5. SITE 287

The Shipboard Scientific Party[1]

SITE DATA

Date Occupied: 15 May 1973 (0800)

Date Departed: 17 May 1973 (1700)

Time on Site: 57 hours

Position:
Latitude: 15°54.67'S
Longitude: 153°15.93'E

Water Depth (from sea level): 4632 corrected meters (echo sounding)

Bottom Felt at: 4653.5 meters (drill pipe)

Penetration: 252 meters

Number of Holes: 1

Number of Cores: 18

Total Length of Cored Section: 157 meters

Total Core Recovered: 73.4 meters

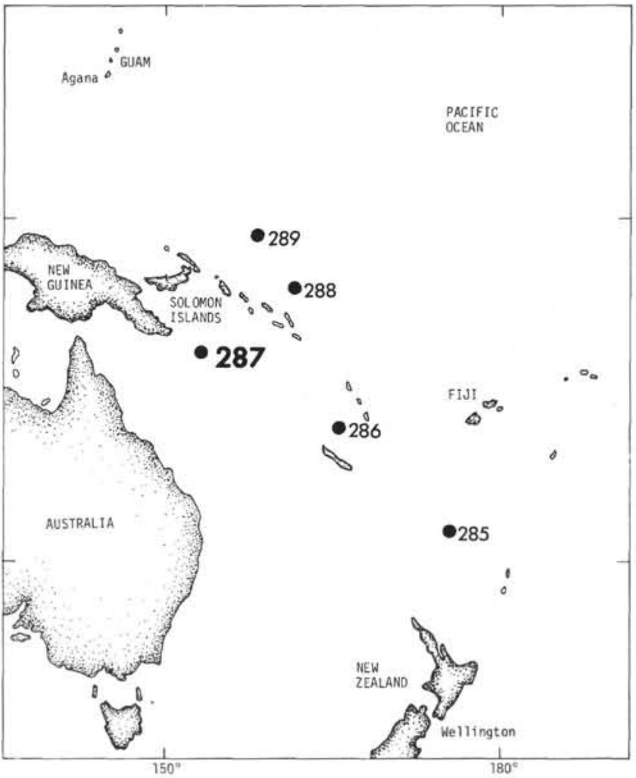
Percentage of Core Recovery: 47%

Oldest Sediment Cored:
Depth below sea floor: 237 meters
Nature: Nannofossil chalk
Age: Early Eocene

Basement:
Depth below sea floor: 0.31 sec (reflection time)
Depth below sea floor: 237 meters
Average velocity to basement: 1.57 km/sec
Nature: Basalt flows

Principal Results: Basalt (252-242.4 m); porphyritic basalt (242.4-236.7 m); lower Eocene to lower middle Eocene nannofossil chalk with interbedded chert (236.7-179.3 m); upper Oligocene nannofossil ooze (179.3-171.6 m); unfossiliferous brown silty clay (171.6-171.0 m) unfossiliferous olive to green clay (171.0-131.9 m); lower upper Pliocene to Pleistocene graded cycles of silt and clay (turbidites) with interbeds of nannofossil ooze.

Site 287 was located adjacent to a basement high in the Coral Sea. Basement age was established as early Eocene. The sequence above the tholeiitic basalt is quite similar to that sampled at Site 210 (42 km to the west-northwest), but turbidites appear later due to the elevation of the basement ridge, and the Eocene-Oligocene regional uncomformity spans a larger interval than at Site 210. The basement ridge appears to have developed shortly after the formation of the basin crust in the early Eocene. Water depth was initially above foram solution depth, but increased below nannofossil solution depth possibly by late Oligocene (certainly early Miocene). The green silty clay may represent the distal ends of turbidity currents which were being deposited as graded cycles in deeper parts of the basin at Site 210. The turbidites built to the level of the sea floor at Site 287 in about early late Pliocene time. The thickness of Pleistocene turbidites (about 90 m) is similar at both sites, as is the frequency of deposition (about one flow per 5000 yr).



BACKGROUND AND OBJECTIVES

Drilling at Site 210 (Burns, Andrews, et al., 1973) failed to reach basement after 711 meters of penetration. The deepest reflector at the site was estimated to be at 680 meters. The oldest sediment drilled at that site is late early Eocene. This means that the date of formation of the Coral Sea crust remained uncertain. It had not been resolved whether it was contemporaneous with the formation of the

---

[1] James E. Andrews, University of Hawaii, Honolulu, Hawaii (Co-chief scientist); Gordon Packham, University of Sydney, N.S.W., Australia (Co-chief scientist); James V. Eade, New Zealand Oceanographic Institute, Wellington, New Zealand; Brian K. Holdsworth, The University of Keele, Staffordshire, England; David L. Jones, U.S. Geological Survey, Menlo Park, California; George deVries Klein, University of Illinois, Champaign-Urbana, Illinois; Loren W. Kroenke, University of Hawaii, Honolulu, Hawaii; Tsunemasa Saito, Lamont-Doherty Geological Observatory, Palisades, New York; Samir Shafik, University of Adelaide, Adelaide, South Australia; Douglas B. Stoeser, University of Oregon, Eugene, Oregon (now at Cambridge Astrophysical Observatory, Cambridge, Mass.); Gerrit J. van der Lingen, New Zealand Geological Survey, Christchurch, New Zealand.

Tasman sea Basin (Late Cretaceous-Paleocene) or formed during the rifting of Australia from Antarctica (Eocene onwards).

The sequence drilled at Site 210 was as follows:

Unit 1—Graded cycles of silt and clay with interbeds of nanno ooze (0.470 m, late Pleistocene to middle Miocene).

Unit 2—Silty clay (470-521.6 m, early-middle Miocene).

Unit 3—Clay-bearing to clay-rich nanno chalk (521.6-540 m, early-middle Oligocene).

Unit 4—Clay-bearing micarb nanno chalk with minor chert (540-550 m, middle-late Eocene).

Unit 5—Clay nanno chalk to micarb clay (550-711 m, middle Eocene-late early Eocene).

Site 287 is located on the flank of an uptilted basement feature within the Coral Sea Basin, on which the preturbidite biogenic sequence appears to be exposed on the sea floor. Prior to the drilling of Site 210, the deepest reflector then known within the basin was taken to be basaltic basement; this reflector is now known to be at the top of the biogenic sequence and the basement reflector has been recognized below it. The unusual structure at Site 287 gives an opportunity to penetrate the oldest sediments in the basin below a minimum thickness of late Tertiary turbidites.

The proposed Site 287 was located on a R/V *Kana Keoki* seismic line from Site 210 to Fiji, 92 km east of Site 210 at 13°48'S, 153°15'E (Figure 1). On arrival at this location the structure was crossed at a point where the Oligocene and older sequence was covered entirely by the turbidites. An extension of the structure or another similar structure, where the older sediments were exposed on the sea floor, was located a little further to the south. The site drilled was at 13°55'S and 153°16'E.

The objectives at Site 287 were: (1) to try to reach basement and determine its age and nature; (2) to determine the date of formation of the structure by comparison of the sections at this site and Site 210; (3) to determine how the turbidite fill in the basin accumulated by determining the age and nature of the base of the turbidite sequence and by comparison with Site 210.

OPERATIONS

Site 287 was originally selected on the basis of a single reflection profile (*Kana Keoki*-71) which showed a portion of the Coral Sea basement and overlying pelagic sediments uplifted so that only a thin section of the basin turbidites need be penetrated to test the basement age. This was an objective not accomplished at Site 210 (Leg 21) due to the very thick section and time limitations at the end of a leg.

Site 287 was approached on a track nearly coincident with the *Kana Keoki* profile, but on crossing the location only a small basement uplift was found which did not satisfy the site requirements. At 0200, on 15 May 1973 a survey track was started (Figure 2). This identified a series of possibly en echelon structures, and the beacon was dropped at 0809, on 15 May 1973 on the northeast side of the largest of the structures identified. The approach track (Figure 3) shows several crossings of the structure, while the profile departing the site over the beacon (Figure 4) clearly shows the relation of basement, pelagic layer, and turbidite fill which was sought. The general location of Site 287 is shown in Figure 5.

A total of 18 cores were cut. Basalt was first cored in Core 287-16 and two additional basalt cores were cut. In several early cores rust knocked from the interior of the drill pipe was trapped behind the plastic sleeve in the core nose and resulted in several undersized cores. A sonobuoy profile (Figure 6) was shot on site (see Correlation of Reflection Profiles with Drilling Results).

The site was departed at 1700, on 17 May 1973.

LITHOLOGY

Hole 287, in the Coral Sea Basin, was drilled in a water depth of 4632 meters and was cored semicontinuously to 169.5 meters, continuously to 226.5 meters, and again continuously from 236 to 252 meters. Eighteen cores were taken and 72.2 meters of sediment recovered. A summary of each is given at the end of the chapter (Table 1) and plotted in Figure 17.

The cored sequence is divided into seven units. The upper five units are sedimentary, Pleistocene to lower middle Eocene in age and these are underlain by two igneous units that apparently predate the sedimentary sequence (Figure 7). Sediment compositions as determined from smear slides are given in Appendix A and plotted in Figure 8. Grain size, carbon-carbonate, and X-ray determination data for each site are in chapters collectively dealing with those subjects for Leg 30 elsewhere in this volume.

The units in descending order are:

Unit 1 (0-131.9 m): Graded rhythms of silt and clay with interbeds of nanno clay. Pleistocene to lower upper Pliocene.

Unit 2 (131.9-171.0 m): Olive to green silty clay with moderate amounts of mica. Unfossiliferous.

Unit 3 (171.0-171.6 m): Brown clay with moderate amounts of mica, micronodules, and zeolites. Unfossiliferous.

Unit 4 (171.6-179.3 m): Yellow-brown nanno ooze. Upper Oligocene.

Unit 5 (179.3-236.7 m): Yellowish-gray clay nanno chalk with moderate amounts of siliceous fossils, zeolite, micarb, and interbedded chert. Lower middle Eocene to lower Eocene.

Unit 6 (236.7-242.4 m): Porphyritic basalt.

Unit 7 (242.4-252 m): Basalt.

Unit 1: Graded Rhythms of Silt and Clay and Interbeds of Nanno Clay

Unit 1 consists of a 131.9-meter-thick sequence of graded cyclic beds of silt and clay (a few grading from silty sand to clay), interbeds of nanno clay, and a few calcareous graded cyclic beds of nanno to foram silt to nanno clay.

Each graded cycle of sandy silt or silt to clay consists of up to four recognizable parts distinguished from each other by color, texture, and mineralogy. Boundaries between parts are gradational.

1) Basal part. Greenish-black (5GY 2/1) sandy silt to silt. The smear-slide examination shows that feldspar, quartz, and mica are dominant with minor amounts of heavy minerals, pyrite, volcanic glass, foraminifera,

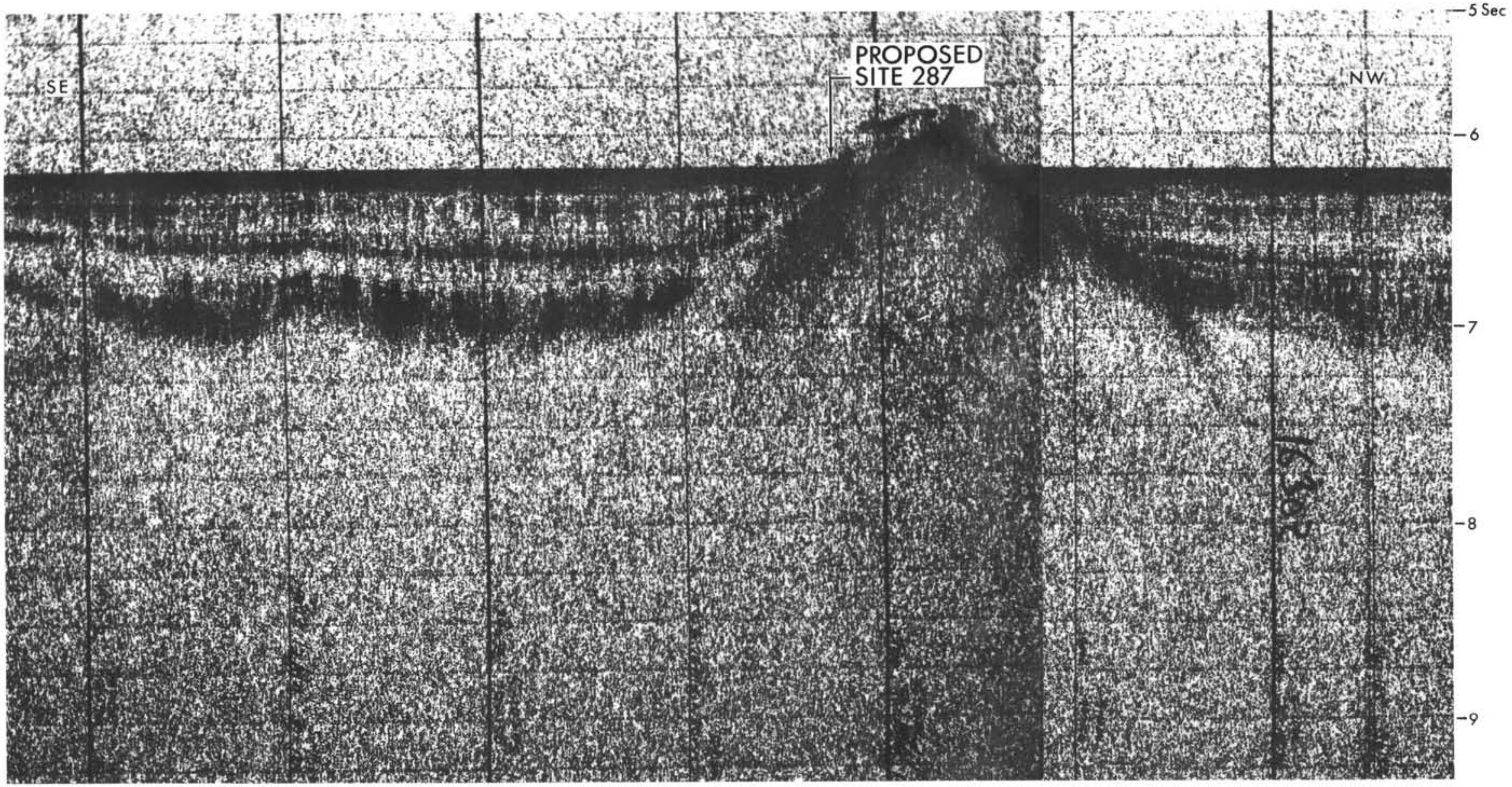


Figure 1. *Proposed Site 287 on seismic profile taken by R/V* Kana Keoki *(Leg 4, 1971, Hawaii Institute of Geophysics).*

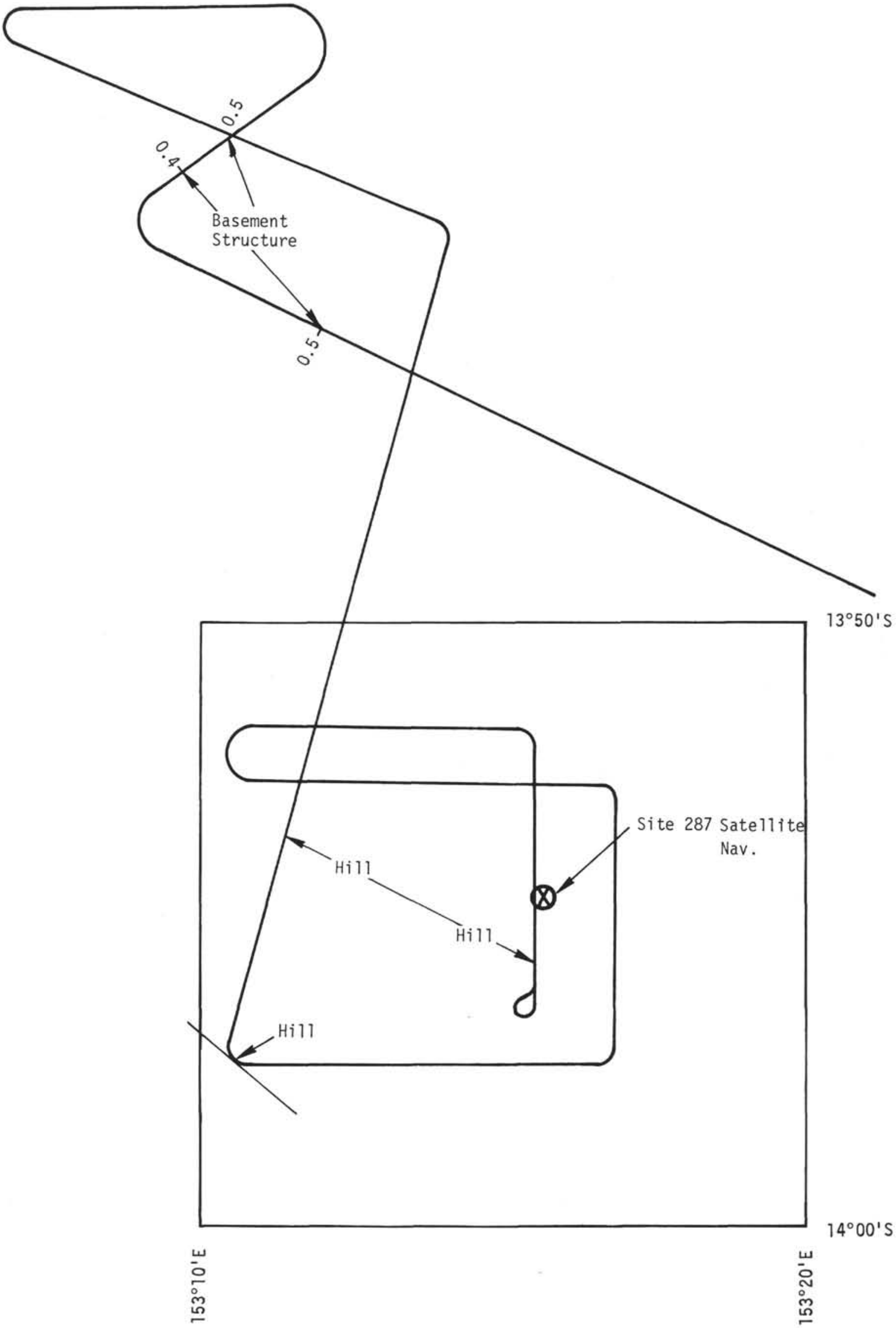


Figure 2. *Survey conducted by D/V* Glomar Challenger *before dropping beacon at Site 287.*

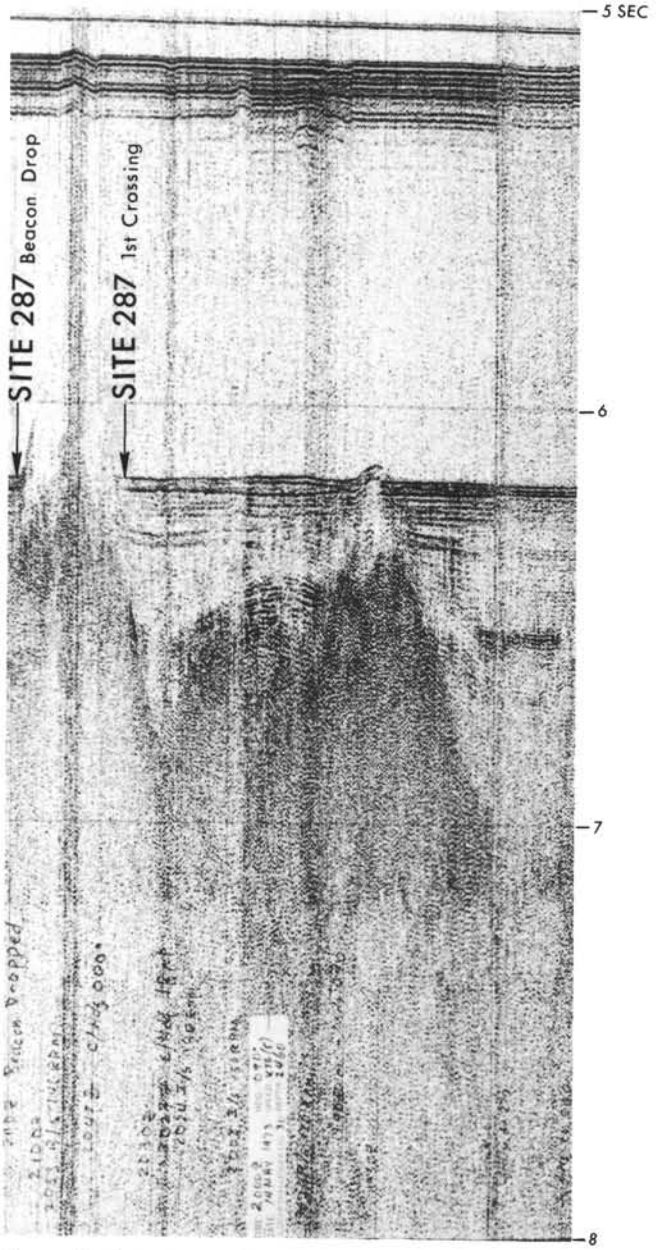


Figure 3. *Seismic profile taken on D/V* Glomar Challenger *on approach to Site 287.*

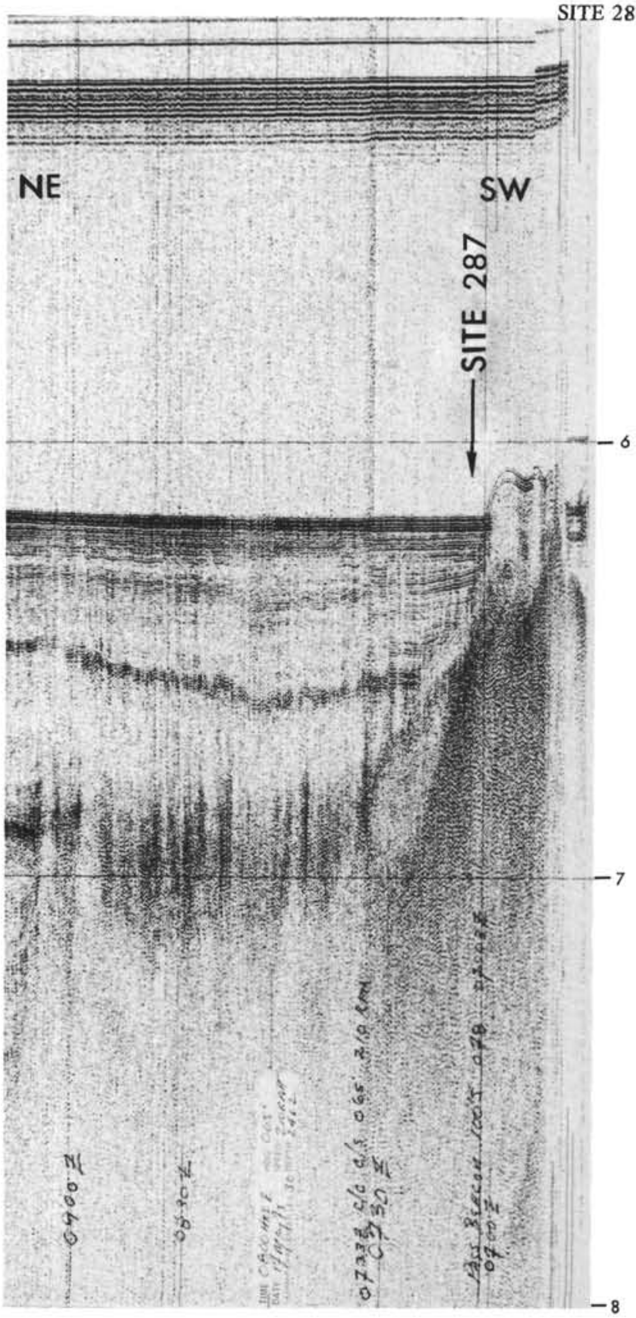


Figure 4. *Seismic profile taken on D/V* Glomar Challenger *on departure from Site 287.*

nannofossils, and plant fragments. In one sample (287-1-4, 72 cm) a few upper bathyal benthonic foraminifera are present with some plant fragments (see Paleontology section). The basal part overlies the preceding cycle with a sharp contact, sometimes erosional.

2) Lower middle part. Dark greenish-gray (5GY 3/1) clayey silt to clay. Dominant minerals seen in the smear slides are clay minerals and mica with minor feldspar, quartz, nannofossils, and foraminifera.

3) Upper middle part. Dark greenish-gray (5GY 4/1) silty clay to clay. Smear-slide examination shows a predominance of clay minerals with lesser quantities of mica, nannofossils, foraminifera, and feldspar. Bulk samples from the upper middle part of four different cycles were examined by X-ray diffraction, and the averaged results show that the main crystalline components are mica (29%), quartz (26%), and plagioclase, (17%) with minor potash feldspar, chlorite, montmorillonite, kaolinite, and calcite.

4) Upper part. Medium dark greenish-gray (5GY 5/1) clay. Clay minerals make up most of the sediment as seen in the smear slides while minor amounts of mica, nannofossils, foraminifera, and feldspar are also present. X-ray analysis of a bulk sample at 287-1-3, 131 cm from the upper part of a cycle shows that the crystalline phase is mostly calcite (24%), quartz (24%), mica (24%), and plagioclase (15%) with minor chlorite, kaolinite, montmorillonite, and potash feldspar.

