# 8. SITE 141

The Shipboard Scientific Party[1]


## ABSTRACT

Site 141 is located about 200 km north of the Cape Verde Islands on a diapiric structure in an area of gently rolling bottom topography.

About 80 meters of chalk ooze of Pleistocene to Pliocene age rests on about 200 meters of brown, red, and green barren clays. These sediments rest on a highly altered, serpentinized basalt at a subbottom depth of 295 meters.

The transition from non-carbonate to carbonate sediments occurs at a total depth of 4232 meters below sea level, which is about 400 meters shallower than that of other sites in the area, and indicates a significant uplift since early Pliocene at this site of deposition.

The structure which was drilled has an appearance on seismic reflection records similar to that of known salt diapirs. The diapiric structure is represented by a steep-sided zone of no acoustic reflection. Neither the ooze-clay boundary nor the underlying basalt are represented by identifiable reflecting horizons. Hole 141 was drilled in the crest of a structure that has a topographic expression of about 40 meters and a diameter of 2 to 4 km. Several apparently similar structures are present nearby.


## SITE DATA

**Time:** 0847 5 November 1970
1134 7 November 1970

**Position:** 19° 25.16′N
23° 59.91′W

**Water Depth:** 13,605 feet
2,183 nominal fathoms
4,148 meters

**Total Penetration:** 298 meters

**Cores Taken:** Ten cores and one sidewall sample

## BACKGROUND, SURVEY, OPERATIONS

A large field of piercement structures is present in the deep basin sediments about 350 km north of the Cape Verde Islands (Schneider and Johnson, 1970). Similar structures have been observed at numerous localities around the North Atlantic continental margins and have been interpreted as salt or mud diapirs (see Pautot *et al.*, 1970).

The recovery of palygorskite-sepiolite, a magnesium rich clay usually associated with evaporite deposits, about 150 km westward at Site 12 of Leg 2 (DSDP), has provided support to the suggestion that the piercement structures were salt diapirs.

The piercement structures are found only in areas where thick sequences (> 2 km) of sediments are present. They are predominantly subsurface features although a slight topographic expression of about 80 meters, or less, is common. Closely spaced geophysical lines give no indication that individual features have any significant linear extent. They appear to be nearly equidimensional in plan and are about 2 to 4 km in diameter.

Seismic records from *Challenger* and from the *Kane* 9 cruise are shown in Figure 1. It is believed that the piercement structure drilled and which is indicated by the arrow on the *Challenger* record, is the same piercement structure indicated by the arrow on the *Kane* 9 profile and can be considered a typical example of these features. The sediments in the general region of the piercements are well layered and essentially flat-lying but show small amounts of upturn and distortion in the near vicinity of the piercement structures. (See Figure 2.) The *Kane* 9 profile is apparently recorded at a somewhat higher frequency band; therefore, a number of thinner layers are resolved with greater detail than is shown on the *Challenger* records. Identification of layer 2 is shown on the left on the *Kane* 9 profile and lies about 1.2-1.5 km below the sea floor. The general bottom morphology consists of gently rolling hills. Note that the regional sea floor gradient does not dip uniformly to the west. The regional morphology is strongly influenced by the proximity of the Cape Verde Plateau (see Figure 1, Chap. 7). A detailed survey was conducted after passing over the first piercement structure indicated in the upper *Challenger* profile, (Figure 2) and the synthesis of that


[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.

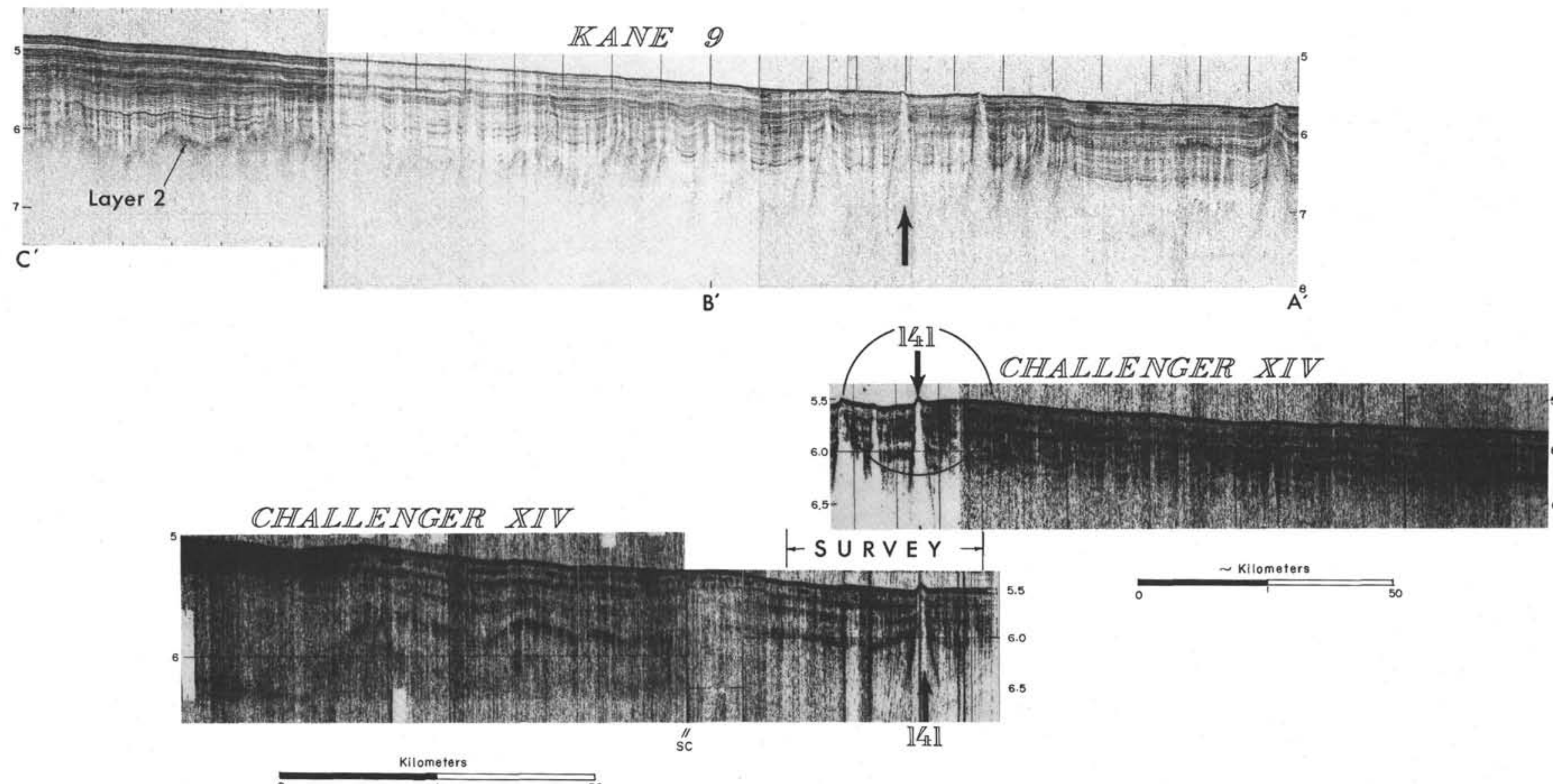



Figure 1. *Seismic reflection profiles in vicinity of Site 141. Circle keys enlargement shown in Figure 2.*

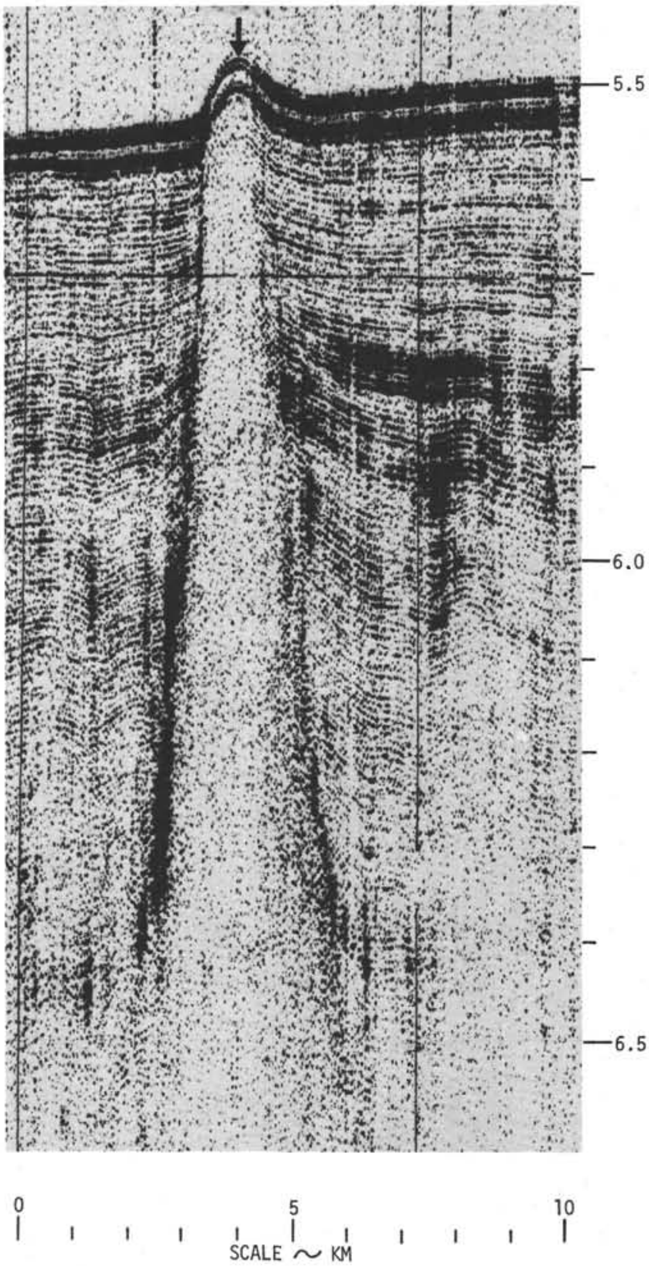



Figure 2. *Detail of seismic profile over Site 141. Vertical exaggeration about 20:1. See Figure 1 for location.*

detailed survey is shown in Figure 3, where the morphology and the limit of the seismically defined piercement structures are mapped. Note that the depths of the zones of no acoustic reflection, representing the piercement structures, generally extend well below the level of the internal, reflectors in the surrounding sediments. If the level of layer 2 as defined on the *Kane* 9 profile is extrapolated horizontally to the vicinity of the 141 site, then the piercement structures could be interpreted as having a source within the basement layer.

The primary objective at Site 141 was to establish the nature of these piercement structures, and in particular, to distinguish between a sedimentary versus igneous origin. The features appear on the seismic records as zones of no acoustic reflection which originate from subbottom depths in excess of 1 km (~ 1.0 sec) and exhibit average slopes of about 20 to 30 degrees (see Figure 2).

| Seismic Reflection Data: | *Kane* *Challenger* |
|---|---|
| Intermediate Reflectors | Over structure, possible zone at about 0.10 sec. |
| | Off flank structure, numerous reflecting horizons to depths 1.0 second. |
| Basement Reflector | ~1.5 sec about 50 km SW of Site 141. |

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

Site 141 was initially approached at 8 knots along a course of 284° to duplicate the *Kane* seismic profile. The *Challenger* passed over a typical "diapiric feature," and a free-floating marker buoy was dropped for reference. A short box survey about 4 km on a side (see Figure 3) was conducted to ensure that the crest of the feature could be identified and to define the areal shape of the feature. The ship was stopped on the crest of the topographic high (minimum sounding, 2183 nom. fathoms) and the beacon was dropped. The survey and beacon-dropping operations went very smoothly and the ship was positioned in the desired spot directly over the small topographic high which had a relief of 40 meters and an areal extent of 3 km.

## BIOSTRATIGRAPHY

### General

Rich calcareous plankton assemblages are found in the white oozes in the uppermost 70 meters of this site. The age diagnostic fossils are listed in Table 2. They provide a very good Pleistocene-Pliocene sequence. The Plio-Pleistocene boundary lies within Core 2. Solution affects the preservation and composition of the assemblages more and more from the early Pliocene downwards until below the transition zone between white ooze and red clay (Core 7) the planktonic foraminifera and, somewhat deeper, the nannoplankton are completely obliterated. Siliceous microfossils are not present in the entire sequence. The oldest sediments that could be dated were in Core 7 and are Late Miocene. Cores 8 and 9 are barren

### Foraminifera

Cores 1 to 7 furnish an excellent sequence of Pleistocene-Pliocene planktonic foraminifera. Many events of biostratigraphic significance can be observed in these samples, such as the extinction levels of *Globoratalia exilis G. miocenica, G. margaritae, G. multicamerata, Globigerina venezuelana, G. nepenthes, Globoquadrinaaltispira,* and *Sphaeroidilellopsis,* or the first appearance of *Sphaeroidinella, Globorotalia multicamerata, G. Truncatulinoides* and *Globigerinoides ruber.* The well-known coiling changes of *Globorotalia cultrata* and of *Pulleniatina primalis* occur in Core 6 and Core 5, respectively (see the detailed fossil charts–Chapter 13). In Cores 6 and 7, we can follow an excellent series of progressive stages of calcite solution until the samples become practically non-calcareous in the lower

TABLE 1
Drilling and Coring Record for Site 141

| Description | Interval Below Sea Floor (m) | Core Recovery (m) | Drilling Rate (m/min) |
|---|---|---|---|
| Core 1 | 5-14 | 8.0 | |
| Core 2 | 14-23 | 8.7 | |
| Core 3 | 23-32 | 9.0 | |
| Core 4 | 32-41 | 9.0 | |
| Core 5 | 41-50 | 9.0 | |
| Drill | 50-59 | | 9.0 |
| Core 6 | 59-68 | 9.0 | |
| Drill | 68-79 | | 1.4 |
| Core 7 | 79-88 | 9.0 | |
| Drill | 88-98<br>98-107 | | 1.3<br>0.4 |
| Core 8 | 117-123 | 2.4 | |
| Drill | 123-126<br>126-135<br>135-162<br>162-172<br>172-181 | | 1.5<br>0.4<br>0.7<br>2.5<br>1.8 |
| Core 9 | 191-200 | 7.2 | |
| Drill | 200-218<br>218-229<br>229-247<br>247-256<br>256-275<br>275-284<br>284-295 | | 0.6<br>0.9<br>0.9<br>0.4<br>0.5<br>1.0<br>0.5 |
| Core 10 | 295-298 | 1.0 | |

part of Core 7. Cores 8 and 9 contain only a few agglutinated benthonic foraminifera, indicating deposition below the calcite compensation depth.

