5. SITE 186

The Shipboard Scientific Party[1]

SITE DATA

Date Occupied: 9-12 Aug 71.

Position:
51°07.81′N
174°00.34′W.

Water Depth: 4522 meters.

Penetration: 926 meters.

Number of Holes: One.

Number of Cores: 28.

Total Core Recovered: 140.7 meters.

Acoustic Basement:
Depth: Approximately 850 meters
Nature: Deformed sediments
Velocity: 2.0 km/sec.

Age of Oldest Sediment: late Miocene, with a short (<60 m) enclosed section of middle Miocene fault block or slump block.

Basement: upper Miocene deformed sediments.

SUMMARY

Site 186 is located near the outer or southern edge of Atka Basin, Aleutian Terrace, in water 4522 meters deep (Figure 1). The sediment sequence penetrated is 926 meters thick and consists predominantly of diatomaceous silty clay ranging in age from late Pleistocene through early Pliocene.

A section (at 622 m) less than 60 meters thick of middle Miocene diatomaceous silty clay is enclosed within a larger section of lower Pliocene silty clay. The microfossils, which include calcareous forms, suggest that the middle Miocene unit is an allochthonous block. Reworked middle Miocene forms also occur in the associated Pliocene beds.

Volcanic ash is interbedded throughout the section and ash beds are particularly common above 20 meters. A middle Pleistocene pumice-bearing ash layer 4.5 meters thick occurs at 165 meters. Beds of sand and silt up to 4.5 meters thick are commonly intercalated in the diatomaceous silty clay. Benthic foraminifera in the thick sandy layer of Cores 10 to 11 (middle to lower Pleistocene) are apparently displaced from shallower depths and imply that the sands are turbidites. Thin layers of calcite-cemented siltstones and diatomaceous, calcitic silt are present in the middle Pliocene between 386 and 509 meters.

The lens-shaped mass of generally undeformed sedimentary deposits underlying Atka Basin, Aleutian Terrace, is approximately 2000 meters thick and consists chiefly of diatomaceous clay younger than late Miocene. Siliceous microorganisms constitute about 35 percent of these Neogene beds. The bulk, about one-half, of the accumulated debris was contributed by the nearby Aleutian Ridge as either hemipelagic silt- and clay-size particles (40%) or sandy turbidite layers (10%) bearing shallow-water foraminifera. Vitric volcanic debris, although rather abundant in the Pleistocene section, is a minor constituent (5%) throughout most of the drilled section.

Atka Basin is guarded by an outer ridge that is underlain by an acoustically unresolvable structure. The deepest prominent acoustic reflector (about 815 m) at Site 186 was not identified stratigraphically but occurs within the lower Pliocene. Drilling at Sites 186 and 187 established that this ridge is in part constructed of uplifted and deformed Pliocene and upper Miocene basin deposits.

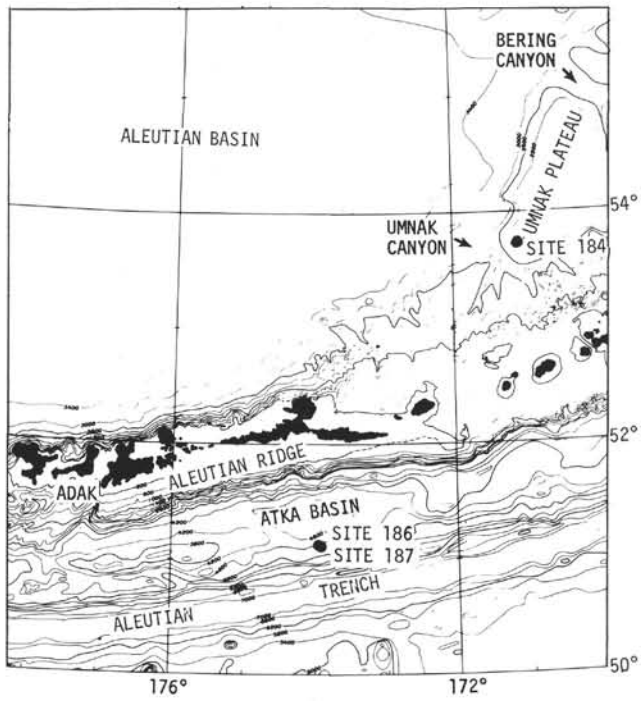

Figure 1. *Base map showing location of Site 186.*

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BACKGROUND AND OBJECTIVES

Description

Atka Basin forms the Aleutian Terrace south of Atka Island, Aleutian Islands. Site 186, 4522 meters, is located near the basin's southern edge, which is commonly marked by a "basement" ridge underlain by acoustically unresolvable structures. Reflection profiles show that Atka Basin contains at least 2000 meters of largely undeformed stratified deposits. Along the inner or northern side of the basin these deposits overlie an acoustic basement that apparently can be traced to outcrops of early Tertiary (pre-Neogene) rocks exposed on nearby Atka and Adak islands. Near the southern side of the basin the lower deposits sweep upward and appear to lap onto the "basement" rock of the outer ridge (Figure 2). These beds also become folded in the vicinity of the outer ridge. Site 186 was positioned over the upturned lower beds a few kilometers north of the outer ridge. Hemipelagic, pelagic, and turbidite beds were anticipated.

Objectives

Formation of Atka Basin can be linked to several mechanisms: (1) graben-like collapse of a segment of the Aleutian Ridge, possibly in conjunction with formation of the adjacent Aleutian Trench; (2) sedimentary infilling behind a deeply submerged volcanic ridge; (3) depositional infilling behind a ridge largely formed by offscraped sedimentary and igneous masses derived from a subducted Pacific plate; and (4) infilling behind a ridge composed of older terrace or archipelagic apron deposits that have been deformed and uplifted by some mechanism (e.g., folding, faulting, or diapirism) to form the present outer ridge of Atka Basin and possibly also the inner wall of the Aleutian Trench.

The principal objective in drilling Site 186 was to determine the age and lithology of the strata underlying the basin as well as that of the acoustic basement beneath them. Presumably, this sort of information would allow some conclusions regarding the dominant mode of sedimentation over the terrace, especially the importance of the nearby Aleutian Ridge as a volcanic and detrital sediment source, and the time of formation of the basin. The pre-basin history could be deduced if basement rocks were obtained. Considered together, the finds at Site 186 would aid in understanding the origin of the basin as well as its relation to the tectonic and igneous history of the Aleutian Ridge and north Pacific region.

OPERATIONS

Pre- and Post-drilling Survey

Site 186 was approached with a ship's heading of 130°T. Although it was recognized at the time that our location

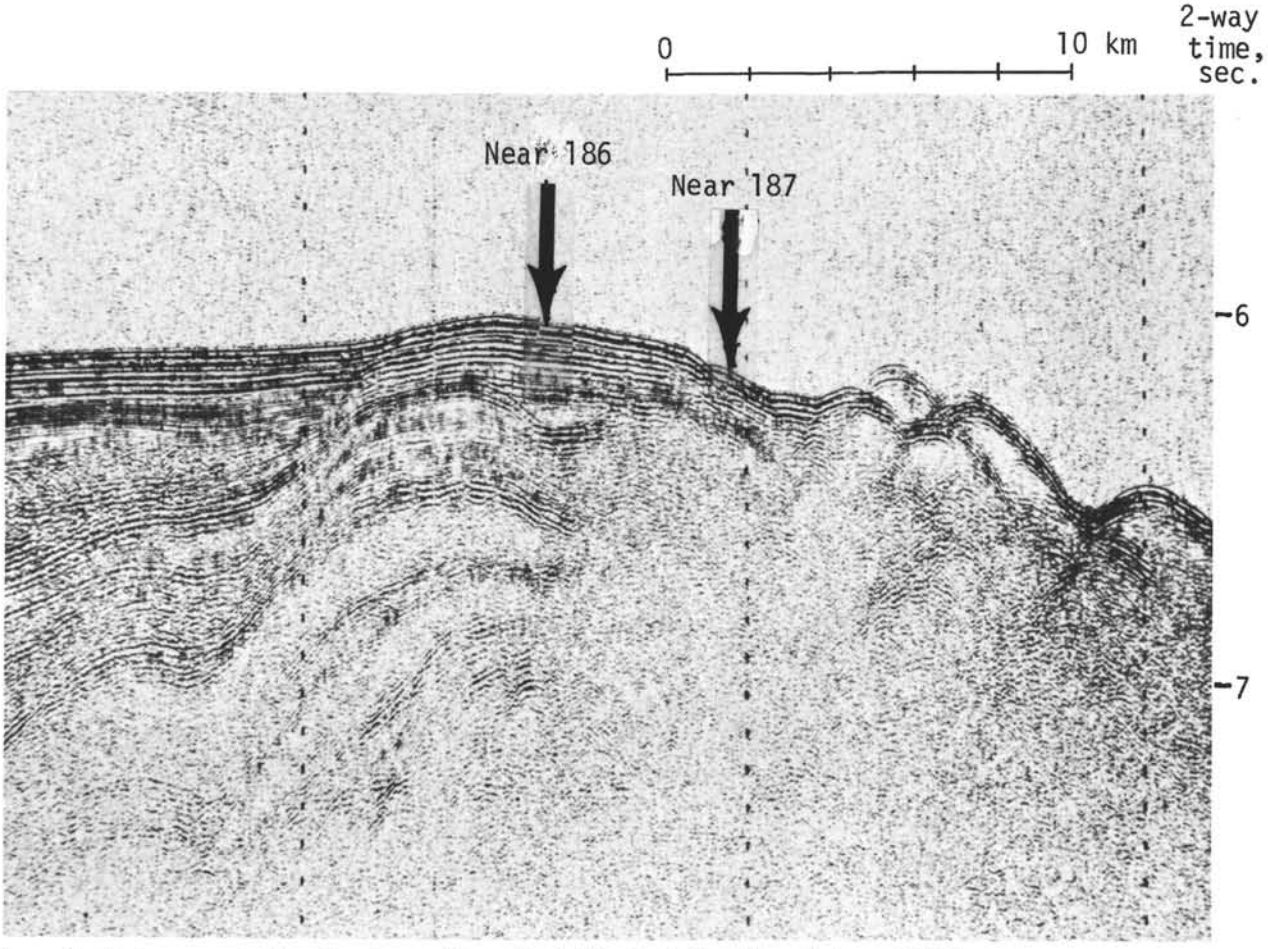

Figure 2. *Reference seismic reflection profile, collected by E. L. Hamilton, 2 August 1970.*

was some mile or more west of the site selected, it was presumed that a similar section would be present along the approach track. This proved to be incorrect. The course was changed to a heading of 325°T which was maintained until we intersected the line of the reference profile collected by E. L. Hamilton of 2 Aug 70 (Figure 2). The ship then steered a course of 116°T, which is reciprocal to the reference track. This heading was maintained until a structure similar to that of the reference profile was seen. The beacon was dropped on the fly at 1225 hrs on 9 Aug 71. The finally accepted satellite position is: 51°07.81′N; 174°00.34′W. The reference seismic profile is shown in Figure 2 and the air-gun profile taken crossing the site on approach is shown in Figure 3. A post-drilling survey air-gun track through Sites 186 and 187 can be seen in Figure 3 of Site 187. A map showing the pre-drilling survey is given as Figure 4 (this site).

Drilling Program

Site 186 was occupied from 1225 hrs (beacon away) 9 Aug 71 until 1000 hrs 12 Aug 71 with alternate coring and washing from the sea floor to a subbottom depth of 926 meters. At this depth the sediment is a firm clayey siltstone (almost shale) with interbedded gaseous sands containing measurable ethane. Because of the drilling difficulty, an age that was still late Pliocene, and the desire to obtain basement if possible, it was decided to abandon the hole and move 3 miles southeast to a point where bedrock appeared nearer the surface.

Using Matthews Tables and information from the U.S. Navy Undersea Research and Development Center, the sonic depth of 2398 fms was corrected to 4476 meters giving a water depth of 4482 meters and a drill-floor depth of 4492 meters. This compares with 4532 meters below drill floor established on the basis of the first core. The difference in depths is attributed to inadequate correction factors and a settling of the beacon into water slightly deeper than taken from the echo sounder. The 4532 meters below drill floor, or 4522 meters below sea level, is the accepted depth for this site.

The entire section drilled and cored to a total depth of 926 meters consisted of diatomaceous clayey silts and silty clays with layers of ash and volcanic sand and traces of methane. Ethane was detected in a few cores. Drilling

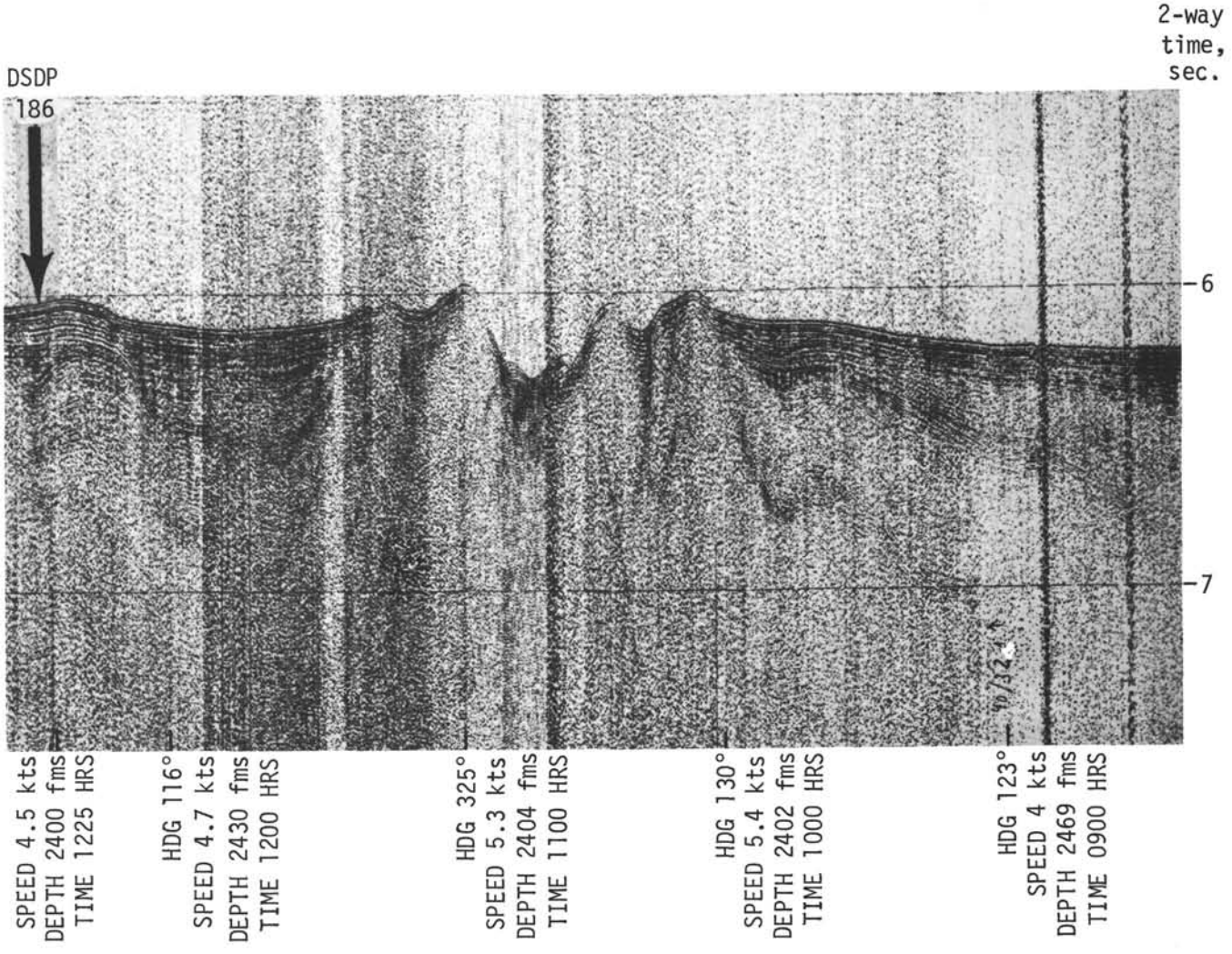

Figure 3. Glomar Challenger *air-gun profile across Site 186.*

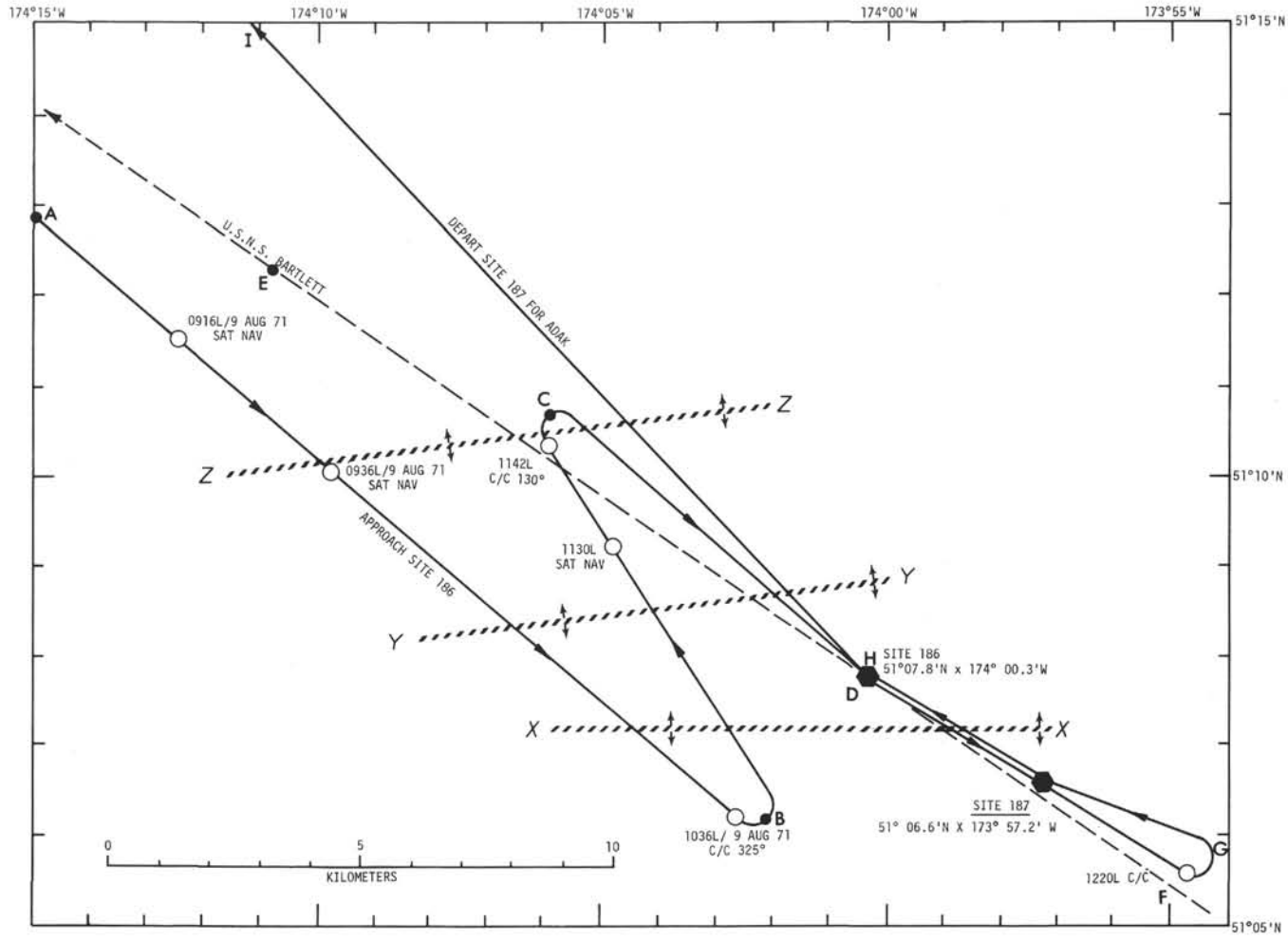

Figure 4. Glomar Challenger *track showing approach and departure, Sites 186 and 187.*

became progressively harder with depth and mud was spotted at subbottom depths of 216 to 245 meters, 618 to 627 meters, and 814 to 861 meters to clean out the hole, necessitated because of slumping associated with sand stringers. One hundred barrels of 10.6# mud was placed at the bottom of the hole before abandonment as a precautionary measure since the ethane content of the sediment here was measurable. A coring summary in given in Table 1.

LITHOSTRATIGRAPHY

The entire 926-meter sedimentary section at Site 186 is dominantly diatomaceous silty clay. Volcanic ash is interbedded throughout the section, and ash beds are particularly common above 20 meters. A pumice-bearing ash layer at least 4.5 meters thick occurs at 165 meters.

Beds of sand and silt are frequently intercalated in the diatomaceous silty clay in layers up to 4.5 meters thick. Diatomaceous calcite silts are present between 386 and 509 meters. One calcite-cemented siltstone is present.

Degree of induration increases sharply in the interval 214 to 245 meters and continues to increase downward to the bottom of the hole. Inclined bedding is present at 440 meters and may occur stratigraphically higher.

At about 622 meters an anomalous section of middle Miocene diatomaceous silty clay is sandwiched in between lower Pliocene diatomaceous silty clays.

Dominant Lithology

Most of the sediments at Site 186 are olive gray diatomaceous silty clay and diatom ooze. Diatoms typically constitute 30 to 40 percent of the sediment, some of which is spicule-bearing. The terrigenous silt/clay ratio is usually about 1:2. Near the top of the section much of the sediment is diatom ooze (50 to 75 percent diatoms). Light olive gray diatomaceous calcite silt layers appear at 448 and 509 meters, and much of the diatomaceous silty clay in the unit is carbonate-bearing. The calcitic layer apparently represents concentrations of nannofossil plates that have been altered by crystal solution and regrowth. Original nannofossil structures are not detectable.

Volcanic Ash

Beds of volcanic ash occur sporadically throughout most of the section but are particularly abundant in the upper 20 meters. The ashes are light gray and brownish gray. The vitric debris in the ashes is colorless to light brown and

TABLE 1
Coring Summary – Site 186

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)
1	0-2	2	2.0	100.0
2	2-11	9	6.0	66.7
3	11-20	9	9.1	101.1
Wash				
4	49-58	9	9.3	103.3
Wash				
5	96-105	9	1.6	17.8
6	105-114	9	6.0	66.7
7	114-123	9	9.5	105.6
Wash				
8	133-142	9	7.0	77.8
Wash				
9	161-170	9	9.5	105.6
10	170-179	9	8.3	92.2
Wash				
11	207-216	9	8.5	94.4
Wash				
12	245-254	9	1.0	11.1
Wash				
13	291-300	9	2.0	22.2
Wash				
14	338-347	9	0.8	8.9
Wash				
15	385-394	9	1.2	13.3
16	394-403	9	2.5	27.8
Wash				
17	422-431	9	3.5	38.9
Wash				
18	440-449	9	3.8	42.2
19	449-458	9	6.0	66.7
20	458-467	9	6.5	72.2
Wash				
21	506-515	9	3.4	37.8
Wash				
22	562-571	9	3.9	43.3
Wash				
23	618-627	9	3.7	41.1
Wash				
24	683-692	9	4.3	47.8
Wash				
25	731-740	9	3.0	33.3
Wash				
26	805-814	9	3.0	33.3
Wash				
27	861-870	9	9.3	103.3
Wash				
28	917-926	9	8.0	88.9
		245	142.7	58.0

unaltered. Grayish green iron-stained (?) bands occur in the lower portions of several beds.

At 161 to 165 meters a distinctive, pumice-bearing ash layer occurs. The bed is dark grayish brown, and as is true with all ashes recovered at Site 186, the fragments are composed of light colored glass.

Silt and Sand Beds

Beds of brownish gray to very dark gray silt and sand are interbedded at some levels within the section: 0 to 20 meters, 100 to 220 meters, 380 to 600 meters, and 850 to 926 meters. The sand layers are up to 4.5 meters thick are medium to coarse grained, and represent crystal concentrates of disaggregated volcanic rocks. Typical compositions are 40% feldspar, 30% pyroxene, and 10% glass grains, with smaller quantities of quartz, amphibole (both common hornblende and basaltic hornblende), chlorite, diatoms, and sponge spicules. Lithic fragments are present in variable concentrations (10 to 40%) and are either microlitic volcanic grains or "alterite," opaque, iron-oxide coated grains of unknown origin. Many of the sand layers have parallel laminations, and the thicker beds display good size grading and convolute laminations (see Figure 5). At 920 meters an exceptionally coarse-grained bed rich in shale grains and pebbles is present.

A thin calcite-cemented siltstone bed appears in the section at 386 meters. In the upper 200 meters gas bubbles were noted in several of the sand layers (see Figure 6).

Figure 5. *Convolute laminations in sand layer (186-27-2, 61-69 cm). Full core width.*

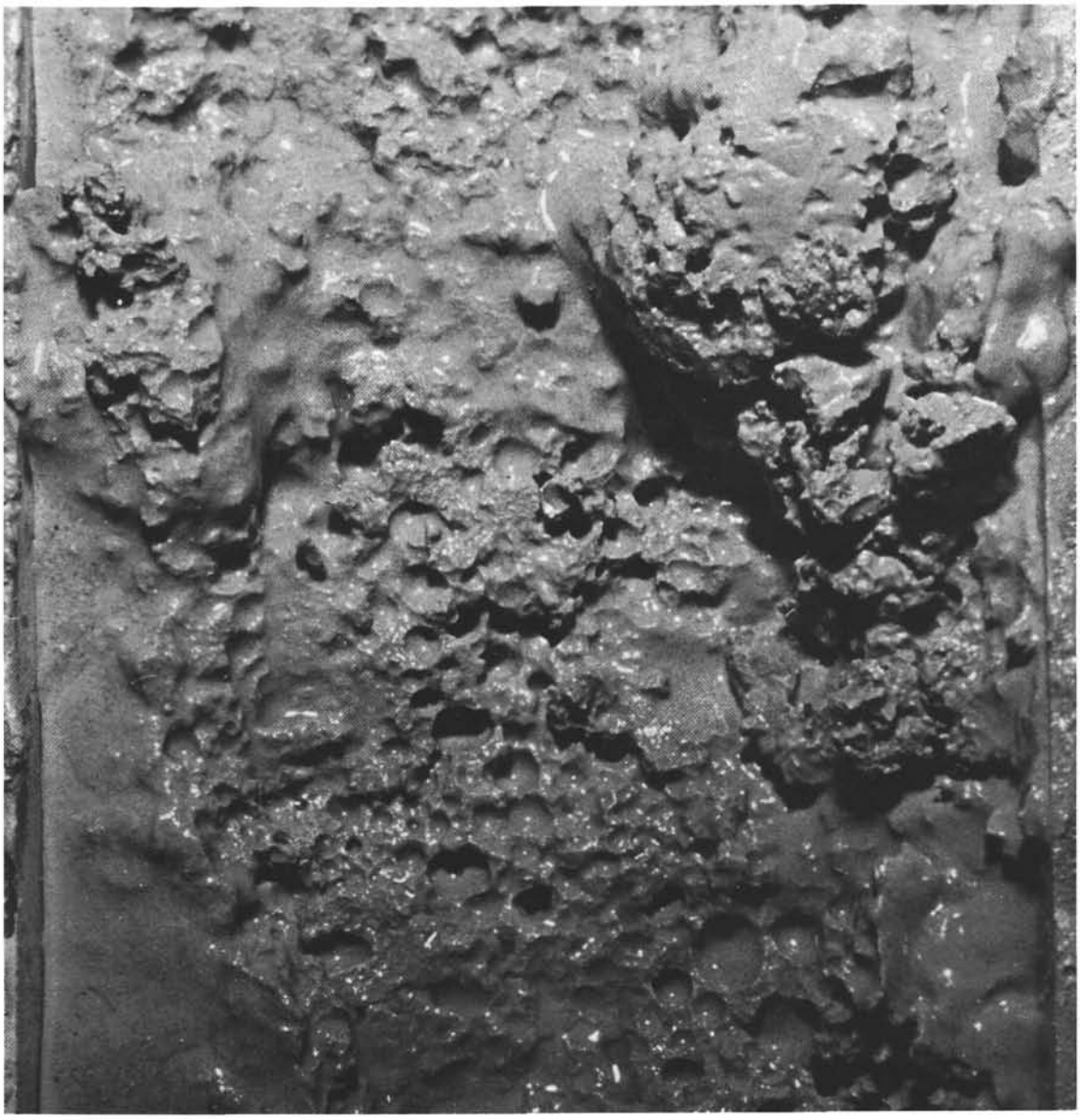

Figure 6. *Deformation by gas bubbles in a volcanic sand layer (196-9-1, 80-83 cm). Full core width.*

Induration

Degree of induration increases sharply in the uncored interval 214 to 245 meters and continues to increase downward to the bottom of the hole.

