# 11. SITE 633: EXUMA SOUND[1]

Shipboard Scientific Party[2]

## HOLE 633A

**Date occupied:** 1 March 1985, 0836 EST

**Date departed:** 2 March 1985, 1948 EST

**Time on hole:** 1 day, 11 hr

**Position:** 23°41.31′N, 75°37.59′W

**Water depth (sea level; corrected m, echo-sounding):** 1681

**Water depth (rig floor; corrected m, echo-sounding):** 1691.3

**Bottom felt (m, drill pipe):** 1689.6

**Total depth (m):** 1916.9

**Penetration (m):** 227.3

**Number of cores:** 24

**Total length of cored section (m):** 227.3

**Total core recovered (m):** 110.8

**Core recovery (%):** 48.7

**Oldest sediment cored:**
Depth sub-bottom (m): 227.3
Nature: periplatform chalk and limestone with turbidites
Age: late Miocene
Measured velocity (km/s): 1.78, Hamilton Frame

**Principal results:** Site 633 at the toe-of-slope in Exuma Sound was occupied 1 and 2 March 1985. Only one hole was drilled, Hole 633A, located at 23°41.31′N, 75°37.59′W, in water depth of 1681 m. The hole reached a total depth of 227 m using hydraulic-piston-corer/extended-core-barrel (HPC/XCB) techniques, with 48.7% recovery.

The following stratigraphic sequence was recovered: (1) 0–52 m sub-bottom; periplatform ooze with thin turbidites, late Pliocene to Holocene in age; (2) 52–151 m sub-bottom; periplatform chalk with few turbidites, late Miocene(?) to Pliocene; and (3) 151–227 m sub-bottom; periplatform chalk and limestone with turbidites, late Miocene.

The turbiditic units at the top and bottom of the hole represent typical basin-floor facies. The distal facies of turbidites in the top unit probably reflects its position on a local topographic high that formed during deposition of the middle unit, either by progradation of a spur of the slope or by slumping. Sediment facies, seismic determinations, and stratigraphic control in the middle unit are compatible with either one of these interpretations.

Both sediments and rocks at the site contain abundant clay-sized aragonite, interpreted as bank-derived material (periplatform ooze and chalk). Interstitial-water chemistry indicates active sulfate reduction throughout the sequence.

## OPERATIONS SUMMARY

The *JOIDES Resolution* left Site 632 for position BAH-11-B at 0120 hr, 1 March. BAH-11-B was located approximately 15 n. mi from Site 632 along ES-07 (see Fig. 1, Site 631 chapter). The ship's speed upon leaving Site 632 was 1 kt in order to allow time to switch from a bottom-hole assembly (BHA) for rotary coring to one suitable for HPC/XCB operations. Speed was increased to 4 kt at 0400 hr, but the ship remained in dynamic-positioning mode with thrusters extended for the entire transit. No underway seismic data were collected, as a line with similar trend had been run en route from Site 631 to Site 632 (see "Operations Summary," Site 632 chapter; Fig. 1, Site 631 chapter).

By 0620 hr, the *Resolution* was approximately 0.6 n. mi from the designated BAH-11-B position at the intersection of ES-07 and LDGO multichannel seismic profile 361 (Fig. 1, Site 631 chapter), but further operations were delayed until a SATNAV fix at 0800 hr definitely placed the vessel 0.5 n. mi northwest of BAH-11-B. After final maneuvering, a 14.5-kHz beacon was deployed at 0836 hr. The Site 633 position is as follows: 23°41.29–33′N, 75°37.55–63′W (range of good SATNAV fixes), less than 0.2 n. mi from BAH-11-B. Water depth was 1674 m (uncorr.) and 1681 m (corr.), for a drilling depth of 1691.3 m.

A successful mud-line HPC core was on deck at 1145 hr from a depth of 1689.6 m. Nine HPC cores were collected in 5.75 hr to a depth of 83.9 m sub-bottom. Recovery using the HPC technique was 84.9%. After the switch to the XCB, 15 cores were collected to a total depth of 227.3 m sub-bottom with a recovery of 27.6%. Overall recovery at Site 633 was 48.7%. The last core came on deck at 1400 hr, 2 March. The drill string was clear of the mud line at 1435 hr; dismantling the BHA was completed at 1945 hr, and the *Resolution* was under way for DSDP Site 98/BAH-3 in the Northeast Providence Channel, approximately a 20-hr transit, at 1948 hr, 2 March.

The coring summary for Site 633 appears in Table 1.

[1] Austin, J. A., Jr., Schlager, W., Palmer, A. A., et al., 1986. *Proc., Init. Repts. (Pt. A), ODP*, 101.

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Table 1. Coring summary, Site 633.

| Core no. | Core type[a] | Date (Mar. 1985) | Time | Sub-bottom depths (m) | Length cored (m) | Length recovered (m) | Percentage recovered |
|---|---|---|---|---|---|---|---|
| Hole 633A | | | | | | | |
| 1 | H | 1 | 1145 | 0-8.7 | 8.7 | 8.67 | 99 |
| 2 | H | 1 | 1230 | 8.7-18.3 | 9.6 | 8.90 | 92 |
| 3 | H | 1 | 1300 | 18.3-28.0 | 9.7 | 9.54 | 98 |
| 4 | H | 1 | 1345 | 28.0-37.6 | 9.6 | 9.14 | 95 |
| 5 | H | 1 | 1415 | 37.6-47.2 | 9.6 | 9.60 | 100 |
| 6 | H | 1 | 1445 | 47.2-56.9 | 9.7 | 9.55 | 98 |
| 7 | H | 1 | 1600 | 56.9-66.4 | 9.5 | 9.42 | 99 |
| 8 | H | 1 | 1645 | 66.4-75.5 | 9.1 | 6.45 | 70 |
| 9 | H | 1 | 1730 | 75.5-84.9 | 9.4 | 0 | 0 |
| 10 | X | 1 | 1915 | 83.9-93.6 | 9.7 | 0 | 0 |
| 11 | X | 1 | 2030 | 93.6-103.1 | 9.5 | 0.60 | 6 |
| 12 | X | 1 | 2130 | 103.1-112.7 | 9.6 | 0.16 | 1 |
| 13 | X | 1 | 2300 | 112.7-122.3 | 9.6 | 4.45 | 46 |
| 14 | X | 2 | 0035 | 122.3-132.0 | 9.7 | 3.77 | 38 |
| 15 | X | 2 | 0155 | 132.0-141.7 | 9.7 | 5.74 | 60 |
| 16 | X | 2 | 0300 | 141.7-151.4 | 9.7 | 9.41 | 97 |
| 17 | X | 2 | 0420 | 151.4-160.0 | 8.6 | 0.70 | 8 |
| 18 | X | 2 | 0540 | 160.0-169.6 | 9.6 | 1.11 | 11 |
| 19 | X | 2 | 0655 | 169.6-179.3 | 9.7 | 1.67 | 17 |
| 20 | X | 2 | 0820 | 179.3-188.9 | 9.6 | 0.39 | 4 |
| 21 | X | 2 | 0930 | 188.9-198.5 | 9.6 | 2.35 | 24 |
| 22 | X | 2 | 1054 | 198.5-208.2 | 9.7 | 6.82 | 70 |
| 23 | X | 2 | 1215 | 208.2-217.8 | 9.6 | 1.19 | 12 |
| 24 | X | 2 | 1400 | 217.8-227.3 | 9.5 | 1.27 | 13 |

[a] H = hydraulic piston; X = extended core barrel.

## SEDIMENTOLOGY

One hole was drilled at Site 633, Hole 633A, which penetrated 227.3 m with a 110.8-m (48.7%) recovery. On the basis of sediment types, sedimentary structures, and compositional data (Fig. 1), three major depositional units are defined for the site, as follows.

### Unit I (0–52 m sub-bottom; Cores 632A-1 to 632A-6H-4, 30 cm)

The lower boundary of Unit I is defined by a gradational sediment color change from white (10YR 8/1) to brown (2.5Y 8/2) as well as increases in the relative degree of diagenetic alteration (lithification) and relative percentages of micrite, including aragonite needles (Fig. 1).

Sediments consist predominantly of unlithified calcareous ooze rich in nannofossils (up to 60%) and bank-derived aragonite needles and are best classified as periplatform oozes. These oozes are typically bioturbated (Fig. 2) and have highly distinctive gray (7.5YR 7/10) pyritic bands that appear in a seemingly random distribution. Locally interbedded with these oozes are minor dark, unlithified mudstones that are relatively rich in noncarbonate terrigenous components. These mud units typically have sharp lower contacts with gradational tops that extend vertically over distances of a few tens of centimeters. Similar-appearing mudstones also were recovered north of Little Bahama Bank (Mullins et al., 1984; see chapters for Sites 627 through 630) as well as from the basin of Exuma Sound (see Site 632 chapter).

Scarce, massive to normally graded, unlithified packstones and grainstones, interpreted as turbidites, are present throughout this unit but are thin (<5–10 cm) and relatively fine grained. Only one coarse-grained, unlithified rudstone was recovered (Core 633A-3H-7). This very coarse sand and gravel deposit, also interpreted as a turbidite, is about 50 cm thick and consists of both shallow- and deep-water-derived allochems. The other, thinner turbidites have fine to medium sand consisting mostly of tests of planktonic foraminifers. Chalk occurs in Core 633A-2H at only 17 m sub-bottom and may be the product of shallow-subsurface diagenesis.

### Unit II (52–151 m sub-bottom; Cores 633A-6H-4, 30 cm, through 633A-16X)

The base of Unit II is defined by the transition from chalk to limestone found between Cores 633A-16X and 633A-17X.

The sediment types in this depositional unit are grossly similar to those in Unit I, but exhibit greater induration. In general, Unit II consists of bioturbated chalks and oozes that represent perennial fine-grained sedimentation with very few thin, fine-grained, unlithified packstones, interpreted as slope-derived turbidites.

Periplatform oozes in Unit II have higher percentages (up to 75%; Fig. 1) of micrite (including aragonite needles) and a relatively lower abundance of nannofossils than those in Unit I. As with other units recovered on Leg 101 with the XCB, chalks in Unit II occur as couplets with soft ooze, having the appearance of primary cycles. However, these cycles are probably artifacts produced during drilling.

### Unit III (151–227 m sub-bottom; Core 633A-17X to 633A-24X)

The first well-lithified limestones occur in Core 633A-17X at a subsurface depth of 151 m and are present for the remainder of the cored interval (227 m sub-bottom). Core recovery of this unit was poor (20%), which may imply that the limestones are interbedded with unconsolidated sediment, although this is uncertain. Relative to Unit II, Unit III is more lithified and contains a higher proportion of nannofossils than micritic needles (Fig. 1).

Unit III consists of a mix of well-lithified wackestones–packstones and grainstones as well as highly fractured and disturbed chalk–ooze couplets. Wackestones–packstones are bioturbated with well-preserved burrows filled with grainstone and appear to represent perennial, fine-grained periplatform ooze. Grainstones, however, are mostly free of large, obvious burrow structures and more typically display distinct plane-parallel and/or cross lami-

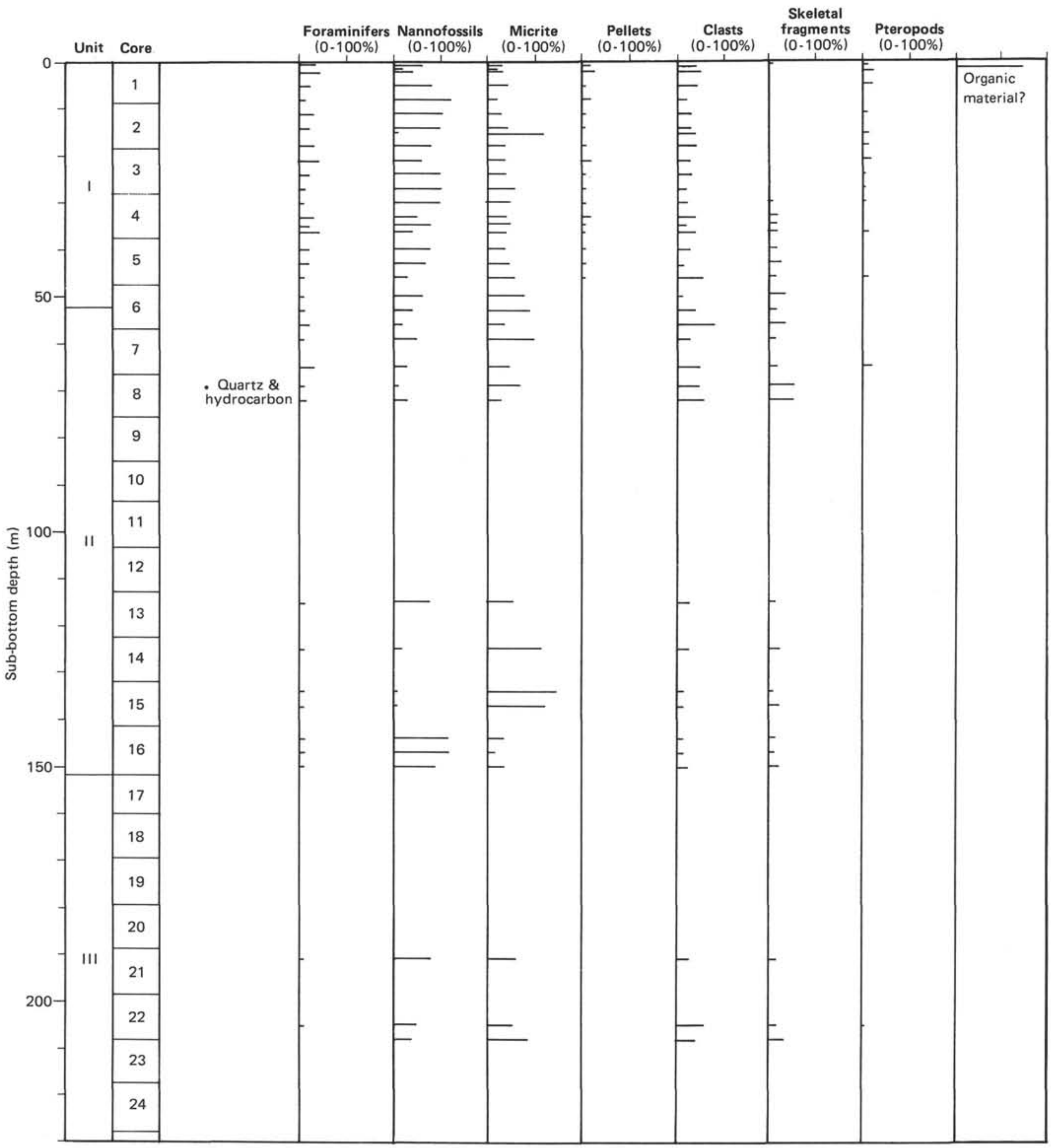


Figure 1. Summary of smear slide data for Site 633.

nations (Fig. 3). The grainstones are normally graded, fine to medium sands with sharp basal contacts and gradational tops. Based on these preserved sedimentary structures, grainstones of Unit III are interpreted as turbidites, which constitute about 30% of the recovered section. These coarse-grained limestones also have secondary, moldic porosity and are locally impregnated with small quantities of tar (see "Organic Geochemistry" section, this chapter).

## Discussion

The most striking aspect of the sedimentology of Site 633 is the paucity of thick, coarse-grained sediment gravity-flow deposits in Units II and III in a basin-margin setting. Previous studies, based on short (<10-m) piston-core samples, have demonstrated that Bahamian Basin margins are preferred sites of turbidite and debris-flow deposition (Mullins and Neumann,

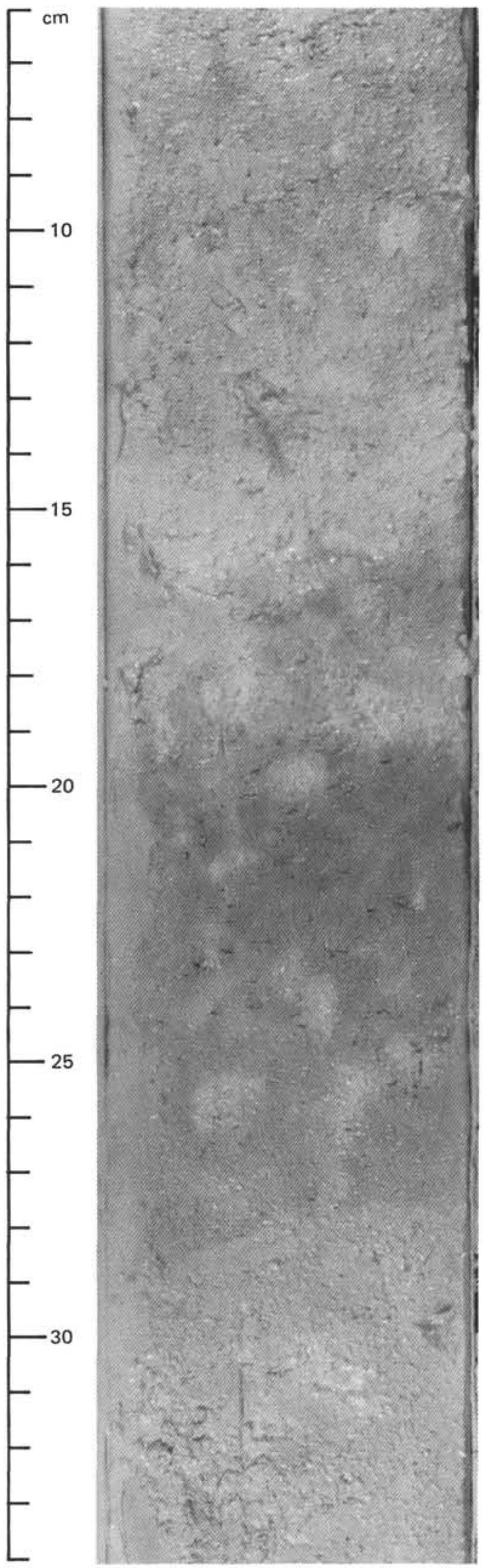


Figure 2. Bioturbated calcareous ooze of Unit I, Section 633A-1H-2.

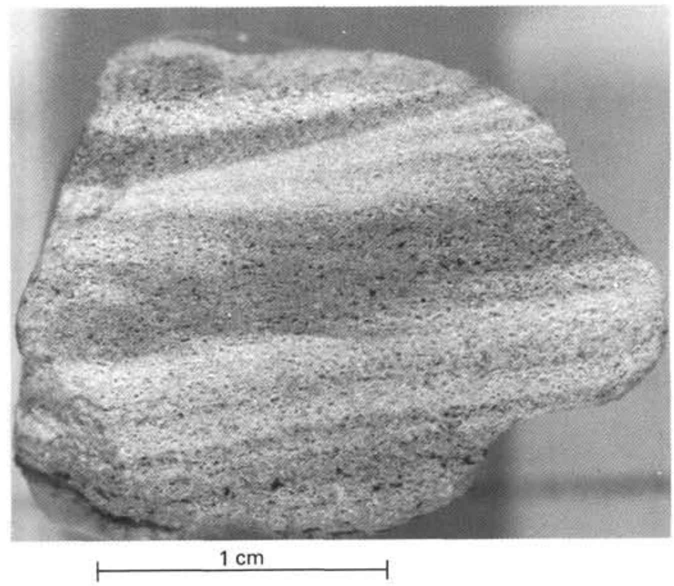


Figure 3. Cross-laminated grainstone turbidite of Unit III, Section 633A-20X-1.

1979; Schlager and Chermak, 1979; Crevello and Schlager, 1980; Mullins et al., 1984). However, Units I and II contain only rare, thin, fine-grained gravity-flow deposits, which become more abundant in Unit III.

These facies relationships may be the product of seaward progradation of the Exuma Sound carbonate slope. During the late Miocene, a series of coarse-grained turbidites, interbedded with periplatform oozes (Unit III), accumulated in a basin-margin setting, having bypassed an upper gullied slope. Starting in the early Pliocene, however, the upper gullied slope may have migrated basinward as the carbonate margin built up and out. Such a scenario could readily explain the vertical succession of facies observed in Units I through III at Site 633.

An alternative working hypothesis is that Unit II represents one or several slumps that originated along the upper slope but were subsequently displaced seaward by slope failure. Unit I would represent a drape on the inferred slumps. This scenario would also explain the paucity of sediment gravity-flow deposits in Unit I, particularly if the slide block had substantial (e.g., a few tens of meters) topographic relief above the surrounding basin-margin seafloor. This alternative draws support from seismic stratigraphic data (see "Seismic Stratigraphy" section, this chapter), which indicate a highly irregular, hummocky seafloor morphology along the basin margin. Unit III, however, appears to represent an *in-situ* accumulation of basin-margin turbidites and periplatform oozes that are similar to coeval facies recovered at Site 632 (see Site 632 chapter, this volume).

In summary (Table 2), the basin-margin rise of southwestern Exuma Sound appears to have been the site of turbidite–periplatform-ooze deposition during the late Miocene. Subsequently, the upper gullied slope either prograded seaward as the platform margin built up and out or was the site of large-scale slope failure that resulted in the emplacement of a relatively undisturbed bypass slope facies (mostly ooze and chalk) on top of an earlier basin-margin facies.

## BIOSTRATIGRAPHY

### Introduction

Drilling at Site 633 penetrated approximately 227 m of periplatform ooze, chalk, and limestone with turbidites. Plankton-

**Table 2. Lithostratigraphic summary, Site 633.**

| Unit | Sub-bottom depth (m) | Age | Accumulation rate (m/m.y.) | Dominant lithology and interpretation |
|---|---|---|---|---|
| I | 0–52 | Quaternary | 21 | Periplatform ooze with thin turbidites (bypass slope, spur, or drape over slump) |
| II | 52–151 | late Miocene–early Pliocene | 58 | Periplatform chalk with thin turbidites (bypass slope, spur, or slump from bypass slope) |
| III | 151–227 | late Miocene | 82–140 | Wackestones–packstones with grainstone turbidites (basin-margin rise) |

ic-microfossil biostratigraphy indicates that this sequence spans the latest Miocene through the Holocene. Low recovery and the well-lithified nature of the rocks in the upper Miocene section limit the biostratigraphic resolution in parts of the sequence, although most of the barren intervals are bracketed by well-dated zones.

### Calcareous Nannofossils

Sample 633A-1H-1, 1 cm, contains abundant *Emiliania huxleyi*, which is characteristic of the *E. huxleyi* Acme Zone. This zone correlates with the latest Pleistocene and the Holocene, suggesting that the mud line was successfully recovered. Sample 633A-1H, CC contains an assemblage in which *E. huxleyi* is still present but in which *Gephyrocapsa caribbeanica* is dominant. The assemblage is assigned to the *E. huxleyi* Zone, the older part of the NN21 Zone, which correlates with the middle Pleistocene. Zone NN19 is represented in Sample 633A-2H, CC, based on the absence of *E. huxleyi* and the presence of *Pseudoemiliania lacunosa*. The assemblage in Sample 633A-3H, CC also belongs to Zone NN19, but small *Gephyrocapsa* spp. are the dominant fossil taxon. Thus the assemblage can be assigned to the small *Gephyrocapsa* Zone of Gartner (1977). In Sample 633A-4H, CC, *Gephyrocapsa caribbeanica* is again the most common species, but *Cyclococcolithina macintyrei* is also present. This assemblage can be assigned to the *C. macintyrei* Zone, which represents the oldest part of the NN19 Zone (Gartner, 1977).

The interval from Samples 633A-5H, CC and 633A-6H-4, 4 cm, contains *Discoaster brouweri, D. pentaradiatus, D. surculus, D. variabilis*, and *Sphenolithus abies*. Such an assemblage is characteristic of NN16, which correlates with the late early Pliocene. Sample 633A-5H, CC is the highest stratigraphic level in which reworked nannofossils from the (lower) Oligocene occur.

In Samples 633A-6H-5, 4 cm, and 633A-7H, a rather well-preserved assemblage is present with *Discoaster asymmetricus* and *Reticulofenestra pseudoumbilica*, indicating that this assemblage belongs to Zone NN14/15. No attempt has been made to subdivide these two zones. The last appearance of *Amaurolithus tricorniculatus*, which defines the boundary between NN14 and NN15, is often too rare to ascertain its true presence or absence reliably. The same assemblage, albeit poorly preserved, has been found in Core 633A-8H. There was no recovery from Cores 633A-9H and 633A-10X.

In Core 633A-11X, a poorly preserved assemblage is present with *Discoaster* sp. cf. *D. quinqueramus*. This assemblage has been tentatively assigned to Zone NN11, which correlates with the late Miocene.

Core 633A-12X is barren of nannofossils with the exception of a few reworked Oligocene nannofossils. Poorly preserved Zone NN11 assemblages occur in Cores 633A-13X and 633A-14X. In the core catchers of Cores 633A-16X and 633A-22X, moderately to well-preserved assemblages of NN11 have been observed. The presence of *Amaurolithus primus* and *Amaurolithus delicatus* makes possible the assignment of these assemblages to the CN9b Subzone of Okada and Bukry (1980), which correlates with the younger part of Zone NN11. The interval from Cores 633A-17X through 633A-21X has not yielded age-diagnostic assemblages.

Reworking from Oligocene strata occurs in all samples downsection from the upper Pliocene. The preservation of these Oligocene nannofossils is as good as the Neogene nannofossils, indicating that the Oligocene nannofossils were reworked and redeposited in a well-preserved state. Dissolution and overgrowth of these Oligocene nannofossils apparently took place after the reworking. It is evident that the erosion of the Oligocene sediments went on for a long time, possibly for the entire Neogene span.

### Planktonic Foraminifers

Cores 633A-1H (8.7 m) and 633A-2H (18.3 m) are of late Pleistocene age (*Globorotalia truncatulinoides* Zone, N23) based on the presence of *Globorotalia truncatulinoides* and pink specimens of *Globigerinoides ruber* as well as the absence of *Globorotalia tosaensis*. The benthic-foraminiferal fauna is composed of deep-water forms such as *Siphonina, Planulina wuellerstorfi*, and *Cibicidoides* with only rare specimens of shallow-water forms (*Lenticulina*). An early Pleistocene to early middle Pleistocene age (*Globorotalia truncatulinoides* Zone, N22) is assigned to Cores 633A-3H (28.0 m) and 633A-4H (37.6 m), based on the co-occurrence of *Globorotalia truncatulinoides* and *G. tosaensis*. Core 633A-3H (28.0 m) is composed largely of skeletal debris (bivalves, corals, bryozoans). Benthic foraminifers that characterize platform (*Amphistegina*), shallow-water (*Lenticulina, Nonionella*), and deep-water (*Planulina wuellerstorfi, Siphonina, Oridorsalis tener tener*) facies are present. Only rare specimens of deep-water benthic foraminifers (*Planulina wuellerstorfi*) are present in Core 633A-4H (37.6 m).

