10. SITE 191

The Shipboard Scientific Party[1]

SITE DATA

Date Occupied: 25-28 Aug 71.

Position:
191: 56°56.70′N; 168°10.72′E
191A: 100 ft., 090°T from 191.
191B: 200 ft., 090°T from 191.

Water Depth:
191: 3854 meters
191A: 3860 meters
191B: 3860 meters.

Penetration:
191: 919 meters
191A: 50 meters
191B: 9 meters

Number of Holes: Three.

Number of Cores:
191: 16
191A: 4
191B: 1

Total Core Recovered:
191: 44 meters
191A: 21.5 meters
191B: 8.5 meters.

Acoustic Basement:
Depth: 900 meters
Nature: Basalt
Velocity: 4.5-5.0 km/sec.

Age of Oldest Sediment: Upper Miocene.

Basement: Basalt, middle Oligocene

SUMMARY

Site 191 is located at a water depth near 3800 meters on the east-central side of the Kamchatka Basin. A 900-meter sediment and sedimentary rock sequence consists of 520 meters of upper Pleistocene to upper Pliocene diatomaceous silty clay, diatom ooze, silty sand, and sandy silt, and 380 meters of underlying Pliocene (?) to upper Miocene (?) indurated silty clay and diatomaceous silty clay containing beds of indurated lithic wacke. These overlie a tholeiitic or low-K (0.24% K_2O) basalt, cored to 19 meters, (1.4 m recovered), containing textural variation that suggests it is a submarine flow (see Stewart et al., this volume). The upper 520 meters has recognizable variations in the abundance of sand, degree of induration, and occurrence of limestone beds. Volcanic ash is present in the upper 240 meters (middle and upper Pleistocene). Reworked extinct Miocene species of diatoms and silicoflagellates, and sublittoral and freshwater diatoms are found to a depth of 520 meters throughout the Pleistocene section and into upper Pliocene beds as well. Shallow-water foraminiferal assemblages are typically associated with the sand layers.

The upper 300 meters of sandy and silty deposits cored in Kamchatka Basin are rather "classically" a turbidite sequence. Size-graded layers are present as well as reworked fossils and displaced freshwater and shallow-water species. size-graded units were not detected below 300 meters. but silty clay containing displaced fresh- and shallow-water diatoms occur to 520 meters, close to the base of the turbidite sequence indicated on seismic reflection records. The coarser upper 300 meters includes all but the lower part of the lower Pleistocene, whereas the finer grained distal turbidites between 300 and 520 meters include beds of late Pliocene age. Nearly identical relationships were found at Site 190 in the adjacent Aleutian Basin (see Scholl and Creager, this volume).

In Kamchatka Basin, the turbidites are much coarser grained and far less diatomaceous than those in the adjoining but much larger Aleutian Basin. Similarly, in Kamchatka Basin, Pliocene and late Miocene (?) mudstone beds containing lithic wackes underlie the turbidite sequence, whereas in the Aleutian Basin the sequence is underlain by silty biogenic pelagic deposits. The coarser and far more terrigenous nature of the Neogene deposits of Kamchatka Basin reflect its small size and nearness to high-gradient drainages.

The geologic implication of the basalt beneath late Miocene deposits in Kamchatka Basin is difficult to assess. Because seismic records (Ludwig et al., 1971a) reveal that the mafic layer is regional in extent, has a gentle but undulating relief, and appears to be buried depositionally. However, during its emplacement, probably in middle Oligocene time, it may have engulfed older Tertiary deposits filling the basin (see Scholl and Creager, and Stewart et al).

BACKGROUND AND OBJECTIVES

Description

Shirshov Ridge, a submerged north-south trending mountain range, projects southward from Cape Olyutorskiy, eastern Siberia, and divides the deep-water region of

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the Bering Sea into Kamchatka Basin (to the west) and the much larger Aleutian Basin (Figure 1). Site 191 is located at a water depth near 3800 meters on the east-central side of the abyssal floor of Kamchatka Basin.

A thick turbidite sequence underlies the gently southward sloping floor of the basin. At Site 191, this sequence is 350 to 400 meters thick and overlies an equally thick section of weakly reflecting strata, presumably a pelagic unit. The lower pelagic section is gently arched over a bedrock knoll encountered acoustically at about 1.0 sec below bottom. Throughout Kamchatka Basin a rather rough acoustic basement appears on seismic reflection records; the knoll at Site 191, part of this basement relief, appears to be depositionally draped by the pelagic sequence.

Objectives

Nearly everywhere in the Aleutian Basin, except near Shirshov Ridge, the sedimentary section is 2 km or more in thickness. In contrast, the sedimentary sequence in Kamchatka Basin is only 1 to 1.5 km thick, and accordingly, can be sampled to bedrock. The principal purpose in drilling Site 191 was to sample and thereby determine the sedimentary history of the basin and the age and composition of the rough acoustic basement underlying it.

Other objectives included a study of the preserved textural and structural properties of the turbidite sequence, and especially the mineralogical composition relative to that of the turbidites cored at Site 190, located in the Aleutian Basin to the east. The terrigenous debris of the turbidites of these basins was contributed by different source areas; central and eastern Alaska for the Aleutian Basin and eastern Kamchatka for the Kamchatka Basin. A comparison of the sedimentary deposits cored at Sites 190 and 191 should be helpful in interpreting sedimentary characteristics typical of two modern marginal oceanic basins, one flanked by high mountain ranges (Kamchatka Basin) and the other having received debris from a major river (the Yukon, for the Aleutian Basin).

OPERATIONS

Pre- and Post-drilling Survey

Site 191 is located in the east-central Kamchatka Basin just west of Shirshov Ridge, along the track of the reference profile obtained by D. W. Scholl, 1970 (Figure 2). The site was approached with a ship's heading of 328°T, about 75° more northerly than the heading used in obtaining the reference profile. The air-gun profile (Figure 3) obtained during the approach revealed the same undulating basement structure as the reference profiles permitting the dropping of the beacon on the fly at 1020 hrs 25 Aug 71. The beacon failed to operate and after 45 minutes a second beacon was dropped. The finally accepted position is: 56°56.70′N; 168°10.72′E. No post-drilling survey was deemed necessary. However, a sonobuoy record was taken over the site (Figure 4); the record taken during departure from Site 191 is included as Figure 5. A map showing the approach and departure tracks plus the site location is shown in Figure 6.

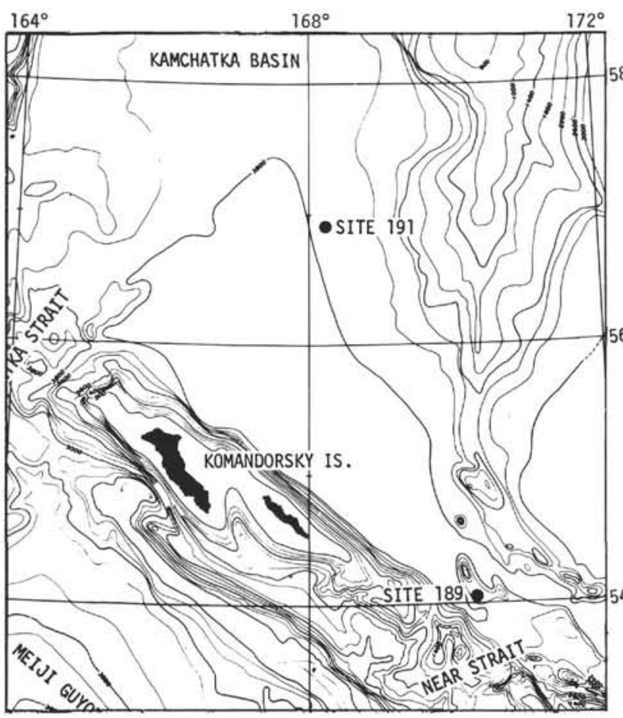

Figure 1. *Base map showing the location of Site 191, Kamchatka Basin.*

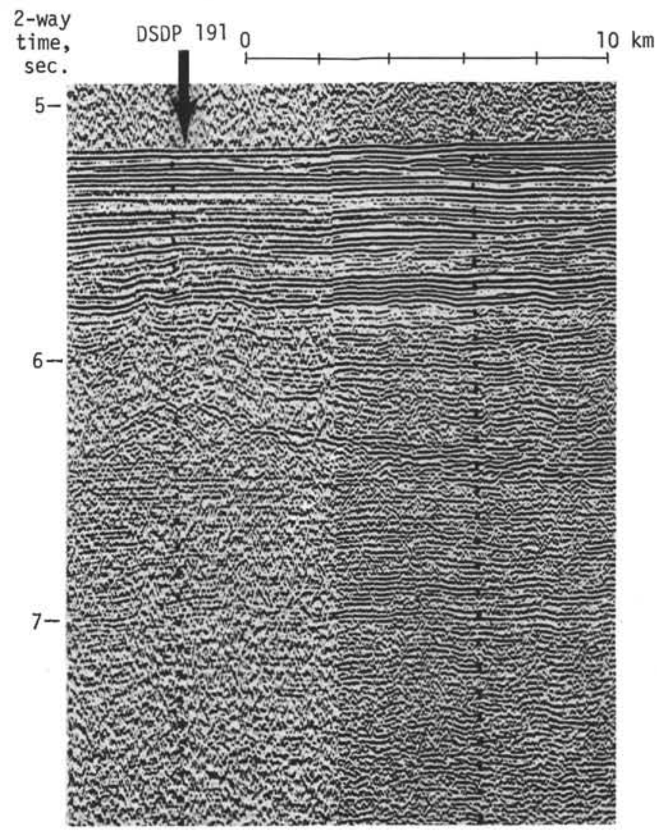

Figure 2. *Reference seismic reflection profile, Site 191, collected by D.W. Scholl, 24 Aug 70.*

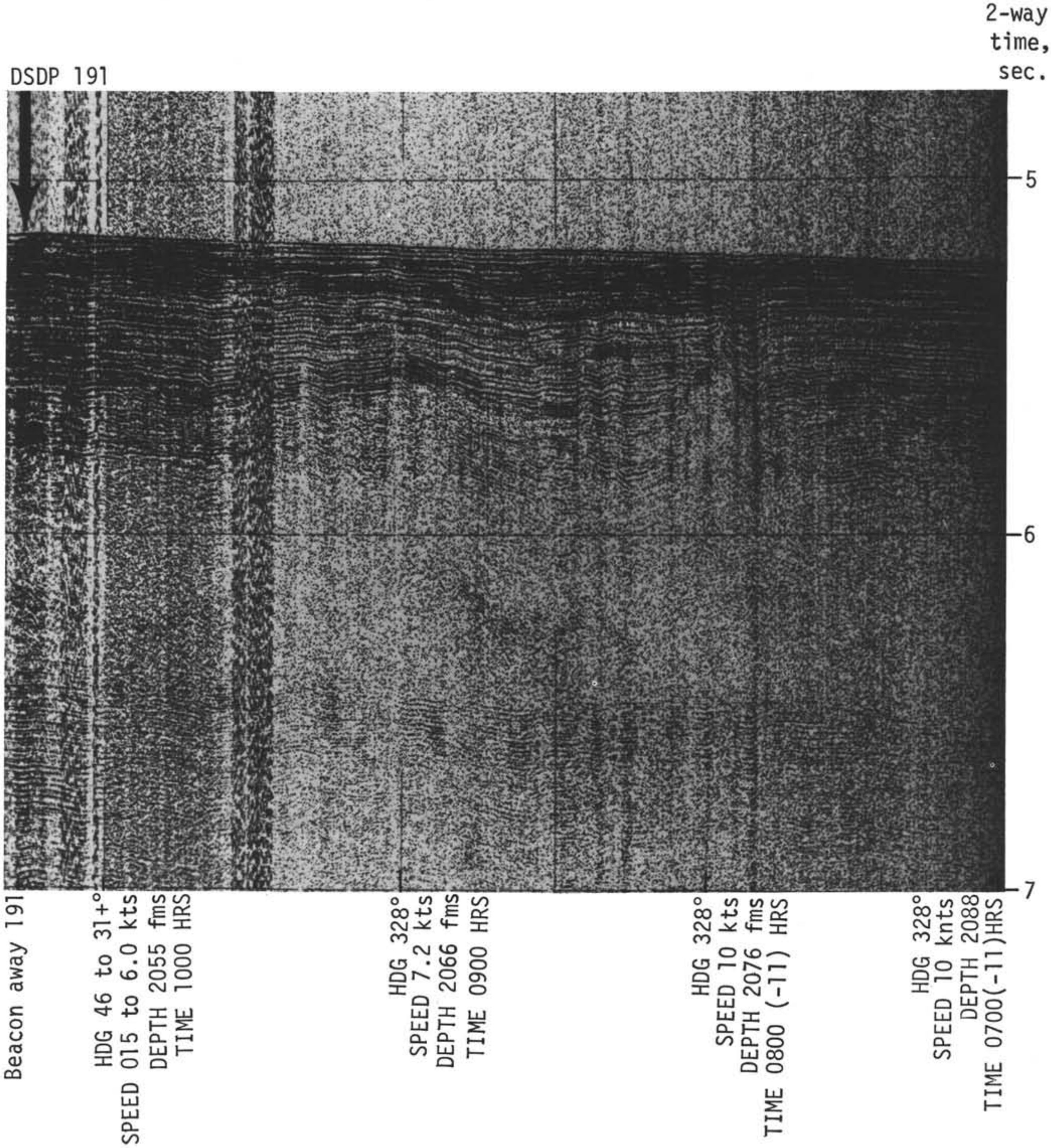

Figure 3. Glomar Challenger *air-gun profile obtained upon approach to Site 191.*

Drilling Program

Site 191 was occupied from 1020 hrs 25 Aug 71 (beacon away) until 0650 hrs 28 Aug 71 with alternating coring and washing from the sea floor to a subbottom depth of 919 meters. At about 900 meters drilling became extremely difficult (slow). A core taken at 905 meters showed the material to be basalt which is correlated with the deepest reflection horizon. One additional core was collected and the hole was abandoned.

Using recently acquired hydrographic data, the sonic depth of 2055 fms was corrected to 3833 meters, giving a water depth of 3839 meters and a drill-floor depth of 3849 meters. This compares with 3864 meters below drill floor based upon "feel" of the drill string by the driller and some sediment recovery in the first coring attempt. The 3864

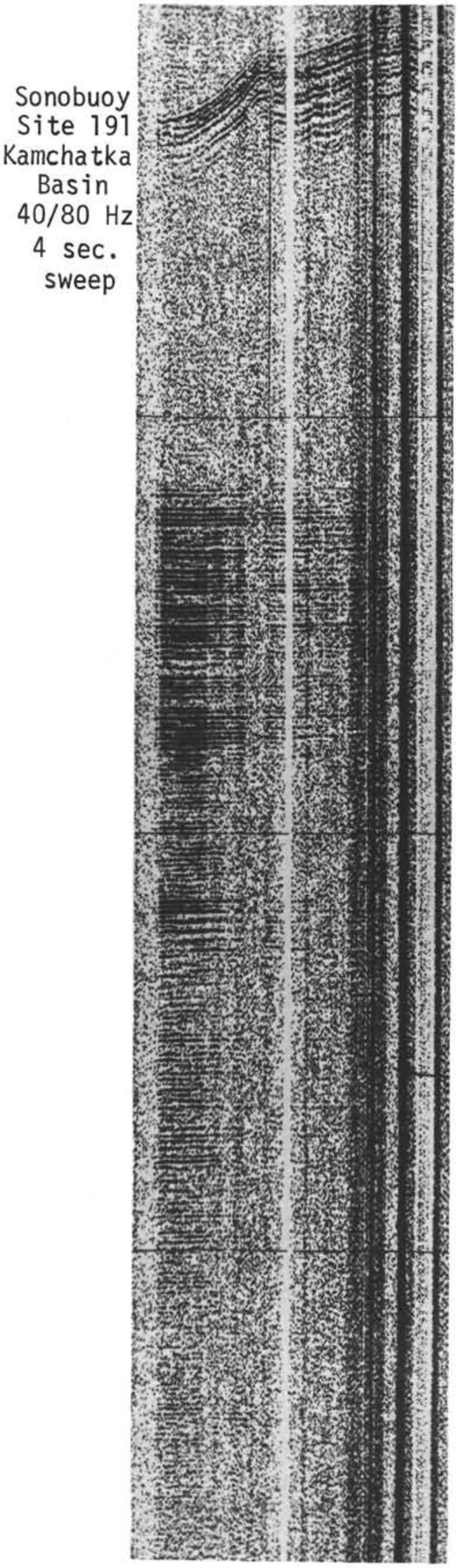

Figure 4. *Sonobuoy record, Site 191.*

meters below drill floor, or 3854 meters below sea level, is the accepted depth for this site.

The first three cores to a depth of 29 meters contained a total of 3.4 meters of sediment. In each case the sock was destroyed or inverted permitting most of the sediment to wash from the core barrel. No other drilling difficulties were encountered in drilling the upper 520 meters of sand and mud. Between 143 and 520 meters drilling was alternately fast and slow, with pump being used. This probably biases the cores collected by washing away the sands and preferentially retaining the muds. Mudstones from 520 to 900 meters required longer drilling times but were not otherwise difficult to drill and core.

By 0650 hrs the drill string had been pulled above the mud line. The ship was moved 100 feet due east (090°T) and Hole 191A was occupied from 0650 hrs to 1515 hrs 28 Aug 1971, with continuous coring to a total subbottom depth of 50 meters. This hole was cored in an attempt to recover the near-bottom sediment which we were not able to collect at Hole 191. Sock difficulties, this time using both cloth and plastic socks, again allowed the first 14 meters of below bottom sediment to escape collection. A depth of 3870 meters below drill floor, or 3860 meters below sea level, determined by driller's "feel" is the accepted depth for this hole.

At 1515 hrs the drill string was again lifted above the mud line and the ship was moved to a position 200 feet due east (090°T) from Hole 191. Hole 191B was occupied from 1515 hrs to 2230 hrs on 28 Aug 71. One 9-meter core was attempted with a recovery of 8.5 meters. The same depths were accepted for this hole as for Hole 191A. A coring summary is given in Table 1.

LITHOSTRATIGRAPHY

AN ODE TO GRAY CLAY
by
Richard J. Stewart, Ph.D.

Semi-lithified and burrowed
dark greenish clay
diatom-bearing silty clay,
with lenses and laminae of
greenish black to olive gray
diatom-bearing silty clay.

At Site 191 a 900-meter sedimentary section overlies basalt. Based on the abundance of sand, the degree of induration, and the occurrence of limestone beds, the section can be subdivided into two units (see Table 2).

Unit A (0-520 m) is diatom-bearing silty clay and diatom ooze, with abundant size-graded layers of silty sand and sandy silt above 290 meters. Volcanic ash is present between 0 and 240 meters. An ice-rafted(?) erratic pebble occurs at 452 meters.

Unit B (520-900 m) is indurated silty clay and diatom-bearing silty clay with beds of lithic sandstone. The upper portion, from 520 to 529 meters, contains a limestone bed and an ice-rafted(?) pebble.

The nature of the basalt-sediment contact at 900 meters is unknown. Textural variations in the basalt suggest it is a submarine lava flow.