Inclined Bedding

Beginning with Core 18, 440 meters below bottom, bedding becomes inclined at an angle of 15 degrees and is inclined throughout the remainder of the core. The steepest dip, 35 to 40 degrees, occurs in the vicinity of the anomalous middle Miocene section encountered in Core 23. Below about 700 meters, bedding inclinations decrease to 15 degrees and continue at this angle to the bottom of the hole.

Above Core 18, bedding may also be inclined; however, drilling operations fragmented Cores 13 through 17 and bedding attitudes were not observable. Bedding is horizontal in Core 12 (245 m below bottom).

Middle Miocene Sediments

The lowermost meter of Core 23 contains middle Miocene diatom flora anomalously older than the lower Pliocene sediments found above and below. The middle Miocene sediment is not particularly distinctive, being diatomaceous silty clay. There is, however, a prominent color break at 621 meters, which apparently marks the top of the middle Miocene unit. The contact is sharp, with olive gray silty clay above in contrast to the grayish olive silty clay of the middle Miocene section.

Below the anomalous middle Miocene unit, the sediments are again olive gray to dark gray diatomaceous silty clay, volcanic sand, and ash of early Pliocene age.

PHYSICAL PROPERTIES

Physical properties measured at Site 186 include bulk density, water content, natural gamma radiation, acoustic velocity, vane shear strength, and residual pore pressure.

Bulk density was measured with the GRAPE system, calculated from shore laboratory water content determinations, and, for the harder materials, measured by the water displacement method.

The bulk densities obtained with the GRAPE system are presented on the site summary sheet. In a majority of the cores, the expansion of gases produced a number of voids distributed along the length of the samples. The GRAPE records obtained, therefore, consist of a series of density peaks separated by zones of zero apparent density. The dashed line plots shown on the core summary sheets represent the envelopes of the density peaks in cores containing many voids. Solid lines are drawn for cores containing fewer voids and are a direct representation of the GRAPE records.

Characteristic GRAPE densities are given for each section on the site summary sheet. The characteristic density is defined as the apparent mean of the envelope of the peak densities for the sections containing numerous voids, and as the mean density for the intact sections. Also shown on the site summary are the water displacement densities, shore laboratory densities, and acoustic velocities.

Bulk Density

GRAPE densities were measured to a sediment depth of 735 meters. Below this point, the material did not fill the core liner and could not be tested accurately. A number of water displacement densities are shown for the deeper material. These agree relatively well with the GRAPE densities.

The general trend of the bulk densities at Site 186 is a rapid increase from 1.5 to 1.8 g/cm^3 over the sediment depth range 0 to 200 meters. This is followed by a gradual increase from 1.8 to almost 1.9 g/cm^3 at 900 meters. No sharp breaks in the density-depth distribution are apparent.

Acoustic Velocity

Acoustic velocity measurements were difficult to obtain at Site 186 because of the high gas content of the sediment. To a sediment depth of 450 meters, the material was incapable of transmitting the acoustic signal used in the Hamilton Frame well enough for velocity measurements. From 450 to 740 meters, only a very weak signal could be received. The material from 860 to 930 meters, however, responded as well as the sediment at other sites.

The velocities measured do not indicate any sharp lithologic changes. The general trend is an approximately linear increase from 1.8 km/sec at 450 meters to around 2.0 km/sec at 900 meters. These values may differ significantly from the in situ velocities because of the disturbance introduced by gas expansion.

Summary

The physical property data at Site 186 do not disclose any sharp changes in lithology over the 900 meters investigated. The density and acoustic velocity increase systematically with depth, but this would be expected with any relatively homogeneous sediment.

The problem of gas expansion complicated the physical property measurements at Site 186. Many of the reported values, therefore, may differ significantly from the in situ situation.

PALEONTOLOGY

Abundant diatoms and common to rare radiolarians and silicoflagellates provide good stratigraphic control throughout the cored section. Except for fragments of arenaceous tests, foraminifera were found only in the sands of Cores 10 and 11, middle to lower Pleistocene, and in the bottom of Core 23. The bottom of Core 23, middle Miocene, contained the only nannofossils found at this site.

Foraminiferal faunas in the sand of Cores 10 and 11 are outer sublittoral *Islandiella* assemblages, probably transported to Site 186 by turbidity currents. No other sand at this site yielded displaced faunas.

The lower 1.5 meters of Core 23 contains a fossil microbiota very different from that in sediments above and below. The diatom assemblages compare to middle Miocene assemblages of North Sakhalin while diatom assemblages below Core 23 are clearly lower Pliocene, although with reworked middle Miocene index species. Among the silicoflagellates of Core 23, there is also a middle Miocene index species, but it is one previously unknown in the North Pacific; sediments above and below Core 23 have only characteristic lower Pliocene silicoflagellates. The foraminiferal fauna of Core 23 could be upper middle Miocene, although a younger age cannot be ruled out. Pliocene sediments above and below Core 23 have no foraminiferal fauna at all, which is typically the case for Pliocene deposits at other North Pacific and Bering Sea sites. Nannofossils in Core 23 are not age-diagnostic. Their occurrence is significant because they are absent above and below. Because all these various elements of the fossil microbiota are so markedly different from those found in sediments above and below, it is believed that resemblances of the diatom flora to a known middle Miocene flora is not fortuitous and the middle Miocene index fauna are not reworked in Core 23, although they are reworked above and below.

Taken together, then, the evidence indicates that the lower 1.5 meters of Core 23 is older than sediments below it. Furthermore, because the microbiota appears to be a coherent assemblage rather than a mixture of older and younger elements and because it occurs in a sediment distinguished by color, although not by texture, from lower Pliocene sediment above and below, the lower 1.5 meters of Core 23 is interpreted as an exotic block of middle Miocene sediment within the lower Pliocene section.

Because the inferred exotic block in Core 23 contains relatively common calcareous fossils it is concluded that either the carbonate compensation depth was much lower in middle Miocene than in Pliocene time or that the exotic block is derived from a water depth considerably less than that in which the Pliocene sediment on either side of it was deposited. Because an indigenous middle Miocene calcareous microbiota was not found at Site 183, which is from a water depth similar to Site 186, the latter interpretation is preferred. However, the benthic foraminiferal fauna contains abyssal indicators, including *Melonis pompilioides*, therefore an upper limit of about 2000 meters can be placed on the deposition depth of the sediment from which the block was derived.

Foraminifera

Examination of core catcher samples yielded only three significant foraminiferal faunas; these three are from Cores 10, 11, and 23. The core catchers of Cores 10 and 11 have a moderately abundant, generally well-preserved benthic fauna dominated by *Islandiella limbata, I. californica,* and *Elphidiella arctica.* This assemblage, typical of outer sublittoral or possibly upper bathyal depth zones, is obviously displaced and indicates that the thick sand beds of Cores 10 and 11 are derived from these depth zones. The faunas, therefore, are supporting evidence that the sand beds are turbidites. A sparse assemblage of sinistrally coiling *Globorotalis (T.) pachyderma* is present.

The core catcher of Core 23 also contained a moderately abundant, well-preserved benthic fauna. All extant species in this fauna are known from lower bathyal depths of the modern ocean; *Melonis pompilioides* indicates a paleodepth of deposition in excess of 2000 meters. The dominant species, *Spirosigmoilinella compressa,* is restricted in northeastern Japan to Miocene sediments inferred to have been deposited at lower bathyal depths (Asano, et al., 1969). There, as in Core 23, it is associated with *Martinottiella communis.* A sparse, dominantly dextral population of *G. (T.) pachyderma* is also present in Core 23. Previously, the lowest reported occurrence of this species is upper middle Miocene. Earliest populations are dextral in the lower Funakawa Formation of northeastern Japan (Asano, et al., 1969) as they are in Core 23, becoming sinistral in the upper Miocene.

Calcareous Nannoflora

The site is essentially barren of calcareous nannofossils with the exception of Core 23, Section 3. This apparently displaced sediment block contains rare but well-preserved specimens resembling *Reticulofenestra dictyoda* and *R. umbilica* and other small (2-3μ) placoliths. This flora is similar to that encountered at Sites 184 and 185.

Radiolaria and Silicoflagellates

All the sediments examined from Site 186, except Core 28, yielded radiolarians and/or silicoflagellates. Sparsity of radiolarian specimens (Table 5, Chapter 28) continues at this site. Furthermore, most of the forms encountered are members of the modern North Pacific and the Bering Sea (surface sediments) fauna and apparently they are rather long-ranging species in these regions.

Occurrence of silicoflagellates from Site 186 is shown in Table 5, Chapter 27. The Pleistocene and early Pliocene microfloral succession of Cores 1 to 21 is similar to that observed at Site 185. In Core 23, the occurrence of *Naviculopsis lata* is noted. This species has been reported only from Europe and from exposures in Italy; it is found in *Calocycletta costata* and *C. virginis* (radiolarian) zones of Sanfilippo (1971). Fragments of possibly *Mesocena apiculata* were also noted in the same core sediments.

Diatoms

The stratigraphic sequence at Site 186 can be divided into five zones as shown in Table 4, Chapter 30. As indicated in the table and as will be discussed in detail later, the microflora of the lower 1.5 meters of Core 23 (from the anomalous section described earlier) is largely dominated by *Coscinodiscus symbolophorus* and *Coscinodiscus marginatus* forma, but it also contains some specimens of such good middle Miocene marker species as *Actinocyclus ingens, Annelus californicus, Denticula lauta, Kieselavia carina,* and *Raphibodiscus marylandicus.*

CORRELATION BETWEEN REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

Sites 186 and 187

The reflection profile that was used for selecting Sites 186 and 187 (taken by E. L. Hamilton in 1971) is shown in Figure 7 along with the stratigraphic column and physical properties for Site 186. The measurements of physical properties at Site 186 was often very difficult due to gassy cores or brittle, fractured sediments, and only very gross trends are apparent in the density and velocity data.

Although the lithology at Site 186 was somewhat uniform, diatomaceous silty clay with various admixtures of volcanic sand, ash, calcareous siltstone, and semilithified mudstone, the reflectors in the upper 400 meters on the profile correlate quite well with lithologic changes. The reflectors are generally sandy or semi-indurated units. Below 400 meters other diffuse reflecting horizons can be seen, but they do not clearly correlate with obvious lithologic variations. Part of the poor correlation below 400 meters may be due to the fact that the ship was positioned 0.5-1.0 km closer to the basement ridge than planned. At Site 187 four cores of upper Miocene diatomaceous silty clay were drilled between 164 and 370 meters. All four cores were within the "acoustical basement." Therefore, it is possible that somewhere between 400 and 926 meters (T.D.) at Site 186 we entered rocks of the acoustic basement drilled at Site 187. The anomalous occurrence of the middle Miocene core at 620 meters at Site 186 (between two lower Pliocene cores) and the presence of 30 to 35 degree bedding inclination further suggest that a zone of deformed terrace sediments may have been reached in the deeper part of the hole. A detailed discussion of interval velocities is not possible with this hole; however, the reflectors in the upper 400 meters seem to correlate fairly well with a 1.65 km/sec velocity.

REFERENCES

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Sanfilippo, A., 1971. Neogene radiolarians of the Mediterranean and western Pacific. *In* Farinacci, A. (Ed.). Proc. 2nd Intern. Plank. Conf. Rome. **II**, 1121.

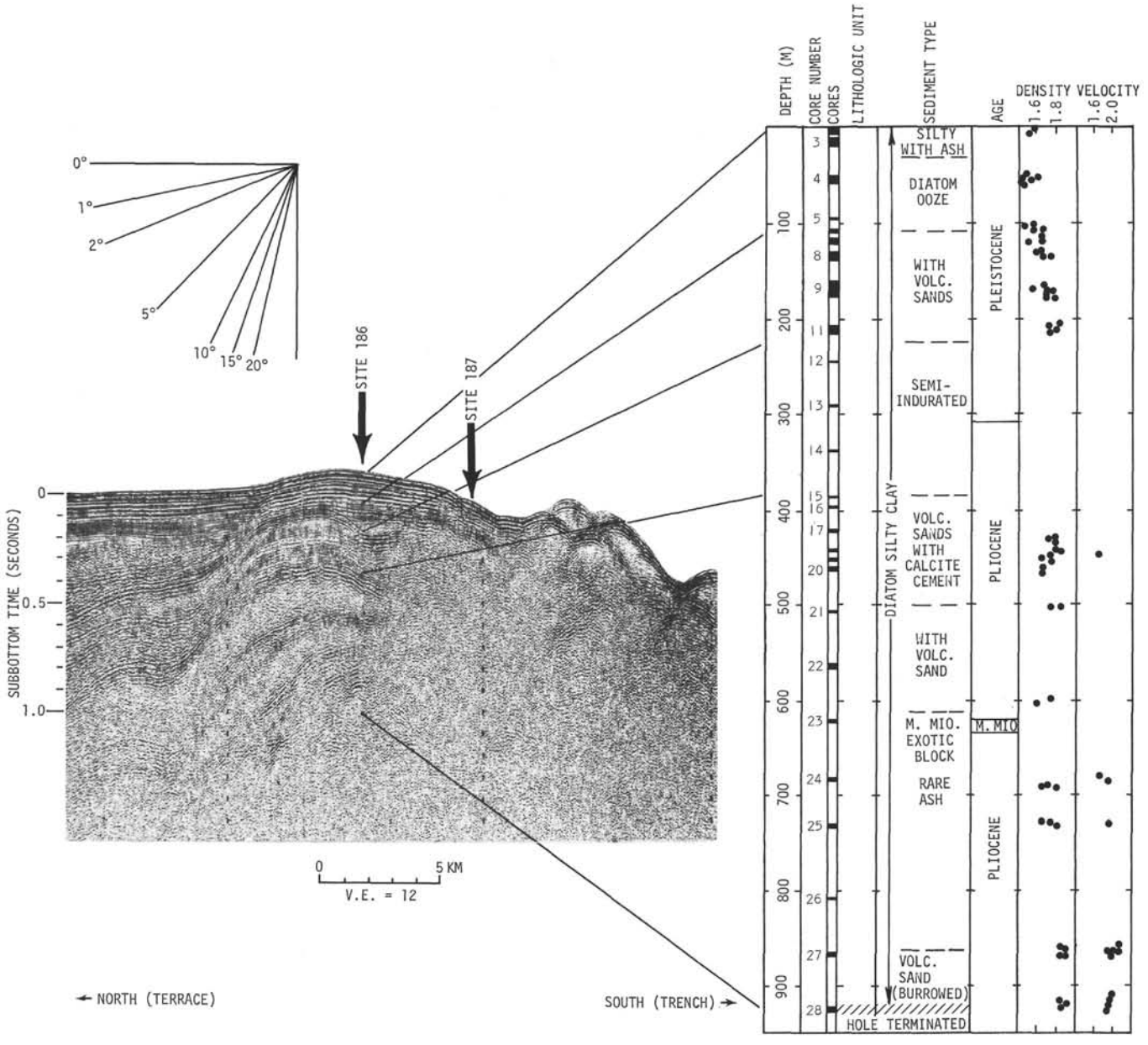
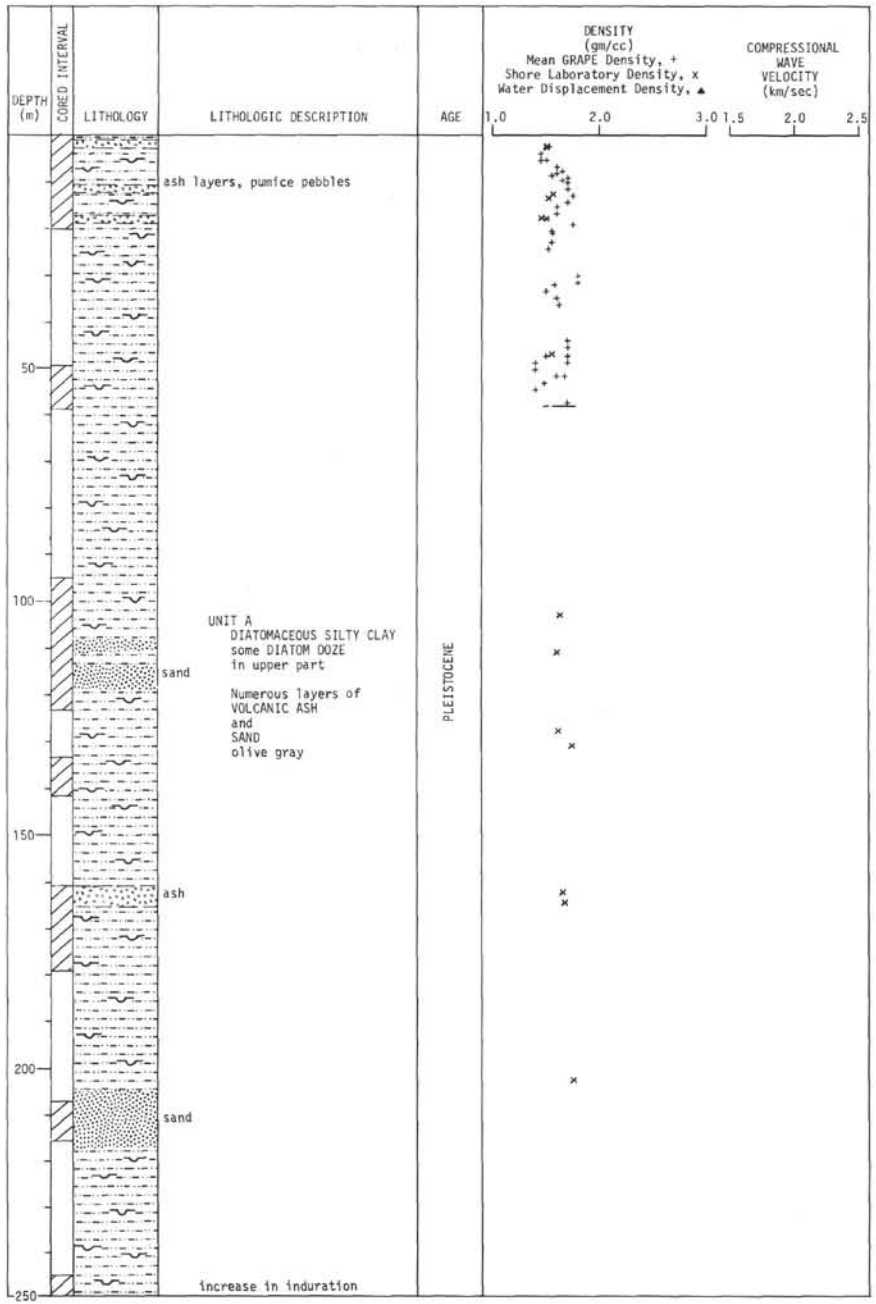
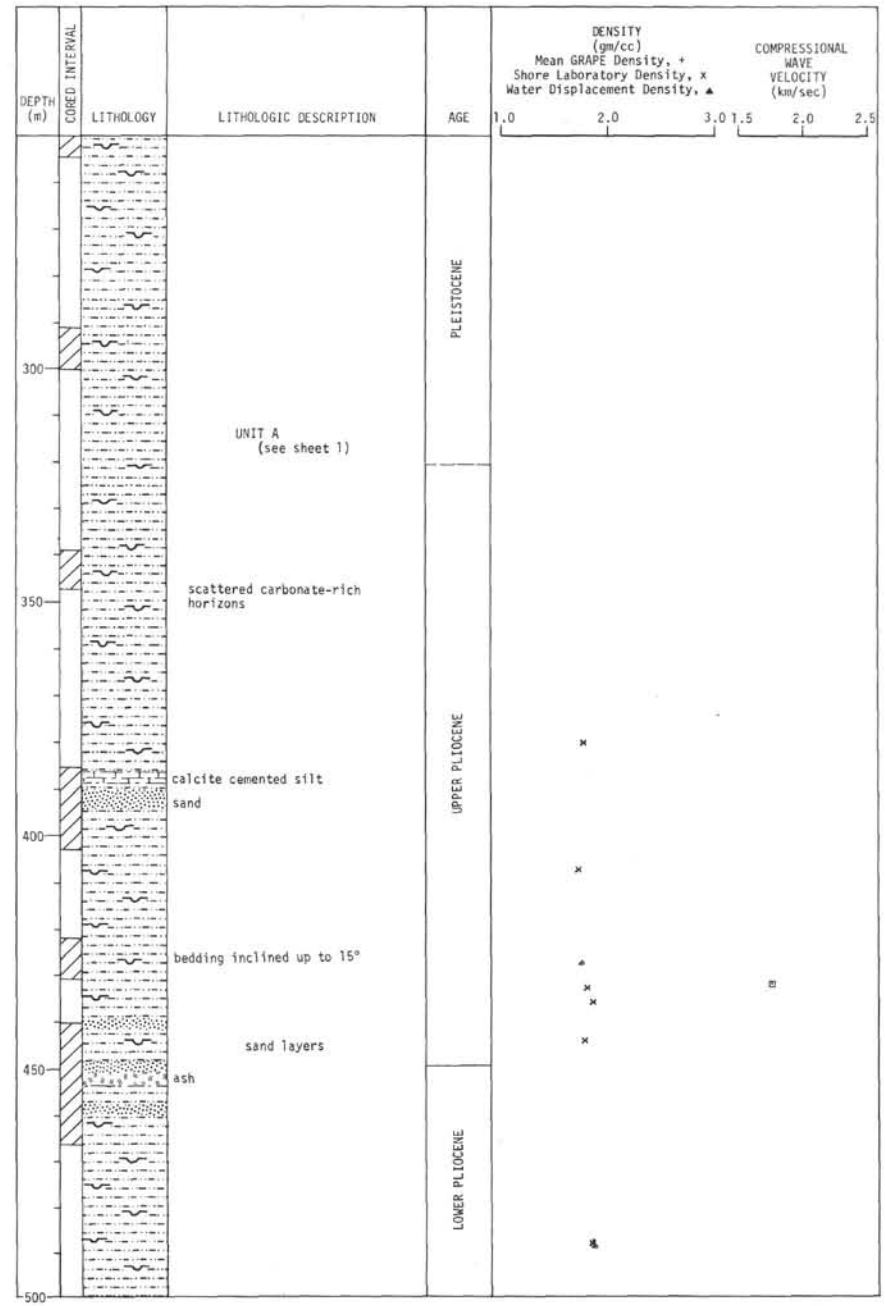


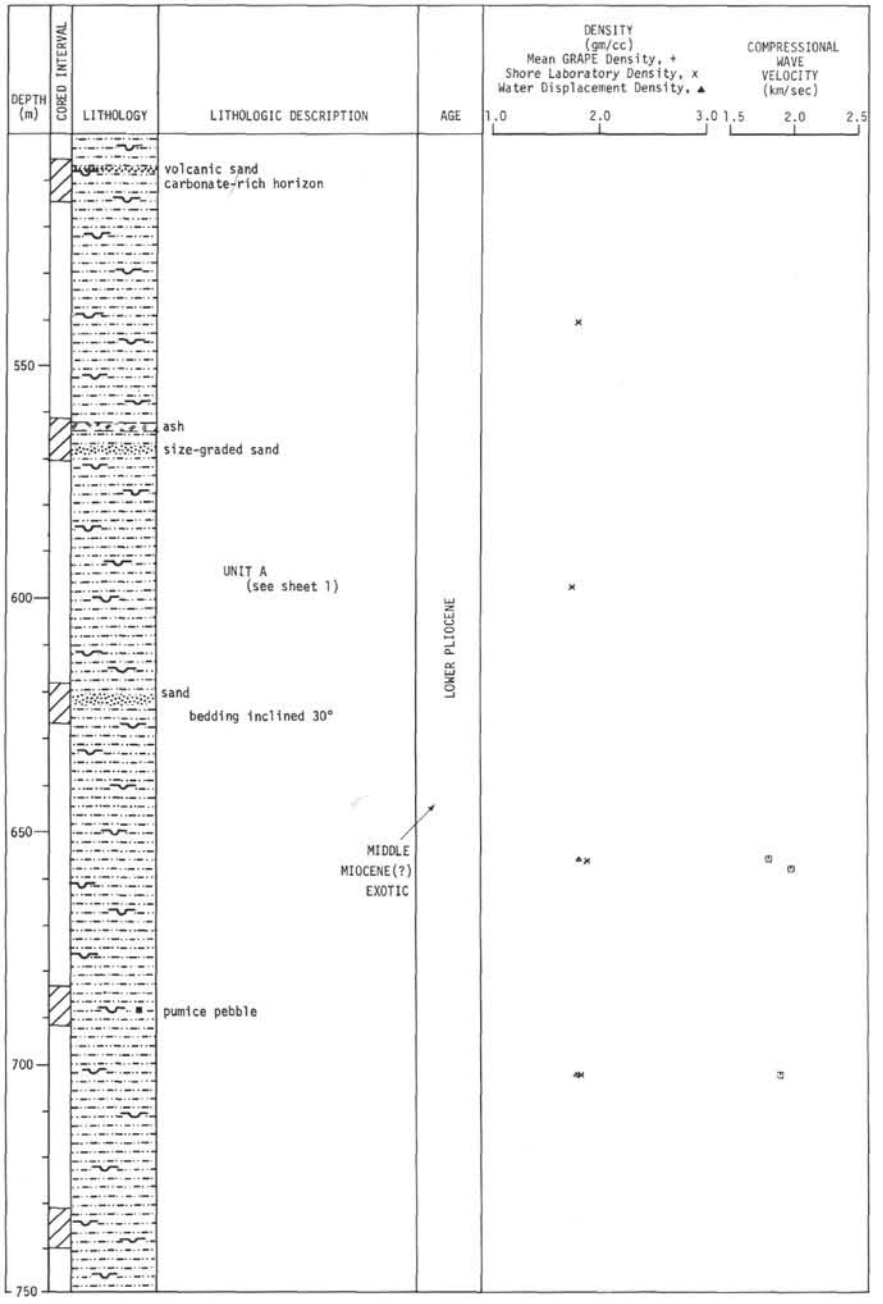
Figure 7. *Correlation of the seismic reflection profile with physical properties and the lithologic column, Sites 196 and 187.*

