3. SITE 45

Shipboard Scientific Party[1]

SITE DATA

Occupied: June 17-20, 1969.

Position: Abyssal floor of Pacific:
Latitude 24° 15.9′N .
Longitude 178° 30.5′W.

Water Depth: 5508 meters.

Hole 45.0: No cores (twisted off).

Hole 45.1: Four cores; total depth 105 meters in Cenomanian carbonates (twisted off).

MAIN RESULTS

The oceanic crust at this site is pre-Cenomanian; beds of lithified and partly silicified tuff and ash, interbedded with brown clay, record an episode of Paleogene (Eocene-Oligocene) and Late Cretaceous vulcanism, and appear to form here the upper opaque layer of the seismic reflection profiles; upper Cretaceous (Cenomanian tuffaceous chalk, limestone, and chert lie near the base of this sequence of closely spaced reflectors.

BACKGROUND

A principal aim of the Pacific Advisory Panel in recommending this site was to identify the composition and age of the upper opaque seismic layer. A survey of the site provided good profile control (Chapter 19 of this report) and a piston core of brown clay. A fauna of badly preserved coccoliths and foraminifera, from Upper Cretaceous to Miocene. Small chert chips and glauconite are also present in some abundance according to the site survey core descriptions. However, the drilling results failed to support this observation. A surface core here failed to reveal either chert or glanconite in the sediment, which was a zeolite brown clay with poorly sorted ash layers. The increase in grain size is attributed to greater volcanic activity in that area. Downward increase in grain size suggested to the site surveyors that this core is a Miocene turbidite, derived from outcrops of Cretaceous and younger sediments in a much shallower setting–perhaps from sea mounts to the north.

Strategy

The area of the proposed site offered nowhere the 60 to 90 meter thickness of acoustically transparent material which would ensure good spudding and quick burial of the brittle bottom-hole assembly of drill collars and bumper sub.

The scientists proceeded, therefore, on the optimistic assumption that the upper opaque layer would prove sufficiently soft for spudding-in, and concentrated their search on finding a structure which brings Horizon B′ relatively close to the surface, so as to be able to reach it and to penetrate beyond it to the basement should B′ prove to be something else.

A small topographic scarp, recorded on the site surveys eastern north-south line (Figure 1) and on a previous east-west *Vema* track near their crossing corresponds to a larger subsurface structure indicated somewhat vaguely on the acoustic profiles, which brings Horizon B′ to within 0.32 seconds of the surface. The *Challenger* topographic and magnetic profile is given as Figure 2. Soundings in the area of Site 45 are given as Figure 3.

OPERATIONS

Site 45 was occupied at 1122 hours on June 17. Hole 45.0 was intended to wash down through the upper 40 meters of sediment before coring, but a hard layer was encountered at 18 meters, so coring began there. While cutting this first core the bottom hole assembly parted at a bumper-sub service connection. Failure was attributed to a long, stiff, unsupported bottom-hole assembly of drill collars and bumper sub, which collapsed when it encountered hard rock close to the surface. Further complications may have been caused by a spudding action of the bumper sub, induced by surges in water pressure.

Hole 45.1 was drilled with only three drill collars and no bumper sub. It encountered hard layers at a depth of only 1.5 meters. Alternate hard and soft layers continued to a total depth of 105 meters, when the drill pipe twisted off above the bit.

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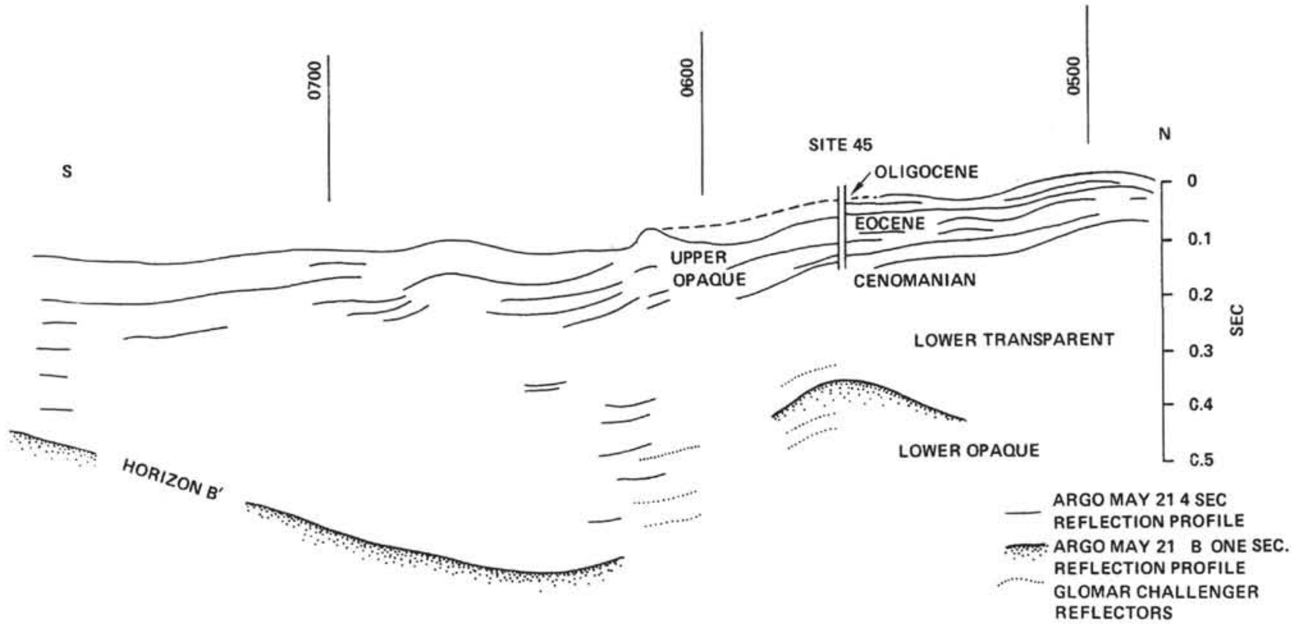

