3. SITE 596: HYDRAULIC PISTON CORING IN AN AREA OF LOW SURFACE PRODUCTIVITY IN THE SOUTHWEST PACIFIC[1]

Shipboard Scientific Party of the *Glomar Challenger*[2]

HOLE 596

Date occupied: 12 February 1983

Date departed: 15 February 1983

Time on hole: 61.6 hr.

Position (latitude, longitude): 23°51.20′S, 165°39.27′W

Water depth (sea level; corrected m, echo-sounding): 5701

Water depth (rig floor; corrected m, echo-sounding): 5711

Bottom felt (m, drill pipe): 5710.5

Penetration (m); 76.1

Number of cores: 9

Total length of cored section (m): 76.1

Total core recovered (m): 39.0

Core recovery (%): 51.2

Oldest sediment cored:
Depth sub-bottom (m): 70.5
Nature: Metalliferous clay
Age: Older than Late Cretaceous
Measured velocity (km/s): 1.4–1.7

Basement:
Depth sub-bottom (m): 70.5–76.1
Nature: Basalt
Velocity range (km/s): Not measured

HOLE 596A

Date occupied: 15 February 1983

Date departed: 15 February 1983

Time on hole: 2.9 hr.

Position (latitude, longitude): 23°51.20′S, 165°39.27′W

Water depth (sea level corrected m, echo-sounding): 5701

Water depth (rig floor; corrected m, echo-sounding): 5711

Bottom felt (m, drill pipe): 5710.5

Penetration (m): 70.0

Number of cores: 1

Total length of cored section (m): 4.0

Total core recovered (m): 8.5

Core recovery (%): 211.5

Oldest sediment cored:
Depth sub-bottom (m): 70.0
Nature: Metalliferous clay
Age: Older than Late Cretaceous
Measured velocity (km/s): 1.3–1.5

Basement:
Depth sub-bottom (m): Not reached

HOLE 596B

Date occupied: 15 February 1983

Date departed: 16 February 1983

Time on hole: 15.2 hr.

Position (latitude, longitude): 23°51.20′S, 165°39.27′W

Water depth (sea level; corrected m, echo-sounding): 5701

Water depth (rig floor; corrected m, echo-sounding): 5711

Bottom felt (m, drill pipe): 5710.5

Penetration (m): 34.3

Number of cores: 1

Total length of cored section (m): 9.6

Total core recovered (m): 9.0

Core recovery (%): 96.4

Oldest sediment cored:
Depth sub-bottom (m): 34.3
Nature: Pelagic clay
Age: Late Cretaceous
Measured velocity (km/s): 1.4–1.5

Basement:
Depth sub-bottom (m): Not reached

Principal results: Hole 596 was cored continuously with the hydraulic piston corer (HPC) to 39.8 m below the seafloor (BSF) with good recovery, then with the extended core barrel (XCB) continuously in sediments 71 m BSF and in basalts to 76.1 m BSF, both with poor recovery. The XCB objective was to recover soft sediments between chert beds, but recovery was less in this interval than the recovery in Hole 595A using rotary coring. One HPC core was taken between 66 and 70 m BSF in Hole 596A to recover an undisturbed sample of oldest sediments above basalts, but missed the basement contact by 1 m. An additional core using the HPC was taken in Hole 596B to recover the interval between 24.7 and 34.3 m BSF not sampled in Hole 596 because of a flapper-valve malfunction. The piston-cored sediments are somewhat disturbed owing to vessel motion. The best recovery in chert-bearing sediments was between 34.4 and 39.8 m BSF using the HPC. Several porcellanite stringers were recovered with apparently all interbedded soft sediment for 4.35 m in this interval. The lithologic sequence combining all three holes is as follows:

Unit I: 0–11 m BSF. Dark reddish brown pelagic clay and zeolitic pelagic clay with hardgrounds encrusted by Fe and Mn oxides.

Unit II: 11–27 m BSF. Very dusky red pelagic clay and zeolitic pelagic clay, having a sharp contact with Unit I.

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[1] Menard, H. W., Natland, J., Jordan, T. H., Orcutt, J. A., et al., *Init. Repts. DSDP*, 91: Washington (U.S. Govt. Printing Office).

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Unit IIIA: 27–38 m BSF. Very dusky red pelagic clay distinguished from Unit II by the presence of thin layers of pale brown pelagic clay. The subunit appears transitional to Unit IIIB, 38–68 m BSF, which is very dusky red pelagic clay with thin layers of pale brown pelagic clay interbedded with porcellanite and chert.

Unit IV: 68–71 m BSF. Reddish black metalliferous clay.

Unit V: 71–76.1 m BSF. Basalt. Only three pieces and some crumbled material were recovered. The pieces have partial orange gray alteration halos and calcite veins. The basalt is typical depleted abyssal tholeiite, with moderately fractionated bulk composition.

The sediments throughout have a high hydrogenous metal content and, near the base, a probable major hydrothermal metalliferous component. Both give very dark colors and high concentrations of amorphous oxides. There are no biogenic carbonates even just above the basalts. Biostratigraphic zonation is based entirely on ichthyoliths. If the estimated magnetic Anomaly M-29 Callovian basement age is correct, our small sample indicates that Jurassic productivity was very low.

BACKGROUND AND OBJECTIVES

Originally, we had planned to piston core at Site 595 in order to meet the sedimentologic and biostratigraphic objectives outlined in the introductory chapter. However, consultation with our colleagues, Thomas Jordan and John Orcutt on board *Melville*, indicated that coring near the ocean bottom seismometer (OBS) array around Hole 595B could alter the programmed signal to noise ratio above which teleseisms trigger recording in the OBSs. They requested that we core no closer than about 8 km from three OBSs nearest Hole 595B, and selected a target for us about that distance to the west. Since a new beacon was required at this distance, a new site number, 596, was designated. Briefly, we planned to obtain oriented hydraulic piston cores to the top of the cherts, then core through the cherts using the extended core barrel (XCB) to basement. With improved recovery, we hoped to reach the sediment/basalt contact, and thus obtain a reliable biostratigraphic determination of the basement age. We planned to obtain at least one core in basement, perhaps more, with time permitting. We planned no geophysical program for the hole.

DRILLING OPERATIONS

A drill site was selected about 7½ mi. west-southwest of Hole 595B on the basis of earlier profiling by *Melville* (Fig. 1). Sediment thickness appeared to be at least as great as at Site 595. The *Challenger* moved to the new area, using only the 3.5-kHz echo sounder for profiling. After crossing the location, an additional 1¼ hr. were spent surveying to verify optimum sediment thickness. The positioning beacon was launched at 1909 hr., 12 February.

The precision depth recorder reading was 5711 m, and the pipe was lowered to 5706.4 m for a seafloor hydraulic piston core (HPC) attempt. The variable length HPC assembly was deployed and run to position at the bit, but attempts to pressure the drill pipe and actuate the corer were unsuccessful. We speculated that the corer's shear pins had failed on the trip down as a result of swell-induced vessel motion. This possibility was eliminated when the corer was recovered unstroked, with the shear pins intact. A second HPC attempt was made at the same depth with the same initial results. The corer was picked up and seated with some force, resulting in apparently normal pressuring and actuation of the piston corer. The corer was then found to be stuck in the bottom-hole assembly. Overshot release pins were sheared on the initial attempt and on a second wireline retrieval try.

A round trip of the pipe was necessary to dislodge the HPC assembly, resulting in the loss of 26 hr. of operations. On recovery, the corer was found to be fully extended through the bit, with the core barrel bent but containing a 5.4-m core. The top of the core barrel was tightly jammed in the bit throat by parts of the broken float-valve flapper.

The damaged components were removed and the core was taken to the laboratory, where the bit subassembly was made up (without a valve flapper) and the bit was inspected and reinstalled. The drill string was then run back to the seafloor and piston coring resumed at the depth reached by the initial core. The coring at Site 596 is summarized in Table 1.

Four additional piston cores were taken in red to dark brown clay before refusal depth was reached as the first thin chert strata were encountered. Core quality was good, despite low and inconsistent actuation pressures and considerable vessel heave. The entire contents of Core 4 were lost because the sticky clay plastered both core catchers open.

At 40 m below the seafloor (BSF), the HPC was retired in favor of the XCB for coring the chert–clay sequence and into basement. Three cores in the sediment interval produced disappointing results roughly equivalent to the performance of the standard rotary-coring system in similar materials at Site 595. Basement was encountered at about 71 m sub-bottom, about 2 m into Core 9. Although the penetration rate was an acceptable 2 m/hr., coring was terminated after 5 m of basement penetration because time was running out and recovery of basal sediments still had top priority. On recovery, the XCB hard-formation cutter shoe was found to be tightly jammed with basalt, with the cutting structure totally destroyed.

Hole 596A

Drilling parameters had indicated that the lowermost 4 to 5 m of sediment were free of hard strata. Since this was considered to represent the most important single core of the site, a last-ditch effort was made to recover at least some of the basal sediment.

The core bit was pulled above the seafloor, and a new hole was spudded immediately at 0853 hr., 15 February. The hole was drilled to 66 m sub-bottom with no core barrel in place, accepting the risk of obstructing the open core throat with broken chert. The cherty section drilled much more easily than had been anticipated, and the drilling was stopped as soon as the bit had broken through the lowermost hard streak, based on the drilling of Hole 596. The HPC was lowered to the bit and pressured past the normal actuation point. The pressure failed to bleed off, indicating incomplete stroke of the corer, and we inferred that the core barrel had been stopped by the basalt. The corer was brought back to the rig floor and the

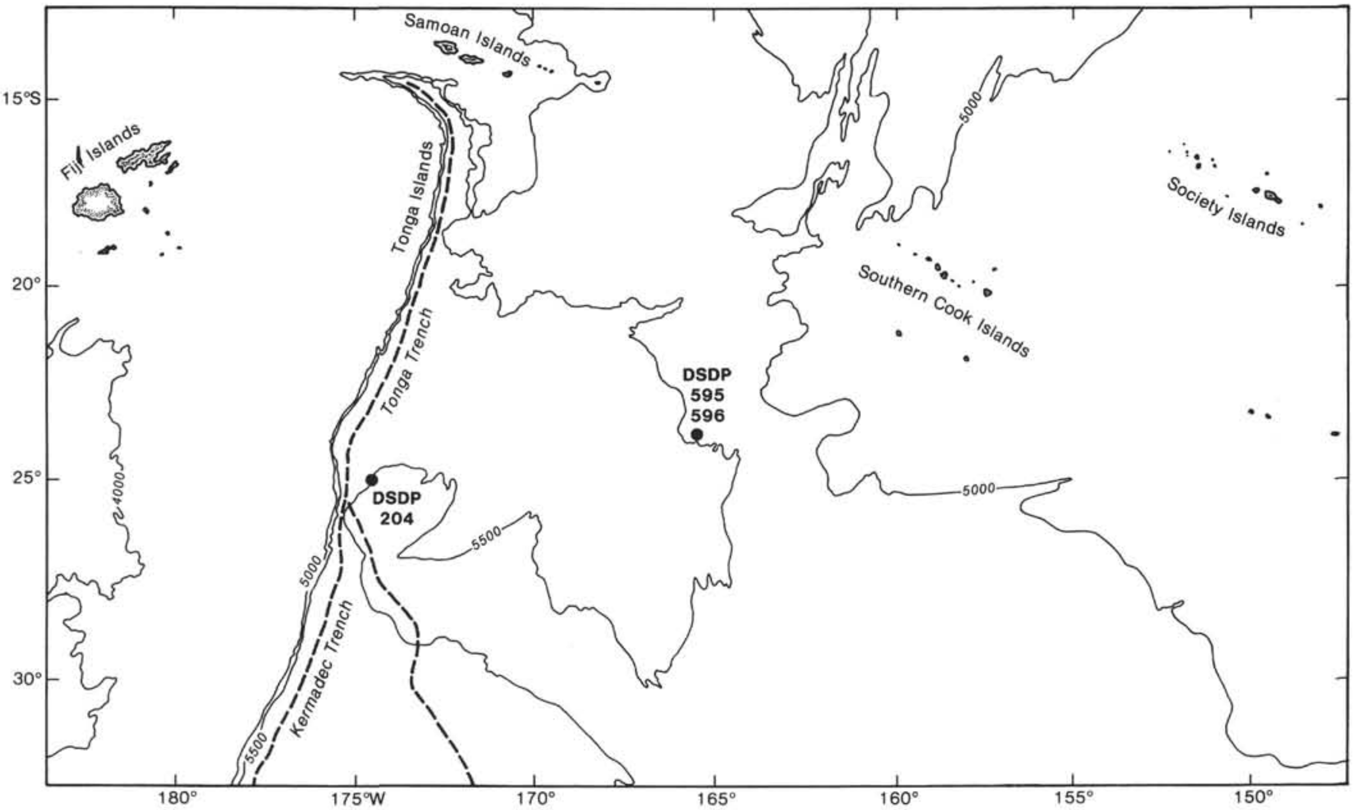


Figure 1. Location of Site 596 in the SW Pacific.

Table 1. Coring summary, Site 596.