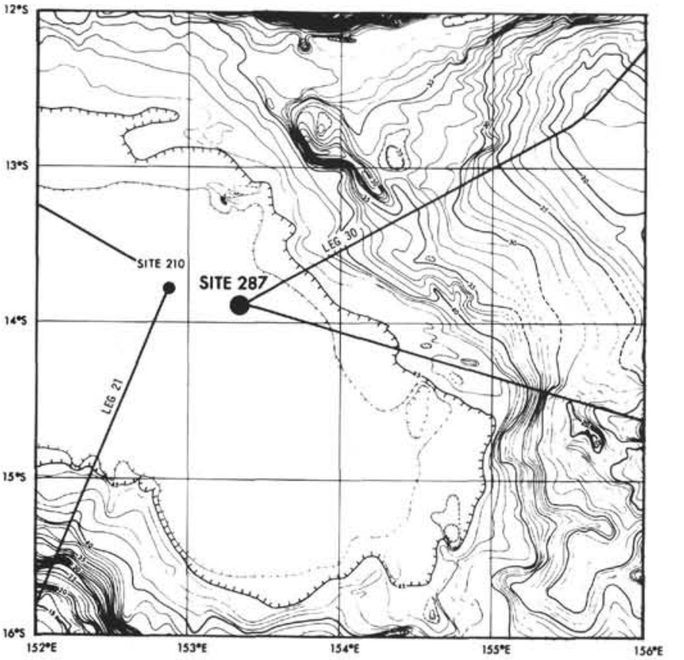


Figure 5. *Location of Site 287 (Leg 30) and Site 210 (Leg 21) in Coral Sea. Contours are in hundreds of meters. (Bathymetric map by Landmesser; see Landmesser et al., this volume.)*

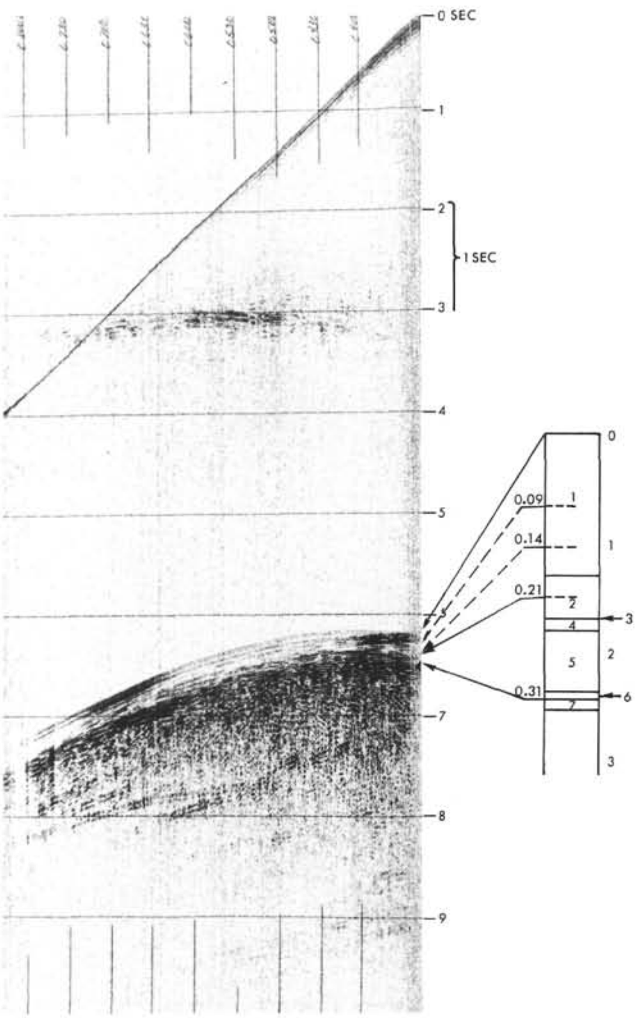


Figure 6. *On-site sonobuoy profile at Site 287 with column showing correlation of reflectors with lithologic units.*

Calcium carbonate percentages are low (14%) and vary little throughout each graded cycle. The average for each part of a cycle is between 8% and 10%.

A few pyrite-filled burrows occur near the middle of Unit 1 (Sections 287-5-2 and 287-5-3). Their relationship with the graded cycle and interbed sequence is obscure due to drilling disturbance, but they appear to occur in the central part of the graded cycle. Most graded cycles consist of a thin lower middle part or basal part (up to 5 cm thick) and thicker overlying parts (each about 5-25 cm thick). The following features suggests a turbidity current origin for the graded cycles:

1) Upward grading from coarser to finer sediment.

2) The predominance of terrigenous material (feldspar, heavy minerals, and plant debris).

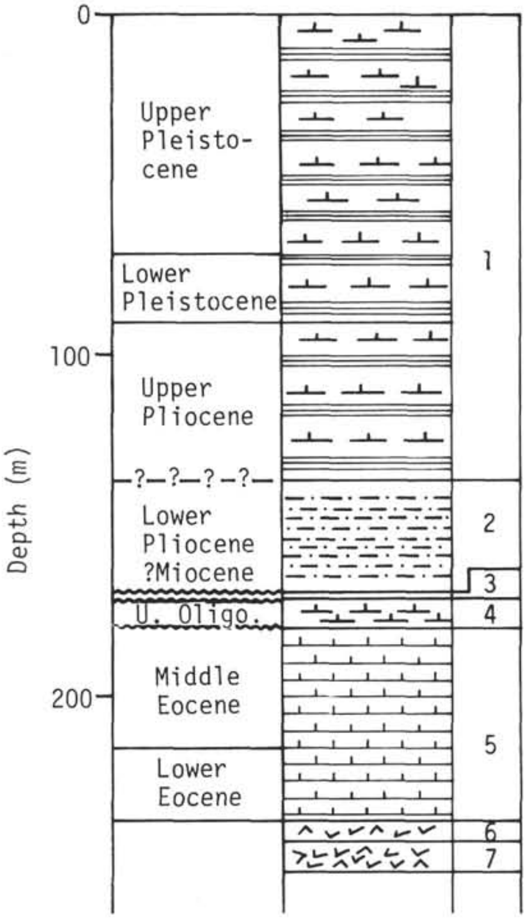
3) Scour evidence at the base of many cycles.

Nanno clay interbeds contain major amounts of clay minerals and nannofossils and minor amounts of volcanic glass and foraminifera. Each bed is uniform in color and texture and has sharp upper and lower contacts. Colors range from greenish-gray (5GY 6/1) to yellowish-gray (5GY 8/1), but are uniform within each interbed.

Three or four carbonate-rich graded cycles were seen in Unit 1. These consist of a nanno or foram silt at the base, grading upwards to a nanno clay. Colors are lighter than the graded cycles of silt and clay and range from moderate greenish-gray (5GY 5/1) to yellowish-gray (5GY 8/1). X-ray diffraction analysis of two bulk samples, one from the finer part of a carbonate-rich cycle (at 287-6-3, 122 cm), the other from the coarser part (at 287-6-3, 126 cm) show that the crystalline phase throughout the cycle is mostly calcite and aragonite (42% average for the fine and coarse parts), and quartz (24% average) with minor mica, plagioclase, kaolinite, and potash feldspar. Minor montmorillonite is also present in the finer part of the cycle. Some foraminifera and many nannofossils are reworked and many specimens of both are either fragmented or show high solution effects. Almost pure foraminiferal sand at one horizon near the base of the unit (Core 287-6-4) is not graded, but contains early Pliocene reworked faunas. Reworked Oligocene nannofossils occur throughout Unit 1. The carbonate-rich cycles and the reworked foraminiferal sand were probably derived locally from basement highs and from the margins of the basin where carbonate sediment lay in depths shallower than the foram solution depth. Burrowing structures are moderate to very common at many levels below Core 287-3. However, the relationship of these sturctures to bedding has been almost completely obscured by drilling disturbance. In Section 287-5-2 burrows appear to be concentrated in the uppermost part of the graded cycle, whereas elsewhere, especially Sections 287-5-4 and 287-6-3, burrows are concentrated in the central part of the cycle.

TABLE 1
Coring Summary, Site 287

Core	Date (May 1973)	Time	Depth From Drill Floor (m)	Depth Below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Recovery (%)
1	15	1910	4653.5-4661.5	0.0-8.0	8.0	8.0	100
2	15	2045	4671.0-4680.5	17.5-27.0	9.5	3.5	37
3	15	2200	4690.0-4699.5	36.5-46.0	9.5	1.1	12
4	15	2325	4709.0-4718.5	55.5-65.0	9.5	2.3	24
5	16	0055	4728.0-4737.5	74.5-84.0	9.5	9.5	100
6	16	0215	4747.0-4756.5	93.5-103.0	9.5	4.9	52
7	16	0350	4766.0-4775.5	112.5-122.0	9.5	0.4	4
8	16	0525	4785.0-4794.5	131.5-141.0	9.5	4.5	47
9	16	0700	4804.0-4813.5	150.5-160.0	9.5	2.7	28
10	16	0825	4823.0-4832.5	169.5-179.0	9.5	4.8	51
11	16	0955	4832.5-4842.0	179.0-188.5	9.5	9.4	98
12	16	1120	4842.0-4851.5	188.5-198.0	9.5	7.2	76
13	16	1300	4851.5-4861.0	198.0-207.5	9.5	3.4	36
14	16	1430	4861.0-4870.5	207.5-217.0	9.5	3.9	41
15	16	1620	4870.5-4880.0	217.0-226.5	9.5	2.4	25
16	16	2330	4889.5-4891.5	236.0-238.0	2.0	1.1	55
17	17	0330	4891.5-4896.0	238.0-242.5	4.5	3.3	73
18	17	0610	4896.0-4905.5	242.5-252.5	9.5	1.0	11
Total					157.0	73.4	47



Unit 1 (0-131.9 m) Graded cycles of silt and clay with interbeds of nanno clay.

Unit 2 (131.9-171.0 m) Olive to green silty clay with moderate amounts of mica.

Unit 3 (171.0-171.6 m) Brown clay with moderate amounts of mica, micronodules, and zeolites.

Unit 4 (171.6-179.3 m) Yellow-brown nanno ooze.

Unit 5 (179.3-236.7 m) Yellowish-gray clay nanno chalk with moderate amounts of siliceous fossils, zeolite, and micarb with interbedded chert.

Unit 6 (236.7-242.4 m) Porphyritic basalt.

Unit 7 (242.4-252 m) Basalt.

Figure 7. *Stratigraphic column for Site 287.*

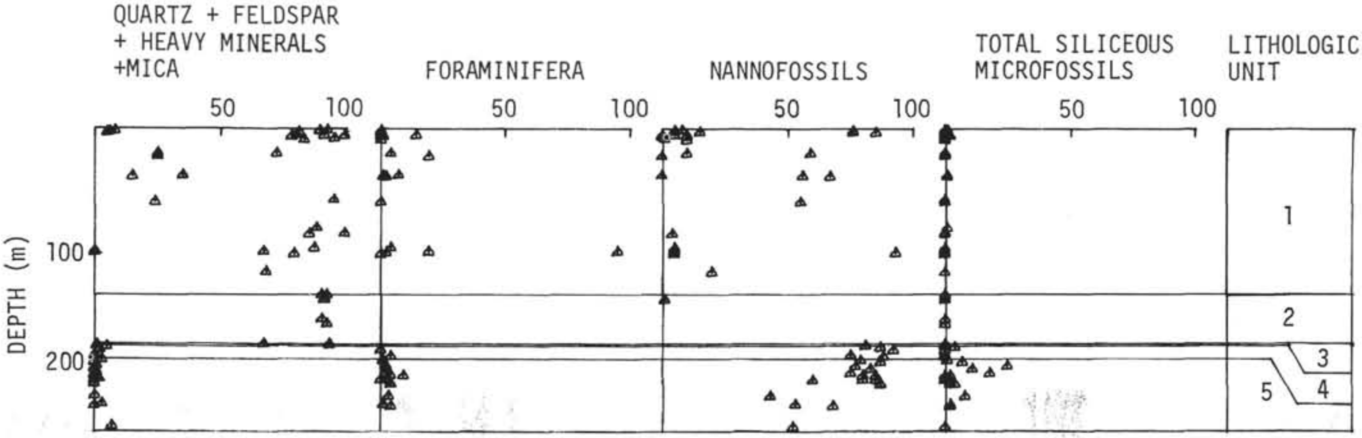


Figure 8. *Sediment composition as determined in smear slides.*

The base of Unit 1 is placed at the base of the lowest graded cycle which is seen in Core 287-8-1. Nanno clay interbeds occur immediately above this graded cycle, but were not seen below it.

Drilling disturbance is high throughout most of this unit and of the 30.1 meters of core recovered, bedding could be recognized with certainty in only 9.2 meters. In these relatively undisturbed parts of the core, 43 graded cycles and 11 interbeds of nanno clay were recognized. The average thickness for the graded cycles is 18 cm and for the nanno clay interbeds 12 cm. About 600 graded cycles are estimated to have been deposited during the 3 m.y. time span of Unit 1. If each graded cycle represents a single turbidite, then turbidity currents have been reaching this part of the Coral Sea Basin at an average rate of approximately one per 5000 yr for the last 3 m.y.

Unit 2: Olive to Green Clay and Silty Clay

This unit consists of 39.1 meters of clay and silty clay of which 7.1 meters of core was recovered.

Olive-gray to grayish-olive clay and silty clay with patches of yellowish-brown silty clay (in Core 287-8) overlie grayish-olive to dusky yellow-green silty clay (Core 287-9 and Core 287-10-1). Color changes are gradational and do not appear to reflect textural changes. Mineralogy is fairly uniform throughout the unit. Smear-slide examination shows a predominance of clay minerals with moderate amounts of mica and feldspar and minor amounts of heavy minerals, mica, pyrite, and zeolite. Two bulk samples (from 287-8-1, 50 cm and 287-9-2, 97 cm) examined by X-ray diffraction have a similar mineralogy. The averaged results show a predominance of mica (31%), plagioclase (24%), and quartz (23%) with minor amounts of chlorite, montmorillonite, and potash feldspar. Plant debris occurs at 287-8-3, 61 cm, but apart from this, the unit is unfossiliferous.

Bioturbation and mottling are moderate in the upper part of the unit down to Core 287-9-2, but neither are clearly visible as color differences are slight and drilling disturbance is high.

Unit 2 is very similar in color, grain size, and mineralogy to the upper middle part of the graded cycles of Unit 1. Because of these similarities and from a comparison of Site 287 with Site 210, Unit 2 is considered to have been formed in a manner similar to that of Unit 1. Unit 2 is interpreted as representing the first phase of sedimentation that is predominantly terrigenous in the Coral Sea Basin. The beginning of this phase in the deeper parts of the basin probably corresponds to initial uplift and erosion of the New Guinea mobile belt in the late Paleogene and early Neogene.

The base of Unit 2 is placed at an apparent abrupt color change (reflecting a change in mineralogy) from grayish-olive of Unit 2 to moderate brown of the underlying unit that takes place between Sections 287-10-1 and 287-10-2.

Unit 3: Brown Silty Clay

This unit, 0.6 meters thick, was totally recovered and consists of moderate brown micronodule and zeolite-rich mica and silty clay. The sediment is predominantly moderate brown and dark yellowish-brown clay. The slight variations in color do not reflect variations in grain size which remains uniform throughout. Smear-slide examination shows a predominance of clay minerals with moderate amounts of micronodules and zeolite and minor amounts of mica, feldspar and opaque minerals. An X-ray analysis of a bulk sample from 287-10-2, 40 cm shows that the crystalline phase is mostly plagioclase (21%), montmorillonite (19%), zeolite (19%), and quartz (17%) with minor amounts of mica, potash feldspar, kaolinite, and chlorite.

A late Oligocene age, the same age as the uppermost part of the underlying nanno ooze, was determined from a poorly preserved nannofossil fauna 52 cm above the base of the unit. As there is visual evidence of burrowing activity in the lower part of the unit and as the age of Unit 3 at Site 210 is early to middle Miocene, the late Oligocene flora in Unit 3 is considered to be reworked. It is unlikely that nonaccumulation of sediment would occur at Site 210 when nearby on the exposed basement high at Site 287 sediment was accumulating. Therefore, the age of Unit 3 at Site 287 probably lies within the age range of the same unit at Site 210 (early to middle Miocene), Figure 9.

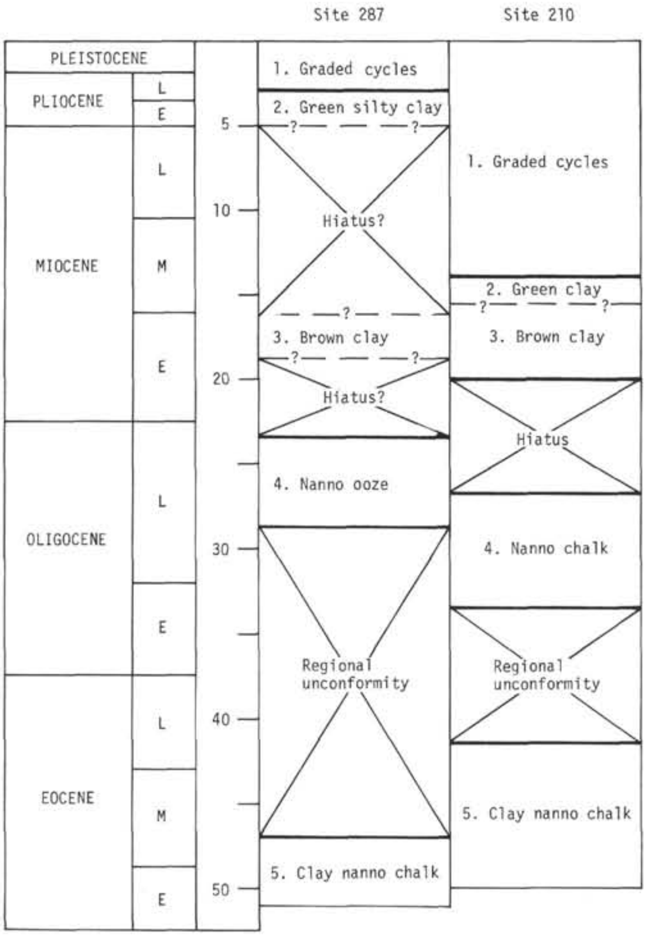


Figure 9. *Tentative age correlation of Sites 287 and 210. (Time scale from Berggren, 1972; unit terminology for both sites is that used for Site 287.)*

The color difference of grayish-olive in Unit 2 from the moderate brown of Unit 3 is due largely to the presence of greater amounts of micronodules in Unit 3 (15% average in smear-slide determinations) than in Unit 2 (1% average). Unit 3 also differs from Unit 2 in having a finer grained sediment and a much higher proportion of zeolites and montmorillonite. Mica and chlorite are less common in Unit 3 than in Unit 2.

Drilling disturbance is high in the upper part of the unit and bedding and bioturbation, if present, are indistinguishable. Near the base, bioturbation is slight. At the base of the unit there is an intensely bioturbated zone of dark yellowish-brown clay with flattened burrows and streaks of moderate yellowish-brown clay. This zone is about 5 cm thick and forms a transitional layer from dark yellowish-brown clay of Unit 3 to the underlying moderate yellowish-brown nanno ooze of Unit 4.

The base of Unit 3 is arbitrarily put at Sample 287-10-2, 57 cm, the center of the transitional bioturbated layer.

Unit 4: Nanno Ooze:

Unit 4 consists of 7.7 meters of moderate yellowish-brown to grayish-orange stiff nanno ooze of which 4.1 meters were recovered.

Nannofossils are the predominant constituent from smear-slide examination. Minor constituents include micronodules, glass, zeolite, pyrite (or an opaque mineral), and clay minerals. Nannofossils are poorly preserved and fragmented especially in the uppermost part of the unit. Foraminifera are scarce and poorly preserved throughout the unit.

X-ray analysis of a bulk sample from Sample 287-10-3, 60 cm shows the crystalline phase to be almost entirely calcite (92%) with minor potash feldspar plagioclase, quartz, and zeolite (both phillipsite and clinoptilolite).

The uniform nature of the sediment is modified only by slight to moderate mottling caused by burrowing by indeterminate organisms. Drilling disturbance is slight to moderate.

The base of Unit 4 lies at 287-11-0-27 cm where there is a sharp contact between the stiff, moderate yellowish-brown nanno ooze of Unit 4 and underlying semilithified yellowish-gray clay nanno chalk of Unit 5.

Unit 5: Clay Nanno Chalk

Unit 5 consists of 57.4 meters of yellowish-gray semilithified clay nanno chalk of which 25.8 meters were recovered.

Abundant, moderately preserved nannofossils, clay, and minor, well-preserved foraminifera are characteristic of this unit. Zeolite, micarb, chert, and siliceous fossils, especially Radiolaria, are also seen in smear slides, but concentrated in zones within the unit.

An X-ray analysis of a bulk sample from Sample 287-14-3, 100 cm shows the crystalline phase to be mostly calcite with small amounts of quartz, mica, montmorillonite, zeolite (clinoptilolite), and cristobalite.

Several thin siliceous-rich beds, consisting of Radiolaria (50%-80%) and sponge spicules, occur in Core 287-12. These are light olive-gray in color and have the same texture and degree of lithification as the clay nanno chalk in which they occur. The color change is not sharp, but takes place over 1-2 mm, giving the boundaries a fuzzy appearance. A few centimeters above one of the siliceous beds the nannofossils are very poorly preserved and are present largely as fragments. Thin, lithified cherty beds with adjacent clay nanno chalk with poorly preserved nannofossils interbedded with the clay nanno chalk with well-preserved nannofossils occur throughout Core 287-13 and between the top of Core 287-16 and Sample 287-16-1, 72 cm, the base of Unit 5. The cherty layers, like the siliceous-rich beds, show a change in color to light olive to light bluish-gray. A section of zeolite-rich nanno chalk occurs between Samples 287-14, CC and 287-15, CC. This is light bluish-gray in color. Pyrite is locally concentrated in thin black streaks and spots at three levels in the upper part of the unit (Cores 287-11-1 and 287-11-2). Calcium carbonate percentages are fairly uniform and moderately high (50%-68%) (Figure 10).

Faint scattered mottling occurs in the upper part of the unit (above Section 287-11-4). Mottling is moderate to intense in the basal 0.5 meters where there are many flattened worm burrows.

The base of Unit 5 is at the sediment-porphyritic basalt contact at 287-16-1, 72 cm. In the lowest recovered section containing sediment (287-16-1), the

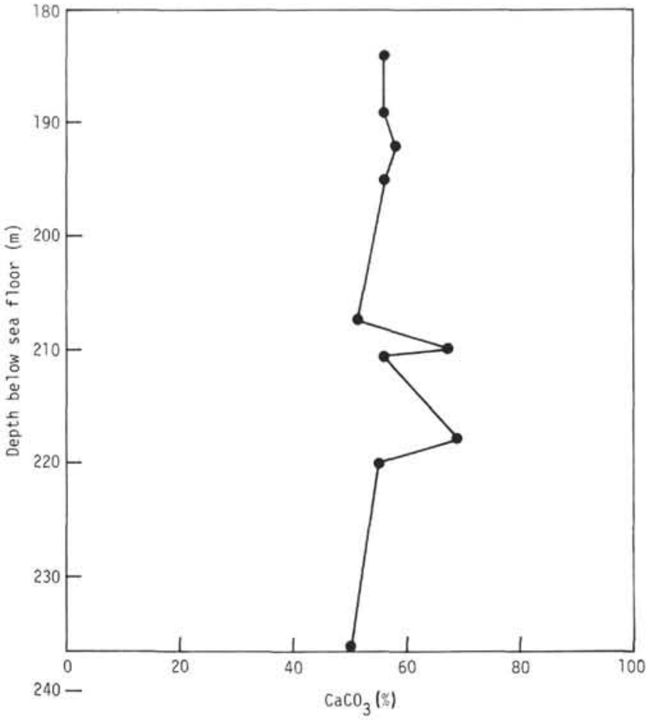


Figure 10. *Calcium carbonate determinations in Unit 5 at Site 287.*

sediment color is darker (dark olive-gray) than sediment in the rest of the unit. Sediment in contact with the porphyritic basalt in Section 287-16-1 is unaltered clay nanno chalk.

Unit 6: Porphyritic Basalt

Basalt was encountered at 236.7 meters. The porphyritic basalt is 5.7 meters thick and overlain by discolored but otherwise unaltered micarb nanno chalk and underlain by another basalt. The Unit 6 basalt is characterized by abundant phenocrysts and glomerocrysts of plagioclase and olivine set in a groundmass whose texture varies from intersertal to subophitic. The porphyritic basalt is interpreted as an extrusive flow based on its textures and the lack of baking of the overlying sediments.

Unit 7: Basalt

Nine and one-half meters of this basalt were penetrated before drilling was stopped, with a recovery of only 1 meter of basalt. The Unit 7 basalt has very sparse small phenocrysts of plagioclase and serpentinized olivine set in a groundmass whose texture grades downwards from a quench texture. This unit is interpreted as an older flow which underlies the Unit 6 flow.

The Unit 6 and 7 basalts are described in detail by Stoeser (this volume).

Breaks in the Sedimentary Sequence at Site 287

A sharp break, visibly defined by differences in color and consolidation, separates Units 4 and 5. Upper Oligocene faunas and floras in stiff yellowish-brown ooze (Unit 4) above the break overlie middle Eocene faunas and floras in semilithified yellowish-gray chalk (Unit 5) below the break (Figure 9).

Other breaks in the sequence are probably present between Units 2 and 3 and between Units 3 and 4. Both Units 2 and 3 are unfossiliferous (apart from a reworked flora in Unit 3) and therefore there is no stratigraphic evidence for either of these breaks. The combined sediments of Units 2 and 3 are 39.7 meters thick and fill a gap of 20 m.y. from the end of Unit 4 in late Oligocene time to the beginning of Unit 1 in the late Pliocene. This represents a minimum average rate of accumulation of 2 meters per million years. At Site 210, where the sequence is thicker and therefore probably more complete, the minimum rate of accumulation for Units 2 and 3 is 4 meters per million years (Burns, Andrews, et al., 1973). As there is very little difference in lithologies between the two sites, the sedimentation rates were probably similar at both sites. If this is the situation, and it seems most likely, then there must be at least one break at Site 287 between the top of Unit 4 and the base of Unit 1. There is no evidence of a break between Units 1 and 2. The contact between Units 2 and 3 is sharp and therefore probably represents a break in the sequence. It also seems probable that the ages of the brown clay of Unit 2 are the same at both sites further supporting the existence of a break between Units 2 and 3 at Site 287. The gradational contact between Units 3 and 4 occurs over a narrow zone (about 5 cm) in which the sediment is highly bioturbated. This contact may also represent a break in the sequence and without burrowing activity would possibly have been preserved as a sharp contact. A break has also been proposed between Units 3 and 4 at Site 210 (Burns, Andrews, et al., 1973).