Figure 1. *Drawing of seismic profile at Site 45.*

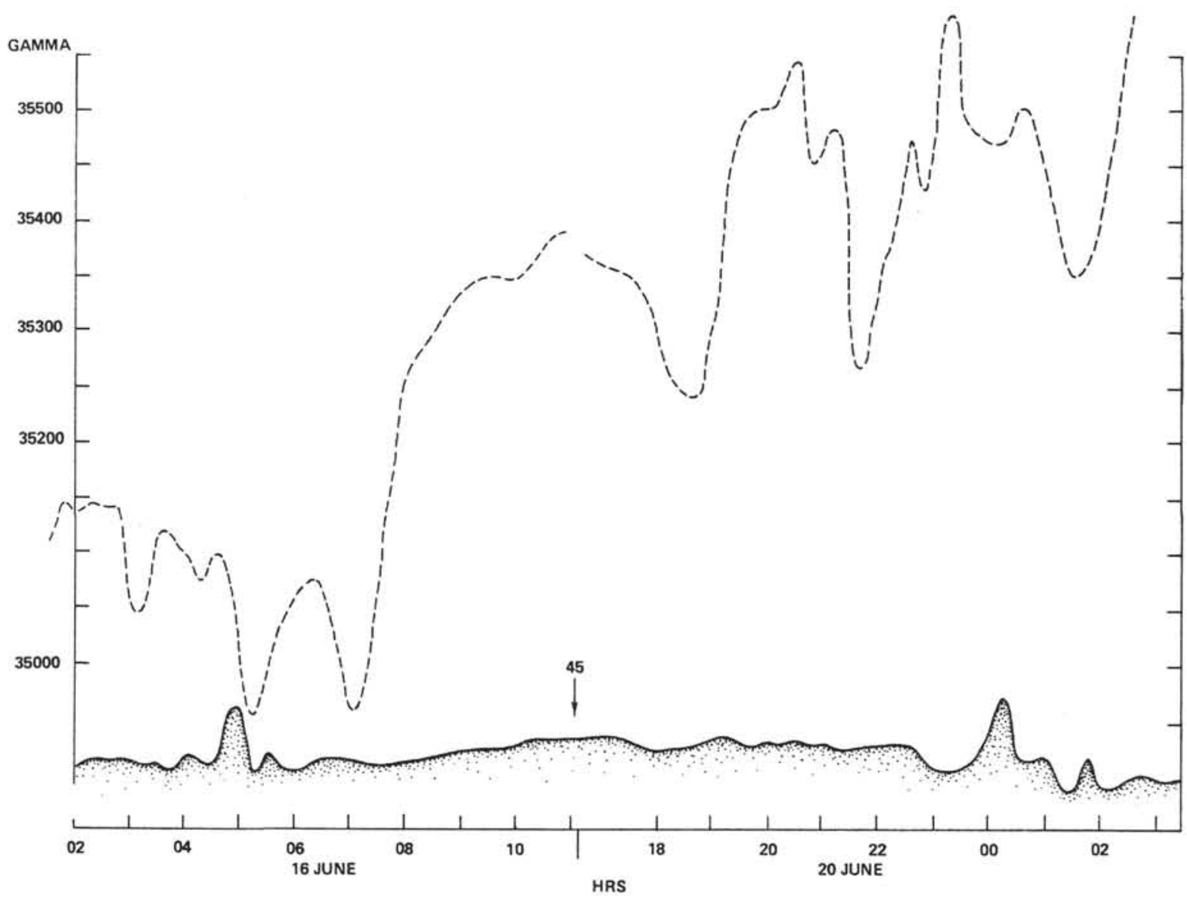

Figure 2. Challenger *bathymetric and magnetic profile at Site 45.*

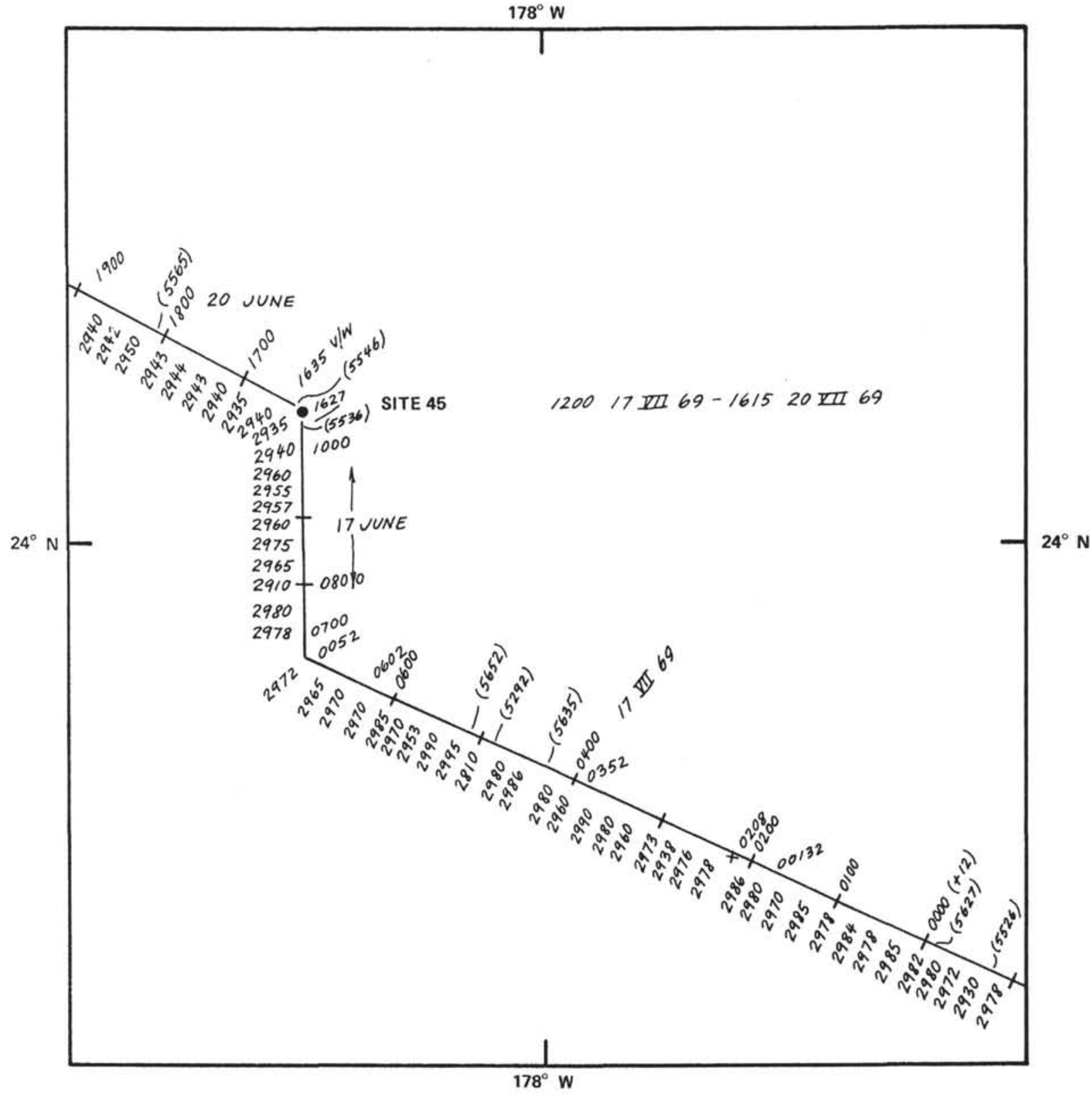

Figure 3. *Bottom soundings in area of Site 45.*

The surges in pump pressure were greater without the bumper sub than with it, and it was concluded that the bumper sub had been fulfilling its function properly in Hole 45.0. Bumper subs were used in all subsequent drilling.

The site was abandoned at 1630 hours on June 20 having twisted off for the third time in as many holes, under extremely difficult drilling conditions.

NATURE OF THE SEDIMENTS

Hole 45.0

A hard layer was encountered at about 20 meters subbottom depth, and the bottom assembly of the drill string was sheared off. A small (1 cubic centimeter) sample of brown clay of Oligocene age was scraped off of the lowermost drill pipe on the string.

TABLE 1
Summary of Coring at Site 45

Core No.	Interval Cored (Below Mudline) (ft)	(m)	Recovery (ft)	(m)
45.1-1	0-27	0.0-8.2	22	2.5
45.1-2	154-184	46.9-56.1	1	0.3
45.1-3	283-313	86.3-95.4	1	0.3
45.1-4	313-343	95.4-104.5	0	0.0

Water depth: 5508.3 meters (18,072 feet)

Hole 45.1

Of the three cores attempted in this hole, only Core 1 recovered significant amounts of sediment.

Seven meters of sediment were recovered in Core 1 which was drilled from 1.5 to 8.5 meters below mudline. The sediment in this core is predominantly moderate brown, zeolitic clay and clayey silt, with interspersed layers and patches of dark yellowish-brown volcanic ash. Most of the structures in this core have been destroyed or distorted by drilling. The brown clay has become water saturated and very soupy. The ash layers have distorted contacts with the clay, and in places form completely isolated blocks surrounded by clay. The ash beds vary in thickness from 5 to 20 centimeters and are most common in Sections 2 through 4 of Core 1. In one place 140 centimeters below the top of Section 2) the lower boundary of an ash layer has been burrowed and mottles of ash occur in the underlying brown clay.

These brown sediments are mainly silty clays to clayey silts, with silt-size grains making up a fourth to two-thirds of the sediment. Compositionally, clay minerals, quartz and feldspars form the bulk of the sediment and zeolites are very abundant, composing up to one-third of the sediment in some cases. Iron oxides, mainly limonite with rare hematite, and both fresh and altered volcanic fragments of silt size are common. Also present in most samples are small amounts, generally less than 5 per cent, of nannofossils, poorly preserved Radiolaria, and dolomite