6. SITES 294/295

The Shipboard Scientific Party[1]

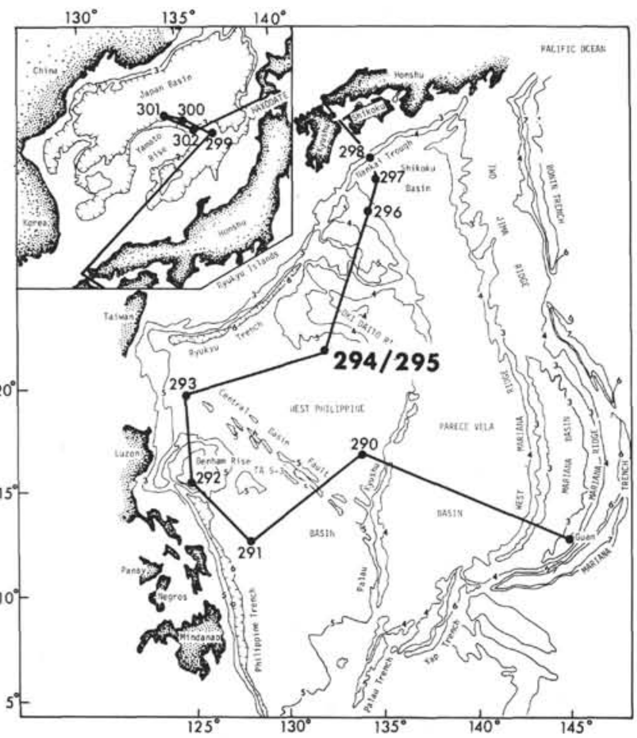

Figure 1. Glomar Challenger *track and location of Sites 294/295. From map: "Topography of North Pacific," T. E. Chase, H. W. Menard, and J. Mammerickx, Institute Marine Resources, Geol. Data Center, Scripps Institution of Oceanography, 1971. Contour depths in kilometers; scale 1:6,500,000.*

SITE DATA

Position: 22°34.74'N, 131°23.13'E

Water Depth (from sea level): 5784 corrected meters (echo sounding)

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Bottom Felt At: 5820 meters (drill pipe)

Penetration: 118 meters

Number of Holes: 1

Number of Cores: 7

Total Length of Cored Section: 51.5 meters

Total Core Recovered: 23.2 meters

Percentage of Core Recovery: 45%

Oldest Sediment Cored:
Depth below sea floor: 112 meters
Nature: Brown mud
Age: Eocene or Paleocene(?)

Basement:
Depth below sea floor: 112-118 meters (drilled)
Nature: Basalt

Principal Results: Site 294 penetrated a thin sediment blanket covering the deeper portions of the West Philippine Basin northeast of the Central Basin Fault in an attempt to obtain another basement age and sediment history. The stratigraphic column consists of 112 meters of brown ferruginous pelagic silt-rich, silty clays and clays, barren of identifiable microfossils except fish teeth, overlying a fine-grained titanium-rich basalt. Estimated rate of sedimentation for brown clay of 2-3 m/m.y. suggests an Eocene to Paleocene basement age.

SITE DATA

Position: 22°33.76'N; 131°22.04'E

Water Depth (from sea level): 5808 corrected meters (echo sounding)

Bottom Felt At: 5812 meters (drill pipe)

Penetration: 158 meters

Number of Holes: 1

Number of Cores: 3

Total Length of Cored Section: 28.5 meters

Total Core Recovered: 19.8 meters

Percentage of Core Recovery: 69%

Oldest Sediment Cored:
Depth below sea floor: 158 meters
Nature: Brown clay
Age: Eocene(?)

Principal Results: Site 295 was drilled in a local basin 12.4 km west of Site 294 in an attempt to obtain a fossiliferous sediment-basement contact in the northeastern West Philippine Basin. It penetrated 158 meters of brown ferruginous silty clay, and clay. Reworked and poorly preserved Eocene nannofossils, and well-preserved mid Paleocene planktonic foraminifera were found in a mixed sample at the base of Site 295 indicating either a Paleocene basement age or that sediments of that age were being transported from the Oki-Daito Ridge to the northeast. This age is compatible with age based on rate of sedimentation of brown clay.

BACKGROUND AND OBJECTIVES

Background

Data from investigations of the first four sites on Leg 31 pointed toward a very restricted late Eocene to early Oligocene age for the basaltic basement of the West Philippine Basin. This restricted age fits none of the proposed basin origins. Because the leg was ahead of schedule, we attempted to resolve this quandary by drilling at an alternate site in the northeastern part of the basin. Sites 294/295, only 2.4 km apart and considered in most respects as a single site, lay 650 km northeast of the Central Basin Fault (Figure 1), in a region of low (less than 200 m), undulating basement relief (Figures 2 and 3).

Overlying basement is a very regular, 100-150 meter thick cover of pelagic sediment, which seems to show no regional changes in thickness. Lamont-Doherty Geological Observatory reflection profiles, which were used to locate this site, indicate that the anomalously smooth basin aspect forms a band adjacent and parallel to the Oki-Daito ridge.

Objectives

Of primary importance at these sites was the identification and dating of the basement-sediment interface. The sites were placed near the center of a local pond to test the idea that the flattish opaque sections of basement between the ridges in the Philippine Basin, and in marginal basins in general, might be highly reflective sediments rather than basalt. More extensive coring of the pelagic section was also planned to test the ideas of transequatorial migration of the Philippine Sea crust and to otherwise investigate the extent of pelagic carbonate deposition in this setting.

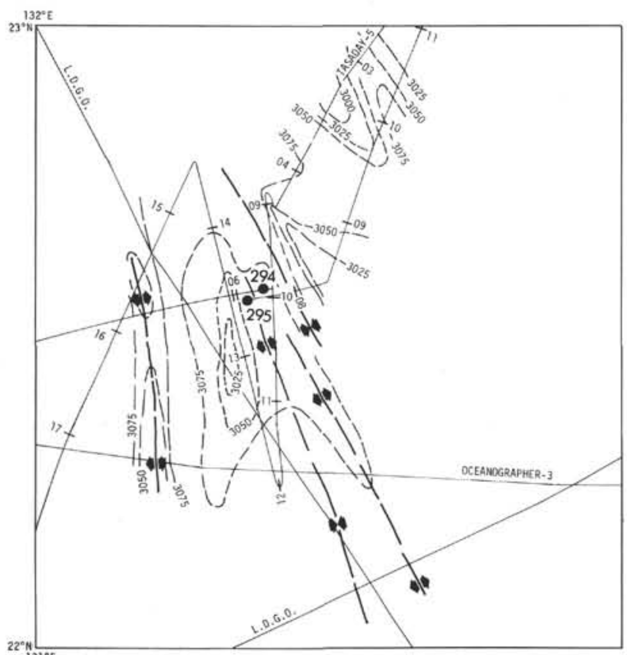


Figure 2. *Satellite-navigated ship tracks near Sites 294/295. Bathymetric contours (in uncorrected fathoms) in the better controlled areas illustrate the low undulating relief, and suggest that ridges trend north northwesterly.*

OPERATIONS

Presite Survey

Site 294 was not originally planned as a first-priority drilling location. However, Sites 290 through 293 were completed ahead of schedule, and it was decided that a hole in the northeastern portion of the West Philippine Basin might yield additional information bearing on the origin of the basin and the nature of the Central Basin Fault zone. Older Alpine Geophysical Corporation and *Vema* seismic reflection profiles illustrate that an undulating bottom of low relief (<200 m), and little sediment (0.1-0.15 sec) characterize a large portion of the basin east of the fault. These records were used as a guide to the location of Site 294.

Site 294 was approached on a course of 077° (gyro) at 10 knots, with underway seismic records displaying the sediment and basement pattern anticipated from the older records (Figures 2 and 3). Sediment thickness varied between 100 and 200 meters over a basement reflector with minor relief. The beacon was released at the site at 1547 LCT, 6 July.

Site 294

Hole 294 was spudded at a depth of 5784 meters (PDR). Total penetration reached 118 meters below the sea floor with seven cores cut (Table 1). Basalt was encountered 1 meter into the 102.5-105.5 meter drilling interval, and an empty core barrel (Core 5) was pulled. Core 6 consisted of almost 1 meter of badly broken basalt mixed with brown clay. Core 7 (112-118 m) was cut in the basalt, but unstable hole conditions and sticking pipe caused the hole to be abandoned.

After pulling the pipe string above the mudline at 1630 LCT, 7 July, the ship was moved at 1 knot along course 295°T over an adjacent portion of the same sediment "pond" penetrated by Site 294. After moving about 8000 feet (2432 m) to a point toward the center of the sediment pond, a 13.5-kHz beacon was released.

Site 295

Seismic records revealed a somewhat thicker sediment section at Site 295. Hole 295 was spudded at a depth of 5802 meters (PDR). Total penetration at this site was 158 meters with only three cores cut (Table 1). The primary objective in drilling a second hole in this general location was to obtain a better record of the sediment-basalt contact encountered at Site 294, and if possible to obtain a section of basalt.