Comparison With Site 210 Coral Sea

Both the type of sediments and the stratigraphic sequence at Site 287 are very similar to those at Site 210, which is 43 km to the east of Site 287 (Figure 11). All

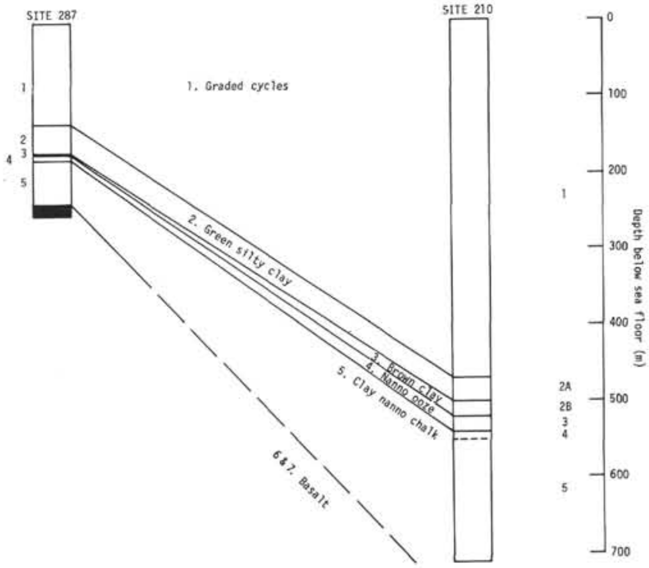


Figure 11. *Comparison of thicknesses of lithologic units and their depths below the Coral Sea Abyssal Plain at Sites 287 and 210.*

five sedimentary units at Site 287 occur at Site 210 and at both sites mineralogy, color, and structure are almost the same. Structures are not as readily identifiable at Site 287 as they are at Site 210, due to drilling disturbance at Site 287.

The greatest difference between the two sites is the thickness of the sequence (Figure 11) and especially the thickness of the graded cyclic sequence (Unit 1) and to a lesser extent the brown clay (Unit 3) and the Eocene clay nanno chalk (Unit 5).

At Site 287, Unit 1 is 131.9 meters thick compared to 470 meters for the graded cyclic sequence at Site 210. Unit 3, the brown clay is only 0.6 meter thick at Site 287 and 21.1 meters thick at Site 210. Unit 5, the Eocene clay nanno chalk is 57.6 meters thick at Site 287 and 171 meters thick at Site 210. The olive-green silty clay unit and Oligocene nannofossil unit are only slightly thicker at Site 210.

Sequence of Events in the Coral Sea Basin

Volcanic Phase

Basaltic lava flows were extruded at Site 287 prior to the deposition of the lower Eocene clay nanno chalk.

Early-Middle Eocene

Accumulation of biogenic pelagic sediment (nannofossils, foraminifera, and Radiolaria) and detrital clay began in the lower Eocene at Site 287 and continued throughout the middle Eocene with little variation in the proportions of the various constituents being supplied. One exception is the supply of Radiolaria which reached peaks at different times in different parts of the basin. Maximum radiolarian supply occurred at times represented by the lowest part and the middle of Unit 5 and Site 287 and later at Site 210. Water depths were above foram solution depth at both sites.

Middle Eocene-Early Oligocene Unconformity

The time gap between Units 4 and 5 (Figure 9) represents an erosional hiatus probably produced by a major bottom water current that swept north past eastern Australia and New Guinea in early and middle Oligocene times (Kennett et al., 1972; Kennett, Houtz, et al., 1975; Edwards, this volume). Some Eocene sediment was probably eroded away and deposition of further pelagic sediment was prevented by the current during the early Oligocene. More of the Eocene is represented at Site 287 than at Site 210. It seems certain, therefore, that the basement high at Site 287 existed at least as early as the early Oligocene and was probably formed at the same time as the basin was formed.

Late Oligocene

Pelagic sedimentation (nanno oozes) resumed at Site 210 in the late early Oligocene and at Site 287 during the early late Oligocene. The waning bottom current prevented deposition at the higher and more exposed Site 287 for a longer period than in the deeper parts of the basin, i.e., Site 210. During the late Oligocene both sites were at water depths just above the foram solution depth, indicating progressive deepening of the basin since Eocene times.

Late Oligocene-?Early Miocene

A period of nondeposition and/or erosion apparently occurred at both sites during the late Oligocene (Figure 9) and probably into the early Miocene. Deepening of the basin occurred about this time from just above the foram solution depth to below the nanno solution depth.

Early Miocene

Quiet conditions existed and brown abyssal clay was deposited below the nanno solution depth.

Middle to Late Miocene

Terrigenous sedimentation commenced at Site 210 as bottom suspension flows from the shelf off Papua, New Guinea spread further from the shelf into deeper parts of the shelf to Coral Sea Basin. Later in the middle Miocene as the basin filled with sediment, turbidite deposition began at this site. Conditions and events at Site 287 for this time are not known. Abyssal clay may have been deposited at this time as water depths probably remained below the nanno solution depth. A tentative interpretation is shown in Figure 9.

Late Miocene-Pleistocene

Turbidite deposition continued at Site 210. In the late Miocene or early Pliocene deposition from bottom suspension flows began at Site 287 and green silty clay was deposited. Turbidite deposition finally started at Site 287 in the early late Pliocene. Subsequently, water depths, which were greater at Site 210 than at Site 287 up to this time, became about the same and have remained the same to the present day. The nannofossils in the turbidites were probably picked up by the currents in basin depths less than the nanno solution depth before the currents flowed into deeper water. The nannofossil clay interbeds and graded carbonate-rich cycles contain many reworked Oligocene fossils that probably were derived from local highs or the sides of the basin where Oligocene nannofossil ooze was exposed. Deposition of these carbonate-rich beds must have been rapid, similar to the rates from turbidite deposition, as the basin floor had sunk below the nanno solution depth in the late Oligocene to early Miocene and is still below the nanno solution depth at present. Where coarse sediment is present, the carbonate-rich cycles are graded, suggesting a turbidity current origin for these cycles. The derived nannofossils in the nannofossil clay interbeds suggest a similar origin for these beds.

GEOCHEMICAL MEASUREMENTS

Results of *p*H, alkalinity, and salinity measurements made on samples from cores at Site 287 are given in Table 2 and shown in Figure 12.

Salinity values are quite constant, but *p*H and alkalinity show increases and decreases, respectively, throughout the turbidite sequence although the mineralogy of the sediments remains constant. In the

TABLE 2
Summary of Shipboard Geochemical Measurements, Site 287

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			8.41/8.35	2.35	35.6
1-5, 144-150	6.44-6.50	22.2	7.49/7.54	6.35	35.2
4-1, 144-150	56.94-57.00	22.0	7.69/7.98	4.50	35.2
6-3, 144-150	97.94-98.00	21.8	7.62/8.03	1.47	34.2
10-3, 144-150	173.94-174.00	22.1	7.55/7.46	1.47	34.9
13-2, 144-150	200.94-201.00	21.4	– /7.38	1.56	35.2
15-2, 144-150	219.00-220.00	21.4	– /7.55	0.78	35.2

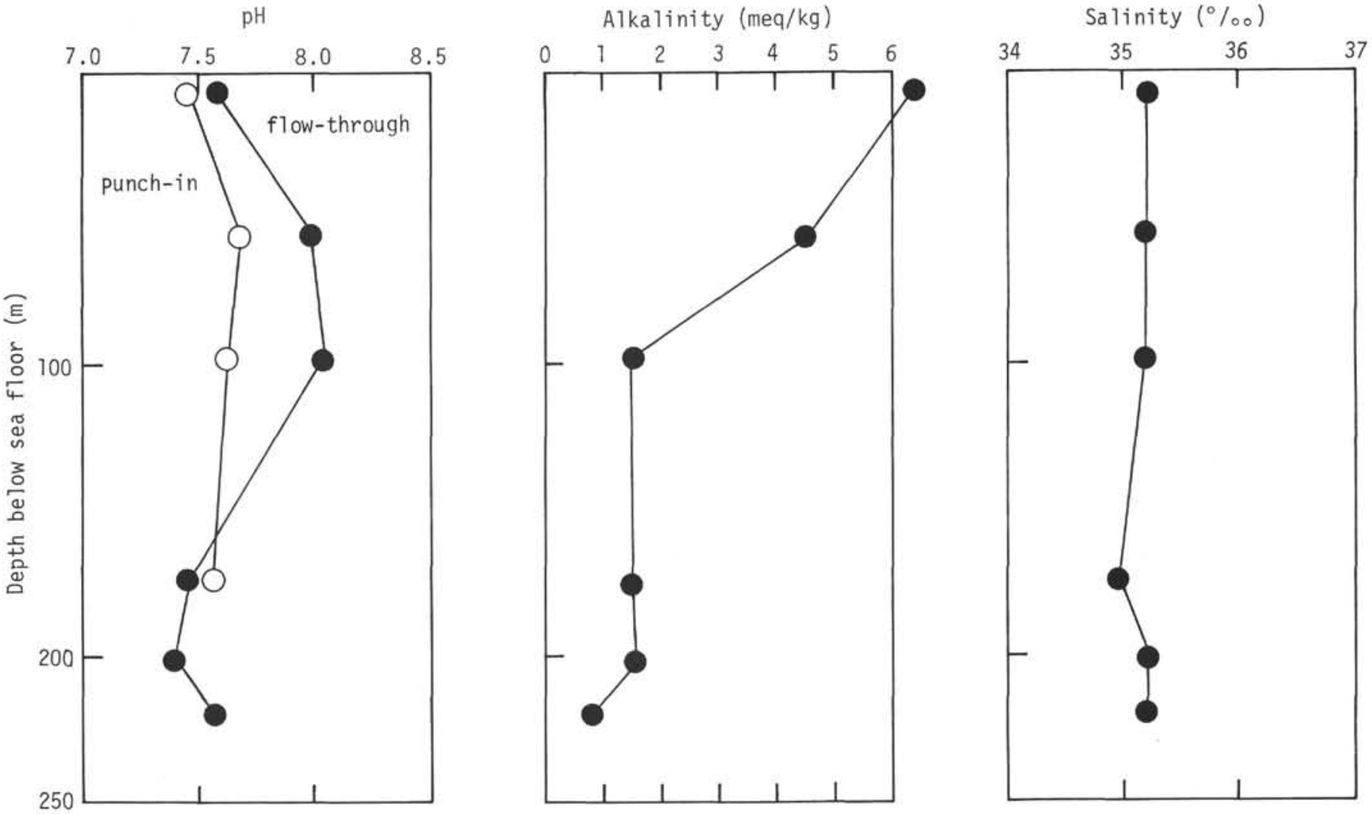


Figure 12. *Graphic summary of geochemical data taken at Site 287.*

Oligocene and Eocene oozes and chalks, the *p*H and alkalinity values are low. The parameters in these sediments may be influenced by the relative abundance of zeolites in them. *p*H shows a wider than normal variation in values for the two methods, but the 8.0 values are typical of siliceous materials at Sites 285 and 286.

PHYSICAL PROPERTIES

Sonic velocity, wet-bulk density, and porosity were measured on samples obtained from cores taken at Site 287, and acoustic impedance and grain density were again calculated based on these measurements. Methods and procedures are the same as those described for Site 285. The results obtained at Site 287 are shown in Figure 13. Although cores were not sampled as frequently at Site 287 as they were at the previous sites, the good correlation between the sonic velocity and the density and porosity curves suggests that the results are fairly reliable.

As was the case at the previous sites, density and porosity are almost mirror images, with velocity again paralleling density. Bulk density ranges from about 1.45 g/cc to about 1.85 g/cc. Porosity ranges from about 75% to about 50%. Grain density, as was seen in the data from other sites, varies considerably probably due again to volumetric errors in the spring determinations. Velocity anisotropy appears to develop below approximately 180 meters and is established above the basalt at the bottom of the hole (Core 287-16).

As was the case in the previous sites, the vertical velocity was used to calculate acoustic impedance. Changes in sonic velocity are very slight, with the velocity ranging from 1.50 to 1.75 km/sec. Problems were experienced in measuring samples from in the first four

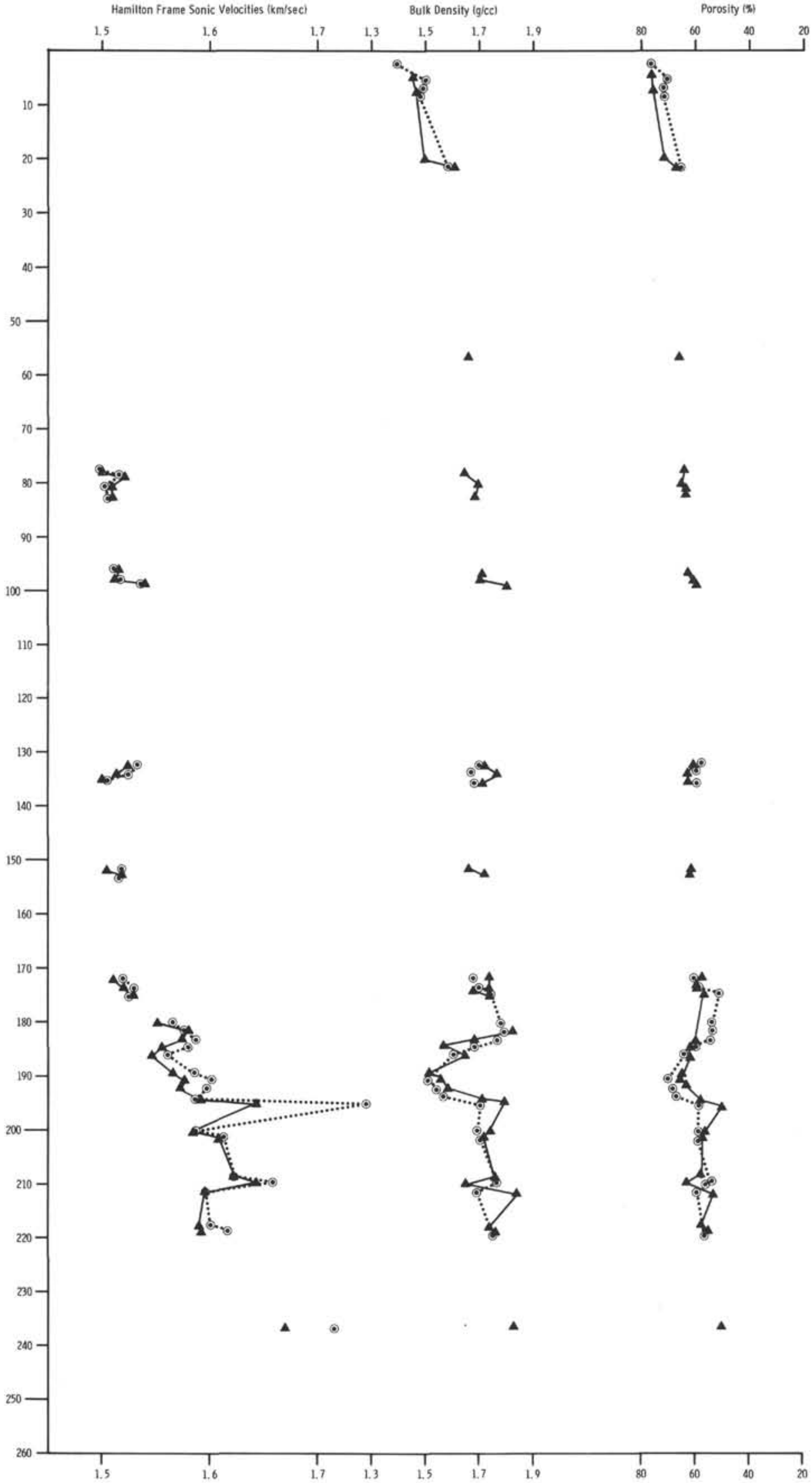


Figure 13. *Graphic summary of shipboard physical properties measurements. Horizontal acoustic velocity, grape density, and grape porosity are shown as a dotted line; vertical velocity, syringe density, and syringe porosity are shown as a solid line.*

cores and these results are not shown in Figure 13. A minor velocity reversal (from 1.53 to 1.50 km/sec) occurs at the top of the clay from Unit 2, described in the lithologic summary. Major excursions of the density and porosity curves (Figure 13) occur between 180 and 200 meters subbottom (across Units 3 and 4, and in the upper part of Unit 5). Minor fluctuations in the sonic velocity also occur here (less than 0.1 km/sec). Changes in lithology and the presence of a major hiatus together with a regional unconformity in this part of the sedimentary section are most likely responsible for changes observed in the physical properties.

Velocity measurements on the basalt cored at Site 287 are shown in Figure 14. The velocity of the upper basalt flow is 5.01 km/sec at the top, decreasing initially to 4.69 km/sec (Sample 287-17-3, 43 cm) and then increasing to 6.16 km/sec near the bottom of the flow (Sample 287-17-3, 144 cm). In contrast, the velocity of the basalt near the top of the lower flow is much lower, averaging 4.08 km/sec (Sample 287-18-1, 95 cm).

CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

Site 287 is located at the base of the surface expression of a prominent basement structure. Because of the proximity and the steep slopes on the structure, reflectors are obscure on the underway profiles (Figures 3 and 4)—small errors in position resulting in large changes in reflector depth. The sonobuoy profile (Figure 6) shows a series of reflectors to over 1 sec—presumably also the result of the slope of the adjacent structure.

Reflectors are recognized at 0.09, 0.14, 0.21, and 0.31 sec (see Figure 6 annotated sonobuoy profile). These correspond to depths of 68 meters (0.09), 105 meters (0.14), 150 meters (0.21), and 240 meters (0.31). The 0.31-sec reflector is the basalt at the base of the section. The signal is weak and masked by side echoes. There is a small velocity, density, and porosity excursion at 99 meters—probably the 0.14-sec reflector—and a velocity and density excursion at 150 meters.

The physical property variations which appear in Unit 5 (179 to 237 m) may be represented in the indistinct group of signals above the 0.31-sec reflector. Slope considerations obscure the relationship.

PALEONTOLOGY

Foraminiferal and calcareous nannofossil assemblages encountered in 16 sediment cores recovered from Site 287 enable the recognition of three distinct biostratigraphic units.

I. Quaternary to late Pliocene (Sections 287-1-1 to 287-8-1) Barren interval (Sections 287-8-2 to 287-10-1)

II. Late Oligocene (Core 287-10-2 to 287-11-0) Disconformity (Sample 287-11-0, 27 cm)

III. Early to middle Eocene (Sections 287-11-0 to 287-16-1)

I) While the lower part of Sections 287-1-1 is totally devoid of any microfossils, calcareous microfossils appear at many other levels within Unit I. However, their abundance and states of preservation vary greatly at different levels. Only at a few levels do common and well-preserved foraminiferal tests occur. Similarly, few to common nannofossils, usually of moderate preservation, occur at comparable levels. Collectively, foraminifers as well as nannofossils show signs of dissolution, and at several levels only the solution-resistant species occur. Radiolaria faunas are virtually absent from this unit, with the exception of some traces of actinommids, spyroids, and orosphaerid debris found in Sample 287-1, CC. The occurrence of reworked calcareous nannofossils, mostly as old as the Oligocene, throughout the unit is notable. Fluctuation of the total nannofossil dissolution depth during the sedimentation of this unit is inferred.

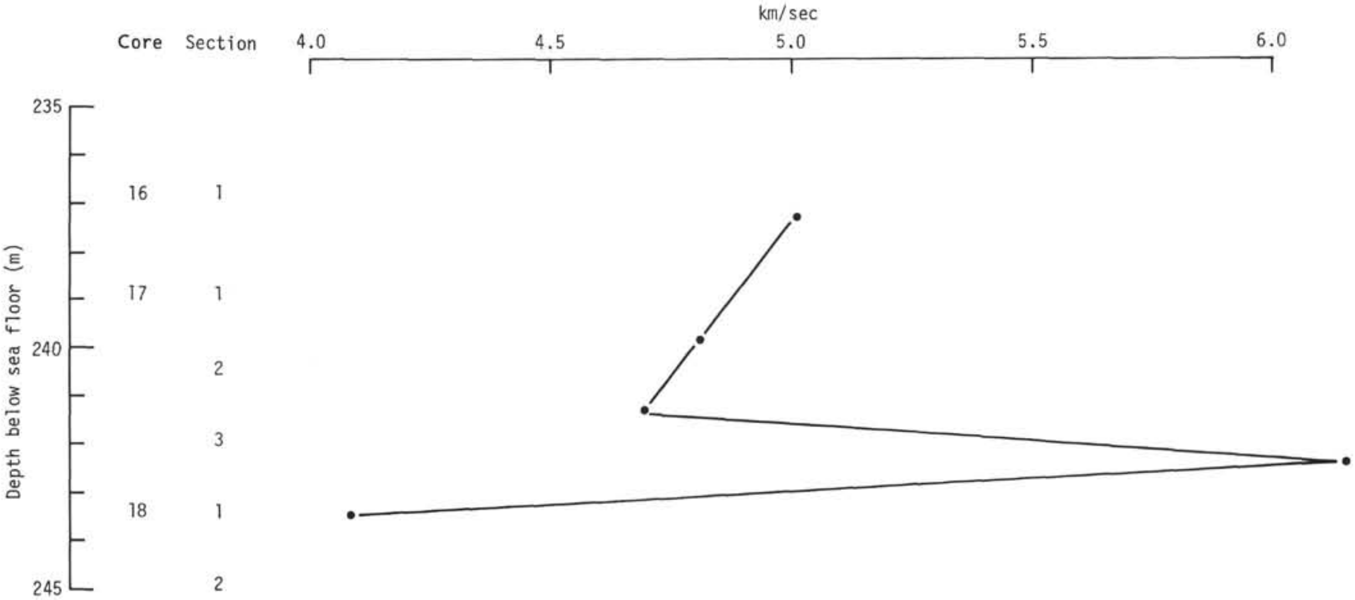


Figure 14. *Acoustic velocities measured in Units 6 and 7 (basalt) at Site 287.*

The foraminiferal sequence recovered from the cores of this unit can be related to the absolute chronology of the geomagnetic time scale, and the Pliocene-Pleistocene boundary is placed between Samples 287-5-6, 147-149 cm and 287-6-1, 128-130 cm. The interval between Sections 287-6-1 and 287-8-1 is dated as late Pliocene on the basis of foraminiferal as well as nannofloral evidence.

The age of the barren interval is indeterminable. Deposition of the sediments of this interval occurred at a deeper level than the total nanno dissolution depth.

II) The late Oligocene unit contains scarce and poorly preserved foraminiferal assemblages. However, low diversified calcareous nannofossils extracted from this unit are common and of rather moderate preservation. Good Radiolaria faunas are absent from this unit and only traces are found in 287-10, CC. Deposition of the sediments of this unit occurred below the carbonate compensation depth, but above the total foram dissolution depth.

The unit contains nannoflora of the *Sphenolithus distentus* Zone in Samples 287-11-0, 24 cm to 287-10, CC and the *S. ciperoensis* Zone in Sample 287-10-4, 120-121 cm to Sample 287-10-2, 4-5 cm of Shafik (1973). Foraminiferal results are correlative with the nannofloral zonal assignments. Reworked middle Eocene foraminifera associated with Oligocene forms are observed in Sample 287-11-0, 22-24 cm.

A sharp lithological break exists in Sample 287-11-0, 27 cm, which coincides with a drastic change in the calcareous microfossil assemblages, indicating a disconformity between the upper Oligocene and the middle Eocene.

III) Planktonic foraminifera, calcareous nannofossils, and Radiolaria coexist in this unit. Common to abundant and well-preserved foraminifera are found throughout the unit. The nannofossils are common but of poor to moderate preservation. Rich to common and well-preserved radiolarian faunas occur only in Sections 287-11-6 to 287-12-4. The abundance and quality of preservation of the Radiolaria decreases rapidly downwards to only traces of recrystallized specimens in 287-15, CC and 287-16-1. Core 287-16-1 contains poorly preserved foraminiferal as well as nannofossil assemblages. Reworked early Paleocene planktonic foraminifera are recorded in Core 16-1. Deposition of most of this unit occurred above the carbonate compensation depth.

Analyses of planktonic foraminifera suggest that faunal provincialism existed in the southwestern Pacific region during early middle Eocene time. The present site, influenced by cool waters, was separated from Site 286 and New Zealand where much warmer waters prevailed. Such an interpretation requires either the Eocene position of the Coral Sea to have lain in latitudes higher than New Zealand and the Site 286 area, or the existence of a cool Eocene current system flowing in a narrow zone closely following the present configuration of Australia (see Kennett, Houtz, et al., 1975; Edwards, this volume).

Nannofossils indicate, however, a different situation. The assemblages extracted from this unit include *Discoaster* representatives predominating over species of *Chiasmolithus*. Such arelationship indicates warming during the middle Eocene at the present site.

