6. SITE 71

Shipboard Scientific Party[1]

SITE DATA

Occupied: November 2-November 10.

Position: Latitude 04° 28.28'N.
Longitude 140° 18.91'W.

Water Depth: 4419 meters.

Total Depth: 558 meters in Eocene chert.

Holes Drilled: Three holes (including heat flow hole).

Cores Taken: Fifty-two cores. Continuous 0 to 436 meters, spot cores at 472 meters, 528 meters, 553 to 558 meters.

RESULTS

Continuous core from the surface to 436 meters provides an excellent record of the stratigraphic succession from Quaternary into upper Oligocene sediments. In redrill Hole 71A, using a heavier bit, lower cores were taken in lower Oligocene chalky limestones; and probable upper Eocene siliceous limestone and calcareous chert.

BACKGROUND

Site 71 is located about 50 miles south of the southern boundary of the Clipperton Fracture Zone near 140°W. It is one of the sites along the N-S line drilled during Leg 8 to investigate the east-west trending accumulation of sediments centered about 2°N near 140°W, and lies about 120 miles south of Site 70 and 260 miles north of Site 72. Site 71 and Site 70, immediately north of the fracture zone, were chosen by the JOIDES Pacific Advisory Panel (PAP Sites 25 and 24) in order to compare the stratigraphy of the sediments and the age and nature of the basement on either side of the fracture zone.

The SCAN survey established that the area was one of gently undulating topography with an occasional hill protruding up to 600 meters above the sea floor. Except for the larger hills, acoustic basement showed small scale relief (0.05 to 0.10 second peak to trough, 2 to 4 miles across) smoothing out upward through 0.50 to 0.65 seconds of overlying sediment. The overlying sediments were found to be nearly transparent; acoustic basement was interpreted as either 'true' basement or more opaque sediments. The proposed drilling site (04° 27.6'N, 140° 14.8'W) was over a northwest trending zone of relatively smooth acoustic basement. A piston core taken at the proposed site recovered 9.9 meters of calcareous-siliceous ooze, Quaternary at top and Middle to Upper Pliocene at the bottom.

The *Challenger* survey data are in agreement with the SCAN results. However, under the assumption that smooth acoustic basement might be a cherty horizon and that the 'hills' in the acoustic basement might be true basaltic basement, an attempt was made to drill on a basement high. This attempt was unsuccessful and Site 71 is located near the base of a 0.10 second bump in the basement (Figure 1 and Figure 10, Chapter 2).

At Site 71 the prominent reflectors are at 0.050, 0.185, 0.375 and 0.595 seconds. The upper reflector (0.050 second) correlates with the bottom of a cyclic unit of alternating siliceous and calcareous ooze at 43 meters and the 0.185 second reflector correlates with a cherty horizon and general increase in resistance to drilling that occurs near 160 meters (Figures 6, 7 and 8, Chapter 2). The 'basement' reflector (0.595 second) correlates with the top of a thick section of semi-indurated chalk, capped by a 3-centimeter chert layer at 470 meters near the bottom of Hole 71.

Geothermal heat flow measurements attempted at Site 71 indicate a value somewhat greater than 1.0 HFU (10^{-6} cal cm^{-2} sec^{-1}) and are discussed in detail in Chapter 18. A measurement during the SCAN survey at the proposed site gave 1.55 HFU; values lower than 1.0 HFU were found in the vicinity by other investigators.

A topographic map of the vicinity of Site 71, airgun records, and further site information are given in Chapter 25.

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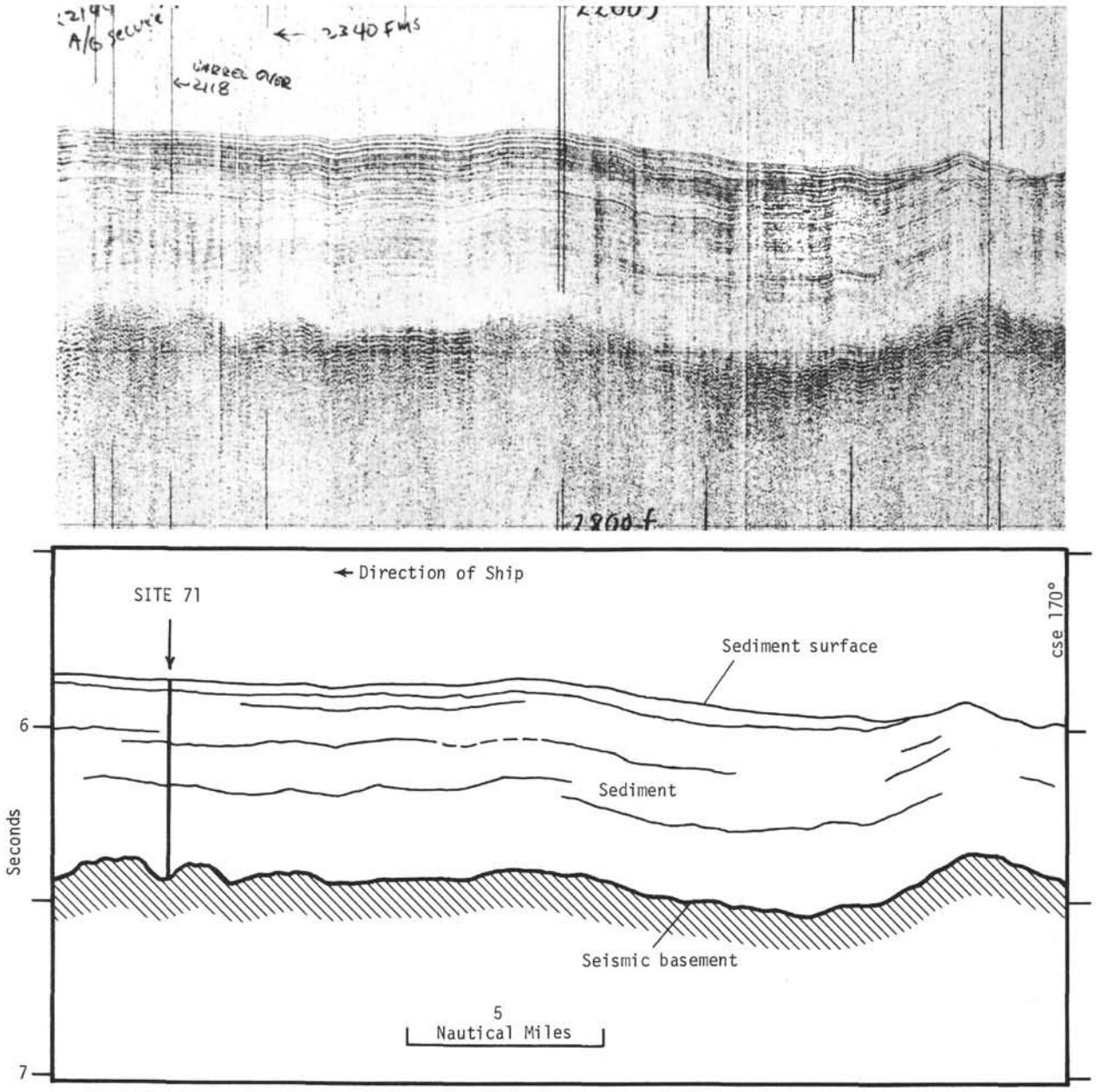


Figure 1. *Airgun record across Site 71 and interpretation.*

OPERATIONS

Hole 71 was cored continuously from the sea floor to a depth of 436 meters with excellent recovery, except for some of the cores taken in Miocene and Oligocene nannofossil ooze, which were "soupy" and much disturbed. Below about 160 meters the ooze was stiffer and the pump was used occasionally during coring.

Below 436 meters it was decided to drill ahead, coring every 30 to 50 meters. A core of thin chert overlying 2 meters of Oligocene chalk was recovered from 472 meters, but another hard layer a little lower could not be penetrated after several hours drilling. The drill string then was pulled in order to replace the bit. A successful Welex log was run on pulling out of the first hole. Hole 71A was drilled through the hard layers to

TABLE 1
Summary of Coring at Site 71

	Core No.	Interval Below Seafloor (meters)	Cored (m)	Recovered (m)	Comments
Hole 71	1	0-9	9.1	9.1	
	2	9-18	9.1	7.0	Seven foot loss assigned to top of core
	3	18-27	9.1	9.1	
	4	27-34	6.1	6.1	20 feet cored; 30 feet recovered; "gain" distributed
	5	34-43	9.1	9.1	
	6	43-52	9.1	9.1	
	7	52-61	9.1	9.1	
	8	61-69	9.1	7.6	5 foot loss at bottom of core
	9	70-79	9.1	9.1	
	10	79-88	9.1	9.1	
	11	89-98	9.1	9.1	
	12	98-107	9.1	9.1	
	13	107-116	9.1	9.1	
	14	116-125	9.1	9.1	
	15	125-134	9.1	9.1	
	16	134-143	9.1	1.5	Loss at top
	17	143-152	9.1	9.1	
	18	152-161	9.1	9.1	
	19	161-170	9.1	9.1	
	20	170-179	9.1	9.1	
	21	179-188	9.1	9.1	
	22	189-198	9.1	8.8	
	23	198-207	9.1	9.1	
	24	207-216	9.1	9.1	
	25	216-225	9.1	7.6	
	26	225-234	9.1	8.2	
	27	235-244	9.1	0.9	One meter recovered, core probably near bottom
	28	244-253	9.1	9.1	
	29	253-262	9.1	8.8	
	30	262-271	9.1	9.1	
	31	271-280	9.1	7.9	Loss probably at top
	32	280-289	9.1	9.1	
	33	290-299	9.1	3.0	Core mostly liquid
	34	299-308	9.1	8.8	
	35	308-317	9.1	9.1	
	36	317-326	9.1	9.1	

TABLE 1 – *Continued*

	Core No.	Interval Below Seafloor (meters)	Cored (m)	Recovered (m)	Comments
Hole 71 – *Continued*					
	37	326-335	9.1	6.1	
	38	336-345	9.1	9.1	
	39	345-354	9.1	1.8	Very poor core at bottom of barrel
	40	354-363	9.1	9.1	
	41	363-372	9.1	1.5	Very poor core recovery assigned to bottom
	42	372-381	9.1	9.1	
	43	381-390	9.1	3.1	Loss probably at top
	44	390-399	9.1	9.1	
	45	399-408	9.1	3.1	Loss probably at bottom
	46	408-417	9.1	8.8	
	47	418-427	9.1	6.1	
	48	427-436	9.1	3.4	
		436-468			Drilled down to hard layer
	49	472-474	6.1	2.1	
		474-475			Drilled
					Core attempted at 16,091 feet; no recovery, no penetration
Total	49	475	442.0	369.1	84% recovery
Hole 71A	1	528-537	9.1	1.1	
	2	553-555	1.8	1.8	
	3		2.7	2.7	
	4	555-558			
Total		558	13.7	5.7	41% recovery

528 meters, where a core of Oligocene chalky limestone was recovered, and two more cores were taken in limestone and chert of probable upper Eocene age, from 553 to 558 meters. The hole was terminated because of time. Penetration in the limestone and chert ranged from 0.3 meter to 0.6 meter per hour.

A third hole, Hole 71B, was drilled as a heat probe hole. Measurements were made at 30, 100, and 250 meters (see Von Herzen and others in Part III, this volume).

LITHOLOGY AND STRATIGRAPHY

Three sedimentary formations are present at Site 71: the Clipperton Oceanic Formation (0 to 188 meters) consisting of a cyclic unit (0 to 43 meters) of alternating calcareous and siliceous ooze, and a varicolored unit (43 to 188 meters) of calcareous ooze; the Marquesas Oceanic Formation (188 to 545 meters) consisting of grayish calcareous ooze; and the Line Islands Oceanic Formation (545 to 558 meters) of silicified limestone with chert intergrowths.

Clipperton Oceanic Formation

The Clipperton Oceanic Formation is composed of two units at Site 71. The upper cyclic unit consists of calcareous oozes alternating with more siliceous oozes from the sea floor to a depth of 43 meters. The contacts between the two lithologies are usually sharp

and marked by color changes. Individual lighter-colored layers typically exhibit sharp basal contacts and grade upward through mottled zones into darker-colored layers. Although the compositional changes are not as great as in the cyclic unit of the Clipperton Oceanic Formation at Sites 69 and 70, they are distinguishable. Individual beds are of the order of 5 to 20 centimeters in thickness. Much of the bedding, however, has been badly disturbed during coring due, in part, to the plasticity of the sediment. The more calcareous beds are radiolarian-nannofossil oozes (50 to 90 per cent calcareous nannoplankton, 10 to 50 per cent Radiolaria) and are white to very light brown. The more siliceous beds are nannofossil-radiolarian oozes (50 to 70 per cent Radiolaria, 30 to 50 per cent calcareous nannoplankton) and are various shades of brown. In general the darker brown the color the lower the carbonate content.

The cyclic unit is Quaternary, Pliocene and late Miocene in age. The contact of the cyclic unit with the underlying varicolored unit is sharp and is placed at the top of the uppermost pastel-hued bed.

The varicolored unit of the Clipperton Formation (43 to 188 meters) is distinguished mainly by its pastel colors. Compositionally it is mostly radiolarian-nannofossil ooze as are the lighter-colored beds of the overlying cyclic unit and the light grayish beds of the underlying Marquesas Formation. Most of the varicolored unit is composed predominantly of calcareous nannoplankton (75 per cent) with Radiolaria (25 per cent). No compositional differences were noted among the various colored beds making up the unit. The 150 to 180 meter interval contains more foraminifera than the rest and has an average composition of 65 per cent calcareous nannoplankton, 20 per cent foraminifera, and 15 per cent Radiolaria. The varicolored unit is characterized by pastel hues of bluish and greenish white and in the upper part of the unit (43 to 68 meters), of purple. This varicolored nature of the unit is more pronounced in the upper portion than in the lower portion resulting in a gradational contact with the underlying Marquesas Formation. The varicolored unit is Miocene in age, most of it being middle Miocene.

Marquesas Oceanic Formation

The Marquesas Oceanic Formation at Site 71 from 188 to 545 meters is a relatively homogeneous highly calcareous (mostly 80 to 90 per cent) nannoplankton ooze, bluish white to very light gray in color. Radiolaria, foraminifera, and diatoms are locally important constituents. The formation appears structureless except for the presence of gray streaks and diffuse layers. The Marquesas Oceanic Formation is more indurated and less disturbed by coring than the overlying Clipperton Oceanic Formation. Induration gradually increases downward from a depth of about 207 meters, apparently due to diagenetic overgrowths of secondary calcium carbonate ($CaCO_3$) particularly on discoasters. A 3-centimeter thick zone of greenish-gray volcanic ash occurs at a depth of 433.5 meters and a 3-centimeter thick fragment of dark gray chert occurs at 470 meters. Both are within highly calcareous, semi-indurated oozes of late Oligocene age.

Most of the section below 436 meters was drilled rather than cored, thus details concerning the sequence are lacking. However, from the nature of the drilling and of the recovered core, we infer that the Oligocene interval is mainly semi-indurated ooze (chalk) similar to that in the Marquesas at Site 70 between 177 and 324 meters. Several harder layers in the uncored interval that took longer to penetrate may represent thin chert stringers within the Marquesas.

The basal contact of the Marquesas Oceanic Formation lies in the uncored interval between 537 and 553 meters and is tentatively placed at 545 meters. The Marquesas is early Miocene and Oligocene in age.

Line Islands Oceanic Formation

The Line Islands Oceanic Formation at Site 71 is composed of an upper Eocene chert-silicified limestone association cored from 553 meters to the bottom of the hole at 558 meters.

Chert (see Chapter 16) occurs as dark olive-gray anastomizing intergrowths and small "whisks" within white silicified limestone. The chert is subordinate to limestone and the intergrowths range in dimension from several centimeters down to fractions of a millimeter. Along with the olive gray chert, a small amount of intergrown vitreous yellowish-brown chert is occasionally present.

In thin section, ghosts of foraminifera and siliceous microfossils are evident, both in the silicified limestone and the chert. The olive gray chert contains many fossil ghosts, ranging in composition from unreplaced calcium carbonate ($CaCO_3$) to total replacement by cristobalite. The yellowish-brown vitreous chert consists of a cryptocrystalline mosaic of quartz. In this type of chert fossil ghosts are rare, due to obliteration by recrystallization.

The silicified limestone exhibits bedding laminae in places, generally less than one millimeter thick. Minute dragfolding of the laminae is seen along slip planes or microfaults that cut the laminae at moderate angles. These microstructures formed before the silicification of the limestone. Burrow structures are numerous, imparting a hieroglyphic appearance.

The hole terminated at 558 meters in what appears to be an increasingly cherty sequence.

Figure 6 is a plot of age versus depth, based on the biostratigraphic zonations of the foraminifera, nannoplankton, and Radiolaria, with the time scale, in millions of years, based on that of Berggren (1969).

PHYSICAL PROPERTIES

Porosities range from less than 40 to about 85 per cent and velocities range between about 1.49 and 1.68 km/sec. In Figure 2 it can be seen that most of the sediment sampled is highly calcareous and that the velocity-porosity data fall near and above the theoretical curve for a grain-matrix density of 2.65 g/cm^3. In general, sonic velocity and impedance increase, and porosity and penetrability decrease, monitonically with depth (Figures 6, 7 and 8, Chapter 2). Sonic velocity first exceeds that for sea water at a depth of about 100 meters.

Velocities and densities were determined for several pieces of limestone, cherty limestone, chert and chalk (Chapter 2). The highest velocity measured from this site, 6.10 km/sec, was for a chert of density 2.55 g/cm^3. Another sample, a cherty limestone, measured 6.03 km/sec and 2.38 g/cm^3.

Maximum natural gamma radiation of about 1250 counts was measured for the very top of the sedimentary section. Activity drops off with depth to a low level and remains low until it increases again near the bottom of the section within the Line Islands Oceanic Formation.

Thermal conductivities measured for this site are given in Chapter 18.

Results of grain-size and carbon-carbonate analyses are tabulated in Appendices II and III, respectively.

PALEONTOLOGY

Foraminifera

Of the two holes drilled at this Site, Hole 71 (with 49 cores) reached a depth of 475 meters. In Hole 71A, deeper penetration was achieved down to 558 meters, and three spot cores were recovered in the Lower Oligocene and Eocene. The 48 continuous cores of Hole 71 have furnished a nearly complete section from the Quaternary down to the Oligocene (*Globorotalia opima opima* Zone, P. 21). The planktonic foraminifera are richer than in Site 70 and permit a fairly reliable and continuous zonation. The Quaternary and Pliocene are relatively thin, but there is an excellent, thick Miocene section. The Oligocene and Eocene were not continuously cored. They appear to be similar in thickness to Site 70, but slightly more calcareous. In the Oligocene and Eocene, the rocks become progressively harder, and in the three cores of Hole 71A we find many compressed specimens of planktonic foraminifera, indicating that the sediment has been affected by compaction.

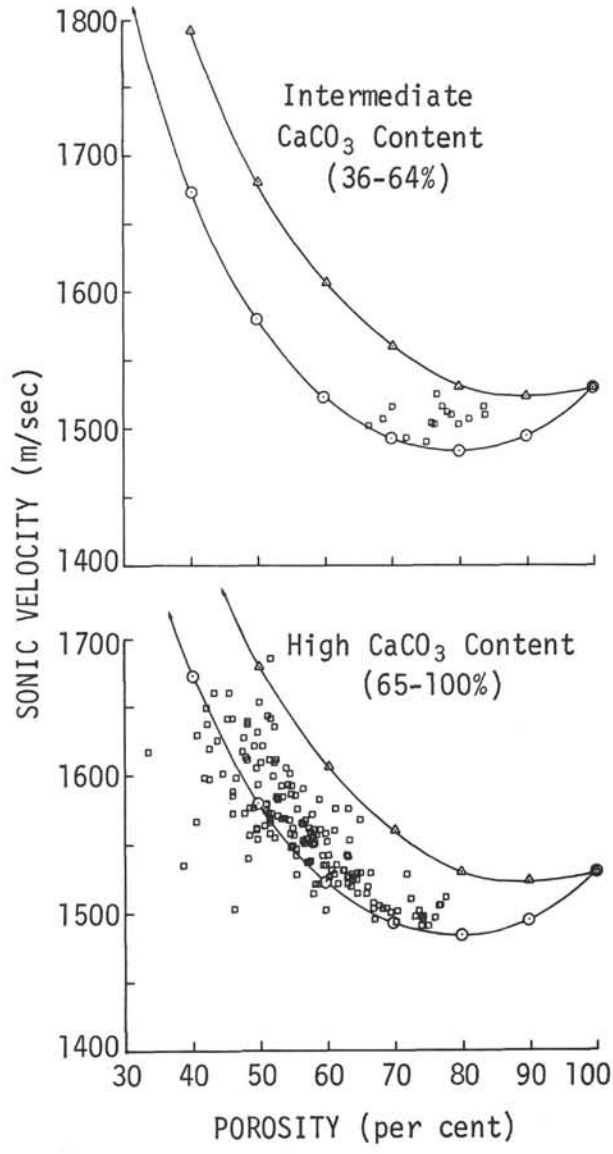


Figure 2. *Sonic velocity versus porosity of unlithified sediments from Site 71 for two ranges of calcium carbonate content. No measured samples contained less than 35 per cent calcium carbonate. Theoretical curves are based on the equation of Wood (1941). Upper curve, grain matrix density 2.2 g/cm^3, appropriate for siliceous ooze. Lower curve, grain-matrix density 2.65 g/cm^3, appropriate for calcareous ooze.*

Although the foraminiferal assemblages of Site 71 are often fairly rich, they are highly variable in preservation, number of specimens, and species diversity. The typically thin-walled genera (*Candeina, Globigerinita*) are practically absent. Small-sized specimens are often missing, and there is a remarkable scarcity of *Globigerinoides* and *Orbulina* throughout the section. These observations indicate that calcium carbonate solution is a main controlling factor. Although the benthonic foraminifera form a lesser percentage of the faunas than in Sites 69 and 70, they are richer in species, particularly of the genera *Dorothia* and *Cibicides.*

Quaternary faunas are found down to Section 71-1-5 (depth 8 meters). The upper Quaternary appears to be much reduced in thickness, since the coiling change from random to dextral in *Pulleniatina* spp., which normally occurs about in the middle of the Pleistocene, is found here only about 150 centimeters below the sea floor (bottom of Section 1 of Core 1). The major constituents of the Quaternary faunas are *Globorotalia tumida, Pulleniatina* spp., *Sphaeroidinella dehiscens* and *Globigerina dutertrei.*

The Pliocene was recognized from the core catcher sample of Core 1 to the bottom of Core 2 (8 to 18 meters). Possibly the three zones N. 21, N. 20 and N. 19 are all present. *Globorotalia tosaensis* occurs in the core catcher sample of Core 1 (its presence at the bottom of Core 2 is probably due to contamination). The earliest *Globorotalia pseudopima*, indicating the base of N. 20, is found in Section 71-2-2. A little below this, in Section 71-2-4, the highest *Sphaeroidinellopsis seminulina* and *S. paenedehiscens* are recorded.

The uppermost Miocene unit, N. 18, characterized by the concurrence of *Sphaeroidinellopsis* spp. and *Globorotalia tumida* (without *Sphaeroidinella*), extends from 71-3-1 to 71-4-2 (18 to 30 meters). The next lower unit, N. 16-17, extends to 71-7-1 (53 meters), where the earliest *Globorotalia acostaensis* appears. *Globorotalia* cf. *plesiotumida* is found down to Section 71-6-3. The interval from 71-7-2 to the bottom of 71-8 (53 to 70 meters) is assigned to the *Globorotalia menardii* Zone (N. 15).

In the Upper Miocene, the foraminifera are usually clearly outnumbered by the Radiolaria, but in the Middle Miocene there is a gradual downward increase of the calcareous microfauna until Core 21. The *Globorotalia mayeri* Zone includes the whole of Core 9 (70 to 79 meters). Below a short poorly defined interval (N. 13?) in the upper part of Core 10, the sample at 71-10-5 shows the youngest representatives of the *Globorotalia fohsi* lineage. The successive zone boundaries are located as follows:

Base of *Globorotalia foshi robusta* Zone: Section 71-12-1 (depth 99 meters).

Base of *G. f. lobata* Zone (approximate base N. 12) at 71-13-5 (115 meters).

Base of *G. f. praefohsi* Zone (N. 11): core catcher sample of 71-15 (134 meters).

Base of *G. f. peripheroacuta* Zone (N. 10) at 71-17-2 (146 meters).

Base of *G. f. peripheroronda* Zone (N. 9), as indicated by the earliest *Orbulina suturalis,* at 71-19-1 (162 meters).

Base of N. 8 (earliest *Globigerinoides sicanus*) at 71-22-6 (198 meters).

The general scarcity of *Orbulina* and *Globigerinoides* at Site 71 has already been mentioned; it is therefore possible that the base of N. 8 and of N. 9 were placed a little too high. In Cores 23 to 25, whose age is most probably N. 7, there is again a temporary increase in the frequency of the Radiolaria.

The highest *Catapsydrax dissimilis,* which marks the top of N. 5-6 (combined *Catapsydrax dissimilis* and *C. stainforthi* Zones), is found at the top of Core 26 (depth 225 meters). The *Globorotalia kugleri* Zone (N. 4) is recognized in Cores 31 to 38 (272 to 345 meters). The earliest *Globigerinoides primordius* was seen in the core catcher sample of Core 36. Cores 39 and 40 are predominantly siliceous and may be either *Globorotalia kugleri* Zone or *Globigerina ciperoensis ciperoensis* Zone. Within Core 41, the samples become again more calcareous and can be placed with more confidence in the *G. ciperoensis ciperoensis* Zone (P. 22). The top of the *Globorotalia opima opima* Zone (P. 21) coincides with the top of Core 46 (at 409 meters). This Zone extends as far down as the spot core 49 (474 meters) and most probably into the uncored interval below.

The Lower Oligocene *Pseudohastigerina/Cassigerinella chipolensis* Zone (P. 18-19) is represented in the spot core 71A-1 (535 to 537 meters). Cores 71A-2 and 71A-3 can be tentatively determined as Upper to upper Middle Eocene (P. 13 or younger) because of the presence of *Catapsydrax dissimilis, Globigerina linaperta* and *Alabamina dissonata.*

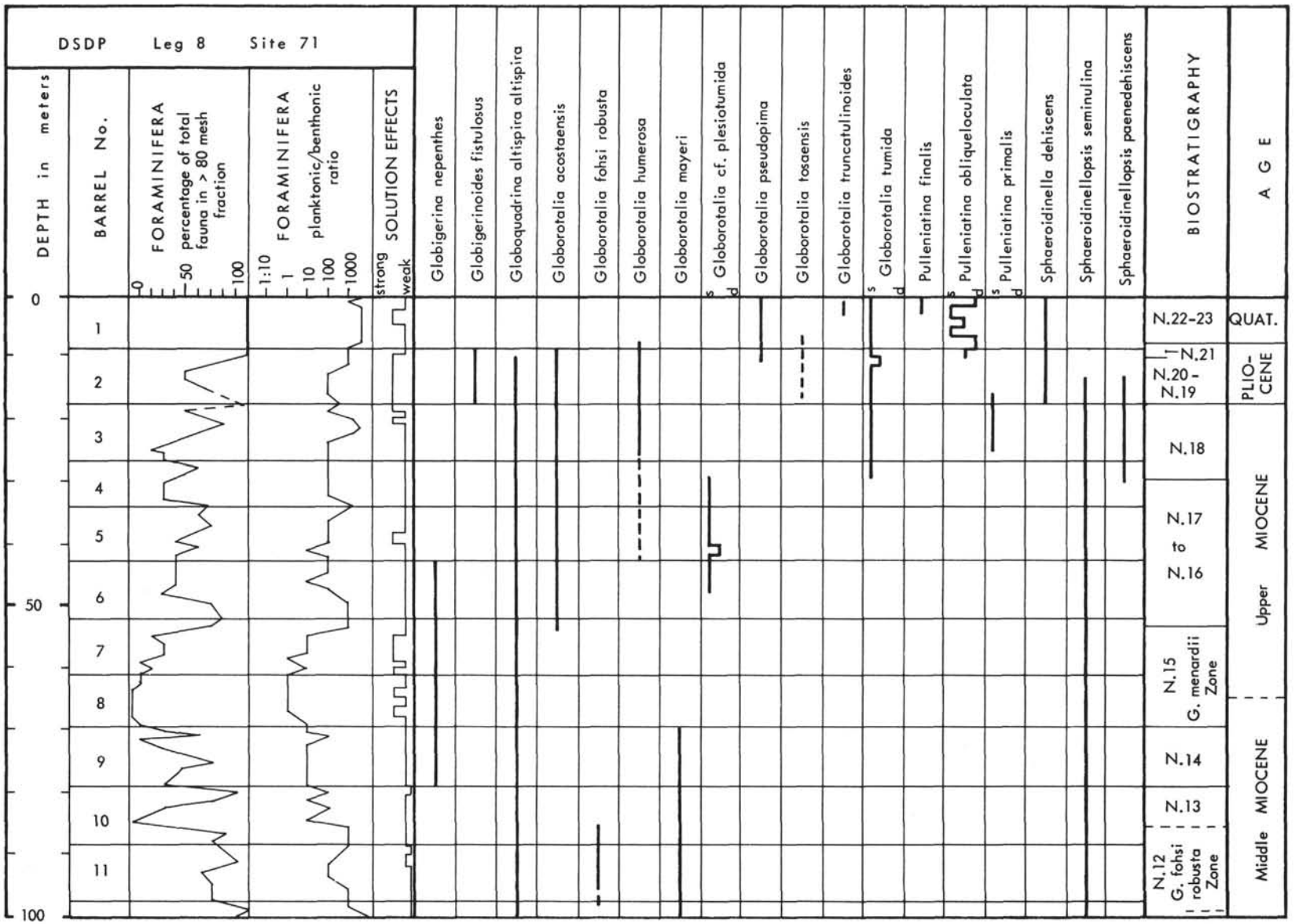
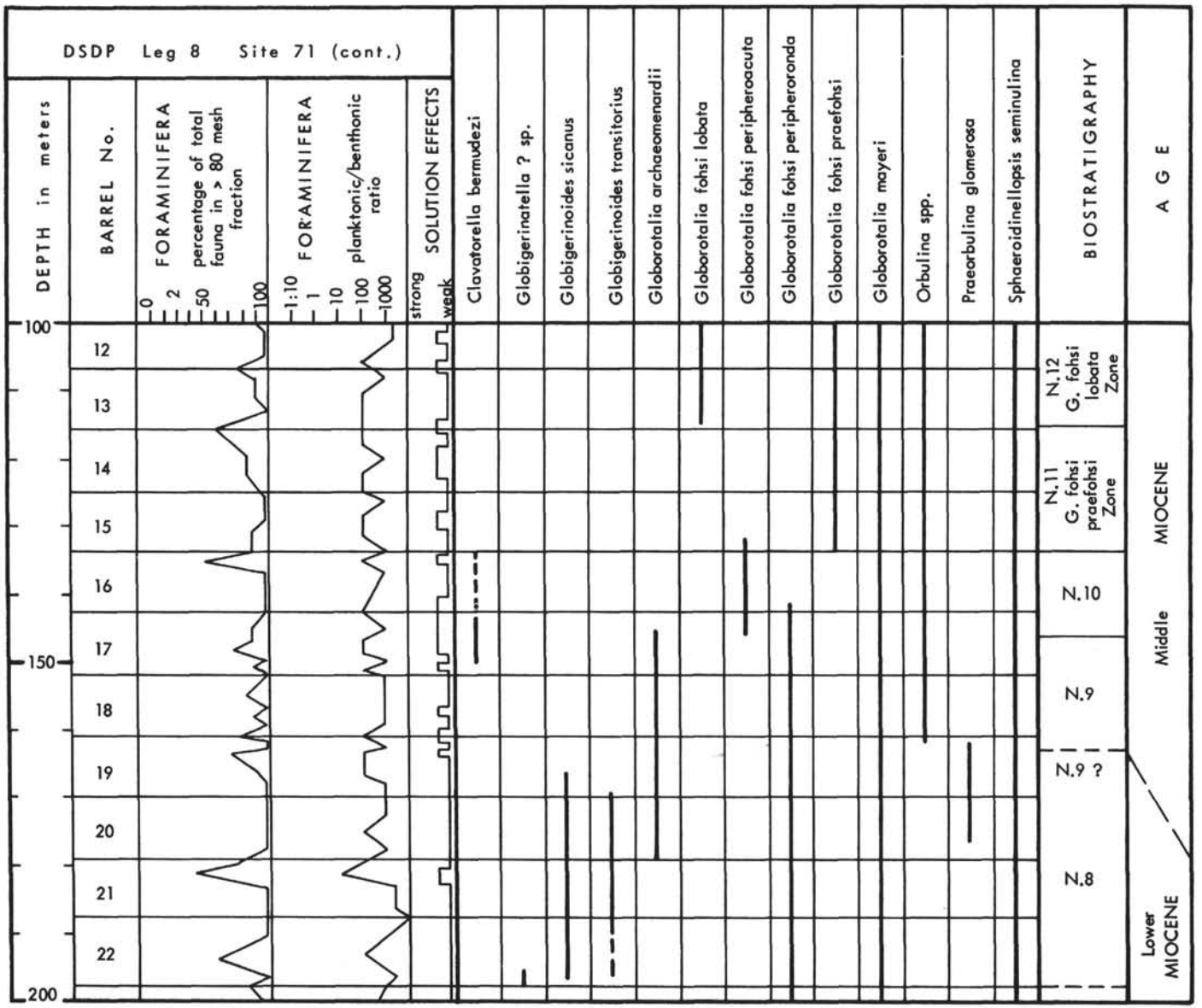


Figure 3. *Foraminifera of Site 71. Frequency distribution, ranges of important species, and biostratigraphy.*



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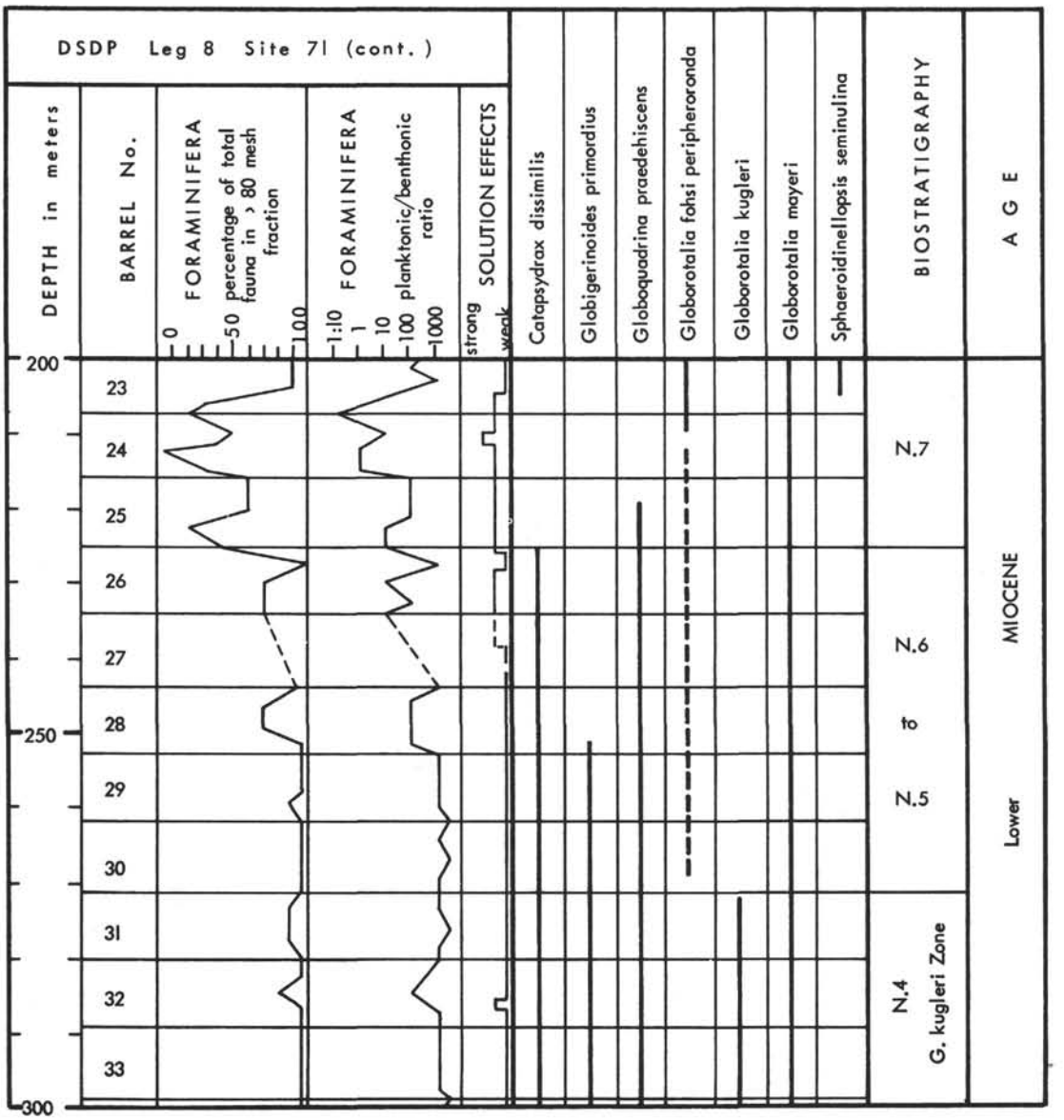

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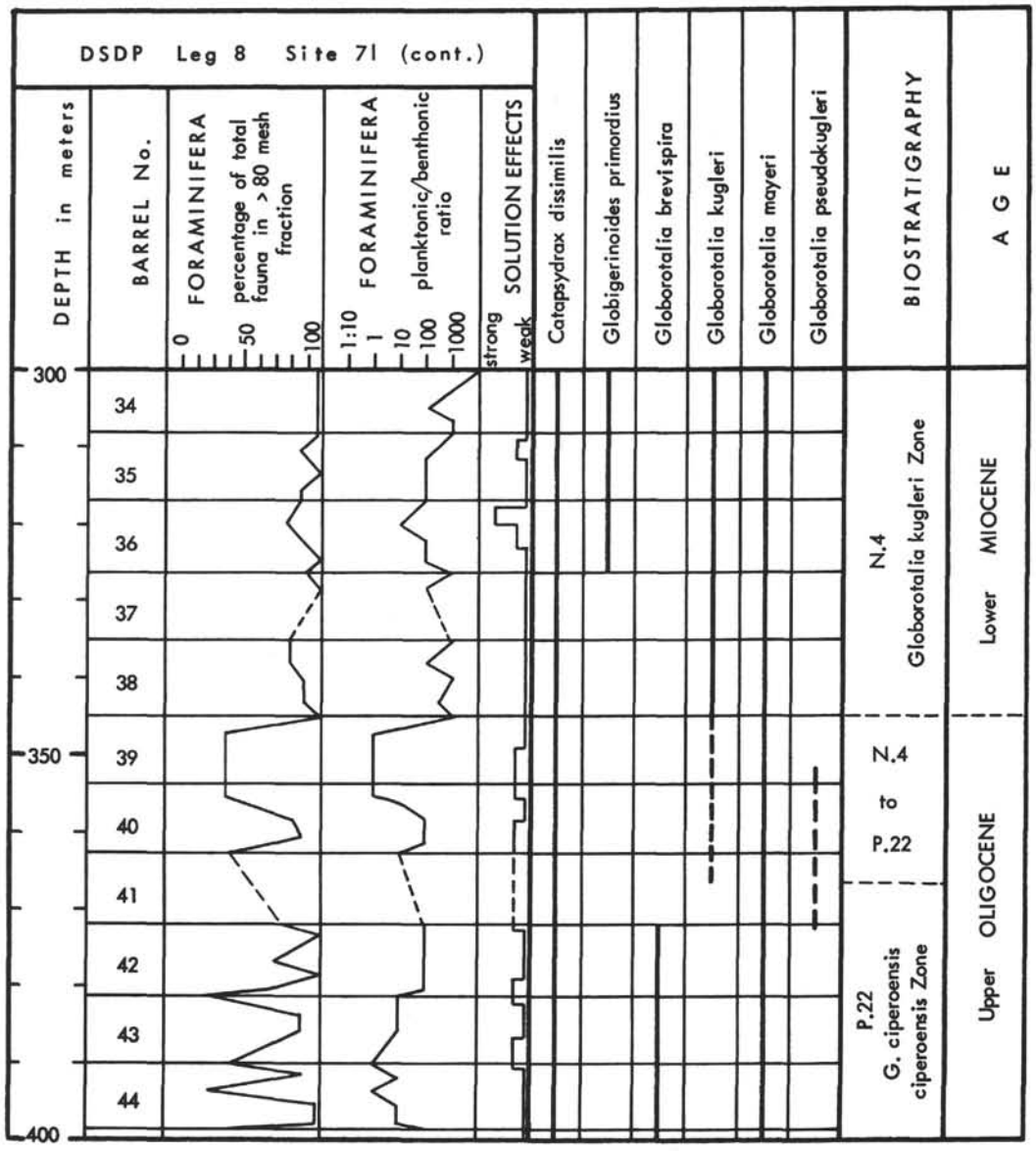

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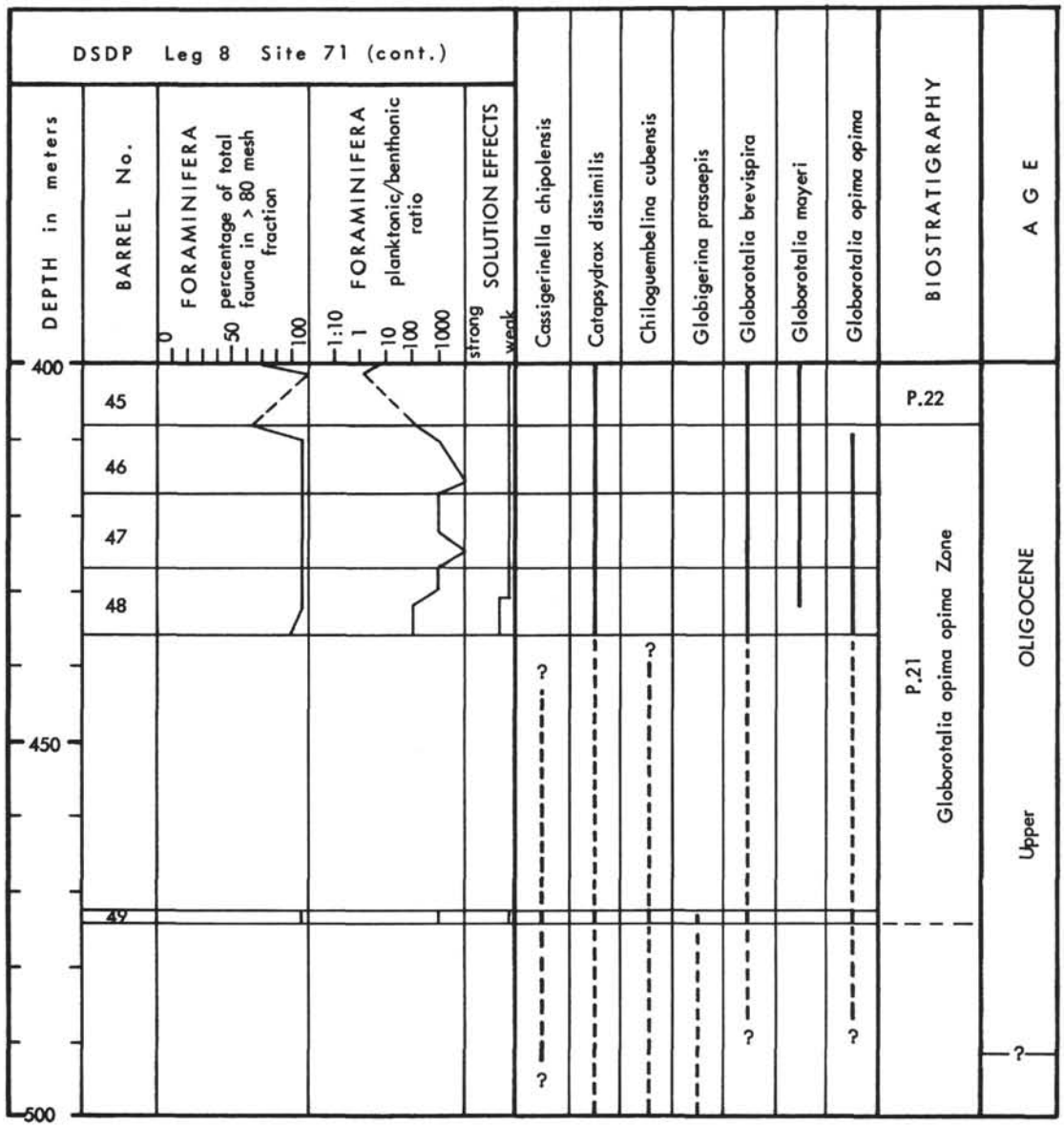

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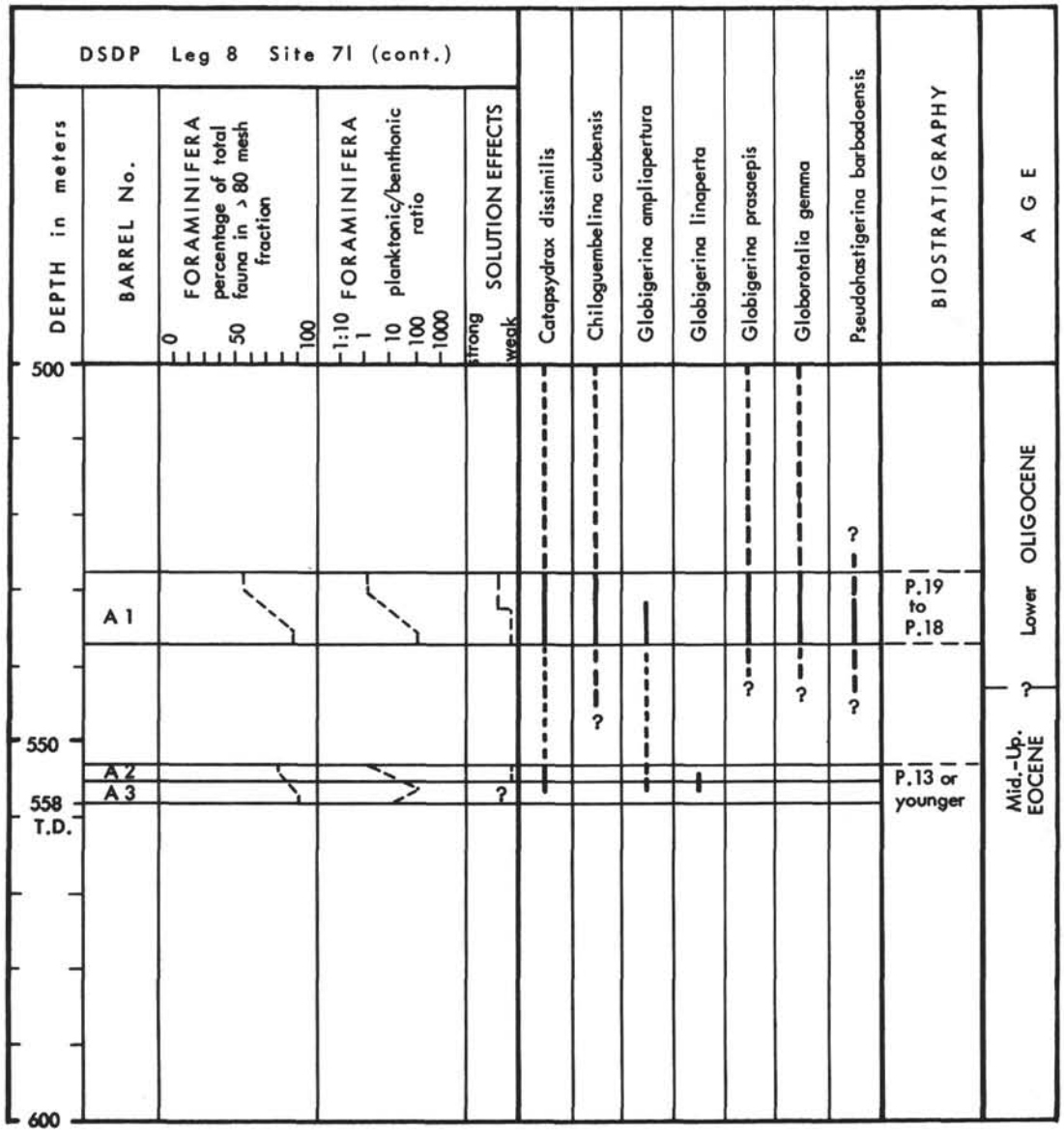

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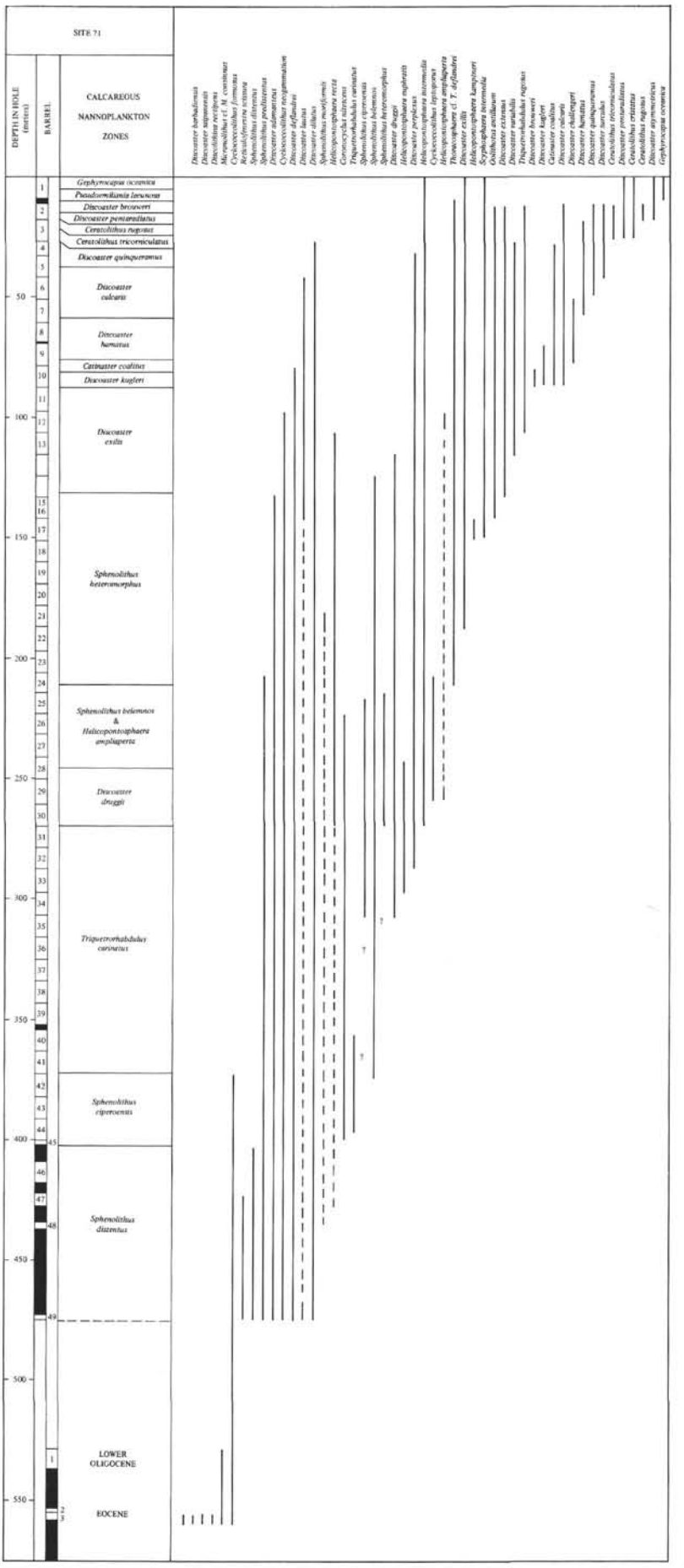


Figure 4. *Calcareous nannoplankton of Site 71. Distribution and biostratigraphy.*

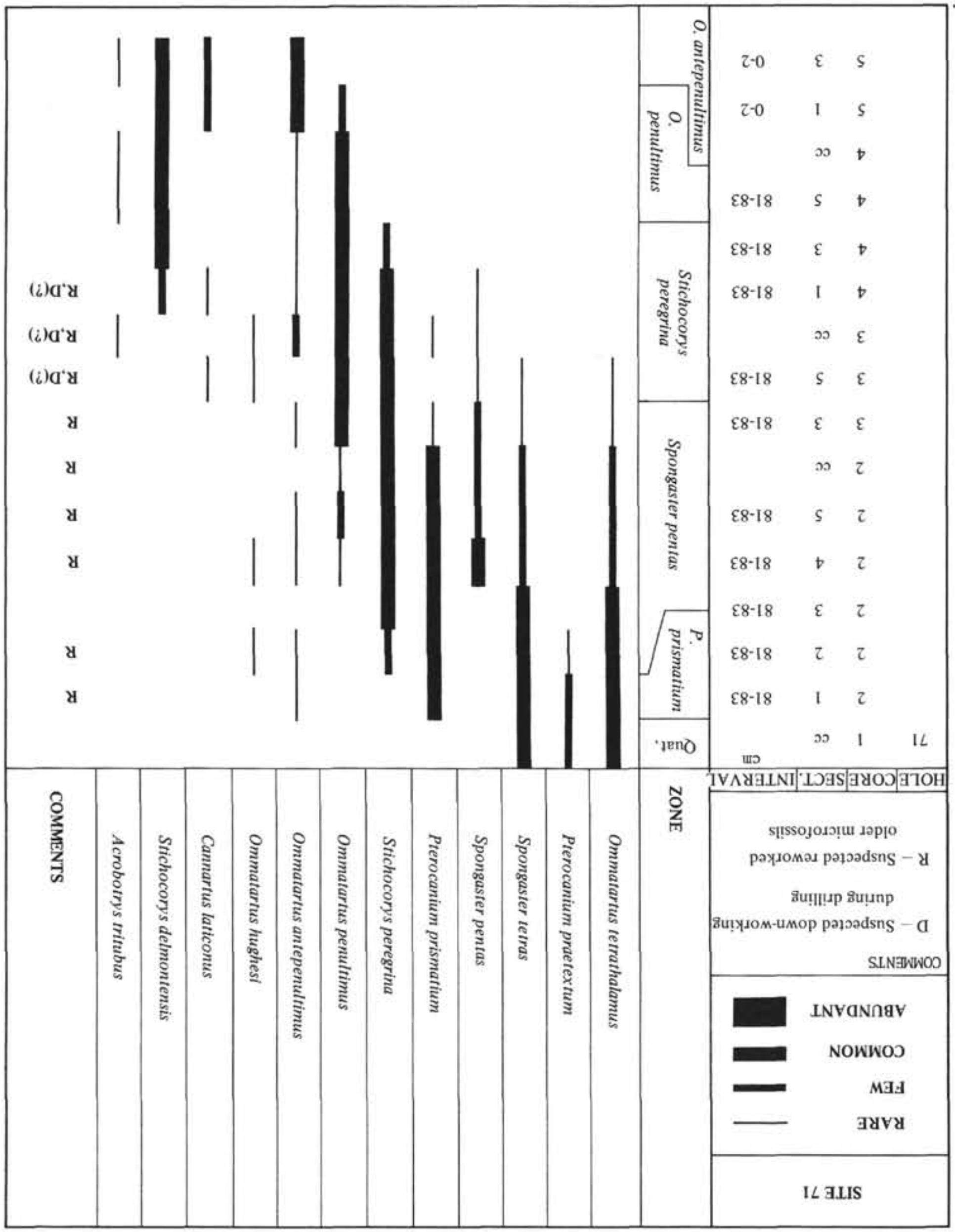
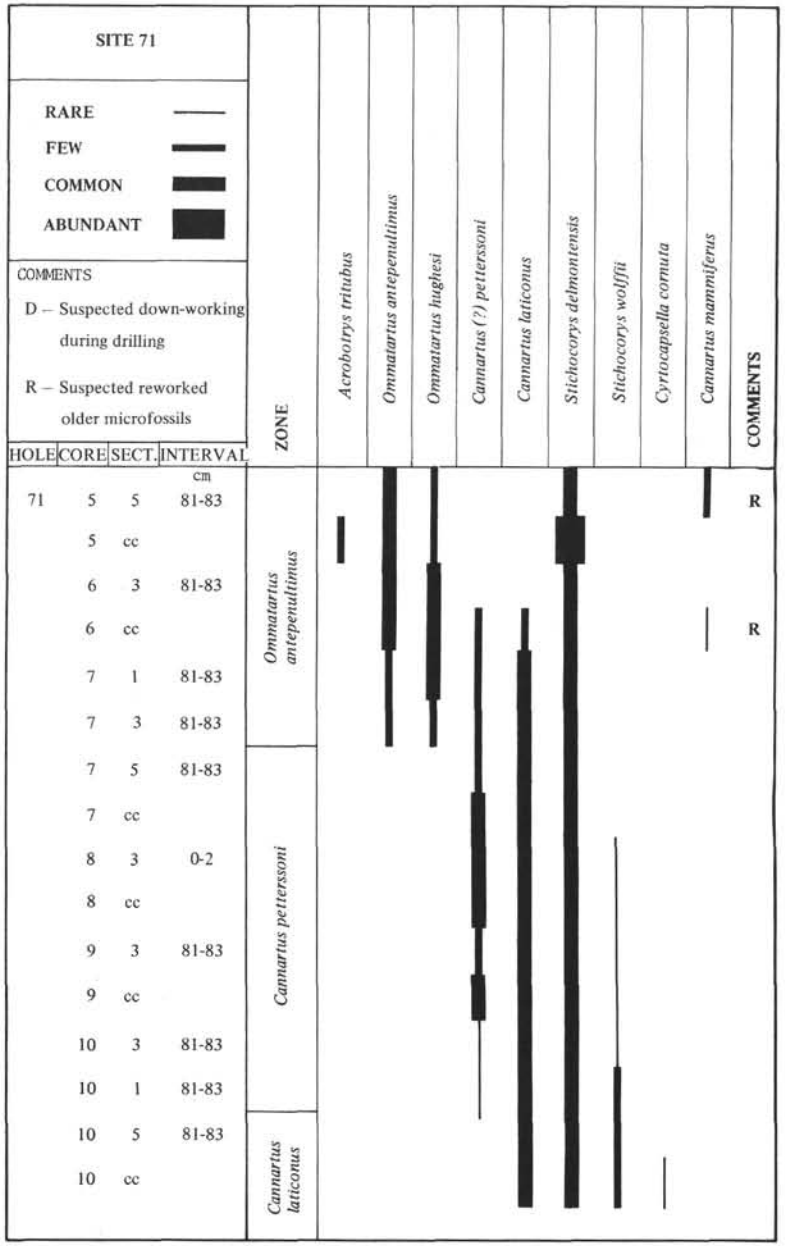


Figure 5. *Radiolaria at Site 71. Frequency, distribution and biostratigraphy.*



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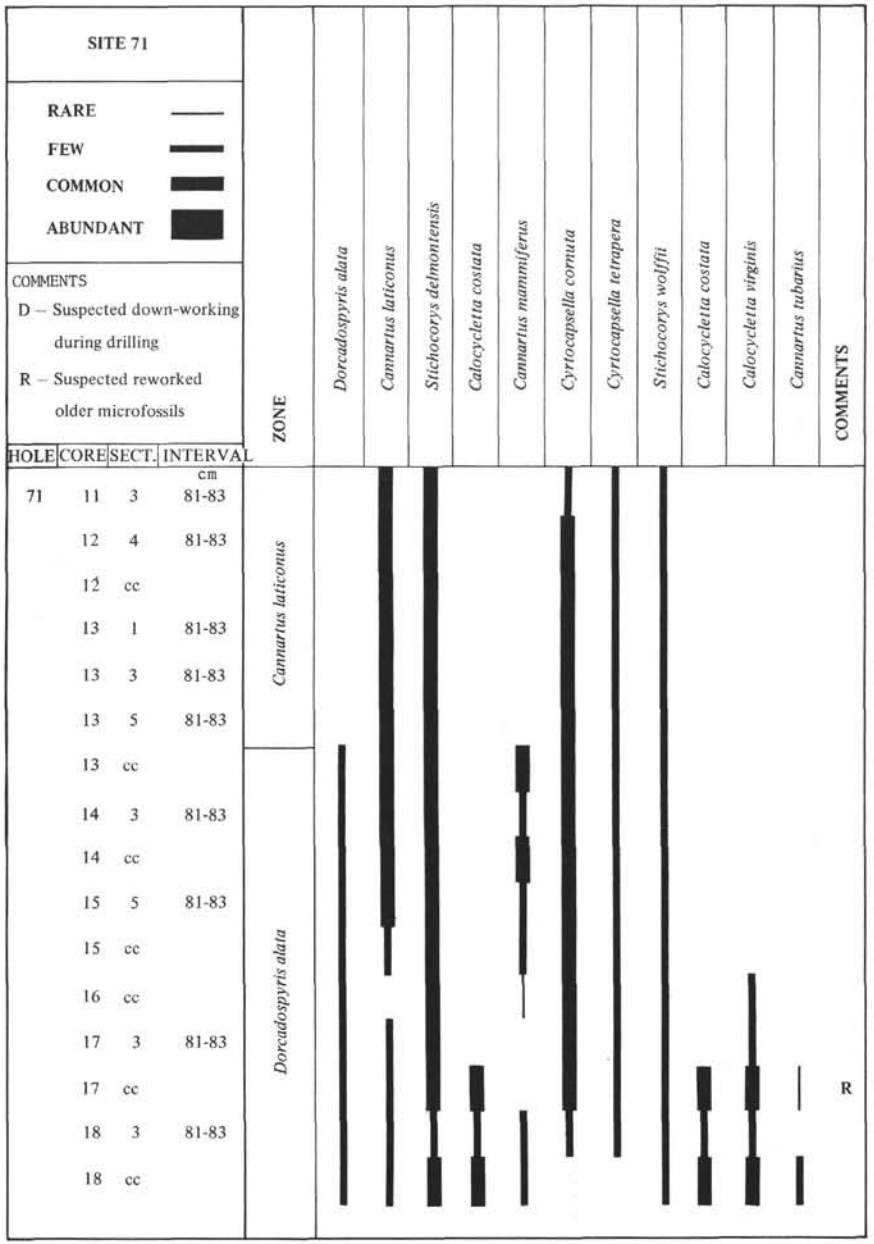

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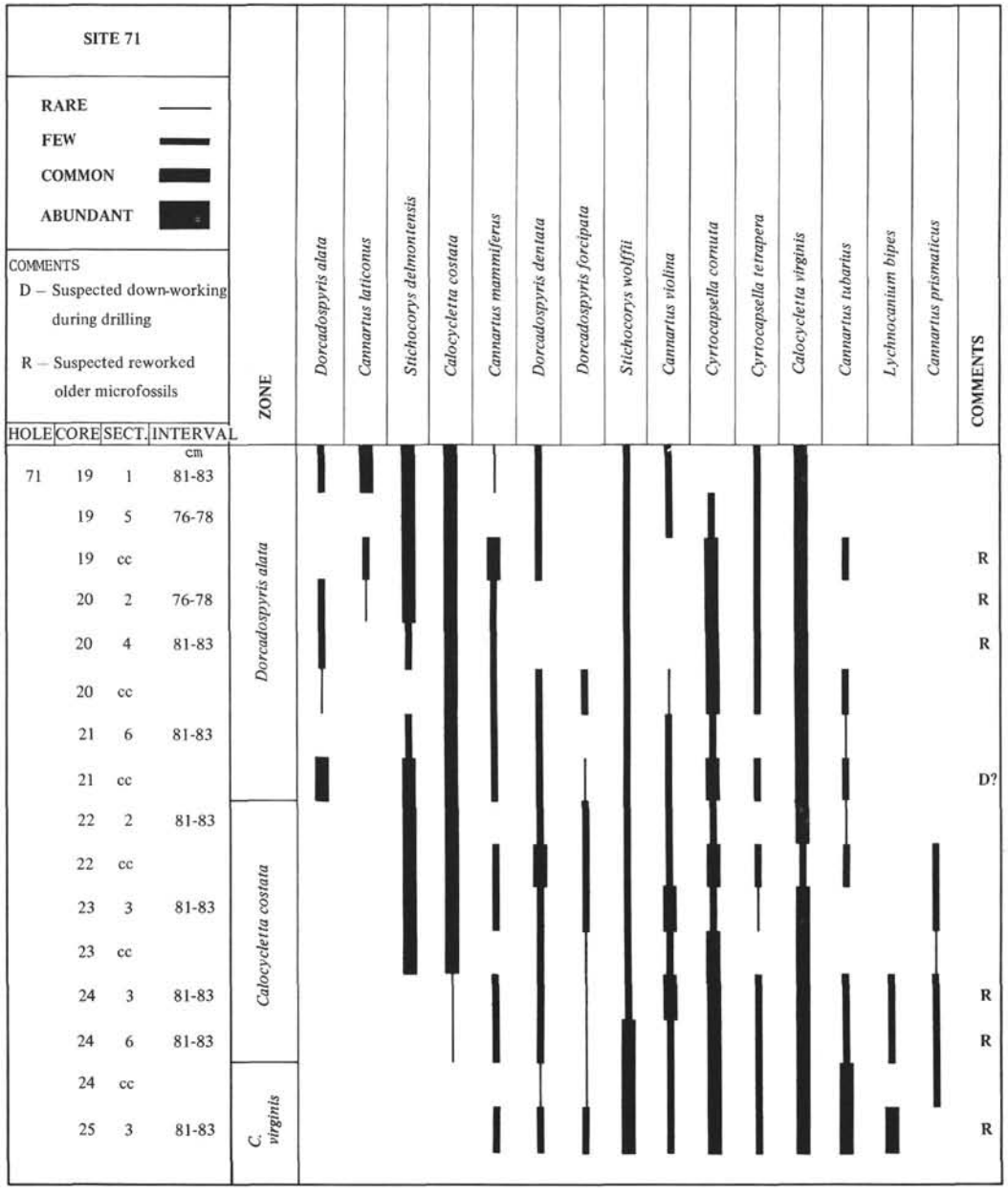

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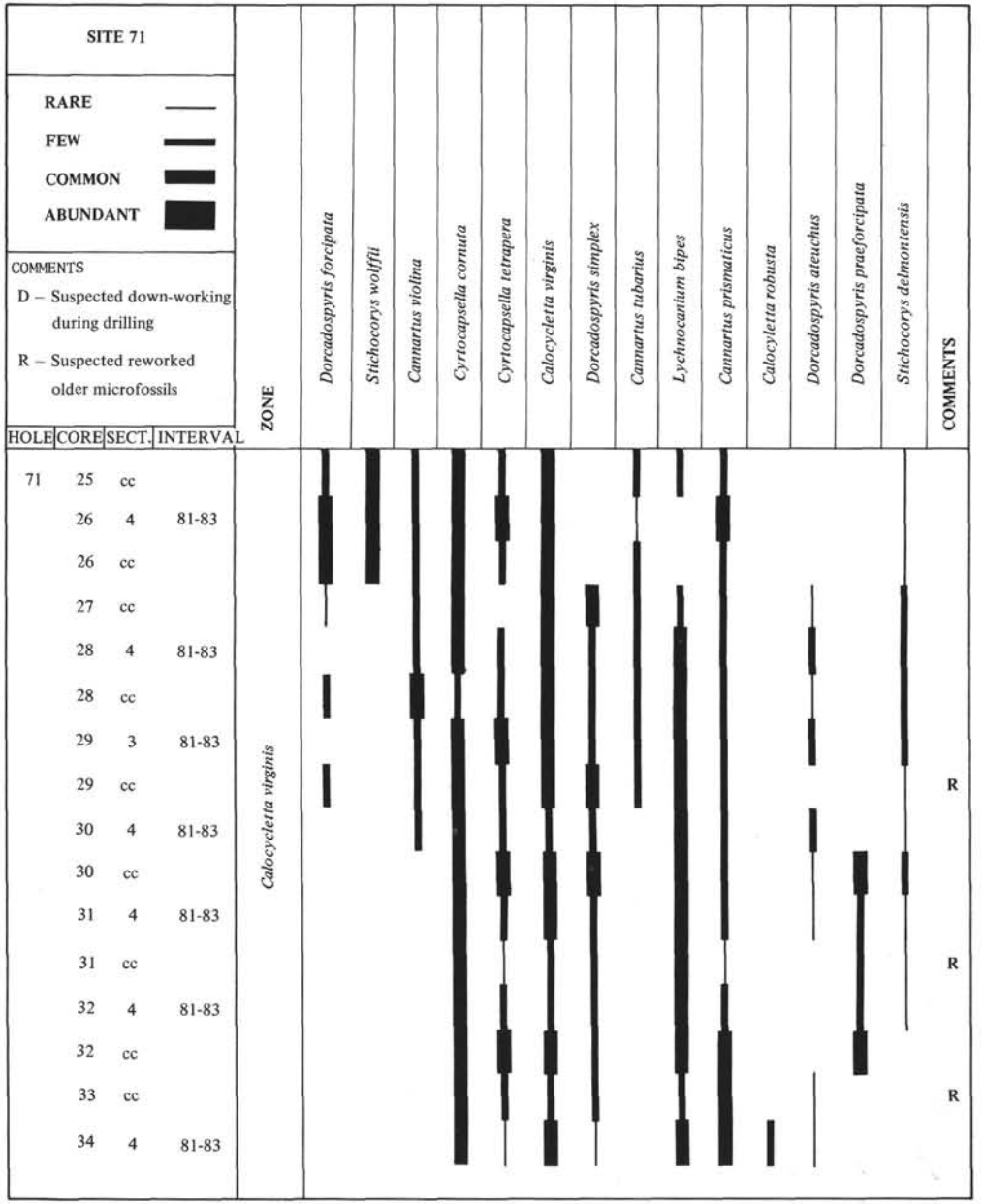

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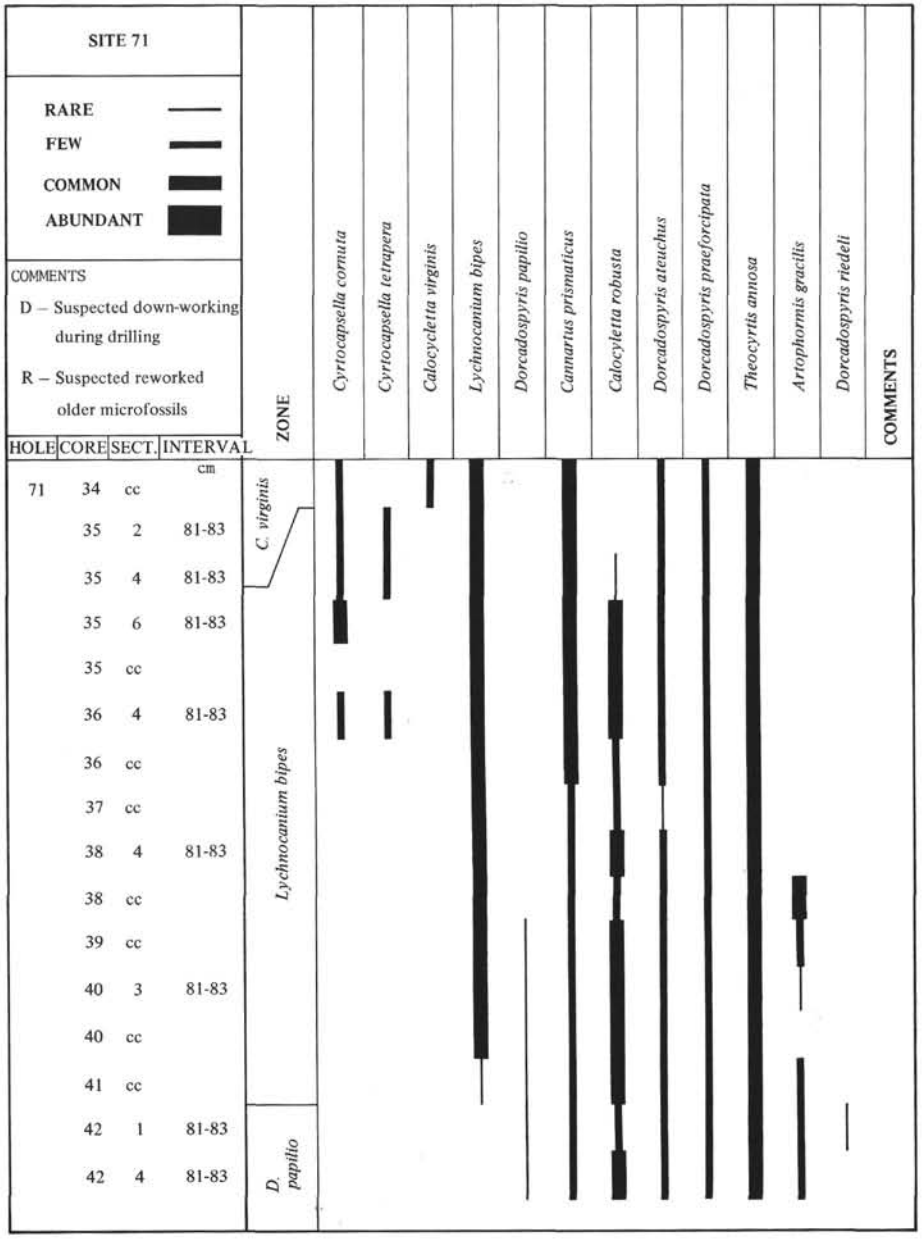


Figure 5. *Continued.*

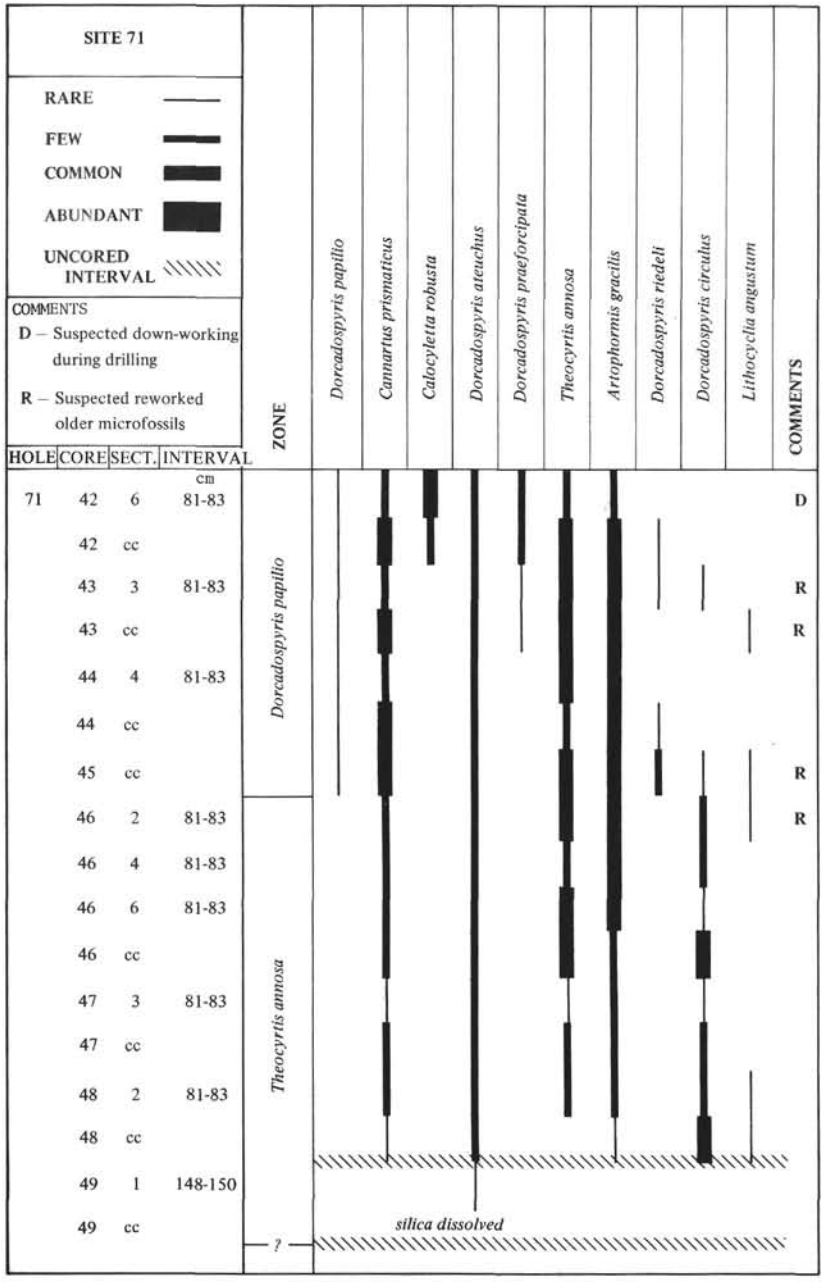


Figure 5. *Continued.*

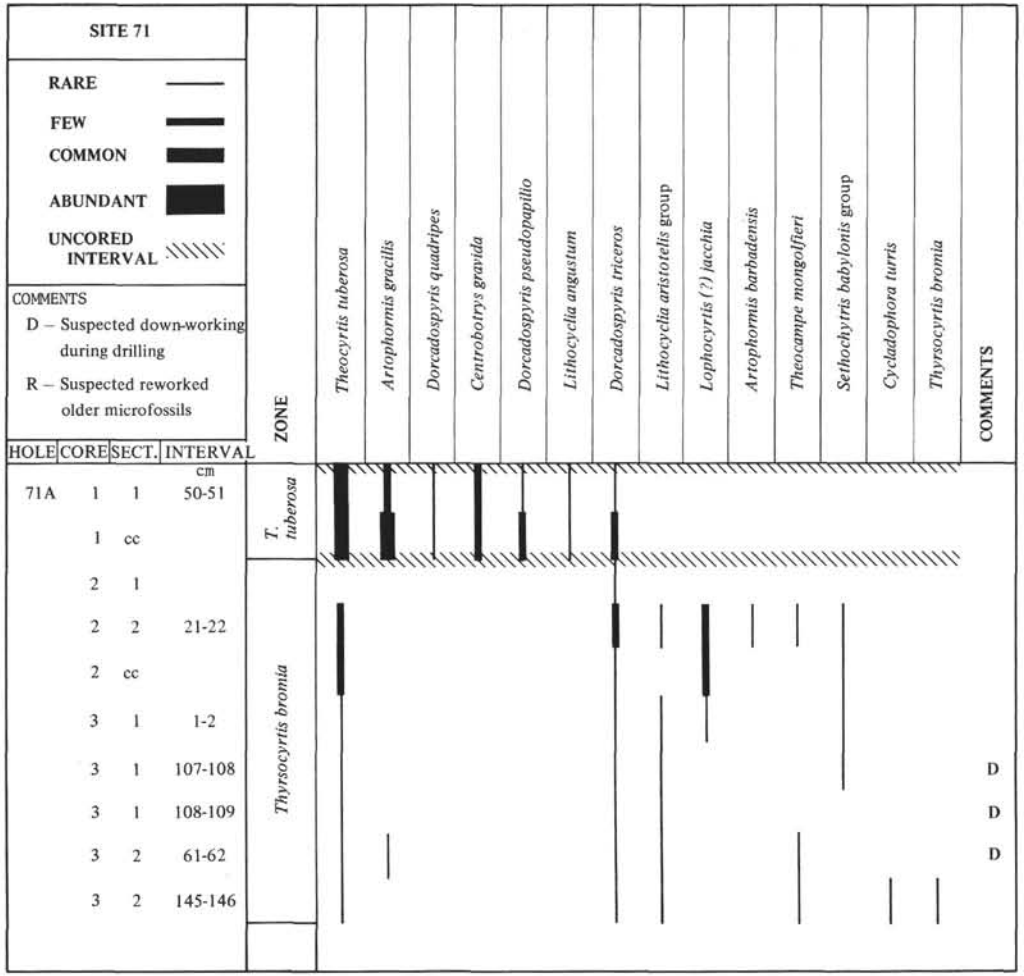


Figure 5. *Continued.*

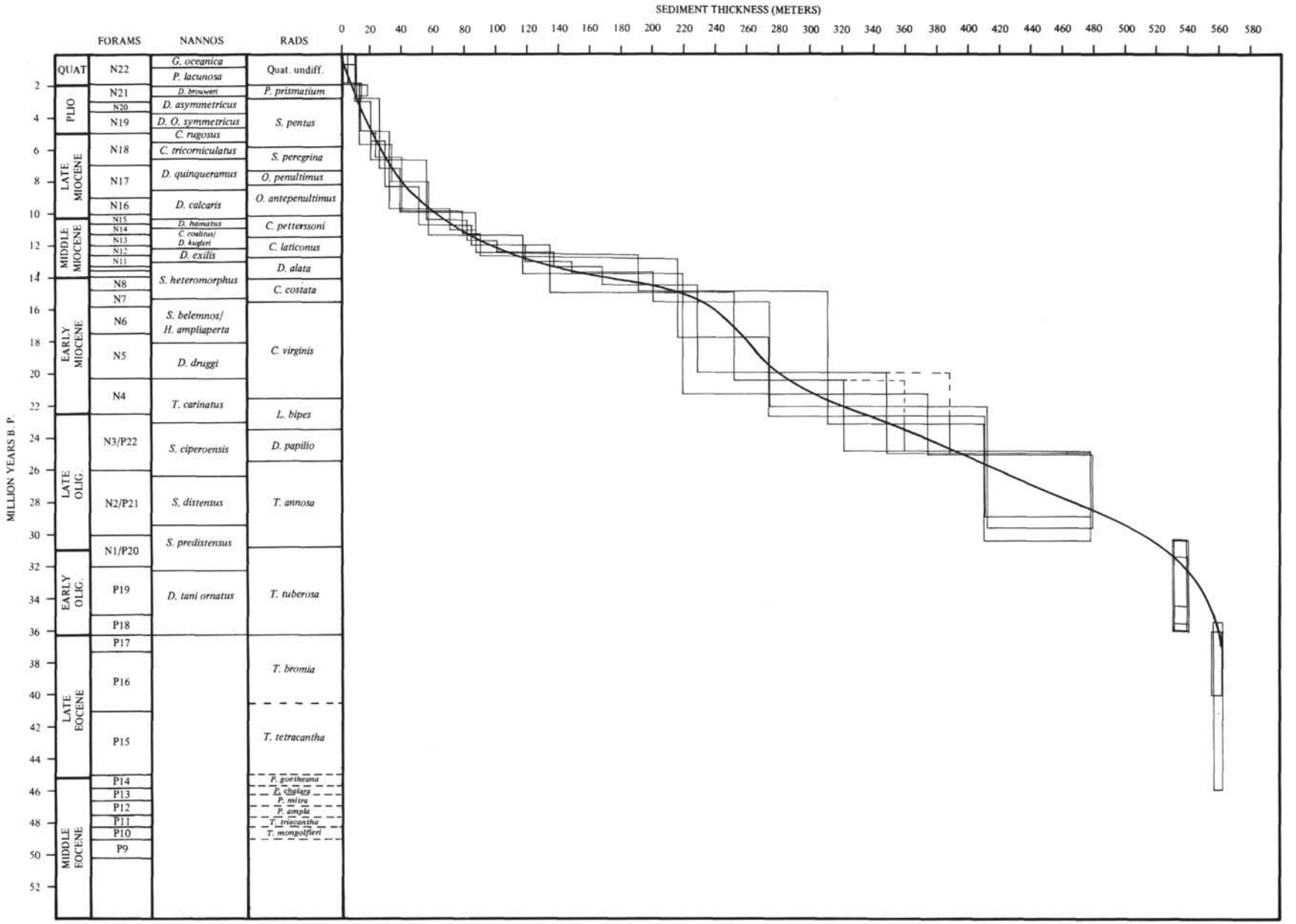


Figure 6. *Age versus depth at Site 71, based on the biostratigraphic zonations of the foraminifera, calcareous nannoplankton and Radiolaria. Ages based on the time scale of Berggren (1969).*

TABLE 2
Calcareous Nannoplankton and Silicoflagellate Occurrences in Holes 71 and 71A

Species	Occurrences (Hole/Core Nos.)
Calcareous Nannoplankton	
Catinaster coalitus Martini and Bramlette	71/9, 10
Ceratolithus cristatus Kamptner	71/1-3
C. rugosus Bukry and Bramlette	71/1-3
C. tricorniculatus Gartner	71/2-5
Coccolithus bisectus (Hay, Mohler and Wade) as figured by Bramlette and Wilcoxon	71/42-49; 71A/1-3
Coronocyclus nitescens (Kamptner) Bramlette and Wilcoxon	71/12-22, 24-30, 47
Cyclococcolithus formosus Kamptner	71A/1-3
C. leptoporus (Murray and Blackman) Kamptner	71/1-8, 11-15
C. neogammation Bramlette and Wilcoxon	71/16-49
Discoaster adamanteus Bramlette and Wilcoxon	71/24-31, 33-39, 41-43, 46, 47, 49
D. asymmetricus Gartner	71/2
D. barbadiensis Tan Sin Hok	71A/3
D. brouweri Tan Sin Hok	71/2-12
D. calcaris Gartner	71/4-10
D. challengeri Bramlette and Riedel	71/2-10
D. deflandrei Bramlette and Riedel	71/12, 13, 15-49
D. dilatus Hay	71/6, 7, 10, 11, 13, 14, 16, 24, 39, 49
D. druggii Bramlette and Wilcoxon	71/25-30, 35?
D. exilis Martini and Bramlette	71/2-4, 9-12, 14-24
D. extensus Hay	71/2, 3, 5-7, 9, 10, 13, 16
D. hamatus Martini and Bramlette	71/7-9
D. kugleri Martini and Bramlette	71/10
D. lautus Hay	71/10, 11, 13-15, 19, 22-27, 29, 46-49
D. pentaradiatus Tan Sin Hok	71/2, 3
D. perplexus Bramlette and Riedel	71/28-30, 33
D. quinqueramus Gartner	71/3-7
D. saipanensis Bramlette and Riedel	71A/3
D. surculus Martini and Bramlette	71/2-6
D. variabilis Martini and Bramlette	71/2-7, 9
Discolithina rectipons Haq	71A/3
Gephyrocapsa oceanica Kamptner	71/1, 2
Helicopontosphaera ampliaperta (Bramlette and Wilcoxon)	71/24, 25, 28, 29
H. euphratis (Haq) Martini	71/14-21, 33, 34
H. intermedia (Martini) Hay and Mohler	71/5, 6, 10-13, 20, 21, 30-32

TABLE 2 – *Continued*

Species	Occurrences (Hole/Core Nos.)
H. kamptneri Hay and Mohler	71/1, 4, 8, 10-16, 20, 21
H. recta (Haq) Martini	71/21, 48
Micrantholithus cf. *M. concinnus* Bramlette and Sullivan	71A/3
Oolithotus antillarum (Cohen) Cohen and Reinhardt	71/1, 4, 8, 10-16, 20, 21
Pseudoemiliania lacunosa (Kamptner) Gartner	71/1
Scyphosphaera intermedia Deflandre	71/17
Sphenolithus belemnos Bramlette and Wilcoxon	71/25-27, 32-34, 36?, 40?, 41?
S. ciperoensis Bramlette and Wilcoxon	71/40, 42-44, 45?
S. distentus (Martini) Bramlette and Wilcoxon	71/47-49
S. heteromorphus Deflandre	71/15-26, 28, 30-41
S. moriformis (Bronnimann and Stradner) Bramlette and Wilcoxon	71/4, 6, 7, 9, 12, 23-49
S. predistentus Bramlette and Wilcoxon	71/45-49
Thoracosphaera cf. *T. deflandrei* Kamptner	71/12, 39
Triquetrorhabdulus carinatus Martini	71/26-45
T. rugosus Bramlette and Wilcoxon	71/4-13
Silicoflagellates	
Corbisema tricantha (Ehrenberg) Hanna	71/12-31
Dictyocha fibula Ehrenberg	71/1-31
D. mutabilis Deflandre	71/1-37
D. crux Ehrenberg	71/1-35
Distephanus speculum (Ehrenberg) Haeckel	71/1-32
Mesocena circularis (Ehrenberg) Ehrenberg	71/3
M. elliptica (Ehrenberg) Ehrenberg	71/1
Naviculopsis navicula (Ehrenberg) Deflandre	71/3

Calcareous Nannoplankton and Silicoflagellates

Calcareous nannoplankton are abundant in samples from Site 71. In the Oligocene part of the section, secondary recrystallization of the nannoplankton makes specific recognition difficult. Silicoflagellates are present sparsely throughout the Miocene but were absent in the Oligocene. Forty-eight species of nannoplankton and seven silicoflagellates were recognized in this material (Table 2).