### Nannoplankton

The almost complete Pliocene-Pleistocene section recovered from this hole allows detailed zonation and correlation of calcareous plankton zonations. (See Table 16, Chapter 14). A rich Lower Pleistocene nannoflora occurs in Core 1. The Upper Pliocene *Discoaster brouweri* Zone can be subdivided into the following three subzones (from top to bottom): *Cyclococcolithina macintyrei,* (Core 2, Sections 1 through 5); *Discoaster pentaradiatus* (Core 2, Section 6, Core 3); *Discoaster tamalis* (Core 4). The Lower Pliocene nannoplankton zones are represented in Cores 5 and 6. Upper Miocene discoasters are almost exclusively present in the upper part of Core 7. They are most resistant to solution which strongly affected the assemblages of this core. The lower part of Core 7 and Cores 8, 9 and the sidewall core do not contain nannoplankton.

## LITHOSTRATIGRAPHY

A single hole was drilled to a depth of 298 meters at Site 141. The upper 100 meters was cored almost continuously with good recovery. The lower section was sampled only by spot cores. The following units are defined:

| Unit | Cores | Lithology | Depth Below Sea Floor (m) | Age |
|---|---|---|---|---|
| 1 | 1,2,3,4 5,6,7 | Nanno marl mud, grading upward to foraminiferal nanno chalk ooze | 0-84 | Late Pleistocene-Late Miocene |
| 2 | 7,8,9 | Silty zeolitic clay | 84-287(?) | ? |
| 3 | Side-wall Core | Fine sand (subarkose) | 287-295(?) | ? |
| | 10 | Basalt, very highly altered | 295-? | ? |

### UNIT 1 – Foram Nanno Chalk Ooze and Marl Mud (Cores 1-7)

Unit 1 is a pelagic carbonate ooze 84 meters thick and is Late Miocene and younger. Although cores in this unit are badly disturbed by flow, distinct dark and light color zones are apparent. The light zones are mostly white to pale yellow, the dark zones grayish brown to brownish gray. The upper sections of Core 1 are relatively undisturbed, and here the color zones appear to alternate cyclically and possibly relate to glacial/interglacial fluctuations. The amount of non-carbonate terrigenous material (clay plus quartz, lesser amounts of feldspar, biotite, chlorite, traces of heavy minerals) is higher (~25%) in the dark than in the light colored layers (~15%).

Planktonic foraminifera in dark layers are less well preserved than those in light layers. Foraminiferal content is high in Cores 1 and 2 (~50%) and decreases downward in the unit. Also, clay plus terrigenous components show a slight increase from 10 to 20 per cent in Core 1 to about 20 to 30 per cent in Core 5. The basal part of Unit 1 (Late Miocene) is transitional from the ooze to the underlying clay of Unit 2. Core 6 is a yellow to white foraminiferal nanno-chalk to marl ooze, with up to 40 per cent clay plus silt-sized terrigenous material Only a few fragments of foraminifera (10%) are present. The upper two sections of Core 7 are nanno marl mud with 45 per cent clay plus terrigenous silt and only 5 per cent foram fragments.

The sharpest part of the transition from Unit 1 to Unit 2 is within Section 3 of Core 7. Section 3 consists of a yellowish brown nannofossiliferous silty clay, consisting of 75 per cent clay minerals, 15 per cent other terrigenous minerals, plus opaques (hematite and manganese oxide), and 15 per cent nannos. Sedimentation rates in Unit 1 are between 10 and 30 meters per million years.

### UNIT 2 – Silty Zeolite Clay (Cores 7, 8, 9)

Unit 2 is varicolored, slightly zeolitic clay of undetermined age. The lower half of Core 7 is yellowish brown, with some zeolite, and about 3 per cent quartz and 2 per cent feldspar. The remainder is biotite, chlorite, and heavy minerals. In Core 8, the clay is predominantly reddish yellow, with bands of brown to grayish brown comprising 20 per cent of the section. The bands are 5 to 10 cm thick; they have sharp upper and gradational lower boundaries

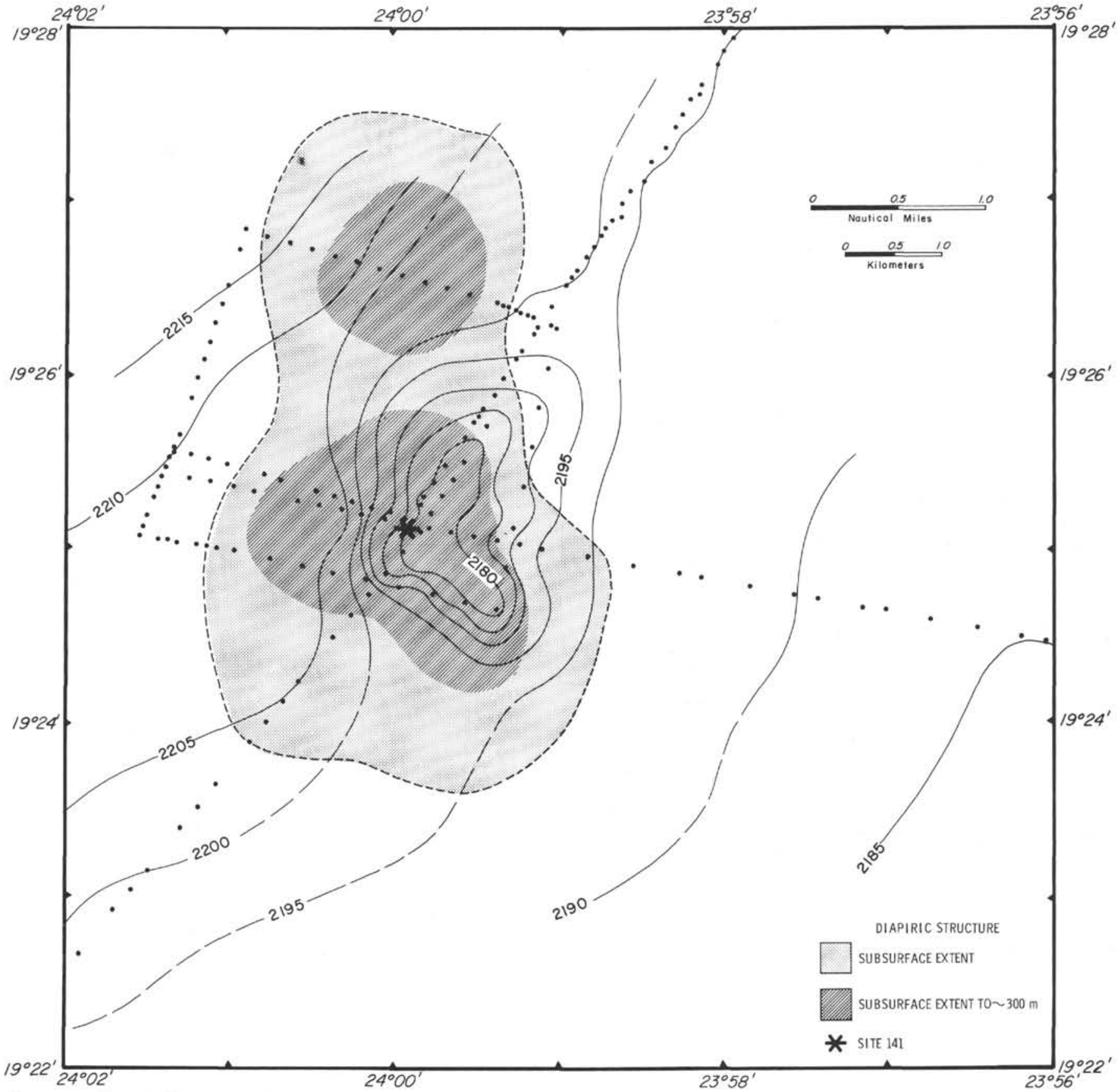



Figure 3. *Detailed location map of Site 141.* Challenger *detailed survey of Site 141. Contours in nominal fathoms (1/400 sec reflection time). Lightly stippled area represents the areal extent of zone of no acoustic reflections defining the apparent piercement structures shown in Figure 1. Darkly stippled area represents areal extent of zone of no acoustic reflections to subbottom depth of 0.3 second reflection time (the approximate depth of the 300 meter level at which basalt was encountered.*

and are rich in manganese. Large Mn blebs (~2 mm ϕ) and streaks seem to follow bedding planes about 1 cm apart. The general composition of light and dark layers is the same (90-95% clay with zeolite, 5% chlorite and biotite, and 5% Fe oxides, with traces of heavy minerals). Two thin pale yellowish layers (a few cm thick) contain up to 40 per cent silt-sized zeolite.

In Core 9, the clay is greenish gray for the top two meters and reddish brown below this. The core shows a high degree of mottling, probably bioturbation, so that most color changes appear gradational. A bleb of pyrite crystals (~1 mm ϕ) occurs at 34 cm. A 1 cm thick silty sand layer at 70 cm ( in the middle of dark greenish gray clay zone) consists mostly of fibrous spherulites of serpentine and about 20 per cent chlorite and degraded mica. It is probably a highly altered tephra.

Drilling rates in this unit ranged from 0.4 to 2.5 meters per minute.

TABLE 2

DIAGNOSTIC FOSSILS HOLE 141

| CORE | FORAMINIFERA | NANNOPLANKTON | AGE |
|---|---|---|---|
| 1 | Rich, predominantly planktonic fauna with *Globorotalia truncatulinoides*, *Gr. inflata*, *Gr. cultrata* (rare), *Gr. hirsuta* (Sec. 4 to Core Catcher sample), *Gr. tumida* (rare in Sec. 1 to 3), *Gr. crassaformis* A (Bolli, Leg IV Initial Report), *Pulleniatina obliquiloculata*, *P. finalis* (Sec. 1 to 3), *Sphaeroidinella dehiscens*, *Globigerinoides ruber*.<br>Age: Quaternary, *Globorotalia truncatulinoides* Zone (The presence of *Globorotalia crassaformis* A in the lower part of the core, possibly up to Sec. 3, indicates Early Pleistocene). | Rich and diversified assemblages including *Pseudoemiliania lacunosa*, *Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *Rhabdosphaera clavigera*.<br>Preservation: G<br>Zone: *Pseudomiliania lacunosa*.<br>Age: Early Pleistocene. | Pleistocene |
| 2 | Rich, predominantly planktonic faunas with *Globorotalia cultrata* (Sec. 1 and 2), *Gr. crassaformis* s.l., *Gr. exilis* (Sec. 5 to Core Catcher), *Gr. miocenica* (Sec. 5 to Core Catcher), *Gr. humerosa*, *Gr.* cf. *tosaensis* (Sec. 3 and 4), *Globigerinoides ruber*, *G. obliquus extremus* (Sec. 2 to Core Catcher), *Globigerina dutertrei*, *Orbulina universa*, *Pulleniatina obliquiloculata* (Sec. 1 to 4), *Sphaeroidinella dehiscens*.<br>Age: Section 1 to upper part of Sec. 3: Early Pleistocene or Late Pliocene.<br>Sec. 3 (below cm 120) and Sec. 4: Late Pliocene, *Globorotalia* cf. *tosaensis* Zone.<br>Sec. 5 to Core Catcher: Late Pliocene, *Globorotalia exilis*/*Gr. miocenica* Zone. | Abundant and well preserved nannoplankton with the following important species: *Discoaster brouweri*, *Coccolithus pelagicus*, *Cyclococcolithina macintyrei*, *Cecatolithus rugosus*. In the lower part of this core (Section 6) *Discoaster pentaradiatus* and *D. surculus* are also present.<br>Preservation: $E_1$ - 01.<br>Zone: *Discoaster brouweri*.<br>Age: Late Pliocene. | Late Pliocene |
| 3 | Rich, predominantly planktonic faunas with *Globorotalia exilis*, *Gr. pertenuis*, *Gr. miocenica*, *Gr. humerosa*, *Gr.* cf. *tosaensis*, *Gr. multicamerata* (Core Catcher only), *Gr. margaritae* (large; Core Catcher only), *Globigerinoides ruber*, *Sphaeroidinella dehiscens*.<br>Age: Pliocene. *Globorotalia exilis*/*Gr. miocenica* Zone except for the Core Catcher sample which is *Gr. margaritae* Zone. | Similar assemblages as in Core 2 were encountered but *Discoaster pentaradiatus* and *D. surculus* are more abundant.<br>Preservation: $E_1$ - 01.<br>Zone: *Discoaster brouweri*.<br>Age: Late Pliocene | Late Pliocene |
| 4 | Rich, predominantly planktonic faunas with *Globorotalia margaritae* (large), *Gr. cultrata* (dextral), *Gr. tumida* (dextral), *Gr. multicamerata*, *Gr. pertenuis*, *Gr. exilis* (rare), *Gr. miocenica*, *Gr. humerosa*, *Gr. acostaensis*, *Gr. crassaformis* s.l., *Gr.* cf. *tosaensis* (Sec. 1 to 3), *Globigerinoides obliquus*, *G. ruber*, *Globigerina venezuelana*, *Globoquadrina altispira*, *Sphaeroidinella dehiscens*.<br>Age: Early Pliocene, *Globorotalia margaritae* Zone. | Rich assemblages including *Discoaster tamalis*, *D. brouweri*, *D. pentaradiatus*, *D. surculus*, *Ceratolithus rugosus*.<br>Preservation: $E_1$ - 01.<br>Zone: *Discoaster brouweri*<br>Age: Late Pliocene | Late to Early Pliocene |