Core no.	Date (Feb. 1983)	Time	Depth from drill floor (m)	Depth below seafloor (m)	Length cored (m)	Length recovered (m)	Amount recovered (%)
Hole 596							
1	13	2200	5710.5-5716.0	0.0-5.5	5.5	5.40	98.2
2	14	1213	5716.0-5725.6	5.5-15.1	9.6	9.51	99.1
3	14	1339	5725.6-5735.2	15.1-24.7	9.6	9.61	>100.0
4	14	1515	5735.2-5744.8	24.7-34.3	9.6	0.00	0.0
5	14	1730	5744.8-5750.3	34.3-39.8	5.5	4.35	79.1
6	14	2114	5750.3-5759.9	39.8-49.4	9.6	9.16	95.4
7	15	0100	5759.9-5769.5	49.4-59.0	9.6	0.20	2.1
8	15	0350	5769.5-5779.1	59.0-68.6	9.6	0.05	1.0
9	15	0815	5779.1-5786.6	68.6-76.1	7.5	0.67	8.9
					76.1	38.95	51.2
				Sediments	70.0	38.68	55.5
				Basalts	6.1	0.27	4.4
Hole 596A							
Washed			5710.5-5776.5	0.0-66.0	—	—	—
1	15	1105	5776.5-5780.5	66.0-70.0	4.0	8.46	211.5[a]
Hole 596B							
Washed			5710.5-5735.2	0.0-24.7	—	—	—
1	15	1300	5735.2-5744.8	24.7-34.3	9.6	9.02	94.0

Note. — means not measured.
[a] HPC sampled to basement, but overcored by drawing in by suction a greater quantity of sediments from near the basement contact than the interval cored.

core barrel, containing nearly 8½ m of sediment, was laid down.

When the core was split (some time later), we found that only the upper 4 m were relatively undisturbed and that the remainder exhibited flow-in type disturbance. On the basis of this evidence, the lack of damage to the core-catcher shoe and the record of the previous hole, we deduced that the corer had been stopped by the stiff clay within 1 m of the basement contact.

Hole 596B

Operations had preceeded so quickly in Hole 596A that time for one more core was squeezed into the schedule. The bit again was pulled momentarily above the seafloor and Hole 596B was spudded at 1145 hr. The soft clay was washed away to the depth of 24.7 m BSF. The piston corer was deployed and the interval of Core 596-4 was recored. A core of over 9 m was recovered, completing coring operations for Leg 91.

The final pipe trip was uneventful and was concluded with a magnaflux inspection of the BHA connections and of the power sub/swivel assembly. The rig floor was then secured and *Glomar Challenger* departed for Tahiti at 0252 hr., 16 February.

SEDIMENT LITHOLOGY

Three holes were drilled at Site 596: 596, 596A, and 596B. In Hole 596, sediments were cored continuously to a depth of 70.5 m below the mud line, using a combination of hydraulic piston coring (HPC) and rotary coring with the extended core barrel (XCB). In Hole 596A, we attempted to recover the oldest sediment above the basement using the HPC, inasmuch as these sediments were not recovered by the XCB in Hole 596. In Hole 596B, we cored an interval that was not recovered between 24.7 and 34.3 m in Hole 596 (Core 596-4) because of core-catcher failure.

Because the quantity and quality of sediments recovered at this site were greater than at Site 595, we use the section at Site 596 as the standard for both sites, defining four lithologic units. Subdivisions are based on major changes downhole in the sediment components and on the occurrence of minor, interbedded lithologies (Fig. 2).

The DSDP sediment classification failed to give adequate guidelines for these highly metalliferous sediments. In most sediments, the proportion of red brown to yellow brown semiopaque oxides (RSOs) is extremely small. Even in sediments where RSOs are observed, the concentration is usually only between 5 and 10%. But at Site 595 and 596, the sediment-accumulation rate was very low, and the average RSO concentration estimated from smear slides is over 30%. In some samples it is as high as 90%. The classification scheme adopted for these sediments, using the combined RSO and micronodule content estimated from smear slides, is: less than 30%—pelagic clay, no modifier; 30–60%—metalliferous pelagic clay; and more than 60%—metalliferous clay, Without chemical data, it is impossible to determine whether the source of the RSOs is hydrothermal (ridge crest) or hydrogenous. Therefore, neither term, metalliferous or RSO, is used with genetic implications.

Unit I: Pelagic Clay and Zeolitic Pelagic Clay

This unit begins at the mud line and continues to a sub-bottom depth of 10.7 m (Sample 596-2-5, 15 cm). From the top to the bottom of the unit, the colors gradually change from dark yellowish brown (10YR 3/4) to dark reddish brown (5YR 3/4). The composition of the sediment changes from a pelagic clay to a zeolitic pelagic clay in Sample 596-1-2, about 100 cm. The lithology change does not correspond to the change in color. Smear-slide estimates of sediments components vary as follows:

Silt-sized fraction	0–20%
Clay-sized fraction	80–100%
Feldspars	0–2%
Clay minerals	40–92%
RSOs	5–25%
Opaque micronodules	0–1%
Zeolites	2–30%
Ichthyoliths	trace–3%
Radiolarians	0%
Foraminifers	0%

From the top to the bottom of Unit I, the clay decreases from 82 to 40%, whereas the RSOs gradually increase from 10 to 25%. At about 2 to 3 m sub-bottom, zeolites increase sharply from 2 to 20% and vary between 20 and 30% for the remainder of Unit I.

Iron–manganese nodules and encrusted hardgrounds occur in several intervals of Unit I. As at Site 595, Fe–Mn nodules occur at the surface of the sediments. These nodules have a crenulated outer surface with a smooth inner surface and again, as at Site 595, are nucleated on sand-sized grains of pelagic clay encrusted with Fe–Mn oxides. In Samples 596-1-4, 122 cm, and 596-2-2, 42 cm, Fe–Mn encrusted hardgrounds occur. In Core 596-1, the soft clay is slightly indurated just below the hardground. This indurated clay is very friable and breaks up into small pieces when the splitting wire was used to divide the core. This gives a rough texture to the split surface of the core. In Core 596-2 the soft clay is progressively more indurated with depth, starting 1 m above the hardground and continuing another 2 m until interrupted by flow-in core disturbance.

Unit II: Metalliferous Pelagic Clay and Zeolitic Metalliferous Pelagic Clay

Unit II begins at 10.7 m and continues to 26.7 m sub-bottom (Samples 596-2-5, 15 cm to 596B-1-2, 65 cm). Between sections 596-3-1 and 596-3-2, the color of the sediment gradually changes from reddish black (10R 2/1) to very dusky red (2.5YR 2/2). In the top 7 m of this unit, the composition gradually changes from a metalliferous pelagic clay to a zeolitic metalliferous pelagic clay. The variation in sediment components is as follows:

Silt-sized fraction	1–10%
Clay-sized fraction	90–99%
Feldspars	0–trace
Clay minerals	23–37%
RSOs	60–30%
Opaque micronodules	0–4%
Zeolites	5–30%
Ichthyoliths	0–10%

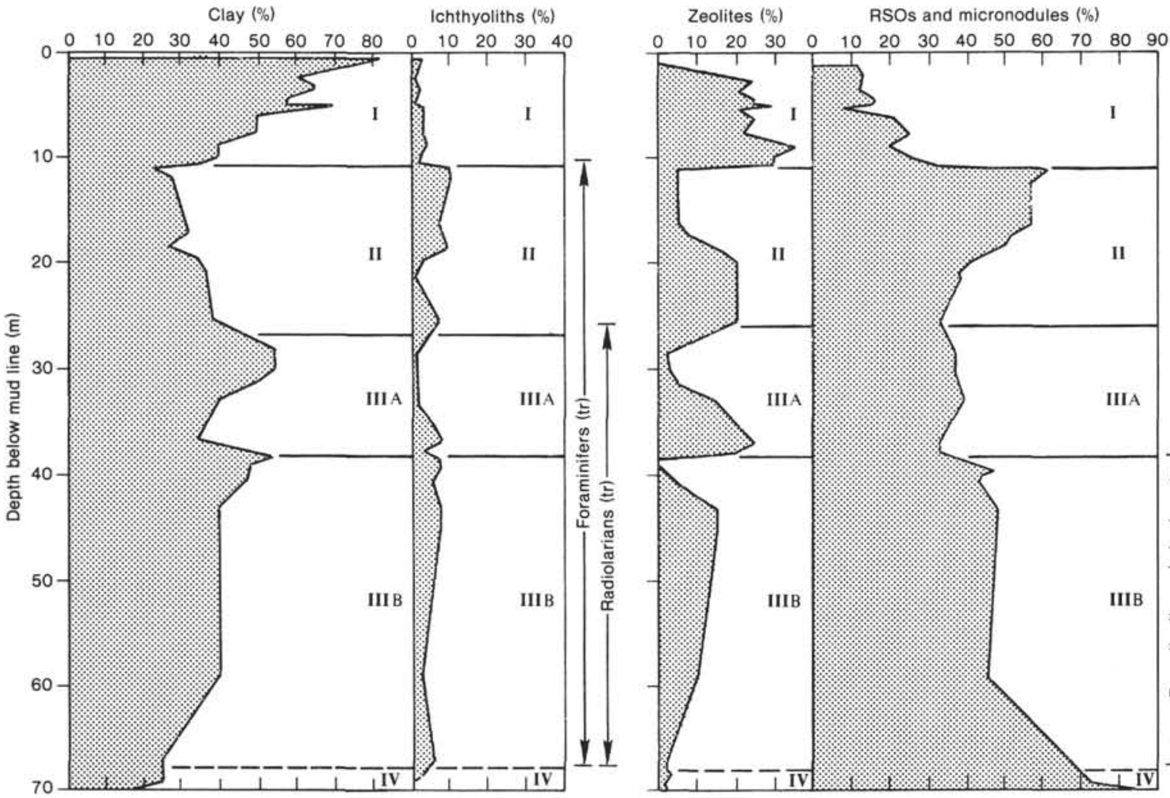


Figure 2. Summary of smear slide data for sediments cored at Site 596, giving percentage of sediment components versus depth below mud line.

Radiolarians	0–2%
Foraminifers	trace

The boundary between Units I and II is marked by an abrupt change in the sediment components. RSOs increase sharply from 25 to 60% and then gradually decrease to 30% at the base of Unit II. This abrupt increase in the RSO content at the Unit I/II boundary is marked by a sharp color change from dark reddish brown (5YR 3/4) to reddish black (10YR 2/1) at a flat contact. Both the clay content and zeolite content drop sharply at the boundary from 40 to 25% and 30 to 5%, respectively. The clay content very gradually increases from 25 to 40% toward the base of the unit. The zeolites maintain a concentration of 5% for the top 6 m then increase to 20% for the remainder of Unit II. Foraminifers (internal molds) are seen in trace quantities from the beginning of Unit II. Radiolarians are first noted at the bottom of Unit II.

Unit II is massive with only rare faint mottling and rare, single halo burrows.

Unit III: Metalliferous Pelagic Clay, Zeolitic Metalliferous Pelagic Clay, Thin Interbeds of Pelagic Clay and Interbedded Radiolarian-Bearing Porcellanite and Chert

Unit III begins at 26.7 m and ends at approximately 68 m (Sample 596B-1-2, 65 cm to Core 596A-1). The position of the lower boundary is uncertain because of poor recovery at this depth in Hole 596 and failure of the HPC to stroke-out fully and reach basement in Hole 596B. The dominant lithology of Unit III is a very dusky red (10R 2/2 to 2.5YR 2/2) metalliferous pelagic clay and zeolitic metalliferous pelagic clay. Interbedded with the dominant sediment are thin (0.5 to 10-cm) stringers of layers of reddish yellow (7.5YR 6/6) and yellowish brown (10YR 5/4) pelagic clay (Fig. 3).

Unit III is further subdivided into Subunits A and B. The basis for this subdivision is the first occurrence of porcellanite interbedded with the above lithologies, at approximately 38 m sub-bottom (Sample 596-5-3, 130 cm). The porcellanites, which are usually 1–2 cm thick, are often banded by very dusky red (10YR 2/2), reddish yellow (7.5YR 6/6), dark olive gray (5Y 3/2), and dark brown (7.5YR 3/2) colors. The cherts are dark gray (10YR 3/1) to black (10YR 2/1) or dark yellow brown (10YR 3/1) in color. Both porcellanite and chert contain radiolarians that are visible in hand specimens under low magnification.

The sediment components of the metalliferous and zeolitic metalliferous pelagic clay varies as follows:

Silt-sized fraction	0–5%
Clay-sized fraction	95–100%
Feldspars	0–trace
Clay minerals	25–55%
RSOs	30–62%
Opaque micronodules	2–10%
Zeolites	0–23%
Ichthyoliths	2–8%
Radiolarians	0–2%
Foraminifers	0–trace

At the boundary with Unit II, the clay content increases from 38 to 55% and declines to 35% at the bound-

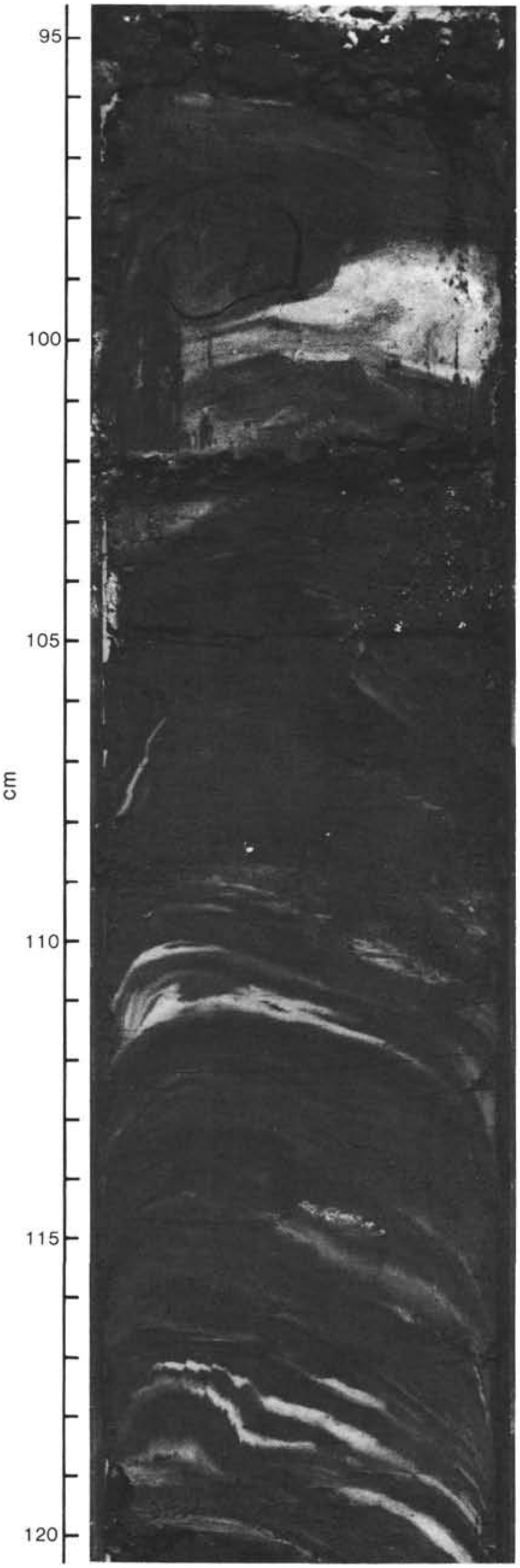


Figure 3. Interbedded radiolarian muds (dark) and porcellanite stringers (light) in Sample 596-5-4, 95–120 cm. The core was obtained using the hydraulic piston corer, and is the first ever obtained in which soft materials between hard porcellanites were recovered.

ary with Subunit IIIB, where it increases sharply back to 55%. Six meters below the boundary of Subunits IIIA and IIIB the clay content decreases to 40% and remains constant to 60 m sub-bottom, where it decreases to 25% in transition to Unit IV.

