3. SITE 136

The Shipboard Scientific Party[1]

ABSTRACT

Site 136 lies about 160 km north of Madeira and 900 km southwest of Gibraltar in an area of abyssal hills.

Pliocene to Miocene nannoplankton chalk ooze overlies early Miocene Clay. From 259 to 268 meters, the Miocene clay passes into a 9 meter interval of barren clay and then into Coniacian to Santonian ash and calcareous red clay. The time period represented by this 9-meter interval is about 60 million years. The oldest sediments cored were multicolored clays and, at 290 meters, nannoplankton marls of Late Aptian age Early Aptian shales were recovered, however, from bit cuttings. Oceanic basalt (tholeiitic diabase) was recovered at a depth of 308 meters which correlates well with the anticipated depth of the acoustic basement. The widespread occurrence of this basement reflector, its acoustic character, and the petrology of the basalt suggest that true oceanic basement was sampled. The oldest sediments at this site are therefore anomalously young considering the site's proximity to the continental margin and the crustal age inferred by Pitman and Talwani (1972) from the analysis of magnetic anomalies.

SITE DATA

Time: 0715 15 October 1970
2000 17 October 1970

Position: 34° 10.13′N
16° 18.19′W

Water Depth: 13,680 feet
2,208 nominal fathoms
4,169 meters

Total Penetration: 313 meters

Cores Taken: Nine cores

BACKGROUND, SURVEY, OPERATIONS

Seismic reflection profiles from the *Chain* (Bunce, personal communication) and *Vema* 27 indicate two areas north of Madeira where acoustic basement (oceanic crust) lies within 500 meters of the sea floor.

This is the closest known site to the African continent which does not have a very thick accumulation of sediments overlying oceanic crust. The main objective at Site 136 was to sample basalt basement and date the sediment immediately overlying it.

The JOIDES Atlantic Advisory Panel originally recommended a site at latitude 33° 22.5′N, longitude 16° 55.0′W, about 60 km north of Madiera, based on the *Chain* seismic record. The *Vema* 27 data, which was not available at the time of the original site selection, clearly shows that the acoustic basement is also close to the sea floor (200 to 500 meters). The proposed site was relocated (Figures 1 and 2) on the basis of the *Vema* 27 data because of its greater distance from Madeira (~160 km) in the hope that the influence of known volcanic activity on the island would be minimized at the drill site.

Figure 2 shows the seismic reflection records from *Vema* and from *Challenger* for the area near Site 136 and for the surrounding area. The locations pertinent to both of these profiles are shown in Figure 1. Only the approximate position of Site 136 is indicated on the *Vema* 27 record. Typical reflections from oceanic basement are shown in the vicinity of the site and are well recorded on the *Vema* records. This reflector can be traced over a large areal extent and for this reason suggests to us that it does not represent a localized volcanic horizon.

The *Challenger* records show the approaches to, and the departure from, Site 136. The circled area indicates that portion of the record which has been enlarged and is shown as part of a composite illustration in Figure 3. Note that layer 2 cannot be traced beneath the flat abyssal plain area shown on the *Vema* record in the vicinity of B′-C′, and reflecting horizons cannot be traced continuously from the northern platform of the Madeira Islands shown near D′E′ on the *Vema* records. In several places some reflectors show small acoustic windows, for example near point B and Site 136 on the *Challenger* record and can be seen in detail in Figure 3. Seismic records collected from the *Chain* (Bunce,

[1] D. E. Hayes, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York; A. C. Pimm, Scripps Institution of Oceanography, La Jolla California; W. E. Benson, National Science Foundation, Washington, D.C.; W. H. Berger, Geologisch Palaeontologisches Institut-Kiel, Kiel, Germany; U. von Rad, Bundesanstalt für Bodenforschung-Hannover, Hannover, Germany; P. R. Supko, Scripps Institution of Oceanography, La Jolla, California, J. P. Beckmann, Geologisches Institut-Zurich, Zurich, Switzerland; P. H. Roth, Geologisches Institut-Zurich, Zurich, Switzerland.

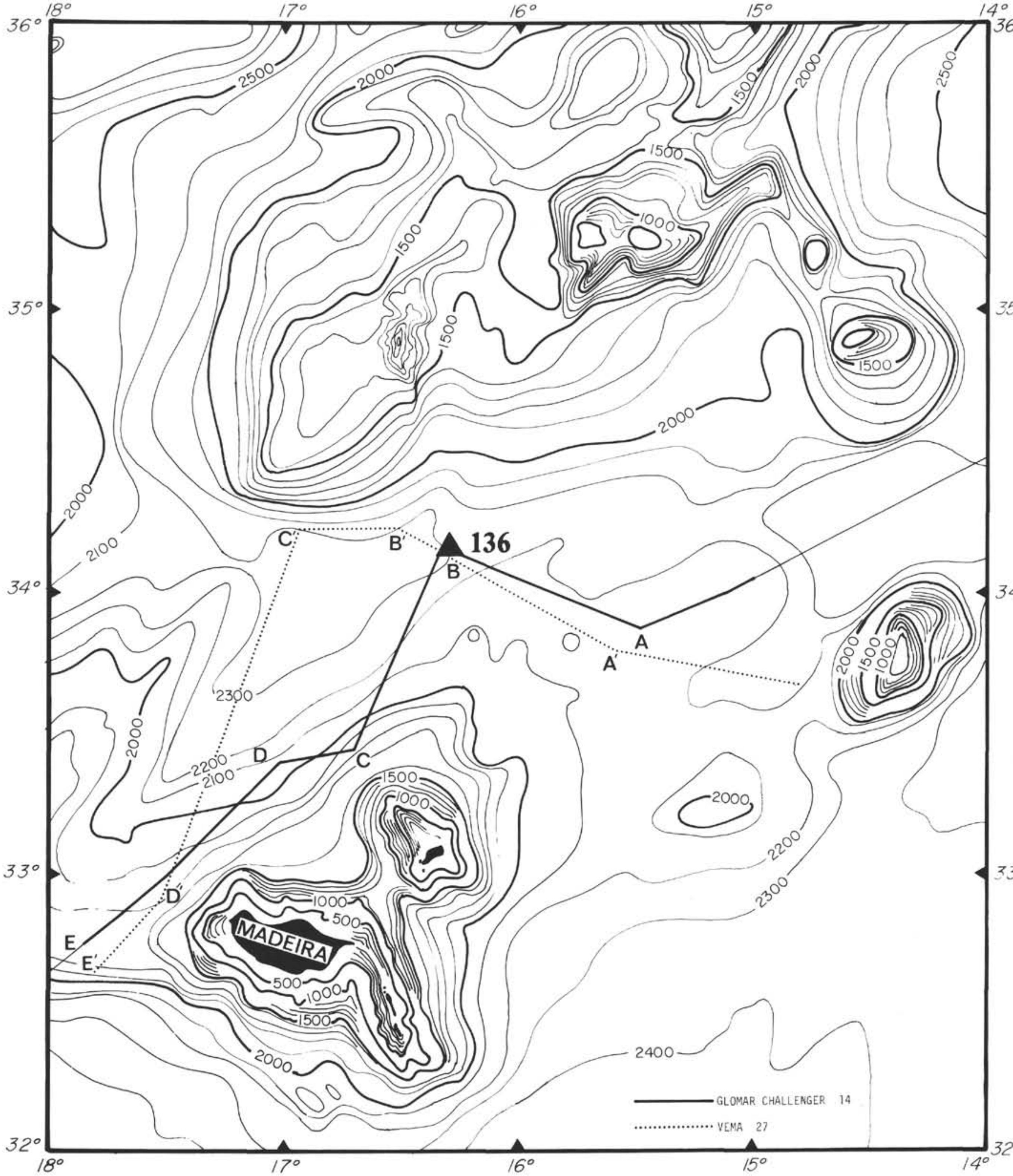


Figure 1. *Location map for Site 136. Contours in nominal fathoms after A. S. Laughton (pers. comm.). Letters shown serve to key profiles in Figure 2.*

personal communication) ~100 km to the south of this area, also show an anomalously thin total blanket of sediment overlying the oceanic basement. The thin sediment section may result from erosion or non-deposition related to the major unconformity recorded at Site 136 (see text) and which likely has a regional or greater extent.

The *Challenger* approached the site along the track of *Vema* 27. The site lies about 100 meters above and just

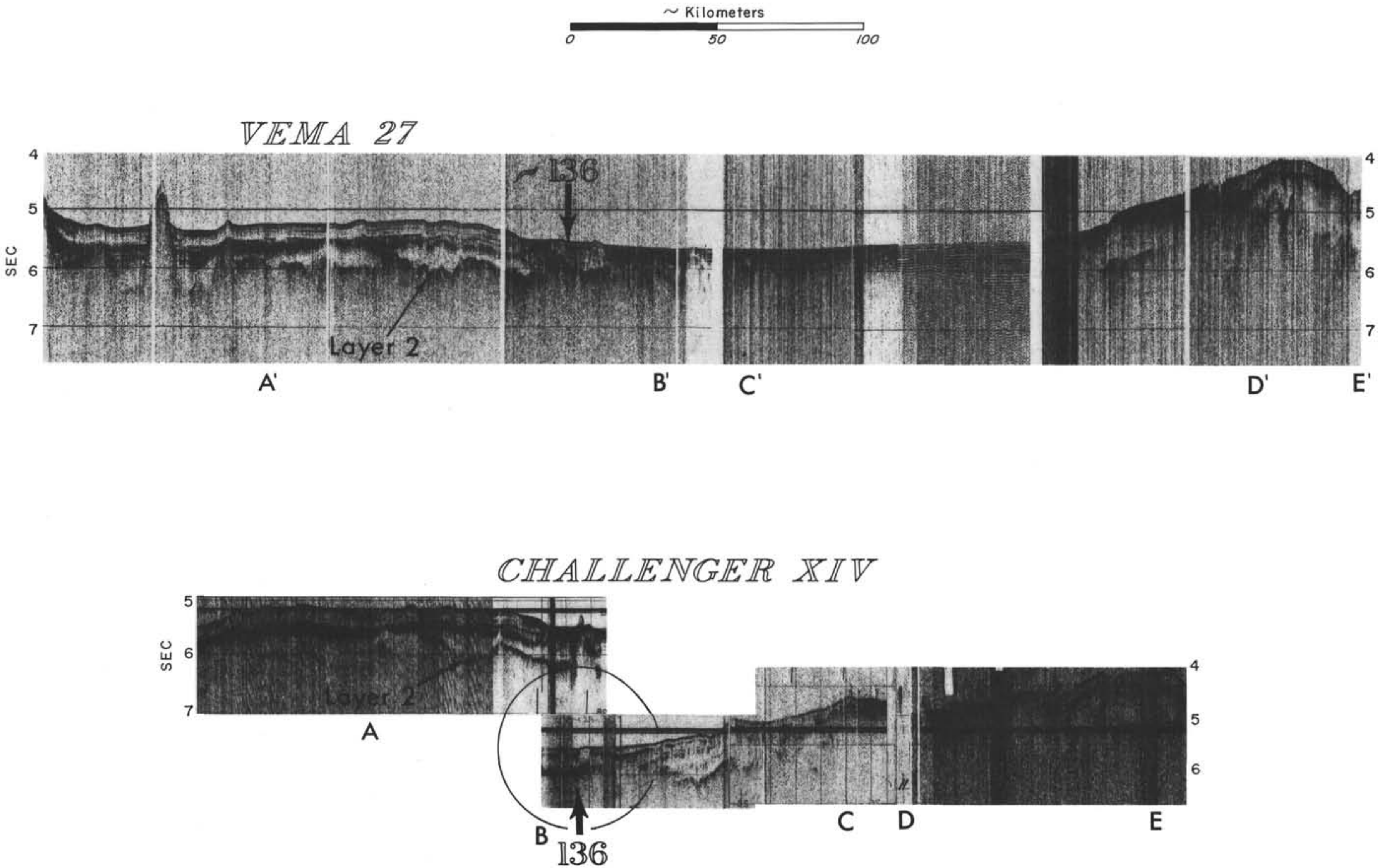


Figure 2. *Seismic reflection profiles in the vicinity of Site 136. The locations of profiles are given in Figure 1.* Vema *27 record is from unpublished Lamont Doherty Geological Observatory data (J. Ewing, pers. comm.).*

