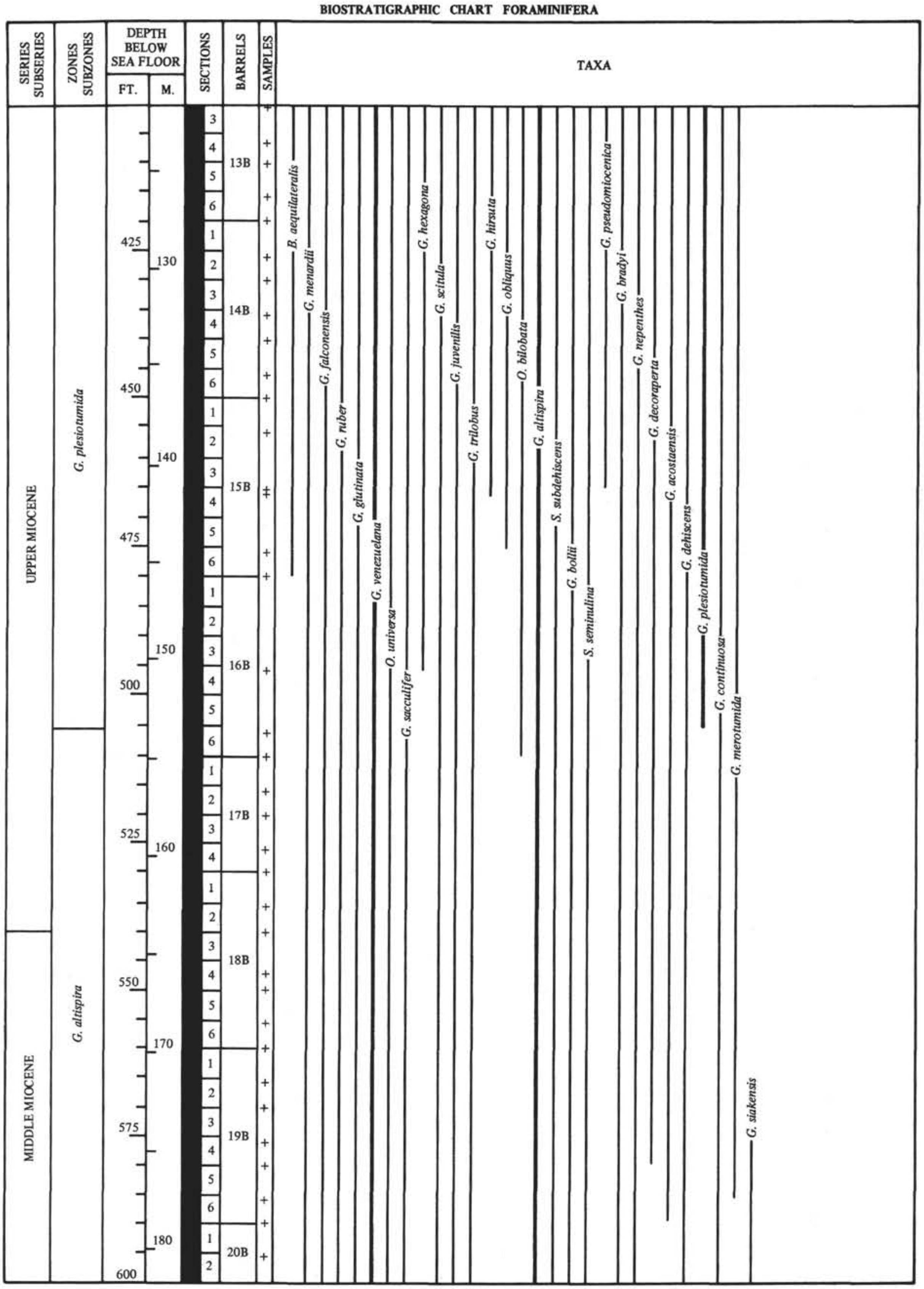


Figure 11. *Site 77 Biostratigraphic Chart Foraminifera (400 to 600 feet).*

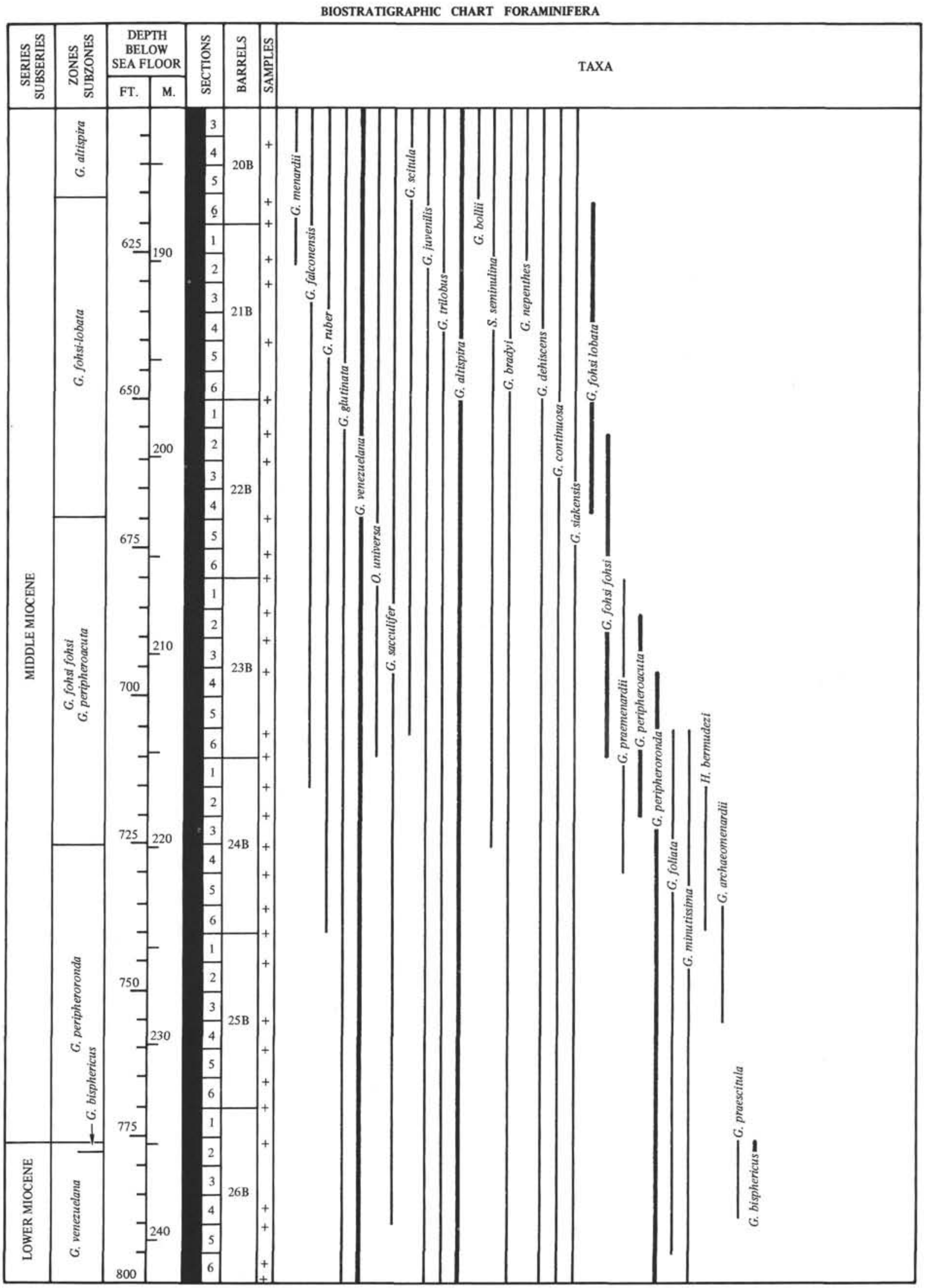


Figure 12. *Site 77 Biostratigraphic Chart Foraminifera (600 to 800 feet).*

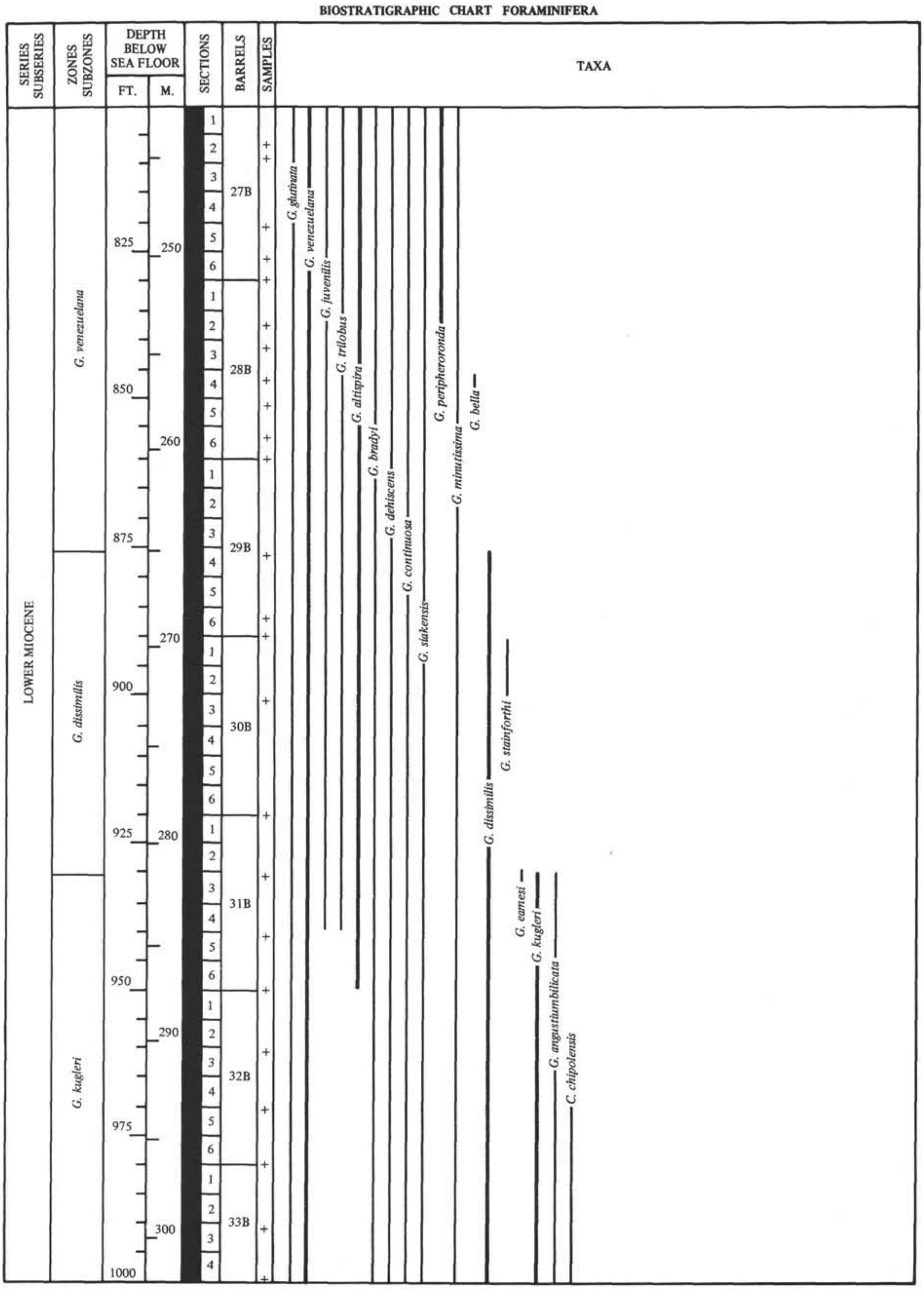


Figure 13. *Site 77 Biostratigraphic Chart Foraminifera (800 to 1000 feet).*

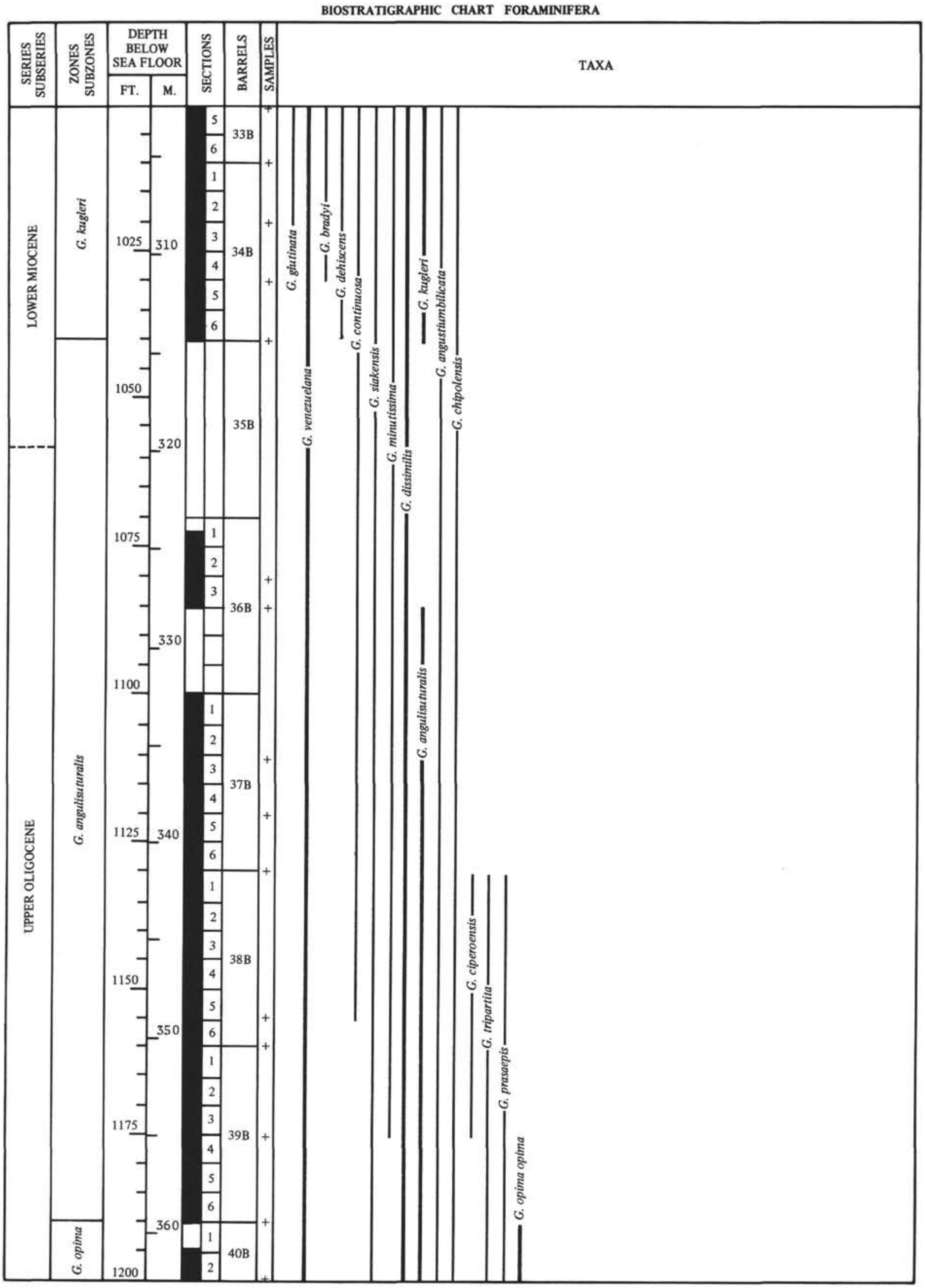


Figure 14. *Site 77 Biostratigraphic Chart Foraminifera (1000 to 1200 feet).*

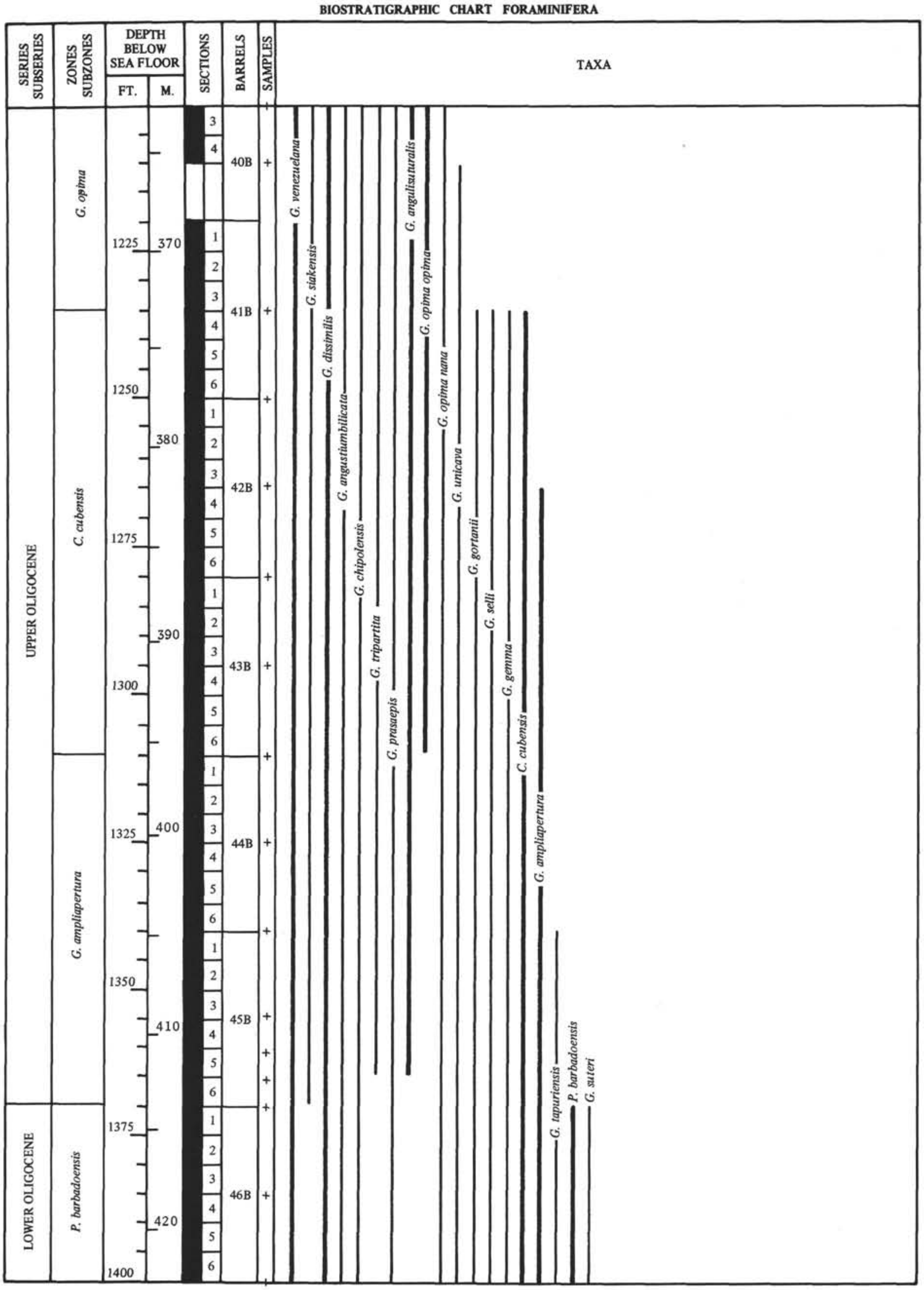


Figure 15. *Site 77 Biostratigraphic Chart Foraminifera (1200 to 1400 feet).*

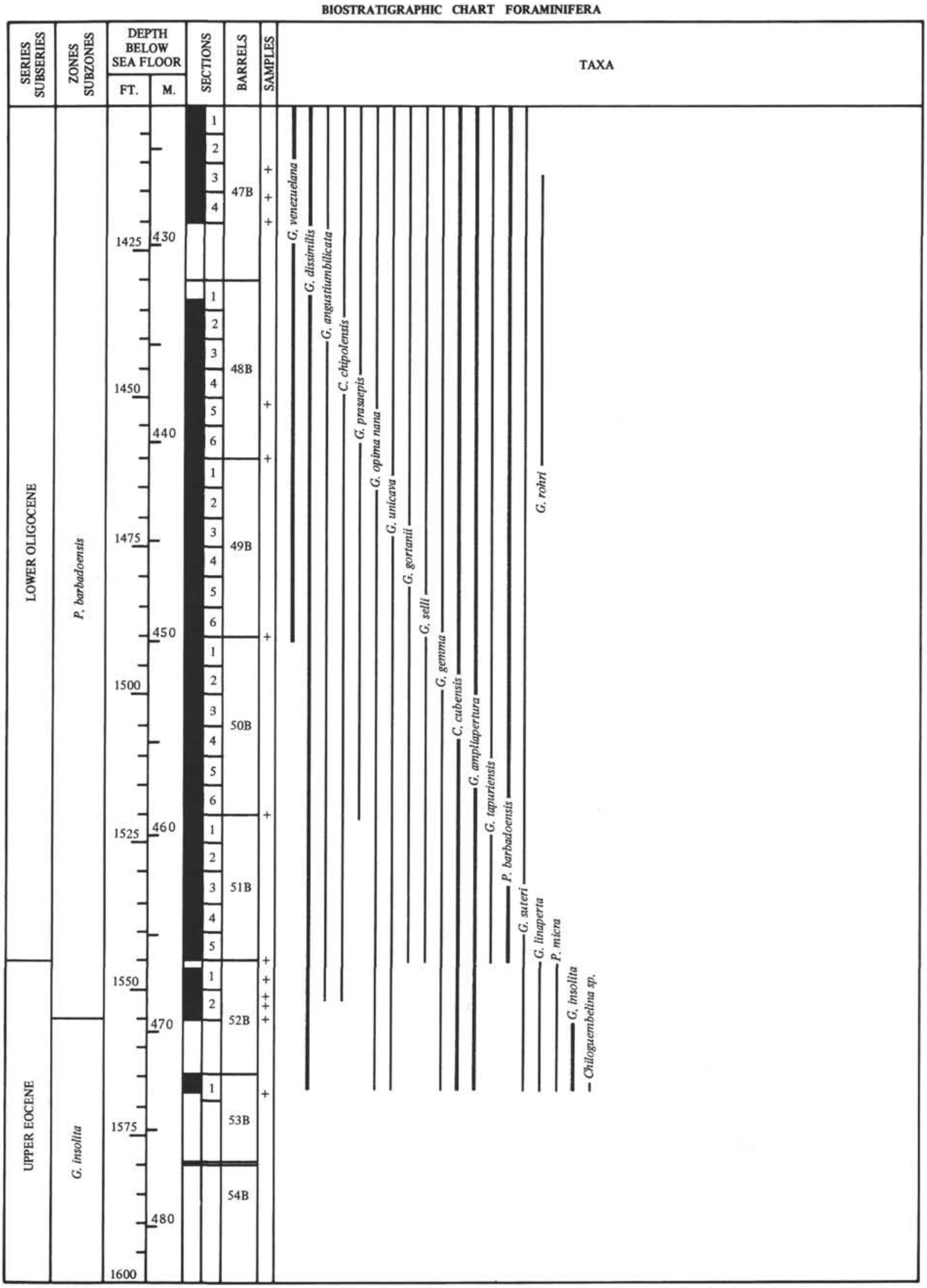


Figure 16. *Site 77 Biostratigraphic Chart Foraminifera (1400 to 1600 feet).*

BIOSTRATIGRAPHIC CHART RADIOLARIA

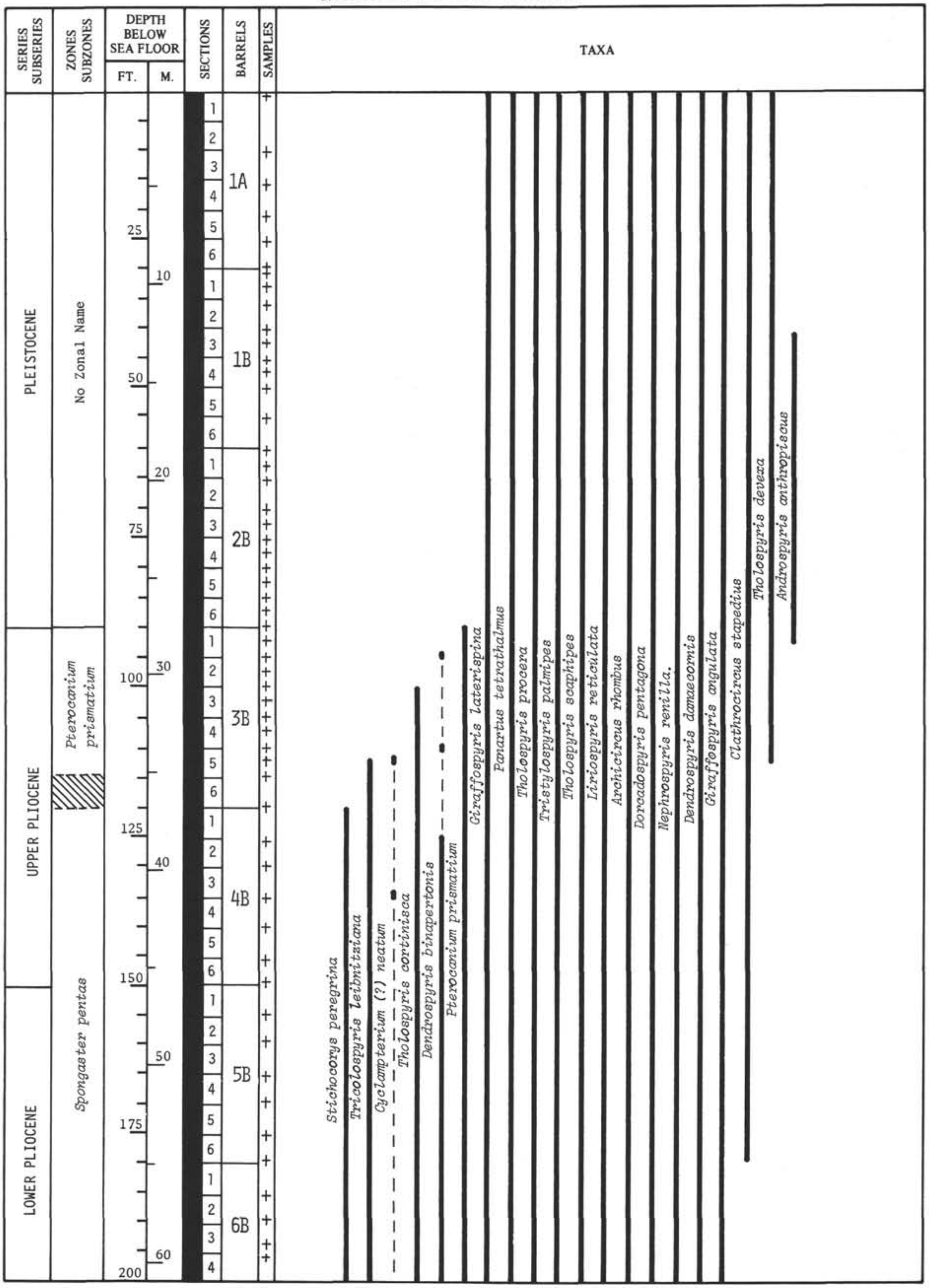


Figure 17. *Site 77 Biostratigraphic Chart Radiolaria (0 to 200 feet).*

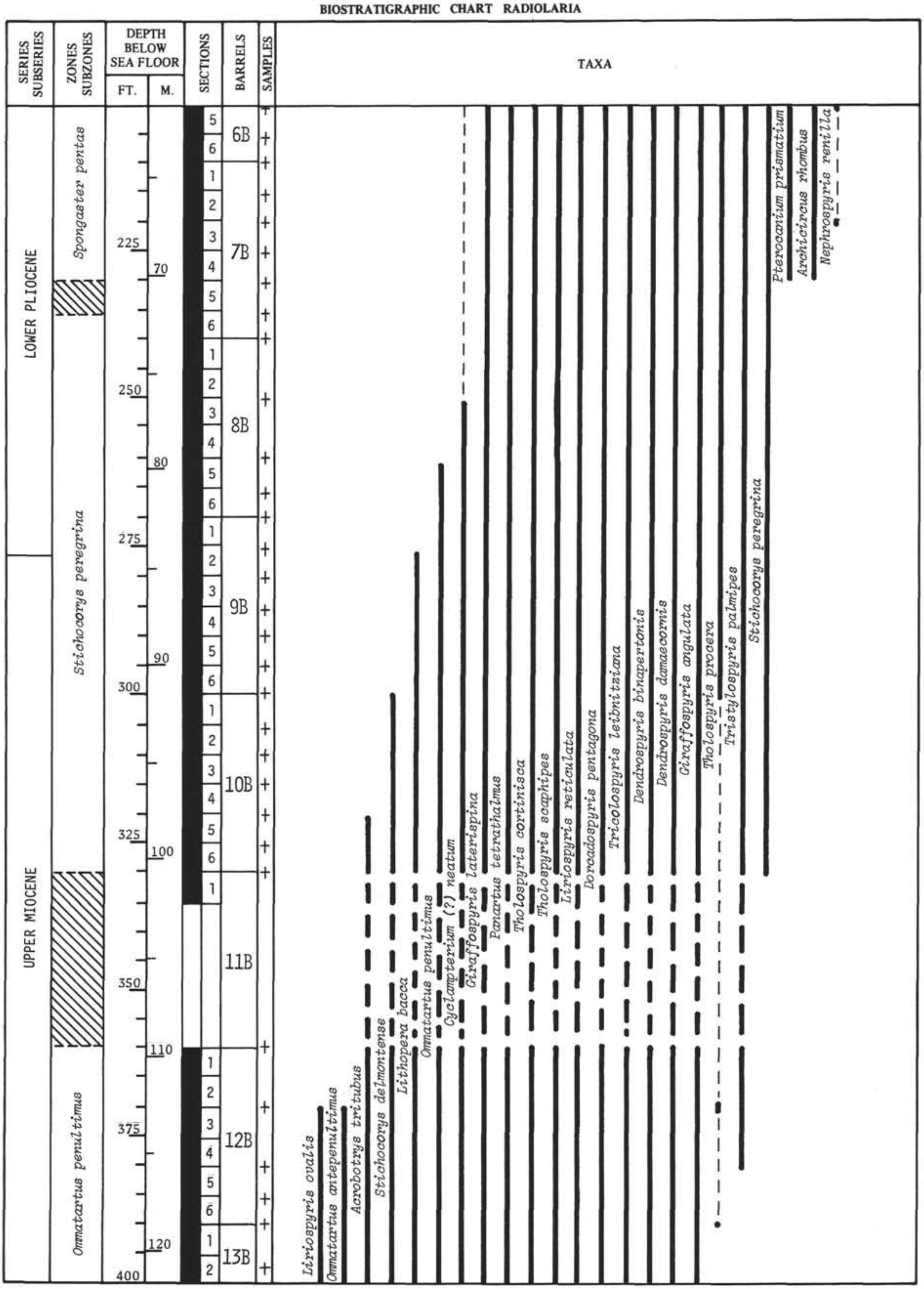


Figure 18. *Site 77 Biostratigraphic Chart Radiolaria (200 to 400 feet).*

BIOSTRATIGRAPHIC CHART RADIOLARIA

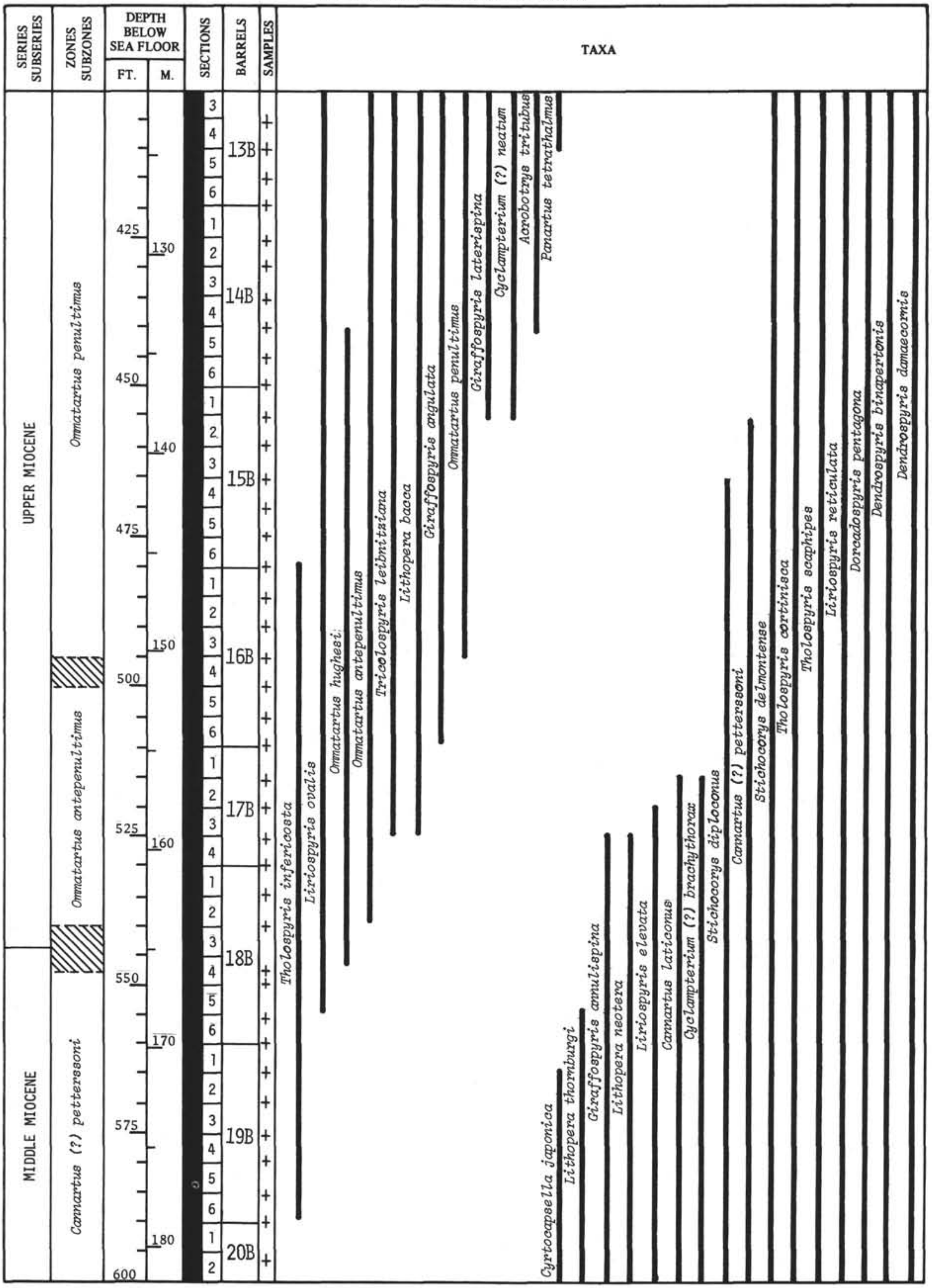


Figure 19. *Site 77 Biostratigraphic Chart Radiolaria (400 to 600 feet).*

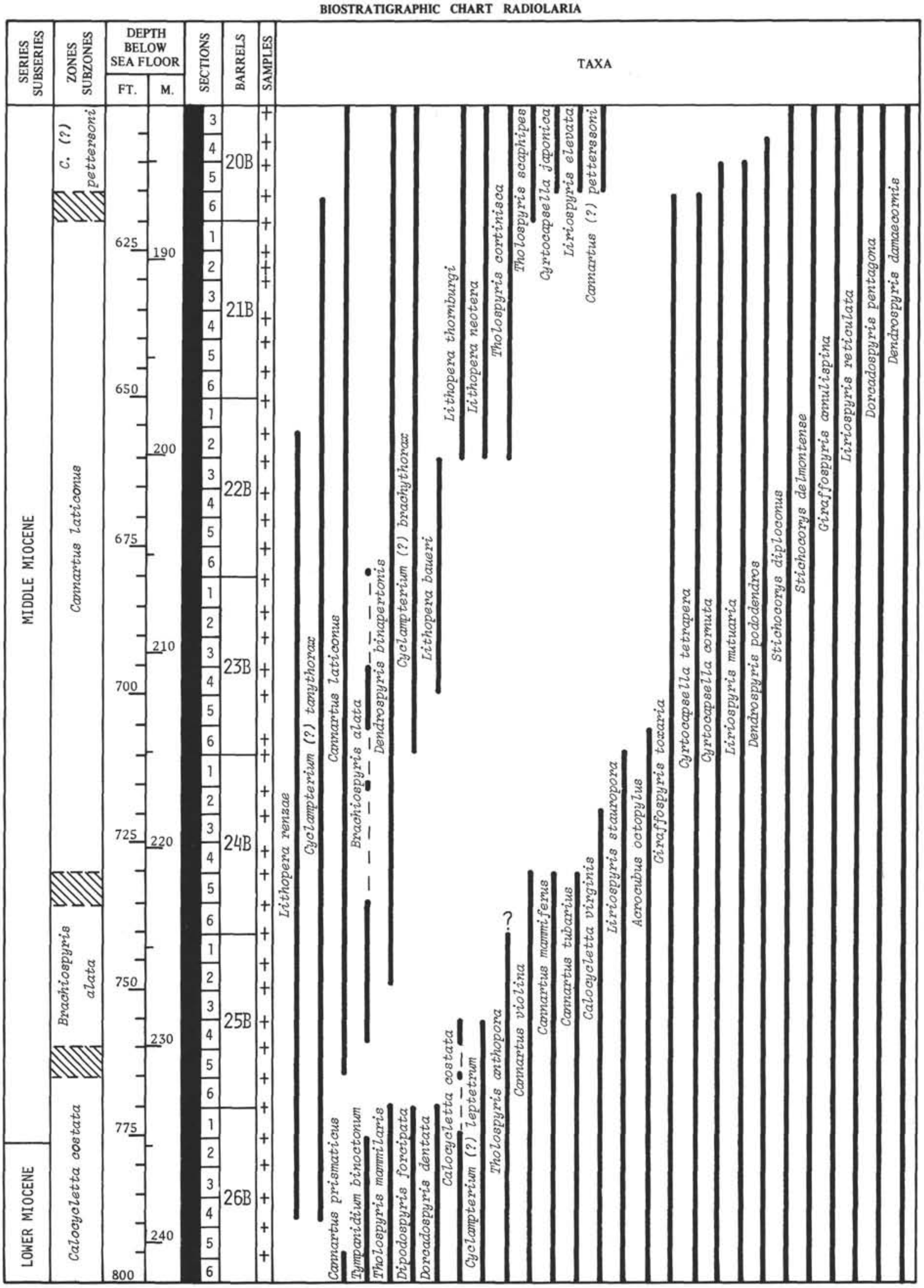


Figure 20. *Site 77 Biostratigraphic Chart Radiolaria (600 to 800 feet).*

BIOSTRATIGRAPHIC CHART RADIOLARIA

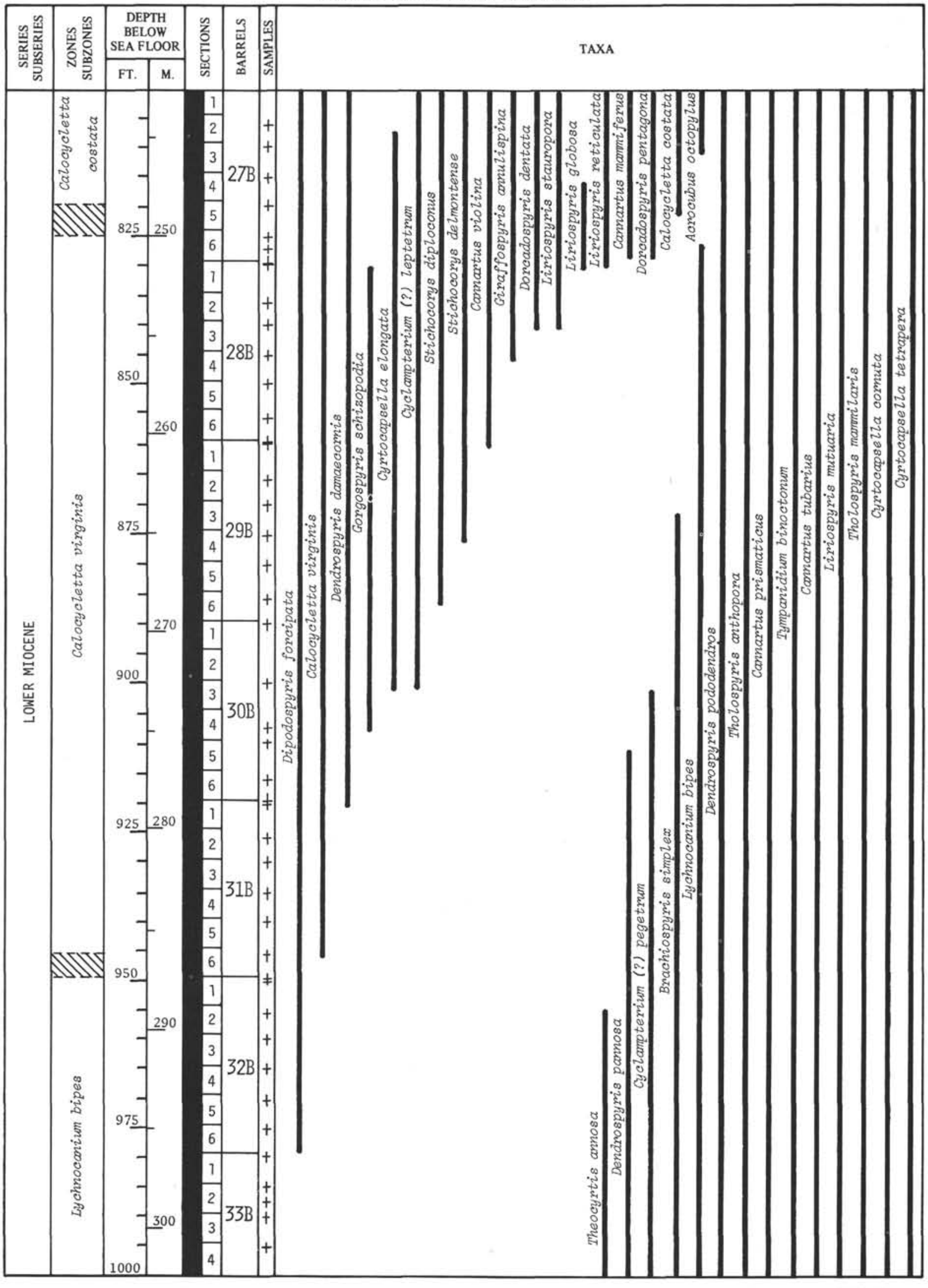


Figure 21. *Site 77 Biostratigraphic Chart Radiolaria (800 to 1000 feet).*

BIOSTRATIGRAPHIC CHART RADIOLARIA

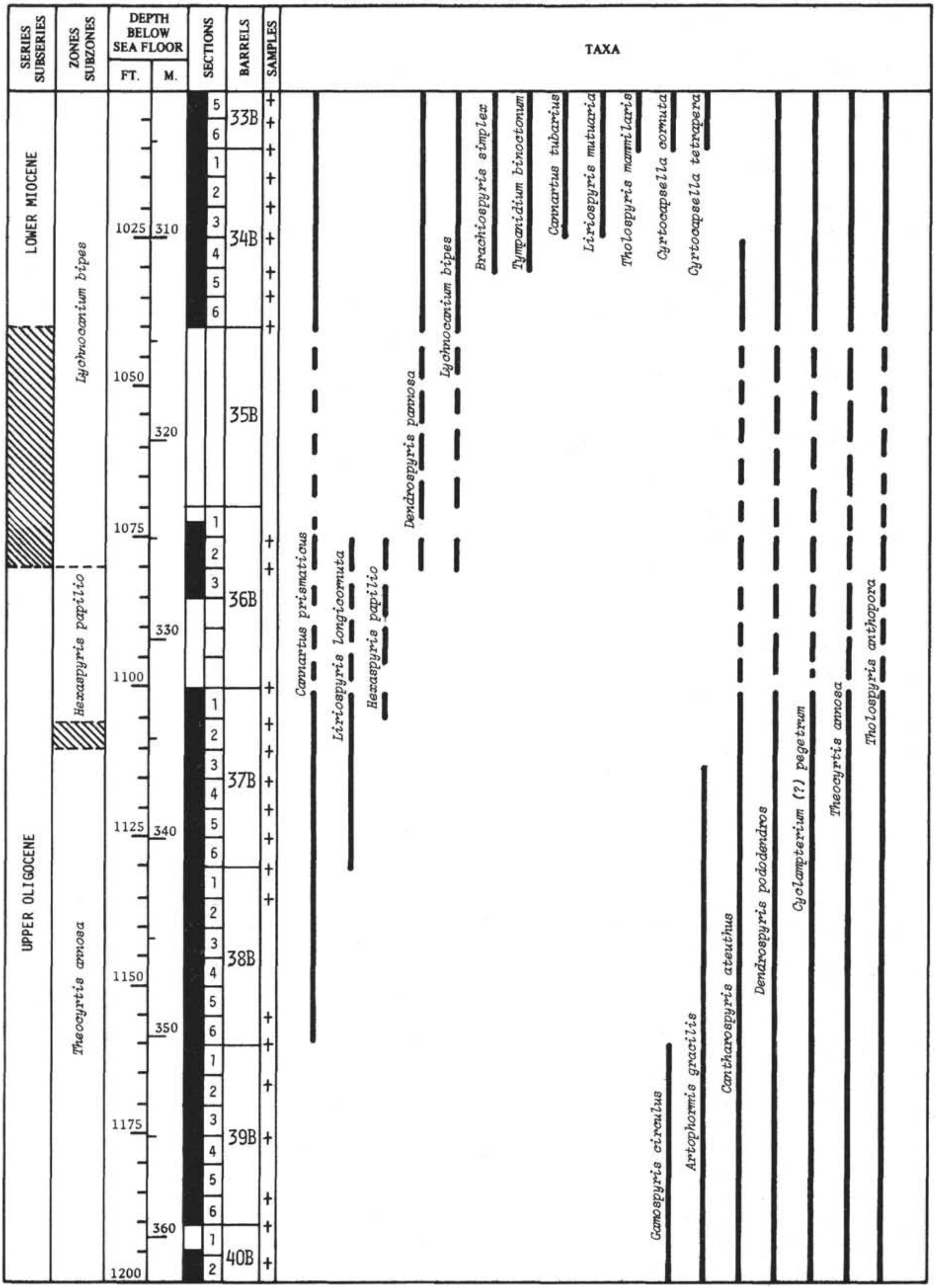


Figure 22. *Site 77 Biostratigraphic Chart Radiolaria (1000 to 1200 feet)*

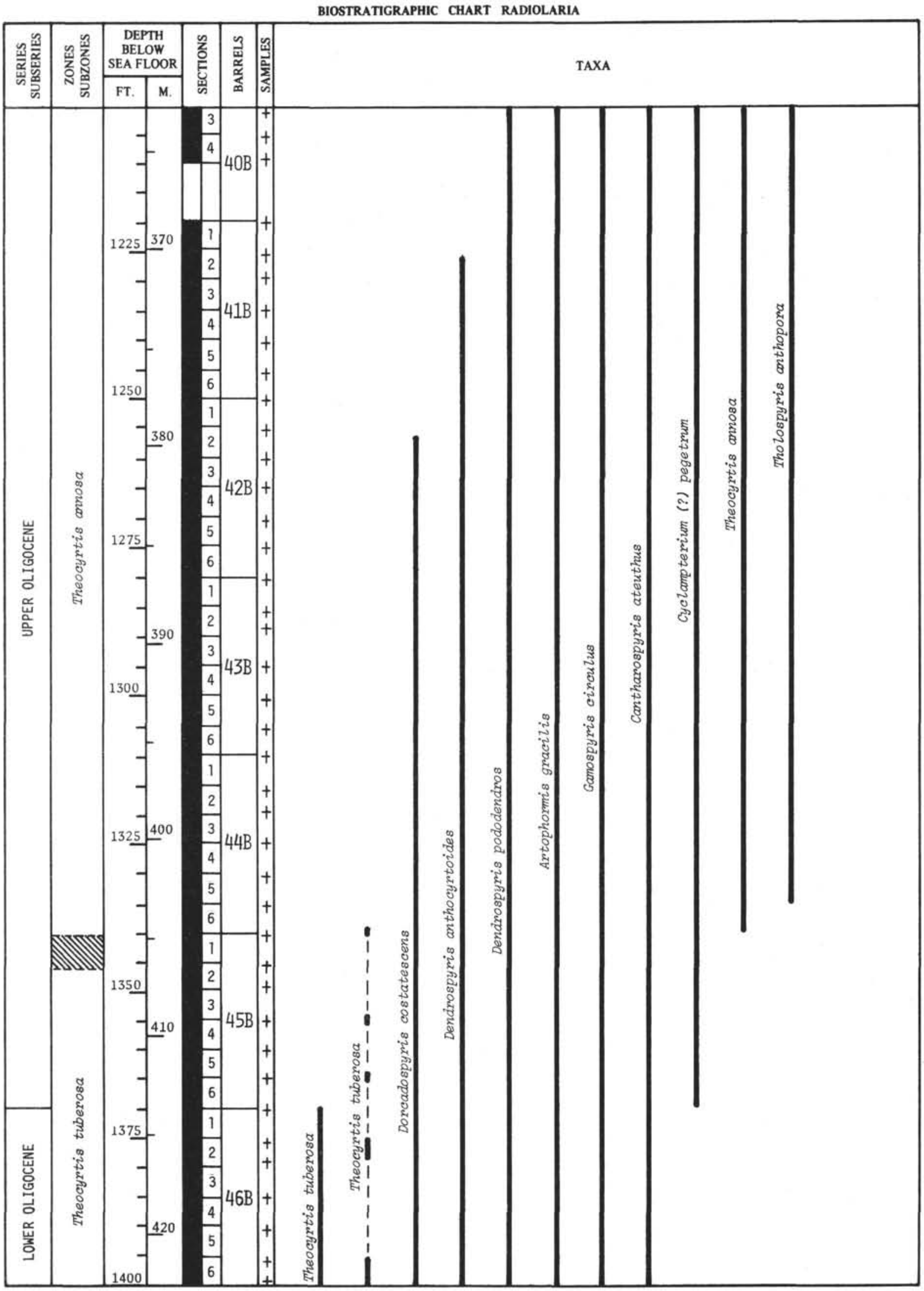


Figure 23. *Site 77 Biostratigraphic Chart Radiolaria (1200 to 1400 feet).*

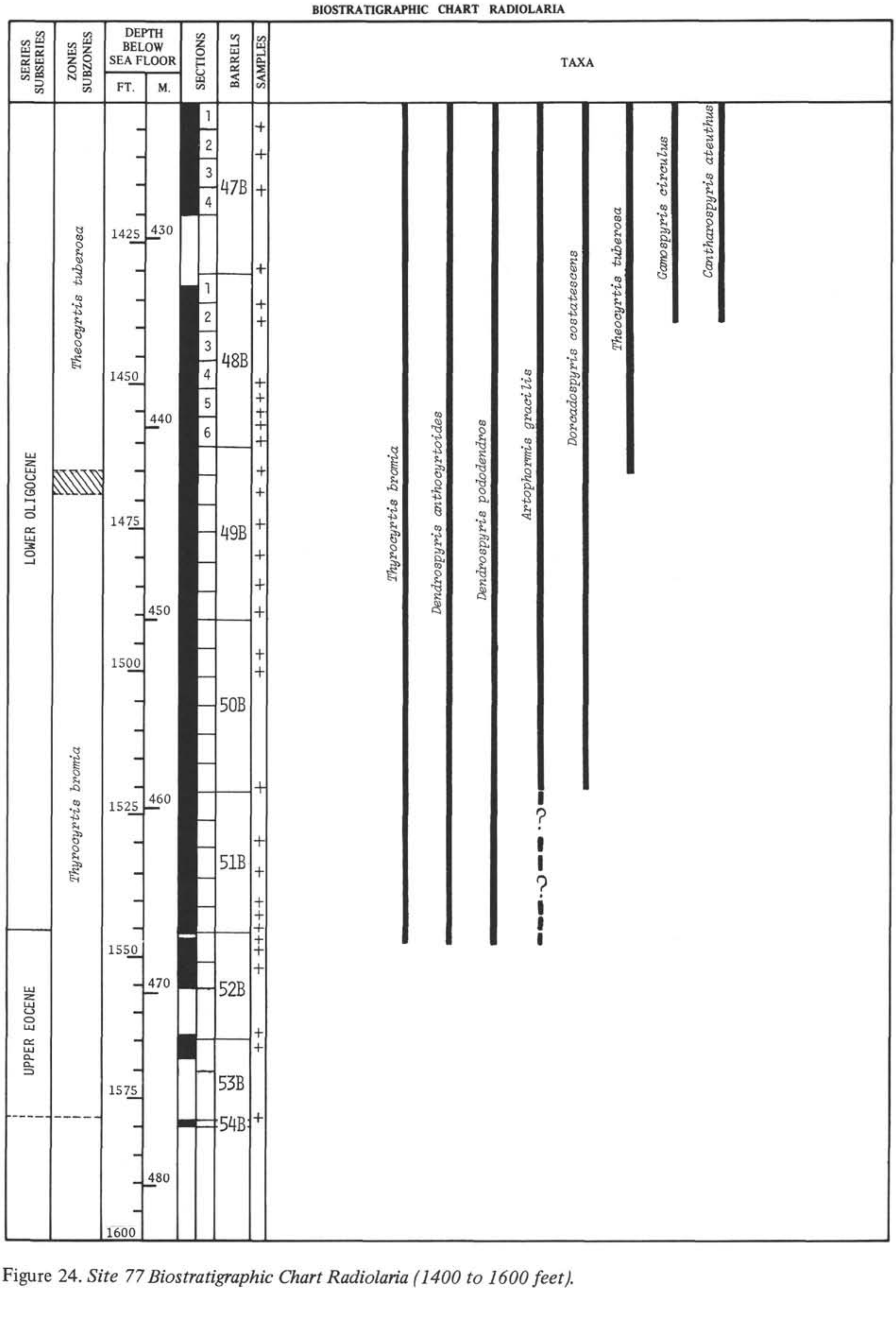


Figure 24. *Site 77 Biostratigraphic Chart Radiolaria (1400 to 1600 feet).*

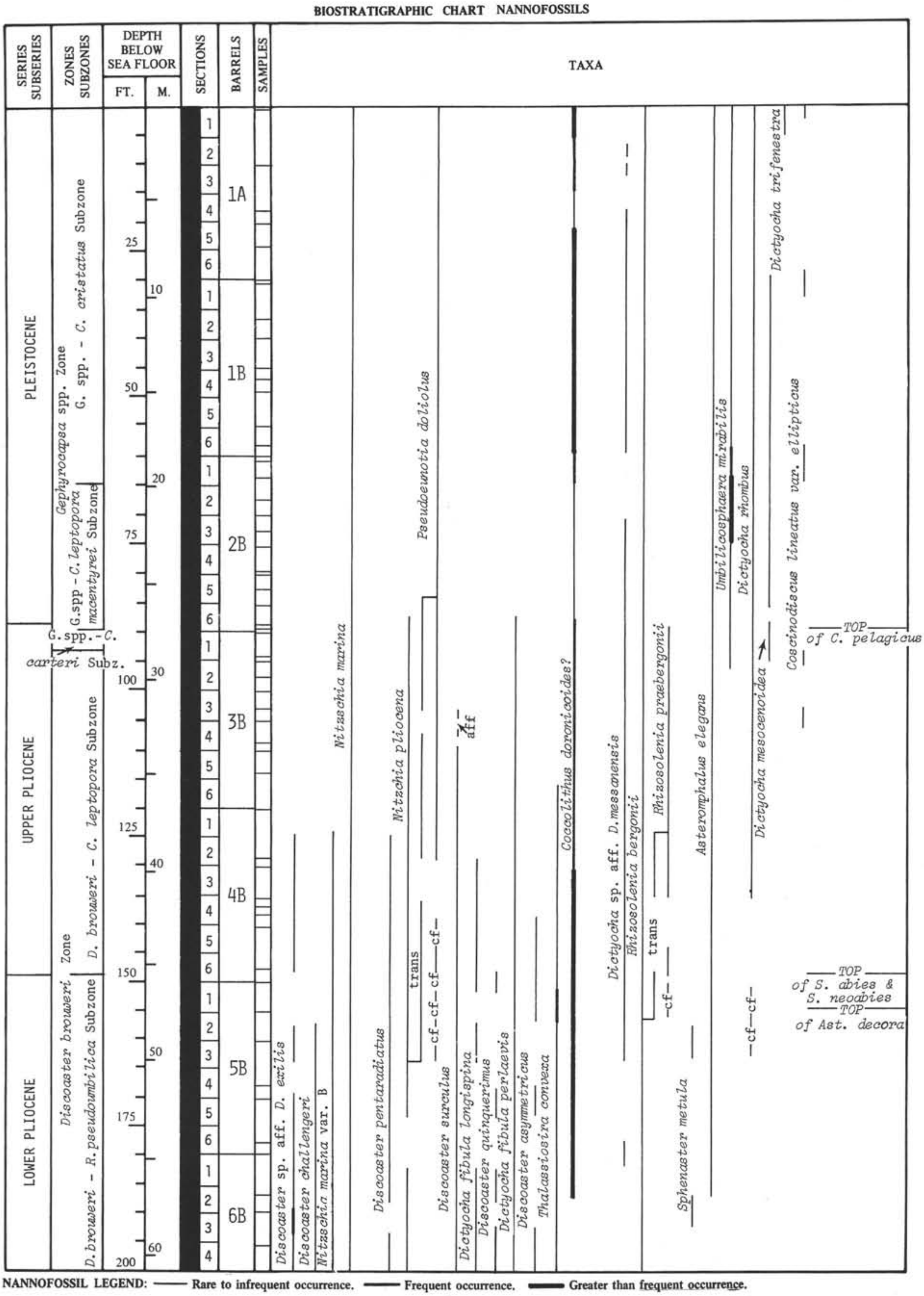


Figure 25. *Site 77 Biostratigraphic Chart Nannofossils (0 to 200 feet).*

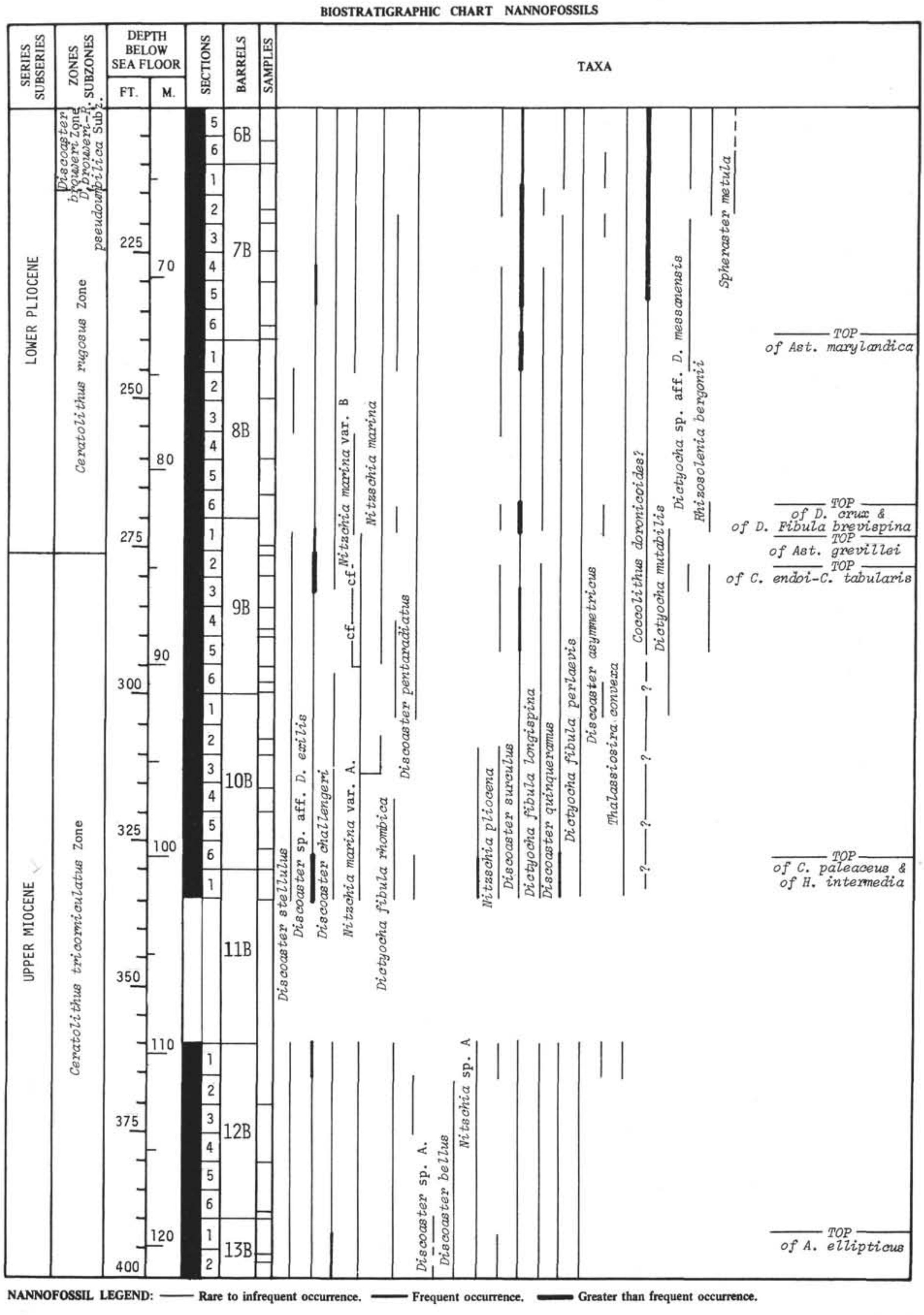
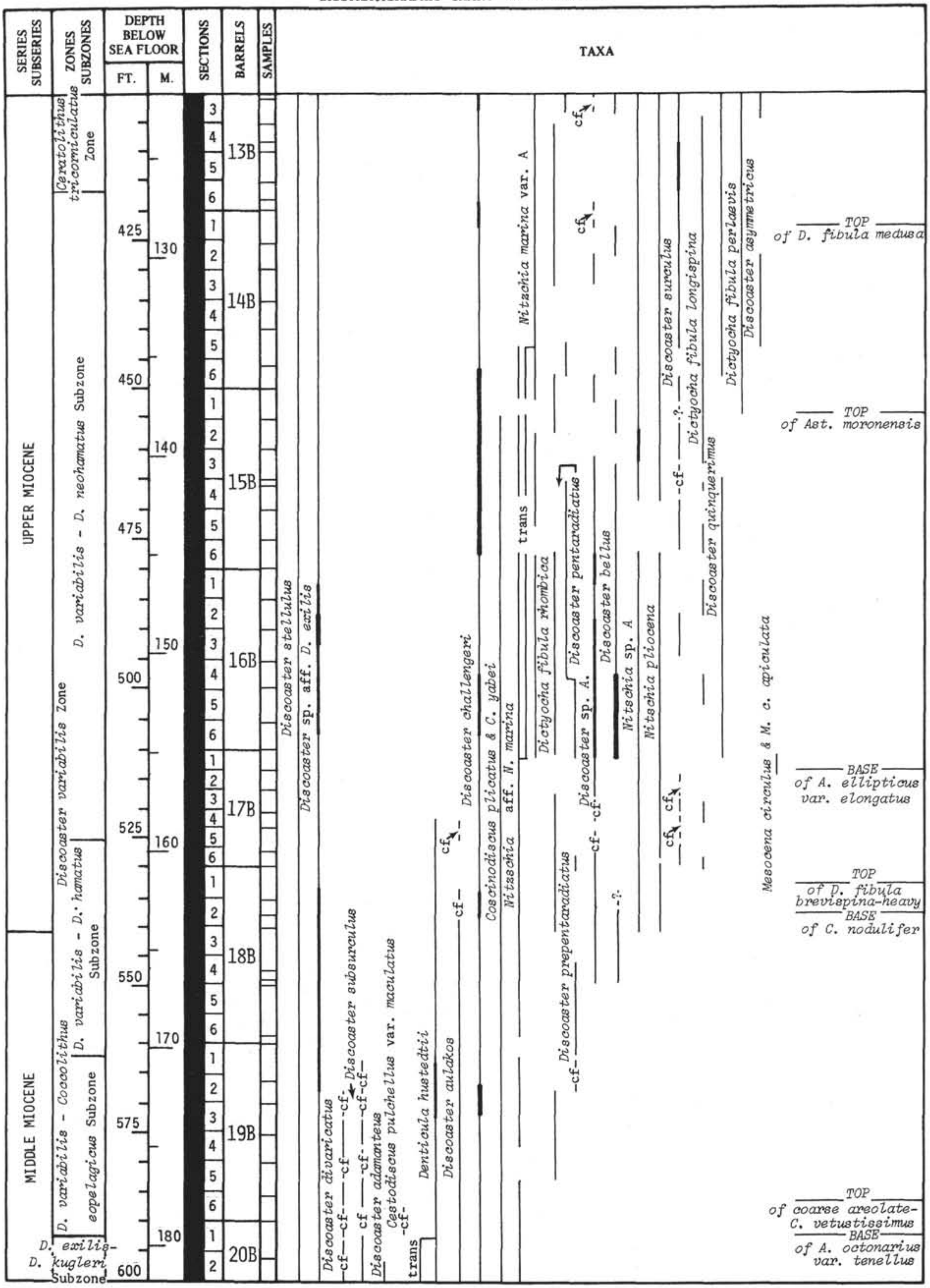


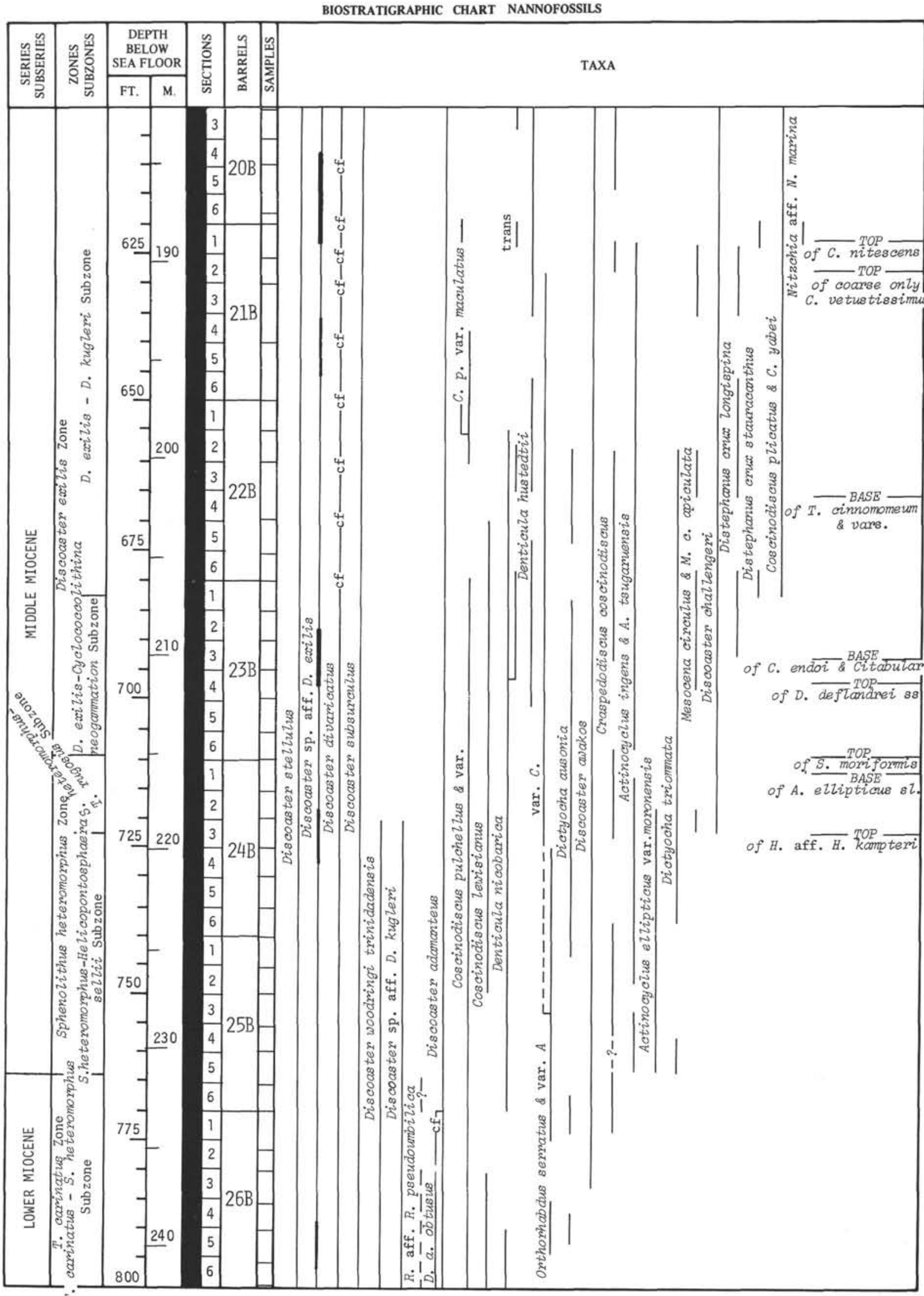
Figure 26. *Site 77 Biostratigraphic Chart Nannofossils (200 to 400 feet).*