There is no major change in the RSO component at the Unit II/III boundary. Throughout Subunit IIIA, RSO's vary between 35 and 40%. At the Subunits IIIA/IIIB boundary, RSOs increase by 10% and vary between 45 to 48% to 60 m sub-bottom. For the remainder of Subunit IIIB, RSOs increase to 70% in transition to Unit IV.

At the Unit II/III boundary, the zeolite abundance drops from 20 to 5%. From 32 m sub-bottom to the base of Subunit IIIA (38 m sub-bottom), the zeolites increase back to 25% and then drop to 6%. From 41 to 43 m sub-bottom the zeolites increase back to 15% and then decrease gradually to 5% toward the boundary with Unit IV.

Rare, faint mottling occurs throughout most of Unit III. The bioturbation may be more intense than can be observed, because of the uniform dark color of the clays. In lighter-colored pelagic clays, bioturbation is moderate and distinct. Very rare, single halo burrows occur throughout Unit III in darker clays. Radiolarians and internal molds of foraminifers occur in trace quantities throughout Unit III.

Unit IV: Metalliferous Clay and Pelagic Clay

Unit IV begins at approximately 68 m sub-bottom (Cores 596-9 and 596A-1) and continues to the top of the basement at 70.5 m. Reddish black (10R 2/1) metalliferous clay is the dominant sediment with thin (2–3 cm) layers of white (2.5Y 8/2) to very pale brown (10R 7/3) pelagic clay. The sediment components vary as follows:

Silt-sized fraction	0–2%
Clay-sized fraction	98–100%
Feldspars	0–1%
Clay minerals	1–25%
RSOs	60–90%
Opaque micronodules	5–10%
Zeolites	2–3%
Ichthyoliths	2–8%
Radiolarians	trace
Foraminifers	0%

In Unit IV the metalliferous component, as indicated by the RSO abundance, dominates the sediments.

A 2- to 4-mm-thick calcite vein (microspar) cuts this basal sediment in Sample 596B-1-4, 52 cm. No alteration is seen next to the vein but this could be hidden by the dark color of the sediment. The calcite is stained to a dark reddish brown (5YR 2/2) and may be related to the calcite veins in the underlying basalts.

Significance of Light-Colored Pelagic Clays

Light-colored pelagic clays occur in Units II, III, and IV as thin layers from 1 to 10 cm in thickness (Fig. 3). Because the lateral extent of the clays cannot be determined from core samples, we do not know whether the clays are discontinuous stringers or are continuous beds of large lateral extent.

Both optical and X-ray analyses failed to detect the presence of opal-CT, indicating that these beds are not incipient porcellanites. One X-ray analysis showed the presence of smectite. Smear-slide observations revealed that clays make up between 82 and 97% of the sediment and that both RSOs and zeolites were either completely absent or reduced to less than 5% of their abundance in the surrounding sediments. If the accumulation of RSOs occurred at a constant rate, these light-colored beds require an almost 100-fold increases in the rate of accumulation of sediment components other than RSOs. The most likely source for brief, rapid impulses of sediment far from continental detrital sources is volcanic ash. Long exposure at the sediment-water interface (because of the abnormally slow sedimentation) would result in ash being completely altered to clay.

BIOSTRATIGRAPHY

Three holes were drilled at Site 596 using both hydraulic piston and rotary coring. Hole 596 was cored continuously with the hydraulic piston corer to 40 m (Cores 1–5) with good recovery. A rotary coring system using the extended core barrel was then used to core the lower 31 m (Cores 6–9) to basement with poor recovery. One core was taken at both Holes 596A and 596B by the hydraulic piston corer. At Hole 596A, the corer recovered 4 m of sediments terminating 1 m above basement. Hole 596B was cored to recover a missed interval between 24.7 and 34.3 m in Hole 596. Cored sediments consist of zeolitic to metalliferous pelagic clays, with the first interbedded porcellanite and cherts occurring at 38 m (Core 5).

Microfossils are limited to common and ubiquitous ichthyoliths, radiolarians, and rare foraminifers. Radiolarians are poorly preserved but common in the lower chert-bearing pelagic clays from 40 to 49 m (Core 5 core catcher and Core 6). A sample from Core 6, Section 5 (46 m) contains sufficient identifiable radiolarians to suggest an age of Albian or Late Cretaceous.

Ichthyoliths

Samples were taken at widely spaced intervals (average 1.5 m) in Holes 596, 596A, and 596B (Table 2). Ichthyoliths are abundant to common in the upper 20 m. Peak abundances occur in Section 4 of Core 2 and Core 3, Section 2. Ichthyoliths are abundant to rare in the interval below 20 m.

Table 2. Sediment samples from Site 596 dated on the basis of ichthyoliths.

Age[a]	Sample (interval in cm)	Depth to top of sample (m)
middle Miocene and younger	596-1-1, 110–112	1.10
	596-1-2, 105–111	2.55
	596-1-2, 109–112	2.59
	596-1-3, 83–88	3.83
	596-1-3, 100–102	4.00
	596-1-4, 100–102	5.50
	596-1-4, 130–136	5.80
	596-1,CC, 8–11	6.28
	596-2-1, 59–63	6.09
early Miocene	596-2-2, 59–63	7.59
	596-2-2, 61–74	7.61
	596-2-3, 54–60	9.04
	596-2-3, 59–63	9.09
	596-2-4, 59–63	10.59
	596-2-4, 134–140	11.34
Eocene–Oligocene	596-2-5, 59–63	12.09
	596-2-6, 59–63	13.59
	596-2,CC	14.87
	596-3-1, 108–111	16.18
Paleocene	596-3-2, 108–111	17.68
	596-3-3, 108–111	19.18
	596-3-4, 108–111	20.68
Cretaceous	596-3-5, 108–111	22.18
	596-3-6, 108–111	23.68
	596-3,CC	24.63
	596B-1-1, 79–82	25.49
	596B-1-2, 79–82	26.99
	596B-1-3, 79–82	28.49
	596B-1-4, 79–82	29.99
	596B-1-5, 79–82	31.49
	596B-1,CC	34.11
	596-5-2, 81–84	36.61
	596-5-3, 81–84	38.11
	596-5-4, 32–34	39.12
	596-5-4, 81–84	39.61
	596-5,CC	40.60
	596-6-1, 85–88	40.65
	596-6-3, 63–67	43.43
	596-6-4, 60–66	44.90
Radiolarians: Late Cretaceous to Albian	596-6-5, 88–91	46.68
	596-6,CC (22–24)	49.25
	596-7,CC	49.49
Cretaceous or older	596-9-1, 42–46	69.02
	596A-1-1, 70–78	67.70
	596A-1-1, 81–84	67.81
	596A-1-2, 81–84	69.31
	596A-1-2, 92–98	69.42
	596A-1-3, 81–84	70.81
	596A-1-3, 95–101	70.95
	596A-1-4, 81–84	72.31

[a] Hachured areas indicate uncertainty of age boundary.

Hole 596

The Cenozoic is contained within the upper 20 m at Site 596. Samples from Core 1 to Core 2, Section 4, are Miocene as indicated by the occurrence of *Triangle sinuous inline, Stippled triangle, Circular with line across*, and *Small triangle long striations*. The presence of *Long ellipse, Narrow triangle ragged base*, and *Elliptical with line across* in the upper 6 m suggests that sediments from Core 1 to Core 2, Section 1 are middle Miocene or younger. The absence of these forms in the lower part of the Miocene section suggests an early Miocene age.

The Eocene–Oligocene/early Miocene boundary is within Core 2, between Sections 4 and 5. No distinction between Eocene and Oligocene can be made because of an irregular and conflicting pattern of first and last occurrences. The Paleocene/Eocene boundary falls between Core 2, Section 6 and Core 3, Section 4.

Sections 2 and 3 of Core 3 are Paleocene on the basis of the first occurrences of Cenozoic taxa, *Triangle with triangular projection, Triangle medium wing* and *Triangle curved margin ends* and the absence of Cretaceous forms.

The Cretaceous/Tertiary boundary is within Core 3 between Sections 3 and 4. All of Core 3, Section 4 and below is Cretaceous or older, on the basis of the latest occurrences of *Triangle square inline* and *Wide triangle projection* and the earliest occurrences of *Triangle long inline* and *Triangle square inline*. Taxa commonly found in the Cretaceous (*Triangle square inline, Wide triangle projection, Triangle long inline*, and *Blunt triangle dendritic inline*) are present throughout Core 6, Section 5. Radiolarians in a sample from Section 5 suggest that the assemblage is not older than Albian. The core catchers from Cores 6 and 7 and Section 1 of Core 9 contain bone fragments, but there are essentially no identifiable ichthyoliths.

Hole 596A

Hole 596A was cored in order to recover the oldest sediments above basement. Mesozoic ichthyoliths have not been studied sufficiently to allow us reliably to discriminate Cretaceous from Jurassic sediments, and moreover ichthyoliths are rare throughout the core.

Hole 596B

Ichthyoliths are common and indicate that the core is Cretaceous. This hole was cored to recover the missed interval between 24.7 and 34.3 m in Hole 596. Comparison of ichthyolith assemblages in this core with that of Hole 596 suggests that drilling depths are approximately correct.

PORE-FLUID CHEMISTRY

Pore fluids were squeezed from four samples in Hole 596 and one each in Hole 596A and 596B (Table 3). All were samples from hydraulic piston cores. Data for pH, alkalinity, salinity, chlorinity, and the abundances of calcium and magnesium are reported in Table 3, and are plotted versus depth in Figure 4. There are only minor differences from sample to sample, and there are no significant trends with depth. Pore-fluid compositions are very similar to those of surface seawater and standard seawater, and they are probably identical to bottom water in the area. The compositions therefore do not reflect the occurrence of reactions between pore fluids and solids either in the sediments or in the basaltic rocks beneath the sediments.

IGNEOUS ROCKS

Of the three holes drilled at Site 596, only one (Hole 596) sampled basement rocks at a sub-bottom depth of 70.5 m. Samples consist of coarse igneous sand and core cuttings, pebbles, and three small cobbles, all produced by disruption and abrasion of basaltic lavas during drilling. The rock is gray, fine-grained, aphyric, and nonvesicular. The color is distinctly lighter and the grain size coarser than a typical fresh ocean-floor basalt. Cobbles are fractured and veined. Fracture and vein surfaces are stained with brown iron-hydroxides and black manganese oxides, plus a small amount of pale green clay mineral. Veins are filled with carbonate. The rock shows yellow brown alteration banding parallel to fractures and veining, although the overall alteration of the rock is moderate.

In thin section, the rock shows skeletal texture, consisting of approximately 50% plagioclase with intersertal clinopyroxene and about 10% interstitial magnetite. Minor interstitial glass, now altered to clay minerals, may also have been present. Plagioclase laths range from 0.1 to 0.4 mm in length. The rock shows slight vesicularity on a microscopic scale. Spherical vesicles range in size from 0.1 to 0.2 mm and are filled with iron oxyhydroxides or carbonate. Overall, the rock is slightly altered, with brownish clay minerals replacing probable glass and titanomagnetite, and reddish brown iron oxides and hydroxides replacing edges of magnetite crystals. The thin section was cut predominantly through an alteration halo, and is marked by the presence of small subparallel fractures about 2–4 mm apart, along which iron oxyhydroxides are especially concentrated.

A chemical analysis (Saunders, this volume) demonstrates that the basalt is depleted abyssal tholeiite moderately enriched in CaO contents because of carbonate veins.

PHYSICAL PROPERTIES

Measurements of physical properties made on cores from Site 596 include shear strength, sound velocity, continuous GRAPE density and porosity, 2-min. GRAPE density and porosity, water content, and thermal conductivity. At this site, comparatively undisturbed sediments recovered using the hydraulic piston corer were available above cherts and just above basement. The cherty intervals were poorly recovered with the extended core barrel, and only indurated porcellanites could be used for measurements of physical properties. A brief discussion of the results of these measurements follows.

