12. SITE 181

The Shipboard Scientific Party[1]

ABSTRACT

A 306-meter Pleistocene sedimentary section was cored and drilled at Site 181. The section is divided into three units. Medium dark gray, soft to firm uniform mud is the dominant lithology of Unit 1. Interbedded with the muds are diatom-rich mud and very fine to fine-graded sands. Pebble erratics are also present. The muds of Unit 2 are similar to those of Unit 1 but are characterized by a marked increase in diatoms near the base and an olive gray color. The upper two units are Holocene and late Pleistocene lower continental slope deposits. In contrast to the two units above, Unit 3 is an early Pleistocene dark gray to olive gray highly consolidated mudstone. Thin well-sorted silt laminae are interbedded with the muds and pebble erratics as well as poorly sorted sandy zones. Some of the observed deformation may have been created by drill bit pressures, but the pervasive microfracturing, irregular folding, and steep dips must have been formed prior to drilling and are probably due to tectonic deformation.

SITE SUMMARY

Date Occupied: 11-15 July 1971.

Position (Satellite):
Latitude: 57°26.30′N.
Longitude: 148°27.88′W.

Number of Holes: One.

Water Depth: 3086 meters below sea level.

Penetration: 369 meters below sea floor.

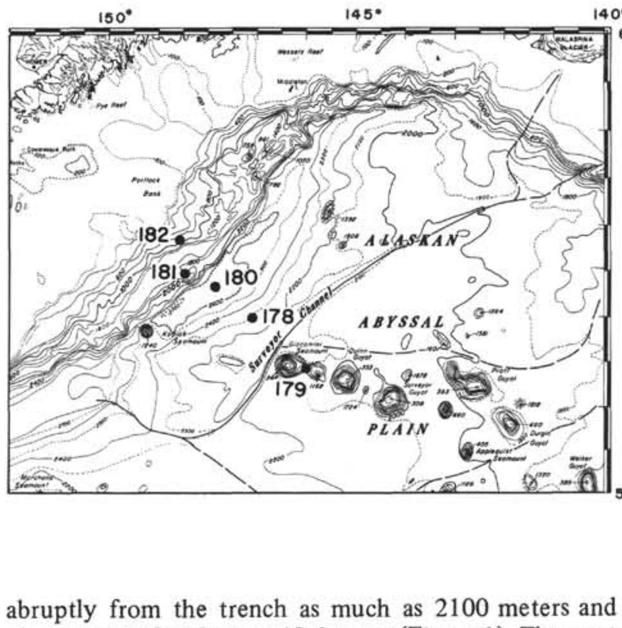
Number of Cores: 30.

Total Core Recovered: 106.5 meters, 41.0% recovery.

Age of Oldest Sediment: Pleistocene.

Acoustic Basement: None.

Basement: None.



BACKGROUND AND OBJECTIVES

Site Description

Site 181 is located on the lower continental slope about 2000 meters above the Aleutian Trench and in 3080 meters of water. In this area the precipitous continental slope rises abruptly from the trench as much as 2100 meters and in places it is inclined up to 40 degrees (Figure 1). The crest of this slope is an irregular ridge with a less steeply inclined landward flank that drops about 500 meters into an elongate perched basin. Most seismic records across the lower continental slope show few reflections that correspond to geologic discontinuities. To a large extent the records show defraction patterns from a rough sea floor and much of the seismic signal is deflected by steep slopes. Because of the inherent difficulties in making seismic records along this type of feature, the nature of rocks along the lower slope can only be inferred from scanty geophysical data. Refraction data indicate acoustic

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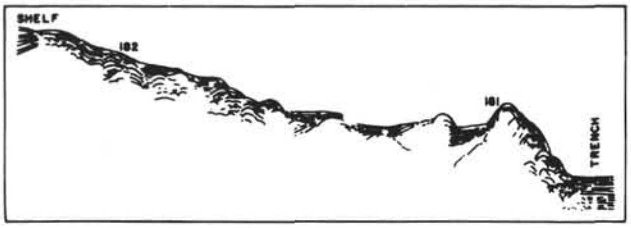

Figure 1. *Diagrammatic section across the continental slope (after seismic reflection records) showing setting of Sites 181 and 182.*

velocities common in consolidated sedimentary rocks. Magnetic anomalies continue unbroken across the trench-slope juncture suggesting that the oceanic basement does not follow the topography of the sea floor. These data suggest that all structure is developed by deformation in sedimentary rocks rather than by faulting of the underlying competent basement rock. However, it is difficult to conceive how soft incompetent sediments in the trench can transmit stress to form a compressional fold 2000 meters high in sediments that are unable to hold a 40 degree slope.

Site Objectives

The objectives at Site 181 were to determine the age, provenance, and properties of rocks deformed in the lower continental slope and ultimately to learn more about the tectonic mechanisms operating in the lower continental slope. Prior to drilling there were four possible explanations of the steep lower slope: 1) older more competent rocks had been deformed and elevated; trench-filling sediment had been deposited against them; 2) through some unknown process young trench sediments had been elevated and had become competent enough to hold steep slopes; 3) large blocks of material had slumped from the continental slope; and 4) the lower steep incline is a fault scarp. By learning more about the age and provenance of rocks in the lower continental slope a choice might be made between the alternate explanations or possibly another explanation would be revealed.

LITHOLOGIC SUMMARY

General Statement

Site 181 is on the lower continental slope and was drilled to a depth of 369.0 meters. All of the thirty cores recovered some sediment but recovery was especially low in the last 19 cores, which were cut in the lower unit. The sequence of sediments is sharply divisible into three major units on the basis of sediment type, induration, and deformation.

Lithologic Units

Unit 1 (0-117 m; Cores 1-13)

The top 20 cm is a brown, soft, foram-bearing silty clay representing the oxidized surface layer below which a medium dark gray, soft to firm uniform silty clay is the dominant sediment. Interbedded with the silty clays are diatom-rich silty clay, fine to coarse silt, and very fine to fine sand. The silty clay is a uniform, massive 7.5-meter interval in Core 8. Typically, however, it is interrupted by silt and very fine sand laminae which are commonly graded or by zones of sand and small pebble erratics. Thin sand and silt lenses occur sporadically and in some cases these may be disrupted beds.

Two thick sand and silt beds occur in Unit 1. The uppermost is a 65 cm bed in Core 5 and the lower is a 135 cm bed in Core 9. These beds are fine to medium sand with fair sorting, slight grading, sharp contacts. Core 10 was mostly sand which washed out of the barrel on deck. Other sand beds have a maximum thickness of 5 cm and are generally very fine grained, silty, and poorly sorted. One obviously graded sand bed consisted of 5 cm of very fine sand that graded up into silty sand, silt, and silty clay. A grain size study is needed to establish the degree of grading in the thick sand beds.

Unit 2 (117-169 m; Cores 13-18)

Unit 2 is essentially a continuation of Unit 1 marked by an increase in diatoms. Lithologies range from diatom-bearing silty clay near the top through diatom ooze with 60 percent diatoms near the bottom. The color is olive gray rather than medium dark gray as in Unit 1 and induration increases from firm to stiff toward the bottom of the unit. The distribution of thin, very fine sand and silt beds and sandy material and pebble erratics is similar to that in Unit 1. Two thin (5 to 10 cm) very fine sand to silt beds appear to be graded and they exhibit sharp lower boundaries.

Unit 3 (169-369.0 m; Cores 19-30)

This unit is characterized by dark gray to olive gray and olive black, highly contorted, compact mudstone with faint bedding. Zones of heterogeneous, poorly sorted medium to coarse sand in a silty clay matrix occur in several cores and about 10 pebble-sized erratics were noted. Although the mudstone is contorted and fractured, the basic lithology is uniform throughout the unit. The mudstone has thin (1 to 5 mm) white laminae of well-sorted angular silt but since they are always folded and never more than 5 to 10 cm long, their stratigraphic spacing is difficult to determine. Much of the fine contorted structure in the core consists of folds outlined by the silt lamina; dips are variable and indistinct. Minute fractures cut the faint bedding and, in at least one section, faulting may have formed several mm of fault clay, however, there is a possibility that some drilling disturbance may be superimposed on the basic structural deformation in the core. In addition it was noted that the mudstones do not show progressively increasing induration with depth. Some cores exhibit less induration than immediately overlying ones.

Occurrence of Erratic Material

Erratic pebbles and sand were found scattered in all units. In general, erratic material is more concentrated in the top 30 meters of a core. Erratics occur in all types of lithology except the sand beds and sections of uniform massive mud in Unit 1. Several erratic pebbles are 3 to 5 cm in size but most are less than 1 cm. A sample of 24 pebbles fall into the following groups: 38 percent slate, 20 percent medium sandstone and graywacke, 17 percent fine-grained sandstone, 17 percent quartzite, 4 percent amphibolite, and 4 percent granodiorite and they represent rocks of the Chugach Mountains. The sand-sized erratic material is found scattered in much of the core and concentrated into coarse zones.

Detailed Observations of 181-1-1 (Figure 2)

Parts of the core appear disturbed. The basic stratigraphy shown in the figure is believed to be primary, because of: (a) the sudden appearance of abundant forams below 38 cm; (b) the continuous granule and pebble-rich beds at about 46 and 72 cm, and (c) the perfect grading in the silty sand bed around 105 cm.

The sediments above 46 cm appear to contain no ice-rafted granules or pebbles, however, it is possible that rare medium sand grains may be erratics. The sediment is unusually rich in silt and very fine sand. If it is hemipelagic, bottom currents may have prevented the deposition of much clay.

The sudden increase in foram and decrease in diatom abundance at 38 cm, without noticeable change in other sediment parameters, might prove to be of time stratigraphic value.

Detailed Observations of Unit 3

Unit 3 is indurated throughout and had to be cut with the band saw. When cut, the inner part not exposed to drilling fluid appeared dry. The whole unit appears disturbed or deformed (Figure 3). Three lithologies are recognized:

1) Uniform dark medium gray mudstone, locally with up to 15% carbonate.

2) Mudstone with silt laminae 1 to 5 mm thick, either singly or in clusters. Thicker laminae are often internally laminated and are sometimes irregular. The silt is medium to fine and well-sorted.

3) Poorly sorted sand bearing coarse mudstone with rare erratic pebbles.

Large erratic pebbles are found individually in some cores. The core catcher of Core 23 recovered a carbonate-cemented fine sandstone. This may be an in situ bed or part of an erratic. Note that at the pump rates used, uncemented sands would probably be washed away. After pulling out of the hole, the bit had marks suggesting it had drilled through a boulder (Figure 3).

The following types of deformation are recognized:

1) A widespread, pervasive small scale fracturing and faulting of the rock, most clearly discerned where offsets in silt laminae are visible.

2) Folding, generally into irregular rounded open folds. No persistent fold axes are recognizable; indeed, the irregularity of the folding is noteworthy.

3) In other sections of core, no folding is visible, but a bedding dip of 30 to 50 degrees is present.

It was thought unlikely, but possible, that the deformation was a drilling artifact. This hypothesis does not account for the unusual induration of the rock. The irregularity of the folding could point to syn-sedimentary deformation ("slumping") or could be tectonic in origin. The microfaulting cutting mudstone and silt laminae suggests considerable induration prior to faulting.

PALEONTOLOGIC SUMMARY

Introduction

Age-diagnostic microfossils are restricted to the upper portion (0 to 187 m) of Hole 181. Moreover, rapid sedimentation at this site has diluted most assemblages with the exception of isolated horizons of diatom-rich mud. Prolific to rare diatom floras occur to a depth of 187 meters (Core 21). Meager radiolarian faunas are present to 169 meters (Core 18), whereas calcareous nannofossils occur to only 94.5 meters (Core 11). Foraminifera are generally rare but occur throughout the entire sequence penetrated (0 to 169 m). All of these groups indicate a Quaternary age for the 0 to 187 meter interval. More specifically, the base of North Pacific Diatom (NPD) Zone II occurs at 165.5 meters (Core 18) indicating that this interval is no younger than 0.26 m.y.

Displaced benthonic foraminifera are common in the sandy interval from 0 to 177 meters (Cores 1 to 19) whereas in situ lower bathyal species predominate below this horizon suggesting that a change in style of sedimentation or source of sediment occurred at 177 meters. Lack of calcareous nannofossils below 94.5 meters (Core 11) may indicate that sediments below this point were deposited beneath the calcium carbonate compensation level (CCL) and subsequently uplifted to their present depth above the CCL.

Calcareous Nannofossils

Cores recovered at Site 181 yielded few calcareous nannofossils and many of these are reworked. Core 1 (0 to 9 m) contains a sparse Pleistocene flora and the cold-water forms *Coccolithus pelagicus* and *C. pliopelagicus* Wise n. sp. occur sporadically in samples taken as low as Core 10 (85 to 94.5 m). Core 9 (75.5 to 85 m) contains small placoliths which may be *Emiliania huxleyi.* Most of the lower portion of this hole is barren of calcareous nannofossils except for reworked Neogene and Mesozoic specimens which are usually found in sand-size pods of calcareous material apparently transported to the site of deposition as descrete sedimentary grains. The absence of indigenous calcareous nannofossils in the lower portion of this hole (Cores 11 to 30; 94.5 to 369 m) indicates this material was likely deposited below the calcium carbonate compensation level (CCL). If this is the case, the site must have been uplifted to its present water depth (3080 m) above the CCL sometime during the last 1.0 m.y.

Diatoms

Cores 1 through 3 (0 to 28 m) contain well-preserved, abundant to rare diatom floras; Cores 4 through 8 (28 to 75.5 m) are barren. Cores 9 through 21 (75.5 to 196 m) contain abundant to rare, well to poorly preserved diatom floras. Prolific diatom floras are present within diatom-rich mud at several horizons (181-1-1, 70-72 cm; 181-1-6, 78-80 cm; 181-2-3, 21-23 cm; 181-12-3, 119-121 cm; 181-13-3, 40-42 cm; 181-14-CC; 181-18-2, 20-22 cm; 181-18-3, 30-32 cm; 181-18-4, 14-16 cm).

The base of Pleistocene NPD Zone I occurs at 104 meters (181-11-CC) and the base of NPD Zone II at 165.5 meters (181-18-4, 14-16 cm). The interval from 187 to

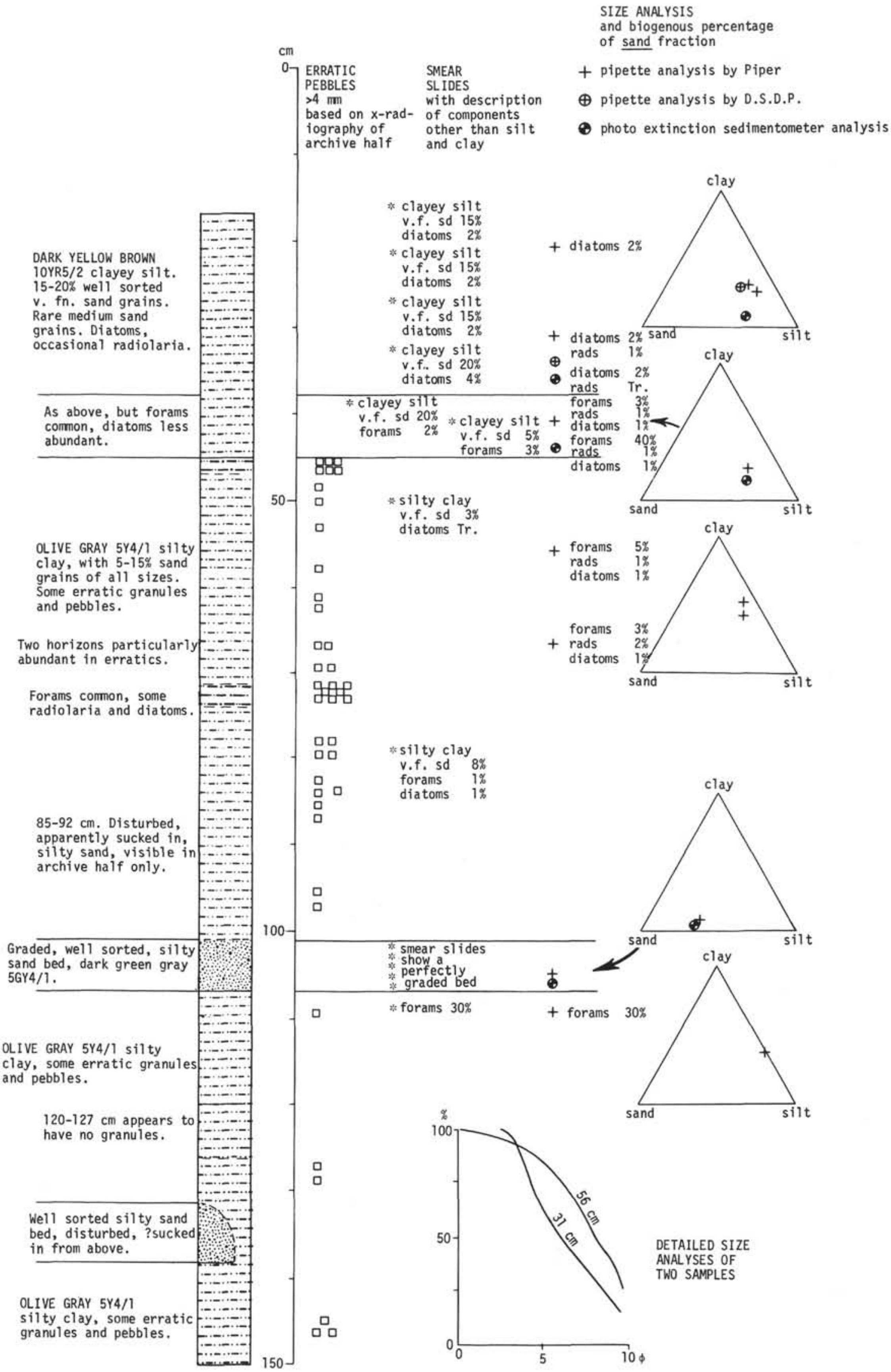

Figure 2. *Detailed section description of 181-1-1.*

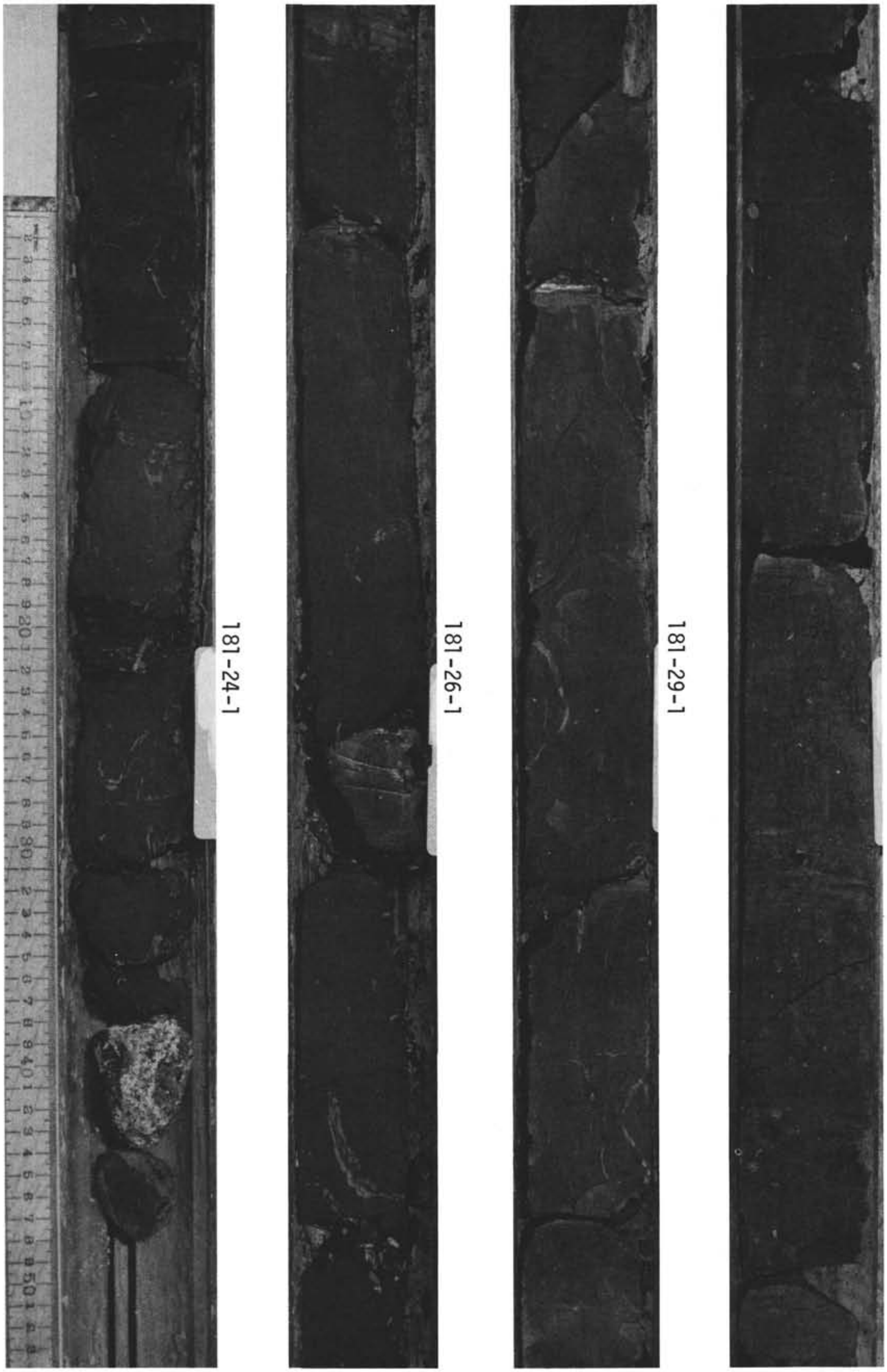

Figure 3. *Cores from Unit 3 showing ice-rafted cherts and deformation. Core to the far right (25-2) contains numerous granules and scattered pebbles of ice rafted material. Core to the far left (24-1) contains a large ice rafted granitic pebble near the bottom. In center cores (26-1 and 29-1) deformation is outlined by the light colored bands of silt.*

360.8 meters (181-21-1, 51-53 cm to 181-30-1, 33-34 cm) is barren of diatoms, thus the base of Pleistocene NPD Zone III could not be delineated. The oldest recovered diatom-bearing sediment is assigned to NPD Zone III (181-21-1, 25 cm).

Planktonic Foraminifera

Sparse and in most cases poorly preserved planktonic foraminifera are present in Cores 1 through 18 (0 to 161 meters) with extremely rare occurrences below this horizon. Sinistral coiling populations of *Globigerina pachyderma* dominate all faunas and in some cases represent the only specimens present. Accessory species include *Globigerina bulloides* (and varieties), *G. quinqueloba,* and rare specimens of *Globorotalia scitula* similar to other Holocene-Pleistocene assemblages encountered in the Gulf of Alaska region.

Benthonic Foraminifera

Very rare to common benthonic foraminifera were found at scattered horizons in Cores 1 through 30 (0 to 369 m); preservation was generally moderate to poor. Benthonic assemblages encountered within the 0 to 177 meter interval (Cores 1 to 19) are dominated by species displaced from shallower horizons. Shelf-depth species present include *Nonionella miocenica stella, Elphidium clavatum* together with many broken specimens of unidentifiable species of *Elphidium* and *Buccella.* Displaced upper bathyal and shelf-edge species present include *Cassidulina transluscens, C. subglobosa,* costate uvigerinids *Epistominella pacifica* and *Cassidulina delicata*, with in situ lower bathyal assemblages represented by *Cibicides wuellerstorfi, Eggerella bradyi, Melonis pompilioides, Nuttalides umbonifera,* and *Pullenia bulloides.*

The interval from 177 to 369.5 meters (Cores 19 to 30) contains a lower percentage of sand than horizons above this interval. Moreover, these sediments are characterized by rare benthonic assemblages composed primarily of in situ bathyal species with only minor percentages of displaced species suggesting that the lithologic break noted at 177 meters represents a change in the style of sedimentation or perhaps a change in source area.

Radiolaria

Radiolarians occur sporadically in Cores 1 through 18 (0 to 169 m) with abundant, diverse assemblages present in Cores 1, 17, and 18. All samples examined contain various extant species but lack *Stylacontrarium acquilonius* and *Axoprunum angelinum*. This indicates that the entire section encompassing Cores 1 through 18 falls within the Upper Pleistocene-to Holocene *Artostrobium miralestense* (= *Eucyrtidium tumidulum*) Zone of Hays (1970) with an estimated age range of 0.4 m.y. to the present.

Spores and Pollen

Woody fragments, but no identifiable palynomorphs are present in samples examined at Site 181. Since conditions of deposition at Site 181 were similar to those at Site 180, lack of well-preserved and abundant spores and pollen was expected.