Cores 633A-5H (47.2 m) through 633A-14H (132.0 m) are contained within the early Pliocene *Globorotalia margaritae* Zone (N18/19 part), based on the presence of *G. margaritae*. Other species include *Globoquadrina altispira altispira, Globigerina nepenthes*, and *Globigerinoides conglobatus*. The benthic-foraminiferal fauna is dominated by deep-water forms such as *Laticarinina pauperata, Planulina wuellerstorfi, Cibicidoides mundulus*, and *Gyroidinoides neosoldanii* as well as a small number of shallow-water forms (*Hoeglundina, Cymbaloperatta*). Core 633A-7H (66.4 m) contains a benthic-foraminiferal fauna that is almost entirely composed of shallow-water forms (*Elphidium, Nonionella, Globulina, Cymbaloperatta*). The planktonic-foraminiferal fauna essentially lacks keeled globorotaliids and contains mainly globigerine forms such as *Globigerina falconensis, G. nepenthes, G. decoraperta, Globigerinoides extremus*, and *G. conglobatus*. Such foraminiferal faunas generally denote shallow-water paleoenvironments. The presence of rare *Uvigerina spinicostata* and *Pleurostomella* indicates that the aforementioned fauna is allochthonous and was transported into a deep-water environment.

Recognition of the Miocene/Pliocene boundary is hindered by generally poor preservation and poor core recovery through this interval. In addition, the sporadic occurrence of *Globorotalia margaritae* and forms bearing close morphologic resemblances, as well as the apparent early extinction of *Globoquadrina dehiscens* in this region, complicates boundary assignment. These datums have been used by various workers to indicate the Miocene/Pliocene boundary (Bolli, 1957, 1966, 1970; Bolli and Premoli-Silva, 1973; Stainforth et al., 1975; Berggren, 1977). As a result, the Miocene/Pliocene boundary is tentatively placed at the first appearance of *Globorotalia margaritae* (s.l.). The latest Miocene is characterized by *Globorotalia cibaoensis* and *G. juanai* without *G. margaritae* (s.l.). Further shore-based study is needed to document the biostratigraphic nature of the Miocene/Pliocene boundary in this region.

Cores 633A-15X (141.7 m) through 633A-23X (217.8 m) are contained within the late Miocene *Neogloboquadrina acostaensis* Zone (N16/17) based on the occurrence of *Globorotalia cibaoensis, G. juanai, G. plesiotumida, Globigerinoides extremus, G. conglobatus*, and *Sphaeroidinellopsis subdehiscens*. The benthic-foraminiferal fauna in this interval is dominated by deep-water forms (*Planulina wuellerstorfi, Cibicidoides mundulus, Pleurostomella)* with only a few shallow-water forms (*Lenticulina, Nonionella, Cymbaloperatta*).

### Larger Foraminifers

Redeposited specimens of the shallow-water-platform species *Amphistegina* sp. gr. *lessonii* occur in core-catcher samples from Cores 633A-2H and 633A-3H and from Cores 633A-1H-5, 633A-4H-3, and 633A-15X-3.

## SEDIMENT-ACCUMULATION RATES

A complete Quaternary section of calciturbidites and ooze in Hole 633A accumulated at an average rate of about 21 m/m.y. (Fig. 4). Similar rates are recorded for Pleistocene sections of Sites 631 and 632. A questionable hiatus of up to 1–2 m.y. may separate Pleistocene from lower Pliocene strata in Core 633A-5H. An accumulation rate of at least 58 m/m.y. characterizes a thick uppermost Miocene and lower Pliocene section in Cores 633A-24X to 633A-5H. Periplatform chalk, ooze, and turbidites in Cores 633A-24X to 633A-13X accumulated at a rate of about 82–140 m/m.y. This latter unit compares closely to the uppermost Miocene–lowermost Pliocene section of Site 632.

## INORGANIC GEOCHEMISTRY

### Interstitial Water

Hole 633A showed the highest depletions in $Ca^{2+}$, $Mg^{2+}$, pH, and $SO_4^{2-}$ encountered during Leg 101. These changes were coupled to a rise in alkalinity from a normal surface-seawater value of 2.4 meq/kg to 22.4 meq/kg at 149 m sub-bottom (see Figs. 5 and 6 and Table 3). The strong negative correlation between concentrations of $SO_4^{2-}$ and alkalinity suggests that $CO_2$, released from the decomposition of organic material, is responsible for raising alkalinity. At the same time, decreases in $Ca^{2+}$ and perhaps also $Mg^{2+}$ indicate precipitation of carbonates. Such precipitation should actually further decrease alkalinity, so in part the rise in alkalinity is masked. The coincidence of $SO_4^{2-}$ and $Mg^{2+}$ minima provokes speculation regarding the influence of $SO_4^{2-}$ on the process of dolomitization. However, while no direct correlation was observed between the interstitial concentrations of $Mg^{2+}$ and $SO_4^{2-}$ and the amount of dolomite in this hole, dolomite generally increases below 45 m sub-bottom coincident with decreases in sulfate and rises in alkalinity. In fact, the region of maximum change in $Ca^{2+}$, $Mg^{2+}$, $SO_4^{2-}$, pH, and alkalinity is also coincident with a decrease in the amount of aragonite. In the same general portion of the hole one particular sample contained up to 40% dolomite (see Table 4).

The final sample (from Hole 633A) from which waters were extracted for analyses corresponds with downhole contamination (see "Sedimentology" section, this chapter). This sample shows values typical of surface seawater (see Table 3 and Figs. 5 and 6).

The causes of the rises in alkalinity and the depletions in $SO_4^{2-}$ relate to the amounts of organic material buried and the rates at which this burial occurred. It is suggested that the sediments containing the alkalinity maximum were deposited extremely rapidly, perhaps in a large slump (see "Sedimentology," "Biostratigraphy," and "Seismic Stratigraphy" sections, this chapter). The organic material thus did not have an opportunity to become oxidized in an aerobic environment. However, it should be noted that even though there is significant generation of $H_2S$, interstitial $SO_4^{2-}$ concentrations are not completely deleted and still remain relatively high, above 18 mmol/L. This value can be compared with some DSDP sites (see Gieskes, 1981) in which $SO_4^{2-}$ decreases to background levels. The failure to observe a complete removal of $SO_4^{2-}$ may relate to (1) diffusion of sulfate into the sediments either from seawater or from below, or (2) low levels of remaining organic materials.

### X-Ray Studies

Percentages of aragonite and calcite in Hole 633A show wide variations and do not appear to exhibit consistent downhole trends such as those observed in Hole 632A. However, three minima in aragonite concentration were observed. The first two of these occur in the Pleistocene at 10 and 40 m sub-bottom, respectively (see Fig. 7). Below this level, aragonite maintains a relatively constant concentration of between 50% and 70% with the exception of an interval between 140 and 160 m sub-bottom in which aragonite percentages fall at the expense of increases in calcite and dolomite (see Fig. 7 and Table 4). This interval also shows the maximum changes in the geochemistry of interstitial water (see discussion of interstitial water).

Quartz is absent from Hole 633A apart from small percentages in the upper 20 m.

### Carbonate-Bomb Data

The percentage of carbonate was lower at Site 633 than at the other two Exuma Sound sites, particularly over the first 60 m sub-bottom (see Table 5 and Fig. 8).

### Summary of Exuma Sound Sites 631, 632, and 633

#### *Interstitial Waters*

Interstitial waters from the three Exuma Sound sites showed a radically different pattern in $Ca^{2+}$, $Mg^{2+}$, $SO_4^{2-}$, and alkalinity compared to those from Sites 627, 628, and 630.

A summary of the trends in $Ca^{2+}$ with increasing depth between Little Bahama Bank and Exuma Sound are shown in Figures 9 and 10. The difference between the two localities can be seen immediately in that the Exuma Sound sites exhibit either small positive downhole $Ca^{2+}$ gradients or none at all. In fact, at Sites 631, 632, and 633, $Ca^{2+}$ concentrations actually fall below surface-seawater concentrations, changes caused by the precipitation of carbonate minerals. In Holes 632A and 633A, there are small increases in $Ca^{2+}$ in the deepest samples taken. The causes for these increases are presently unknown, but it is probable that Exuma Sound lacks the extensive sequence of Cretaceous terrigenous sediments at sub-bottom depths similar to Little Bahama Bank. However, it should be noted that rates of sedimentation were considerably reduced at Sites 627, 628, and 630. In fact, the oldest strata penetrated in Exuma

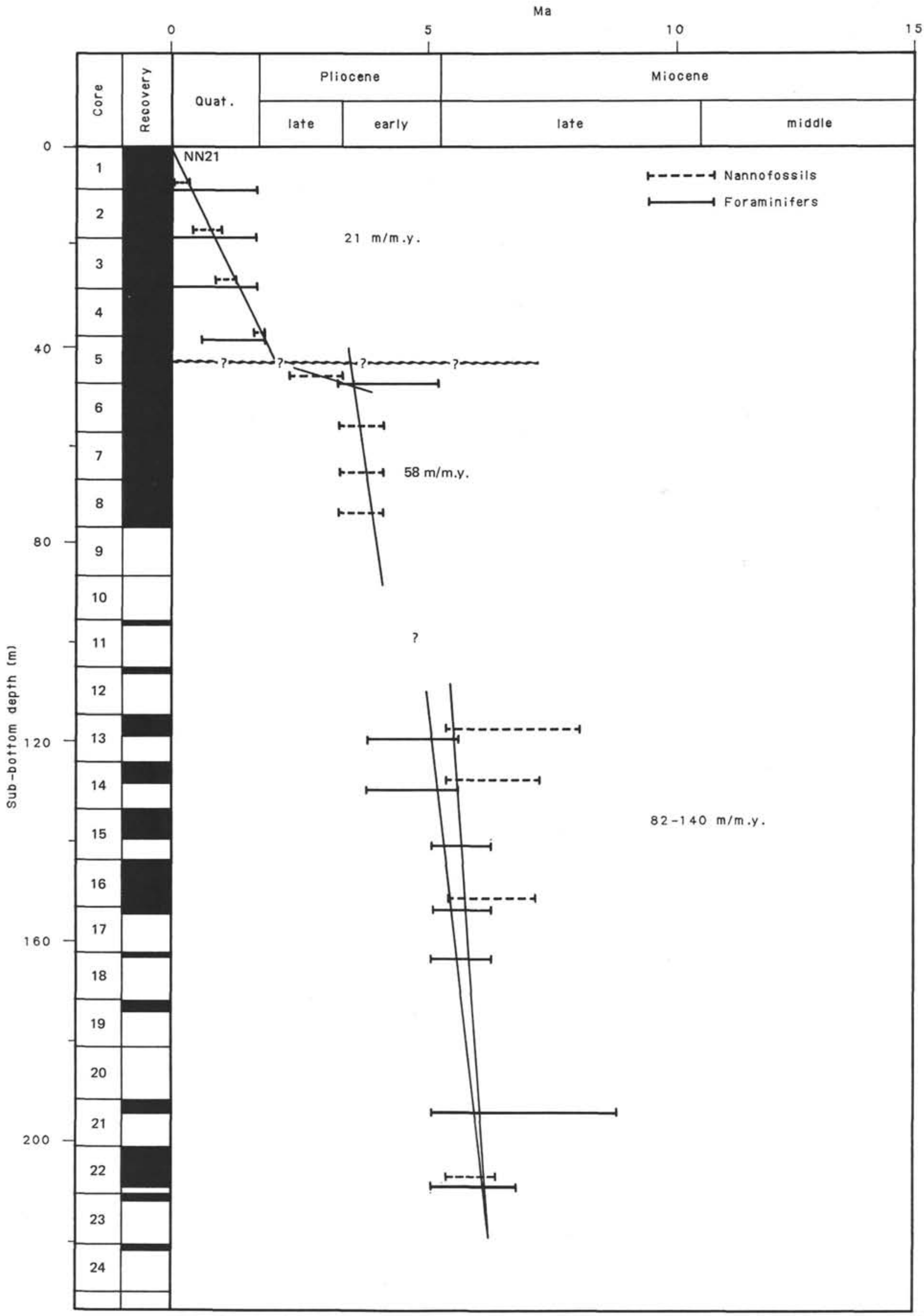


Figure 4. Sediment-accumulation rates, Site 633.

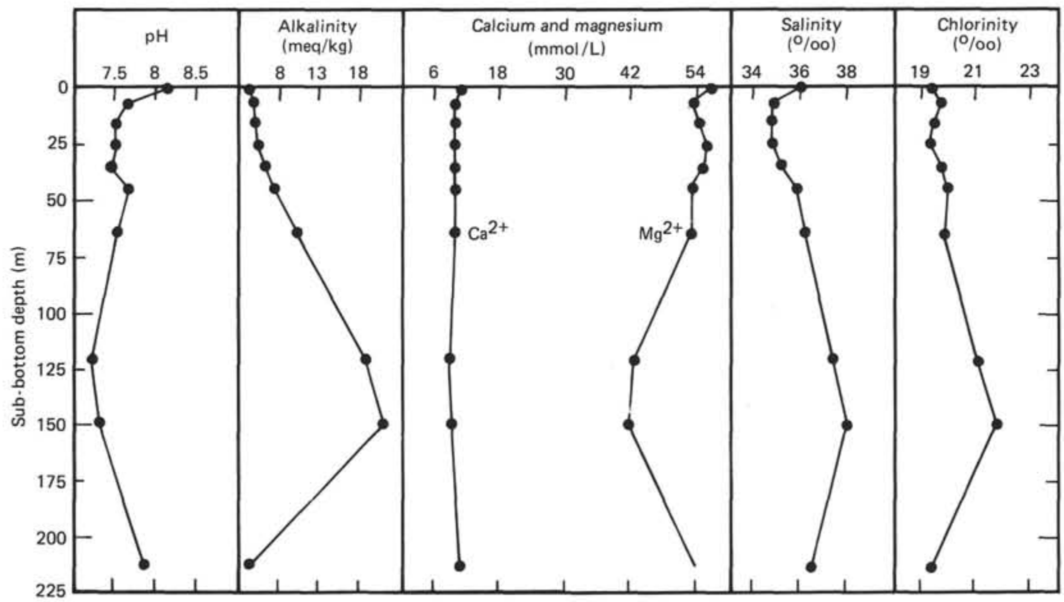


Figure 5. Summary of interstitial-water analyses, Hole 633A.

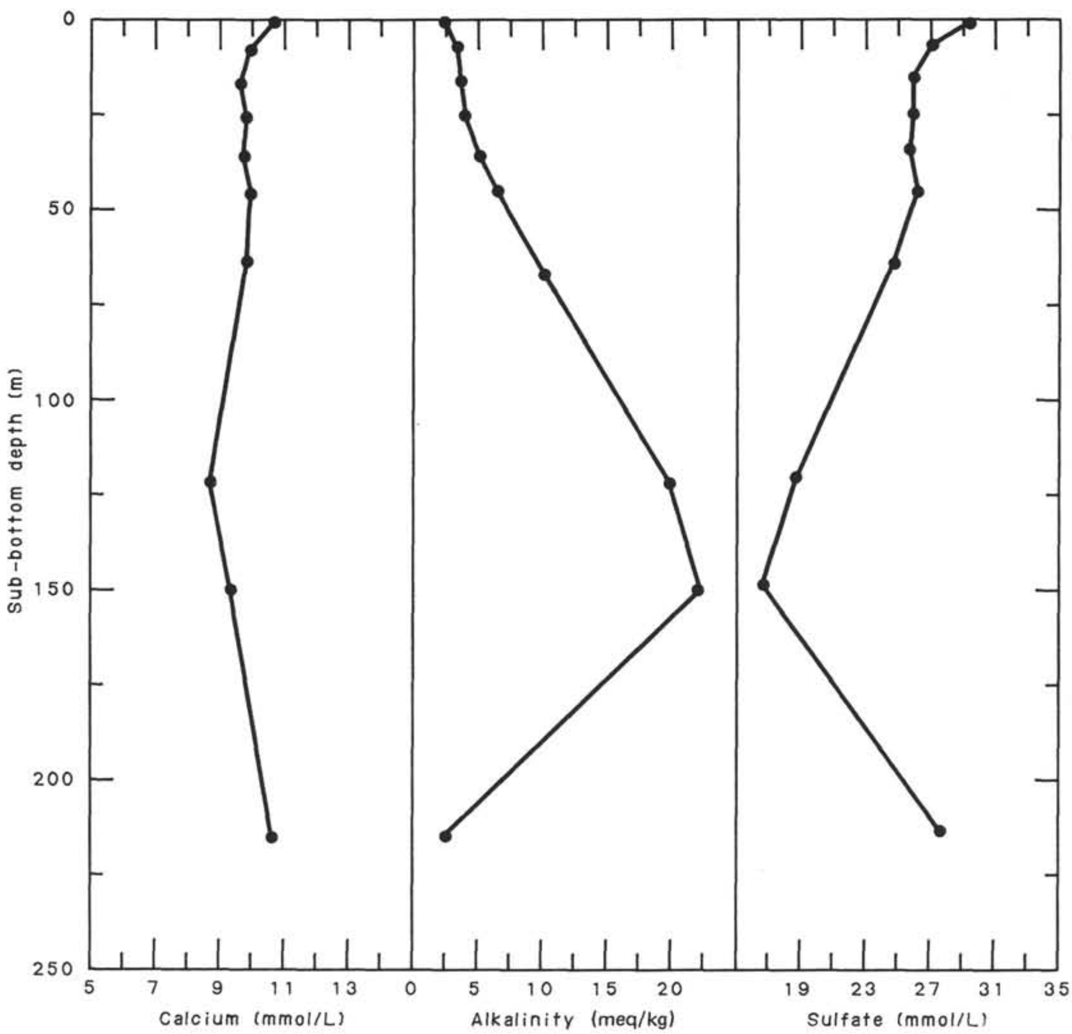


Figure 6. Interstitial-water calcium, alkalinity, and sulfate concentrations, Hole 633A.

Table 3. Analyses of interstitial waters from Hole 633A.

| Sub-bottom depth (m) | pH | Alkalinity (meq/kg) | Salinity (‰) | Chlorinity (‰) | Ca (mmol/L) | Mg (mmol/L) | $SO_4$ (mmol/L) |
|---|---|---|---|---|---|---|---|
| Surface seawater | 8.14 | 2.43 | 36.0 | 19.36 | 10.43 | 56.73 | 28.88 |
| 7.4 | 7.63 | 3.45 | 34.8 | 19.74 | 9.92 | 53.15 | 26.88 |
| 16.1 | 7.51 | 3.68 | 34.8 | 19.44 | 9.65 | 54.30 | 25.62 |
| 25.7 | 7.52 | 4.05 | 34.8 | 19.27 | 9.84 | 55.87 | 25.69 |
| 35.4 | 7.45 | 5.16 | 35.2 | 19.74 | 9.73 | 55.16 | 25.35 |
| 45.0 | 7.67 | 6.51 | 35.8 | 19.98 | 9.99 | 53.02 | 26.05 |
| 64.3 | 7.52 | 9.76 | 36.2 | 19.81 | 9.82 | 52.96 | 24.83 |
| 120.1 | 7.21 | 19.78 | 37.4 | 21.06 | 8.72 | 42.31 | 18.71 |
| 149.1 | 7.31 | 22.44 | 38.0 | 21.80 | 9.39 | 41.42 | 16.85 |
| 212.9 | 7.86 | 2.53 | 36.4 | 19.36 | 10.66 | 53.88 | 27.65 |

Table 4. X-ray analyses of samples from Hole 633A.

| Sub-bottom depth (m) | Calcite (%) | Aragonite (%) | Dolomite (%) | Quartz (%) | Comments |
|---|---|---|---|---|---|
| 2.2 | 25 | 72 | 3 | 0 | High-Mg calcite, 38%; low-Mg calcite, 62%; illite-montmorillonite present |
| 4.2 | 38 | 57 | 3 | 2 | Illite-montmorillonite present |
| 7.4 | 59 | 41 | 0 | 0 | |
| 8.2 | 61 | 39 | 0 | 0 | Illite-montmorillonite present |
| 10.9 | 85 | 13 | 0 | 1 | Illite-montmorillonite present |
| 16.1 | 74 | 26 | 0 | 0 | |
| 20.5 | 70 | 23 | 3 | 3 | |
| 23.5 | 55 | 43 | 2 | 0 | |
| 25.7 | 47 | 53 | 0 | 0 | |
| 26.5 | 26 | 72 | 2 | 0 | Illite-montmorillonite and palygorskite(?) present |
| 28.0 | 57 | 43 | 0 | 0 | Illite-montmorillonite present |
| 33.2 | 42 | 58 | 0 | 0 | Illite-montmorillonite present |
| 36.1 | 64 | 36 | 0 | 0 | |
| 39.8 | 98 | 2 | 0 | 0 | Palygorskite(?) present |
| 45.0 | 86 | 14 | 0 | 0 | |
| 45.8 | 48 | 38 | 14 | 0 | Illite-montmorillonite present |
| 49.4 | 42 | 54 | 4 | 0 | Illite-montmorillonite present |
| 55.4 | 11 | 70 | 19 | 0 | |
| 59.1 | 28 | 70 | 2 | 0 | Illite-montmorillonite present |
| 64.3 | 6 | 75 | 19 | 0 | Illite-montmorillonite present |
| 68.6 | 15 | 75 | 10 | 0 | Illite-montmorillonite present |
| 93.2 | 35 | 53 | 12 | 0 | |
| 120.1 | 41 | 49 | 10 | 0 | |
| 123.9 | 33 | 57 | 10 | 0 | Illite-montmorillonite present |
| 124.5 | 26 | 64 | 10 | 0 | Illite-montmorillonite present |
| 135.4 | 28 | 62 | 10 | 0 | Illite-montmorillonite present |
| 143.9 | 69 | 15 | 16 | 0 | Palygorskite(?) present |
| 149.1 | 66 | 30 | 4 | 0 | |
| 151.5 | 51 | 47 | 3 | 0 | Illite-montmorillonite present |
| 160.3 | 43 | 20 | 40 | 0 | |
| 169.7 | 19 | 71 | 10 | 0 | Illite-montmorillonite present |
| 190.7 | 31 | 58 | 11 | 0 | Illite-montmorillonite present |
| 212.6 | 37 | 58 | 5 | 0 | |
| 217.8 | 37 | 58 | 5 | 0 | Illite-montmorillonite present |

Sound were of late Oligocene age (Site 631). This sediment contained an interstitial $Ca^{2+}$ concentration of 15.3 mmol/L comparable to material of similar age from Site 628. Therefore, the possibility exists that a unit similar to the Cenomanian marls underlies Exuma Sound and is responsible for the slight change in $Ca^{2+}$. If this scenario is correct, then an extrapolation of the $Ca^{2+}$ to the concentrations determined at Site 627 would project that these marls should be present at 725 m sub-bottom at Site 631.

Differences in the sulfate concentrations and alkalinity at Sites 631, 632, and 633 relate to the burial of organic material and sulfate reduction. Unfortunately, the parts of these holes that exhibited maximum changes in geochemistry also exhibited poor biostratigraphic control (see "Sedimentology" section, this chapter), and therefore deposition rates are uncertain. However, the fact that the stratigraphy is uncertain may indicate rapid rates of sedimentation and burial of fresh organic material.

### X-Ray Studies

A major feature of the Exuma Sound transect (Sites 631, 632, and 633) was the persistence of aragonite throughout all holes (see Fig. 11). However, a comparison with Sites 627, 628, and 630 (Little Bahama Bank transect) reveals that aragonite persisted into strata of similar age at both localities. Nevertheless, the occurrence of aragonite at depths up to 250 m sub-bottom is a startling observation, considering its rapid disappearance in open-ocean sediments.

Other major differences between Little Bahama Bank and Exuma Sound relate to the presence of detrital minerals such as feldspar and quartz. These are largely absent at Sites 631, 632,

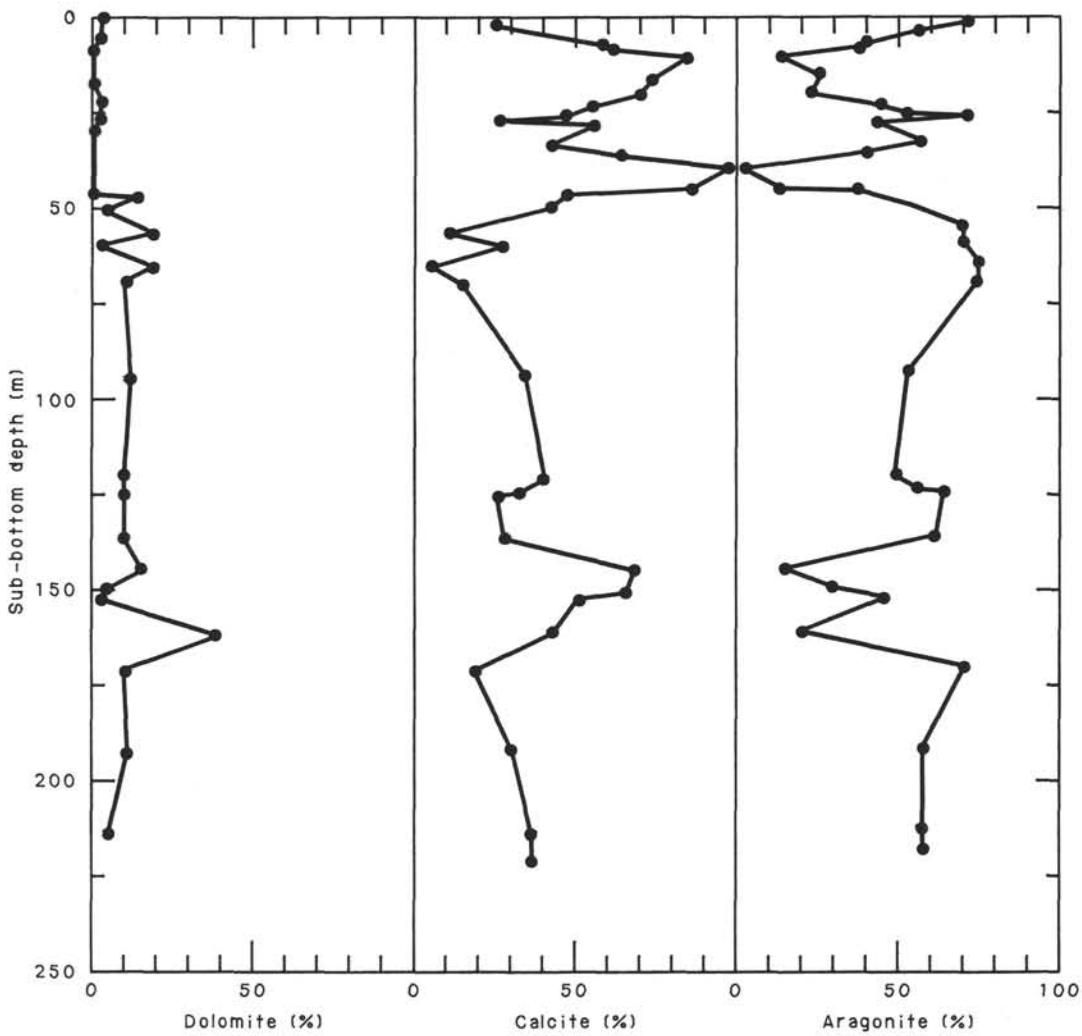


Figure 7. Percentages of dolomite, calcite, and aragonite content, Hole 633A.

