# 3. SITE 315

The Shipboard Scientific Party[1]

## SITE DATA

**Date Occupied:** 13 November 1973 (0200Z)

**Date Departed:** 19 November 1973 (1430Z)

**Time on Site:** 114.5 hours

**Position:**
  Latitude: 4°10.26'N
  Longitude: 158°31.54'W

**Water Depth (sea level):** 4152 corrected meters, echo sounding

**Water Depth (rig floor):** 4162 corrected meters, echo sounding

**Bottom Felt at:** 4164 meters, drill pipe

**Penetration:**
  Hole 315: 85 meters
  Hole 315A: 1034.5 meters

**Number of Holes:** 2

**Number of Cores:**
  Hole 315: 4
  Hole 315A: 34

**Total Length of Cored Section:**
  Hole 315: 37.5 meters
  Hole 315A: 323.0 meters

**Total Core Recovered:**
  Hole 315: 17.2 meters
  Hole 315A: 130.5 meters

**Percentage Core Recovery:**
  Hole 315: 45.9%
  Hole 315A: 40.4%

**Oldest Sediment Cored:**
  Depth below sea floor:
    Hole 315: 65.0 meters
    Hole 315A: 996.3 meters
  Nature
    Hole 315: Gray foram nannofossil ooze
    Hole 315A: Green siltstone interlayered with brown mudstone
  Age:
    Hole 315: Lower Pliocene
    Hole 315A: Upper Cretaceous (Santonian or older)
    Measured velocity:
      Hole 315: 1.55 km/sec
      Hole 315A: 2.0 km/sec

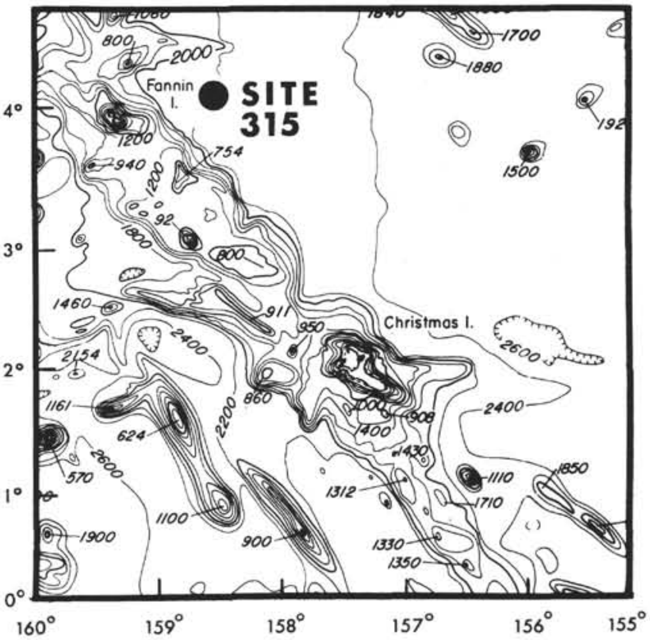

Figure 1. *Location of Site 315; bathymetry by Chase, et al., (1970).*

**Basement:**
  Depth below sea floor:
    Hole 315: Not reached
    Hole 315A: 996.3-1034.5 meters
  Nature:
    Hole 315: n.a.
    Hole 315A: Basalt
  Velocity:
    Hole 315: n.a.
    Hole 315A: 4.0 km/sec

**Principal Results:** Spudded into late Pleistocene foram-nannofossil oozes; spot cored through late Pliocene to late Paleocene oozes, chalks, limestones, and cherts, into Cretaceous limestones, shales, and volcanogenic sands of Santonian or older age. These sands probably record the growth and erosion of the volcanic edifice of Fanning Island. Redeposited shallow-water skeletal debris including large foraminifers, bryozoans, rudistids, and calcareous algae of probable Late Cretaceous age suggest the growth of reefs or banks on the Fanning edifice following the cessation of volcanism. Drilled and cored 38.2 meters of probable alkalic basalt that represents at least six flow units related to the Fanning edifice. The section is much like that encountered at Site 165, Leg 17 (Winterer, Ewing, et al., 1973), except that the Quaternary section is present here and the Tertiary section is considerably thicker here. The basalt drilled at Site 315 appears to be the same age as that drilled at Site 165, which is approximately 780 km further north along the Line Islands chain.

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## BACKGROUND AND OBJECTIVES

The objectives of Site 315 (Figure 1) were: (1) to determine the date of cessation of volcanism at this south central point of the Line Islands chain; (2) to study the volcanic petrology of the Line Islands province; (3) to determine the post-volcanic history of the Line Islands ridge by a study of the turbidite debris and other sedimentary rocks above the volcanic basement; and (4) to gain an understanding of the sedimentological history, of the large fans that surround the Line Islands ridge—in this case, the fan nearest Fanning Island.

These objectives, we felt, could only be completely met by a program of continuous coring. Airgun profiles (Figure 2) provided by *Vema*-24 (17 March 1971, record 383-384), and interpretations of Hawaii Institute of Geophysics (HIG) records (Figure 3), suggested a stratigraphic thickness to acoustic basement near Site 315 of approximately 0.85 sec. Accordingly, 6.5 days were allotted for continuous coring at the site. At the time these objectives were set, we planned to allow 4.3 steaming days from Site 314 to Site 315. After departure from Site 314 on 7 November (1500 local), however, we learned on 9 November (1530 local) that a coil, for which we had no replacement, had burned out in the main engine system. This resulted in an actual sailing time to the beacon drop at proposed Site 315 of more than 5 days, which effectively cut 1 day from our projected drilling time. Furthermore, on approaching the site, our own airgun profiles revealed a deeper reflector indicating a considerably thicker section (0.95 sec) than we had anticipated (see Figure 4). Our drilling program was, because of time and thickness considerations, revised to a spot-coring program by which we at least hoped to sample the major reflectors in the section.

With the unanticipated loss of the bottom-hole assembly due to faulty positioning on 13 November (see Operations), a third spot-coring plan was devised to salvage as many of the original objectives as possible in the approximately 3.9 drilling days still available.

## OPERATIONS

### Predrilling Site Survey

Site 315 (Fanning Fan East) was originally selected on the basis of available *Vema*-24 (LDGO) profiles and published interpretations (Winterer, Riedel, et. al., 1971) of *Mahi* 1968 (HIG) profiles (Figures 2, 3) that showed a thick section of up to 0.8 sec thickness of presumed submarine fan deposits, over probable Eocene cherts, Mesozoic sediments, and basement. A site within an island- and peak-bounded trough was considered optimal in this area, so that the provenance of any turbidite sediments would not be problematical. In Honolulu a number of HIG profiles near Fanning Island, including the *Mahi* December 1968 records, were obtained and the final site was selected at approximately the *Mahi* 1200Z, 12 December 1968 location. There, 0.95 sec of total section includes reflectors at 0.15, 0.40, 0.65, and 0.70 sec. The last reflector was postulated to be the Eocene chert horizon. As shown in Figure 5, we attempted to maneuver onto the *Mahi* line (Later plotting showed us to be several miles to the northwest) by changing course from 133° to 245° at 1430 (local) 12 November; the almost perfect resemblance of the *Glomar Challenger* profile to the *Mahi* profile induced us to drop the beacon at 1600 hr, steam on, turn 180° and occupy Site 315. The *Glomar Challenger* seismic profile at the site shows reflectors at 0.15, 0.28, 0.40, 0.65, 0.70, and 0.74 and a very vague, cloudy reflector at about 0.95 sec (Figure 2); the last two reflectors were taken to represent the Eocene chert beds, and the basaltic basement, respectively. The depth to basalt was estimated as approximately 800 meters. The *Glomar Challenger* profile leaving Site 315 is shown is Figure 4a.

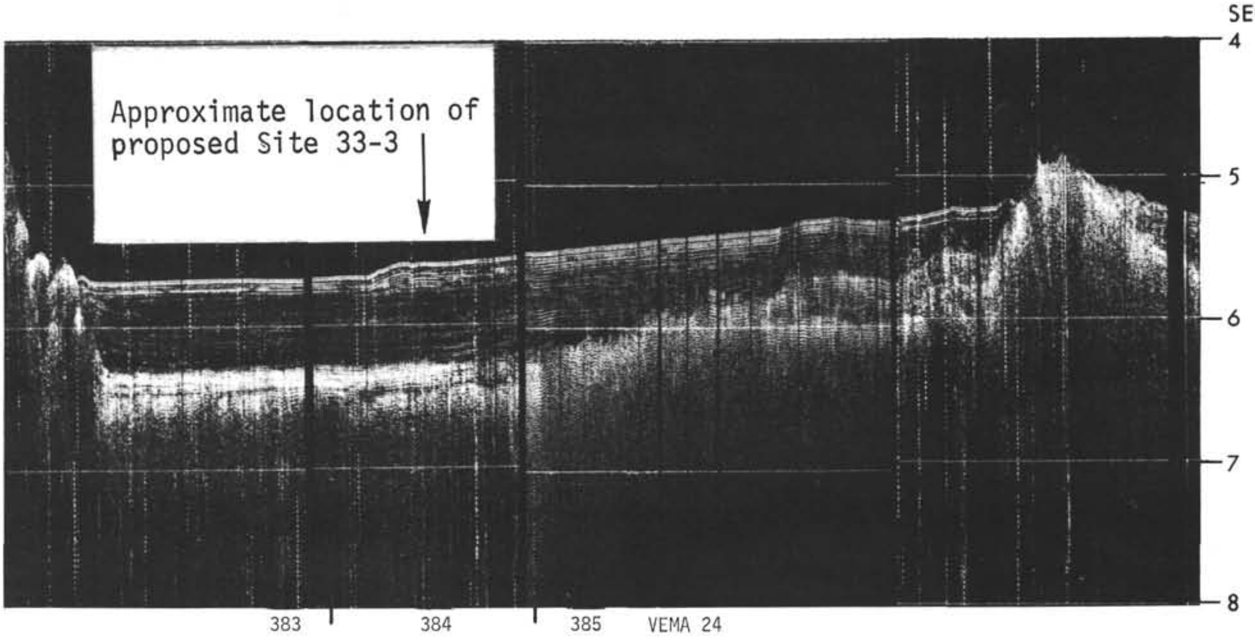

Figure 2. Vema-*24 (LDGO) seismic reflection profile used in precruise planning, showing location of Site 315 (proposed Site 33-3); see Figure 5 for line of profile.*

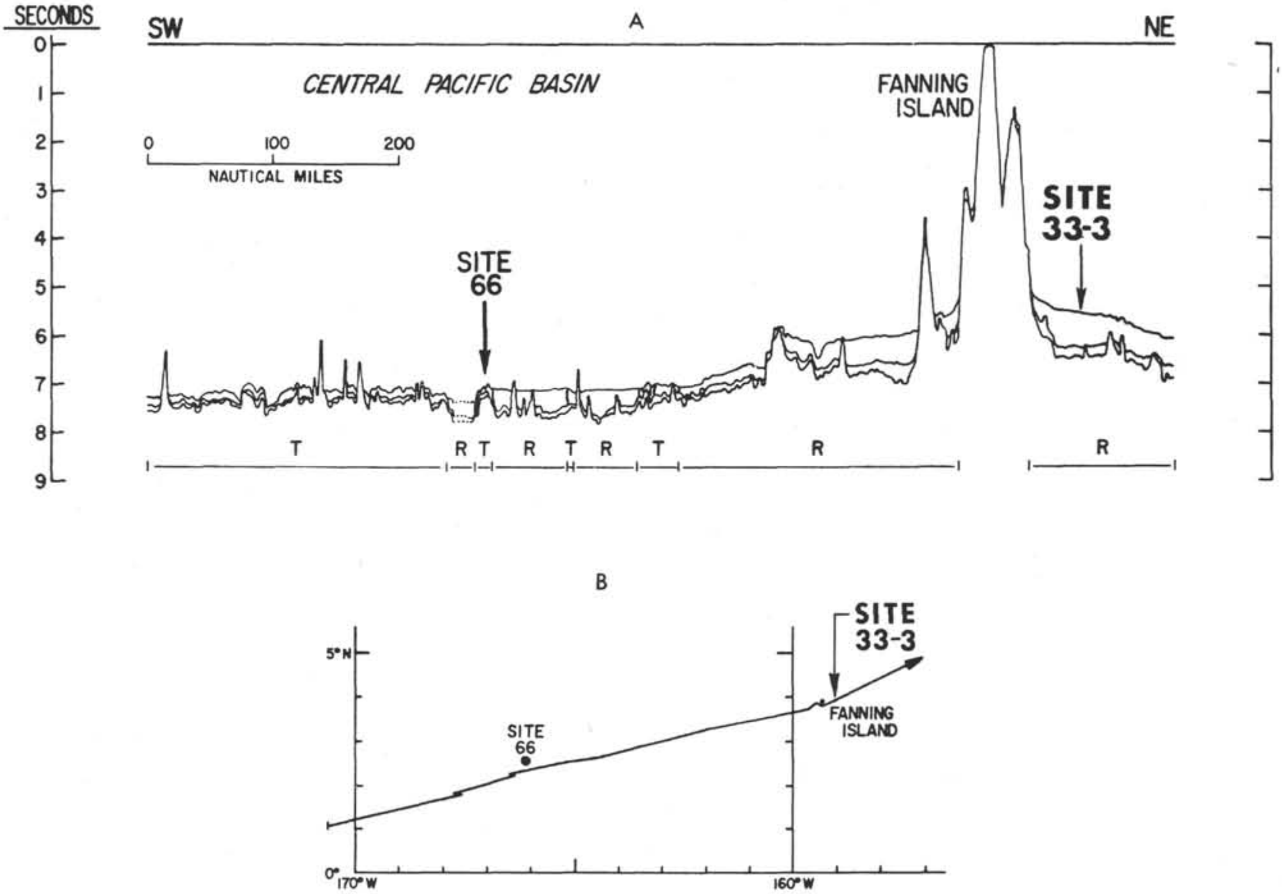

Figure 3. *(A) Line drawing of Hawaii Institute of Geophysics (HIG) seismic reflection profile in the vicinity of DSDP Site 66 and proposed Site 33-3 (Site 315) showing thin upper transparent layer (T) of central basin and thicker, more reflective upper layer (R) near Line Islands. (B) Ship's track for this profile. (From Winterer, Riedel, et al., 1971.)*

The PDR depth of 2211.5 fathoms at Site 315 was corrected to 4146 meters (Matthew's tables, Area 41) giving a derrick floor to mudline depth of 4162 meters. The drill pipe length to bottom was 4164 meters and this value was adopted as the drill floor to mudline depth. When Site 315 was respudded on 15 November in preparation for drilling Hole 315A, drill pipe length to mudline was again 4164 meters.

### Sonobuoy Survey

A sonobuoy was launched as soon as practicable, at 1900 (local 12 November, almost immediately after arrival at Site 315, and 3 hr of sonobuoy record were obtained. The batteries lasted 3 hr, during which time the sonobuoy drifted approximately 9 km (6 sec *D*) at a steady rate. Interval velocities were estimated using the inverse slope ratio method and are discussed in detail below.

### Drilling Program

The first core was a punch core that recovered 9 meters of white nannofossil ooze. A regular core barrel with a plastic sock was then inserted, and an attempt made to core the interval 9.0-18.5 meters. In this case, the sock tore loose, jammed the check valve, and only a few grams of material were recovered in the catcher. At this time we withdrew from the hole, reentered, and again attempted to core the same interval; again we recovered little sample. We then washed to a depth of 4220.5 meters and cored the interval 55.5-65.0 meters below bottom, achieving 86% recovery of lower Pliocene, gray, foraminifer-nannofossil ooze. Drilling was continued to a depth of about 85 meters, when at 0836, we were advised by the bridge that we were more than 1000 meters off beacon and instructed to pull clear of the mudline immediately. On pulling the drill string, the bottom-hole assembly was found to have suffered extensive damage due to the excursion.

The damage was repaired in about 24 hr, and we spudded in a second time, on beacon, and at the same water depth (4164.0 m) at 1000 (local), 14 November, having lost 1 day drilling time. The new hole (315A) was immediately washed down to 4239.5 meters and the spot coring program resumed. No further complications ensued, and we drilled a total of 1034.5 meters below mudline, cored a total of 323.0 meters and recovered 130.5 meters of core. Bit wear was minimal, in spite of drilling nearly 60 meters of chert and 40 meters of basalt. (We were later advised that a bearing on one bit cone had failed.) A total of 34 cores was taken, the last at 1505 (local), 18 November. At that time the string was pulled, and stowed at 0400 (local), 19 November. A summary of drilling results is given in Table 1.

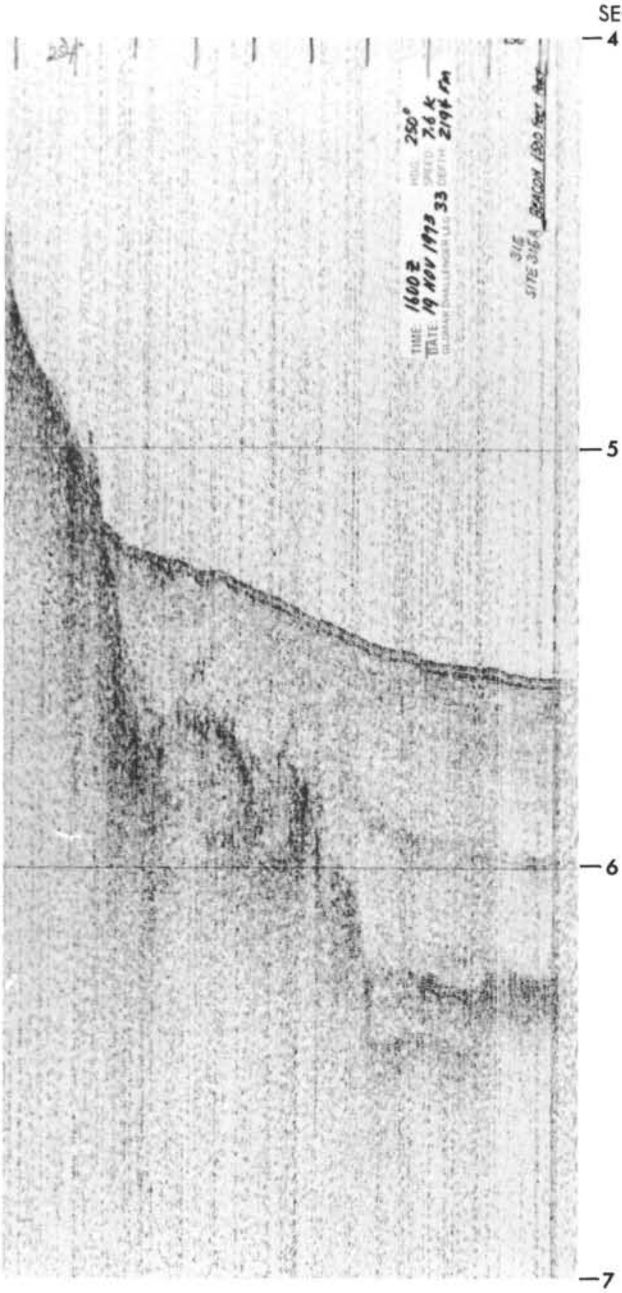

Figure 4a. Glomar Challenger *seismic reflection profile departing from site; see Figure 5 for line of profile.*

Modification of the heave compensation apparatus continued during the entire drilling period, although at the cessation of drilling, the device was still not ready for operational testing.

### Port Call

*Glomar Challenger* had arranged to rendezvous at Fanning Island to land an engineer and to take on parts flown in from Honolulu. The vessel departed Site 315 at 0430 (local), 19 November. The ship's track therefore shows a somewhat circuitous route from Site 315 (Fanning Fan East) to Site 316 (Line Islands South).

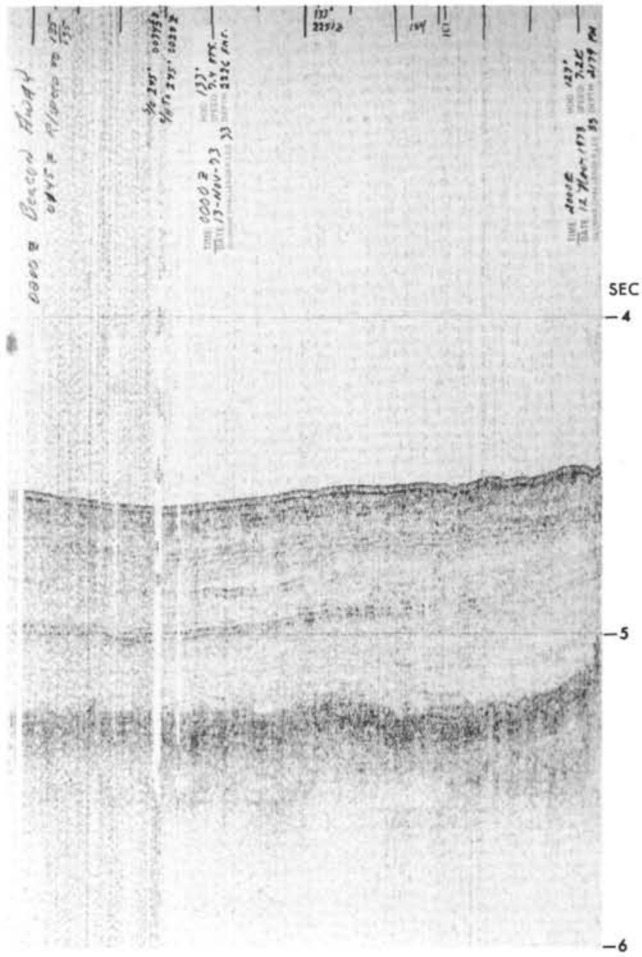

Figure 4b. Glomar Challenger *on approach to site; see Figure 5 for line of profile.*

## LITHOLOGIC SUMMARY

### Sedimentary Rocks

Five major lithologic units have been defined above basalt at this site (Figure 6).

Unit 1 (0-56 m)—Cyclic ooze: A unit of white to pale yellowish and dark brownish foraminifer-nannofossil and radiolarian-nannofossil oozes. These are represented by Cores 1 and 2 from Hole 315.

Unit 2 (56-710 m)—Variegated ooze: A sequence of pale purple, green, and white foraminifer-nannofossil to radiolarian-nannofossil oozes, represented in Cores 1A through 8A, and part of 9A.[2]

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[2] Here, and elsewhere in the present volume, where holes are not specified cores are, for convenience, referred to holes by following the core number with the hole designation. Thus, cores from Hole 315 would be designated simply 1 through 4, whereas those from Hole 315A would be Cores 1A through 34A. Sections of core from unspecified Hole 315 would be designated 1-3; those from Hole 315A would be designated 1A-3A.

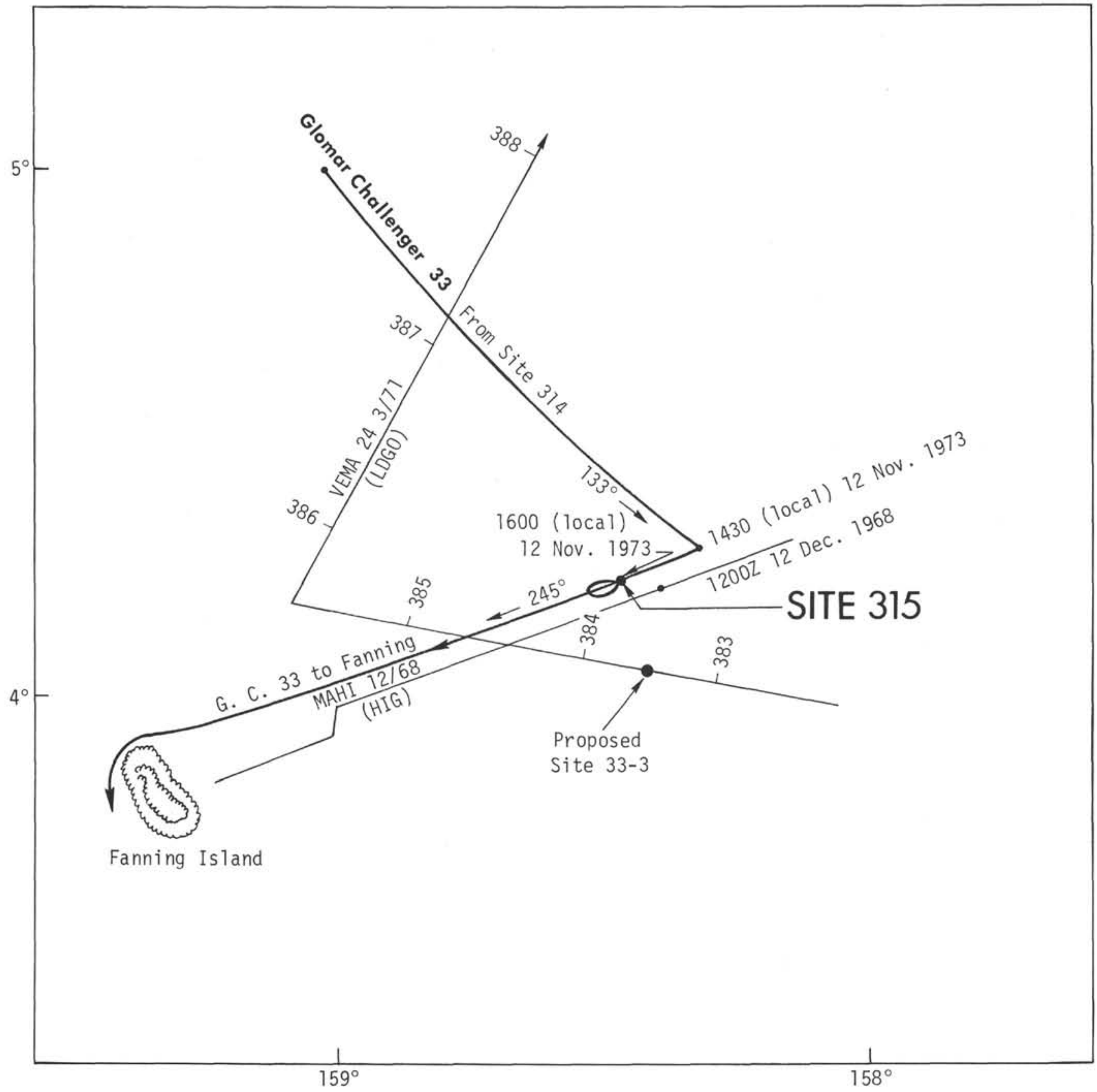

Figure 5. *Location of Site 315 and tracks of relevant surveys.*

Unit 3 (710-844m)—Limestone, chert, and claystone: Nearly continuously cored, these sediments characterize the section found in Cores 10A to 21A.

Unit 4 (844-911 m)—Volcaniclastic sediments and micritic limestone: Greenish-gray, graded volcaniclastic sandstones, siltstones, and claystones, interbedded with variable amounts of clayey and micritic limestones occur in Cores 21A to 26A.

Unit 5 (911-996.3 m)—Basal claystones and volcaniclastic sediments: Dark reddish-brown ferruginous and blue-green siliceous claystones with interbedded, graded volcaniclastic sands and silts occur in Cores 26A through 30A. They are underlain by basalt at 996 meters.

Generally, Site 315 comprises biogenic calcareous oozes and limestones. However, recovery is biased toward the cherty and volcanogenic sediments due to spot coring in the calcareous sediments of the upper 710 meters. In addition, soft clays and clayey sediments in the lower cores may have been missed as a result of the alternate coring and washing-ahead technique used.

This site is characterized by a very thick section with a large proportion of diverse graded, redeposited sediment. In the upper part (0-710 m) numerous graded foraminiferal sands are commonly accompanied by bits of volcanogenic material. Where induration increases, there is ample evidence of redeposition of fine-grained calcareous material. Typically, a clearly graded thin,

TABLE 1
Coring Summary

| Core | Date (1973) | Time (local) | Depth From Drill Floor (m) | Depth Below Sea Floor (m) | Length Cored (m) | Length Recovered (m) | Recovery (%) |
|---|---|---|---|---|---|---|---|
| **Hole 315** | | | | | | | |
| 1 | 13 Nov | 0335 | 4146.0-4173.0 | 0-9.0 | 9.0 | 9.0 | 100 |
| 2 | 13 Nov | 0450 | 4173.0-4182.5 | 9.0-18.5 | 9.5 | CC | <1 |
| 3 | 13 Nov | 0600 | 4173.0-4182.5 | 9.0-18.5 | 9.5 | CC | <1 |
| 4 | 13 Nov | 0710 | 7219.5-4289.5 | 55.5-65.0 | 9.5 | 8.2 | 86 |
| Total | | | | | 37.5 | 17.2 | 45.9 |
| Total depth 85 meters | | | | | | | |
| **Hole 315A** | | | | | | | |
| 1 | 14 Nov | 1140 | 4239.5-4249.0 | 75.5-85.0 | 9.5 | 9.5 | 100 |
| 2 | 14 Nov | 1320 | 4287.5-4297.0 | 123.5-133.0 | 9.5 | 1.3 | 15 |
| 3 | 14 Nov | 1505 | 4306.0-4315.5 | 142.0-151.5 | 9.5 | 9.5 | 100 |
| 4 | 14 Nov | 1732 | 4420.0-4429.5 | 256.0-265.0 | 9.5 | 3.5 | 37 |
| 5 | 14 Nov | 2003 | 4534.0-4543.5 | 370.0-379.5 | 9.5 | 3.0 | 30 |
| 6 | 14 Nov | 2359 | 4629.0-4688.5 | 465.0-474.5 | 9.5 | 4.0 | 42 |
| 7 | 15 Nov | 0200 | 4676.5-4684.0 | 512.5-522.0 | 9.5 | 2.9 | 30 |
| 8 | 15 Nov | 0430 | 4752.5-4762.0 | 588.5-599.0 | 9.5 | 3.4 | 36 |
| 9 | 15 Nov | 0748 | 4866.5-4876.0 | 702.5-712.0 | 9.5 | 2.2 | 23 |
| 10 | 15 Nov | 1054 | 4894.5-4904.0 | 730.5-740.0 | 9.5 | 9.5 | 100 |
| 11 | 15 Nov | 1315 | 4904.0-4913.5 | 740.0-749.5 | 9.5 | 0.5 | 5 |
| 12 | 15 Nov | 1530 | 4913.5-4923.0 | 749.5-759.0 | 9.5 | 0.25 | 2 |
| 13 | 15 Nov | 1810 | 4923.0-4988.5 | 759.0-768.5 | 9.5 | 0 | 0 |
| 14 | 15 Nov | 2110 | 4932.5-4942.0 | 768.5-778.0 | 9.5 | CC | 1 |
| 15 | 16 Nov | 0045 | 4942.0-4951.5 | 778.0-787.5 | 9.5 | 2.5 | 26 |
| 16 | 16 Nov | 0315 | 4951.5-4961.0 | 787.5-797.0 | 9.5 | 2.1 | 20 |
| 17 | 16 Nov | 0631 | 4961.0-4970.5 | 797.0-806.5 | 9.5 | 3.0 | 32 |
| 18 | 16 Nov | 1016 | 4970.5-4980.0 | 806.5-816.0 | 9.5 | 5.5 | 60 |
| 19 | 16 Nov | 1350 | 4980.0-4989.5 | 816.0-825.5 | 9.5 | 8.0 | 85 |
| 20 | 16 Nov | 1655 | 4989.5-4999.0 | 825.5-835.0 | 9.5 | 6.1 | 65 |
| 21 | 16 Nov | 2026 | 4999.0-5008.5 | 835.0-844.5 | 9.5 | 8.0 | 84 |
| 22 | 16 Nov | 2244 | 5008.5-5018.0 | 844.5-854.0 | 9.5 | 5.0 | 52 |
| 23 | 17 Nov | 0107 | 5018.0-5027.5 | 854.0-863.5 | 9.5 | 4.9 | 57 |
| 24 | 17 Nov | 0503 | 5037.0-5046.5 | 873.0-882.5 | 9.5 | 8.3 | 87 |
| 25 | 17 Nov | 0749 | 5056.0-5065.5 | 892.0-901.5 | 9.5 | 3.2 | 37 |
| 26 | 17 Nov | 1110 | 5075.0-5084.5 | 911.0-920.5 | 9.5 | 2.8 | 29 |
| 27 | 17 Nov | 1400 | 5094.0-5103.5 | 930.0-939.5 | 9.5 | 5.2 | 54 |
| 28 | 17 Nov | 1710 | 5113.0-5122.5 | 949.0-958.5 | 9.5 | 3.1 | 34 |
| 29 | 17 Nov | 1955 | 5132.0-5141.5 | 968.0-977.5 | 9.5 | 3.0 | 31 |
| 30 | 17 Nov | 2255 | 5151.0-5160.5 | 987.0-996.5 | 9.5 | 2.7 | 29 |
| 31 | 18 Nov | 0440 | 5160.5-5170.0 | 996.5-1006.0 | 9.5 | 0.5 | 05 |
| 32 | 18 Nov | 0900 | 5170.0-5179.5 | 1006.0-1015.5 | 9.5 | 5.0 | 52 |
| 33 | 18 Nov | 1230 | 5179.5-5189.0 | 1015.5-1025.0 | 9.5 | 0.7 | 8 |
| 34 | 18 Nov | 1505 | 5189.0-5198.5 | 1025.0-1034.5 | 9.5 | 1.2 | 14 |
| Total | | | | | 323.0 | 130.5 | 40.4 |

Total depth 1034.5 meters

basal zone with volcanogenic grains is present, overlain by a thick, undifferentiated body, which usually grades upward to a zone with darker coloration and increasing evidence of burrowing. Calcareous graded beds tend to become thinner down-section and are supplanted by increasing amounts of volcaniclastic graded sandstone to claystone. This parallels the general trend of decreasing carbonate content downhole. The volcanogenic layers show a variety of sedimentary structures generally associated with turbidites. Tops are typically burrowed and show an "exponential" decrease of activity.

This site bears, in part, a striking resemblance to Site 165 of Leg 17, DSDP (Winterer, Ewing, et al., 1973). It is similar in that it includes layers containing resedimented shallow-water material. However, it differs in several respects. At Site 315, the Miocene is thicker and the Eocene thinner than at Site 165. Site 315 also has distinctly less volcaniclastic sediment in the lower part of the section than Site 165. Grain size in the sand layers also tends to be smaller and there is less volcaniclastic breccia.

### Unit 1—Cyclic Ooze (0-56 m)

Sediments similar to this unit have been recognized over a large portion of the equatorial Pacific basin (Tracey, Sutton, et al., 1971; Cook, 1972, 1975). These calcareous sediments are distinguished by the cyclic interlayering of white to pale orange, and light to medium brown nannofossil oozes. Grain size analyses persistently indicate silty clay with a clay content between 60% and 75%. Darker brown layers are generally 5-50 cm thick and conspicuously mottled, while lighter layers

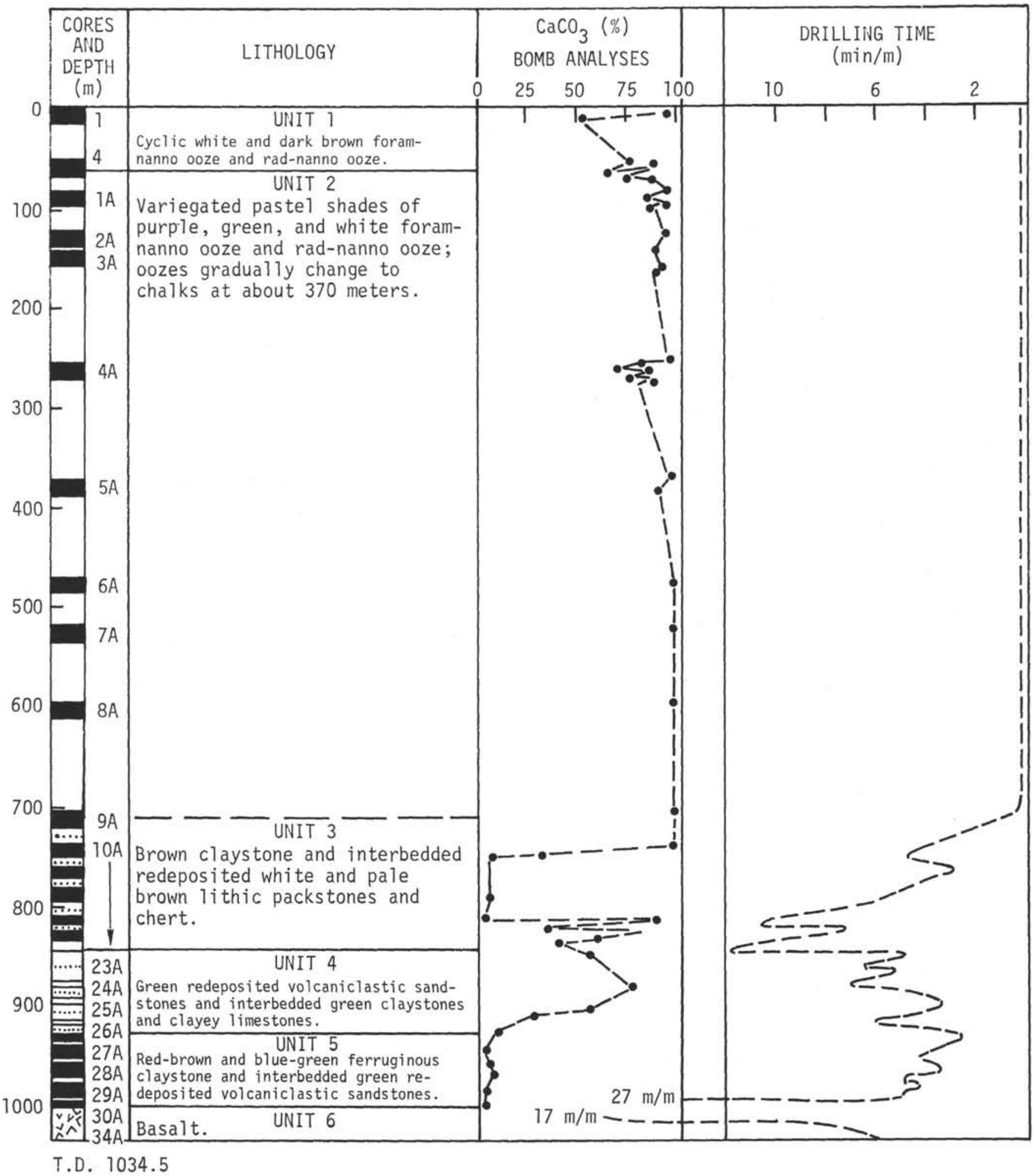

Figure 6. *Graphic log of lithologic units, carbonate content, and drilling rates at Site 315.*

are usually thicker. These light beds are commonly included in unconsolidated graded beds of foraminiferal sand. Coarse fractions also show the accessory fragments to include abraded sparry calcite, volcanogenic grains, and gypsum. Pyroxenes show hacksaw terminations. Shallow-water redeposited material is present mostly as fragments of bryozoa, coral, shells, micritic limestone, and large foraminifers. Anatase traces were detected in the X-ray patterns (Cook and Zemmels, this volume).

Color boundaries are diffuse, commonly confused by burrowing. Pale layers are generally richer in foraminifer tests. Brownish layers, although still at least 80%-90% calcite show an abundance of siliceous fossils, mainly radiolarians, and amorphous iron oxides-hydroxides. X-ray analysis shows that typical constituents of the acid residues include minor quartz, mica, feldspar, barite, and zeolites.

### Unit 2—Varicolored Ooze (56-710 m)

The contact between Units 1 and 2 was not cored but may represent a hiatus. The calcareous sediments in this unit are characterized by a very thick, colorful sequence of interbedded, fine-grained pastel blue, green, and purple burrowed to laminated foraminifer to radiolarian nannofossil oozes and chalk. Color boundaries are both gradual and sharp, commonly marked by the presence of a burrow lined with purple. Purplish hues tend to become more dominant downhole. Thicknesses of the various colored layers range from a few centimeters to several meters. Although not as thick, similar deposits accupying this same stratigraphic position have been described from the equatorial Pacific (Tracey, Sutton, et al., 1971; Cook, 1972; Cook and Zemmels, this volume).