Vane Shear Strength

Vane shear-strength measurements were made on sediments from the first 40 m below the mud line. Figure 5

Table 3. Summary of shipboard inorganic geochemical data, Site 596.

Sample (interval in cm)	Sub-bottom depth (m)	pH	Alkalinity (mEq/l)	Salinity (‰)	Chlorinity (‰)	Calcium (m*M*)	Magnesium (m*M*)
SSW		7.69	2.569	36.3	20.23	10.49	54.95
IAPSO		7.93	2.796	37.1	19.375	10.55	55.00
596-1-3, 140–150	4.1	7.16	2.540	35.5	19.41	10.27	50.84
596-2-4, 140–150	10.5	7.02	2.702	34.6	19.51	10.13	51.64
596-3-4, 140–150	20.1	6.85	2.672	35.5	19.75	10.41	50.70
596-5-4, 140–150	39.6	7.11	2.635	35.2	19.65	10.25	51.82
596A-1-4, 140–150	71.4	7.08	2.14	34.1	18.79	13.63	45.44
596B-1-3, 140–150	30.6	7.04	2.527	33.6	18.73	10.33	51.68

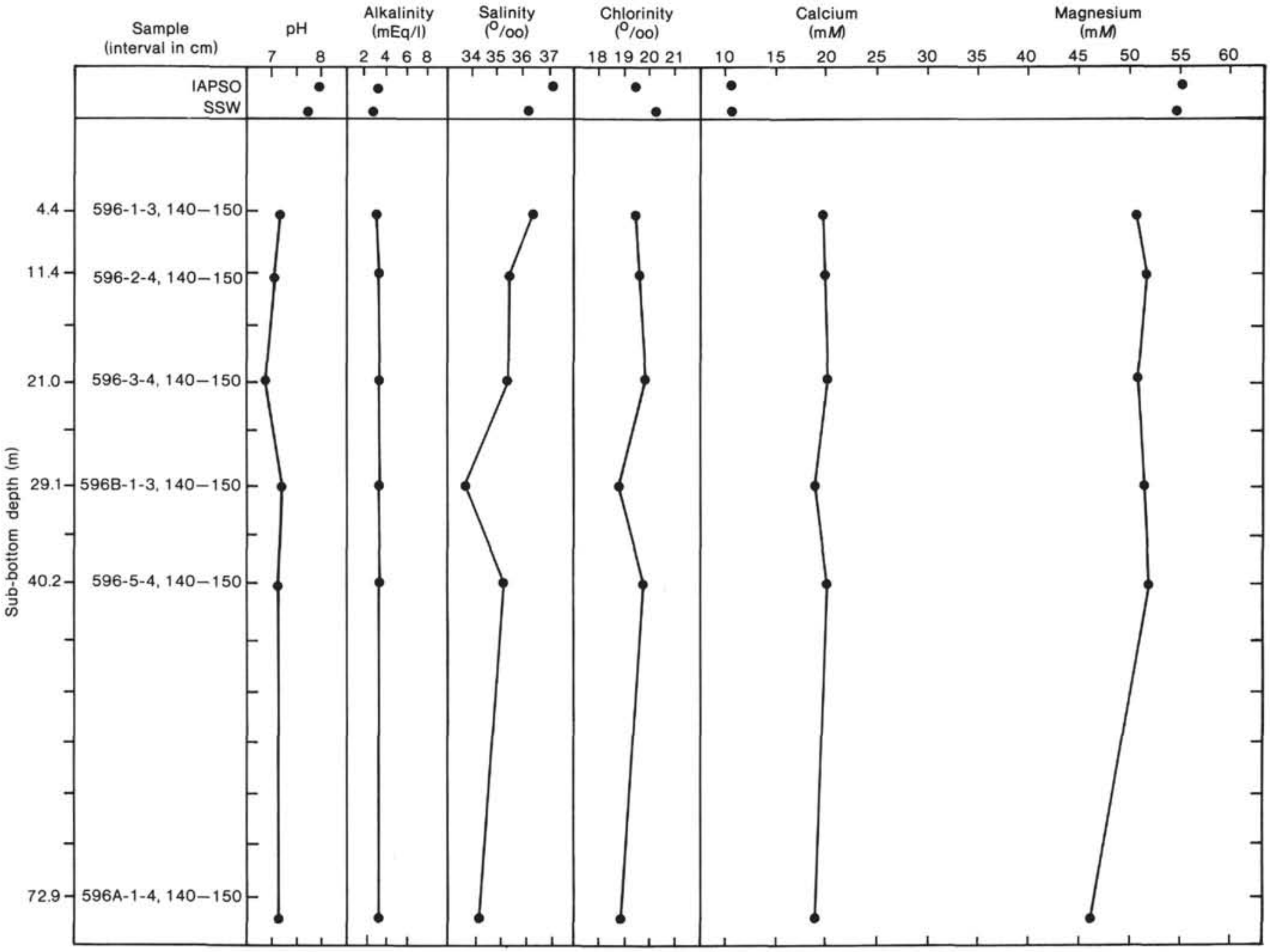


Figure 4. Compositions of pore fluids extracted from sediments cored at Site 596, plotted versus sub-bottom depth.

shows shear strength plotted against depth downhole. Shear strength increases 6.3 to 14.0 kPa in the sediments just above a Mn-encrusted hardground found at about 6 m below the seafloor (m BSF). Just below this Mn layer, shear strength increases further to 20.9 kPa.

Below 11 m BSF, sediment shows a steady increase in shear strength from 6.9 to 24.1 kPa at 38 m BSF. Sediments cored below 66 m were too strong for the motor to turn the vane, and therefore no shear strength measurements were possible.

Wet-Bulk Densities

Individual samples were taken from cores using the cylinder technique described by Boyce (1976). These samples had 2-min. GRAPE counts done on them and then were given to the chemist for water-content analyses. Results from both these methods (Table 4 and Fig. 5) indicate that wet-bulk densities of the piston-cored sediments remain fairly constant (1.21–1.29 g/cm^3 from water-content analyses and 1.24–1.34 g/cm^3 from GRAPE counts) downhole to about 40 m. Between 40–65 m BSF, cores (obtained by the extended core barrel) were too disturbed to give reliable measurements. However, at about 68 m BSF, the density of piston-cored sediments increases as basement is approached. The wet-bulk density increase from 1.22 to 1.64 g/cm^3 occurs within a 6-m interval (water content analysis), and probably reflects an increased concentration of amorphous oxides in the basal metalliferous sediments (Unit V). Two basalt fragments from the core catcher at approximately 76 m have wet-bulk densities of 2.72 and 2.82 g/cm^3.

Sonic Velocity

Sonic-velocity measurements were made on sediments in split cores. In few cases, however, the core liners had been shattered during coring and it was necessary to tape the liners to hold them together. When this occurred, the sediment was usually stiff enough to remove from the liner and measure velocity without external support. In Figure 5, velocity is plotted versus depth.

Velocities vary dramatically in places. The manganese-encrusted hardground encountered at about 6 m BSF appears to represent a significant boundary in the sonic velocity–depth plot. There is an increase in velocity from 1.48 km/s above the hardground to 1.62 km/s below it. Also there is a sharp color change in the sedi-

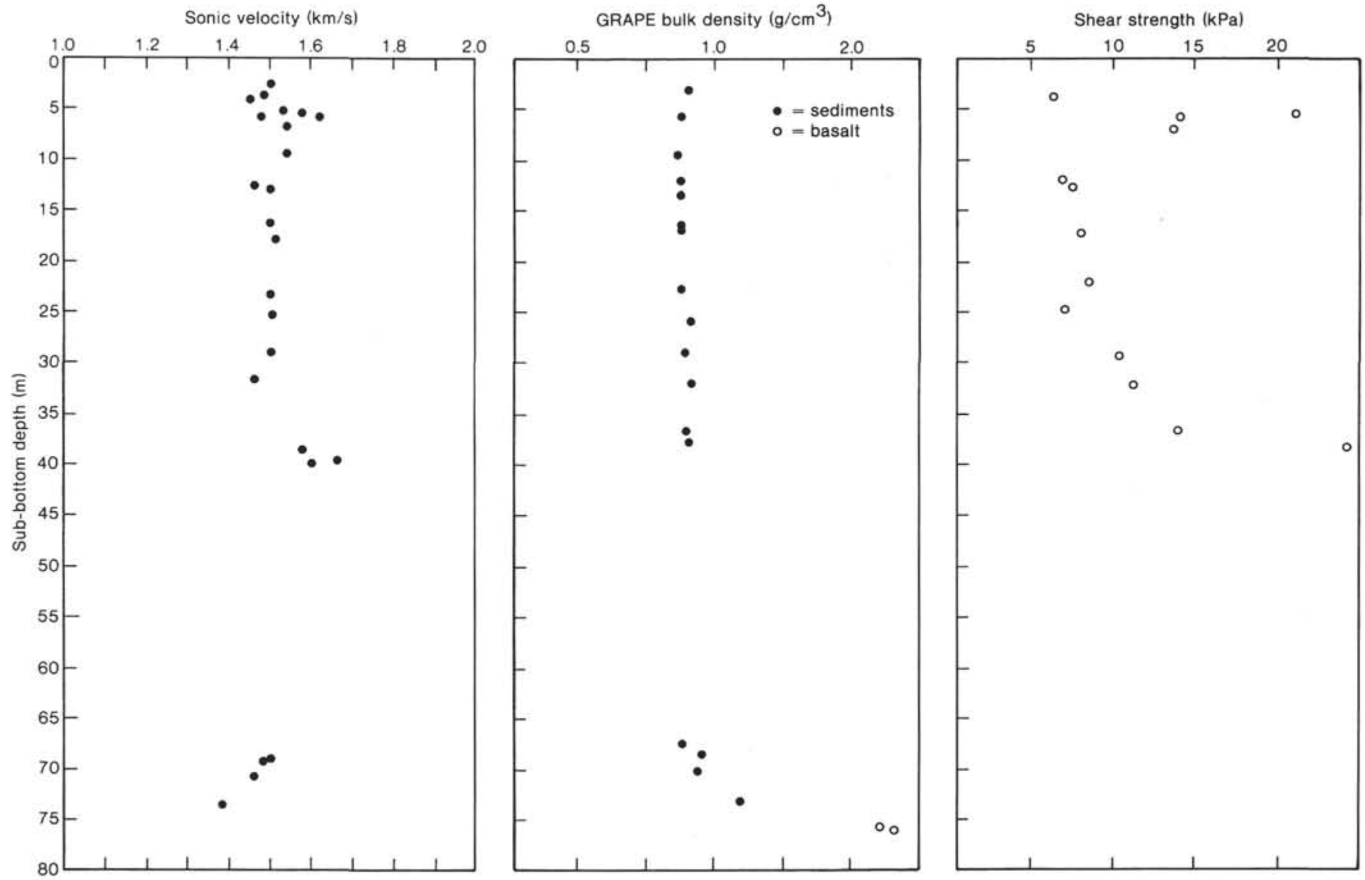


Figure 5. Sonic velocity, GRAPE bulk density, and shear strength of sediments cored at Site 596, plotted versus sub-bottom depth.

ment at approximately 11 m BSF; a velocity of 1.54 km/s was measured above it and 1.46–1.50 km/s measured below. Sonic velocity increased to 1.58–1.60 km/s in pelagic sediments with light brown clay bands (lithologic Unit IIIA). The sonic velocity of a nodule apparently consisting of porcellanite from Unit IIIB is 1.66 km/s. In sediments cored close to basement, sonic velocities fall in the range 1.38–1.50 km/s.

CORRELATION BETWEEN PHYSICAL PROPERTIES AND 3.5-kHz PROFILES

The 3.5-kHz profiler system provided the only information on sub-bottom structure collected by *Glomar Challenger* at Site 596. *Melville* had already surveyed the site and reported an acoustically transparent layer at 34 m and basement at 45 m below seafloor. The *Glomar Challenger* profile (Fig. 6) shows a strong reflector at 5 m, which appears to be the hardground cored at 6 m, where the sound velocity increases abruptly from 1.48 to 1.62 km/s and other physical properties change. The 3.5-kHz record does not show any coherent reflector below the top layer of porcellanite cored at 38 m. The top of a corresponding reverberant layer ranges from 33 to 42 m in depth, suggesting great local variability in the distribution of porcellanite.

The basement was cored at 68 m, but recorded by *Melville* at 45 m. We are not sure that we cored where *Melville* made the record. However, the great difference in apparent depth indicates, by the argument presented for Site 595, that much, perhaps half, of sedimentary Unit III is porcellanite or chert.

SUMMARY AND CONCLUSIONS

The objectives of Site 596 were to obtain a well-cored reference sediment section in the vicinity of Site 595, where the marine seismic system was deployed, and the age of the oldest sediments in the area, thus dating basement. Originally we planned to do this coring in a hole using the Site 595 beacon; and the reports in this chapter would then have been part of the Site 595 report. However, radio consultation with the chief scientists aboard *Melville* persuaded us that coring in the vicinity of their OBS array might trigger recording in the instruments. If this happened frequently enough in the first 24 hr., it might needlessly consume tape and cause the instruments to adopt a higher signal:noise ratio before accepting seismic events for triggered recording. Earthquakes might then be screened out.

Thus, we moved to a location about 8 km west and slightly south of Site 595 and dropped a beacon for a new site, 596. The site selected was on the recommendation of *Melville's* scientific staff. It is located in a fairly wide flat-bottomed depression with sediment cover almost precisely as thick as at Site 595.