This section provided the most complete biostratigraphic zonation during Leg 8. Eighteen nannoplankton zones were recognized.

Hole 71	
Core 1-1 to 1-3:	*Gephyrocapsa oceanica* Zone
Core 1-4 to 1-CC:	*Pseudoemiliania lacunosa* Zone
Core 2-1 to 2-4:	*Discoaster brouweri* Zone
Core 2-5 to 2-CC:	*Discoaster pentaradiatus* Zone
Core 3-1 to 3-2:	*Ceratolithus rugosus* Zone
Core 3-3 to 3-6:	*Ceratolithus tricorniculatus* Zone
Core 3-CC to 5-3:	*Discoaster quinqueramus* Zone
Core 5-4 to 7-5:	*Discoaster calcaris* Zone
Core 7-6 to 9-4:	*Discoaster hamatus* Zone

Core 9-5 to 10-2:	*Catinaster coalitus* Zone
Core 10-3 to 10-CC:	*Discoaster kugleri* Zone
Core 11-1 to 15-5:	*Discoaster exilis* Zone
Core 15-6 to 24-4:	*Sphenolithus heteromorphus* Zone
Core 24-5 to 28-3:	*Sphenolithus belemnos* and *Helicopontosphaera ampliaperta* Zone
Core 28-4 to 30-6:	*Discoaster druggii* Zone
Core 30-CC to 41-CC:	*Triquetrorhabdulus carinatus* Zone
Core 41-CC to 45-CC:	*Sphenolithus ciperoensis* Zone
Core 46-2 to 49-CC:	*Sphenolithus distentus* Zone
Hole 71A	
Core 1-1 to 1-CC:	Lower Oligocene
Core 2-1 to 3-CC:	Eocene

Radiolaria

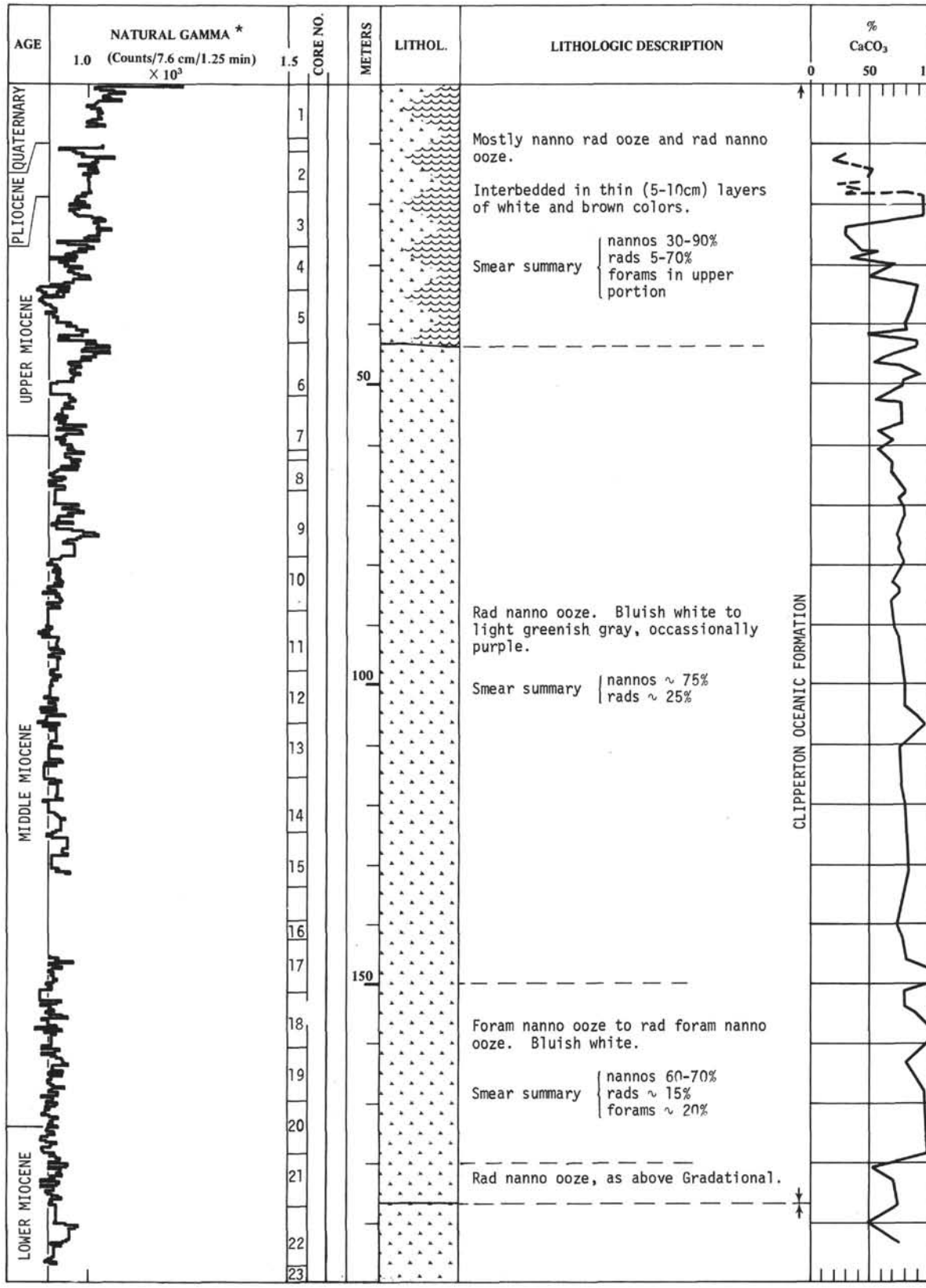
The Radiolaria are numerous and moderately well-preserved in the Neogene sediments cored at this site. The Middle and Lower Miocene sediments are particularly thick at this location and show scant sign of reworked Radiolaria. This section should provide excellent material for more detailed stratigraphic studies. Above this part of the record, the Upper Miocene, Pliocene and Quaternary sections do contain reworked material as old as the Early Miocene. Below the Lower Miocene, the Upper Oligocene is thick, but, beginning in the lowermost Miocene (*Lychnocanium bipes* Zone) and continuing into the middle part of the Oligocene, the Radiolaria are not well preserved and the assemblages contain a small number of reworked Lower Oligocene microfossils.

The Upper to Lower Oligocene and Lower Oligocene to Upper Eocene boundaries are probably located in the uncored intervals (474 to 528 meters and 537 to 553 meters, respectively). Core 71A-1 is within the middle part of the *Theocyrtis tuberosa* Zone.

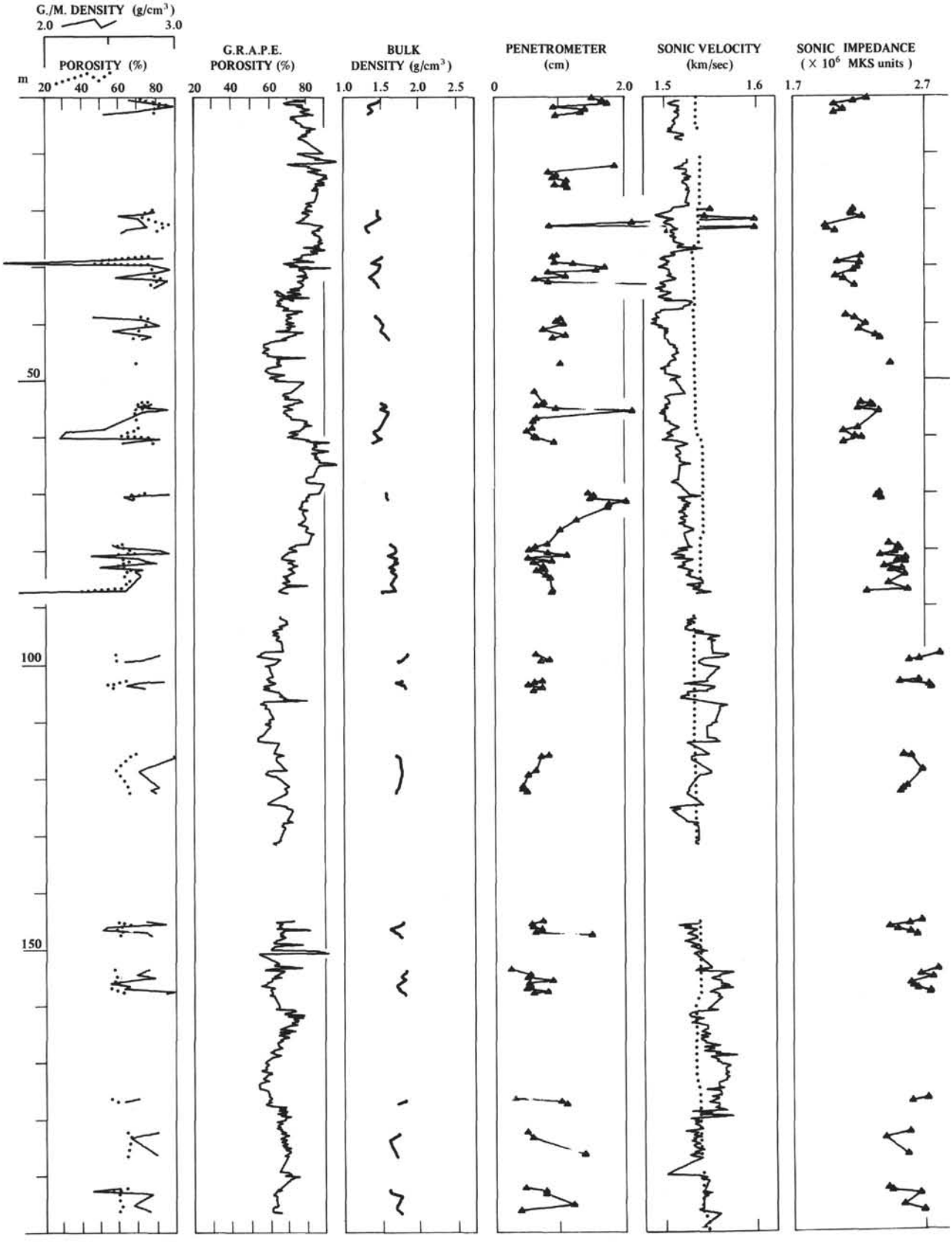
Cores 71A-2 and 71A-3 contain a few, very poorly preserved Upper Eocene Radiolaria. Considering the fact that Eocene Radiolaria are generally more robust and resistant to solution than the Radiolaria of younger Tertiary epochs, it is not absolutely certain that finding sparse Eocene Radiolaria indicates an Eocene age for these cores. However, one species present in Cores 71A-1, -2, and 3, *Theocyrtis tuberosa*, is usually abundant in both the uppermost Eocene and Lower Oligocene. In the Lower Oligocene it has very pronounced knobby protuberances on its thorax; in the Eocene its thorax is comparatively smooth, marked primarily by longitudinal plicae. Because all specimens of *T. tuberosa* present in these cores are of the Eocene variety, it is concluded that these samples are probably from the Eocene. Because no specimens of Lower Eocene, Middle Eocene, or lower Upper Eocene Radiolaria are present, it is probably correct that Cores 71A-2 and -3 are no older than the latest Eocene. Based on the several species preserved in 71A-2 and -3, these cores are approximately correlative to the lower part of Core 70A-27 at the previous site.

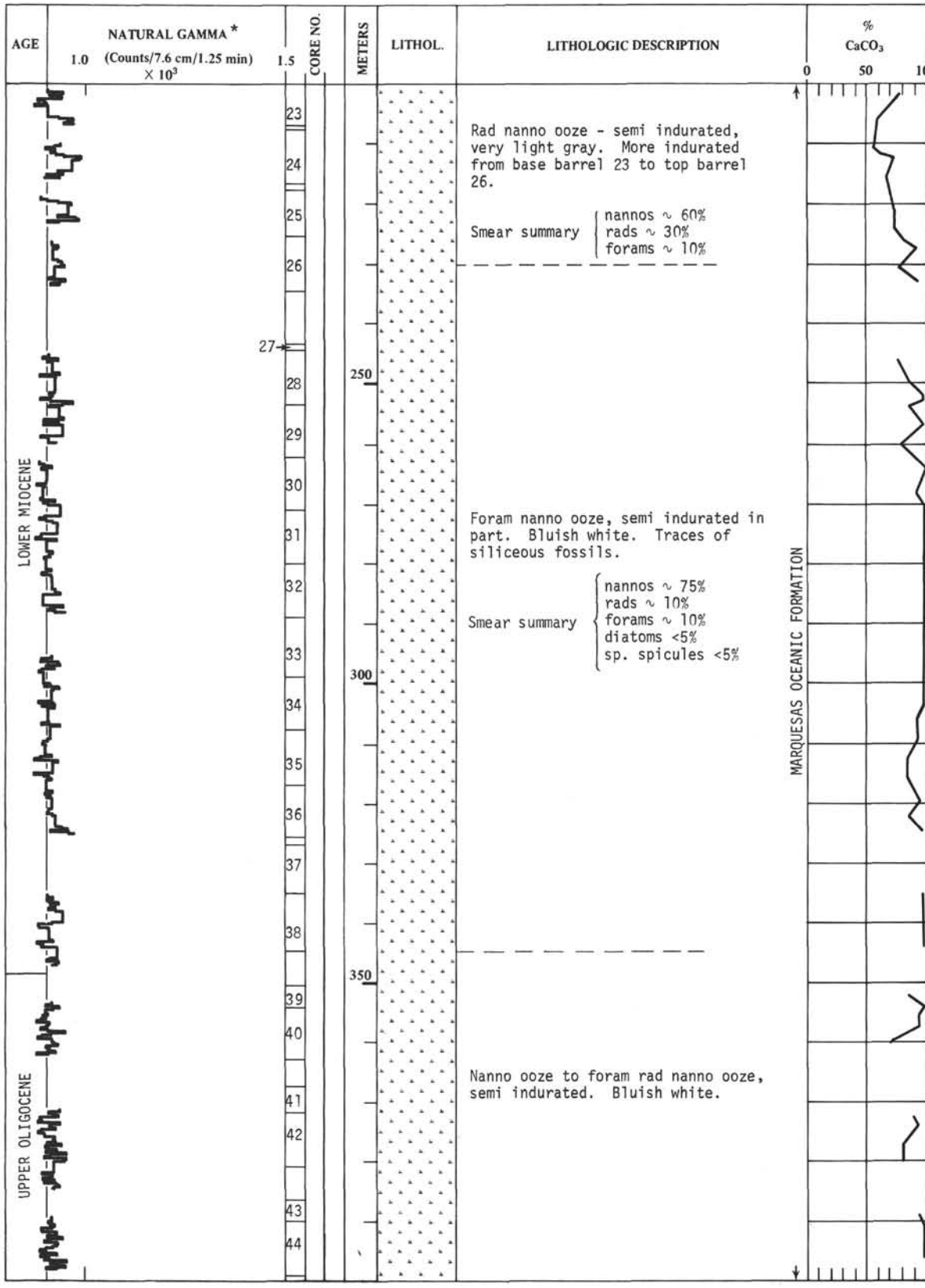
REFERENCE

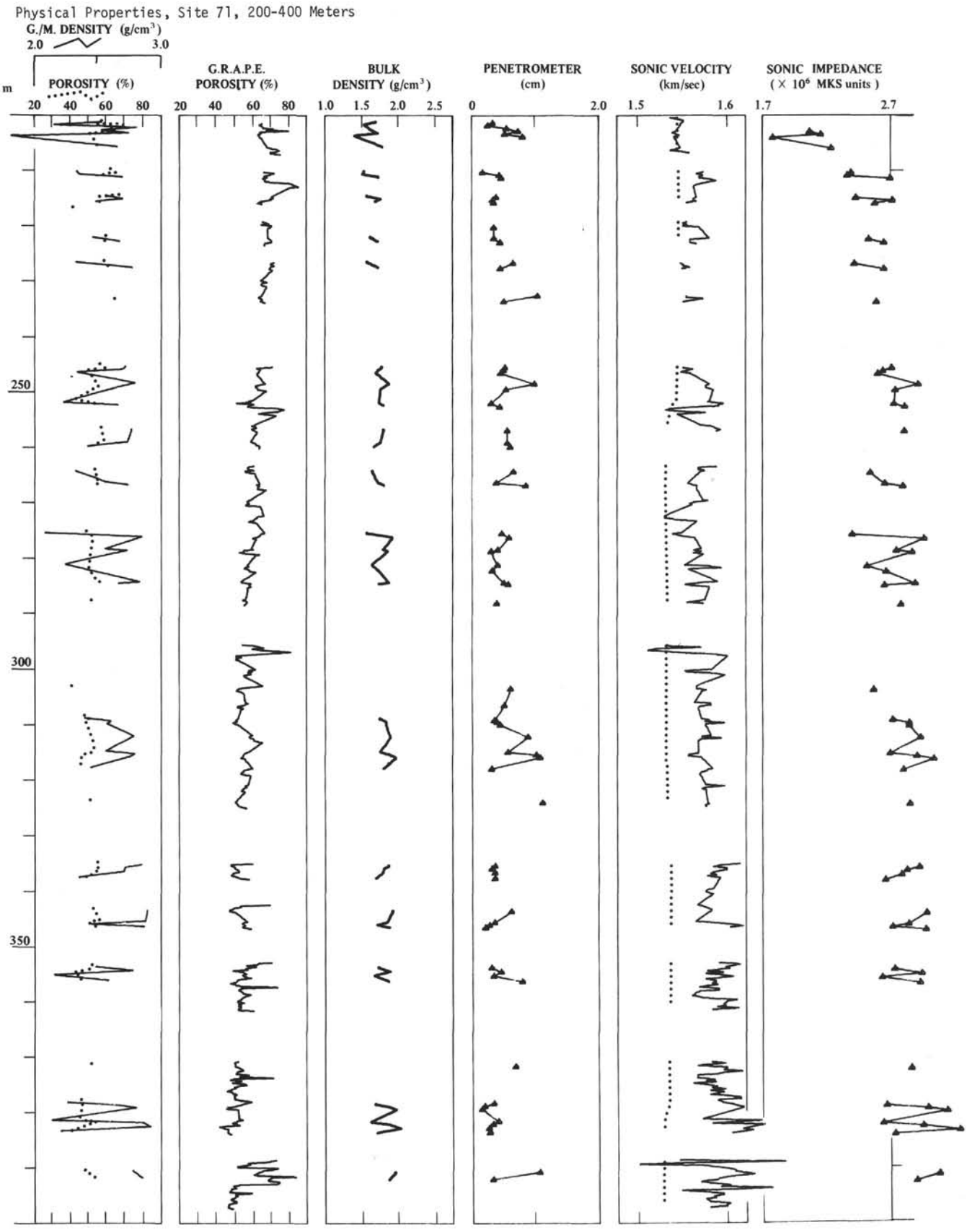
Berggren, W. A., 1969. Cenozoic chronostratigraphy, planktonic foraminiferal zonation and the radiometric time scale. *Nature.* **224**, 1072.

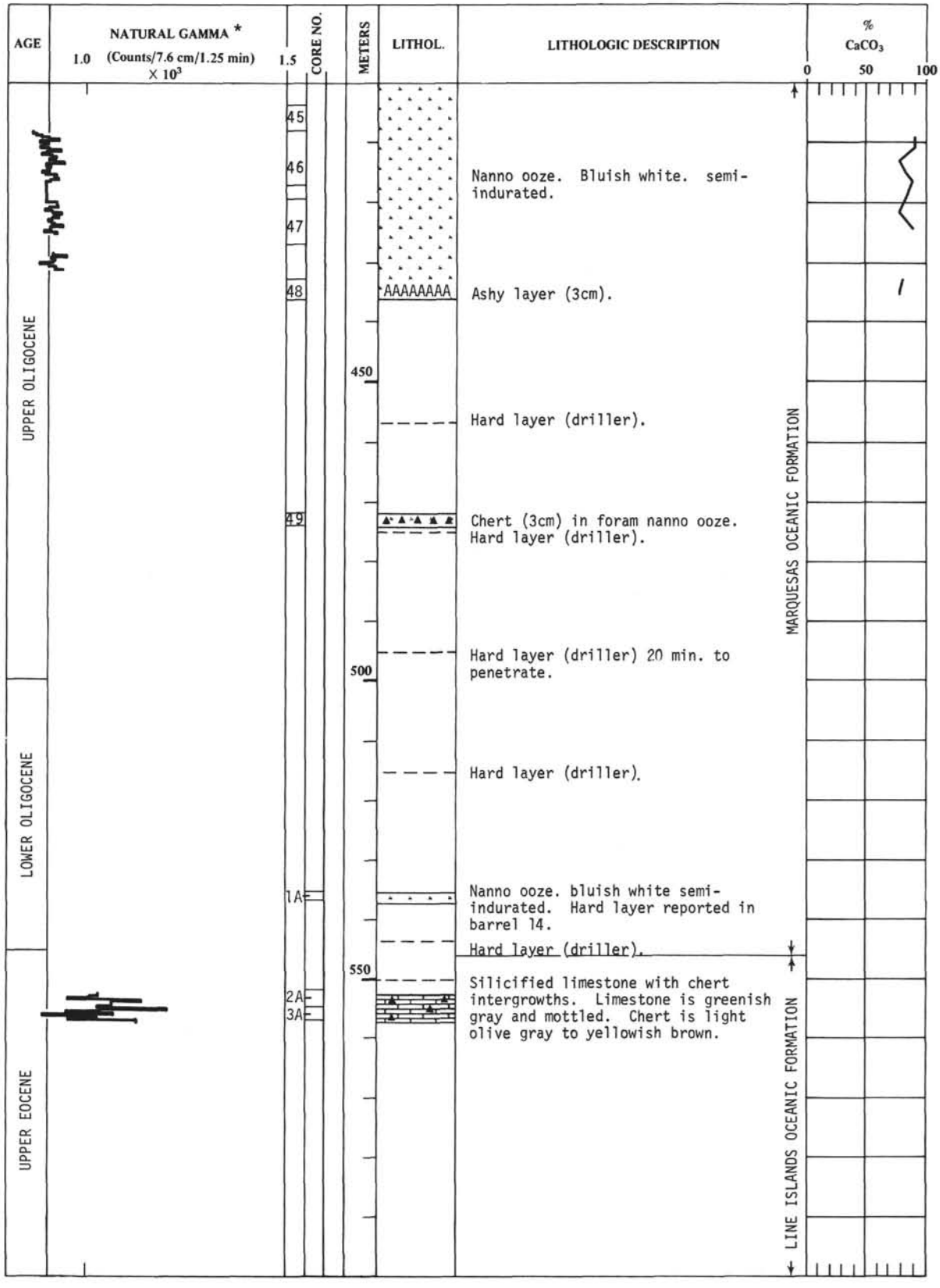

AGE
NATURAL GAMMA *
1.0 (Counts/7.6 cm/1.25 min) 1.5
× 10³
CORE NO.
METERS
LITHOL.
LITHOLOGIC DESCRIPTION
% CaCO₃
0 50 100
QUATERNARY
PLIOCENE
UPPER MIOCENE
MIDDLE MIOCENE
LOWER MIOCENE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
50
100
150
Mostly nanno rad ooze and rad nanno ooze.
Interbedded in thin (5-10cm) layers of white and brown colors.
Smear summary
nannos 30-90%
rads 5-70%
forams in upper portion
Rad nanno ooze. Bluish white to light greenish gray, occassionally purple.
Smear summary
nannos ∿ 75%
rads ∿ 25%
Foram nanno ooze to rad foram nanno ooze. Bluish white.
Smear summary
nannos 60-70%
rads ∿ 15%
forams ∿ 20%
Rad nanno ooze, as above Gradational.
CLIPPERTON OCEANIC FORMATION

Physical Properties, Site 71, 0-200 Meters

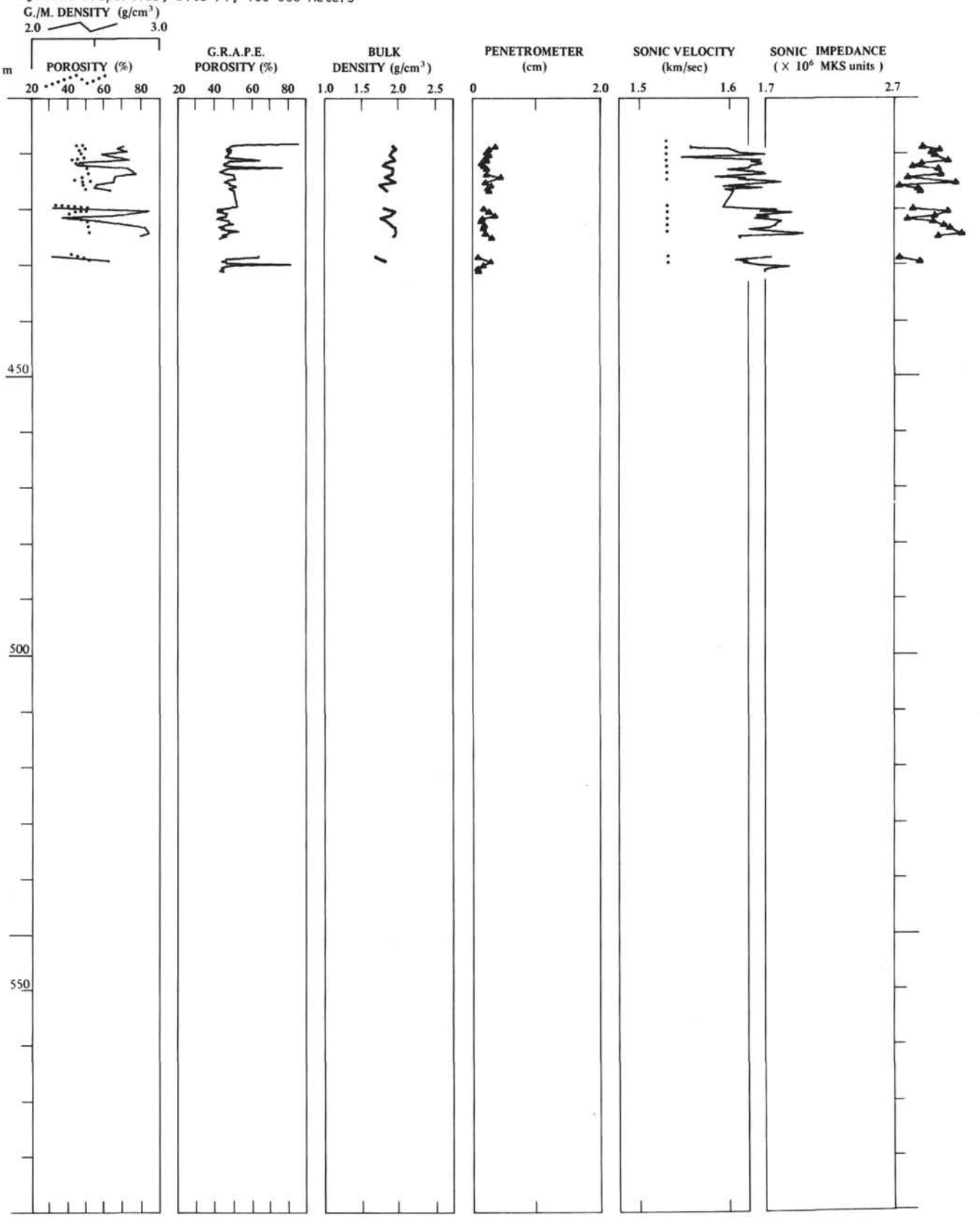



AGE
NATURAL GAMMA *
1.0 (Counts/7.6 cm/1.25 min) 1.5
× 10³
CORE NO.
METERS
LITHOL.
LITHOLOGIC DESCRIPTION
% CaCO₃
0 50 100
LOWER MIOCENE
UPPER OLIGOCENE
MARQUESAS OCEANIC FORMATION
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
250
300
350
Rad nanno ooze - semi indurated, very light gray. More indurated from base barrel 23 to top barrel 26.
Smear summary
nannos ∿ 60%
rads ∿ 30%
forams ∿ 10%
Foram nanno ooze, semi indurated in part. Bluish white. Traces of siliceous fossils.
Smear summary
nannos ∿ 75%
rads ∿ 10%
forams ∿ 10%
diatoms <5%
sp. spicules <5%
Nanno ooze to foram rad nanno ooze, semi indurated. Bluish white.

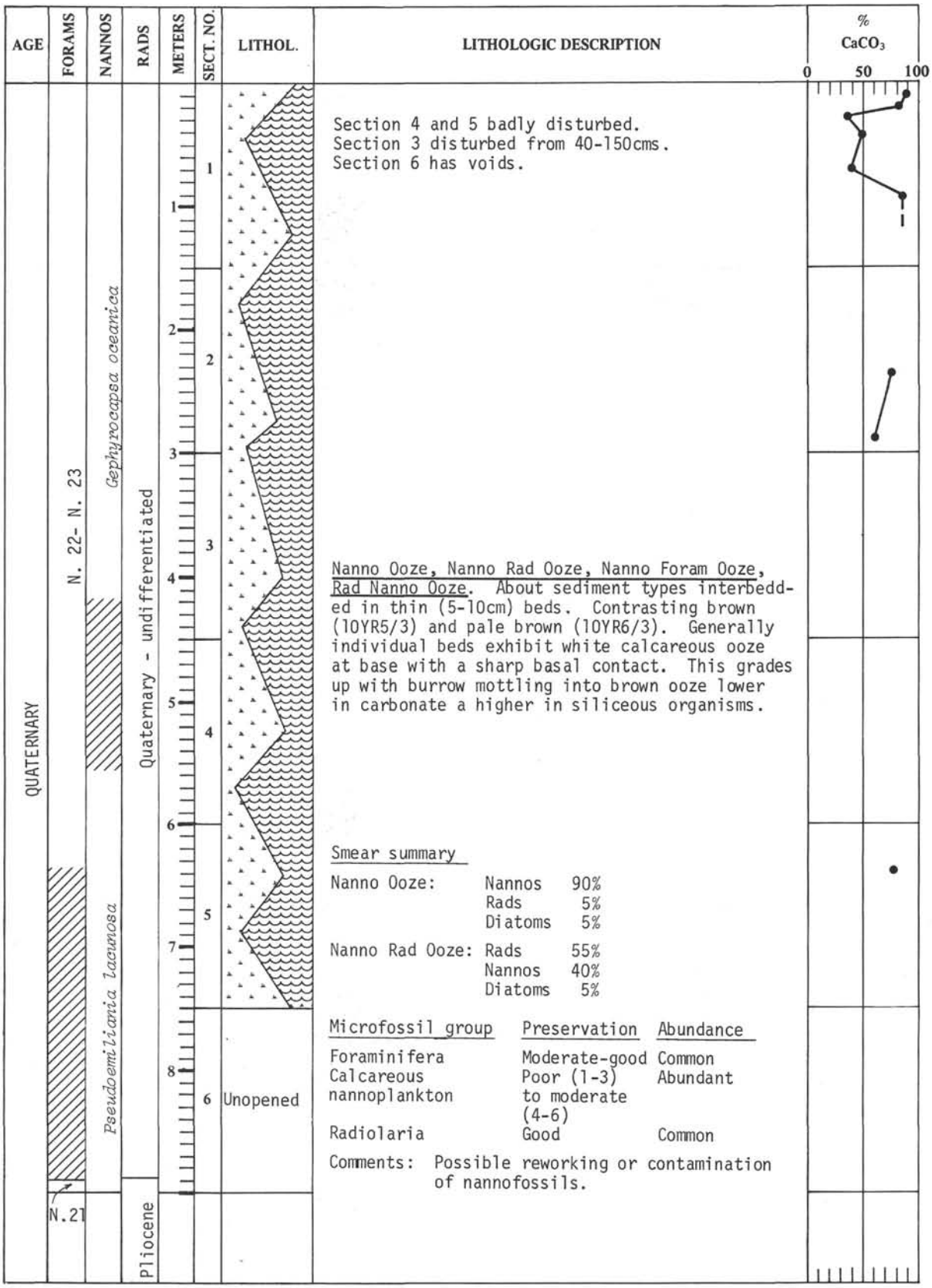

Physical Properties, Site 71, 200-400 Meters
G./M. DENSITY (g/cm³)
2.0
3.0
m
POROSITY (%)
20 40 60 80
G.R.A.P.E. POROSITY (%)
20 40 60 80
BULK DENSITY (g/cm³)
1.0 1.5 2.0 2.5
PENETROMETER (cm)
0
2.0
SONIC VELOCITY (km/sec)
1.5
1.6
SONIC IMPEDANCE (× 10⁶ MKS units)
1.7
2.7
250
300
350


AGE
NATURAL GAMMA *
1.0 (Counts/7.6 cm/1.25 min) 1.5
× 10³
CORE NO.
METERS
LITHOL.
LITHOLOGIC DESCRIPTION
% CaCO₃
0 50 100
UPPER OLIGOCENE
LOWER OLIGOCENE
UPPER EOCENE
45
46
47
48
49
1A
2A
3A
450
500
550
AAAAAAAA
Nanno ooze. Bluish white. semi-indurated.
Ashy layer (3cm).
Hard layer (driller).
Chert (3cm) in foram nanno ooze.
Hard layer (driller).
Hard layer (driller) 20 min. to penetrate.
Hard layer (driller).
Nanno ooze. bluish white semi-indurated. Hard layer reported in barrel 14.
Hard layer (driller).
Silicified limestone with chert intergrowths. Limestone is greenish gray and mottled. Chert is light olive gray to yellowish brown.
MARQUESAS OCEANIC FORMATION
LINE ISLANDS OCEANIC FORMATION

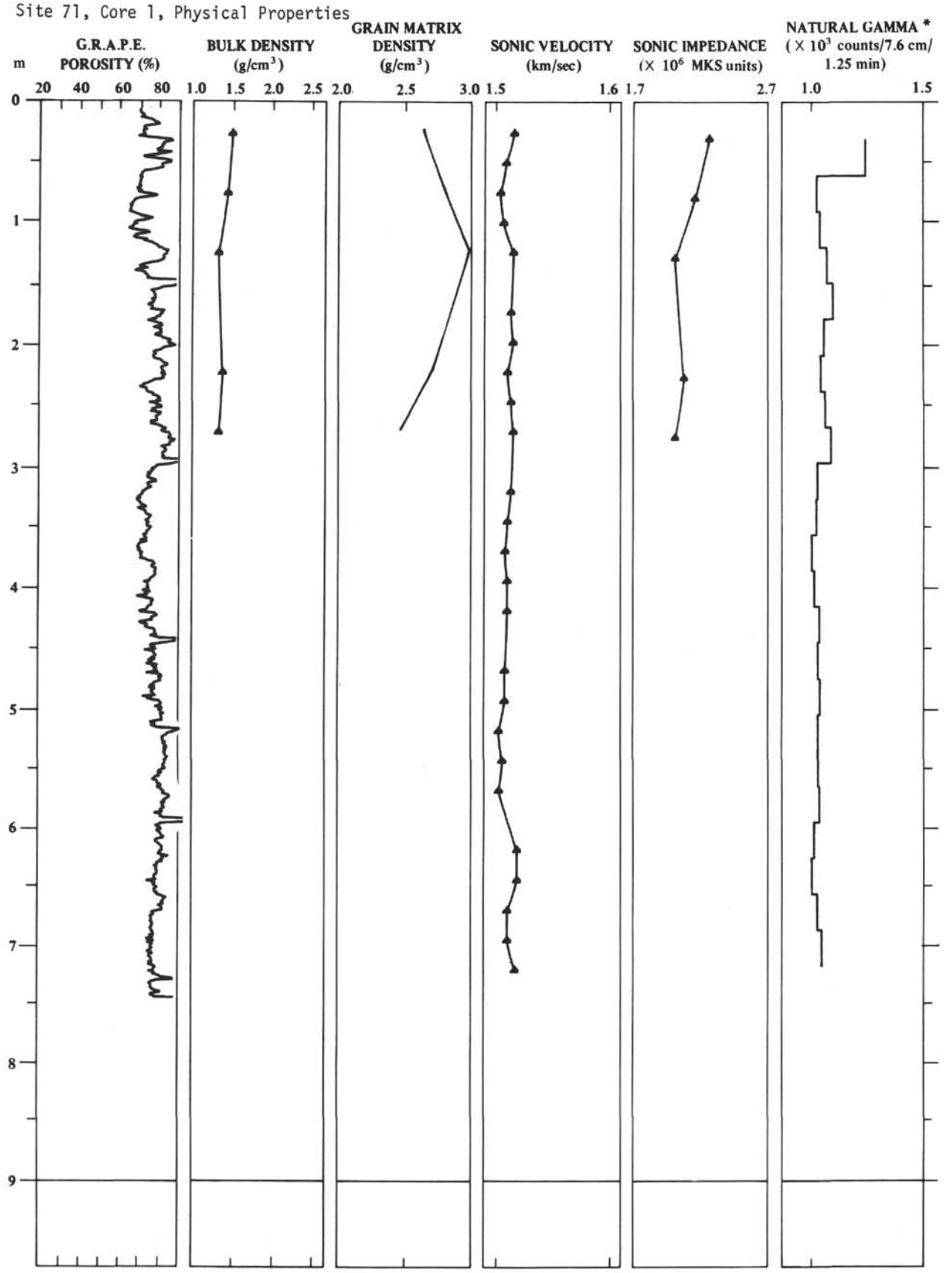
Physical Properties, Site 71, 400-600 Meters



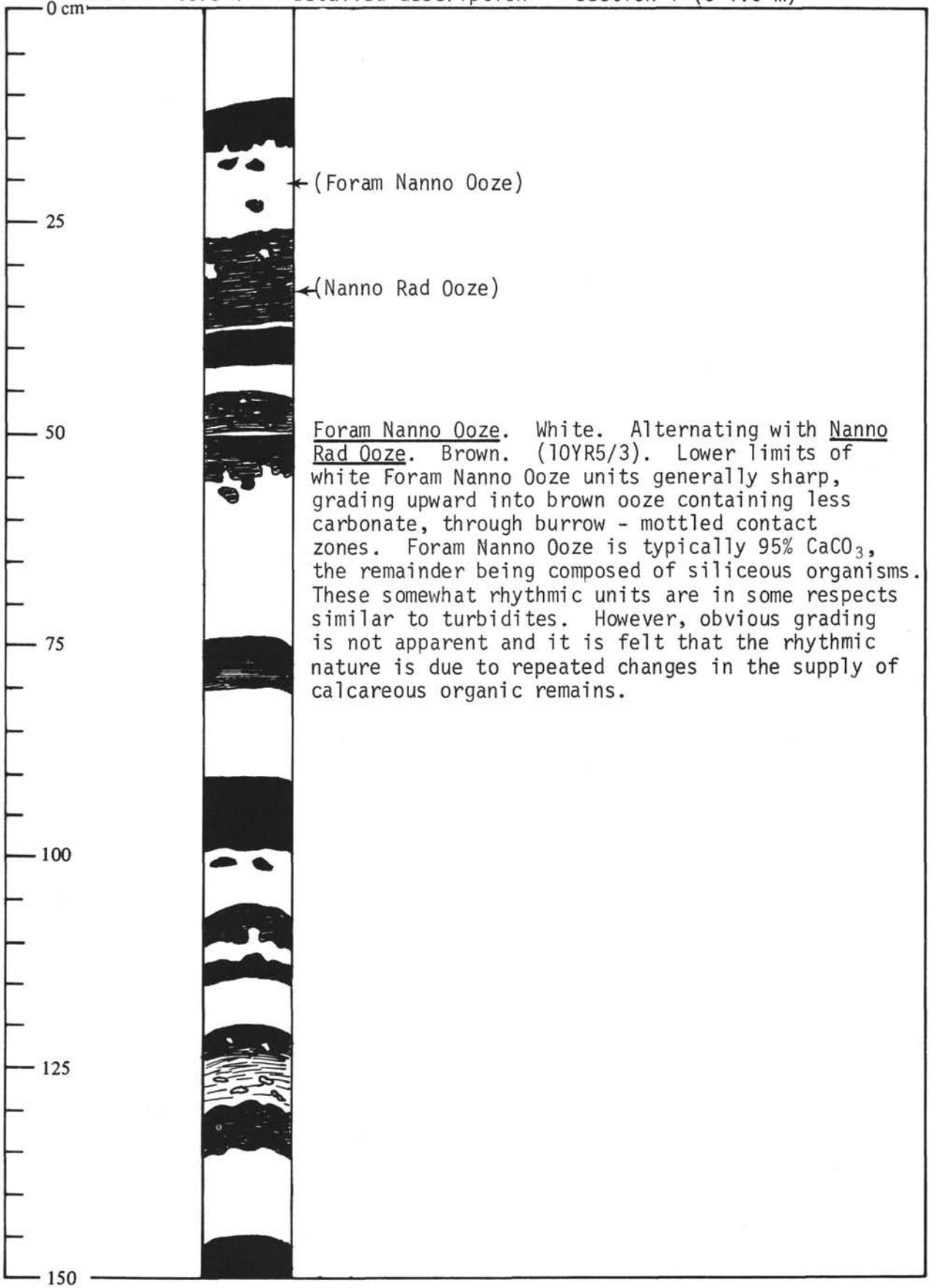
SITE 71 Core 1 Cored interval: 0-9 m



Site 71, Core 1, Physical Properties

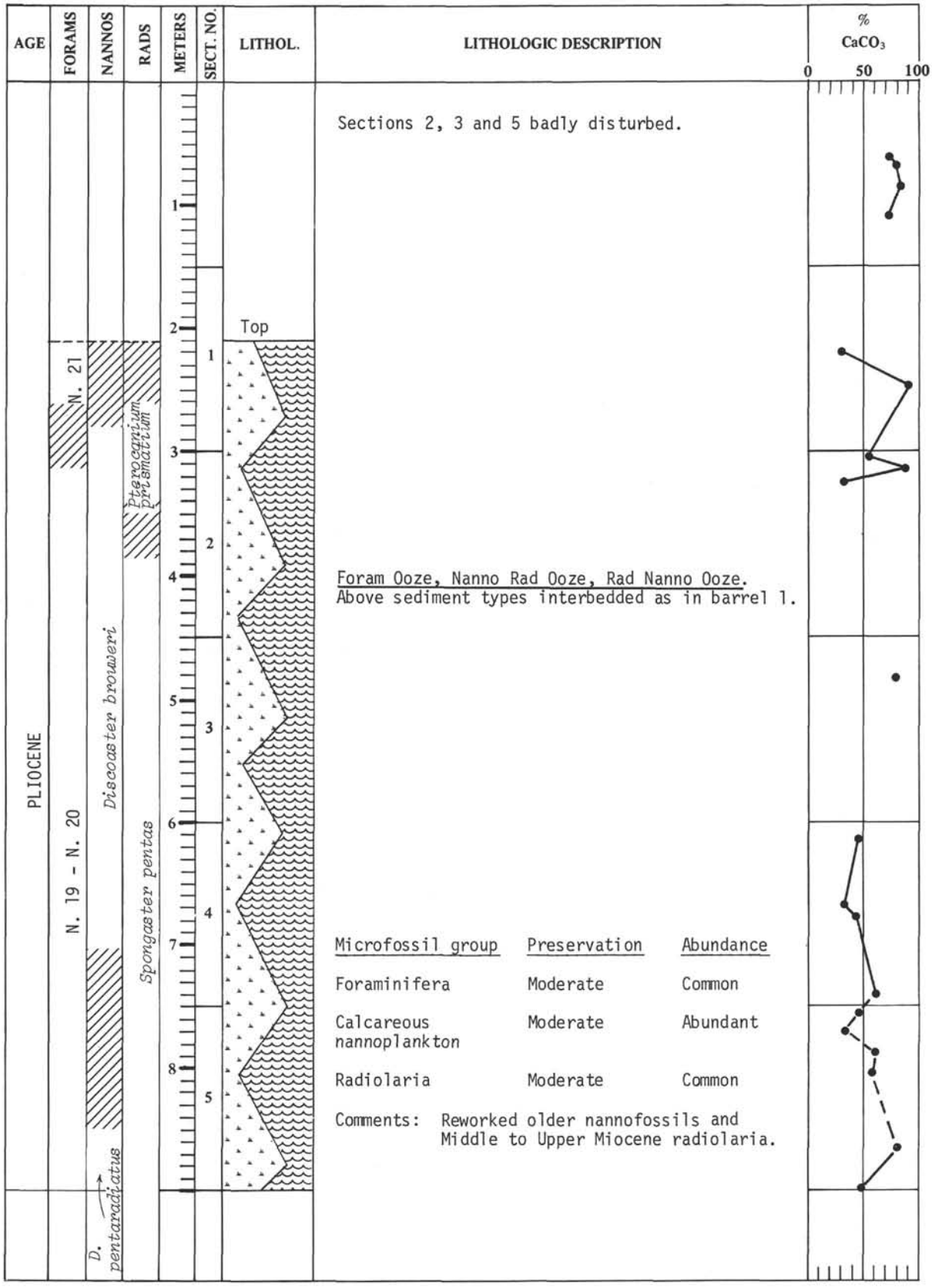


SITE 71 Core 1 Detailed description Section 1 (0-1.5 m)

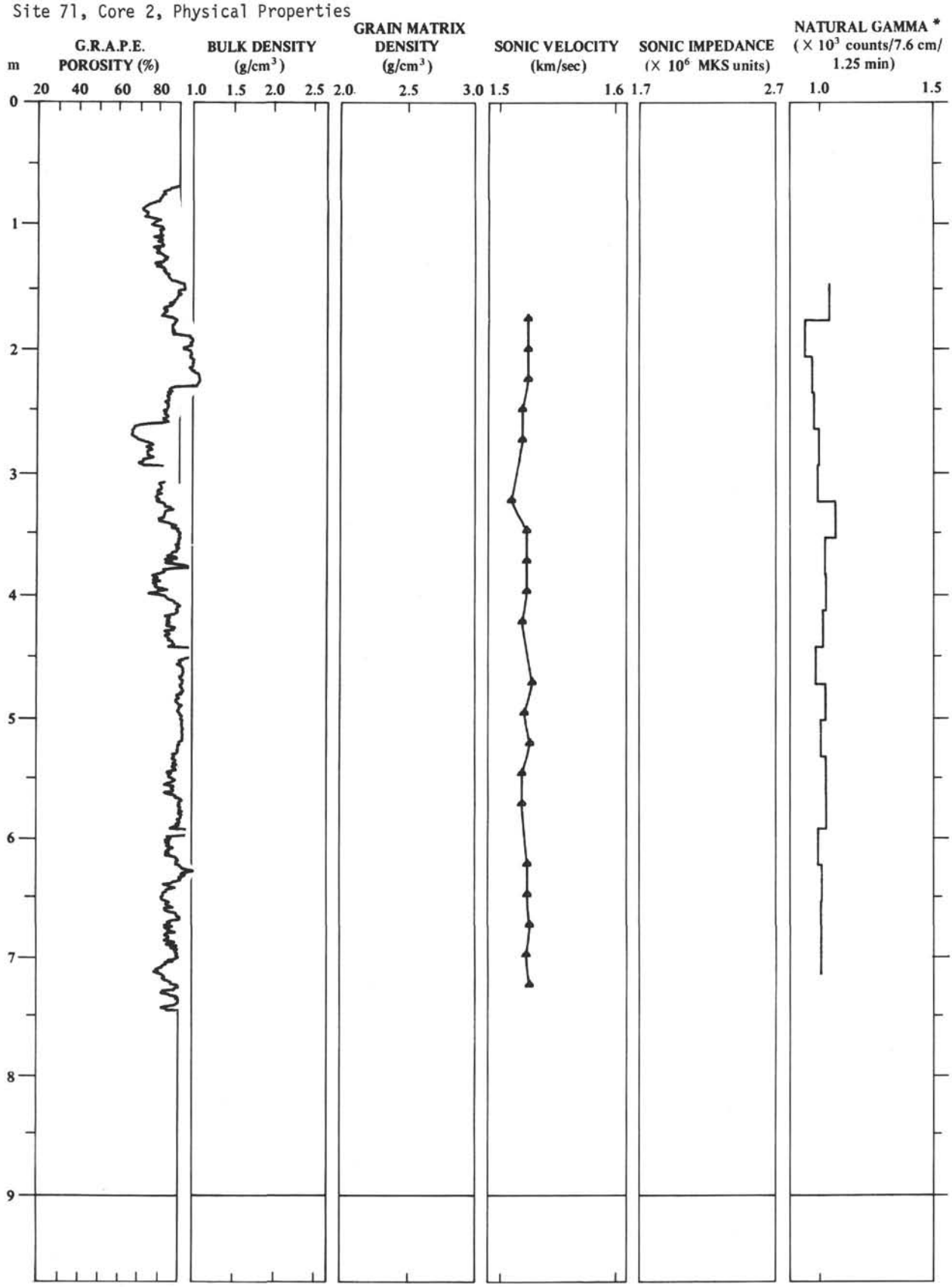


Foram Nanno Ooze. White. Alternating with Nanno Rad Ooze. Brown. (10YR5/3). Lower limits of white Foram Nanno Ooze units generally sharp, grading upward into brown ooze containing less carbonate, through burrow - mottled contact zones. Foram Nanno Ooze is typically 95% $CaCO_3$, the remainder being composed of siliceous organisms. These somewhat rhythmic units are in some respects similar to turbidites. However, obvious grading is not apparent and it is felt that the rhythmic nature is due to repeated changes in the supply of calcareous organic remains.