TABLE 2 – *Continued*

| CORE | DIAGNOSTIC FOSSILS HOLE 141 FORAMINIFERA | NANNOPLANKTON | AGE |
|---|---|---|---|
| 5 | Rich, predominantly planktonic faunas with *Globorotalia margaritae* (small), *Gr. cultrata* (dextral), *Gr. tumida* (dextral), *Gr. multicamerata*, *Gr. pertenuis*, *Gr. miocenica*, *Gr. humerosa*, *Gr. acostaensis* (dextral), *Gr. crassaformis* s.l., *Globigerinoides obliquus*, *G. ruber* (Sec. 1 and 2), *Globoquadrina altispira*, *Sphaeroidinella dehiscens* (Sec. 1), *Sphaeroidinellopsis seminulina*, *S. paenedehiscens*, *Pulleniatina primalis* (dextral coiling in Sec. 1 to 4, sinistral coiling in Sec. 5 to Core Catcher)<br>Age: Early Pliocene, *Globorotalia margaritae* Zone. | Sections 1 through 4: *Reticulofenestra pseudoumbilica*, *Discoaster asymmetricus*, *D. variabilis*, *Ceratolithus rugosus*.<br>Zone: *Reticulofenestra pseudoumbilica*.<br>Sections 5 and 6: *Ceratolithus rugosus*, *C. tricorniculatus*.<br>Preservation: $E_1$ - O1.<br>Zone: *Ceratolithus rugosus*.<br>Age: Early Pliocene. | Early Pliocene |
| 6 | Fairly rich, mainly planktonic faunas with increasing signs of calcite solution towards the bottom of the core. With *Globorotalia margaritae* (small), *Gr. cultrata* (gradual coiling change in Sec. 4 and 5 from sinistral below to dextral above), *Gr.* cf. *tumida/plesiotumida*, *Gr. multicamerata* (Sec. 1), *Gr. miocenica*, *Gr. humerosa*, *Gr. acostaensis* (sinistral), *Gr. crassaformis* s.l. (Sec. 1 and 2), *Gr. pseudopima*, *Globigerinoides obliquus*, *Globigerina nepenthes* (Sec. 2 to Core Catcher), *Spharoidinellopsis seminulina*, *S. paenedehiscens* (Sec. 1 to 3), *Pulleniatina primalis* (Sec. 1).<br>Age: Early Pliocene, *Globorotalia margaritae* Zone. | Rich and diversified nannoplankton assemblages including *Ceratolithus tricorniculatus*, *C. amplificus*, *Triquetrorhabdulus rugosus*.<br>Zone: *Ceratolithus tricorniculatus*.<br>Age: Early Pliocene | Early Pliocene |
| 7 | This core is a good exhibit of the final stages of calcite solution in the deep sea. Sections 1 to 3 contain a poor residual fauna with *Globorotalia cultrata*, *Globigerina venezuelana*, *Globoquadrina dehiscens*, *Globigerina nepenthes*, *Sphaeroidinellopsis seminulina*, and benthonic foraminifera (*Stilostomella*, *Gyroidina*, *Laticarinina*). In the lower part of the core, one finds mainly fish debris and some badly etched fragments of foraminiferal shells.<br>Age: Early Pliocene to Late (or Late Middle?) Miocene. | Only the upper part (Sections 1 through 3) contains nannofossils. Solution effects lead to a concentration of discoasters with respect to other nannofossils. *Discoaster neohamatus*, *D. hamatus*, *D. bollii* and *D. brouweri* (mostly straight arms but some specimens with curved arms).<br>Preservation: $E_3$<br>Zone: *Discoaster hamatus* Zone.<br>Age: Late Miocene. | Middle to Late Miocene |
| 8 | Very rare agglutinated foraminifera *Bathysiphon* sp., *Cyclammina* cf. *deformis*.<br>Age: Tertiary (undifferentiated). | None | |
| 9 | Rather poor faunas consisting of agglutinated foraminifera such as *Bathysiphon* sp., *Pelosina* spp., *Lituotuba lituiformis*, *Haplophragmoides eggeri*, *Glomospira charoides*, *Gaudryina* cf. *bentonensis*, *Trochamminoides coronatus*, *Ammodiscus in certus*, *Ammoglobigerina* sp. etc.<br>Age: Uncertain (possibly early Tertiary). | None | Early Tertiary? |
| SW1 | None | None | |

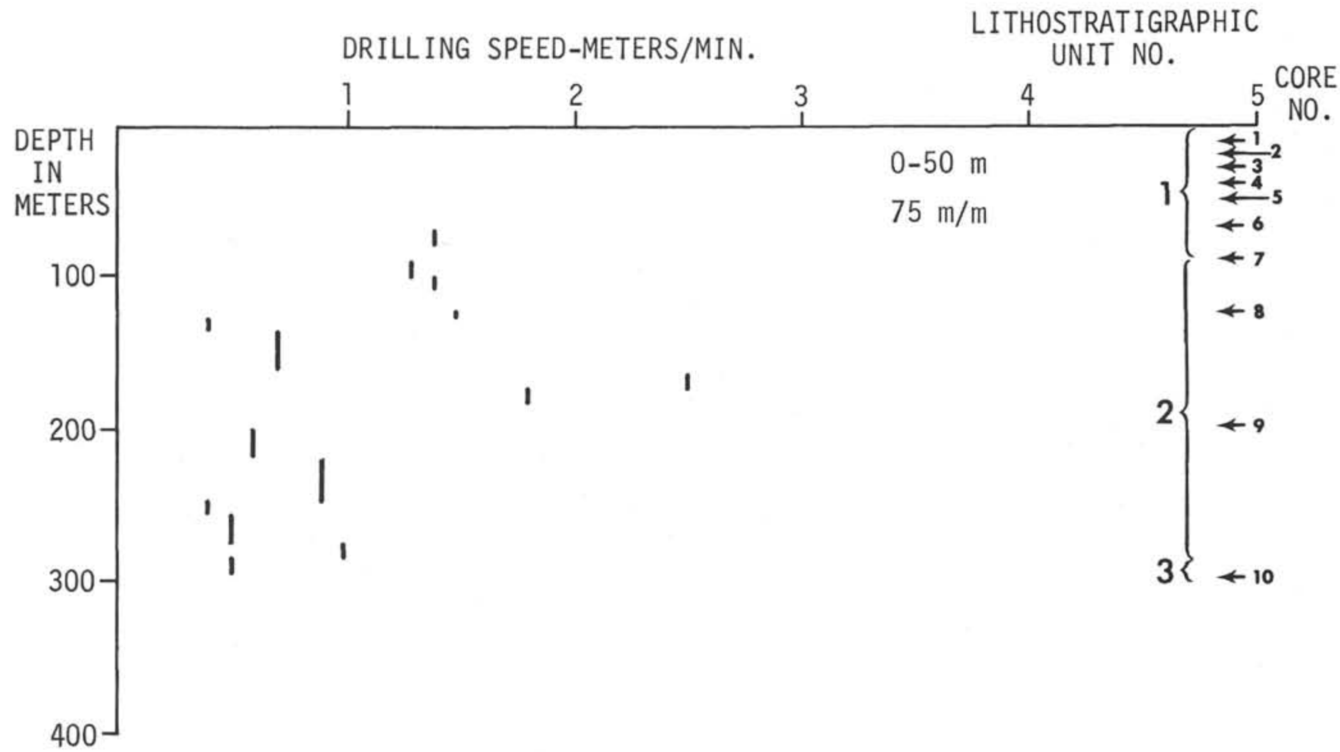



Figure 4. *Drilling and coring summary at Site 141.*

**UNIT 3 – Subarkosic Sand (Sidewall Core 1)**

Unit 3 is defined on the basis of a single 15 cm long sidewall core taken 8 meters above the igneous basement. It is a greenish gray, slightly muddy, fine sand of subarkosic composition. As the base of the core has a sand content of about 65 per cent, and at the top a sand content of about 35 per cent, the unit may be a graded bed although the exact orientation of the sidewall sample is unknown. The composition is: 65 per cent quartz, 10 per cent feldspar (with K-feldspar microcline, orthoclase, sanidine–exceeding plagioclase), 5 per cent hornblende, 4 per cent heavy minerals (zircon, garnet, apatite, sphene, (?)rutile, Fe oxides), 1 per cent biotite and chlorite, the rest clay.

**Basalt**

The hole bottomed in igneous rock, highly fractured and healed with calcite and serpentine veins. The rock is a highly altered greenstone, a mixture of saussurite, prehnite, and serpentine. Serpentine (both chrysotile and antigorite) is present as veins, as intergranular masses, and as large massive areas. Chlorite and chlorophaeite are also present. In a very few places, where alteration is not quite complete, ragged laths of partly saussuritized labradorite are separated by serpentine. Both are partly enclosed in a microcrystalline groundmass of antigorite and/or chlorophaeite. The relict tecture and the mineralogy suggests that the original rock was a basalt, probably alkalic with intergranular texture. The alteration is somewhat higher in grade than for other sampled basalts altered by deep sea weathering. This is consistent with the interpretation that the basalt is a plug, altered hydrothermally under a cap of sediment.

**PHYSICAL & CHEMICAL PROPERTIES**

The cores taken in the top 50 meters of the hole were too disturbed and watery to give reliable penetrometer measurements. At about 65 meters, penetrometer readings averaged 35 (mm $\times 10^{-1}$) and decreased downward to about 15 at 195 meters.

Wet-bulk densities in the ooze (Table 3) have a scatter of values from 1.49 to 1.72 but average about 1.60. The red clays from 84 meters to the bottom of the hole have, except for anomalously low values in Core 8, a remarkably uniform density of about 1.71.

Porosities (Table 3) average about 62 per cent in the upper part of the oozes. They then decrease to between 55 and 60 per cent below 60 meters, below which they remain fairly constant. The clays below 84 meters range from 49 to 59 per cent, averaging less than 55 per cent. Except for anomalously high values in Core 8, water contents of the samples decrease fairly uniformly from about 45 per cent near the sea floor to about 30 per cent at a depth of 195 meters.

Natural gamma readings correlate well with the detailed lithology of the cores. The counts in the upper 50 meters of ooze run about 200 to 500 above the average background, with a scatter in readings corresponding to the background scatter. Between 59 and 68 meters, peak values of up to 900 correlate with beds of high clay content. In Core 7 (79-87 m), readings rise from about 900 to over 2000, marking the change from the calcareous clays at the base of lithologic Unit 1 to the non-calcareous zeolitic clays of Unit 2.

Counts average about 1500 in Core 9. Local peaks, up to 2250 at 192 meters, appear to match thin beds with unusually high zeolite content.

TABLE 3
Summary of Density, Porosity and Water Content Data for Site 141

| | | | 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 (%) |
| 141 | 1 | 1 | 5.75 | 1.49 | 65 | 6.20 | 45 | 1.47 | 66 |
| 141 | 1 | 2 | 7.25 | 1.56 | 60 | 6.64 | 41 | 1.51 | 63 |
| 141 | 1 | 3 | 8.75 | 1.55 | 61 | 8.14 | 44 | 1.50 | 65 |
| 141 | 1 | 4 | 10.25 | 1.58 | 59 | – | – | – | – |
| 141 | 1 | 5 | 11.75 | 1.61 | 57 | 11.14 | 41 | 1.50 | 61 |
| 141 | 1 | 6 | 13.25 | 1.60 | 58 | – | – | – | – |
| 141 | 2 | 1 | 14.75 | 1.51 | 66 | 14.60 | 42 | 1.48 | 62 |
| 141 | 2 | 2 | 16.25 | 1.64 | 57 | 15.65 | 39 | 1.61 | 62 |
| 141 | 2 | 3 | 17.75 | 1.57 | 61 | – | – | – | – |
| 141 | 2 | 4 | 19.25 | 1.59 | 60 | – | – | – | – |
| 141 | 2 | 5 | 20.75 | 1.53 | 64 | 20.15 | 41 | 1.51 | 62 |
| 141 | 2 | 6 | 22.25 | 1.51 | 66 | 21.64 | 41 | 1.56 | 64 |
| 141 | 3 | 1 | 23.75 | 1.56 | 63 | 23.15 | 39 | 1.58 | 61 |
| 141 | 3 | 2 | 25.25 | 1.57 | 62 | – | – | – | – |
| 141 | 3 | 3 | 26.75 | 1.59 | 61 | 26.14 | 36 | 1.55 | 56 |
| 141 | 3 | 4 | 28.25 | 1.60 | 60 | 27.64 | 38 | 1.61 | 61 |
| 141 | 3 | 5 | 29.75 | 1.57 | 62 | 29.14 | 41 | 1.55 | 64 |
| 141 | 3 | 6 | 31.25 | 1.56 | 63 | 30.64 | 41 | 1.53 | 64 |
| 141 | 4 | 1 | 32.75 | 1.45 | 70 | – | – | – | – |
| 141 | 4 | 2 | 34.25 | 1.50 | 67 | – | – | – | – |
| 141 | 4 | 3 | 35.75 | 1.56 | 64 | 35.14 | 36 | 1.62 | 58 |
| 141 | 4 | 4 | 37.25 | 1.51 | 67 | – | – | – | – |
| 141 | 4 | 5 | 38.75 | 1.53 | 66 | – | – | – | – |
| 141 | 4 | 6 | 40.25 | 1.53 | 66 | – | – | – | – |
| 141 | 5 | 1 | 41.75 | 1.66 | 57 | – | – | – | – |
| 141 | 5 | 2 | 43.25 | 1.64 | 58 | – | – | – | – |
| 141 | 5 | 3 | 44.75 | 1.64 | 58 | – | – | – | – |
| 141 | 5 | 4 | 46.25 | 1.72 | 53 | 45.65 | 34 | 1.63 | 55 |
| 141 | 5 | 5 | 47.75 | 1.67 | 57 | – | – | – | – |
| 141 | 5 | 6 | 49.25 | 1.57 | 63 | 48.65 | 35 | 1.67 | 59 |
| 141 | 6 | 1 | 59.75 | 1.52 | 67 | – | – | – | – |
| 141 | 6 | 2 | 61.25 | 1.64 | 58 | – | – | – | – |
| 141 | 6 | 3 | 62.75 | 1.67 | 57 | 62.14 | 33 | 1.80 | 58 |
| 141 | 6 | 4 | 64.25 | 1.69 | 56 | 64.40 | 30 | 1.74 | 52 |
| 141 | 6 | 5 | 65.75 | 1.69 | 55 | 65.68 | 34 | 1.60 | 54 |
| 141 | 6 | 6 | 67.25 | 1.65 | 58 | 66.66 | 30 | 1.66 | 50 |
| 141 | 7 | 1 | 79.75 | 1.73 | 51 | 79.14 | 32 | 1.71 | 54 |
| 141 | 7 | 2 | 81.25 | 1.72 | 52 | 80.64 | 31 | 1.68 | 52 |
| 141 | 7 | 3 | 82.75 | 1.72 | 52 | 82.14 | 35 | 1.63 | 57 |
| 141 | 7 | 4 | 84.25 | 1.74 | 48 | 83.64 | 34 | 1.63 | 55 |
| 141 | 7 | 5 | 85.75 | 1.73 | 49 | 85.14 | 34 | 1.61 | 55 |
| 141 | 7 | 6 | 87.25 | 1.71 | 51 | 86.64 | 35 | 1.63 | 57 |
| 141 | 8 | 1 | 117.75 | 1.46 | 65 | 117.60 | 50 | 1.35 | 68 |
| 141 | 8 | 2 | 119.25 | 1.54 | 59 | 118.64 | 43 | 1.51 | 65 |
| 141 | 9 | 1 | 191.75 | 1.58 | 59 | 191.50 | 40 | 1.51 | 60 |
| 141 | 9 | 2 | 193.25 | 1.73 | 48 | 192.64 | 33 | 1.68 | 55 |
| 141 | 9 | 3 | 194.75 | 1.71 | 50 | 194.15 | 31 | 1.70 | 52 |
| 141 | 9 | 4 | 196.25 | 1.72 | 49 | 195.65 | 30 | 1.65 | 50 |
| 141 | 9 | 5 | 197.75 | 1.72 | 49 | – | – | – | – |
| 141 | 10 | 1 | 295.75 | 1.62 | 56 | – | – | – | – |

Sonic velocity measurements on selected samples are listed in Table 4.

Chemical property measurements yield pH and salinity values (Table 5) well within the normal range for deep sea sediments. The pH ranged from 7.35 to 7.48 in the calcareous oozes and from 6.77 to 6.84 in the clays. Salinities were 35.2 ppt in the ooze and 33.6 to 34.7 ppt in the clay.

## DISCUSSION AND CONCLUSIONS

Site 141 is located on the top of a well developed diapiric structure about 350 km north of the Cape Verde Islands.

