7. SITE 412

Shipboard Scientific Party[1]

SITE DATA — HOLE 412

Date Occupied: 0530 24 August 1976

Date Departed: 1500 25 August 1976

Time on Hole: 14.5 hours

Position: Latitude: 36°33.74′ N; Longitude: 33°09.96′ W

Water Depth (sea level): 2609 corrected meters, echo sounding

Water Depth (rig floor): 2619 corrected meters, echo sounding

Bottom felt at: 2624 meters, drill pipe

Penetration: 171.5 meters

Number of Holes: 2

Number of Cores: 15

Total Length of Cored Section: 133.5 meters

Total Core Recovered: 85.89 meters

Percentage Core Recovery: 64 per cent

Oldest Sediment Cored:
Depth sub-bottom: 165.5 meters
Nature: Nannofossil chalk
Chronostratigraphic Unit: Pleistocene
Measured velocity: 1.58 km/s

Basement:
Depth sub-bottom: 160 meters[2]
Nature: Basalt

Principal Results: Site 412 is about a mile south of the north wall of fracture zone B, FAMOUS area.

At Site 412 two holes were drilled. The first one penetrated 171.5 meters of rock, including 11.5 meters of basalt. Drilling was stopped when an experimental bit failed. Hole 412A penetrated 294 meters, including 131 meters into basalt. We recovered 23.1 meters of basalt. Sediments are 165.5 meters of Quarternary white to yellow nannofossil ooze and chalk. The lowest few meters are oxidized. The age is consistent with the magnetic anomaly to the north (about 1.6 m.y.). Basement consists of phyric basalt flows interlayered with limestone that shows dips up to 30° on bedding planes. The upper part of the basalt section includes rocks in which olivine, plagioclase, and clinopyroxene phenocrysts occur together. In the lower part of the section, clinopyroxene is absent as a phenocryst phase.

SITE DATA — HOLE 412A

Date Occupied: 1530 25 August 1976

Date Departed: 2300 27 August 1976

Time on Hole: 2 days, 7.5 hours

Position: Latitude: 36°33.74′ N; Longitude: 33°09.96′ W

Water Depth (sea level): 2609 corrected meters, echo sounding

Water Depth (rig floor): 2619 corrected meters, echo sounding

Bottom felt at: 2626 meters, drill pipe

Penetration: 294 meters

Number of Holes: 2

Number of Cores: 15

Total Length of Cored Section: 138.0 meters

Total Core Recovered: 23.07 meters

Percentage Core Recovery: 17 per cent

Oldest Sediment Cored:
Depth sub-bottom: 286 meters
Nature: Nannofossil chalk
Chronostratigraphic Unit: Pleistocene

Basement:
Depth sub-bottom: 163 meters[3]
Nature: Basalt
Velocity range: 4.52-6.59 km/s

Principal Results: Slickenside sets recovered from intercalated limestone show normal, reverse, and strike-slip (right) movement.

BACKGROUND AND OBJECTIVES

If one seeks a site of very young basement age with a thick sedimentary cover (in order to drill a zero-age site), one of the obvious places to look is in a fracture-zone valley. Such valleys accumulate sediment much more rapidly than the hills on the flanks of the ridge, and sedimentation rates in excess of 100 m/m.y. seem to be common. Until now, however, the strategy of the Deep Sea Drilling Project has been to avoid fracture zones, and thus

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[2]Based on drilling log.

[3]Based on drilling log.

not to count the sedimentary basins there as candidates for zero-age sites. The reasons for this strategy appear to be, first, that fracture zones are anomalous, and that drilling in them would not sample typical oceanic crust, and second, that the rocks in fracture zones must obviously be fractured and so lead to difficult hole conditions. It seemed to us on careful consideration that these objections to drilling in fracture zones were essentially theoretical, and that it would be important to test them empirically before making a final decision not to use fracture zones for drilling into young crust. In particular, the experience of Legs 37, 45, 46, and now 49, was that normal, young oceanic crust away from fracture zones is intensely fractured, and crust in fracture zones might be no worse. It is possible to argue that circulation of hydrothermal fluids in fracture zones would lead to cementing of fractures with secondary minerals, and so to better drilling conditions. In addition, the argument for crustal abnormality seemed to be based on the concept of fracture zones as very narrow fault zones which approach the idealized transform fault model. In practice, differences from such a model might lead to fracture-zone crust being much less abnormal than predicted.

Finally, we wanted to find out something about the structure of fracture zones themselves. JOIDES has had considerable difficulty selecting drill sites which were clearly away from fracture zones. In fact, it is usually possible to dismiss the aberrant results from any site, especially one on crust more than 5 m.y. old, as resulting from proximity to a fracture zone. Crust sufficiently near fracture zones to be influenced by them may account for as much as 10 per cent of the area of the ocean crust — and as much again may well be open to this influence. In order to identify and allow for such influences, a better knowledge of what does happen in fracture zones is clearly desirable.

Site 412 was chosen in the fracture-zone valley of fracture zone B in the FAMOUS area (see Figure 1). This fracture zone is the one to the south of the stretch of median valley where most of the detailed work was done. The sediment isopach map of Phillips and Fleming (unpublished) shows an area of thin sediment at the junction of the fracture zone with the median valley running north. This is not suitable for drilling, but to the east the inactive fracture zone becomes a sedimentary basin. Site 412 was chosen where the sediment in this basin, according to the map, reaches a thickness of 100 meters. It was positioned on the edge of the 100-meter isopach, as far north as possible, so as to lie on young crust. The magnetic anomaly map (Phillips and Fleming, unpublished) shows that the crust to the north of the fracture zone at this point is about 1.6 m.y. old (just younger than the Olduvai event); the crust to the south is about 3.4 or 3.5 m.y. old (just older than anomaly 2′ [= 2A]). Extrapolation of the present line of the transform fault linking the stretches of median valley to the north and south of fracture zone B, as far as it could be determined from the map, suggested that Site 412 would be on the young side of the fault and should thus lie on crust only half a million years older than that at Site 411. The large size of the sediment pond meant that finding the site and spudding in would not be the exhausting experience it had been on Site 411.

OPERATIONS

Upon leaving Site 411, we laid out a dead-reckoning track that would minimize error in placing the hole caused by uncertainty about the ship's speed. We crossed the median valley on a course of 110°, and then, using the topographic map of Phillips and Fleming (unpublished), turned to 182° as we crossed the 1100-fm contour at 36°43′N, 33°09′W. This brought us down across the northern slope of the fracture-zone basin into the sediment-filled area. Basement reflections from beneath the sediment were diffuse, but soon it seemed clear that at least 100 meters of sediment lay beneath the ship, and a 13.5-kHz beacon was dropped on the first pass at 0340 on 24 August. Because of the diffuse nature of the basement reflections, and the appearance of a shadowy basement high that might underlie the beacon, the ship was offset 1000 feet to the south of the beacon. Figure 2 shows the tracks approaching and leaving the site, and Figure 3 is the seismic reflection profile coming up to and running past the beacon drop.

This site was chosen for trying an experimental bit designed to improve core recovery. It cored successfully through 160 meters of sediment (two parts of two joints each were washed down to speed up operations), but failed after coring about 3 meters of basalt (Table 1). The string was pulled and the bit was found to have lost two cones. The opportunity for comparison with a standard bit seemed ideal, and the string was run again with a standard bit and washed down to basement, where coring started. This attempt was Hole 412A. The sediment at this site was nannofossil ooze to nannofossil chalk, and made a much better material for drilling than the foraminifer sand of Site 411. After seven cores of basalt had been cut, however, we were unable to restore circulation and rotation after making each connection. This seemed to result from pieces of fractured basalt caving in from the walls of the hole, or from back-flow of cuttings lodged in some washed-out cavity higher up the hole while the water was circulating. This trouble grew progressively worse; Core 10 took 5 hours to make, including 2 hours becoming unstuck before any cutting was attempted. After that it was decided to fill the hole with mud before pulling the core barrel each time, and this procedure was very successful; it shortened times per core to 1½ to 2 hours. Soon after that, however, the cone bearings began to fail, and the core diminished in size. The collars began sticking on the sides of the by now too small hole, and the last core, which reached 131 meters sub-basement, brought up nothing at all.

The last core was brought up at 1135 on 27 August (Table 1), and an inclinometer survey was run. This showed a maximum deviation of 1¾°, not of concern to the paleomagnetists. However, when this was being retrieved, the sand line broke, delaying the pulling of the pipe. When the core barrel was retrieved it was jammed by cuttings.

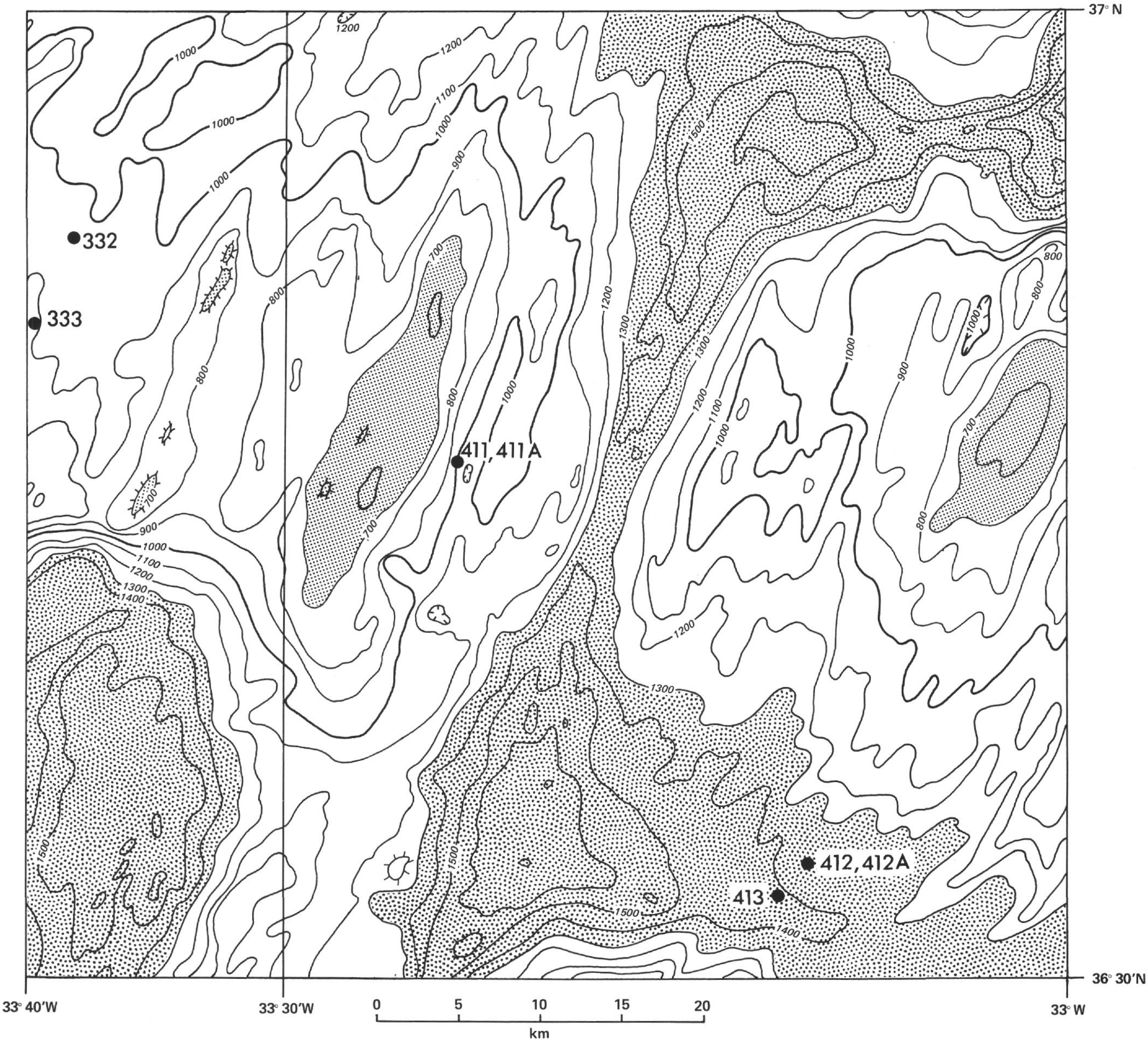

Figure 1. *Topographic chart of fracture zone B region in uncorrected fathoms (after Phillips and Fleming, unpublished).*

These cuttings were preserved for comparison with the sands drilled at Site 410.

SEDIMENT LITHOSTRATIGRAPHY

Hole 412 — Introduction

Hole 412 was cored continuously to basement at 165.5 meters (recovered depth), except for two washed intervals (32.5 to 51.5 m and 61.0 to 80.0 m). Including a zone of no recovery (127.5 to 137.0 m), we cored a total of 127.5 meters of sediment, with approximately 67 per cent recovery. The sediment is nannofossil ooze with down-core gradations in total carbonate content and in amounts of foraminifer and biogenic silica. The basalt at Hole 412 does not contain interlayered sedimentary intervals.

Description of the Sediments

(Cores 1 through 14, 0 to 165.5 m)

The entire sedimentary sequence is Pleistocene nannofossil ooze. The sediment of the upper 84 cm of Core 1, Section 1 is yellowish brown, and the lower 8.6 meters (Core 14, Section 1, 9 cm to basement) is yellowish brown, and the lower 8.6 meters (Core 14, Section 1, 9 cm to basement) is yellowish gray. The intervening sediment between these oxidized zones is light to very light gray.

Carbonate-bomb results show a gradual increase of $CaCO_3$, from 75 per cent at the top to 95 per cent at 90 meters sub-bottom, then a gradual decrease to about 85 per cent at 160 meters (Figure 4).

Foraminifers are more abundant in Cores 1 through 6 than in most of the deeper cores (Figure 5). Several foraminiferal

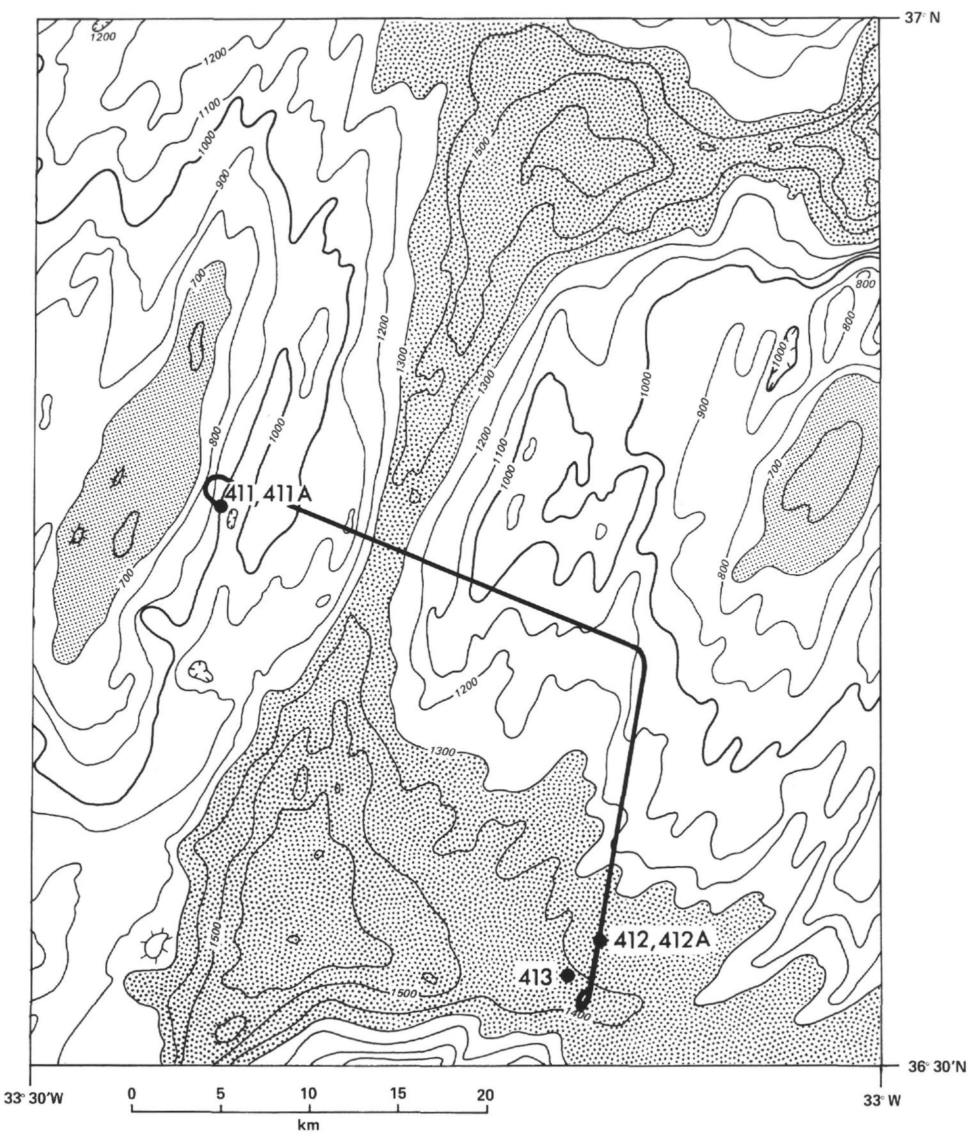

Figure 2. *Track of* Glomar Challenger *approaching and leaving Site 412.*

sand turbidite sequences occur in Core 6 (80 to 89.5 m); one sample contains 70 per cent foraminifers. Cores 1 through 4 are structureless, owing to drilling disturbance. Small amounts of "unspecified carbonate" (5 to 10%) occur in most samples. These silt-size, irregularly shaped, and spine-like particles are more abundant in samples with high foraminifer contents, suggesting that they may be foraminifer fragments. Core 8 contains scarce, broken discoasters.

Non-carbonate material is mostly biogenic silica in the form of sponge spicules, diatoms, radiolarians, silicoflagellates, and in several samples, abundant silt-size silica spines that may be fragments of radiolarians, sponge spicules, or silicoflagellates. These siliceous components range between 1 per cent and as much as 45 per cent in smear-slide analyses (Figure 5). The percentage of biogenic silica components, although variable, decreases down the sediment column (Figure 5). Samples with higher silica content correlate with those of somewhat lower carbonate content (Figures 4 and 5).

Lithogenous particles, such as silt-size feldspar, volcanic glass, palagonite, and opaques (mostly pyrite grains), seldom exceed 1 per cent. Glauconitic (1 to 2% galuconite) laminations are present in Cores 2 through 5, and there are a few laminations rich in manganese micronodules (up to 40%). Limonite, occurring as silt-size particles and as fillings of foraminifers, are dispersed throughout Core 14, and also appear in several laminated sandy units (each about 3 cm thick) at the bottom of Core 14, directly above the basalt.

Many of the cores or parts of them are highly deformed or structureless. Sedimentary structures do occur, however, as for example the glauconitic and manganese-rich laminations in Cores 2 through 5, the well-defined foraminifer sand turbidites of Core 6, purple, light gray, and white bioturbation mottles (?) scattered throughout the section, and a few pyrite-filled burrows in Cores 4, 5, 7, and 9.

Hole 412A — Introduction

The sediment was washed down to basement. Nannofossil chalk and small amounts of ooze occur as interlayered sediments within basalt in Cores 3, 11, 12, and 14. Basaltic gravel occurs at the base of the hole (the drill pipe jammed at 294.0 meters).

Description of Interlayered Sediment

Core 3 (Section 1, Piece 10A), Core 11 (254.2 to 254.5 m), and Core 14 (282.9 to 283.4 m sub-bottom)

The sediment is pale yellow nannofossil chalk with 1 to 3 per cent foraminifers and traces of volcanic glass, biogenic silica, feldspar, and manganese micronodules. In Core 3, the chalk is present only as a thin fracture filling in Piece 10A of Section 1.

The chalk in Core 11 is structureless. The chalk in Core 14 contains pale olive laminations with thinner interlayers of light brown limonitic ooze. The bedding dips from 10° to 35° relative to apparent horizontal in the core.

Pieces 4 through 10 of Core 14 show many small-displacement (1 to 2mm) faults, which give the laminations a rippled appearance. Olive-brown slicken-side surfaces, roughly parallel to the vertical cut surface of the core, suggest high-angle normal and reverse faults in pieces 4A and 4B, Core 14; small step-like parting surfaces oriented at nearly right angles to the plane of movement and the slickenside lineation suggest right-lateral movement.