rhombs. The zeolites, presumably phillipsite or harmotome or both, occur as slender, silt-size laths that frequently have a distinct twinned intergrowth habit. Margins of the individual zeolite laths are usually irregular and ragged, suggesting solution effects or irregular crystal growth. Most zeolite crystals appear to contain numerous tiny inclusions of clay minerals and possibly other materials. Limonite occurs in the form of fine silt to clay size grains or granular aggregates that have a variety of shapes including rounded, subrounded, and doughnut-shaped.

The volcanic ash layers of Core 1 are very poorly sorted; they are mainly clayey silts at the top, becoming silty sands toward the base. Volcanic glass and apparently altered volcanic glass are the dominant components of these ashes. Less abundant in the ash layers are very angular, fine sand to silt size grains of plagioclase and quartz. Minor constituents are opaque minerals, clay-size zeolite laths, and what appear to be separated amygdaloids of microcrystalline quartz or zeolites. Ashes in the bottom part of Section 4 and the top part of Section 5 of Core 1 are highly calcareous due to the presence of a small amount of nannofossils and a much larger amount of anhedral calcite that occurs as highly irregular clay to fine silt grains. Origin of this latter calcite is not certain, but in some cases these grains appear to be partially replacing fragments of altered volcanic rock, thus they are of probably diagenetic origin.

The volcanic glass in these ash layers shows a wide range of alteration. A small amount, probably less than 10 per cent, is fresh and unaltered dark brown to red brown mafic glass. Most glass, however, appears to have been altered to either palagonite[1] or, more commonly to a finely granular and poorly resolvable aggregate of clay minerals, opaque iron oxides, and possibly fine-grained zeolites. Palagonite occurs as brownish-yellow to bright yellow, sand, silt and clay-size grains. In some cases incipient alteration can be observed around the edges of palagonite grains, producing a fine-grained halo of weakly birefringent material. In other cases, the entire grain is altered to a cryptocrystalline mass of weakly birefringent material (clay minerals?) although the distinctive bright yellow color of the grain is retained. The most advanced stages of alteration seem to produce the finely granular aggregates mentioned above, although no transitional stages from altered palagonite to these aggregates were observed. Cristobalite was recognized in the X-ray studies of Rex in Section 5 of Core 1, but was not observed visually in the smear slides.