The first 101 meters of sediment at Site 295 were washed through a pelagic brown clay, with Core 1 cut from 101-110.5 meters. Following another washed interval, Core 2 was taken from 120-129.5 meters, within a

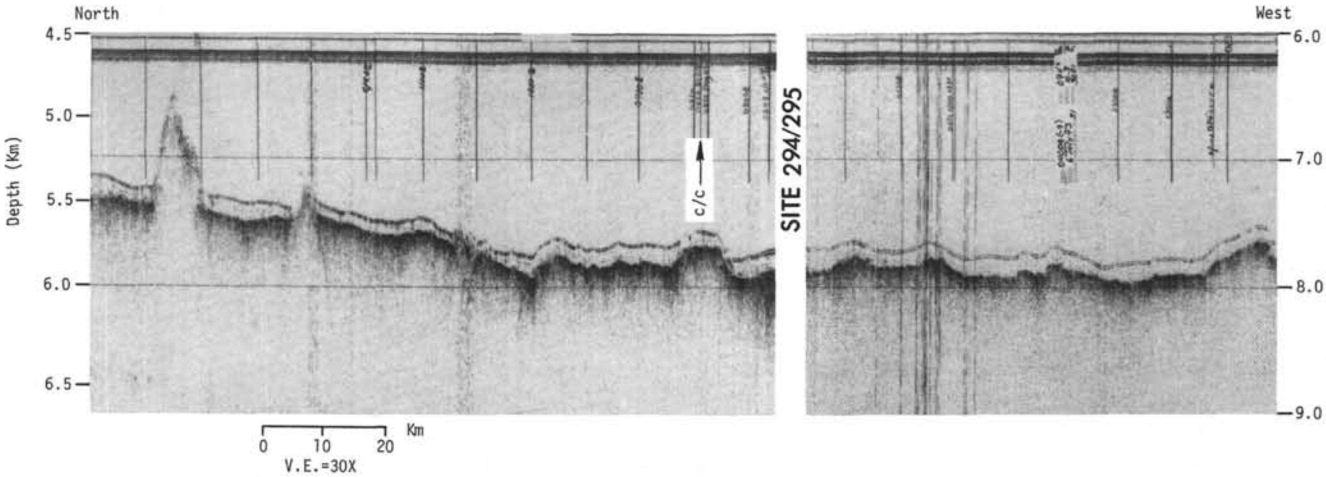


Figure 3. Glomar Challenger *seismic reflection profile approaching and leaving Sites 294/295. The thin uniform pelagic sediment cover is well displayed along this track.*

TABLE 1
Coring Summary, Sites 294/295

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered (m)	Recovered (%)	Remarks [a]
Site 294					
1	0.0–7.5	7.5	4.8	50.0	Punch Core
Wash	7.5–45.5				
2	45.5–55.0	9.5	2.0	21.0	
Wash	55.0–74.0				
3	74.0–83.5	9.5	6.3	66.0	
Wash	83.5–93.0				
4	93.0–102.5	9.5	8.1	85.0	
5	102.5–105.5	3.0	0.0	0.0	
6	105.5–112.0	6.5	1.3	14.0	
7	112.0–118.0	6.0	0.7	7.0	
Total	118.0	51.5	23.2	45.0	
Site 295					
Wash	0.0–101.0				
1	101.0–110.5	9.5	6.4	67.0	
Wash	110.5–120.0				
2	120.0–129.5	9.5	8.8	93.0	
Wash	129.5–139.0				
3	139.0–148.5	9.5	4.6	48.0	Abrupt decrease in drilling rate
Wash	148.5–158.0	9.5	0.6		Material recovered in liner during wash
Total	158.0	28.5	19.8	69.0	

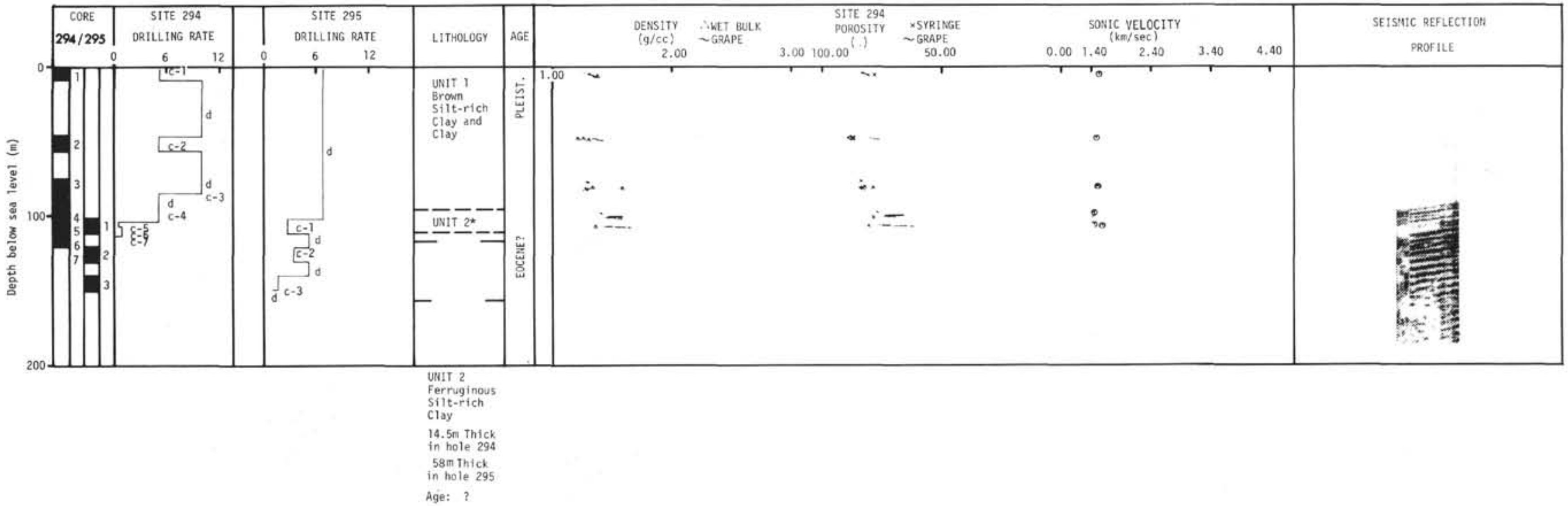
[a]See Figure 4 for graph of drilling rates and lithology.

brown clay. The interval from 129.5-139 meters was washed. Core 3 cut from 131 to 143.5 meters (Table 1), with an abrupt decrease in drilling rate about halfway through the final joint of pipe marking a basalt (?) contact (Figure 4). Unfortunately, only brown clay was retrieved. However, the change in drilling rate suggests that the basalt horizon was touched, if not actually penetrated. Again caving and sticking pipe created conditions similar to those encountered at Site 294, causing Site 295 to also be abandoned. Site 295 was departed at 1630 LCT, 8 July.

Computer malfunction and breakdown (in the power source) created positioning problems throughout the drilling of Sites 294/295, with the ship positioning system in manual mode much of the time.

LITHOLOGY

Seven cores were recovered from Site 294 and contained 22.5 meters of clay and 0.7 meters of basalt for a 45% recovery. Site 295 was drilled to a depth of 158 meters. Three cores were recovered with 19.8 meters of clay (69% recovery). Collapsing hole conditions required the abandoning of both holes. The close proximity of the two holes and tectonic equivalence justify the combining of both sites as one locality. Three lithologic units are defined (Table 2 and Figure 4).



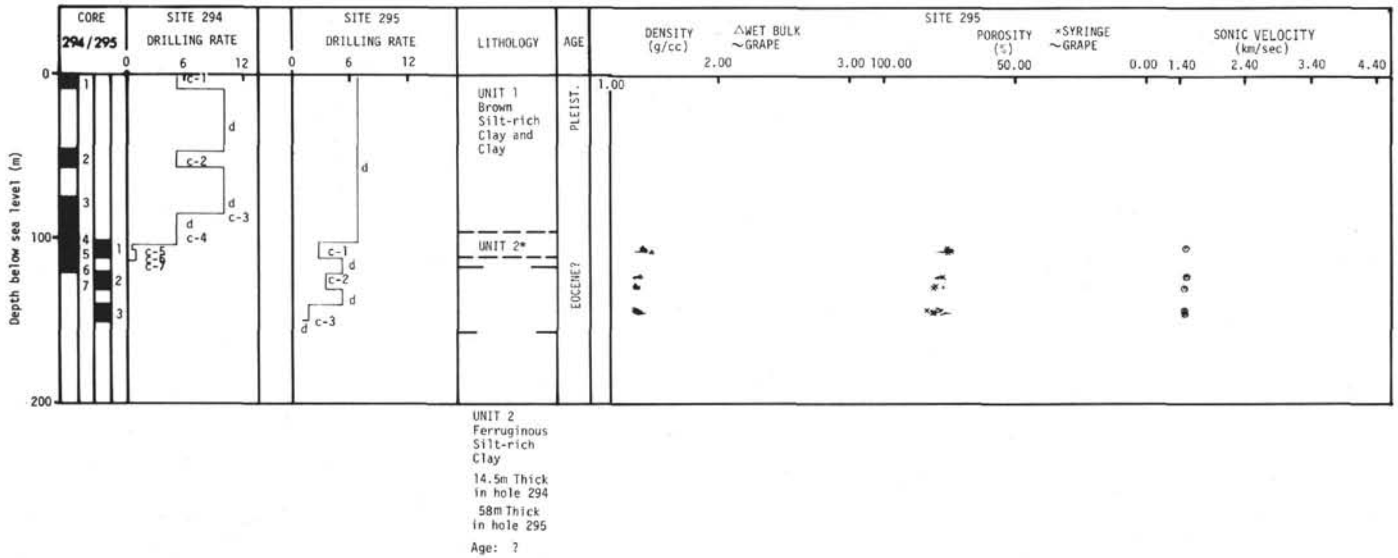


Figure 4. *Hole summary diagram, Sites 294/295.*

TABLE 2
Unit Descriptions, Depths, Thicknesses, and Ages, Sites 294/295

Unit and Descriptions		Depth (m)	Thickness (m)	Age
1	Brown silt-rich clay and clay	0.0–97.5 (294)	97.5 (294)	Pleistocene (Holocene)
2	Ferruginous silt-rich clay, ferruginous silty clay, and clay (zeolite-rich)	97.5–112.0 (294) 101.0–158.0 (?) (295)	14.5 (294) 57.0 (295)	Eocene (?)
3	Tholeiitic basalt	112.0–118.0 (294)	>6 (?)	?

Unit 1

Unit 1 occurred in Core 1 to Core 4, Section 3 at Site 294 and is composed of a moderate brown, silt-rich clay. The contrast to Unit 2 is based predominantly on the color change to blackish-red (5R 2/2) in Unit 2. This is supported by the high goethite and hematite percentage reported on X-ray analyses for Unit 2 samples. Volcanic debris in the form of altered volcanic glass, feldspar and mafic mineral fragments, and zeolite occur with up to 2% calcareous nannofossils and trace amounts of Radiolaria. The unit is composed predominantly of clay minerals (44%-75%), with iron oxides (5%-10%), which contribute to the brown color. The true thickness is unknown, but is believed about 97.5 meters at Site 294. Radiolarians and calcareous nannofossils indicate a Pleistocene-Holocene age.