Excellent biostratigraphic control by means of the calcareous microfossils is achieved for this unit. The segment of Samples 287-11-0, 31-33 cm to 287-12-1, 105-107 cm is assigned to the middle Eocene Zone P11. Assignment of Samples 287-12-2, 60-62 cm through 287-14, CC to the basal middle Eocene Zone P10 is based on the occurrence of the foraminifera *Globigerina boweri*. Core 287-15 is assigned to the early Eocene Zone P9. Calcareous nannofossils recovered from this unit provide a basis for further biostratigraphic subdivisions. Samples 287-11-0, 29-30 cm to 287-11, CC belong to the *Chiasmolithus gigas* Zone. Cores 287-12 and 287-13 are assigned to the *Nannotetrina fulgens* Zone. Cores 287-14 and 287-15 are placed in the *Discoaster sublodoensis* Zone; Core 287-14 belongs to the basal middle Eocene *Rhabdosphaera inflata* Subzone and Core 287-15 belongs to the lower Eocene *Discoasteroides kuepperi* Subzone. The sediments immediately above the basalt in Core 287-16-1 are assigned to the foraminiferal Zone P.8 and the nannofossils *Tribrachiatus orthostylus* Zone. Samples 287-11-6, 28-30 cm to 287-12-4, 70-72 cm fall within the upper half of the radiolarian *Theocampe mongolfieri* Zone, and the junction between P.11 and P.10 appears to lie within this thickness. Radiolaria evidence indicate that Core 287-14, CC is not older than the base of the middle Eocene.

Foraminifera

Foraminiferal faunas of Quaternary to late Pliocene, late Oligocene, early middle Eocene, and early Eocene were recovered from this site. Foraminifera are most abundant and best preserved in the Eocene sequence, and are scarce and least well preserved in the Oligocene sequence. The preservation and occurrence of foraminifera in the Quaternary to late Pliocene section vary rather considerably; layers containing rich and well-preserved faunas alternate with nonfossiliferous to foraminifera-poor layers at irregular intervals.

Discussions of foraminifera are given below by dealing separately with each of four intervals in the cored sequence, conveniently distinguished on the basis of foraminiferal assemblages and characteristics.

Quaternary-Late Pliocene:
Core 287-1 to Sample 287-8-1, 8-10 cm

Foraminifera occur irregularly in this interval, sometimes rarely and sometimes commonly. Some levels are totally devoid of foraminifera. When foraminifera are common, they are generally well preserved. While planktonic foraminifera are conspicuously absent in Samples 287-1-1, 120-122 cm and 287-7-1, 142-144 cm, they are common in Samples 287-2, CC; 287-4-2, 38-40 cm; and 287-6-4, 0-1 cm. The remaining levels show intermediate degrees of selective solution and such solution-resistant species as *Sphaeroidinella dehiscens, Globorotalia tumida, Pulleniatina* spp., and *Globoquadrina dutertrei* largely make up the faunas in varying proportions. Because of the similarity between the faunas recovered at this site and those reported by Hays et al. (1969) from the eastern Equatorial Pacific, the

Quaternary to upper Pliocene sequence at Site 287 can be correlated rather precisely with the paleomagnetically dated eastern Equatorial Pacific sequence (Figure 15).

Precise biostratigraphic positions of samples from the upper part of the section is difficult to determine, but it appears that Samples 287-1-2, 138-140 cm to 287-2, CC are all within the younger part of the Pleistocene as evidenced by the presence of *Globigerina rubescens* and *Globigerinoides ruber*, both of which retain the original pink pigments of their test. Empirical data reveal that such coloring of foraminifera generally disappears in faunas older than about 1 m.y.

The Brunhes/Matuyama Geomagnetic Polarity Epoch boundary can be placed more confidently as laying between Samples 287-3, CC and 287-4-2, 38-40 cm. The drastic decrease in abundance or virtual disappearance of *Sphaeroidinella dehiscens*, which has previously been observed in sedimentary sequences of the world's ocean across this boundary from below to above (Hays et al., 1969), occurs at this level. *Pulleniatina finalis* first appears at this site in Sample 287-5-5, 90-92 cm. It is followed by a sharp sinistral to dextral coiling change in species of *Pulleniatina* (Figure 16). These criteria are used to place Core 287-5 within an interval between the Jaramillo and Olduvai events of the Matuyama Epoch. Core 287-6 is placed in the lower part of the Matuyama Series, below the Olduvai Event, on account of the presence of a sinistrally coiled population of *Pulleniatina* in association with *Pulleniatina primalis, Globigerinoides obliquus,* and *Globorotalia tosaensis*.

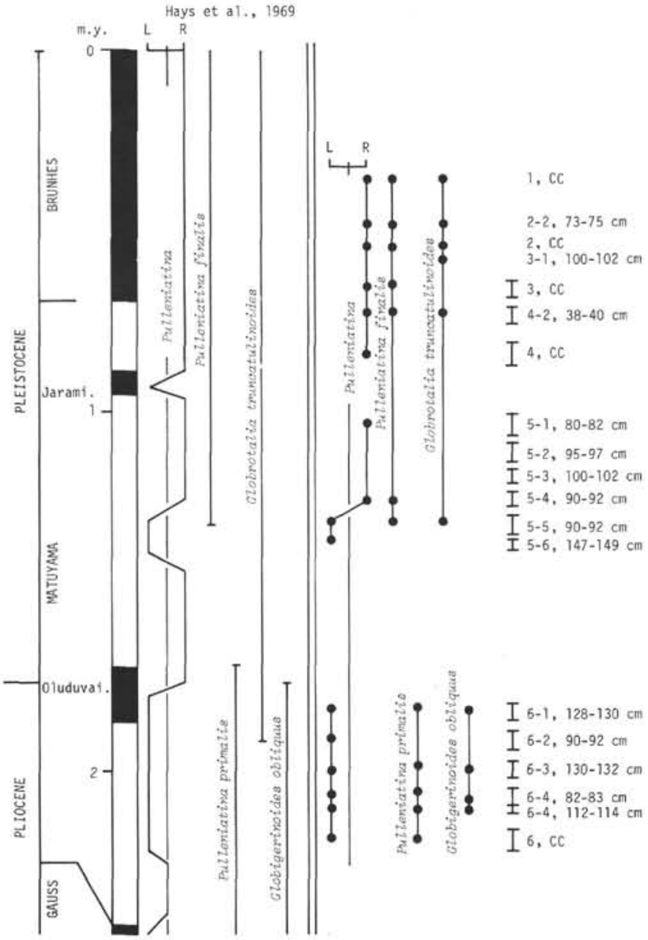


Figure 15. *Correlation of foram samples from Unit 1 at Site 287 with the Quaternary to upper Pliocene sequence of the Eastern Equatorial Pacific.*

Samples 287-7, CC and 287-8-1, 80-100 cm are both in the lower Piacenzian (upper Pliocene) and are assigned to an interval below the top of Kaena but above the Mammoth Event of the Gauss Series. The faunas are characterized by the joint occurrence of *Globoquadrina altispira, Globorotalia multicamerata, G. tosaensis, Globigerinoides fistulosus*, and a dextrally-coiled population of the genus *Pulleniatina*. A thin foraminiferal sand layer at the top of Section 287-6-4 and foraminiferas and smudging the wall of Section 287-6-3 both consist of lowest Piacenzian faunas and are apparently of reworked origin. No benthonic foraminifera indicative of littoral and inner neritic depths were observed in this interval, although a few juvenile specimens (less than 100 μm) of upper bathyal species were found in Sample 287-1-4, 72-74 cm mixed with a quantity of wood fragments.

Foraminifera-barren Interval of Unknown Age: Samples 287-8-2, 60-62 cm to 287-10-1

Foraminifera, both planktonic and benthonic, are absent in this interval. A few fish teeth were occasionally seen in washed residues. On account of the absence of both foraminifera and calcareous nannofossils, sediments of this interval are interpreted to characterize deposition below the total dissolution depth of the calcareous planktonic microfossils.

Oligocene: Samples 287-10-2, 100-102 cm to 287-11-0, 22-24 cm

Foraminifera are scarce and poorly preserved throughout the interval. All the samples examined reveal selective enrichment of calcareous benthonic foraminifera, indicating deposition deeper than the calcium carbonate compensation depth but above the foram dissolution depth. Sample 287-10-2, 100-102 cm is in the *Globorotalia kugleri* Zone of Bolli (1957). This zone is defined by the total range of the zonal marker and brackets the Miocene/Oligocene boundary which in turn is delineated by the first evolutionary incoming of *Globigerinoides primordius* near the middle of the zone. Blow (1969) subsequently established the basal Miocene Zone N4 corresponding to only the upper half of the *G. kugleri* range where it is associated with *Globigerinoides*. The upper part of the uppermost Oligocene Zone P22 (= N3) of Blow (1969), therefore, is also characterized by the lower range of *G. kugleri*. Because of the poor foraminiferal assemblage, it is not possible to decide whether the *Globorotalia kugleri* assemblage in Sample 287-10-2, 100-102 cm belongs to N4 or P22. Since the calcareous nannofossil data indicate this level still contains floras indicative of the late Oligocene, the sample is correlated with Zone P22 of the uppermost Oligocene. Samples 287-10-3, 100-102 cm; 287-10, CC; and 287-11-0, 22-24 cm all contain poor planktonic foraminifera, and short-ranging, age-diagnostic taxa are absent. Species present are useful only insofar as they indicate a

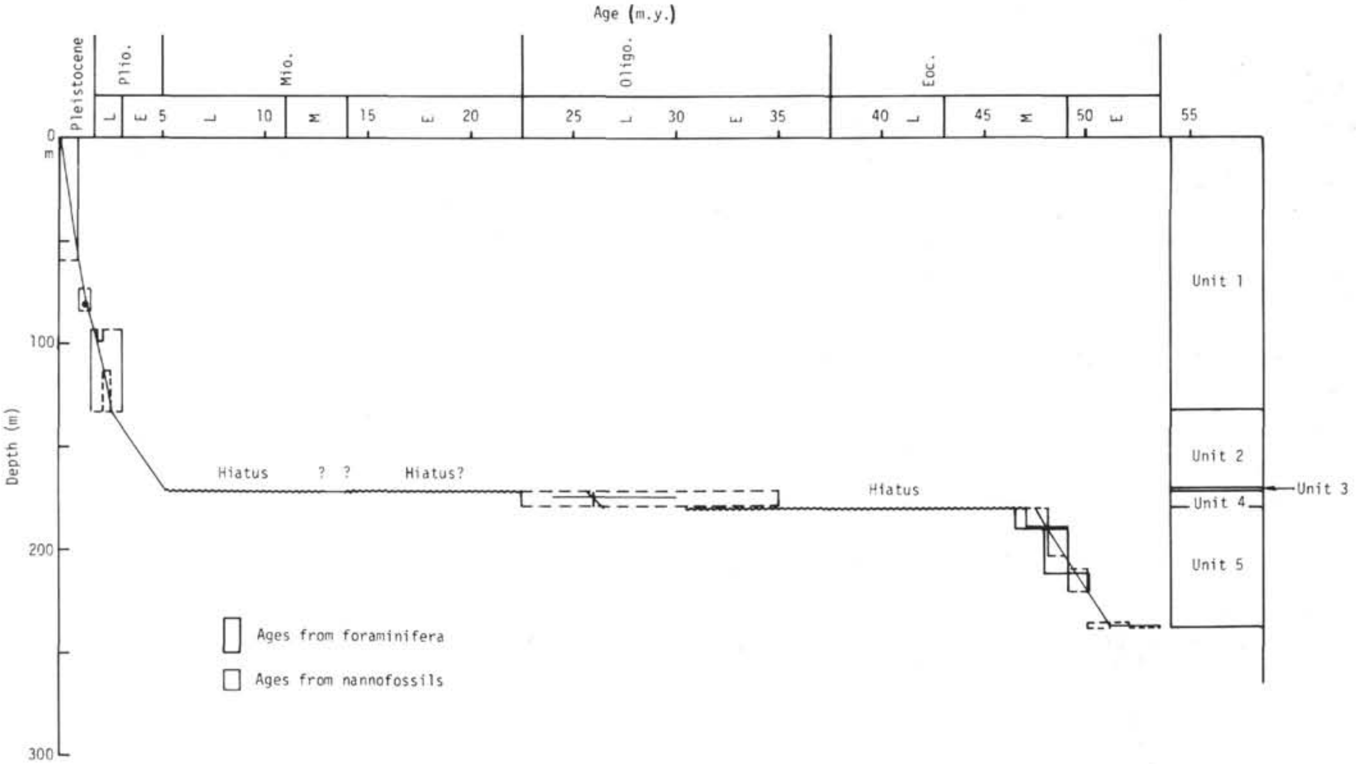


Figure 16. *Sediment accumulation curve for Site 287 based on nannofossil and foraminiferal age determination. Values in brackets are estimates only. (Time scale of Vincent, 1974.)*

broad positioning of these samples between a lowest possible level of P19 and a highest possible level of Zone P22.

Middle to Early Eocene: Samples 287-11-0, 31-33 cm to 287-16-1, 74-75 cm

The middle Eocene sediments disconformably underlie the Oligocene sequence, and the contact occurs in Sample 287-11-0-27 cm with a sharp lithological break. Planktonic foraminifera are common to abundant and well preserved throughout this interval, except at the base of the sequence in Section 287-16-1. Despite rich planktonic foraminiferal assemblages, many index species of the zones which are widely used today for worldwide stratigraphic correlation are absent at this site, making precise delineation of the planktonic zonal boundaries difficult. Notable age-diagnostic species absent from the area are *Globorotalia centralis, Globigerapsis kugleri, Globigerapsis index,* and *Hantkenina aragonensis*. In the same middle Eocene sediments (P11 Zone) from Site 286, west of Malekula Island which lies at a more southerly latitude than Site 287, both *Globorotalia centralis* and *Globigerapsis index* occur as the major components of the planktonic foraminiferal assemblage. These taxa have also been reported from New Zealand (Jenkins, 1966). The absence of these two species in the otherwise well-preserved planktonic fauna of the Coral Sea therefore points to the existence of faunal provincialism during early middle Eocene time in the southwestern Pacific region.

G. centralis and *G. index* are both common in the tropical fauna, and their absence in the Coral Sea fauna seems to suggest that the Coral Sea region was under the influence of much cooler waters than those prevailing over New Zealand and the Site 286 area. Such an interpretation requires either the Eocene geographic position of the Coral Sea site to be closer to the pole than New Zealand and the Site 286 area or the presence of a cool Eocene current system flowing in a narrow zone closely following the present configuration of Australia.

Samples 287-11-0, 31-33 cm to 287-12-1, 105-107 cm commonly include *Globigerina senni, Acarinina bullbrooki, Acarinina rotundimarginata,* and *Truncorotaloides rohri* which are used to assign this interval to the Zone P.11. Because of the absence of *G. kugleri*, the base of Zone P.11 is drawn at the incoming of *Truncorotaloides rohri* in Sample 287-12-1, 105-107 cm. Samples 287-12-2, 60-62 cm to 287-14, CC are included in the basal middle Eocene Zone P.10 (= *Hantkenina aragonensis* Zone) due to the conspicuous occurrence of *Globigerina boweri* throughout the interval. The zonal boundary between P.10 and P.9 is also the middle/lower Eocene boundary and is defined by the first evolutionary appearance of *G. boweri* at the base of Zone P.10. Core 287-15 predates this evolutionary appearance and is assigned to the Zone P.9 (= *Acarinina densa* Zone). Characteristic species occurring in this zone are *Acarinina soldadoensis angulosa, Acarinina broedermanni, Acarinina convexa,* and *Globorotalia aragonensis*. Sediments immediately overlying the basalt in Core 287-16-1 were examined at two levels, 53-55 cm and 74-75 cm depth. Both samples contain rare and partially recrystallized foraminifera. Specimens of benthonic and planktonic foraminifera occur in nearly equal proportion, suggesting sedimentation depth close to the carbonate compensation depth. Benthonic foraminifera are all indicative of bathyal depths. Planktonic foraminifera identified are *Acarinina broedermanni, Acarinina primitiva, Globigerina gravelli, Globigerina prolata, Globigerina senni* (primitive form), and *Pseudohastigerina* sp., and are assigned to the Zone P.8 (= *Globorotalia aragonensis* Zone). An interesting aspect of the oldest fauna at this site is an admixture of *Globorotalia pseudobulloides*, a Danian-early Paleocene species. The species is obviously derived, but its source will be difficult to locate at present with our meager knowledge of the geographic distribution of Danian-lower Paleocene sediments in the nearby area.

Calcareous Nannofossils

Calcareous nannofossils extracted from the recovered sediments indicate an incomplete lower Eocene-Quaternary section. Three distinct biostratigraphic units and a barren segment are recognized. Their boundaries coincide to a large extent with lithologic boundaries. Sediments immediately above the basement are of early Eocene age.

The highest biostratigraphic unit (Pliocene to Quaternary in age) comprises Sections 287-1-1 to 287-8-1. Fluctuations of the relative level of the nanno solution depth during the deposition of this unit are reflected by certain characteristics of the nannofossil assemblages contained in the unit. Of particular importance are the changes from levels with relatively rich, relatively diverse populations to levels with very sparse assemblages of low diversity, changes largely dependent upon the degree of selective solution. Levels barren of nannofossils are also detected; Samples 287-1-1, 116-117 cm; 287-4-1, 120-121 cm; 287-5-2, 30-31 cm; and 287-5-3, 30-31 cm are totally devoid of nannofossils. The nannofossil assemblages encountered in Samples 287-1-3, 30 cm; 287-4-2, 30-31 cm; 287-5, Sections 4, 5, 6, and CC; 287-6-1, 120-121 cm; 287-6-2, 30-31 cm; and 287-7, CC represent resistant residues left after intense dissolution. Other core samples yielded a few to common nannofossil assemblages usually of moderately good preservation.

Rare reworked nannofossils probably as old as the Paleogene are found throughout the unit, and obvious concentrations of reworked forams occur at several levels. Extremely rare Upper Cretaceous species are present in Sample 287-6, CC.

The generally poor preservation of the nannofossils together with the presence of reworked elements make the zonal assignments within the unit rather difficult and largely tentative.

Among the elements of the 287-4, CC assemblage, *Gephyrocapsa oceanica* is identified. Sediments above and including Sample 287-4, CC are therefore assigned to the *Emiliania huxleyi-Gephyrocapsa oceanica* zonal interval and a maximum age of late Pleistocene is established. Sample 287-5-3, 120-121 cm is tentatively placed in the *Gephyrocapsa caribbeanica* Zone on account of the presence of barred *Gephyrocapsa* sp.

The consistent occurrence of a wide range of derived nannofossils in that part of the sequence incorporating Core 287-6 to Sample 287-8-1, 10-11 cm hinders refined zonal assignment, and these cores are provisionally placed in the *Discoaster triradiatus-Pseudoemiliania lacunosa* zonal interval. Questionable *Gephyrocapsa caribbeanica* and *G. lumina* are, however, noted in Sample 287-6-1, 120-121 cm assemblage. Nevertheless, a maximum age of late Pliocene for these cores is adopted.

The segment including Samples 287-8-1, 120-121 cm to 287-10-1, 120-121 cm is totally lacking nannofossils, and its age is therefore indeterminable. The segment is bounded by fossiliferous sediments, late Pliocene and late Oligocene in age, and its sedimentation is inferred to be below the total nanno solution depth. The segment represents a total thickness of ca. 46.5 meters, hardly a thickness to accommodate the unrecorded part of the nannostratigraphic sequence bracketed by the overlying and underlying fossiliferous units; an unconformity is likely.

The middle biostratigraphic unit (late Oligocene) includes Samples 287-10-2, 4-5 cm to 287-11-0, 24-25 cm. The unit contains abundant calcareous nannofossils of moderately good preservation but relatively low diversity. Samples 287-10-2, 4-5 cm to 287-10-4, 30-31 cm are assigned to the upper Oligocene *Sphenolithus ciperoensis* Zone. Samples 287-10-4, 120-121 cm to 287-11-0, 24-25 cm belong to the *Sphenolithus distentus* Zone.

At the top of this unit a gradual decrease in the nannofossil contents is noticed pointing to a gradual shifting in the depositional conditions resulting in the formation of the overlying barren segment. On the other hand, at the bottom part of the unit a distinct lithologic break exists in Sample 287-11-0, 27 cm, which coincides with a drastic change in the nannofossil assemblages, indicating a major disconformity between the upper Oligocene and the underlying middle middle Eocene unit.

The lowest biostratigraphic unit (early to middle Eocene) is represented by Samples 287-11-0, 29-30 cm to 287-16-1. The nannofossils extracted from this unit are abundant, diversified, and of moderately good preservation. Core 287-16-1 is an exception in having a few poorly preserved nannofossils.

Samples 287-11-0, 29-30 cm to 287-11, CC are assigned to the *Chiasmolithus gigas* Zone. The nannofossil assemblages recovered from Cores 287-12 and 287-13 correlate with the *Nannotetrina fulgens* Zone. Cores 287-14 and 287-15 are assigned to the *Discoaster sublodoensis* Zone; Core 287-14 belongs to the basal middle Eocene *Rhabdosphaera inflata* Subzone, and Core 287-15 belongs to the lower Eocene *Discoasteroides kuepperi* Subzone.

The sediments immediately above the basement (Core 287-16-1) are assigned to the lower Eocene *Tribrachatus orthostylus* Zone.

Radiolaria

The sequence of graded silts and clays (green and brown) and brown nanno ooze recovered in the upper 10 cores at this site proved essentially devoid of radiolarians. Traces of Radiolaria in 287-1, CC and 287-10, CC are quite inadequate for biostratigraphic purposes. The lower lithologic unit of yellowish-gray nanno chalk, immediately below the Oligocene-Eocene discontinuity at 287-11-0, 27 cm, also proved to be barren of

Radiolaria down to 287-11-2, 40-42 cm. Trace quantities of Radiolaria occur down to 287-11-4, 28-30 cm and rare, moderately preserved specimens were found in 287-11-5, 37-39 cm. Abundant, well-preserved radiolarians are present by 287-11-6, 28-30 cm and such rich, well-preserved assemblages persist at least through the next 6.9 meters to 287-12-4, 70-72 cm. From this point through the 31 meters to basement, only sporadic traces of extremely poorly preserved radiolarians were encountered.

The reason for restriction of common radiolarians to a short segment of the nanno chalk is not wholly apparent. Smear-slide data reveal no correlation with any nonbiogenic component, and the lowest rich Radiolaria level is some 4.5 meters above the highest recorded chert in Core 287-13. Smear-slide data do, however, suggest an increase in sponge debris through the radiolarian-rich segment, and it is possible that an increased mass of organic opal allowed silica saturation of pore water to be achieved during early diagenesis without dissolution of a significant percentage of opaline fossils.

Zonal Allocation

The very poor fauna of 287-14, CC contains *Phormocyrtis striata striata* in the absence of *Phormocyrtis striata exquisita* and cannot, therefore (Foreman, 1973), be lower than the *P. striata striata* Zone, basal zone of the middle Eocene. It could well be considerably higher.

The tabulation of the biostratigraphically more important taxa in the rich segment of Sections 287-11-6 through 287-12-4 apparently shows the morphotypic base of *Thyrsocyrtis triacantha* and the virtual extinction of *Thyrsocyrtis hirsuta hirsuta.* There appears to be good agreement with Foreman's (1973) tabulation of the segment 94-21-2 through 94-22-4 at Site 94 (Foreman, 1973, p. 412), except that *Theocampe mongolfieri* is excessively and surprisingly scarce at Site 287. In the very poor fauna of Sample 287-11-5, 37-39 cm *T. hirsuta tensa* is still almost certainly numerically in excess of *T. triacantha.* If, therefore, following Foreman (1973, p. 412), the base of the *T. triacantha* Zone is taken at the evolutionary transition between *T. h. tensa* and *T. triacantha*, then the entire segment of Cores 287-11-5 through 287-12-4 belongs to the immediately lower *T. mongolfieri* Zone.

For tabulation of Radiolaria see Holdsworth (this volume).

At the adjacent DSDP Coral Sea site, Site 210, Radiolaria were found through some 50 meters of sub-Oligocene nanno chalk, never, apparently, as abundant or well preserved as at Site 287 (Burns, Andrews, et al., 1973, p. 380). The top of the radiolarian-bearing segment is of *P. mitra* Zone, clearly younger than the uppermost radiolarian sediments of Site 287, and, judging by Leg 30 experience, of middle Eocene age, not late Eocene as indicated in Burns, Andrews, et al., 1973, p. 440. The lowest adequate fauna, that of Sample 210-39, CC, is indicated to be of *T. triacantha* Zone (op. cit., p. 380). If so, relatively well preserved Radiolaria at Site 210 are entirely younger than at Site 287, but close comparison of the earliest faunas cannot be made.

SEDIMENTATION RATES

The sedimentation accumulation curve for this site is presented in Figure 16 and the sedimentation rates are calculated and given in Table 3. At this site the porosities in the highest cores are close to 70% and the sedimentation rates have been calculated on the basis that this represents the initial porosity. The time scale used is that of Vincent (1974).

Sedimentation rates cannot be calculated with any accuracy for Units 2, 3, and 4. Units 2 and 3 are barren and Unit 4 has only a short time duration.

The average rate of deposition of Unit 5, the early to middle Eocene clay nanno chalk, is around 25 m/m.y., a higher rate than the nanno oozes at the previous sites but taking into account the fact that clay constitutes about half the sediment, the clastic plus pelagic rate is reasonable. It appears that the depositional rate may have increased during the deposition of the unit, especially if the older date for the base of the unit (52 m.y.) indicated by the nannofossils is correct.

The depositional rate is probably a good deal lower in Unit 4 since a greater water depth is indicated by the scarcity of planktonic foraminifera. Units 4 and 5 are separated by the regional Eocene-Oligocene hiatus described by Burns, Andrews, et al. (1973). The depositional rate reached its lowest level in Unit 3, thin abyssal clay.