BIOSTRATIGRAPHIC CHART NANNOFOSSILS



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

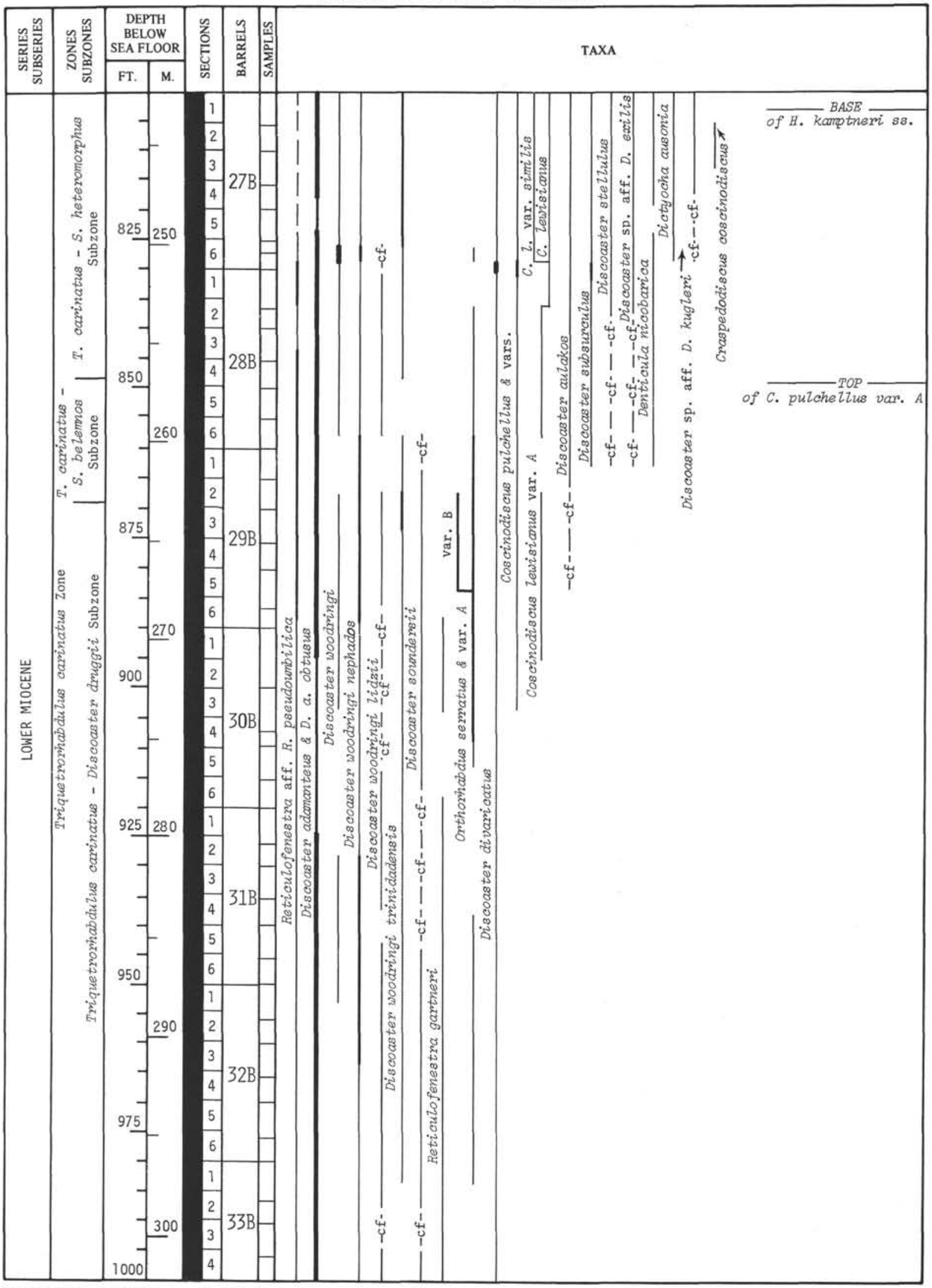
Figure 27. *Site 77 Biostratigraphic Chart Nannofossils (400 to 600 feet).*



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

Figure 28. *Site 77 Biostratigraphic Chart Nannofossils (600 to 800 feet).*

BIOSTRATIGRAPHIC CHART NANNOFOSSILS



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

Figure 29. *Site 77 Biostratigraphic Chart Nannofossils (800 to 1000 feet).*

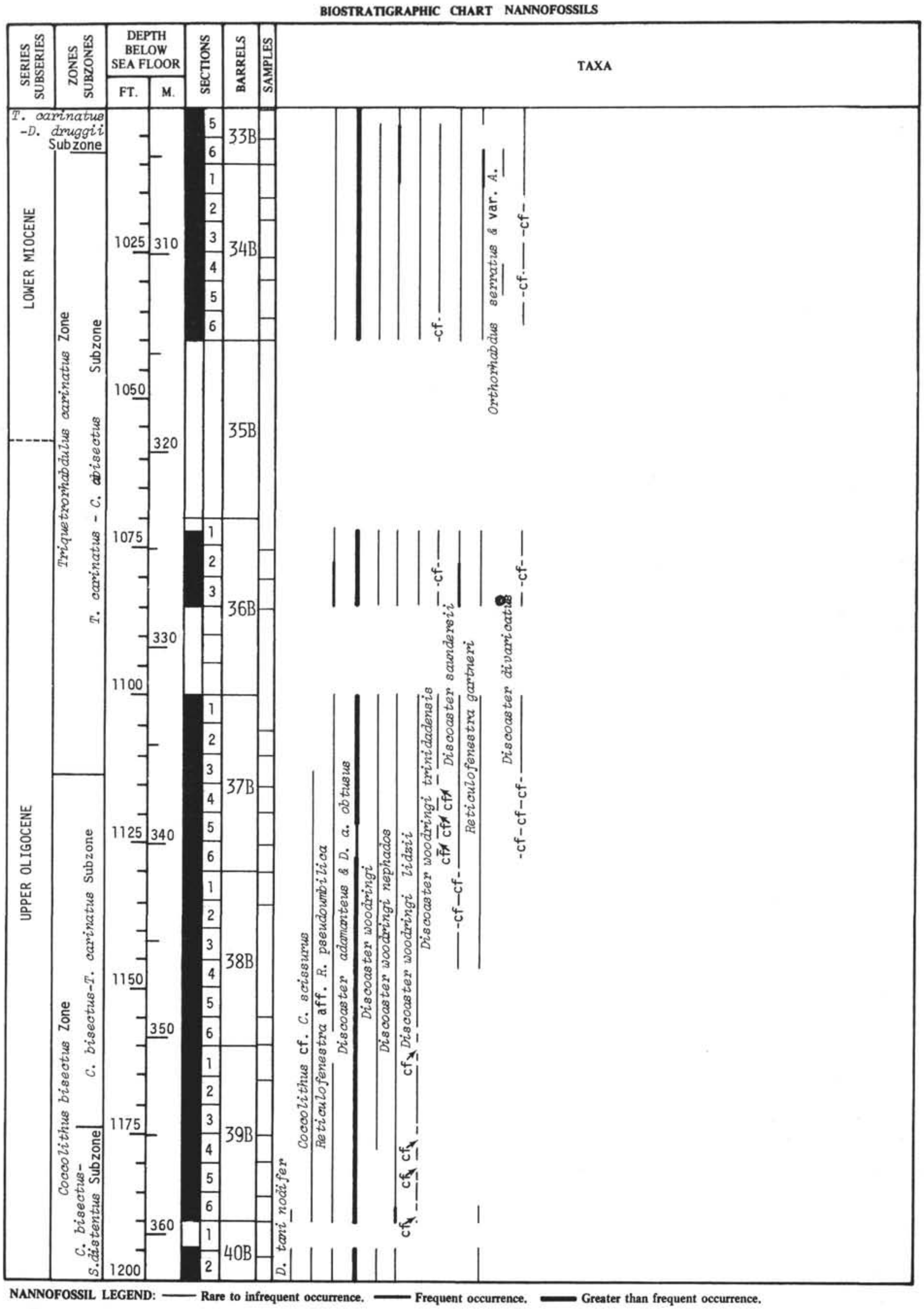


Figure 30. *Site 77 Biostratigraphic Chart Nannofossils (1000 to 1200 feet).*

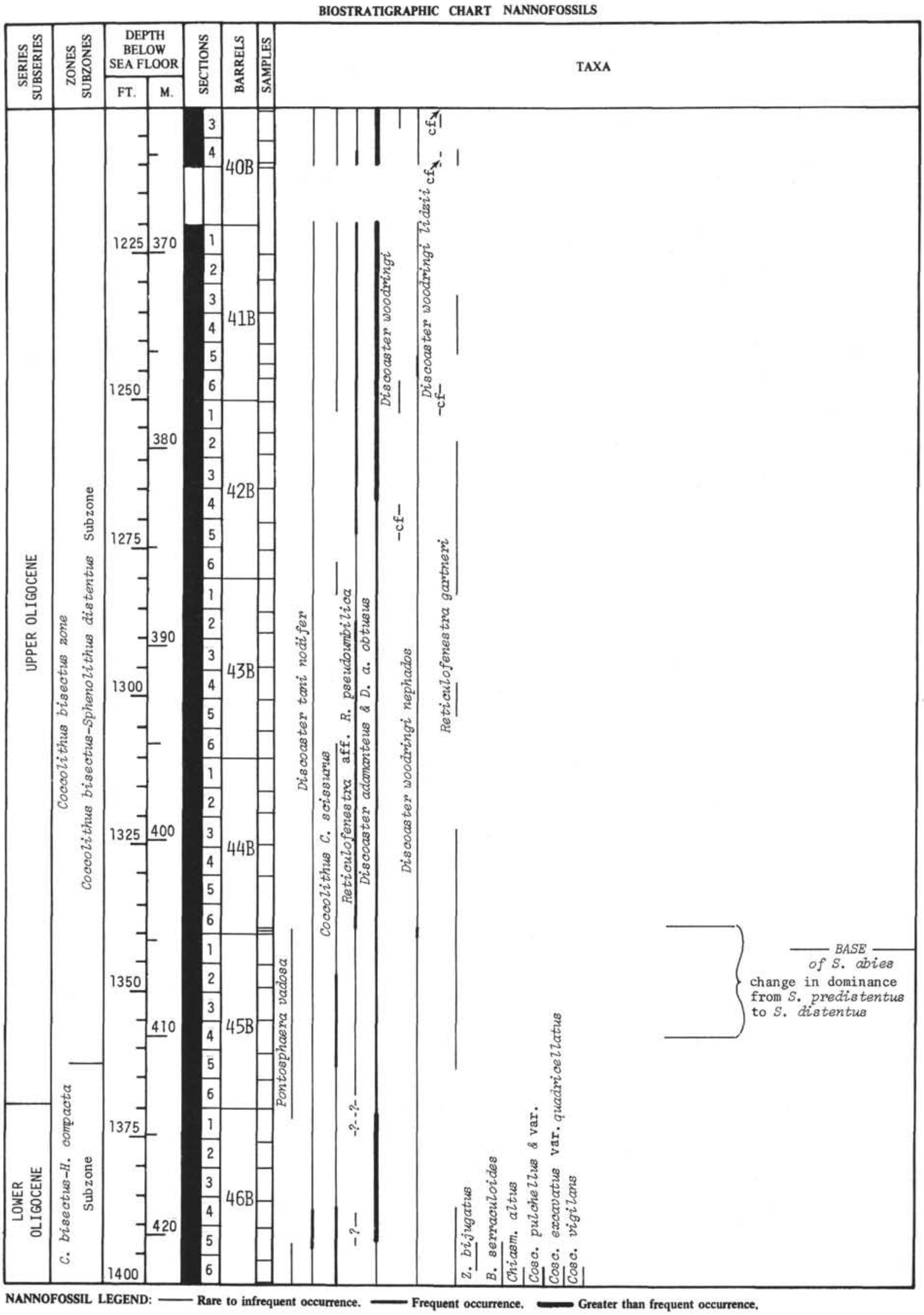


Figure 31. *Site 77 Biostratigraphic Chart Nannofossils (1200 to 1400 feet).*

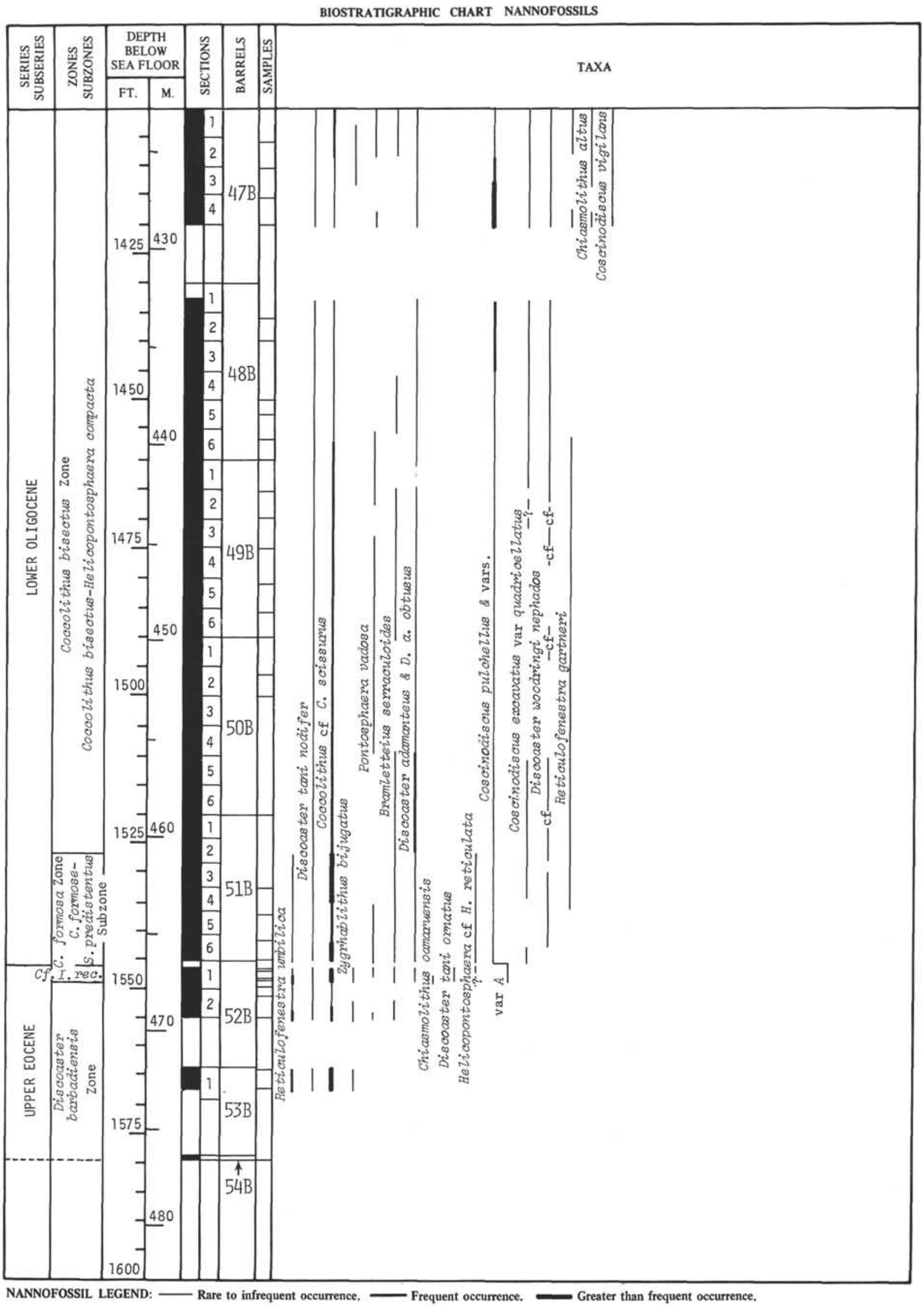


Figure 32. *Site 77 Biostratigraphic Chart Nannofossils (1400 to 1600 feet).*

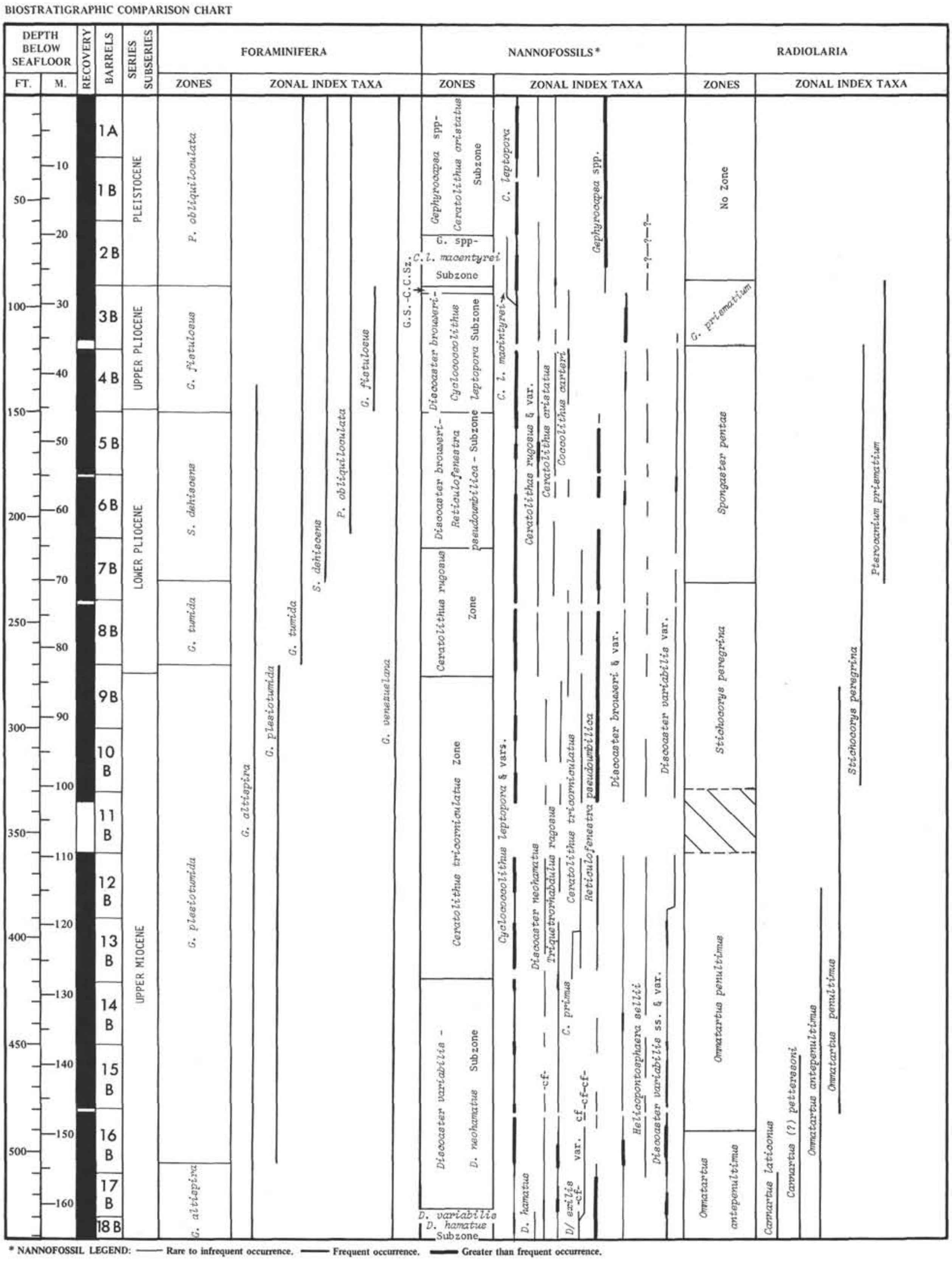


Figure 33. *Site 77 Biostratigraphic Comparison Chart.*

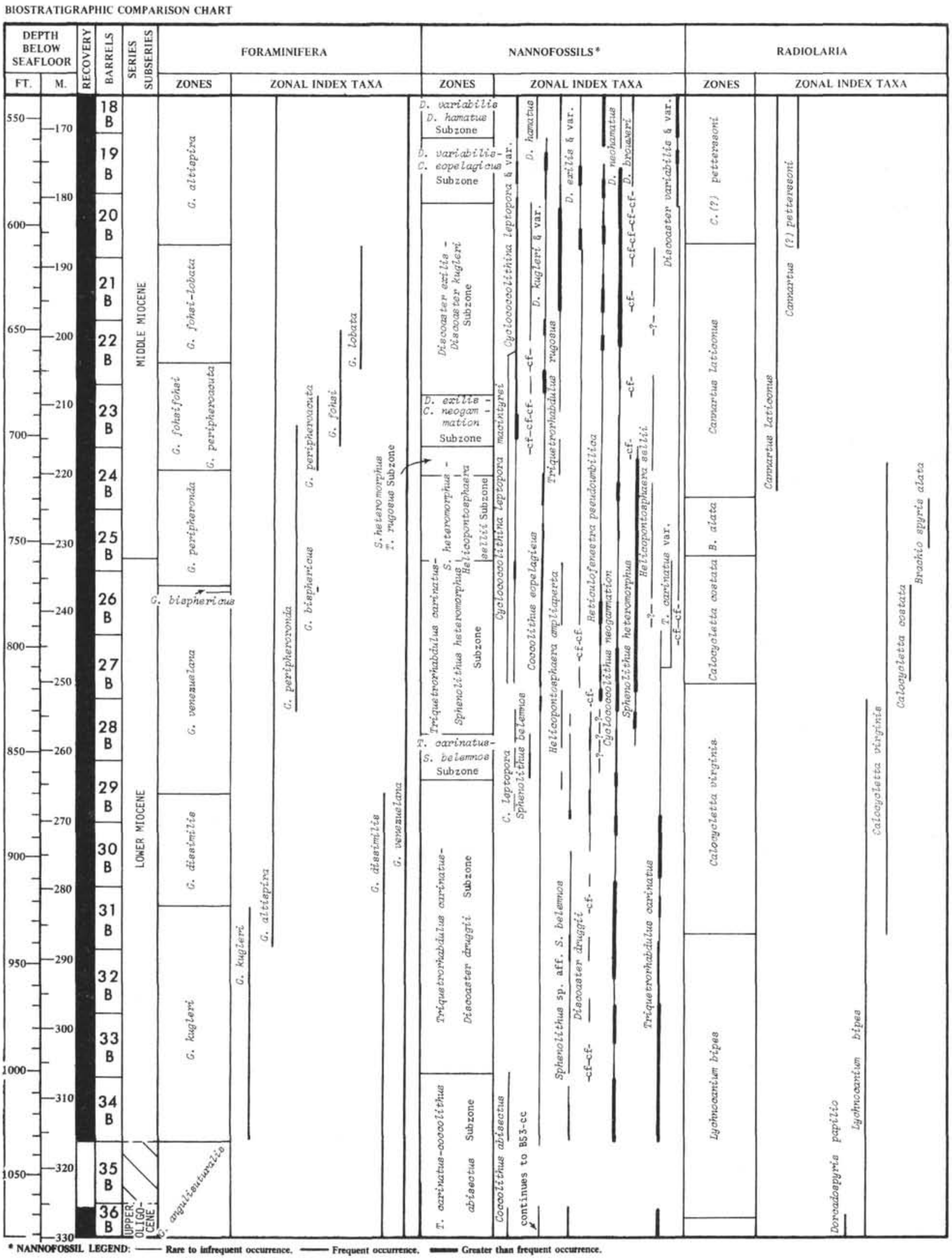
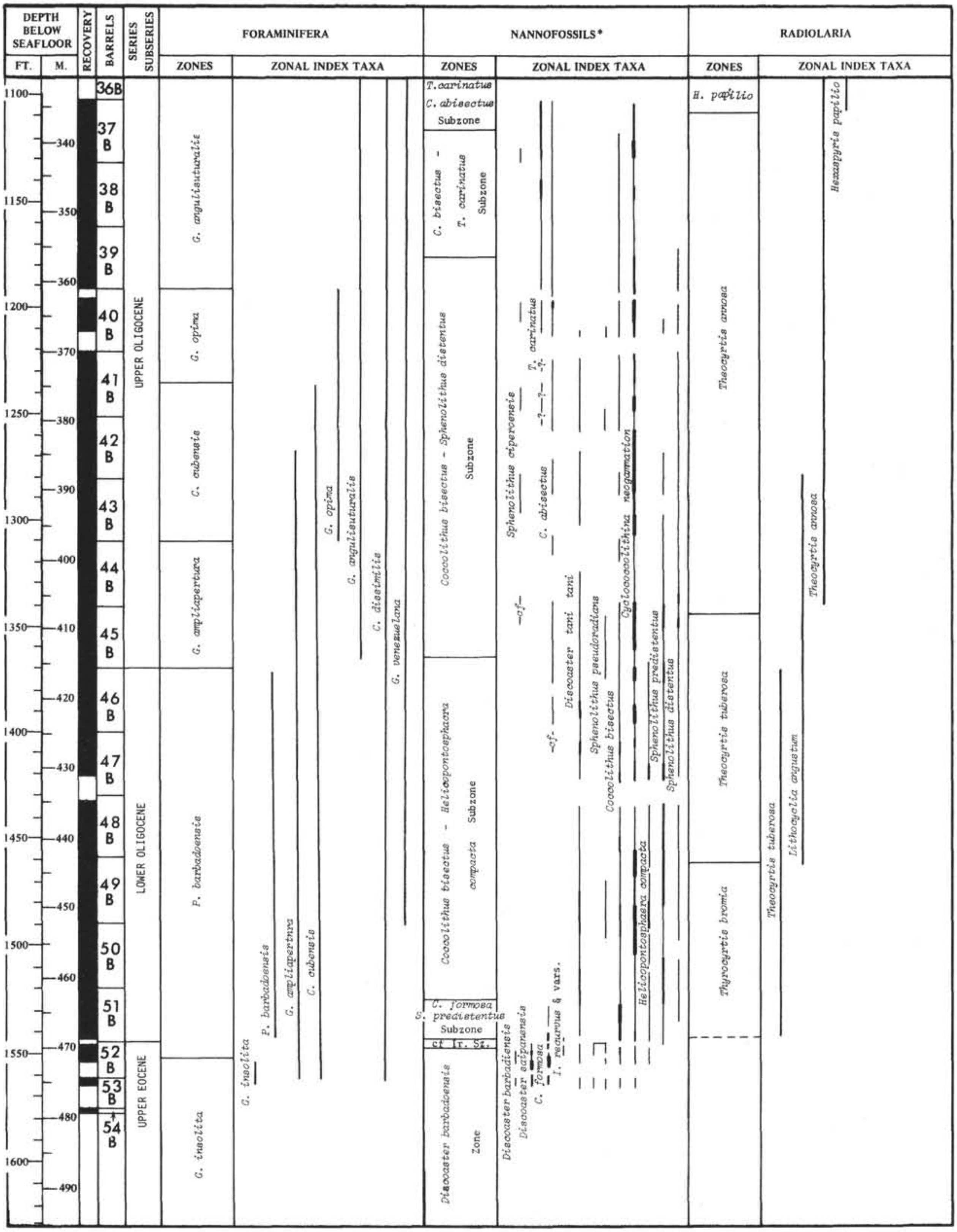


Figure 34. *Site 77 Biostratigraphic Comparison Chart (continued).*

BIOSTRATIGRAPHIC COMPARISON CHART



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

Figure 35. *Site 77 Biostratigraphic Comparison Chart (continued).*

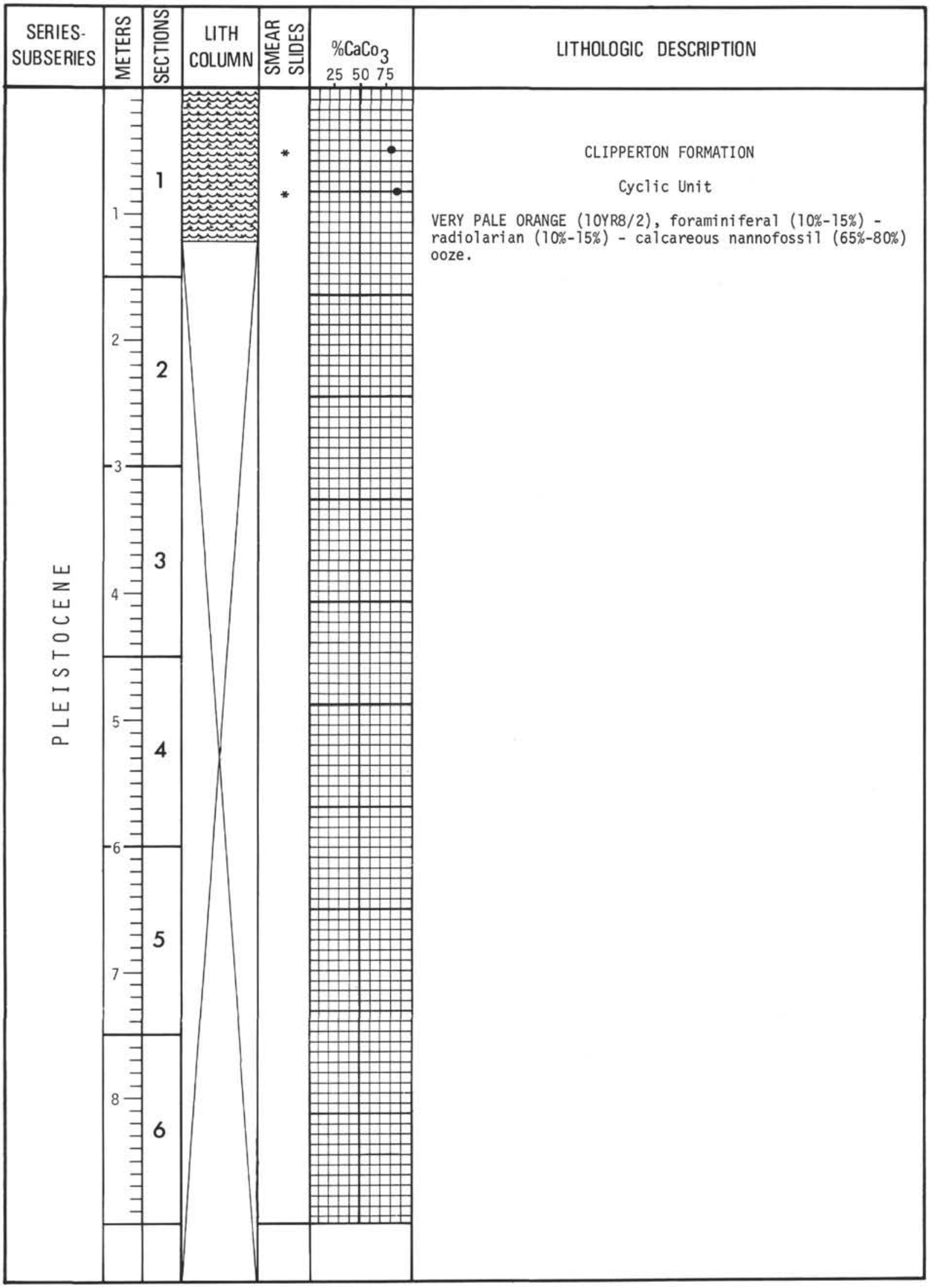


Figure 36. *Hole 77, Core 1 (0 to 1.1m).*

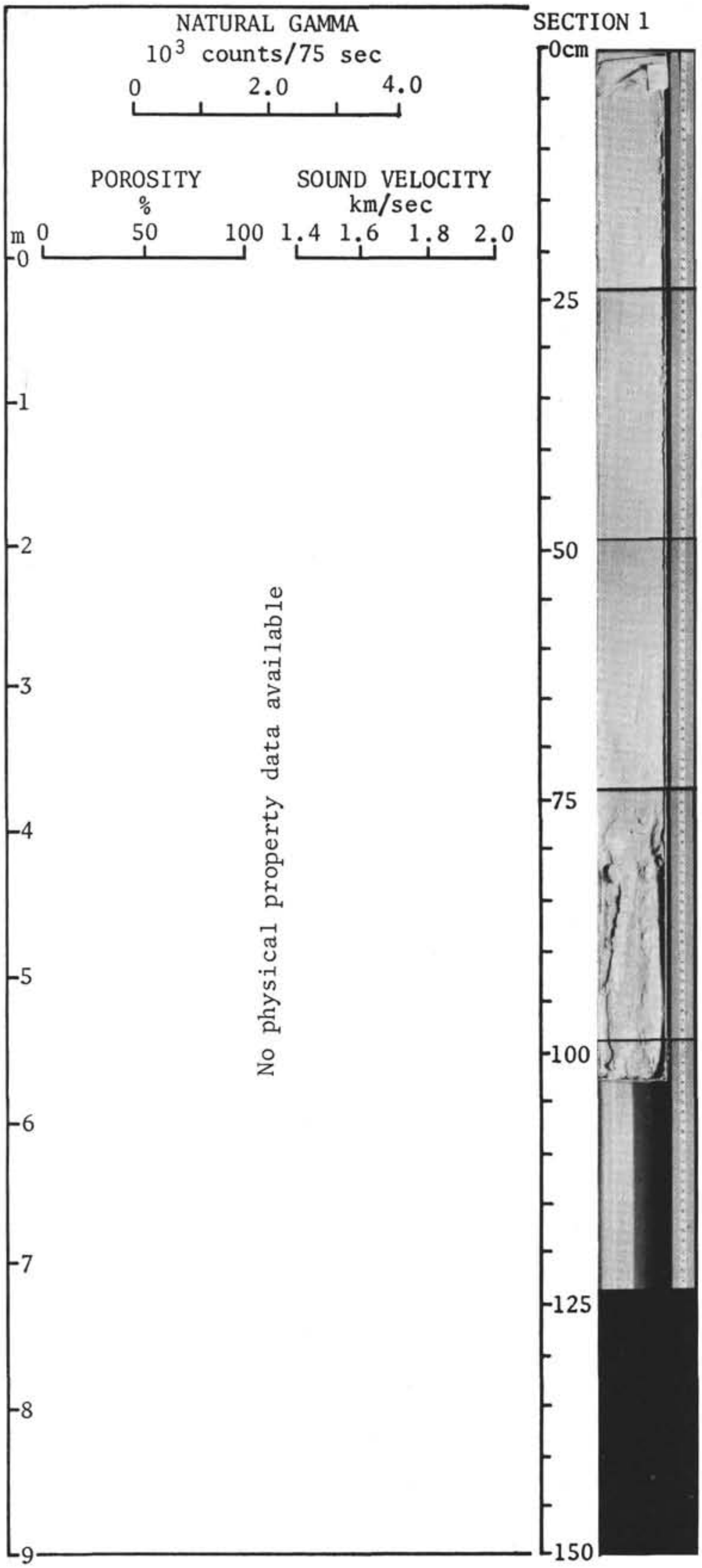


Figure 37. *Hole 77, Core 1, Section 1, Physical Properties.*

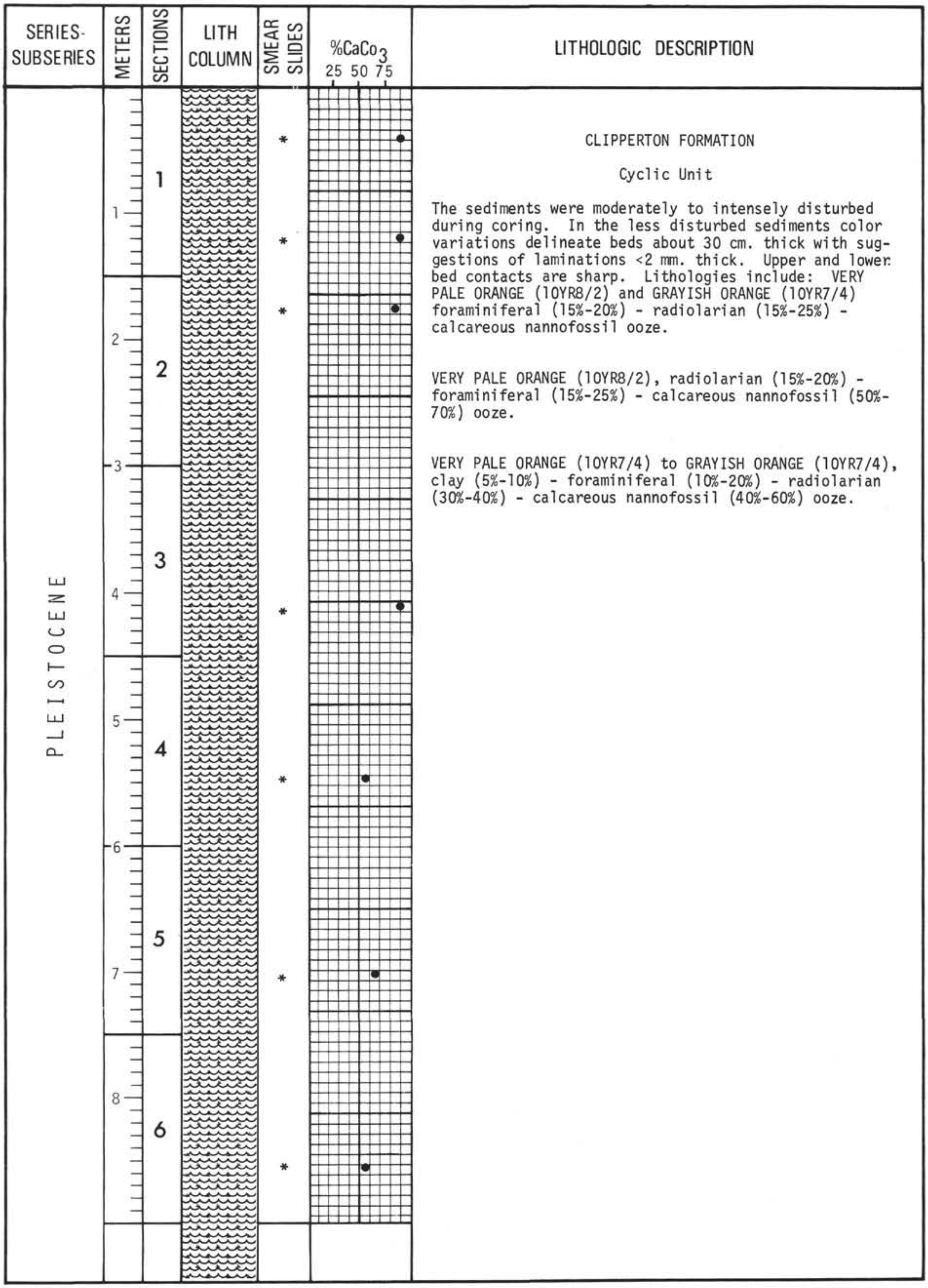


Figure 38. *Hole 77A, Core 1 (0 to 9.1m).*

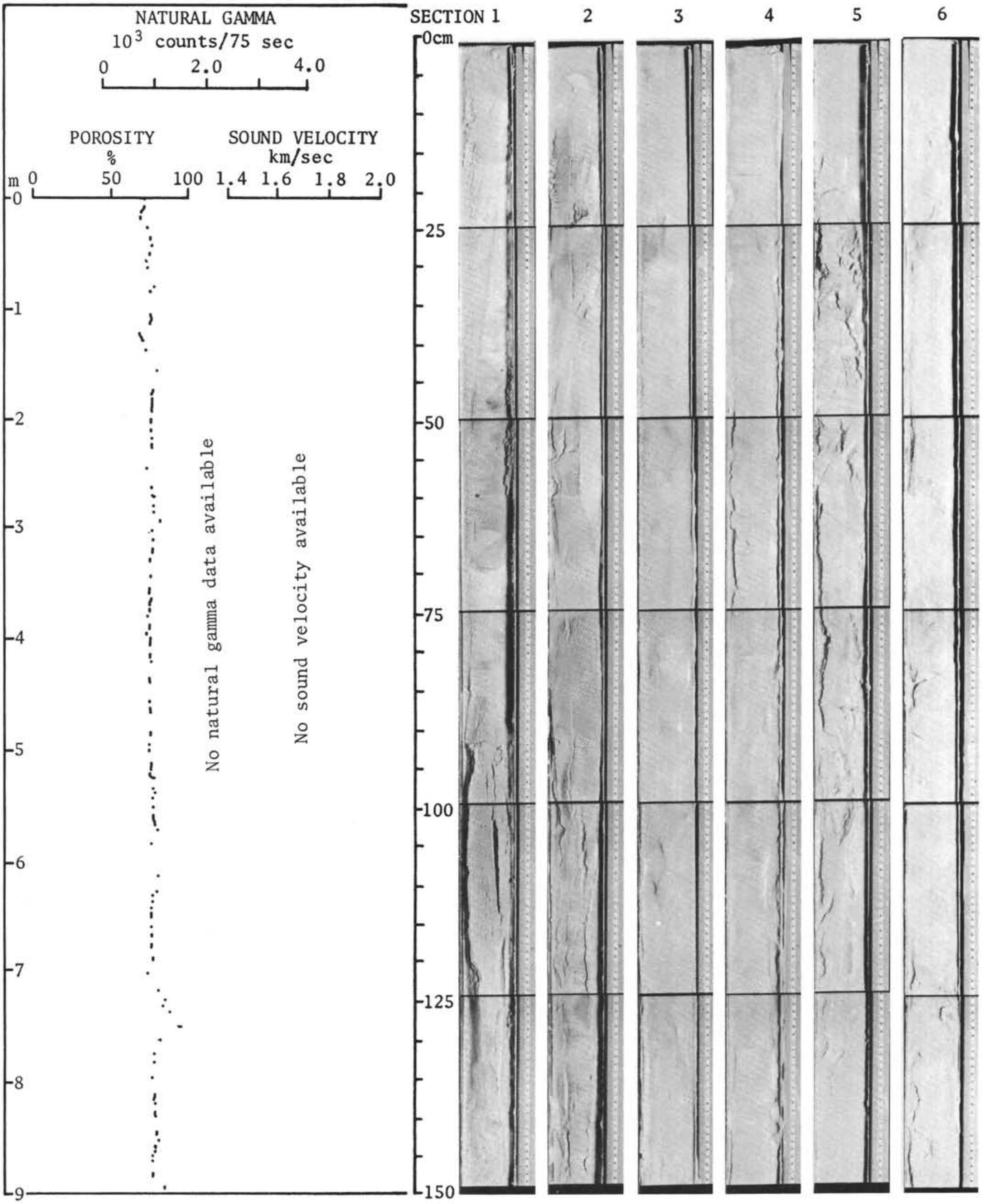
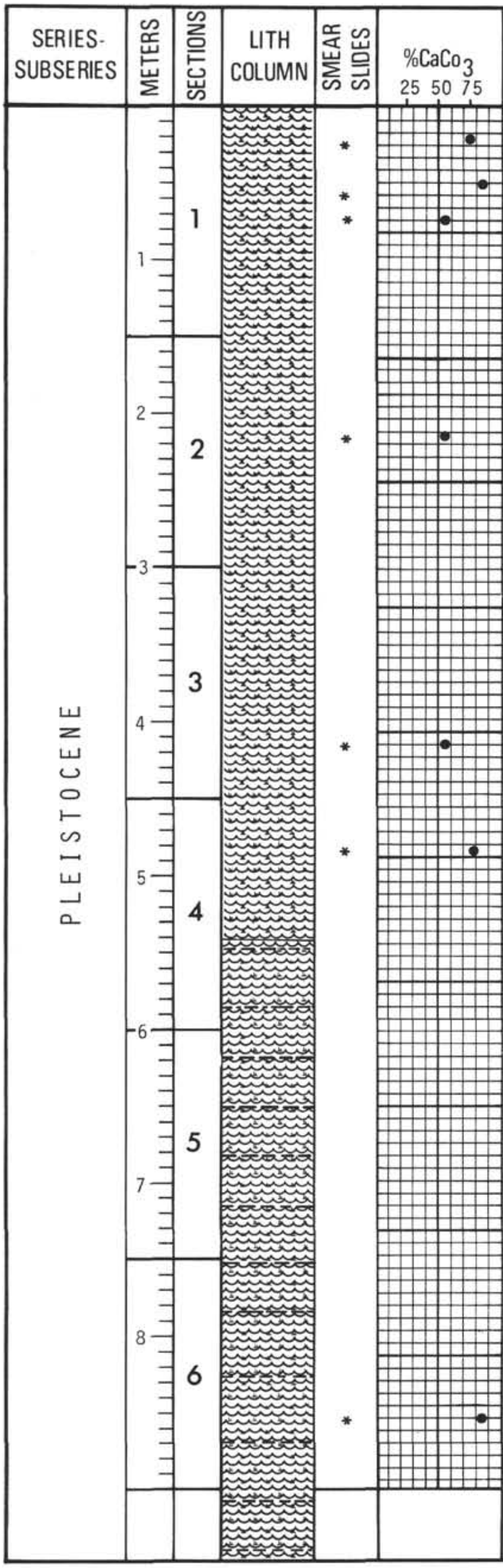


Figure 39. *Hole 77A, Core 1, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Cyclic Unit

Moderately to intensely disturbed sediments occuring in interbedded 1-5 cm. beds with faint suggestions of laminations <2 mm. thick. Color contacts sharp. Interbedded lithologys cyclically alternate between silica rich and silica poor sediments corresponding to their radiolarian content.

WHITE (N9), and VERY LIGHT GRAY (N8), foraminiferal (15%-20%) - radiolarian (15%-20%) - calcareous nannofossil (60%-70%) ooze.

YELLOWISH GRAY (5Y7/2), clay (1%-5%) foraminiferal (15%-20%) - calcareous nannofossil (30%-50%) - radiolarian (40%-60%) ooze.

Figure 40. *Hole 77B, Core 1 (9.1 to 18.2m).*

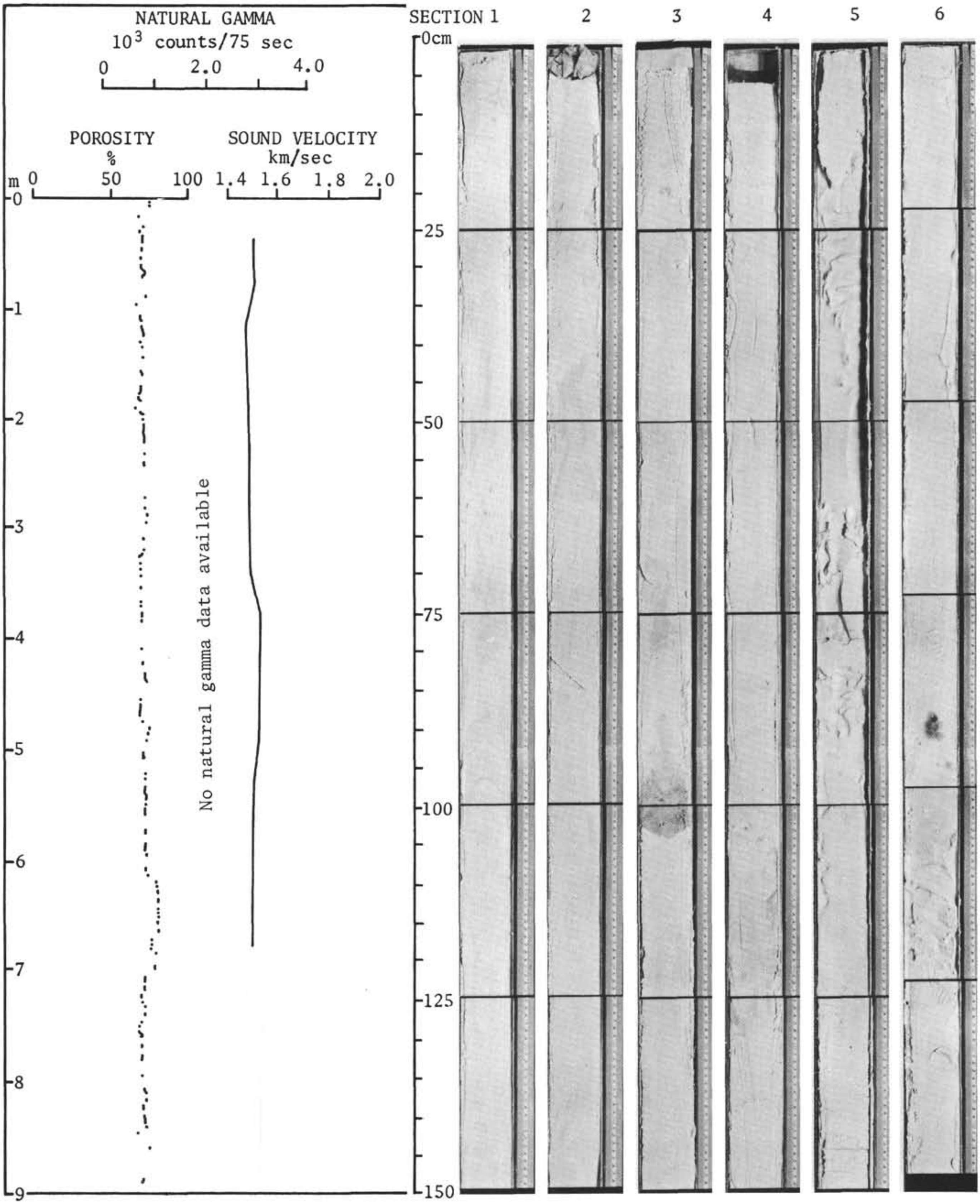
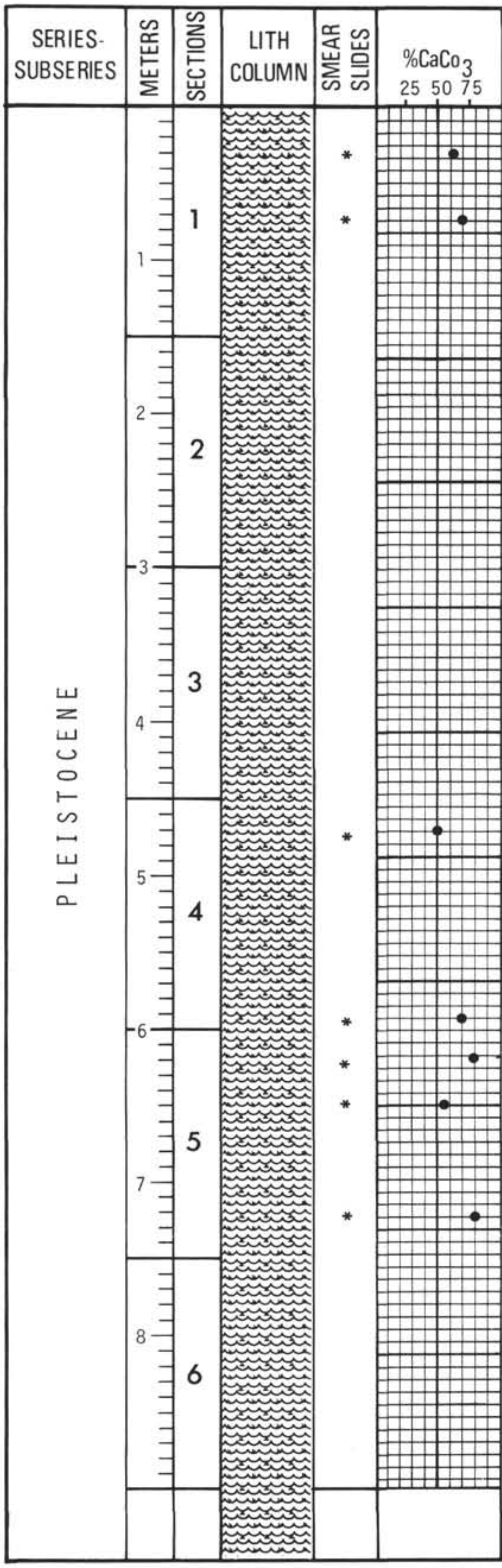


Figure 41. *Hole 77B, Core 1, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Cyclic Unit

Moderately disturbed; lithologys occur in beds 1-30 cm. thick with smeared contacts. Silica content fluctuates cyclically as in Core 1.

Interbedded:

YELLOWISH GRAY (5Y7/2), clay (1%-10%) - foraminiferal (10%-15%) - calcareous nannofossil (30%-40%) - radiolarian (50%-60%) ooze.

VERY PALE ORANGE (10YR8/2), radiolarian (15%-25%) - foraminiferal (15%-25%) - calcareous nannofossil (50%-70%) ooze.

MODERATE YELLOWISH BROWN (10YR5/4), clay (1%-10%) - foraminiferal (20%-25%) - radiolarian (30%-40%) - calcareous nannofossil (40%-50%) ooze.

