3. SITE 285

The Shipboard Scientific Party[1]

SITE DATA

Date Occupied: 29 April 1973 (2231)

Date Departed: 1 May 1973 (0330)

Time on Site: 30.5 hours

Position:
Latitude: 26°49.16'S
Longitude: 175°48.24'E

Water Depth (from sea level): 4658 corrected meters (echo sounding)

Bottom Felt at: 4674 meters (drill pipe)

Penetration:
Hole 285: 83.5 meters
Hole 285A: 584 meters

Number of Holes: 2

Number of Cores:
Hole 285: 5
Hole 285A: 9

Total Length of Cored Section:
Hole 285: 45.5 meters
Hole 285A: 85.5 meters

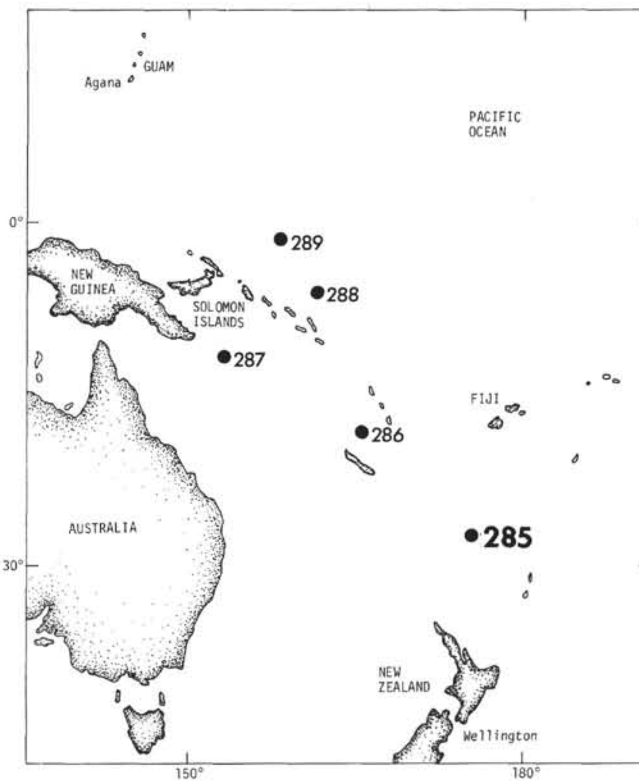
Total Core Recovered:
Hole 285: 42.2 meters
Hole 285A: 47.5 meters

Percentage of Core Recovery:
Hole 285: 92.7%
Hole 285A: 55.5%

Oldest Sediment Cored:
Depth below sea floor: 564.8 meters
Nature: Altered glass shard siltstone
Age: Early middle Miocene

Basement:
Depth below sea floor: 0.65 sec (reflection time)
Depth below sea floor: 564.8 meters (drilled)
Average velocity to basement: 1.74 km/sec
Nature: Intrusive diabase sill

Principal Results: Site 285 is situated in a small, east-northeast-trending sediment-filled basin in the central part of the South fiji Basin. Two holes were drilled.



Hole 285 was abandoned at 83.5 meters subbottom depth due to the loss of the bottom-hole assembly. Hole 285A reached 584 meters subbottom depth. Coring was discontinuous. The sampled lithologic sequence is described commencing with the deepest unit:

Intrusive diabase, age unknown (584-564.8 m); lower middle Miocene clastic cycles of sandy siltstone and siltstone—main components glass shards and nannofossils (564.8-453 m); lower to upper middle Miocene glass shard-bearing nanno ooze to nanno-bearing glass shard sandy silt (stone) or ash (tuff)—in part reworked (clastic) (453-74 m); upper Miocene nanno-radiolarian ooze to nanno ooze (74-24 m); upper Miocene to lower Pliocene nanno ooze (24-18 m); clay-rich zeolite and micronodule-rich clay ("abyssal red clay") unfossiliferous (18 m to sea floor).

The sequence at Site 285 parallels that drilled to the northeast at Site 205 (Leg 21) in that a middle to late Miocene coarse ashy succession is followed by a late Miocene to early Pliocene biogenic section and by abyssal clay. However, the volcaniclastic sequences at Site 205 are not cyclic. East-west-trending structural ridges in the basin block clastic sedimentation from the south, and it is suggested that the source of the volcanic sediment was the Lau Ridge. This provenance conforms to the present slope of the sea floor.

The Oligocene biogenic sequence intersected at Site 205 unconformably below the early middle Miocene ash was not intersected at Site 285. Drilling ended in a diabase sill.

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BACKGROUND AND OBJECTIVES

Site 285 is located towards the western side of the South Fiji Basin in the deepest area of the basin (Figure 1). To the east lies the Lau Ridge, to the southwest is the Three Kings Rise, and to the west and northwest lies the Norfolk Ridge. Site 205 is located on the western flank of the Lau Ridge, 265 km to the east-northeast. At that site the succession comprised a thin sequence of abyssal clays with beds of nanno ooze in the lower part, underlain by middle to late Miocene volcanic ash (that coarsens downward) interbedded with ash-rich nanno ooze. This overlies ash-bearing chalks of middle to late Oligocene age. The lowest unit intersected was basalt with pillow-like features, but the adjacent sediment appeared to be baked.

The rocks of the Norfolk Ridge as displayed in New Caledonia extend back to early Mesozoic (or ?late Paleozoic) while the oldest rocks to the east are pre-middle Eocene basic volcanics of Eua Island on the Tonga Ridge (Stearns, 1971). The Tonga Ridge appears to have been separated from the Lau Ridge by the development of the Lau-Havre Trough in the late Miocene to Pleistocene (Karig, 1970). The basement ages on the basin margins are older than the age implied from drilling at Site 205.

A site was originally selected on the Leg 21 seismic profile at 26°38'S and 175°45'E where the basement profile was distinct and the estimated sediment thickness was 550 meters. The apparent regularity of the basin structure evidenced by the available east-west profiles and the bathymetry suggested strong similarity to Site 205. The site was approached along a north-south track from the vicinity of Great Barrier Island north of Auckland, New Zealand. Along this track the basin structure is radically different from that shown by east-west profiles, having a rough basement structure with a wave length of approximately 65 km. A gradually thinning wedge of sediment extends into the basin from the base of the Venig Meiniz) Fracture. This is interrupted by the basement irregularities and two large (2250 m relief) and several small (500-750 m relief) seamounts, most of which are not shown on current bathymetric charts.

The principal objective at this site was to obtain a stratigraphic column which could be compared with that at Site 205 (located to the east) to see whether basement age differed significantly and to compare the subsequent depositional histories of the two sites. If the South Fiji Basin has developed by extension, evidence of age differences might be found that could give a clue to the nature of the extensional process involved. The possibility that the basin is a captured part of the Pacific crust could also be tested.

OPERATIONS

The original choice of the site was made from the seismic profile between Sites 205 and 206 (Leg 21). No other site survey was available.

The proposed site was approached from the south (Figure 1), and at the site location the Leg 21 track was crossed with good agreement between sea floor and basement depths from the profiles. The profile contained a smaller number of seismic reflectors and presumably a less complete section than were seen in an adjacent basin to the south. A location some 10 miles south of the originally planned site was chosen for Site 285. Accordingly, the seismic profile along the approach track (Figure 2) presents two crossings of the site and adjacent structures.

The beacon was dropped at 2231 on 29 April 1973, and the hole was spudded in at 1215, 30 April. The location of Site 285 is 26°49'S and 175°48'E in a water depth of 4658 meters (corrected echo sounding). After cutting and retrieving five cores in soft sediments, the entire bottom-hole assembly was lost due to a fracture failure in the upper bumper sub. A new assembly was rigged and Hole 285A was spudded at 0515, 2 May 1973. Coring intervals were extended to compensate for the lost time, and intrusive diabase was reached at 564.65 meters subbottom. Two additional cores were cut in the diabase, but necking of the core on the second, indicating bit failure, coupled with hole stability problems resulted in termination of the drilling before the thickness of the sill could be determined. On recovery the three cone roller bit was found to have lost one cone and bent the inner lip so that further coring would have been impossible.

An on-site sonobuoy profile (Figure 3) was shot to check reflector depth (see Correlation of Seismic Profile with Drilling Results). Before leaving the site the logging winch was run as a test for the reentry work on the Ontong-Java Plateau. The site was departed at 0400 on 4 May 1973.

LITHOLOGY

Hole 285 (water depth 4674 m) was cored every other 9 meters to a subbottom depth of 83.5 meters. After the recovery of Core 285-5, the drill string was pulled out due to a mechanical failure and a second hole (Hole 285A) started. From 131 meters to 555.5 meters the section was spot-cored. From 555.5 meters downwards the section was cored continuously. Drilling was stopped at 584 meters due to mechanical problems. A total of 14 cores was recovered. Summaries of each of these are given in Table 1.

The lithologic sequence can be divided into five units (Figures 4, 13). Unit 4 has been subdivided further into two subunits. Oldest sediments recovered are of early middle Miocene age. Sediment composition, as determined from smear slides, is given in Appendix A and plotted in Figure 5. Grain size, carbon-carbonate, and X-ray determination data are presented in chapters pertaining to these subjects collectively for Leg 30 elsewhere in this volume.

The units are, from top to bottom:

Unit 1 (0.18 m): Clay-rich zeolite micronodulite, and zeolite and micronodule-rich clay (popularly called "red abyssal clay"). Unfossiliferous.

Unit 2 (18-23.9 m): Nanno ooze. Lower Pliocene to upper Miocene.

Unit 3 (23.9-61.5 m): Nanno ooze with various amounts of siliceous fossils. Upper Miocene.

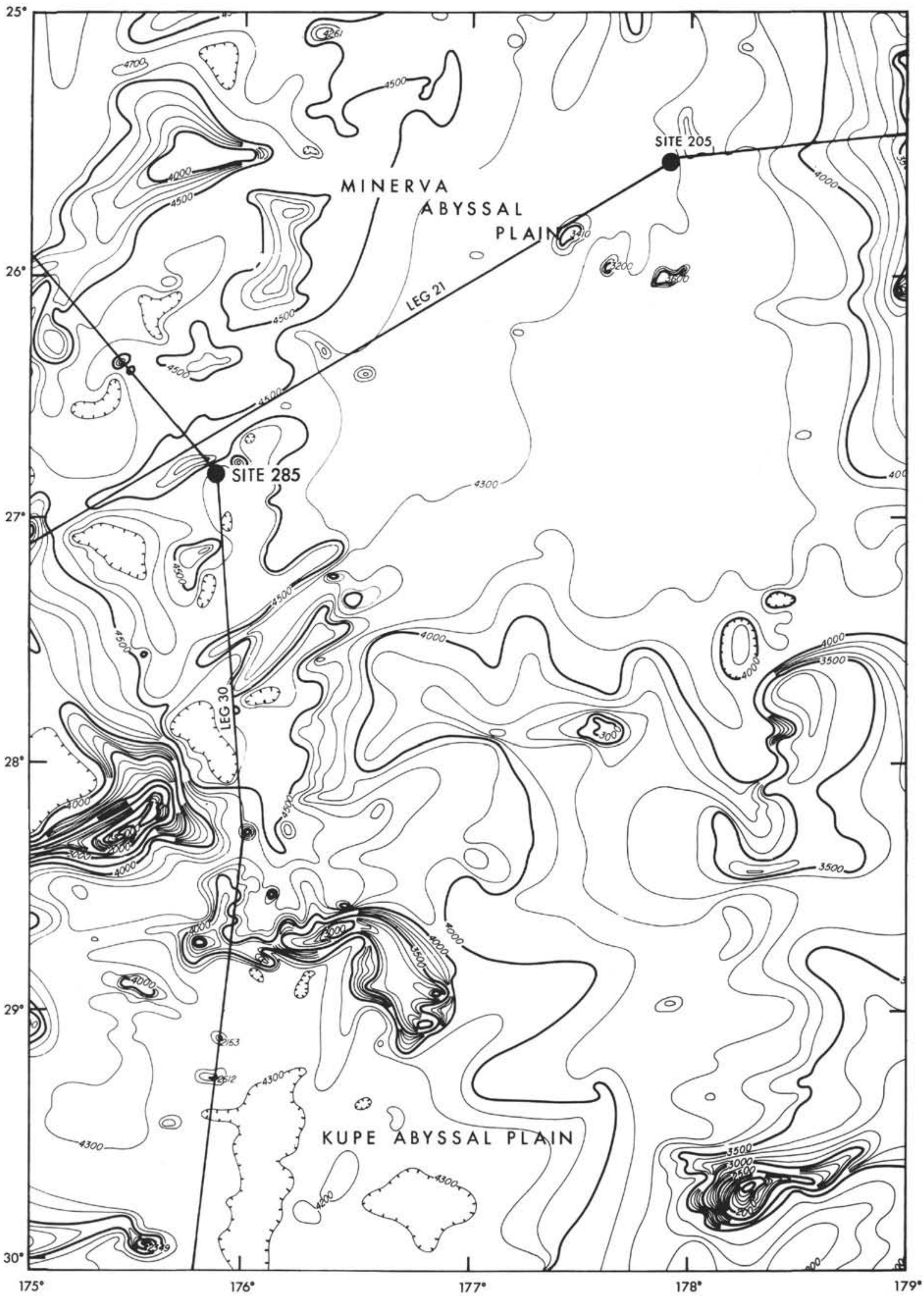

Figure 1. *Location of South Fiji Basin Sites 285 (Leg 30) and 205 (Leg 21). Contour interval 100 meters (after Packham and Terrill, this volume).*

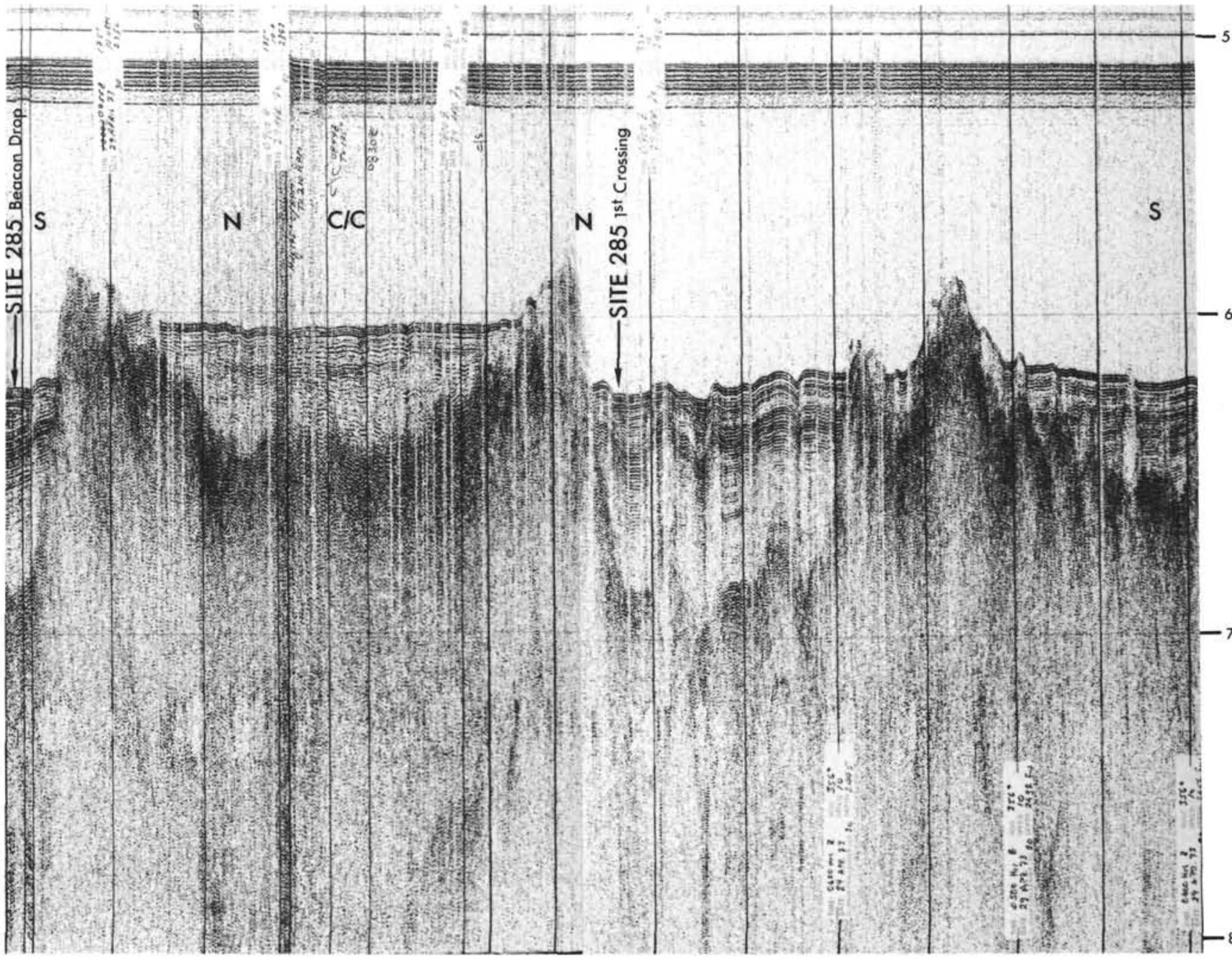

Figure 2. *Seismic profile of approach track to Site 285. First crossing of site and profile north of site into adjacent basin and south to Site 285.*

Subunit 4A (61.5-453 m): Glass shard-bearing nanno ooze to nanno-bearing) glass shard sandy silt (stone) or ash (tuff). Semilithified below 187 meters. In part reworked (clastic) sediments. Upper Miocene to lower middle Miocene.

Subunit 4B (453-564.8 m): Clastic cycles of sandy siltstone and siltstone. Main components are glass shards and nannofossils. Lower middle Miocene.

Unit 5 (564.8-584 m): Diabase sill. Age unknown.

Unit 1

This unit, recovered in Core 285-1 and the top of 285-2, consists of dusky red mixtures of micronodules, clay, and zeolites, with minor admixtures of quartz, feldspar, and glass shards. It is virtually unfossiliferous, and only a few specimens of arenaceous foraminifera were encountered. This type of sediment is popularly known as "red abyssal clay" and is thought to have accumulated well below the carbonate compensation depth. The sediment is disturbed by drilling, and no sedimentary structures were observed.

Unit 2

This unit was recovered within Core 285-2, and is characterized by an abundance of nannofossils (50% to 96%). Minor constituents are micronodules, zeolites, and glass shards. Sediment colors are shades of yellow-brown with subordinate horizons of dusky red and dark brown sediments that contain higher percentages of micronodules. Locally, pumiceous fragments (up to 0.5 cm) occur. Drilling disturbance has obliterated any sedimentary structures which might have existed. Near the boundary with Unit 1 there is a suggestion of alternation of the two lithologies, but this may be a result of drilling disturbance.

Unit 3

This unit was recovered in Cores 285-2 to 285-4. The major sediment components are nannofossils, radiolarians, and volcanic glass shards. Minor components are other siliceous fossils, foraminifera, micronodules, and zeolites. Sporadic occurrences of very small amounts of quartz, feldspar, micarb, clay

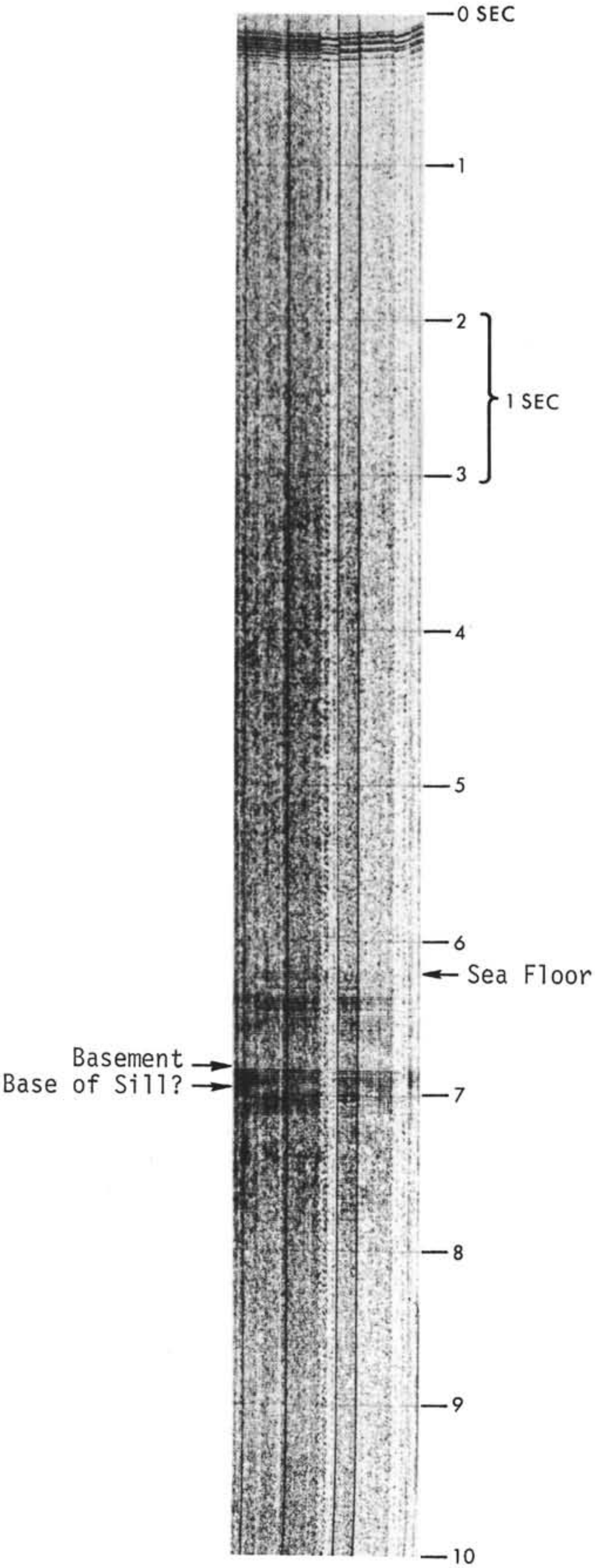

Figure 3. *On site sonobuoy profile at Site 285.*

minerals, and heavy minerals have been observed in smear slides (Appendix A). In the core catcher of Core 285-4 about 1% of wood fragments occur. X-ray mineralogy data indicate some plagioclase and augite in all analyzed samples, and small amounts of quartz and montmorillonite in some of the analyzed samples. However, the percentages of individual components vary greatly from one sample to another. Major components can become minor, and vice versa (Appendix A). Sediment names, therefore, vary greatly as well. The main sediment colors are pale brown, light brownish-gray, and light gray. Any sedimentary structures, if present originally, have been destroyed by drilling.

Unit 4

This unit consists mainly of various amounts of glass shards and nannofossils. The subdivision into Subunits 4A and 4B, made on board the ship, was based primarily on the degree of preservation of sedimentary structures and on the frequency of clearly defined sedimentary cycles, both being higher in Subunit 4B. X-ray mineralogy data show that the boundary between Subunits 4A and 4B is also characterized by the appearance (upwards) of the detrital mineral augite. Clinoptilolite is present in Subunit 4B only.