PHYSICAL PROPERTIES

Physical properties were measured at Site 181 in the standard manner. In a preliminary data reduction, GRAPE porosities were seen to correlate well with carefully taken pairs of syringe porosity determinations. Frequent erratics made parts of the GRAPE record difficult to interpret.

Cores of Unit 3 were broken into short lengths and did not completely fill the core liner. GRAPE porosities were difficult to obtain and interpret. The rock was too hard for syringe porosity determinations to be made. Laboratory measurements of physical properties are given in Lee (this volume).

Sonic velocity measurements were made on the least disturbed and most consolidated material in one or more sections of most cores. The material was taken out of the liner and three measurements were made. In Units 1 and 2, velocities (with two exceptions) range from 1.58 km/sec to 1.66 km/sec; in Unit 3 there is an abrupt increase to between 1.82 km/sec and 2.02 km/sec.

CORRELATION BETWEEN REFLECTION RECORDS AND THE STRATIGRAPHIC COLUMN

Site 181 was chosen on the basis of the USGS seismic record on which Figure 1 is based (Figure 4a). Another record was made by the *Glomar Challenger* in a pre-drilling site survey part of which is shown in Figure 4b. Both records show a complex sequence of reflection marked by defraction patterns and the complex outgoing seismic signal. It is difficult to establish any structure from these records. From the overall reflection pattern in these and additional records near this site, it can be said that the lower slope may be composed of highly deformed sedimentary rocks. Overlying the deformed rocks there is often a blanket of well-stratified sediment that commonly shows tilting, folding, and faulting. Although it cannot be distinguished with confidence in the records at Site 181, this blanket of sediment may be correlative with the soft muds and sands above 169 meters.

SUMMARY AND CONCLUSIONS

Site 181 is just over the crest of a 2100-meter high ridge that rises abruptly from the floor of the eastern Aleutian Trench. The immediate objective here was to establish the age, provenance, and condition of sediments in the lower continental slope. Thereby, the theory that proposes continuous accretion of trench sediment against the slope as oceanic crust is thrust under a continent could be examined. Drilling and safety considerations made it advisable not to drill in the crestal area. The 369-meter section that was cored and drilled has two distinctive lithologies that differ principally in the degree of consolidation and deformation.

The upper lithology is further divided into two units. The first unit (0 to 117 m) consists of soft to firm mud with thin-graded and ungraded sand laminae and sand and pebble erratics. The second unit (117 to 169 m) is similar to the first but has more diatoms and less sand. The third unit (169 to 369 m) is a highly compacted hard mudstone with thin silt laminae and rare erratic pebbles. Its water content is about 10% and consolidation measurements

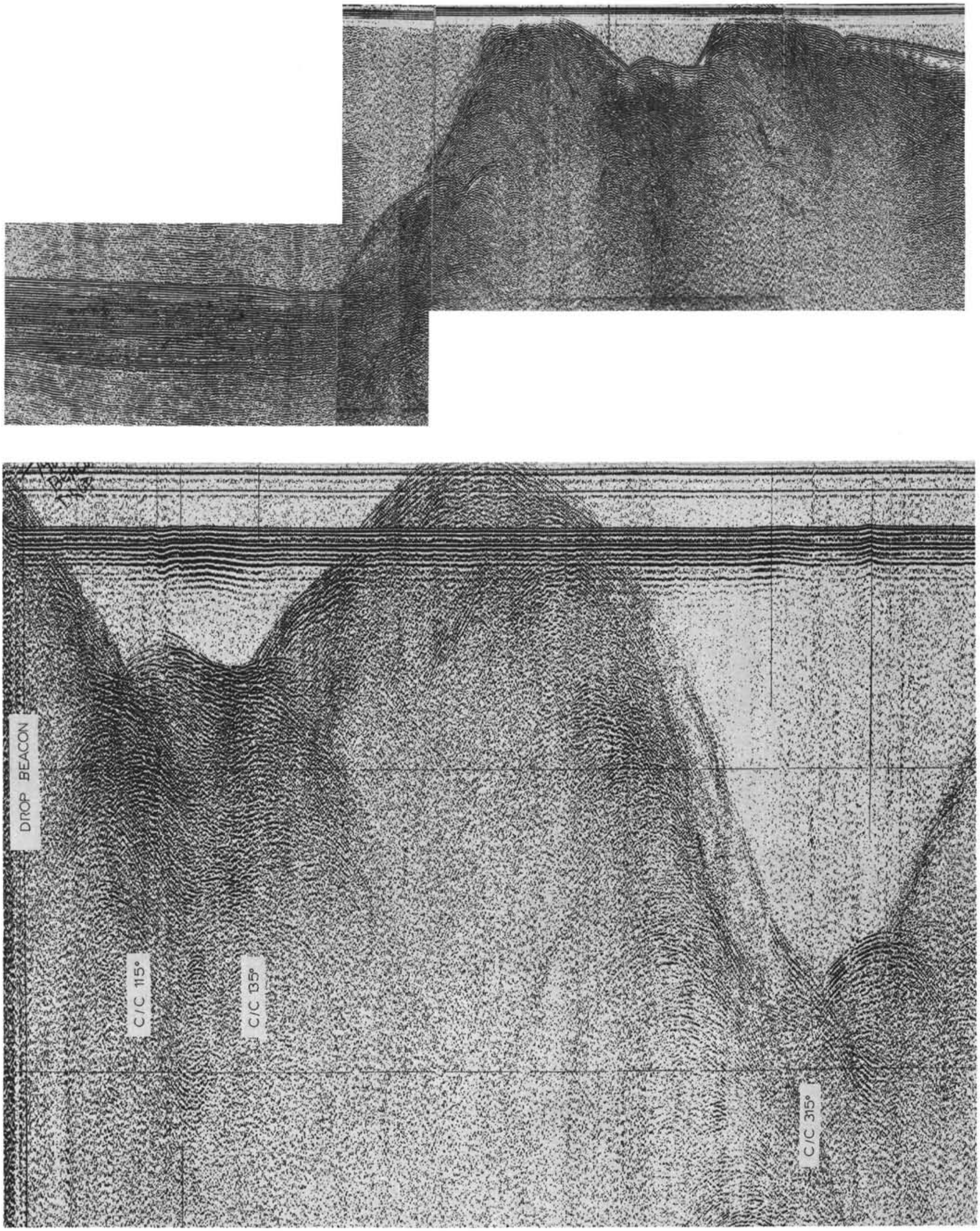

Figure 4. a. *Seismic profile of Site 181 area (U.S.G.S. seismic profile).* b. *Seismic profile of Site 181 taken by* Glomar Challenger *during pre-site survey.*

suggest burial of 1.5 km deep (see Lee, this volume). Although the mudstone may have been partly deformed by the very high drill bit pressures required for drilling, the pervasive microfaulting, irregular folding and bedding dips are thought to be in situ features. The irregularity of folding could result from syn-sedimentary deformation or tectonism, however, microfaulting suggests considerable induration prior to deformation, thus favoring a tectonic origin. It would be very difficult to accomplish the dewatering and consolidation with a non-tectonic process.

Meager radiolaria, foraminifera, and calcareous nannofossil assemblages were found in the upper two units of this hole. Varying abundances of diatoms were found from the surface through the top of the third unit. Displaced species of benthonic foraminifera from shallower environments were found in all units. The sparse reworked calcareous nannofossils recovered may suggest deposition below the calcium carbonate compensation level. Radiolaria are generally rare to few, but one sample with abundant tests and good species diversities indicates that sediments of the upper two units are younger than 0.4 m.y. and possibly 0.3 m.y.

The upper two units are probably mildly deformed lower continental slope deposits that contain displaced microfossils. The 40 to 50 cm thick foram-rich clayey silt at the top of the core indicates a period during which the site was beyond the reach of turbidity currents or slumps. However, a clean graded sand only 70 cm down the hole marks the first of many such layers farther down. These layers indicate that the site was on a continuous slope in the path of turbidity currents or slumps rather than in its present position on the side of an isolated knoll. The maximum age of the deformation which isolated the site from the rest of the slope is given by the 0.26 m.y. diatom age at 104 meters; in 0.26 m.y., 104 meters of sediment accumulated and deformation raised the site some 465 meters relative to the adjacent landward trough (see Figure 1).

The sudden change between undeformed sediments of Unit 2 and deformed sediment of Unit 3 indicates a tectonic contact between them. Since the radiolaria in the lower part of Unit 2 indicate an age less than 0.4 m.y. and the diatoms in the upper part of Unit 3 indicate an age no less than 0.92 m.y., the hiatus is at least 0.5 m.y.

The unusual sediment cored at this site was most probably deformed, dewatered, and compacted through tectonism rather than by syn-sedimentary processes or slumping. It would be difficult to get past pressures equivalent to burial at least 1500 meters deep or to squeeze 80% of the moisture out of this mudstone by the latter processes. A very forceful and dynamic mechanism is suggested by the nature of the rock and there is much evidence of tectonism in the uplift of the knoll where this hole was drilled, in the tectonic contact and hiatus between lithologies in the core, and in possible folding seen in the seismic records (von Huene, 1972). At this point the more pertinent question might concern the rates of tectonism.

In this situation where there is an absence of insight into the tectonic mechanism, the limiting rates of uplift are the most readily available indicators of tectonic rate. The minimum vertical component of deformation is indicated by the previously mentioned interruption of downslope turbidites through isolation of the knoll on which Site 181 is located, which is at least 1800 m/m.y. (465 m/260,000 year). A similar minimum rate is suggested by the 1500 m/minimum past pressure assuming of course that the sediment was exposed through tectonism (1500 m/0.92 m.y. = Ca 1700 m/m.y.). Maximum rates depend on the original provenance of the mudstone whether in the trench or at its present elevation on the lower slope.

TABLE 1
DSDP Site 181 Coring Summary

Core	Cored Interval Below		Cored (m)	Recovered	
	Derrick Floor (m)	Sea Floor (m)		(m)	(%)
1	3114.0-3123.0	0-9.0	9.0	9.0	100.0
2	3123.0-3132.5	9.0-18.5	9.5	9.0	94.7
3	3132.5-3142.0	18.5-28.0	9.5	5.5	57.9
4	3142.0-3151.5	28.0-37.5	9.5	4.5	47.4
5	3151.5-3161.0	37.5-47.0	9.5	4.0	42.1
6	3161.0-3170.5	47.0-56.5	9.5	4.0	42.1
7	3170.5-3180.0	56.5-66.0	9.5	4.5	47.4
8	3180.0-3189.5	66.0-75.5	9.5	7.5	78.9
9	3189.5-3199.0	75.5-85.0	9.5	6.0	63.2
10	3199.0-3208.5	85.0-94.5	9.5	CC	–
11	3208.5-3218.0	94.5-104.0	9.5	1.0	10.5
12	3218.0-3227.5	104.0-113.5	9.5	3.5	36.8
13	3227.5-3237.0	113.5-123.0	9.5	9.5	100.0
14	3237.0-3246.5	123.0-132.5	9.5	2.5	26.3
15	3246.5-3256.0	132.5-142.0	9.5	7.0	73.7
16	3256.0-3265.5	142.0-151.5	9.5	0.5	5.3
17	3265.5-3275.0	151.5-161.0	9.5	7.5	78.9
18	3275.0-3283.0	161.0-169.0	8.0	5.0	62.5
19	3283.0-3291.0	169.0-177.0	8.0	1.0	12.5
20	3291.0-3300.5	177.0-186.5	9.5	1.5	15.8
21	3300.5-3310.0	186.5-196.0	9.5	1.5	15.8
22	3310.0-3319.5	196.0-205.5	9.5	0.5	5.3
23	3319.5-3329.0	205.5-215.0	9.5	0.5	5.3
24	3329.0-3338.5	215.0-224.5	9.5	1.0	10.5
25	3338.5-3348.0	224.5-234.0	9.4	2.5	26.3
26	3348.0-3353.0	234.0-239.0	5.0	1.0	20.0
27	3389.0-3395.0	275.0-281.0	6.0	2.0	33.3
28	3433.5-3436.5	319.5-322.5	3.0	0.5	16.7
29	3451.5-3454.5	337.5-340.5	3.0	3.0	100.0
30	3474.5-3483.0	360.5-369.0	8.5	1.0	11.8
		Total	259.5	106.5	41.0

T.D. = 369.0 meters.

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APPENDIX A. OPERATIONS

Pre-drilling Survey

Site 181 lies on the landward flank of the first prominent ridge on the lower continental slope. The site was approached on course 279°T from Site 179 at a speed of 10 knots. At 1449 hours the speed was reduced to 6 knots, and then at 1520 hours the speed was reduced to 4 knots and the course changed to 189° (Figure 5). From 1520 to 1900 hours, several course changes were made to cross the ridge at several places perpendicular to its strike and to locate a suitable drilling site off-structure. The following course changes were made from 1526 to 1900 hours: 1526, C/C to 099°; 1600, C/C to 280°; 1640, C/C to 135°; 1720, C/C to 045°; 1730, C/C to 315°; 1833, C/C to 135°; and 1844, C/C to 115°. The beacon was dropped at 1900 hours while the vessel was underway along course 115°.

Drilling Program

The water depth at Site 181 was calculated using the Matthews tables plus the Hawaii factor and by adding a factor to correct for the increased water depth due to a bottom slope of 10° (i.e.: 3019 + 14 + 47 = 3080 m to the transducer or 3096 m to the derrick floor). After some probing with the drill string, the bottom was found at 3114 meters or 18 meters deeper than calculated. The bottom slope may have been steeper than calculated, which would increase the total depth or the drill stem may initially have slid downhill. Our depth calculations at Sites 178, 179, and 180 were close to the drill pipe length, but they were all made from a flat surface. The hole was spudded-in without difficulty on the sloping sea floor.

Site 181 was continuously cored to a depth of 239.0 meters with both coring and drilling to a total depth of 369.0 meters below the sea floor. The first core was brought aboard at 0340 hours on 12 July.

Recovery was above average for the leg (50%) in Cores 1 to 18 (0 to 169 m), but below this interval (169 to 369 m) it dropped off dramatically. Soft gray muds with some glacial erratics occur in the upper interval and dark gray hard mudstones in the lower. Both coring and drilling were slowed down to about 6 meters per hour in the mudstones. The total recovery rate for Site 181 is 41.0 percent.

Most of the cores taken in the interval between 169 to 369 meters display a great deal of deformation of the thin layers of well-sorted silt. After considerable discussion among the sedimentologists and drilling operations people, it was concluded that some of the deformation may be caused by drilling but that much of it existed within the deposits cored.

The position of Site 181 was determined from an average of 10 satellite fixes, 57°26.30'N latitude and 148°27.88'W longitude.

Drilling Specifications

The drill pipe touched bottom at 3114 meters. Penetration totaled 369 meters of which 109.5 meters were drilled and 259.5 meters were cored. The 106.5 meters of core pulled gives a 41 percent recovery rate. Total time spent on site was 97.25 hours, which includes 14.75 hours drilling and 59.50 hours coring.

A Smith 3 cone bit was used on the same bottom hole assembly that was used on Site 180.

Site 181 exhibited the same core recovery problems that were encountered on Site 180. At 169 meters (Core 19), the hard stickly clay changed to a mudstone and core recovery dropped to 15 percent in the lower part of the hole. Shorter intervals, 3 to 6 meters, were cored on the last 5 cores which increased the recovery to that encountered in the larger 9.5-meter intervals.

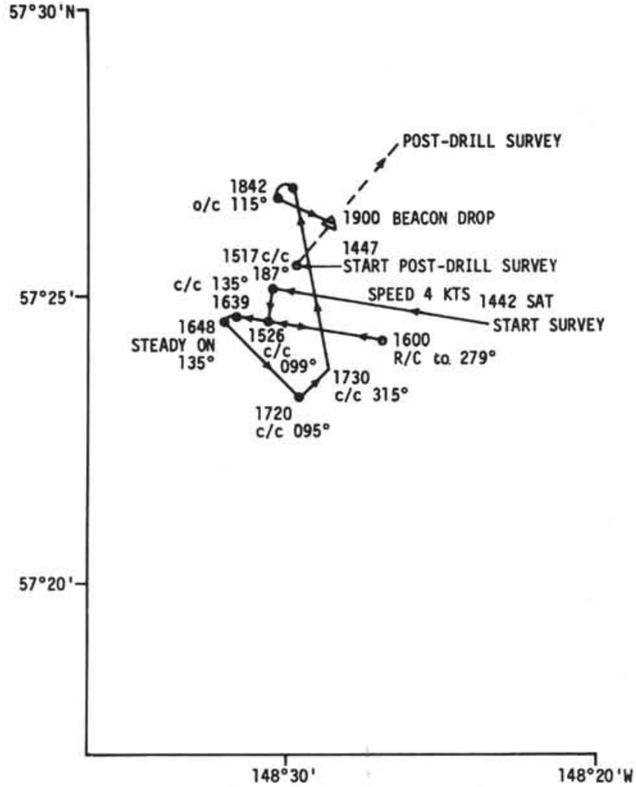
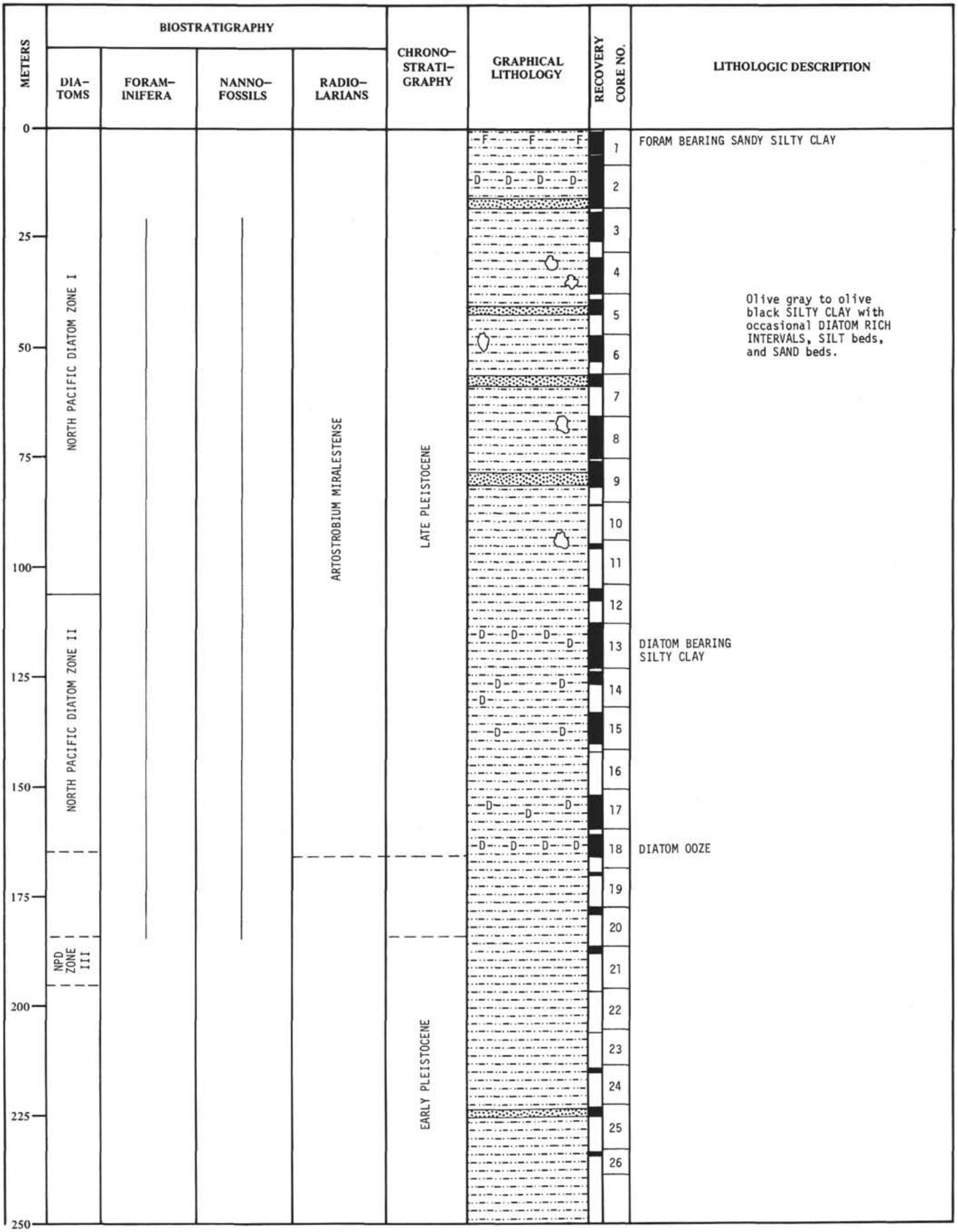
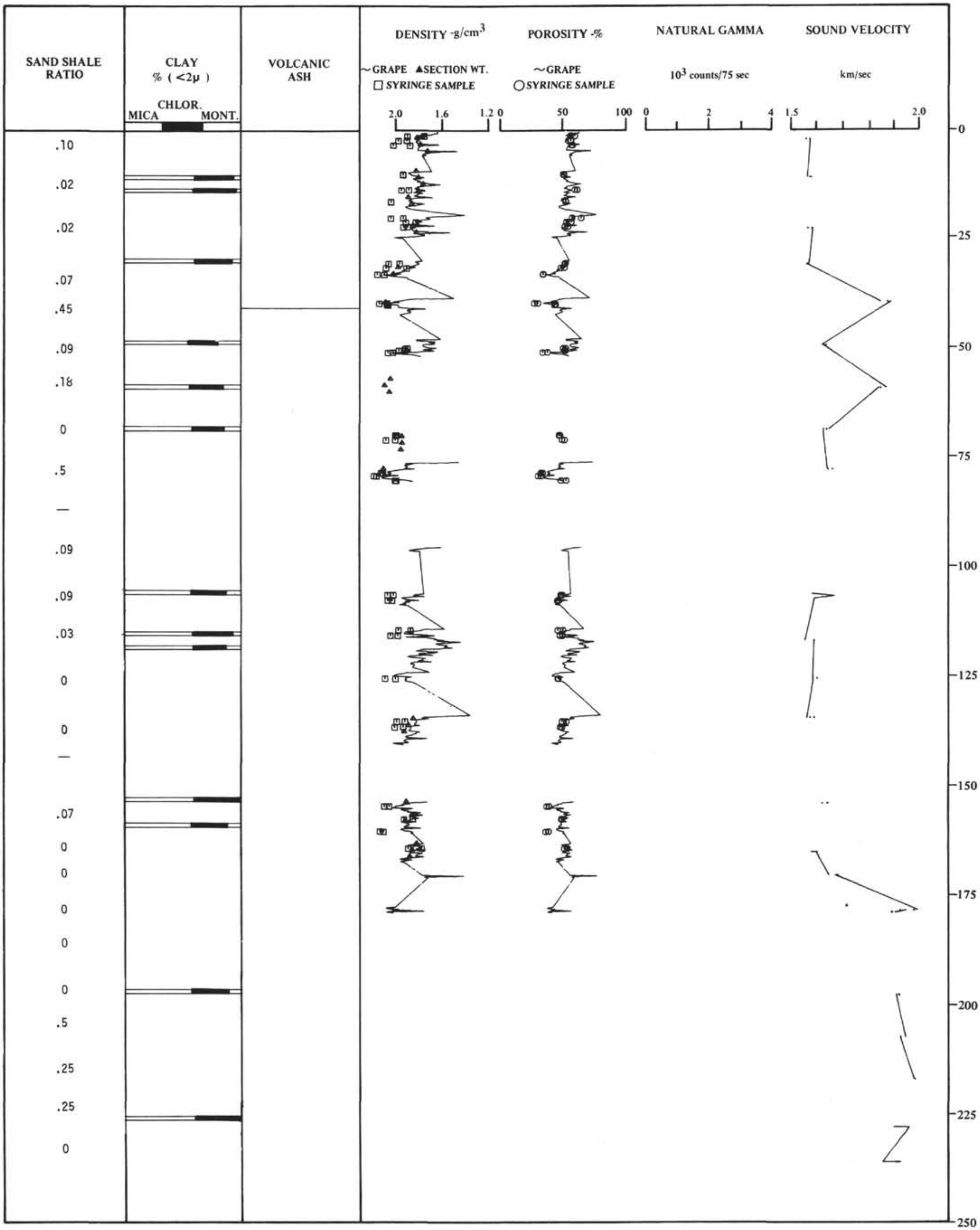


Figure 5. *Track chart of* Glomar Challenger *survey of Site 181.*

Post-drilling Survey

The gear was streamed at 1420 hours, 15 July, to conduct a brief post-drilling survey. *Challenger* came to course 045° at 1447 hours at a speed of 4 knots. A course change was made to 025° at 1503 hours and later changed to 044° at 1514 hours to complete the survey over the beacon. The survey ended at 1543 hours. A 4-sec sweep was used on the seismic reflection record.