**Table 5. Carbonate-bomb data, Site 633.**

| Sub-bottom depth (m) | $CaCO_3$ content (%) |
|---|---|
| 8.2 | 85 |
| 13.9 | 73 |
| 23.5 | 85 |
| 36.2 | 85 |
| 45.8 | 87 |
| 55.9 | 90 |
| 59.1 | 90 |
| 68.6 | 88 |
| 93.7 | 92 |
| 113.4 | 88 |
| 124.6 | 92 |
| 133.9 | 92 |
| 146.7 | 91 |
| 151.5 | 96 |
| 160.3 | 96 |
| 169.9 | 93 |
| 190.7 | 95 |
| 208.5 | 96 |

and 633, consistent with the more protected setting of Exuma Sound.

## ORGANIC GEOCHEMISTRY

Twenty-two samples were taken from Hole 633A for analysis using the Rock-Eval technique (see Figs. 12 through 18), and 14 samples were taken from unsplit cores for gas analysis. The lithology consisted of periplatform oozes, chalk, and limestone with turbidites (late Miocene to Holocene).

The organic material consists mainly of small amounts of detrital, oxidized, terrestrial organic matter with a kerogen content ($S_2$) below 0.5 (see Fig. 12). $T_{max}$ values of these samples indicate a mixture of material of differing maturities (see Fig. 14). However, in several of the samples, $S_2$ values were above 0.5, and some of the $T_{max}$ values were near 430°C, as in Holes 631A and 632A. The content of extractable material ($S_1$, see Fig. 15) varied as the $S_2$ content.

Graphs for total methane, ethane, and carbon dioxide content are shown in Figures 16 through 18. The antipathetic variation of the methane to carbon dioxide content was not observed in Hole 633A. Ethane concentrations were almost 20 times less than methane but generally showed a similar trend.

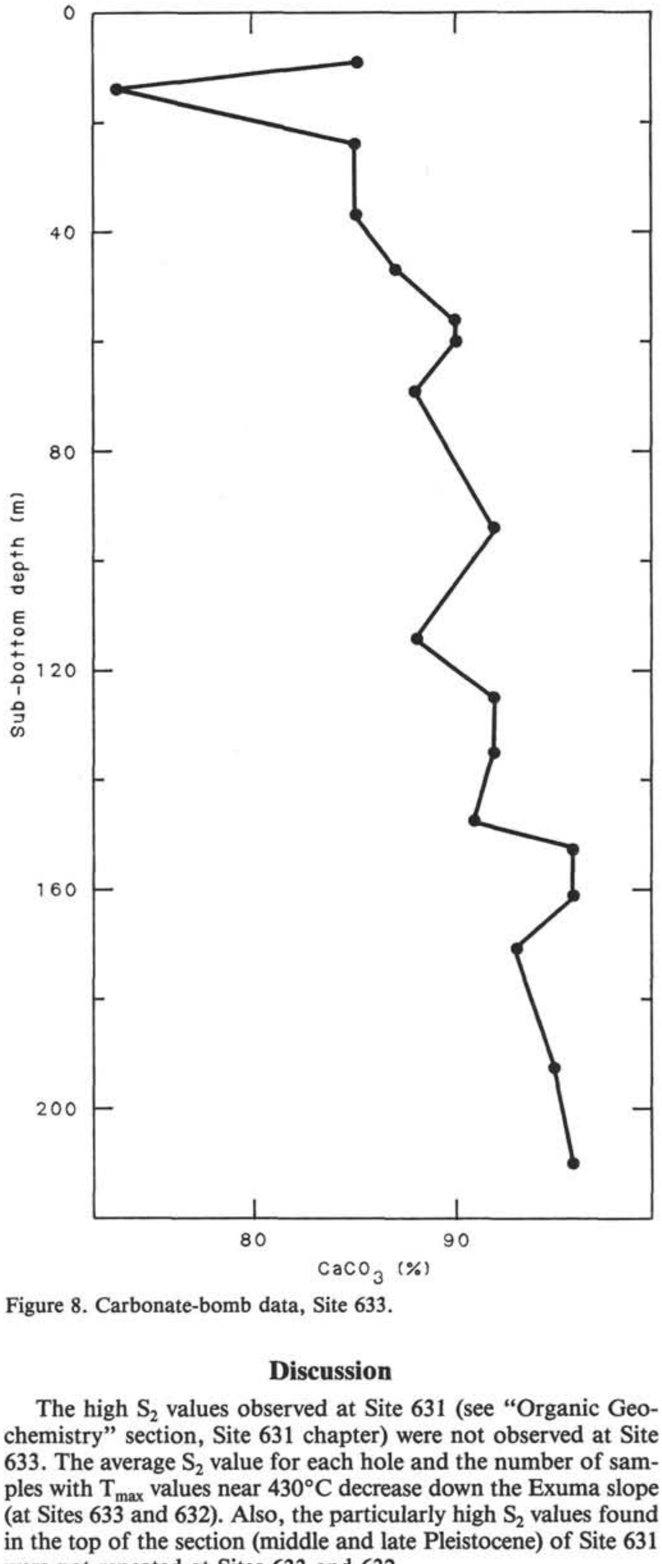


Figure 8. Carbonate-bomb data, Site 633.

### Discussion

The high $S_2$ values observed at Site 631 (see "Organic Geochemistry" section, Site 631 chapter) were not observed at Site 633. The average $S_2$ value for each hole and the number of samples with $T_{max}$ values near 430°C decrease down the Exuma slope (at Sites 633 and 632). Also, the particularly high $S_2$ values found in the top of the section (middle and late Pleistocene) of Site 631 were not repeated at Sites 633 and 632.

The high sedimentation rates at Site 631 would explain its relatively high $S_2$ content compared to the other Exuma Sound sites (Sites 633 and 632). However, the similarities observed in Quaternary deposits at the three sites would not explain the great increase in $S_2$ content at Site 631 during the middle to late Pleistocene. Therefore, it is possible that this site was more favorably located within a mid-water oxygen minimum during the late Quaternary than were the other two sites.

## PALEOMAGNETISM

### Natural Remanent Magnetization

Twenty oriented paleomagnetic samples were removed from Cores 633A-1H through 633A-4H in order to assess the magnetic-field recording capability of the carbonate sediments in Hole 633A prior to further shore-based study. Samples below Section 4 of Core 633A-2H (approximately 13.2 m sub-bottom) were too weakly magnetized to be measured with the shipboard Molspin spinner magnetometer. Shallower samples, however, were much more strongly magnetized. The maximum recorded magnetization from these samples was $4.4 \times 10^{-5}$ emu.

Cores 633A-1H and 633A-2H have been dated as Pleistocene in age (see "Biostratigraphy" section, this chapter). All of the samples taken from Core 663A-1H and those from the top of Core 633A-2H are normally magnetized, probably having been magnetized during the Brunhes polarity epoch. Between Samples 633A-2H-3, 55 cm, and 633A-2H-4, 55 cm, the magnetizations become reversed. This reversal is tentatively identified as the Matsuyama-Brunhes polarity boundary that occurred 0.73 Ma (Chron 1r, Harland et al., 1982). As this reversal is approximately 12.5 m downhole, it implies a sedimentation rate of about 16.8 m/m.y., agreeing reasonably well with the sedimentation rate estimated from biostratigraphy (see "Biostratigraphy" section, this chapter).

Eleven of the most strongly magnetized samples give a mean inclination of 46.2° with a standard deviation of 17.0°. This nearly matches the expected present-day geocentric axial dipole inclination for Site 633 of 41.1°.

### Magnetic Susceptibility

Before being split for sampling, each core section recovered from Hole 633A was measured every 10 cm downhole for magnetic susceptibility. In all, 962 readings were generated. In Figure 19A, the susceptibility values are plotted versus depth. Above 73 m sub-bottom (the bottom of Core 633A-8H), few gaps appear in the susceptibility-depth record. Farther downhole, however, recovery was intermittent, and the record is less complete.

In Cores 633A-1H and 633A-2H, just below the seafloor, the susceptibility is high for sediments dominated by calcium carbonate. The average for each section of these cores ranged from $0.8 \times 10^{-6}$ G/Oe to $2.4 \times 10^{-6}$ G/Oe. High susceptibility values recorded near the seafloor have also been noted in Holes 627B, 631A, and 632A. Similar susceptibility-depth profiles have been observed in anoxic sedimentary environments of the northeast Pacific and the Gulf of California (Karlin, 1983; Karlin and Levi, 1983). This behavior is attributed to a diagenetic dissolution of magnetite grains with a subsequent transferral of the iron into authigenic, nonmagnetic iron sulfides. The most notable aspect of the susceptibility decrease with depth in Hole 633A (as well as in Holes 627B and 632A) is that it occurs over a much larger depth range of the sediment column. In other studies, the reduction in the susceptibility and magnetization typically occurs within the upper meter of the sediments, whereas in the Bahamas it appears over a 10–20-m depth.

With the exception of a few large-amplitude spikes probably caused by metallic contamination from the drill string, most of the rest of the hole is characterized by susceptibility values near $-0.1 \times 10^{-6}$ G/Oe. Figure 19B shows the susceptibility in the upper 50 m of Hole 633A in greater detail. Although many of the peaks may be only noise, other variations appear roughly cyclical in nature. In the upper 20 m of the hole, a broad variation with an amplitude of about $3 \times 10^{-6}$ G/Oe and a wavelength of about 10-15 m is seen, peaking at 10 m sub-bottom. Superimposed on top of this long-wavelength variation are fluctuations of lesser amplitude and shorter wavelength. In the 25–50-m sub-bottom interval of the hole (Fig. 19B), these short-

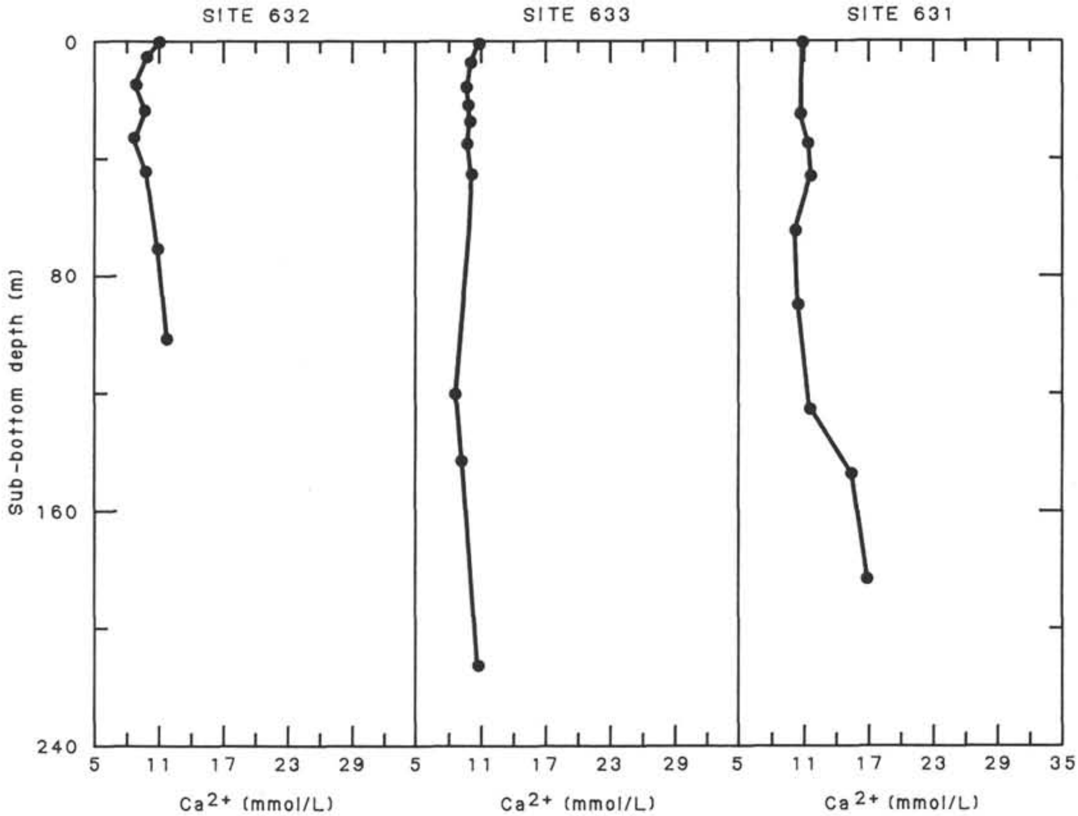


Figure 9. Summary of $Ca^{2+}$ concentrations in interstitial water from Exuma Sound, Sites 631, 632, and 633. Sites are arranged in order of decreasing water depth, from left to right.

wavelength features are seen more clearly. Apparently, they have an amplitude of approximately $0.5 \times 10^{-6}$ to $0.8 \times 10^{-6}$ G/Oe and a wavelength of about 1 m. At the sedimentation rate estimated from biostratigraphic determinations for the upper 45 m of the hole, about 20 m/m.y., the longer wavelength feature suggests a change occurring over a period on the order of 0.5 m.y., whereas the shorter wavelength fluctuations indicate a period of about 0.05 m.y. In future studies, sedimentation-rate corrections will be made to the susceptibility-depth record, and the wavelengths will be determined more rigorously by calculating spectra.

## PHYSICAL PROPERTIES

Physical-property measurements were made on sediment recovered from Site 633 (see Table 6) as described in the chapter entitled "Introduction and Explanatory Notes." The quality (in terms of physical-property measurements) of recovered sediment was good from the top of the hole to 70 m sub-bottom, relatively good between 120 and 150 m sub-bottom, and very poor below 150 m sub-bottom.

### Compressional Wave Velocity

Compressional wave velocity measured on sediment in the core liner averages 1700 m/s (Fig. 20) between 25 and 70 m sub-bottom and shows little variation. Between 130 and 180 m sub-bottom the average velocity increases slowly from 1700 to 1886 m/s. The highest values, greater than 3000 m/s, were measured in intervals of sparse recovery where softer sediment was lost in the drilling process and not available for analysis.

Compressional wave velocity measured on samples removed from the core liner shows clearly the increase in velocity from 1480 to 1780 m/s with increasing depth from 0 to 60 m sub-bottom. Below this depth, velocity values are high, varying between 2200 and 4500 m/s, but these are only representative of the (rather small) indurated portion of the sedimentary column.

### Wet-Bulk Density, Porosity, and Water Content

In general, density values increase regularly with increasing depth from 1.67 g/cm$^3$ at 2.2 m sub-bottom to 2.06 g/cm$^3$ at 217 m sub-bottom (Fig. 20). Porosity values decrease with increasing depth from 65% at 2.2 m sub-bottom to 40% at 217 m sub-bottom, and water content decreases with increasing depth from 60% at 2.2 m sub-bottom to 22% at 217 m sub-bottom. The decrease in water content and porosity correlates with the increase in density.

However, as a result of the poor core recovery, major gaps exist in the data column, and continuous values were collected only in two zones: (1) Z1, between 2.2 and 68 m sub-bottom, is characterized by an increase in density with depth from 1.67 to 1.8 g/cm$^3$, a decrease in porosity from 65% to 54%, and a decrease in water content from 60% to 50%; (2) Z2, between 120 and 150 m sub-bottom, is characterized by constant average values of density, porosity, and water content—density, 1.9 g/cm$^3$; porosity, 55%; and water content, 40%. Zone Z1 corresponds to ooze and chalk with thin turbidites. Zone Z2 corresponds to alternating chalk and ooze.

Below 150 m sub-bottom, only three measurements seem to be compatible with the general trend for each property. However, these measurements suggest a downhole increase in density from 1.87 to 2.06 g/cm$^3$, a decrease in porosity from 49% to 40%, and a decrease in water content from 34% to 22%.

At 180 m sub-bottom, one sample, 633A-9H-1, 12 cm, may be representative for this part of the column. It is a highly fria-

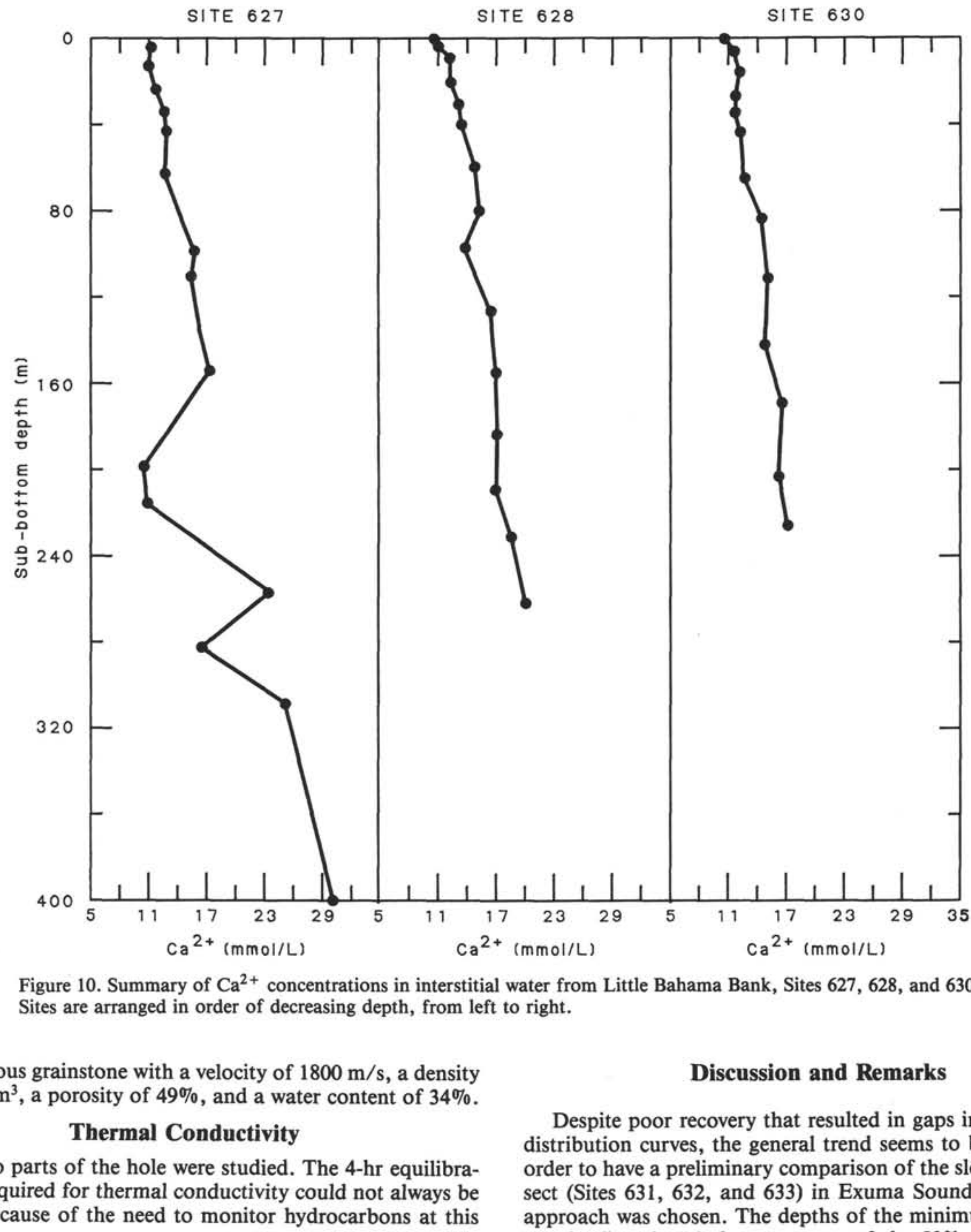


Figure 10. Summary of $Ca^{2+}$ concentrations in interstitial water from Little Bahama Bank, Sites 627, 628, and 630. Sites are arranged in order of decreasing depth, from left to right.

ble, calcareous grainstone with a velocity of 1800 m/s, a density of 1.87 g/cm$^3$, a porosity of 49%, and a water content of 34%.

### Thermal Conductivity

Only two parts of the hole were studied. The 4-hr equilibration time required for thermal conductivity could not always be provided because of the need to monitor hydrocarbons at this location.

In general, conductivity increases with increasing depth from $2 \times 10^{-3}$ cal $\times$ °C$^{-1}$ $\times$ cm$^{-1}$ $\times$ s$^{-1}$ at 2.2 m sub-bottom to $2.8 \times 10^{-3}$ cal $\times$ °C$^{-1}$ $\times$ cm$^{-1}$ $\times$ s$^{-1}$ at 140 m sub-bottom.

In detail, there is a sharp gradient from $2 \times 10^{-3}$ cal $\times$ °C$^{-1}$ $\times$ cm$^{-1}$ $\times$ s$^{-1}$ at 2.2 m sub-bottom to $2.6 \times 10^{-3}$ cal $\times$ °C$^{-1}$ $\times$ cm$^{-1}$ $\times$ s$^{-1}$ at 20 m sub-bottom. Below this depth, the conductivity displays an average value of $2.6 \times 10^{-3}$ cal $\times$ °C$^{-1}$ $\times$ cm$^{-1}$ $\times$ s$^{-1}$. Between 130 and 140 m sub-bottom, we note an average value of $2.8 \times 10^{-3}$ cal $\times$ °C$^{-1}$ $\times$ cm$^{-1}$ $\times$ s$^{-1}$.

### Shear Strength

Shear strength displays no strong changes, and values are between 5 and 10 kPa. Values seem to decrease with depth between 2.2 m sub-bottom and 62 m sub-bottom from 4 to 1 kPa.

### Discussion and Remarks

Despite poor recovery that resulted in gaps in the downhole distribution curves, the general trend seems to be recorded. In order to have a preliminary comparison of the slope/basin transect (Sites 631, 632, and 633) in Exuma Sound, the following approach was chosen. The depths of the minimum density value, the first downhole occurrence of the 50% porosity value, and the 30% water-content value of representative samples are plotted for each site of the transect (Fig. 21). Generally, these values occur at lower depth toward the basin than higher on the slopes. This may indicate that the degree of diagenetic alteration increases basinward.

## SEISMIC STRATIGRAPHY

### Introduction

Site 633 (BAH-11-B) was located at the intersection of UTIG site survey line ES-07 and LDGO large-volume air-gun multichannel seismic profile 361 (Fig. 1, Site 631 chapter). This site served as the middle of the Exuma Sound slope transect (see "Background and Objectives" section, Site 631 chapter). It was

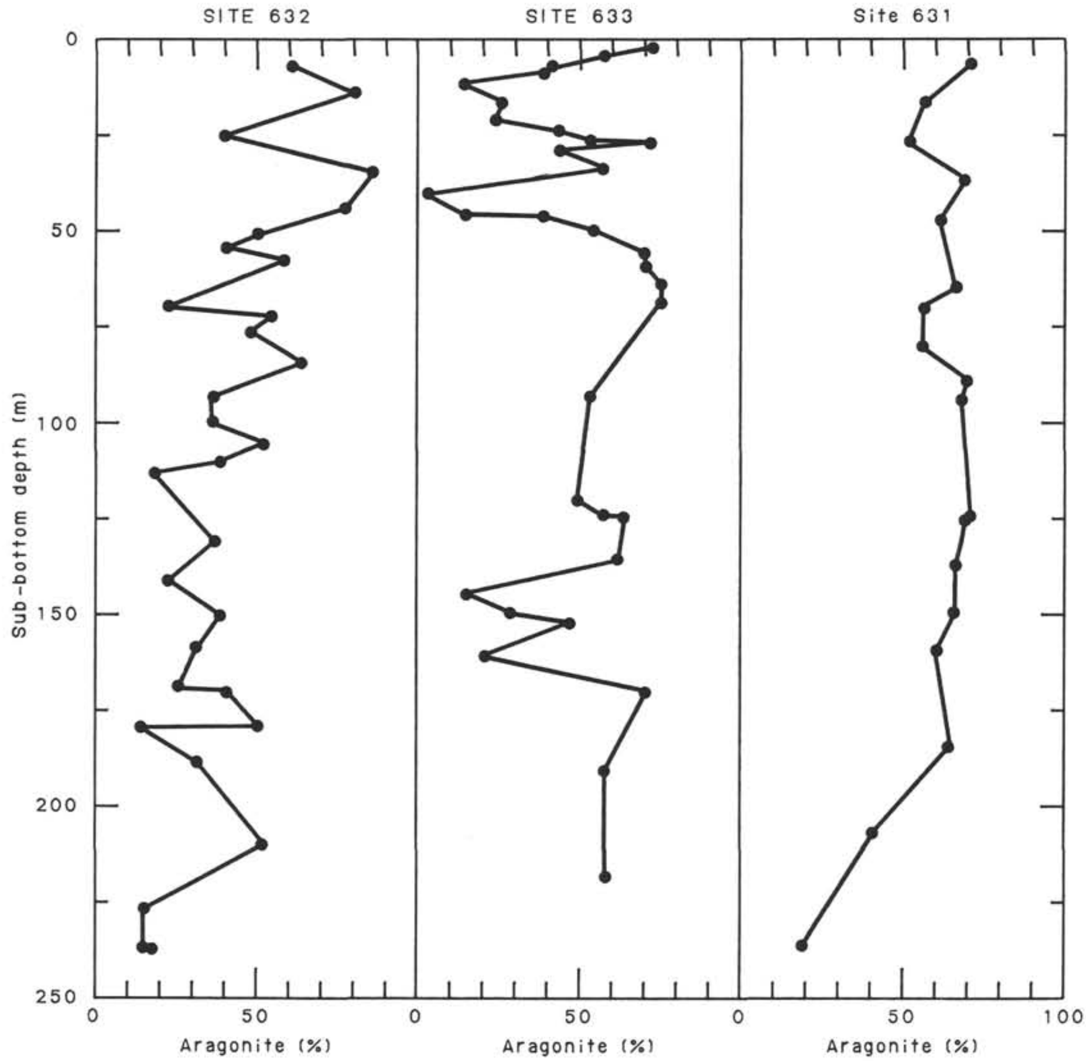


Figure 11. Summary of x-ray data from Exuma Sound, Sites 631, 632, and 633.

designed to sample the sedimentary regime at the toe of a bypass slope.