Core 12 (260.5 to 261.0 m)

Two lumps of pale yellow nannofossil ooze occur at the top of Core 12, together with an admixture of foraminifers (5%), clay (3%), and traces of sponge spicules, volcanic glass, feldspar, and opaques.

Basaltic Gravel (Core 15, Other, 294.0 m)

After the drill pipe jammed, we found basaltic gravel in the core barrel that is very similar to the materials found at the base of other holes. The gravel is composed of moderately rounded to well-rounded pebble- to coarse sand-size basalt particles and minor quantities of translucent calcite and pale yellow limestone grains. Further discussion of this and similar materials appears in Roberts (this volume).

BIOSTRATIGRAPHY

Sediments recovered from the two holes drilled at Site 412 are Pleistocene. Microfossils just above basalt from Hole 412 (Sample 14,CC, 165 m sub-bottom) suggest a level near, but above, the Pleistocene/Pliocene boundary. This agrees well with the expected basement age of less than 1.6 m.y. Nannofossil chalk interlayered with basalt as deep as 129 meters below the top basalt in Hole 412A yields lower Pleistocene nannofossils (Table 2).

At Hole 412, the common occurrence of discoasters in Core 10 (118 to 126 m sub-bottom), as well as the occurrence (in Sample 10,CC) of several specimens of a planktonic foraminifer not usually encountered in the Pleistocene, may indicate slump (?) of Pliocene sediments within the Pleistocene section.

Planktonic Foraminifers

Globorotalia inflata, G. scitula, Globigerina bulloides, Turborotalita quinqueloba, and *Orbulina universa* are common to abundant in all samples from Hole 412. *Globorotalia truncatulinoides* is also present in every sample, which indicates that the entire section is Pleistocene. *Globorotalia hirsuta* is abundant in the upper part of the section (Samples 1,CC through 4,CC), whereas *G. crassaformis* occurs only below Sample 4,CC (32 m sub-bottom).

Several specimens of *Globigerinoides obliquus* are present in Sample 10,CC (126 m sub-bottom). Although *Globigerinoides obliquus* does range into the lowest Pleistocene, its absence from samples below 10,CC, and the abundant occurrence, of discoasters in Core 10, suggest a Pliocene slump (?) within the Pleistocene section.

Nannofossils

All sediments recovered at Site 412 can be characterized here as nannofossil oozes in which abundance and preservation of the taxa are in general good. The following age determinations were made only on core-catcher (CC) samples, unless otherwise noted.

Hole 412

All sediments examined contain common to abundant occurrences of *Coccolithus pelagicus, Cyclococcolithina leptopora, Gephyrocapsa* spp., *Helicopontosphaera kamptneri,* and *Pontosphaera discopora. Rhabdosphaera clavigera, R. stylifera, Scyphosphaera apsteini,* and *Syracosphaera histrica* occur consistently, but in lesser amounts. *Emiliania annula* is common to abundant in all samples except Samples 3,CC, 4,CC, and 5,CC, where it is absent. The absence of *E. huxleyi* rules out uppermost Pleistocene or Holocene sediments (Zone NN 21) in the samples examined. Samples 3,CC, 4,CC, and 5,CC (23.0 to 57.2 m sub-bottom) are interpreted as upper Pleistocene, Zone NN 20, on the presence of *Gephyrocapsa aperta, G. caribbeanica,* and *G. oceanica,* and on the absence of *E. annula.*

Samples 1,CC, 2,CC, and 6,CC through 14,CC (3.4, 13.2, and 85.1 to 165.7 m, respectively) are lower Pleistocene, Zone NN 19, judging by the presence of the above-mentioned gephyrocapsids and the presence of *E. annula. Discoaster brouweri* and *D. variabilis* occur in small numbers in Sample 10,CC (126.2 m), suggesting the presence of some Pliocene sediment, possibly introduced by slumping.

Hole 412A

Nannofossils recovered at Hole 412A were obtained from indurated crusts occurring on basalt fragments. All samples contain lower Pleistocene assemblages. The following samples were dated using the nannofossils present.

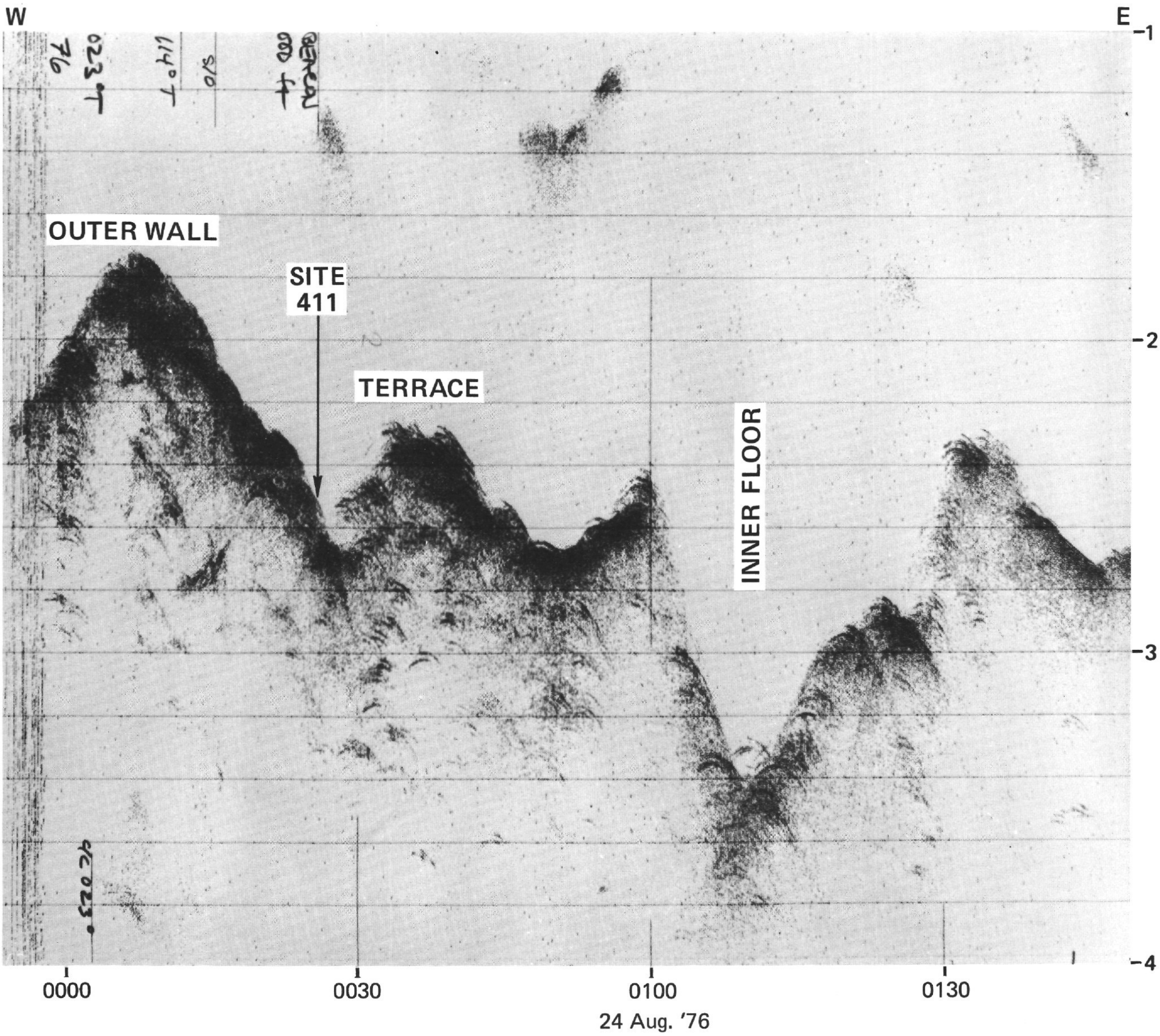

Figure 3. *Seismic reflection profile approaching and passing the beacon drop for Site 412. See track in Figure 2.*

Core	Section	Piece No.
3	1	10A
4	1	9
5	1	2
11	3	3B
11	CC	—
14	4	4
15	Other	—

Typically present are *Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *Gephyrocapsa* spp. *Helicopontosphaera kamptneri*, *Emiliania annula*, and *Scyphosphaera* spp. No discoasters were found.

PHYSICAL PROPERTIES OF SEDIMENTS

Hamilton Frame sonic velocity and wet bulk density by weight are plotted against depth in Figures 6 and 7.

The top four cores were quite disturbed, and this is reflected in the lower wet bulk density values for these cores. Sonic velocities for these cores center around that of seawater, 1.5 km/s, with a single value of 1.59 at 33 meters sub-bottom, the proper depth for correlating with the 25 m sub-bottom reflector observed in the seismic reflection profile. Below this there is a stepwise increase in both sonic velocity and wet bulk density, at about 105 meters sub-bottom, that does not correlate with either a particular lithostratigraphy or a sub-bottom reflector. The deepest sonic velocity samples show a characteristic rise in velocity near basement.

GEOCHEMISTRY

Only four samples were taken for interstitial-solution analyses at this site, because the sediment was only 160 meters thick. However, the chemistry of the interstitial solutions is remarkably similar to that described for Hole 410, where the trends are clearer, owing to the greater number of samples.

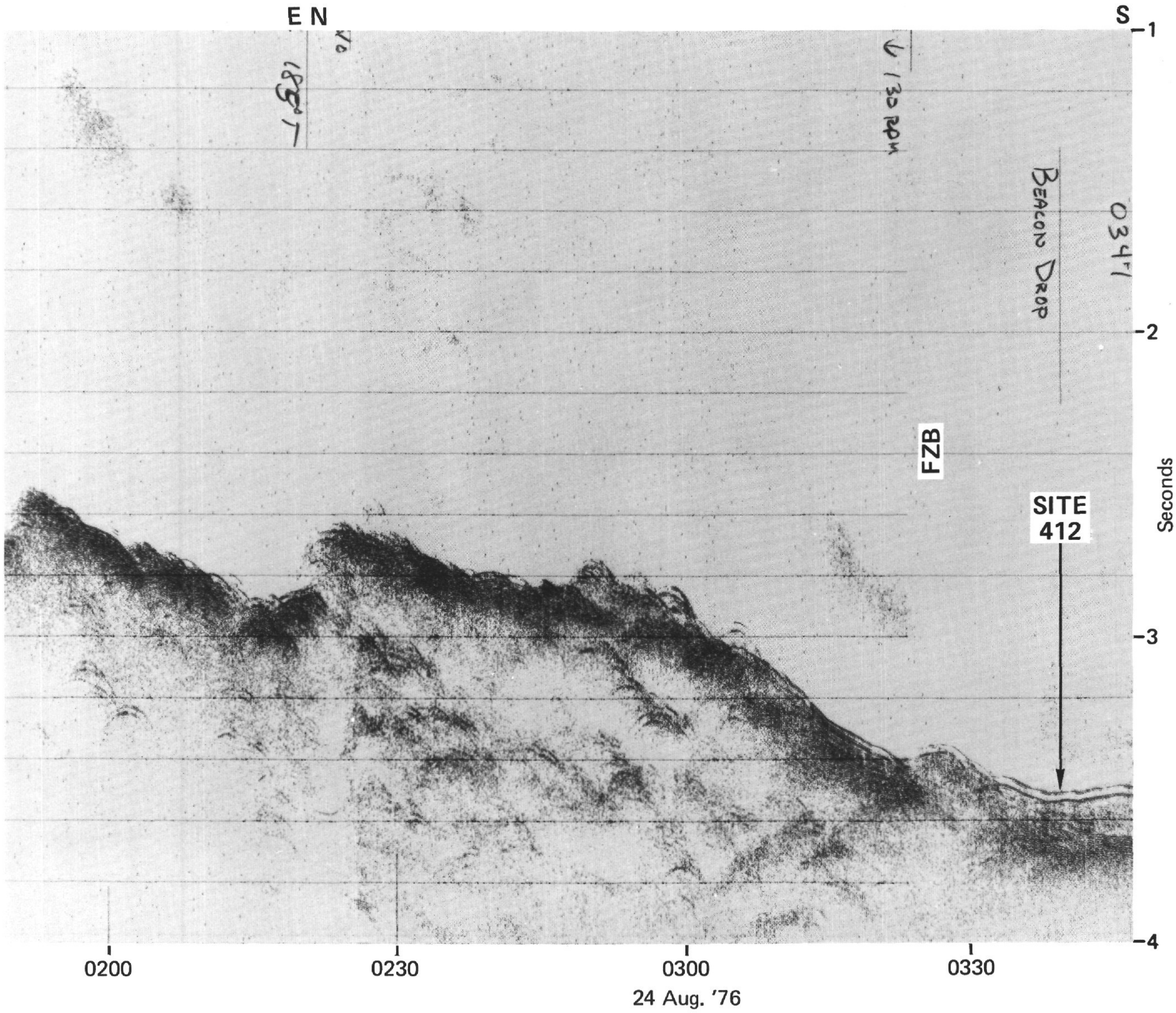

Figure 3. *Continued.*

Although the sediments represent a more compressed sequence here than at Hole 410, the two successions are quite similar. Here we have 165.5 meters of Pleistocene nannofossil ooze with a very high average deposition rate of 10 cm/1000 years. The top 84 cm of the sequence is brown, suggesting an oxidizing environment; below that, the sequence grades into a reducing environment, as reflected by the abundance of pyrite as nodules and as finely disseminated material throughout the gray/white sediment. The reducing conditions continue throughout the sedimentary sequence to about 10 meters above basement, where the sediments become yellow-gray and the pyrite becomes oxidized.

*p*H, Ca^{++}, Mg^{++}, alkalinity, chlorinity, and salinity are plotted against sub-bottom depth in Figure 8, and should be compared with the results shown for Hole 410. Alkalinity shows the most dramatic changes through the sequence, and at 60 meters increases to approximately three times its seawater value, indicating extensive sulfate reduction. The alkalinity increases to 7.7 at 110 meters, suggesting that the sulfate reduction is the predominant post-deposition process to at least this depth. *p*H shows the inverse variation to alkalinity, although it is less well defined. *p*H is lower in the mud line than seawater, and decreases slightly with depth down to 110 meters sub-bottom. The low *p*H is also consistent with sulfate-reducing processes in the sediment.

Ca^{++} is depleted, relative to seawater, and shows a 25 per cent increase from the mud line to 110 meters sub-bottom depth. The Ca^{++} decrease may be explained as shift, caused by excess HCO_3^- (produced by the sulfate-reduction process), in the equilibrium of the reaction described in Equation 2 of the geochemistry section, Site 410, chapter (this volume), a shift which subsequently causes calcium carbonate to precipitate from solution. Mg^{++} in the mud-line sample is depleted, relative to seawater, but shows almost no variation with depth. The Mg^{++} depletion may be

TABLE 1
Coring Summary, Site 412

Core	Date (Aug. 1976)	Time	Depth From Drill Floor (m)	Depth Below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Recovery (%)
Hole 412							
1	24	1625	2624.0-2628.0	0.0-4.0	4.0	3.40	85
2	24	1740	2628.0-2637.5	4.0-13.5	9.5	9.20	97
3	24	1840	2637.5-2647.0	13.5-23.0	9.5	9.50	100
4	24	1945	2647.0-2656.5	23.0-32.5	9.5	9.20	97
Wash 32.5-51.5 meters							
5	24	2100	2675.5-2685.0	51.5-61.0	9.5	5.67	60
Wash 61.0-80.0 meters						5.14	
6	24	2215	2704.0-2713.5	80.0-89.5	9.5	5.14	54
7	24	2315	2713.5-2723.0	89.5-99.0	9.5	2.93	31
8	25	0010	2723.0-2732.5	99.0-108.5	9.5	9.73	102
9	25	0104	2732.5-2742.0	108.5-118.0	9.5	8.60	91
10	25	0158	2742.0-2751.5	118.0-127.5	9.5	8.19	85
11	25	0250	2751.5-2761.0	127.5-137.0	9.5	0.00	0
12	25	0350	2761.0-2770.5	137.0-146.5	9.5	4.22	44
13	25	0450	2770.5-2780.0	146.5-156.0	9.5	0.44	45
14	25	0650	2780.0-2789.5	156.0-165.5	9.5	9.47	100
15	25	1000	2789.5-2795.0	165.5-171.5	6.0	0.20	2
Total					133.5	85.89	64
Hole 412A							
1	26	0000	2780.0-2789.5	156.0-165.5	9.5	0.25	3
2	26	0136	2789.5-2799.0	165.5-175.5	9.5	1.27	13
3	26	0320	2799.0-2808.5	175.0-184.5	9.5	2.83	20
4	26	0440	2808.5-2818.0	184.5-194.0	9.5	0.68	7
5	26	0700	2818.0-2827.5	194.0-203.5	9.5	0.65	7
6	26	0855	2827.5-2837.0	203.5-213.0	9.5	0.65	7
7	26	1015	2837.0-2846.5	213.0-222.5	9.5	2.10	22
8	26	1233	2846.5-2856.0	222.5-232.0	9.5	2.40	25
9	26	1535	2856.0-2865.5	232.0-241.5	9.5	0.90	9
10	26	2040	2865.5-2875.0	241.5-251.0	9.5	0.35	4
11	26	2245	2875.0-2884.5	251.0-260.5	9.5	3.00	32
12	26	2355	2884.5-2894.0	260.5-270.0	9.5	0.30	3
13	27	0225	2894.0-2903.5	270.0-279.5	9.5	2.90	31
14	27	0625	2903.5-2913.0	279.5-289.0	9.5	4.79	50
15	27	1135	2913.0-2918.0	289.0-294.0	5.0	0.00	0
Total					138.0	23.07	17

[a] Basement at 2786 m (160 m sub-bottom).

explained by a shift in the equilibrium of reaction, resulting from a sulfate-reduction process. However, the absence of an inverse relationship between Ca^{++} and Mg^{++} characteristic of biogenic ocean-floor sediment (e.g., Sites 408 and 409, where Ca^{++} increases in the interstitial solutions as Mg^{++} decreases) suggests that replacement of Ca^{++} in the sediment carbonate by Mg^{++} has not occurred to any great extent in this sedimentary sequence. Paleomagnetism data suggest that the basement at this site is about 1.6 m.y. old, and perhaps there has not been sufficient time for the Mg^{++} -Ca^{++} substitution to occur.