SITE 186

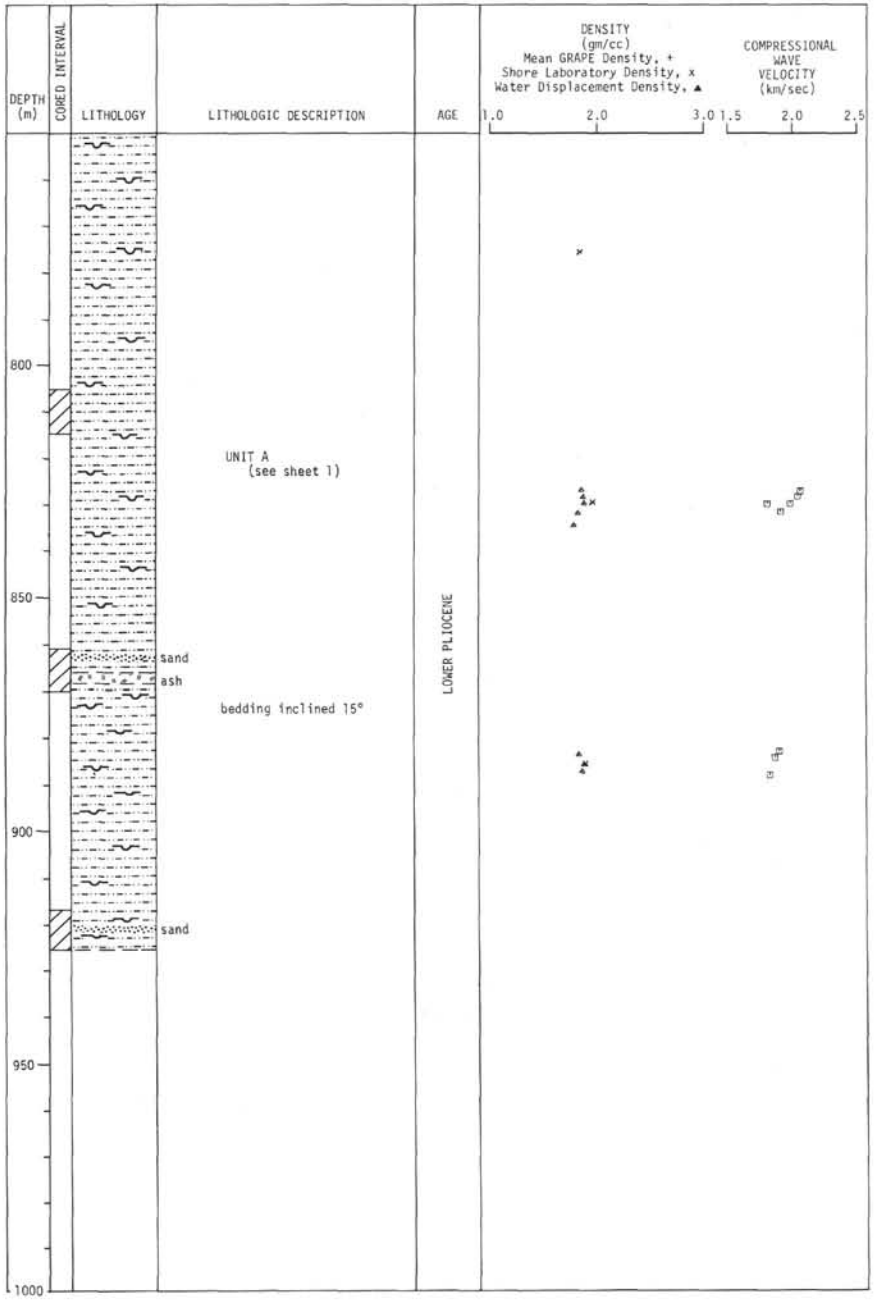


SITE 186




DEPTH (m)
CORED INTERVAL
LITHOLOGY
LITHOLOGIC DESCRIPTION
AGE
DENSITY (gm/cc)
Mean GRAPE Density, +
Shore Laboratory Density, x
Water Displacement Density, ▲
1.0
2.0
3.0
COMPRESSIONAL WAVE VELOCITY (km/sec)
1.5
2.0
2.5
550
600
650
700
750
volcanic sand
carbonate-rich horizon
ash
size-graded sand
UNIT A
(see sheet 1)
sand
bedding inclined 30°
MIDDLE MIOCENE(?) EXOTIC
LOWER PLIOCENE
pumice pebble

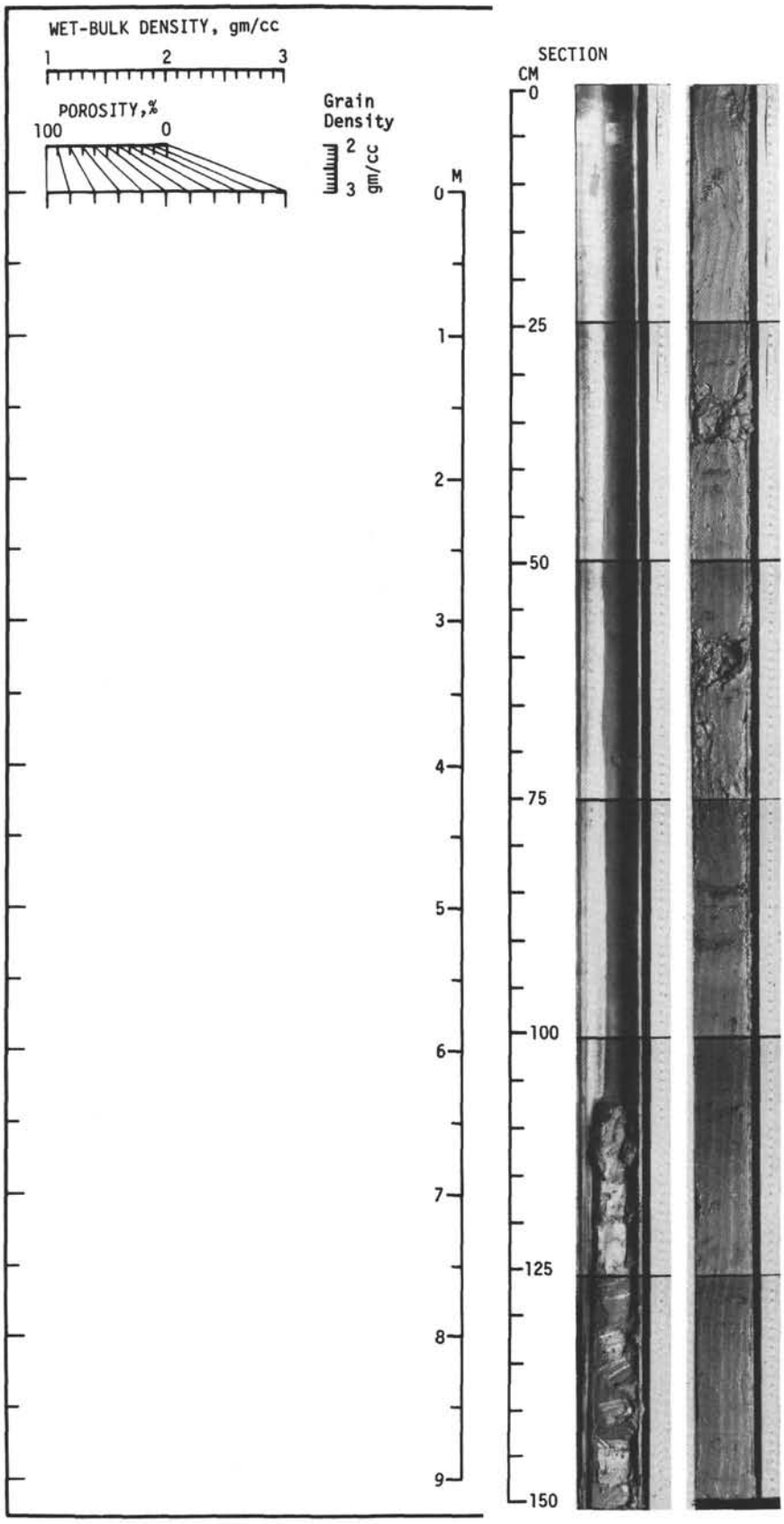
SITE 186


DEPTH (m)
CORED INTERVAL
LITHOLOGY
LITHOLOGIC DESCRIPTION
AGE
DENSITY (gm/cc)
Mean GRAPE Density, +
Shore Laboratory Density, x
Water Displacement Density, ▲
1.0
2.0
3.0
COMPRESSIONAL WAVE VELOCITY (km/sec)
1.5
2.0
2.5
800
850
900
950
1000
UNIT A
(see sheet 1)
sand
ash
bedding inclined 15°
sand
LOWER PLIOCENE

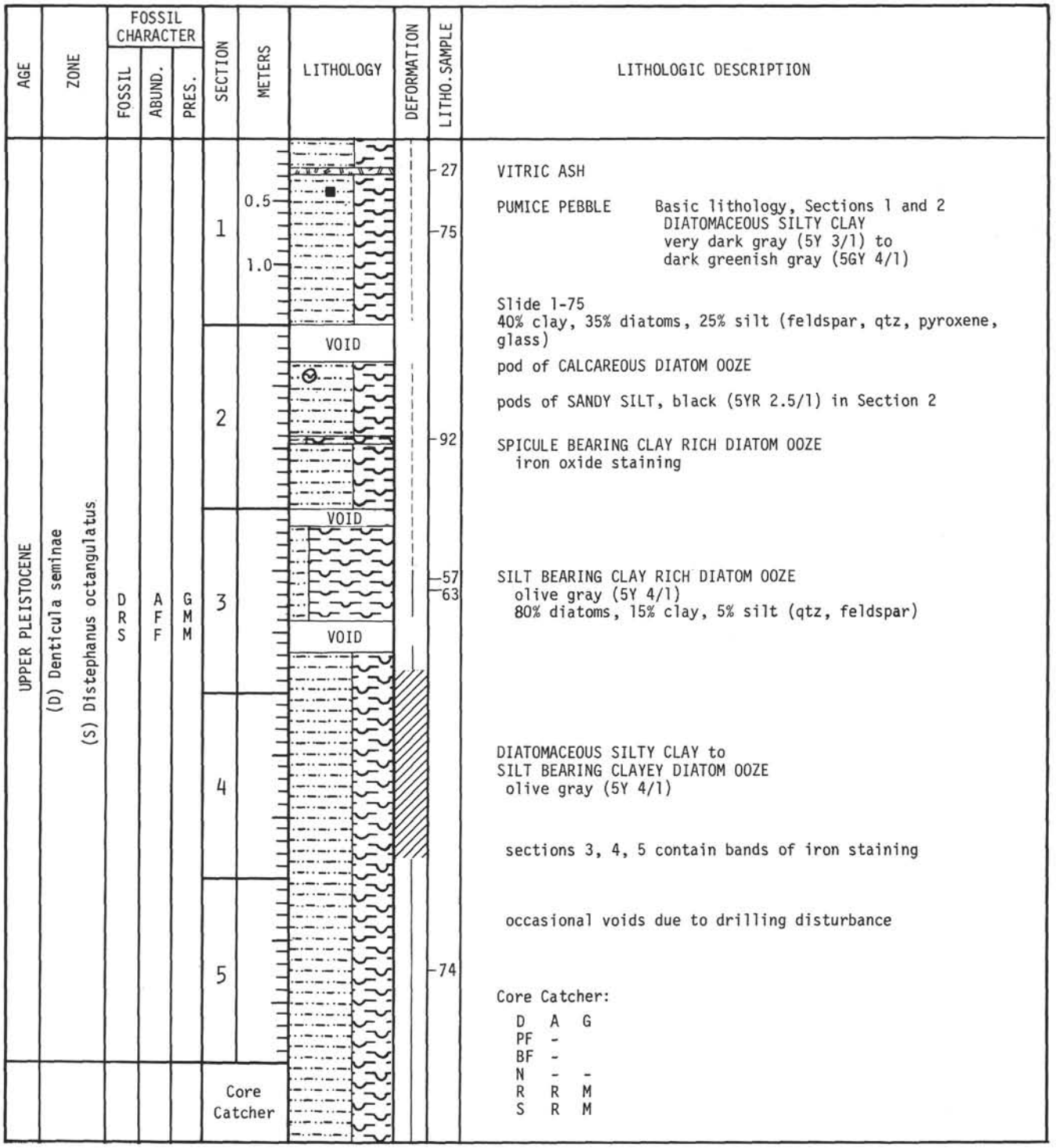
Site 186 Hole Core 1 Cored Interval: 0-2

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLEISTOCENE	(D) Denticula seminae (S) Distephanus octangulatus	R S	R -	M -	1	0.5	VOID			Basic lithology DIATOM RICH SILT olive gray (5Y 3/2)
						1.0			130	
									5	SILT BEARING SAND, 60% feldspar, 40% pyroxene
					2				50	
									87	DIATOM OOZE, yellowish brown (10YR 4/4)
					Core Catcher					Core Catcher: D A G N - - R F M S F M PF R BF -

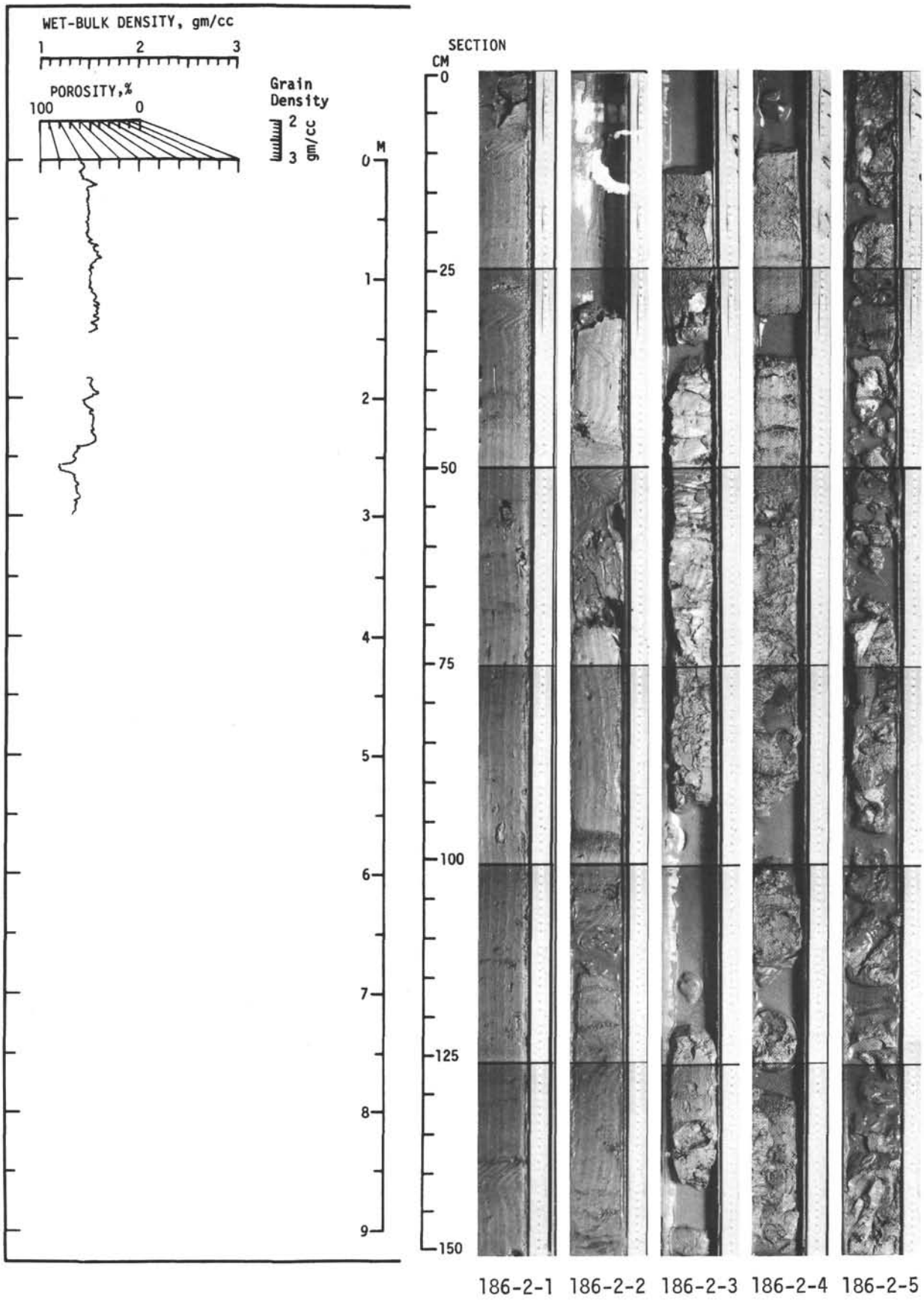
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-1-1
186-1-2

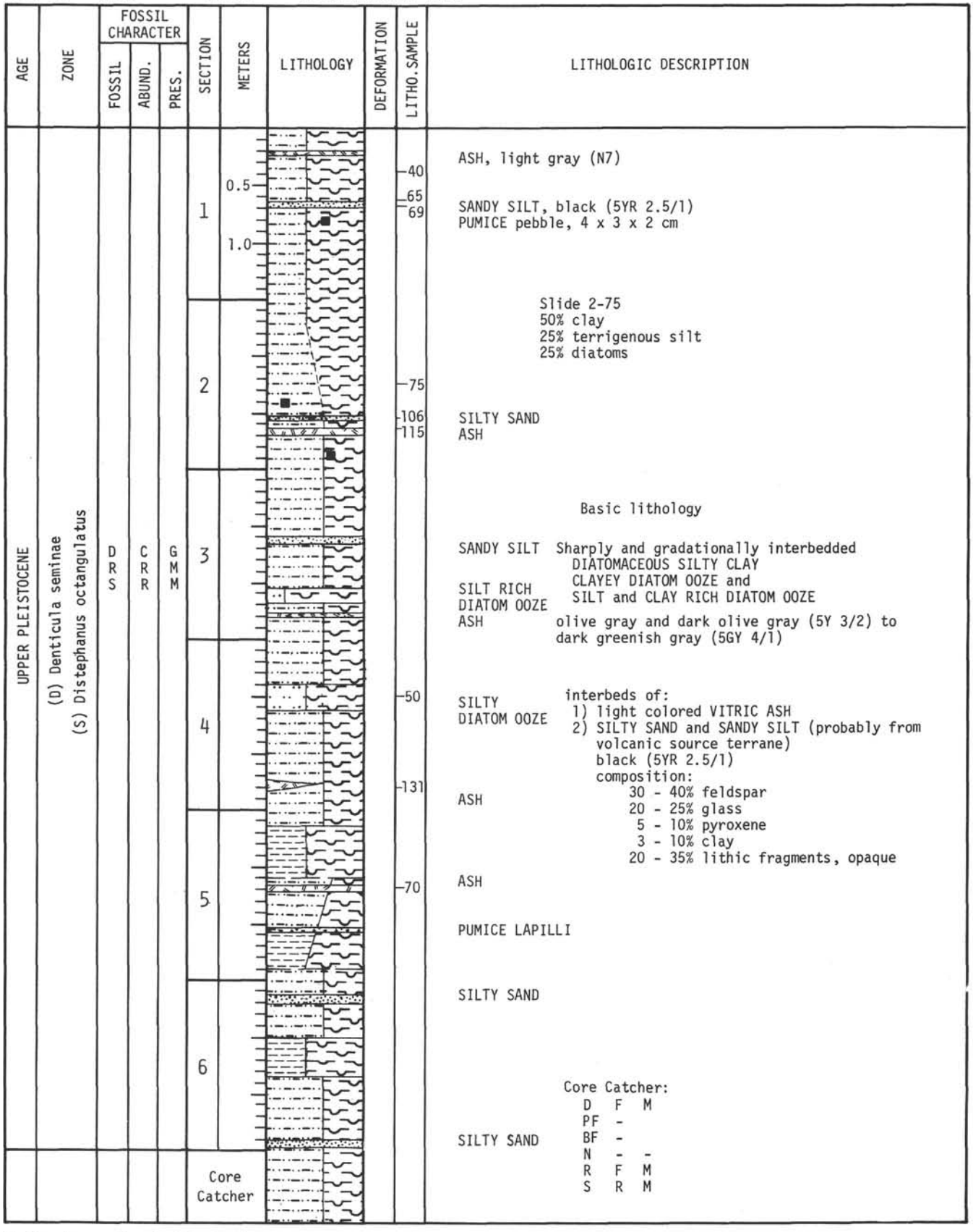
Site 186 Hole Core 2 Cored Interval: 2-11



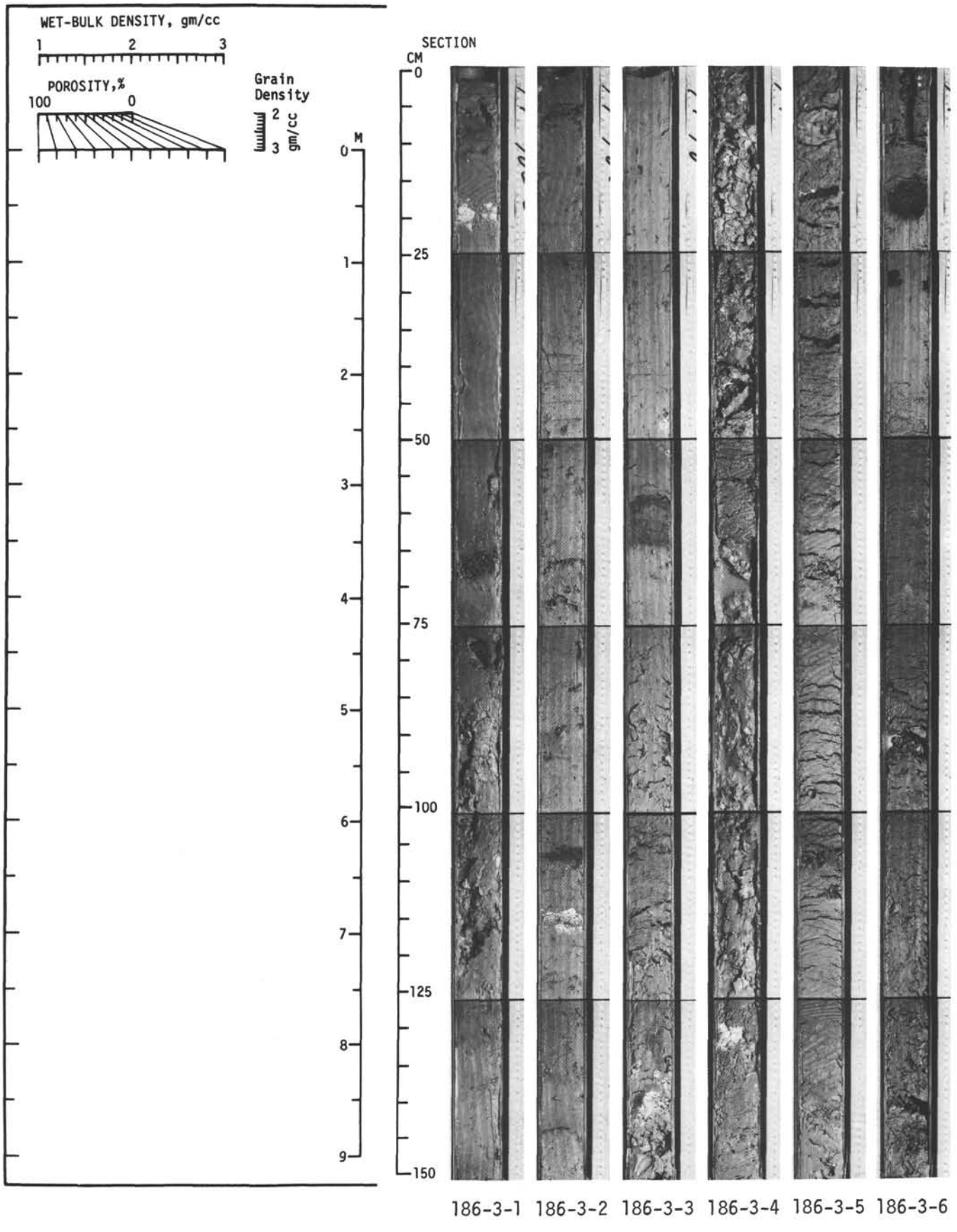
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-2-1
186-2-2
186-2-3
186-2-4
186-2-5

Site 186 Hole Core 3 Cored Interval: 11-20



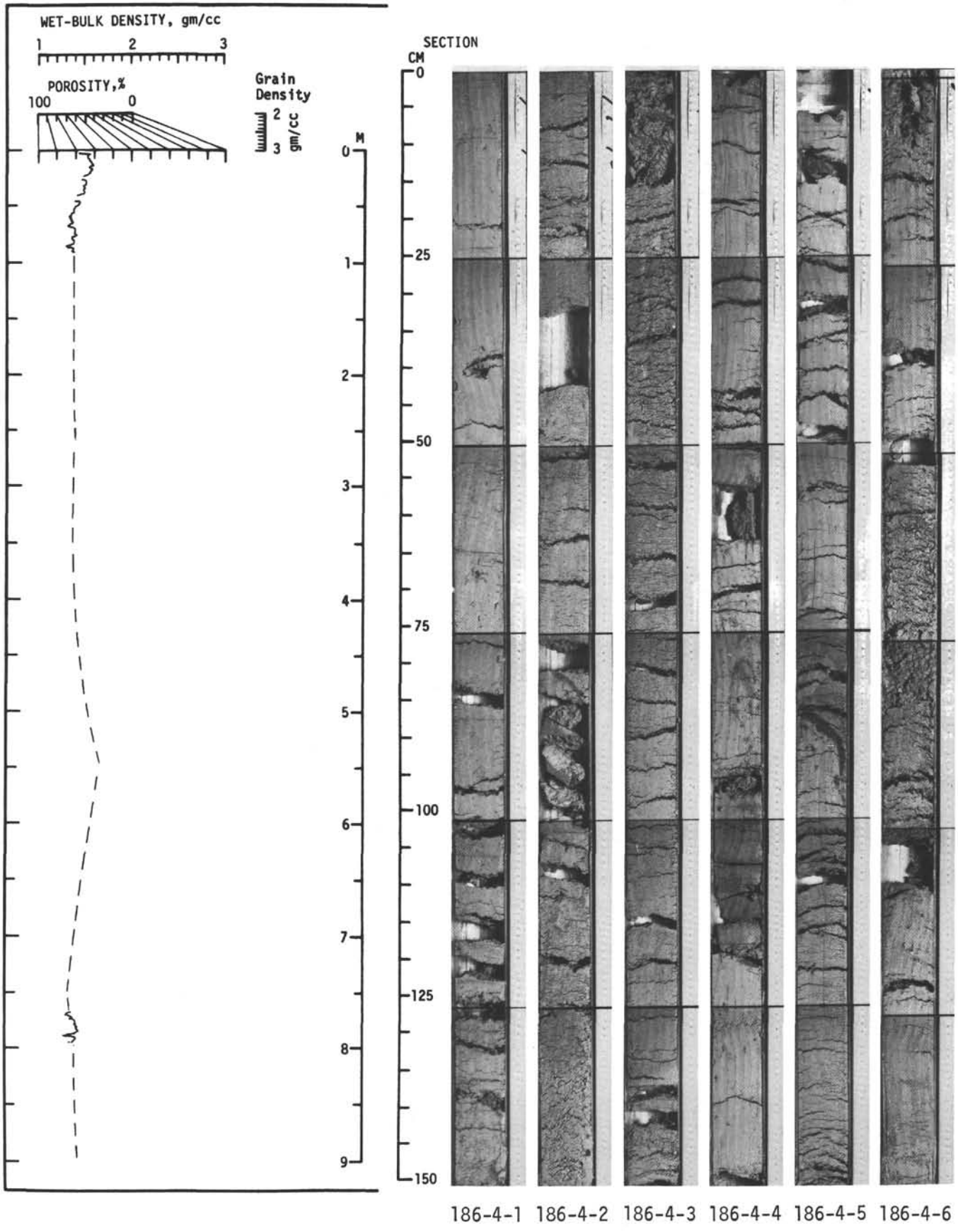
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-3-1
186-3-2
186-3-3
186-3-4
186-3-5
186-3-6