Lithification of the calcareous sediments generally increases downhole. A marked increase in induration in Core 5A near 370 meters marks the change from firm ooze to chalk. Macroscopically, however, the lithology changes very little. Successive stages of calcite overgrowth on discoasters, destruction of coccoliths, and recrystallization to micrite can be followed in a downhole series of smear slides. Burrowing structures, including *Chondrites, Zoophycos,* and *Planalites*, become more prominent downhole. Evidence of compaction, as seen in Core 5A, is present as microfracture patterns crossing laminations and burrows. Purplish coloration is associated with increased abundances of radiolarian tests. Purple pigmentation is often concentrated along burrows where siliceous fossils are selectively replaced, coated, or cemented by pyrite or iron sulfide. Acid residues in Core 4A, for instance, show up to 50% pyrite. An accessory mineral assemblage of quartz, feldspar, plagioclase, mica, and traces of clay and barite show on X-ray traces (Cook and Zemmels, this volume).

Fine-grained, yellowish-gray, graded foraminifer-nannofossil sands ranging in thickness from a few centimeters to over 100 cm occur repeatedly throughout the unit. A typical bed may be distinguished by a light colored, basal section with faint laminations and sprinklings of volcanogenic grains, and rare benthonic foraminifers and shallow-water limestone fragments. Benthonic foraminifers show mixed ages of Upper Cretaceous and Tertiary. There is a gradual upward change to fine-grained, intensively burrowed, calcareous sediment indistinguishable from the host sediment. Indurated grainstone and packstones rich in large benthonic foraminifers, red algae, and bryozoan fragments are present in the lower sections of the unit. These have presumably been displaced from a shallow-water photic environment.

A medium dark gray, cherty appearing nodule was found in Section 3 of Core 8A at 62-66 cm. This nodule has a density of 4.07 g/cc (GRAPE), and was indicated by X-ray diffraction to be celestite or barite.

### Unit 3—Limestone, Chert, and Claystone (710-844 m)

The upper contact of this unit is delineated by the first occurrence of massive reddish-brown chert in the core catcher of Core 9A. The unit is characterized by the presence of various hard cherts and silicified deposits interbedded with a complex series of orange, brown, and greenish-gray micritic and clayey limestones and brown claystones. Also present is a variety of redeposited sediments including calcite-cemented grainstones with shallow-water biogenic fragments.

Although some nannofossils persist in the micritic limestones, their preservation is poor. Two general limestone facies can be recognized: (1) limestones typically with slightly compacted, prominent fucoid burrows as found in Cores 10A (see Figure 7), 15A, and 20A; and (2) limestones with conspicuous soft-sediment deformation structures (so-called phacoids; Voight, 1962). Cores 10A, 17A, and 18A contain typical examples. Styolites in hard, white, sparry limestones were encountered in Cores 16A and 17A (see Figure 8).

Graded redeposited sediments are common and redeposited sediments are, in general, more abundant than in Unit 2. Included are fine-grained layers in which grading is identified mainly by a color gradation from a

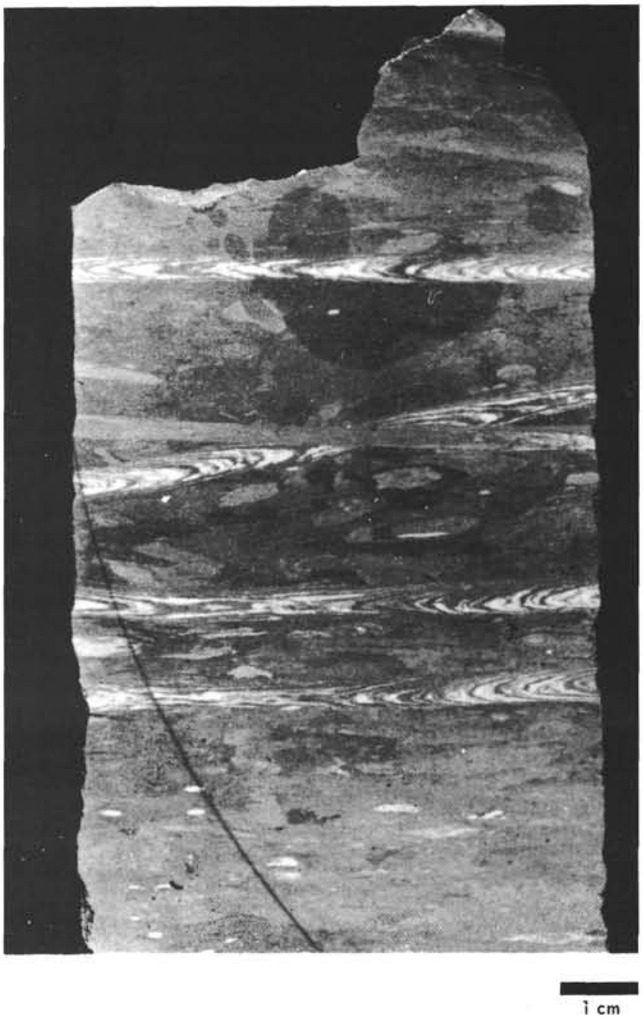

Figure 7. *Example of the intensely burrowed, "fucoid" type facies crossed by subparallel* Zoophycos *burrows in Oligocene limestone of lithologic Unit 3 (Hole 315A, Core 10, Section 4, 80-100 cm; 736 m below the sea floor).*

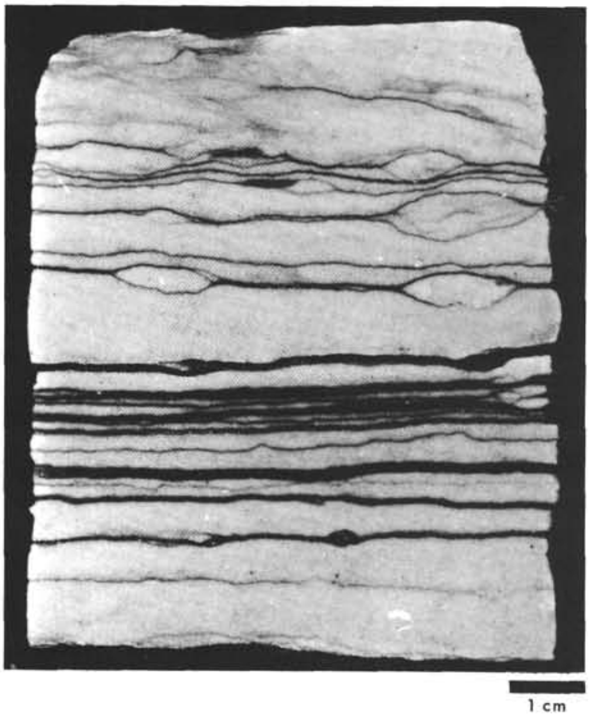

Figure 8. *Creamy white, well indurated Maestrichtian foraminiferal limestone containing very thin, subparallel, red-brown, ferriginous stylolytic seams forming "Augen" or "Microknollen" (Hole 315A, Core 17, Section 2, 120-125 cm; 800 m below the sea floor).*

light base to a dark, burrowed top. Coarse foraminiferal grainstones, some partly silicified, with varying admixtures of volcanogenic and shallow-water bioclastic components are common. Graded beds with abundant volcanogenic grains also show a variety of sedimentary structures. As a typical example, Core 19A contains repeated 5- to 15-cm-thick units with little host sediment. Structures such as flame structures, rip-up clasts, current laminations, and cross-beds are visible. Core 18A contains wackestone layers with large clay pebbles floating in a fine-grained, brownish matrix.

X-ray diffraction (Cook and Zemmels, this volume) indicates a persistent assemblage of 60%-80% calcite, with accessory minerals including quartz, mica, plagioclase, clay minerals, and common traces of gypsum. Amorphous constituents are common in some layers.

Brown claystones devoid of calcite occur as interlayers in the Paleocene sediments of Cores 15A and 16A. These are commonly laminated and fissile. Varieties include brownish-black claystone with fish debris, brown zeolitic claystone, and slightly silicified brown claystone. X-ray diffraction indicates that they are composed mostly of amorphous material, with abundant quartz and clinoptilolite, common mica, feldspar, and montmorillonite, plus traces of magnetite in the crystalline fraction. This assemblage matches that from the acid residues in the carbonate facies.

The youngest occurrence of chert at this site is middle Oligocene, while the oldest is presumably Campanian; however, most of the chert is confined to the Eocene and Paleocene of this unit. A variety of colors is represented. In general, nodular varieties in limestones are gray, while those in silicified claystones are brown. Red brown Eocene cherts, in clayey limestones, are commonly cut by translucent quartz veins (Cores 10A, 11A, 13A). Numerous brecciated and recemented samples were recovered (Core 12A). Partially silicified redeposited planktonic foraminiferal grainstone layers are common. The limestone matrix is first replaced by cristobalite, leaving remnant specks and blebs of calcitic foraminifera. The matrix is thus mostly cristobalitic while infilling of some foram tests is with chalcedony.

The lower contact of Unit 3 is defined by the decreasing frequency of limestone occurrences. Changes are transitional, with an increasing number of volcaniclastic beds near the base of the unit.

### Unit 4—Micritic Limestones and Volcaniclastic Sediment (844-911 m)

Below Core 21A limestone beds bearing calcareous nannofossils become scarcer. Carbonate content declines below Core 25A to less than 10%.

Greenish-gray micritic to clayey limestones are interlayered with abundant commonly graded deposits of volcaniclastic sandstones, siltstones, and claystones. Some of the coarse layers show hyaloclastic grain texture. The redeposited layers vary in thickness from thin laminae to 100-cm graded beds (Core 24A), but 5- to 20-cm beds are prevalent. They exhibit a wide spectrum of turbidite-like sedimentary structures. Some beds show slumping and slippage structures. Repetition of volcaniclastic redeposited layers can be frequent enough that the host sediment is undiscernible, as in Core 24A. The redeposited layers are composed of moderately to poorly sorted, coarse to fine, subrounded to angular grain with little matrix. Components include palagonite, volcanic glass, fresh-looking and altered feldspars, altered mafic minerals, and rare clastic carbonate grains. The matrix mineral and cement is montmorillonite and rarely calcite. X-ray diffraction commonly indicated abundant plagioclase and montmorillonite as well as amorphous glasses. Some samples in Cores 20A and 23A contain diagenetic K-feldspar. In contrast to Site 165A and Site 316 in the Line Islands (Winterer, Ewing, et al., 1973), analcite is absent.

### Unit 5—Claystone and Volcaniclastic Sediments (911-996 m)

This basal unit is characterized by negligible calcite and the presence of a new host lithology of brightly colored, interbedded claystones of two varieties. One is blue-green and partially silicified, while the other is laminated, red to reddish-brown, and ferruginous. Some beds of fissile, reddish claystones, especially those directly overlying the vesicular basalt, show faint evidence of current cross-bedding.

Radiolarians reappear in some scattered layers, although they are severely overgrown and infilled by silica. Fe-Mn oxide-hydroxides coat clay minerals and feldspars and quartz in the red claystones.

X-ray diffraction indicates the presence of abundant hematite and quartz, and amorphous constituents in some layers. The dominant clay mineral is montmorillonite, although in some layers significant amounts of mica occur. Several interesting singular mineral assemblages were detected including aragonite, quartz, mica, and montmorillonite in sand from Core 29A, Section 2; K-feldspar, montmorillonite, and clinoptilolite in brown claystone from Core 27A, Section 2; a single bluish-green layer with 80% carbonate in Core 18A, Section 3; and a blue-green siltstone consisting dominantly of quartz and mica in Core 28A, Section 3. One black chert nodule was also noted in Core 28A, Section 3.

Thin laminae and thick graded (20-30 cm) beds of volcanogenic siltstone and sandstone persist to basement. The coarser fractions of graded beds contain no bioclastic material. Grain packing textures are typically hyaloclastic, with highly irregular glassy and palagonitic shards. Nonvolcanic detritus is rare to absent. Thin sections commonly show subhedral and euhedral K-feldspars, overgrowths, and rim alterations on volcanic grains, and abundant clusters of microlitic grains altering from the glass.

### Igneous Rocks (996-1034.5 m)

Basalt was encountered at a depth of 996.3 meters below mudline in the lower 20 cm and core catcher of Core 30A. The basalt is in sharp contact with an overlying red, cross-bedded claystone, and it is apparent that this ferruginous claystone has been transported and is not simply a weathering product of the basalt. A total thickness of 38 meters was drilled below Core 30A, and recovered core in that interval consisted entirely of basalt, although recovery was only 7.4 meters. We cannot, therefore, eliminate the possibility that volcaniclastic sediments may be present in the missing intervals, although no traces of them were found in the recovered cores. It seems at least equally likely that the unrecovered intervals arealso basaltic, but were not recovered due to jammed catchers, pyroclastic intervals, or more altered glassy or clinkery sections between flows that were washed out during coring. During drilling of Cores 31A-34A soft intervals were noted at 998-1000 meters below mudline in Core 31A, at 1010-1014 meters in Core 32A, at 1022-1024 meters in Core 331, and at 1029-1033 meters in Core 34A. Unfortunately, we have no way of relating these intervals to cores actually recovered and described in the visual core description sheets.

At least six flow units were identified among the recovered core in Cores 30A-34A, and three contacts were observed. None of the contacts showed evidence of weathering, nor of interbedded sedimentary rocks; all consist of highly altered aphanitic zones averaging 10-15 cm thick, separating flow units with distinctly different textures. Thus, although we cannot discount the possibility that sedimentary layers are present in the lower 38 meters of cored hole, none were observed in the recovered core.

The six identifiable flow units returned from this interval were numbered 1-6. Because of incomplete coring, the section may, of course, contain a greater number of flows. Only one flow unit was complete within cored intervals (Unit 3 of Core 32A), and this unit proved to be about 1.5 meters thick. Minimum thicknesses may be calculated for the other flow units, the thickest being Units 2 and 4 of Core 32A, which are both at least 1.8 meters thick. The descriptions of these units, which follow, are based largely on low-power binocular microscope examination of cores in the round; thin-sections from the core catcher of Cores 30A, 31A, and 32A were all that were available at the time of writing.

Flow Unit 1 consists of the lower 20 cm of Section 2 of Core 30A plus the 30 cm of basalt which comprises the entire recovery of Core 31A. The basalt consists of a grayish-green to dark greenish-gray, aphyric, vesicular, altered basalt with a variolitic to intersertal texture. The rock presumably consisted of plagioclase, clinopyroxene, glass, and minor amounts of opaque minerals. Plagioclase relicts average about 0.3 × 1.0 mm and are partially altered. A few relicts of clinopyroxene remain, but nearly all is altered. All of the original glass is altered to clay minerals, and considerable calcite replacement has occurred locally. Vesicles are round, average 1%-2% of the rock, are generally 0.5-1.0 mm in diameter, and are invariably filled with calcite minerals. The original grain size of the rock was on the order of 0.3-0.4 mm.

Unit 2 comprises the entire 63 cm recovered in Section 1 of Core 32A, and the upper 123 cm of Section 2. The basalt consists of a dark greenish-gray, aphyric, vesicular to vuggy altered rock that is diabasic and vesicular near the top, but becomes steadily coarser, more vuggy, and trachitic in texture in the lower part of the unit. Near the top, round unfilled vesicles 0.5-2.0 mm in diameter make up 1%-5% of the rock and are commonly arranged in concentrated lines perpendicular to the core. Plagioclase laths are stubby, and average 0.2 × 0.4 mm. Near the center of the unit, irregular to flattened vugs average 2.0 mm in diameter, and some are as large at 5.0 mm. These make up 2%-5% of the rock and are open. Plagioclase laths become elongate downward in the unit, averaging 0.2 × 2.0 mm, and rarely reach as much as 5.0 mm in length. These are very strikingly aligned perpendicular to the core axis. In the lowest part of the unit, grain size decreases somewhat but the vuggy, trachitic character of the unit persists. The plagioclase in the unit is little altered, but only relict clinopyroxenes remain. Apparently, little glass was present, but considerable calcite replacement occurred, especially in the upper part of the unit.

Unit 3 comprises the lower 28 cm of Section 2, and the upper 121 cm of Section 3 of Core 32A. Mineralogically, stratigraphically, and texturally, it is nearly identical to Unit 2.

Unit 4 comprises the lower 30 cm of Core 32A, Section 3, and all 150 cm of Section 4. The uppermost 10 cm of this flow is a bluish-gray, nearly aphanitic basalt, and probably contained considerable glass prior to alteration. Otherwise, the unit grades down to coarser, vuggy basalt much in the manner of Units 2 and 3, but the interior of the flow is even more vuggy than in those units (up to 10% of the rock) and feldspar laths lie at angles as much as 15° off perpendicular to the core. Again, toward the lower part of Section 4, the rock becomes finer grained and more diabasic. Alteration appears to be similar to that of Units 2 and 3.

Unit 5 appears to comprise the entire 76 cm recovered in Core 33A, and the upper 18 cm of that recovered in Core 34A. The basalt is medium bluish-gray, aphyric, vesicular (averaging about 3% spherical vesicles, commonly 0.5 mm in diameter, but ranging up to 1.5 mm).

All vesicles are filled with calcite. Most of the rock is aphanatic, but in coarser portions the texture is diabasic to intersertal. The unit was apparently quite glassy, particularly in the upper part. The plagioclase appears to be partially altered, and most of the pyroxene and all of the glass have been replaced by lower temperature assemblages.

Unit 6 comprises the remaining 76 cm of Core 34A. Its upper 10 cm is bluish-gray highly altered aphanatic basalt with a sharp contact against Unit 5. Lower in the section, the unit gradually becomes dark greenish-gray, and although it remains quite fine grained (0.3-0.4 mm), its texture becomes recognizably diabasic. The unit is vesicular, with sporadically distributed spherical, filled vesicles that comprise 0%-10% of the rock and average about 1.0 mm in diameter. The upper chilled border appears to be completely altered, the remainder of the unit considerably altered.

The texture of these basalts, and their general mineralogy, including alteration minerals, compare quite favorably with the volcanogenic sands that lie above them, and similar basalts could certainly furnish the source material for the Cretaceous debris.

It is obviously impossible at this time to determine whether the basalts have tholeiitic or alkalic affinities; low-calcium pyroxene was looked for, but not found, in the three thin sections available, and the absence of phenocrysts in either affinity is atypical, but not unknown. An exhaustive study of similar rocks from Site 165, Leg 33 led Bass et al. (1973) to the conclusion that these rocks were alkalic, and the presence of trachitic textures at Site 315 may be an early clue to a similar origin. If so, then it becomes difficult to assign a Hawaiian-type analogy to either the Line Islands seamount near Site 165, or to the Fanning edifice, for Hawaiian basalts at such distances from the center of edifices, where studied, are tholeiitic (Moore, 1965).

In any event, the lack of weathering between contacts, and the presence of vesicles and vugs in all flow units at Site 315 point to a depth of origin shallower than that which the basalts now occupy. If these basalts are tholeiitic, or have similar contents of fugative constituents, data from Moore (1965) would suggest they crystallized in water depths as shallow at 500 meters. Data from the sediments that overlie them, however, strongly suggest originally greater depths during eruption. Limited data on the thickness of the flows suggest they are quite thin (on the order of 1.5-2.0 m), and the lack of sedimentary debris at the recovered flow contacts further suggests that the flows had low viscosity and a rapid eruption rate at the time of their formation.

## GEOCHEMICAL MEASUREMENTS

The results of *p*H, alkalinity, and salinity analyses of interstitial waters are summarized in Table 2 and Figure 9. The $CaCO_3$ content of the sediments is shown in Figure 6. Techniques used are those routinely performed on shipboard on *Glomar Challenger.*

### pH Values

The *p*H values from 0 to 800 meters were all below that of the surface seawater, which averages 8.16 at Site 315. From 4.5 to about 78 meters the *p*H dropped from a maximum of 7.5 to 7.06 (Figure 9). From 78 to 800 meters the flow-through technique and the combination-electrode technique gave conflicting results. The flow-through method shows a gradual *p*H increase down-section, whereas the combination-electrode technique yields *p*H values that are roughly the same through the 78-100 meter interval, and then values that decrease sharply at 800 meters (Figure 9).

### Alkalinity

The alkalinity in the first 70 meters is about that of the surface seawater. Below 70 meters, however, the alkalinity rises to a maximum value of 4.11 meq/kg and then shows a gradual decrease downhole to a minimum value of 0.59 meq/kg at 781 meters (Figure 9).

### Salinity

The salinity approximately parallels the alkalinity curve from 0 to 250 meters and from 600 to 781 meters; between 250 and 600 meters the data vary between 35.5‰ to 35.2‰ (Figure 9).

### $CaCO_3$

The $CaCO_3$ content of Site 315 sediments is shown in Figure 6. Brown radiolarian-rich beds in Unit 1 have about 50% $CaCO_3$ whereas the radiolarian-poor beds have $CaCO_3$ content greater than 90% throughout most its extent. Units 3, 4, and 5 have considerably lower $CaCO_3$ percentages, reflecting their very high clay content.

## PHYSICAL PROPERTIES

### Density-Porosity Methods

Aboard *Glomar Challenger* the parameters of wet-bulk density, wet-water content, and porosity were determined by (1) gravimetric rock chunk techniques, and (2) gamma-ray attenuation techniques.

These parameters are defined as follows: wet-bulk density is the weight of a wet-saturated sediment or rock divided by its volume, and is expressed as g/cc. Wet-water content is defined as the weight of seawater in the sediment divided by the weight of total wet-saturated sediment, and is expressed as a percentage. Porosity is defined as the volume of pore space of the sediment or rock divided by the volume of the wet-saturated sediment or rock, and is also expressed as a percentage.

The gravimetric techniques, calculations, and salt corrections (after Hamilton, 1971) are discussed by Boyce (1973, this volume). The data presented here are with salt corrections, assuming an interstitial water salinity of 35‰. Individual samples were from relatively undisturbed portions of the cores. The wet-water contents determined by the rock-chunk technique have a precision of ±2% (absolute).

Aboard *Glomar Challenger* is a device called the Gamma Ray Attenuation Porosity Evaluator (GRAPE) which determines rock density by measuring the attenuation of gamma rays as they pass through a sample. If the geologist knows the grain density of the rock, then porosity may be determined (note the porosity nomogram in the hole and core plots). By selecting the proper grain density values from this nomogram, the wet-bulk

**TABLE 2**
**Summary of Shipboard Geochemical Data, Site 315**

| Sample (Interval in cm) | Depth Below Sea Floor (m) | *p*H Punch-in | *p*H Flow-through | Alkalinity (meq/kg) | Salinity (‰) | Remarks[a] |
|---|---|---|---|---|---|---|
| Surface Seawater | | 8.18 | 8.21 | 2.54 | 35.2 | 8.10 |
| **Hole 315** | | | | | | |
| 1-3 144-150 | 4.5 | 7.50 | 7.37 | 2.93 | 35.2 | 7.47 |
| 4-4, 144-150 | 62.5 | 7.41 | 7.34 | 2.93 | 35.2 | 7.41 |
| **Hole 315A** | | | | | | |
| 1-2, 144-150 | 78.5 | 7.39 | 7.06 | 3.42 | 35.5 | 7.37 |
| 3-5, 144-150 | 149.5 | 7.11 | 7.08 | 4.11 | 35.8 | 7.33 |
| 4-2, 144-150 | 259 | 7.19 | 7.15 | 3.81 | 35.2 | 7.34 |
| 5-1, 144-150 | 371.5 | – | 7.20 | 3.42 | 35.5 | 7.33 |
| 6-1, 144-150 | 466.5 | – | 7.27 | 3.23 | 35.5 | 7.38 |
| 7-1, 143-150 | 514 | – | 7.27 | 2.83 | 35.2 | 7.43 |
| 8-2, 144-150 | 591.5 | – | 7.32 | 2.64 | 35.5 | 7.35 |
| 9-1, 144-150 | 704 | – | 7.41 | 2.25 | 35.2 | 7.46 |
| 15-2, 0-6 | 781 | – | 7.46 | 0.59 | 34.9 | 7.18 |

[a] Combination electrode *p*H.

density graph is also a porosity graph. Wet-bulk density determinations by the routine analog GRAPE date have a precision of ±11% (2-sec counting period). Detailed discussions of the GRAPE data, derivations, and techniques are presented by Boyce (1973 and in this volume).

The GRAPE analog data are displayed only in the core scale graphs. Where the sediment is soft and the core liner completely filled, and the computer program required no diameter corrections, and the data are plotted as a single solid line. Where the analog GRAPE scanned cores of hard rocks with varying diameter the data are presented as two lines. The solid line plot is the routine analog record assuming a 6.61-cm sample diameter. This line is presented if it is found necessary to consult photographs, measure diameters, and apply diameter corrections other than those used here. The dotted line represents data to which diameter corrections have been applied (Boyce, Chapter 26, this volume). Caution should be used when interpreting either the solid or dotted lines for the rock segments in many cases are very short and the data appear as a series of peaks. Only the maximum density values of the peaks, in these cases, represent good density values; therefore, the density values of the shoulders of the density peaks should be ignored. When diameters of short core segments were measured, only one measurement, of the maximum diameter, was made; therefore the shoulders of the dotted line peaks should be ignored, as the real density value is the maximum peak density value.

The GRAPE instrument can also be used to determine wet-bulk density of discrete or "special" samples, by placing the GRAPE in a 2-min counting mode. This sample will be referred to as the "GRAPE Special" or "2-Minute Density," which is a wet-bulk density determination that was counted for a 2-min period after being removed from the plastic liner and cleaner. Because of the especially long counting period, density for these samples has a precision of ±2%. The density value assumes the grains have an attenuation coefficient identical to that of quartz.

These GRAPE Special samples are the same as those on which sound velocity and wet-water content were determined. The GRAPE Special wet-bulk density and the salt-corrected wet-water content values also allow an approximate porosity to be calculated by multiplying the wet-water content times the GRAPE Special wet-bulk density. These porosity values are listed in Table 3 only and are not plotted.

### Sound Velocity

Compressional wave sound velocities at 400 kHz were measured perpendicular and parallel to sawed rock core segments. The accuracy and precision have been described by Boyce (1973), and a brief discussion is included in Appendix I of the present volume. The only procedures that differ from those published are that correction factors were applied to the velocities because the shipboard oscilloscope was out of calibration during Leg 33. Correction factors are listed and discussed in Appendix I of this volume.

Impedance is defined here as the product of the velocity and wet-bulk density. The velocities and Special GRAPE wet-bulk densities, which were used in impedance calculations, were measured on the same sample, perpendicular to bedding, unless otherwise noted in Table 3. The velocity measurements were made after cores came to room temperature (4+ hr) and processed soon after splitting the core and cutting the sample. The wet-bulk density measurements were usually processed within 5 min after the velocity measurement had been made. Reflections ($R$) coefficients were calculated as follows:

$$R = \frac{(\text{impedance of layer 2}) - (\text{impedance of layer 1})}{(\text{impedance of layer 2}) + (\text{impedance of layer 1})}$$

where layer 1 overlies layer 2.

### Results

The GRAPE Special wet-bulk density, gravimetric wet-water content porosity, sound velocity (perpen-

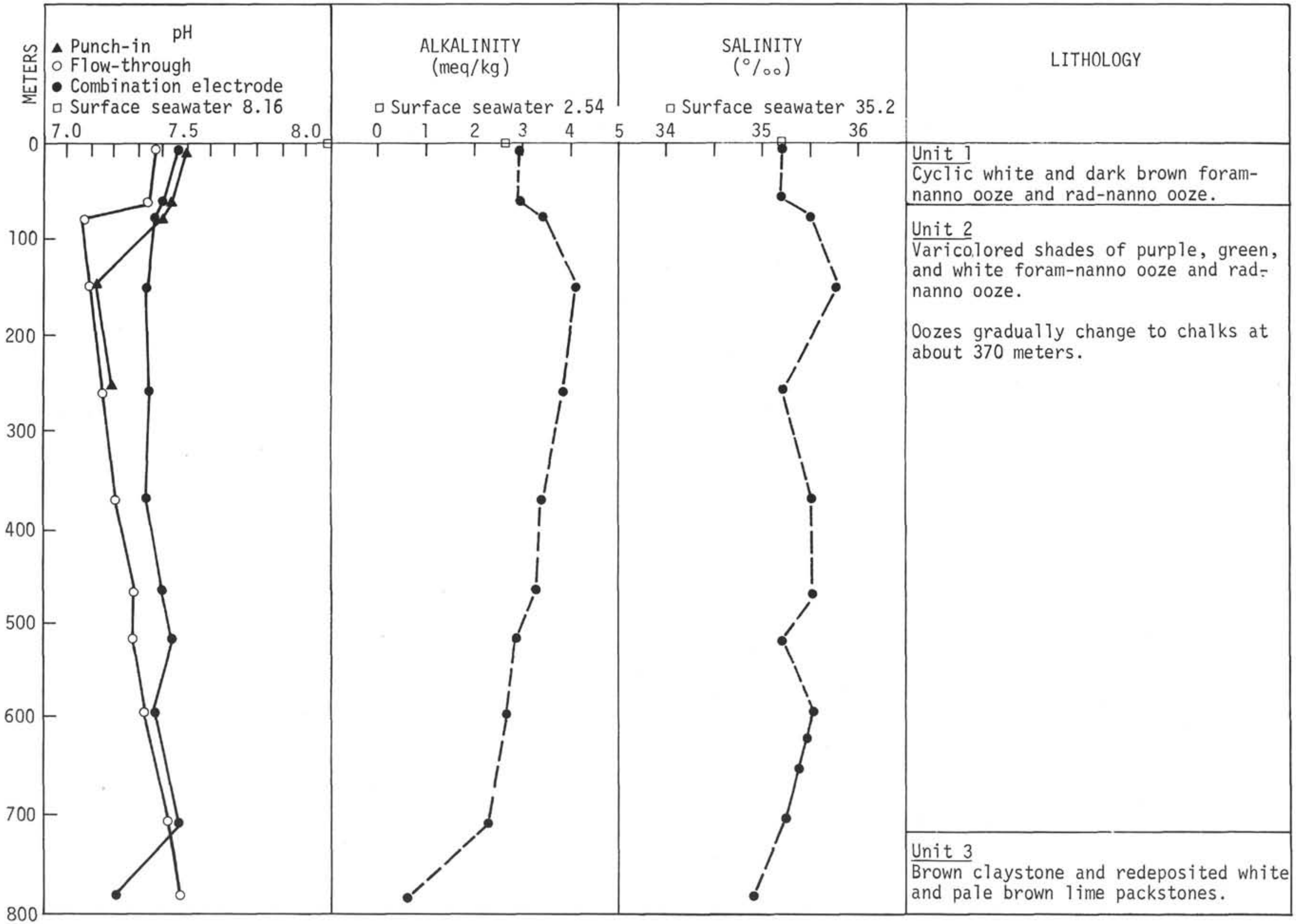

Figure 9. *Graphic log of shipboard* pH, *alkalinity, and salinity measurements at Site 315.*