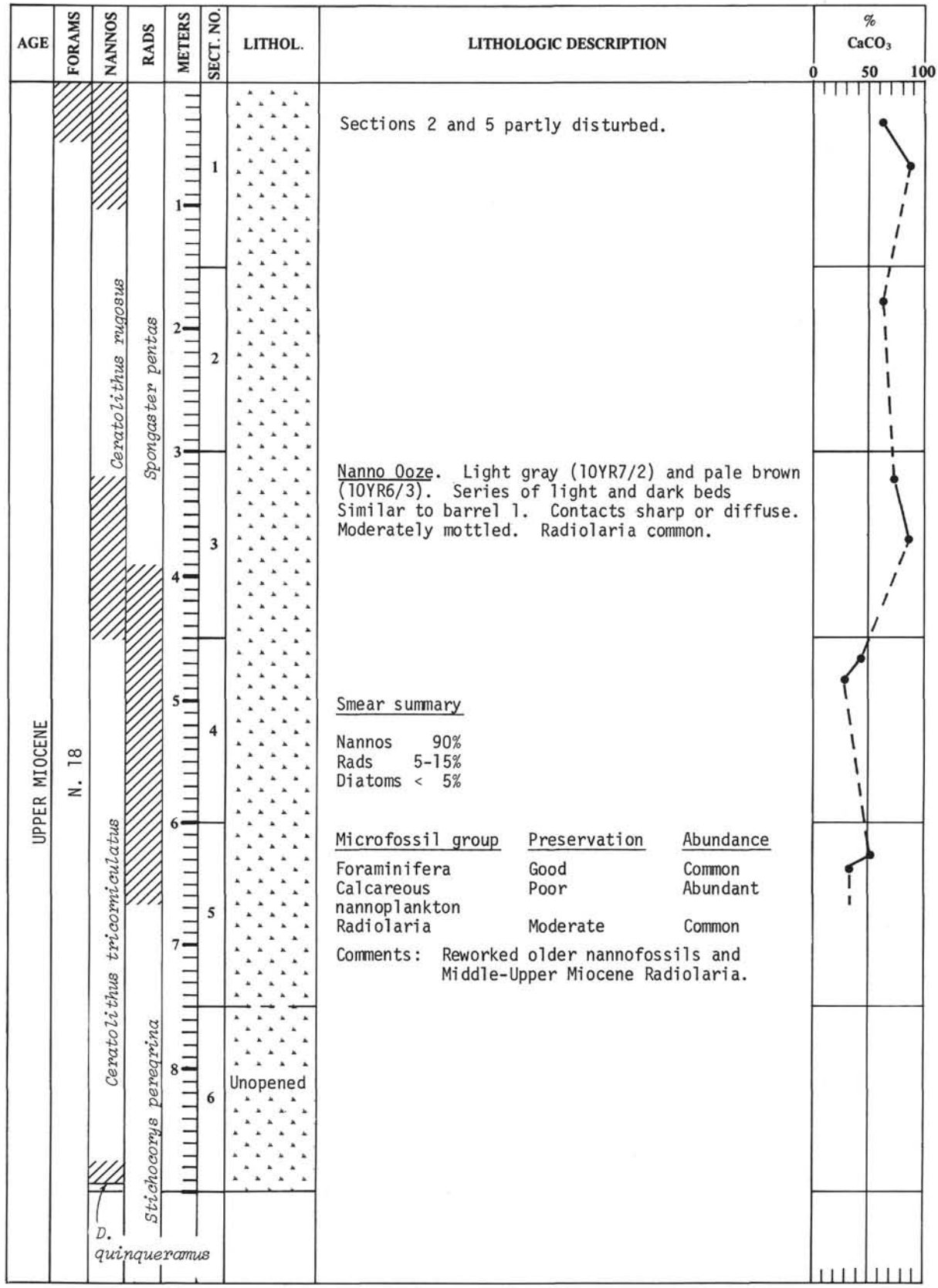
SITE 71 Core 2 Cored interval: 9-18 m



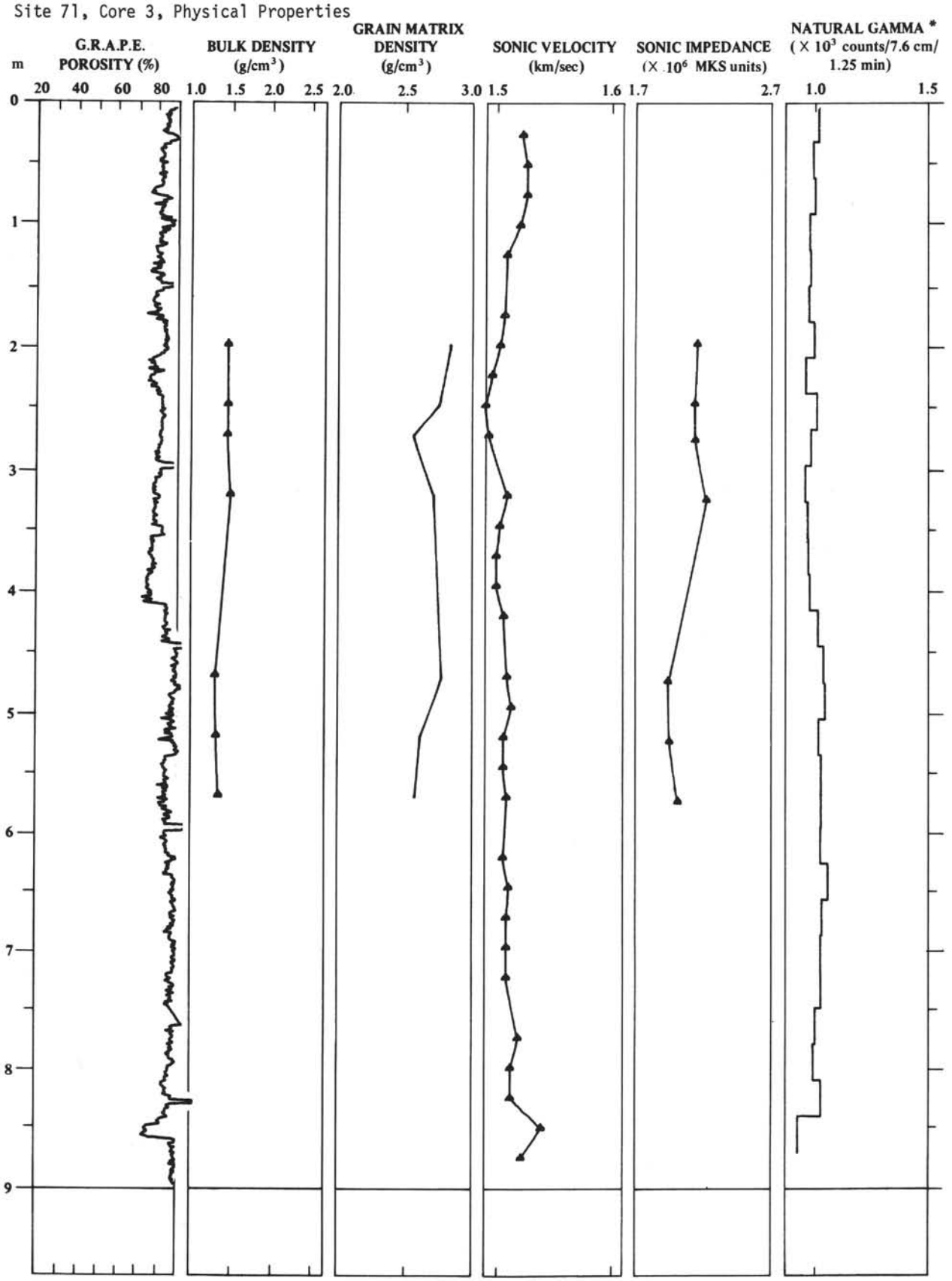
Site 71, Core 2, Physical Properties



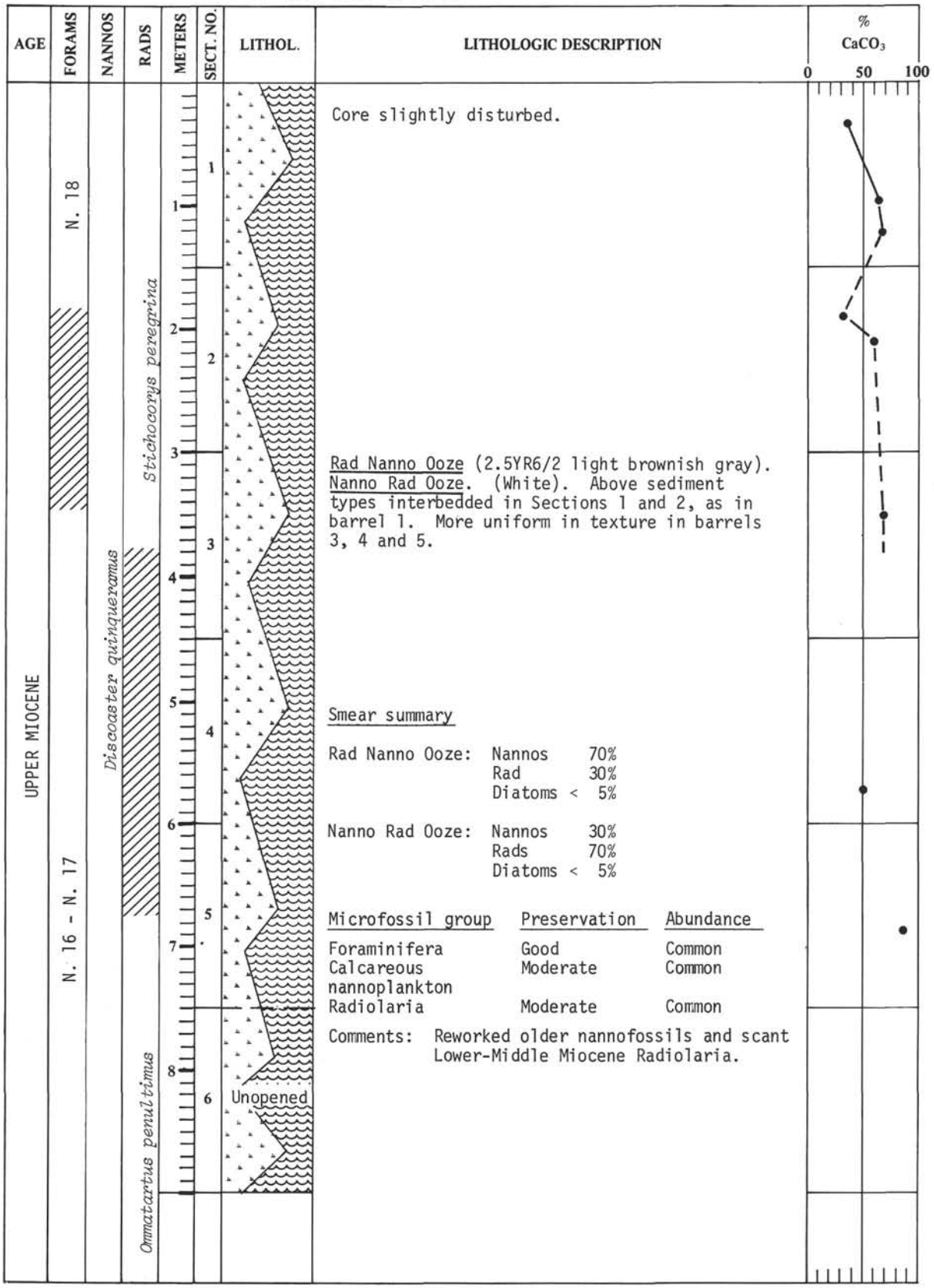
SITE 71 Core 3 Cored interval: 18-27 m



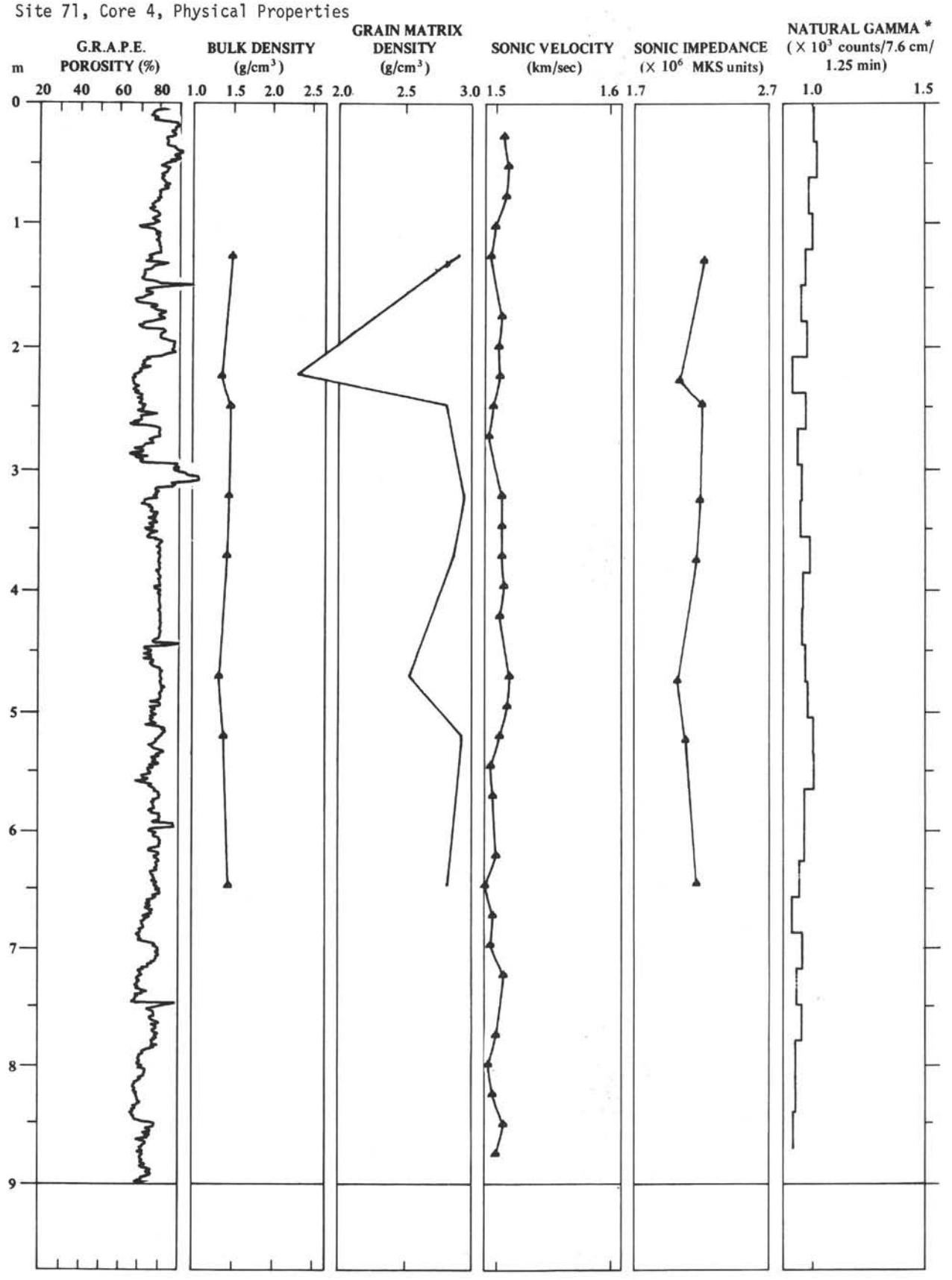
Site 71, Core 3, Physical Properties



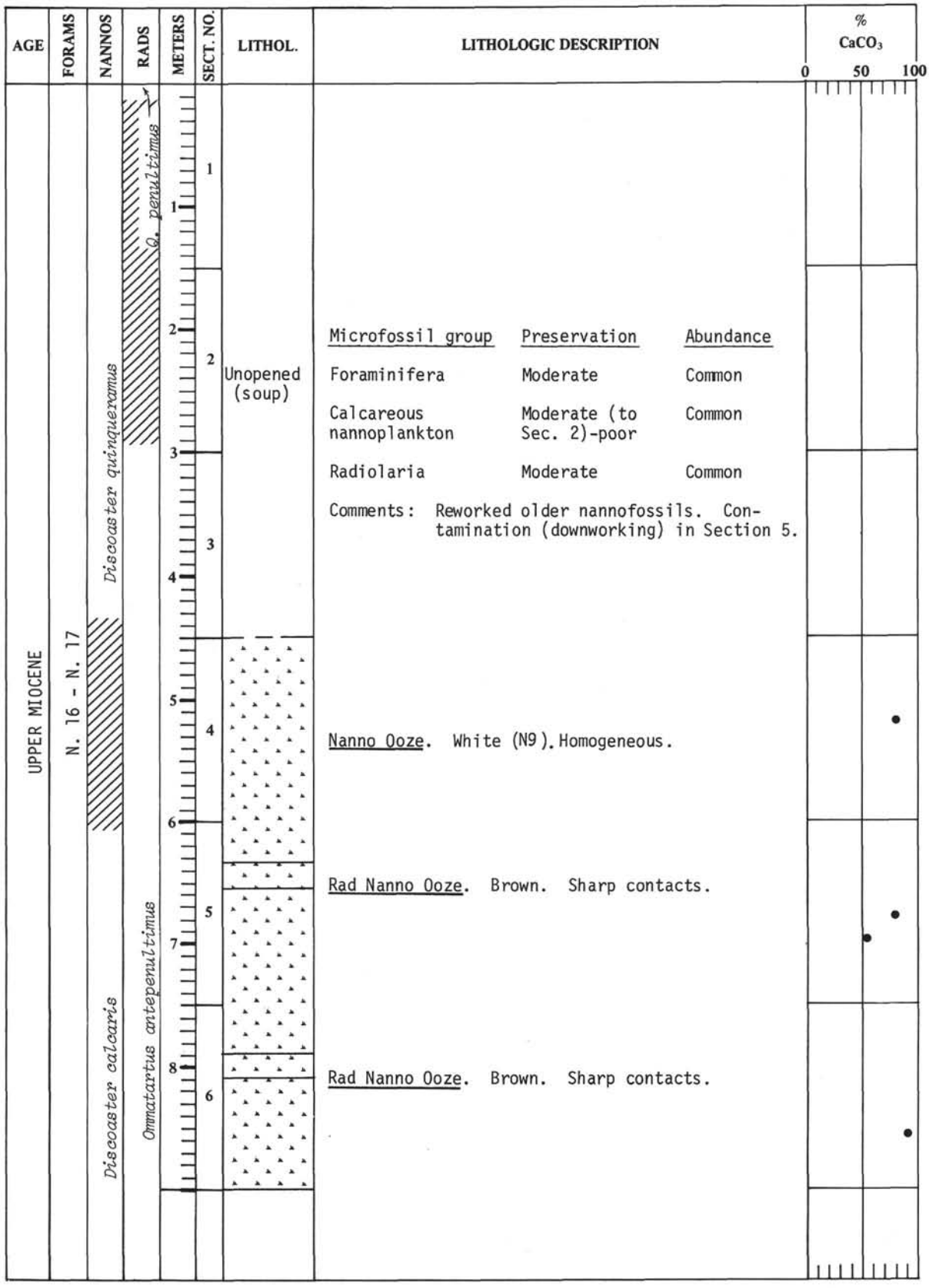
SITE 71 Core 4 Cored interval: 27-34 m



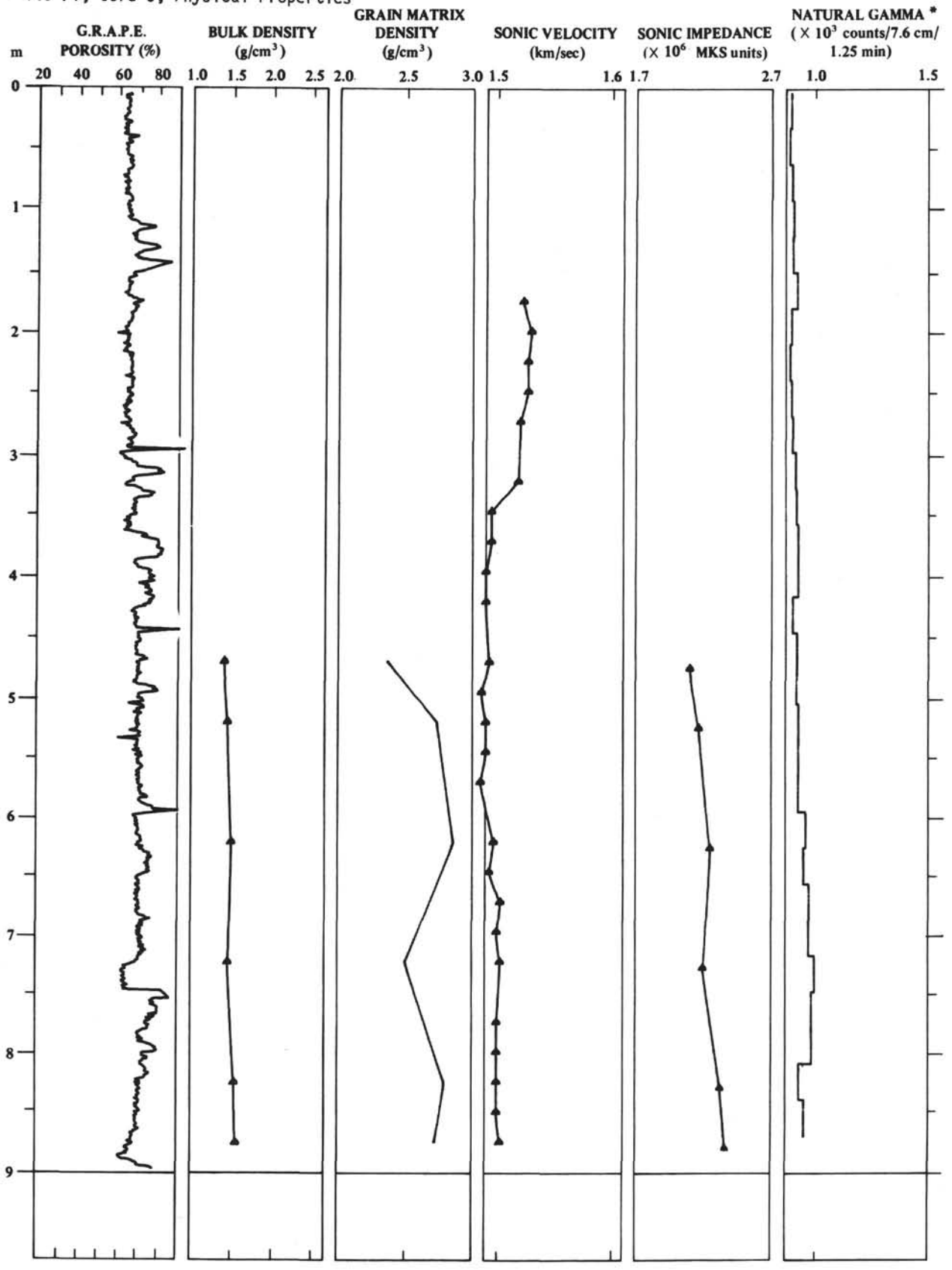
Site 71, Core 4, Physical Properties



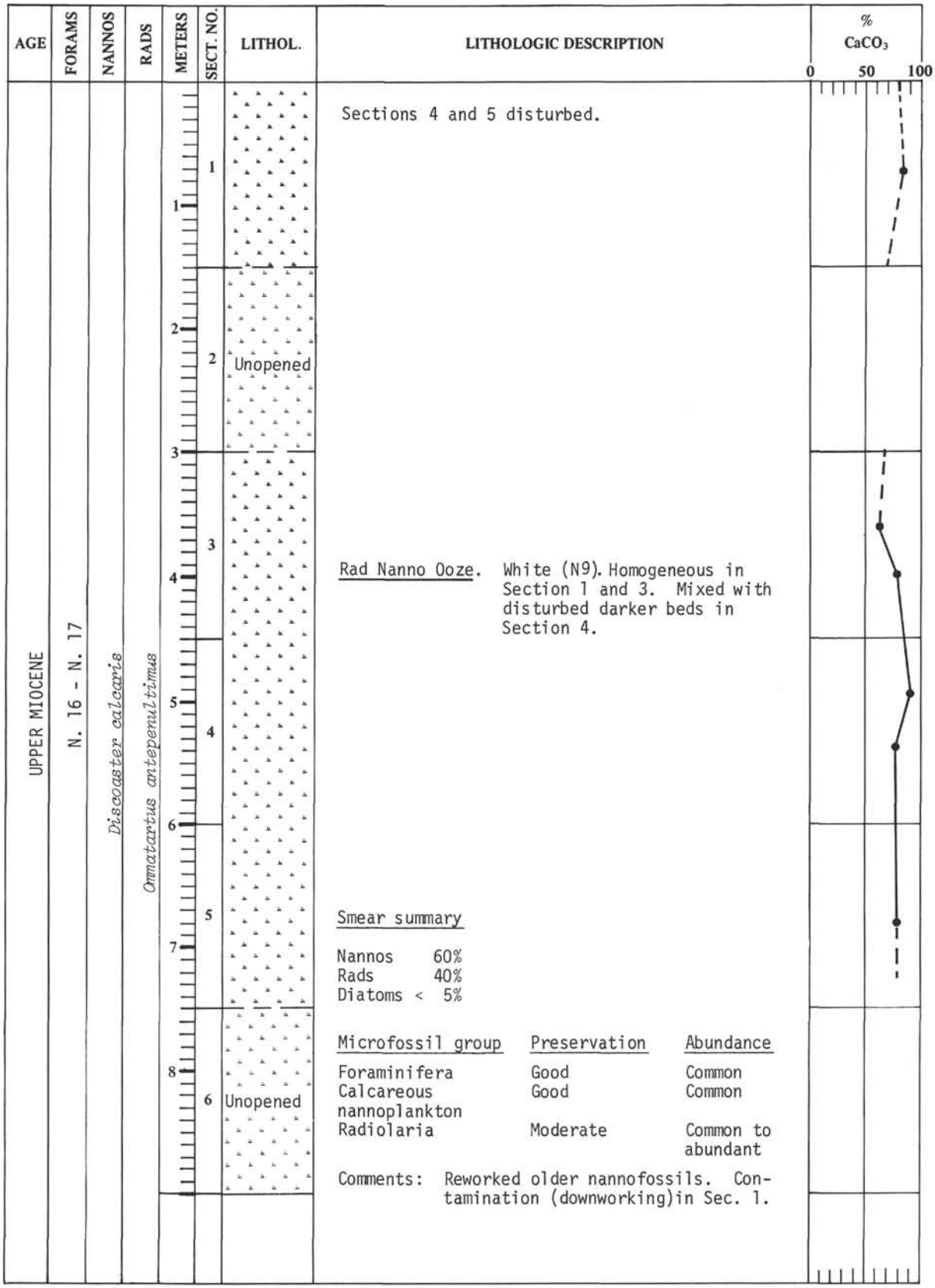
SITE 71 Core 5 Cored interval: 34-43 m



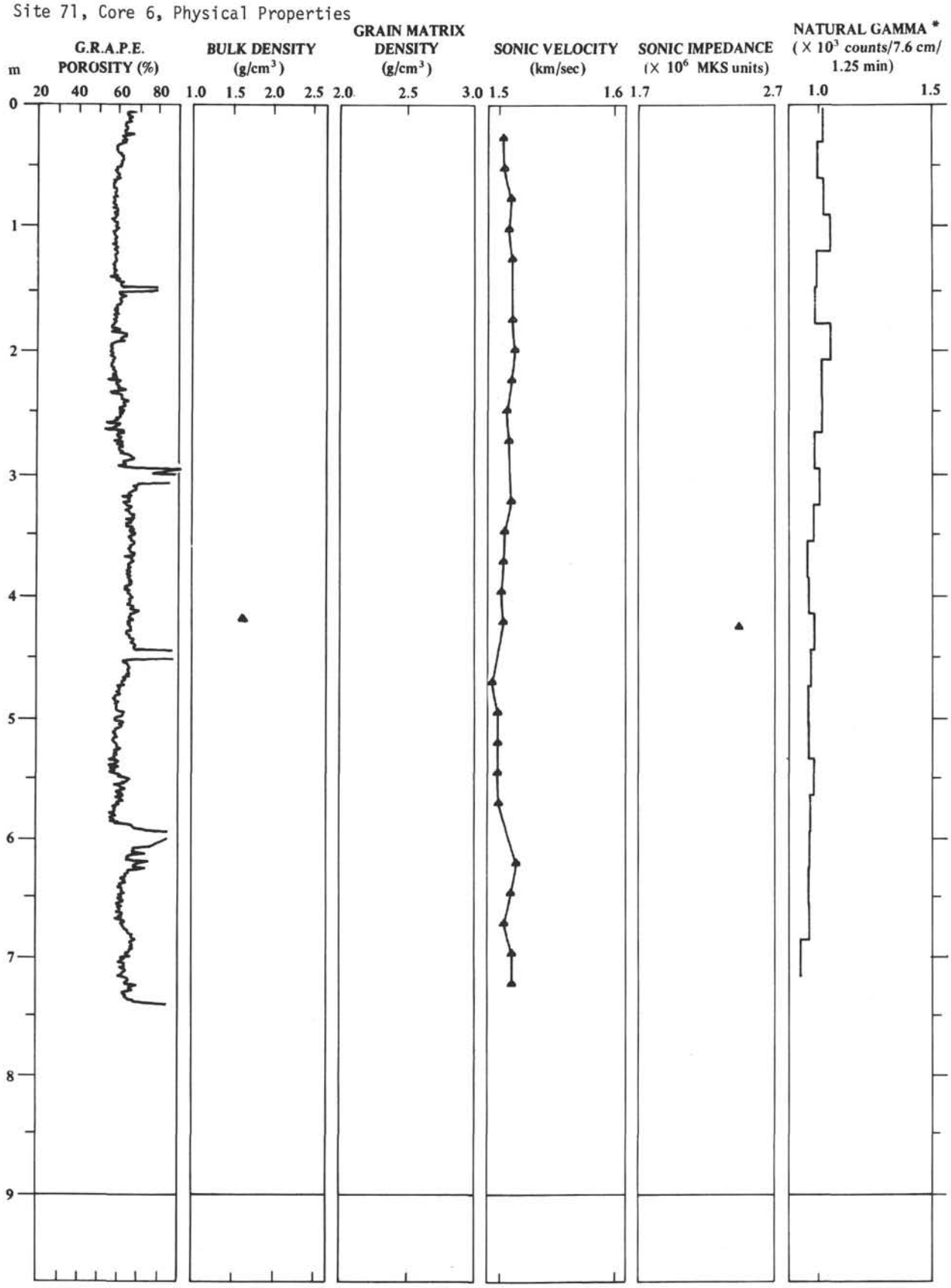
Site 71, Core 5, Physical Properties



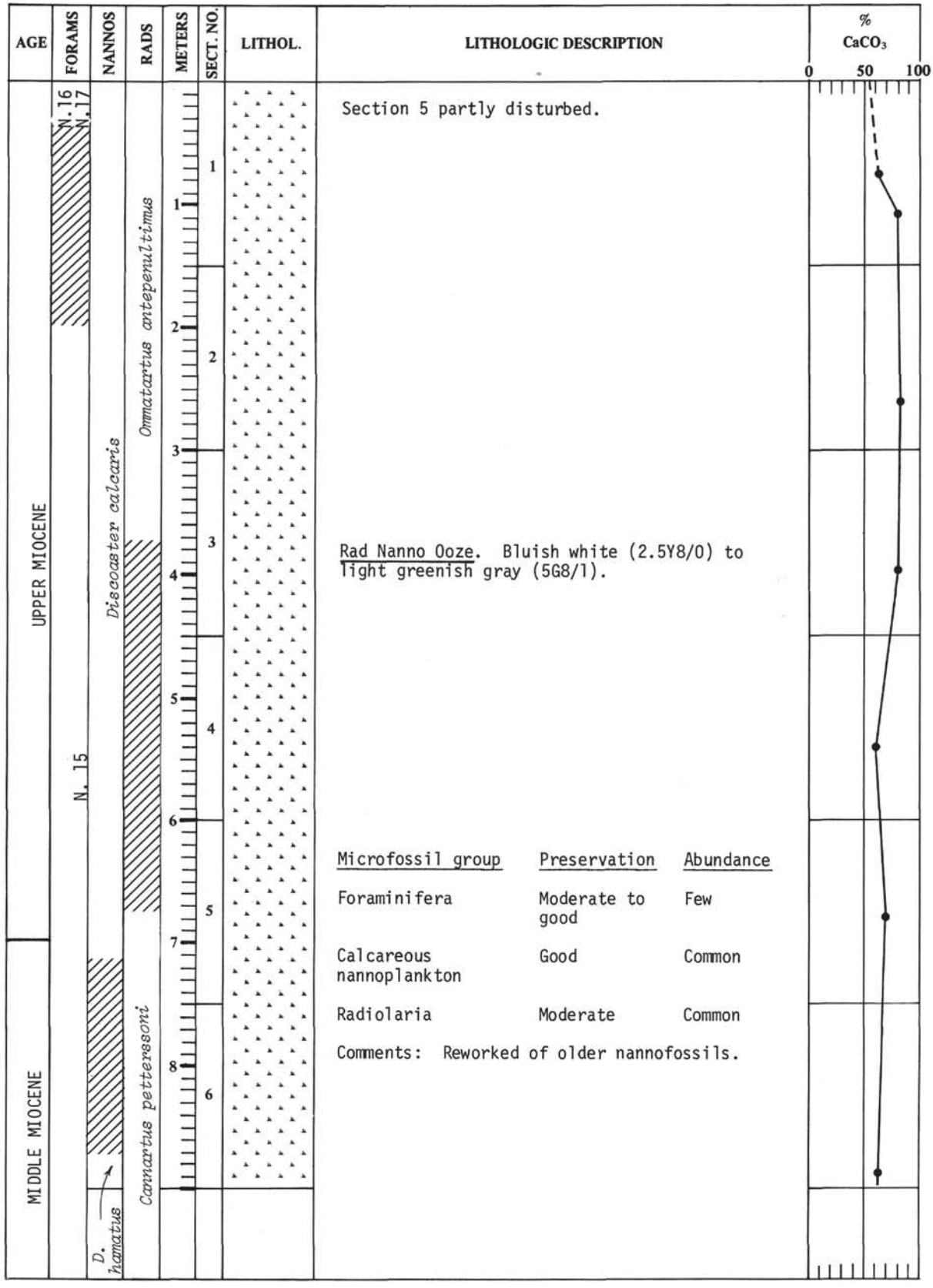
SITE 71 Core 6 Cored interval: 43-52 m



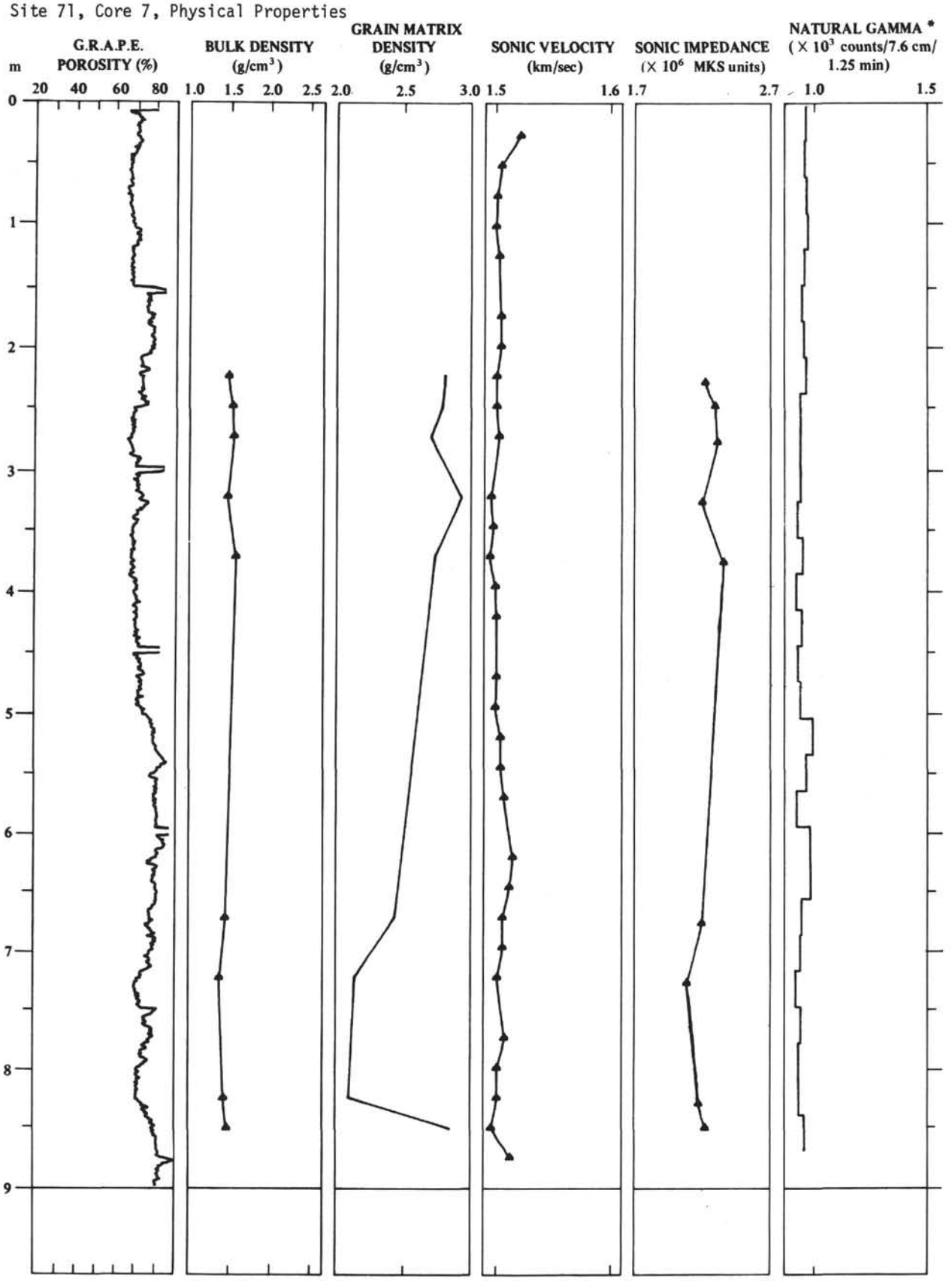
Site 71, Core 6, Physical Properties



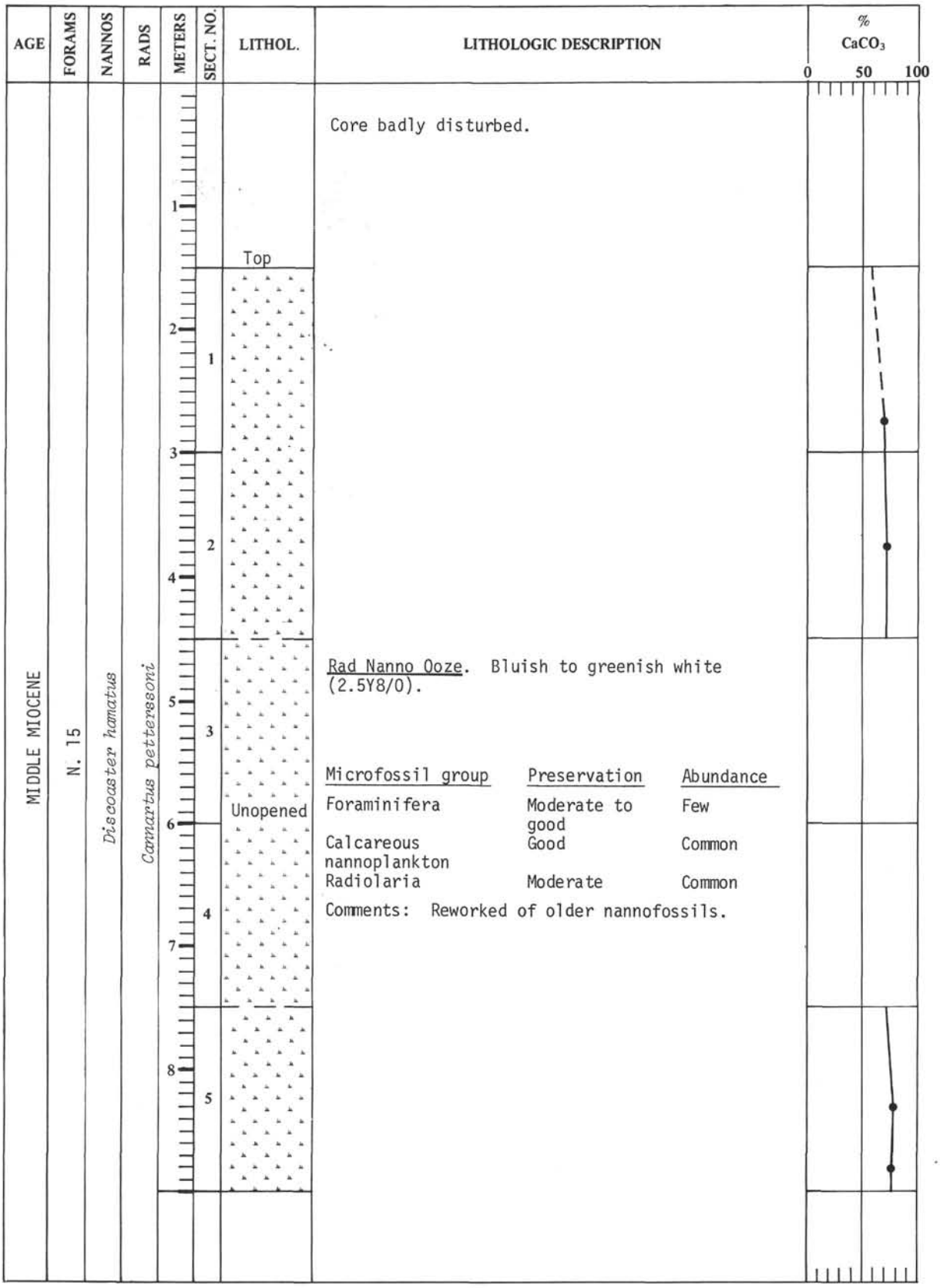
CORE 71 Core 7 Cored interval: 52-61 m



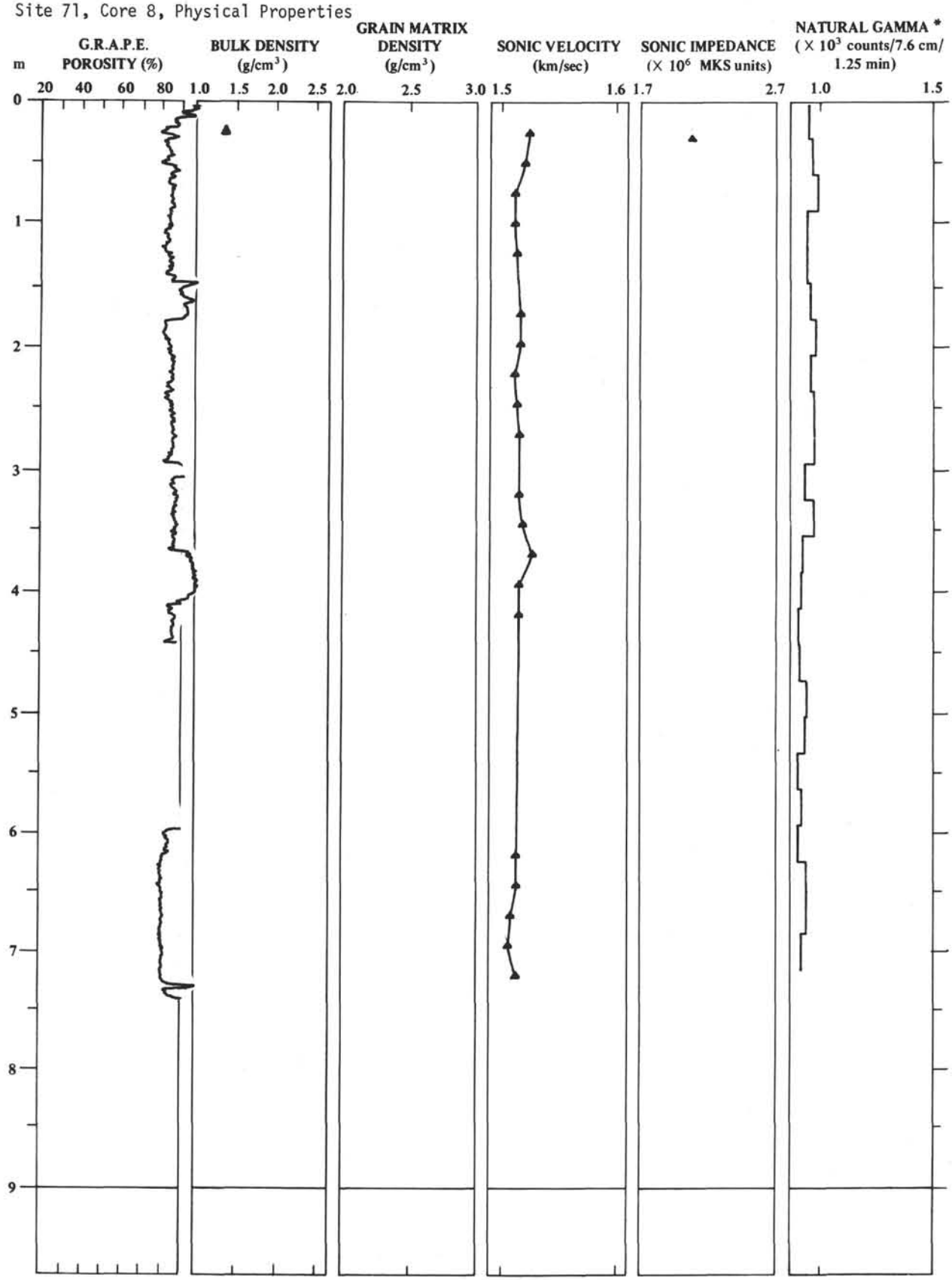
Site 71, Core 7, Physical Properties



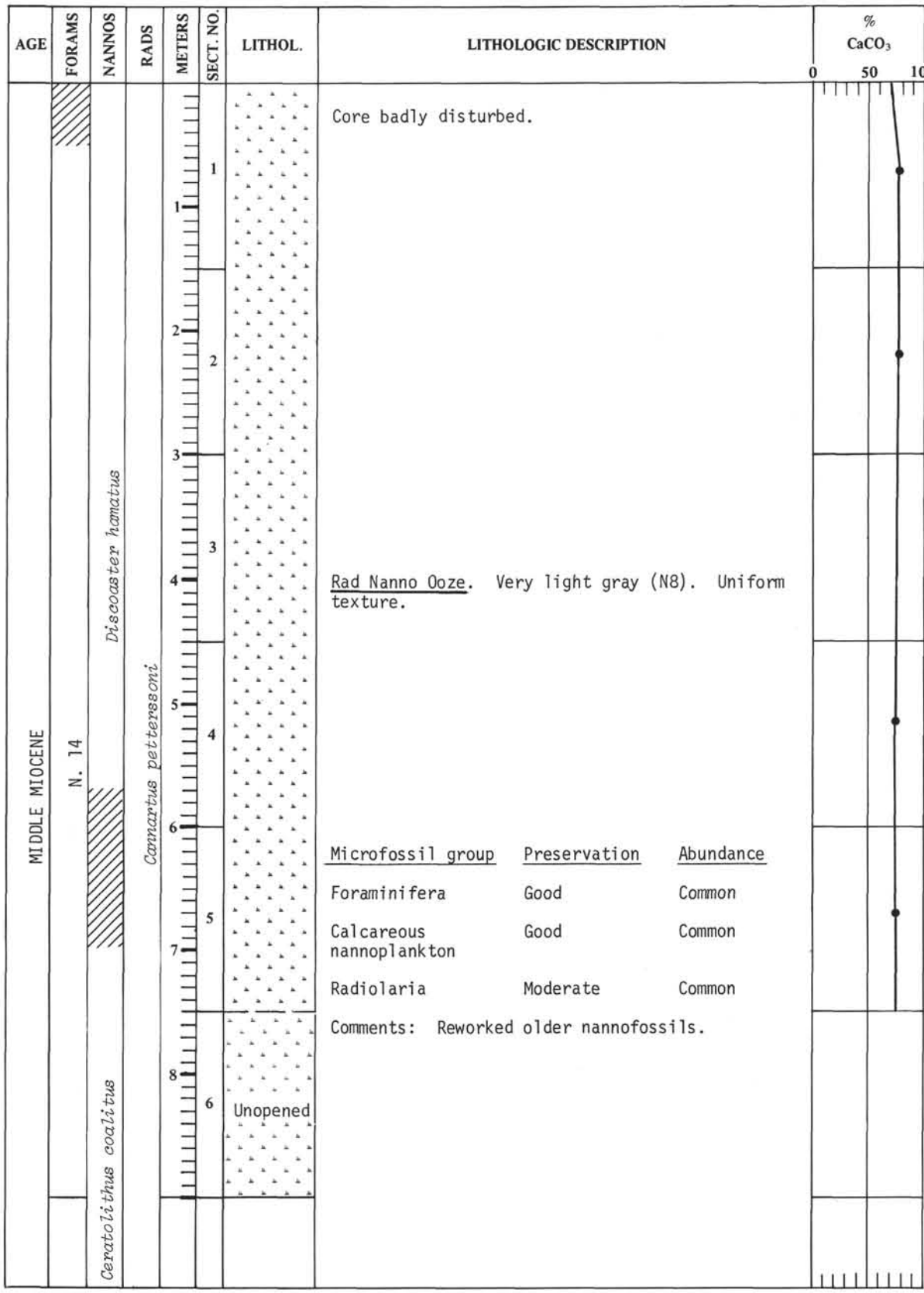
SITE 71 Core 8 Cored interval: 61-69 m



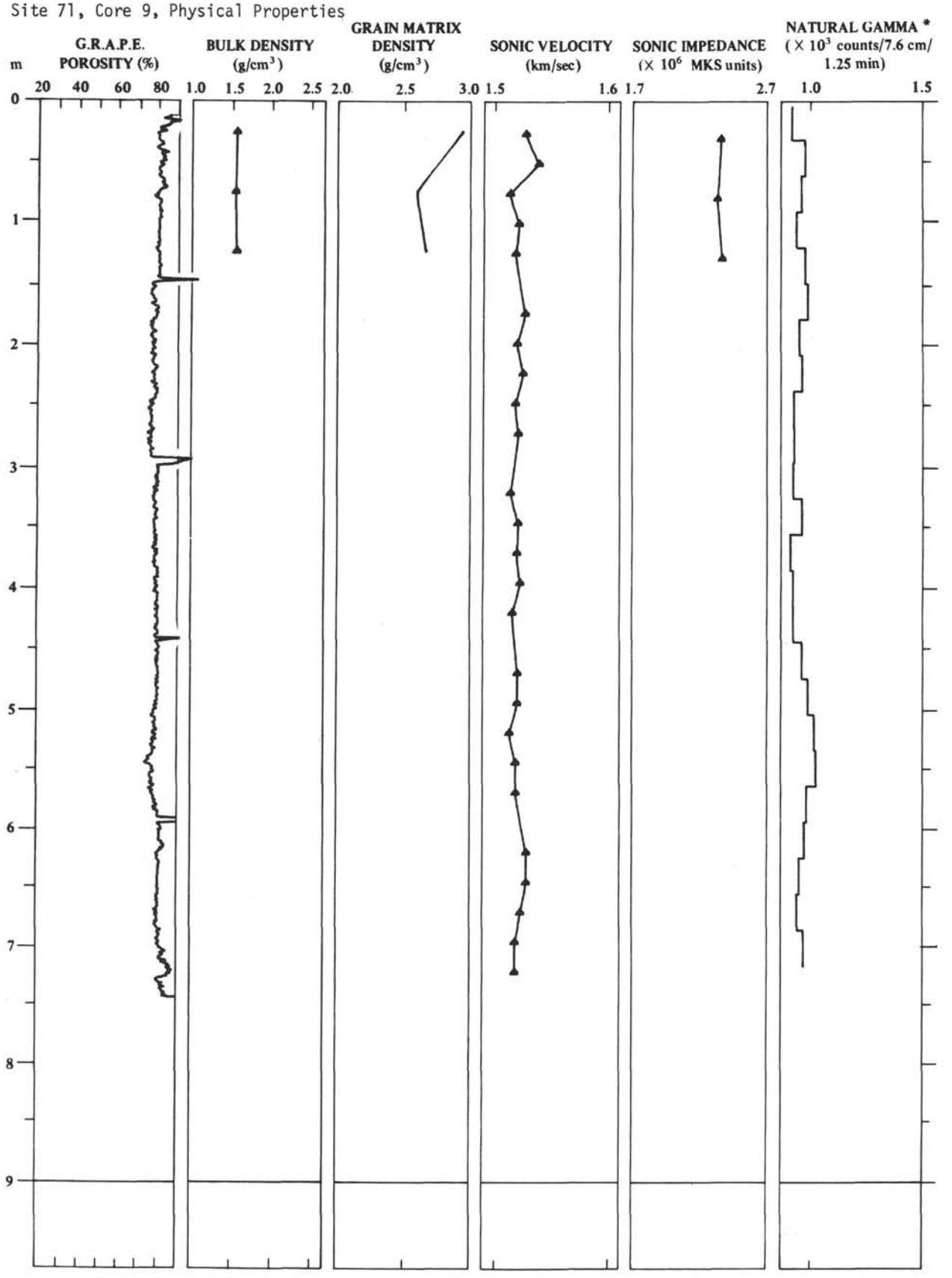
Site 71, Core 8, Physical Properties



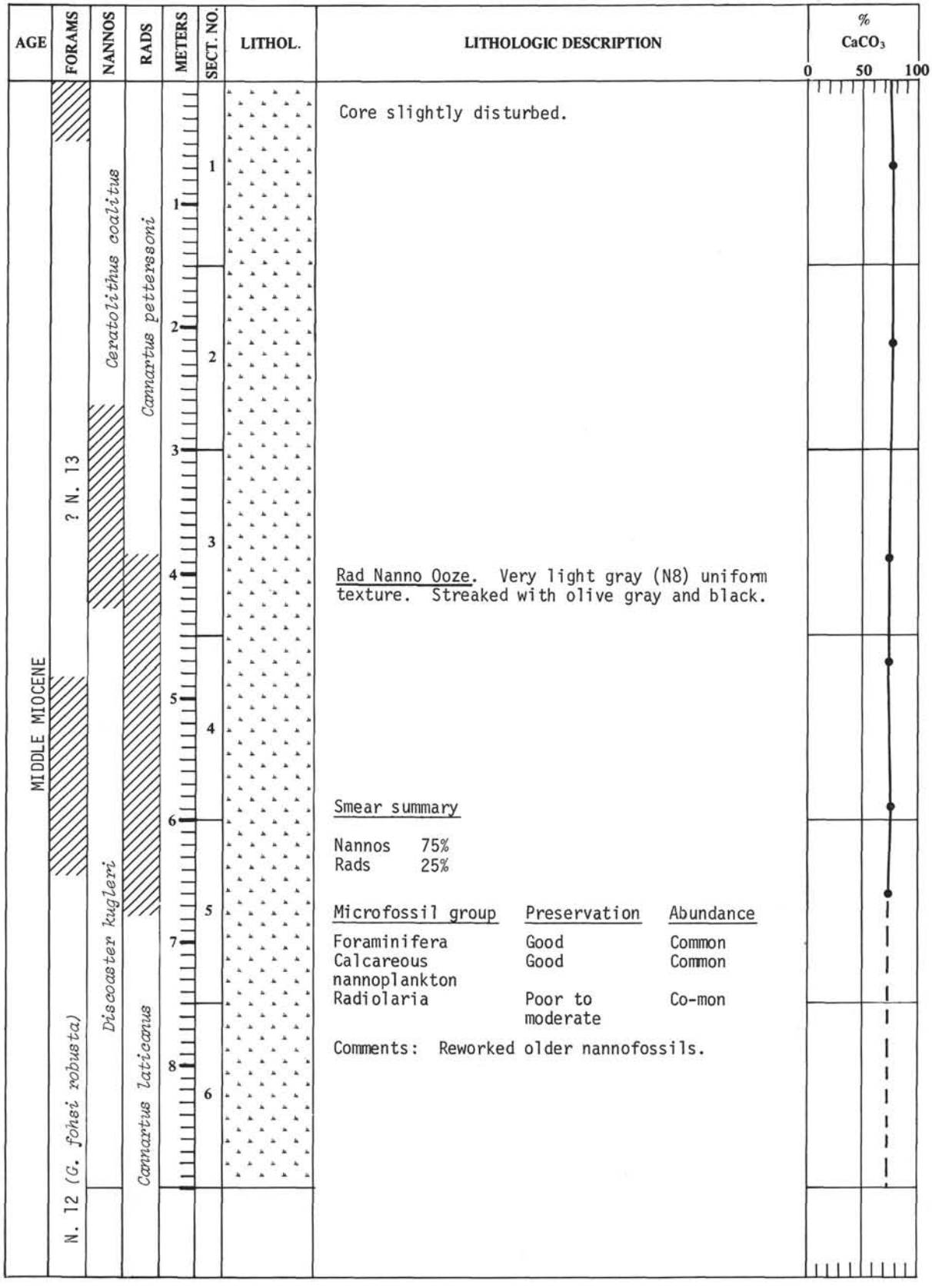
SITE 71 Core 9 Cored interval: 70-79 m

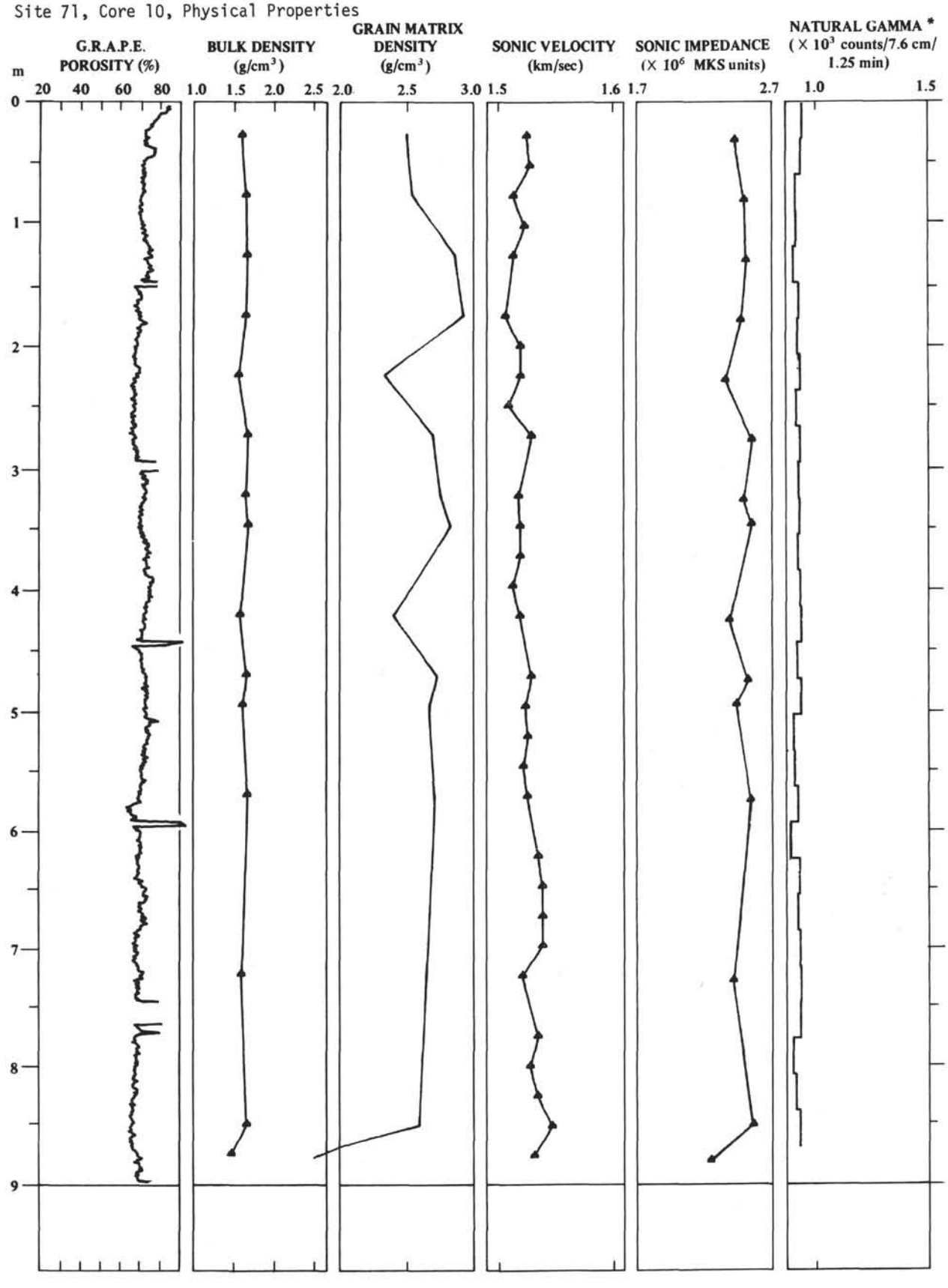


Site 71, Core 9, Physical Properties

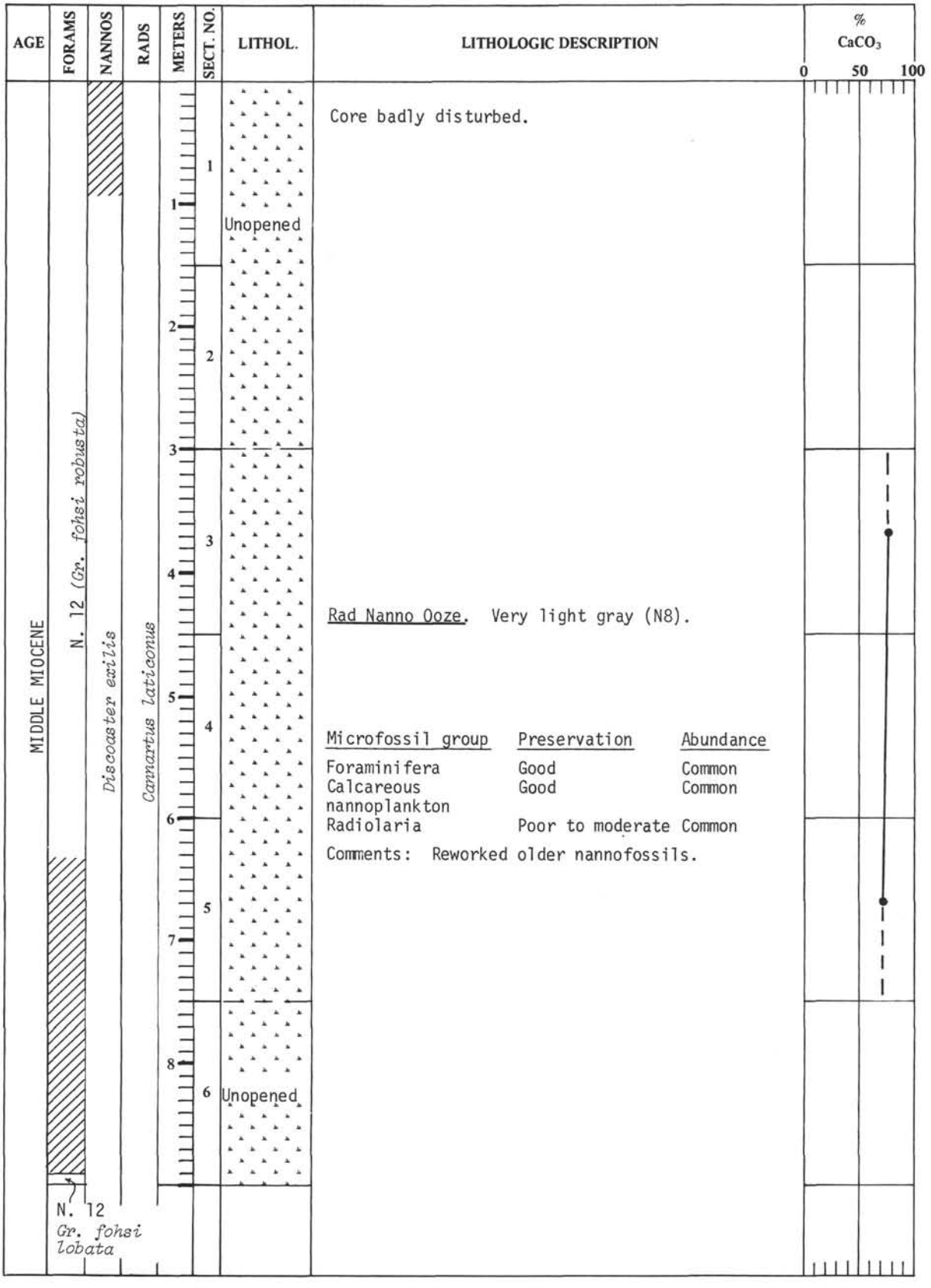


SITE 71 Core 10 Cored interval: 79-88 m

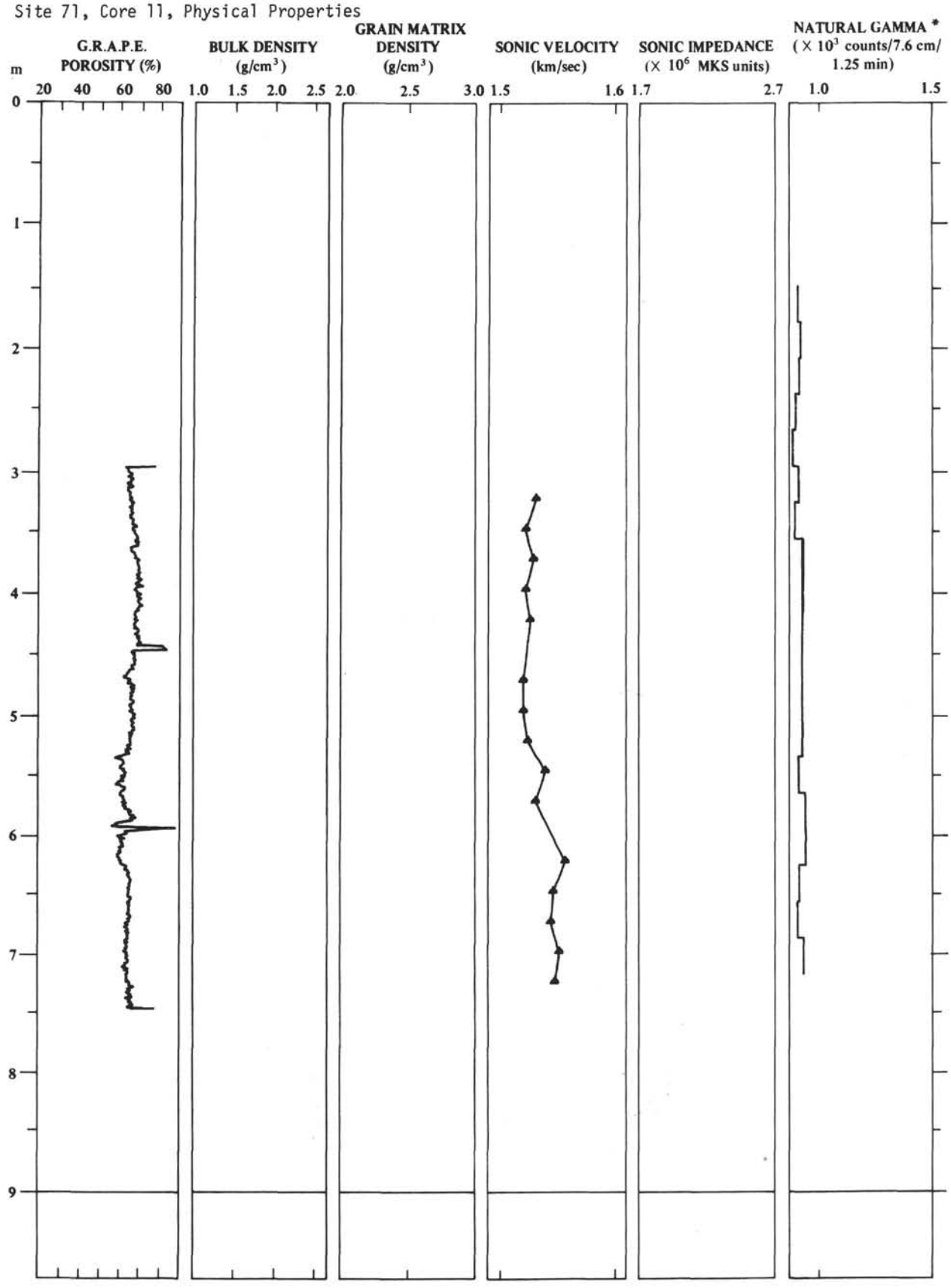



Site 71, Core 10, Physical Properties
G.R.A.P.E. POROSITY (%)
BULK DENSITY (g/cm³)
GRAIN MATRIX DENSITY (g/cm³)
SONIC VELOCITY (km/sec)
SONIC IMPEDANCE (× 10⁶ MKS units)
NATURAL GAMMA * (× 10³ counts/7.6 cm/ 1.25 min)
m
0
1
2
3
4
5
6
7
8
9
20 40 60 80
1.0 1.5 2.0 2.5
2.0 2.5 3.0
1.5 1.6
1.7 2.7
1.0 1.5

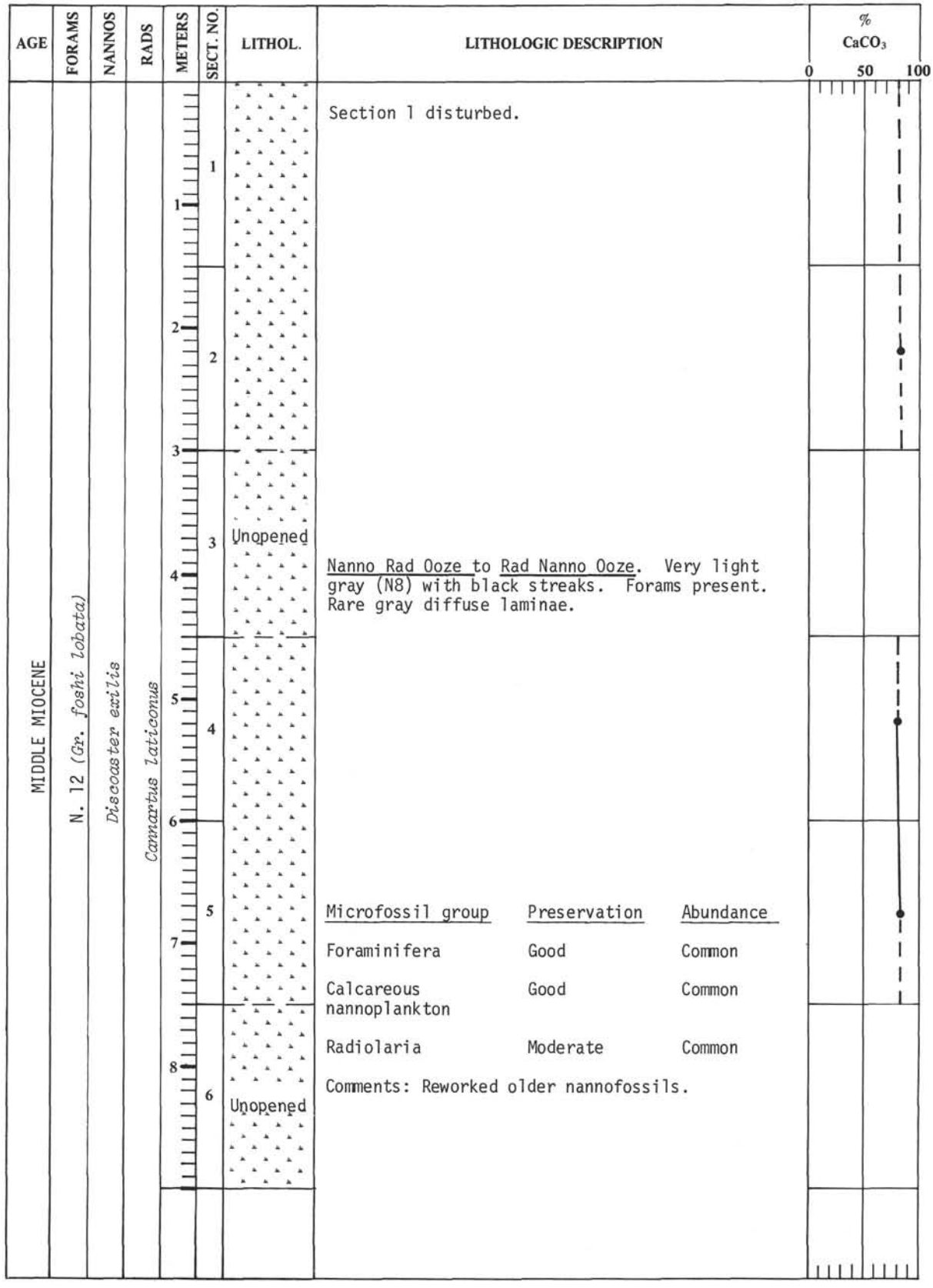
SITE 71 Core 11 Cored interval: 89-98 m



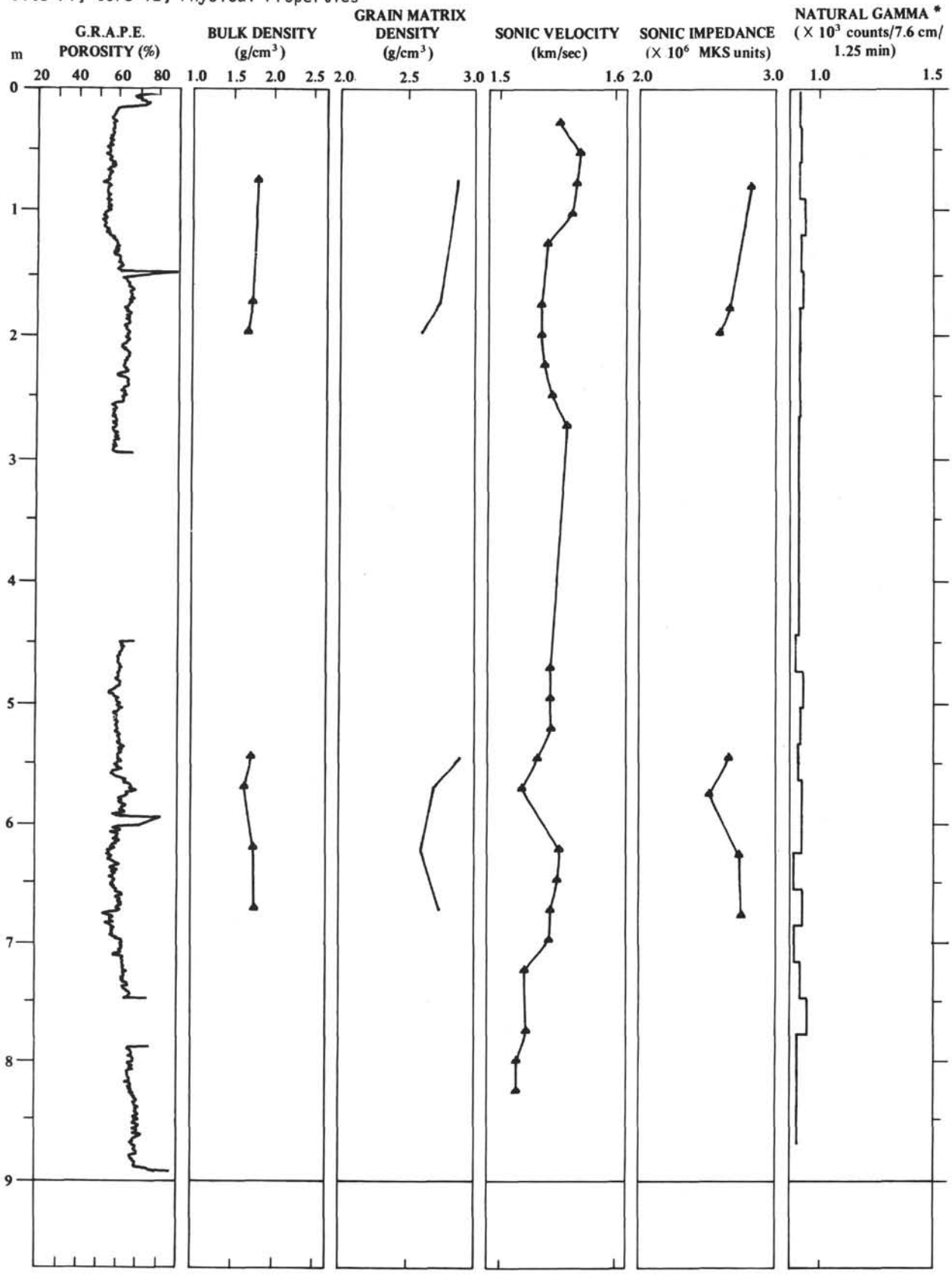
Site 71, Core 11, Physical Properties



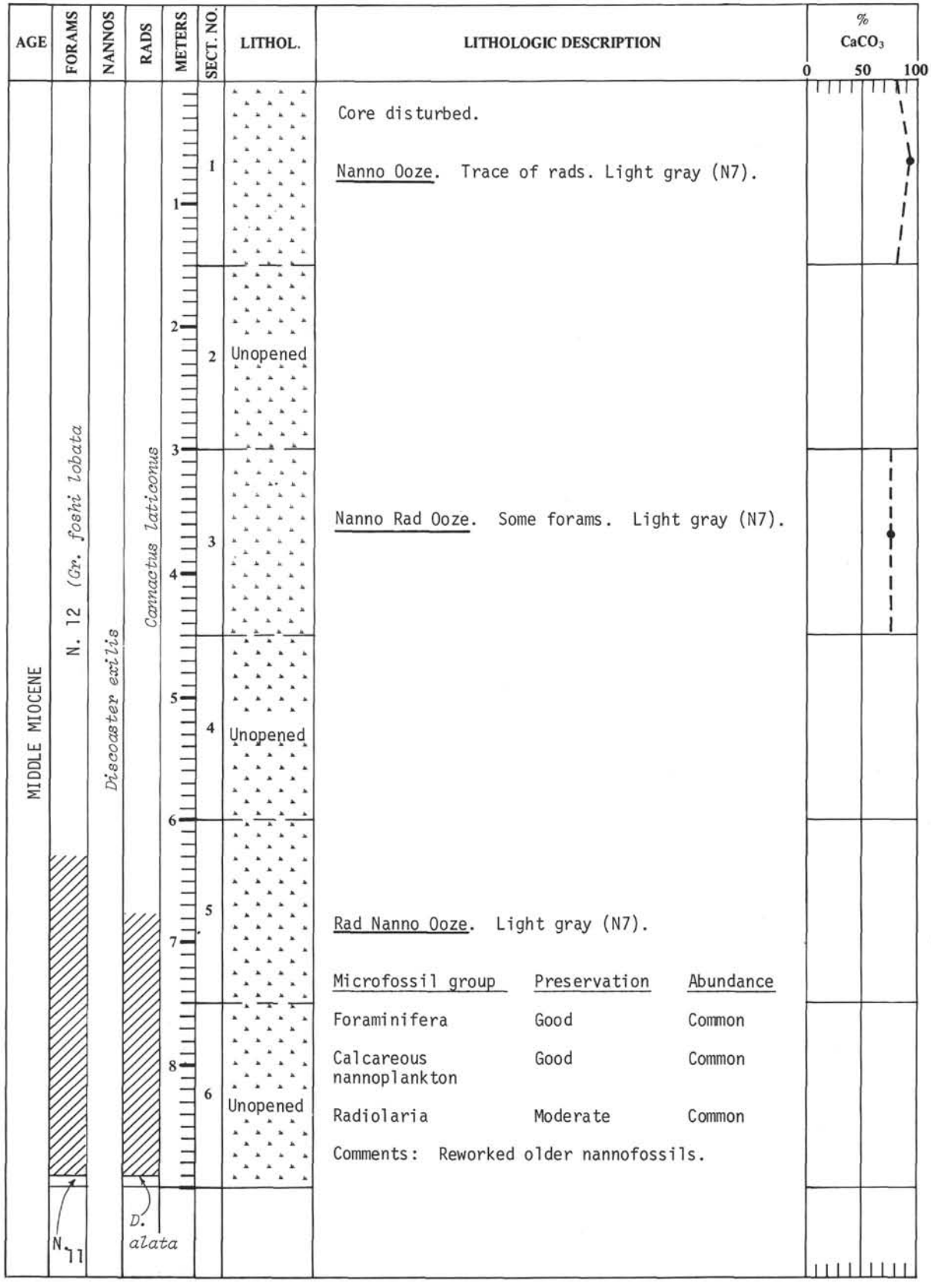
SITE 71 Core 12 Cored interval: 98-107 m



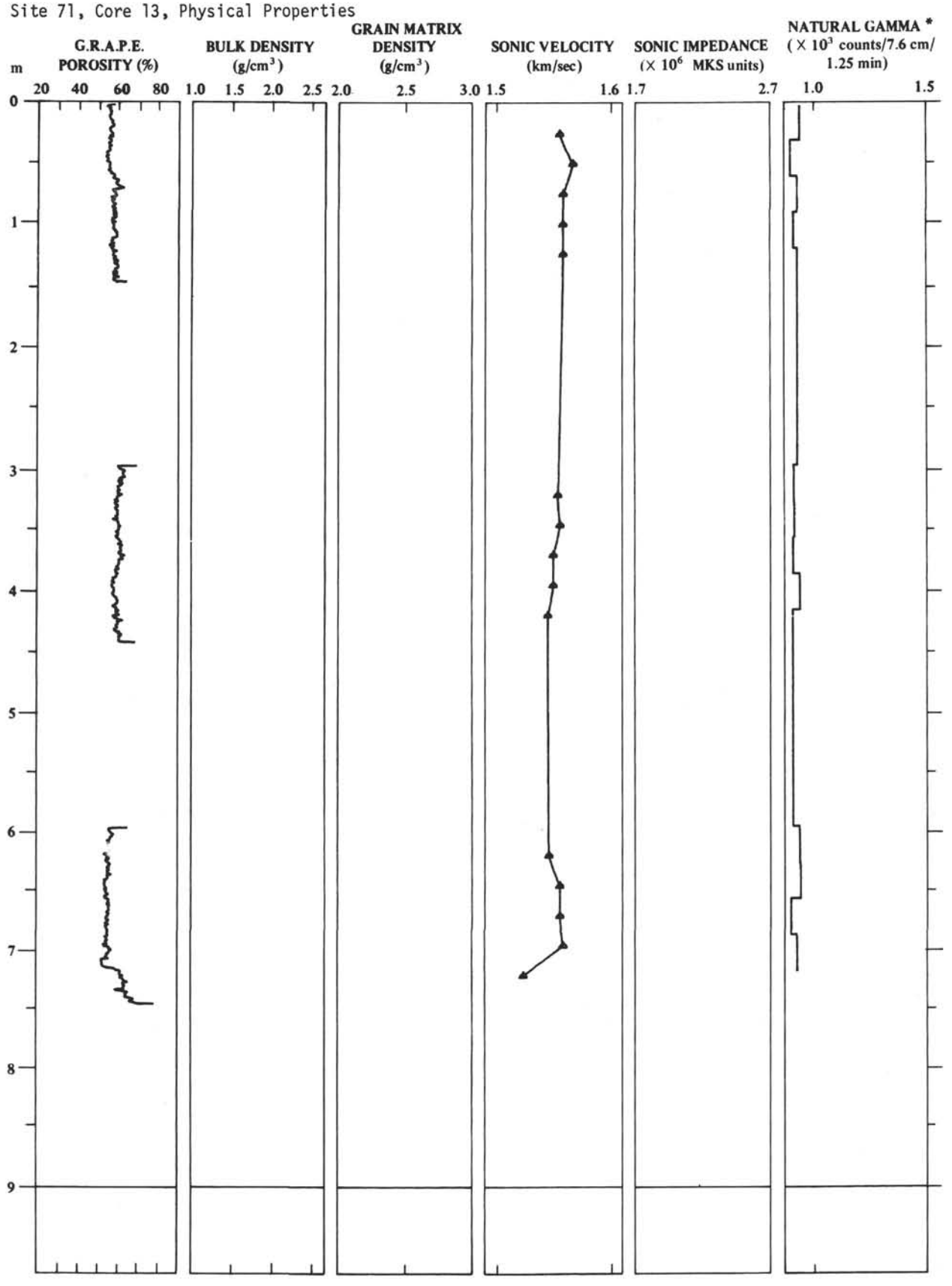
Site 71, Core 12, Physical Properties



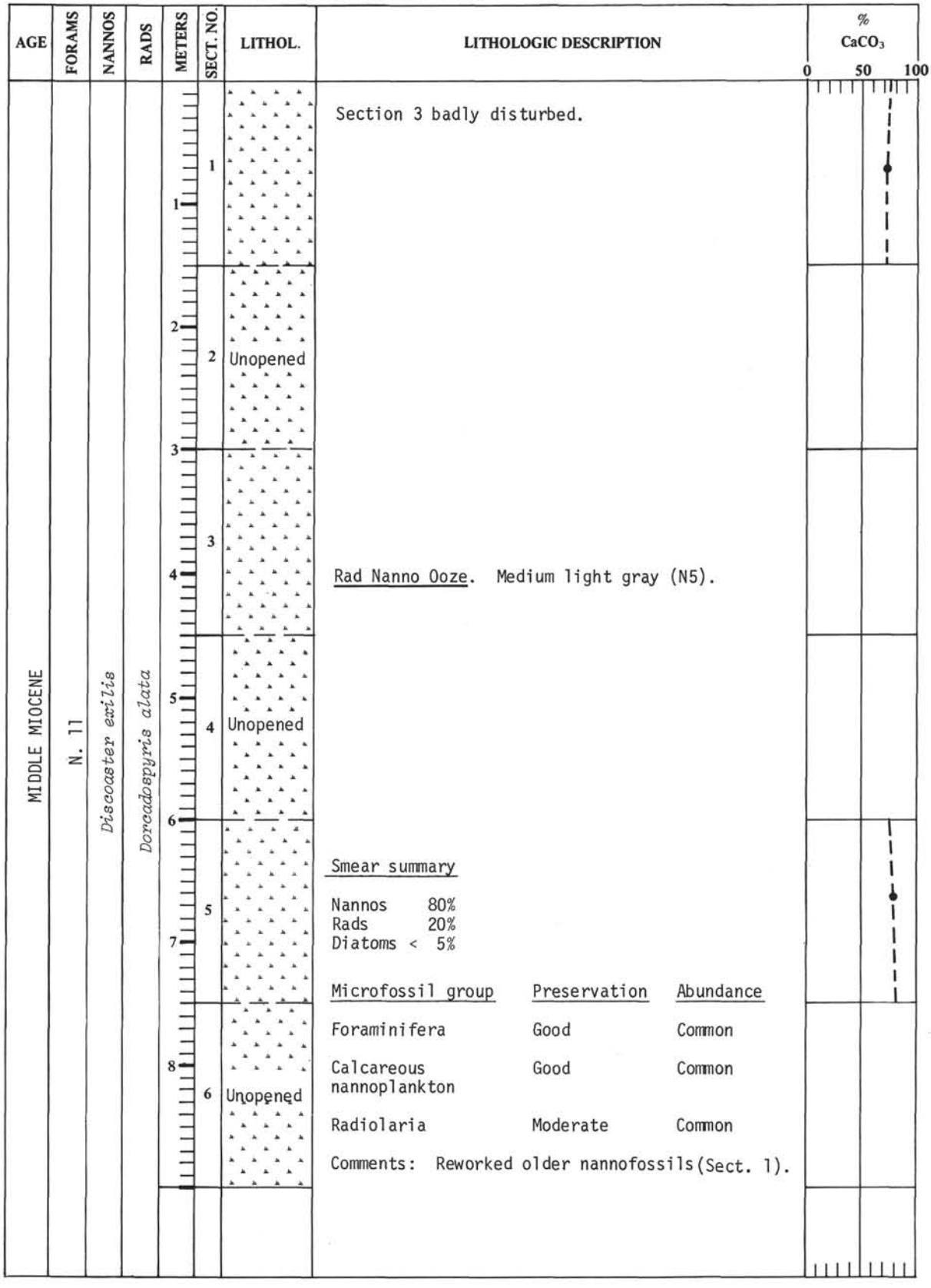
SITE 71 Core 13 Cored interval: 107-116 m



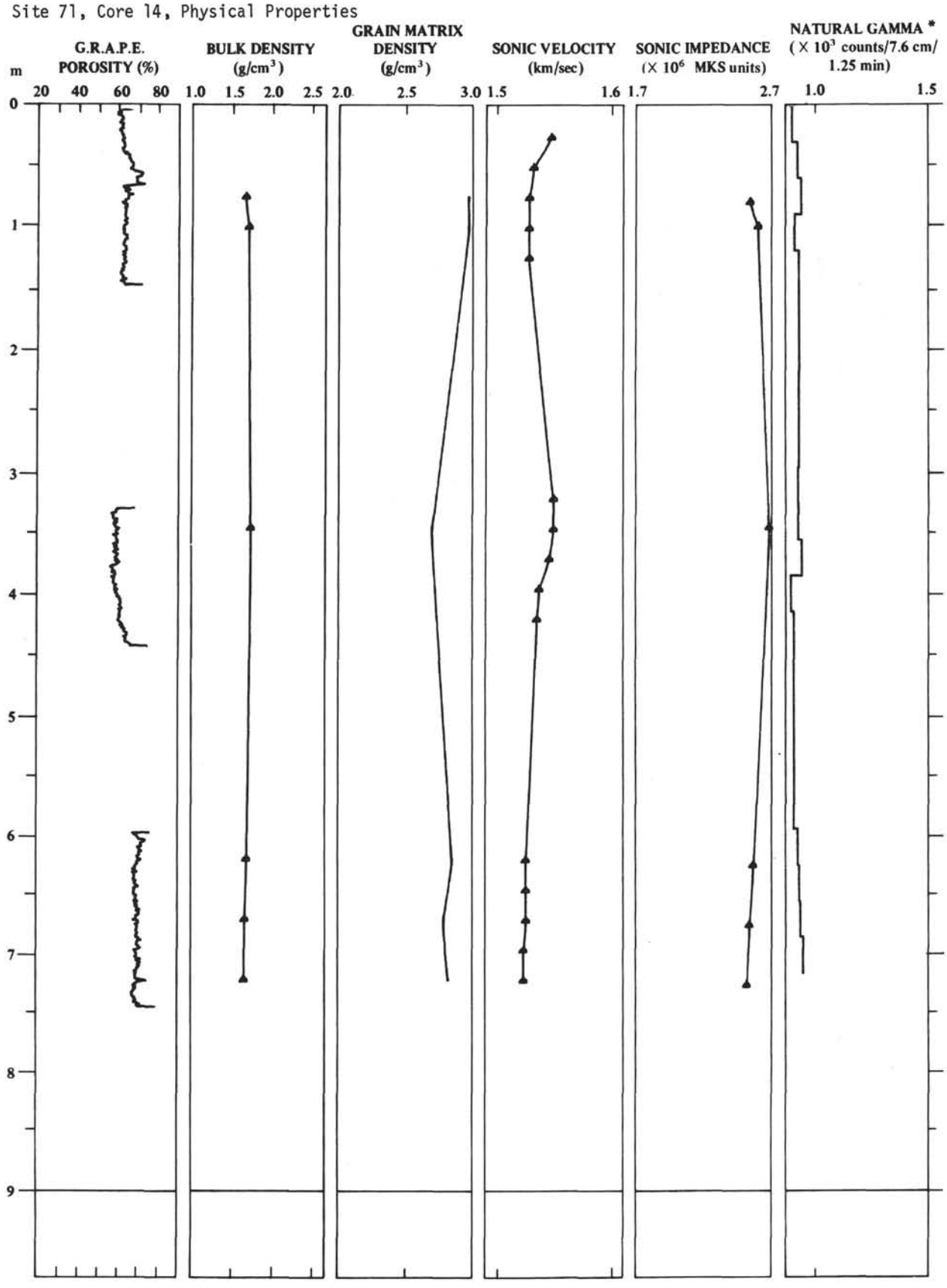
Site 71, Core 13, Physical Properties



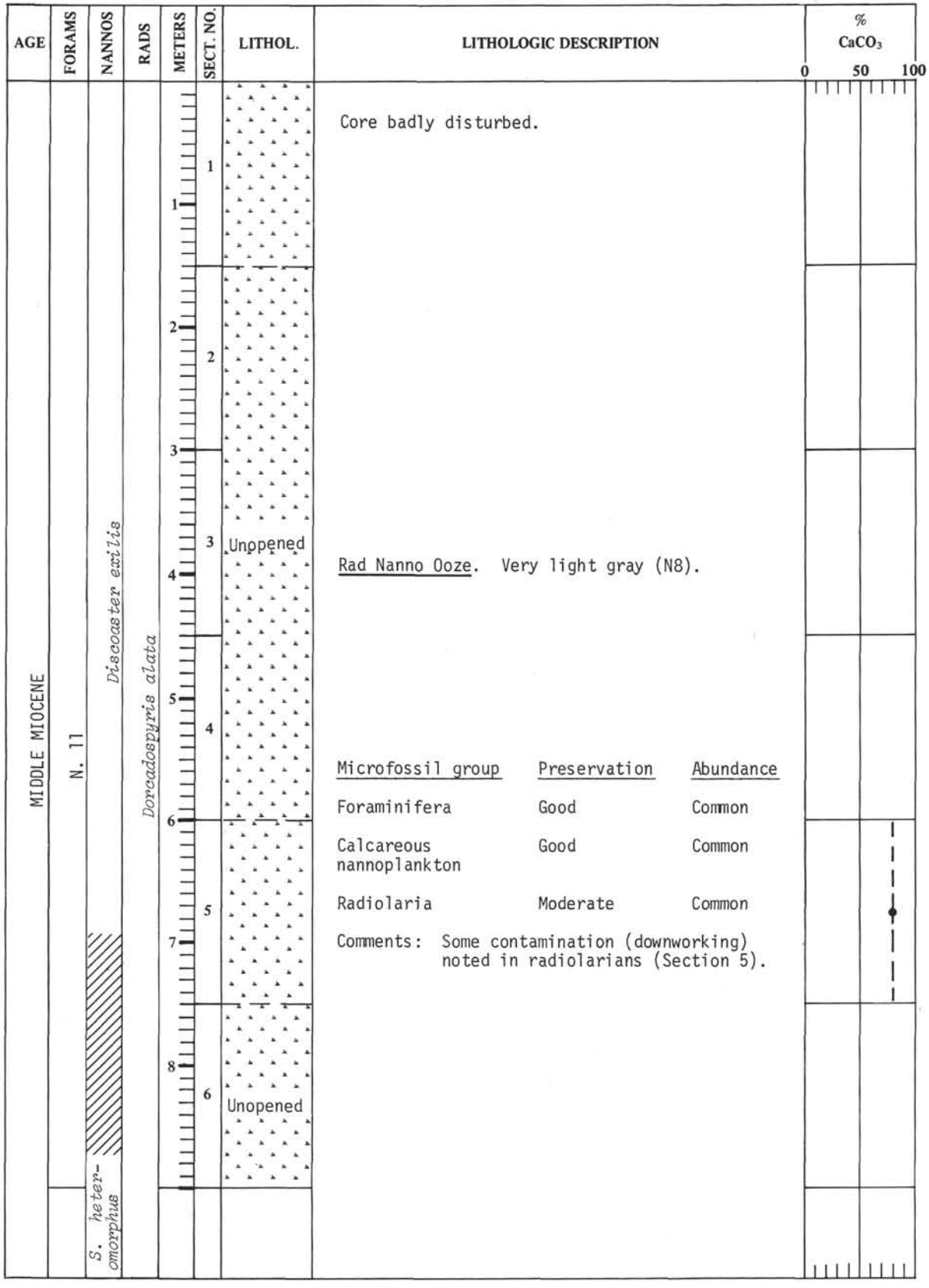
CORE 71 Core 14 Cored interval: 116-125 m



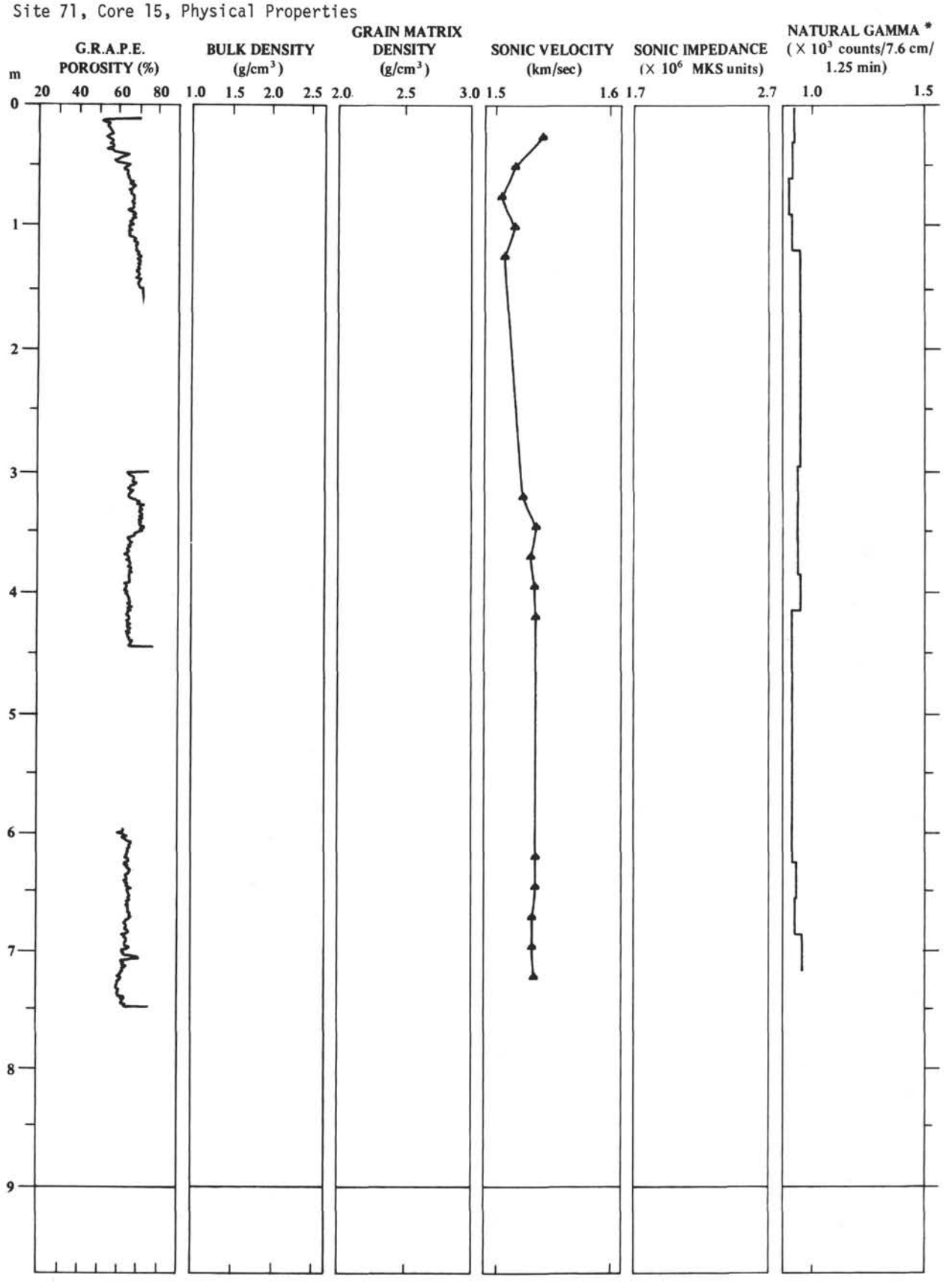
Site 71, Core 14, Physical Properties



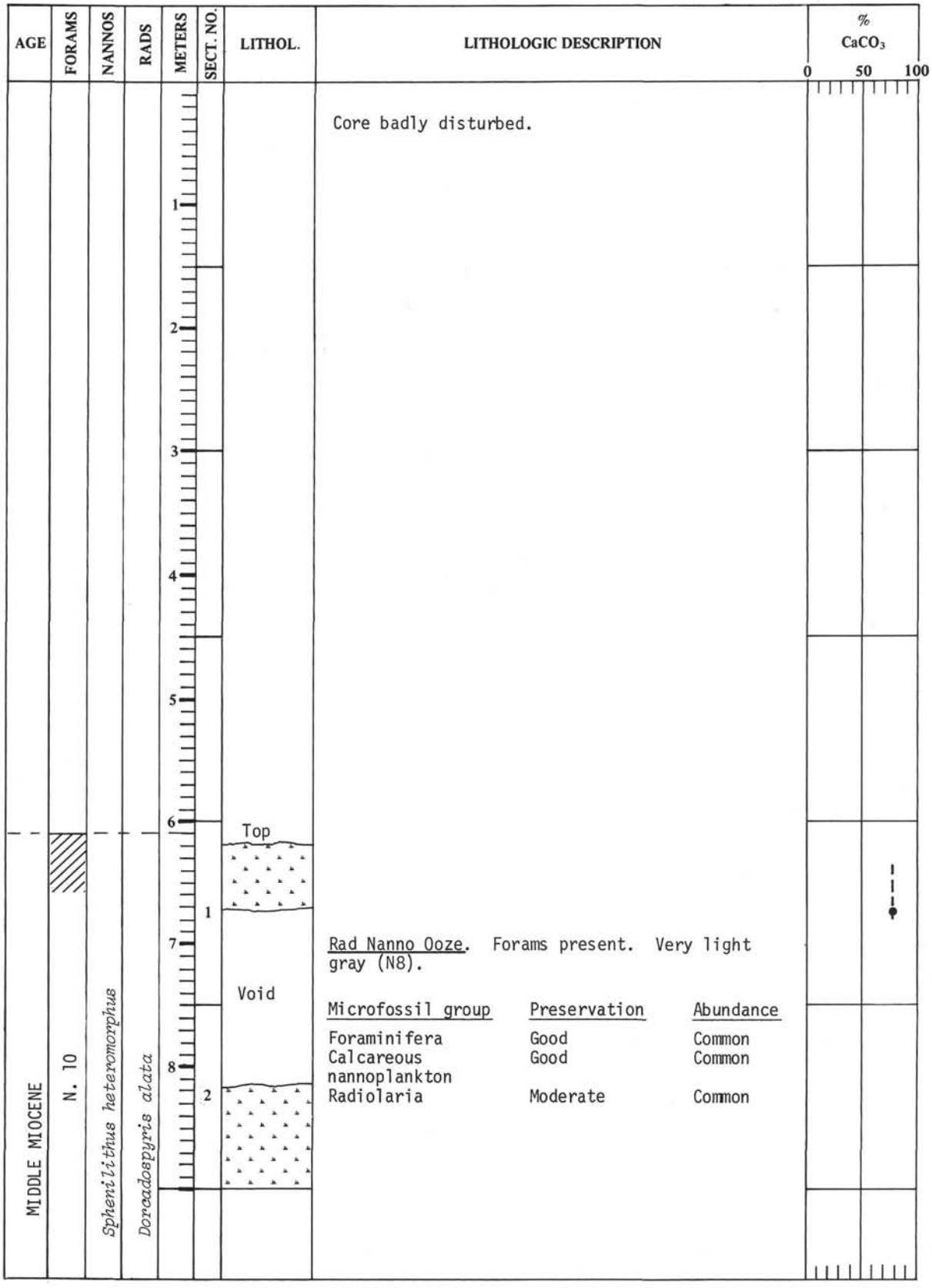
CORE 71 Core 15 Cored interval: 125-134 m