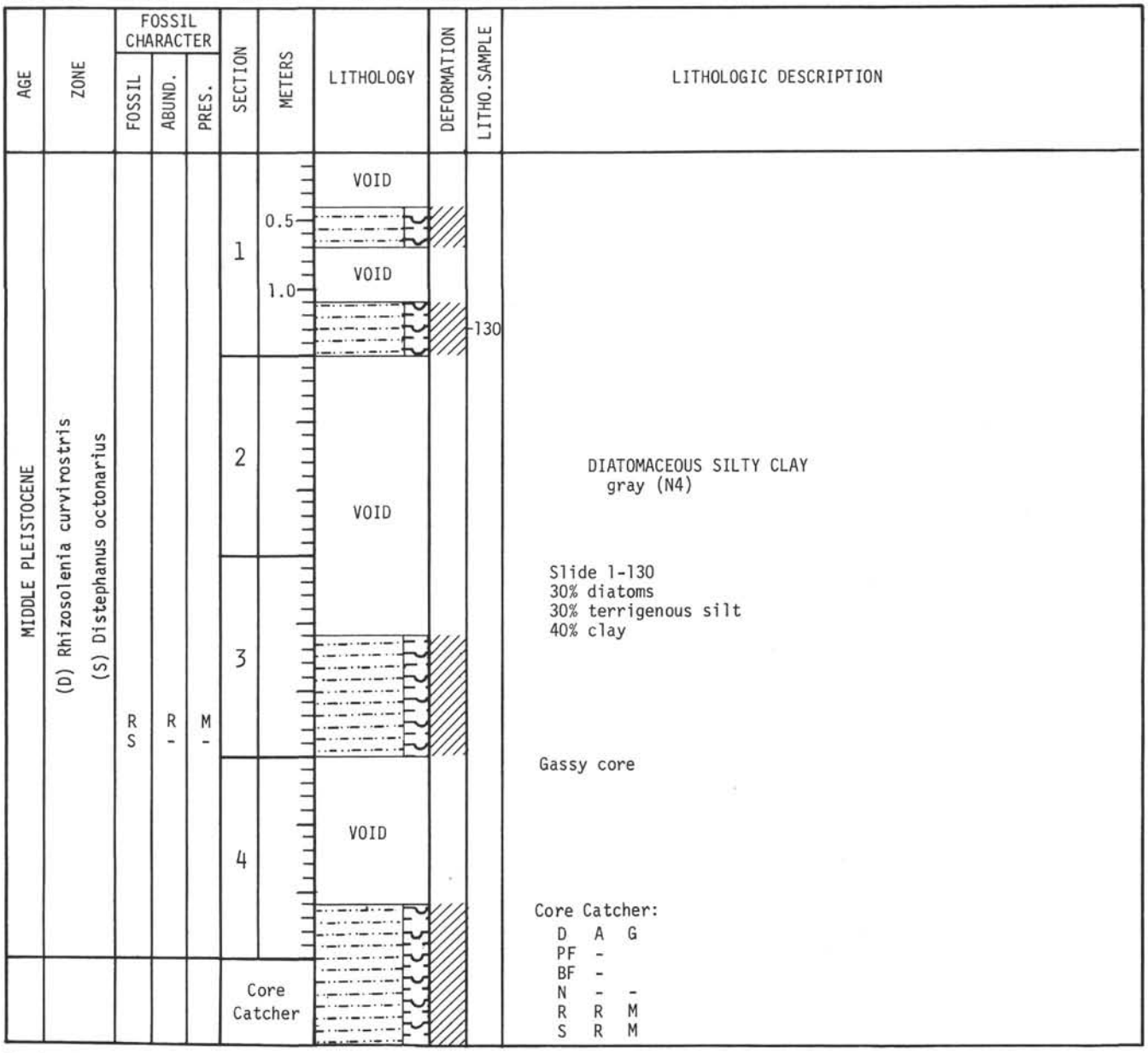
Site 186 Hole Core 4 Cored Interval: 49-58

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE PLEISTOCENE	(D) Rhizosolenia curvirostris (S) Distephanus octonarius	D R S	A R A	G M M	1	0.5 – 1.0			75	SPICULE BEARING, SILT RICH CLAYEY DIATOM OOZE dark gray (2.5Y 4/0) Slide 1-75 50% diatoms, 30% clay, 15% qtz, feld., 5% spicules grades downward to:
					2					SILT BEARING CLAY RICH DIATOM OOZE gray (5Y 4/1) Slide 3-75 75% diatoms, 15% clay, 10% qtz, feld, opaque 5-10 mm long white pods of sponge spicules at 91, 99, and 103 cm (section 3)
					3				75 103	SPONGE Slide 103 100% spicules
		R S	R -	M -	4				80	DIATOM RICH SILTY CLAY medium dark gray (N4)
					5				60 87	SPICULE and DIATOM BEARING SANDY SILT
									140	SILT and CLAY BEARING DIATOM OOZE grades downward to:
					6					CLAYEY DIATOM OOZE Entire core is gassy, numerous voids
					Core Catcher					Core Catcher: D PF - BF - N - - R R M S - -

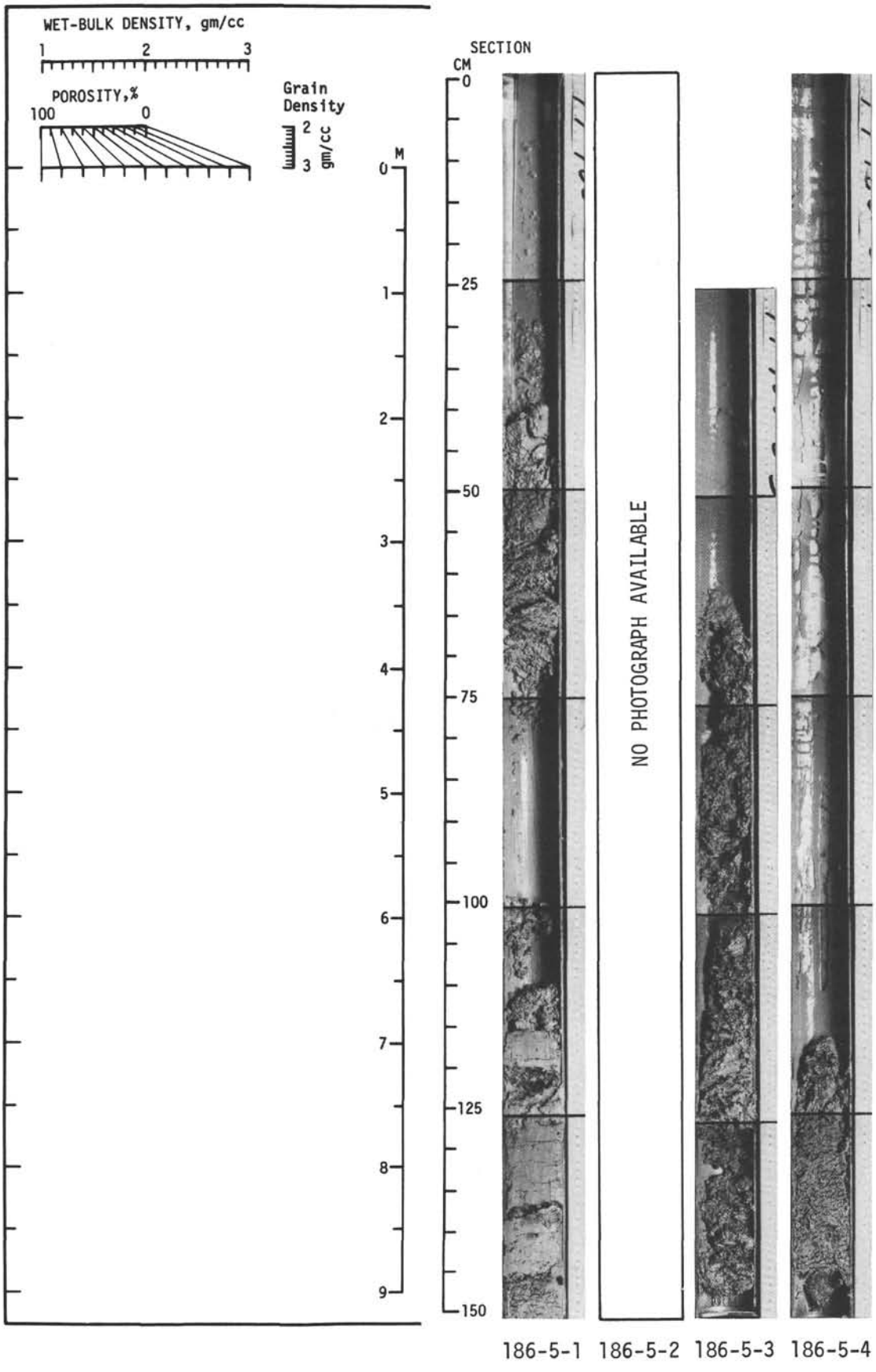
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-4-1
186-4-2
186-4-3
186-4-4
186-4-5
186-4-6

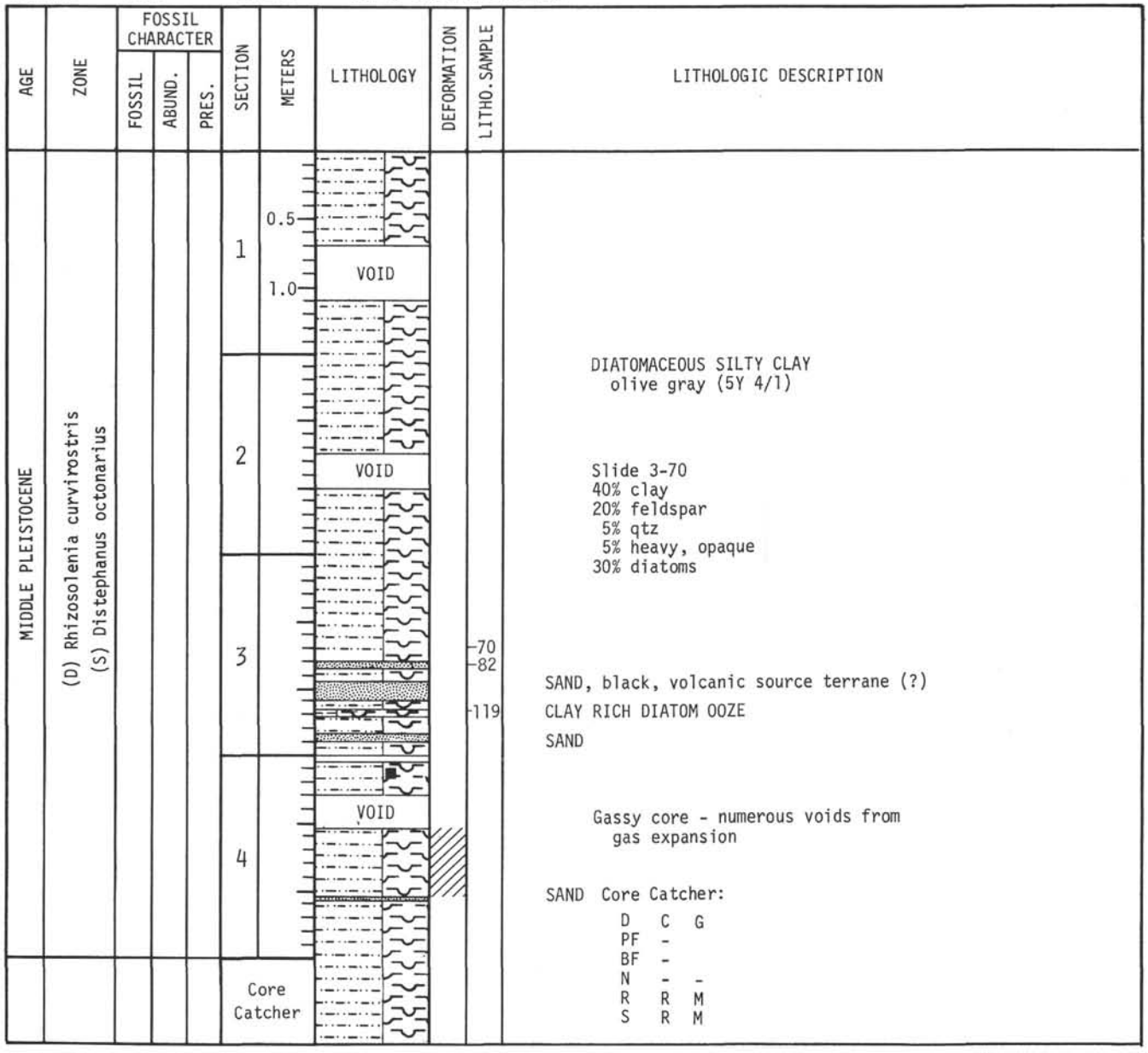
Site 186 Hole Core 5 Cored Interval: 96-105



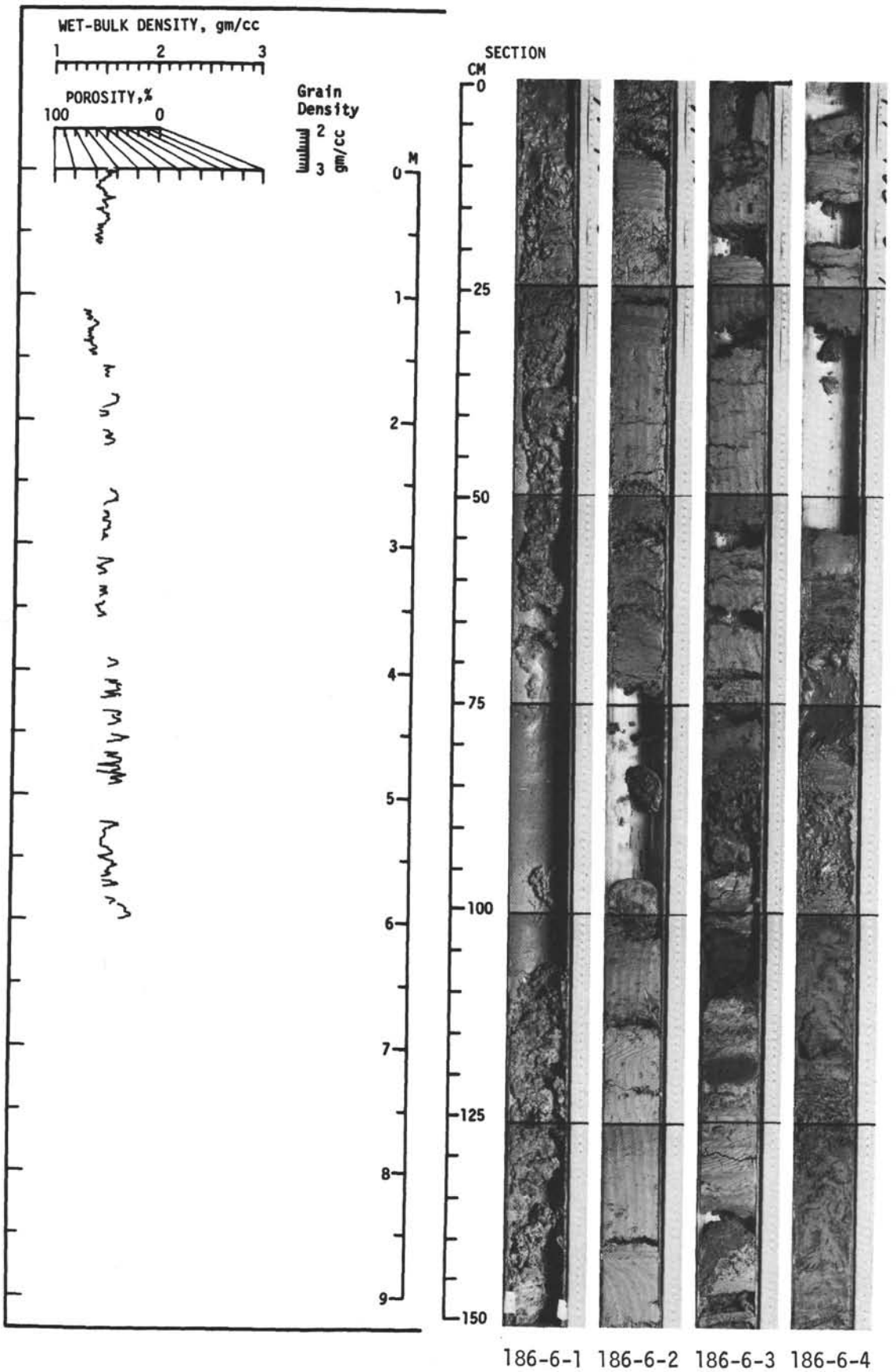
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
NO PHOTOGRAPH AVAILABLE
186-5-1
186-5-2
186-5-3
186-5-4

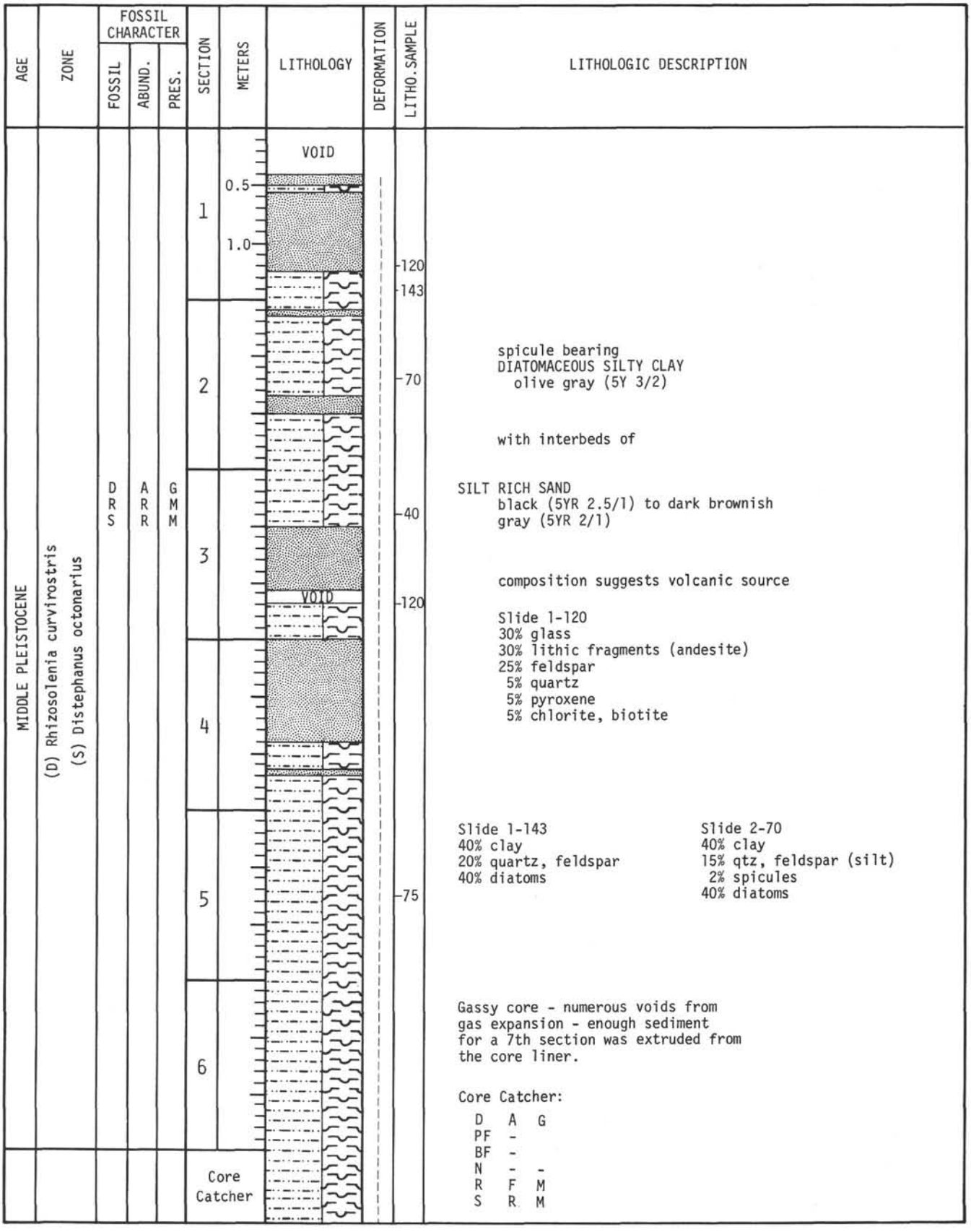
Site 186 Hole Core 6 Cored Interval: 105-114



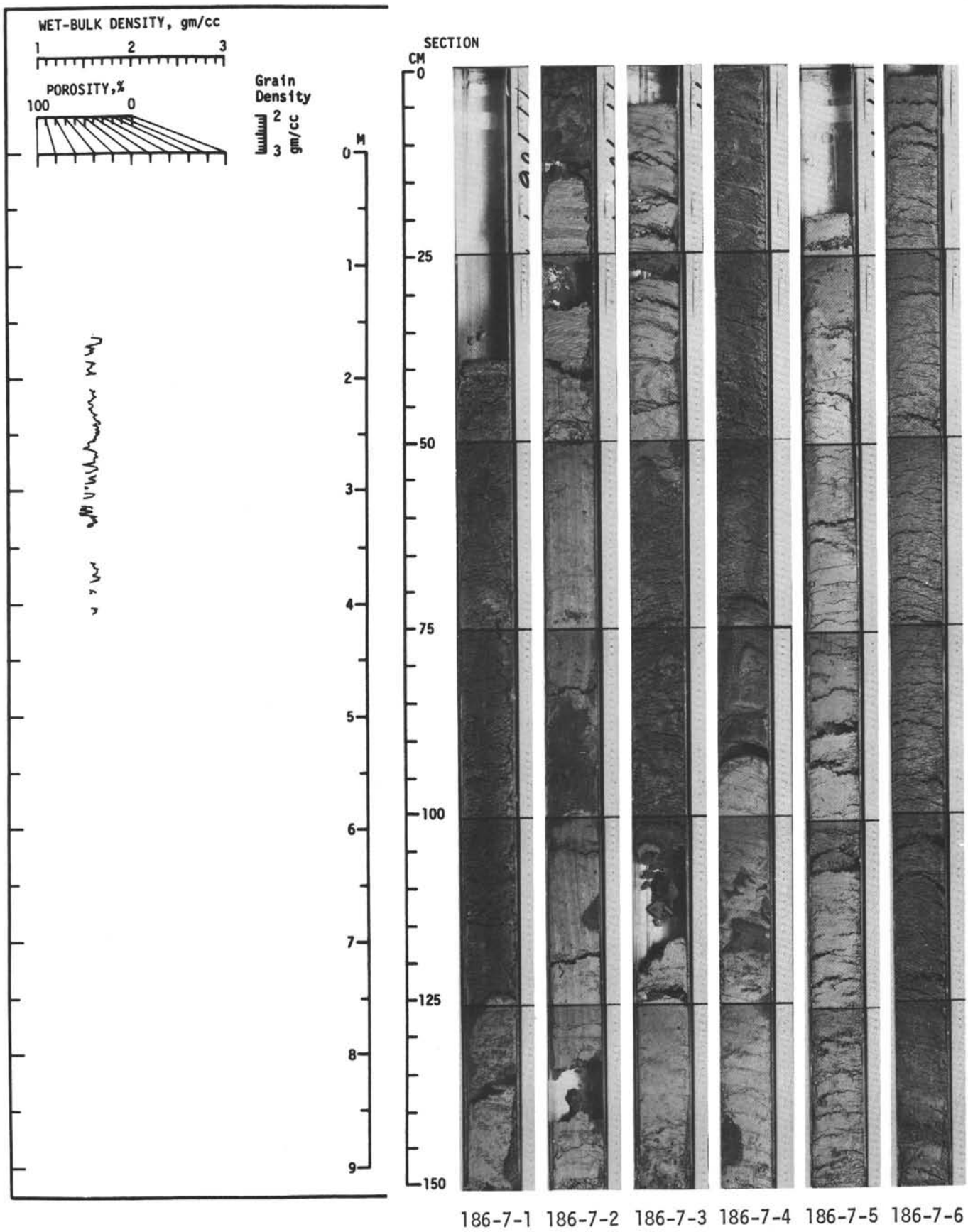
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-6-1
186-6-2
186-6-3
186-6-4

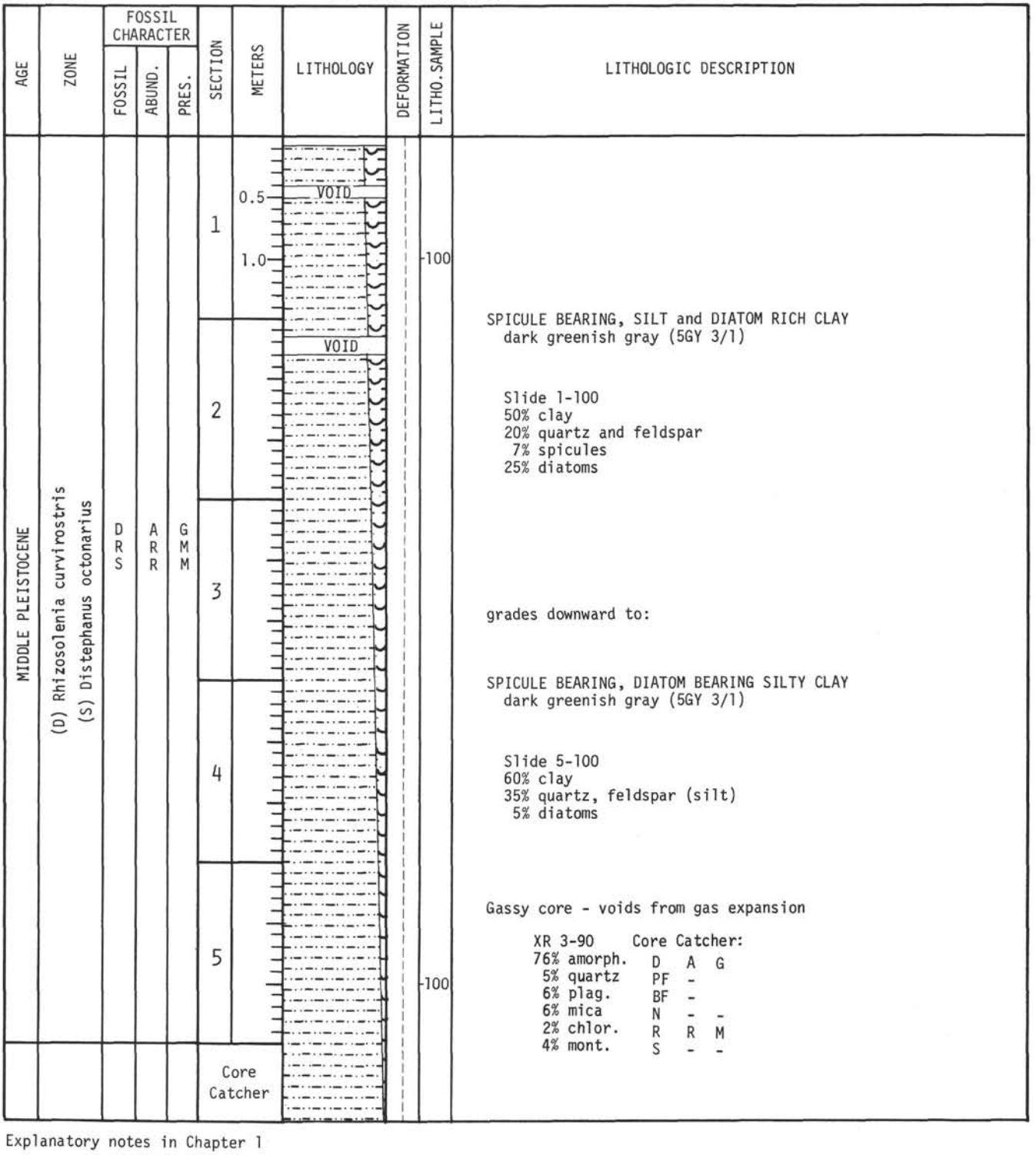
Site 186 Hole Core 7 Cored Interval: 114-123