TABLE 3
Sedimentation Rates, Site 287

						Sedimentation Rate (m/m.y.)	
Unit	Age (m.y.)	Depth (m)	Interval Thickness (m)	Porosity (%)	Thickness Corrected to 70% Porosity (m)	Observed Thickness	Corrected Thickness to 70% Porosity
1	0-0.9	0-60	60	70	60	120	120
	0.9-2.5	60-131.9	71.9	63	97	45	52
2	(2.5-5)	131.9-171	39.1	60	59	(16)	(24)
3	(14-15)	171-171.6	0.6	58	1.0	(0.6)	(1)
4	(25.7-26.5)	171.6-179.3	7.7	58	12	(8)	(12)
5	47.5-51 or 52	179.3-236.7	57.4	57	95	16 or 13	27 or 21

Note: Values in parentheses are based on an assumed gradient of the sediment accumulation curve.

With the onset of turbidite sedimentation in the basin, silty clays representing attenuated phases of the turbidites were deposited at the site. A suggested average sedimentation rate is in the range of 25 m/m.y. This probably increases upwards through the unit as the turbidite level in the basin rose. It appears that the sedimentation rate in Unit 1 increased over twofold from 50 m/m.y. (assuming initial 70% porosity) from the late Pliocene to 120 m/m.y. for the Quaternary.

SUMMARY AND CONCLUSIONS

Summary

The cored sequence is divided into seven units. The upper five units are sedimentary, Pleistocene to early middle Eocene in age, and these are underlain by two igneous units that apparently predate the sedimentary sequence (Figure 7).

The units is descending order are:

Unit 1 (0-131.9 m): Graded cycles of silt and clay with interbeds of nanno clay. Pleistocene to lower upper Pliocene.

Unit 2 (131.9-171.0 m): Olive to green silty clay with moderate amounts of mica. Unfossiliferous.

Unit 3 (171.0-171.6 m): Brown clay with moderate amounts of mica, micronodules, and zeolites. Unfossiliferous.

Unit 4 (171.6-179.3 m): Yellow-brown nanno ooze. Upper Oligocene.

Unit 5 (179.3-236.7 m): Yellowish-gray clay nanno chalk with moderate amounts of siliceous fossils, zeolite, and micarb, and with interbedded chert. Lower middle Eocene to lower Eocene.

Unit 6 (236.7-242.4 m): Porphyritic basalt.

Unit 7 (242.4-252 m): Basalt.

The depositional rate for Unit 5 was about 30 m/m.y. and deposition took place above the depth of total solution of planktonic forams. The oldest beds were assigned to foram Zone P8 (50-51 m.y. B.P.) and the highest beds to Zone P11 (46.5-48 m.y. B.P.). Unit 4 overlies Unit 5 with a sharp contact, and the nannofossil flora above the contact indicates the late Oligocene Zone of *Sphenolithus distentus* (26-30 m.y. B.P.). The youngest part of Unit 5 is in the early middle Eocene subzone of *Chiasmolithus gigas* and P11 (about 47-48 m.y. B.P.). This demonstrates a break in the depositional record of around 20 m.y. Because of the short duration of sedimentation represented by Unit 4, no sedimentation rate could be determined, but its deposition close to the depth of total solution of planktonic foraminifera would probably indicate a slower accumulation rate than for Unit 5.

Because a hiatus was found between the corresponding units at Site 210 (42 km to the west), a similar break is suggested between Units 3 and 4 at this site (see Lithology). Unit 3 is an unfossiliferous brown abyssal clay which is in turn overlain by unfossiliferous green silty clay (Unit 2). These sediments of Unit 2 are thought to form a transgressive sheet deposited by bottom suspension flows. If this interpretation is correct, there is probably a hiatus between Units 2 and 3 (see Lithology), and the sedimentation rate increases upwards as the elevation of the abyssal plain approached that of the hill on which the site is located. The average rate of deposition of Unit 2 is probably substantially less than the rate from 50-80 m/m.y. for the upper Pliocene to 120-180 m/m.y. for the Quaternary for Unit 1. Unit 1 shows an upward increase in sedimentation rate. Like Unit 3, Units 1 and 2 were deposited below or near the nanno solution depth.

Reworked fossils are common in Unit 1. Nannofossils as old as Upper Cretaceous were encountered, but forams older than upper Pliocene were not recorded. Some displaced upper bathyal forams and wood fragments were, however, noted in foram preparations. In the oldest beds of Unit 5 (early Eocene) reworking was noted in both the nanno and foram assemblages, including forms as old as Danian. The foram *Globorotalia pseudobulloides* is prominent in the assemblage. This species has recently been recorded from Danian rocks near Port Moresby (Palmieri, 1971). It is also significant that these basal assemblages show noticeably more solution than the later ones of the unit and are thus thought to have been deposited at a greater depth.

Discussion

Comparison of Site 210 and Site 285 results

The relationship between the stratigraphy of this site and Site 210 is a close one (Figures 9 and 11). Essentially the same lithologic succession has been recognized at both, but differences in the successions, sedimentation rates, and the durations of the breaks in sedimentation are significant. In this discussion the ages and thicknesses of units at Site 210 used here are as given in the table for Leg 21 drilling results forming part of the Initial Report (Burns, Andrews, et al., 1973). A comparison of the history of the two sites is as follows.

1) Eocene: Although basement was not reached at Site 210, 53 meters of lower Eocene were drilled. This is overlain by 110 meters of middle Eocene and 8 meters of upper Eocene. Lithologies are clay nanno chalks and calcareous clays in the lower and middle Eocene passing up into clay-bearing nanno chalk with minor chert in the upper Eocene. At Site 287 basement was reached and is overlain by lower Eocene consisting of 19.7 meters of sediment (less than half the thickness of the incomplete sequence at Site 210). The incomplete sequence of middle Eocene consists of 36.7 meters of sediment; no upper Eocene is present. The lithologies at Site 287 are similar to those at Site 210. It is clear that the sedimentation rates at Site 210 are higher than that for the Eocene represented at Site 287. Also, about 4 m.y. more of the Eocene stratigraphic record is preserved at Site 210 below the erosional break under the Oligocene.

The differences between the sedimentation rates and durations of the Eocene sequences can be accounted for by assuming that the sea floor at Site 287 was a little shallower in the Eocene than at Site 210 and that some winnowing of sediment by bottom currents took place. This would imply that the basement hill on which Site 287 was located was in existence by at least some time in the early Eocene. The indications of deeper water during the time of deposition of the lower Eocene at the site and the contamination of the basal beds with Paleocene microfossils suggest that the basement feature was formed soon after the commencement of sedimentation in the early Eocene. Site 210 is also located on a basement high, but one of lower elevation than the present site. Interpretation of the seismic profiles in the vicinity of Site 287 suggests that the Eocene sequence in the deeper local basins of the Coral Sea could be thicker and possibly stratigraphically more extensive than at Site 210.

2) Oligocene: The Oligocene sediments at both sites are similar in lithology, being nanno chalks, but again the thickness is greater at Site 210 (18.4 m) than Site 287 (7.7 m). Sedimentation commenced at Site 210 in the early Oligocene and continued into the early late Oligocene, but did not commence until the late Oligocene at Site 287. The interval of the erosional break (Kennett et al., 1972) would be expected to be greater if the sea floor was more elevated at Site 287, assuming that the current velocity increases over seafloor hills. The greater depth of water in the Oligocene places both sites close to the depth of total solution of planktonic foraminifera, with Site 210 possibly a little deeper. The brown Oligocene chalks could be an indication of intermixing with abyssal clay.

3) Latest Oligocene-early Miocene-?early middle Miocene: At Site 210 abyssal clay was deposited. The age of the corresponding abyssal clay unit at Site 287 is unknown. However, as in lower units, the thickness is greater at Site 210 (21.1 m as against 0.6 m).

4) Middle Miocene: At Site 210 on top of the abyssal clay 30.5 meters of green silty clay were deposited. These sediments are very similar to Unit 2 of Site 287 and appear to be related at least mineralogically to the overlying turbidite sequence. These beds at Site 210 are probably contemporaneous with turbidites deposited in deeper basins adjacent to that site. The water depth was below the nanno solution depth during the deposition of the green silty clay.

5) Middle Miocene to Recent: Turbidites were deposited at Site 210 from the middle Miocene onwards. The turbidites reached the level of the sea floor at Site 287 at about the beginning of the late Pliocene, preceded by the green silty clay (39.9 m thick). The thickness of the Pleistocene turbidites at each site is very similar (nearly 100 m). This would be expected if the sites had not been affected by tectonism during that time, since depositional gradients are very low (the sea floor is only 2 m deeper at Site 287 than Site 210, 42 km away). Deposition probably took place below or close to the total nanno solution depth. Rapid fluctuations of quality of fossil preservation occur. The presence of well-preserved fauna can probably be attributed to its derivation from shallower depths and its subsequent rapid burial as evidenced by the high rate of sedimentation (averaging 45 m/m.y. at Site 287).

Regional Implications

The basement age of early Eocene at Site 287 (about 51 m.y.) compares closely with the date for the commencement of rifting of Australia from Antarctica (about 55 m.y. B.P.; Weissel and Hayes, 1971) and the suggested date of emplacement of the obducted oceanic crust of the Papuan Ultramafic Belt (Davies and Smith, 1971) although Dow (personal communication) considers that the earlier suggested Oligocene age is more likely. It should be noted that the width (north-south) of the Coral Sea is about 400 km in this region and assuming that the direction of crustal extension of the basin was parallel to the width and the rate of growth was high (10 cm/yr) then it would have taken 4 m.y. to form the basin and for a slow rate (3 cm/yr) it would have required 13 m.y. A sum of this kind makes no assumptions about the process involved. Whatever the process, a time range of some millions of years should be envisaged for its formation. Thus if Site 287 is in the youngest part of the basin, the oldest could be close to the middle of the Paleocene and if in the oldest part, the youngest could be near the end of the Eocene. The oldest sediment penetrated at Site 209 on the Queensland Plateau on the southern margin of the Coral Sea was middle Eocene foram ooze, indicating that the southern margin of the basin had subsided at least by then (ca. 45 m.y. B.P.). On the northern margin of the basin in the southeastern part of Papua extensive areas of Eocene basaltic pillow lavas occur (Davies and Smith, 1971). The pillow lavas which are thought to have been extruded on the deep ocean floor are associated with limestones containing planktonic foraminifera. Shallow-water benthonic foraminifera of late middle to early late Eocene age have been located at Mullins Harbor (southeastern Papuan Peninsula). These data from both sides of the basin favor a minimum age for the end of basin formation of middle Eocene. It is not easy to fix a maximum age. There is a possibility that the formation of the crust represents a northern extension of the spreading episode of the Tasman Sea, which, according to Hayes and Ringis (1973), lasted from 81 to 60 m.y. B.P. This conclusion was arrived at by analysis of the magnetic anomalies from about 30°S to 45°S. The pole of this opening was located in central New Guinea (J. Ringis, personal communication). Although linear magnetic anomalies parallel to the length of the Coral Sea Basin have been detected they have defied identification as part of the normal spreading series (D. Falvey, personal communication). If the Coral Sea was formed as an extension of the Tasman spreading, it would have commenced at about the conclusion of the Tasman spreading, and the southeastern edge of the Coral Sea crust would have been a transform feature. Subsequent to this, the crust of the sea would have been modified in some way so that the magnetic anomaly pattern became complex. The development of the basement highs after the crust was formed, as suggested earlier in the discussion, could have been a contributing factor. A complex pattern of later intrusions such as those found at Sites 285 and 286 could also have occurred. For instance, a marked magnetic anomaly was found associated with a piercement feature in the survey conducted prior to dropping the beacon at Site 287.

The axis of the Owen Stanley Range of southeastern New Guinea is occupied by Mesozoic sialic metamorphic rocks, mostly of greenschist grade (Davies and Smith, 1971). Eocene sediments east of Port Moresby contain clasts of schist and strained quartz, probably shed from the metamorphics and thereby putting an upper limit on the date of metamorphism while Upper Cretaceous fossils in the metamorphics fix a lower limit. The Cretaceous oceanic crust comprising the Papuan Ultramafic Belt has been thrust over the metamorphics. The evidence, therefore, does not support the notion that the Coral Sea crust developed by arc migration, but rather rifting of continental crust from the edge of the Australian continent. The date of the thrusting is thought to be early Eocene since hornblende granulite from the thrust below the sheet has been radiometrically dated at 52 m.y. In addition, tonalite intrusions into the ultramafics have been dated at 50-55 m.y. The meaning and reliability of these dates, however, can be debated.

It seems that the Coral Sea developed by the formation of new oceanic crust behind the metamorphics that now form the Owen Stanley Range and that the metamorphics were overthrust by the Papuan Ultramafic Belt near or later than the time of formation of the Coral Sea. Davies and Smith (1971) attribute the metamorphism and overthrusting to the same movement which they interpret as an arc-continent collision that predates for formation of the Coral Sea. There is no clear documentary evidence for the existence of this arc. The obducted oceanic crust could be part of the Pacific plate with the plate boundary located in Eastern Papua at the time of overthrusting.

The existence of a consuming plate boundary in the region is indicated by the results of drilling at Site 286 where middle to upper Eocene evidence of andesitic volcanism nearby was found. Important contrasts exist between the Sites 286 and 287:

1) Andesitic volcanics occur at Site 286 but not at Site 287;

2) At Site 287 (and also 210 and 209) the Eocene microfloras and faunas have low diversity, indicating a cooler (?temperate) climate than at Site 286, the latter containing typical tropical forms absent from Site 287 (see Paleontology);

3) There is no Eocene-Oligocene erosional unconformity at Site 286. On the basis of data gathered during Leg 21, this erosional break was explained by Kennett et al. (1972) as having been caused by a circumpolar current which ceased to flow around the north of Australia when Australia rifted sufficiently far from Antarctica;

4) The marked (?) early Miocene deformation found at Site 286 and possibly Site 285 is not apparent at Site 287.

The differences of faunal diversity might be explained if the cool current was restricted by New Caledonia, the Norfolk Ridge, and New Zealand to a region close to Australia. The tectonic features bespeak a quite different tectonic history for the two sites. The Coral Sea site is located in a stable region from the middle Eocene onwards (apart from gentle uplift on the northern margin basin relatively recently), and the Coral Sea behaved as part of the India plate from its time of formation onwards. Interaction between the India and Pacific plates has occurred further north and has resulted in the uplift of the New Guinea Highlands and the deposition of the turbidite sequence of Unit 1. Site 286 is in the region which has been frequently affected by the interaction of the Pacific and Australia plates and has been transferred from one plate to the other as the plate boundary has relocated from time to time.

REFERENCES

Blow, W.H., 1969. Late middle Eocene to Recent planktonic foraminiferal biostratigraphy. *In* Internatl. Conf. Plank. Microfossils, Proc. 1st, v. 1, p. 199.

Bolli, H.M., 1957. Planktonic foraminifera from the Oligocene-Miocene Cipero and Lengua Formations of Trinidad, B.W.I. *U.S. Nat. Museum Bull.*, v. 215, p. 155.

Burns, R.E., Andrews, J.E., et al., 1973. Site 210. *In* Burns, R.E., Andrews, J.E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 21: Washington (U.S. Government Printing Office), p. 369-386.

Davies, H.L. and Smith, I.E., 1971. Geology of Eastern Papua: Geol. Soc. Am. Bull., v. 82, p. 3299.

Foreman, H.P., 1973. Radiolaria of Leg 10 with systematics and ranges for the families Amphipyndacidae, Artostrobidae, and Theoperidae. *In* Worzel, J.L., Bryant, W., et al., Initial Reports of the Deep Sea Drilling Project, Volume 10: Washington (U.S. Government Printing Office), p. 407.

Hayes, D.E. and Ringis, J., 1973. Seafloor spreading in the Tasman Sea: Nature, v. 243, p. 454.

Hays, J.D., Saito, T., Opdyke, N.P., and Burckle, L.H., 1969. Pliocene-Pleistocene sediments of the equatorial Pacific: their paleomagnetic, biostratigraphic and climatic record: Geol. Soc. Am. Bull., v. 80, p. 1481.

Jenkins, D.G., 1966. Planktonic foraminiferal zones and new taxa from the Danian to lower Miocene of New Zealand: New Zealand J. Geol. Geophys., v. 10, p. 1064.

Kennett, J.P., Burns, R.E., Andrews, J.E., Churkin, M., Davies, T.A., Dumitrica, P., Edwards, A.R., Galehouse, J.S., Packham, G.H., and van der Lingen, G.T., 1972. Australia-Antarctic continental drift, paleocirculation changes and Oligocene deep-sea erosion: Nature Phys. Sci., v. 239, p. 51.

Palmieri, V., 1971. Occurrence of Danian at Port Moresby: Queensland Geol. Surv. Rept., no. 63.

Shafik, S., 1973. Eocene-Oligocene nannoplankton biostratigraphy in the western and southern margins of Australia: ANZAAS Conf., Perth, 1973 (abstract).

Vincent, E., 1974. Cenozoic planktonic biostratigraphy and paleooceanography of the Western Indian Ocean. *In* Fisher, R.L., Bunce, E.T., et al., Initial Reports of the Deep Sea Drilling Project, Volume 24: Washington (U.S. Government Printing Office), p. 1111.

Weissel, J.K. and Hayes, D.E., 1971. Assymmetric seafloor spreading south of Australia: Nature, v. 231, p. 518-522.

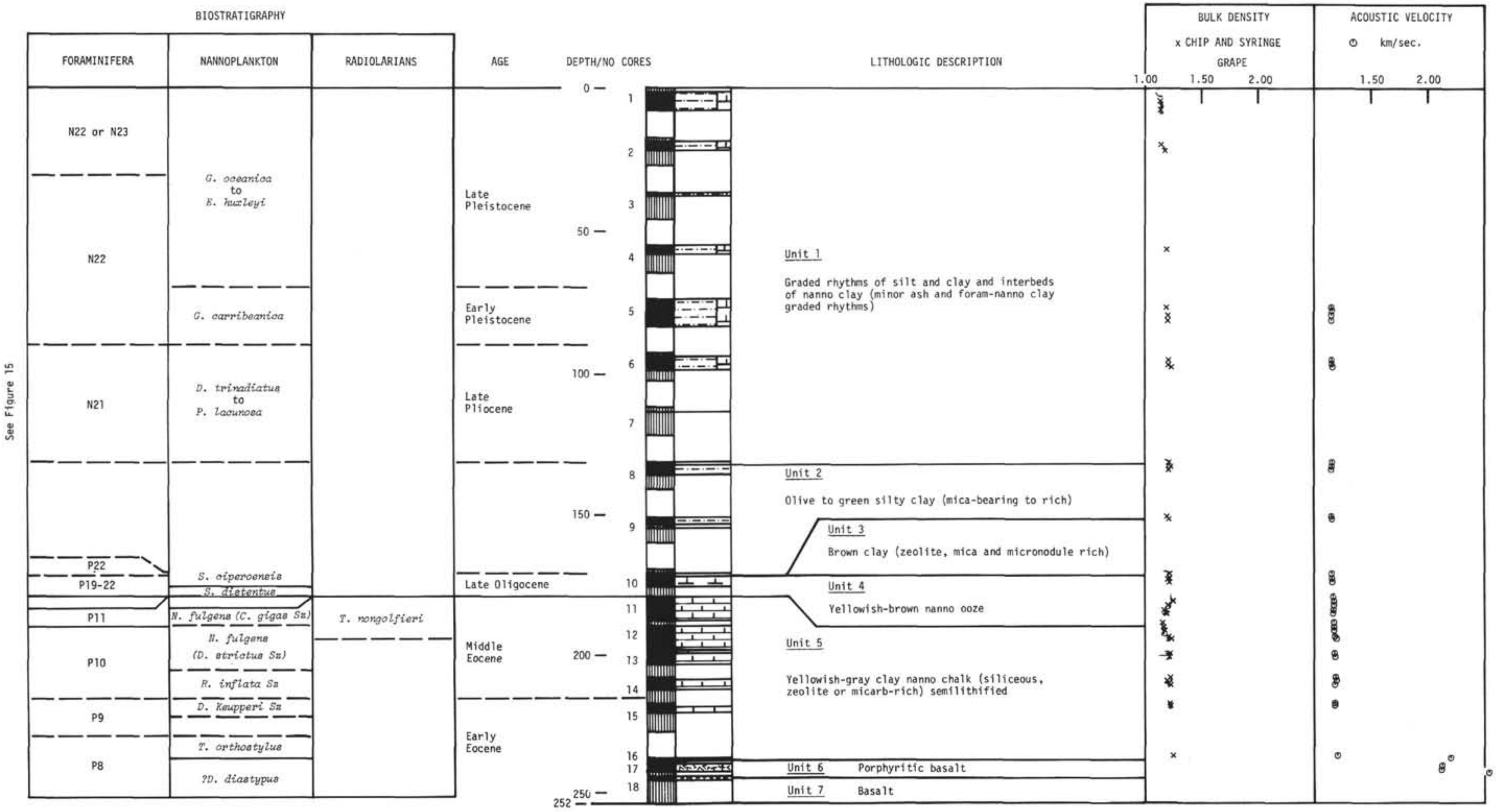


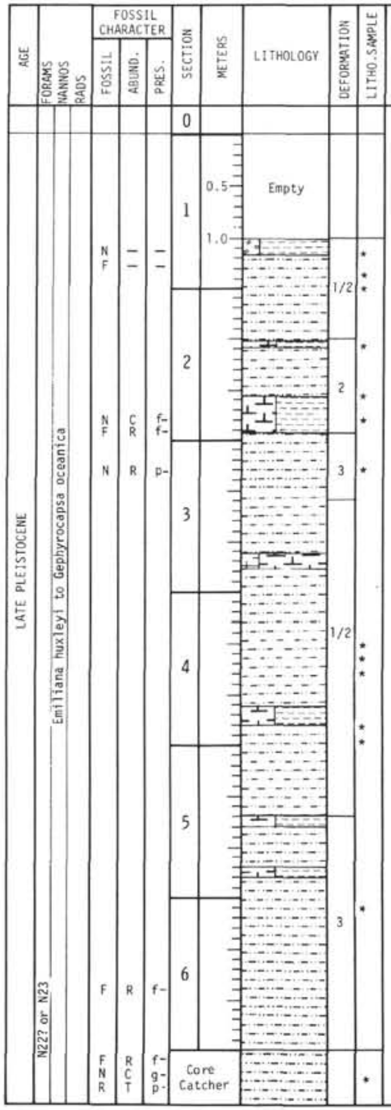
Figure 17. *Composite biostratigraphy, lithology, and physical properties, Site 287.*

APPENDIX A
Smear-Slide Determinations, Site 287 (values in percent)

Sample (Interval in cm)	Depth (m)	Grain Size			Quartz	Feldspar	Clay minerals	Heavy minerals	Mica	Chlorite	Volc. rock fragments	Volcanic glass	Pyrite (or opaque)	Micronodules	Zeolite	Micarb	Glauconite	Forams	Nannos	Radiolaria	(Sponge) spicules	Diatoms	Silicoflag.	Fish remains	Plant debris	Lithologic Unit
		Sand	Silt	Clay																						
1-1, 116	1.16			75		2	75		15			tr		4	2											1
1-1, 145	1.45	2	35	63		4	63	7	15			tr		1				1	8	1					tr	
1-2, 002	1.52	60	30	10		25	10	15	39			tr						1	5		1					
1-2, 58	2.08								8			tr	3	2		10			76							
1-2, 103	2.53		25	75		1	75	1	4			tr		2				1	15	1					tr	
1-2, 130	2.80					1			5			tr	1	1	1	15			76							
1-3, 30	3.30								5			tr				10			85							
1-4, 52	5.02		5	95			95		4			tr		1												
1-4, 69.5	5.20	5	60	35		7	30	1	53			tr	1	1				1	5	1					tr	
1-4, 72	5.22	10	90		?	65		15					5					15								
1-4, 139	5.89	10	20	70		5	52	1	20			tr	4	2	1	1		1	10							
1-4, 149	5.99	20	80		?	60		3	15			tr	15			3		2			2					
1-6, 12	7.62		20	80		12	78	1	4			tr	2	1		1			1							
1, CC	9.10		25	75		3	58	2	20			tr		2		3		1	10			1				
2-2, 68	19.68		20	80		15	47		10			tr	2		1	5			10							
2-2, 77	19.77						20		5			tr			1	10		5	59							
2-3, 135	21.85	20	57	5		5	10		10			tr				55		20								
3-1, 80	37.30					5	20		10			tr			1	55		8			1					
3-1, 118	37.68					2	25		8			tr			1	5		2	56		1					
3, CC	38.10		25	75		5			10			tr		2	1	10		3	67		1				1	
4-1, 122	56.72		40	60		5	58	2	30			tr	2		1	2										
4, CC	58.60					5	10	1	8			tr				20		1	55							
5-3, 134	79.14		20	80		5	77	1	5			tr	4	1	1	4	1				1					
5-6, 90	83.20	40	60									100														
5, CC	83.90		20	80		5	65		15			tr		2	1	8			4							
6-1, 146	94.96		20	80		3	84						1			2		5	5							
6-3, 142	97.92	20	60	20	?	30	27	2	8			tr			2	11	1	20	5							
6-4, 1	98.01	95		5														95	5							
6-4, 82	98.82														1	3		3	93							
6, CC	99.60		20	80		8	51		20			tr				5		1	5							
7, CC	114.10		20	80		5	48		15			tr	2	2		8			20							
8-1, 36	131.86	20	60	20		30	25	30	5			tr	7		2		1									
8-1, 52	132.02		20	80		5	70	2	15			tr	3	3	2											2
8-3, 70	135.20	5	45	50	?	15	44	2	20	10		tr	2	2	5											
8, CC	136.10		40	60		10	63	3	15			tr	2	1	5				1							
9-1, 85	151.35	2	18	80	?	5	73		10	2		tr	2		8											
9, CC	155.10		20	80	?	20	60	2	10			tr	4	1	1	1									1	
10-1, 145	170.95		30	70		5	62		25		1	tr			2	5										
10-2, 3	171.03	4	36	60		3	59		5			tr	3	20	10									tr		3
10-2, 50	171.50		40	60		1	56	1	35			tr	2	5												
10-2, 110	172.10					1							1	1	1	15			81							4
10-3, 93	173.43						5						2	2					87		4					
10, CC	175.60											2	1	3	1			1	92							
11-1, 62	179.92												25						75							5
11-1, 130	180.60												1		1	2		5	88							
11-4, 25	184.05		85	15								3			5	10		2	79		1					
11-4, 125	184.05														5	1		tr	87	1	6					
11, CC	188.40											1			2	2		3	77	20	5					
12-2, 53	190.53															2		3	83	5	6	1				
12-4, 73	193.73		100									1				3		3	75	11	7					
12-5, 130	195.80														1			5	80	tr	2					
12, CC	196.10														3	2		10	85							
13-1, 120	199.20					1		1					1		1	15		1	80							
13-1, 143	199.43												1		3	6		3	85		2					
13-2, 4	199.54														2	38			60							
13-3, 116	202.16														4	2		5	87		2					
13, CC	202.60														2	3		5	87		4					
14, CC	212.10											tr			25	20		4	43		8					
15-2, 37	218.87	2	78	20			?	3					5		15	20		2	53		2					
15, CC	220.10		90	10											15	10		5	68		2					
16-1, 68.5	236.69		40	60								7	3		3	35			52							

Note: In samples from Units 1, 2, and 3 green and brownish-green grains lacking birefringence were identified on-board ship as volcanic glass. In view of the large percentages of mica in the X-ray determinations, the optical identification appears to be in error. This table has been adjusted accordingly.