METERS
BIOSTRATIGRAPHY
DIA-TOMS
FORAM-INIFERA
NANNO-FOSSILS
RADIO-LARIANS
CHRONO-STRATI-GRAPHY
GRAPHICAL LITHOLOGY
RECOVERY
CORE NO.
LITHOLOGIC DESCRIPTION
0
25
50
75
100
125
150
175
200
225
250
NORTH PACIFIC DIATOM ZONE I
NORTH PACIFIC DIATOM ZONE II
NPD ZONE III
ARTOSTROBIUM MIRALESTENSE
LATE PLEISTOCENE
EARLY PLEISTOCENE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
FORAM BEARING SANDY SILTY CLAY
Olive gray to olive black SILTY CLAY with occasional DIATOM RICH INTERVALS, SILT beds, and SAND beds.
DIATOM BEARING SILTY CLAY
DIATOM OOZE


SAND SHALE RATIO
CLAY % (<2μ)
MICA CHLOR. MONT.
VOLCANIC ASH
DENSITY -g/cm3
~GRAPE ▲SECTION WT.
□ SYRINGE SAMPLE
POROSITY -%
~GRAPE
○SYRINGE SAMPLE
NATURAL GAMMA
10³ counts/75 sec
SOUND VELOCITY
km/sec
.10
.02
.02
.07
.45
.09
.18
0
.5
.09
.09
.03
0
0
.07
0
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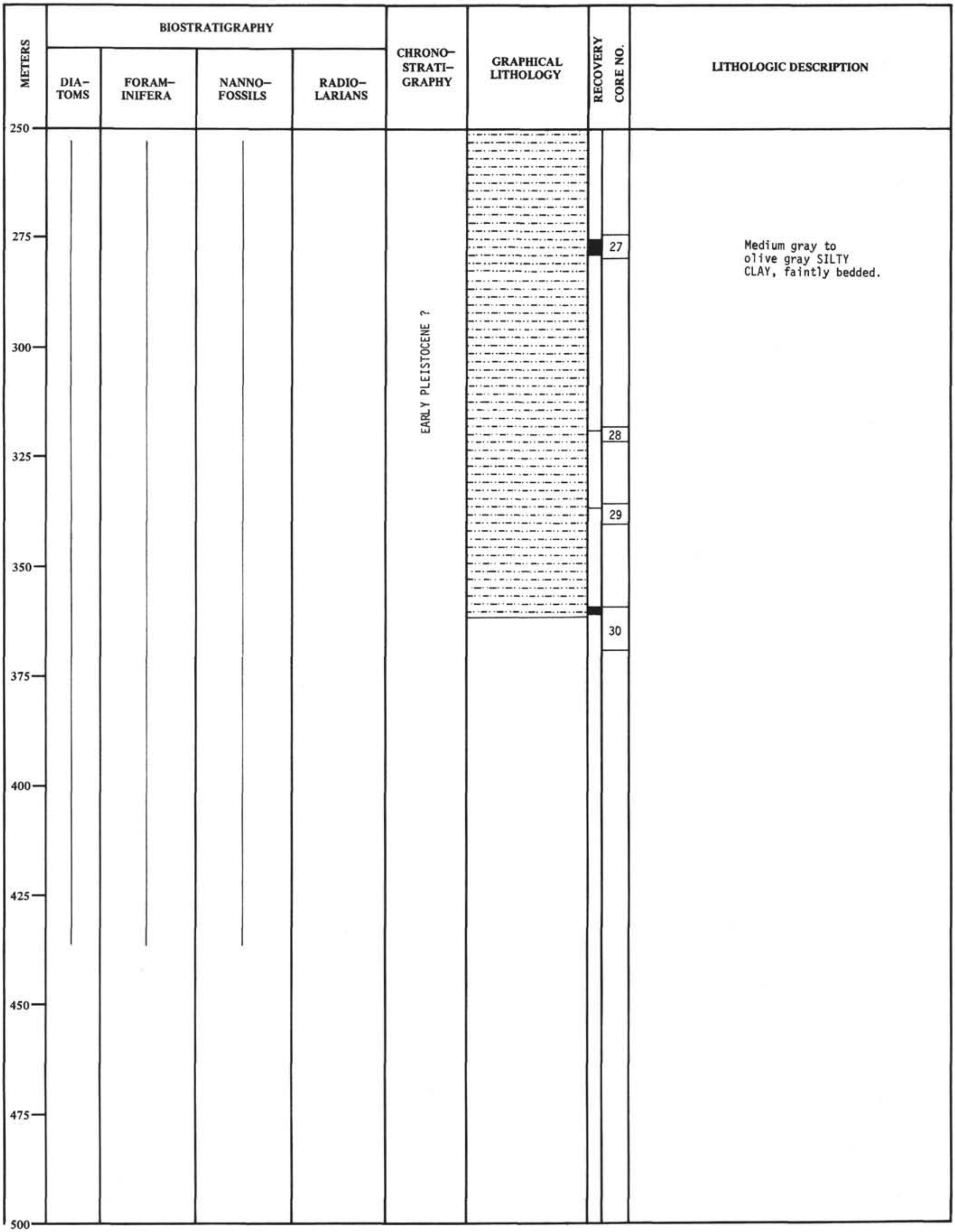
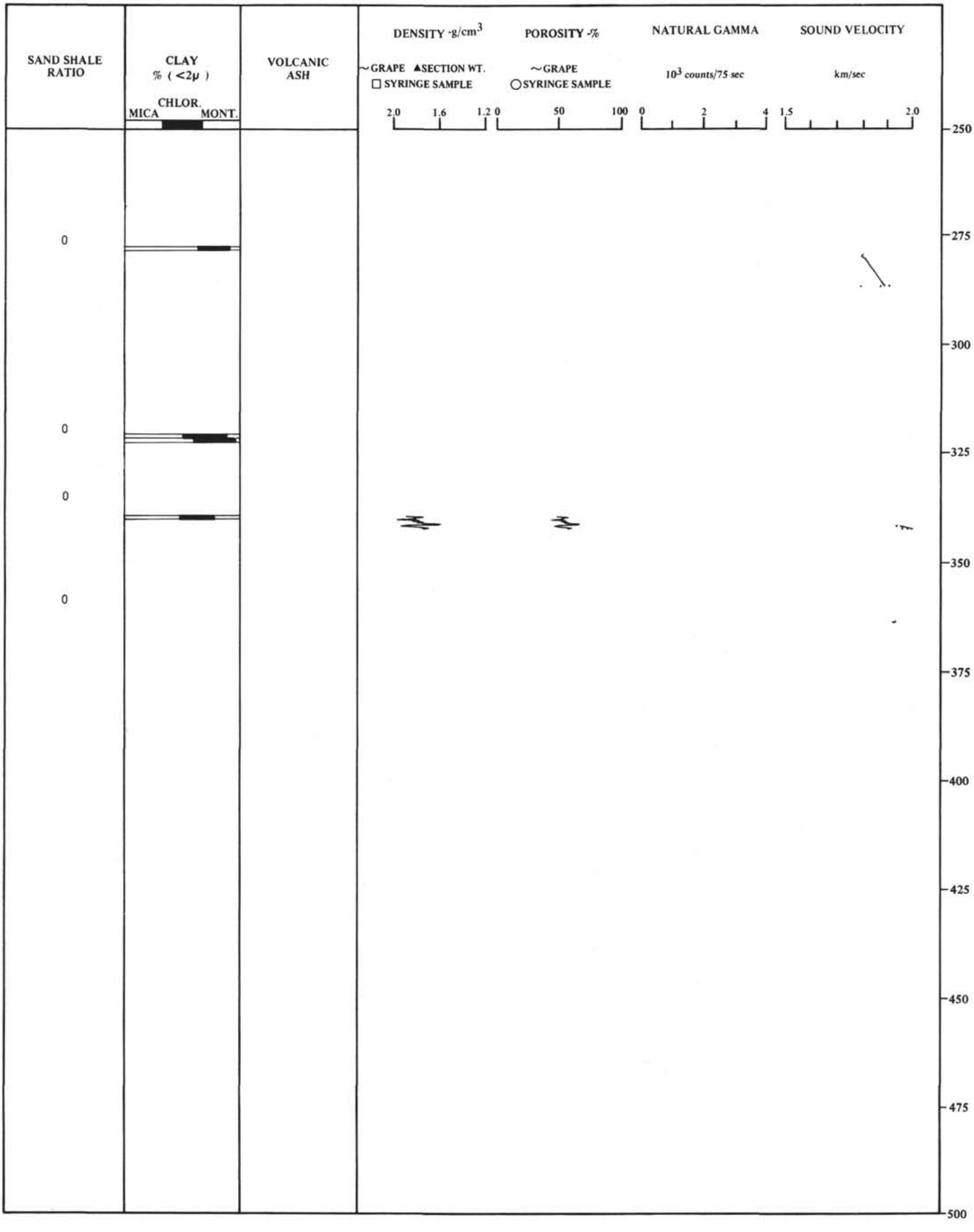
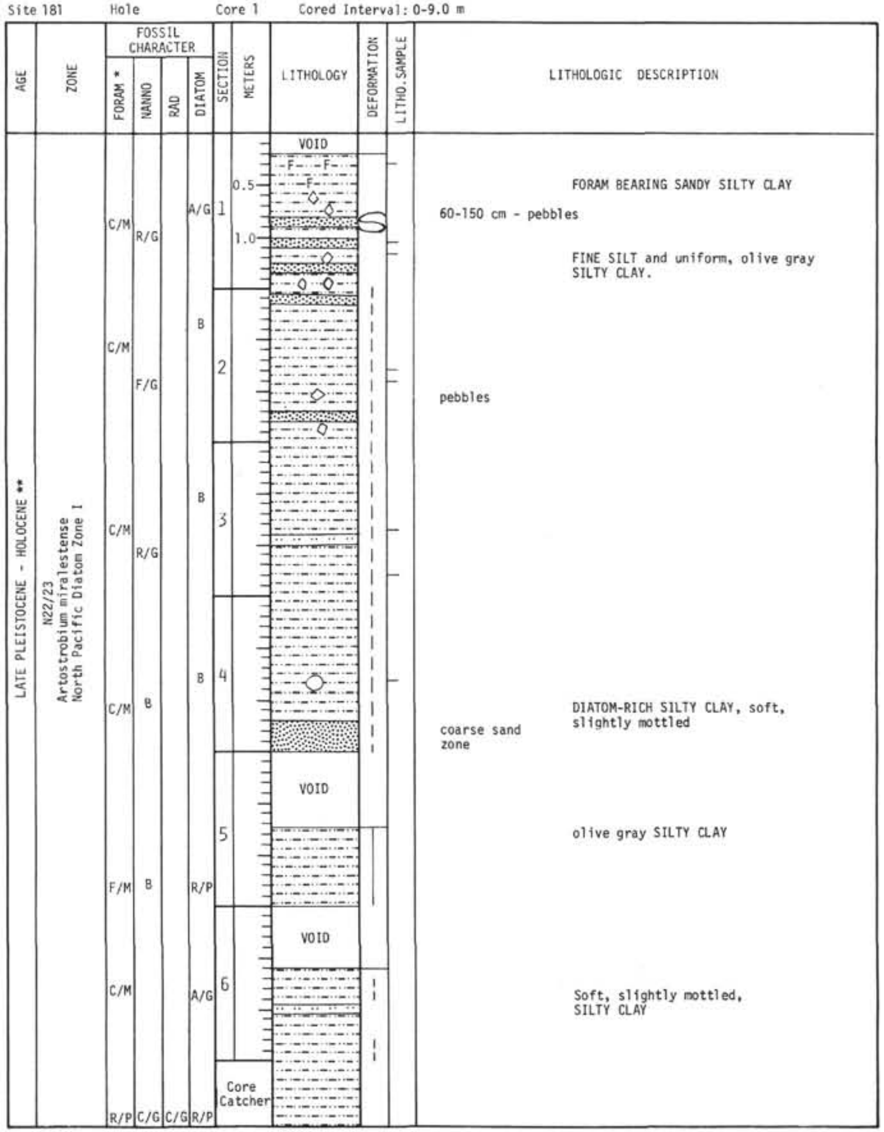
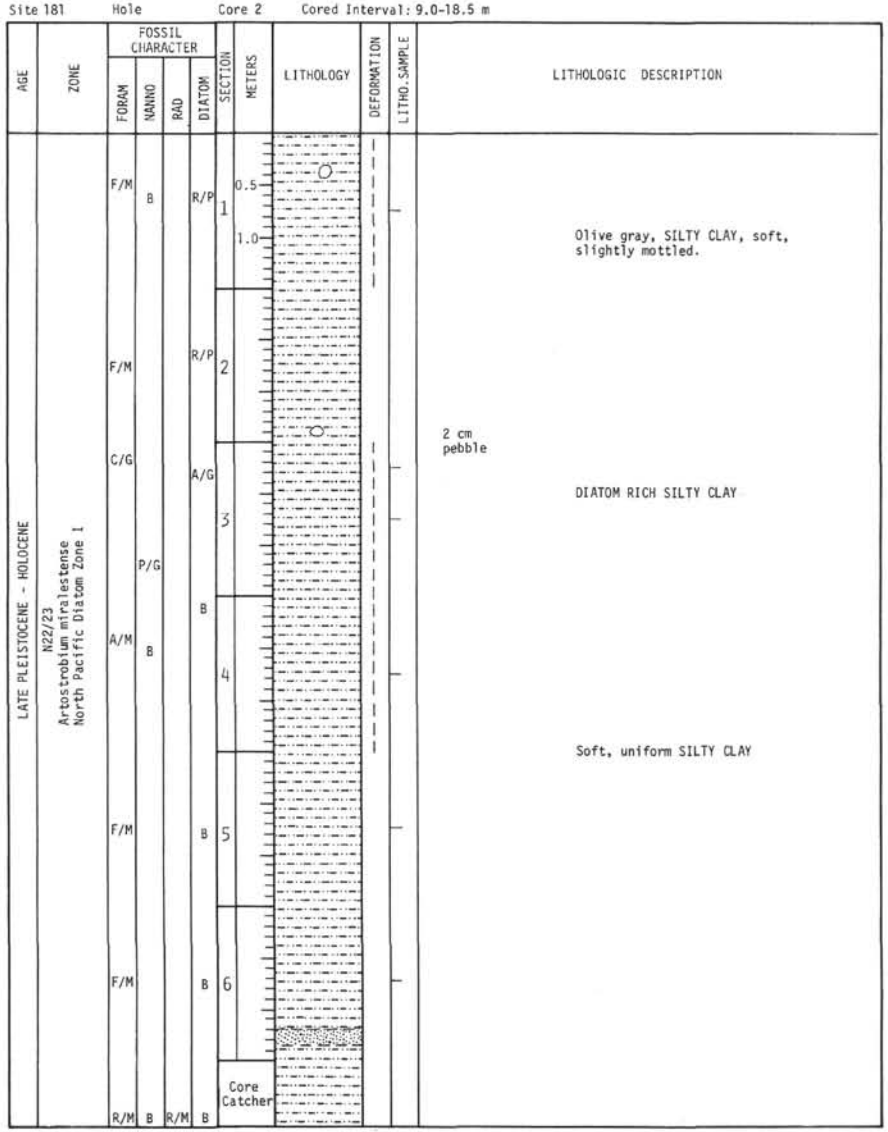
150
175
200
225
250


METERS
BIOSTRATIGRAPHY
DIA-
TOMS
FORAM-
INIFERA
NANNO-
FOSSILS
RADIO-
LARIANS
CHRONO-
STRATI-
GRAPHY
GRAPHICAL
LITHOLOGY
RECOVERY
CORE NO.
LITHOLOGIC DESCRIPTION
250
275
300
325
350
375
400
425
450
475
500
EARLY PLEISTOCENE ?
27
28
29
30
Medium gray to
olive gray SILTY
CLAY, faintly bedded.


SAND SHALE RATIO
CLAY % (<2μ)
CHLOR.
MICA
MONT.
VOLCANIC ASH
DENSITY -g/cm3
~GRAPE ▲SECTION WT.
□ SYRINGE SAMPLE
POROSITY -%
~GRAPE
○SYRINGE SAMPLE
NATURAL GAMMA
10³ counts/75 sec
SOUND VELOCITY
km/sec
2.0 1.6 1.2
0 50 100
0 2 4
1.5 2.0
0
0
0
0
250
275
300
325
350
375
400
425
450
475
500



Explanatory notes in chapter 1
*Planktonic foraminifera
**Holocene-Pleistocene boundaryd could not be delineated with certainty and Holocene sediments may well be present below Core 1 but no lower than Core 12.



Explanatory notes in chapter 1

Site 181 Hole Core 3 Cored Interval: 18.5-28.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone I				B	1	0.5, 1.0	VOID			Olive gray SILTY CLAY, soft, sticky and uniform
		R/M			R/P	2					fine-medium sand; silty blebs
		B			R/M	3					SILTY CLAY, soft to firm, slightly mottled; sand blebs
		R/M			C/G	4					sand blebs, 1 cm bedding remnants; SANDY SILTY CLAY
		R/M	B	R/M	B	Core Catcher					

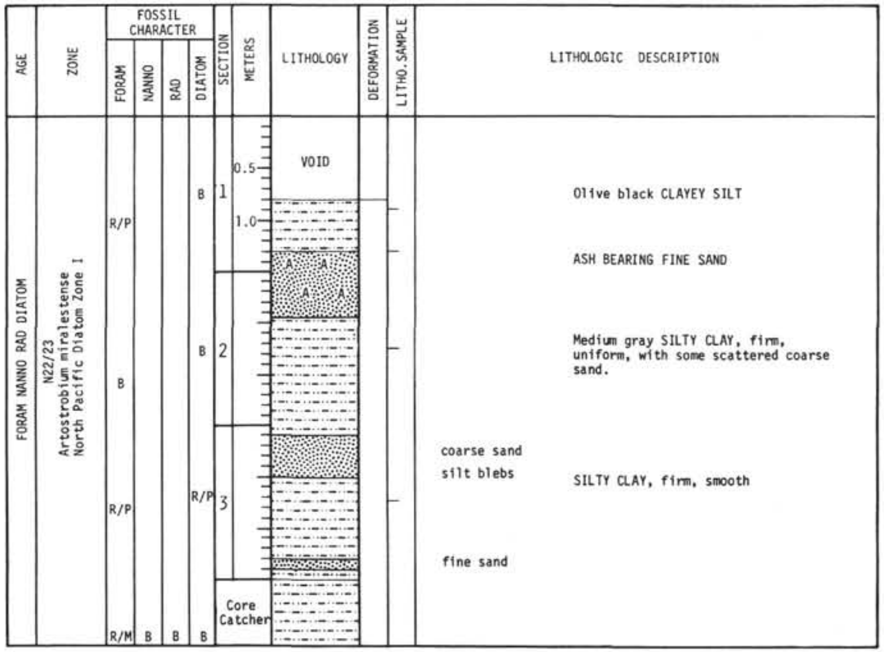
Explanatory notes in chapter 1

Site 181 Hole Core 4 Cored Interval: 28.0-37.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLESITOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone II	B			B	1	0.5, 1.0	VOID			
					R/P	2					pebble zone; coarse sand zone; Olive black SILTY CLAY
		B			B	3					SILT, poorly sorted
		B			B	4					very fine sand; SILTY CLAY, firm, uniform
						5					
						6					
		R/M	B	B	B	Core Catcher					

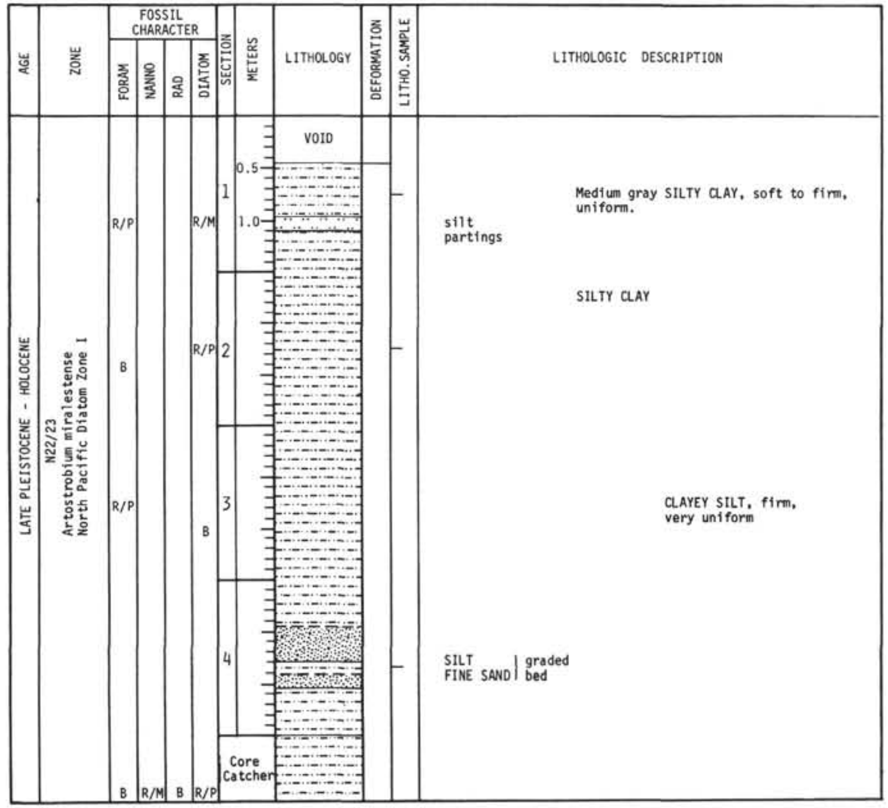
Explanatory notes in chapter 1

Site 181 Hole Core 5 Cored Interval: 37.5-47.0 m



Explanatory notes in chapter 1

Site 181 Hole Core 6 Cored Interval: 47.0-56.5 m



Explanatory notes in chapter 1

Site 181 Hole Core 7 Cored Interval: 56.5-66.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone I				R/P	1	0.5, 1.0				SANDY SILT; pebbles; Medium gray, SILTY CLAY, firm, uniform, poorly bedded
		R/P			B	2					SILT, firm, uniform, thick bedded and CLAYEY SILT; very fine SAND
		R/P			B	3					SANDY SILT; SILTY CLAY, firm, uniform; SANDY SILT; pebbles
		R/M	B	B	R/P	Core Catcher					

Explanatory notes in chapter 1

Site 181 Hole Core 8 Cored Interval: 66.6-75.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone I				B, B	1	0.5, 1.0				4 cm pebble; Medium gray SILTY CLAY, firm, uniform, massive.
		R/P			R/P	2					
		B			B	3					
		B			R/P	4					
		R/P			R/P	5					
		B	R/P	B	B	Core Catcher					

Explanatory notes in chapter 1

Site 181 Hole Core 9 Cored Interval: 75.5-85.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone I	R/P			R/P	1	0.5, 1.0	VOID			scattered pebbles; SILTY CLAY, firm to compact, uniform
					R/P						sand blebs
		F/P			C/G	2					rare pebbles and coarse sand
						3					SAND, fine to medium grained, fair sorting, possible slight grading
		R/P			R/M						pebbles; coarse sand
		B			C/G	4					SILTY CLAY, fine grained, uniform, compact, smooth
		R/M	F/G	B	R/P	Core Catcher					

Site 181 Hole Core 10 Cored Interval: 85.0-94.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
L. PLEIST HOLOCENE	N22/23 A. miralestense NPD I	B	R/G	B	R/P	Core Catcher					Fine grained SAND and SILTY CLAY; SAND

Explanatory notes in chapter 1

Site 181 Hole Core 11 Cored Interval: 94.5-104.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 A. miralestense NPD I	B			B	1	0.5, 1.0	VOID			2 cm pebble; olive gray SILTY CLAY, firm to compact, fine grained, uniform.
					B						SAND layer
		F/M	B	B	C/G	Core Catcher					

Site 181 Hole Core 12 Cored Interval: 104.0-113.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone II	R/P			R/M	1	0.5, 1.0	VOID			
		R/P			R/M	2					SAND blebs; Medium dark gray SILTY CLAY, firm to compact, uniform
											blebs of VERY FINE SAND
		B			A/G	3					3 cm pebble; FINE AND MED. SAND
					C/G						1 cm pebble
		R/P	B	F/M	C/G	Core Catcher					

Explanatory notes in chapter 1

Site 181 Hole Core 13 Cored Interval: 113.5-123.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone II	R/M			C/G	1	0.5, 1.0	1 cm pebble and smaller pebbles — Olive gray, SILTY CLAY
		R/P			C/G	2		3 cm pebble and smaller pebbles — Medium dark gray to olive gray DIATOM BEARING SILTY CLAY, firm and uniform
		R/M			A/G	3		2 cm pebble — SILTY CLAY
		R/M			C/G	4		pebble — DIATOM BEARING SILTY CLAY; FINE GRAINED SAND, FAIR SORTING; 3 cm pebble
		R/M			R/G, R/P	5		small pebbles and COARSE SAND ZONE
		R/P			R/P, R/P	6		sand bleb — SILTY CLAY, firm to compact, uniform, fine grained.; SILTY MUD
		R/M	B	F/M	R/P	Core Catcher		

Explanatory notes in chapter 1

Site 181 Hole Core 14 Cored Interval: 123.0-132.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone II	R/G			B	1	0.5, 1.0	VOID	Fine to medium grained Med. dark gray to olive gray SANDY SILTY CLAY
		R/P			C/G	2			DIATOM BEARING SILTY CLAY, very slightly bedded at the top.
		R/M	B	F/M	A/G	Core Catcher			

Explanatory notes in chapter 1

Site 181 Hole Core 15 Cored Interval: 132.5-142.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone II					1	0.5	VOID			
							1.0				
		B			C/G						Med. dark gray to olive gray SILTY CLAY
		B			C/G	2					some COARSE SAND
		B			C/G	3					DIATOM BEARING SILTY CLAY, firm to stiff, uniform, massive.
					C/G	4					
					C/G						
					C/G						
		R/P				5					
		B			C/G						
					C/G						CLAYEY SILT
		R/M	B	F/M	C/G	Core Catcher					

Site 181 Hole Core 16 Cored Interval: 142.0-151.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
L. PLEIS.-HOLOCENE	N22/23-A. miralestense NPD II	B	B	B	C/G	Core Catcher					FINE SAND, SILT, and CLAY

Explanatory notes in chapter 1

Site 181 Hole Core 17 Cored Interval: 151.5-161.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23 Artostrobium miralestense North Pacific Diatom Zone II					1	0.5	VOID			
							1.0				
					R/M						Med. gray SILTY CLAY, firm to stiff, uniform
		B			R/M	2					SILT blebs
											carbonaceous SILTY AND CLAY
		R/P			R/M	3					CLAY
					C/G						
		B			C/G	4					Med. dark gray DIATOM BEARING SILTY CLAY, firm to stiff, uniform, massive.
		R/M			C/G	5					SILTY CLAY
		B			C/G	6					SILT, uniform, graded bed
					R/M						
		R/M	B	C/M	C/G	Core Catcher					

Explanatory notes in chapter 1

Site 181 Hole Core 18 Cored Interval: 161.0-169.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE - HOLOCENE	N22/23? Artostrobium miralestense North Pacific Diatom Zone II	F/M, R/M, R/P, B, R/P	B	R/M	C/G, A/G, C/G, A/G, A/G, A/G, A/G, A/G, A/G, B	1, 2, 3, 4, Core Catcher	0.5, 1.0	VOID			Med. dark gray SILTY CLAY COARSE SAND GRAINS SILT BLEBS DIATOM SILTY CLAY firm to stiff, slightly mottled, slightly sandy. silt beds SILTY CLAY DIATOM OOZE, firm to stiff. diffuse contact pebble silty layers pebbles silty blebs Olive gray DIATOM RICH SILTY CLAY

Site 181 Hole Core 19 Cored Interval: 169.0-177.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	—	B, B	B	B	B, B	1, Core Catcher	0.5, 1.0	VOID			Greenish black SILTY CLAY, compact to hard, fine parting of white silt, dips to 65°, fine fracture pattern now firmly cemented.