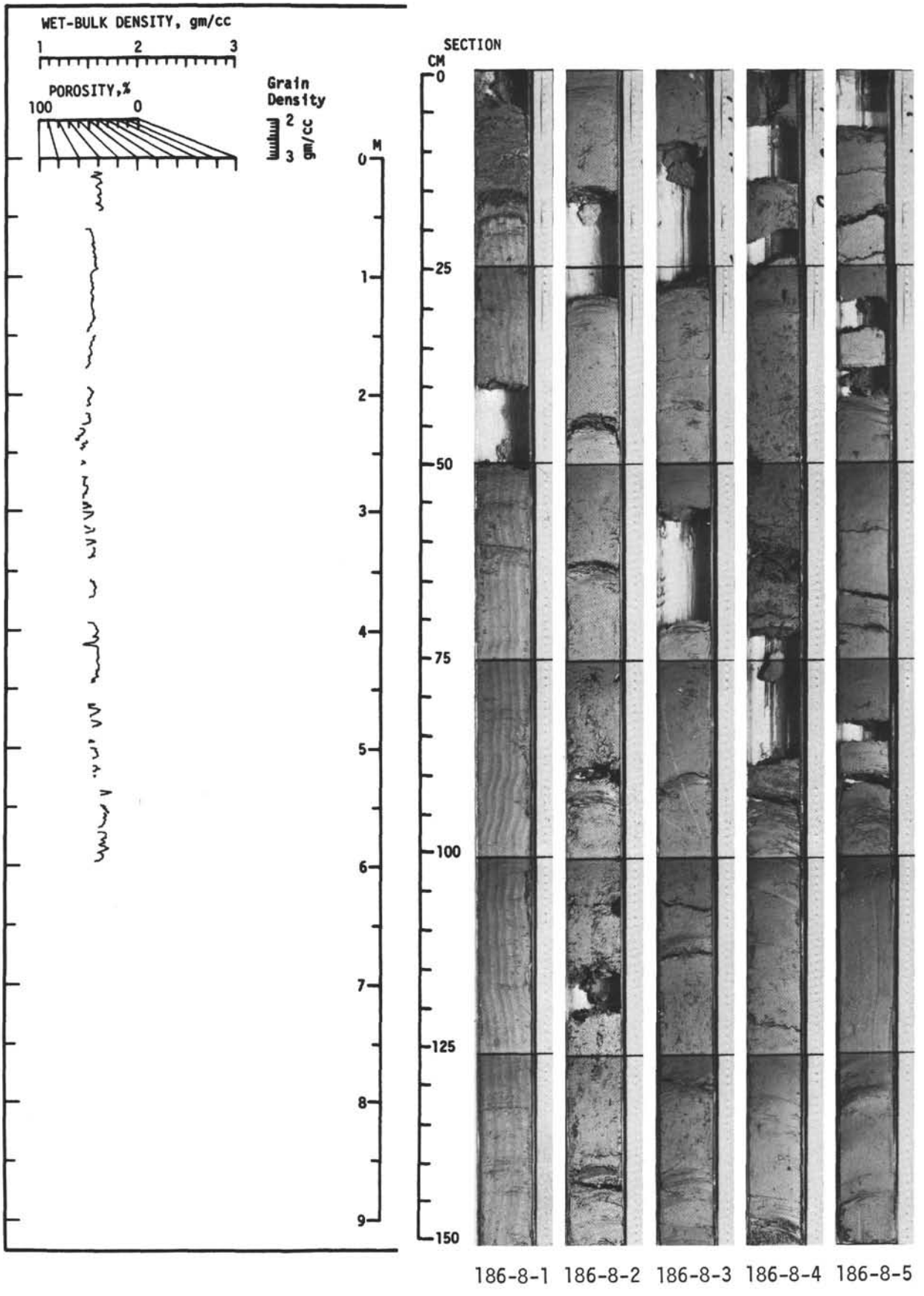
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-7-1
186-7-2
186-7-3
186-7-4
186-7-5
186-7-6

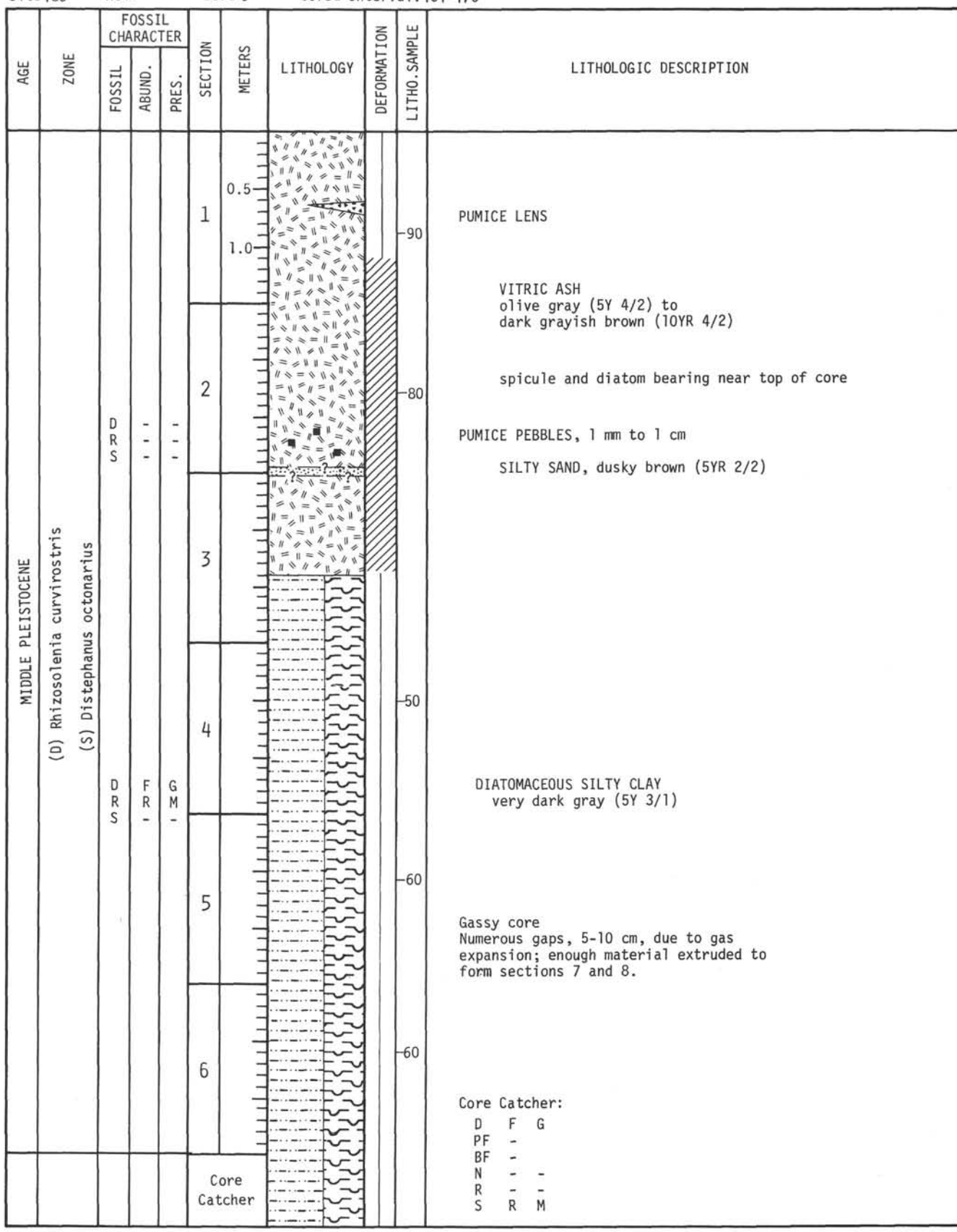
Site 186 Hole Core 8 Cored Interval: 133-142



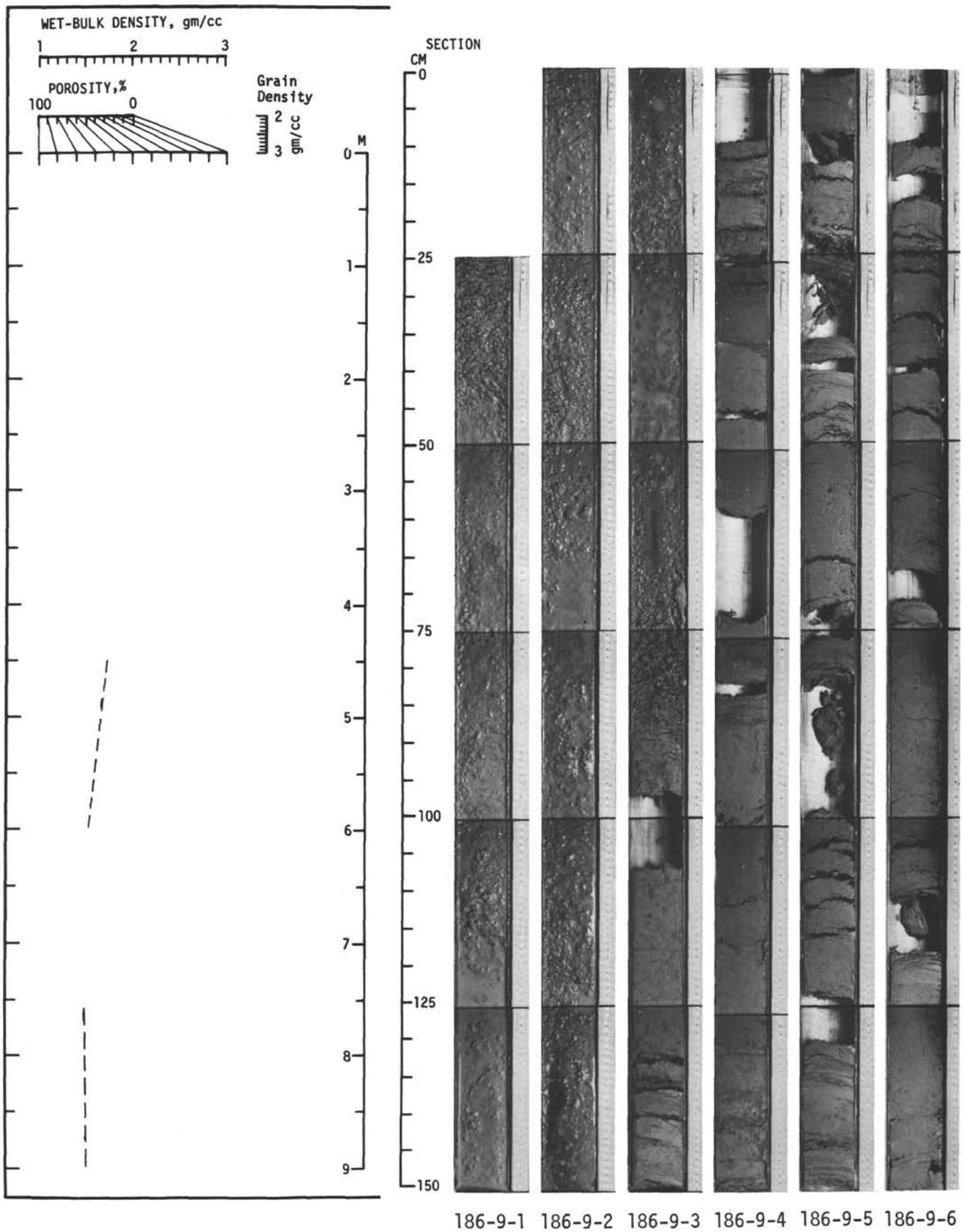
Explanatory notes in Chapter 1

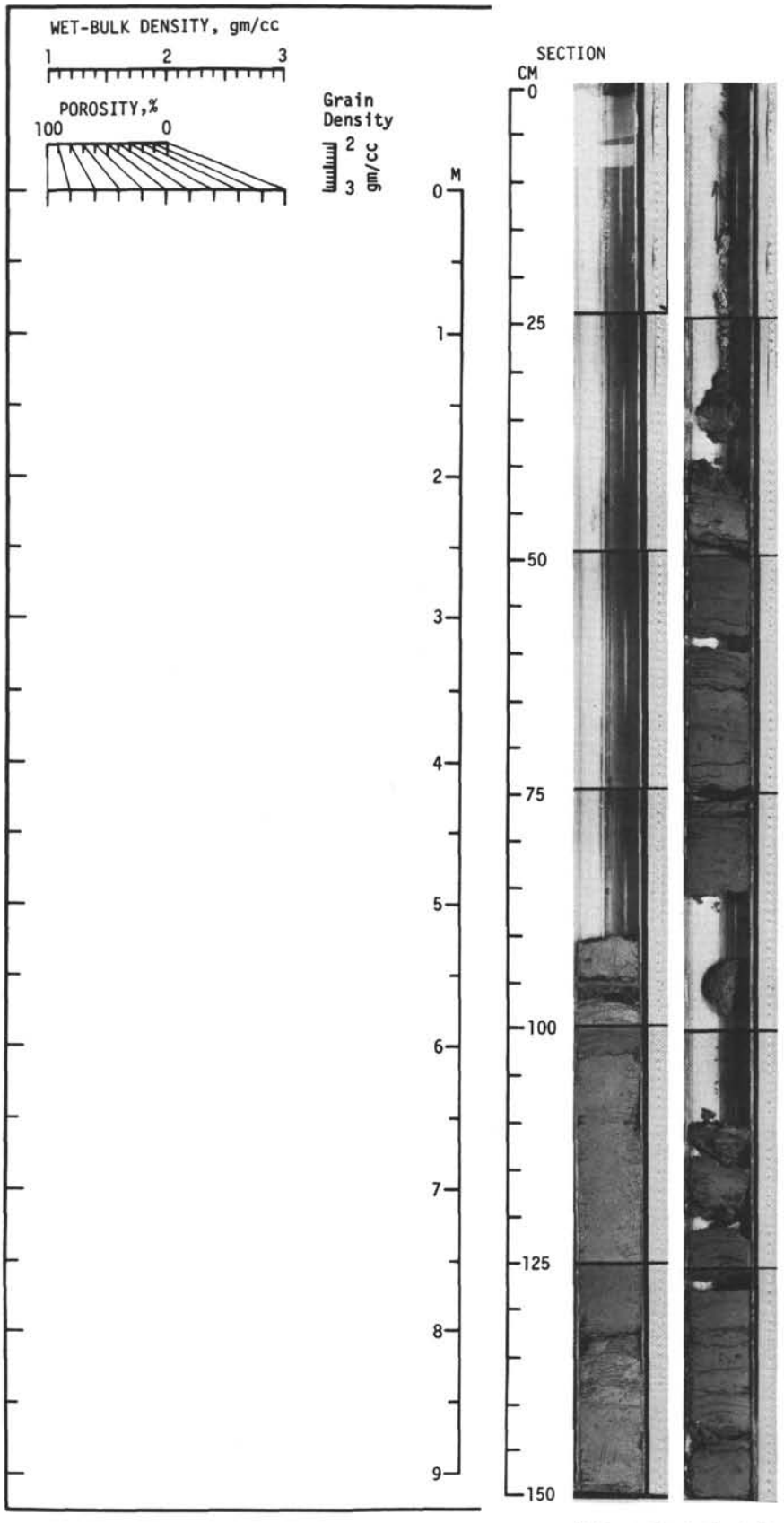

WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-8-1
186-8-2
186-8-3
186-8-4
186-8-5

Site 186 Hole Core 9 Cored Interval: 161-170



Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-9-1
186-9-2
186-9-3
186-9-4
186-9-5
186-9-6


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9

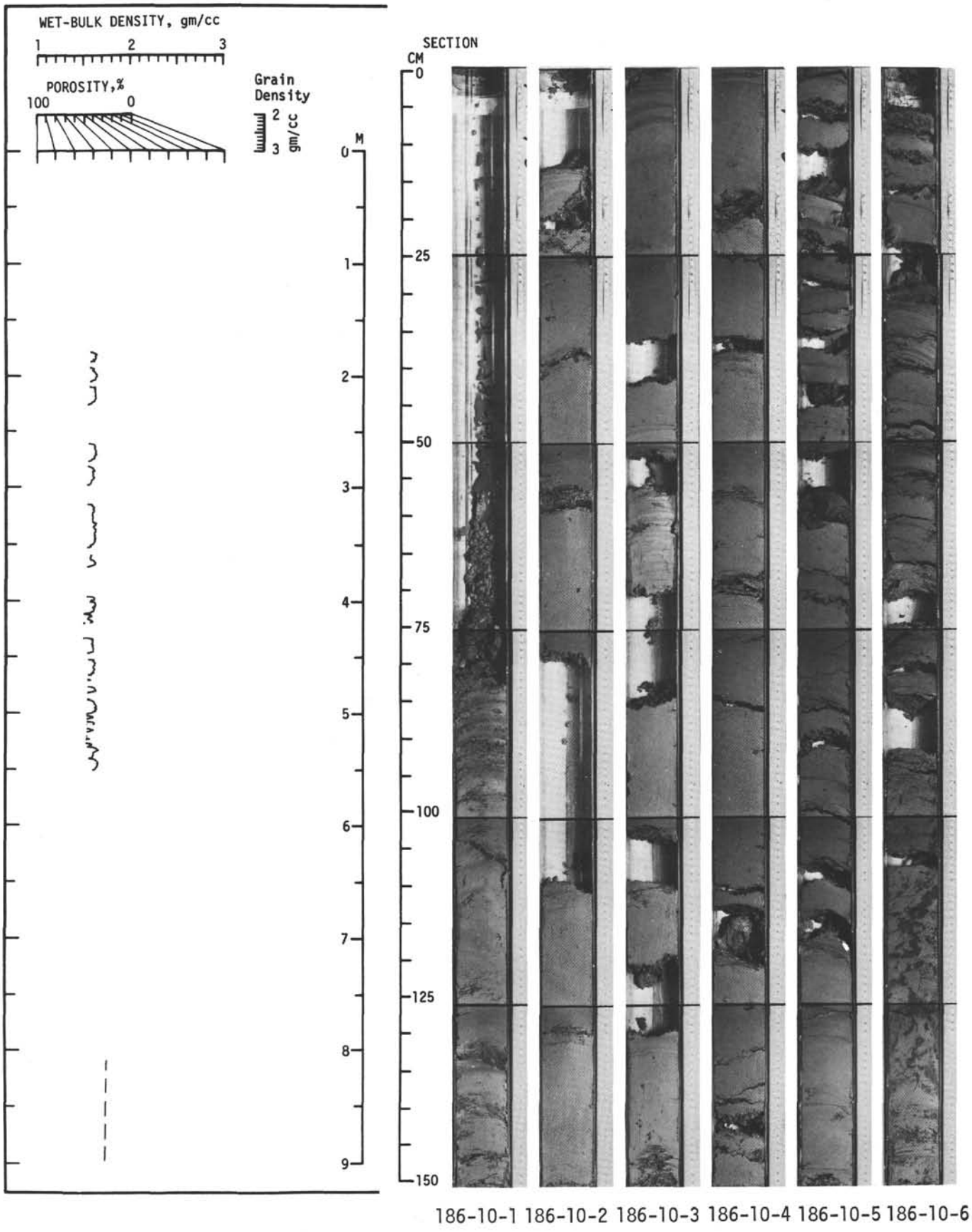
SECTION
CM
0
25
50
75
100
125
150

186-9-7 186-9-8

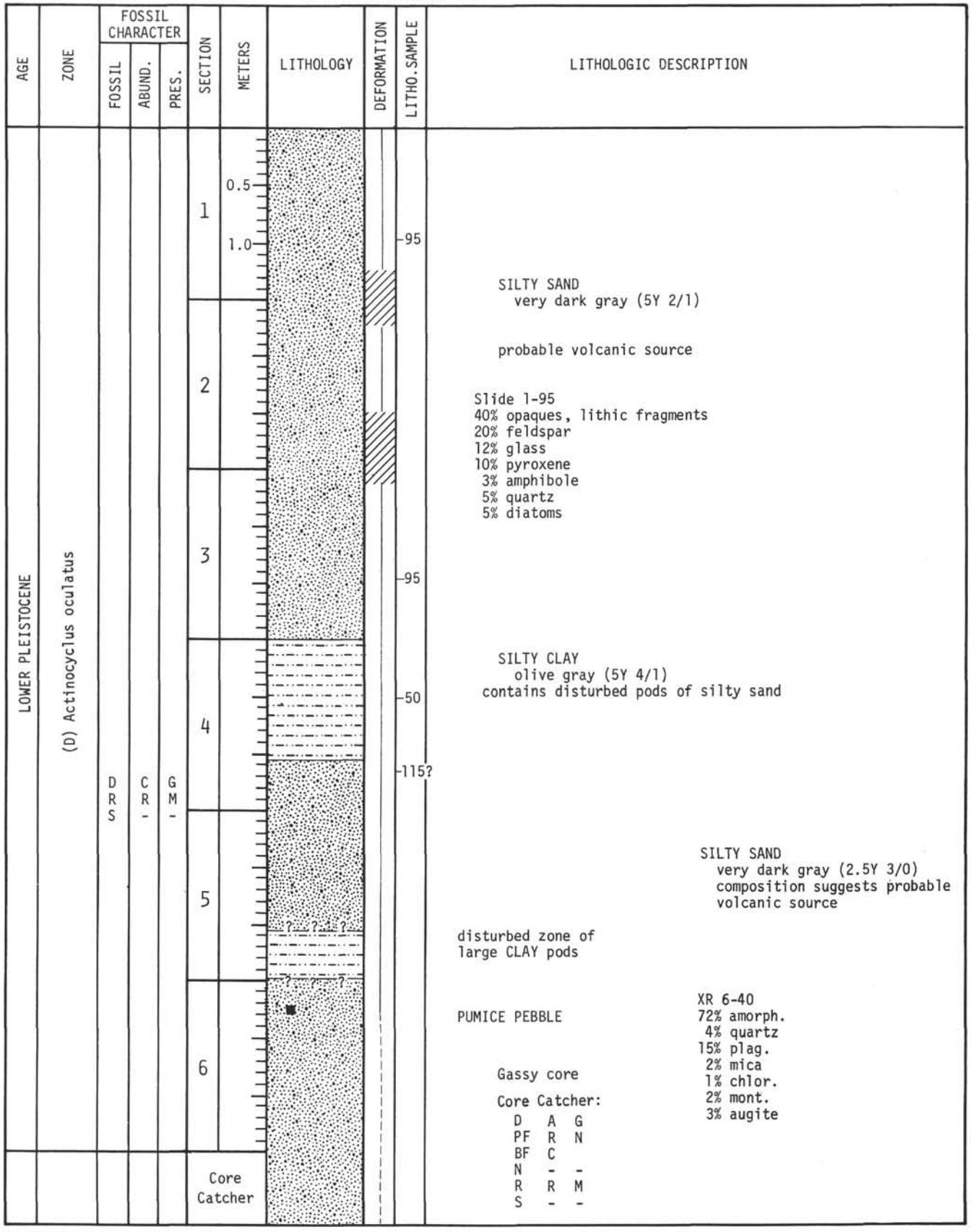
Site 186 Hole Core 10 Cored Interval: 170-179

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE PLEISTOCENE	(D) Rhizosolenia curvirostris (S) Distephanus octonarius	D R S	F F -	G M -	1	0.5	VOID			
						1.0				
					2					
					3					DIATOMACEOUS SILTY CLAY very dark gray (5YR 3/0)
										Gassy core Numerous 1-10 cm voids caused by gas expansion
					4				-75	Slide 4-75 40% clay 35% terrigenous silt 25% diatoms
					5					
					6				-103	pods of SAND, black
					Core Catcher					Core Catcher: D A G; PF R M; BF C; N - -; R R M; S R M

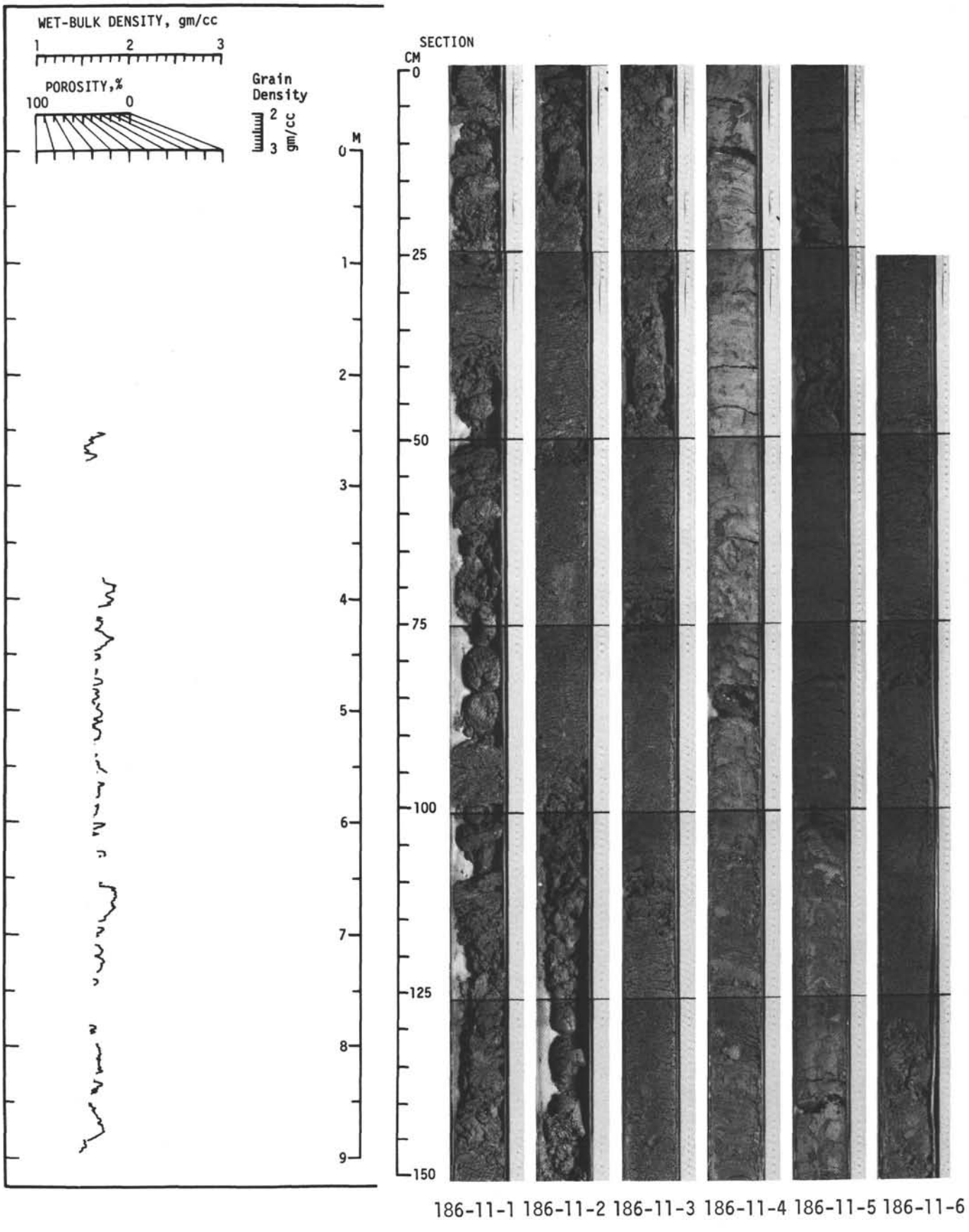
Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-10-1
186-10-2
186-10-3
186-10-4
186-10-5
186-10-6

Site 186 Hole Core 11 Cored Interval: 207-216



Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-11-1
186-11-2
186-11-3
186-11-4
186-11-5
186-11-6