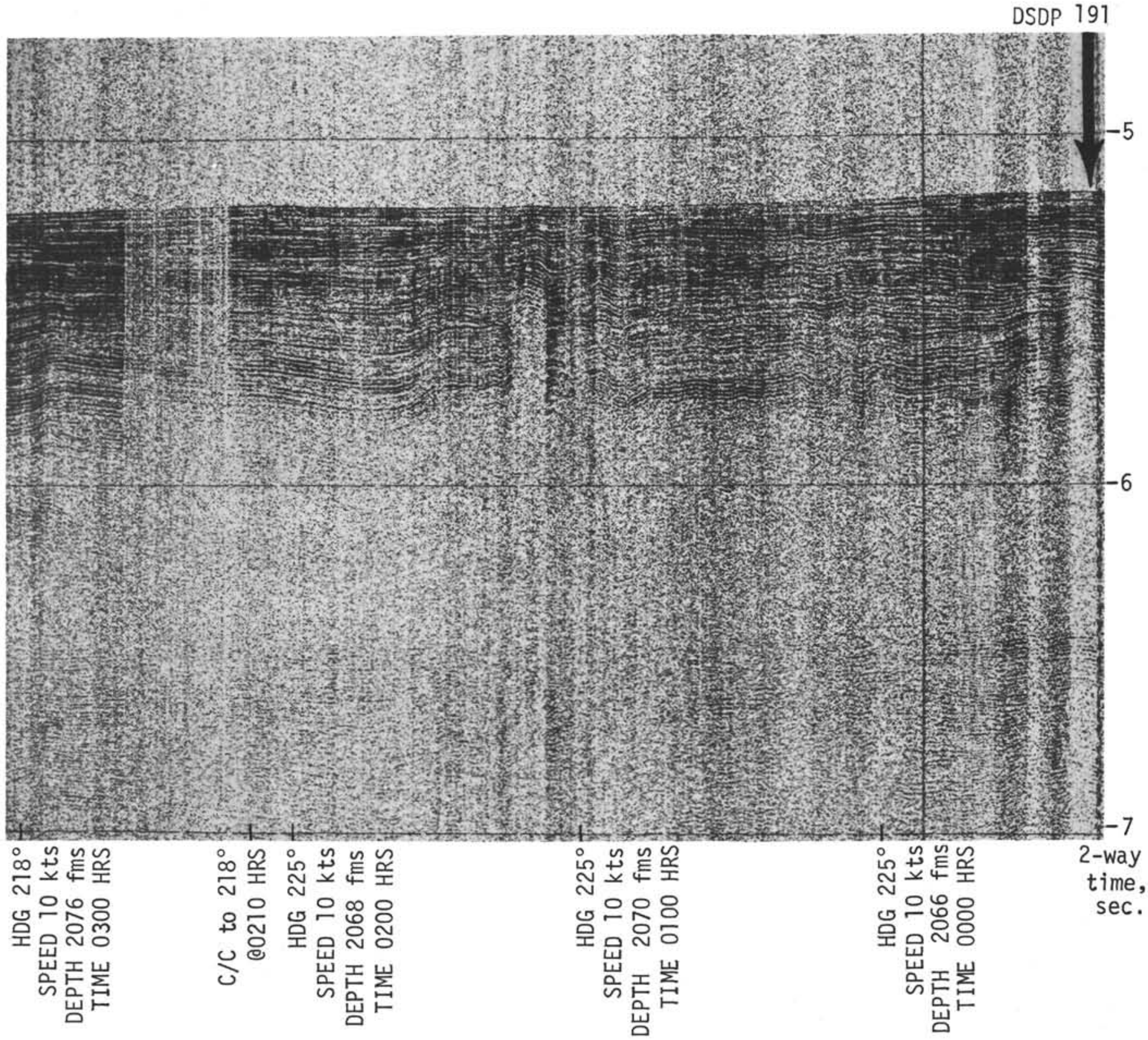

Figure 5. Glomar Challenger *air-gun profile obtained upon departure from Site 191.*

Unit A – 0 to 520 meters

In the first 300 meters size-graded beds of olive black sandy silt and silty sand are commonly intercalated in dark gray diatomaceous and diatom-rich silty clay and olive gray silt-rich clayey diatom ooze. The sand layers are up to 1.0 meter thick, are usually size-graded, and have sharp bottom contacts in contrast to the often indistinct tops. Typical compositions are 45% feldspar, 35% lithic fragments, 5% quartz, and 10% pyroxene, with lesser quantities of epidote, amphibole, biotite, chlorite, garnet, and zircon.

Pods and lenses of dark greenish gray carbonate-bearing clay are abundant in Core 4 (78 to 87 m). A crystal ash bed occurs at 179 meters (Core 6). An ice-rafted(?) pebble occurs in the catcher of Core 1 (0 to 1 m).

The first semilithified sediments occur in Core 7 (227-236 m) and coincide with the occurrence of frequent mottles and lenses of olive gray calcite silty clay. The dark gray silty clay is extensively burrowed.

Two beds of olive gray to grayish olive limestone occur at 236 meters (Core 7) and 281 meters (Core 8). An olive gray ash layer composed of light-colored glass occurs at 235 meters (Core 7).

Between 300 and 520 meters, distinct size-graded sand or silty sand layers were not recovered. The basic lithology is semilithified and burrowed, dark greenish gray diatom-bearing silty clay, with lenses and laminae of greenish black to olive gray diatom-bearing silty clay. An ice-rafted(?) volcanic pebble occurs at 460 meters (Core 11; see Figure 7).

Unit B – 520-900 meters

At 520 meters the drilling rate dropped sharply, coinciding with a sharp increase in lithification, decrease in diatom

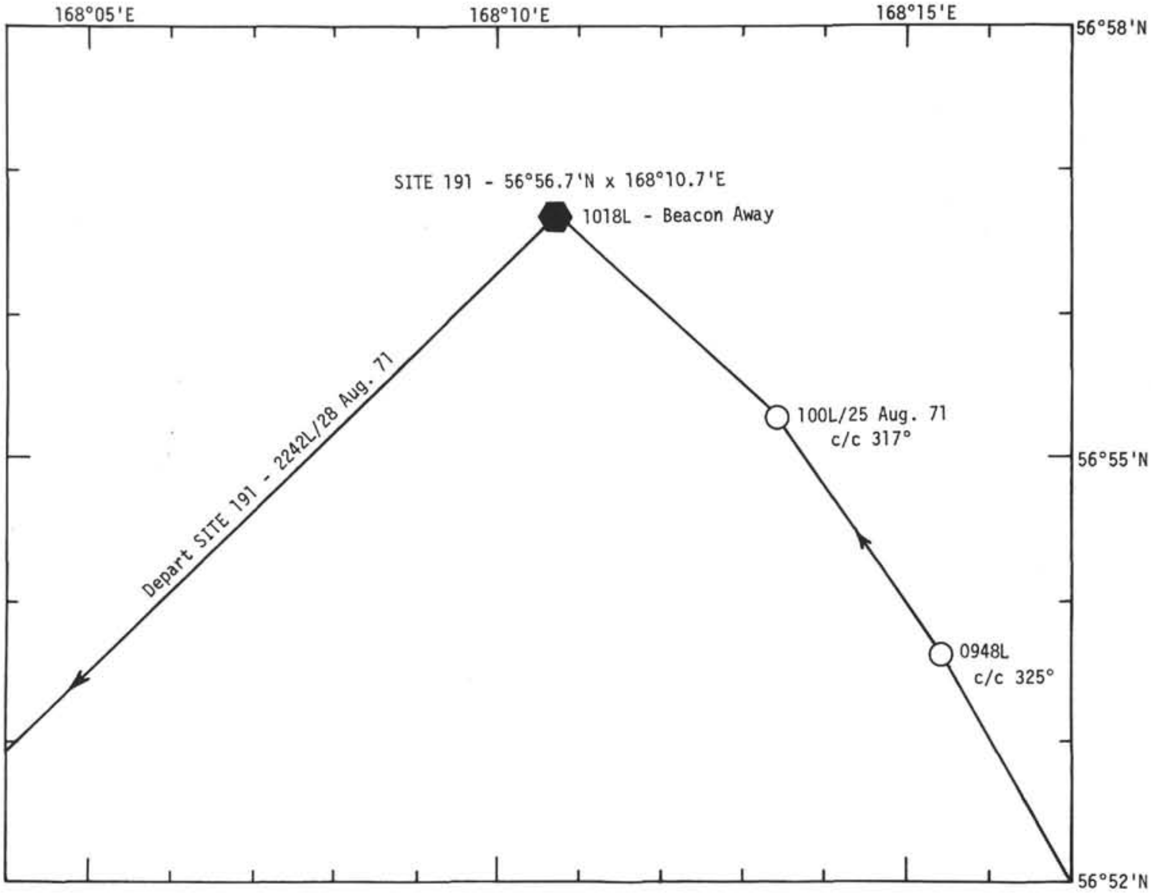

Figure 6. *Approach and departure tracks,* Glomar Challenger, *Site 191.*

content, and the presence of limestone beds and carbonate-cemented sandstone. Sediments in the interval 520 to 900 meters are dominantly dark gray to dark greenish gray silty clays with beds of light gray to dark gray and olive black lithic sandstone. In contrast to the sands recovered at other Leg 19 sites, most of the sand layers recovered at Site 191 are not calcite-cemented, but instead have a firm clay matrix and are poorly sorted lithic wackes or textural graywackes. Size-grading is not evident in most beds, as poor recovery and fracturing during drilling destroyed most top and bottom contacts. However, one ungraded sand with both sharp top and bottom contacts occurs at 628 meters (Core 13; see Figure 8). Limestone and calcite-cemented sandstone occur at 527 meters (Core 12).

Greenish black silt-bearing, clay- and silt-rich diatom ooze occurs at 520 to 523 meters (Core 12). An ice rafted(?) pebble was recovered from 523 meters (Core 12).

Basalt

Basalt totaling 1.4 meters was recovered in two cores (191-15CC and 191-16) and the drilling rate record indicates that it was probably first reached at about 900 meters. Unfortunately, the critical contact zone was not cored. The recovered material is variolitic pyroxene-plagioclase high-alumina tholeiite basalt grading downward to subdiabasic basalt in one apparently continuous unit. A K-Ar date of 30 m.y. was obtained on plagioclase microlite fractions of the basalt (see Stewart et al., this volume, Table 3), corroborating the inference from textural evidence and geophysical records that the basalt is extrusive and probably regional in extent. Detailed petrography is given in appendix to this chapter while chemistry, mineralogy and regional significance of the basalt are discussed in Stewart et al. (loc cit).

Holes 191A and 191B

Hole A at Site 191 penetrated to a depth of 50 meters. The recovered sediment is identical to the upper part of Unit A. The section is dominantly dark gray diatom-bearing silty clay and dark gray to dark greenish gray diatom ooze, with frequent intercalations of olive black silty sand and sandy silt. Ash beds occur at approximately 20 meters (light-colored glass), 21 meters (dark-colored glass), 23 meters (light-colored glass), and 48 meters (light-colored glass). An ice-rafted(?) pebble was recovered from the core catcher of Core 3 (32 to 41 m).

Hole B penetrated to a depth of 9.0 meters. The recovered sediment consists of olive gray silt and clay-bearing to silt- and clay-rich diatom ooze, with interbedded olive black silty sand.

PHYSICAL PROPERTIES

Bulk density, water content, natural gamma radiation, acoustic velocity, vane shear strength, and residual negative pore water pressure were measured on the samples obtained

TABLE 1
Coring Summary – Hole 191

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)
Hole 191				
1	0-1	1	0.05	5.0
2	1-10	9	3.3	36.7
Wash				
3	20-29	9	CC	0.0
Wash				
4	78-87	9	9.5	105.6
Wash				
5	134-143	9	9.5	105.6
Wash				
6	171-180	9	2.2	24.4
Wash				
7	227-236	9	1.8	20.0
Wash				
8	274-283	9	2.6	28.9
Wash				
9	321-330	9	1.5	16.7
Wash				
10	384-393	9	3.1	34.4
Wash				
11	452-461	9	2.0	22.2
Wash				
12	520-527	7	2.5	35.7
Wash				
13	620-629	9	3.0	33.3
Wash				
14	723-732	9	1.7	18.9
Wash				
15	905-910	5	CC	0.0
16	910-919	9	1.4	15.6
		130	44.15	34.0
Hole 191A				
1	14-23	9	9.0	100.0
2	23-32	9	4.5	50.0
3	32-41	9	CC	0.0
4	41-50	9	8.0	88.9
		36	21.5	59.7
Hole 191B				
1	0-9	9	8.5	94.4

TABLE 2

Unit	Cores	Depth Below Sea Floor (m)	Lithology	Age
A	1-6	0-200	Diatom silty clay, diatom ooze, and silty sand	Upper and middle Pleistocene
	7, 8	200-300	Semi-indurated diatom-bearing silty clay and sandy silt	Middle and lower Pleistocene
	9-11	300-520	Semi-indurated diatom-bearing silty clay	Lower Pleistocene and Pliocene
B	12-15	520-900	Indurated silty clay and lithic wacke	Pliocene? and upper Miocene?
Basalt	15CC, 16	900-919	Pyroxene-plagioclase basalt	Upper Miocene?

Figure 7. *An ice-rafter (?) pebble in silty clay. (191-11-1, 144-150 cm).*

at Site 191. Bulk density was measured in the usual three ways. Two unsplit segments of core were obtained and sealed for shore consolidation testing (Lee, this volume).

GRAPE densities are shown on the core summary sheets. Mean GRAPE densities are shown on the site summary sheet along with shore laboratory densities, water displacement densities, and measured acoustic velocities.

A problem with gas expansion-induced disturbance was once again encountered at Site 191. The zone from about 20 to 140 meters was affected most severely, and the physical properties measured on samples from this range are relatively unreliable.

Bulk Density

The GRAPE density was measured to a sediment depth of 450 meters, below which the sediment no longer filled the core liner. The density for the remainder of the sediment was measured by the water displacement method.

The GRAPE densities, as shown on the core summary sheets, once again required modification to compensate for gas expansion-induced disturbance. The dashed lines shown represent envelopes which enclose the peak density values in the most severely disturbed sections. In the less disturbed portions, sand and ash layers appear as dense sections while the silty clay zones appear as medium-dense sections. Very little detail is apparent in the badly disturbed sections. The

Figure 8. *Sandstone with sharp top and bottom contacts and angular shale pebble (rip-up?) at base. (191-13-2, 108-116 cm).*

most interesting GRAPE record is that for Hole 191B, Core 1. The increase in the clay density over the length of this core is well shown and allows for a relatively reliable calculation of the sediment compressibility (Lee, this volume).

The general density trends for this site are shown by the average values plotted on the site summary sheet. The first core is seen as a zone of rapidly increasing density as discussed above. The section which follows, to a depth of 140 meters, is characterized by considerable data scatter resulting from ash and sand layers and gas expansion-induced disturbance. From 140 to 520 meters, the density is virtually constant and equal to about 1.75 g/cm^3. The density then increases gradually to 2.0 g/cm^3 at 730 meters. The basalt at the bottom of the hole has a density of 2.65 to 2.75 g/cm^3.

Acoustic Velocity

The acoustic velocity remains around 1.5 km/sec for the first 250 meters. It then begins to increase gradually, reaching a value of 2.2 km/sec at 730 meters. The basalt at the bottom of the hole has an acoustic velocity of 4.5 to 5.0 km/sec. Sandstone layers between 500 and 700 meters have velocities of about 2.5 km/sec.

Summary

The basic silty clay material at Site 191 is relatively uniform and dense throughout the upper 520 meters. Below this point, the density and acoustic velocity increase gradually and consistently to 2.0 g/cm^3 and 2.2 km/sec, respectively, at 730 meters. The only sharp deviations from this trend occur in the vicinity of high-velocity sandstones in the zone, 500 to 700 meters. A marked change in physical properties occurs at the bottom of the hole where basalt with a density of 2.7 g/cm^3 and an acoustic velocity of 4.7 km/sec occurs.

PALEONTOLOGY

Sediments from this site contain poor microfossil assemblages; calcareous nannofossils are essentially absent; Radiolaria and silicoflagellates are low in number of specimens as well as species; foraminifera, both planktonic and benthic, are usually sparse to absent; and even diatoms, which have been the dominant fossil element in the Bering Sea and Northeast Pacific deposits, are diminished in number.

Reworked microfossils are found throughout the Pleistocene intervals. They are either extinct Miocene species or sublittoral and fresh-water diatoms. Inner sublittoral and outer sublittoral plus bathyal foraminiferal groups are frequently associated with deep-sea sand at this site.

The thick Pleistocene section is apparently the product of turbidity currents, as inferred from the seismic record. The presence of fresh-water diatoms plus sublittoral diatoms and foraminifera combined with low radiolarian and silicoflagellate populations supports this contention.

Foraminifera

At Site 191 the vertical distribution of foraminifera generally follows the pattern established at previous sites in the Bering Sea. That is, fluctuating abundances of planktonic and calcareous benthic populations in the Quaternary, a barren Pliocene (but perhaps not the total Pliocene at this site), and sparse arenaceous populations in the Miocene.

Displaced tests are much more common than at previous sites. Displaced species may be divided into a sublittoral group and an outer sublittoral and bathyal group (Table 3). The sublittoral group, dominated by *Eliphidium clavatum,* is very similar to that occurring in sediments deposited during late Wisconsin time on what is now the outer shelf of the Bering Sea (Knebel et al., in press). The outer sublittoral and bathyal group is very similar to that reported by Smith (*In* Hopkins et al., 1969) in lower Pleistocene rocks dredged from the Pribilof Canyon on the continental slope of the Bering Sea. During times of low sea level, the inner shelf species group would have inhabited the present outer shelf, while the outer shelf bathal species group probably was confined beyond the shelf break. The two groups are subequally represented in sediments of Site 191 and, in some samples, outnumber the indigenous group of species. In Core 1, core catcher, near-surface sediments appear to have been sampled; these lack displaced tests. Sparse middle Pleistocene benthic faunas also lack displaced tests, but the sampling density is too low to attach significance to this. Greater frequency of displaced tests at this site is associated with a greater proportion of deep-sea sands than at previous sites. The sand content in individual samples having displaced tests may not be particularly high, but some sand is always present.

The typical upper Miocene arenaceous fauna was not found in the core catcher sample of Core 12, but it has

TABLE 3
Number of Displaced Foraminifera of the Sublittoral Group and the Outer Sublittoral-Upper Bathyal Group Compared to the Number of Probable Indigeneous Foraminifera of the Bathyal-Abyssal Group

Age		Depth in Hole (m)	Samples (all CC)	Sublittoral Group	*Elphidium clavatum*	*E. bartletti*	*E. frigidum*	*E. subarcticum*	*Bucella frigida*	*Buliminella elegantissima*	*Cassidulina noruangii*	*Protelphidium orbiculare*	Total	Outer Sublittoral-Upper Bathal Group	*Angulogerina angulosa*	*Epistominella* cf. *E. pacifica*	*Nonionellina labradorica*	*Uvigerina hollocki*	Total	Total Bathyal-Abyssal Group
Pleistocene	Late	1	1																	19
		10	2				1		1				2		1	3	1	1	6	6
		23	1A		11		1		1			1	14			1		9	10	164
		32	2A		40					1	1		42			19	2	7	28	63
	M	87	4		9	1		5					15			3	5	2	10	28
		143	5																	2
		180	6																	4
	Early	236	7																	6
		283	8													1			1	
Pliocene	Late	330	9					2					2			2			2	12
		393	10		5								5							3

been found in center bit cuttings from between 732 and 905 meters, and also in the core catcher of Core 14.

Calcareous Nannoflora

Nannofossils are rare in the Pleistocene and are not age-diagnostic. They are absent below the Pleistocene. Their absence at many levels may be a result of their exclusion from low-temperature surface waters.

Radiolaria and Silicoflagellates

Except for the upper Pleistocene section, sediments were generally poor in radiolarians and silicoflagellates. Species diversity and population density are very low, and from Core 12 to the bottom of the hole, sediments are barren of these siliceous microfossils.

Radiolarians (Table 10, Chapter 28) identified in Cores 1 and 2 of Holes 191 and 191A, and Core 1 of 191B, were those found in the surface sediment of previous Bering Sea sites. From Core 191-3 downward, species diversity decreases and only a few long-ranging forms were found.

Silicoflagellates from the site are rather poor (Table 10, Chapter 27), being similar to Site 189 in this regard. However, reworked forms were noted; they are: *Mesocena circulus* var. *apiculata* (late Miocene) in Cores 191A-1 and 191B-1, and *Ehriopsis antiqua* (spineless form) (early Pliocene-Miocene) in 191B-1. A similar observation was made on diatoms, suggesting that reworking at this site is more apparent than at previous sites in the Pleistocene section. The high sedimentation rate may account for the low frequency of microfossils recovered from this site.

Diatoms

Diatoms recovered from samples at Site 191 are moderate to well preserved, and their stratigraphic sequence is shown in Table 9, Chapter 30.

Samples in the lowest part of the sequence are barren of diatoms, except a sample (191-14-2, 4-5 cm) which contains poorly preserved *Coscinodiscus marginatus* (common) and *Thalassiosira zablinae* (few), suggesting a possible late Pliocene age.

CORRELATION BETWEEN REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

The ship tracks followed by the *Glomar Challenger* to and from Site 191 are shown in Figure 9, and the corresponding reflection profiles with magnetics are shown in Figures 10 and 11. The upper sediment (0.6 sec) in Kamchatka Basin is generally flat lying except near the periphery of the basin and shows strong internal stratification. Below 0.6 sec the sediment appears transparent and only locally do deeper reflections or basement appear on the *Challenger's* profile. Records by other vessels in this area have found a continuous but irregular basement between 1.0 and 1.5 sec. The magnetometer data generally show small anomalies over Kamchatka Basin except for the 350 gamma anomaly just south of Site 191 (Figure 11). The magnetic anomalies over the Shirshov and Komandorsky ridges are also relatively small for volcanic features.