Explanatory notes in chapter 1

Site 181 Hole Core 20 Cored Interval: 177.0-186.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLEISTOCENE	—	B, B	B	B	B, B	1, Core Catcher	0.5, 1.0				Gray black and greenish black SILTY CLAY, indurated and hard. Contains fine white silt laminae with 70° dips. Has fine fracture pattern.

Site 181 Hole Core 21 Cored Interval: 186.5-196.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	North Pacific Diatom Zone III	B, B	B	B	C/M, B	1, Core Catcher	0.5, 1.0				Dark gray SILTY CLAY firm to compact. (Possible down hole cuttings). Pebbles scattered throughout.

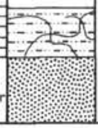
Site 181 Hole Core 22 Cored Interval: 196.0-205.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE	—	B, B	B	B	B, B	1, Core Catcher	0.5, 1.0	VOID			SILTY CLAY with coarse sand grains; indurated, fine fractures throughout.

Explanatory notes in chapter 1

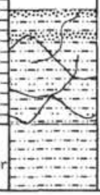
Site 181 Hole Core 23 Cored Interval: 205.5-215.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0	VOID			SILTY CLAY, compact and solid with silt laminae. Much coarse sand scattered throughout core.
		B	B	B	B	Core Catcher					



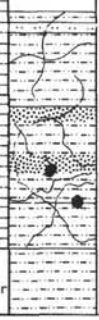
Site 181 Hole Core 24 Cored Interval: 215.0-224.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0	VOID			COARSE SAND SILTY CLAY, solid fine grained, with rare silt laminae dipping 0° to 90°.
		B	B	B	B	Core Catcher					



Site 181 Hole Core 25 Cored Interval: 224.5-234.0 m

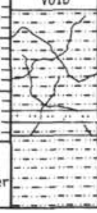
AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0	VOID			Dark olive to greenish black SILTY CLAY, hard to indurated, with white SILT laminae 1-2 mm thick, contorted bedding and fine fracture.
		B			B	2					pebbles very sandy pebbles coarse sand
		B	B	B	B	Core Catcher					



Explanatory notes in chapter 1

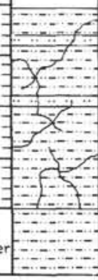
Site 181 Hole Core 26 Cored Interval: 234.0-239.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0	VOID			SILT BLEBS Olive black SILTY CLAY, firm to compact, highly fractured. 6 mm silt laminae
		B	B	B	B	Core Catcher					



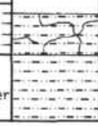
Site 181 Hole Core 27 Cored Interval: 275.0-281.0 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0	VOID			Medium dark gray SILTY CLAY, firm to compact, fine fracture pattern.
		B			B	2					SILT BLEBS SILT BLEBS
		B	R/M	B	B	Core Catcher					



Site 181 Hole Core 28 Cored Interval: 319.5-322.5 m

AGE	ZONE	FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0	VOID			SILTY CLAY, compact to hard with flow structure and coarse sand grains.
		B	B	B	B	Core Catcher					



Explanatory notes in chapter 1

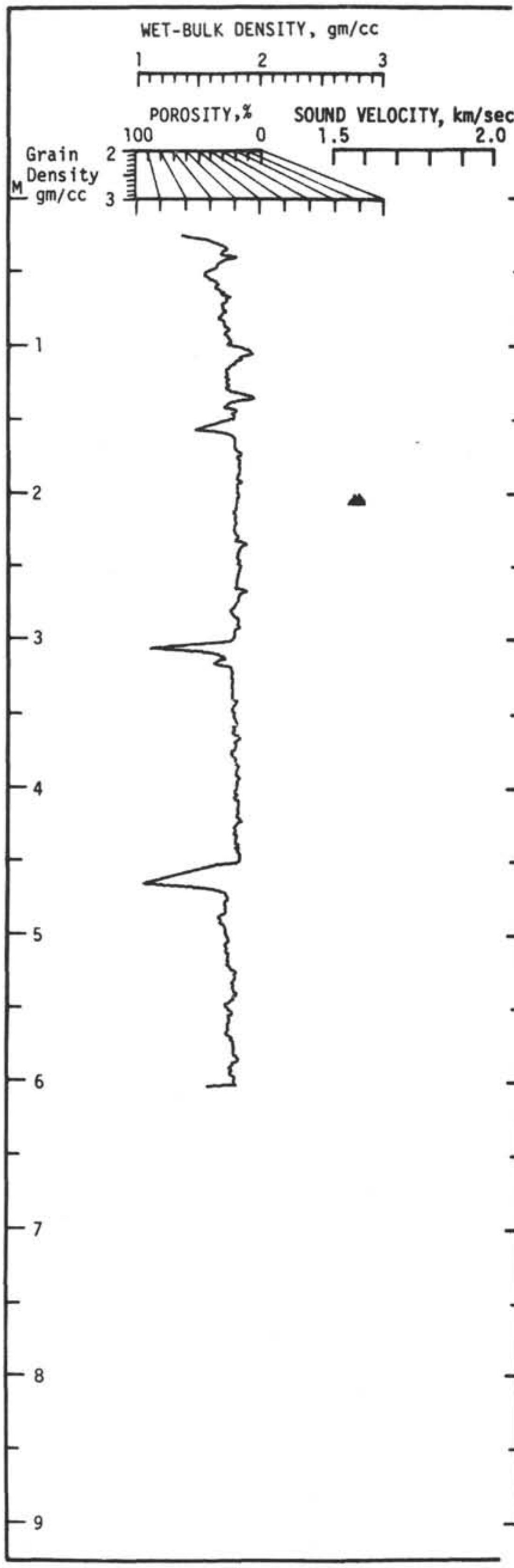
Site 181 Hole Core 29 Cored Interval: 337.5-340.5 m

AGE	ZONE	FOSSIL CHARACTER FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0				Medium dark gray to olive black SILTY CLAY, firm to compact, uniform, faint bedding, fine fracture, moderate distortion.
		B			B	2					
		B				Core Catcher					

Site 181 Hole Core 30 Cored Interval: 360.5-369.0 m

AGE	ZONE	FOSSIL CHARACTER FORAM	NANNO	RAD	DIATOM	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLEISTOCENE ?	—	B			B	1	0.5, 1.0				Medium gray to olive gray SILTY CLAY, firm to compact, slight silty, faintly bedded, finely fractured.
		B	B	B	B	Core Catcher					

Explanatory notes in chapter 1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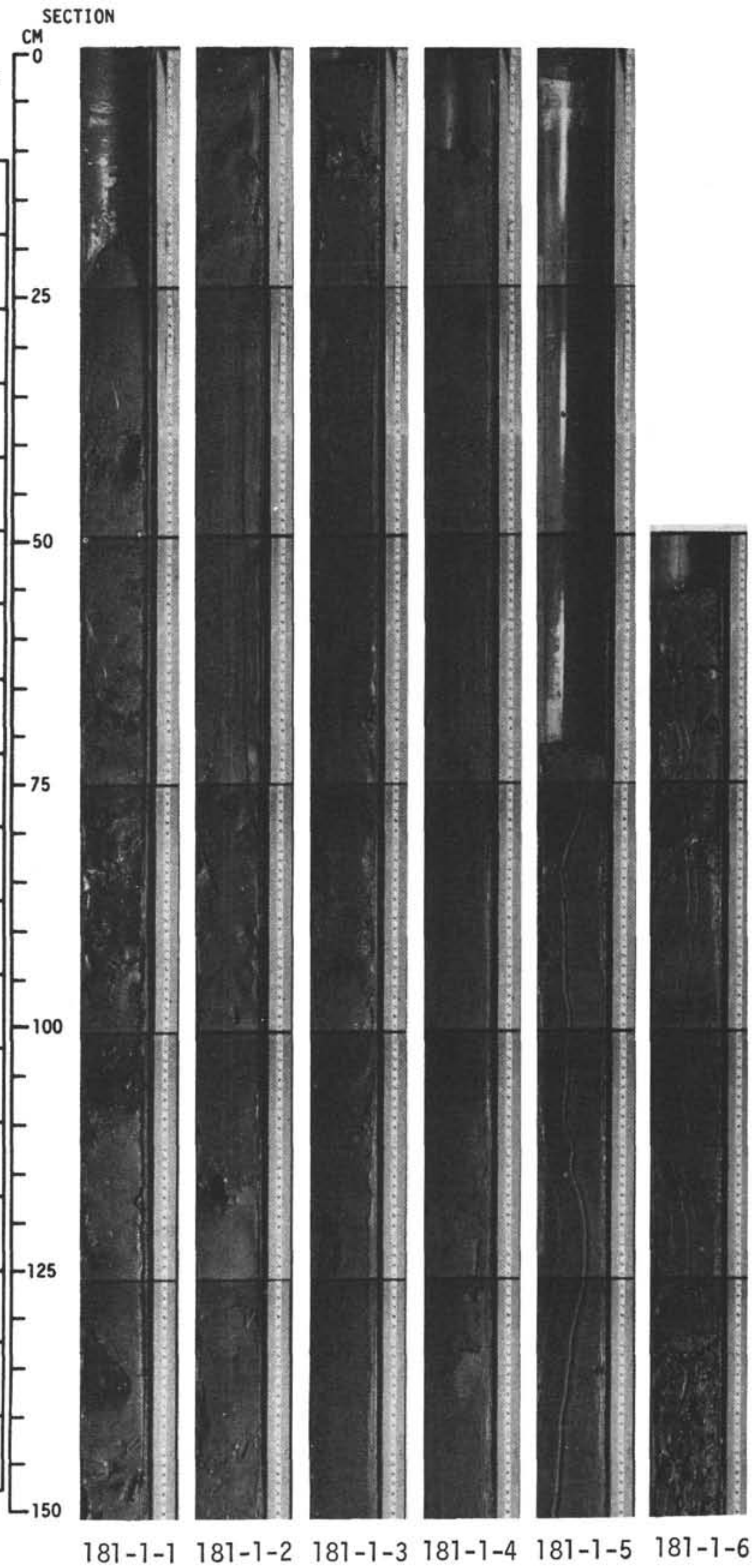
1
2
3
POROSITY,%
100
0
SOUND VELOCITY, km/sec
1.5
2.0
Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
8
9