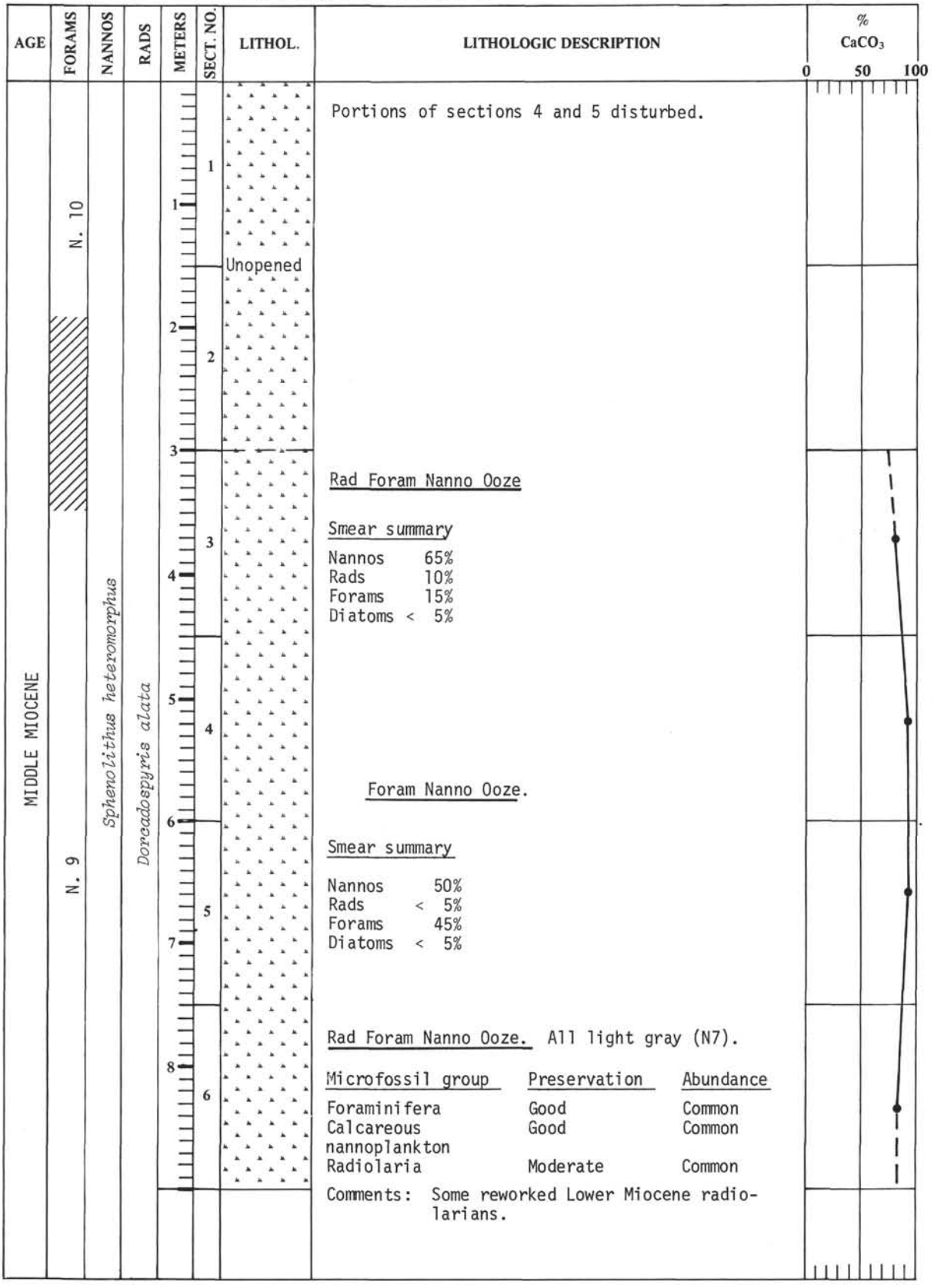
Site 71, Core 15, Physical Properties



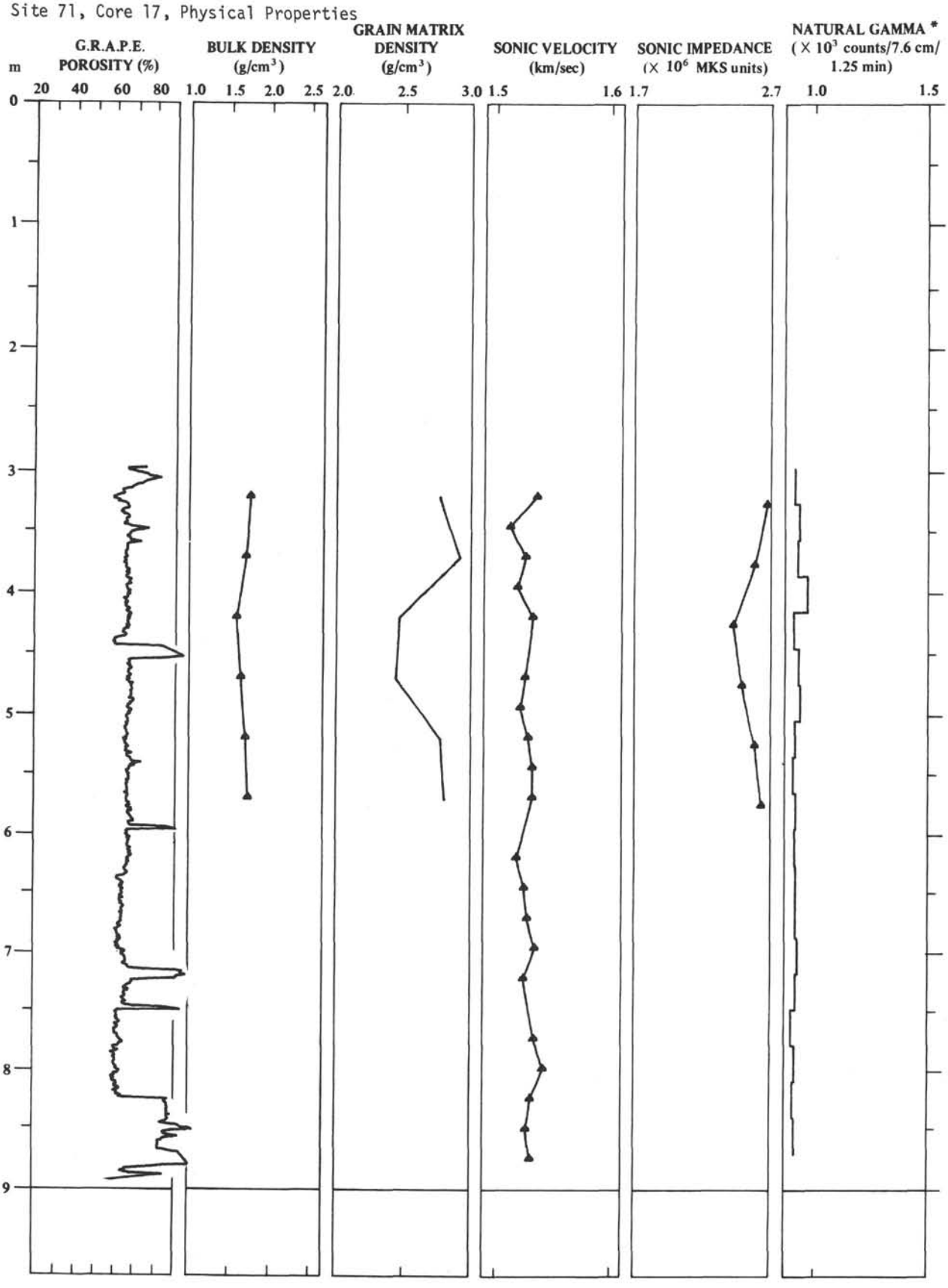
SITE 71 Core 16 Cored interval: 134-143 m



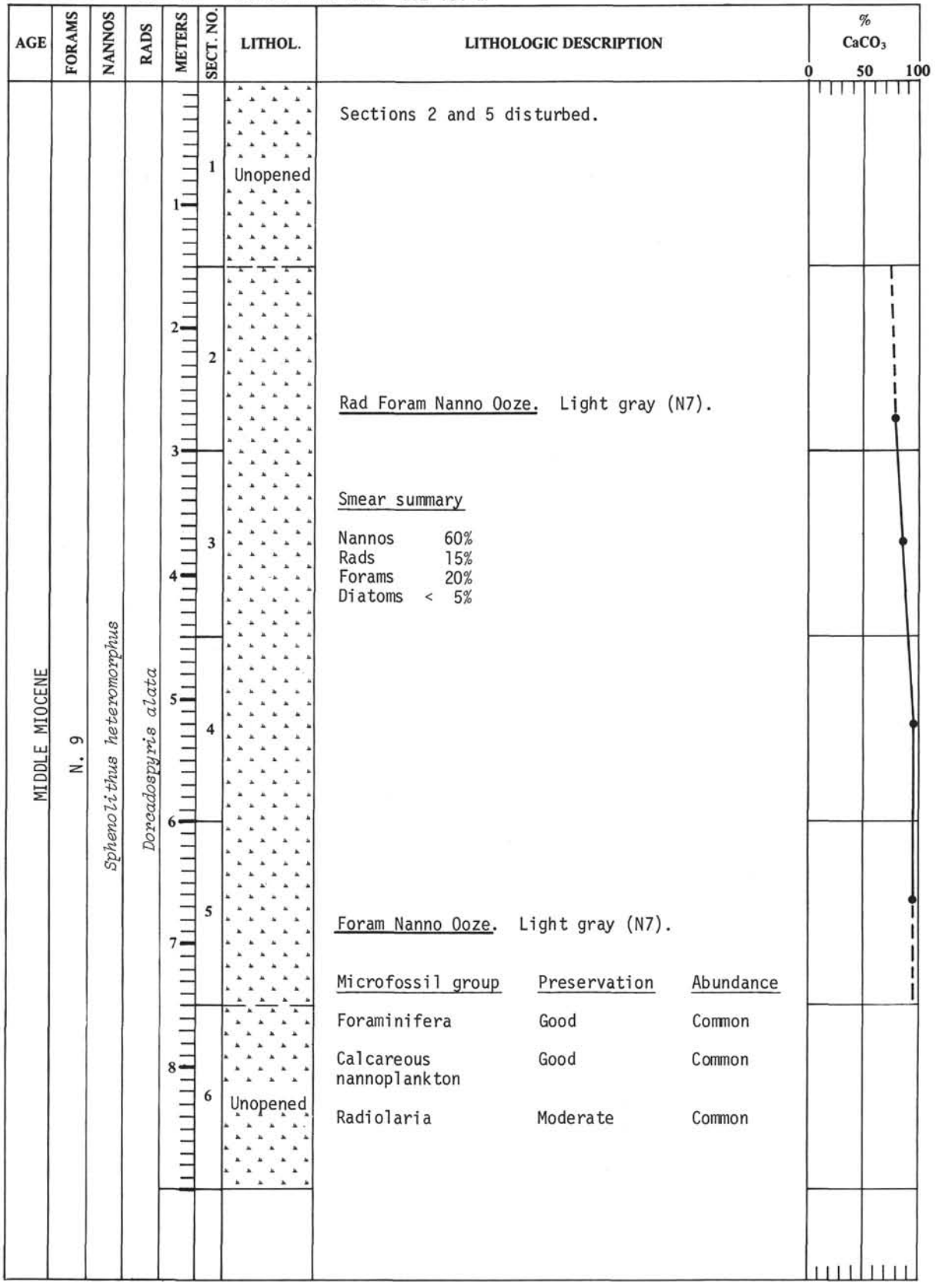
SITE 71 Core 17 Cored interval: 143-152 m



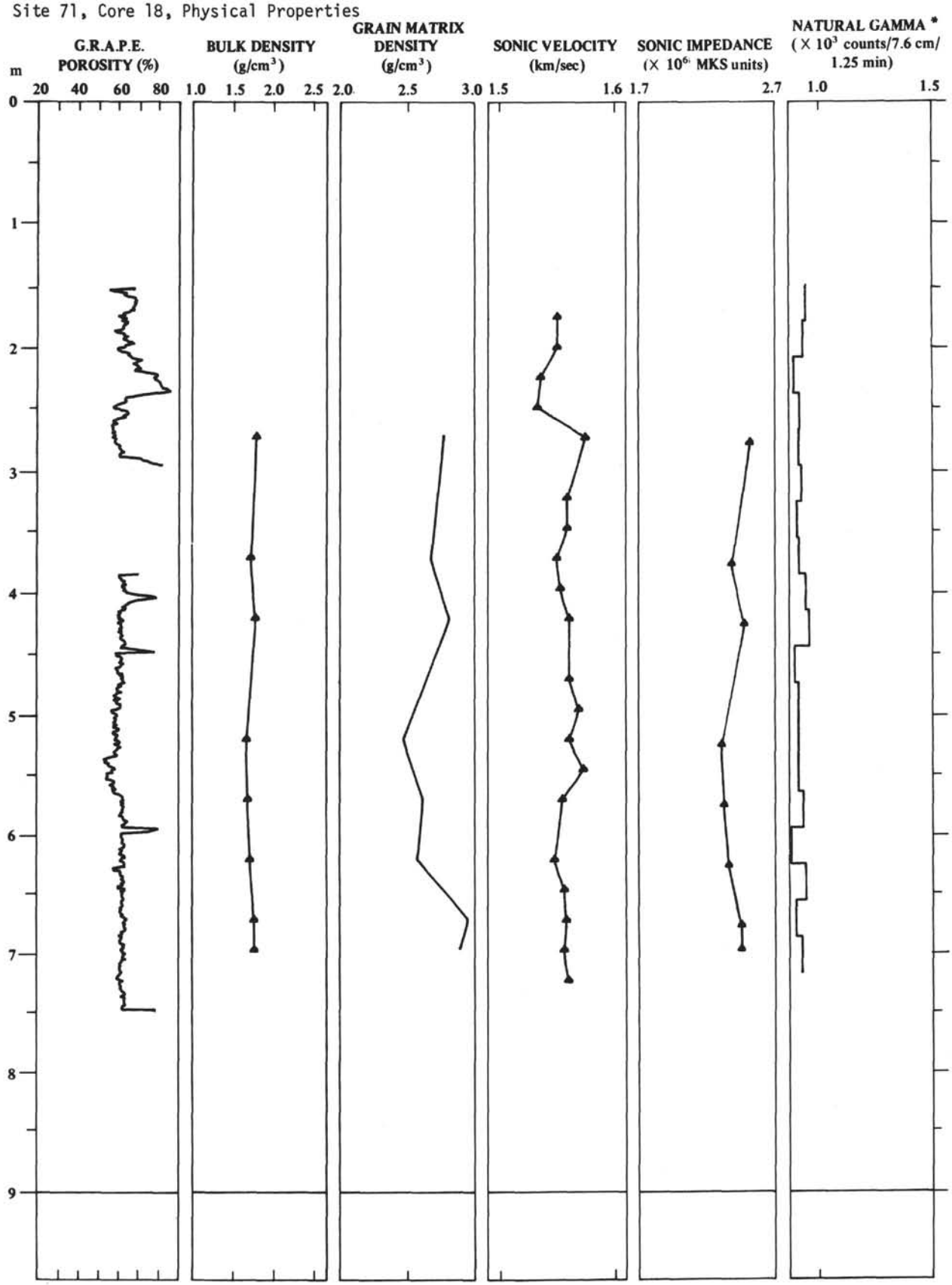
Site 71, Core 17, Physical Properties



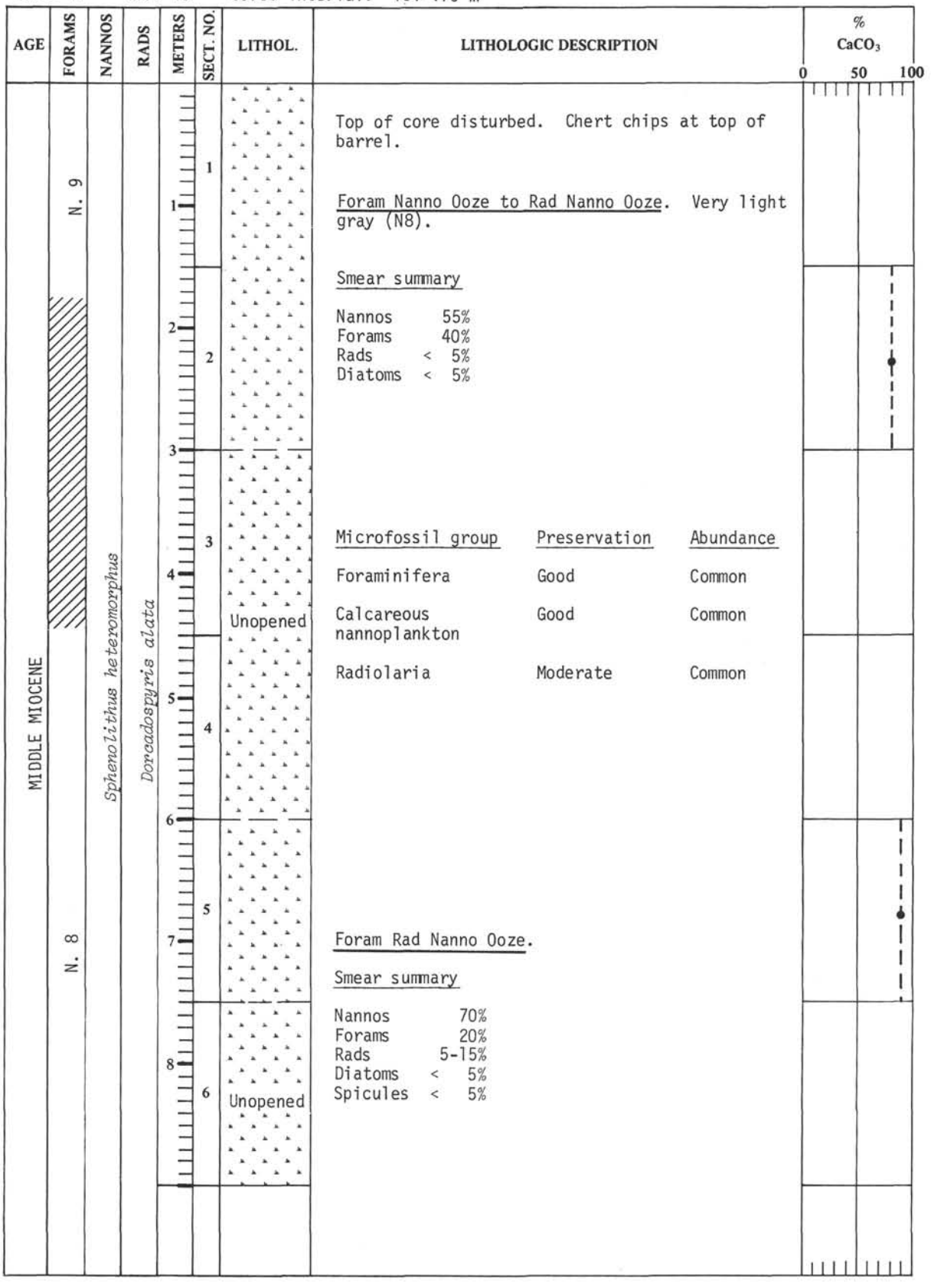
SITE 71 Core 18 Cored interval: 152-161 m



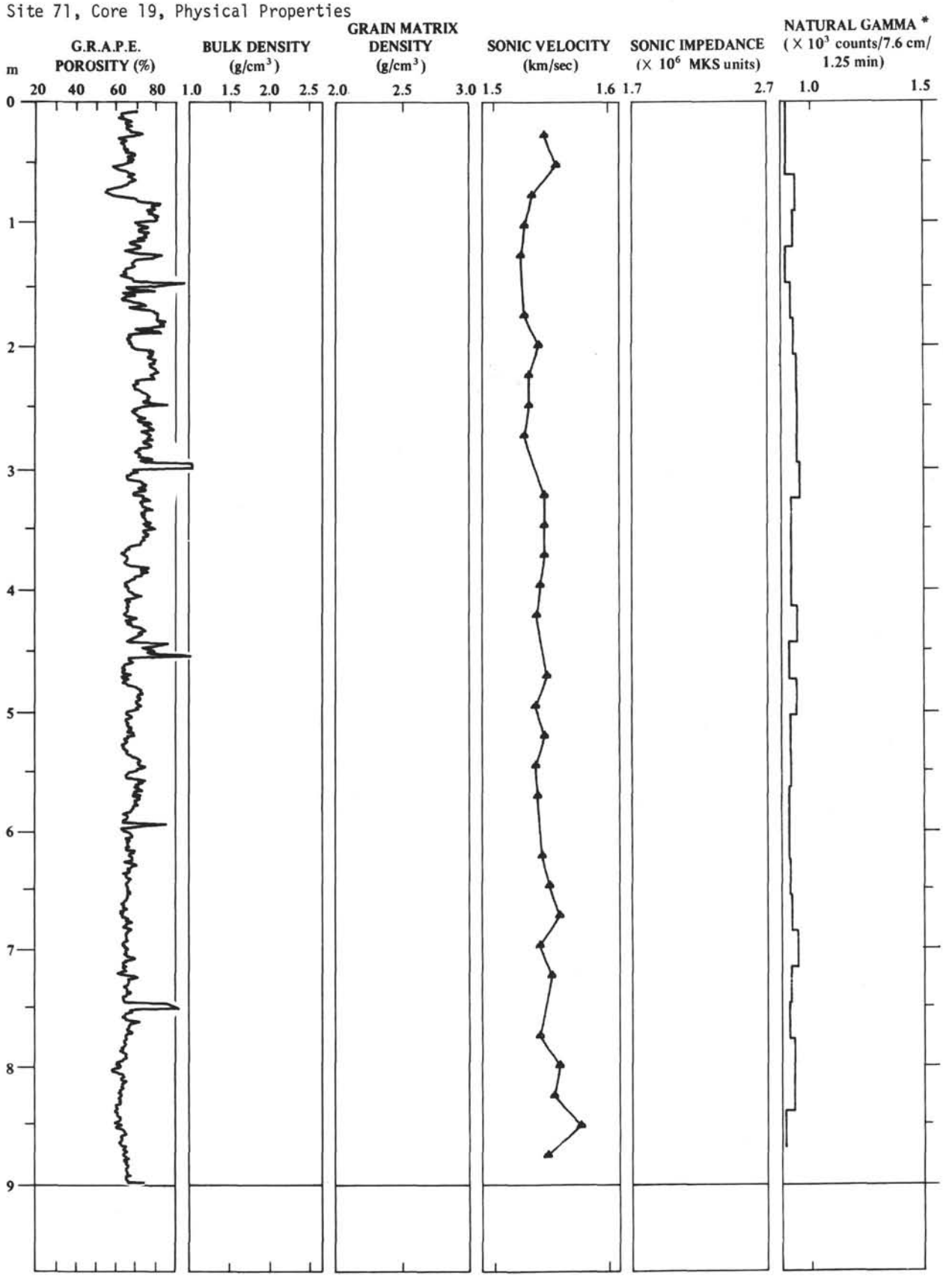
Site 71, Core 18, Physical Properties



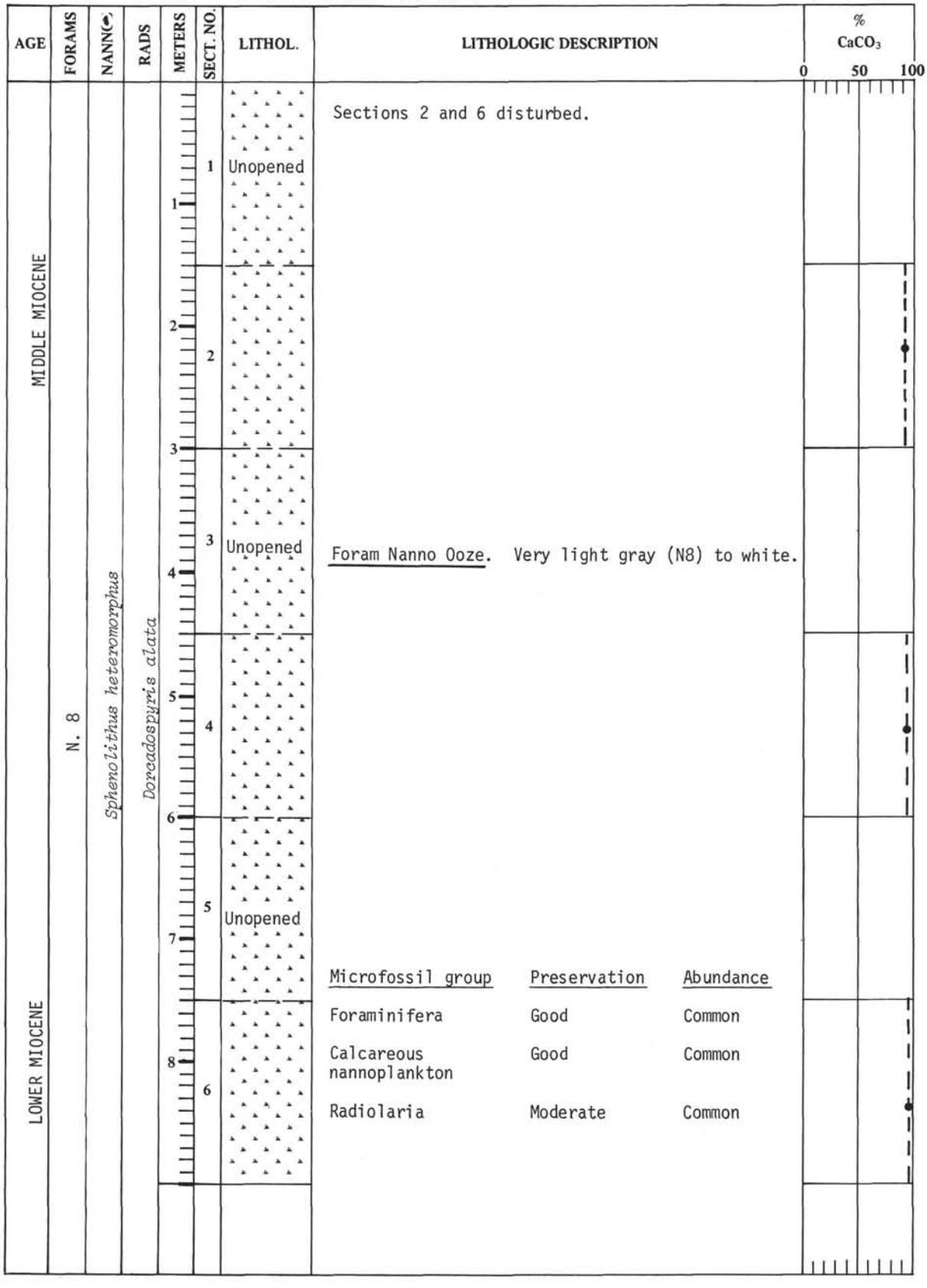
SITE 71 Core 19 Cored interval: 161-170 m



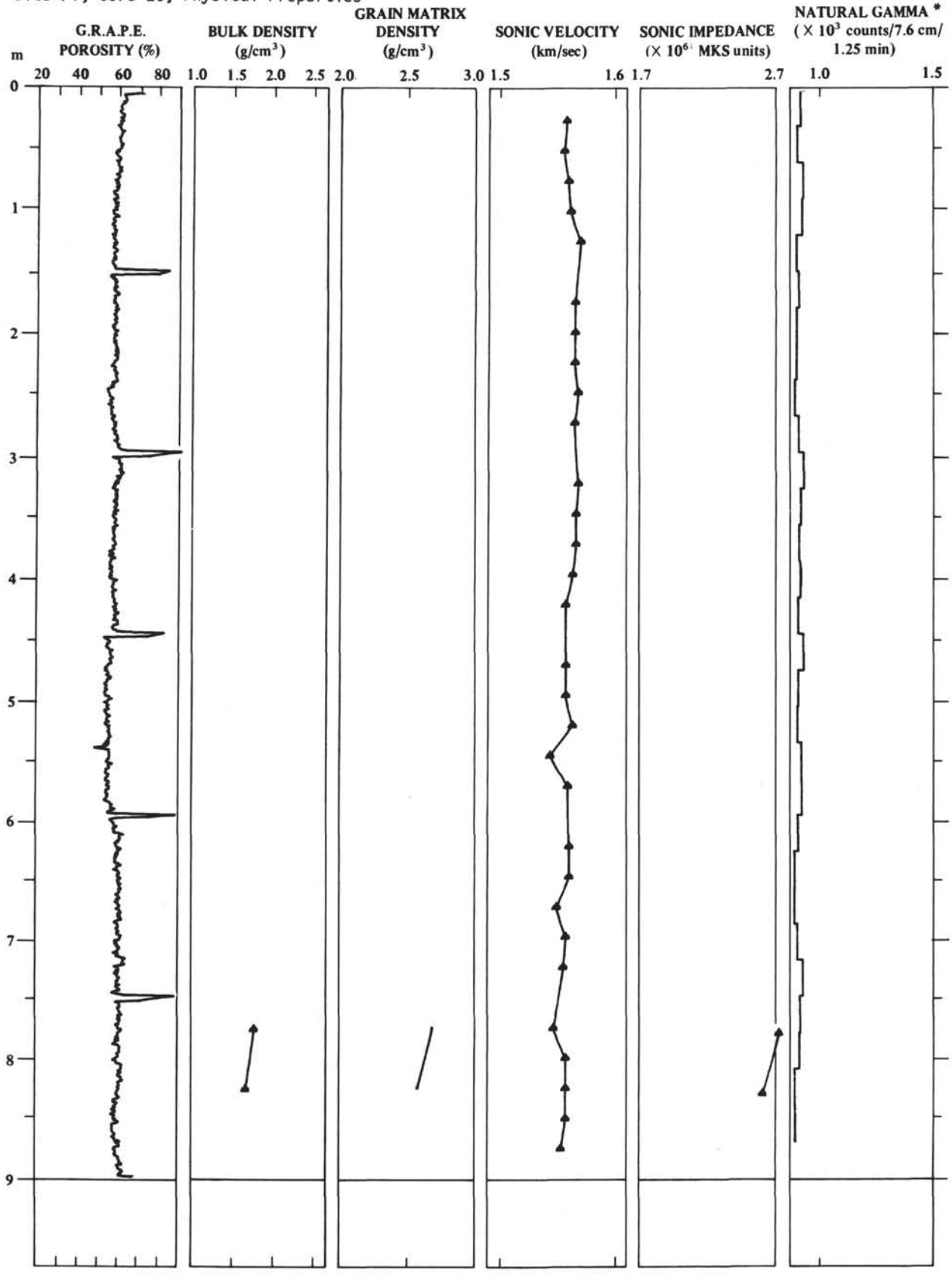
Site 71, Core 19, Physical Properties



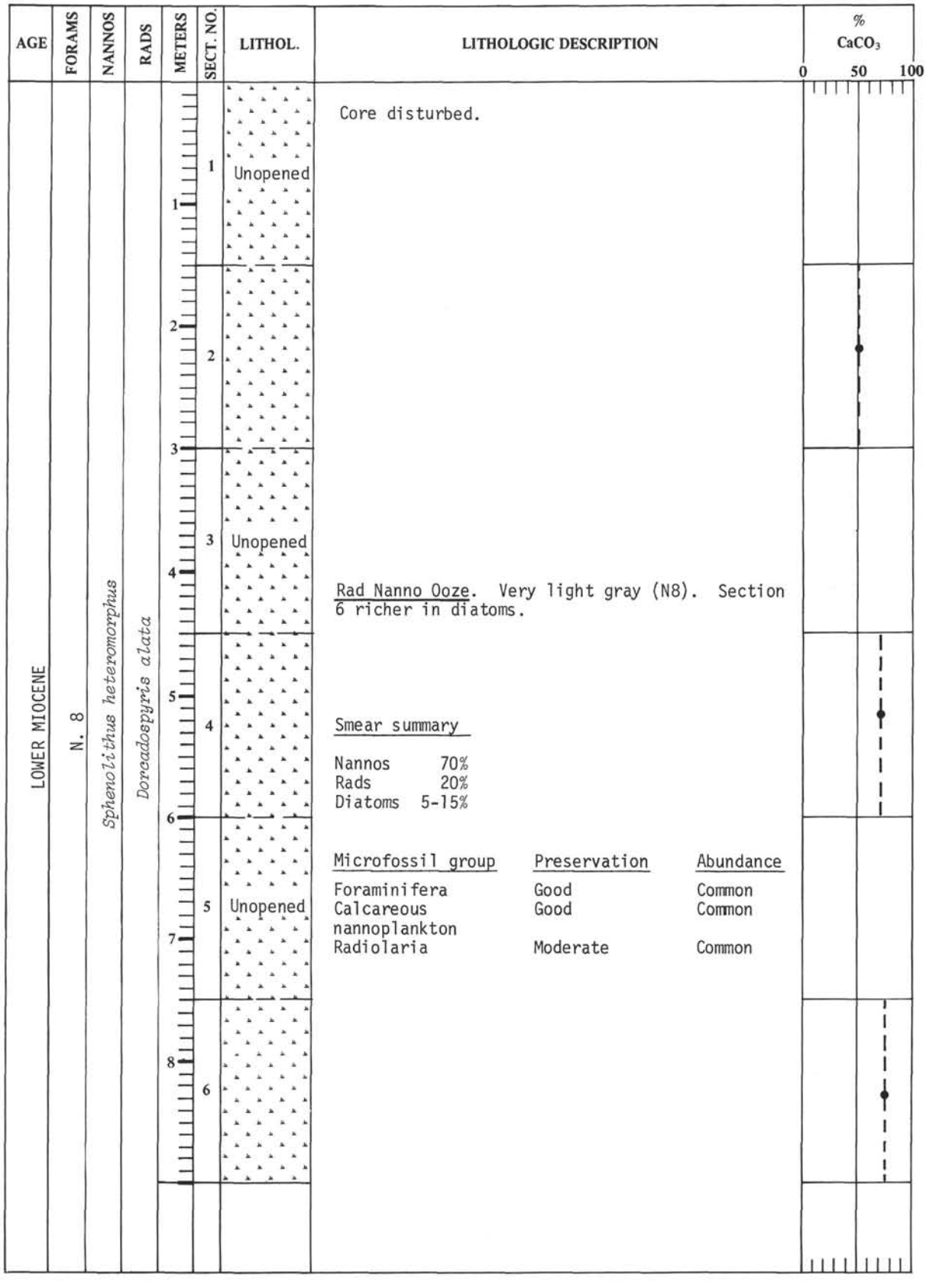
SITE 71 Core 20 Cored interval: 170-179 m

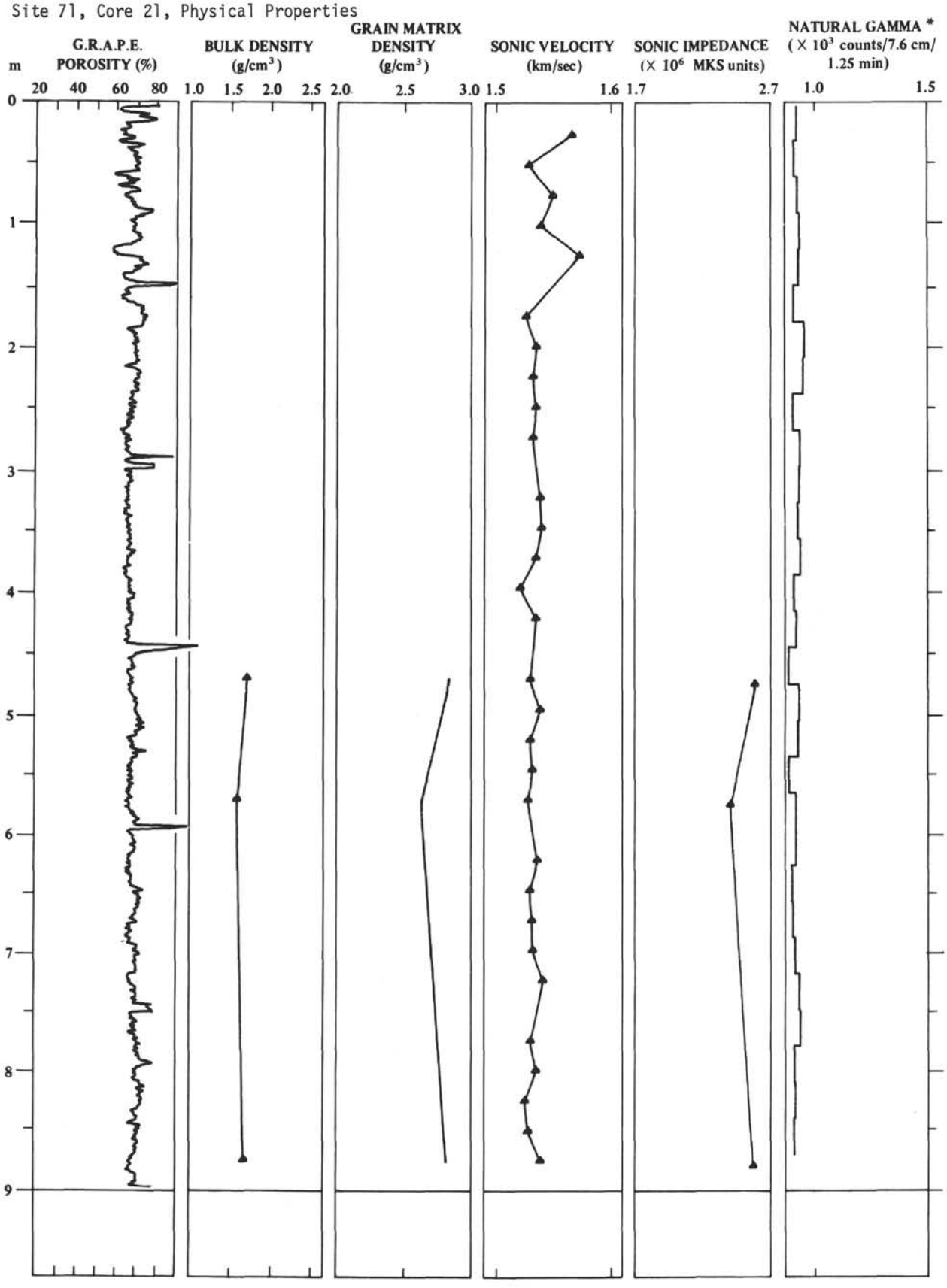


Site 71, Core 20, Physical Properties

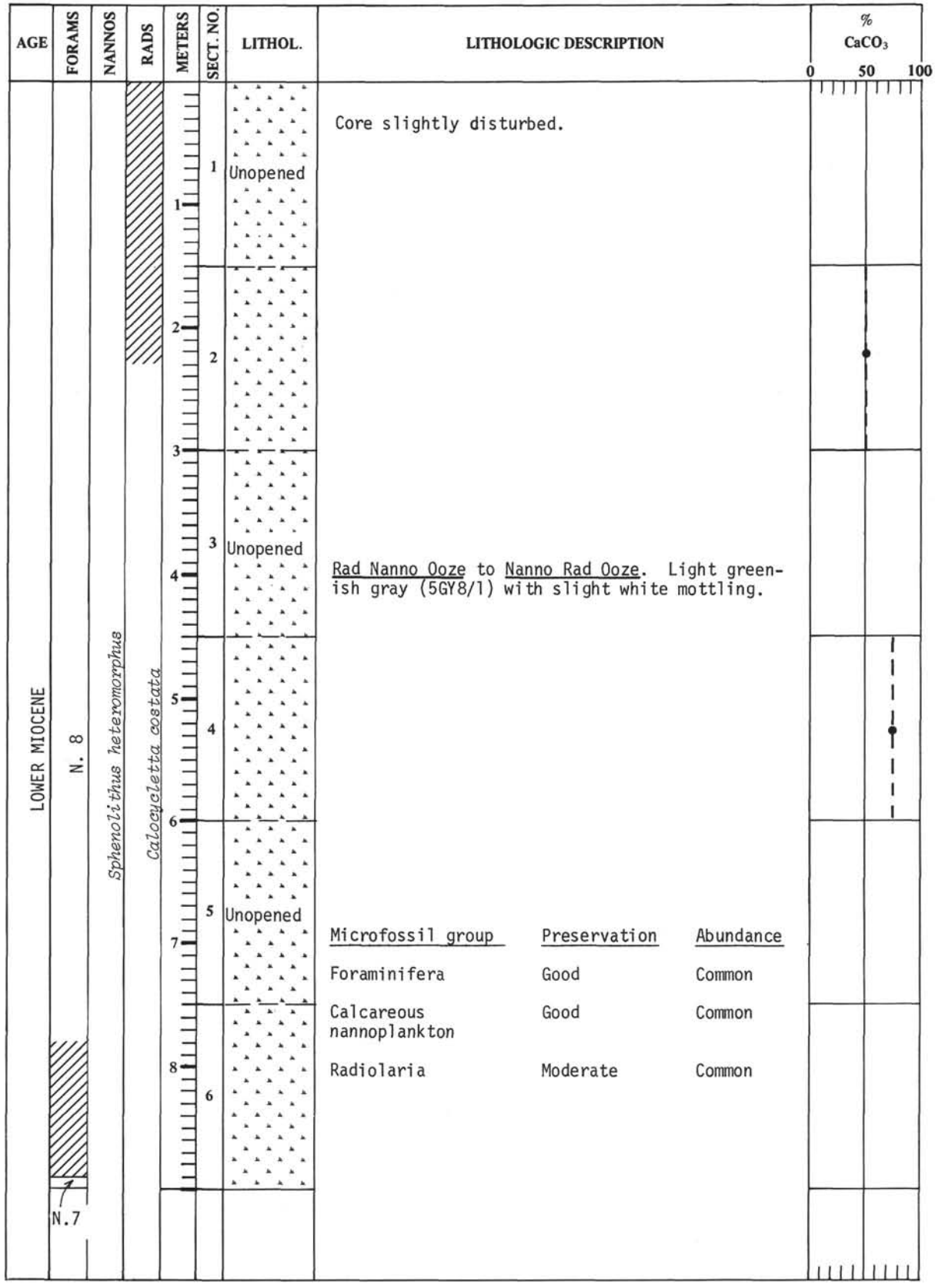


SITE 71 Core 21 Cored interval: 179-188 m

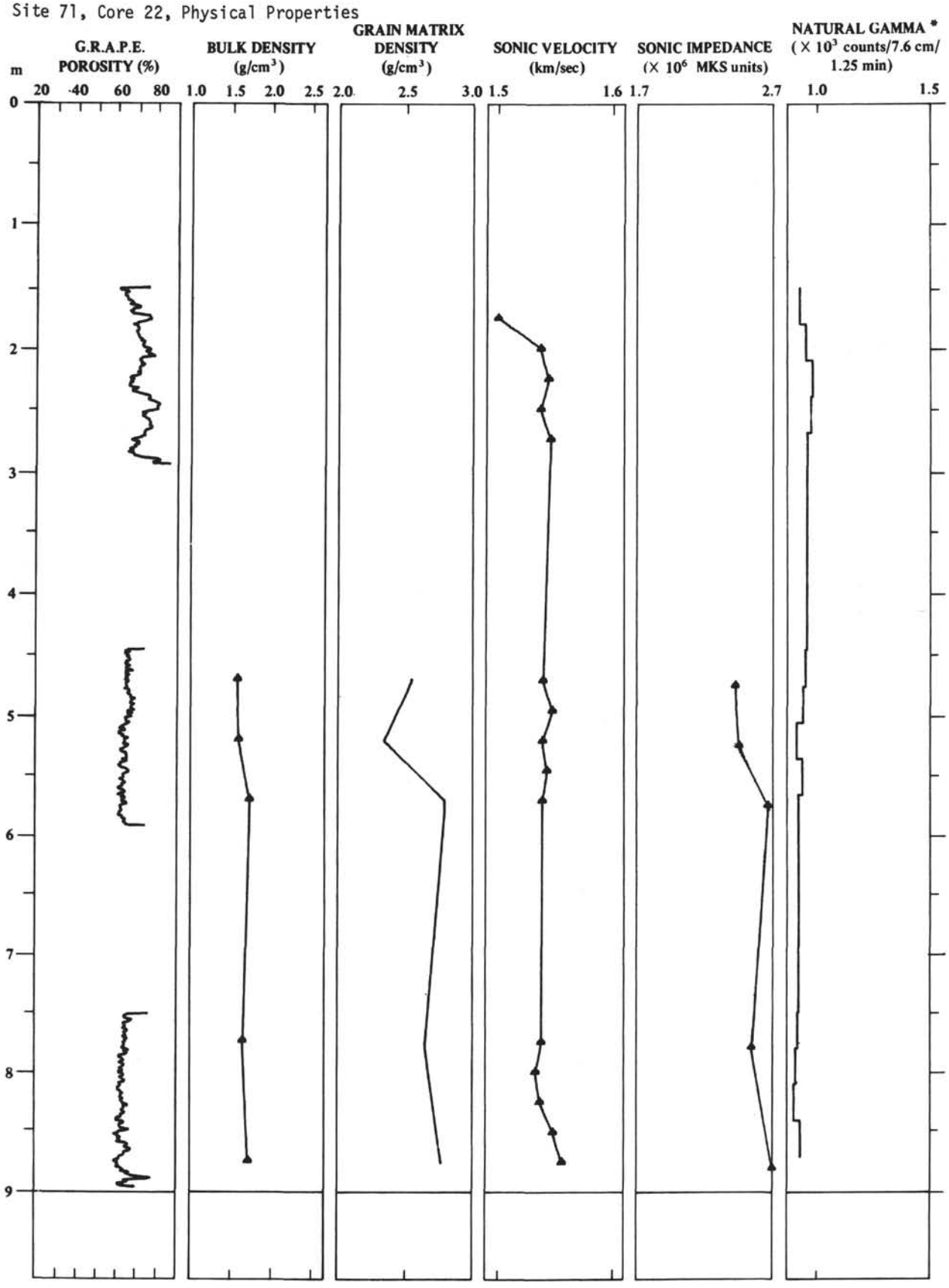



Site 71, Core 21, Physical Properties
m
G.R.A.P.E. POROSITY (%)
20 40 60 80
BULK DENSITY (g/cm³)
1.0 1.5 2.0 2.5
GRAIN MATRIX DENSITY (g/cm³)
2.0 2.5 3.0
SONIC VELOCITY (km/sec)
1.5 1.6
SONIC IMPEDANCE (× 10⁶ MKS units)
1.7 2.7
NATURAL GAMMA * (× 10³ counts/7.6 cm/ 1.25 min)
1.0 1.5
0
1
2
3
4
5
6
7
8
9

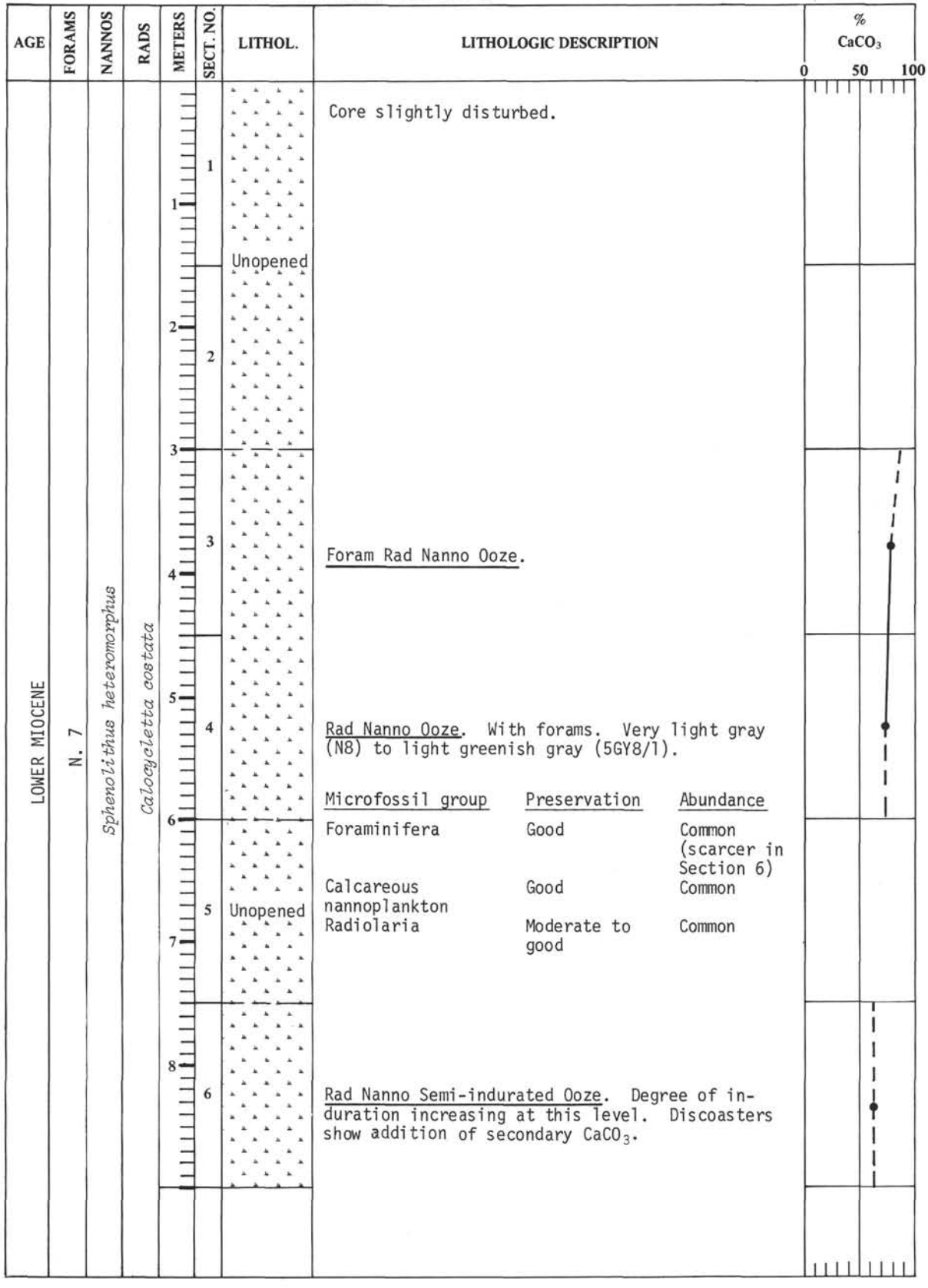
SITE 71 Core 22 Cored interval: 189-198 m



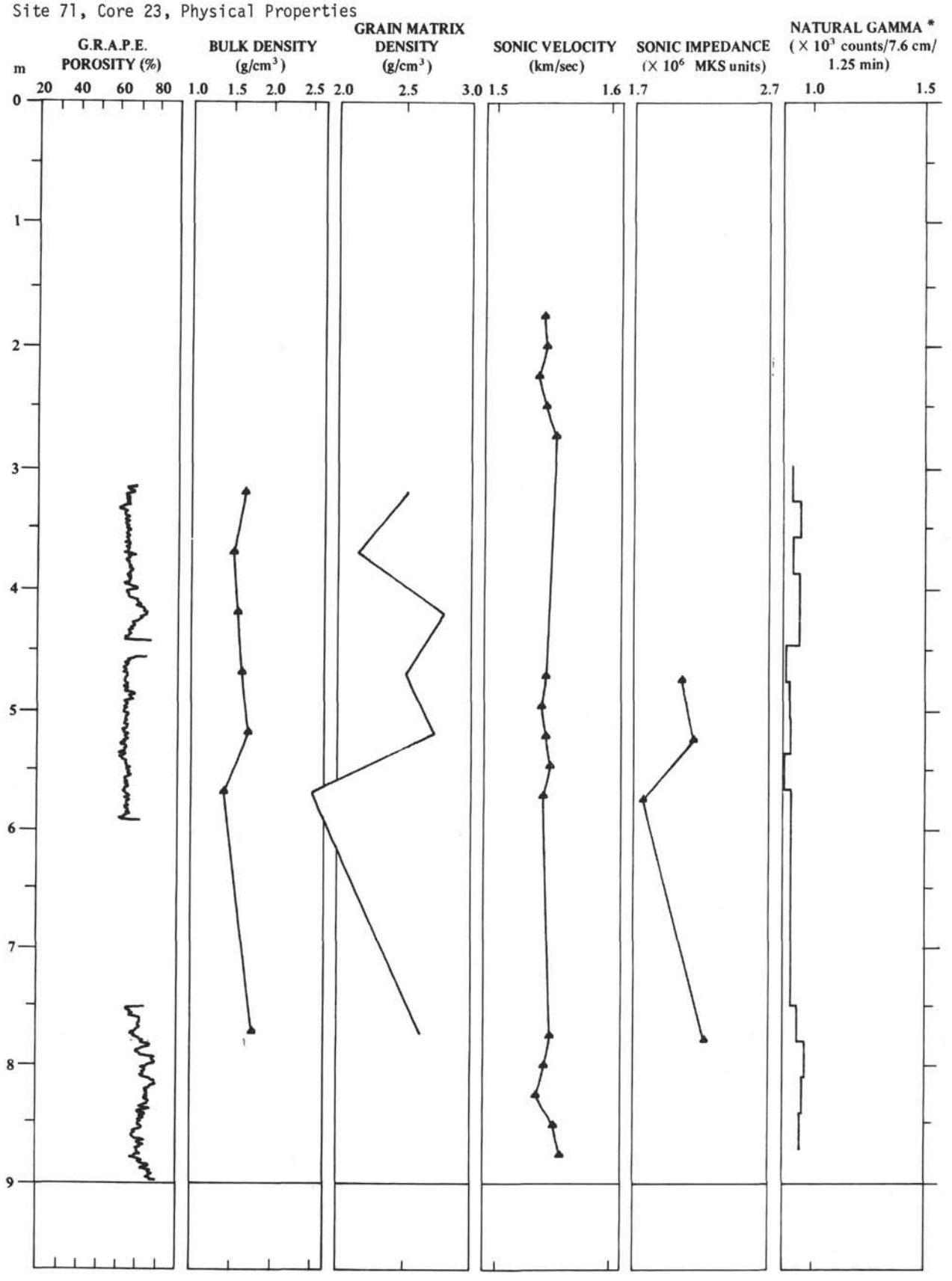
Site 71, Core 22, Physical Properties



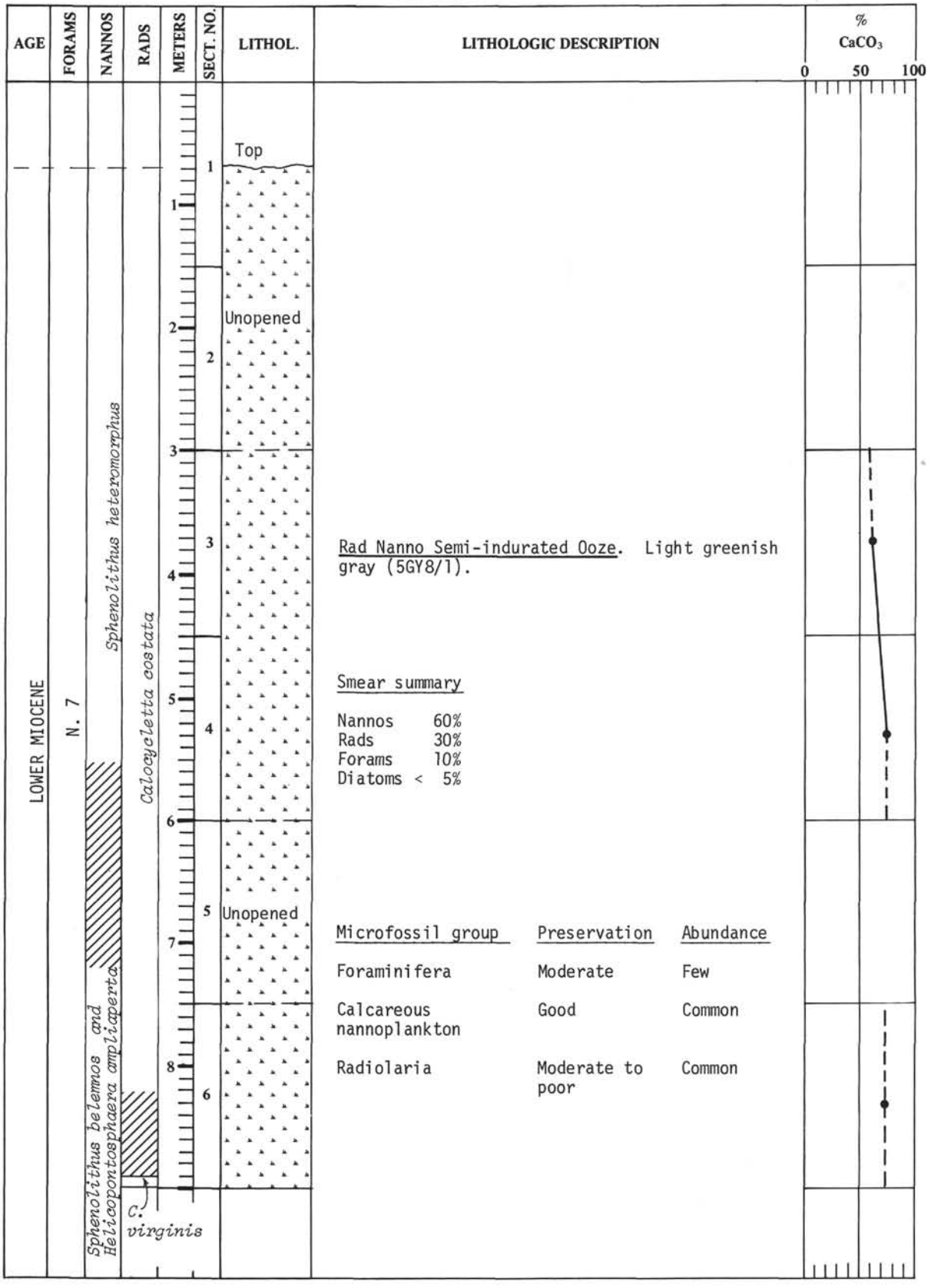
SITE 71 Core 23 Cored interval: 198-207 m



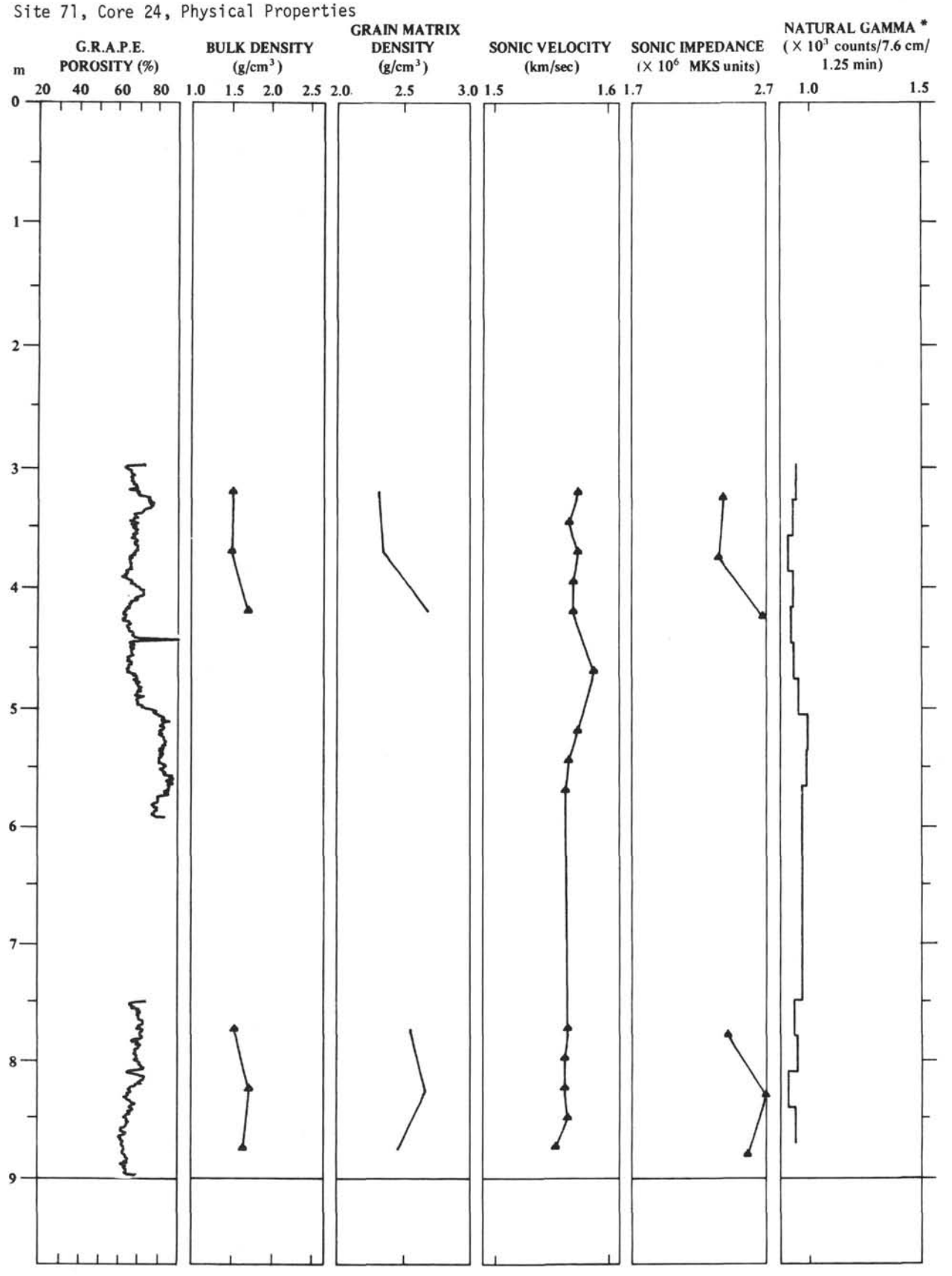
Site 71, Core 23, Physical Properties



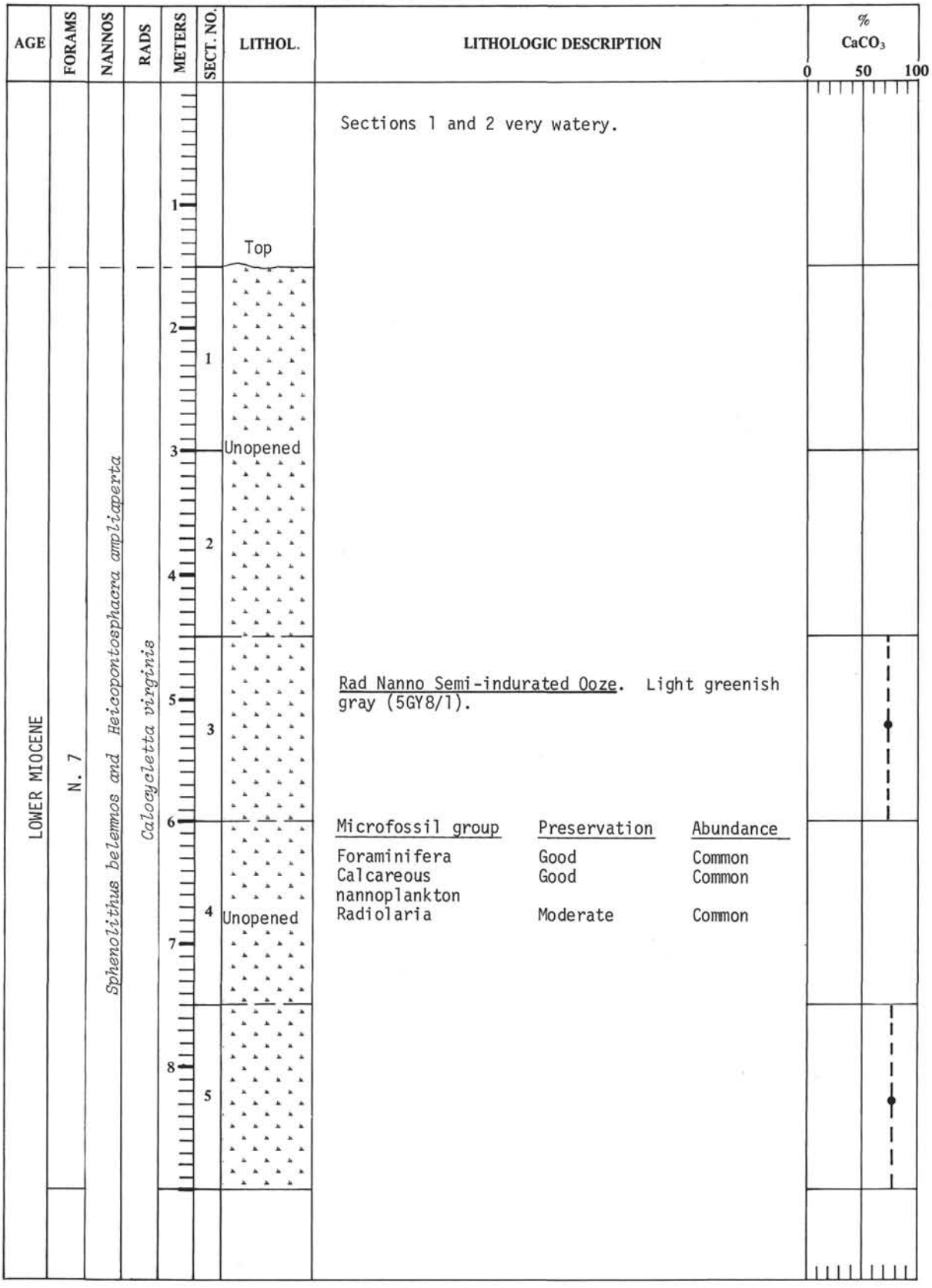
SITE 71 Core 24 Cored interval: 207-216 m



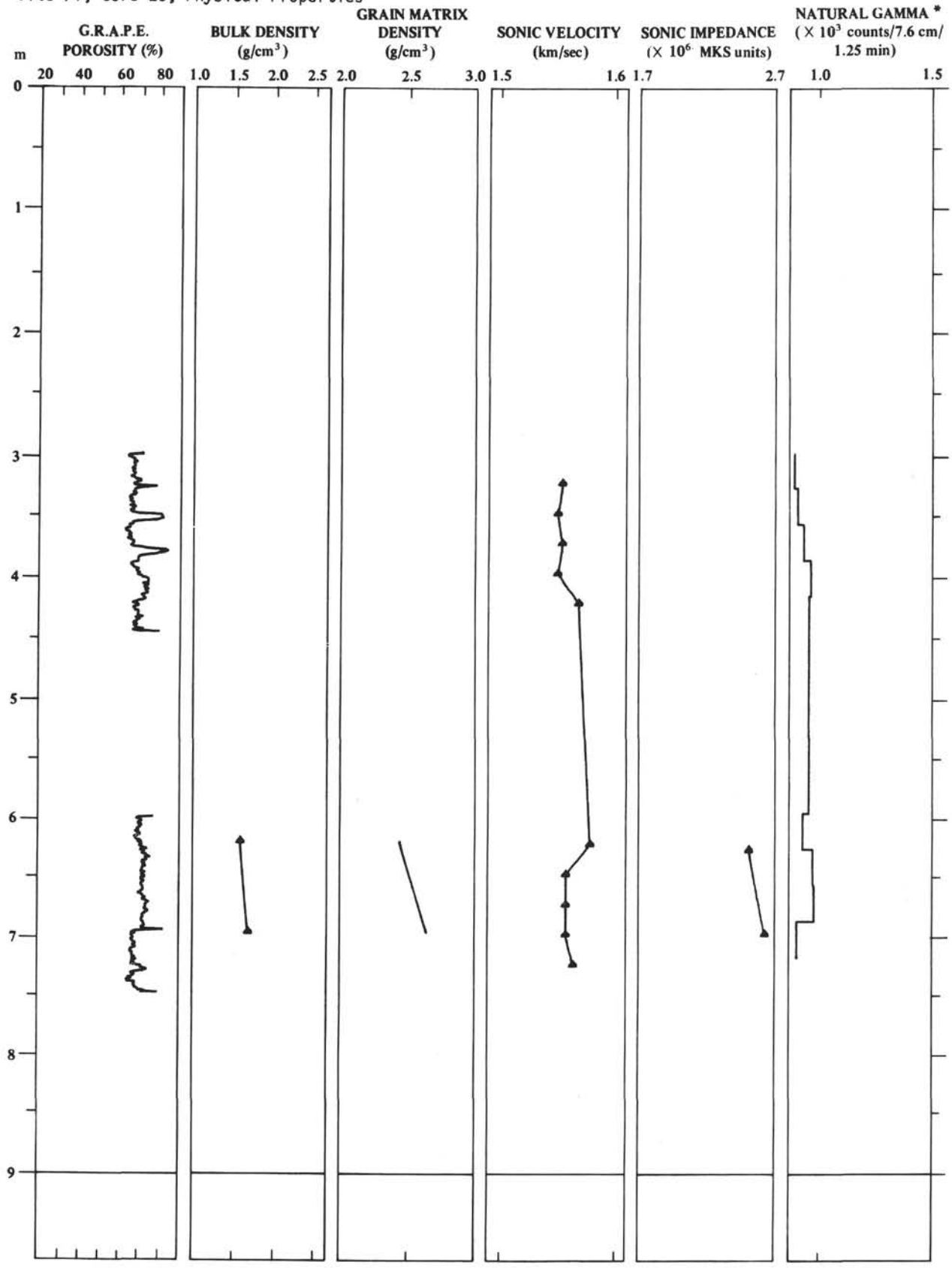
Site 71, Core 24, Physical Properties



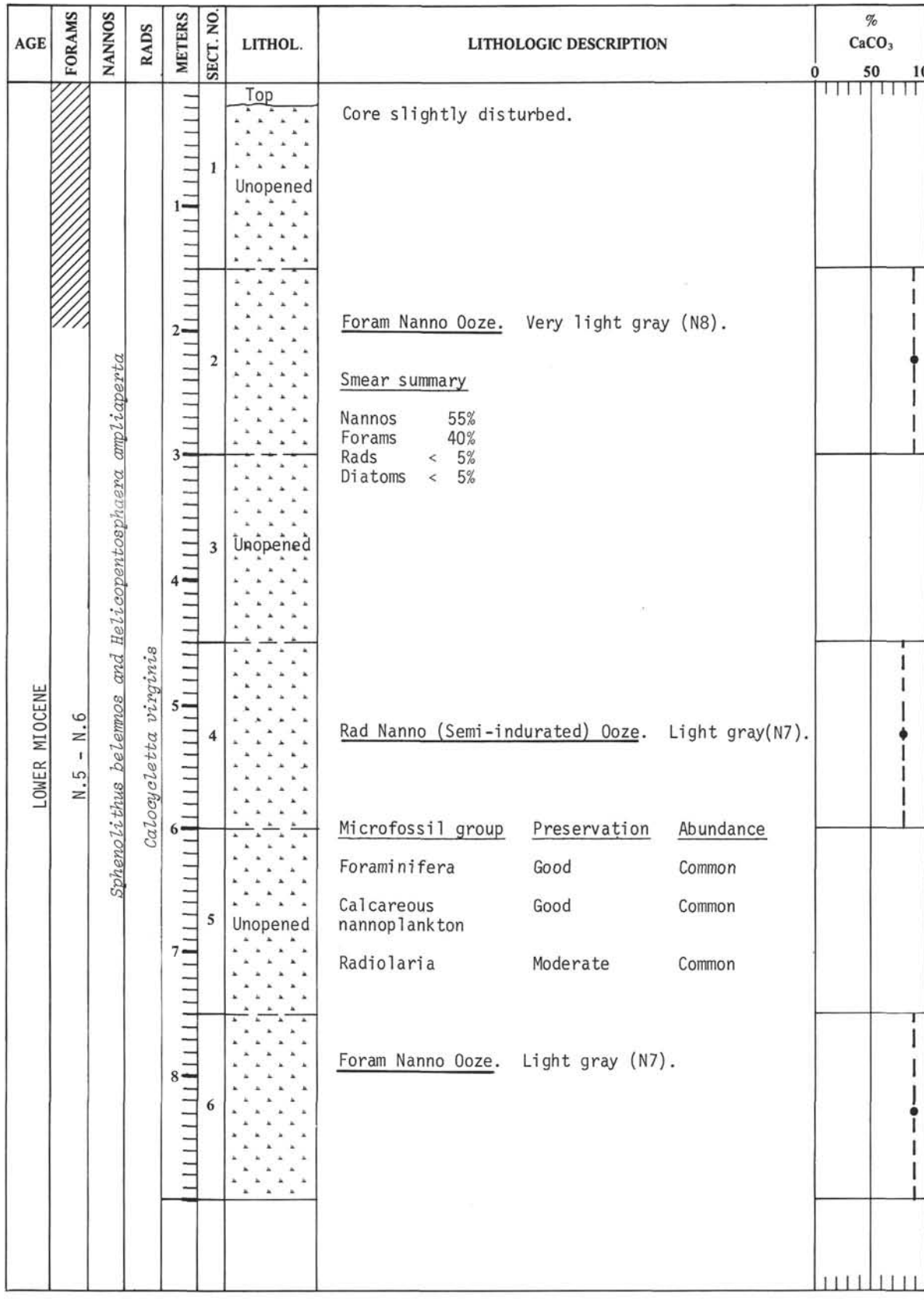
SITE 71 Core 25 Cored interval: 216-225 m



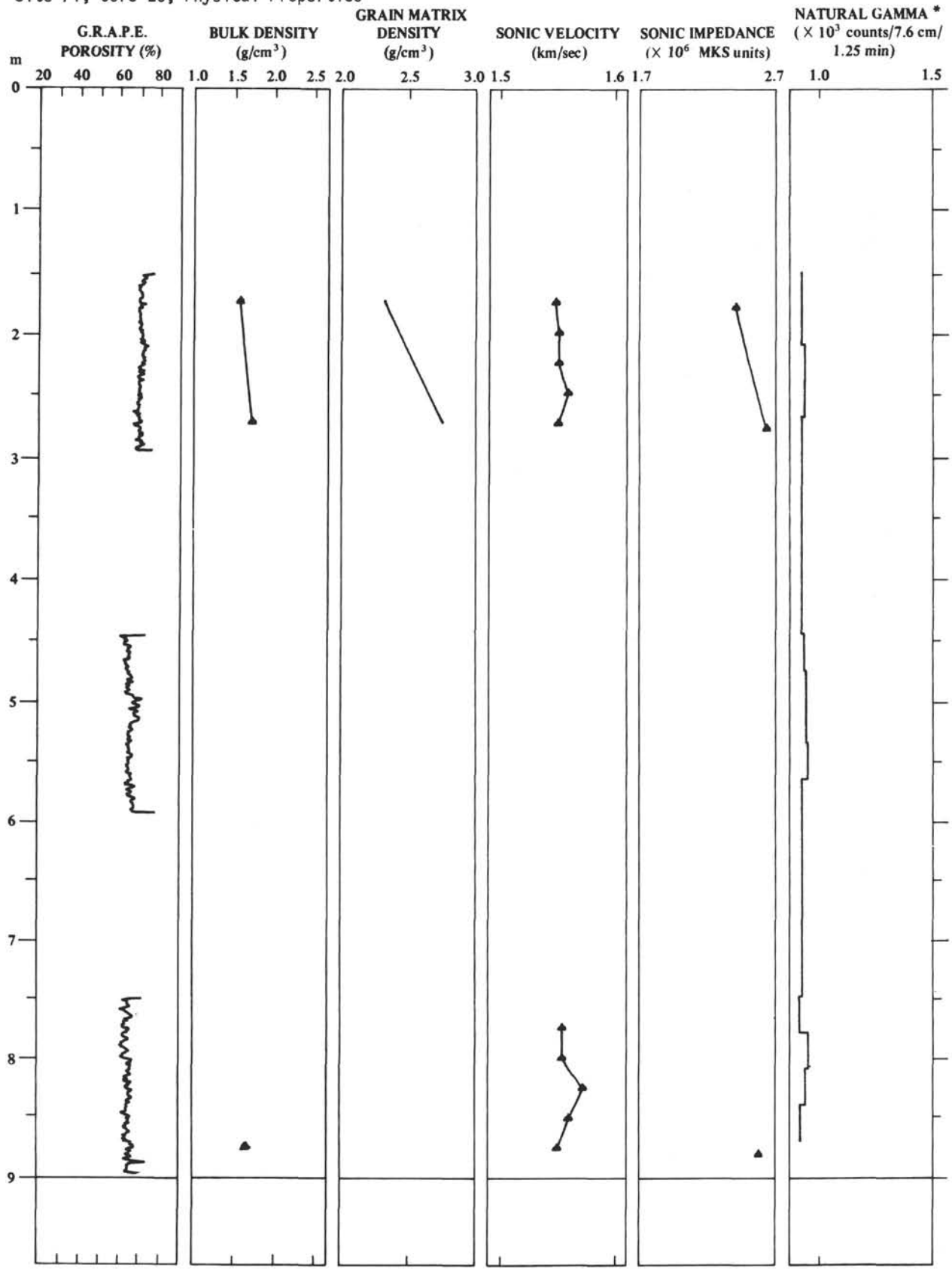
Site 71, Core 25, Physical Properties



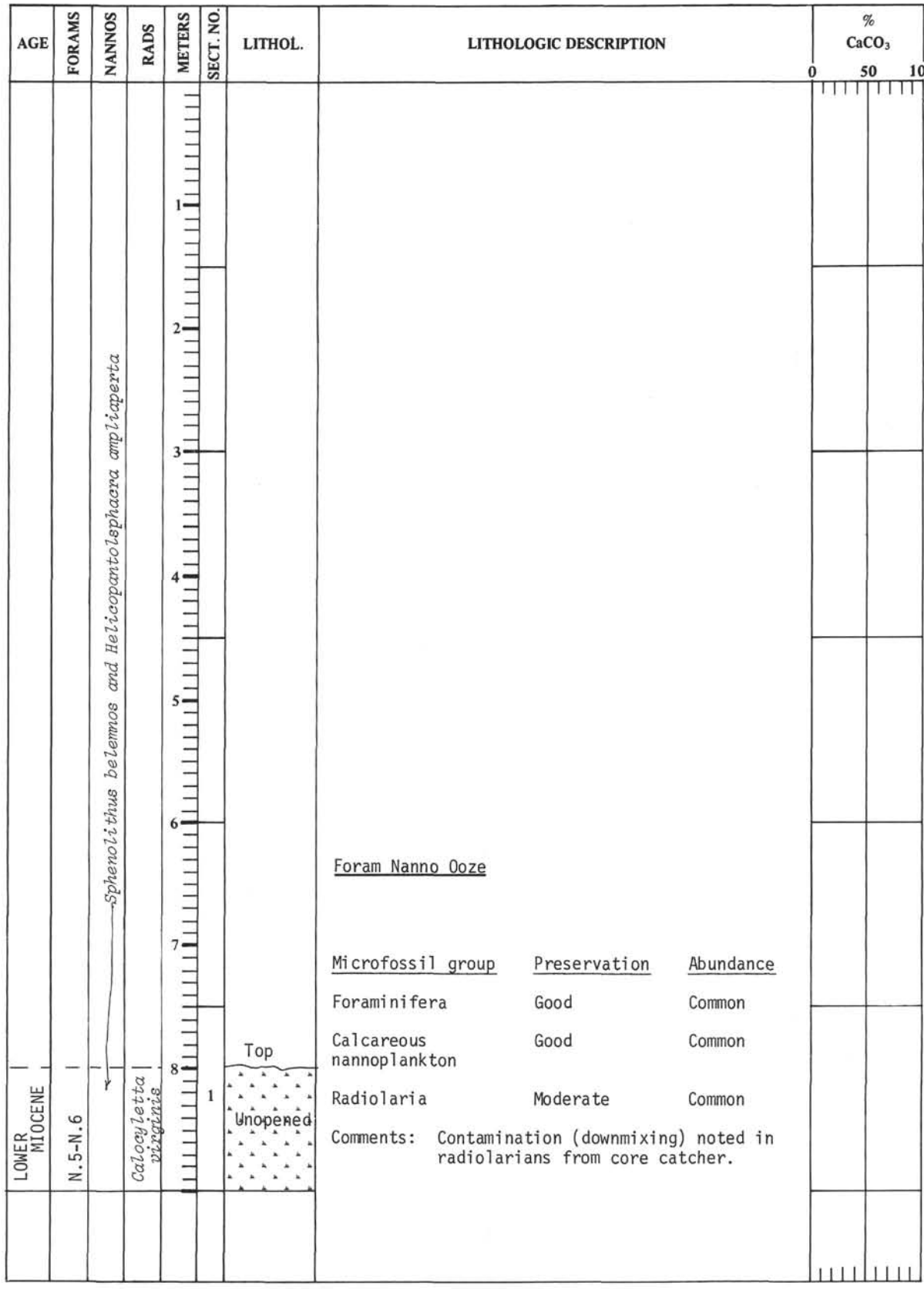
SITE 71 Core 26 Cored interval: 225-234 m