Unit 2

Unit 2 is present in Core 4, Section 4 through Core 6 at Site 294 and in Cores 1 through 3 at Site 295. It is composed of a blackish-red to dark reddish ferruginous silt-rich clay and silty clay. The unit is composed predominantly of clay minerals (60%-90%), iron oxides (goethite and hematite, 5%-30%), with zeolites (0-20%), manganese micronodules (0-15%), and mineral fragments (trace to 5%). Traces of nannofossils are usually found as clusters, indicating that reworking has occurred. In a general way the clay fraction and micronodule content increase with depth. Towards the base of the section, thin dark yellowish-orange layers and patches occur and are composed largely of palagonite, clays, and zeolites. These zones generally indicate small ash horizons of pumice fragments. The age of the unit could not be determined due to the lack of microfossils, although reworked Eocene nannofossils and reworked Paleocene foraminifera were found at the base of Site 295. This unit is about 14.5 meters thick at Site 294 and at least 58 meters thick at Site 295.

Unit 3

Tholeiitic basalt was recovered in Core 7 (0.7 m) and in Samples 6, CC and 7, CC at Site 294.

Basalt Petrography

The basalt is composed of a felted matte of lath-like plagioclase crystals in an intersertal matrix. A few larger, pink, titanaugite crystals also occur in the felted network. The interstitial material is composed of a mass of quench crystals, composed of fine acicular titanaugite enclosed in plagioclase. Two generations of oxides occur: one consists of euhedral crystals scattered through the thin section, and the other of skeletal crystals within the interstitial areas. In general the texture is intersertal, although sections near the top of the unit are variolitic. Plagioclase is slightly zoned with cores of An_{52} composition, many crystals have cores of microcrystalline material. The interstitial areas are generally altered to a brown serpentine product and calcite.

Lithologic Interpretations

The oceanic crust beneath this locality seemingly has remained within essentially the same oceanic environment since its formation. It has formed and remained beneath the carbonate compensation depth, accumulating fine-grained inorganic debris, with infalls of tephra. The increase of volcanogenic components in Unit 2 of both holes is indicative of nearness to a source area such as a volcanic arc or continental margin. Calculated sedimentation rates are in agreement with average rates established for "brown clays."

The presence of reworked(?) fossils suggests that some debris may have been carried in from local topographic highs or fault scarps. However, the sediments do not illustrate strong evidence of lateral transport, and significant topographic highs are absent near the sites. It is possible that the fossils represent a basal sediment section of this area, and if so, the Paleocene age of these reworked(?) fragments may give some indication of a minimum basement age in this area.

PHYSICAL PROPERTIES

Bulk Density, Porosity, and Water Content

In general the sediments cored at Sites 294/295 are of low density and high porosity, reflecting their poor consolidation. The bulk-density data from both sites define continuous curves (Figure 4). The density increases and the porosity decreases downhole at Site 294; however, at Site 295 these values show little change, or possibly even reverse their trends with depth. These effects may be due to the greater drilling disturbance of cores from Site 295, compared to those from Site 294.

The syringe method, bulk density, and porosity measurements correlate closely with GRAPE data, confirming the trends discussed above. In general, the sediments of Sites 294/295 showed a high water content, and, therefore, a low degree of consolidation. Water content decreased downhole at Site 294, but showed a slight increase with depth at Site 295.

Vane Shear

The monotonous lithology of Sites 294/295 provides an opportunity to study the variation of shear strength with depth. Accordingly, one or more vane-shear measurement was made on every suitable core section from Sites 294/295.

The shear-strength data for both sites show a general increase downhole, apparently reflecting the progressive consolidation of the brown mud. The rather large variations in shear strength at a given depth must be a property of the sediment, since vane-shear measurements are reproducible with less than 10% error. Part of the shear-strength fluctuation is probably natural; however, major variations may be artificially induced. Both mechanical deformation and increases in water content due to drilling would decrease the strength of the sediment. Thus the shear strengths presented here must be considered as minimum values. The measurements were selective, testing only the firmest, least-disturbed sediment. Measurements taken from the split core face (vertical) are probably more reliable than the data from the ends of core sections (horizontal); in the former case there is a better opportunity to select undisturbed material.

The cores from Site 294 were clearly less disturbed than those from Site 295. Accordingly, the Site 294 data outline a well-defined trend. Arithmetic and semilogarithmic plots suggest an exponential relationship between shear strength and depth (i.e., as depth increases arithmetically, shear strength increases geometrically). Such a curve extrapolates to an expectedly low shear strength at the mudline, but unreasonably high shear strengths occur at depths exceeding several hundred meters. Thus, even if the above exponential relationship is valid, it could only describe shallow depth-strength relationships. Additional discussions will be found in Bouma and Moore (this volume).

Sonic Velocity

Sonic-velocity measurements are tabulated in Table 3 and displayed in Figure 4. The velocities were low, but uniform as indicated by a mean value of 1.487 ±0.046 km/sec for 12 measurements. The data also reflect the uniformly poor sediment consolidation.

Thermal Conductivity

As expected from high water content, the thermal conductivities measured at Sites 294/295 were low, even at depths of 100 meters subbottom (Table 4, Figure 5). The thermal conductivity of Core 294, Section 1 is similar to other measurements made on surface cores from this area. The slight discontinuity in thermal conductivities noted between Sites 294/295 might be due to technical error.

GEOCHEMICAL MEASUREMENTS

Alkalinity, *p*H, and salinity measurements from Sites 294/295 are summarized in Table 5.

TABLE 3
Sonic-Velocity Measurements, Sites 294/295

Sample (Interval in cm)	Hole Depth (m)	Sonic Velocity (km/sec)[a]
Site 294		
1-4, 49	5.0	1.53
2-2, 75	47.7	1.49
3-5, 34	80.3	1.52
4-4, 50	98.0	1.45
4-5, 35	99.3	1.39
6-1, 54	106.0	1.45[b]
6-1, 119	106.7	1.58[b]
Site 295		
1-3, 24	104.3	1.49
2-2, 30	121.8	1.51
2-6, 130	128.8	1.47
3-3, 35	142.3	1.47
3-4, 104	144.5	1.48

[a]All values measured in horizontal direction.

[b]Watery portion of core (10 cm thick).

Alkalinity

The average alkalinity of the three samples examined for Site 294 is 2.25 meq/kg. All values and the average are below the surface seawater reference value of 2.49. The highest value, 2.44, is found in Unit 1 (Core 2, Section 1) 47 meters below the sea floor. The lowest value (1.96) is in Unit 2 (Core 4, Section 5) 100.8 meters below the sea floor. Unit 1 contains a brown silt-rich clay and brown clay, while Unit 2 is a ferruginous silt-rich clay, silty clay, and clay, locally being zeolite rich.

The average alkalinity of the three samples from Site 295 is 2.25 meq/kg. One value is higher than the surface seawater reference value of 2.25, while one is lower. The third value is equal to the seawater reference value. The highest value (2.35) is found in Core 1, Section 4 107 meters below the sea floor. A rather sharp drop in values occurs between Cores 1 and 2 (2.35 to 2.15, respectively); however, both cores contain the ferruginous sediment of Unit 2. The samples at Site 295 are from deeper depths than at Site 294, and the alkalinity values are generally higher than those values for Site 294, even though they are the same unit.

pH

*p*H values were all below that of seawater at the site (8.28 to 8.21). The punch-in *p*H for Site 294 averaged 7.54, while the flow-through values averaged 7.45. The punch-in *p*H values show a tendency to increase with depth; however, the flow-through values do not clearly show this trend. Flow-through values are lower than punch-in values at corresponding depths.

*p*H values obtained for Site 295 were all below that of the seawater reference at the site (8.31 to 8.32). The punch-in values averaged 7.39, while the flow-through values averaged 7.36. All *p*H values show an increasing trend with depth and are lower than those recorded at Site 294. The samples at Site 294 represent shallower intervals.

TABLE 4
Thermal Conductivities Measured at Sites 294/295

Sample (Interval in cm)	Hole Depth (m)	Thermal Conductivity in 10^{-3} cal/cm sec° C Needle Probe	Average	From Water Content
Site 294				
1-4, 35	7	1.92		
1-4, 75		1.62	1.84	1.81 ±0.10
1-4, 115		1.98		
3-5, 20	80	1.59		
3-5, 40				1.98 ±0.12
3-5, 55		1.63	1.58	
3-5, 90				1.65 ±0.09
3-5, 95		1.45		
3-5, 130		1.66		
4-5, 40	101	1.65	1.60	
4-5, 110		1.54		
4-5, 144-150				1.96 ±0.11
6-1, 60	110	1.58	1.67	1.75 ±0.10
6-1, 125		1.75		
Site 295				
1-3, 30	110	1.94		1.89 ±0.11
1-3, 75		1.98	1.92	
1-3, 120		1.85		
1-3, 143-150				1.96 ±0.11
2-2, 40	123	1.79	1.81	1.85 ±0.10
2-2, 110		1.84		
2-6, 40	129	1.45	1.55	
2-6, 110		1.65		1.77 ±0.10
3-3, 40	142	1.55	1.59	1.72 ±0.10
3-3, 105		1.63		
3-4, 40	144	2.40	2.40	1.79 ±0.10

Salinity

Three salinity measurements at Site 294 averaged 34.9‰. All values were equal to or higher than the seawater reference value of 35.2‰. The salinity trend shows a general, but slight increase with depth.

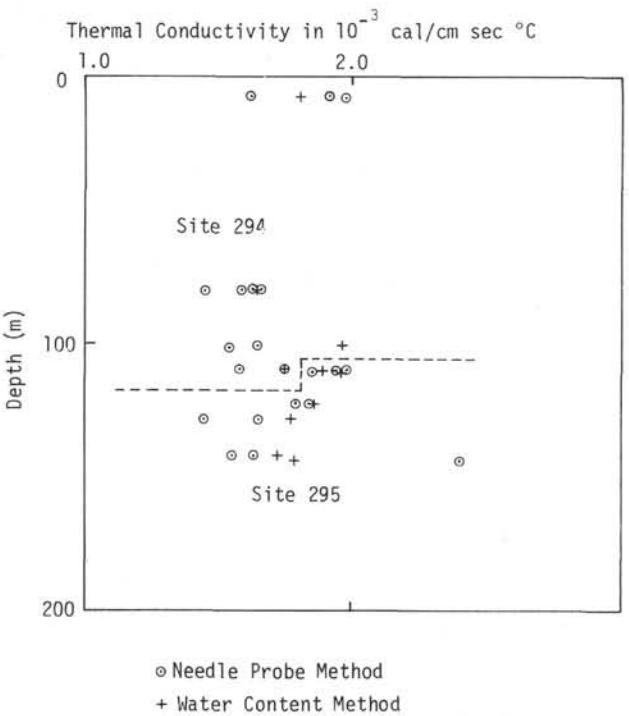


Figure 5. *Thermal-conductivity results, Sites 294/295.*

Three salinity measurements at Site 295 averaged 35‰. All values were equal to or higher than the overlying seawater value of 35.2‰. The salinity trend also shows a general, but slight increase with depth. The values obtained at Site 295 do not differ significantly from those obtained at Site 294, keeping in mind that sample depths differ.