SECTION
CM
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50
75
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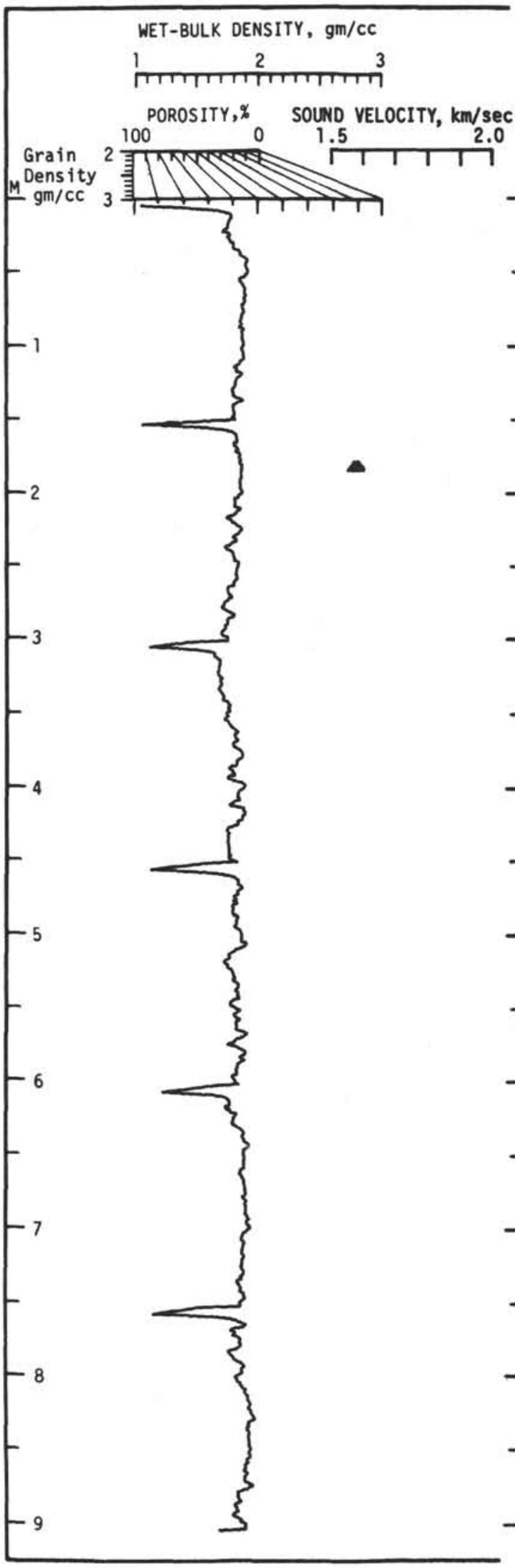
125
150
181-1-1
181-1-2
181-1-3
181-1-4
181-1-5
181-1-6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2
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POROSITY,%
100
0
SOUND VELOCITY, km/sec
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Grain Density gm/cc
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8
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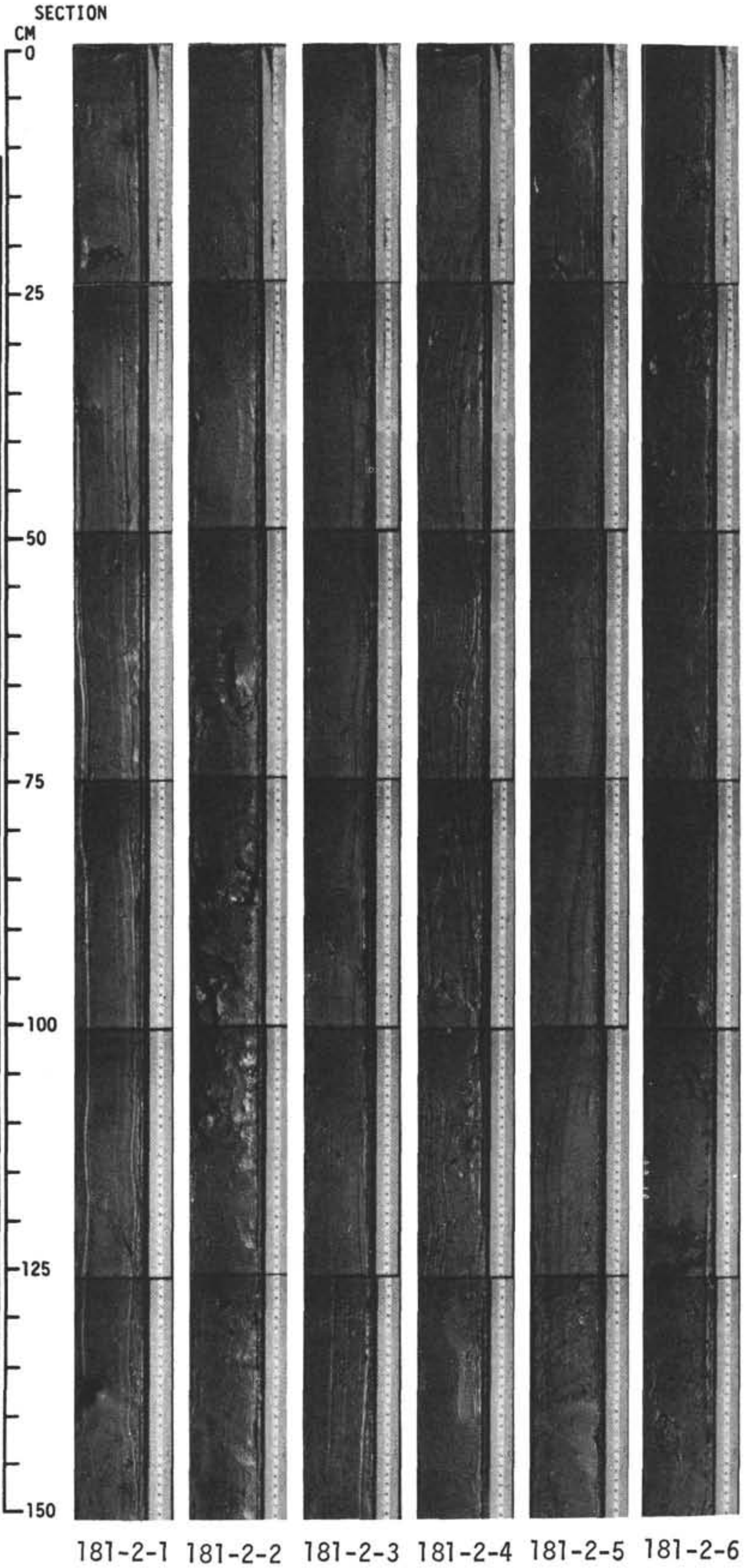
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181-2-4
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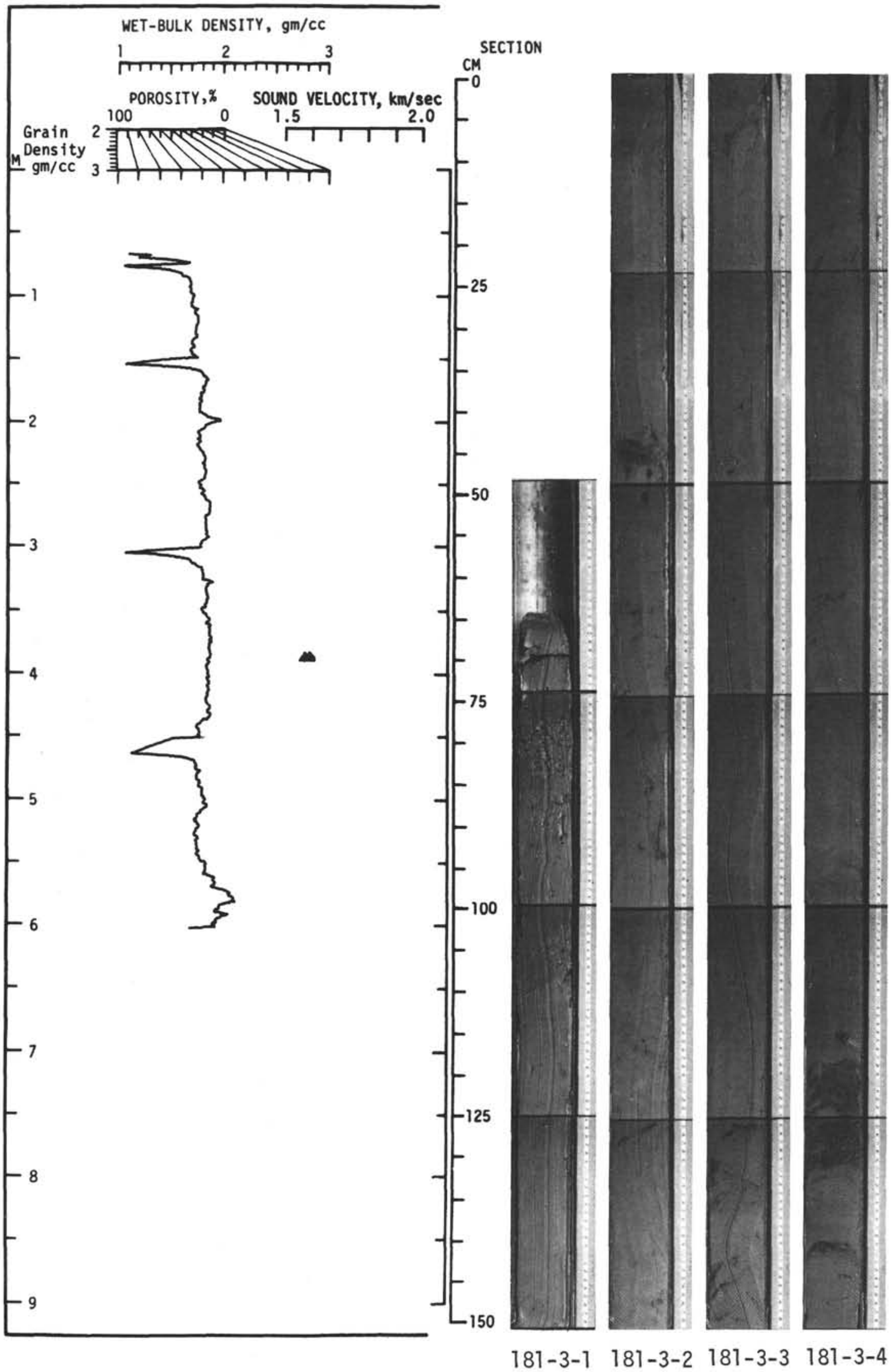
181-2-6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SOUND VELOCITY, km/sec
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2.0
Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
8
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SECTION
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75
100
125
150
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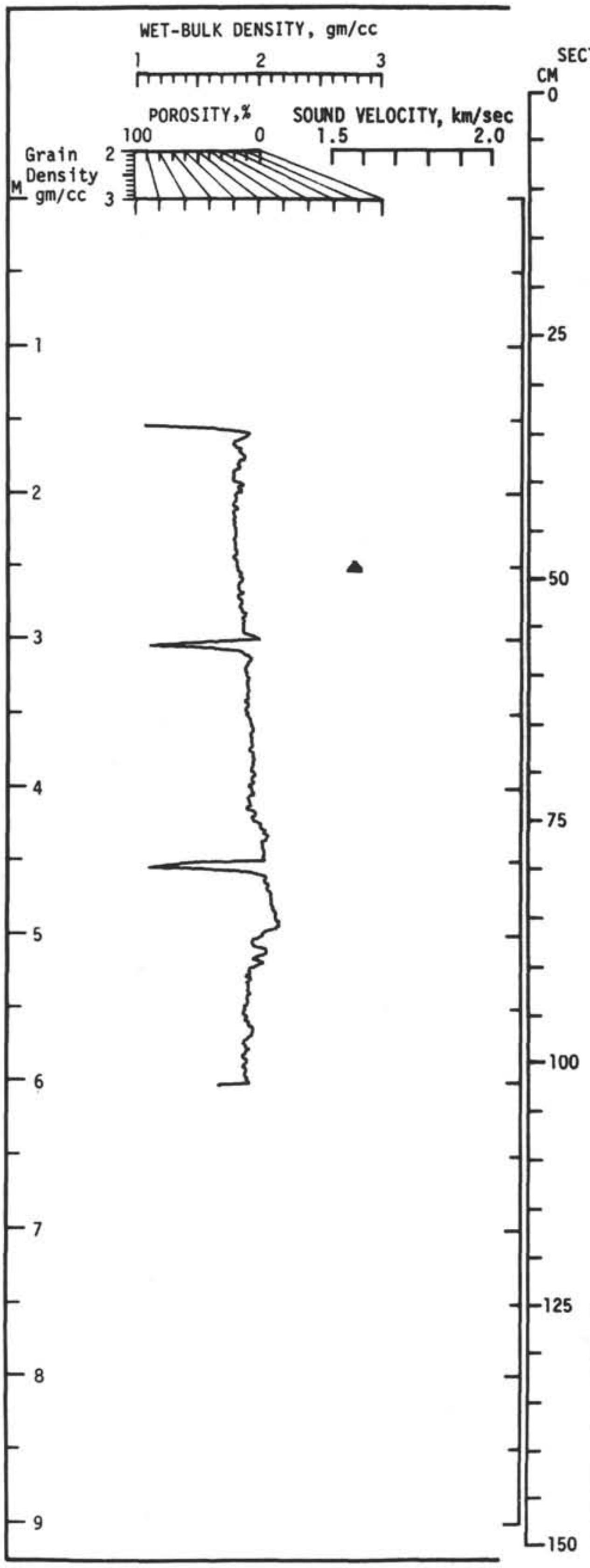
181-3-3
181-3-4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POROSITY,%
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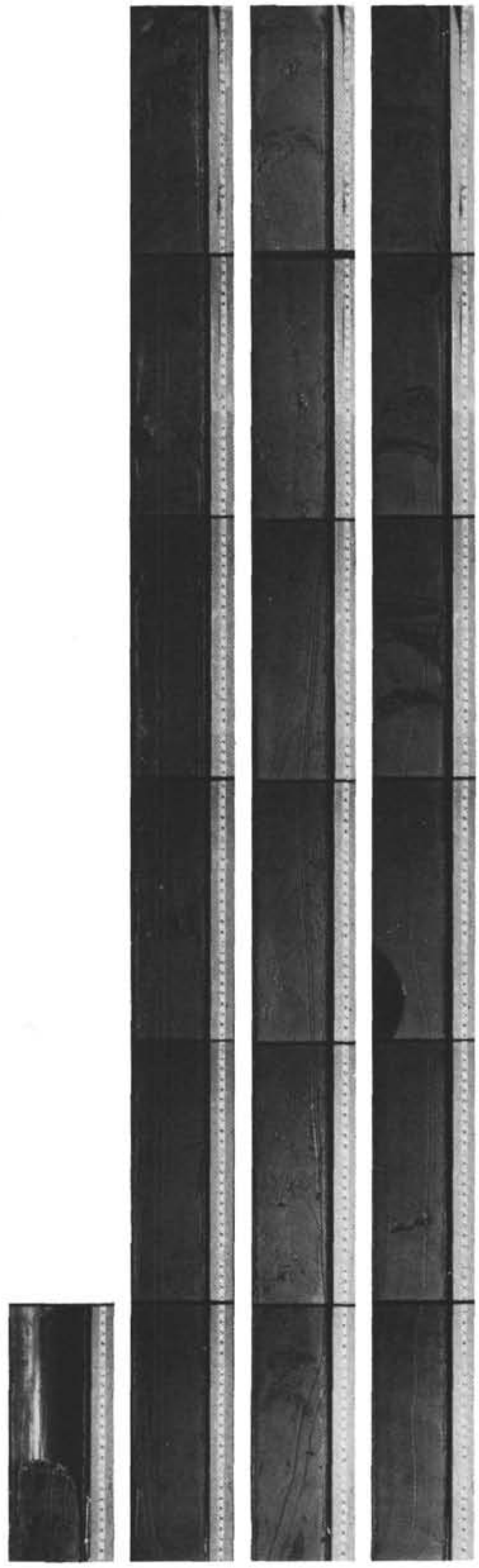
SOUND VELOCITY, km/sec
1.5
2.0
Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150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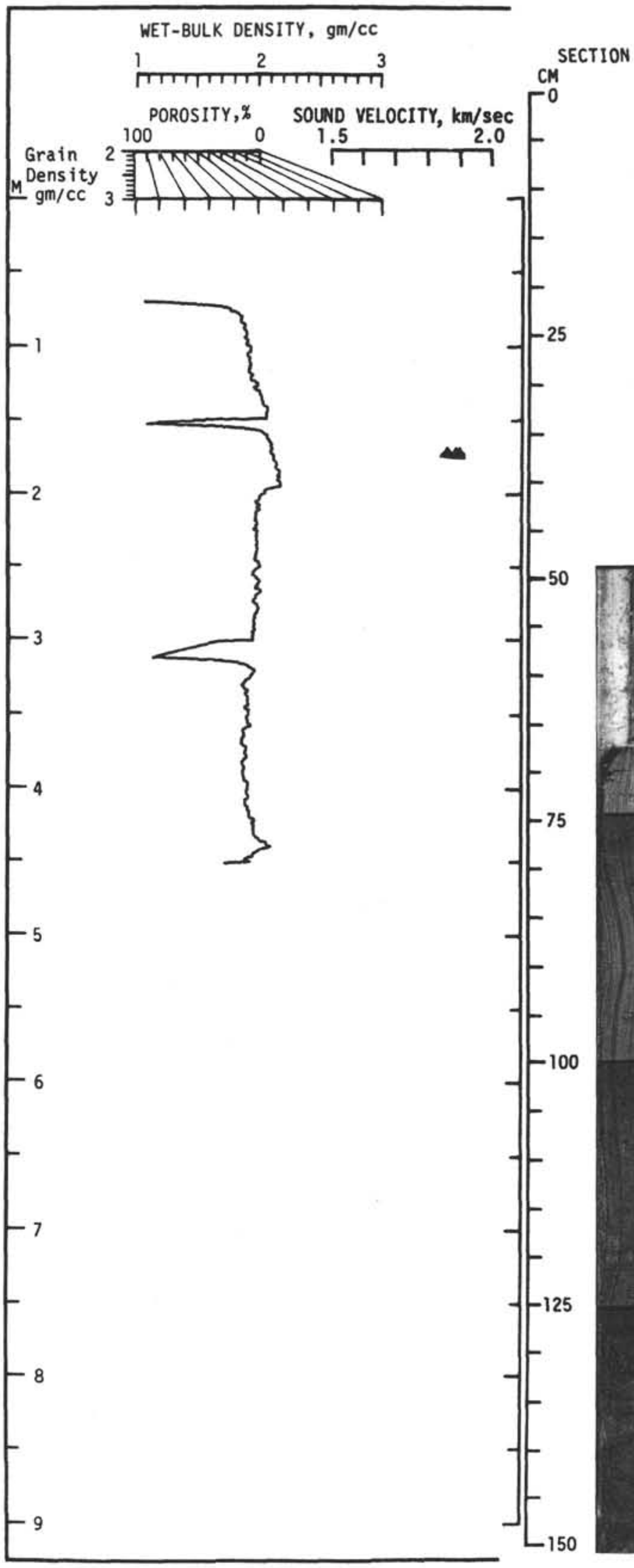
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100
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SOUND VELOCITY, km/sec
1.5
2.0
Grain Density gm/cc
2
3
M
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3
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7
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9
SECTION
CM
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75
100
125
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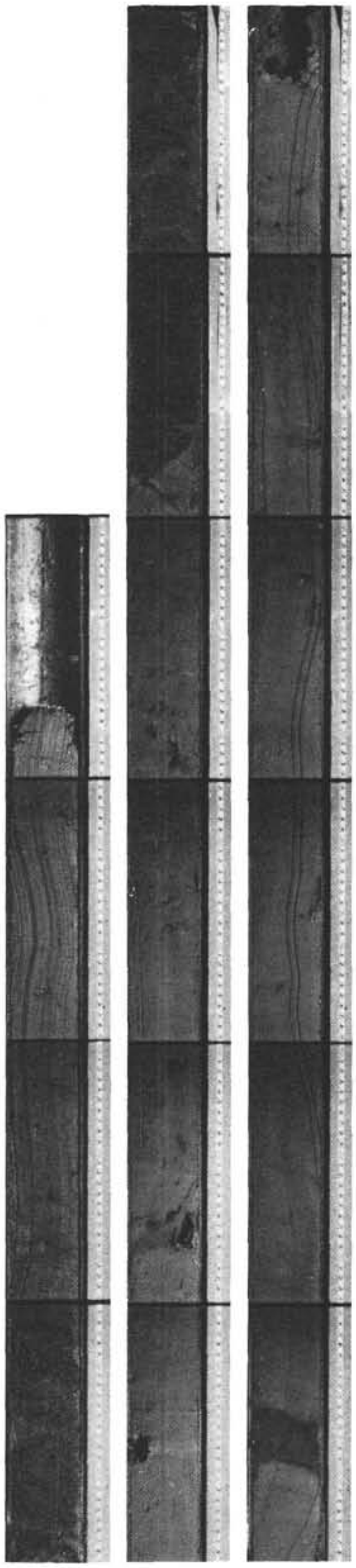
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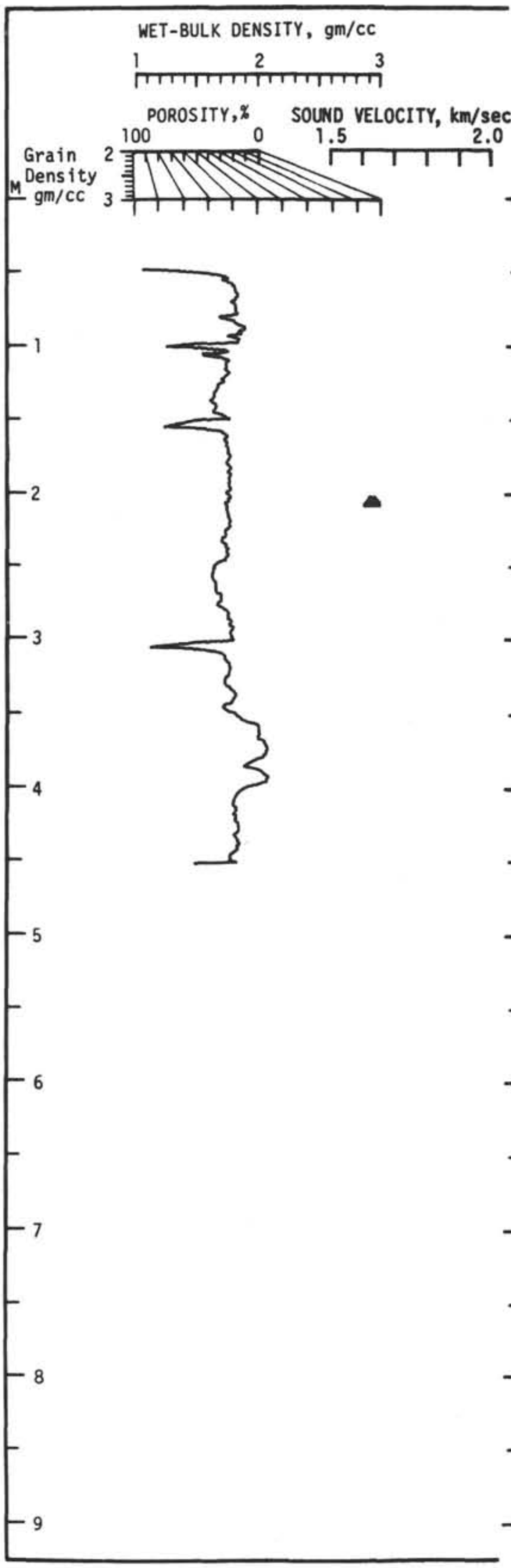

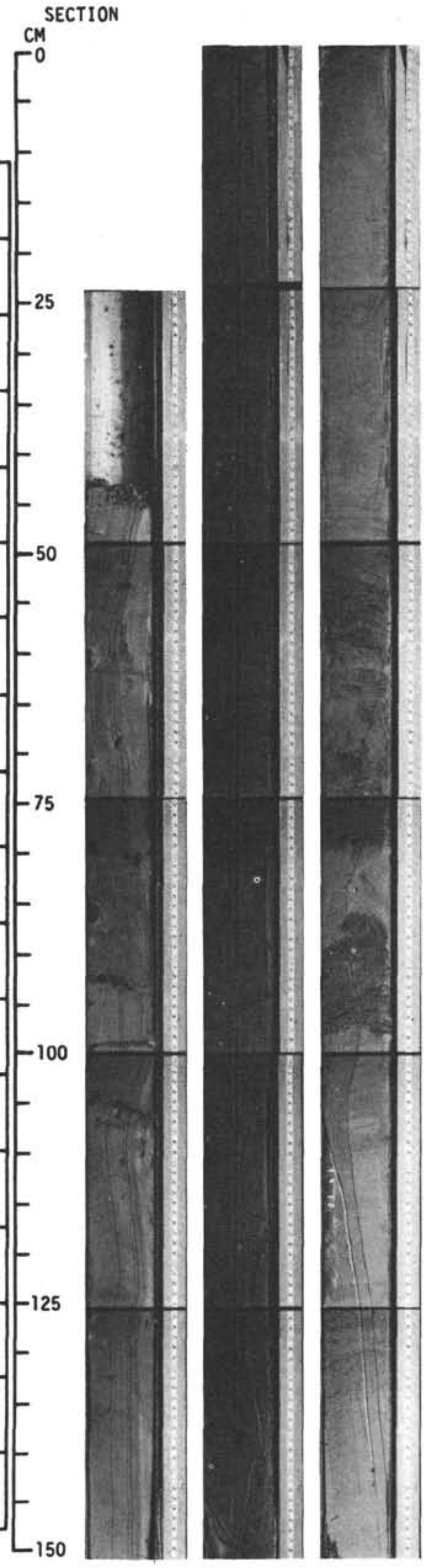

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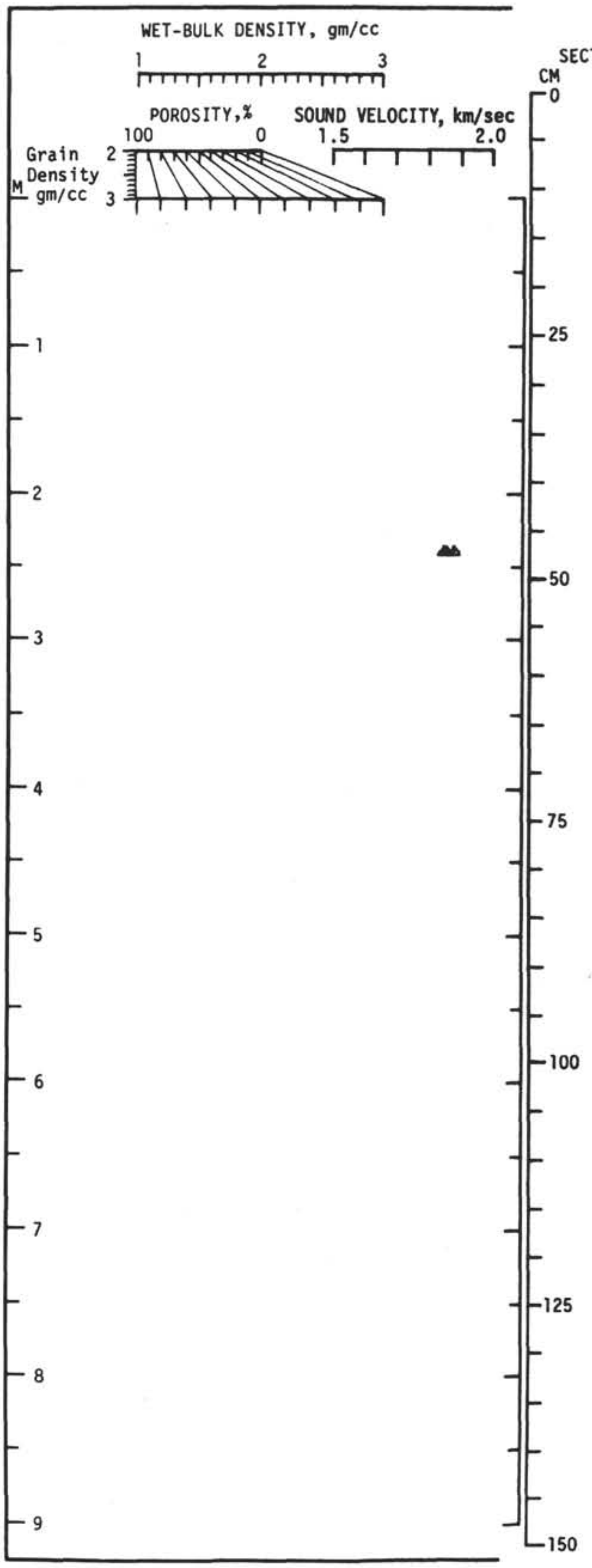

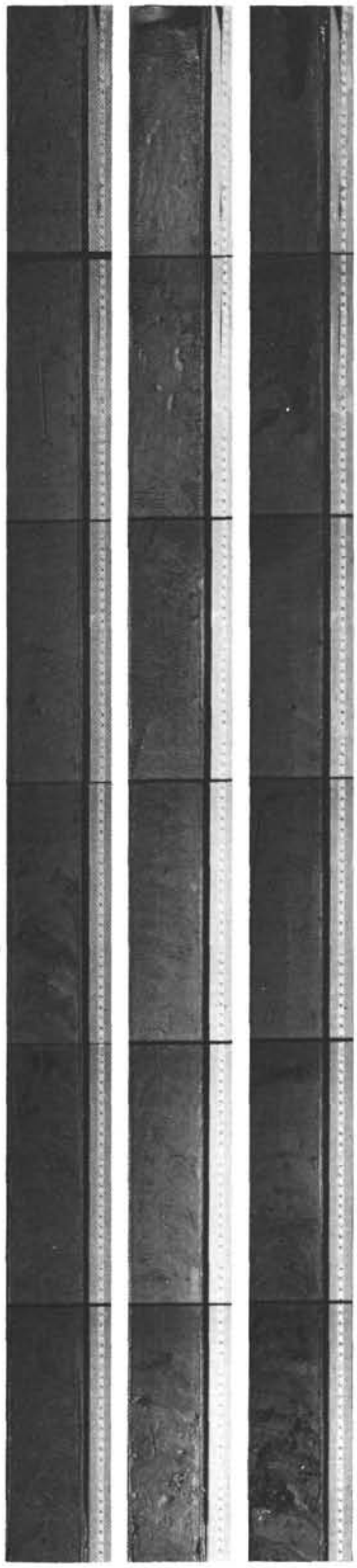
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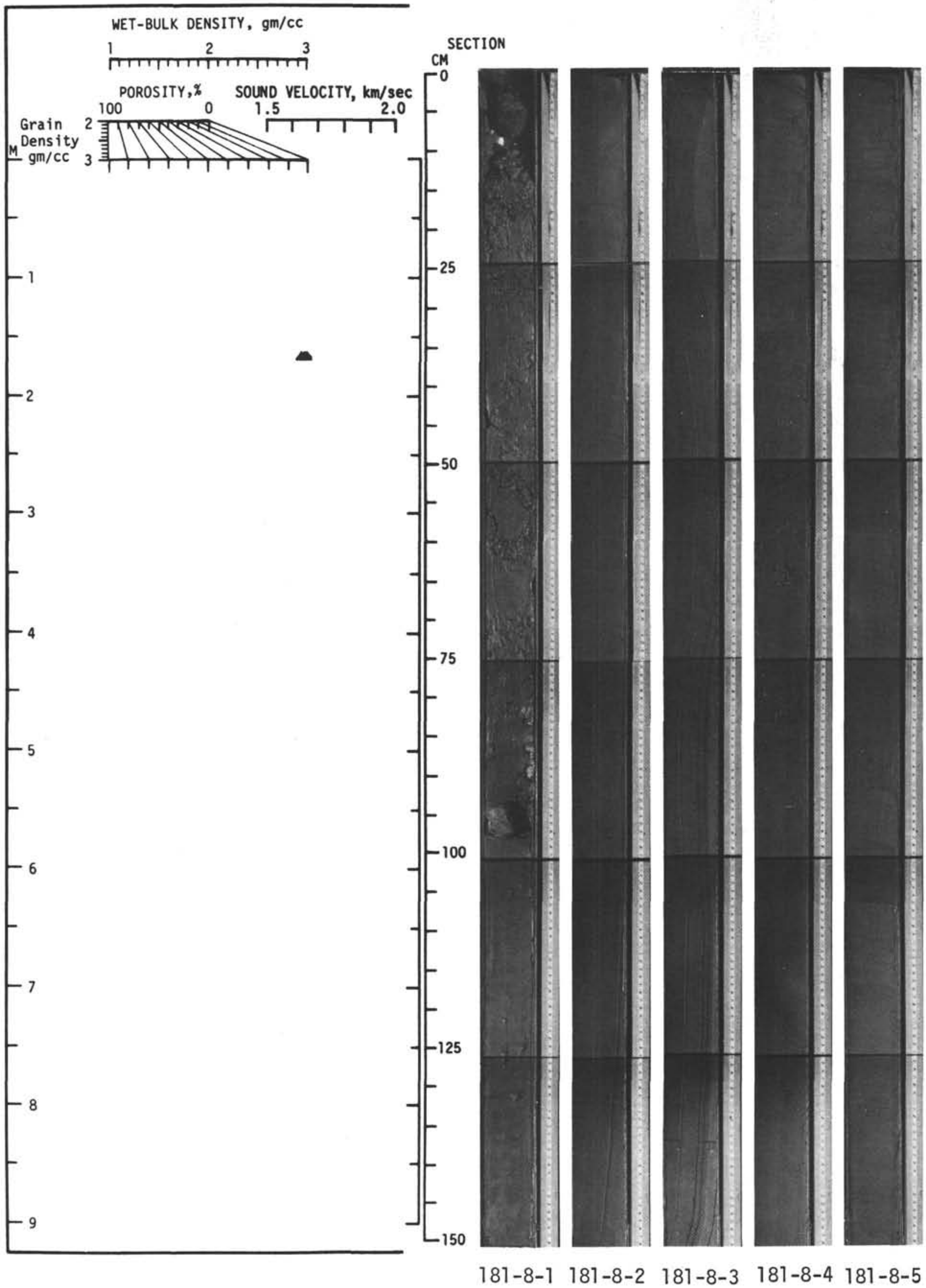
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SOUND VELOCITY, km/sec
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2.0
Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
8
9
SECTION
CM
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75
100
125
150
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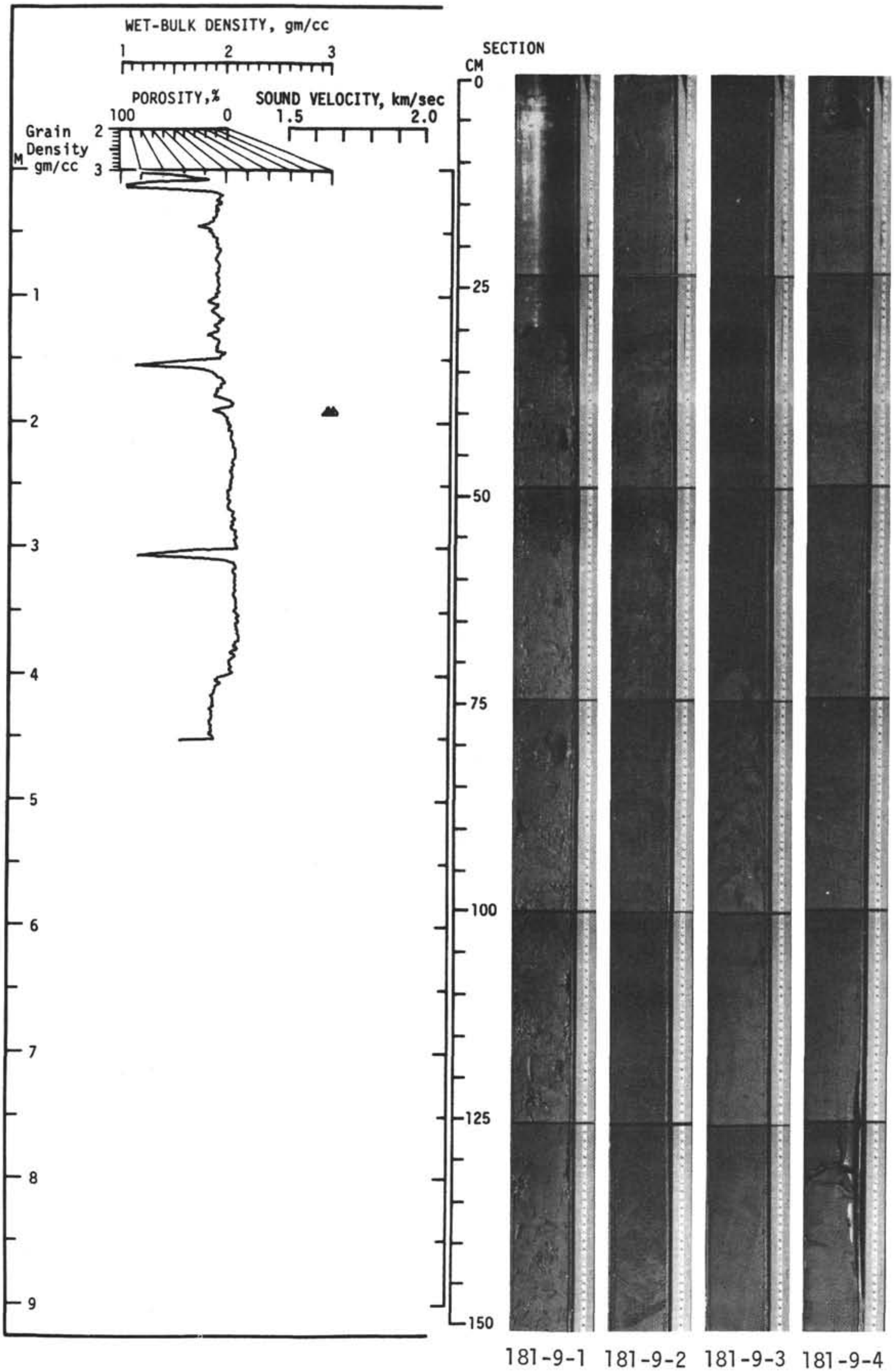
181-8-5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Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
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SECTION
CM
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50
75
100
125
150
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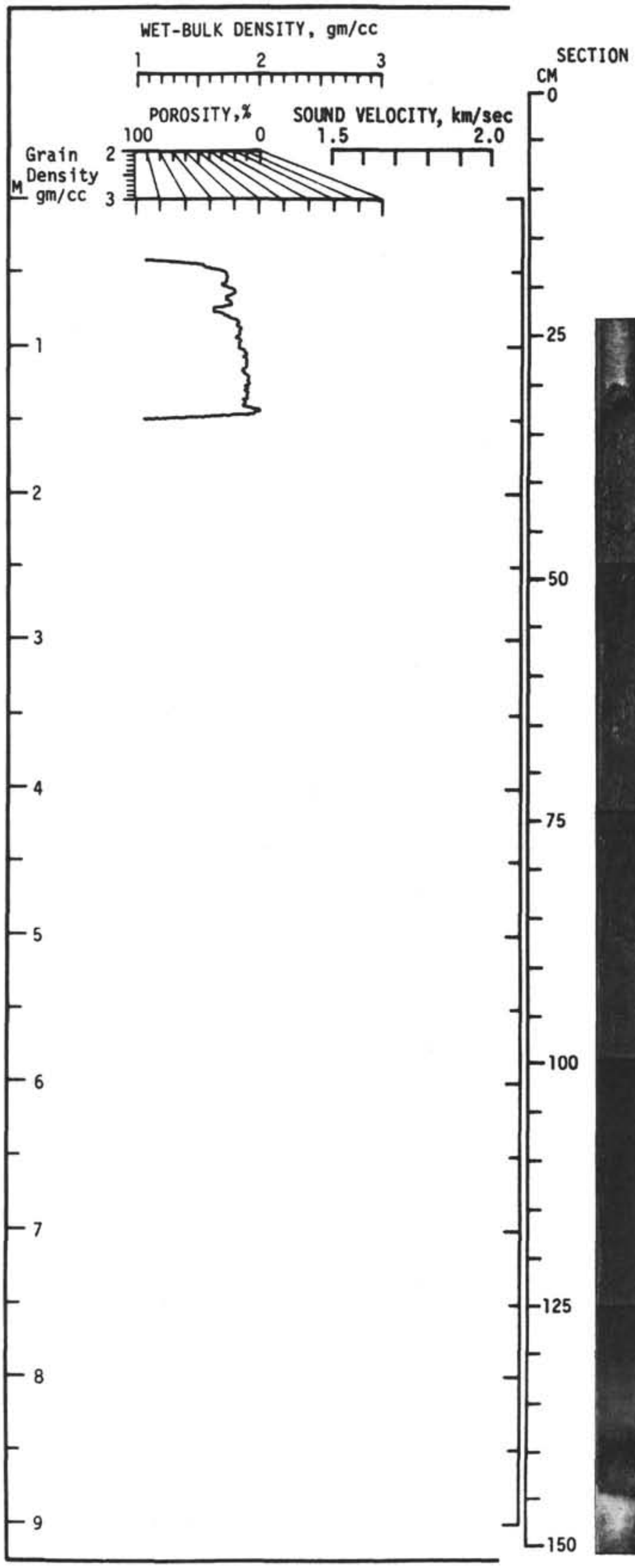
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Grain Density gm/cc
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CM
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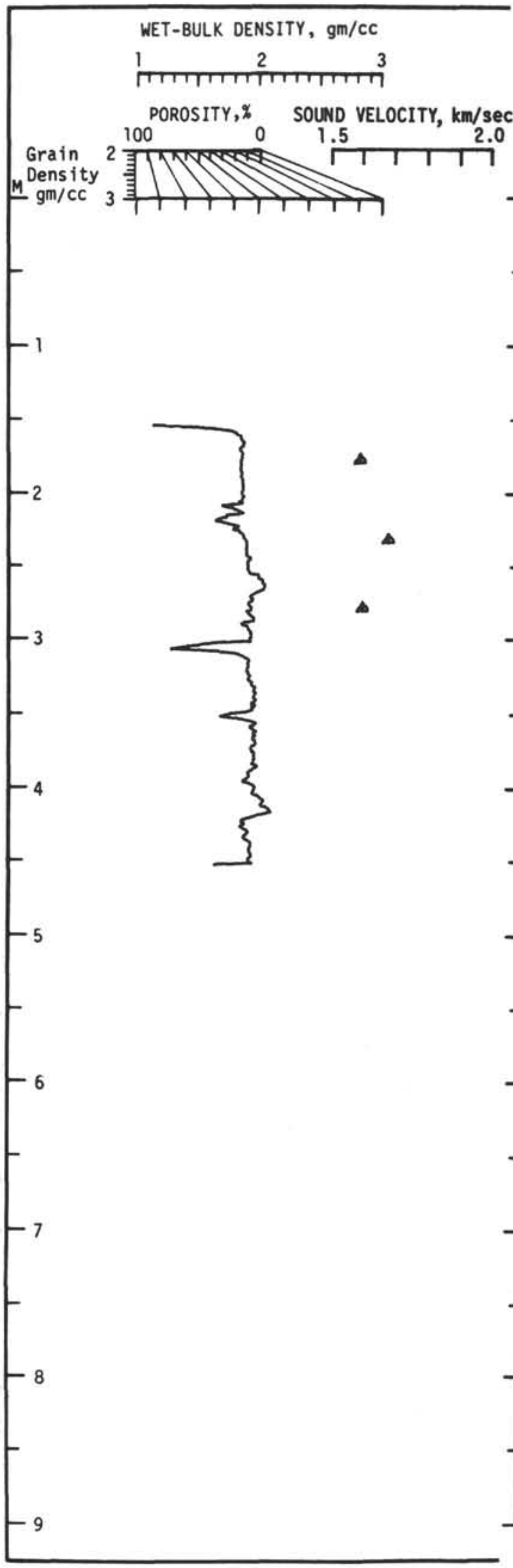

