6. SITE 139

The Shipboard Scientific Party[1]

ABSTRACT

Site 139 is situated on the middle continental rise about 250 km northwest of Cap Blanc, Africa.

About 520 meters of nannoplankton chalk and marl ooze, with a small terrigenous component increasing downwards, overlies at least 140 meters of diatom ooze with interbedded quartz sands. The carbonate sequence is Early to Middle Miocene and younger in age, and the siliceous material Early Miocene.

The strongest intermediate reflector seen on the seismic profiles is at about 0.60 second, which may correspond with the pronounced change in lithology at a depth of 523 meters.

The sediments show a marked salinity gradient from 33 ppt in Core 1 to 75 ppt in Core 7.

SITE DATA

Date: 0040 October 29, 1971
2000 October 30, 1971

Position: 23° 31.14′N
18° 42.26′W

Water Depth: 9,994 feet
1,626 nominal fathoms
3,047 meters

Total Penetration: 665 meters

Cores Taken: Seven Cores, One sidewall sample

BACKGROUND, SURVEY, OPERATIONS

Site 139 lies on the smooth middle continental rise about 250 km northwest of Cap Blanc, Africa in a water depth of about 3000 meters (~1600 m; Figure 1). The site is situated about midway between the eastern Atlantic magnetic quiet zone boundary and the African continent (see map in folder at back of this volume). Seismic records indicate the pronounced sediment stratification below about 0.55 seconds at Site 139, is typical for the area and exhibits no major change in character from the upper rise (~1800 m) to the lower rise (~4200 m) (Figure 2).

The approximate locations of Sites 139 and 140 are indicated on the *Vema* records (Figure 2). The approaching and departing seismic traverse near Site 139 is shown on the *Challenger* records, and the continuous profile between Sites 139 and 140 is shown at the bottom (Figure 2). An enlargement of the seismic profile at Site 139 is given in the composite diagram in Figure 3. The thick relatively undisturbed prograded sediment wedges are well illustrated on all profiles. Many of the major reflectors can be traced beneath this portion of the rise for several hundred kilometers. Unpublished Lamont-Doherty sonobuoy results indicate that the depth to layer 2 (seismic velocity, about 5 km/sec) is about 1.7-2.0 km below the sea floor near Site 140. Layer 2 appears to be essentially flat-lying, at least for a distance of ~200 km toward Site 139 from Site 140 (J. Ewing, pers. comm.). Note that the extent of the prograding is most prominent for the deeper sediment layers, and that the thickness of the uppermost seismic unit, is not very different at Site 139 than at 140. The low frequency seismic energy penetrates the sediments on the middle continental rise (vicinity of Site 139) considerably less than those on the lower continental rise (vicinity of Site 140). This suggests to us the likelihood of a much greater proportion of highly reflective terrigenous components in the lower part of the section comprising the middle and upper continental rise.

The morphology of the rise province and inferred sediment disposition at this location, contrasts sharply with that of the rise off the east coast of the United States, where the profiles show that the sediments above reflecting Horizon A have been eroded and slumped through rotational faulting. There, the rise is much narrower than off Cap Blanc, and strong boundary currents are presumed responsible for controlling the evolution of the rise off the United States. There is no evidence that a similar boundary current exists west of Cap Blanc.

The primary objective of Site 139 was to sample the upper portion of the sedimentary section to determine the nature of sediment disposition along this continental rise, and to compare it with the DSDP Leg 11 results on the continental rise off Eastern U. S., and with results from Site 138 located further down the West African continental rise.

Seismic Reflection Data:	*Vema* 27	*Challenger*
Intermediate Reflectors	0.35 sec	0.30 sec
	0.60 sec	0.55 sec
	0.80 sec	0.75 sec

[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.

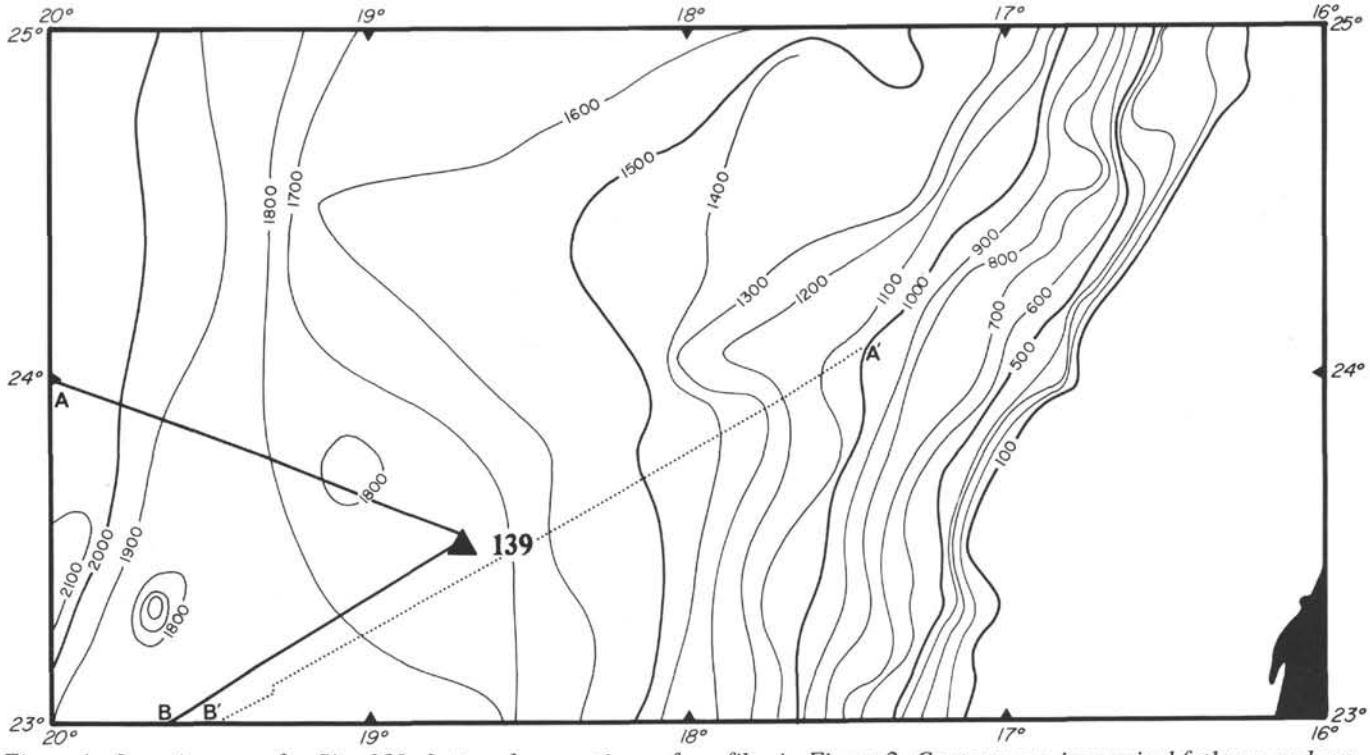


Figure 1. *Location map for Site 139. Letters key portions of profiles in Figure 2. Contours are in nominal fathoms and are taken from U. S. Naval Oceanographic Office B.C. Chart 0205N. Note the discrepancy of about 100 fathoms between the depths observed at the site and those shown on the B.C. Chart suggesting the contours are not well determined in this area.*

A summary of the drilling and coring record is given in Figure 4 and Table 1. This was the only site at which a Reed tooth bit was used in an attempt to penetrate and spot core a thick succession rapidly. Although this objective was achieved, core recovery was extremely poor.

TABLE 1
Drilling and Coring Record for Site 139

Description	Interval Below Sea Floor (m)	Core Recovery (m)	Drilling Rate (m/min)
Drill	0-114		5.2
Core 1	114-123	2.6	
Drill	123-225		3.5
Core 2	225-234	5.1	
Drill	234-345		1.1
Core 3	345-354	0	
Drill	354-455		1.1
Core 4	455-463	0	
Drill	463-484		1.2
	484-503		1.0
	503-541		0.7
	541-551		1.0
	551-571		1.2
Core 5	570-576	0.3	
Drill	576-598		1.1
	598-607		0.5
Core 6	607-612	0.4	
Drill	612-637		1.8
	637-656		0.8
Core 7	656-665	9.0	

BIOSTRATIGRAPHY

General

Pliocene sediments recovered from the upper part of this hole (Cores 1 and 2) contain rich assemblages of planktonic foraminifera, nannoplankton, Radiolaria and diatoms. Temperate influence is indicated both by planktonic foraminifera and nannoplankton. The Middle Miocene sediments yield rich radiolarian and diatom assemblages together with planktonic foraminifera. Cores 3 and 4 belong to the same planktonic foraminiferal and nannoplankton zone. Since both are known to be of a short duration, this indicates a high sedimentation rate or slumping. Transported benthonic foraminifera (of shallow water origin) dominate over planktonic foraminifera in Cores 5 through 7. Etched Middle to Lower Miocene nannoplankton, together with common diatoms and Radiolaria, occur in Cores 5 and 7. A list of the age diagnostic calcareous fossils is given in Table 2.