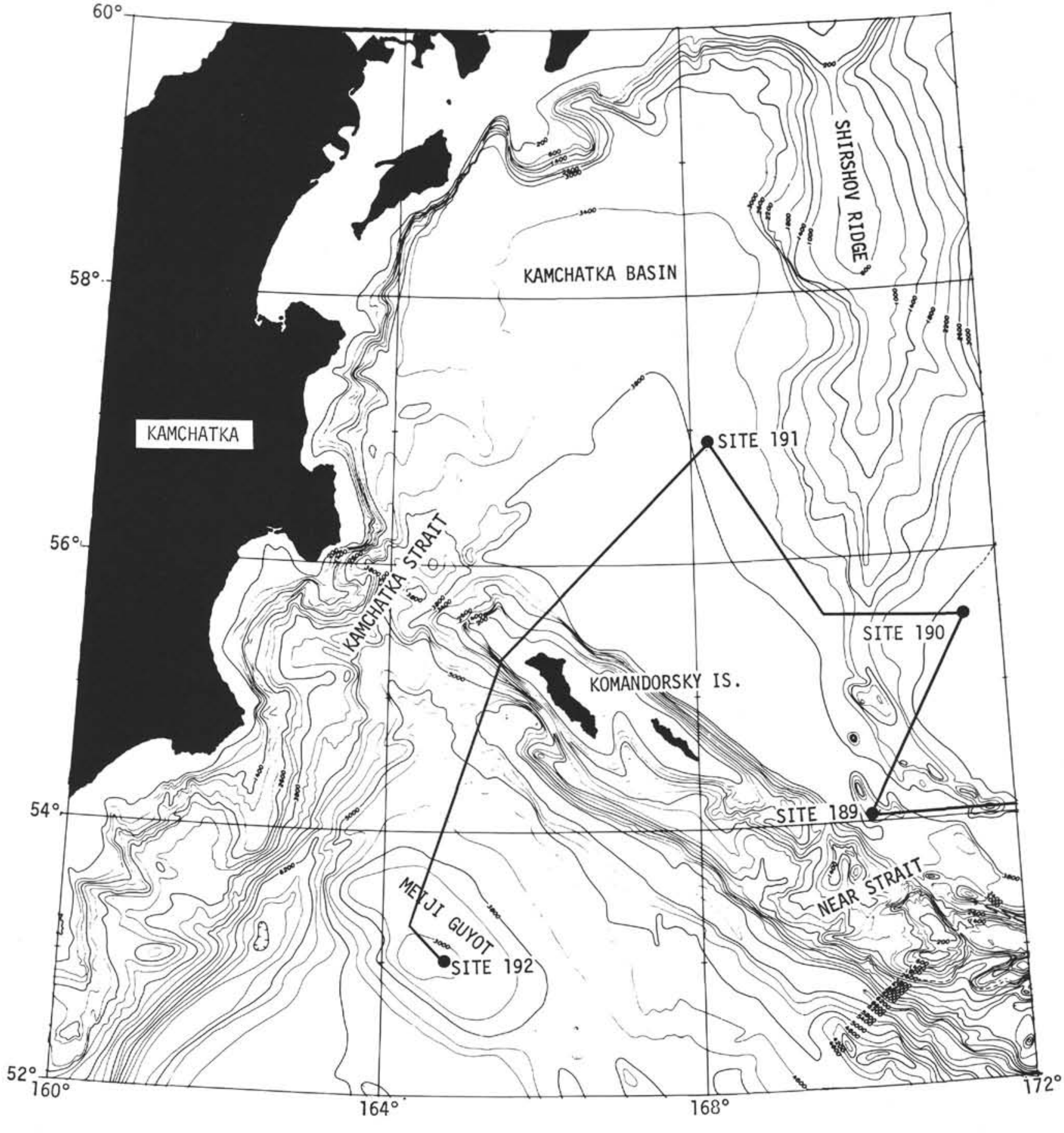

Figure 9. *Ship's track of* Glomar Challenger *to and from Site 191, shown with respect to bathymetry.*

A sonobuoy profile taken by the *Challenger* while on Site 191 is shown in Figure 12 along with the stratigraphic column and physical properties. The sonobuoy profile shows the same stratified sequence for the upper 0.65 sec and the underlying transparent layer, but it also shows a clear terminal reflector at 1.0 sec. The upper sequence is composed of Unit A, Plio-Pleistocene turbidites, while the transparent Unit B is upper Miocene mudstone and sandstone. The 1.0-sec reflection is from the surface of a basalt basement reached at 900 meters. Unfortunately, the important sediment-basalt contact was not cored.

Interval velocities for Unit A range from 1.5 to 1.7 km/sec according to the shipboard laboratory data, while the travel-time estimates are 1.6 km/sec (520 m by 0.65 sec). Unit B has very heterogeneous shipboard laboratory values, ranging from 1.6 to 2.6 km/sec, in spite of its apparent homogeneity, suggested by the profiler record. The time-travel estimate for velocity of Unit B is 2.2 km/sec.

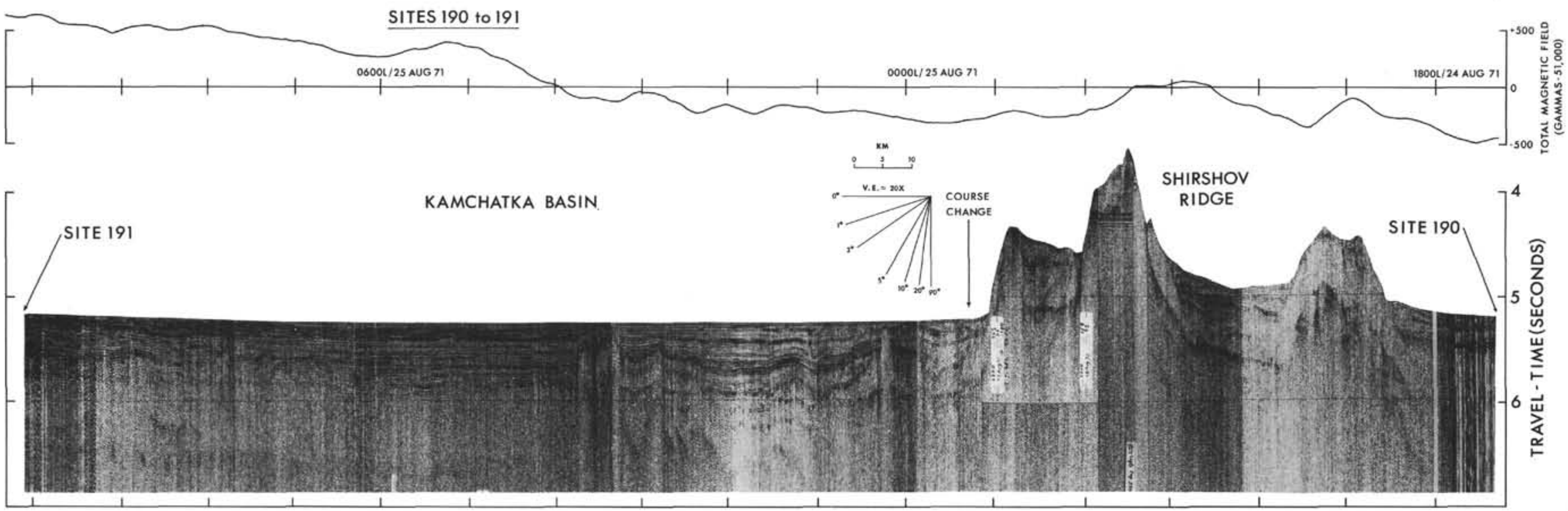

Figure 10. *Seismic reflection profile obtained by* Glomar Challenger *approaching Site 191, with corresponding magnetics.*

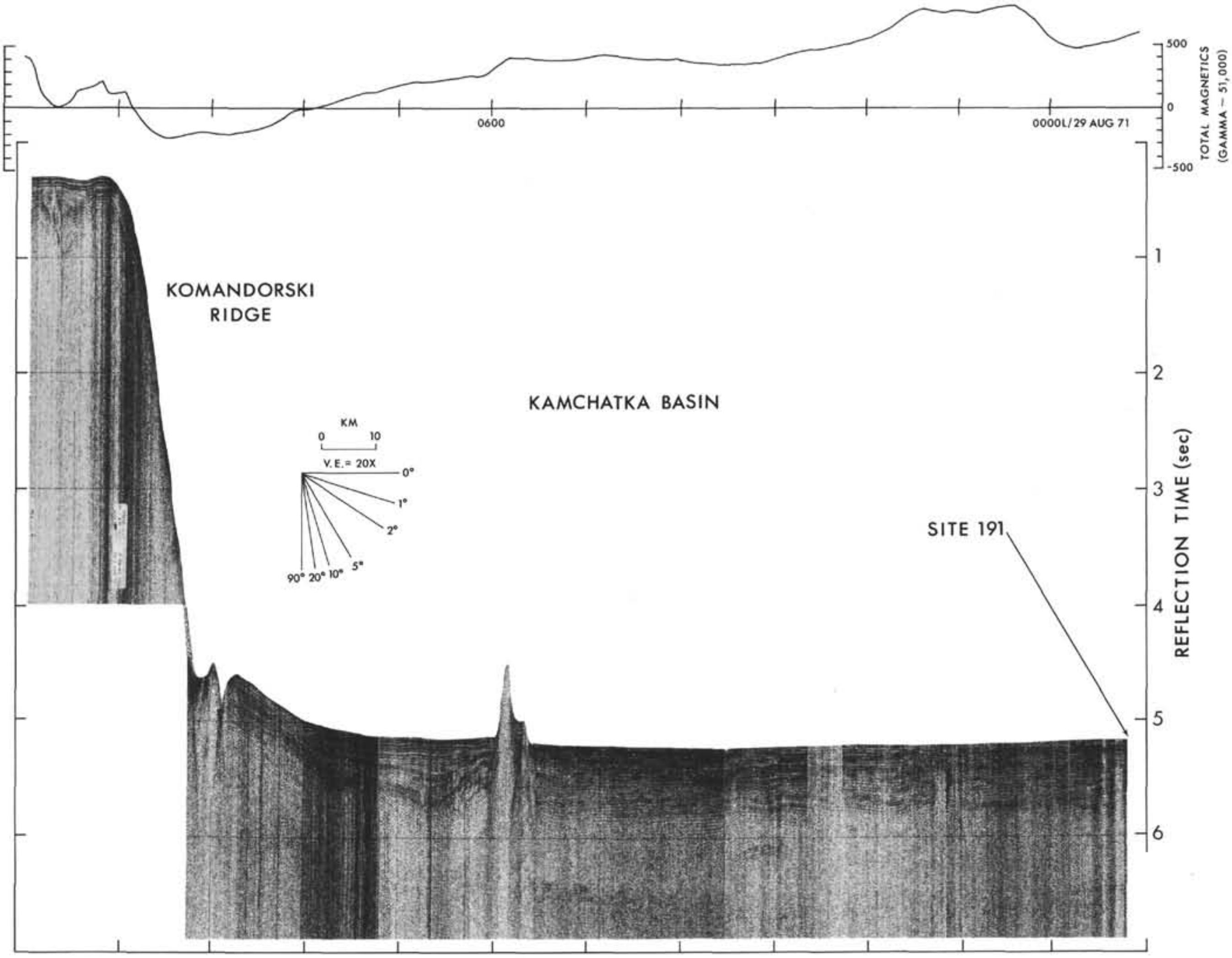

Figure 11. *Seismic reflection profile obtained by* Glomar Challenger *departing Site 191, with corresponding magnetics.*

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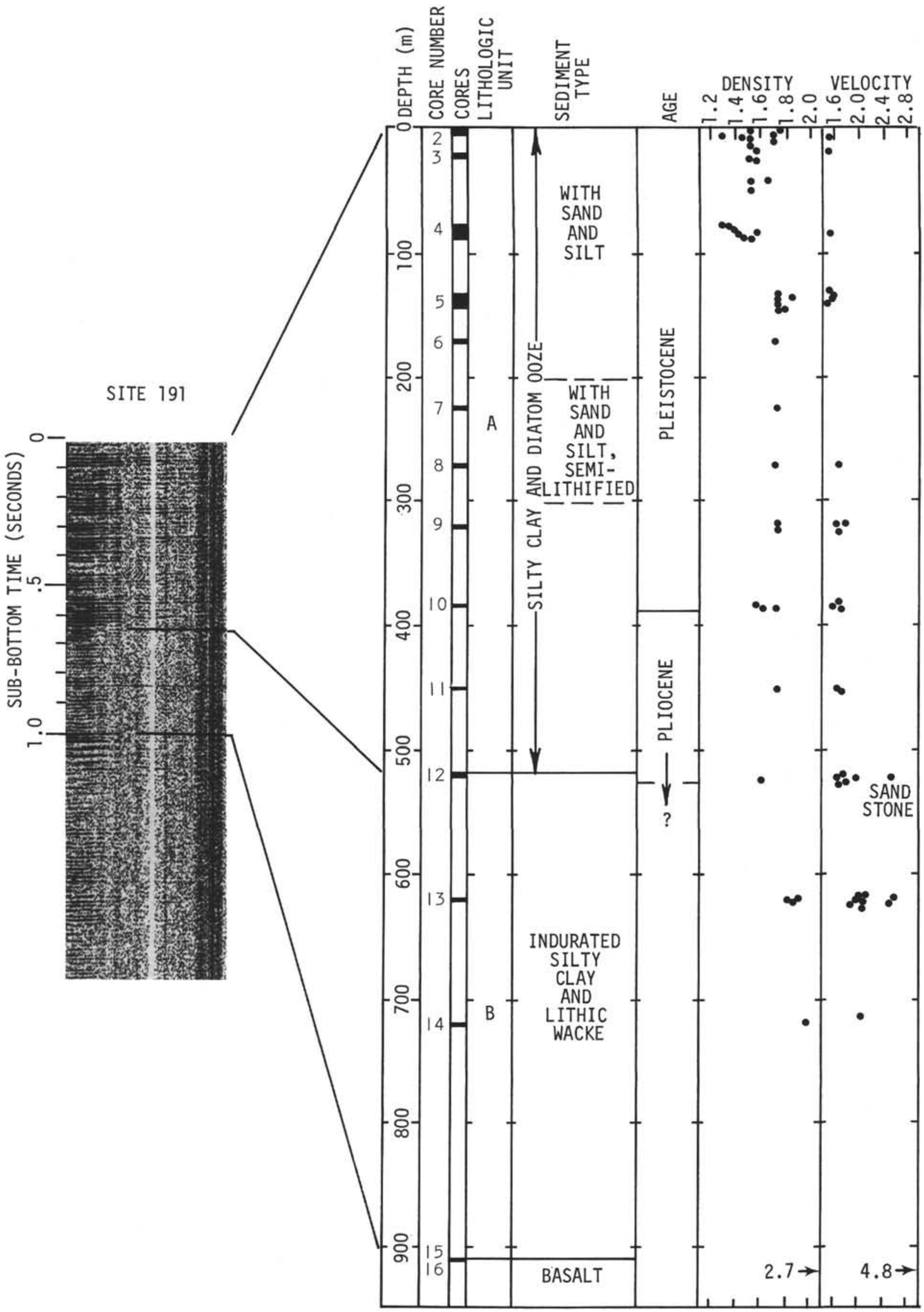

Figure 12. *Correlation of sonobuoy profile with stratigraphic column and physical properties, Site 191.*

APPENDIX
PETROGRAPHY OF BASALT, SITE 191

James H. Natland, Department of the
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University of Washington, Seattle, Washington

Basalt was recovered in two cores (191-15CC and 191-16) and the drilling rate record indicates that basalt was probably first reached at about 900 meters. Unfortunately, the critical contact zone was not cored. The recovered material is variolitic pyroxene-plagioclase high-alumina tholeiitic basalt (See Stewart et al., this volume) grading downward to subdiabasic basalt in one apparently continuous unit. No glassy material was recovered at any interval.

A thin section of the topmost variolitic material (191-15 CC) contains acicular needles and laths of labradorite up to 1.5 mm long set in a matrix of plumose sheafs of intimately intergrown plagioclase and pyroxene needles (Figure 13). The larger feldspar needles often have splayed ends and cores of pyroxene needles, usually parallel to the plagioclase 010 direction, with length to width ratios of 10 or 20:1. The intergrown plagioclase microlites typically follow the bends and twists of the pyroxene sheafs and tufts, arranged roughly parallel with the pyroxene needles, alternating with them as integral parts of the variolites. There are essentially no glassy patches free of variolites or crystals, but some patches of green nontronite may be their remains. Where variolites are relatively free of the plagioclase microlites, sometimes a fine cross-hatched pattern can be seen where two pyroxene sheafs have intergrown. Opaques are ubiquitous, very tiny, and rather uniformly scattered, except rarely where they are concentrated between variolites. These may be secondary. A few labradorite microphenocrysts and a few 0.5 mm or smaller vesicles, well outlined by surrounding pyroxene sheafs, are scattered through the section.

Further down the core (191-16), the variolitic habit involves larger crystals. Labradorite laths with splayed ends, not quite so acicular, commonly form spoke-like radial clusters, and the cross-hatched pyroxene variolites develop a distinctive herringbone-type texture. The pyroxene sheafs are more distinct, plagioclase microlites tending to develop around rather than inside the variolites.

Toward the base of the 1.4 meters of basalt recovered, the texture is subdiabasic (Figure 14), with light brown pyroxenes forming fairly well-defined grains with impressive herringbone texture. Opaques again are widespread, particularly along grain boundaries. The feldspars only rarely develop splayed ends or radial clusters. A curious feature of the lower parts of the core, however, is spheres up to 2 mm in diameter of herringbone-type pyroxenes, usually with some glass generally altered to green nontronite, plated or armored tangentially by small plagioclase laths. Several of these can be seen in some sections. If, as seems the case, the crystallizing basalt was on the pyroxene-plagioclase cotectic, the spheres may have been incipient pyroxene phenocrysts that settled from the top part of the melt with a surrounding droplet of melt; the addition of this mafic mass surrounded by its glassy membrane may have forced the invaded liquid to attempt to restore equilibrium by clustering the invader with plagioclase.

Figure 13. *Variolitic texture in basalt. Crossed nicols. Scale bar is 0.5 mm. (191-15-CC).*

Figure 14. *Subdiabasic texture in basalt. Crossed nicols. Scale bar is 0.5 mm. (191-16-1, 128 cm).*

Other glomerophenocrysts (Figure 15), predominantly of feldspar, occur sporadically in the subdiabasic material. Phenocrystal plagioclase compositions are An_{70-75} (carlsbad-albite twins); microlites range from An_{70-60}.

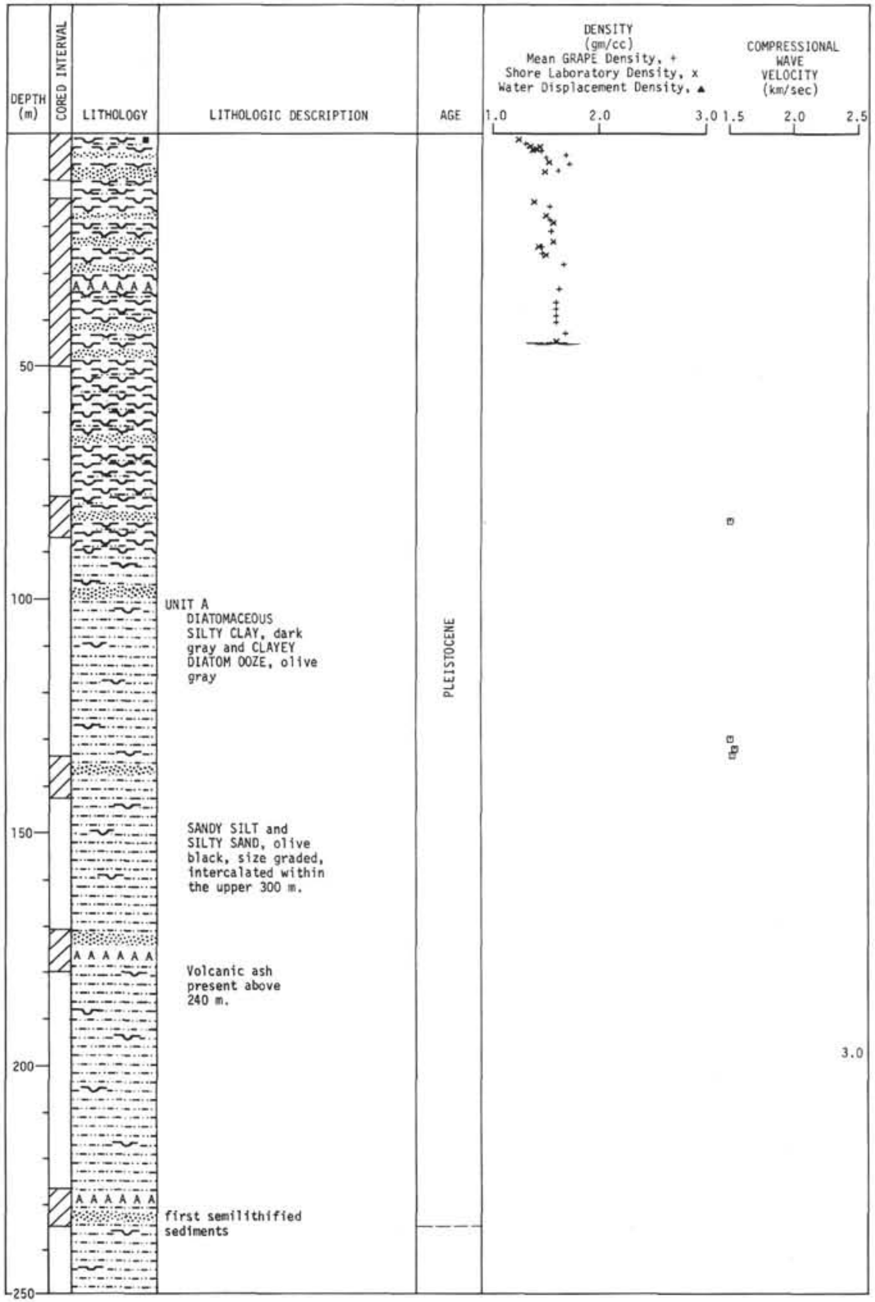
Figure 15. *Glomeroporphorytic clot. Plane light. Scale bar is 0.5 mm. (191-16-1, 128 cm).*

Microprobe data (Stewart et al., this volume) on pyroxenes show them to be augites.