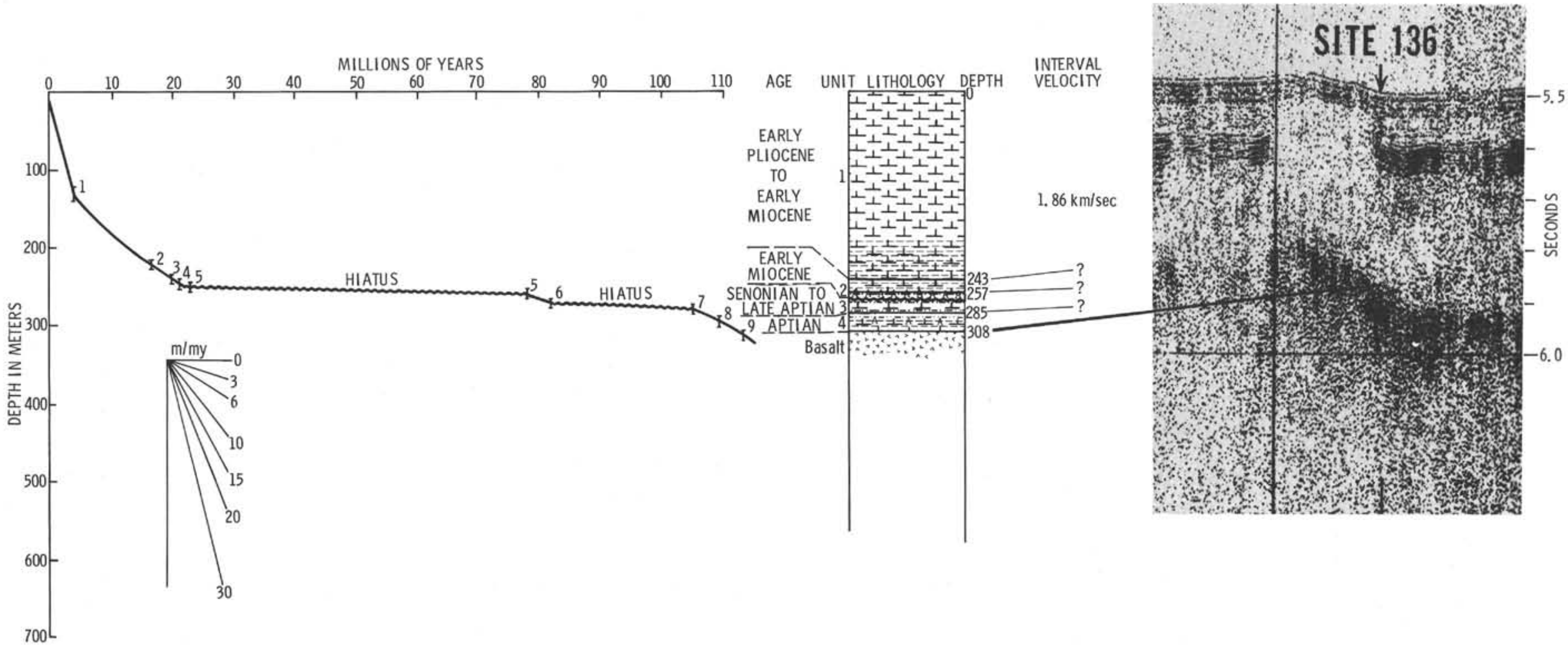


Figure 3. *Geological synthesis at Site 136.*

north of the abyssal plain bounded by a northeasterly trending ridge and by the Madeira Islands platform. (See Figure 1.)

Seismic Reflection Data:	*Vema* 27	*Challenger*
First Reflector	0.10 sec	0.10 sec
Basement Reflector	0.27 sec	0.33 sec

Drilling and coring records are given in Table 1 and Figure 4.

BIOSTRATIGRAPHY

General

From the few available cores, the Tertiary section (Pliocene to Lower Miocene) is judged to contain a calcareous pelagic fauna with moderate to strong evidence of calcite solution. Within Section 1 of Core 5 (depth about 255 m), there is a distinct change in the character of the organogenic residue that coincides with a major hiatus. From this depth down to Core 8, Section 1 (about 282 m), only rather poor faunal assemblages indicating a Late Cretaceous (probably Turonian to Santonian) age are present. Whether the poor state of preservation of the micro- and nannofossils in this interval is due to a great water depth or to the influence of vulcanism, is uncertain. Within Core 8, there is again a sharp contrast, since from Section 2 downwards a well preserved fossil assemblage of about Albian age was found. Also, a rich sporomorph flora of Albian age occurs in this core. It appears, therefore, that in this hole at least two unconformities were cored; one between the Lower Miocene and the Upper Cretaceous (in Core 5); and the other between the Turonian? and Albian (Core 8). The oldest sediments (Aptian?) were dated by nannoplankton from chips of a "bumper sub" sample below Core 8.

The age diagnostic fossils from each core are given in Table 2.

Foraminifera

The Tertiary faunas of Cores 1 to 3 consist predominantly of solution-resistant species such as *Sphaeroidinellopsis seminulina*, *Globigerina nepenthes* and *Globoquadrina dehiscens*. In Core 4 the solution of the foraminifera is practically complete. The Upper Cretaceous faunas (Core 5 to Core 8, Section 1) consist of relatively few specimens of Globotruncanidae and benthonic species. The fauna in the lower part of Core 8, on the other hand, is well-preserved although most of the specimens are rather small-sized.

Nannoplankton

Abundant nannoplankton were found in the Lower Pliocene (Core 1) and Middle Miocene (Core 2). Calcite solution resulted in a gradual reduction in the number of species in the Lower Miocene sediments of Cores 3 and 4. The top of Core 5 (Section 1) contains only rare specimens of Tertiary coccoliths which are at least in part derived from higher parts of the hole. The core-catcher of Core 5 yielded poorly preserved Santonian (?) nannoplankton. Poor assemblages, indicating a Cenomanian age, were recovered from Core 6. A rich Upper Aptian nannoflora was found in Core 8. Some large rock fragments from the "bumper sub" contain Lower Aptian nannoplankton assemblages with common nannoconids.

Organic Microfossils

D.O.J. Diederix, R. de Haan and W.O. Tichler[2]

Core 8 Section 1: 103-105 cm:

No sporomorphs or microplankton were recovered.

Core 8 Section 6: 142-144 cm:

A rather rich sporomorph flora with abundant *Classopollis classoides*, common *Araucariacites australis, Gleicheniidites senonicus, Ephedripites sp.*, and rare *Trilites sp.* (Jardiné & Magloire 1963, type S.CI.128), *Eucommiidites troedsonii, Acanthotriletes varispinosus, Equitriradites sp., Tricolpites psilatus* group, *Dictyophyllidites harrisii* and a doubtful specimen of *Galeacornea sp.*

Age: Early Cretaceous, most probably Albian.

No microplankton found.

LITHOSTRATIGRAPHY

A single hole was drilled to basement at Site 136. Coring, which started at 130 meters, recovered material classified below as lithostratigraphic units:

Unit	Cores	Lithology	Depth Below Sea Floor (m)	Age
1	1,2,3	Nannofossil chalk ooze	0-243	Early Pliocene to Early Miocene
2	3,4,5	Silty clay	243-257	Early Miocene
		HIATUS		
3	5,6,7,8	Silty clay with ash	257-284.5	Senonian-Albian
		HIATUS?		
3A	8	Banded colored clay	284.5-285	Late Aptian to Early Cenomanian
4	8	Nannofossil marl ooze	285-308	Aptian
	9	Basalt	308-?	

UNIT 1 – Nannofossil Chalk Ooze (Cores 1, 2, 3)

Unit 1, recovered in Cores 1, 2 and upper part of Core 3, consists of nannofossil chalk ooze in the upper part, grading into marl ooze downward. Colors range from very pale orange to pale brown. Of the nannofossils, about 70-80 per cent are coccoliths; the rest are discoasters. Pelagic forams are scarce, comprising a maximum of 4 per cent of the sediment and usually 1 per cent or less. Preservation of planktonic foraminifera generally is poor and degrades downward in the unit. This increase in dissolution is reflected in a slowing of sedimentation rates from 30 m/m.y. at top of the unit to about 5 m/m.y. at its base. Quartz, biotite, and chlorite characterize the terrigenous suite, which is present to a maximum of 2 per cent. Traces of authigenic carbonate were noted in Cores 2 and 3.

Drilling rates vary between 1.8 and 3.3 m/min, and generally decrease downward.

UNIT 2 – Silty Clay (Cores 3, 4, 5)

At the bottom of Core 3 there is a gradual transition from the ooze to a pale brown and then to a grayish brown

[2]Koninklijke/Shell Exploratie en Produktie Laboratorium, The Hague.

TABLE 1
Drilling and Coring Record for Site 136

Description	Interval Below Sea Floor (m)	Core Recovery (m)	Drilling Rate (m/min)
Drill	0-24		8.0
	24-44		2.9
	44-63		3.1
	63-82		2.4
	82-101		2.7
	101-120		2.7
	120-130		3.3
Core 1	130-139	9.0	
Drill	139-159		2.9
	159-178		2.1
	178-196		2.2
	196-216		1.8
Core 2	216-225	9.0	
Drill	225-235		2.0
Core 3	235-244	4.70	
Core 4	244-253	3.93	
Core 5	253-262	1.18	
Core 6	262-271	3.00	
Core 7	271-180	0.35	
Core 8	280-289	2.49	
Drill	289-308		1.9
Core 9	308-313	0.20	
	Water Depth 4169 meters		

calcareous silty clay, defined as Unit 2. Rhombohedra of authigenic carbonate are locally abundant (up to 70%) in the bottom of core 3 but comprise only a few percent of the sediments in the top of Core 4. Unidentified clays comprise 75-90 per cent of the sediment. The silt fraction is dominated by quartz and other terrigenous minerals. Nannofossils are important (20%) only in the top of Section 1 of Core 4. They occur again at the bottom of this stratigraphic unit in Core 5, which also contains a few per cent rhombohedra of authigenic carbonate. Only a trace of carbonate is present in most of Core 4. Sedimentation rate is less than 5 m/m.y. years. Because of continuous coring, the drilling rate was undetermined.

The boundary between Units 2 and 3, tentatively put into section 1 of Core 5, represents a hiatus from the Lower Miocene to the Upper Cretaceous.

UNIT 3 – Silty Clay with Ash (Cores 5, 6, 7, 8)

Lithostratigraphic Unit 3 is 27.5 m thick and was recovered in Cores 5,6,7, and 8. It consists of brown, reddish brown, and red clays, silty clays, and clayey silt, all interbedded with layers of volcanic ash a few mm to 10 cm thick. The ash layers are light to dark grayish brown, and yellowish brown, and brownish red. They are mostly silty to sandy, and are composed of both crystalline and glassy fragments. Large dark grains (probably lithified ash), feldspar, and basaltic glass are common. The ash also contains some admixed quartz and mica, presumably, from a non-volcanic source. The other sediments range from "normal" pelagic clay assemblages (~80 per cent unidentified clay minerals, with quartz, feldspar, mica, some zeolite, glass, hematite and manganese) to anomalous clayey carbonate silts. The carbonate occurs as spindle-shaped fragments derived from re-sedimentation of calcite-cemented ash. This is shown by occasional coarse grains containing both ash and calcite veinlets. The carbonate-rich and carbonate-poor zones cannot be differentiated by color. Drilling rates are as above.