## TABLE 3
### Velocity-Density Parameters, Hole 315A

| | | Compressional Sound Velocity | | | | | “Special” Wet-Bulk Density 2-min count (g/cc) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Anisotropy | | | | | | | | |
| Sample (Interval in cm) | Depth in Hole (m) | ∥ Beds (km/sec) | ⊥ Beds (km/sec) | ∥-⊥ (km/sec) | (∥-⊥) ÷ ⊥ (%) | Temp (°C) | ∥ Beds | ⊥ Beds | Wet Water Content Salt Cor. (%) | Porosity[b] (%) | Acoustic Impedance $\frac{g\ 10^5}{cm^2\ sec}$ | Lithology |
| 3-1, 7-11 | 142.27 | | 1.542 | | | 24.0 | | | 48.05 | | | Rad nanno ooze |
| 4-1, 120-125 | 257.20 | 1.586 | 1.573 | +0.013 | + 0.83 | 23.0 | | 1.753 | 37.58[c] | 65.88 | 2.76 | Rad nanno chalk |
| 5-1, 120-124 | 257.20 | 1.621 | 1.583 | +0.038 | + 2.40 | 20.0 | | 1.784 | | | 2.82 | Foram nanno chalk |
| 5-2, 81-83 | 372.31 | 1.681 | 1.674 | +0.007 | + 0.04 | 20.0 | | 1.714 | 32.46[c] | 55.64 | 2.87 | Rad foram nanno chalk |
| 6-1, 101-103 | 466.01 | 1.792 | 1.639 | +0.153 | + 9.33 | 21.0 | | 1.773 | 20.02 | 35.50 | 2.91 | Rad rich foram nanno chalk |
| 6-2, 116-118 | 467.66 | 1.684 | 1.665 | +0.019 | + 1.14 | 21.0 | | 1.690 | 29.25[c] | 49.43 | 2.81 | Rad nanno chalk |
| 6-3, 12-14 | 468.12 | 1.655 | 1.646 | +0.009 | + 0.55 | 21.0 | | 1.767 | 20.99 | 37.09 | 2.91 | Rad nanno chalk |
| 7-1, 44-46 | 512.94 | 1.711 | 1.690 | +0.021 | + 1.24 | 21.0 | | 1.846 | 15.19 | 28.04 | 3.12 | Rad-rich foram nanno chalk |
| 7-2, 30-32 | 514.30 | 1.678 | 1.679 | -0.001 | - 0.06 | 21.0 | | 1.830 | 13.09 | 23.95 | 3.07 | Foram-rich rad nanno chalk |
| 8-7, 21-22 | 588.71 | 1.658 | 1.641 | +0.017 | + 1.04 | 21.0 | | 1.892 | 15.46 | 29.25 | 3.11 | Foram-rich rad nanno chalk |
| 8-2, 141-145 | 591.41 | 1.654 | 1.646 | +0.008 | + 0.49 | 21.0 | | 1.822 | 22.61 | 41.20 | 3.00 | Foram-rich rad nanno chalk |
| 8-3, 58-64 | 592.11 | | 4.696 | | | 20.0 | | 4.069 | 0.00[c] | 0.00 | 19.11 | Celestite barite? |
| | | | 4.681 | | | 20.0 | | | | | | |
| 8-3, 131-133 | 592.81 | 1.778 | 1.734 | +0.044 | + 2.54 | 20.0 | | 1.968 | 14.69 | 28.91 | 3.41 | Foram-rich rad nanno chalk |
| 9-2, 12-14 | 704.12 | 1.705 | 1,689 | +0.016 | + 0.95 | 20.0 | | 1.865 | 27.39 | 51.08 | 3.15 | Foram nanno chalk |
| 10-1, 18-21 | 730.98 | 2.085 | 1.990 | +0.095 | + 4.77 | 19.0 | | 2.088 | 15.68 | 32.74 | 4.16 | Nanno chalk |
| 10-2, 19-21 | 732.49 | 2 248 | 2.190 | +0.058 | + 2.65 | 19.0 | | 2.115 | 14.94 | 31.60 | 4.63 | Nanno chalk |
| 10-2, 31-33 | 732.61 | 3.512 | 3.367 | +0.145 | + 4.31 | 19.0 | | 2.145 | 13.93[c] | 29.88 | 7.22 | Chert |
| 10-3, 24-27 | 734.06 | 2.212 | 2.120 | +0.092 | + 4.34 | 19.0 | | 2.166 | 16.60 | 35.96 | 4.59 | Nanno chalk |
| 10-3, 102-109 | 734.82 | 4.731 | | | | 19.0 | 2.393 | | 8.53[c] | 20.41 | 11.32[d] | Chert |
| 10-3, 124-134 | 735.04 | 4.593 | | | | 19.0 | 2.344 | | 9.01[c] | 21.12 | 10.77[d] | Foram clay grainstone chert |
| 10-4, 40-43 | 735.70 | 2.171 | 1.979 | +0.192 | + 9.70 | 21.0 | | 2.167 | 16.67 | 36.12 | 4.29 | Nanno chalk |
| 10-4, 122-125 | 736.52 | 1.881 | 1.796 | +0.085 | + 4.73 | 21.0 | | 1.525 | 39.81 | 60.71 | 2.74 | Clay-rich rad nanno chalk |
| 10-5, 54-57 | 737.34 | 1.863 | 2.326? | +0.463? | -19.91? | 19.0 | | 1.544 | 40.04 | 61.82 | 3.59 | Rad nanno chalk |
| 10-5, 129-131 | 738.09 | 1.817 | 1.745 | +0.072 | + 4.13 | 19.0 | | 1.430 | 48.93 | 69.97 | 2.50 | Nanno rad claystone |
| 10-6, 22-24 | 738.52 | 1.909 | 1.839 | +0.070 | + 3.81 | 19.0 | | 1.892 | 32.10 | 60.73 | 3.48 | Clay-rich rad nanno chalk |
| 10-6, 118-120 | 739.48 | 1.812 | 1.732 | +0.080 | + 4.62 | 19.0 | | 1.465 | 40.81 | 59.79 | 2.54 | Spic. clay-rich rad nanno chalk |
| 11-1, 143-145 | 741.42 | 5.260 | | | | 20.0 | 2.537 | | 0.92 | 2.33 | 13.34[d] | Chert |
| 12, CC | 751.01 | 4.763 | | | | 20.0 | | 2.431 | 1.94 | 4.72 | 11.58[d] | Breccia chert |
| 15-1, 71-74 | 778.71 | 2.783 | 2.649 | +0.134 | + 5.06 | 20.0 | | 2.158 | 11.83 | 25.53 | 5.72 | Clayey nanno chalk |
| 15-1, 122-124 | 779.22 | 1.672 | 2.001 | -0.329 | -16.44 | 19.0 | | 1.726 | 26.80 | 46.26 | 3.45 | Rad claystone |
| 15-2, 44-50 | 779.94 | 2.688 | | | | 20.0 | | | 8.79 | 19.06 | 5.83[d] | Clayey nanno chalk |
| 16-1, 138-140 | 788.88 | 2.126 | 1.888 | +0.238 | +12.61 | 22.0 | | 2.019 | 22.39 | 45.21 | 3.81 | Fissil claystone |
| 16-2, 68-70 | 789.68 | 4.957 | | | | 22.0 | 2.591 | | 0.94 | 2.44 | 12.84[d] | Chert |
| 16-2, 82-85 | 789.82 | 2.504 | 2.193 | +0.311 | +14.18 | 22.0 | | 2.189 | 16.35 | 35.79 | 4.80 | Clayey nanno limestone |
| 17-1, 71-73 | 797.71 | 4.347 | 4.256 | +0.091 | + 2.14 | 22.0 | | 2.563 | 4.23 | 10.84 | 10.91 | Nanno foram limestone |
| 17-2, 5-7 | 798.55 | 3.886 | 3.774 | +0.112 | + 2.97 | 21.0 | | 2.449 | 5.69 | 13.93 | 9.24 | Foram limestone |
| 18-1, 91-93 | 807.41 | 4.333 | 4.157 | +0.176 | + 4.23 | 20.0 | | 2.513 | 7.00 | 17.59 | 10.45 | Foram limestone |
| 18-1, 101-106 | 807.51 | 3.387 | 2.791 | +0.596 | +21.35 | 20.0 | | 2.377 | 6.69 | 15.90 | 6.63 | Foram sparry grainstone |
| 18-1, 105-109 | 807.55 | 4.598 | 3.690 | +0.908 | +24.61 | 20.0 | | 2.504 | 5.03 | 12.60 | 9.24 | Nanno claystone |
| 18-2, 93-96 | 808.93 | 3.523 | 2.815 | +0.708 | +25.15 | 20.0 | | 2.461 | 5.93 | 14.59 | 6.93 | Packstone: rounded, unsorted |
| 18-2, 116-118 | 809.16 | 4.392 | 4.390 | +0.002 | + 0.05 | 19.0 | | 2.539 | 5.37 | 13.63 | 11.15 | Foram grainstone |
| 18-3, 86-88 | 810.36 | 4.666 | 4.621 | +0.045 | + 0.97 | 19.0 | | 2.522 | | | 11.65 | Foram limestone |
| 18-4, 90-94 | 811.90 | 3.637 | 3.053 | +0.584 | +19.13 | 20.0 | | 2.377 | 6.94 | 16.50 | 7.26 | Foram limestone, laminated |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19-2, 7-12 | 817.57 | 2.940 | | | | 20.0 | 2.314 | | 10.46 | 24.20 | 6.80† | Nanno claystone |
| 19-2, 78-83 | 818.28 | 4.380 | 4.060 | +0.320 | + 7.88 | 20.0 | | 2.597 | 3.47 | 9.01 | 10.54 | Foram nanno limestone |
| 19-3, 68-71 | 819.68 | 3.577 | 3.041 | +0.536 | +17.63 | 20.0 | | 2.418 | 9.35 | 22.61 | 7.35 | Foram limestone |
| 19-4, 40-42 | 820.90 | 3.387 | 3.178 | +0.209 | + 6.58 | 20.0 | | 2.309 | 7.38 | 17.04 | 7.34 | Clayey nanno limestone |
| 19-5, 13-15 | 822.13 | 3.357 | 2.894 | +0.463 | +16.00 | 20.0 | | 2.413 | 9.14 | 22.05 | 6.98 | Nanno claystone |
| 19-6, 18-21 | 823.68 | 3.147 | 2.838 | +0.309 | +10.89 | 20.0 | | 2.346 | 9.41 | 22.08 | 6.66 | Nanno claystone |
| 20-2, 103-106 | 828.03 | 3.310 | 3.129 | +0.181 | + 5.78 | 20.0 | | 2.315 | 10.76 | 24.91 | 7.24 | Clayey nanno limestone |
| 20-3, 77-80 | 829.27 | 3.181 | 2.960 | +0.221 | + 7.47 | 20.0 | | 2.321 | 8.18 | 18.99 | 6.87 | Nanno claystone |
| 20-4, 20-22 | 830.20 | 3.087 | 3.153 | +0.066 | - 2.09 | 21.0 | | 2.279 | 12.16 | 27.71 | 7.19 | Nanno micritic claystone |
| 20-5, 19-21 | 831.69 | 3.243 | 2.703 | +0.540 | +19.98 | 21.0 | | 2.351 | 8.26 | 19.42 | 6.35 | Nanno micritic claystone |
| 21-2, 69-73 | 837.19 | 3.942 | 3.057 | +0.885 | +28.95 | 21.0 | | 2.303 | 11.24 | 25.88 | 7.04 | Micritic claystone |
| 21-3, 19-21 | 838.18 | 3.129 | 2.994 | +0.135 | + 4.51 | 22.0 | | 2.094 | 22.57 | 47.26 | 6.27 | Clayey micritic limestone |
| 21-4, 7-10 | 839.57 | 3.464 | 3.197 | +0.267 | + 8.35 | 22.0 | | 2.240 | 8.01 | 17.94 | 7.16 | Clayey micritic limestone |
| 21-5, 10-12 | 841.10 | 3.143 | 2.994 | +0.149 | + 4.98 | 22.0 | | 2.292 | 12.41 | 28.44 | 6.86 | Clayey micritic limestone |
| 21-6, 50-53 | 843.00 | 3.261 | 2.926 | +0.335 | +11.45 | 22.0 | | 2.317 | 11.15 | 25.83 | 6.78 | Clayey micritic limestone |
| 21-6, 98-100 | 843.48 | 2.532 | | | | 22.0 | 2.066 | | | | 5.23$^d$ | Volcanic sandstone, graded |
| 22-2, 6-9 | 846.06 | 3.222 | 3.119 | +0.103 | + 3.30 | 21.5 | | 2.266 | 10.09 | 22.86 | 7.07 | Clayey micritic limestone |
| 22-3, 33-35 | 847.83 | 2.655 | 2.233 | +0.422 | +18.90 | 21.0 | | 2.265 | 13.79 | 31.23 | 5.06 | Volcanic sandstone |
| 22-4, 26-29 | 849.26 | 2.444 | 2.989 | -0.545 | -18.23 | 21.0 | | 2.240 | 11.74 | 26.30 | 6.69 | Clayey micritic limestone |
| 22-4, 68-70 | 849.68 | 2.250 | 2.289 | -0.039 | - 1.70 | 21.0 | | 2.017 | 22.58 | 45.54 | 4.62 | Volcanic sandstone |
| 23-2, 71-73 | 856.21 | 2.506 | 2.348 | +0.158 | + 6.73 | 20.0 | | 2.059 | 17.05 | 35.11 | 4.83 | Volcanic sandstone |
| 23-3, 39-41 | 857.39 | 2.750 | 2.992 | -0.242 | - 8.09 | 20.0 | | 2.040 | 11.33 | 23.11 | 6.10 | Clay-rich micritic limestone |
| 23-3, 105-109 | 858.05 | 2.413 | | | | 20.0 | 2.105 | | 21.33 | 44.90 | 5.08$^d$ | Volcanic sandstone |
| 24-2, 20-21 | 874.70 | 5.079 | | | | 21.0 | 2.479 | | 1.83 | 4.66 | 12.59$^d$ | Chert |
| 24-2, 51-52 | 875.01 | 3.307 | 3.067 | +0.240 | + 7.83 | 21.0 | | 2.254 | 12.56 | 28.31 | 6.91 | Clayey micritic limestone |
| 24-3, 61-63 | 876.61 | 3.328 | 2.966 | +0.362 | +12.20 | 21.0 | | 2.353 | 11.62 | 27.34 | 6.98 | Clayey micritic limestone |
| 24-4, 100-102 | 878.50 | 3.337 | 3.197 | +0.140 | + 4.38 | 21.0 | | 2.261 | 12.48 | 28.22 | 7.23 | Clayey micritic limestone |
| 24-5, 68-70 | 879.68 | 2.994 | 2.781 | +0.213 | + 7.66 | 19.0 | | 2.215 | 13.30 | 29.46 | 6.16 | Micritic limestone |
| 24-6, 38-40 | 880.88 | 3.002 | 2.843 | +0.159 | + 5.59 | 20.0 | | 2.317 | 11.59 | 26.85 | 6.59 | Micritic limestone |
| 25-2, 132-137 | 894.82 | 2.436 | 2.217 | +0.219 | + 9.88 | 20.0 | | 2.097 | 16.50 | 34.60 | 4.65 | Calc. clayey siltstone |
| 25-3, 81-83 | 895.81 | 3.954 | 3.472 | +0.482 | +13.88 | 20.0 | | 2.349 | 6.23 | 14.63 | 8.16 | Calc. sandstone: clay grains |
| 26-1, 144-147 | 912.44 | 2.393 | 2.100 | +0.293 | +13.95 | 20.0 | | 2.041 | 20.30 | 41.43 | 4.29 | Micritic claystone |
| 26-2, 143-145 | 913.93 | 2.961 | 2.625 | +0.336 | +12.80 | 20.0 | | 2.150 | 15.09 | 32.44 | 5.64 | Volcanic graded siltstone |
| 27-1, 108-111 | 931.08 | 2.752 | 2.367 | +0.385 | +16.27 | 20.0 | | 2.085 | 17.71 | 36.93 | 4.94 | Micritic claystone |
| 27-2, 122-124 | 932.72 | 2.226 | 2.249 | -0.023 | - 1.02 | 20.0 | | 2.020 | 15.64 | 31.59 | 4.54 | Micritic claystone |
| 27-6, 28-30 | 937.78 | 2.349 | 2.187 | +0.162 | + 7.41 | 20.0 | | 2.064 | 15.70 | 32.40 | 4.51 | Fissil claystone |
| 28-2, 11-13 | 950.61 | 2.169 | 2.103 | +0.066 | + 3.14 | 22.0 | | 1.947 | 24.08 | 46.88 | 4.09 | Volcanic sandy siltstone |
| 28-3, 38-40 | 952.38 | 2.798 | | | | 22.0 | 1.882 | | | | 5.27$^d$ | Volcanic graded sandstone |
| 28-3, 41-43 | 952.41 | 2.100 | | | | 22.0 | 2.094 | | | | 4.40$^d$ | Volcanic sandstone |
| 29-1, 120-122 | 969.20 | 2.060 | 1.825 | +0.235 | +12.88 | 20.0 | | 2.067 | 20.71 | 42.81 | 3.77 | Ferruginous silty claystone |
| 29-2, 139-141 | 970.89 | 2.585 | 2.055 | +0.530 | +25.79 | 20.0 | | 2.159 | 14.39 | 31.07 | 4.44 | Silty claystone |
| 30-1, 80-82 | 987.80 | 2.235 | 1.981 | +0.254 | +12.82 | 21.0 | | 2.075 | 21.45 | 44.51 | 4.11 | Laminated silty claystone |
| 30-2, 71-73 | 989.23 | 2.380 | | | | 20.0 | 2.063 | | | | 4.91† | Volcanic sandstone |
| 30 2, 114-116 | 989.65 | 2.050 | | | | 20.0 | 2.199 | | | | 4.51† | Ferruginous claystone |
| 31 CC | 998.01 | 4.024 | | | | 20.0 | | | | | | Basalt |
| 31, CC | 998.01 | 3.886 | | | | 20.0 | | | | | | |
| 31, CC | 998.01 | 3.978 | | | | 20.0 | 2.554 | | | | 10.16$^d$ | Piece 2: Basalt |
| 31, CC | 998.01 | | 3.710 | | | 21.0 | | 2.535 | | | 9.40 | Minicore 2B: basalt |
| 31, CC | | | 3.712 | | | 21.0 | | | | | | Minicore 2B: basalt |
| 31, CC | 998.01 | | 3.963 | | | 21.0 | | 2.572 | | | 10.19 | Minicore 2C: basalt |
| | | | 3.923 | | | 21.0 | | | | | | Minicore 2C: basalt |
| 32-1, 139-141 | 1007.39 | 3.902 | 3.907 | -0.005 | - 0.13 | 22.0 | | 2.587 | | | 10.11 | Minicore 6B: basalt |
| 32-1, 143-145 | 1007.43 | 4.068 | 3.913 | +0.155 | + 3.96 | 22.0 | | 2.561 | | | 10.02 | Minicore 6C: basalt |
| 32-1, 145-147 | 1007.45 | 4.019 | | | | 20.0 | 2.590 | | | | 10.41$^d$ | Piece 6: basalt |
| 32-2, 81-83 | 1008.31 | 3.944 | 3.868 | +0.076 | + 1.96 | 28.0 | | 2.607 | | | 10.08 | Minicore 8B: basalt |

**TABLE 3** – *Continued*

| Sample (Interval in cm) | Depth in Hole (m) | Compressional Sound Velocity ‖ Beds (km/sec) | ⊥ Beds (km/sec) | Anisotropy ‖-⊥ (km/sec) | Anisotropy (‖-⊥) ÷ ⊥ (%) | Temp (°C) | "Special" Wet-Bulk Density 2-min count (g/cc) ‖ Beds | ⊥ Beds | Wet-Water Content Salt Cor. (%) | Porosity[b] (%) | Acoustic Impedance $\frac{g\ 10^5}{cm^2\ sec}$ | Lithology |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32-2, 84-85 | 1008.34 | 3.971 | 3.991 | -0.020 | - 0.50 | 28.0 | | 2.582 | | | 10.30 | Minicore 8C: basalt |
| 32-2, 125-130 | 1008.75 | 4.112 | | | | 20.0 | 2.623 | | | | $10.79^d$ | Piece 15: basalt |
| 32-3, 6-8 | 1009.06 | 4.001 | 4.000 | +0.001 | + 0.03 | 28.0 | | 2.549 | | | 10.20 | Minicore 1B: basalt |
| 32-3, 10-12 | 1009.10 | 3.954 | 3.948 | +0.006 | + 0.15 | 28.0 | | 2.524 | | | 9.96 | Minicore 1C: basalt |
| 32-3, 85-87 | 1009.85 | 3.968 | 3.994 | -0.026 | - 0.65 | 24.0 | | 2.538 | | | 10.14 | Minicore 8C: basalt |
| 32-3, 88-90 | 1009.88 | 3.996 | 4.048 | 0.052 | 1.28 | 24.0 | | 2.583 | | | 10.46 | Minicore 8D: basalt |
| 32-3, 110-113 | 1010.10 | 4.163 | | | | 20.0 | 2.547 | | | | $10.60^d$ | Piece 9: basalt |
| 32-4, 55-57 | 1011.05 | 4.365 | 4.378 | -0.013 | - 0.30 | 22.0 | | 2.677 | | | 11.72 | Minicore 5B: basalt |
| 32-4, 59-61 | 1011.09 | 4.419 | 4.391 | +0.028 | + 0.64 | 22.0 | | 2.645 | | | 11.61 | Minicore 5C: basalt |
| 32-4, 60-62 | 1011.10 | 4.453 | | | | 20.0 | 2.704 | | | | $12.04^d$ | Piece 5: basalt |
| 33-1, 113-115 | 1016.63 | 3.818 | 3.788 | +0.030 | + 0.79 | 24.0 | | 2.548 | | | 9.65 | Minicore 8B: basalt |
| 33-1, 115-120 | 1016.65 | 3.845 | | | | 20.0 | 2.536 | | | | $9.75^d$ | Piece 8: basalt |
| 33-1, 118-120 | 1016.68 | 3.729 | 3.760 | -0.031 | - 0.82 | 24.0 | | 2.546 | | | 9.57 | Minicore 8C: basalt |
| 34-1, 25-32 | 1025.25 | 3.611 | | | | 20.0 | | | | | | Piece 9: basalt |
| 34-1, 55-57 | 1025.55 | 3.781 | | | | 20.0 | 2.541 | | | | $9.61^d$ | Piece 19: basalt |
| 34-1, 55-57 | 1025.55 | 3.708 | | | | 20.0 | | | | | | (Rerun after drying and labeling) |
| 34-1, 72-74 | 1025.72 | 3.673 | 3.697 | -0.024 | - 0.65 | 22.0 | | 2.554 | | | 9.44 | Minicore 21B: basalt |
| 34-1, 74-76 | 1025.74 | 3.593 | 3.688 | -0.095 | - 2.58 | 22.0 | | 2.540 | | | 9.37 | Minicore 21C: basalt |
| 34-1, 75-76 | 1025.75 | 3.772 | | | | 20.0 | | | | | | Piece 21: basalt |

[a] $\rho_g$ & $\rho_{gc}$ = 2.70 for sed. rocks, 2.65 for cherts, and 2.86 for basalt.

[b] Porosity = (salt corrected wet-water content) X (wet-bulk density).

[c] Large sample.

[d] Horizontal.

dicular and parallel to bedding), absolute velocity anisotropy, percentage velocity anisotropy, acoustic impedance, and reflection coefficients are presented in Table 3, with most of these parameters graphically displayed in the site plot (Figure 10) and core plots. The GRAPE analog data are presented only in graphic form in the core plots.

The physical property data in the site reports will be primarily presented in tables and graphs and only briefly discussed. Detailed discussion and interpretation about the interrelationships of the laboratory physical property data are treated more thoroughly in Chapter 26, this volume.

From cores recovered at Site 315, sound velocity, wet-bulk density, wet-water content, acoustic impedance, and reflection coefficients were measured on foram and radiolarian nannofossil chalks, cherts, limestones, claystones, volcanic clasts, and basalt recovered from 0 to 1034 meters below the sea floor. The section drilled at Site 315 may be divided into seven intervals, each of which has distinct physical characteristics as depicted and summarized in Table 4, and marked by horizontal dashed lines in Figure 10. These do not necessarily coincide precisely with either the lithologic units described earlier with the biostratigraphic subdivision, or with the interpreted acoustistratigraphy.

Cores 1A and 2A, in the upper 250 meters, were completely disturbed by drill coring. Vertical structures are common, and presumably resulted from the sediments being injected into the core barrel. Data were collected only where undisturbed samples were retrieved; therefore, data above 250 meters will not be discussed. The 250-meter boundary below the disturbed cores is arbitrarily placed.

The second physical properties interval from ~250 to ~480 meters was selected because of a consistently low wet-bulk density of about 1.77 g/cc, and a typical sound velocity of 1.60 km/sec, compared to an apparently (as the core sampling is too sparse to be certain) higher density of 1.85 g/cc and velocity of 1.67 km/sec in the underlying interval. The ~480 meter boundary is arbitrary because of the large cores spacing. The wet-water content and porosity in the ~250- to ~480-meter interval both decrease with depth, while below Core 6A (480 m), in the third interval, the wet-water content and porosity remain stable, or even increase slightly with depth. There also appears to be a slight increase in velocity and acoustic impedance below ~480 meters.

The fourth physical properties interval is from ~712 to ~790 meters. Its upper contact is strongly marked by wide variation in all physical properties, but with values that are distinctly higher and lower than above ~712 meters. Some of these variations are caused by silicification and thin layers of chert, but other variations are caused by basic changes (other than chert) in the lithology and in the degree of cementation. The lower boundary at ~790 meters is marked by a density change from 2.20 g/cc in claystone to 2.5 g/cc in foraminiferal limestone. Sound velocity increases at this same boundary, and porosity and water content decrease significantly.

The interval between ~790 and 902 meters is the fifth physical properties grouping. The limestone from ~790 to 902 meters gradually becomes less cemented and contains more clastics as depth increases. As a result of the cementation and composition changes, density and velocity decrease and the porosity and wet-water content increase. The lower boundary at 902 meters is subtly marked by a change in density; that is, it no longer decreases but remains constant and even slightly increases with increasing depth.

The seventh interval, below ~996 meters, is marked distinctly by abrupt changes in all parameters as the lithology changes from semilithified volcaniclastics to basalt. Velocities and densities for basalt were measured on the denser, least vesicular segments to be certain that they were saturated with water. However, because of shipboard sampling regulations, it was not possible to obtain wet-water content samples from the basalts.

The basalt was divided into six units (labeled 1 through 6) by the shipboard igneous petrologist. These units can also be grouped by sound velocity as follows:

Units 1, 2, and 3 = 3.87-416 km/sec
Unit 4 = 4.37-4.45 km/sec
Unit 5 = 3.73-3.84 km/sec
Unit 6 = 3.59-3.78 km/sec

## Discussion

Sound velocity is generally faster parallel rather than perpendicular to bedding. Between 0 and 712 meters the Tertiary chalks are only slightly anisotropic, ranging from 0% to 3% with 2% being typical. A cemented layer at 463 meters, however, has a relatively high anisotropy of 9%.

Below ~712 meters, the Cretaceous limestones and semilithified clastics have a significantly greater sound velocity anisotropy with the horizontal velocities being greater from 0% to 26%, with 5% to 15% being typical. The greatest anisotropies occur at about 800 meters in a few cemented claystones and sandstones, and some limestones. A few negative anisotropies were found; these may be errors, or perhaps caused by burrows, cracks, veins, nodules, or other structures. The anisotropy data are further discussed in Chapter 25 of the present volume.

Sound velocity anisotropy should be of interest to refraction and reflection profile interpretation, especially as the basalts do not have a significant anisotropy as compared to the overlying sedimentary rock. Also of significance is the presence of low velocity rocks beneath high velocity layers.

It is interesting to note that reflectors within strata deeper than about 700-800 meters are quite faint, if not altogether lacking. Reflection coefficients at these and greater depths are large. These high reflection coefficients in the deeper, harder Cretacous rocks are probably real; the lack of reflectors probably is due to the attenuation of the energy of the airgun pulse before it reaches the Cretaceous rocks. Another explanation is that the energy is absorbed by internal reflection within the Cretaceous rocks.

An unusual rock was sampled at 592 meters in Core 8A, Section 3, 58-64 cm. This cherty appearing rock gave a very high density value on the GRAPE of 4.07 g/cc. This rock has been identified as celestite or barite by X-ray diffraction.

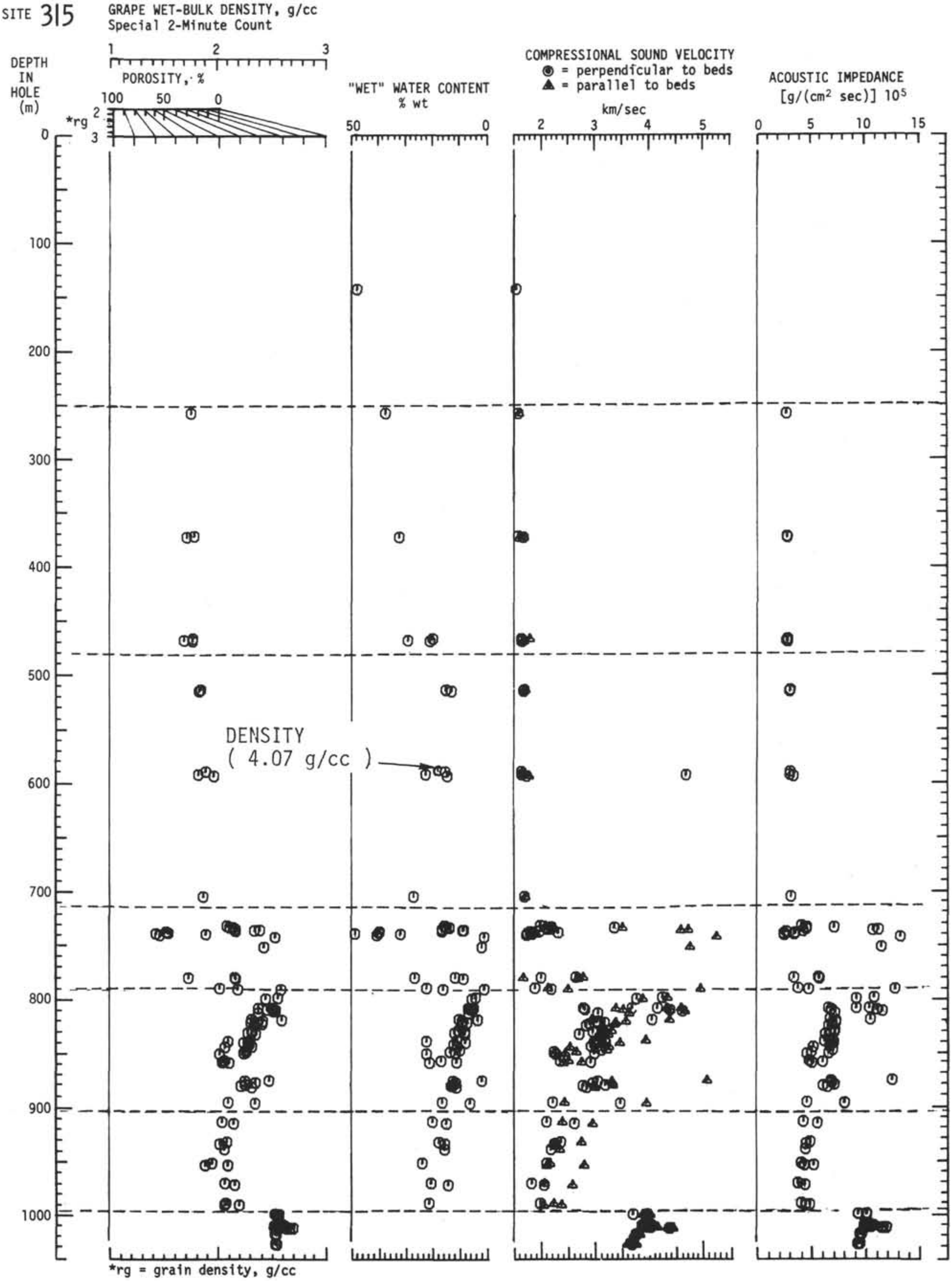

Figure 10. *Summary of physical properties at Site 315. GRAPE analog data, both corrected and uncorrected for actual core diameter, are presented separately at the end of this chapter.*

TABLE 4
Site 315 Summary of Stratigraphic Grouping on the Basis of Rock Physical Properties (Lab. Temp. and Pressure)

| Lithology | Depth (m) | Cores | Typical Wet-Bulk Density (g/cc) | Typical Wet-Water, Content (wt %) | Typical Porosity (vol %) | Typical Sound Velocity (km/sec) | Typical Impedance $\frac{g\,10^5}{cm^2\,sec}$ | Typical Reflection Coefficient |
|---|---|---|---|---|---|---|---|---|
| Foram and rad nanno ooze: Quaternary to mid Miocene | 0 to ~250 | 1A-3A | 1.6 Disturbed (estimate) | 48 Disturbed (estimate) | 77 Disturbed (estimate) | 1.54 Disturbed (estimate) | 2.5 Disturbed (estimate) | |
| | | | | | | | | 0.06 |
| Foram and rad nanno chalk: mid Miocene | ~250 to ~480 | 4A-6A | 1.77 | 30 decreasing 38-20 downward | 55 decreasing 65-50&35 downward | 1.60 | 2.8 | |
| | | | | | | | | 0.05 |
| Foram and rad nanno chalk and chert: late and mid Oligocene | ~480 to ~712 | 7A-9A | 1.85 | 20 increasing 14-27 downward | 50 increasing 24-51 downward | 1.67 | 3.1 | |
| | | | | | | | | 0.14 |
| Nanno chalk, claystone, and chert: Oligocene to mid Maestrichtian | ~712 to ~790 | 10A-16A | 1.4-2.2 (chert – 2.1-2.6) | 50-9 (chert – 14-1) | 70-20 (chert – 30-2) | 1.7-2.8 (chert – 3.3-5.3) | 2.5-6.0 (chert – 7-13) | |
| | | | | | | | | 0.39 |
| Limestone, claystone, volcaniclastics, chert: mid Maestrichtian to Campanian | ~790 to ~902 | 16A-25A | 2.6-2.0 generally decreasing downward | 1.0-23 generally increasing downward | 10-48 generally increasing downward | 4.6-2.1 generally decreasing downward | 7 generally decreasing downward | |
| Volcaniclastics: Campanian-Santonian | ~902 to ~996 | 26A-30A | 2.1 Slightly increasing downward | 20 | 40 (31-46) | 2.2 | 4.5 | |
| | | | | | | | | 0.39 |
| Basalt | ~996 to ~1035 | 30A-34A | 2.55 (2.55-2.70) | | | 4.0 (3.6-4.5) | 10 (9.5-12) | |

## CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

Several seismic reflection profiles are available that show the acoustic stratigraphy in the vicinity of Site 315. In addition to the profiles run by *Glomar Challenger* on approaching and leaving the site (Figure 4), we had onboard a record from the Hawaiian Institute of Geophysics (*Mahi*, Dec 1968) along a parallel course a mile or two south of our own line, and a Lamont-Doherty line (*Vema*-24, March 1971) taken a few miles farther south on a somewhat different course (Figure 5). All these profiles show a very similar set of reflectors in the vicinity of the site:

1) An upper acoustically well-stratified unit about 0.10 sec thick, resting on a more transparent layer about 0.05 sec thick.

2) A weak but persistent reflector at about 0.15 sec below the sea floor.

3) A stronger, very persistent reflector at about 0.4 sec of two-way reflection time. This reflector is generally overlain by about 0.1 sec of acoustically very transparent material. Between the 0.15 and 0.40 sec reflectors, a much less persistent reflector can be seen in some places about 0.28 sec below the sea floor.

4) A diffuse reflector is generally (but not everywhere) present at about 0.65 sec.

5) A strong reflector is everywhere present just below the 0.65-sec event, at about 0.70 sec. It is difficult to discriminate these two reflectors in some places, but generally the lower reflector is strong enough to be seen separately.

6) Below the strong reflectors, the rest of the acoustic stratigraphy is much less distinct than those described above. A fuzzy reflector can generally be discerned at about 0.95 sec, and occasionally parts of profiles show a reflector at about 1.0 and 1.1 sec.

At Site 315, the *Glomar Challenger* record shows the reflectors at 0.15, 0.28, 0.40, 0.65, 0.70, 0.74, 0.95, and 1.12 sec (very vague). The reflectors at 0.15, 0.40, and 0.70 sec are the most prominent.

A sonobuoy released from *Glomar Challenger* at Site 315 (Figure 11) gave results as shown in Table 5.

Other reflectors than those shown in Table 5 could not be traced with enough certainty on the record to yield a solution.

Using a combination of the sound velocity and impedance data derived from measurements on cored samples, observations on lithology, and changes in drilling rates, a possible sequence of acoustistratigraphic units was derived and is shown in Table 6. The agreement between the core data and the sonobuoy data is good and shows that the deepest reflector commonly visible on the seismic profiler records in the Line Islands region is not petrologic (basaltic) basement, but rather a change from Cenozoic cherty chalks and marls to Cretaceous limestones. The very prominent regional reflector at about 0.70 sec probably represents a change from chalk to cherty chalk, within upper Oligocene strata.

The correlation of rock units with acoustic units is shown in Figure 12.

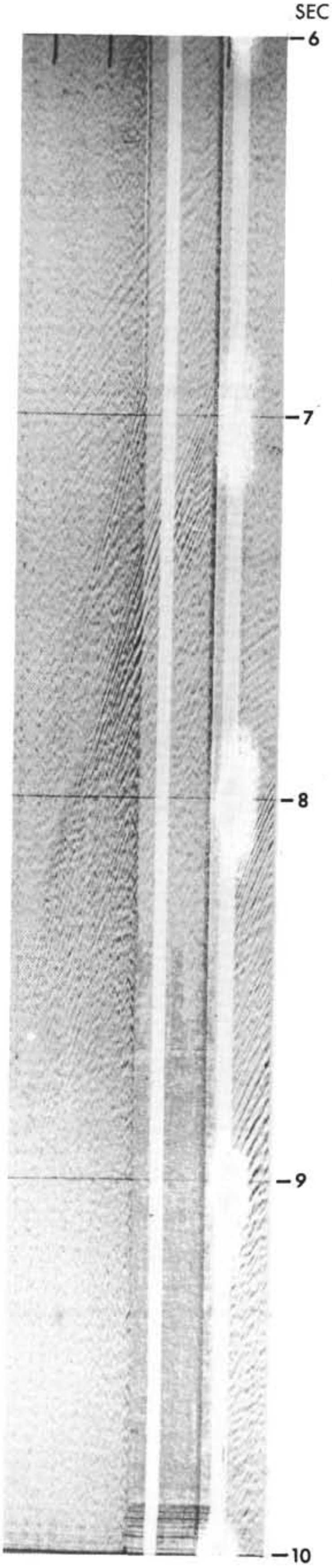

Figure 11. Glomar Challenger *sonobuoy record at Site 315.*

## PALEONTOLOGY

### Biostratigraphic Summary

Holes 315 and 315A provided a stratigraphic sequence of sedimentary rocks of upper Cretaceous to Quaternary age (Core 1 through Core 15A). Above the stratigraphically highest chert recovered in the core catcher of Core 9A, the section includes 190 meters of upper Oligocene, 440 meters of Miocene, 45 meters of Pliocene, and 35 meters of Pleistocene pelagic calcareous oozes interbedded with pelagic turbidites. Deposition rates for this section are high, in the range of 20 m/m.y. for the middle Miocene to Pleistocene rocks, and somewhat more than 50 m/m.y. for the upper Oligocene-lower Miocene sediments. The Cretaceous/Tertiary boundary was penetrated at a depth of approximately 790 meters (between Cores 15A and 16A), and the Upper Cretaceous sequence continues down to 996.5 meters, where basalt was first encountered. Because of stringent time restrictions, the section was continuously cored only in the interval between 740 and 863 meters (Cores 10A to 23A); as a result, biostratigraphic data are somewhat scattered. The data are further limited by poor core recovery, particularly in the chert beds.

Calcareous nannoplankton, foraminifers, and radiolarians, as well as diatoms and silicoflagellates occur in the upper part of the sequence. The diatom population decreases in Core 4A, and silicoflagellates disappear below Core 5A. Preservation of all fossil groups is good in the uppermost cores, but becomes increasingly poor below Core 4A. At deeper levels discoasters are heavily overgrown and solution effects appear on coccoliths. In addition, foraminifer assemblages seem to be impoverished by dissolution. Radiolarians are badly corroded in the Paleogene part of the section, and were not found below Core 10A.

A probable hiatus occurs in Core 6A, where part of the lower Miocene is missing. This is succeeded below by an apparently disturbed lowest Miocene-upper Oligocene boundary section in Core 7A to 9A. In the Eocene interval below Core 10A, only chert was recovered, and paleontological data are therefore not available. Nannoplankton found in Core 15A indicate an upper Paleocene age. Lower Paleocene and uppermost Maestrichtian sediments are apparently missing, inasmuch as Core 16A contains a rather poor nannoplankton assemblage of middle Maestrichtian age. The preservation of calcareous nannoplankton is poor throughout the Upper Cretaceous. Foraminifers were encountered only sparsely in thin sections of these beds, and radiolarians are also extremely rare and poorly preserved. In Core 26A the last nannofossils were found,

**TABLE 5**
**Shipboard Sonobuoy Results, Site 315**

| Reflector Sea Floor (sec) | Average Velocity From Sea Floor (km/sec) | Interval Velocity (km/sec) | Depth to Reflector (m) |
|---|---|---|---|
| 0.40 | 1.54 | 1.54 | 308 |
| 0.64 | 1.60 | 1.70 | 512 |
| 0.95 | 1.74 | 2.00 | 822 |

indicating a Santonian age for the base of this particular core. Sediments recovered in Cores 27A through 30A are barren of planktonic fossils.

The biostratigraphic subdivision of Site 315 sediments is shown in the site summary figure at the end of this chapter and preceding the core logs.

### Calcareous Nannoplankton

The 4 cores from Hole 315, and 10 cores from Hole 315A, to a depth of 740 meters below sea floor, all yielded calcareous nannoplankton assemblages ranging in age from Quaternary to upper Eocene. Well-preserved nannoplankton assemblages of the Quaternary (standard Zones NN19, NN20, and NN21) and uppermost Pliocene (Zone NN18) were found in the four spot cores of Hole 315. The Pliocene-Pleistocene boundary apparently lies between the core-catcher samples of Cores 2 and 3, from which there was no other recovery. Core 4 yielded nannoplankton of lower Pliocene Zones NN13, NN14, and NN15.

The first three cores in Hole 315A contain moderately well preserved nannoplankton of Zone NN11, with *Ceratolithus tricorniculatus* present in Cores 1A and 2A. From Core 4A (middle Miocene Zone NN6) downward, nannoplankton preservation became increasingly poor; solution effects on coccoliths and excess calcite on discoasters made species assignment difficult or, in some cases, impossible. Core 5A yielded nannoplankton of Zone NN5, with abundant *Sphenolithus heteromorphus*. The upper part of Core 6A can be assigned either to Zone NN5 or NN4, inasmuch as the marker species (*Helicopontosphaera ampliaperta*) of the boundary between NN4 and NN5 is not present in the equatorial Pacific; and *Discoaster exilis*, which was used as a substitute marker for this boundary during Leg 7, cannot be identified with certainty because of overcalcification. In Section 2 of Core 6A, a mixed NN4/5 and lower NN1 assemblage (with fairly common *Coccolithus abisectus*) was found and the core catcher of the core contains a good lower NN1 assemblage. These data indicate a possible hiatus within this core interval. Cores 7A to 9A seem to represent a disturbed interval, with lower NN1 assemblages present in Cores 7A and 9A and upper NN1 assemblages in Core 8A. The base of Core 9A contains a nannoplankton assemblage indicative of the Oligocene Zone NP24. In Core 10A, nannoplankton of the lower Oligocene Zones NP21 and NP22 were found. The Eocene/Oligocene boundary was encountered in Section 6 of this core, between 39 and 52 cm, as also indicated by a sharp change in accumulation rate. The upper Eocene nannoplankton assemblage is restricted to sturdy forms with heavy excess calcite overgrowths, but most likely represents Zones NP20 or NP19. Nannoplankton from Cores 11A to 14A are not available as a result of the recovery only of chert in these cores. The lowest Tertiary in Hole 315A can be dated as upper Paleocene by moderately well preserved nannoplankton in Core 15A which indicate Zones NP8 and NP9. The Cretaceous Tertiary boundary lies between Cores 15A and 16A, in which a poorly preserved nannoplankton assemblage of middle Maestrichtian (*Lithraphidites quadratus* Zone) age was observed. Calcareous nannofossils found down to Core 26A are poorly preserved throughout, with both heavy dissolution and overgrowth effects, especially on *Micula staurophora*. The assemblages are rather meager, and only a few nannofossil species remain.

The occurrences of *Tetralithus aculeus, T. trifidus, T. gothicus,* and *Marthasterites furcatus* were used to subdivide the Upper Cretaceous of Hole 315A into a middle Maestrichtian section between Core 16A and the upper part of Core 19A, a lower Maestrichtain/upper Campanian section in Cores 19A to 21A, a middle Campanian section in Cores 22A to 24A, and a lower Campanian section in the lower part of Core 24A and in the upper part of Core 26A. The Santonian, with *Marthasterites furcatus* present, was observed in the lower part of Core 26A. Cores 27A to 29A, and Core 30A, in which basalt was first recovered, proved to be barren of nannofossils.

**TABLE 6**
**Acoustistratigraphic Units, Site 315**

| Depth From Sea Floor (m) | Lithology | Interval Velocity (km/sec) | Reflection Time Interval (sec) | Reflection Time From Sea Floor (sec) | Average Velocity From Sea Floor (km/sec) |
|---|---|---|---|---|---|
| 0-115 | Soft ooze | 1.54 | 0.15 | 0.15 | 1.54 |
| 115-312 | Ooze to firm ooze | 1.56 | 0.25 | 0.40 | 1.56 |
| 312-510 | Soft chalk | 1.64 | 0.25 | 0.65 | 1.59 |
| 510-560 | Firm chalk | 1.68 | 0.06 | 0.70 | 1.60 |
| 560-725 | Hard chalk with chert | 1.71 | 0.19 | 0.89 | 1.63 |
| 725-790 | Hard chalk and chert | 2.25 | 0.06 | 0.95 | 1.66 |
| 790-850 | Limestone, marlstone, ss. | 3.30 | 0.04 | 0.99 (vague) | 1.72 |
| 850-996 | Claystone, volcanic ss. | 2.30 | 0.13 | 1.12 (vague) | 1.78 |
| 996 (drilled) | Basalt | 4.0 | | | |

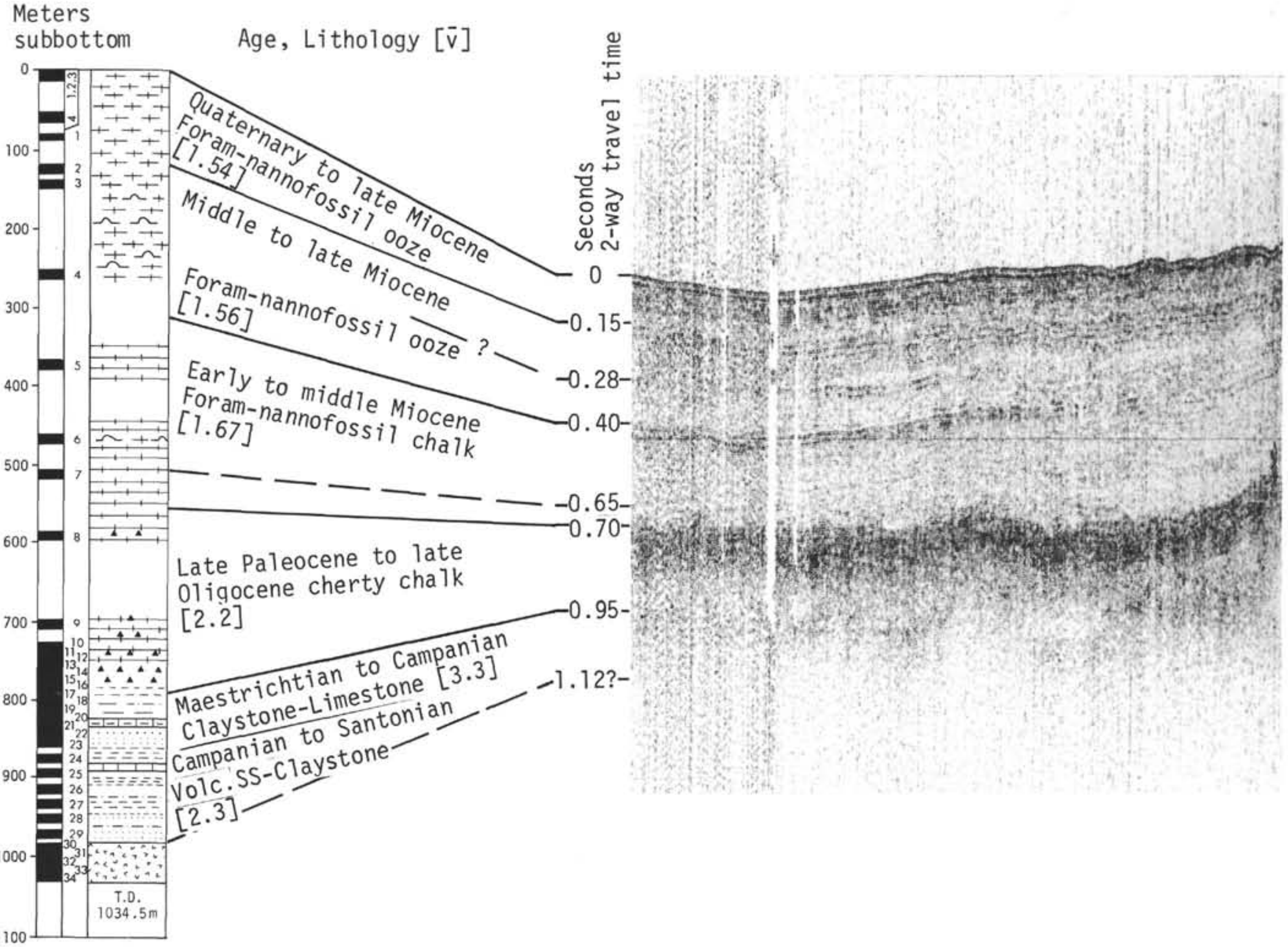

Figure 12. *Correlation of* Glomar Challenger *seismic reflection profile with the section drilled at Site 315.*

**Silicoflagellates**

Silicoflagellates occur in varying amounts in all cores of Hole 315 and indicate the presence of the *Dictyocha epiodon* Zone, *Mesocena quadrangula* Zone, and *Dictyocha fibula* Zone.