Site 287 Hole Core 1 Cored Interval: 0.0-8.0 m



5GY 2/1

3†

2

4

5

3

?

MICRONODULE BEARING GLASS SHARD RICH CLAY; soft to stiff.

<u>SS 1-116</u>

75% Cl	4% Nod	2% Z
15% Mica	2% Fsp	2% Py

GRADED CYCLES AND INTERBEDS OF BIOGENIC CLAY.

<u>$CaCO_3$ 3-115</u> (13)

<u>Grain Size 3-124</u> (0, 43, 57)

<u>X-ray 3-131</u> (Bulk)

24% Quar	15% Plag	4% Mont
24% Mica	5% Chlo	3% Potash Fsp.
18% Calc	4% Kaol	1% Amph

<u>Water Content 3-135</u> (52)

<u>Water Content 5-144</u> (52)

<u>X-ray 6-11</u> (Bulk)

28% Quar	19% Plag	6% Chlo 5% Potash Fsp.
28% Mica	8% Mont	6% Kaol 1% Amph

The following comments apply to the sediments in Cores 1 through to the top of Core 8:

GRADED CYCLES may consist of a coarest basal layer of sandy silt grading up through progressively finer silty sediment to silty clay and clay at the top. Sand is rarely seen in a cycle and most cycles consist of a thin basal silt grading up through clayey silt and silty clay to clay. At the top of one cycle the clay grades up into nanno clay.

Average thickness is 28 cm per cycle with a thickness range of 5 to 40 cm.

Cycles are usually darker at the base and grade up through lighter colors to the top. Bases are usually greenish black (5GY 2/1) to dark greenish gray (5GY 3/1) or olive black (5Y 2/1) to dark olive gray (5Y 3/1). Most of the cycle is usually dark greenish gray (5GY 4/1). Occasionally the top is medium greenish gray (5GY 5/1).

BIOGENIC CLAY. Four distinct beds of nanno clay can be clearly recognized. Three beds consist of uniform nanno clay (greenish gray - 5GY 6/1 to yellowish gray - 5GY 8/1). One bed consists of graded foram-nanno clay to nanno clay. Bed thickness ranges from 2 to 40 cm averaging about 14 cm.

(Continued on Core 2).

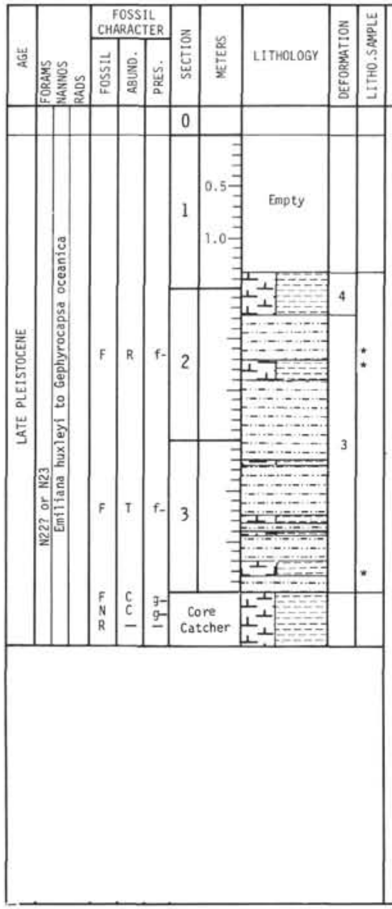
5GY 4/1 dark greenish gray

MICARB, FELDSPAR AND NANNO BEARING, MICA RICH SILTY CLAY; soft.

---

†These numbers refer to the number of graded cycles of silt and clay in the indicated intervals.

Site 287 Hole Core 2 Cored Interval:17.5-27.0 m



2

3?

?

5

1

2

1

(Continued from Core 1).

GENERALIZED MINERALOGY for Cores 1-7.

Graded cycles consist of a maximum of 4 units of different grain size each characterized by a different color.

1. Basal unit, greenish black (5GY 2/1).

Fsp	20-40%	average 32%
Q	10-30%	average 20%
Mica	0-37%	average 18%
HM	3-15%	average 11%
Bio. Sed.	0-15%	average 9%

Minor pyrite, micarb, and clay minerals.

2. Lower middle unit, dark greenish gray (5GY 3/1).

Cl M.	25-45%	average 37%
Mica	10-53%	average 28%
Fsp	7-15%	average 9%
Bio. Sed.	7-11%	average 9%

Minor pyrite, micarb, micronodules, quartz, zeolite and heavy minerals.

3. Upper middle unit, dark greenish gray (5GY 4/1).

Cl M.	58-77%	average 66%
Mica	4-30%	average 15%
Bio. Sed.	0-17%	average 7%
Fsp	1- 5%,	average 4%

Minor micarb, heavy minerals, micronodules, and zeolite.

4. Top unit, medium dark greenish gray (5GY 5/1).

Cl M.	49-93%	average 75%
Mica	0-20%	average 8%
Bio. Sed.	0-10%	average 5%
Fsp	0- 8%	average 4%

Minor micarb and zeolite.
Some top units grad up to nanno ooze.
Nanno interbeds are mainly nannos and clay minerals with small amounts of volcanic glass, forams, micarb, and zeolite.

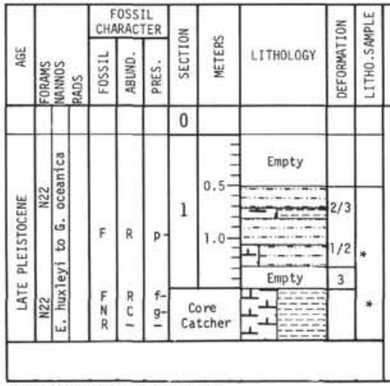
<u>Water Content 2-79</u> (48)

<u>Water Content 3-140</u> (42)

5GY 5/1 medium greenigh gray

NANNO CLAY; soft-stiff.

Site 287 Hole Core 3 Cored Interval:36.5-46.0 m



? 2

?

GRADED CYCLES AND NANNO CLAY INTERBEDS

Too disturbed to recognize the number of graded cycles with confidence.

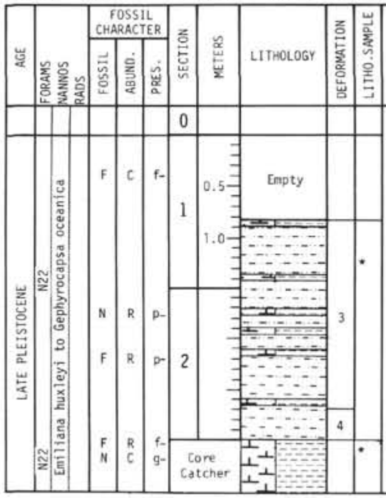
Soft to stiff.

5G 6/1 and 5GY 4/1 greenish gray

FORAM, FELDSPAR AND MICA BEARING NANNO CLAY; soft - stiff.

Explanatory notes in Chapter 2

Site 287 Hole Core 4 Cored Interval:55.5-65.0 m



LITHOLOGIC DESCRIPTION

GRADED CYCLES AND INTERBEDS OF NANNO CLAY AND CARBONATE SANDY SILT

Water Content 1-144 (40)

2

?

?

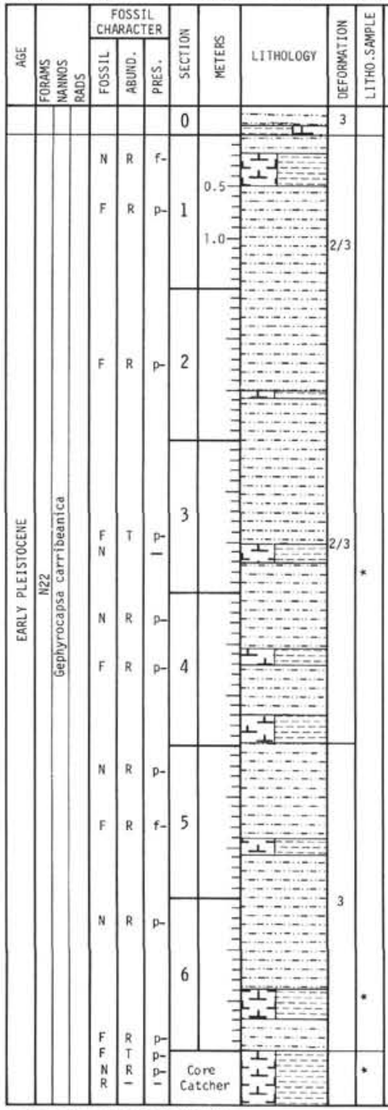
?

?

?

5GY 4/1 dark greenish gray FELDSPAR AND MICA BEARING NANNO CLAY; soft.

Site 287 Hole Core 5 Cored Interval:74.5-84.0 m



LITHOLOGIC DESCRIPTION

1

FORAM RICH NANNO CLAY

NONCALCAREOUS GRADED CYCLES, CALCAREOUS GRADED CYCLES AND INTERBEDS OF NANNO CLAY

?

worm burrow filled with pyrite

worm burrow filled with pyrite

Water Content 2-120 (39)

?

2 worm burrows filled with pyrite

X-ray 3-30 (Bulk)

31% Mica	15% Plag	7% Calc	5% Kaol
26% Quar	8% Chlo	5% Potash Fsp	3% Mont

Water Content 3-85 (33)

Grain Size 4-57 (0, 29, 71)

3?

$CaCO_3$ 4-59 (43)

$CaCO_3$ 4-67 (38)

Grain Size 4-68 (0, 57, 43)

Water Content 4-99 (38)

2

Water Content 5-138 (37)

?

?

?DEVITRIFIED GLASS SHARD ASH, a small patch, probably from a distinct thin bed.

SS 6-90
100% Gl

5G 3/2
dusky green

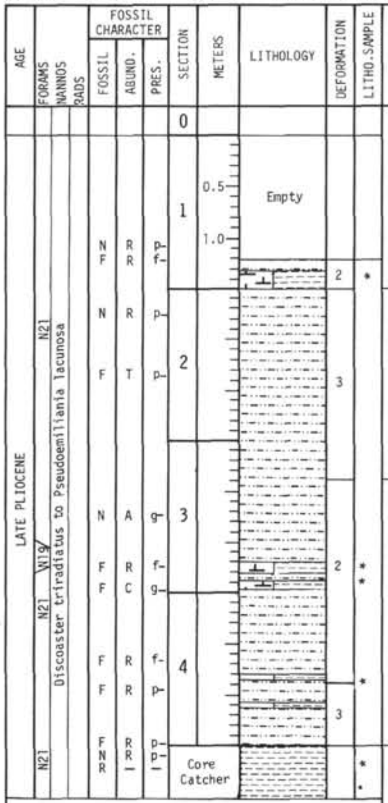
?

NANNO, FELDSPAR AND MICARB BEARING MICA RICH CLAY; soft.

5GY 4/1
dark greenish gray

Explanatory notes in Chapter 2

Site 287 Hole Core 6 Cored Interval:93.5-103.0 m



LITHOLOGIC DESCRIPTION

Water Content 1-144 (35)

GRADED CYCLES AND INTERBEDS OF NANNO CLAY.

1

7+

Water Content 2-120 (37)

Water Content 3-100 (37)

Grain Size 3-108 (0, 28, 72)

CaCO$_3$ 3-111 (5)

X-ray 3-112 (Bulk)
29% Mica 13% Plag 8% Mont 6% Chlo
23% Quar 10% Calc 7% Potash Fsp 4% Kaol

Grain Size 3-119 (0, 12, 88)

1

X-ray 3-122 (Bulk)
36% Calc 9% Kaol 4% Mont
22% Quar 7% Arag 3% Potash Fsp
14% Mica 5% Plag 1% Chlo

6

CaCO$_3$ 3-122 (30)

X-ray 3-126 (Bulk)
28% Quar 12% Plag 3% Kaol
24% Calc 9% Mica 2% Pyri
17% Arag 5% Potash Fsp 1% Chlo

3

Grain Size 3-127 (0, 65, 35)

?

CaCO$_3$ 3-129 (32)

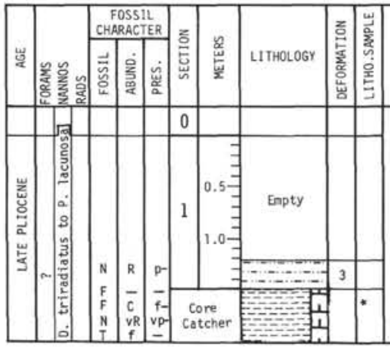
Most cycles range from basal silts to silty clays, 3 carbonate cycles range from basal foram silty sands to silt.

Water Content 4-69 (33)

Several pyritized worm burrows

5Y 2/1 olive black to 5GY 6/1 greenish gray	NANNO, MICARB, FELDSPAR AND PLANT DEBRIS BEARING MICA RICH CLAY; soft.

Site 287 Hole Core 7 Cored Interval:112.5-122.0 m



LITHOLOGIC DESCRIPTION

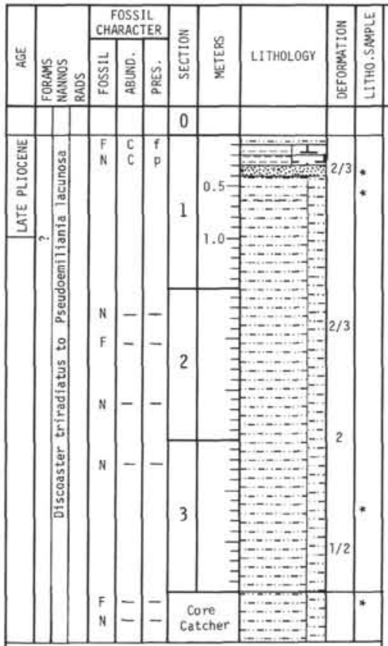
GRADED CYCLES

2

5Y 4/1 olive gray	FELDSPAR AND MICARB BEARING GLASS SHARD AND NANNO RICH CLAY; soft - stiff.

v denotes very

Site 287 Hole Core 8 Cored Interval: 131.5-141.0 m



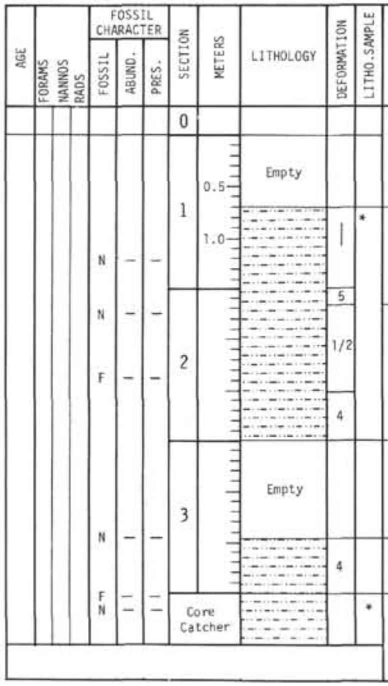
LITHOLOGIC DESCRIPTION

3 thin nanno beds

5GY 4/1	SILTY CLAY AND NANNO CLAY INTERBEDS
10YR 4/2 5Y 5/2 (light olive gray)	Grain Size 1-2 (0, 24, 76) CaCO$_3$ 1-19 (1) X-ray 1-20 (Bulk) 28% Mica 20% Plag 7% Mont 5% Chlo 26% Quar 8% Potash Fsp 5% Kaol 2% Amph
to	OPAQUE, MICA BEARING, CLAY RICH, SANDY CLAYEY SILT, dark greenish gray; stiff.
10YR 5/2 (yellowish brown)	SS 1-36 30% Fsp 25% Cl 5% Opaq 2% Z 30% HM 5% Mica 2% Py 1% G Grain Size 1-42 (1, 26, 73) CaCO$_3$ 1-44 (0) X-ray 1-50 (Bulk) 29% Mica 23% Plag 6% Chlo 3% Amph 25% Quar 7% Potash Fsp 5% Mont 2% Kaol
10YR 4/2 grayish olive	MICRONODULE, PYRITE, FELDSPAR MICA RICH SILTY CLAY, dark yellowish brown; stiff, faint moderate mottling at a few levels. SS 1-52 72% Cl 5% Fsp 3% Nod Tr% Z. 15% Mica 3% Py 2% HM Water Content 1-94 (35) Water Content 2-100 (35) Water Content 3-66 (36) CHLORITE BEARING, FELDSPAR AND MICA RICH SILTY CLAY, grayish olive; stiff, faint (slightly darker) slight to moderate mottling. SS 3-70 44% Cl 10% Chlo 2% Nod 20% Mica 2% HM Tr% Z 15% Fsp 2% Opaq ?% Q Grain Size 3-74 (0, 40, 60) CaCO$_3$ 3-74 (0)
5Y 4/1 olive gray	HEAVY MINERALS, ZEOLITE AND FELDSPAR BEARING MICA SILTY CLAY; soft

Explanatory notes in Chapter 2

Site 287 Hole Core 9 Cored Interval: 150.5-160 m



LITHOLOGIC DESCRIPTION

5GY 5/2
dusky yellow
green

10Y 4/2
grayish olive

MICA BEARING FELDSPAR RICH SILTY CLAY, dusky yellow green; stiff, slight mottling, mottles are medium greenish gray (5GY 5/1).

SS 1-85
73% Cl 12% Fsp 2% Opaq ?% Q
10% Mica 2% Chlo 1% Z

Water Content 1-119 (37)

Water Content 2-60 (36)

Grain Size 2-74 (0, 44, 56)

$CaCO_3$ 2-74 (0)

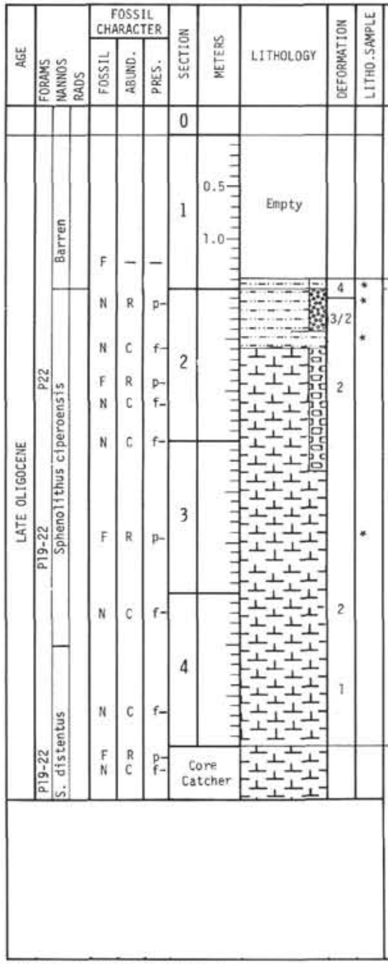
X-ray 2-97 (Bulk)
33% Mica 20% Quar 8% Mont 2% Amph
25% Plag 8% Chlo 4% Potash Fsp

10Y 4/2
grayish olive

5GY 5/2
dusky yellow
green

MICA BEARING FELDSPAR RICH SILTY CLAY

Site 287 Hole Core 10 Cored Interval: 169.5-179.0 m



LITHOLOGIC DESCRIPTION

10Y 4/2
grayish
olive

5YR 3/4
moderate brown
10YR 4/2

10YR 5/4
moderate
yellowish
brown with
grayish brown
mottles
(10YR 7/4)

10YR 6/4
yellowish
brown

10YR 7/4
grayish
orange

FELDSPAR AND MICARB BEARING, MICA SILTY CLAY; stiff, no structures.

SS 1-145
62% Cl 5% Fsp 2% Z
25% Mica 5% M 1% Vol. R

Grain Size 1-145 (0, 39, 61)

$CaCO_3$ 1-145 (1)

FELDSPAR, OPAQUE, MICA AND ZEOLITE BEARING, MICRONODULE RICH CLAY; stiff.

SS 2-3
59% Cl 10% Z 3% Fsp Tr% Fish D.
20% Nod 5% Mica 3% Opaq

$CaCO_3$ 2-15 (0)

Grain Size 2-25 (0, 16, 84)

X-ray 2-40 (Bulk)
24% Phil 19% Mont 8% Clin 8% Kaol
20% Quar 13% Mica 8% Plag

MICRONODULE AND MICA BEARING, ZEOLITE RICH CLAY; stiff, intensely bioturbated at this level, dark yellowish brown (10YR 4/2) with a few dusky yellowish brown spots (10YR 2/2).

SS 2-50
56% Cl 5% Nod 1% Fsp
35% Mica 2% Mag 1% HM

$CaCO_3$ 2-75 (81)

Water Content 2-90 (33)

$CaCO_3$ 3-58 (76)

X-ray 3-60 (Bulk)
92% Calc 2% Plag 1% Mont
3% Phil 1% Quar 1% Clin

CLAY AND CALCAREOUS SPICULE BEARING NANNO OOZE, mottling slight to moderate.

SS 3-93
87% N 5% Cl 2% Nod
7% Calc S. 2% Py

Water Content 3-113 (34)

$CaCO_3$ 4-92 (85)

Water Content 4-97 (32)

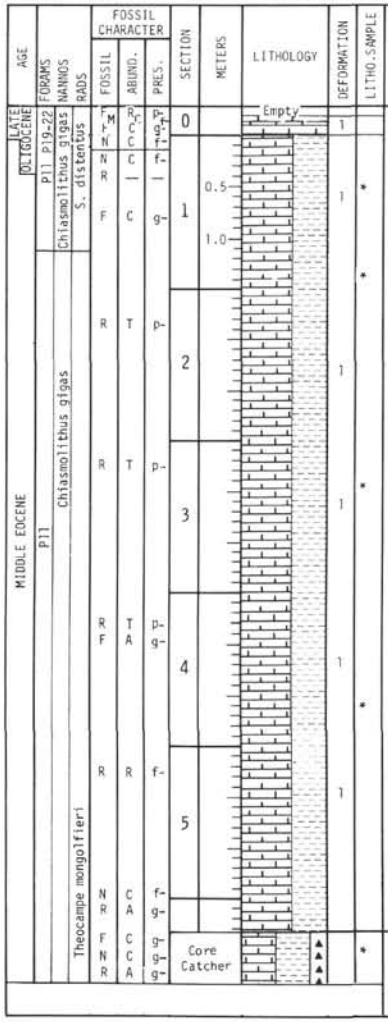
5GY 5/2
dusky yellow
green

MICRONODULE BEARING NANNO OOZE

SS CC
90% N 2% Gl 2% Cl
3% Nod 1% Py 1% Z

Explanatory notes in Chapter 2

Site 287 Hole Core 11 Cored Interval:179.0-188.5 m



LITHOLOGIC DESCRIPTION

10YR 5/4 moderate yellowish brown — NANNO OOZE
5Y 7/2 yellowish gray — CLAY NANNO CHALK
5Y 7/2 yellowish gray — Semilithified
5Y 8/1 — a few black streaks and spots
5Y 7/2 — CLAY AND OPAQUE RICH NANNO CHALK, from thin (1-2 mm) black streak.

SS 1-62
55% N 25% Opaq 20% Cl

CALCAREOUS SPICULE AND FORAM BEARING CLAY NANNO CHALK.

SS 1-130
53% N 5% F 2% M 1% Z
38% Cl 3% Calc S. 1% Py

5Y 7/2 — Water Content 2-79 (41)

Faint traces of moderate mottling.

Water Content 3-77 (35)

5Y 8/1

GLASS SHARD AND ZEOLITE BEARING CLAY NANNO CHALK.

SS 4-25
54% N 5% Z 2% M 1% Calc S.
33% Cl 3% Gl 2% F

$CaCO_3$ 4-61 (56)

Water Content 4-105 (39)

ZEOLITE AND SPONGE SPICULE BEARING CLAY NANNO CHALK.

SS 4-125
56% N 5% S 1% M Tr% F
31% Cl 5% Z 1% Calc S.