PALEONTOLOGIC SUMMARY

Introduction

Paleontologic recovery from Sites 294/295 was very poor, resulting in marginal age determinations. Diatoms and silicoflagellates are not present in samples from either site. Pleistocene radiolarians are found at Site 294, Core 1 but are absent in other samples from both Sites 294/295. Calcareous nannofossils confirm a late Pleistocene age for Site 294, Core 1 with reworked Eocene nannofossils recognized in a sample from Core 3 in Hole 295.

A reworked arenaceous benthonic foraminiferal fauna was recovered at Core 294-3, but it is not age diagnostic. Reworked Paleocene planktonic foraminifera were found in matrix from Core 3, Hole 295. Fish teeth were observed in samples from Site 294, Core 1, Section 3 and Site 295, Core 1, Section 3.

Calcareous Nannofossils

Nannofossil recovery was very sparse and none of the specific zones could be recognized. Sample 294-1-2, 75 cm contains *Cyclococcolithina leptopora* and reworked specimens of *Discoaster deflandrei* and *Sphenolithus* sp. This assemblage is not incompatible with the Quaternary age determined for this core by radiolarians.

TABLE 5
Summary of Shipboard Geochemical Data, Sites 294/295

Sample (Interval in cm)	Depth Below Sea Floor (m)	pH Punch-in	pH Flow-through	Alkalinity (meq/kg)	Salinity (°/oo)	Lithologic Unit
Site 294						
Surface seawater reference		8.28	8.21	2.49	35.2	
2-1, 144-150	47.6	7.48	7.47	2.44	35.2	Unit 1
3-4, 144-150	80.0	7.53	7.44	2.15	35.2	
4-5, 144-150	100.5	7.61	7.49	1.96	34.4	Unit 2
Average		7.54	7.45	2.25	34.9	
Site 295						
Surface seawater reference		8.31	8.32	2.25	35.2	
1-4, 143-150	107.0	7.31	7.33	2.35	35.2	
2-5, 144-150	127.5	7.42	7.35	2.15	35.2	Unit 2
3-3, 144-150	143.5	7.44	7.41	2.25	34.6	
Average		7.39	7.36	2.25	35.0	

The remaining samples from Site 294, as well as core-catcher samples from Cores 1, 2, and 3 at Site 295, are either barren, or contain only a few reworked Eocene to Miocene nannofossils including *Discoaster saipanensis* and *Reticulofenestra umbilica*(?).

Foraminifera

Only two samples from Sites 294/295 were found to contain foraminifera. A benthonic arenaceous foraminiferal assemblage characterized by *Turritellella spectabilis, Glomospira gordialis, Involutina anguillae,* and *Cyclammina* sp., was recovered from Sample 294-3, CC. Several of the specimens are cemented together into aggregates, while others appear to be abraded. This strongly suggests that this faunal assemblage is reworked. None of the species recognized are age significant.

Several foraminifera, including the Paleocene planktonic species *Globorotalia* sp. cf. *G. angulata* and *G. perclara,* were recovered from Core 3, Hole 295. *Globorotalia angulata* is restricted in its occurrence to the middle part of the Paleocene, and *G. perclara* ranges throughout the Paleocene and up to the earliest Eocene. The other faunal components could not be identified because they are immature forms lacking any morphologically diagnostic features. A few other species of planktonic foraminifera of varying ages are present with the Paleocene forms. No planktonic foraminifera were recognized within any of the pieces of hard red clay present in the sample. Thus the fauna may have been introduced along with soupy mud, probably from somewhere close to the site. As a result, the entire assemblage has been interpreted as representing a reworked fauna.

Radiolarians and Silicoflagellates

Among the samples examined from Sites 294/295 only one was found to contain radiolarians. Sample 294-1-3, 13-15 cm contains radiolarians; species present include *Lithopera bacca, Euchitonia* spp., *Polysolenia spinosa* group, *Spongaster tetras tetras,* and *Ommatartus tetrathalamus tetrathalamus.* These species are commonly found in Quaternary surface sediments in warm-water regions.

No silicoflagellates were observed at Sites 294/295.

SUMMARY AND INTERPRETATIONS

Summary

Sites 294/295 were drilled in the low relief, undulating topography of the northeastern sector of the West Philippine Basin. Drilling revealed that the entire 100-150 meter pelagic cover overlying the acoustic basement in this region consists of brown clay. The sediment section was subdivided into two units on the basis of lithologic variations in the clay as follows:

Unit 1 (cored at Site 294 only): Moderate brown silty clay. Silt-sized material consists of volcanic glass and mineral fragments. The true thickness is unknown, but the unit was cored between 0-7.5 meters and 45.5-97.5 meters.

Unit 2: Moderate to dusky brown clay with a higher content of iron oxide and manganese micronodules than Unit 1.

Unit 3: Basalt (sampled only at Site 294), reached at 104 meters at Site 294 and 155 meters at Site 295, according to drilling characteristics.

Interpretation

The age span of this sediment sequence remains in doubt because of the near absence of diagnostic fossils. Eocene nannofossils and Paleocene foraminifers were recovered from a slurry in a final core at Site 295, which represented a caved and redrilled interval above the basalt contact, and also in clay recovered from the bit face. The weight of evidence now favors the interpretation that these fossils are reworked from some nearby topographic high, in this case probably the Oki-Daito Ridge. These nannofossils range upward from the mid-middle Eocene, and afford a maximum age of basement at Sites 294/295. Almost all these fossils show abrasion and internal cementation. Although there is no obvious evidence of lateral transport in the drilled section, this evidence might not be obvious in a nearly pure brown clay section. The pelagic cover does thin markedly up the southern flank of the Oki-Daito Ridge, which lies some 150 km away. Similar transport distances from the Palau-Kyushu Ridge to Hole 290 demonstrate the adequacy of transport mechanisms. Finally, there is no significant difference in the regional thickness of the pelagic cover near Sites 294/295 and near both Sites 290 and 291, where basement was dated as late Eocene to early Oligocene. Moreover, an estimated sedimentation rate for the brown clay of 2.5 m/m.y. yields a maximum early Eocene age for the base of the hole (Figure 6).

The significance of the smooth basement is difficult to evaluate. Analysis of the on-station sonobuoy record at Site 294 suggested that the basalt formed acoustic basement (Table 1), but the travel time to basement, together with an assumed 1.6 km/sec sediment velocity, on the sonobuoy record at Site 295 suggests that the top of the stiff brown clay represented acoustic basement and that basalt lay slightly below this.

Also puzzling were the very low frequency (10-40 Hz) reflections arriving 0.2 sec after the bottom return, well after the 0.14-sec acoustic basement reflection. Continuous reflection profiles convey the impression that the basement in the area around Sites 294/295 consists of topographic highs, separated by flat areas. This morphology might result from the ponding of basalt flows in the trough of a ridge-trough topography which is typical of marginal basins. The deeper reflector could represent the trough floor beneath a fill of basalt flows and possible interbedded sediments.

Seismic refraction results in the West Philippine Basin (Henry et al., this volume; Murauchi et al., 1968) delineate a thin (1.3 km) second layer. This precludes the existence of a significant layer of sediments beneath basalt flows which erupted well after crustal generation (Karig, this volume). A better interpretation is that, at the time of crustal generation, basalt flows and perhaps minor sediment layers infilled basement troughs in the smooth zone of the West Philippine Basin in which Sites 294/295 are located.

No site survey was obtained during or prior to Leg 31, but the integration of available, well-controlled track lines (Figure 2) show that if bathymetric lineations do exist, they are of very low amplitude and probably trend north-northwesterly. Peak to peak magnetic anomalies in the area are less than 100 gammas and cannot be correlated at this time.

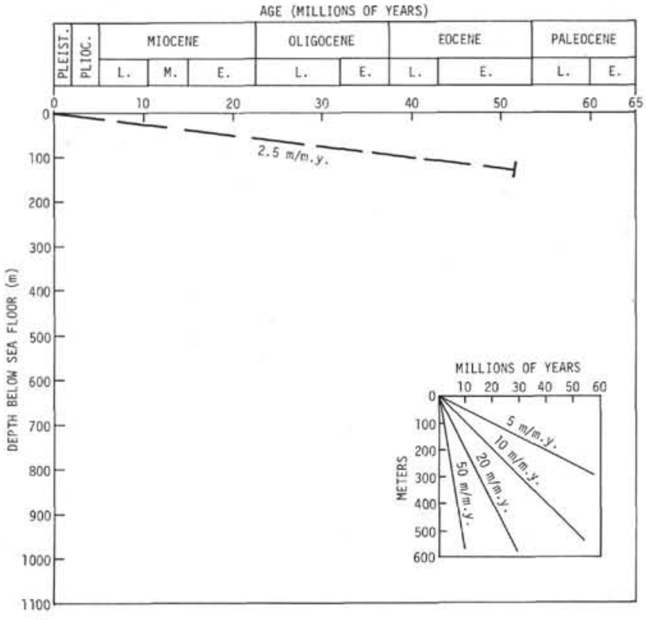


Figure 6. *Estimated rate of sedimentation at Sites 294/295 based on an assumed rate of deposition of red clay of 2.5 m/m.y. Mid-Paleocene microfossils found at the base of Hole 295 are thought to represent reworked and/or redeposited material from Oki-Daito Ridge.*

REFERENCE

Murauchi, N., Den, N., Asano, S., Hotta, H., Yoshii, T., Asanuma, T., Hagiwara, K., Ichikawa, K., Sato, T., Ludwig, W. J., Ewing, J. I., Edgar, N. T., and Houtz, R. E., 1968. Crustal structure of the Philippine Sea: J. Geophys. Res., v. 73, p. 3143-3171.