In Hole 315A, silicoflagellates were found as far down as Core 5A with the *Dictyocha fibula* Zone present in Cores 1A and 2A, the *Dictyocha rhombica* Zone in Core 3A, and the *Dictyocha triacantha* Zone (?) in Core 5A. The diatom population decreases in Core 4A, and below Core 5A silicoflagellates disappear.

**Planktonic Foraminifers**

What appears to be a fairly standard Quaternary to upper Oligocene planktonic foraminiferal sequence was discontinuously cored at Site 315. Foraminifers are frequent to abundant in Cores 1 through 9A, though solution effects of moderate to large degrees affect all assemblages, especially in the upper Miocene of Cores 2A and 3A. Below Core 9A, the sediments appear to be barren of in situ planktonic foraminifers.

Core 1 recovered a low-latitute upper Pleistocene assemblage including rare *G. truncatulinoides* and common *G. pseudofoliata.* Cores 2 and 3 did not contain sufficient sediment for a foraminiferal sample. Core 4 contains a good lower Pliocene assemblage, including well-developed specimens of *Pulleniatina spectabilis.*

Core 1A contains upper Miocene assemblages with *Pulleniatina primalis* but no *Globorotalia tumida.* Cores 2A and 3A are also upper Miocene (*G. acostaensis* Zone) and contain rare specimens of *G. acostaensis*; however, the assemblages are sparse, poorly preserved, and occur in a dominantly radiolarian facies.

Core 4A contains the upper two zones of the *Globorotalia fohsi* series. The base of the core is in the *G. fohsi lobata* Zone while Section 1 contains well-developed, large specimens of *G. fohsi robusta*, as well as primitive *G. menardii.* A fairly high degree of dissolution is indicated in this core by the relatively monotonous fauna dominated by *G. siakensis.*

The *G. bisphericus/G. insueta* Zone was recovered in Core 5A. Both nominate species are rare, and the scarcity of the genus *Globigerinoides* attests to impoverishment of the foraminiferal fauna by dissolution.

A hiatus in Core 6A separates highly corroded assemblages of the upper lower Miocene (with common *Globorotalia peripheroronda*) in the core-catcher sample. The *G. kugleri* Zone was also found in Cores 7A and 8A. the lack of *Globigerinoides primordius* in these cores suggests an upper Oligocene age, although this may be a dissolution effect.

Core 9A contains a *G. opima* Zone (upper Oligocene) assemblage, but also contains redeposited Upper Cretaceous (*Globotruncana* spp.) and lower/middle Eocene (*Globigerina* cf. *G. frontosa, G.* cf. *G. soldadoensis*) forms.

Because of chert and poor core recovery, no samples for foraminiferal treatment were available from the interval of 315A, 10-17 cm. However, reworked larger foraminifers were observed in cores from 10A-3, 134-135 cm and 17A-2, 117-119 cm. Recovery was good for Core 18A, but none of five samples yielded foraminifers in residues, despite the fact that abundant recrystallized specimens, including larger foraminifers, were evident in unprocessed cores at several levels. Apparently, the entire interval is highly turbiditic and contains both shallow-water and reworked material.

Sample 19A-2, 29-30 cm provided common, moderately well preserved Maestrichtian planktonics of mixed Maestrichtian aspect (middle *Globotruncana gansseri* Zone and lower *Globotruncana arca* Zone). Sample 19A-3, 38-40 cm yielded excellent *Globotruncana calcarata*, thus placing the Campanian-Maestrichtian boundary between these two levels, or at 818.7 ±0.7 meters.

The upper Campanian (*Globotruncana calcarata* Zone) continues from 19A-3, 38-40 cm through 21A-5, 119-120 cm (842.2 m).

The lower Campanian (*Globotruncana elevata* Zone) fauna appears in 21A-6, 84-87 cm (843.44-47 m), placing the lower-upper Maestrichtian boundary between these two levels, or at 842.8 ±0.6 meters.

Below Core 21A only 3 of 28 samples (23A-3, 0-2 cm; 23-3, 16-18 cm; 24A-3, 116-118 cm) yielded even a few foraminifers. However, they are planktonics and typical of the *G. elevata* Zone, suggesting the continuation of the zone to basalt.

### Radiolarians

Radiolarians are common and well preserved in samples from the Quaternary through upper Oligocene at this site (Cores 1 through 8A; depth 0-598 m). Radiolarians are highly corroded and barely identifiable in the upper Oligocene through uppermost Eocene sediments (Cores 9A and 10A; depth 720-740 m). Radiolarians were not found in any of the material examined from below Core 10A (740 m), although coarse fractions from a few levels in the Upper Cretaceous indicate that trace amounts of radiolarians may be present. None were identified for the purposes of the preliminary shipboard report, however.

The following radiolarian zonal boundaries were identified in the Site 315 material: the base of the Quaternary lies between the bottom of Core 1 and the top of Core 4 (9.0-55.5 m). The *Pterocanum prismatium* Zone was not sampled. The base of the *Spongaster pentas* Zone lies between Core 4 and Core 1A (65.0-75.5 m). The base of the *Stichocorys peregrina* Zone lies between Cores 1A and 2A (85.0-123.5 m). The *Ommatartus penultimus* Zone was not sampled. The base of the *Ommatartus antepenultimus* Zone lies within Core 3A between Section 6 and the core-catcher sample (150-151.5 m). The base of the *Cannartus petterssoni* Zone lies between Cores 3A and 4A (151.5-256.0 m). The base of the *Cannartus laticonus* Zone lies between Cores 4A and 5A (265.5-370.0 m). The base of the *Dorcadospyris alata* Zone lies within Core 5A between Section 1 and Section 2 (387-373 m) The base of the *Calocycletta costata* Zone lies within Core 6A between Section 2 and Section 3 (468-470 m). The base of the *Calocycletta virginis* Zone lies between Cores 7A and 8A (522-588.5 m). The base of the *Lychnocanoma elongata* Zone lies between Cores 8A and 9A (598-702.5 m). The base of the *Dorcadospyris ateuchus* Zone lies between Cores 9A and 10A (712-730.5 m). The base of the *Theocyrtis tuberosa* Zone lies within Core 10A, Section 4 (735.5 m), the lowest core in which identifiable radiolarians were found.

The increasingly poor preservation of the radiolarian assemblages in sections older than the upper Oligocene may be a consequence of northward Pacific plate motion, such that Site 315 migrated into the productive equatorial latitudes during the middle Tertiary, yielding an increasingly silica-rich faunal assemblage in the sediments.

## ACCUMULATION RATES

In spite of the fact that operational constraints necessitated spot rather than continuous coring at Site 315, remarkably continuous data on accumulation rates were acquired. These data are summarized in Figure 13, which is an age versus depth plot for Holes 315 and 315A. The basis for absolute age assignments to biostratigraphic zones is discussed in Chapter 1, this volume.

It is apparent from the figure that rather rapid accumulation (~20-50 m/m.y.) has been typical for this area from about the late Oligocene to the present; that the early Tertiary was a time of slow sediment accumulation (~2 m/m.y.); and that Cretaceous sediments accumulated at more or less normal deep-sea rates (~10 m/m.y.) in this area. Further discussions of these data are contained in the Summary and Conclusions section.

## SUMMARY AND CONCLUSIONS

In spite of the various operational difficulties encountered enroute to Site 315, unanticipated on-site delays, and the presence of a thicker section of Cretaceous strata than was anticipated, the original objectives involved in planning a deep hole on the eastern slopes of the Fanning Island submarine fan were met, if not exceeded.

The depth to in-place volcanic flows at Site 315 proved to be 996.3 meters beneath the sea floor; the total depth penetrated was 1034.5 meters. The deepest datable sediments, at 911 meters, contain Santonian nannofossils, placing the cessation of volcanism at this site in the Late Cretaceous, 85-87 m.y. ago by extrapolation of the accumulation rate. This date proved exceedingly instructive, inasmuch as it is virtually identical to the date of cessation of volcanism at DSDP Site 165, a site that is approximately 780 km north of Site 315, along the Line Islands chain. These ages, obtained by direct drilling, are considerably older than minimum ages obtained by dredging in this general area (Jarrard and Clague, personal communication).

A total thickness of 38 meters of material with a slow drilling rate was cut below the first appearance of basalt,

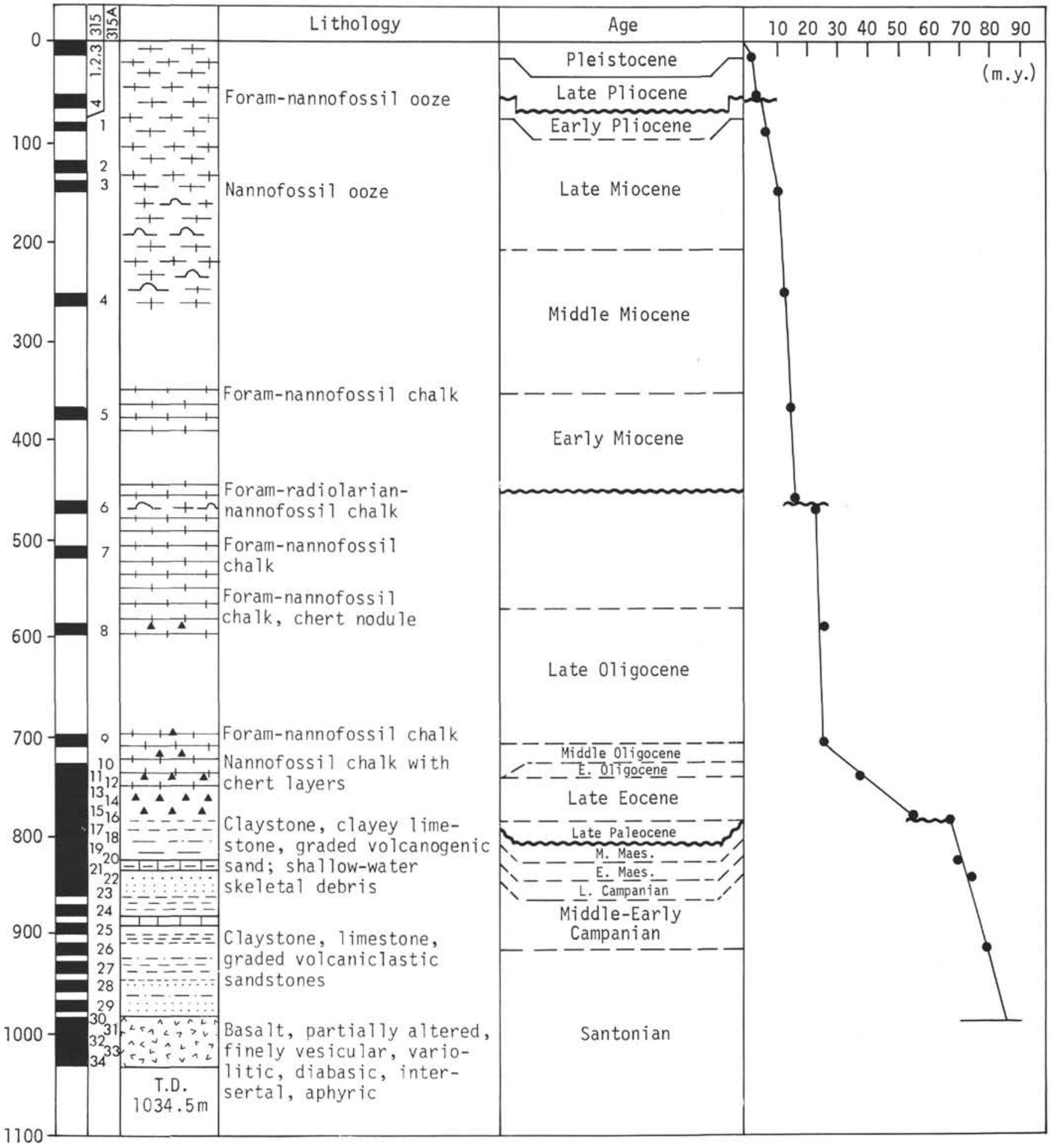

Figure 13. *Graphic log showing lithology, age, and rate of accumulation of sediments at Site 315.*

but only 7.4 meters of core were recovered. While we cannot say with certainty that sedimentary layers do not separate basalt flows in the cored area, no material other than aphyric basalt was present in the cores. At least six flow units were identified in the recovered core. Only one of these flow units was complete in a cored interval, and this unit proved to be about 1.5 meters thick. Minimum thicknesses of two other units were 1.8 meters. It seems most likely that the drilled interval consisted of flows, perhaps locally separated by altered flow tops, clinkery zones, or, less likely, sedimentary rocks, and that these flows are on the order of 1.5-2.0 meters thick. Unfortunately, the few core-catcher samples which were sectioned aboard ship were badly altered, although, for the most part, they retained typical diabasic, variolitic, intersertal, or intergranular basaltic textures. Three flow units, however, appeared to have trachytic textures in their central parts; these textures are rare in either tholeiitic or alkalic basalts. Because of the state of alteration, it was impossible to say definitively whether the basalts have tholeiitic or alkalic affinities, but we suspected them to be alkalic. Bass et al. (1973) have concluded that basalts at Site 165 are alkalic. The presence and sizes of vesicles and coarse vugs in the Site 315 basalts suggest that they were erupted in somewhat shallower depths than they now occupy. If the data of Moore (1965) apply to these rocks, and we are uncertain from other evidence that they do, then original submarine eruption depths could have been as shallow at 500 meters. On the other hand, the unfossiliferous nature of the sediments immediately overlying the basalts suggest water depths of the magnitude of kilometers rather than hundreds of meters.

The sedimentary section above the basaltic rocks at Site 315 was divided into five lithologic units from top to bottom of the drilled interval:

1) Cyclic ooze; white to light and dark brownish foraminiferal nannofossil and radiolarian nannofossil ooze. This unit occupies the interval 0 to 56 meters and is separated from the underlying unit by a hiatus within the Pliocene between foraminiferal Zones N.19 and N.21 within Core 4 and between nannofossil Zones NN15 and NN18 (Hole 315) (see Figures 13 and 14).

2) Variegated ooze: purple, green, and white foraminiferal nannofossil ooze to radiolarian nannofossil ooze. The unit occupies the interval from the Pliocene hiatus (at 56 m) to a depth of 710 meters in Core 9A in upper Oligocene strata. At a depth of approximately 370 meters the unit becomes chalky. Within the variegated ooze unit there is a marked hiatus in Core 6A which occurs within lower Miocene strata (see Figure 12).

3) Claystone, chert, and limestone: this unit extends downwards from the top of Core 10A, and possibly from the base of Core 9A. Chert, poorly recovered, dominates the unit from approximately 750 to 780 meters. The base of this unit is in Core 21A (844 m) near the middle/upper Campanian boundary. Core 17A contains graded beds of reefal skeletal debris made up of abraded tests of large foraminifers, red calcareous algae, echinoderms, and bryozoans.

4) Volcaniclastic sandstones, claystones, and micritic limestones: This unit extends from the base of Core 21A into Core 26A; 844 to 911 meters. Numerous sedimentary structures of diverse origin, including a wide assortment of turbidite structures, characterize this unit. The base of the unit appears to coincide with the Campanian-Santonian boundary (see Figures 13 and 14).

5) Ferruginous claystones and graded volcanic sandstones in the interval from 911 meters to basalt at 996.3 meters: Below Core 26A the sediments are of Santonian age.

In terms of sedimentary history, Site 315 underwent a ?Coniacian to an early-middle Campanian period of volcaniclastic turbidite deposition, followed by the deposition of reef-derived bioclastic debris from a nearby shallow-water or even subaerial source, which continued into middle Maestrichtian time. A condensed Paleocene section rich in fish debris suggests very slow deposition, and perhaps winnowing, followed by the ubiquitous Eocene chert section, From early Oligocene to the present, highly calcareous pelagic oozes have been depostied. In Core 10A however, turbidites with large foraminifers indicate erosion of a preexisting terrain during late Eocene and early Oligocene time.

In general, then, the sedimentary history is much like that of Site 165 (Winterer, Ewing, et al., 1973): volcanogenic turbidites over basalt succeeded by limestone with debris suggesting shallow-water reefal origin, succeeded by chert and a thick carbonate pelagic section containing turbidite units. The very high sediment accumulation rates of up to 50 m/m.y. may result from the addition by turbidite action of some tens of m/m.y. to the normal "pelagic" rate of perhaps 10-20 m/m.y. Differences between Sites 315 and 165 include the presence of a very thick middle Eocene section at Site 165 that is missing at Site 315, and, conversely, a very thick Miocene section at Site 315, whose equivalent has been stripped off by submarine erosion at Site 165.

Based on the increasing numbers of reflection seismic profile records from around the Line Islands, it is becoming evident that stripped submarine "pediments" are present where erosion has been arrested at a particular reflector over a large area. In steaming at an angle to the washboard topography that intersects the main Line Islands trend, one sees that each trough has been, at some time, stripped to a particular level.

Schlanger and Douglas (1974) have suggested that there are four major sets of reflectors in the post-Eocene chert section in the central Pacific. These are designated as follows:

| Reflector | Faunal Zone | Age |
|---|---|---|
| "a" | N.20 | 3 m.y. |
| "b" | N.17-N.18 | 5-6 m.y. |
| "c" | N.12-N.14 | 13-14 m.y. |
| "d" | P.22 | 22-26 m.y. |
| "e" | P.13-P.14 | 43-44 m.y. (Eocene chert) |

At Site 315 the following reflectors, and lithologic or dilling breaks are suggested to be correlative with the above reflectors (see Figures 12, 13, and 14 for data).

| Seismic Reflector, Lithologic Change, or Drilling Break | Schlanger-Douglas Reflector |
|---|---|
| Drilling break at base of cyclic ooze, at approximately 60 meters and at hiatus at top of Core 4 (NN15-NN18) at 3.0 to 3.7 m.y. | – – – – – "a" |
| 0.15-sec reflector at 115 meters (V of 1.54); at ~7 m.y. | – – – – – "b" |
| 0.40-sec reflector at 312 meters (V of 1.56); (NN5-NN6) at 12.5 to 15 m.y. | – – – – – "c" |
| 0.70-sec reflector at 560 meters (V of 1.60); (NN1) at ~22 to 24 m.y. | – – – – – "d" |

The "e" reflector is not well defined, since it seems to be hidden below the 0.64 reflector.

The present high degree of interest in ophiolite complexes and their overlying sediments naturally leads to a comparison of the sedimentary facies of the section drilled at Site 315 to certain sections exposed in the Mediterranean region as outlined below:

| Site 315 | Europe Facies Equivalents |
|---|---|
| Units 1 and 2 | Tertiary chalk over the ophiolite basement of the Troodos Massif on Cyprus |
| Unit 3 | Marne a fucoidi and Scaglia of the Italian Apennines |
| Units 4 and 5 (upper) | Jurassic sediments over the Ligurian ophiolites of the northern Italian Apennines |
| Unit 5 (basal) | Cretaceous "umbers" directly overlying the basalts of the Troodos Massif |

One of the broader goals of Leg 33 was to examine the idea that the Line Islands represent a linear island chain parallel to the Emperor Seamount chain and the Marshall-Gilbert-Ellice chain, formed by the steady movement of the Pacific plate over a "hot spot" or thermal plume (Wilson, 1963; Morgan, 1971, 1972a, b). While it is too early in the program to embark on a detailed discussion of the problem or origin of linear island chains, it seems immediately apparent that, if the basalts drilled at Site 315 are a part of the Fanning volcanic edifice, and are the same age as basalts drilled near a Line Islands edifice at Site 165, nearly 800 km to the north, that the youngest volcanism along the chain must be grossly episodic (Shaw, 1973; Shaw and Jackson, 1973) or coeval. In the latter event, the Line Islands chain, with its prototype name, may not be related to chains of the Hawaiian-Emperor type in genesis, a possibility already raised by Winterer (1973), Clague and Jarrard (1973), and Jackson and Shaw (1975). The presence of alkalic flow units at a considerable distance from the central part of the edifice drilled at Site 165, and their possible presence at Site 315, some 120 km from what we suppose to be the center of the Fanning edifice, is beyond the distance known for alkalic eruptions on Hawaii (Powers, 1955; Moore, 1965) and raises further questions as to whether the mode of origin of all linear islands chains is similar.

Furthermore, the question of whether basalts and debris related to the major Line Island edifices have indeed been sampled depends partially on the definition of which islands and seamounts belong to this chain, and as to whether the strong northeasterly trending structures in this area are part of the chain or not. What is clear is that no evidence of primary volcanic activity was observed at Site 315 younger than about 85 m.y.B.P., as determined onboard ship.

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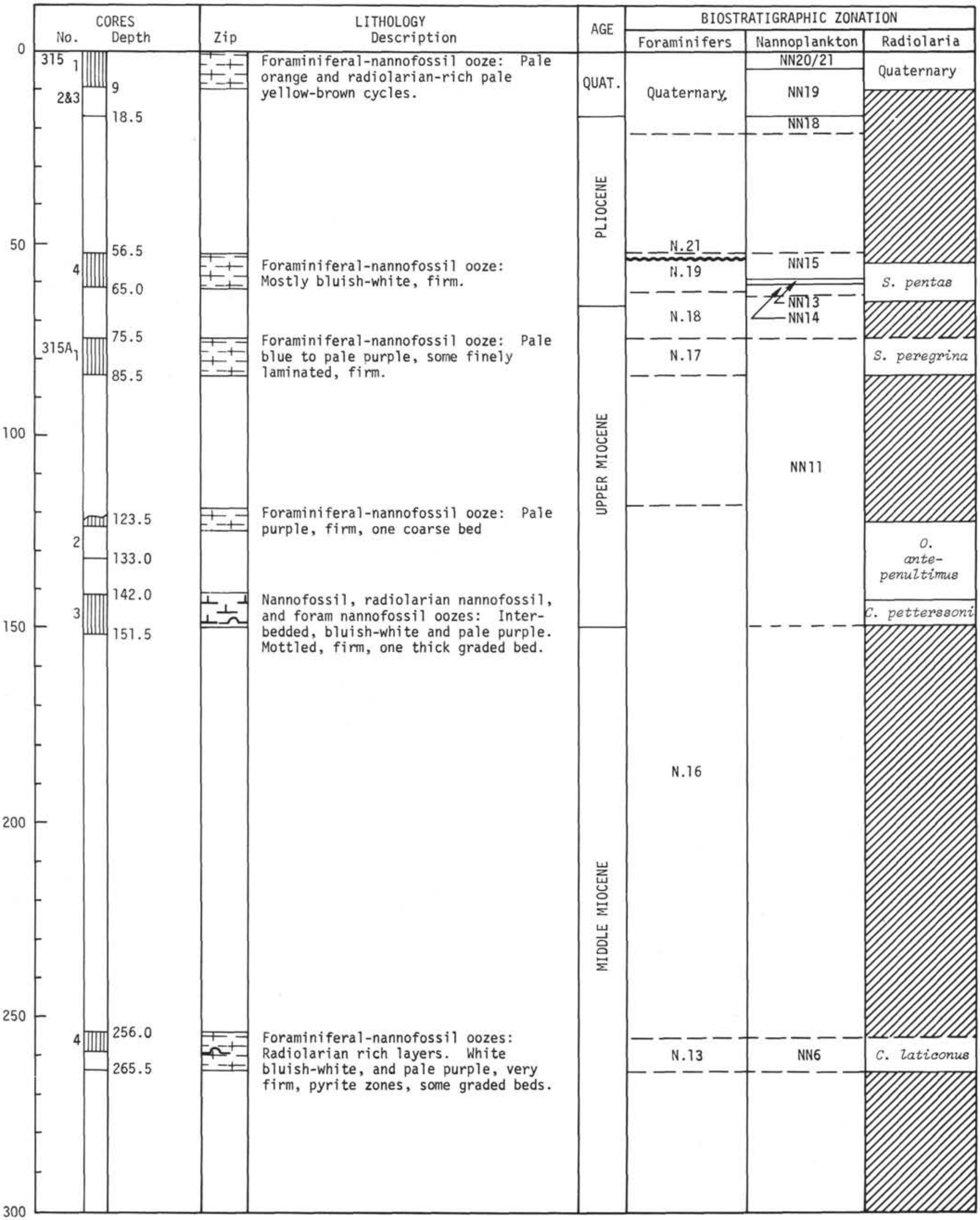


Foraminiferal-nannofossil ooze: Pale orange and radiolarian-rich pale yellow-brown cycles.

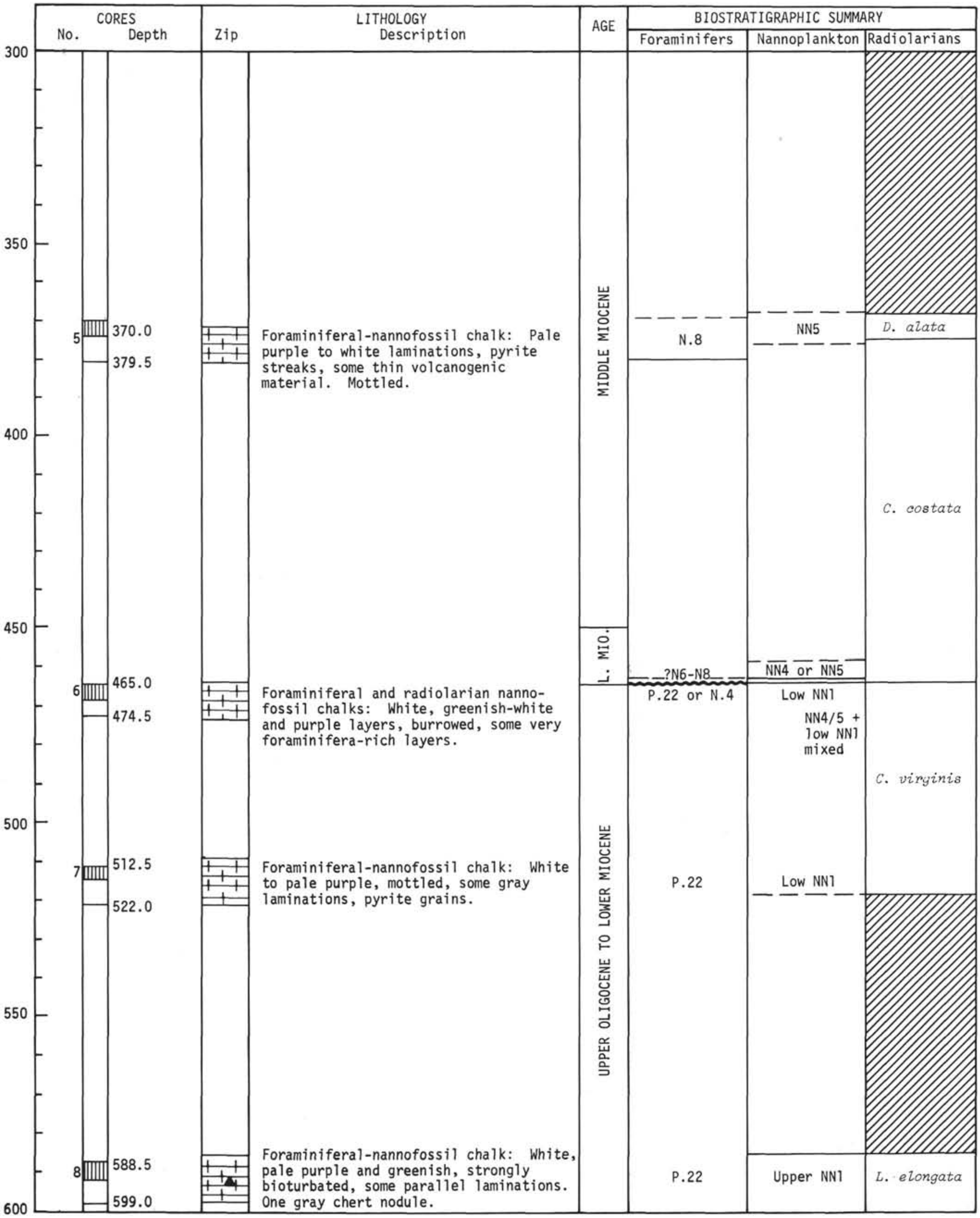
Foraminiferal-nannofossil ooze: Mostly bluish-white, firm.

Foraminiferal-nannofossil ooze: Pale blue to pale purple, some finely laminated, firm.

Foraminiferal-nannofossil ooze: Pale purple, firm, one coarse bed

Nannofossil, radiolarian nannofossil, and foram nannofossil oozes: Interbedded, bluish-white and pale purple. Mottled, firm, one thick graded bed.

Foraminiferal-nannofossil oozes: Radiolarian rich layers. White bluish-white, and pale purple, very firm, pyrite zones, some graded beds.

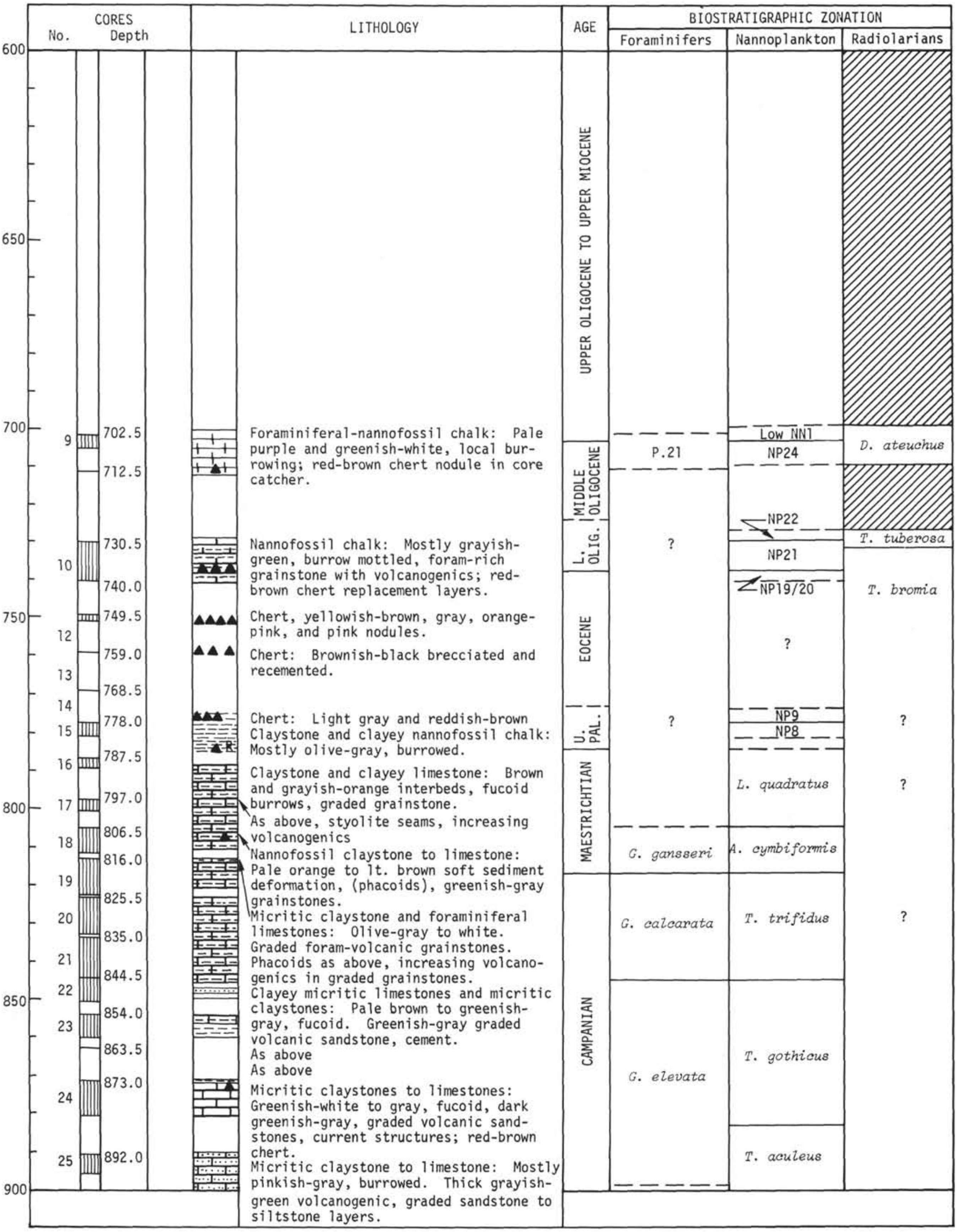


Foraminiferal-nannofossil chalk: Pale purple to white laminations, pyrite streaks, some thin volcanogenic material. Mottled.

Foraminiferal and radiolarian nannofossil chalks: White, greenish-white and purple layers, burrowed, some very foraminifera-rich layers.

Foraminiferal-nannofossil chalk: White to pale purple, mottled, some gray laminations, pyrite grains.

Foraminiferal-nannofossil chalk: White, pale purple and greenish, strongly bioturbated, some parallel laminations. One gray chert nodule.



Foraminiferal-nannofossil chalk: Pale purple and greenish-white, local burrowing; red-brown chert nodule in core catcher.

Nannofossil chalk: Mostly grayish-green, burrow mottled, foram-rich grainstone with volcanogenics; red-brown chert replacement layers.

Chert, yellowish-brown, gray, orange-pink, and pink nodules.

Chert: Brownish-black brecciated and recemented.

Chert: Light gray and reddish-brown

Claystone and clayey nannofossil chalk: Mostly olive-gray, burrowed.

Claystone and clayey limestone: Brown and grayish-orange interbeds, fucoid burrows, graded grainstone.

As above, styolite seams, increasing volcanogenics

Nannofossil claystone to limestone: Pale orange to lt. brown soft sediment deformation, (phacoids), greenish-gray grainstones.

Micritic claystone and foraminiferal limestones: Olive-gray to white. Graded foram-volcanic grainstones.

Phacoids as above, increasing volcanogenics in graded grainstones.

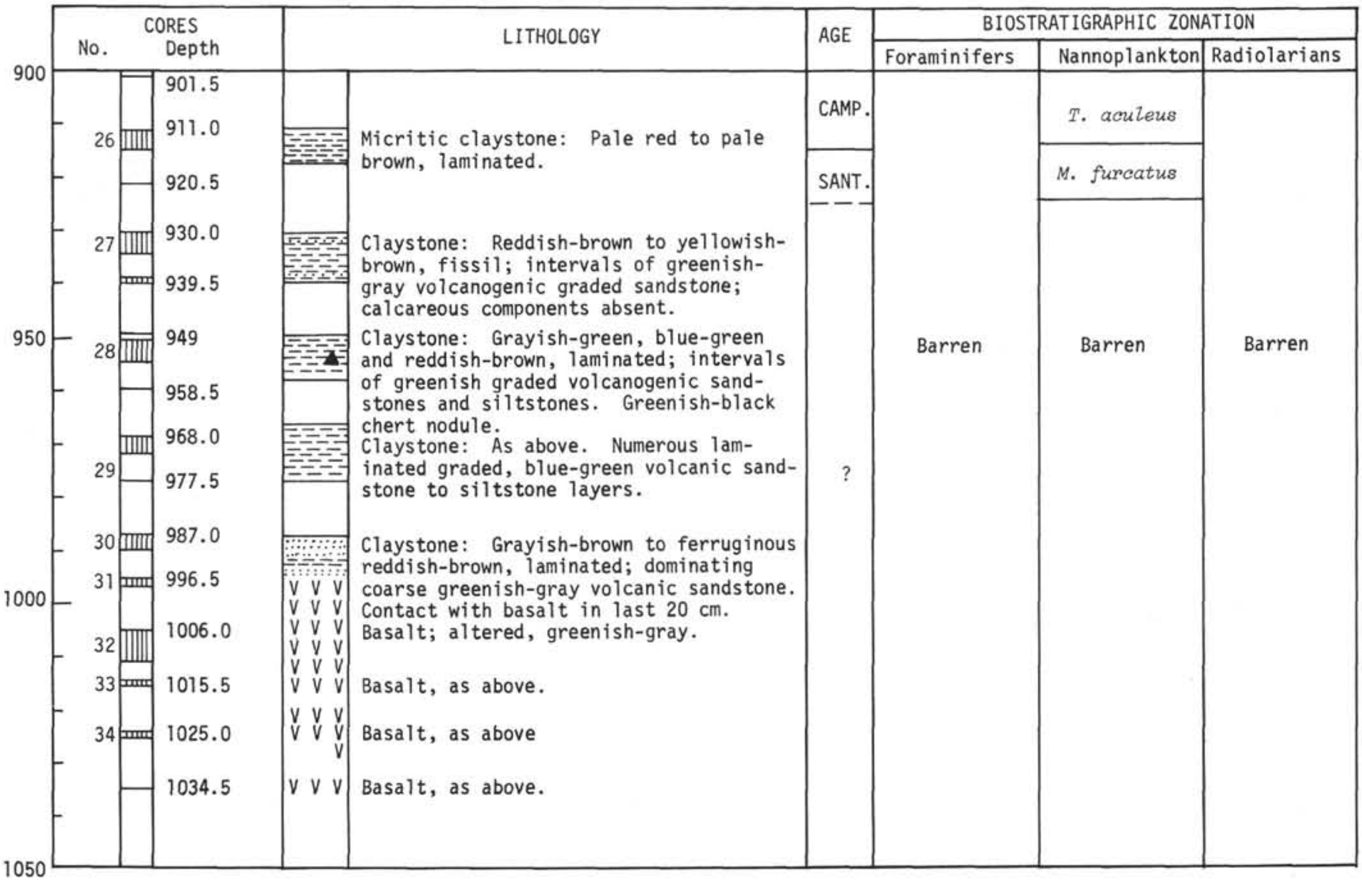
Clayey micritic limestones and micritic claystones: Pale brown to greenish-gray, fucoid. Greenish-gray graded volcanic sandstone, cement.

As above

As above

Micritic claystones to limestones: Greenish-white to gray, fucoid, dark greenish-gray, graded volcanic sandstones, current structures; red-brown chert.

Micritic claystone to limestone: Mostly pinkish-gray, burrowed. Thick grayish-green volcanogenic, graded sandstone to siltstone layers.



Micritic claystone: Pale red to pale brown, laminated.

Claystone: Reddish-brown to yellowish-brown, fissil; intervals of greenish-gray volcanogenic graded sandstone; calcareous components absent.

Claystone: Grayish-green, blue-green and reddish-brown, laminated; intervals of greenish graded volcanogenic sandstones and siltstones. Greenish-black chert nodule.

Claystone: As above. Numerous laminated graded, blue-green volcanic sandstone to siltstone layers.