Table 4. Water content cylinder data, Site 596.[a]

Core-Section (top of interval in cm)	Sub-bottom depth (m)	Wet-bulk density (g/cm^3)	Wet water content (%)	Dry water content (%)	Porosity (g/cm^3)	Void[b] ratio	Grain density (g/cm^3)
Hole 596							
1-2, 125	2.6	1.25	76.0	284	94.6	17.50	6.16
1-3, 110	3.8	1.28	65.2	176	83.4	5.01	2.85
1-4, 70	4.7	1.27	66.1	182	83.7	5.14	2.81
2-1, 20	5.7	1.26	67.1	190	84.5	5.47	2.87
2-2, 30	7.2	1.23	68.4	201	84.1	5.30	2.63
2-3, 106	9.1	1.23	70.8	224	87.4	6.95	3.10
2-6, 36	11.8	1.24	68.9	205	85.4	5.84	2.84
3-1, 120	16.3	1.21	74.2	261	89.6	8.65	3.31
3-2, 30	16.8	1.21	72.4	240	87.9	7.24	3.01
3-6, 25	21.3	1.26	66.7	187	84.1	5.29	2.82
2-5, 50	10.9	1.24	71.0	225	87.8	7.18	3.19
5-2, 80	36.5	1.28	67.2	191	86.4	6.33	3.31
5-3, 54	37.6	1.29	64.5	170	83.2	4.96	2.90
Hole 596A							
1-1, 135	68.4	1.22	74.5	265	91.2	10.40	3.93
1-2, 105	69.6	1.32	69.2	208	91.1	10.20	4.95
1-3, 106	71.1	1.37	65.3	176	89.2	8.27	4.68
1-5, 105	74.1	1.64	50.6	99	83.2	4.94	4.99
Hole 596B							
1-3, 120	28.9	1.29	66.5	185	85.7	5.98	3.23
1-1, 123	25.5	1.29	67.6	194	87.3	6.85	3.53
1-5, 120	31.9	1.28	66.5	185	85.4	5.83	3.15

[a] Corrected for salt content.

[b] Void ratio $= \frac{\text{porosity}}{100 - \text{porosity}}$.

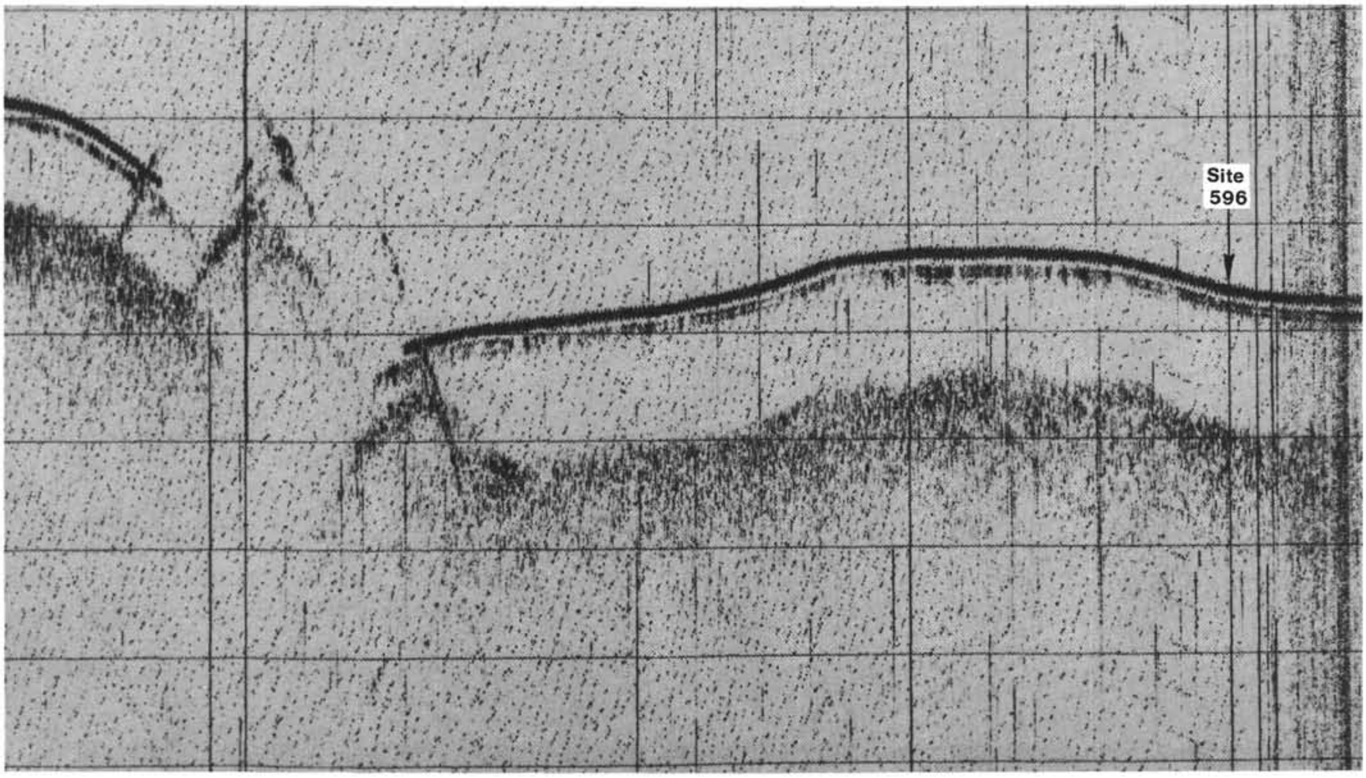


Figure 6. *Glomar Challenger* 3.5-kHz profile over Site 596 showing a thin but uniform sediment drape over acoustic basement.

Three holes were drilled at Site 596. At Hole 596 we used the hydraulic piston core for 35 m until cherts were reached. The hole was then rotary cored to basement, with poor recovery. Holes 596A and 596B were single hydraulic piston cores, above basement and above the cherts, respectively.

Combining the results of all the holes at Site 596, we recovered 51.8 m of the sediment section in 70.5 m cored for an overall recovery rate of 73.5%. This contrasts with a sediment recovery of 40.5% in Hole 595A. The sediments at Site 596 are also far less disturbed and much more suitable for biostratigraphy and measurements of physical properties.

The sediments have been divided into four units, and the third of these into two subunits, Unit I at the top of the sediments is a typical variably zeolitic pelagic clay with manganese nodules both at the surface and forming a hardground associated with stiff clay about 6 m below the mud line. The stiff clay is somewhat denser than adjacent softer clays and has a higher shear strength. It probably corresponds to a very shallow reflector observed in 3.5-kHz records at Site 595.

The contact with Unit II occurs at 10.7 m below the mud line and is very sharp and horizontal in the piston-cored sediments. The sediments below the contact are significantly darker than those above. They are also softer, smoother, and have lower shear strength. Smear slides contain a higher proportion of an amorphous iron oxyhydroxide, termed RSOs in the sediment lithology section of this report. The significance of the lithologic contrast between Unit I and II is difficult to say at this time. It may mark a significant change in the deep circulation of the South Pacific, since that circulation is largely responsible for the dispersal of metalliferous components produced at the East Pacific Rise. These may be the principal pigments in the sediments.

Unit III, between 26.7 and about 68 m BSF, consists mainly of very dusky red, variably zeolitic pelagic clays similar to those of Unit II. However, the upper part of the unit (Subunit IIIA; 28.7–38 m BSF) also contains thin beds of much paler reddish yellow and yellowish brown clay. The lower part to the unit (Subunit IIIB; 38–68 m BSF) contains similar clays, especially in Core 596-5, the final hydraulic piston core, but also contains porcellanites and cherts. The origin of the pale clay intervals is obscure. They are almost pure smectite, but are almost completely devoid of the amorphous iron oxyhydroxides that color the surrounding clays. Some of the pale clay beds show minor bioturbation but a number of them show none. Lower in the unit, some porcellanites have a similar pale color, but X-ray diffractograms of the pale clays show no trace of cristobalite, and they are devoid of radiolarians in smear slides. They may be highly altered ash beds, but if so there are no relict feldspars or other minerals that might indicate a volcanic origin. Until chemical data can be obtained on these sediments, their origin must remain a puzzle.

As mentioned earlier, the top of Subunit IIIB was sampled with the hydraulic piston corer and contains interbedded porcellanites, zeolitic pelagic-clays—some of them radiolarian bearing, and a few of the pale clay beds described above. Below Core 596-5, only highly disrupted and broken porcellanite, chert, and semi-indurated siliceous pelagic clay was recovered in this subunit.

The deepest sediments, piston cored in Hole 596A from 66 to 70 m BSF, are those of Unit IV. These are a most unusual, very dark, metalliferous sediment rich in black, evidently manganese rich, micronodules and dark amorphous oxyhydroxides. They are not the typical brownish red color of basal metalliferous sediments, but they are clearly a type of such sediment related to axial hydrothermal activity. A coarse fraction of a sample of these sediments contains radiolarians which, regrettably, were too overgrown to be suitable for obtaining the age of the crust at this site. The basal sediments of Unit IV are significantly denser than overlying sediment, presumably because of their high metalliferous content.

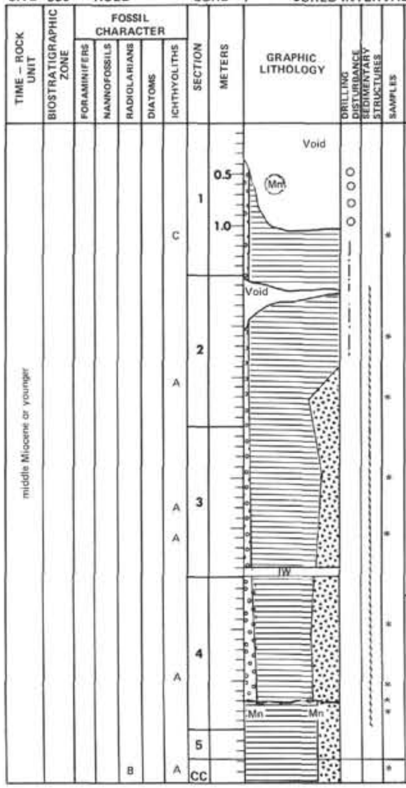
Sites 595 and 596 were estimated by H. W. Menard to be on magnetic Anomaly M-29, Callovian (Jurassic) in age, or about 158 Ma. This is much older than anyone on board originally had expected. Ichthyolith ages (Winfrey et al., this volume) indicate an age of at least Early Cretaceous for this site. Sites 595 and 596 are thus located in some of the oldest crust ever drilled in the Pacific. Only Site 534, on the Blake Spur in the North Atlantic, has reached sediments as old as these may be. It is premature to discuss the full implications of the sediments at Sites 595 and 596 to the paleoenvironment of the Mesozoic world ocean, but if these sites are representative, and as old as the magnetic anomalies suggest, that ocean was a very unproductive place and supplied almost no biogenic sedimentary material to the seafloor. As suggested in the discussion of sediment lithology for Site 595, the pre-Late Cretaceous section in this part of the Pacific may indeed generally be vanishingly thin, perhaps at most 5 or 10 m thick.

Only three basalt chips of significant size were recovered in Hole 596. They contain alteration halos and carbonate veins. A thin section prepared of the basalts shows them to be aphyric, sparsely vesicular, and rich in secondary iron oxyhydroxides which are concentrated along fine fractures in the alteration halos.

REFERENCE

Boyce, R. E., 1976. Definitions and laboratory techniques of compressional sound velocity parameters and wet-water content, wet-bulk density, and porosity parameters by gravimetric and gamma ray attenuation techniques. *In* Schlanger, S. O., Jackson, E. D., et al., *Init. Repts. DSDP*, 33: Washington (U.S. Govt. Printing Office), 931–958.

SITE 596 HOLE CORE 1 CORED INTERVAL 0.0–5.5 m



LITHOLOGIC DESCRIPTION

Piston core

10YR 3/4

5YR 3/2

PELAGIC CLAY and ZEOLITIC PELAGIC CLAY with Fe/Mn NODULES and Fe/Mn encrusted HARDGROUND. Dominant colors are dark yellowish brown (10YR 3/4) which grades to dark reddish brown (5YR 3/2) at the top of Section 4.

Faint mottles are rare to moderate throughout core.

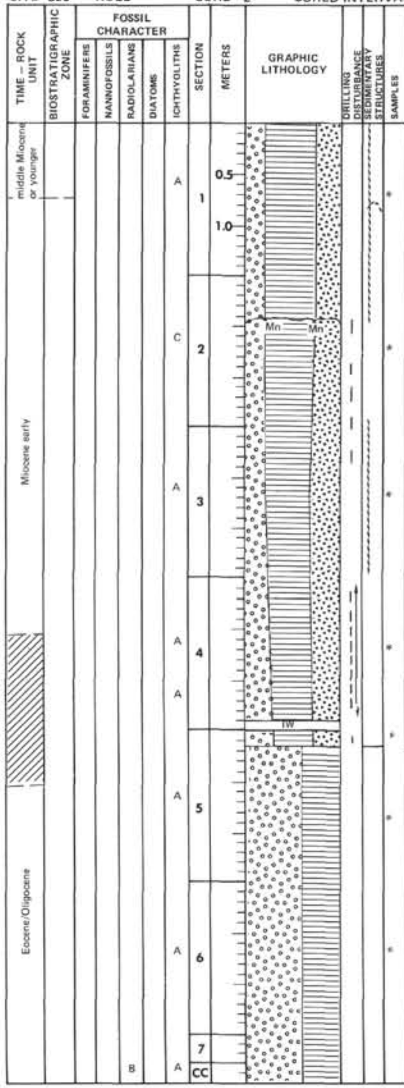
Clay firm at the top of core but becomes progressively indurated toward Fe/Mn encrusted hardground in Section 4. Below the hardground the clay is firm again.