Figure 42. *Hole 77B, Core 2 (18.2 to 27.3m).*

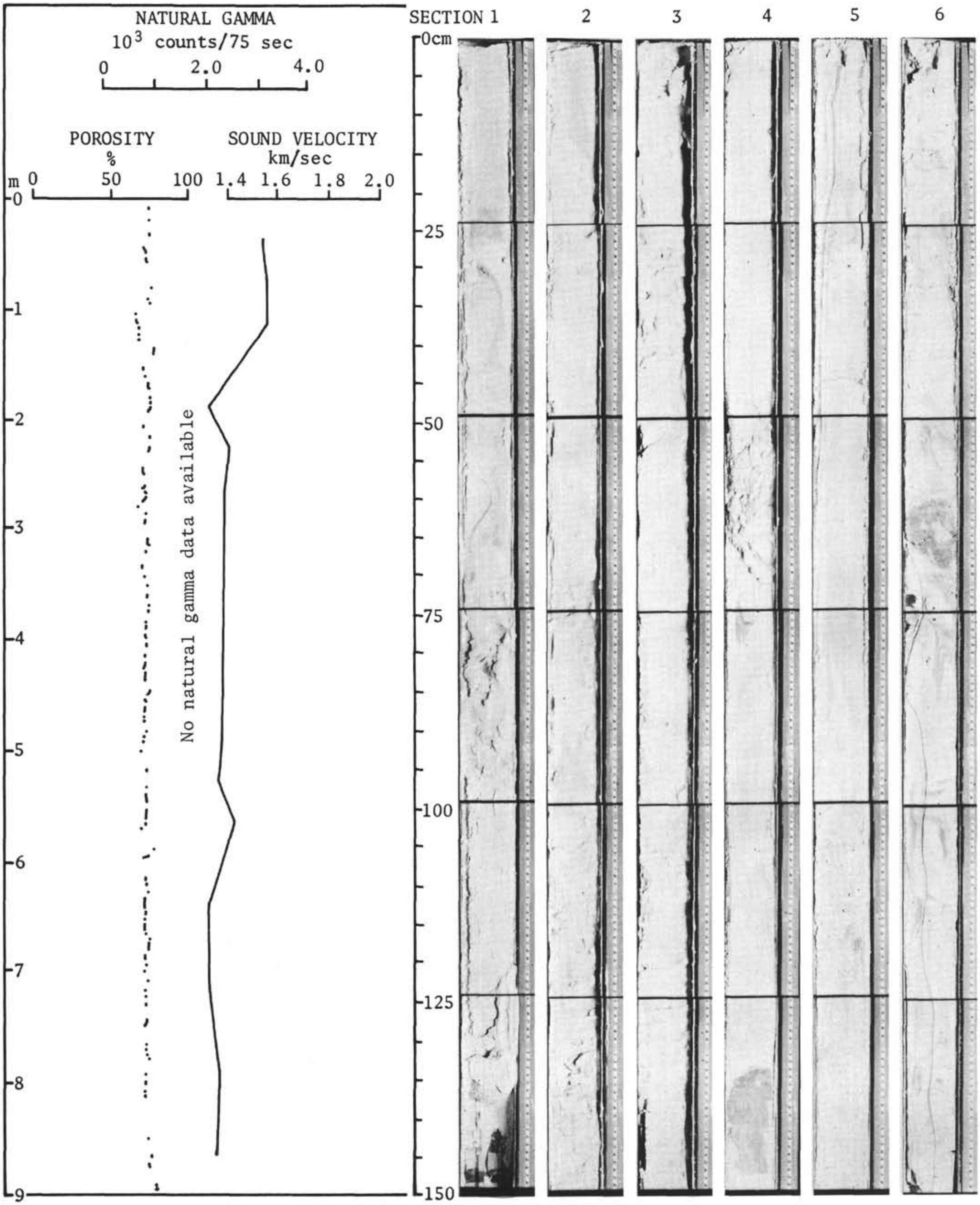


Figure 43. *Hole 77B, Core 2, Sections 1-6, Physical Properties.*

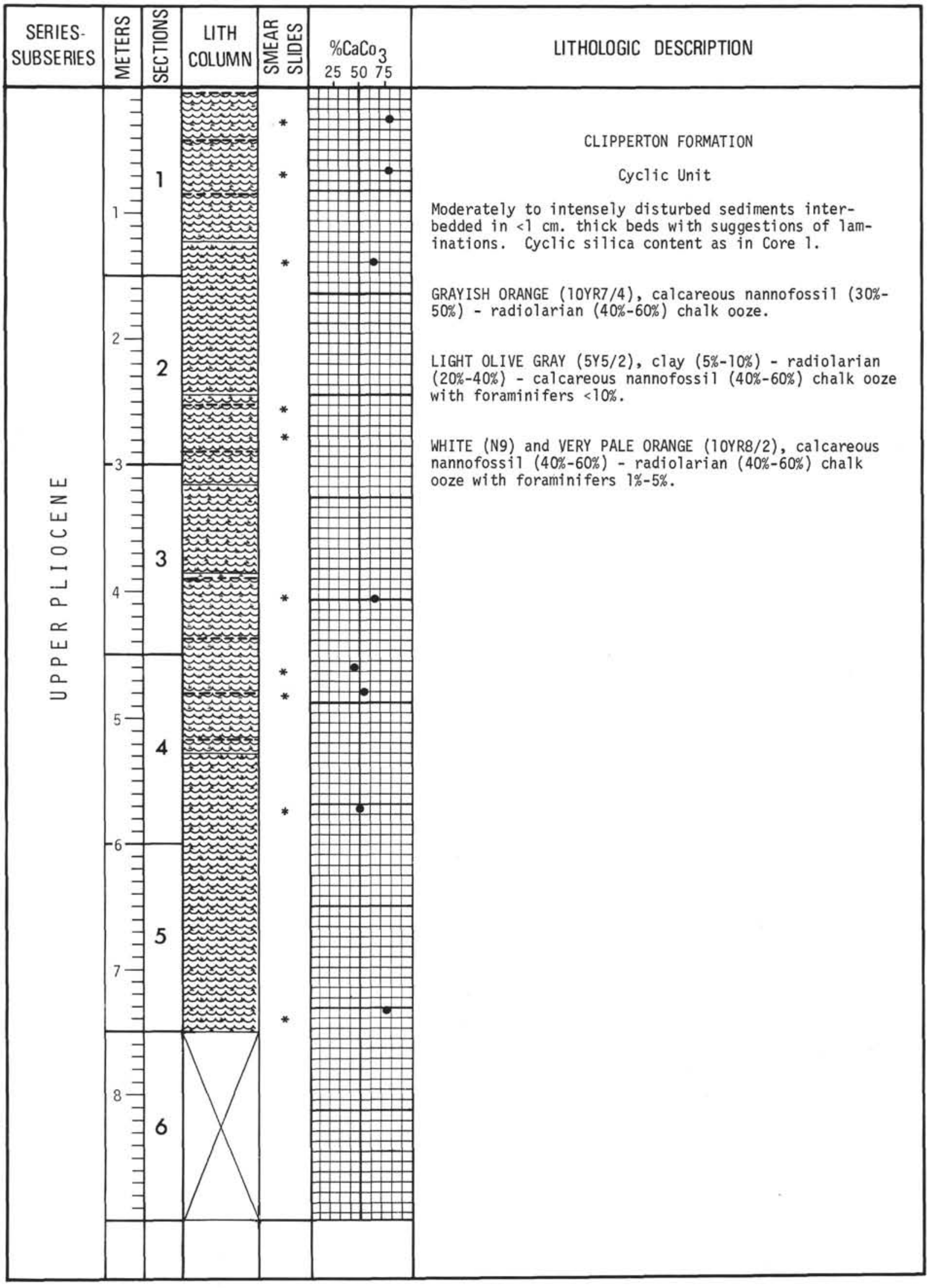


Figure 44. *Hole 77B, Core 3 (27.3 to 36.6m).*

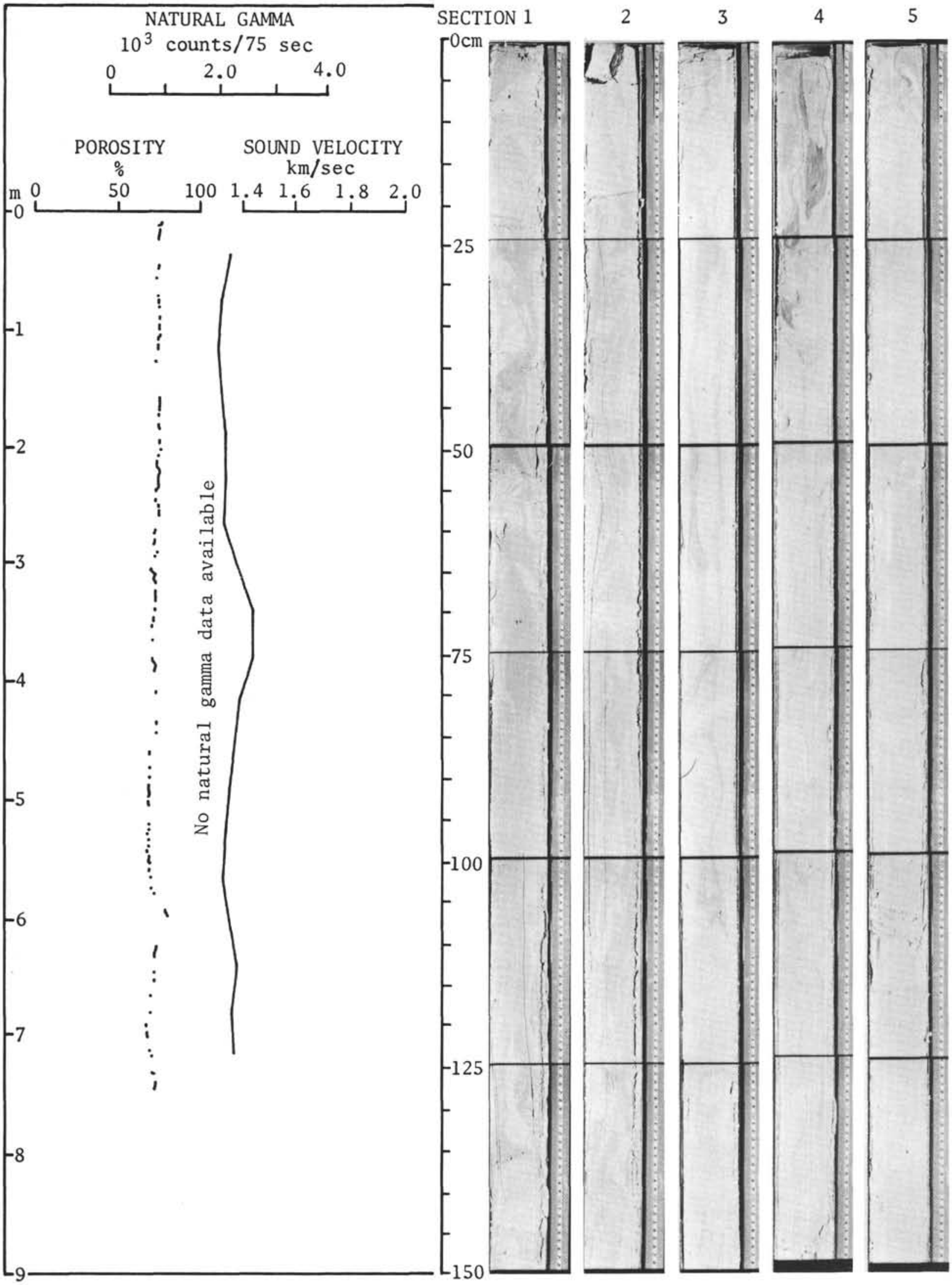


Figure 45. *Hole 77B, Core 3, Sections 1-5, Physical Properties.*

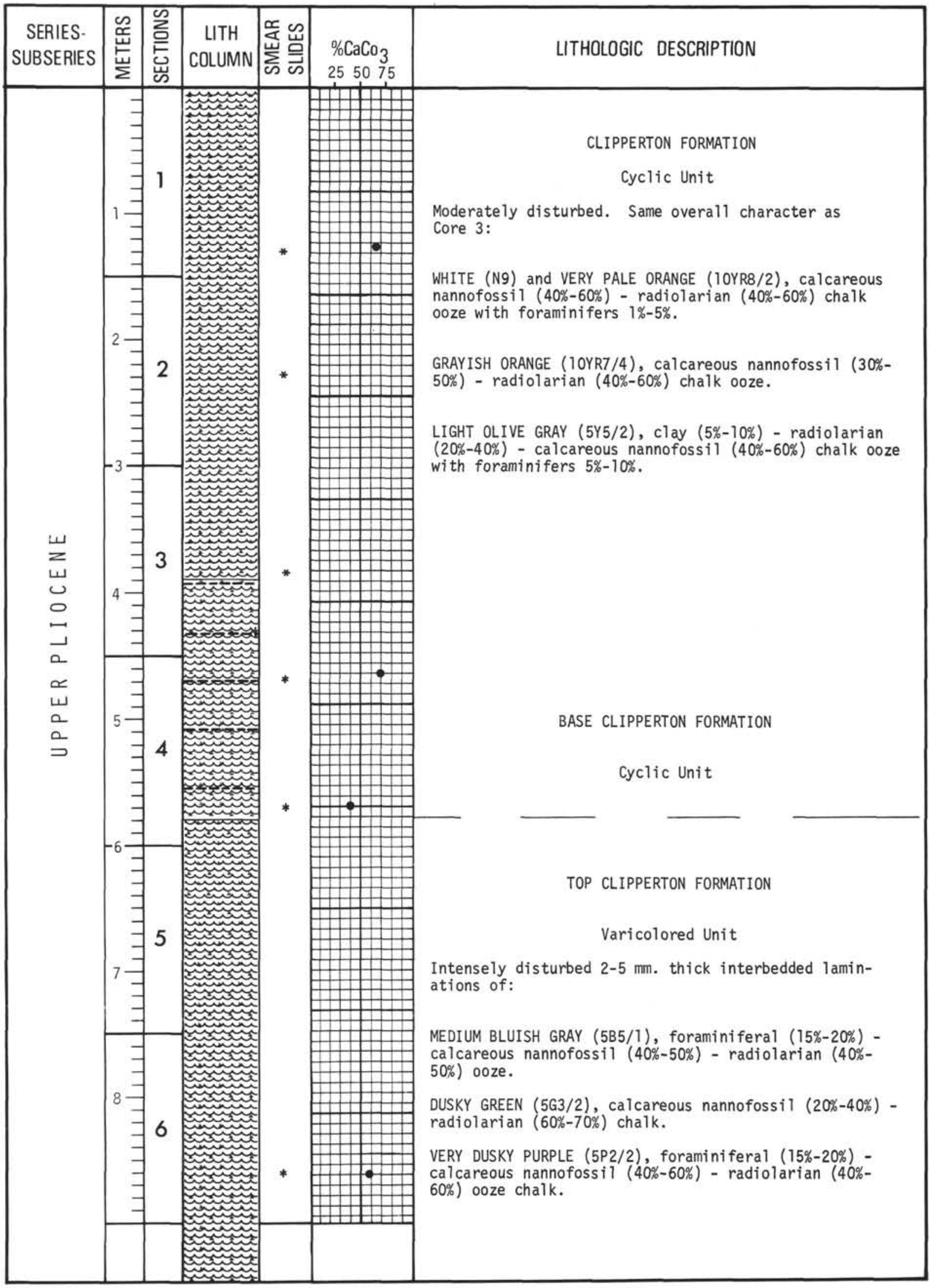


Figure 46. *Hole 77B, Core 4 (36.6 to 45.6m).*

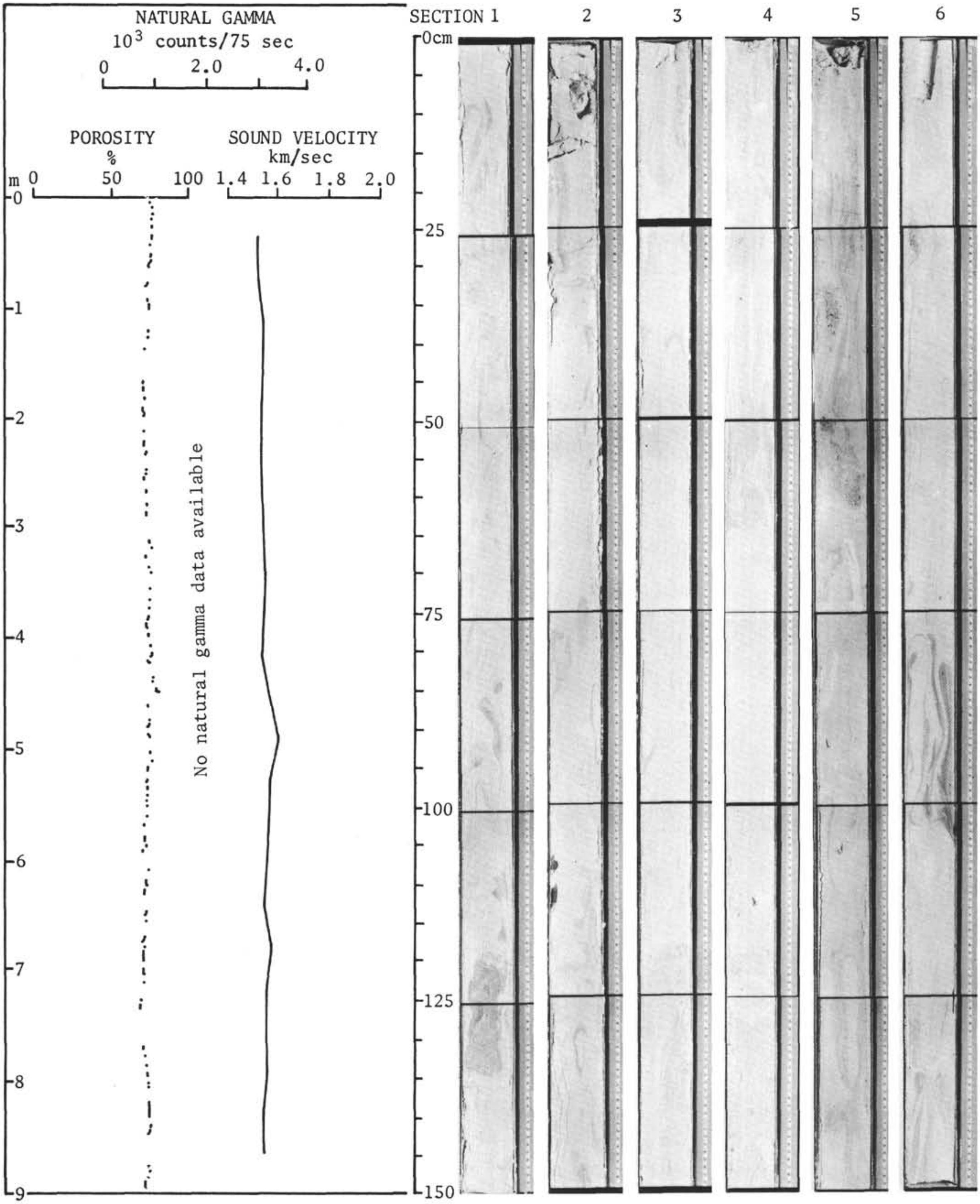


Figure 47. *Hole 77B, Core 4, Sections 1-6, Physical Properties.*

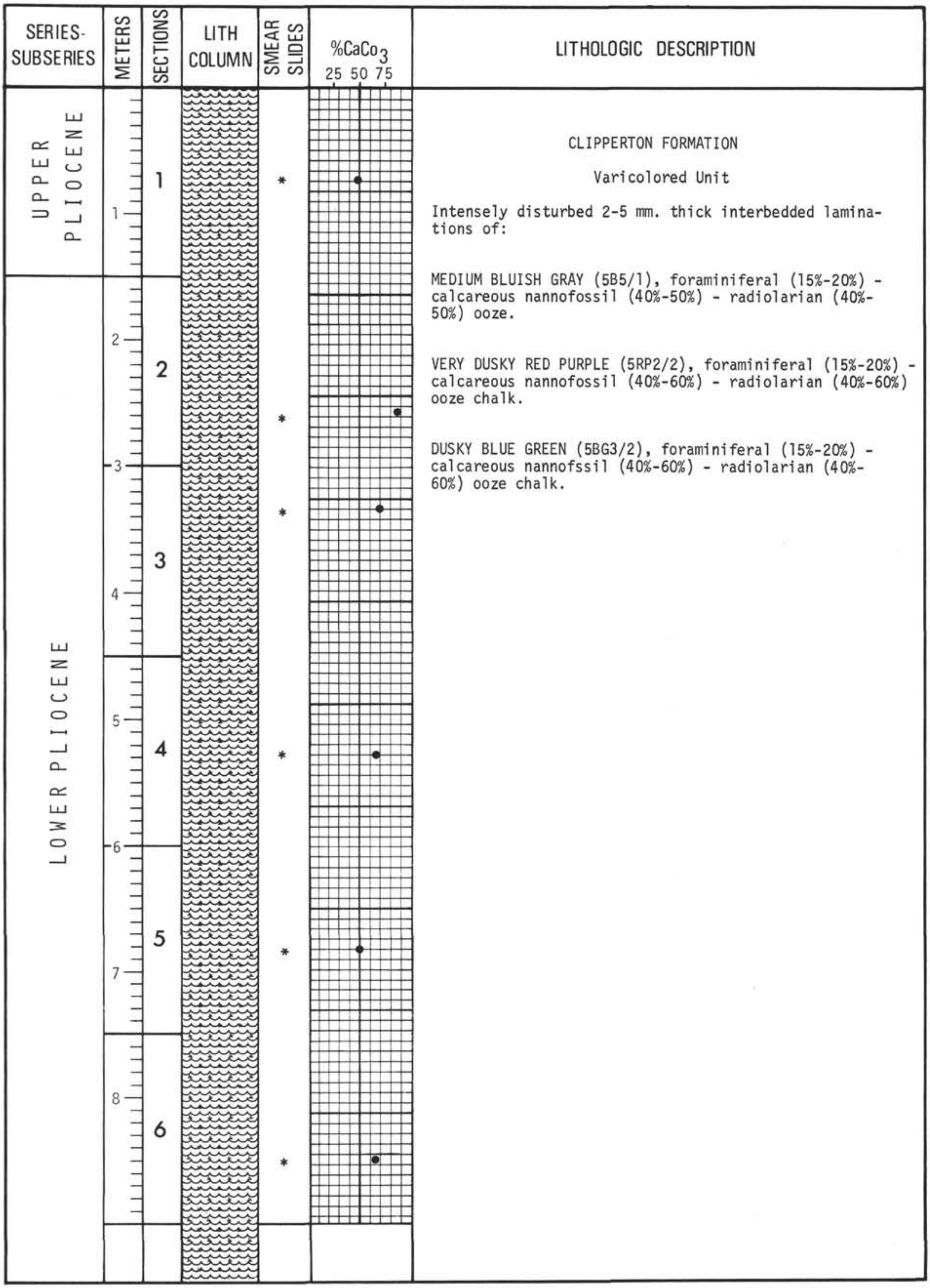


Figure 48. *Hole 77B, Core 5 (45.6 to 54.8m).*

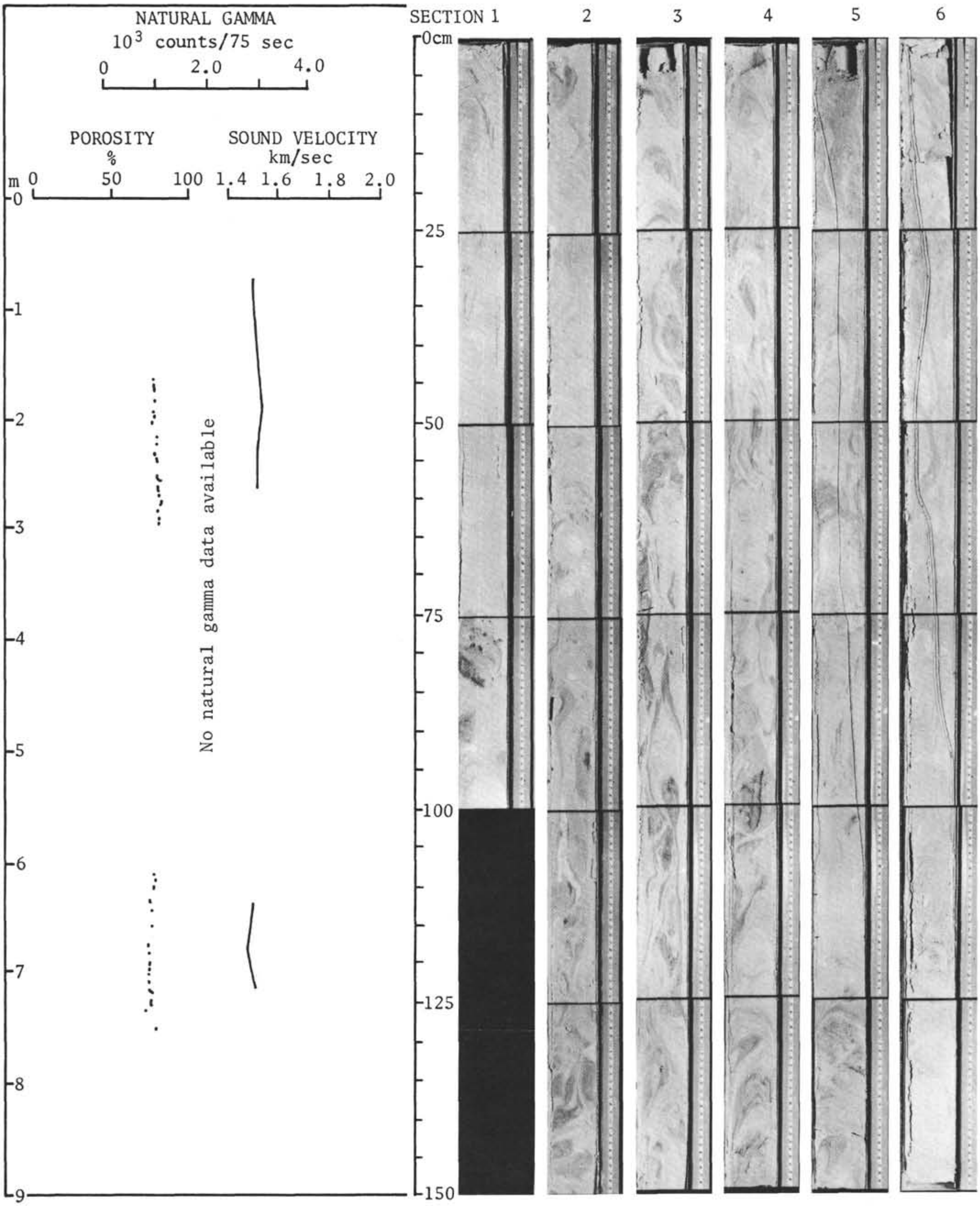
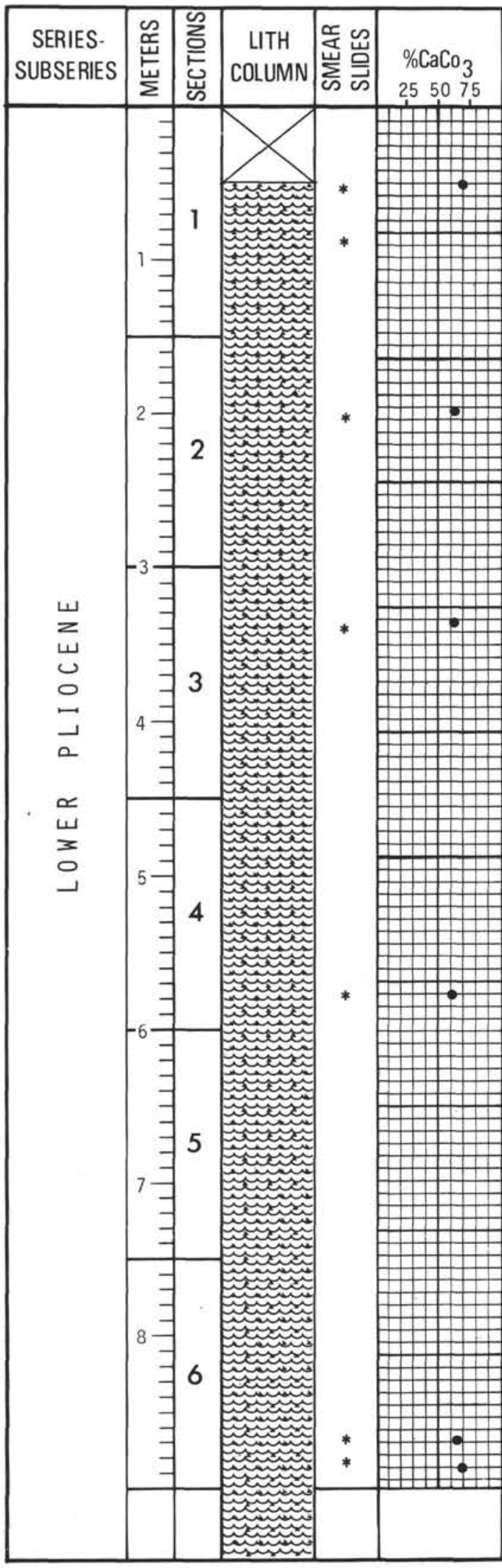


Figure 49. *Hole 77B, Core 5, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Varicolored Unit

Intensely disturbed 1-5 cm. thick interbedded sediments of:

VERY DUSKY RED PURPLE (5RP2/2), foraminiferal (15%-20%) - calcareous nannofossil (40%-60%) - radiolarian (40%-60%) ooze chalk.

LIGHT BLUISH GRAY (5B7/1), foraminiferal (10%-15%) - radiolarian (10%-15%) - calcareous nannofossil (70%-80%) ooze.

GREENISH GRAY (5G6/1) and WHITE (N9), radiolarian (30%-40%) - calcareous nannofossil (50%-60%) ooze.

Figure 50. *Hole 77B, Core 6 (54.8 to 64.0m).*

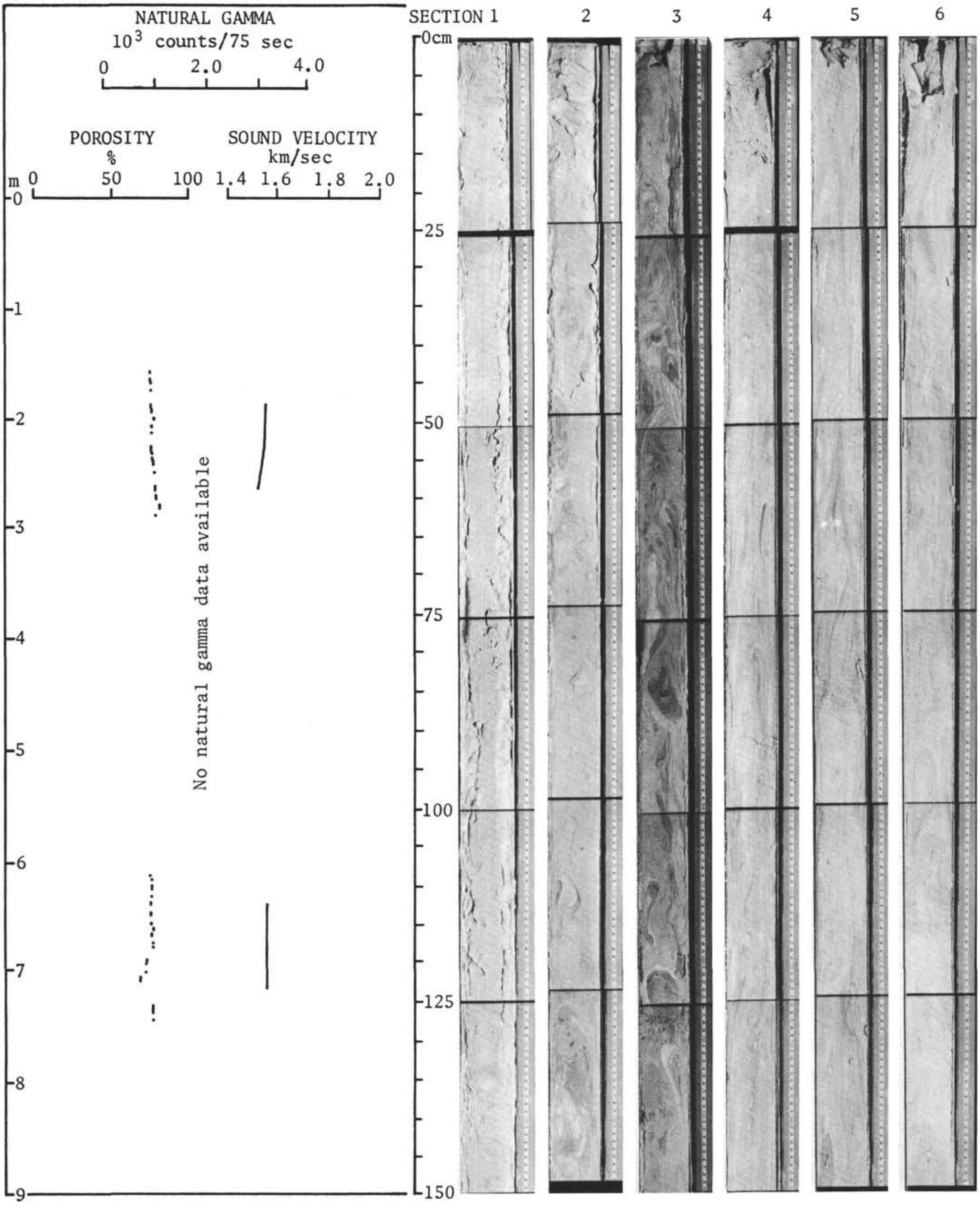
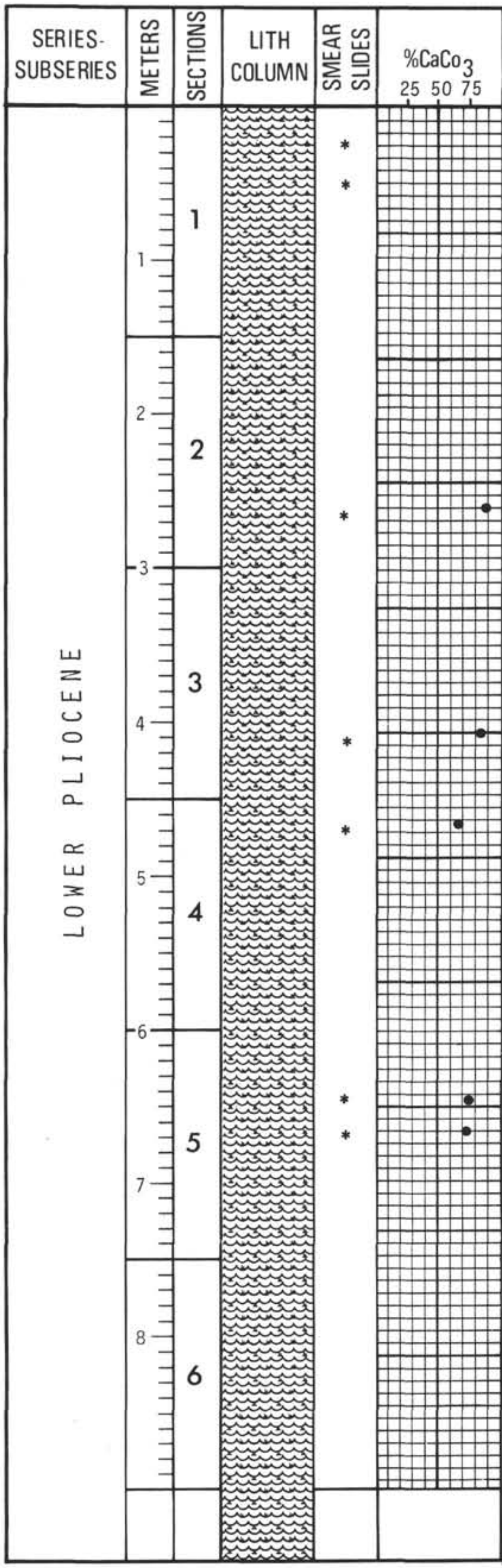


Figure 51. *Hole 77B, Core 6, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Varicolored Unit

Slightly to intensely disturbed, 1-10 cm. thick, laminated, interbedded:

WHITE (N9), BLUISH WHITE (5B9/1), PALE BLUE (5PB7/2), and VERY PALE PURPLE (5P7/2), foraminiferal (10%-15%) - radiolarian (10%-15%) - calcareous nannofossil (70%-80%) ooze.

VERY PALE GREEN (10G8/2), and WHITE (N9) to VERY LIGHT GRAY (N8), radiolarian (20%-30%) - calcareous nannofossil (70%-80%) ooze.

Figure 52. *Hole 77B, Core 7 (64.0 to 73.1m).*

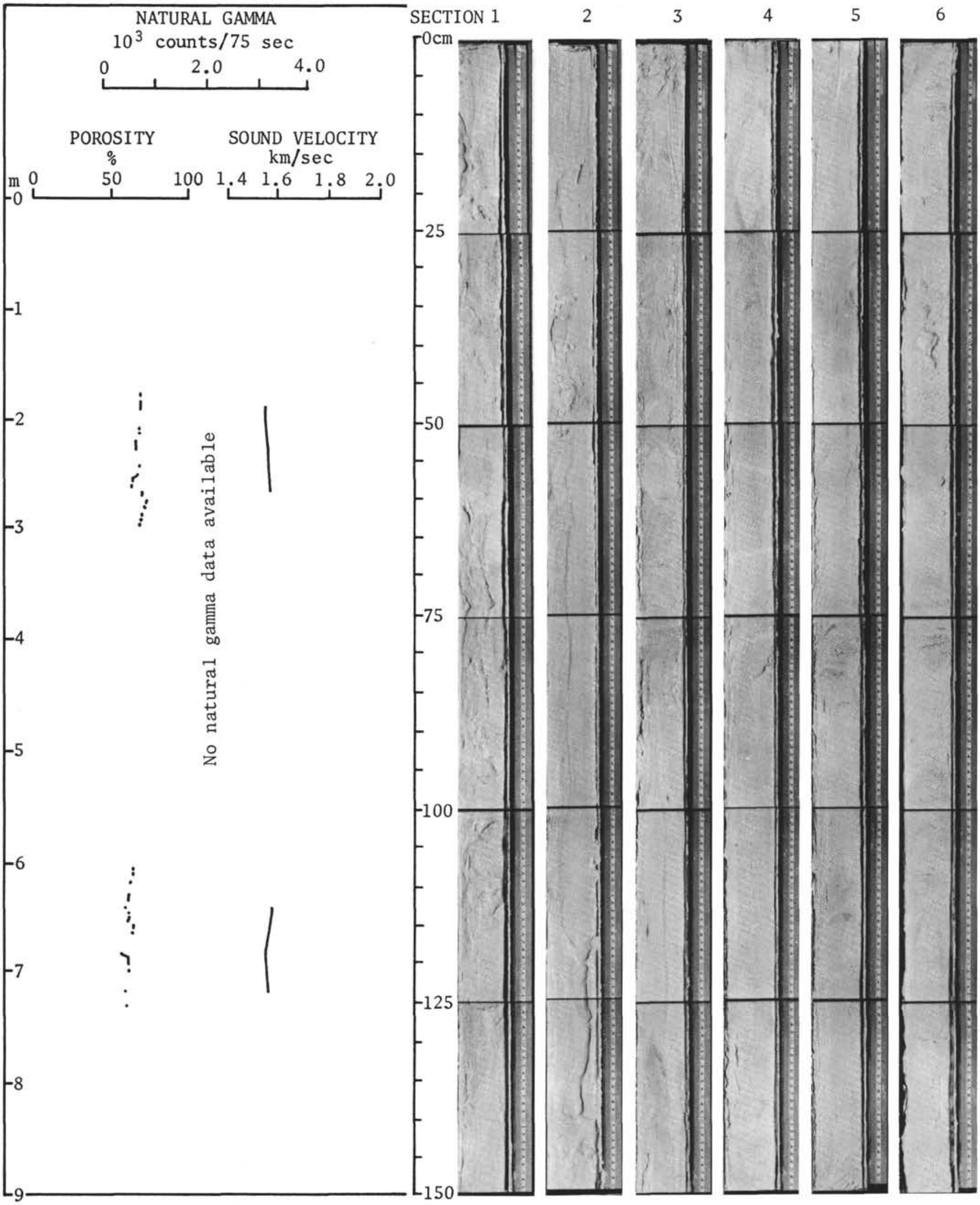


Figure 53. *Hole 77B, Core 7, Sections 1-6, Physical Properties.*

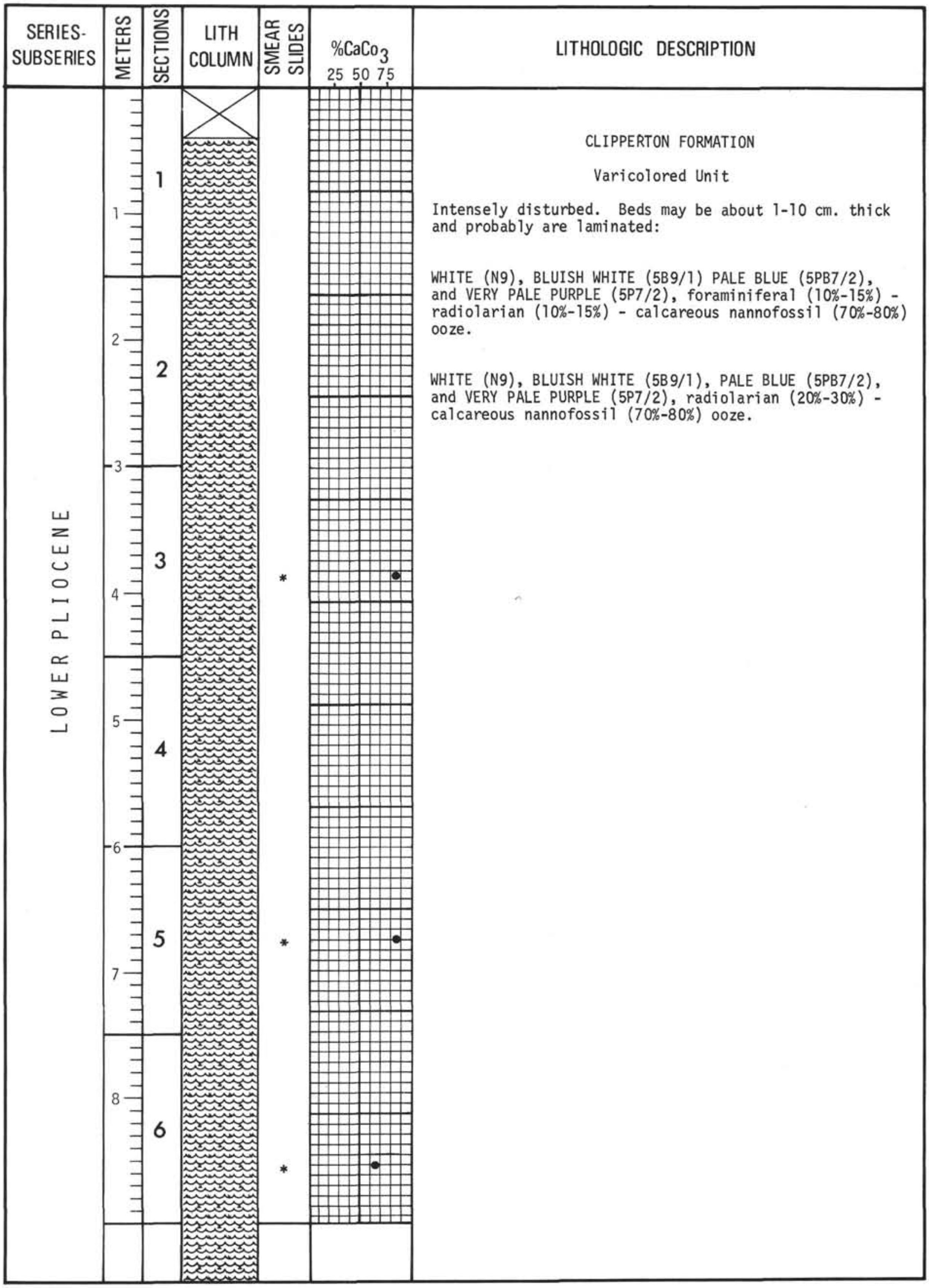


Figure 54. *Hole 77B, Core 8 (73.1 to 82.2 m).*

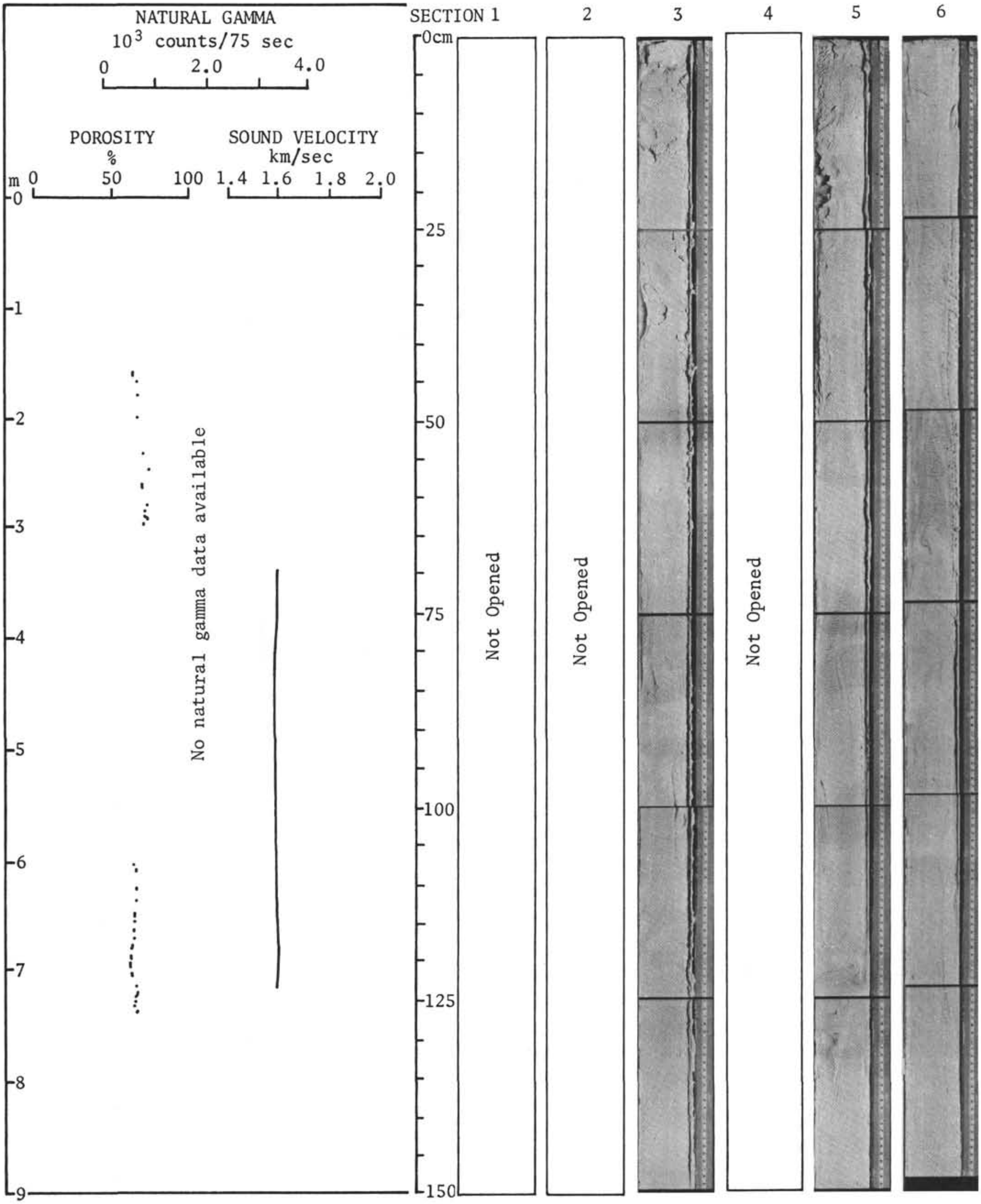


Figure 55. *Hole 77B, Core 8, Sections 1-6, Physical Properties.*

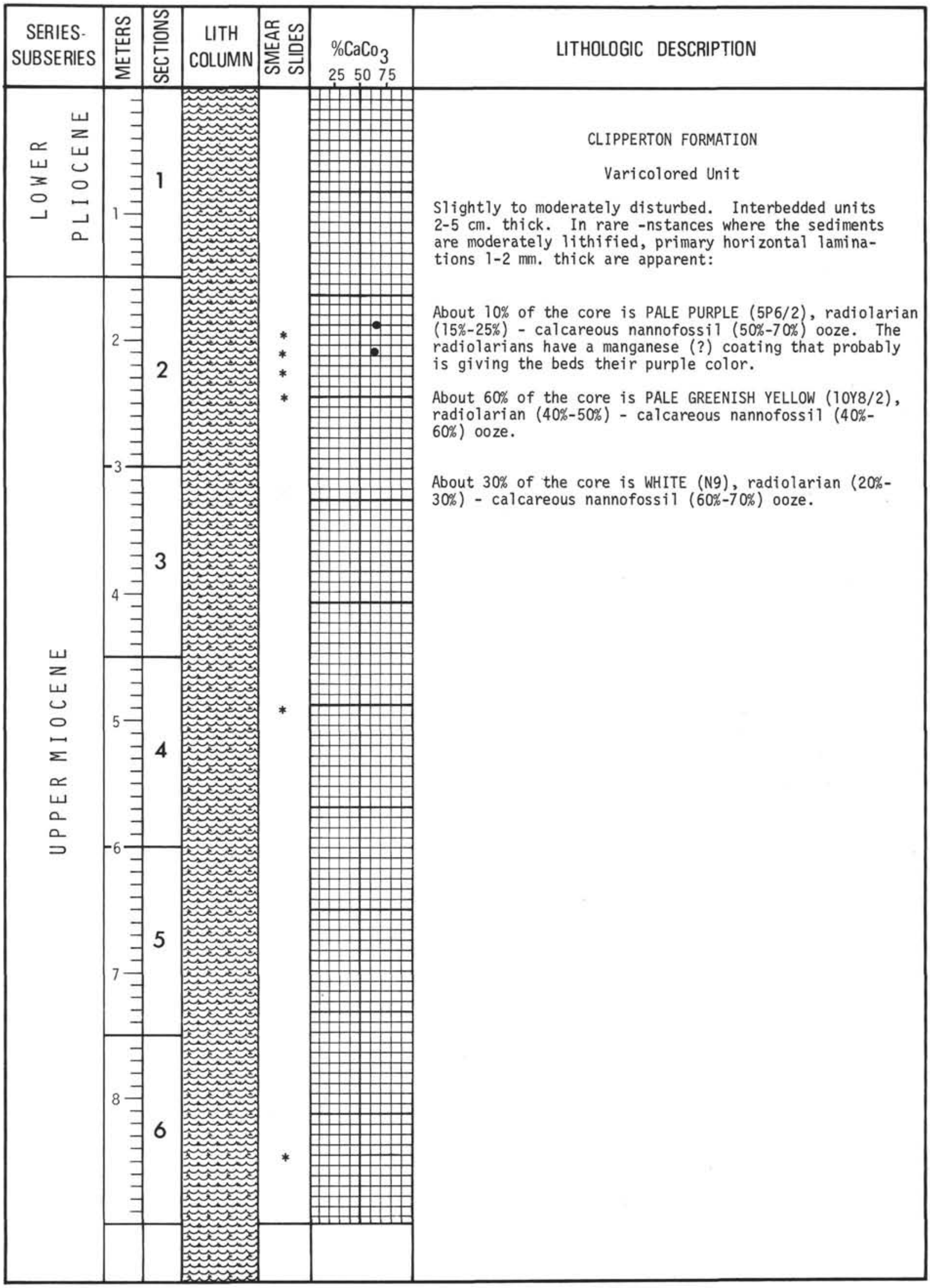


Figure 56. *Hole 77B, Core 9 (82.2 to 95.1 m).*

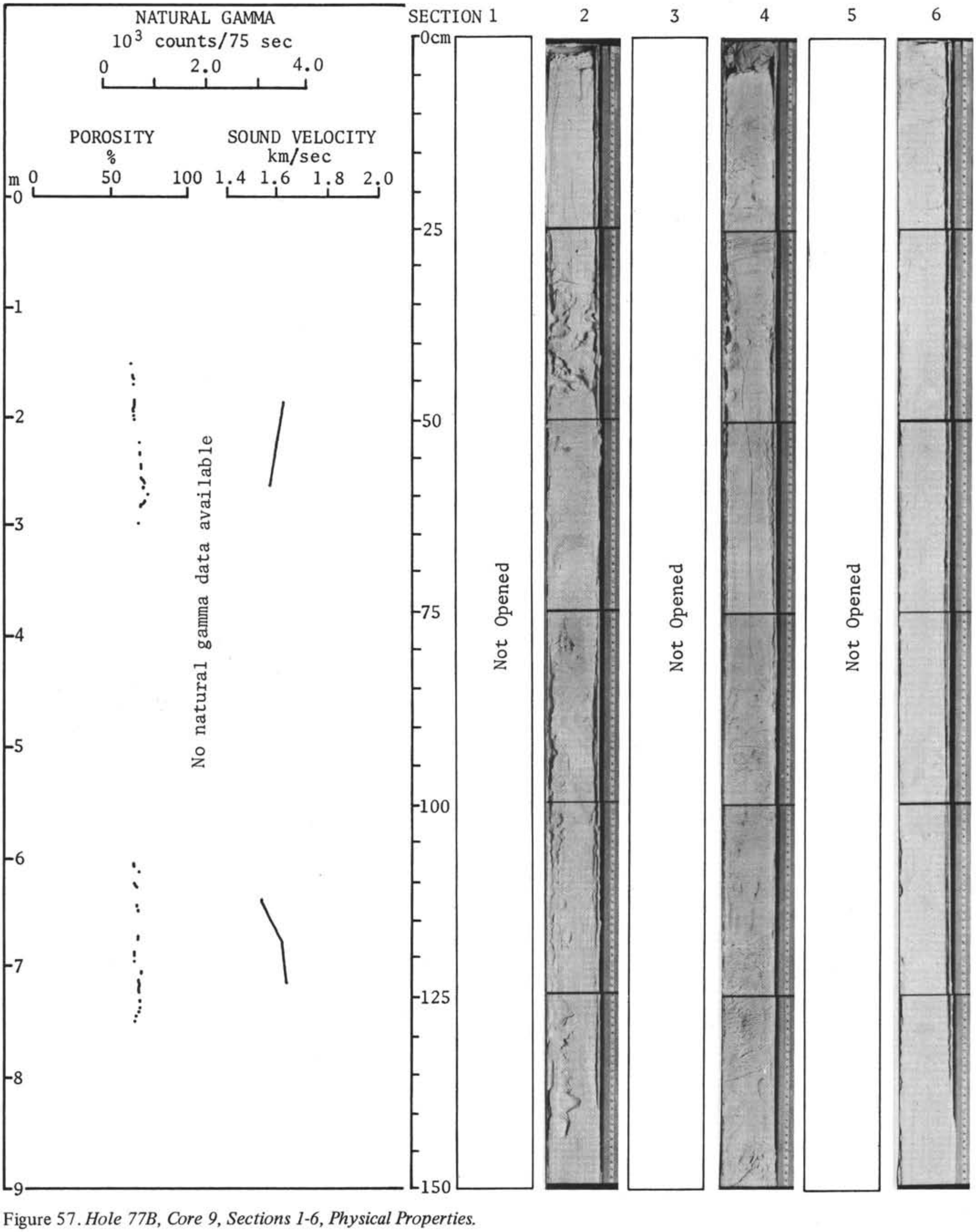


Figure 57. *Hole 77B, Core 9, Sections 1-6, Physical Properties.*

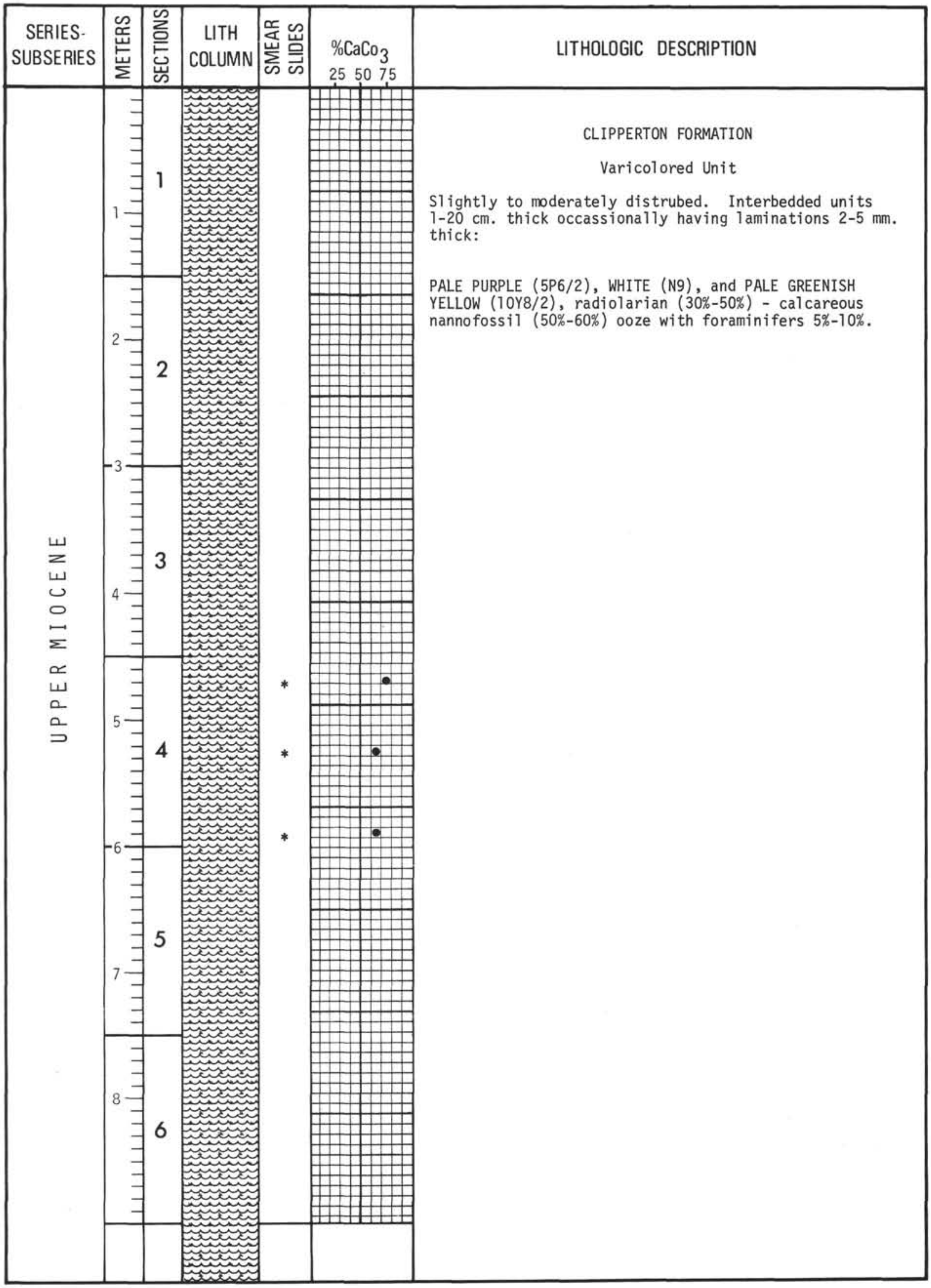


Figure 58. *Hole 77B, Core 10 (91.5 to 100.6m).*

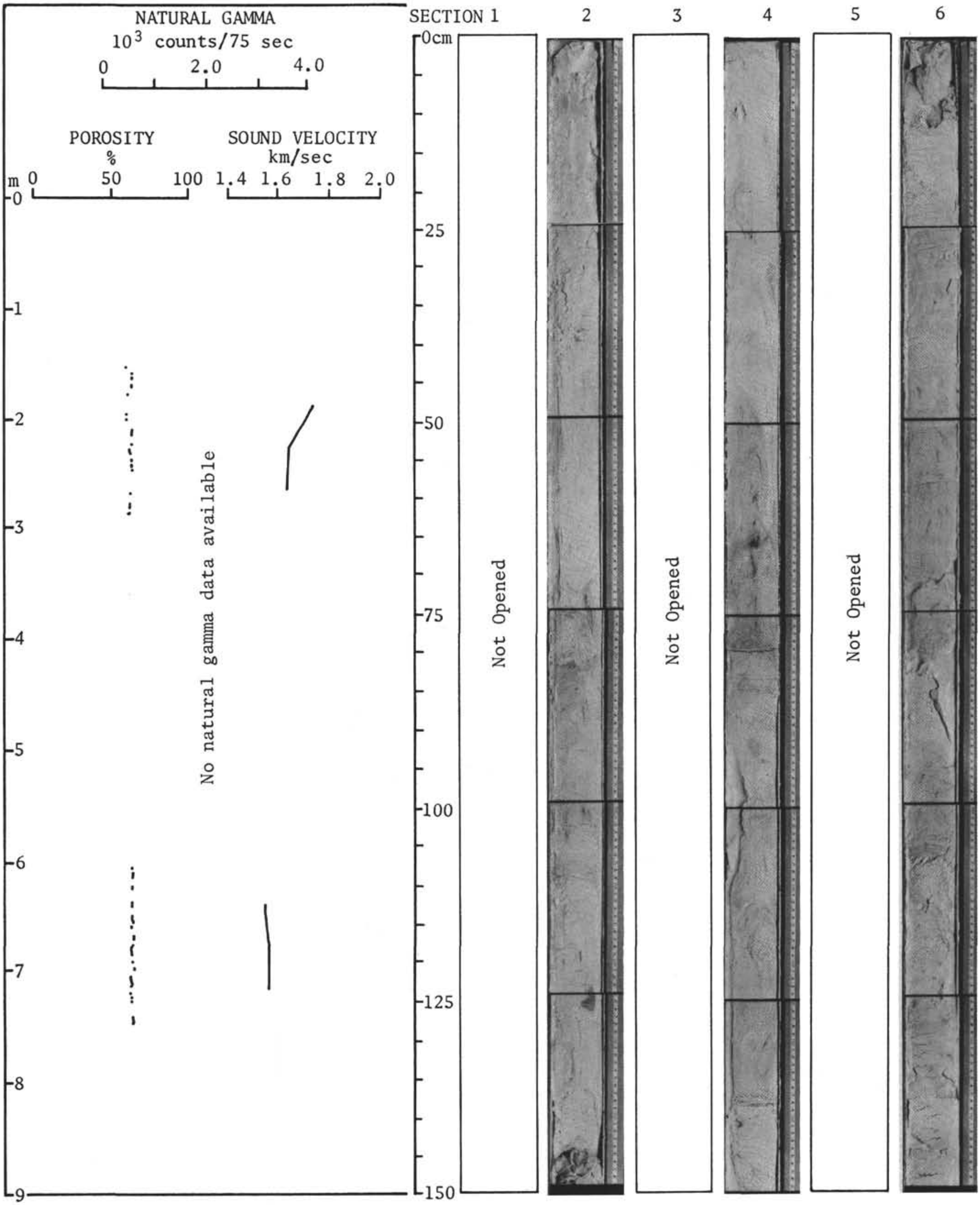
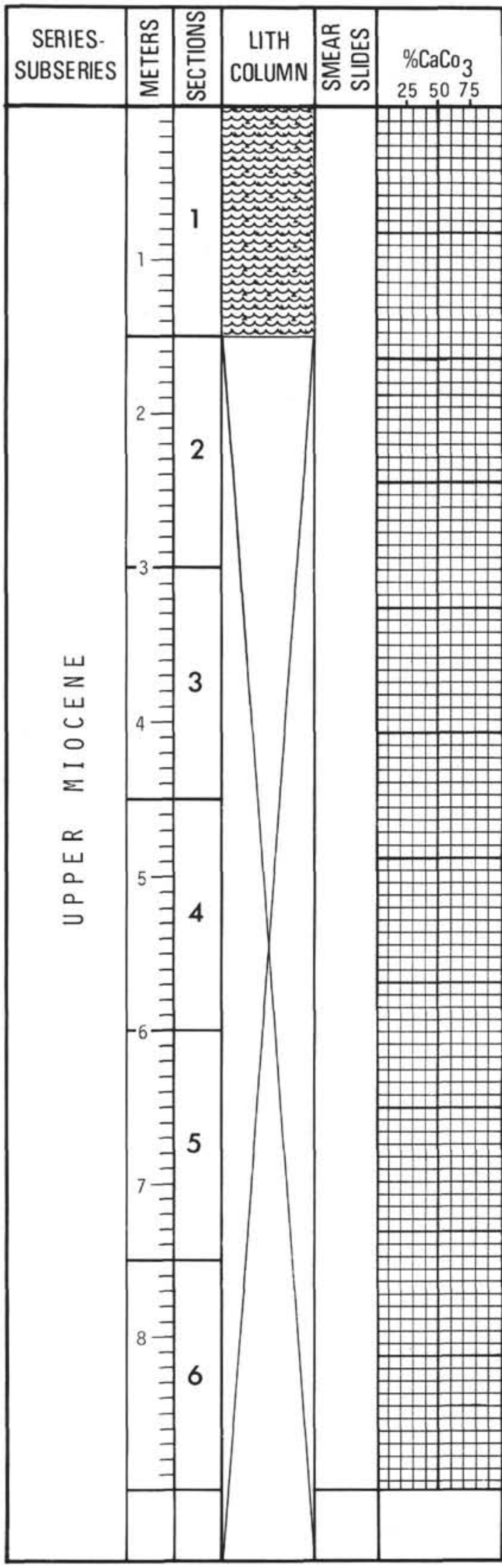


Figure 59. *Hole 77B, Core 10, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Varicolored Unit

Core in oversized core liner; based on smear samples from ends this core is the same lithology as Core 10.

Figure 60. *Hole 77B, Core 11 (100.6 to 109.6m).*

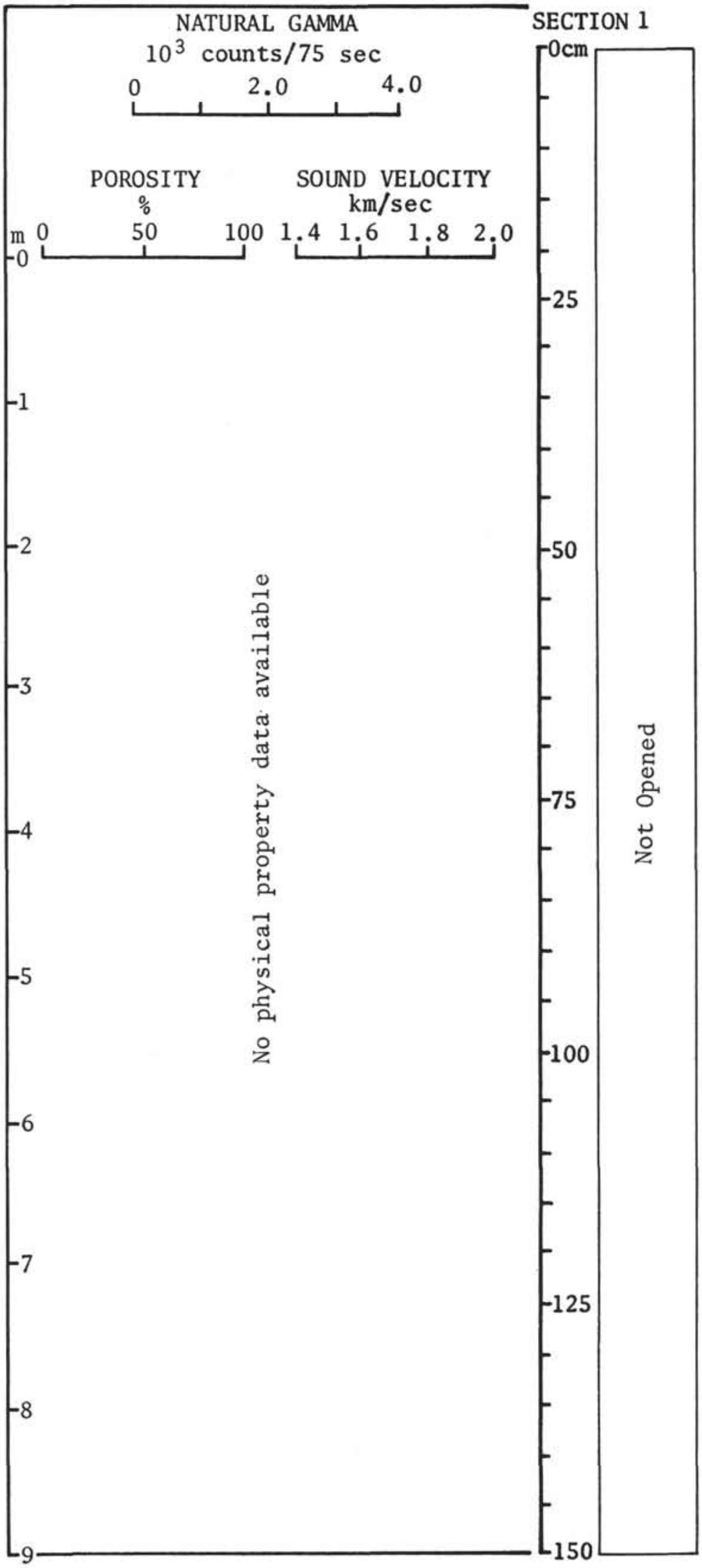


Figure 61. *Hole 77B, Core 11, Section 1, Physical Properties.*

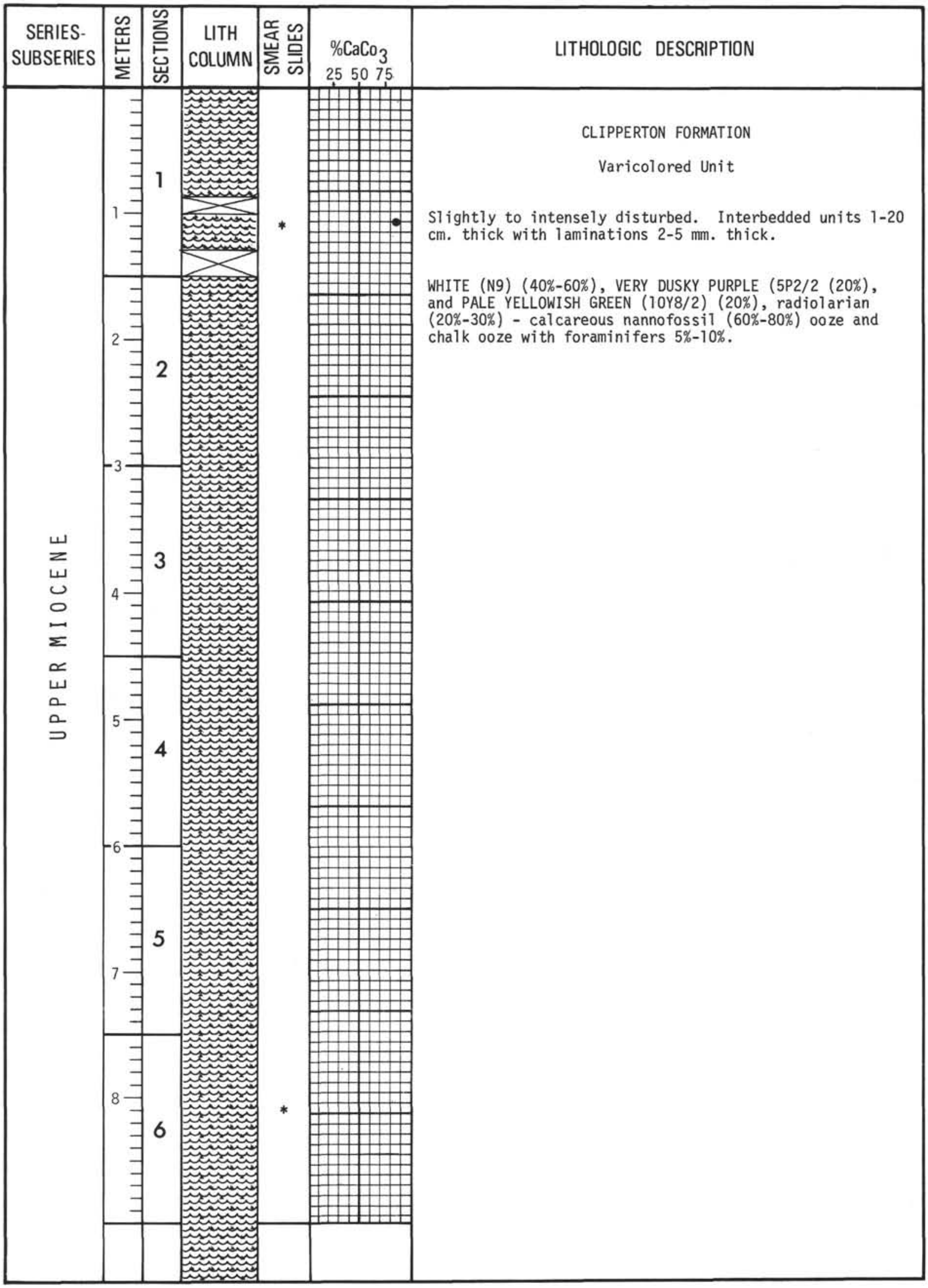


Figure 62. *Hole 77B, Core 12 (109.6 to 118.8 m).*

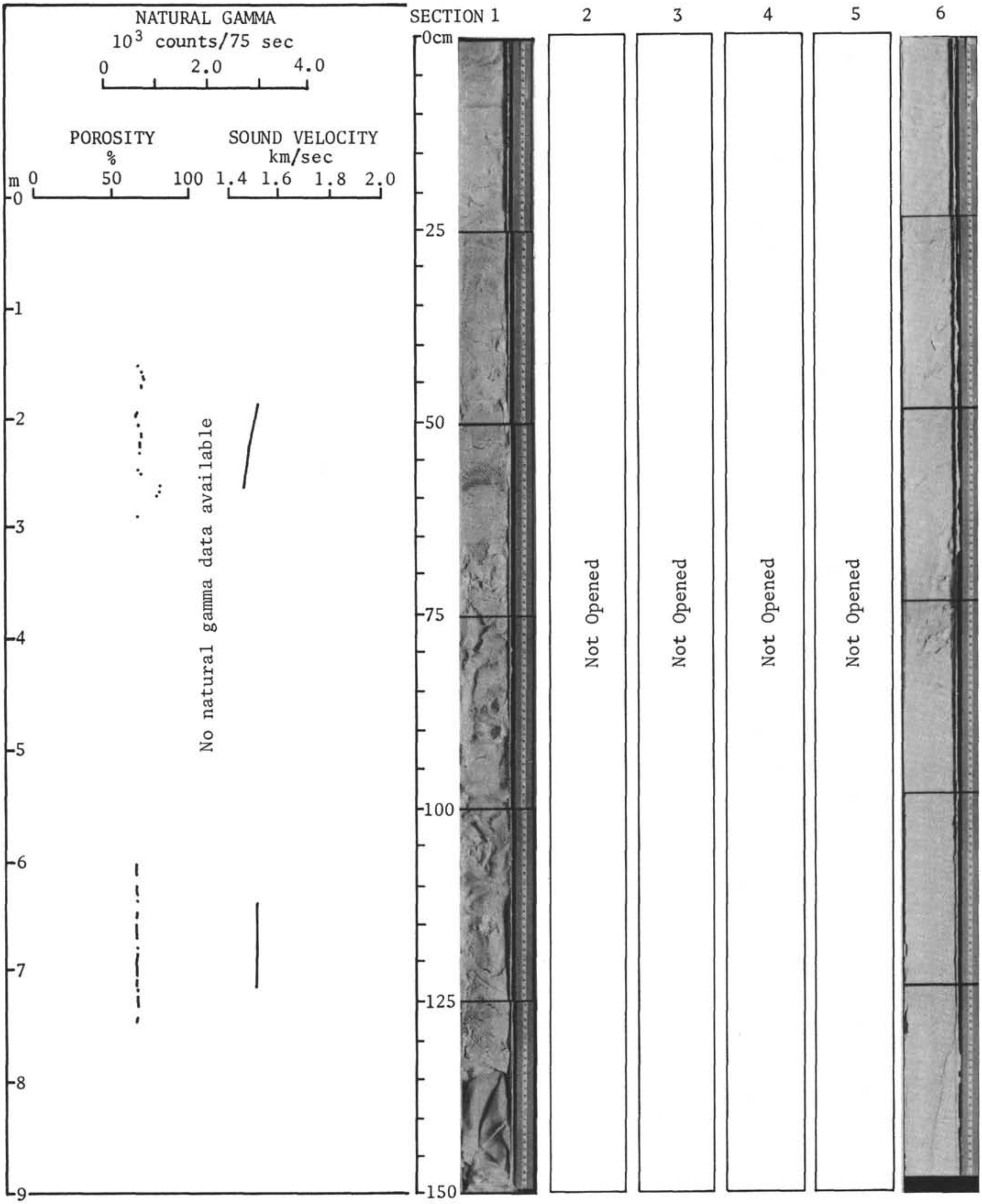


Figure 63. *Hole 77B, Core 12, Sections 1-6, Physical Properties.*

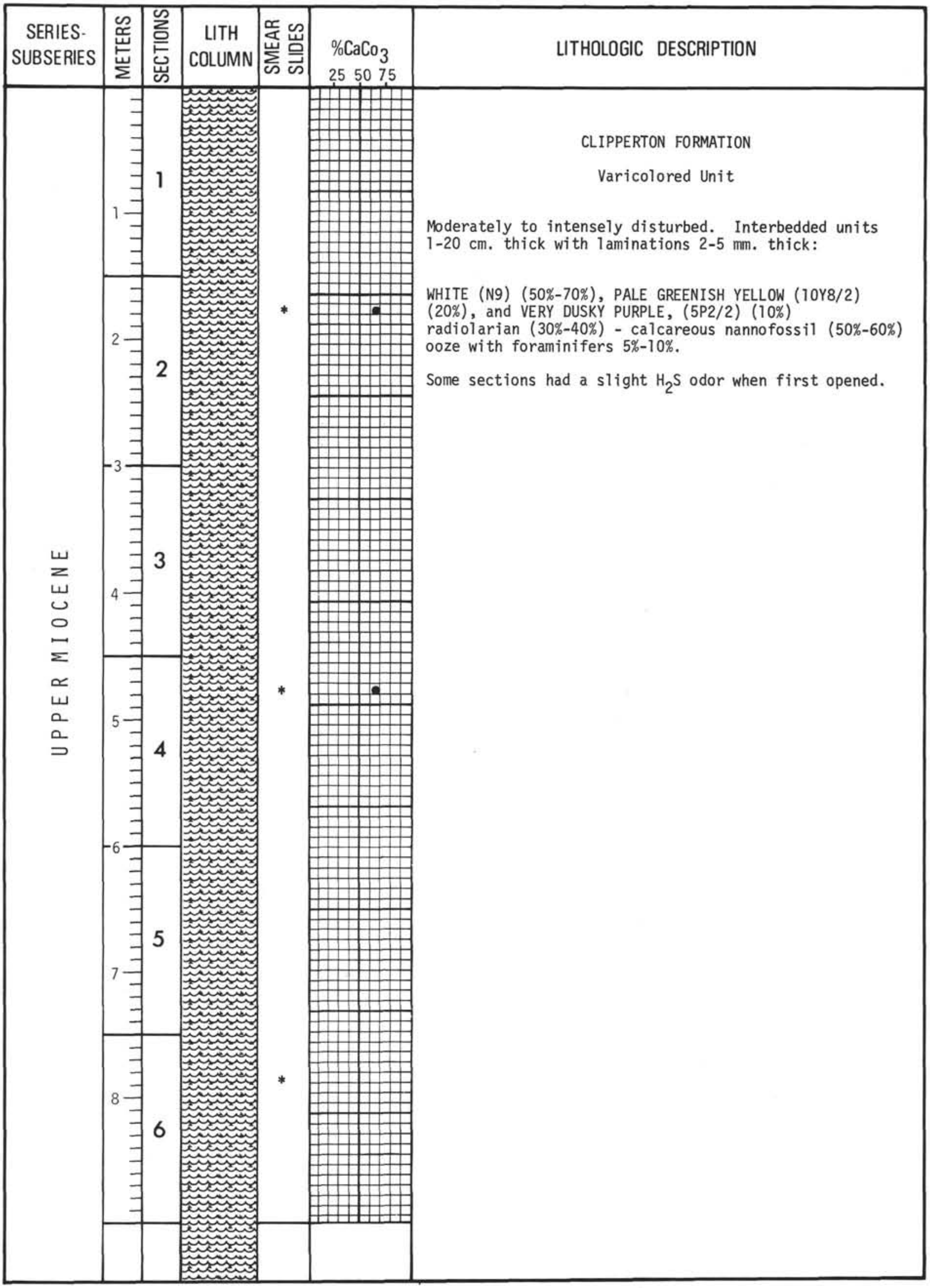


Figure 64. *Hole 77B, Core 13 (118.8 to 128.0m).*

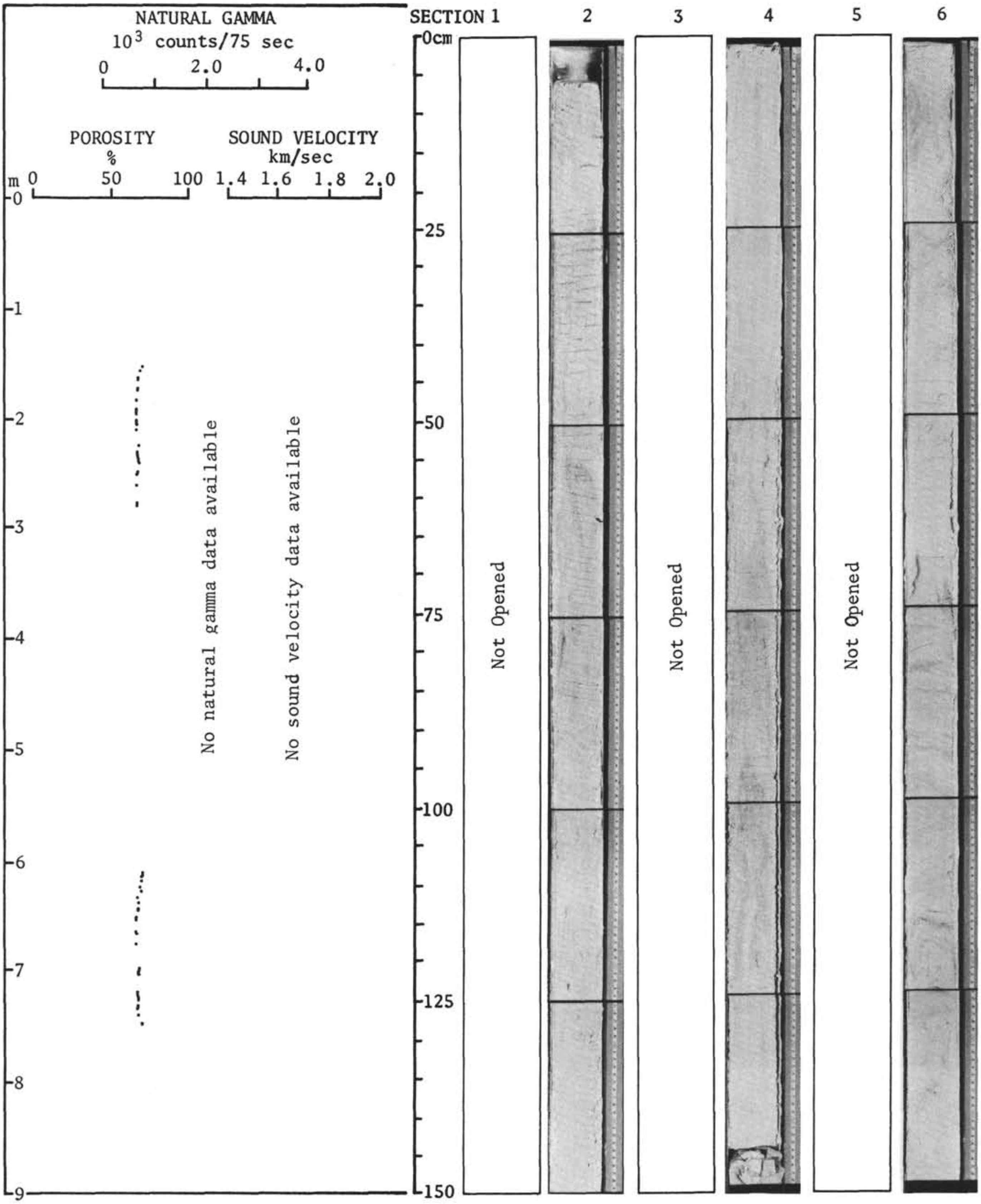
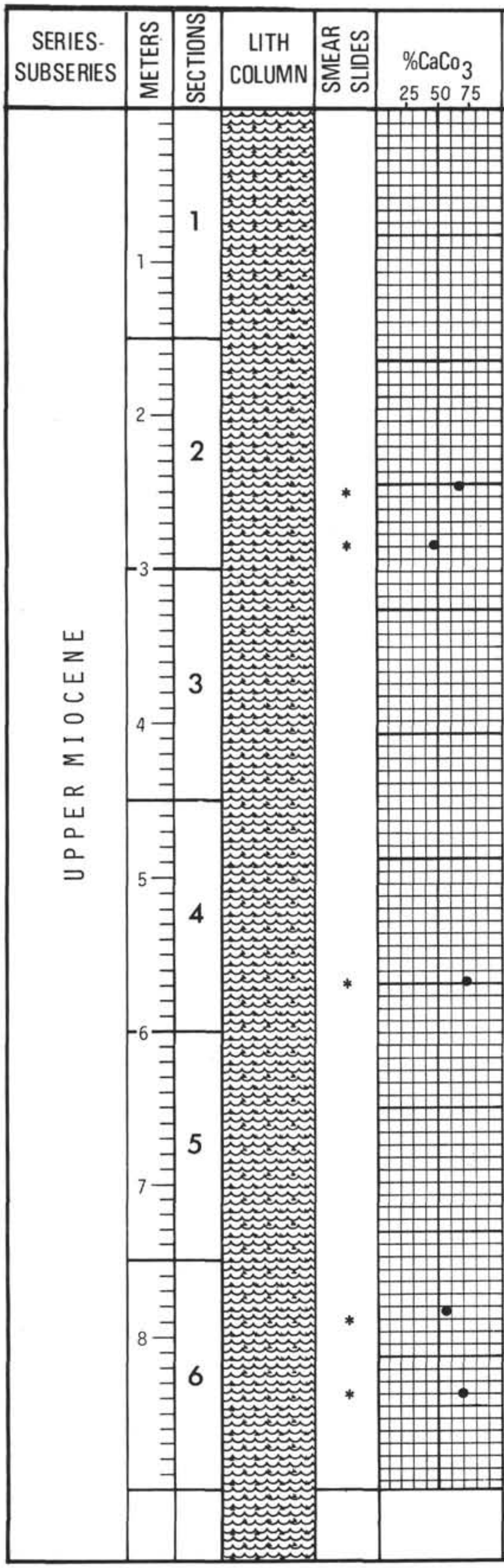


Figure 65. *Hole 77B, Core 13, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Varicolored Unit

Generally intensely disturbed with rare portions only moderately disturbed. Beds are 1-10 cm. thick with laminations 1-5 mm. thick. Interbedded:

About 50% of core is WHITE (N9) to BLUISH WHITE (5B9/1), radiolarian (30%-40%) - calcareous nannofossil (60%-70%) chalk ooze with foraminifers <10%.