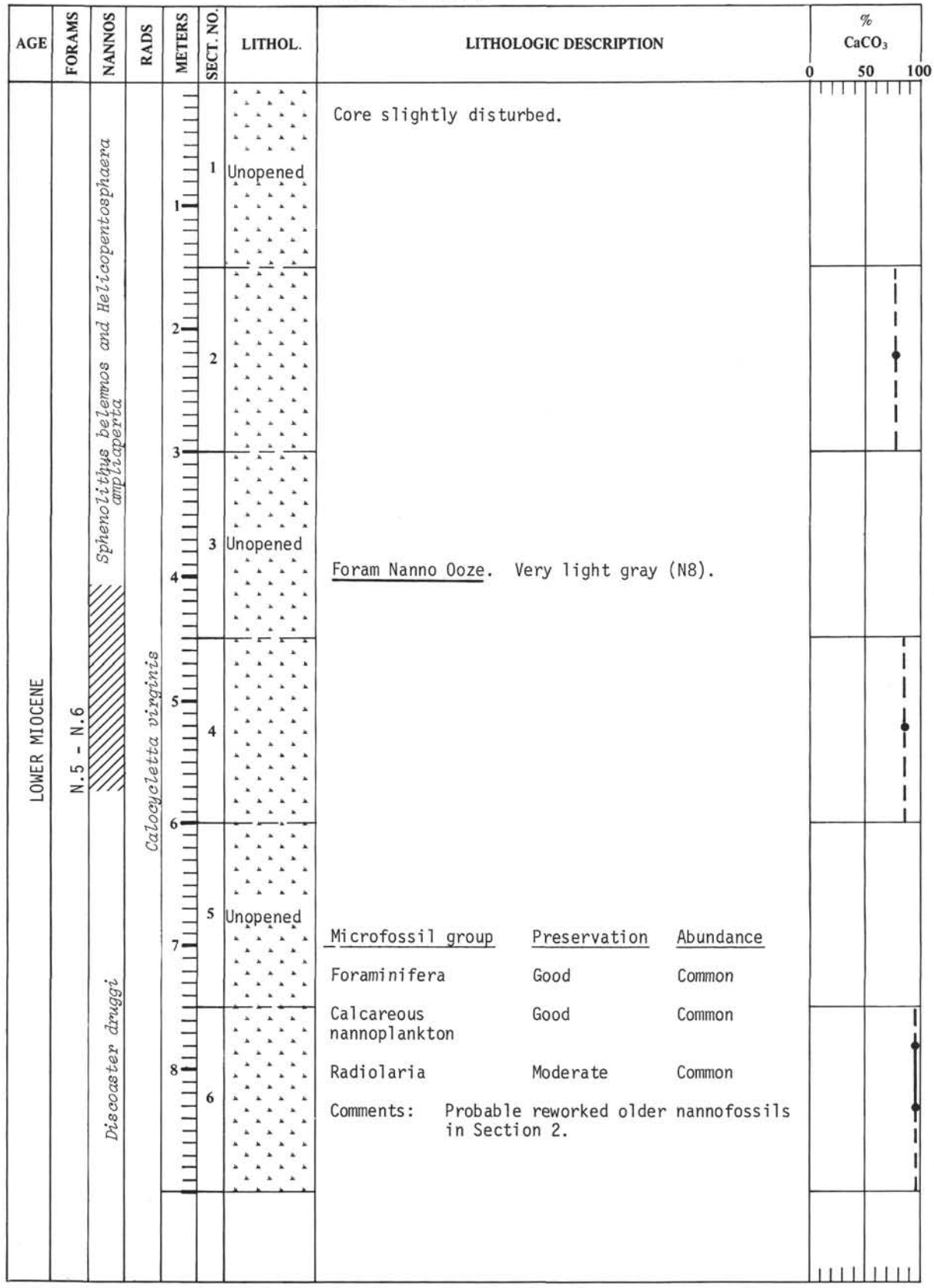
Site 71, Core 26, Physical Properties



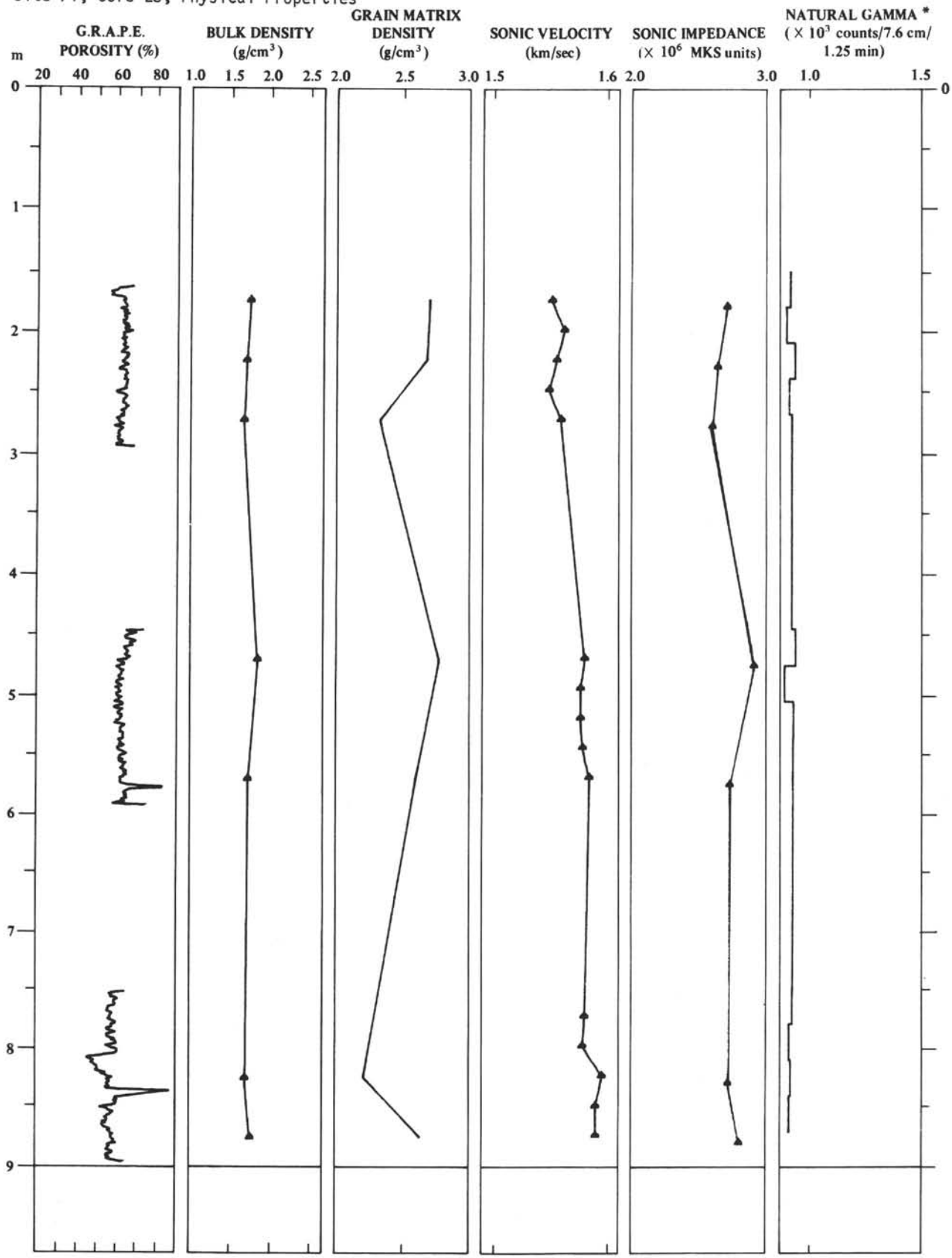
SITE 71 Core 27 Cored interval: 235-244 m



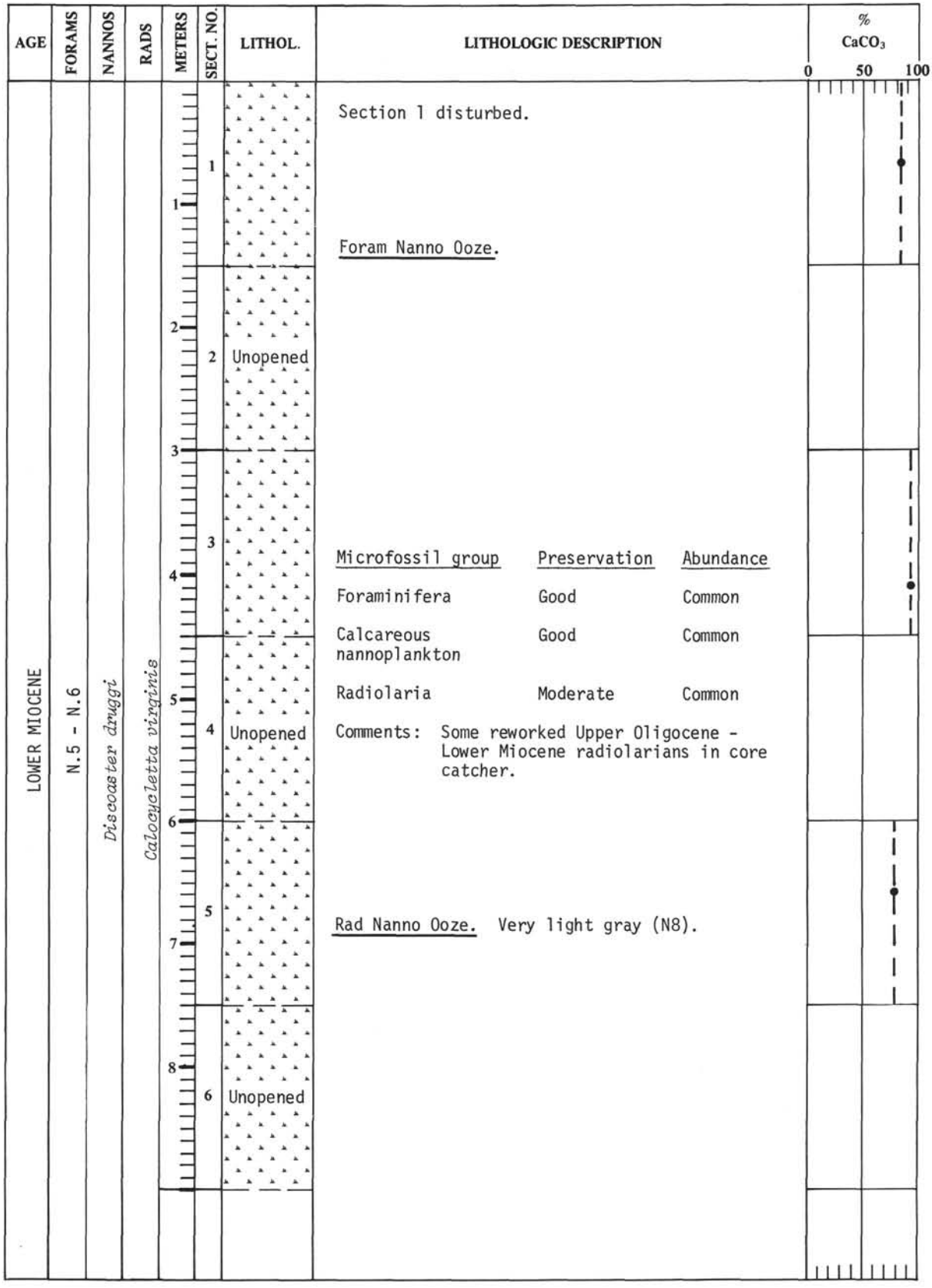
SITE 71 Core 28 Cored interval: 244-253 m



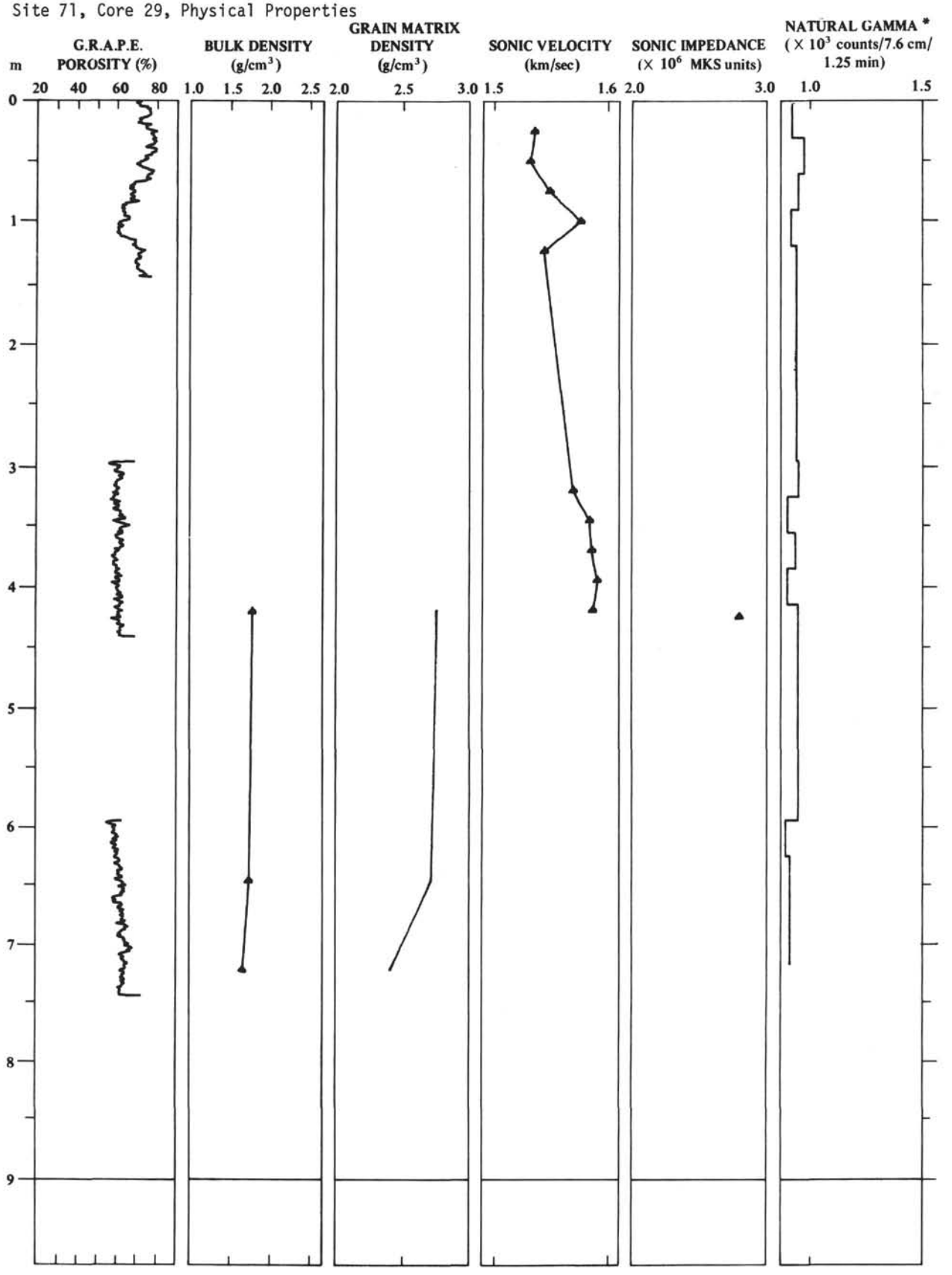
Site 71, Core 28, Physical Properties



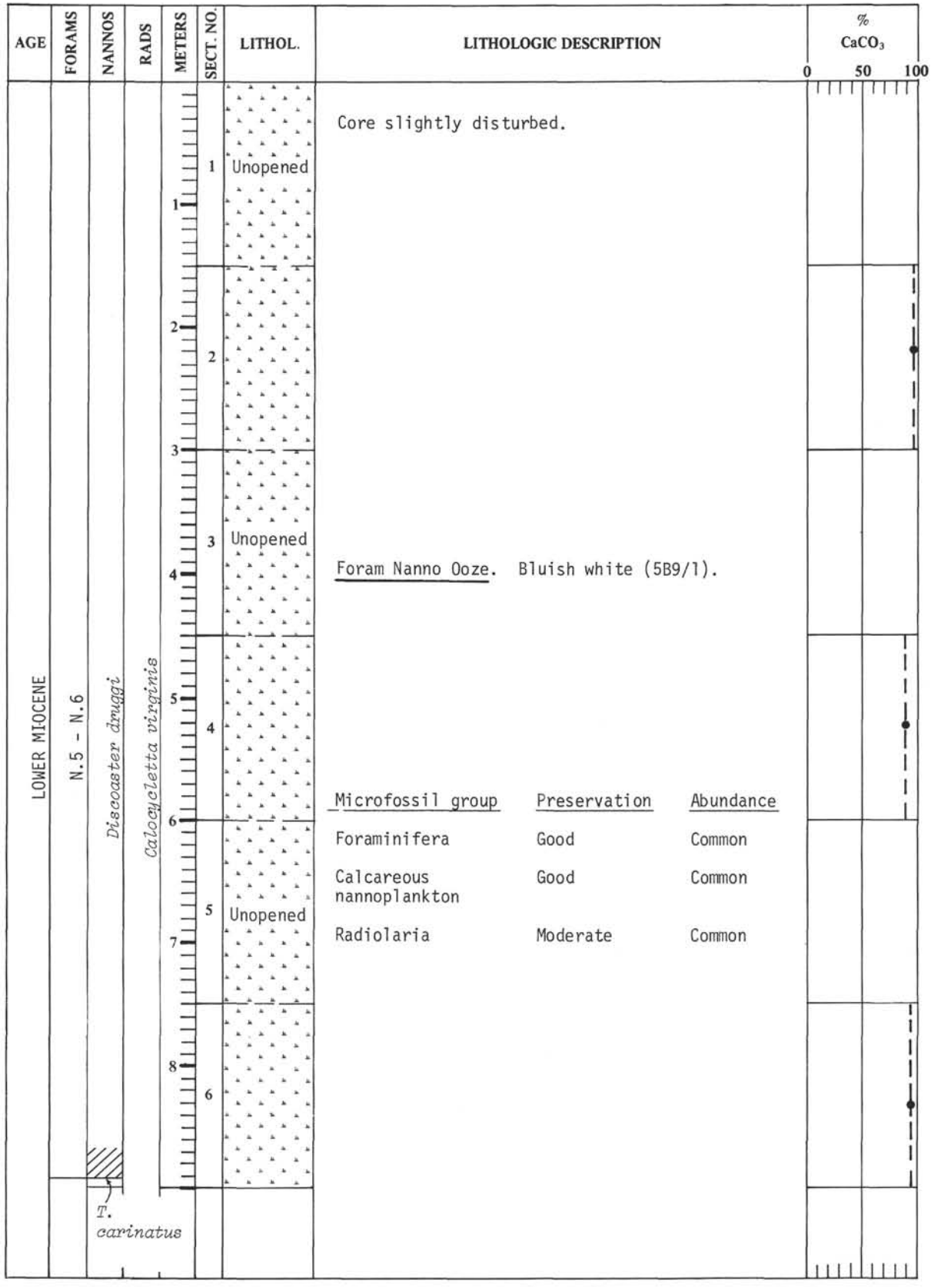
SITE 71 Core 29 Cored interval: 253-262 m



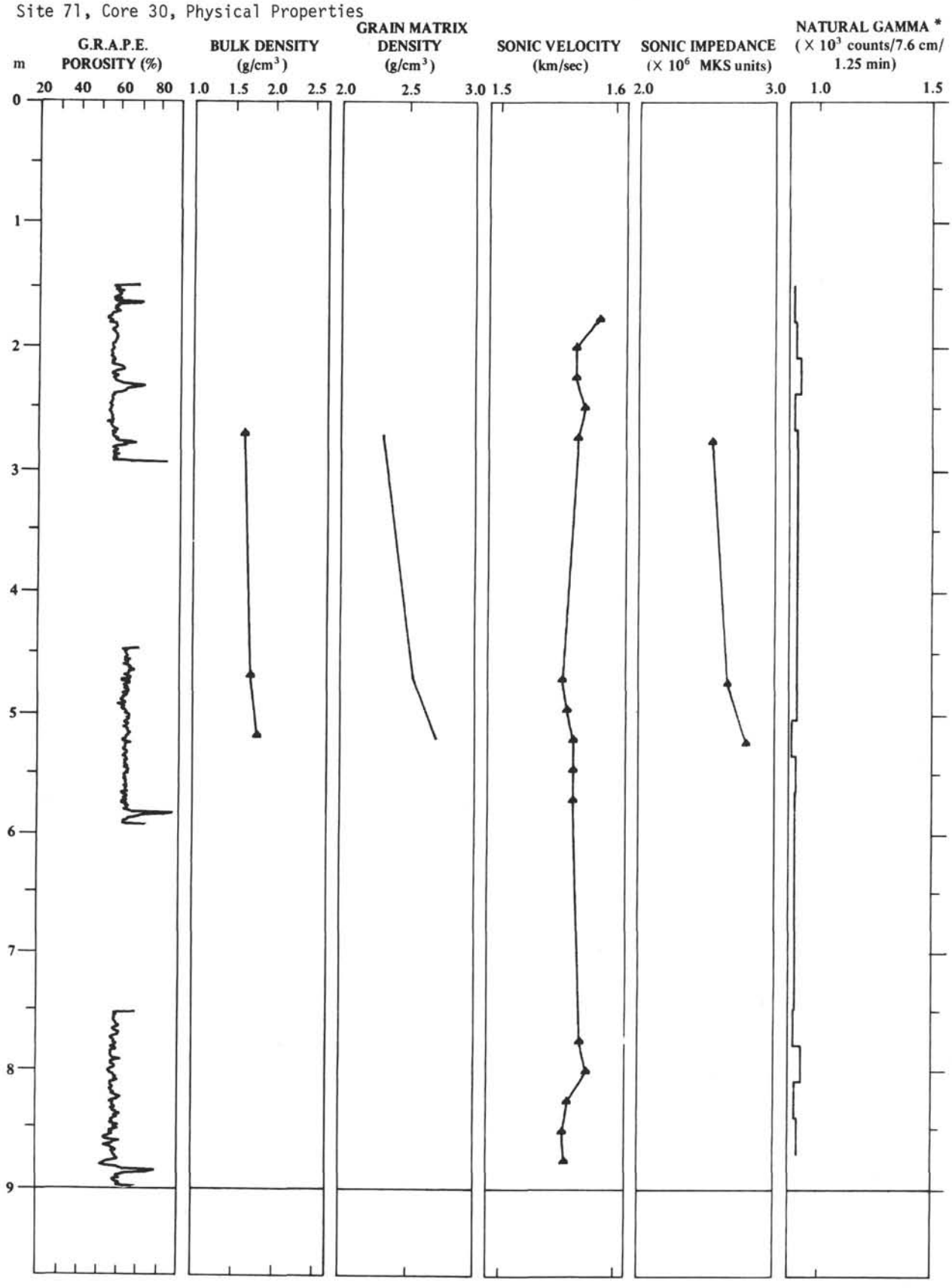
Site 71, Core 29, Physical Properties



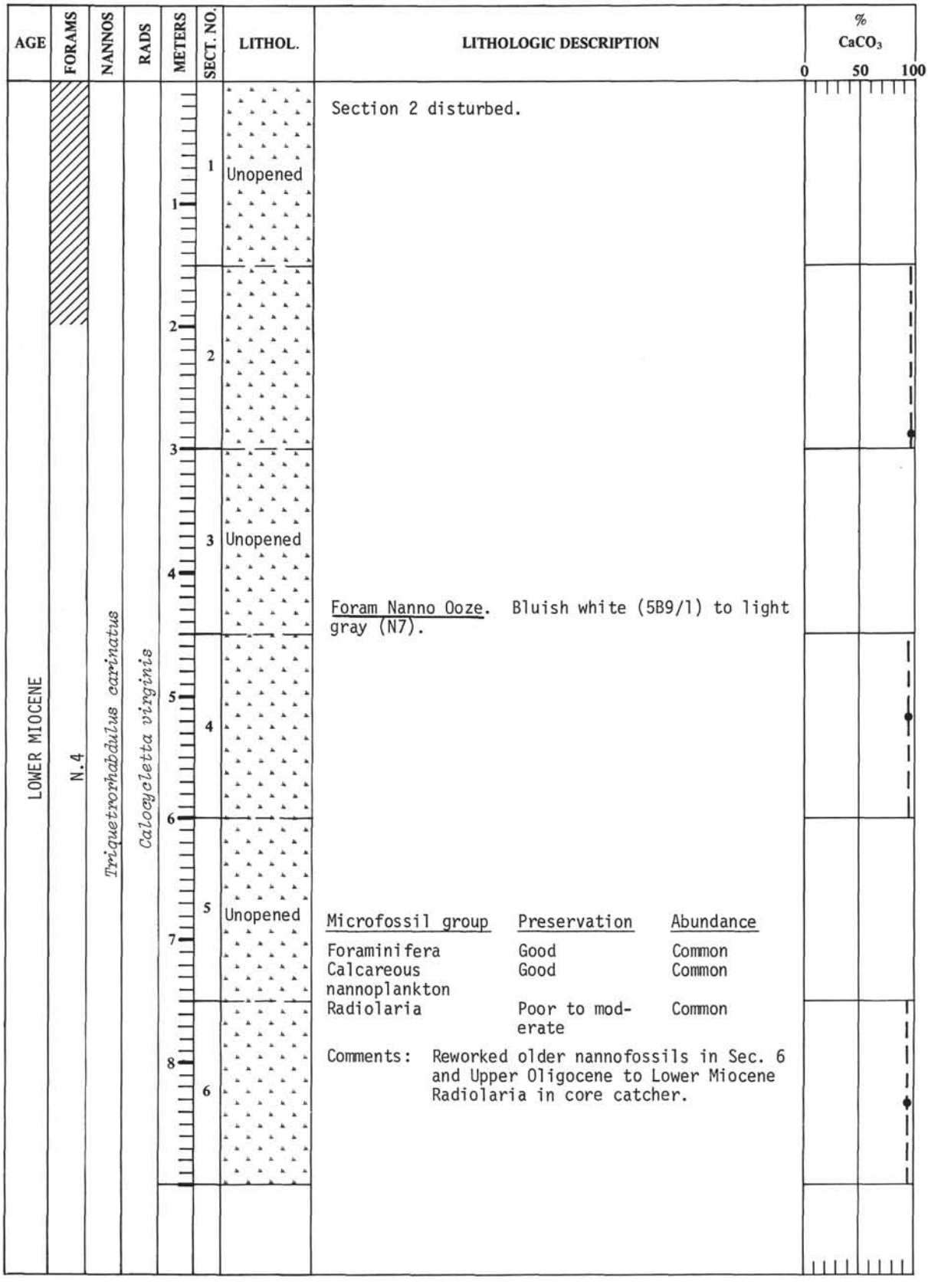
SITE 71 Core 30 Cored interval: 262-271 m



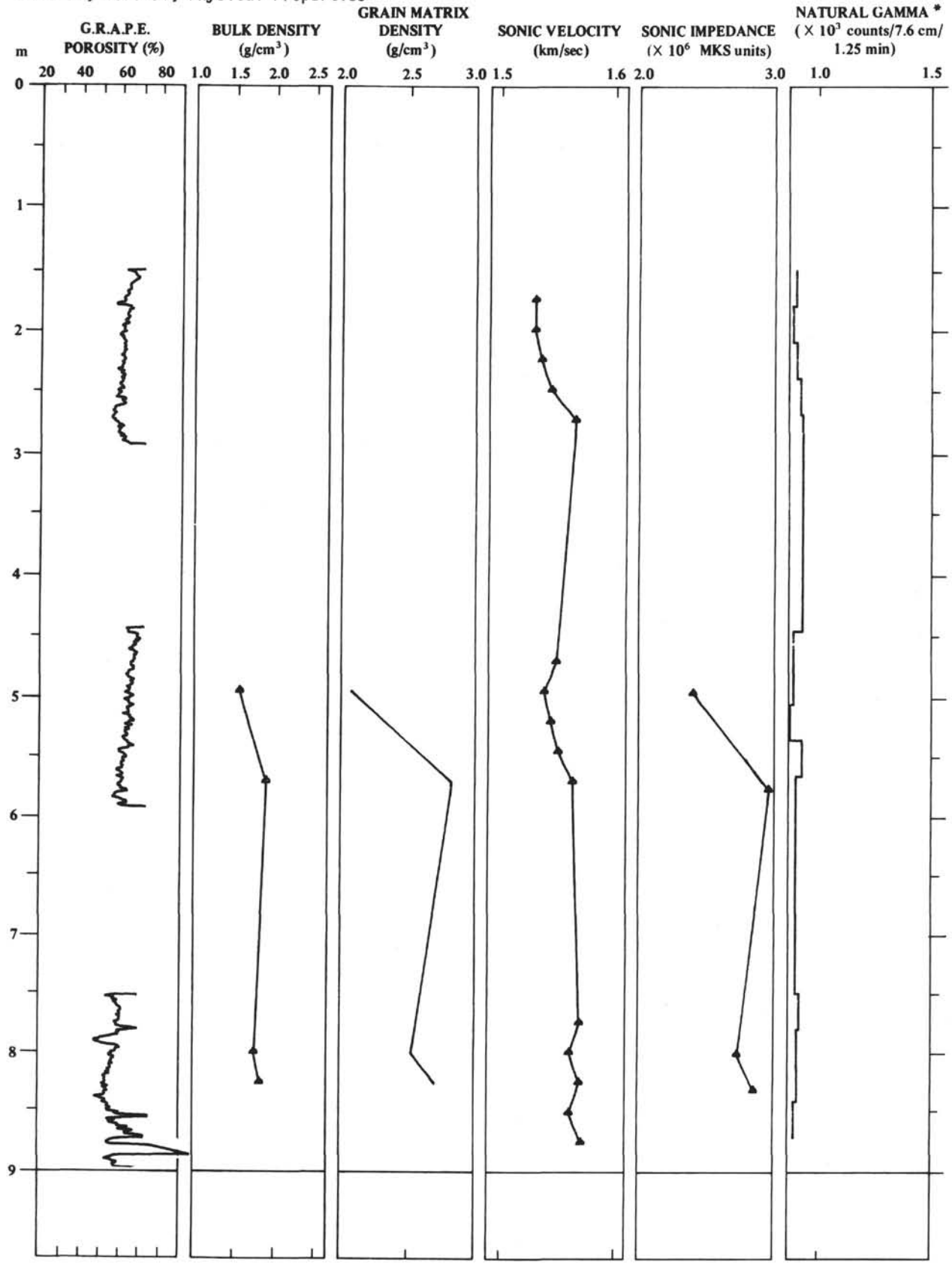
Site 71, Core 30, Physical Properties



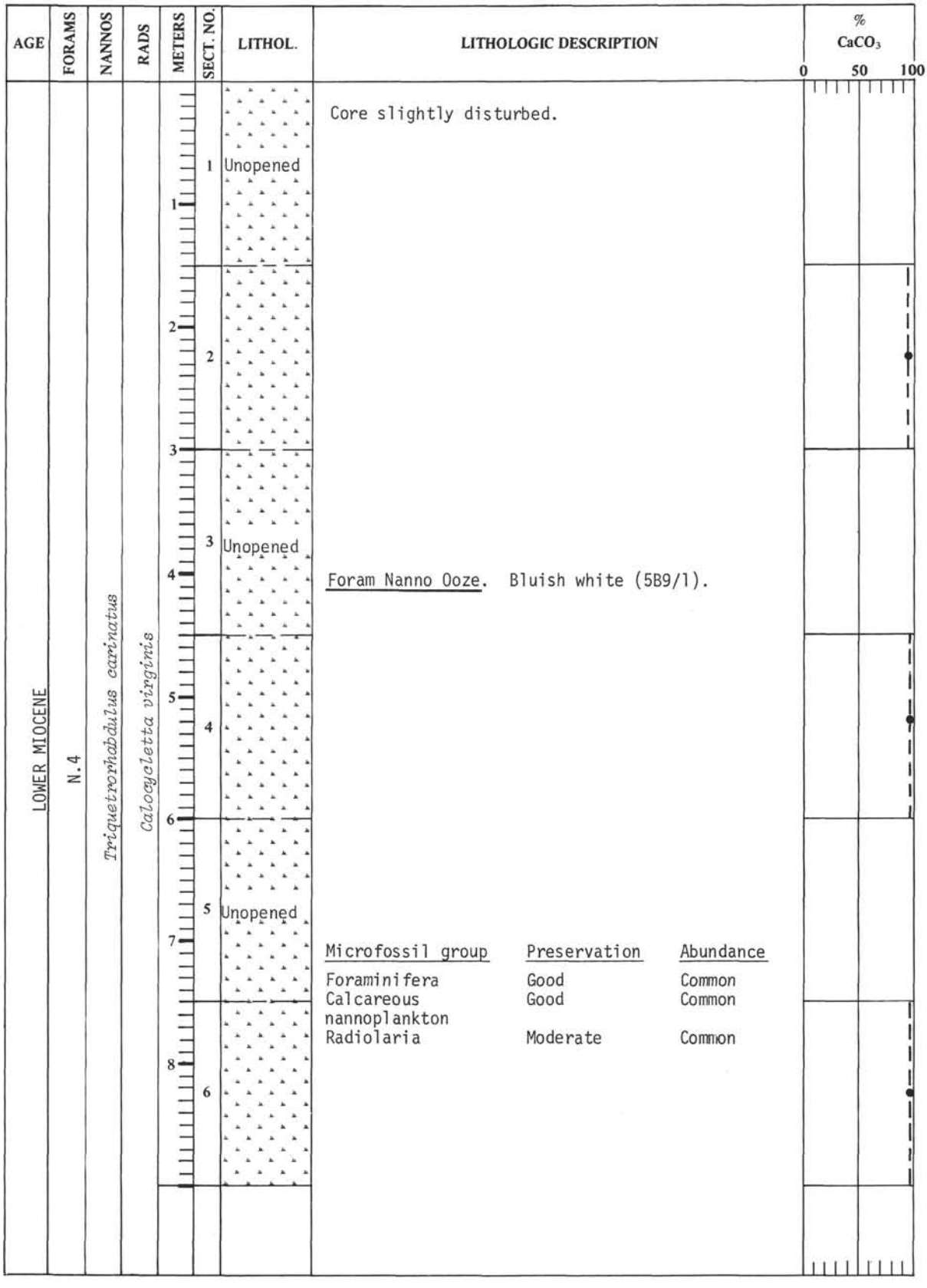
SITE 71 Core 31 Cored interval: 271-280 m



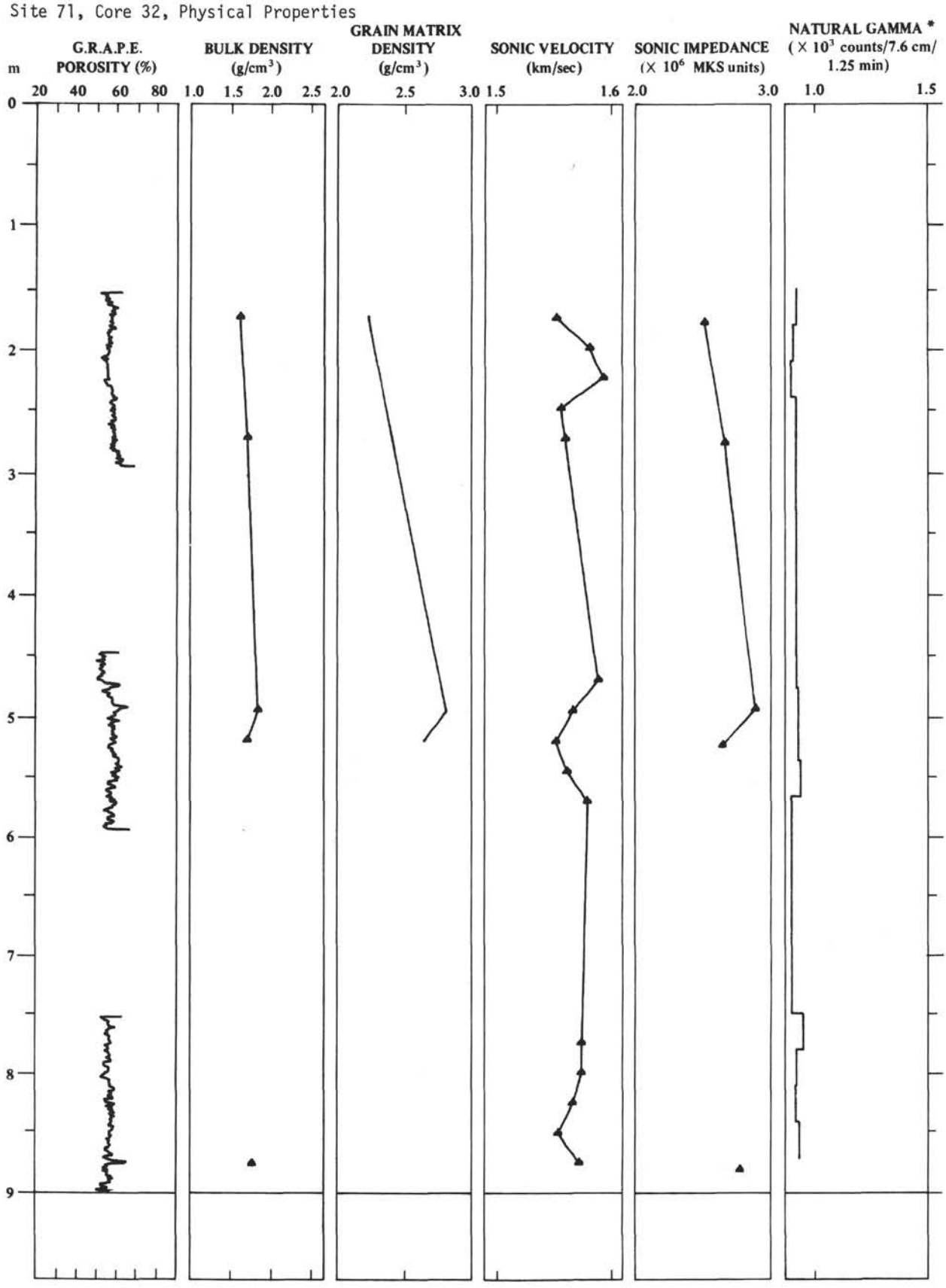
Site 71, Core 31, Physical Properties



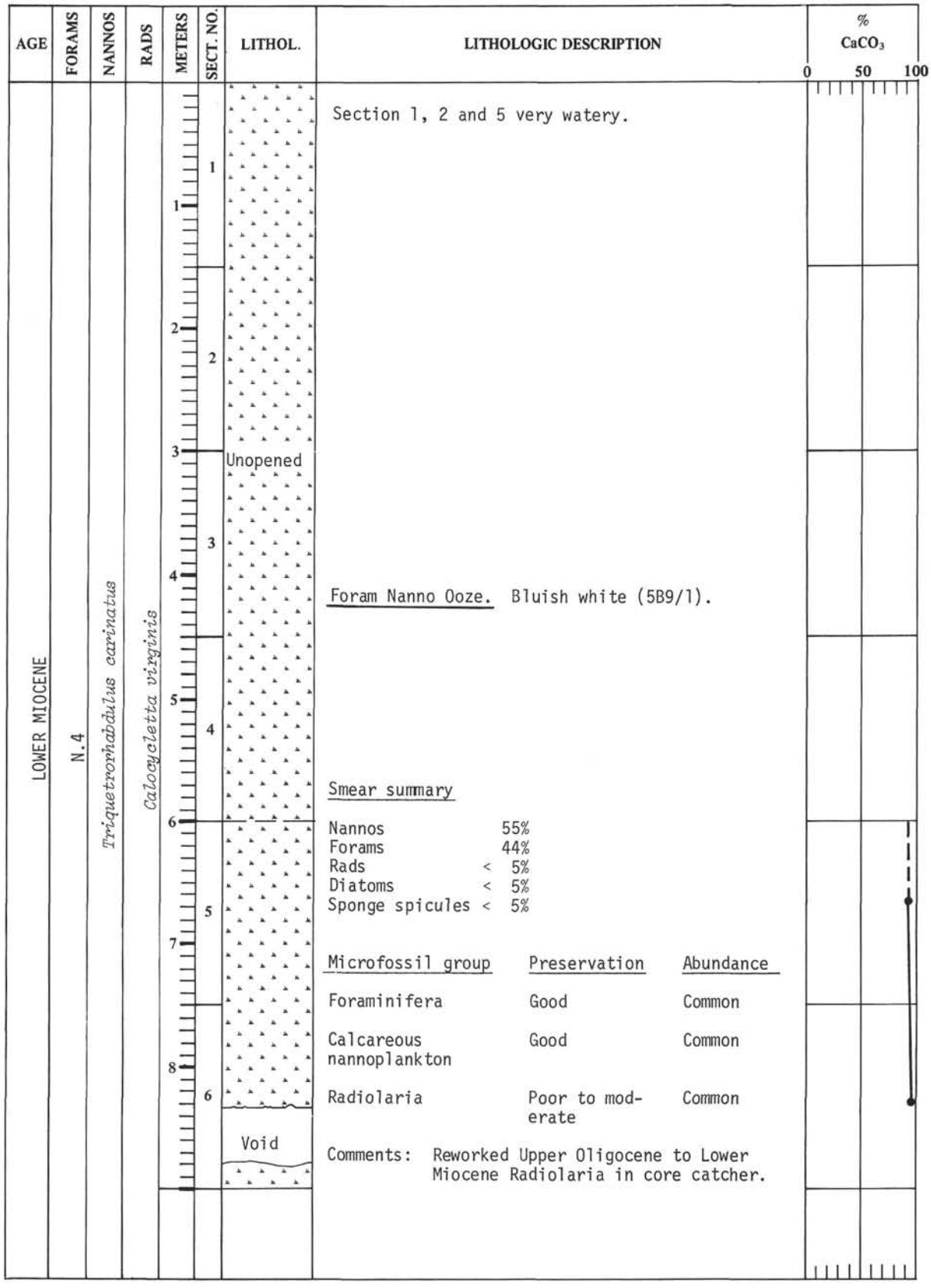
SITE 71 Core 32 Cored interval: 280-289 m



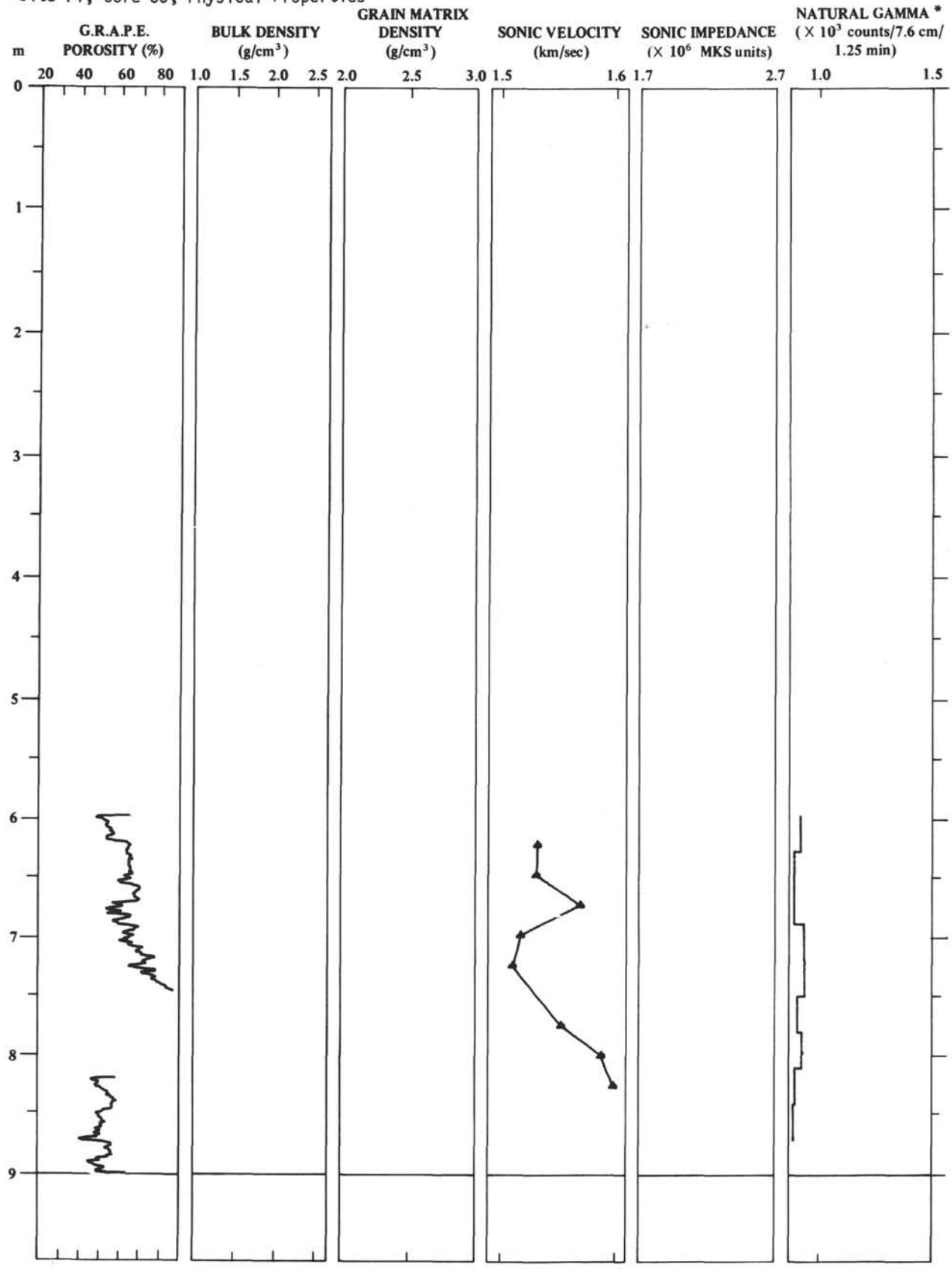
Site 71, Core 32, Physical Properties



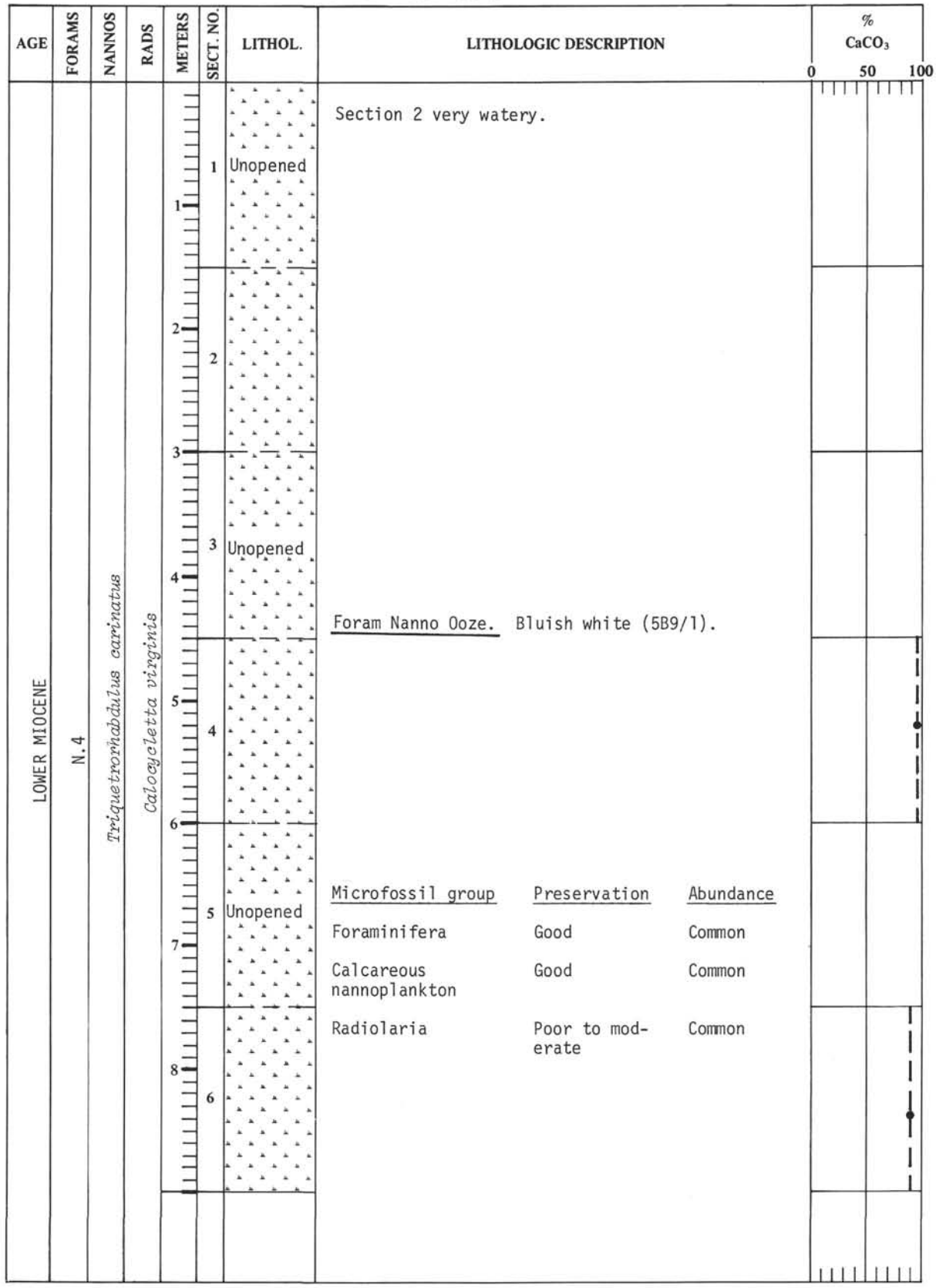
SITE 71 Core 33 Cored interval: 290-299 m



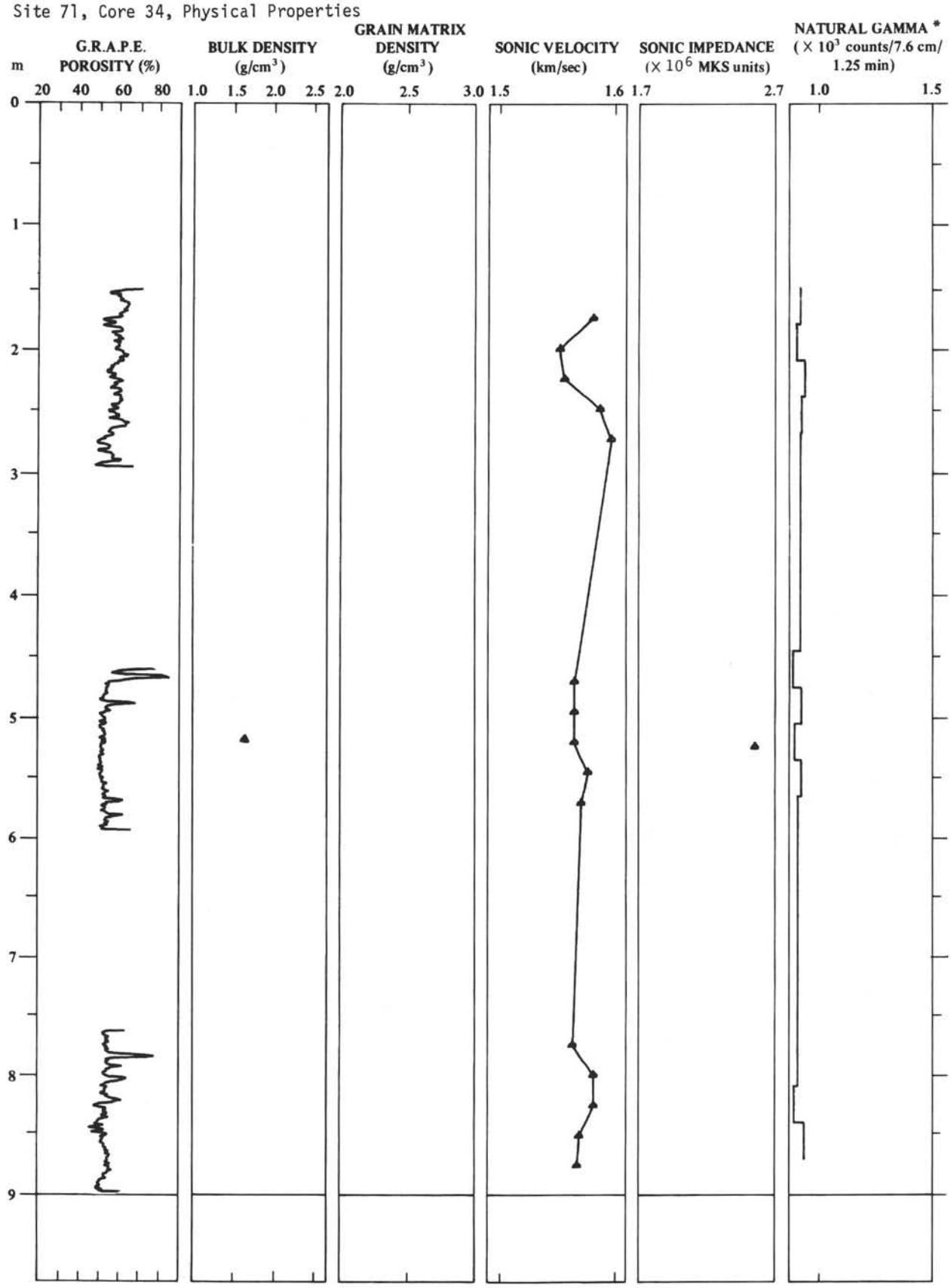
Site 71, Core 33, Physical Properties



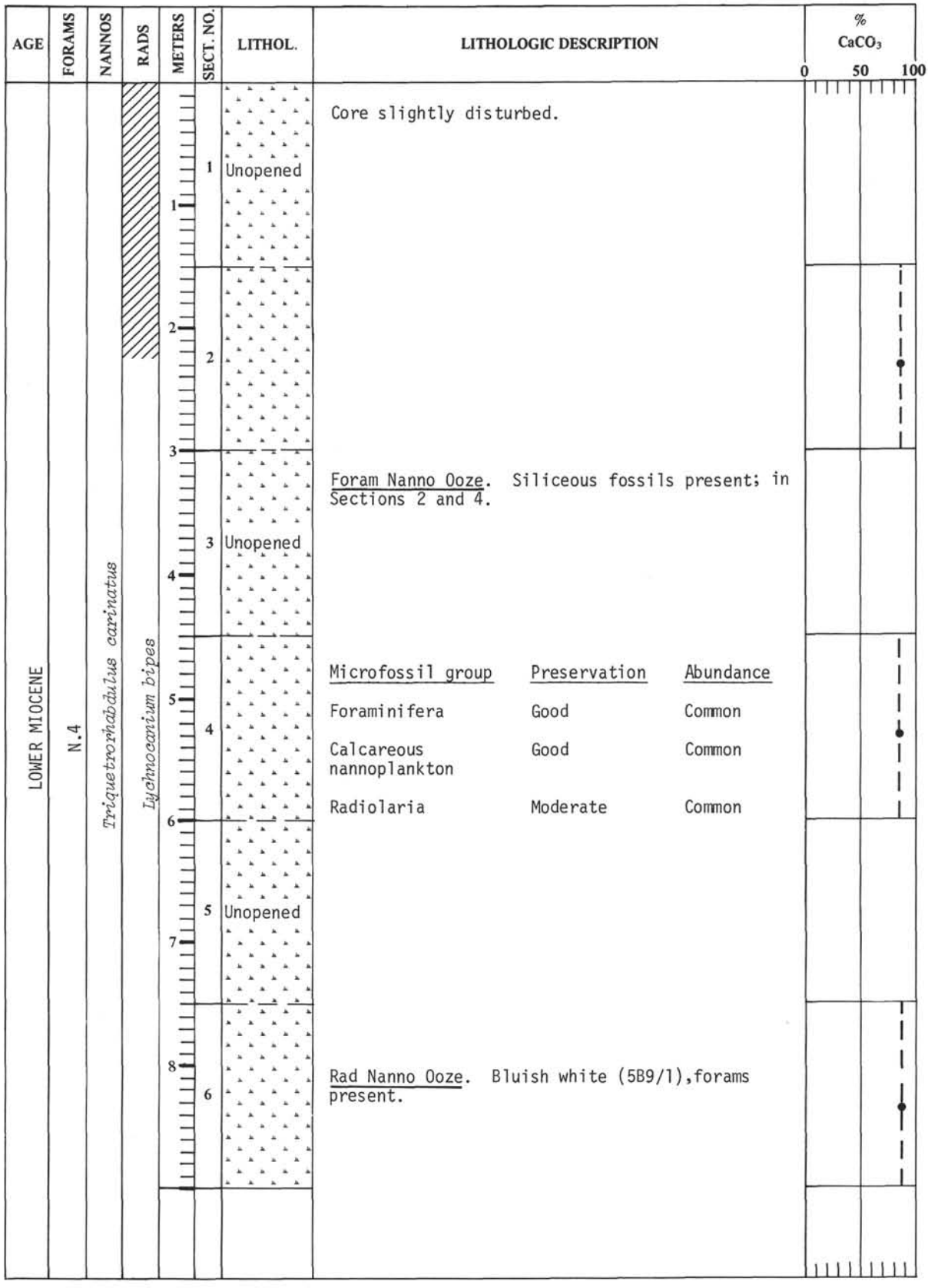
SITE 71 Core 34 Cored interval: 299-308 m



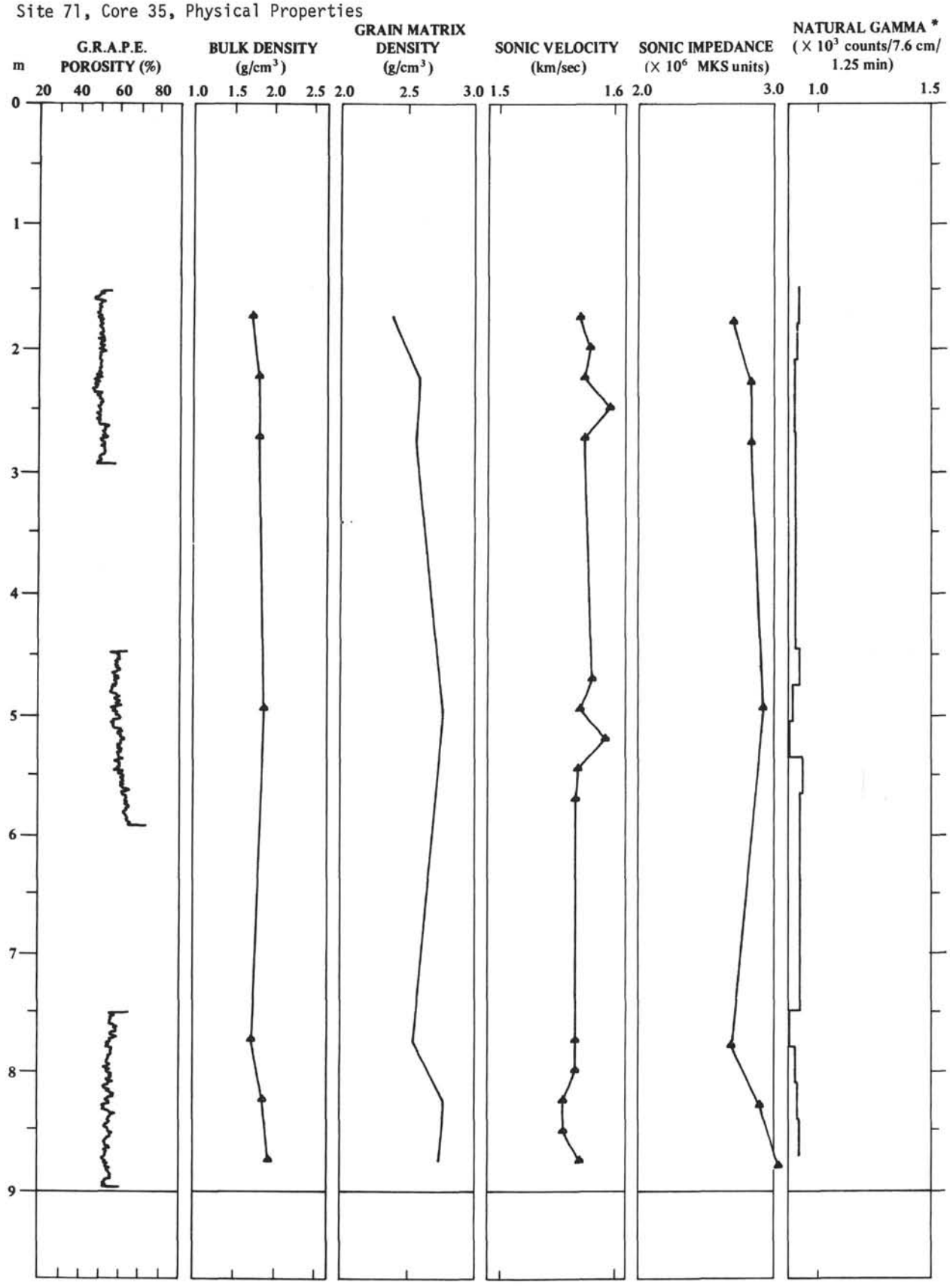
Site 71, Core 34, Physical Properties



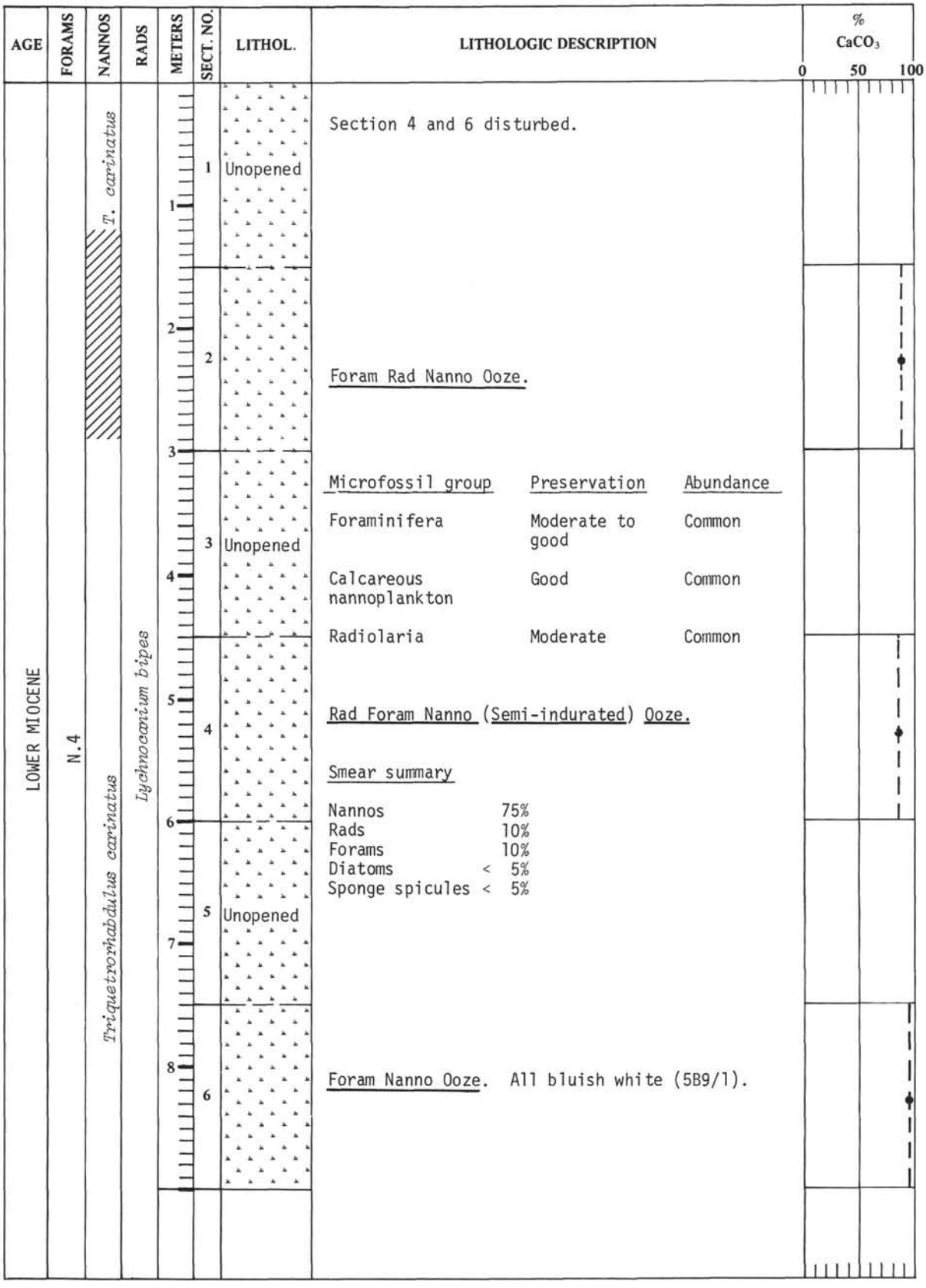
SITE 71 Core 35 Cored interval: 308-317 m



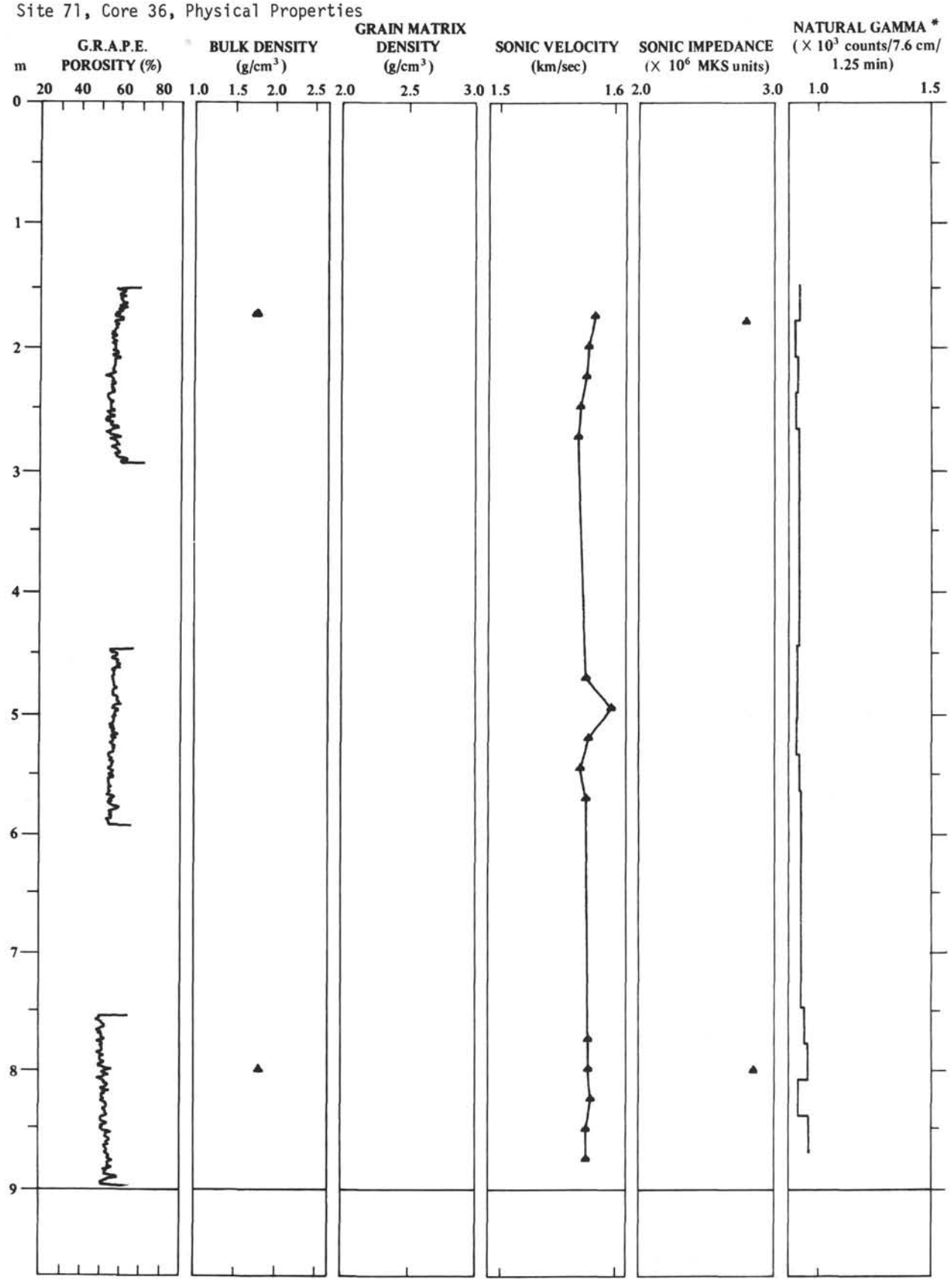
Site 71, Core 35, Physical Properties



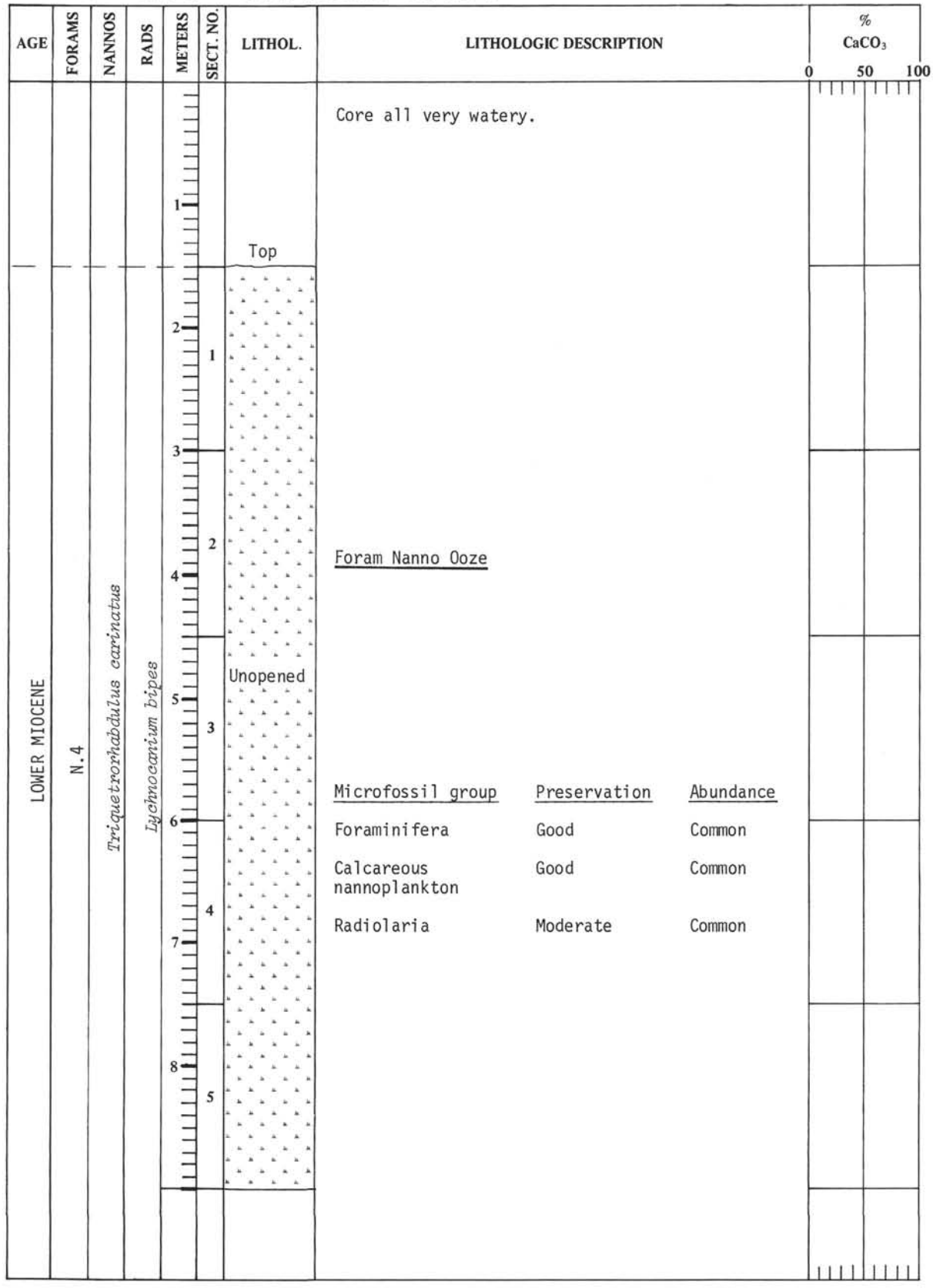
SITE 71 Core 36 Cored interval: 317-326 m



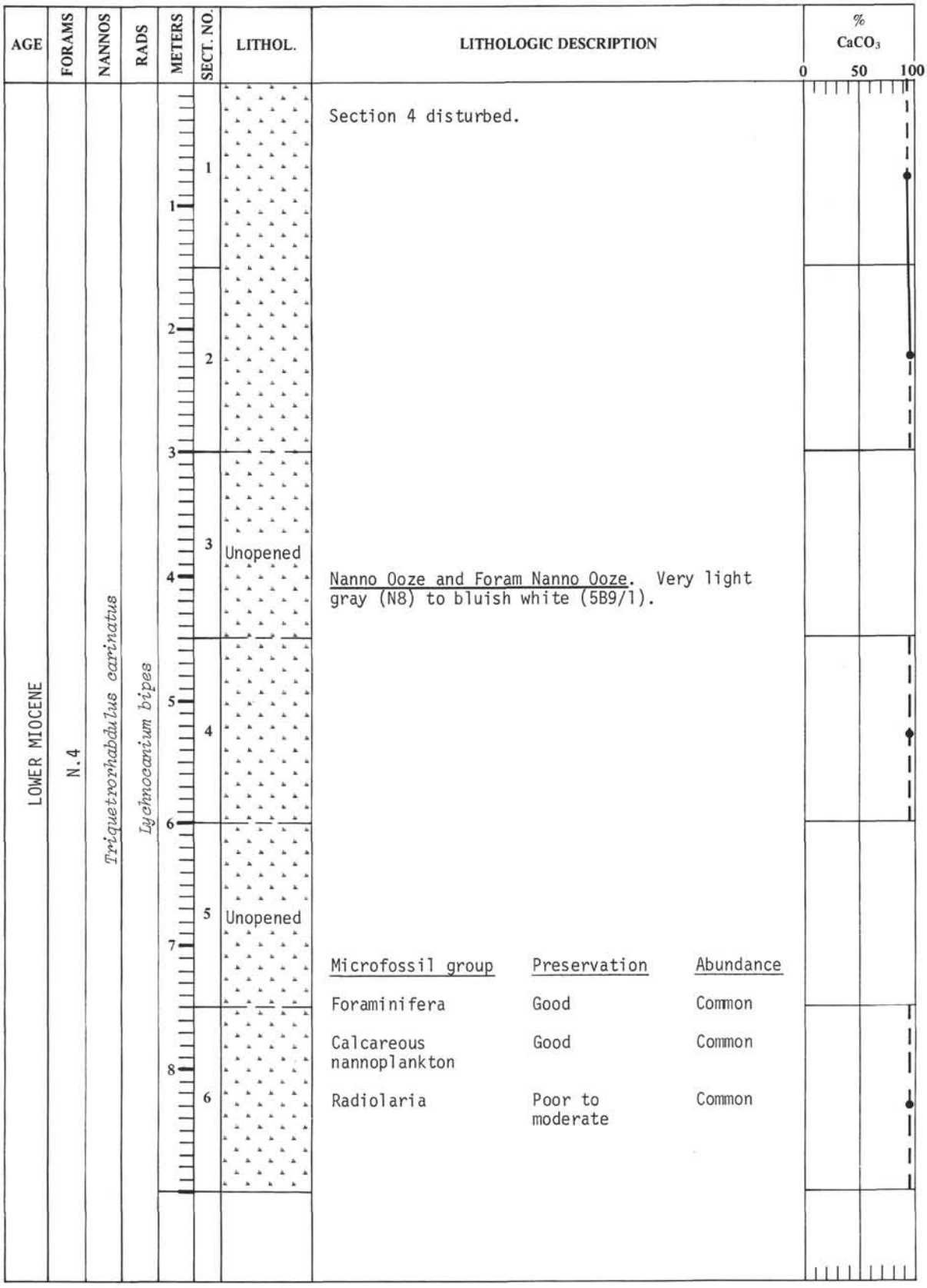
Site 71, Core 36, Physical Properties



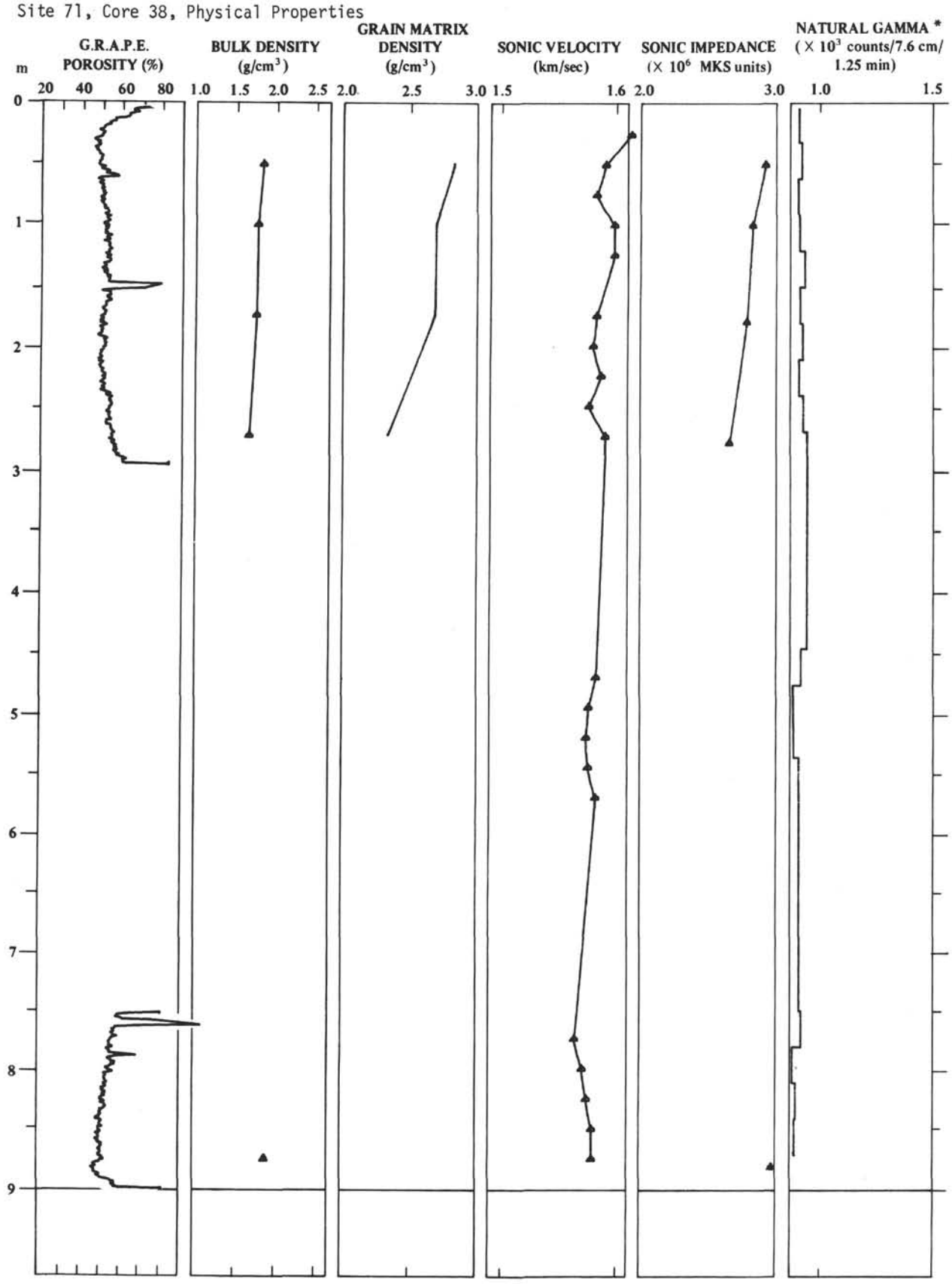
SITE 71 Core 37 Cored interval: 326-335 m