## Acoustic Correlations

Hole 633A sampled to 227.3 m sub-bottom. Three lithologic units were identified, all composed of periplatform ooze, chalk, and limestone with varying amounts of turbidites. Line ES-07 in the vicinity of this hole can be interpreted to support the presence of these lithologies (Fig. 22). First, intervals of parallel, high-amplitude reflectors are compatible with intercalations of unlithified to lithified periplatform ooze. Second, hummocky clinoforms, which suggest the existence of prodelta lobes/slumps (Mitchum et al., 1977) perhaps associated with the sampled turbidites, can be mapped at three different depth ranges (assuming a conversion velocity of 1.78 km/s for Hole 633A developed on the basis of Hamilton Frame measurements): (1) seafloor (1680 m), 0.085 s, or 0–76 m sub-bottom; (2) 0.11–0.145 s, or 98–129 m sub-bottom; and (3) 0.167–0.255 s, or 149–227 m sub-bottom.

From ES-07 (Fig. 22) and the lithologic and biostratigraphic results of Hole 633A (see "Sedimentology" and "Biostratigraphy" sections, this chapter), the following preliminary conclusions can be drawn:

1. The interpreted slumps are not evenly distributed at the toe-of-slope of Exuma Sound, either horizontally or vertically.
2. As at Site 631 farther upslope, the seismic facies probably represent gravitational creep of periplatform (interfluve) sediments.

Other emplacement mechanisms cannot be ruled out, but they must explain both generally high accumulation rates and uninterrupted deposition (see "Sediment-Accumulation Rates" section, this chapter). Evidence for tranquil depositional conditions includes the upper 52 m of Hole 633A, which is almost entirely pelagic (Fig. 22; see also "Sedimentology" section, this chapter), and the fact that the turbidite component is consistently minor. (Most turbidites still must be bypassing this location on their way basinward.) In contrast, episodic deposition is favored both by the potential for repeated sections in Hole 633A, especially below the upper pelagic section where accumulation rates go from 21 m/m.y. to more than 58 m/m.y. (see "Sediment-Accumulation Rate" section, this chapter), and by the presence of hummocky clinoforms (e.g., those labeled *2*, Fig. 22).

Only one of the regionally mapped acoustic horizons could be identified in Hole 633A (see "Seismic Stratigraphy" section, Site 632 chapter). The "O" sequence boundary of J. Ladd and

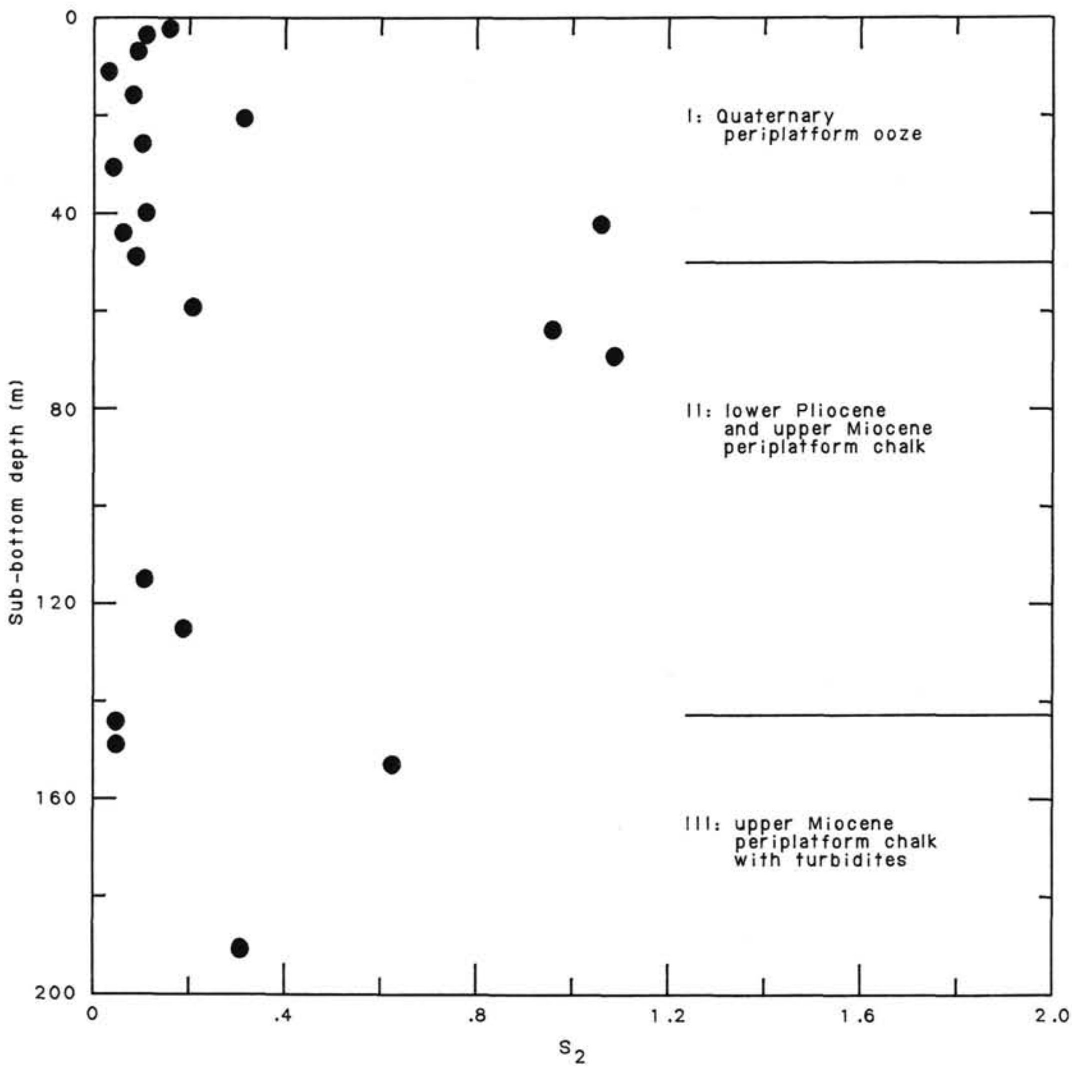


Figure 12. Downhole variation in bitumen content ($S_2$), Hole 633A, showing several samples with values of about 0.5.

R. Sheridan (unpubl. data) occurs at 149 m sub-bottom on ES-07 at Site 633 (Fig. 22). As in Hole 632A, "O" correlates in depth with the lithologic boundary at 152 m sub-bottom that separates upper Miocene wackestones-packstones with grainstone turbidites (Unit III, see "Sedimentology" section, this chapter) from uppermost Miocene–lowermost Pliocene periplatform chalk with thin turbidites (Unit II, see "Sedimentology" section, this chapter). In both Holes 632A and 633A, "O" also corresponds with an upward decrease in off-bank accumulation rates tentatively associated with the deepening of the adjacent platform (see "Summary and Conclusions" section, Site 632 chapter). The coeval 10/9 boundary beneath the Straits of Florida also correlates with a decrease in accumulation rates, implying that a productivity "crisis," perhaps associated with rising sea level, affected the entire Bahamian carbonate province in the late Miocene (ca. 6.6–5 Ma; "Summary and Conclusions" section, Site 632 chapter).

## SUMMARY AND CONCLUSIONS

Site 633 is in the center of the three-site slope transect of Exuma Sound. The present setting of the site is at the basin-margin rise, 8 km seaward of the base of the gullied slope drilled at Site 631 and 22 km bankward of Site 632, which is close to the central axis of the basin. Hole 633A, the only hole drilled at the site, penetrated 227 m of sediment with the HPC/XCB technique. The following succession of lithostratigraphic units was encountered ("Sedimentology" and "Biostratigraphy" sections, this chapter, and Fig. 23): (1) Unit I, periplatform ooze with cyclic variations in color (and organic content?) and 1- to 5-cm-thick turbidites, late Pliocene to Holocene, 52 m; (2) Unit II, soupy periplatform ooze with limestone clasts, intervals of stiff ooze-chalk, few turbidites, late Miocene(?) to Pliocene, 99 m; and (3) Unit III, periplatform chalk and limestone with turbidites (lime grainstone and packstone), late Miocene, 76 m.

Units I and III of this sequence display the rhythmic alternation of periplatform ooze and turbidites that characterizes the modern basin floors of the Bahamas (Schlager and Chermak, 1979; Mullins et al., 1984). Considering their rather proximal position, turbidites in Unit I are unusually thin and fine grained. This may be a result of the location of the site on a topographic high that rises 20 to 40 m above the surrounding seafloor ("Seismic Stratigraphy" section, this chapter). This high seems to have formed during deposition of Unit II. It did not exist during Unit III time, as indicated by the flatness of reflector "O" at the top of Unit III and by the similarity in age and facies of Unit III at both Sites 632 and 633. The high may have formed either by progradation of a spur of the gullied slope or by slumping. Sediment facies, seismics, and biostratigraphy are compatible with

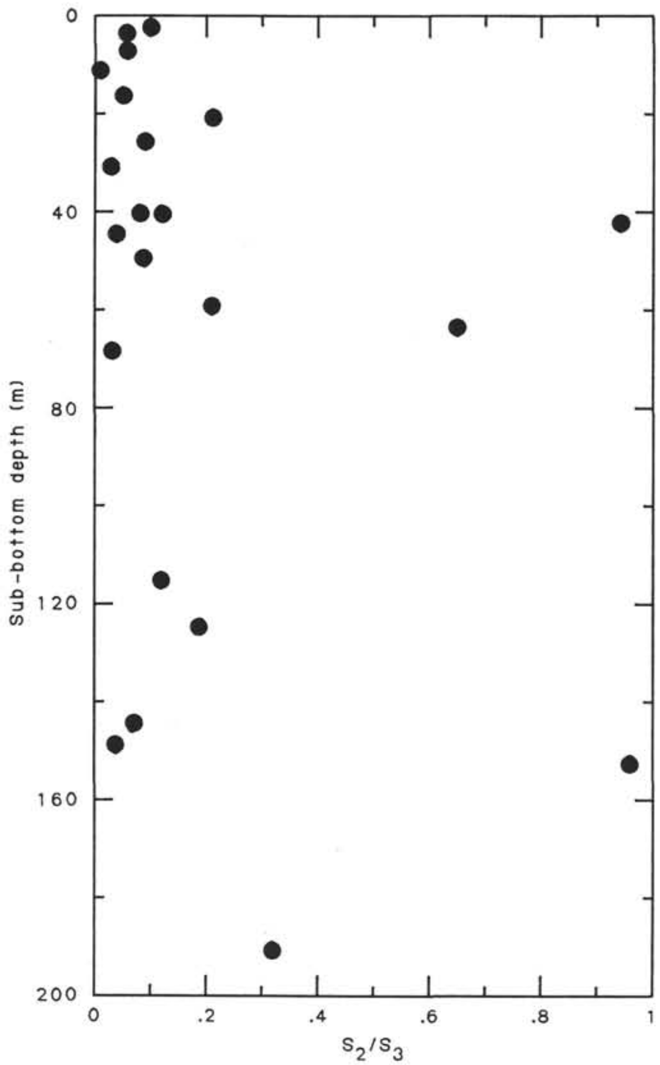


Figure 13. Downhole variations of $S_2/S_3$ ratios, Hole 633A. These values may be misleading because of high carbonate content of samples.

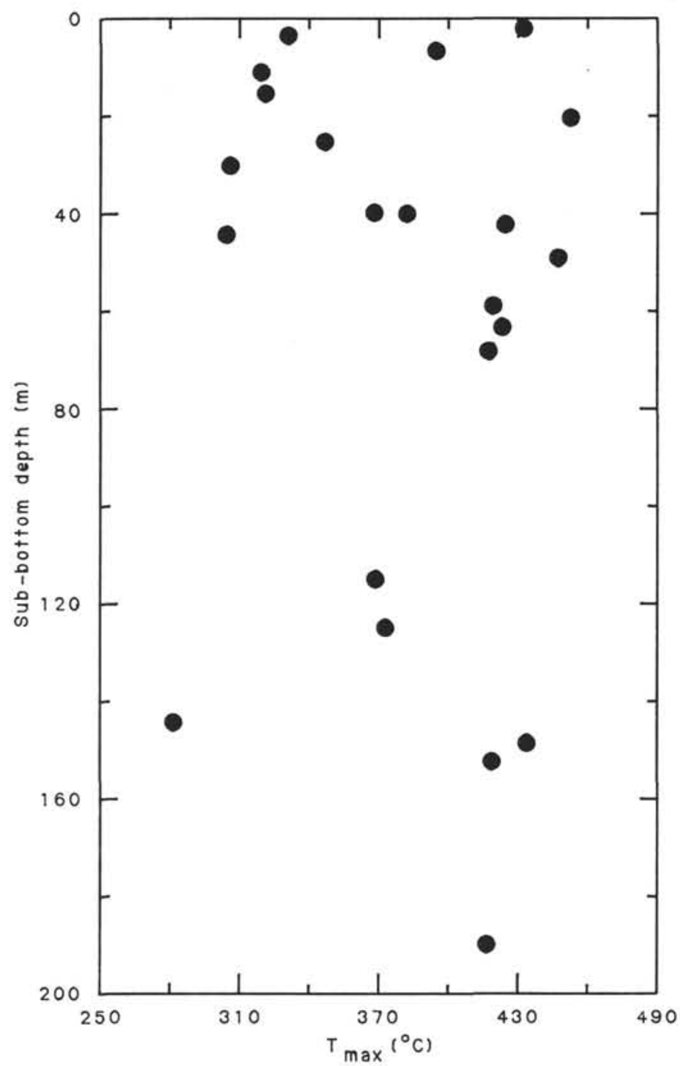


Figure 14. $T_{max}$ values, showing some samples with values near 430°C as at Sites 633 and 632.

either of these interpretations (Figs. 23 and 24). The slump hypothesis would imply at least two separate events, one in the late Miocene and another in the early Pliocene ("Biostratigraphy" section, this chapter). Three or more separate events are implied by the seismic stratigraphy of Site 633.

The slumping hypothesis derives circumstantial support from the nearly constant aragonite content of Unit II that interrupts the steady decrease with depth observed at Site 632. Similar interruptions or reversals of the normal downhole trends are observed in the curves of porosity, density, and water content ("Physical Properties" section, this chapter). A common lithology in the possible slump masses of Unit II is greenish silty periplatform ooze, a lithology that currently accumulates on the upper slope just below the marginal escarpment of the platform (Schlager and Droxler, unpubl. data). This lithology is also common at Site 631. Large-scale downslope displacement of this upper-slope facies with its low plankton content might explain the difficulties in dating the periplatform ooze at Sites 631 and 633 ("Biostratigraphy" section, this chapter, and Site 631 chapter).

Pore waters at Site 633 point to intensive sulfate reduction coupled with oxidation of organic matter and an increase in alkalinity. An alkalinity maximum, sulfate minimum, and calcium minimum mark the base of Unit II ("Inorganic Geochemistry" section, this chapter).

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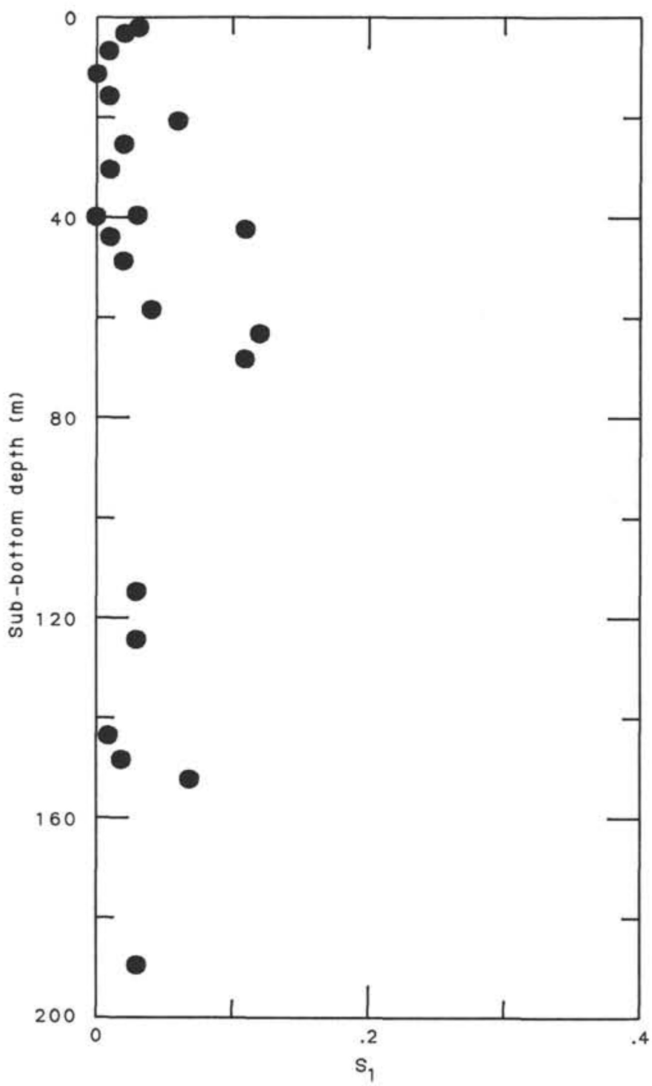



Figure 15. Downhole variation of $S_1$ values, Hole 633A.

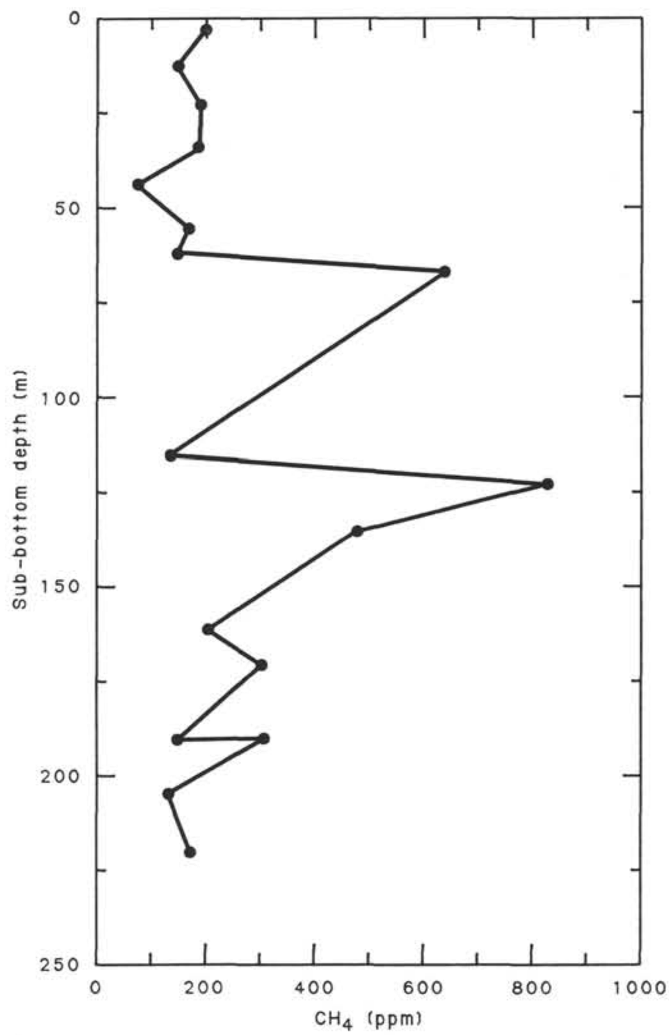



Figure 16. Downhole variation of methane content, Hole 633A.

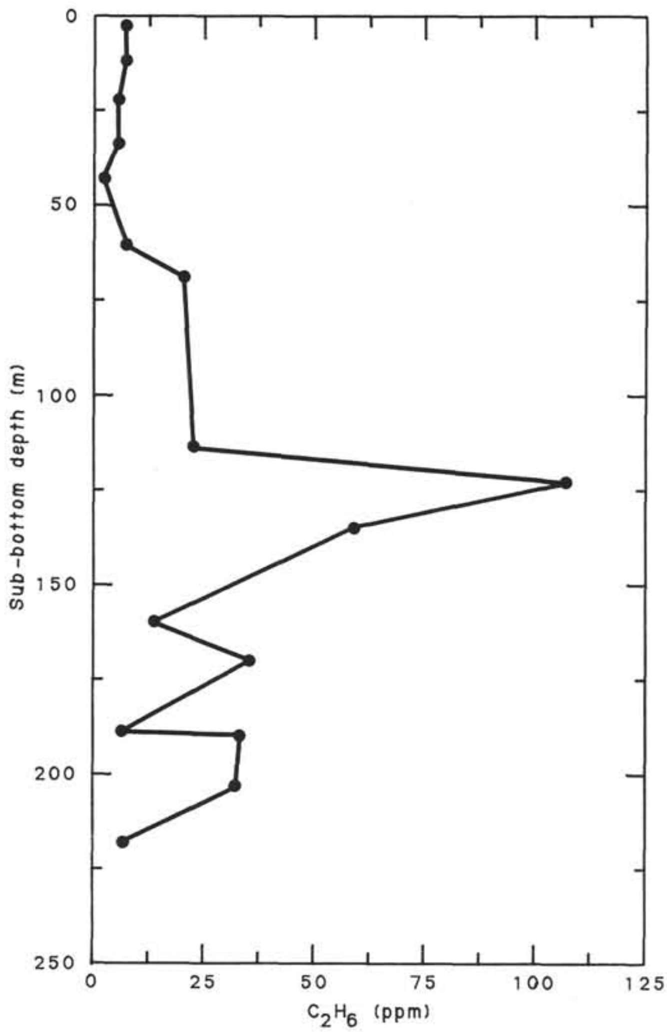



Figure 17. Downhole variation of ethane content, Hole 633A.

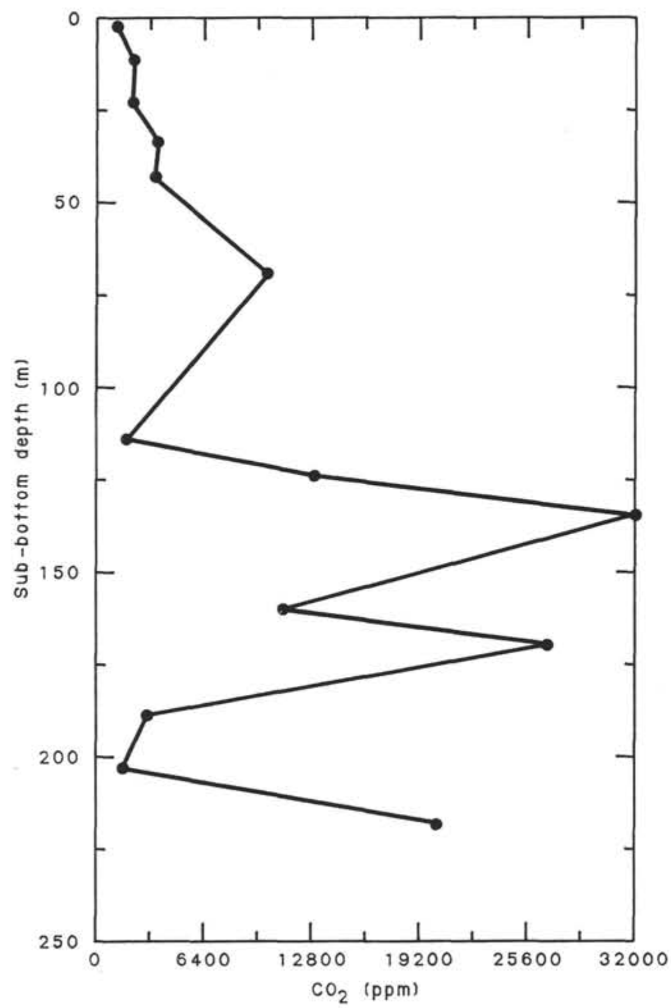



Figure 18. Downhole variation of carbon dioxide content, Hole 633A.