Site 186 Hole Core 12 Cored Interval: 245-254

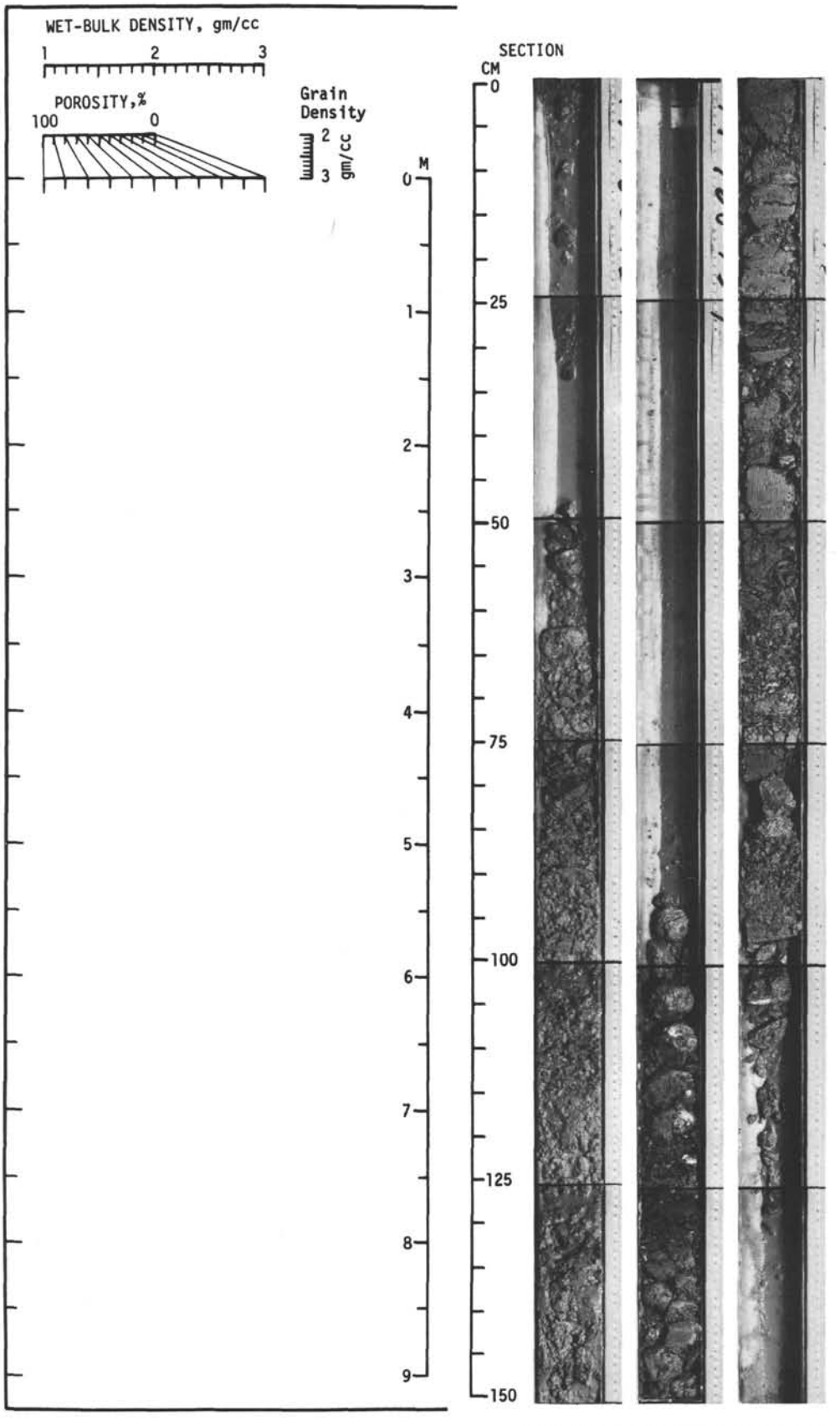
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLEISTOCENE	*	R S	R A	M G	1	0.5 1.0	VOID		118	DIATOM RICH SILTY CLAY dark olive gray (5Y 3/2) PUMICE PEBBLE Gassy core Core Catcher: D A G; PF -; BF -; N - -; R R M; S R M Slide 1-118 20% diatoms 50% clay 30% silt: qtz, feldspar, pyroxene, hornblende, chlorite, glass
					Core Catcher					

*(D) Actinocyclus oculatus
(S) Dictyocha subarctios

Site 186 Hole Core 13 Cored Interval: 291-300

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLEISTOCENE	(D) Actinocyclus oculatus (S) Dictyocha subarctios	R S	R A	M G	1	0.5 1.0	VOID		23	Semi-indurated DIATOMACEOUS SILTY CLAY olive gray (5Y 3/2) ERRATIC PEBBLE 4 x 3 x 3 cm Core Catcher: D C G; PF -; BF -; N - -; R R M; S R M Gassy core? Slide 2-23 45% diatoms 15% silt 40% clay
					2					
					Core Catcher		VOID			

Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-12-1
186-13-1
186-13-2

Site 186 Hole Core 14 Cored Interval: 338-347

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	*				1	0.5 1.0	VOID		-120	Semi-indurated, fractured SPICULE BEARING DIATOMACEOUS SILTY CLAY olive gray (5Y 3/2) Core Catcher: D A G Slide 1-120 PF - 40% diatoms BF - 35% clay N - - 25% terrigenous silt R R M S - -
					Core Catcher					

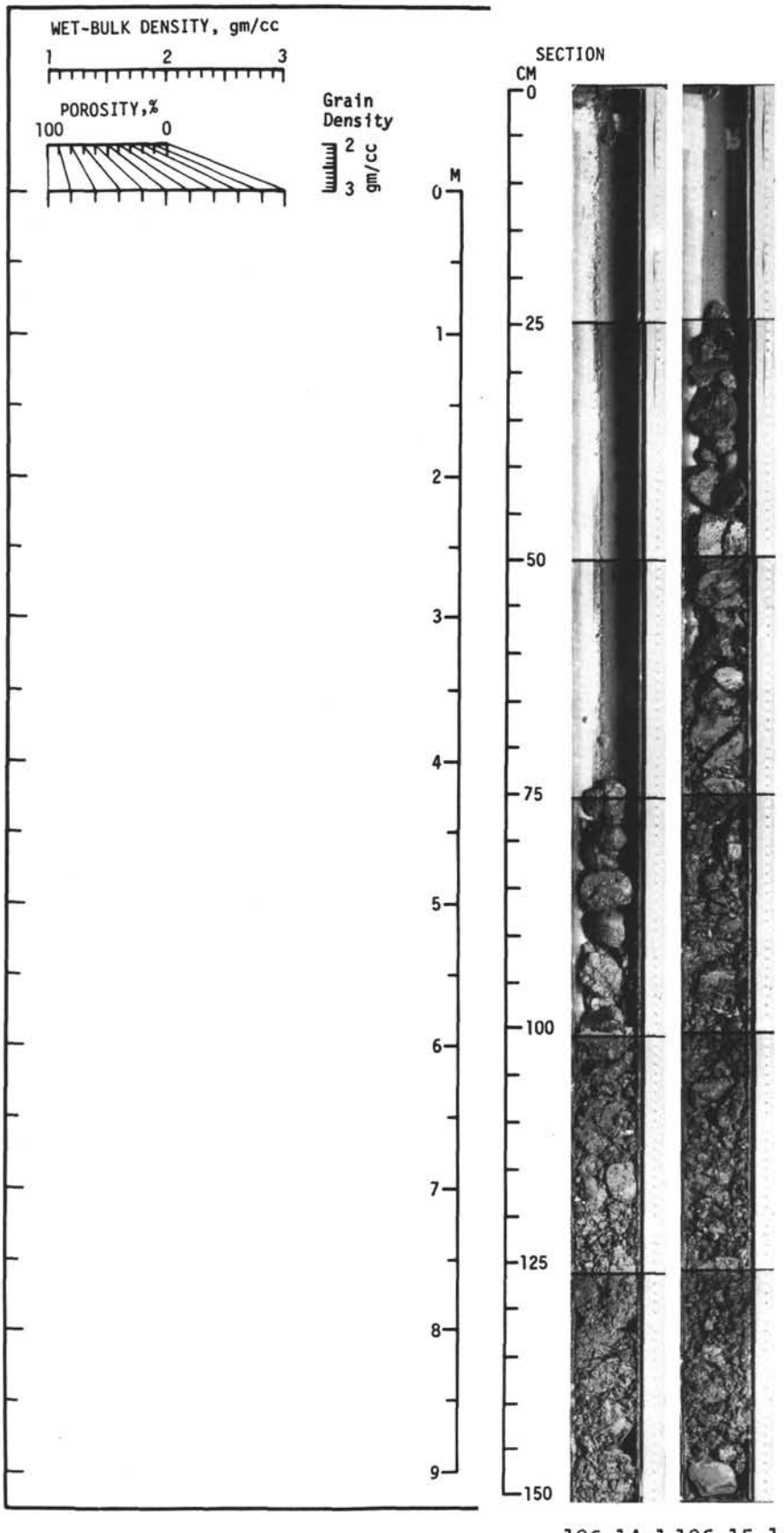
Explanatory notes in Chapter 1

*(D) Thalassiosira zabelinae

Site 186 Hole Core 15 Cored Interval: 385-394

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	*				1	0.5 1.0	VOID		44 46	DIATOM RICH CLAYEY SILT and SILTY CLAY olive gray (5Y 3/2) semi-indurated, fractured CALCITE CEMENTED SILT XR 1-10 71% amorph. 5% quartz 7% plag. 11% mica 4% chlor. 2% mont. 1% amph. Core Catcher: D A G PF - BF - N - - R R M S - -
					Core Catcher					

Explanatory notes in Chapter 1 *(D) Thalassiosira zabelinae


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-14-1
186-15-1

Site 186 Hole Core 16 Cored Interval: 394-403

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	(D) Thalassiosira zabelinae (S) Ammodochium rectangulare	D R S	A - R	G - M	1	0.5	VOID			SILTY SAND layers black
						1.0			-75	
									-92	CARBONATE BEARING DIATOMACEOUS SILTY CLAY olive gray - light olive gray (5Y 3/2 - 4/2)
					2		VOID			
									-70	SILTY SAND, graded
									-100	
									-120	pods of SILTY SAND volcanic source (?)
					Core Catcher					Slightly gassy core

Slide 1-92
40% clay
40% diatoms
10% terrigenous silt
10% carbonate

Core Catcher:

	A	G
D		
PF	-	
BF	-	
N	-	-
R	-	-
S	R	M

Site 186 Hole Core 17 Cored Interval: 422-431

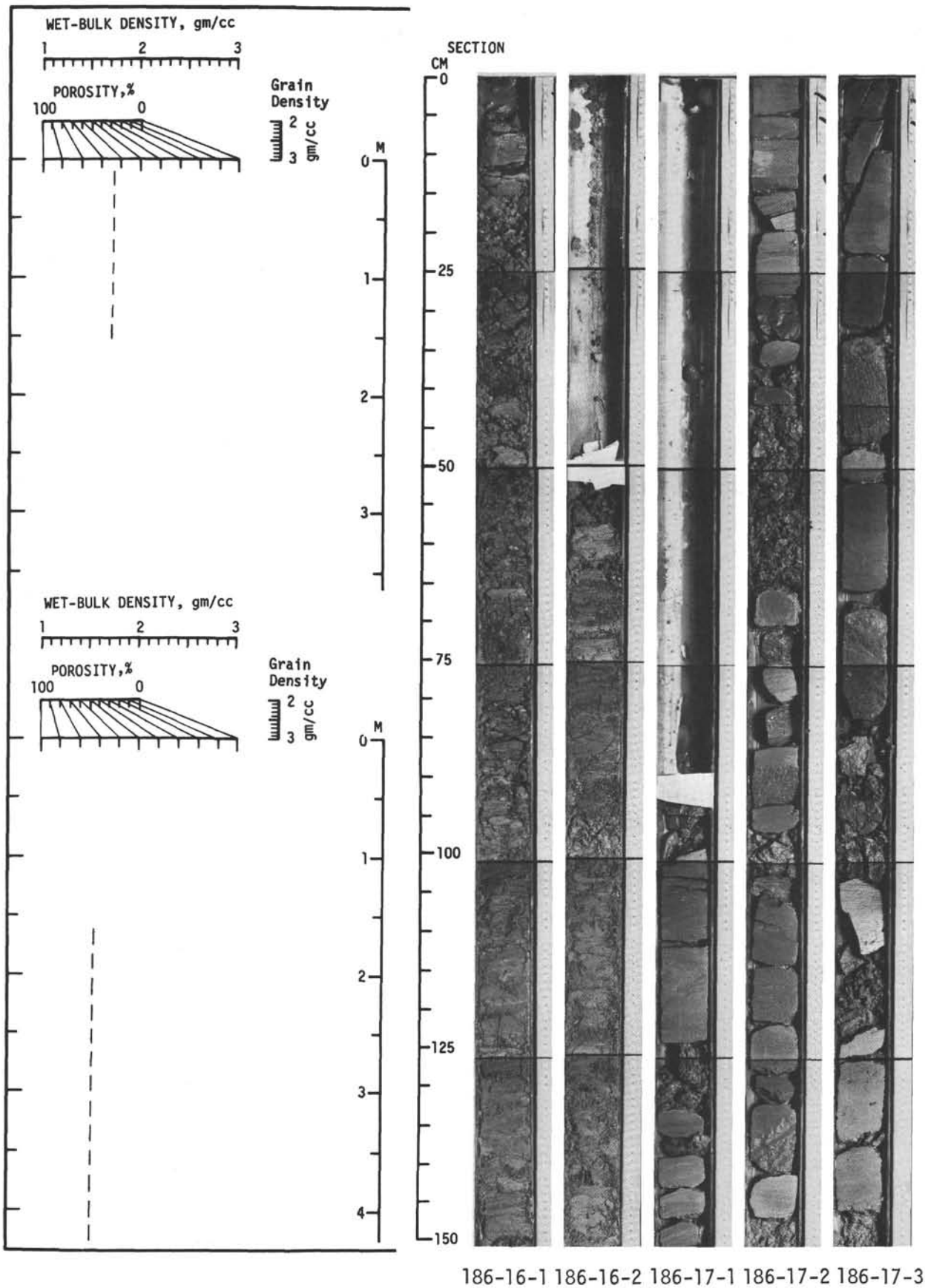
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	(D) Thalassiosira zabelinae (S) Ammodochium rectangulare	D R S	C R C	G M M	1	0.5	VOID			
						1.0				Semi-indurated, fractured
					2					DIATOMACEOUS SILTY CLAY greenish black (5G 2/1)
					3					Slightly gassy core.
					Core Catcher					burrowed

XR 3-100
75% amorph.
5% quartz
7% plag.
7% mica
2% chlor.
4% mont.

Core Catcher:

	C	G
D		
PF	-	
BF	-	
N	-	-
R	R	M
S	R	M

Explanatory notes in Chapter 1


WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
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2
3
POROSITY,%
100
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Grain Density
2
3
gm/cc
M
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1
2
3
4
SECTION
CM
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50
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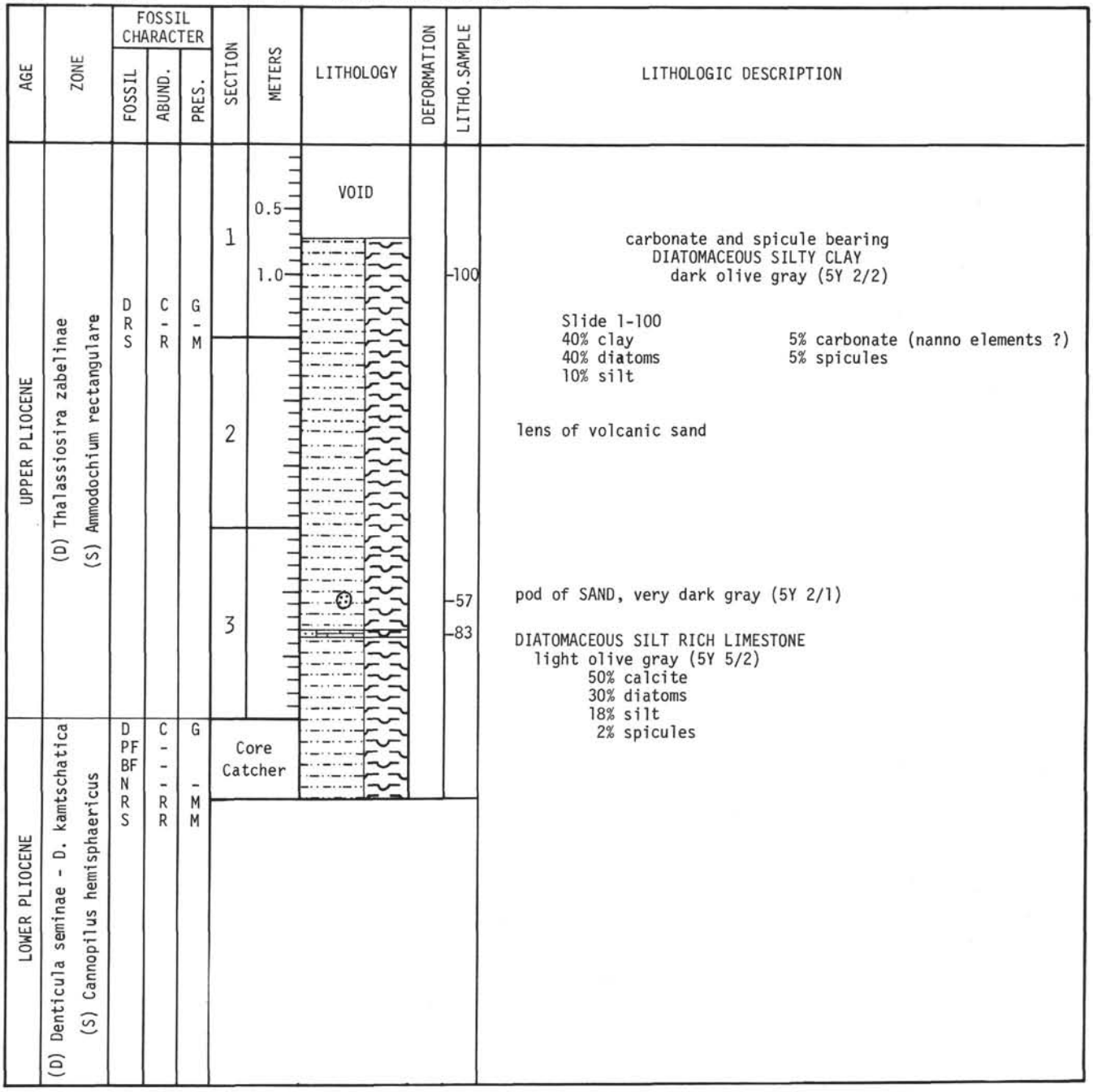
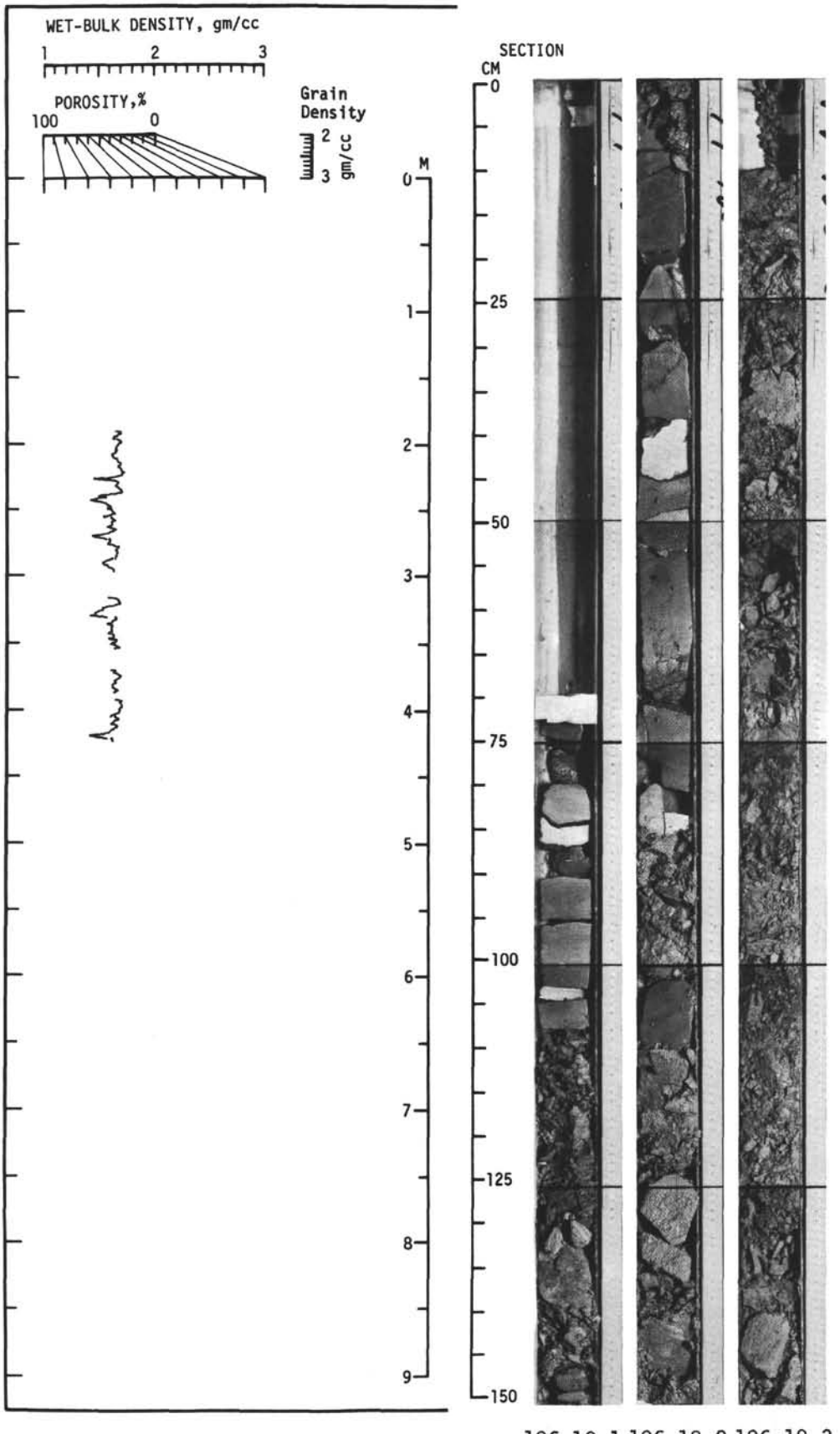
186-17-1
186-17-2
186-17-3

Site 186 Hole Core 18 Cored Interval: 440-449



Explanatory notes in Chapter 1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gm/cc
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2
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4
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7
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9
SECTION
CM
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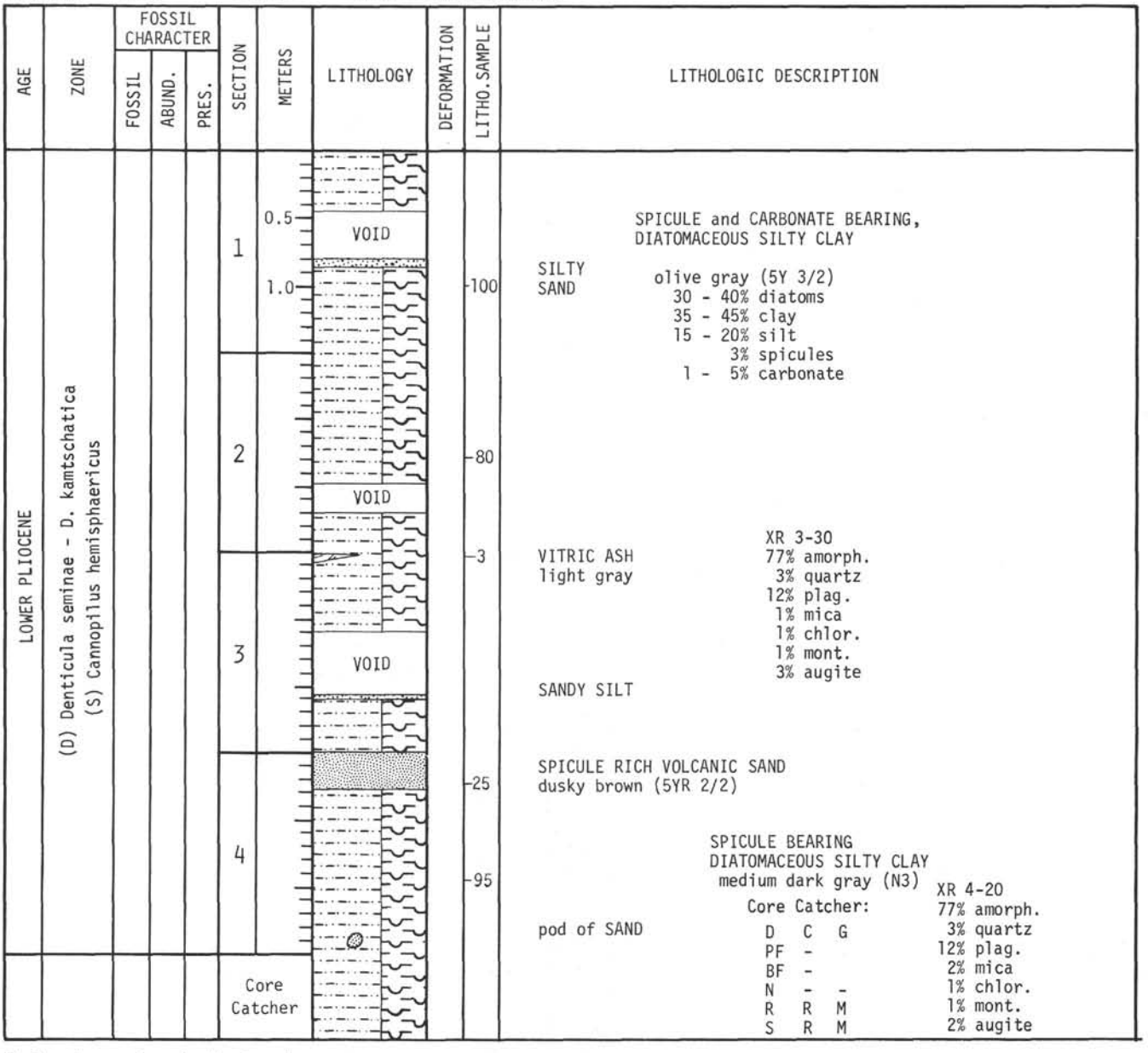
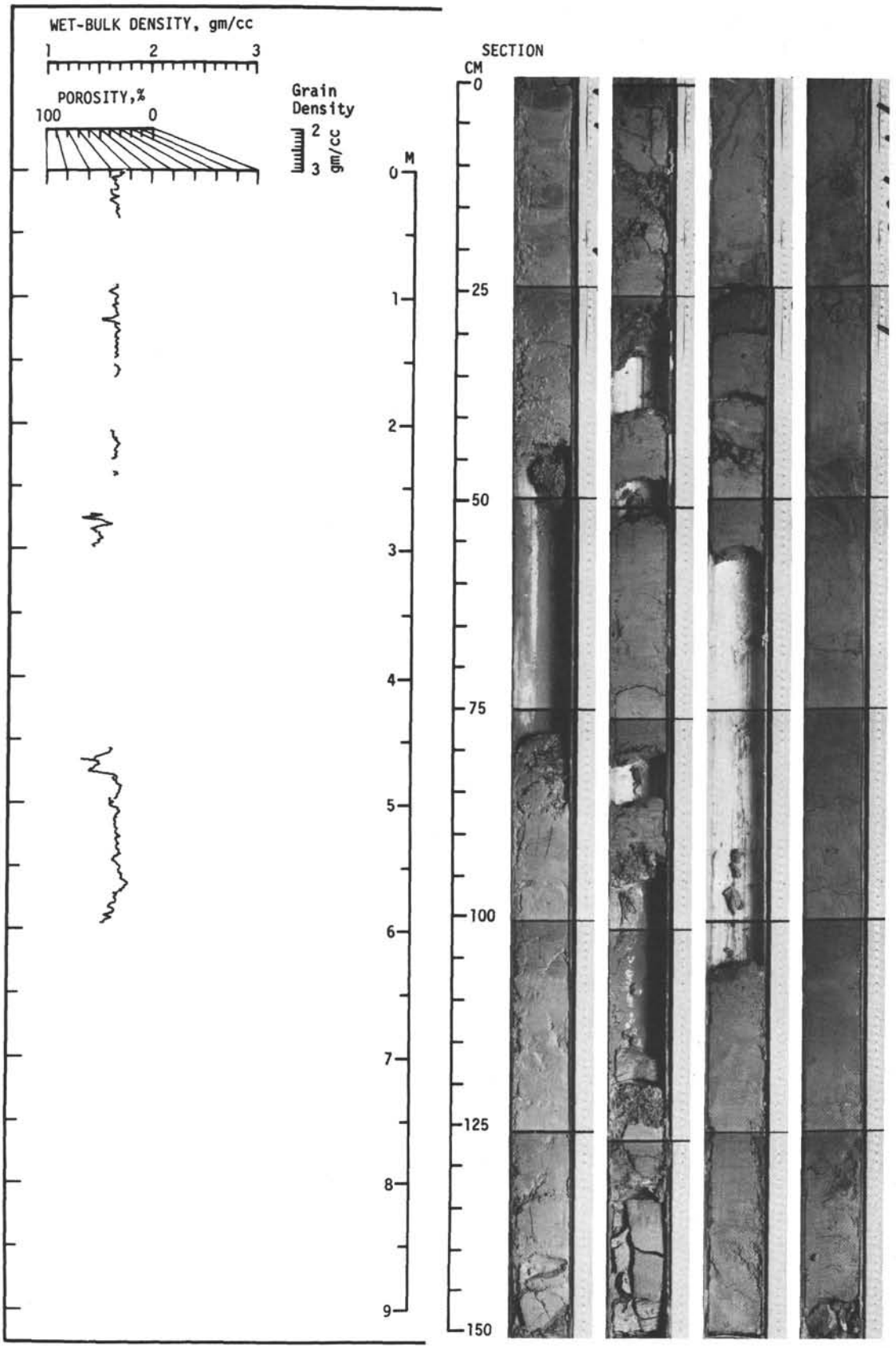
186-18-2
186-18-3