UNIT 3A – Banded Colored Clay (Core 8)

Unit 3A is a fossiliferous clay that comprises the bottom 35 cm of Unit 3. It overlies the dark nannofossil marl ooze of Unit 4. It is similar to the clays of Unit 3 but is set apart by an unusual sequence of vivid colors–red brown, olive yellow, olive, green, reddish orange and yellow. Each layer is only a few millimeters to centimeters thick.

UNIT 4 – Nannofossil Marl Ooze (Core 8)

Unit 4 is an olive gray to gray black nannofossil marl. A total of only 65 cm (mostly disturbed) was recovered in Core 8, but it probably continues 23 meters to the top of the basalt at 308 meters. This unit contains about 50 per cent nannofossils and 50 per cent clay with minor constituents being quartz, feldspar, mica, and angular calcite fragments.

Basalt – (Core 9)

The basaltic basement rock (tholeiitic diabase) is an intergranular to subophitic diabase with plagioclase and two clinopyroxenes (augite, and pigeonite) in an altered groundmass. The pyroxenes are partly altered to serpentine and chlorophaeite. The groundmass is serpentized or chloritized. Feldspar laths are 0.1 to 0.75 mm. They show twinning and zoning and have an apparent average composition in the andesine range. Feldspar and plagioclase show a moderate amount of alteration. Approximate composition: feldspar 35-40 per cent, pyroxene 30-35 per cent, groundmass 15-20 per cent, Fe oxides <5 per cent, calcite <5 per cent. (See also Chapter 23).

PHYSICAL AND CHEMICAL PROPERTIES

Except for the natural gamma radiation, the measurements of the physical properties of the cores from Site 136 show only a very general correlation with lithology. None of the physical properties change significantly across the hiatus between the Lower Miocene and Upper Cretaceous beds.

Penetrometer readings range from 6 to 123 (mm × 10^{-1}); the highest being in the Pliocene ooze at about 135 meters. Below this, the values decrease to a depth of about 235 meters and remain relatively constant (but with a wider scatter) down to the top of the basalt.

Wet bulk densities (gm/cc), as measured on the GRAPE, average about 1.80 in the Tertiary oozes, with most measurements falling between 1.70 and 1.85. The highest densities in the sedimentary section (1.85) were recorded in the lower part of the ooze between 222 and 238 meters. In the muds and ash-rich beds below the ooze the density values have a wide scatter but show an unexplained gradual decrease with depth. They reach a minimum of about 1.50 in the Cretaceous marls (286 meters).

The porosity of the Tertiary oozes ranges from 40 to 65 per cent, averaging just over 50 per cent. Below the ooze, porosity increases irregularly (as the bulk density decreases) with depth. It reaches a maximum of about 90 per cent

TABLE 2

CORE	DIAGNOSTIC FOSSILS HOLE 136 FORAMINIFERA	NANNOPLANKTON	AGE
1	Fairly rich, mostly planktonic faunas, consisting mainly of thick-walled, solution-resistant species: *Sphaeroidinellopsis seminulina, S. paenedehiscens, Globigerina nepenthes.* Also present are *Globigerinoides obliquus, Globoquadrina altispira* and small *Globorotalia margaritae.* The age is Early Pliocene (*Globorotalia margaritae* Zone)	Slightly etched nannoplankton with *Ceratolithus tricorniculatus, C. primus, Triquetrorhabdulus rugosus.* Preservation: E1-01 Zone: *Ceratolithus tricorniculatus* Age: Early Pliocene	Early Pliocene
2	Moderately rich faunas showing rather strong solution effects. Predominant planktonic species are *Sphaeroidinellopsis seminulina* and *Globoquadrina dehiscens.* Also present are *Globorotalia fohsi peripheroronda* (some with subacute periphery) and common benthonic foraminifera (*Stilostomella, Gyroidina, Anomalinidae*). An earliest Middle Miocene age (*Globorotalia fohsi peripheroronda* Zone) is indicated.	Moderately etched nannoflora with *Sphenolithus heteromorphus* and *Discoaster exilis* Preservation: E2-02 Zone: *Sphenolithus heteromorphus* Age: Middle Miocene	Middle Miocene
3	Mainly benthonic foraminifera *(Gyroidina, Stilostomella, Cibicides)* and fish teeth. Few planktonics including *Catapsydrax dissimilis.* Poor samples with strong evidence of calcium carbonate solution. Considerable downhole contamination. Age: Early Miocene or ?older.	Poorly and strongly etched assemglabes. Section 1 and 2: rare *Sphenolithus belemnos, Discoaster deflandrei* Zone: *Sphenolithus belemnos* Section 3, 4 and core catcher: *Discoaster druggii, D. deflandrei* Preservation: E3-02 Zone: *Discoaster druggii* Age: Early Miocene	Early Miocene
4	Few undetermined, rolled and polished specimens of rotaloid foraminifera. Common fish teeth	Section 2: Very poor assemblage consisting of *Discoaster deflandrei, Triquetrorhabdulus carinatus, Reticulofenestra abisecta* Preservation: E3 Zone: *Triquetrorhabdulus carinatus*? Age: Early Miocene	Early Miocene
5	Section 1: *Bathysiphon*? sp., fish debris. Section 5 and Core Catcher: Few specimens of *Globotruncana canaliculata, Gt.* cf. *pseudolinneiana, Gt.* cf. *fornicata, Gt.* cf. *angusticarinata, Stensioeina* cf. *exsculpta gracilis, Bandyella greatvalleyensis* Age: Late Cretaceous (?Coniacian-Santonian)	Section 1: Only a few badly preserved specimens of *Coccolithus eopelagicus* and some admixed Miocene to Quaternary coccoliths and sphenoliths. Core Catcher: *Eiffelithus turriseiffel, Prediscosphaera cretacea, Cretarhabdus surirellus, Marthasterites* cf. *furcatus,* Santonian (?)	Coniacian Santonian ?
6	Poor faunas with *Globotruncana canaliculata, Gt.* cf. *renzi, Gt. indica, Gt.* cf. *linneiana, Heterohelix globulosa, Hedbergella* cf. *amabilis*, indicating a Late Cretaceous (probably Coniacian-Santonian) age.	Rather poor assemblage with *Cretarhabdus coronadventis, Prediscosphaera cretacea, Eiffellithus turriseiffeli, Zygodiscus exiguus, Prediscosphaera spinosa, Cribrosphaerella ehrenbergi, Corollithion signum, Eiffellithus trabeculatus, Microrhabdulus decoratus, Eiffelithus augustus* Age: Senonian	Coniacian Santonian

TABLE 2 – *Continued*

CORE	DIAGNOSTIC FOSSILS HOLE 136 FORAMINIFERA	NANNOPLANKTON	AGE
7	Single specimens of *Globotruncana* cf. *coronata* and *Hedbergella* cf. *bosquensis*. The age is Late Cretaceous (? Turonian to Santonian).	Barren	?Turonian Santonian
8	Section 1: Rare *Globotruncana* cf. *canaliculata*, *Heterohelix globulosa*, *H.* cf. *pulchra*, *Hedbergella* spp. Age: Late Cretaceous (undifferentiated). Section 2 to bottom: Rather poor assemblages of small-sized specimens of *Hedbergella planispira*, *Globigerinelloides tururensis*, *Gavelinella intermedia* group, *G.* cf. *schloenbachi*, *Lenticulina secans*, *L. subangulata*, *L. dubiensis*, *L. saxocretacea*, *Lingulina loryi* Age: Aptian to early Cenomanian, most probably Albian.	Rich and well-preserved nannoflora containing *Cretarhabdus coronadventis*, *Hayesites albiensis*, *Parhabdolithus angustus*, *Corollithion achylosum*, *Cyclagelosphaera margareli*, *Diazomatholithus lehmani*, *Corollithion ellipticum* Age: Late Aptian	Late Aptian to Early Cenomanian
BS		Bumper sub: Abundant nannoplankton with *Eiffellithus anceps*, *Cyclagelosphaera margareli*, *Diazomatholithus lehmani*, *Cretaturbella rothii*, *Nannoconus colomi*, *N. bucheri*, *N. truitti*, *N. globulus* Age: Early Aptian	Early Aptian

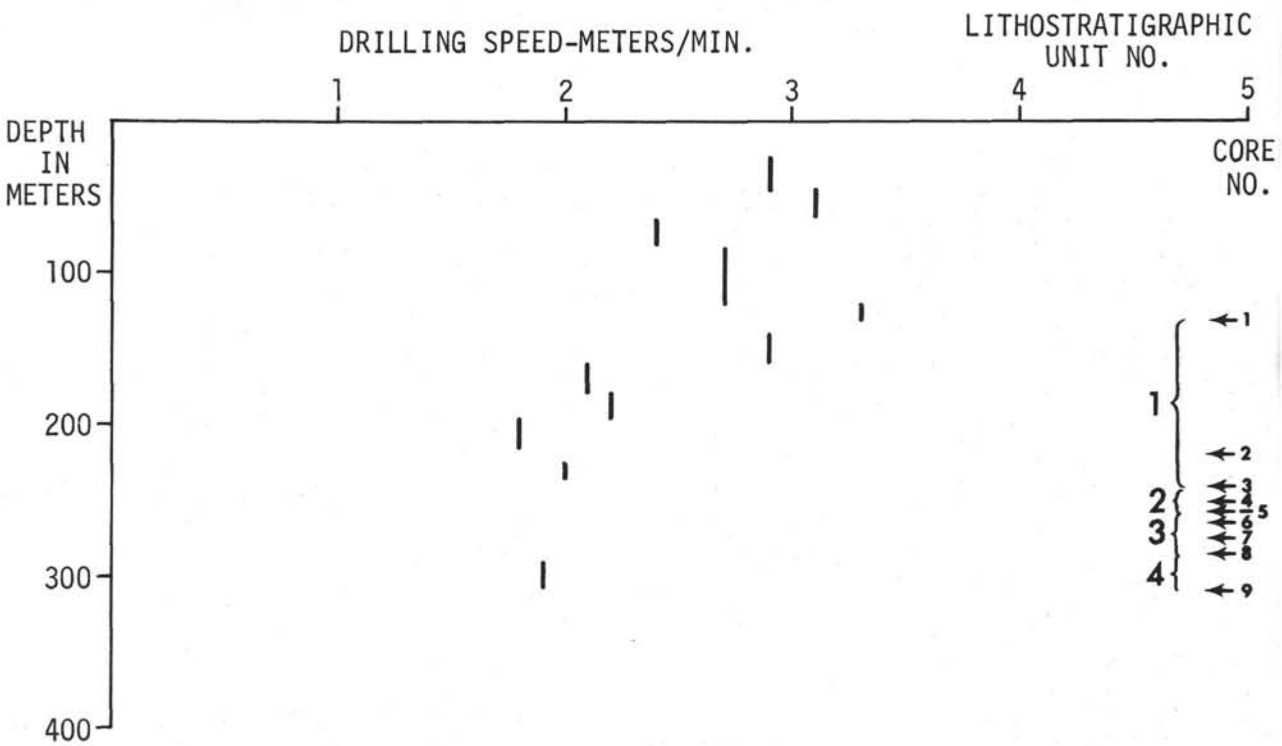


Figure 4. *Drilling and coring summary at Site 136.*

(absolute value is questionable, but the porosity is undoubtedly relatively high) at the bottom of Core 7. The increase in porosity (and decrease in bulk density) with depth is anomalous. Water content has the same anomalous pattern. It ranges from about 30 to 35 per cent in the ooze and increases with depth in the Cretaceous sediments to a maximum of 43 per cent at about 280 meters (Table 3).