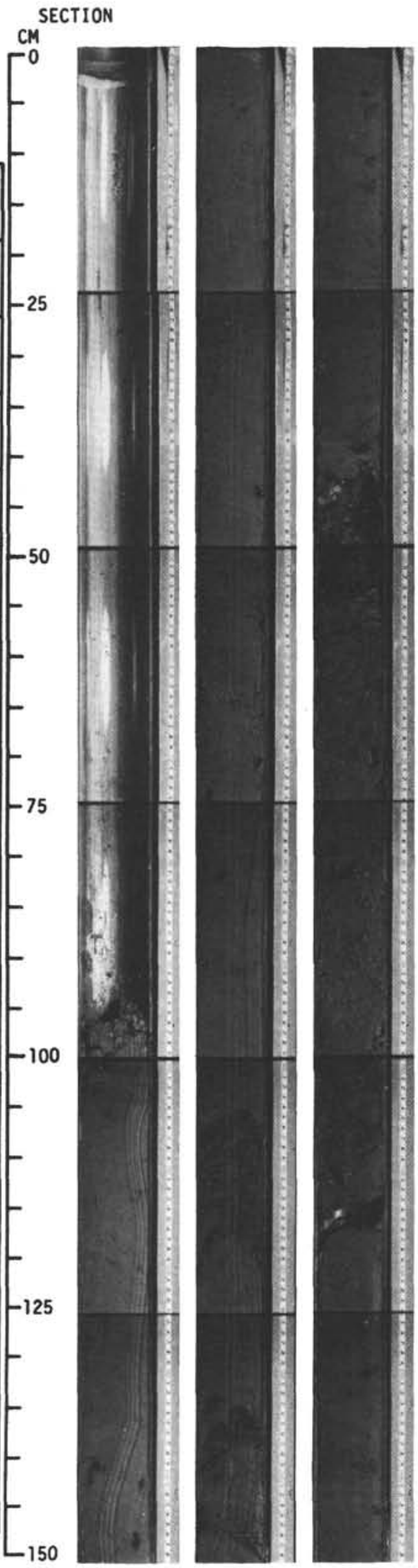

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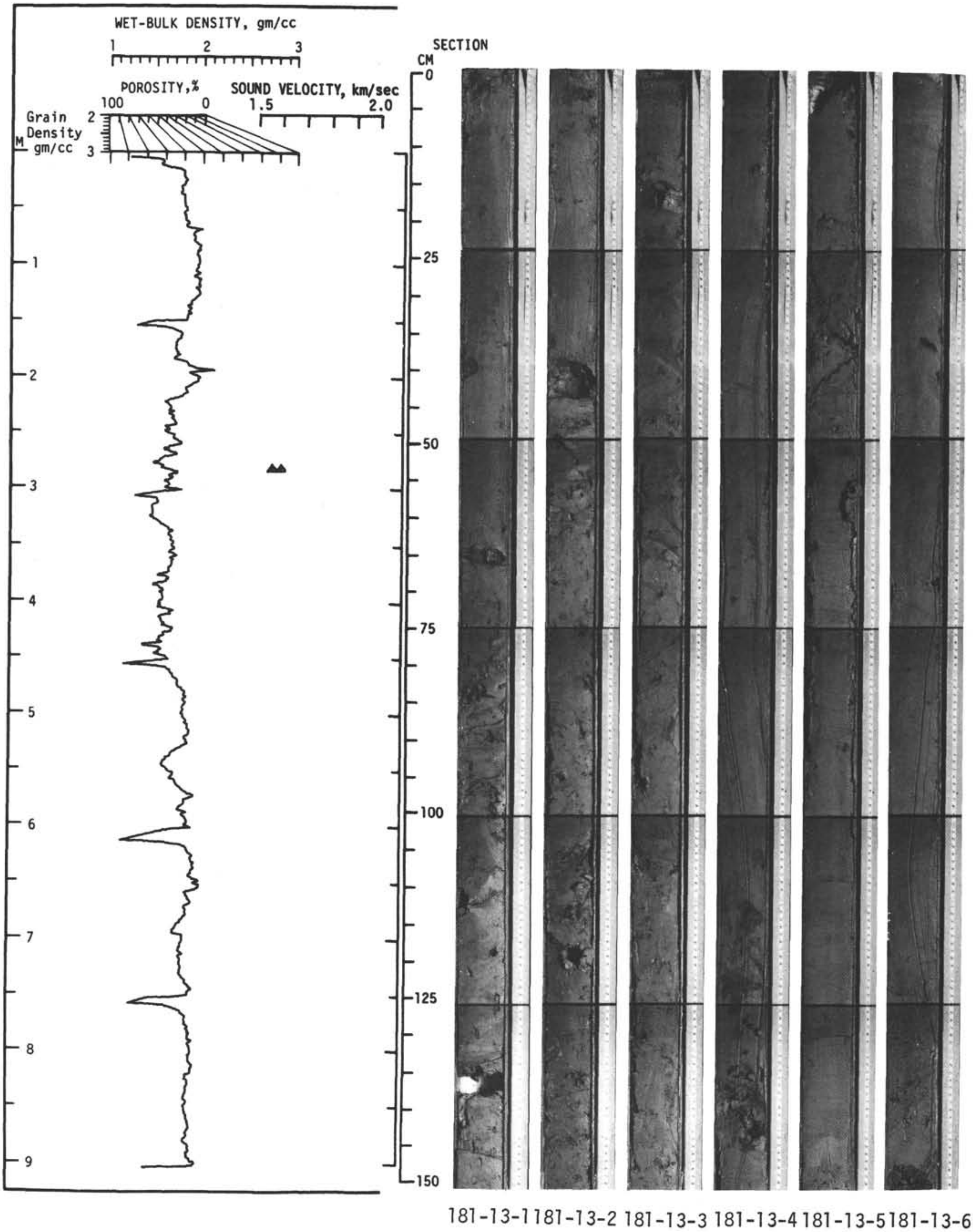
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SOUND VELOCITY, km/sec
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Grain Density gm/cc
2
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M
1
2
3
4
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7
8
9
SECTION CM
0
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125
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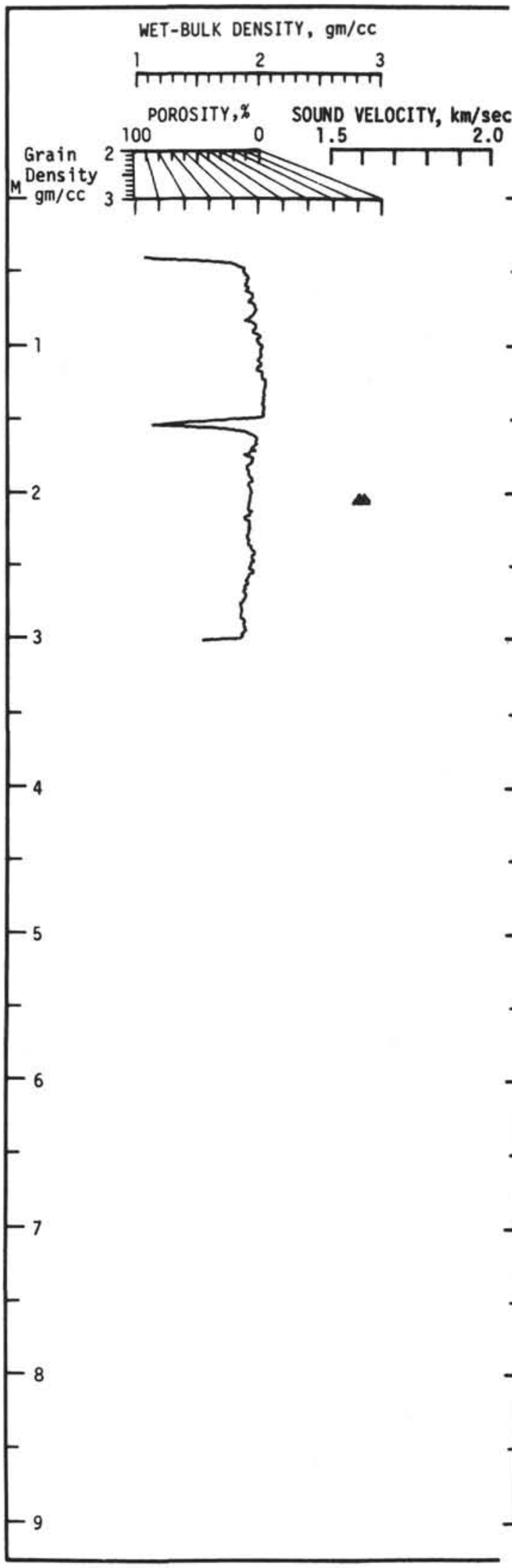

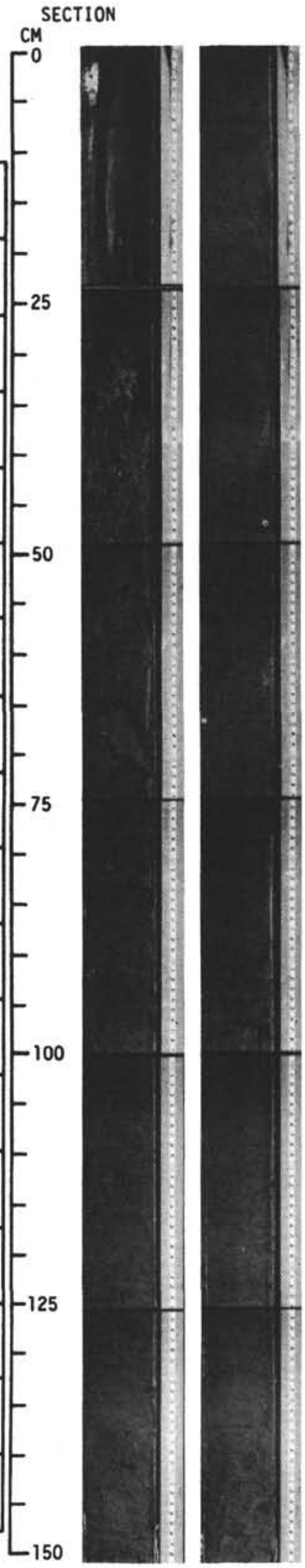

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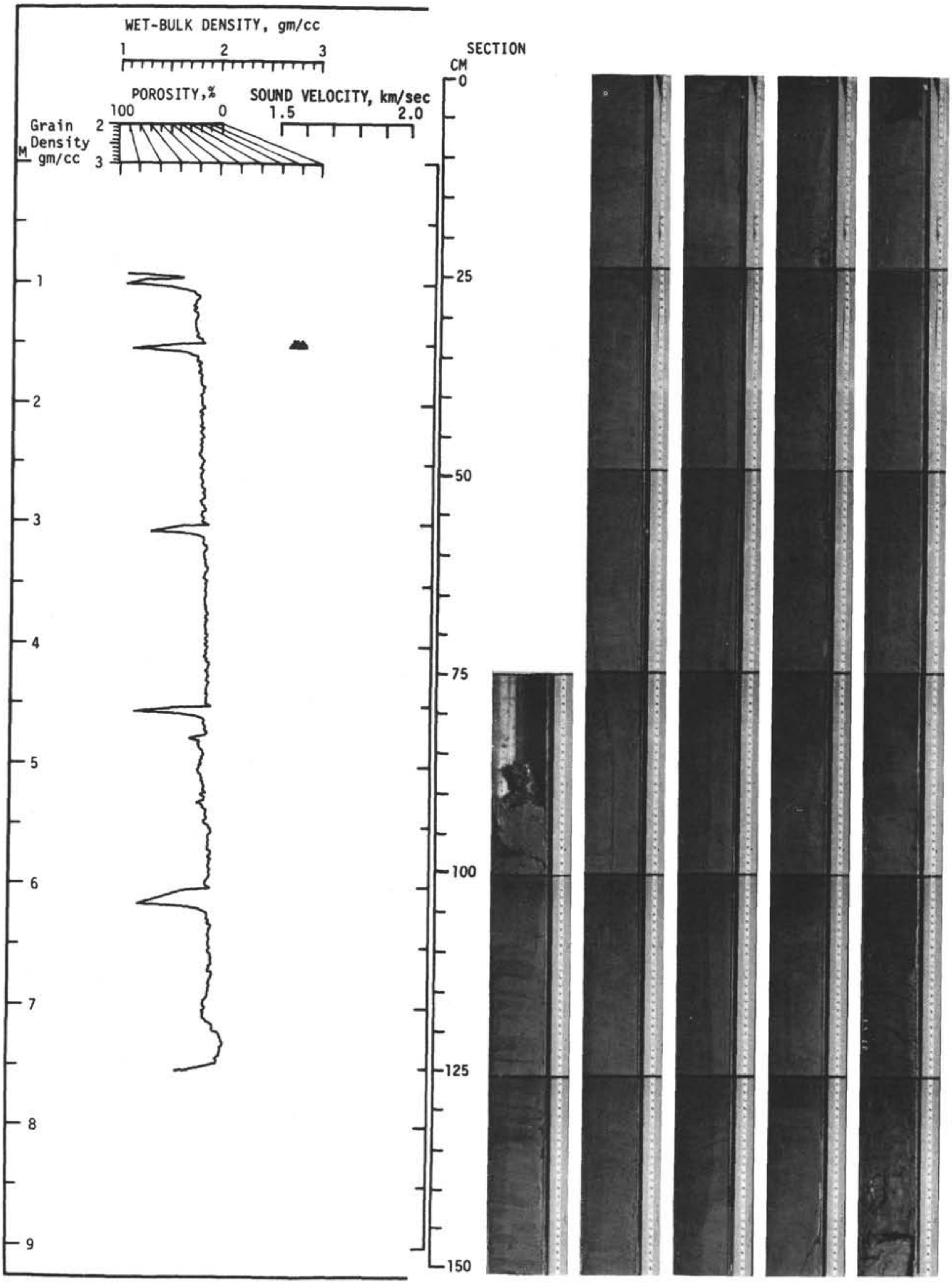

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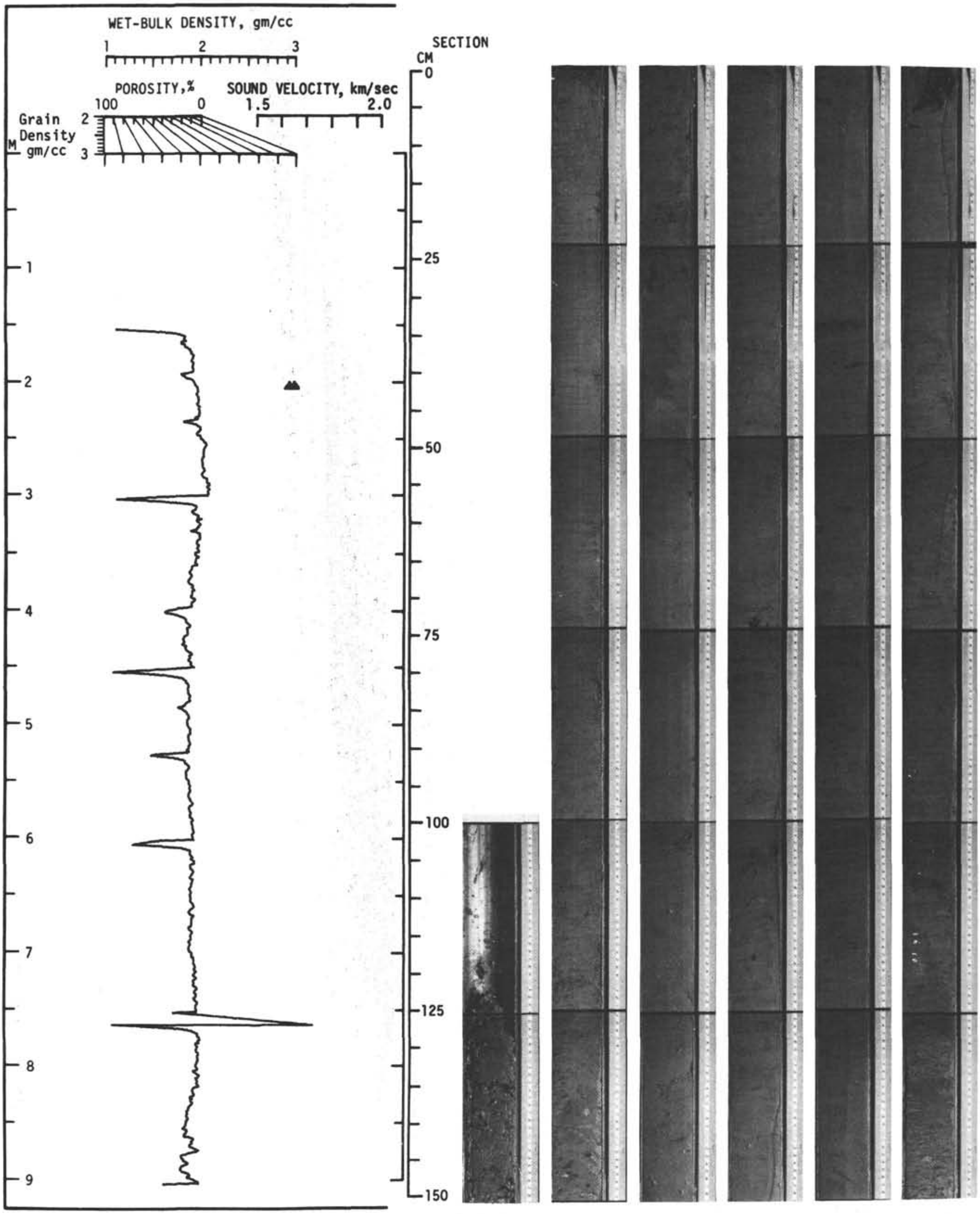