About 40% of core is PALE YELLOWISH GREEN (70Y8/2), radiolarian (40%-50%) - calcareous nannofossil (40%-50%) ooze chalk.

About 10% of core is PALE PURPLE (5P6/2), radiolarian (30%-40%) - calcareous nannofossil (60%-70%) ooze chalk.

Figure 66. *Hole 77B, Core 14 (128.0 to 137.1m).*

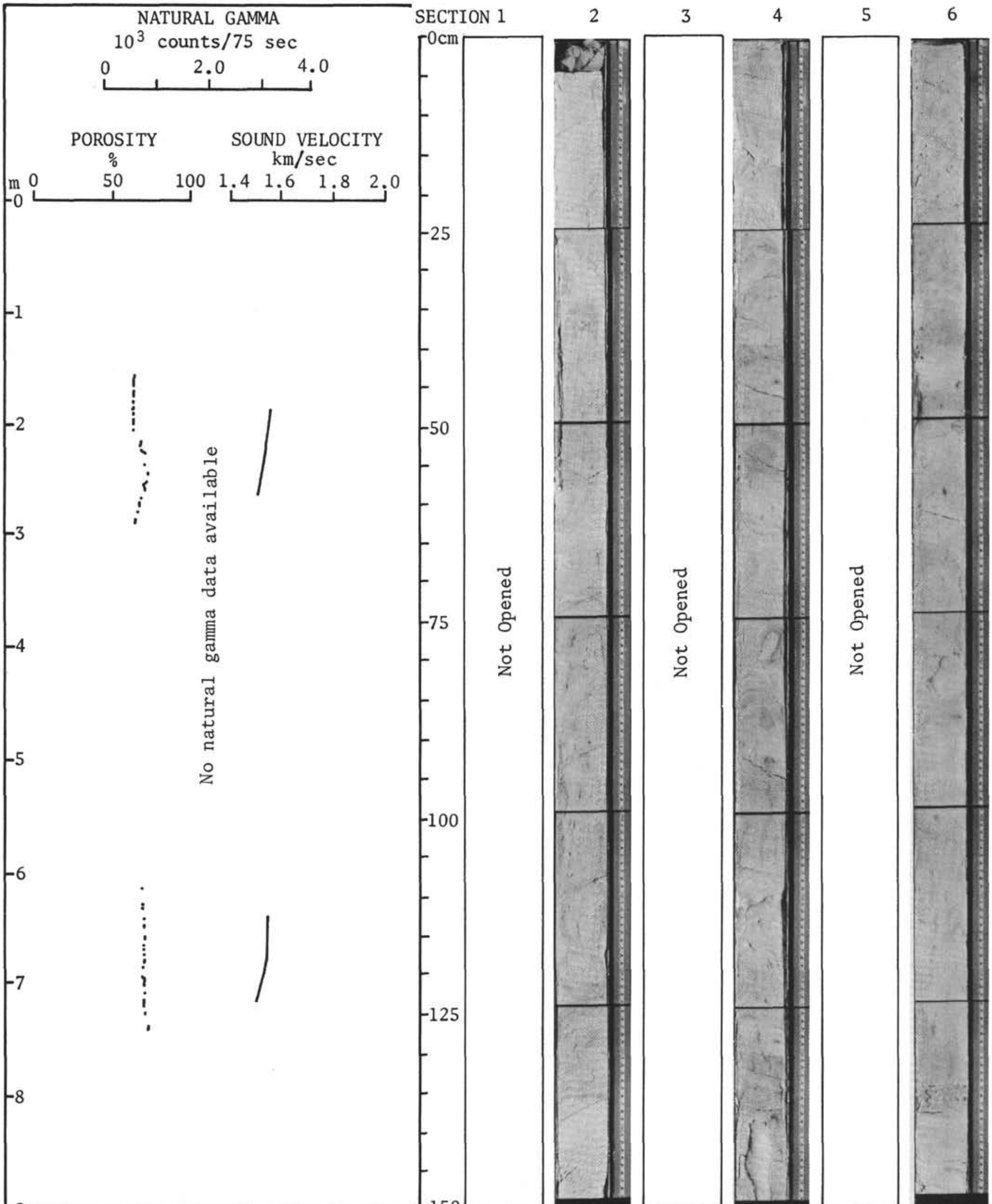


Figure 67. *Hole 77B, Core 14, Sections 1-6, Physical Properties.*

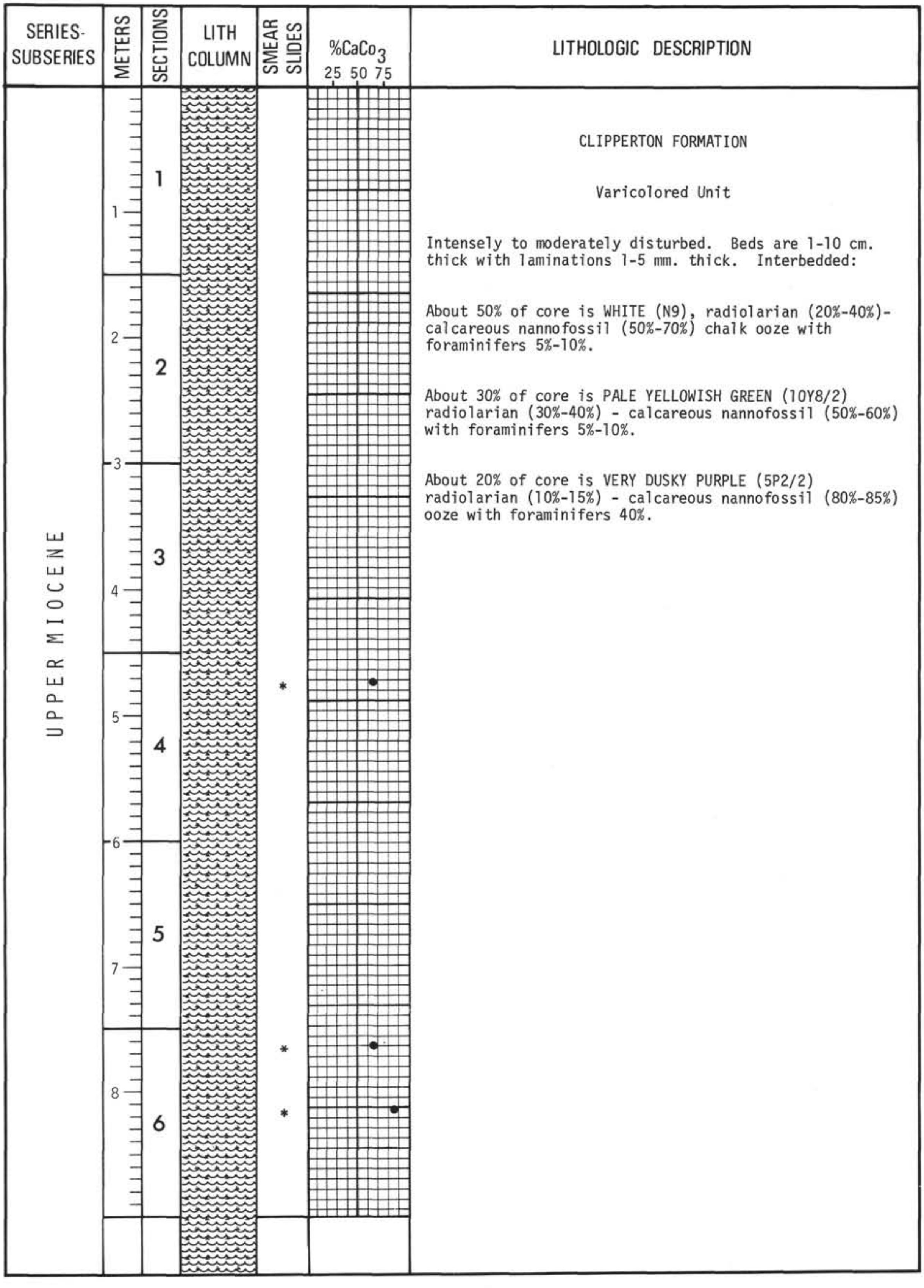


Figure 68. *Hole 77B, Core 15 (137.1 to 146.2m).*

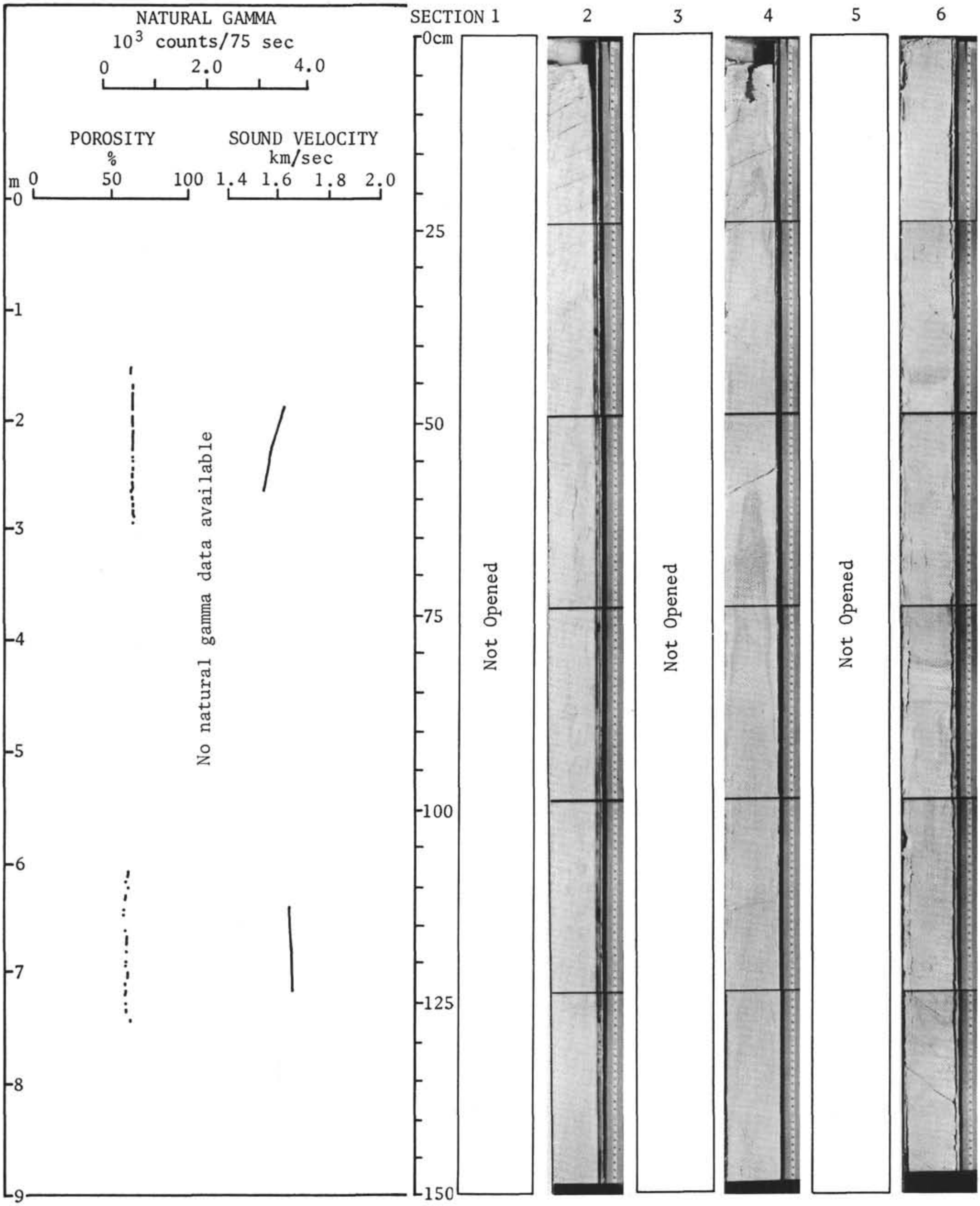
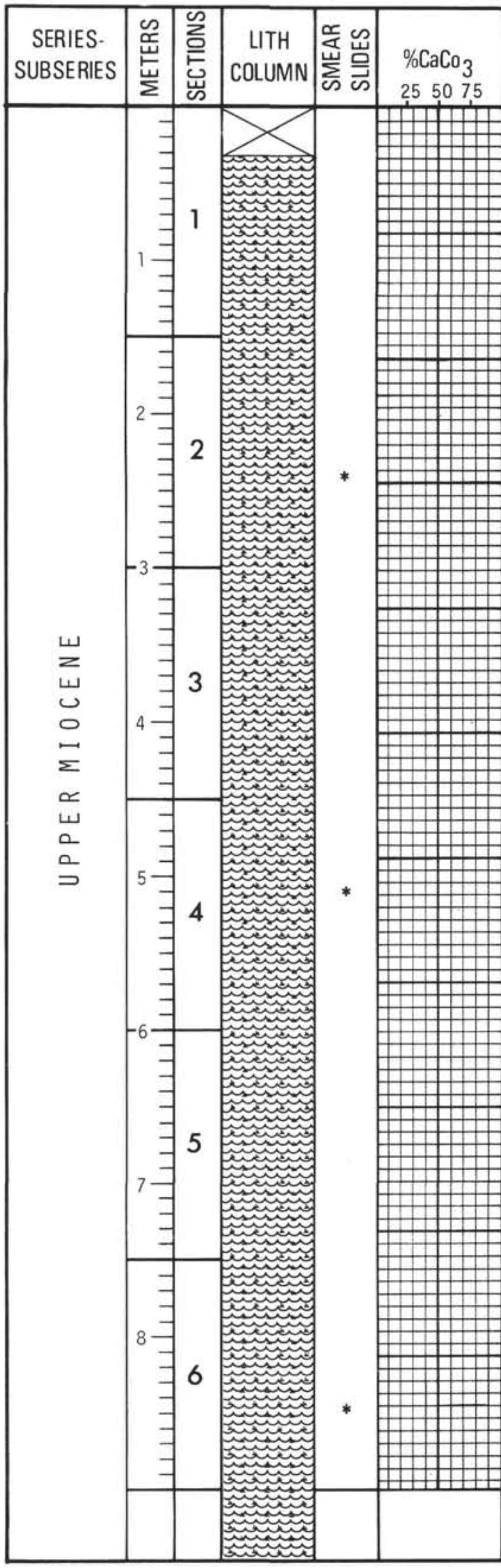


Figure 69. *Hole 77B, Core 15, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

CLIPPERTON FORMATION

Varicolored Unit

Intensely to slightly disturbed. Beds are 1-5 cm. thick with laminations 1-2 mm. thick. Interbedded:

About 40% of core is WHITE (N9), radiolarian (20%-40%) - calcareous nannofossil (50%-70%) chalk ooze with foraminifers 5%-10%.

About 40% of core is PALE YELLOWISH GREEN (10Y8/2), radiolarian (30%-40%) - calcareous nannofossil (50%-60%) ooze with foraminifers 5%-10%.

About 20% of core is VERY DUSKY PURPLE (5P2/2), radiolarian (10%-15%) - calcareous nannofossil (80%-85%) ooze with foraminifers <5%.

Figure 70. *Hole 77B, Core 16 (146.2 to 155.5m).*

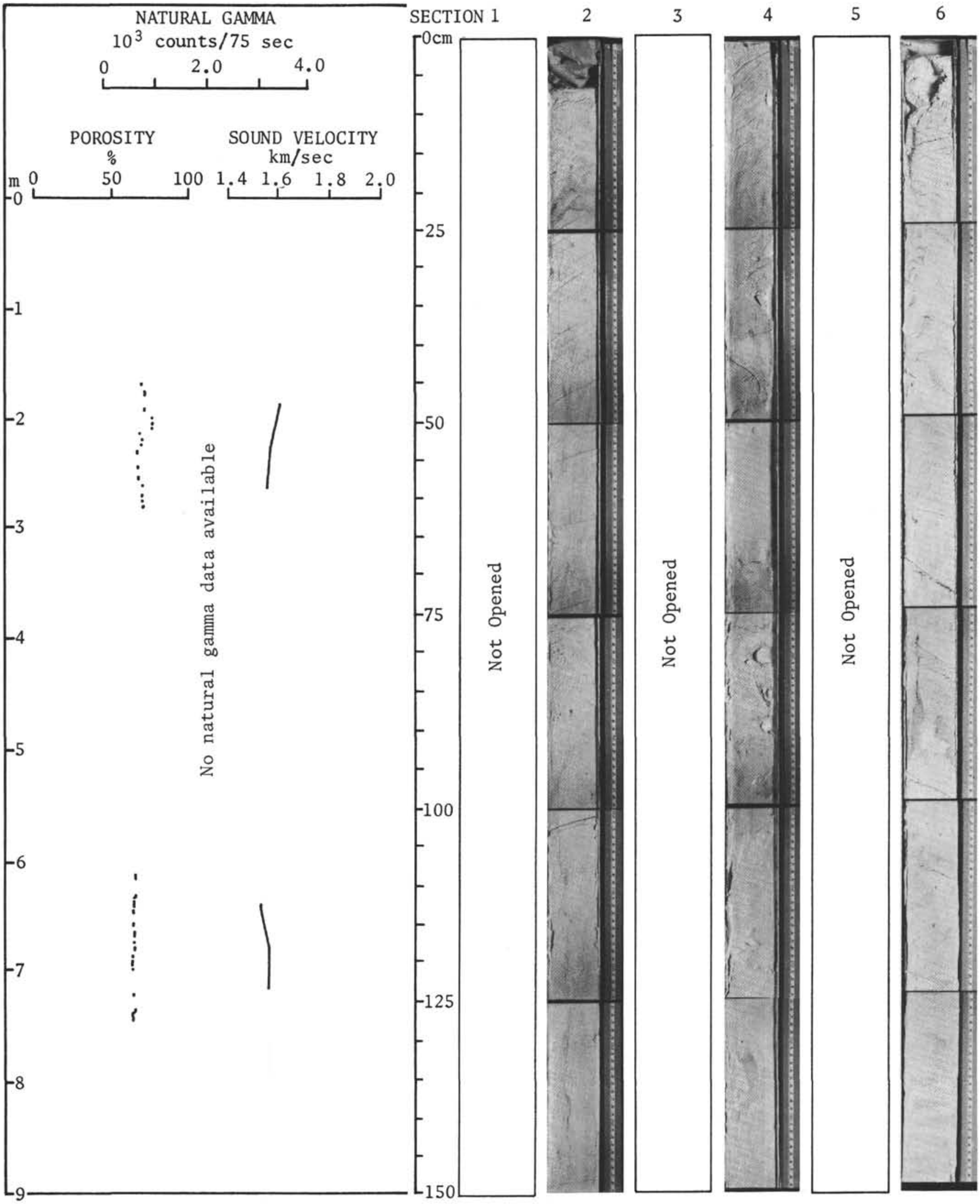


Figure 71. *Hole 77B, Core 16, Sections 1-6, Physical Properties.*

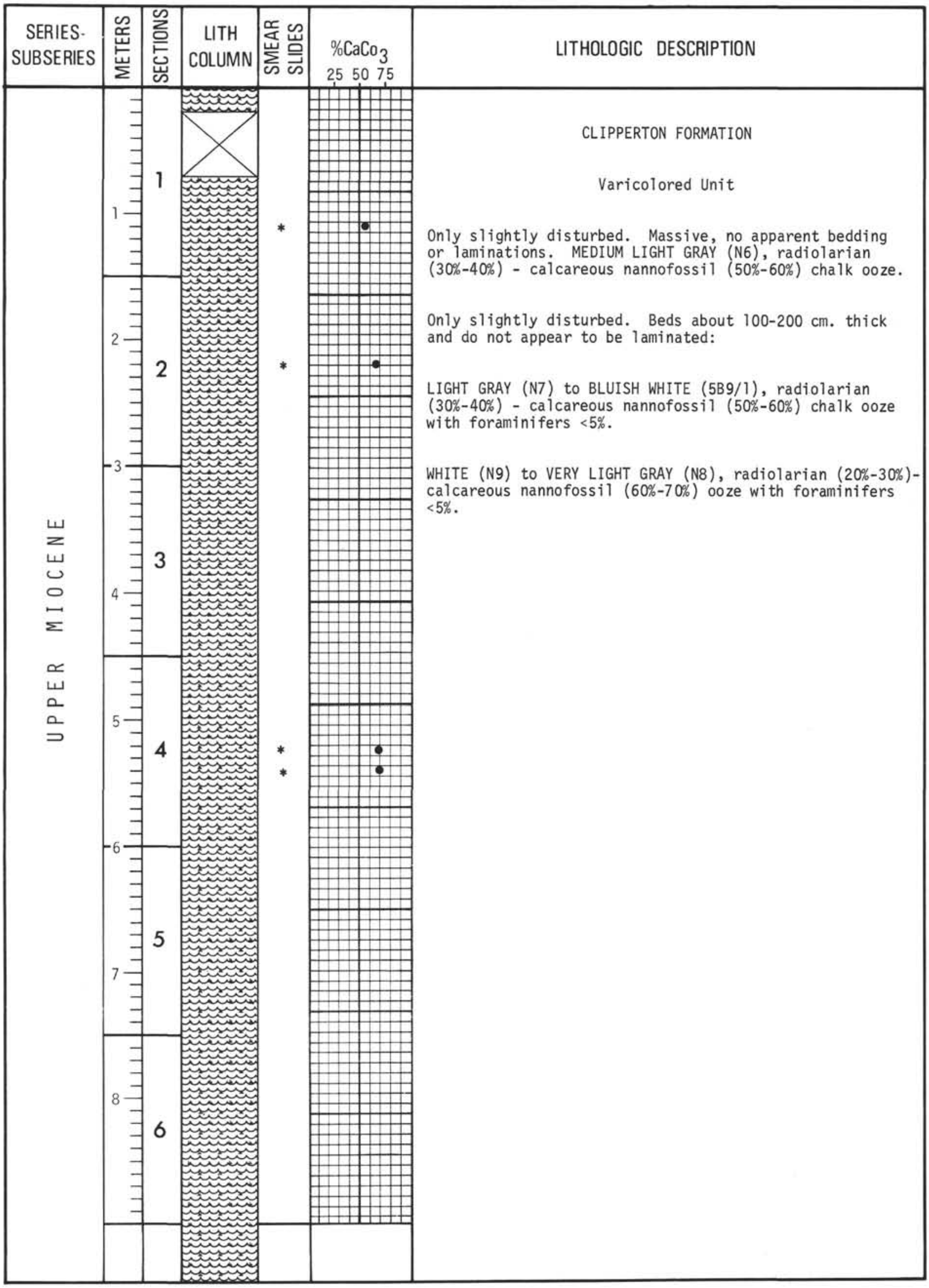


Figure 72. *Hole 77B, Core 17 (155.5 to 161.6m).*

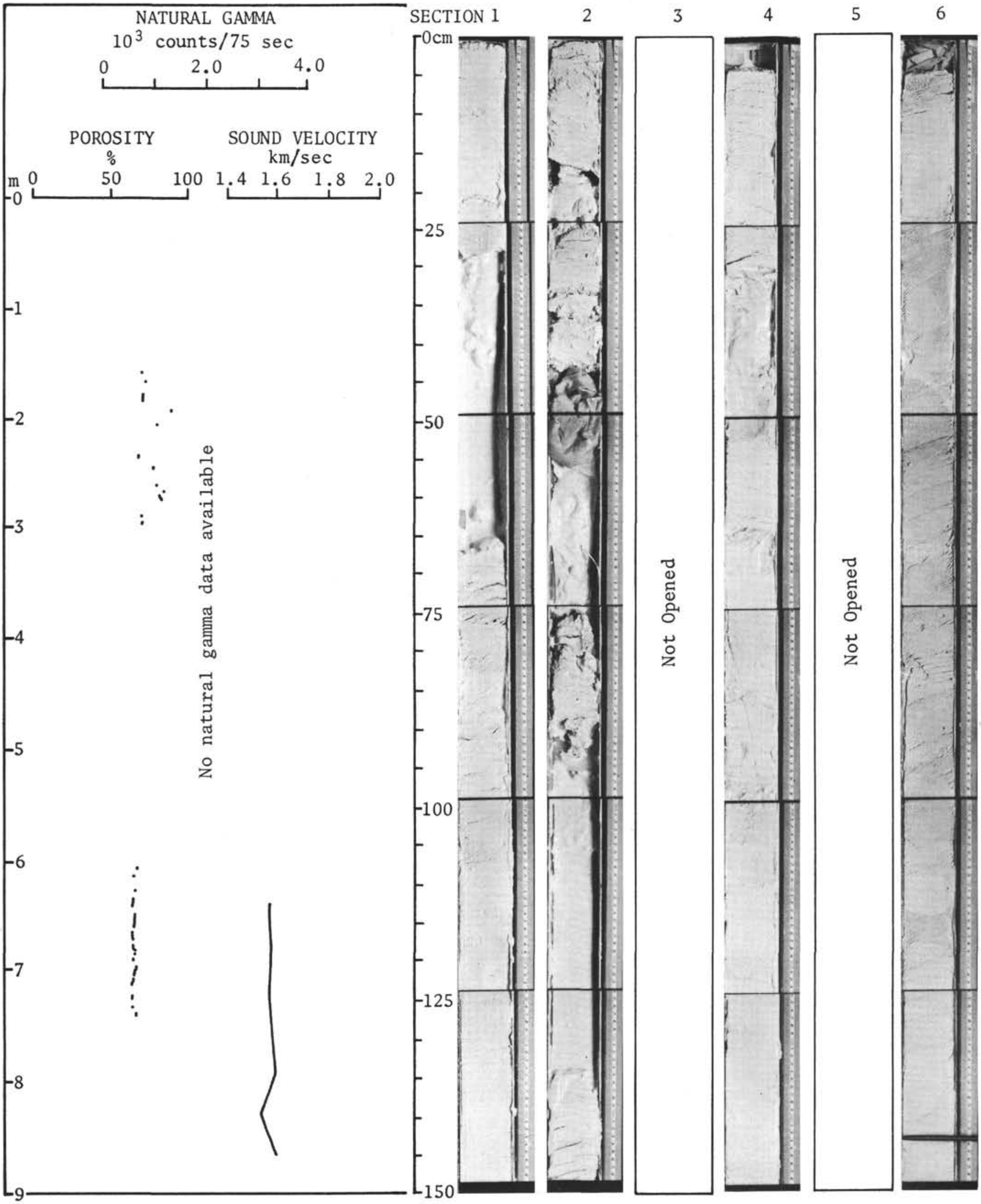


Figure 73. *Hole 77B, Core 17, Sections 1-6, Physical Properties.*

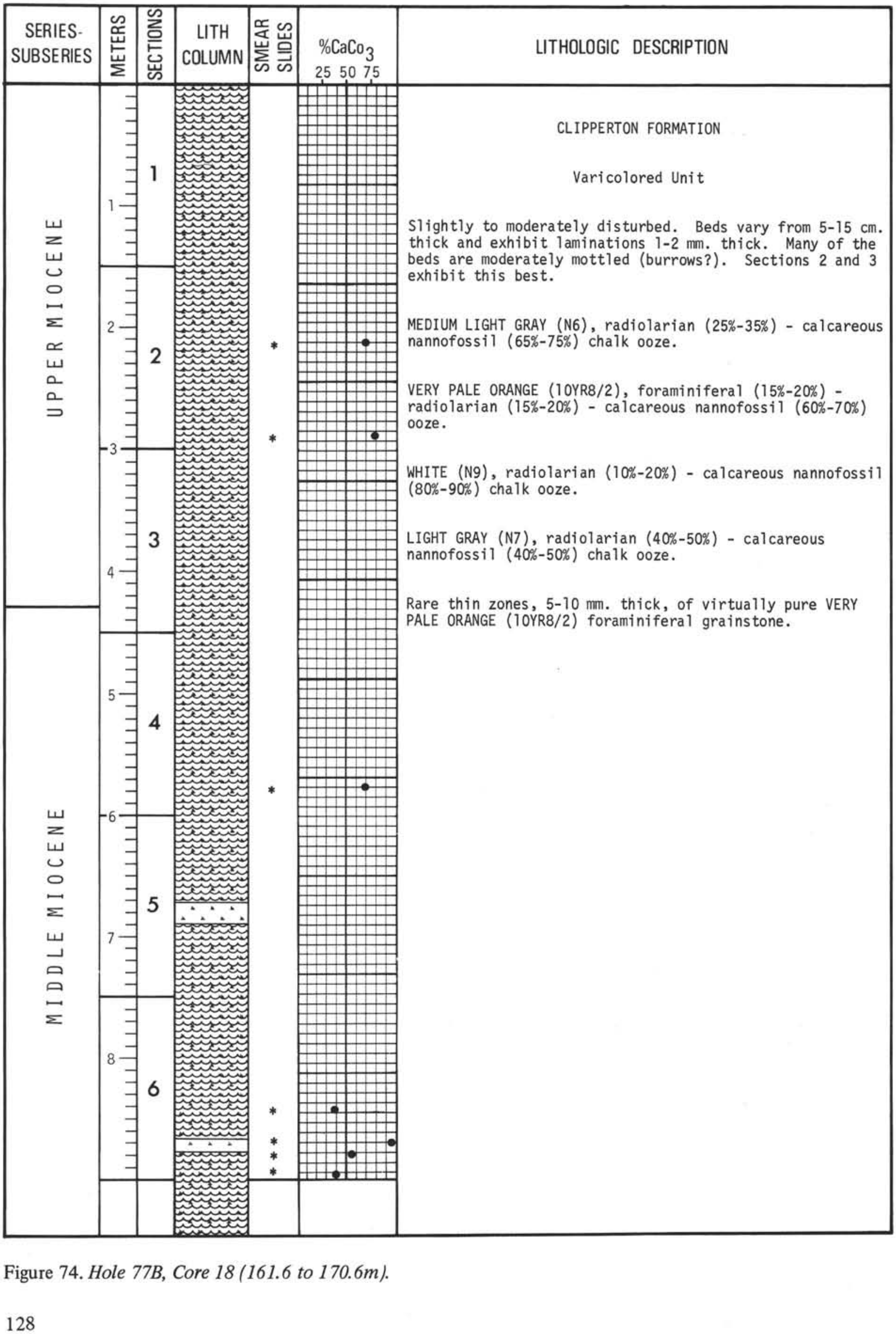


Figure 74. *Hole 77B, Core 18 (161.6 to 170.6m).*

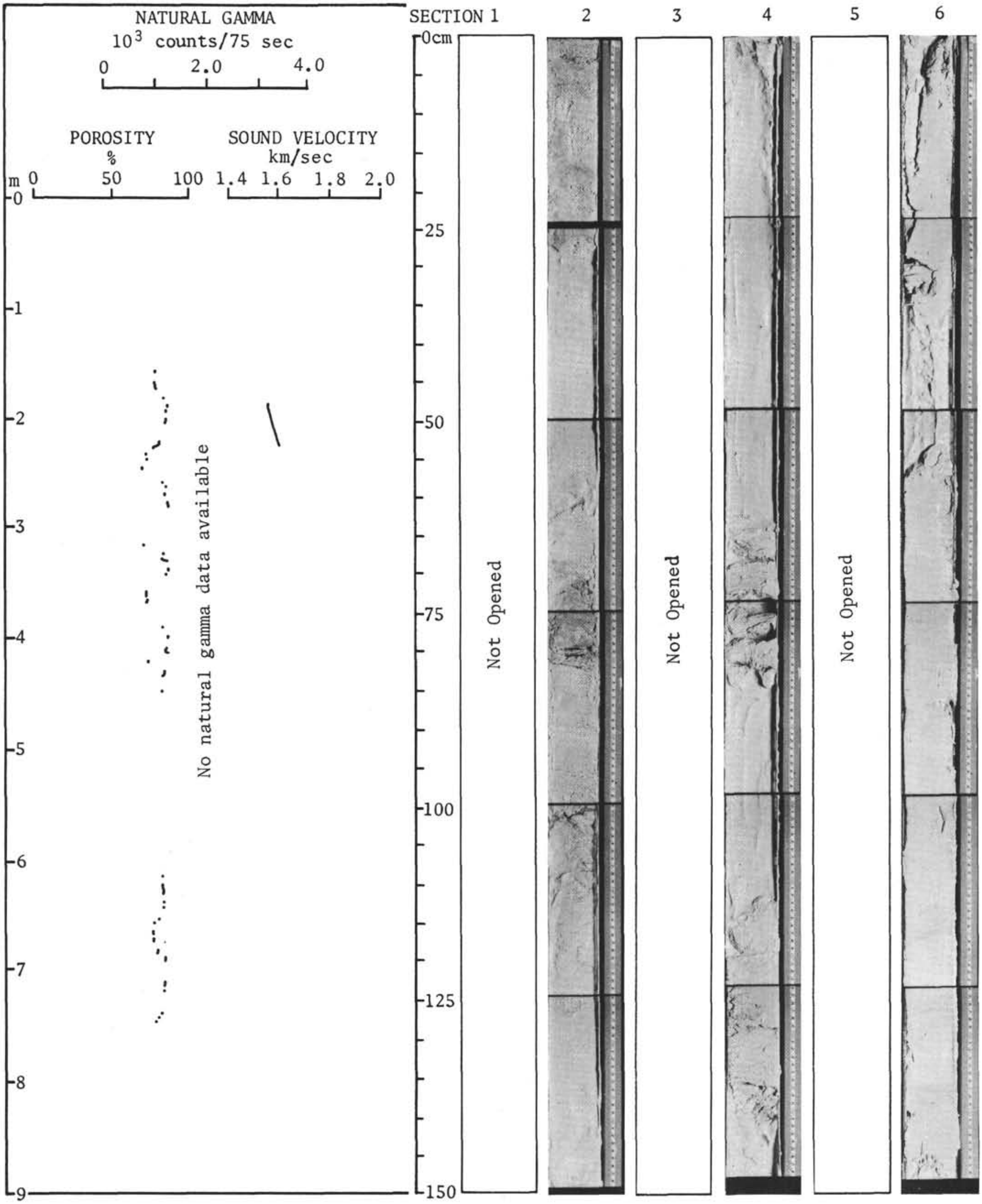


Figure 75. *Hole 77B, Core 18, Sections 1-6, Physical Properties.*

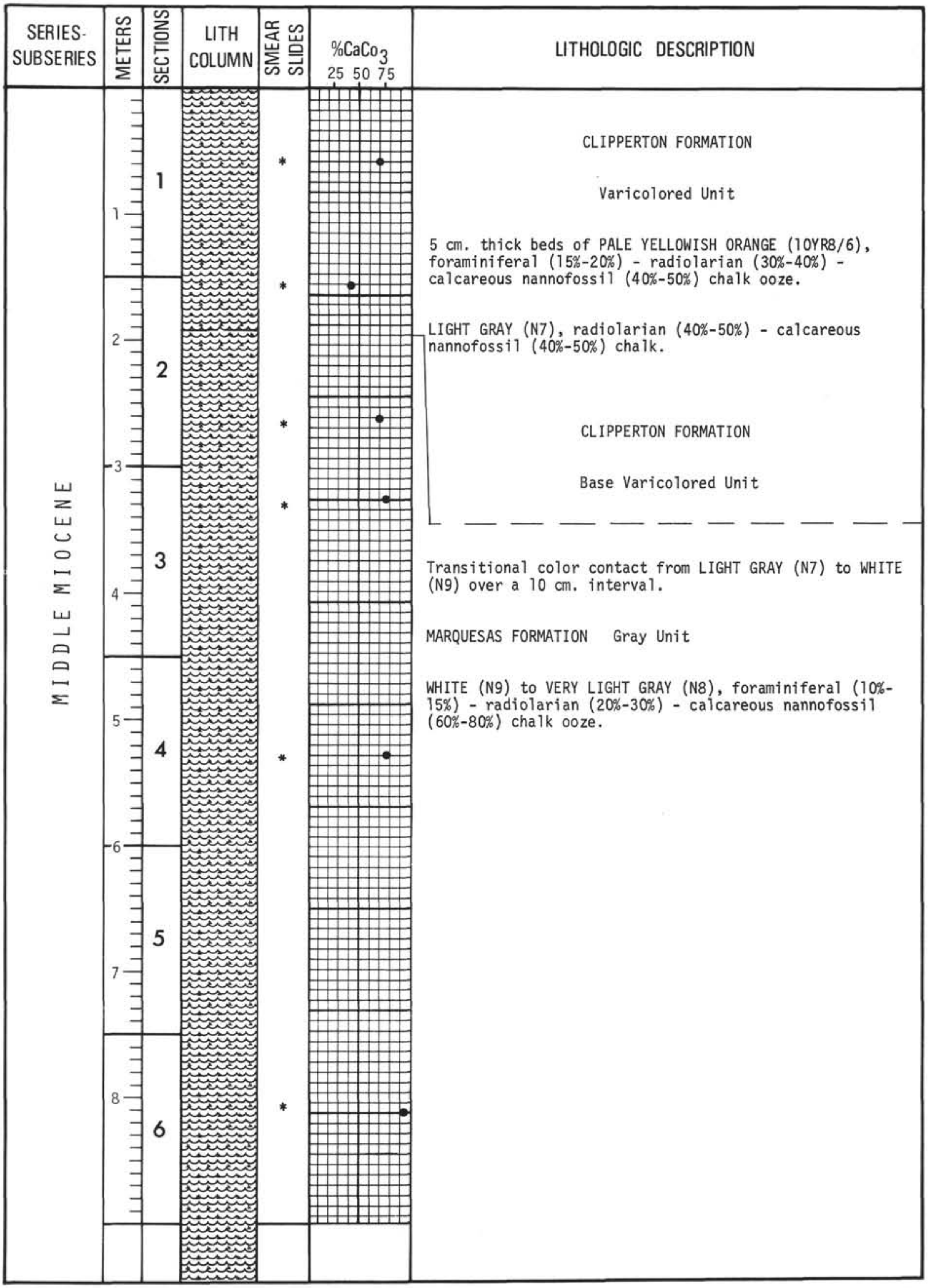


Figure 76. *Hole 77B, Core 19 (170.6 to 179.7m).*

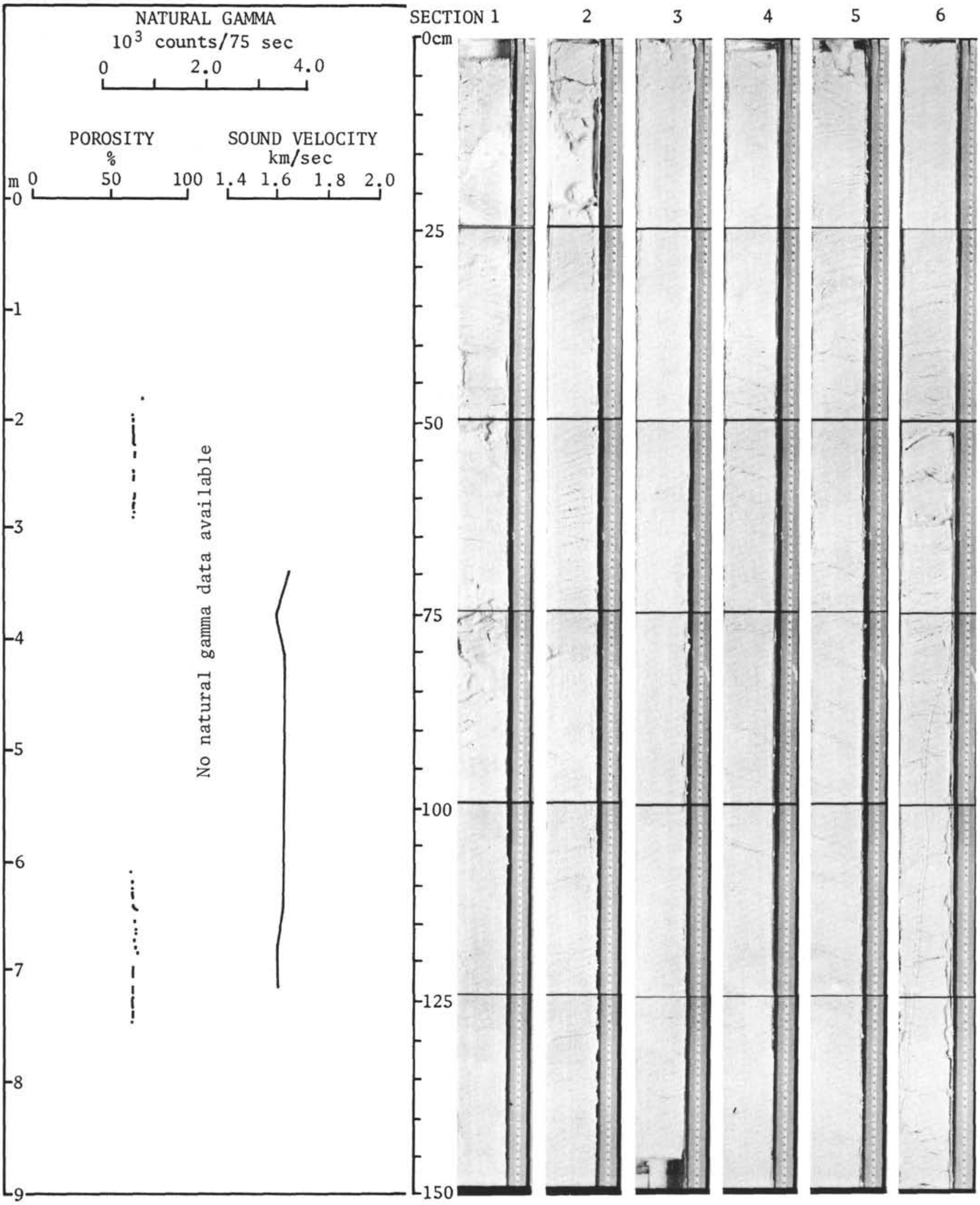


Figure 77. *Hole 77B, Core 19, Sections 1-6, Physical Properties.*

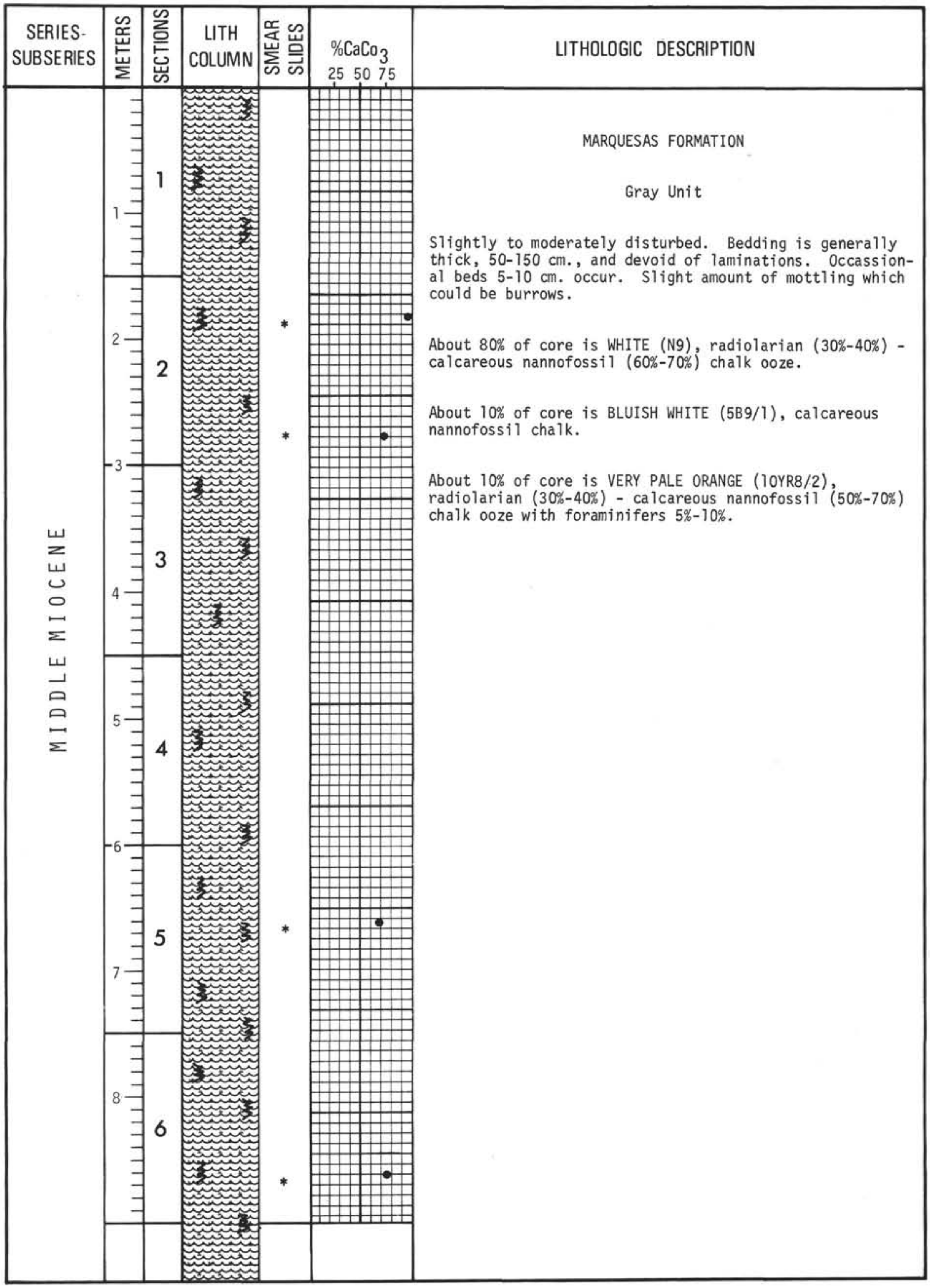


Figure 78. *Hole 77B, Core 20 (179.7 to 189.0m).*

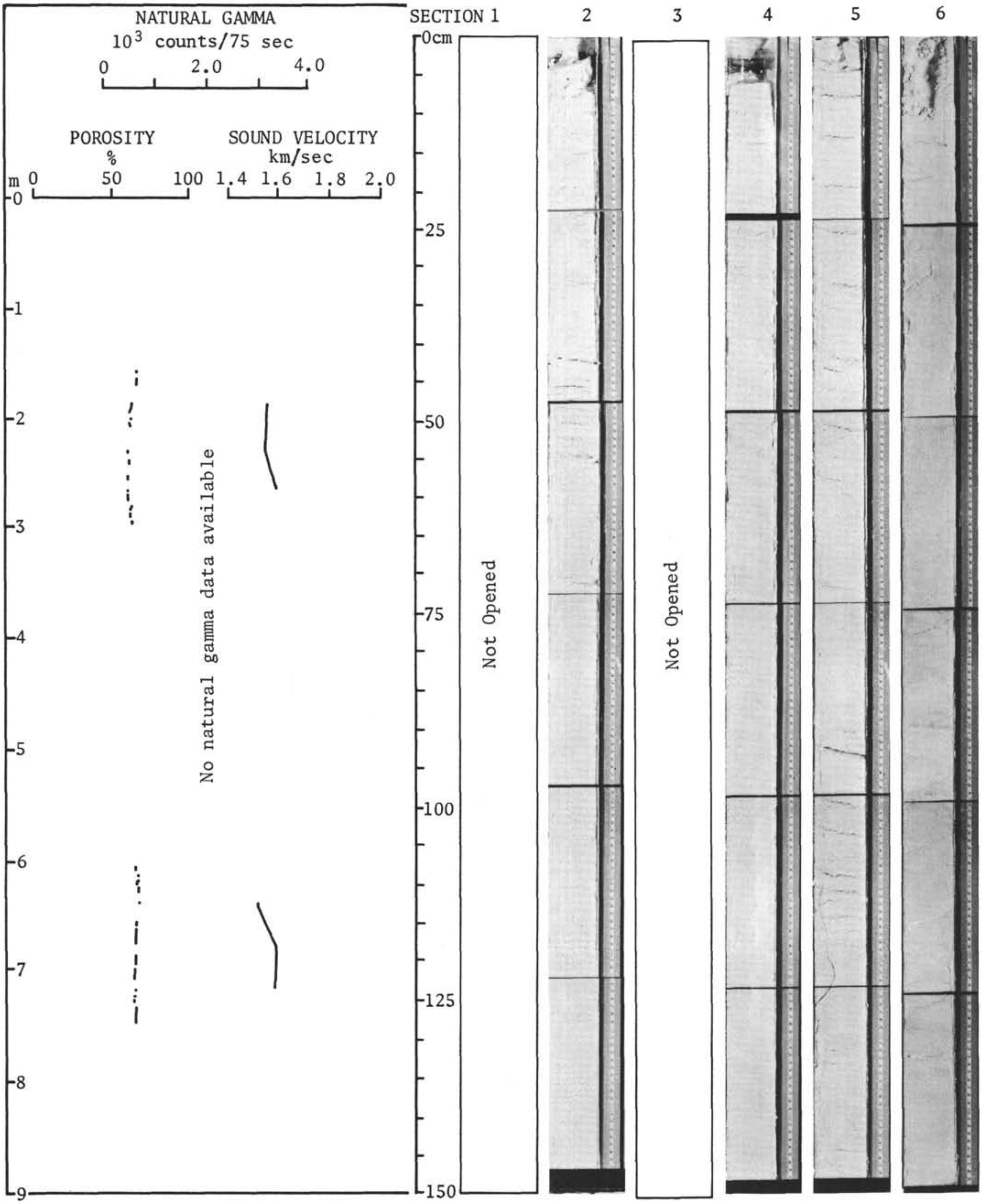
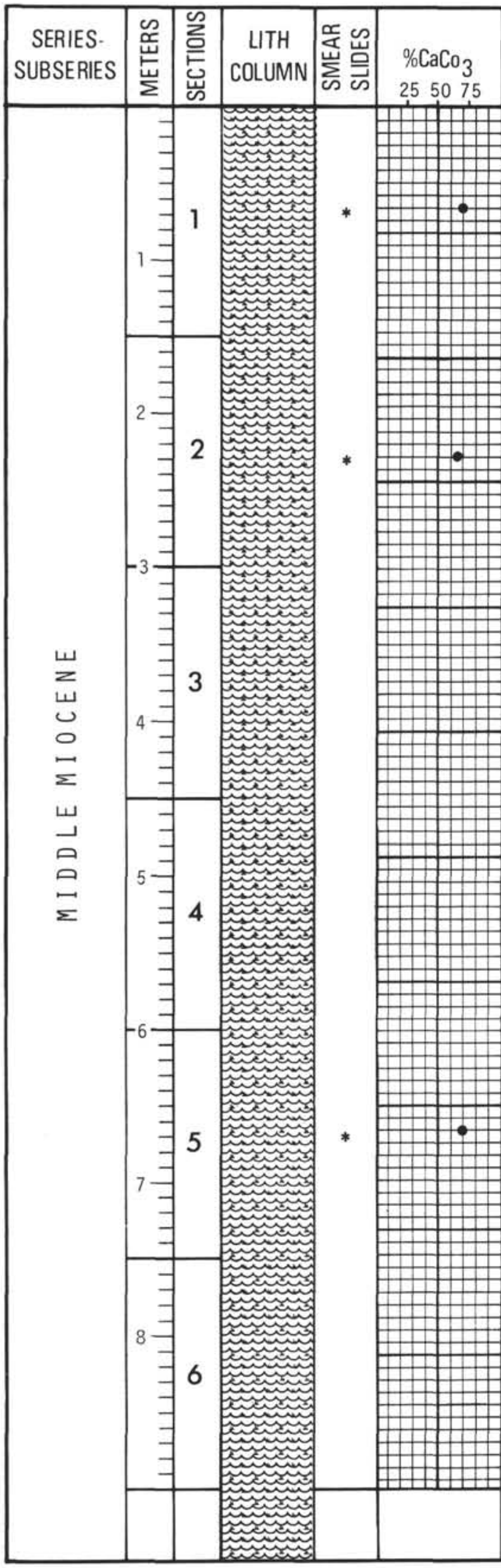


Figure 79. *Hole 77B, Core 20, Sections 1-6, Physical Properties.*



MARQUESAS FORMATION

Gray Unit

Highly disturbed massive, WHITE (N9), radiolarian (10%-20%) - calcareous nannofossil (60%-70%) ooze with foraminifers <10%.

VERY DUSKY PURPLE (5P2/2), radiolarian - calcareous nannofossil ooze. Occurs as rare laminations <0.1 mm. thick.

Figure 80. *Hole 77B, Core 21 (189.0 to 198.1m).*

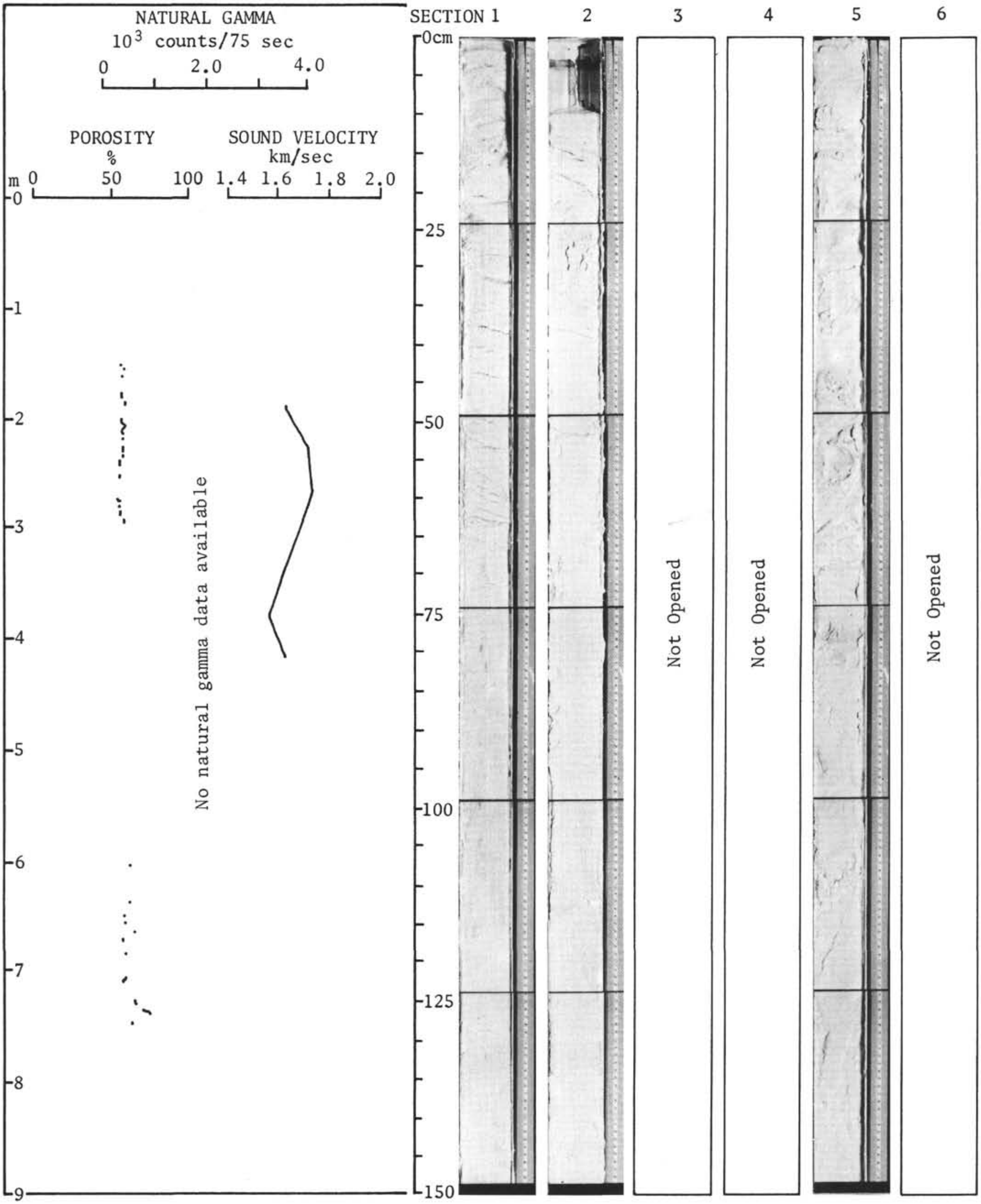
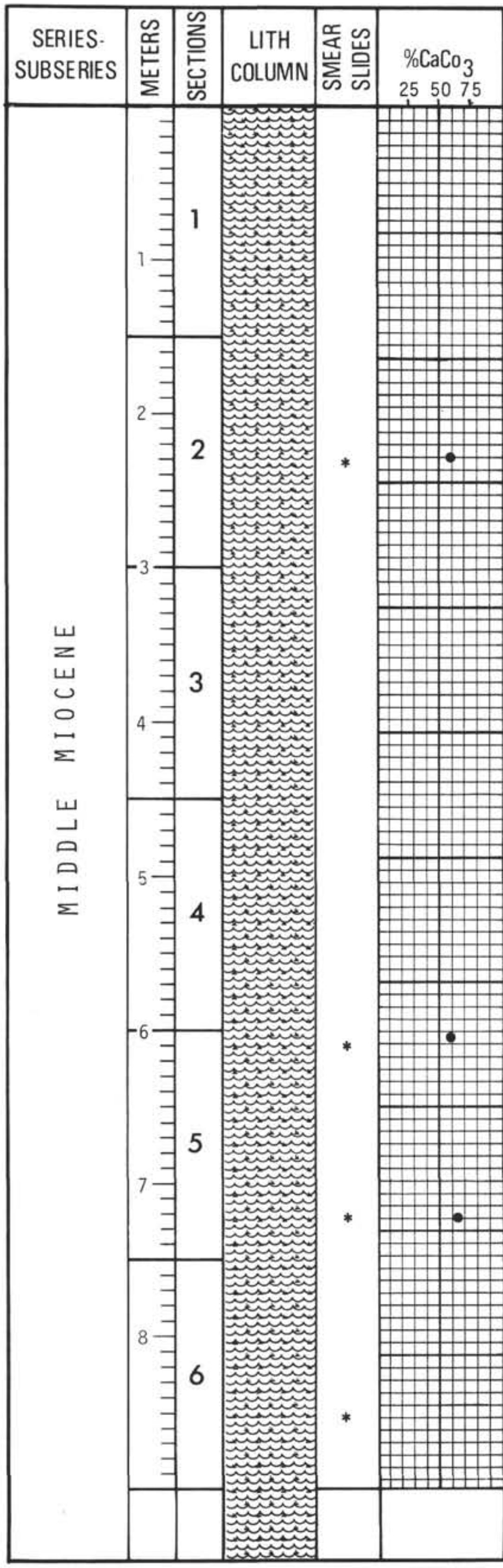


Figure 81. *Hole 77B, Core 21, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Moderately to intensely disturbed. Generally massive bedding 100-200 cm. thick with no apparent laminations.

About 95% of core is WHITE (N9) to BLUISH WHITE (5P9/1), radiolarian (30%-40%) - calcareous nannofossil (50%-60%) chalk ooze.

GRAYISH GREEN (10GY5/2), radiolarian (30%-40%) - calcareous nannofossil (50%-60%) ooze chalk.

Rare laminations of PALE PURPLE (5P6/2), radiolarian - calcareous nannofossil ooze.

Figure 82. *Hole 77B, Core 22 (198.1 to 207.2m).*

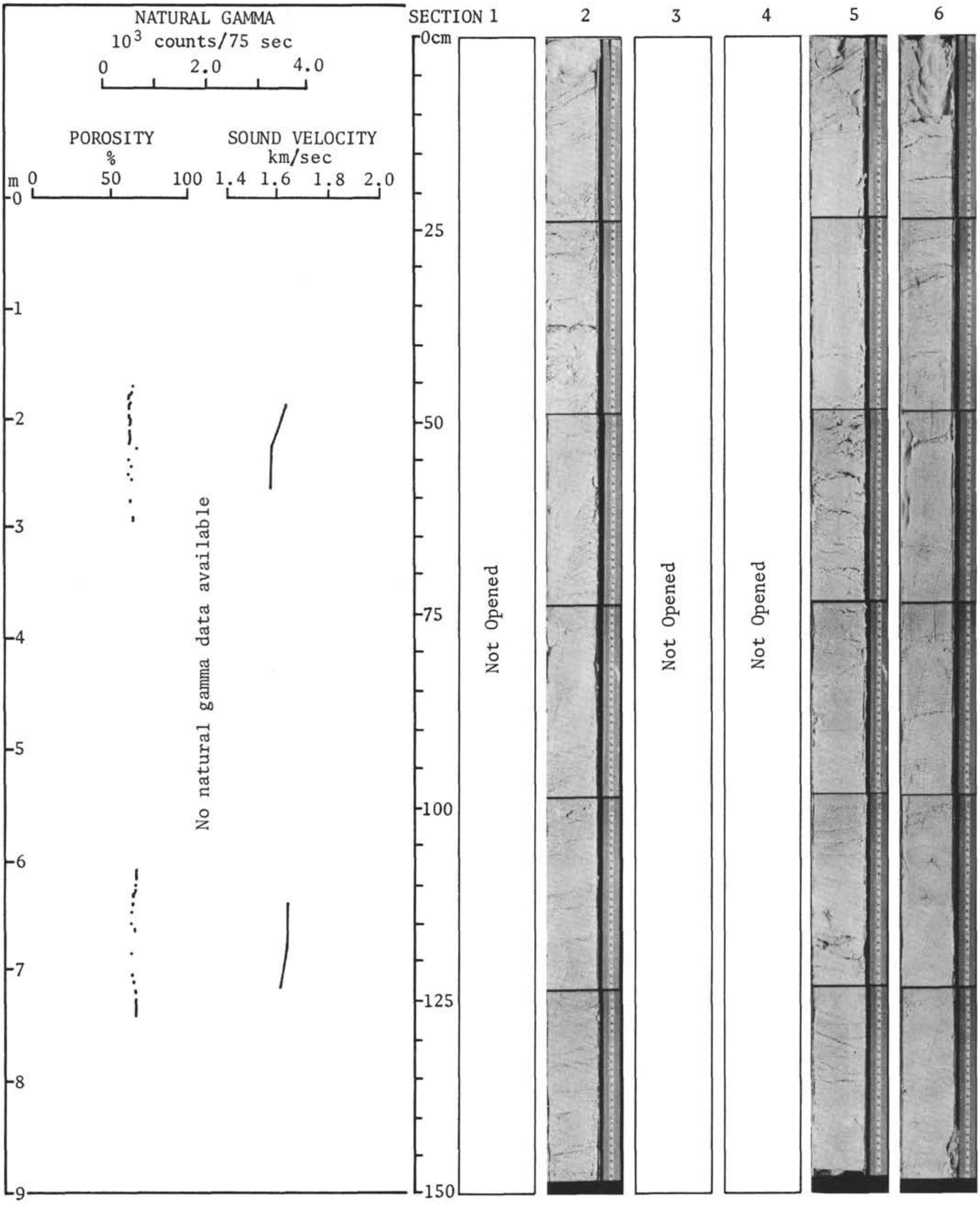
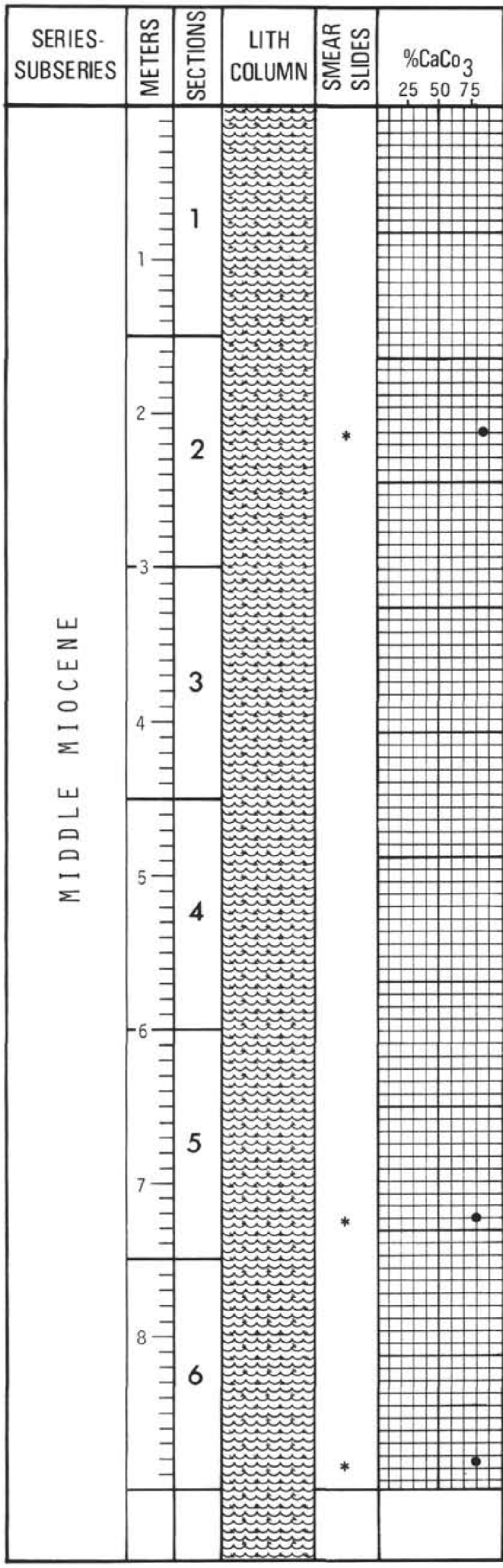


Figure 83. *Hole 77B, Core 22, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Moderately to intensely deformed. Massive with no apparent bedding features in BLUISH WHITE (5B9/1) sediments.