Natural gamma radiation shows a general correlation with lithology. Chalk ooze and ash beds have lower counts than marls and silty clays. The lowest counts (less than 10

TABLE 3
Summary of Density, Porosity and Water Content Data for Site 136

Hole	Core	Section	GRAPE Depth Below Sea Floor (m)	GRAPE Density (gm/cc)	GRAPE Porosity (%)	Sediment Sample Depth Below Sea Floor (m)	Sediment Sample Water Content (%)	Sediment Sample Density (gm/cc)	Sediment Sample Porosity (%)
136	1	1	130.75	1.67	49	130.14	34	1.61	54
136	1	2	132.25	1.74	43	131.64	40	1.51	60
136	1	3	133.75	1.72	45	133.14	32	1.64	52
136	1	4	135.25	1.72	45	134.64	29	1.65	48
136	1	5	136.75	1.71	45	136.14	27	1.70	47
136	1	6	–	–	–	137.64	29	1.63	48
136	2	1	216.75	1.58	65	216.14	24	1.86	45
136	2	2	218.25	1.74	55	–	–	–	–
136	2	3	219.75	1.59	65	–	–	–	–
136	2	4	221.25	1.59	65	–	–	–	–
136	2	5	222.75	1.85	49	222.14	28	1.87	52
136	2	6	224.25	1.78	53	223.64	27	1.79	47
136	3	1	234.75	1.26	84	–	–	–	–
136	3	2	236.25	1.70	55	235.65	28	1.71	47
136	3	3	237.75	1.84	46	238.00	25	1.89	47
136	3	4	239.25	1.67	57	238.64	24	1.87	44
136	4	1	244.75	1.46	69	244.70	36	1.62	59
136	4	2	246.25	1.35	77	–	–	–	–
136	4	3	247.75	1.52	65	247.22	32	1.64	53
136	5	1	253.75	1.62	57	254.00	36	1.60	58
136	5	5	259.75	1.56	62	–	–	–	–
136	6	1	262.75	1.55	61	262.14	40	1.52	62
136	6	2	264.25	1.56	60	–	–	–	–
136	7	1	275.75	1.49	65	–	–	–	–
136	7	4	280.25	1.16[a]	89	–	–	–	–
136	8	1	280.75	1.58	52	280.44	43	1.45	62
136	8	2	282.25	1.75	37	–	–	–	–
136	8	5	286.75	1.28[a]	78	–	–	–	–
136	8	6	288.25	1.38[a]	77	288.65	27	1.81	49

[a]Values doubtful as Core disturbed.

per cent of the maximum) were obtained from the oozes of Core 1. The counts increase downward reaching local highs of 1000 to 1200 in the chalk oozes but averaging about 600. Below the oozes the marls and silty clays had counts between 1000 and 3000. Ash layers had lower counts, 600 to 1000, which is consistent with their identification as basaltic tephra (rhyolitic or andesitic ash should run higher). The multi-colored clays in Core 8 had low counts of only a few hundred.

One sonic velocity measurement made on the basalt in Core 9, section 1 gave a velocity of 5.03 km/sec, but is considered suspect in view of the lower values measured by Fox *et al.* (Chapter 24).

The interstitial waters show salinities within the normal seawater range–32.5 to 34.1 but have anomalously low pH values. All readings (including those in the ooze) were below 7.0 (5.36 to 6.87 see Table 4). As the shipboard instrument showed a normal 8.27 for the pH of sea water at this site, we infer that the interstitial waters are, for some reason, not in equilibrium with the oozes and marls.

TABLE 4
Chemical Property Measurements on Samples from Site 136

Hole	Core	Section	Sample Interval (cm) Top	Sample Interval (cm) Bottom	pH	Eh	Salinity (°/oo)
136	1	5	0.0	9.0	5.36	+181	34.1
	2	6	0.0	5.0	6.87	+166	34.1
	3	4	0.0	5.0	6.75	+142	33.6
	4	3	145.0	150.0	6.82	+132	34.1
	6	1	148.0	150.0	6.59	+122	32.5
	8	2	0.0	5.0	6.53	+122	33.6

DISCUSSION AND CONCLUSIONS

The primary objective at this site was to sample and date basement in the far eastern part of the Atlantic close to the eastern magnetic quiet zone described by Heirtzler and Hayes (1967).

The *Challenger* seismic reflection profile showed a conspicuous basement reflector at about 0.33 seconds. Correlating this reflector with the depth to the sampled basalt yields an average velocity of 1.86 km/sec of the overlying sediments which is reasonable for the lithologies represented in the recovered material. (See figure 3)

The oldest sediment cores was nannoplankton marl ooze of Late Aptian age (about 104 m.y. old). The bottom of the core was 19 meters above the basalt and extrapolation of sedimentation rates through this interval indicates an age of 108 m.y. for the oldest sediment. On recovering the drill string, additional material from the bottom hole assembly was found to contain early Aptian marl ooze (106-109 m.

y. old). The basalt at Site 136 is a tholeiitic diabase whose petrology (see Chapter 23) appears to be typical oceanic basement (layer 2).

If the magnetic quiet zone represents a 155 m.y. isochron, as suggested from the data of Leg XI DSDP (Hollister and Ewing *et al.,* 1972), and if spreading rates on opposite flanks of the Mid-Atlantic Ridge have been roughly the same and uniform between 80 and 155 m.y., then an age of 108 m.y. for basaltic basement of Site 136 is anomalously young.

The discovery of a major sedimentary hiatus between the early Miocene and middle Upper Cretaceous, representing ~60 m.y. (Core 5) is very important. A major hiatus also occurs between the Oligocene-Miocene and the Lower Cretaceous (~75 m.y.) sediments in Site 105 (Hollister and Ewing *et al.,* 1972).

The depositional history at Site 136 can be summarized as follows:

During the Aptian and Early Albian, marl oozes with a well preserved calcareous flora were deposited probably at a rate of <1 cm/1000 years. During the Albian, exotically colored clays, silts, and some sand (mostly of volcanic origin) may indicate varying redox conditions.

During the Coniacian to Santonian, sand and silty clay was laid down with clay. The elongate silt-size calcite grains in Cretaceous sediments apparently also are of volcanogenic derivation, being closely associated with fragments of reworked lithified ash. In core catcher 6, for example, a piece of cemented tuff was recovered with a 1 cm thick calcite vein attached. No terrigenous sands were cored, but some of the coarse tuffaceous sands contain a small admixture of non-volcanic material. The important role played by currents in bottom transporting materials, versus gravity settling of volcanic materials, is demonstrated by the presence of parallel and cross laminations. In some places these currents have been strong enough to rework material deposited previously. During the late Cretaceous, it is probable that the water depth at the site deepened as the nannoplankton are well preserved lower down and strongly etched higher up.

In the Late Cretaceous, sedimentation ceased (or sediments of this age were deposited, but later eroded) until Early Miocene when calcareous silty clays, mostly of terrigenous origin, were unconformably laid down on the Cretaceous sediments. The unconformity is overlain by 14 meters of Miocene silty clay, moderately rich in quartz and with traces of K-feldspar. There is a gradual and fluctuating transition from calcareous silty clay overlying coccolith ooze. Apparently, the depositional site became shallower than the carbonate compensation level during Early Miocene.

Later in the Miocene, nannoplankton chalk ooze was the dominant sediment type with sedimentation rates increasing from 5 to 30 m/m.y. The nannoplankton and foraminifera indicate a relative shallowing of the sea during the time from the deposition of the silty clay below to the chalk ooze above. Only a few of the most solution resistant foraminifera are present in the silty clay, and the nannoplankton preservation is poor. Foraminifera are still very subordinate to nannoplankton in the chalk ooze, but those forms that do occur are well preserved. The extreme preponderance of coccoliths may indicate low fertility and would help explain the relative absence of siliceous fossils.

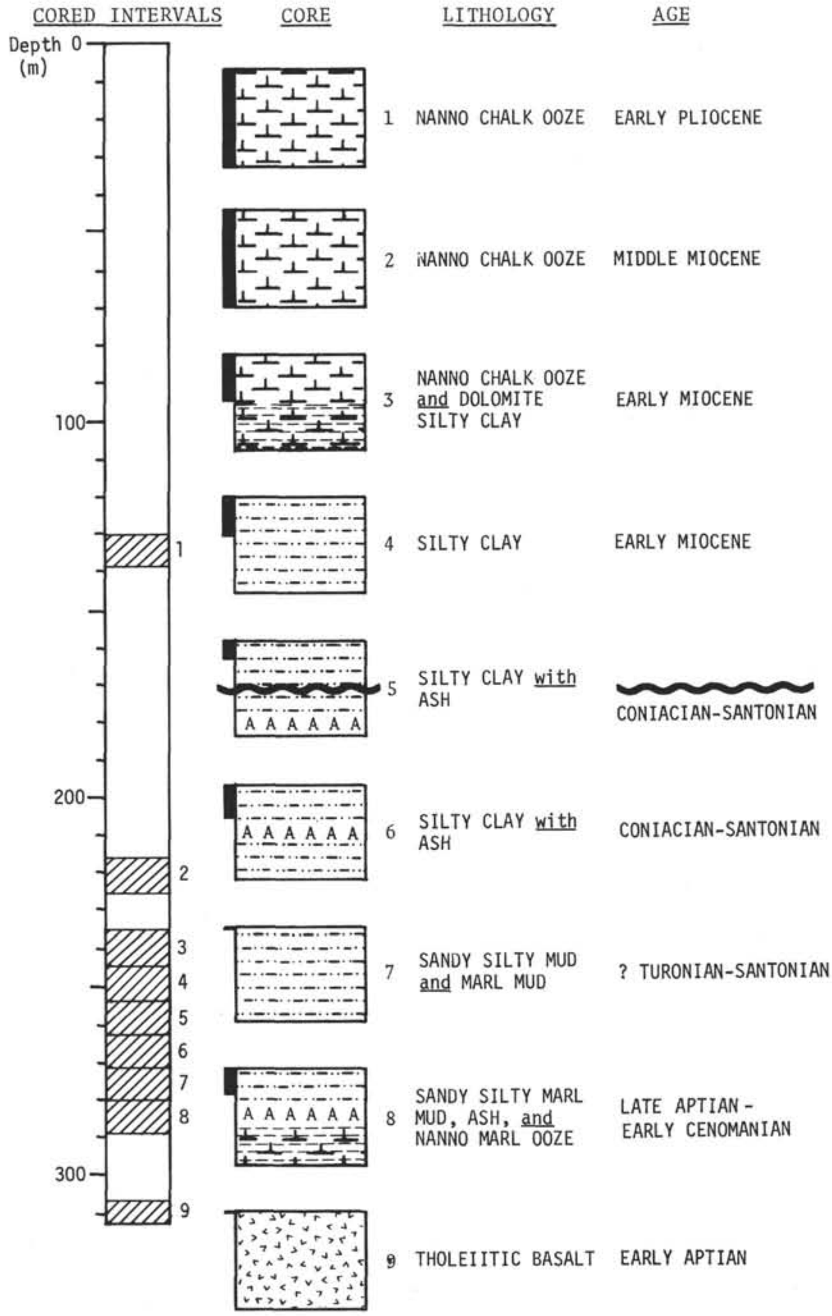
REFERENCES

Heirtzler, J. and Hayes, D. E., 1967. Magnetic boundaries in the North Atlantic Ocean. *Science.* **157**, 185-187.

Hollister, C. D., Ewing, J. I., *et al.,* 1972. *Initial Reports of the Deep Sea Drilling Project, Volume XI,* Washington (U. S. Government Printing Office).

Pitman, W. and Talwani, M., 1972. Sea-floor spreading in the North Atlantic, *Bull. Geol. Soc. Amer.,* **83**, No. 3, 619-646.