In Section 4 the Fe/Mn NODULE is black (7.5YR N2) with crenulated outer surface and a smooth inner surface. The nodule has nucleated on Fe/Mn coated grains.

SMEAR SLIDE SUMMARY (%):

	1, 101	2, 60	3, 50	4, 50	CC
	D	D	D	D	D
Texture:					
Silt	–	–	2	–	1
Clay	100	100	98	100	99
Composition:					
Feldspar	–	TR	1	1	TR
Clay	83	92	71	58	70
Micronodules	1	TR	1	TR	TR
Zeolite	2	2	15	25	20
Sponge spicules	TR	–	–	–	–
Fish remains	2	TR	2	1	3
RSO	10	5	10	15	7

SITE 596 HOLE CORE 2 CORED INTERVAL 5.5–15.1 m



LITHOLOGIC DESCRIPTION

Piston core

5YR 3/4

10R 2/1

ZEOLITIC PELAGIC CLAY from the top of the core to Section 5, 15 cm.

Dominant color is dark reddish brown (5YR 3/4).

Mottling is faint and rare.

Fe/Mn encrusted hardground occurs at Section 2, 42 cm.

Stiff clay occurs throughout the core, except for approximately one meter below the hardground, where the clay is partially indurated.

METALLIFEROUS PELAGIC CLAY begins at Section 4 and continues to the end of the core.

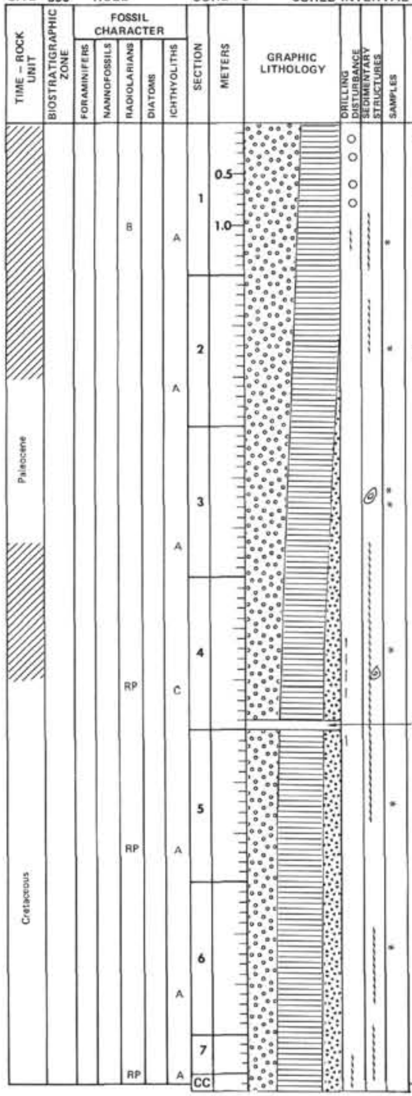
Dominant color is reddish black (10R 2/1).

Massive, stiff clay.

SMEAR SLIDE SUMMARY (%):

	1, 70	2, 70	4, 70	5, 70	6, 70
	D	D	D	D	D
Texture:					
Silt	2	–	20	10	5
Clay	98	100	80	90	95
Composition:					
Quartz	–	TR	–	–	–
Feldspar	TR	TR	TR	TR	–
Clay	50	50	40	23	28
Micronodules	1	–	1	2	2
Zeolite	26	22	30	5	5
Fish remains	3	3	2	10	10
RSO	20	25	25	60	55

SITE 596 HOLE CORE 3 CORED INTERVAL 15.1–24.7 m



LITHOLOGIC DESCRIPTION

Piston core

10R 2/1

2.5YR 2/2

METALLIFEROUS PELAGIC CLAY grading to ZEOLITIC METALLIFEROUS PELAGIC CLAY in Section 2.

Dominant colors are reddish black (10R 2/1) and very dusky red (2.5YR 2/2). These color gradually change between Sections 1 and 2.

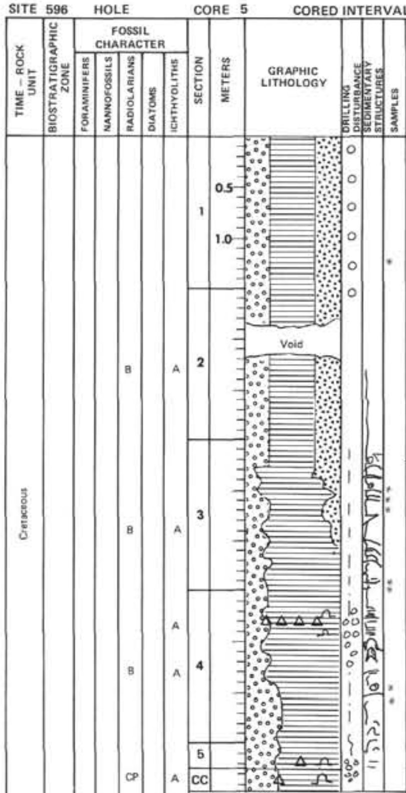
Stiff massive clay with rare faint mottling. Single halo burrows are seen in Sections 3 and 4.

SMEAR SLIDE SUMMARY (%):

	1, 117	2, 70	3, 70	4, 70	5, 70
	D	D	D	D	D
Texture:					
Silt	2	1	2	2	2
Clay	98	99	98	98	98
Composition:					
Feldspar	TR	–	–	–	–
Clay	31	32	27	35	37
Micronodules	2	2	4	2	3
Zeolite	5	8	15	20	20
Foraminifers	TR	TR	–	TR	TR
Fish remains	7	8	9	–	5
RSO	55	50	45	40	35

NOTE: Core 4, 24.7–34.3 m: no recovery.

SITE 596 HOLE CORE 5 CORED INTERVAL 34.3–39.8 m



LITHOLOGIC DESCRIPTION

Piston core

10R 2/2

10R 2/2 with streaks of 7.5YR 6/6, 10R 2/1, and 7.5YR 3/2

From the top of the core to the top of Section 3, the dominant sediment type is ZEOLITIC METALLIFEROUS PELAGIC CLAY. In the remainder of the core the lithology is highly variable. METALLIFEROUS PELAGIC CLAY and PELAGIC CLAY is interbedded with RADIOLARIAN-BEARING PORCELLANITE.

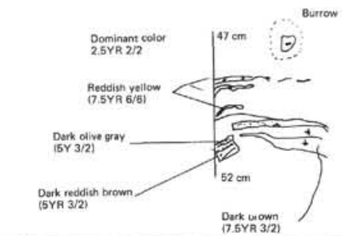
The dominant color is very dusky red (10R 2/2). The interbedded pelagic clay and porcellanite is banded and streaked by reddish yellow (7.5YR 6/6) dark olive gray (5Y 3/2) and dark brown (7.5YR 3/2), see sketch.

Much the linear was shattered and extensive reconstruction was necessary. Faults with small offsets throughout core and porcellanite breccia, are the result of coring.

Where not removed by coring deformation, faint, rare, mottles occur throughout the core. Single halo burrows are seen in Sections 3 and 4.

SMEAR SLIDE SUMMARY (%):

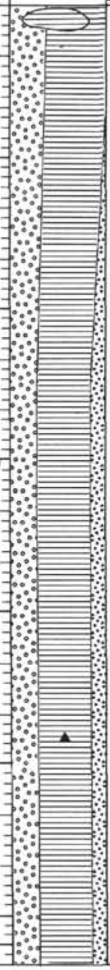
	2, 114	3, 48	3, 50	4, 94	4, 91
	D	M	D	M	D
Texture:					
Silt	5	–	–	–	5
Clay	95	100	100	100	95
Composition:					
Clay	34	83	75	83	48
Micronodules	3	TR	3	TR	4
Zeolite	25	3	2	–	–
Radiolarians	–	TR	–	10	72
Fish remains	8	2	5	5	7
RSO	30	2	15	2	41



SITE 596 HOLE CORE 6 CORED INTERVAL 39.8–49.4 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	ICHTHYOLITHS	SECTION	METERS
Cretaceous	R: Albian or Late Cretaceous			RP		A	1	0.5, 1.0
							2	
				CP		A	3	
				CP		A	4	
				CP		C	5	
						R	6	
							7	
				CP			CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / SAMPLES

LITHOLOGIC DESCRIPTION

Rotary cored by extended core barrel

10YR 6/6

METALLIFEROUS PELAGIC CLAY and ZEOLITIC METALLIFEROUS PELAGIC CLAY with minor occurances of PELAGIC CLAY and CHERT.

Dominant color is very dusky red (2.5YR 2/2).

Coring disturbance has destroyed all structure.

The palagic clay at the top of Section 1 is brownish yellow (10YR 6/6) and is slightly burrowed.

The chert in Section 5 appears to be a fragment of a chertified burrow.

SMEAR SLIDE SUMMARY (%):

	1, 5	1, 96	3, 70	5, 106
	M	D	D	D
Texture:				
Silt	–	–	5	2
Clay	100	100	95	98
Composition:				
Feldspar	–	–	TR	TR
Clay	85	47	40	40
Micronodules	2	3	3	3
Zeolite	5	5	15	15
Foraminifers	–	TR	–	TR
Radiolarians	TR	TR	TR	TR
Fish remains	5	5	7	7
RSO	3	40	35	35

2.5YR 2/2

SITE 596 HOLE CORE 7 CORED INTERVAL 49.4–59.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	ICHTHYOLITHS	SECTION	METERS
Mesozoic				RP		Bone fragments	CC	

GRAPHIC LITHOLOGY

LITHOLOGIC DESCRIPTION

Rotary cored with extended core barrel

METALLIFEROUS PELAGIC CLAY with PORCELLANITE and CHERT.

Drilling breccia.

Color of sediment is very dusky red (2.5YR 2/2), porcellanite is very pale brown (10YR 8/4) and chert varies between dark gray (10YR 3/1) to black (10YR 2/1).

SMEAR SLIDE SUMMARY (%):

	CC
	D
Texture:	
Clay	100
Composition:	
Clay	40
Micronodules	10
Zeolite	10
Radiolarians	TR
Fish remains	2
RSO	38

SITE 596 HOLE CORE 8 CORED INTERVAL 59.0–68.6 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	ICHTHYOLITHS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
							CC		Mn				Rotary cored with extended core barrel

CHERT with METALLIFEROUS PELAGIC CLAY.

Chert is dark gray (10YR 3/1) with streaks of very pale brown (10YR 7/3).

Sediments very dusky red (2.5YR 2/2).

SMEAR SLIDE SUMMARY (%):

	CC D
Texture:	
Silt	2
Clay	98
Composition:	
Clay	33
Micronodules	10
Zeolite	2
Radiolarians	3
Fish remains	7
RSO	45

SITE 596 HOLE CORE 9 CORED INTERVAL 68.6–76.1 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER: FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	ICHTHYOLITHS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
						Bone fragments	1	0.5	Mn / Basalt			*	Rotary cored with extended core barrel

METALLIFEROUS CLAY with CHERT.

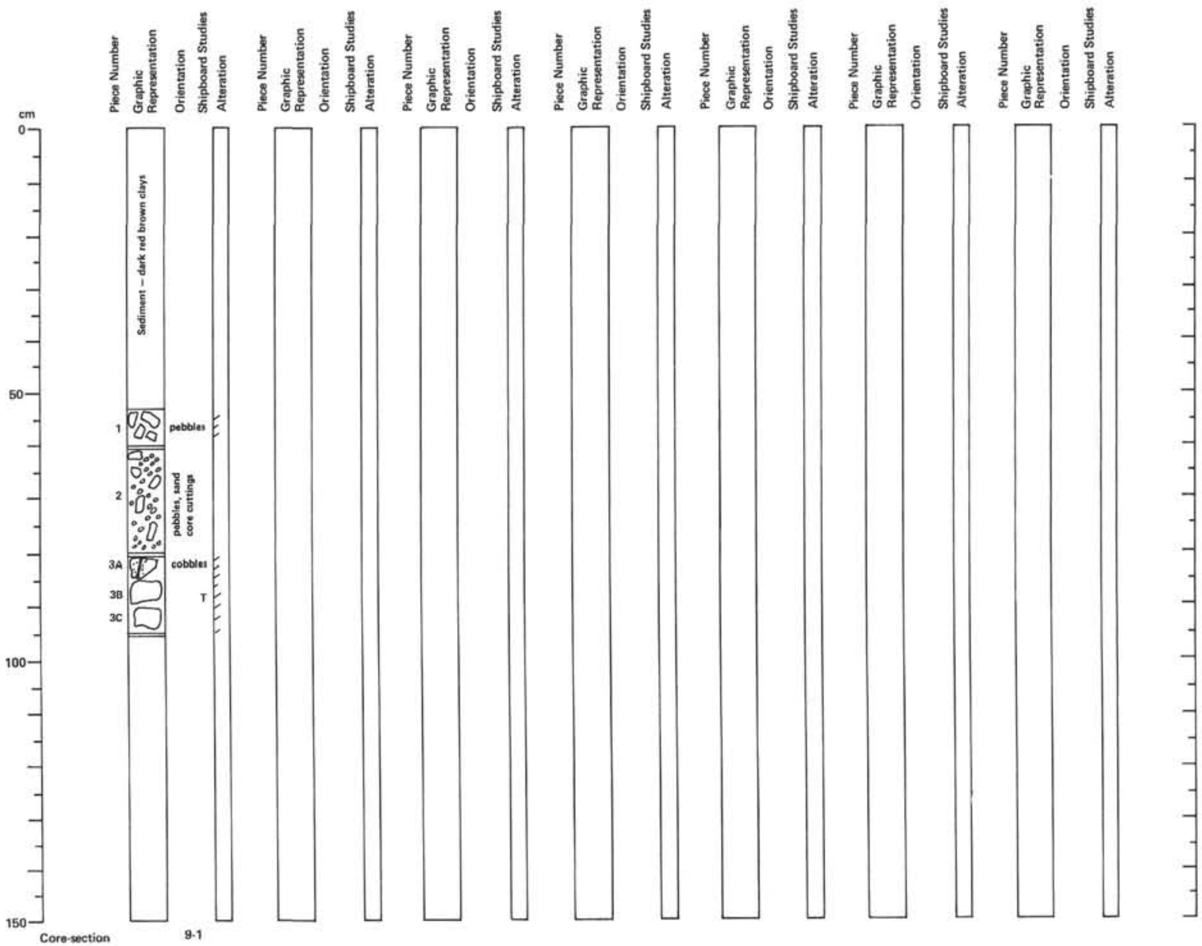
Drilling breccia.