APPENDIX A
Summary of X-Ray, Grain Size, and Carbon-Carbonate Results, Sites 294/295

Section	Sample Depth Below Sea Floor (m)	Lithology	Age	Bulk Sample Major Constituent			2-20μm Fraction Major Constituent			<2-20μm Fraction Major Constituent			Grain Size			Classification	Carbon Carbonate			Comments
				1	2	3	1	2	3	1	2	3	Sand (%)	Silt (%)	Clay (%)		Total (%)	Organic (%)	CaCo (%)	
Site 294																				
294-1-4	5.2-5.3	Unit 1 Silt-Rich Clay and Clay	Pleistocene –Holocene	Mica	Quar.	Plag.	Quar.	Mica	Plag.	Mica	Quar.	Plag.	0.1	22.4	77.5	Clay	0.1	0.1	0	
294-3-5	80.9	Unit 2		Mont.	K-Fe.	Quar.	Mont.	K-Fe.	Mica	Mont.	K-Fe.	Quar.	0.0	6.5	93.5	Clay	0.1	0.1	0	Goet. (major) in Bulk, Abund. in
294-4-3	96.8	Ferruginous		K-Fe.	Mont.	Quar.	K-Fe.	Mont.	Quar.	Mont.	K-Fe.	Quar.	0.0	19.7	80.3	Clay				2-20μm; major in <2-20μm
294-4-4	99.0	Silt-rich clay,	Eocene (?)	Hema.	Mont.	K-Fe.	K-Fe.	Mont.	Hema.	Hema.	Mont.	K-Fe.	0.1	21.0	78.9	Clay	0.1	0.0	0	Goet. (pres) in Bulk, 2-20μm and <2μm
294-6-1	106.1-106.2	Silty clay and											1.1	21.0	77.9	Clay	0.1	0.1	0	
294-6-1	106.9	Zeolite-rich clay		Hema.	Mont.	Quar.	Hema.	Mont.	K-Fe.	Hema.	Mont.	Quar.								
Site 295																				
295-1-5	107.7-107.8	Unit 2		Mont.	Quar.	Mica.	Quar.	Mica	K-Fe.	Mont.	Quar.	Mica	0.0	4.5	95.5	Clay	0.1	0.1	0	Clin. (1.7%) in <2μm
295-2-2	121.9			Clin.	K-Fe.	Quar.	Clin.	Mont.	K-Fe.	Mont.	K-Fe.	Quar.	0.0	10.6	89.4	Clay	0.1	0.1	1	Goet. (major) in Bulk, present in
295-2-6	128.6	See Above	Eocene (?)	Clin.	K-Fe.	Mont.	Clin.	K-Fe.	Mont.	Mont.	Quar.	Clin.	0.0	21.3	78.7	Clay	0.1	0.1	0	2-20μm, major in <2μm
295-3-4	143.9			Clin.	K-Fe.	Mont.	Clin.	Quar.	K-Fe.	Mont.	Quar.	Clin.	0.1	28.8	71.1	Silty Clay	0.1	0.1	0	Goet. (major) in Bulk, present in 2-20μm, major in <2μm

Note: Complete results of X-ray, Sites 294/295, will be found in Part V, Appendix I. X-Ray mineralogical legend in Appendix A, Chapter 2.

Site 294 Hole Core 1 Cored Interval: 0.0-7.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
PLEISTOCENE-HOLOCENE						1	0.5 / 1.0	VOID				
			Rp			2		Fe		*75	5YR 4/4	
				Cm		3		Fe		*14, *20	10YR 6/6	
											5YR 4/4	
						4				*80, *147	10YR 6/6	
		B		B		Core Catcher				*CC	5YR 4/4	

Unit 1 - color basically moderate brown (5YR 4/4). Drilling deformation intense (soupy), to intense and moderate downcore. Streaks of dark yellow→orange (10YR 6/6) occur in Section 3.

SILT-RICH CLAY (brown)
Smears: 2-75, 3-20, 4-80, CC

Texture	Composition
79-89% Clay	59% Clay minerals
10-20% Silt	5-10% Quartz, feldspar
1% Sand	5-10% Zeolite
	5% Fe-oxides
	2- 5% Heavy minerals
	1- 3% Volcanic glass
	Tr- 1% Nannofossils
	Tr- 1% Radiolarians

ASH-RICH CLAY (Minor Lith)
Smears: 3-14, 4-147

Texture	Composition
80% Clay	65% Clay minerals
18% Silt	12% Volcanic glass
2% Sand	15% Fe-oxides
	5% Heavy minerals
	3% Feldspar
	2% Quartz
	2% Zeolite
	2% Nannofossils
	Tr% Radiolarians

Grain Size 1-70
0.1, 22.4, 77.5

Carbon Carbonate 1-76
0.1, 0.1, 0

X-ray 1-80 (Bulk)
38.6% Mica
34.2% Quar
18.6% Plag
5.2% Chlo
3.4% Mont

Explanatory notes in chapter 1

Site 294 Hole Core 2 Cored Interval: 45.5-55.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5 / 1.0	VOID; VOID; GEOCHEM SAMPLE			5YR 3/4; 10YR 6/6	
						2		Fe		*75	5YR 3/4	
		B	RP	B		Core Catcher		Fe; Fe			5YR 3/4	

Color moderate brown (5YR 3/4) with scattered areas of dark yellow orange (10YR 6/6); generally moderately deformed; core is stiff.

BROWN CLAY
Smear: 2-75

Texture	Composition
95% Clay	75% Clay minerals
5% Silt	10% Fe-oxides
	10% Quartz, feldspar
	1% Heavy minerals

Explanatory notes in chapter 1

Site 294 Hole Core 3 Cored Interval: 74.0-83.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5 / 1.0	VOID; Fe			5YR 2/2	
						2				*25	10YR 6/6	
						3		Fe			5YR 2/2	
						4		GEOCHEM SAMPLE				
						5				*65, *90	10YR 6/6 with 5YR 2/2	
	BF	Cm	Rm	B		Core Catcher		Fe		*CC	5YR 2/2	

Core is moderately deformed, stiff; color dominantly dusky brown (5YR 2/2) with scattered dark areas of yellow orange (10YR 6/6).

BROWN CLAY
Smears: 5-90, CC

Texture	Composition
90-100% Clay	63-73% Clay minerals
0- 10% Silt	13% Feldspar
	5-10% Fe-oxides
	5% Quartz
	2- 5% Zeolite
	1- 3% Heavy minerals
	Tr- 1% Nannofossils

ASH-RICH CLAY (Minor Lith)
Smears: 2-25, 5-65

Texture	Composition
100% Clay	67% Clay minerals
	8-12% Devit. glass, palagonite
	5-15% Fe-oxides
	1- 5% Heavy minerals
	1- 5% Nannofossils
	2% Feldspar
	2% Zeolite

Grain Size 5-87
0.0, 6.5, 93.5

Carbon Carbonate 5-90
0.1, 0.1, 0

X-ray 5-91 (Bulk)
64.6% Mont
26.0% K-Fe
9.4% Quar

Explanatory notes in chapter 1

Site 294 Hole Core 4 Cored Interval: 93.0-102.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		B	RP	B		1–6, Core Catcher	0.5, 1.0	VOID; VOID; GEOCHEM SAMPLE; VOID		2-65, 4-100, 4-150, 5-20, CC	

Core has drilling breccia in Section 1. Moderate - some intense deformation thereafter; color is dusky brown (5YR 2/2) with scattered moderate brown (5YR 3/4) to section 4 (Unit 2) where color is a dominant blackish red (5R 2/2) with some scattered dark yellow orange (10YR 6/6); some mottling noticed through core.

5YR 2/2
5YR 3/2

FERRUGINOUS SILT-RICH CLAY
Smears: 4-150, 5-20, CC

Texture	Composition
80% Clay	39-56% Clay minerals
20% Silt	30-35% Fe-oxides
	12% Feldspar
	6% Opaques
	1- 2% Zeolite
	Tr% Nannofossils
	Tr% Foraminifera

5YR 2/2

Some low Fe content clay at 2-65.

PALAGONITE ASH (Minor Lith)
Smear: 4-100

Texture	Composition
100% Clay	85% Palagonite
	5% Clay minerals
	5% Heavy minerals
	3% Mica
	2% Feldspar
	Tr% Nannofossils

10YR 6/6
5R 2/2
10YR 6/6
5R 2/2

Grain Size 3-78
0.0, 19.7, 80.3

Grain Size 4-146
0.1, 21.0, 78.9

Carbon Carbonate 4-146
0.1, 0.0, 0

X-ray 3-80 (Bulk)
41.1% K-Fe
24.7% Mont
21.1% Quar
9.9% Mica
3.1% Clin
M Goet

X-ray 4-148 (Bulk)
34.2% Hema
28.1% Mont
24.8% K-Fe
7.1% Plag
5.9% Quar
P Goet

5YR 2/2 with 5R 2/2 (mixed)
5YR 2/2

Explanatory notes in chapter 1

Site 294 Hole Core 5 Cored Interval: 102.5-105.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		B		B		Core Catcher					Trace amount of FERRUGINOUS SILT-RICH CLAY in core catcher. Foraminifera and radiolarians noted.

Explanatory notes in chapter 1

Site 294 Hole Core 6 Cored Interval: 105.5-112.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		B	Fm	B		1, Core Catcher	0.5, 1.0	VOID		141, CC	

mixed colors
5R 2/2
5Y 4/1

Section 1 is alternating drilling breccia - intensely deformed; dominant color is blackish red (5R 2/2), with small scattered light brown (5YR 5/6) areas; areas also mottled with dark reddish brown (10R 3/4).

FERRUGINOUS SILT-RICH CLAY
Smears: 1-141, CC

Texture	Composition
80% Clay	60% Clay minerals
20% Silt	40% Fe-oxides
	Tr% Nannofossils
	Tr% Quartz

BASALT (Unit 3)
Intersertal-tholeiitic basalt; felted network of lath-like plagioclase (An_{52}) in groundmass of fine grained interstitial Ti-augite needles in brown altered glass; calcite and serpentine alteration material; scattered euhedral opaques.

Composition
55% Plagioclase
20% Pyroxene
10% Oxides
10% Interstitial
5% Calcite

Grain Size 1-62
1.1, 21.0, 77.9

Carbon Carbonate 1-65
0.1, 0.1, 0

X-ray 1-139 (Bulk)
69.8% Hema
28.9% Mont
1.3% Quar

Explanatory notes in chapter 1

Site 294 Hole Core 7 Cored Interval: 112.0-118.0 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		B		B		1, Core Catcher	0.5, 1.0	VOID		TS	

5Y 4/1

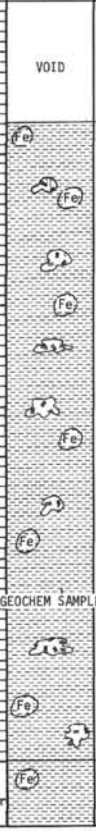
BASALT
Intersertal tholeiitic basalt; lath-like plagioclase (An_{54}) in groundmass of fine-grained interstitial material of Ti-augite needles in altered glassy material; scattered euhedral opaques with small skeletal crystals in groundmass.