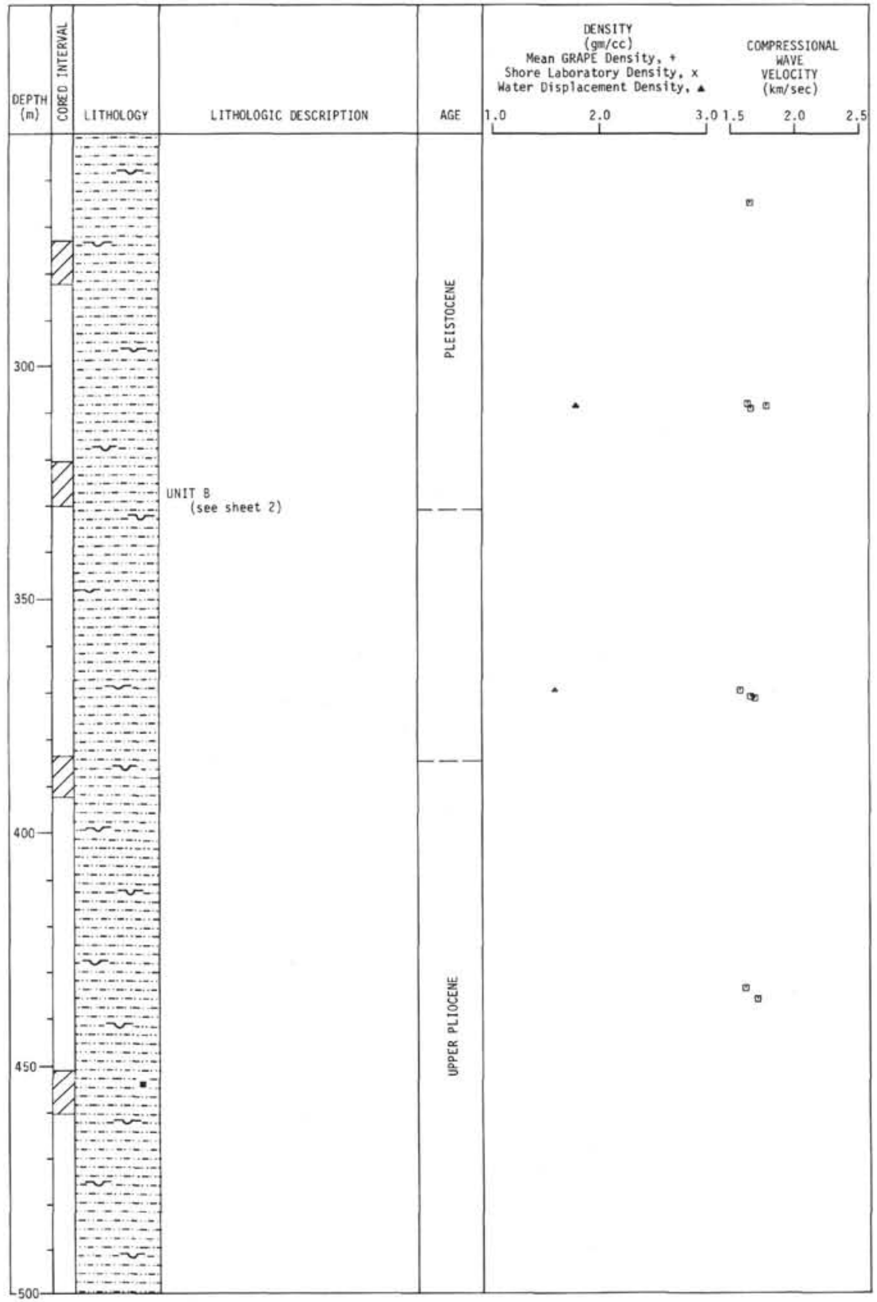
The rock is fairly well altered. Patches of bright green nontronite fill rare vesicles and form irregular patches replacing interstitial material. Sometimes the vesicles are festooned with tiny hemispheres of dark brown-red iron oxides or hydroxides along their rims; the remainder is filled in radially by the green clay fibers. Sometimes a clear, isotropic mineral of low relief (zeolite?) forms the cores of these green spherulites. Some of the plagioclases show incipient sericitization. The degree of alteration decreases downward with the least altered rocks being the subdiabasic bottom of Core 16. In places the rock is fractured, the cracks filled with dark red-brown iron oxides and sponge-like green nontronite. These cracks are similar to those in the basalts of Site 192. There, iron oxide fillings in cracks seem related to a layer of ferruginous clays above the volcanics. Perhaps a similar layer of ferruginous sediment exists at Site 191, but was not cored.

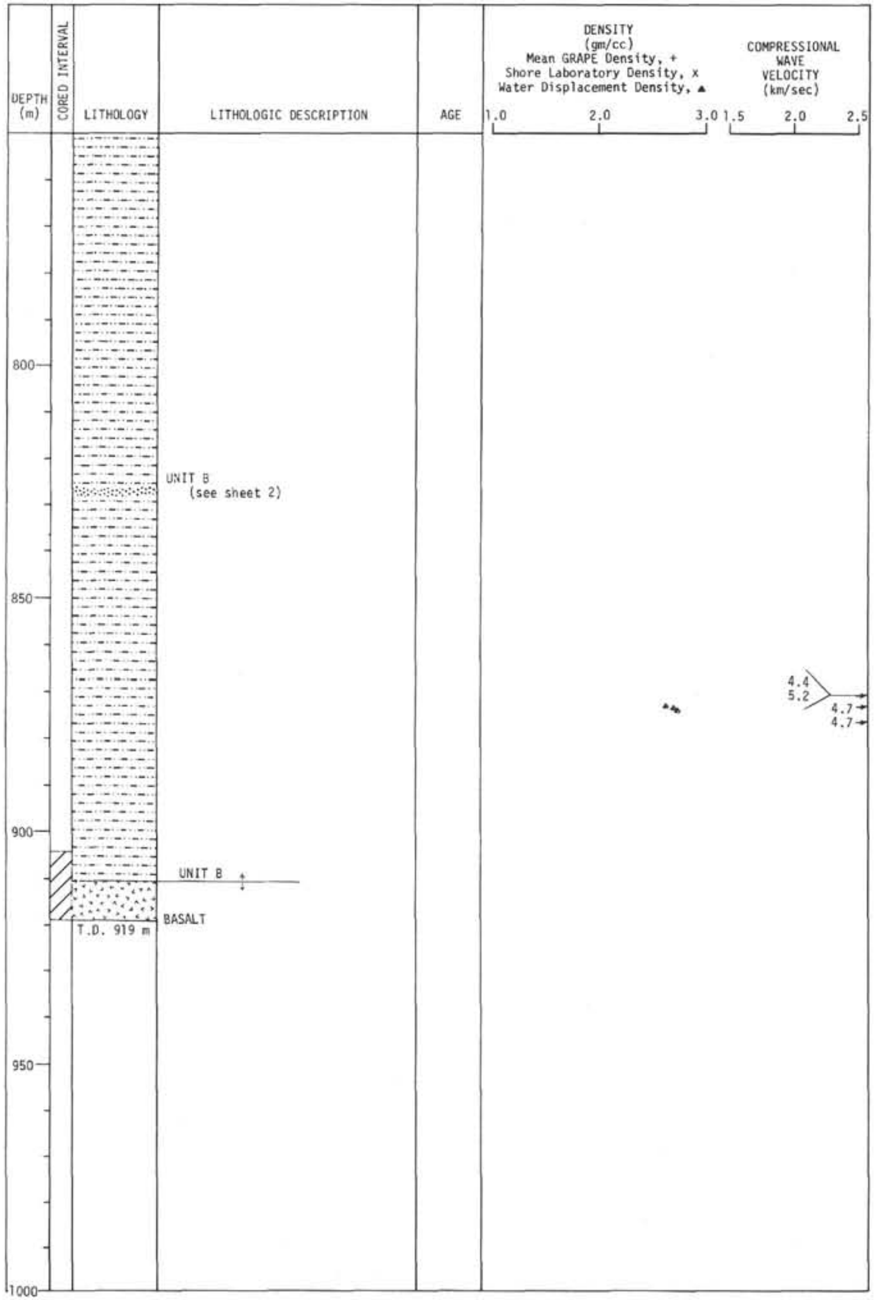
Because the sediment-basalt contact was not recovered, it is difficult to determine a mode of emplacement for the basalt. The thickness of the section, and the gradational textural changes suggest the margin of a dike or sill. The variolitic texture is probably the result of rapid freezing of a basaltic liquid and is most commonly reported from the quenched margins of submarine basalt flows, but has been reported from sills. A radiometric age of 30 m.y. on the basalt much older than the late Miocene or early Pliocene sediments overlying it, virtually certifies an extrusion origin, as further suggested by the regional extent of the basement acoustic reflector and apparent depositional relations of overlying sediments to it (see Stewart et al., this volume).

SITE 191

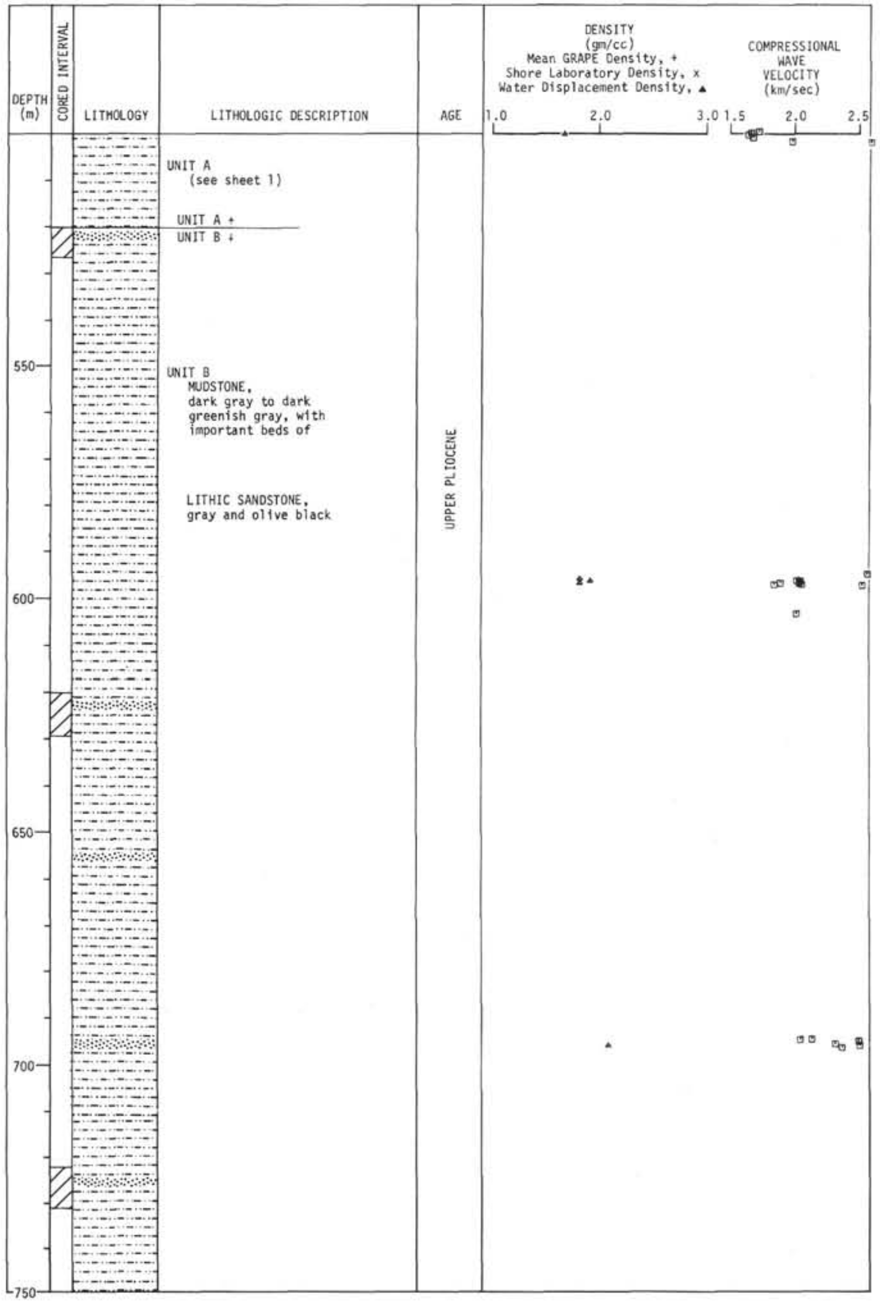


SITE 191




DEPTH (m)
CORED INTERVAL
LITHOLOGY
LITHOLOGIC DESCRIPTION
AGE
DENSITY (gm/cc)
Mean GRAPE Density, +
Shore Laboratory Density, x
Water Displacement Density, ▲
COMPRESSIONAL WAVE VELOCITY (km/sec)
1.0 2.0 3.0
1.5 2.0 2.5
800
850
900
950
1000
UNIT B
(see sheet 2)
4.4
5.2
4.7
4.7
UNIT B
BASALT
T.D. 919 m

SITE 191


DEPTH (m)
CORED INTERVAL
LITHOLOGY
LITHOLOGIC DESCRIPTION
AGE
DENSITY (gm/cc)
Mean GRAPE Density, +
Shore Laboratory Density, x
Water Displacement Density, ▲
COMPRESSIONAL WAVE VELOCITY (km/sec)
1.0 2.0 3.0
1.5 2.0 2.5
UNIT A
(see sheet 1)
UNIT A ↑
UNIT B ↓
550
UNIT B
MUDSTONE,
dark gray to dark greenish gray, with important beds of
LITHIC SANDSTONE,
gray and olive black
UPPER PLIOCENE
600
650
700
750

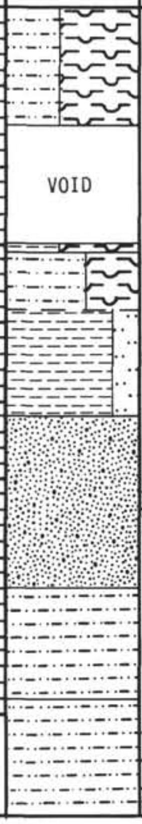
Site 191 Hole Core 1 Cored Interval: 0-1

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
UPPER PLEISTOCENE	(D) Denticula seminae (S) Distephanus octangulatus	D - N R S PF BF	A R R R R F F	G M M M M	Core Catcher					CLAY BEARING SILTY DIATOM OOZE erratic core catcher only

Explanatory notes in Chapter 1

Site 191 Hole Core 2 Cored Interval: 1-10

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLEISTOCENE	(D) Denticula seminae (S) Distephanus octangulatus	D R S	A R F	G M M	1	0.5, 1.0	VOID		7, 33	SILT RICH CLAYEY DIATOM OOZE moderate olive brown (5Y 4/4) locally contains more silt and less clay
					2				7, 10	CARBONATE and CLAY RICH DIATOM OOZE, olive gray (5Y 4/2) DIATOMACEOUS SILTY CLAY, dark gray (5Y 4/1) contains pods of overlying unit
									100, 130	PYRITE and DIATOM BEARING SILT RICH CLAY dark gray (5Y 4/1)
					3					SANDY SILT - SILTY SAND, olive black (5Y 2/1) size graded
									67, 90	CLAYEY SILT, olive gray (5Y 3/2) to dark olive gray (5Y 3/1) Slide 3-90: 55% silt, 45% clay
					Core Catcher				148	SILTY CLAY, olive gray (5Y 3/2) Slide 3-148: 40% silt, 60% clay



Slide 2-7
55% diatoms
25% clay
15% carbonate
5% silt

Slide 2-10
40% diatoms
45% clay
15% silt
TR forams

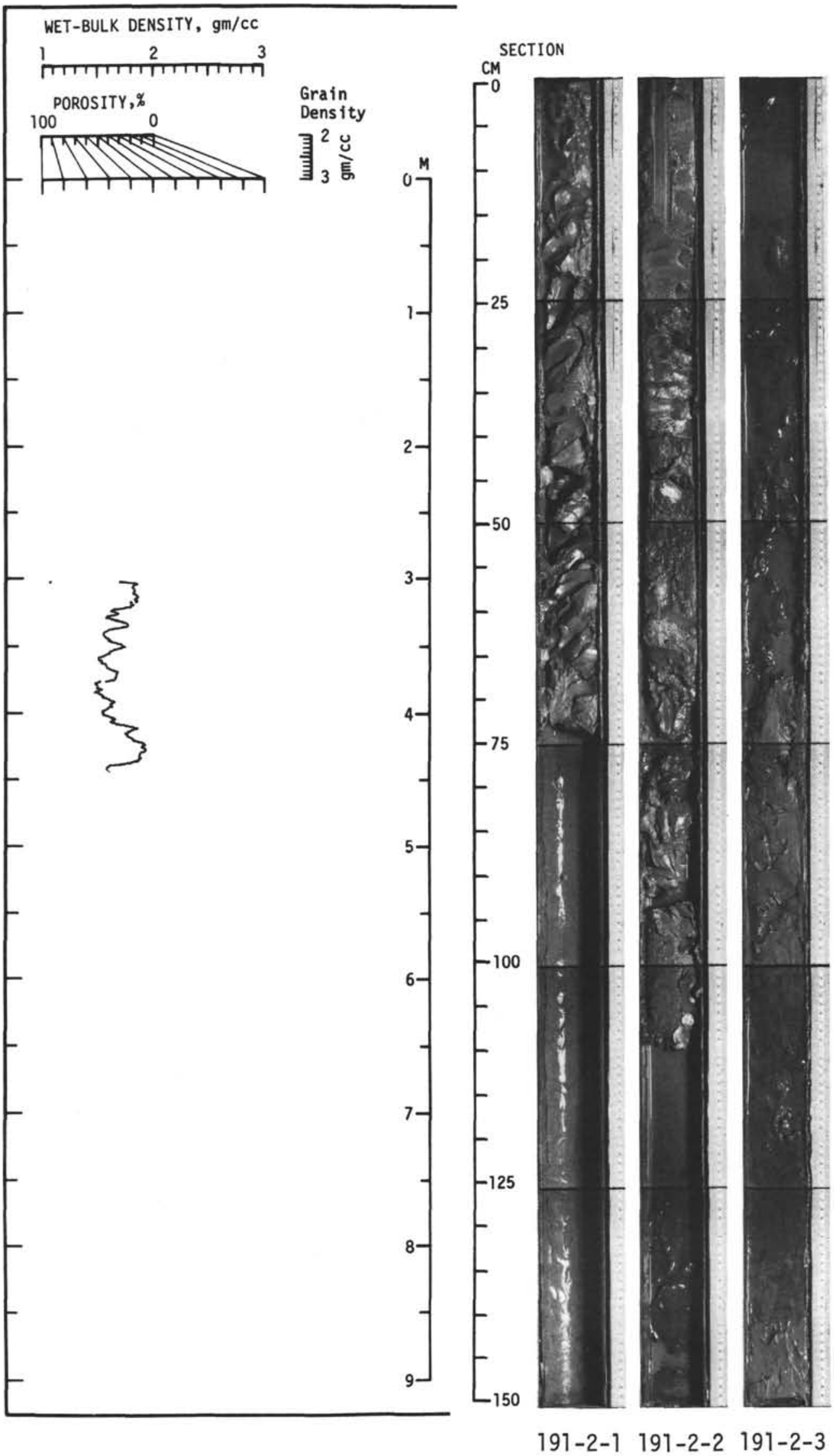
Core Catcher:

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

Slide 2-100
5% diatoms
10% silt
80% clay
3% pyrite
2% fine carbonate
TR forams

Slide 3-67
TR diatoms
TR foram fragments
40% lithic frags. and altered grains incl. chert
45% feldspar
10% pyroxene
1% chlorite

Explanatory notes in Chapter 1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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
191-2-1
191-2-2
191-2-3

Site 191 Hole Core 3 Cored Interval: 20-29

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
*	*	D N R S	F - R -	M - P -	Core Catcher				–	CLAY RICH SILTY SAND Slide: 40% sand, 40% silt, 20% clay 40% feldspar 30% lithic fragments 20% clay 5% chert 3% pyroxene 2% other