Foraminifera

The Pliocene to Middle Miocene faunas of Cores 1 and 4 are of the normal pelagic type, consisting mainly of planktonic foraminifera. The almost exact repetition in the faunas of Cores 3 and 4 (both *Globorotalia fohsi robusta* Zone) is probably anomalous, otherwise this single foraminiferal zone, which is believed to be of relatively short duration, would be represented by a sediment thickness of 120 meters or more. The deeper cores in this hole (Cores 5 to 7 and Sidewall Core 1) have a different character. The benthonic foraminifera (Buliminidae, Nodosariidae, various Rotalidea) outnumber the planktonic specimens in most cases. The normal environment of

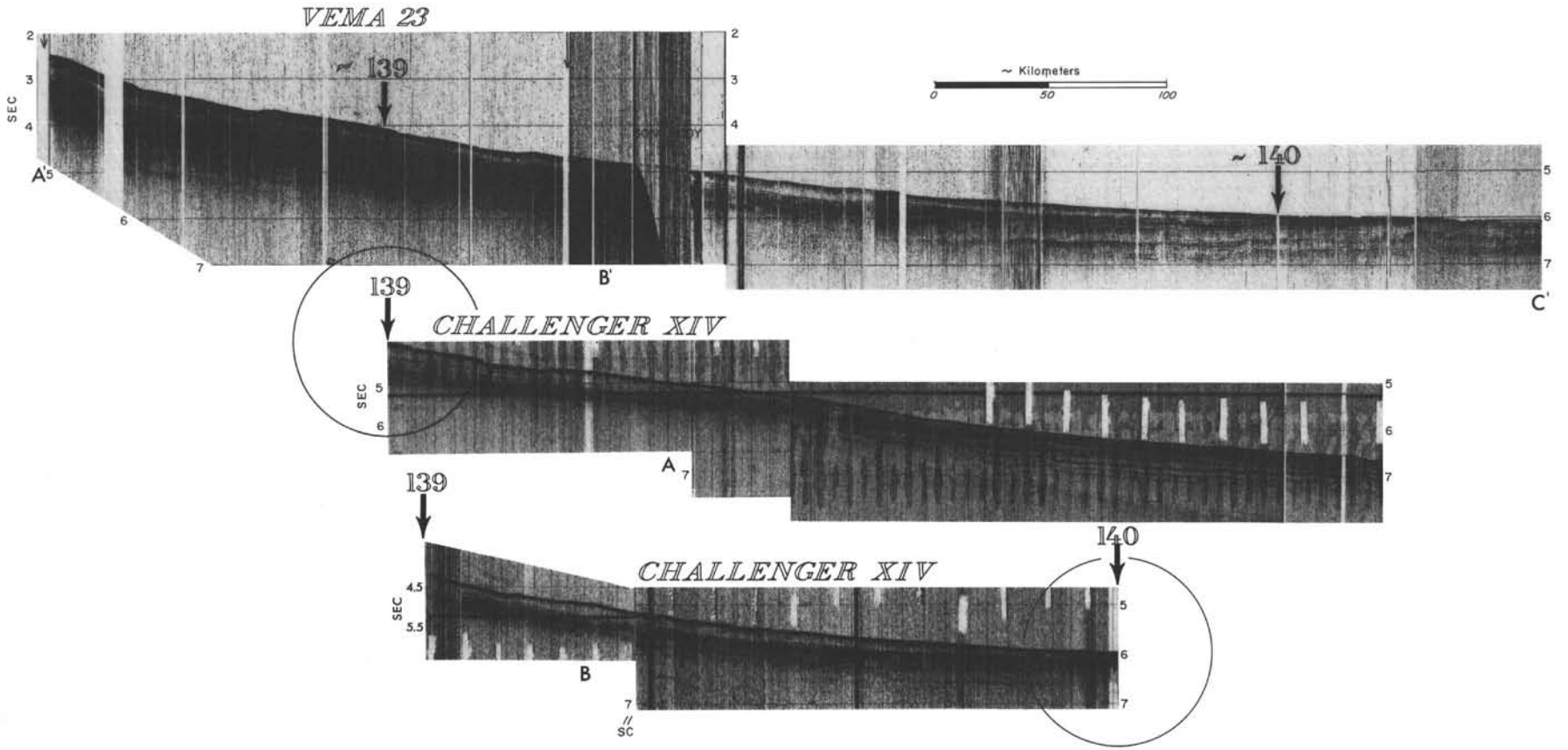


Figure 2. *Seismic reflection records in the vicinity of Sites 139 and 140. Location of profiles shown in Figure 1 and in Chapter 7, Figure 1. Note there is a change on the vertical scale near point B on the* Challenger *profile. The* Vema *profile is from unpublished Lamont Doherty Geological Observatory data (J. Ewing, pers. comm.).*

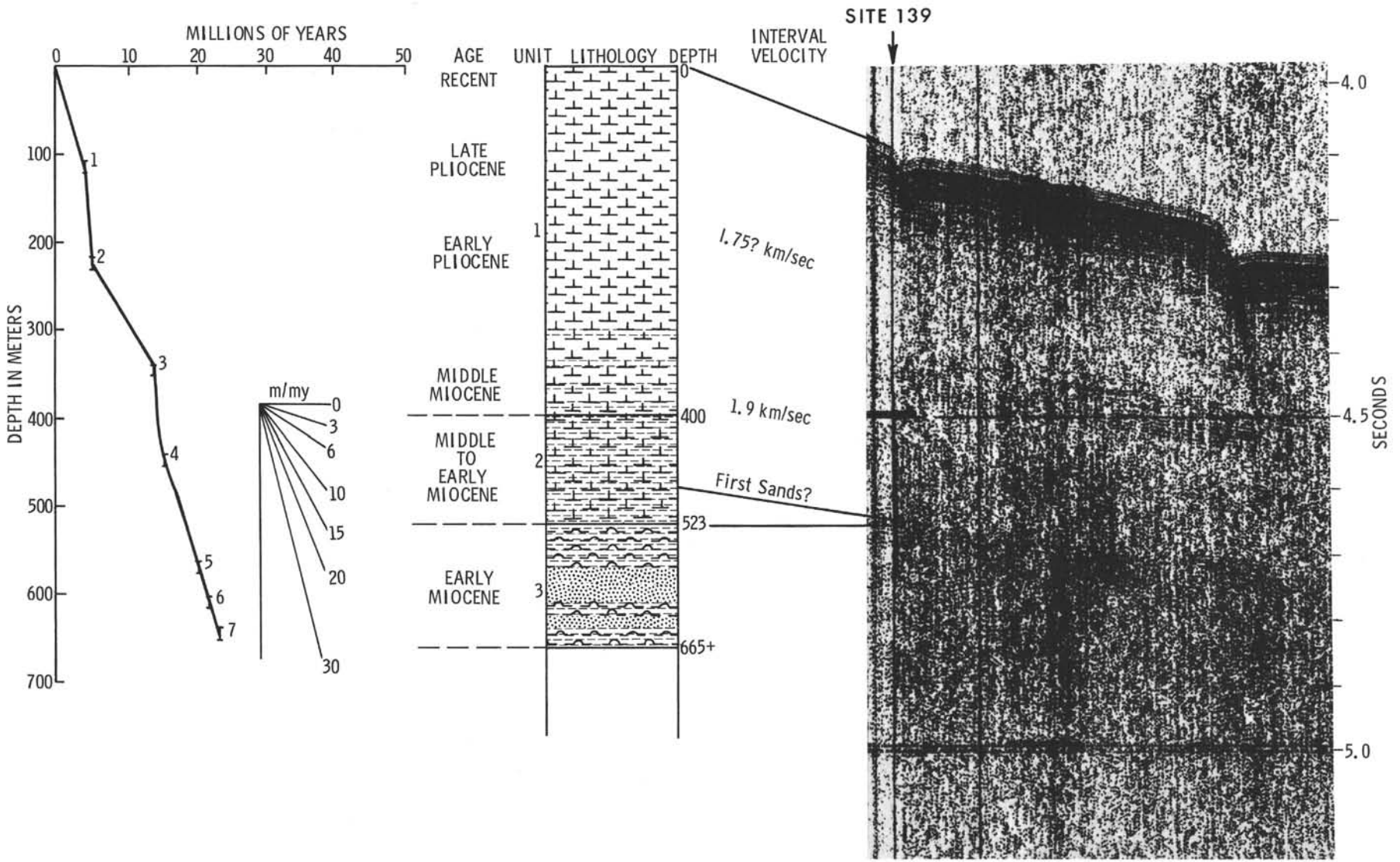


Figure 3. *Geological synthesis at Site 139. Two alternative correlations are shown (see text).*