Sediment is reddish black (10R 2/1). All structures destroyed by coring disturbance.

Chert is black (2.5YR N2).

SMEAR SLIDE SUMMARY (%):

	1, 20 D
Texture:	
Clay	100
Composition:	
Clay	25
Micronodules	5
Zeolite	2
Foraminifers	TR
Fish remains	3
RSO	65

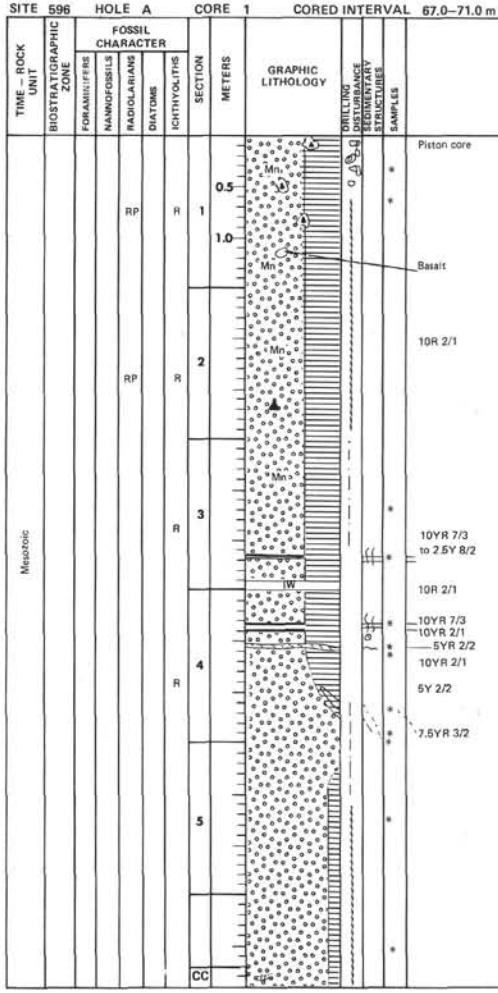


91-596-9 Core depth: 5779.1–5786.6 m Sub-bottom depth 68.6–76.1 m

Section 1:

Fine-grained, gray, aphyric igneous rock, quite felsic in appearance. Non-vesicular. Veined. Veins filled with iron-oxides, carbonates. Fracture surfaces stained with iron-hydroxides, manganese coatings. Also, small amount green smectites. Thin alteration halos along fractures, defined by yellow-brown staining. Whole rock alteration appears to be minimum.

SITE 596 HOLE A CORE 1 CORED INTERVAL 67.0–71.0 m



LITHOLOGIC DESCRIPTION

METALLIFEROUS CLAY and interbedded PELAGIC CLAY.

Pieces of basalt and chert mixed into Sections 1 and 2 are believed to be contamination from Hole 596. Below Section 4, 130 cm all this sediment has flow-in disturbance and has been drawn in by suction and does not represent a cored interval.

Dominant color is reddish black (10R 2/1).

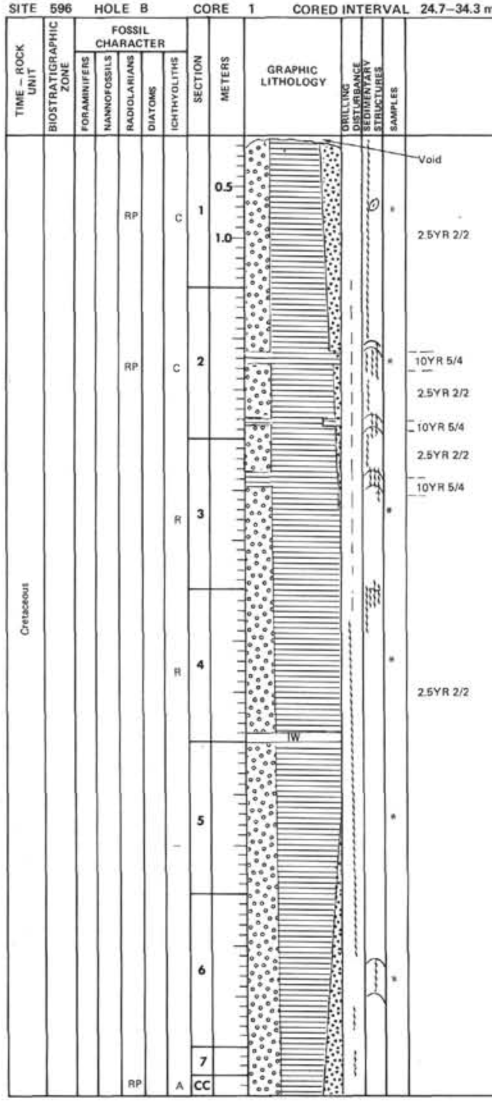
MICROSPAR (calcite) vein cuts across the sediment in Section 4 at 53 cm. No alteration rind is visible, but is believed to be of hydrothermal origin and not sedimentary. Color is dark reddish brown (5YR 2/2).

In Section 3, 114–116 cm and Section 4, 31–36 cm moderately bioturbated, very pale brown (10YR 7/3) to white (2.5Y 8/2) pelagic clay.

SMEAR SLIDE SUMMARY (%):

	1, 70	3, 71	4, 32	4, 54	4, 136
	D	D	M	D	D
Texture:					
Silt	2	–	–	–	–
Clay	98	100	100	100	100
Composition:					
Quartz	TR	–	–	–	–
Feldspar	1	TR	TR	–	–
Clay	25	25	97	25	–
Micronodules	5	8	1	10	–
Zeolites	2	3	–	2	–
Radiolarians	–	TR	TR	TR	–
Fish remains	5	2	–	–	1
RSO	62	60	2	63	99

SITE 596 HOLE B CORE 1 CORED INTERVAL 24.7–34.3 m



LITHOLOGIC DESCRIPTION

Piston Core.

ZEOLITIC METALLIFEROUS PELAGIC CLAY to METALLIFEROUS PELAGIC CLAY with thin interbeds (7–12 cm) of PELAGIC CLAY.

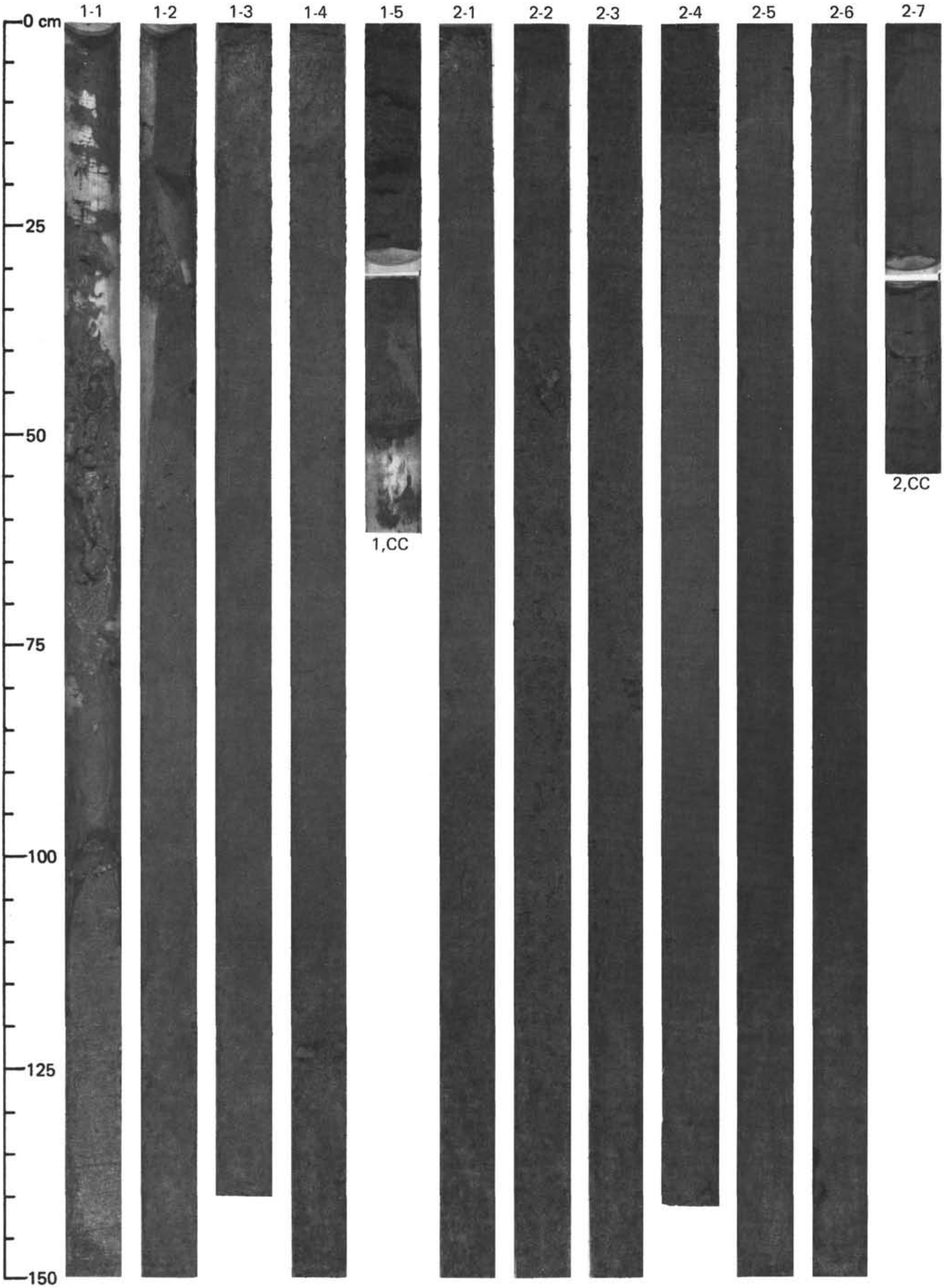
Dominant color is very dusky red (2.5YR 2/2). Interbeds of pelagic clay are yellowish brown (10YR 5/4).

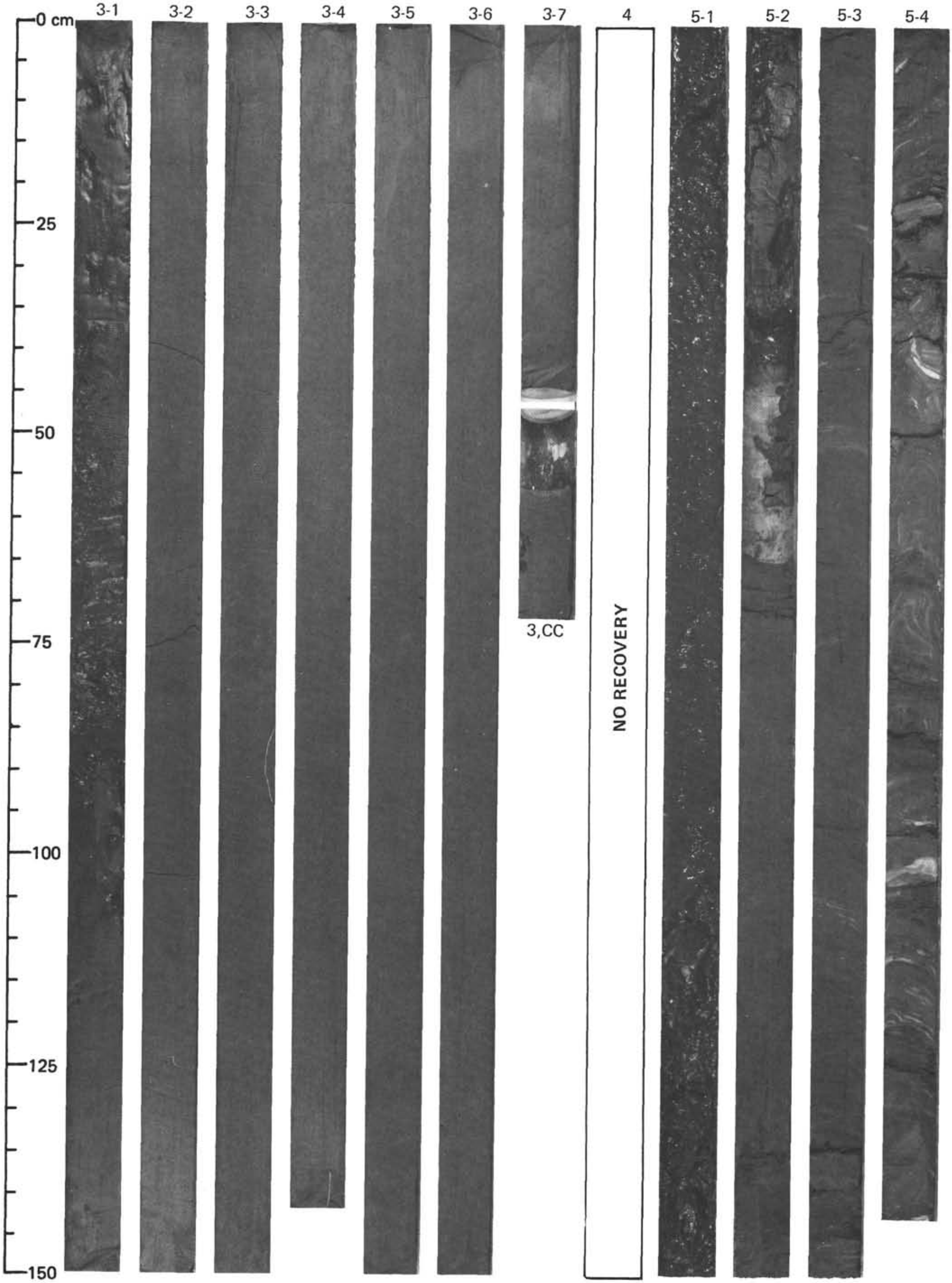
The clay is stiff and generally massive. Only faint, rare to moderate mottling is seen the darker color clay. In the lighter color clay is strongly bioturbated. Single halo burrow is seen in Section 1.