SITE 136-SUMMARY



SITE 136 **CORE** 1 **DEPTH (m)** 130-139

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	SMEAR SLIDE	LITHOLOGIC DESCRIPTION
EARLIEST PLIOCENE	*Globorotalia margaritae*	*Ceratolithus tricorniculatus*		1, 2, 3, 4, 5, 6, CC	1–8	90, 75, 135, 100, 115, 145	see below

GZ 1-36-63 — $CaCO_3$ 90

NANNO CHALK OOZE

Very pale orange (10YR 8/2)
and very pale brown (10YR 7/4)

Smear Slide Average:

Nannos	90-95%
Forams	<5%
Clay	~5%
Quartz	1%
Biotite and chlorite	1%

$CaCO_3$ 94

GZ 0-41-59

Coarse Fraction:
Planktonic forams, poorly to very poorly preserved, some benthonic forams

GZ 0-39-61 — $CaCO_3$ 98

Very pale orange (10YR 8/2)
Very pale brown (10Y 8/3)

GZ 1-35-64 — $CaCO_3$ 92

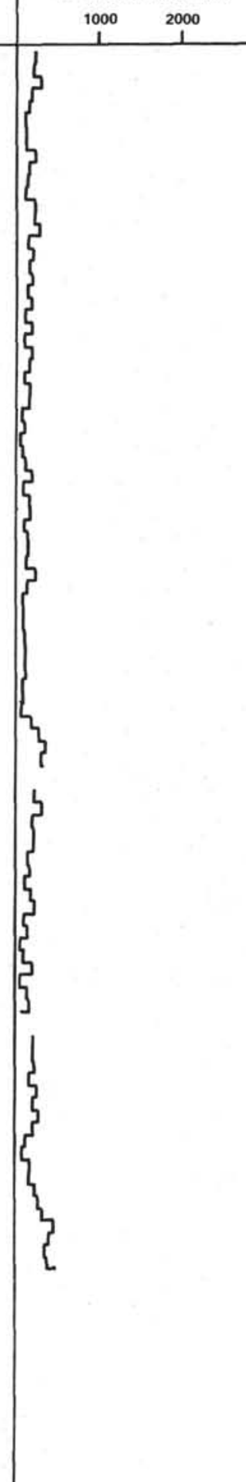
Very pale orange

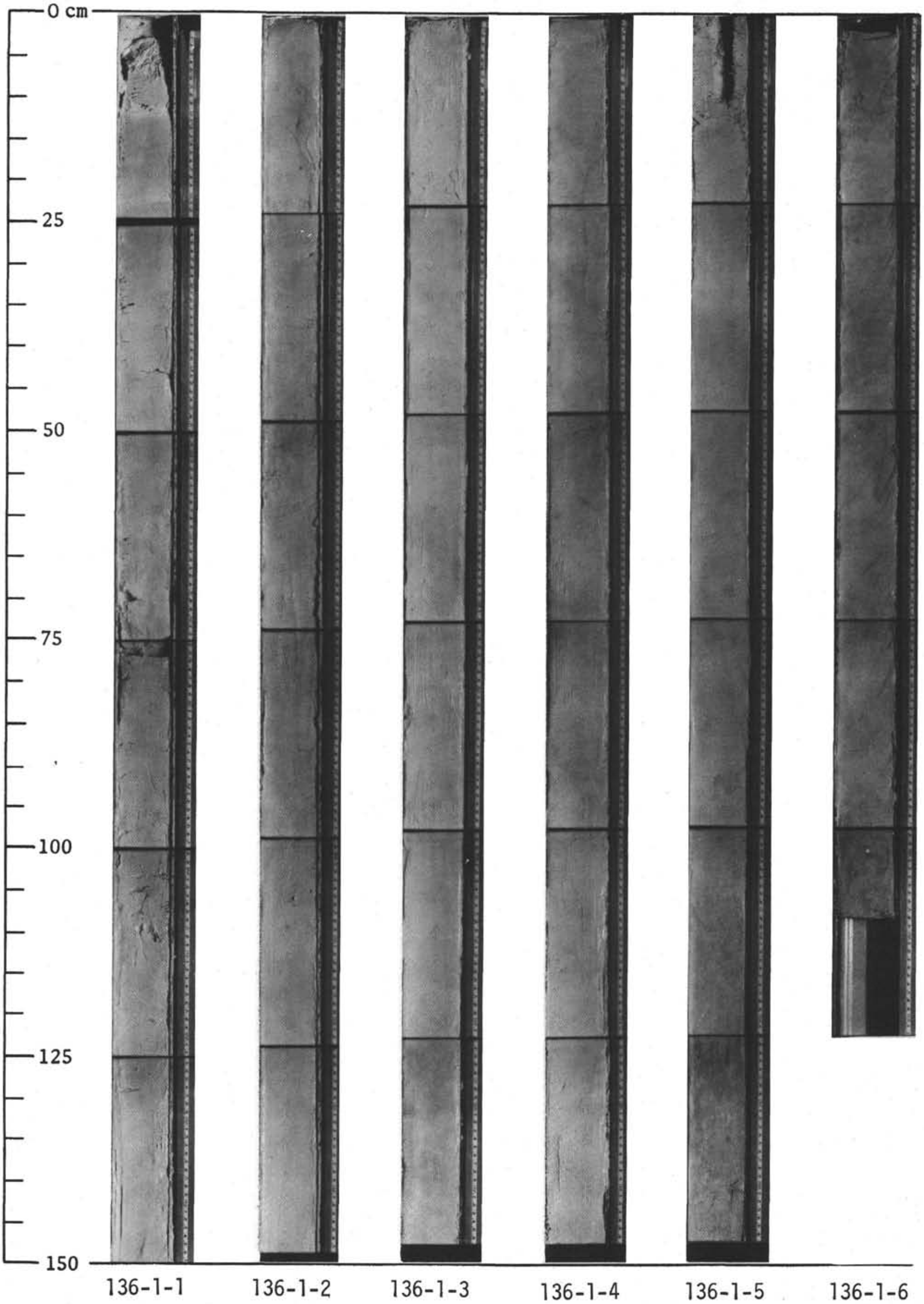
GZ 0-34-66 — $CaCO_3$ 95

Very pale brown
Grayish orange (10YR 7/2)

GZ 0-37-63 — $CaCO_3$ 90

NATURAL GAMMA RADIATION
COUNTS/7.6 cm/1.5 min




0 cm
25
50
75
100
125
150
136-1-1
136-1-2
136-1-3
136-1-4
136-1-5
136-1-6

SITE 136 CORE 2 DEPTH (m) 216-225

AGE: EARLY TO MIDDLE MIOCENE

ZONE — FORAM: *Globorotalia fohsi peripheroronda*; NANNO: *Sphenolithus heteromorphus*; RAD

SECTION: 1, 2, 3, 4, 5, 6, CC

METERS: 1, 2, 3, 4, 5, 6, 7, 8

LITHOLOGIC SYMBOLS: VOID, VOID

SMEAR SLIDE: 15, 60, 140, 50, 100, 30, 75, 10, 80

NATURAL GAMMA RADIATION — COUNTS/7.6 cm/1.5 min: 1000, 2000

LITHOLOGIC DESCRIPTION

GZ 0-35-65 $CaCO_3$ 35

NANNO CHALK OOZE

Colors are patches (originally bedding?) of light olive gray (5Y 6/2), pale brown (10YR 6/3), and pale orange (10YR 8/2).

Smear Slide Average:

Nannos	~95%
Forams	F<5%
Mica	Tr.-2%
Quartz	Tr.-2%
Carbonate rhombs	Tr.

GZ 2-41-57 $CaCO_3$ 86

Coarse Fraction:
Planktonic forams, very poorly preserved, benthonic forams, fish debris

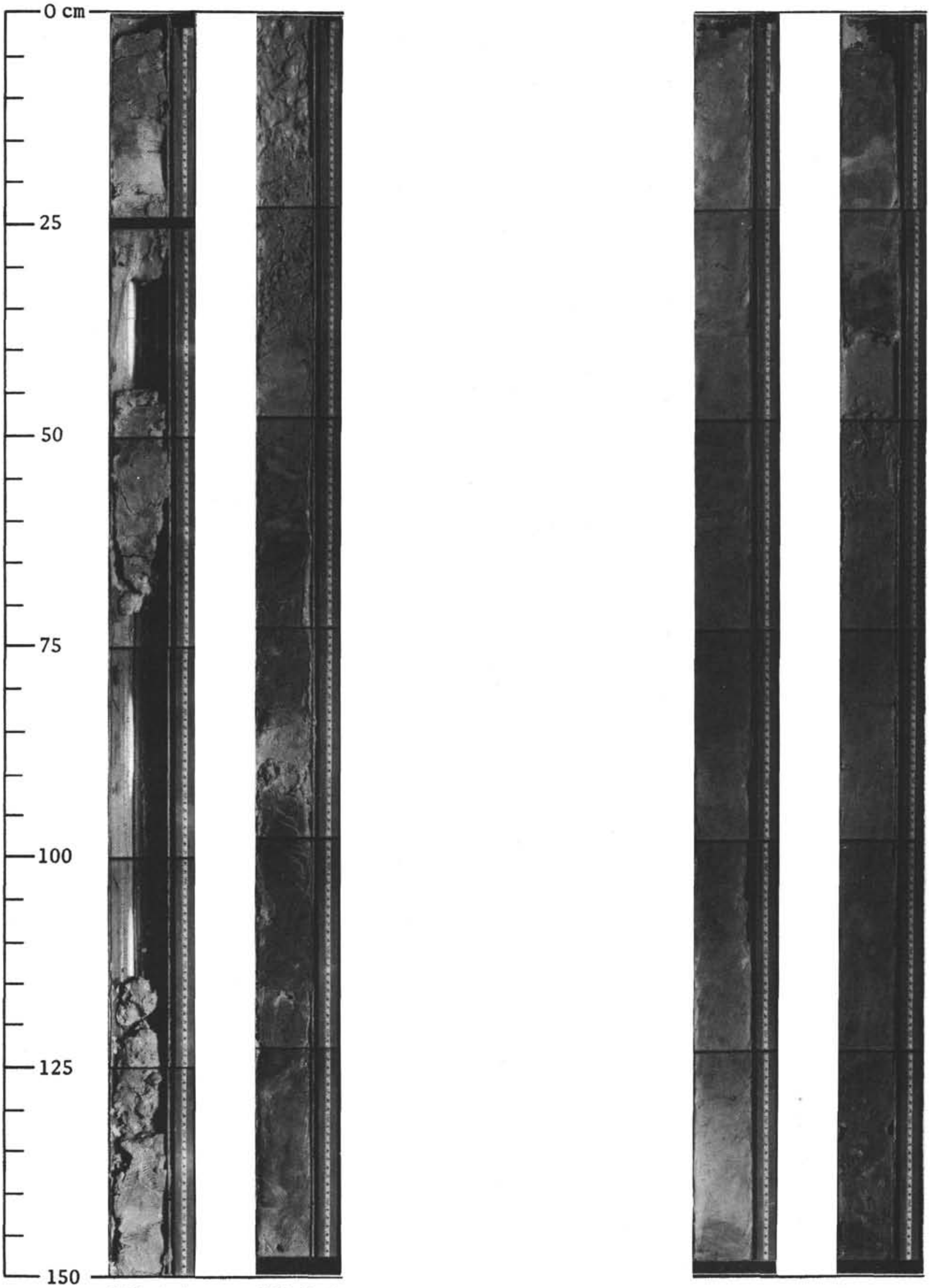
Section 3 not cut, soupy

Section 4 not cut, soupy

GZ 1-32-67 $CaCO_3$ 86

In Sections 5 and 6 are alternating hard (pale brown (10YR 6/3) and soft very pale orange (10YR 8/2). The 'hard vs soft' phenomenon is thought due to injection during the coring process $CaCO_3$ 52

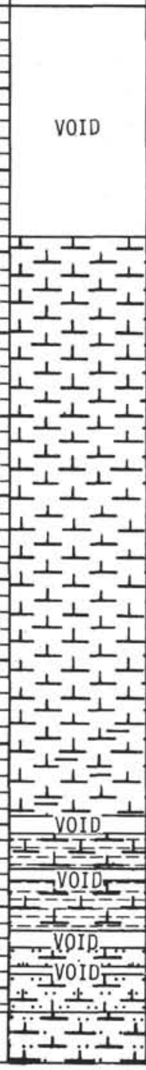
GZ 0-28-72



136-2-1 136-2-2 136-2-5 136-2-6

SITE 136 **CORE** 3 **DEPTH (m)** 235-244

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE
EARLY MIOCENE		*Sphenolithus belemnos*		1	0–1.5	VOID	
				2	1.5–3		46, 80
		Discoaster druggii		3	3–4.5		75
				4	4.5–6	VOID, VOID, VOID, VOID	65, 75, 110, 145
				CC			