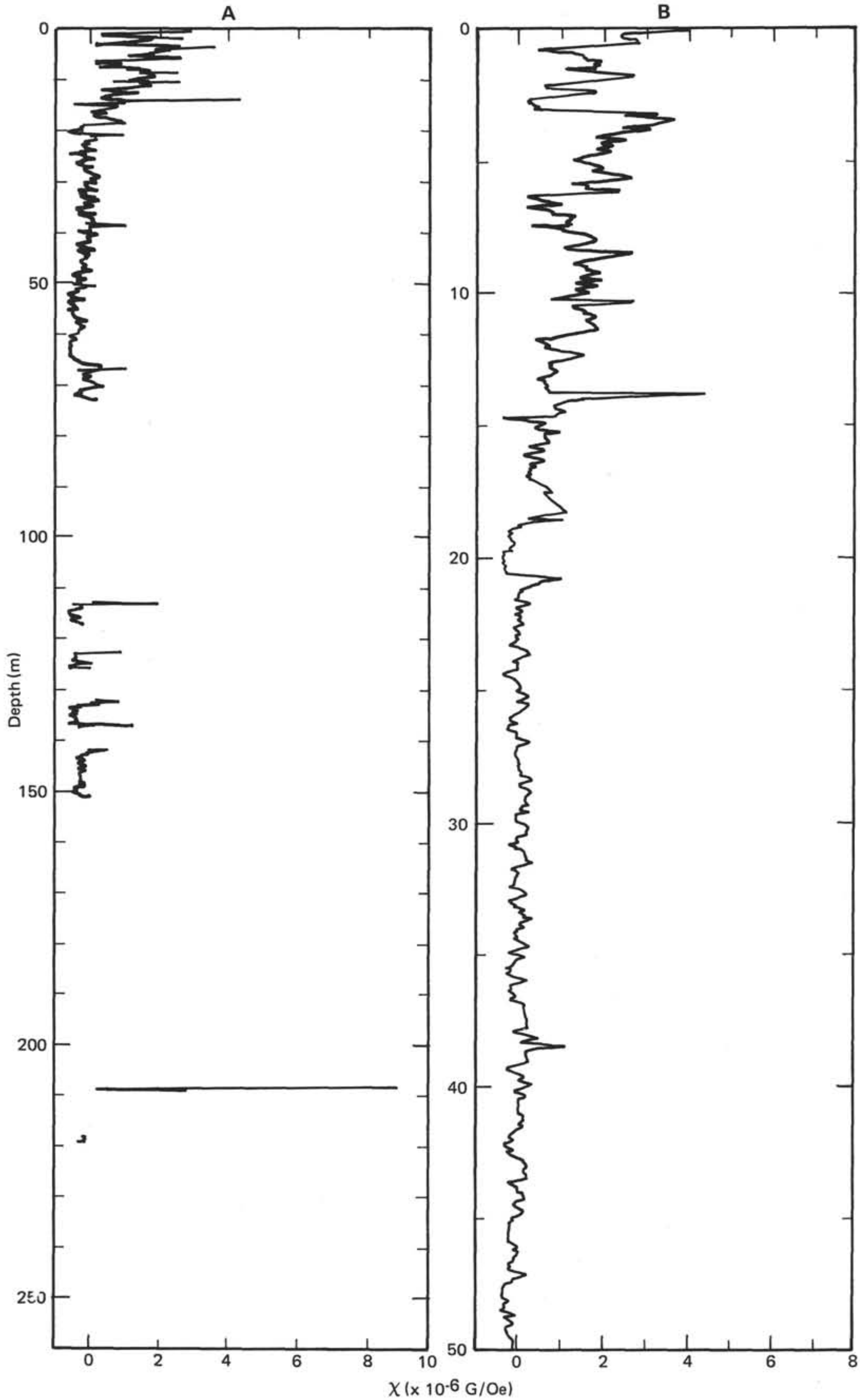



Figure 19. Magnetic-susceptibility values ($\times 10^{-6}$ G/Oe) plotted vs. depth for Hole 633A. A. Raw susceptibility values. B. Upper 50 m, from Cores 633A-1H to 633A-6H, on an expanded scale.

**Table 6. Physical properties of sediments, Site 633.**

| Sample (level in cm) | Sub-bottom depth (m) | Velocity (m/s) | Velocity in liner (m/s) | Wet-bulk density ($g/cm^3$) | Dry water content (%) | Porosity (%) | Thermal conductivity ($10^{-3} \times cal \times °C^{-1} \times cm^{-1} \times s^{-1}$) | Shear strength (kPa) |
|---|---|---|---|---|---|---|---|---|
| 1-2, 70 | 2.2 | 1427 | | 1.67 | 61.98 | 64.25 | 2.018 | 2.67 |
| 1-3, 75 | 3.7 | | | | | | 1.891 | |
| 1-4, 75 | 5.2 | | | 1.73 | 55.37 | 61.90 | 2.181 | 6.34 |
| 1-5, 75 | 6.7 | | | | | | 2.071 | |
| 1-6, 75 | 8.2 | | | 1.67 | 61.73 | 64.20 | 3.028 | 3.85 |
| 2-2, 70 | 10.9 | 1467 | | 1.71 | 57.89 | 62.78 | 2.464 | 2.60 |
| 2-2, 100 | | | 1497 | | | | | |
| 2-3 | 12.4 | | | | | | 2.449 | |
| 2-4, 75 | 13.9 | | | | | | 2.633 | 10.19 |
| 2-4, 90 | | 1451 | | 1.71 | 71.13 | 71.32 | | |
| 2-5, 75 | 15.4 | | | | | | 2.675 | |
| 2-6, 20 | | | 1632 | | | | | |
| 2-6, 70 | 16.9 | 1672 | | 1.72 | 54.38 | 60.77 | 2.505 | 2.27 |
| 2-6, 100 | | | 1452 | | | | | |
| 3-2, 75 | 20.5 | 1459 | | 1.77 | 50.16 | 59.30 | 2.517 | 3.06 |
| 3-3, 75 | 22.0 | | | | | | 2.758 | |
| 3-4, 20 | | | 1653 | | | | | |
| 3-4, 70 | 23.5 | 1700 | | 1.84 | 44.44 | 56.75 | 2.845 | 4.53 |
| 3-4, 100 | | | 1695 | | | | | |
| 3-5, 75 | 25.0 | | | | | | 2.834 | |
| 3-6, 20 | | | 1687 | | | | | |
| 3-6, 75 | 26.5 | | | 1.84 | 45.32 | 57.15 | 2.496 | 6.23 |
| 3-6, 110 | | | 1732 | | | | | |
| 4-2, 20 | | | 1654 | | | | | |
| 4-2, 75 | 30.2 | | | | | | 2.416 | 5.78 |
| 4-2, 110 | | | 1683 | 1.76 | 43.49 | 53.32 | | |
| 4-3, 75 | 31.7 | | | | | | 2.629 | |
| 4-4, 20 | | | 1761 | | | | | |
| 4-4, 70 | 33.2 | 1688 | | 1.75 | 34.50 | 61.77 | 2.557 | 0.91 |
| 4-4, 100 | | | 1682 | | | | | |
| 4-5, 75 | 34.7 | | | | | | 2.520 | 5.89 |
| 4-6, 20 | | | 1661 | | | | | |
| 4-6, 60 | 36.2 | 1774 | | 1.88 | 40.01 | 53.54 | | |
| 4-6, 120 | | | 1682 | | | | | 1.13 |
| 5-2, 20 | | | 1647 | | | | | |
| 5-2, 75 | 39.8 | | | 1.73 | 44.30 | 53.08 | 2.741 | 2.72 |
| 5-2, 100 | | | 1694 | | | | | |
| 5-3, 75 | 41.3 | | | | | | 2.802 | |
| 5-4, 20 | | | 1691 | | | | | |
| 5-4, 80 | 42.8 | 1640 | | 1.67 | 59.08 | 62.02 | 2.835 | |
| 5-4, 100 | | | 1724 | | | | | 3.40 |
| 5-5, 75 | 44.3 | | | | | | 2.650 | |
| 5-6, 30 | | | 1809 | | | | | |
| 5-6, 75 | 45.8 | 1651 | | 1.8 | 46.71 | 57.14 | 2.891 | 4.76 |
| 5-6, 100 | | | 1749 | | | | | |
| 6-2, 20 | | | 1730 | | | | | |
| 6-2, 70 | 49.4 | 1754 | | 1.98 | 40.22 | 56.46 | 3.020 | 4.76 |
| 6-2, 120 | | | 1632 | | | | | |
| 6-3, 75 | 50.9 | | | | | | 2.712 | |
| 6-4, 20 | | | 1779 | | | | | |
| 6-4, 75 | 52.4 | | | 1.82 | 36.90 | 48.73 | 2.687 | 4.76 |
| 6-4, 95 | | | 1713 | | | | | |
| 6-5, 75 | 53.9 | | | | | | 2.727 | |
| 6-6, 20 | | | 1794 | | | | | |
| 6-6, 75 | 55.4 | | | | | | 2.531 | 1.59 |
| 6-6, 120 | | 1761 | 1442 | 1.86 | 42.96 | 55.86 | | |
| 7-2, 20 | | | 1799 | | | | | |
| 7-2, 70 | 59.1 | 1782 | | 1.95 | 36.11 | 51.34 | 2.669 | 2.27 |
| 7-2, 130 | | | 1698 | | | | | |
| 7-3, 75 | 60.6 | | | | | | 2.606 | |
| 7-4, 75 | 62.1 | | | 1.79 | 48.51 | 58.41 | 2.375 | |
| 7-5, 75 | 63.6 | | | | | | 2.590 | |
| 7-6, 75 | 65.1 | | | 1.77 | 50.29 | 59.12 | 2.580 | |
| 8-1, 75 | 68.6 | | | | | | 2.578 | |
| 8-2, 20 | | | 2213 | | | | | |
| 8-2, 75 | 70.1 | | | 1.76 | 51.42 | 59.87 | 2.660 | |
| 8-2, 100 | | | 1706 | | | | | |
| 8-3, 75 | 73.6 | | | | | | 2.560 | |
| 8-4, 20 | | | 1716 | | | | | |
| 8-4, 75 | | | | | | | 2.560 | |
| 8-4, 120 | | 2335 | 2400 | 2.10 | 29.41 | 47.35 | | |
| 11-1, 10 | 93.7 | 2692 | | 2.03 | 28.73 | 44.87 | | |
| 13-2, 50 | 114.7 | 1806 | | 1.84 | 44.68 | 56.65 | | |
| 14-1, 75 | 123.0 | | | | | | 2.800 | |
| 14-2, 20 | 124.0 | | 1680 | | | | | |

**Table 6 (continued).**

| Sample (level in cm) | Sub-bottom depth (m) | Velocity (m/s) | Velocity in liner (m/s) | Wet-bulk density (g/cm³) | Dry water content (%) | Porosity (%) | Thermal conductivity ($10^{-3}$ × cal × °C$^{-1}$ × cm$^{-1}$ × s$^{-1}$) | Shear strength (kPa) |
|---|---|---|---|---|---|---|---|---|
| 14-2, 65 | 124.4 | | 1996 | | | | | |
| 14-2, 86 | | | 1603 | 1.81 | 43.05 | 54.45 | 2.864 | |
| 14-2, 110 | 124.9 | 2110 (a) | | 1.95 | 36.96 | 52.31 | | |
| | | 2035 (c) | | | | | | |
| 14-2, 123 | 125.0 | | 2219 | | | | | |
| 14-3, 20 | 125.5 | | | | | | 3.245 | |
| 15-1, 32 | | | 2236 | | | | | |
| 15-1, 60 | | | | 1.87 | 42.50 | 55.47 | | |
| 15-1, 68 | 132.7 | 2009 (a) | | | | | 2.406 | |
| | | 2017 (c) | | | | | | |
| 15-2, 75 | 134.2 | | | 1.92 | 36.04 | 50.71 | 2.964 | |
| 15-3, 40 | | | | 1.84 | 42.56 | 54.72 | | |
| 15-3, 75 | 135.7 | | | | | | 2.771 | |
| 15-4, 50 | 137.0 | | | | | | 3.09 | |
| 16-2, 120 | 144.4 | | 1488 | 1.88 | 38.93 | 52.49 | | |
| 16-4, 50 | | | 3571 | 1.82 | 44.65 | 56.2 | | |
| 16-4, 100 | 145.7 | | 1715 | | | | | |
| 16-6, 70 | 148.5 | | 1438 | 1.79 | 45.81 | 56.25 | | |
| 17-1, 14 | 151.5 | 4378 (a) | | 2.39 | 11.30 | 23.8 | | |
| | | 4439 (b) | | | | | | |
| | | 4034 (c) | | | | | | |
| 18-1, 30 | 160.3 | | 1825 | 2.14 | 18.88 | 33.55 | | 6.23 |
| 19-1, 12 | 169.7 | 1786 (a) | 1886 | 1.87 | 50.07 | 62.38 | | |
| | | 1824 (b) | | 1.96 | 34.09 | 49.44 | | |
| | | 1837 (c) | | | | | | |
| 20-1, 6 | 179.4 | 4593 (a) | | 2.47 | 6.26 | 14.25 | | |
| | | 4445 (b) | | | | | | |
| 21-2, 20 | 190.6 | | 2080 | | | | | 6.12 |
| 21-2, 30 | | | | 2.04 | 25.78 | 41.49 | | |
| 23-1, 11 | 208.3 | 2995 (a) | | | | | | |
| | | 2138 (b) | | | | | | |
| 23-1, 30 | 208.5 | | | 2.06 | 23.57 | 38.79 | | 5.27 |
| 23, CC | 217.8 | | | 2.2 | 22.14 | 39.37 | | |
| 24-1, 75 | 218.5 | 3773 (a) | | | | | | |
| | | 4081 (b) | | | | | | |
| | | 3966 (c) | | | | | | |

[a] See footnote to Table 9, Site 627 chapter.

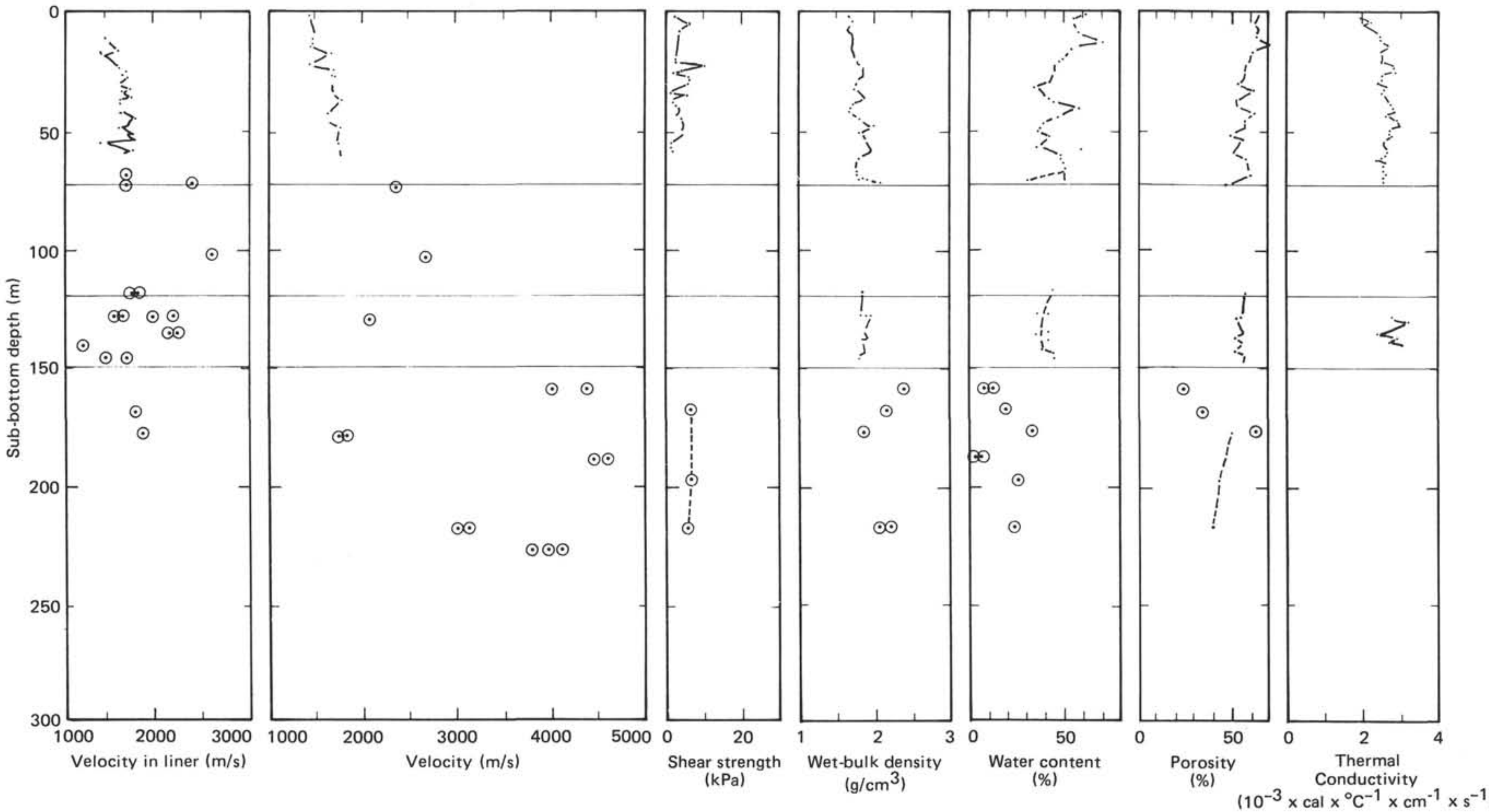



**Figure 20. Graphic summary of physical properties, Hole 633A.**

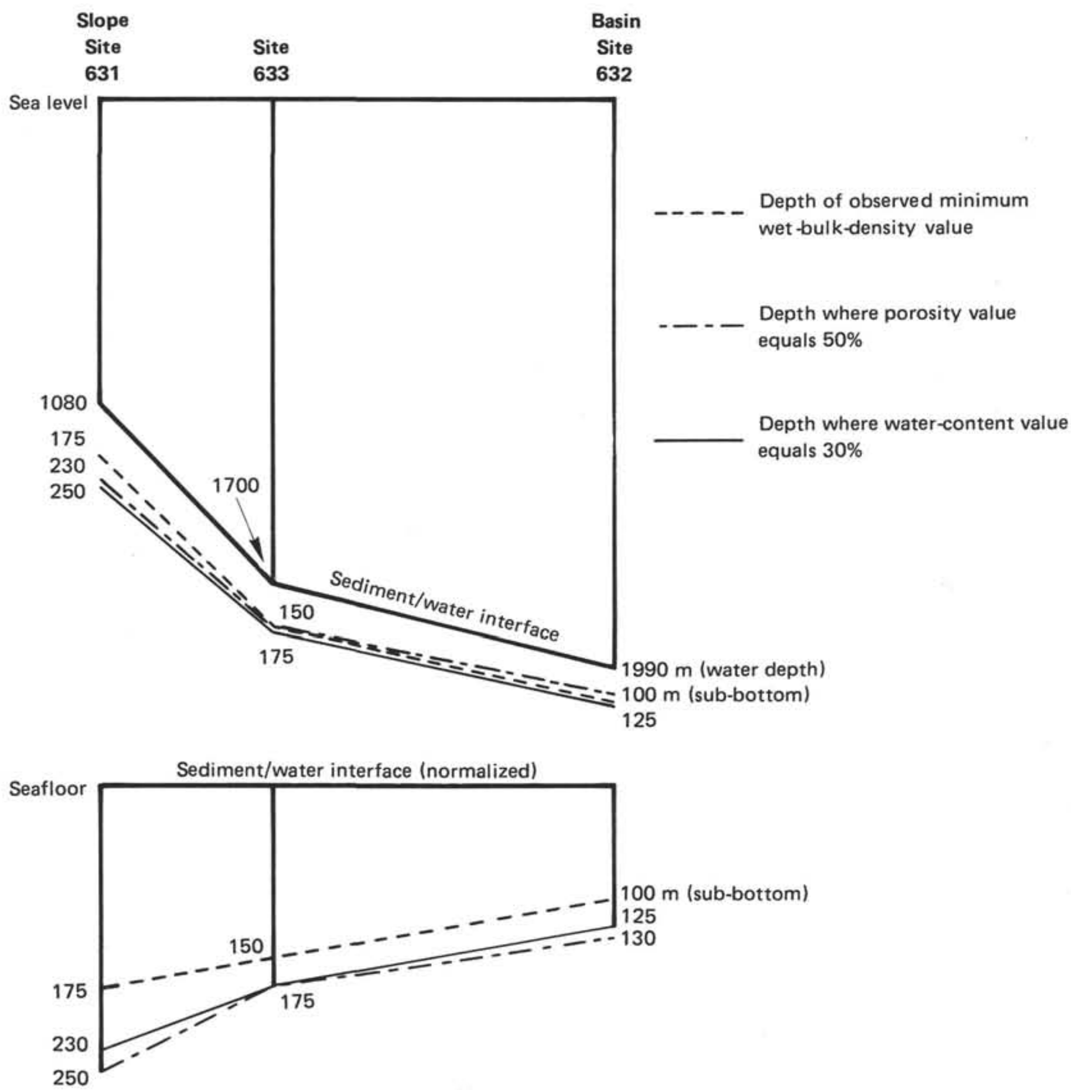



Figure 21. Values for wet-bulk density, porosity, and water content, Sites 631, 633, and 632.

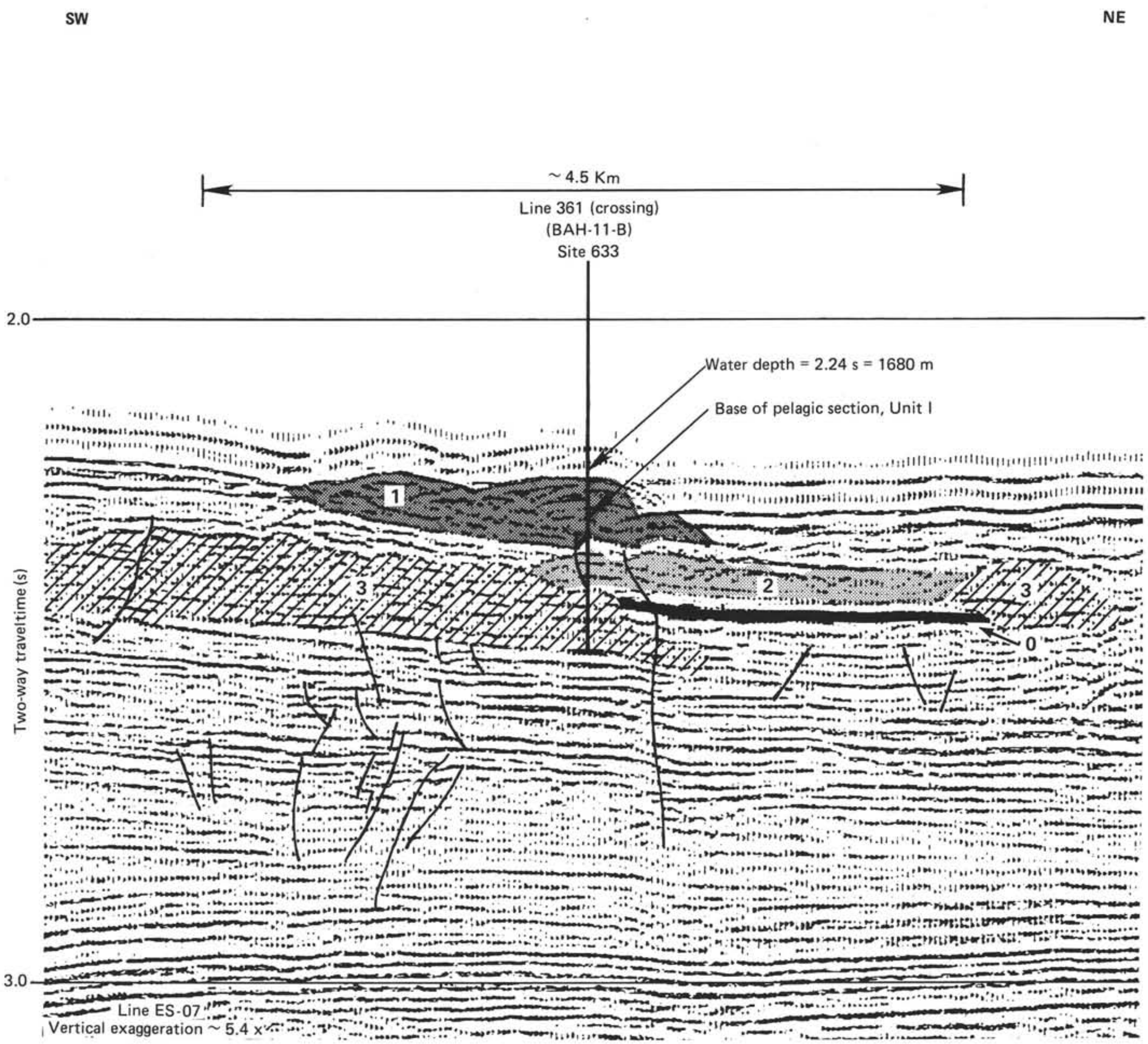



Figure 22. Part of site-survey line ES-07, showing distribution of hummocky clinoforms (labeled *1* through *3*; slumps–debris flows?) and parallel reflector sequences (pelagic ooze, chalk, limestone) at the toe-of-slope near Site 633. Reflector "O" (J. Ladd and R. Sheridan, unpubl. data) is indicated. The vertical line denotes depth of penetration of Hole 633A.

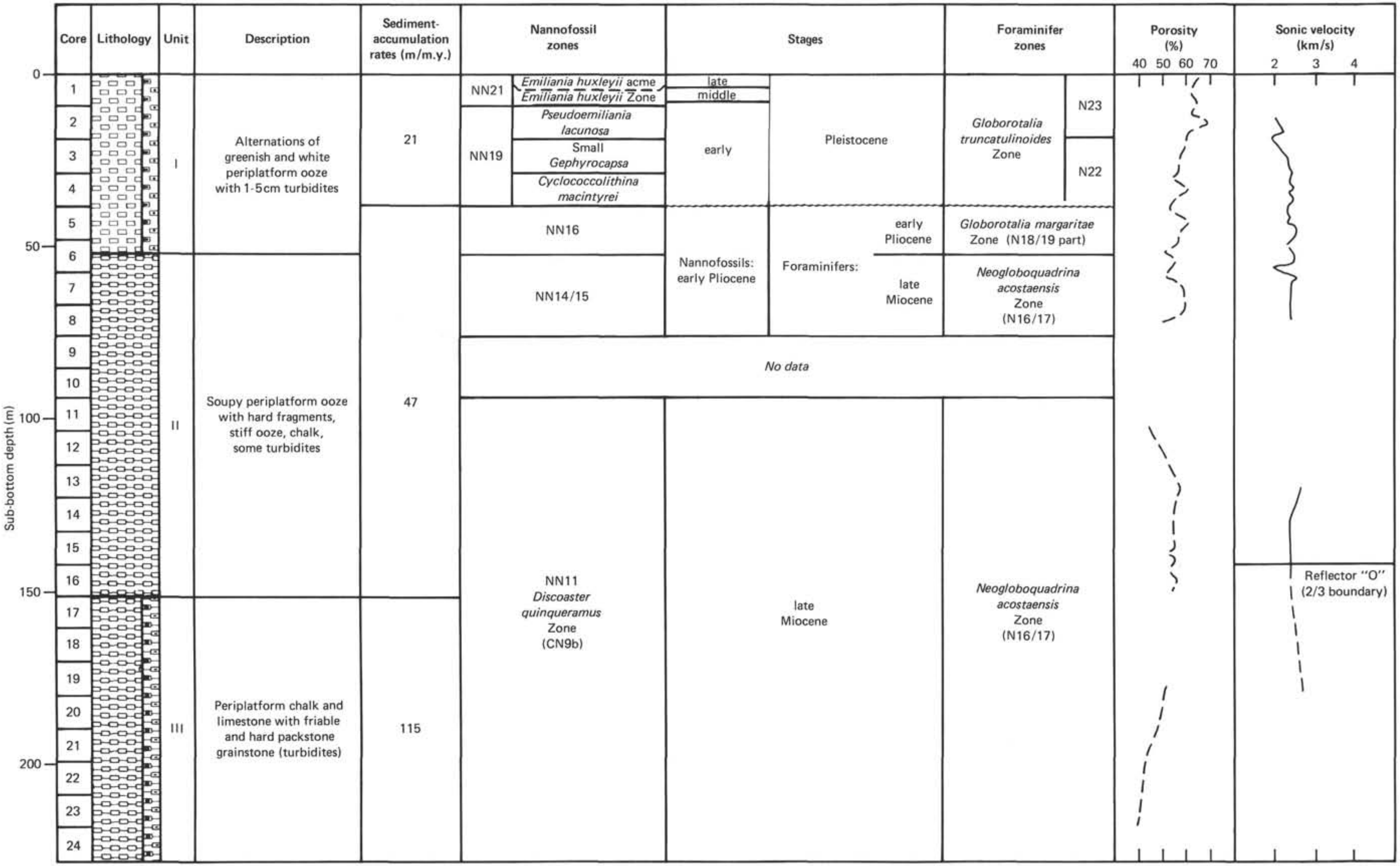



Figure 23. Summary of data for Site 633.