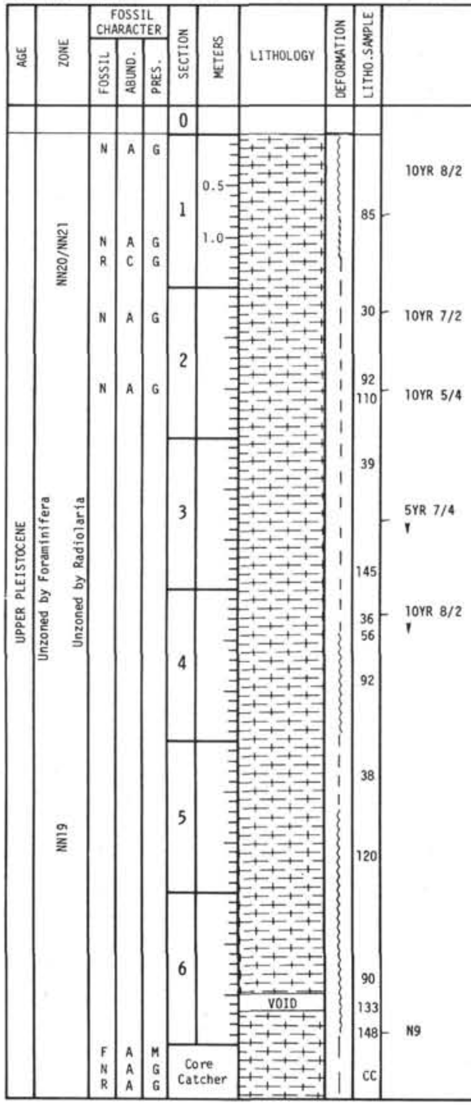
Claystone: Grayish-brown to ferruginous reddish-brown, laminated; dominating coarse greenish-gray volcanic sandstone. Contact with basalt in last 20 cm. Basalt; altered, greenish-gray.

Basalt, as above.

Basalt, as above

Basalt, as above.

Site 315 Hole Core 1 Cored Interval: 0.0-9.0 m



LITHOLOGIC DESCRIPTION

Some soupy horizons, mostly moderately to light deformed foraminifera-nannofossil ooze with varying siliceous admixtures.

Appears to be bedded in cyclic units (approx. 75 cm thick) which are shades of pale orange(10YR 8/2) to pale yellow brown (10YR 7/4) in basal portions and moderate-yellow brown (10YR 5/4) in upper part. Upper zones are mottled apparently due to burrowing.

FORAMINIFERAL-NANNOFOSSIL OOZE

Smear Slide Summary:

| | |
|---|---|
| Nannos | D |
| Forams | C |
| Diatoms | R to C |
| Rads | R to C |
| Sp. Spic. | R |
| Silicofl. | R |
| Further Clay | R |

Acid-insoluble Residue:

| | |
|---|---|
| Clay | D |
| Siliceous Fossils | D |

With rare volcanic glass, palagonite, zeolites, length-slow chalcedony, quartz, micas(?), barite.

GRAIN SIZE

| | |
|---|---|
| (1-122 cm): | 4.3 Sand<br>20.6 Silt<br>75.1 Clay |
| (2-24 cm): | 3.4 Sand<br>33.5 Silt<br>63.1 Clay |
| (2-82 cm): | 6.3 Sand<br>26.5 Silt<br>67.2 Clay |
| (3-81 cm): | 4.3 Sand<br>22.6 Silt<br>73.1 Clay |
| (4-46 cm): | 3.3 Sand<br>26.2 Silt<br>70.5 Clay |
| (5-23 cm): | 6.9 Sand<br>26.9 Silt<br>66.2 Clay |
| (6-137 cm): | 5.3 Sand<br>21.9 Silt<br>72.8 Clay |

Site 315 Hole Core 2 Cored Interval: 9.0-18.5 m

| AGE | ZONE | FOSSIL CHARACTER | | | SECTION | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | | FOSSIL | ABUND. | PRES. | | | | | | |
| | | | | | 0 | | | | | NO RECOVERY<br>Very small (<1 cc) sample recovered in core catcher. |
| PLEISTOCENE | N.A.<br>NN19<br>N.A. | N | A | G | Core Catcher | | | | | |

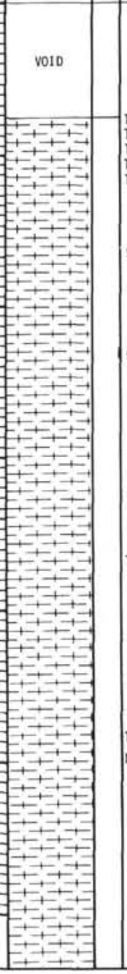
Site 315 Hole Core 3 Cored Interval: 9.0-18.5 m

| AGE | ZONE | FOSSIL CHARACTER | | | SECTION | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | | FOSSIL | ABUND. | PRES. | | | | | | |
| | | | | | 0 | | | | | NO RECOVERY<br>Very small sample recovered in core catcher. |
| PLEISTOCENE | N.A.<br>NN18<br>N.A. | N | A | G | Core Catcher | | | | | |

Explanatory notes in Chapter 1

Site 315 Hole Core 4 Cored Interval: 56.5-65.0 m

| AGE | ZONE | FOSSIL | ABUND. | PRES. | SECTION | METERS | LITHOLOGY | LITHO. SAMPLE | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | | | | |
| U. PLIOCENE | G. limbata<br>NN18? | N<br>F<br>N<br>R | A<br>A<br>A<br>A | G<br>M<br>G/M<br>G | 1 | 0.5<br>1.0 | VOID | 121<br>123<br>133<br>144<br>149 | (5B 9/1)<br>5B 6/2<br>5B 8/2<br>10YR 8/2<br>5Y 7/2<br>5B 8/2 |
| LOWER PLIOCENE | NN15<br>Globorotalia tumida | N | A | G/M | 2 | | | 92 | 5B 8/2<br>5B 9/1<br>5B 2/1 (mottled) |
| | | | | | 3 | | | 56 | 5G 8/1<br>5B 8/2<br>5B 9/1 |
| | | N | A | G/M | 4 | | | 40<br>104 | 5GY 8/1<br>5B 8/2 |
| | NN15<br>NN14 | N<br>N | A<br>A | G/M<br>G/M | 5 | | | 8<br>132<br>NCL<br>20 | |
| | NN14 | N<br>R<br>N | A<br>A<br>A | G/M<br>G<br>G/M | 6 | | | | |
| | NN13 | F<br>N<br>R | A<br>A<br>A | M<br>M<br>G | Core Catcher | | | * | |



LITHOLOGIC DESCRIPTION

Moderately to highly disturbed pale blue (5B 8/2) to bluish white (5B 9/1) FORAMINIFERAL-NANNOFOSSIL firm OOZE. Some faint laminations and mottling (burrows), layering.

Minor pale orange (10YR 8/2 to yellowish gray (5Y 7/2) RADIOLARIAN NANNOFOSSIL OOZE.

Smear Slide Summary:

| | |
|---|---|
| Nannos | D to A |
| Forams | C |
| Rads | C to R |
| Diatoms | R to C |
| Sp. Spic. | R |

Some clay, volcanogenic grains, pyrite(?), silicoflagellates.

Acid Residue: 4 to 5
- Siliceous Fossils
- Green Clay R.I. >1.57
- Brown Clay R.I. <1.57
- Glass Fragments
- Zeolite Rosettes
- Oxyhornblende, Barite

GRAIN SIZE

| | | |
|---|---|---|
| (2-118 cm): | 4.9 | Sand |
| | 29.4 | Silt |
| | 65.7 | Clay |
| (3-60 cm): | 4.5 | Sand |
| | 29.9 | Silt |
| | 65.6 | Clay |
| (3-92 cm): | 6.7 | Sand |
| | 32.1 | Silt |
| | 61.2 | Clay |
| (4-CC): | 4.3 | Sand |
| | 29.3 | Silt |
| | 66.4 | Clay |

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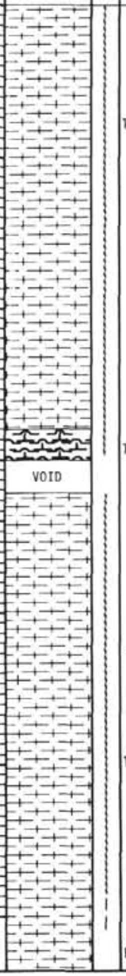
Site 315 Hole A Core 1 Cored Interval: 75.5-85.0 m

| AGE | ZONE | FOSSIL | ABUND. | PRES. | SECTION | METERS | LITHOLOGY | LITHO. SAMPLE | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | | | | |
| UPPER MIOCENE | NN11<br>Globorotalia pleisotumida<br>NN11<br>Stichocorys peregrina | N<br>R | A<br>A | M<br>G | 1 | 0.5<br>1.0 | | 114 | 5PB 8/2<br>5P 7/2<br>N8 |
| | | | | | 2 | | | | N8 |
| | | | | | 3 | | | 142 | 5PB 7/2<br>5PB 6/2 |
| | | | | | 4 | | VOID | | 5PB 7/2 |
| | | | | | 5 | | | 35<br>145 | 5GY 9/1<br>5P 4/2<br>5P 7/2<br>5P 4/2<br>5P 7/2 |
| | | | | | 6 | | | | 5GY 9/1 |
| | NN11 | F<br>N<br>R | A<br>A<br>A | M<br>M<br>G | Core Catcher | | | CC<br>HCL | |



LITHOLOGIC DESCRIPTION

Pale purple to pale blue FORAMINIFERAL NANNOFOSSIL OOZE, highly deformed. RAD-NANNO OOZE and DIATOM-FORAM OOZE occur rarely. Graded NANNOFOSSIL FORAMINIFERAL layers occur at 1-80 to 120 and 2-24 to 50.

Finely laminated intervals occur in this core.

Smear Slide Summary:

| | |
|---|---|
| Nannos | D (A) |
| Forams | A to C to R |
| Rads | R to C |
| Diatoms | R to C |
| Sp. Spic. | R |

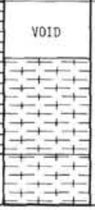
Some Clay

Acid Insoluble Residue: CC
- Clay
- Siliceous Microfossils
- (Sponge Spicules coated with Pyrite)
- Glass Shards
- Zeolites, Barite

Explanatory notes in Chapter 1

Site 315 Hole A Core 2 Cored Interval: 123.5-133.0 m

| AGE | ZONE | FOSSIL | ABUND. | PRES. | SECTION | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | | | | | |
| UPPER MIOCENE | Globorotalia acostaensis<br>NN11<br>Ommatartus antepenultimus | R | A | G | 1 | 0.5<br>1.0 | VOID | ¦ | 70<br>101<br>104 | 5P 7/2 |
| | | F<br>N<br>R | R<br>A<br>A | P<br>M<br>G | Core Catcher | | | | CC | |
| UPPER MIOCENE | Globorotalia acostaensis<br>NN11<br>Ommatartus antepenultimus | | | | | | | | | |



Very pale purple FORAM-NANNO OOZE with greenish yellow streaks. Coarse layer at 1-68 to 1-76.

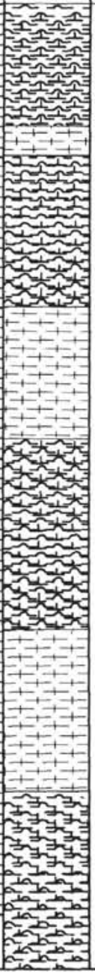
Smear Slide Summary:

| | |
|---|---|
| Nannos | D |
| Forams | C |
| Rads | R to C |
| Diatoms | R |
| Sp. Spic. | R |

---

Site 315 Hole A Core 3 Cored Interval: 142.0-151.5 m

| AGE | ZONE | FOSSIL | ABUND. | PRES. | SECTION | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | | | | | |
| UPPER MIOCENE | Globorotalia acostaensis<br>NN11<br>Ommatartus antepenultimus | N<br>R | A<br>A | M<br>G | 1 | 0.5<br>1.0 | | ¦ | 58 | 5P 8/2<br>5B 9/1<br>5B 9/1 |
| | | N | A | M | 2 | | | | | 5B 9/1<br>5P 7/2 streaks |
| | | N | A | M | 3 | | | | 90 | 5B 9/1<br>5PB 6/2 streaks<br>5GY 8/1 streaks |
| | | N | A | M | 4 | | | | | 5B 9/1<br>5P 7/2 layers |
| | | N | A | M | 5 | | | | 15<br>92 | 5B 9/1<br>5P 7/2<br>5P 8/2<br>5P 7/2 |
| | | N | A | M | 6 | | | ¦ | 24<br>107 | 5P 8/2<br>5B 9/1<br>5B 9/1 |
| | C. petterssoni | F<br>N<br>R | R<br>A<br>A | P<br>M<br>G | Core Catcher | | | ¦ | CC | |



Bluish-white RAD-NANNO, NANNO-FORAM and FORAM NANNO OOZE to firm OOZE; pale purple mottles and streaks. Some fine laminations graded unit (RAD-NANNO firm OOZE at top to NANNO-FORAM OOZE at base) from 5-15 to 6-25.

Smear Slide Summary of major lithology: 1-58, 3-90, 5-15, 6-107, CC

| | |
|---|---|
| Nannos | D |
| Forams | R to C to A |
| Rads | C to A |
| Diatoms | R to C |
| Sp. Spic. | R to C |

Some clay, volcanic glass, fish remains.

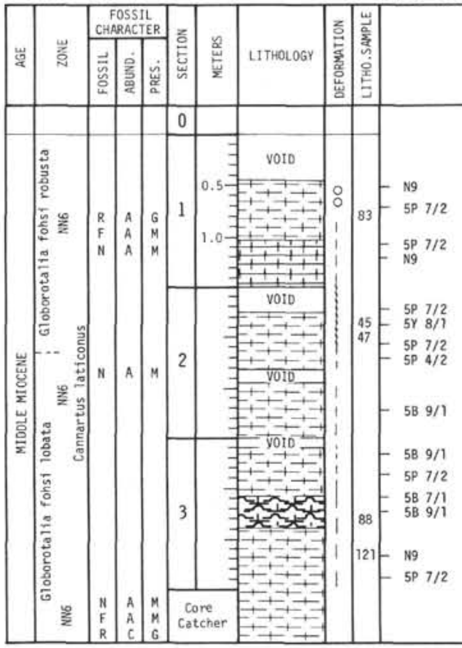
Smear Slide Summary of coarser lithology: 5-92, 6-24

| | |
|---|---|
| Nannos | A |
| Forams | D |
| Rads | R to C |
| Diatoms | - |
| Sp. Spic. | R |

Some palagonite, fish remains.

Explanatory notes in Chapter 1

Site 315 Hole A Core 4 Cored Interval: 256.0-265.5 m



LITHOLOGIC DESCRIPTION

White, bluish-white and pale purple RAD-NANNO, FORAM NANNO and NANNO-FORAM OOZE to firm OOZE and CHALK. Some faint layering. Pyritic zones. Coarse yellow-gray NANNO-FORAM OOZE at 2-42 to 46. Light gray NANNO-FORAM OOZE with volcanic glass at 2-46 to 48.5. White NANNO-FORAM OOZE, graded, at 3-97 to 124.

Smear Slide Summary of major lithology: 1-83, 3-88

| | |
|---|---|
| Nannos | D |
| Forams | C |
| Rads | C |
| Diatoms | R |
| Sp. Spic. | R |

Smear Slide Summary of coarser material: 2-45, 2-47, 3-121

| | |
|---|---|
| Nannos | A |
| Forams | D |
| Rads | R |
| Diatoms | R |
| Sp. Spic. | R |
| Silicofl. | R |

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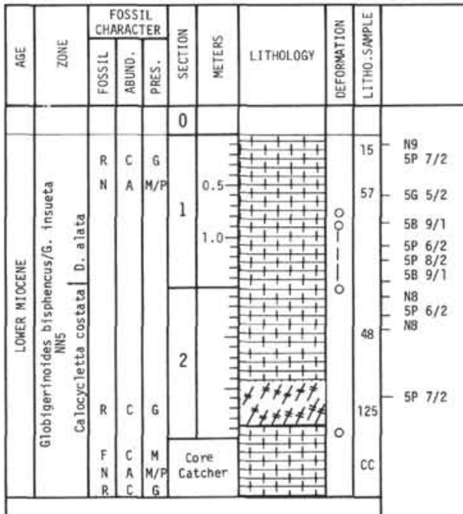
Site 315 Hole A Core 5 Cored Interval: 340.0-379.5 m



LITHOLOGIC DESCRIPTION

Pale pureple to white FORAM-NANNO CHALK. Bed-parallel and angular (~30°) laminations picked out by color differences. Burrows common. Coarse FORAM-RICH layer at 1-0 to 1-20. Layer rich in green palagonitic fragments at 1-57. Black pyritic NANNO-SPICULAR SILICEOUS OOZE at 2-125.

Smear Slide Summary of major lithology: 1-57, 2-48, CC

| | |
|---|---|
| Nannos | A to D |
| Forams | C to A |
| Rads | R |
| Diatoms | R |
| Sp. Spic. | R |

Smear Slide of coarse layer: 1-15

| | |
|---|---|
| Nannos | A |
| Forams | D |
| Rads | R |
| Diatoms | R |
| Sp. Spic. | R |

Smear Slide of dark pyritic layer: 2-125

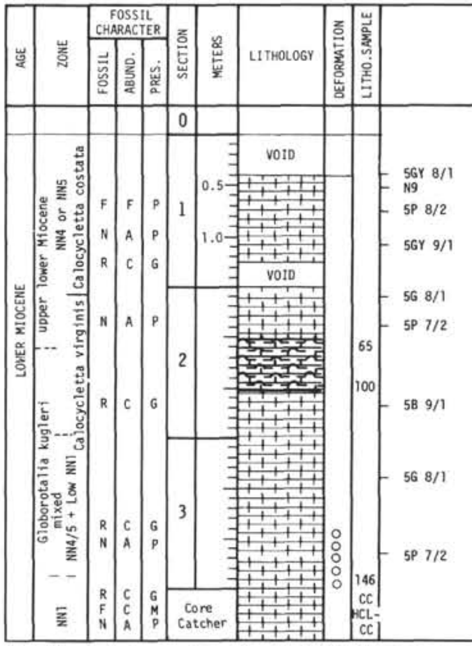
| | |
|---|---|
| Nannos | A |
| Forams | C |
| Rads | R |
| Diatoms | R |
| Sp. Spic. | A |

GRAIN SIZE

| | |
|---|---|
| (1-12 cm): | 28.6 Sand |
| | 32.6 Silt |
| | 38.8 Clay |

Explanatory notes in Chapter 1

Site 315 Hole A Core 6 Cored Interval: 465-474.5 m



LITHOLOGIC DESCRIPTION

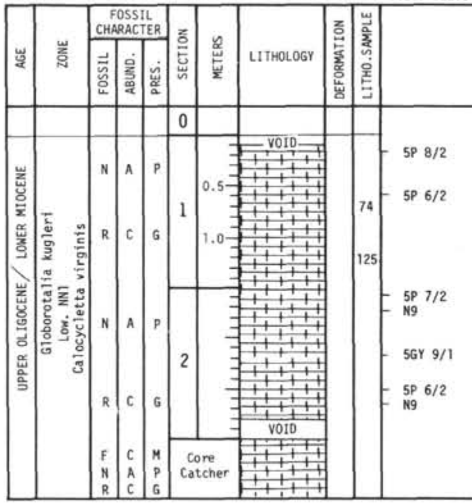
White, purplish white and greenish white FORAM- and RAD-NANNO CHALK. Intensely burrow mottled. Rare laminations. FORAM-RICH layers at 2-15 and 2-85.

Smear Slide Summary:

| | |
|---|---|
| Nannos | D |
| Forams | R to C |
| Rads | R to C |
| Diatoms | R |
| Sp. Spic. | R |

Acid Treated Sample: CC
Many Rads with sponge spicules and a few diatoms. Small fragments of chalcedony.

Site 315 Hole A Core 7 Cored Interval: 512.5-522.0 m



LITHOLOGIC DESCRIPTION

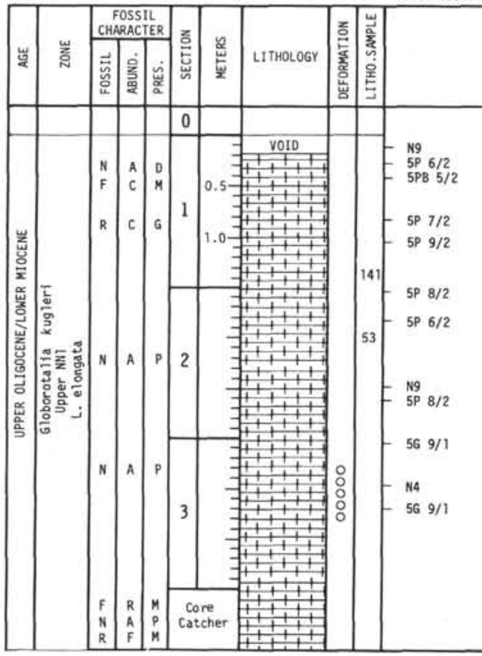
White to pale purple FORAM-NANNO CHALK. Extensive burrow mottling. Some dark gray laminations, bed parallel, curving and angular. Coarser level at 1-58. Pyrite fragments at 2-95 to 2-110.

Smear Slide Summary:

| | |
|---|---|
| Nannos | D |
| Forams | C |
| Rads | R |
| Sp. Spic. | R |

Some Clay

Site 315 Hole A Core 8 Cored Interval: 588.5-599.0 m



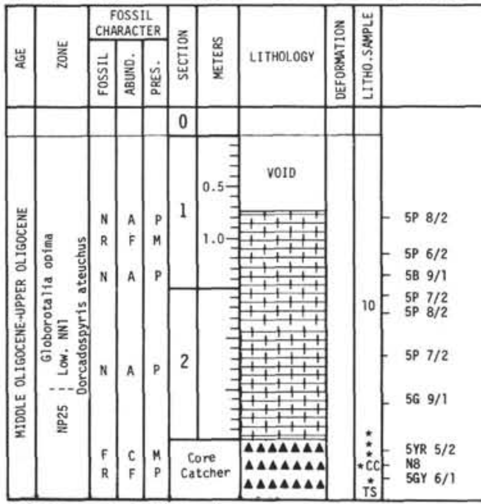
LITHOLOGIC DESCRIPTION

White to pale purple and greenish white FORAM-NANNO CHALK. Strongly bioturbated, with many well-developed burrows, some bed-parallel laminations. Medium dark gray chert nodule at 3-58 to 3-67, determined by X-ray to consist of celestite.

Smear Slide Summary:

| | |
|---|---|
| Nannos | A to D |
| Forams | C to A |
| Rads | R |
| Diatoms | |
| Sp. Spic. | R |

Site 315 Hole A Core 9 Cored Interval: 702.5-712.5 m



LITHOLOGIC DESCRIPTION

Pale purple to greenish white FORAM-NANNO CHALK to NANNO CHALK. Pale brown chert nodule (3 cm) in core catcher. Parallel laminations and burrows occur locally. Some burrows disrupt lamination; others do not.

Smear Slide Summary:

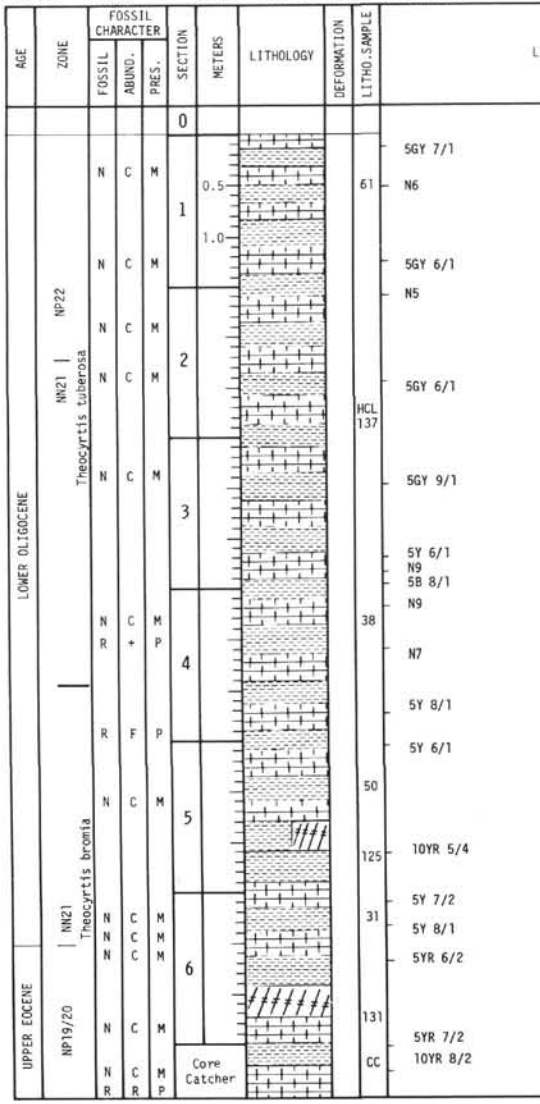
| | |
|---|---|
| Nannos | D |
| Forams | R to A |
| Diatoms | R |

Some fish remains and volcanic glass/palagonite grains.

Thin sections of chert: CC
Chiefly microcrystalline silica, with ghosts of Radiolaria. Sediment-filled forams with calcitic walls preserved, replaced or dissolved. Patches of unreplaced carbonate.

Explanatory notes in Chapter 1

Site 315 Hole A Core 10 Cored Interval: 730.5-740.0 m



LITHOLOGIC DESCRIPTION

Light grayish-green, olive-gray clayey NANNOFOSSIL CHALK in sections 1 to 4. Yellowish-gray in basal sections. SPICULE-RAD and SPICULE-NANNO CLAYSTONES occur locally. Widespread burrow mottling "fucoids" with both dark and light compacted burrow infills. FORAM-RICH GRAINSTONES, with green volcanogenic fragments, present as discrete intervals. Replacement chert occurs within chalk and FORAM-RICH GRAINSTONES.

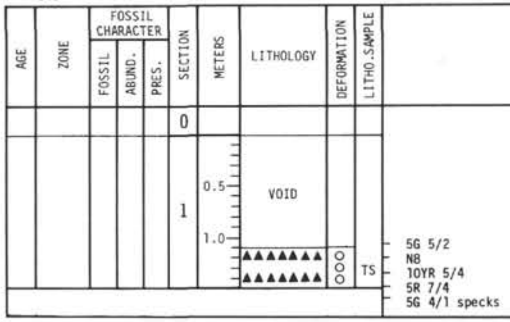
Smear Slide Summary:

| | |
|---|---|
| Nannos | C to A to D |
| Forams | R to Absent |
| Rads | R to C |
| Diatoms | R |
| Sp. Spic. | R to C |

Clay is abundant to dominant. Some micrite. A little volcanic glass.

Acid Residue: 2-137
98% Clay, with very rare highly corroded Radiolarian skeletons.

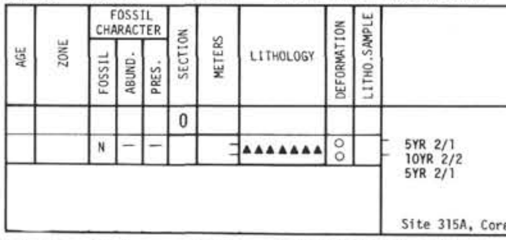
Site 315 Hole A Core 11 Cored Interval: 740.0-749.5 m



LITHOLOGIC DESCRIPTION

Yellowish-brown gray, orange-pink and pink CHERT nodules of replacement origin. Some silicified claystone. Some chert fragments laminated, others more grainy that partially replace coarse foram layers with green volcaniclastic detritus.

Site 315 Hole A Core 12 Cored Interval: 749.5-759.0 m

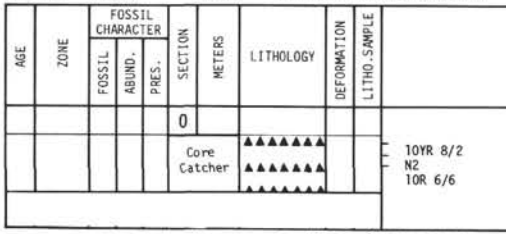


LITHOLOGIC DESCRIPTION

Brownish-black to dusky yellow-brown brecciated and recemented CHERT. Some light gray zones in chert are feebly calcareous.

Site 315A, Core 13, 759.0-768.5 m: NO RECOVERY

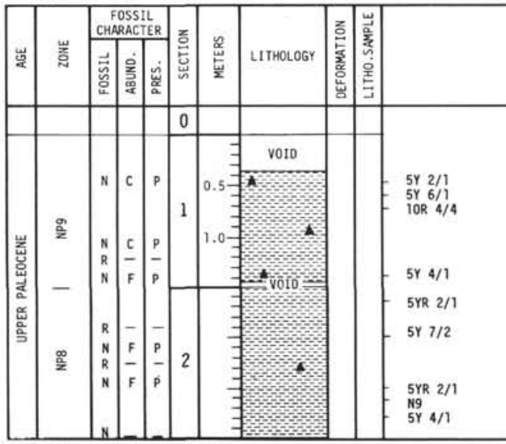
Site 315 Hole A Core 14 Cored Interval: 768.5-778.0 m



LITHOLOGIC DESCRIPTION

One fragment of light gray and moderate reddish-brown replacement CHERT. Some unreplaced calcareous matrix.

Site 315 Hole A Core 15 Cored Interval: 778.0-787.5 m



LITHOLOGIC DESCRIPTION

Olive gray, dusky brown and brownish black CLAYSTONE to CLAYEY NANNO-CHALK. Numerous "fucoid" burrows. Some zones of silicification. Some dark chert.

Brownish-black clay layers are rich in fish remains; these layers are interlaminated with lighter, more calcareous sediments.

Level of silicified packstone at 1-104 to 1-112.

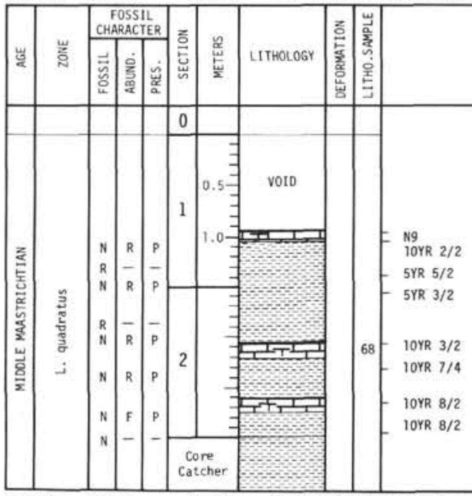
Smear Slide Summary:

| | |
|---|---|
| Nannos | R to C to D |

Clay often dominant, often >75%. Fish material common.

Explanatory notes in Chapter 1

Site 315 Hole A Core 16 Cored Interval: 787.5-797.0 m



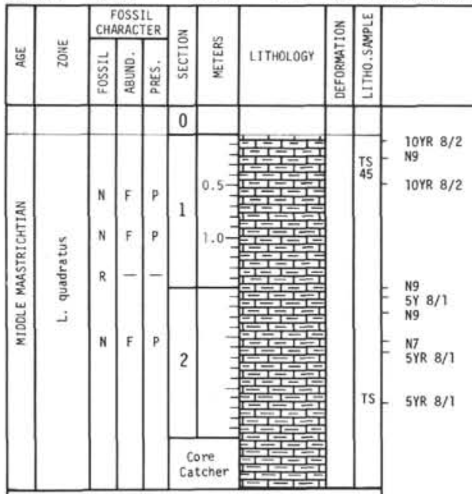
LITHOLOGIC DESCRIPTION

Dusky yellowish-brown, brownish-black, and dark yellowish-brown CLAYSTONE, interlaminated with burrowed "fucoidal" grayish-orange clayey limestone.

Intervals of pale orange foraminiferal grainstones to packstones, graded and laminated. Locally silicified to reddish-brown chert.

Smear Slide of finely laminated foram-rich grainy bed:
Forams D
Pieces of fish remains, with fragments (c.50μm) of sparry calcite.

Site 315 Hole A Core 17 Cored Interval: 797.0-806.5 m



LITHOLOGIC DESCRIPTION

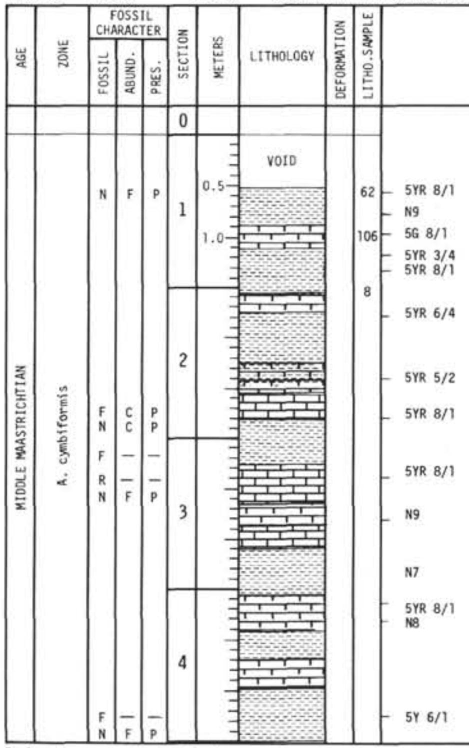
Light grayish-brown to dark yellowish-brown CLAYSTONE to LIMESTONE. Burrowed, with "fucoids". Stylolitic seams. Brown chert nodules. Numerous intervals (centimeter scale) of white to pale orange graded, laminated calcareous grainstones to packstones.

Yellowish graded layer at 2-96 to 2-118 contains additional green volcanogenic grains and clay clasts of millimeter scale. Large foraminifera visible on cut surface.

Smear Slide of a coarse foraminiferal layer: 1-45
Forams D
Altered volcanic glass common; rare feldspar crystals and fish remains.

Thin section description:
1-43 to 45
Packstone containing highly recrystallized planktonic forams, with occasional (c100-400μm) feldspar crystals.
2-117 to 119
Packstone containing large forams, red algae, bryozoa, echinoderm material, feldspar fragments and pieces of volcanic rock with trachytic texture.

Site 315 Hole A Core 18 Cored Interval: 806.5-816.0 m



LITHOLOGIC DESCRIPTION

Pale orange, light brown, moderate brown NANNO CLAYSTONE, involved in soft-sediment deformation (phacoid structures). Contorted burrows common. Rare dark brown chert nodules.

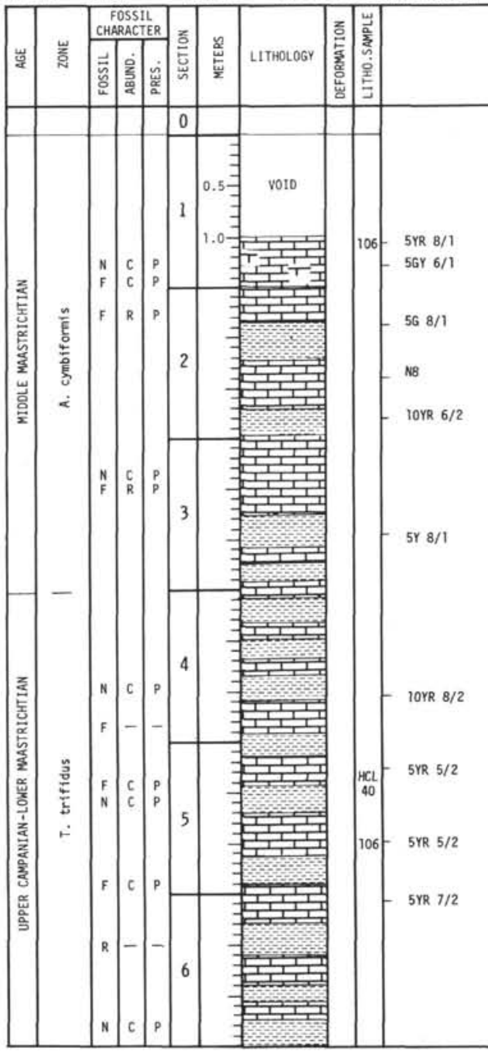
Intercalations of white, pinkish gray and light greenish gray foraminiferal grainstones to packstones; graded and laminated with burrows at clay-rich tops. Green volcanogenic fragments common in basal layers of graded units.

Smear Slide of claystone:
1-62
Nannos C
Dominant clay, with rare volcanic glass and fish remains.

Smear Slides of coarse foraminiferal sandstones:
1-106, 2-8
Nannos R
Forams C to D
Some clay, with fragments of sparry calcite.

Explanatory notes in Chapter 1

Site 315 Hole A Core 19 Cored Interval:816.0-825.5 m



LITHOLOGIC DESCRIPTION

Pale orange, pale brown, grayish-orange pink, and olive-gray NANNO- and MICRITIC CLAYSTONES interbedded with white and gray FORAMINIFERAL LIMESTONES. The coarser limestone units are of centimeter scale; they are graded, and laminated and contain green vologenic grains. Load casts at base.

The claystones are burrowed and contorted into "phacoids".

Smear Slide of claystone:
5-106
Nannos C
Forams R
Clay dominant; some micrite.

Smear Slide of coarser unit: 1-106
Nannos C
Forams A
Some clay, and some micrite.

Smear SLide of acid-treated sample:
5-40
95% Clay
Ferruginous matter.

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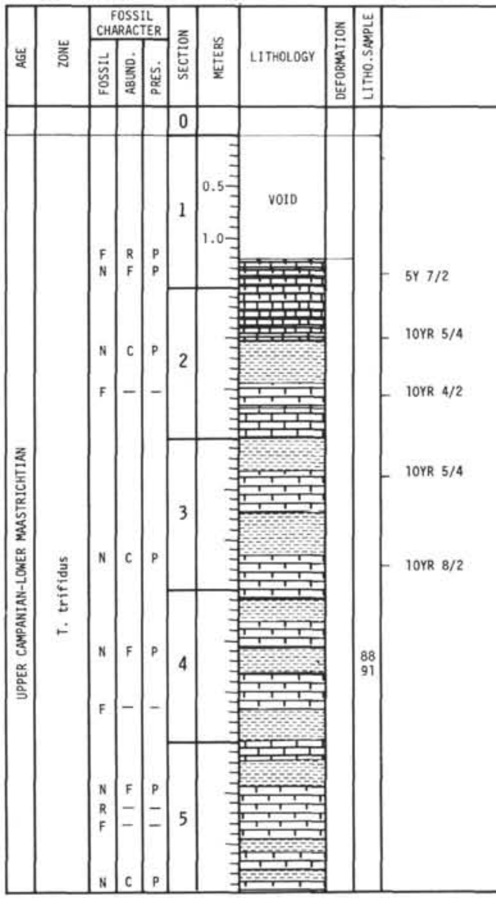
Site 315 Hole A Core 20 Cored Interval: 825.5-835.0 m



LITHOLOGIC DESCRIPTION

Light olive gray, pale orange, and grayish orange pink NANNO CLAYSTONE to CLAYEY NANNO LIMESTONE. Burrowed and mottled, with phacoid structures.

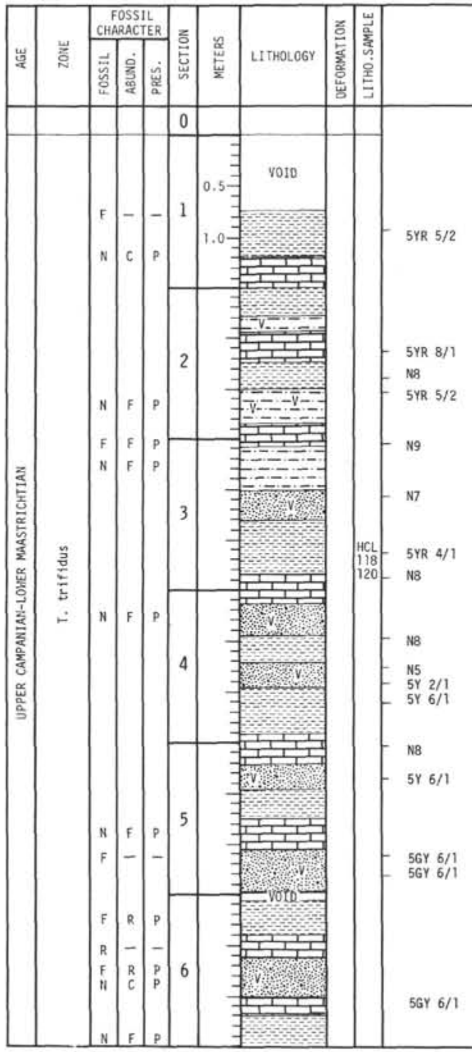
Incalations of grayish yellow green grainstones to packstones containing volcanogenic grains and foraminifera. Units are graded and laminated, with scours at base.