The deepest interstitial water sample, from 140 meters sub-bottom, shows a reversal in the trends described above; i.e., *p*H and Ca^{++} increase slightly and alkalinity decreases drastically. These trends represent change from reduction to oxidation processes in the sediment, corresponding approximately to the change from sulfide-bearing gray-white nannofossil ooze to yellow-gray nannofossil ooze, with oxidized iron oxide replacing the sulfide. Such trends in the base of the sedimentary sequence at Hole 410 were interpreted as having been produced by late hydrothermal solutions emanating from the basement, perhaps reflecting off-axis volcanism. It appears that a similar interpretation may be applied to the data for this site. The position of this site in a fracture zone might be used to suggest that this is a zone of upwelling in a convective hydrothermal system, i.e., an area where the escape of hydrothermal solutions from the basement is enhanced simply by its tectonic environment. That pyrite formation in the basal sediments at one stage during the post-depositional history of this site suggests, however, that the hydrothermal fluids have not been continually emanating from the

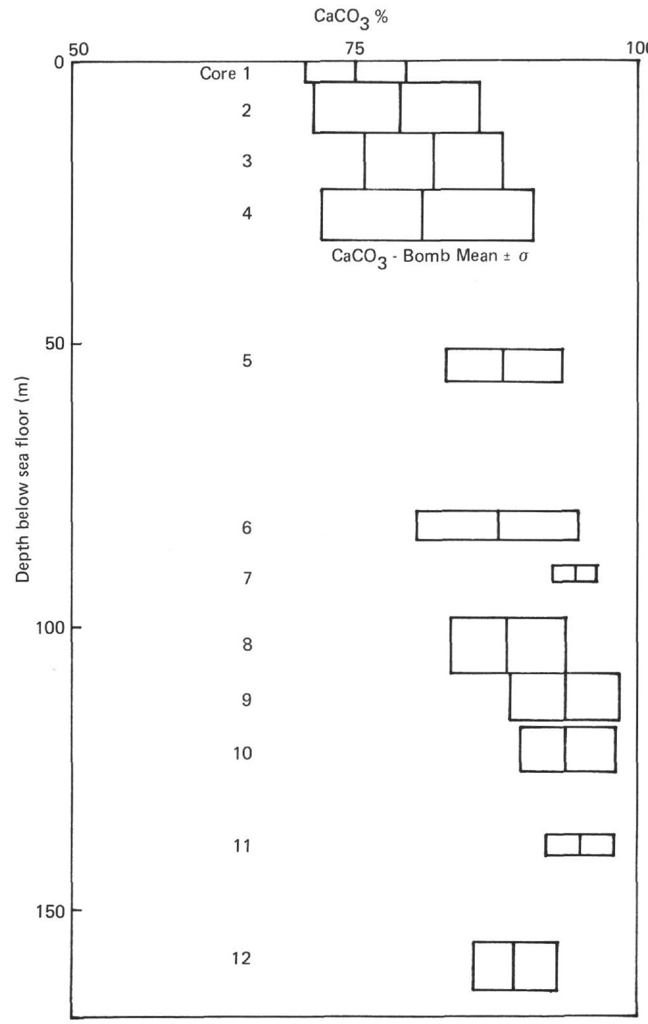

Figure 4. *$CaCO_3$ (carbonate-bomb results) contents, Hole 412.*

basement since its formation (probably in the axial rift zone). One possibility is that the subsequent oxidation of the basal sediments is related to a distinct post-depositional hydrothermal/volcanic event near this site. Another explanation, which may also apply to Hole 410, is that the zone of upwelling of the hydrothermal convective system associated with the mid-ocean rifting process occurs some distance away from the central rift. In this case, as sediments are deposited on the basaltic crust in the central rift, reducing conditions would prevail within the sediments. However, as the sea-floor spreading process continued to move the basaltic crust away from the central rift into the zone of hydrothermal upwelling, the reducing conditions in the basal sediments would be gradually affected by the emanating fluids. If this last explanation applies to both Holes 410 and 412, it must operate on a variable time scale, because of the different time spans involved.

We conclude that the interstitial-solution chemistry has contributed significantly to our understanding of the post-depositional history of both sediment and basement at this site. We suggest that further shore-based comparisons

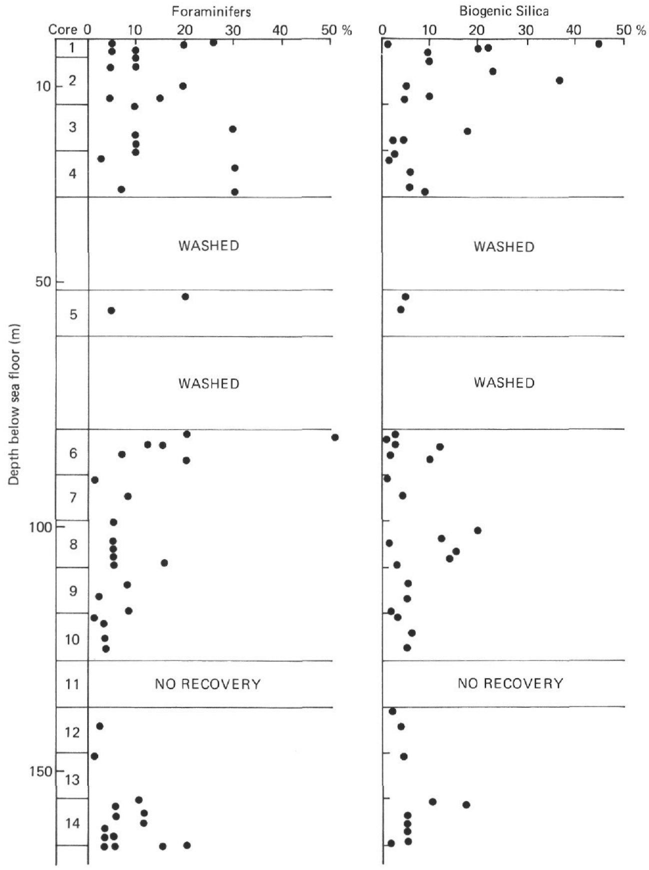

Figure 5. *Foraminifers and biogenic silica contents, Hole 412, obtained by smear-slide analyses.*

between the interstitial-solution chemistry of Holes 412 and 410 may prove worthwhile.

PALEOENVIRONMENTAL INTERPRETATION

Sediment Accumulation Rate

The average rate of accumulation, based on the total sediment thickness in Hole 412 of 165.5 meters and the magnetic age of basement of 1.6 million years, is approximately 100 m/m.y.

Although many cores and parts of cores are structureless or highly deformed, the presence of turbidites in Core 6 and possibly at the base of Core 14, and the several thick structureless zones, suggest that the rapid deposition was caused by a combination of turbidity currents and slumping. The presence of *Discoaster brouweri* and other common discoasters of the upper Pliocene in Core 10 suggests reworking of sediment from the older wall of the fracture zone, but the foraminifer assemblages indicate that the entire sediment column is Pleistocene.

In the upper part of the sediment column (Cores 1, 2, 3, 4, and 8), there is a correlation between low $CaCO_3$ content, high biogenic silica, concentrations of foraminifers, and laminations. This evidence suggests that bottom currents winnowed the nannofossils during intervals between slumping or turbidity currents.

Sediment Diagenesis

The uppermost 84 cm of Core 1, Section 1, Hole 412, is yellowish brown, suggesting an oxidizing environment. The interval between Samples 1-1,84 cm and 14-1,9 cm (156.9 m sub-bottom) is light gray, indicating reducing conditions. Pyrite nodules and widely dispersed fine pyrite grains occur in this interval. Glauconitized fillings of foraminifer tests and glauconitic laminations and mottles indicate microreducing conditions in the light gray sediment. The remainder of the sediments below Sample 14-1,9 cm, down to contact with basalt at 165.5 meters, is yellowish brown, with many scattered limonite grains, and there is a lower zone of laminated limonitic sand. The limonite particles may have originally been pyrite oxidized by interstitial fluids, or they may have deposited from iron-rich solutions. Changes in the alkalinity of interstitial waters, which is high in pyritic units and lower in limonitic ones, may be related to the changes in oxidation state.

BASEMENT LITHOSTRATIGRAPHY

Hole 412

Basement was first encountered at 153 meters sub-bottom depth[4]. A single cobble of aphyric basalt was recovered from Core 13, where it was interbedded with lower Pleistocene nannofossil ooze. Thirty centimeters of basalt was retrieved from the core catcher of Core 14, and an additional 20 cm was recovered from Core 15. Disintegration of the bit forced us to terminate the hole at this point.

Except for the single cobble from Core 13, all basalt from Hole 412 is fine- to medium-grained olivine plagioclase phyric, with variable and lesser amounts of emerald-green clinopyroxene phenocrysts. The fine-grained samples contain 2 to 5 per cent total phenocrysts; the medium-grained samples contain up to 10 per cent, or rarely 15 per cent, total phenocrysts (plagioclase-olivine-clinopyroxene). The medium-grained material has a micro-gabbroic texture. Alteration varies from weak to moderate.

Although core recovery was only 2 per cent, correlation of drilling rate (Figure 9) with vesicle-enriched zones and gradational changes in grain size suggest that parts of four units were recovered. Grain size suggests that these rocks might be intrusives (sills or dikes), but the presence of numerous vesicles argues against this. Medium-grained basalt flows with similar mineralogy have been reported at several of the Leg 37 sites. A stratigraphic column is presented as Figure 9. Figure 10 shows that there is no marked geochemical break in this short sequence.

Hole 412A

Basement was first encountered at 165 meters sub-bottom and drilled to a depth of 294 meters. Of the 131 meters penetrated, 23.07 meters of basalt and foraminifer chalk (17.6%) were recovered from 14 cores. Correlation of drilling rate (Figure 9) with changes in grain size,

[4]Depths are calculated from drilling rates.

TABLE 2
Paleo/Biostratigraphic Summary of Core-Catcher Samples (CC)

Core	Depth (m)	Chronostratigraphic Unit	Planktonic Foraminifers	Calcareous Nannofossils	Zone
1	3.4	Pleistocene	*Globorotalia inflata* *G. truncatulinoides* *G. hirsuta* *G. scitula* *Neogloboquadrina pachyderma* (D) *N. dutertrei* *Globigerinoides ruber* *G. succulifer* *Globigerina bulloides* *G. falconensis* *Turborotalita quinqueloba*	*Coccolithus pelagicus* *Helicopontosphaera kamptneri* *Gephyrocapsa* spp. *Rhabdosphaera stylifera* *Cyclococcolithina leptopora* *Emiliania annula*	NN 19
2	13.2	Pleistocene	As above	As above	NN 19
3	23.0	Pleistocene	As above washed down 32.5 to 51.5 m	*C. pelagicus* *C. leptopora* *H. kamptneri* *Gephyrocapsa* spp. *R. stylifera*	NN 20 (?)
4	32.2	Pleistocene	As above	As above	
5	57.2	Pleistocene	*G. inflata* *G. truncatulinoides* *G. crassaformis* *G. scitula* *T. quinqueloba* *N. pachyderma* (D) *N. dutertrei* *G. ruber* *G. conglobata* *G. bulloides* *G. falconensis*	As above	
6	Washed down 61.0 to 80.0 m	Pleistocene	*Globorotalia inflata* *G. truncatulinoides* *G. crassaformis* *G. scitula* *Turborotalita quinqueloba* *Neogloboquadrina pachyderma* (D) *N. dutertrei*	*H. kamptneri* *Gephyrocapsa* spp. *Scyphosphaera* spp. *E. annula* *C. leptopora*	NN 19
7	92.4	Pleistocene	As above	As above	NN 19
8	108.5	Pleistocene	As above	As above	NN 19
9	117.1	Pleistocene	*Globorotalia inflata* *G. truncatulinoides* *G. crassaformis* *G. scitula* *G. tosaensis* *Turborotalita quinqueloba* *Neogloboquadrina pachyderma* *N. dutertrei* *Globigerinoides ruber* *Globigerina bulloides* *G. falconensis*	As above	NN 19
10	126.2	Pleistocene	*Globorotalia inflata* *G. crassaformis* *G. truncatulinoides* *G. tosaensis* *G. scitula* *Turborotalita quinqueloba* *Neogloboquadrina pachyderma* *N. dutertrei* *Globigerinoides ruber* *G. obliqua* ?*Sphaeroidinellopsis subdehiscens* *Globigerina bulloides*	As above plus *D. broeweri* plus *D. variabilis*	
11	(127.5)		No Recovery		
12	165.5	Pleistocene	*Globorotalia inflata* *G. crassaformis* *G. truncatulinoides* *G. scitula* *Turborotalita quinqueloba* *Neogloboquadrina pachyderma* (D) *N. dutertrei* *Globigerinoides ruber* *Globigerina bulloides*	*C. pelagicus* *H. kamptneri* *E. annula* *C. leptopora* *Gephyrocapsa* spp.	NN 19
13	146.9	Pleistocene	As above, plus *G. tosaensis*	As above	
14	165.5	Pleistocene	*Globorotalia inflata* *G. crassaformis* *G. truncatulinoides* *G. tosaensis* *Turborotalita quinqueloba* *Neogloboquadrina pachyderma* (D) *N. dutertrei* *G. bulloides*	As above	

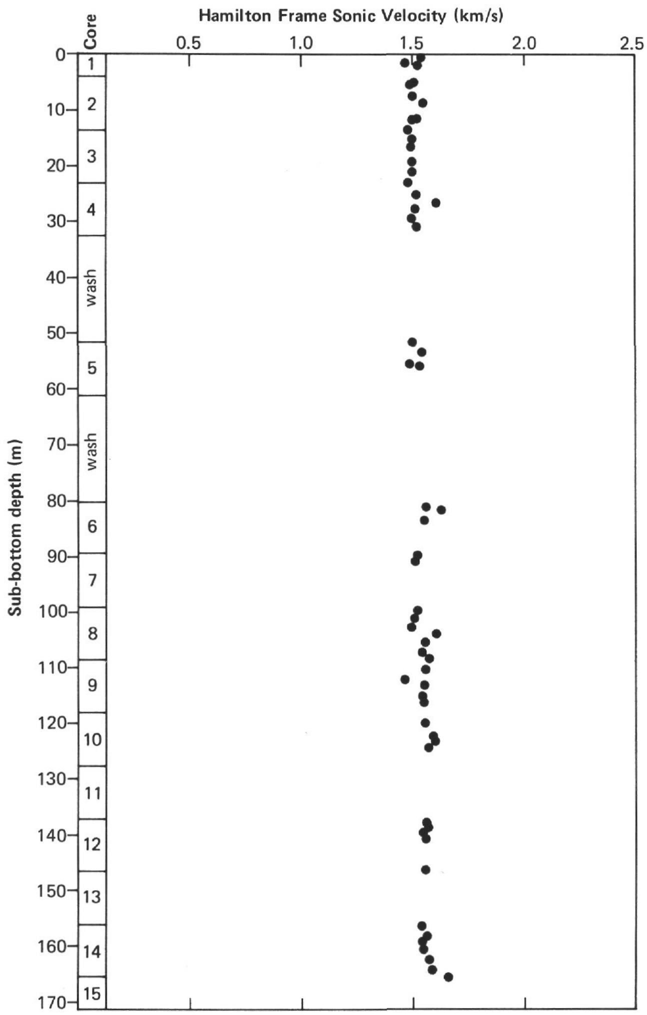

Figure 6. *Sonic velocity versus depth, Hole 412.*

vesicle-enriched zones, rare glass selvages, and phenocryst content suggest that 26 or 27 flows or groups of flows were penetrated.

The top five cores are largely fine- to coarse-grained olivine plagioclase phyric (5-20%) basalt with rare emerald-green clinopyroxene phenocrysts. A few sub-aphyric to sparsely phyric flows also occur in this interval. These lavas are comparable in composition to the basalt recovered at Hole 412. The remainder of the cores are rather uniform fine- to medium-grained, even-textured aphyric to occasionally sparsely phyric basalt with scattered microphenocrysts of plagioclase and/or olivine. Clinopyroxene phenocrysts are absent. Octahedral inclusions of spinel occur in olivine phenocrysts in Cores 8 and 9. Interbedded foraminifer chalk was recovered in Cores 11, 12, and 14; drilling rates suggest that it is more abundant than recovery indicates. A stratigraphic column is presented in Figure 9. The geochemical profiles of Figure 10 show that the basalt of this hole (412A) is similar to that of Hole 412, but those sub-units can be distinguished on the basis of variability of major elements. Both the upper and lowest units are variable in composition, but the middle unit is rather constant.

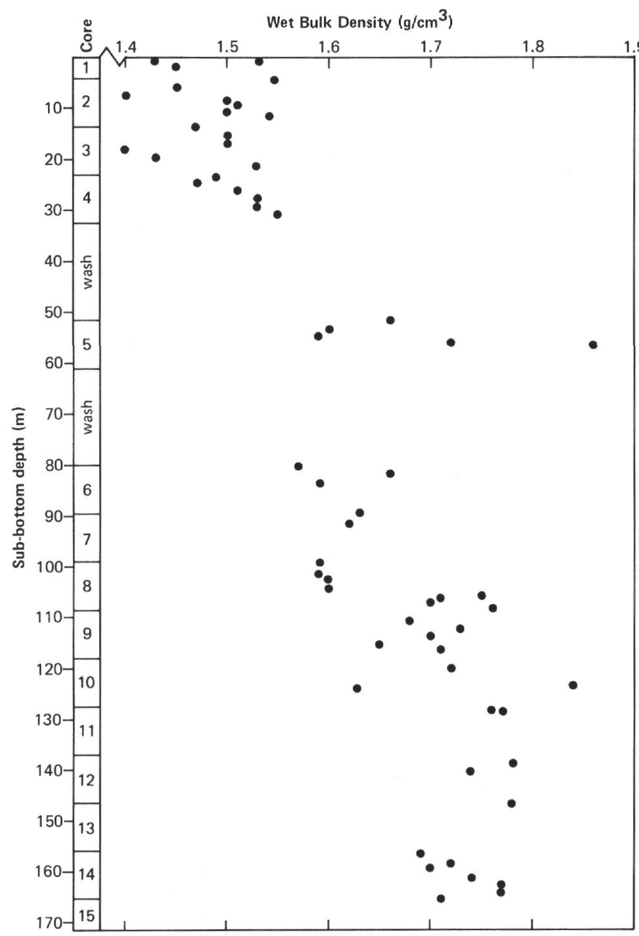

Figure 7. *Wet bulk density versus depth, Hole 412.*

IGNEOUS PETROGRAPHY

Introduction

Basaltic basement was reached at 160 meters at Hole 412 and at 163 meters at Hole 412A. At Hole 412, a large decrease in the drilling rate occurred between 153 and 156 meters, in the lower part of the sedimentary section (bottom of Core 13), and a fragment of aphyric basalt was recovered in the nannofossil ooze, indicating the possible occurrence there of a flow or sill of aphyric basalt interlayered in the sediments.

Basalt was drilled for 15 meters (175 m sub-bottom depth) before the bit failed at Hole 412, and for 131 meters (294 m sub-bottom depth) at Hole 412A.

Similar phyric basalts were recovered in both holes in the first 20 meters of penetration into basement. The succession of units is not exactly the same, however; sparsely phyric lavas are interlayered at different places in the two holes.

At Hole 412A, although phyric lavas dominate in the upper part of the sequence (< 205 m sub-bottom depth) and sparsely phyric to aphyric lavas are found below, the interlayering of the lava types is irregular, with no apparent systematic cycles. We will therefore, describe the rocks as petrographic types, rather than in the stratigraphic order in which they occur. Petrographic types have been

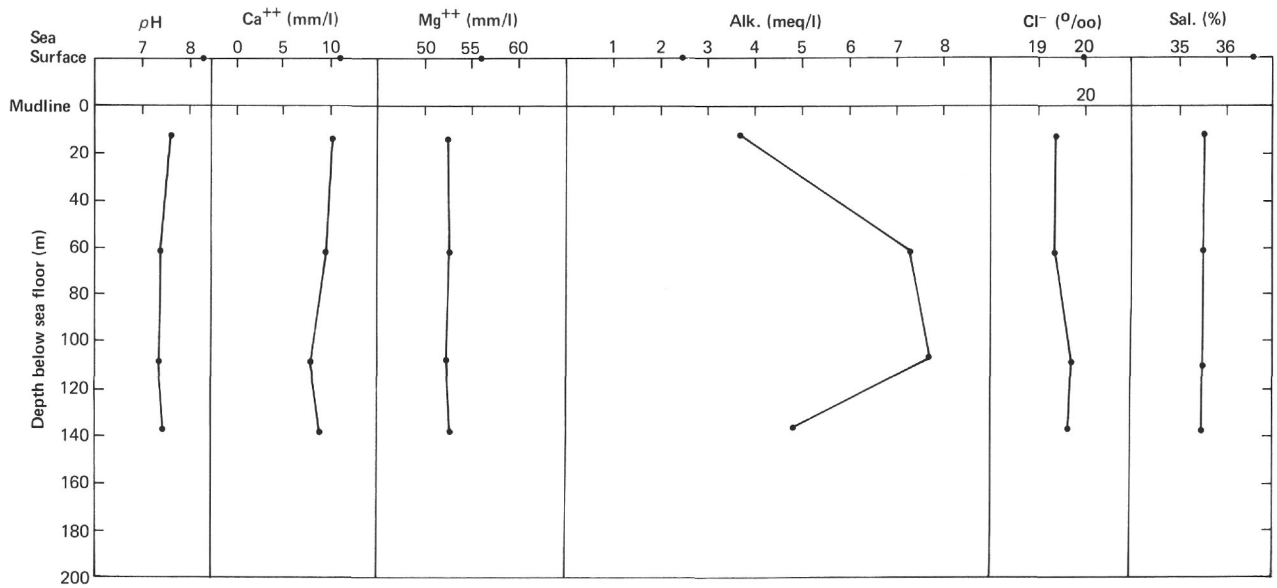

Figure 8. *Interstitial water chemistry, Hole 412.*

distinguished according to the phenocryst assemblages and proportions, and the groundmass composition and texture.