LITHOLOGIC DESCRIPTION

NANNO CHALK OOZE

Very pale brown (10YR 7/3) to pale brown (10YR 6/3) — $CaCO_3$ 40

GZ 1-28-71

Smear Slide Average (46, 80, 75 cm):

Nannos	95%
Clay	<5%
Carbonate rhombs	Tr.-3%

Coarse Fraction:
Planktonic forams, very poorly preserved, benthonic forams, fish debris, Mn/Fe oxide, claystone fragments

$CaCO_3$ 44

Section 4 is transitional from above lithology to SLIGHTLY CALCAREOUS CLAY, then DOLOMITE SILTY CLAY

GZ 0-25-75 — $CaCO_3$ 48

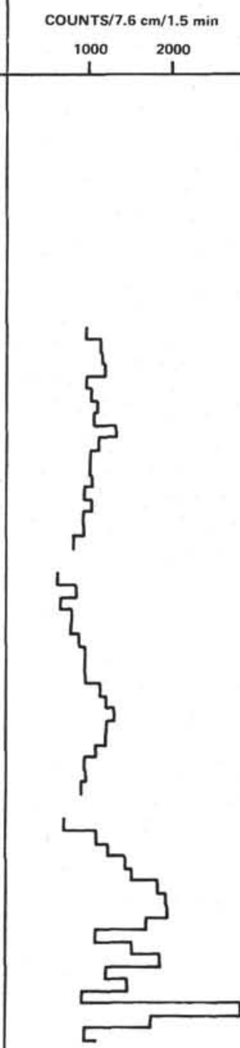
Smear Slide Average (65, 75 cm):

Nannos	70-80%
Clay	10-25%
Quartz	Tr.-3%
Carbonate rhombs	1--2%

Smear Slide Average (110, 145 cm):

Clay	60-75%
Carbonate rhombs	20-25%
Quartz	5-15%
Fe oxide	Tr.-2%
Nannos	Tr.-2%
Carbonaceous matrix	Tr.-2%
Pyrite	Tr.

NATURAL GAMMA RADIATION



0 cm
25
50
75
100
125
150

Photograph not available

Photograph not available

136-3-1 136-3-2 136-3-3 136-3-4

SITE 136 CORE 4 DEPTH (m) 244-253

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE
LATE OLIGIOCENE TO EARLY MIOCENE		*Triquetrorhabdulus carinatus?*		1	1	VOID	90, 94
				2	2	VOID	90
				3	3, 4	VOID	75, 148
				CC			

LITHOLOGIC DESCRIPTION

SILTY CLAY, slightly quartzose

Mottled pale brown (10YR 6/3) and grayish brown (10YR 5/2)

Smear Slide (90 cm): $CaCO_3$ 1

Clay	60%
Nannos	20%
Zeolite	5%
Quartz	5%
Biotite	3%
Feldspar	2%
Heavies, pyrite	Tr.

At 94 cm, bleb of light gray (10YR 7/1) nanno chalk ooze

Smear Slide Average (90, 75, 148 cm):

Clay	75-90%
Quartz	2-15%
Micas and chlorite	2--5%
Fe oxide	2%
Nannos	Tr.-3%
Zeolite	Tr.-2%
Feldspar	Tr.-2%

$CaCO_3$ 0

X-ray (55 cm, Sec. 3)

Quartz	A
Mica, montmorillonite, palygorskite, chlorite kaolinite, calcite	C
Feldspar, dolomite	Tr.

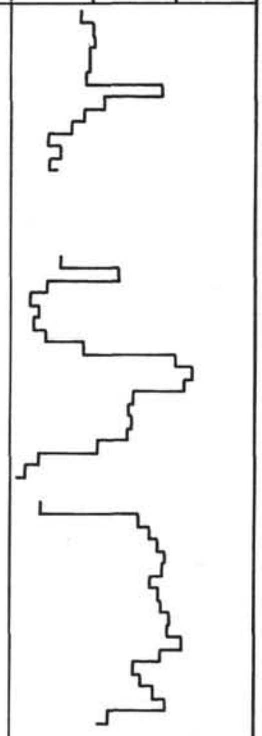
Coarse Fraction:
Benthonic forams, fish teeth, Mn/Fe oxide, quartz, claystone fragments

sec.1, 60 cm GZ 1-22-77

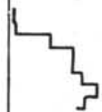
NATURAL GAMMA RADIATION

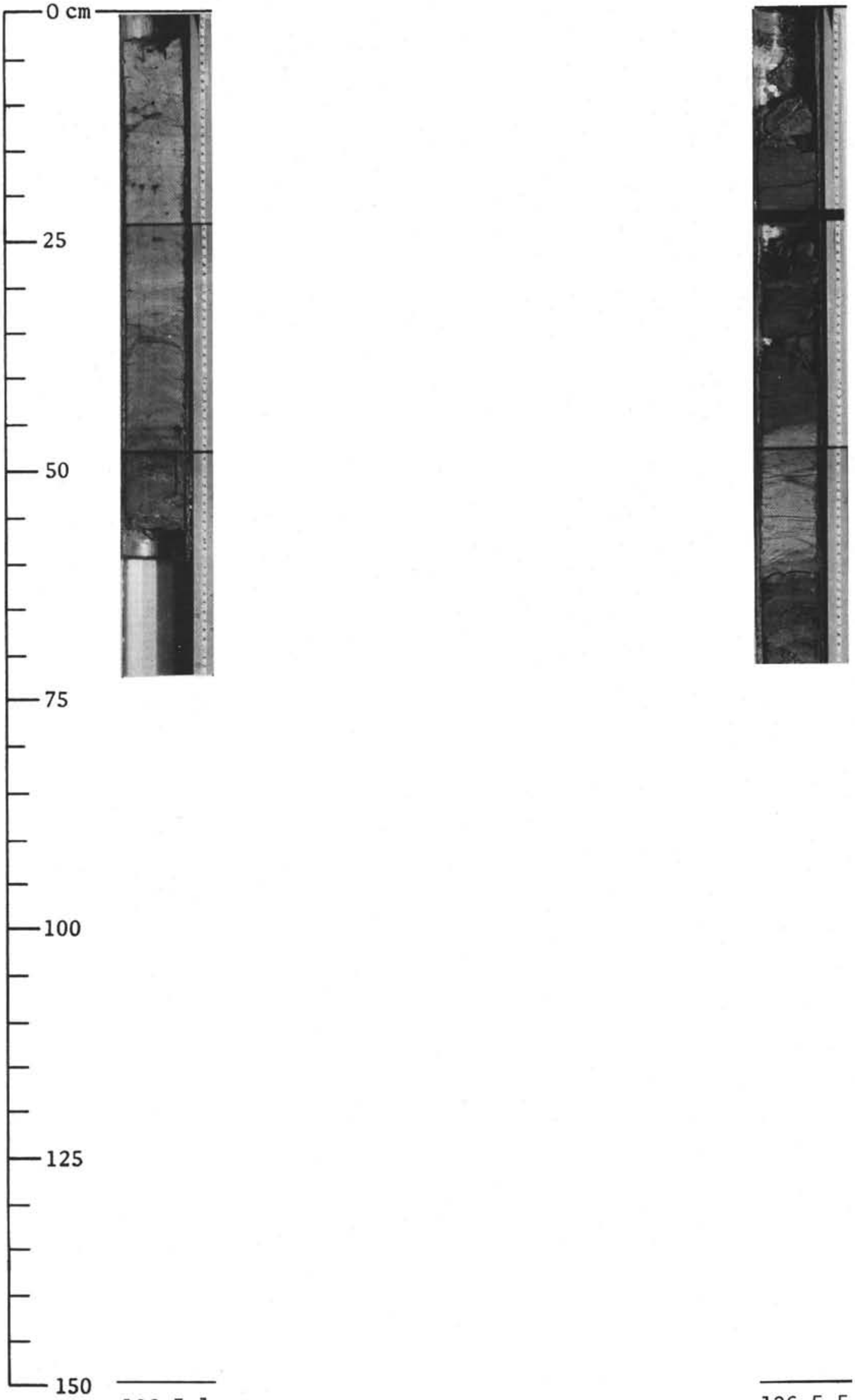
COUNTS/7.6 cm/1.5 min

1000 2000



SITE 136 CORE 5 DEPTH (m) 253-262

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE	LITHOLOGIC DESCRIPTION	NATURAL GAMMA RADIATION (COUNTS/7.6 cm/1.5 min; 1000, 2000)
UNKNOWN				1*	0–1.5	VOID	*	SILTY CLAY Shades of brown CaCO3 5 GZ 0-29-71 The ash at the base of Section 1 may belong with the (Cretaceous) sediments of Section 5.	
CONIACIAN - SANTONIAN				2	1.5–3			* See Section Summaries	
				3	3–4.5	VOID			
				4	4.5–6				
SECTION 5 & CC				5*	6–7.5		*	GZ 14-41-45 SILTY CLAY, with ASH LAYERS	
				CC					

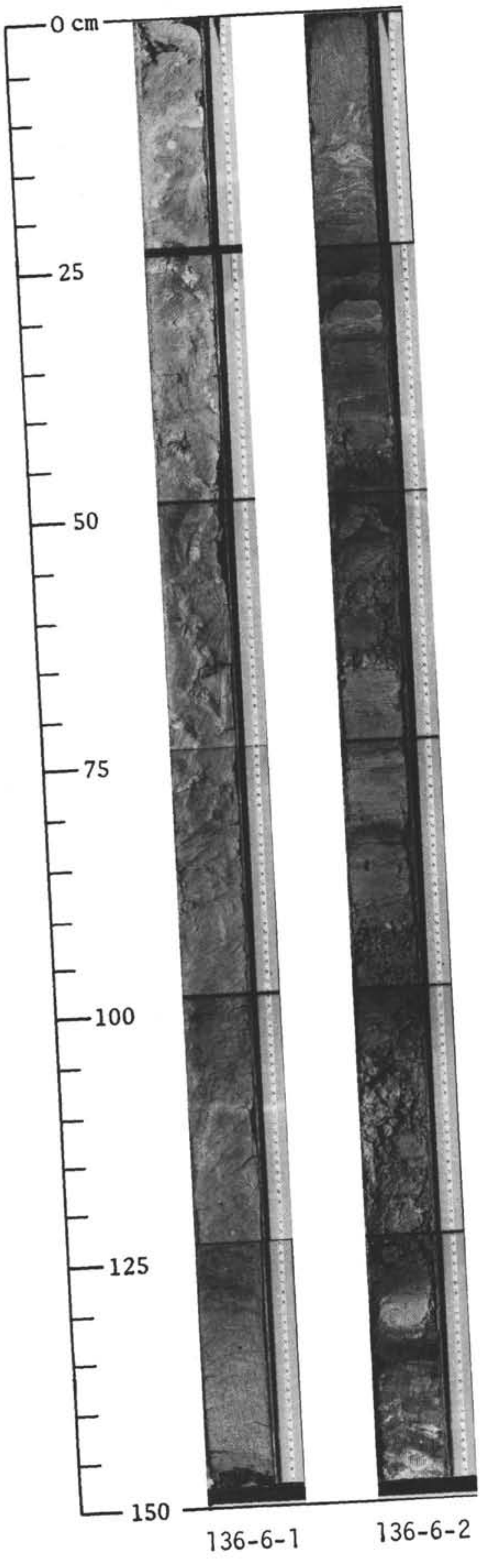


136-5-1

136-5-5

SITE 136 CORE 6 DEPTH (m) 262-271

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE	LITHOLOGIC DESCRIPTION	NATURAL GAMMA RADIATION COUNTS/7.6 cm/1.5 min (1000, 2000)
CONIACIAN-SANTONIAN				1	1		*	CaCO3 5 SILTY CLAY with ASH LAYERS Pale brown (10YR 6/3) and reddish brown (5YR 3/2), mottled Silt consists of ash fragments and elongate calcite crystals with parallel extinction	
				2	2		*	Coarse Fraction: Clay lumps (ash?), tuff fragments, large spindle-shaped calcite crystals, fish debris 25 cm GZ 26-48-26 GZ 5-56-39 * See Section Summaries	
				CC					


0 cm
25
50
75
100
125
150
136-6-1
136-6-2

SITE 136 CORE 7 DEPTH (m) 271-280

AGE: ?TURONIAN-SANTONIAN

ZONE: FORAM / NANNO / RAD

SECTION: 1, 2, 3, 4, CC

METERS: 1, 2, 3, 4, 5, 6

LITHOLOGIC SYMBOLS: VOID; VOID

SMEAR SLIDE: 138; 145

NATURAL GAMMA RADIATION — COUNTS/7.6 cm/1.5 min (1000, 2000)

LITHOLOGIC DESCRIPTION

SANDY SILTY MUD and MARL MUD

Red and brown colors
131-136 cm: yellowish red (5HR 4/6), disturbed mixture
136-141 cm: reddish brown (10YR 4/3), sand and sandy silt, altered tephra

Smear Slide (138 cm):

Glass	30%
Fe oxide	20%
Clay plus yellow mica	25%
Zeolite	10%
Mica	5%
Feldspar	5%
Calcite prisms	3%
Quartz	2%
Carbonate rhombs, heavies	Tr.