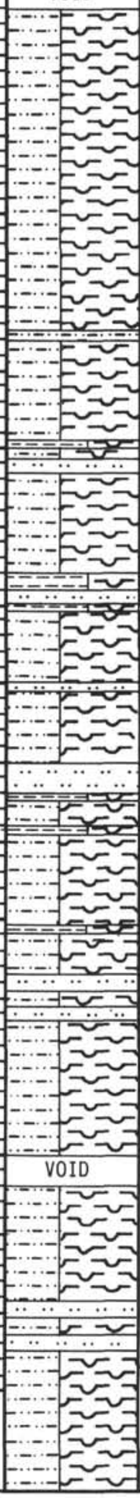
Explanatory notes in Chapter 1

* UPPER PLEISTOCENE

*(D) Denticula seminae

Site 191 Hole Core 4 Cored Interval: 78-87

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLEISTOCENE	(D) Denticula seminae	D R S	A R C	G M M	1	0.5, 1.0	VOID		110	
					2				78 1	
					3				148 2 1; 2 1 2; 1	
					4				1 2 2	
				D R S	A F F	G M M	5				2 1 1	
					6		VOID		1 1	
					Core Catcher					



Basic lithology
PYRITE BEARING SILT RICH CLAYEY DIATOM OOZE
olive gray (5Y 4/1 - 4/2)

with thin (up to 10 cm) interbeds of:

1) CLAYEY SILT and SILT, very dark gray (5Y 3/1) to olive black (5Y 2/1)

and 2) CARBONATE BEARING DIATOMACEOUS CLAY dark greenish gray (5GY 4/1)

Slide 1-110 (basic lith.)
55% diatoms
15% silt (feldspar etc.)
30% clay
3% pyrite

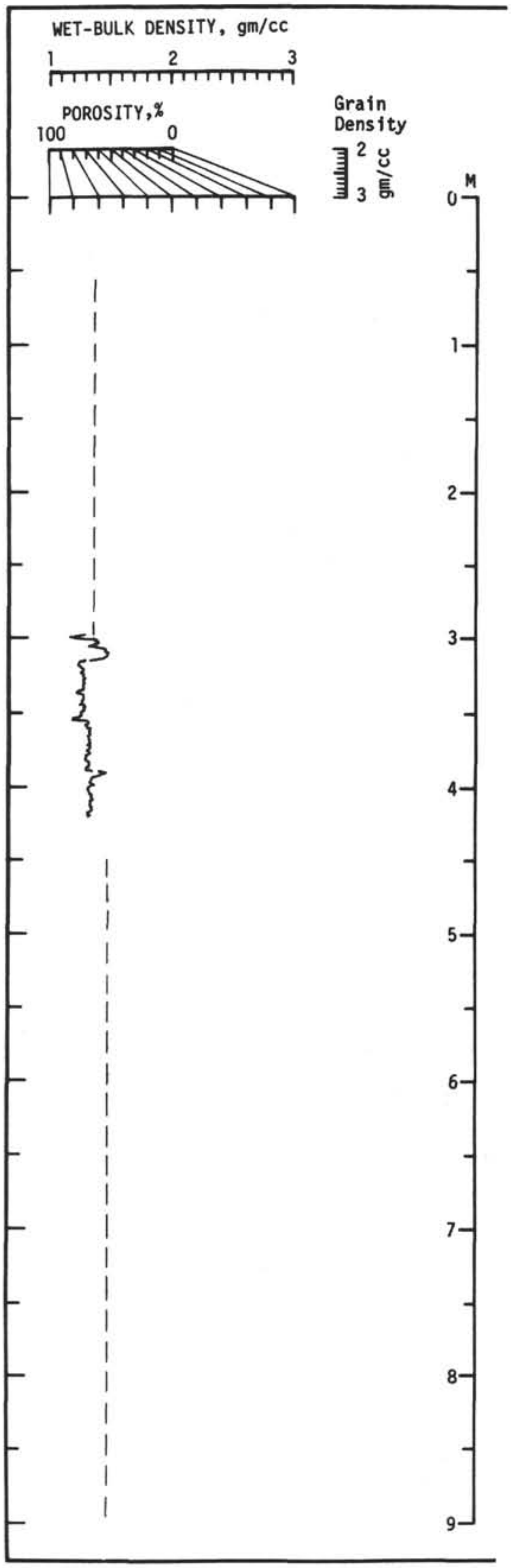
Slide 2-78 (lith #1)
65% feldspar
10% lithics and altered grains
10% diatoms
5% glass
5% pyroxene
3% pyrite
2% chlorite

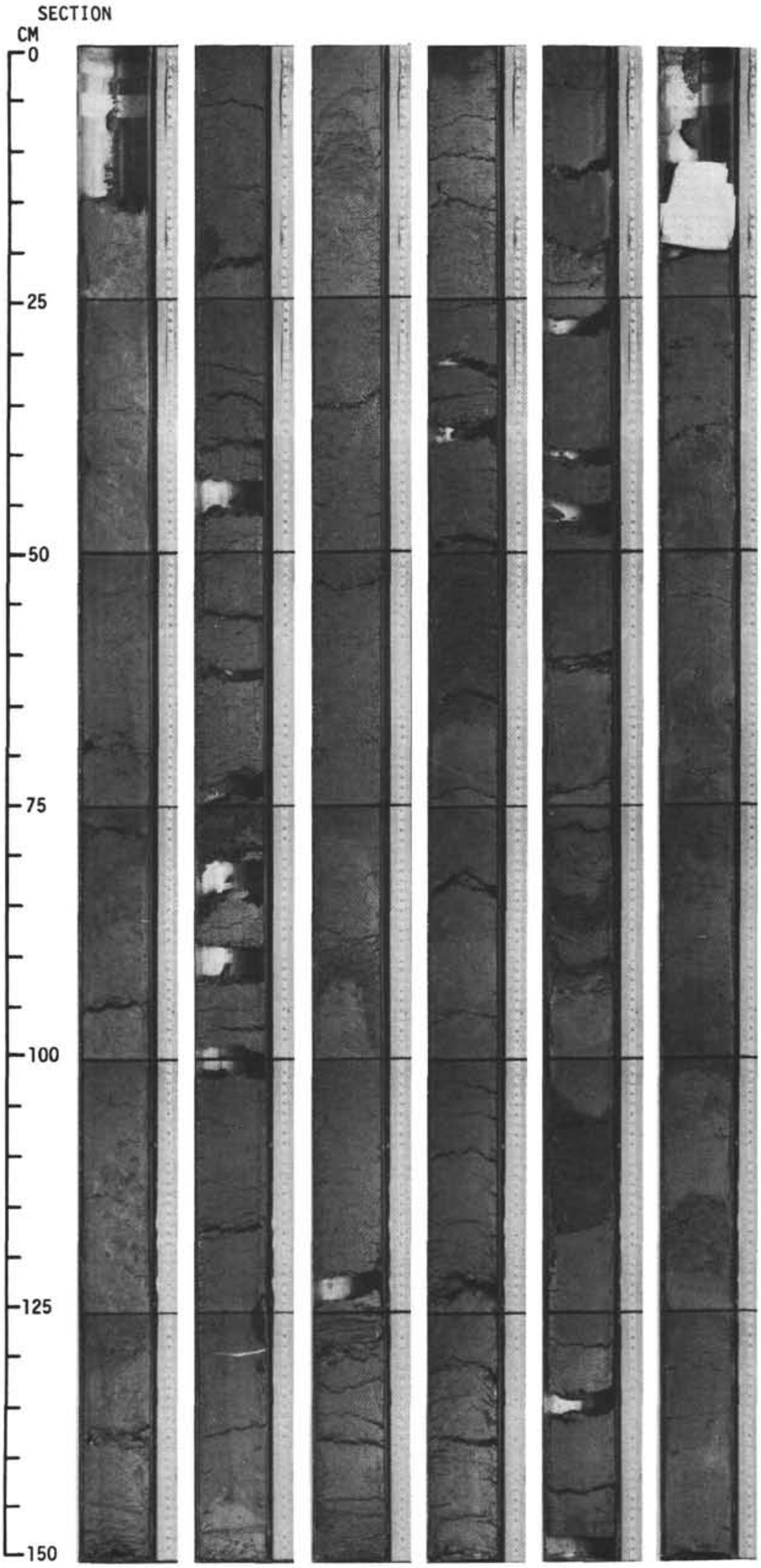
Slide 2-148 (lith #2)
40% diatoms
50% clay
5% silt
5% carbonate

Core Catcher:

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

Explanatory notes in Chapter 1





191-4-1 191-4-2 191-4-3 191-4-4 191-4-5 191-4-6

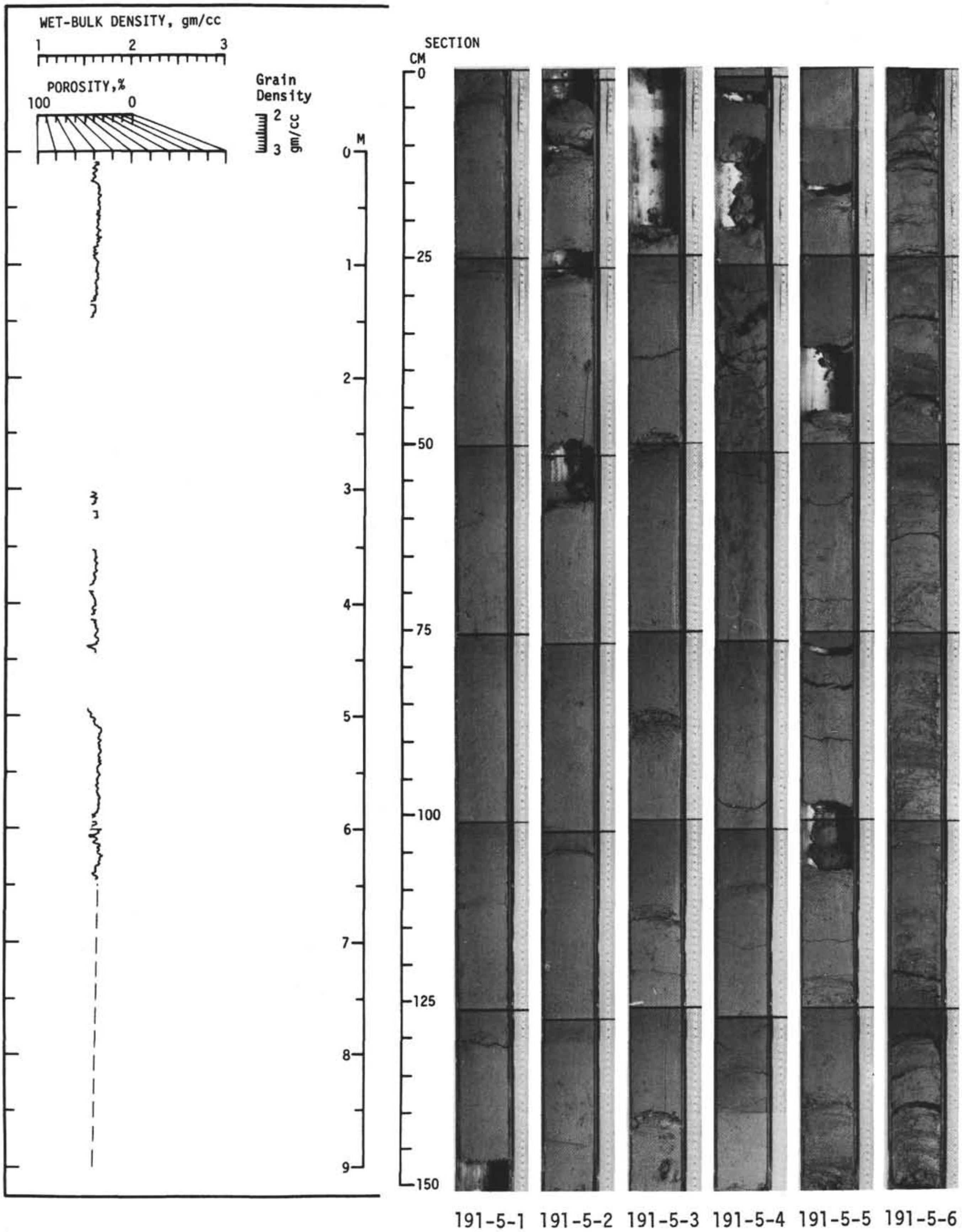
Site 191 Hole Core 5 Cored Interval: 134-143

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE PLEISTOCENE	(D) Rhizosolenia curvirostris				1	0.5 1.0			-60 -76	pods of olive gray (5Y 4/1) CLAY RICH SILT 80% silt, 20% clay SILTY CLAY medium dark gray (N4)
					2				-83	pods of olive black (5Y 2/1) SILT RICH CLAY 10% silt, 90% clay
					3		VOID		-75 -89	SILT RICH CLAY, medium dark gray (N4) 25% silt, 75% clay to SILTY CLAY to
					4				-50	CLAYEY SILT, dark gray (N3) 70% silt, 30% clay SILT, olive black (5Y 2/1) lab grain size determ. sect. 4, 117 cm: 6% sand 38% silt 56% clay
					5				-84 -105	pods of FELDSPAR SILT, grayish olive (10Y 4/2 - 3/2) extremely well sorted
		D R S	F R -	M M -	6				-57 -75	Slide 6-75 25% diatoms 15% silt 60% clay SILT and DIATOM RICH CLAY very dark gray (5Y 3/1) with thin interbeds of: SANDY SILT
					Core Catcher					

Core Catcher:

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

Explanatory notes in Chapter 1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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
191-5-1
191-5-2
191-5-3
191-5-4
191-5-5
191-5-6

Site 191 Hole Core 6 Cored Interval: 171-180

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
MIDDLE PLEISTOCENE	(D) *Rhizosolenia curvirostris*	D R S	C R R	G M M	1	0.5, 1.0	VOID		-90
					2				-74 -83 -140
					Core Catcher				

LITHOLOGIC DESCRIPTION

Basic lithology
PYRITE and DIATOM BEARING SILTY CLAY
dark gray (5Y 4/1)

5 - 10% diatoms
35 - 40% silt
50 - 55% clay
2 - 5% pyrite

SILTY SAND, black, graded

SAND, black
CRYSTAL ASH

Slide 2-74 (ash layer)
50% glass
35% feldspar
10% lithic frags.
5% pyroxene

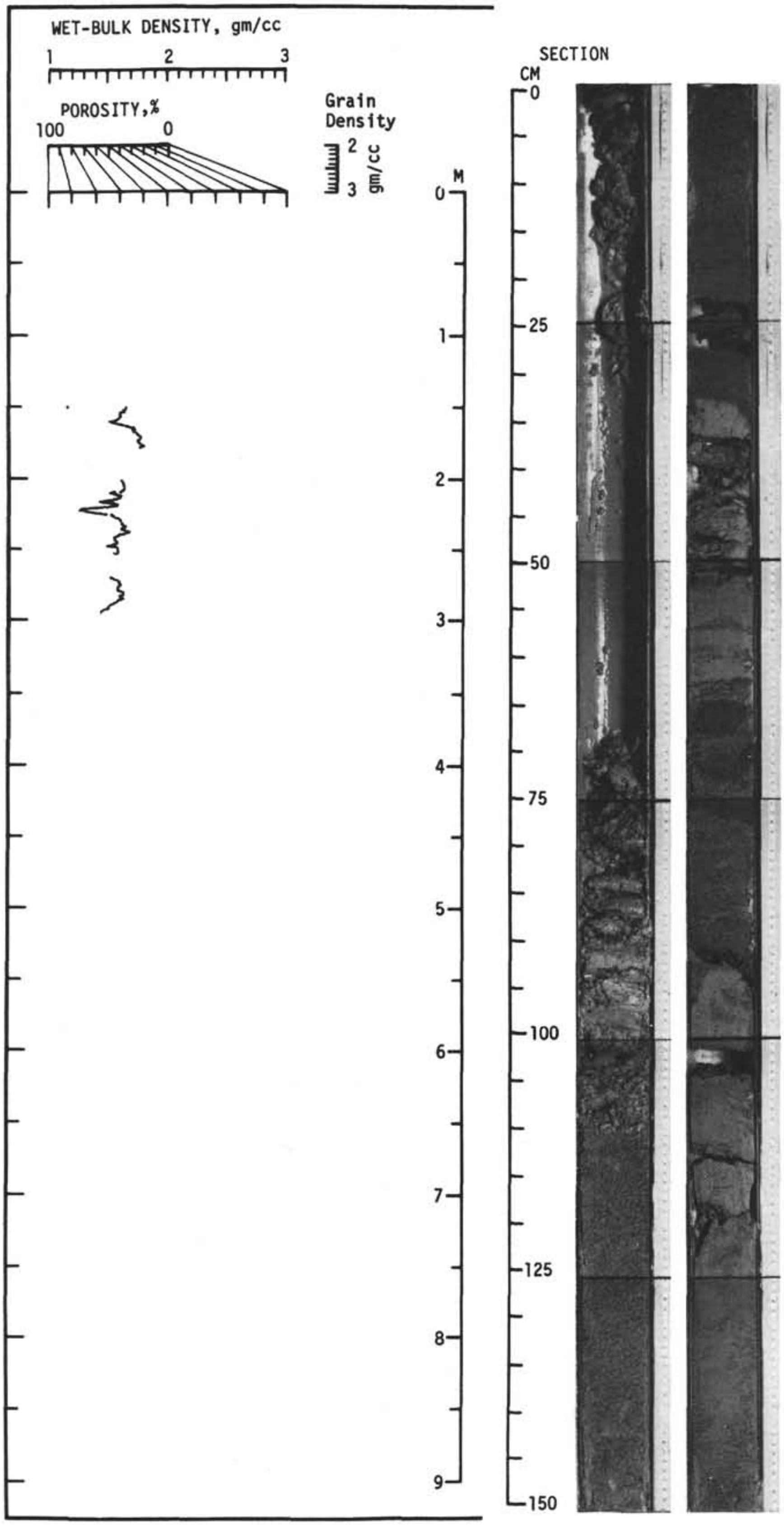
Core Catcher:

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

lab sand/silt/clay percents for graded unit, sect. 1-2

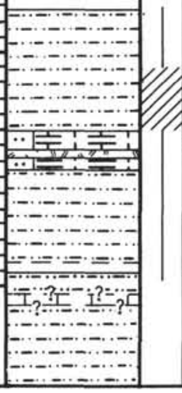
sect. 1	112 cm	62	26	12
	143 cm	67	23	10
sect. 2	3 cm	73	17	10
	16 cm	75	16	9
	31 cm	83	11	6

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

191-6-1 191-6-2

Site 191 Hole Core 7 Cored Interval: 227-236

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE PLEISTOCENE	(D) Rhizosolenia curvirostris	D	-	-	1	0.5, 1.0	VOID			
					1–2				135	Semi-lithified SILTY CLAY, olive black (5Y 2/1) with interbeds, lenses and mottles of TERRIG. SILT RICH CARBONATE MUD 90% $CaCO_3$
					2				55, 56, 66	VITRIC ASH, olive gray (5Y 4/1)
									105	DIATOM BEARING SILTY CLAY, olive black (5Y 2/1)
									138	SILT, olive gray (5Y 4/1), graded
*	*				Core Catcher					DIATOM BEARING LIMESTONE olive gray to light olive gray (5Y 4/1 - 6/1) mottles and lenses

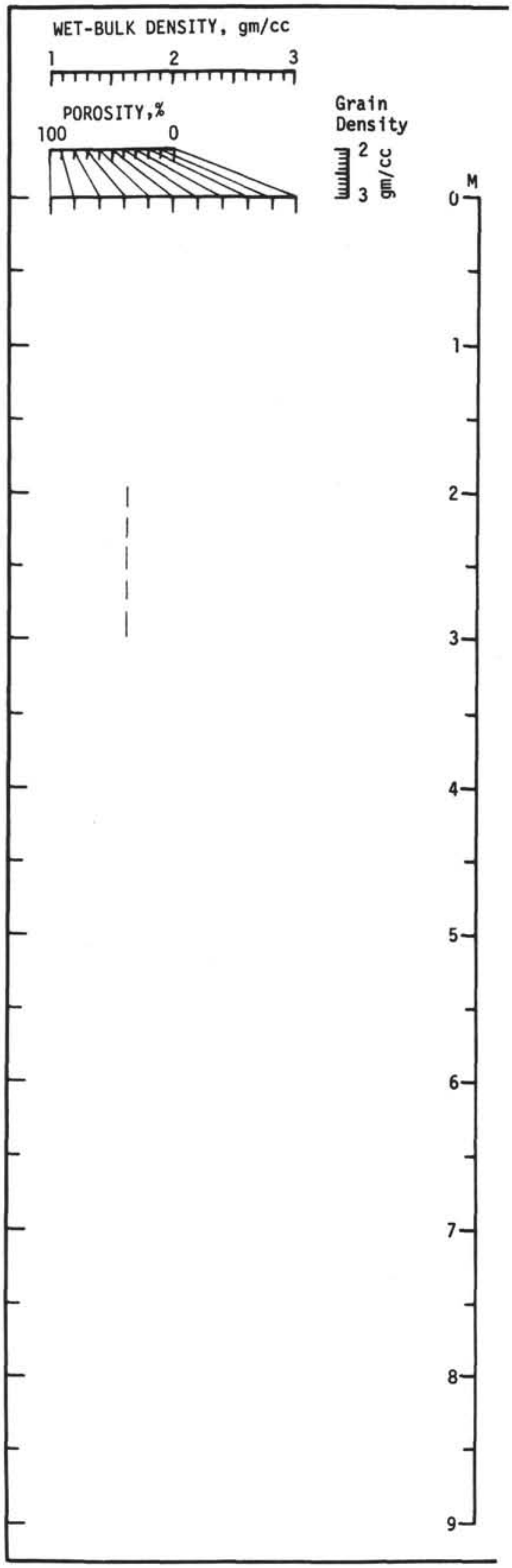
Core Catcher:

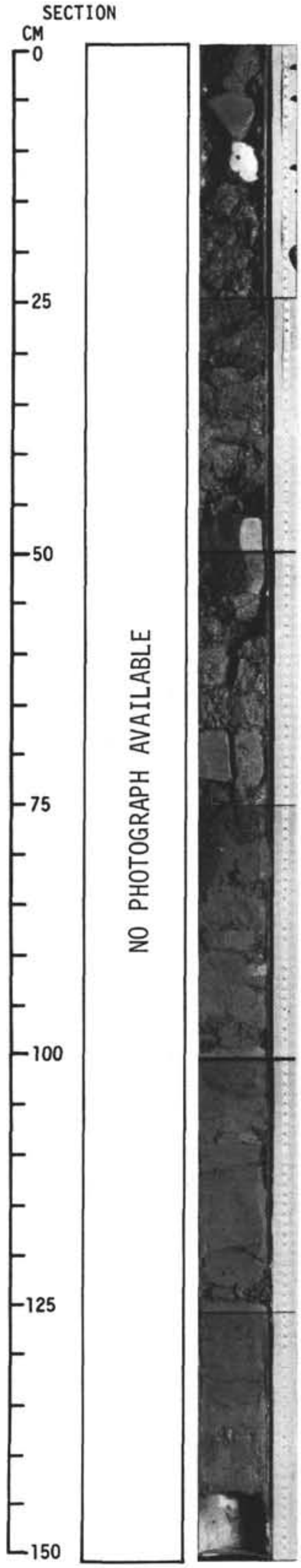
	D	F	G
N	N	-	-
R	R	R	M
S	S	R	M
PF		F	
BF		R	

Slide 1-135	Slide 2-105	XR 2-100
20% feldspar	5% diatoms	70% amorph.
3% pyroxene	25% feldspar	7% quartz
2% opaque	TR pyroxene	5% plag.
75% clay	TR chlorite	13% mica
	70% clay	3% chlor.
		2% mont.