Subunit 4A

This unit consists of olive-gray to dark gray relatively fine grained (silt) and more coarse grained (sandy silt) sediments that are more consolidated than those of the overlying units. Consolidation ranges from stiff (at the top) to semilithified (from 187 m downwards). With increasing consolidation, sedimentary structures become better preserved. The coarsest grained sediment (containing up to 90% sand) is restricted to discrete intervals, showing either parallel lamination and/or microcross-lamination. The thickness of these intervals ranges from 3 to 15 cm. Because these sediments have obviously been reworked by currents, they are given clastic names. The intervals of more fine grained sediments are either structureless or show slight bioturbation. Again, increased consolidation results in better preserved structures. Because the clastic character of these more fine grained sediments cannot be established, no clastic names have been given. However, it is possible that the sediments of this unit are basically similar to those of Subunit 4B, for which a clastic origin has been inferred.

The major components of the sediments are glass shards (5% to 81%) and nannofossils (5% to 83%). Minor components are quartz, feldspar, heavy minerals, pyrite, micronodules, zeolite, micarb, and foraminifera.

Locally abundant pumice fragments (up to 1.5 cm) are present, mainly in the top part of the unit (e.g., Cores 285-5-3 and 285A-1-1 to 285A-1-3).

Subunit 4B

This unit consists of relatively coarse and fine grained sediments. Due to consolidation ("semilithified"), the sedimentary structures are well preserved. The boundary with Subunit 4A is probably gradational. Cycles

TABLE 1
Coring Summary, Site 285

Core	Date (April 1973)	Time	Depth From Drill Floor (m)	Depth Below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Recovery (%)
Hole 285							
1	30	1345	4674[a]-4681.5	0 - 7.5	7.5	7.5	100
2	30	1515	4691-4700.5	17-16.5	9.5	6.9	73
3	30	1705	4710-4719.5	36-45.5	9.5	9.3	98
4	30	1945	4729-4738.5	55-64.5	9.5	9.0	95
3	30	2315	4748-4757.5	74-83.5	9.5	9.5	100
Total					45.5	42.2	93
Hole 285A							
1	2	0915	4805.0-4814.5	131.0-140.5	9.5	6.0	63
2	2	1130	4861.0-4870.5	187.0-196.5	9.5	1.5	16
3	2	1515	4918.0-4927.5	244.0-253.5	9.5	2.1	22
4	2	1920	5022.5-5032.0	348.5-358.0	9.5	2.0	21
5	2	2335	5127.0-5136.5	453.0-462.5	9.5	6.5	68
6	3	0220	5184.0-5193.5	510.0-519.5	9.5	9.5	100
7	3	0535	5229.5-5239.0	555.5-565.0	9.5	9.5	100
8	3	0345	5239.0-5248.5	565.0-574.5	9.5	4.5	50
9	3	1305	5248.5-5258.0	574.5-584.0	9.5	5.7	60
Total					85.5	47.3	55

ranging from 8 to 160 cm thickness and consisting of three intervals can be distinguished:

Interval a: The base of this interval (base of cycle) is erosional. The sediments are mainly microcross-laminated changing upwards into parallel lamination; an occasional cycle shows parallel lamination throughout the interval. Grain size varies from one set of laminae to another, and the amount of sand ranges from 5% to 40%. Conglomerate, consisting of pebbles of volcanic rock fragments and pumice (sizes up to 1 cm) is present at the base of one interval (Sample 285A-7-5, 8 cm). Thicknesses of Interval a range from about 1 cm to 20 cm. The boundary with Interval b is gradational.

Interval b: This interval (siltstone) is more fine grained than Interval a and shows only vague parallel lamination. Its thickness can range up to 130 cm. The boundary with Interval c is gradational.

Interval c: This interval has the same grain size as Interval b, but is characterized by moderate to intense mottling. Recognizable burrow structures are rare. *Chondrites* was observed in Cores 285A-5-3, 285A-6-1, and 285A-6-6, and *Zoophycos* in Cores 285A-6-2 and 285-6-3. Interval thickness is up to 50 cm.

The composition of these sediments, as determined in smear slides, is basically similar to that of Subunit 4A. The main differences are a decrease (downwards) in nannofossil content (maximum 40%) and a slight change in color (to dark bluish-gray). Near the contact with the underlying basaltic diabase the sediment color has changed to very dark gray and dark reddish-brown (about 20 cm), and sediment components have been altered (glass shards are devitrified and secondary hematite is present), both as a result of heating by the intrusive diabase.

The sediments of Subunit 4B (and probably also of Subunit 4A) are interpreted as being redeposited by marine currents, but the nature of these currents is still uncertain. No obvious grading can be observed; however, Interval a is more coarse grained than Intervals b and c.

Unit 5

Basaltic igneous rock was encountered at 564.8 meters. This unit is interpreted as a diabase sill because of the baked appearance of the overlying sediments and the fine-grained chill zone which grades downwards to a diabase with a maximum grain size of 1 to 2 mm. The sill is subdivided into three zones (with depths given from the sill-sediment contact): (1) chill zone (0.0-0.7 m), (2) amygdaloidal zone (0.7-2.1 m), (3) diabase zone (2.1-19.2 m). The diabase sill unit is discussed in detail by Stoeser (this volume).

Lithologic Summary

The basaltic diabase underlying Unit 4 is considered to be an intrusive sill.

The sediments of Subunit 4B (and probably of 4A) were deposited by marine currents of yet unknown nature. Sedimentation rates were relatively high, as both Subunits 4B and 4A (490.3 m) have been deposited within the middle Miocene (see discussion of Sedimentation Rates). Biogenic productivity was high (mainly nannoplankton) and biogenic content increases irregularly upwards through the unit. The nannofossil percentage is probably a function of volcanic ash supply (dilution), as the combined percentage of biogenic components and glass shards averages about 90% over most of both units (Figure 5). Assuming the biogenic production to be constant and the volcanic ash supply variable, there is an irregular decrease in ash supply upwards. This is reflected in an upward decrease in the sedimentation rate.

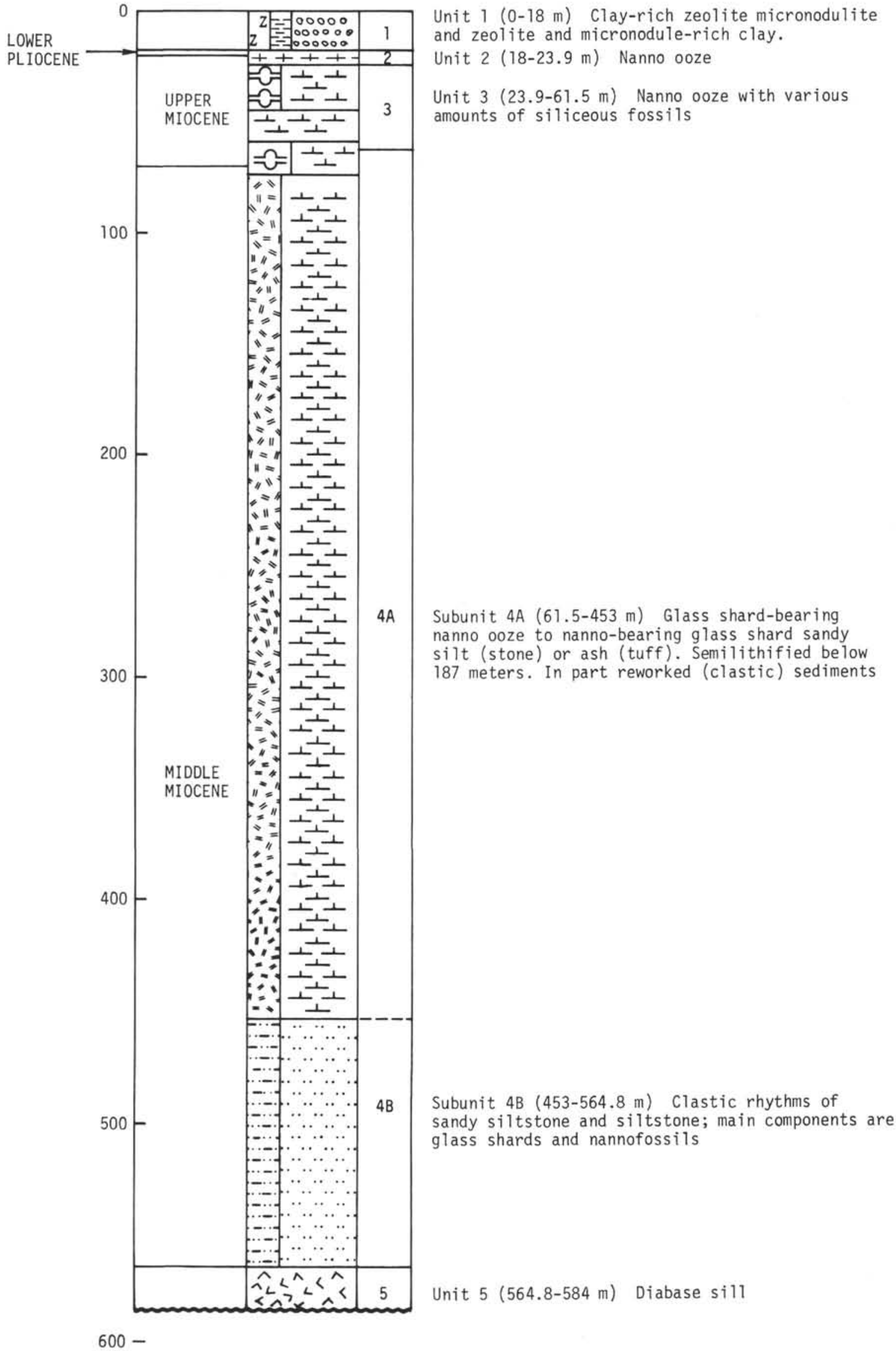

Figure 4. *Stratigraphic column for Site 285.*

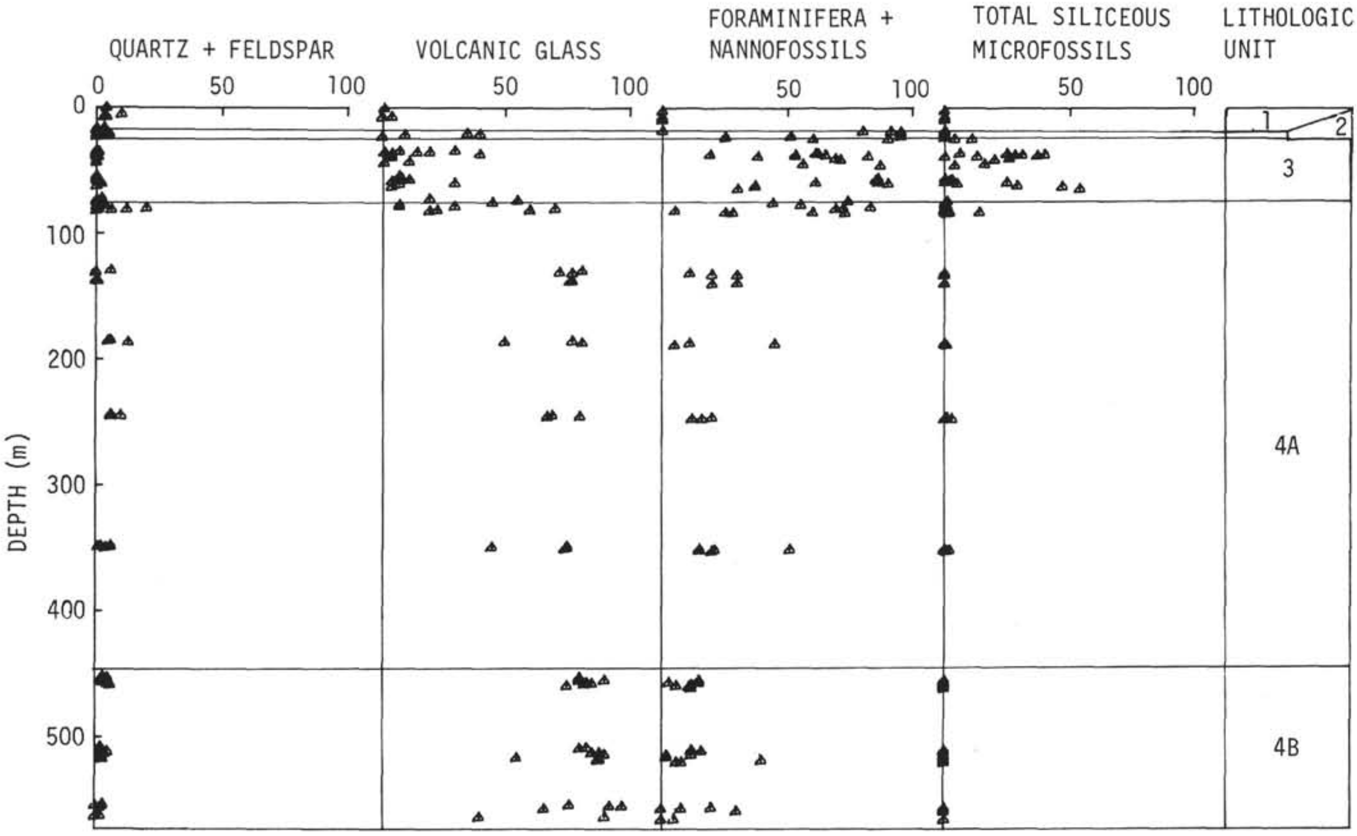

Figure 5. *Sediment compositions as determined by smear slides.*

The sedimentary cycles of Subunit 4B have an erosional boundary and start with a sandy interval (Interval a), followed by a silty interval, which is bioturbated at the top (Intervals b and c). This suggests that spasmodic current activity destroyed the infauna, followed by a quieter period during which sedimentation rates decreased; fine-grained sediments only were deposited, and the infaunal activity was restored. Cyclic sedimentation is less clearly displayed in Subunit 4A, but this may in part be due to a lesser degree of sediment consolidation.

The sediments of Unit 3 are biogenic. The production of siliceous fossils was high, with a short period of reduced production during the deposition of part of Core 4. Volcanic activity contributed subordinate amounts of sediments only. The absence of current structures is not significant as structures could easily have been destroyed by drilling. However, reworking is indicated by the presence of older microfossils (upper Oligocene to middle Miocene) and wood fragments.

Unit 2 consists of almost pure nanno ooze.

Units 2 and 3 have been deposited above the carbonate compensation depth. The depth of deposition for Subunits 4A and 4B is not certain, due to the reworked character of the sediments. However, deposition above carbonate compensation depth seems probable because of the lack of indications of carbonate solution. Derivation from a shallow-water environment is suggested by the faunal and floral data (see Biostratigraphic Summary).

Unit 1 consists of sediments, normally called "red abyssal clay." They are virtually unfossiliferous and are thus considered to have accumulated well below the carbonate compensation depth.

A comparison of Sites 205 and 285 is given in Packham and Terrill (this volume).

GEOCHEMICAL MEASUREMENTS

The results of *p*H, alkalinity, and salinity measurements taken on cores obtained at Holes 285 and 285A are presented in Figure 6 and Table 2. A progressive increase of *p*H and salinity is indicated with depth below the sea floor. In contrast, alkalinity generally decreases with depth. A *p*H of 8.0 or greater is found in the ash sequence of Unit 4 and is accompanied by low alkalinities. The alkalinity curve particularly shows the contrast of nanno ooze with the lower part of the sequence that contains abundant volcanic glass. The increase of salinity and *p*H with depth probably reflects the progressive increase in diagenetic change in the glassy fraction of the sediment.

PHYSICAL PROPERTIES

Methods and procedures for the measurement and determination of physical properties onboard D/V *Glomar Challenger* have been previously discussed and summarized by others (Gealy, 1971; Pimm, et al., 1971). Improvement in equipment and technique (notably the use of the Hamilton frame for velocity measurements

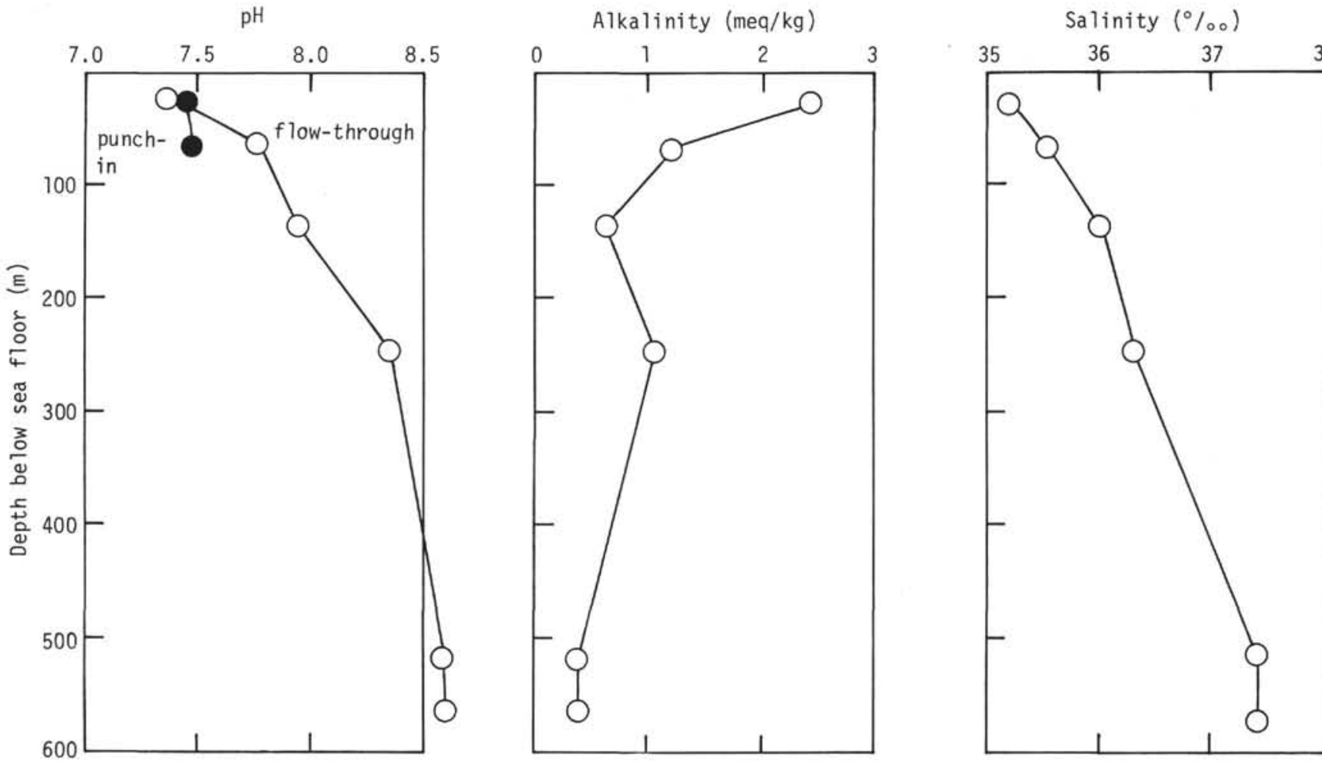

Figure 6. *Graphic summary of geochemical measurements taken at Site 285.*

TABLE 2
Summary of Shipboard Geochemical Measurements, Site 285

Sample (Interval in cm)	Depth Below Sea Floor (m)	Lab Temp (°C)	*p*H Punch-in/ Flow-through	Alkalinity (meq/kg)	Salinity (°/oo)
Surface seawater			8.30/8.26	2.35	36.3
2-4, 144-150	22.94 - 23.00	22.5	7.44/7.38	2.44	35.2
4-5, 144-150	62.44 - 62.50	21.8	7.48/7.77	1.20	35.8
1A-3, 144-150	134.44-134.50	21.9	– /7.94	0.63	36.0
3A-1, 145-150	245.45-245.50	21.7	– /8.36	1.08	36.3
6A-5, 144-150	516.94-517.00	21.6	– /8.58	0.39	37.4
7A-4, 142-150	560.92-561.00	21.0	– /8.60	0.39	37.4

and improvement in porosity determinations) have considerably increased the precision of various measurements (Boyce, unpublished; von Huene et al., 1973). Several procedural changes were instituted on Leg 30 in order to further increase the precision of physical property measurements, and establish more meaningful correlation with lithologic parameters.

Cubes of sediment and syringe samples or chips were extracted from the same or proximal horizons within each core section. Using the Hamilton frame method, sonic velocities of the sediment cubes were measured in both longitudinal and transverse directions relative to the core (parallel to the length, and across the diameter of the liner). Basalt velocities were measured in two orthogonal directions on samples "in the round" across the unsplit core diameter. Syringe samples were taken from unlithified sediments for determination of water content, porosity, and wet-bulk density. Samples which showed obvious voids, coring disturbances, or any other indications of error in volumetric measurement were excluded. Similarly, chips were taken from semilithified sediments for determinations of these same physical properties.

In Figure 7, acoustic impedance, sonic velocity, wet-bulk density (including syringe and chip determinations), porosity, and grain density are plotted versus depth and drilling rates. Considering the small number of cores obtained, the results are thought to be fairly representative of the sedimentary column drilled. Bulk density ranges between about 1.7 and 2.0 g/cc, and porosities range between 45% and 85%. In general, bulk density increases and porosity decreases with depth. Grain density ranges around 2.7 g/cc at the top of the column (with much scatter) and decreases to 2.6 to 2.5 in the lower part of the column (Hole 285A). Scatter in these data based on syringe measurements from Hole 285 (near the top of the column), although attributed to undetected errors in volumetric determinations, may be the manifestation of unavoidable coring disturbances or perhaps of actual bottom slumping and resultant sedimentary deformation. Both lithologic and paleontologic reworking is reported from these cores (i.e., Cores 285-3 through 285-5). Moreover, a slight discordance below the base of this cored interval (below 84 m) is observed in the reflection profile taken across the site at approximately 0.14 sec of reflection time or the equivalent depth of 104 meters.

No singularly large contrasts in the values calculated for acoustic impedance are observed in Figure 7. This seems largely due to the effect of the large sampling interval, rather than the absence of any sharp contrast in acoustic impedance. No significance, therefore, can be attached to the apparent gradual increase of acoustic impedance with depth.

Sonic velocities range between 1.5 km/sec (slightly less than seawater) up to 2.3 km/sec. A thick low velocity channel similar to that reported by Tracey et al. (1971) is seen in the plotted sonic velocities (Figure 7). The most striking aspect of this plot, however, is the pronounced sedimentary anisotropy characterizing the lower part of the column. Horizontal (transverse) velocities are significantly higher than vertical (longitudinal) velocities, differing by over 0.2 km/sec near the base of the column. The curves below 450 meters, although diverging slightly, are essentially congruent. The strong parallelism of these two velocity curves near the bottom of the hole, together with agreement in excursions of the porosity and density curves attest to both the validity of the measurements and the reality of the anisotropy. Similar results were also previously found by G. Sutton as reported by Tracey et al. (1971).

The vertical velocities of basalt cored from a sill at the bottom of the hole are plotted in Figure 8. Velocity generally increases with depth in the sill, ranging from about 4.9 km/sec to 5.8 km/sec, correlating with the changes in lithology reported earlier. Velocity initially decreases slightly below the chilled zone (0.0-0.7 m below sill-sediment contact) reaching a minimum (4.91 km/sec) within the amygdaloidal zone (0.7-2.1 m). Thereafter, the velocity increases with a few sharp reversals reaching a maximum well within the diabase zone (2.1-19.2 m) over 14.7 meters into the sill. Horizontal anisotropy was also thought to be detected in the basalt. Measurements in one sample were made approximately every 45° across the core through 360° (Figure 9). Values obtained along reciprocal directions were in close agreement with one exception at 135° and 315°. Measurements repeated at these azimuths resolved the discrepancy and the anisotropy was accepted as real.

CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

Correlation of physical properties and lithology with the reflection profiles is somewhat tenuous due to the few cores obtained; however some correlation is possible. The reflection profile across the location and beacon drop of Site 285 is shown in Figure 2. The profile at beacon drop shows a slight shift in depths due to the lower ship speed. A tracing of the firstcrossing profile is shown in Figure 10. See also the annotated sonobuoy profile (Figure 3).

At the site, strong reflectors are visible in the profile at about 0.03, 0.18, and 0.60 sec of reflection time. Moderate reflectors are seen at 0.06, 0.14, 0.22, 0.31, 0.36, and 0.65 sec. Weak reflectors are seen at 0.1 and 0.69 sec with a few interspersed weaker reflectors. The strong reflector at 0.03 sec correlates with a small positive velocity excursion at the top of Unit 3. The strong reflector at 0.18 sec, although not sampled, appears to be located immediately below Core 285A-1 near the top of Unit 4. The reflector at 0.6 sec lies within Core 285A-6 and correlates again with small velocity and density excursions. Intrusive basaltic diabase encountered at the bottom of the hole appears to correlate with the moderate intensity reflector seen at 0.65 sec. The deeper and weaker reflector at 0.69 sec, if real, may represent the base of the sill, suggesting a thickness in excess of 120 meters; or alternately, perhaps, the top of original basaltic basement.

PALEONTOLOGY

Summary

From the two complementary holes at this site, sediments containing microfossils of early Pliocene to early middle Miocene were recovered in the total of 12 sedimentary cores.

The first core taken from 0 to 7.6 meters depth consists entirely of dusky red clay and is almost totally devoid of both siliceous and calcareous planktonic microfossils. The age of the uppermost part of the sedimentary sequence at this site is thus indeterminable.

Cores 2 to 5 of Hole 285 and Cores 1 to 7 of Hole 285A are all dominated by calcareous nannofossils with subordinate amounts of radiolarians and foraminifera occurring in parts of the recovered sequence. Consequently, the calcareous nannofossils provided most of the paleontological ages determined for this site. Well-preserved radiolarian faunas are present in Cores 2 to 4 of Hole 285 and poorly preserved radiolarian faunas showing distinct signs of dissolution also occur in Cores 4 and 7 of Hole 285A. Foraminifera are sporadically encountered, providing only two dates supplementary to those already established on the basis of calcareous nannofossils.

The stratigraphic distribution of calcareous nannofossil floras indicates that the upper two sections of Core 285-2 are assigned to the lower Pliocene and the lower four to the uppermost part of the upper Miocene. The Pliocene/Miocene boundary is placed between Samples 285-2-2, 76-77 cm and 285-2-3, 33-34 cm. Although zonal assignments are tentative, Core 285-2-2 has a flora correlative with the lower Pliocene, *Ceratolithus acutus* Subzone and Core 285-2-3 contains an assemblage of the upper Miocene, *Ceratolithus primus* Zone. Species indicative of the uppermost

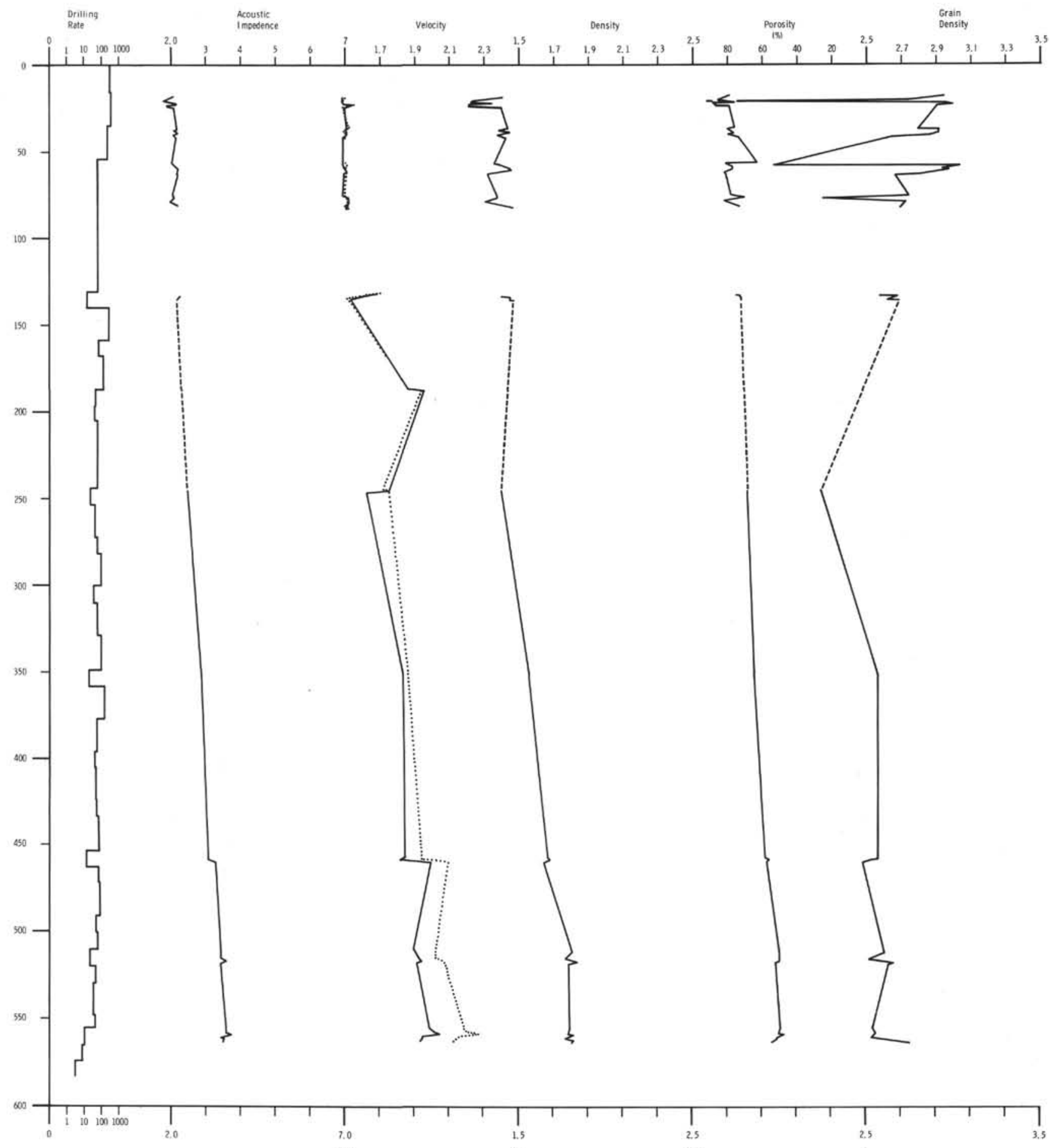

Figure 7. *Graphic summary of shipboard physical property measurements. Horizontal acoustic velocity is shown as a dotted line; vertical velocity as a solid line.*

calcareous nannofossil subzone of *Triquetrorhabdulus viefosus* were not observed in this interval and may suggest a brief stratigraphic hiatus across the Pliocene/Miocene boundary. The minimum possible age based on Radiolaria in Sample 285-2-5, 126-128 cm (no younger than *Stichocorys peregrina* Zone) supports this determination.

Cores 3 to 5 of Hole 285 and Core 1 of Hole 285A are assigned to the upper Miocene. This correlation is supported by the radiolarians in Cores 285-3 to 285-4, which indicate the upper Miocene, *Ommatartus antepenultimus* Zone, and by the foraminifera in Samples 285-2, CC and 285-3-1, 96-98 cm, which contain species indicative of the upper Miocene, Kapitean

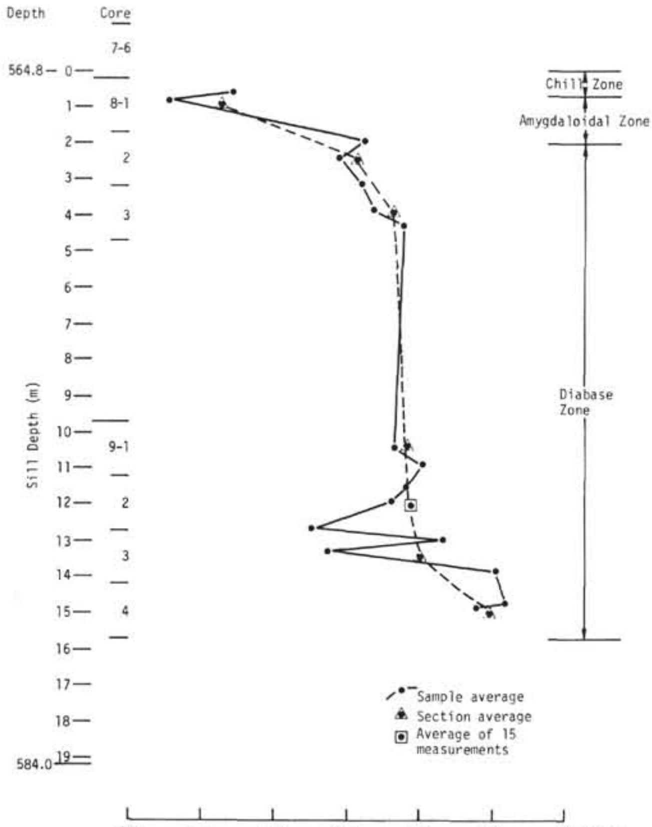

Figure 8. *Diabase acoustic velocities, Site 285.*

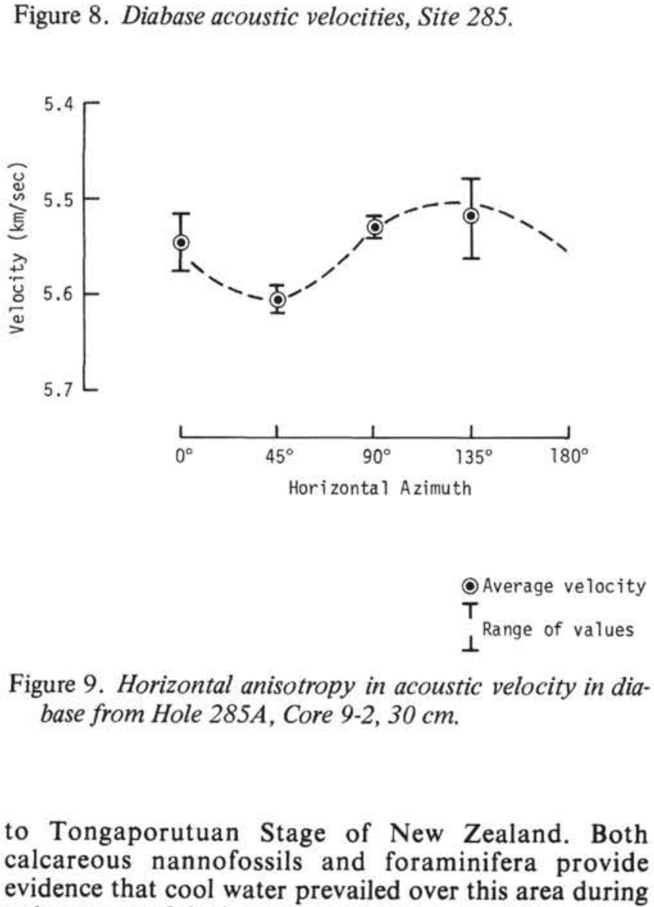

Figure 9. *Horizontal anisotropy in acoustic velocity in diabase from Hole 285A, Core 9-2, 30 cm.*

to Tongaporutuan Stage of New Zealand. Both calcareous nannofossils and foraminifera provide evidence that cool water prevailed over this area during at least part of the late Miocene as represented by Cores 285-3 to 285-5. The absence of many index microfossil species of the zones widely used today for worldwide stratigraphic correlation may be also due to prevailing cool water in the Site 285 area. Type areas of these zones tend to be areas of warm-water fauna. Samples 285-2-3, 33-34 cm to 3-1, 36-37 cm contain calcareous nannofossils assignable to the *C. primus* Subzone of late Miocene. The section from Sample 285-3-2, 51-52 cm down to the base of Core 285-4 is correlated with the late Miocene *Discoaster neohamatus* Zone. The apparent absence of the zonal index species of the *P. berggrenii*, the lower subzone of the *Discoaster quinqueramus* Zone, suggests a short, but distinct stratigraphic break occurring in Core 285-3. Reworked older microfossils—middle Miocene nannofossils, upper Oligocene and middle Miocene foraminifera, and upper Oligocene-lower Miocene Radiolaria—also occur in this interval, hindering the precise determination of ranges of many microfossil taxa.

Cores 1 to 7 of Hole 285A are considered to range from the middle middle Miocene to early middle Miocene largely on the evidence of calcareous nannofossils. Paucity of foraminifera and poor preservation of Radiolaria in this interval allow little refinement of the paleontological ages. Core 285A-3 is of middle middle Miocene (*D. kugleri* Zone—NN 7) age and Core 285A-4 is dated as early middle Miocene (*S. heteromorphus* Zone—NN 5) age. Thus, the boundary between the middle middle Miocene and early middle Miocene lies in the uncored interval of 95 meters. The overlapping range of *Cyclococcolithina leptopora* and *Cyclicargolithus floridanus* which characterizes the *Sphenolithus heteromorphus* Zone (lowest middle Miocene) is observed in Sample 285A-4, CC and the zonal marker *S. heteromorphus* itself is present in Cores 5, 6, and 7 of Hole 285A. The oldest sediments immediately above the diabase are also assigned to the *Sphenolithus heteromorphus* Zone which, according to the Cenozoic time scale of Berggren (1972), dates from 15 to 16.5 m.y.B.P.

As was also observed in the middle to upper Miocene sequence at Site 205, shallow-water benthonic foraminifera are conspicuous in the 285 area. The widespread occurrence of shallow-water faunas mixed with deep-water benthonic foraminifera in sediments in the basin indicates that a significant portion of the sediment now lying below the water depth of 4670 meters was transported from littoral depths during middle and late Miocene times. Additional evidence to support sediment transport from shallow depths is found in the calcareous nannofossil floras of Hole 285A. Firstly there is a large amount of fragmented nannoplankton debris, suggesting transportation in highly turbulent water. Secondly, the presence at this site of such solution-prone species as *Pontosphaera multipora*, which are generally not preserved in water below shelf depth, indicates their transport in sediment derived from a site at shallow depth and subsequent rapid burial on arrival at the deep-sea floor. This sediment transport and rapid burial is compatible with the great thickness of the middle and upper Miocene sequence, unusual in a basin of such great water depth.

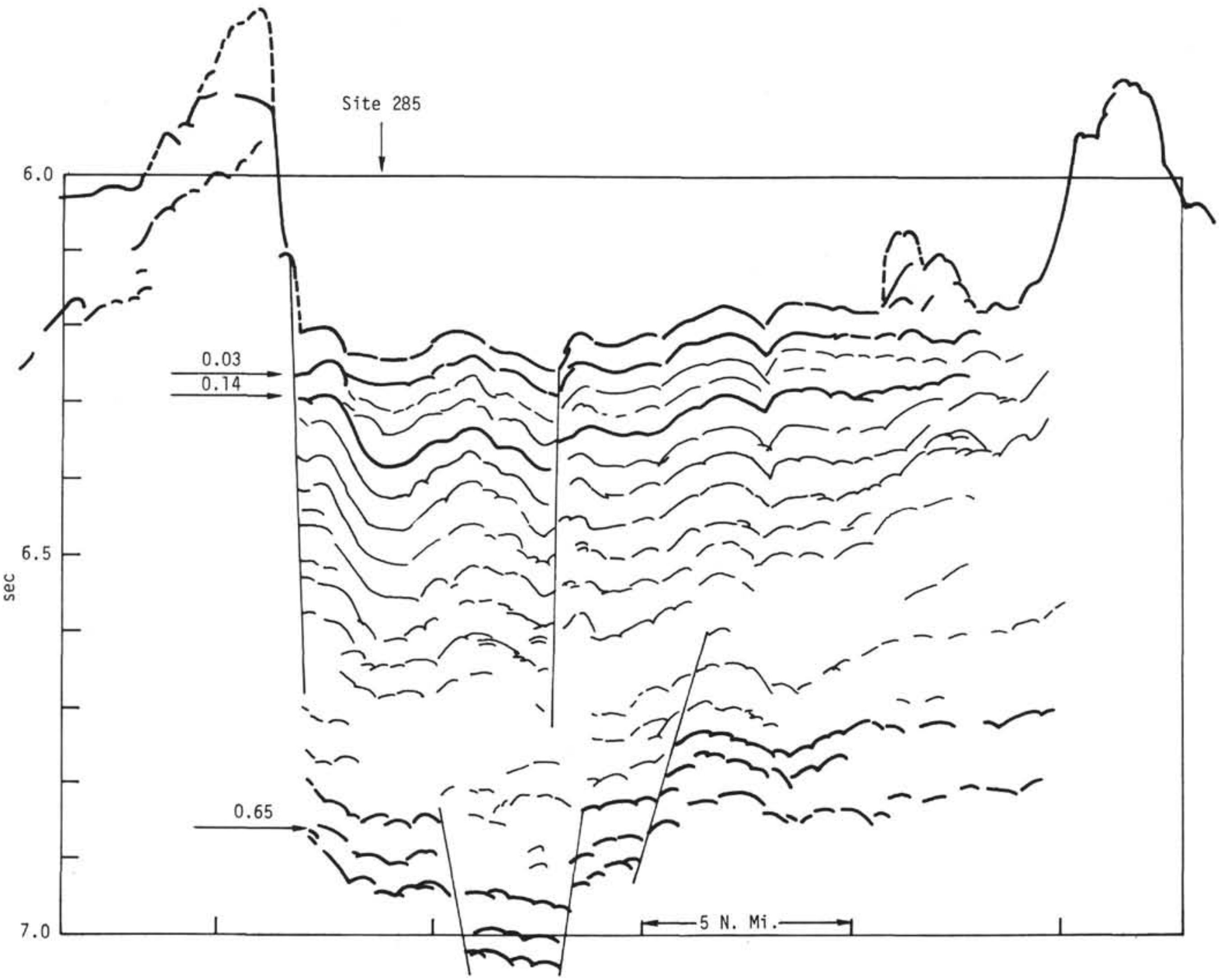

Figure 10. *Tracing of seismic profile taken by* Glomar Challenger *on first crossing of Site 285.*

Foraminifera

Foraminifera are largely absent or only sporadically encountered in sediments cored at this site. Even when foraminifera are present, their abundance is so low that most of the species identified in each sample are represented only by a few specimens. Samples of siltstone and sandy siltstone, consisting mainly of volcanic glasses, from Hole 285A are semiindurated so that the kerosene method of rock maceration was necessary to separate foraminifera.

At this site, three layers bearing a rich fauna occur: Core 285-3-1 at 96 to 98 cm depth; Core 285A-1-1 at around 100 cm and 128 cm depths. At these intervals, frequencies of both planktonic and benthonic foraminifera are high with moderately good preservation of specimens.

Foraminifera are practically absent in Core 285-1 due to dissolution of carbonate. A few specimens of arenaceous foraminifera, possibly of the genus *Dorothia* and *Trochammina*, were found in smear slides.

In Sample 285-2-1, 120-122 cm an assemblage containing a mixed fauna of two distinctly different ages is recognized. Except *Globigerinoides obliquus*, which shows strong signs of corrosion, other species in the assemblage are all less than 100 μm in size and possibly suggest their sorting by bottom currents. The younger fauna of the assemblage is characterized by *G. obliquus* and *Globigerina multiloba*, which are known to become extinct before the Quaternary, and also includes others which have longer ranges up to Recent. The older, definitely reworked fauna comprises both late Oligocene and early to middle Miocene species.

The shallowest level which was able to be dated by foraminifera at this site is in Sample 285-2, CC. The presence of distinctly keeled *Globorotalia conoidea* and *Globigerina nepenthes* indicate a correlation of this level with the upper Miocene, Kapitean to Tongaporutuan Stage of New Zealand. A similar upper Miocene fauna containing New Zealand-type species also occurs in Sample 285-3-1, 96-98 cm. The occurrence of sinistrally coiled *Globigerina pachyderma* in this sample signifies that the area was under the influence of a cool current at least during a part of the late Miocene.

No age-diagnostic foraminfera are observed throughout Cores 285-4 and 5.

A poorly sorted ash layer at about 120-130 cm depth in Core 285A-1-1 is the second level which was able to be dated by foraminifera. The fauna characterized by *Globorotalia conoidea, G. lenguaensis, G. merotumida, G. miotumida, Globigerina nepenthes, Globigerinoides ruber,* and *Globoquadrina dehiscens* indicates a correlation with the Zone N16 (early late Miocene) of Blow (1969) or the *Globorotalia miotumida miotumida* Zone of New Zealand established by Jenkins (1967) for the Tongaporutuan Stage (late Miocene). Neither younger nor older reworked planktonic foraminifera are observed in this late Miocene assemblage. A diversified benthonic foraminiferal fauna is also found at this depth. One important aspect of the benthonic fauna is the presence of *Amphistegina lessonii* and *Elphidium* spp., species whose habitats are known to be restricted to the littoral or sunlit zone of oceans. However, the fauna also includes upper bathyal depth taxa (*Uvigerina* sp., *Cassidulina* spp.) as well as bathyal forms (*Dentalina* sp., *Nodosaria* sp.). The admixture of species characterizing various depth ranges suggests sediment transport from continental shelf depths via slope to basinal depths. A highly battered appearance of *Amphistegina* also indicates transportation over a large distance. The shallow-water foraminifera *Amphistegina* is found in varying frequencies in Samples 285A-1-6, 136-140 cm and 285A-1, CC. At Site 205, Burns, Andrews, et al., (1973) also noted the occurrence of *Amphistegina* in sediments from Sample 205-8, CC to 205-22, CC (early middle to early late Miocene). The widespread occurrence of the reworked shallow-water foraminifera in the sediments now underlying the Fiji Basin suggests that a significant portion of the sediments found its way into the basin from littoral to continental shelf depths.

The occurrence of *Globocassidulina tumida* (Heron-Allen and Earland) in Sample 285A-1-1, 127-128 cm is noteworthy since this species is today distributed only in the vicinity of the Three Kings Islands, New Zealand (Eade, 1967). If the distribution of this taxon is proven to be restricted similarly in late Miocene time, it would provide additional evidence with regard to the source of pyroclastic sediments underlying the Fiji Basin.

Single specimens each of *Globorotalia peripheroronda* and *Cassigerinella alpha* in Sample 285A-1, CC date this level to be Zone N9 (early middle Miocene age or older), but more precise correlation cannot be achieved due to the lack of other diagnostic species. Cores 285A-6 and 285A-7 are practically barren of foraminifera, though poorly preserved juvenile forms (less than 100 μm in diameter) are occasionally seen.