Numerous diapiric structures have been discovered along many continental margins of the North Atlantic. On the basis of their similarity in appearance to the other known

TABLE 4
Microtran Sonic Velocity Measurements from Site 141

| Core | Section | Interval | Lithology | Velocity m/sec |
|---|---|---|---|---|
| 8 | 1 | 142 | Brown Clay | 1627 |
| 10[a] | 1 | 22 | Basalt | 4139 |
| 10[a] | 1 | 97 | Basalt | 4152 |
| 10[a] | 1 | 145 | Basalt | 3770 |

[a]Compare with results given in Chapter 24.

TABLE 5
Chemical Property Measurements on Samples from Site 141

| Hole | Core | Section | Sample Interval (cm) Top | Bottom | pH | Eh | Salinity (‰) |
|---|---|---|---|---|---|---|---|
| 141 | 1 | 6 | 0.0 | 10.0 | 7.40 | +10 | 35.2 |
| | 2 | 5 | 0.0 | 10.0 | 7.41 | −14 | 35.2 |
| | 3 | 6 | 0.0 | 10.0 | 7.37 | 0 | 35.2 |
| | 4 | 4 | 0.0 | 10.0 | 7.48 | −21 | 35.2 |
| | 5 | 6 | 0.0 | 10.0 | 7.35 | −16 to +50 | 35.2 |
| | 7 | 6 | 0.0 | 8.0 | 6.77 | +121 | 34.7 |
| | 8 | CC | | | 6.84 | +152 | 34.7 |
| | 9 | 5 | 0.0 | 7.0 | 6.84 | +159 | 33.6 |

salt domes, and because of their proximity to salt basins at the continental edge, many authors (Pautot et al., 1970; Rona, 1969; Schneider and Johnson, 1970) have speculated that all of these diapiric structures are salt diapirs. Rona (1969) and Schneider and Johnson (1970) further speculate that these presumed salt diapirs can be used to infer the time and nature of the initial North Atlantic rifting and the environment of ocean circulation at that time.

There can be no question that Site 141 was located on the crest of one of the diapirs previously cited in the literature. The structure is roughly 2 to 4 km diameter with slopes up to about 30 degrees and is recorded on seismic reflection records as a zone of no acoustic reflection. The zone reaches to at least within 0.10 second of the sea floor and it was anticipated that the "core" of the structure would be encountered near or above 100 meters subbottom penetration.

The inferred sedimentary history at this site is as follows: Since the Late Miocene, conditions have been favorable for the accumulation of pelagic carbonate sediments. Foraminifera are more abundant and better preserved in the Late Pliocene-Early Pleistocene sediments than they are in the older sediments. Paradoxically, sedimentation rates seem to increase downward, suggesting that neither fertility changes nor solution rate changes are sufficient to cause the trend in foraminiferal proportions. Increasing winnowing effects during Pliocene-Pleistocene may be indicated. A general decrease of carbonate content downward in Late Miocene ooze leads to the transition from chalk ooze to marl ooze, or marl mud, that finally grades downward into the zeolitic clays of Unit 2. This general change in lithology is as expected from other sites and represents an increase of carbonate dissolution downward. The position of the changeover from clay to marl occurs at a depth that is too shallow by 400 meters when compared with other nearby drill sites. This fact indicates that the sea floor around the depositional site was raised by 400 meters since the beginning of the Pliocene at a rate of uplift of at least 8 cm/1000 years. The local topographic relief (~40 m) of the structure is an order of magnitude too small to account directly for the inferred vertical uplift of the site. The presumed level of the carbonate compensation depth at Pliocene time, as recorded 150 km to the west at site 12 (Leg II DSDP, Peterson et al., 1970), precludes the possibility of major regional uplift. We must conclude that most of the uplift occurred at a horizontal scale of >5 km but <150 km.

At 295 meters, a highly altered and serpentinized basalt with vein fillings of calcite and other minerals was cored and recovered. This unit occurs well into the zone of "no reflection" of the seismic record and therefore was not recorded seismically.

The zeolitic clay of Unit 2 contains very little quartz. The sediment appears derived mainly from alteration of volcanic material (high per cent zeolite, and traces of olivine and serpentine in sand bed in Core 9).

Abundant palygorskite was detected by X-ray analysis (Chapters 19 and 20) in samples from 117 to 123 and 191 to 192 meters. For several reasons, discussed elsewhere in this volume (Chapters 20, 26, 27), we do not consider this indicative of evaporite deposition but rather a product of diagenesis of montmorillonite-rich clay.

Oxidation-reduction states varied during the deposition of Unit 2, based on observed alternations of reddish and greenish sediment. Redeposition processes also could produce such alternations. The cores are mottled throughout thus indicating the presence of a benthic fauna. However, bioturbation was not so great as to destroy the Mn-rich layers in Section 2, Core 8.

The subarkosic sand of Unit 3 indicates granitic provenance. A rough estimate of size distribution indicates it may be graded bed. The freshness of the feldspar suggests minor weathering and probably rapid transportation and deposition. This site apparently was not a topographic high at the time this sand was deposited by bottom currents. Drilling rates between Cores 9 and 10 (0.8 m/min) are typical of the zeolitic clay in the rest of the section. Therefore, the sand layer is probably fairly thin.

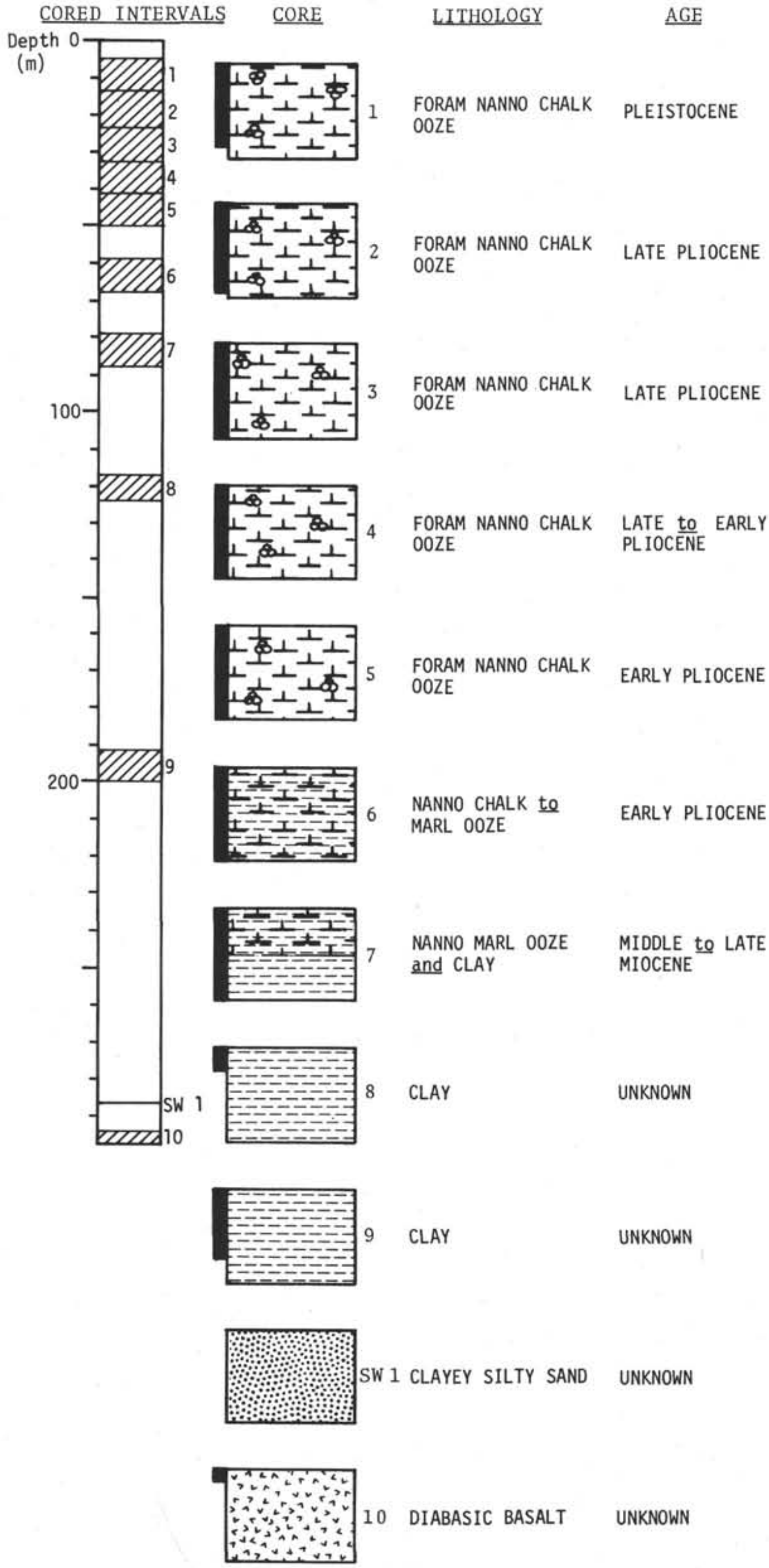
We recognize the common occurrence of fine-grained mafic igneous rocks in association with evaporite domes (O'Brien, 1968), but the detailed cause and effect relationship of the association is not well known. However, salinities of the interstitial waters of the core samples were normal, ~35 ppt for the uppermost cores, and varied little throughout the entire section. There is no indication of any anomalous salt concentration. This factor, accompanied by the recovery of mafic rocks, leads us to conclude that the diapiric structure drilled at Site 141 is not directly related to salt tectonism, but is a local igneous intrusion.

## REFERENCES

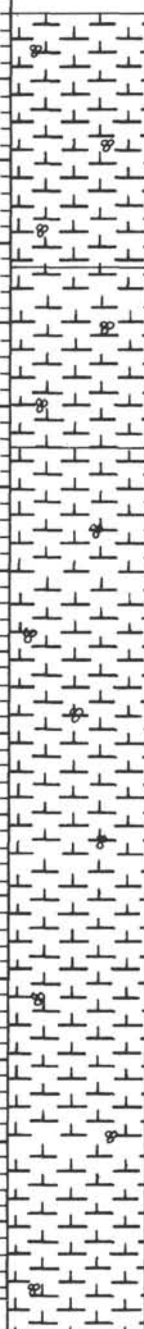
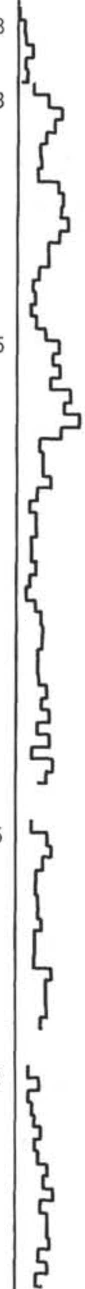
Bolli, H. M., 1970. The Foraminifera of Sites 23-31, Leg 4, Deep Sea Drilling Project. In Bader, R. G., *et al.,* 1970. *Initial Reports of the Deep Sea Drilling Project, Volume IV.* Washington (U. S. Government Printing Office), 577-643.

Braunstein, J. and O'Brien, G. D. (Eds.), 1968. Diapirism and Diapirs, *Amer. Assoc. of Petrol. Geol.* **Memoir 8**, 444.

# SITE 141-SUMMARY



SITE 141 CORE 1 DEPTH (m) 5-14

| 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 PLEISTOCENE | *Globorotalia truncatulinoides* | *Pseudoemiliania lacunosa* | | 1, 2, 3, 4, 5, 6, CC | 1, 2, 3, 4, 5, 6, 7, 8 | VOID  | 20, 130, 40, 130, 75, 70 | see below |  |

FORAM NANNO CHALK OOZE
Two basic colors:

A) White (2.5Y 8/2) to light gray (2.5Y 7/2)

B) Light brownish gray (2.5Y 6/2) to grayish brown (2.5Y 5/2)

$CaCO_3$ 68

GZ 16-25-59 $CaCO_3$ 63

A / B: Sections 2 and 3 show a cyclicity of about 80-110 cm, with B grading upward to A. Other core sections are disturbed, but blebs are dominantly one color or the other in one area, indicating cyclicity may continue.

GZ 24-29-47 $CaCO_3$ 76

Smear Slide Average

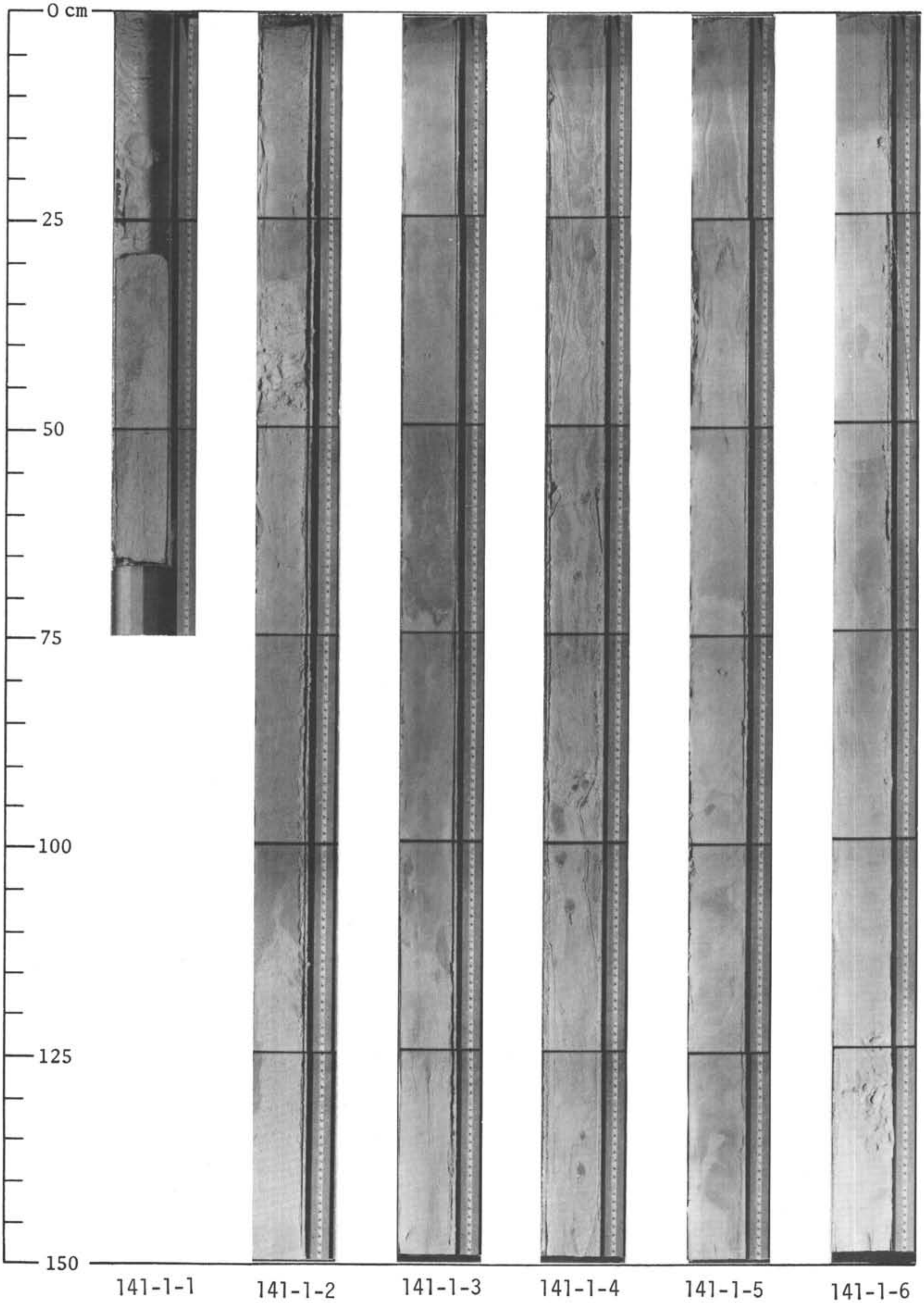
| | |
|---|---|
| Nannos | 30-60% |
| Forams | 30-50% |
| Clay | 10-20% |
| Quartz | Tr.-5% |
| Biotite, chlorite | Tr. |