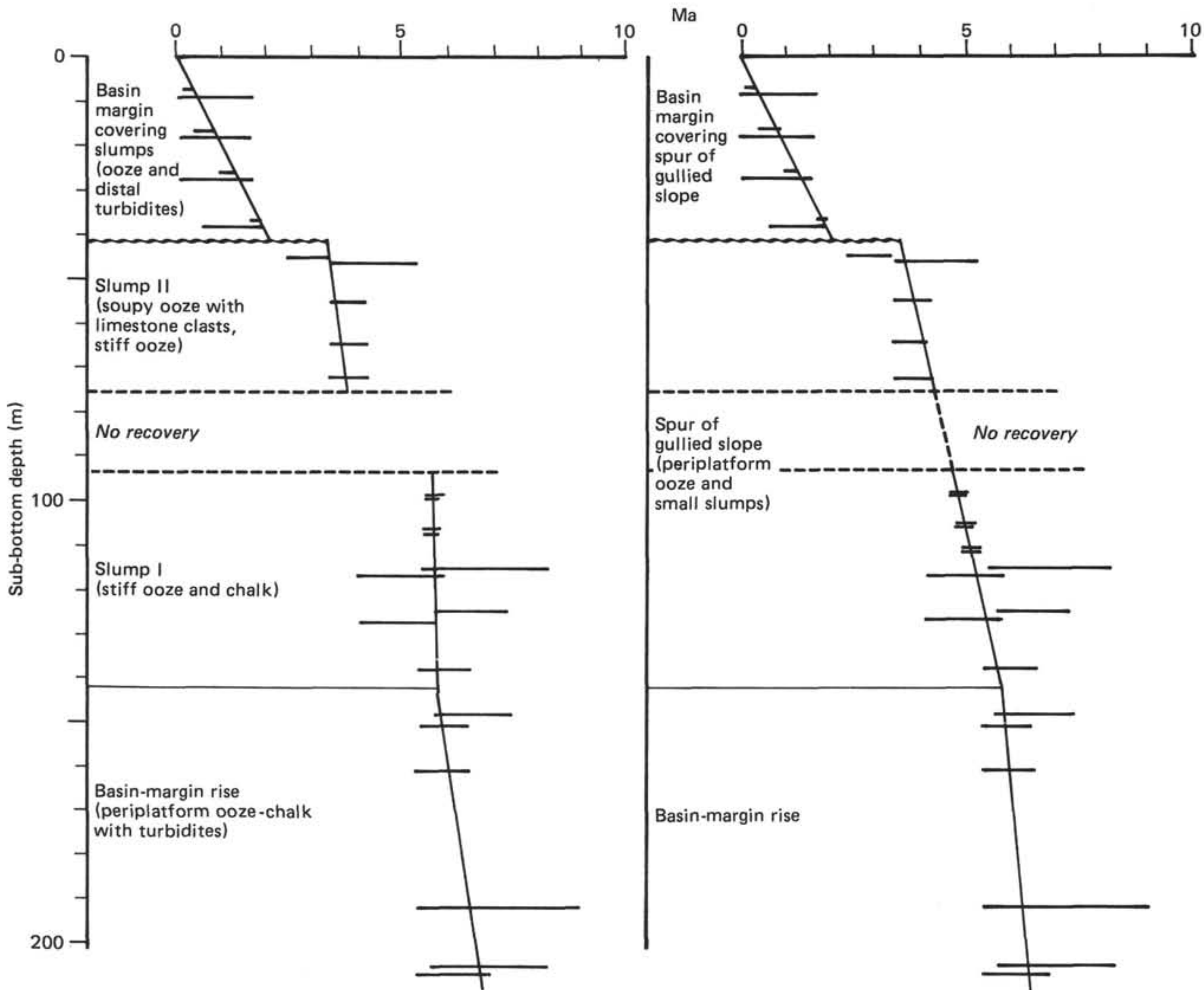
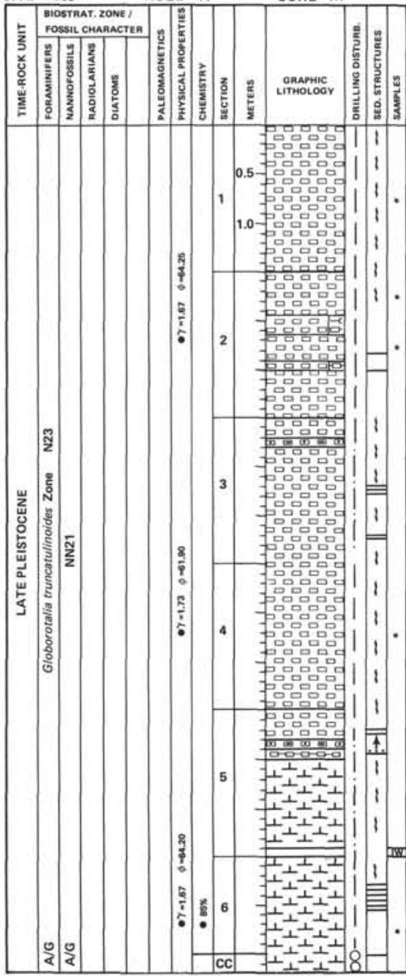



Figure 24. Contrasting interpretations of stratigraphy and accumulation history at Site 633. Horizontal lines denote biostratigraphic control.

SITE 633 HOLE A CORE 1H CORED INTERVAL 1679.1-1687.8 mbsl; 0-8.7 mbsf




LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE with minor NANNOFOSSIL OOZE, UNLITHIFIED PACKSTONE and CHALK

CALCAREOUS OOZE, very pale brown to pale brown (10YR 7/3, 10YR 6/3) at top, changing to white (10YR 8/2, 10YR 8/1) and light gray (10YR 7/2) lower in core. OOZE occurs throughout core with other lithologies interbedded. A pteropod-rich layer occurs in the OOZE in Section 1, 96-99 cm. Purple/gray bands present; small grain aggregates occur below Section 1, 130 cm.

NANNOFOSSIL OOZE, white (10YR 8/1) to gray (10YR 7/1), grades from CALCAREOUS OOZE (containing periplatform material: micrite, skeletal fragments, and pellets) in Section 5 and is present through the base of the core. Contains some grain aggregates.

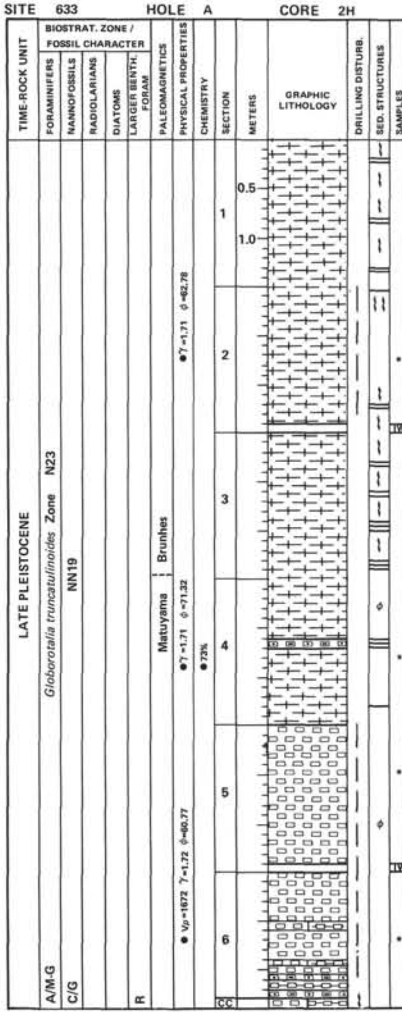
UNLITHIFIED PACKSTONE, white (10YR 8/2), gray (10Y 7/1) and yellow (10YR 8/6), occurs as several thin (1-2 cm) beds in Section 1, between 48 and 66 cm and 94 and 96 cm, and as thicker beds in Section 3, 19-26 cm (very coarse to medium sand) and in Section 5, 31-42 cm (graded; medium to fine sand).

CHALK, white (10YR 8/1), occurs as a single bed in Section 5, 42-47 cm.

SMEAR SLIDE SUMMARY (%):

| | 1,75 D | 2,26 M | 2,75 D | 4,75 D | 6,75 D |
|---|---|---|---|---|---|
| COMPOSITION: | | | | | |
| Accessory Minerals: | | | | | |
| Organics | – | 80 | – | – | – |
| Foraminifers | 15 | – | 20 | 10 | 5 |
| Nannofossils | 30 | 10 | 20 | 40 | 60 |
| Sponge Spicules | 1 | – | – | – | – |
| Pellets | 10 | – | 10 | 5 | 10 |
| Pteropods | 5 | – | 10 | 5 | – |
| Skeletal Fragments | 20 | – | 25 | 20 | 15 |
| Clasts (aggregates) | 4 | – | – | – | – |
| Micrite | 15 | 10 | 15 | 20 | 10 |

SITE 633 HOLE A CORE 2H CORED INTERVAL 1687.8-1697.4 mbsl; 8.7-18.3 mbsf




LITHOLOGIC DESCRIPTION

FORAM-NANNOFOSSIL OOZE, with minor CALCAREOUS OOZE, UNLITHIFIED PACKSTONE and CHALK

FORAM-NANNOFOSSIL OOZE, various shades of white (10YR 8/1, 5Y 8/1, 2.5Y 8/0, 7.5Y 8/0) to gray (5Y 7/1), occurs from Section 1, 0 cm, through Section 5, where it grades into CALCAREOUS OOZE (containing periplatform material: micrite, skeletal fragments, and pellets). OOZE containing clay, gray (10YR 6/1, 5Y 5/1), occurs in Section 2, 2-10 cm.

CALCAREOUS OOZE, white (10YR 8/1, 5Y 8/1), grades from FORAM-NANNOFOSSIL OOZE as abundance of periplatform material increases in Section 5, and occurs through the base of the core interbedded with other lithologies. OOZE containing clay, gray (10YR 6/1, 5Y 5/1), occurs in Section 5, 46-52 cm.

UNLITHIFIED PACKSTONE, white (2.5Y 8/0), occurs in Section 4, 58-65 cm (fine grained), and in Section 6, 111-116 cm (very coarse to coarse-grained, with *Halimeda* fragments up to 4 cm length and skeletal debris), and 125-129 cm (fine to medium grained).

CHALK, white (10YR 8/1, 5Y 8/1), occurs as thin beds in Section 6, 52-53 cm, 98-100 cm and 116-125 cm.

SMEAR SLIDE SUMMARY (%):

| | 2,75 D | 4,75 D | 5,50 M | 6,75 D |
|---|---|---|---|---|
| COMPOSITION: | | | | |
| Clay | – | – | 15 | – |
| Volcanic Glass | – | – | 1 | – |
| Foraminifers | 15 | 10 | – | 15 |
| Nannofossils | 50 | 50 | 5 | 40 |
| Pellets | 5 | 5 | – | 5 |
| Pteropods | Tr | – | 1 | 2 |
| Skeletal Fragments | 15 | 15 | 18 | 20 |
| Micrite | 15 | 20 | 60 | 18 |

SITE 633 HOLE A CORE 3H CORED INTERVAL 1697.4-1707.1 mbsl; 18.3-28.0 mbsf

TIME-ROCK UNIT: EARLY-MIDDLE PLEISTOCENE

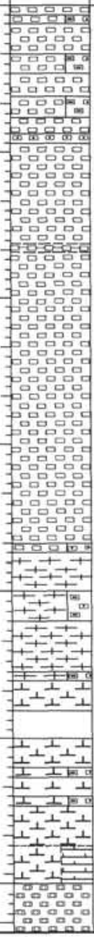
BIOSTRAT. ZONE / FOSSIL CHARACTER: FORAMINIFERS: *Globorotalia truncatulinoides* ZONE N22, A/G; NANNOFOSSILS: NN19, A/9; LARGER BENTH. FORAM: F

PHYSICAL PROPERTIES: ● γ = 1.77 φ = 59.30; ● Vp = 1700 γ = 1.84 φ = 56.75; ● γ = 1.84 φ = 57.15; ● Vp = 1703 in liner

CHEMISTRY: ● 85%

SECTION: 1, 2, 3, 4, 5, 6, 7, CC

METERS: 0.5, 1.0



SAMPLES: OG

## LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE, FORAM-NANNOFOSSIL OOZE, NANNOFOSSIL OOZE with minor UNLITHIFIED PACKSTONE, CHALK, UNLITHIFIED GRAINSTONE, and UNLITHIFIED RUDSTONE

CALCAREOUS OOZE, various shades of white (10YR 8/1, 2.5Y 8/0, 5Y 8/1, 7.5Y 8/0), in Sections 1 through 4, interbedded with other lithologies. CALCAREOUS OOZE grades into FORAM-NANNOFOSSIL OOZE in Section 4 as the relative abundance of foraminifers and nannofossils relative to periplatform material (micrite, bioclasts and pellets) increases. Purple/gray bands common throughout.

FORAM-NANNOFOSSIL OOZE, white (5Y 8/1, 10YR 8/1), occurs in Sections 4 and 5; it grades upward into CALCAREOUS OOZE and downward into NANNOFOSSIL OOZE based on the relative abundance of foraminifers and nannofossils versus periplatform material.

NANNOFOSSIL OOZE, white (5Y 8/1, 10YR 8/1), occurs in Section 6 through the base of the core, as the abundance of nannofossils relative to foraminifers and to periplatform material.

UNLITHIFIED PACKSTONE, light gray (10YR 7/2), occurs as several thin (2-5 cm) beds in Sections 1, 5 and 6.

UNLITHIFIED GRAINSTONE, light gray (10YR 7/2), occurs in Section 1, 134-137 cm. Contains coarse to medium grained material.

UNLITHIFIED RUDSTONE, white (10YR 8/1), occurs in Section 7 and the CC. Very coarse sand to granule-sized material including *Halimeda*, skeletal fragments, and clasts.

SMEAR SLIDE SUMMARY (%):

| | 2,75 D | 4,75 D | 6,75 D |
|---|---|---|---|
| COMPOSITION: | | | |
| Foraminifers | 20 | 10 | 5 |
| Nannofossils | 30 | 50 | 50 |
| Pellets | 10 | 5 | 5 |
| Pteropods | 5 | Tr | 2 |
| Skeletal Fragments | 15 | 15 | 10 |
| Micrite (+ arag. needles) | 20 | 20 | 28 |

SITE 633 HOLE A CORE 4H CORED INTERVAL 1707.1-1716.7 mbsl; 28.0-37.6 mbsf

TIME-ROCK UNIT: EARLY-EARLY MIDDLE PLEISTOCENE

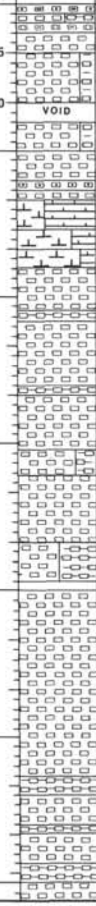
BIOSTRAT. ZONE / FOSSIL CHARACTER: FORAMINIFERS: *Globorotalia truncatulinoides* Zone N22, A/G; NANNOFOSSILS: NN19, C/M

PHYSICAL PROPERTIES: Vp = 1683 in liner; ● γ = 1.76 φ = 53.32; Vp = 1688; φ = 61.77; ● γ = 1.75; Vp = 1774; φ = 53.54; ● γ = 1.88

CHEMISTRY: ● 85%

SECTION: 1, 2, 3, 4, 5, 6, 7

METERS: 0.5, 1.0



SAMPLES: IW

## LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE and CHALK, with minor NANNOFOSSIL OOZE and NANNOFOSSIL CHALK, UNLITHIFIED PACKSTONE, UNLITHIFIED GRAINSTONE and UNLITHIFIED FLOATSTONE. No CC.

CALCAREOUS OOZE and CHALK intercalated, white (5Y 8/1, 10YR 8/1), occurs throughout the core. Relative proportions of OOZE and CHALK vary. Contains some clasts.

NANNOFOSSIL OOZE and NANNOFOSSIL CHALK, white (5Y 8/1, 2.5Y 8/1), occurs in Section 2, grading upwards and downwards into CALCAREOUS OOZE, based on relative abundance of nannofossils relative to periplatform material (micrite, skeletal fragments and pellets).

UNLITHIFIED PACKSTONE, white (10YR 8/1), occurs in Section 1, 0-3 cm; probably downhole contamination.

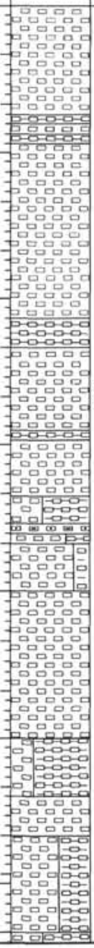
UNLITHIFIED GRAINSTONE, white (2.5Y 8/1), occurs in Section 2, 35-37 cm; medium to coarse grained, contains predominantly foraminifers

UNLITHIFIED FLOATSTONE, white (10YR 8/1), occurs in Section 1, 24-30 cm.

SMEAR SLIDE SUMMARY (%):

| | 2,75 D | 4,75 D | 5,75 D | 6,75 D |
|---|---|---|---|---|
| COMPOSITION: | | | | |
| Foraminifers | 5 | 15 | 10 | 20 |
| Nannofossils | 50 | 25 | 40 | 20 |
| Pellets | 5 | 10 | 5 | 5 |
| Pteropods | Tr | – | – | 5 |
| Skeletal Fragments | 10 | 20 | 10 | 20 |
| Clasts (aggregates) | 5 | 10 | 10 | 10 |
| Micrite | 25 | 20 | 25 | 20 |

SITE 633 HOLE A CORE 5H CORED INTERVAL 1716.7-1726.3 mbsl; 37.6-47.2 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PLIOCENE | *Globorotalia margaritae* Zone N18/19 part; A/G | NN16; C/M | | | | Vp=1694 in liner; φ=53.08; γ=1.73; Vp=1640; φ=62.02; γ=1.67; Vp=1651; φ=57.14; γ=1.8 | 87% | 1, 2, 3, 4, 5, 6, 7, CC | 0.5, 1.0 |  | | | |

LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE and CHALK with minor UNLITHIFIED PACKSTONE

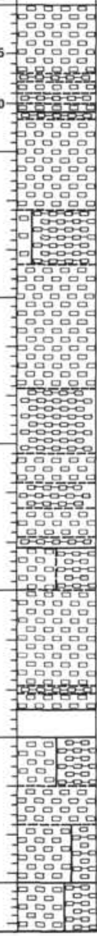
CALCAREOUS OOZE and CHALK intercalated, white (5Y 8/1, 2.5Y 8/0), occurs throughout the core; relative proportions of CHALK and OOZE vary.

UNLITHIFIED PACKSTONE, white (2.5Y 8/0), occurs in Section 4, 84-88 cm.

SMEAR SLIDE SUMMARY (%).

| | 2,75 D | 4,75 D | 6,75 D |
|---|---|---|---|
| COMPOSITION: | | | |
| Foraminifers | 10 | 10 | 5 |
| Nannofossils | 40 | 35 | 15 |
| Pellets | 5 | 5 | 5 |
| Skeletal Fragments | 15 | 10 | 30 |
| Clasts (aggregates) | 10 | 15 | 10 |
| Micrite | 20 | 25 | 30 |

SITE 633 HOLE A CORE 6H CORED INTERVAL 1726.3-1736.0 mbsl; 47.2-56.9 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EARLY PLIOCENE | *Globorotalia margaritae* Zone (N18/N19 part); R/P | NN14/15; F/M | | | | Vp=1754; φ=56.46; γ=1.98; Vp=1750 in liner; φ=48.73; γ=1.82; Vp=1761; φ=55.86; γ=1.86 | 90% | 1, 2, 3, 4, 5, 6, CC | 0.5, 1.0 |  | | | OG |

LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE and CHALK. Strong odor of hydrogen sulfide noted in Sections 4 through 7.

CHALK and CALCAREOUS OOZE interbedded, white (2.5Y 8/0, 10YR 8/1), occurs throughout the core. Relative proportions of OOZE and CHALK vary. Some clasts (aggregates) and burrow mottles are present.

SMEAR SLIDE SUMMARY (%).

| | 2,75 D | 4,75 D | 6,75 D |
|---|---|---|---|
| COMPOSITION: | | | |
| Dolomite | – | Tr | – |
| Foraminifers | 5 | 5 | 10 |
| Nannofossils | 30 | 20 | 10 |
| Pteropods | – | Tr | – |
| Skeletal Fragments | 5 | 20 | 40 |
| Clasts (aggregates) | 20 | 10 | 20 |
| Micrite (+ arag. needles) | 40 | 45 | 20 |

SITE 633 HOLE A CORE 7H CORED INTERVAL 1736.0-1745.5 mbsl; 56.9-66.4 mbsf

TIME-ROCK UNIT: LATE MIOCENE - EARLY PLIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: FORAMINIFERS: *Globorotalia margaritae* Zone (N18/N19 part), C/M; NANNOFOSSILS: NN14/15, C/M

PHYSICAL PROPERTIES: Vp=1782; φ=51.34; γ=1.95; Vp=1706; φ=58.41; γ=1.79; Vp 1782; φ=59.12; γ=77

CHEMISTRY: 90%

SECTION: 1, 2, 3, 4, 5, 6, 7, CC

SAMPLES: IW

LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE with minor CHALK, LIMESTONE, and UNLITHIFIED FLOATSTONE (probably drilling breccia). Strong hydrogen sulfide odor throughout core.

CALCAREOUS OOZE and CHALK, white (5Y 8/2) to light gray (2.5Y 7/2), throughout core with other lithologies interbedded. OOZE is very soupy in Sections 2 through 7. Variable degree of lithification in CHALK.

LIMESTONE, light gray (2.5Y 7/2), occurs as rounded pieces 2-5 cm in diameter in Sections 1 and 2.

UNLITHIFIED PACKSTONE, light gray (2.5Y 7/2), occurs in Section 1, 115-127 cm; contains fine sand.

UNLITHIFIED FLOATSTONE, light gray (2.5Y 7/2), in Section 1, 0-8 cm; probably is drilling breccia.

SMEAR SLIDE SUMMARY (%):

| | 2,75 D | 6,75 D |
|---|---|---|
| COMPOSITION: | | |
| Foraminifers | 5 | 15 |
| Nannofossils | 25 | 15 |
| Pteropods | 50 | 10 |
| Skeletal Fragments | 15 | 25 |
| Clasts | 5 | 10 |
| Micrite (+ arag. needles) | — | 25 |

SITE 633 HOLE A CORE 8H CORED INTERVAL 1745.5-1754.6 mbsl; 66.4-75.5 mbsf

TIME-ROCK UNIT: Indeterminate

BIOSTRAT. ZONE / FOSSIL CHARACTER: FORAMINIFERS: R/P; NANNOFOSSILS: NN14/15, F/R

PHYSICAL PROPERTIES: γ=1.76; φ=59.87; Vp=1706 in liner; γ=2.10; φ=47.35; Vp=2335 (rock)

CHEMISTRY: =88%

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

LITHOLOGIC DESCRIPTION

CALCAREOUS OOZE and CHALK; odor of hydrogen sulfide noted

CALCAREOUS OOZE and CHALK with varying lithification, light gray (2.5Y 7/2), occurs throughout core, with a few discrete layers of CHALK interbedded. Relative proportions of OOZE and CHALK vary. Somewhat silty and slightly bioturbated; fractured by drilling.

SMEAR SLIDE SUMMARY (%):

| | 2,75 D | 4,75 D |
|---|---|---|
| COMPOSITION: | | |
| Quartz | Tr | — |
| Accessory Minerals: | | |
| Organics | Tr | Tr |
| Foraminifers | 5 | 10 |
| Nannofossils | 5 | 15 |
| Skeletal Fragments | 25 | 30 |
| Clasts | 30 | 30 |
| Micrite (+ arag. needles) | 35 | 15 |

CORE 9 NO RECOVERY

CORE 10 NO RECOVERY

SITE 633 HOLE A CORE 11X CORED INTERVAL 1772.7-1782.2mbsl; 93.6-103.1mbsf

TIME-ROCK UNIT: ?

BIOSTRAT. ZONE / FOSSIL CHARACTER: FORAMINIFERS: ?, R/P; NANNOFOSSILS: ?, R/P

PHYSICAL PROPERTIES: φ=44.87; γ=2.03; Vp=2692

CHEMISTRY: 92%

SECTION: 1, CC

LITHOLOGIC DESCRIPTION

LIMESTONE, CALCAREOUS OOZE and CHALK; may all be drilling breccia. Odor of hydrogen sulfide noted.

LIMESTONE, white (5Y 8/1), occurs as hard pebbles in Section 1 and in the CC; probably drilling breccia.

CALCAREOUS OOZE and CHALK, white (2.5Y 8/1), occur in the CC; probably drilling breccia.

SITE 633 HOLE A CORE 12X CORED INTERVAL 1782.2-1791.8 mbsl; 103.1-112.7 mbsf

TIME-ROCK UNIT: LATE MIOCENE - EARLY PLIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: F/P *Globorotalia margaritae* Zone (N18/N19 part); B

Section: CC

Drilling disturb.: x

LITHOLOGIC DESCRIPTION

Empty core liner. CHALK in CC; may be drilling breccia. Strong organic (?) odor.