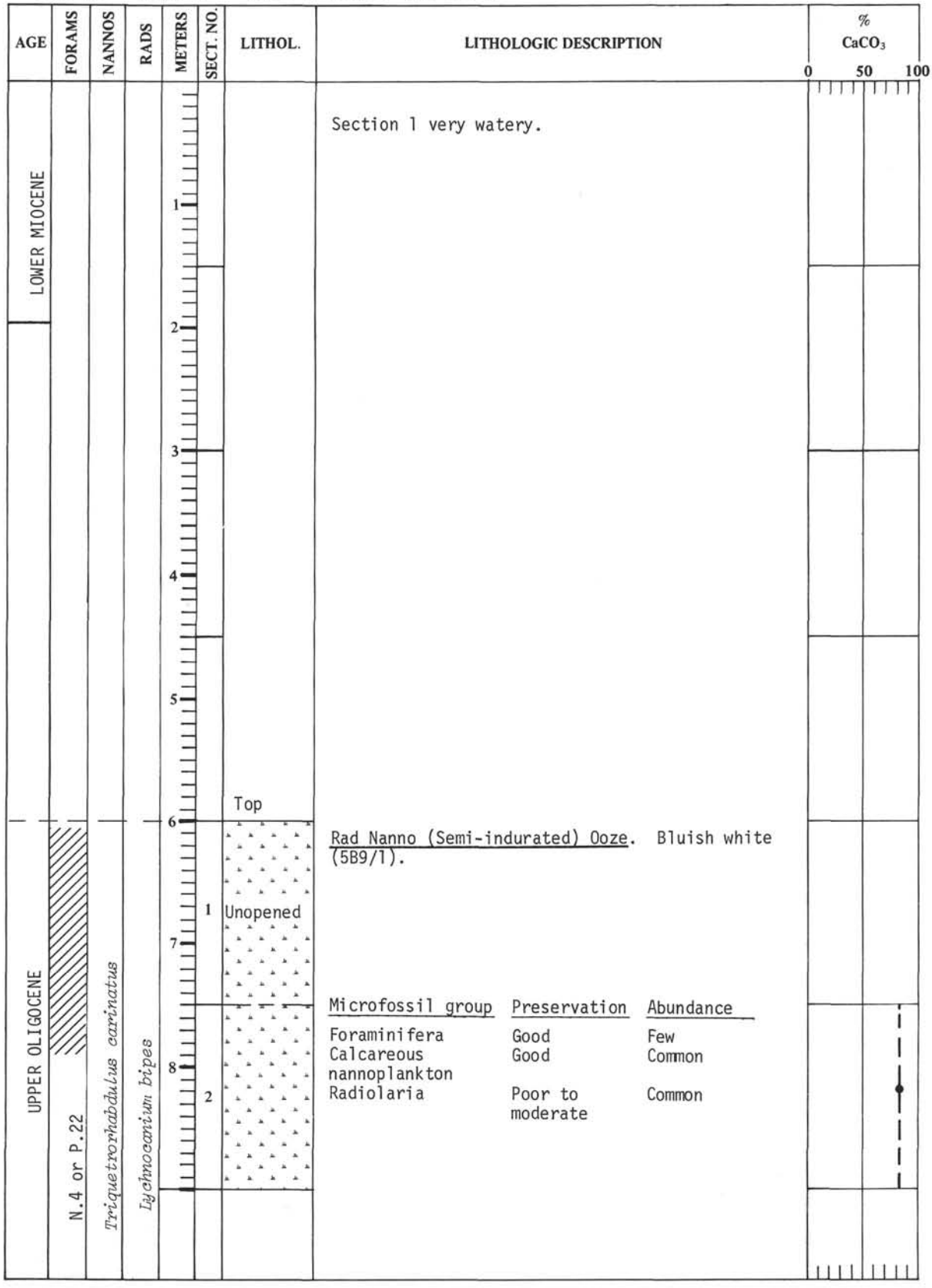
SITE 71 Core 38 Cored interval: 336-345 m



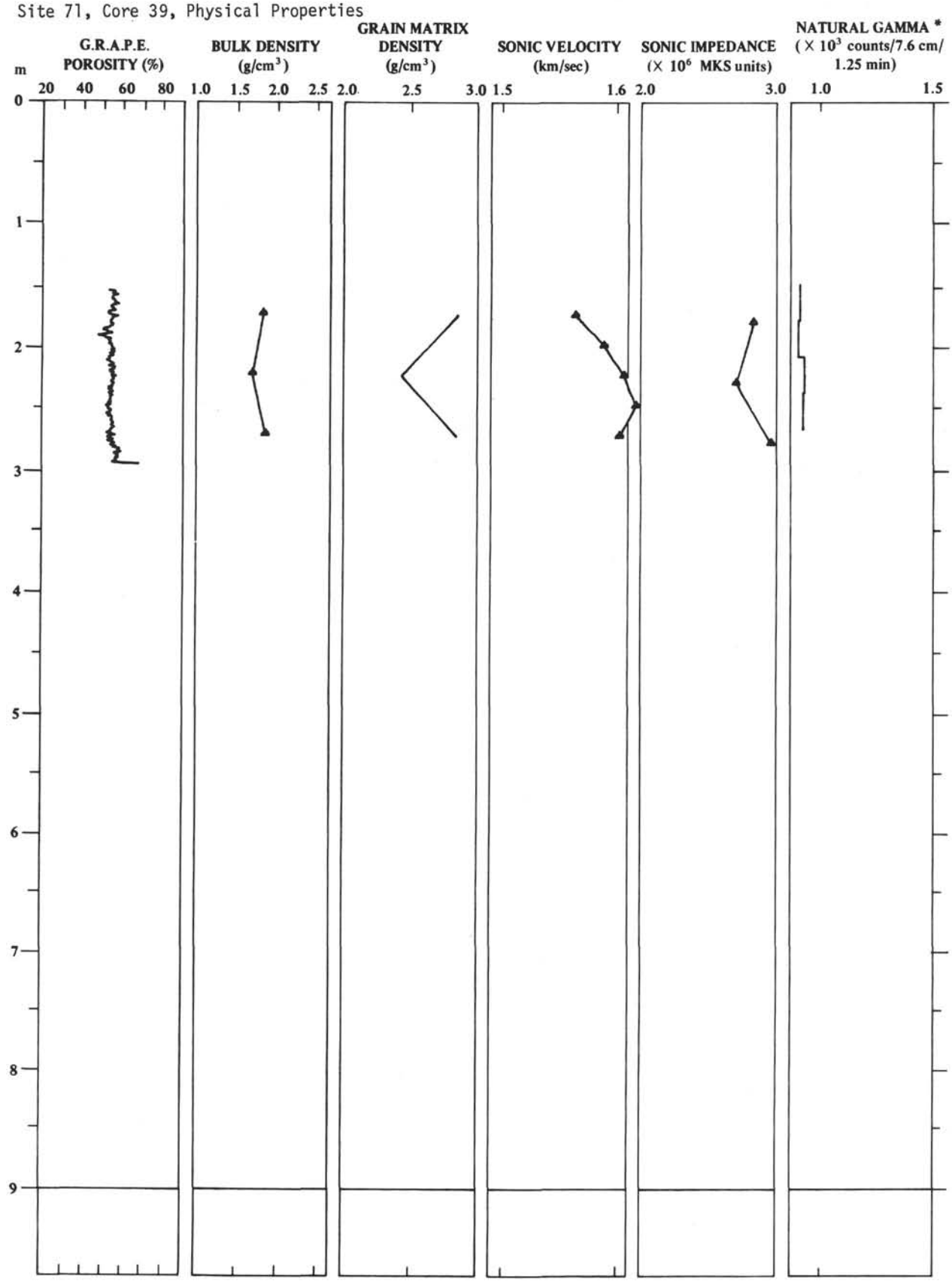
Site 71, Core 38, Physical Properties



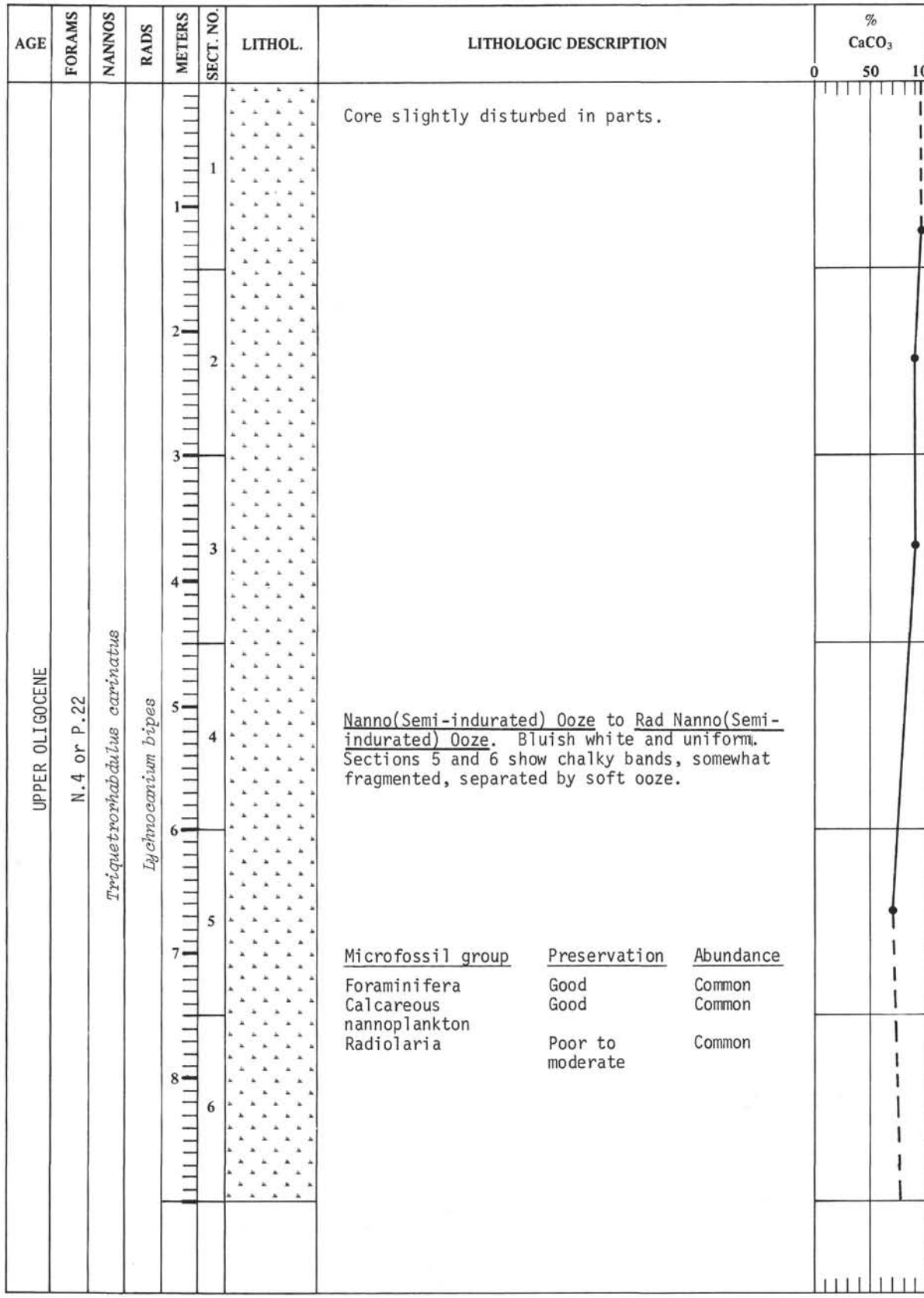
SITE 71 Core 39 Cored interval: 345-354 m



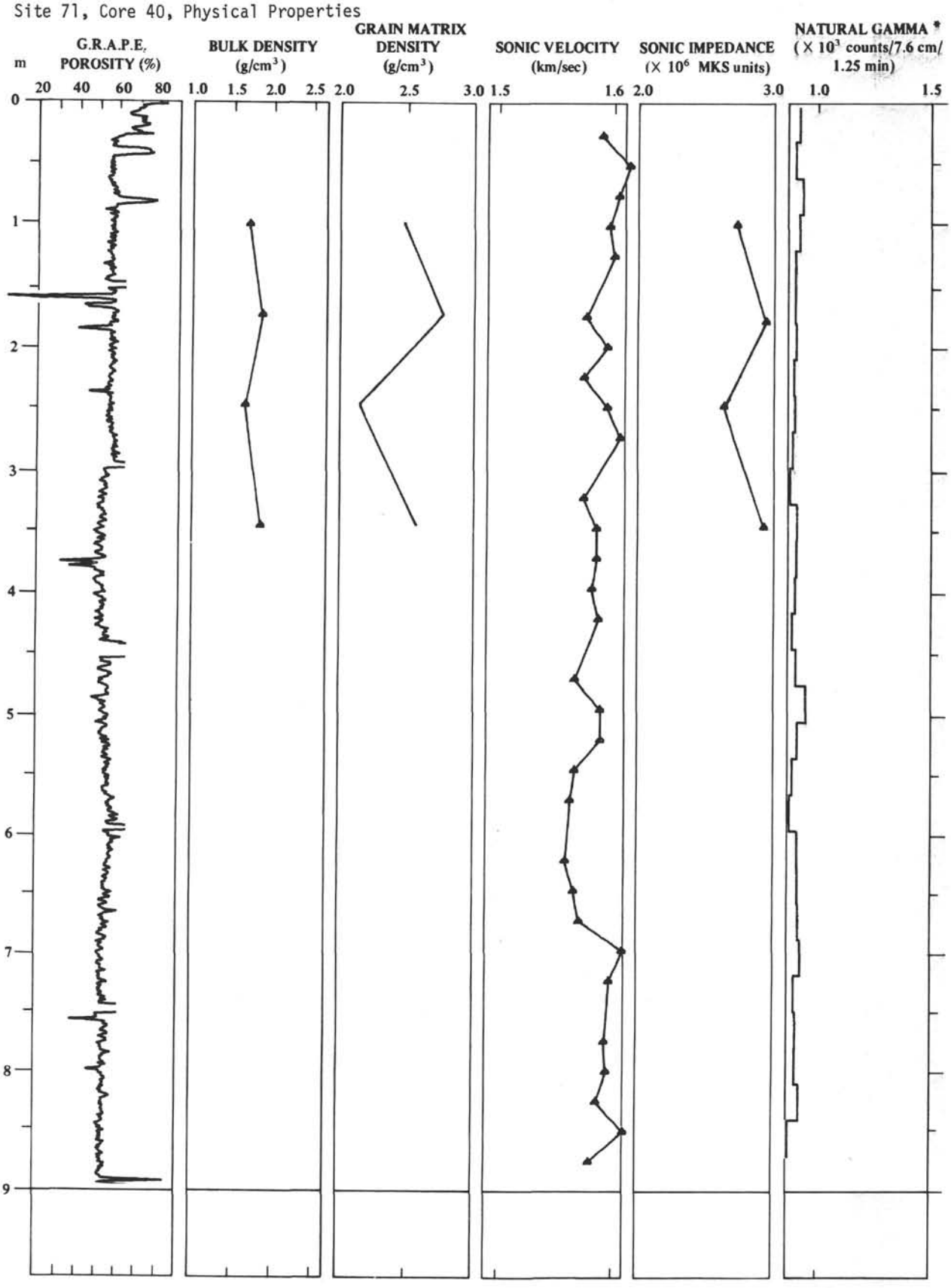
Site 71, Core 39, Physical Properties



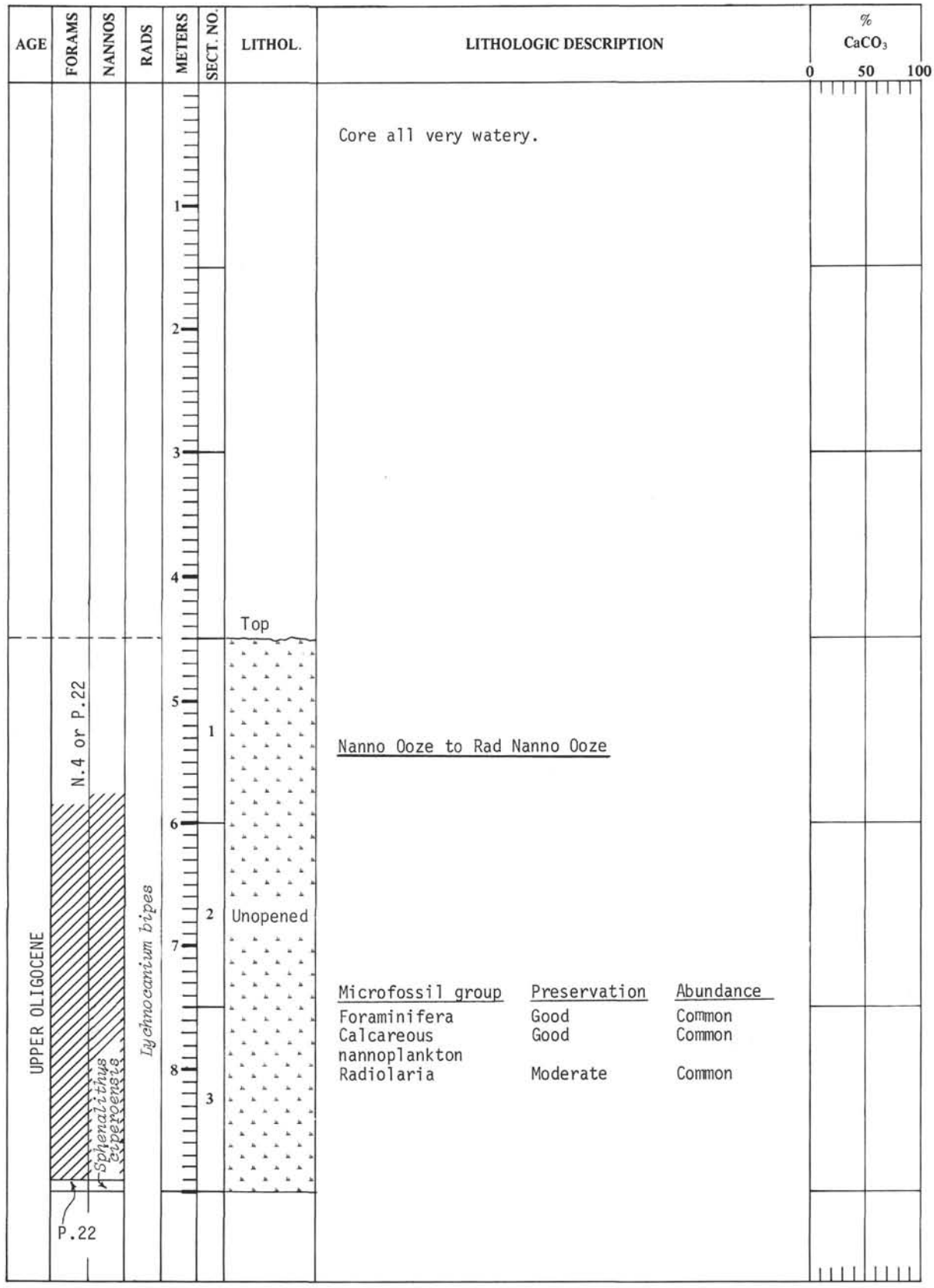
SITE 71 Core 40 Cored interval: 354-363 m



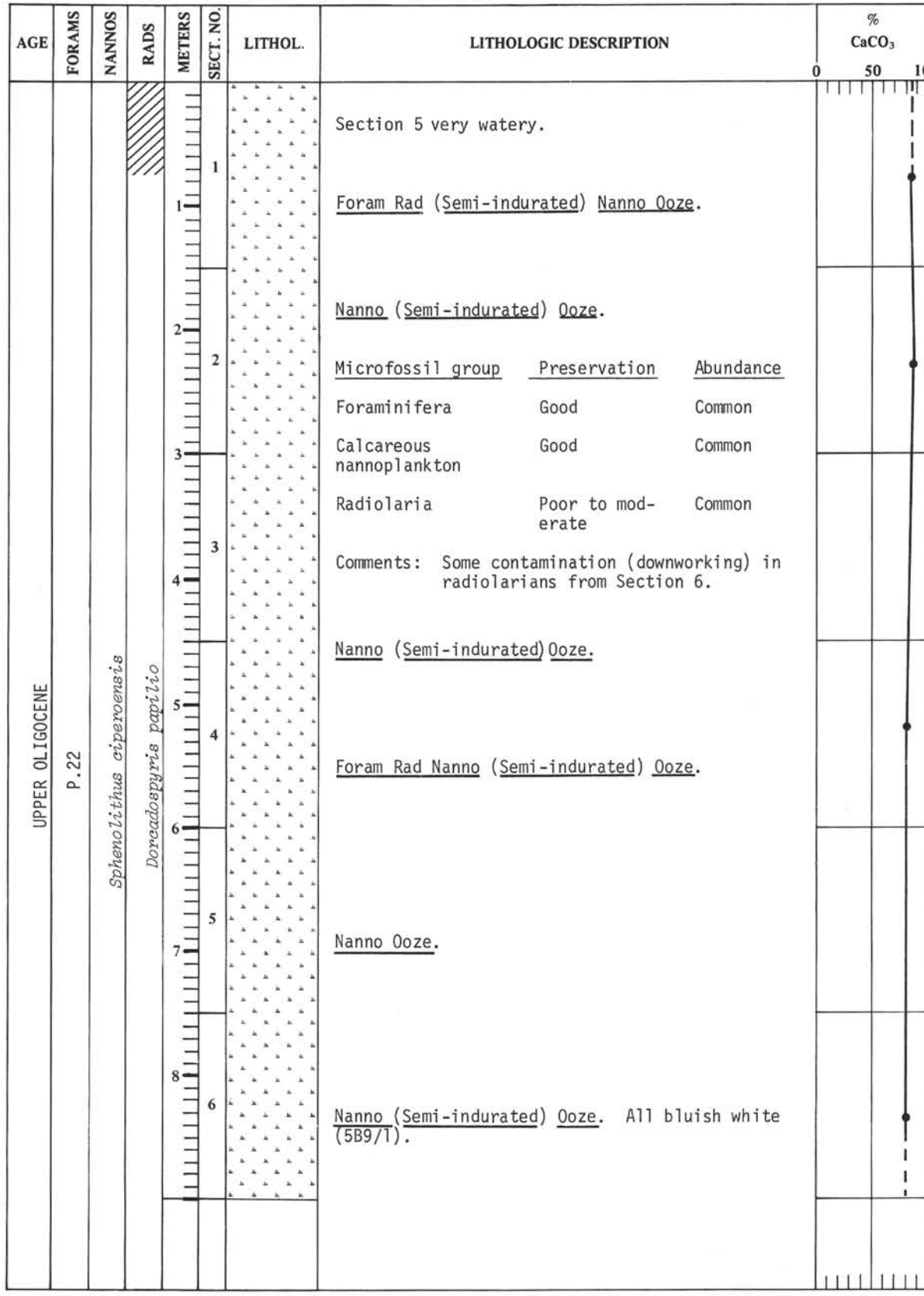
Site 71, Core 40, Physical Properties



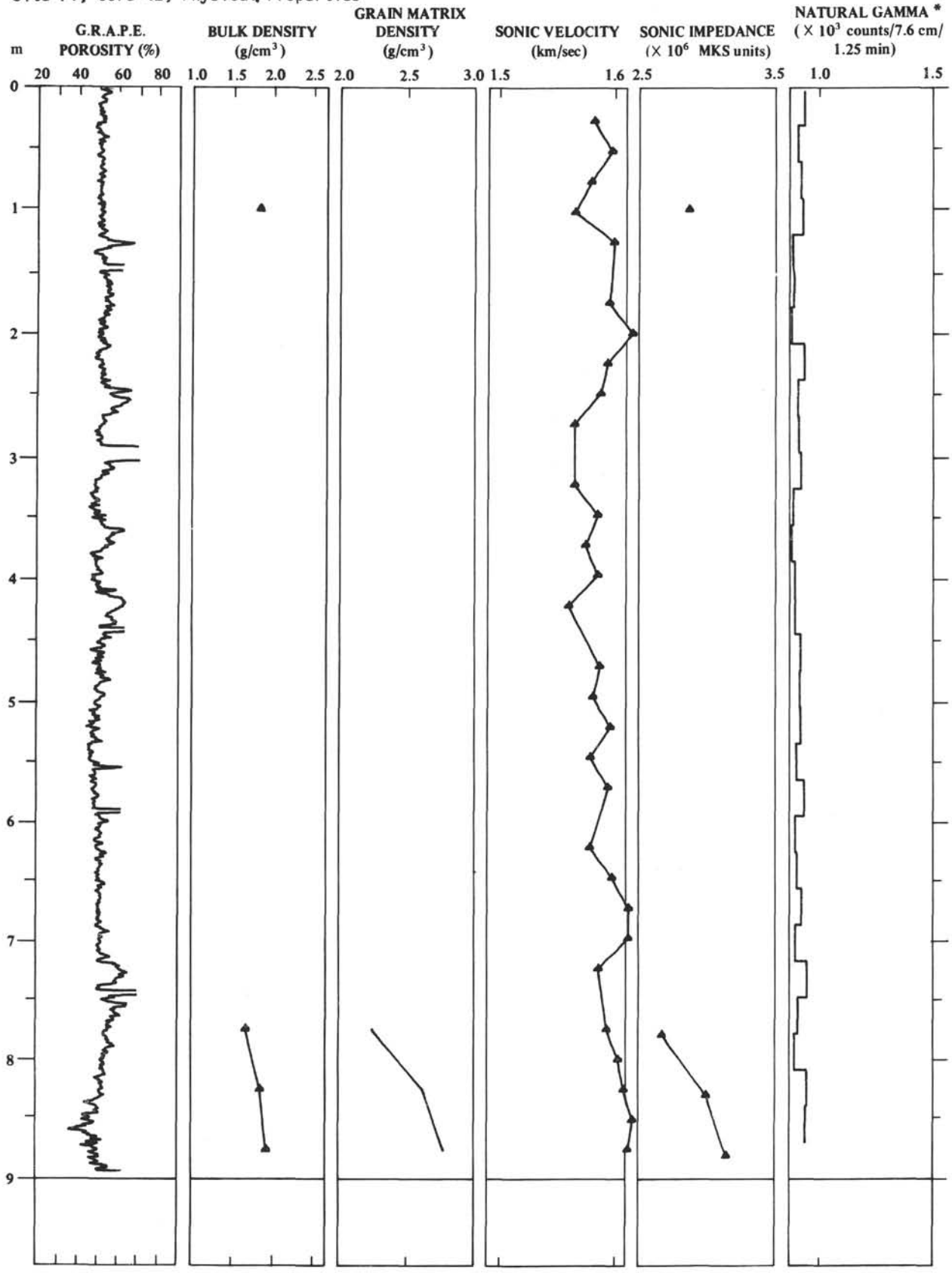
SITE 71 Core 41 Cored interval: 363-372 m



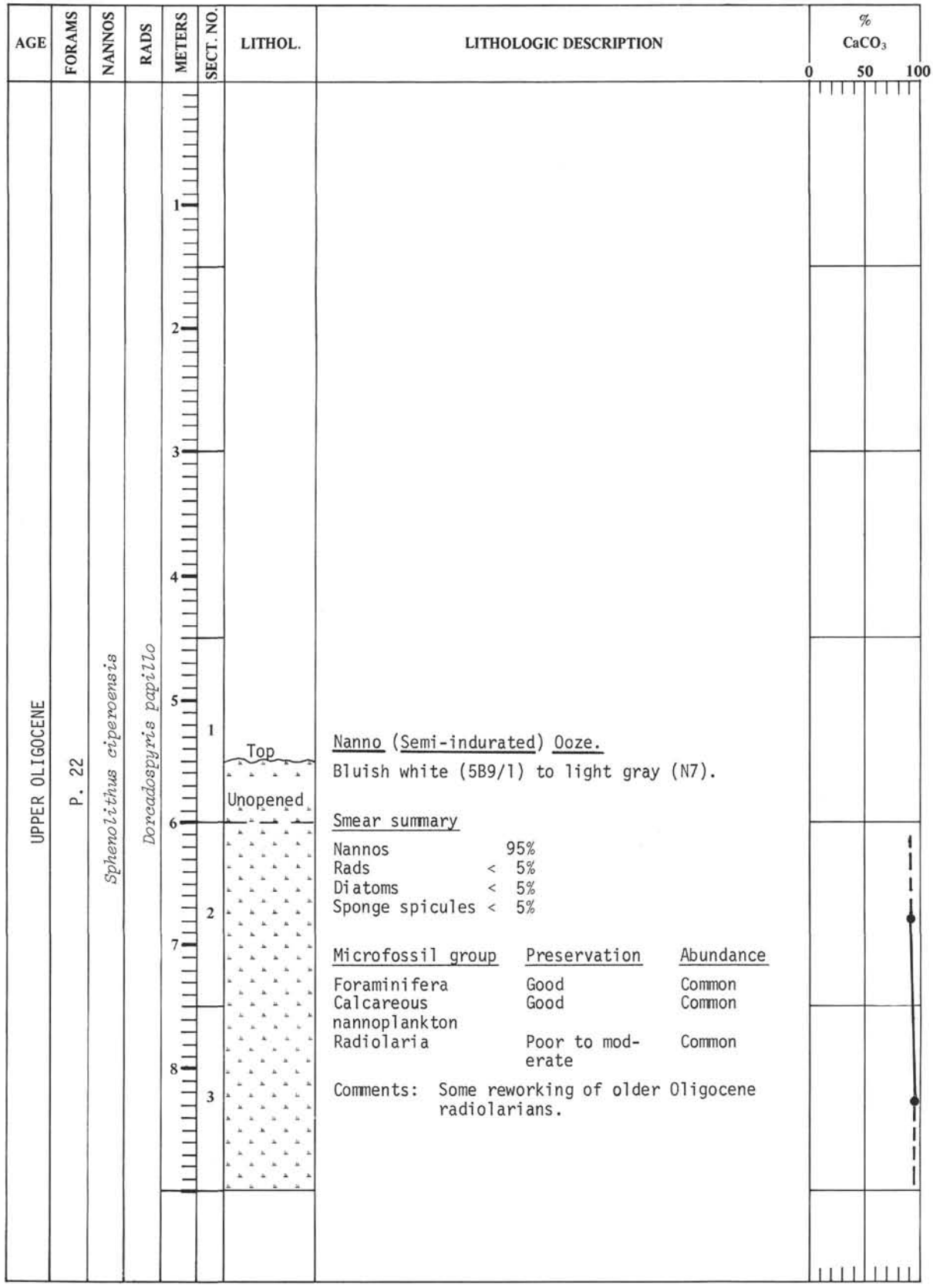
SITE 71 Core 42 Cored interval: 372-381 m



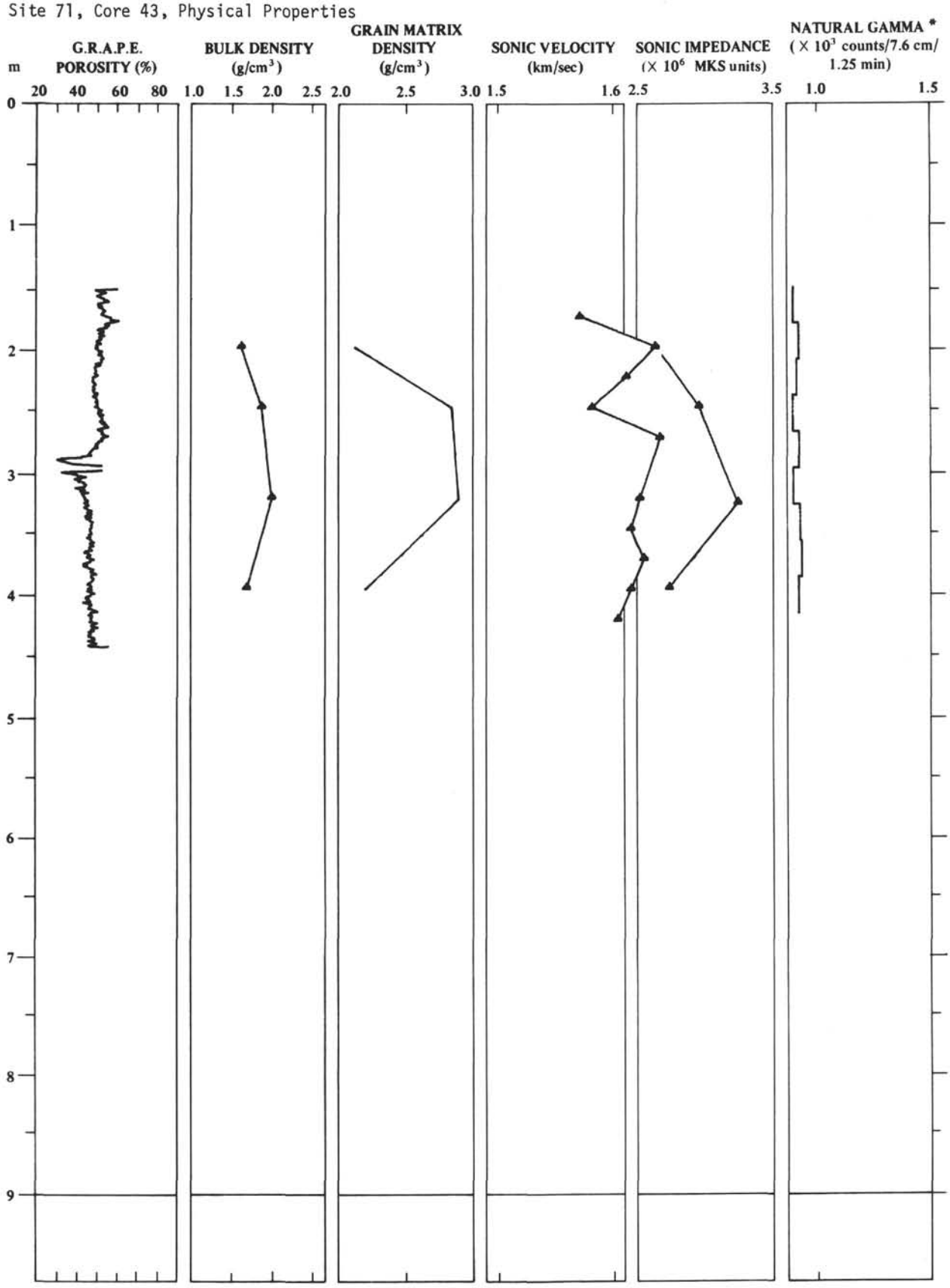
Site 71, Core 42, Physical Properties



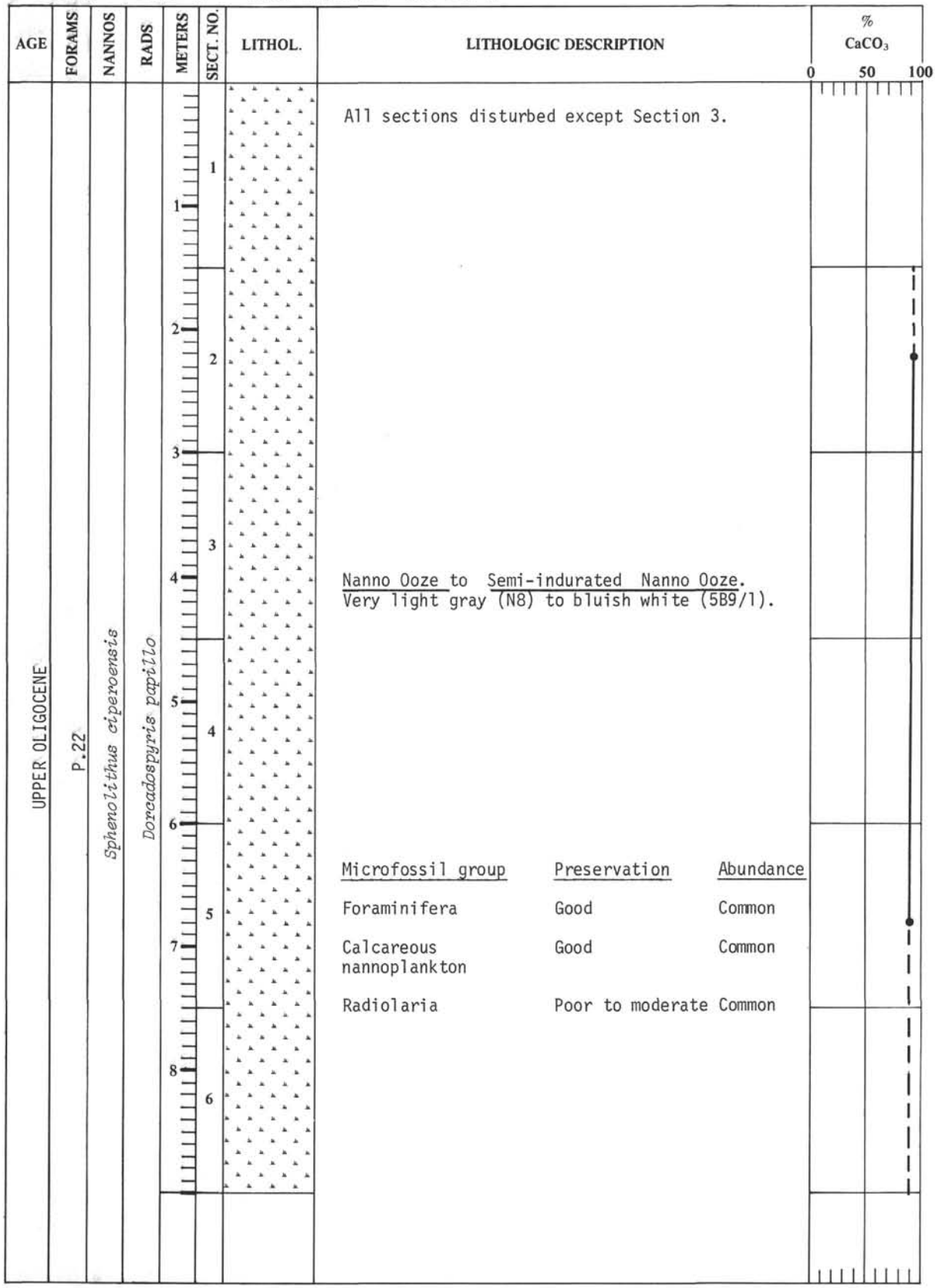
SITE 71 Core 43 Cored interval: 381-390 m



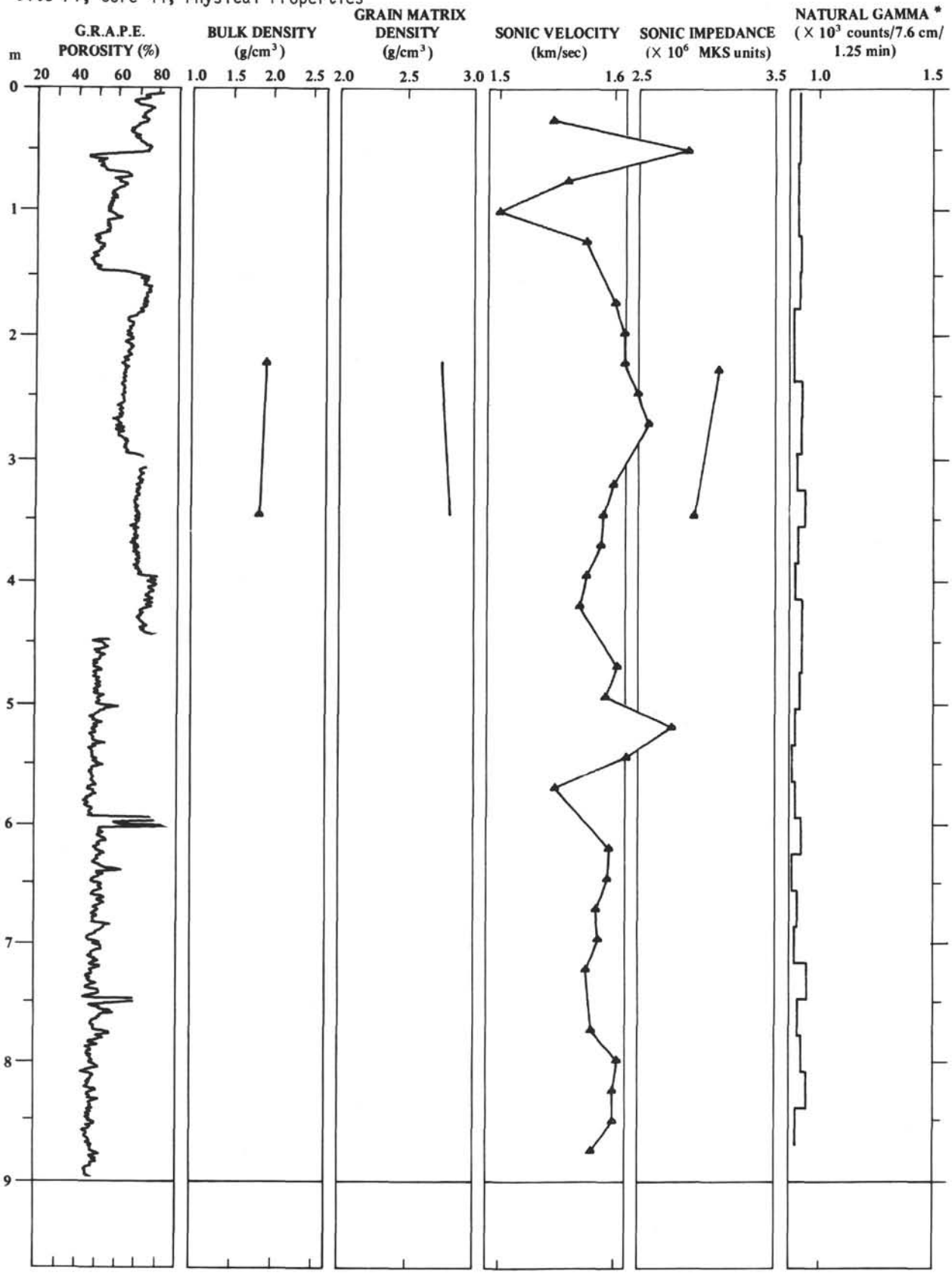
Site 71, Core 43, Physical Properties



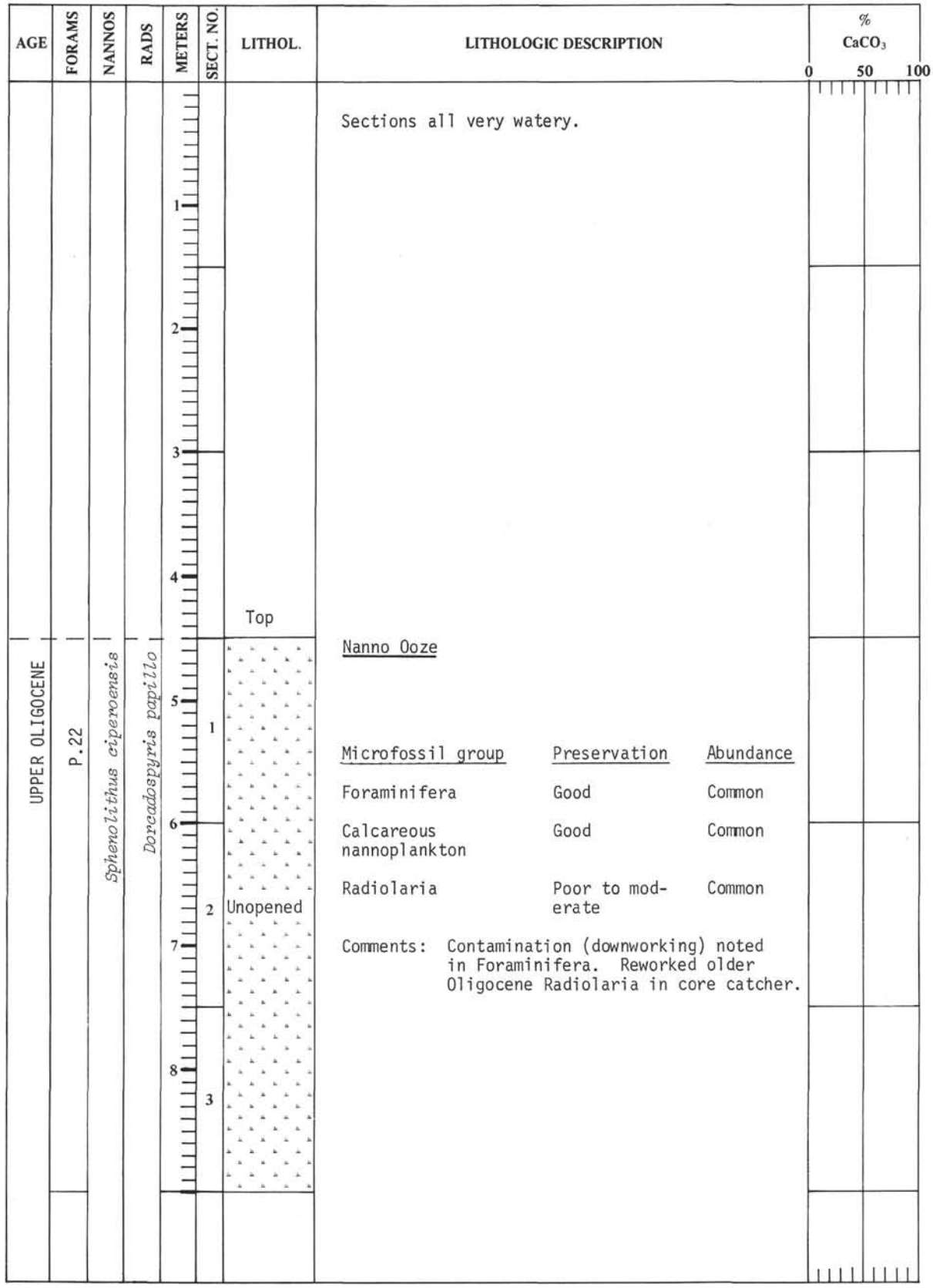
SITE 71 Core 44 Cored interval: 390-399 m



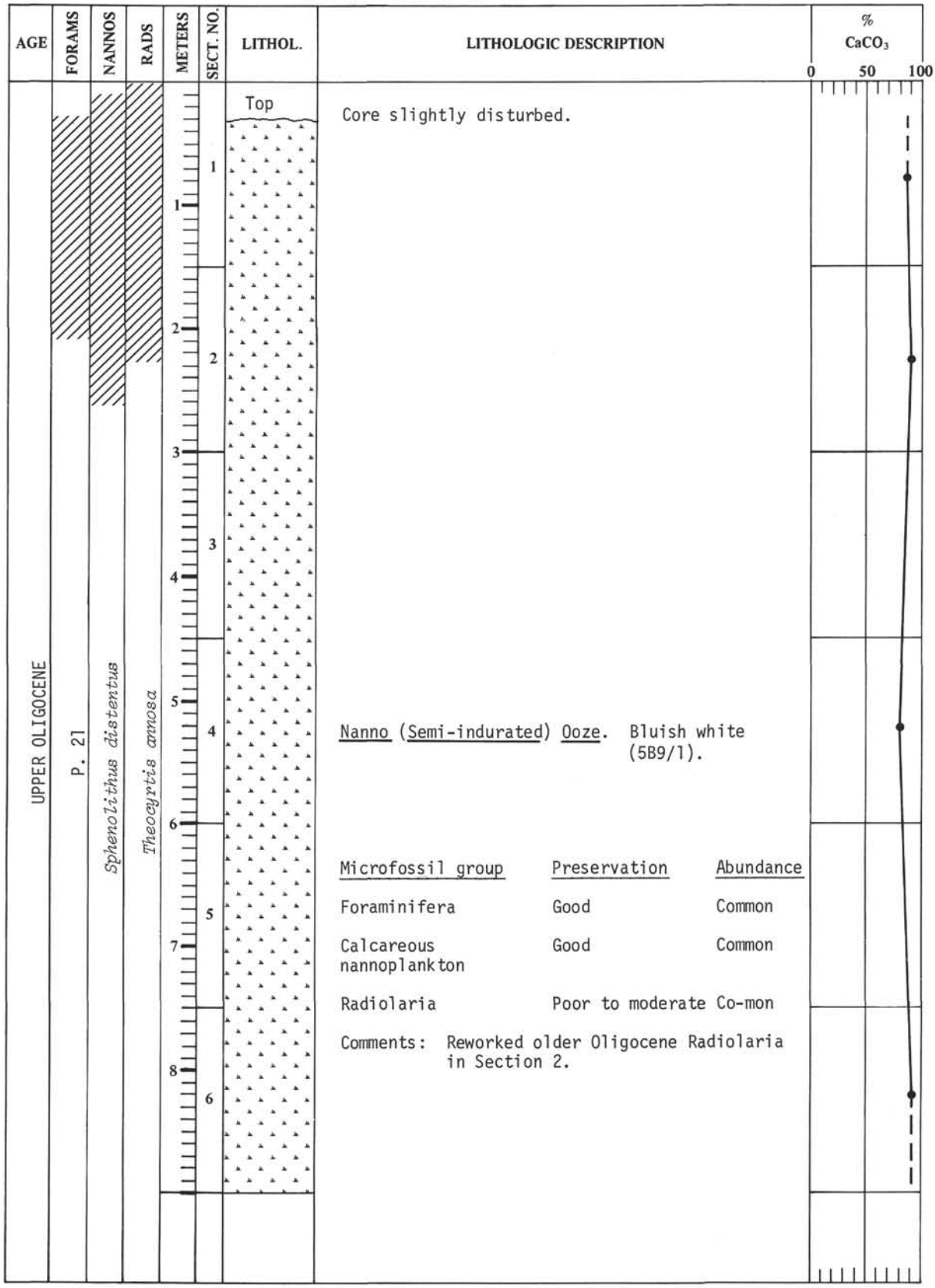
Site 71, Core 44, Physical Properties



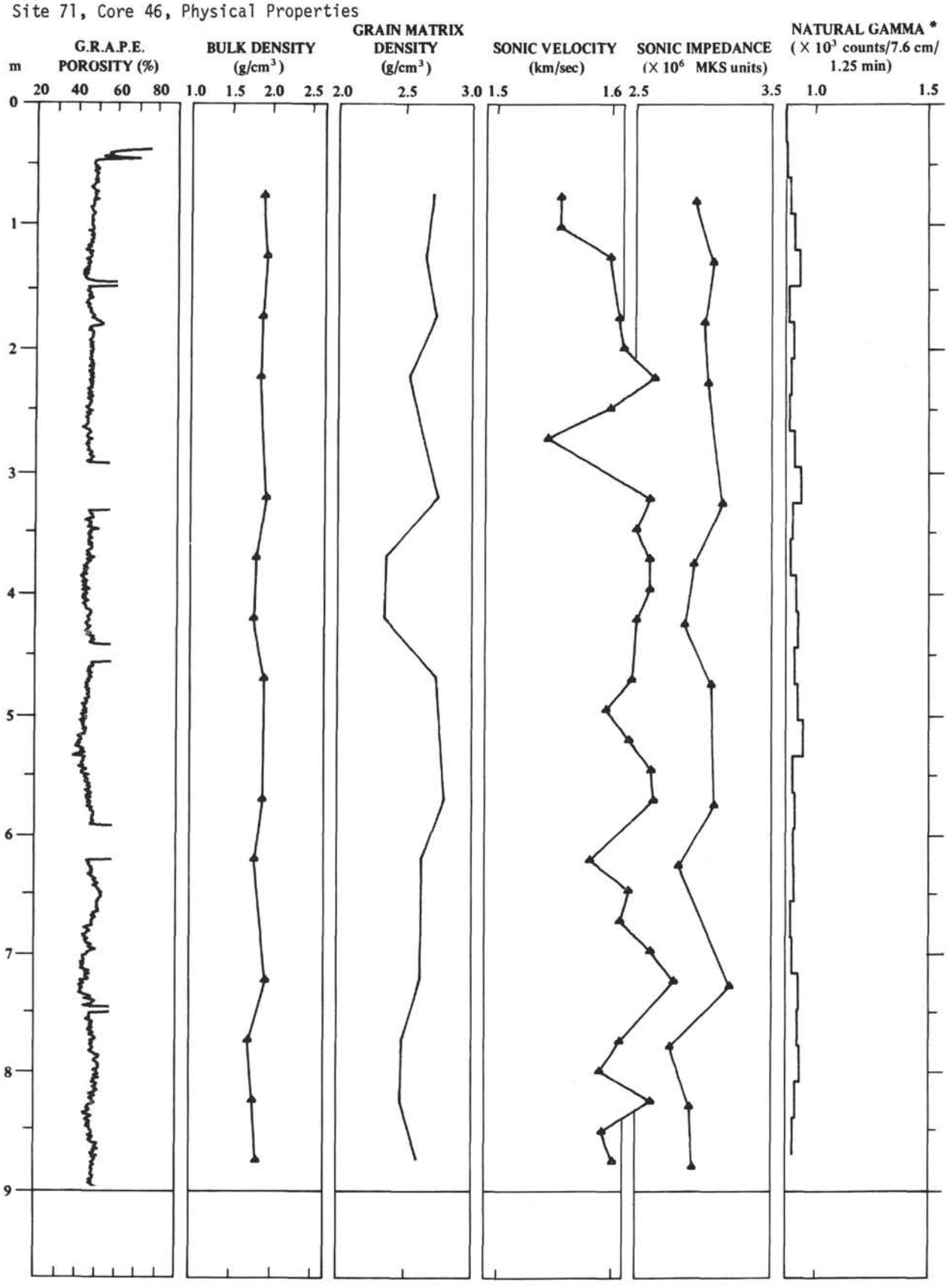
SITE 71 Core 45 Cored interval: 399-408 m



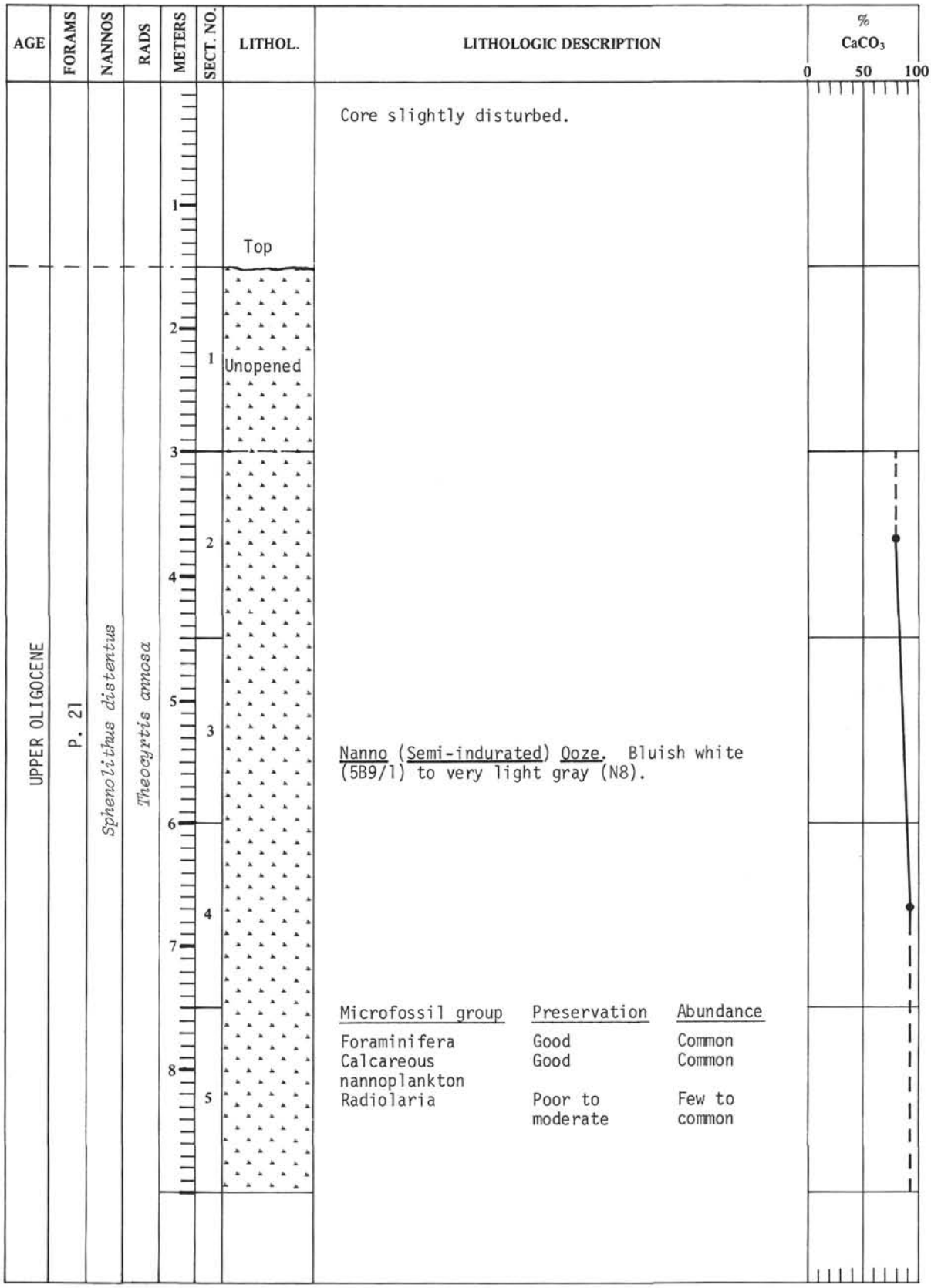
SITE 71 Core 46 Cored interval: 408-417 m



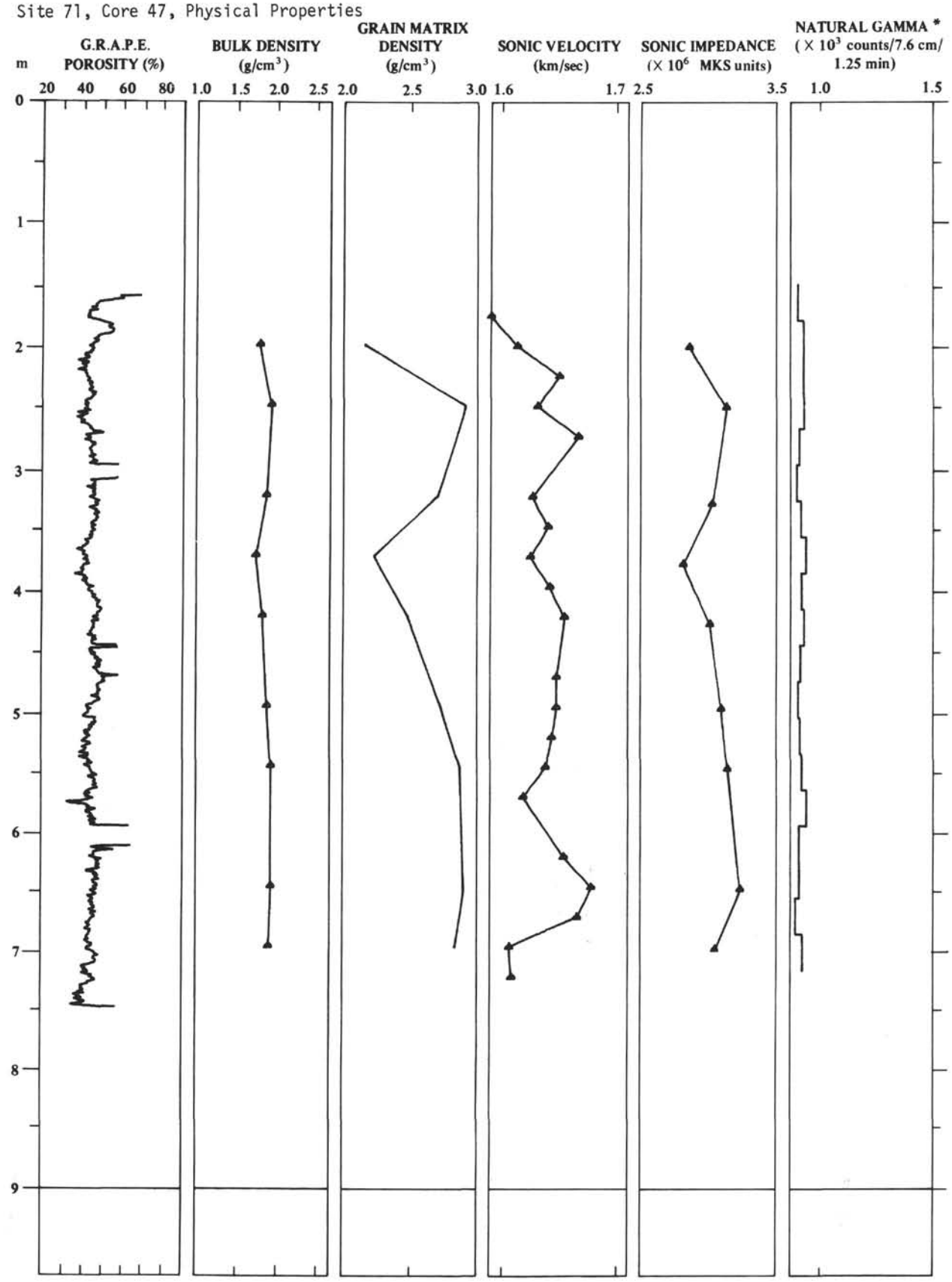
Site 71, Core 46, Physical Properties



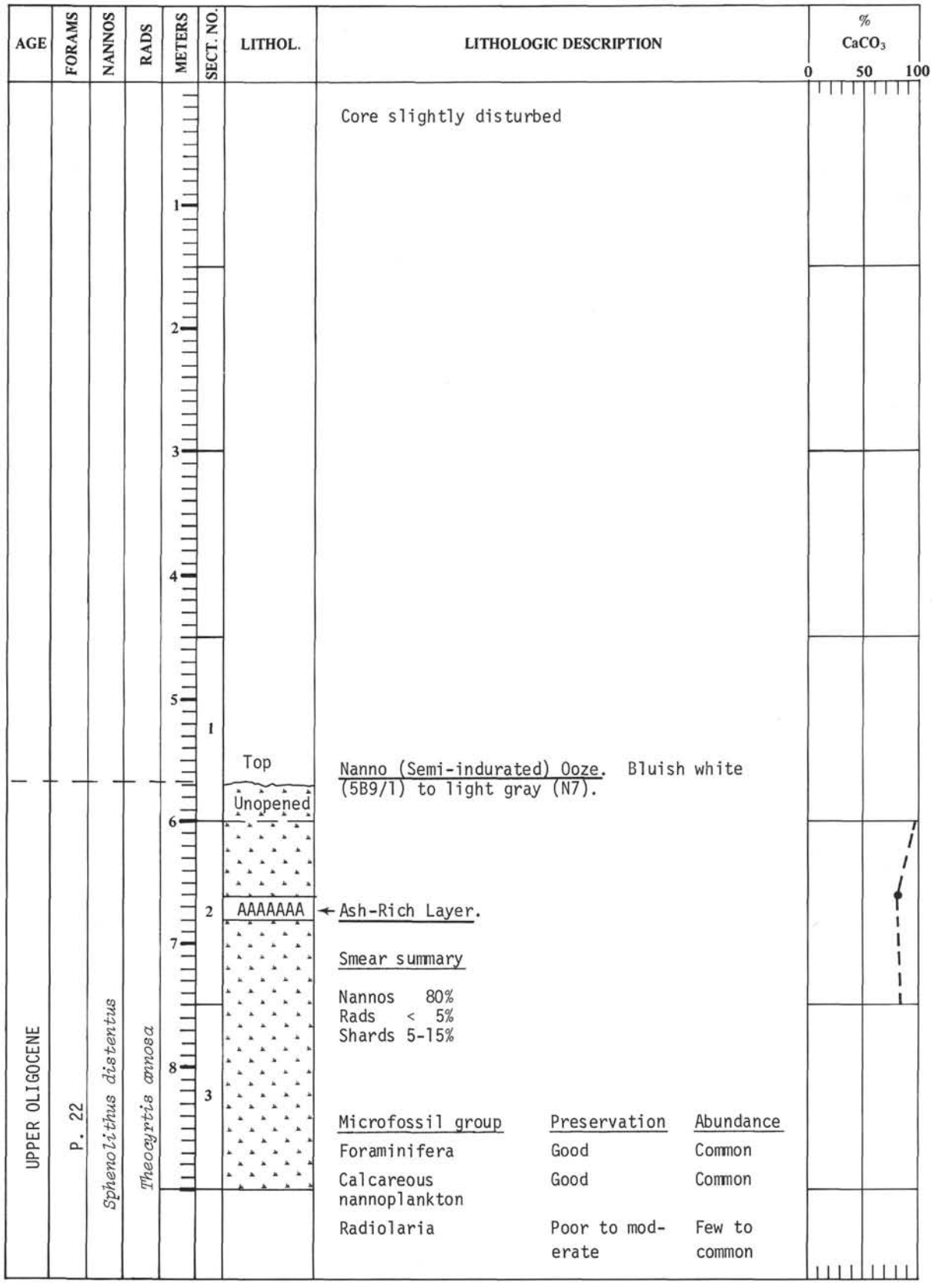
SITE 71 Core 47 Cored interval: 418-427 m



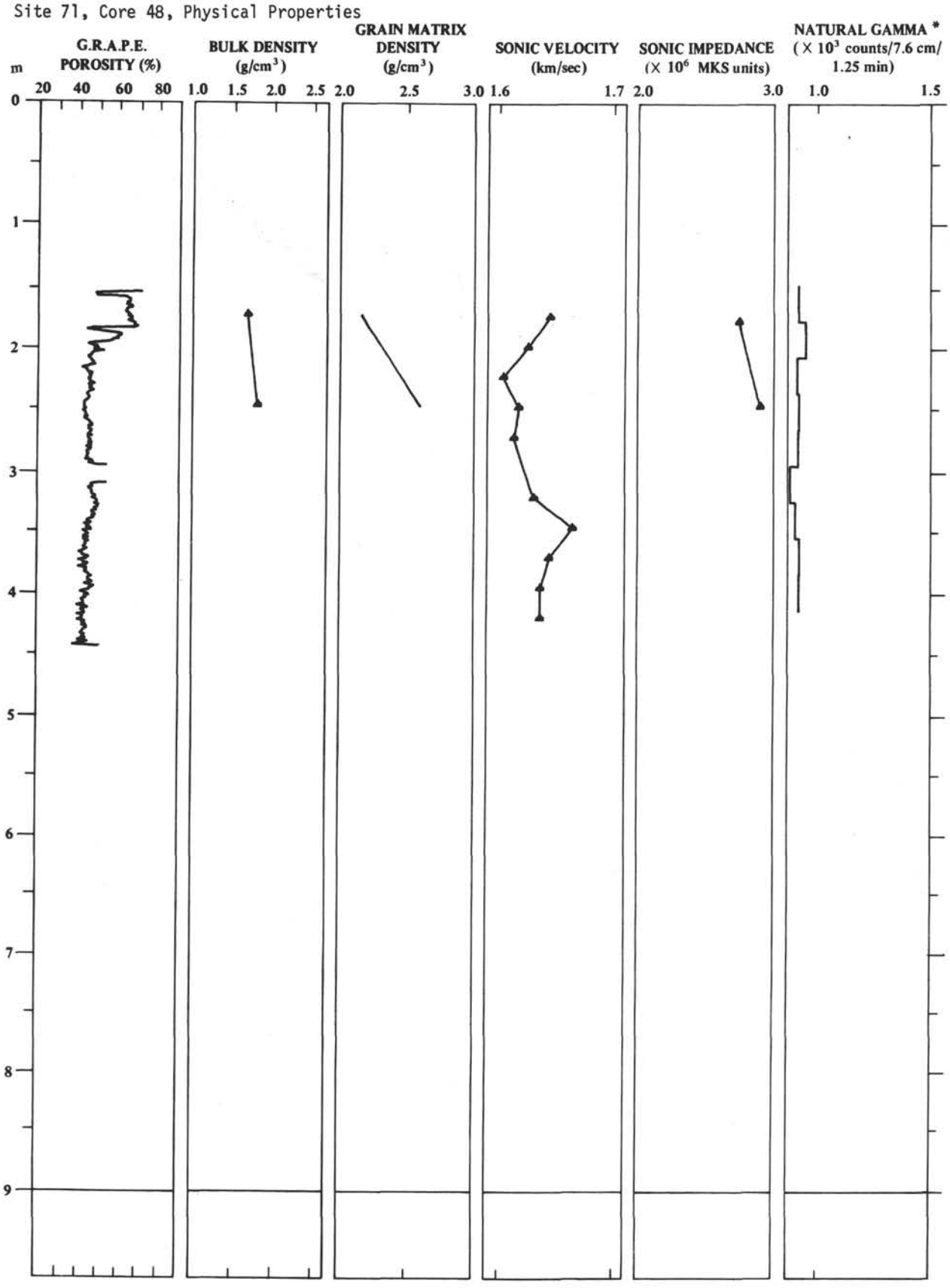
Site 71, Core 47, Physical Properties



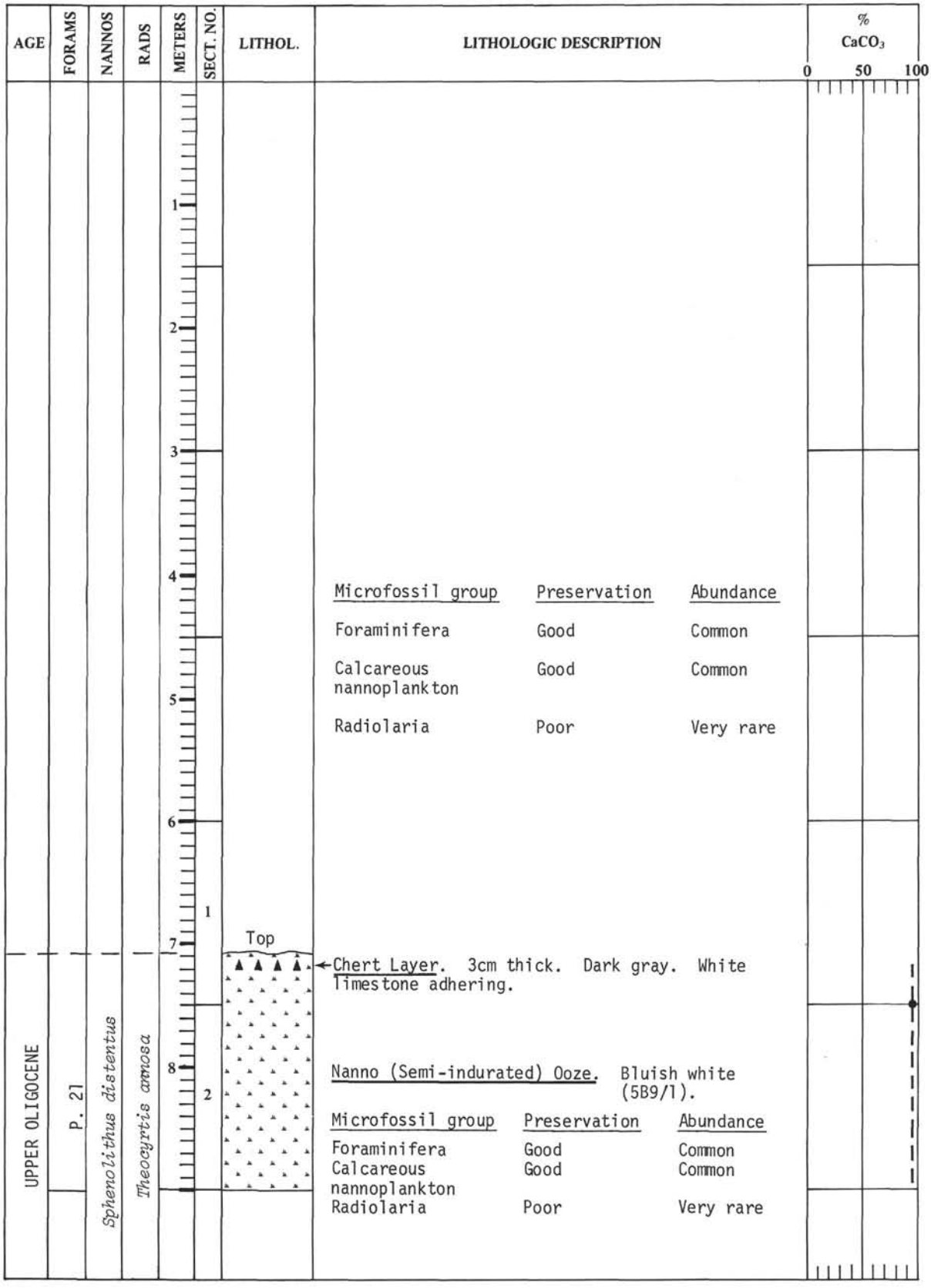
SITE 71 Core 48 Cored interval: 427-436 m



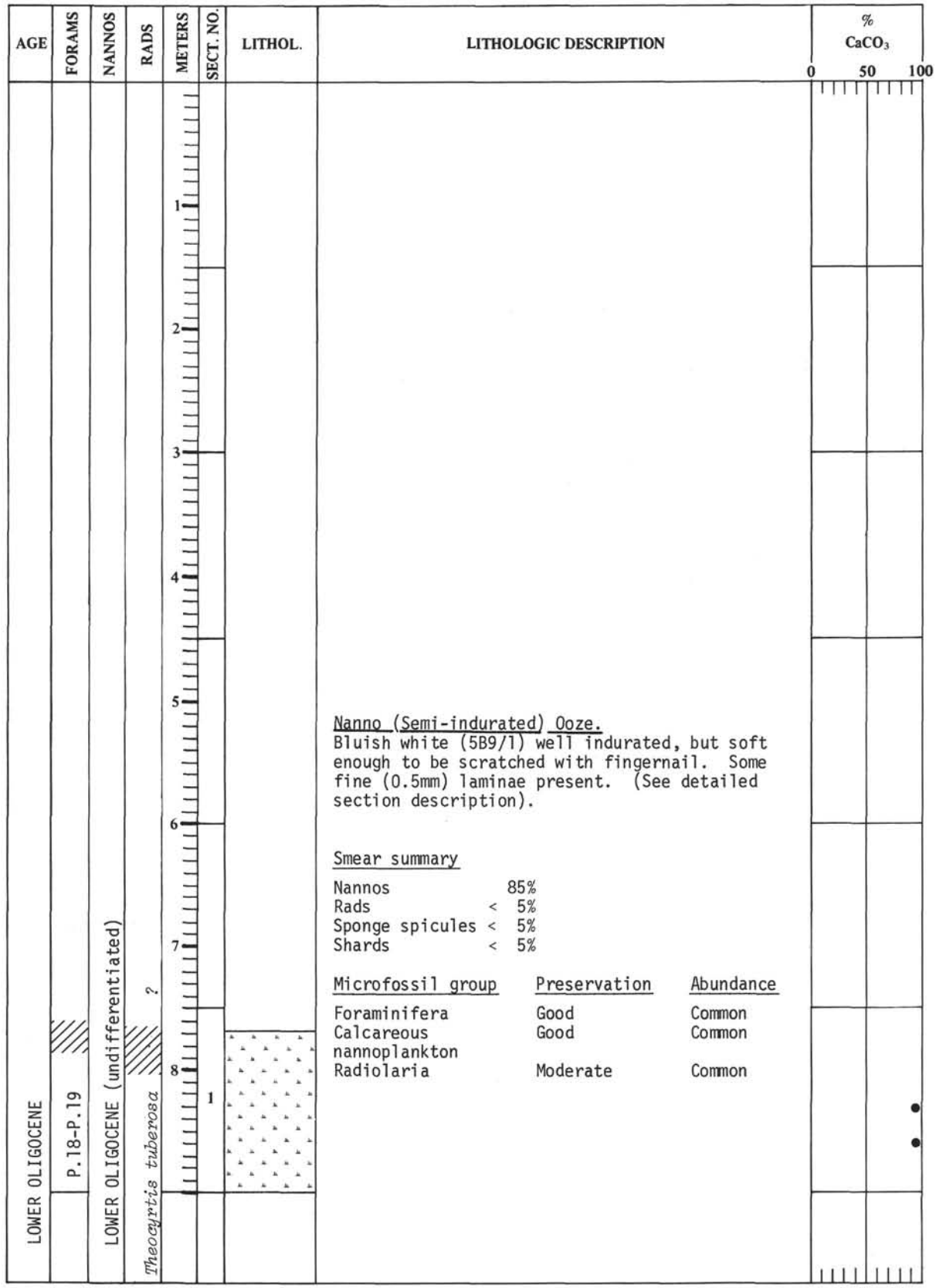
Site 71, Core 48, Physical Properties



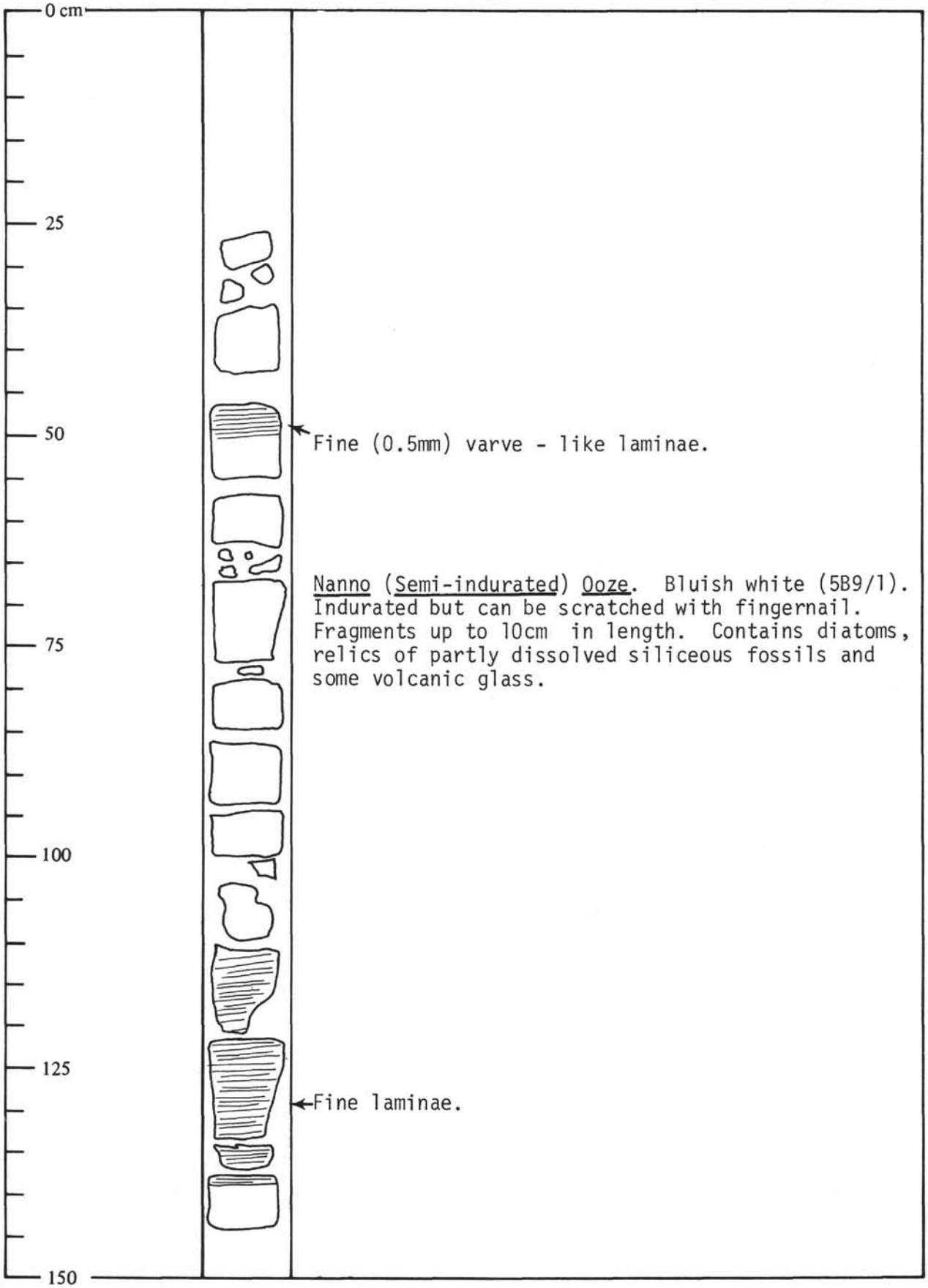
SITE 71 Core 49 Cored interval: 472-474 m