B) zones appear to be generally higher in clay content

Coarse Fraction:
Planktonic forams, well to moderately well-preserved

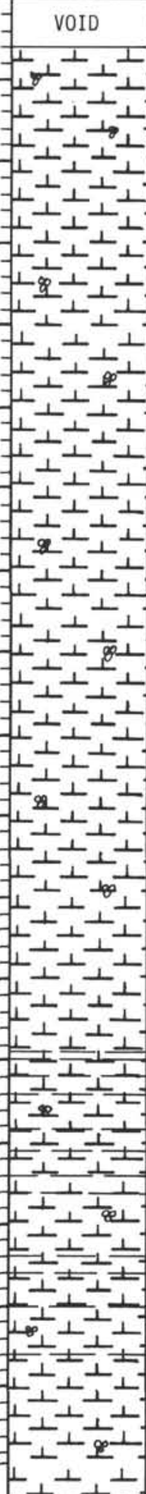
GZ 21-22-57 $CaCO_3$ 75

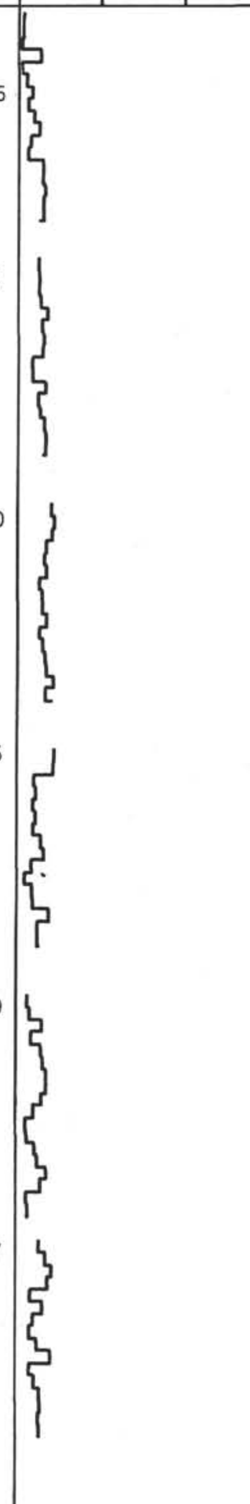
GZ 12-26-62 $CaCO_3$ 82


0 cm
25
50
75
100
125
150
141-1-1
141-1-2
141-1-3
141-1-4
141-1-5
141-1-6

SITE 141 CORE 2 DEPTH (m) 14-23

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| LATE PLIOCENE | *Globorotalia* cf. *tosaensis* (Sections 1–4); *Gr. exilis/Gr. miocenica* (Sections 5–6, CC) | *Discoaster broweri* | | 1, 2, 3, 4, 5, 6, CC | 1–8 | VOID (top of Section 1) | 100, 100, 100, 10, 110, 75 | see below | see figure |





FORAM NANNO CHALK OOZE

GZ 18-22-60 CaCO$_3$ 85

Sections 1 and 2, white (2.5Y N8) to very pale yellow (2.5Y 7/2 to 8/2) and homogeneous. Toward bottom, alternations of

A) White (N8) and light gray (2.5Y N8, 2.5Y 7/1, 2.5Y 8/2) CaCO$_3$ 90

GZ 12-23-65

B) Light yellowish brown (2.5Y 6/4), light brownish gray (2.5Y 6/2), light gray (10YR 7/2)

Smear Slide Average:

| | |
|---|---|
| Nannos | 35-50% |
| Foram fragments | 30-45% |
| Forams | 15-35% |
| Hematite, Mn oxide (?) | Tr.-3% |
| Quartz | 1-2% |
| Feldspar | Tr. |

CaCO$_3$ 80

GZ 15-27-58

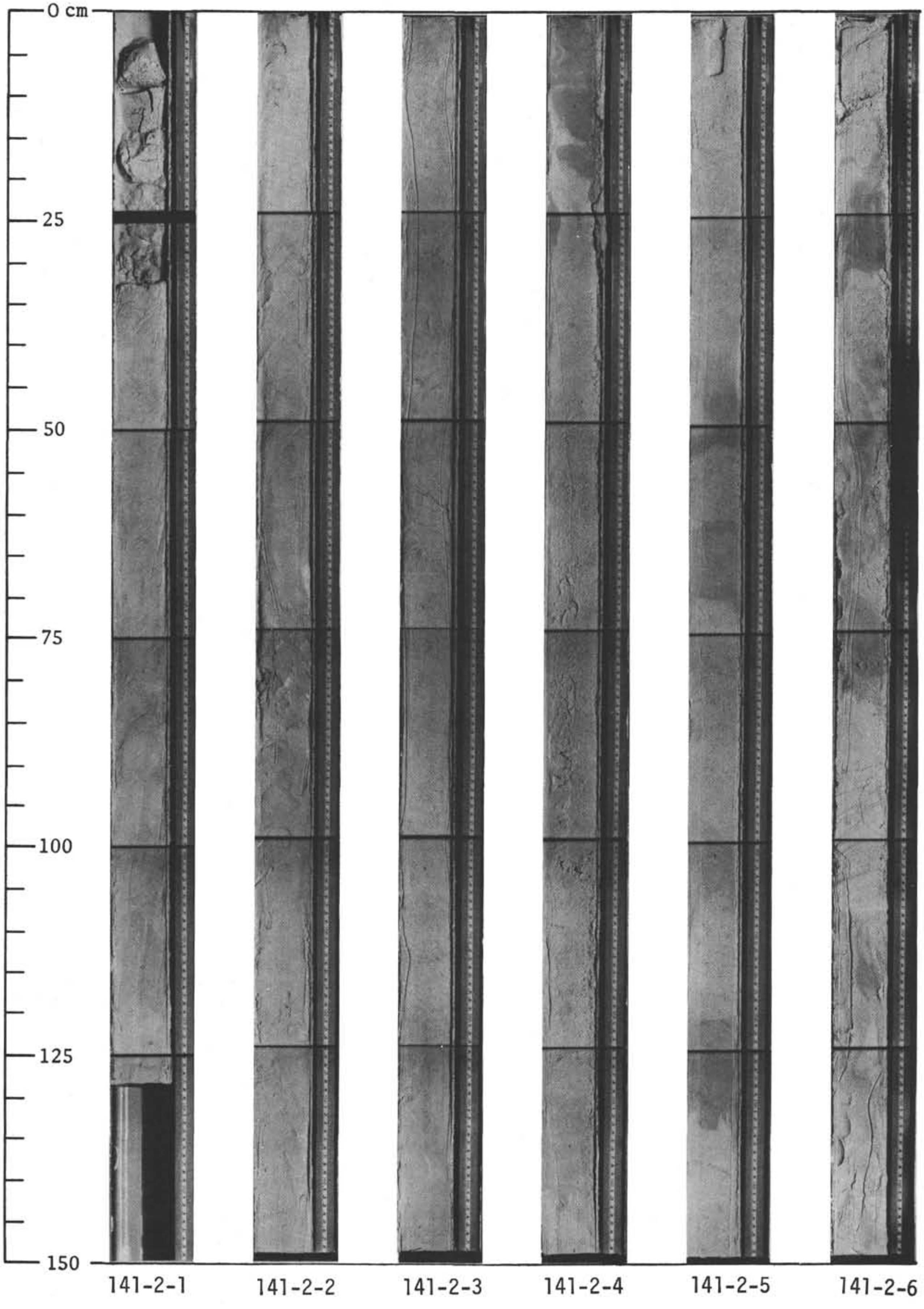
Coarse Fraction:
Planktonic forams, moderately well to poorly preserved

GZ 0-94-6 CaCO$_3$ 65

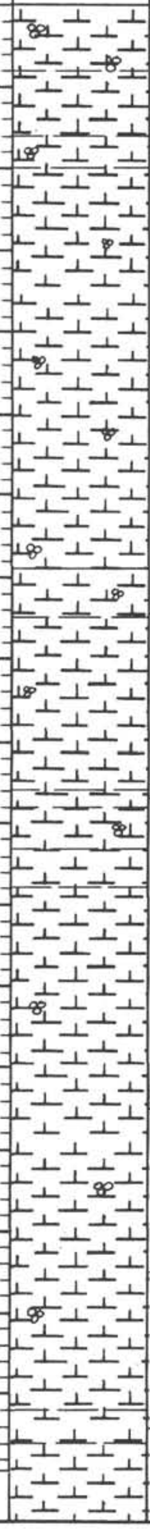
GZ 19-27-54 CaCO$_3$ 89

Alternations in Sections 5 and 6 (smear slide column): B, A, B, A, B, A, B, A, B, A, B, A

CaCO$_3$ 87


0 cm
25
50
75
100
125
150
141-2-1
141-2-2
141-2-3
141-2-4
141-2-5
141-2-6

SITE 141 CORE 3 DEPTH (m) 23-32

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| LATE PLIOCENE | *Globorotalia exilis - G. miocenica* | *Discoaster browweri* | | 1, 2, 3, 4, 5, 6, CC | 1–8 |  | 20 B; 75 B; 75; 70 B; 30 B; B; 70; 24; 120 B | see below |  |

FORAM NANNO CHALK OOZE

CaCO$_3$ 70

GZ 10-36-54

Two basic colors:

A) White (2.5Y N8/1, 2.5Y 8/2) and very light gray (N8, N7)

B) Light brownish gray (2.5Y 6/3, 6/2), grayish brown (2.5Y 5/2), light gray (2.5Y 7/2)

Dominant light (A) colors

Smear Slide Average:

| | |
|---|---|
| Nannos | 50-75% |
| Foram fragments | 10-20% |
| Forams | 5-15% |
| Clay | Tr.-20% |
| Quartz | 2-5% |
| Chlorite and mica | 1-5% |
| Heavies, Mn oxide, hematite | Tr. |

CaCO$_3$ 81

The darker (B) zones are richer in terrigenous components.

The entire core has been disturbed by coring, but the darker areas appear to have been layers in the predominantly white ooze

CaCO$_3$ 86

Coarse Fraction:
Planktonic forams; well, moderately well, and poorly preserved

sec.3, 30 cm GZ 16-31-53

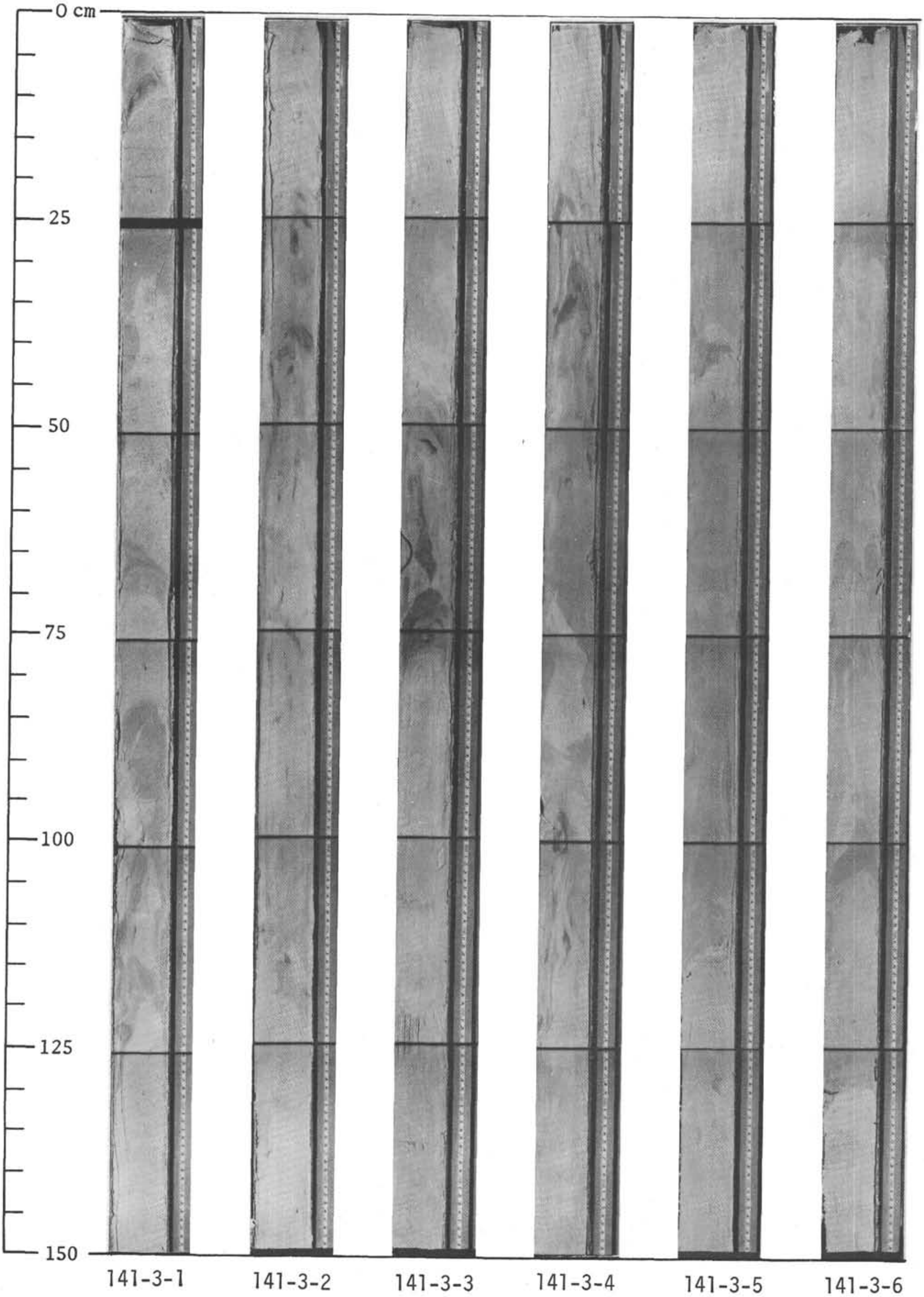
20 cm GZ 13-33-54

CaCO$_3$ 92

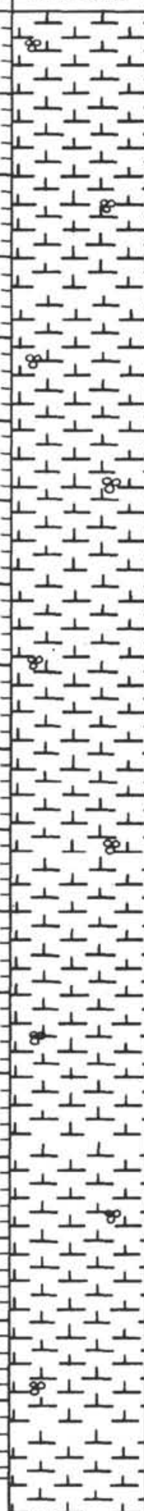
GZ 9-34-57

CaCO$_3$ 90

GZ 14-36-50


0 cm
25
50
75
100
125
150
141-3-1
141-3-2
141-3-3
141-3-4
141-3-5
141-3-6

SITE 141 CORE 4 DEPTH (m) 32-41

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| LATE EARLY PLIOCENE | *Globorotalia margaritae* | *Discoaster broweri* | | 1, 2, 3, 4, 5, 6, CC | 1–8 |  | 100 | see below |  |