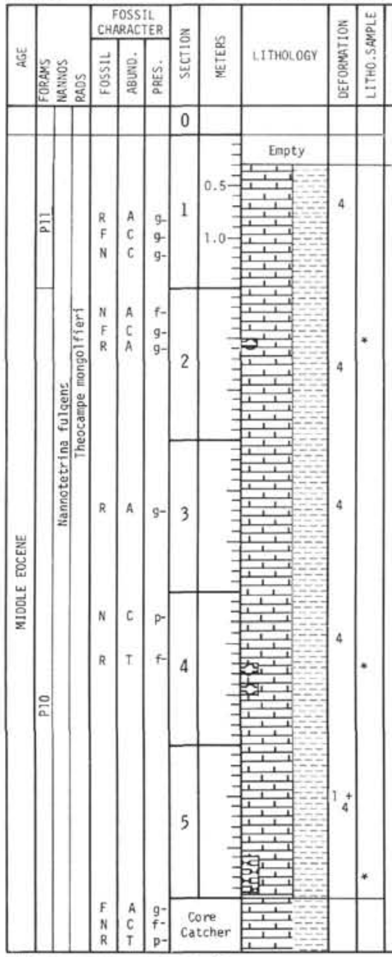
5Y 8/1 — Drilling disturbance is slight but sections 5 and 6 were brecciated during splitting.

5GY 6/1 greenish gray — Water Content 5-72 (37)

5Y 8/1 — FORAM, AND SPONGE SPICULE BEARING RAD RICH CLAY NANNO CHALK.

5Y 8/1 — SS CC
31% N 20% R 3% F 2% M
30% Cl 5% S 2% Z 1% Gl

Site 287 Hole Core 12 Cored Interval:188.5-198.0 m



Explanatory notes in Chapter 2

LITHOLOGIC DESCRIPTION

$CaCO_3$ 1-61 (56)

Water Content 1-71 (42)

5Y 8/1 yellowish gray

Semilithified

FORAM, RAD AND SPONGE SPICULE BEARING CLAY NANNO CHALK.

5Y 6/1 light olive gray — SS 2-53
53% N 5% R 3% F 1% S
30% Cl 5% S 2% M 1% Calc S.

Water Content 2-80 (42)

5Y 8/1 — CLAY NANNO CHALK WITH SILICEOUS RICH BEDS, light greenish gray.

$CaCO_3$ 3-53 (58)

Water Content 3-53 (40)

FORAM AND SPONGE SPICULE BEARING RAD RICH CLAY NANNO CHALK.

5GY 8/1 light greenish gray 5GY 8/1 — SS 4-73
50% N 11% R 3% M 2% Calc S.
36% Cl 5% S 3% F 1% Gl

Water Content 4-124 (34)

$CaCO_3$ 5-51 (56)

Water Content 5-51 (28)

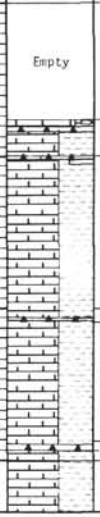
5Y 8/1 — FORAM BEARING, MICARB RICH CLAY NANNO CHALK.

SS 5-130
52% N 12% M 2% Calc S.
40% Cl 5% F 1% Z

ZEOLITE AND FORAM BEARING CLAY NANNO CHALK.

5GY 8/1
5Y 8/1 — SS CC
45% N 10% F 2% M
40% Cl 3% Z

Site 287 Hole Core 13 Cored Interval: 198.0-207.5 m



AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE
							0				
MIDDLE EOCENE	P10	Nannotetrina fulgens					1	0.5 1.0	Empty	4	* * *
				N	C	p-	2			1	
							3			4 4	*
				F N R	A C T	g- f- vp-	Core Catcher				

LITHOLOGIC DESCRIPTION

Semilithified

5Y 5/2 light olive gray - CHERT (lithified).

5B 7/1 light bluish gray - CHALKY CHERT (lithified)

MICARB BEARING CLAY NANNO CHALK.

5Y 8/1 yellowish gray

SS 2-4	
55% N (broken)	5% M
38% Cl	2% Z

Water Content 2-144 (28)

5Y 5/2 - CHERT (lithified).

5Y 8/1 Water Content 3-42 (34)

5B 7/1 ZEOLITE AND FORAM BEARING CLAY NANNO CHALK; semilithified.

SS 3-116		
50% N	5% F	2% M
37% Cl	4% Z	2% Calc S.

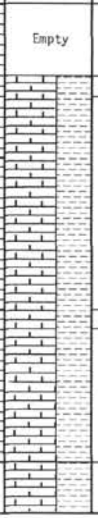
5B 7/1 - CHALKY CHERT (lithified).

5B 7/1 CaCO$_3$ core catcher (51)

MICARB, CALCAREOUS SPICULE AND FORAM BEARING CLAY NANNO CHALK.

SS CC			
45% N	5% F	3% Calc S.	1% S
41% Cl	3% M	2% Z	

Site 287 Hole Core 14 Cored Interval: 207.5-217.0 m



AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE
							0				
MIDDLE EOCENE	P10	Discoaster sublodoensis (Rhabdosphaera inflata Subzone)					1	0.5 1.0	Empty	4	
				N	C	f-	2			1	
				N	C	f-	3			4 1	
				F N R	A C R	g- f- vp-	Core Catcher				

LITHOLOGIC DESCRIPTION

Water Content 1-114 (33)

CLAY NANNO CHALK; semilithified.

5B 7/1 light bluish gray

Mottling moderate but faint.
A few ZOOPHYCOS burrows.

CaCO$_3$ 2-80 (67)

Water Content 2-80 (38)

CaCO$_3$ 3-5 (56)

Water Content 3-80 (32)

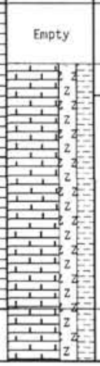
X-ray 3-100 (Bulk)		
84% Calc	4% Quar	3% Mont
5% Clin	3% Mica	1% Plag

FORAM, MICARB, CLAY AND CALCAREOUS SPICULE BEARING, ZEOLITE RICH NANNO CHALK.

5GY 8/1 light greenish gray

SS CC			
51% N	8% Calc S.	5% M	Tr% Gl
25% Z	7% Cl	4% F	

Site 287 Hole Core 15 Cored Interval: 217.0-226.5 m



AGE	FORAMS	NANNOS	RADS	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE
							0				
LOWER EOCENE	P9	Discoaster sublodoensis * *		N F	C A	f- g-	1	0.5 1.0	Empty	4	
				N	C	f-	2			|	*
				N	C	f-					
				F N R	C C T	g- f- vp-	Core Catcher				

LITHOLOGIC DESCRIPTION

Water Content 1-88 (33)

CaCO$_3$ 1-91 (68)

5B 7/1 light gluish gray

Semilithified

Water Content 2-16 (32)

5B 7/1 CaCO$_3$ 2-141 (55)

HEAVY MINERAL MICARB AND PYRITE BEARING, ZEOLITE AND CLAY RICH NANNO CHALK (from black streak).

SS 2-27			
53% N	15% Cl	5% Py	2% F
15% Z	5% M	3% HM	2% Calc S.

5G 8/1 light greenish gray

FORAM AND MICARB BEARING, ZEOLITE AND CLAY RICH NANNO CHALK.

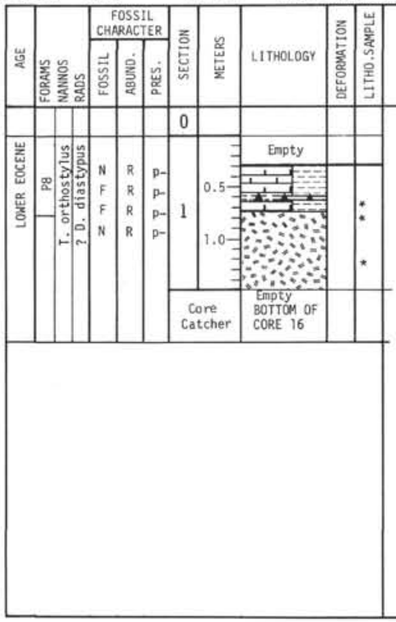
5G 8/1

SS CC		
48% N	15% Z	5% F
25% Cl	5% M	2% Calc S.

Explanatory notes in Chapter 2

* * (Discoasteroides kuepperi Subzone)

Site 287 Hole Core 16 Cored Interval:236.0-238.0 m



LITHOLOGIC DESCRIPTION

5Y 4/1 olive gray to 5Y 3/1 dark olive gray

Water Content 1-42 (27)

$CaCO_3$ 1-49 (50)

CHALK CHERT (lithified).

OPAQUE, ZEOLITE MICARB AND GLASS SHARD - BEARING CLAY NANNO CHALK; semilithified, olive gray (5Y 4/1), moderate to intense burrowing (flattened).

SS 1-68.5

45% N	7% Gl	3% Z
37% Cl	5% M	3% Opaq

PORPHYRITIC BASALT

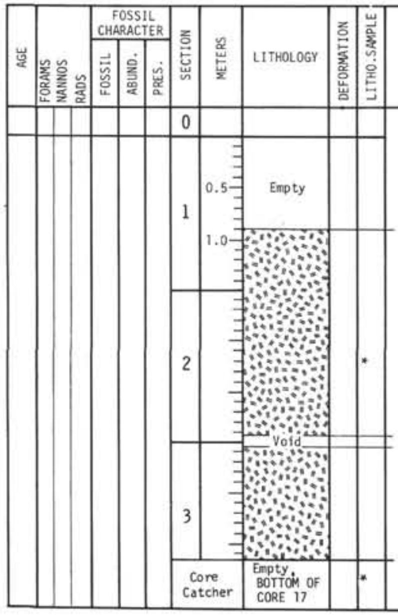
72-78 cm: dry pale purple (5P 6/2), wet medium gray (N5).
79-150 cm: dry medium light gray (N6), wet dark gray (N3).

~15-20% plagioclase phenocrysts and glomerocrysts, <5 mm (long axis).
~5% serpentine-calcite pseudomorphs after olivine phenocrysts, <2 mm diameter, <2%.

Groundmass plagioclase increases downwards from <0.2 mm at top of an average of 0.20-0.25 mm at the bottom of Section 1. Considerable replacement of groundmass glass(?) and pyroxene by chlorite. Intersertal texture.

Abundant calcite and/or chlorite veins, <3 mm wide.

Site 287 Hole Core 17 Cored Interval:238.0-242.5 m



LITHOLOGIC DESCRIPTION

PORPHYRITIC BASALT continued.

Like basalt of Core 16.

CORE CATCHER - PORPHYRITIC BASALT continued.

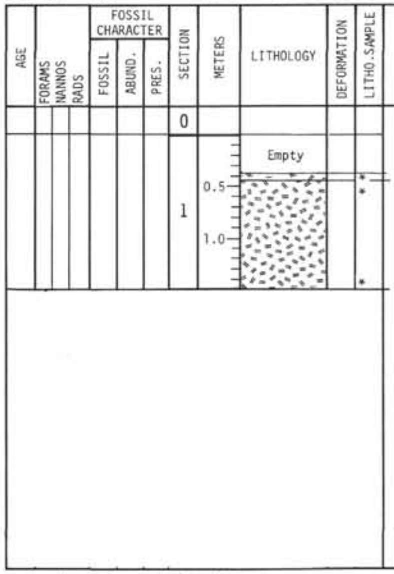
No amygdules or vesicles in middle part *of core catcher; rock very fresh.*

olivine phenocrysts	5.0	
plagioclase phenocrysts	14.5	40.1
plagioclase, groundmass	25.6	
groundmass pyroxene	48.0	(~3% was groundmass olivine)
magnetitie	4.0	
chloritic alteration	4.0	
chlorite amygdules	0.4	(250 points)

Increase of chlorite amygdules to ~5%, <2 mm diameter

chemical analysis #9

Site 287 Hole Core 18 Cored Interval:242.5-252.0 m



LITHOLOGIC DESCRIPTION

PORPHYRITIC BASALT continued.

Like Core 16; average groundmass plagioclase ~0.2-0.25 mm.

chemical analysis #10

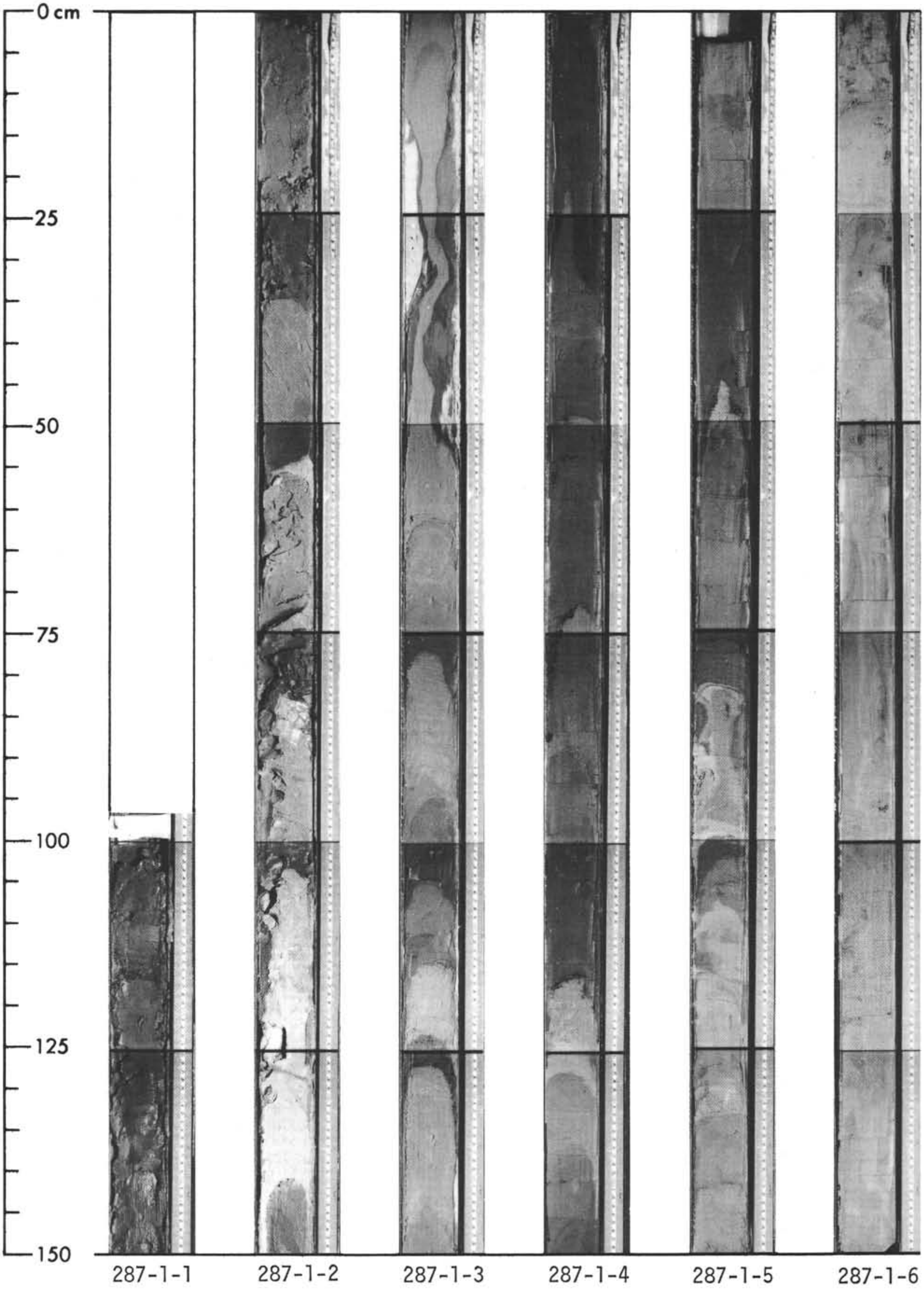
BASALT

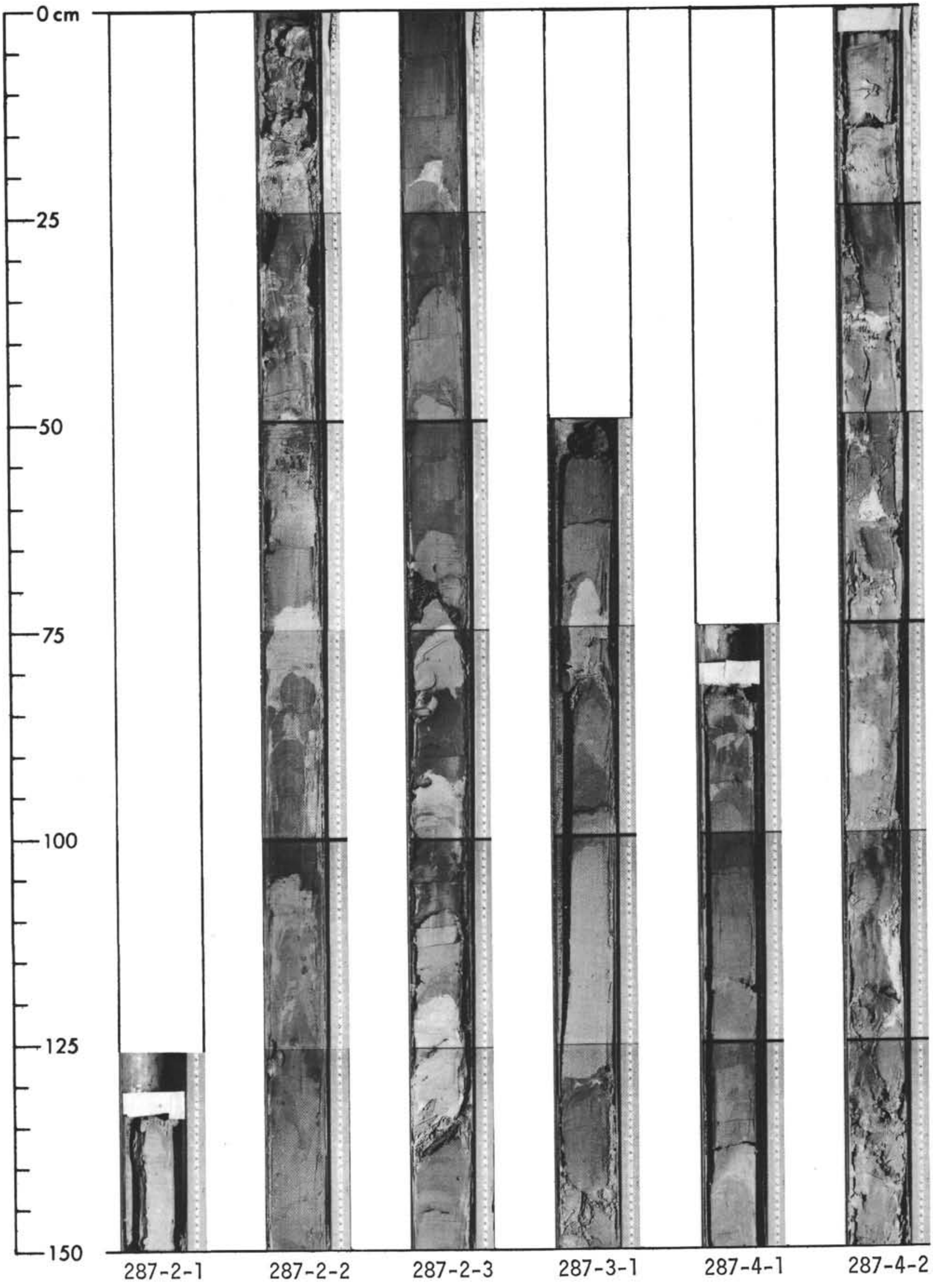
Dry medium to medium dark gray (N5-N4), wet grayish black (N2).

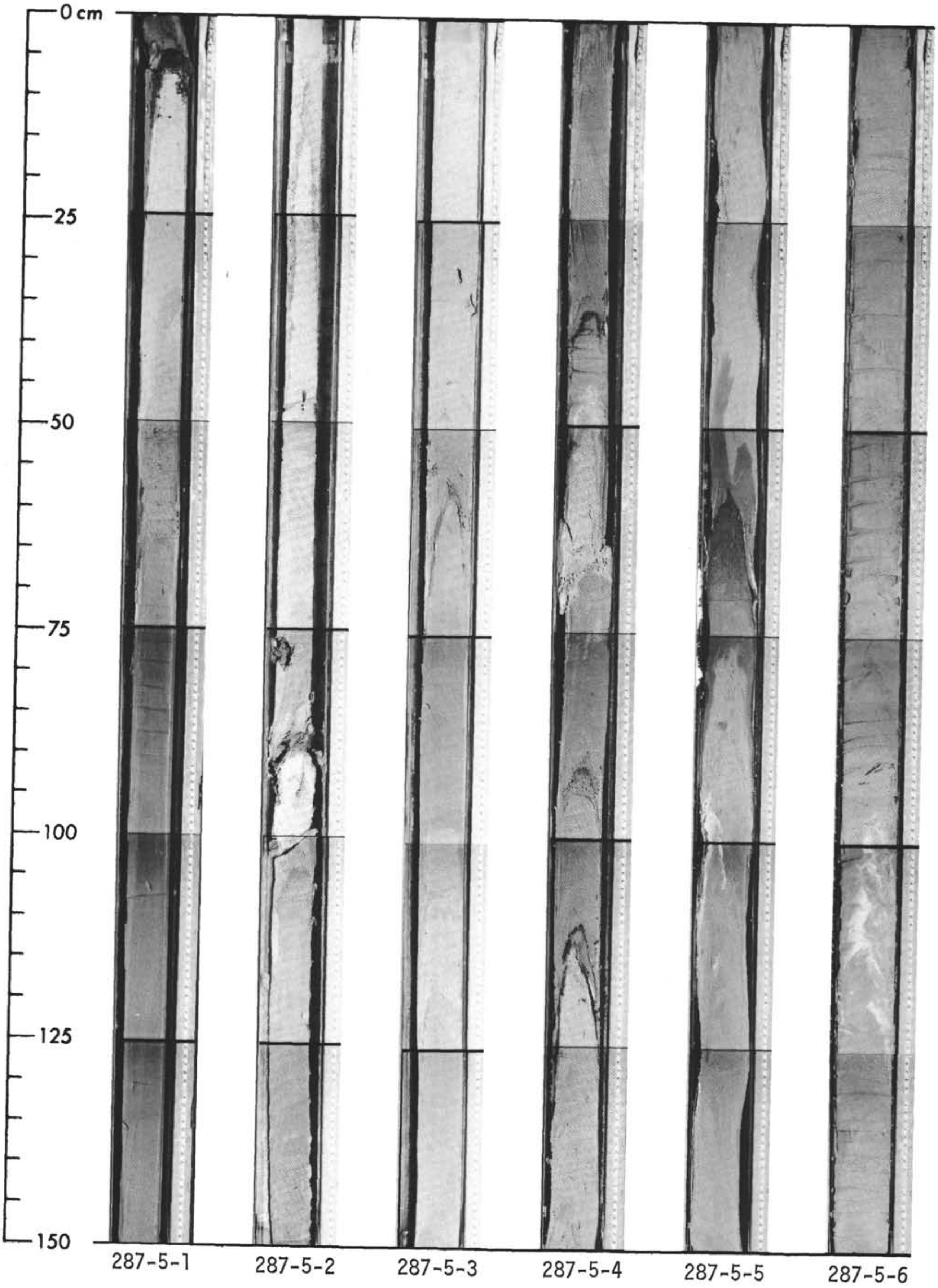
Very fine-grained basalt with sparse phenocrysts of plagioclase, <0.25 mm and rare serpentine pseudomorphs after olivine (not visible in hand specimen), <0.25 mm. Intersertal texture, with chlorite groundmass around the plagioclass microlites. Chloritic alteration has destroyed all groundmass pyroxene. The average grain-size of the groundmass plagioclase varies from <30µ at the top (chill-zone) to ~0.20-0.25 mm at the bottom of Section 1.

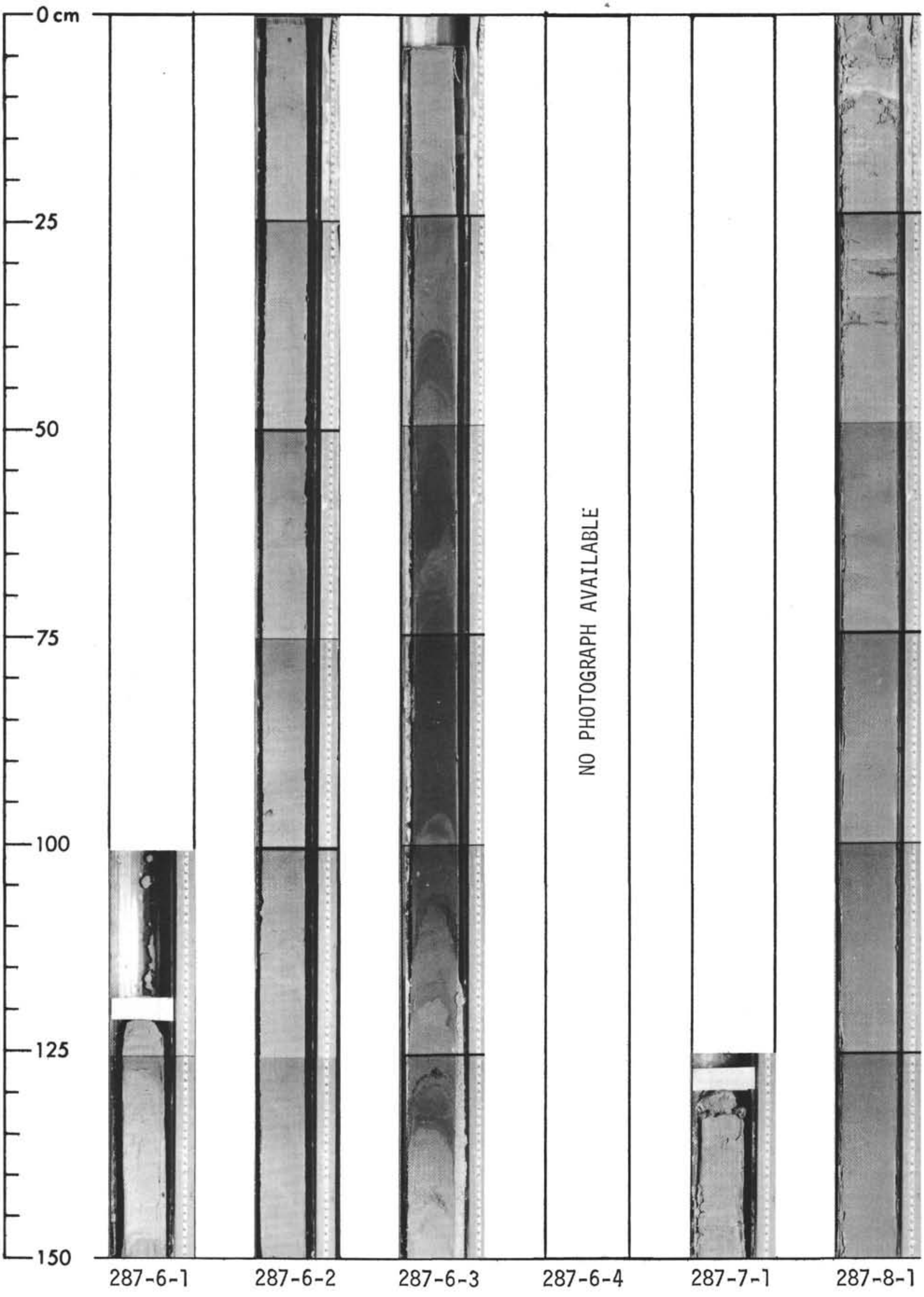
Chlorite and sparse calcite amygdules; abundant calcite and/or chlorite veins.