Rock Types: Occurrence and Variations

Six rock types have been distinguished. Plagioclase-clinopyroxene-olivine phyric basalts and plagioclase-olivine sparsely phyric basalts are most abundant. Aphyric basalts, sparsely plagioclase phyric, olivine-plagioclase-clinopyroxene sparsely phyric, and olivine phyric varities are less common. The relative proportions of these petrographic types are given in Table 3.

Basalts which are aphyric or contain only one type of phenocryst form thinner flows (3 m or less) than those bearing polymineral phenocryst assemblages (4 m or more). This may indicate that some phenocrysts partially crystallized in thick, well-insulated flow interiors or that flows with more than one variety of phenocryst were relatively viscous, and could not spread in thin sheets. Both explanations are equally valid, since a continuous decrease in grain size occurs in most of the phyric flows (as in Cores 13 and 14, Hole 412A), and phenocrysts are present in the quenched glassy margins of the phyric flows.

Medium- to coarse-grained rocks occur in both holes. With few exceptions, these rocks are the most phyric varieties. They always form the thickest flow units, 4 to 10 meters thick. Coarse- to medium-grained rocks occur at the following sub-bottom depths: 160 to 167 meters and below 170 meters at Hole 412; 170 to 175 meters, 183 to 187 meters, 205 to 214 meters, 273 to 287 meters, and below 288 meters at Hole 412A.

Aphyric Basalts

A small fragment of aphyric basalt was recovered in the nannofossil ooze in Core 13, Hole 412. Another piece was recovered in the upper part of Core 8, Hole 412A (223 m sub-bottom). Much aphyric basalt was also recovered in Core 13, Hole 412A (273 to 277.5 m sub-bottom). These basalts are fine- to medium-grained and tend to be glassy toward flow margins, as shown by the piece recovered from Hole 412. The groundmass is intergranular (Section 13-1, Piece 3) or sub-ophitic (Section 8-1, Piece 1). Olivine is generally not present, and rare plagioclase microphenocrysts (less than 1%) may occur. These basalts may therefore not differ much from the plagioclase sparsely phyric basalts.

Plagioclase Sparsely Phyric Basalts

These were recovered at 163 meters and again at 177 to 182 meters sub-bottom depth. Plagioclase phenocrysts are rare (around 1%) and relatively sodic (An_{61-54}). Olivine is generally absent or very rare. Two generations of clinopyroxene are present in the groundmass, indicating a possible occurrence of a low-calcium (sub-calcic augite or pigeonite) variety that crystallized late. The nature of these grains could not be determined more exactly by optical methods because of their very small size (Figure 11). Groundmass texture ranges from intergranular to sub-ophitic to variolitic, and the glass (altered) does not exceed 5 per cent.

Olivine Phyric Basalts

Basalts with olivine as the only or dominant phenocryst were recovered in Hole 412A at 206 to 208 meters, 226 to 229 meters, 253 to 255 meters, and 277.5 to 280 meters (Cores 7, 8, 11, and 13, respectively).

Study of Section 7-2, Piece 7, shows that nearly 10 per cent of olivine is present in a coarse-grained basalt with sub-ophitic texture. Large plagioclase (An_{68}) laths occur in the groundmass, together with colorless clinopyroxens, opaques, and 20 per cent pale brown glass.

Section 8-1, Piece 7 and Section 8-2, Piece 4A show that olivine is the only phenocryst present, although less abundant than in Core 7. The rock is otherwise quite similar to Section 7-2, Piece 7.

Section 11-1, Piece 4 shows the association of olivine (around 7%) and plagioclase (1%) phenocrysts of An_{60}

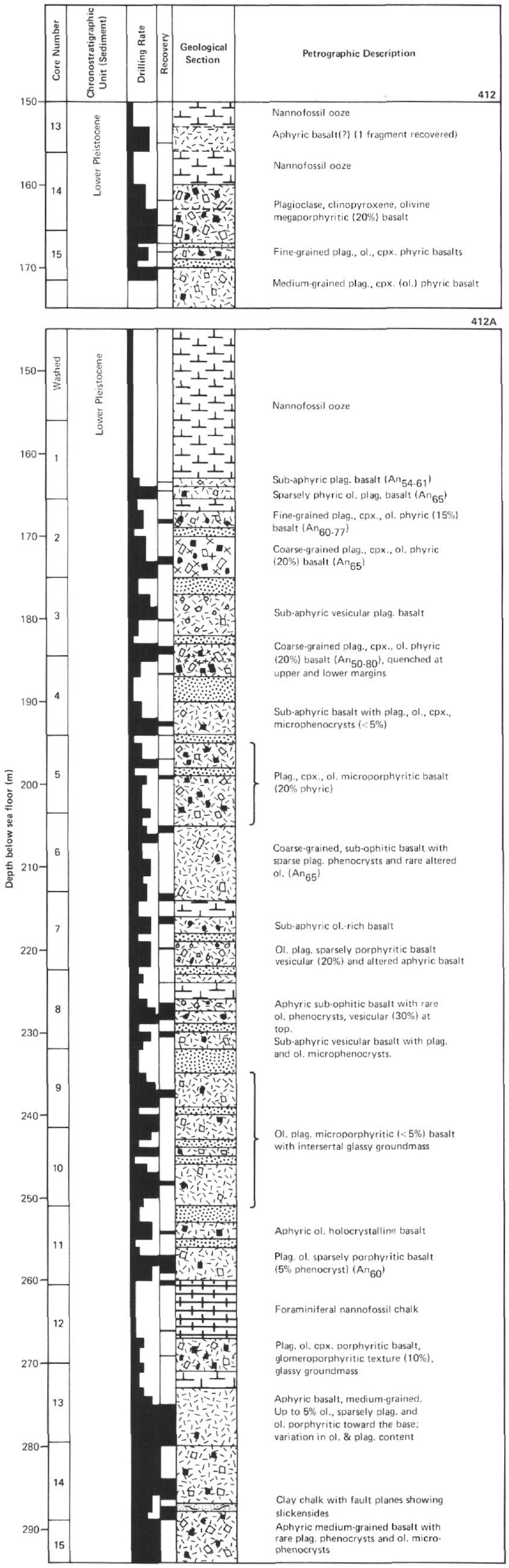

Figure 9. *Drilling rate, core recovery, and stratigraphic section, Holes 412 and 412A.*

composition, in a well-crystallized sub-ophitic groundmass, where olivine is also present.

Section 13-2, Piece 5 displays a similar phenocryst assemblage in an intergranular to variolitic groundmass. Clinopyroxene frequently shows hourglass structures. Groundmass olivine is present.

The rocks of this group may not represent a unique magma type: variations are noticed in the groundmass structure and mineralogy.

Plagioclase-Olivine Sparsely Phyric Basalts

This is the most common rock type at Hole 412A, in both the number of meters drilled and the number of flows traversed. It characterizes the middle and lower parts of Hole 412A, and was also found in one occurrence in the upper part of Hole 412A (168 m depth), but was not found in Hole 412.

Phenocryst content ranges from nearly 0 to 10 per cent, with an average of 3 to 5 per cent. Both olivine and plagioclase are present, and plagioclase is generally more abundant. Plagioclase compositions range from An_{72} to An_{60}, with typical values of An_{65} in most of the flows. Olivine is frequently fresh, but is altered to smectite and rarely replaced by calcite in some flows, especially in the 219 to 245-meter interval. This seems to be related to flow thickness; thinner flows undergo more rapid alteration.

Groundmass texture varies from intersertal to glassy, but tends to become sub-ophitic in more coarse grained varieties. Clinopyroxenes are generally colorless, but two generations of clinopyroxenes are present in some rocks, which may indicate the occurrence of a low-calcium phase.

These rocks, although they contain some olivine phenocrysts (5% to 0.2%), do not bear groundmass olivine as do some of the olivine slightly phyric rocks described above. They should therefore be considered as olivine tholeiites, or even typical tholeiites.

Plagioclase-Clinopyroxene-Olivine Sparsely Phyric Basalt

One flow bearing this three-phase assemblage was recovered in Hole 412 in the 190 to 194-meter interval. Study of Section 4-1, Piece 5, reveals that these three minerals are present as phenocrysts in small amounts (nearly 1% each). The order of appearance of the phases is olivine- plagioclase-clinopyroxene, both as phenocrysts and as groundmass minerals. Olivine and as much as 20 per cent glass are present in the groundmass of intergranular to variolitic varieties.

This is the only flow containing this mineral phenocryst assemblage in such limited amounts. It is interlayered with more phyric (15% to 20%) flows displaying the same mineralogical assemblages.

Plagioclase-Clinopyroxene-Olivine Phyric Basalts

This petrographic type is very common, so we consider it as characteristic of the upper part of Hole 412 (over 205 m sub-bottom depth). It is characterized by large megacrysts of green augite, yellow olivine, and transparent to white plagioclase, up to 1 cm in diameter. The total phenocryst content varies from 15 to 25 per cent.

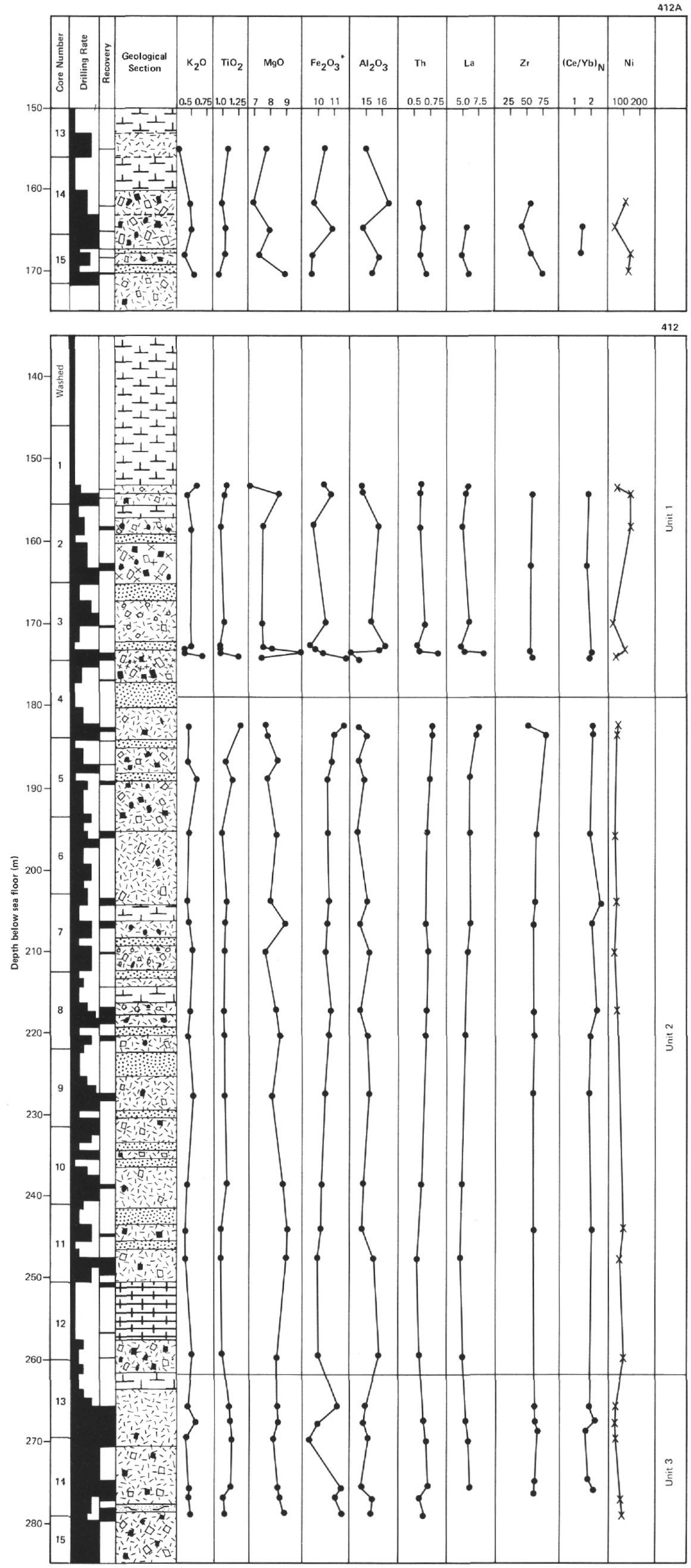

Figure 10. *Geochemical profiles in Cores 13, 14, and 15, Hole 412.*

TABLE 3
Petrographic Types Present at Site 412; Relative Abundance

	Hole 412		Hole 412A		Total Site 412		
	No. flow Units	Total Thickness (m)	No. flow Units	Total Thickness (m)	No. flow Units	Total Thickness (m)	Average Flow Thickness (m)
Aphyric basalts	1 (?)	3.0	2	5.5	3	8.5	3.0
Olivine sparsely phyric basalts	0	0.0	3	7.0	3	7.0	2.3
Plagioclase-olivine sparsely phyric basalt	0	0.0	10	44.0	10	44	4.4
Plagioclase sparsely phyric basalts	0	0.0	2	6.0	2	6.0	3.0
Ol-pl-cpx sparsely phyric basalts	0	0.0	1	4.0	1	4.0	4.0
Pl-cpx-ol porphyritic basalts	3	13.5	6	24.0	9	37.5	4.2

Figure 11. *Two types of clinopyroxene, crystallized in two stages after the plagioclases crystallized; sub-aphyric basalt.*

Plagioclase is generally dominant (10% to 15%) and varies in composition from An_{75} to An_{62}, whereas olivine is least abundant (3% to 8%). Clinopyroxene is quite abundant (5% to 12%) and larger than olivine. Olivine frequently contains spinel inclusions.

The groundmass varies from fine-grained to glassy varieties in the flow margins or thinner flows to coarse-grained in flow interiors. Olivine, plagioclase, and clinopyroxene are also present in the groundmass, and crystallized in this order, together with later opaques and sometimes with residual glass.

One flow belonging to this petrographic type was found between 268 and 272 meters, which is anomalous at first sight, since such rocks are confined to the upper part of the section below the sediment. We should note, however, that this flow occurs below a rather thick (7 m) layer of nannofossil chalk.

Discussion

Basalts of the lower and rather thick sequence of sparsely phyric (containing olivine or plagioclase or both) to aphyric lavas are of tholeiitic affinity, and they probably represent a sequence of basaltic crust produced during the early Pleistocene activity of the FAMOUS rift segment between fracture zones A and B.

Basalts in the upper part of Hole 412A and at Hole 412, as well as some of the underlying olivine or clinopyroxene phyric basalts, cannot be considered as merely evolved products of the magmas producing the associated aphyric and sub-aphyric basalts, since their plagioclase composition

(An_{75} to An_{72} at phenocryst cores) is the most basic found at this site. The occurrence of dark green pyroxenes, of spinel, and of olivine as both phenocrysts and in the groundmass, suggests that these basalts result from the accumulation of up to 30 per cent of earlier crystallized phases. They should be considered as *cumulates*; evidence of *in situ* crystal settling does in fact occur in some of the thickest flow units.

Other occurrences of pyroxene-bearing lava cumulates have been observed elsewhere in the FAMOUS area, as in the upper part of the major western wall (Hekinian et al., 1976) and at Hole 332 (Leg 37), Unit 7 (Aumento, Melson, et al., 1977). The alternation of aphyric and cumulated lavas in a vertical section suggests that the cumulation may have taken place in near-surface magma chambers.

The geochemical measurements show that the basalts from Site 412 are similar to those dredged in the FAMOUS rift segment nearby. The composition of the basalts in the deep Hole 412A is, by comparison with other sites on Leg 49, exceptionally constant.

ALTERATION PETROGRAPHY

At this site as at Site 411, the amount of secondary alteration of the primary igneous mineralogy is small. The only secondary phases common in the rocks are varieties of clay minerals and pyrite. Calcite is apparent as a minor vesicle fill in hand specimen, but not in thin section. The clay minerals rim and fill vesicles, partially or completely replace olivine, replace mesostasis originally composed of glass and fine-grained crystals, and occasionally fill veins or cleavage cracks in crystals. The proportion of the rock made up by these minerals is variable from specimen to specimen. In general, however, the rocks at the top and bottom of the sequence have a smaller proportion of secondary minerals, and those in the middle have a higher proportion of them.

Primary pyrite is present in the rocks as spherical blobs, representing a sulfide liquid phase unmixed from the magma during crystallization. The secondary pyrite occurs as ragged grains, often within the smectite rimming the vesicles, or otherwise closely associated with the clay minerals. Distinction is based both on morphology and association. Secondary pyrite is most common in the rocks more heavily altered by secondary processes.

No carbonate minerals or zeolites are evident in any of the thin sections of rocks from Hole 412. Both groups of minerals were absent from the thin sections of Hole 411, too, the only Leg 49 drill site younger than this one. This suggests that much of the secondary alteration at other sites may be late-stage, and may form over periods of millions of years after formation of the oceanic crust. As such it could be considered an extension of submarine weathering. But, development of low-temperature secondary minerals is also controlled by the composition and nature of the solid phases in the rock, as Walker (1960) showed in Iceland. It may be that the rocks of the FAMOUS area inhibit crystallization of carbonates and zeolites.

BASEMENT PALEOMAGNETISM

Hole 412A

Twenty-seven basalt specimens were taken from Cores 1 through 14, cored from 130 meters of basaltic crust about 1.6 m.y. old at 36.5°N. Section 11-3, Piece 4A (254 m) is from a 20-cm section of chalk interbedded with basalt. The NRM intensities of the basalts vary unsystematically through the section from 0.7×10^{-3} emu cm^{-3} to 8.5×10^{-3} emu cm^{-3}, averaging 3.7×10^{-3} emu cm^{-3} (Figure 12). The chalk specimen had NRM intensity of 0.016×10^{-3} emu cm^{-3}.

Twenty-four of the basalts had reversed NRM inclinations; four were very shallow (< 10°). The specimen from Core 1, Section 1 (uppermost specimen), 156 meters, was normal (~ +60°) on inital measurement, as was that from Section 13-3 (274 m), a specimen very altered in appearance, which was steep and normal (~ +80°), and that from Section 14-2 (282 m), which was shallow and normal (~ +3°). However, AF demagnetization caused both specimens 13-3 and 14-2 to change to reversed inclination and steepen to a stable end-point around 50°. Specimen 1-1, nevertheless, remained very constant in inclination and was concluded to have original magnetization. The specimens with reversed NRM inclination steepened on AF demagnetization; this was particularly noticeable in the initially very shallow cases. Figures 13 and 14 illustrate the response of specimens to AF demagnetization, and stable inclinations are plotted in Figure 12.

Two extreme types of magnetic behavior can be distinguished, with several specimens intermediate between them. Seven specimens (2-2, 3-1, 3-2, 8-2, 13-3, 14-2, 14-5, depths as in Table 4 and Figure 12) were highly viscous, and sometimes acquired magnetization in the short time required to move between the AF unit and the spinner magnetometer. Decay of magnetization upon repeated measurement of the same component was proportional to the time of exposure to the laboratory field. The viscous specimens showed very low resistance to alternating fields, some losing 40 to 50 per cent of their initial intensity after 25 Oe, and exhibited considerable directional change on AF demagnetization. Their NRM intensities were less than 2×10^{-3} emu cm^{-3}. In contrast, eight specimens (1-1, 2-1, 7-1, 7-2, 9-1, 11-3, 13-2, 14-4) had NRM intensities above 3×10^{-3} emu cm^{-3}, high directional stability, and greater resistance to alternating fields. The two types seem to alternate down the hole, but the longest sequence of viscous specimens is from Sections 2-2 (167 m) to 3-2 (177 m), and the longest sequence of stable, high-intensity ones is from Sections 11-3 (255 m) to 13-2 (272 m). Several specimens are intermediate in intensity and also in stability of direction. A better correlation seems to be with mineral grain size rather than depth. Over half the low-stability specimens have large phenocrysts; none of the high stability ones do. Furthermore, half the high stability specimens are vesicular, and none of the low stability ones are.