Composition	
43% Interstitial	57% Plagioclase
40% Plagioclase	45% Pyroxene
8% Oxides	8% Opaques
5% Pyroxene	
4% Calcite	

Explanatory notes in chapter 1

Site 295 Hole Core 1 Cored Interval: 101.0-110.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	
						1	0.5, 1.0	VOID			
						2					5YR 4/4, 10YR 8/6, 10YR 8/6
						3				*40	5YR 3/4, 10YR 8/6
						4		GEOCHEM SAMPLE			10YR 8/6, 5YR 3/4
						5				*41, *75	10YR 8/6, 10YR 8/6
		B		B		Core Catcher				*CC	5YR 3/4



LITHOLOGIC DESCRIPTION

Unit 2 color moderate brown (5YR 4/4-3/4) with mottled streaks of pale yellow orange (10YR 8/6). Intense to moderate drilling deformation.

FERRUGINOUS-RICH CLAY
Smears: 5-75, CC

Texture	Composition
95% Clay	46% Clay minerals
5% Silt	20% Fe-oxide
	15% Quartz
	12% Feldspar
	1% Palagonite
	1% Heavy minerals
	1% Volcanic glass
	Tr- 4% Zeolite

PALAGONITE CLAY (Minor Lith)
Smears: 3-40, 5-41

Texture	Composition
98% Clay	71% Palagonite
2% Silt	20% Clay minerals
	5% Nannofossils
	2% Opaques
	1% Feldspar
	1% Quartz

Nannofossils in silt-size clusters.

Grain Size 5-73
0.0, 4.5, 95.5

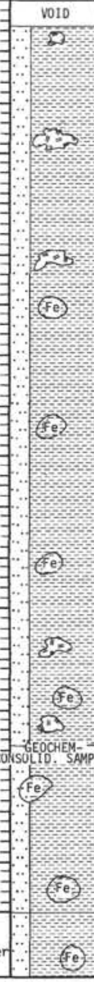
Carbon Carbonate 5-74
0.1, 0.1, 0

X-ray 5-75 (Bulk)
30.5% Mont
27.4% Quar
18.2% Mica
13.4% K-Fe
7.2% Plag
3.4% Chlo

Explanatory notes in chapter 1

Site 295 Hole Core 2 Cored Interval: 120.0-129.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	
						1	0.5, 1.0	VOID		*125	5YR 3/4 to 5YR 3/2, 10YR 8/6
						2					5YR 3/2, 10YR 8/6
						3					5YR 4/4, 5YR 3/4, ---- color boundary, 5YR 3/2, 5YR 2/2
						4				*75	5YR 3/2, 5YR 3/2 color boundary, 5YR 4/4
						5		GEOCHEM-CONSOLID. SAMPLES		*133	10YR 8/6, 5YR 3/2 to 5YR 2/2, 10YR 8/6
						6					5YR 2/2
		B		B		Core Catcher				*CC	5YR 3/2



LITHOLOGIC DESCRIPTION

Core moderate to grayish brown (5YR 3/4 to 5YR 3/2) color in Sections 1, 2, 3; dusky brown (5YR 2/2) Sections 3-6; moderate deformation (stiff) to intense; mottling of colors noted in core.

FERRUGINOUS CLAY
Smears: 4-75, 5-133, CC

Texture	Composition
95-100% Clay	63-88% Clay minerals
0- 5% Silt	25-30% Fe-oxides
	0- 2% Zeolite
	0- 2% Micarb
	0- 1% Feldspar
	Tr- 3% Nannofossils
	Tr- 1% Heavy minerals

PALAGONITE CLAY (Minor Lith)
Smear: 1-125

Texture	Composition
95% Clay	79% Palagonite
5% Silt	12% Feldspar
	5% Fe-oxides
	2% Zeolite
	2% Opaques
	1% Heavy minerals
	1% Quartz

Grain Size 2-42
0.0, 10.6, 89.4

Grain Size 6-106
0.0, 21.3, 78.7

Carbon Carbonate 2-40
0.1, 0.1, 1

Carbon Carbonate 6-110
0.1, 0.1, 0

X-ray 2-37 (Bulk)
39.3% Clin
29.7% K-Fe
12.2% Quar
11.7% Plag
7.1% Mica

X-ray 6-112 (Bulk)
54.7% Clin
25.4% K-Fe
10.7% Mont
5.5% Quar
3.7% Plag
M Goet

Explanatory notes in chapter 1

Site 295 Hole Core 3 Cored Interval: 139.0-148.5 m

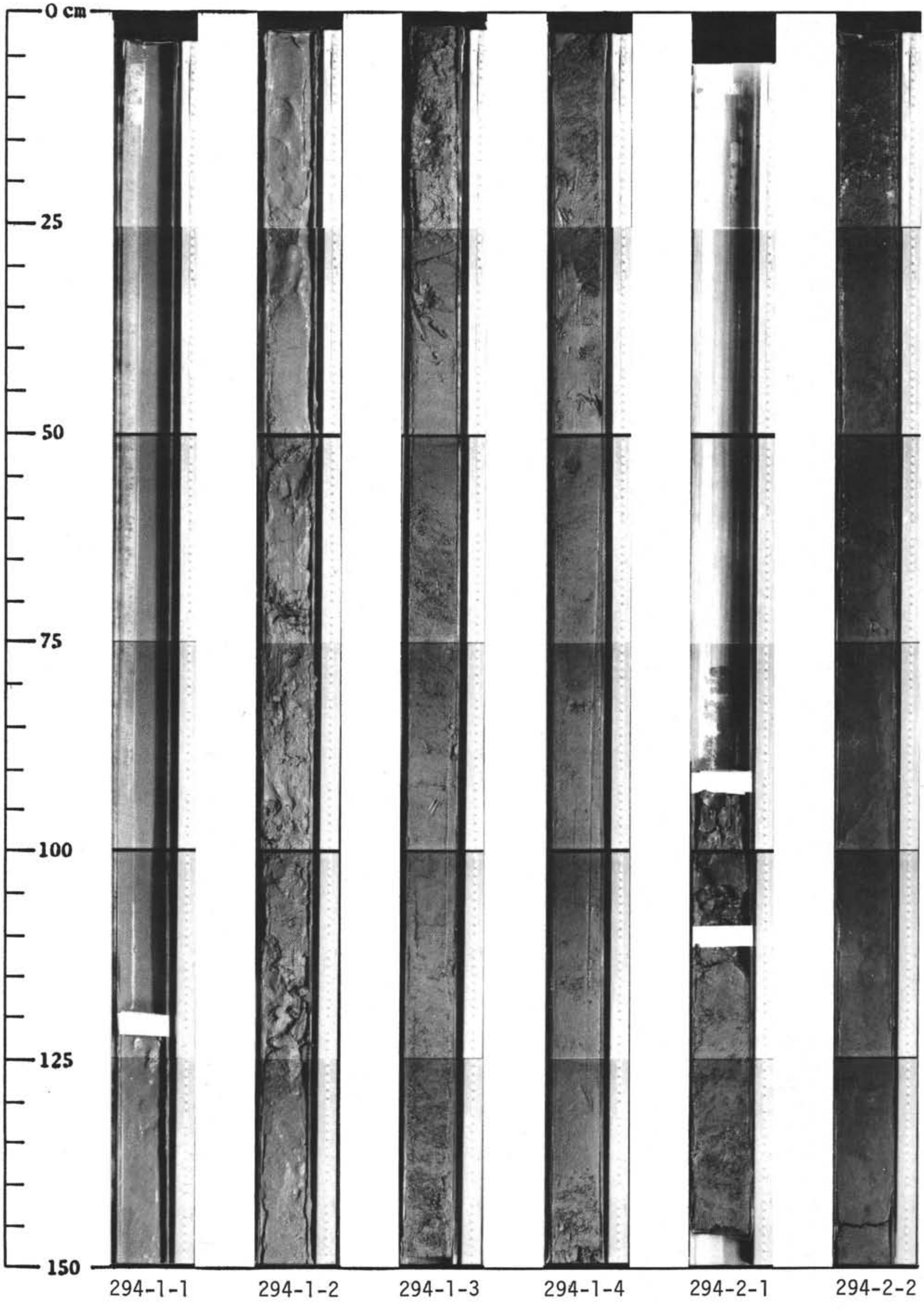
AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
						1	0.5 1.0	VOID			5YR 2/2	Core is dusky brown (5YR 2/2) with some lighter brown mottling; indistinct banding of colors; intense deformation. FERRUGINOUS ZEOLITE-RICH SILTY CLAY Smears: 4-40, CC Texture: 71% Clay, 29% Silt Composition: 44% Clay minerals, 25% Fe-oxides, 20% Zeolites, Tr- 1% Nannofossils, 10% Quartz, feldspar Nannofossils in silt-sized clusters. Grain Size 4-35 0.1, 28.8, 71.1 Carbon Carbonate 4-40 0.1, 0.1, 0 X-ray 4-41 (Bulk) 55.8% Clin 14.4% K-Fe 12.1% Mont 10.3% Quar 7.5% Plag M Goet
					2		Fe			5YR 2/2 with 5YR 3/2	
					3		Fe GEOCHEM SAMPLE				
					4		Fe		*40	5YR 2/2 mottled 10YR 8/6	
		B		B		Core Catcher		Fe		*CC	5YR 2/2	

Explanatory notes in chapter 1

Site 295 Hole Core * Cored Interval: 148.5-158.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	OTHERS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
PALEOCENE(?)	P3? "reworked"					1	0.5 1.0	VOID Fe			5YR 2/2	*Material recovered in core barrel was from a 9.5 m section that was washed <u>not</u> cored; hole subsequently abandoned due to collapse. FERRUGINOUS SILTY CLAY (5YR 2/2) Chunky - disturbed by drilling.
		Cm	Rp	B		Core Catcher		Fe			5YR 2/2	