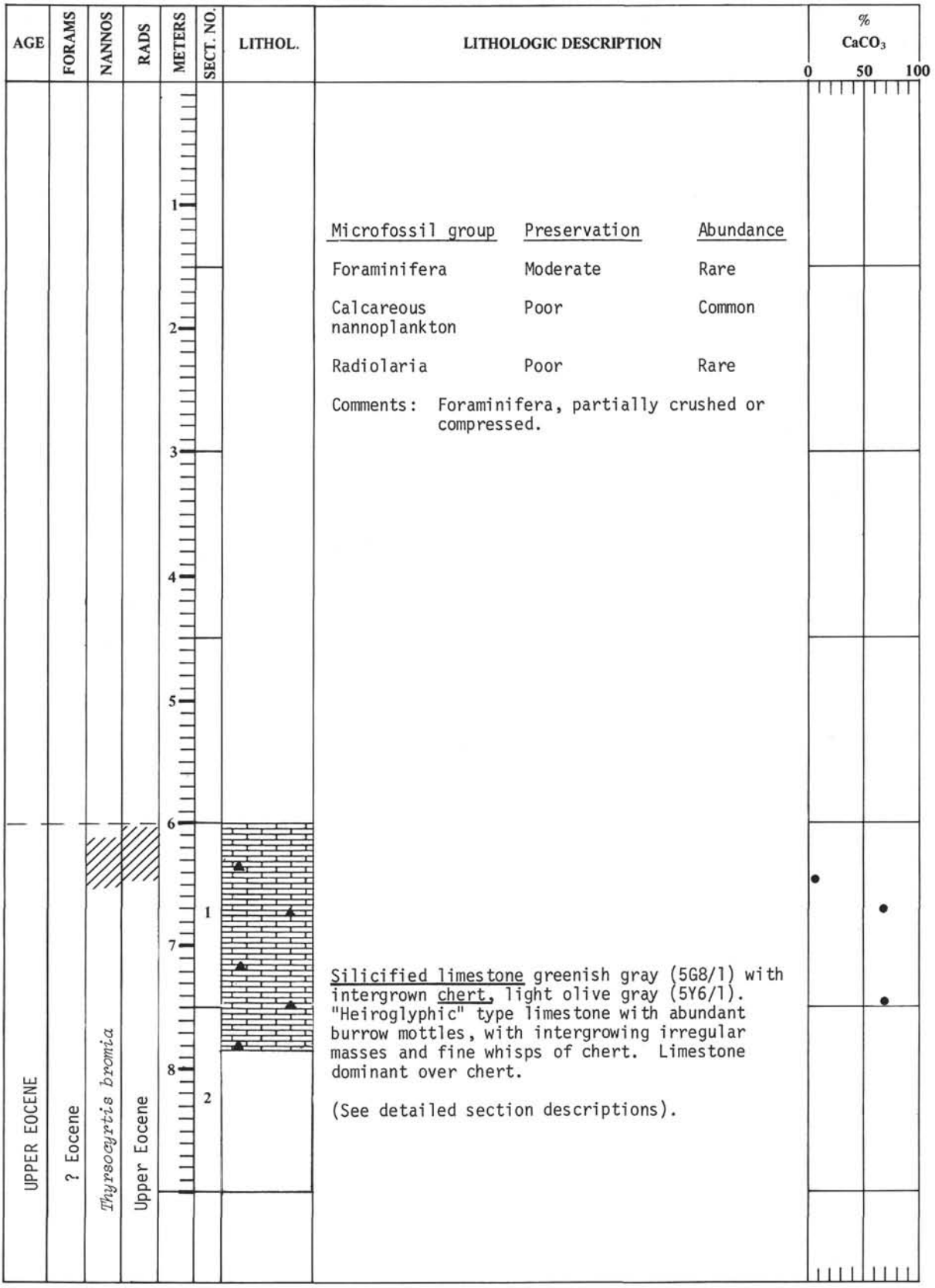
SITE 71A Core 1A Cored interval: 528-537 m



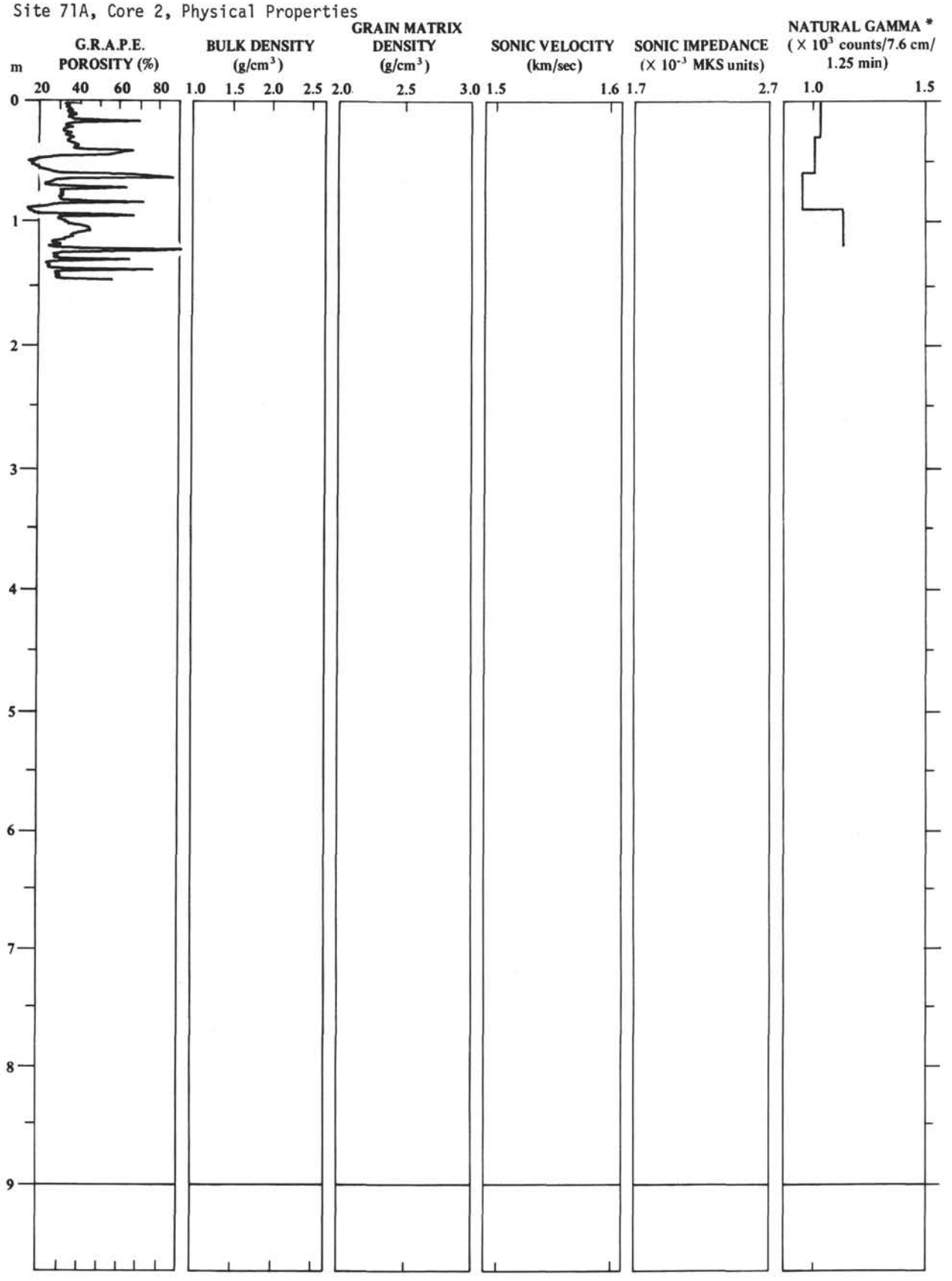
SITE 71A Core 1A Detailed description Section 1 (472-474 m)



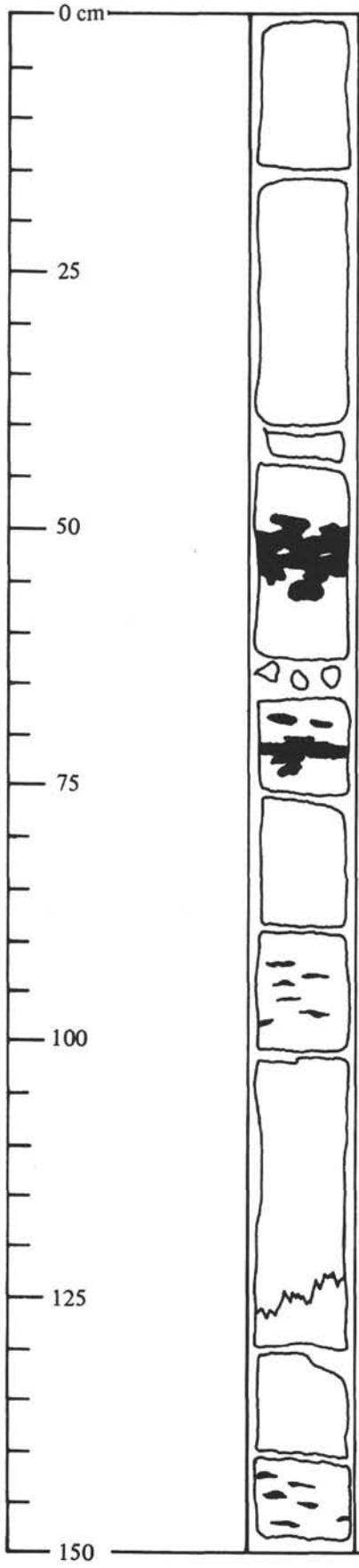
SITE 71A Core 2A Cored interval: 553-555 m



Site 71A, Core 2, Physical Properties



SITE 71A Core 2A Detailed description Section 1 (553-554.5 m)



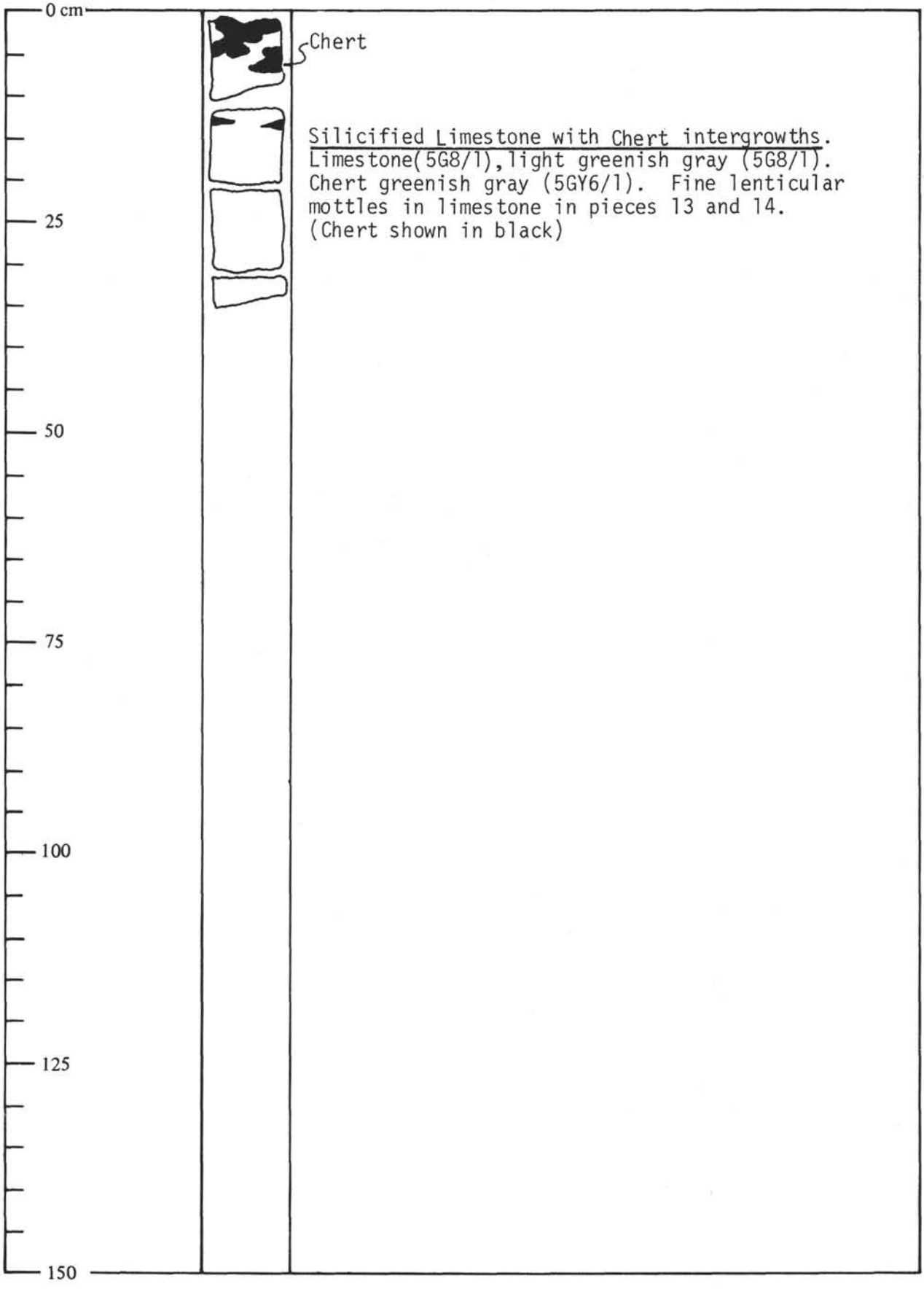
Chert

Silicified Limestone with Chert intergrownths. Limestone is light greenish gray (5G8/1). Chert is light olive gray (5Y6/1). (Chert shown in black).

Chert Whisps

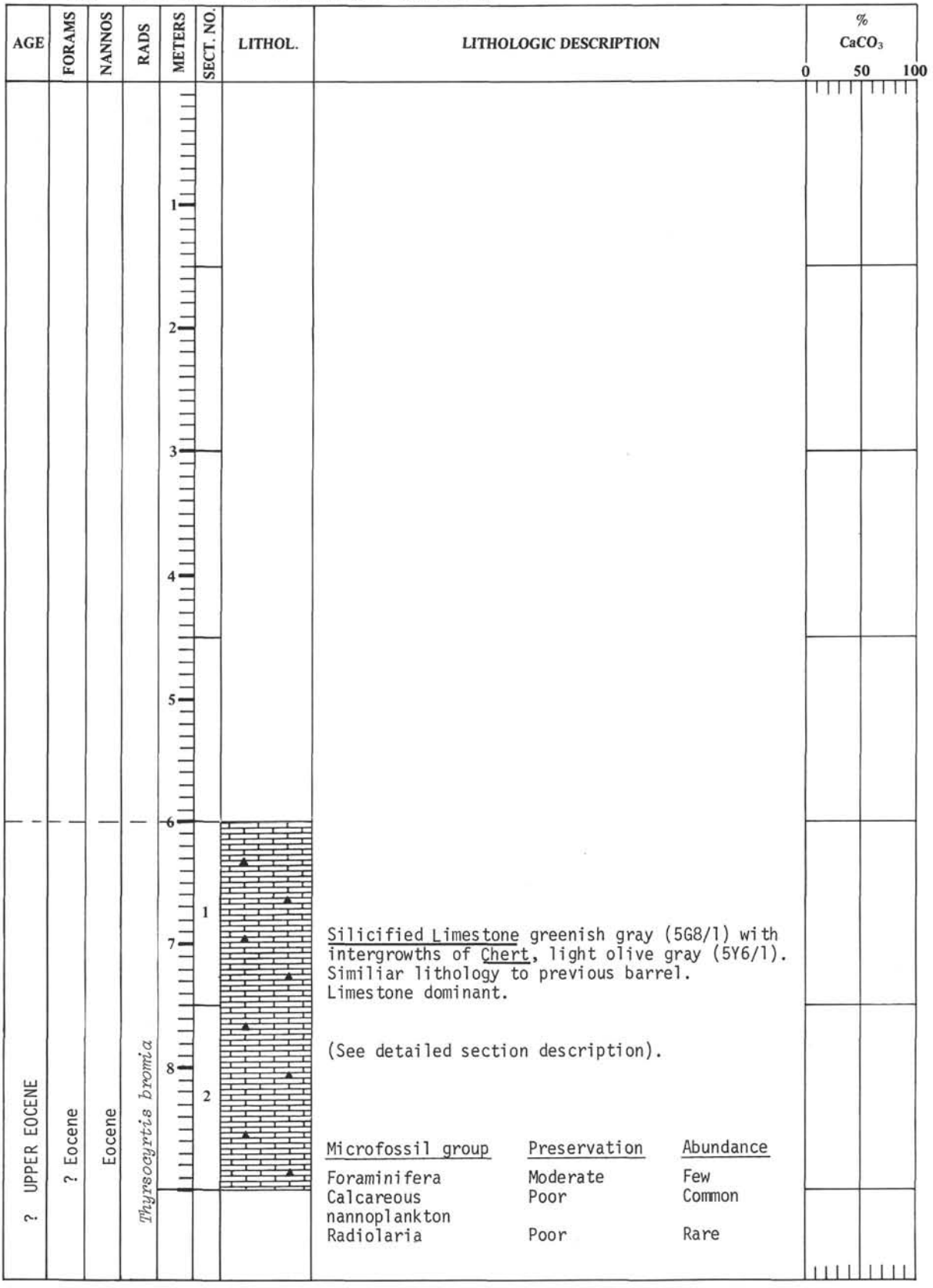
Stylolite-like "fracture". Apparent offset.

SITE 71A Core 2A Detailed description Section 2 (554.5-555 m)

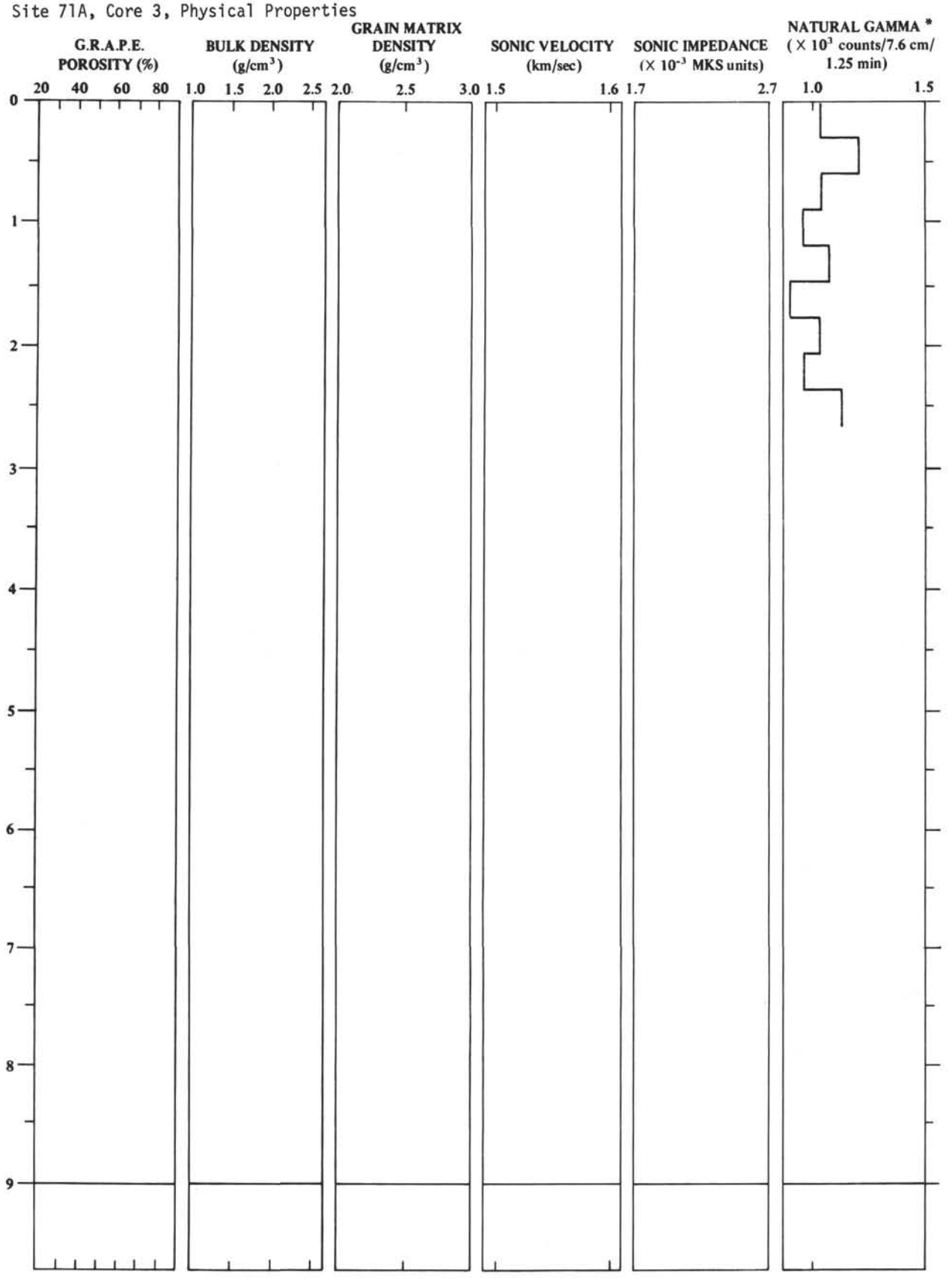


Silicified Limestone with Chert intergrowths.
Limestone(5G8/1),light greenish gray (5G8/1).
Chert greenish gray (5GY6/1). Fine lenticular
mottles in limestone in pieces 13 and 14.
(Chert shown in black)

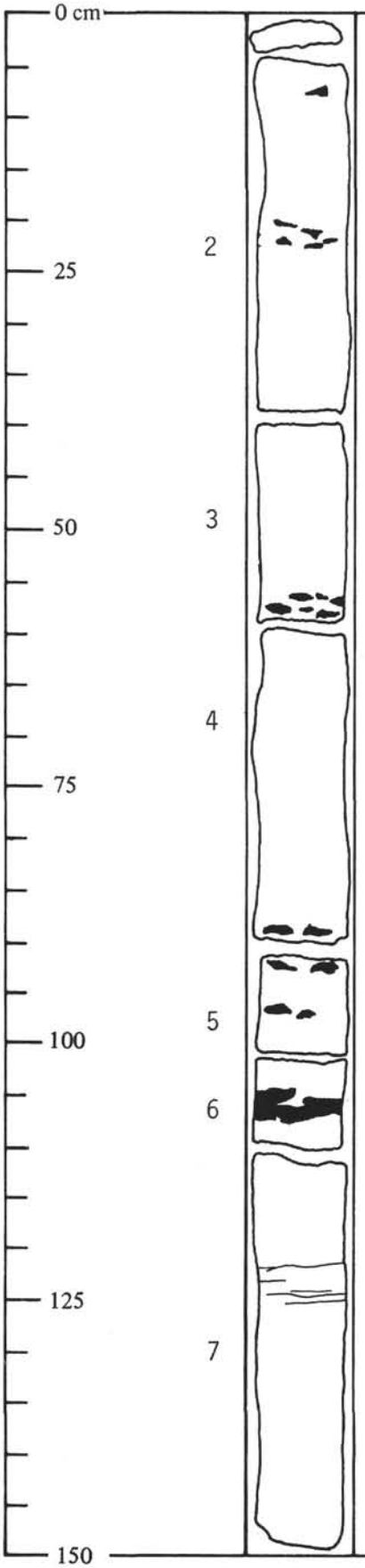
SITE 71A Core 3A Cored interval: 555-558 m



Site 71A, Core 3, Physical Properties



SITE 71A Core 3A Detailed description Section 1 (555-556.5 m)



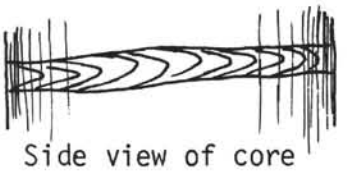
Chert Whisps

Silicified Limestone with Chert intergrowths.
Limestone light greenish gray (5G8/1) with thin lenticular mottles of greenish gray (5GY6/1) mottling possibly due to burrows.

(Chert shown in black).

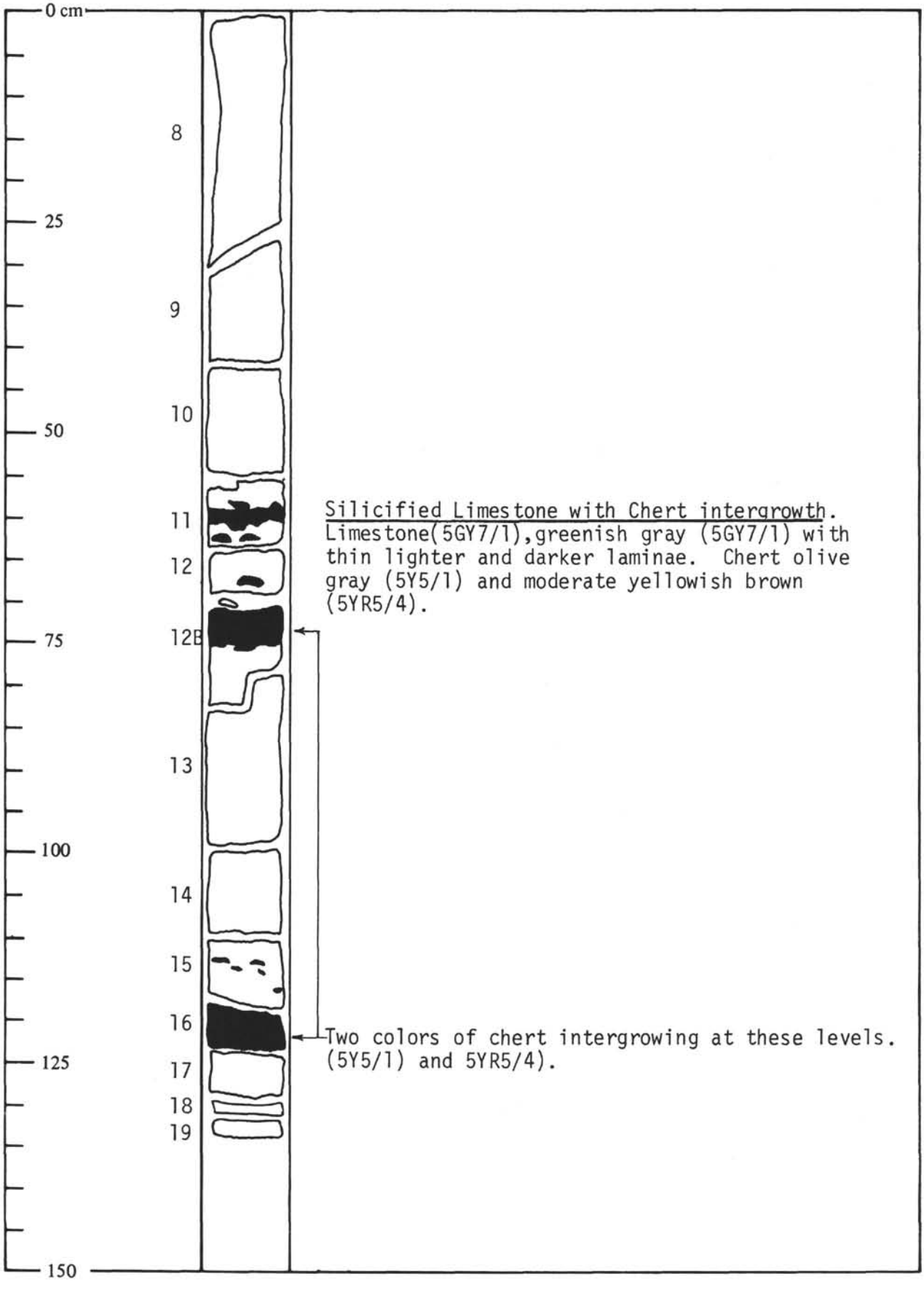
Chert intergrowth.

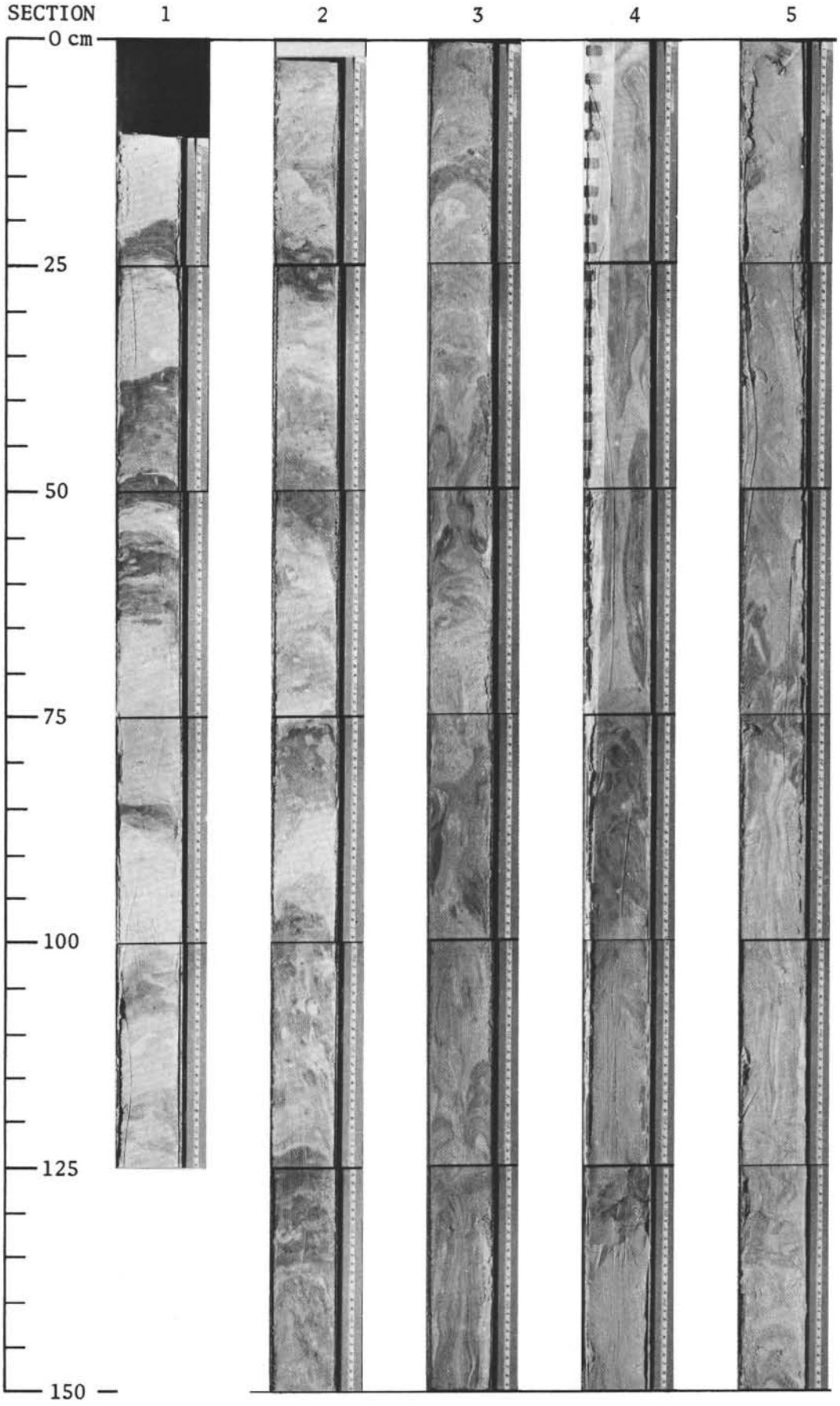
Thin (3mm) white bands at slight angle to bedding. Bands contain micro-fold-like markings, possibly due to benthonic organisms.



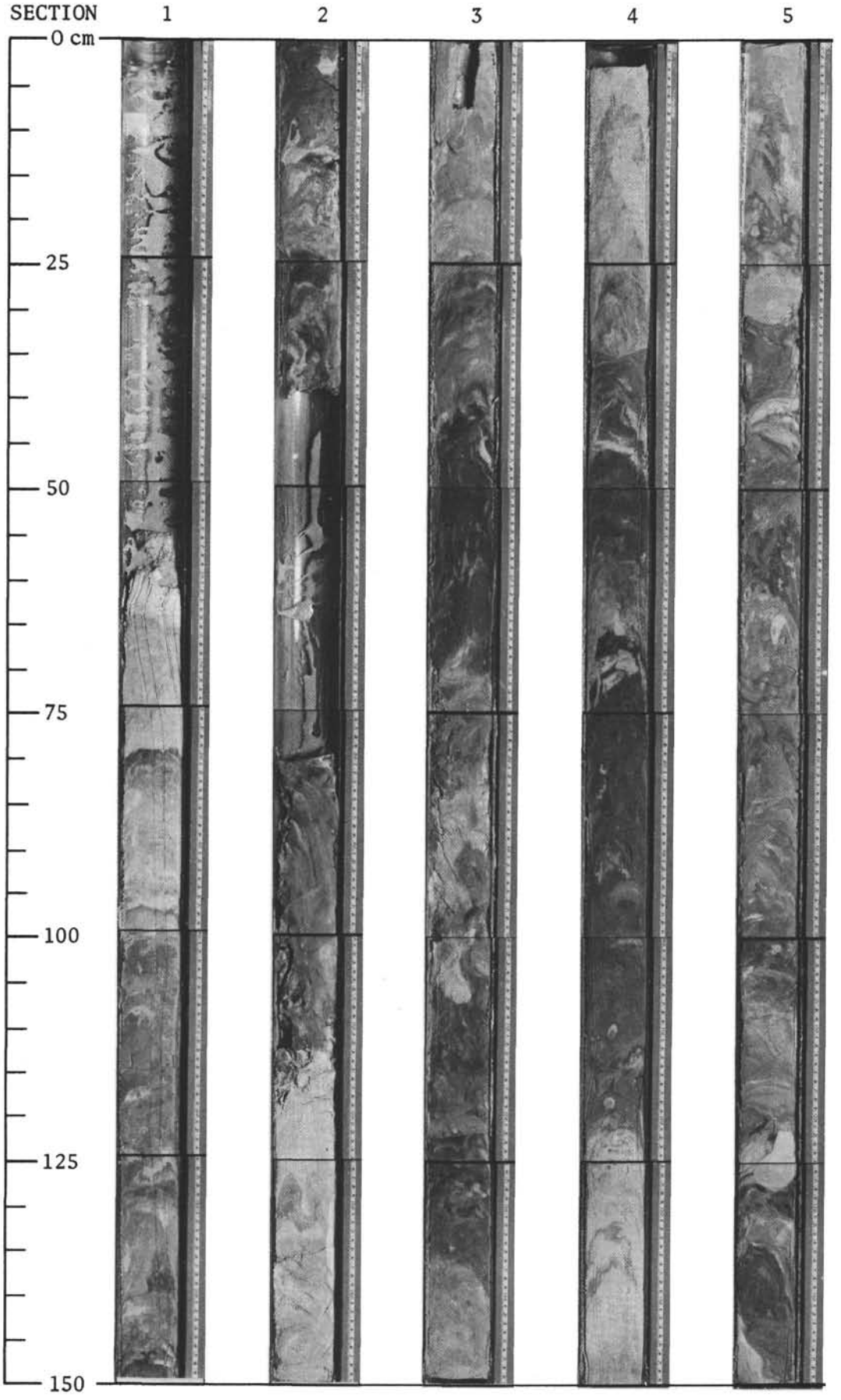
Side view of core

SITE 71A Core 3A Detailed description Section 2 (556.5-558 m)

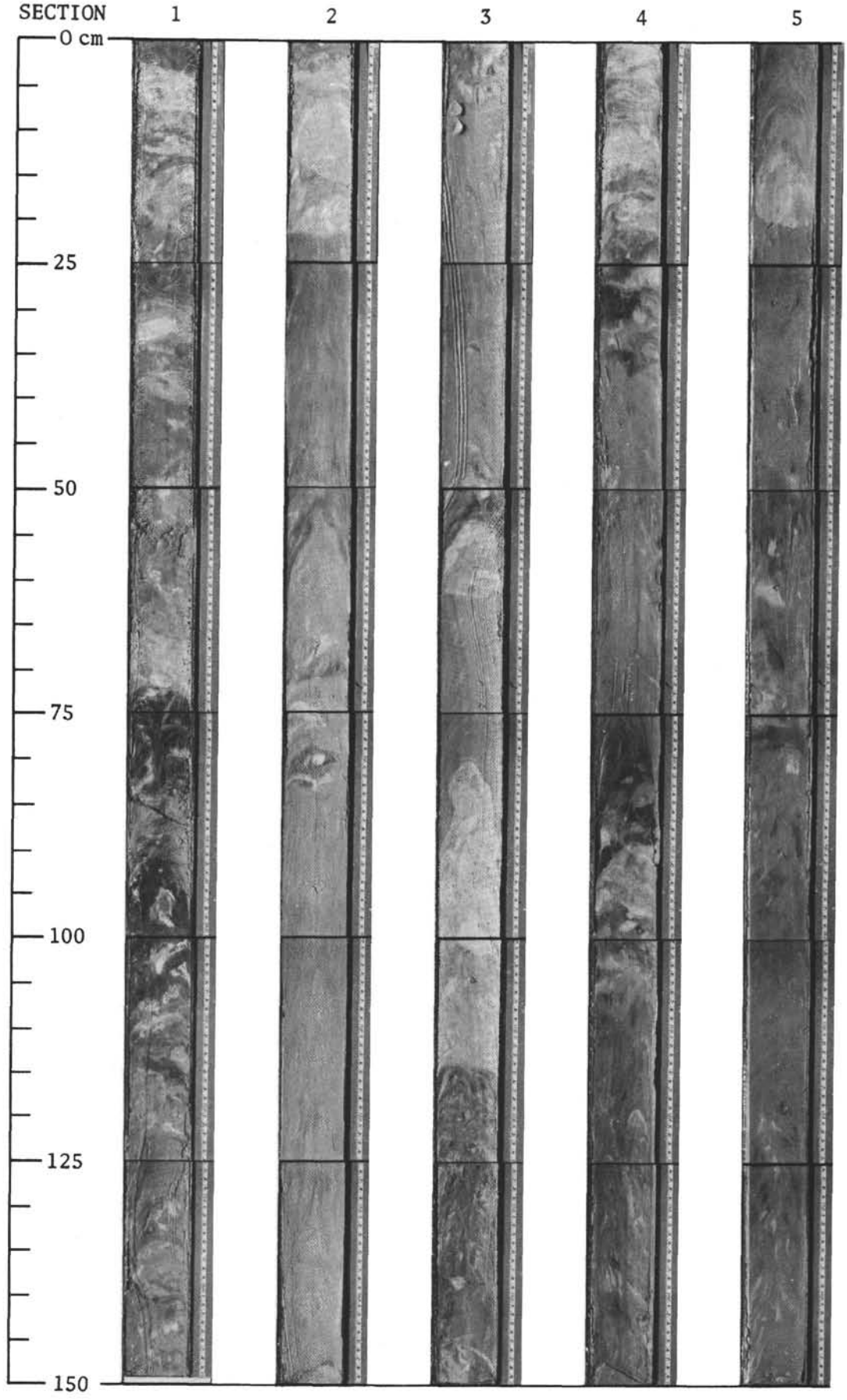




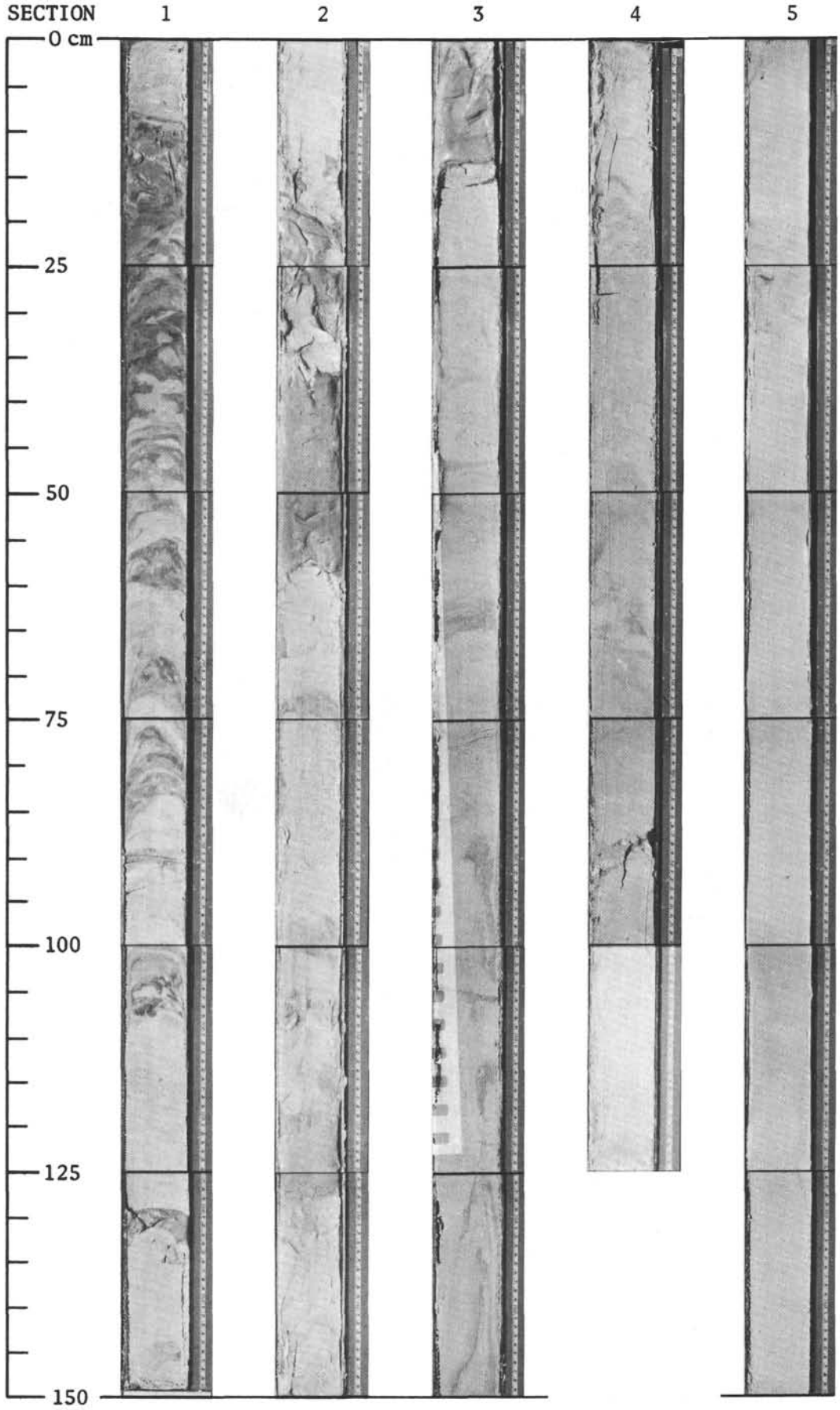
Site 71, Core 1, Sections 1-5.



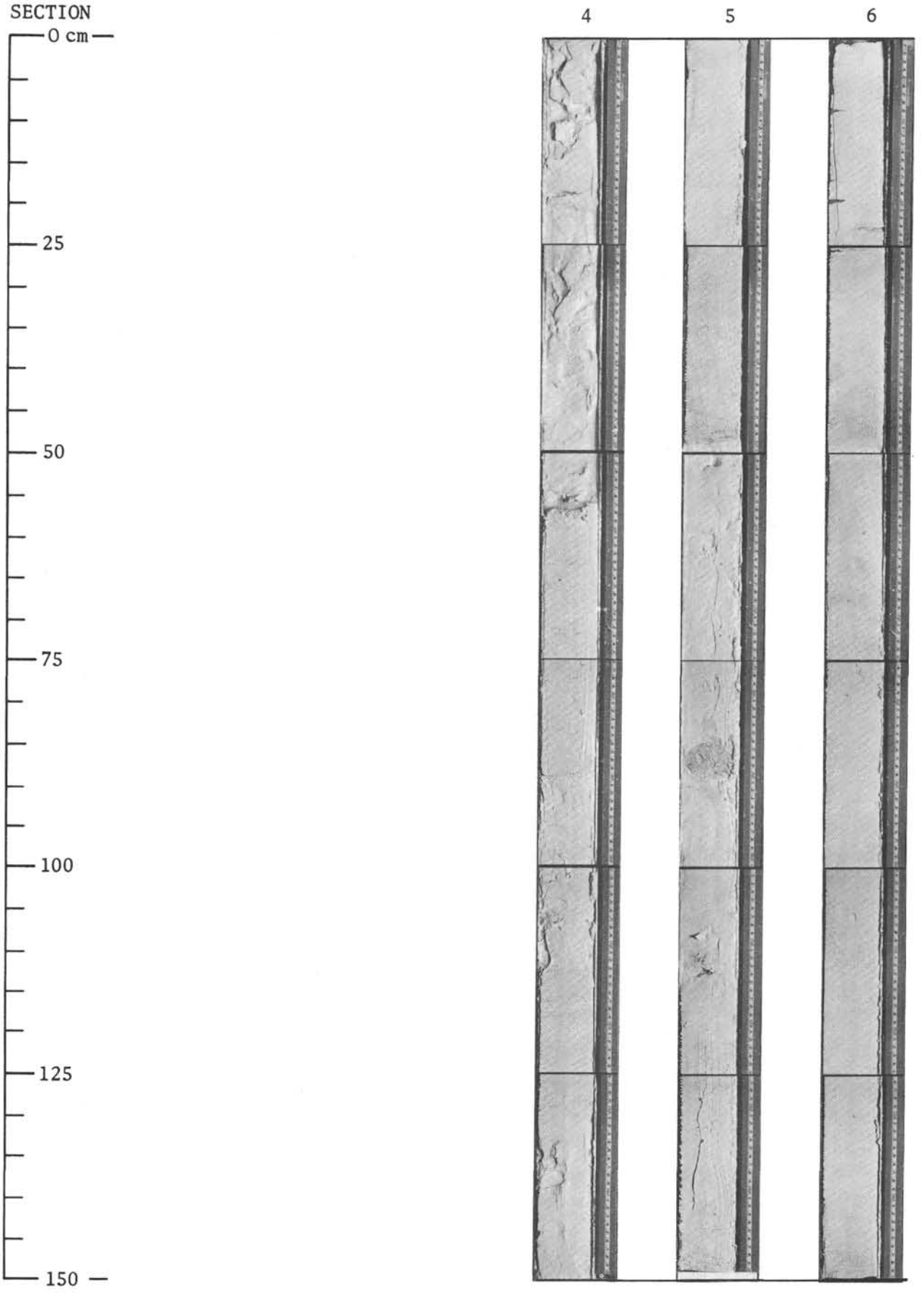
Site 71, Core 2, Sections 1-5.



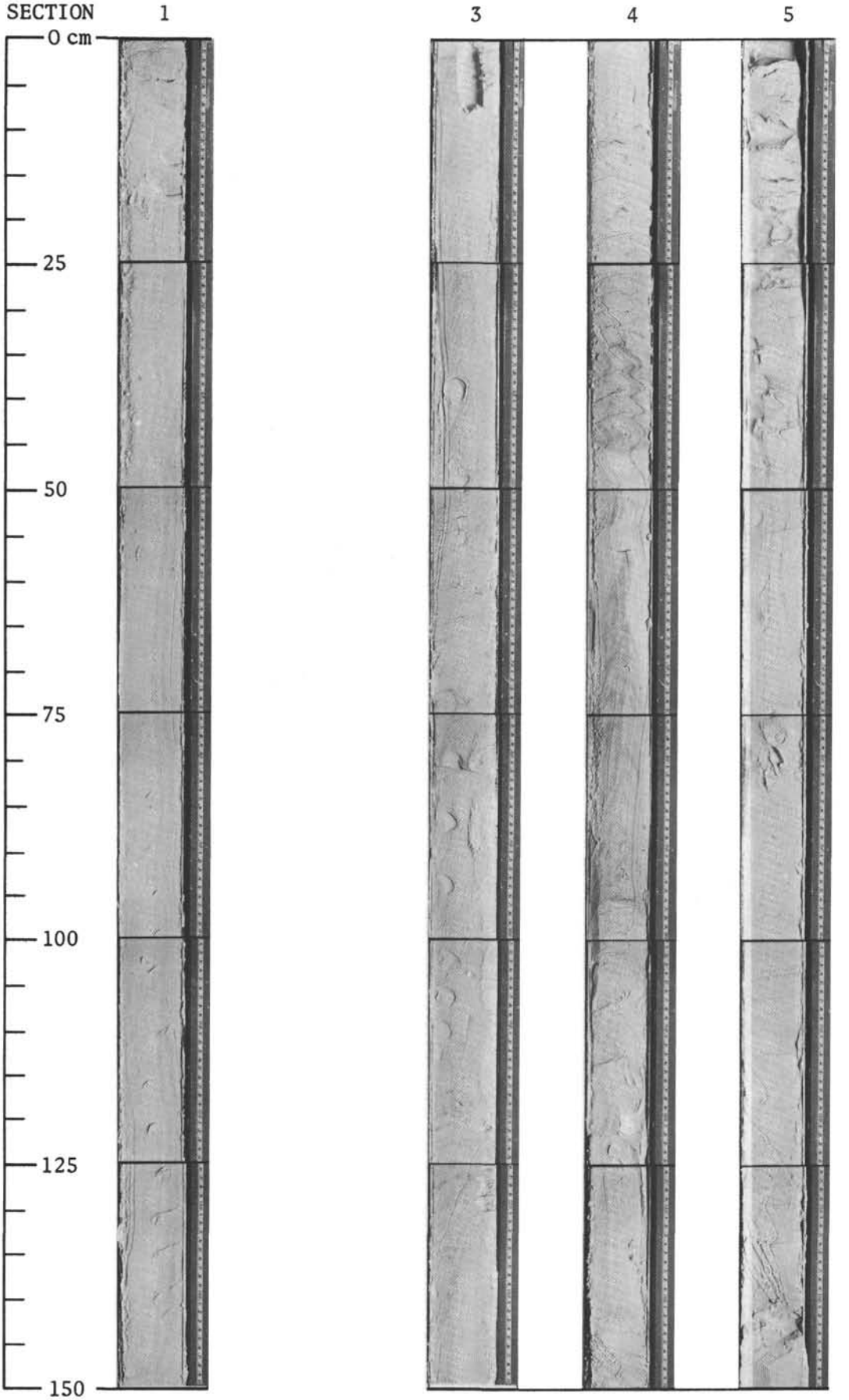
Site 71, Core 3, Sections 1-5.



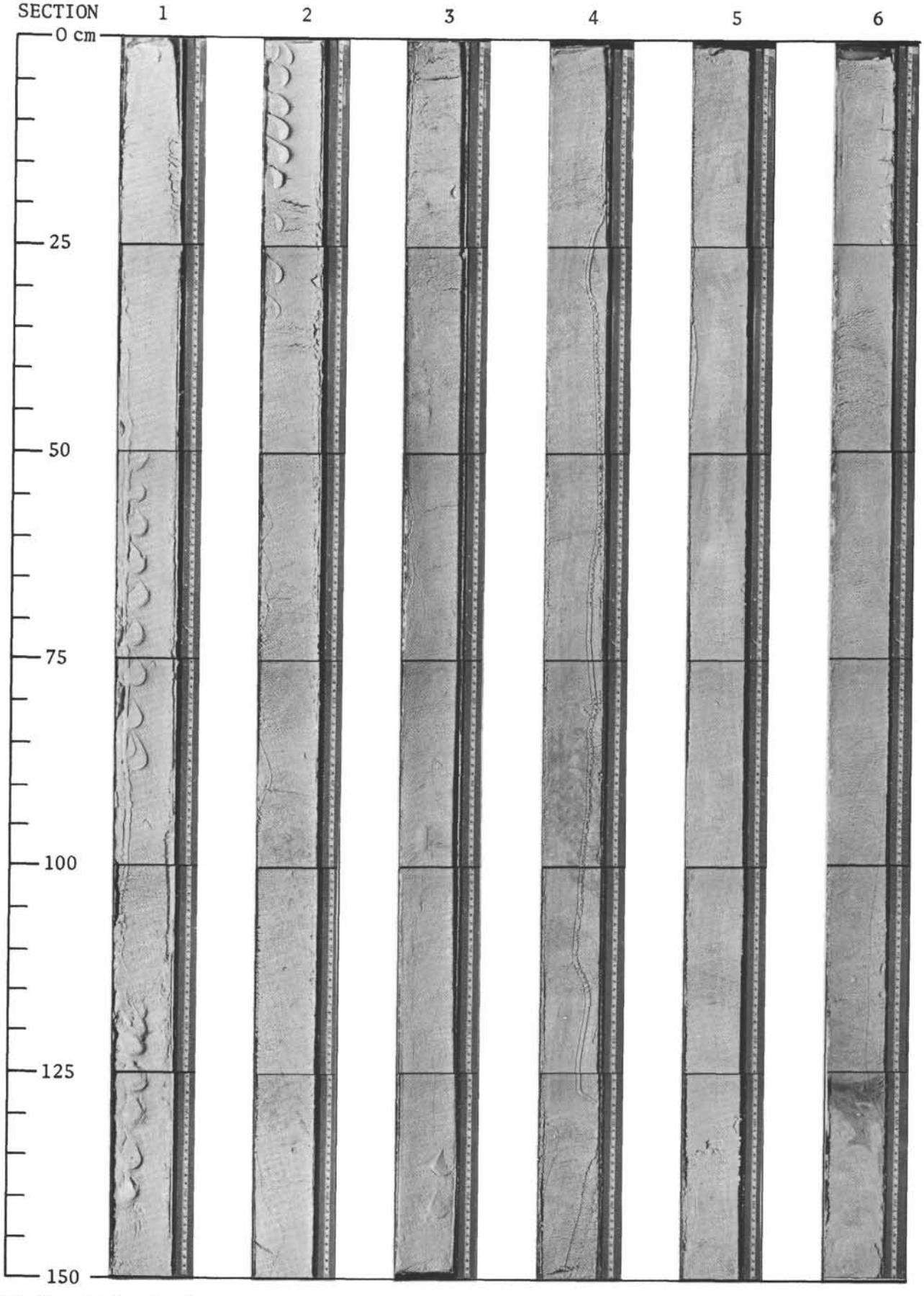
Site 71, Core 4, Sections 1-5.



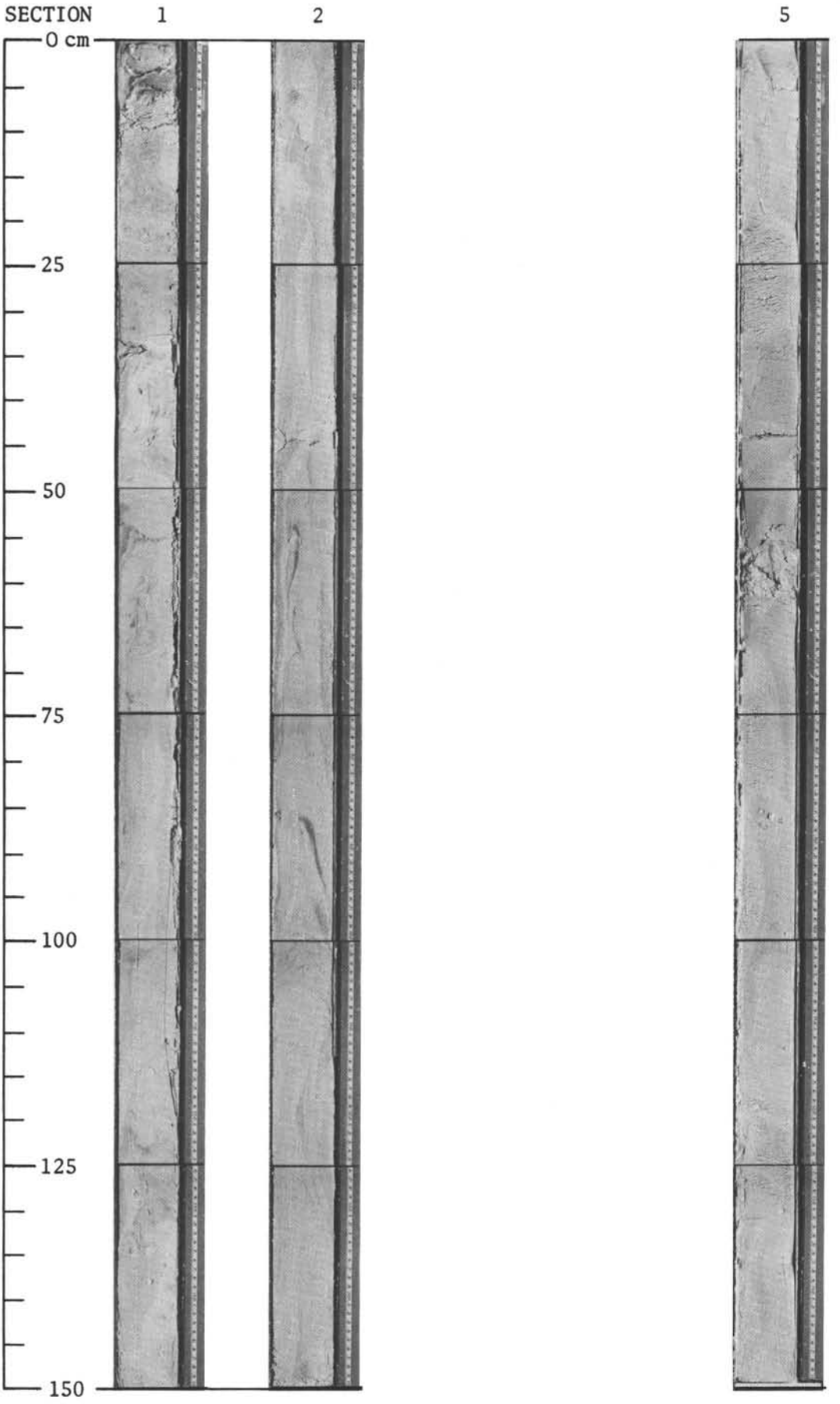
Site 71, Core 5, Sections 4, 5, 6.



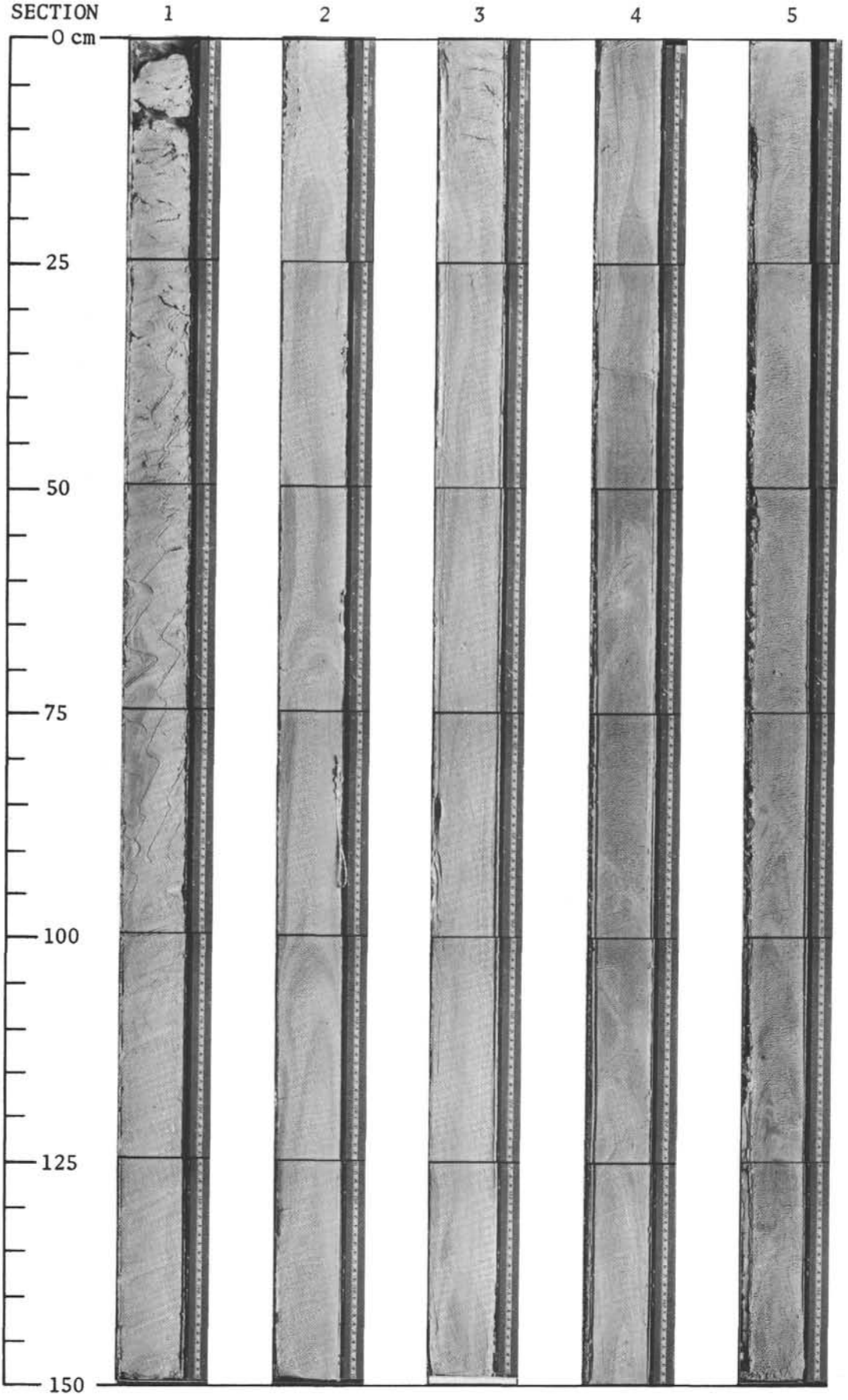
Site 71, Core 6, Sections 1, 3, 4, 5.



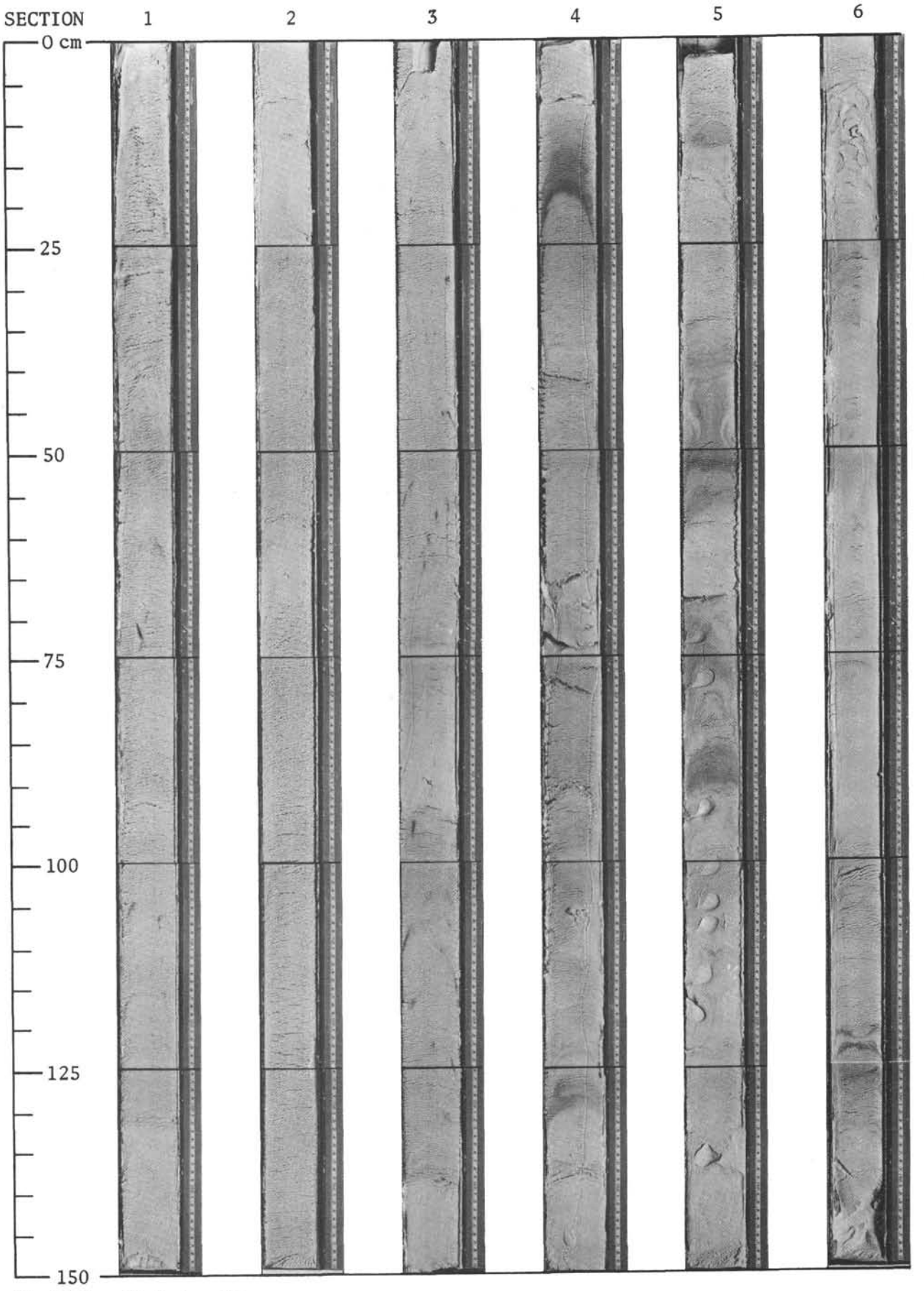
Site 72, Site 71, Core 7, Sections 1-6.



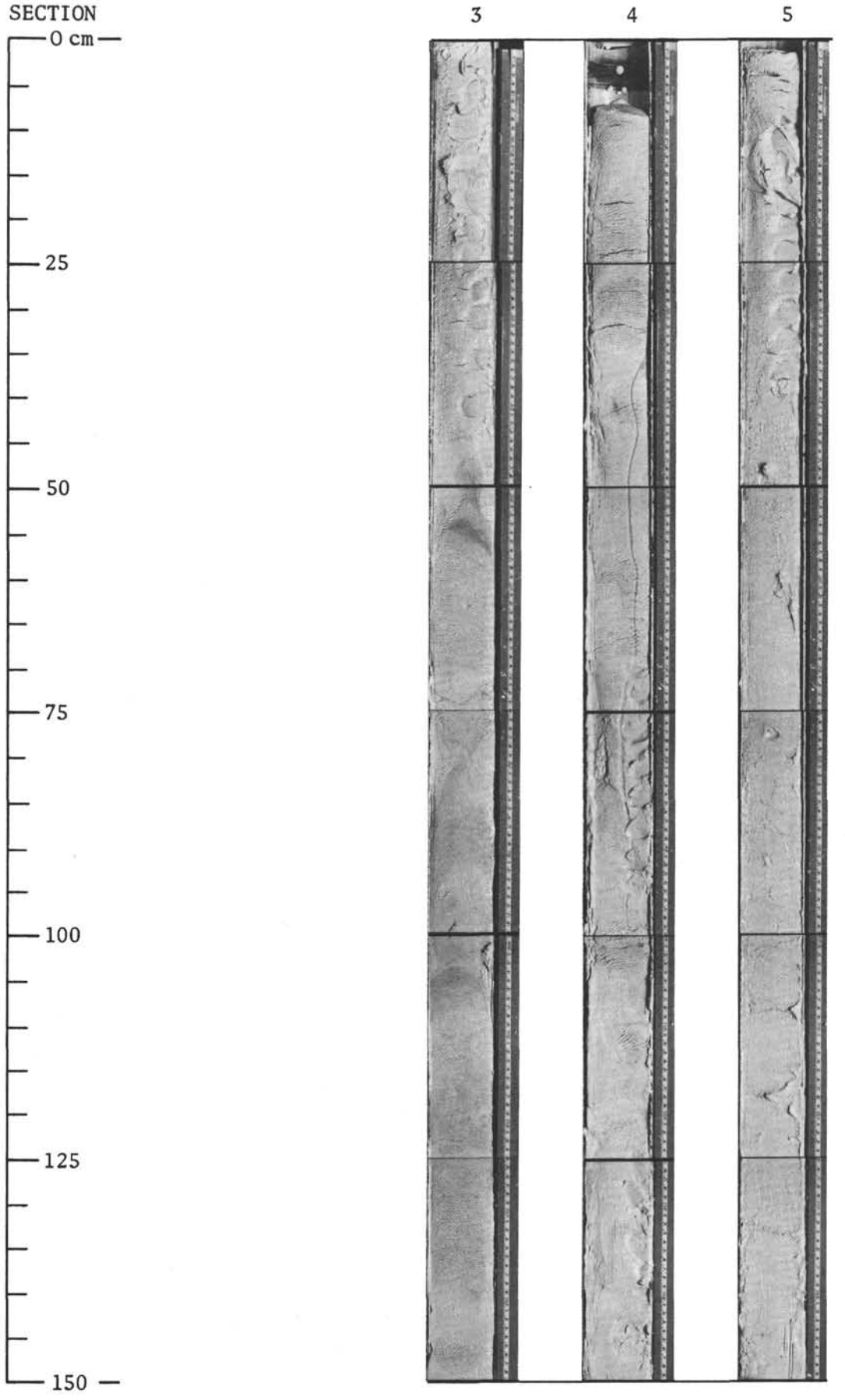
Site 71, Core 8, Sections 1, 2, 5.



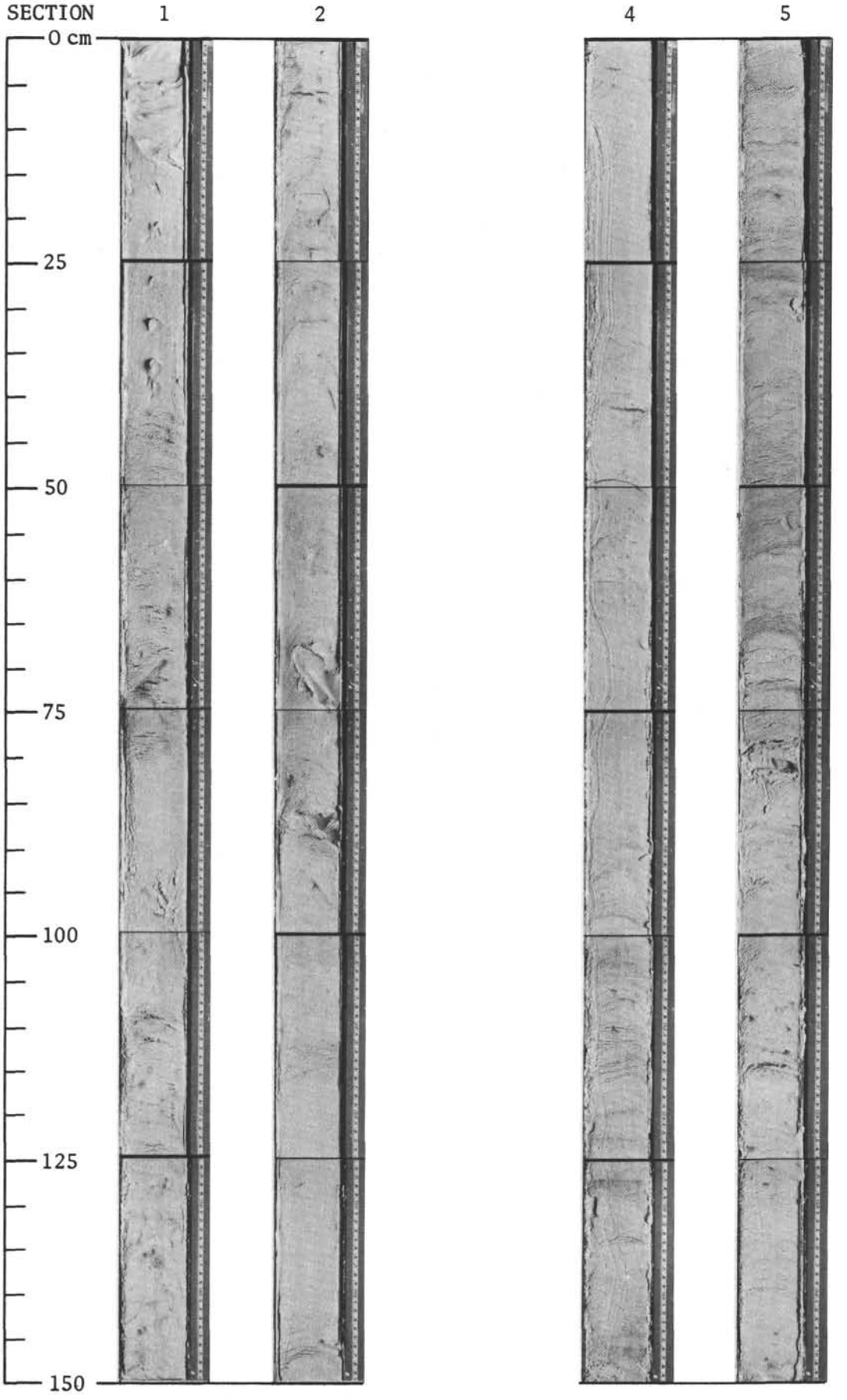
Site 71, Core 9, Sections 1-5.



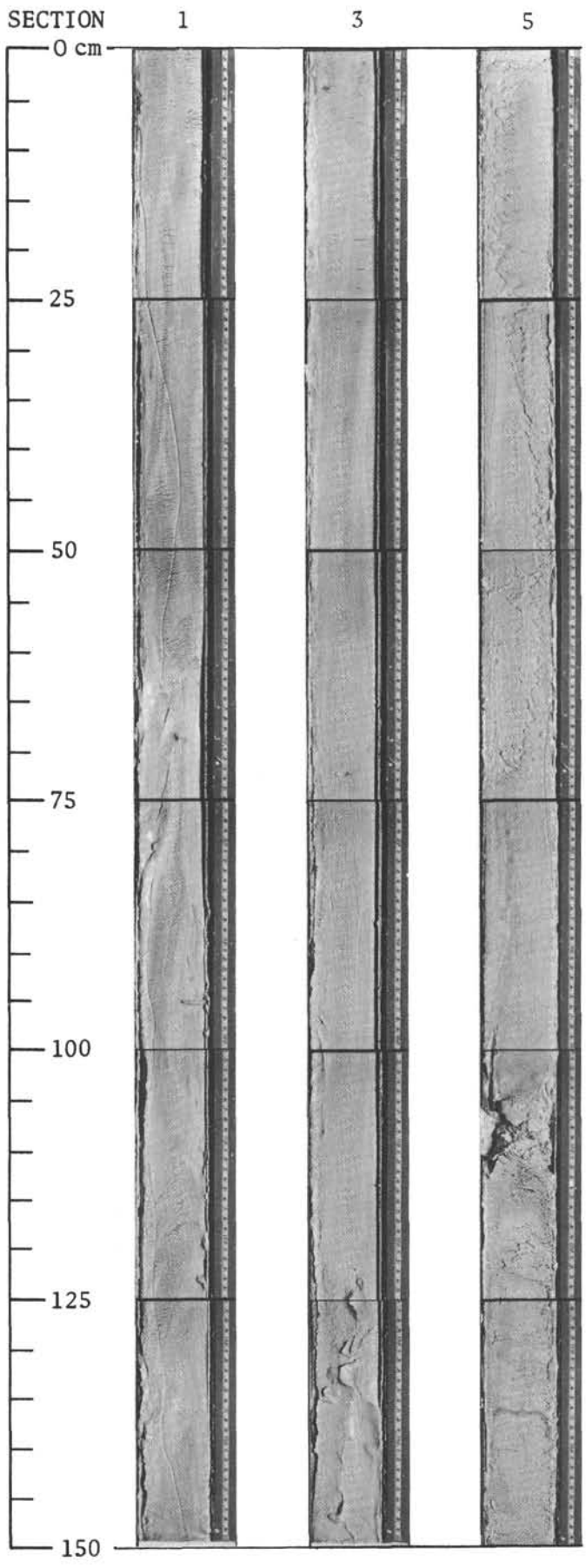
Site 71, Core 10, Sections 1-6.



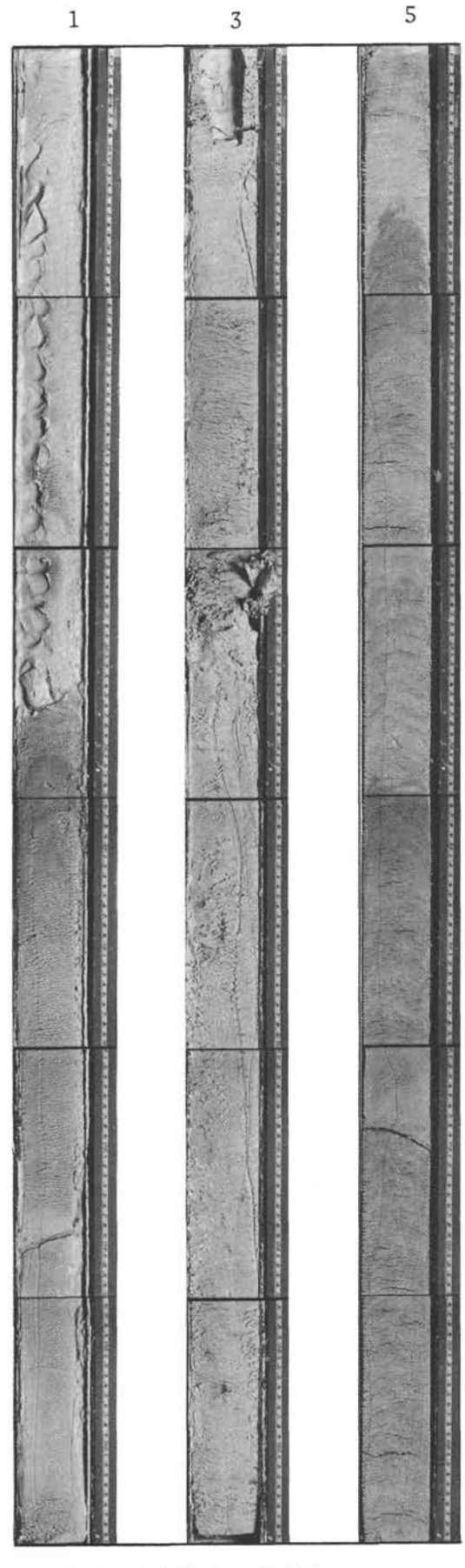
Site 71, Core 11, Sections 3, 4, 5.



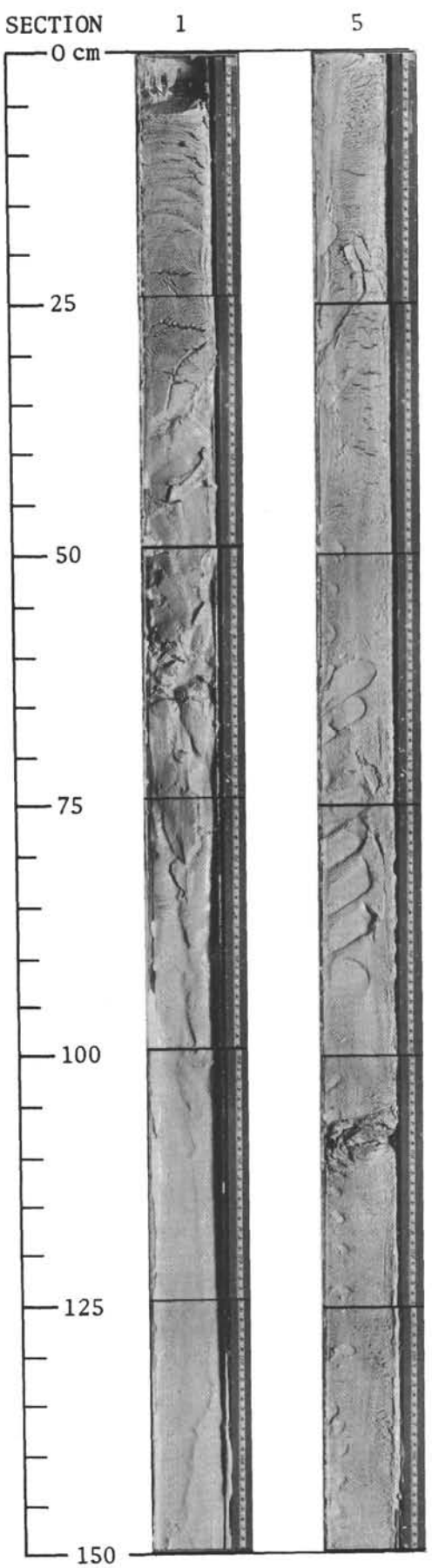
Site 71, Core 12, Sections 1, 2, 4, 5.



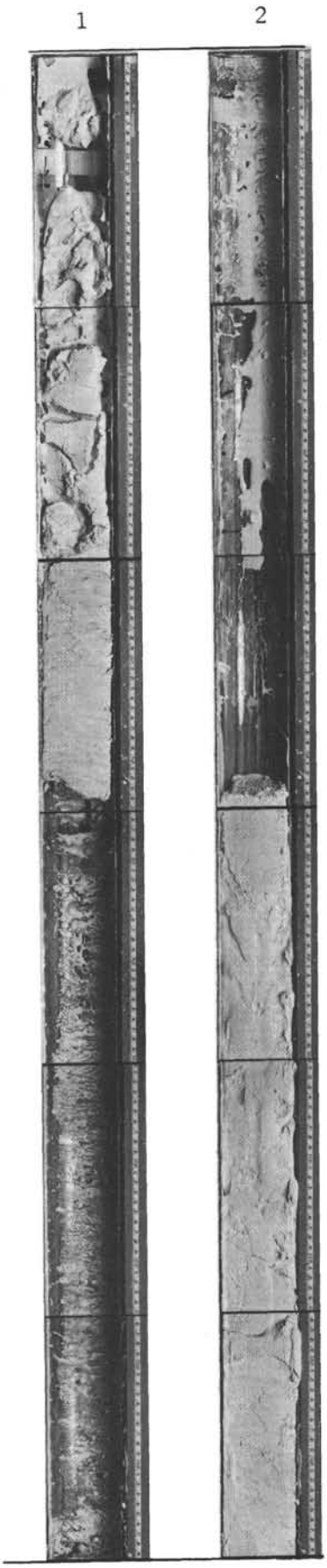
Site 71, Core 13, Sections 1, 3, 5.