141-145 cm: grayish brown (10YR 5/2) to red (2.5YR 4/6) silty marl mud

Smear Slide (145 cm):

Calcite fragments (prisms?)	50%
Clay	35%
Feldspar, glass, biotite, pyroxene, feldspar	15%

Total of 33 cm. recovered as shown, but probably contiguous.

Reddish brown (2.5YR 4/4) to red (2.5YR 4/6) silty marl mud, as at 141-145 above.

Siltier (more calcite fragments) 136-142 cm., more clayey 142-150 cm.

SITE 136 **CORE** 8 **DEPTH (m)** 280-289

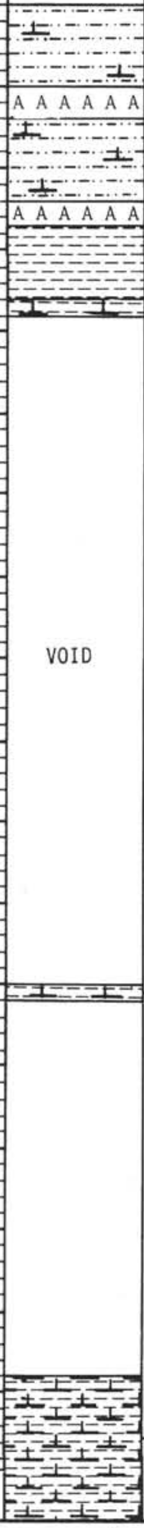
AGE: LATE APTIAN-EARLY CENOMANIAN

ZONE: FORAM | NANNO: *Parhabdolithus ansustus* | RAD

SECTION: 1, 2*, 3, 4, 5, 6, CC

METERS: 1–8

LITHOLOGIC SYMBOLS



SMEAR SLIDE: *, *, 3, 138

LITHOLOGIC DESCRIPTION

SANDY SILTY MARL MUD alternating with vitreous ASH LAYERS CaCO₃ 3

Reddish brown (2.5YR 5/4)

60 cm GZ 3-56-41

CLAY, and NANNO MARL OOZE

Clay: varicolored and banded

Coarse Fraction:
Pink claystone fragments (probably calcite-cemented tuff), spindle-shaped calcite crystals

* See Section Summary

Nanno marl ooze in Sections 2 and 5 probably contiguous

NANNO MARL OOZE

Banded in olive gray (5Y 3/2), light olive gray (5Y 5/2) and grayish olive (10Y 4/2)

Smear Slide (3 cm):

Clay	60%
Nannos	35%
Calcite prisms	3%
Zeolite, feldspar, mica, chlorite	2%

CaCO₃ 67

NANNO MARL OOZE

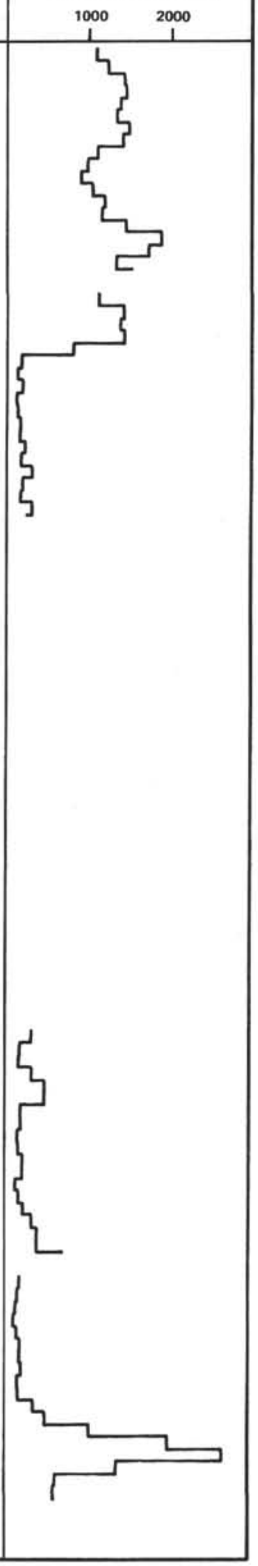
Badly mixed and disturbed shades of gray (N2, N7) and olive gray (5Y 4/1).

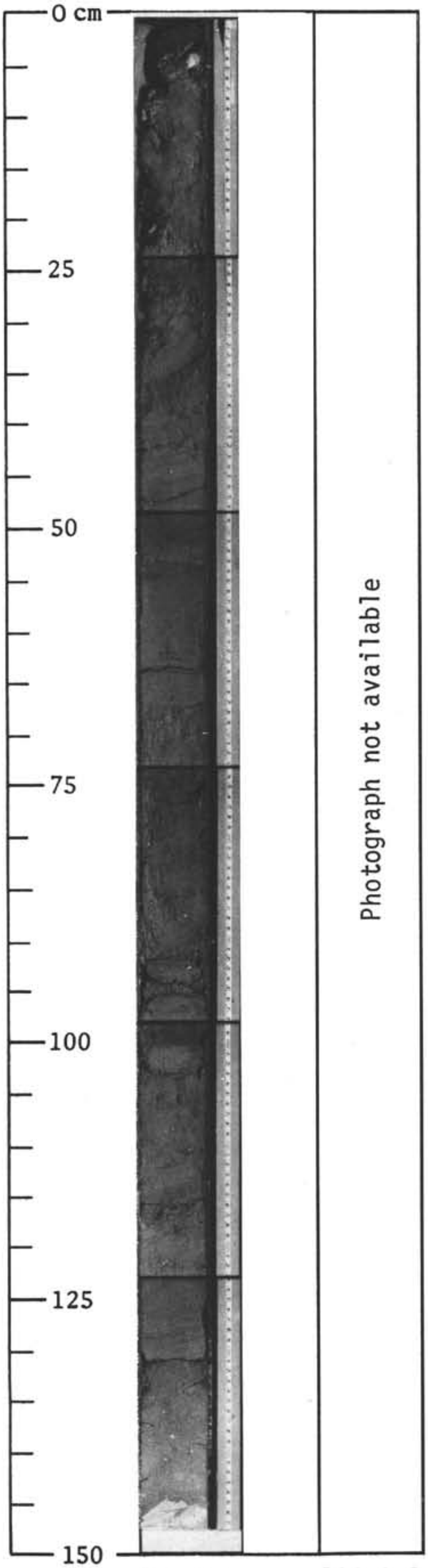
Composition as above.

130 cm GZ 1-22-77

NATURAL GAMMA RADIATION

COUNTS/7.6 cm/1.5 min

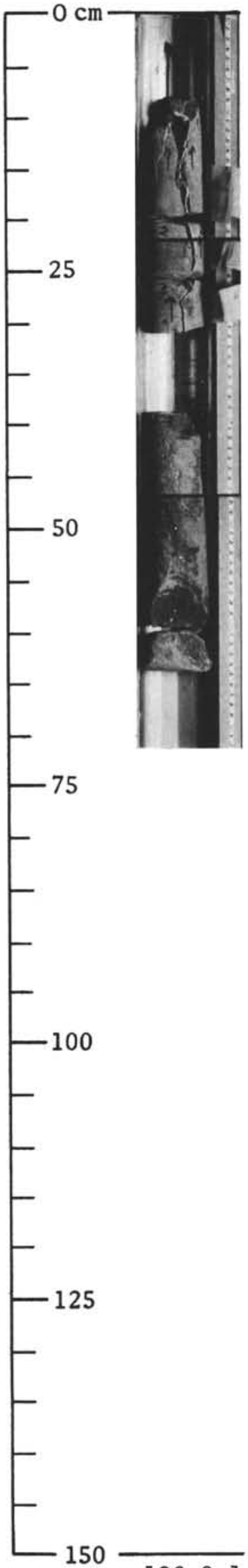




136-8-1 136-8-2

SITE 136 CORE 9 DEPTH (m) 308-313

AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE	LITHOLOGIC DESCRIPTION	NATURAL GAMMA RADIATION COUNTS/7.6 cm/1.5 min (1000, 2000)
UNKNOWN				1	1	VOID	T.S.	BASALT Tholeiitic, altered, with fractures and vesicles filled with calcite and in some cases pyrite, chalcopyrite and smectite. Plagioclase ($\sim An_{30-60}$) and pyroxene in a matrix of altered glass Thin Section: Feldspar 45% Fe oxides and opaques 9% Pyroxene 17% Glass 15% Zeolite 3% Clay 1% Calcite 1%	
				CC					



136-9-1

SITE 136 CORE 5 SECTION 1

AGE	SECTION PHOTO	cm	LITHO	SMEAR SLIDE	DESCRIPTION
UNKNOWN		25, 50, 75, 100, 125, 150	VOID	100, 120, 135, 145	SILTY CLAY, various shades of brown in rapid alternation, contacts sharp. Black irregular streaks approximately horizontal. Fine mottling pattern in places.

SILTY CLAY, various shades of brown in rapid alternation, contacts sharp. Black irregular streaks approximately horizontal. Fine mottling pattern in places.

Smear Slide Average:

Clay	80-85%
Carbonate Rhombs	Tr.10%
Quartz	Tr.10%
Fe oxide	Tr. 5%
Micas and Chlorite	3%
Pyrite	Tr.

X-ray (120-124 cm):

Montmorillonite, palygorskite	A
Quartz, feldspar, mica, kaolinite, dolomite	C
Siderite	Tr.

Light yellowish brown (10YR 6/4), with MnO blebs and streaks

Light brown (7.5YR 6/4.5) with MnO blebs and streaks, strongly but finely mottled between 120-125 cm.