Smear Slide of clay-rich horizon:
4-91
NANNOS R
Sp. Spic. -
Mostly micrite with abundant clay.

Smear Slide of coarser layer:
4-88
Nannos R
Forams C
Much micrite, with sparry calcite.
Forams highly recrystallized.

Explanatory notes in Chapter 1

Site 315 Hole A Core 21 Cored Interval: 835.0-844.5 m



LITHOLOGIC DESCRIPTION

Pale brown, pale gray, dark greenish gray and white CLAYEY MICRITIC LIMESTONES and MICRITIC CLAYSTONES. Fucoids. Intercalations of olive gray, olive black, greenish gray and white volcaniclastic foraminiferal sands, and clays; graded and laminated. Layers range in thickness from 1 to 2 cm to 15 cm. Scours sometimes present at base.

Smear Slide of fine-grained material: 3-120

| | |
|---|---|
| Nannos | R |
| Much micrite; and much Clay. | D |

Smear Slide of acid-treated sample: 3-118

Mainly clay with palagonite grains and numerous small feldspar crystals.

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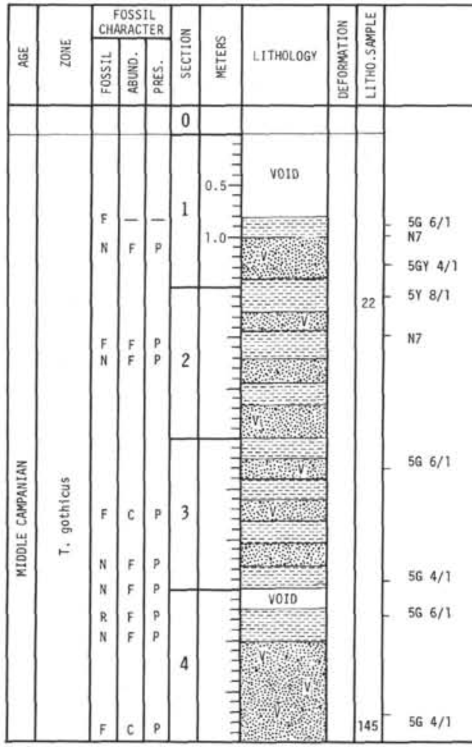
Site 315 Hole A Core 22 Cored Interval: 844.5-854.0 m



LITHOLOGIC DESCRIPTION

Light gray, yellowish gray to greenish-gray CLAYEY MICRITIC LIMESTONE to CLAYSTONE. Some olive black claystone levels. Many burrows. Intervals of greenish gray to dark greenish gray volcaniclastic sandstones, graded, cross- and parallel laminated with burrowed clay-rich tops. Scours at base. Clay clasts included in sandy units.

Smear Slide of Claystone: 2-22

Mainly clay, with admixture of feldspars, mafic minerals, and volcanic glass.

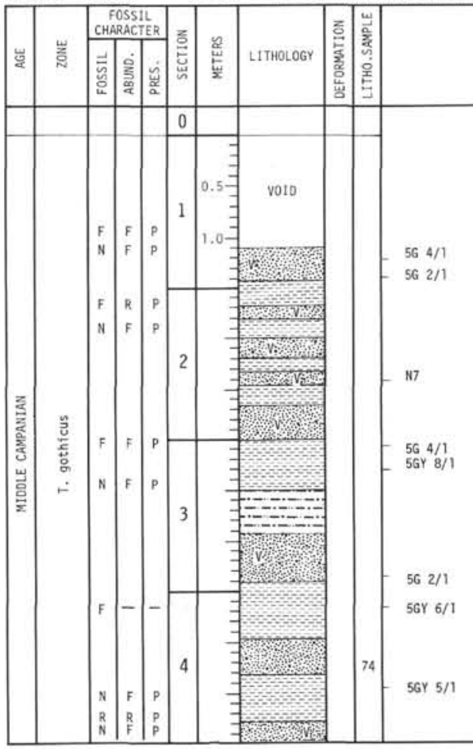
Smear Slide of Volcanic Sandstone: 4-145

| | |
|---|---|
| Sp. Spic. | B |

Numerous feldspars, altered mafic minerals, including clinopyroxenes, volcanic glass and fragments of sparry calcite.

Explanatory notes in Chapter 1

Site 315 Hole A Core 23 Cored Interval: 854.0-863.5 m



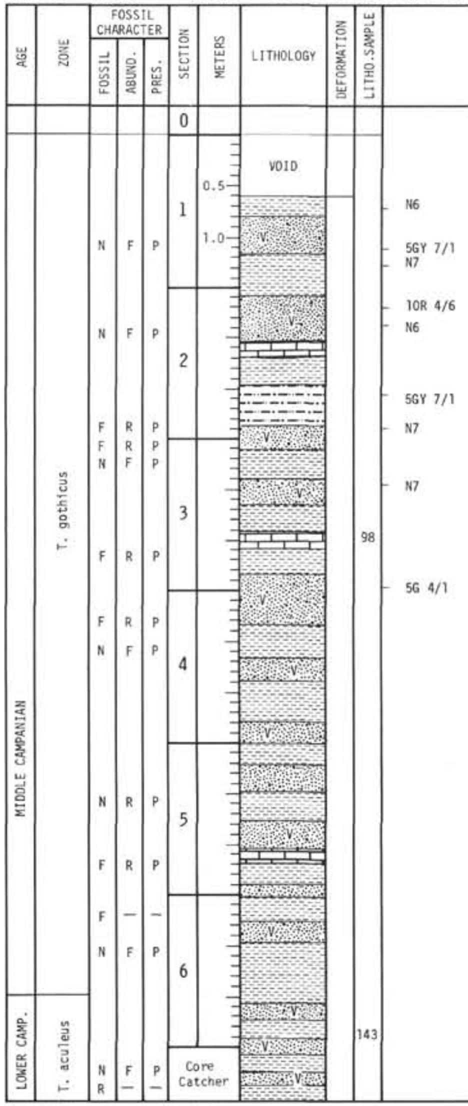
LITHOLOGIC DESCRIPTION

Light gray, olive gray, and greenish gray NANNO to MICRITE CLAYSTONES to LIMESTONES, mottled and burrowed. Dark greenish gray to greenish black volcaniclastic sandstones occur as interbeds; calcareous fragments and mud clasts occur in their coarser basal units. Tops are parallel or cross-laminated, with burrow traces.

Smear Slide of clay-rich facies:
4-74
Nannos C
Much clay, with micrite as well as nannos.

---

Site 315 Hole A Core 24 Cored Interval: 873.0-882.5 m



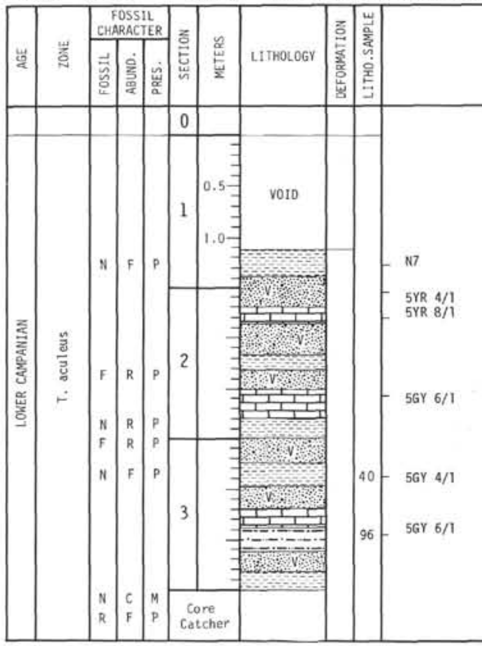
LITHOLOGIC DESCRIPTION

Greenish white to greenish gray *MICRITIC CLAYSTONES to LIMESTONES* with localized burrows (fucoids). Red brown chert nodule at 2-19 to 2-25, replacing light gray micritic limestone. Some small chert stringers. Interbeds of dark olive black, dark greenish gray volcaniclastic sandstones, graded, parallel- and cross-laminated.

Smear Slide Summary of Claystones:
3-98, 6-143
Nannos R
Clay varies from abundant to dominant, with corresponding decrease in micrite from abundant to common.

Explanatory notes in Chapter 1

Site 315 Hole A Core 25 Cored Interval: 892.0-901.5 m



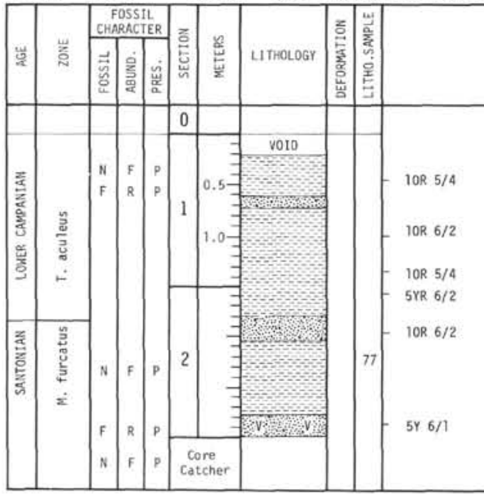
LITHOLOGIC DESCRIPTION

Pinkish gray to light brown gray MICRITIC CLAYSTONE to LIMESTONE. Heavily burrowed intercalations of light olive gray and grayish green calcareous and volcaniclastic sandstones; graded with clay clasts at base. Levels of dusky yellow green to dark greenish gray finely laminated claystone.

Smear Slide of Claystone: 3-40
Nannos R to C
Clay dominant, with micrite common. Feldspars.

Smear Slide of coarser unit: 3-96
Nannos R
Clay common, with abundant micrite, fragments of sparry calcite and feldspar.

Site 315 Hole A Core 26 Cored Interval: 911.0-920.5 m

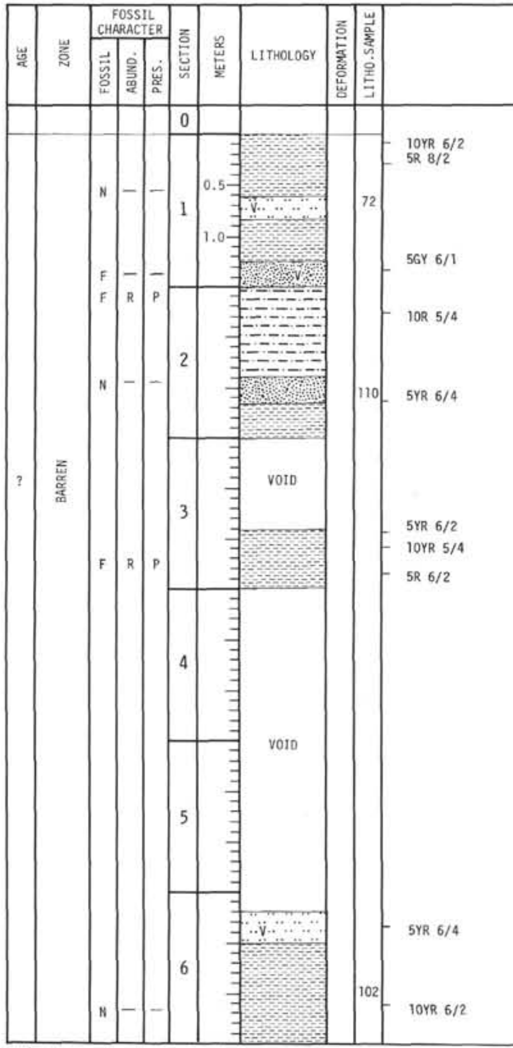


LITHOLOGIC DESCRIPTION

Pale red to pale brown laminated MICRITIC CLAYSTONES, with burrowed zones. Some coarser graded layers containing volcaniclastic grains.

Smear Slide: 2-77
Nannos R
Clay dominant, with micrite common.

Site 315 Hole A Core 27 Cored Interval: 930.0-939.5 m



LITHOLOGIC DESCRIPTION

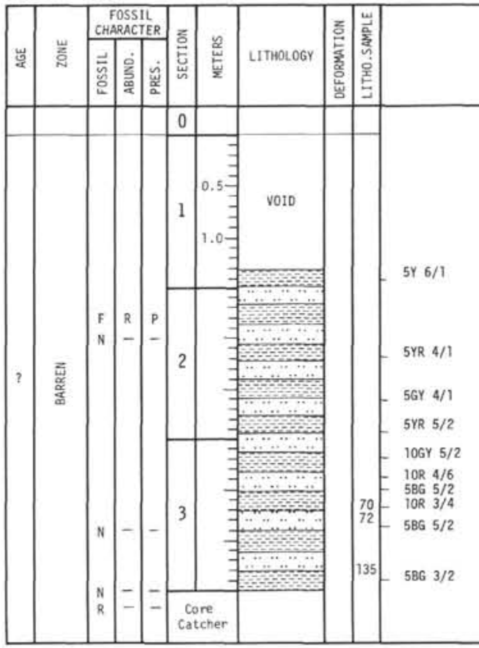
Pale reddish brown MICRITIC CLAYSTONE and yellow brown CLAYSTONE, fissile, with rare burrows. Intervals of greenish-gray volcaniclastic sand to clay, graded, with bed-parallel and angular laminations.

Smear Slide Summary of Claystone: 1-72, 2-110
Nannos R to Absent
Clay is dominant, with much iron ozide-hydroxide material. Occasional feldspars.

Smear Slide Summary of Volcanic Sandstone: 6-102
Abundant palagonite, with clay common. Numerous pyroxene and feldspar grains.

Explanatory notes in Chapter 1

Site 315 Hole A Core 28 Cored Interval: 949.0-958.5 m



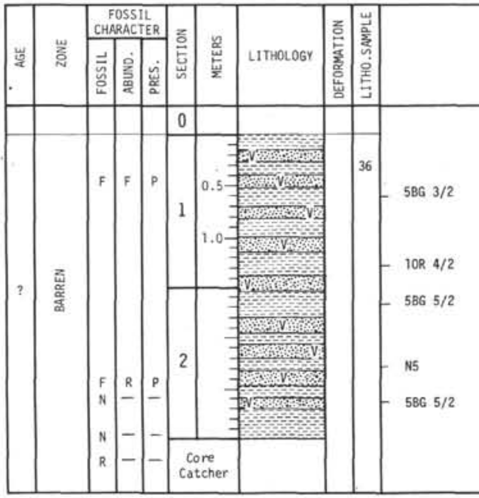
LITHOLOGIC DESCRIPTION

Gray, grayish green, blue-green to grayish black ferruginous CLAYSTONES with some graded and laminated silty and sandy levels. Greenish black chert nodule at 3-82. Some red brown levels, a few centimeters thick, are Radiolarian ferruginous claystones.

Smear Slide of green Claystone: 3-72
Rads R
The Radiolarians are infilled and overgrown with silica; only two specimens seen.

Smear Slide Summary of red Claystone: 3-70, 3-135
Rads R to C
Abundant to dominant clay, with much iron oxide-hydroxide matter, palagonite and feldspar grains. Radiolarians are all infilled and overgrown with silica.

Site 315 Hole A Core 29 Cored Interval: 968.0-977.5 m



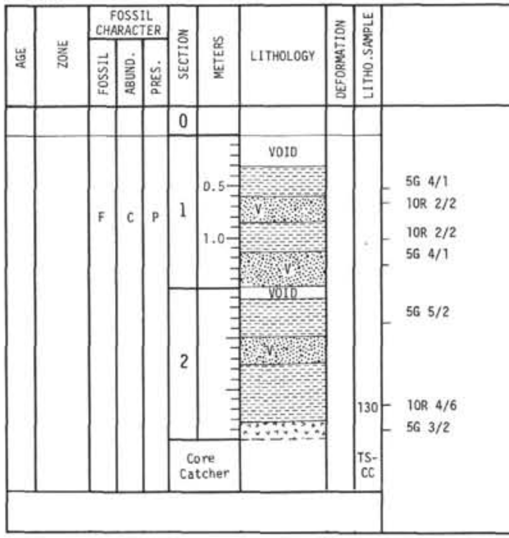
LITHOLOGIC DESCRIPTION

Grayish blue-green and grayish-red ferruginous CLAYSTONE, intercalated with numerous grayish blue-green graded, laminated volcaniclastic silt-sand layers. Chert at 1-27.

Smear Slide of grayish blue-green Claystone: 1-36
Predominantly a green clay.

Smear Slide Summary of grayish red Claystone: 1-28, 1-139
Rads R to Absent
Predominantly clay, with considerable amounts of iron oxide-hydroxide. A little palagonite.

Site 315 Hole A Core 30 Cored Interval: 987.0-996.5 m



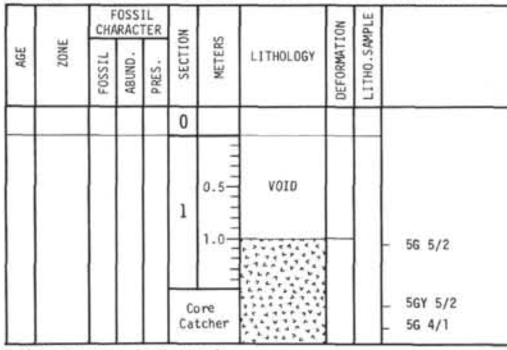
LITHOLOGIC DESCRIPTION

Grayish red to dark reddish brown ferruginous CLAYSTONE; laminated, fissile. Interbedded with greenish-gray graded volcanic sandstones with bed-parallel and cross-laminated levels. Some ripple bedding.

Smear Slide reddish Claystone: 2-130
Predominantly clay, with many feldspars and altered mafic minerals.
All basalts below appear to be alkalic. Circled numbers are flow units. Basalt at 2-133 to 2-150. Basalt is grayish green altered aphyric dense variolitic-intersertal type.

Thin section description: TS-CC
Plagioclase in variolitic laths, partly altered. Clinopyroxene interstitial, highly altered. Intersertal glass completely altered to clay minerals. Calcite common as replacement mineral.

Site 315 Hole A Core 31 Cored Interval: 996.5-1006.5 m

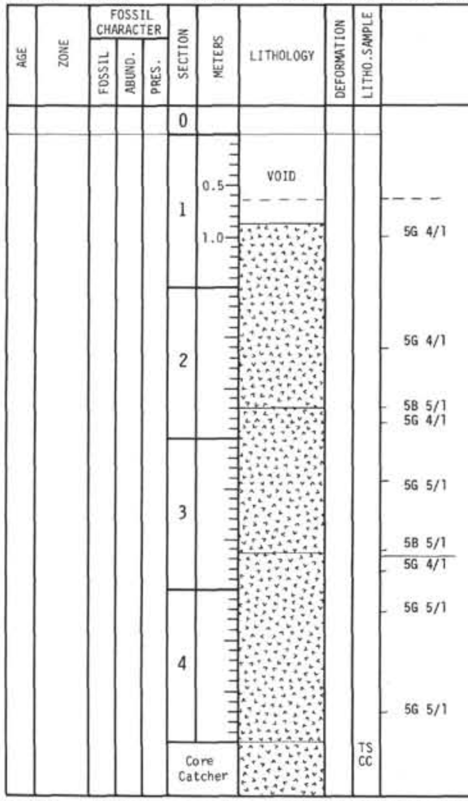


LITHOLOGIC DESCRIPTION

Grayish green to dark greenish gray altered aphyric dense variolitic-intersertal basalt.

Explanatory notes in Chapter 1

Site 315 Hole A Core 32 Cored Interval: 1006.5-1015.5 m

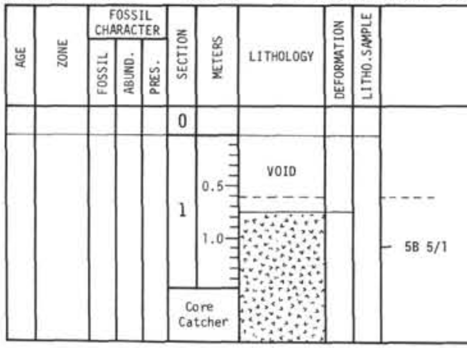


LITHOLOGIC DESCRIPTION

Dark greenish gray to medium bluish gray basalts with variable textures and grain size, all partially to extensively altered. Intergranular in flow Unit 2, diabasic-trachytic in flow Units 3 and 4. Chilled margins at 2-123, 3-121. All basalts vesicular to vuggy.

Thin section description: TS-CC Plagioclase in stubby laths, clinopyroxenes equant. Average grain size circa 0.4 mm. Plagioclase relatively fresh, clinopyroxenes 75% altered to clay aggregates. Considerable calcite replacement.

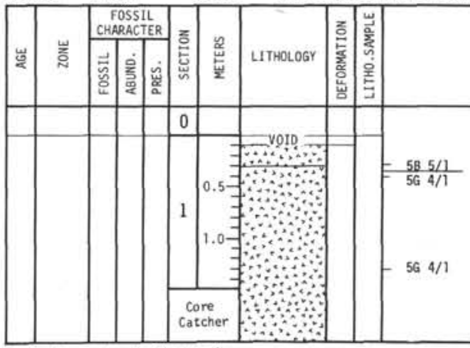
Site 315 Hole A Core 33 Cored Interval: 1015.5-1025.0 m



LITHOLOGIC DESCRIPTION

Flow Unit 5.
Medium bluish gray aphyric very fine-grained vesicular altered basalt.

Site 315 Hole A Core 34 Cored Interval: 1025.0-1034.5 m

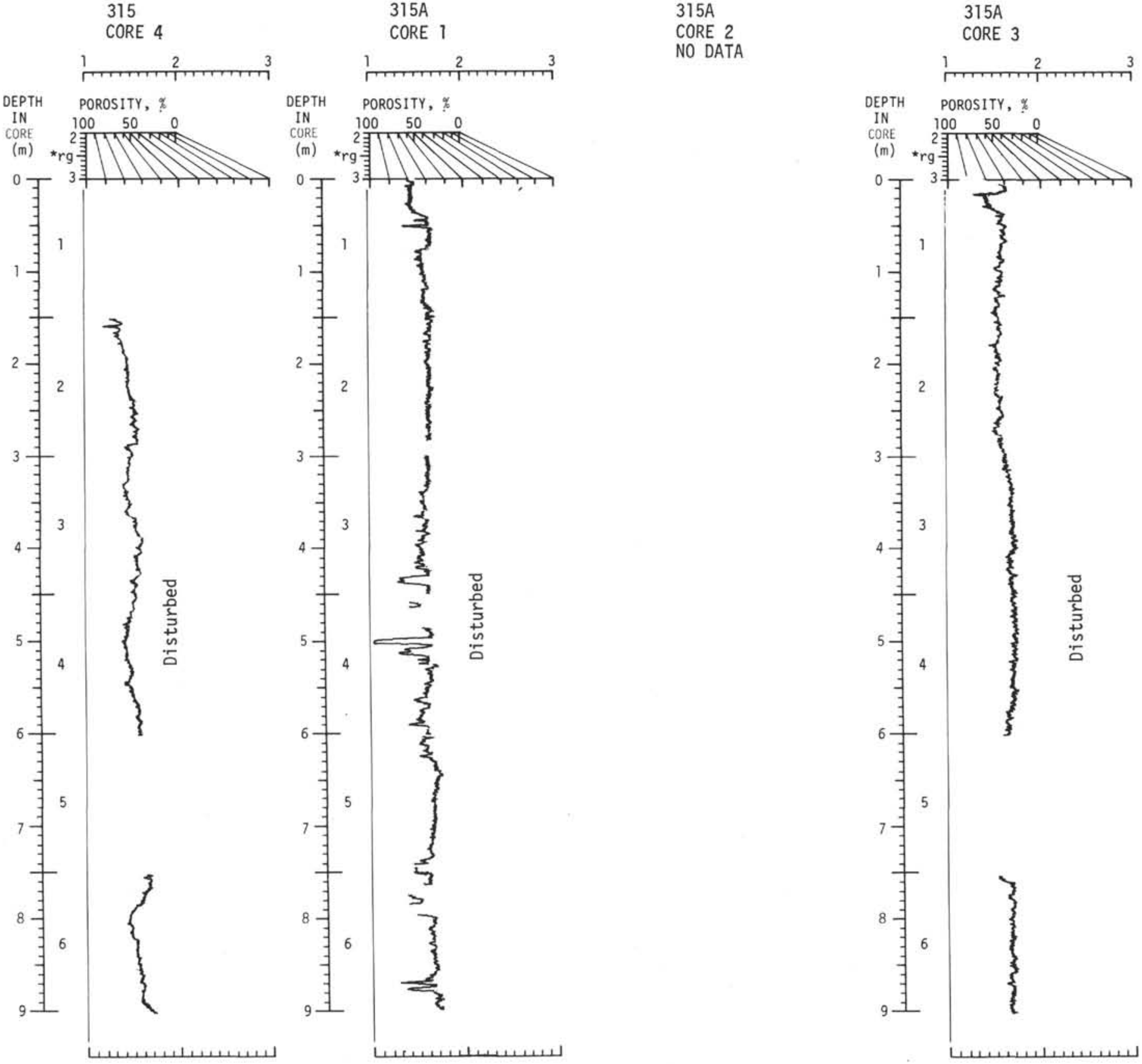


LITHOLOGIC DESCRIPTION

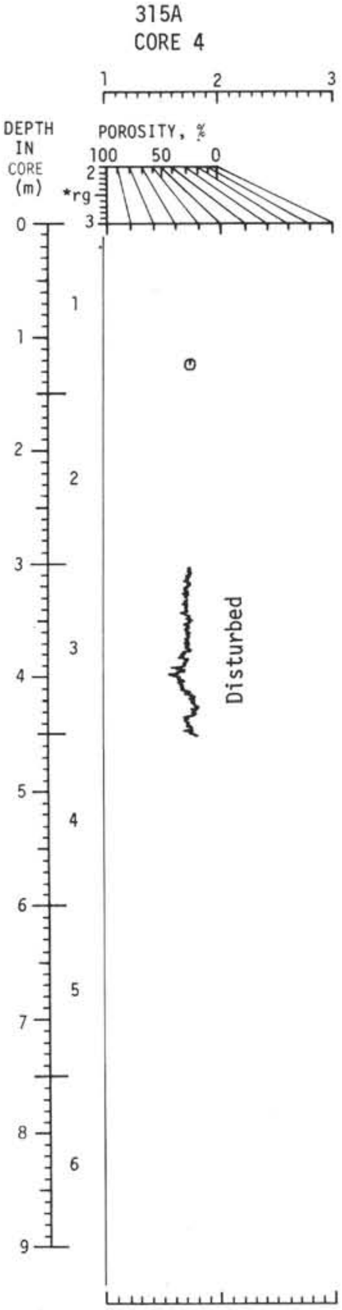
Flow Unit 6 chilled margin at 1-25.
Medium bluish gray to dark greenish gray aphyric very fine-grained vesicular altered basalt with diabasic texture.

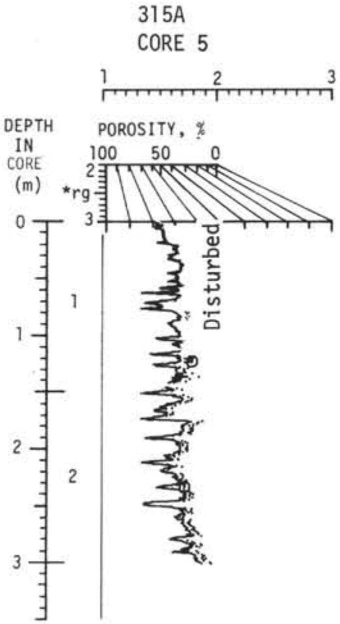
Explanatory notes in Chapter 1

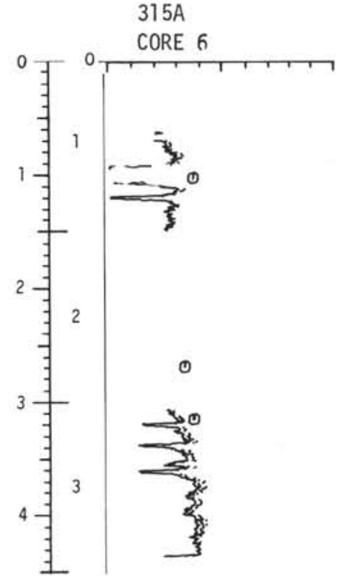
315
CORE 1
NO DATA
315
CORE 2
NO DATA
315
CORE 3
NO DATA

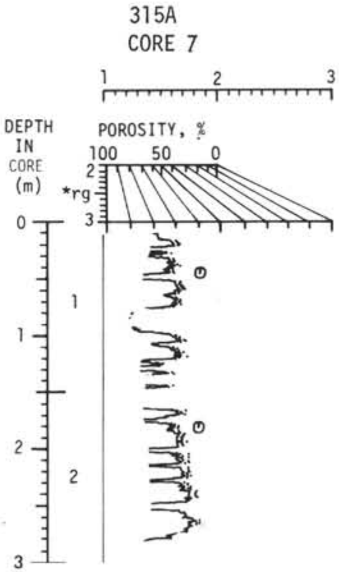


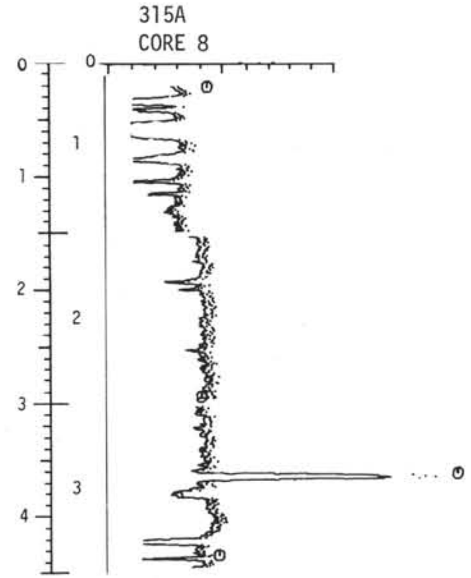
NOTE: The upper scale is GRAPE Wet-Bulk Density (1.0 to 3.0 g/cc): solid lines (——) are GRAPE analog data assuming a 6.61 cm core diameter; dotted lines (. . . . .) are GRAPE analog data adjusted for actual core diameter; circled ( ⊙ ) dots are the wet-bulk density calculated from two-minute counts on a stationary sample; the porosity nomogram allows a porosity scale to be determined by selecting the proper grain density ($r_g$) and extrapolating horizontally.

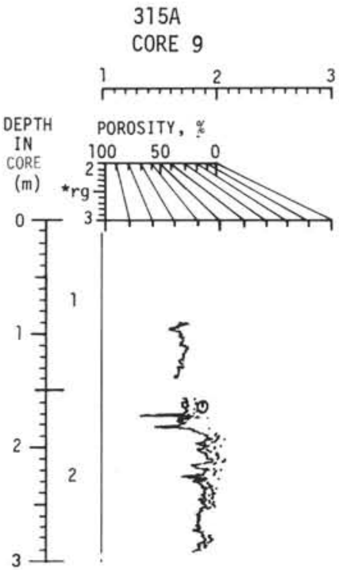

315A
CORE 4
1
2
3
DEPTH IN CORE (m)
POROSITY, %
100
50
0
2
*rg
3
0
1
2
3
4
5
6
7
8
9
Disturbed