TABLE 2

CORE	DIAGNOSTIC FOSSILS HOLE 139		
	FORAMINIFERA	NANNOPLANKTON	AGE
1	Rich, predominantly planktonic faunas of Late Pliocene age *(Globorotalia exilis/G. miocenica* (Zone) with *Globorotalia exilis* (rare), *Gr. miocenica, Gr. cultrata* (dextrally coiled), *Gr. acostaensis, Gr. humerosa, Gr. crassaformis, Gr. hirsuta, Globigerinoides ruber.*	Rich nannoflora with *Reticulofenestra pseudoumbilica, Ceratolithus rugosus, Discoaster brouweri, D. asymmetricus, D. pentaradiatus, D. surculus, Coccolithus pelagicus.* Preservation: E1-01 Zone: *Reticulofenestra pseudoumbilica* Age: Late Pliocene	Late Pliocene
2	Rich, predominantly planktonic faunas indicating an Early Pliocene age *(Globorotalia margaritae* Zone), with *Globorotalia margaritae* (large specimens aff. *Gr. praehirsuta), Gr. cultrata* (predominantly sinistral), *Gr. tumida* (sinistral), *Gr. acostaensis, Globigerinoides obliquus, Globoquadrina altispira, Globigerina venezuelana,* and *Uvigerina asperula.*	Abundant nannofossils, *Ceratolithus tricorniculatus, Triquetrorhabdulus rugosus, Discoaster brouweri, D. pentaradiatus, D. surculus, D. variabilis.* Preservation: E1-01 Zone: *Ceratolithus tricorniculatus.* Age: Early Pliocene	Early Pliocene
3	A fairly rich, predominantly planktonic fauna of Middle Miocene age *(Globorotalia fohsi robusta* Zone), with *(Globorotalia fohsi robusta, Gr. fohsi lobata, Gr. praemenardii, Gr. mayeri, Globigerinoides subquadratus, Globoquadrina dehiscens.*	Moderately rich assemblage with *Discoaster exilis, D. kugleri, Coccolithus eopelagicus.* Preservation: E2-01 Zone: *Discoaster kugleri* Age: Middle Miocene	Middle Miocene
4	A fairly rich, mainly planktonic fauna with *Globorotalia fohsi robusta, Gr. praemenardii, Gr. mayeri, Globigerinoides subquadratus,* and *Globoquadrina dehiscens.* Age: Middle Miocene, *Globorotalia fohsi robusta* Zone.	It contains the same assemblage in the same state of preservation as core 3. Zone: *Discoaster kugleri.* Age: Middle Miocene	Middle Miocene
5	The microfossil assemblage is mainly siliceous (radiolarians, diatoms) but benthonic foraminifera are also fairly common and well preserved. *(Uvigerina, Gyroidina, Nodosaria, Epistominella, Lagena, Lenticulina, Bulimina* etc.). Planktonic foraminifera *(Catapsydrax dissimilis, Globorotaloides* sp.) are rare and indicate an age not younger than *Catapsydrax stainforthi* Zone (Early Miocene), but possibly older.	Strongly etched poor assemblages with *Discoaster deflandrei, D. divaricatus, Reticulofenestra pseudoumbilica.* Preservation: E3 Age: Middle to Early Miocene	Early Miocene
SW1	Foraminifera are scarce and include *Globigerinoides trilobus, Globoquadrina* sp., and some representatives of the genera *Uvigerina, Epistominella, Gyroidina, Nonionella,* and *Lenticulina.* Age: Miocene (or younger?).	Poorly preserved nannoplankton, *Discoaster deflandrei, Cyclococcolithina floridana.* Preservation: E3 Age: ?Early Miocene	Early Miocene
6	Rare benthonic foraminifera (Nonionidae?, Anomalinidae?) identified in thin section.	No nannoplankton	?
7	A rather poor fauna of planktonic and benthonic foraminifera is found in Section 6 only. It contains *Catapsydrax dissimilis, Globorotalia mayeri, Globigerinoides immaturus, G.* cf. *primordius, Globoquadrina praedehiscens,* as well as representatives of the genera *Gyroidina, Uvigerina, Cibicides, Nodosaria, Globocassidulina, Nonionella, Stilostomella, Karreriella* etc. Age: Early Miocene, *Globorotalia kugleri* Zone to *Catapsydrax stainforthi* Zone.	Common nannoplankton, *Triquetrorhabdulus, Reticulofenestra abisecta, Discoaster deflandrei.* Preservation E2 to E3 - 01. Zone: *Triquetrorhabdulus carinatus.* Age: Early Miocene	Early Miocene

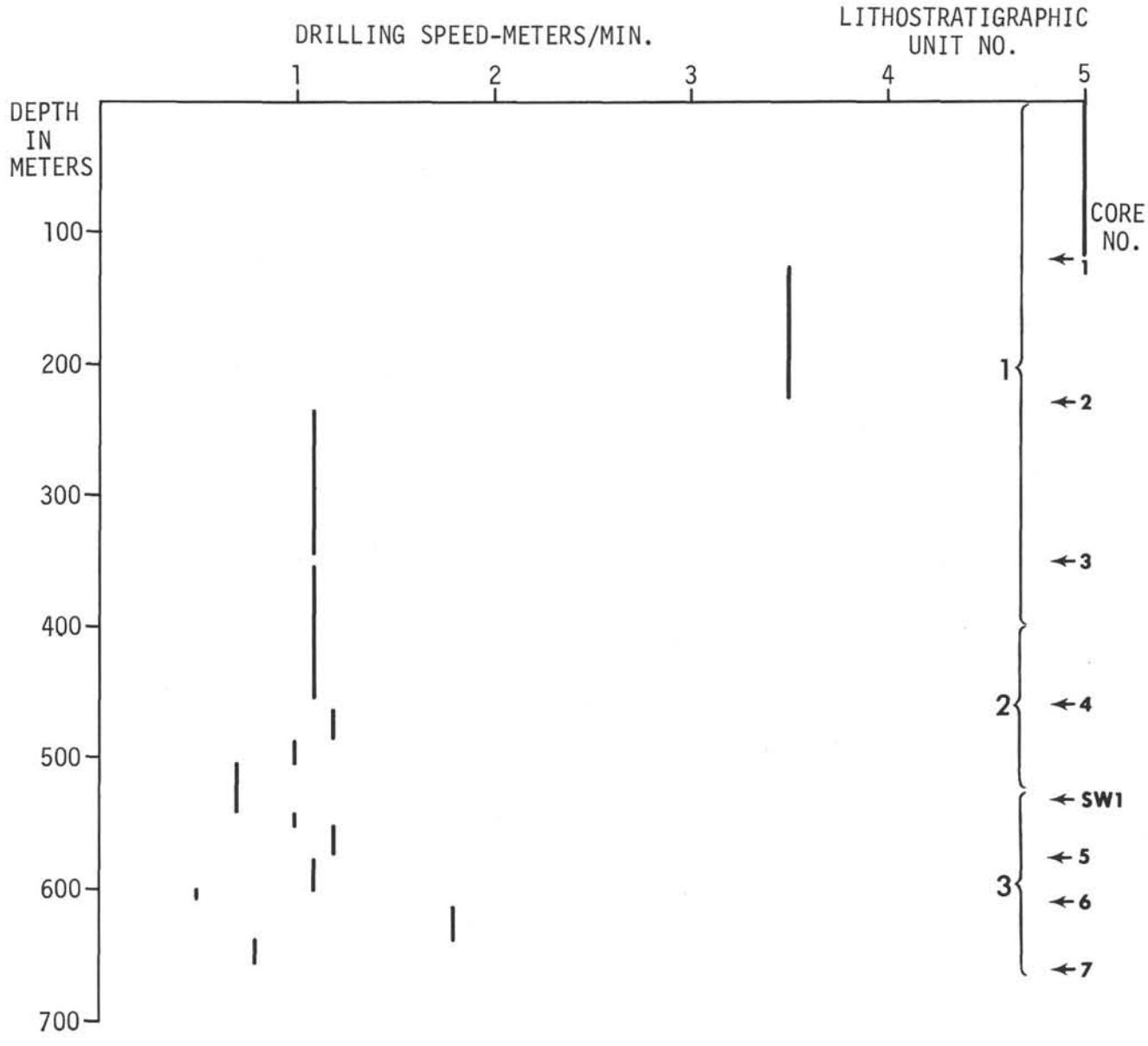


Figure 4. *Drilling and coring summary at Site 139.*

deposition of this type of assemblage would most probably be the neritic (or upper bathyal?) zone, but the association with abundant siliceous microfossils and quartz sand strongly suggests transportation and redeposition in deep water.

Nannoplankton

Rich Upper Pliocene assemblages recovered from Core 1, contain abundant *Coccolithus pelagicus* indicating a temperature paleoclimate for the late Pliocene at this latitude. Lower Pliocene assemblages in Core 2 are rich and diversified. Cores 3 and 4 belong to the same nannoplankton zone (*Discoaster kugleri* zone). Cores 5 and 7 recovered strongly etched Lower Miocene nannoplankton.