Explanatory notes in Chapter 1

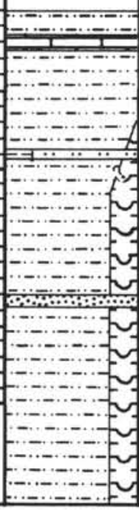
* LOWER PLEISTOCENE
* (D) Actinocyclus oculatus


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

191-7-1 191-7-2

Site 191 Hole Core 8 Cored Interval: 274-283

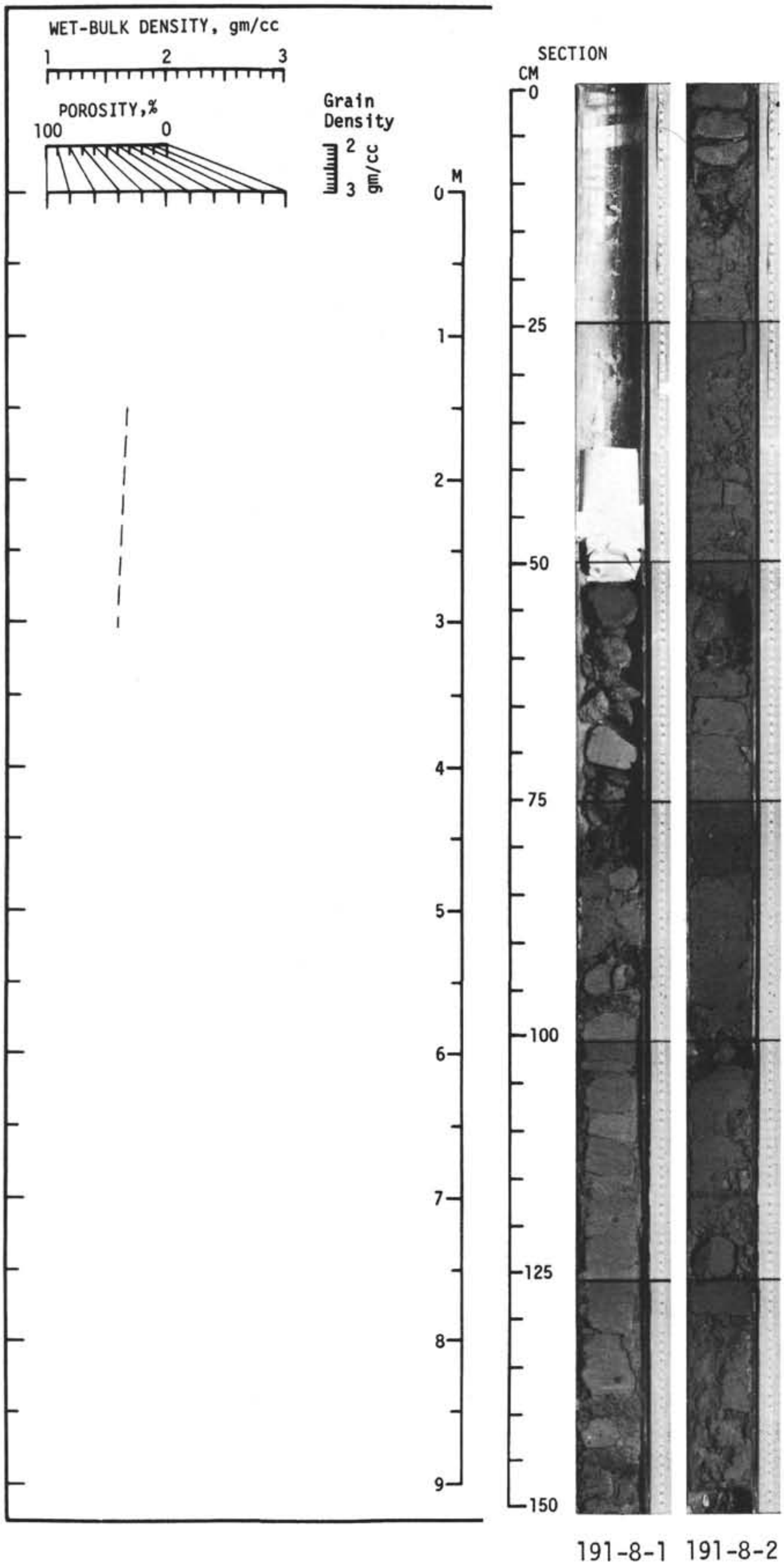
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLIOCENE	(D) Actinocyclus oculatus	D R S D	F R - A	M M - G	1 2	0.5 1.0	VOID 		120 138 148 90	LIMESTONE, grayish olive (10Y 4/2) (layer about 4 cm thick) SILTY CLAY, dark gray (N3), semi-lithified, burrowed 40% silt, 60% clay DIATOM BEARING, CLAY RICH SILT, olive gray (5Y 3/2) 5% diatoms, 75% silt, 20% clay SAND, olive black (5Y 2/1) DIATOM RICH SILTY CLAY gray (N3-4) with thin laminae of olive black (5Y 2/1) SAND
					Core Catcher					

Slide 2-90
20% diatoms
35% silt
45% clay

Core Catcher:

N	-	-
R	R	M
S	R	M
PF	R	
BF	R	

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
191-8-1 191-8-2

Site 191 Hole Core 9 Cored Interval: 321-330

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LOWER PLEISTOCENE	*				1	0.5, 1.0			12, 75	SILTY CLAY dark olive gray (5Y 3/1) thin, irregular lenses and bands containing carbonate, light olive gray (5Y 5/1)
					Core Catcher					

Slide 1-75
35% silt
65% clay

XR 1-60
71% amorph.
7% quartz
5% plag.
11% mica
2% chlor.
3% mont.
TR amphib.

Core Catcher:

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

Semi-lithified

*(D) Actinocyclus oculatus

Site 191 Hole Core 10 Cored Interval: 384-393

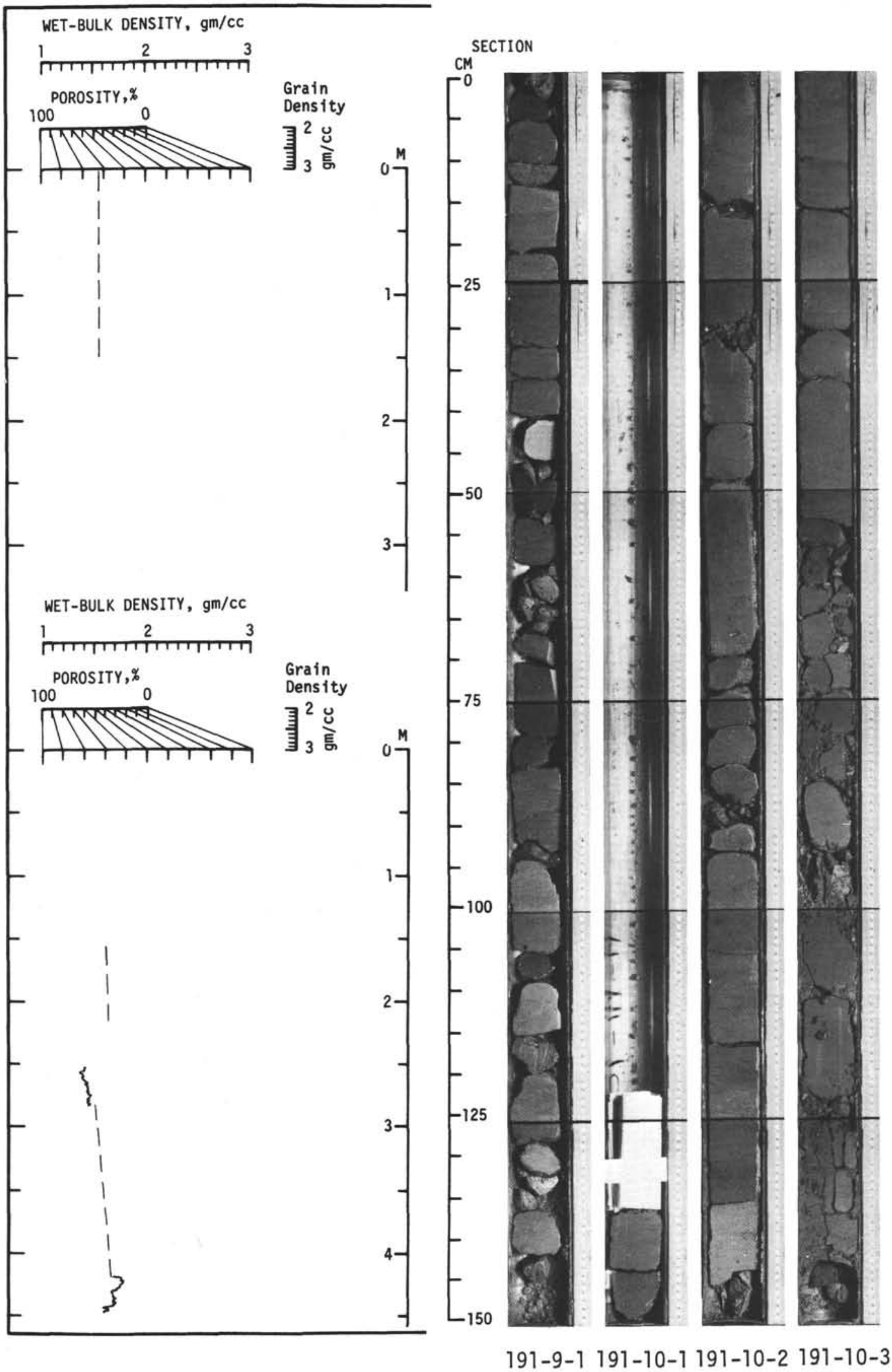
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	(D) Thalassiosira zabelinae	D R S	F - -	M - -	1	0.5, 1.0	VOID			
					2				70	Semi-indurated, burrowed DIATOM BEARING SILTY CLAY dark greenish gray (5GY 4/1) mottled: greenish black (5GY 2/1) to olive gray (5Y 4/1)
					3					
					Core Catcher					

Slide 2-70
5 - 10% diatoms
35% silt
60% clay

Core Catcher:

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

Explanatory notes in Chapter 1



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1 2 3
POROSITY,%
100 0
Grain Density
2 3 gm/cc
M
0 1 2 3
WET-BULK DENSITY, gm/cc
1 2 3
POROSITY,%
100 0
Grain Density
2 3 gm/cc
M
0 1 2 3 4
SECTION
CM
0 25 50 75 100 125 150
191-9-1 191-10-1 191-10-2 191-10-3

Site 191 Hole Core 11 Cored Interval: 452-461

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	(D) Thalassiosira zabelinae (S) Ammodochium rectangulare	R S	R -	M -	1	0.5 1.0	VOID		130	Semi-lithified rounded porphyritic volcanic pebble
					2				75	DIATOM BEARING SILTY CLAY dark greenish gray (5GY 3/1) section less silty than section 1
					Core Catcher					

XR 2-110: 65% amorph., 10% quartz, 6% plag., 13% mica, 3% chlor., 3% mont., 1% amphib.

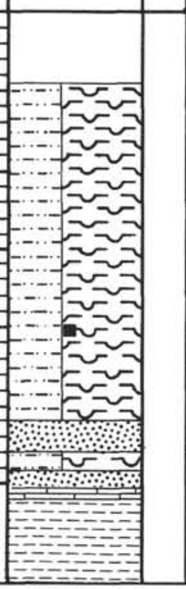
5 - 10% diatoms
20 - 30% silt
65 - 75% clay

Core Catcher:

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

Site 191 Hole Core 12 Cored Interval: 520-527

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
UPPER PLIOCENE	(D) Thalassiosira zabelinae (S) Ammodochium rectangulare	D R S	C R R	G M M	1	0.5 1.0			120	Semi-lithified, burrowed SILT and CLAY RICH DIATOM OOZE greenish black (5Y 3/1) 65 - 70% diatoms 10 - 20% silt 10 - 25% clay
					2				78 125	erratic pebble lithic fragment SAND graded, lithic SAND; lower part in CC (?) calcite cemented
					Core Catcher					core catcher sample also contains: SAND and SILT BEARING LIMESTONE and CARBONATE and SILT BEARING CLAY with scattered solution corroded diatoms

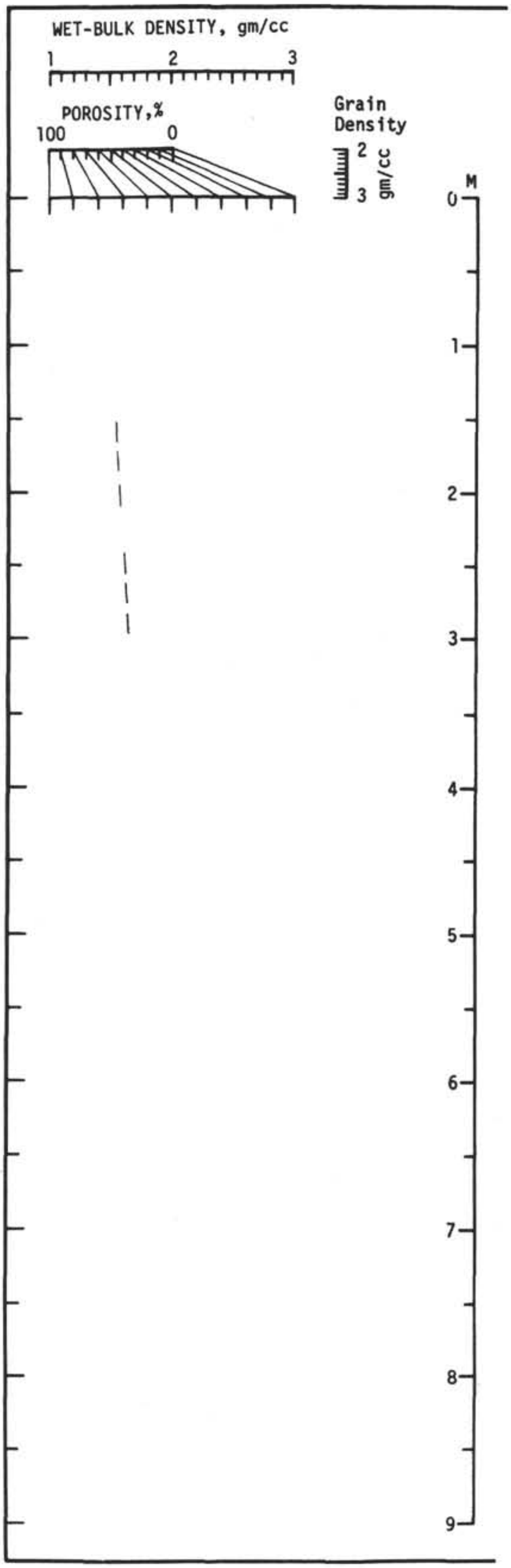


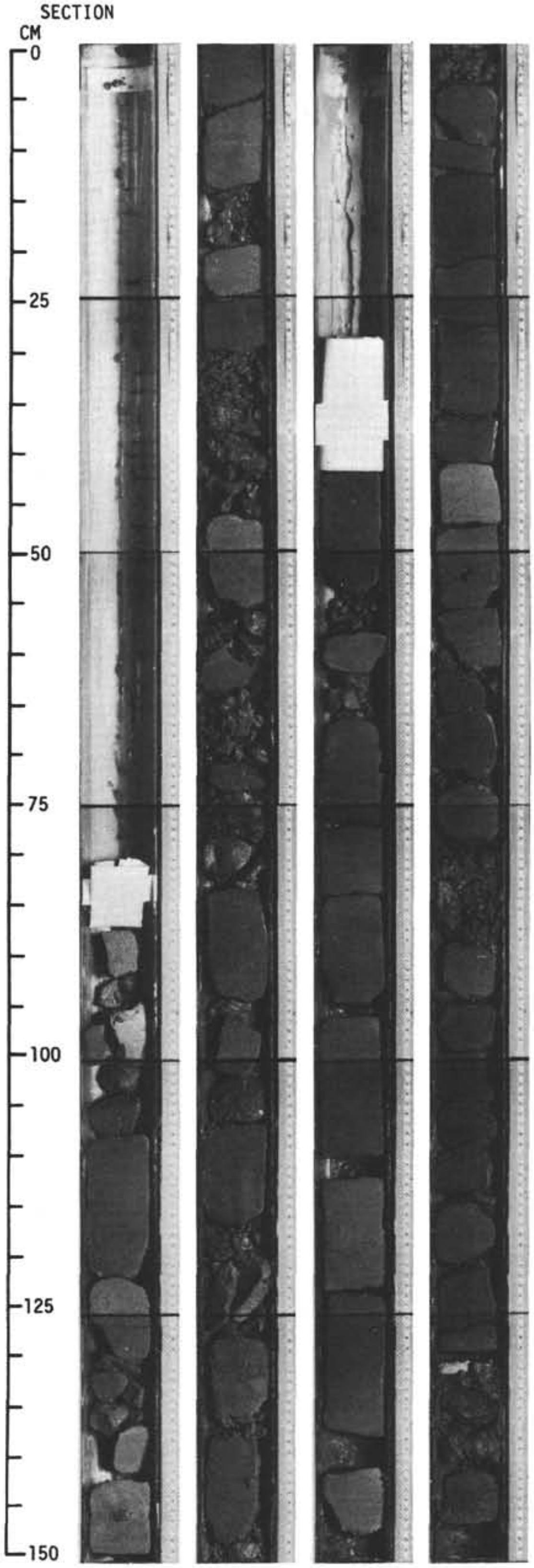
XR 2-30: 70% amorph., 8% quartz, 5% plag., 12% mica, 3% chlor., 3% mont.