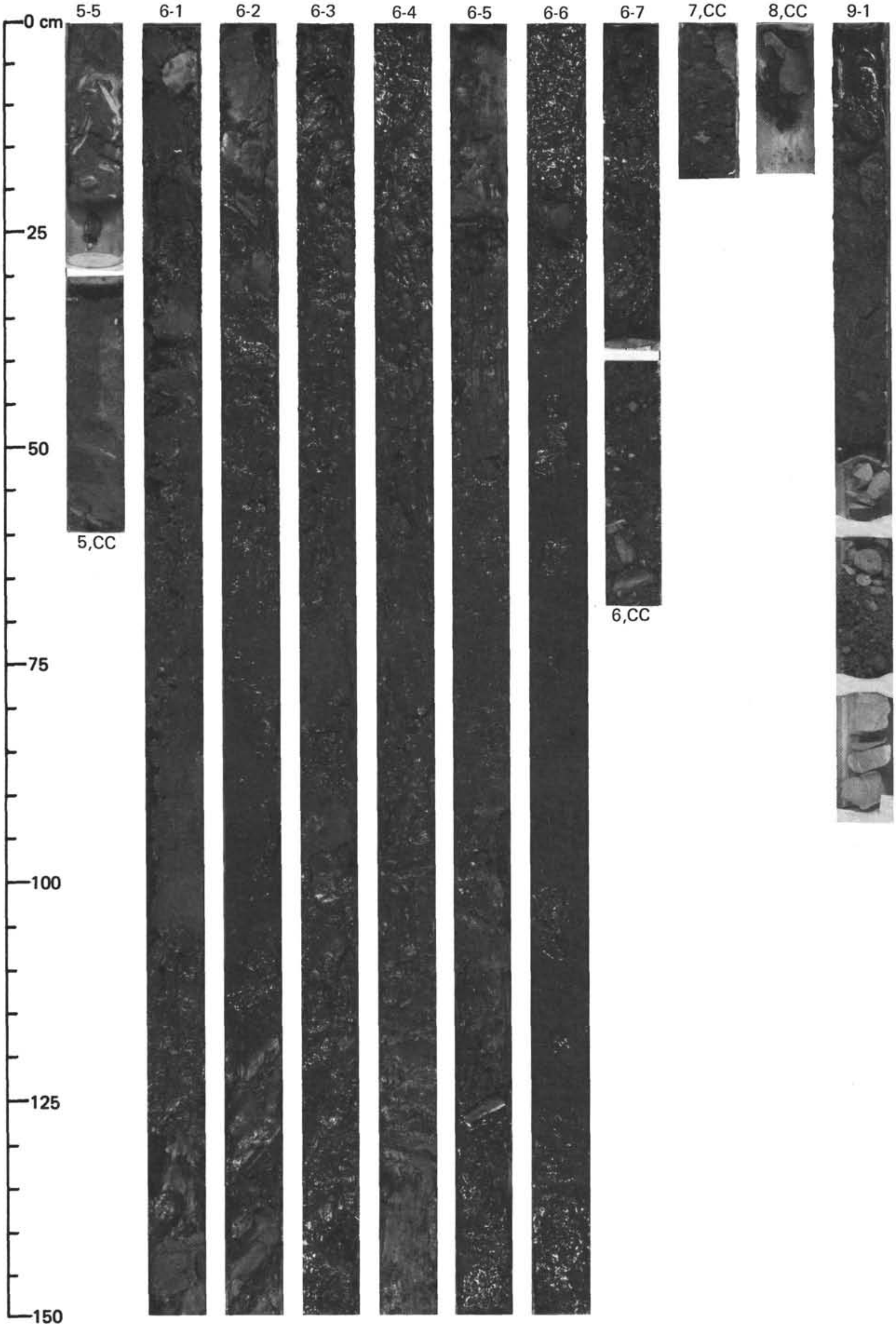
Radiolarians are first observed in this core.

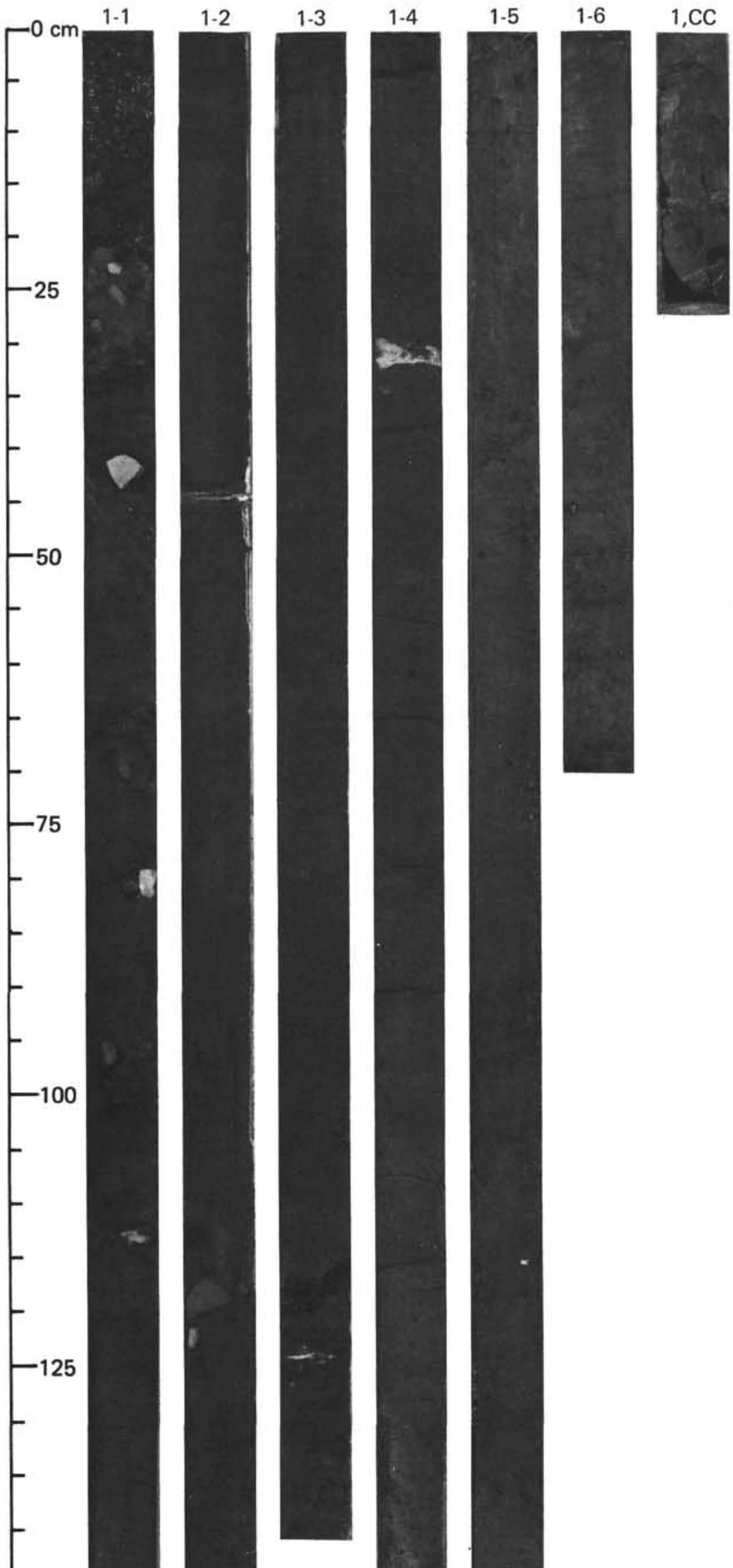
SMEAR SLIDE SUMMARY (%):

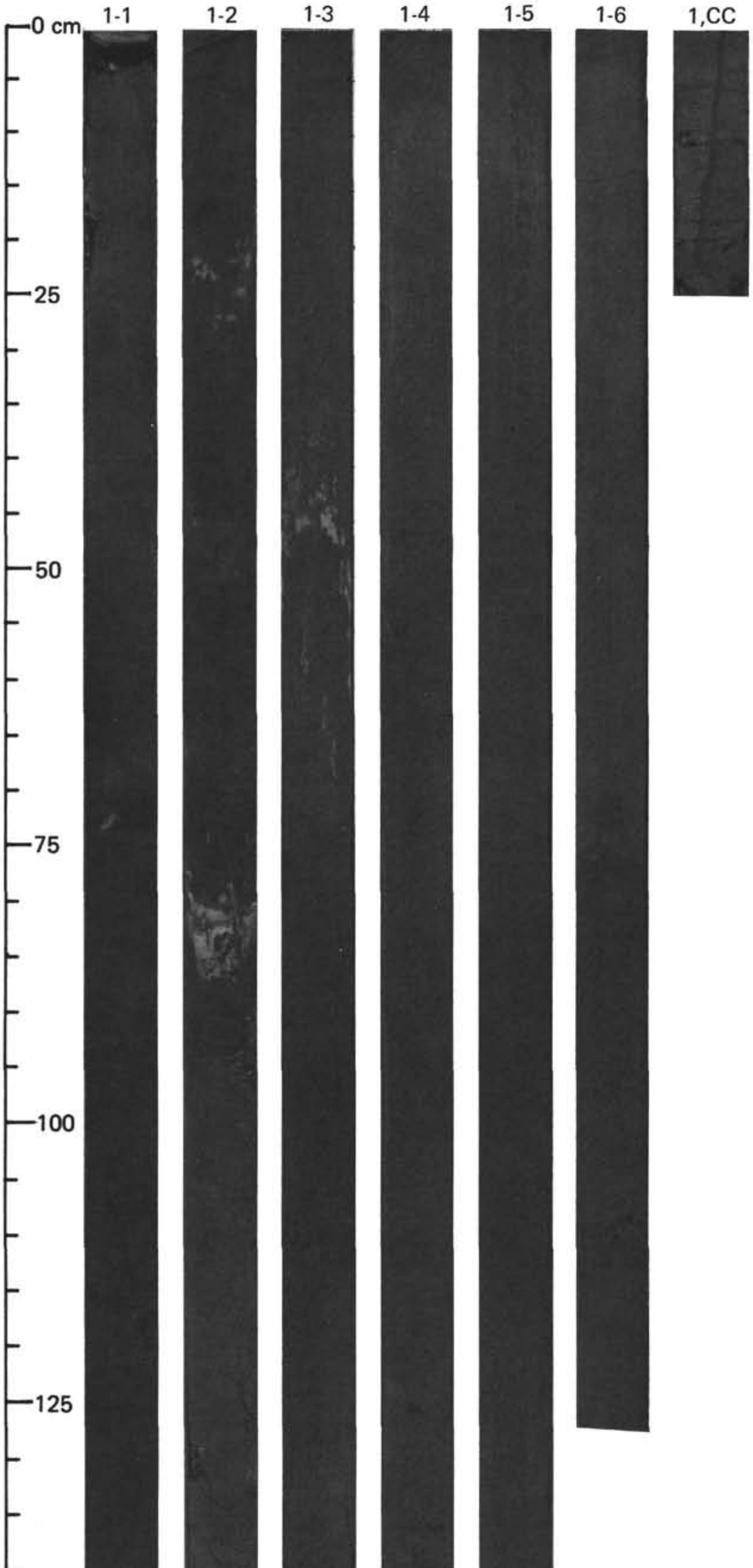
	1, 85	2, 70	3, 70	5, 70	6, 80
	D	M	D	D	D
Texture:					
Silt	2	2	–	–	–
Clay	98	98	100	100	100
Composition:					
Feldspar	–	–	TR	–	–
Clay	35	82	55	50	40
Micronodules	3	–	2	3	3
Zeolite	20	7	2	5	15
Radiolarians	2	TR	1	–	1
Fish remains	7	8	5	7	5
RSO	30	3	35	35	36


1-1
1-2
1-3
1-4
1-5
2-1
2-2
2-3
2-4
2-5
2-6
2-7
0 cm
25
50
75
100
125
150
1,CC
2,CC


0 cm
25
50
75
100
125
150
3-1
3-2
3-3
3-4
3-5
3-6
3-7
3,CC
4
NO RECOVERY
5-1
5-2
5-3
5-4


0 cm
25
50
75
100
125
150
5-5
5,CC
6-1
6-2
6-3
6-4
6-5
6-6
6-7
6,CC
7,CC
8,CC
9-1


1-1
1-2
1-3
1-4
1-5
1-6
1,CC
0 cm
25
50
75
100
125
150


0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1-4
1-5
1-6
1,CC