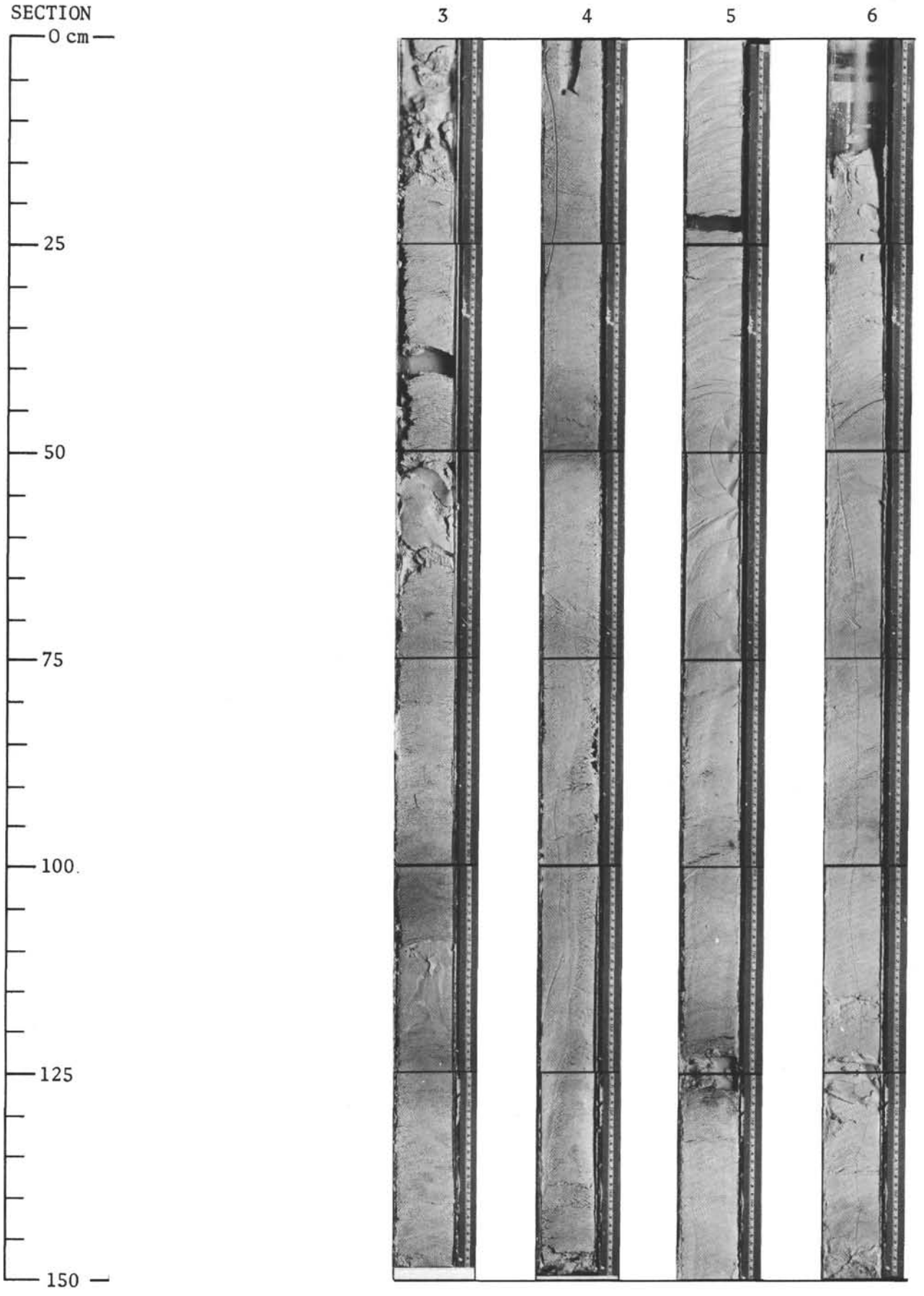
Site 71, Core 14, Sections 1, 3, 5.



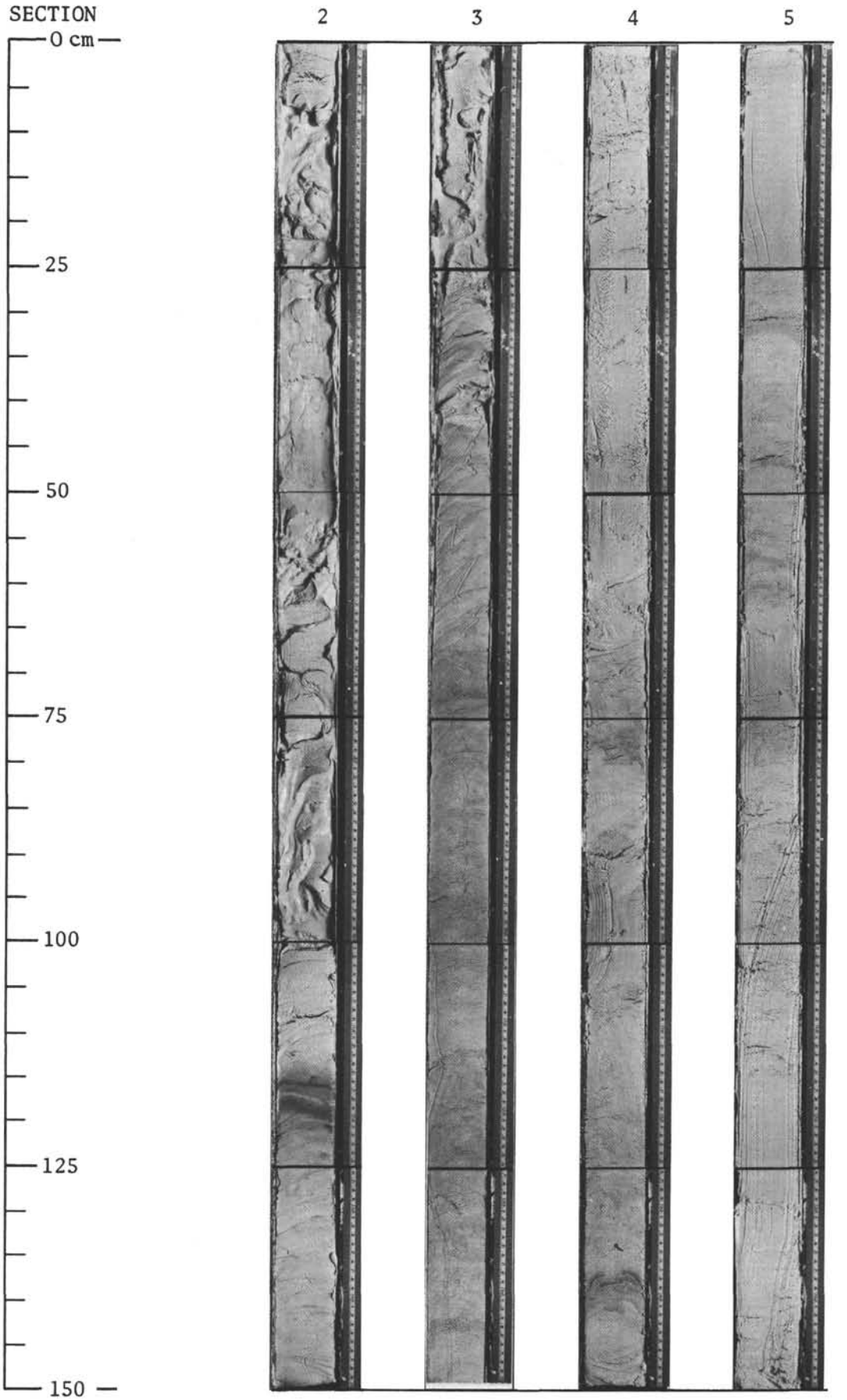
Site 71, Core 15, Sections 1, 5.



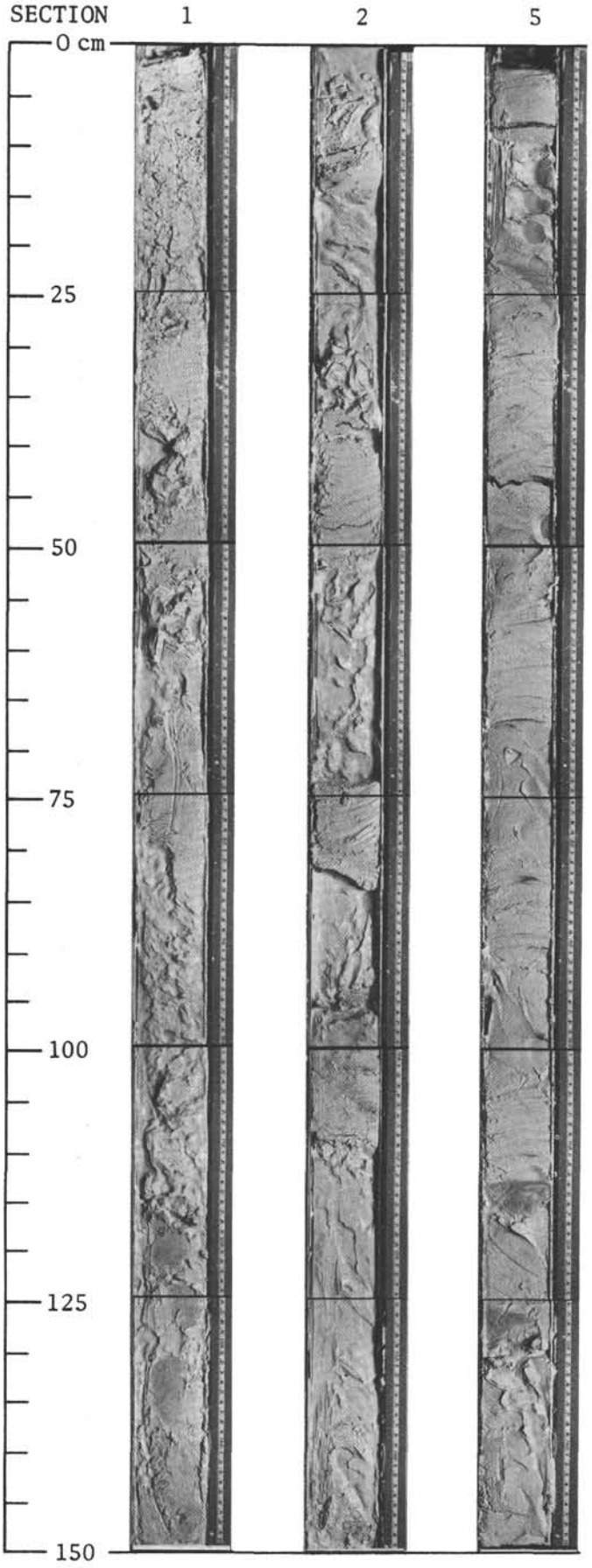
Site 71, Core 16, Sections 1, 2.



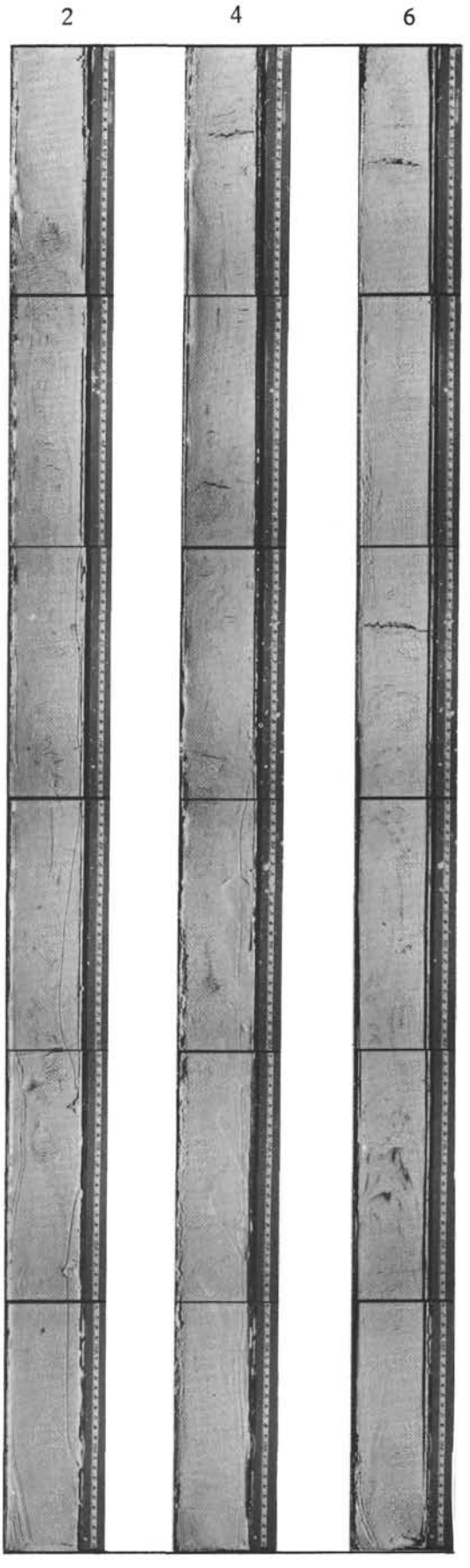
Site 71, Core 17, Sections 3-6.



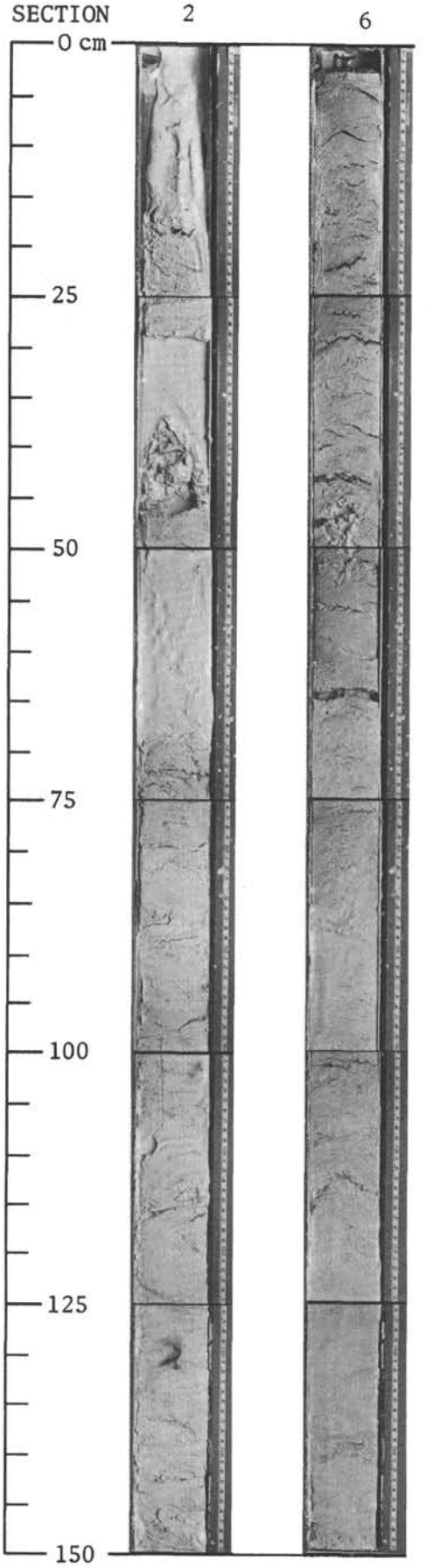
Site 71, Core 18, Sections 2-5.



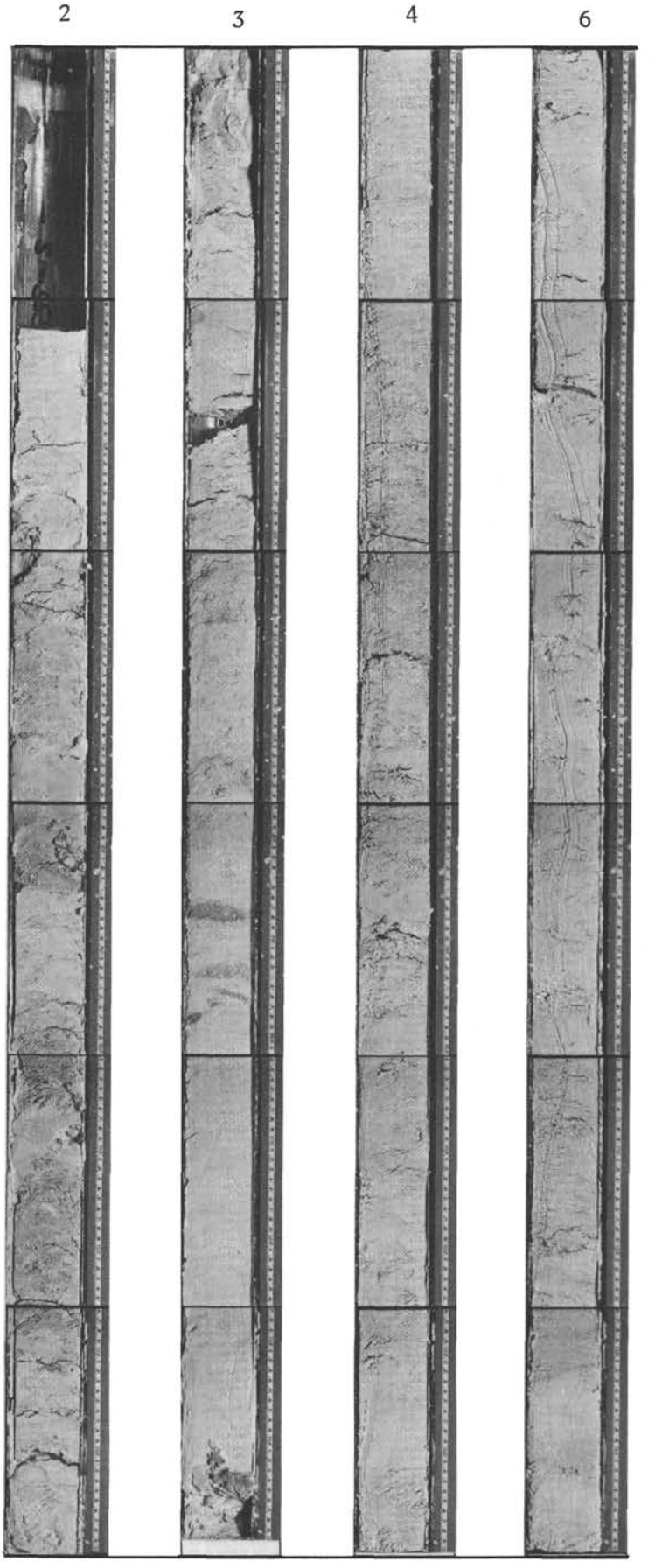
Site 71, Core 19, Sections 1, 2, 5.



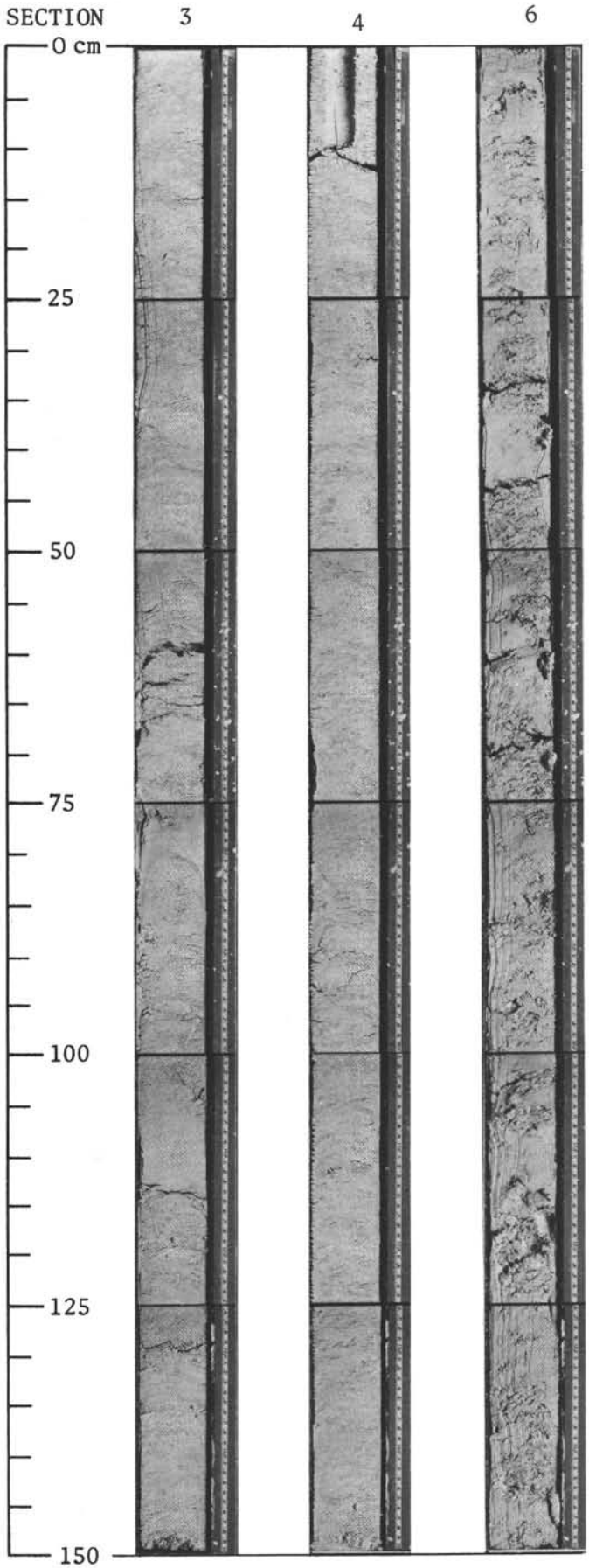
Site 71, Core 20, Sections 2, 4, 6.



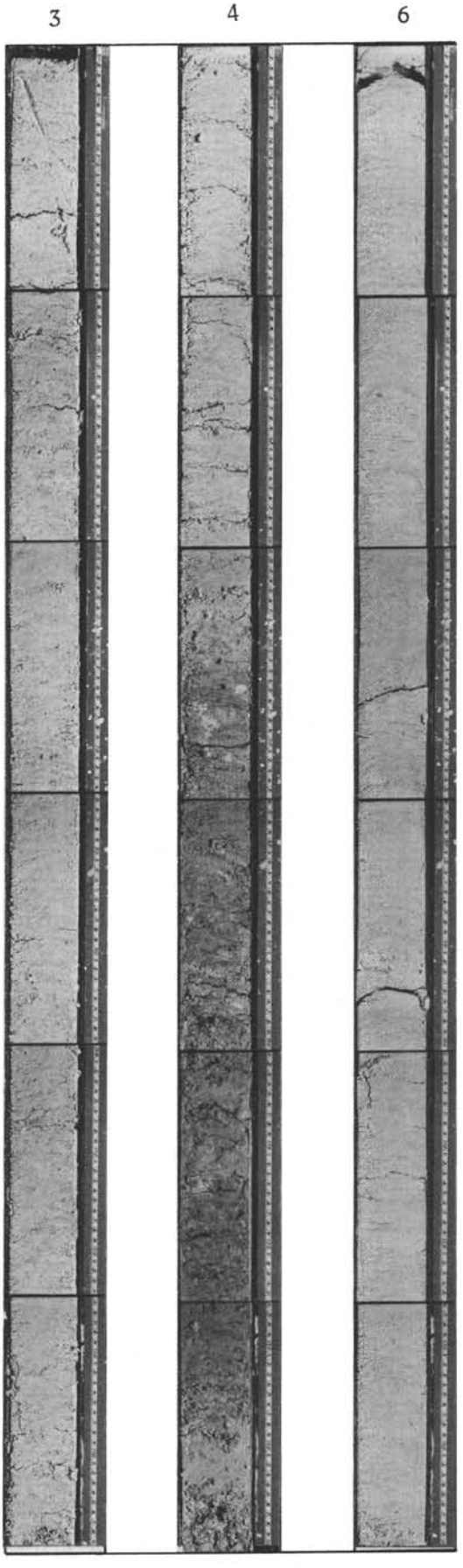
Site 71, Core 21, Sections 2, 6.



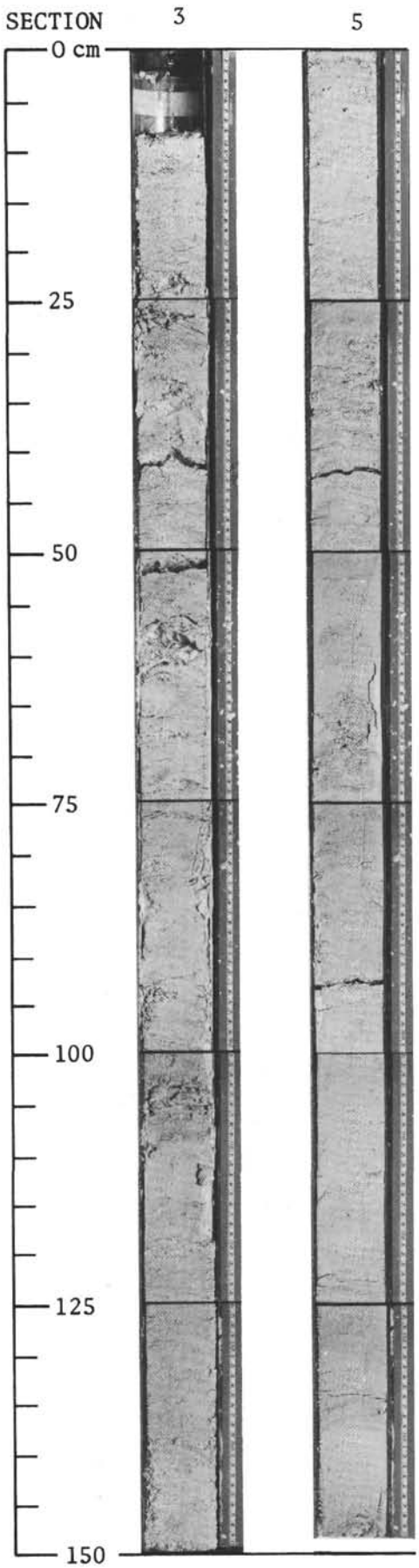
Site 71, Core 22, Sections 2, 3, 4, 6.



Site 71, Core 23, Sections 3, 4, 6.

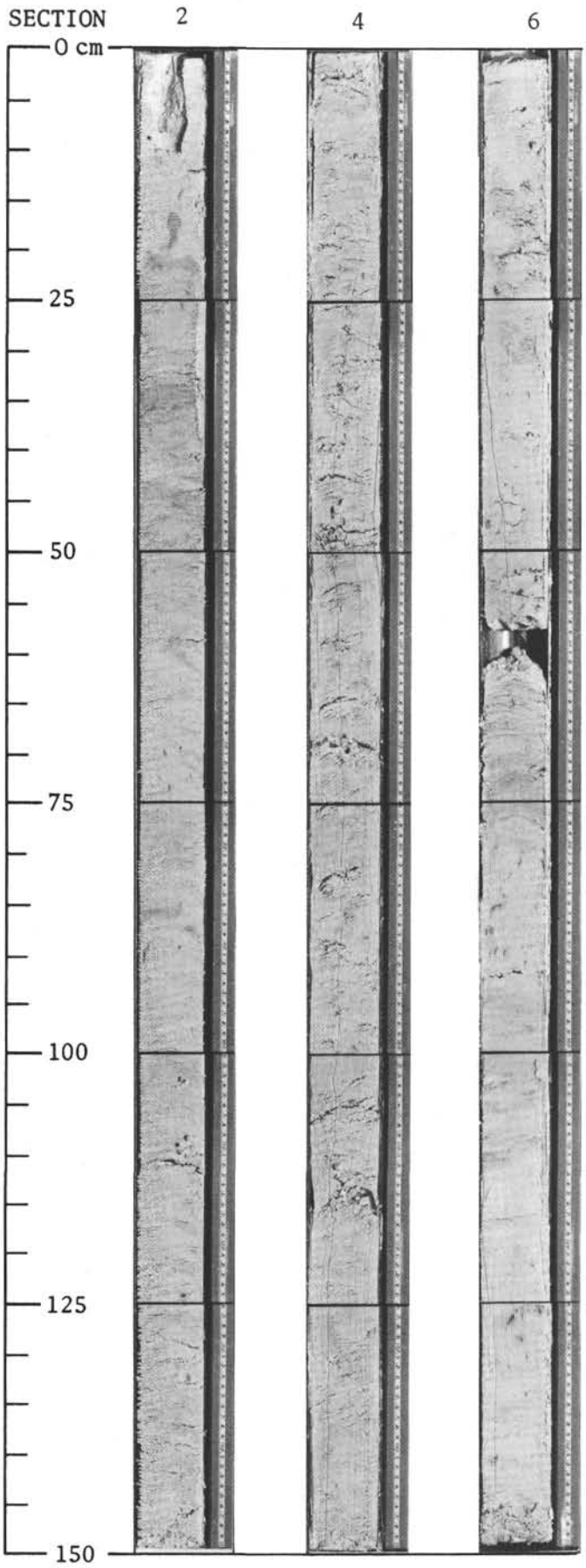


Site 71, Core 24, Sections 3, 4, 6.

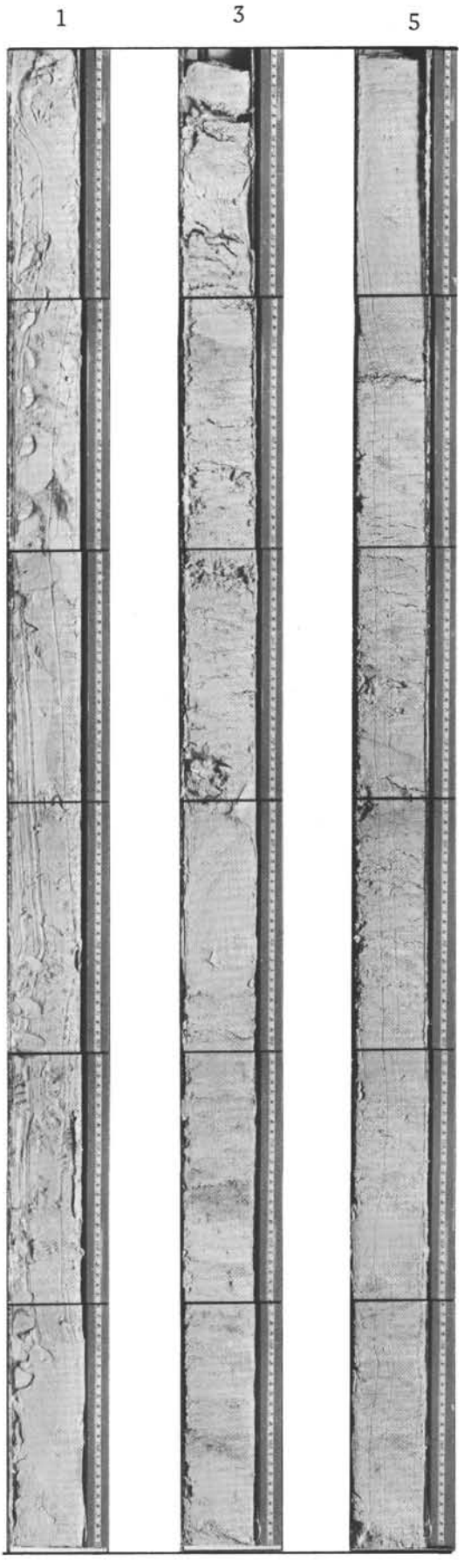


Site 71, Core 25, Sections 3, 5.

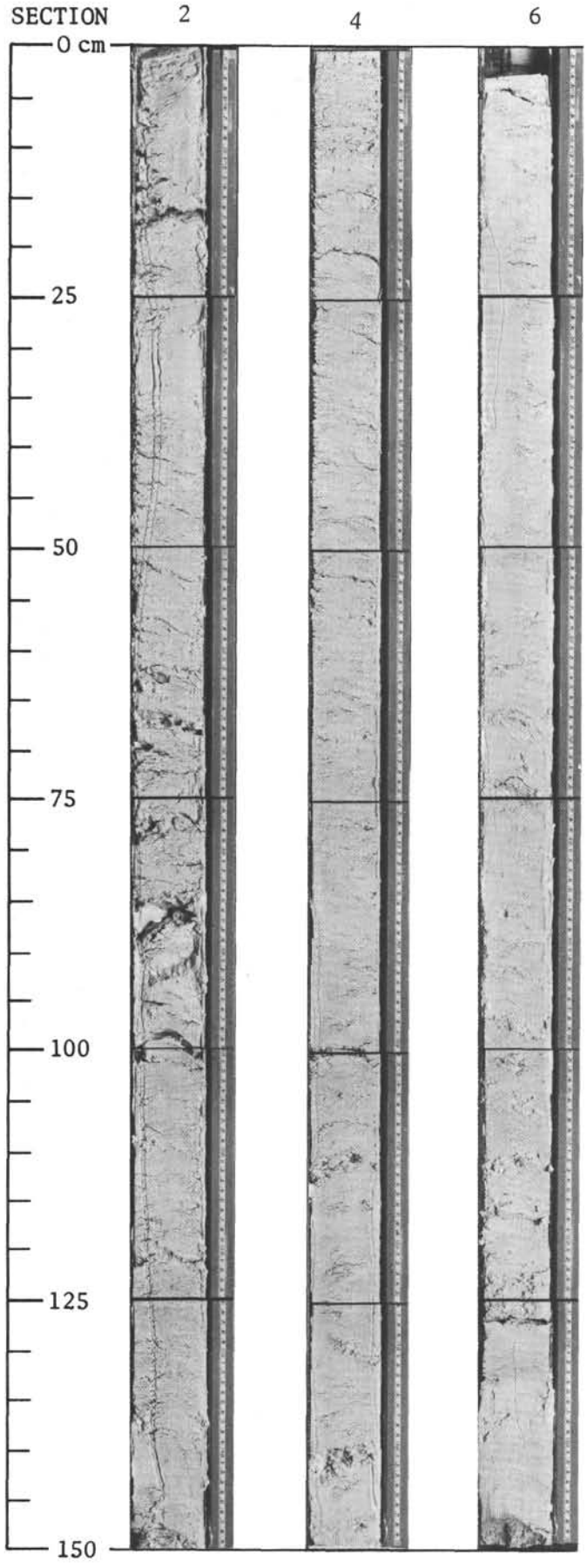
Site 71, Core 26, Sections 2, 4, 6.



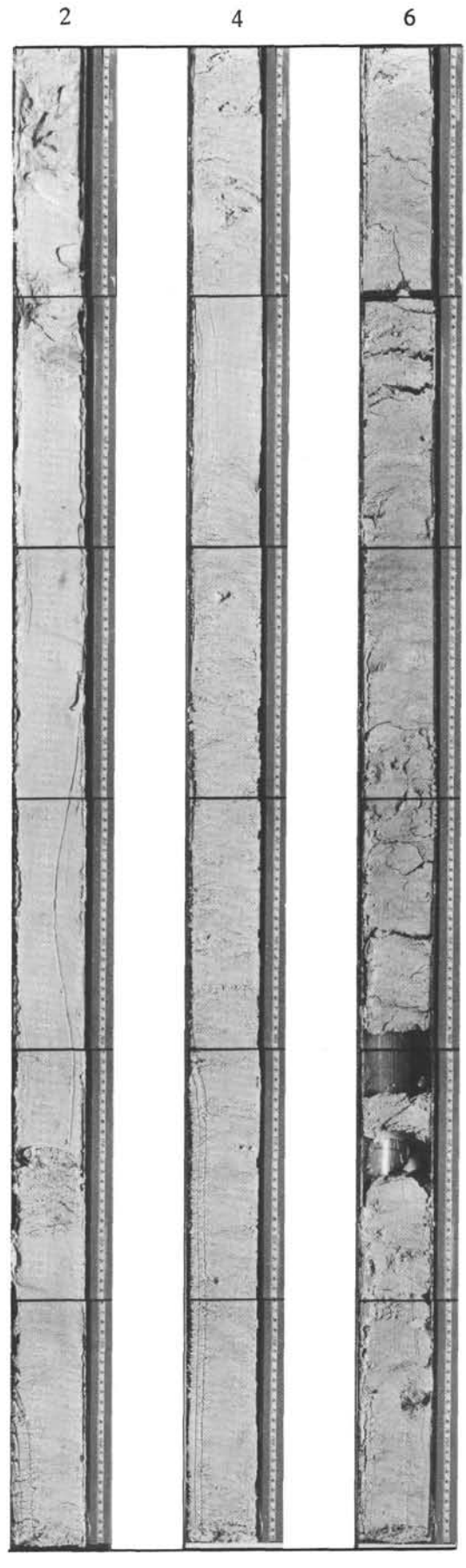
Site 71, Core 28, Sections 2, 4, 6.



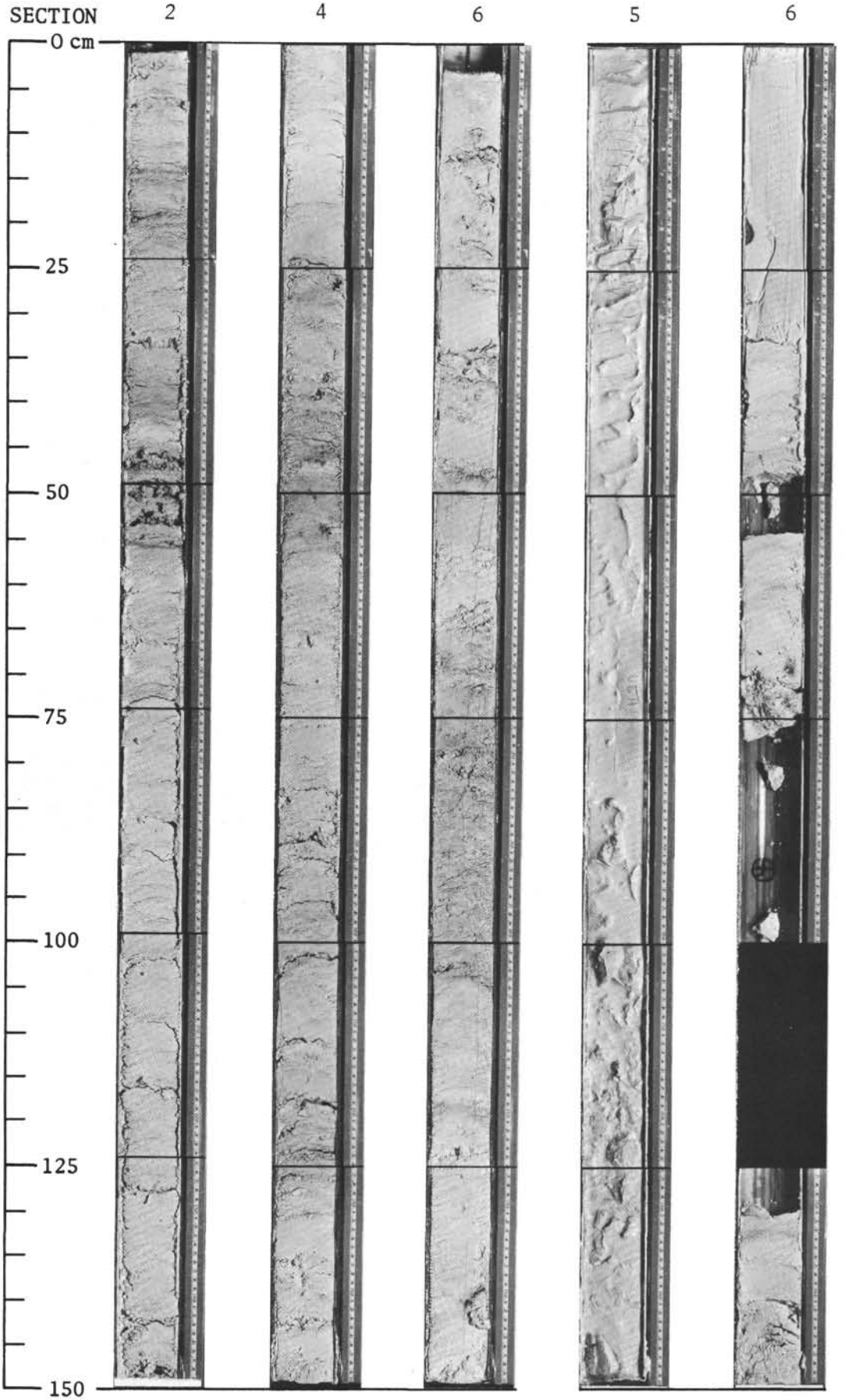
Site 71, Core 29, Sections 1, 3, 5.



Site 71, Core 30, Sections 2, 4, 6.

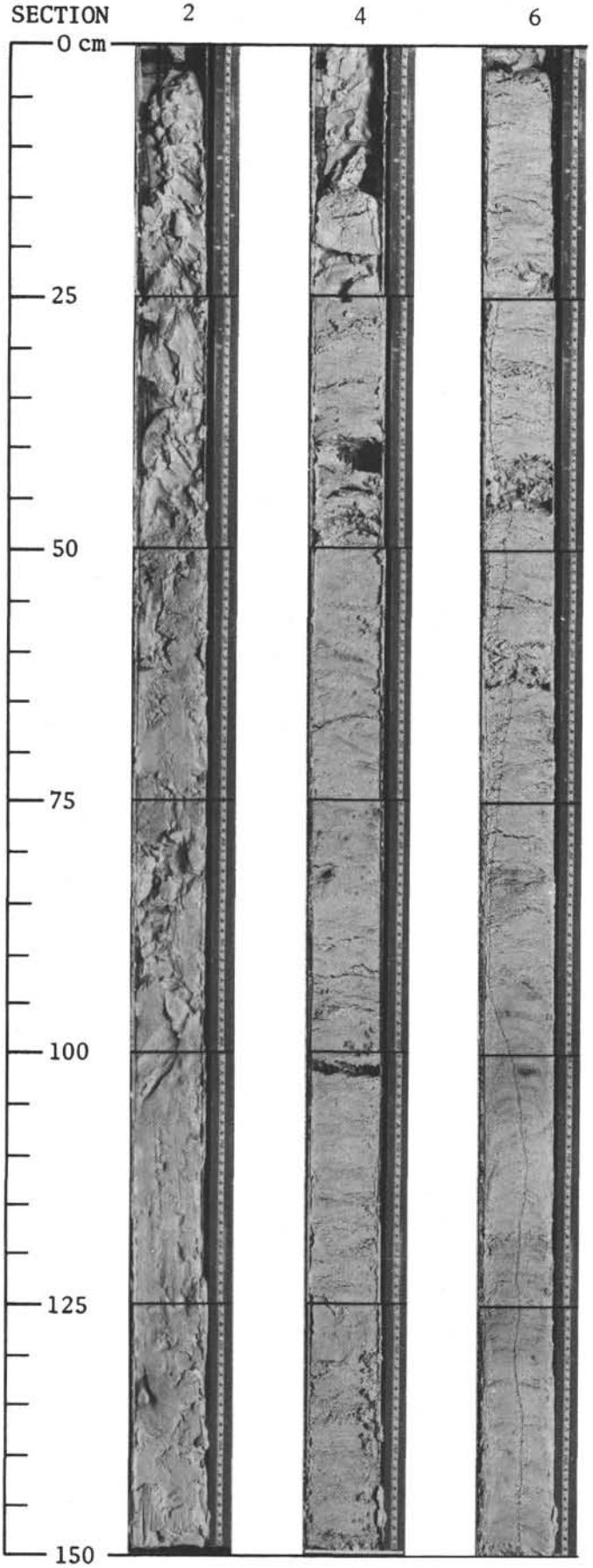


Site 71, Core 31, Sections 2, 4, 6.

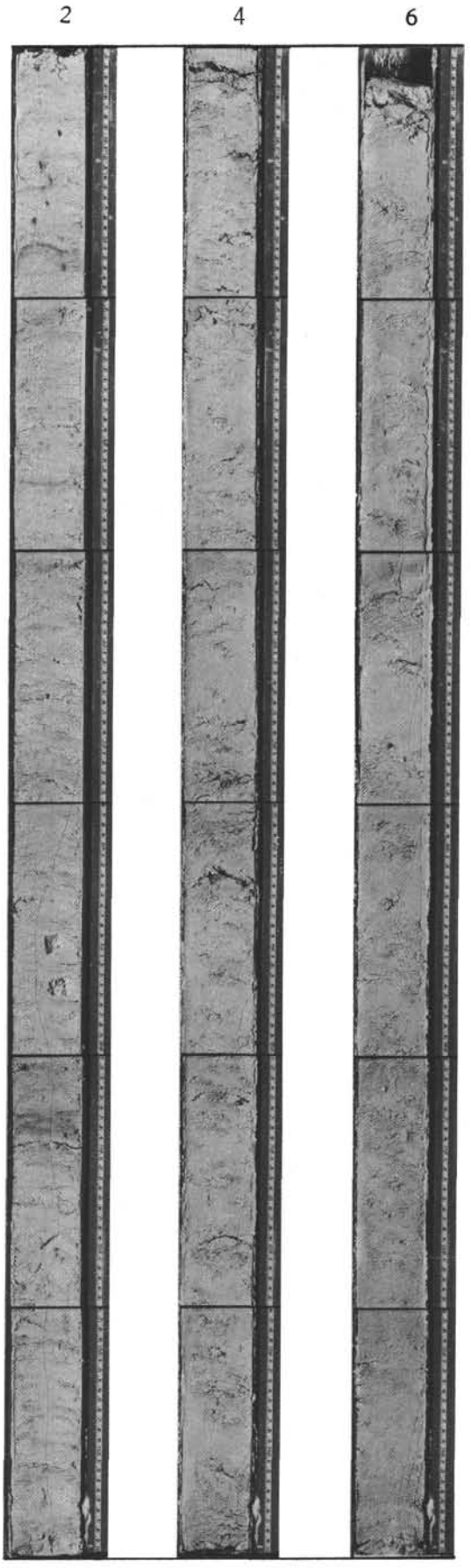


Site 71, Core 32, Sections 2, 4, 6.

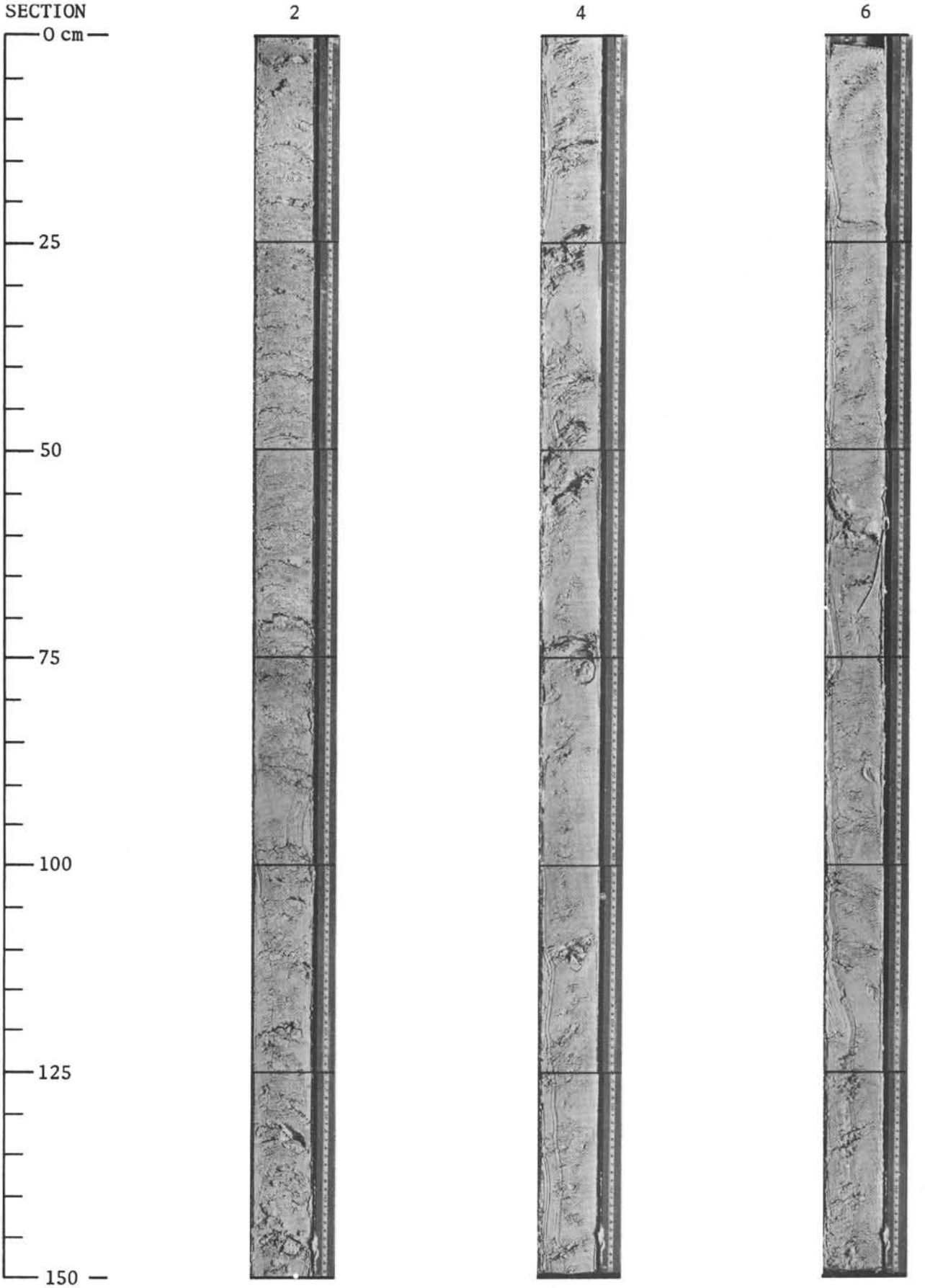
Site 71, Core 33, Sections 5, 6.



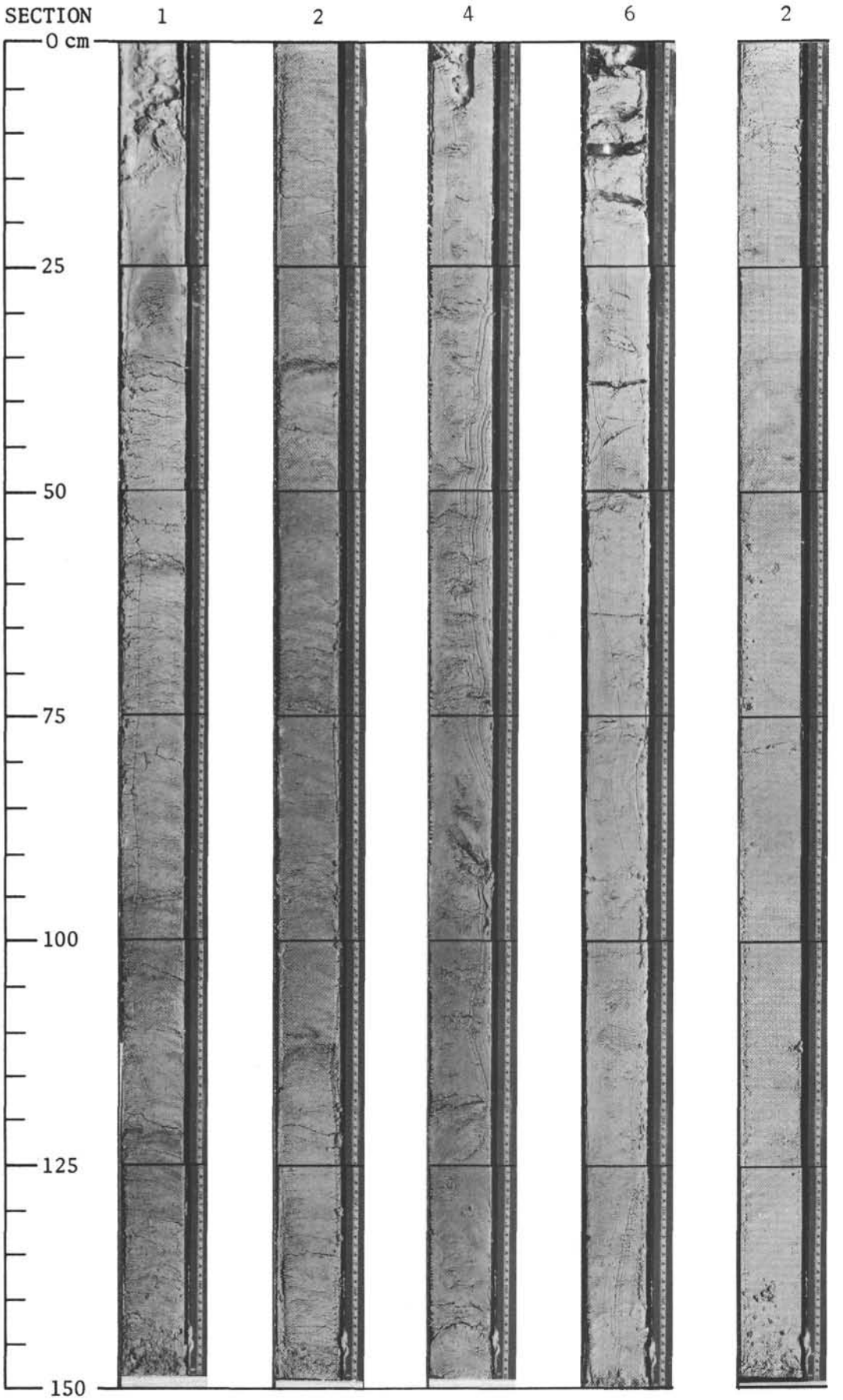
Site 71, Core 34, Sections 2, 4, 6.



Site 71, Core 35, Sections 2, 4, 6.

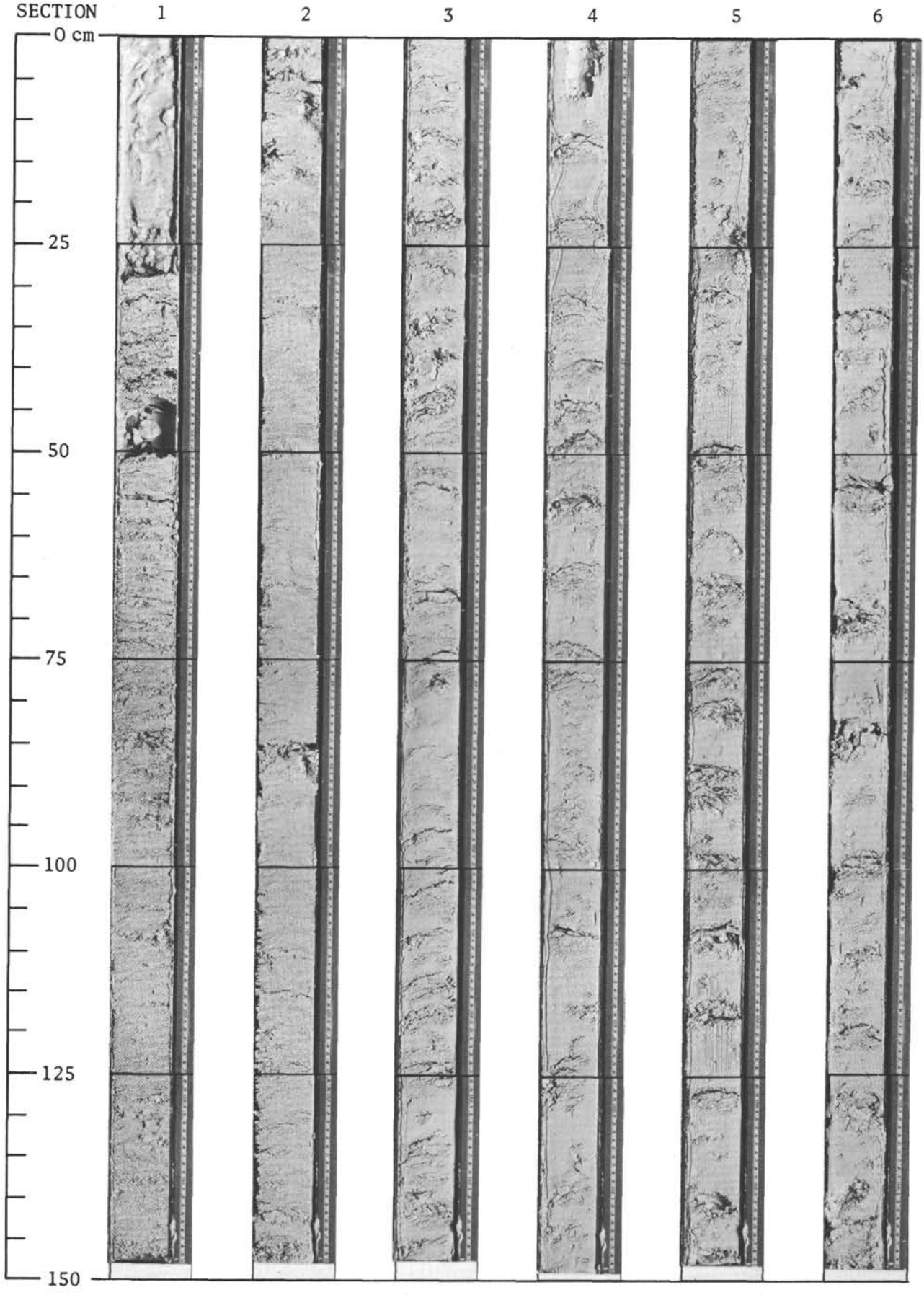


Site 71, Core 36, Sections 2, 4, 6.

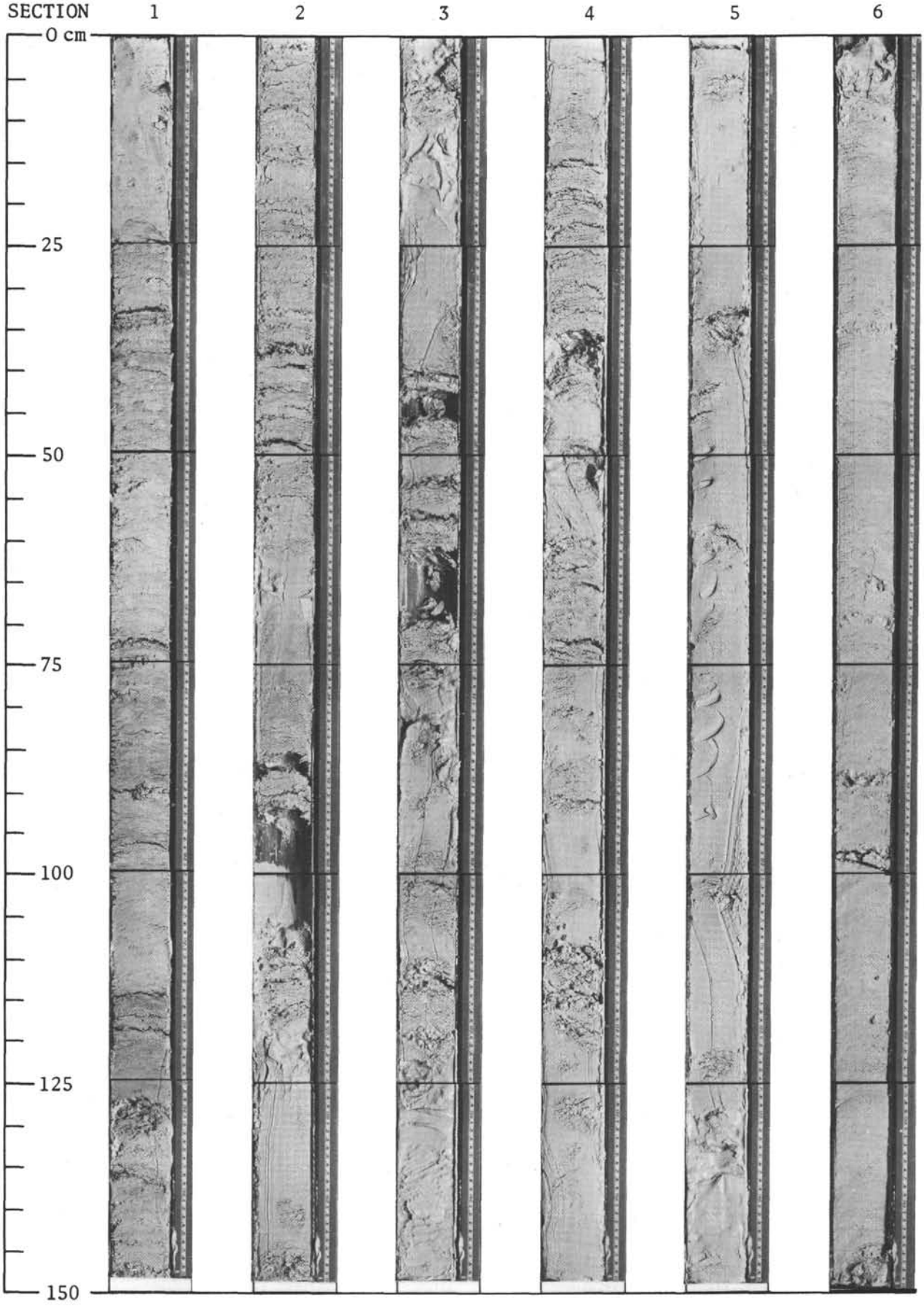


Site 71, Core 38, Sections 1, 2, 4, 6.

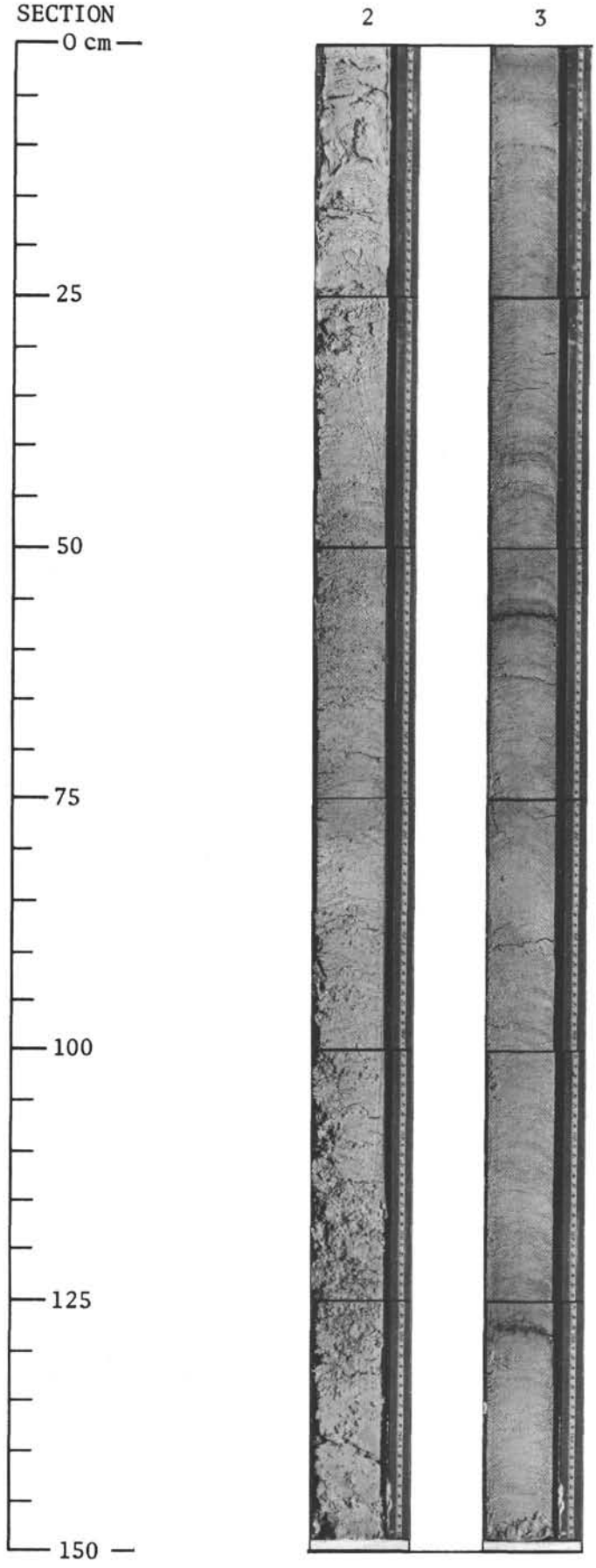
Site 71, Core 39, Section 2.



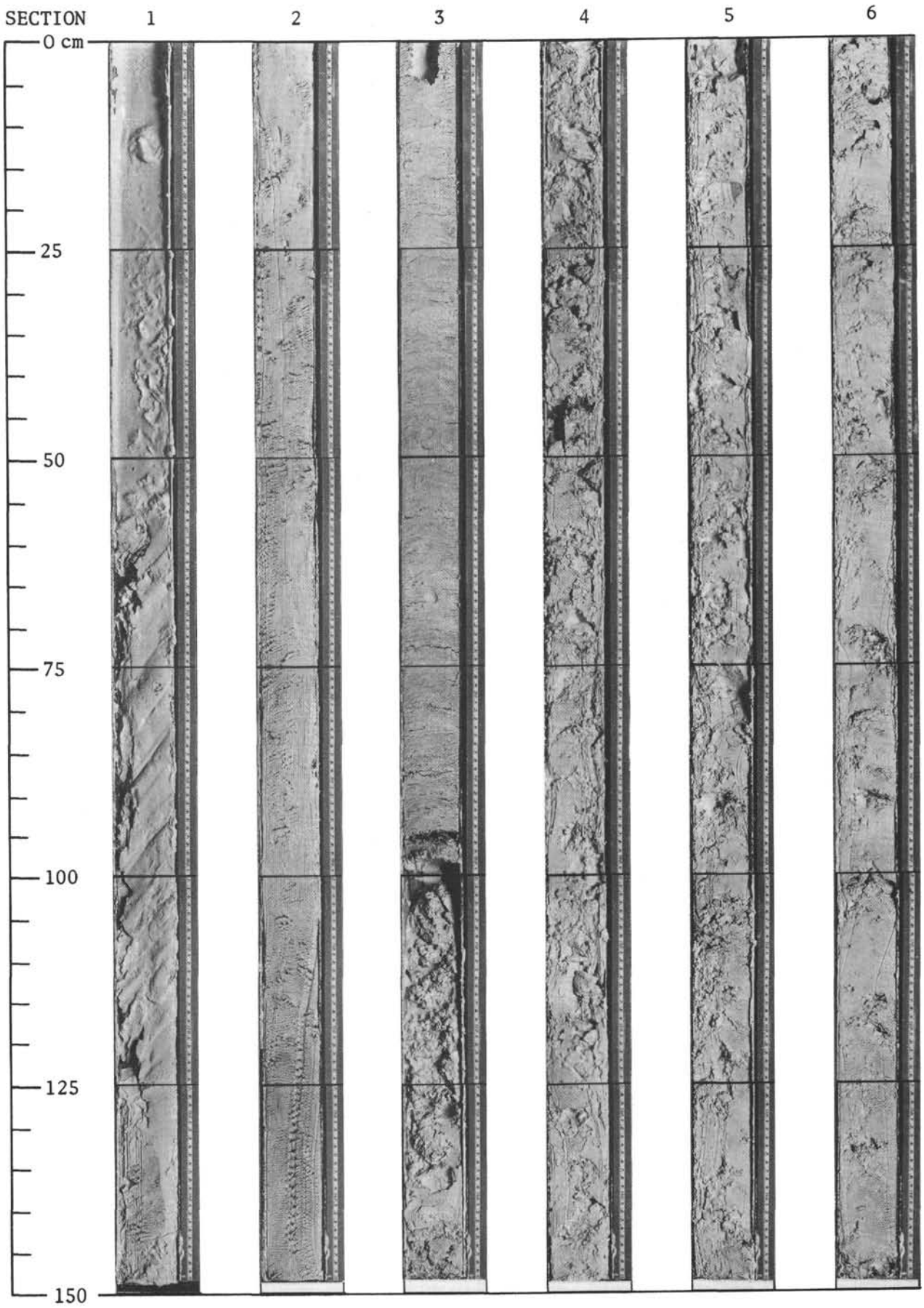
Site 71, Core 40, Sections 1-6.



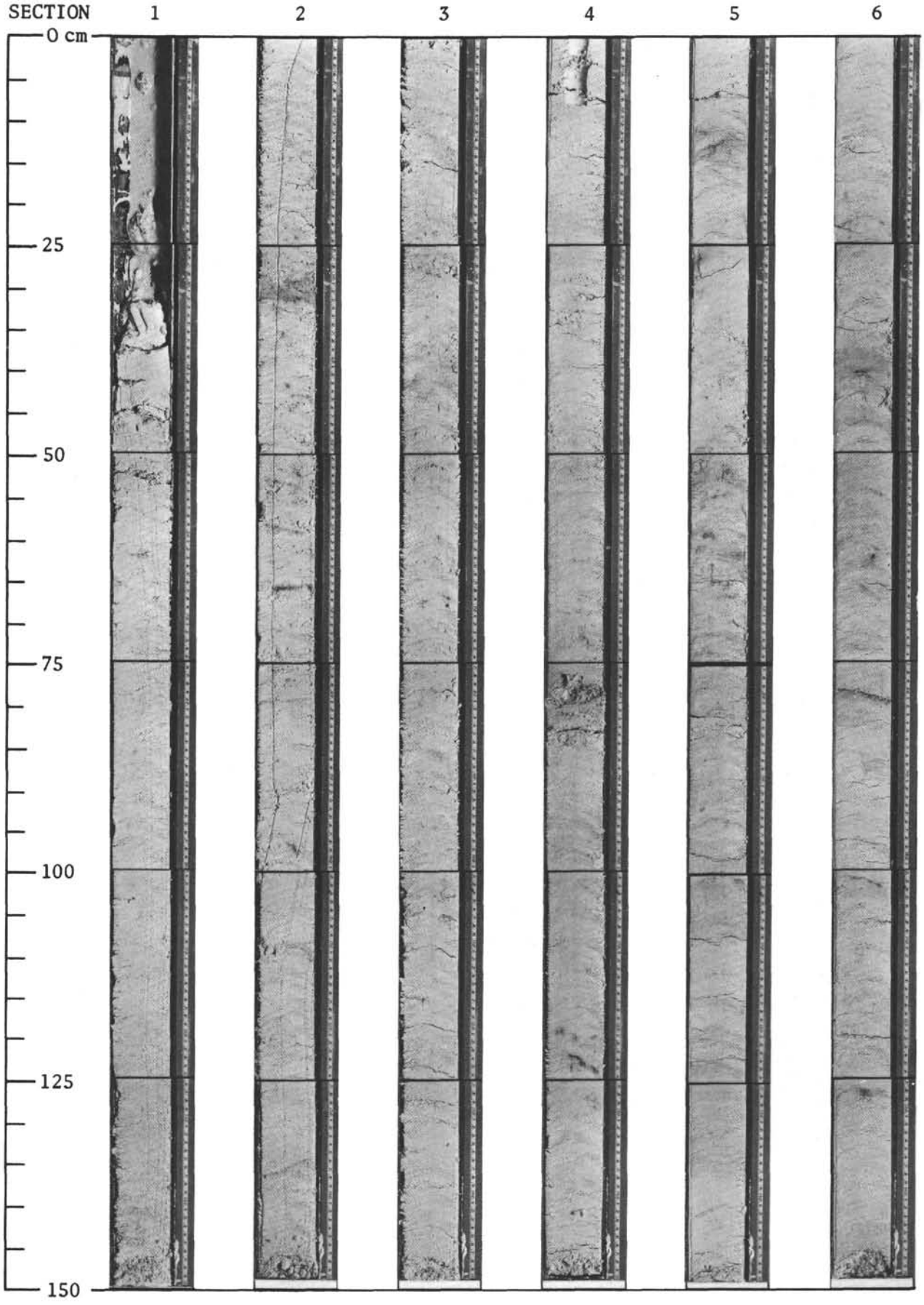
Site 71, Core 42, Sections 1-6.



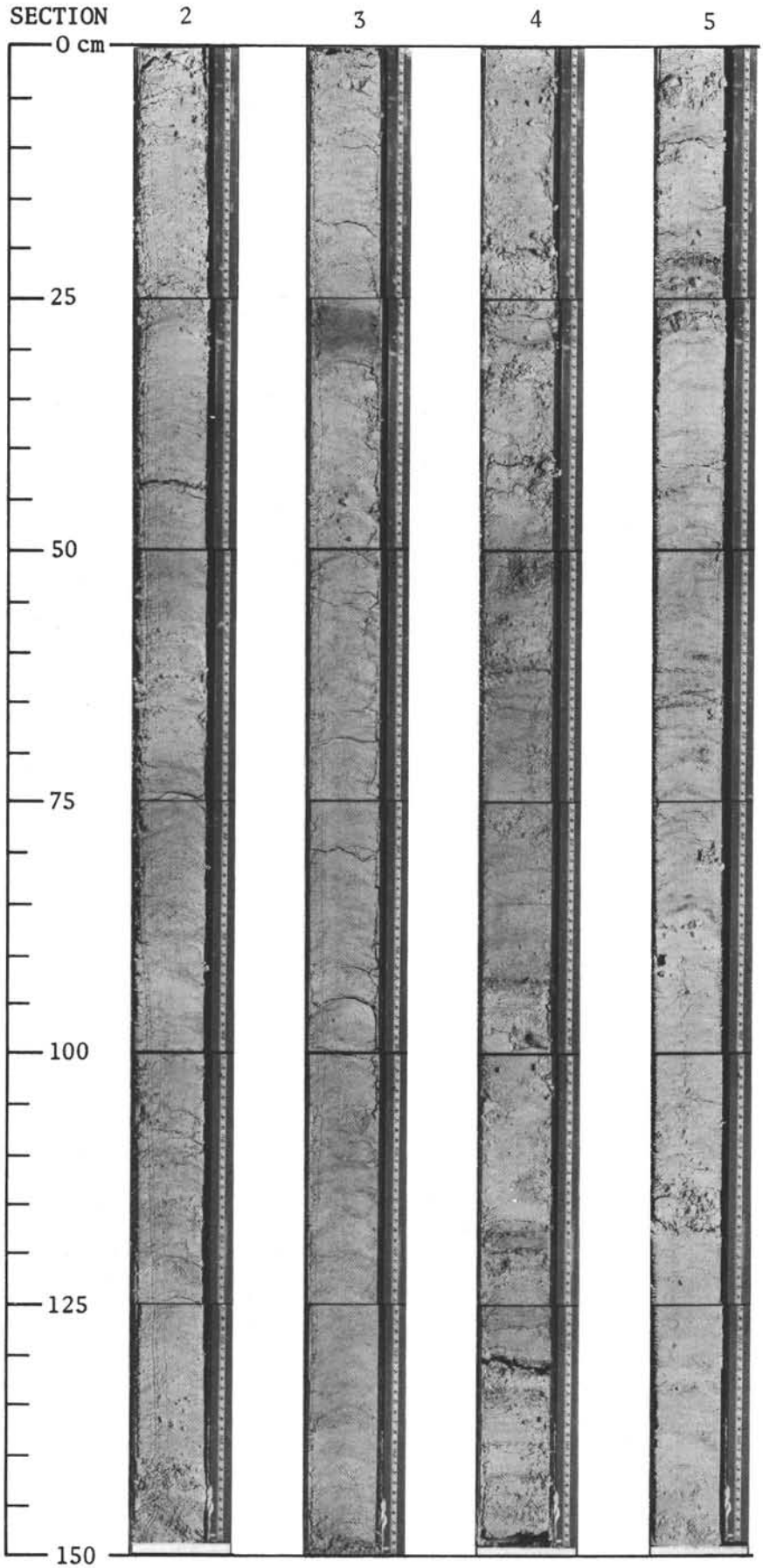
Site 71, Core 43, Sections 2, 3.



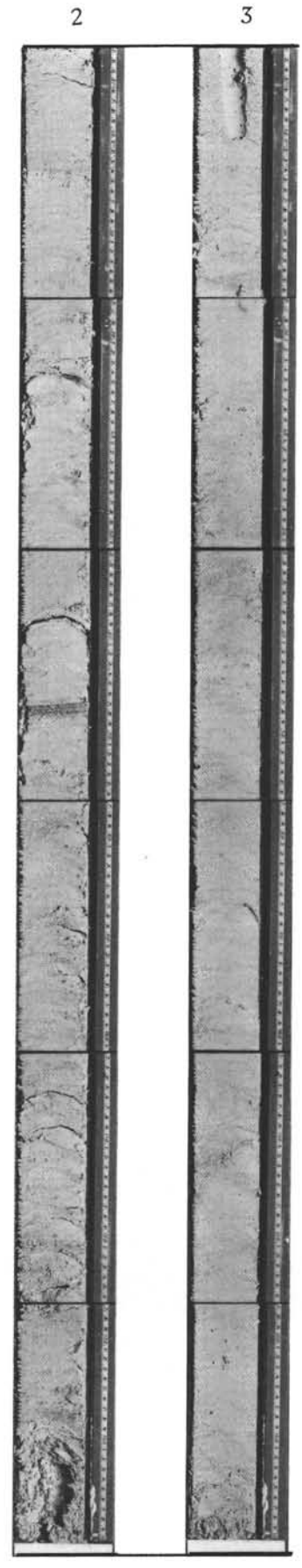
Site 71, Core 44, Sections 1-6.



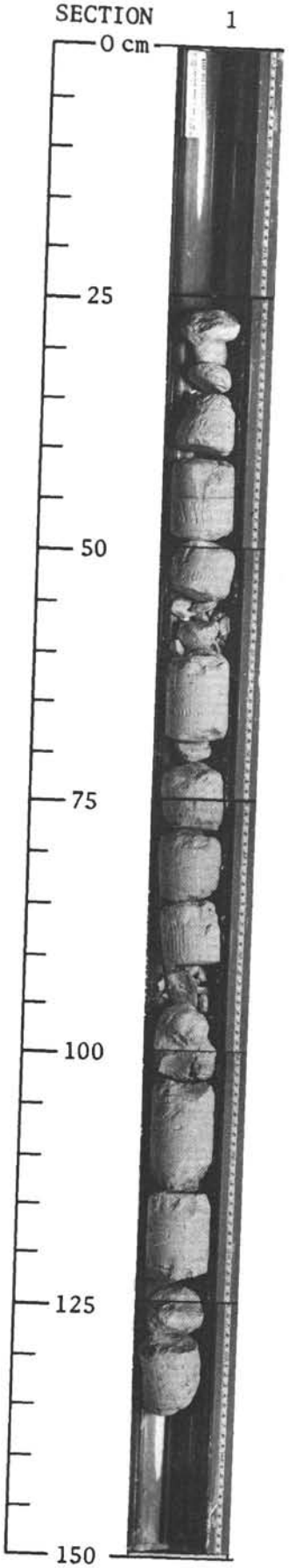
Site 71, Core 46, Sections 1-6.



Site 71, Core 47, Sections 2-5.

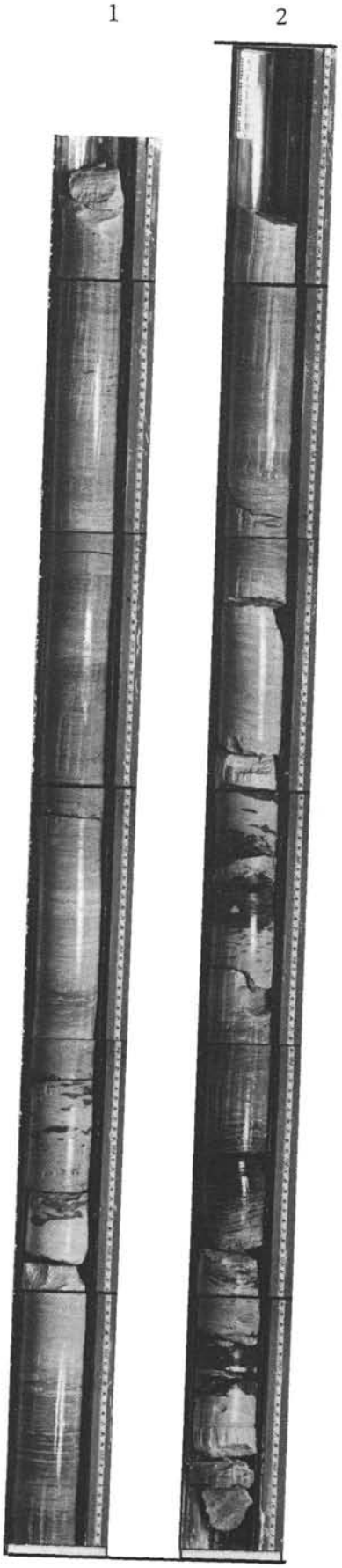


Site 71, Core 48, Sections 2,3.



Site 71A, Core 1, Section 1.

Site 71A, Core 2, Section 1.



Site 71A, Core 3, Sections 1, 2.