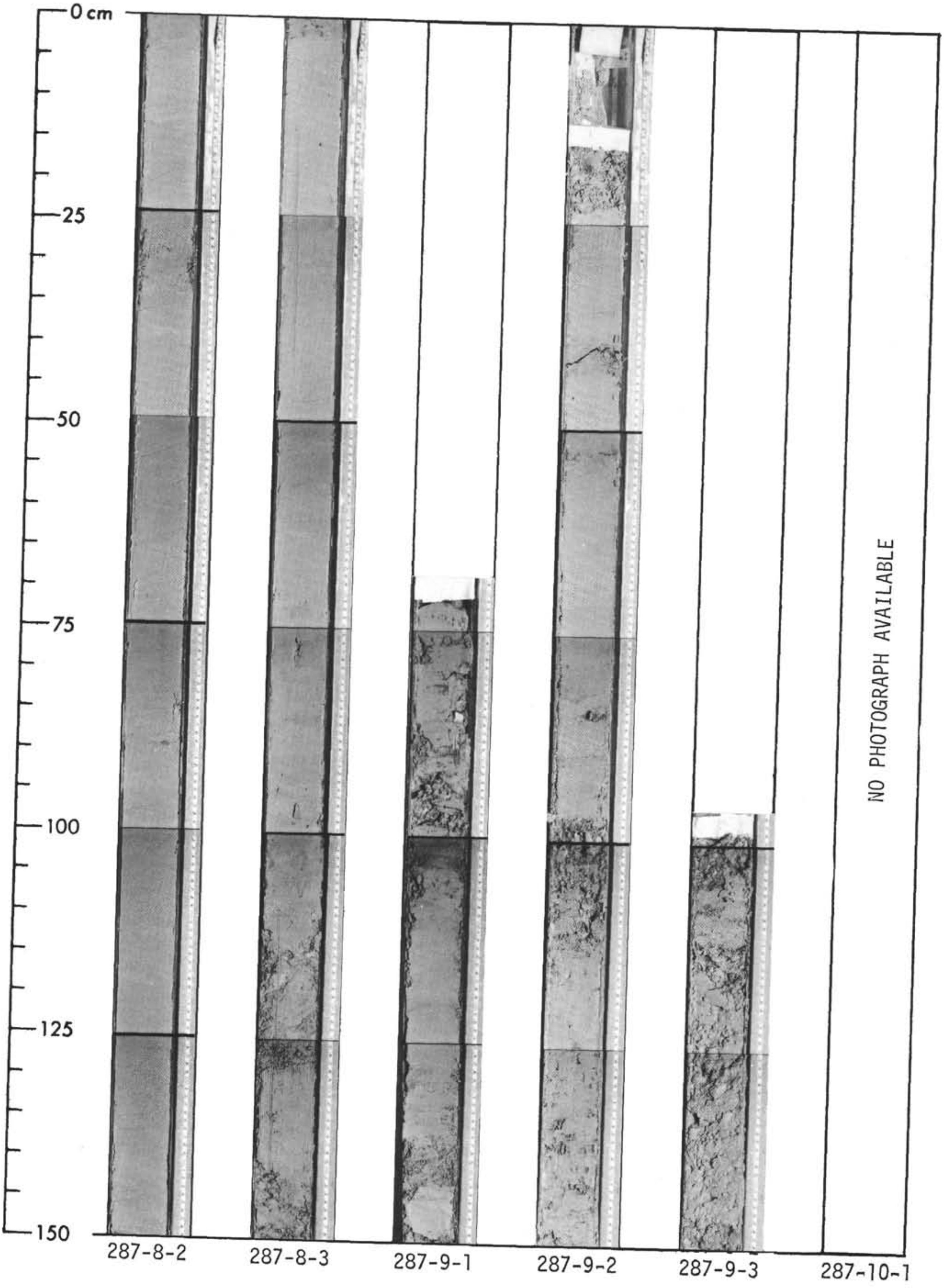
Explanatory notes in Chapter 2

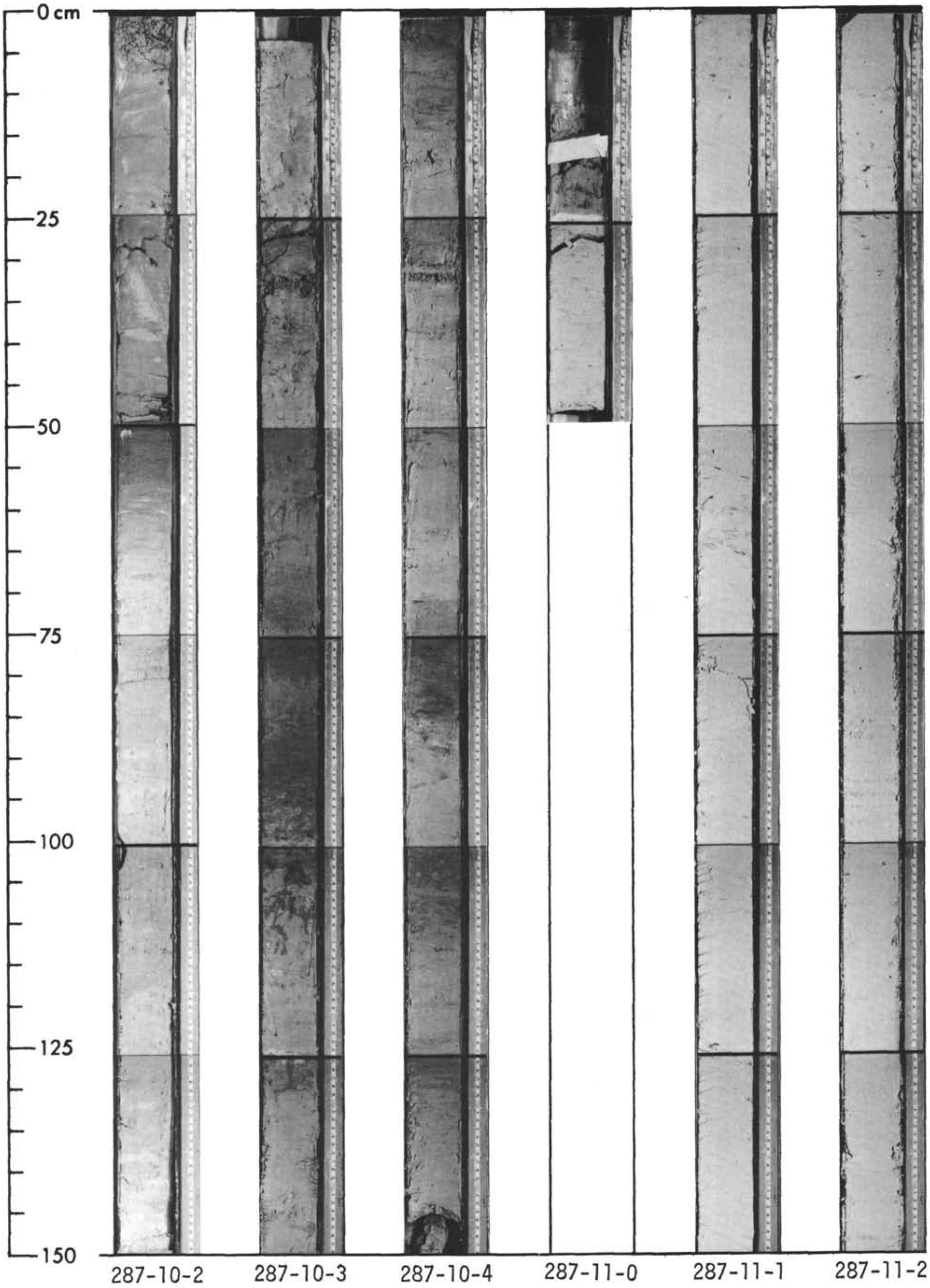

0 cm
25
50
75
100
125
150
287-1-1
287-1-2
287-1-3
287-1-4
287-1-5
287-1-6

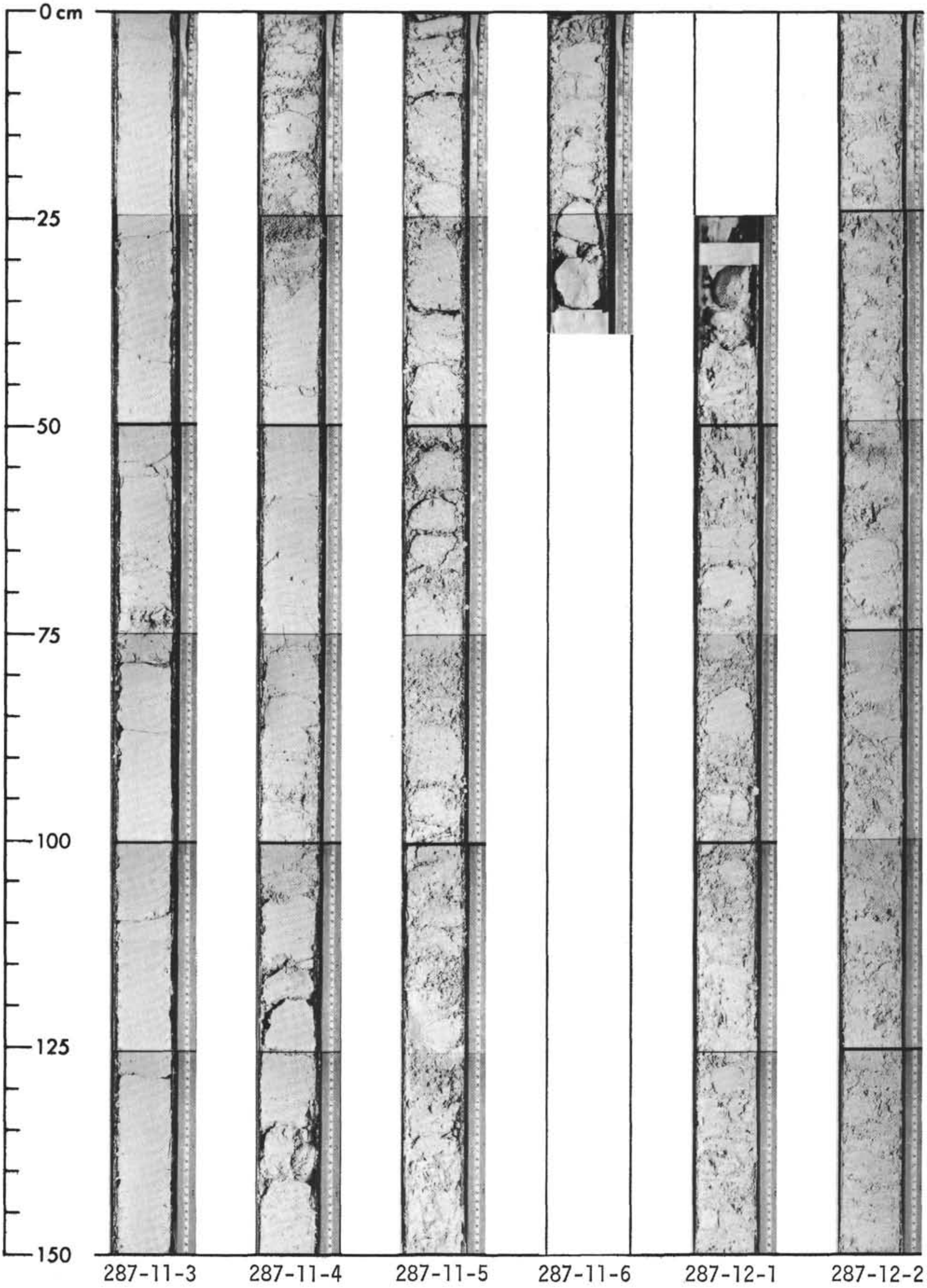

0 cm
25
50
75
100
125
150
287-2-1
287-2-2
287-2-3
287-3-1
287-4-1
287-4-2

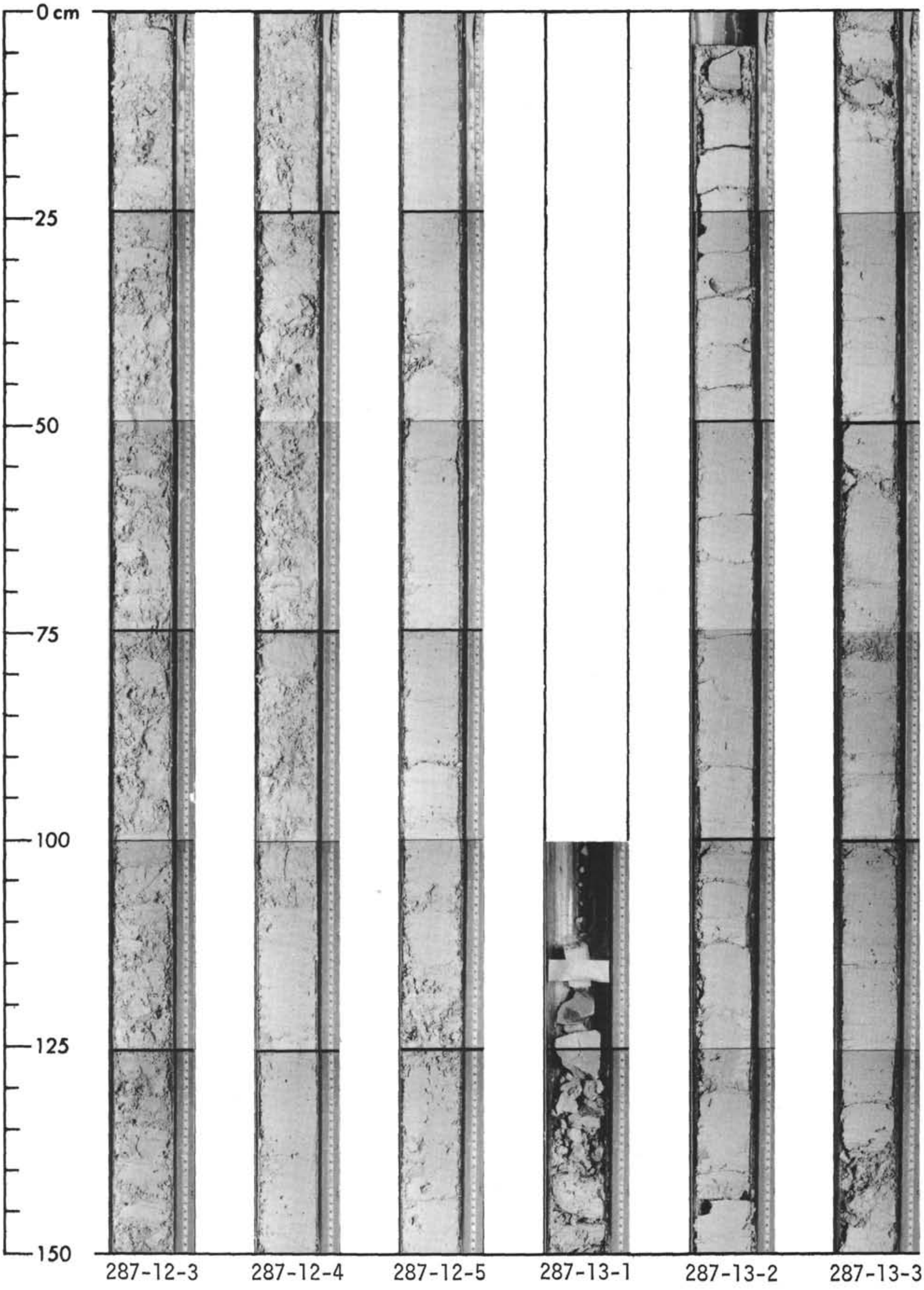

0 cm
25
50
75
100
125
150
287-5-1
287-5-2
287-5-3
287-5-4
287-5-5
287-5-6

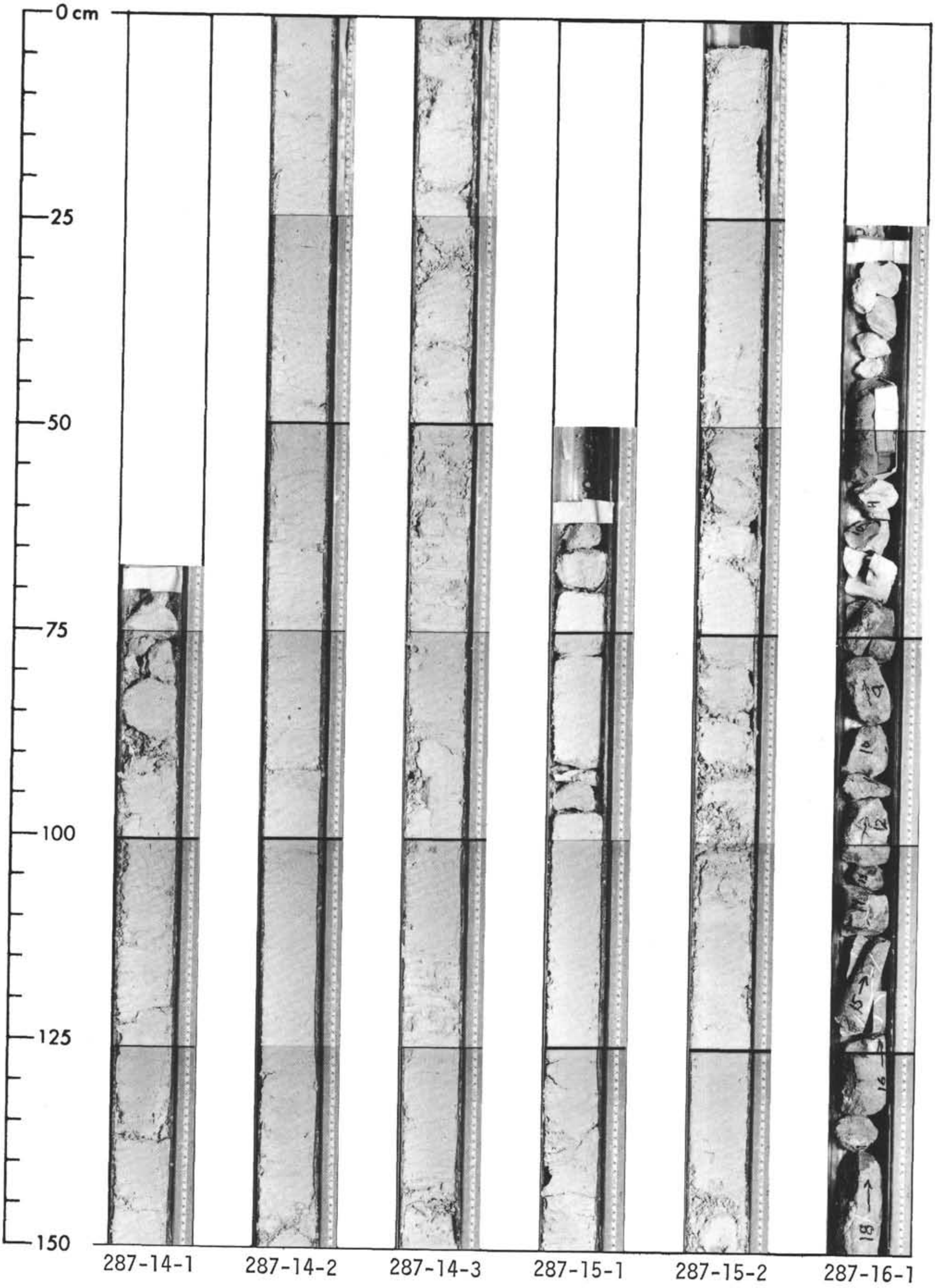

0 cm
25
50
75
100
125
150
NO PHOTOGRAPH AVAILABLE
287-6-1
287-6-2
287-6-3
287-6-4
287-7-1
287-8-1

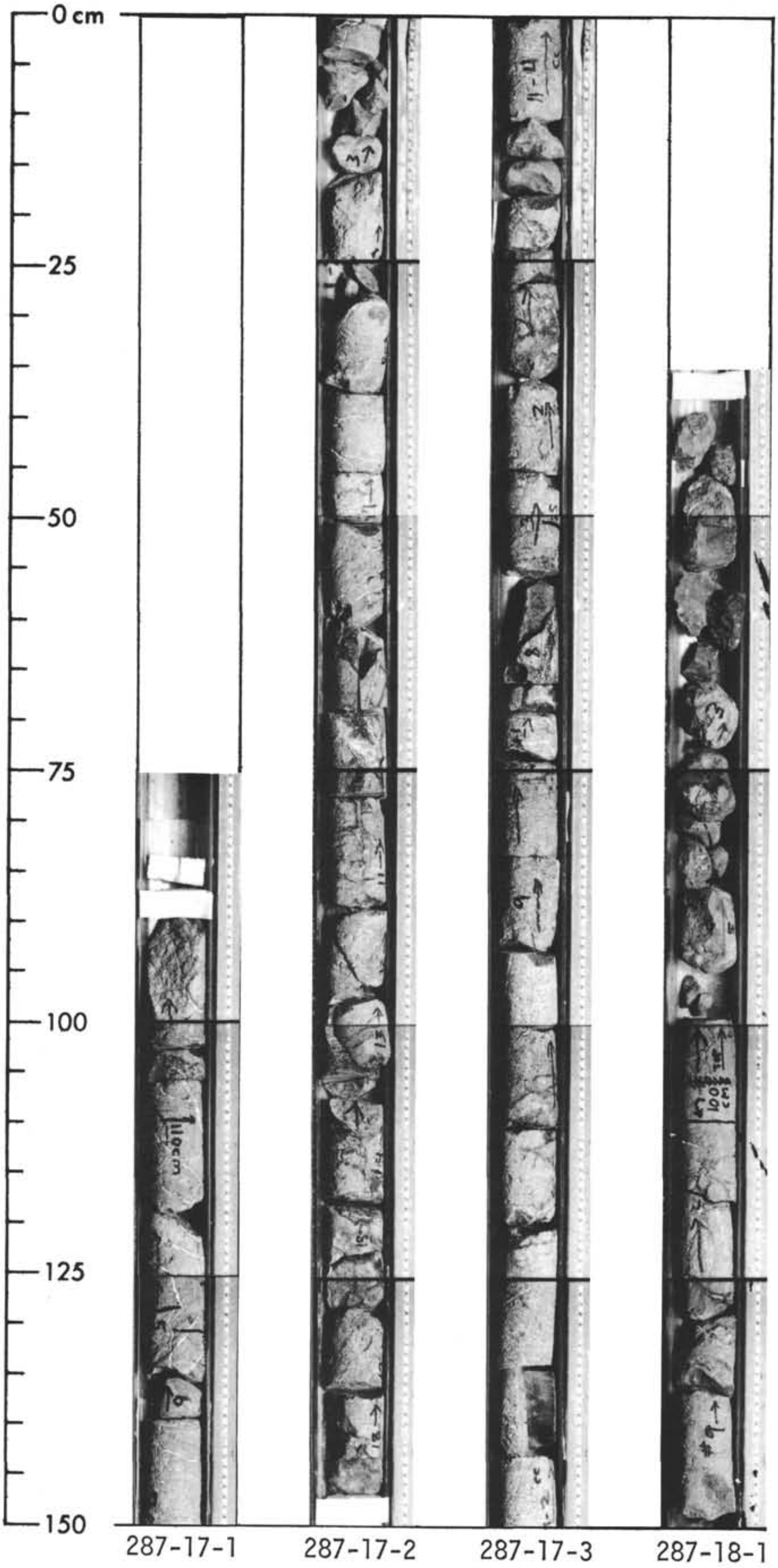

0 cm
25
50
75
100
125
150
287-8-2
287-8-3
287-9-1
287-9-2
287-9-3
287-10-1
NO PHOTOGRAPH AVAILABLE


0 cm
25
50
75
100
125
150
287-10-2
287-10-3
287-10-4
287-11-0
287-11-1
287-11-2


0 cm
25
50
75
100
125
150
287-11-3
287-11-4
287-11-5
287-11-6
287-12-1
287-12-2


0 cm
25
50
75
100
125
150
287-12-3
287-12-4
287-12-5
287-13-1
287-13-2
287-13-3


0 cm
25
50
75
100
125
150
287-14-1
287-14-2
287-14-3
287-15-1
287-15-2
287-16-1


0 cm
25
50
75
100
125
150
287-17-1
287-17-2
287-17-3
287-18-1