Core Catcher:

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

Explanatory notes in Chapter 1





191-11-1 191-11-2 191-12-1 191-12-2

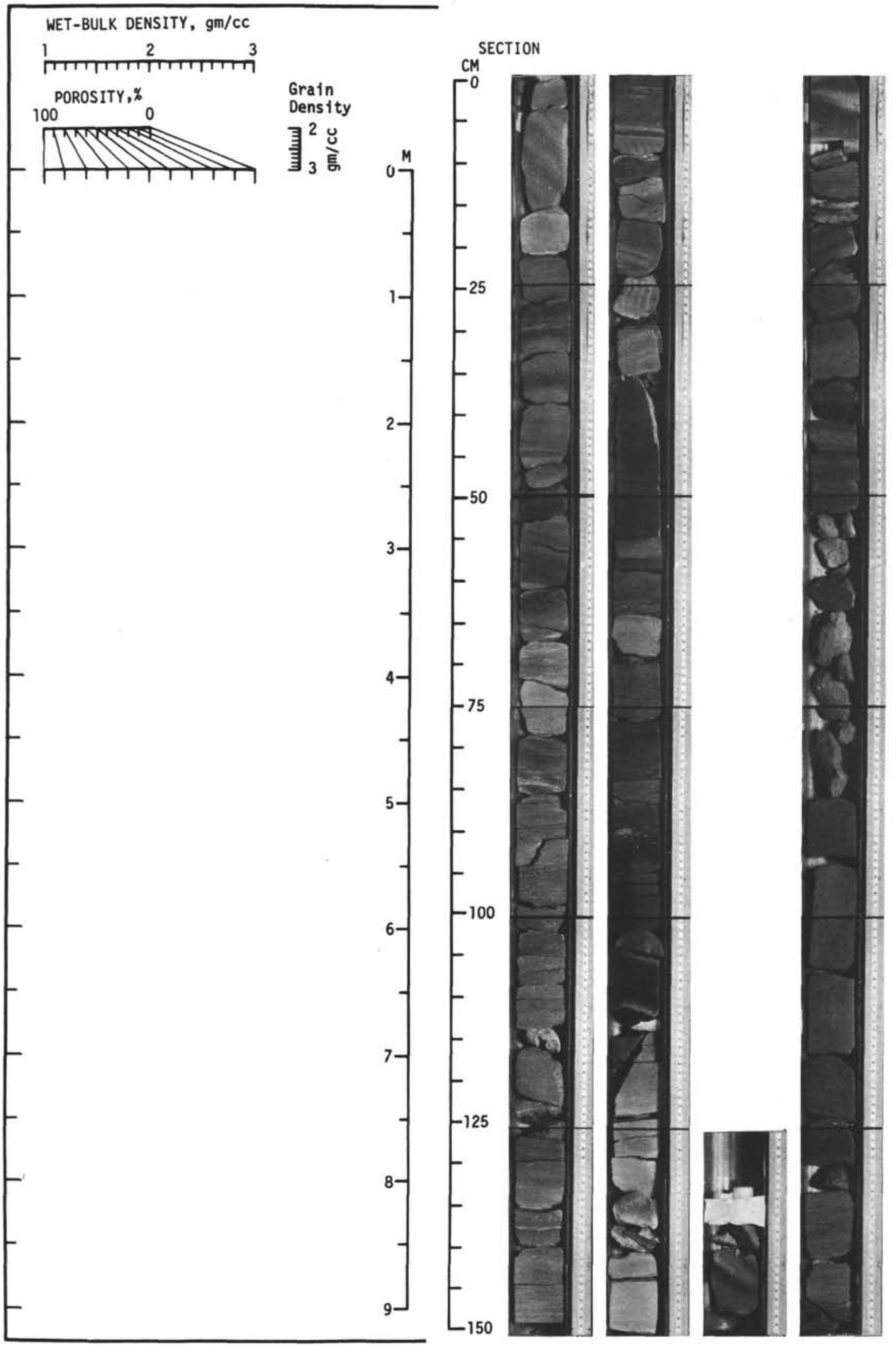
Site 191 Hole Core 13 Cored Interval: 620-629

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0			15 75	SILTY SAND Semi-lithified SILT RICH CLAY very dark gray (5Y 3/1) to dark gray (5Y 4/1) horizontal, lensy bedding burrowed scattered forams XR 2-60 71% amorph. 7% quartz 4% plag. 8% mica 2% chlor. 4% mont. 3% clinop. 1% pyrite
					2				113 115	SAND layers Slide 1-75 10% feldspar, etc. 3% opaque 85% clay
		D N R S	R - - -	M - - -	Core Catcher					

Site 191 Hole Core 14 Cored Interval: 723-732

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	VOID			
		D R S	R - -	P - -	2				50 110	Basic lithology SILTY CLAY, dark greenish gray (5GY 2/1) burrowed; thin sand laminae 70% clay, 30% silt SILTY SAND, olive black (5Y 2/1) 60% feldspar, some altered 25% lithics and opaques 5% pyroxene 5% chert TR chlorite
					Core Catcher					Core Catcher: D R M N - - R - - S - - PF - BF R

Explanatory notes in Chapter 1



191-13-1 191-13-2 191-14-1 191-14-2

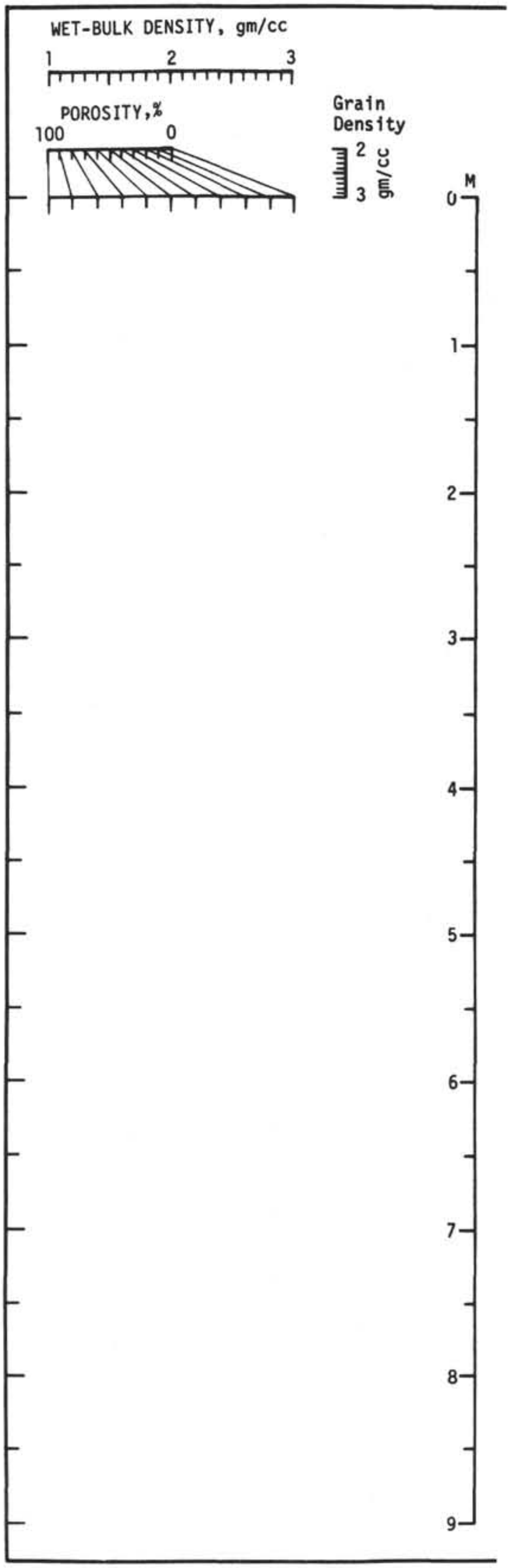
Site 191 Hole Core 15 Cored Interval: 905-910

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					Core Catcher					core catcher sample only BASALT dark gray (N3) Core Catcher: D - - N - - R - - S - -

Site 191 Hole Core 16 Cored Interval: 910-919

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	VOID			BASALT dark gray (N3) Core Catcher: D - - N - - R - - S - -
					Core Catcher					

Explanatory notes in Chapter 1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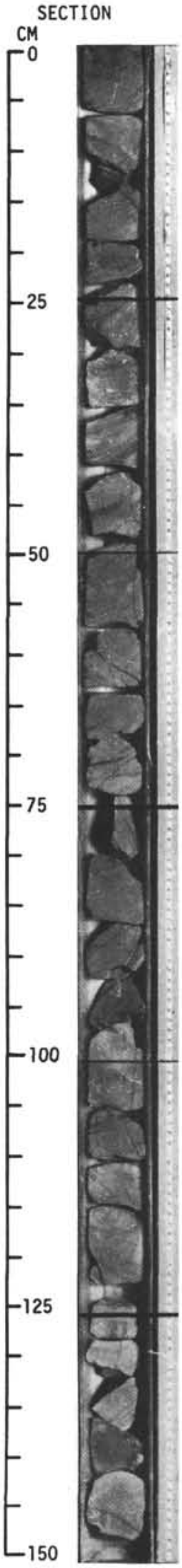
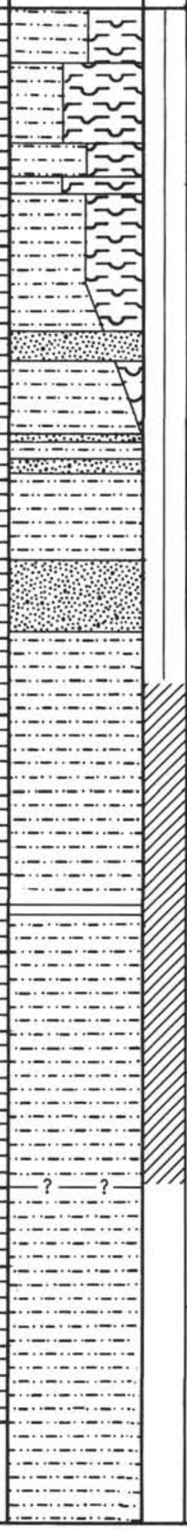
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9


SECTION
CM
0
25
50
75
100
125
150

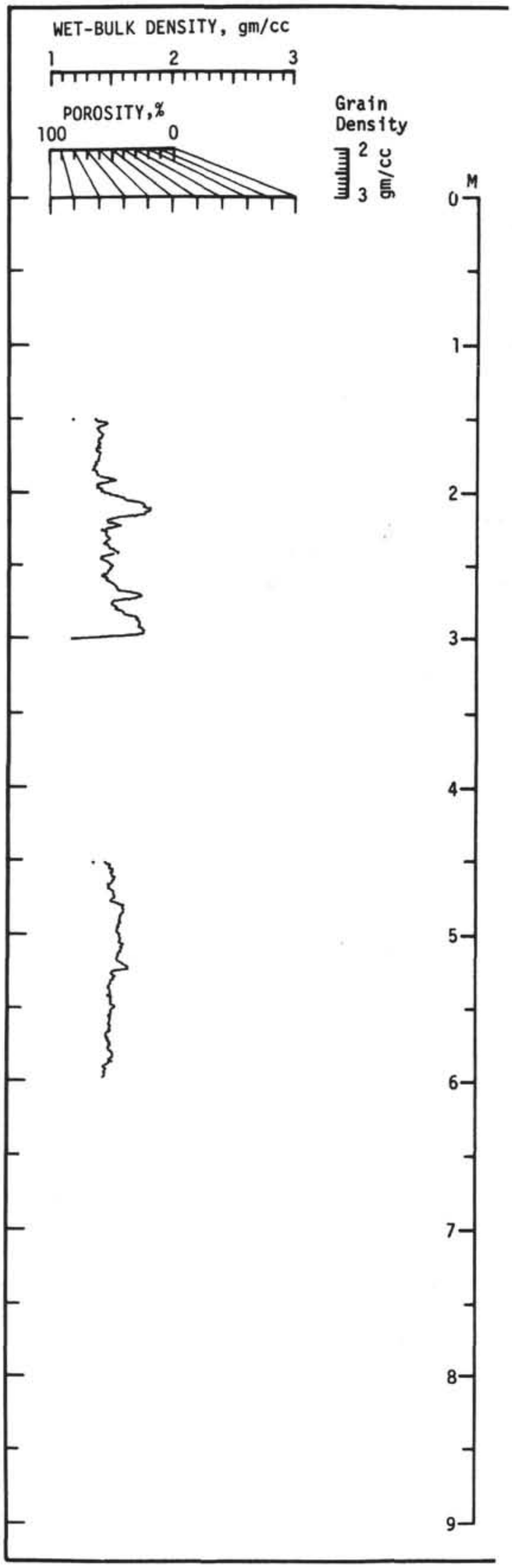
191-16-1

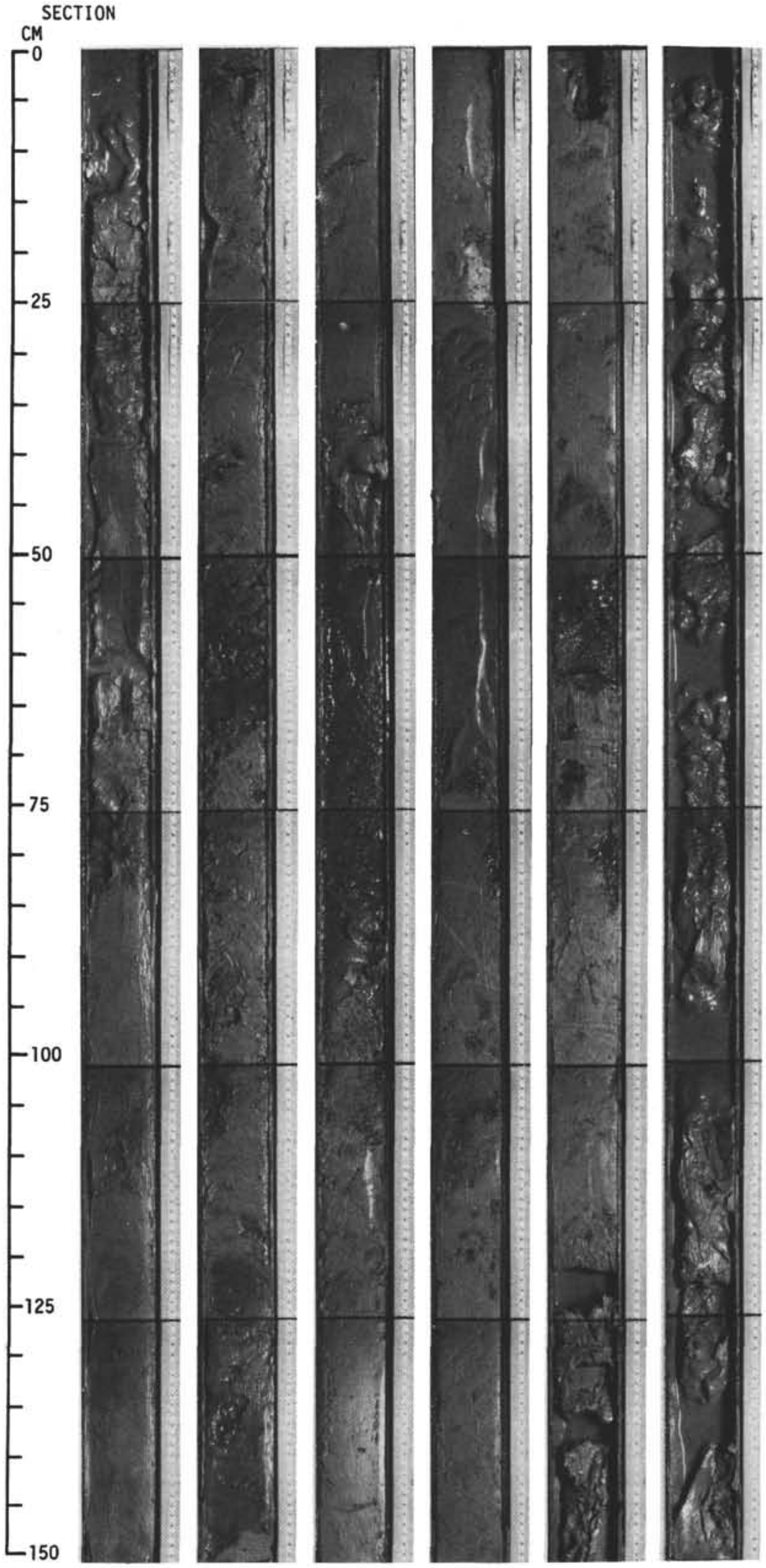
Site 191 Hole A Core 1 Cored Interval: 14-23

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		R S	R -	M -	1	0.5 1.0			110 130	Alternating: SILT RICH DIATOMACEOUS CLAY, dark gray (5Y 4/1) and SILT and CLAY RICH DIATOM OOZE, olive gray (5Y 4/2) Slide 1-110: 60% diatoms, 15% silt, 25% clay Slide 1-130: 35% diatoms, 15% silt, 50% clay
					2				65 130	SILTY SAND SILTY SAND SILTY SAND SAND BEARING SILTY CLAY very dark gray (5Y 3/1) Slide 2-130: 25% silt (incl. minor sand), 75% clay
					3				75 140	GLASS BEARING SILTY SAND 55% feldspar 20% lithic fragments 10% glass 10% clay 5% pyroxene 2% chlorite
					4				23 75 105	SILTY CLAY olive gray (5Y 4/1) with disturbed streaks and pods of: — VOID
					5				30 75	1) FELDSPATHIC SANDY SILT, olive black (5Y 2/1) 70% feldspar, 20% glass, 10% pyroxene 2) VITRIC ASH light olive gray (5Y 5/2) and olive black (5Y 2/1) 3) SILT RICH CLAY, dark greenish gray (5GY 4/1) 20% silt, 80% clay
					6				75	soupy section DIATOM BEARING SILTY CLAY very dark gray (5Y 3/1) Slide 6-75: 10% diatoms, 45% silt, 45% clay Core Catcher: D PF C M BF C N - - R F M S R M
					Core Catcher					



Explanatory notes in Chapter 1

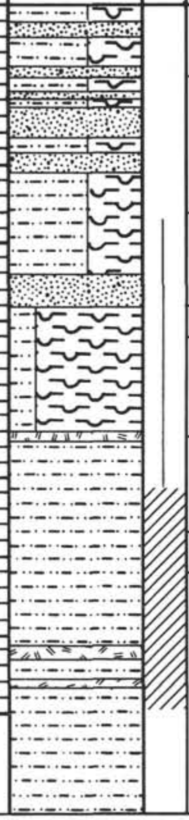




191A-1-1 191A-1-2 191A-1-3 191A-1-4 191A-1-5 191A-1-6

Site 191 Hole A Core 2 Cored Interval: 23-32

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
					1	0.5, 1.0			-44, -130
		R S	F -	M -	2				-40, -60, -123
					3				-33, -60
					Core Catcher				



LITHOLOGIC DESCRIPTION

Alternating:
DIATOMACEOUS SILTY CLAY

and

GLASS BEARING FELDSPATHIC SANDY SILT
very dark gray (5Y 3/1)

SILT BEARING, CLAY RICH DIATOM OOZE
dark greenish gray (5GY 4/1)

SILT BEARING VITRIC ASH, light olive gray (5Y 5/2)

SILTY CLAY and CLAYEY SILT
olive gray (5Y 3/2)
pods of SILT BEARING CLAY, dark greenish gray (5G 4/1)

ASH (?) olive black (5Y 2/1)

Slide 1-44 and 2-40 (sandy silt)
50 - 55% feldspar
30% altered grains; lithics
5 - 10% glass
3 - 5% pyroxene
2 - 5% diatoms
2% chlorite

Core Catcher:

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

Slide 1-130 (basic lith)
30% diatoms
20% silt
50% clay

Slide 2-60 (basic lith)
75% diatoms
10% silt
15% clay (incl. minor carbonate)

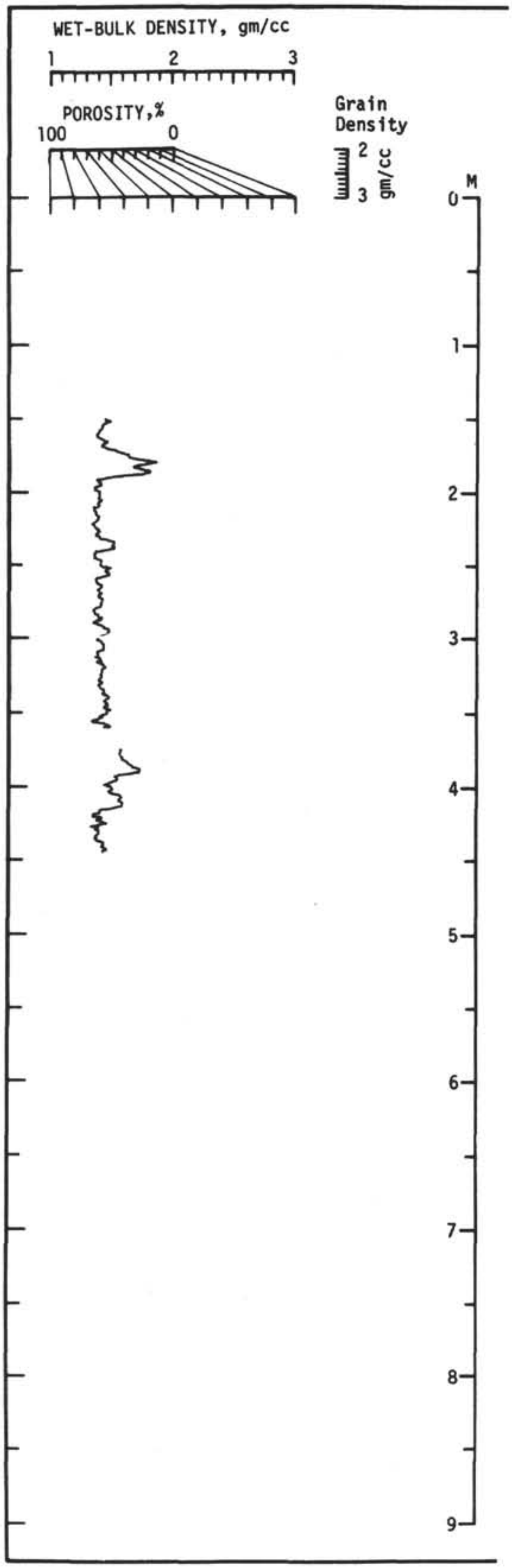
Slide 3-60 (basic lith)
30% silt
70% clay

lab grain size 3-90
9% sand
73% silt
18% clay

Site 191 Hole A Core 3 Cored Interval: 32-41

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					Core Catcher					CC only VOLCANIC PEBBLE