Calcareous Nannofossils

At Site 285, five cores were recovered from Hole 285 in semicontinuous coring and seven sedimentary cores from Hole 285A in a spot-coring program. Core 285-1 consists of dusky red zeolitic clays and lacks calcareous nannoplankton remains. Its age is indeterminable, and its deposition is inferred as below the nanno solution depth. However, on account of the nannofossil content of the underlying core, a Recent to early Pliocene age is assumed for Core 285-1.

Core 285-2 contains abundant, diversified, and moderately well preserved nannofossil assemblages. Besides considerable amounts of reworked lower Neogene elements, the core also contains taxa indicative of early Pliocene and late Miocene ages.

The segment including the top two sections of Core 285-2 contains substantial numbers of *Ceratolithus rugosus*, and hence a maximum age of early Pliocene is given despite the presence of upper Miocene taxa such as *Discoaster quinqueramus* and *Triquetrorhabdulus rugosus*. Samples 285-2-3, 77-78 cm to 285-3-1, 36-37 cm are assigned to the upper Miocene *Discoaster quinqueramus* Zone on account of the concurrent occurrence of *Ceratolithus primus* and *D. quinqueramus*; *Ceratolithus acutus* and *C. rugosus* are present in the top part of Core 285-2, Sections 1, 2, but absent from lower levels. A substantial change in the autochthonous nannofossil elements of Samples 285-3-1, 36-37 cm and 285-3-2, 51-52 cm is noted, associated with a sudden appearance of *Discoaster berggrenii, D. quinqueramus,* and *Ceratolithus primus* in the former.

The segment of Samples 285-3-2, 51-52 cm to 285-4, CC is assigned to the upper Miocene *Discoaster neohamatus* Zone notwithstanding the occurrence of middle Miocene taxa such as *D. hamatus.* The absence of the *Discoaster berggrenii* Zone between the *D. quinqueramus* and *D. neohamatus* zones indicates a hiatus.

Core 285-5 belongs to the middle Miocene *Discoaster hamatus* Zone. Moreover, the occurrence of *Catinaster calyculus* throughout the core designates its positioning high in the *D. hamatus* Z one, the *Catinaster calyculus* Subzone.

The sediment represented by Cores 285A-1 to 285A-5-5, 9-10 cm is assigned to the middle Miocene *Discoaster exilis* Zone and 285A-5, CC to 285A-7-6 are assigned to the basal middle Miocene *Sphenolithus heteromorphus* Zone. These assignments are based essentially on the restricted occurrence of the cosmopolitan *Sphenolithus heteromorphus* to the lower samples. In addition, the upper samples contain solution-resistant long-rayed discoasters characteristic of the middle middle Miocene, as well as *Sphenolithus abies* and rare occurrences of *Triquetrorhabdulus rugosus.*

Generally, the low diversity and poor preservation of the indigenous nannofossils suggest deposition near the nanno solution depth. However, the *D. exilis* Zone attains a great thickness (ca. 328 m compared with ca. 81 m on the Ontong-Java Plateau, Site 289). This is attributed to the influx of volcanic material during the accumulation. The addition of volcanic ash contributed also to the scarcity of the nannofossils; nannofossils are sparse in ordinary light microscopic preparations. However, common to rare inshore nannofossil elements, poorly preserved (mechanical fragmentation rather than dissolution), consistently occur throughout most of the section. This essentially suggests transportation from shallow to great depths followed by rapid burial.

In conclusion, the fossiliferous parts of the Hole 285 sequence range in age from late middle Miocene (the *Catinaster calyculus* Subzone) to early Pliocene. A hiatus within the upper Miocene is detected, The sedimentary segment in Hole 285A represents a thick section of early middle to middle middle Miocene in age; sediments immediately above the intrusive diabase belong to the basal middle Miocene *Sphenolithus heteromorphus* Zone. In Hole 285A, the poor state of preservation and the reduced diversity of the indigenous nannofossil elements indicate selective dissolution through the water column and their final accumulation near the nanno solution depth. The occurrence of large amounts of nannofossil debris in a thick pile of nanno-bearing ash indicates transportation of inshore nannoplankton remains in turbulent water containing ash ensued by rapid burial.

Radiolaria

Radiolaria in biostratigraphically useful quantities are confined to a short segment of Sample 285-2-5, 126-128 cm through Sample 285-4, CC. The richest faunas are those of Cores 2 and 3 in Radiolaria-nanno oozes, brown, yellow, or green in color with variable volcanogenic content and largely lacking planktonic foraminifera.

The segment of Cores 285-1 through 285-2-4, 80-82 cm yielded only traces of orosphaerids and collosphaerids, or proved entirely barren. Traces only of Radiolaria, mainly collosphaerids and orosphaerids, were found from Core 285-5 to the base of Hole 285. In Hole 285A most processed samples proved barren or yielded only traces of spongodiscids, orosphaerids, and collosphaerids. A slightly richer fauna with *Saturnalis* sp., *Carpocanopsis* ? sp., *Stichocorys peregrina*, and *Lithopera bacca* was found in Sample 285A-2, CC, but specimens are so excessively rare that the possibility of downhole reworking or sieve contamination must be taken into account.

Zonal Allocation

Preservation of the faunas of Cores 285-2-5 through 285-4, CC is only moderate, *Cannartus* and *Ommatartus* species in particular being both scarce and poorly preserved except for the robust "*Cannartus pseudoprismaticus.*" *Acrobotrys tritubus* is present in Samples 285-2-5, 126-128 cm through 285-3-1, 120-122 cm and absent in 285-3-2, 80-82 cm through 285-4, CC, where only *Acrobotrys* sp. (two tubes) occurs. *Lithopera bacca* is common in all rich samples from the segment; *Solenosphaera omnitubus* is totally absent in all samples.

The rather monotonous sequence of assemblages in this probably slowly deposited segment, together with marked differences in degree of preservation of specimens within assemblages, suggest some upward reworking—confirmed by the nannofossils. The thickness 285-4, CC through 285-3-1 probably belongs to the *Ommatartus antepenultimus* Zone, OS.11-10. Thickness of Cores 285-3-1 through 285-2-5 appears to belong to the *O. antepenultimus* Zone, OS.9-8. The suggested upward limit depends, however, upon the absence of *S. omnitubus* which has not been proved to exist at relatively high latitudes and is probably not to be expected (W.R. Riedel, personal communication). The persistence of *A. tritubus* to Core 285-2-5 suggests the sample to be no younger than the *Stichocorys peregrina* Zone, OS.6, presuming the specimens are not reworked.

For tabulation of Radiolaria see Holdsworth (this volume).

In thickness, depth, lithology, and faunal content the Radiolaria-rich Hole 285 segment appears to compare very closely with that at the adjacent Site 205 (Burns, Andrews, et al., 1973, p. 66) which was allocated entirely to the *S. peregrina* Zone.

Sedimentation Rate

An age-depth plot is presented in Figure 11. The ages of the sediments have been derived using the nannofossil determinations of Shafik in this chapter and the subdivision of the zone of *D. exilis* into *D. kugleri* and *C. miopelagicus* by Bukry (this volume) and the time scale of Vincent (1974) and Saito (unpublished data). The age-depth curve has been divided into segments of approximately uniform gradient. The sedimentation rates based on the present depths are given in Table 3. In addition, these depths have been adjusted assuming an initial sediment porosity of 80% (the observed surface porosity at the site). Although the estimate is only an approximate one, the modified figures give a better comparative sedimentation rate than the observed depths.

The method of calculation of the original thickness compared with the observed thickness follows that described by Schlanger et al. (1973). The porosity data used are that from shipboard lab determinations using syringe samples and cubes of sediment where the sediment is sufficiently consolidated.

The curve shows a progressive upward decrease in rate of sedimentation of the column from an initial rate of around 1000 m/m.y. throughout Subunit 4B and the lower part of Subunit 4B at the bottom of the hole. The rate decreases rapidly above 135 meters as the volcanic content of the sediment decreases. It is about 40 m/m.y. between 61.5 and 135 meters. In Unit 3 (61.5 to 23.9 m) the rate drops to about 15 m/m.y. This unit consists of nanno ooze. The sedimentation rate is lowest in Unit 2 (nanno ooze) being only 1.8 m/m.y. Sedimentation was presumably discontinuous. Unit 1, "abyssal red clay" shows an average accumulation rate of 4 m/m.y.

The two principal factors influencing the sedimentation rates at this site are volcanic input and subsidence. The extremely high rates of sedimentation are associated with turbidite input from the Lau Tonga Ridge, an island arc source (see Packham and Terrill, and Klein, this volume). As volcanism waned the biogenic component became more important and the rate of sedimentation declined. With the progressive subsidence of the site, the biogenic accumulation rate also declined until the site subsided below the nanno solution depth in the lower Pliocene.

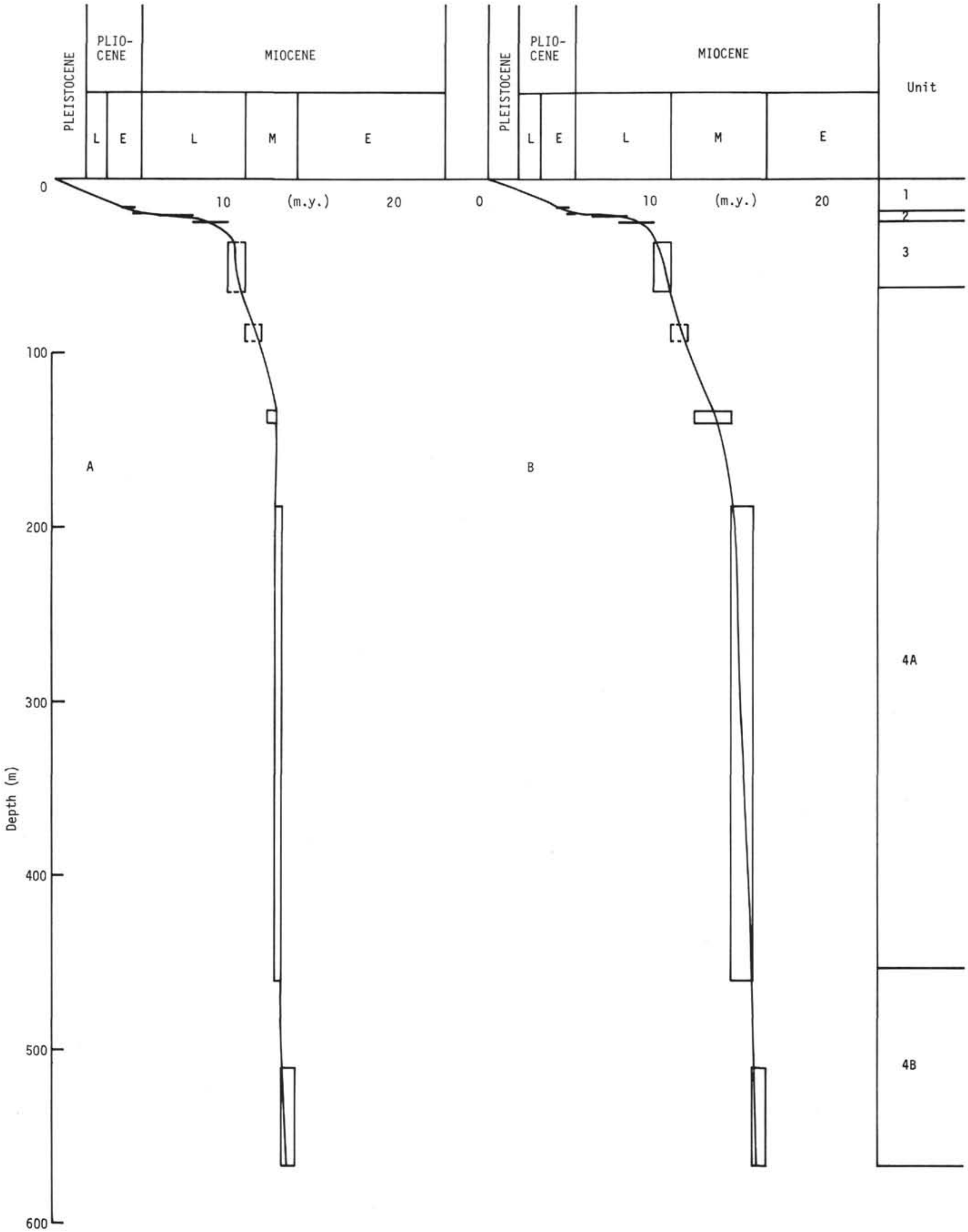

Figure 11. *Sediment accumulation rate curve for Site 285 based on nannofossils (a) using time scale of Vincent (1974), (b) using time scale of Saito (unpublished data).*

TABLE 3
Sedimentation Rates, Site 285

Unit	Depth (m)	Thickness (m)		Porosity (%)	Thickness Corrected to 80% Porosity		Age (m.y.)	Duration (m.y.)	Sedimentation Rate m/m.y. Observed Thickness	Sedimentation Rate m/m.y. Thickness Corrected to 80% Porosity
1	0 - 18	18		80	18		0 - 4.7	4.7	3.8	3.8
							4.7 - 7.9[a]	3.2	1.8	1.8
2	18-23.9	5.9		80	5.9		4.7 - 8.0	3.3	1.8	1.8
							7.9-10.4[a]	2.5	15	17
3	23.9-61.5	37.6		77	43		8.0-10.6	2.6	14	17
4A	61.5-110	48.5	73.5	75	61	94	10.4-13[a]	2.6	28	36
	110-135	25		74	33		10.6-12.7	2.1	35	45
	135-245	110		70	165		13.0-15.2[a]	2.2	145	250
	245-350	105	318	66	179	550	12.7-13.1	0.4	800	1400
	350-453	103		60	106					
4B	453-480	27	112	56	59	272	15.2-15.5[a]	0.3	370	900
	480-565	85		50	213		13.1-13.3	0.2	560	1400

[a]Using time scale of Saito (unpublished data).

SUMMARY AND CONCLUSIONS

Summary

The succession sampled at Site 285 is comprised of five lithologic units, the oldest of which is of early middle Miocene age. The units are, from top to bottom:

Unit 1 (0-18 m): Clay-rich zeolite micronodulite, and zeolite and micronodule-rich clay ("red abyssal clay"). Unfossiliferous.

Unit 2 (18-23.9 m): Nanno ooze. Lower Pliocene to upper Miocene.

Unit 3 (23.9-61.5 m): Nanno ooze with varying amounts of siliceous fossils.

Subunit 4A (61.5-453 m): Glass shard-bearing nanno ooze to nanno-bearing glass shard sandy silt (stone) or ash (tuff). Semilithified below 187 meters. In part reworked (clastic) sediments. Upper to lower middle Miocene.

Subunit 4B (453-564.8 m): Clastic cycles of sandy siltstone and siltstone. Main components are glass shards and nannofossils. Lower middle Miocene.

Unit 5 (564.8-584 m): Diabase sill. Age unknown.

The sequence was deposited above the carbonate compensation level during the time of deposition of Units 2 to 4 and passed below it when Unit 1 was being deposited. The sedimentation rate decreased upward throughout the section, being in the range of 1000 m/m.y in the lower third of Unit 4, and 4 m/m.y. in the abyssal clay section. The rate of about 15 m/m.y. of biogenic section represented by Unit 3 and the rate in the upper part of Unit 4 of 36 to 45 m/m.y. average to about 30 m/m.y. A short hiatus is present in the late Miocene so that Unit 2 has an average accumulation rate of about 2 m/m.y. Reworking of fossils was recognized at a number of levels, especially at the top of the biogenic sequence where foraminifera and radiolarian species dating back to late Oligocene have been found. Reworked middle Miocene nannofossils are found in the upper Miocene sequence down to Core 5 (84 m) (Unit 3 and the top of Subunit 4A). Shallow-water forams are found in the upper Miocene at Core 285A-1 (131 m) in Subunit 4A.

The diabase sill, which has intruded the deepest part of the section, has a narrow chilled margin, an amygdaloidal zone, and a coarser zone. The sill was penetrated for 19.2 meters.

Discussion

The east-west profile (Leg 21) across the South Fiji Basin, on which the site was selected, shows a smooth westerly sloping surface with sediment covering a basement of slight irregularity. The profile northwards, approaching the site from the direction of Great Barrier Island (New Zealand), shows that the sea floor is very irregular. The basement structure has a relief of 0.5-1.0 sec and a wavelength of about 65 km with a gradually thinning wedge of sediment extending north from New Zealand. A prominent east-west ridge 200 km south of Site 285 dams the sediment wedge extending from the south (see Packham and Terrill, this volume). The structural grain of the basin is approximately east-northeast rather than north-south. A north-south grain would have been expected had the basin been formed as the Tonga-Lau arc migrated eastwards.

The direction of the grain is significant in trying to determine the direction of provenance of the clastic sediment in Unit 4. The rhythmic sedimentation in Subunit 4B, with microcross-bedded sandy silts forming the bottoms of most of the cycles, is indicative of significant current activity. If the basement relief is pre-middle Miocene, then the currents depositing the beds are most likely to have been moving parallel to the grain of the basin and thus a generally easterly or westerly source for the sediments can be inferred.

The reflector pattern in the basins in the vicinity of the site indicates that the sediments were laid down as horizontal sheets progressively filling the basins, the draping of sediment over basement highs being insignificant. Although it is possible that the originial basement relief has been emphasized by faulting along the margins of the basement highs, the small amount of sediment on the highs, as seen on the seismic records, indicated that such movements have only modified the basement configuration to a minor extent and consequently have not altered the direction of the grain. The profile approaching the site shows an upper sequence of sediments 0.1 sec thick, the lower boundary of which appears to be an unconformity. This horizon can be traced along the record to Site 285 where it coincides approximately with the top of Unit 4. The sediment in the basin in which Site 285 is located has been disturbed by possible small piercement features and recent minor faulting.

The ascending sequence of strata at Site 285 parallels the succession in the upper part of the section at Site 205 in that a coarse ashy succession is followed by a biogenic section and then by abyssal clay (Figure 12). However, cyclic volcanogenic sediments observed at Site 285 do not occur at Site 205 where the lower part of the Miocene section consists of coarse ash. Above the coarse ash at Site 205, ash beds alternate with ashy oozes. The onset of abyssal clay deposition appears to have been contemporaneous at both sites, but volcanic ash deposition persisted longer at Site 205 (to present) compared with Site 285 (NN11 or earlier). At Site 205 the volcanic sequence rests unconformably on late Oligocene oozes. Although these were not intersected at Site 285, their presence on some of the ridges in the vicinity of Site 285 may be indicated by the presence of reworked late Oligocene foraminifera in Unit 2. The age of the oldest Miocene sediments at Site 205 (N7) is close to the age of the oldest sediments sampled at Site 285 (within 2 m.y.). It is likely therefore that if an Oligocene sequence is present beneath the Miocene at Site 285, the diabase sill probably intruded along its junction with the middle Miocene beds.

The source of the volcanic detritus at Site 285 cannot be specified on the basis of the available data. Miocene volcanism is known to be widespread in the region, occurring on the Lau Ridge, Fiji, Tonga and northern New Zealand (Coromandel Peninsula), and the New

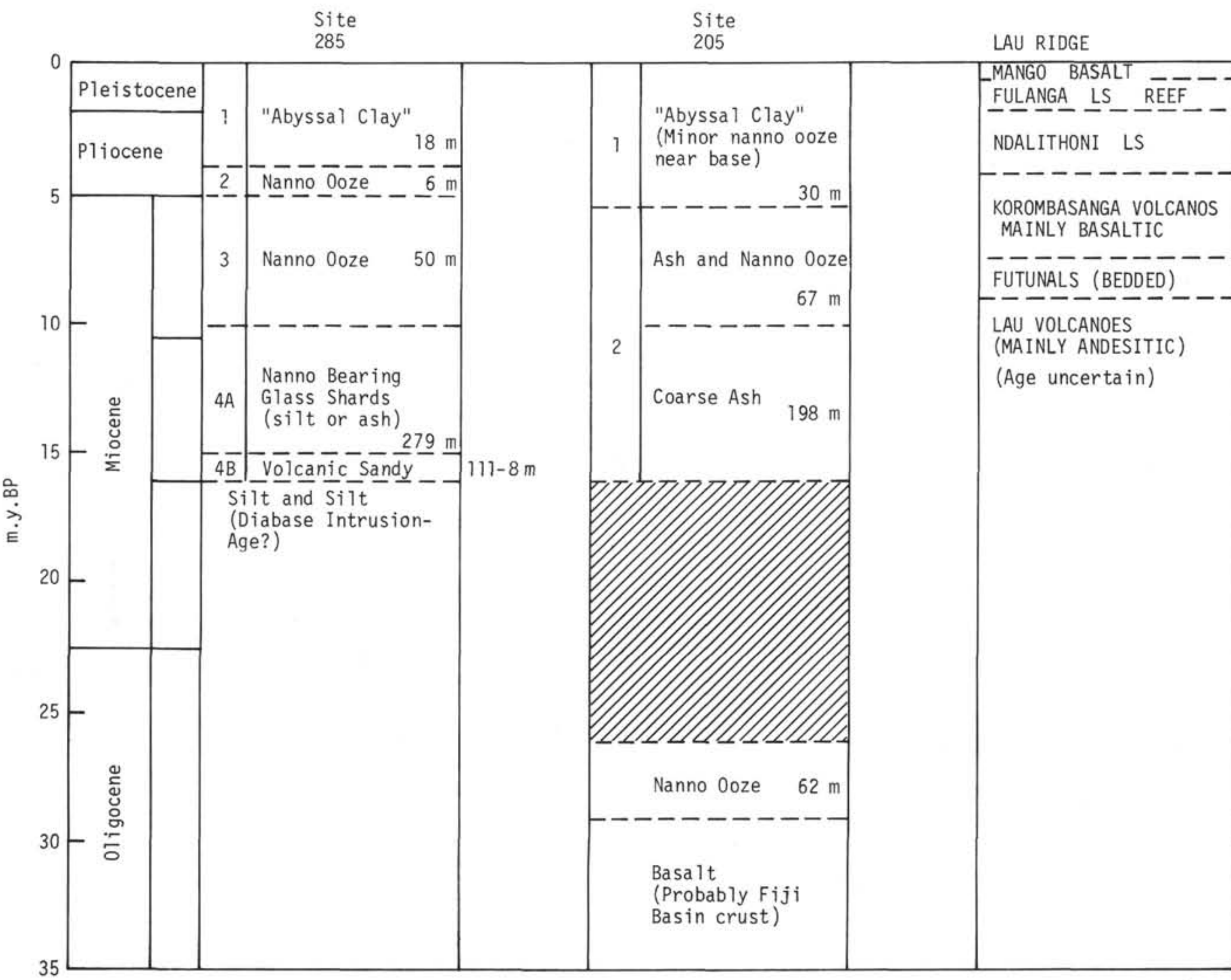

Figure 12. *Time-stratigraphic correlation of sequences at Sites 285, 205, and on Lau Ridge.*

Hebrides. The grain of the basin suggests a generally easterly or westerly source. The type of volcanism (intermediate to acidic) further suggests that the volcanism was associated with an island arc. In the absence of evidence for volcanism of this type on the Norfolk Ridge or the Three Kings Rise, it is suggested that the source of the volcanism was the Lau Ridge. An easterly source also conforms with the present slope of the sea floor. Displaced shallow-water foraminifera are more widespread in the sequence at Site 205 than that at Site 285. For instance, *Amphistegina* was found throughout the early middle to early late Miocene sediments at Site 205, whereas at Site 285 it was restricted to the late Miocene sediments. The shorter stratigraphic distribution of this shallow-water fauna supports a sediment source to the east of the area.