About 95% of core is BLUISH WHITE (5B9/1), radiolarian (20%-30%) - calcareous nannofossil (60%-70%) chalk with foraminifers <10%.

About 5% of core is intensely disturbed laminations of VERY DUSKY PURPLE (5P2/2), radiolarian - calcareous nannofossil ooze.

Figure 84. *Hole 77B, Core 23 (207.2 to 216.3).*

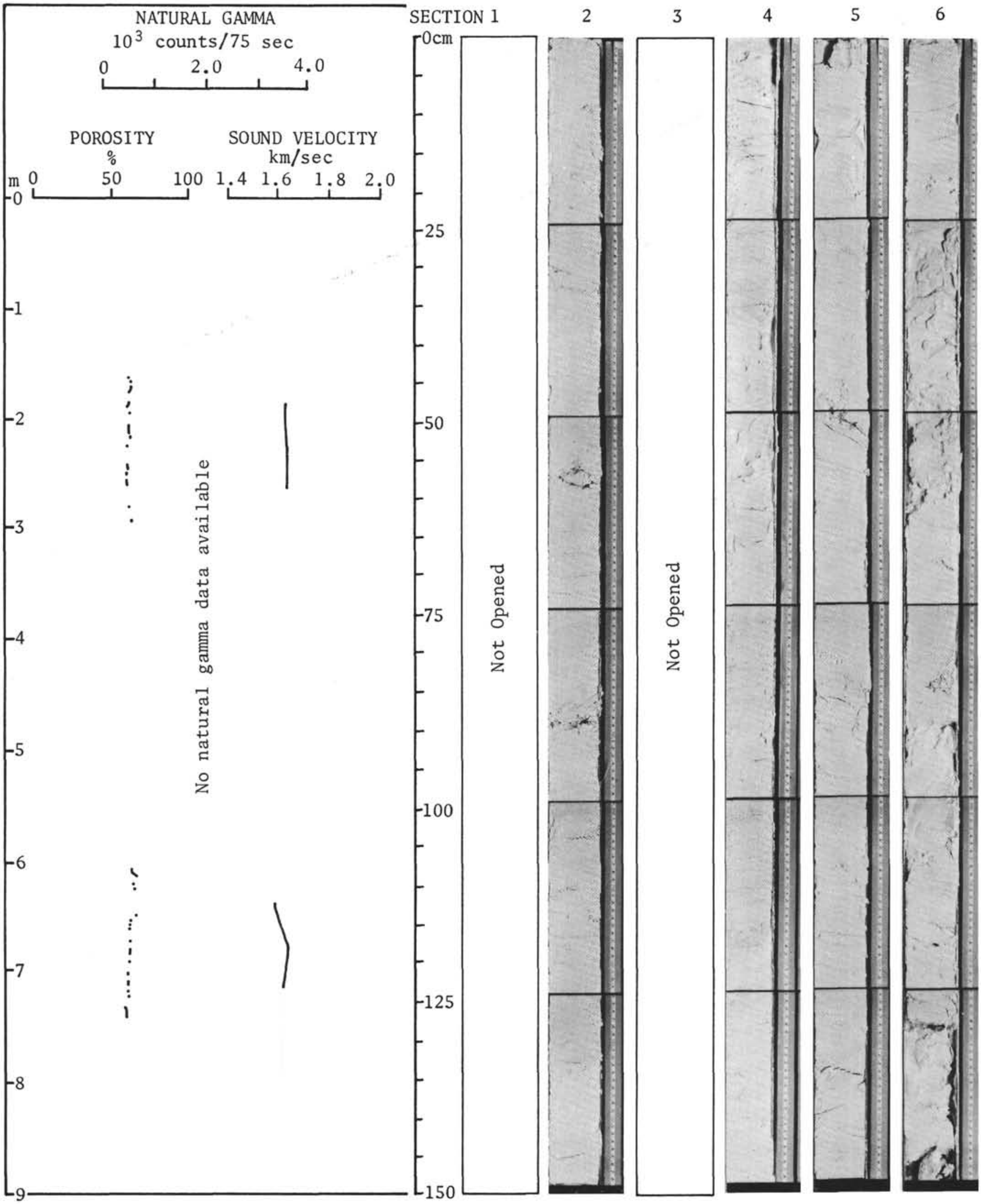
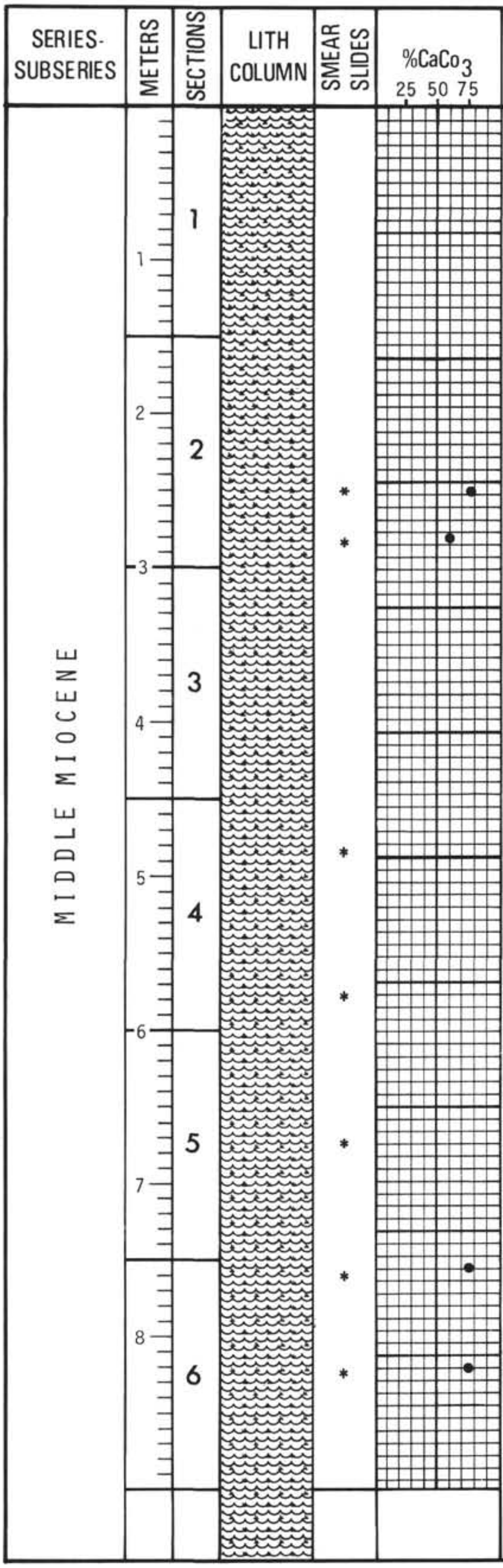


Figure 85. *Hole 77B, Core 23, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Moderately disturbed. Different interbedded colored sediments occur in 5-100 cm. thick beds with no apparent laminations within the beds.

About 75% of core is BLUISH WHITE (5B9/1), radiolarian (30%-40%) - calcareous nannofossil (60%-70%) chalk with foraminifers <10%.

About 25% of core is WHITE (N9), foraminiferal (<10%) - radiolarian (20%-30%) - calcareous nannofossil (60%-70%) ooze.