Explanatory notes in chapter 1


0 cm
25
50
75
100
125
150
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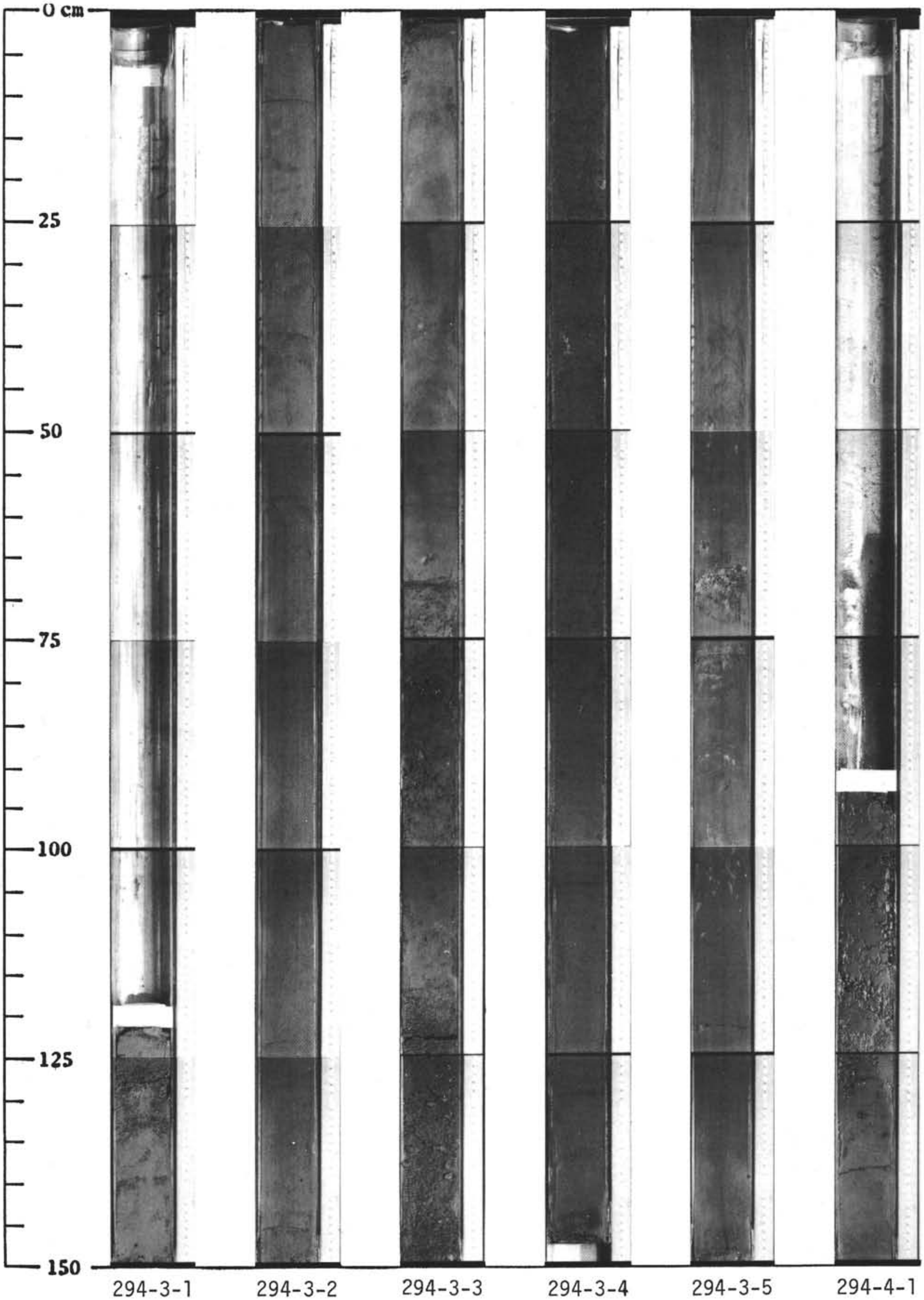
294-1-2
294-1-3
294-1-4
294-2-1
294-2-2


0 cm
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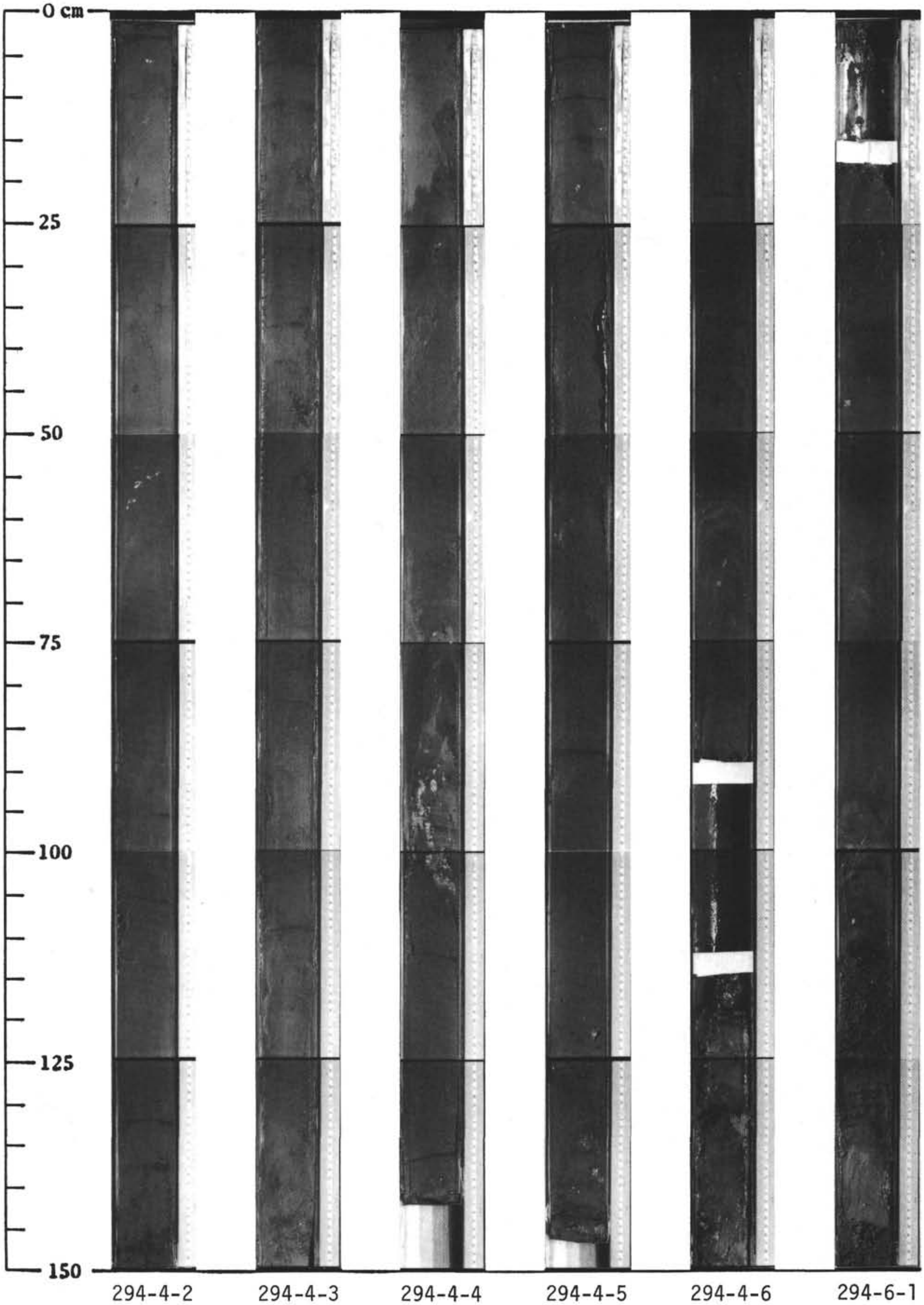
294-3-5
294-4-1


0 cm
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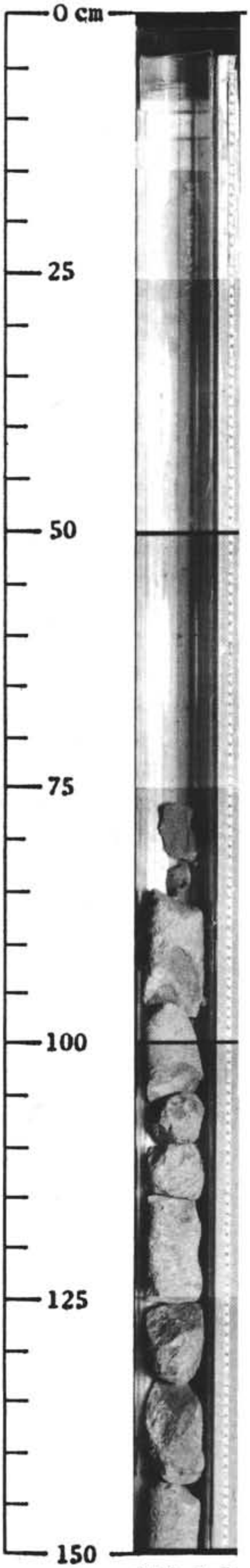
294-4-3
294-4-4
294-4-5
294-4-6
294-6-1