Conclusions

In summary, the history of the basin seems to be as follows:

1. Possible formation of the South Fiji Basin in the Oligocene with a ridge and basin structural grain trending in a roughly east-northeast direction developed prior to the middle Miocene.

2. Deposition of ashy biogenic sediments at a little above the nanno solution depth at Site 205 in the middle to late Oligocene.

3. No record of events in most of the early Miocene is preserved, and the only faunas of this age are derived. Ooze deposition may have continued or the basin may have been below the nannofossil solution depth.

4. Late early to late Miocene intermediate to acidic volcanism in the region, possibly preceded by some tectonic activity. Pyroclastics were deposited at Site 205 on late Oligocene oozes and transported ashes laid down at Site 285. The latter was located in the deeper part of the basin. The intensity of the volcanism decreased through the Miocene. Derived shallow-water fossils are occasionally incorporated in the sediments. Post mid-Miocene intrusion of the diabase sill occurred along the Oligocene/Miocene hiatus.

5. If the Lau Ridge is the source of the volcanism, as suggested by basin structure and the drilling at Sites 205 and 285, then it is important to note that activity on the Lau Ridge postdates formation of the South Fiji Basin.

6. In the latest Miocene, biogenic deposits laid down near the calcium carbonate compensation depth predominated at Site 285, while those at Site 205 still contained a significant ash component. The thick accumulation of clastic sediments may have been sufficient to raise the depositional surface above the nannofossil solution depth.

7. Tectonic activity at about the end of the Miocene exposed the Oligocene to early Miocene sequence within the basin and submarine erosion redeposited some of the sediment in the highest Miocene and early Pliocene sediments. These eroded sequences may have been draped over basement highs and not covered by the thick later volcanogenic sequence.

8. The ?latest Pliocene to Recent deposits were deposited in water below the carbonate compensation depth either as a result of basin subsidence (possibly due to decrease in heat flow) and/or rise in the carbonate compensation depth due to fall in bottom-water temperature.

9. Recent minor faulting with throws on the order of tens of meters has disturbed some local basins, e.g., the one in which Site 285 is located.

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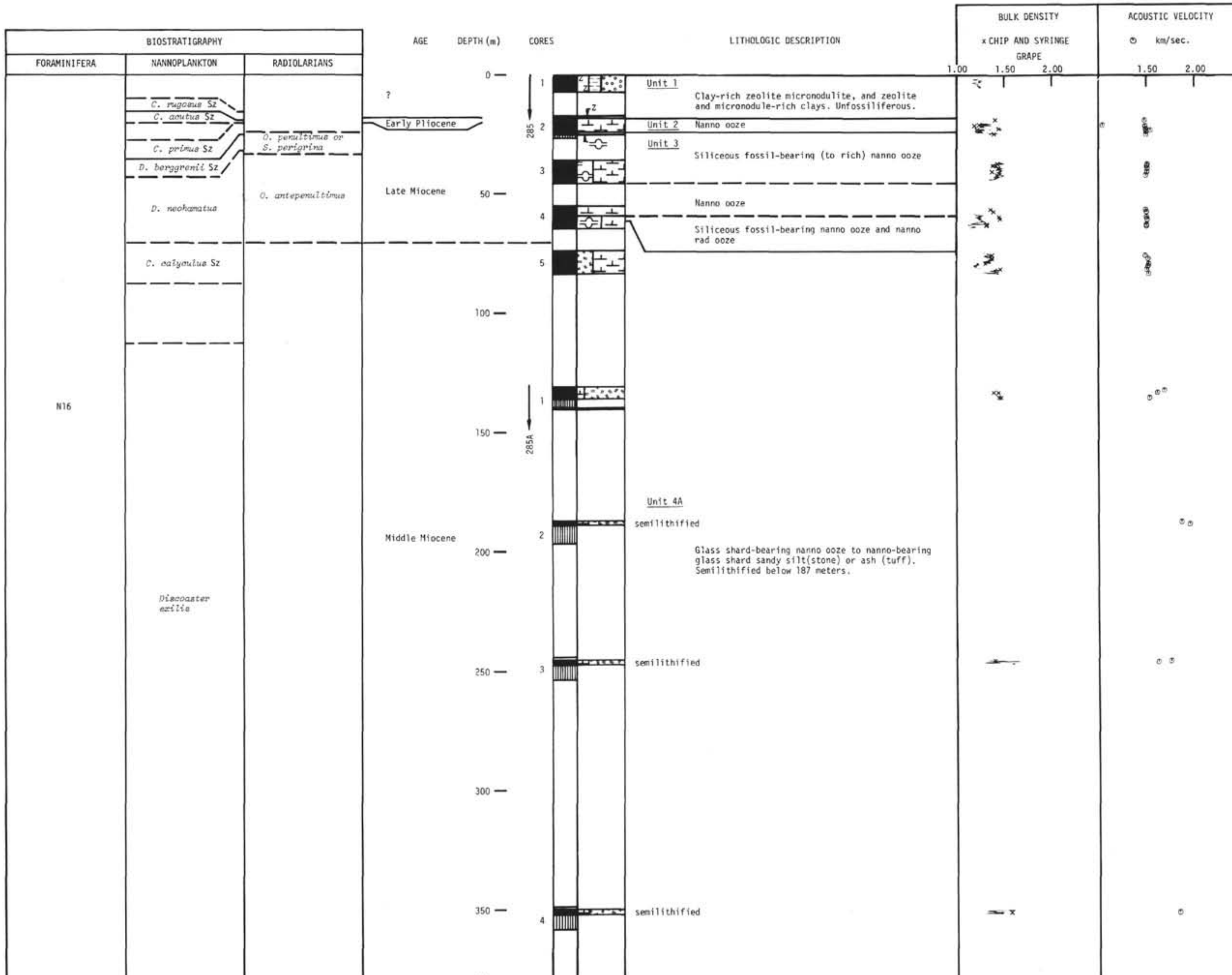


Figure 13. *Composite biostratigraphy, lithology, and physical properties, Site 285.*

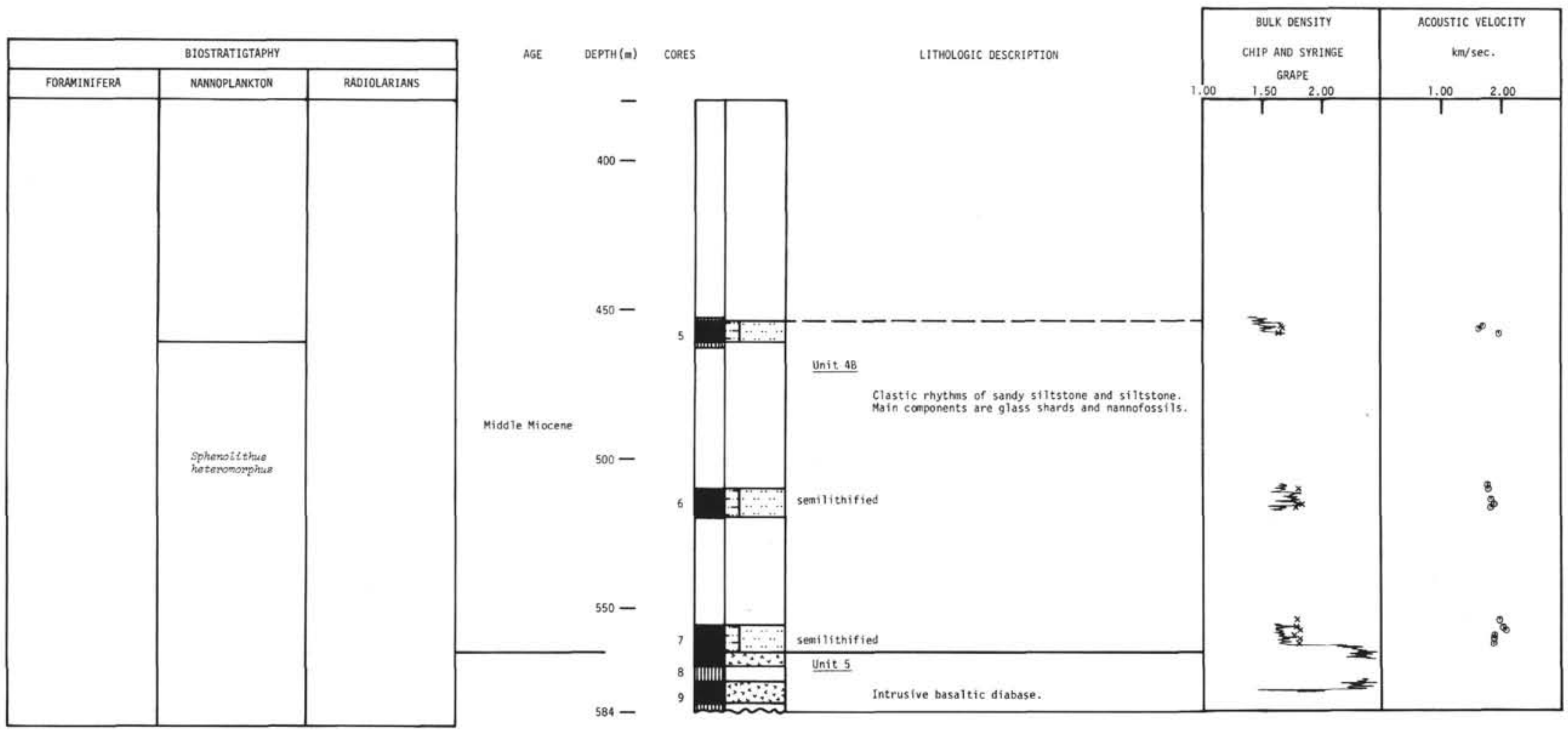


Figure 13. *(Continued).*

APPENDIX A
Smear-Slide Determination, Site 285 (values in percent)

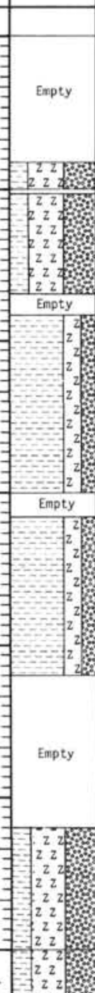
Sample (Interval in cm)	Depth (m)	Detrial Sand	Detrial Silt	Detrial Clay	Quartz	Feldspar	Clay minerals	Heavy minerals	Mica	Volc. glass	Pyrite	Micronodules	Zeolite	Micarb	Forams	Nannos	Radiolaria	Sponge spicules	Diatoms and Silicoflagellates	Plant debris	Lithologic Unit
1-2, 50	2.00		45	55	2	2	24	tr		2		40	30		tr						
1-5, 102	7.02		30	70	5	5	48	2				20	20			tr					
1-6, 140	8.90		45	55	2	1	20	1		1		45	30								1
1, CC	9.10		45	55	2	2	20	1		5		40	30		tr						
2-1, 75	17.75		45	55	2	1	35	2		tr		30	20								
2-1, 144	18.46	10	85	5								20			tr	80					
2-1, 146	18.46	1	95	4			2					5	2		1	90					
2-2, 60	19.10	tr	97	3								3	2			95					
2-2, 102	19.52		95	5								2	2			96					
2-4, 87	22.37	tr	97	3						tr		3	2		tr	95					2
2-4, 92	22.42	tr	90	10	1	1	2			35		10			1	50					
2-4, 95	22.45	65	30	5	5					40		30			5	20					
2-5, 30	23.30	20	20	60		5	40			10		20				25					
2-5, 140	26.40		95	5			1					3	2		tr	90	3	1	tr		
2, CC	26.60		80	20			15			1		8	5		tr	60	8	2	1		
3-0 (top)	36.00	10	80	10						30	1	1		1	1	60	5	tr	1		
3-1, 10	36.40	5	90	5						8		5				62	20	5			
3-1, 71	37.01	60	40					1		20		20			15	4	40				
3-1, 92	37.22	30	68	2	1					15		1	2		1	52	26		2		
3-1, 97	37.27	15	75	10			2			2			2		tr	65	26	2	3		3A
3-1, 140	37.70		85	15						5		5				53	25	2	10		
3-2, 60	38.40	55	45							40		20		2	3	35		tr	tr		
3-2, 70	38.50	8	85	7						5			tr		2	80	11	tr	2		
3-3, 92	40.22	10	80	10						5					3	66	10	5	11		
3-4, 19	40.99	5	90	5		1				5		3				71	10		10		
3-6, 80	44.60	5	85	10						12			1	5	1	55	16	tr	tr		
3-CC	45.40	5	90	5						2		5			2	85		2	2		
4-1, 105	56.05		95	5			5			8			1			86					
4-2, 80	56.30	5	90	5						8		2		1		85		3			3B
4-2, 120	57.70		95	5						9		2		1	1	85	1	1			
4-3, 69	58.69		95	5						12		2	tr		1	85		tr			
4-3, 116	59.16	5	90	5						12		2			1	60	10	5	10		
4-4, 50	60.00	1	95	4						5					tr	90	1	1	3		
4-5, 56	61.56	30	70		1					30	1			2	2	35	27		2		3C
4-5, 140	62.40	15	80	5		2			1	8		5				37	30	2	15		
4, CC	64.10	10	85	5						5		10				30	40	5	9	1	
5-0 (top)	74.00	5	90	5	1	1		1	1	20		1				74	tr	1			
5-1, 81	75.31	30	70		tr	tr				55	1				tr	44					
5-2, 76	76.76	25	75		tr					45					tr	55					
5-3, 140	78.90	2	93	5	1	2			1	8		3		1		83	tr	1			
5-4, 76	79.76	2	93	5	1	2		1	2	8		3		1		72	tr				
5-4, 110	78.10	20	80							30	tr	1	tr			69		tr			
5-5, 112	81.62	90	10		20	tr				70	5				tr	5					
5-6, 79	82.97	15	85		1	tr				23	2					60	12	1	1		
5-6, 107	83.07	40	60		4	8				60	2	1				25					
5-6, 139	83.39	30	60	10	2	4		1	1	60	1			1	4	24		2			
5, CC	83.60	5	90	5				2		20	2	2				73		1			
1A-1, 40	113.40	60	35	5	3	3		2		81					1	10					
1A-1, 138	132.38	2	78	20	tr	tr		1		72	2		5			20					4A
1A-2, 56	133.06	1	70	29		tr		tr		77	1		2		tr	30	tr	tr			
1A-6, 109	133.59	1	70	29		tr				77	1		2			30					
1A-CC	140.10	5	90	5	1			1	1	76				1	tr	20		tr			
2A-1, 19	187.19	70	30		3	3		1	1	77				4	1	10					
2A-1, 70	187.70		40	60	tr	5		tr		50						45					
2A, CC	188.60	5	95		5	8				81						5		1			
3A-2, 65	246.15	5	90	5	3	3		1	1	69	1			1		20		1			

APPENDIX A – *Continued*

Sample (Interval in cm)	Depth (m)	Detrital Sand	Silt	Clay	Quartz	Feldspar	Clay minerals	Heavy minerals	Mica	Volc. glass	Pyrite	Micronodules	Zeolite	Micarb	Forams	Nannos	Radiolaria	Sponge spicules	Diatoms and Silicoflagellates	Plant debris	Lithologic Unit
3A-2, 142	266.92	2	78	20	3	3		1		80	1			tr		12					
3A, CC	267.10	1	96	3	5	5		1	1	67	2				1	15		3			
4A-1, 130	349.80	5	75	20	3	3		1		75	2			1		15		tr			
4A-2, 26	350.26	2	95	3	1	1			1	45	1				1	50	tr				
4A-2, 56	350.56	30	65	5	tr	1				75				3		21					
4A-2, 90	350.90	5	85	10	3	3		1		75				1		15		2			
4A, CC	351.60		95	5	2	2			1	74	1			1		20		1			
5A-1, 146	456.46	10	80	10	tr	3				80	1			1		15					
5A-2, 80	455.30	30	60	10		5				80	tr			tr		15					
5A-3, 4-1	456.41	15	70	5		5			1	90				1		3					
5A-3, 75	456.75	20	70	10	tr	2				80	2			1		15					
5A-4, 70	458.20	5	85	10		3				83	2			tr		12					
5A-4, 133	458.83	15	80	5		5			1	85	2			1	1	5					
5A-5, 60	459.60	15	80	5		5		1	1	82					1	10					
5A, CC	460.60	5	85	10		6				75	2			5	tr	12					
6A-0 (top)	510.00		90	10		2				83	1			2		12					
6A-1, 20	510.67	2	90	8		2				80	1			1	1	15					
6A-3, 17	513.66	5	90	5	1	4				88	1			4	tr	2					4B
6A-4, 19.5	515.42	40	60			4		1		90	2			1		2					
6A-3, 20	513.67		95	5		2				85	1			tr		12					
6A-5, 140	517.87	5	90	5		2		1	1	55	1					40					
6A-6, 145	519.42		95	5		2				88	1			1	tr	8					
6A, CC	519.57	20	75	5		3		1	1	87	2				1	5					
7A-0 (top)	555.50	5	90	5		3			1	76						20					
7A-1, 35	556.35	15	85			3				97											
7A-1, 45	556.45	2	88	10		tr				92	tr			tr		8					
7A-2, 83	588.33	10	85	5	2					66				2		30					
7A-6, 117	564.67	10	85	5		2			1	90	2				tr	5					
7A-6, 128	564.78	10	30	60			60		1	40	tr					tr					

Site 285 Hole Core 1 Cored Interval: 0.0-7.5 m

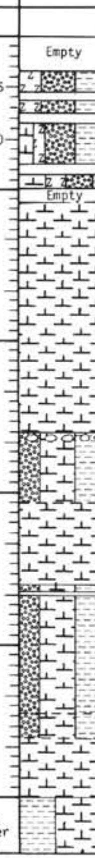
AGE	FORAMS / NANNOS / RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE		LITHOLOGIC DESCRIPTION
INDETERMINATE					0						
					1	0.5 1.0	Empty	3		2.5YR 3/2	X-ray 1-123 80% Amor 35% Plag 17% Mont 12% Augi 20% Cryst 9% Mica 2% Clin 15% Quar 2% Chlo 8% Phil Grain Size 1-126 (3.1, 41.5, 55.4) CLAY RICH ZEOLITE MICRONODULITE, dusky red; soft (slightly crumbly); no internal structures.
					2		Empty	3	*	2.5YR 3/2	SS 2-50 40% Nod 24% Cl 2% Q Tr% HM 30% Z 2% Gl 2% Fsp
					3			3	*	2.5YR 3/2	Grain Size 3-80 (0.0, 37.8, 62.2) QUARTZ AND FELDSPAR BEARING ZEOLITE AND MICRONODULE RICH CLAY, dusky red with irregular patches of dark yellowish orange (10YR 6/6) at 75, 100 to 107, and 133 to 137 cm; soft to stiff; no internal structures. SS 3-102 48% Cl 20% Z 5% Fsp Tr% N 20% Nod 5% Q 2% HM
					4		Empty	3 5		2.5YR 3/2	Similar; soupy to soft; faint patches of 10YR 6/6.
					5		Empty				CLAY RICH ZEOLITE MICRONODULITE, dusky red with patches of 10YR 6/6 at 50 cm; soupy to soft; no structures.
					6			3	*	2.5YR 3/2	SS 6-140 45% Nod 20% Cl 1% Fsp 1% Gl 30% Z 2% Q 1% HM GLASS SHARD BEARING CLAY RICH ZEOLITE MICRONODULITE, dusky red; soft.
		FB R N	T T —	e- p- —	Core Catcher				*	2.5YR 3/2	SS CC 50% Z 5% Gl 2% Fsp Tr% F 40% Nod 2% Q 1% HM



FB- Agglutinated benthonic forams
-Denotes absence

Site 285 Hole Core 2 Cored Interval: 17.0-26.5 m

AGE	FORAMS / NANNOS / RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	Ceratolithus rugosus subz				0		Empty				X-ray 1-51 62% Amor 15% Plag 48% Phil 38% Cryst 6% Mica 1% Amph 10% Quar 14% Mont 6% Augi
	?	N R N F	C T C R	g p g f	1	0.5 1.0		2 2 3/2 1	* *	2YR 3/2 change from 2YR 3/2 to 10YR 5/4	ZEOLITE RICH MICRONODULE CLAY, dusky red; soft; gradual change in color (to moderate yellowish brown) from 85 to 105 cm. SS 1-75 35% Cl 20% Z 2% HM Tr% Gl 30% Nod 2% Q 1% Fsp $CaCO_3$ 1-138 (75)
	Ceratolithus acuetus subz	N F N R	C T C	g p f	2		Empty	1/2	* *		MICRONODULE BEARING NANNO OOZE, moderate yellow brown (10YR 5/4), mixed irregularly with other colors (dusky red, 2YR 3/2; and grayish orange, 10YR 7/4). Some disturbed lamination. SS 2-60 95% N, 3% Nod, 1% Z, Tr% F SS 2-102 (grayish orange) 96% N, 2% Nod, 2% Z, Tr% F
	?	N	C	f	3			2			X-ray 3-52 59% Amor 3% Calc 14% Plag 6% Mont 41% Cryst 9% Quar 5% Mica 63% Phil
	Ceratolithus primus subz	R N	C	f						sharp color change to 2.5YR 3/2	$CaCO_3$ 3-86 (62) $CaCO_3$ 4-61 (75) MICRONODULE BEARING NANNO OOZE, yellowish brown to light yellowish brown; soft to stiff. Irregular color patches.
	?	R N	T C	p f	4			2/3	* * *	10YR 5/6 gradual change to 10YR 6/4 7.5YR 3/2 to 10YR 4/3 2.5YR 3/2	SS 4-87 95% N 2% Z Tr% F 3% Nod Tr% Gl QUARTZ AND FORAM BEARING NANNO RICH MICRONODULE GLASS SHARD ASH, very dark gray, thin disturbed (patchy) lamina. SS 4-95 40% Gl 20% N 5% F 30% Nod 5% Q
LATE MIOCENE	Discoaster berggrenii subz D. penultimus or S. perigrina	N R F N	C C T C	g g p g	5			2 3	* *	7.5YR 3/2 (dark brown) 10YR 5/4	X-ray 5-12 99% Amor 10% Quar 2% Chlo 21% Cryst 27% Plag 5% Mont 40% Calc 5% Mica 11% Augi FELDSPAR AND GLASS SHARD BEARING MICRONODULE AND NANNO RICH CLAY, dusky red; soft. No structures. SS 5-30 40% Cl 20% Nod 5% Fsp 25% N 10% Gl
		F R N	R C C	f g g	Core Catcher				*		$CaCO_3$ 5-131 (64) ZEOLITE, MICRONODULE, AND RAD BEARING CLAY RICH NANNO OOZE, moderate yellowish brown (10YR 5/4). SS CC 60% N 8% R 1% Gl 15% Cl 5% Z 1% D 8% Nod 2% S Tr% F

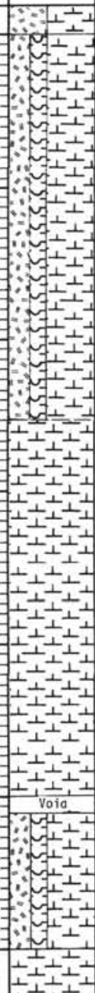


Explanatory notes in Chapter 2

Site 285 Hole Core 3 Cored Interval 35.5-45.5 m

AGE: LATE MIOCENE
NANNOS: Discoaster neohamatus
RADS: Ommatartus antepenultimus

SECTION	METERS	FOSSIL	ABUND.	PRES.	DEFORMATION
0					
1	0.5, 1.0	N, N, F, N, R, N, F	A, C, C, C, C, C	g, f, g, f, g, f	1/2
2		N, R	C, C	g, g	1/2
3		R, N, F	C, C	g, f	3
4		N, N	A, C	g, g	3
5		R	C	g	3
6		N	C	g	3
Core Catcher		FB, R, N	T, C, C	g, g, g	



LITHOLOGIC DESCRIPTION

10YR 6/4 — RAD BEARING GLASS SHARD NANNO OOZE.