Brown (10YR 5/3) "banded" clay, banding due to sub-parallel MnO streaks

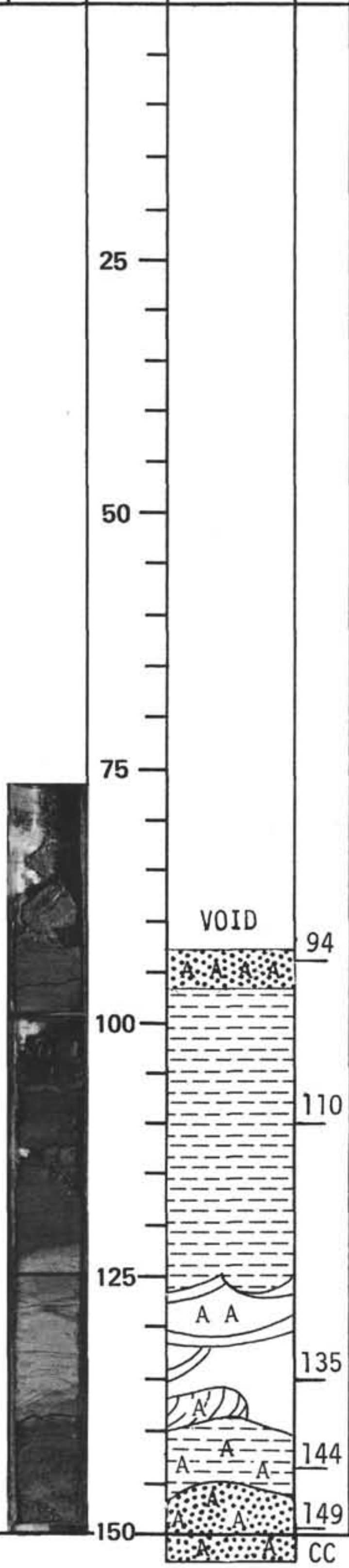
Dark brown (10YR 4/3), larger MnO streaks

Dark grayish brown (10YR 4/2), less silty

SITE 136 **CORE** 5 **SECTION** 5

AGE | SECTION PHOTO | cm | LITHO | SMEAR SLIDE | DESCRIPTION

CONIACIAN-SANTONIAN?



SILTY CLAY, including ASH, with discrete coarse ASH LAYERS

Smear Slide Averages (Ash Layers) (94, 135, 144, 149 cm):

Clay	40-70%
Opaques	5-25%
Biotite and Chlorite	5%
Quartz	0-3%
Zeolite	2-10%
Glass and Palagonite	Tr.-20%
Calcite Prisms	0-15%
Carbonate Rhombs	Tr.-3%
Feldspar	Tr.-5%
Heavies (mostly Pyroxene)	Tr.-4%

Smear Slide (110 cm) (silty clay):

Clay	75%
Detrital carbonate	15%
Fe oxide	10%
Quartz	Tr.
Pyrite	Tr.

Thin Section, Core Catcher (vitreous tuff):

Sideromelane	55%
Altered volcanic rock frags. (inc. Feldspar)	11%
Calcite spar cement	15%
Palagonite	9%
Fe oxide and opaques	7%
Clay	3%

93-97 cm: dark grayigh brown (2.5Y 4/2), with laminae of white and grayish brown (10YR 5/2)

97-125 cm: dark reddish gray (5YR 4/2) with gray silt laminae. Subparallel horizontal red streaks from 121-124 cm.

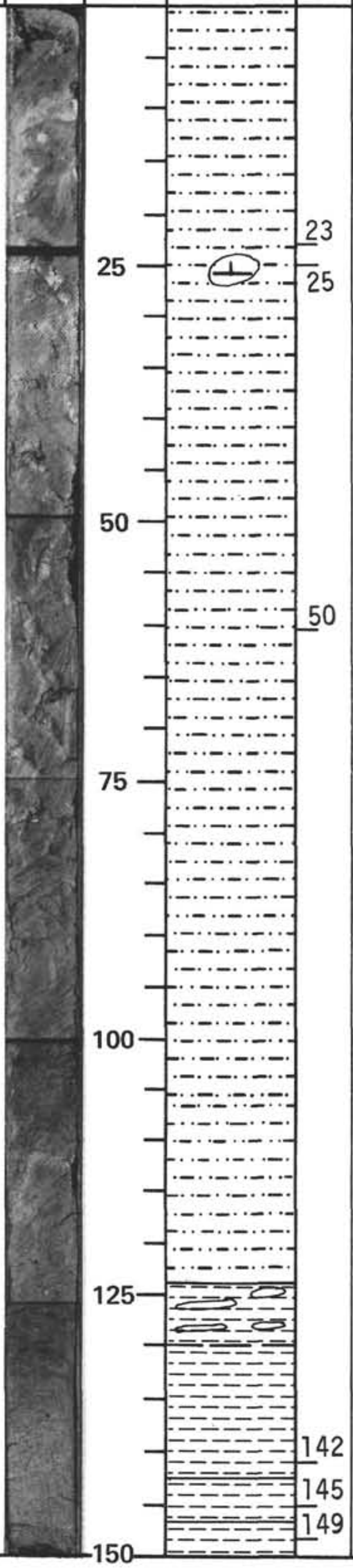
Very pale brown (10YR 7/3)

Banded clayey ash, browns and reds

Brownish yellow (10YR 6/6) sandy ash

SITE 136 CORE 6 SECTION 1

AGE	SECTION PHOTO	cm	LITHO	SMEAR SLIDE	DESCRIPTION



SILTY CLAY; silt is either altered ash fragments or elongate calcite prisms showing parallel extinction

At 25 cm, bleb of white nanno chalk ooze

Smear Slide Average (23, 60 cm):

Clay (altered ash/)	75%
Calcite prisms	20%
MnO plus hematite	5%

Smear Slide Average (142, 145, 149 cm):

Clay (altered ash?)	80-90%
Fe O plus hematite	5-10%
Zeolite	Tr.-5%
Carbonate rhombs	Tr.-3%
Glass and palagonite	Tr.-3%
Mica, pyrite, heavies	Tr.

X-Ray (145 cm):

Montmorillonite	A
Feldspar	C
Quartz	Tr.

Below 125 cm, little (<5%) carbonate, some hematite
Pale brown (10YR 6/3) clay with dark gray to black subhorizontal streaks (Mn O?)

Dark reddish brown (5YR 3/2), mottled

Reddish brown (5YR 4/4), laminated

SITE 136 CORE 6 SECTION 2

AGE	SECTION PHOTO	cm	LITHO	SMEAR SLIDE	DESCRIPTION
SENONIAN		25, 50, 75, 100, 125, 150		46, 70, 106, 129, 148	see below

CLAY and SILTY CLAY with ASH LAYERS
Mainly yellowish brown (10YR 5/3), laminated

Ash is moderate yellow brown (10YR 5/3), sharper contacts at base.

Fine laminations

Smear Slide (46 cm):

Montmorillonite and yellowish mica	50%
Fe oxide	25%
Glass	10%
Biotite	5%
Zeolite	5%
Carbonate prisms	10%
Palagonite, heavies	Tr.

Smear Slide (70 cm):

Clay	80%
Fe oxide	10%
Zeolite	5%
Glass	3%
Feldspar	2%
Calcite prisms	Tr.

Silty clay, banded reds and browns

Smear Slide (106 cm):

Calcite prisms	70%
Clay aggregates	30%
Feldspar, pyroxene, chlorite	Tr.

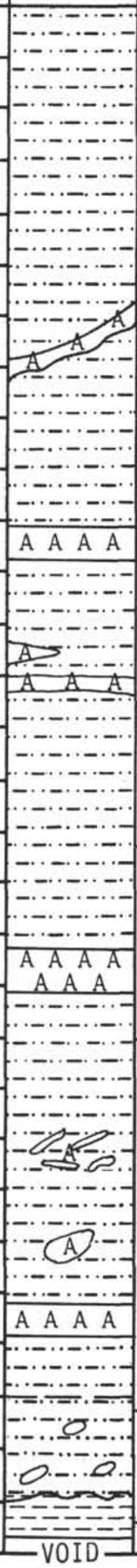
Smear Slide (129 cm):

Calcite prisms	75%
Clay	20%
Nannos	5%

Mixed clay and ash

Very pale yellow brown (10YR 8/2), calcite prisms

SITE 136 **CORE** 8 **SECTION** 1

AGE	SECTION PHOTO	cm	LITHO	SMEAR SLIDE	DESCRIPTION
UNKNOWN		25 50 75 100 125 150		53 82 101 137 147	see below

SILTY MARL MUD, reddish brown (2.5 YR 5/4)

X-Ray (53 cm):

Almost X-ray amorphous	
Feldspar	C
Quartz	Tr.

Laminated

X-Ray (146 cm):

Palygorskite	A
Quartz, feldspar mica	C
Hematite, dolomite	
Montmorillonite, chlorite	Tr.

VITREOUS ASH, yellow brown (10YR 5/4)

Smear Slide (53 cm):

Clay plus yellow mica	60%
Sideromelane	20%
Zeolite	8%
Palagonite	5%
Fe oxide	5%
Quartz, feldspar	1%
Calcite prisms, pyroxene	Tr.

Smear Slide Average (82, 101 cm):

Clay	30-60%
Calcite prisms	30-60%
Fe oxide	5-10%
Glass	0--3%
Quartz	2--5%
Feldspar, mica	Tr.

ASH as layers and intraclasts

137-153 cm: SILTY CLAY, yellowish brown (10YR 5/4) overlying white CLAY, clasts of clay floating in the silty clay

Smear Slide Average (137, 147 cm):

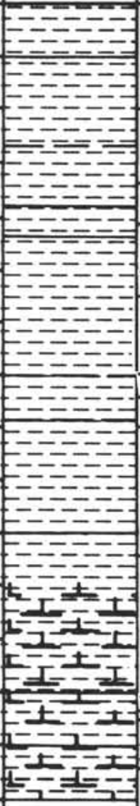
Clay	95%
Quartz	3%
Feldspar	2%
Biotite and chlorite	Tr.

SITE 136 **CORE** 8 **SECTION** 2

AGE	SECTION PHOTO	cm	LITHO	SMEAR SLIDE	DESCRIPTION

PHOTOGRAPH NOT AVAILABLE

cm: 10, 20, 30, 40, 50



Smear slide: 5, 8.5, 10, 14, 18.5, 20, 26, 33.5, 35

0-2.5 cm: CLAY, pale reddish brown (10R 5/4) and olive yellow (2.5Y 6/6)

2.5-7 cm: Pale olive (5Y 6/4) and pale reddish brown (10R 5/4), Clay 95%, Nannos 5%, Quartz Tr.

7-9.5 cm: Moderate orange pink (10R 7/4) and moderate reddish orange (10R 6/6)

9.5-11 cm: Yellowish green (10GY 6/4), Clay 65%, Yellow micaceous mineral (Nontronite?) 30%, Mica 2%, Quartz 1%, Feldspar 10%, Chlorite, Zeolite Tr.

11-17.5 cm: Pale olive (5Y 6/4) and pale reddish brown (10R 5/4). Clay 95%, rest Quartz, Glass, Feldspar, Chlorite, Opaques, Nannos

17.5-20 cm: Yellow (2.5Y 7/6). Clay 75%, Fe oxide 20%, Zeolite 2%, Quartz 1%, Biotite, Chlorite, Carbonate Tr.

20-25 cm: Olive (5Y 5/4) and olive yellow (2.5Y 6/4). Clay 90%, Nannos 5%, Quartz 3%, Fe oxide 2%

25-32 cm: Gray, transitional to

32-37.5 cm: NANNO MARL OOZE, light gray (2.5Y 7/10) at top to very dark grayish brown (2.5Y 3/2) at base. Nannos 60%, Clay 40%, Quartz, Glass Tr.

<u>X-Ray (8.5 cm):</u>

Montmorillonite	A
Quartz, K Feldspar	C
Palygorskite	Tr.

<u>X-Ray (10 cm):</u>

Disordered Mica, Illite, Quartz	C

<u>X-Ray (17.5-18.5 cm):</u>

Quartz, Mica, Montmorillonite, Palygorskite	C
Chlorite	Tr.

<u>X-Ray (20-24 cm):</u>

Quartz, Mica, Montmorillonite, Palygorskite	C
Feldspar	Tr.

<u>X-Ray (27 cm):</u>

Calcite	A
Quartz, Montmorillonite	C
Palygorskite, Mica Feldspar, Chlorite	Tr.

<u>X-Ray (33.5 cm):</u>

Calcite	A
Quartz, Feldspar, Mica	Tr.