Diatoms

Determinations listed here made by Hans Schrader[2]

Core 1, Section 1, 100 cm:

Coscinodiscus lineatus, Stephanopyxis turris, Thalassionema nitzschioides, Melosira sulcata, Achnanthes spec., Hemidiscus cuneiformis, Fragilariopsis spec. *Actinocyclus ellipticus var. elongatus, Pseudoeunotia doliolus.* Well preserved diatom assemblage with high species diversity. Rads and sponge spicules common. *Actinocyclus ellipticus* indicates a Pliocene age.

[2]Geologisch-Palaontologisches Institut und Museum der Universitat, Kiel

Age: (Pliocene) No other age diagnostic fossils were found.

Core 1, Section CC:

Coscinodiscus nodulifer, Stephanopyxis turris, Chaetoceros spores, *Hemidiscus cuneiformis, Triceratium alternans, Coscinodiscus lineatus, Actinoptychus undulatus, Actinocyclus ehrenbergi. Archaeomonadaceae, Silicoflagellatae* and Radiolaria are common.

Age: No age diagnostic diatom species were found.

Core 3, Section CC:

Rhaphoneis amphiceros, Coscinodiscus radiatus, Diploneis smithii, Thalassiothrix longissima, Thalassionema nitzschioides, Actinoptychus undulatus, Melosira sulcata, Coscinodiscus marginatus, Chaetoceros spores and bristles. High percentage of littoral diatoms (underlined) indicates either shallow water depositional environment or transportation of littoral material into this depositional environment. Sponge spicules, Radiolaria, *Silicoflagellatae* are common.

Age: No age diagnostic species recovered.

Core 5, Section 1, 7 cm:

Strongly etched poor diatom assemblage, no rads, no sponge spicules.

Core 5, Section 1, 140 cm:

Pseudopyxilla capreolus, Coscinodiscus marginatus, Stephanopyxis turris, Melosira sulcata, Liradiscus rugulosus FORTI, *Sceptroneis caduceus, Rhizosolenia* spec., *Goniothecium rogersii* EHR., *Stephanogonia polyacantha* FORTI, *Synedra jouseana, Chaetoceros cinctus, Xystotheca hustedti* HANNA. Diatom ooze with well preserved fustules. High percentage of littoral species shows near shore depositional environment with extreme high production of primary producers (upwelling).

Age: Somewhat similar to the diatomaceous deposits of Maryland, U.S.A., Middle to Upper Miocene.

Core 5, Section CC:

Similar assemblage to that above.

Core 6, Section 32, 35 cm:

Caves in the sandstone are filled with fine diatom material, Taxonomic investigation was impossible on the thin section.

Age: No age diagnostic species were recovered.

Core 6, Section 32, 38 cm:

Similar to the above sample.

Core 6, Section CC:

Strongly etched diatoms, no rads, no sponge spicules.

Core 7, Section 1, 130 cm:

Stephanopyxis turris, Melosira sulcata, Rhaphoneis amphiceros, Rhaphoneis paralis HANNA, *Xystotheca hustedti* HANNA. Few *Silicaflagellatae,* Radiolaria and sponge specules.

Age: No age diagnostic species were recovered.

Core 7, Section 2, 146 cm:

Melosira sulcata, Rhaphoneis amphiceros, Goniothecium rogersii EHR., *Actinocyclus subtilis, Xystotheca hustedti* HANNA, *Fragilariopsis* spec., *Surirella temblorsis* HANNA. Diatom ooze with well preserved frustules. High percentage of littoral species (*Rhaphoneis, Melosira, Surirella*) indicates near shore depositional environment with upwelling character and nutrient rich waters.

Age: Somewhat similar to the diatomaceous deposits of Maryland, U.S.A., middle Miocene (?).

Core 7, Section 3, 50 cm:

Similar to the above sample, but different in the high percentage of *Chaetoceros* spores.

Core 7, Section 4, 67 cm:

Cymatosira andersoni HANNA, *Rhaphidodiscus marylandicus* CHRISTIAN, *Actinoptychus splendens, Melosira sulcata, Rhaphoneis amphiceros, Meulleriella limbata, Coscinodiscus marginatus.* Similar to 139-7-3-50. Different by the above mentioned species.

Age: Lower to Middle Miocene.

Core 7, Section 5, 117 cm:

Similar to the above sample.

Core 7, Section CC:

Rhaphoneis amphi ceros, Thalassiothrix longissima, Pyxilla johnsoniana, Rhaphidodiscus marylandicus, Actinoptychus undulatus, Synedra jouseana, Chaetoceros spores. Similar to the above listed assemblages.

Age: Lower to Middle Miocene if the *Pyxilla* is reworked or older if the species is not reworked.

LITHOSTRATIGRAPHY

Site 139, drilled on the continental rise at 3,047 meters depth, consisted of one hole which was terminated at 665 meters in lowermost Miocene sediments. Seven cores were taken, several with poor recovery. Three units can be tentatively distinguished on the basis of this material.

Unit	Cores	Lithology	Depth Below Sea Floor (m)	Age
1	1,2,3	Nannofossil marl chalk ooze, 10% forams, trace terrigenous material	0-~400	Middle Miocene to Pliocene (Recent: foram ooze)
2	4	Silty nannofossil marl ooze, trace forams, 20% terrigenous material	~400-523	Early to Middle Miocene
3	5,6,7	Intercalcated diatom ooze and quartz-sand (stone)	523->665	Early Miocene

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

This unit is about 400 meters thick and consists of light olive gray, light gray and greenish gray nannofossil chalk to marl ooze (60% nannos, 12% forams). It also contains traces of siliceous fossils, authigenic carbonate, and terrigenous minerals deposited since Middle Miocene. The sediments smell of H_2S and contain several per cent of pyrite. Despite much disturbance through coring, some original banding appears discernible. In the lower part of the unit, calcareous fossils decrease slightly and siliceous fossils become somewhat more abundant. The age of Unit 1

is Middle Miocene and younger. The preservation of planktonic foraminifera, generally, decreases downward. Sedimentation rates were between 20 and 60 m/my. Drilling rates decreased downwards from 5.2 to 1.1 meters/minute.

UNIT 2 – Silty Nannofossil Marl Ooze (Core 4)

This unit is much like Unit 1, except for a strong admixture (~20%) of terrigenous minerals; mainly quartz. However, the unit is defined on the basis of only one core. It is a greenish gray silty ooze of Middle Miocene age. The sedimentation rate between Cores 3 and 4 is extremely high according to the paleontologic dates. This may indicate large scale redeposition within this interval. The preservation of planktonic foraminifera is somewhat better than expected from extrapolation of the usual Upper Tertiary trend (see Chapter 26). This supports the theory of redeposition from shallower regions. Drilling rates ranged from 1.2 to 0.7 meters/minute.

UNIT 3 – Diatom Ooze and Quartz Sand (stone) (Cores 5, 6, 7, SW 1)

This unit consists of greenish gray and olive brown diatom ooze (30-60% diatoms and some rads) with abundant (up to 20%) nannos and lime-carbonate fragments of quartzose diatom mud, and of intercalated dark greenish gray quartz sands that are lime-cemented in places. The age of the unit is Early Miocene. The quartz sand is fine to medium, well-rounded, and contains minor admixture of feldspar, chert, mica, fresh glauconite, pyrite and fossils. The sands contain about 10 to 30 per cent silt and clay, rock fragments (brown chert, metaquartzite, fine-grained sandstone, and schist), and a rich association of heavy minerals (pyroxene, amphibole, zircon, etc.). The sandstone of Core 6 is cemented by macrocrystalline sparry calcite. The quartz grains (400-500μ) are well rounded to subrounded; some grains show silica overgrowth; all grains are slightly etched by the calcite cement. The good rounding, relatively high mineralogical maturity (high quartz: feldspar ratio, mostly stable heavies), and the good sorting (low muddy matrix content) suggests second or higher cycle sediment (for example, derivation from a beach environment). Drill rates ranged from 1.8 to 0.5 meters/minute. The lowermost part of Unit 3 locally contains fragments of light bluish gray nanno ooze.

PHYSICAL AND CHEMICAL PROPERTIES

Because of poor core recovery, data on the physical properties of the sediments at Site 139 are too few and widely spaced to be significant.

Penetrometer measurements (mm $\times$ 10^{-1}) ranged from highs of 60-78 in Core 1 (about 120 meters) to lows of 9-18 in Core 7 (660 meters).

Bulk densities (as measured on the GRAPE) average 1.6 gm/cc in Core 1 and about 1.7 in Core 2 (c. 230 meters). Below this, there are no data until Core 7, where the densities measured on the ship show an extremely wide range. This is probably due to the high initial gas content of the core. The corrected GRAPE densities for Core 7 (see Table 2) range only from 1.50 to 1.61. In contrast, the densities calculated from water content measurements range from 1.70 to 2.03 (Table 2). There is no satisfactory explanation for this discrepancy.

Porosities in Cores 1 and 2 range from 48 to 61 per cent as measured on the GRAPE to 51 to 61 per cent as calculated from water content (Table 3). As with the bulk density, porosity measurements have a wide range in Core 7; and again, they are probably due to the gas content of the core. The GRAPE readings are anomalously high compared to the water content calculations.