10YR 6/3

SS from top

60% N	1% Py	1% F	Tr% SI
30% Gl	1% Nod	1% D	
5% R	1% M	Tr% S	

GLASS SHARD AND RAD RICH NANNO OOZE, pale brown with swirls of grayish brown (10YR 5/2); soft to stiff.

10YR 7/3
10YR 4/4
10YR 5/4

SS 1-92

52% N	2% SI	1% Nod
25% R	2% Z	1% F
15% Gl	1% Q	Tr% D

10YR 3/3 to 10YR 4/4 — FORAM BEARING MICRONODULE-RICH, NANNO GLASS-SHARD ASH.

10YR 7/2

SS 2-60

40% Gl	20% Nod	2% M	Tr% SI
35% N	3% F	Tr% S	

CaCO$_3$ 2-90 (64)

X-ray 2-91

35% Amor	92% Calc	4% Augi
65% Cryst	3% Plag	

X-ray 3-93

49% Amor	86% Calc	8% Plag
51% Cryst	1% Quar	5% Augi

2.5Y 6/2 (light brownish gray)

10YR 7/2 swirls of 2.5Y 6/2

RAD, DIATOM, SILICOFLAGELLATE, GLASS SHARD AND MICRONODULE BEARING NANNO OOZE, light brownish gray, and light gray, with swirls of light brownish gray; soft to stiff.

SS 4-19

71% N	5% Gl	5% SI	1% Fsp
10% R	5% D	3% Nod	

CaCO$_3$ 5-60 (64)

MICARB BEARING, GLASS SHARD AND RAD RICH NANNO OOZE; soft to stiff.

same colors

SS 6-80

55% N	12% Gl	1% Z	Tr% S
16% R	5% M	1% F	Tr% SI

MICRONODULE BEARING NANNO OOZE, very pale brown (10YR 7/3).

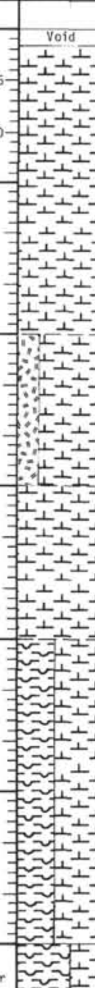
SS CC

85% N	2% Gl	2% D
5% Nod	2% F	2% S

Site 285 Hole Core 4 Cored Interval: 55.0-64.5 m

AGE: LATE MIOCENE
NANNOS: Discoaster neohamatus
RADS: Ommatartus antepenultimus

SECTION	METERS	FOSSIL	ABUND.	PRES.	DEFORMATION
0					
1	0.5, 1.0	N	C	g	3
2		N	C	g	3
3		F, R, N	R, C, C	f, g, g	3
4		F, N	—, A	—, g	3
5					3
6					3
Core Catcher		R, N	C, C	p, f	



LITHOLOGIC DESCRIPTION

CLAY AND GLASS SHARD BEARING NANNO OOZE, light brownish gray; soupy to soft; no internal structures.

2.5Y 6/2

SS 1-105

85% N	5% Cl	1% S
8% Gl	1% Z	

X-ray 1-106

44% Amor	86% Calc	5% Plag	5% Augi
56% Cryst	1% Quar	3% Mont	

CaCO$_3$ 1-107 (54)

SS 2-120

85% N	2% Nod	1% F	1% S
9% Gl	1% M	1% R	

GLASS SHARD RICH NANNO OOZE, light brownish gray or gray (below Section 3-75), with patches and swirls of olive gray; soft.

2.5Y 6/2 with patches and swirls of 5Y 5/2

SS 3-69

85% N	3% Nod	Tr% Z	Tr% S
12% Gl	1% F	Tr% D	

Grain Size 3-110 (0.0, 50.6, 49.4)

5Y 5/8 with swirls of 5Y 5/2

X-ray 3-116

51% Amor	85% Calc	8% Plag	5% Augi
49% Cryst	1% Quar	1% Mont	

CaCO$_3$ 4-50 (44)

5Y 5/1 with 5Y 5/2

Grain Size 4-61 (0.0, 52.0, 48.0)

X-ray 5-136

73% Amor	52% Calc	24% Plag	5% Mont
27% Cryst	4% Quar	2% Mica	13% Augi

5Y 5/1 with sreaks of 5Y 6/1, 5Y 2.5/1, 5Y 3/2

MICRONODULE, SILICOFLAGELLATE, GLASS SHARD *AND DIATOM BEARING RAD NANNO OOZE*, gray, with streak of light gray, black, and dark olive gray; soft.

SS 5-140

37% N	8% Gl	2% Fsp
30% R	5% Nod	2% S
10% D	5% SI	1% Mi

CaCO$_3$ 6-40 (16)

GLASS SHARD, DIATOM, SPONGE SPICULE, SILICOFLAGELLATE, MICRONODULE-BEARING, NANNO RAD OOZE, dark greenish gray.

SS CC

40% R	10% Nod	5% D	4% SI
30% N	5% Gl	5% S	1% Plant D.

5GY 4/1

Explanatory notes in Chapter 2

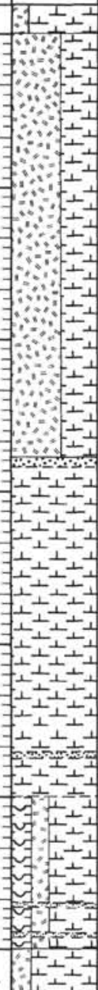
Site 285 Hole Core 5 Cored Interval: 73.0-83.5 m

AGE: MIDDLE MIOCENE | NANNOS: Catinaster calyculus subz; Discoaster hamatus

Columns: AGE | FORAMS | NANNOS | RADS | FOSSIL CHARACTER (FOSSIL, ABUND., PRES.) | SECTION | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION

Fossil character: Section 1: N C f; Section 2: R T p, N C f; Section 3: R T p; Section 4: R T p; Section 5: R T p; Section 6: N C f, F T p; Core Catcher: F R f, R T p, N C f

Sections: 0, 1 (0.5, 1.0), 2, 3, 4, 5, 6, Core Catcher. Deformation: 1/2



5Y 5/2 — GLASS SHARD RICH NANNO OOZE.

SS from top
74% N 1% Fsp 1% Nod
20% Gl 1% Mi 1% S
1% Q 1% HM Tr% R

5Y 5/2 — NANNO GLASS SHARD ASH, olive gray; stiff; no structures.

SS 1-81
55% Gl 1% Py Tr% Fsp
44% N Tr% Q Tr% F

Grain Size 1-81 (0.0, 55.2, 44.8)

5Y 5/2 — GLASS SHARD NANNO OOZE, olive gray, with some darkerpatches; stiff.

SS 2-76
55% N 45% Gl Tr% Q Tr% F

X-ray 2-77
65% Amor 70% Calc 14% Plag 9% Augi
35% Cryst 2% Quar 5% Mont

SS 3-140
83% N 3% Nod 1% Q 1% M
8% Gl 2% Fsp 1% Mi 1% S

From Section 3-115 to 127 - rounded pumice fragments (→3 cm) in matrix of similar sediment as above. Sediment below Section 3-127 is:

5Y 4/1 (dark gray) — MICRONODULE AND GLASS SHARD BEARING NANNO OOZE, olive gray, with vague mottling; stiff; scattered pumice fragments.

5Y 5/2

5Y 5/2

SS 4-76
72% N 1% Q
8% Gl 1% HM
3% Nod 1% M
2% Fsp Tr% R
2% Mi

SS 4-110 (lighter patch)
69% N Tr% Py
30% Gl Tr% Z
1% Nod Tr% S

X-ray 4-76
66% Amor 50% Calc 22% Plag 16% Mont
34% Cryst 4% Quar 2% Mica 6% Augi

5Y 4/2 (olive gray) — $CaCO_3$ 4-80 (14)

From Section 5-108 to 114 - finely laminated laminae slightly inclined. At Section 5-114 - pumice fragments.

5Y 5/2 — PYRITE AND NANNO BEARING QUARTZ-RICH GLASS SHARD SAND (laminae).

SS 5-112
70% Gl 5% Py Tr% Fsp
20% Q 5% N

Grain Size 6-96 (2.2, 54.4, 43.4)

RAD AND GLASS SHARD RICH NANNO OOZE, olive gray; stiff.

SS 6-97
60% N 2% Py 1% SI Tr% D
23% Gl 1% Q Tr% Fsp
12% R 1% S Tr% Chlo.

5Y 4/2
5Y 3/1
5Y 4/2
5Y 3/1
5Y 4/1

GLASS SHARD RICH NANNO OOZE

SS CC
73% N 2% HM 2% Nod
20% Gl 2% Py 1% S

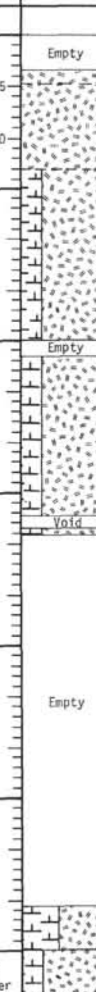
Site 285 Hole A Core 1 Cored Interval: 131.0-140.5 m

AGE: MIDDLE MIOCENE | FORAMS: N16 | NANNOS: Discoaster exilis

Columns: AGE | FORAMS | NANNOS | RADS | FOSSIL CHARACTER (FOSSIL, ABUND., PRES.) | SECTION | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION

Fossil character: Section 1: N C p, F C f; Section 2: N R p, R T p; Section 3: N R p, R T p, F ---; Section 6: N R p, R T p, F T p; Core Catcher: FB T f, R T p

Sections: 0, 1 (0.5, 1.0), 2, 3, 4, 5, 6, Core Catcher. Deformation: 3, 1/2, 1/2, 1/2, 1



QUARTZ-FELDSPAR AND NANNO BEARING COARSE GLASS SHARD ASH, very dark gray; soft to stiff; at top rounded pumice fragments (→1.5 cm).

SS 1-40
81% Gl 3% Q 2% HM
10% N 3% Fsp 1% F

Grain Size 1-67 (0.1, 44.3, 55.7)

5Y 3/2

X-ray 1-67
68% Amor 4% Quar 24% Mont
32% Cryst 17% Plag 1% Anal
44% Calc 2% Chlo 9% Augi

Below Section 1-128 cm: ZEOLITE BEARING, NANNO RICH GLASS SHARD ASH, dark olive gray, fine grained sediment (clayey silt); stiff.

SS 1-138
72% Gl 5% Z 1% HM Tr% Fsp
20% N 2% Py Tr% Q

X-ray 2-55
74% Amor 4% Quar 15% Mont 2% Magn
26% Cryst 29% Plag 2% Anal
36% Calc 1% Chlo 11% Augi

Grain Size 2-60 (0.3, 66.7, 33.0)

$CaCO_3$ 2-64 (11)

NANNO GLASS SHARD ASH, very dark gray; stiff to semilithified.

SS 6-109
77% Gl 2% Z Tr% Fsp
30% N 1% Py

5Y 3/2 — NANNO RICH GLASS SHARD ASH, very dark gray (5Y 3/1).

SS CC
76% Gl 1% Q 1% HM Tr% F
20% N 1% Mi 1% M Tr% S

Explanatory notes in Chapter 2

Site 285 Hole A Core 2 Cored Interval: 187.0-196.5 m

AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		Discoaster exilis		N	R	P	1	0.5, 1.0		1	* *	
				F R N	– T R	– P P	Core Catcher					

5Y 3/1 and 5Y 4/1

Alternating:

QUARTZ, FELDSPAR, MICARB, AND NANNO BEARING GLASS SHARD SILTY SANDSTONE, dark gray (5Y 4/1); semilithified; finely laminated with some granule size (up to lapilli size) pumice fragments. Bulk sediment has grain sizes up to coarse sand.

SS 1-19

77% Gl	4% M	3% Fsp	1% HM
10% N	3% Q	1% Mi	1% F

Grain Size 1-19 (70, 30, 0)

and:

FELDSPAR BEARING NANNO GLASS SHARD TUFF, dark gray (5Y 4/1); semilithified; no lamination, but shows generally moderate mottling (some *Chondrites* - type burrows at 148 cm). Finer grained (silty clay) than laminated horizons. Sporadic pumice fragments (~1.5 cm).

SS 1-70

50% Gl	5% Fsp	Tr% HM
45% N	Tr% Q	

Grain Size 1-70 (0, 40, 60)

5Y 3/1

NANNO, QUARTZ, AND FELDSPAR-BEARING, GLASS SHARD TUFF, very dark gray; semilithified.

SS CC

81% Gl	5% Q	1% S
8% Fsp	5% N	

Site 285 Hole A Core 3 Cored Interval: 244.0-253.5 m

AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		Discoaster exilis					1	0.5, 1.0	Empty			
							2			0	*	
				F R N	R T R	f p p	Core Catcher				* *	

QUARTZ AND FELDSPAR BEARING NANNO RICH GLASS SHARD TUFF, dark gray; semilithified; sediment fine grained (silt); moderate mottling all over.

X-ray 2-30

74% Amor	45% Calc	25% Plag	7% Augi
26% Cryst	5% Quar	18% Mont	

5Y 4/1

From Section 2-100 to 118 a layer of coarser grained sediment with pumice fragments and greenish volcanic fragments (containing phenocrysts of feldspar and amphibole - <1 mm); very dark gray (5Y 3/1). Particles ~0.5 mm.

SS 2-65		SS 2-142	
69% Gl	1% HM	80% Gl	1% HM
20% N	1% Py	12% N	1% Py
3% Q	1% M	3% Q	Tr% M
3% Fsp	1% S	3% Fsp	
1% Mi			

SPICULE, QUARTZ AND FELDSPAR BEARING NANNO RICH GLASS SHARD TUFF, dark gray (5Y 4/1); semilithified.

SS CC

67% Gl	5% Q	3% S	1% HM
15% N	5% Fsp	1% Mi	1% F

Site 285 Hole A Core 4 Cored Interval: 348.5-358.0 m

AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE MIOCENE		Discoaster exilis		N	C	p	1	0.5, 1.0	Empty	0	*	
				N	C	p	2				* * *	
				F R N	– T R	– p p	Core Catcher					

5Y 4/1

QUARTZ AND FELDSPAR-BEARING, NANNO-RICH GLASS SHARD TUFF, (or siltstone, if reworked), dark gray, alternating finely-laminated horizons are from Section 1-110 to 115; Section 2-30 to 55, 63 to 82, 87 to 94, and 117 to 132. Other intervals mottled (moderate to intense). Overall color is dark gray (5Y 4/1). Modal grain size is silt. Overall sediment name: QUARTZ AND FELDSPAR BEARING NANNO RICH GLASS SHARD TUFF.

SS 1-130

75% Gl	3% Fsp	1% M
15% N	2% Py	1% Z
3% Q	1% HM	Tr% S

Grain Size 1-130 (5, 75, 20)

X-ray 2-126

70% Amor	40% Calc	26% Plag	1% Clin
30% Cryst	4% Quar	20% Mont	9% Augi

2.5Y 4/1

NANNO RICH GLASS SHARD TUFF dark gray; semilithified (conchoidal fractures).

SS CC

74% Gl	2% Q	1% Mi	1% M
20% N	2% Fsp	1% Py	1% S

Explanatory notes in Chapter 2

Site 285 Hole A Core 5 Cored Interval: 453.0-462.5 m

AGE: MIDDLE MIOCENE

FORAMS / NANNOS / RADS: Discoaster exilis; Sphenolithus heteromorphus

FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION
N	C	p	2
F	T	p	2
F	T	p	4
F	T	p	Core Catcher
N	R	p	Core Catcher

SECTION: 0, 1, 2, 3, 4, 5, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY:

Section 1: Empty

DEFORMATION: b, a, b, a, b, a, c, b, a, ?, b, a, b, b, ?, a, b

LITHO. SAMPLE

LITHOLOGIC DESCRIPTION

Core 5 till contact with basalt in Core 7 Section 6 is a sequence of reworked NANNO RICH ASHES[1], which displays a rhythmic repetition of 3 intervals characterized by sediment structures and/or grain size. The base of each 'rhythm' is erosional. For convenience of description, the intervals are desingated here with the letters "a", "b", and "c".

Interval a: Generally micro-cross-laminated, rarely parallel-laminae, at the base, parallel-laminae at the top, where it gradually merges into interval b. Grain size of this interval ranges from sandy silt to silt. For clearness of description, the "sandy silt" symbol will be used for all "a" intervals.

Interval b: Characterized by vague parallel lamination. Grain size is mainly silt. Gradual contacts with intervals a and c.

Interval c: Characterized by moderate to intense bioturbation (mottling). Grain size is mainly silt. Upper contact with interval a is erosional. Colors of all intervals are mainly dark greenish gray (5GY 4/1) to dark bluish gray (5B 4/1), with lighter and darker shades.

5Y 6/1 olive gray

Intervals b and c will be symbolized by "silt" data. Erosional base will be represented by a solid line, other boundaries with a dashed line. Interval symbols "a", "b", and "c" are indicated in 'deformation' column. If not clear, a "?" is used.

Please note that micro-cross laminae sets are of thicknesses ranging from a few mm to about 1 cm. Parallel laminae are of the order of 1 mm.

X-ray 2-81

$CaCO_3$ 2-81 (6)

50° inclined black laminae

SS 3-41
90% Gl 3% N 1% M
3% Fsp 1% Mi

Grain Size 3-41 (5, 80, 5)

parallel laminae offset (micrograben)

SS 3-75
80% Gl 2% Fsp 1% M
15% N 2% Py

Grain Size 3-75 (20, 70, 10)

X-ray 3-75
47% Amor 31% Calc 20% Plag 25% Clin
53% Cryst 6% Quar 18% Mont

SS 4-70
83% Gl 3% Fsp Tr% M
12% N 2% Py

Grain Size 4-70 (5, 85, 10)

MICARB AND FELDSPAR BEARING NANNO RICH GLASS SHARD SILTSTONE.

SS CC
75% Gl 12% N 2% Py
15% Fsp 5% M

[1] Cores 5 to 7 are semilithified, lithologic terms used will be "sandy siltstone" (a) and "siltstone" (b and c).

Site 285 Hole A Core 6 Cored Interval: 509.5-519.5 m

AGE: EARLY MIDDLE MIOCENE

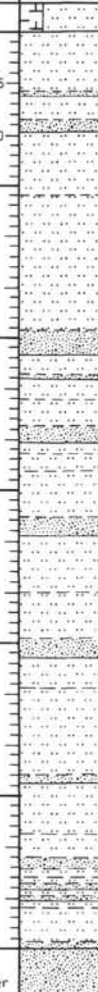
FORAMS / NANNOS / RADS: Sphenolithus heteromorphus

FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION
F	T	p	Core Catcher
N	R	p	Core Catcher

SECTION: 0, 1, 2, 3, 4, 5, 6, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY:



DEFORMATION: b, a, ?, a, c, b, a, c, a, c, ?, a, c, ?, b, a, c, b, a, c, b, a, c, b, a, c, b, a, b, a

LITHO. SAMPLE

LITHOLOGIC DESCRIPTION

NANNO RICH GLASS SHARD SILTSTONE.

5B 4/1

SS from top
83% Gl 2% Fsp 1% Py
12% N 2% M

X-ray 1-20
48% Amor 24% Calc 22% Plag 10% Clin
52% Cryst 4% Quar 40% Mont

CHONDRITES burrows between Section 1-131 to 136.

ZOOPHYCOS burrow at Section 2-2.

FELDSPAR AND MICARB BEARING GLASS SHARD SILTSTONE.

SS 3-17 (a)
88% Gl 4% M 1% Q Tr% F
4% Fsp 2% N 1% Py

Grain Size 3-17 (5, 90, 5)

FELDSPAR BEARING GLASS SHARD SANDY SILTSTONE.

SS 3-19.5 (basal coarse lamina of a)
90% Gl (altered) 2% Py 1% HM
4% Fsp 2% N 1% M

Grain Size 3-19.5 (40, 60, 0)

Grain Size 3-23 (0.1, 42.8, 57.1)

X-ray 3-110
40% Amor 8% Calc 12% Plag 60% Mont
60% Cryst 5% Quar 2% Mica 13% Clin

X-ray 4-17
40% Amor 16% Calc 15% Plag 17% Clin
60% Cryst 5% Quar 47% Mont

X-ray 4-43
28% Amor 10% Calc 22% Plag 16% Clin
72% Cryst 4% Quar 48% Mont

← 7 cm long subvertical burrow

X-ray 4-89
44% Amor 34% Calc 14% Plag 15% Clin
56% Cryst 5% Quar 32% Mont

NANNO GLASS SHARD SILTSTONE.

SS 5-140 (c)
55% Gl 2% Fsp 1% HM
40% N 1% Mi 1% Py

5B 7/1 light bluish gray

Grain Size 5-140 (5, 90, 5)

NOTE: In any interval the coarseness of the laminae may vary. There is consequently no regular grading, at most an 'overall' grading, per rhythm.

FELDSPAR, CHLORITE AND NANNO BEARING GLASS SHARD SILTSTONE.

SS CC
84% Gl 3% Fsp 2% Py 1% HM
5% N 3% Chlo. 1% Mi 1% F

Grain Size CC (+20, 75, 5)

Explanatory notes in Chapter 2

Site 285 Hole A Core 7 Cored Interval: 555.0-565.0 m

AGE: EARLY MIDDLE MIOCENE

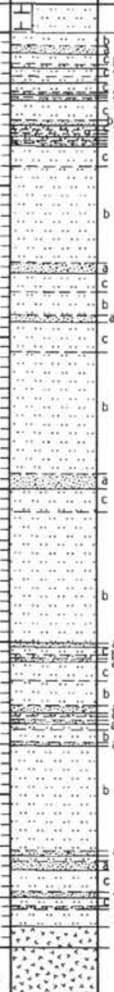
NANNOS zone: *Sphenolithus heteromorphus*

FOSSIL	ABUND.	PRES.
N	R	p
N	R	p
F	T	p
R	T	p

SECTION: 0, 1, 2, 3, 4, 5, 6, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY



LITHOLOGIC DESCRIPTION

5B 5/1 — FELDSPAR BEARING NANNO RICH GLASS SHARD TUFF, medium bluish gray.

SS from top
76% Gl 20% N 3% Fsp 1% Mi

At Section 1-35 and 90 cm, the base of a rhythm has only lensoid remnants of interval 'a', generally of black color.