The stable inclinations from this site are grouped around a unit-weight arithmetic mean value of −53°, $\sigma = 7.28°$ (σ = unbiased estimate of the standard deviation; $n = 21$, see Table 4 and Figures 12, 15). This is only slightly shallower than the axial dipole field inclination of 56.4° at this site. The result is similar to that of the top unit of nearby Hole 411, half a million years younger, with a stable inclination of 50° and also slightly shallower than the axial dipole field. The sign of the inclinations is quite consistent with the

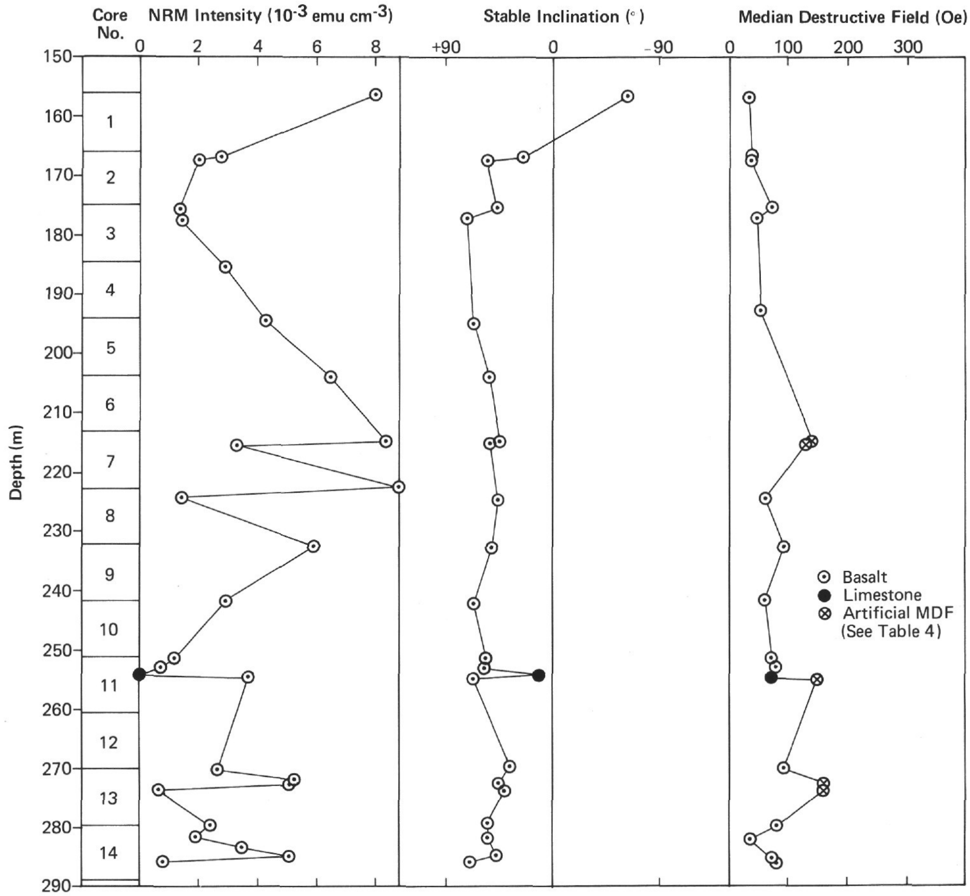

Figure 12. *Downhole plot of paleomagnetism data, Hole 412A.*

location of this site on the younger side of the fracture zone and therefore in the Matuyama reversed epoch.

The single specimen taken from the interbedded chalk of Core 11, Section 3, has NRM intensity 0.017×10^{-3} emu cm^{-3}, which is higher than has been found for the nannofossil oozes of our previous sites. Its inclination was reversed, consistent with the basalts above and below it, although, at −36° (NRM), shallower than the average for the basalts. Upon AF demagnetization, the inclination became even more shallow, reaching −30° by 100 Oe. The chalk specimen's stability to AF demagnetization was intermediate between that of the low- and high-stability basalts. Bedding in the chalk indicated that the beds from which the specimen was taken had been tilted 25° to the horizontal. The relative inclination azimuth is east, which gives a dip direction of southeast. Correction of the magnetic direction for this dip caused the inclination to become very shallow, −10°; the meaning of this tilt is therefore unclear: either the magnetization was originally shallow or secondary CRM has taken place. Two other specimens were taken from other tilted chalk units (Core 14, Section 4).

Thermal demagnetization of five specimens, shown in Figure 16, revealed at least three blocking temperatures, one at 310°C to 330°C, a second at 420°C to 440°C and a third at 570°C to 590°C. The lowest blocking temperatures are exhibited by two specimens from high in the hole (Sections 2-2 and 3-1, depths 167 m and 176 m), both of which have near neighbors with low AF stability, low NRM intensity, and large phenocrysts. On this leg, 310°C to 330°C are the lowest blocking temperatures observed so far.

There appears to be a tendency for the blocking temperature to increase with depth in the hole; e.g., a sample in Section 8-1, depth 224 meters, shows blocking temperatures of 400°C to 450°C, and Section 13-2, 272 meters, has blocking temperatures as high as 570°C to 600°C. The number of heated specimens is, however, too small for firm deductions to be made, particularly in the lower portion of the hole. Shore-based studies will examine whether the blocking temperature really does vary systematically with depth, and how it correlates with degree of oxidation and titanium content of the opaque iron oxide minerals. In previous studies, it has usually been assumed that blocking temperature is wholly dependent on the degree of low-temperature oxidation or cation deficiency alone, with constant titanium content throughout one episode of magmatic activity. If this turns out to be so here, we must then ask: What is the major factor controlling the degree of oxidation? Would it have been simply grain size, or permeability to hydrothermal solutions?

In conclusion, we emphasize that the low stability to AF demagnetization of certain specimens both in the top and bottom of this core (Cores 1 and 2, 13 in part, and 14) is the lowest we have encountered anywhere on this leg. The

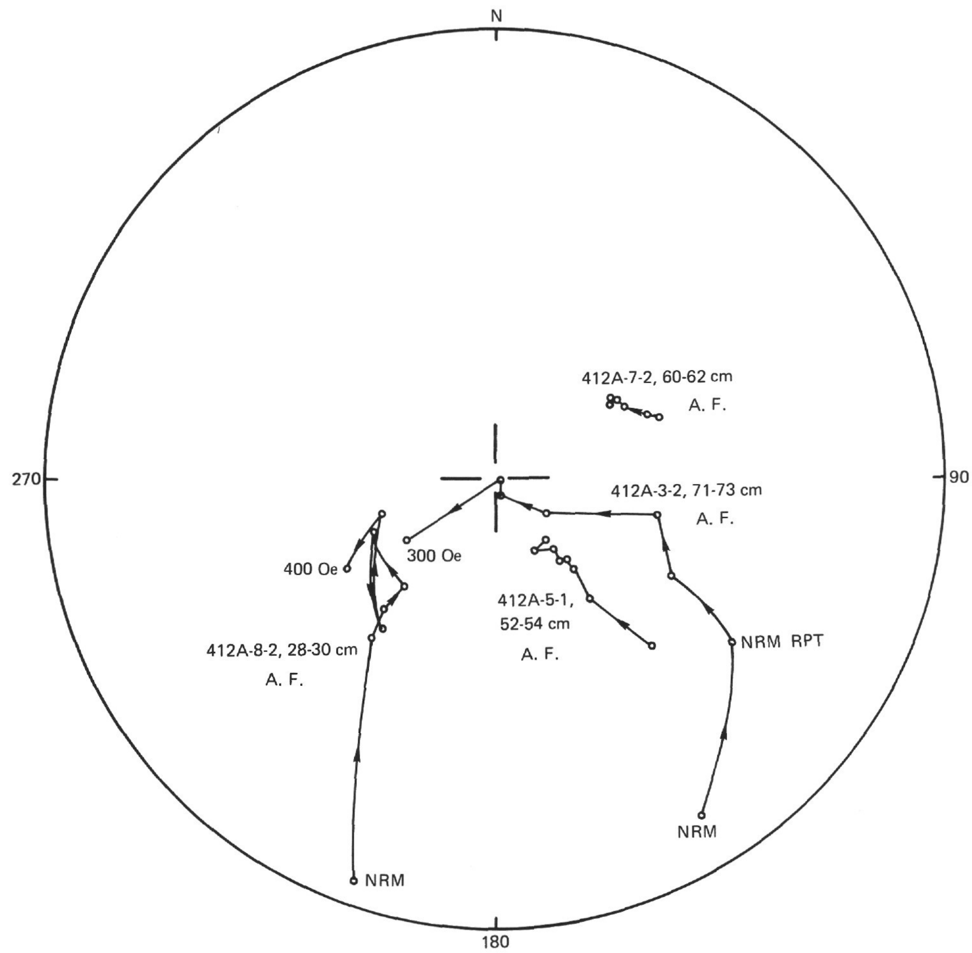

Figure 13. *Directional changes upon AF demagnetization, Hole 412A.*

viscosity in laboratory fields has also not been observed at any of our previous sites. Also, the large phenocrysts are unique to this site of this leg, although some were reported at Site 332 (Leg 37). The petrology suggests that these specimens bearing large phenocrysts are from the interior of flows. The correlation between large phenocrysts, low magnetic stability, and low NRM intensity suggests that these specimens probably have a large complement of multi-domain magnetic minerals, in addition to the single- or pseudo- single-domain remanence-carrying grains. The directions of these specimens after AF demagnetization are not generally different, however, from those of the high-stability specimens.

PHYSICAL PROPERTIES OF BASEMENT ROCKS

Hamilton Frame sonic velocity and wet bulk density by both weight and gamma ray attenuation are plotted against depth in Figures 17, 18, and 19.

Although the scatter is quite large, the sonic velocities have a mean of about 5.5, similar to that of basement rocks at Hole 411 and higher than those of the previous holes. Samples were taken over a sufficient range of depths to suggest a slight negative gradient of both velocity and density with increasing depth in the uppermost 100 meters of basement.

CORRELATION OF SEISMIC REFLECTION PROFILE WITH DRILLING RESULTS

The reflection profile approaching Site 412 showed steadily increasing thickness of sediment into Fracture Zone B (Figure 3). Some of the section is draped almost conformably on the north wall. Near the beacon drop point, the section thickness varies from 130 to 180 ms (DT). A small basement high which peaks at about 80 ms is also evident. The projected location of the site was determined by allowing for the distance between the crane that drops the beacon and the reflection point for the hydrophone array. At a speed of 5 knots this amounts to 2 minutes reflection record. The site was offset 1000 feet from this point, and the sediment thickness here is 180 ms (DT) beneath a side echo. Assuming a gradient of 1.0 s^{-1} and a bottom water sound velocity of 1500 m/s, basement would be at 141 meters. Comparing this with drilled depths of 160 meters at Hole 412 and 163 meters at Hole 412A gives a 16 per cent error. A sub-bottom reflector is seen at 25 ms (DT); it may be the bubble pulse or a side echo, since the appropriate interval was cored and no lithologic or drilling-rate contrast was encountered. The reflection record leaving the site (Figure 3) shows this reflector to be much better developed and more difficult to explain as an artifact. It may be a

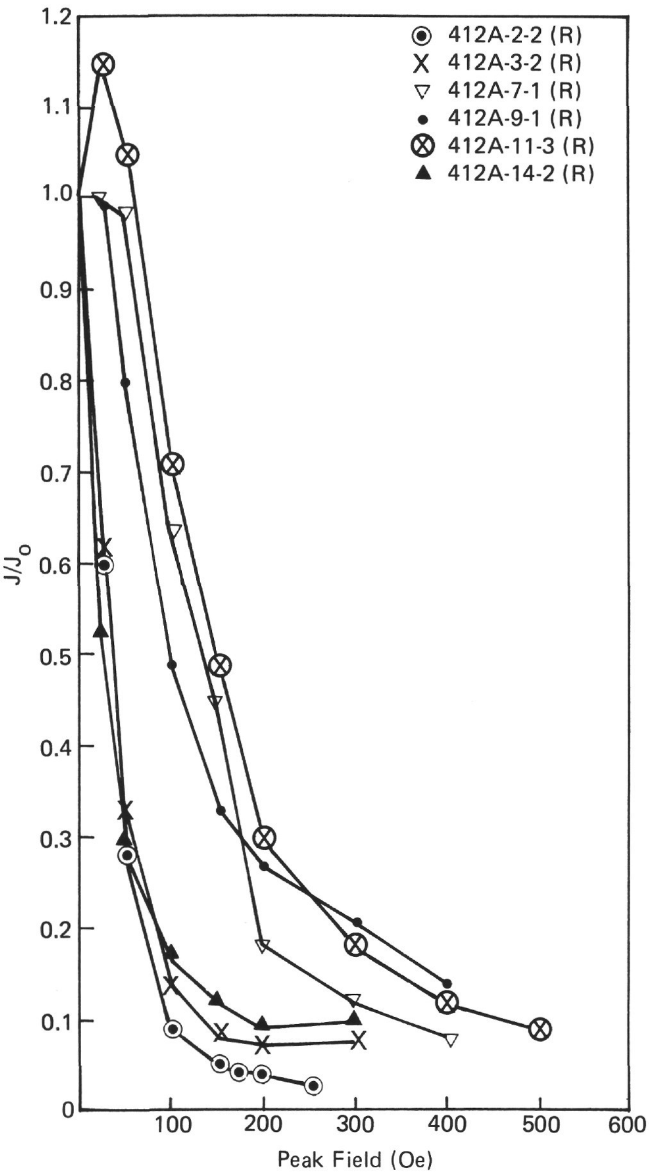

Figure 14. *AF demagnetization, Hole 412A.*

consolidation change at a depth shallower than 25 meters, but our upper cores at Hole 412 were too deformed to support this interpretation.

SUMMARY AND CONCLUSIONS

Our primary objective at Site 412 was to explore the crustal structure of a fracture zone. To date, such sites have generally been avoided because of presumptions about geologic complexities in these settings. The holes we drilled were to be a first investigation of these complexities and structure. Two holes were drilled on the floor of fracture zone B, FAMOUS area, in 2600 meters of water. Total penetration was 294 meters, with 131 meters into basalt (412A). We positioned the site near the north wall of the valley so as to be nearest to the younger side. Anomaly 2 (about 1.6 m.y.) projects into the fracture zone just east of our site.

About 160 meters of calcareous sediment was penetrated. This is mainly nannofossil ooze, with occasional foraminifers that are more abundant above 80 meters sub-bottom. The non-carbonate material is primarily silica: diatoms, radiolarians, sponge spicules, and silico-flagellates. Coarser graded material near 80 meters suggests turbidites. Pyritized burrows in the upper half of the section indicate reducing conditions. Near the base of the section, the sediments are more yellowish, which may result from the presence of limonite. Orange lumps may mark the former position of pyrite nodules. Thus, the lower sediments have been oxidized.

The entire section is no older than lower Pleistocene (NN19), which shows that the crust in the fracture zone is the same age as that in the rift mountains to the north. Limestone and nannofossil ooze within the basalt section also proved to be lower Pleistocene. Abundant reworked discoasters were found near 250 meters sub-bottom.

An internal reflector at 25 ms (DT) within the section could not be correlated with drilling results. This may indicate a consolidation or water-content change at the base of turbidites, but the cores were too disturbed to evaluate this.

Hole 412A penetrated 131 meters of basement, compared with 11.5 meters at Hole 412. No offsets were made between holes. The basalts at Hole 412 generally compare with those recovered at Hole 412A. At Hole 412A, 26 or 27 flows were penetrated, according to drilling logs and the occurrences of vesicular and glassy zones. Some flows were thick enough to be rather coarsely crystalline, and are even suspected of having cumulate structures. The upper fifty meters or so is somewhat different from the lower basalts — more consistently phyric. Phenocrysts of olivine, plagioclase, and emerald-green clinopyroxene are notable. Six different rock types can be characterized through the section by the abundance and type of phenocrysts. Rocks very similar to these have been dredged from the western wall of the FAMOUS rift, and were recovered from Hole 332, Leg 37 (Aumento, Melson, et al., 1977). The entire lava pile is again, as with Hole 411, relatively free of alteration products. Calcite and zeolite vein materials are rare, and they are not present in thin section.

Finely bedded limestone was recovered from within the basalt section. Dips are uniformly around 25° to 30°. Slickenside sets on the limestone show evidence of normal, reverse, and strike-slip faulting. The fault planes generally parallel the strike of the bedding. Stepped ridges identified on the strike-slip face indicate right-lateral faulting. If this fault plane has the same strike as the transform fault, then the sense of faulting is opposite to that expected. These may be conjugate shears.

The magnetization of the basalt section is reversed and at a high inclination near the expected dipole value. Intensities are similar to those at Hole 411: 10^{-2} to 10^{-3} emu cm^{-3}. Some specimens exhibited highly viscous behavior. This low stability, and comparatively low NRM intensity, seem correlated with the predominance of large phenocrysts in the rock. These basalts evidently have a large fraction of multi-domain grains. It is possible, but not yet certain, that some of the basalt section may have been tilted along with

TABLE 4
Paleomagnetism Data

Sample (Interval in cm)	Depth in Hole (m)	NRM Intensity (10^{-3} emu cm^{-3})	Initial Inclination (°)	Stable Inclination (°)	MDF (Oe)	Comments
412A-1-1, 29-30	156.3	7.99[a]	+62.7	++62.4	30	
412A-2-1, 118-119	166.8	2.80[a]	-18.4	-23.9	35	
412A-2-2, 35-37	167.4	1.99	-5.2	-55.2	35	
412A-3-1, 73-75	175.7	1.26	-10.3	-46.4	65	
412A-3-2, 71-73	177.2	1.47	-5.9	-73.4	45	
412A-4-1, 26-29	184.8	2.90		(not demagnetized)		
412A-5-1, 52-54	194.5	4.35	-35.6	-67.0	50	
412A-6-1, 48-50	204.0	6.46	-38.0	-51.8	(Leeds Thermal/demag)	
412A-7-1, 159-160	214.6	8.42	-41.1	-45.4	135[c]	
412A-7-2, 60-62	215.1	3.28	-46.9	-54.5	125[c]	
412A-8-1, 106-108	222.5	8.79		(not demagnetized)		
412A-8-2, 28-30	224.3	1.39	-2.1	-47.4	60	
412A-9-1, 48-50	232.5	5.88	-43.6	-51.7	95	
412A-10-1, 39-41	241.9	2.87	-53.3	-67.1	60	(Leeds)[d]
412A-11-1, 54-56	251.6	1.21	-49.5	-56.1	70	
412A-11-2, 31-33	252.8	0.73	-56.9	-58.4	80	(Leeds)
412A-11-3, 37-39	254.4	0.02	-35.9	-30.3[b]	75	Limestone
412A-11-3, 69-71	254.7	3.72	-67.5	-66.4	150[c]	
412A-13-1, 28-30	270.3	2.73	-16.6	-35.1	95	
412A-13-2, 52-54	272.0	5.34		(not demagnetized)		
412A-13-2, 79-81	272.3	5.06	-33.3	-45.1	130[c]	Badly altered
412A-13-3, 89-91	273.9	0.67		-42.2	130[c]	(Leeds)
412A-14-1, 12-14	279.6	2.36	-38.4	-53.0	80	
412A-14-2, 99-101	282.0	1.95	+3.9	-53.9	30	
412A-14-3, 80-82	283.3	3.47		(not demagnetized)		
412A-14-4, 105-108	285.1	5.08	-37.3	-47.6	70	
412A-14-5, 30-32	285.8	0.79	-1.3	-70.5	75	

[a]Intensity extrapolated from 1 cm × 1 cm core volume to 2.4 × 2.5 cm core volume.
[b]Limestone corrected for tilt has inclination of −10°.
[c]Not true MDF. Higher value arises from superposition of reversed and normal components and concomitant intensity rise in low fields.
[d](Leeds) = measurements made at Leeds University, not on shipboard.

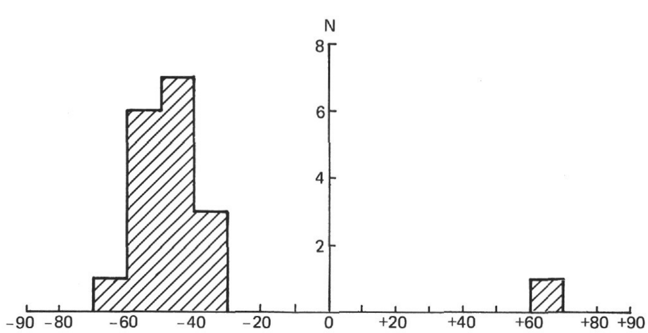

Figure 15. *Histogram of stable inclinations at Hole 412A.*

the interlayered limestones. Without knowing the relative magnetic and dip directions it is not possible to correct for this, but a maximum range of 24° to 74° can be estimated for the untilted inclinations. Relative directions were measured on a piece of bedded limestone which indicated a dip correlation of about 20 degrees toward shallower values.