Figure 86. *Hole 77B, Core 24 (216.3 to 225.6m).*

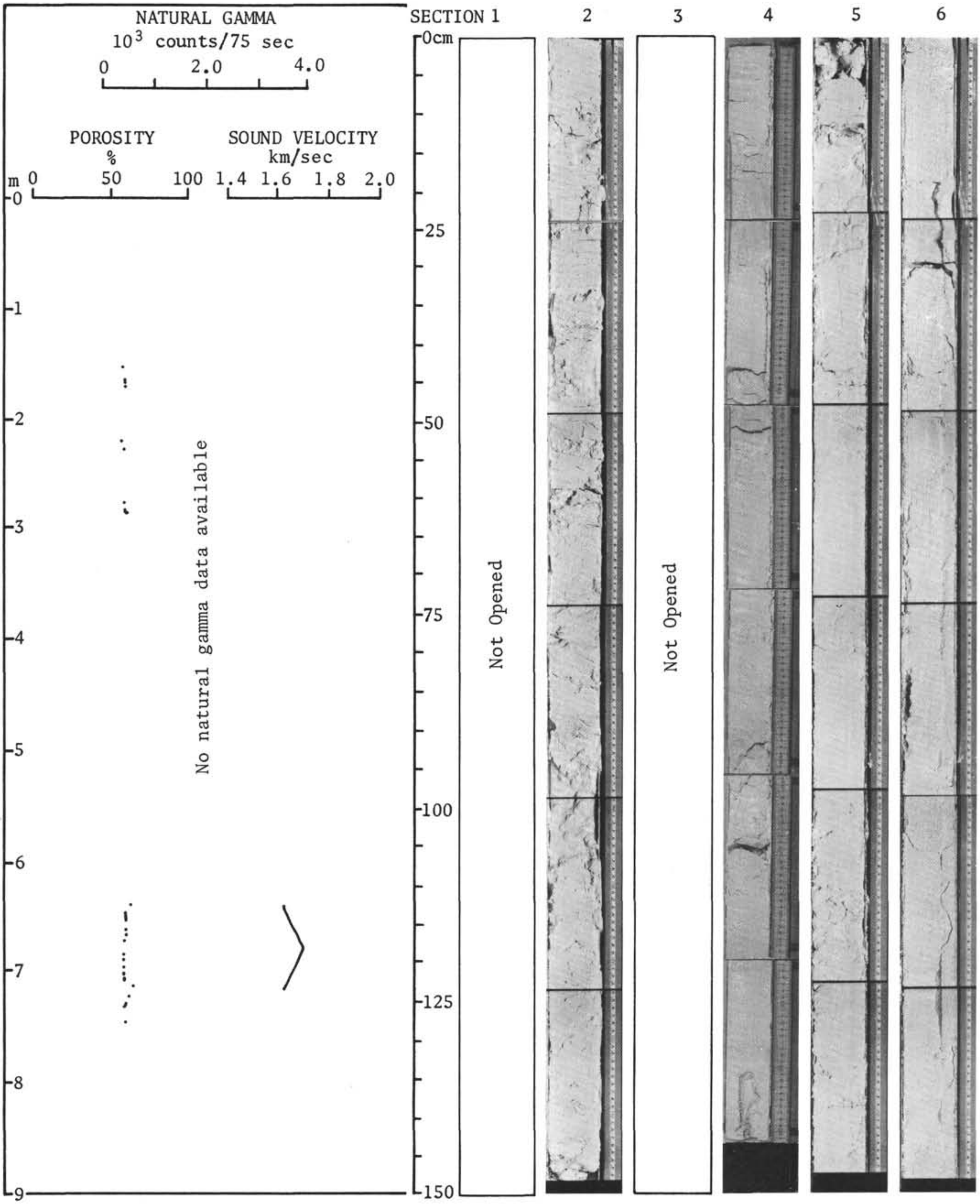


Figure 87. *Hole 77B, Core 24, Sections 1-6, Physical Properties.*

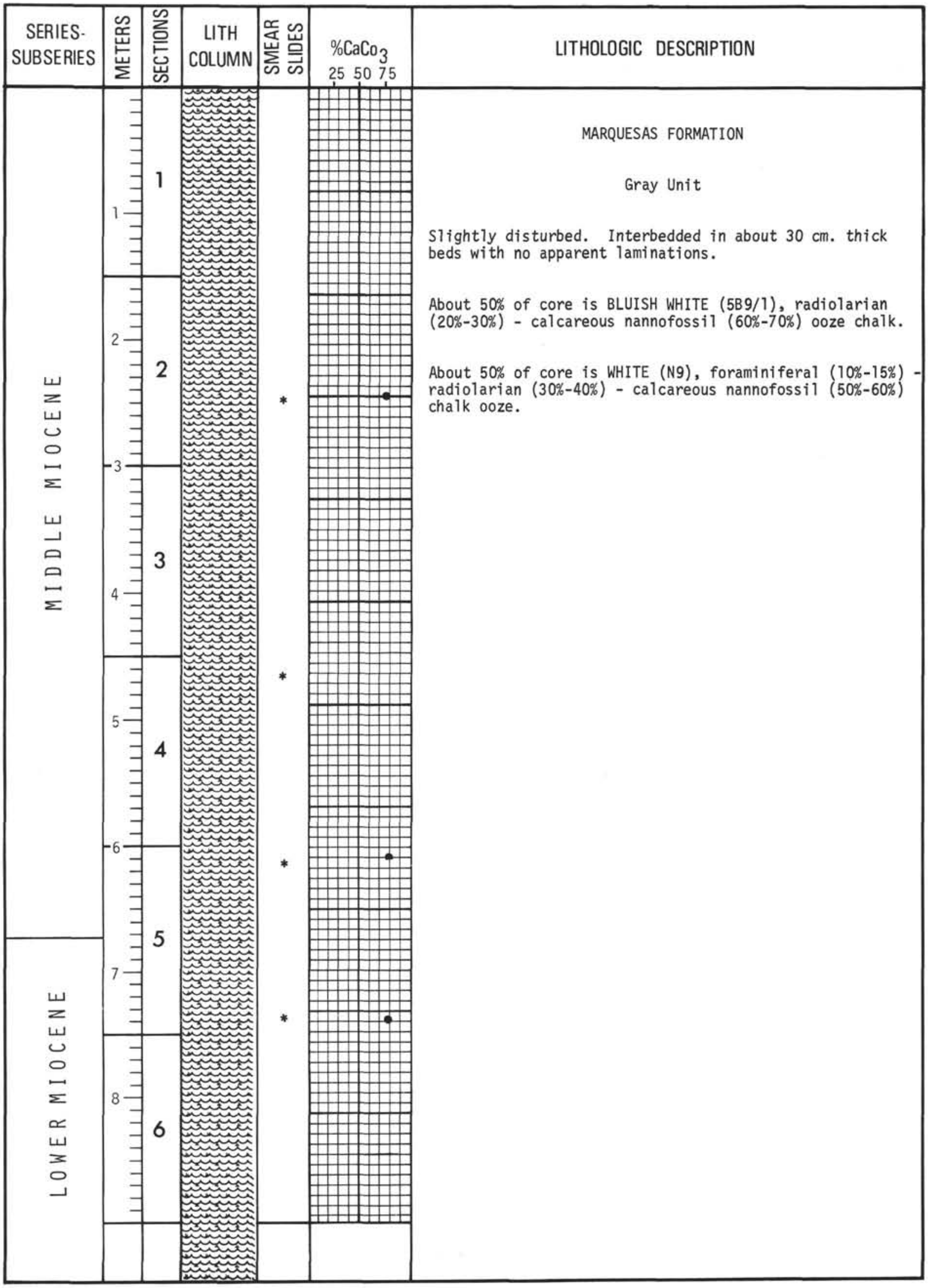


Figure 88. *Hole 77B, Core 25 (225.6 to 234.6m).*

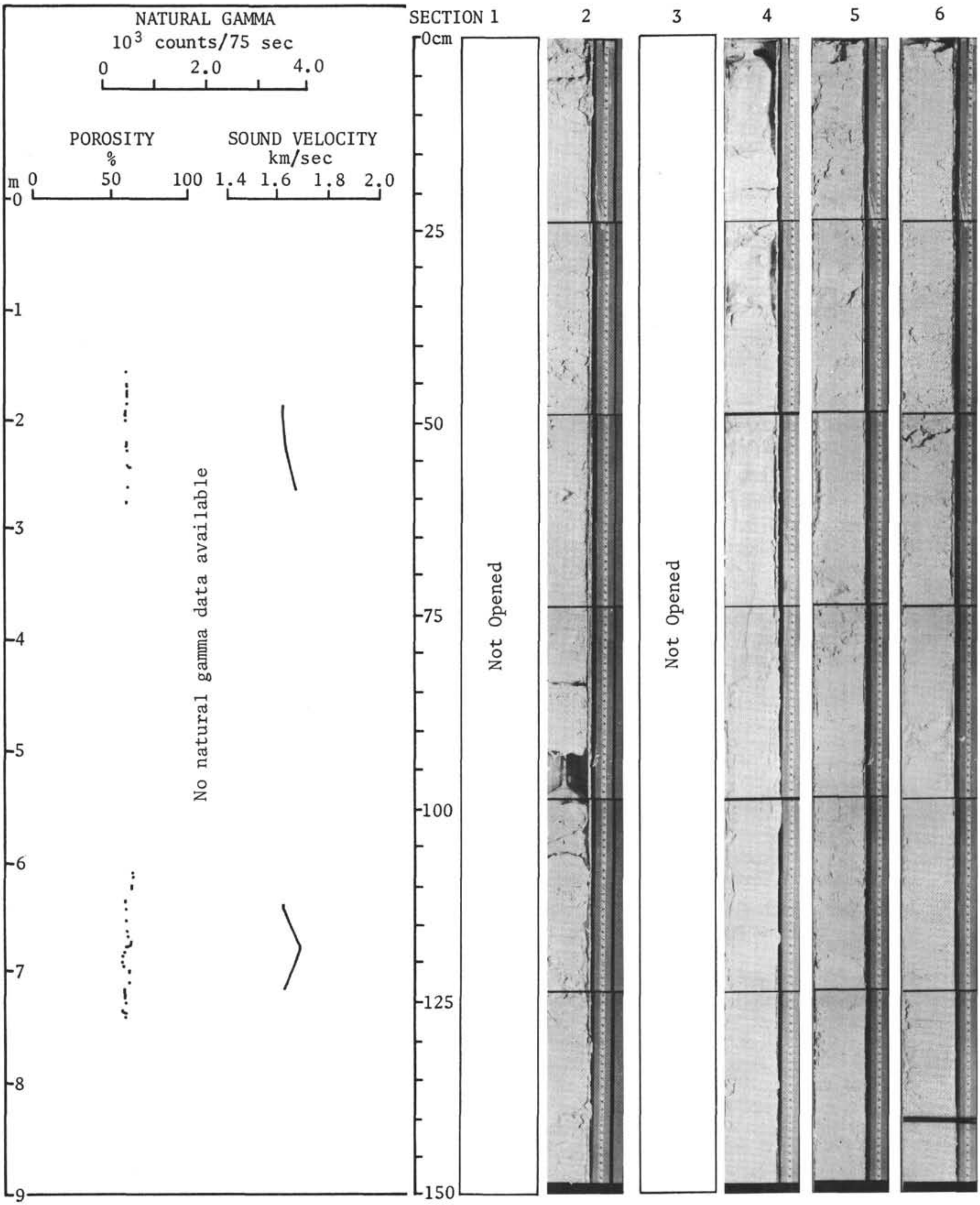


Figure 89. *Hole 77B, Core 25, Sections 1-6, Physical Properties.*

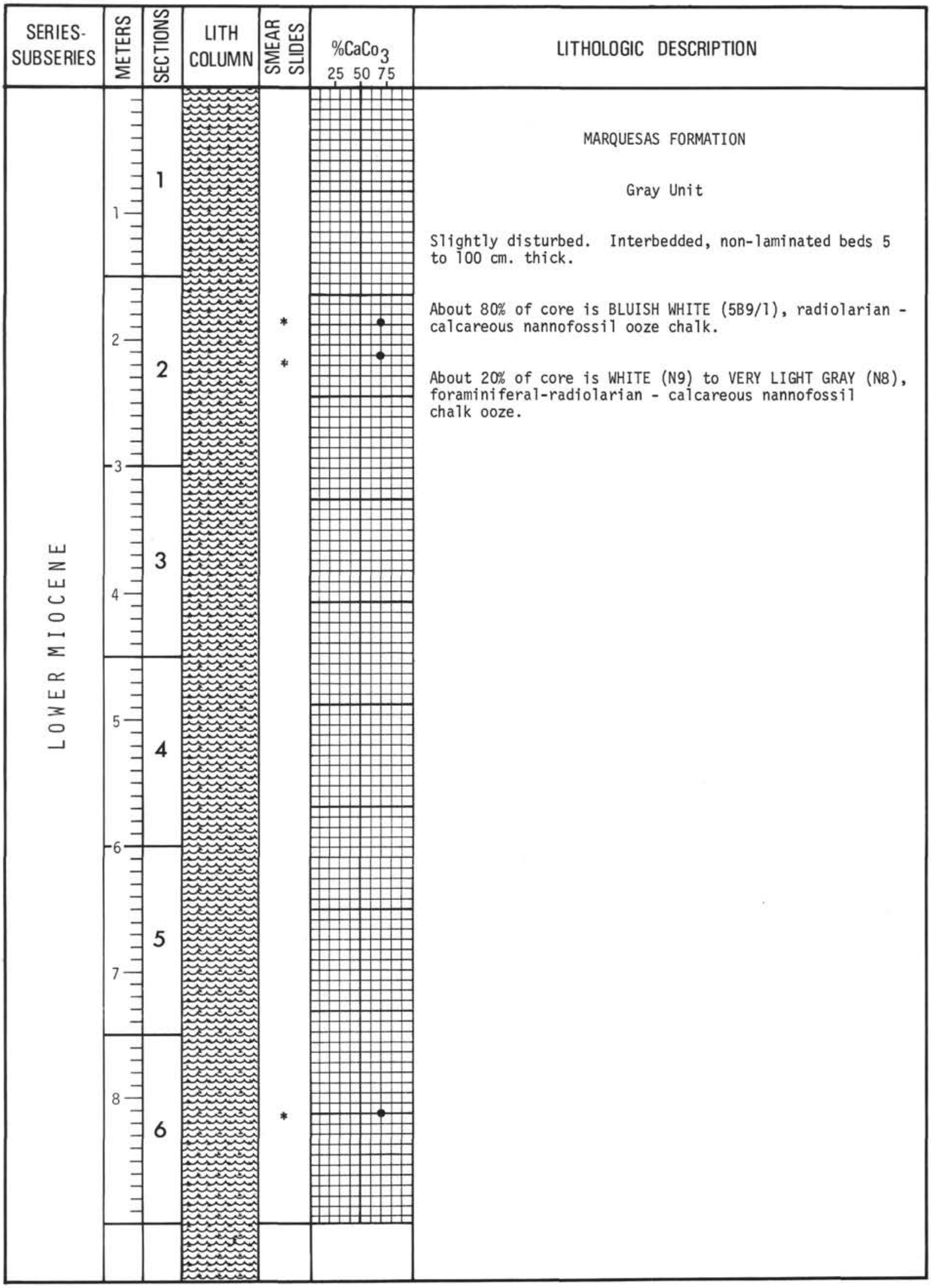


Figure 90. *Hole 77B, Core 26 (234.6 to 243.8m).*

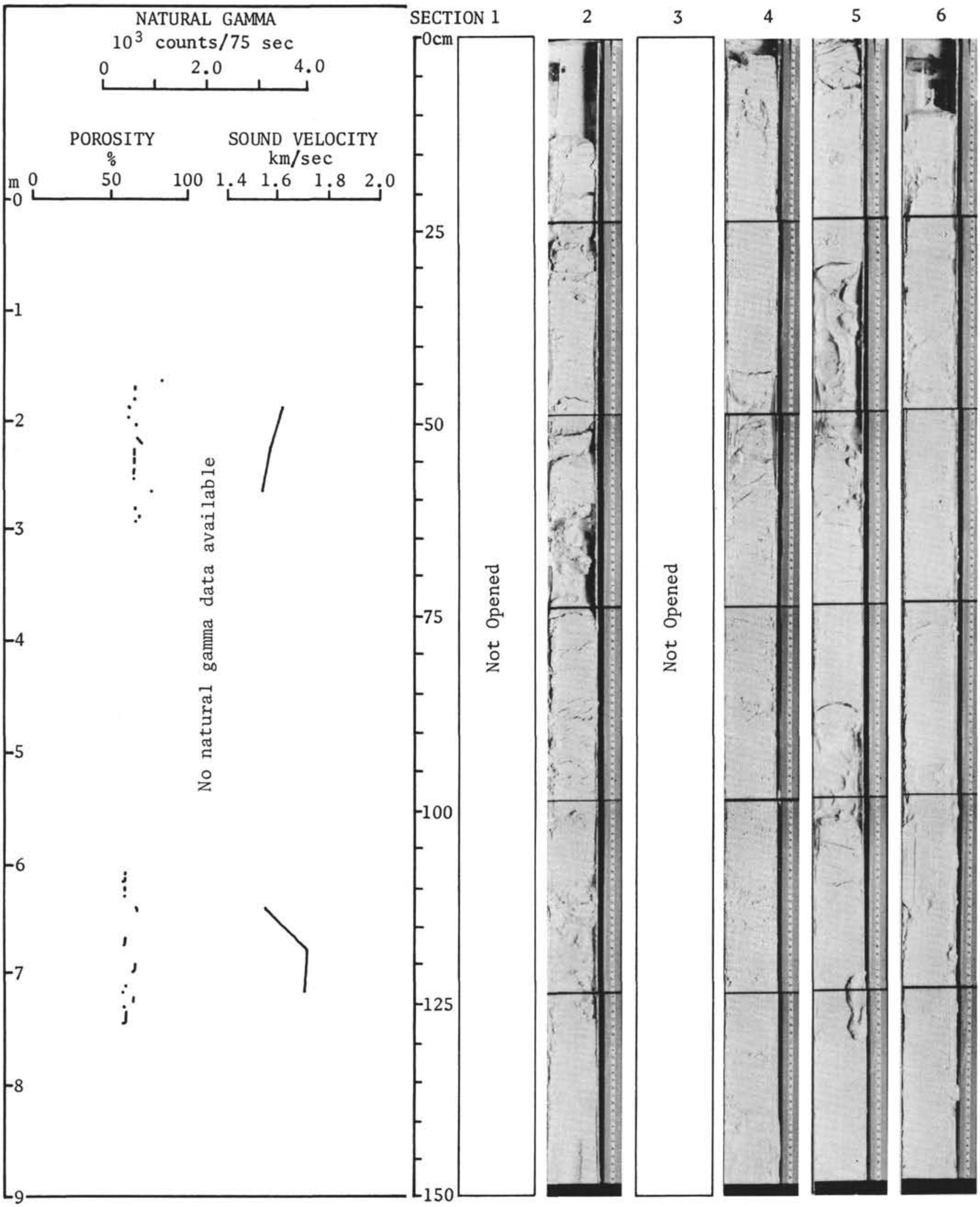


Figure 91. *Hole 77B, Core 26, Sections 1-6, Physical Properties.*

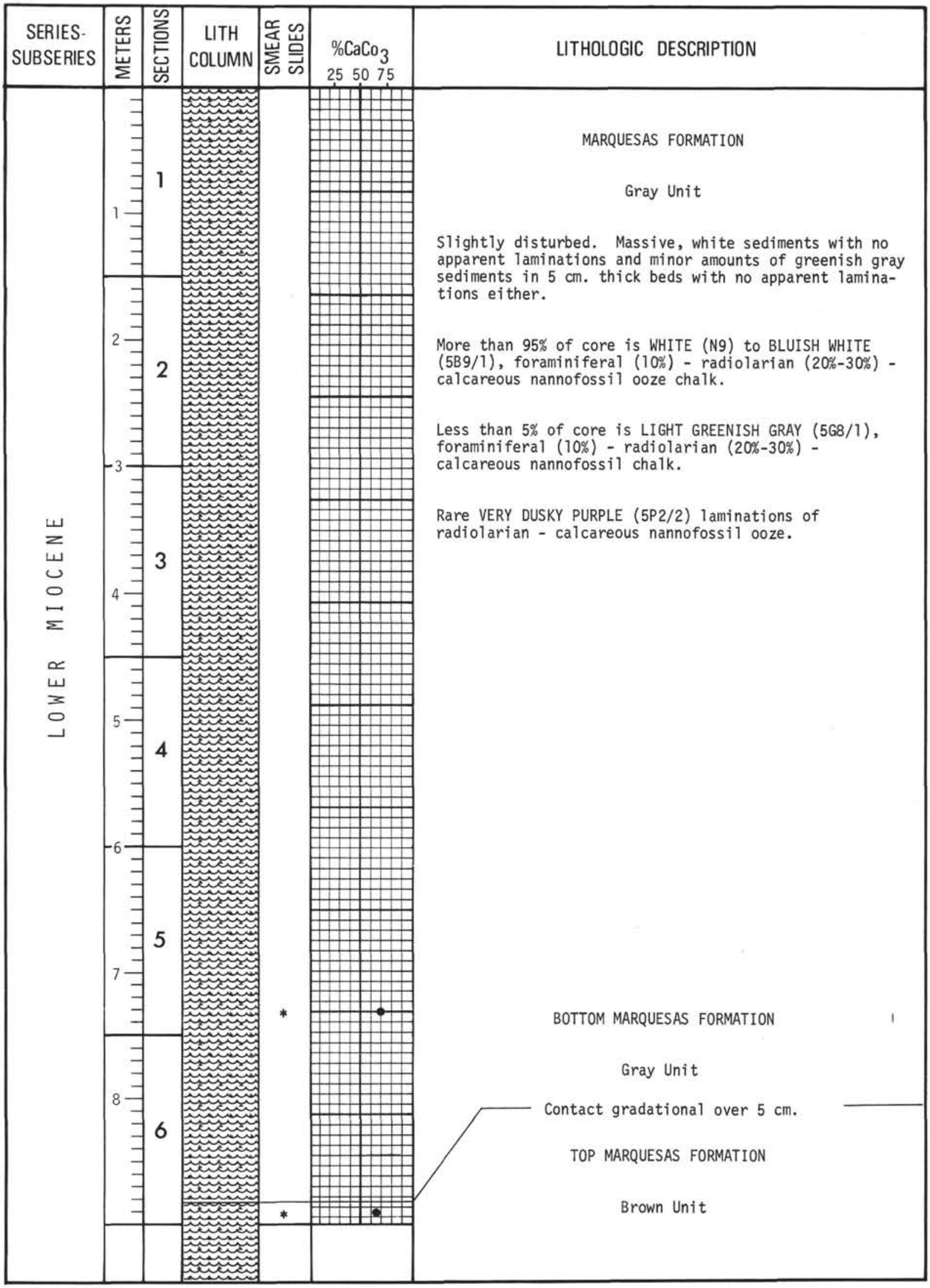


Figure 92. *Hole 77B, Core 27 (243.8 to 253.0m).*

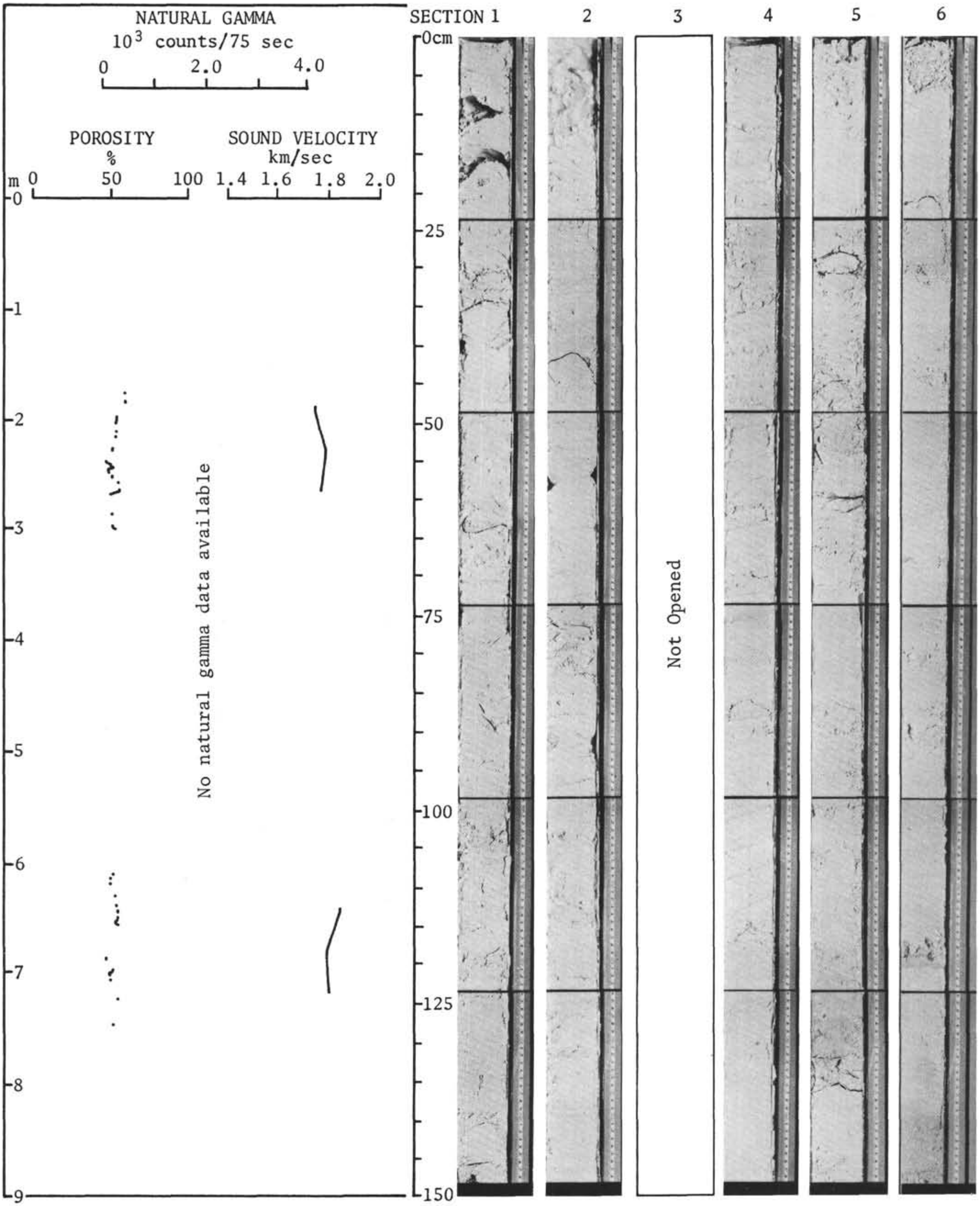


Figure 93. *Hole 77B, Core 17, Sections 1-6, Physical Properties.*

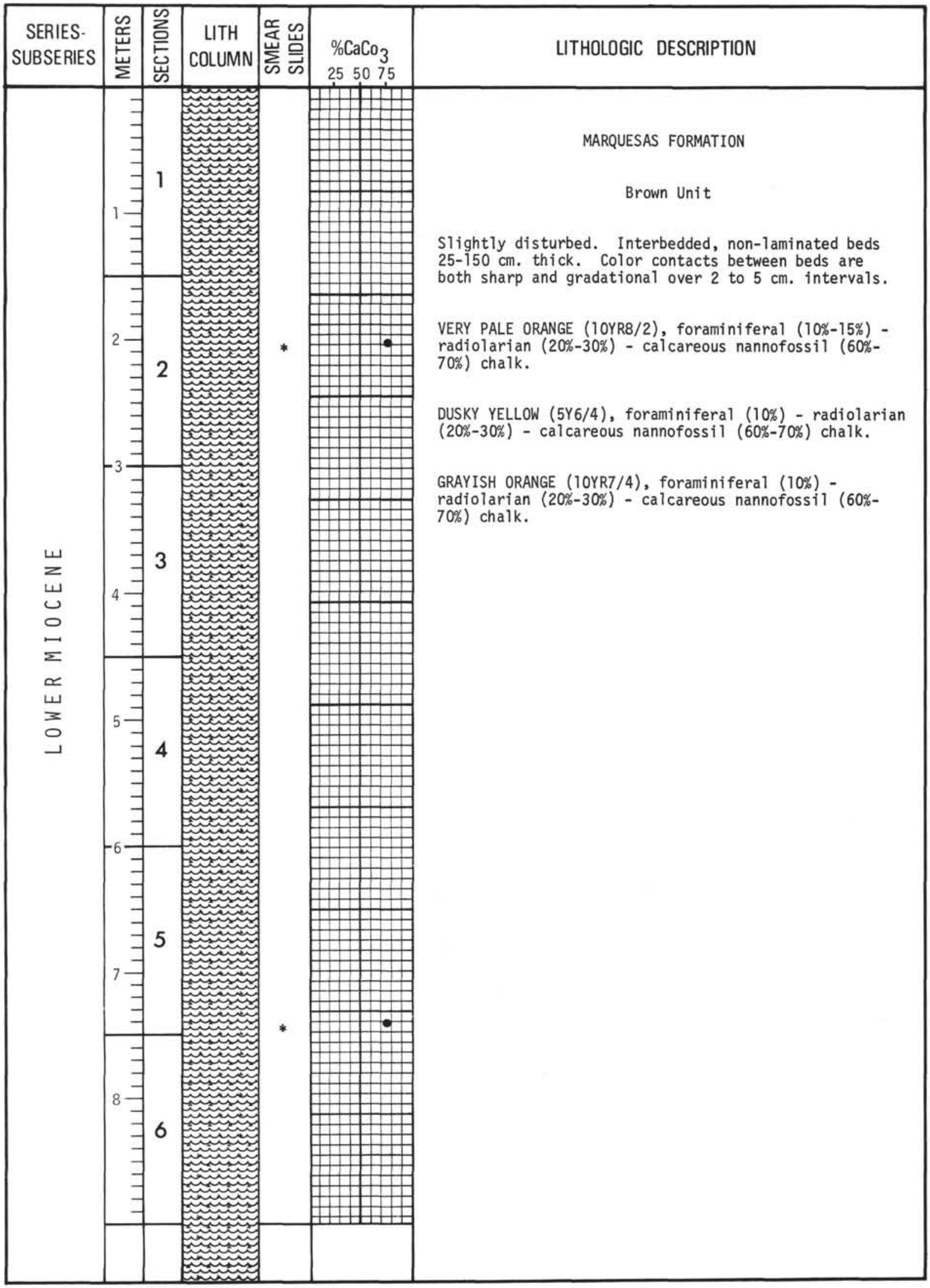


Figure 94. *Hole 77B, Core 28 (253.0 to 262.1m).*

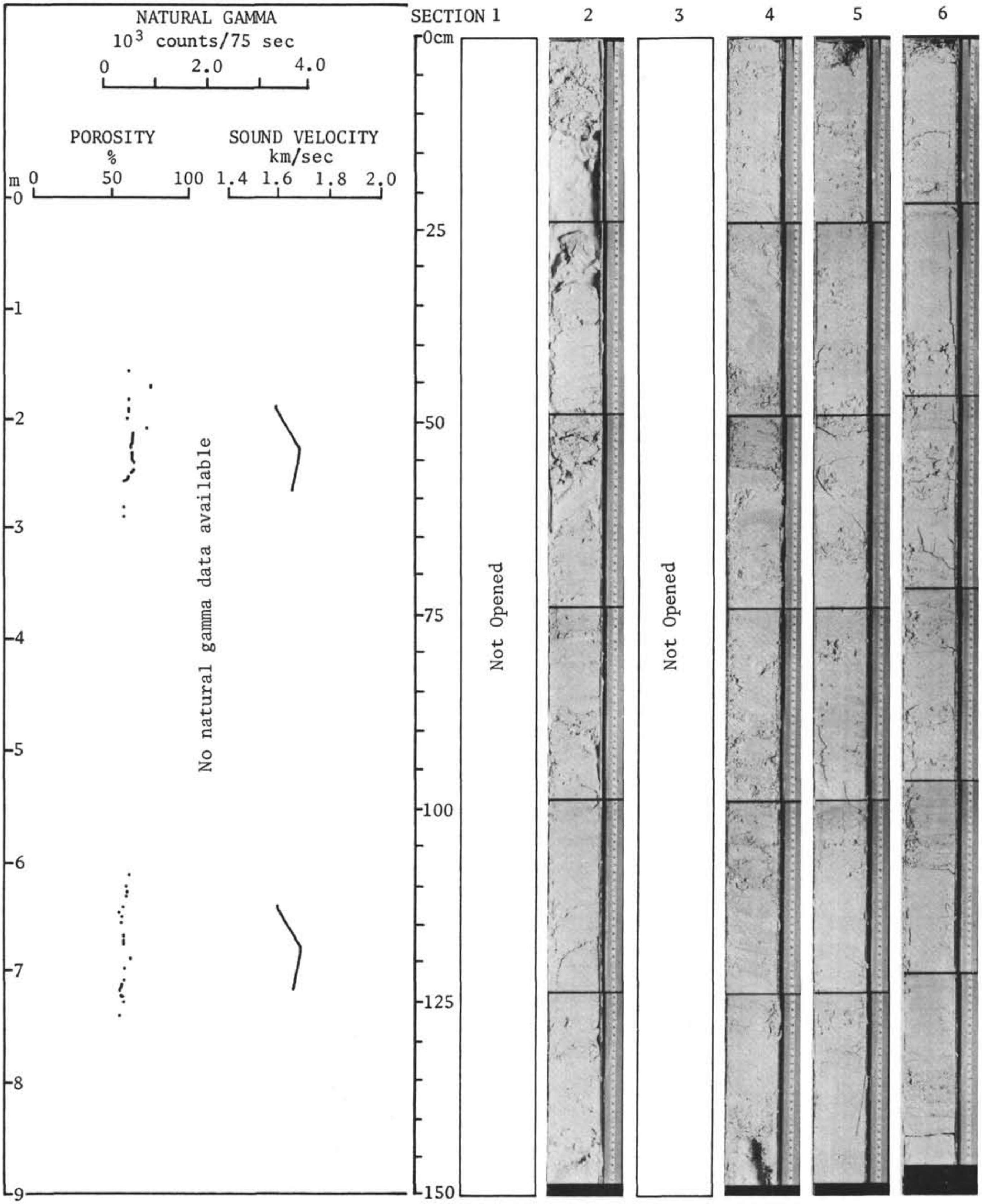


Figure 95. *Hole 77B, Core 28, Sections 1-6, Physical Properties.*

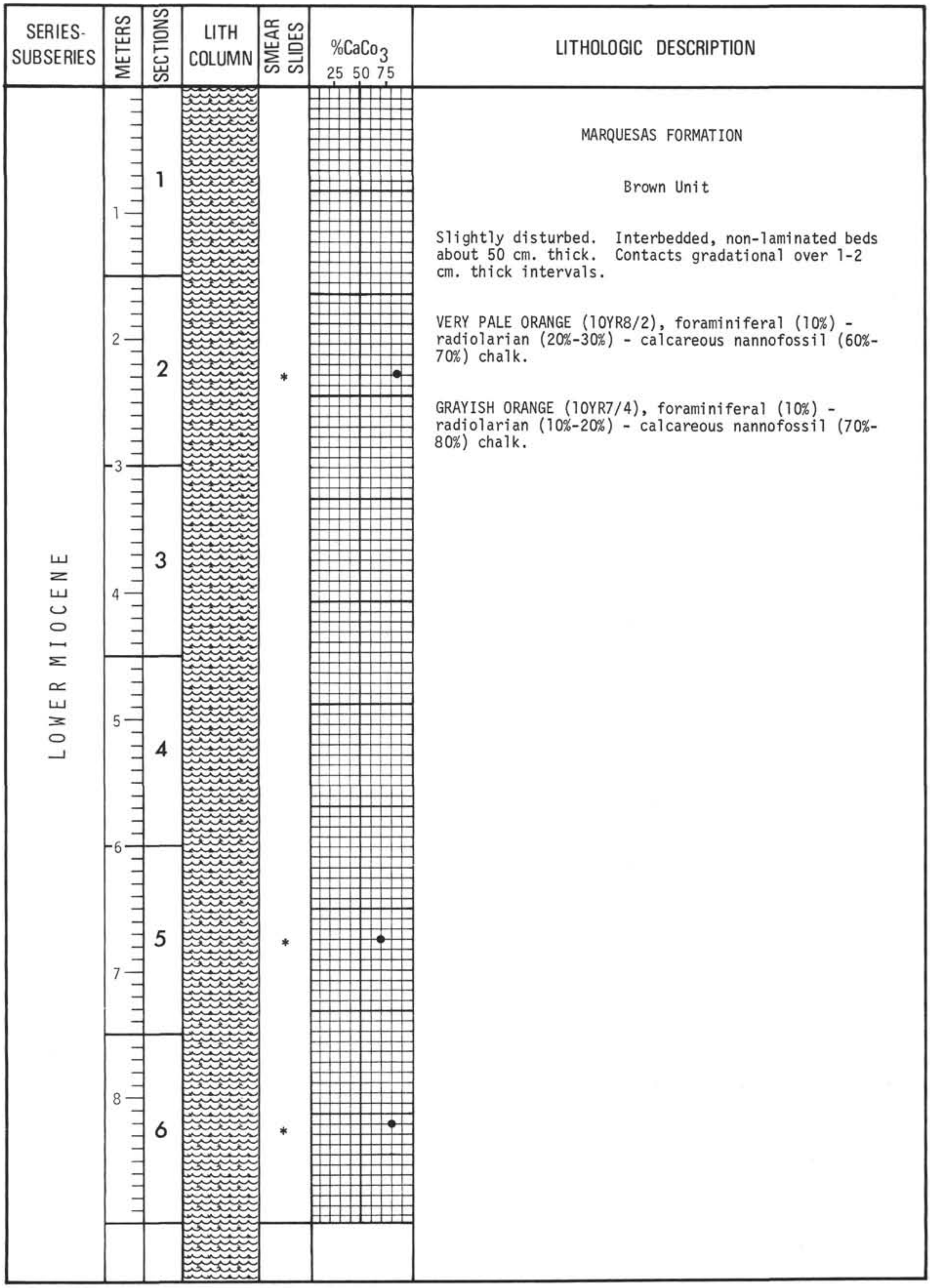


Figure 96. *Hole 77B, Core 29 (262,1 to 271.2m).*

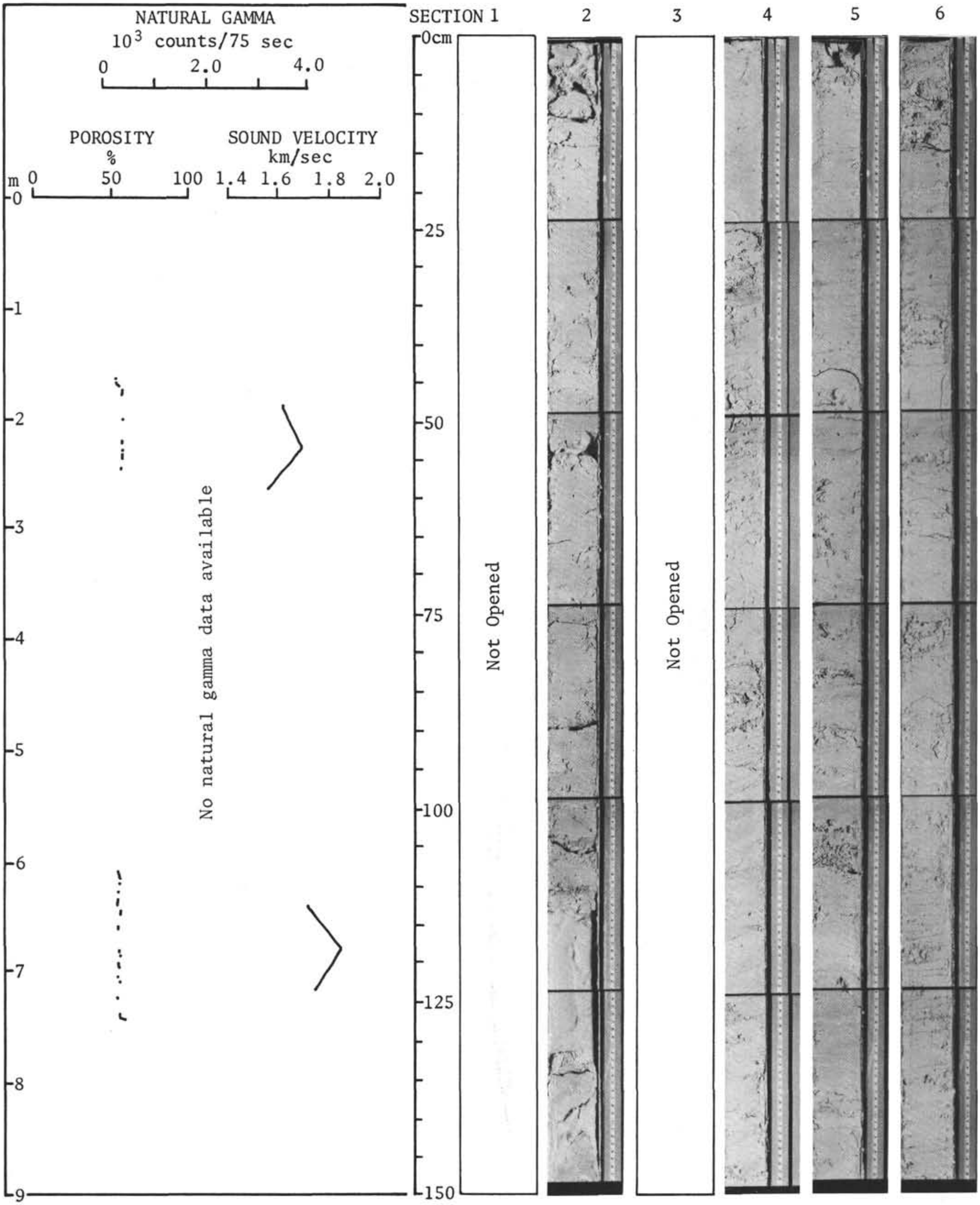


Figure 97. *Hole 77B, Core 29, Sections 1-6, Physical Properties.*

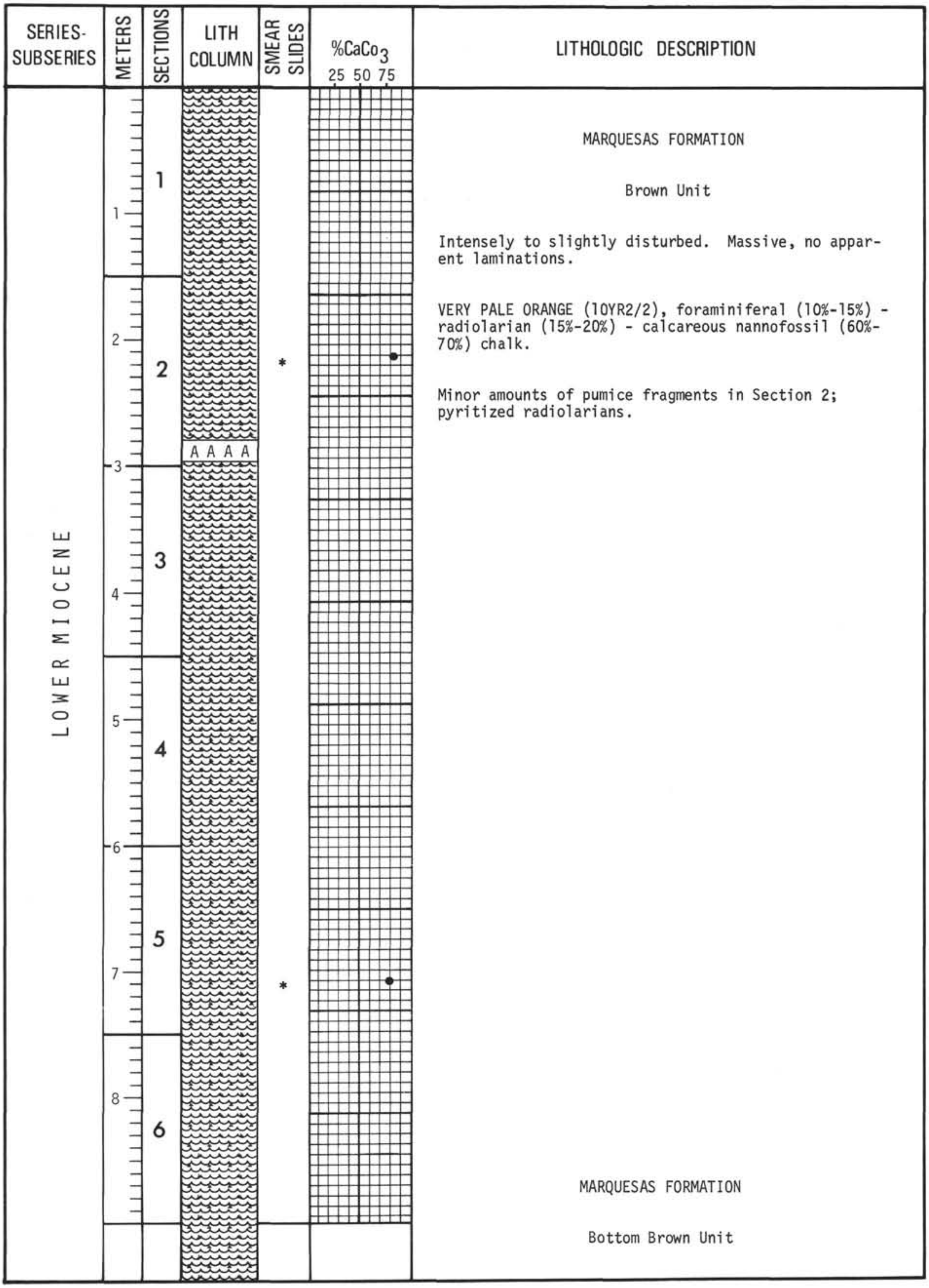


Figure 98. *Hole 77B, Core 30 (271.2 to 280.3m).*

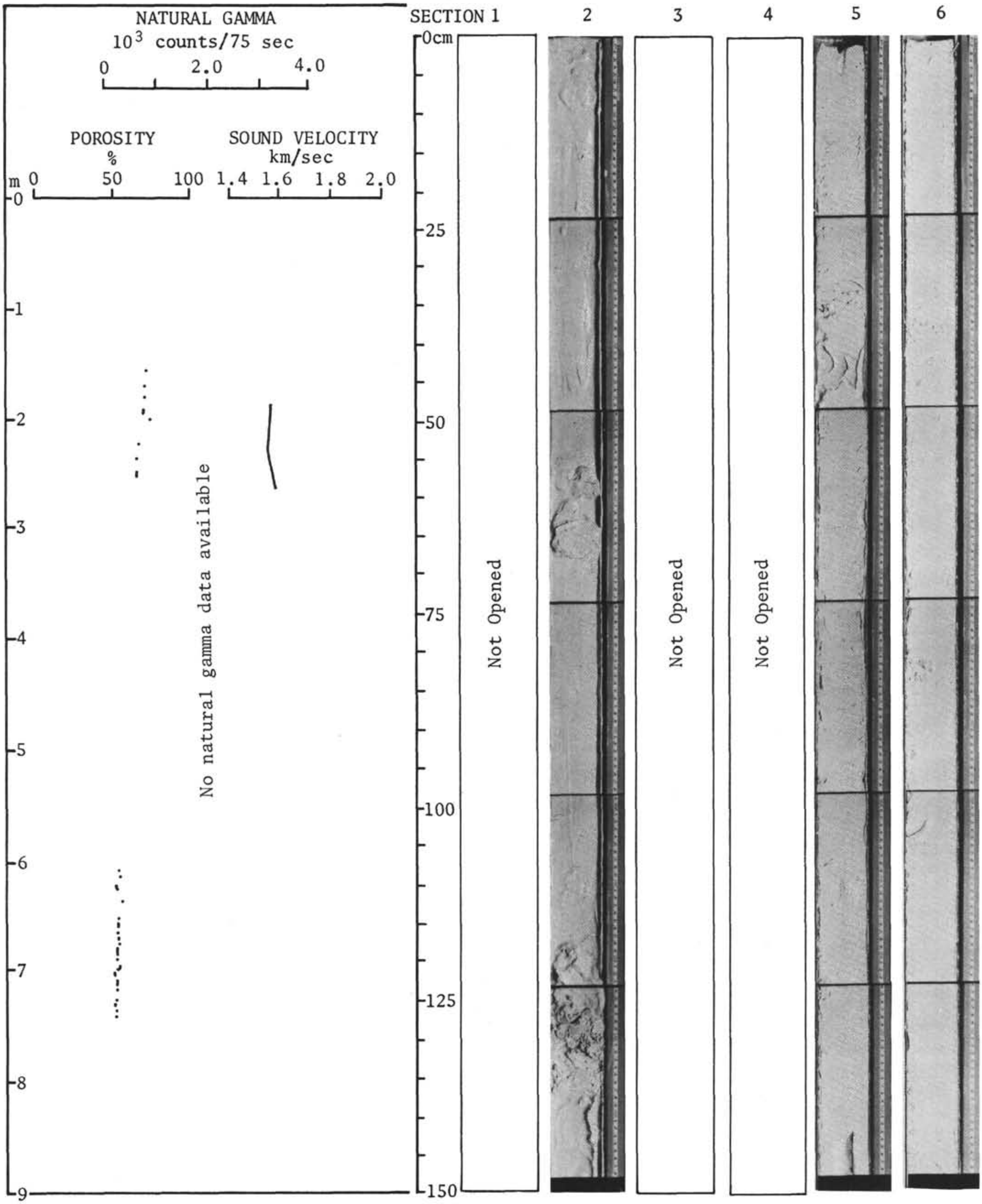


Figure 99. *Hole 77B, Core 30, Sections 1-6, Physical Properties.*

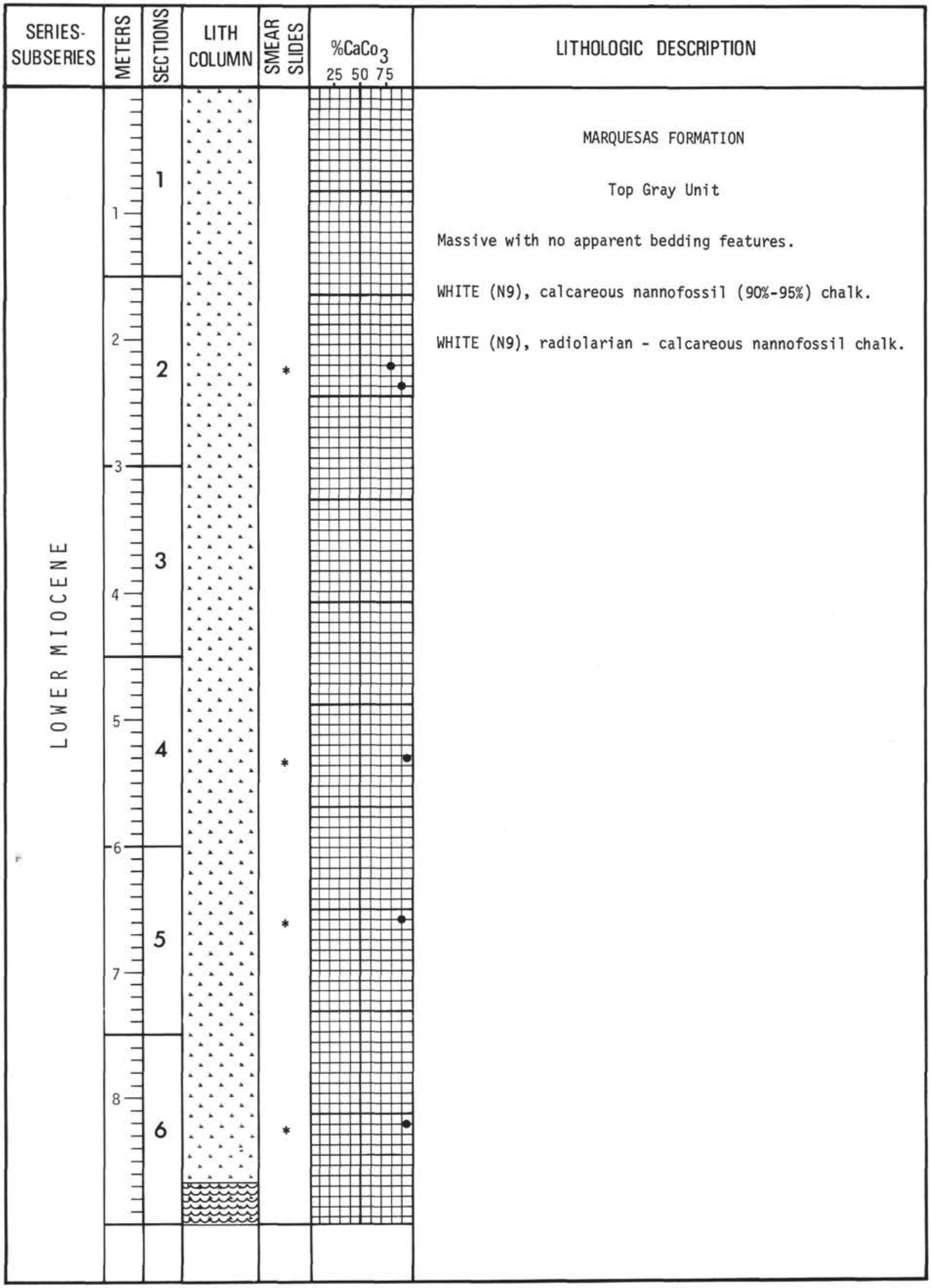


Figure 100. *Hole 77B, Core 31 (280.3 to 289.6m).*

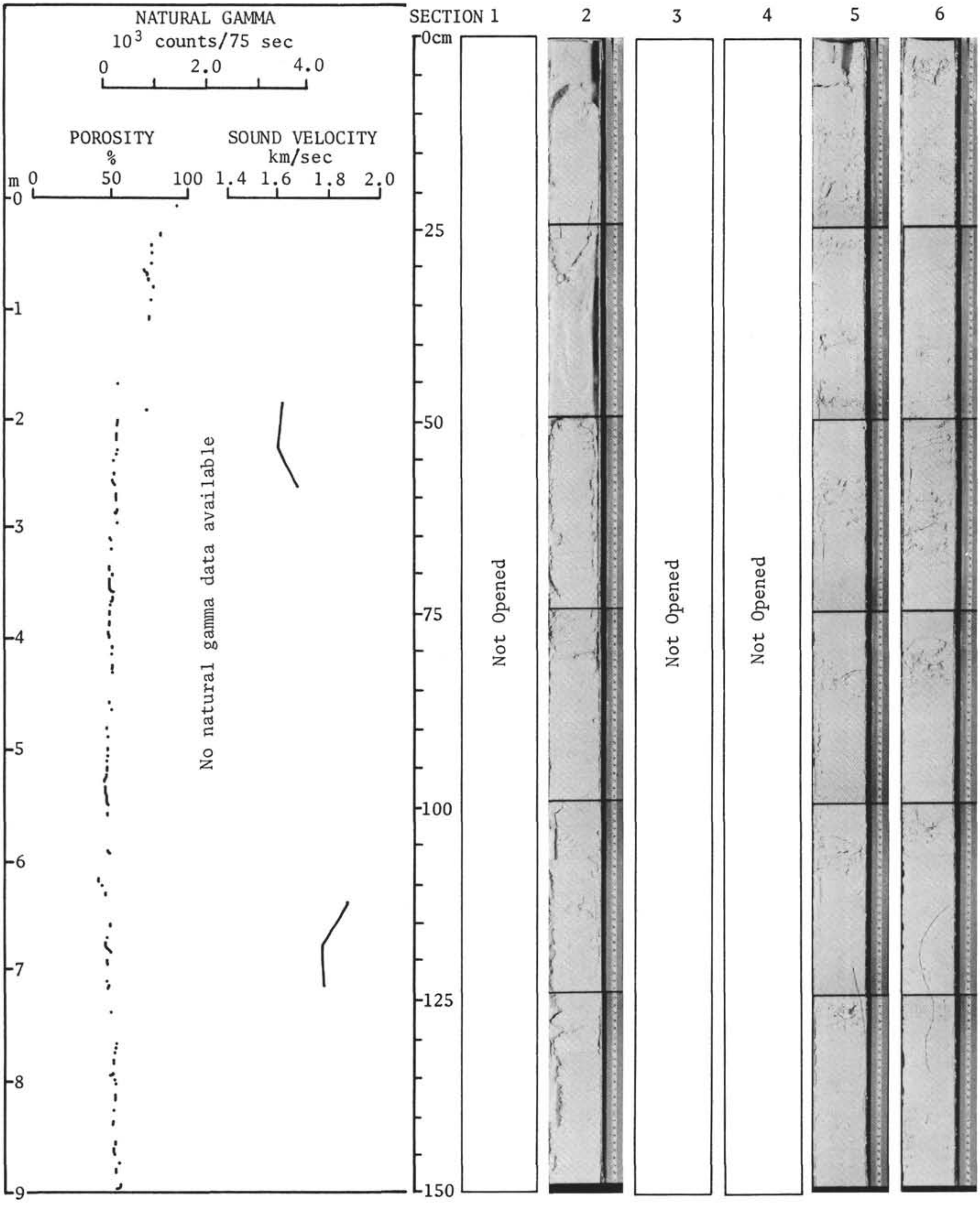


Figure 101. *Hole 77B, Core 32, Sections 1-6, Physical Properties.*

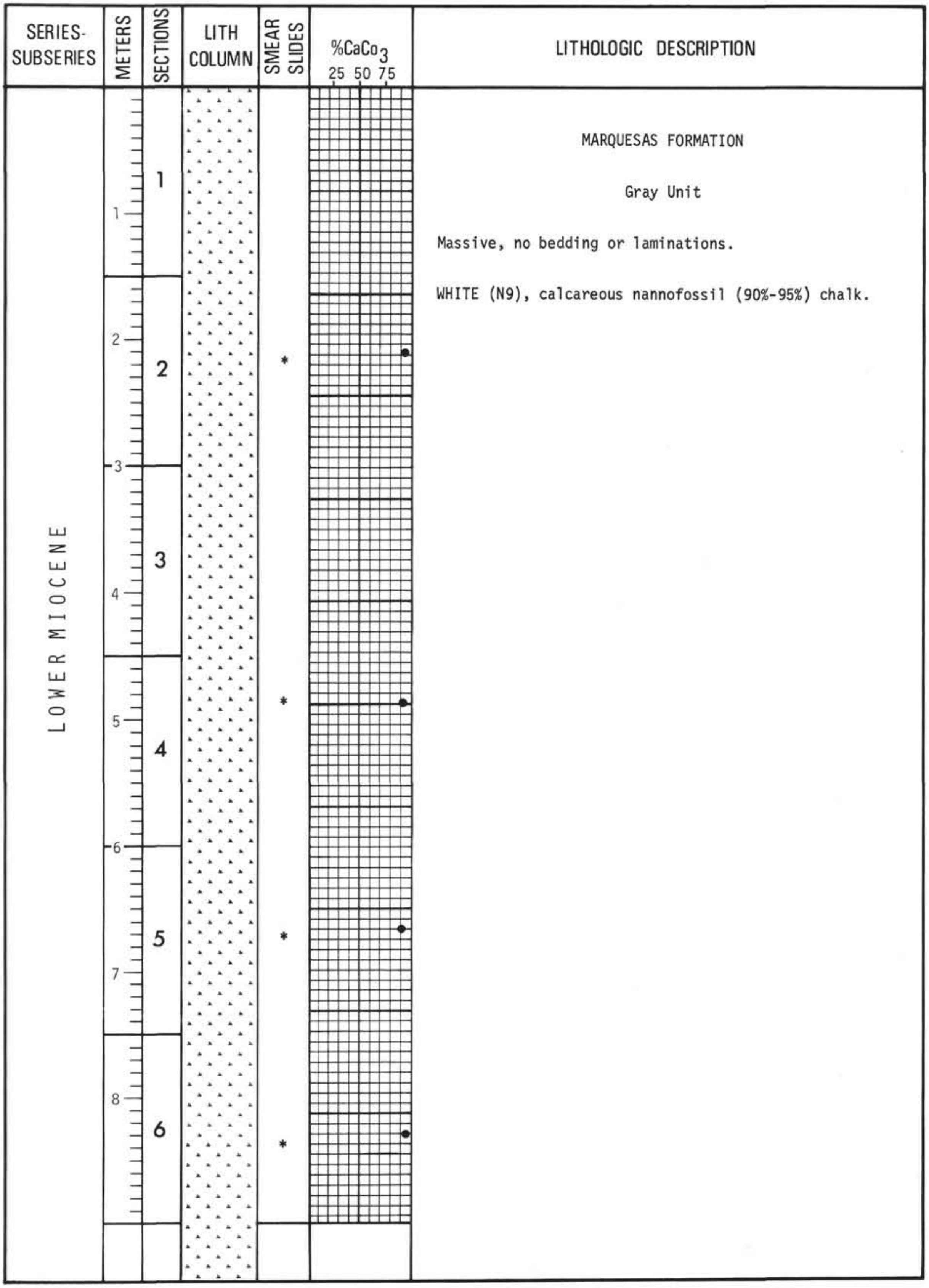


Figure 102. *Hole 77B, Core 32 (289.6 to 298.6m).*

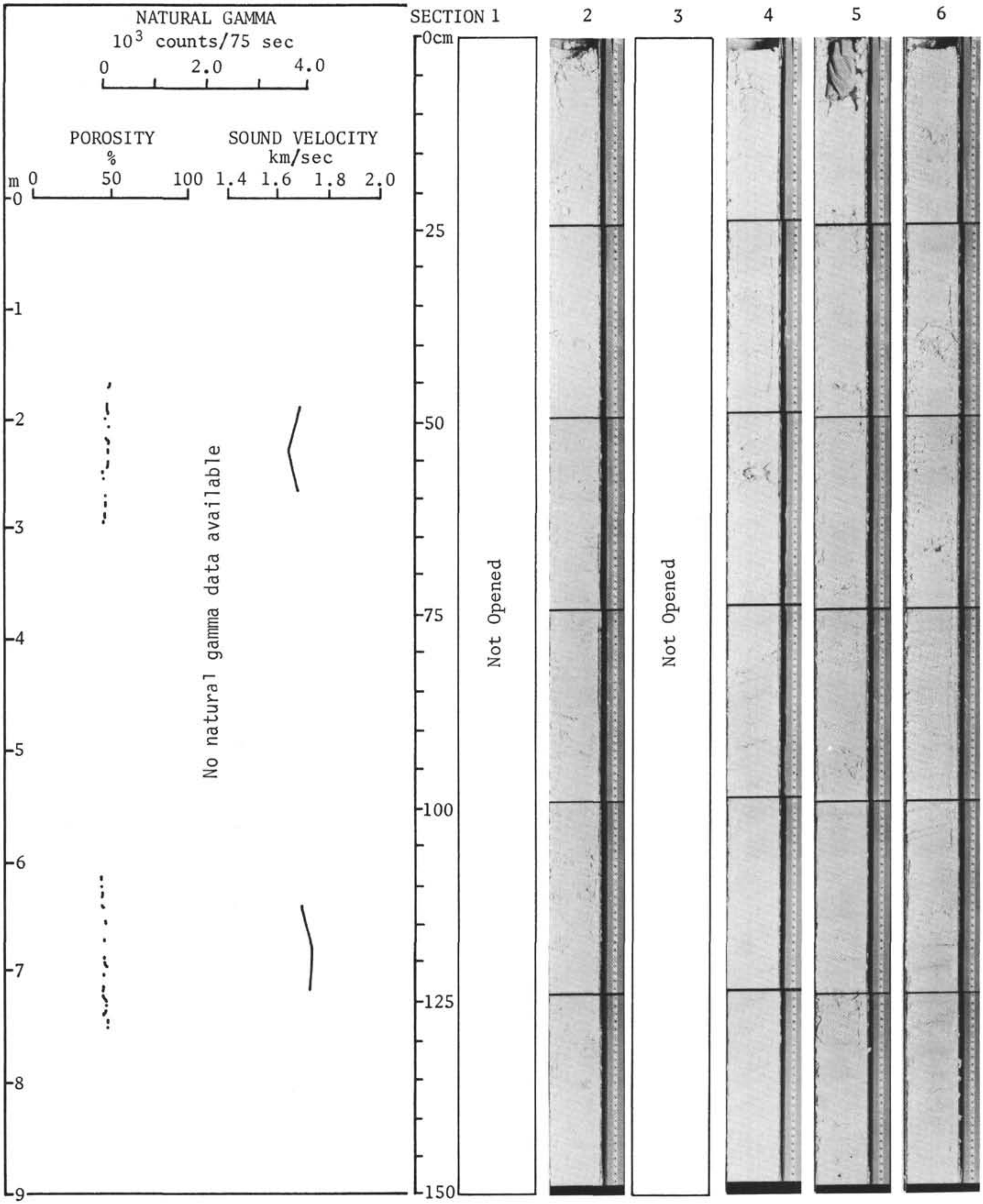


Figure 103. *Hole 77B, Core 32, Sections 1-6, Physical Properties.*

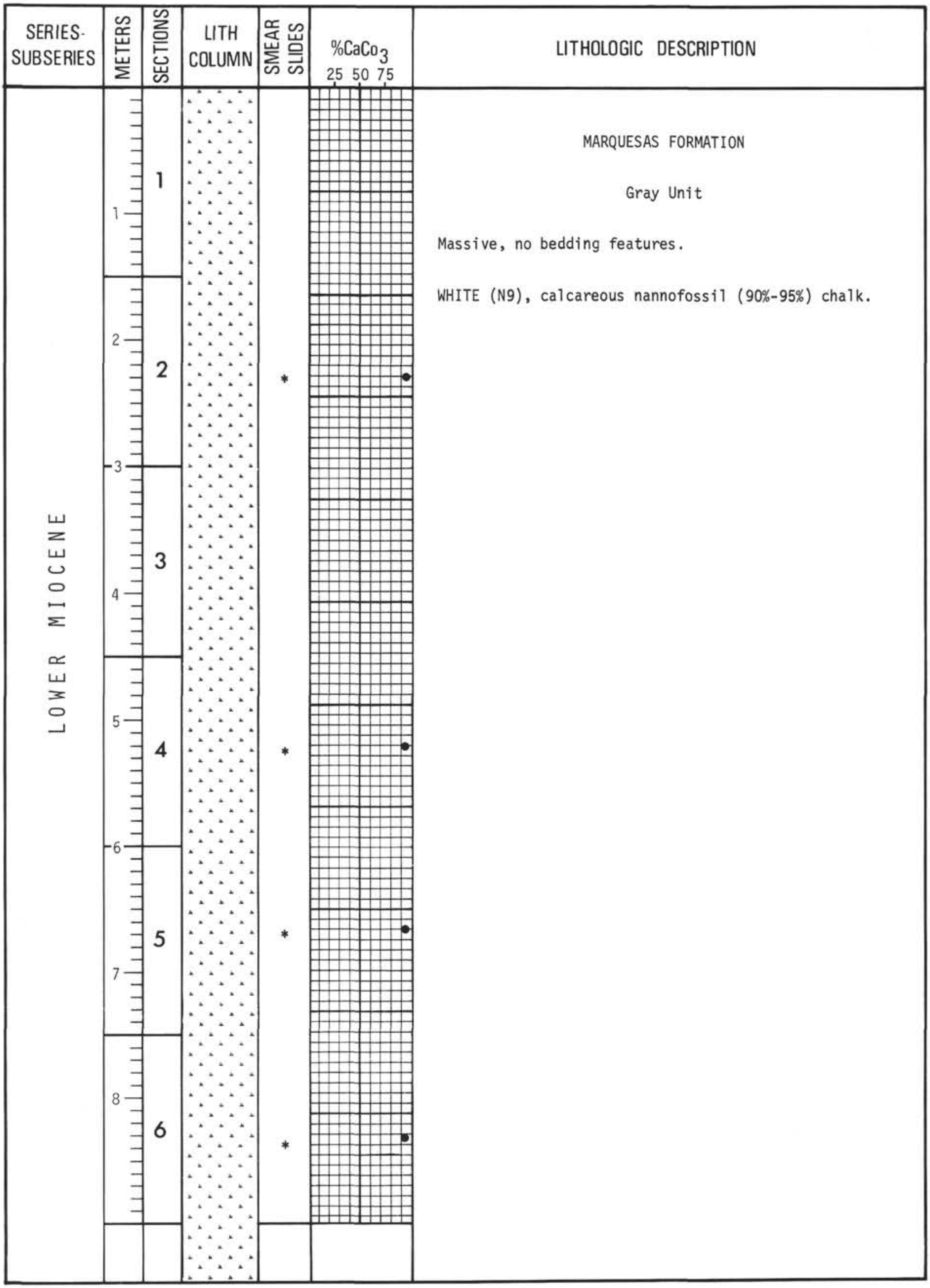


Figure 104. *Hole 77B, Core 33 (298.6 to 207.8m).*

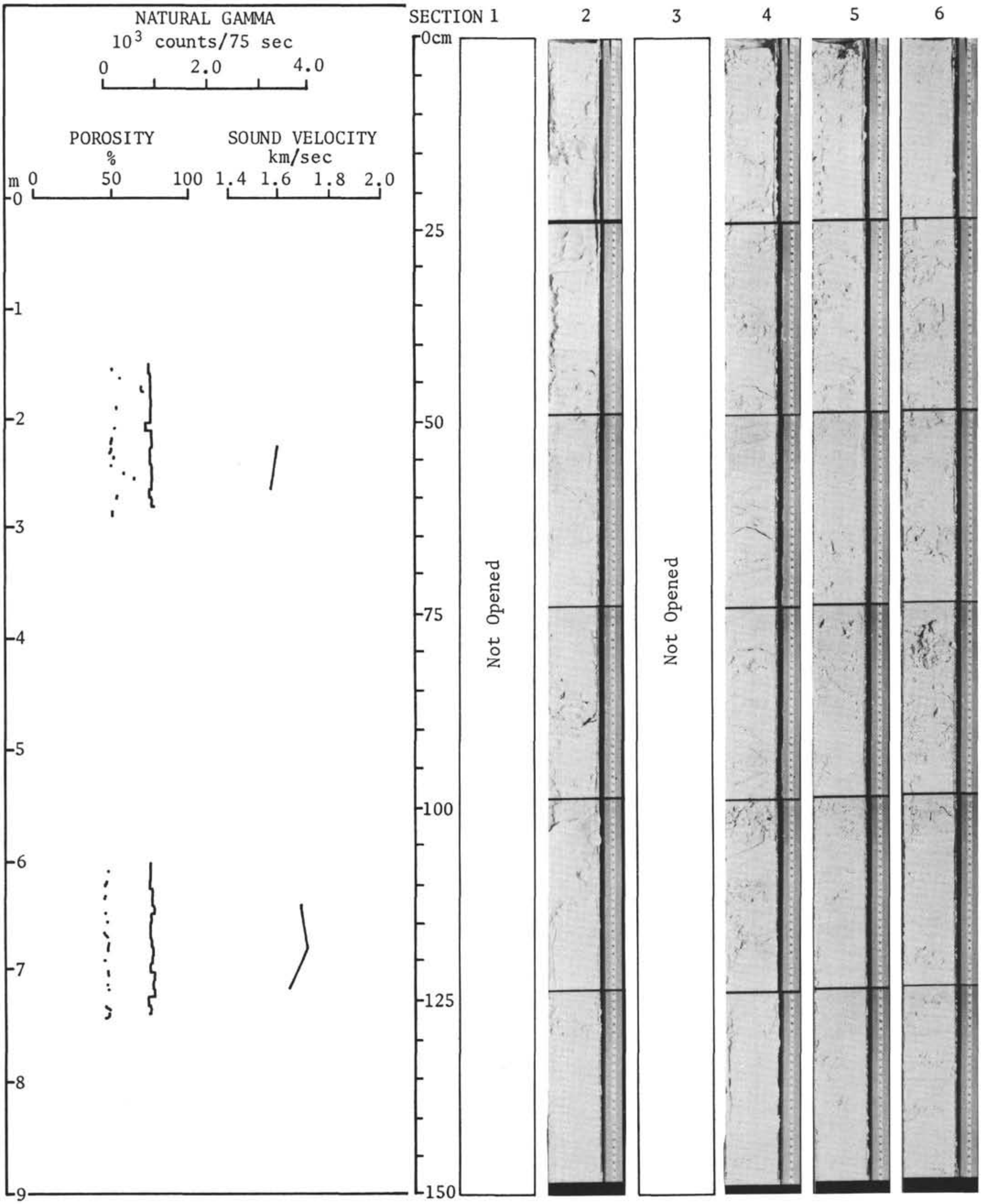


Figure 105. *Hole 77B, Core 33, Sections 1-6, Physical Properties.*

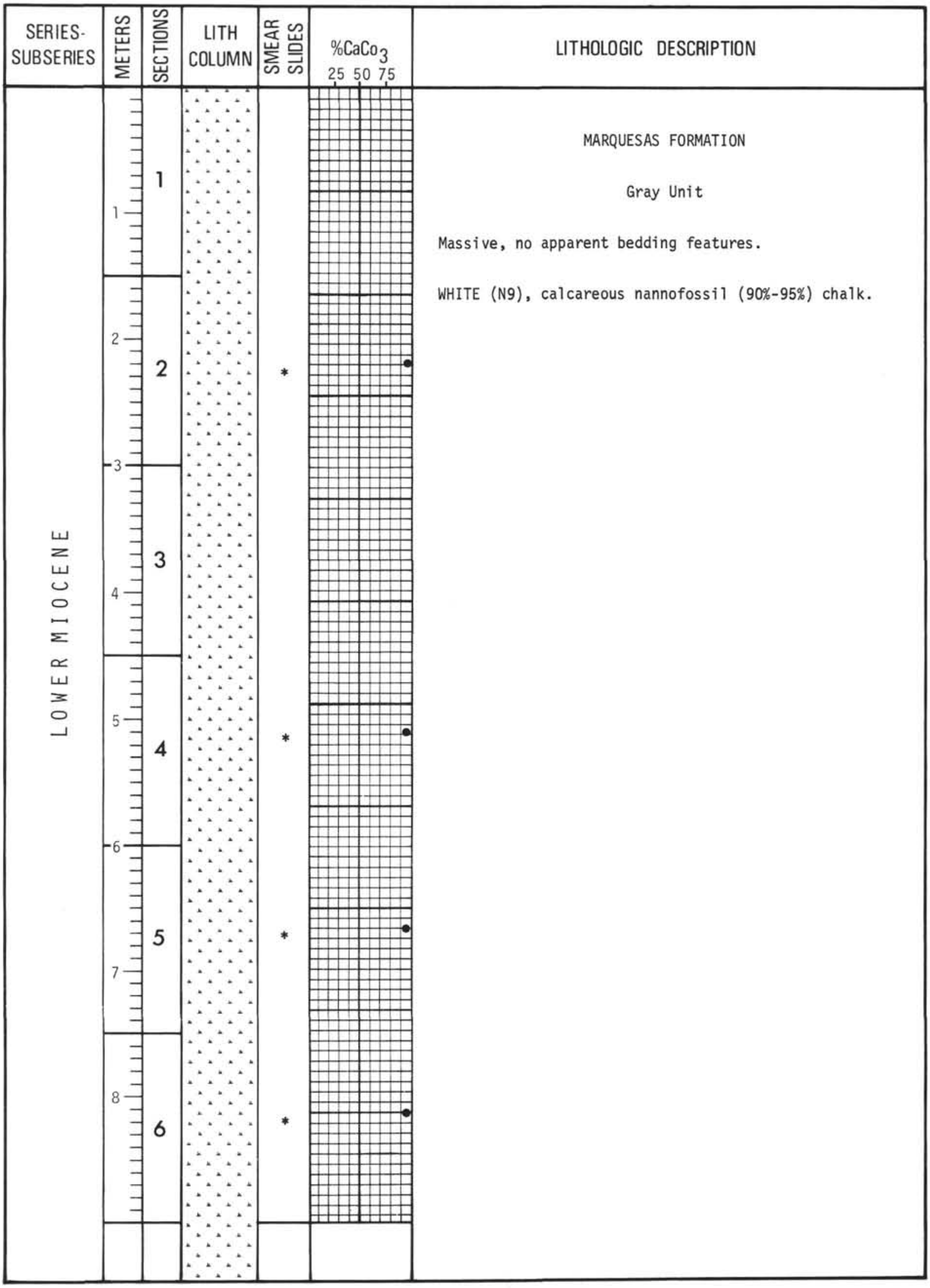


Figure 106. *Hole 77B, Core 34 (307.8 to 317.0m).*

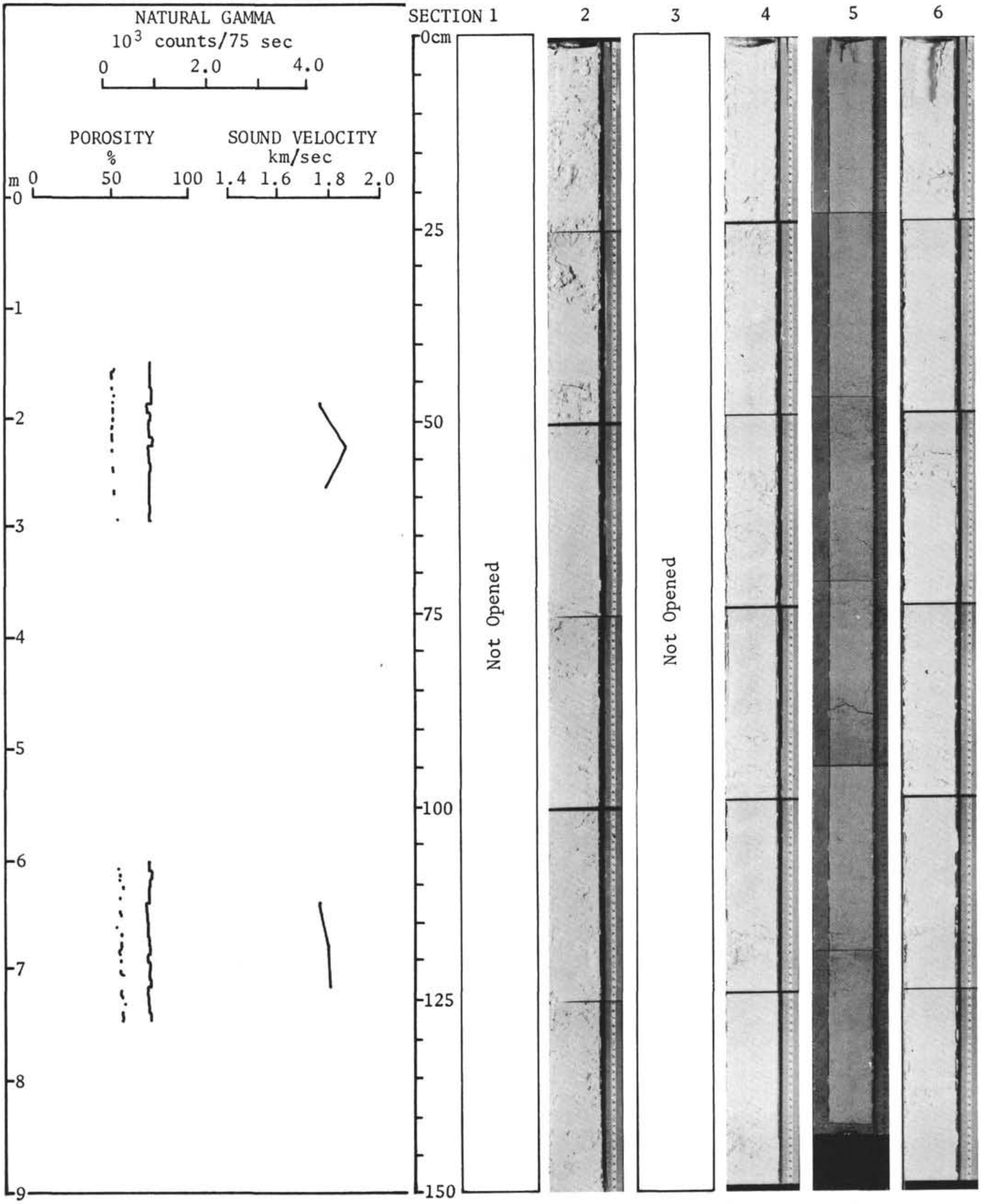


Figure 107. *Hole 77B, Core 34, Sections 1-6, Physical Properties.*

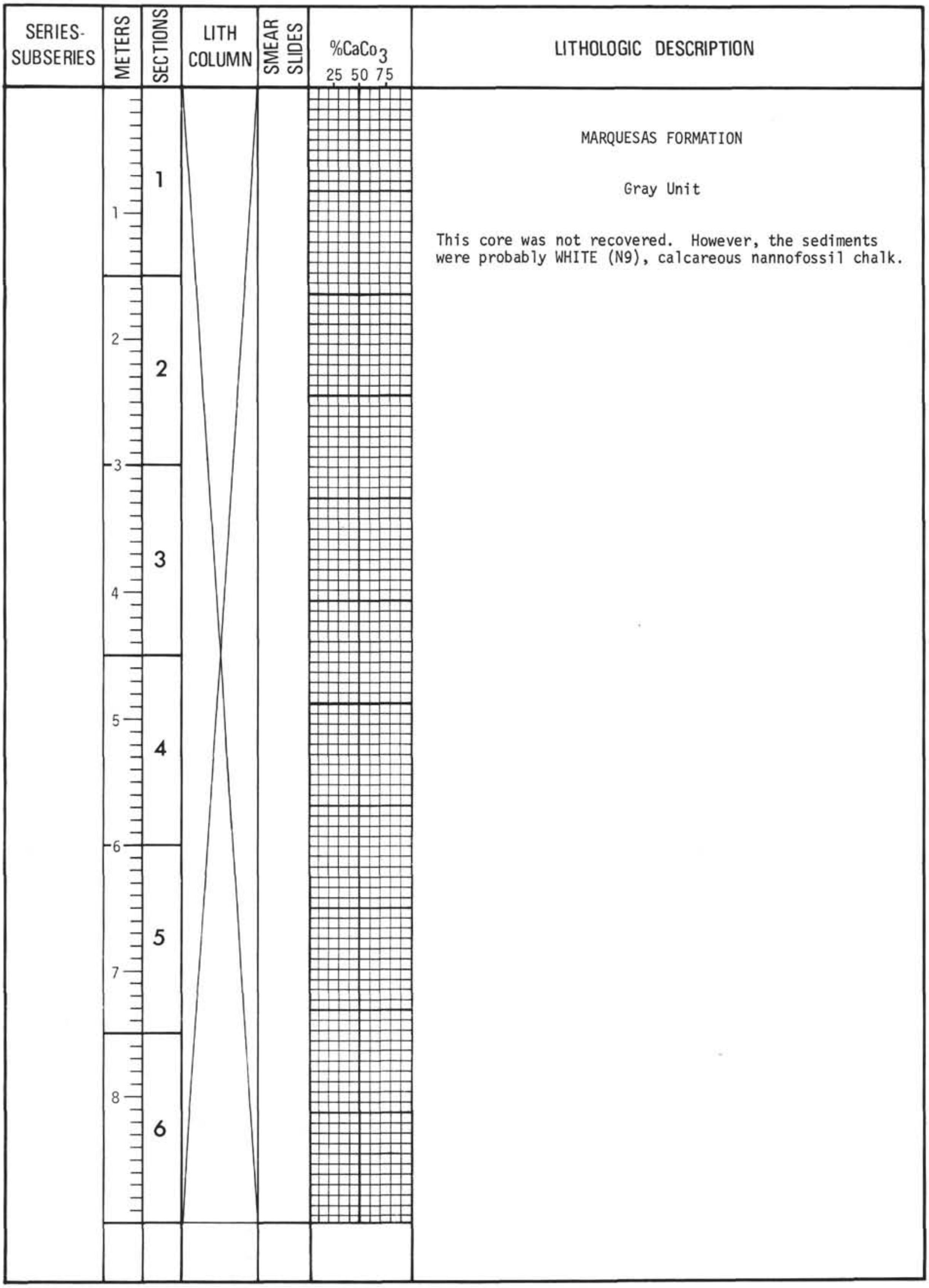


Figure 108. *Hole 77B, Core 35 (317.0 to 326.1m).*

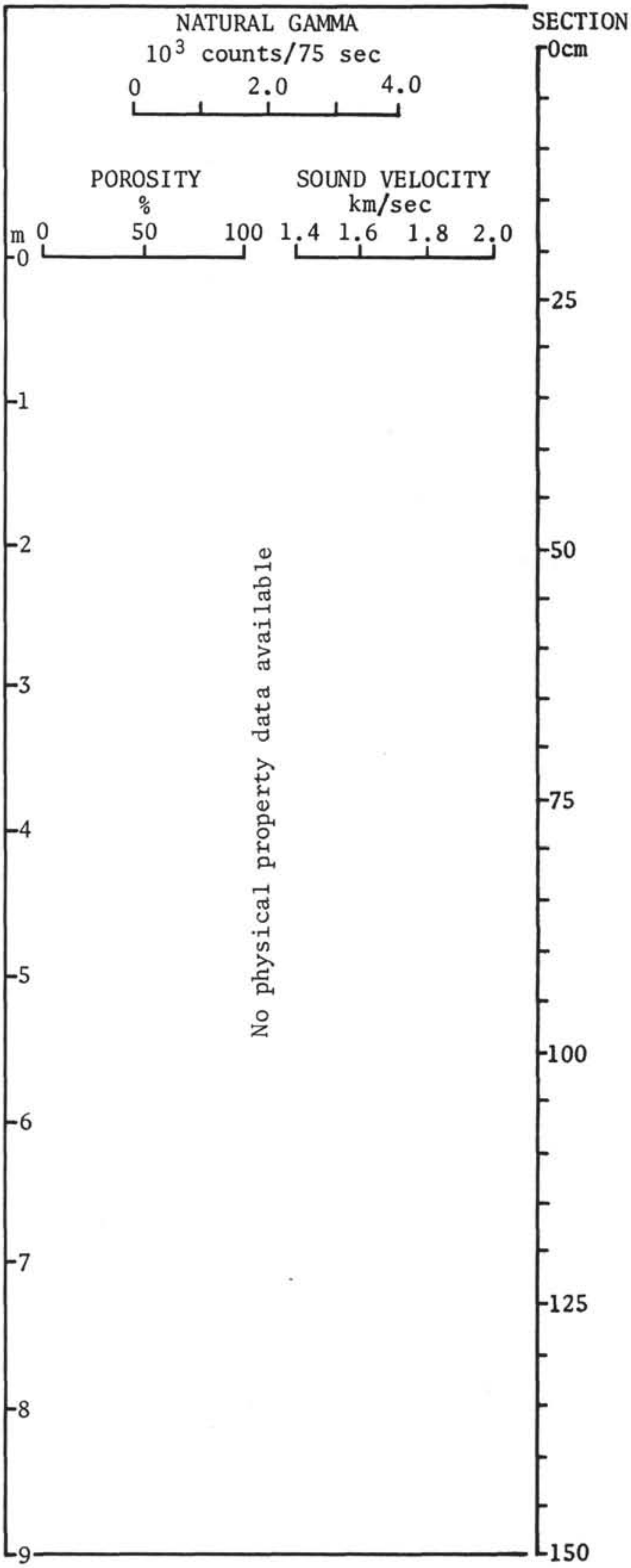


Figure 109. *Hole 77B, Core 35*

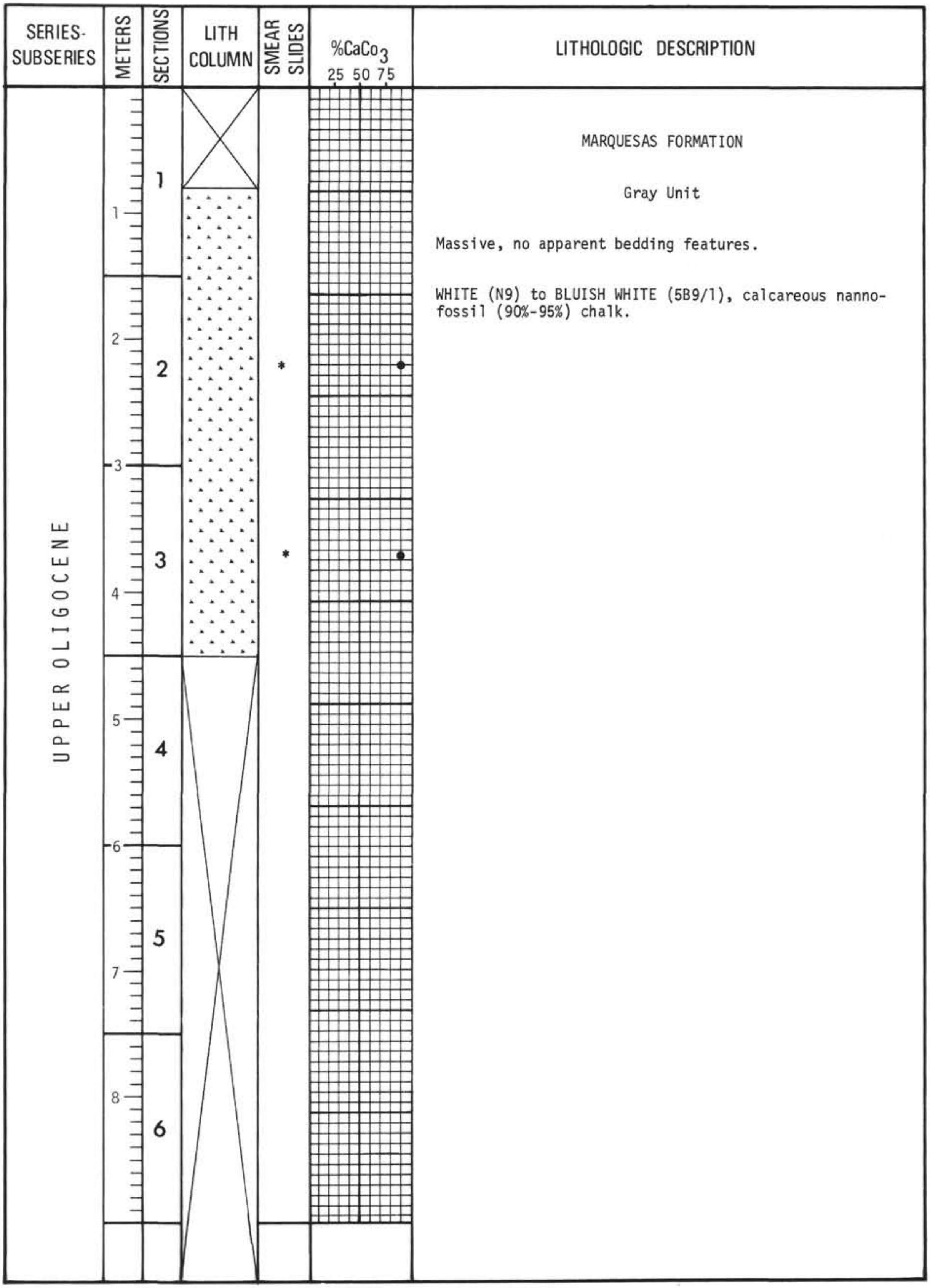


Figure 110. *Hole 77B, Core 36 (326.1 to 335.2m).*

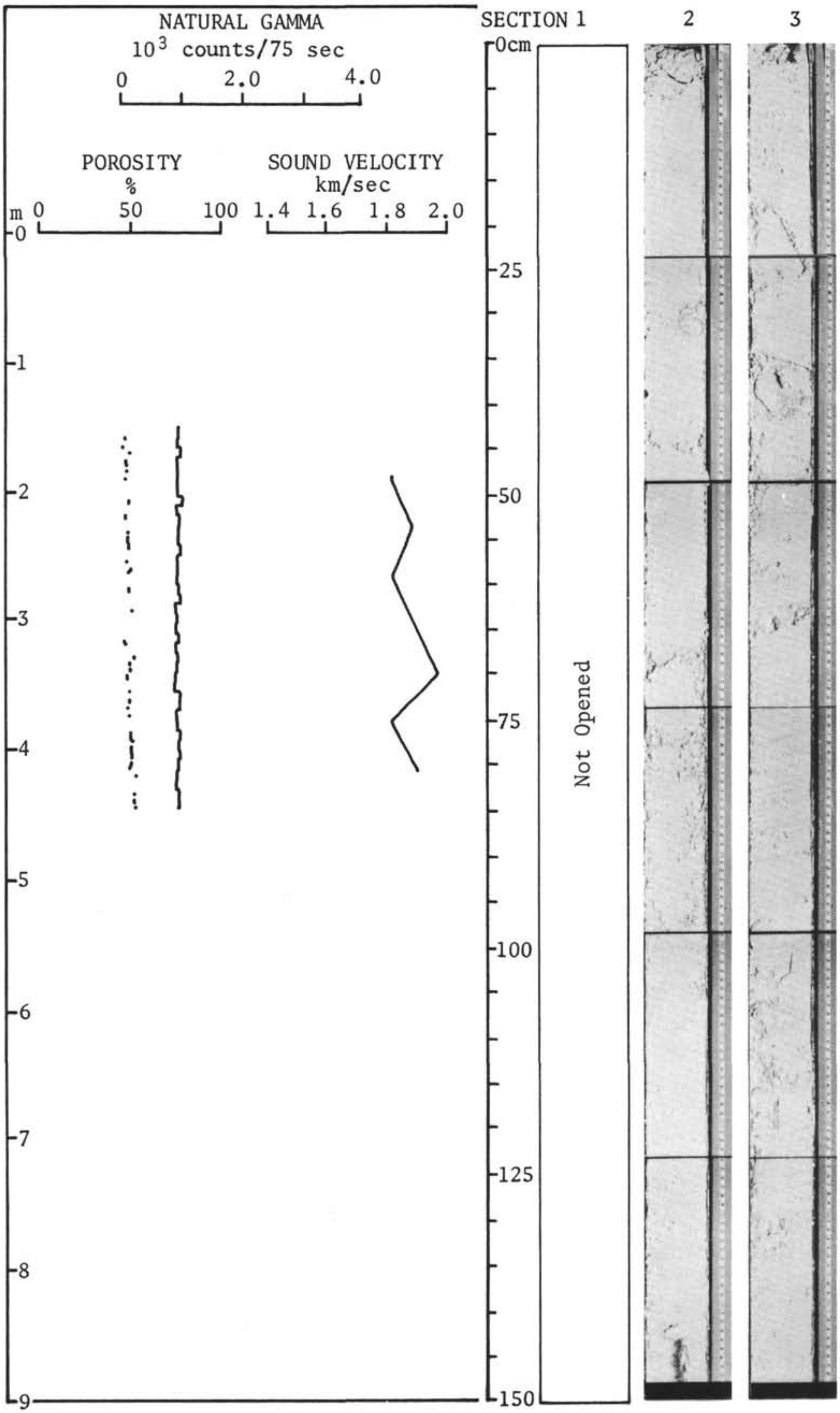
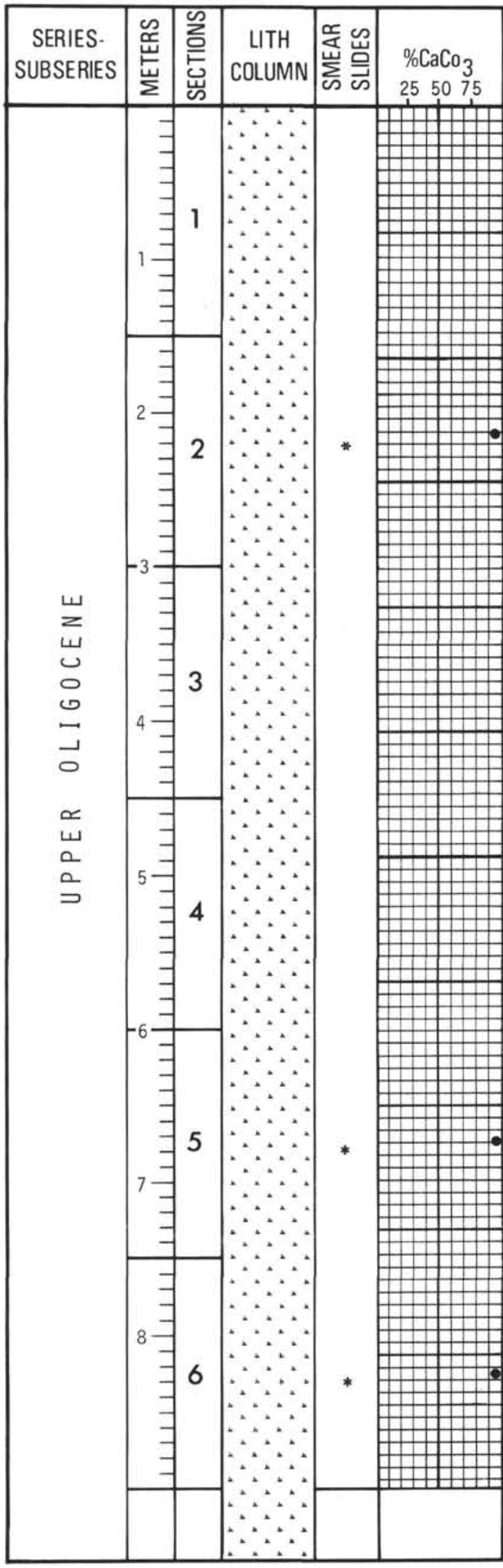


Figure 111. *Hole 77B, Core 36, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Massive, no apparent bedding features.

WHITE (N9), calcareous nannofossil chalk.

Minor WHITE (N9), foraminiferal - calcareous nannofossil chalk in Section 6.

Figure 112. *Hole 77B, Core 37 (335.2 to 244.2m).*

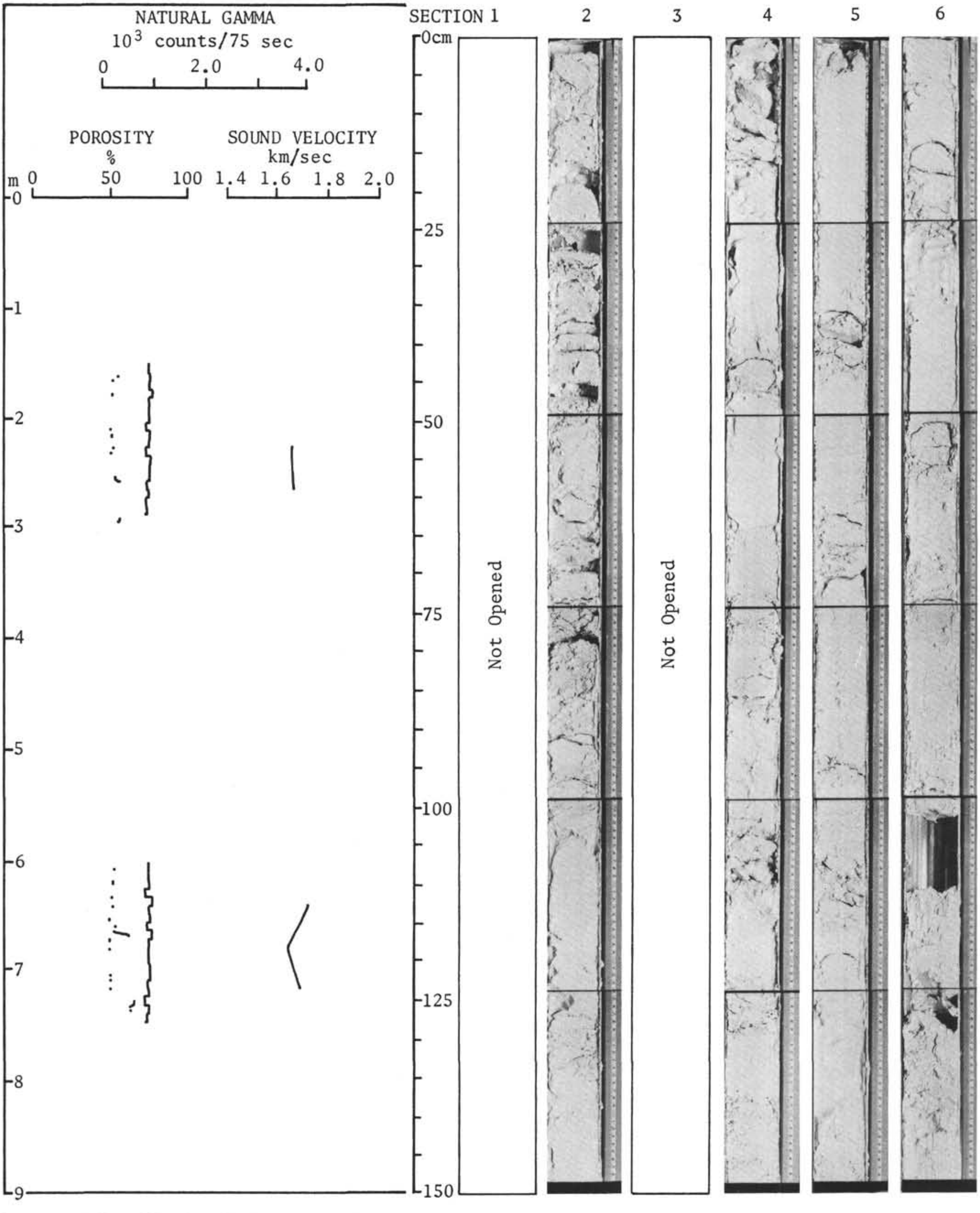


Figure 113. *Hole 77B, Core 37, Sections 1-6, Physical Properties.*

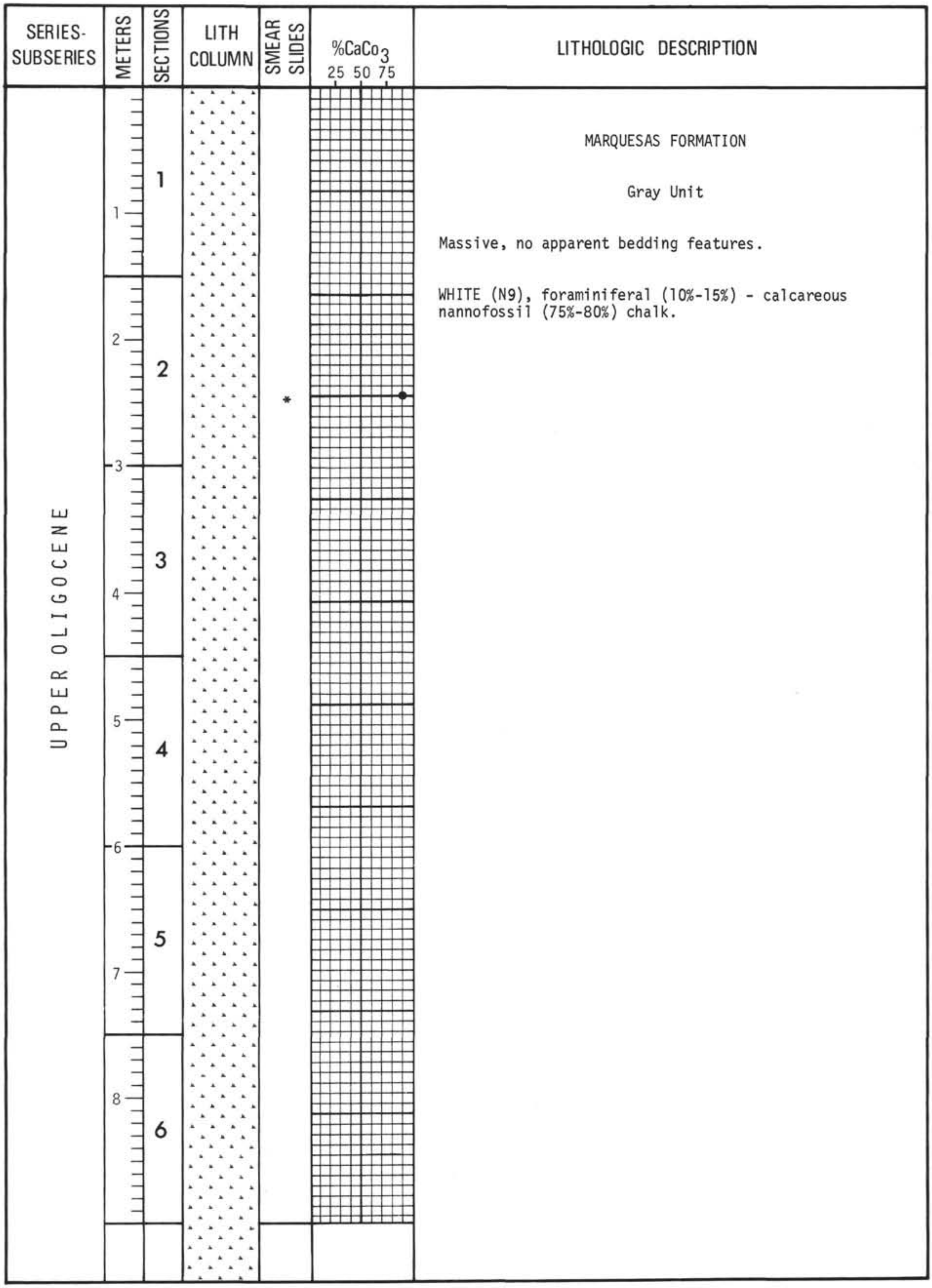


Figure 114. *Hole 77B, Core 38 (244.2 to 253.6m).*

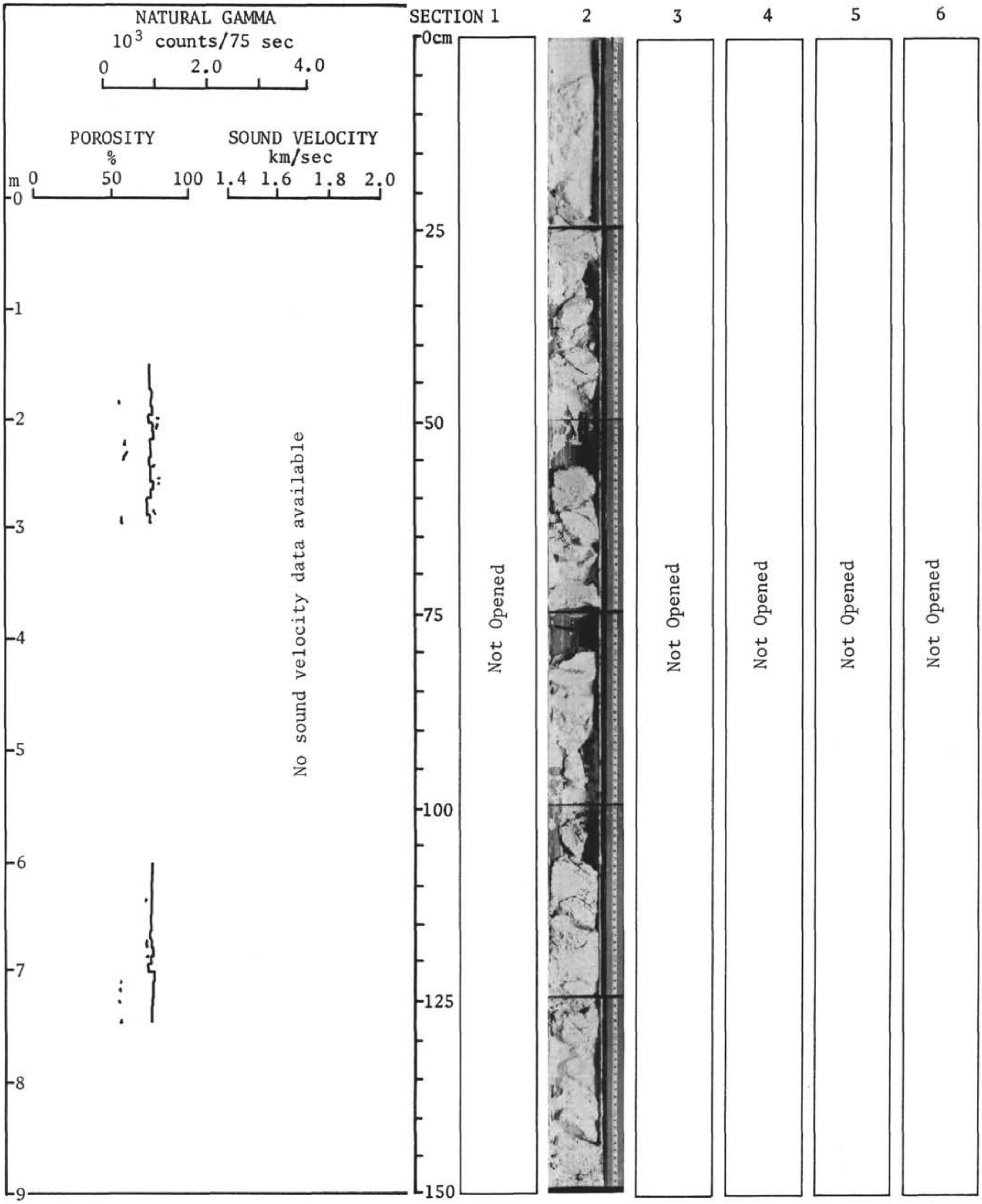
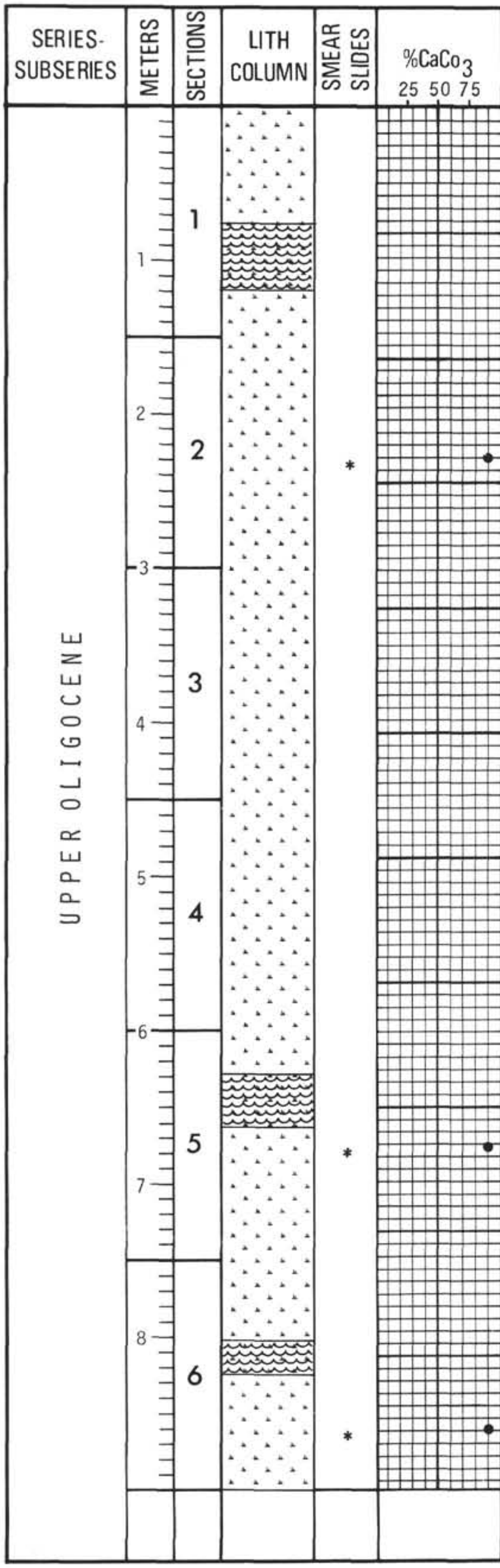


Figure 115. *Hole 77B, Core 38, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Massive, no bedding except in Section 4.

WHITE (N9), foraminiferal (10%) - radiolarian (10%) - calcareous nannofossil (80%) chalk.

Minor PALE YELLOWISH ORANGE (10YR8/6), foraminiferal - radiolarian - calcareous nannofossil chalk.

Rare, VERY DUSKY PURPLE (5P2/2) laminations of manganese coated radiolarian - calcareous nannofossil chalk.