Site 186 Hole Core 19 Cored Interval: 449-458



Explanatory notes in Chapter 1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POROSITY,%
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Grain
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gm/cc
M
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4
5
6
7
8
9
SECTION
CM
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186-19-1
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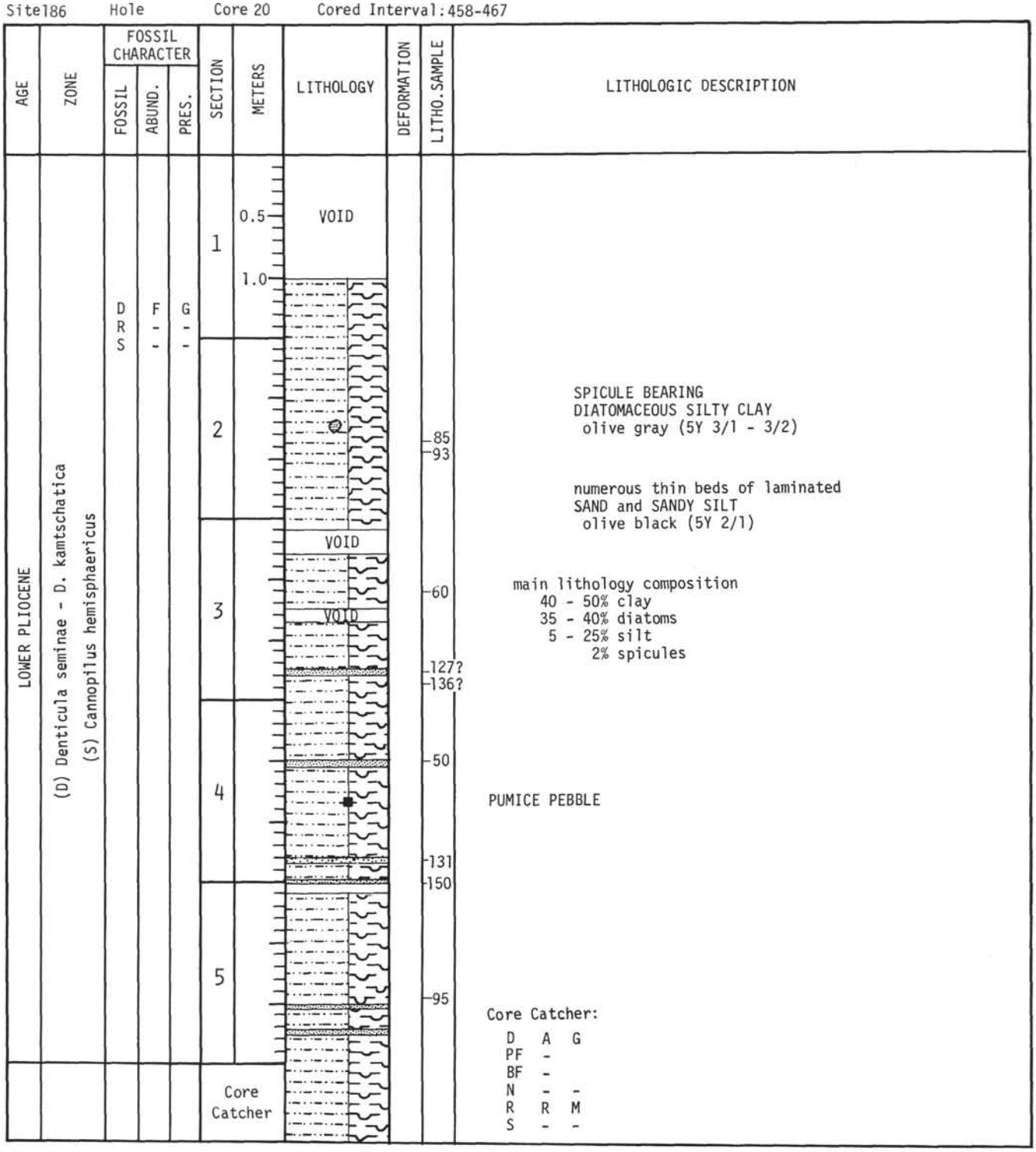
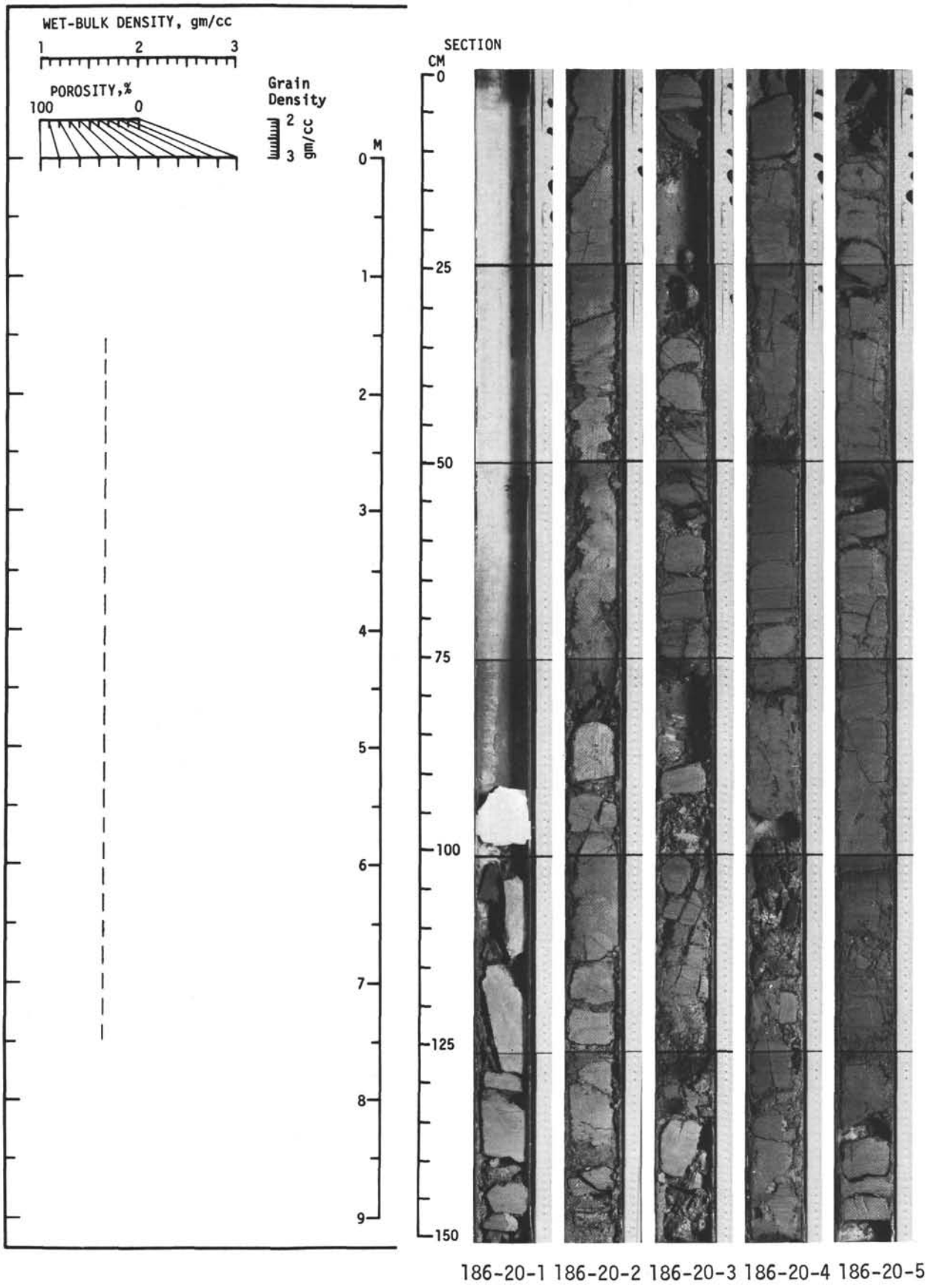
186-19-3
186-19-4

Site 186 Hole Core 20 Cored Interval: 458-467



Explanatory notes in Chapter 1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gm/cc
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SECTION
CM
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50
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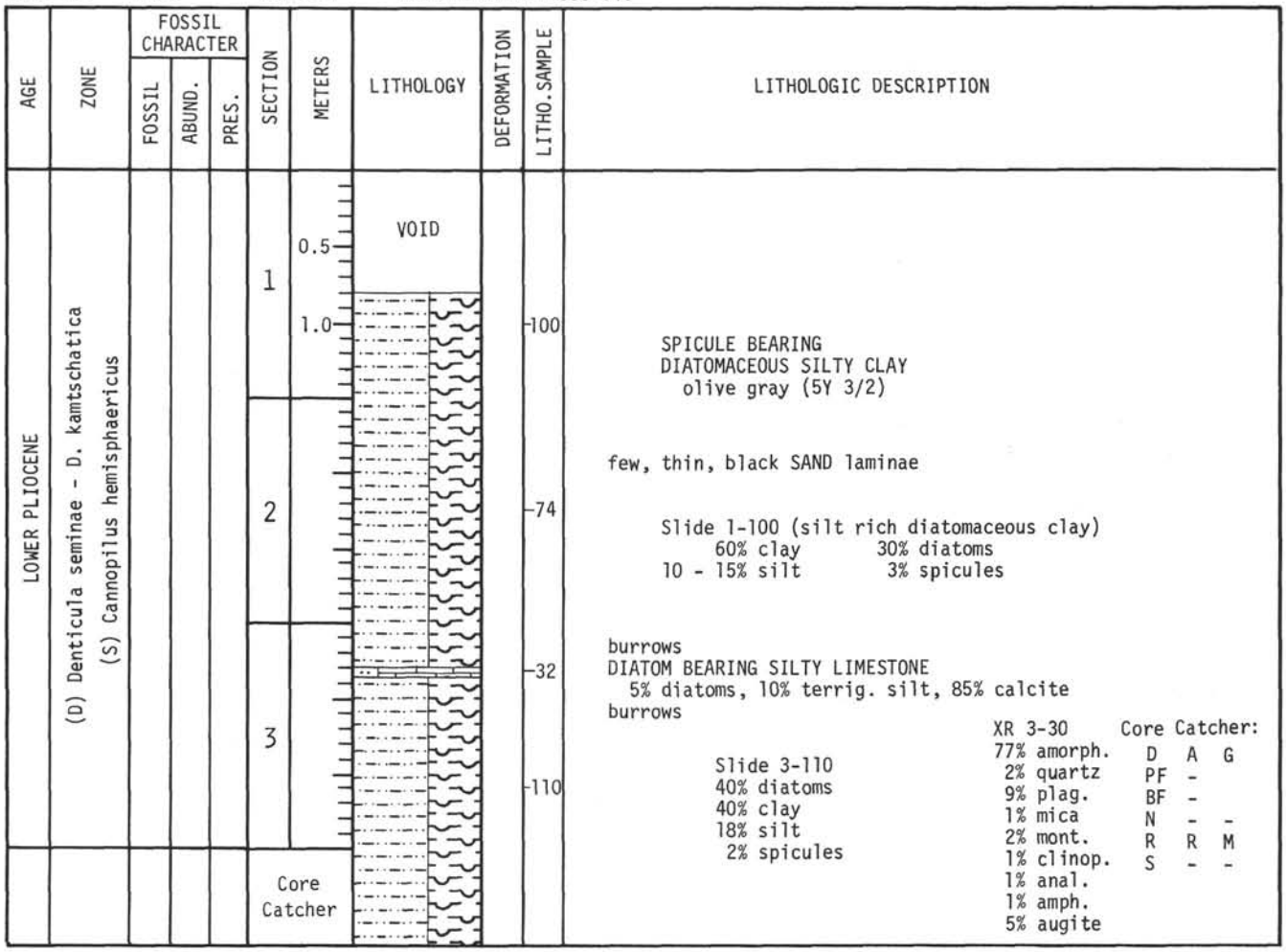
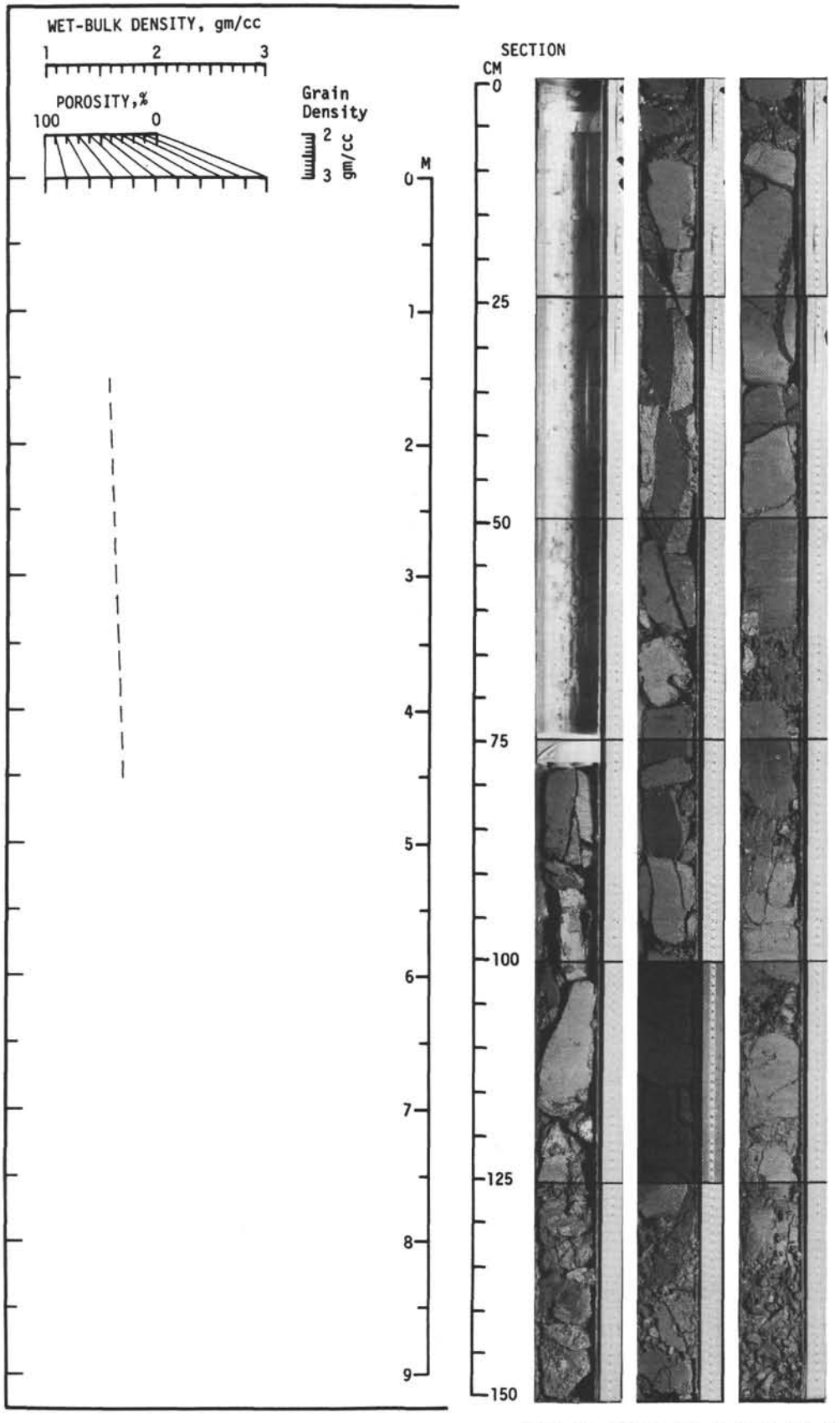
186-20-5

Site 186 Hole Core 21 Cored Interval: 506-515



Explanatory notes in Chapter 1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gm/cc
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SECTION
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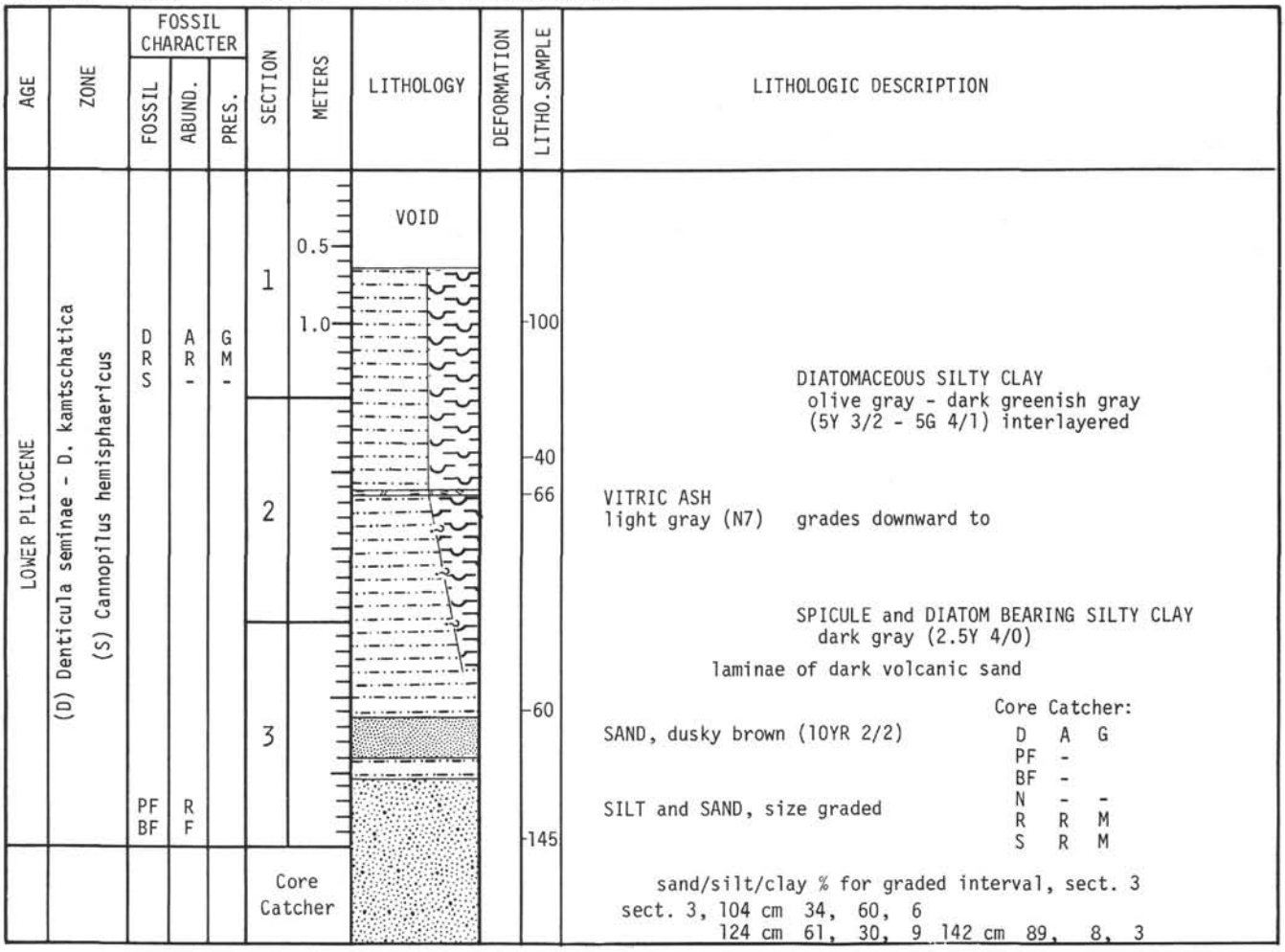
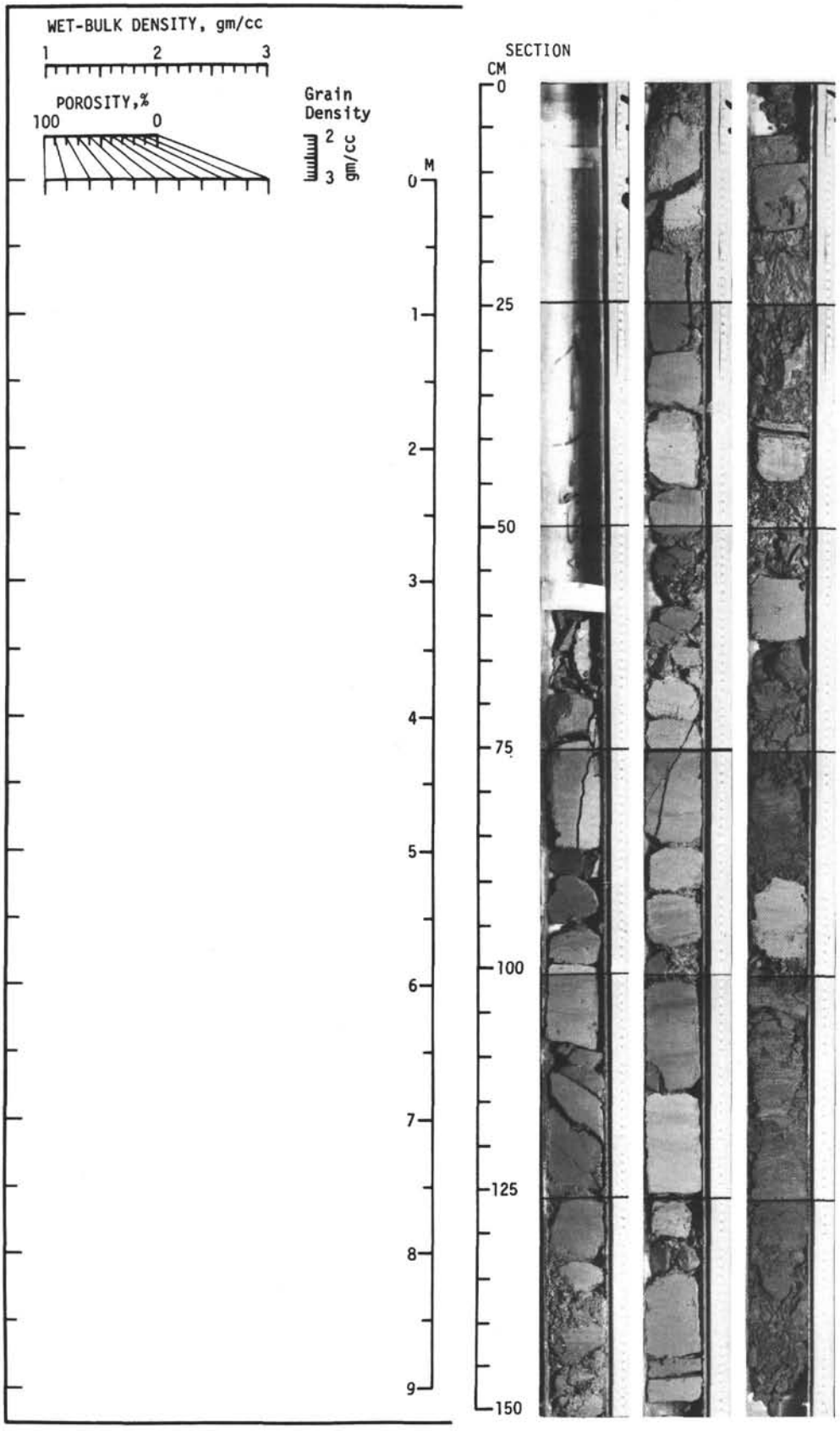
Site 186 Hole Core 22 Cored Interval: 562-571