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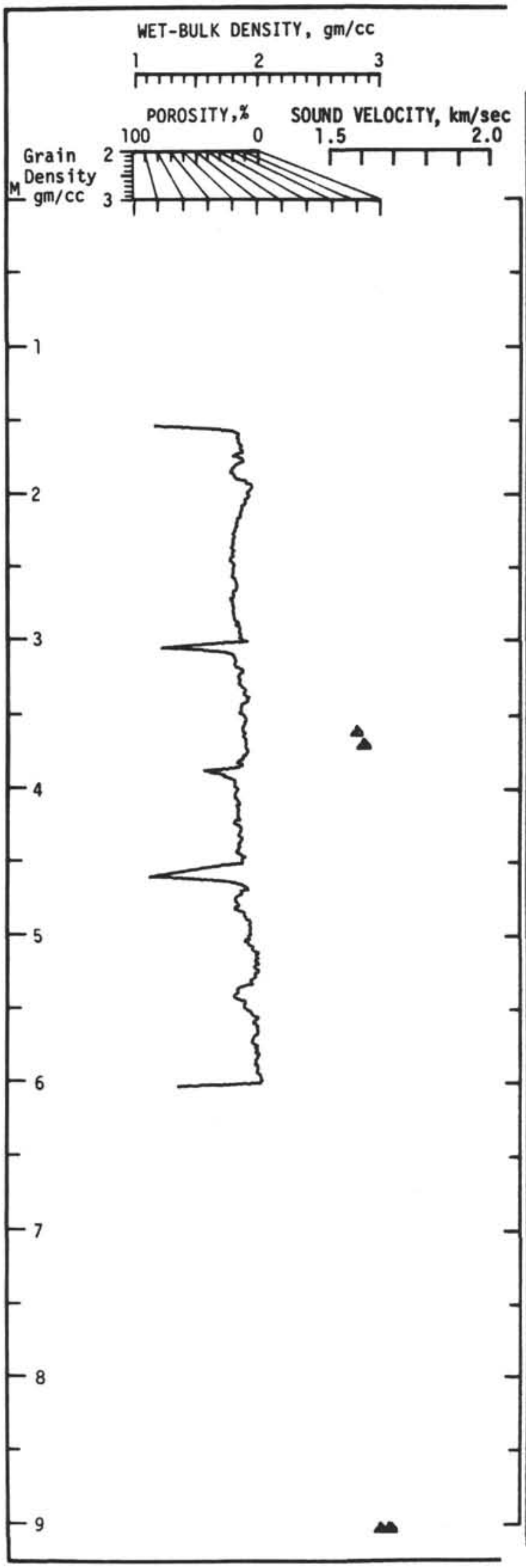
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SOUND VELOCITY, km/sec
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Grain Density gm/cc
2
3
M
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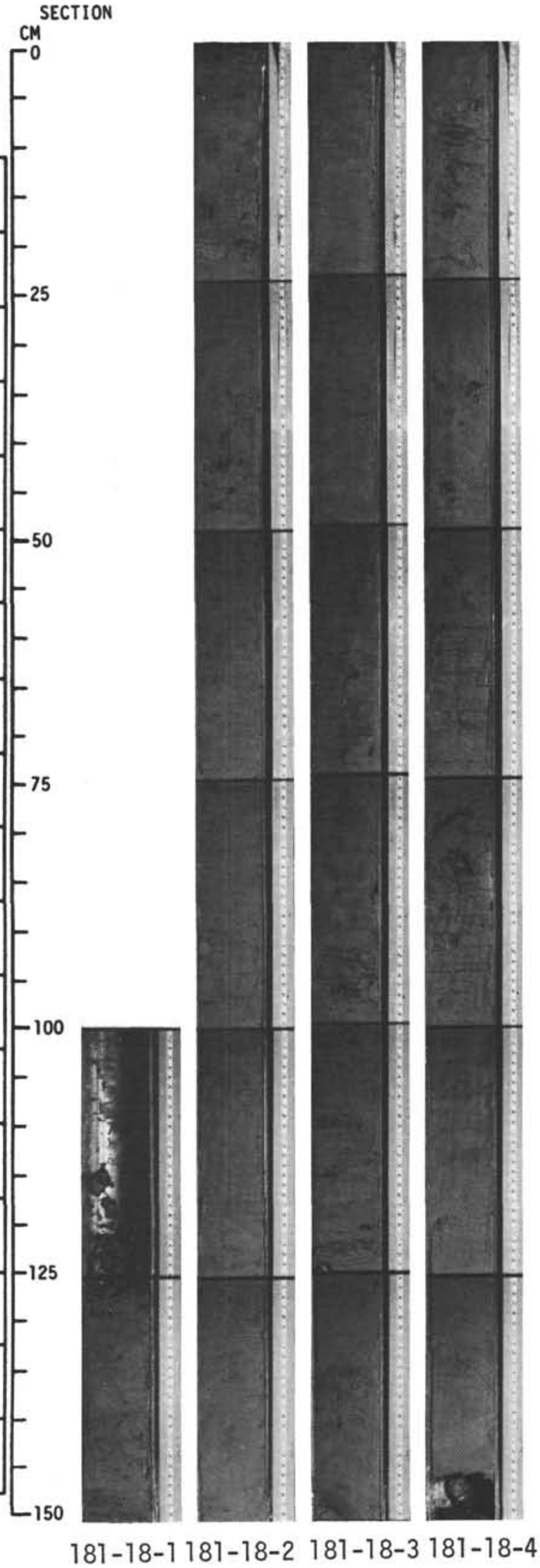
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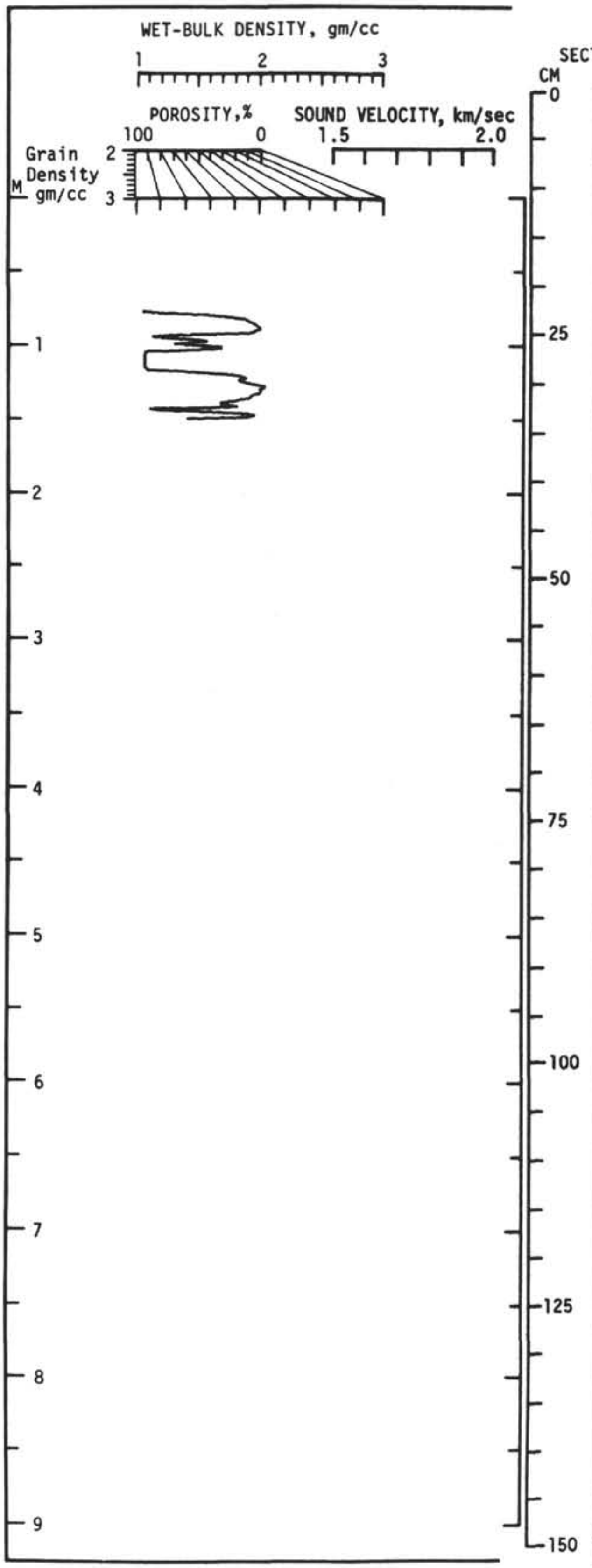
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SOUND VELOCITY, km/sec
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2.0
Grain
Density
gm/cc
2
3
M
1
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3
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7
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SECTION
CM
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50
75
100
125
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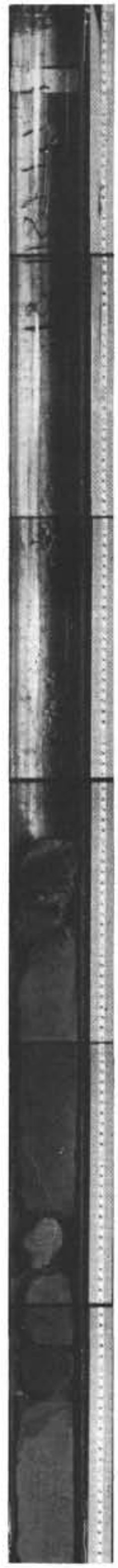

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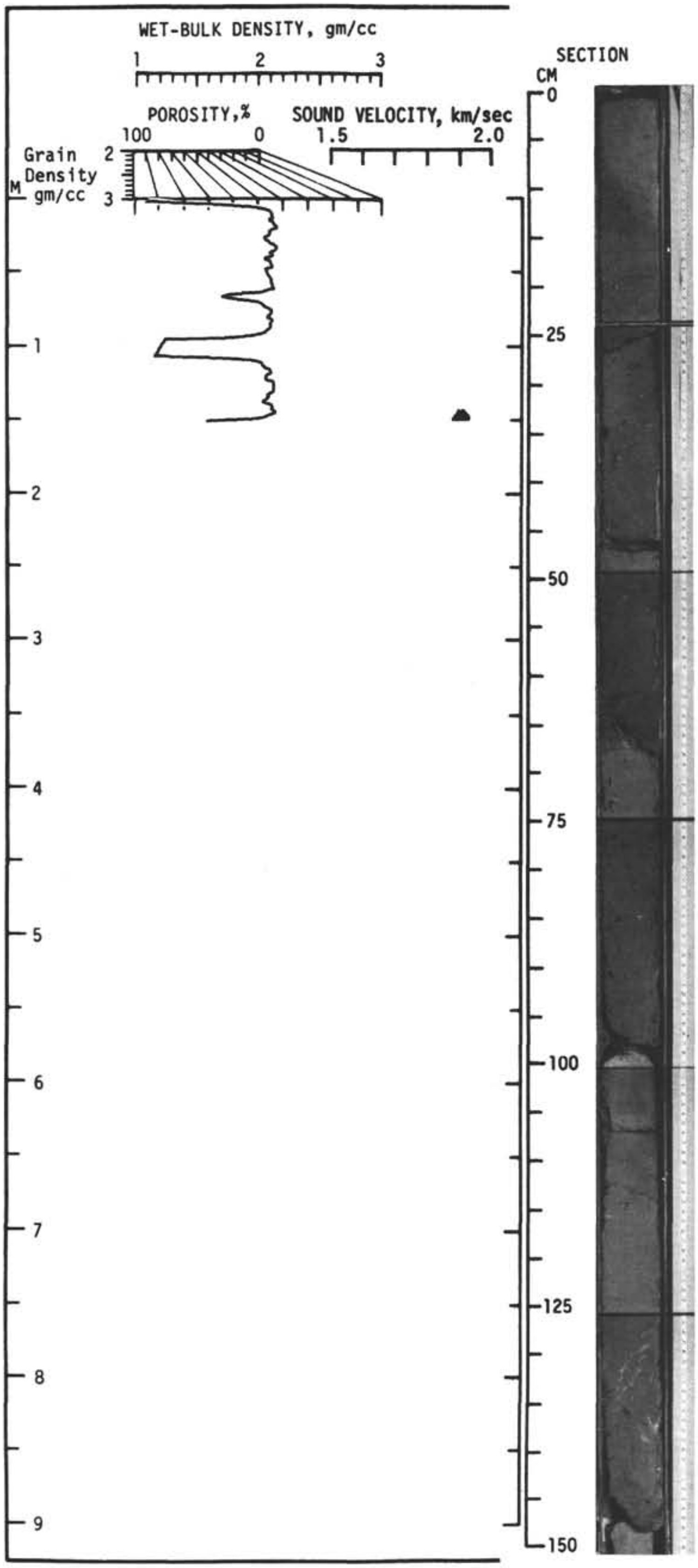
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SOUND VELOCITY, km/sec
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2.0
Grain Density gm/cc
2
3
M
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SECTION
CM
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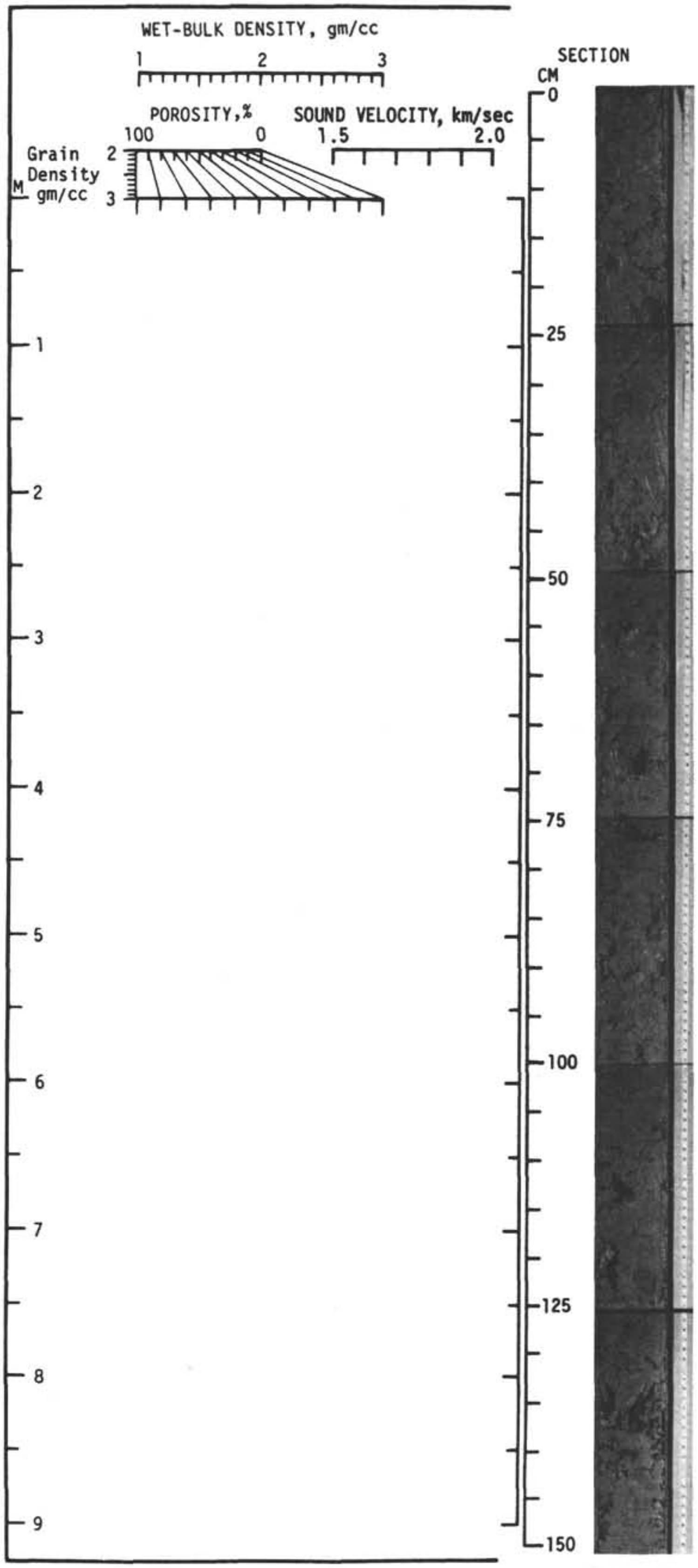
150

181-20-1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2.0
Grain Density gm/cc
2
3
M
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7
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SECTION
CM
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125
150

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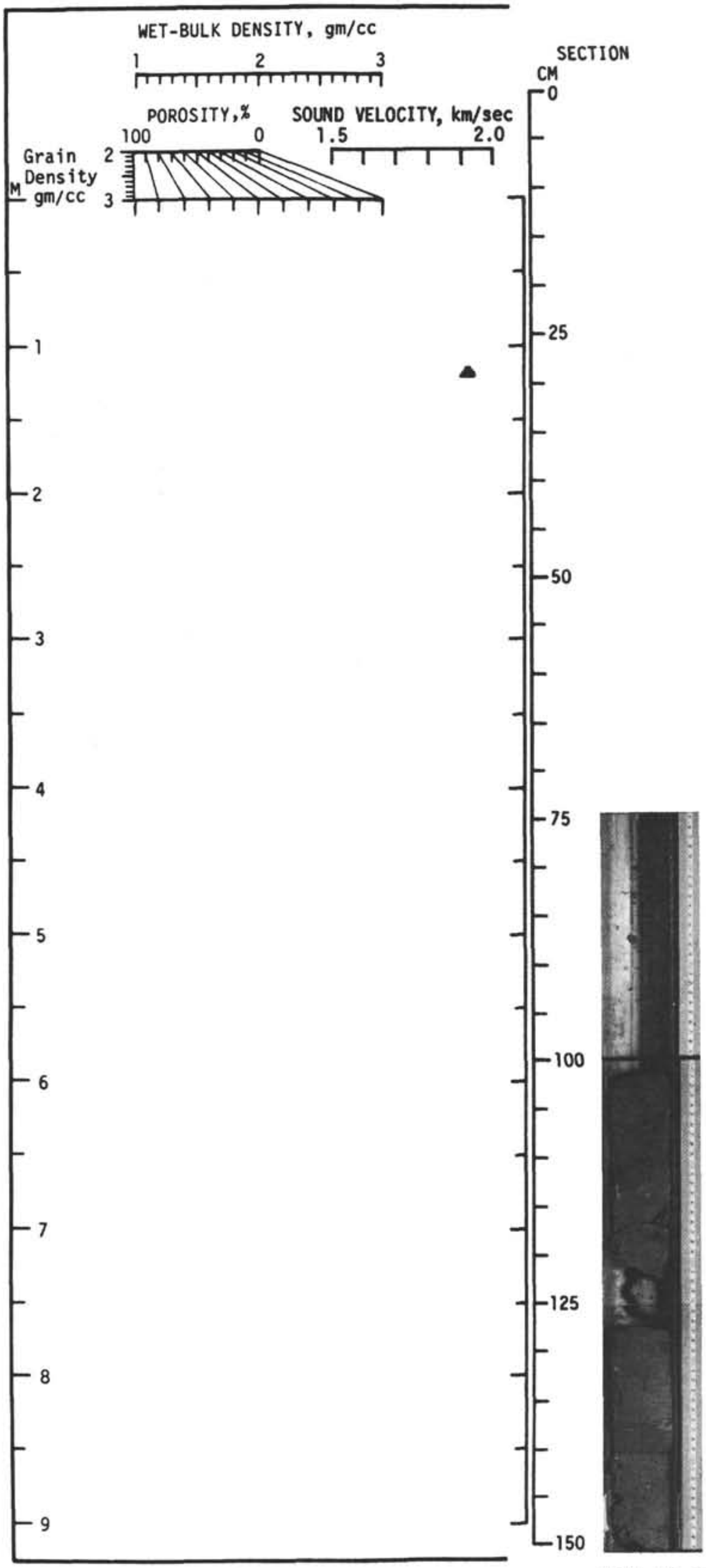
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Grain Density gm/cc
2
3
M
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7
8
9
SECTION
CM
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25
50
75
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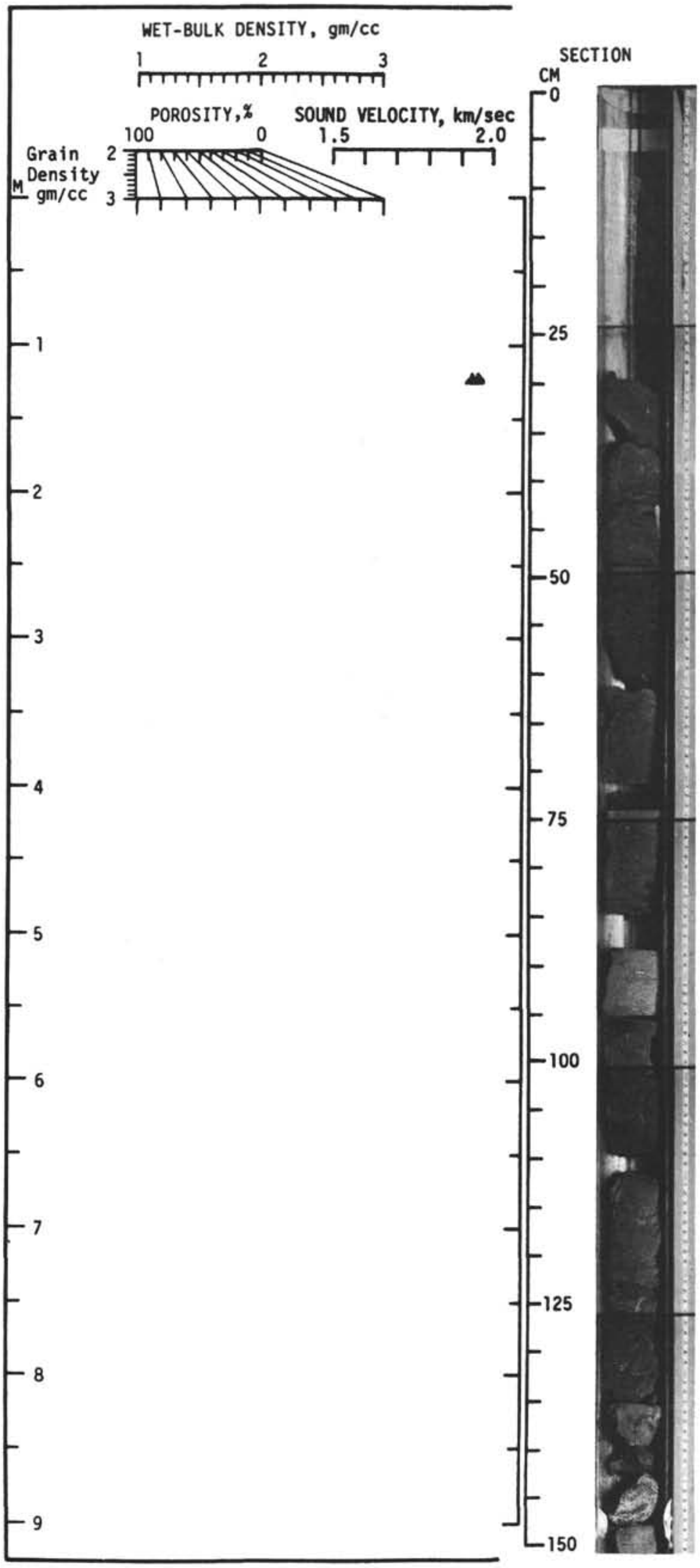
181-22-1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Grain Density gm/cc
2
3
M
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SECTION
CM
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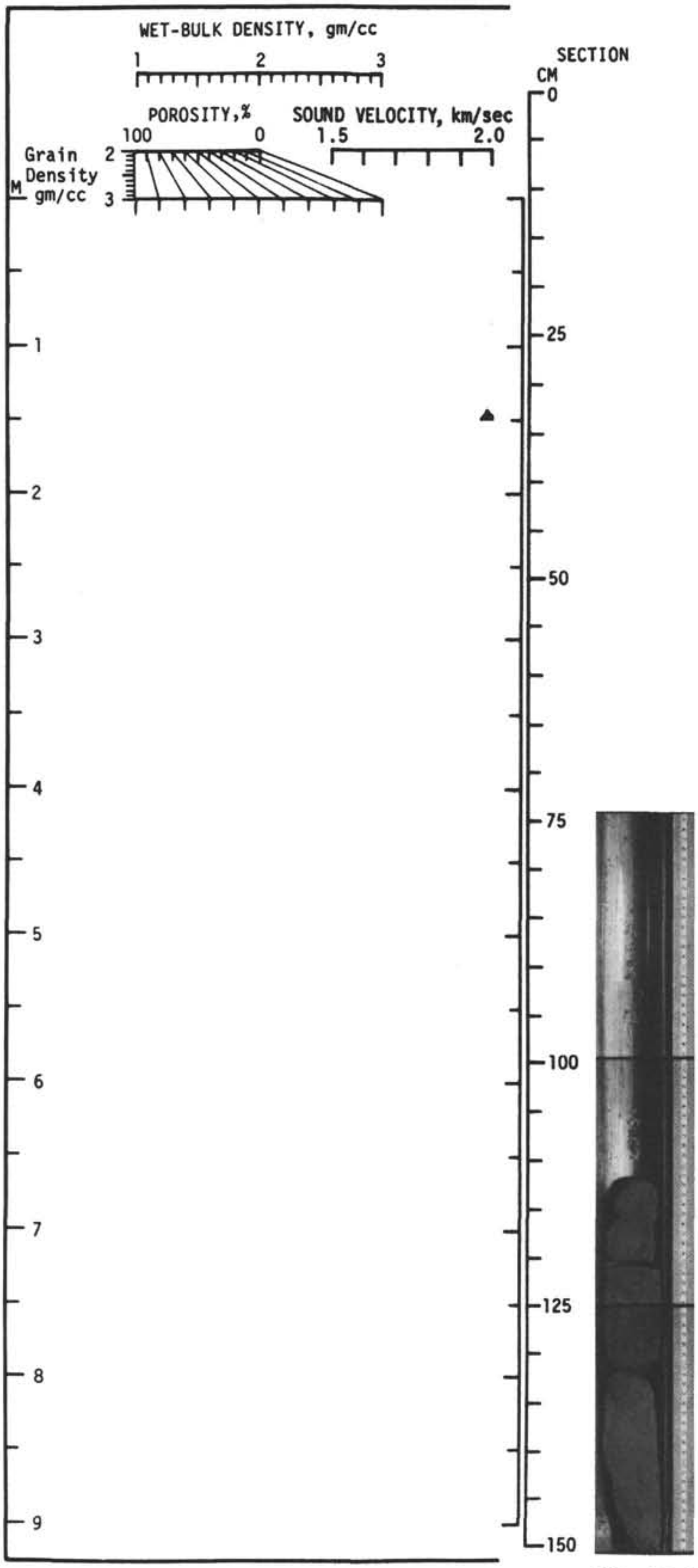
25
50
75
100
125
150