On the whole, drilling at this site accomplished a very successful penetration into igneous basement. Perhaps the

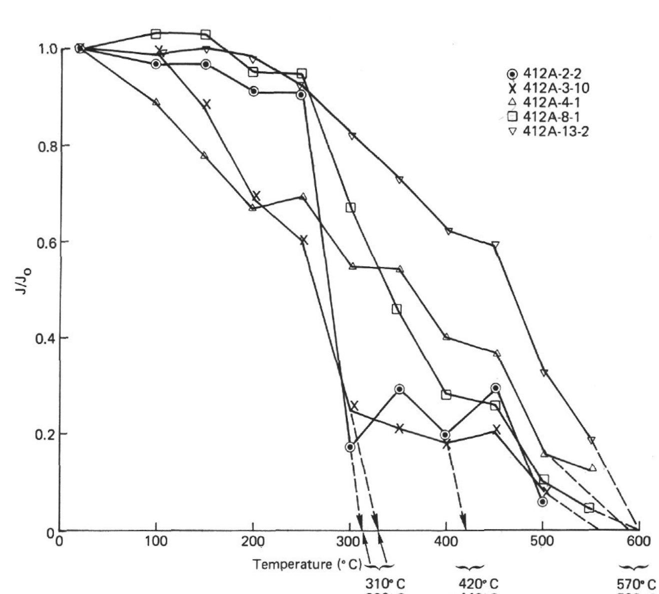

Figure 16. *Thermal demagnetization, Hole 412A.*

most striking general observation to be made is the geologic simplicity of this fracture zone site. Contrary to the view of a fracture-zone valley as a complex shear zone of variously altered crustal rocks and intruded ultrabasics, the picture here shows fresh basalts, little altered and of the same age as the adjacent rift mountains. This geologically straightforward setting also holds for fracture zone A immediately north of here. In this area, deep-tow and submersible operations showed the valley to be undisturbed except at its edges (Detrick et al., 1973; ARCYANA, 1975). Exotic rock types were not generally found, except for isolated hydrothermal deposits. The plate boundary was found to be precisely through the middle of the fracture zone. With this suite of observations it would be reasonable to plan future drilling in fracture zones and transforms to learn more about young crust and the geology of these plate boundaries.

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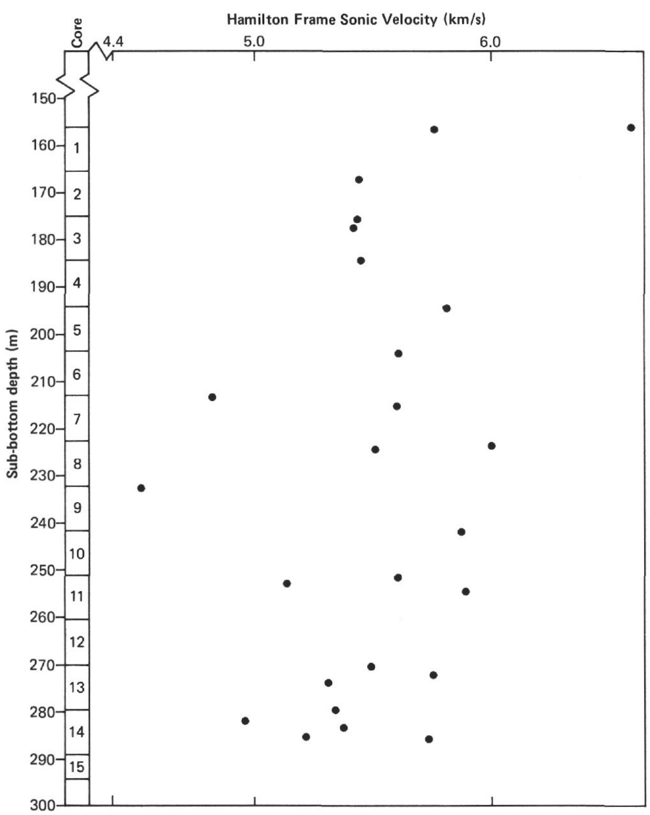


Figure 17. *Sonic velocity versus depth, Hole 412A.*

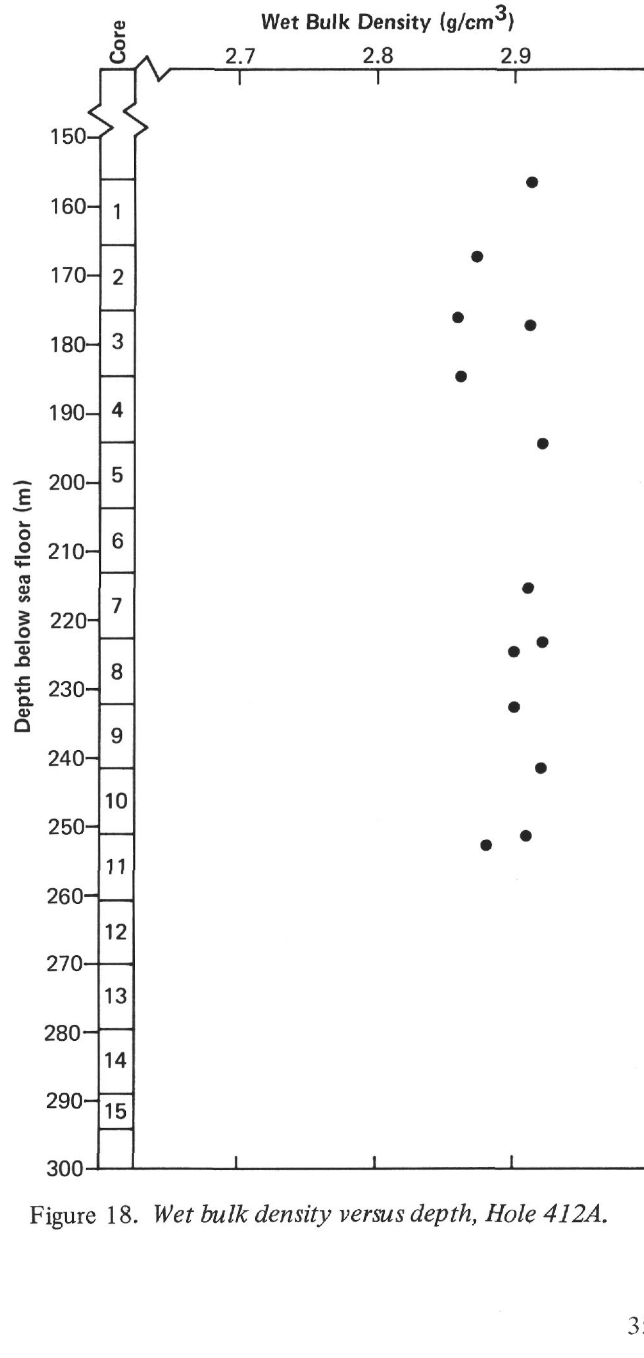


Figure 18. *Wet bulk density versus depth, Hole 412A.*

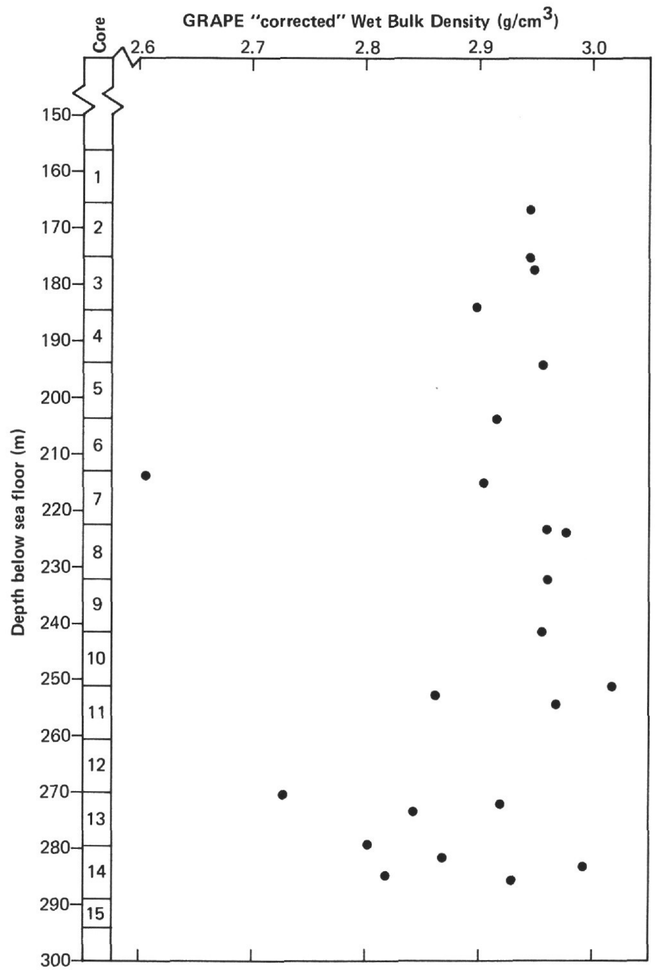


Figure 19. *GRAPE "corrected" wet bulk density versus depth, Hole 412A.*

SITE 412 **HOLE** **CORE** 1 **CORED INTERVAL:** 0.0-4.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
PLEISTOCENE	N23 NN19	Ag	Ag		1, 2, 3, CC	0.5, 1.0	VOID			

LITHOLOGIC DESCRIPTION

moderate yellowish brown (10YR 5/4)

5GY 6/1, wisps of 5Y 2/1,

5GY 5/2

5GY 6/1

interlayered 5GY 6/1, 5Y 6/1, 5Y 5/2, with wisps of 5Y 2/1

5GY 6/1

SILICEOUS FORAMINIFERAL-NANNOFOSSIL OOZE

Yellowish brown ooze at top, then mostly olive gray foraminiferal nannofossil ooze, some interlayers of abundant biogenic silica including small (silt-size) spines without central tube.

Smear Slides

	1-25	1-101	1-106	2-15	2-52	2-148
nannos	26	21	60	71	63	64
forams	25	20	5	5	10	10
carb. unsp.	10	5	10	10	10	10
diatoms	--	5	3	3	2	5
rads	--	5	15	5	3	3
sp. spic.	2	5	2	2	2	2
volc. glass	5	5	3	2	5	5
palagonite	10	2	Tr	--	--	Tr
silicoflag.	--	10	2	2	3	--
siliceous spines	--	20	2	--	--	2
fspr.	2	1	--	--	--	--
H. min.	Tr	1	--	--	--	--
clay	20	--	--	--	--	--
micronod.	--	--	--	Tr	2	1

Carbonate Bomb

1-47	76%
1-102	81%
1-144	71%
2-53	72%

Explanatory notes in Chapter 1

SITE 412 **HOLE** **CORE** 2 **CORED INTERVAL:** 4.0-13.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
PLEISTOCENE	N23 NN19	Ag	Ag		1, 2, 3, 4, 5, 6, CC	0.5, 1.0	VOID			36, 18, 95, 10, 30, 114

LITHOLOGIC DESCRIPTION

interlayers (<1 to 10 cm thick) of light olive gray (5Y 6/1), greenish gray (5GY 6/1), light gray (N7) with soft lumps of grayish green (10GY 5/2) and wisps of olive black (5Y 2/1)

SILICEOUS FORAMINIFERA-RICH NANNOFOSSIL OOZE

Interlayered light olive gray, greenish gray glauconitic laminae, and light gray with some wisps of manganese rich ooze. Siliceous hair-like spines (<63 μm) common along with silicoflagellates and *sponge spicules. Few glauconitic* laminations preserved. Pteropod found in Section 1 at 70 cm.

Smear Slides (Major lithology)

	1-36	2-18	3-95	5-30
nannos	59	55	39	70
forams	10	5	10	5
carb. unsp.	15	15	5	10
diatoms	2	5	5	--
rads	--	--	2	--
sp. spic.	2	5	5	4
silicoflag.	1	--	10	1
siliceous spines	--	13	15	5
volc. glass	10	2	5	5
palagonite	Tr	--	1	--
fspr.	--	--	2	--
H. min.	--	--	1	--
glauconite	--	--	--	--

Smear Slides (Minor lithology)

	4-10	5-114
nannos	52	71
forams	20	15
carb. unsp.	10	2
diatoms	1	--
rads	--	--
sp. spic.	3	1
silicoflag.	Tr	2
siliceous spines	--	2
volc. glass	2	3
palagonite	--	1
fspr.	--	2
H. min.	--	1
glauconite	12	--

Carbonate Bomb

1-53	72%
2-53	78%
4-53	84%
5-53	83%
6-53	83%
6-63	66%

SITE 412 HOLE CORE 3 CORED INTERVAL: 13.5-23.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
PLEISTOCENE	N22/N23 NN20	Ag	Ag		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0	VOID			86, 40, 133, 23

CC=20 cm

interlayered light gray (N7), gray (5G 6/1), greenish gray (5G 6/1), and very dusky purple (5P 2/2), with pale olive (10Y 6/2)

LITHOLOGIC DESCRIPTION

FORAMINIFERAL NANNOFOSSIL OOZE

Owing to highly deformed nature of cores, what were probably laminations of different colors now are a complex mixture. Predominantly nannofossils with varying amounts of forams. Manganese micronodules locally abundant. Siliceous spines too small to be classified as sponge spicules common.

Smear Slides

	1-86	3-40	4-133	5-23
nannos	72	30	59	46
forams	10	2	10	10
carb. unsp.	10	2	5	3
diatoms	1	--	--	--
rads	--	2	--	1
sp. spic.	3	5	1	1
silicoflag.	1	10	--	2
siliceous spines	--	2	2	2
volc. glass	2	Tr	5	2
palagonite	1	1	5	1
fspr.	--	--	2	2
H. min.	--	--	1	--
micronod.	--	--	10	30

Carbonate Bomb

1-53	90%
2-53	83%
3-53	84%
4-33	71%
5-63	82%
6-53	82%

Explanatory notes in Chapter 1

SITE 412 HOLE CORE 4 CORED INTERVAL: 23.0-32.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
PLEISTOCENE	N22/N23 NN20	Ag	Ag		1, 2, 3, 4, 5, 6, CC	0.5, 1.0	F		P	42, 94, 57, 130, 67

complex intermixture of light gray (N7), olive gray (5Y 5/2), light olive gray (5Y 6/1), grayish yellow green (5GY 7/2), greenish gray (5GY 7/2) with small spots of very dusky purple (5P 2/2), minor mixture of pale yellowish green (10GY 7/2)

LITHOLOGIC DESCRIPTION

FORAMINIFERA-RICH NANNOFOSSIL OOZE

Mostly light gray to olive gray with mixture of several other colors, highly deformed in most sections, one foraminiferal sand layer in Section 3, pyrite burrow Section 5 (110 cm).

Smear Slides

	1-42	1-94	3-57	5-130	6-67
nannos	79	82	36	71	54
forams	5	3	30	7	30
carb. unsp.	10	10	5	10	3
diatoms	--	--	--	2	--
rads	--	--	1	--	1
sp. spic.	3	1	2	5	2
silicoflag.	Tr	1	1	1	1
siliceous spines	--	--	2	--	5
volc. glass	2	2	2	2	2
palagonite	Tr	Tr	Tr	Tr	--
fspr.	--	--	1	1	2
H. min.	--	--	--	--	Tr
micronod.	--	1		1	--

Carbonate Bomb

1-53	67%
2-53	83%
3-53	89%
4-53	73%
5-53	87%
6-53	87%

SITE 412 HOLE CORE 5 CORED INTERVAL: 51.5-61.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS	LITHOLOGIC DESCRIPTION
PLEISTOCENE	N22/N23 NN20	Ag	Ag		1, 2, 3, 4, CC	0.5, 1.0	N8; 5Y 6/1; olive gray (5Y 6/1); VOID; greenish gray (5G 6/1) and olive gray (5Y 6/1); N8; N8 and light greenish gray (5GY 8/1)

Lithologic samples: 118, 133

FORAMINIFERAL NANNOFOSSIL OOZE
Mostly olive gray ooze with several pyrite-filled burrows, few interlayers of white nanno ooze.

Smear Slides

	1-118	3-133
nannos	65	79
forams	20	5
carb. unsp.	5	10
diatoms	1	--
sp. spic.	3	3
silicoflag.	Tr	1
volc. glass	5	2
palagonite	Tr	Tr
micronod.	1	--

Carbonate Bomb

1-53	87%
2-53	86%
3-53	84%
4-53	96%

Explanatory notes in Chapter 1

SITE 412 HOLE CORE 6 CORED INTERVAL: 80.0-89.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS	LITHOLOGIC DESCRIPTION
PLEISTOCENE	N22/N23 NN19	Ag	Ag		1, 2, 3, CC	0.5, 1.0	N8 and 5Y 6/1; 5GY 6/1; 5Y 6/1; 5GY 6/1; 5Y 6/1; 5GY 6/1; 5Y 6/1; 5GY 6/1; 5GY 7/2 + 5GY 8/1; interlayers of 5Y 6/1, 5GY 6/1, N8; 5Y 6/1; mottled 5Y 6/1, 5Y 5/2, 5Y 2/1; 5Y 6/1; 5GY 6/1; N7; 5GY 6/1 and N7

FORAMINIFERAL NANNOFOSSIL OOZE
Mostly gray turbiditic ooze with coarse unit of turbidite sequence, white with up to 70 percent foraminifera of sand-size. Pumice(?) fragment at 2 (110). Some areas with abundant fine silt-size spines of silica.

Smear Slides

	1-53	2-2	2-38	3-88	3-140
forams	70	15	12	7	20
nannos	16	68	58	70	59
carb. unsp.	10	10	7	15	5
diatoms	--	--	3	--	1
rads	--	--	2	--	--
sp. spic.	1	3	5	2	2
siliceous spines	--	--	10	--	5
volc. glass	2	3	--	5	5
palagonite	Tr	1	1	1	Tr
micronod.	1	--	--	--	--
fspr.	--	--	--	--	1
H. min.	--	--	--	--	--
silicoflag.			2	--	2

Carbonate Bomb

1-53	94%
2-53	87%
3-53	78%
4-33	92%

SITE 412 HOLE CORE 7 CORED INTERVAL: 89.5-99.0 m

TIME-ROCK UNIT: PLEISTOCENE
BIOSTRAT ZONE: N22 NN19
FOSSIL CHARACTER: FORAMS Ag; NANNOS Ag; RADS
SECTION: 1, 2, CC
METERS: 0.5, 1.0
GRAPHIC LITHOLOGY: VOID
LITHOLOGIC SAMPLE: 47, 110

LITHOLOGIC DESCRIPTION

mixture of very light gray (N8) and light gray (5Y 6/1)

slightly sandy, light gray (N7)

NANNOFOSSIL OOZE
Soft, light gray, with one pyrite nodule at 1-115 cm.

Smear Slides

	1-47	2-110
clay	2	5
forams	1	8
nannos	97	82
diatoms	Tr	2
rads		Tr
sp. spic.		2
silicoflag.		Tr
unsp. carb.		1

Carbonate Bomb

1-53	97%
2-53	94%

Explanatory notes in Chapter 1

SITE 412 HOLE CORE 8 CORED INTERVAL: 99.0-108.5 m

TIME-ROCK UNIT: PLEISTOCENE
BIOSTRAT ZONE: N22 NN19
FOSSIL CHARACTER: FORAMS Ag; NANNOS Ag; RADS
SECTION: 1, 2, 3, 4, 5, 6, 7, CC
METERS: 0.5, 1.0
GRAPHIC LITHOLOGY: VOID
LITHOLOGIC SAMPLE: 70, 70, 55, 90, 106, 94

LITHOLOGIC DESCRIPTION

light gray (N7) with dark gray (N3) mottling
5Y 4/2
5Y 7/2
greenish gray (5GY 6/1)
light gray (N7) mottled with 5Y 7/2 (1, 85-150 cm) and 5GY 6/1 (throughout)
5GY 6/1
gray (N6)
N7 mottled with white (N9)
N7 mottled with greenish gray (5G 6/1)
very light gray (N8) with 5G 6/1; N3 mottles
N7 mottled as above
white (N9) & 5Y 7/2
5G 6/1 laminae & N7 ∿.50 cm each
white (N8) & 5G 6/1 laminae
N7
N8
5Y 7/2 with 5G 6/1 laminations
5G 6/1 & N8 laminae
5G 6/1 & N7 laminae
N8
N8 with N3 laminae
N7, N8
N7, greenish gray (5GY 6/1)

NANNOFOSSIL OOZE
silica-rich in parts. Pyrite burrow filling at 6-57 cm; pyrite aggregate with forams in CC. Extensively laminated from 5-143 to base. Greenish laminae appear to be glauconitic. Soft ooze throughout, highly deformed in Sections 1-3. A few discoasters are seen on smear slides, apparently reworked. Silica is in form of diatoms and fine spines (possibly radiolarian or sponge spicules).