Explanatory notes in Chapter 1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gm/cc
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SECTION
CM
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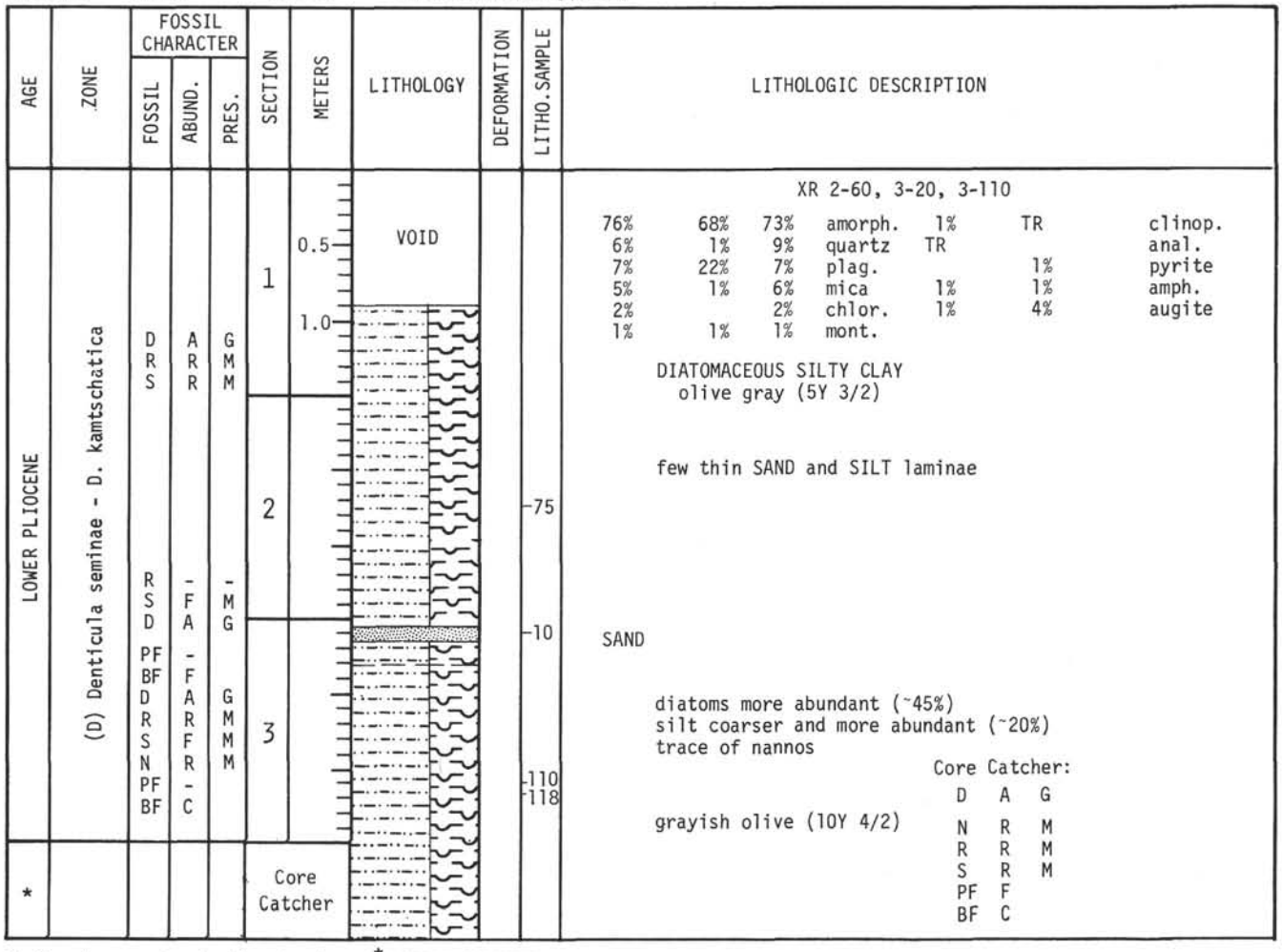
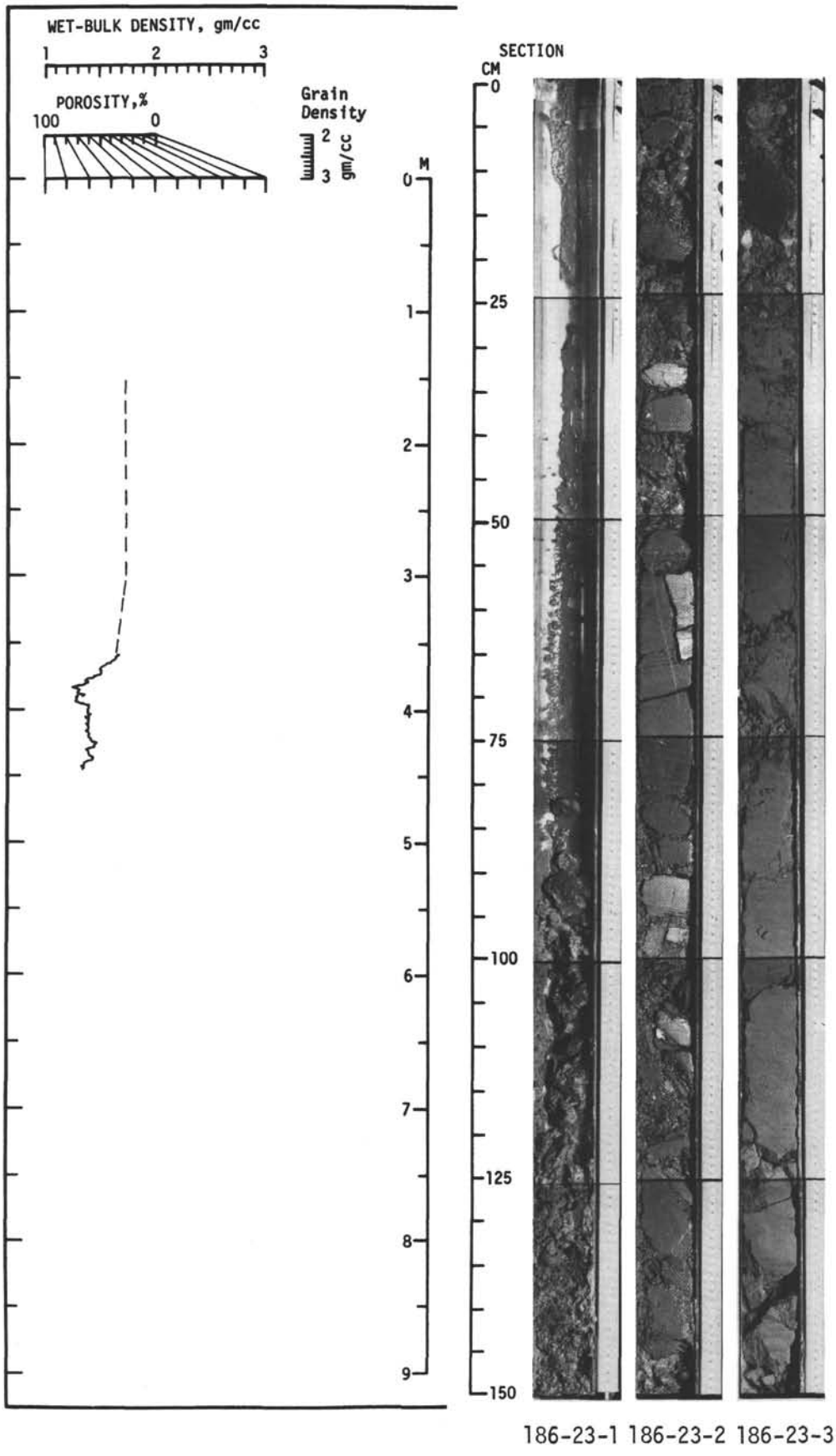
186-22-3

Site 186 Hole Core 23 Cored Interval: 618-627



Explanatory notes in Chapter 1 * MIDDLE MIOCENE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POROSITY,%
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Grain Density
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gm/cc
M
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6
7
8
9
SECTION
CM
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75
100
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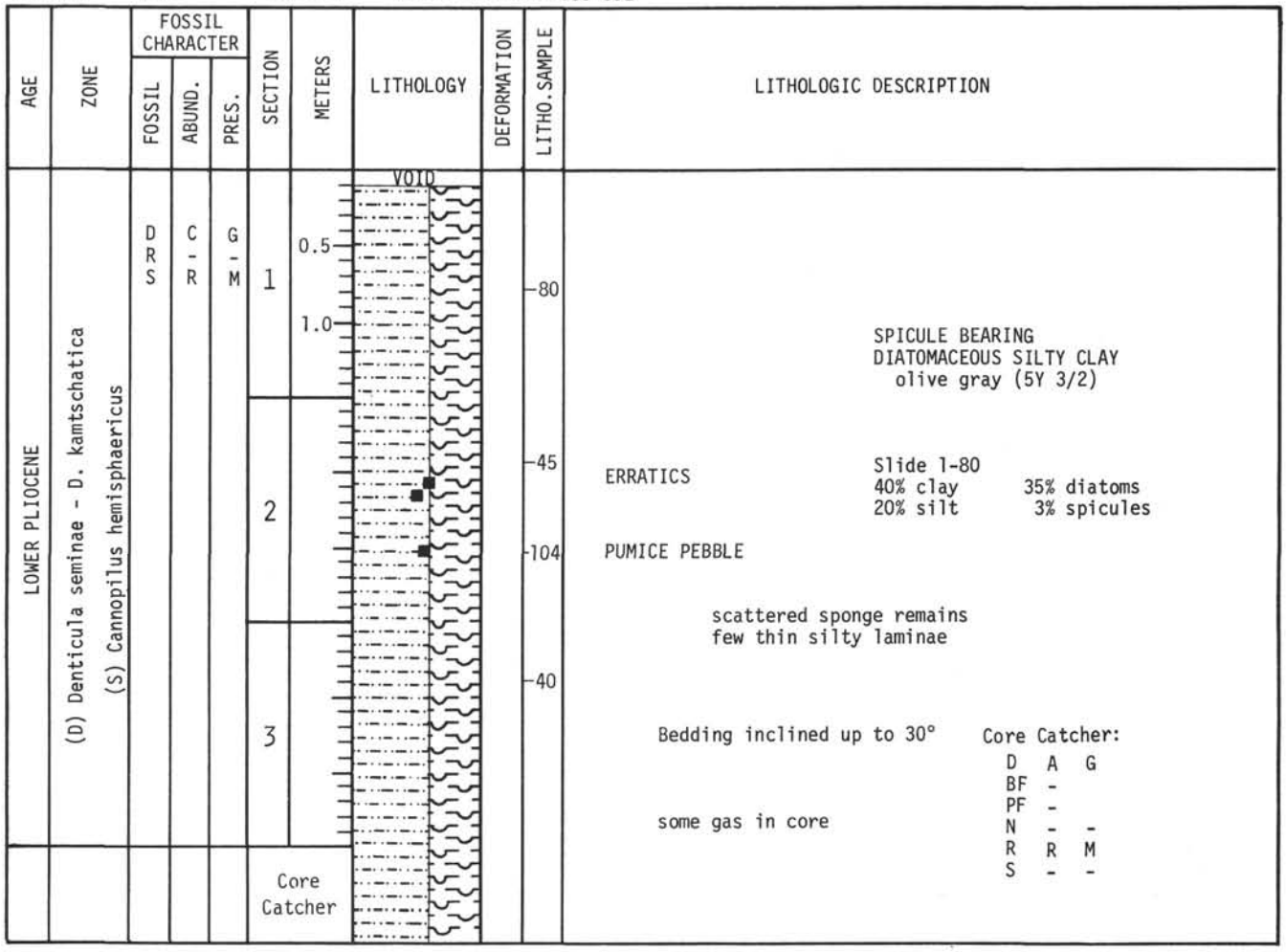
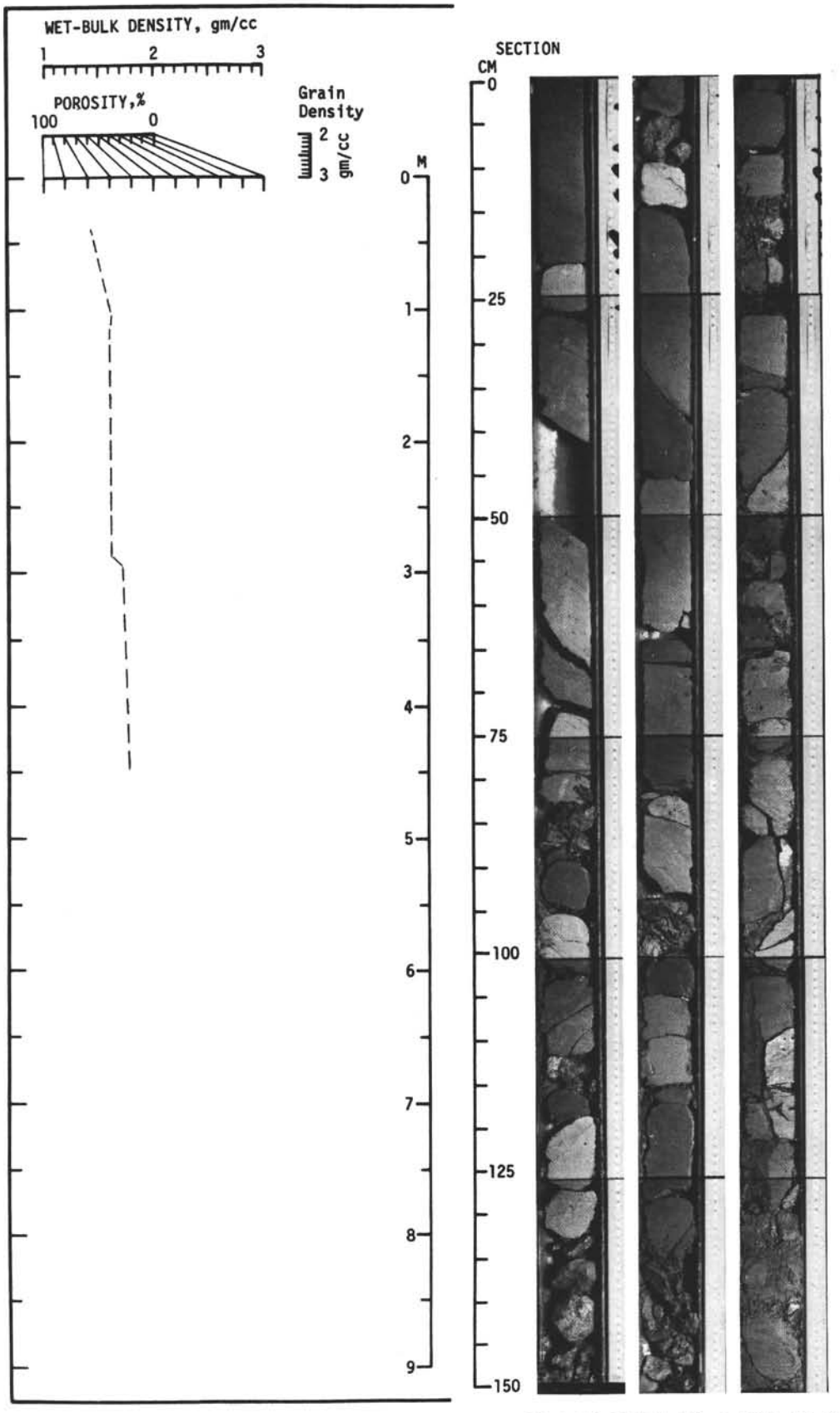
150
186-23-1
186-23-2
186-23-3

Site 186 Hole Core 24 Cored Interval: 683-692



Explanatory notes in Chapter 1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POROSITY,%
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Grain Density
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gm/cc
M
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2
3
4
5
6
7
8
9
SECTION
CM
0
25
50
75
100
125
150
186-24-1
186-24-2
186-24-3

Site 186 Hole Core 25 Cored Interval: 731-740

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	(D) Denticula seminae - D. kamtschatica (S) Cannopilus hemisphaericus				1	0.5				DIATOM RICH SILTY CLAY olive gray (5Y 3/2) 50% clay, 30% silt, 20% diatoms
						1.0			-80	
									-136	DIATOM RICH SANDY SILTY CLAY olive gray (5Y 3/2)
					2				-67	SPICULE BEARING SILTY CLAY med. to dark gray (N4 - N3)
									-145	SAND LAMINAE gassy core
					Core Catcher					

Core Catcher:

	D	C	G
PF	-		
BF	-		
N	-	-	
R	-	-	
S	R	M	

Site 186 Hole Core 26 Cored Interval: 805-814

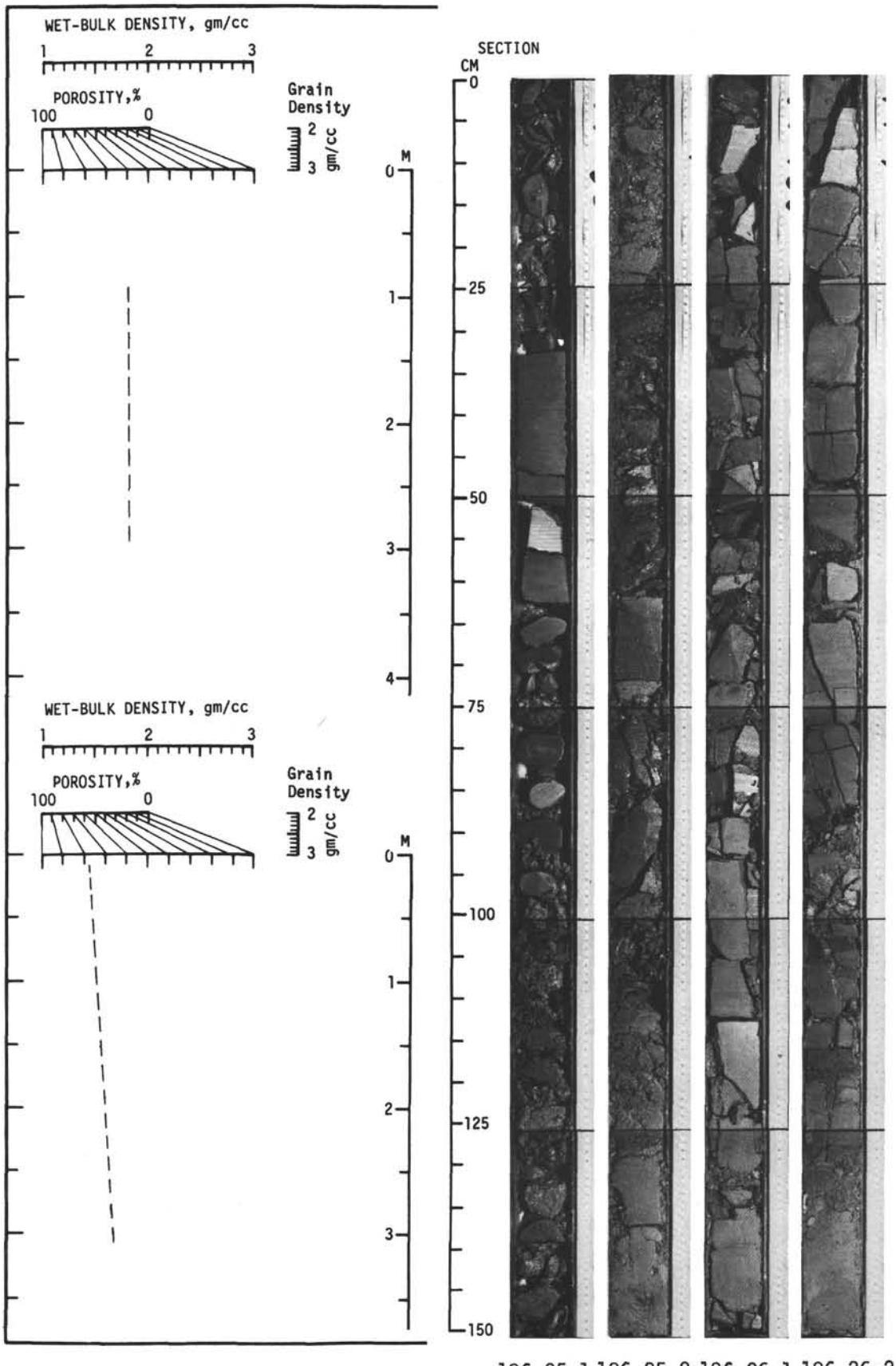
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	(D) Denticula seminae - D. kamtschatica				1	0.5				SPICULE BEARING, DIATOM RICH SILTY CLAY olive gray (5Y 3/2)
						1.0			-100	
					2				-51	
									-146	SPICULE BEARING, DIATOM RICH CLAYEY SILT dark olive gray (5Y 3/2) 40% silt, 25% clay, 20% diatoms, 5-10% spicules
					Core Catcher					

	D	F	G
PF	-		
BF	-		
N	-	-	
R	-	-	
S	-	-	

Slide 1-100: 60% clay, 20% diatoms, 15% terrig. silt, 5% spicules
grades downward to: DIATOMACEOUS SILTY CLAY

	XR 2-30, 2-120		
	80%	78%	amorph.
	5%	5%	quartz
	7%	7%	plag.
	3%	6%	mica
	1%	2%	chlor.
	2%	1%	mont.
	1%		clinop.
	TR		anal.
		TR	amphib.
	1%		augite

Explanatory notes in Chapter 1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POROSITY,%
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Grain Density
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gm/cc
M
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1
2
3
4
WET-BULK DENSITY, gm/cc
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POROSITY,%
100
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Grain Density
2
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gm/cc
M
0
1
2
3
SECTION
CM
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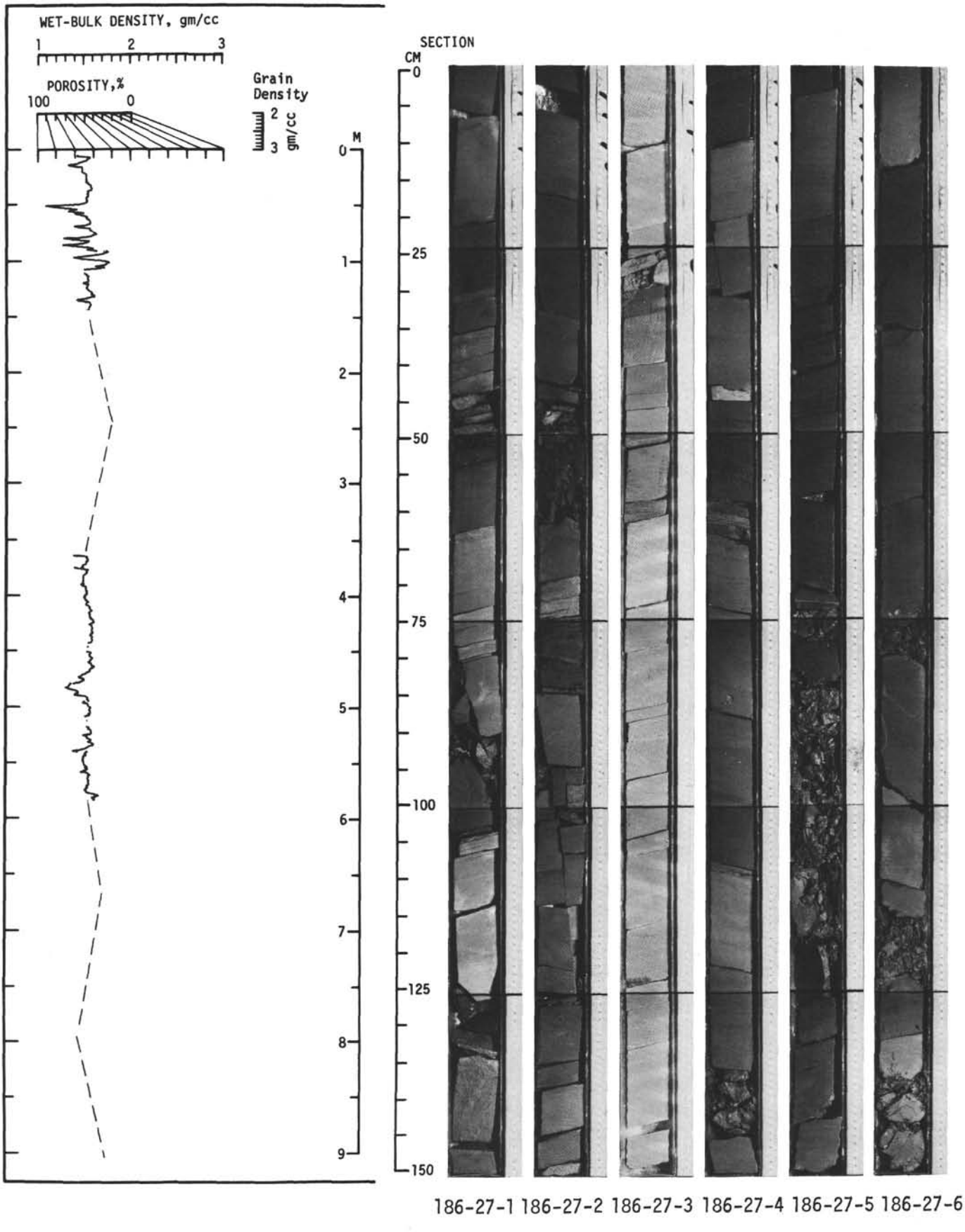
25
50
75
100
125
150
186-25-1
186-25-2
186-26-1
186-26-2

Site 186 Hole Core 27 Cored Interval: 861-870

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	(D) Denticula seminae - D. kamtschatica	D	F	M	1	0.5 – 1.0			-85	DIATOM and SILT BEARING CLAY olive gray (5Y 3/2) 75% clay, 10% silt, 5% glass, 5% diatoms 2% carbonate
		PF BF	- -		2				-90	zone of parallel sand and silt laminae
					3				-85	convolute graded laminae
					4				-85	SPICULE and DIATOM BEARING SILTY CLAY olive gray (5Y 3/2)
					5					laminated sand and silty sand layers (up to 10 cm thick) and thin sand laminae throughout core burrowed bedding inclined about 15°
					6				-77	XR 3-30, 6-80 76% 73% amorph. 6% 6% quartz 7% 7% plag. 6% 8% mica 2% 3% chlor. 1% 3% mont. 1% clinop. TR anal. TR 1% amphib. VITRIC ASH, light gray Core Catcher: D F G PF - BF - N - - R - - S - -
					Core Catcher					

Explanatory notes in Chapter 1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POROSITY,%
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Grain Density
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gm/cc
M
0
1
2
3
4
5
6
7
8
9
SECTION
CM
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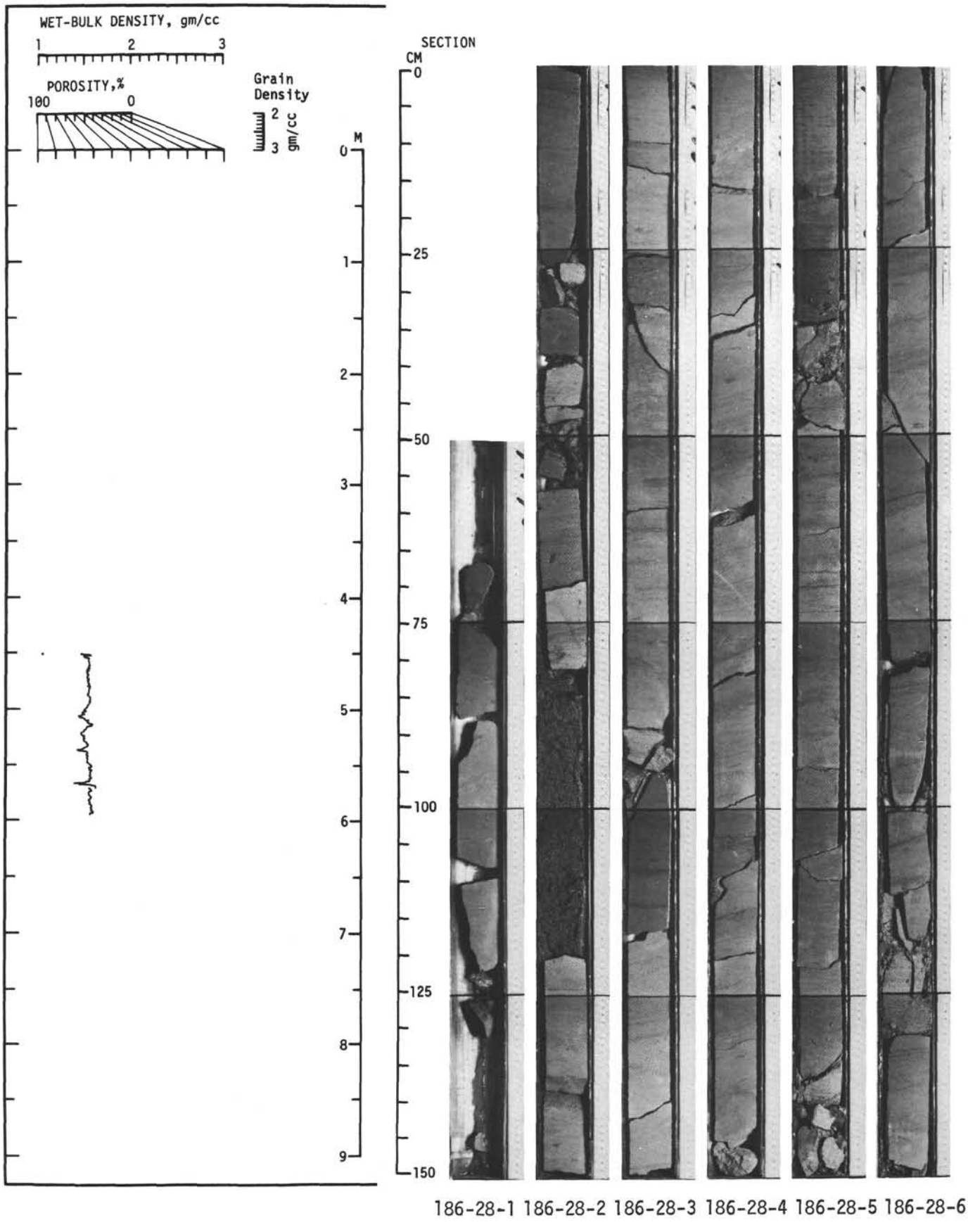
50
75
100
125
150
186-27-1
186-27-2
186-27-3
186-27-4
186-27-5
186-27-6

Site 186 Hole Core 28 Cored Interval: 917-926

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	(D) Denticula seminae - D. kamtschatica				1	0.5 1.0	VOID		120	
		PF BF	- -		2				112	SAND black 40% feldspar, 25% pyroxene, 15% opaque, 10% qtz, 5% amphibole
					3				51 75 78	SHALE PEBBLE CONGLOMERATE rounded clasts, 3 x 6 cm, of same composition as remainder of core Basic lithology SPICULE and DIATOM BEARING SILTY CLAY and SILT RICH CLAY olive gray (5Y 3/2)
					4				58 81	1 cm thick interbeds are dark greenish gray to greenish black (5G 4/1 - 2/1) and contain more chlorite than lighter layers
					5					entire core extensively burrowed bedding inclined 15 - 20° XR 2-110, 3-60 59% 72% amorph. 1% 7% quartz 32% 8% plag. 1% 8% mica 3% chlor. 2% mont. 4% 1% amph. 3% augite 1% magn.
					6				111	Core Catcher: D R M F N - - R - - S - -
					Core Catcher					

Explanatory notes in Chapter 1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Grain Density
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gm/cc
M
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3
4
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7
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9
SECTION
CM
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150
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186-28-4
186-28-5
186-28-6