CHALK, light gray (2.5Y 7/2) and white (2.5Y 8/0), occurs in the CC as fragments. CHALK is silty, contains planktonic foraminifers and skeletal fragments (drilling breccia ?).

SITE 633 HOLE A CORE 13X CORED INTERVAL 1791.8-1801.4 mbsl; 112.7-122.3 mbsf

TIME-ROCK UNIT: EARLY PLIOCENE - LATE MIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: C/M *Globorotalia margaritae* Zone (N18/N19 part); C/P NN11

PHYSICAL PROPERTIES: Vp=1806 γ=1.84 ϕ=56.65; 88%

Sections: 1, 2, 3, CC; Samples: OG, IW

LITHOLOGIC DESCRIPTION

CHALK and CALCAREOUS OOZE (may be drilling paste). Odor of hydrogen sulfide noted.

CHALK and CALCAREOUS OOZE, various shades of white (5Y 8/1, 2.5Y 8/0 and 7.5YR 8/0), occurs throughout the core as alternating layers; CHALK may be "drilling biscuits" with "drilling paste" of OOZE in between. Contains pyrite flecks, only CHALK is bioturbated.

SMEAR SLIDE SUMMARY (%):

| | 2,75 |
|---|---|
| COMPOSITION: | |
| Foraminifers | 5 |
| Nannofossils | 40 |
| Skeletal Fragments | 15 |
| Clasts | 10 |
| Micrite (+ aragonite needles) | 30 |

SITE 633 HOLE A CORE 14X CORED INTERVAL 1801.4-1811.1 mbsl; 122.3-132.0 mbsf

TIME-ROCK UNIT: EARLY PLIOCENE - LATE MIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: C/P-M *Globorotalia margaritae* Zone (N18/N19 part); C/M NN11 (CN9B)

PHYSICAL PROPERTIES: γ=1.95 ϕ=52.31; γ=1.81 ϕ=54.45 Vp=1680 in liner; 92%

Sections: 1, 2, 3, CC

LITHOLOGIC DESCRIPTION

CHALK and CALCAREOUS OOZE (may be drilling paste), with minor UNLITHIFIED RUDSTONE (probably drilling breccia). Strong odor of hydrogen sulfide.

CHALK and CALCAREOUS OOZE, various shades of white (7.5YR 8/0, 5Y 8/1, 10YR 8/1), occurs throughout the core as alternating layers; CHALK may be "drilling biscuits" with "drilling paste" of OOZE in between. CHALK is bioturbated and fractured; contains pyrite flecks. Some tarry organic matter is present in the CC, 33 cm.

UNLITHIFIED RUDSTONE, white (7.5YR 8/0), occurs in Section 1, 0-8 cm (drilling breccia?).

SMEAR SLIDE SUMMARY (%):

| | 2,75 |
|---|---|
| | D |
| COMPOSITION: | |
| Foraminifers | 5 |
| Nannofossils | 10 |
| Skeletal Fragments | 10 |
| Clasts | 15 |
| Micrite (+ arag. needles) | 60 |

SITE 633 HOLE A CORE 15X CORED INTERVAL 1811.1-1820.8 mbsl; 132.0-141.7 mbsf

TIME-ROCK UNIT: LATE MIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: A/G *Neogloboquadrina acostaensis* Zone (N16/N17); R/P ?

PHYSICAL PROPERTIES: ϕ=54.72 γ=1.84; 92%; ϕ=60.71 γ=1.92 Vp=2230 in liner ϕ=55.47 γ=1.87

Sections: 1, 2, 3, 4, CC

LITHOLOGIC DESCRIPTION

CHALK and CALCAREOUS OOZE (may be drilling paste). Strong odor of hydrogen sulfide noted.

CHALK and CALCAREOUS OOZE, various shades of white (2.5Y 8/0, 10YR 8/1, 2.5Y 8/2), occurs throughout the core as alternating layers; CHALK may be "drilling biscuits" with "drilling paste" of OOZE between. OOZE and CHALK contain silt to fine sand sized planktonic foraminifers and skeletal fragments. CHALK is highly fractured and occurs in small fragments. Some organic matter occurs in Section 4, 70 cm, and in the CC.

Strong $H_2S$ smell. Organic material at Section 4, 70 cm, and in CC.

SMEAR SLIDE SUMMARY (%):

| | 2,75 | 4,75 |
|---|---|---|
| | D | D |
| COMPOSITION: | | |
| Foraminifers | 5 | 5 |
| Nannofossils | 5 | 5 |
| Skeletal Fragments | 10 | 10 |
| Clasts | 5 | 15 |
| Micrite (+ arag. needles) | 75 | 65 |

**SITE 633 HOLE A CORE 16X CORED INTERVAL 1820.8-1830.5 mbsl; 141.7-151.4 mbsf**

TIME-ROCK UNIT: LATE MIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: *Neogloboquadrina acostaensis* Zone (N16/N17); NN11 (CN9b); Foraminifers F/P-M; Nannofossils A/M

PHYSICAL PROPERTIES: γ =1.88 φ =52.44; γ =1.82 φ =56.2 Vp=3571; γ =1.79 φ =56.25

CHEMISTRY: 91%

SECTION: 1, 2, 3, 4, 5, 6, 7, CC

METERS: 0.5, 1.0

SAMPLES: IW

LITHOLOGIC DESCRIPTION

CHALK and CALCAREOUS OOZE (may be drilling paste). Strong odor of hydrogen sulfide noted.

CHALK and CALCAREOUS OOZE, white (2.5Y 8/0, whiter than 5Y 8/1), occurs throughout core as alternating layers; CHALK may be "drilling biscuits" with "drilling paste" of OOZE in between. OOZE varies between soft and stiff; CHALK is partially indurated, sandy, slightly bioturbated and highly fractured. Some moldic porosity in CHALK. Organic matter is present in Section 2.

SMEAR SLIDE SUMMARY (%):

COMPOSITION:

| | 2,75 | 4,75 | 6,75 |
|---|---|---|---|
| Foraminifers | 5 | 15 | 10 |
| Nannofossils | 60 | 60 | 45 |
| Skeletal Fragments | 5 | 10 | 15 |
| Clasts | 10 | 5 | 10 |
| Micrite (+ arag. needles) | 20 | 10 | 20 |

**SITE 633 HOLE A CORE 17X CORED INTERVAL 1830.5-1839.1 mbsl; 151.4-160.0 mbsf**

TIME-ROCK UNIT: LATE MIOCENE

BIOSTRAT. ZONE / FOSSIL CHARACTER: Indeterminate; Foraminifers F/M; Nannofossils B

PHYSICAL PROPERTIES: γ =2.39 φ =23.8 Vp=4378

CHEMISTRY: 96%

SECTION: 1, CC

LITHOLOGIC DESCRIPTION

LIMESTONE, LITHIFIED GRAINSTONE and LITHIFIED PACKSTONE (may be drilling breccia, in part). Odor of hydrogen sulfide noted.

LIMESTONE, white (2.5Y 8/1, 5Y 8/2, 10YR 8/2), occurs as fragments in Section 1, 0-25 cm. Burrow mottles, sand-filled burrows, moldic porosity and foraminifers (miliolids and planktonic) are present.

LITHIFIED GRAINSTONE and LITHIFIED PACKSTONE, white (10YR 7/2), present in Section 1, 25 cm through base of the core. Contain foraminifers, skeletal fragments and flecks of organic matter. Material in CC is highly fragmented and may be drilling breccia.

**SITE 633 HOLE A CORE 18X CORED INTERVAL 1839.1-1848.7 mbsl; 160.0-169.6 mbsf**

TIME-ROCK UNIT: LATE MIOCENE ?

BIOSTRAT. ZONE / FOSSIL CHARACTER: Foraminifers R/P ?; Nannofossils R/P ?

PHYSICAL PROPERTIES: γ =2.14 φ =33.55 Vp=1825

CHEMISTRY: 96%

SECTION: 1, CC

METERS: 0.5

LITHOLOGIC DESCRIPTION

LIMESTONE, CHALK and CALCAREOUS OOZE; may be drilling breccia. Organic odor noted.

LIMESTONE and CHALK, various shades of white (5Y 8/1, 2.5Y 8/1, 2.5Y 8/0, 2.5Y 8/2), and CALCAREOUS OOZE, very pale brown (10YR 8/3) to white (2.5Y 8/0), occur throughout core; may be drilling breccia. LIMESTONE occurs in Section 1, 0-35 cm, and CHALK occurs in Section 1, 35-76 cm, and in the CC, both as fragments in a drilling paste of OOZE.

**SITE 633 HOLE A CORE 19X CORED INTERVAL 1848.7-1858.4 mbsl; 169.6-179.3 mbsf**

BIOSTRAT. ZONE / FOSSIL CHARACTER: Indeterminate; Foraminifers R/P; Nannofossils R/P ?

PHYSICAL PROPERTIES: γ=1.96 φ=49.44 Vp=1824

CHEMISTRY: 93%

SECTION: 1, CC

METERS: 0.5, 1.0

LITHOLOGIC DESCRIPTION

LITHIFIED GRAINSTONE, LITHIFIED PACKSTONE and CALCAREOUS OOZE; may be drilling breccia. Odor of hydrogen sulfide noted.

LITHIFIED GRAINSTONE and LITHIFIED PACKSTONE, light gray (2.5Y 7/2), occur in fragments throughout the core, may be drilling breccia. Fine sand sized skeletal fragments and foraminifers present; organic flecks throughout. Some intervals laminated.

CALCAREOUS OOZE, light gray (2.5Y 7/2), occurs as a drilling paste, particularly in soupy material in Section 1, 37-84 cm, and in the CC.

SITE 633 HOLE A CORE 20X CORED INTERVAL 1858.4-1868.0 mbsl; 179.3-188.9 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BARREN | BARREN | | | | Vp=4445 φ=14.25 ρ=2.47 ● | | 1<br>CC | | | | | | |

LITHIFIED GRAINSTONE and LIMESTONE (probably drilling breccia)

LITHIFIED GRAINSTONE, white (2.5Y 8/2) and light brownish gray (2.5Y 6/2), occurs in Section 1, 0-10 cm. Fragments contain flecks of organic matter and fine sand-sized foraminifers and bioclasts, also cross laminations, climbing ripples and flame structures (probably drilling breccia).

LIMESTONE, white (2.5Y 8/2), occurs in CC. Fragments are burrowed, with some burrows 1 to 3 cm in diameter and sand-filled; several generations of burrows are present (probably drilling breccia).

SITE 633 HOLE A CORE 21X CORED INTERVAL 1868.0-1877.6 mbsl; 188.9-198.5 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LATE MIOCENE | *Neogloboquadrina acostaensis* Zone (N16/N17)<br>R/P | ?<br>R/P | | | | ● ρ=2.04 φ=41.49 V=2080 in liner | ● 95% | 1<br>2<br>CC | 0.5<br>1.0 | | | | * | |

CHALK and CALCAREOUS OOZE. Odor of hydrogen sulfide noted.

CHALK and CALCAREOUS OOZE, white (5Y 8/1, 7.5YR 8/0), alternate throughout core. CHALK is highly fractured, Bioturbation evident in larger fragments. Some flecks of organic matter present. OOZE may be "drilling paste."

SMEAR SLIDE SUMMARY (%):

| | 2,30 |
|---|---|
| **COMPOSITION:** | |
| Foraminifers | 5 |
| Nannofossils | 40 |
| Skeletal Fragments | 15 |
| Clasts | 5 |
| Micrite (sparse needles) | 35 |

SITE 633 HOLE A CORE 22X CORED INTERVAL 1877.6-1887.3 mbsl; 198.5-208.2 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LATE MIOCENE | *Neogloboquadrina acostaensis* Zone (N16/N17)<br>A/G | NN11 (CN9b) | | | | | | 1<br>2<br>3<br>4<br>5<br>CC | 0.5<br>1.0 | | | | IW<br>*<br>* | |

UNLITHIFIED GRAINSTONE (probably downhole contamination) with minor UNLITHIFIED PACKSTONE, CALCAREOUS OOZE and CHALK (possibly drilling breccia)

UNLITHIFIED GRAINSTONE, white (10YR 8/1), occurs from Section 1, 0 cm, through Section 3, 140 cm. Contains coarse to very coarse grained material including pteropods, *Halimeda*, *Homotrema*, bivalves, gastropods, echinoid spines, mud balls up to 2 cm diameter and rust flakes.

UNLITHIFIED PACKSTONE, white (10YR 8/1), occurs in Section 5, 0-33 cm. Soup; contains pteropods, echinoid spines, bivalve fragments, *Halimeda*, balls of soft OOZE and black drillpipe fragments.

CALCAREOUS OOZE and CHALK, white (10YR 8/2, 7.5YR 8/0), occurs in Section 1, 33-43 cm (OOZE only), and in the CC. CHALK is fractured and fragmented by drilling, and may be drilling breccia.

SMEAR SLIDE SUMMARY (%):

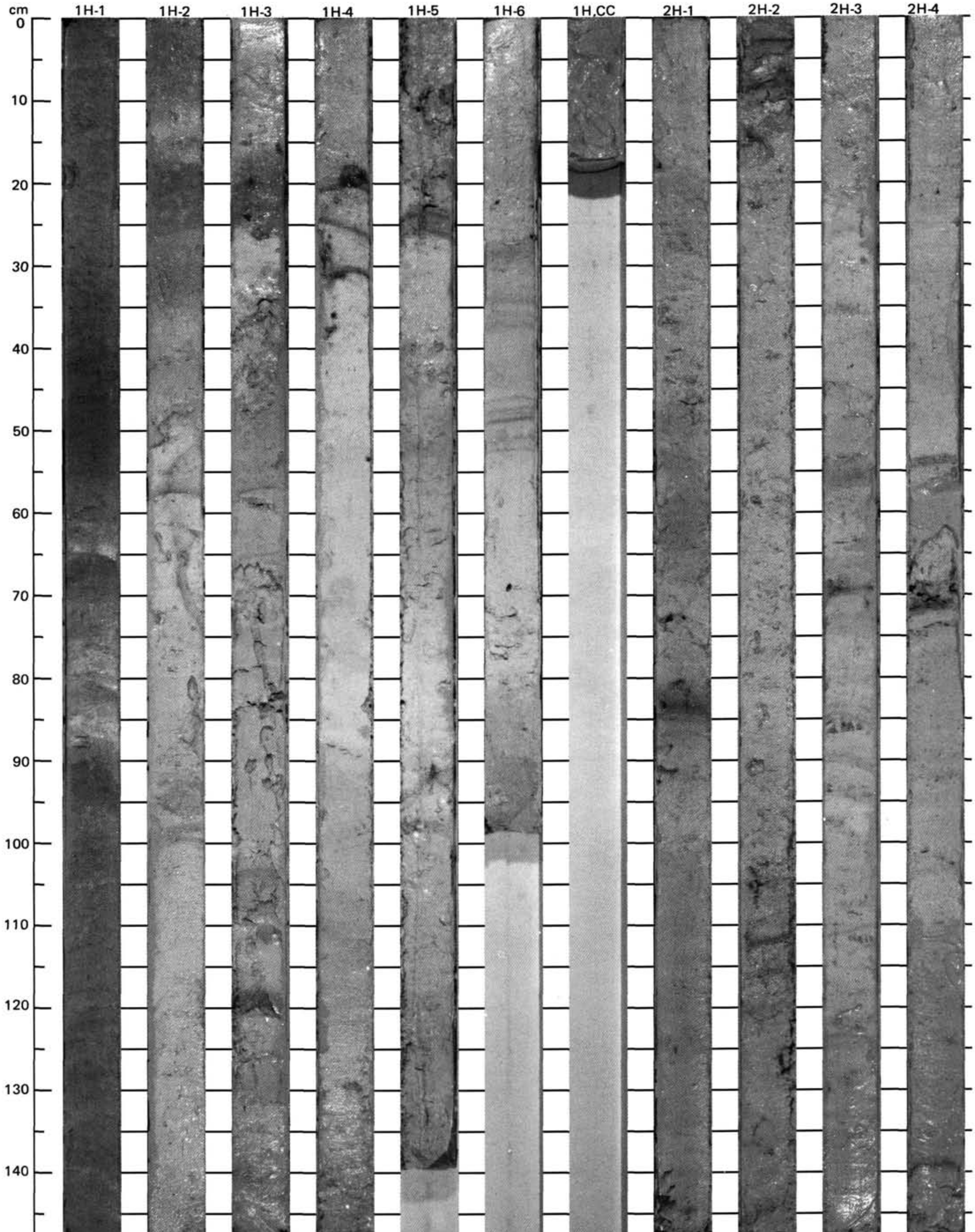
| | 5,36 | CC,22 |
|---|---|---|
| | D | D |
| **COMPOSITION:** | | |
| Foraminifers | 5 | Tr |
| Nannofossils | 25 | 20 |
| Sponge Spicules | Tr | – |
| Skeletal Fragments | 30 | 20 |
| Clasts (cemented aggregates) | | |
| Micrite | 10 | 15 |
| Pteropods | 30 | 45 |

SITE 633 HOLE A CORE 23X CORED INTERVAL 1887.3-1896.9 mbsl; 208.2-217.8 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LATE MIOCENE | F/M *Neogloboquadrina acostaensis* Zone N16/N17 | R/P ? | | | | Vp=3138 $\phi$=38.79 $\rho$=2.06 ● | 96% ● | 1<br>CC | 0.5<br>1.0 | | | | | CALCAREOUS OOZE and CHALK with minor LIMESTONE (possibly drilling breccia)<br><br>CALCAREOUS OOZE and CHALK, light gray (2.5Y 7/2) to white (10YR 8/2), occur as intermixed fragments in Section 1, 0 cm, through the CC, 30 cm. Some burrows may be present in the OOZE.<br><br>LIMESTONE, white (7YR 8/0), occurs in the CC, 30-40 cm, as fragments. |