Water content apparently decreased with depth. The cause of the anomalously high porosity and water content in Core 5 is not known.

Natural gamma counts range from 300 to 600 in the oozes of Core 1 and 2 and from 600 to 1350 in the siliceous clays and sands of Core 7. An anomalously high count of over 1000 from the ooze near the base of Core 2 (c. 230 meters) could not be correlated with any visible lithologic change.

Salinity of the interstitial waters, measured at the following four depths, is unusually high: 48.4 ppt at 730 meters; 59.4 at 354 meters; 60.5 at 463 meters; and 74.8 at 660 meters. The pH readings were in the normal range; 7.09 to 7.29 (Table 4).

DISCUSSION AND CONCLUSIONS

The sedimentary sequence cored shows a regular succession from diatom ooze and mud deposited in Early Miocene to nanno chalk ooze deposited in Pliocene time. This grades into foram marl/chalk in the Holocene (*Vema* piston core 23-98). Mixed into this pelagic sequence is an influx of terrigenous sediments from the shelf and upper slope. This influx manifests itself as quartz sand in the Early Miocene, as quartz silt in the Middle Miocene, and only a trace after Late Middle Miocene, although redeposition of pelagic sediments downslope probably continued.

A minimum average sedimentation rate since earliest Miocene (22.5 million years) at Site 139 would be 32 m/my. In the upper 400 meters of calcareous ooze, the sedimentation rates range from 20 meters/my to as high as 60 m/my, even though only traces of terrigenous material occur in this interval.

The relatively high sedimentation rate in the calcareous ooze is probably due to redeposition. Some evidence for this is seen in the occurrence of relatively well preserved foraminifera mixed with much less well-preserved forms in the calcareous section and in redeposition of shallow water benthonic foraminifera, as well as littoral diatoms, in the older part of the section.

The *Challenger* seismic reflection profile at Site 139 shows a mostly transparent section. Exceptions are the weak reflective zones at 0.30 seconds and 0.45 seconds, down to 0.55 seconds below which a moderately strong reflective zone is seen at 0.75 seconds (Figures 2 and 3). If this major transition from a transparent to a reflective acoustic character is correlated with the major lithologic change from calcareous ooze to diatom ooze and quartz sands at 523 meters, then an average sound velocity of 1.9 km/sec is obtained for the upper calcareous sequence. This appears to be too high for typical calcareous ooze.

TABLE 3
Summary of Density, Porosity and Water Content Data for Site 139

			GRAPE			Sediment Sample			
Hole	Core	Section	Depth Below Sea Floor (m)	Density (gm/cc)	Porosity (%)	Depth Below Sea Floor (m)	Water Content (%)	Density (gm/cc)	Porosity (%)
139	1	1	114.75	1.56	61	114.70	42	1.46	61
139	1	2	116.25	1.60	59	115.64	37	1.65	60
139	2	1	225.75	1.69	48	–	–	–	–
139	2	2	227.25	1.70	48	226.64	31	1.62	50
139	2	3	228.75	1.66	50	228.14	31	1.64	51
139	2	4	230.25	1.70	47	229.64	31	1.65	52
139	5	1	–	–	–	571.41	61	1.18	72
139	7	1	656.75	1.53	60	656.14	17	2.03	34
139	7	2	658.25	1.64	52	657.68	16	1.95	32
139	7	2	–	–	–	658.85	18	1.87	34
139	7	3	659.75	1.50	63	659.50	28	1.57	45
139	7	4	661.25	1.61	54	660.64	16	1.94	31
139	7	5	662.75	1.56	58	662.14	25	1.70	43
139	7	6	664.25	1.54	59	663.64	25	1.70	43

TABLE 4
Chemical Property Measurements on Samples from Site 139

			Sample Interval (cm)				
Hole	Core	Section	Top	Bottom	pH	Eh	Salinity (°/oo)
139	1	2	0.0	10.0	7.28	−90	38.0
139	2	4	0.0	10.0	7.29	?	48.4
139	3	CC			7.13	+17	59.4
139	4	CC			7.09	+5	60.5
139	7	3	0.0	8.0	7.12	+53	74.8

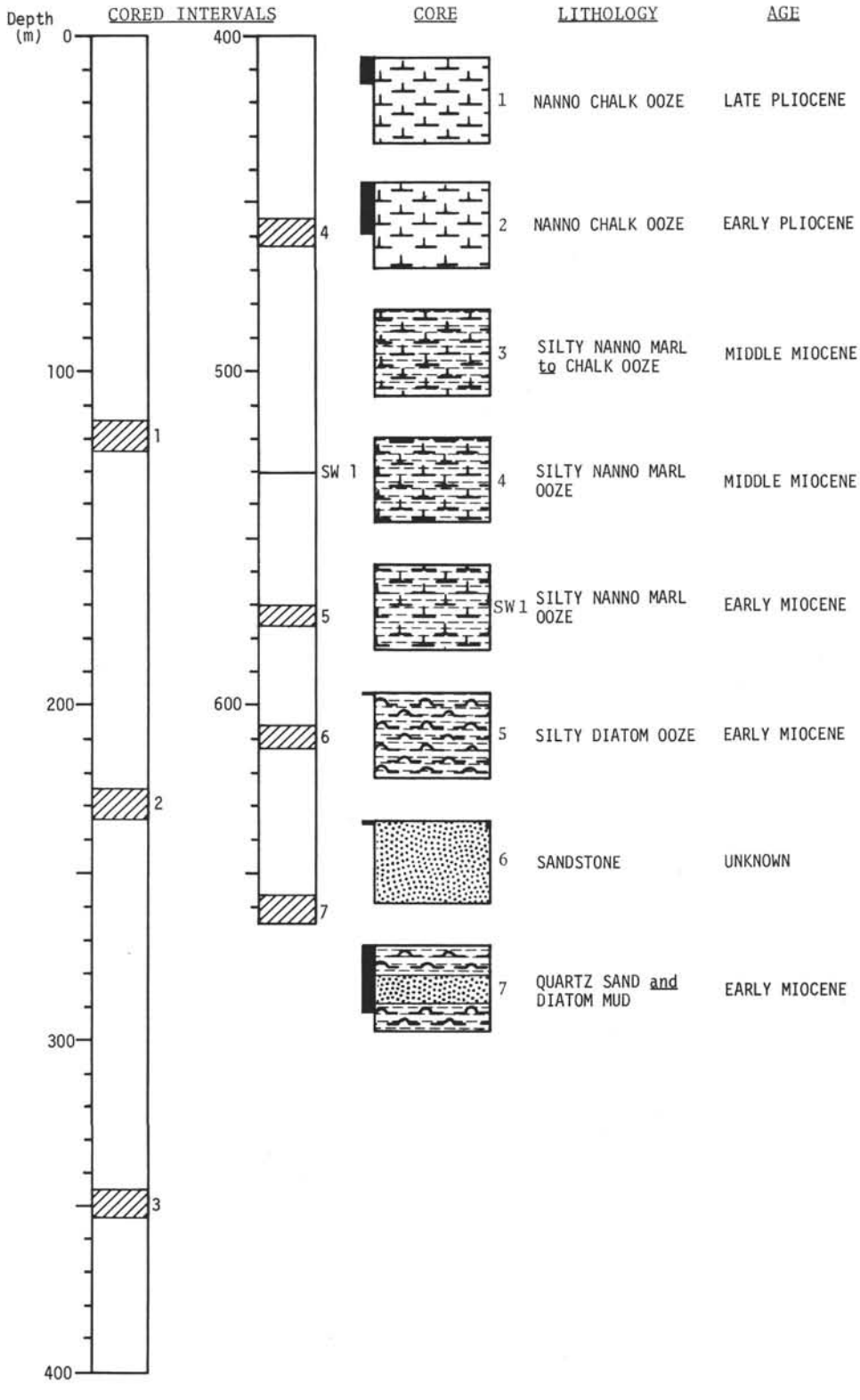
However, there is some evidence of sand layers higher in the succession despite the poor recovery, so perhaps the acoustic boundary marks the first major occurrence of sand within Unit 2 (the marl ooze) at about 480 meters; this would give an average sound velocity of 1.75 km/sec for the ooze (see Figure 3).

The calcareous ooze at Site 139 commonly has a strong odor of H_2S and an abundance of fine pyrite grains, both of which, usually form under reducing conditions. The occurrence of such features, in what is normally an oxygenated environment, may be related to the high sedimentation rate thereby causing reducing conditions locally within the sediment.

Another important feature of the sediments at Site 139 is that they show a marked salinity increase with depth, reaching 74.8 ppt in the last core taken at 656 meters. Such salinity values indicate strongly the presence of salt concentrations lower in the section.