FORAM NANNO CHALK OOZE
Light gray (10YR 7/1), 5Y 7/2), yellow gray (5Y 8/1), white (10YR 8/1, 2.5Y 8/2)

Smear Slide (100 cm):

| | |
|---|---|
| Nannos | 55% |
| Foram fragments | 30% |
| Forams | 10% |
| Clay, quartz, mica, pyrite, carbonate rhombs, zeolite | 10% |

$CaCO_3$ 89

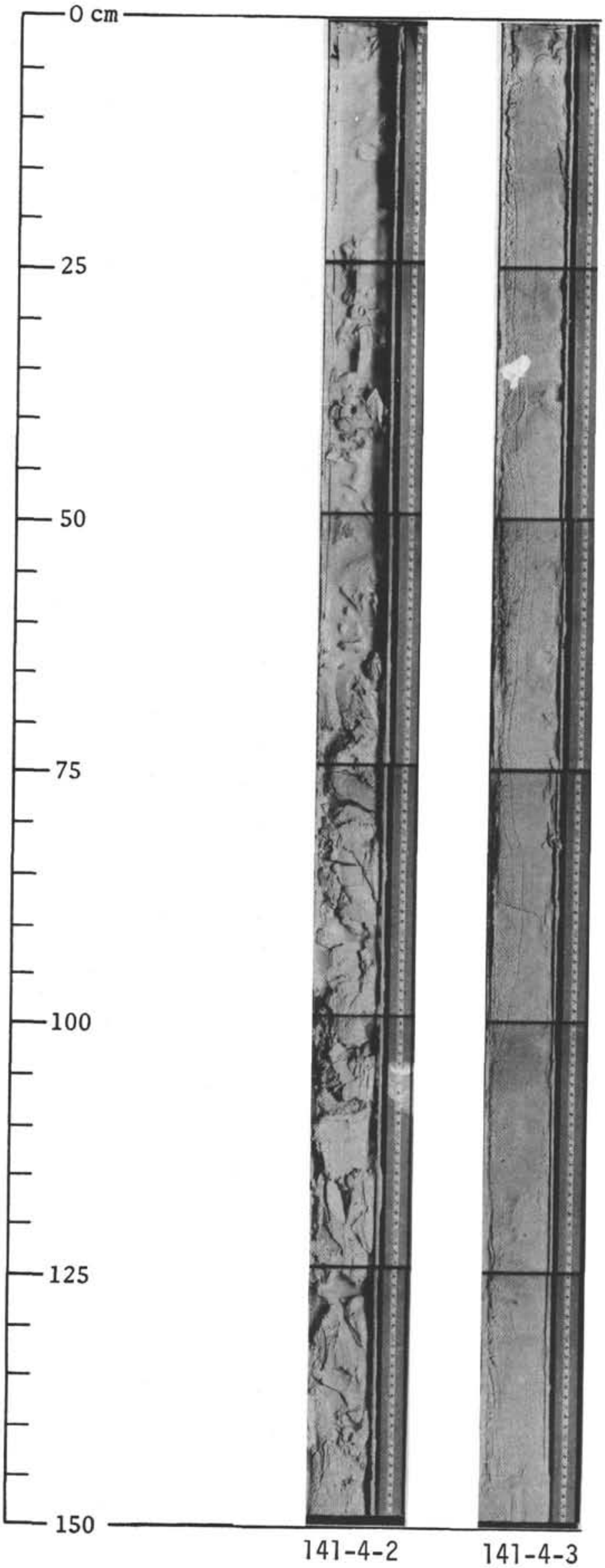
25 cm GZ 12-37-51

Only Sections 2 and 3 cut, others too watery

$CaCO_3$ 70

GZ 13-34-53

GZ 25-32-43


0 cm
25
50
75
100
125
150
141-4-2
141-4-3

SITE 141 CORE 5 DEPTH (m) 41-50

| AGE | ZONE: FORAM | ZONE: NANNO | ZONE: RAD | SECTION | METERS | LITHOLOGIC SYMBOLS | SMEAR SLIDE |
|---|---|---|---|---|---|---|---|
| MIDDLE EARLY PLIOCENE | *Globorotalia margaritae* | *Reticulofenestra pseudoumbilica* (Sections 1–4); *Ceratolithus rugosus* (Sections 5–6, CC) | | 1, 2, 3, 4, 5, 6, CC | 1–8 | | 1: 75, 120; 2: 75; 3: 75; 4: 75, 115; 6: 75 |

**LITHOLOGIC DESCRIPTION**

GZ 5-33-62 $CaCO_3$ 71

FORAM NANNO CHALK OOZE

Entire core is disturbed by flow-in, but there are two basic color groups:

A) White (10YR 8/1, 8/2), light yellow gray (2.5Y 8/4)

B) Light gray (2.5Y 7/2) to light brownish gray (2.5Y 6/2) $CaCO_3$ 81

20 cm GZ 8-27-65

Predominant light colors, with B) colors as local blebs

Smear Slide Averages:

Light Colors:

| | |
|---|---|
| Nannos | 50-60% |
| Forams and foram fragments | 30-35% |
| Clay | 10% |
| Quartz and other terrigenous | 1-5% |

$CaCO_3$ 86

Dark Colors:

| | |
|---|---|
| Nannos | 60% |
| Clay | 20% |
| Forams and foram fragments | 10-15% |
| Quartz, plus some feldspar, mica, chlorite, hematite | ~10% |

30 cm GZ 10-34-56

GZ 4-37-59 $CaCO_3$ 80

Coarse Fraction:

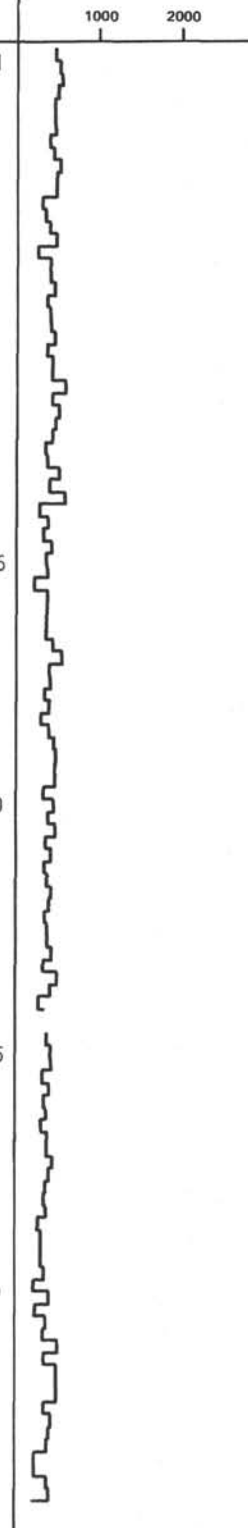
Planktonic forams, moderately well to very poorly preserved

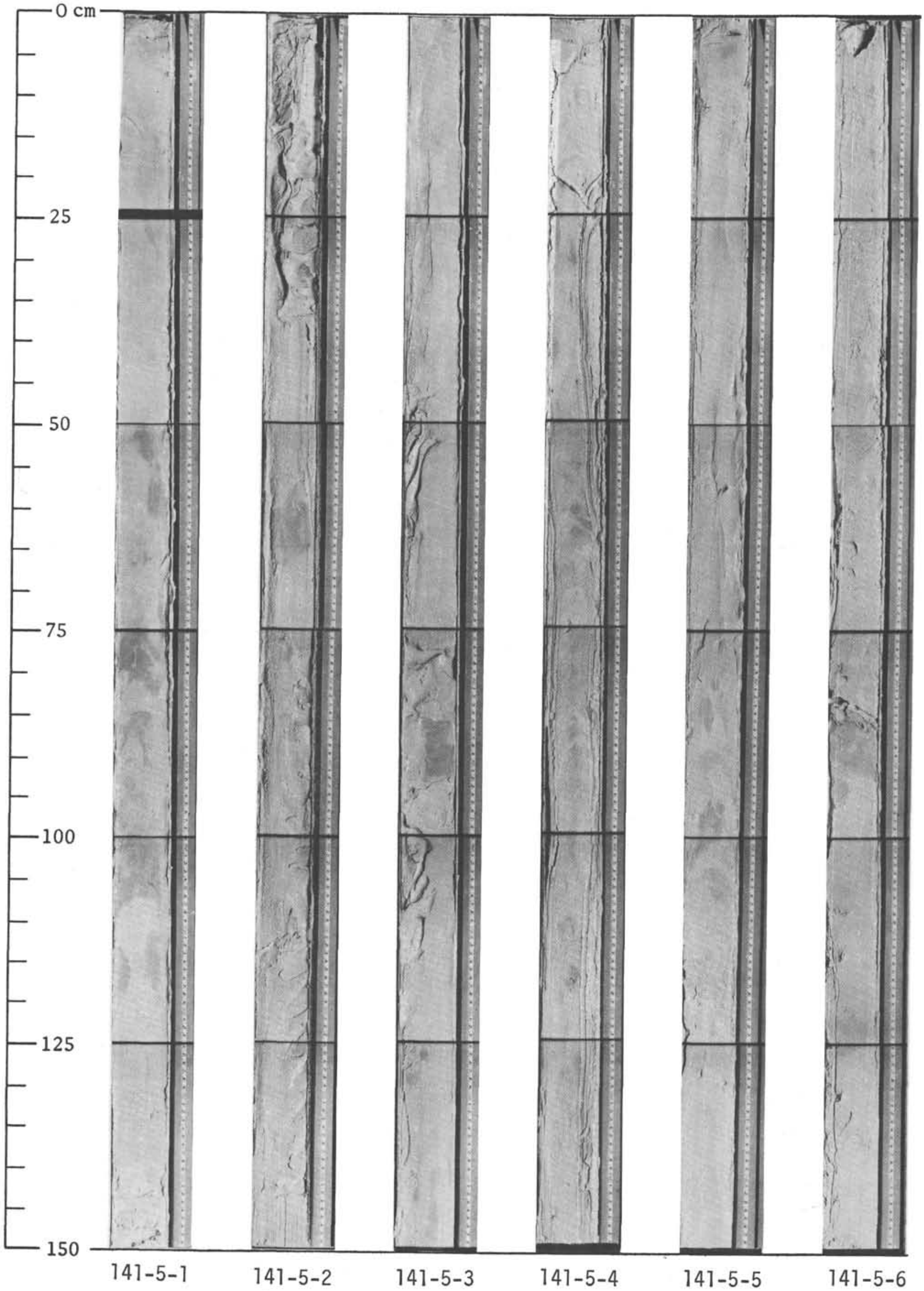
GZ 7-36-57 $CaCO_3$ 85

GZ 5-35-60 $CaCO_3$ 89

NATURAL GAMMA RADIATION

COUNTS/7.6 cm/1.5 min



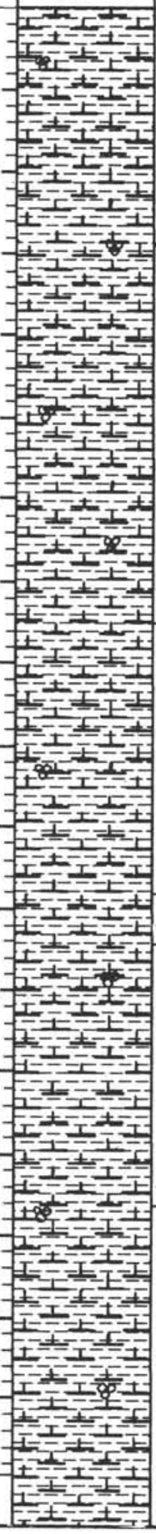

0 cm
25
50
75
100
125
150
141-5-1
141-5-2
141-5-3
141-5-4
141-5-5
141-5-6

**SITE** 141 **CORE** 6 **DEPTH (m)** 59-68

| AGE | ZONE: FORAM | ZONE: NANNO | ZONE: RAD | SECTION | SMEAR SLIDE |
|---|---|---|---|---|---|
| EARLY PLIOCENE | *Globorotalia margaritae* | *Ceratolithus tricorniculatus* | | 1 | |
| | | | | 2 | |
| | | | | 3 | 75 |
| | | | | 4 | 90, 120 |
| | | | | 5 | 130 |
| | | | | 6 | |
| | | | | CC | |

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

LITHOLOGIC SYMBOLS



**LITHOLOGIC DESCRIPTION**

NANNO CHALK to MARL OOZE
White to pale yellows and browns as indicated

Smear Slide Average:

| | | |
|---|---|---|
| Nannos | 45-55% | $CaCO_3$ 78 |
| Clay | ~30% | |
| Forams and foram fragments | 5-15% | |
| Quartz | 5% | |
| Chlorite and micas | 1% | |
| Feldspar | Tr. | |
| Opaques (fe oxides, Mn oxides, limonite, black grains) | Tr. | |
| Heavies (mostly pyroxene, some hornblende, rutile, zircon) | Tr. | |

Sections 1 and 2 not cut, soupy

GZ 0-27-72

$CaCO_3$ 68

GZ 0-29-71

White (10YR 8/1) with streaks (originally beds?) of very pale yellow (2.5Y 8/2)

GZ 1-30-68

White (10YR 8/2) with 5-10 cm bands of light yellowish brown (10YR 6/4) making up ~10% of section