FELDSPAR BEARING ALTERED GLASS SHARD (CHLORITIC) SILTSTONE.

SS 1-35 (black remnant)
97% Gl 3% Fsp

Grain Size 1-35 (15, 85, 0)

SS 1-45 (b)
92% Gl Tr% Fsp Tr% M
8% N Tr% Py

Grain Size 1-45 (2, 88, 10)

5GY 8/1 greenish gray — SS 2-83 (a)
66% Gl 30% N 2% Q 2% M

Large ZOOPHYCOS burrow, part of central axis exposed (length ~10 cm).

Grain Size 2-83 (10, 85, 5)

X-ray 6-61
45% Amor 11% Calc 26% Plag 8% Clin
55% Cryst 4% Quar 51% Mont

X-ray 6-120
41% Amor 2% Calc 31% Plag 7% Clin
59% Cryst 1% Quar 57% Mont 2% Magn

X-ray 6-130
48% Amor 39% Quar 5% Mica 3% Mont
52% Cryst 20% Plag 3% Chlo 30% Hema

← 'a' interval consist of pebbles of pumice and volcanic rock, size of pebbles ~1 cm

← patch of 'faecal pellets' (light gray), base of 'a' is light greenish gray (5G 8/1)

At Section 6-112 to 117 and 125 to 130 the rock has reddish tint (112 to 117: very dark gray-5YR 3/1; 125 to 130: dark reddish brown - 5YR 2.5/5).

At Section 6-130 is the boundary (no contact in whole core-piece), with fine-grained basalt.

The dark reddish brown sediment is highly altered glass →to Fe-oxide. Glass in sediment at Section 6-112 to 117 is devitrified.

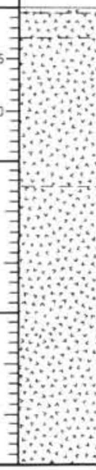
5GY 2/1 (wet-greenish black) fine-grained basalt. Numerous zeolite veins. Thin section show plagioclase laths and pyroxene phenocrysts.

Site 285 Hole A Core 8 Cored Interval: 565.0-574.5 m

SECTION: 0, 1, 2, 3

METERS: 0.5, 1.0

LITHOLOGY



LITHOLOGIC DESCRIPTION

5Y 4/1 — Basalt, olive gray, fine-grained, average grain size <1/2 mm; amygdules rare and <1 mm diameter; chlorite veins abundant.

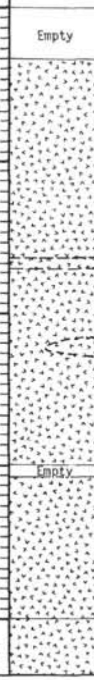
N2 — Basalt, grayish black (wet), fine-grained, average grain size <1/2 mm; amygdules of chlorite and/or calcite increasing downwards, average approximately 5% by volume.

N2 — Basalt, grayish black, (wet) amygdaloidal, average grain size approximately 3/4 mm, amygdules common with maximum development between 65 to 100 cm of Section 1 where amygdules constitute 15 to 20% with diameters up to 8 mm; calcite-chlorite veins sparse. Thin section 8-1-2.2: plagioclase laths with interstitial calcium-rich clinopyroxene, magnetite, ilmenite, chlorite and devitrified glass; amygdules filled with antigorite(?), calcite and chlorite; rare phenocrysts plagioclase and clinopyroxene <2 mm.

N2 — Diabase, grayish black, (wet) average grain size 1-2 mm; amygdules <2% from 26 to 150 cm Section 2 and below that very rare; sparse antigorite(?), chlorite, calcite veins throughout.
Thin section 8-3-6.3: 50% Plagioclase, 33% Clinopyroxene, 7% Opaque, 7% Chlorite, and 3% Devitrified Glass.

Explanatory notes in Chapter 2

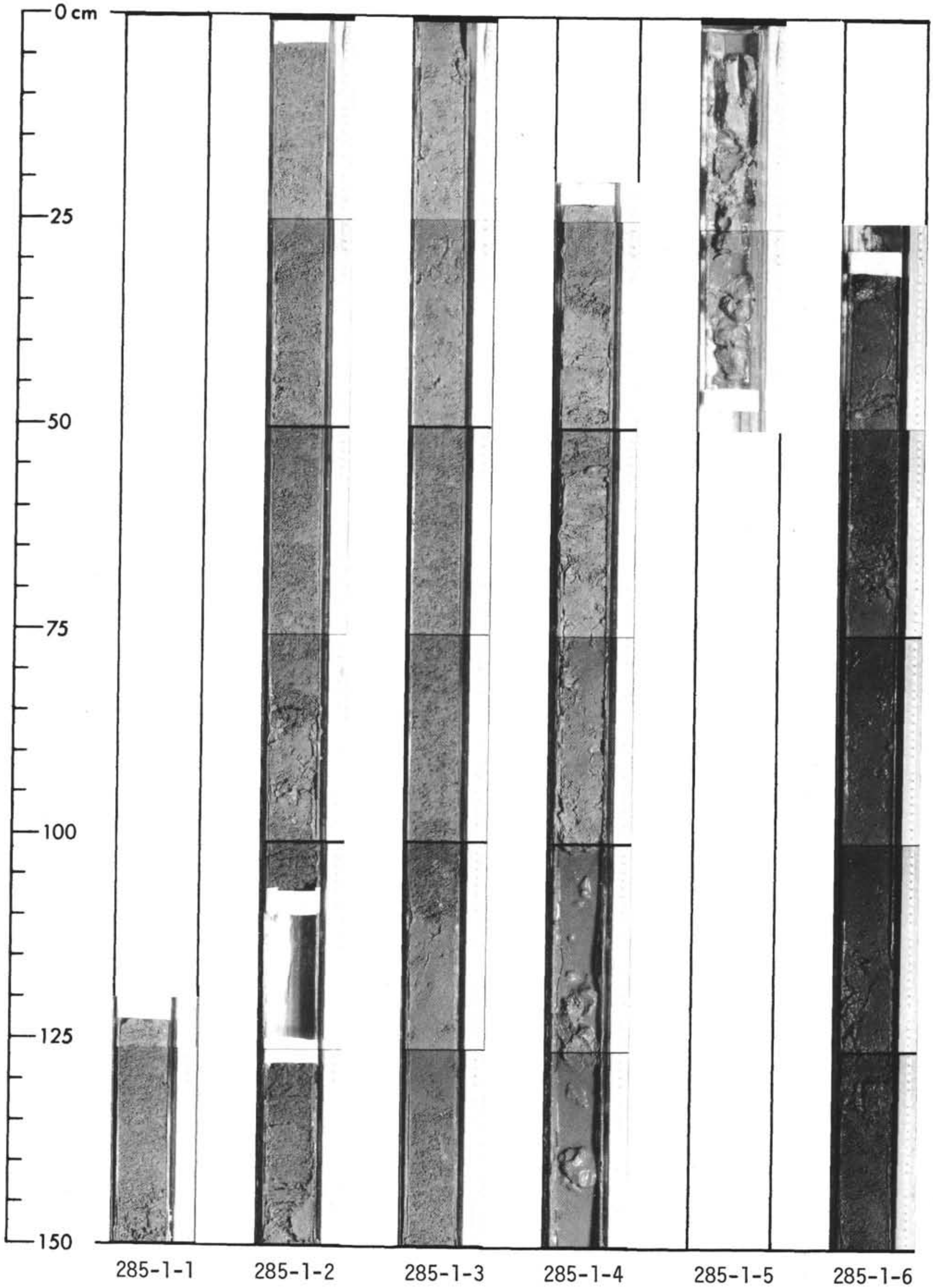
Site 285 Hole A Core 9 Cored Interval: 574.5-584.0 m

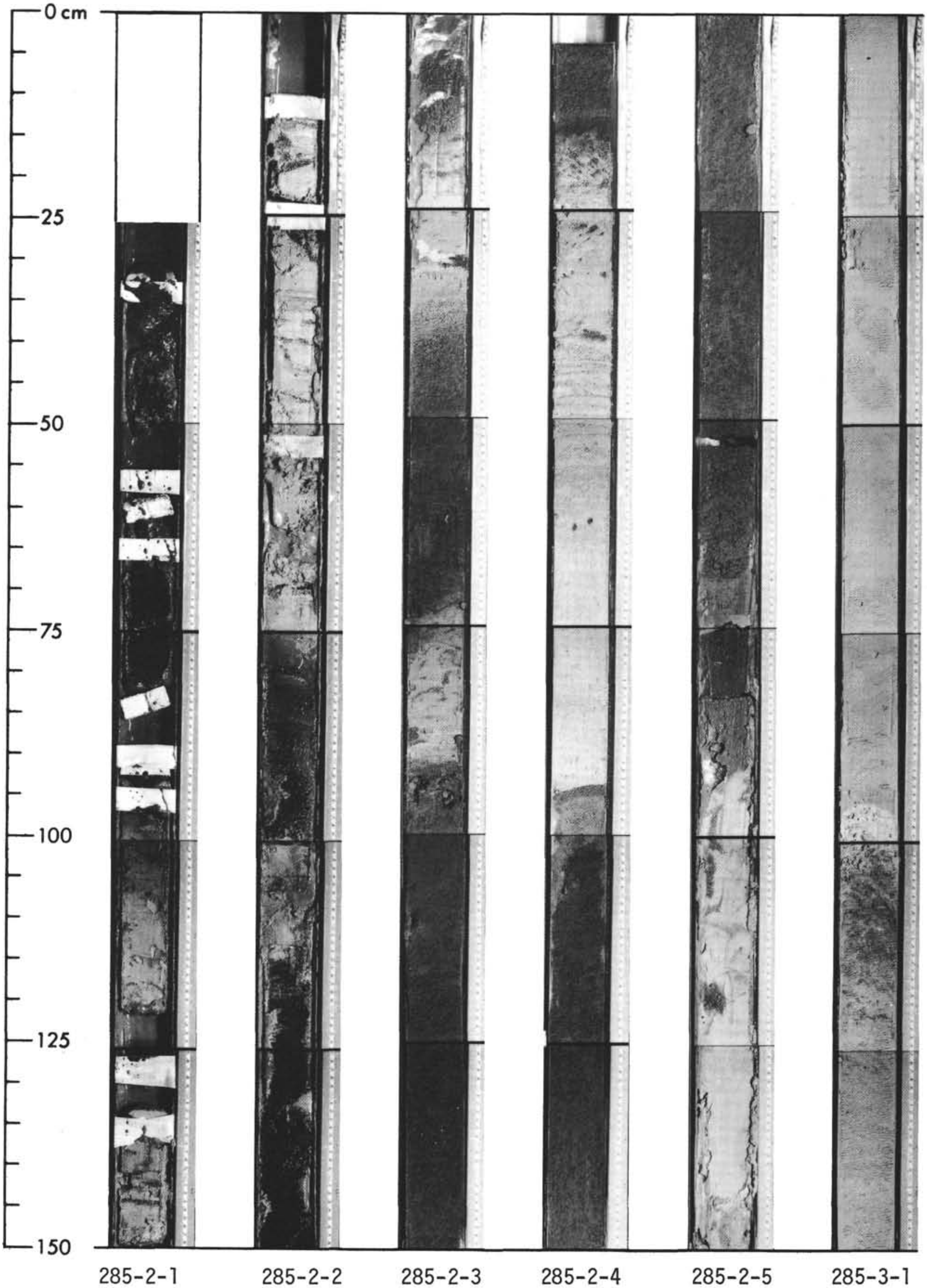


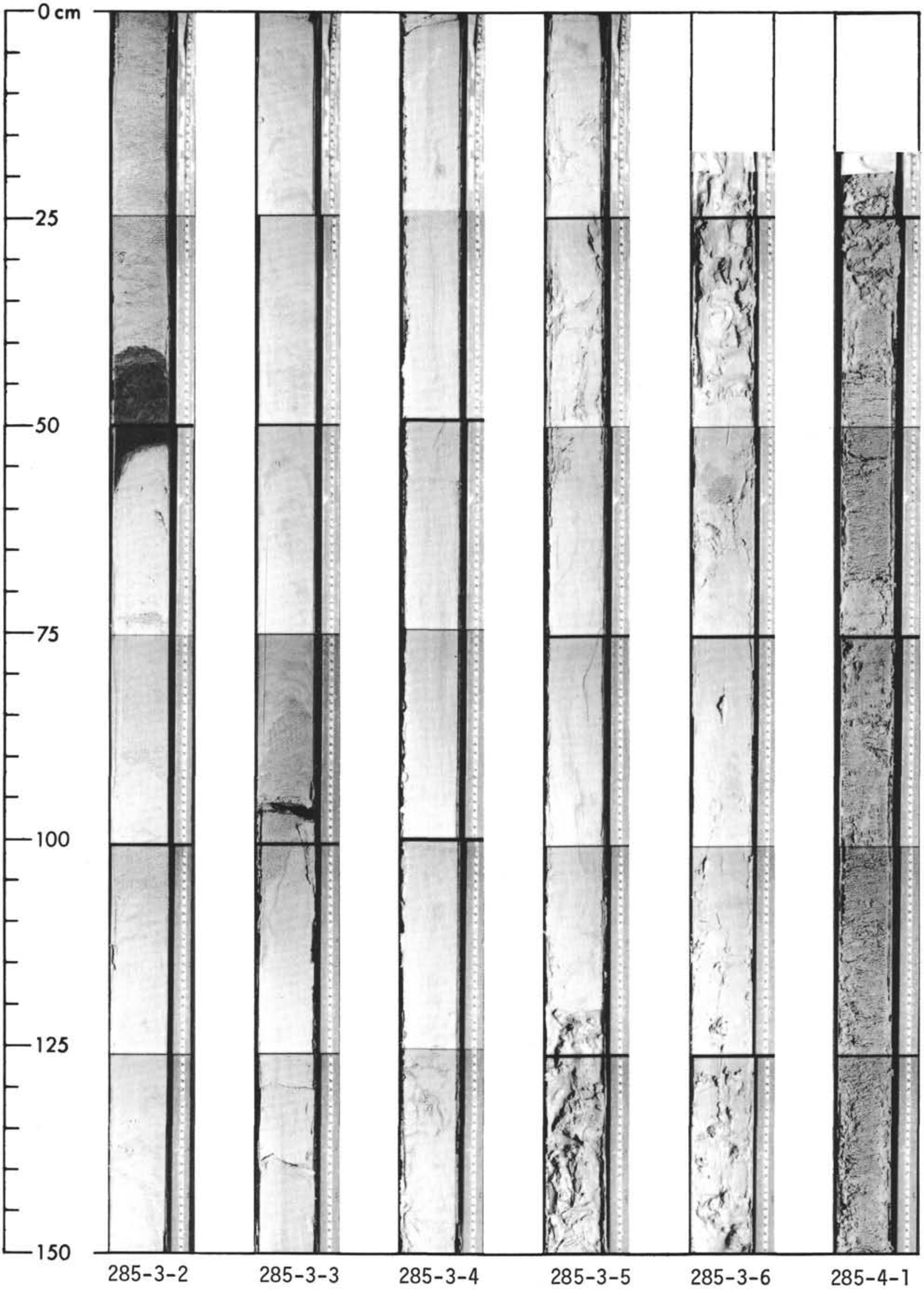
AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE		LITHOLOGIC DESCRIPTION
							0						
							1	0.5 1.0	Empty		*	N2	Diabase, grayish black like Section 8-3 above; amygdules very rare; rare phenocrysts of plagioclase <4 mm; grain size medium 1-2 mm average. Thin section 9-1-5.3: 52% Plagioclase, 28% Clinopyroxene, 7% Opaque, 3% Chlorite, and 10% Devitrified Glass(?). Plagioclase laths with interstices filled with pyroxene, opaques, chlorite and devitrified glass(?).
							2					N2	gabbroic 'zones'
							3				*	N2	Average grain size approximately 2 1/2-3 mm; like the diabase but coarser. Thin section 9-3-4.4: very zoned plagioclase (cores approximately An62) and clinopyroxene (cpx) with a fine-grained (quenched) groundmass; visual estimate: 45% Plagioclase, 35% Clinopyroxene, and 20% Groundmass.
							4		Empty		*	N2	Thin section 9-4-14.4 like 9-1-5.3 above except grain size average appears to be slightly smaller with definite large areas of devitrified glass: 44% Plagioclase, 31% Clinopyroxene, 8% Opaque, and 17% Devitrified Glass.
							Core Catcher					N2	Diabase, grayish black, as above; 26 1/2 cm.

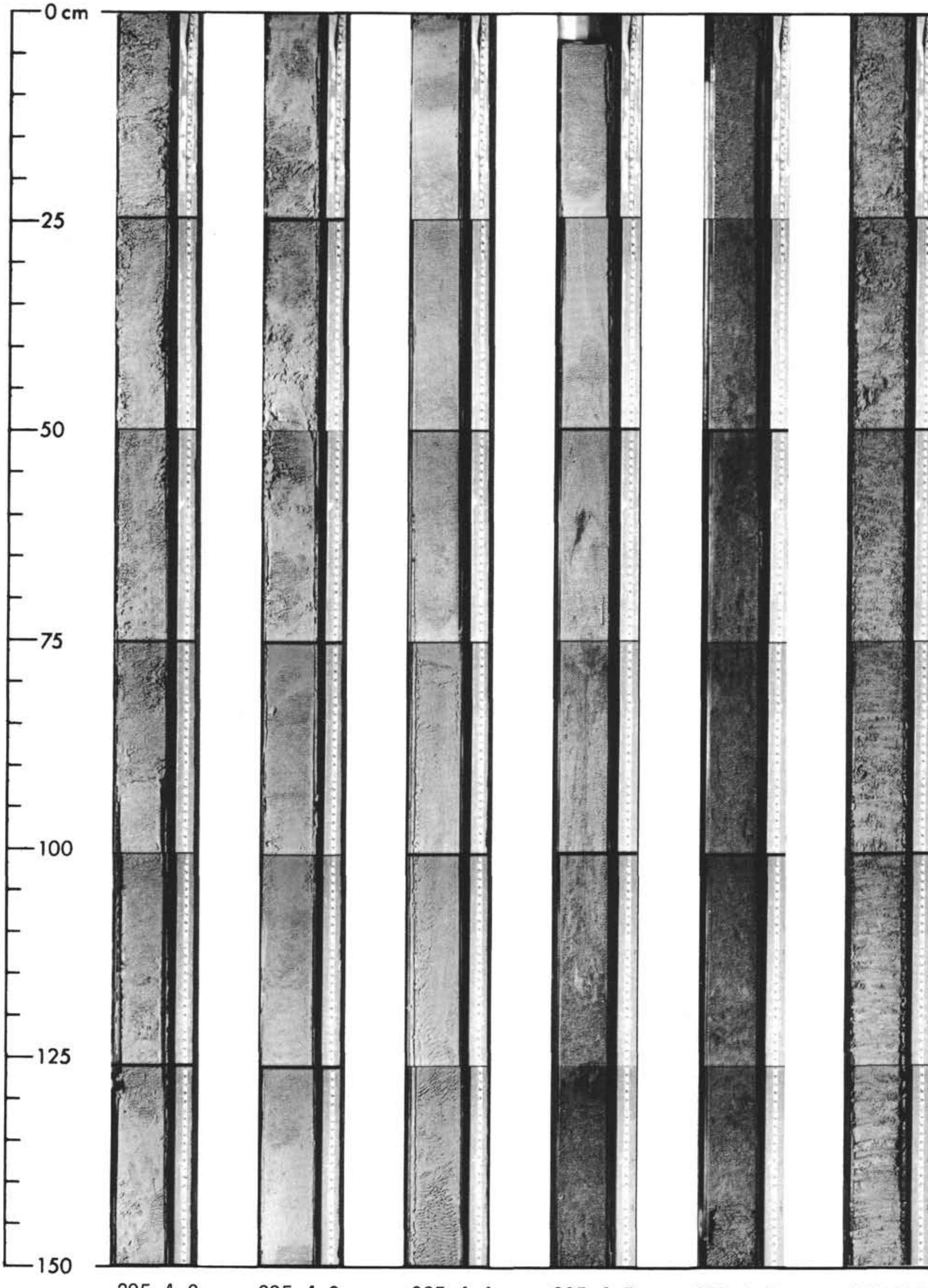
FOSSIL CHARACTER: FOSSIL, ABUND., PRES.