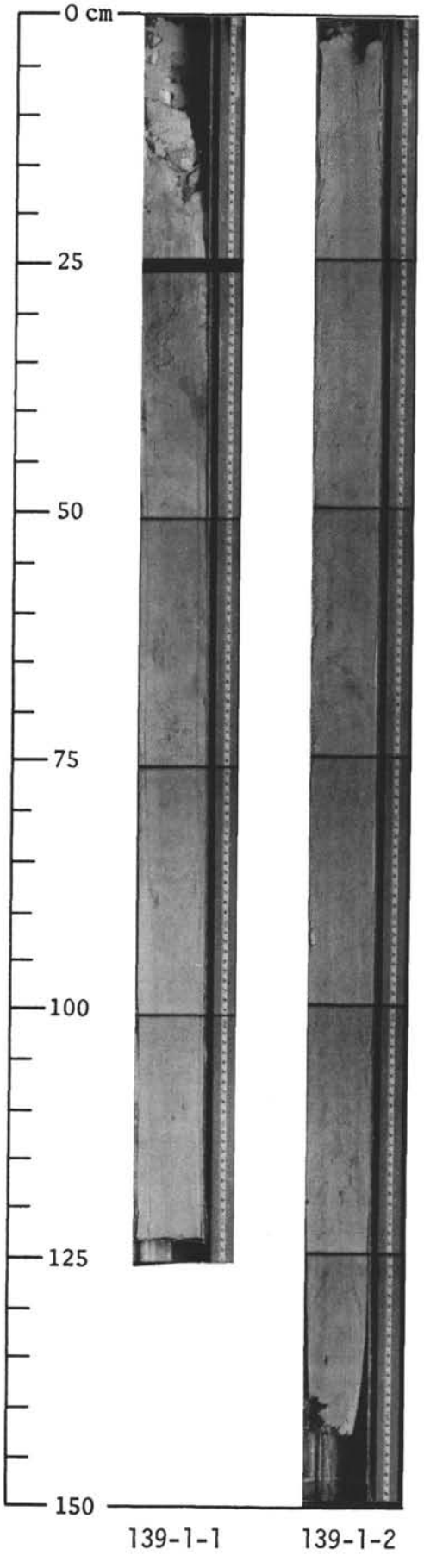
Core 7 recorded at 656 meters contained significant amounts of gas.