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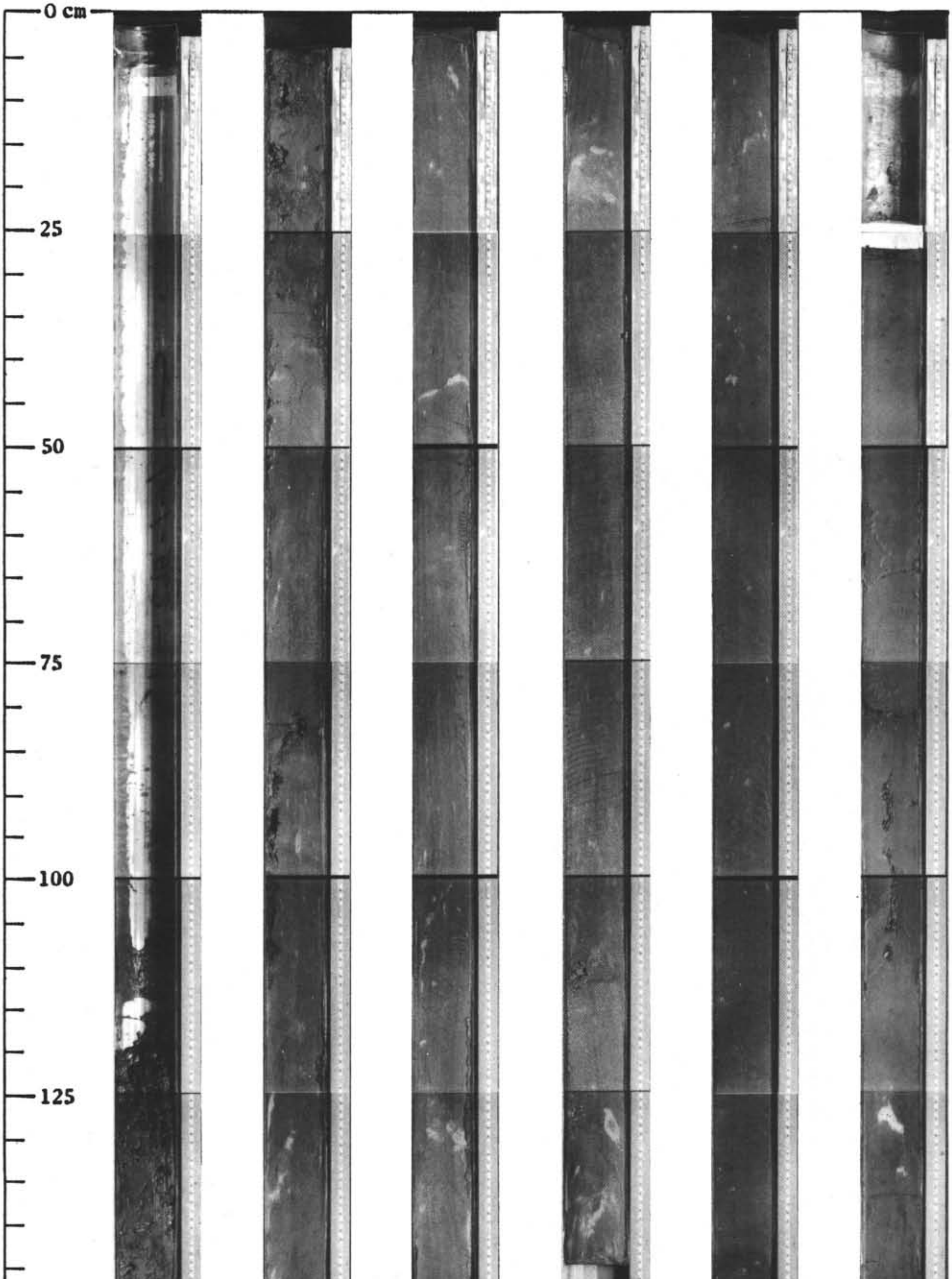
0 cm
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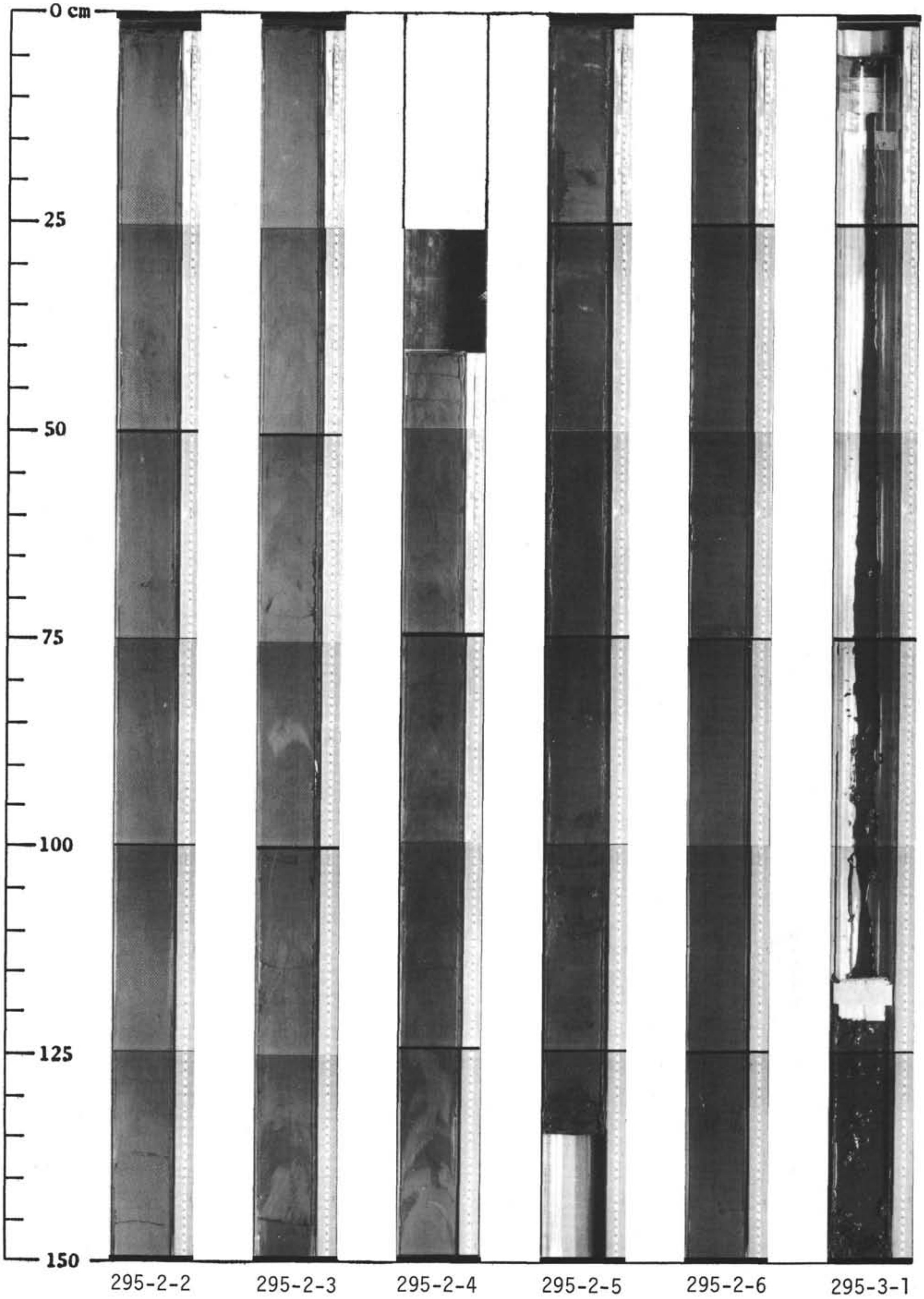
100
125
150
295-1-1
295-1-2
295-1-3
295-1-4
295-1-5
295-2-1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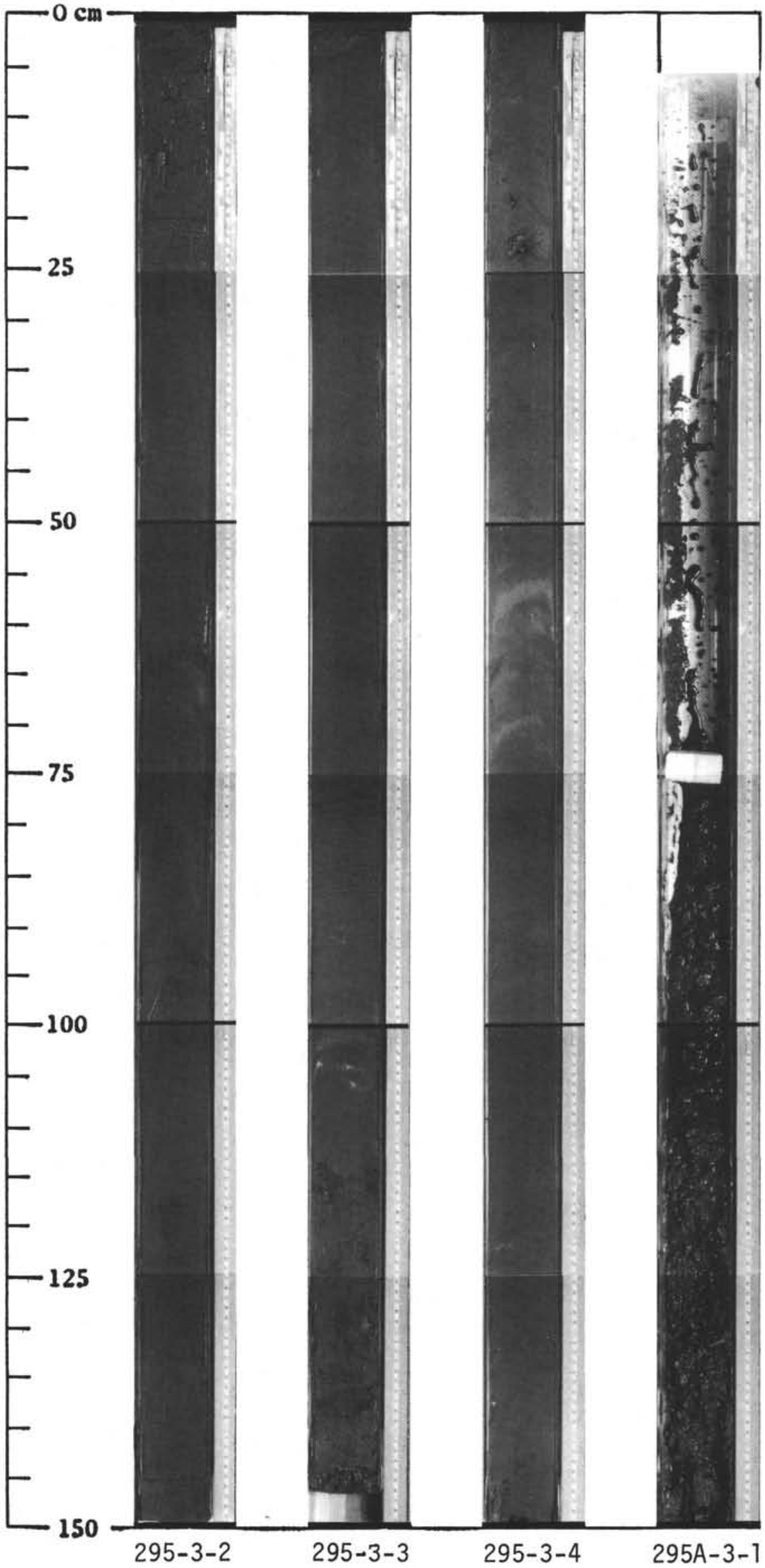
295-2-3
295-2-4
295-2-5
295-2-6
295-3-1


0 cm
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50
75
100
125
150
295-3-2
295-3-3
295-3-4
295A-3-1