Smear Slides (Major lithology)

	1-70	2-70	4-90	5-106
total detrital	5	5	8	8
volc. glass	1	1	Tr	1
forams	5	5	5	15
nannos	70	78	73	63
unsp. carb.	Tr			
diatoms	8	5	5	5
rads	1	1	Tr	Tr
sp. spic.	10	5	9	7
silicoflag.	Tr	Tr	1	Tr
"clumps" (sand-size)				
glauconite				
zeolite			Tr	1
pyrite				Tr

Smear Slides (Minor lithology)

	3-55	6-94
total detrital	6	2
volc. glass	Tr	Tr
forams	5	5
nannos	77	88
unsp. carb.		
diatoms		1
rads		Tr
sp. spic.	Tr	2
silicoflag.		Tr
"clumps" (sand-size)	10	
glauconite	Tr	
zeolite	1	
pyrite	1	

green mottle

Carbonate Bomb

1-70	86%
2-70	79%
3-70	90%
4-70	89%
5-70	92%
6-70	90%
7-16	94%

SITE 412 HOLE CORE 9 CORED INTERVAL: 108.5-118.0 m

TIME-ROCK UNIT: PLEISTOCENE

BIOSTRAT ZONE: N22 NN19

FOSSIL CHARACTER: FORAMS Ag; NANNOS Ag; RADS

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

METERS: 0.5, 1.0

GRAPHIC LITHOLOGY: VOID; VOID; P P P

DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE: 70 (Sections 2, 3, 4, 5, 6)

LITHOLOGIC DESCRIPTION

greenish gray (5GY 6/1)

light gray (N7) & very light gray (N8) mixed

light gray (N7) mottled with N8, N9, & 5G 6/1

light gray (N7) mottled with greenish gray (5GY 6/1 & 5G 6/1)

light gray (N7)

very light gray (N8)

N7 with mottling of N8 and N3

N8 with mottling of N7, N3, 5G 6/1

N7 and N8 mixed

very light gray (N8) with mottling of light gray (N7), dark gray (N3), & greenish gray (5G 6/1)

CC=27 cm 7 cm VOID

very light gray (N8)

NANNOFOSSIL OOZE
soft, highly deformed. One pyritized burrow at 5-111 cm. Light gray to very light gray throughout with some greenish gray (glauconitic) and dark gray (fine pyrite) mottles. No discoasters observed. Silica (biogenic) <5% throughout.

Smear Slides

	2-70	4-70	6-70
total detrital	3	3	2
volc. glass	Tr		Tr
forams	8	2	8
nannos	86	91	89
unsp. carb.			
diatoms	1	2	Tr
rads	Tr	Tr	
sp. spic.	2	2	1
silicoflag.	Tr	Tr	
zeolite	Tr	Tr	Tr
micronod.	Tr		
pyrite		Tr	Tr

Carbonate Bomb

2-90	98%
3-90	92%
4-70	87%
5-90	98%
6-70	92%

Explanatory notes in Chapter 1

SITE 412 HOLE CORE 10 CORED INTERVAL: 118.0-127.5 m

TIME-ROCK UNIT: PLEISTOCENE

BIOSTRAT ZONE: N22 NN19

FOSSIL CHARACTER: FORAMS Ag; NANNOS Ag; RADS

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

METERS: 0.5, 1.0

LITHOLOGIC SAMPLE: 70 (Sections 1, 2, 3, 4, 5)

LITHOLOGIC DESCRIPTION

light gray (N7)

light gray (N7) and very light gray (N8)

light gray (N7) including CC's)

NANNOFOSSIL OOZE
extremely deformed light gray nannofossil ooze. Soupy in upper section (1). Discoasters scattered to common in smear slides suggest some of uniformity possibly original, caused by slumping of nearby Pliocene material.

Smear Slides

	1-70	3-70	5-70
total detrital	3	5	2
volc. glass	Tr		Tr
forams	1	3	3
nannos	92	86	87
unsp. carb.			2
diatoms	1	3	2
rads	Tr	1	Tr
sp. spic.	2	2	2
silicoflag.		Tr	
zeolite	1	Tr	Tr
micronod.		Tr	2

Carbonate Bomb

1-70	87%
2-70	95%
3-119	98%
4-70	90%
5-30	96%
6-35	95%

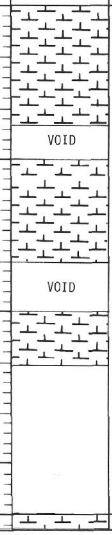
Site 412, Core 11, Cored interval: 127.5-137.0 m: NO RECOVERY

CC=36 cm

SITE 412 **HOLE** **CORE** 12 **CORED INTERVAL:** 137.0-146.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS
PLEISTOCENE	N22 NN19	Ag	Ag		1, 2, 3, CC	0.5, 1.0

GRAPHIC LITHOLOGY



LITHOLOGIC SAMPLE: 70 (Section 1), 70 (Section 2)

LITHOLOGIC DESCRIPTION

very light gray (N8) with dark gray (N3) mottles

light gray (N7) with slight mottling of dark gray (N3), greenish gray (5G 6/1)

NANNOFOSSIL OOZE

Highly disturbed core of soft, light to very light gray nannofossil ooze. No discoasters observed in smear slides.

Smear Slides

	1-70	2-70
clay, H. min.	10	11
volg. glass	Tr	Tr
zeolite	Tr	Tr
forams	3	2
nannos	86	83
diatoms	Tr	2
rads	Tr	
sp. spic.	1	2
glauconite		Tr

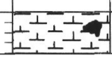
Carbonate Bomb

1-70	98%
2-70	95%
3-30	92%

SITE 412 **HOLE** **CORE** 13 **CORED INTERVAL:** 146.5-156.0 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS
PLEISTOCENE	NN19	Ag	Ag			

GRAPHIC LITHOLOGY



LITHOLOGIC SAMPLE: 30

LITHOLOGIC DESCRIPTION

light gray (N7) and very light gray (N8) mixed

NANNOFOSSIL OOZE

Nannofossil ooze (soft, light gray) with angular basalt pebble (2x2x2 cm) @ 1, 14-16 cm. Core Catcher sample is in liner, now called Section 1, 20-40 cm. Recovery possibly low due to drilling hard basalt? layer (see drilling log).

Smear Slides

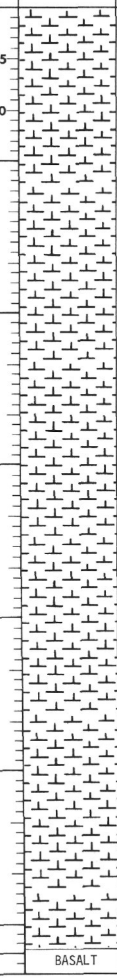
	1-30
clay	2
volc. glass	Tr
zeolite	Tr
forams	1
nannos	94
diatoms	1
rads	Tr
sp. spic.	2
silicoflag.	Tr

Explanatory notes in Chapter 1

SITE 412 **HOLE** **CORE** 14 **CORED INTERVAL:** 156.0-165.5 m

TIME-ROCK UNIT	BIOSTRAT ZONE	FORAMS	NANNOS	RADS	SECTION	METERS
PLEISTOCENE	N22 NN19	Ag	Ag		1, 2, 3, 4, 5, 6, 7, CC	0.5, 1.0

GRAPHIC LITHOLOGY



LITHOLOGIC SAMPLE: 5, 70 (Sections 1–6), 17, 25, 28 (Section 7)

LITHOLOGIC DESCRIPTION

medium light gray (N6)

yellowish gray (5Y 8/1) with mottles and chips of pale yellow (5Y 8/4) and yellow (5Y 7/6)

yellowish gray (5Y 8/1)

yellowish gray (5Y 8/1)

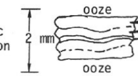
grayish orange (10YR 7/4)

yellowish gray (5Y 7/2)

NANNOFOSSIL OOZE

Pale yellow nannofossil ooze with limonitic concretions scattered throughout (see figure). Contact with overlying gray nannofossil ooze is sharp, occurring at 1-9 cm. Basalt was recovered from the Core Catcher. Sandier units begin at 6-142 cm and increase to a purely foram sand at 7-24 cm to base of sediments at 7-31 cm. Short (4-6 cm) indurated units beginning at 5-106 cm continue to the base - they appear similar to basal turbidite units, but do not seem significantly sandier than intercalated soft ooze.

limonitic concretion



This core is quite similar to the basal sediments at Site 410, and appears to represent a secondary oxidation and remobilization of finely disseminated pyrite→limonite.

Smear Slides (Major lithology)

	1-70	3-70	5-70
qtz. + fspr.	1	Tr	
clay		2	5
forams	5	3	3
nannos	74	88	83
unsp. carb.	3	1	1
diatoms	2		
rads			
sp. spic.	13	4	4
silicoflag.	2	1	1
opaques	Tr	1	Tr
micronod.			3

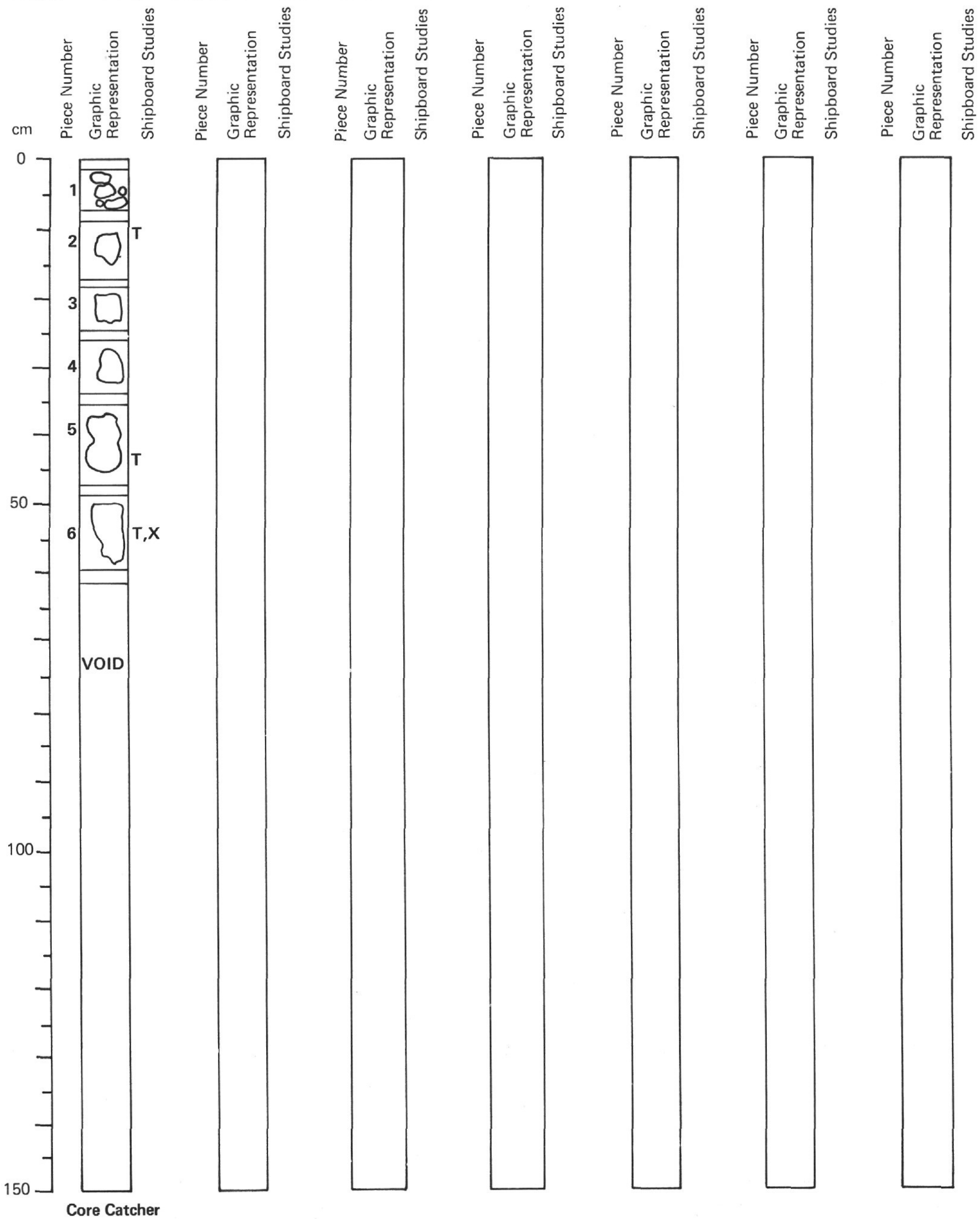
Smear Slides (Minor lithology)

	1-5	7-17	7-25	7-28
qtz. + fspr.	Tr		Tr	Tr
clay	5	5	3	5
forams	10	5	15	20
nannos	69	83	75	63
unsp. carb.	5	1	1	2
diatoms	1			
rads				
sp. spic.	6		1	Tr
silicoflag.	3			
opaques	1	1	Tr	Tr
micronod.		5	5	10

Carbonate Bomb

1-69	92%	5-70	87%
2-70	89%	6-70	92%
3-70	87%	7-20	94%
4-70	83%		

LEG **49** SITE **412** HOLE CORE **14** DEPTH **156.0-165.5 m**

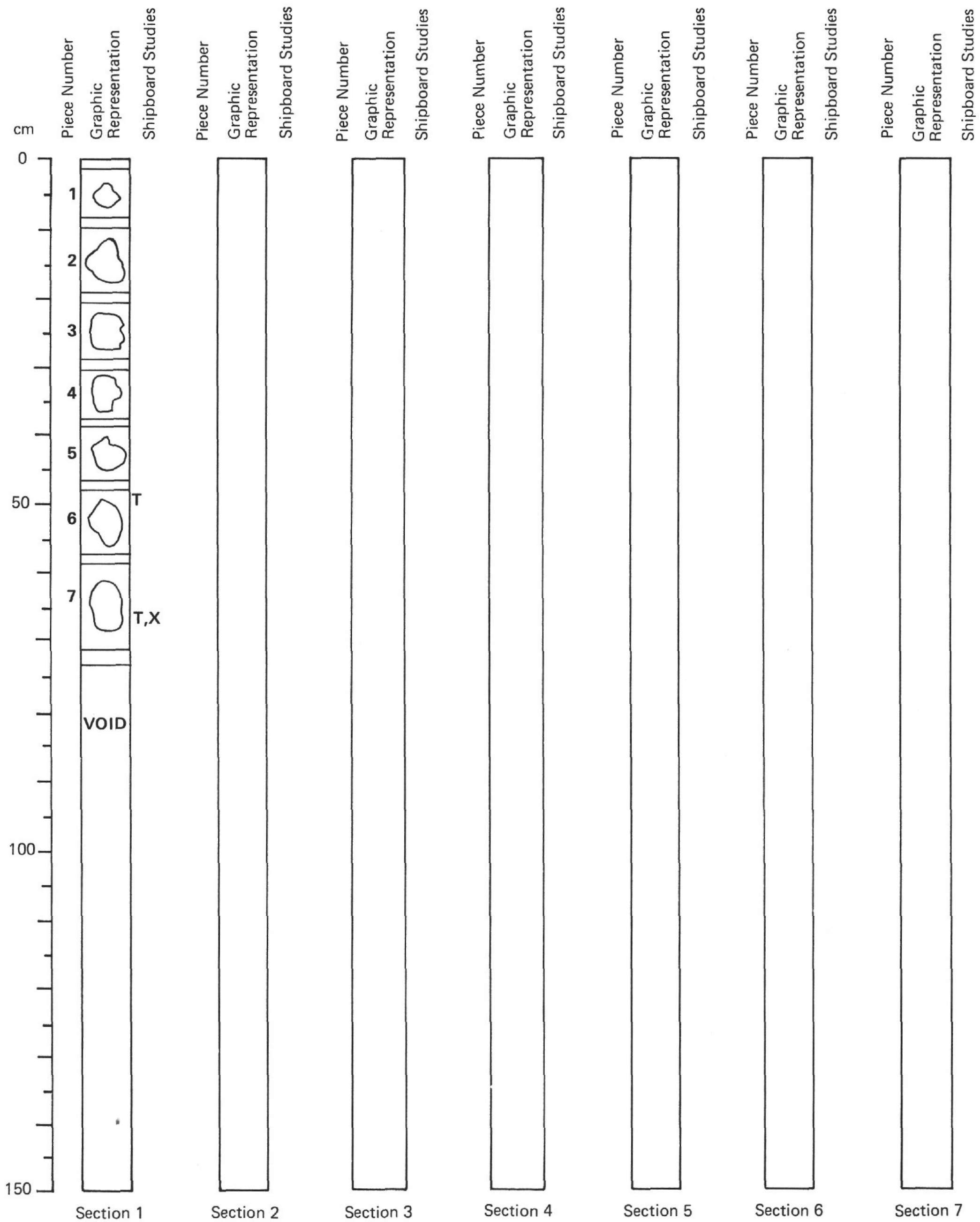


Original basalt recovery was 0.35 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Type 1: medium-grained phyric basalt. About 10% of plagioclase, olivine, and clinopyroxene, phenocryst, 3 to 4 mm in size. Plagioclase> olivine≥clinopyroxene. Weak to moderate secondary alteration of rock.

Type 2: fine-grained, vesicular version of Type 1. Two to five per cent phenocrysts, about 2 mm in size, 7 to 10% vesicles, as large as 1.5 mm. Some vesicles partly lined with smectite.

LEG **49** SITE **412** HOLE CORE **15** DEPTH **165.5-171.5 m**

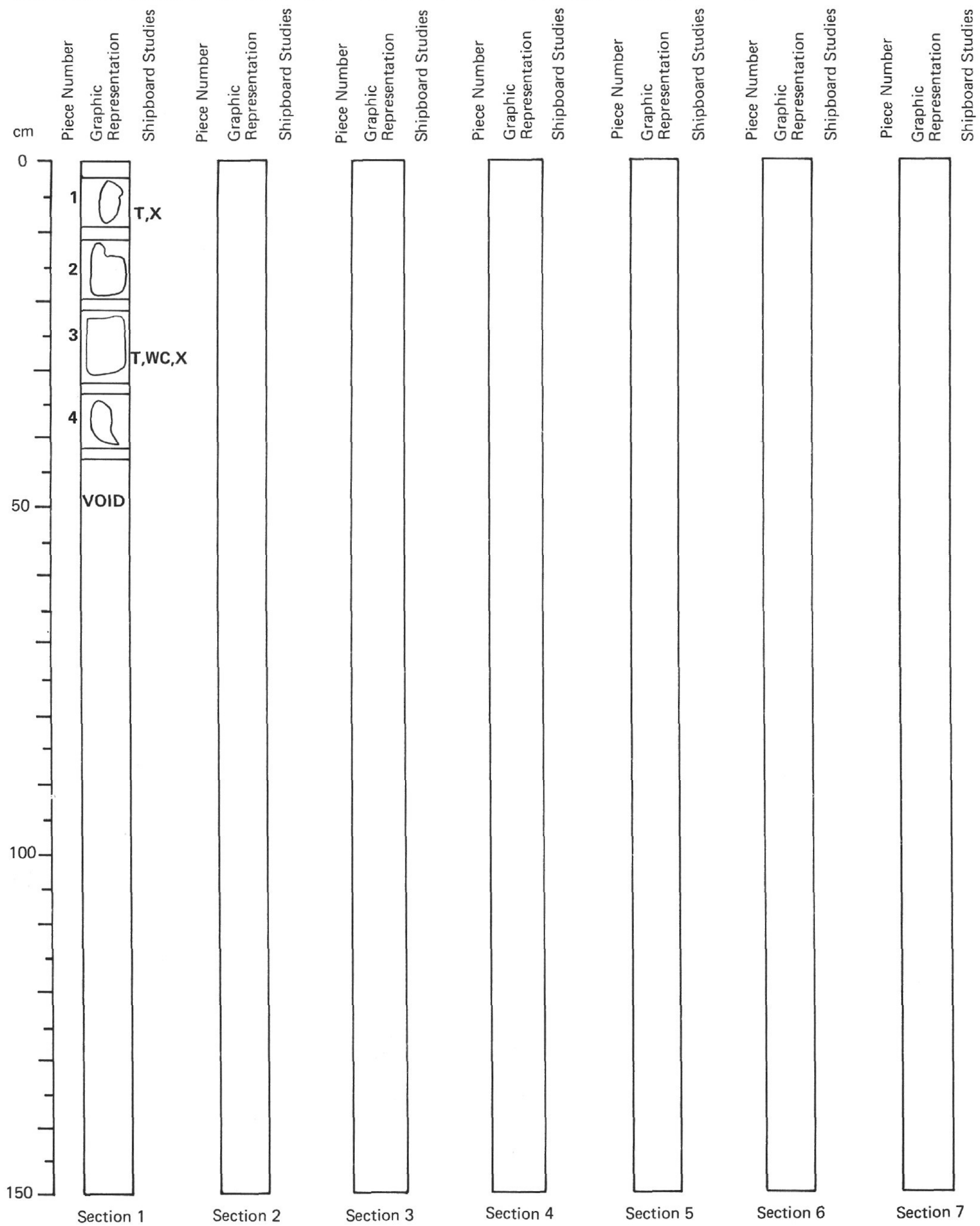


Original basalt recovery was 0.20 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Type 1: medium-grained, phyric basalt, 5 to 10% plagioclase, olivine, clinopyroxene phenocrysts, about 3-5 mm in size. Plagioclase> olivine ~ clinopyroxene. Weak to moderate alteration.