Figure 116. *Hole 77B, Core 39 (353.6 to 362.6m).*

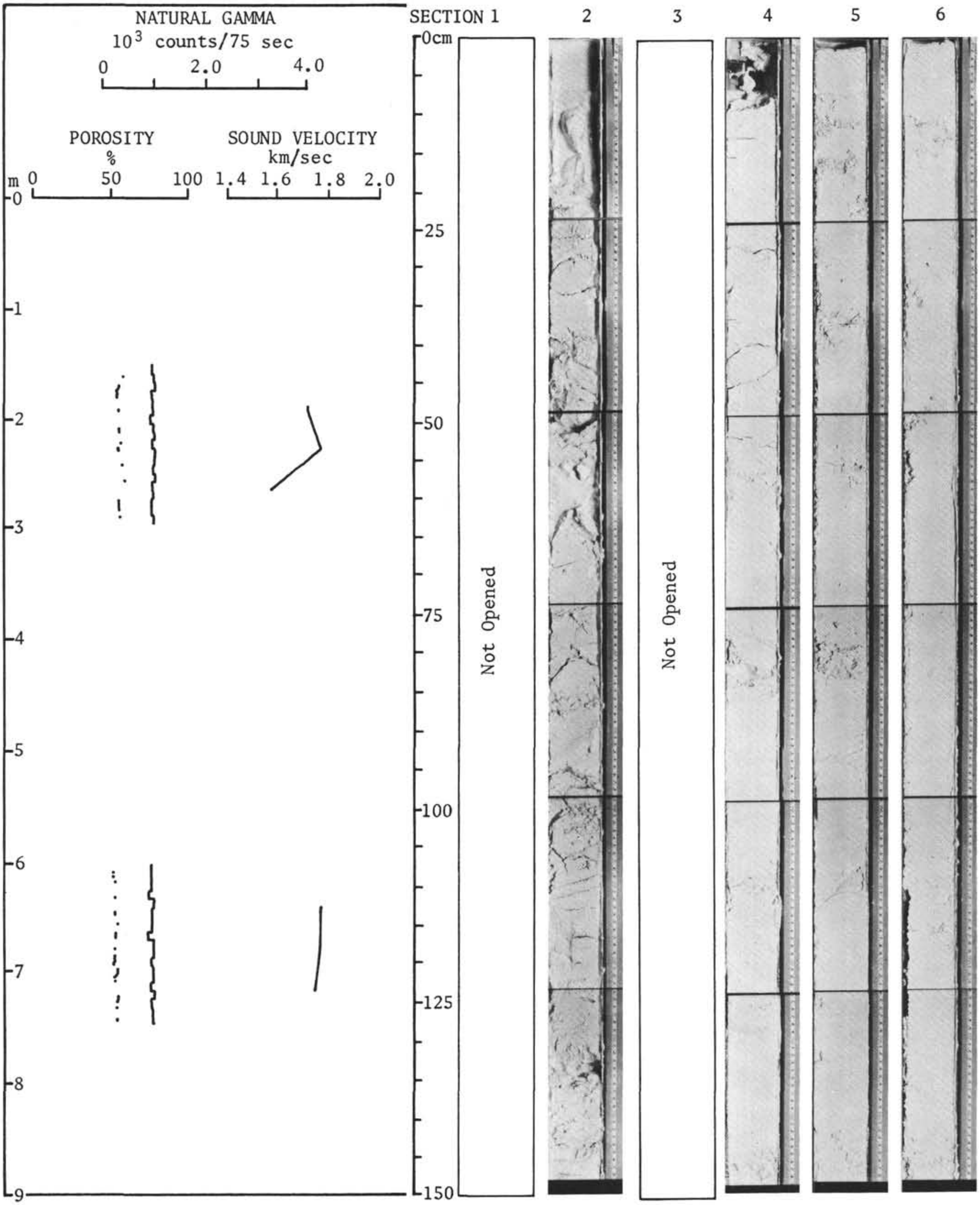


Figure 117. *Hole 77B, Core 39, Sections 1-6, Physical Properties.*

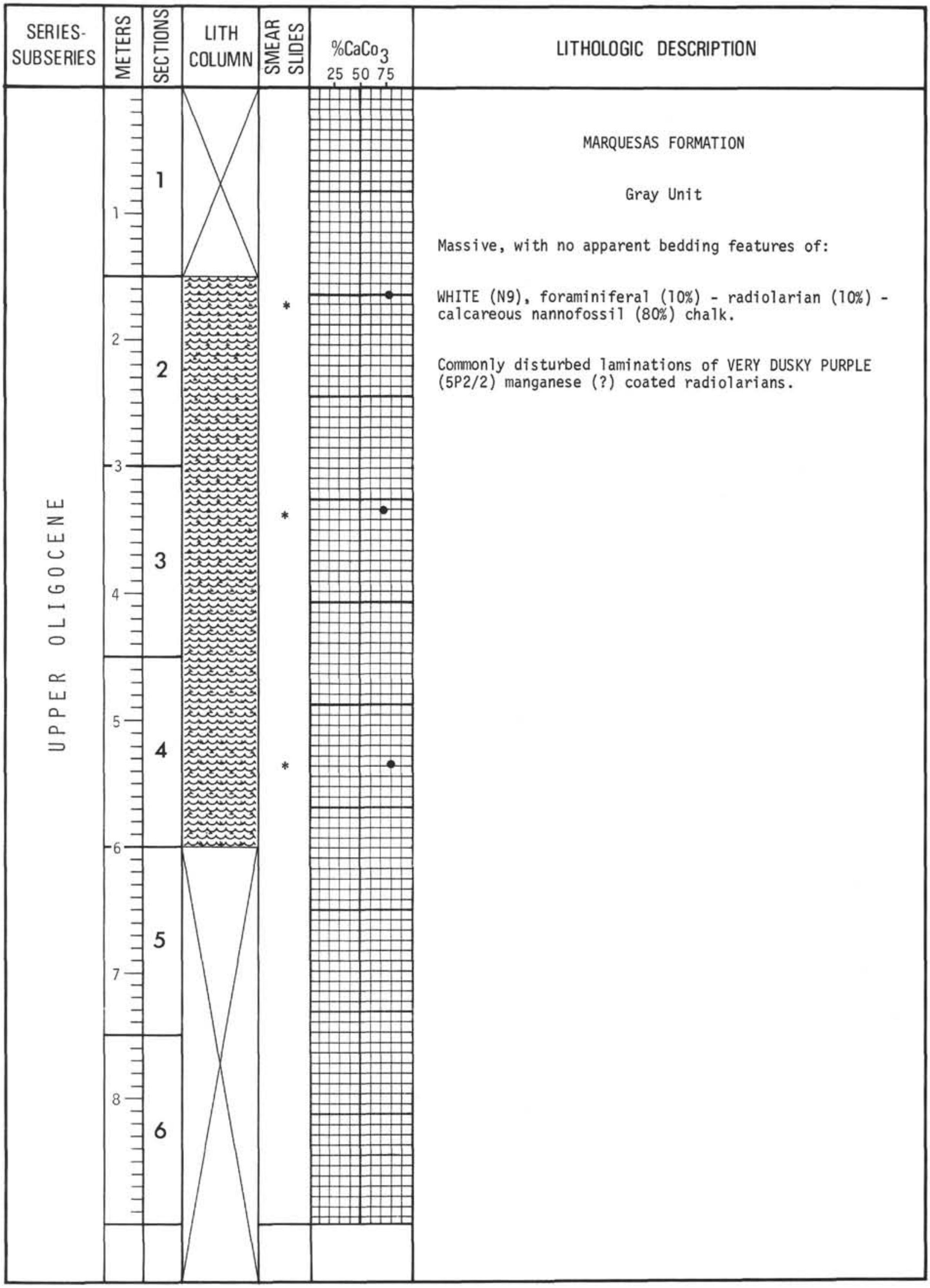


Figure 118. *Hole 77B, Core 40 (362.6 to 371.8m).*

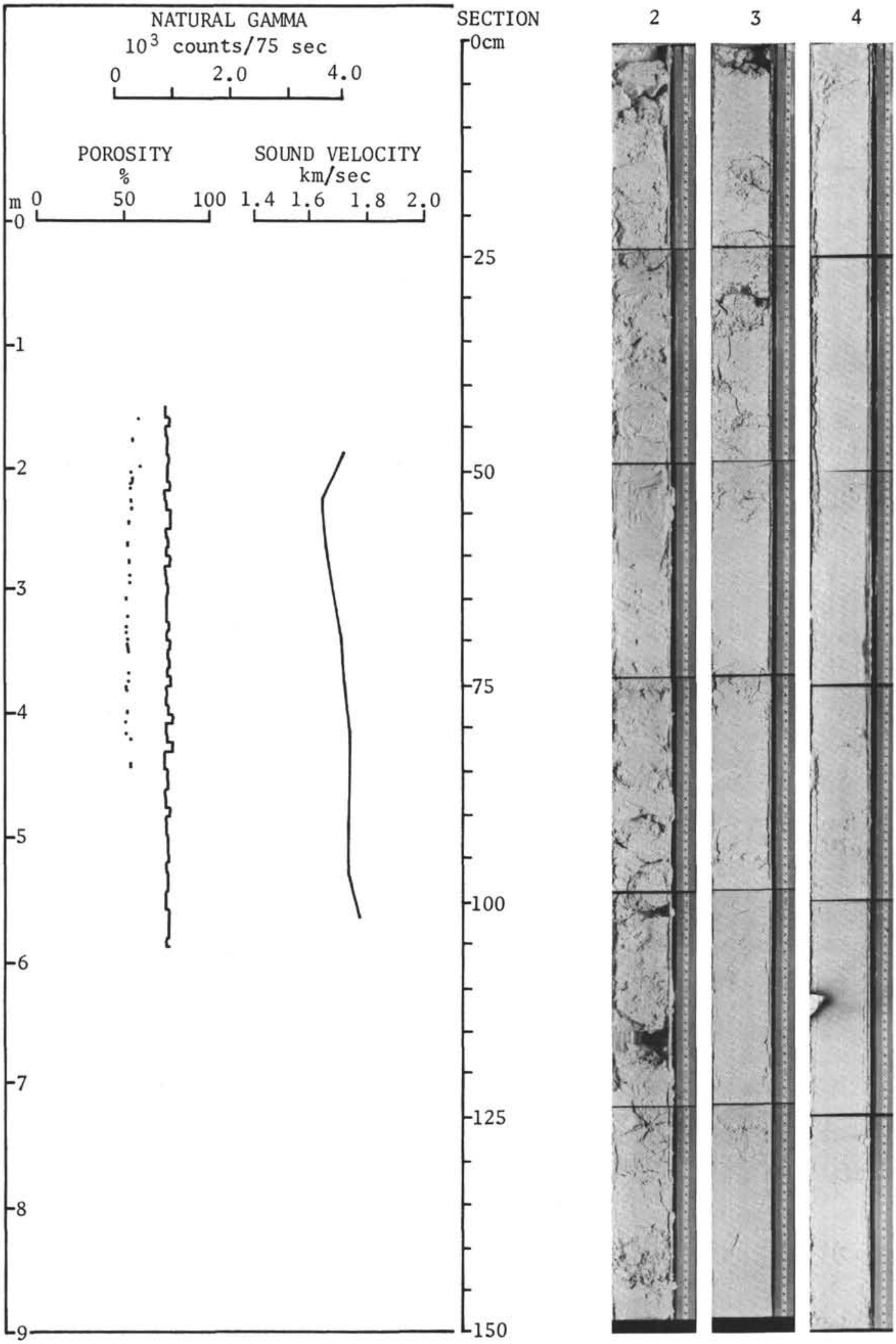


Figure 119. *Hole 77B, Core 40, Sections 1-6, Physical Properties.*

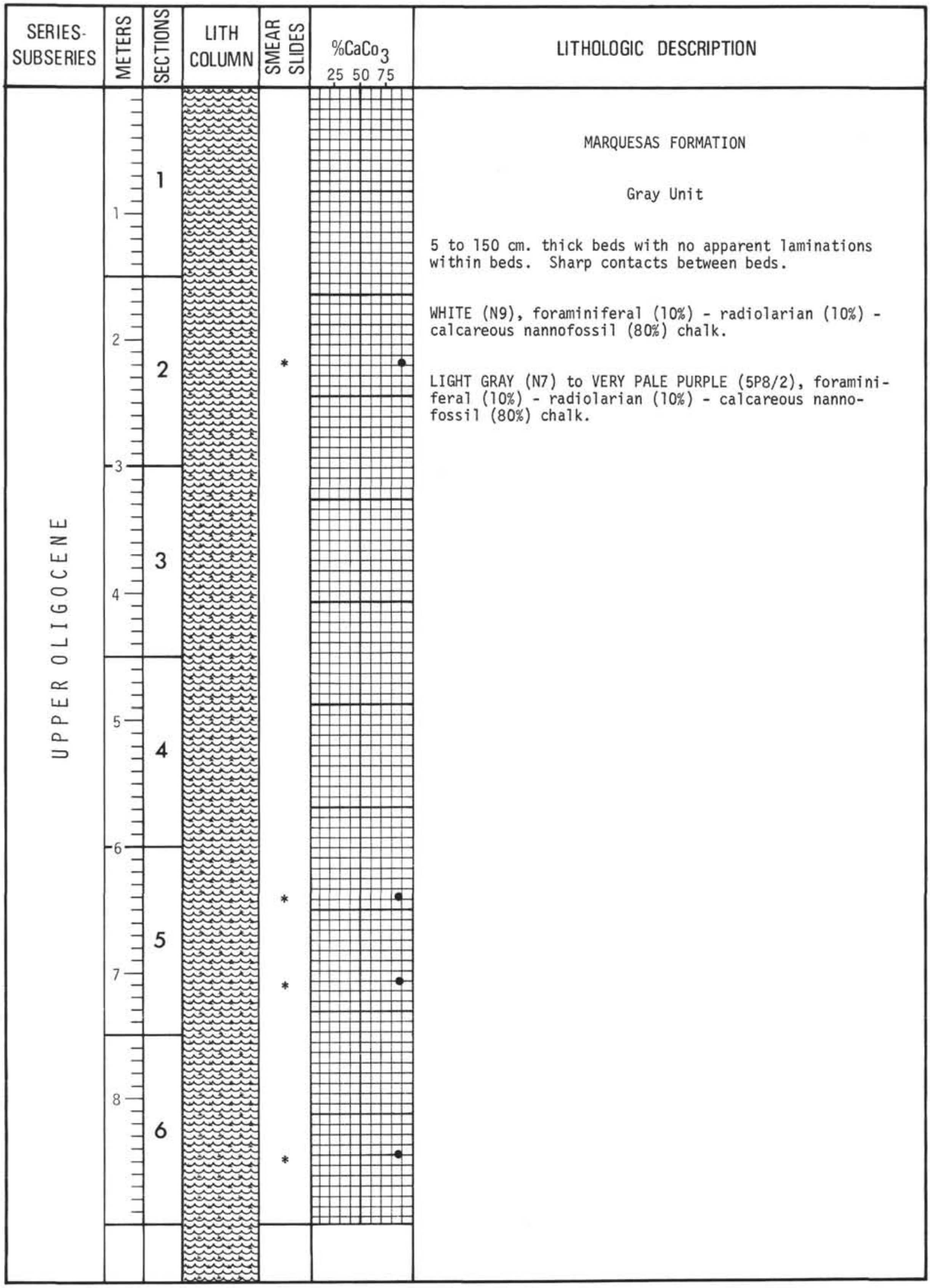


Figure 120. *Hole 77B, Core 41 (371.8 to 381.0m).*

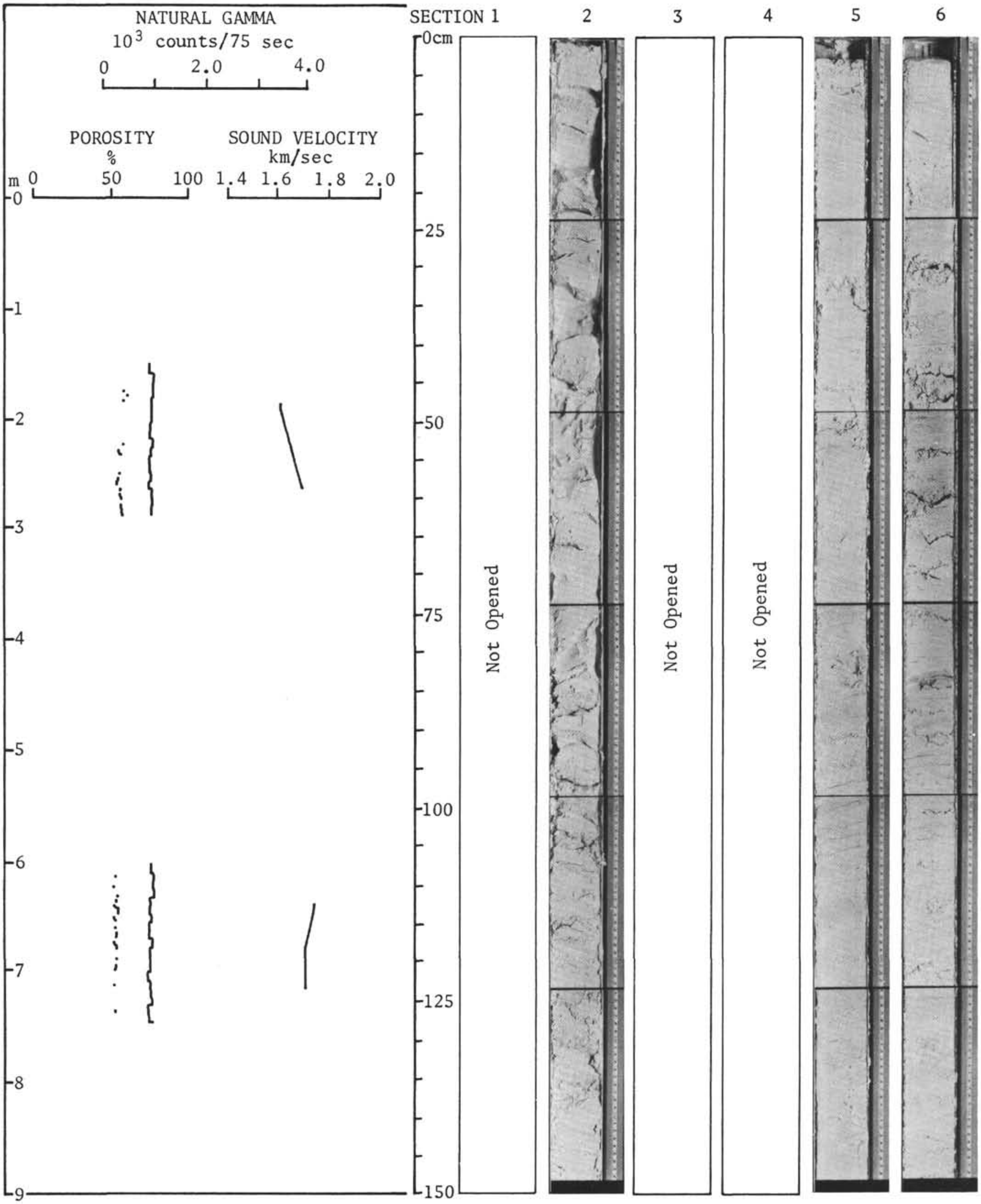


Figure 121. *Hole 77B, Core 41, Sections 1-6, Physical Properties.*

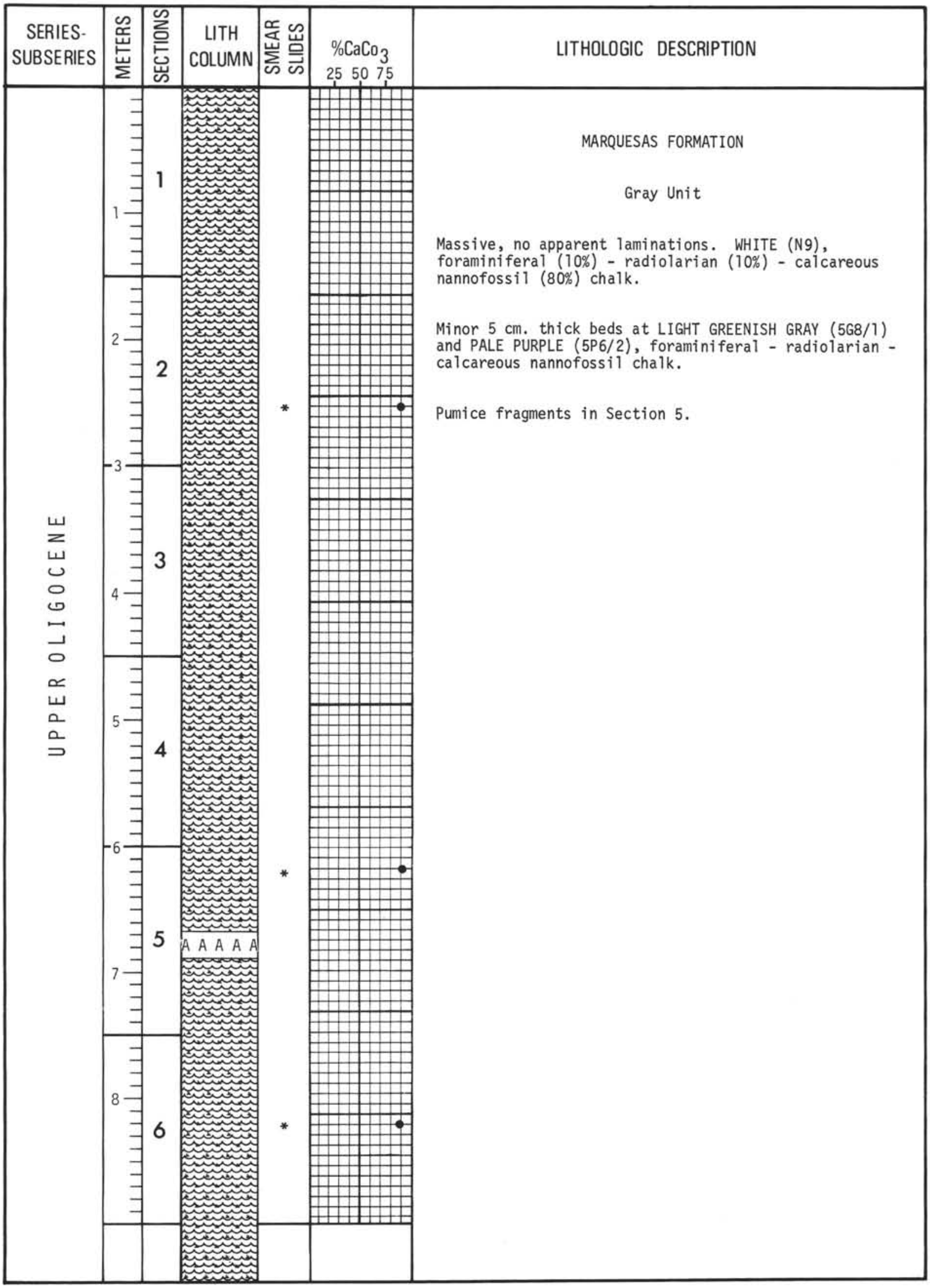


Figure 122. *Hole 77B, Core 42 (381.0 to 290.1m).*

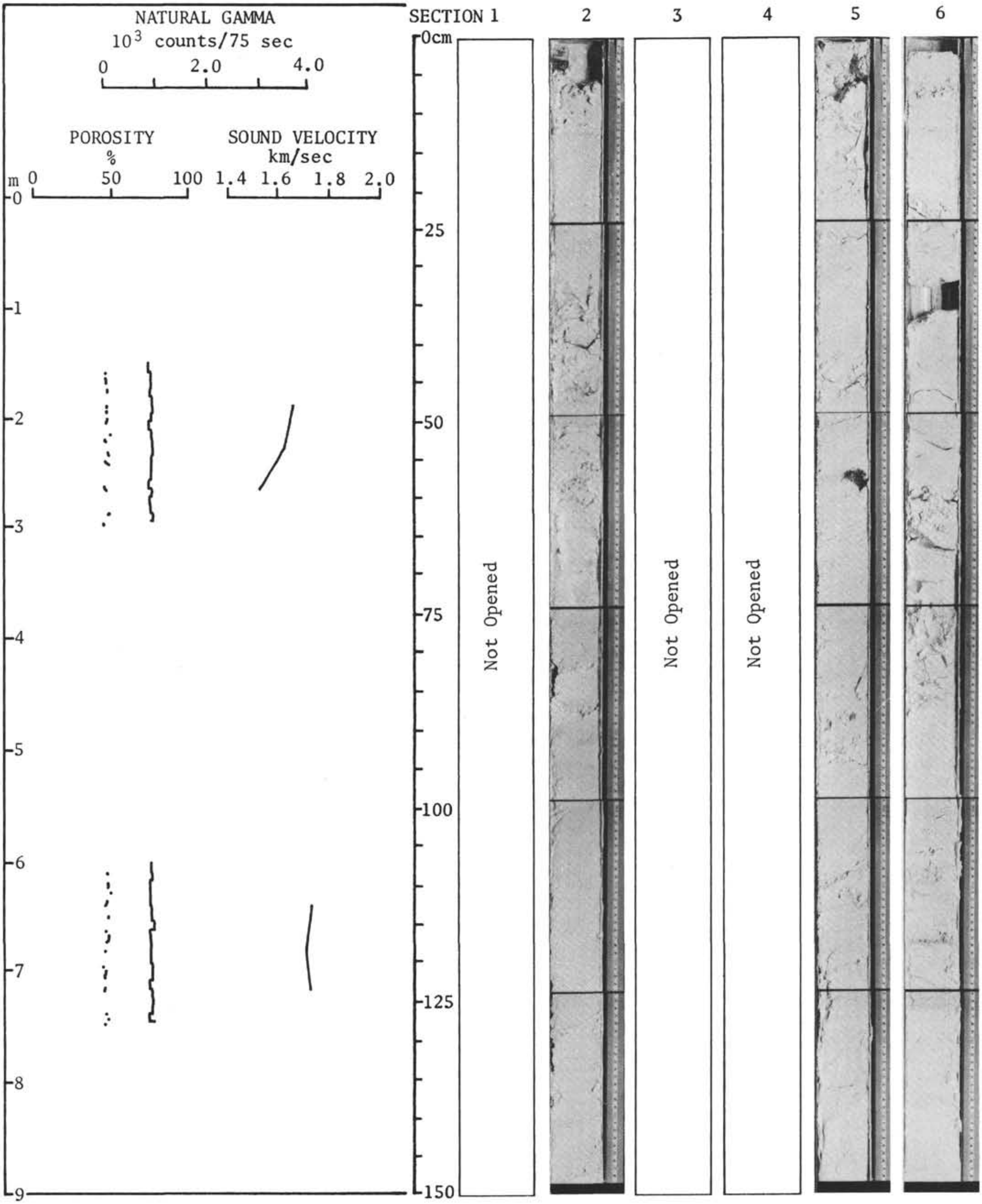


Figure 123. *Hole 77B, Core 42, Sections 1-6, Physical Properties.*

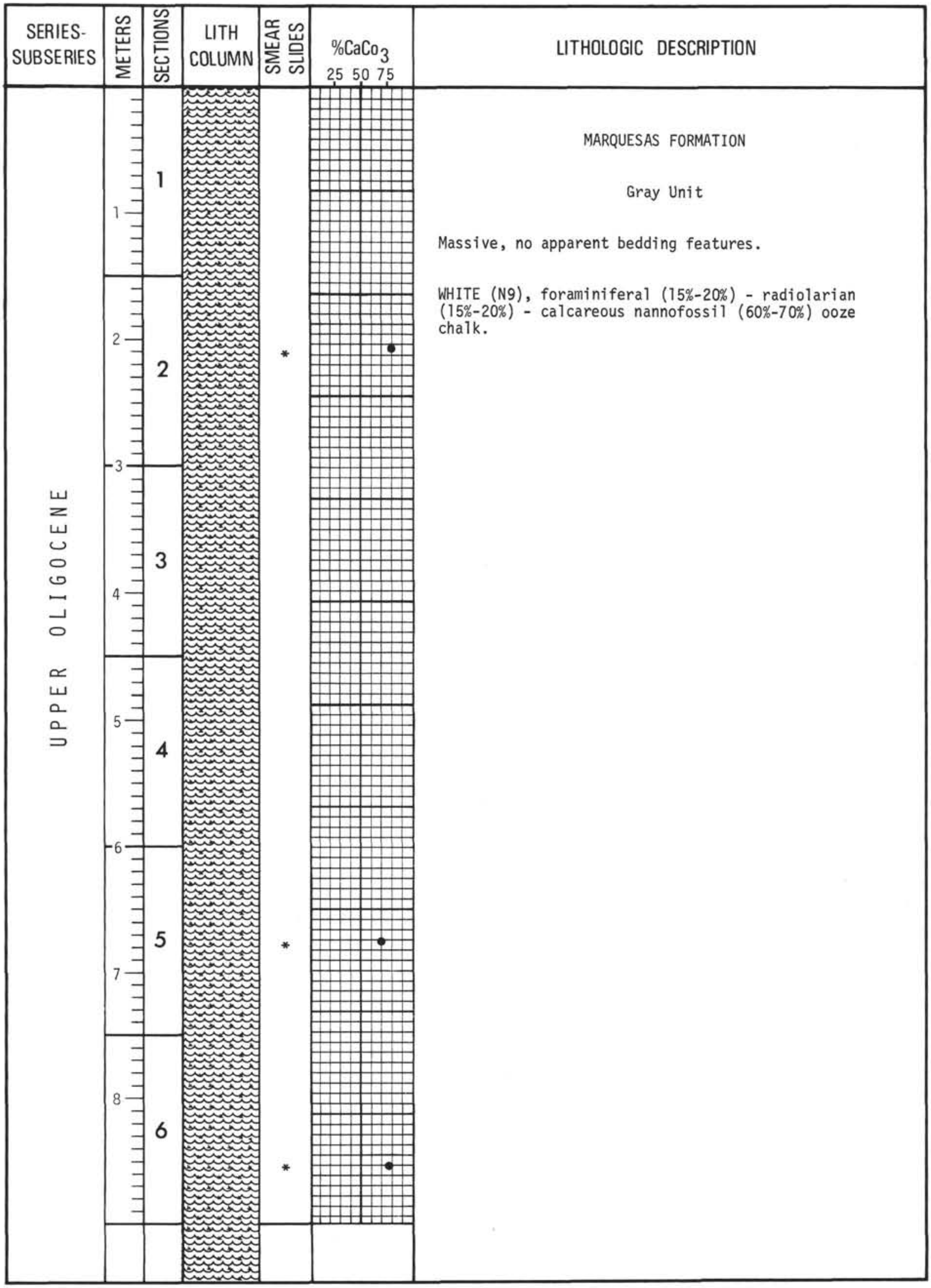


Figure 124. *Hole 77B, Core 43 (390.1 to 399.2m).*

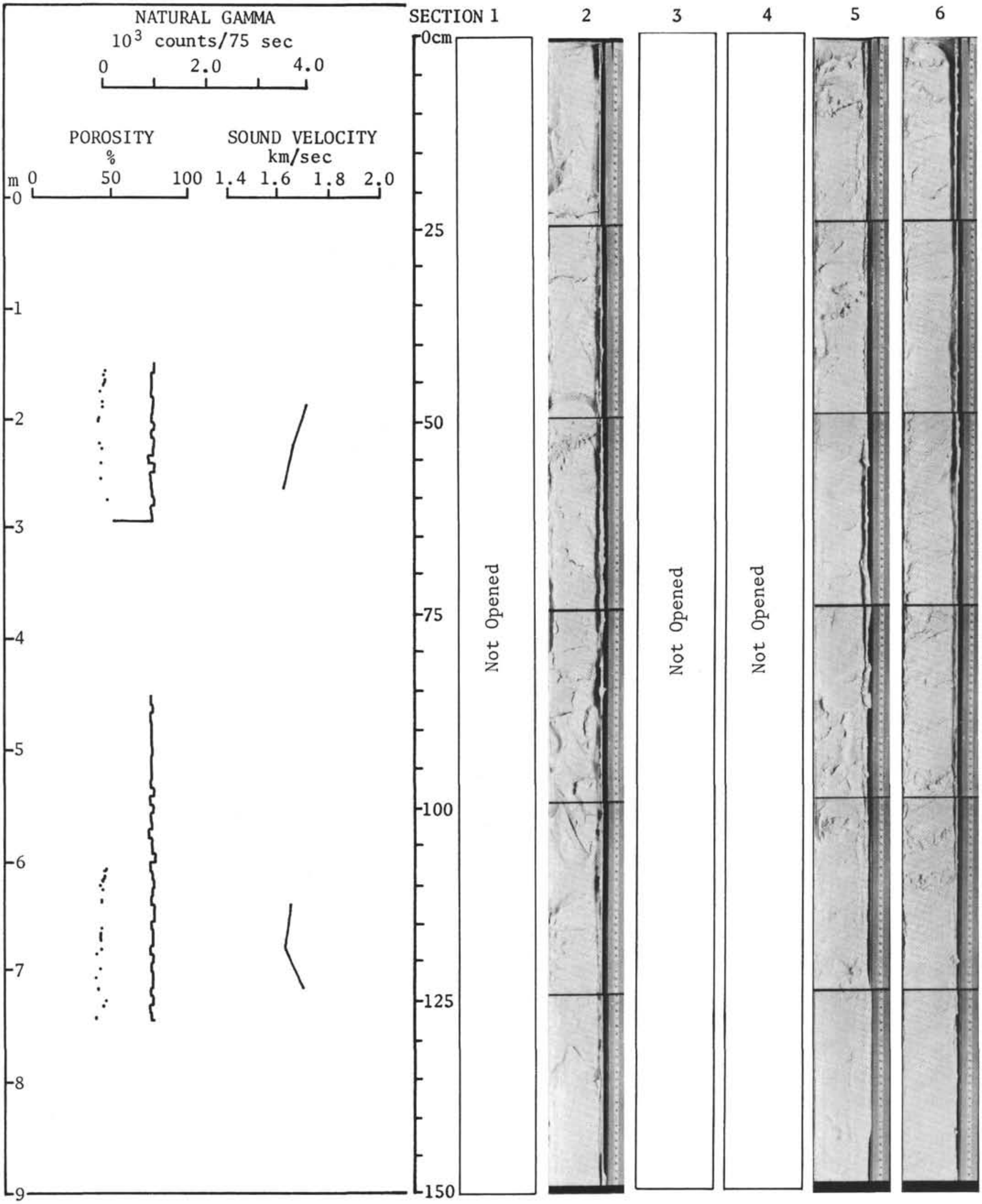


Figure 125. *Hole 77B, Core 43, Sections 1-6, Physical Properties.*

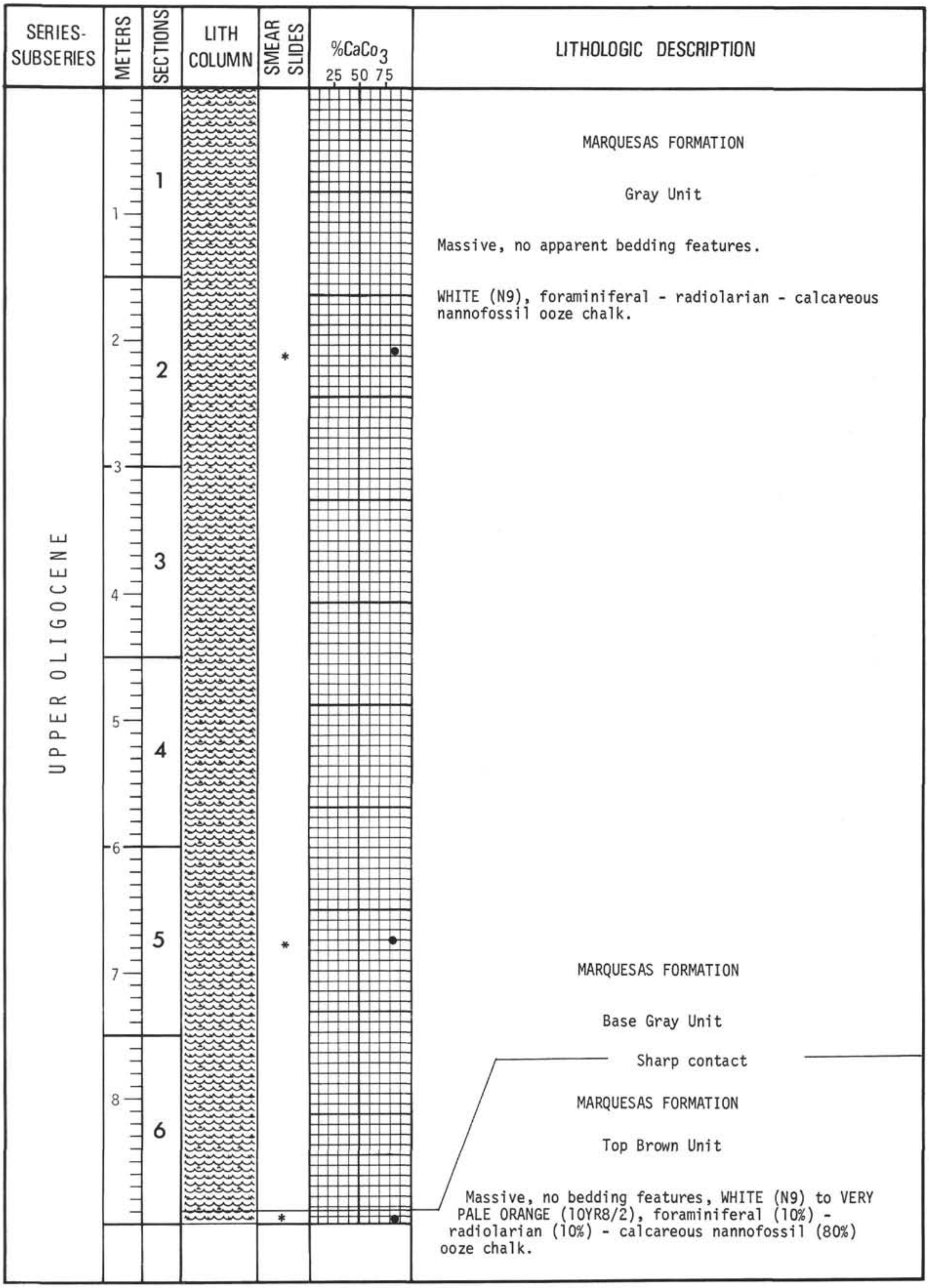


Figure 126. *Hole77B, Core 44 (399.2 to 408.3m).*

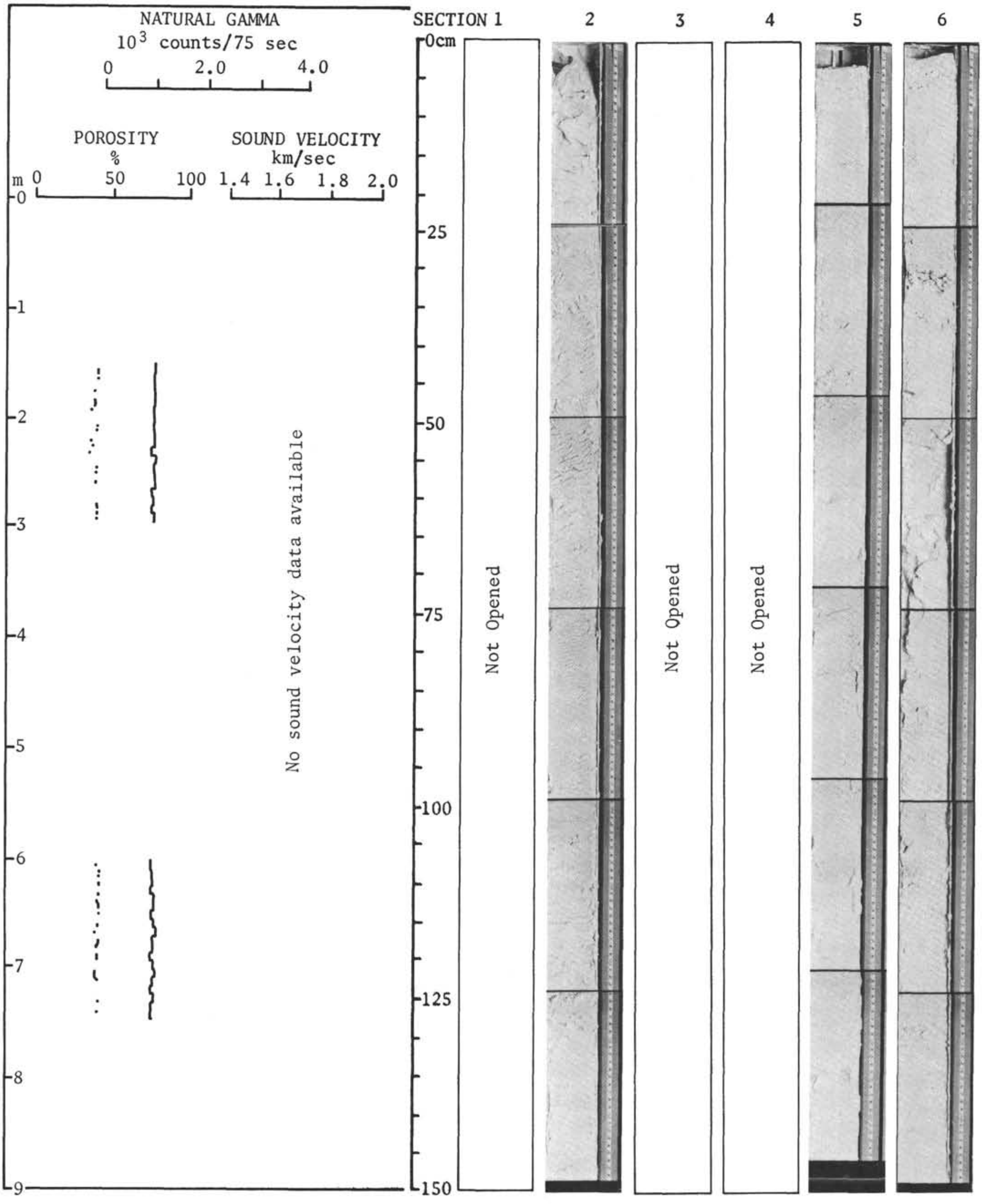


Figure 127. *Hole 77B, Core 44, Sections 1-6, Physical Properties.*

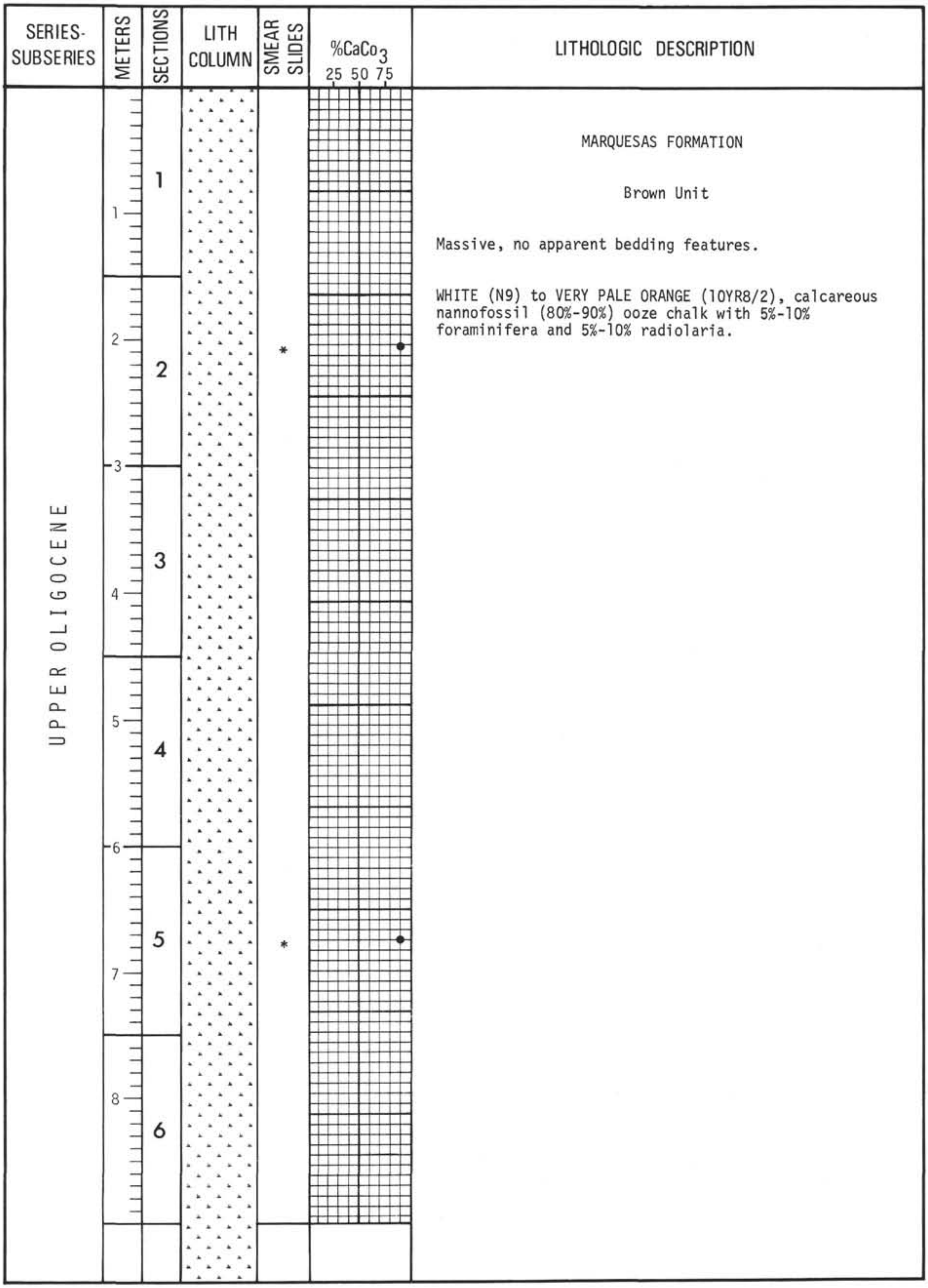


Figure 128. *Hole 77B, Core 45 (408.3 to 417.6m).*

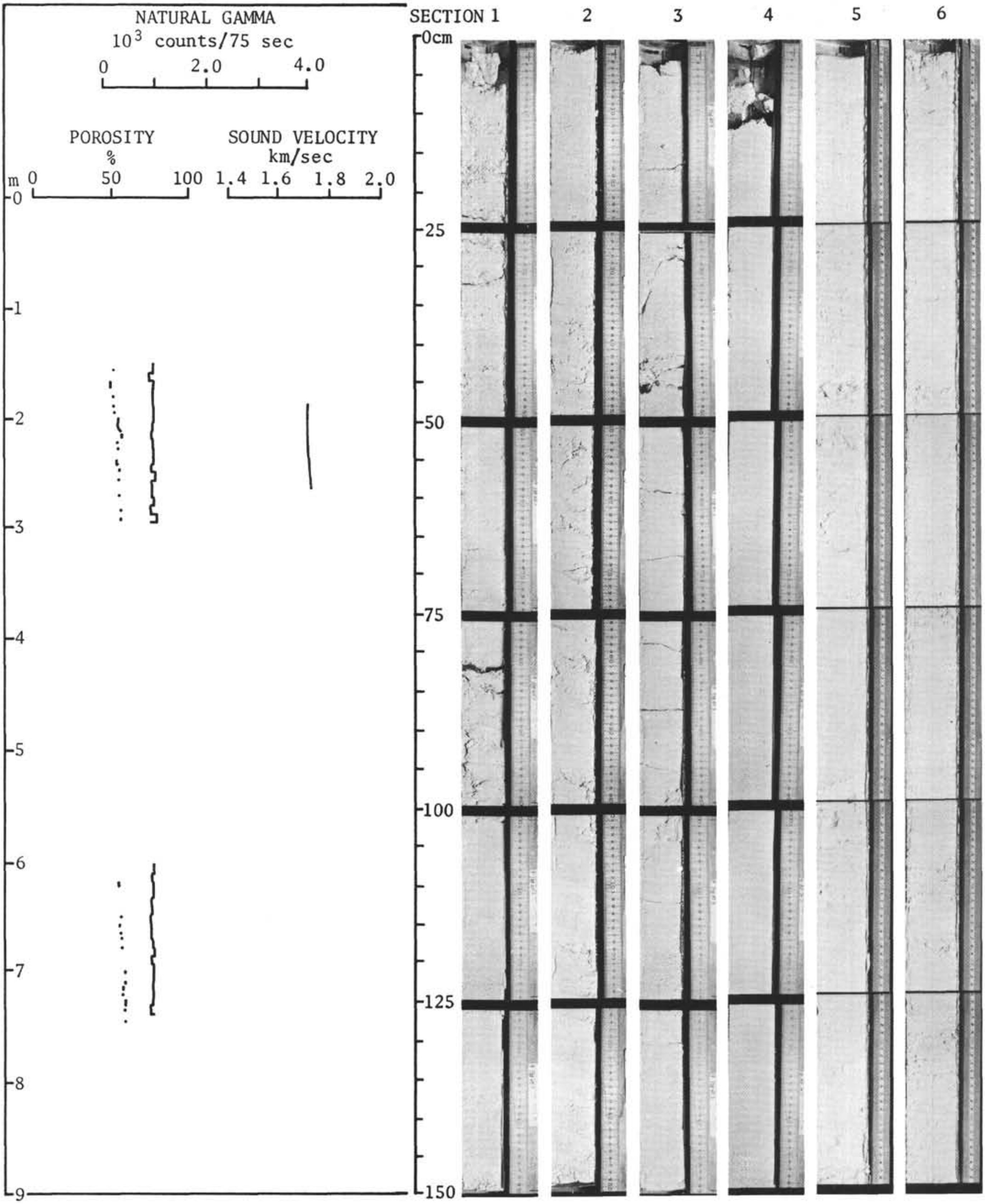


Figure 129. *Hole 77B, Core 45, Sections 1-6, Physical Properties.*

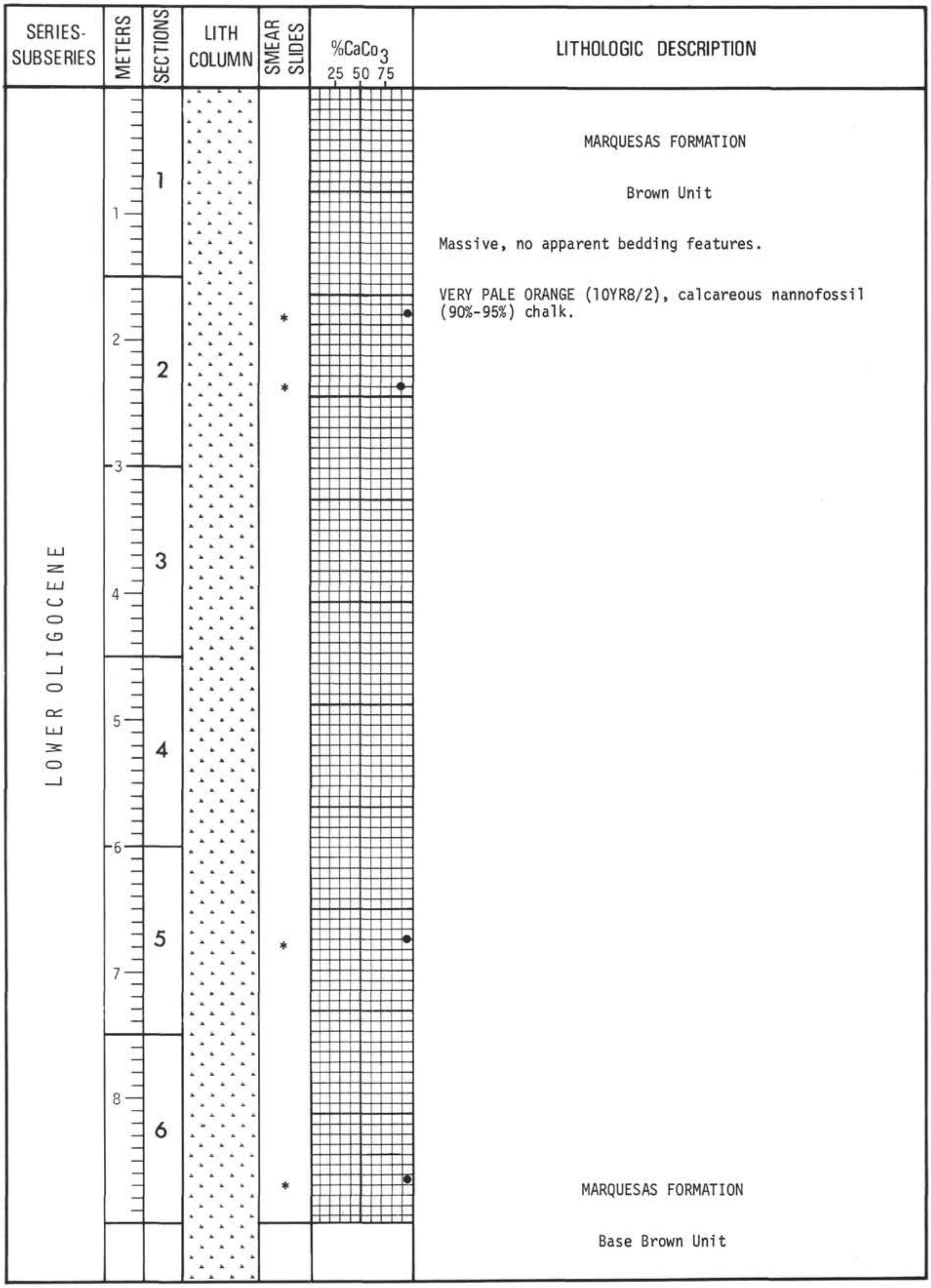


Figure 130. *Hole 77B, Core 46 (417.6 to 426.6m).*

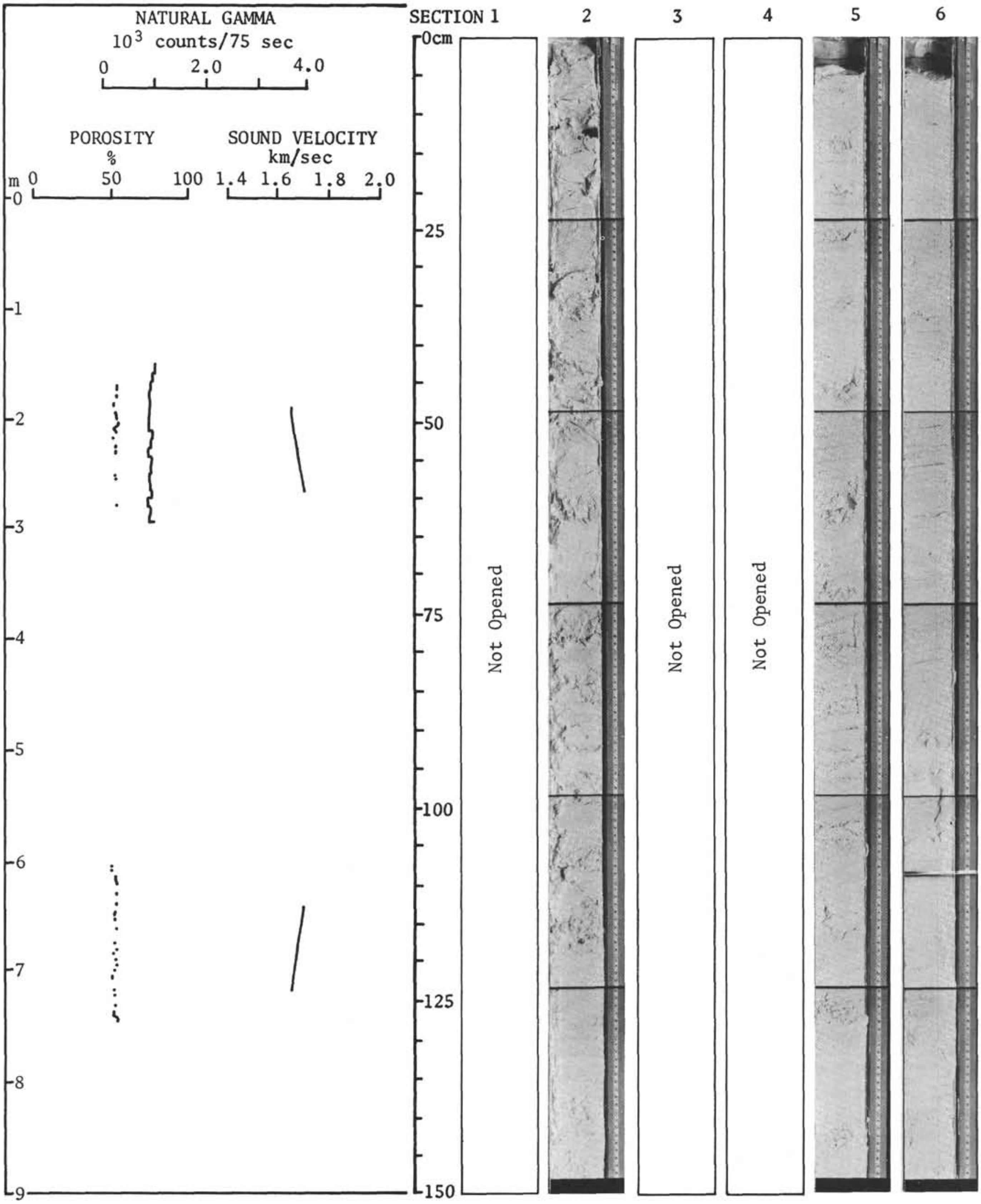


Figure 131. *Hole 77B, Core 46, Sections 1-6, Physical Properties.*

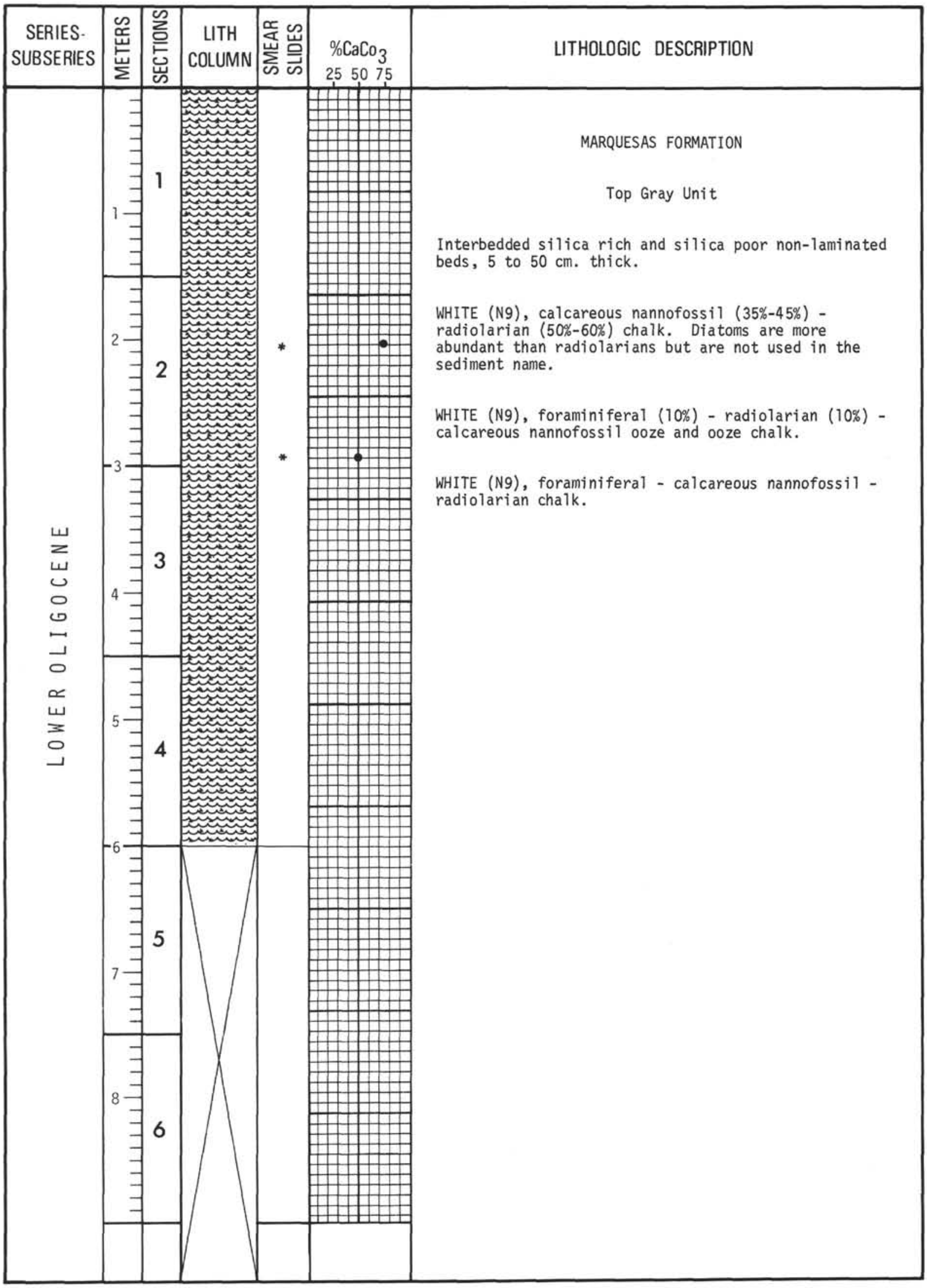


Figure 132. *Hole 77B, Core 47 (426.6 to 435.8m).*

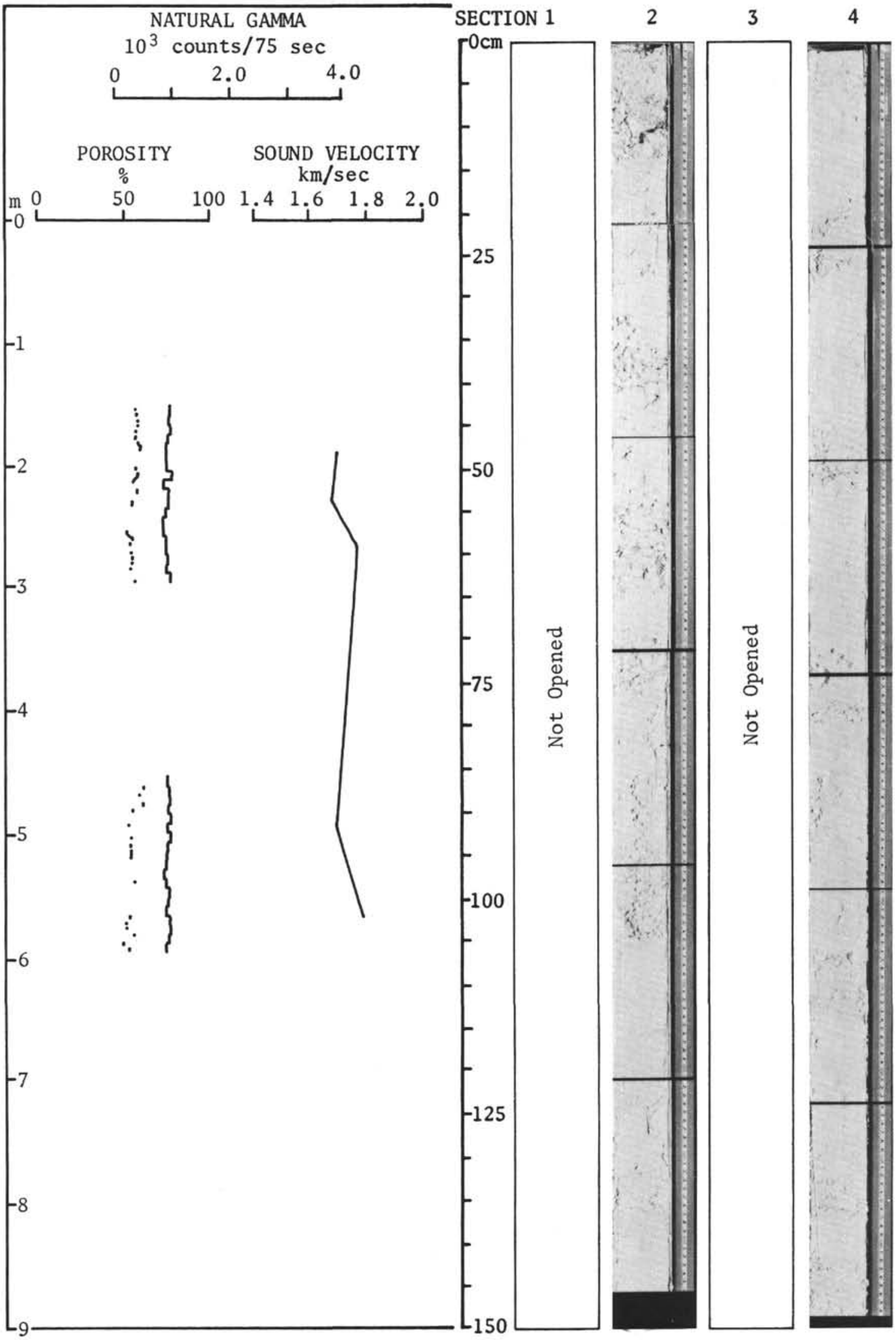


Figure 133. *Hole 77B, Core 47, Sections 1-6, Physical Properties.*

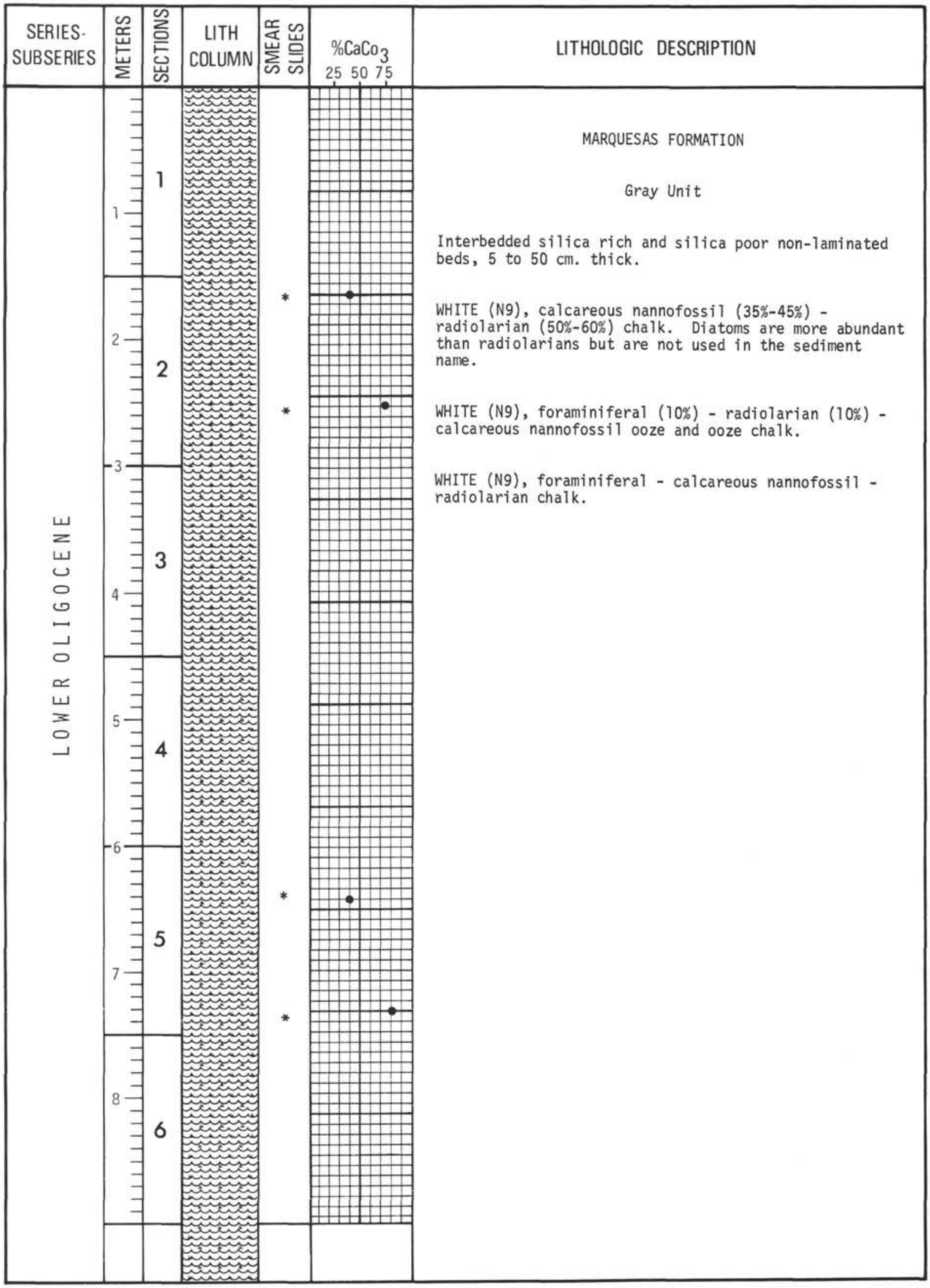


Figure 134. *Hole 77B, Core 48 (435.8 to 445.0m).*

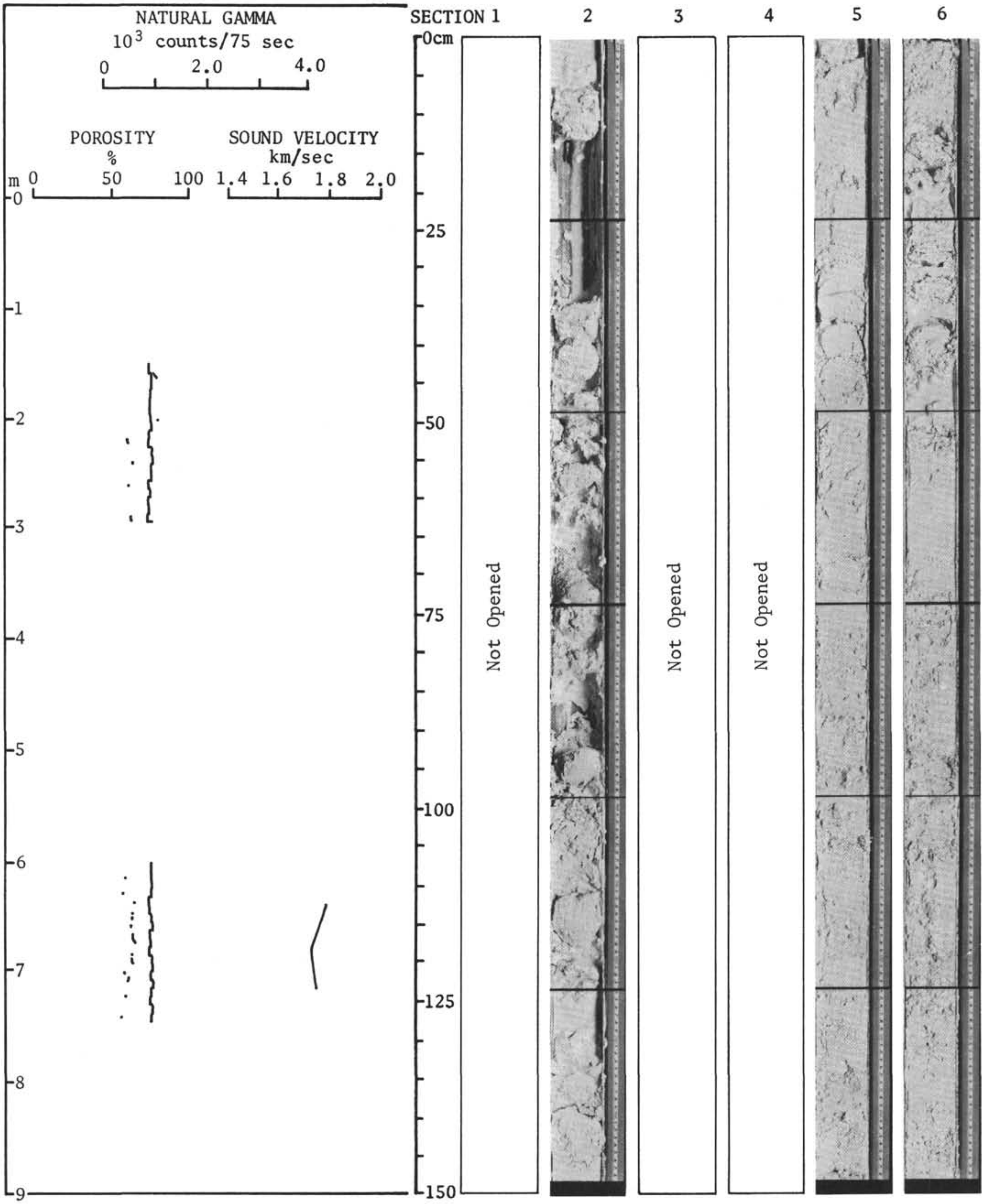


Figure 135. *Hole 77B, Core 48, Sections 1-6, Physical Properties.*

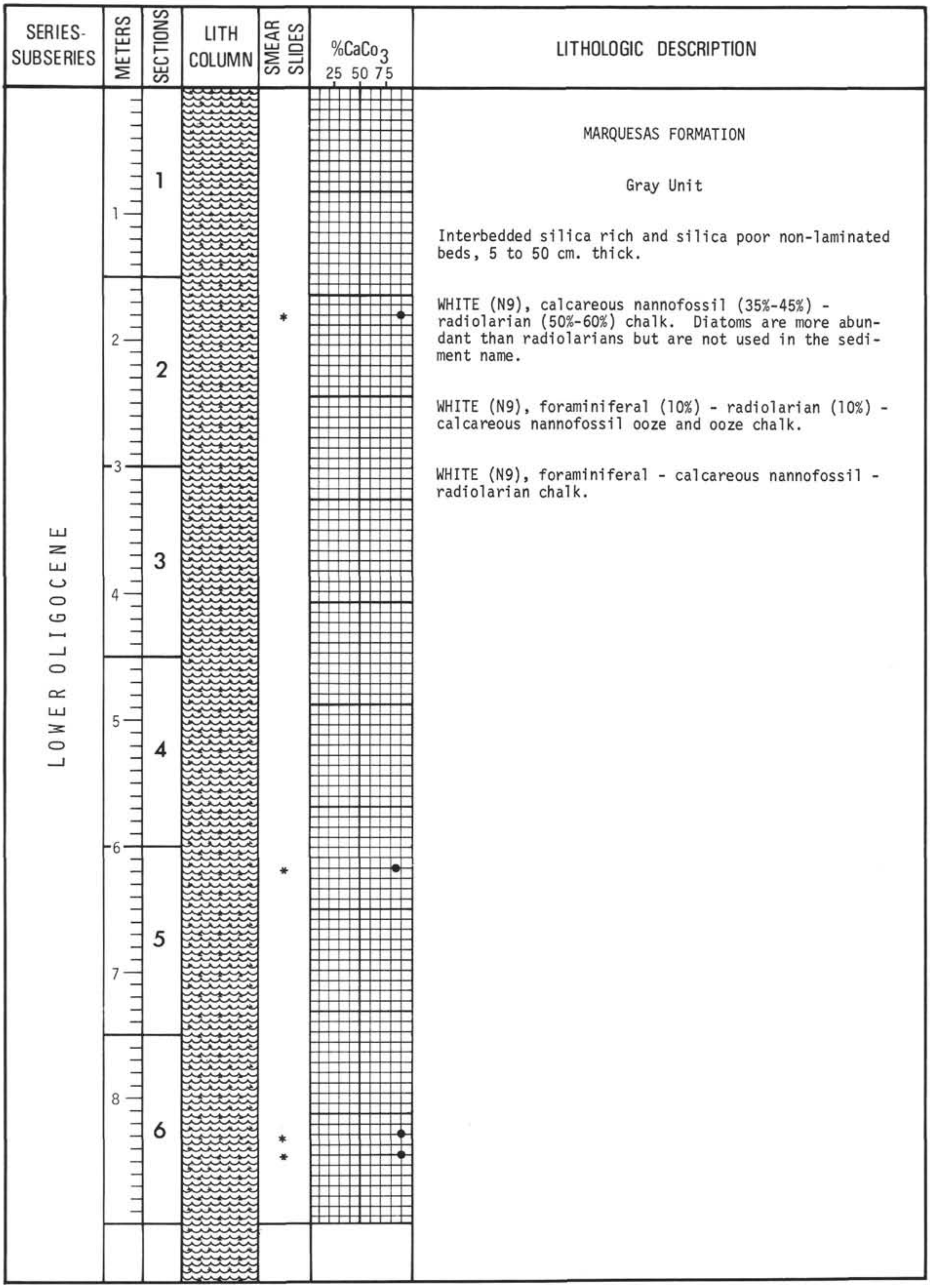


Figure 136. *Hole 77B, Core 49 (445.0 to 454.1m).*

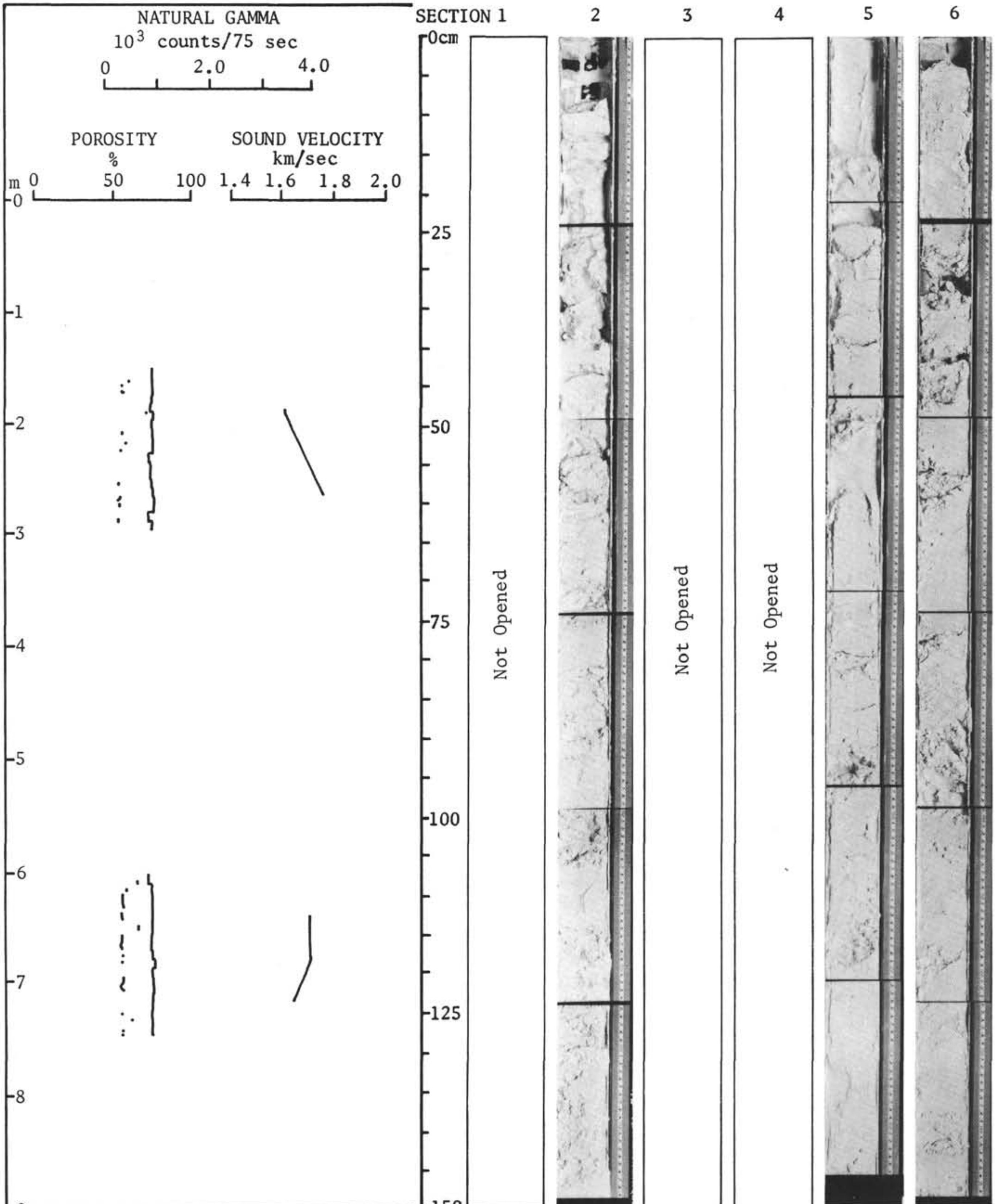
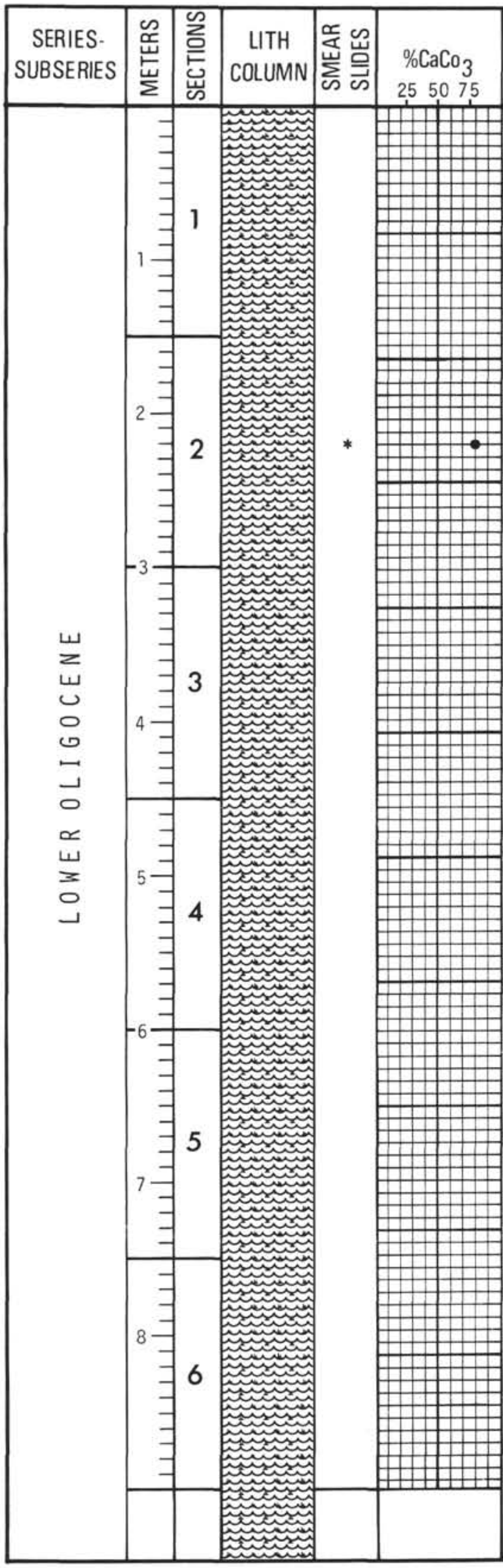


Figure 137. *Hole 77B, Core 49, Sections 1-6, Physical Properties.*



LITHOLOGIC DESCRIPTION

MARQUESAS FORMATION

Gray Unit

Interbedded, 20-50 cm. thick, non-laminated beds of:

WHITE (N9), foraminiferal - radiolarian - calcareous nannofossil chalk.

WHITE (N9), radiolarian - foraminiferal - calcareous nannofossil ooze chalk.