181-23-1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Grain Density gm/cc
2
3
M
1
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7
8
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SECTION
CM
0
25
50
75
100
125
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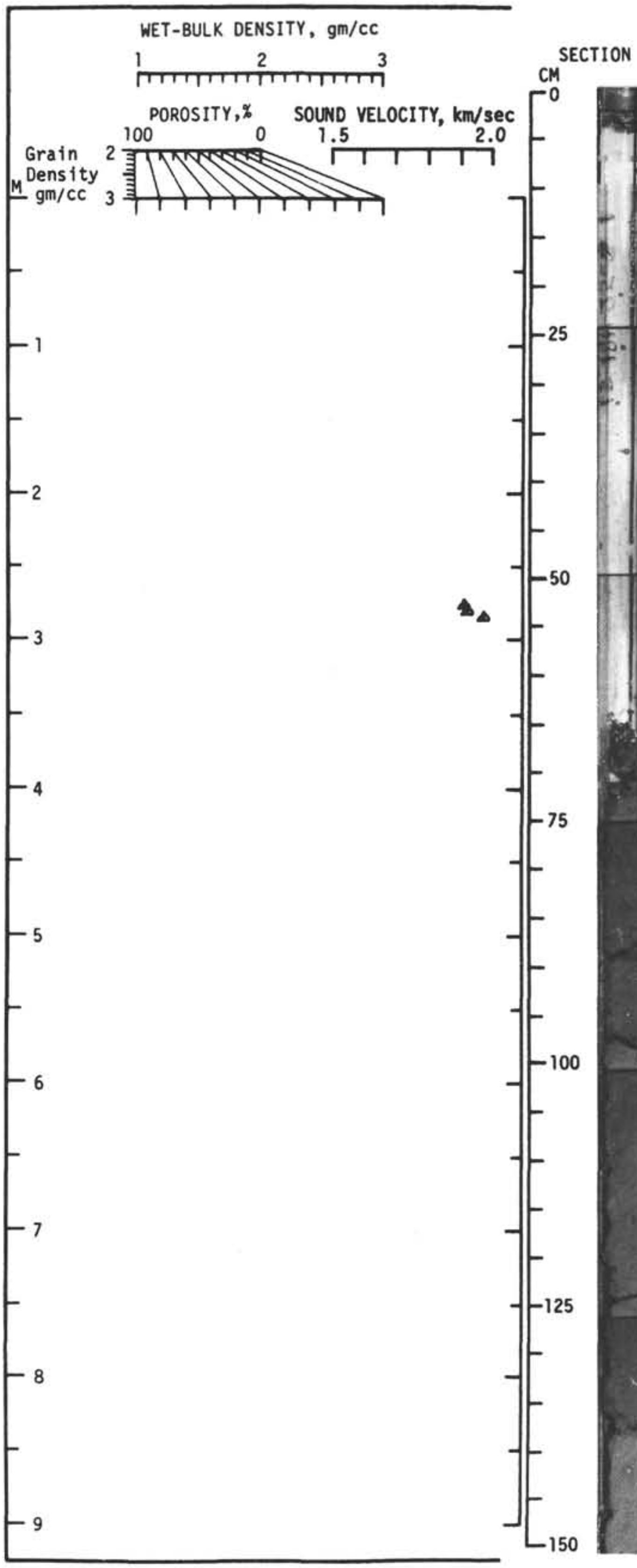
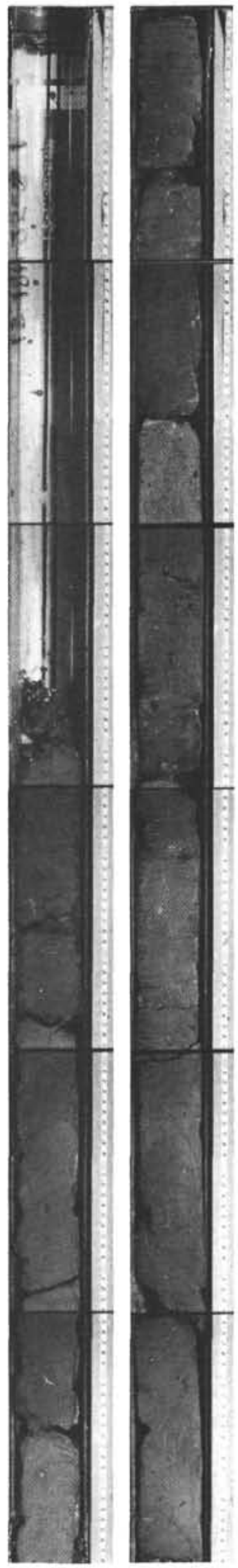
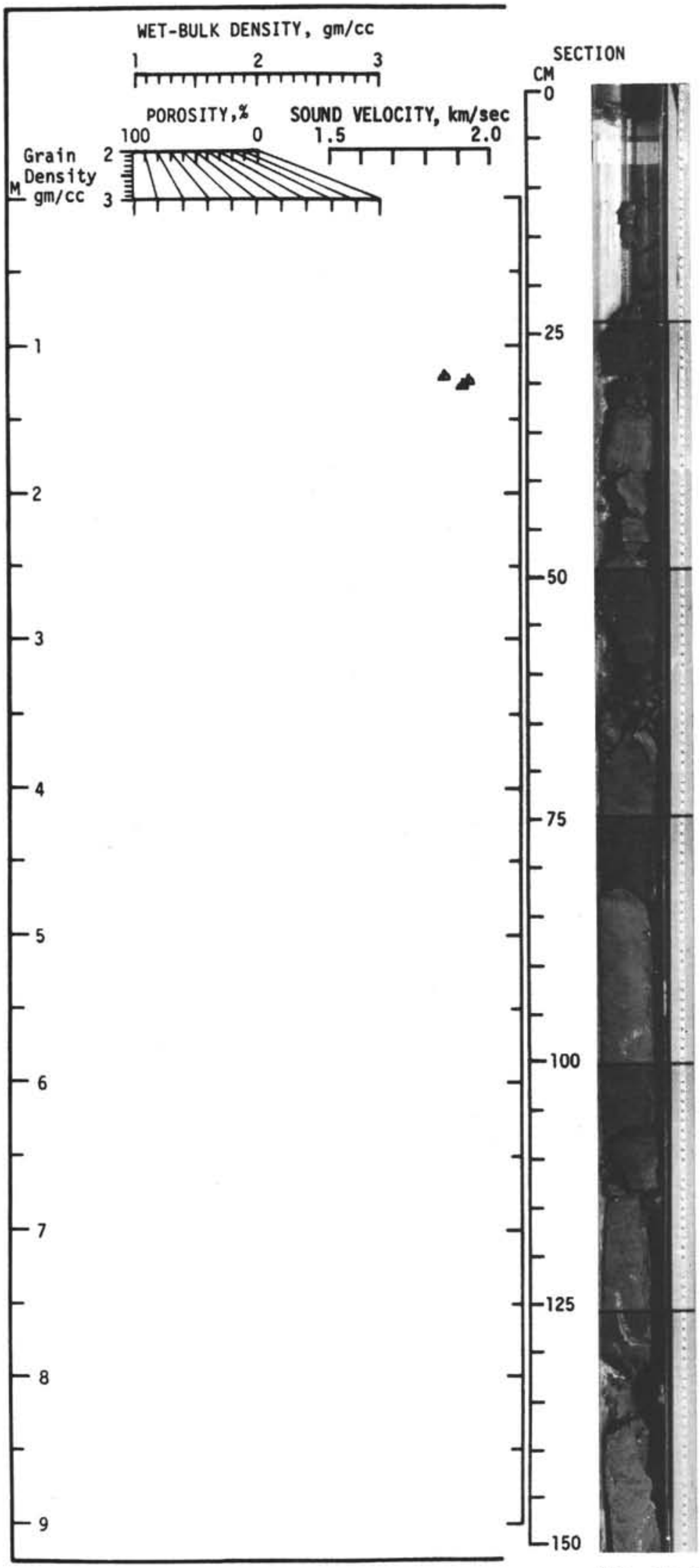




181-25-1 181-25-2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Grain Density gm/cc
2
3
M
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SECTION
CM
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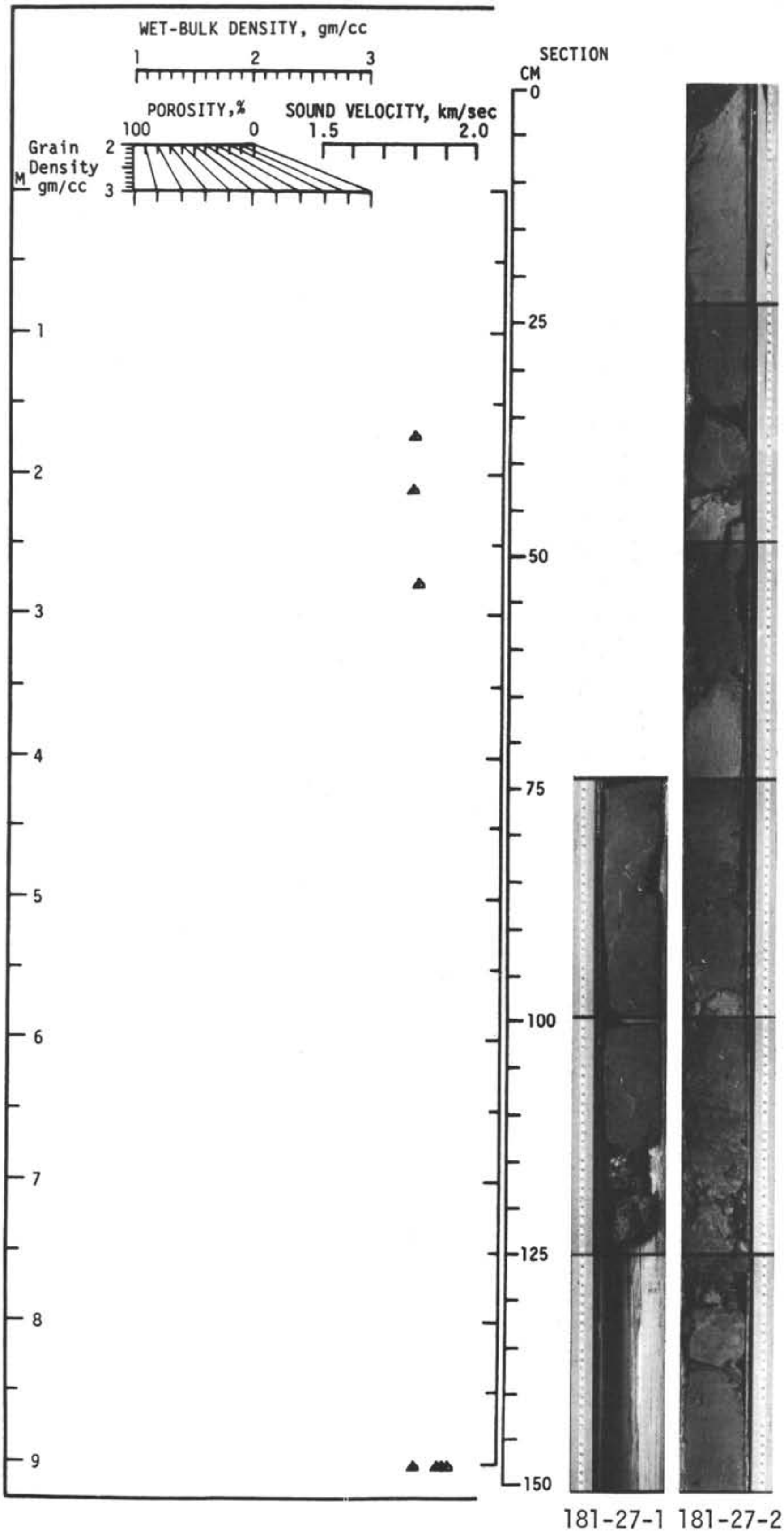
100
125
150

181-26-1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Grain Density gm/cc
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M
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SECTION
CM
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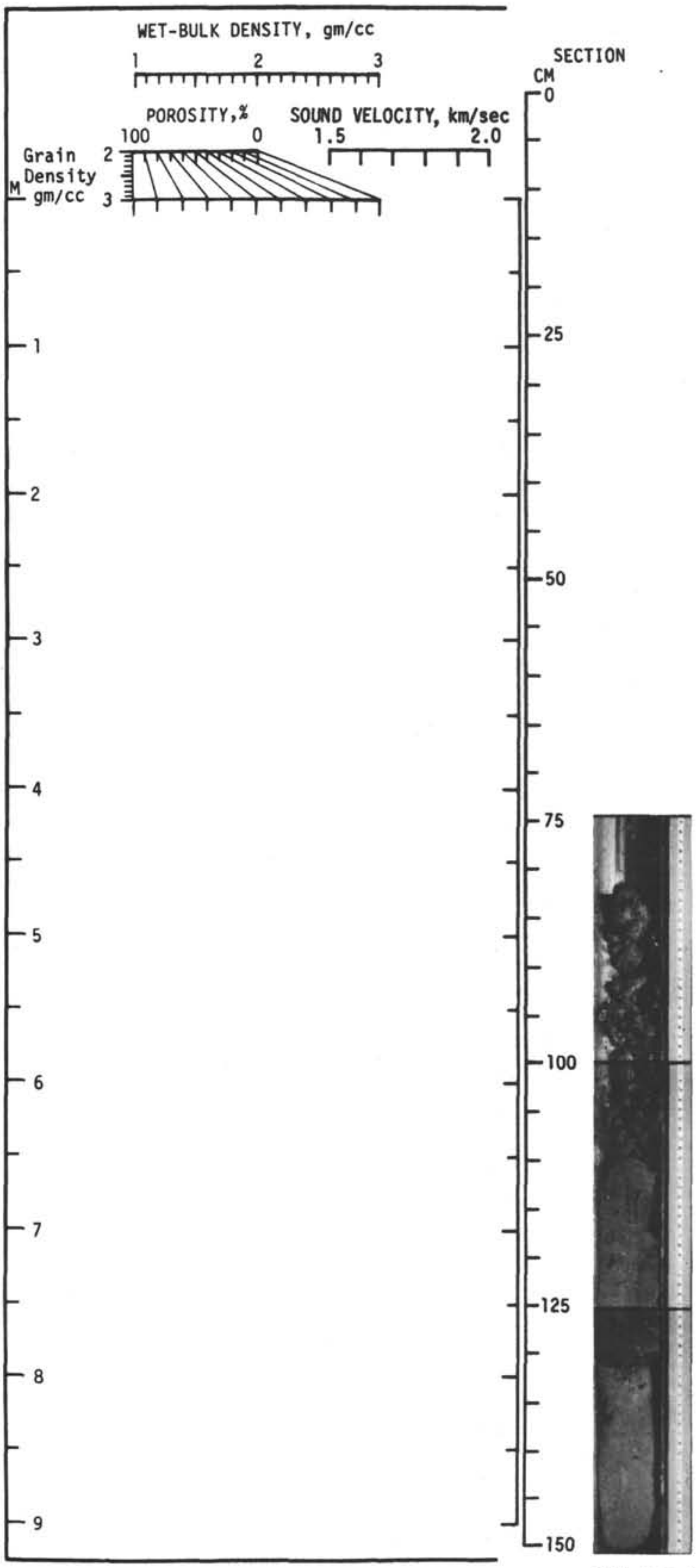
100
125
150
181-27-1
181-27-2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SOUND VELOCITY, km/sec
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2.0
Grain Density gm/cc
2
3
M
1
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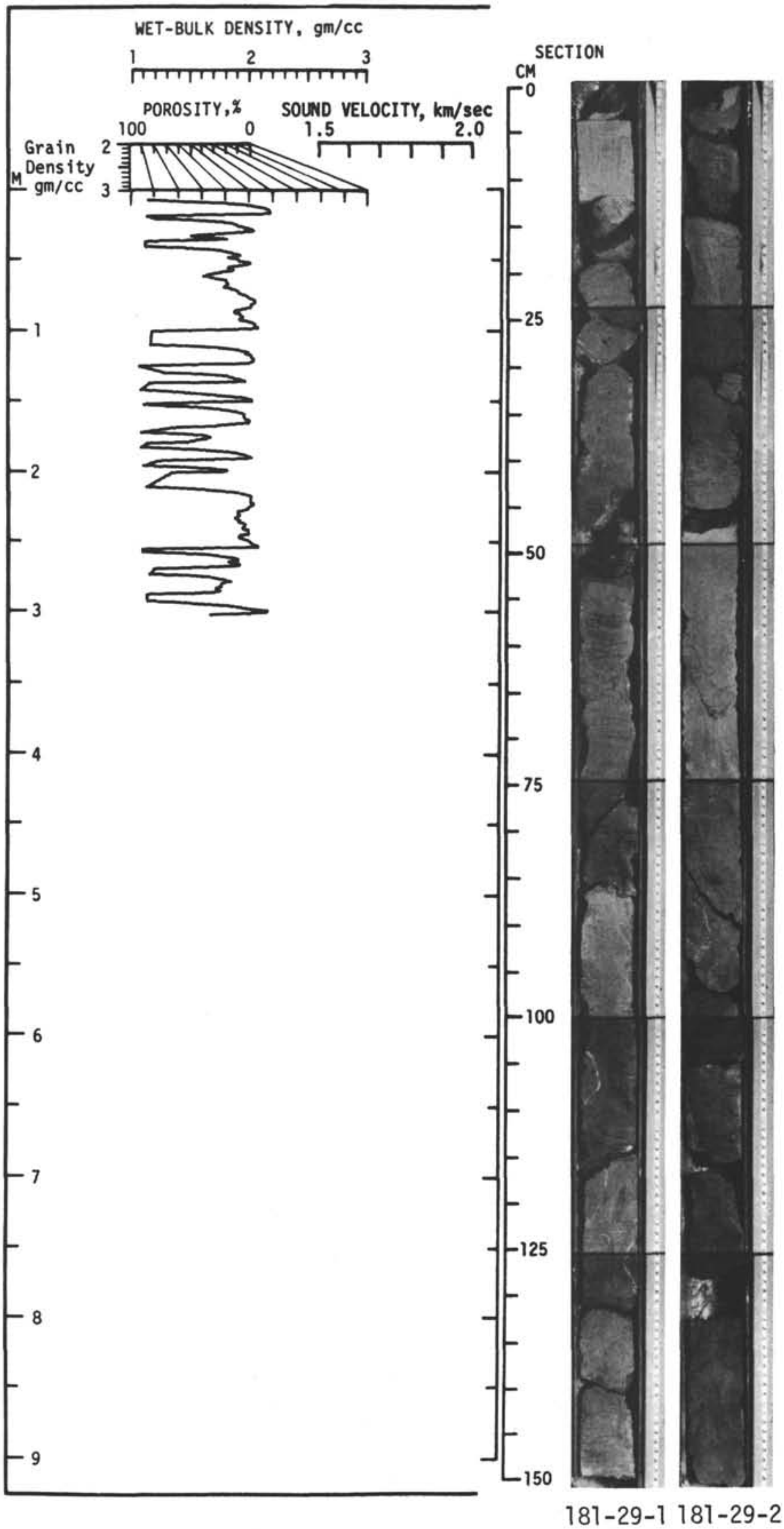
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150

181-28-1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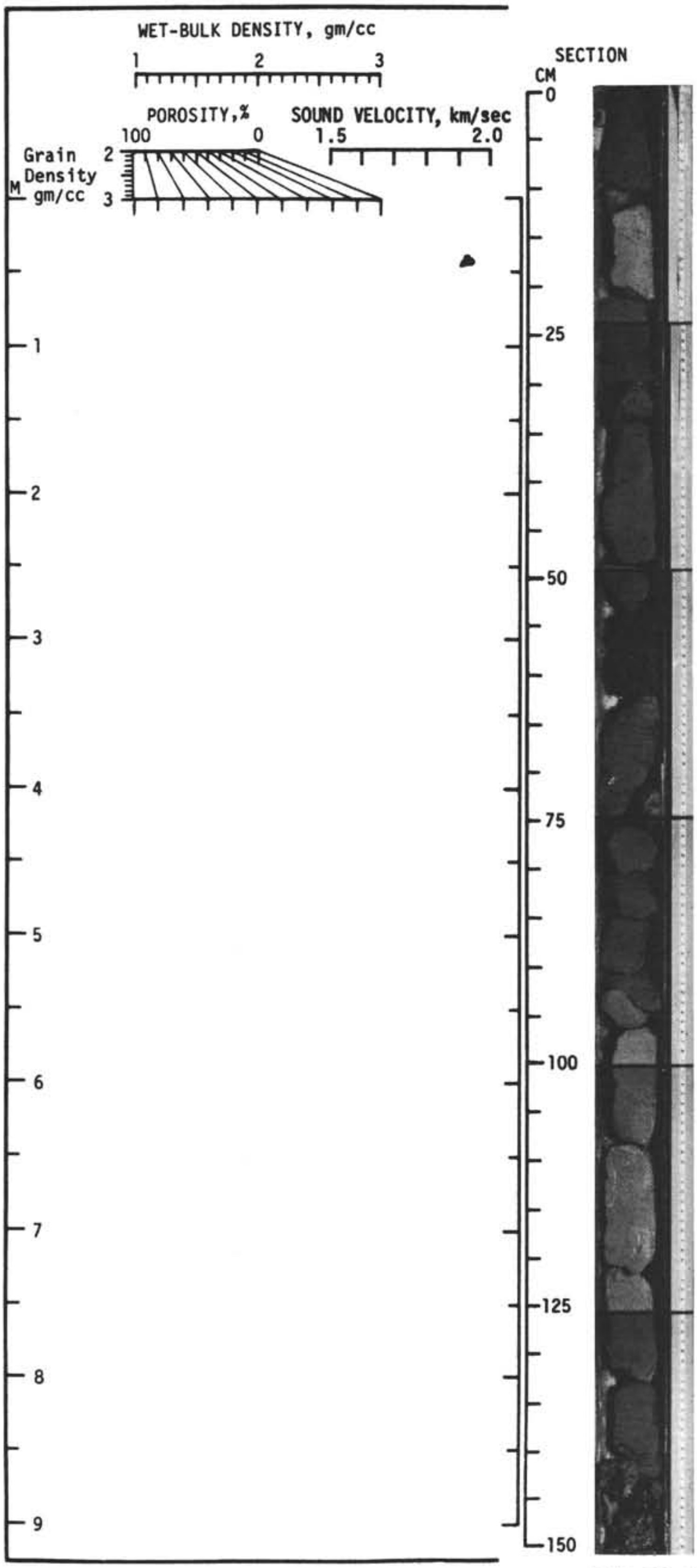
SOUND VELOCITY, km/sec
1.5 2.0
Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
181-29-1 181-29-2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SOUND VELOCITY, km/sec
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2.0
Grain Density gm/cc
2
3
M
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150

181-30-1