Explanatory notes in Chapter 1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POROSITY,%
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Grain Density
2
3
gm/cc
M
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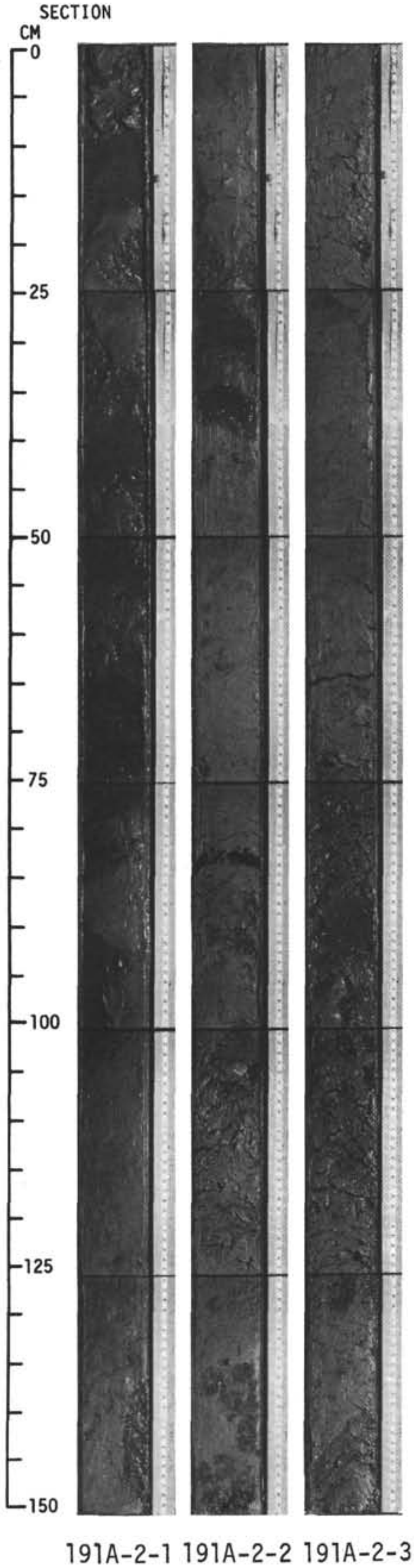
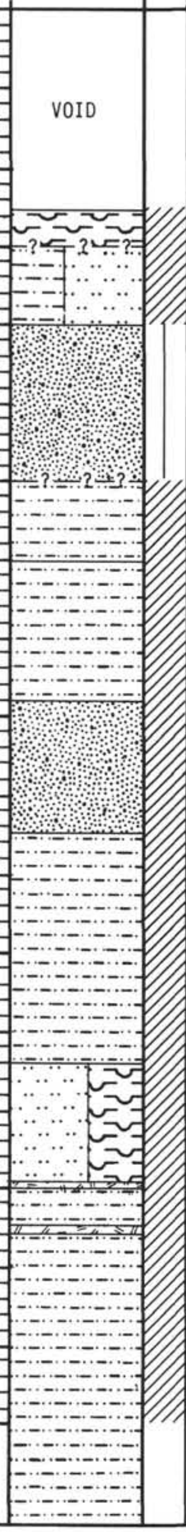
5
6
7
8
9

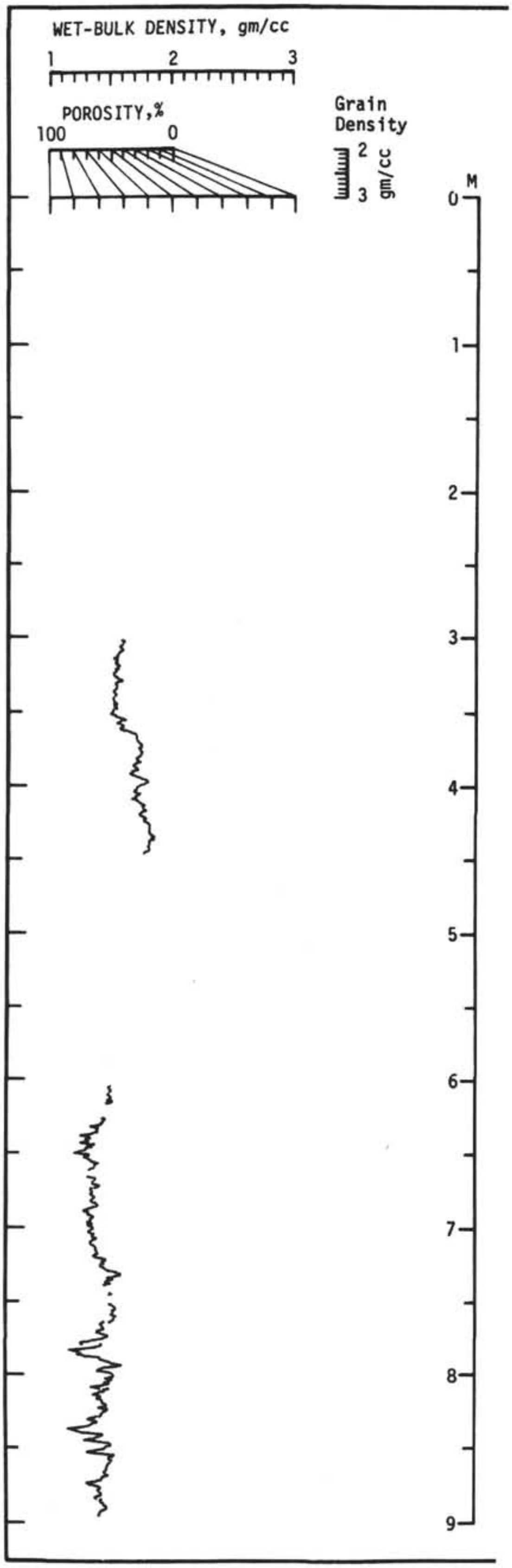

SECTION
CM
0
25
50
75
100
125
150
191A-2-1 191A-2-2 191A-2-3

Site 191 Hole A Core 4 Cored Interval: 41-50

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0	VOID			
		R S	F C	M M					135	DIATOM OOZE, grayish olive (10Y 4/2), 95% diatoms
					2				25	CLAY and SAND RICH SILT, very dark gray (5Y 3/1) 45% feldspar, 20% clay, 20% lithics, 7% pyroxene, 1% hornblende
									100	GLASS BEARING FELDSPATHIC SILTY SAND very dark gray (5Y 3/1)
					3				20 130	CLAYEY SILT, med. dark gray (N4) 70% silt, 30% clay fine: 50% silt, 50% clay graded SILTY SAND to CLAYEY SILT, olive black (5Y 2/1) coarse: 60% sand, 40% silt
					4				145 10	SILTY SAND dark olive gray (5Y 3/1)
									87? 110	SILTY CLAY medium gray (N5) Slide 4-110 30% silt 70% clay
					5					DIATOMACEOUS SILT dark olive gray (5Y 3/1)
									148	VITRIC ASH, very light gray (N8)
					6				79 140	SILTY CLAY medium gray (N5) Slide 6-140 35% silt 65% clay
					Core Catcher					Core Catcher: D PF - BF - N - - R R M S R M



Explanatory notes in Chapter 1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POROSITY,%
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Grain Density
2 3 gm/cc
M
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7
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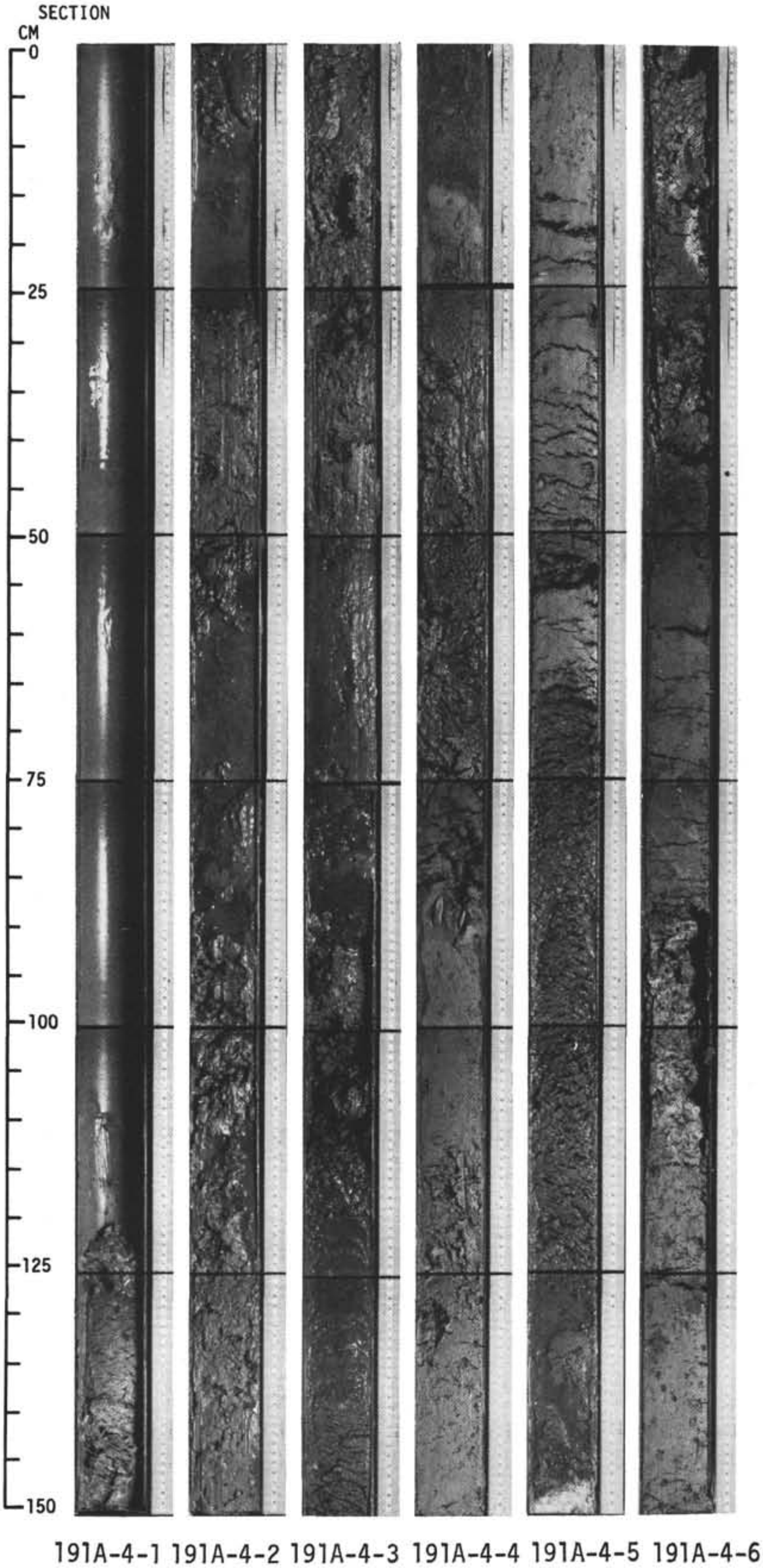
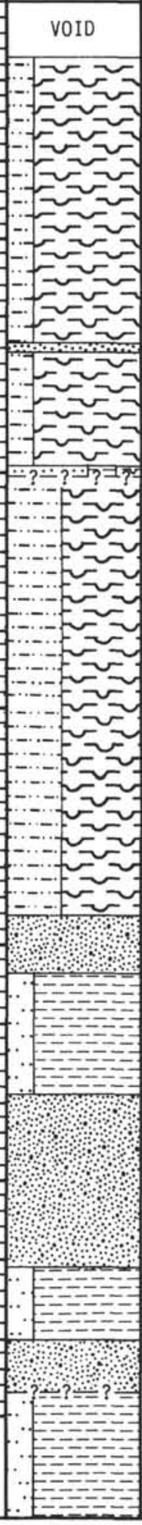
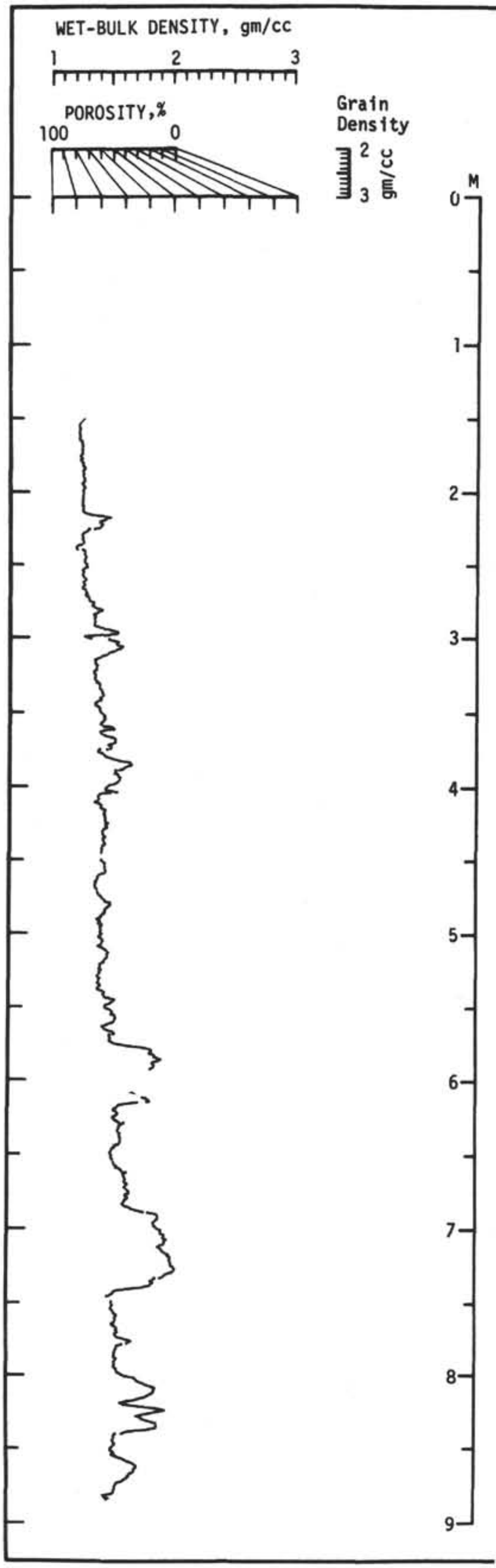

SECTION
CM
0
25
50
75
100
125
150
191A-4-1 191A-4-2 191A-4-3 191A-4-4 191A-4-5 191A-4-6

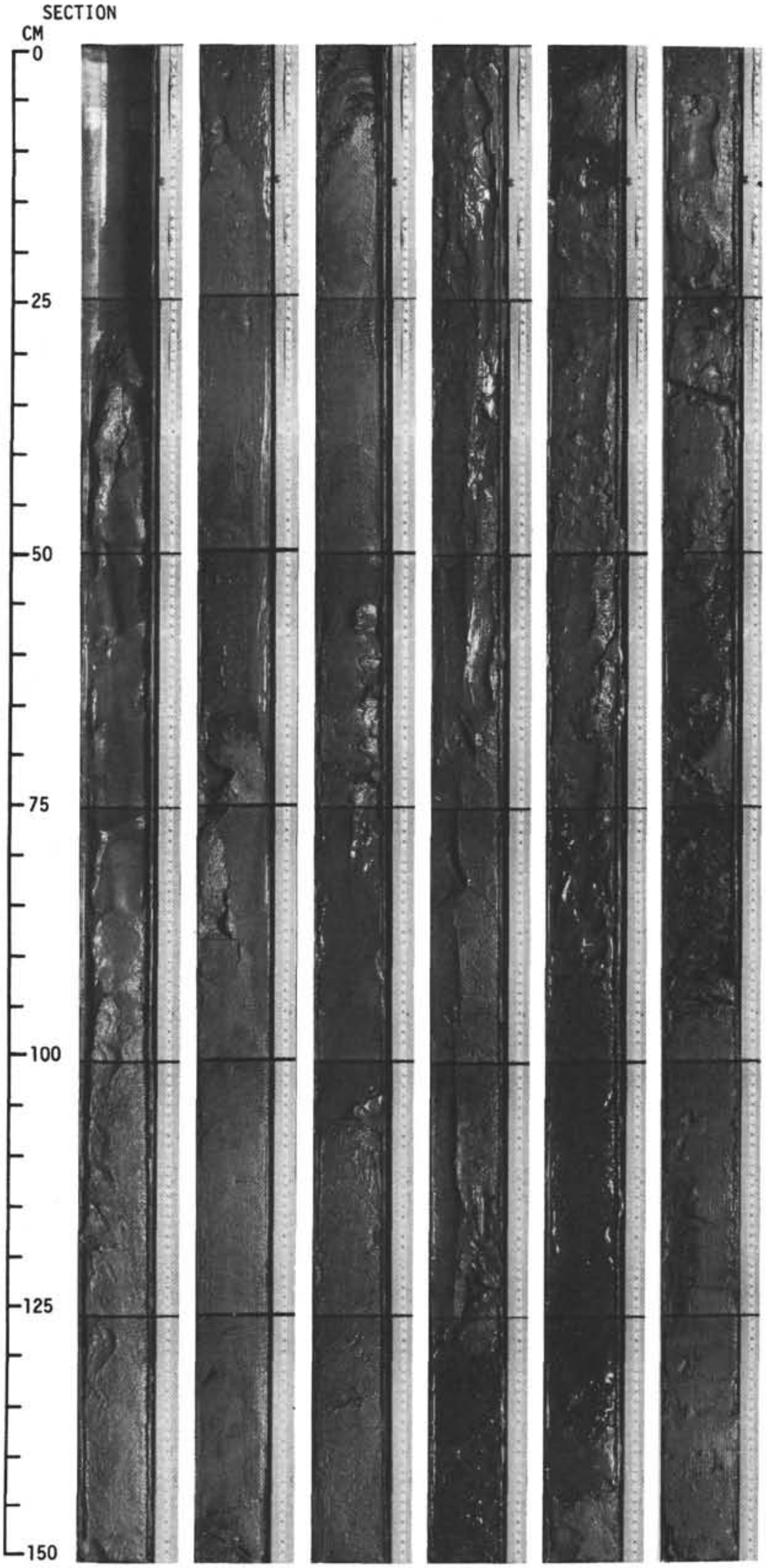
Site 191 Hole B Core 1 Cored Interval: 0-9

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					1	0.5 1.0			118 124	SILT and CLAY BEARING DIATOM OOZE olive gray (5Y 4/2) and grayish olive (10Y 4/2) to olive brown (5Y 3/4) composition range: 80 - 90% diatoms 3 - 10% silt 5 - 10% clay locally contains TR carbonate
					2				65 70 74 150	SAND, olive black (5Y 2/1) (1-2 cm thick) CLAY and DIATOM RICH SILT, dusky yellowish brown (10YR 2/2) 20% diatoms 70% silt 10% clay TR forams
					3				75	SILT and CLAY RICH DIATOM OOZE to SILT RICH CLAYEY DIATOM OOZE dark gray (5Y 4/1)
					4				22 75 140	Slide 3-75: 50% diatoms, 15% silt, 35% clay. Slide 4-75: 70% diatoms, 10% silt, 20% clay, TR nannos and forams
					5				65 120	Interbedded: SILT RICH CLAY, olive gray (5Y 4/1) and SANDY SILT or SILTY SAND, olive black (5Y 2/1)
					6				145	Slide 5-65: 15% silt, 85% clay. Slide 5-120: 30% sand, 70% silt
					Core Catcher					Core Catcher: D; N - -; R R M; S R M



Explanatory notes in Chapter 1





191B-1-1 191B-1-2 191B-1-3 191B-1-4 191B-1-5 191B-1-6