SITE 139-SUMMARY

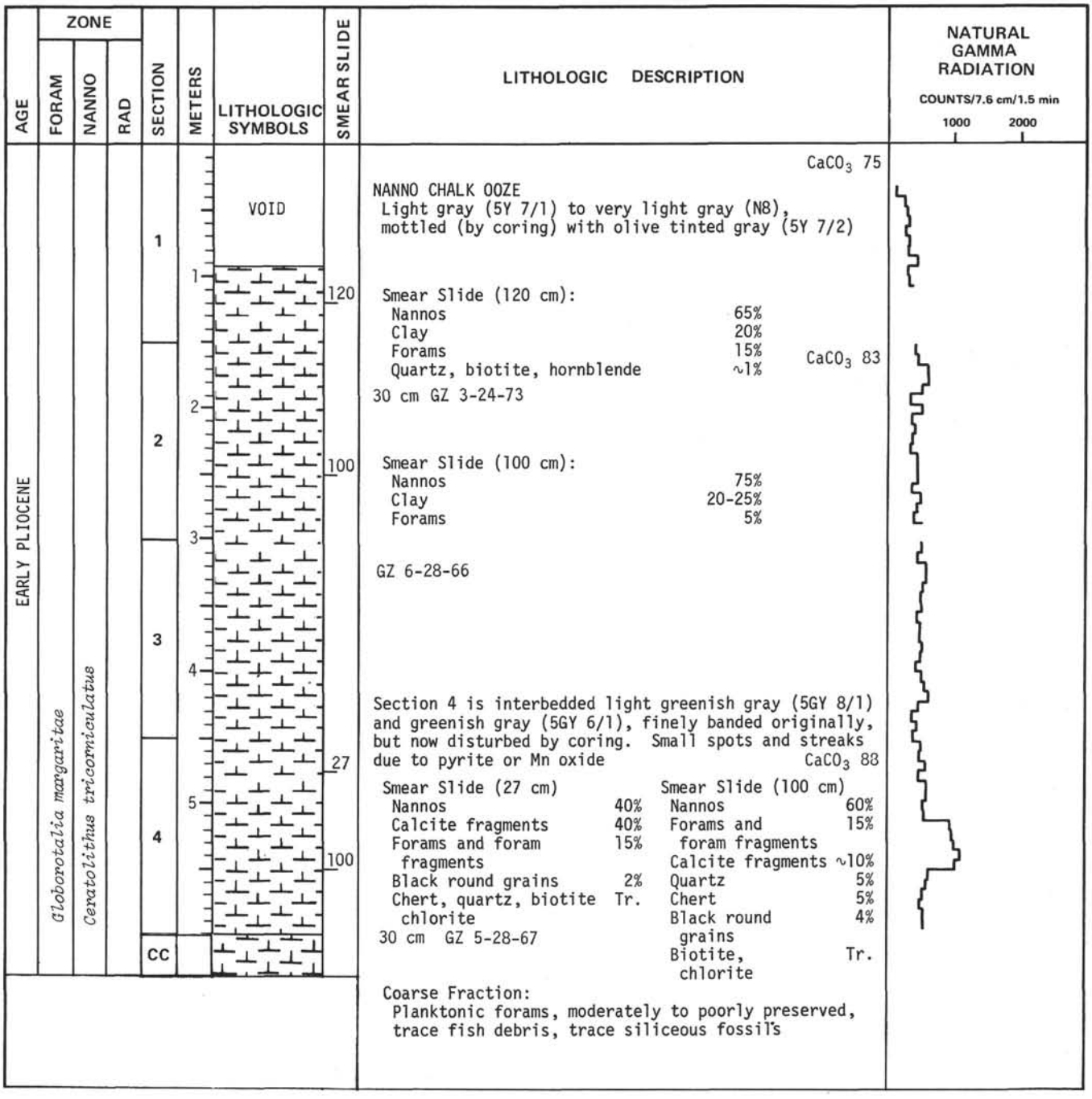


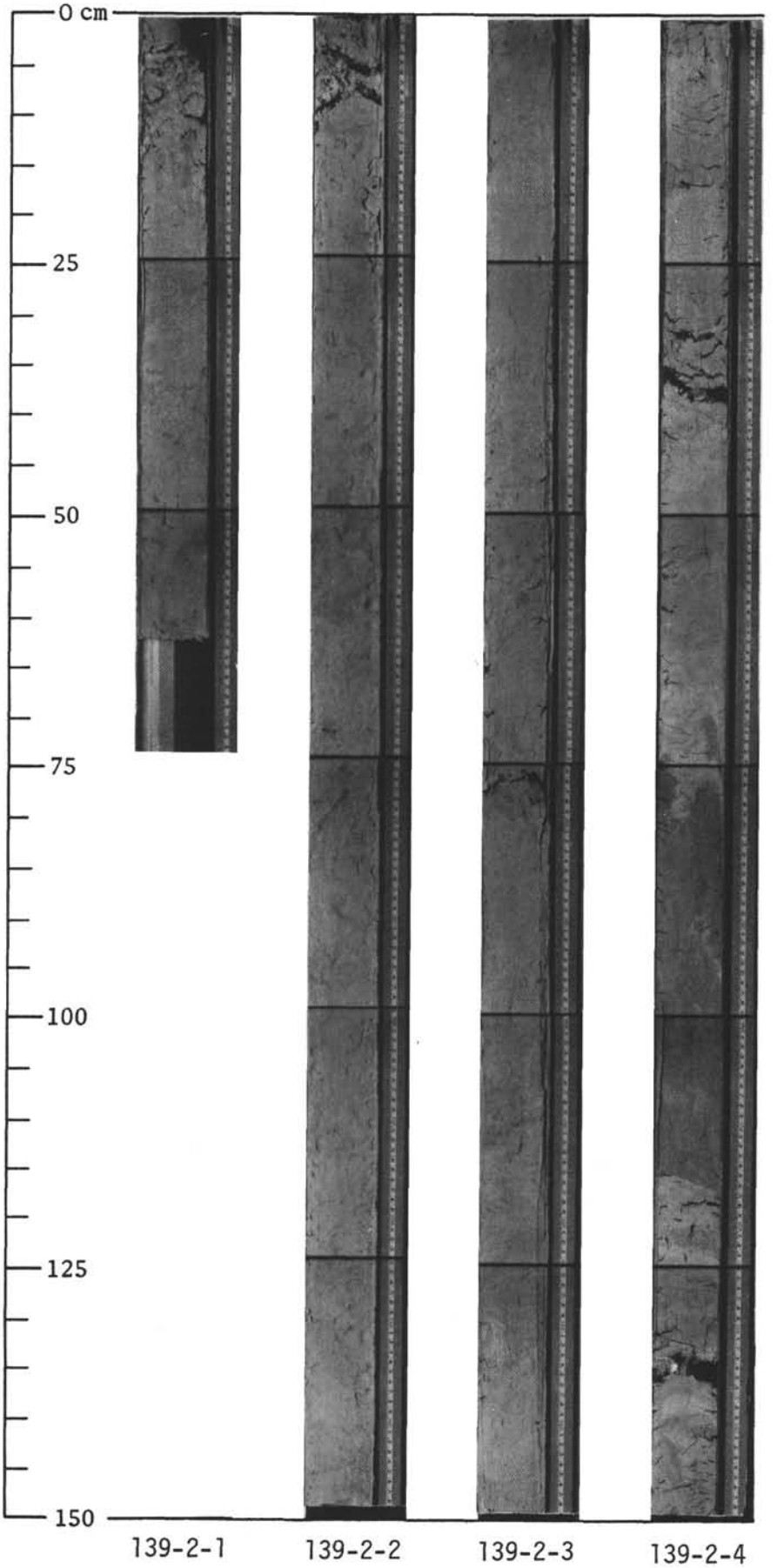
SITE 139 CORE 1 DEPTH (m) 114-123

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)
MIDDLE PLIOCENE	*Globorotalia exilis/G. miocenica*	*Reticulofenestra pseudoumbilica*	*Pterocanium prismatium*	1	1	VOID	100	120 cm GZ 7-26-67 NANNO CHALK OOZE Light olive gray (5Y 6/2) to light gray (5Y 7/1) $CaCO_3$ 73 Smear Slide (100 cm): Nannos ~55% Clay 25% Forams 5-15% Diatoms, silico-flagellates ~5% Radiolaria, biotite, hornblende 1% $CaCO_3$ 86 Carbonaceous matter 2% Heavies 1% Core exhibited strong H_2S odor when cut. Flecks of (?) pyrite or (?) Mn oxide Coarse Fraction: Planktonic forams, moderately to poorly preserved, a few diatoms and other siliceous fossils 30 cm. GZ 2-30-68 sec.6, 130 cm GZ 2-69-29	
				2	2				
				CC					


0 cm
25
50
75
100
125
150
139-1-1
139-1-2

SITE 139 CORE 2 DEPTH (m) 225-234




0 cm
25
50
75
100
125
150
139-2-1
139-2-2
139-2-3
139-2-4

SITE 139 CORE 3 DEPTH (m) 345-354

AGE	ZONE FORAM	ZONE NANNO	ZONE RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE
MIDDLE MIOCENE	*Globorotalia fohsi robusta*	*Discoaster kugleri*		1 CC		NOT TO SCALE	

LITHOLOGIC DESCRIPTION

SILTY NANNO MARL to CHALK OOZE
Greenish gray (5G 6/1); slightly fissile

Smear Slide (cc):

Nannos	65%
Clay	10%
Forams	10%
Sponge spicules	5%
Radiolaria	2%
Diatoms	2%
Carbonate rhombs	2%
Quartz	2%
Pyrite	1%
Biotite	Tr.

X-Ray (cc):

Calcite	A
Quartz, mica, montmorillonite, kaolinite dolomite	C
Feldspar, hematite	Tr.

Coarse Fraction:
Planktonic forams, benthonic forams, spicules, pyrite

130 cm GZ 1-25-74

NATURAL GAMMA RADIATION
COUNTS/7.6 cm/1.5 min
1000 2000

SITE 139 CORE 4 DEPTH (m) 455-463

AGE	ZONE FORAM	ZONE NANNO	ZONE RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE
MIDDLE MIOCENE	*Globorotalia fohsi robusta*	*Discoaster kugleri*		1 CC		NOT TO SCALE	

LITHOLOGIC DESCRIPTION

SILTY NANNO MARL OOZE
Greenish gray (5G 6/1)

Only core catcher recovery

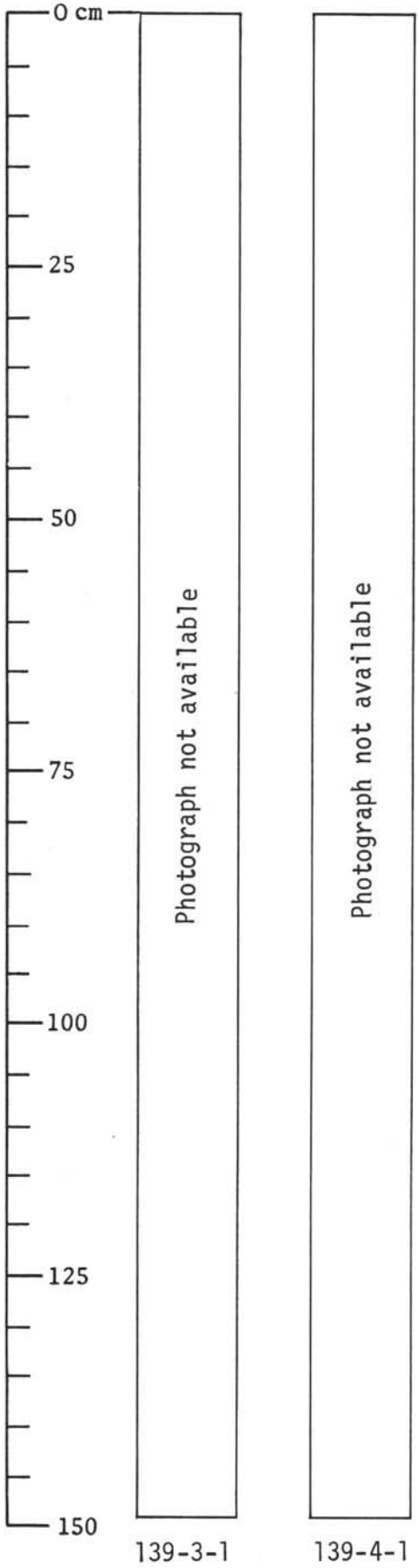
Smear (cc):

Clay	40%
Nannos	30%
Quartz	15%
Diatoms	3%
Carbonate rhombs	3%
Feldspar	2%
Pyrite	2%
Radiolaria	1%
Sponge spicules	1%
Apatite	1%
Pyroxene, hornblende, forams, biotite, chlorite, zircon, tourmaline	Tr.

Coarse fraction:
Planktonic forams, benthonic forams, spicules, diatoms

100 cm GZ 1-28-71

NATURAL GAMMA RADIATION
COUNTS/7.6 cm/1.5 min
1000 2000

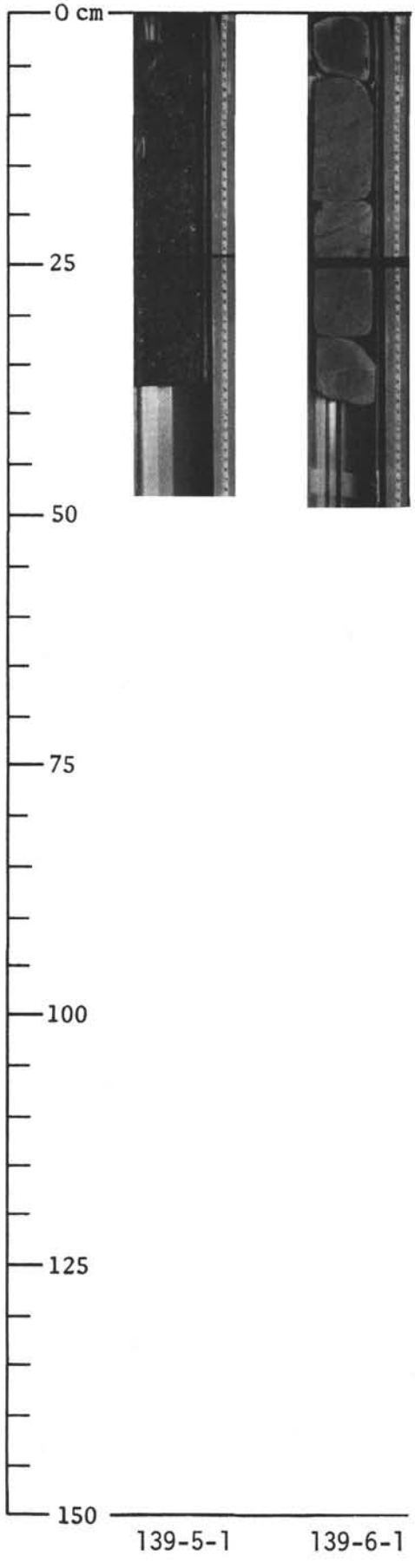

0 cm
25
50
75
100
125
150
Photograph not available
Photograph not available
139-3-1
139-4-1