A lithified tuff layer, about 7 centimeters thick, occurs near the top of Section 5, Core 1. This layer is composed of angular sand-size grains of dark, mafic, volcanic rock fragments and vesicular altered glass. The latter grains, which dominate, are a deep red-brown color and appear to be composed largely of fibrous chlorophaeite and very fine-grained clay minerals and chlorite. Secondary

[1]The term palagonite as used in this report is restricted to the yellow or brownish-yellow, *isotropic* mineraloid considered by many workers to be an alteration product of basaltic glass.

sparry calcite fills some of the vesicles and locally replaces parts of the altered glass. The grains are cemented in a fine-grained matrix of clay minerals and possibly zeolites.

Core 2 was drilled from 49 to 58 meters below mudline, but the only recovery consisted of a few rock fragments (up to 7 by 4 by 2 centimeters) that were lodged in the core catcher. These rocks are fine-grained, radiolarian-rich mudstones that are banded in colors ranging from moderate brown to light brown. The color bands range in thickness from 1 to 15 millimeters, but most commonly are less than 5 millimeters thick. Thin veinlets, about 1 millimeter across, traverse the rock in various directions, but those veinlets perpendicular to the banding are the best developed. The veinlets contain clear, fibrous chalcedonic quartz that appear to have filled an open crack into which pieces of the wall rock apparently also sloughed from time to time (Chapter 38). In places the color bands of the mudstone are slightly offset on opposite sides of veinlets. Scattered through a very fine-grained matrix of clay minerals, iron oxides, carbonates and very fine-grained microcrystalline quartz are radiolarian molds filled by secondary quartz, both microcrystalline and chalcedonic (Chapter 38).

Core 3, drilled from 88 to 97 meters below mudline, likewise had recovery only from the core catcher. This consisted of one piece of somewhat friable limestone (5 by 3 by 2 centimeters) and sand to gravel size chips of limestone and siliceous mudstone, along with some free foraminifera. The limestone consists largely of micrite in which are embedded occasional poorly preserved planktonic foraminiferal and radiolarian remains (Chapter 38). In the latter, no trace of the original shell is left, and the radiolarian molds are either filled with secondary microcrystalline and fibrous chalcedonic quartz or are empty. Foraminiferal chambers may likewise be filled with secondary quartz or remain empty; in about half of the foraminifera some vestige of the shell wall remains. Shipboard staining tests suggest the presence of aragonite as well as calcite, the former possibly as a cement, and scanning electron micrographs (Chapter 38) show microfossil cavities lined by secondary crystals of calcite and aragonite. Electron microscopy also shows the micritic matrix to be coccolith-rich (Chapter 38).

Along with the sand-and-gravel-size chips in this core catcher sample are some free planktonic foraminifera of Cenomanian age, showing that the Cenomanian sequence at this site also contains softer sediments—presumably marl or chalk. Indeed the piece of limestone recovered in the core catcher is probably exceptional, judging by the manner in which the coring rate varied from slow to rapid.

PHYSICAL PROPERTIES

The sediments were disturbed during drilling operations, thus all physical property measurements at this site may not represent *in situ* values.

Natural Gamma Radiation

Four and one-half meters of Oligocene brown zeolite clay with ash layers recovered from 0 to 10 meters in Hole 45.1 emitted natural gamma radiation ranging from 400 to 850 counts/7.6-cm core segment/1.25 minutes, averaging about 600 (see hole and core plots). Only three sections of Core 1 were analyzed at this site. The highest count of 850 occurred in Section 1 (average of 600). This high count appears to correlate to the zeolitic rich sediments in addition to a greater silt-size fraction which is in part volcanic ash. The highest gamma counts of Sections 2 and 3 were 600 and 700, respectively, which can be related to concentrations of volcanic ash. The matrix sediment (zeolitic clays) in Sections 2 and 3 had counts up to 500.

Porosity, Wet-Bulk Density, and Water Content

From Hole 45.1, six meters of Oligocene brown zeolitic clay with ash layers were recovered from 0 to 10 meters below the sediment surface. Porosities and wet-bulk densities ranged from 65 to 88 per cent and from 1.21 to 1.58 g/cc, respectively, with typical values of about 80 per cent and 1.36 g/cc. Water contents spanned 47 to 69 per cent and averaged 60 per cent (see hole and core plots). The ash layers in Core 1 had porosities about 66 to 75 per cent and wet-bulk densities of 1.44 to 1.55 g/cc. The silty and clayey sediments had porosities ranging from 80 to 88 per cent with wet-bulk densities as low as 1.20 to 1.35 g/cc. In general, these ash layers are easily distinguished in the GRAPE records by irregular blocks of lower porosities and higher wet-bulk densities than the surrounding sediment. The coarser grain size distribution of the ash was responsible for the lower porosities.

Sound Velocity

Sound velocities through Oligocene brown zeolitic clay, which were recovered within 0 to 10 meters at Hole 45.1, spanned 1.50 to 1.58 km/sec, and averaged 1.53 km/sec at ambient laboratory temperatures and pressures. Velocity measurements were made only through Sections 1, 2, and 3 of Core 1 (see core plot). No sound velocity measurements appear to have been taken through the ash layers.

Penetrometer

Penetrometer measurements in Oligocene brown zeolitic clay which was cored between 0 to 10 meters below the sediment surface at Hole 45.1 ranged from zero to 205×10^{-1} millimeters and averaged about 115×10^{-1}.

Thermal Conductivity

At Hole 45.1 a single thermal conductivity value of 2.05×10^{-3} cal-°C^{-1}cm^{-1}sec^{-1} was measured in predominantly an ash layer but partially in a disturbed clay and ash mixture (Core 1, Section 3) of Oligocene age.