SITE 633 HOLE A CORE 24X CORED INTERVAL 1896.9-1906.4 mbsl; 217.8-227.3 mbsf

| TIME-ROCK UNIT | FORAMINIFERS | NANNOFOSSILS | RADIOLARIANS | DIATOMS | PALEOMAGNETICS | PHYSICAL PROPERTIES | CHEMISTRY | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURB. | SED. STRUCTURES | SAMPLES | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ? | BARREN | BARREN | | | | ● Vp=3773 | | 1<br>CC | 0.5 | | | | | LIMESTONE, LITHIFIED GRAINSTONE and LITHIFIED PACKSTONE<br><br>LIMESTONE, LITHIFIED GRAINSTONE and LITHIFIED PACKSTONE, white (2.5Y 8/2), occur as fragments throughout core. Grading observed in GRAINSTONE fragment in Section 1, 82-87 cm; moldic porosity and some hydrocarbon specks also noted in GRAINSTONE. |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100
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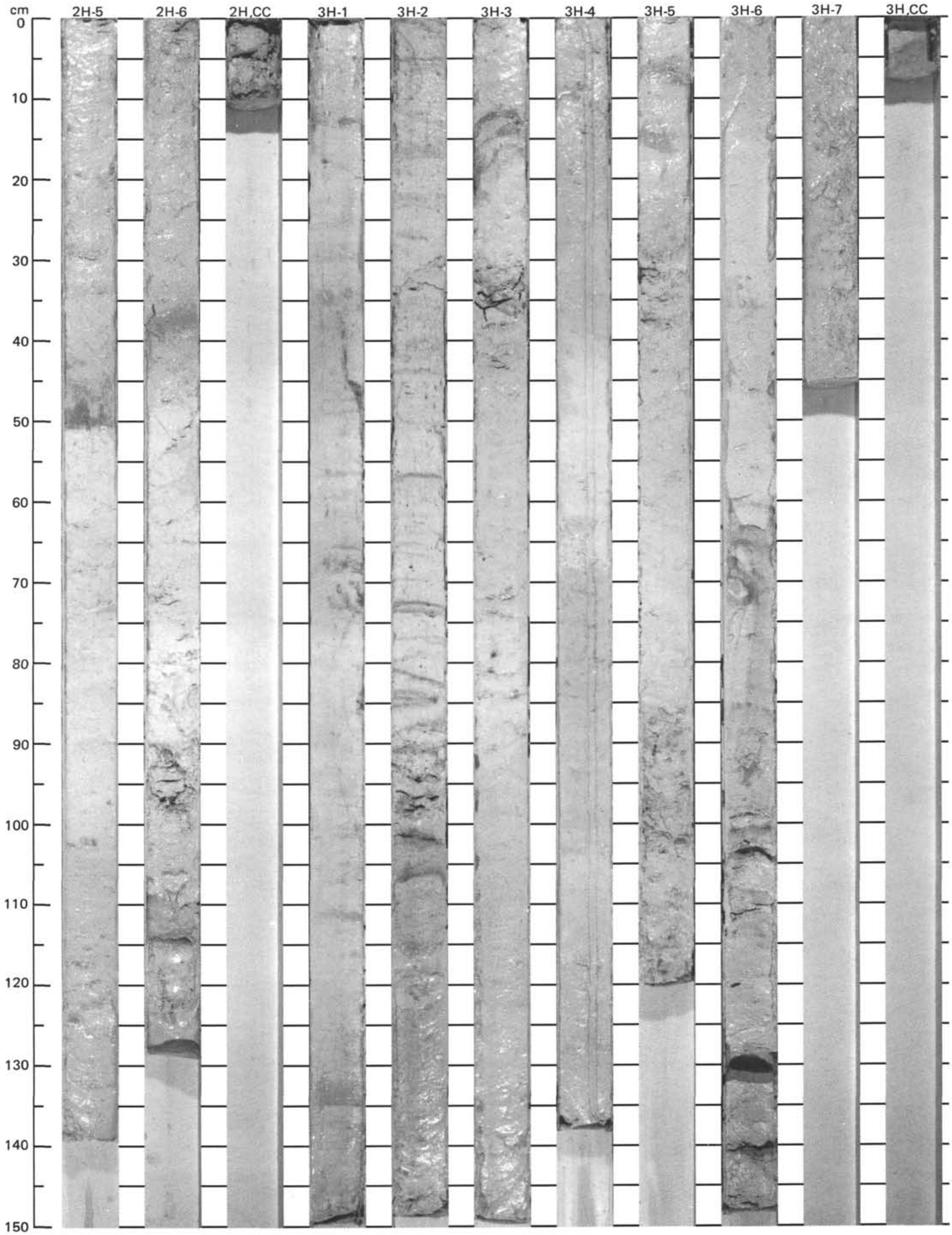
120
130
140
150
1H-1
1H-2
1H-3
1H-4
1H-5
1H-6
1H,CC
2H-1
2H-2
2H-3
2H-4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100
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120
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140
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2H-5
2H-6
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3H-5
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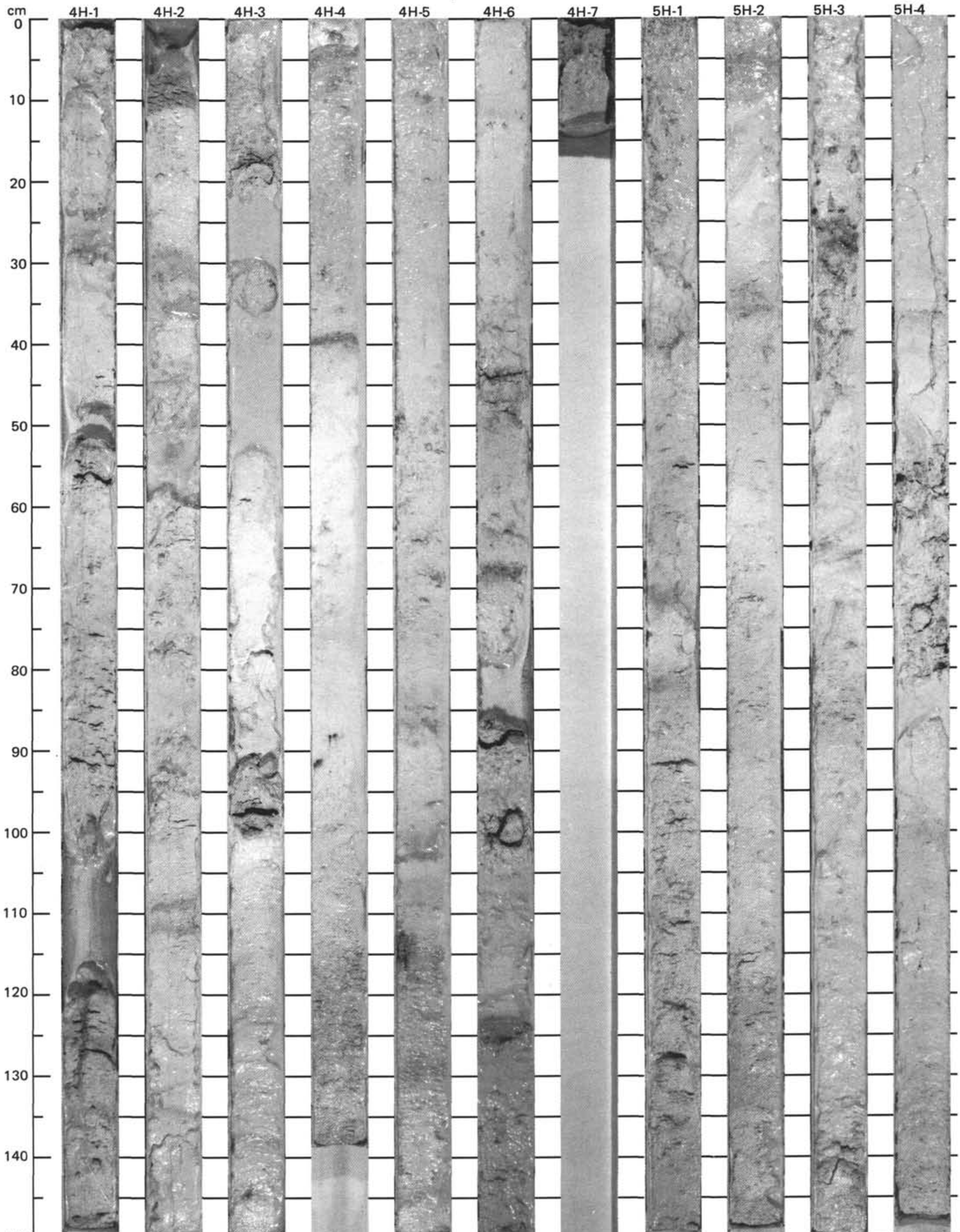
3H-7
3H,CC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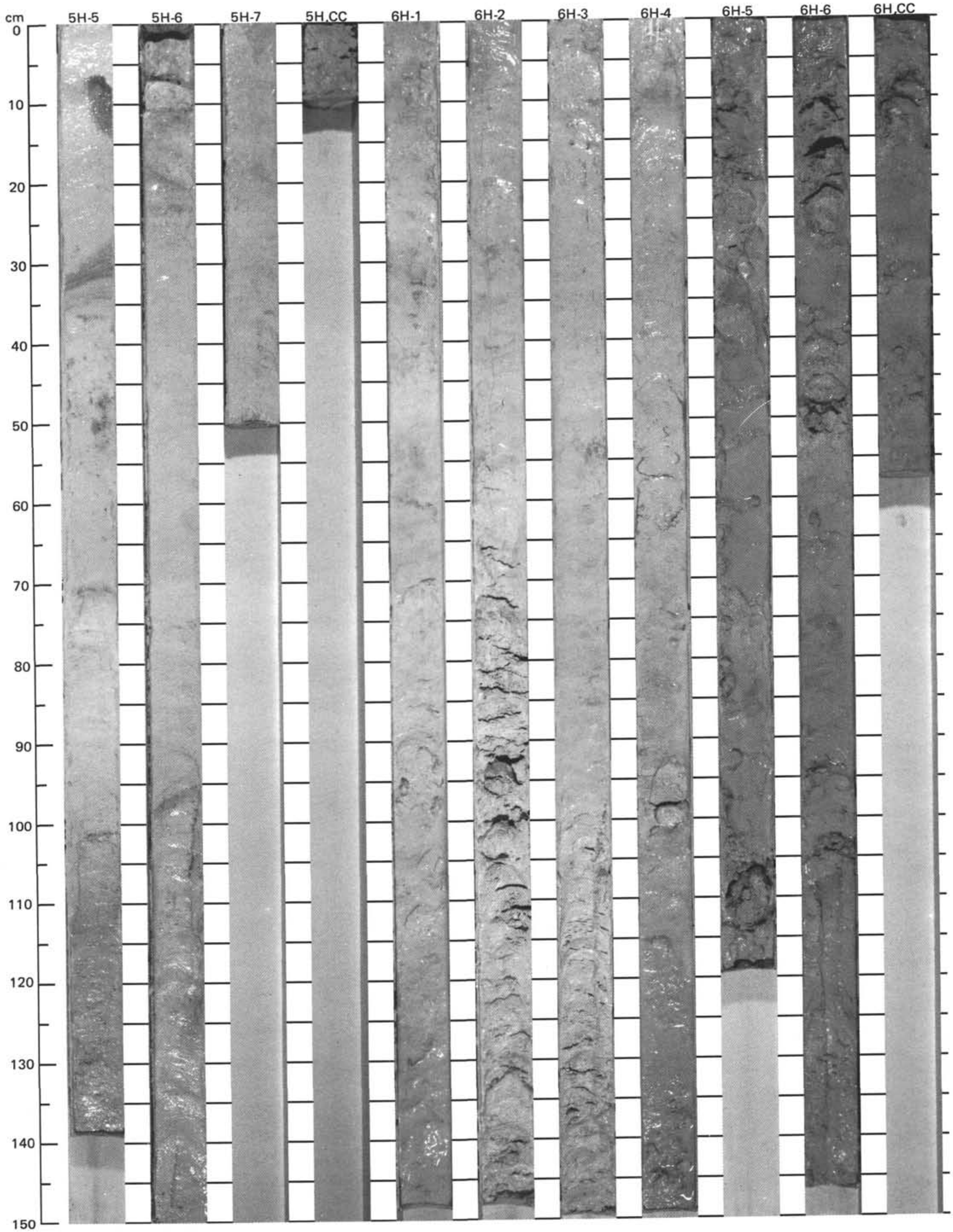
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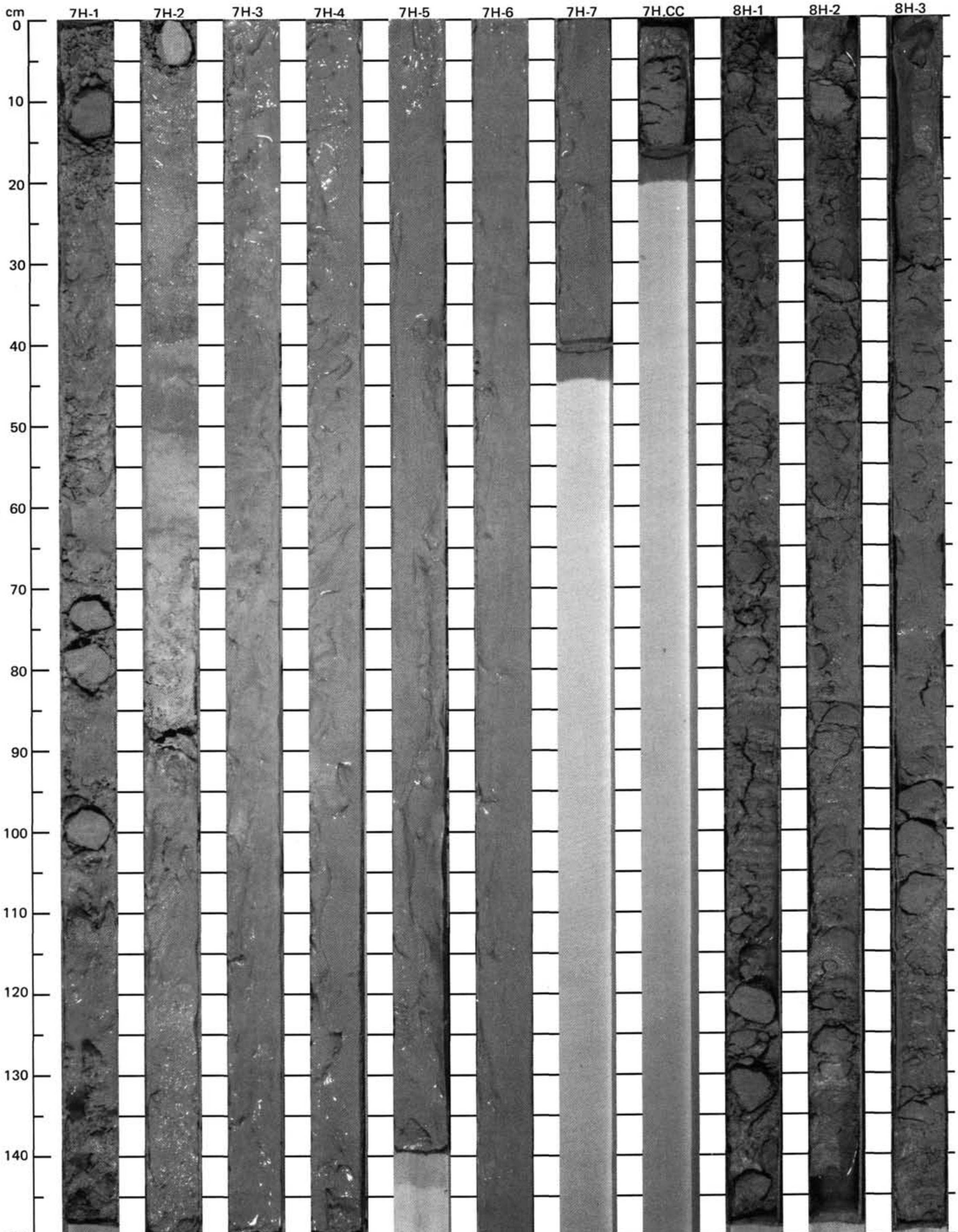
6H-6
6H,CC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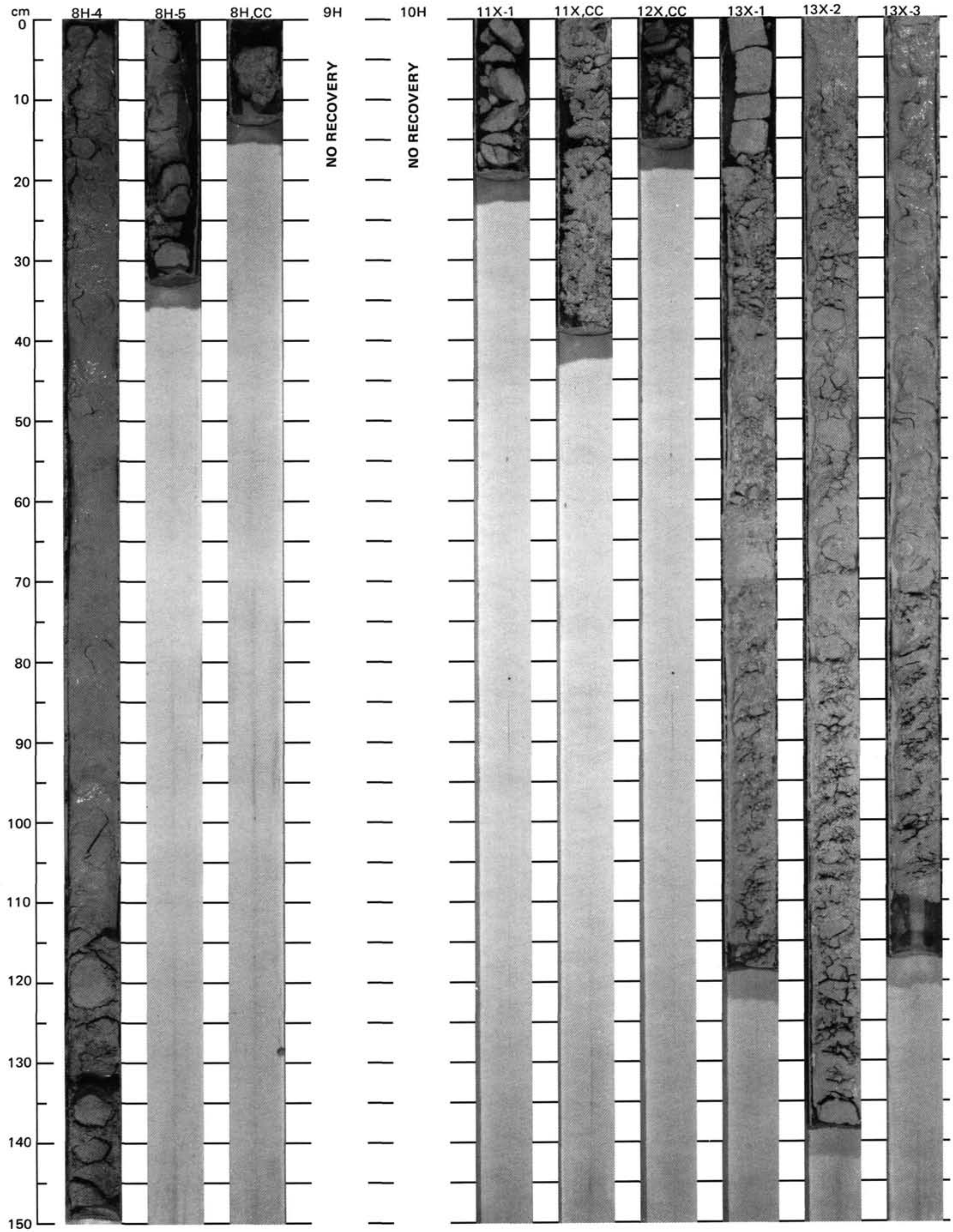
7H-7
7H,CC
8H-1
8H-2
8H-3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9H
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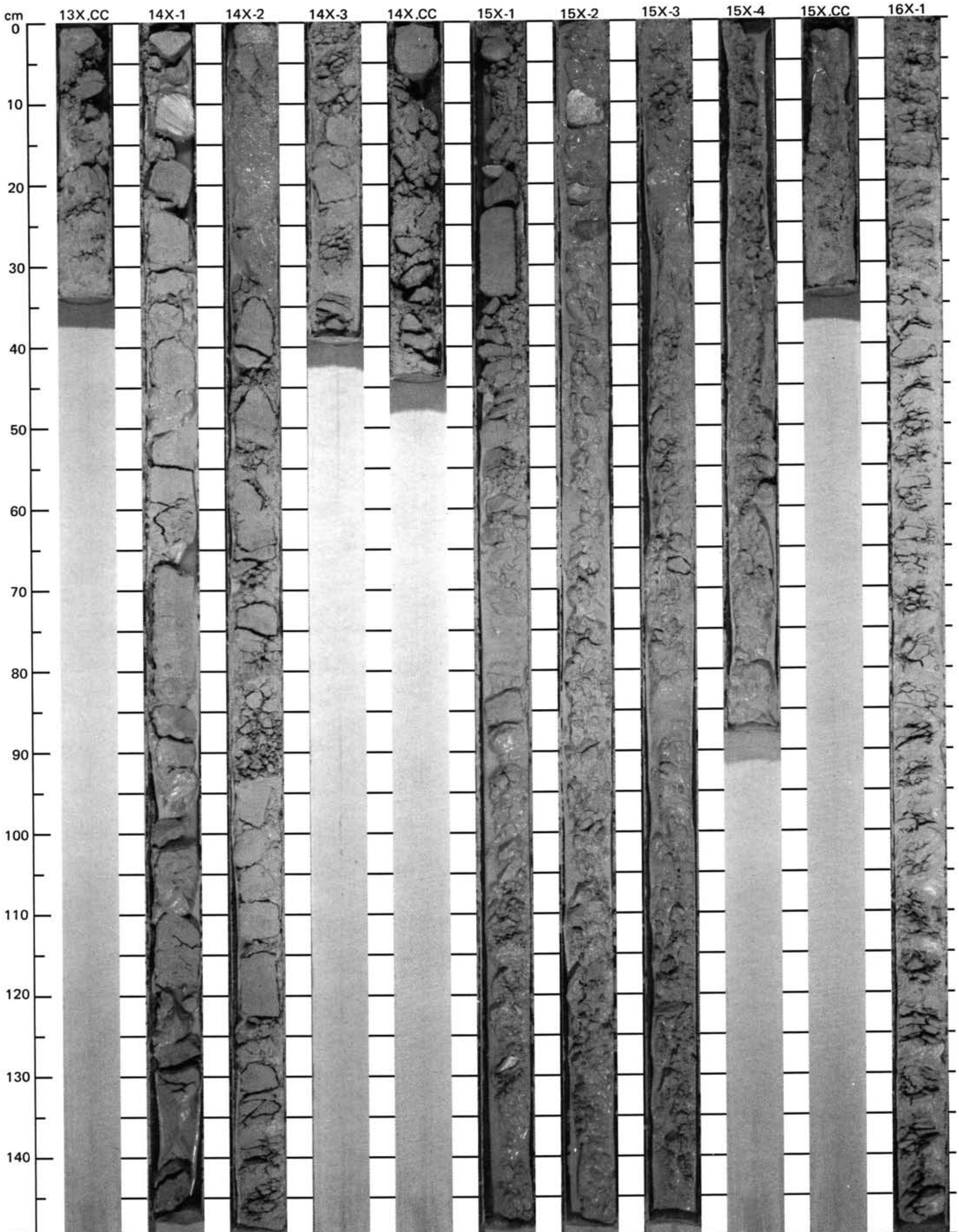
12X,CC
13X-1
13X-2
13X-3



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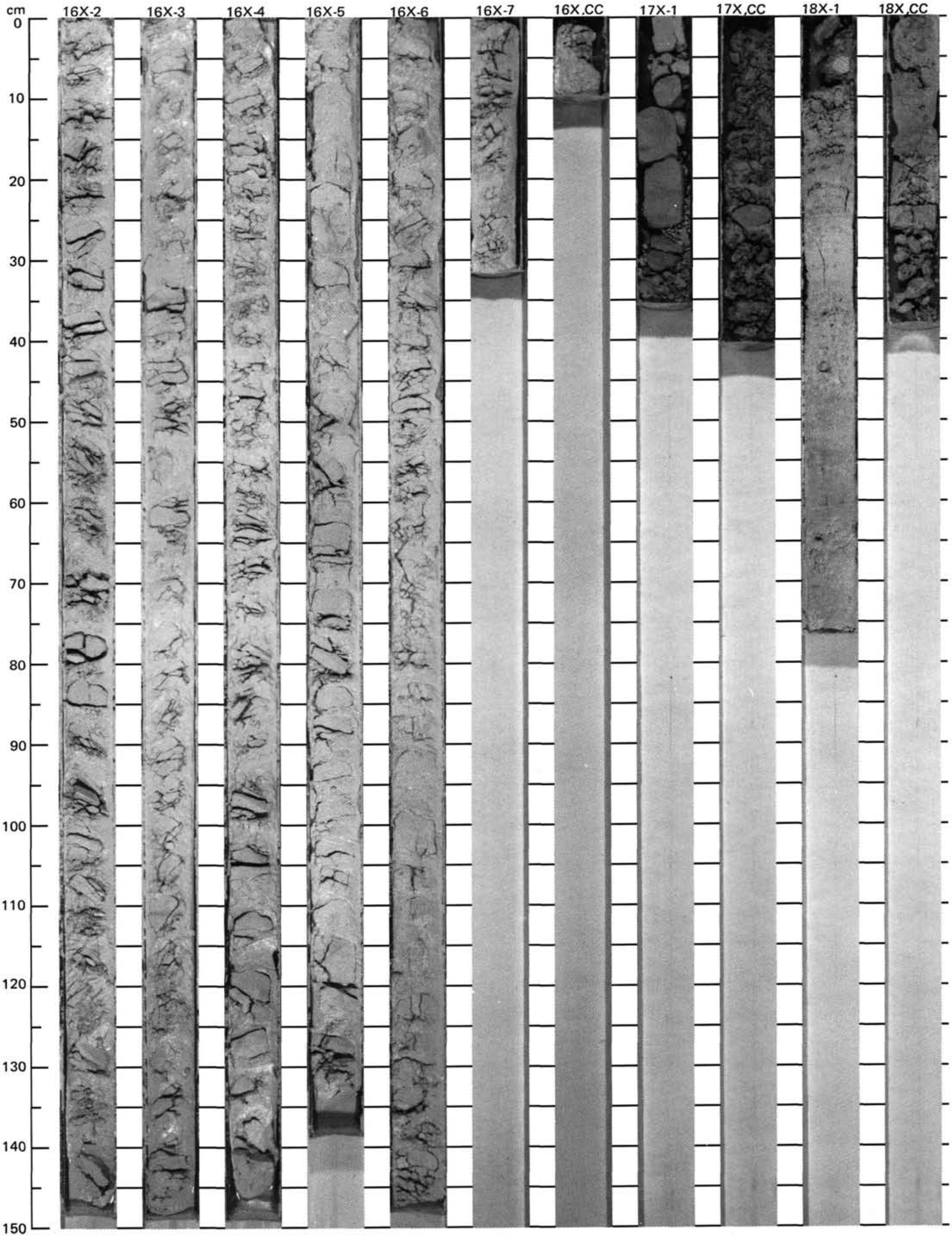
140
150
13X,CC
14X-1
14X-2
14X-3
14X,CC
15X-1
15X-2
15X-3
15X-4
15X,CC
16X-1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16X-7
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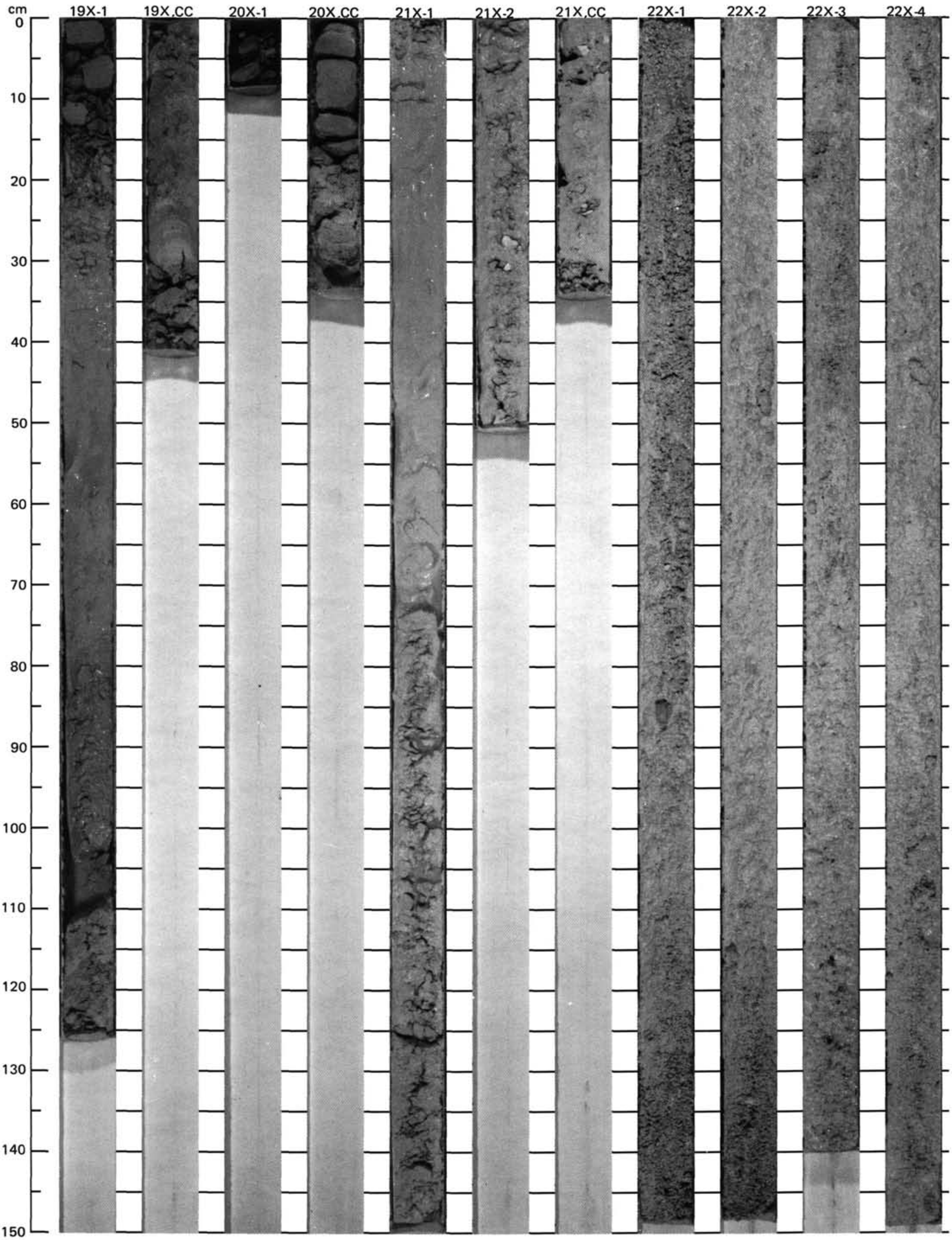
17X-1
17X,CC
18X-1
18X,CC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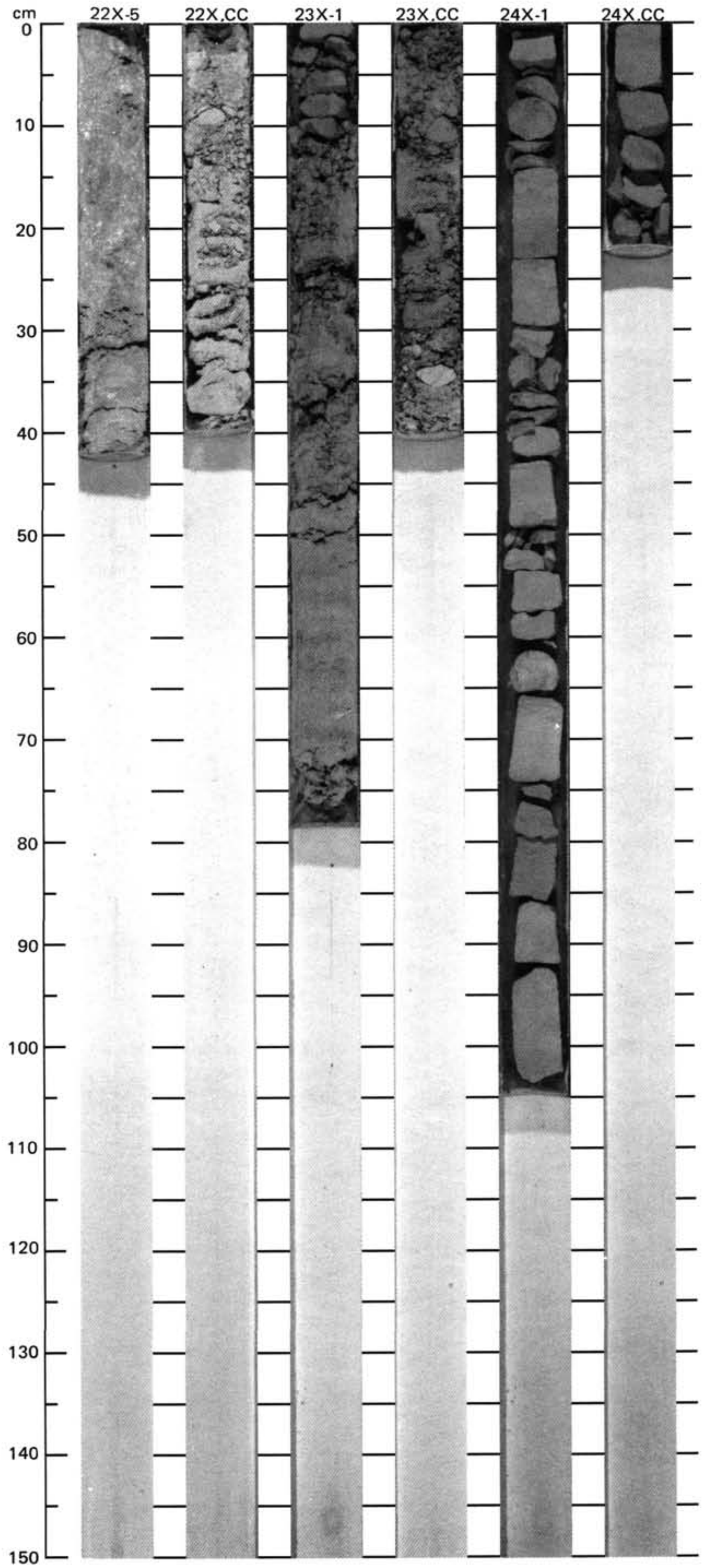
22X-4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23X-1
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24X,CC