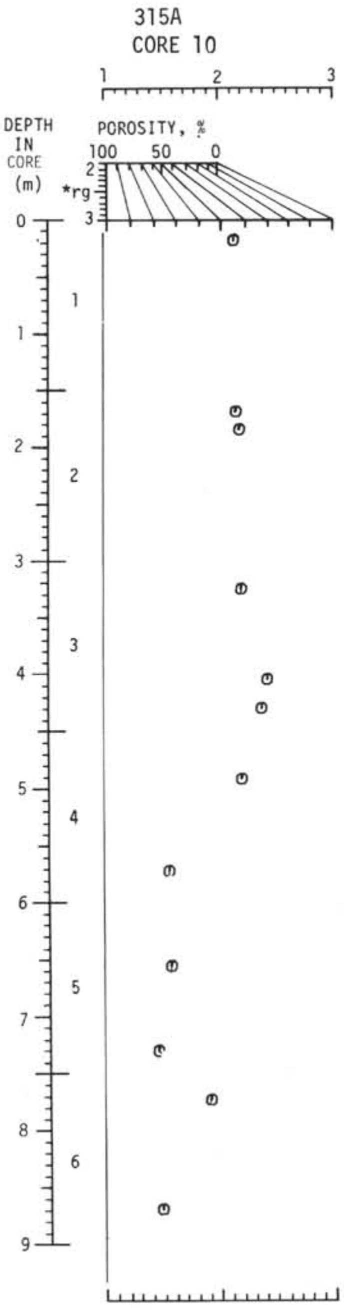

315A
CORE 5
1
2
3
DEPTH IN CORE (m)
POROSITY, %
100
50
0
*rg
Disturbed


315A
CORE 6
0
1
2
3
4

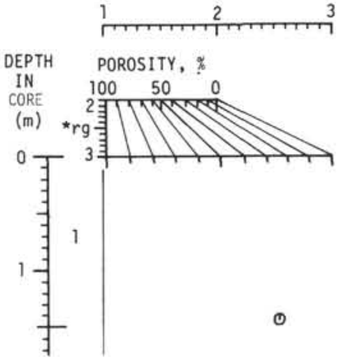

315A
CORE 7
1
2
3
DEPTH IN CORE (m)
POROSITY, %
100
50
0
*rg


315A
CORE 8
0
1
2
3
4

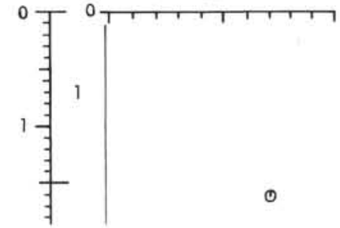

315A
CORE 9
1
2
3
DEPTH IN CORE (m)
POROSITY, %
100
50
0
*rg


315A
CORE 10
1
2
3
DEPTH IN CORE (m)
POROSITY, %
100
50
0
*rg
0
1
2
3
4
5
6
7
8
9

315A
CORE 11



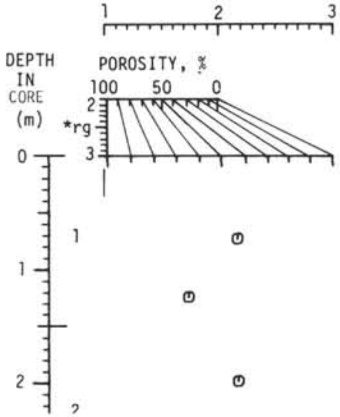
315A
CORE 12



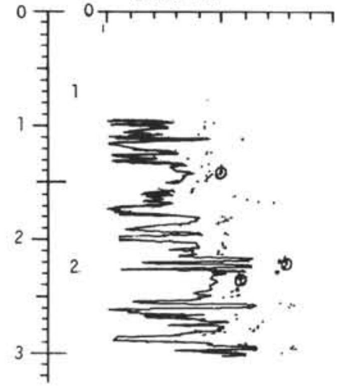
315A
CORE 13
NO DATA

315A
CORE 14
NO DATA

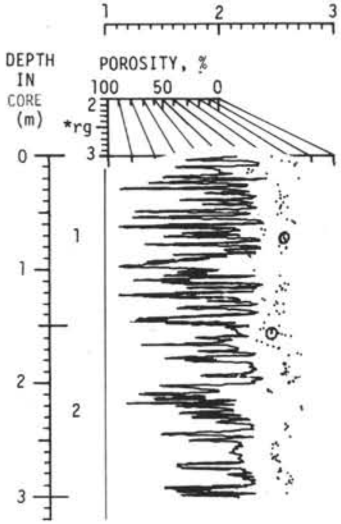
315A
CORE 15



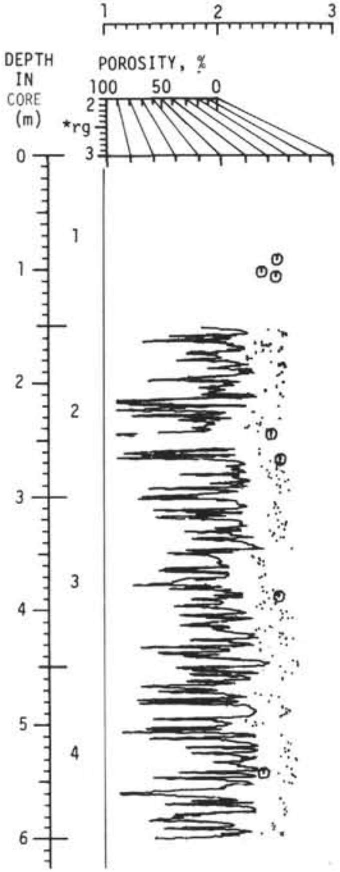
315A
CORE 16



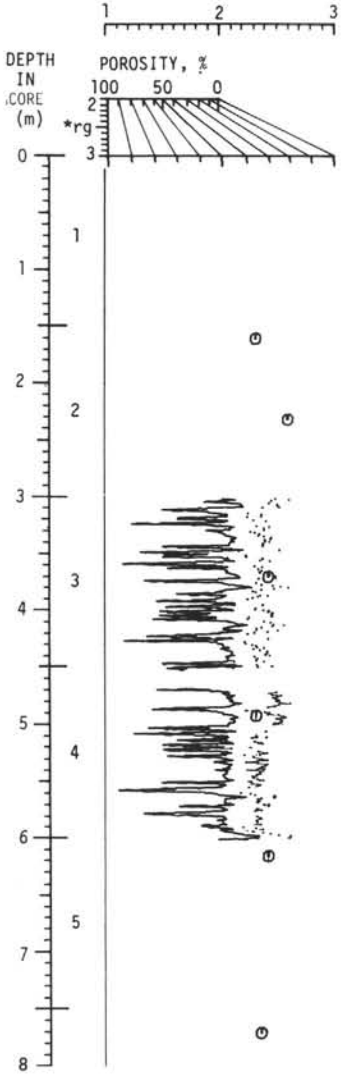
315A
CORE 17

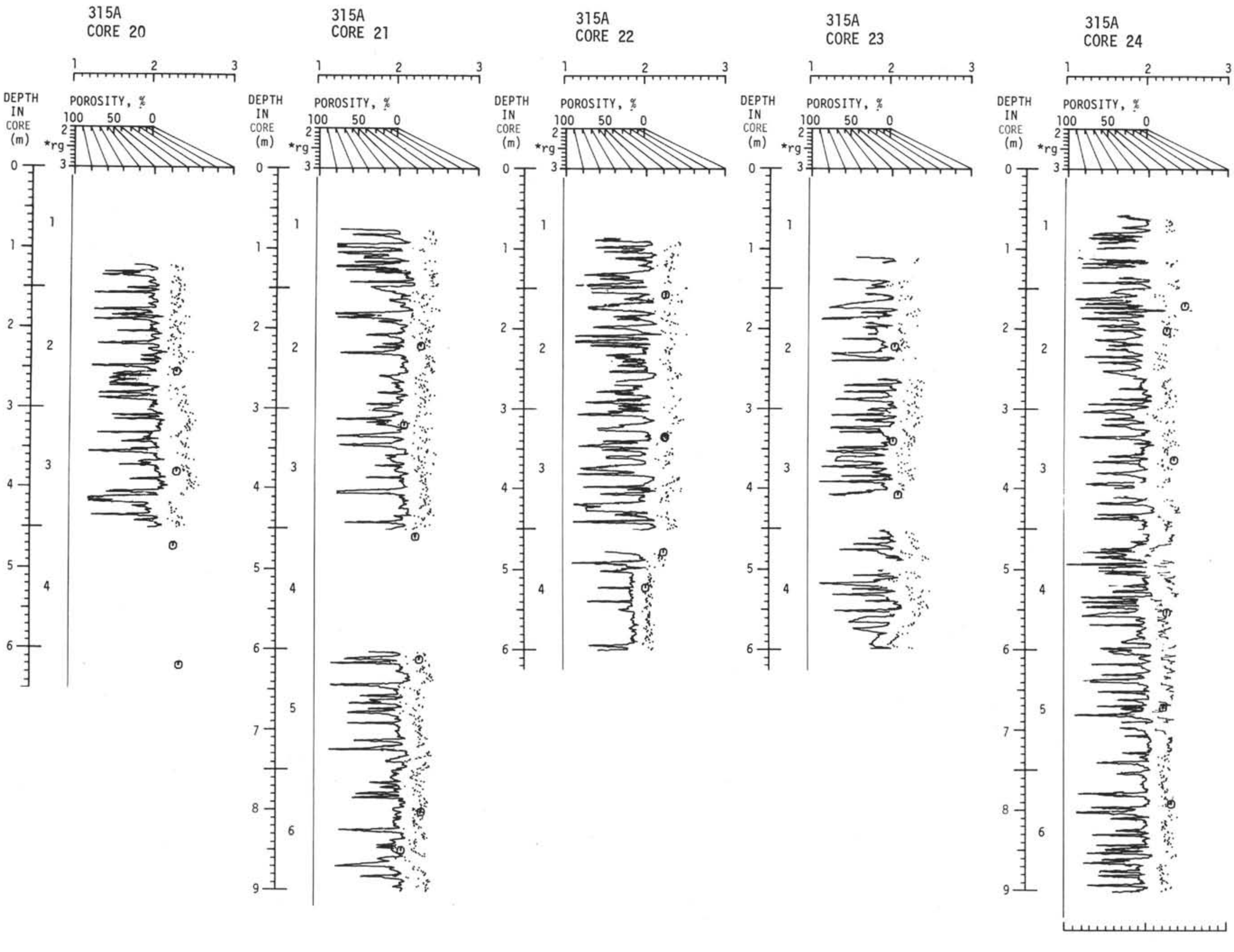


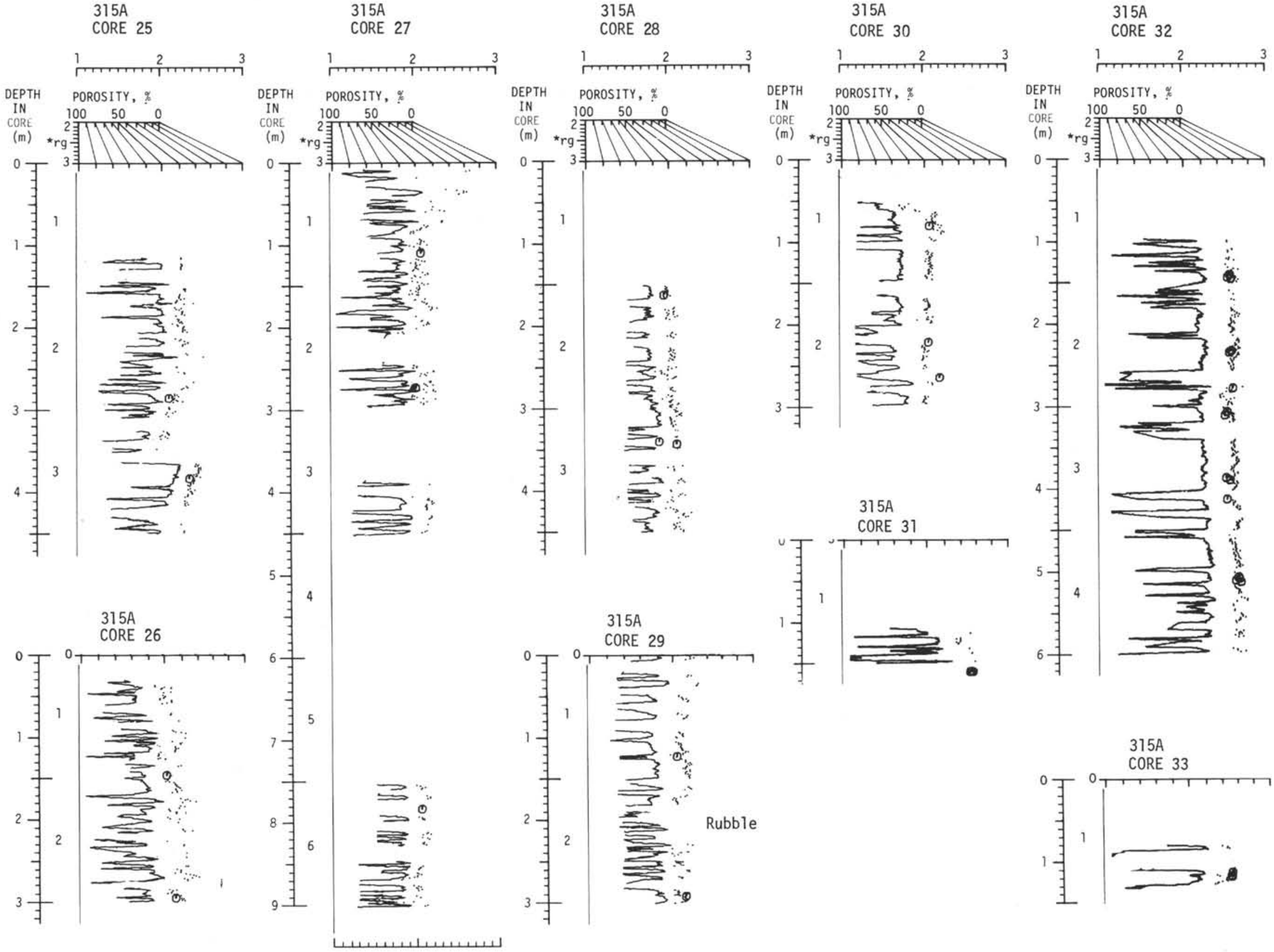
315A
CORE 18



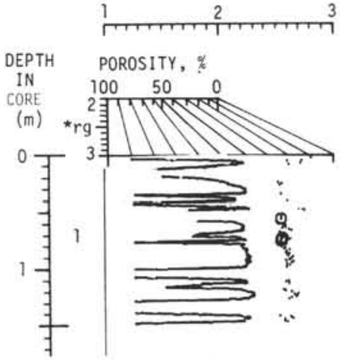
315A
CORE 19

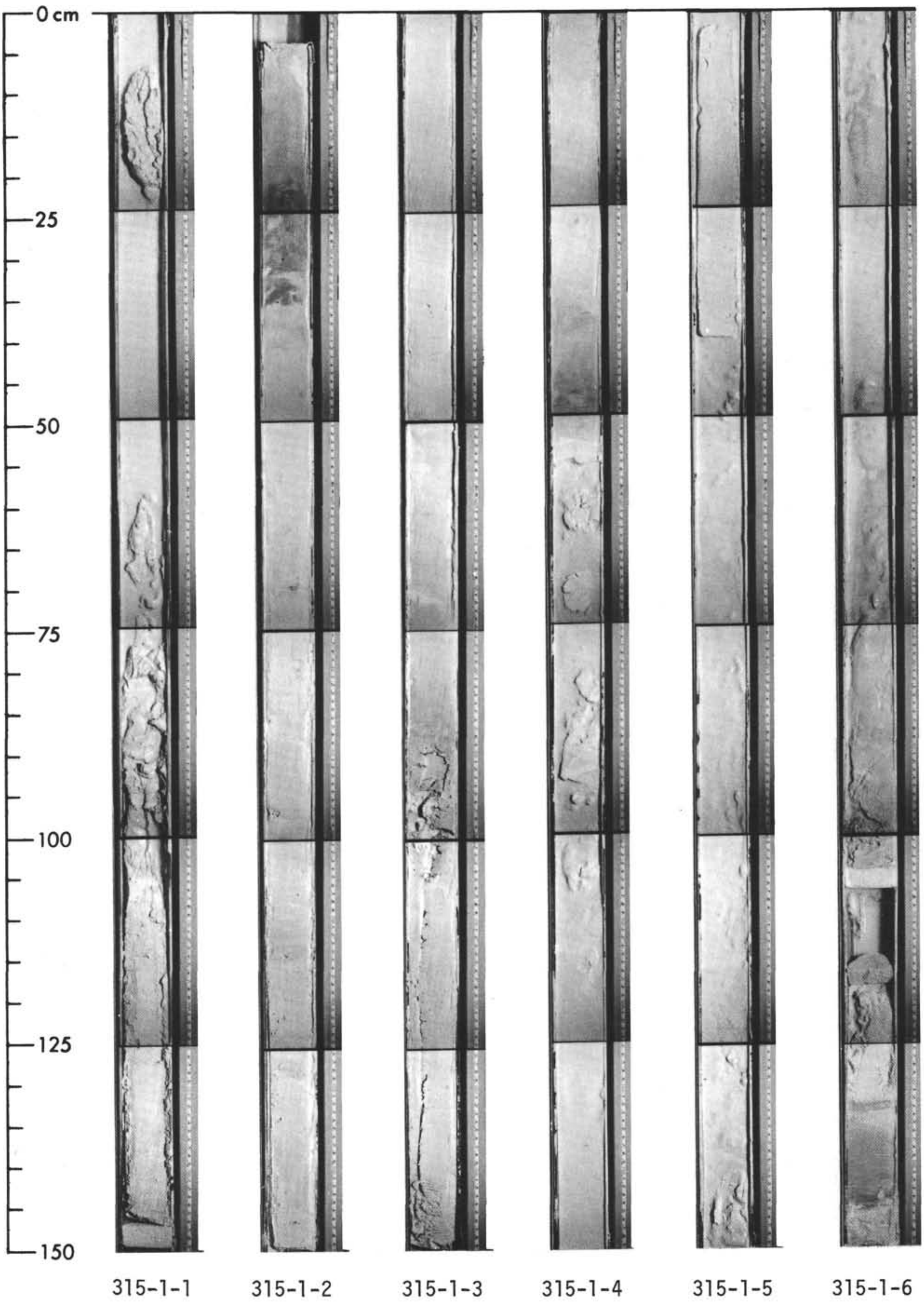


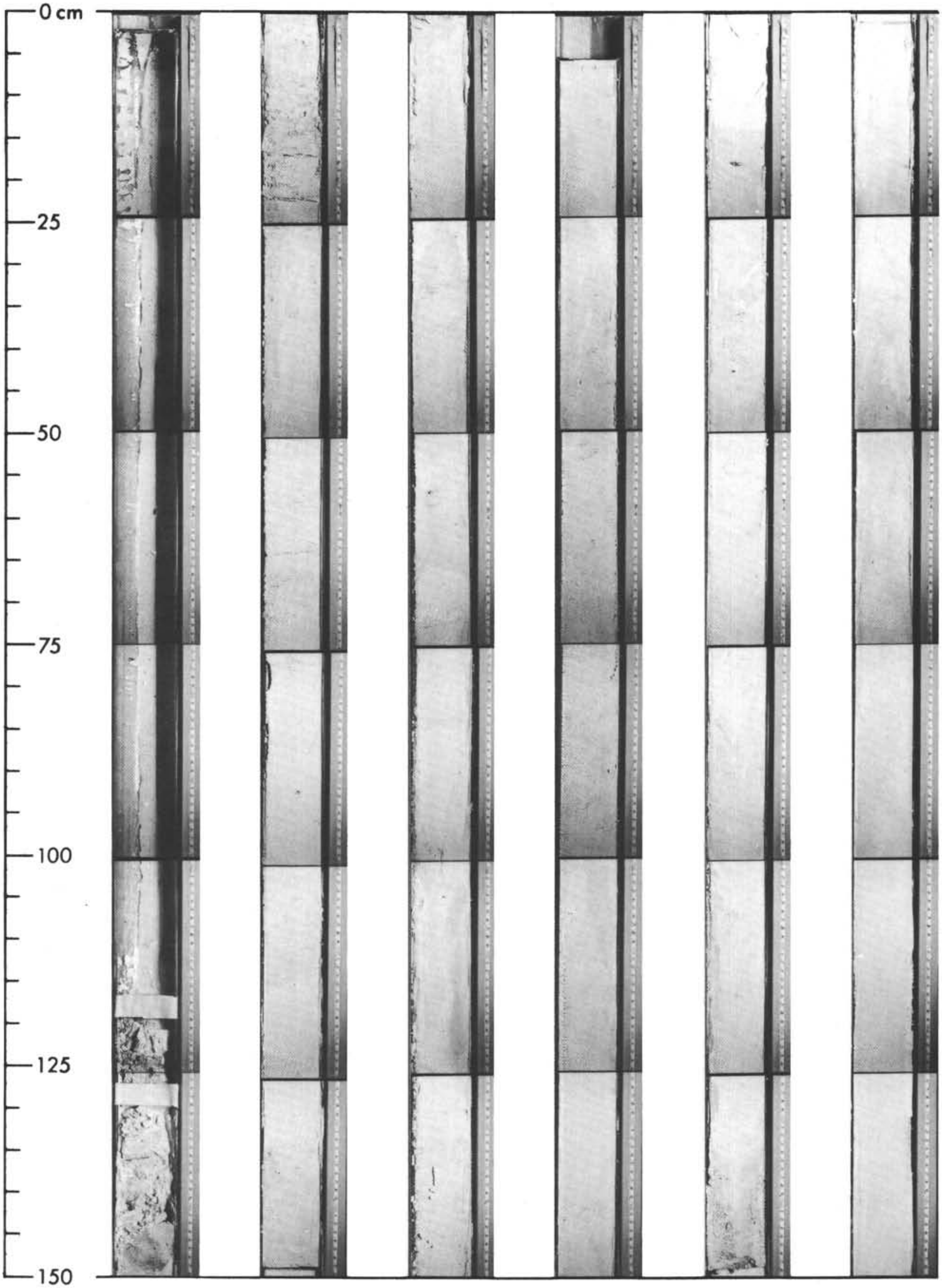

315A
CORE 20
315A
CORE 21
315A
CORE 22
315A
CORE 23
315A
CORE 24
DEPTH
IN
CORE
(m)
POROSITY, %
100
50
0
*rg
1
2
3
0
1
2
3
4
5
6
7
8
9


315A CORE 25
315A CORE 26
315A CORE 27
315A CORE 28
315A CORE 29
315A CORE 30
315A CORE 31
315A CORE 32
315A CORE 33
DEPTH IN CORE (m)
POROSITY, %
100 50 0
*rg
1 2 3
Rubble

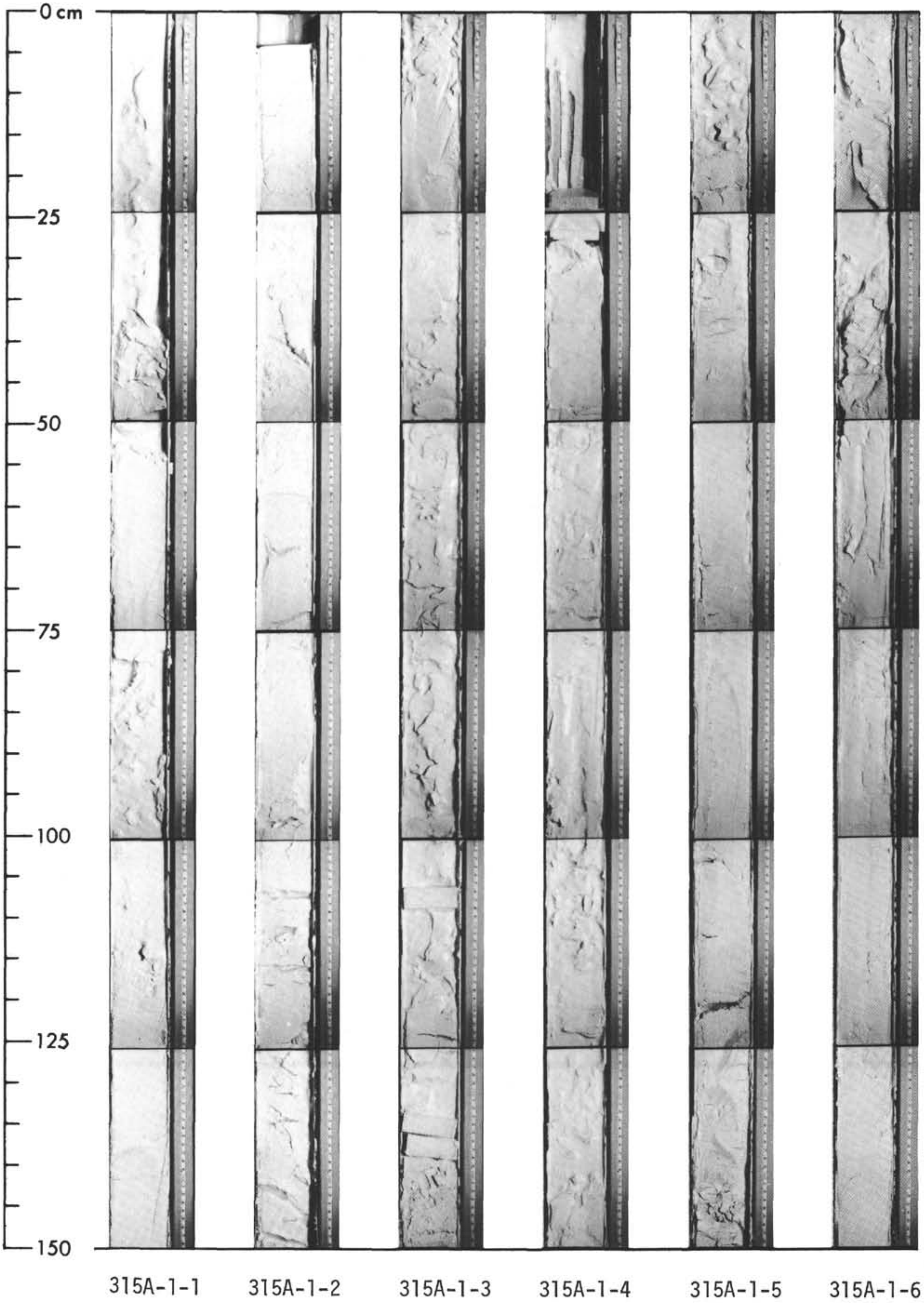
315A
CORE 34

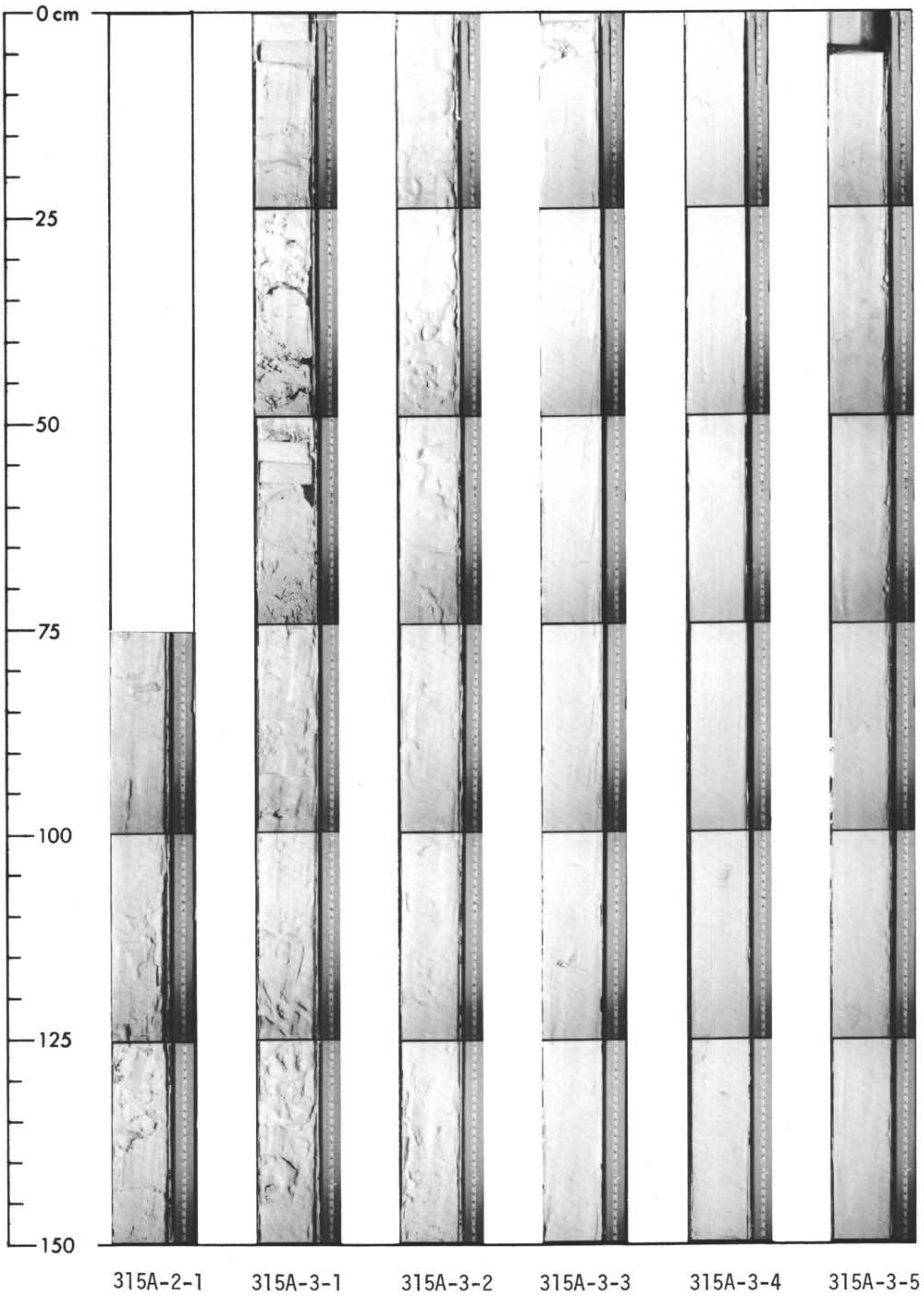



0 cm
25
50
75
100
125
150
315-1-1
315-1-2
315-1-3
315-1-4
315-1-5
315-1-6



315-4-1 315-4-2 315-4-3 315-4-4 315-4-5 315-4-6


0 cm
25
50
75
100
125
150
315A-1-1
315A-1-2
315A-1-3
315A-1-4
315A-1-5
315A-1-6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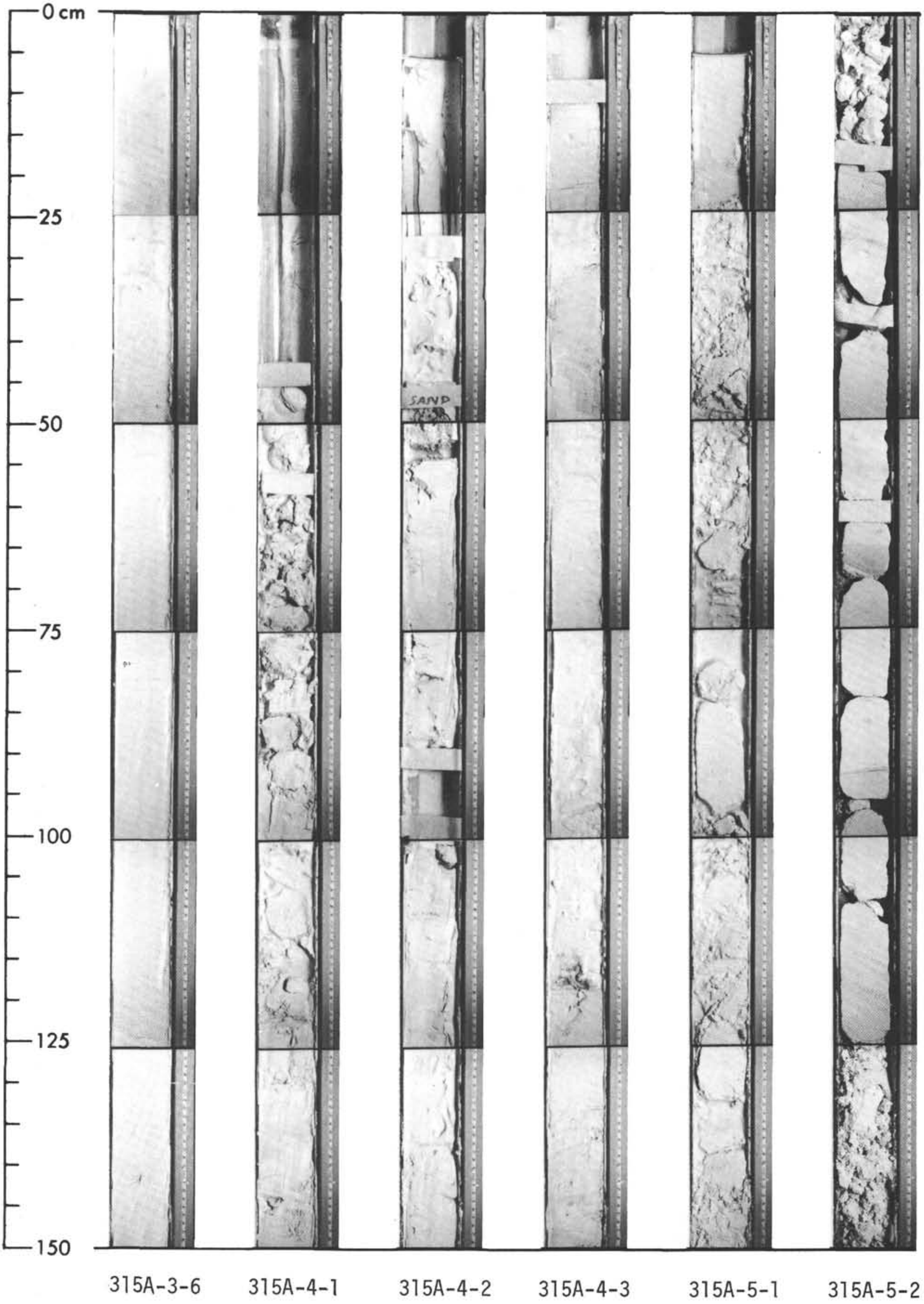
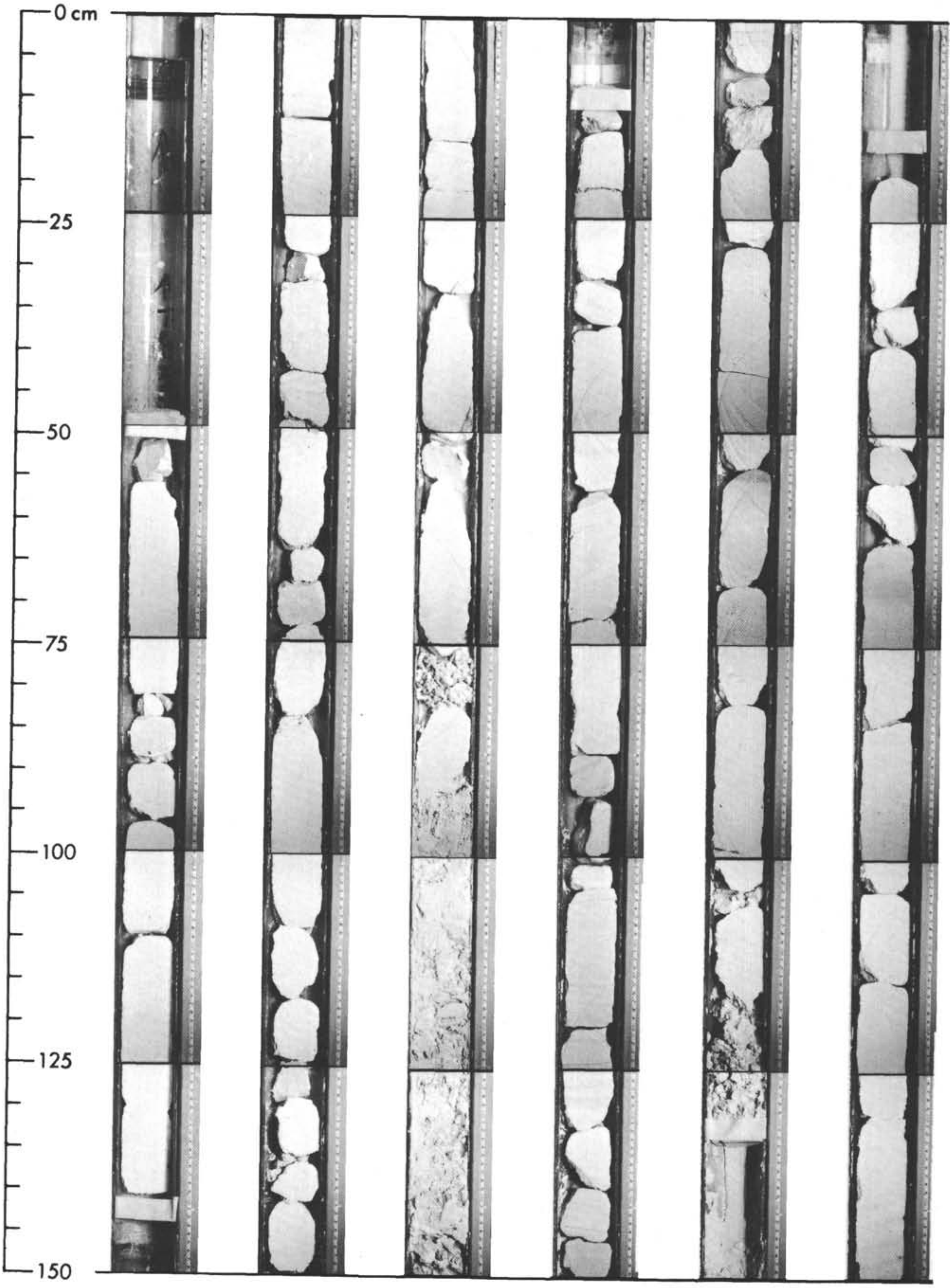
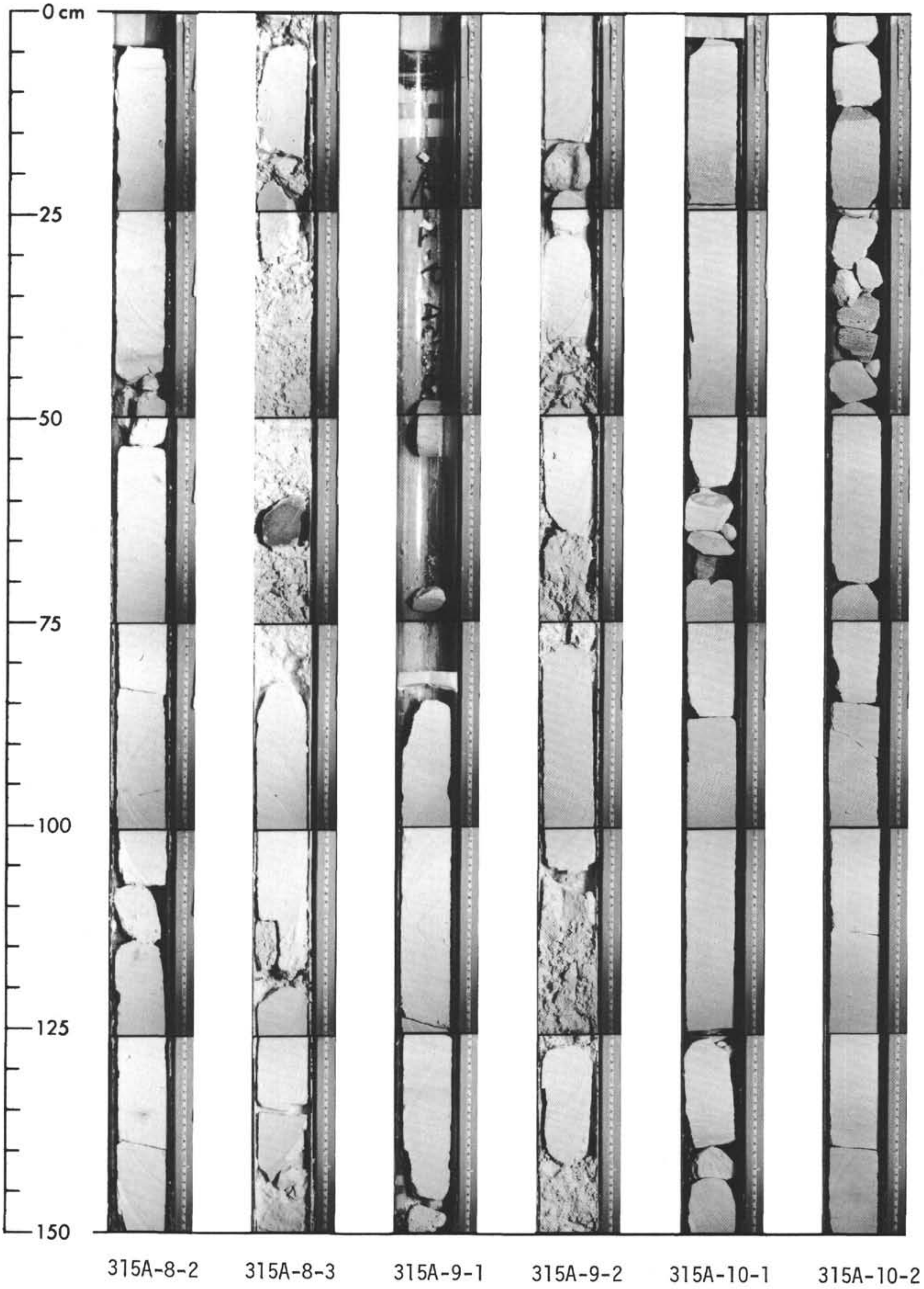
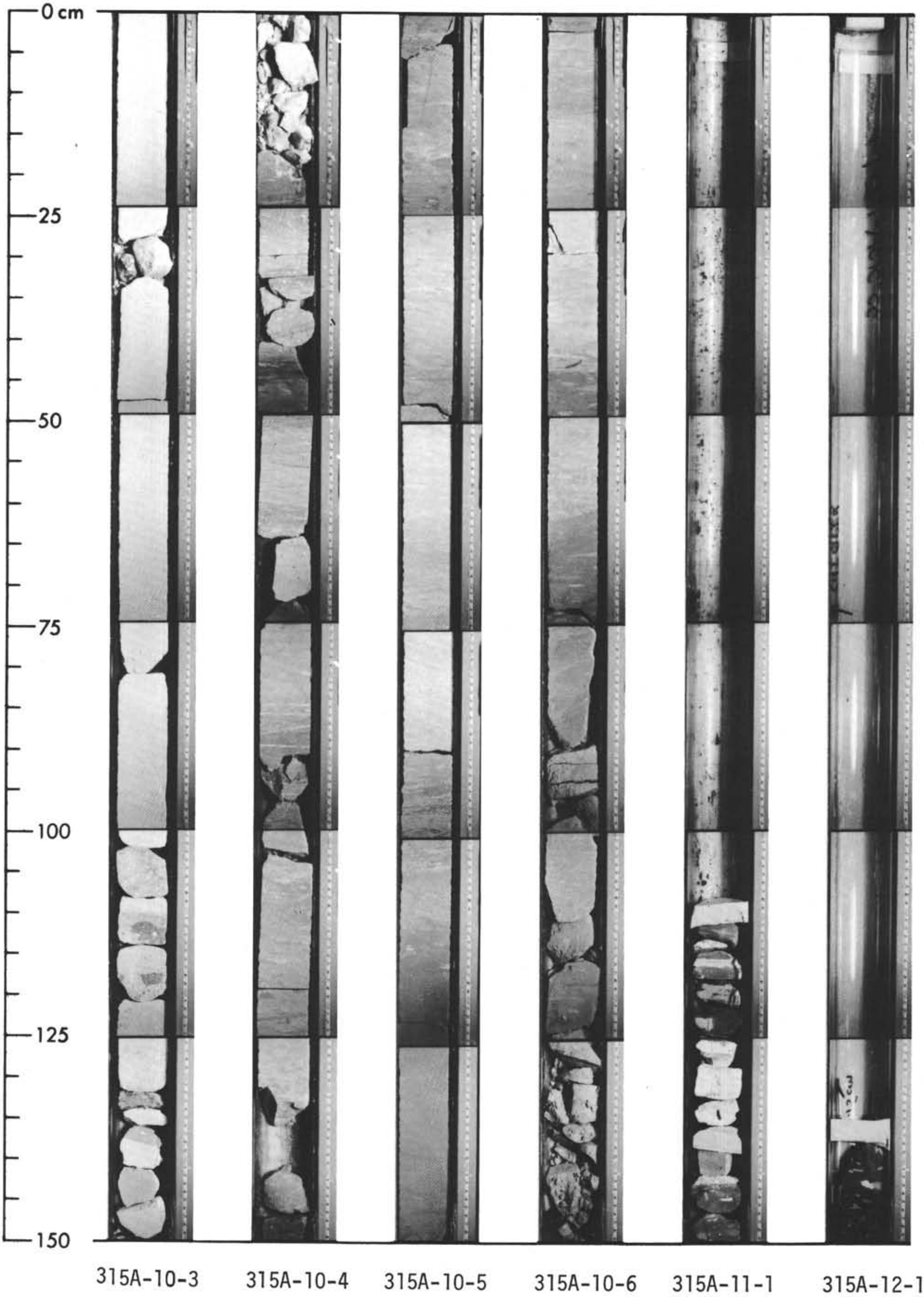
25
50
75
100
125
150
315A-2-1
315A-3-1
315A-3-2
315A-3-3
315A-3-4
315A-3-5