CONCLUSIONS

The upper opaque layer at Site 45 is a brown zeolitic deep-sea clay containing layers of volcanic tuff and ash; some of these are soft and others are lithified and partly silicified. The uppermost core in the upper opaque layer (probably only slightly below its top) is of Oligocene age, and the lowest core recovered from it is Eocene. Its base may be as old as Late Cretaceous.

The deepest core, taken from the general contact zone of the upper opaque and lower transparent acoustic yielded small pieces of hard Cretaceous (Cenomanian) tuffaceous limestone, and chert, and free Cenomanian planktonic foraminifera.

If carbonate sedimentation here occurred at the rate of 5 Bubnoff units (mm/thousand years), the top of B′ would coincide approximately with the beginning of Cretaceous time.

However, the actual nature of the lower transparent layer here remains speculative, and B′ or basement were not reached.

The general lithic sequence is one from chalk and limestone in the Cenomanian to brown clay with ash in the Eocene and Oligocene. The presence of Campanian to Maestrichtian and Eocene coccoliths and foraminifera in the last core, presumably as cavings from up-hole, suggests that the carbonate compensation depth was crossed sometime before or during the Eocene.

The presence of silt-grade volcanic tuff—not encountered in any of the other sites drilled by Leg 6 in the Pacific—is evidence of near-by volcanism in late Cretaceous to Oligocene time. The most likely source would appear to be the Hawaiian Ridge, to the north—in particular the region near Midway.