Explanatory notes in Chapter 2


0 cm
25
50
75
100
125
150
285-1-1
285-1-2
285-1-3
285-1-4
285-1-5
285-1-6


0 cm
25
50
75
100
125
150
285-2-1
285-2-2
285-2-3
285-2-4
285-2-5
285-3-1


0 cm
25
50
75
100
125
150
285-3-2
285-3-3
285-3-4
285-3-5
285-3-6
285-4-1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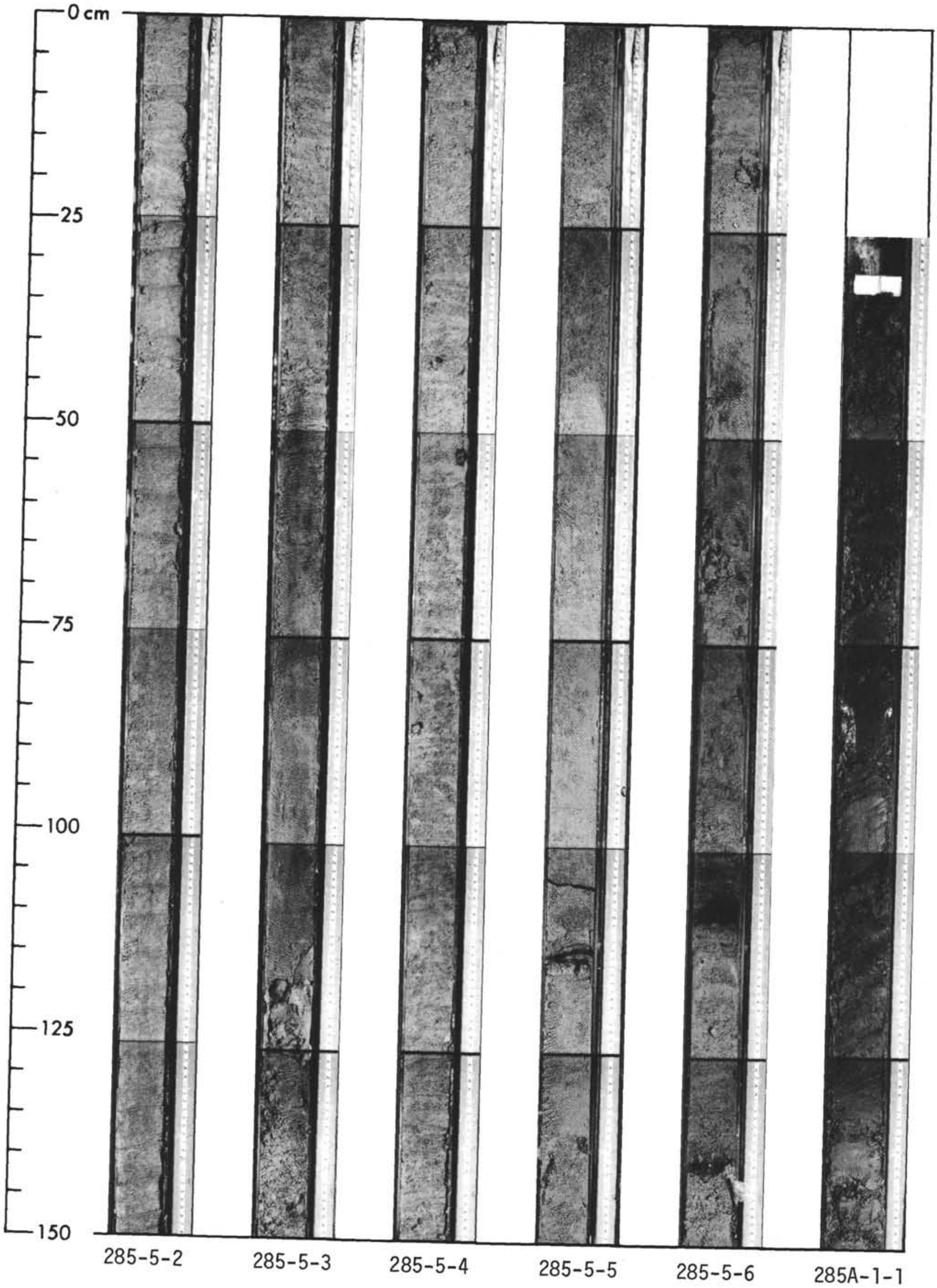
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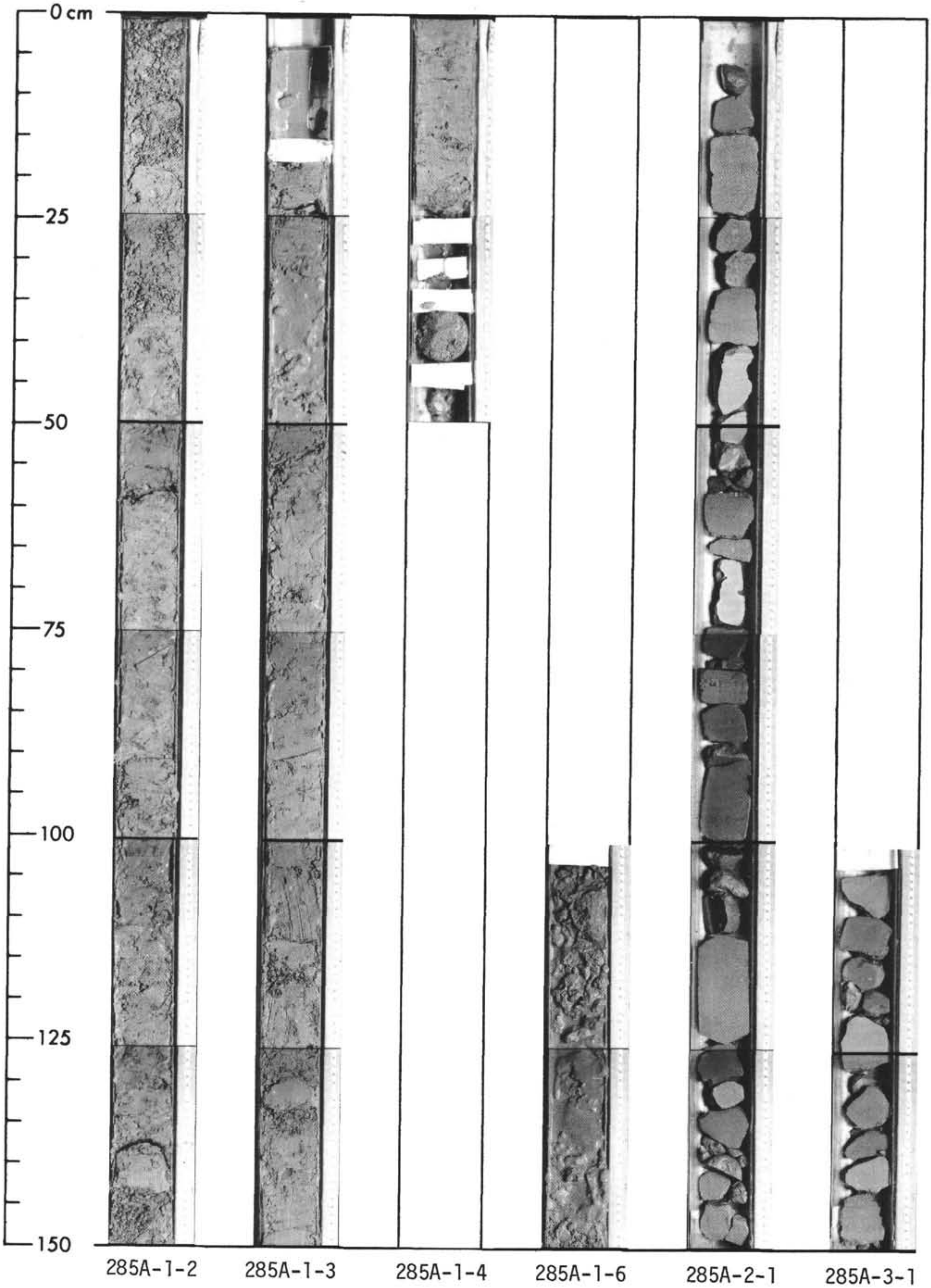
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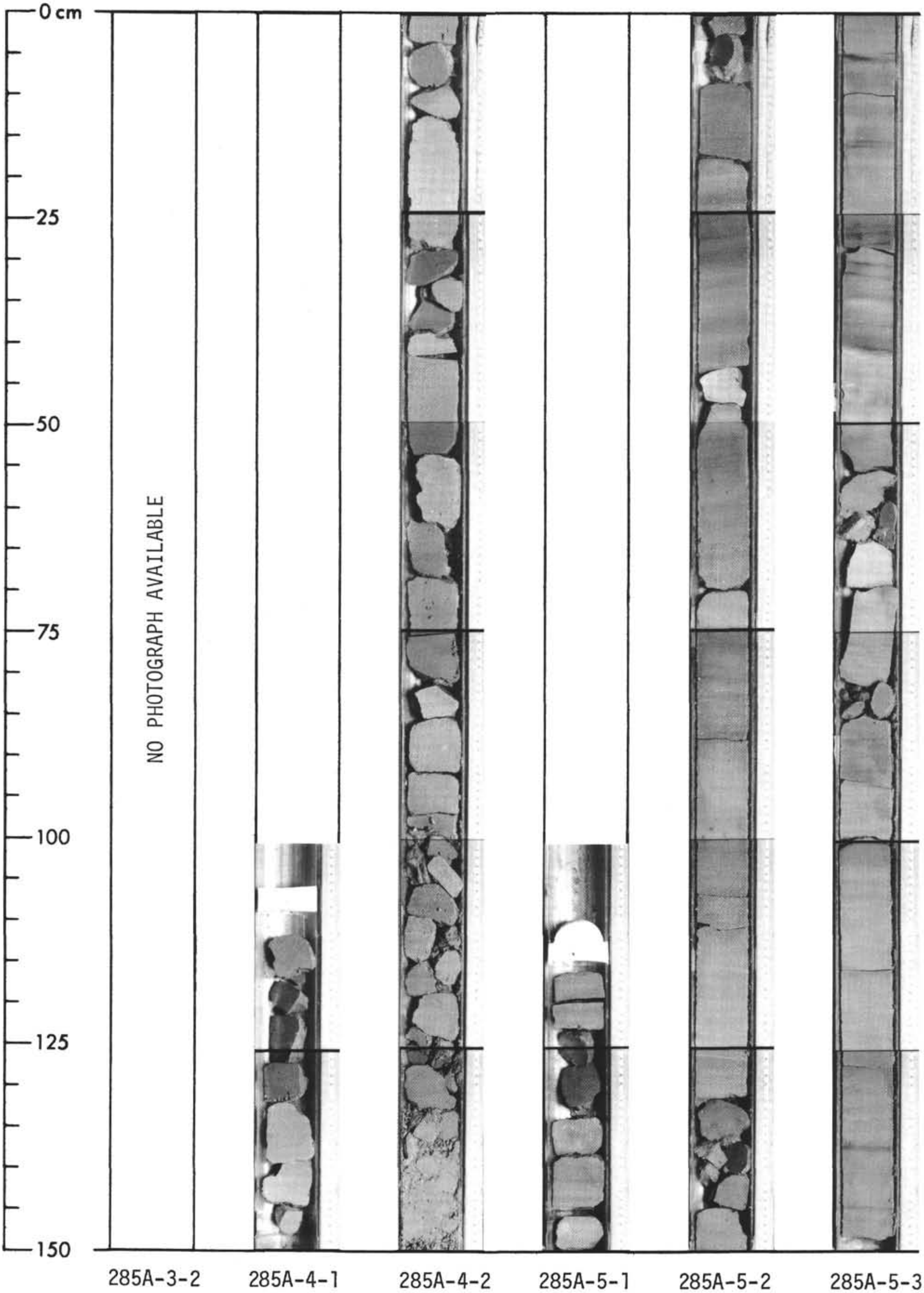
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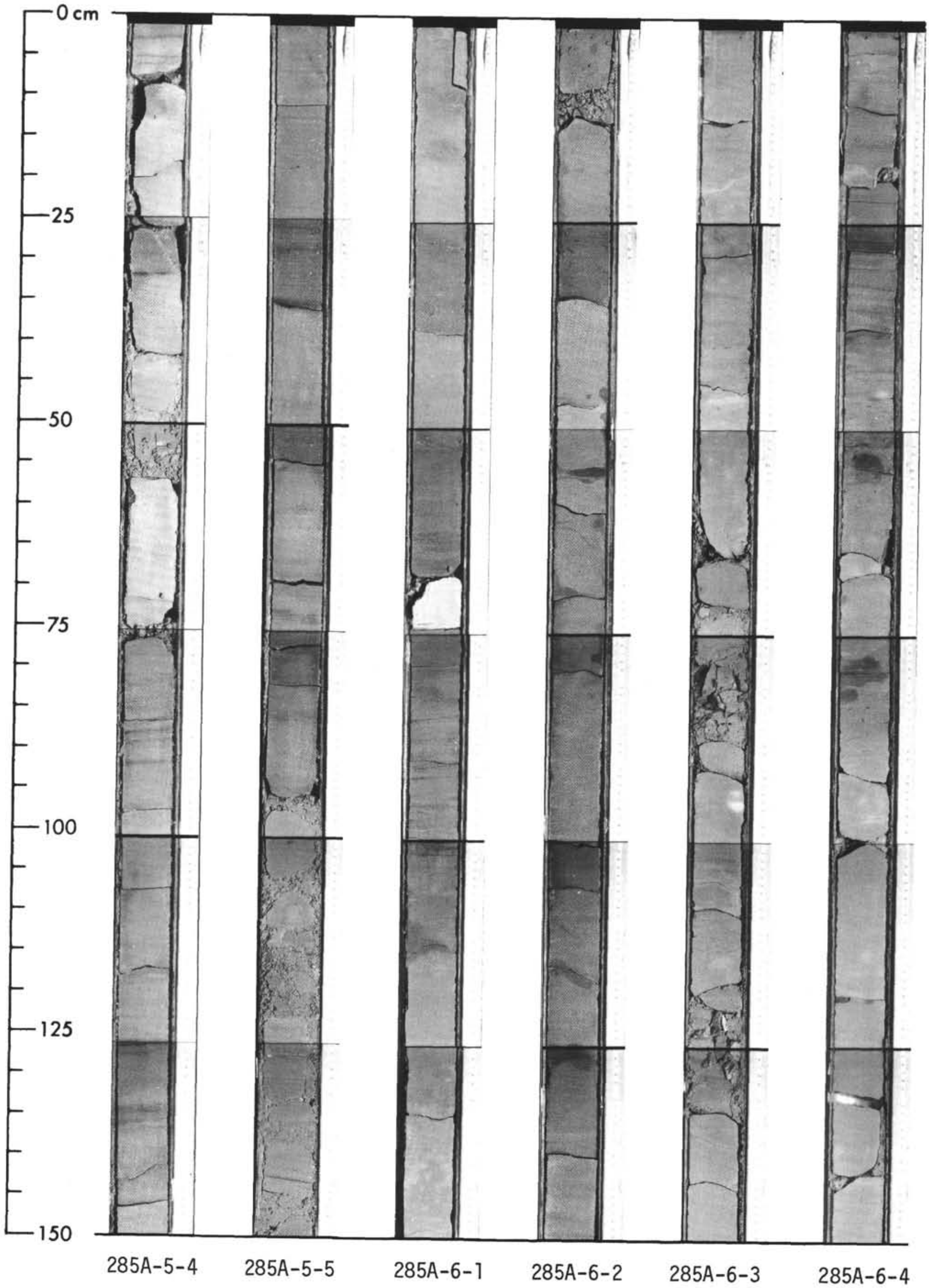
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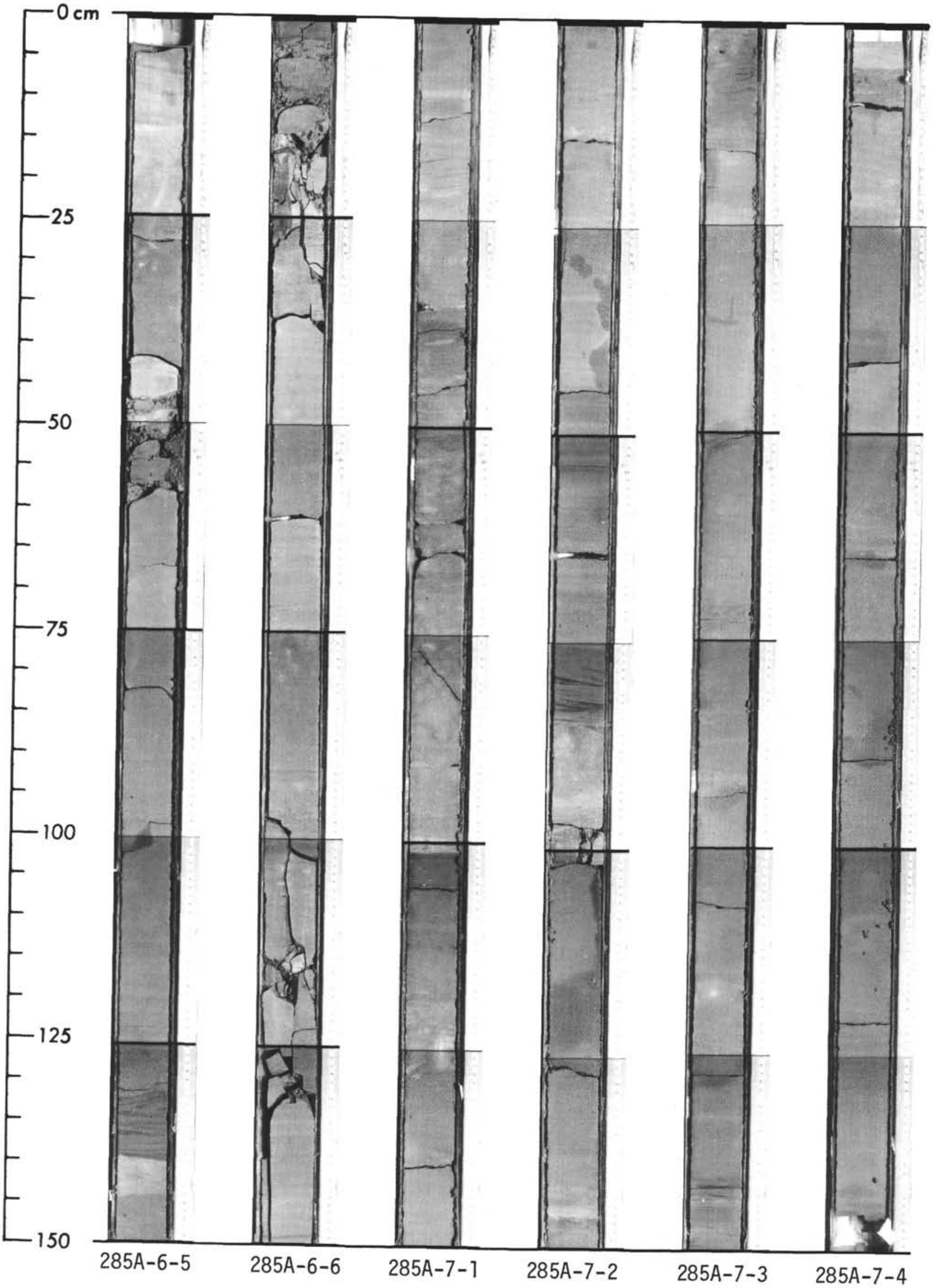
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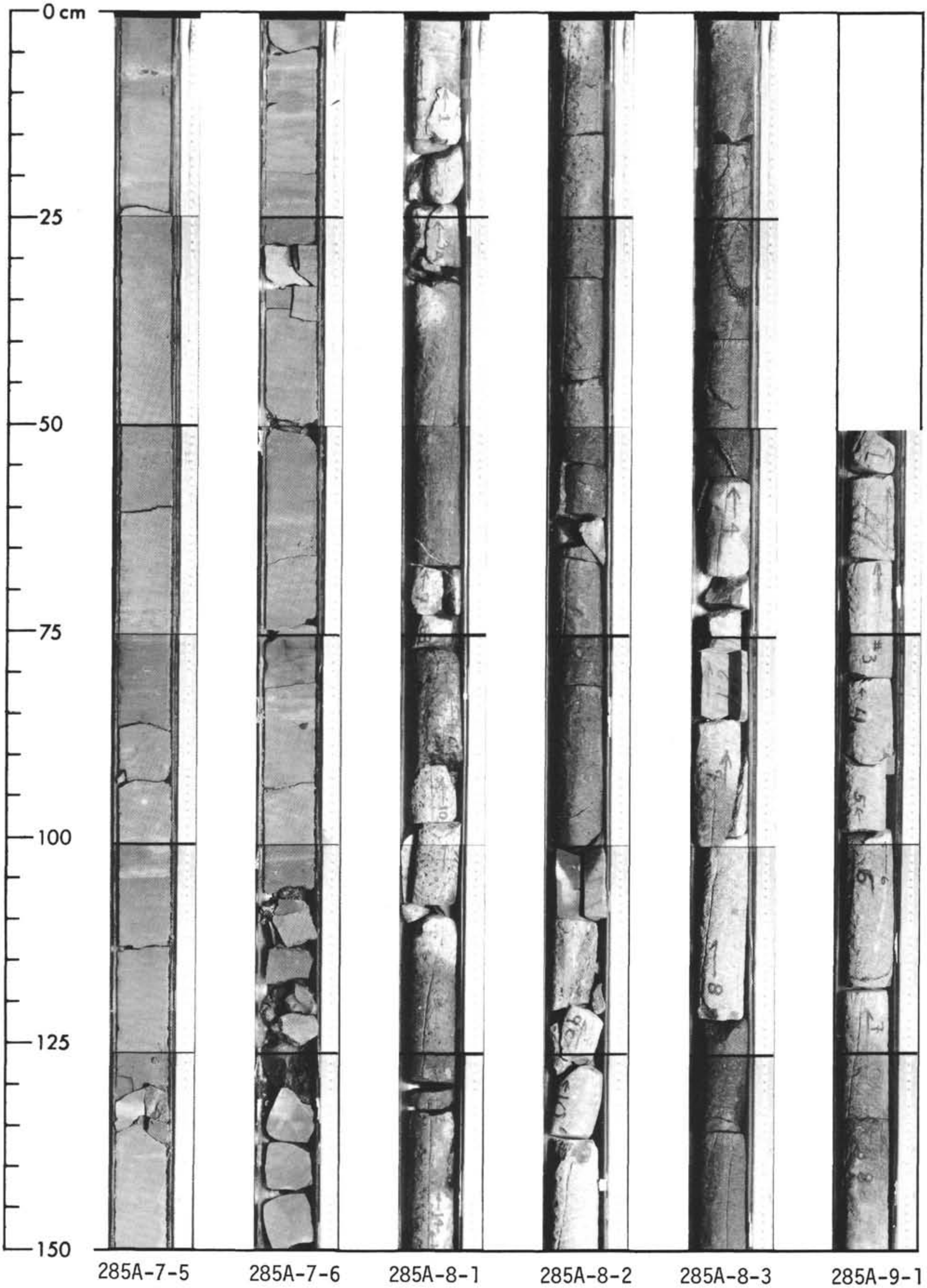
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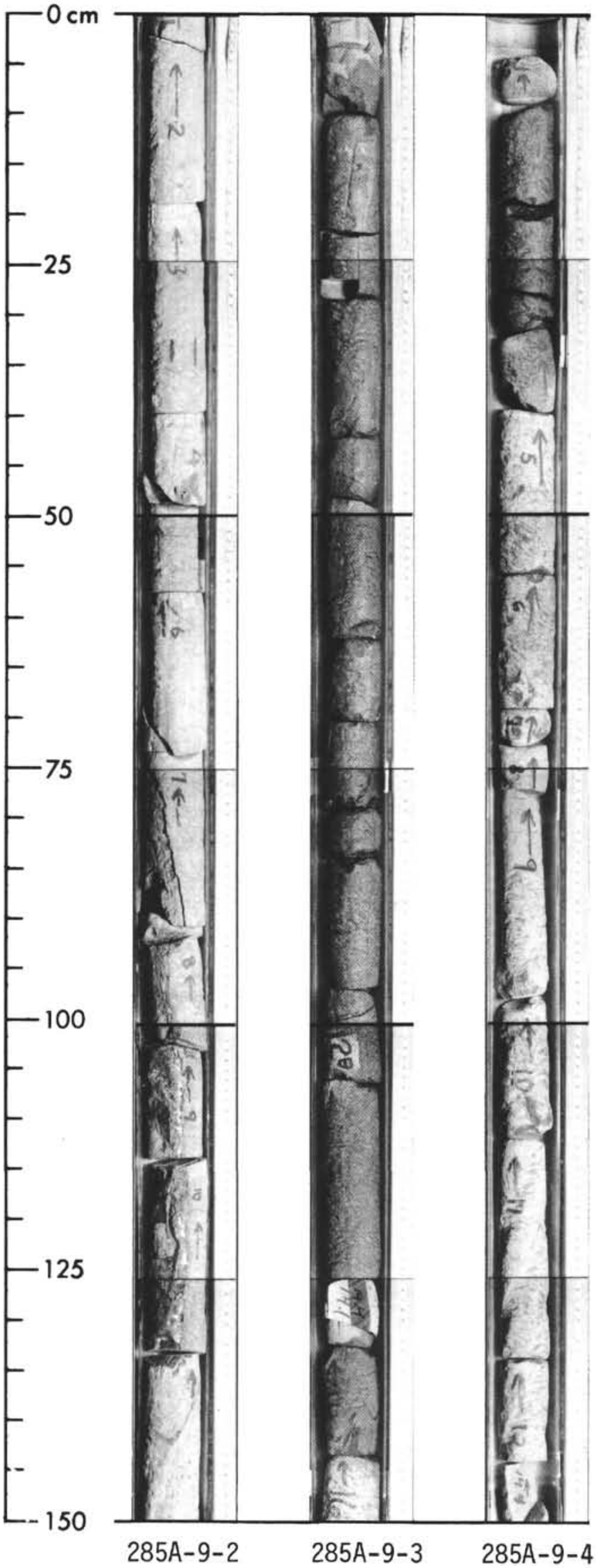
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