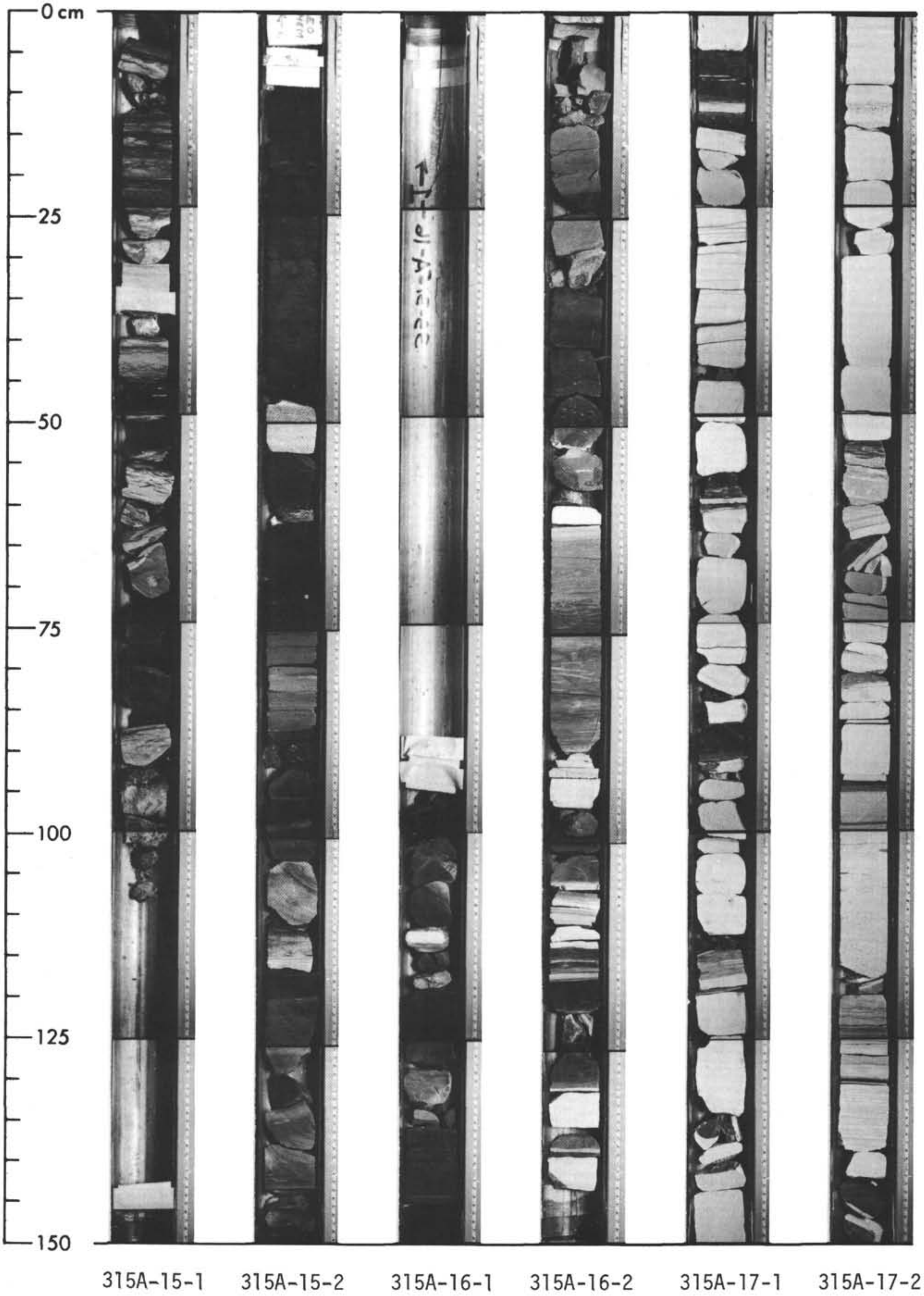

0 cm
25
50
75
100
125
150
SAND
315A-3-6
315A-4-1
315A-4-2
315A-4-3
315A-5-1
315A-5-2

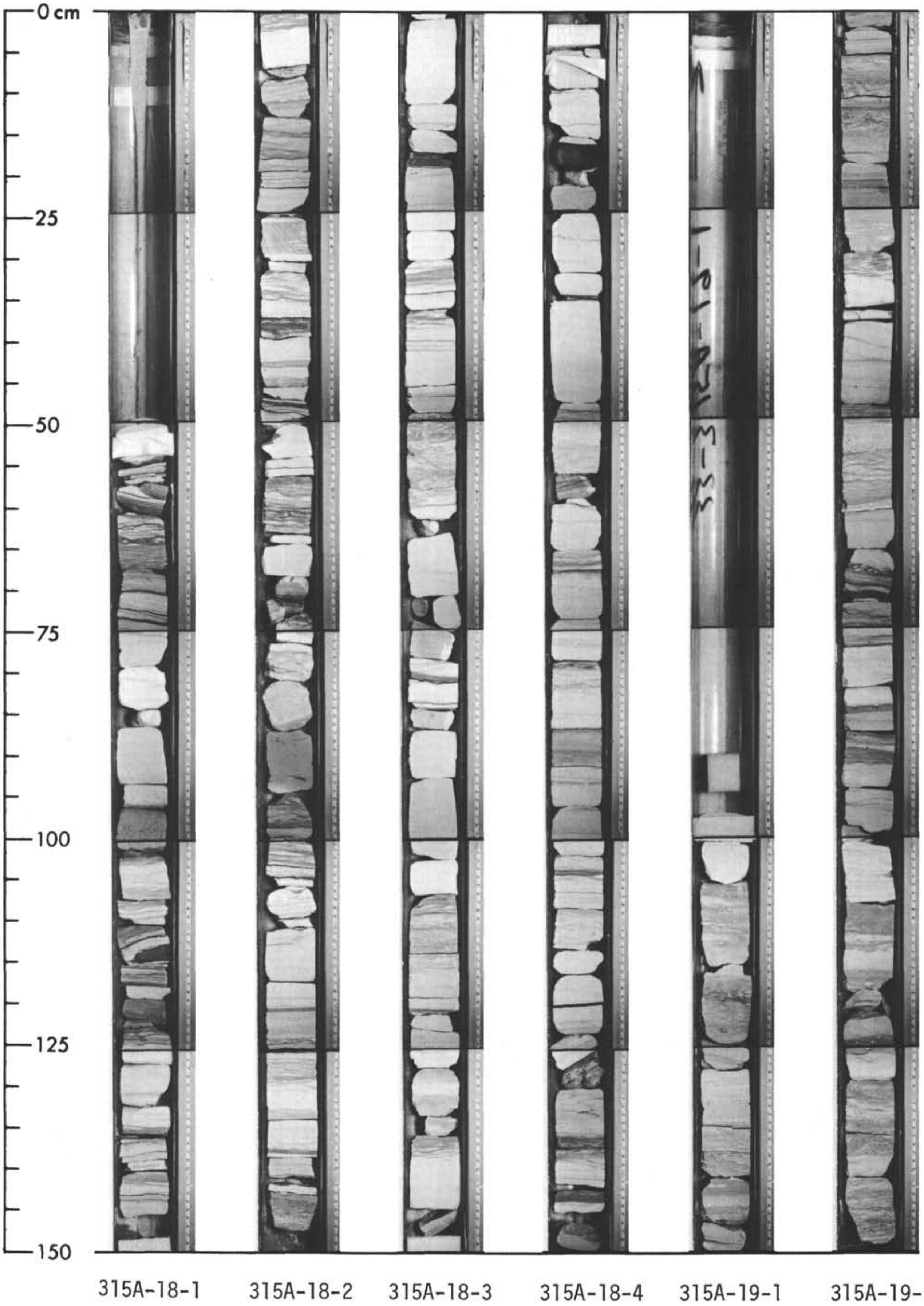


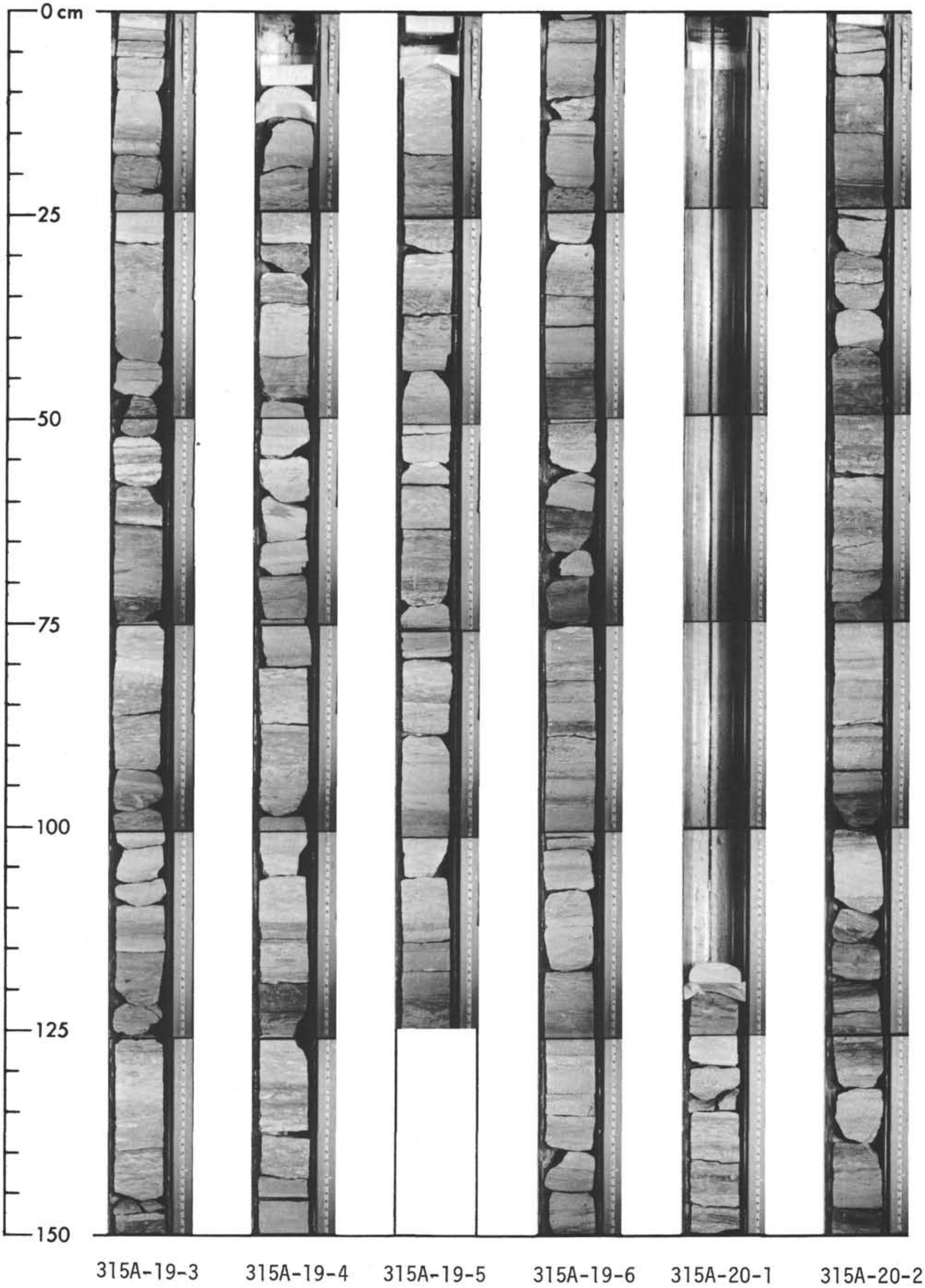
315A-6-1 315A-6-2 315A-6-3 315A-7-1 315A-7-2 315A-8-1

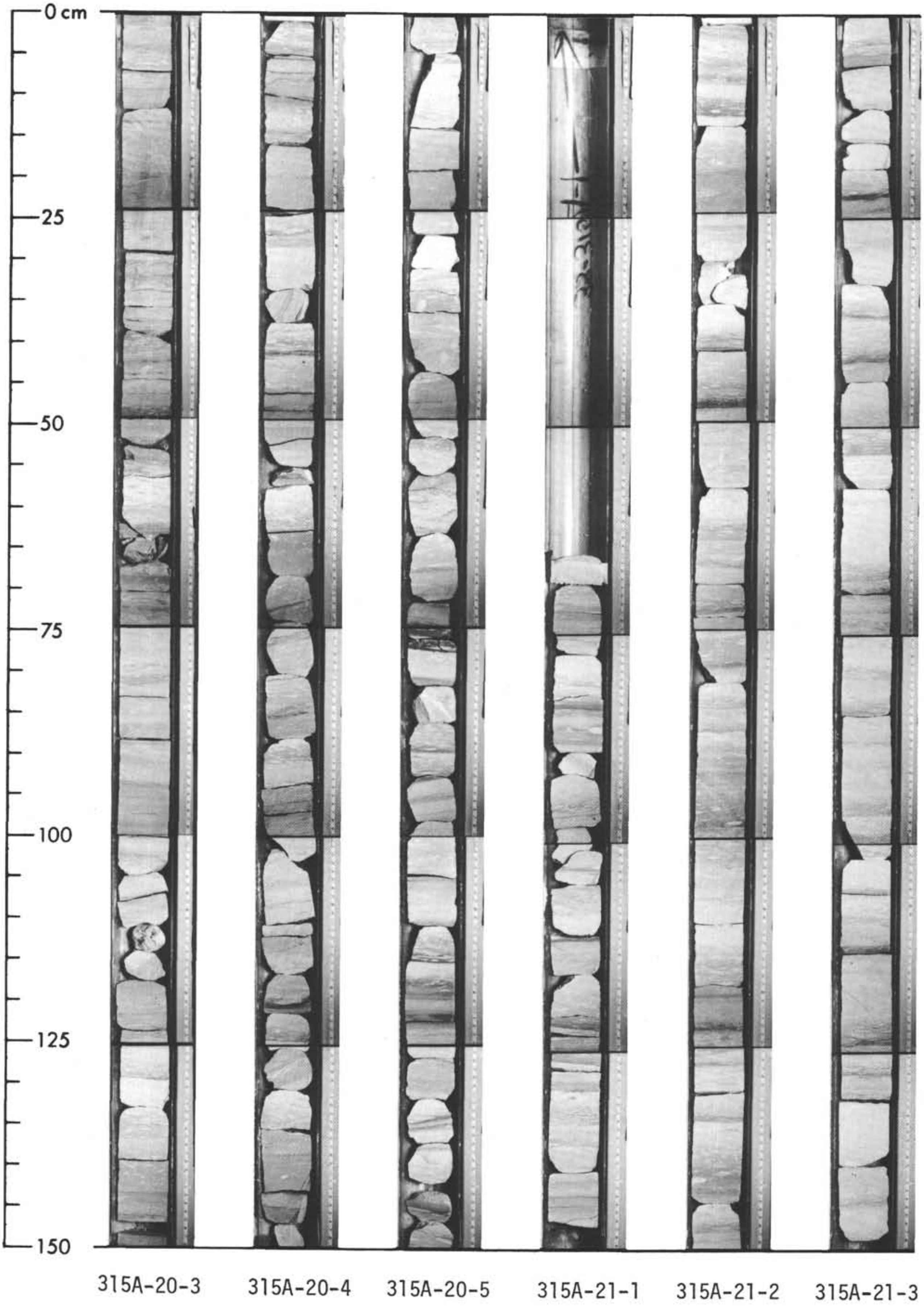

0 cm
25
50
75
100
125
150
315A-8-2
315A-8-3
315A-9-1
315A-9-2
315A-10-1
315A-10-2

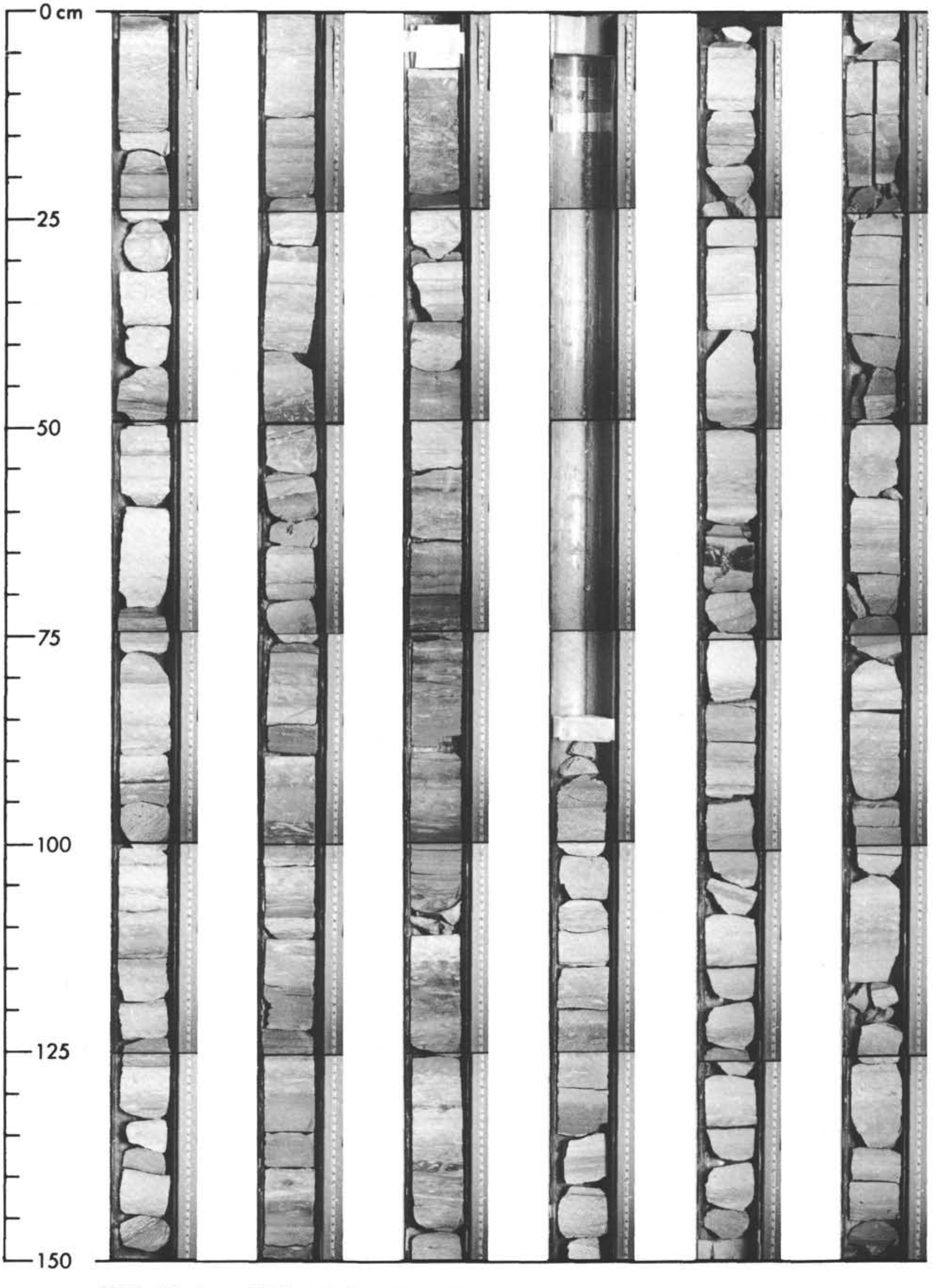

0 cm
25
50
75
100
125
150
315A-10-3
315A-10-4
315A-10-5
315A-10-6
315A-11-1
315A-12-1

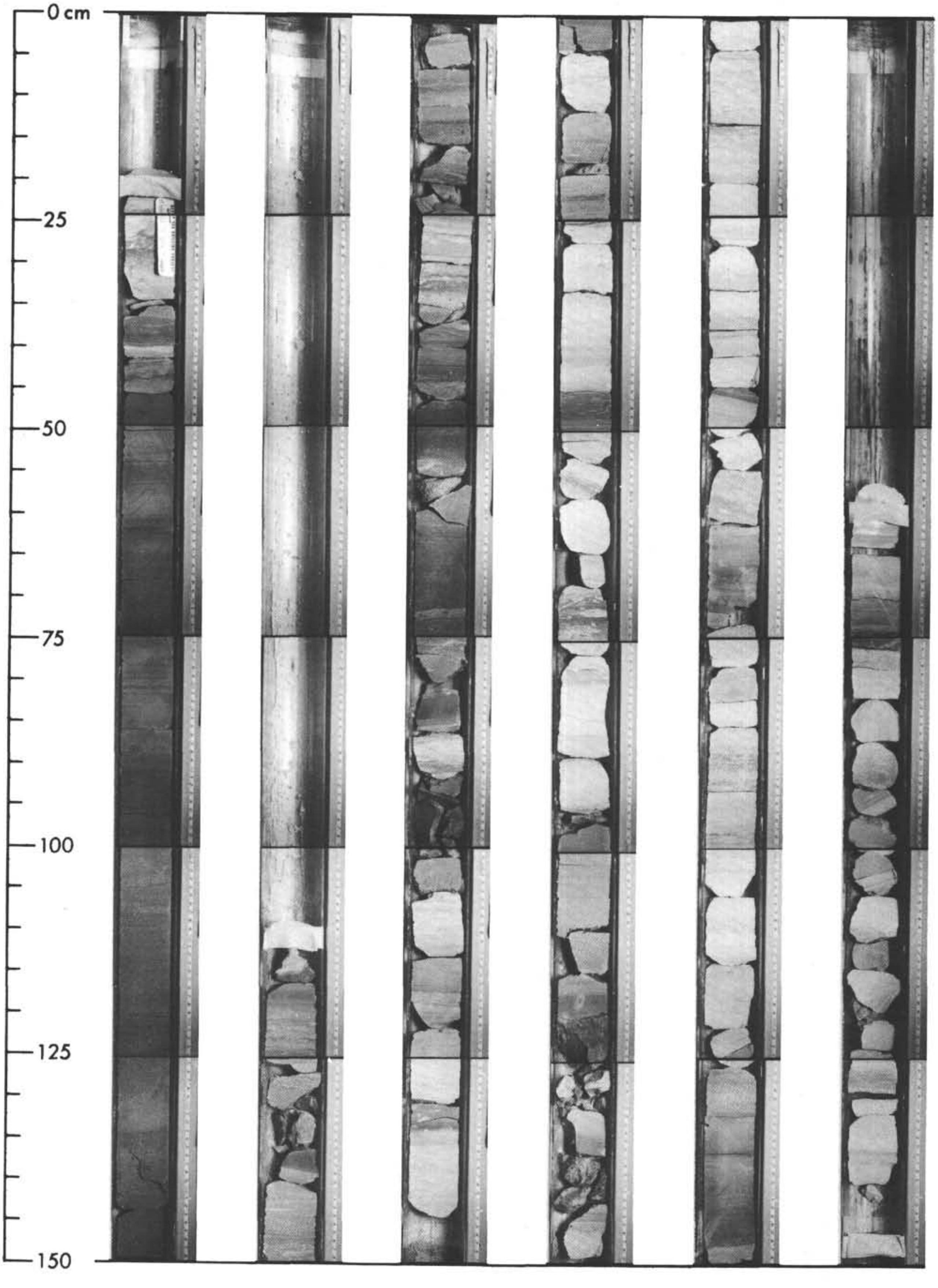

0 cm
25
50
75
100
125
150
315A-15-1
315A-15-2
315A-16-1
315A-16-2
315A-17-1
315A-17-2


0 cm
25
50
75
100
125
150
315A-18-1
315A-18-2
315A-18-3
315A-18-4
315A-19-1
315A-19-2

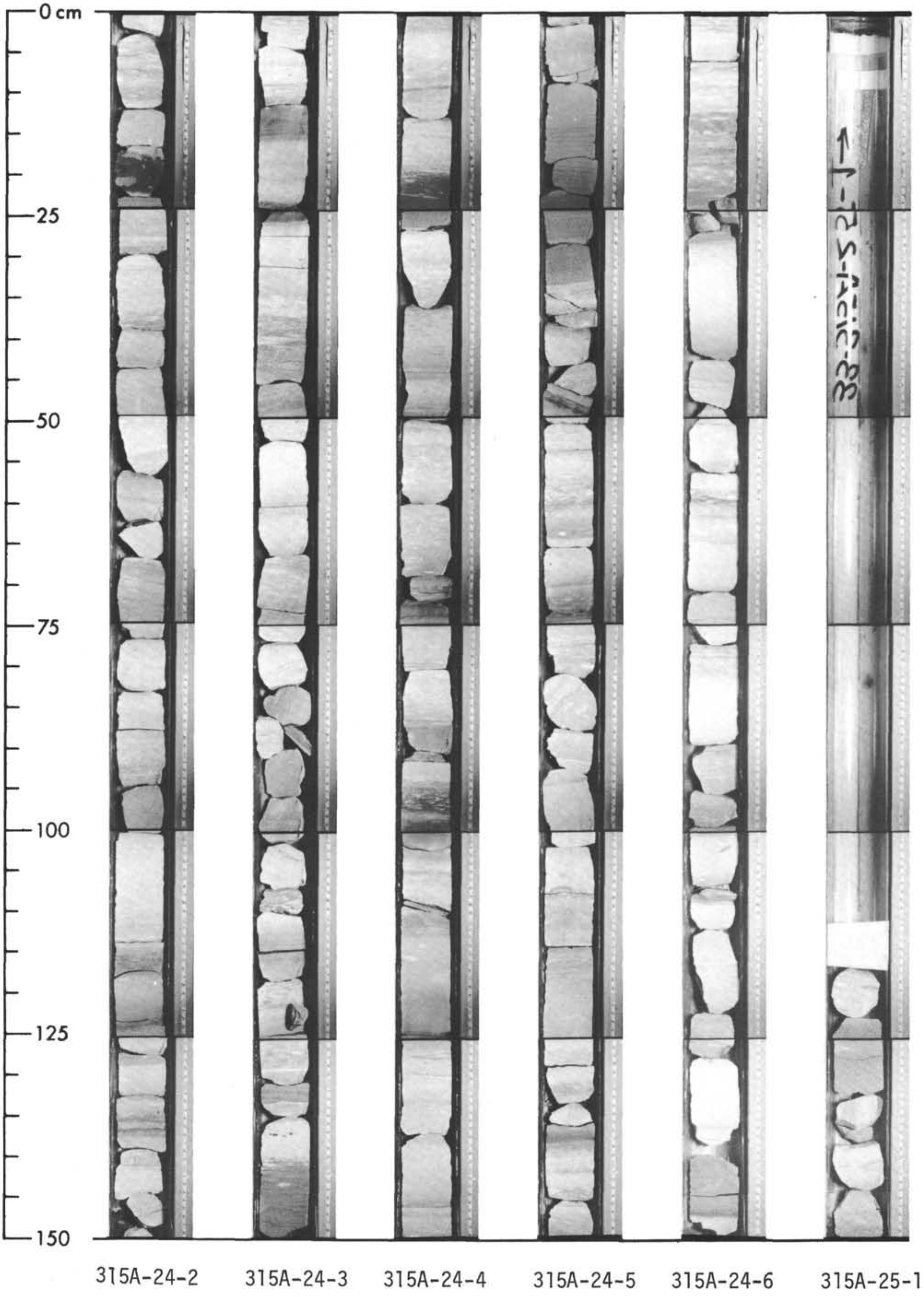

0 cm
25
50
75
100
125
150
315A-19-3
315A-19-4
315A-19-5
315A-19-6
315A-20-1
315A-20-2

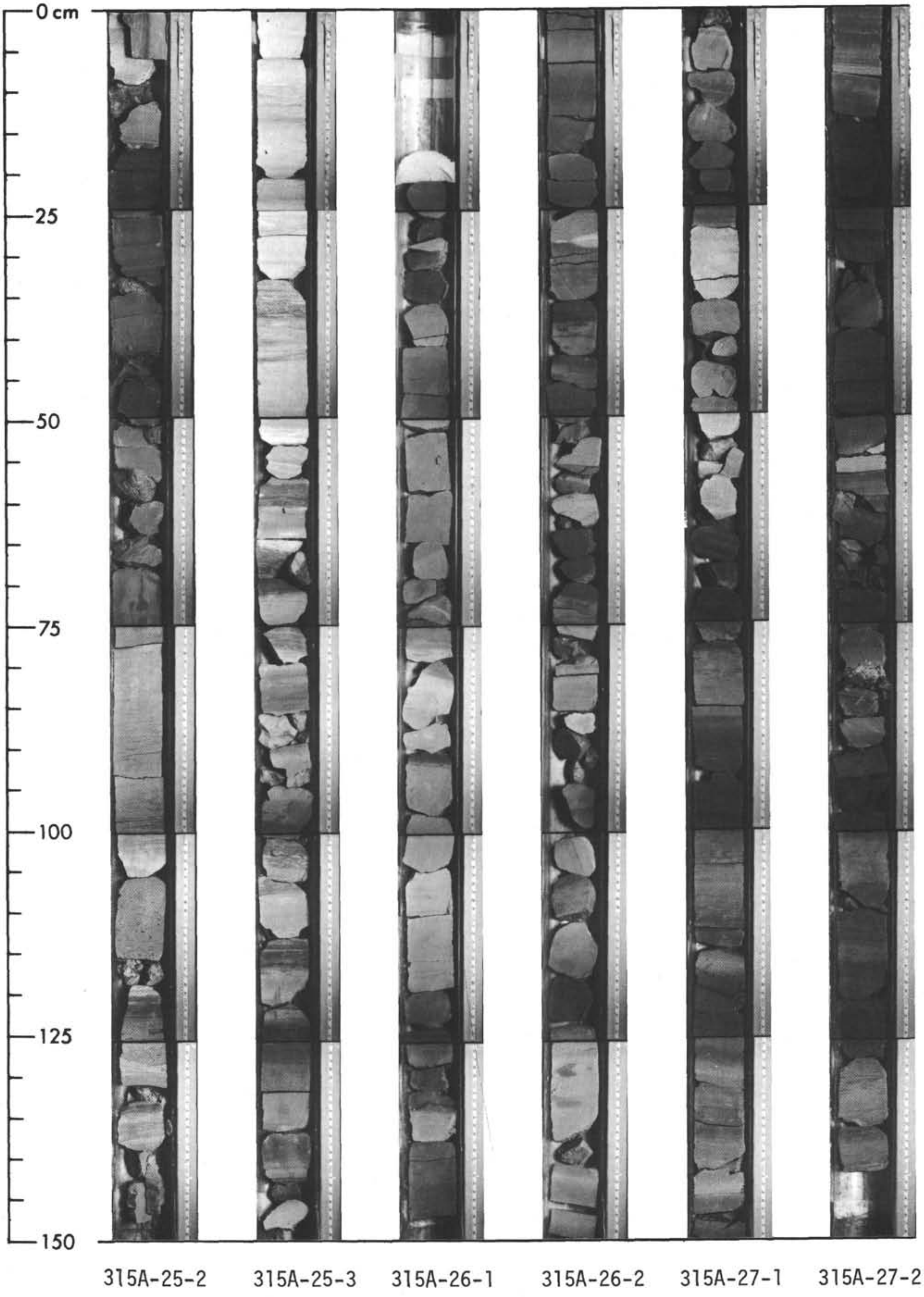

0 cm
25
50
75
100
125
150
315A-20-3
315A-20-4
315A-20-5
315A-21-1
315A-21-2
315A-21-3

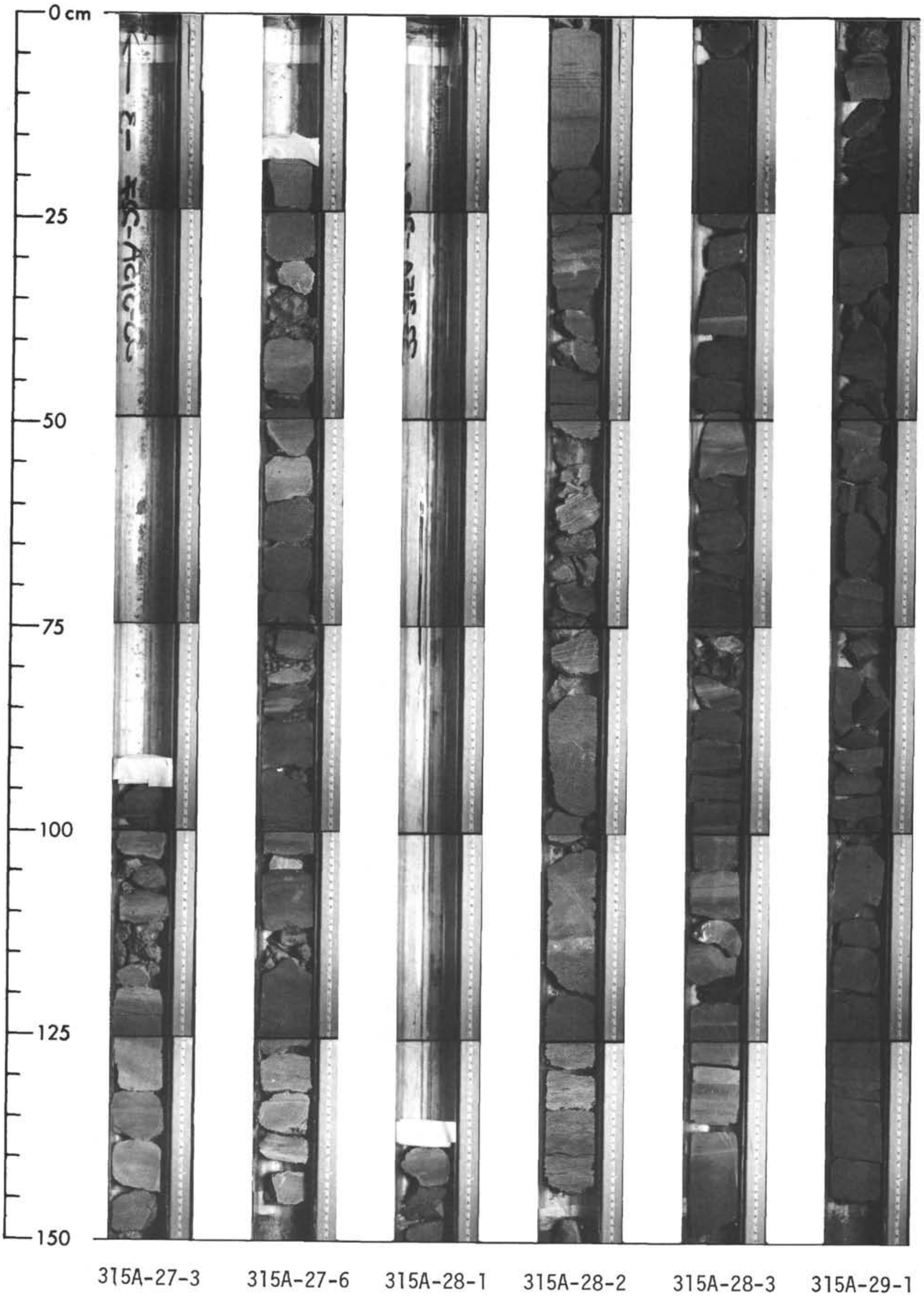

0 cm
25
50
75
100
125
150
315A-21-4
315A-21-5
315A-21-6
315A-22-1
315A-22-2
315A-22-3

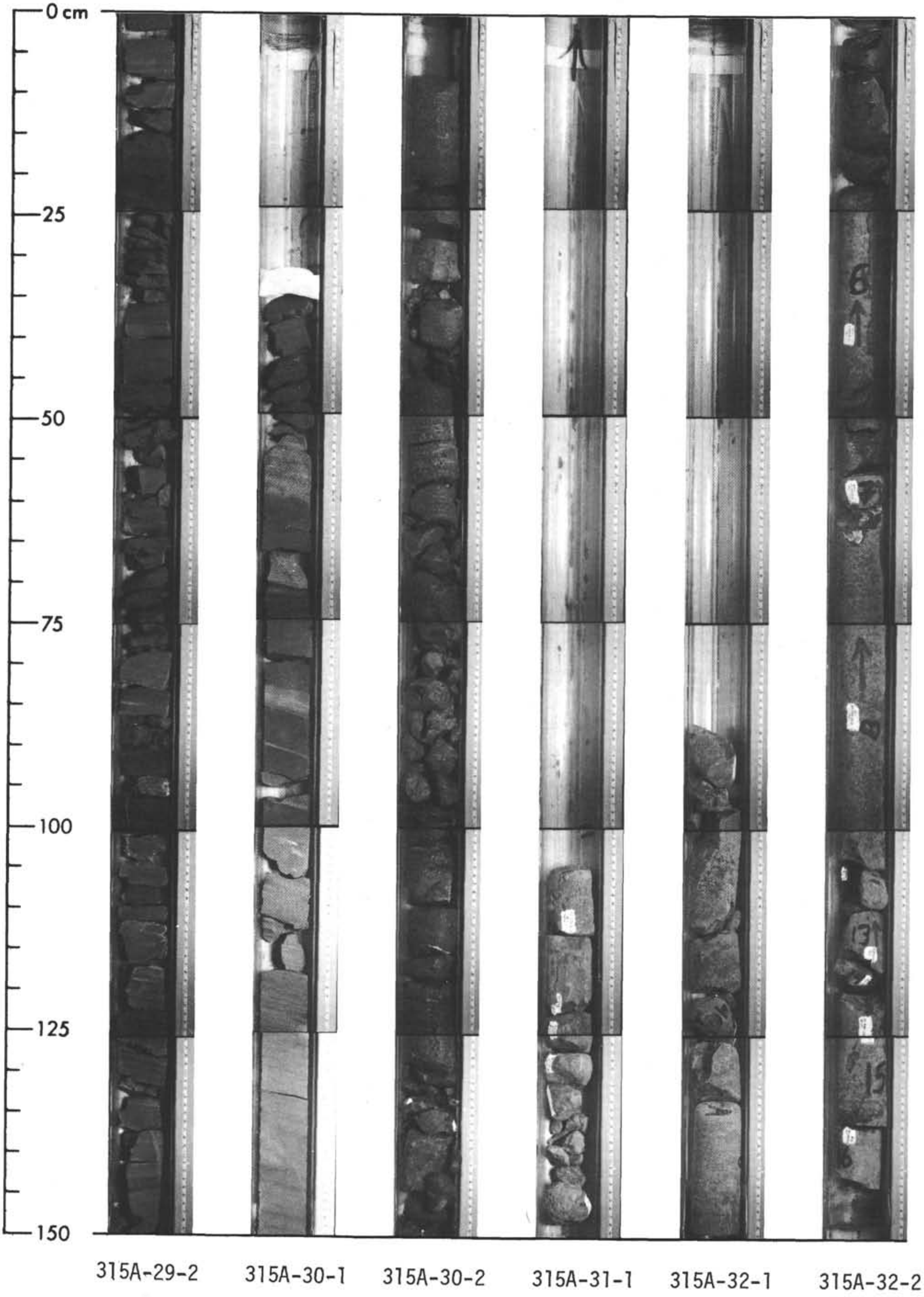


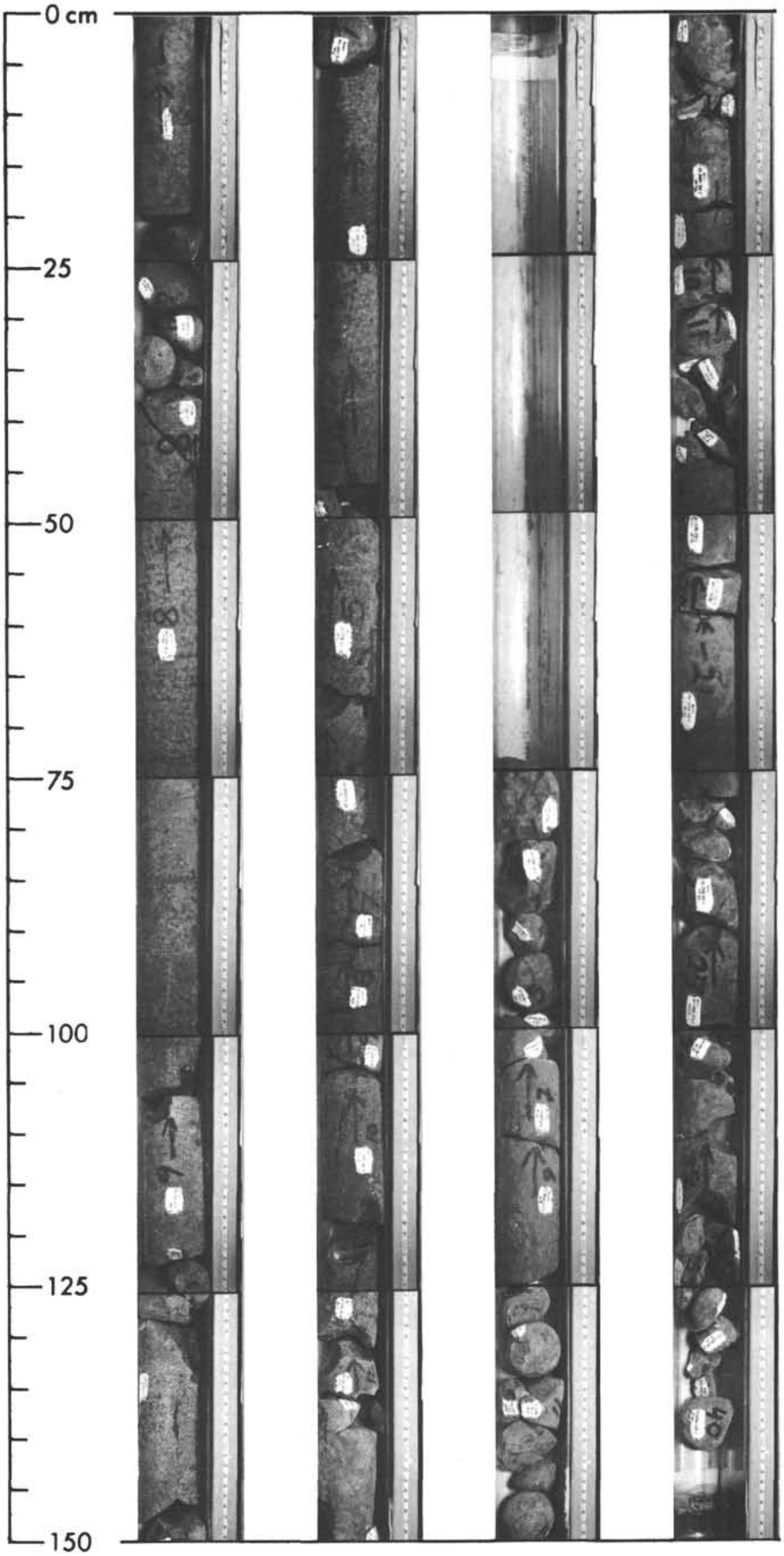
315A-22-4 315A-23-1 315A-23-2 315A-23-3 315A-23-4 315A-24-1


0 cm
25
50
75
100
125
150
315A-24-2
315A-24-3
315A-24-4
315A-24-5
315A-24-6
315A-25-1


0 cm
25
50
75
100
125
150
315A-25-2
315A-25-3
315A-26-1
315A-26-2
315A-27-1
315A-27-2


0 cm
25
50
75
100
125
150
315A-27-3
315A-27-6
315A-28-1
315A-28-2
315A-28-3
315A-29-1


0 cm
25
50
75
100
125
150
315A-29-2
315A-30-1
315A-30-2
315A-31-1
315A-32-1
315A-32-2


0 cm
25
50
75
100
125
150
315A-32-3
315A-32-4
315A-33-1
315A-34-1