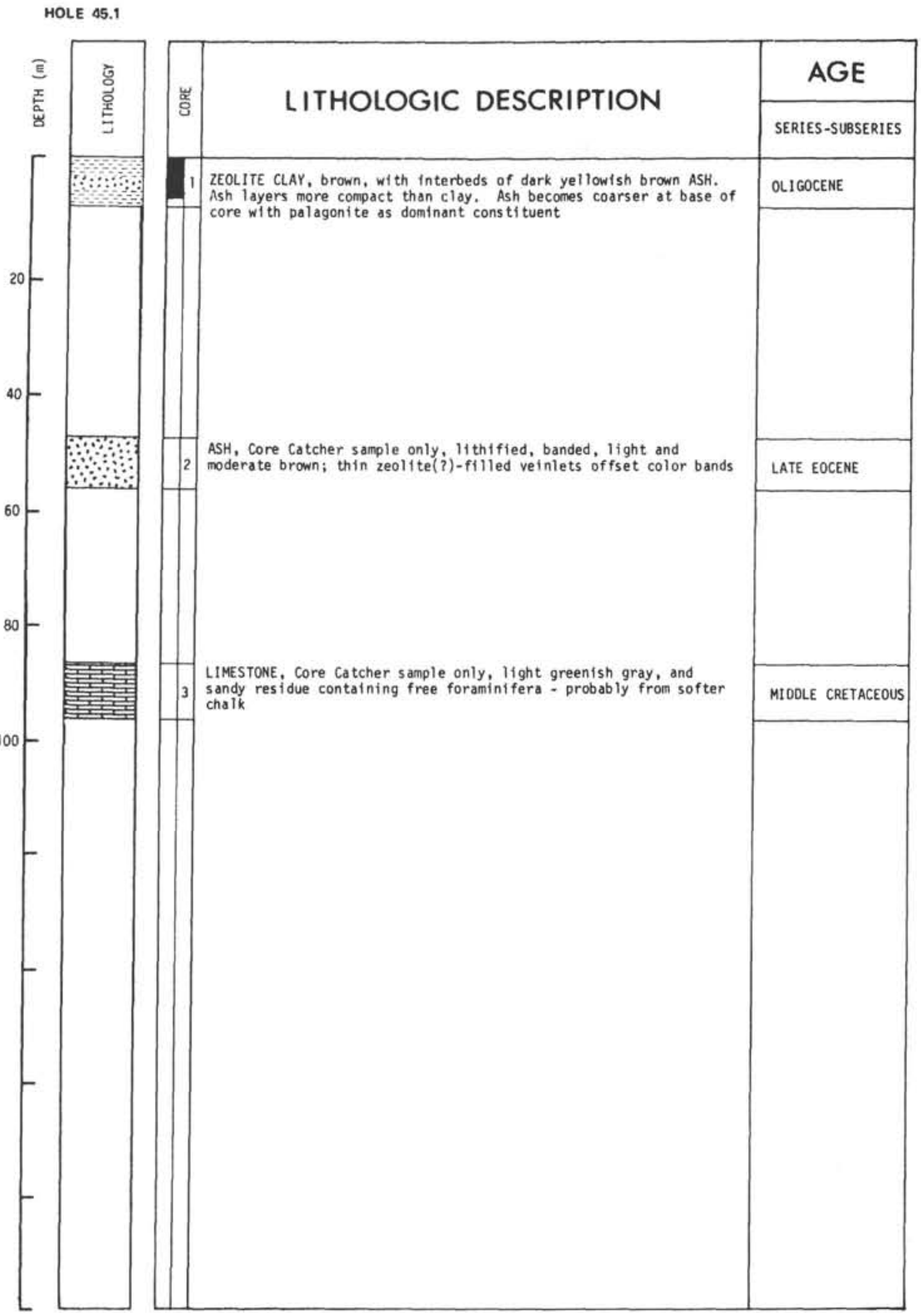

Figure 4. *Summary of lithology in Hole 45.1.*

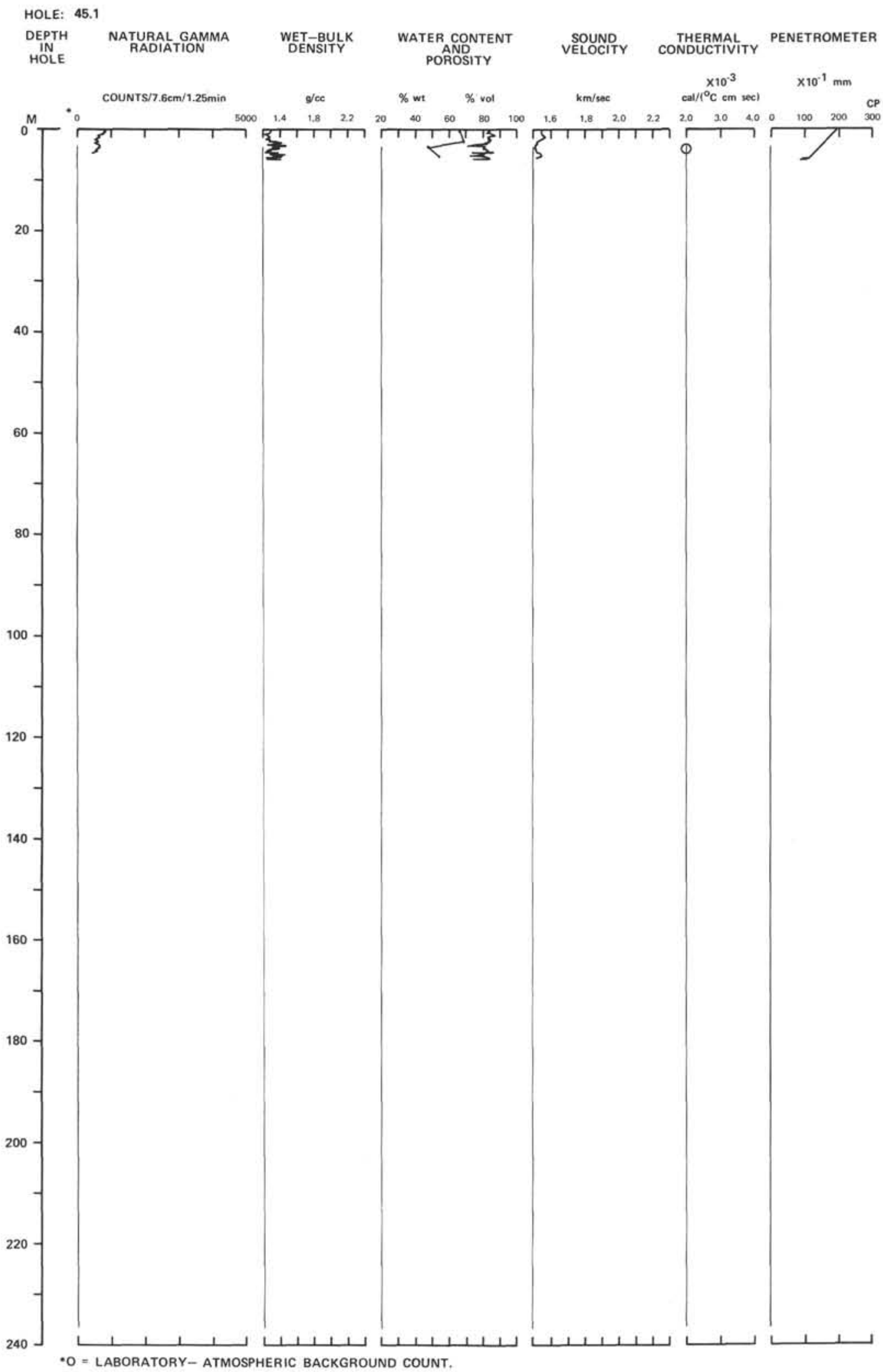

Figure 5. *Summary of physical properties in Hole 45.1.*

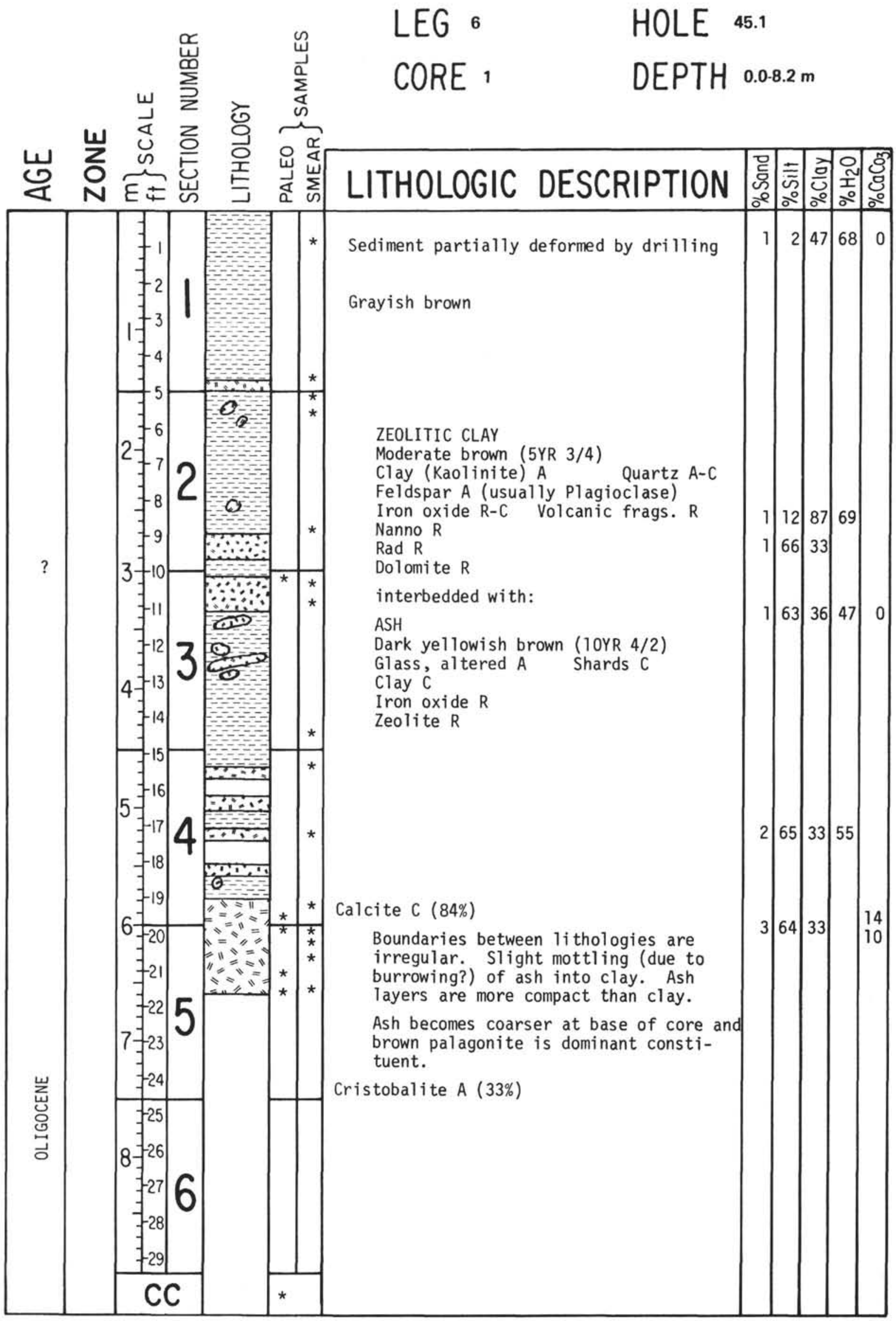

Figure 6. *Summary of lithology in Hole 45.1 Core 1.*

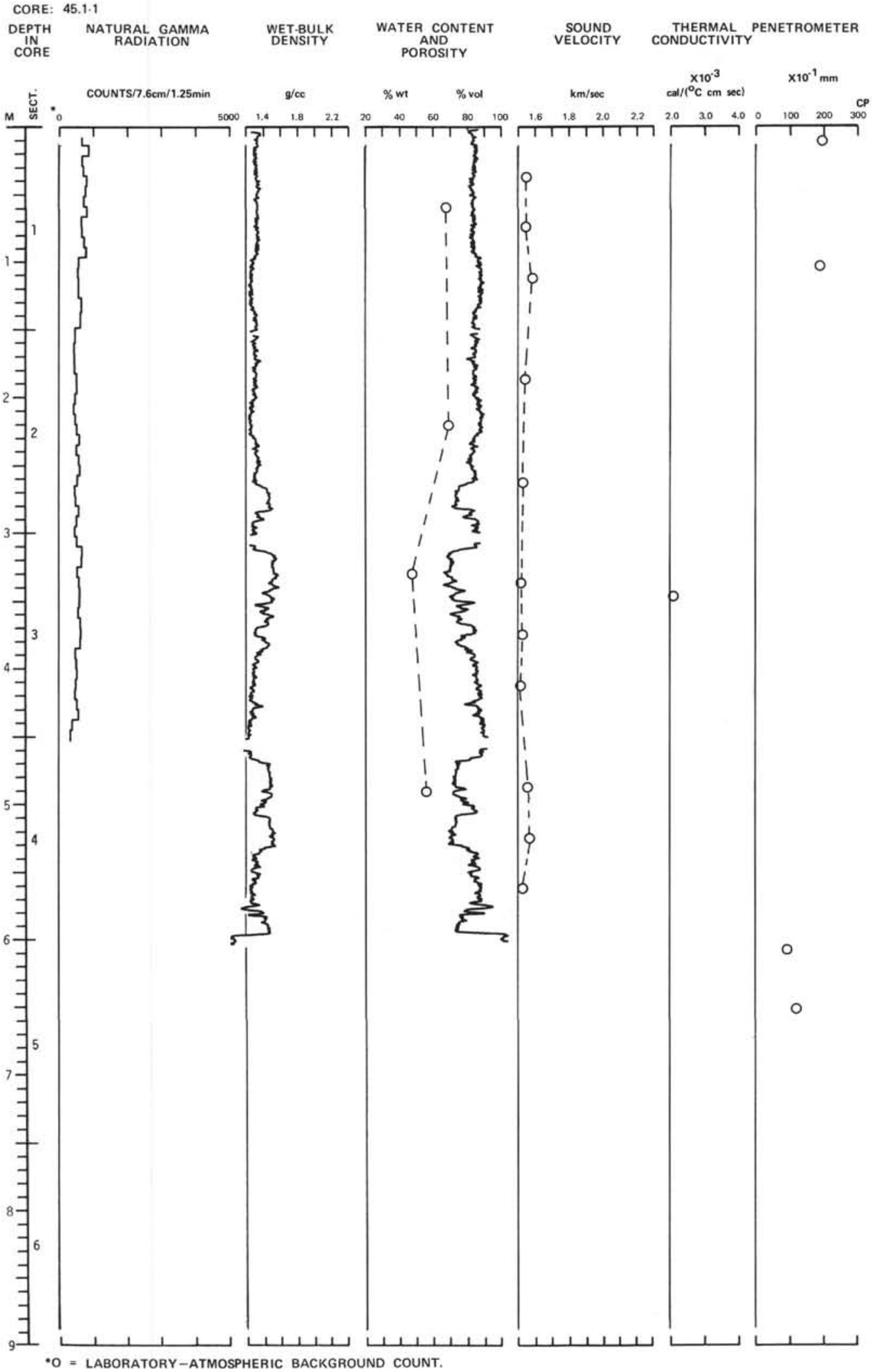

Figure 7. *Summary of physical properties in Hole 45.1 Core 1.*

LEG 6 HOLE 45.1

CORE 1 DEPTH 0.0-8.2 m

FORAMINIFERA	NANNOPLANKTON	RADIOLARIA
None.	In core 1, the upper brown clays are barren but the ash beds in the lower part of the core contain a spare and poorly preserved assemblage of nannoplankton including *Coccolithus* sp. aff. *C. bisectus* that indicates an Oligocene correlation.	A few specimens of Mesozoic forms, poorly to moderately well preserved, were obtained from rock fragments in the core catcher sample.