$CaCO_3$ 63

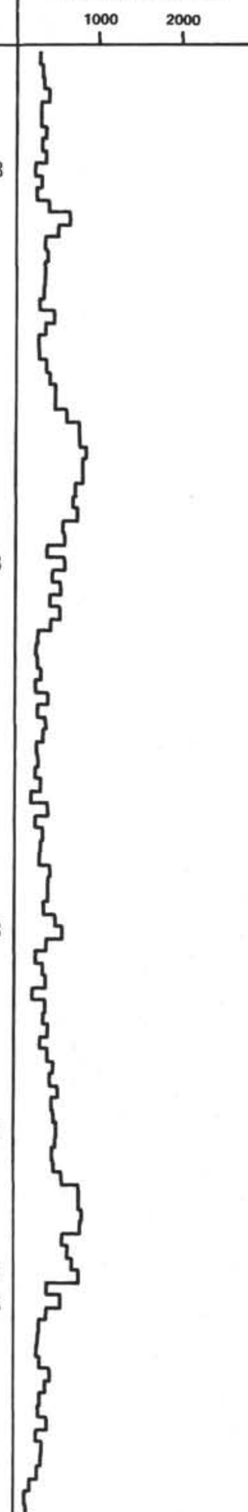
Entire core disturbed by flow-in; only Section 4 relatively intact

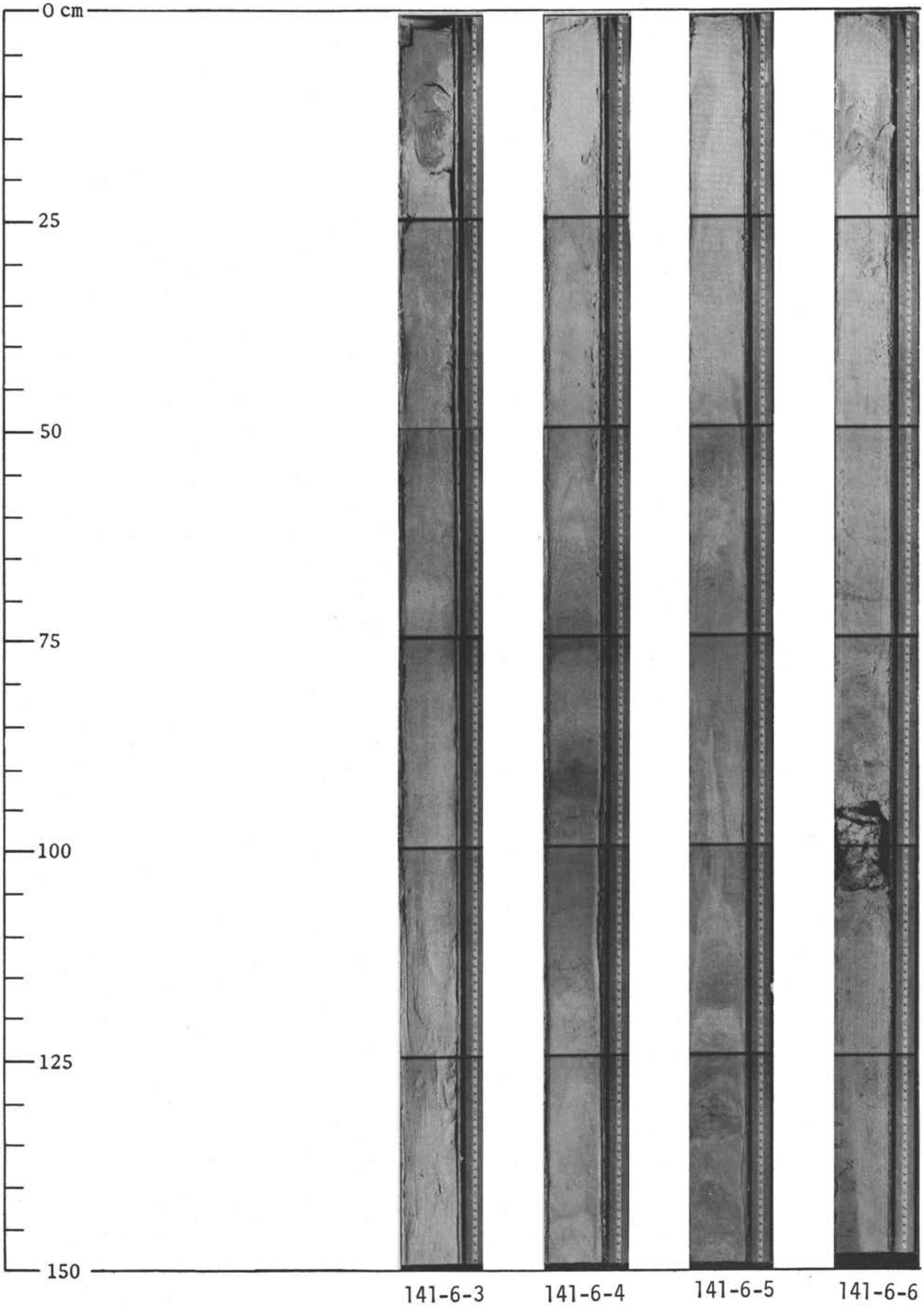
GZ 2-26-72
Coarse Fraction:
Planktonic forams, very poorly preserved — $CaCO_3$ 77

Mottled (?) and finely banded (?) White (10YR 8/1), gray (10YR 6/1) and light yellowish brown (10YR 6/4). Gray and brown colors each comprise ~25% of Section 6 — $CaCO_3$ 66

20 cm GZ 1-27-72

**NATURAL GAMMA RADIATION**
COUNTS/7.6 cm/1.5 min

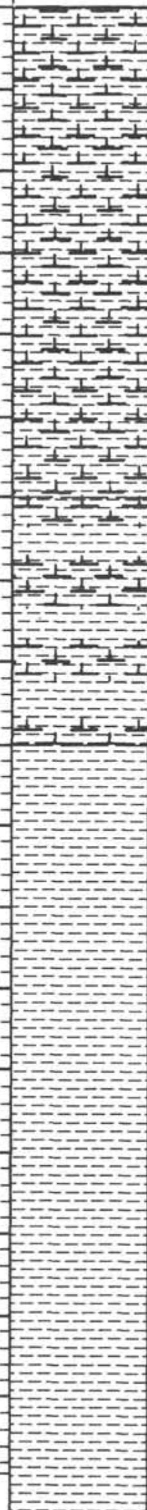



0 cm
25
50
75
100
125
150
141-6-3
141-6-4
141-6-5
141-6-6

SITE 141 CORE 7 DEPTH (m) 79-88

| AGE | ZONE: FORAM | ZONE: NANNO | ZONE: RAD | SECTION | METERS | SMEAR SLIDE |
|---|---|---|---|---|---|---|
| LATE LATE MIOCENE (Sections 1–3); EARLY PLIOCENE TO LATE MIDDLE MIOCENE (Sections 3–CC) | EARLY PLIOCENE TO LATE MIDDLE MIOCENE | *Discoaster hamatus* | | 1 | 1 | 75 |
| | | | | 2 | 2 | 75 |
| | | | | 3 | 3, 4 | 40, 135 |
| | | | | 4 | 5 | 75 |
| | | | | 5 | 6, 7 | 75 |
| | | | | 6 | 8 | 25 |
| | | | | CC | | |

LITHOLOGIC SYMBOLS



## LITHOLOGIC DESCRIPTION

Sections 1 and 2
NANNO MARL OOZE — $CaCO_3$ 38

Brownish yellow (10YR 6/6), streaks of yellowish brown (10YR 5/4)

Smear Slide (75 cm)(Sec 1):

| | |
|---|---|
| Nannos | ~55% |
| Clay | 20% |
| Carbonate fragments | 7% |
| Quartz | 5% |
| Chlorite, muscovite, biotite | 3% |
| Hematite and opaques | 6% |
| Feldspar, tourmaline, zircon, topaz | Tr. |

$CaCO_3$ 22

Smear Slide (75 cm)(Sec 2):

| | |
|---|---|
| Nannos | 50% |
| Clay | 35% |
| Carbonate fragments | 4% |
| Quartz, dolomite, hematite | 3% |
| Biotite and chlorite | 3% |
| Feldspar, pyroxene, hornblende, topaz | Tr. |

sec.1, 30 cm GZ 0-27-73   sec.2, 30 cm GZ 0-23-77

Section 3 is transitional from NANNO MARL OOZE at top to CLAY at the base — $CaCO_3$ 14

Smear Slide (135 cm)(Sec 3):

| | |
|---|---|
| Clay | 70% |
| Nannos | 15% |
| Quartz | 7% |
| Hematite and opaques | 6% |
| Mica | 2% |
| Feldspar, hornblende, apatite | Tr. |

35 cm GZ 0-21-79   sec.4, 20 cm GZ 0-25-75

CLAY

Shades of yellowish brown (10YR 5/4-5/6); mixed by drilling — $CaCO_3$ 2

Smear (75 cm)(Sec 4)

| | |
|---|---|
| Clay | 75% |
| Quartz | 10% |
| Feldspar | 2% |
| Biotite | 3% |
| Carbonate | 2% |
| Heavies (sphene, olivine, pyroxene, hornblende, apatite) | 1% |
| Fe oxide & pyrite | 3% |
| (?) Nontronite | 5% |

$CaCO_3$ 0

Smear (75 cm)(Sec 5)

| | |
|---|---|
| Clay | 90% |
| Quartz | 4% |
| Feldspar | 3% |
| Mica, zeolite | 1% |
| Glass, pyroxene, olivine, sphene, apatite, hematite | Tr. |

Brown to light brown (7.5YR 5/4-6/4)

Smear slide (75 cm)(Sec 6) — $CaCO_3$ 0

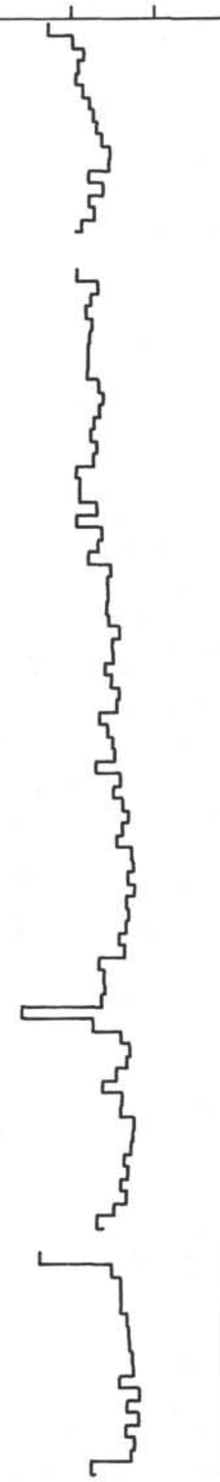
| | |
|---|---|
| Quartz | 30% |
| (?) Nontronite | 30% |
| Clay | 20% |
| Fe oxide and opaque | 10% |
| Biotite | 5% |
| Heavies (apatite, tourmaline) | 2% |

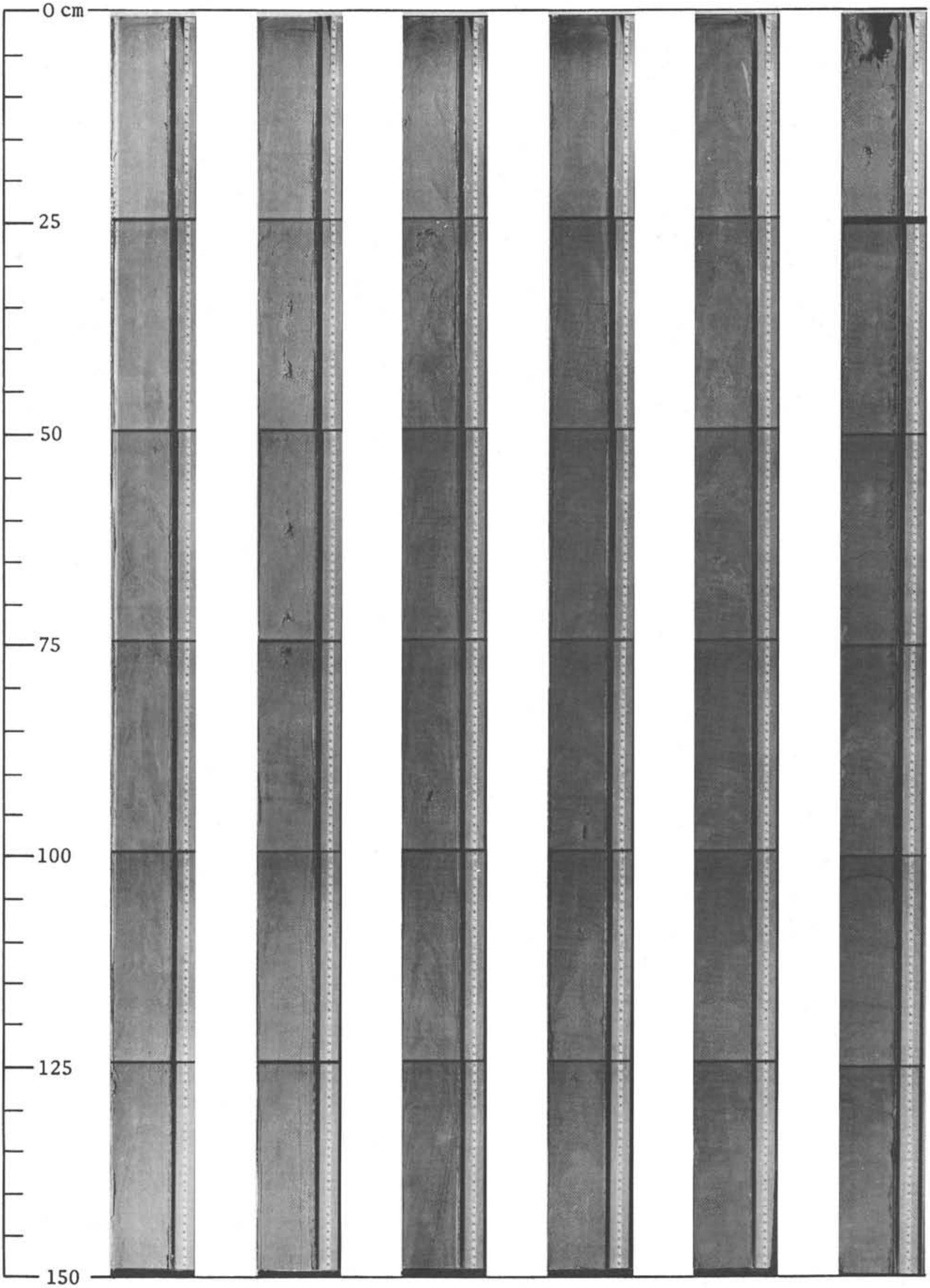
X-Ray (cc):

| | |
|---|---|
| Quartz, kaolinite | A |
| Feldspar, mica, palygorskite | C |
| Montmorillonite, gypsum | Tr. |

sec.5, 20 cm GZ 0-18-82   sec.6, 25 cm GZ 0-19-81

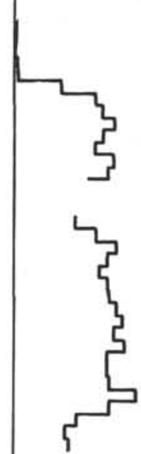
NATURAL GAMMA RADIATION
COUNTS/7.6 cm/1.5 min