SITE 139 CORE 5 DEPTH (m) 570-576

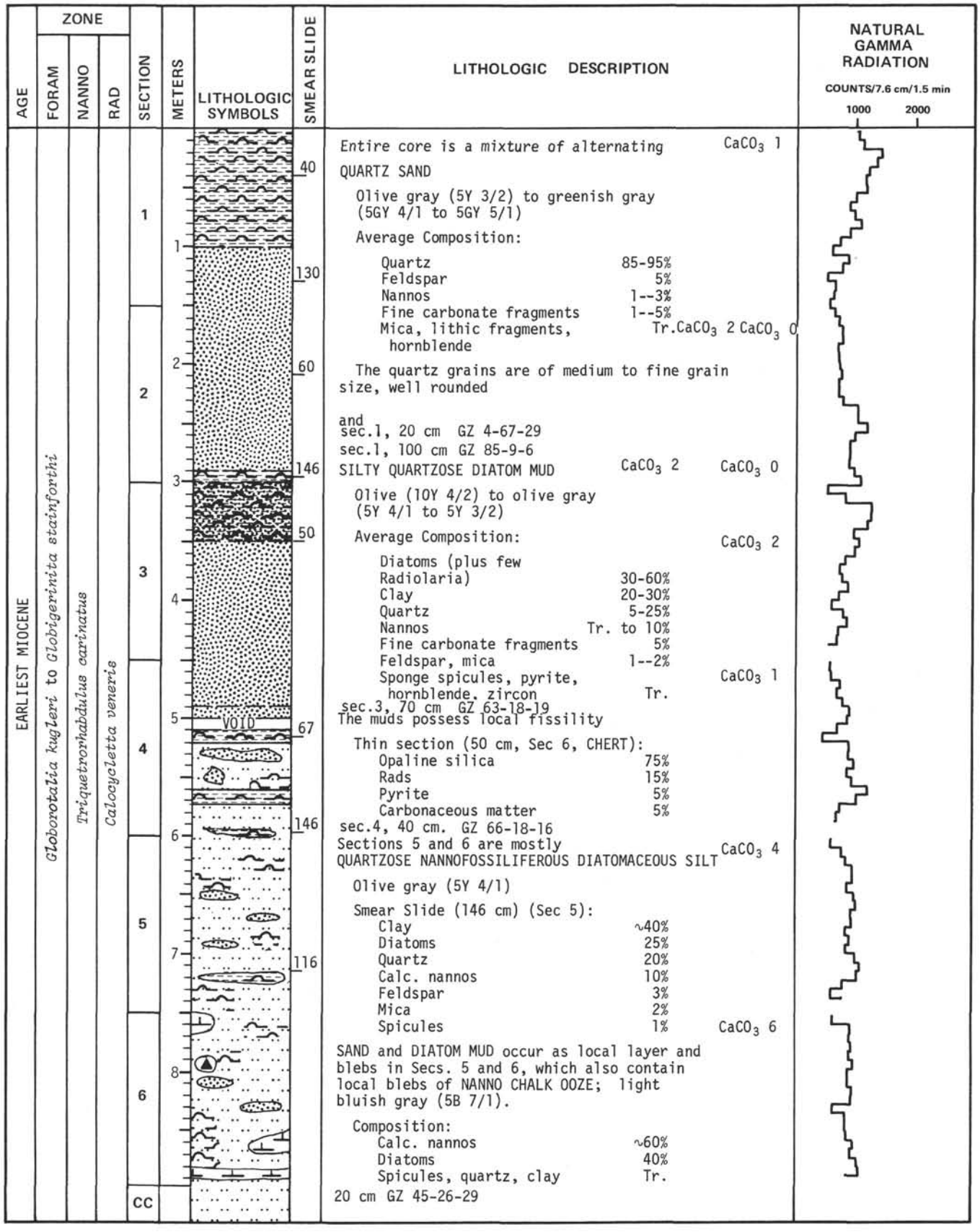
AGE	ZONE: FORAM	ZONE: NANNO	ZONE: RAD	SECTION	METERS	LITHOLOGIC SYMBOLS	SMEAR SLIDE	LITHOLOGIC DESCRIPTION	NATURAL GAMMA RADIATION (COUNTS/7.6 cm/1.5 min; 1000–2000)
EARLY MIDDLE MIOCENE			*Calocyclettia costata*	1	1	VOID	140	SILTY DIATOM OOZE Olive brown with Radiolaria and calcareous nanno fossils Smear Slide (140 cm): Diatoms and Radiolaria 50%; Clay 30%; Calcareous nannos ~20%; Quartz 2%; Mica, authigenic carbonate Tr. Smear Slide (cc): Diatoms and Radiolaria 40%; Clay 40%; Calcareous nannos 20%; Quartz, 1%; Mica, authigenic carbonate Tr.; $CaCO_3$ 10 140 cm GZ 0-34-66	
				CC			CC		

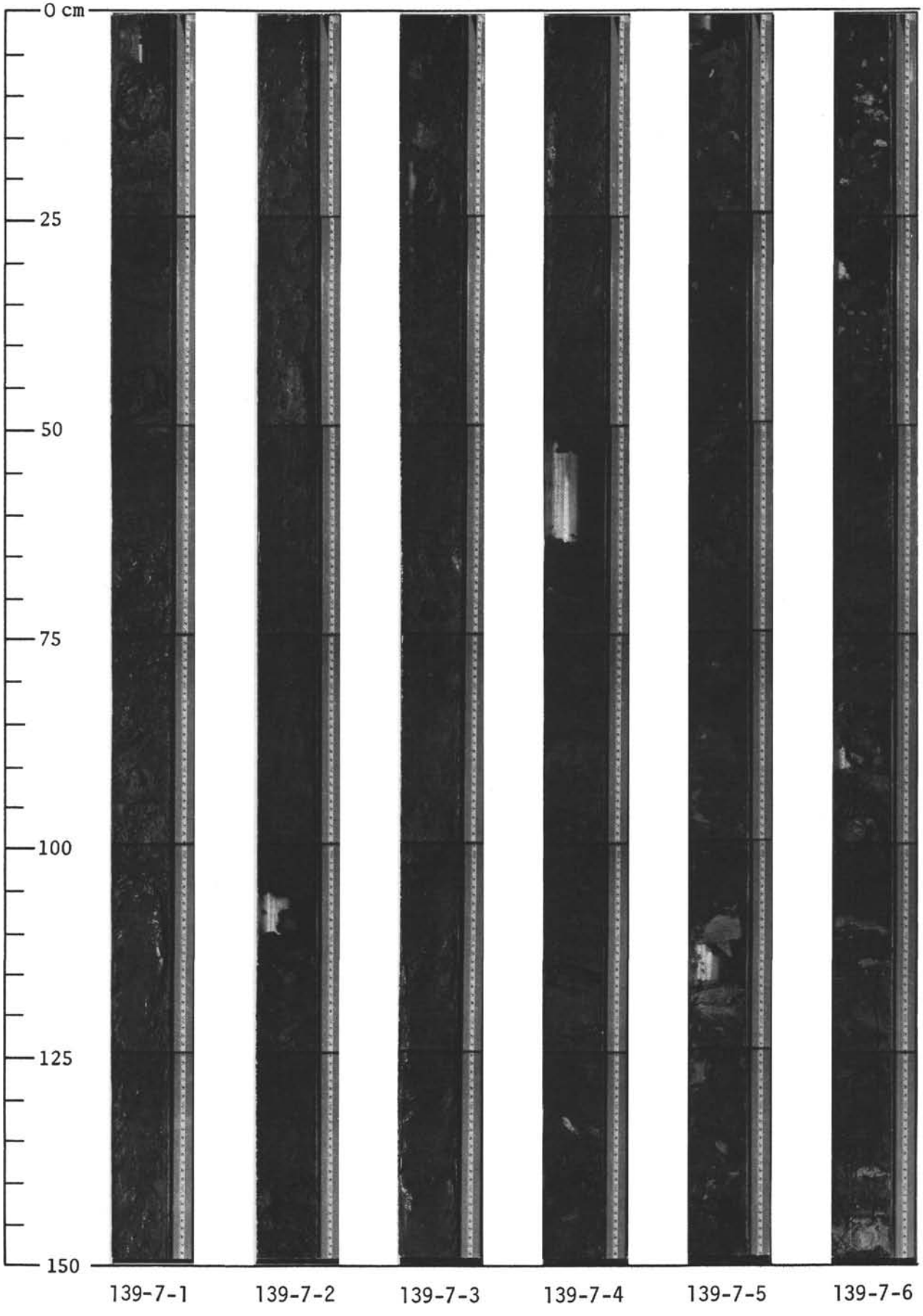
SITE 139 CORE 6 DEPTH (m) 607-612

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							TS	SANDSTONE (QUARTZ ARENITE) Dark greenish gray (5G 4/1) and olive gray (5Y 4/1); unbedded homogeneous silty sandstone, with 5-20 mm. mudstone fragments Average of 3 Thin Sections: Quartz 55-62% Micrite to sparry calcite 29-35% Feldspar 2-3% Metamorphic rock fragments 1-2% Siliceous fragments 1-2% Clasi 1-2% Degraded biotite and chlorite 0-1% Fe oxide, chert fragments 0-1%	
				CC					


0 cm
25
50
75
100
125
150
139-5-1
139-6-1

SITE 139 CORE 7 DEPTH (m) 656-665




0 cm
25
50
75
100
125
150
139-7-1
139-7-2
139-7-3
139-7-4
139-7-5
139-7-6