Figure 138. *Hole 77B, Core 50 (454.1 to 463.2m).*

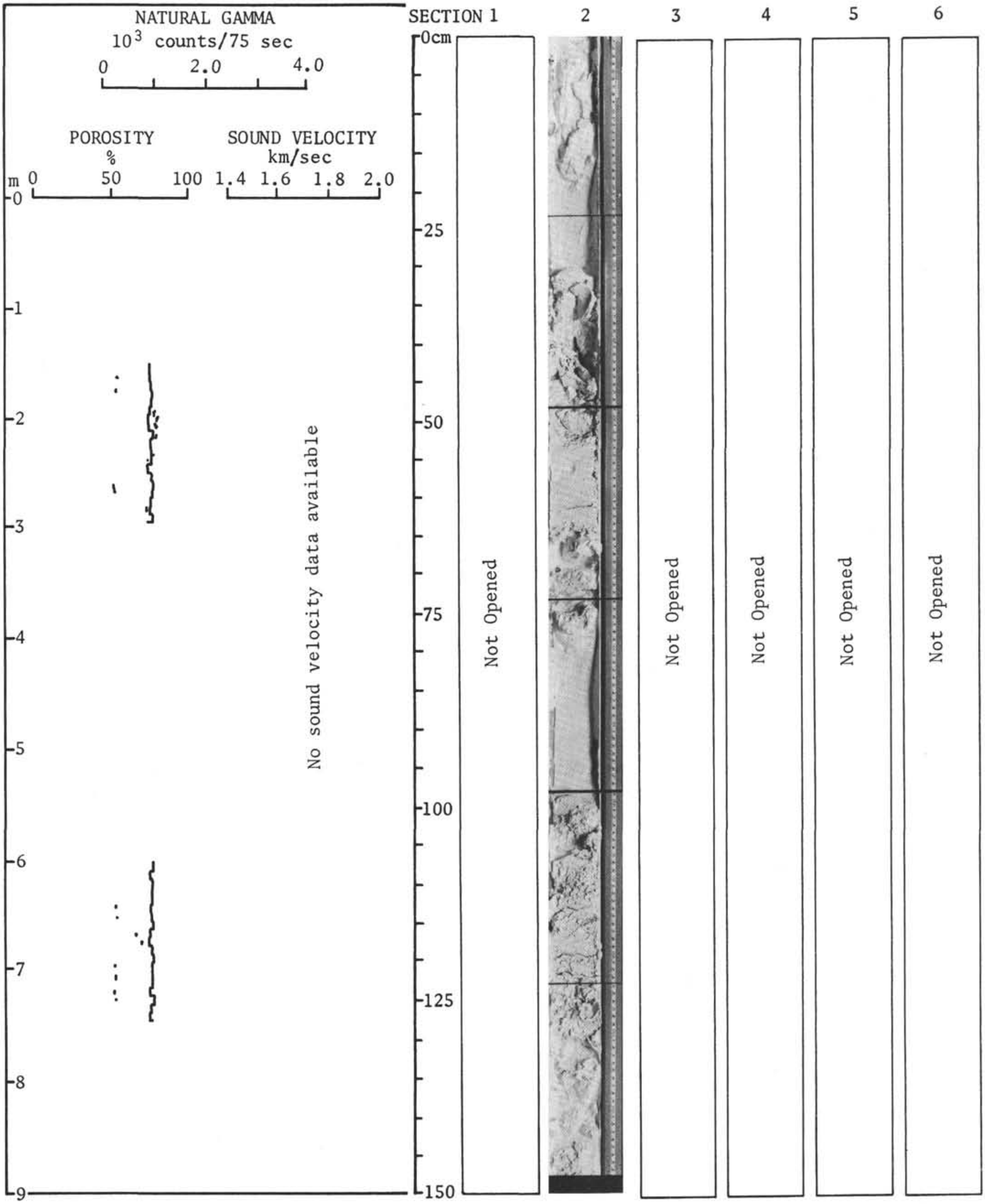


Figure 139. *Hole 77B, Core 50, Sections 1-6, Physical Properties.*

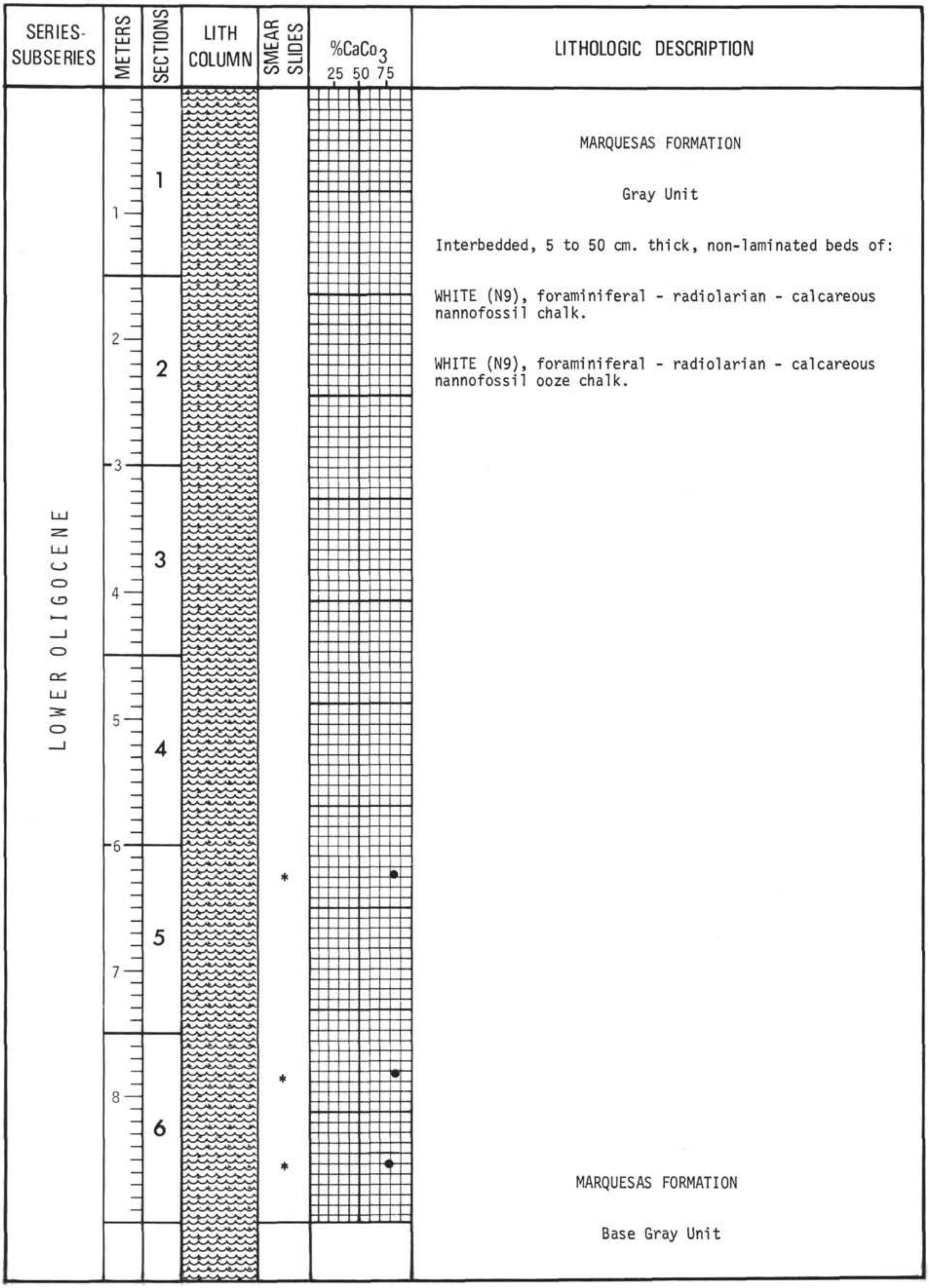


Figure 140. *Hole 77B, Core 51 (463.2 to 470.8m).*

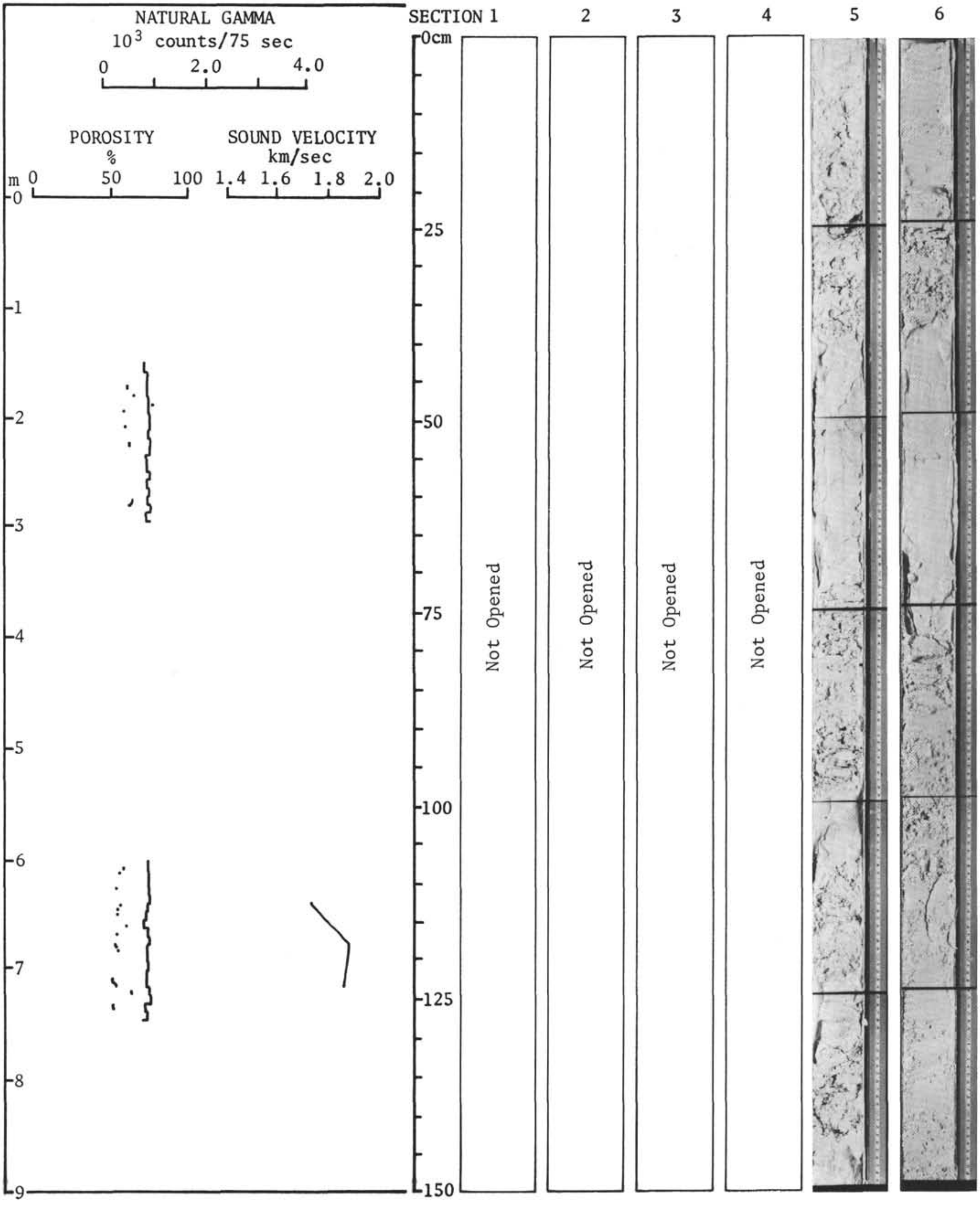


Figure 141. *Hole 77B, Core 51, Sections 1-6, Physical Properties.*

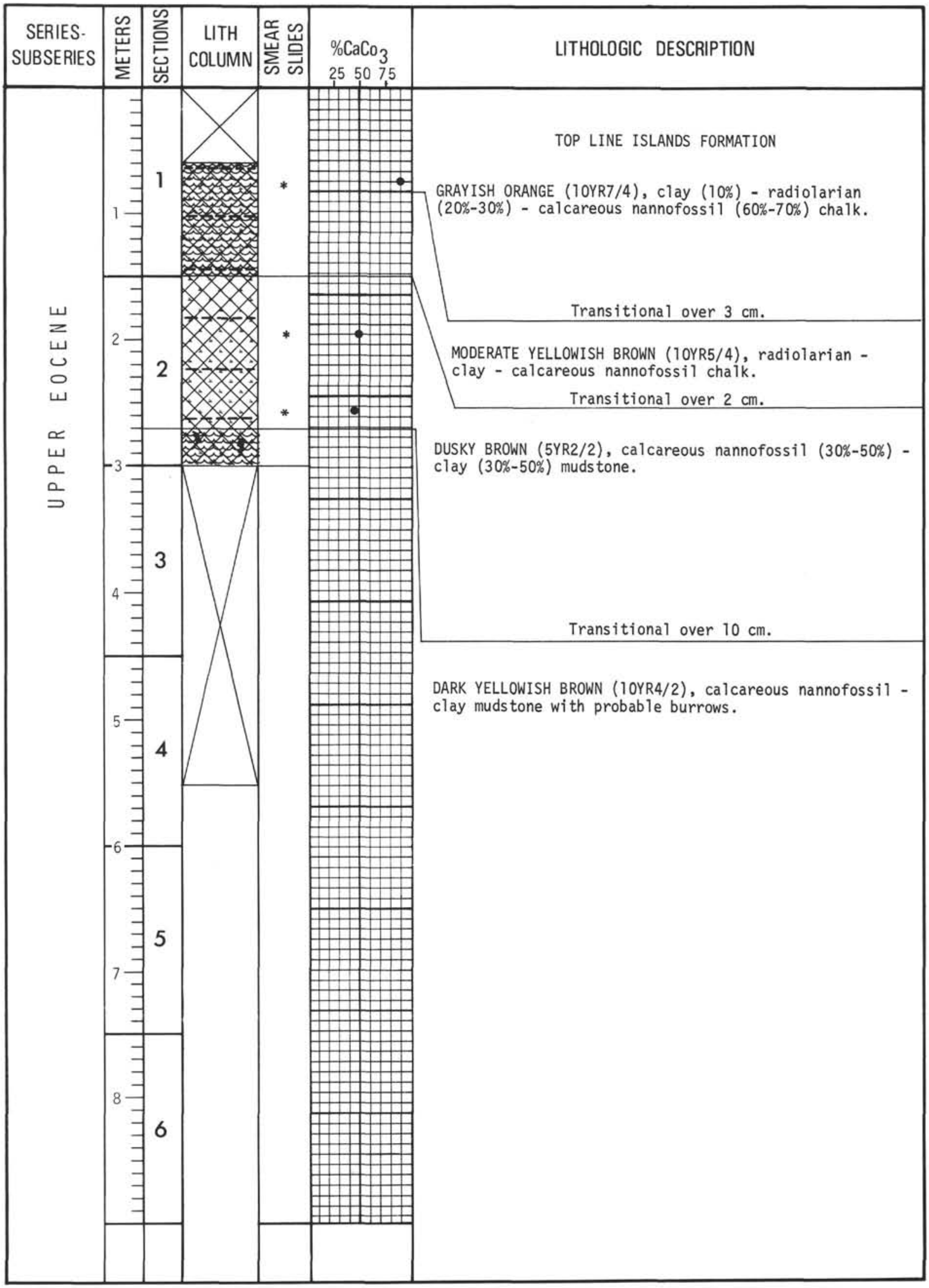


Figure 142. *Hole 77B, Core 52 (470.8 to 476.3m).*

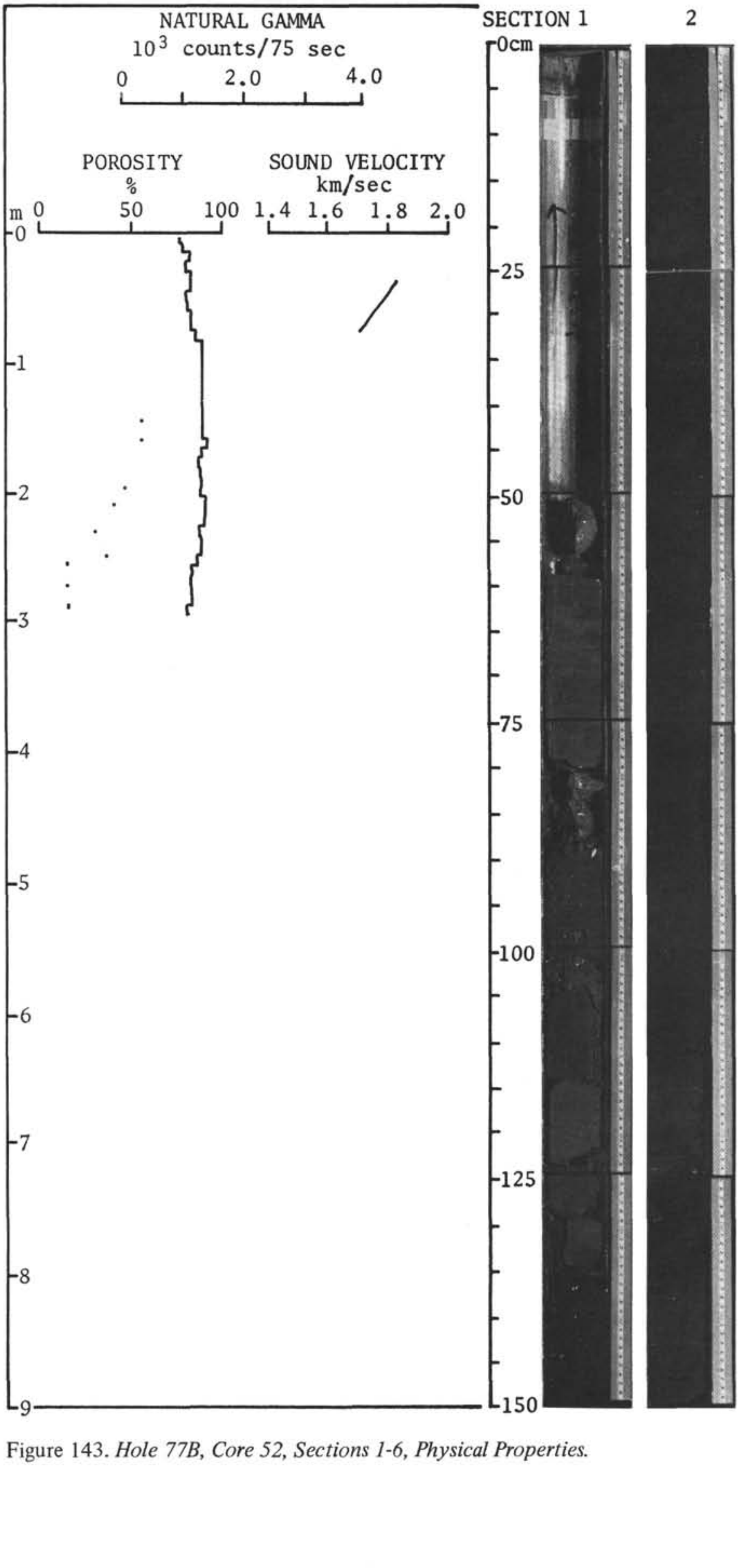


Figure 143. *Hole 77B, Core 52, Sections 1-6, Physical Properties.*

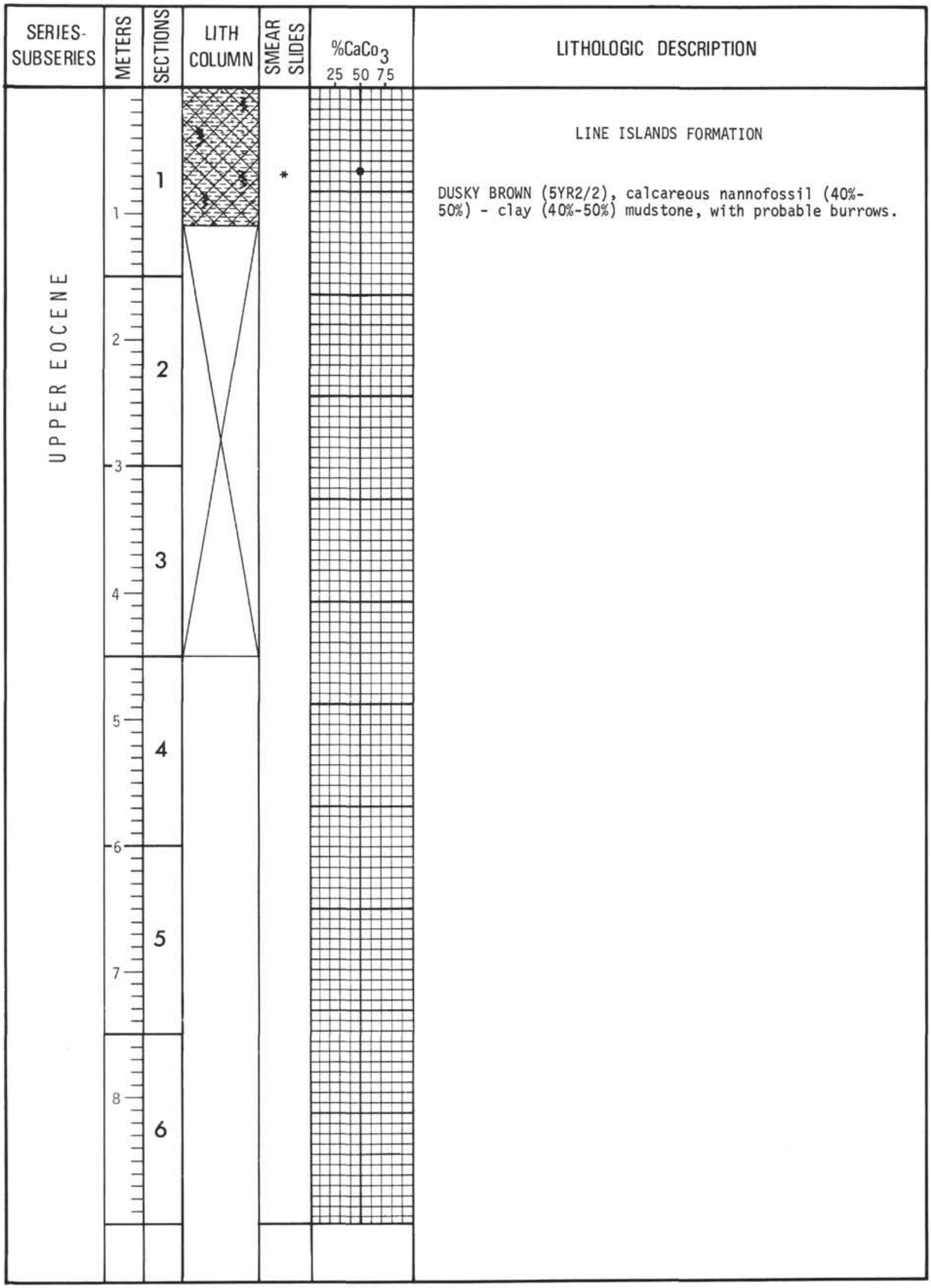


Figure 144. *Hole 77B, Core 53 (476.3 to 481.0m).*

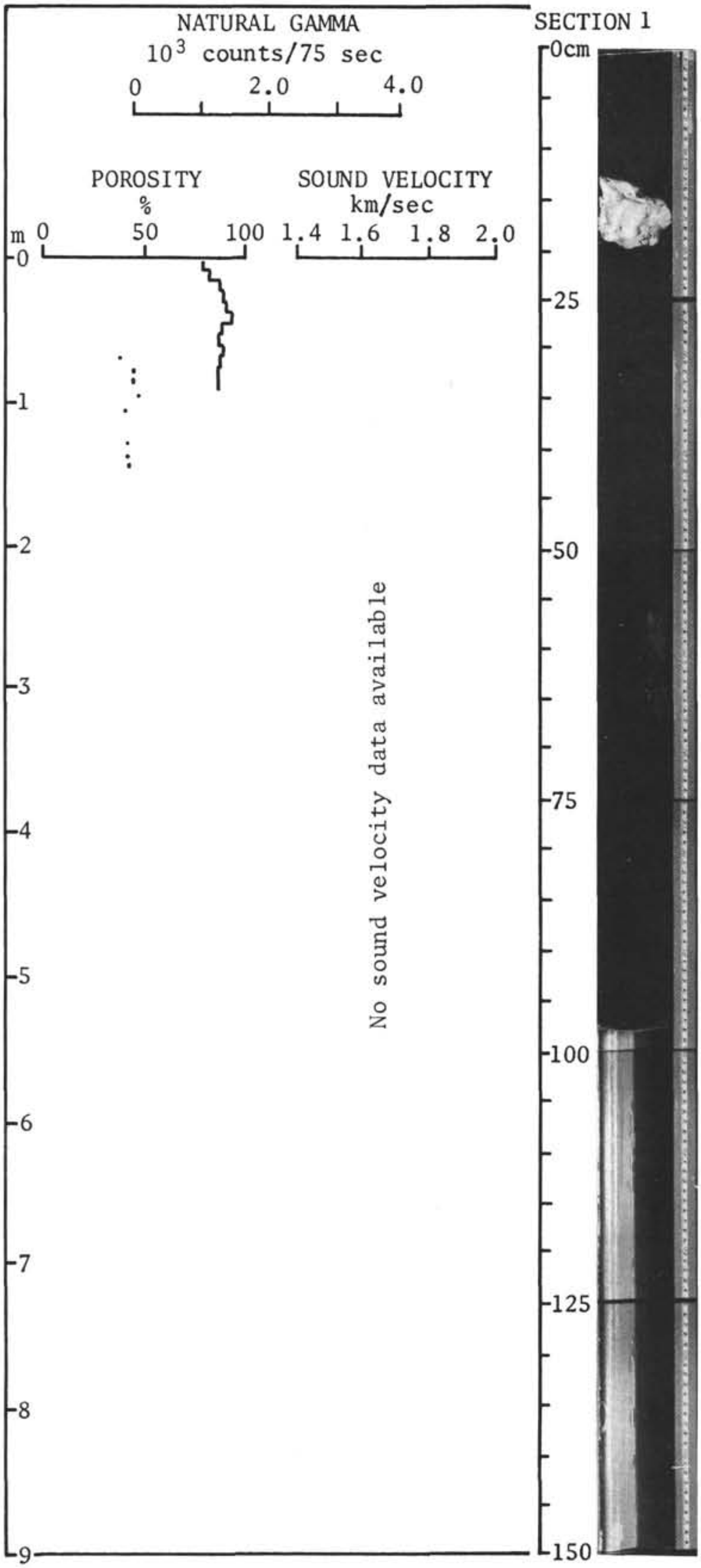


Figure 145. *Hole 77B, Core 53, Sections 1-6, Physical Properties.*

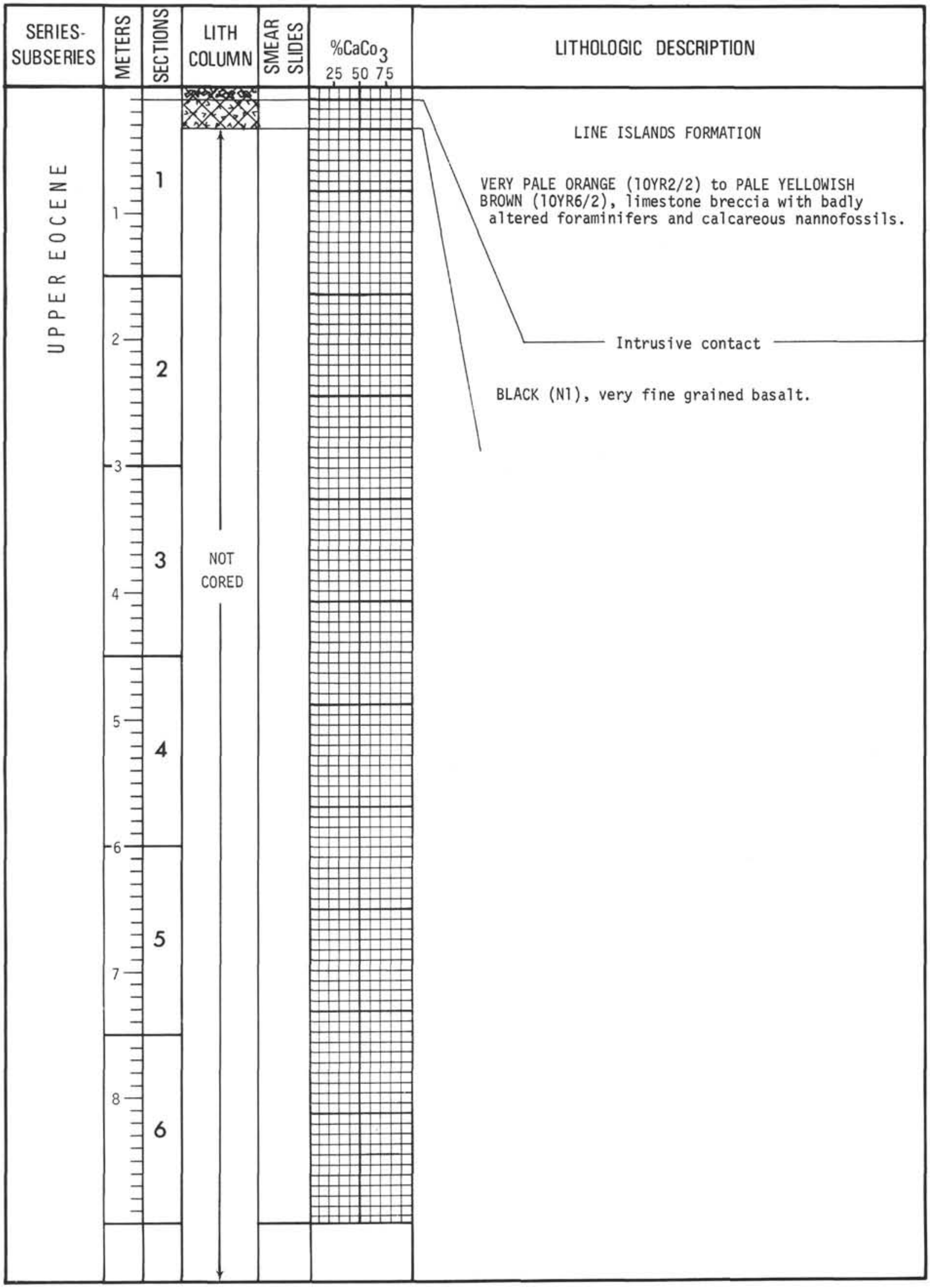


Figure 146. *Hole 77B, Core 54 (481.0 to 481.2m).*

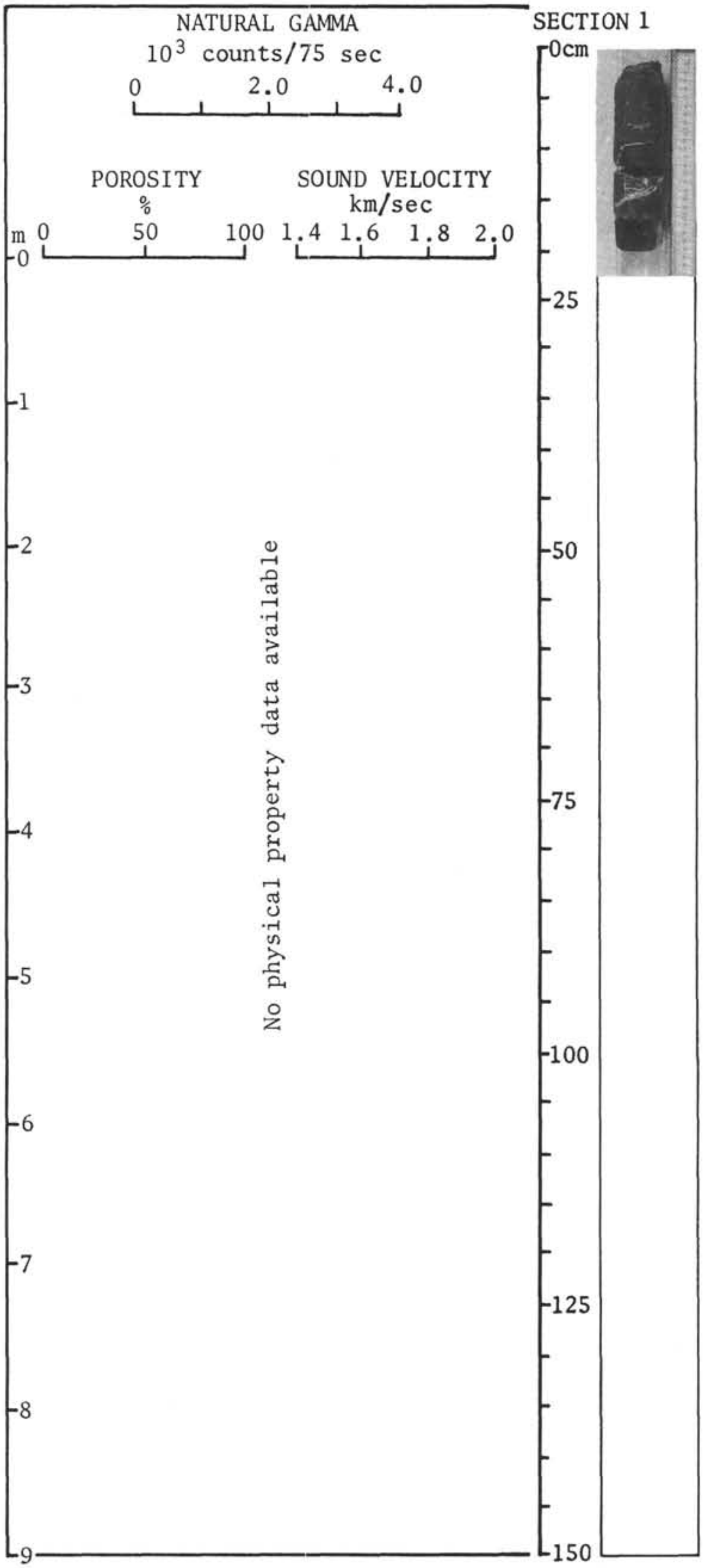


Figure 147. *Hole 77B, Core 54, Section 1, Physical Properties.*

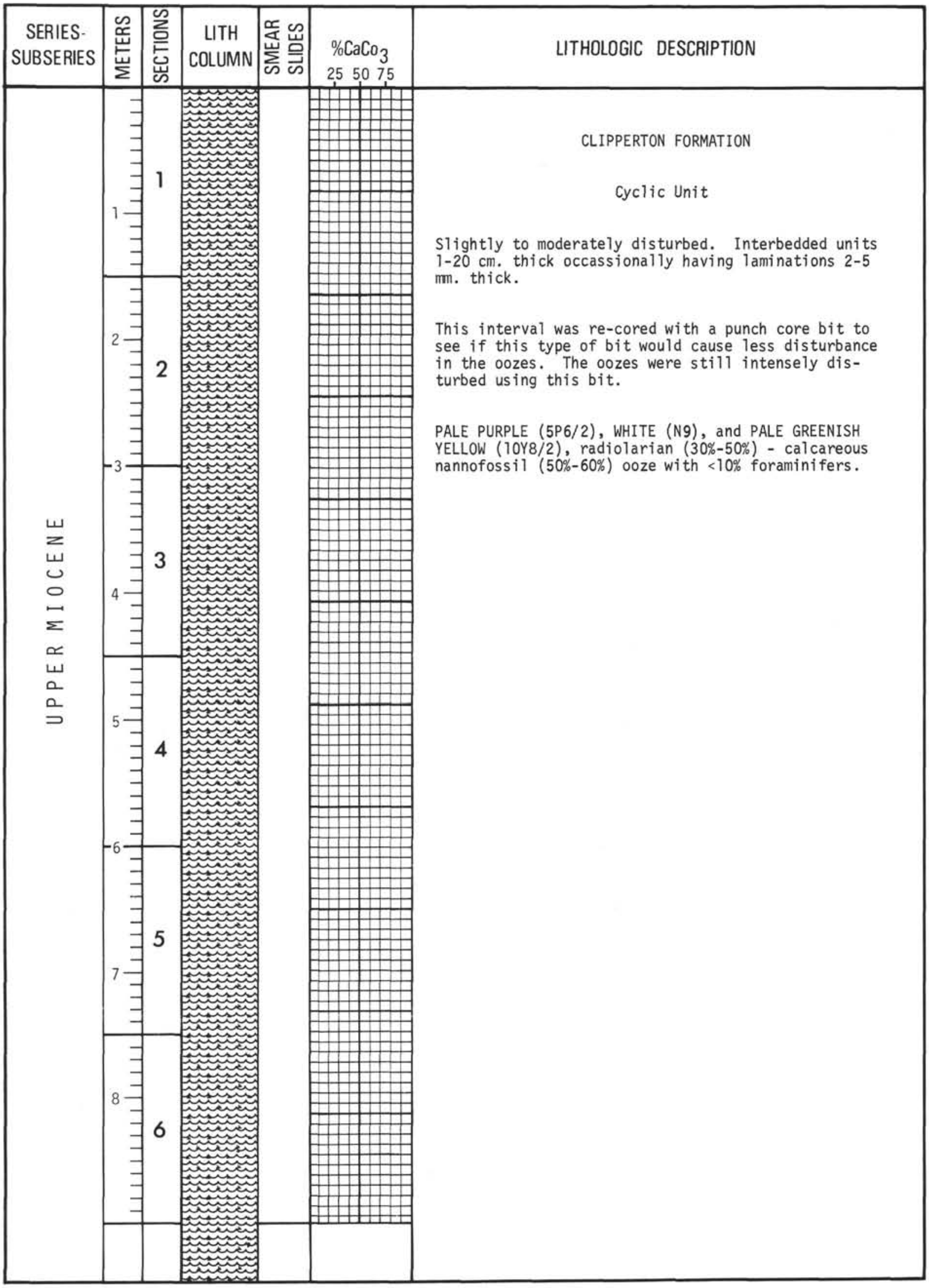


Figure 148. *Hole 77C, Core 1 (91.5 to 100.6m).*

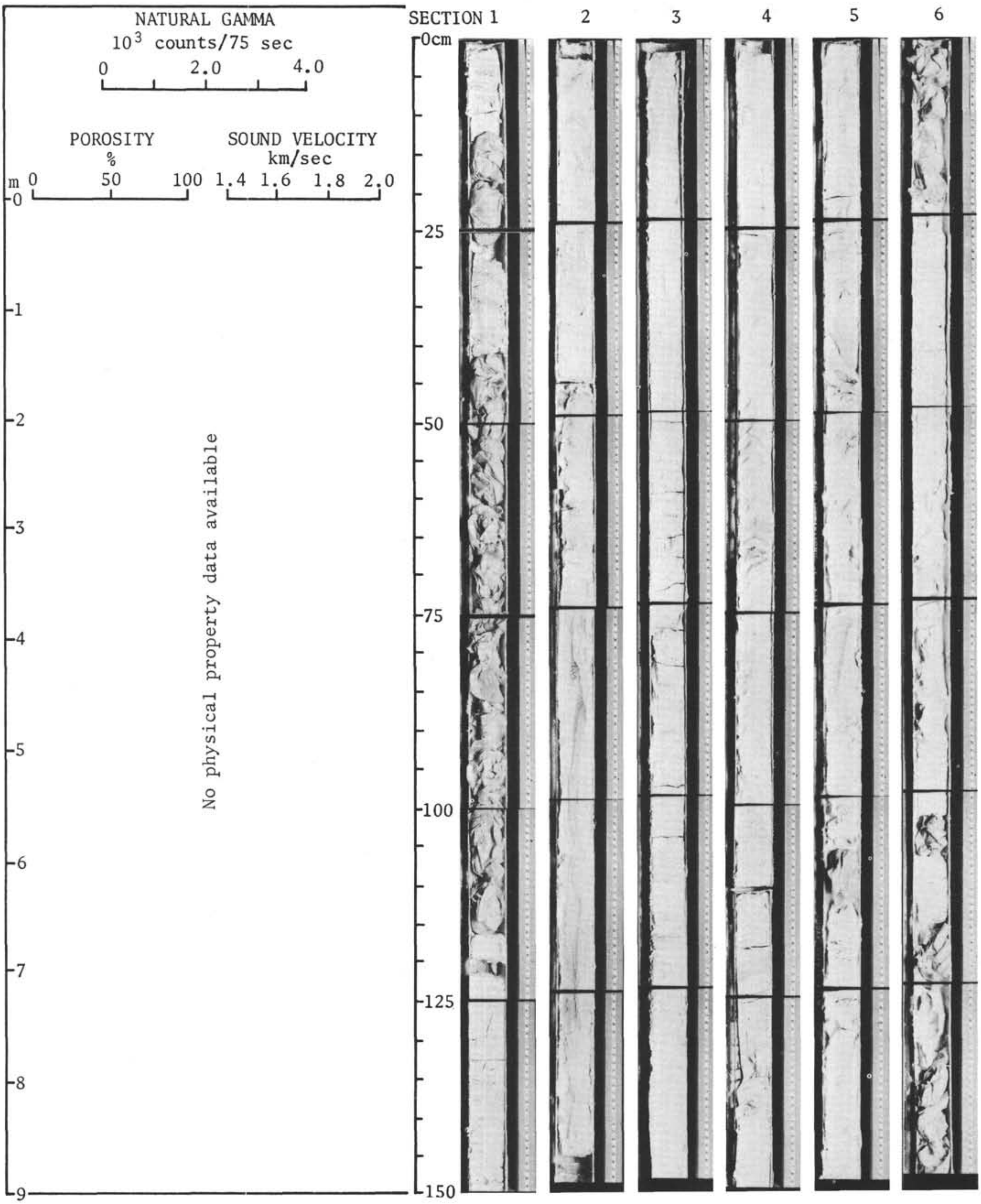


Figure 149. *Hole 77C, Core 1, Sections 1-6*

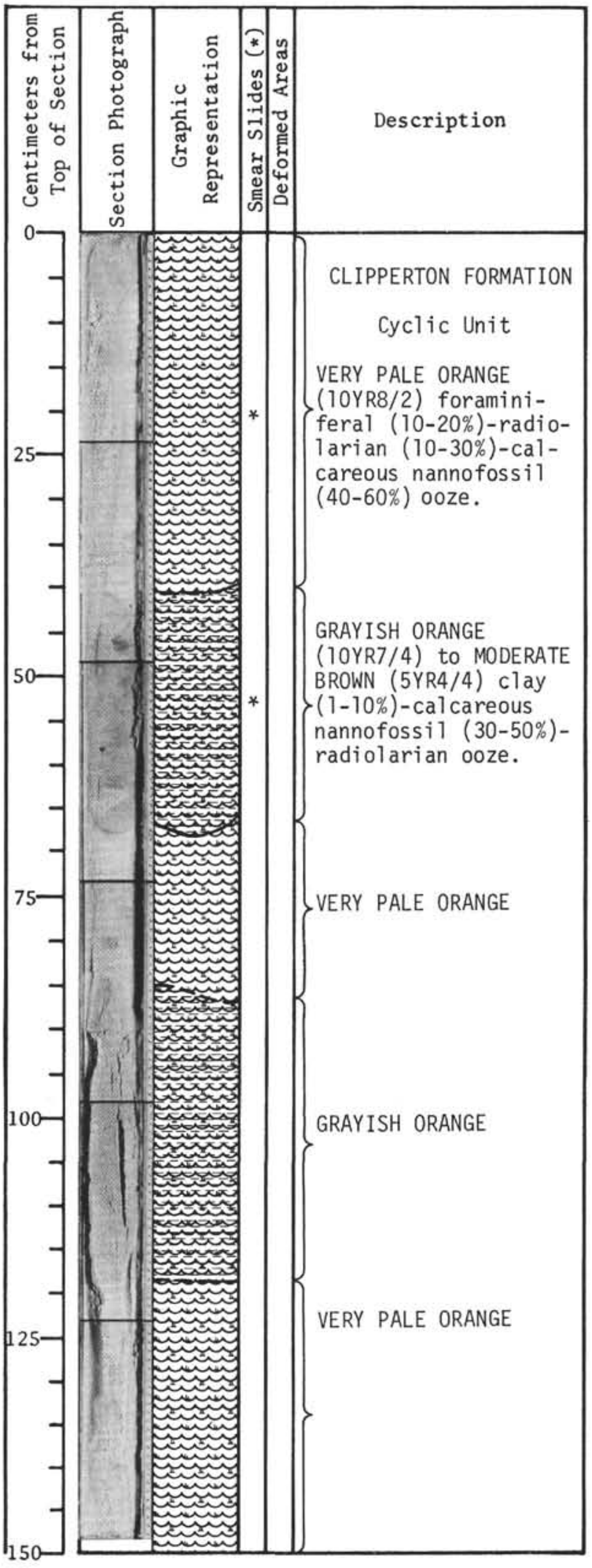


Figure 150. *Hole 77A, Core 1, Section 1.*

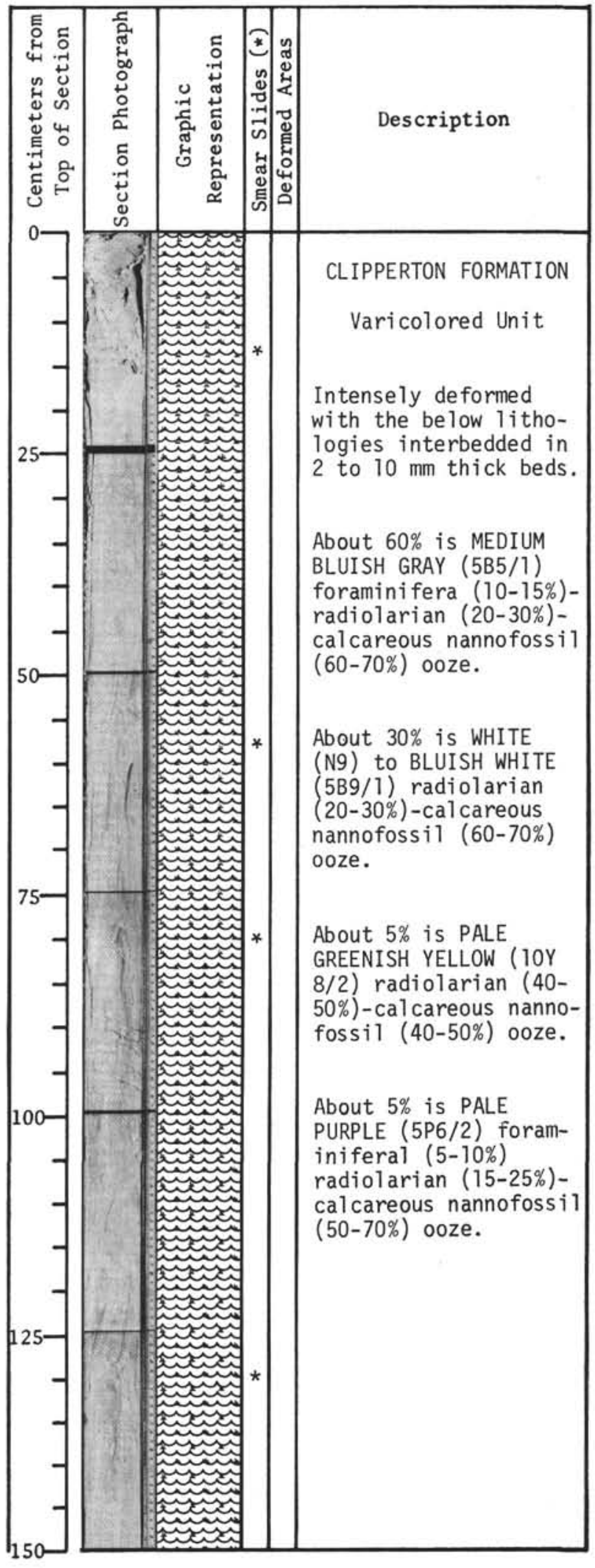


Figure 151. *Hole 77B, Core 6, Section 4.*

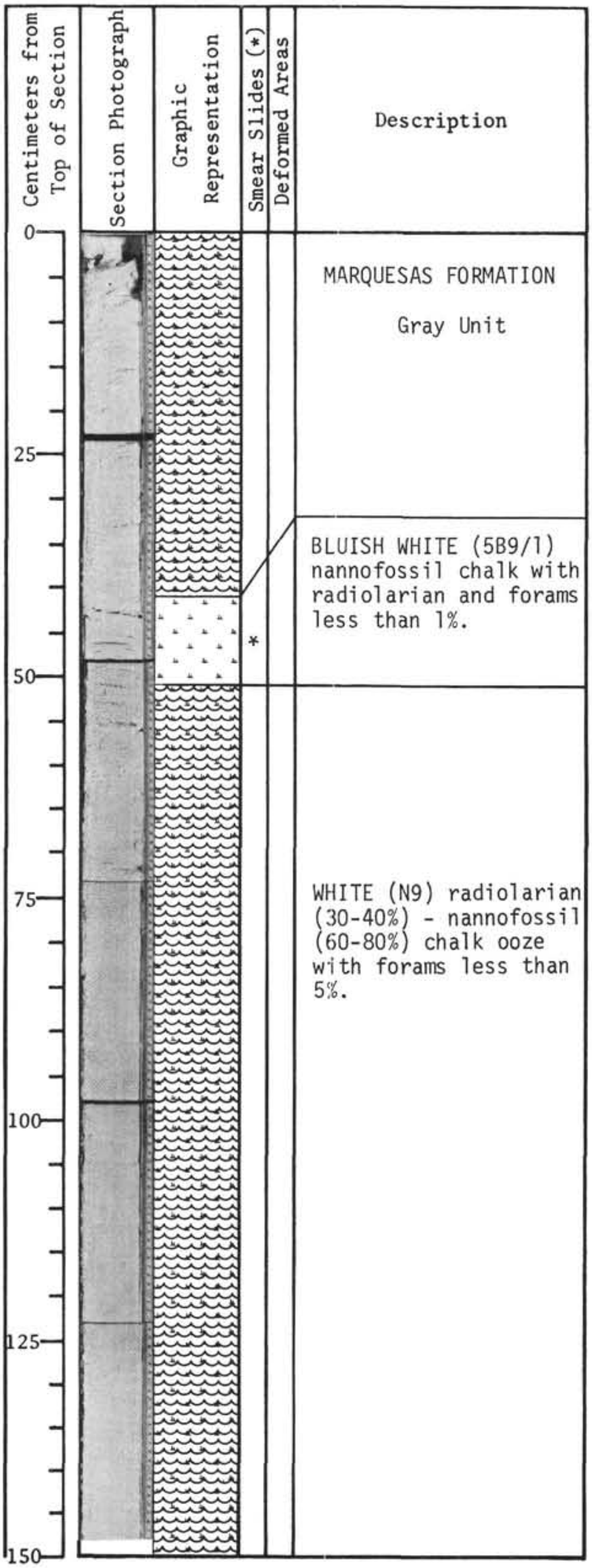


Figure 152. *Hole 77B, Core 20, Section 2.*

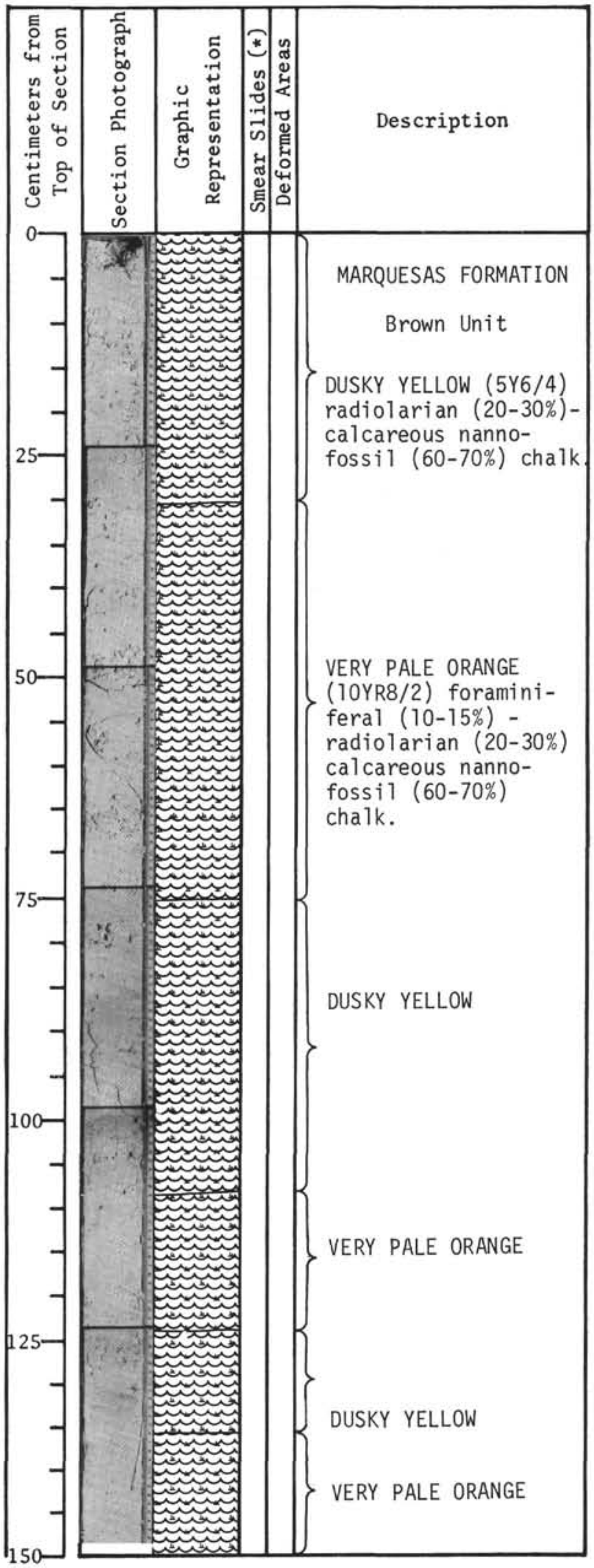


Figure 153. *Hole 77B, Core 28, Section 5.*

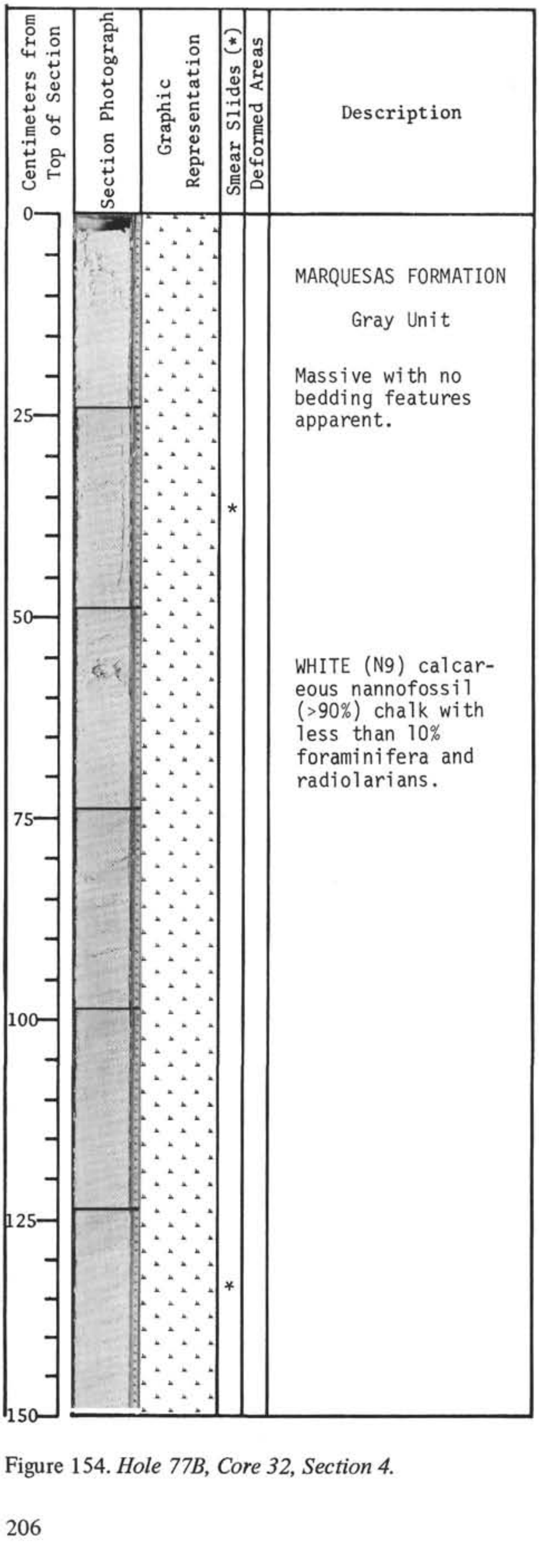


Figure 154. *Hole 77B, Core 32, Section 4.*

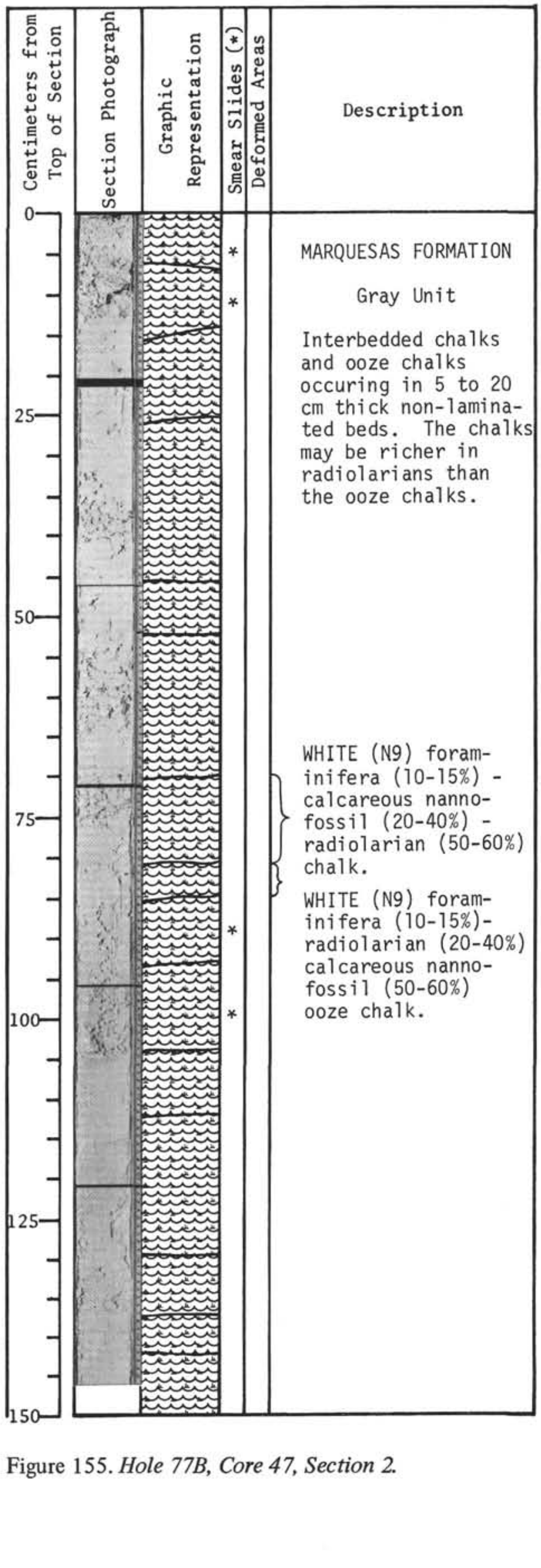


Figure 155. *Hole 77B, Core 47, Section 2.*

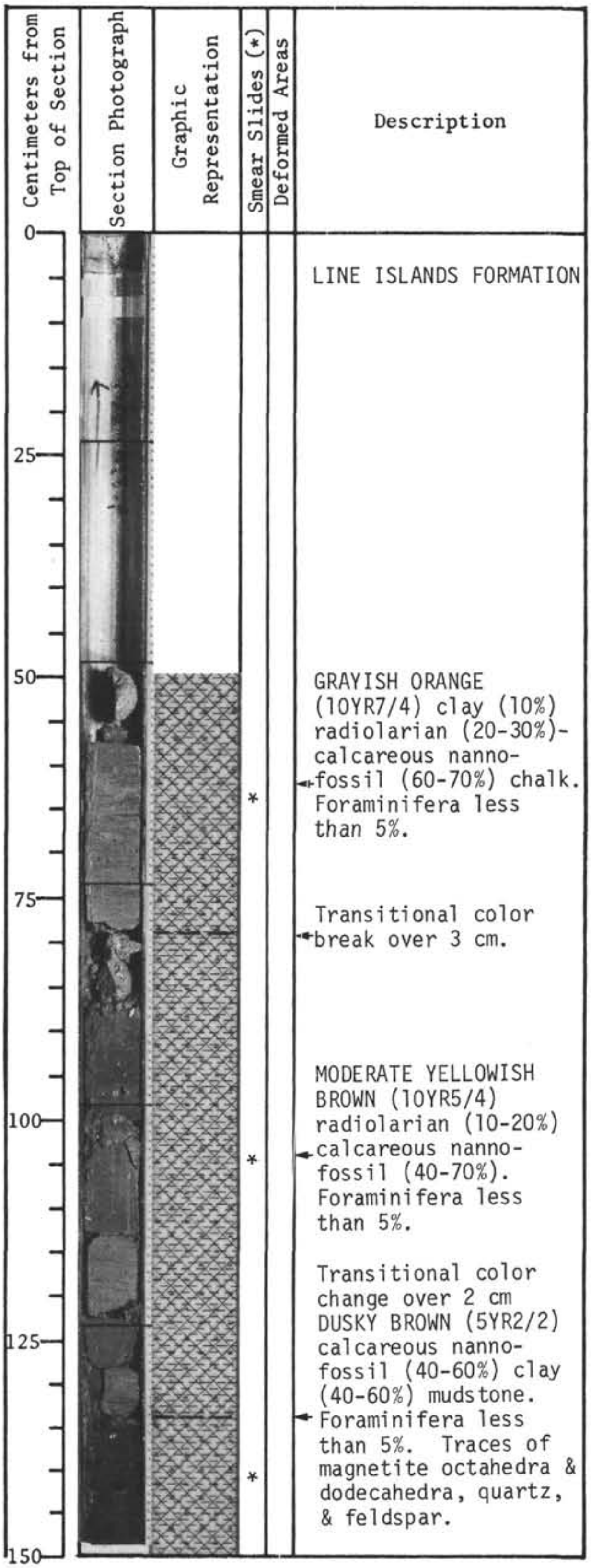


Figure 156. *Hole 77B, Core 52, Section 1.*

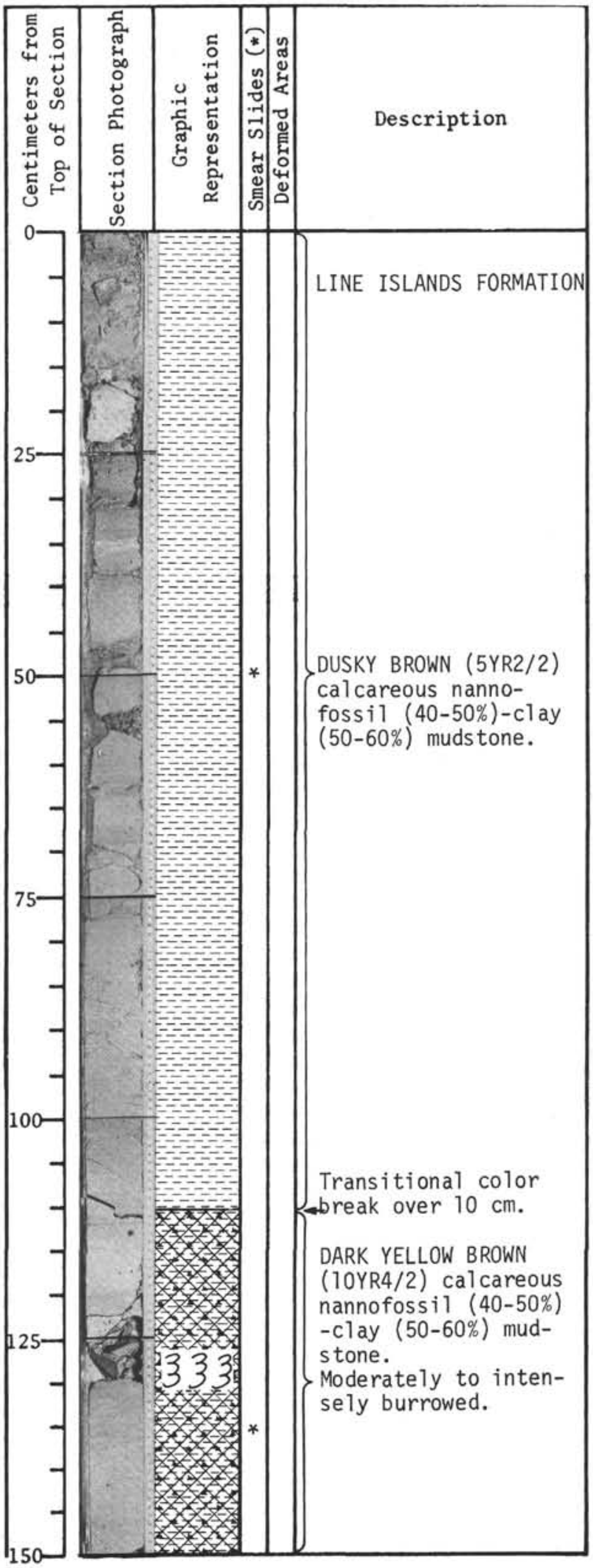


Figure 157. *Hole 77B, Core 52, Section 2.*

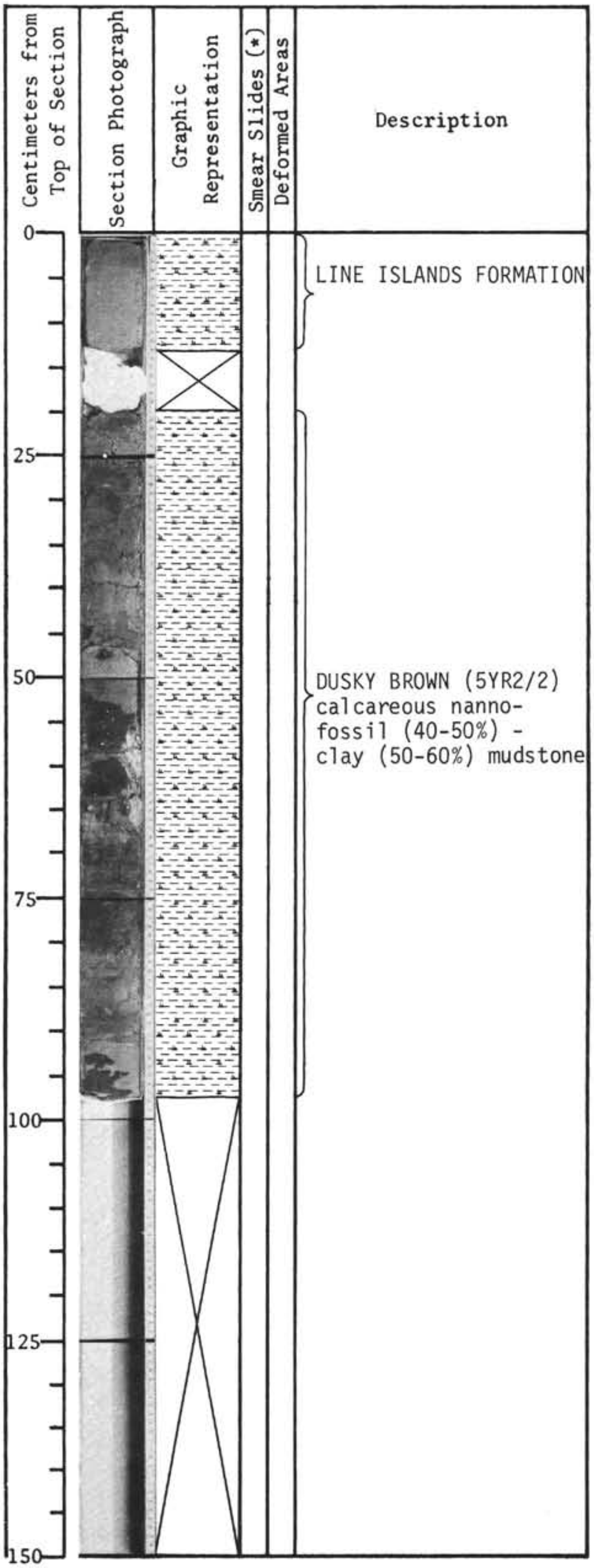


Figure 158. *Hole 77B, Core 53, Section 1.*