Figure 8. *Summary of biostratigraphy in Hole 45.1 Core 1.*

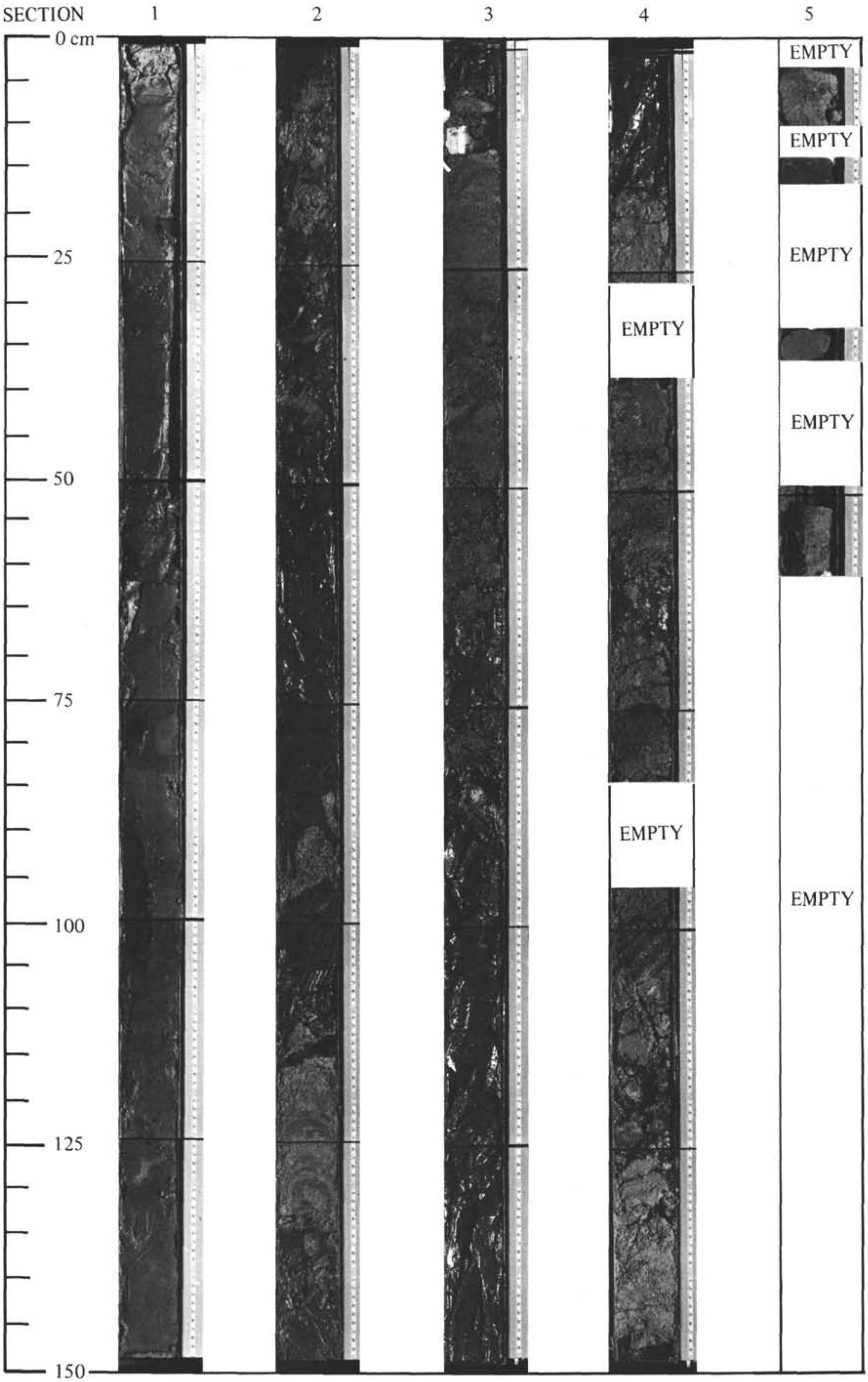

Plate 1. *Photographs of Hole 45.1 Core 1.*

LEG 6 HOLE 45.1

CORE 2 DEPTH 46.9-56.1 m

AGE	ZONE	SCALE m / ft	SECTION NUMBER	LITHOLOGY	SAMPLES PALEO	SAMPLES SMEAR	LITHOLOGIC DESCRIPTION	%Sand	%Silt	%Clay	%H_2O	%$CaCO_3$
LATE EOCENE	*Discoaster barbadiensis*	0–9 m / 0–29 ft	1		*		Center Bit sample					
			2									
			3				Core Catcher sample only Lithified ASH Fragments (up to 7 x 4 x 2 cm) of hard microcrystalline to glassy ash. Ash is color banded (bands 1-15 mm thick) in light and moderate brown. Thin veinlets offset color bands; they are filled with translucent mineral (zeolite).					
			4									
			5									
			6									
			CC		*	*						

Figure 9. *Summary of lithology in Hole 45.1 Core 2.*

LEG 6 HOLE 45.1

CORE 2 DEPTH 46.9-56.1 m

FORAMINIFERA	NANNOPLANKTON	RADIOLARIA
None	The center-bit and core-catcher samples representing core 2 contain a sparse assemblage of the upper Eocene *Discoaster barbadiensis* Zone. Species present include *Cyclococcolithus formosus* and *Discoaster barbadiensis*.	None.

Figure 10. *Summary of biostratigraphy in Hole 45.1 Core 2.*

LEG 6 HOLE 45.1

CORE 3 DEPTH 86.3-95.4 m

FORAMINIFERA	NANNOPLANKTON	RADIOLARIA
Rare specimens of middle Cenomanian foraminifera were present with the sand and gravel fragments recovered from the core catcher. Core Catcher sample: *Rotalipora evoluta, R. greenhornersis, R. cushmani, Praeglobotruncana delrioensis, Planomalina buxtorfi, Hedbergella brittonensis, H. delrioensis, H. planispira, Globigerinelloides caseyi, Heterohelix moremani.*	In core 3, Cenomanian (Upper Cretaceous) nannoplankton is present in both the chalk block and variegated rock fragments of the core catcher. Species present include: *Apertapetra gronosa, Eiffellithus eximus,* and *Prediscosphaera columatus.* The assemblage in the chalk is smaller with *Watznaueria barnesae* being dominant.	None.

Figure 11. Summary of biostratigraphy in Hole 45.1 Core 3.