141-7-1 141-7-2 141-7-3 141-7-4 141-7-5 141-7-6

SITE 141 CORE 8 DEPTH (m) 117–123

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| UNKNOWN | | | | 1 | 1 | VOID | 70 A, B; 100 A, B, A, B, A, B | See below |  |
| | | | | 2 | 2, 3 | | 50 A, B; A; 100 Silty, A | | |
| | | | | CC | | | | | |

CLAY

Two basic colors:

A) Reddish yellow (7.5YR 7/6 - 6/6)

B) Brown (10YR 5/3) to dark grayish brown (10YR 4/2)

Smear Slide Average: $CaCO_3$ 0

| | |
|---|---|
| Clay | 60-75% |
| Quartz | 10-30% |
| Chlorite and mica | 5% |
| Fe oxides $CaCO_3$ 0 | 4% |
| Feldspar, partly altered pyroxene, olivine, apatite | 2% |

Dark layers (B) are 5-10 cm thick (one is 35 cm), have sharp upper contacts and gradational lower contacts. In the dark layers, large Mn blebs (~2 mm dia) and streaks seem to follow 'bedding planes' ~1 cm. apart

sec.1, 60 cm GZ 0-9-91

X-Ray (36-48 cm)(Sec 2):

| | |
|---|---|
| Palygorskite | A |
| Quartz, feldspar, mica, montmorillonite chlorite, kaolinite | C |

X-Ray (50-70 cm)(Sec 2):

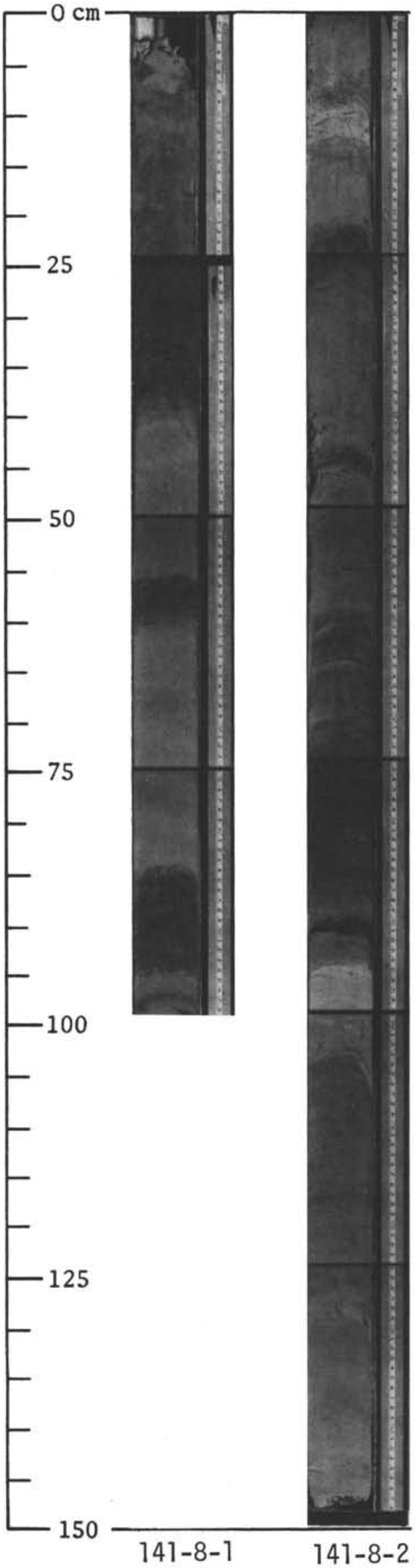
| | |
|---|---|
| Palygorskite | A |
| Quartz, feldspar, mica, kaolinite, | C |
| Montmorillonite | Tr. |

X-Ray (98 cm)(Sec 2):

| | |
|---|---|
| Palygorskite | A |
| Quartz, feldspar, mica, kaolinite, montmorillonite | C |

Coarse Fraction:
Claystone fragments, fish debris

sec.2, 20 cm GZ 0-16-84


0 cm
25
50
75
100
125
150
141-8-1
141-8-2

SITE 141 CORE 9 DEPTH (m) 191-200

| AGE | ZONE: FORAM | ZONE: NANNO | ZONE: RAD | SECTION | METERS | LITHOLOGIC SYMBOLS | SMEAR SLIDE |
|---|---|---|---|---|---|---|---|
| UNKNOWN | | | | 1 | 0–1.5 | VOID; ash layer (A A A A A A) | 62 |
| | | | | 2 | 1.5–3 | | |
| | | | | 3 | 3–4.5 | | 70 |
| | | | | 4 | 4.5–6 | | |
| | | | | 5 | 6–7.5 | | 149 |
| | | | | CC | | | |

## LITHOLOGIC DESCRIPTION

CLAY - colors as indicated
Reddish yellow (7.5YR 6/6)

Alternations of shades of greenish gray (5G 6/1-4/1), transitional boundaries

30 cm GZ 0-17-83

$CaCO_3$ 0

Grayish green (5G 5/2, 5G 6/2); local pyrite at 32 cm

35 cm GZ 0-15-85

Color transition

$CaCO_3$ 0

GZ 0-13-87

$CaCO_3$ 0
GZ 0-21-79
Reddish brown (5YR 5/4, 5YR 4/3)

at 15-20 cm, gray (5Y 5/1)

GZ 0-13-87

X-Ray (63 cm) (Sec 1):
- Montmorillonite A
- Quartz, feldspar, mica, palygorskite, kaolinite Tr.
- $CaCO_3$ 0

X-Ray (149 cm, Sec 1):
- Montmorillonite A
- Quartz, feldspar, mica, kaolinite, pyrite C
- Chlorite Tr.

Smear Slide Average:
- Clay plus zeolites 90-95%
- Hematite, opaque aggregates (limonite?) 3%
- Chlorite, biotite, feldspar, pyroxene 2%

Ash Layer (Smear Slide 62 cm, Sec 1)
- Serpentine (?) or saponite (Chlorite-like fibrous spherulites) 25%
- Clay 55%
- Pyrite 10%
- Fe oxide and opaque 5%
- Zeolite 2%

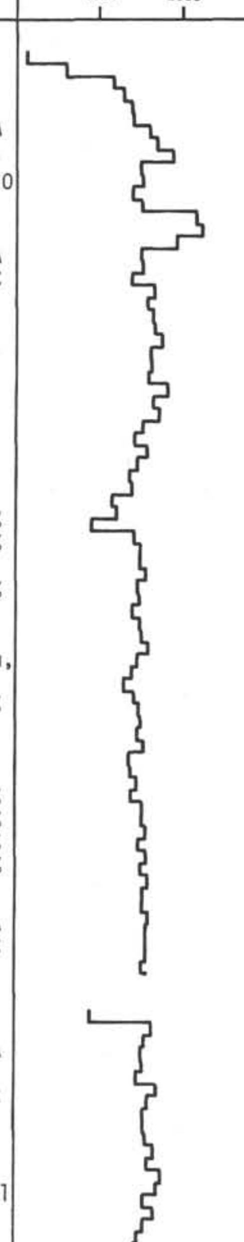
X-Ray (70 cm, Sec 3):
- Montmorillonite A
- Quartz, mica, palygorskite, kaolinite C
- Feldspar Tr.

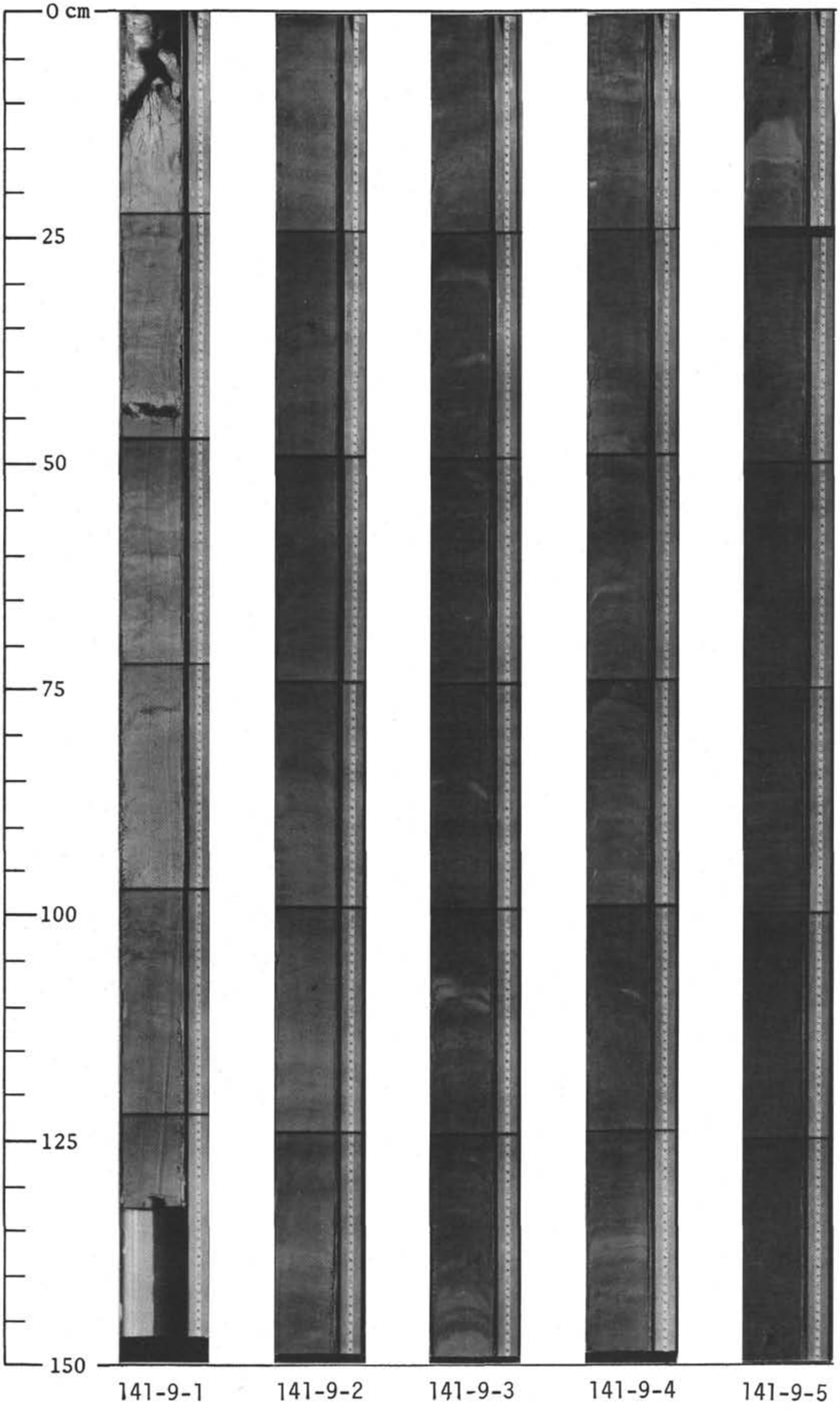
X-Ray (149 cm, Sec 5):
- Quartz, mica, montmorillonite, kaolinite A
- Palygorskite C
- Feldspar, gypsum Tr.

Entire core is intensely mottled on a fine scale, causing contacts to appear transitional. $CaCO_3$ 1

## NATURAL GAMMA RADIATION

COUNTS/7.6 cm/1.5 min




0 cm
25
50
75
100
125
150
141-9-1
141-9-2
141-9-3
141-9-4
141-9-5

SITE 141 CORE SW-1 DEPTH (m) 287

| 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 | NOT TO SCALE | TOP BOT. | GZ 0-21-79 | |
| | | | | CC | | | | | |

GZ 0-21-79

CLAYEY SILTY SAND

Greenish gray (5G 6/1)

Smear Slide (Top)::

| | |
|---|---|
| Clay | 60% |
| Quartz | 30% |
| K Feldspar | 5% |
| Plagioclase | 3% |
| Heavies (sphene, clinozoisite) | 2% |
| Chert fragments | 1% |
| Pyrite | Tr. |

Smear Slide (Bottom):

| | |
|---|---|
| Quartz | 60% |
| K Feldspar | |
| Corthoclase, sanidine, microcline | 15% |
| Clay | 10% |
| Heavies (sphene, apatite, garnet hornblende) | 5% |
| Plagioclase | 5% |
| Biotite | 2% |
| Chlorite | 2% |
| Pyrite | 1% |
| Siliceous fragments | 2% |

X-Ray:

| | |
|---|---|
| Quartz, montmorillonite | A |
| Feldspar, mica, palygorskite, chlorite | C |

SITE 141 CORE 10 DEPTH (m) 295-298

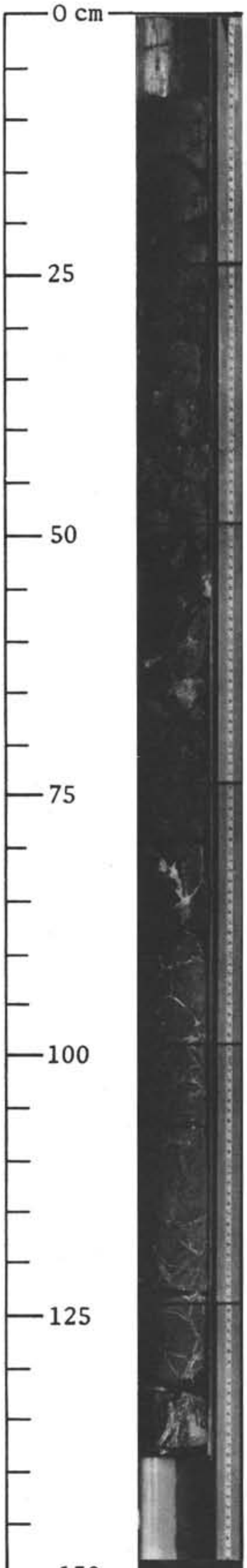
| AGE | ZONE: FORAM | ZONE: NANNO | ZONE: RAD | SECTION | METERS | LITHOLOGIC SYMBOLS | SMEAR SLIDE | LITHOLOGIC DESCRIPTION | NATURAL GAMMA RADIATION COUNTS/7.6 cm/1.5 min 1000 2000 |
|---|---|---|---|---|---|---|---|---|---|
| UNKNOWN | | | | 1 | 1 | VOID | | |  |
| | | | | CC | | | | | |

DIABASIC BASALT

Grayish olive green (5GY 3/2), olive gray (5Y 3/2), dusky yellow green (5GY 5/2)

MEGASCOPIC: Highly altered and fractured, largely aphanitic. Many dark green to black serpentine veins above 90 cm, white calcite veins below, discrete areas of dark green serpentine locally, some spherulitic.

MICROSCOPIC: Alteration virtually complete, except in some coarser-grained areas where Plagioclase (lauradorite) laths are 0.1 - 0.6 mm long, partly sassuritized and albitized. Pyroxenes are replaced by serpentine. Ground mass is microcyrstalline serpentine and/or chlorophaeite. Prehnite locally present, often as spherulites; some spherules appear filled with saponite.




141-10-1