Type 2: vesicular variety of Type 1, 5 to 15% vesicles, up to 5 mm in size. Some vesicles lined with smectite(?).

LEG 49 SITE 412 HOLE A CORE 1 DEPTH 156.0-165.5 m



Original basalt recovery was 0.25 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Top: fine-grained, vesicular basalt with rare microphenocrysts (up to 1.5 mm) at plagioclase. Vesicles from 0.2 to 1.0 mm, about 7-10% of rock. Some vesicles filled or partly filled by smectite, celadonite, chlorite(?), and calcite.

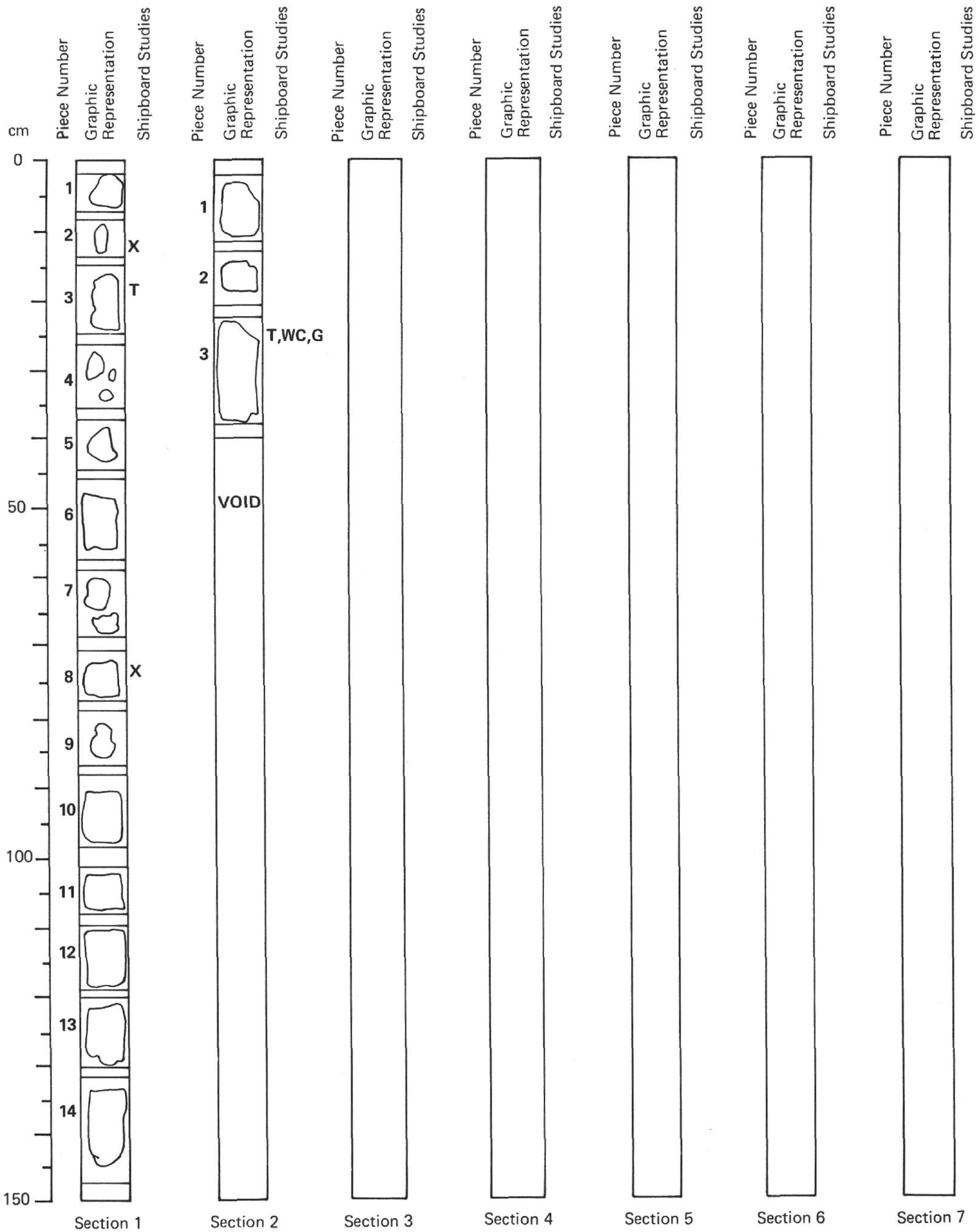
Middle: vesicular, olivine, plagioclase, clinopyroxene basalt. Phenocrysts from 1.5 to 3.0 mm with plagioclase> olivine+clinopyroxene. Phenocrysts < 1%. Vesicles from 0.2 to 1.5 mm, about 3-5% of rock - some lined with smectite.

Bottom: vesicular, fine-grained, plagioclase, olivine, clinopyroxene basalt. Phenocrysts from 3 to 5 mm, with plagioclase> clinopyroxene ~ olivine, total of 7-10%. Rare vesicles, some lined with smectite(?).

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 25 cm:	6.54	842	+61°

LEG **49** SITE **412** HOLE **A** CORE **2** DEPTH **165.5-175.0 m**



Original basalt recovery was 1.27 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

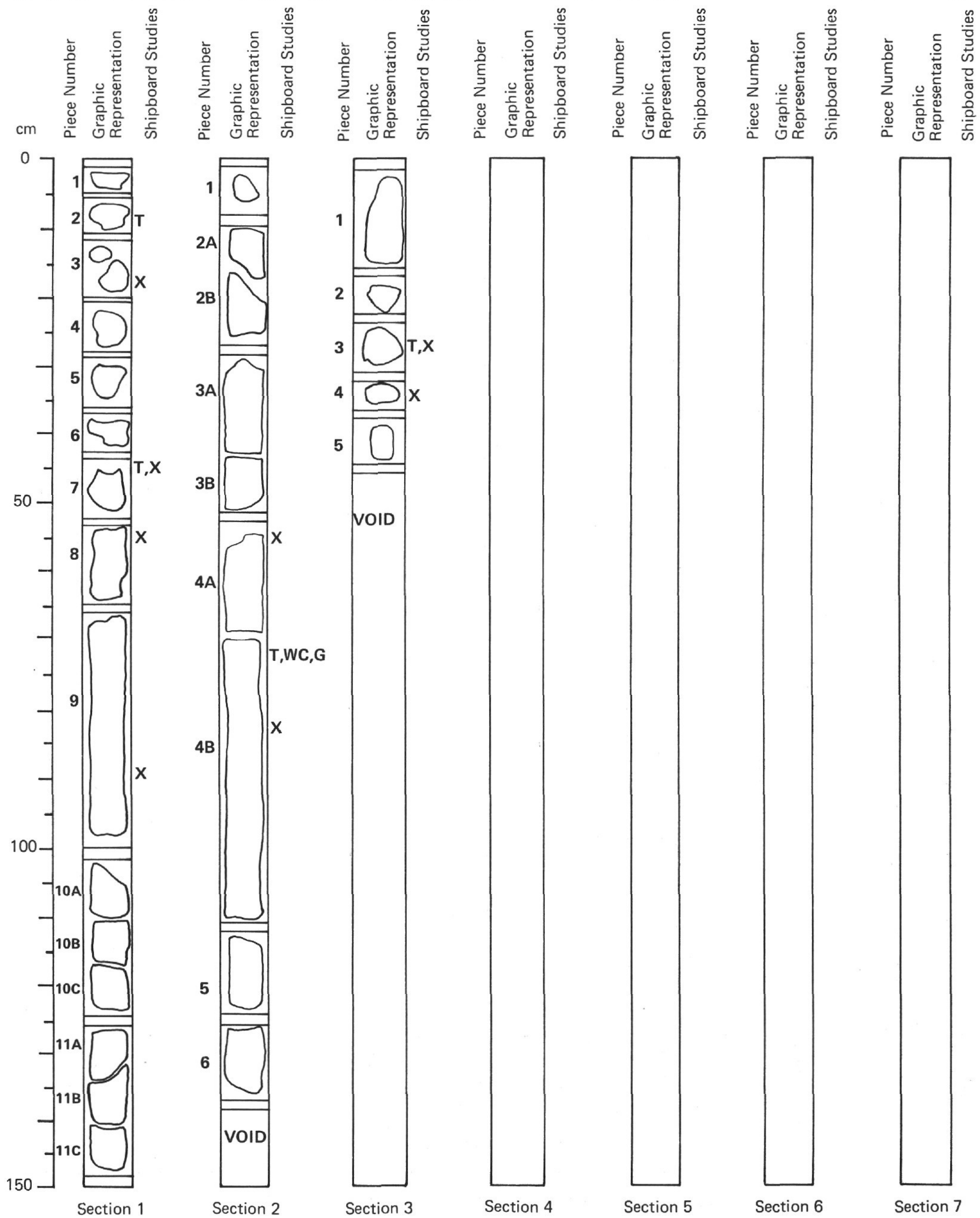
Top: vesicular, plagioclase, clinopyroxene, olivine basalt. Phenocrysts from 3 to 5 mm, with plagioclase most abundant. Vesicles from 3 to 4 mm, about 15 to 20% of rock. Some vesicles lined with smectite and celadonite(?).

Bottom: medium-grained, plagioclase, olivine, clinopyroxene basalt. Phenocrysts from 2 to 7 mm, about 15% of rock. Plagioclase> olivine> clinopyroxene. Vesicles are rare. Some partly filled with zeolite(?) + calcite(?). Some rock fragments show distinct alteration zones.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 45 cm:	––	880	-34°
Sect. 1, 100 cm:	––	––	Reversed
Sect. 2, 40 cm:	5.44	55	-60°

LEG **49** SITE **412** HOLE **A** CORE **3** DEPTH **175.0-184.5 m**



Original basalt recovery was 2.83 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

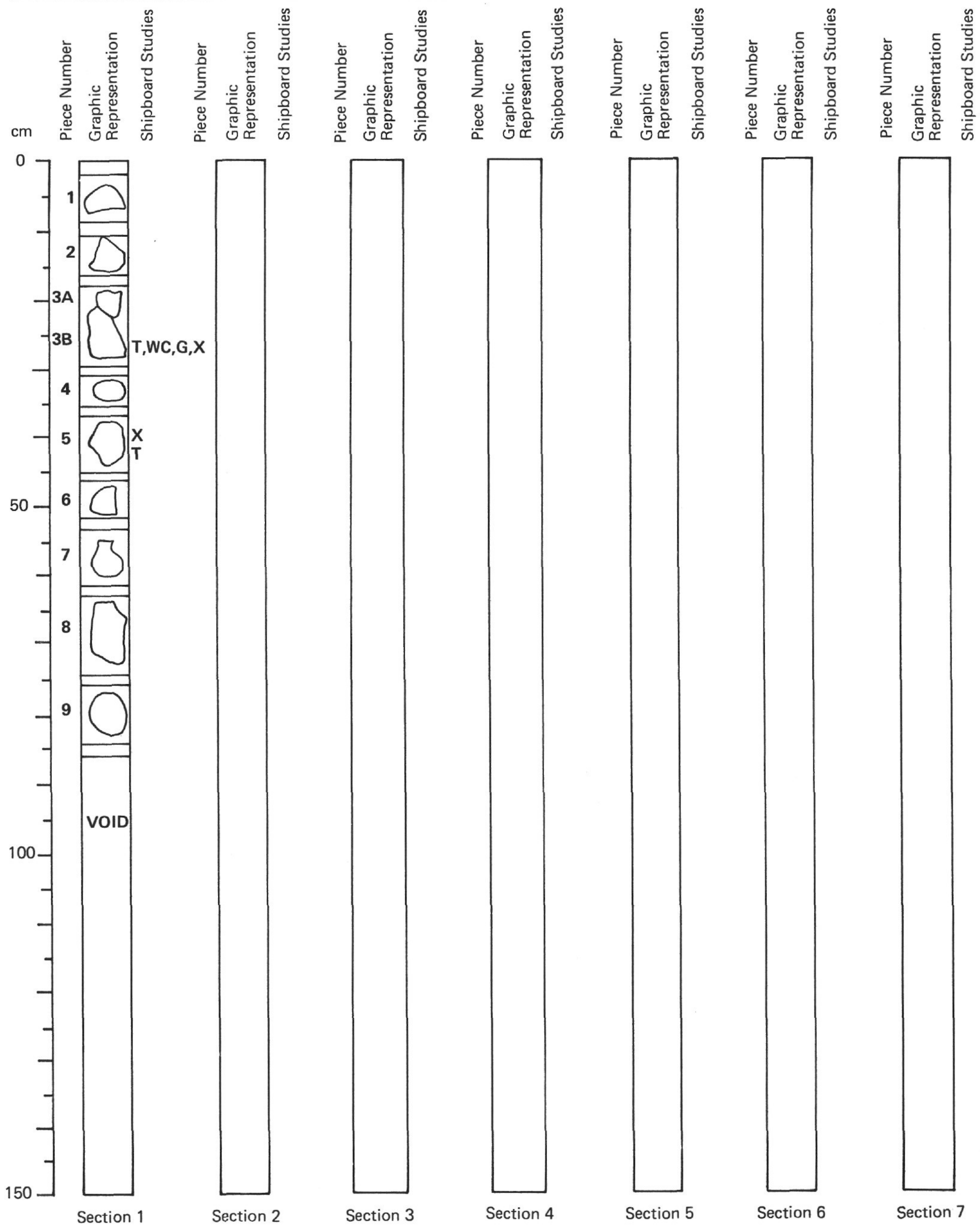
Type 1: vesicular, plagioclase, olivine, clinopyroxene, basalt. Phenocrysts from 2 to 5 mm, and from 1 to 10% of rock. Plagioclase> olivine> clinopyroxene. Vesicles from 0.2 to 2 mm, and from 5 to 10% of the rock.

Type 2: medium-grained, plagioclase, olivine, clinopyroxene basalt. Phenocrysts from 2 to 10 mm and from 10 to 20% of rock. Plagioclase> olivine> clinopyroxene. Some pieces show distinct alteration zones.

Shipboard Data

	Vp	**NRM**	**Inc.**
Sect. 1, 80 cm:	5.43	134	-46°
Sect. 2, 70 cm:	5.42	984	-41°

LEG **49** SITE **412** HOLE **A** CORE **4** DEPTH **184.5-194.0 m**



Original basalt recovery was 0.68 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

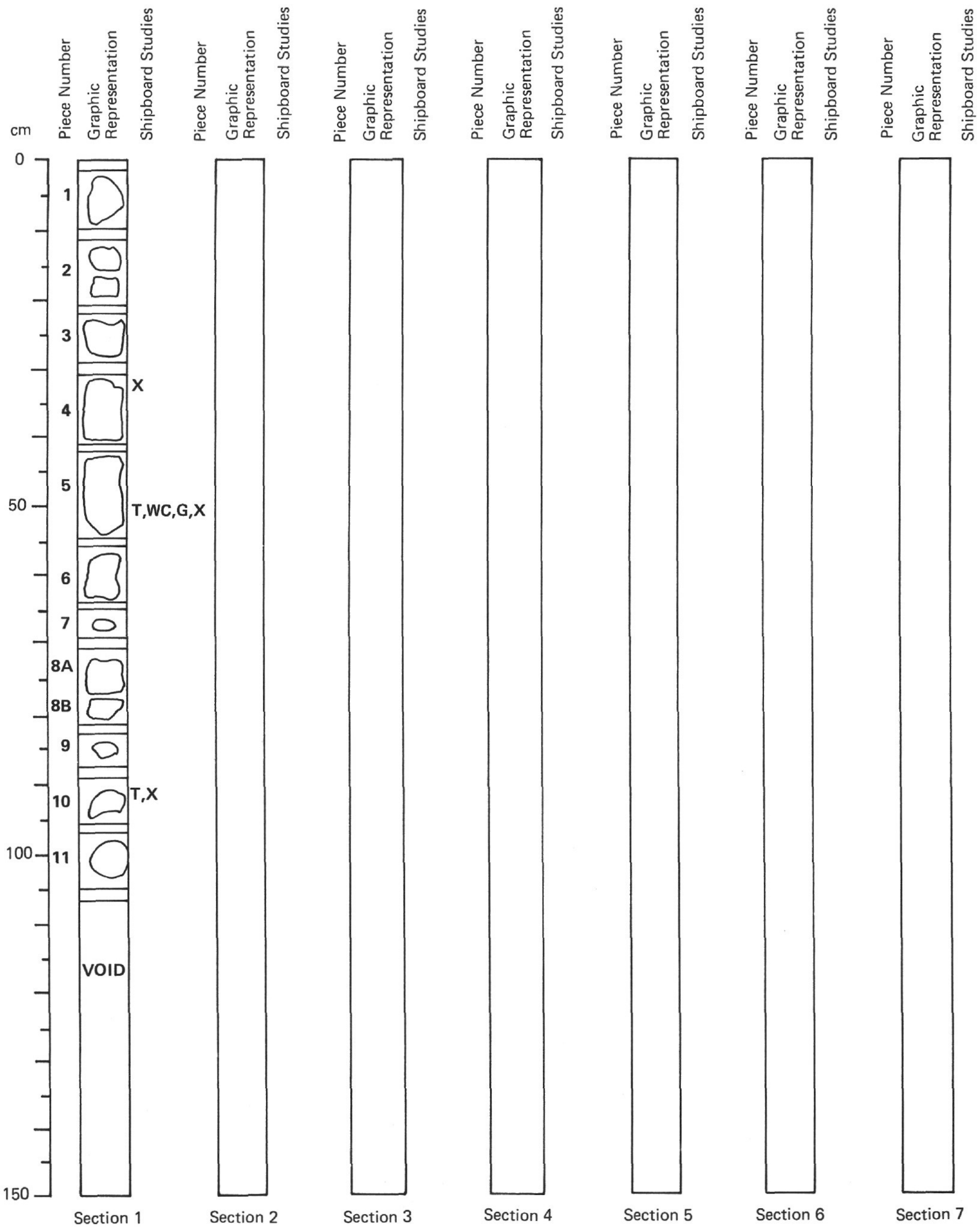
Type 1: fine- to medium-grained phyric basalt. Phenocrysts from 2 to 5 mm, and from 5 to 15% of the rock. Plagioclase> olivine ± lesser amounts of clinopyroxene. Some pieces show distinct alteration zones.

Type 2: vesicular variety of Type 1. About 10 to 20% vesicles, from 0.2 to 1.5 mm.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 25 cm:	5.44	592	-82°

LEG **49** SITE **412** HOLE **A** CORE **5** DEPTH **194.0-203.5 m**



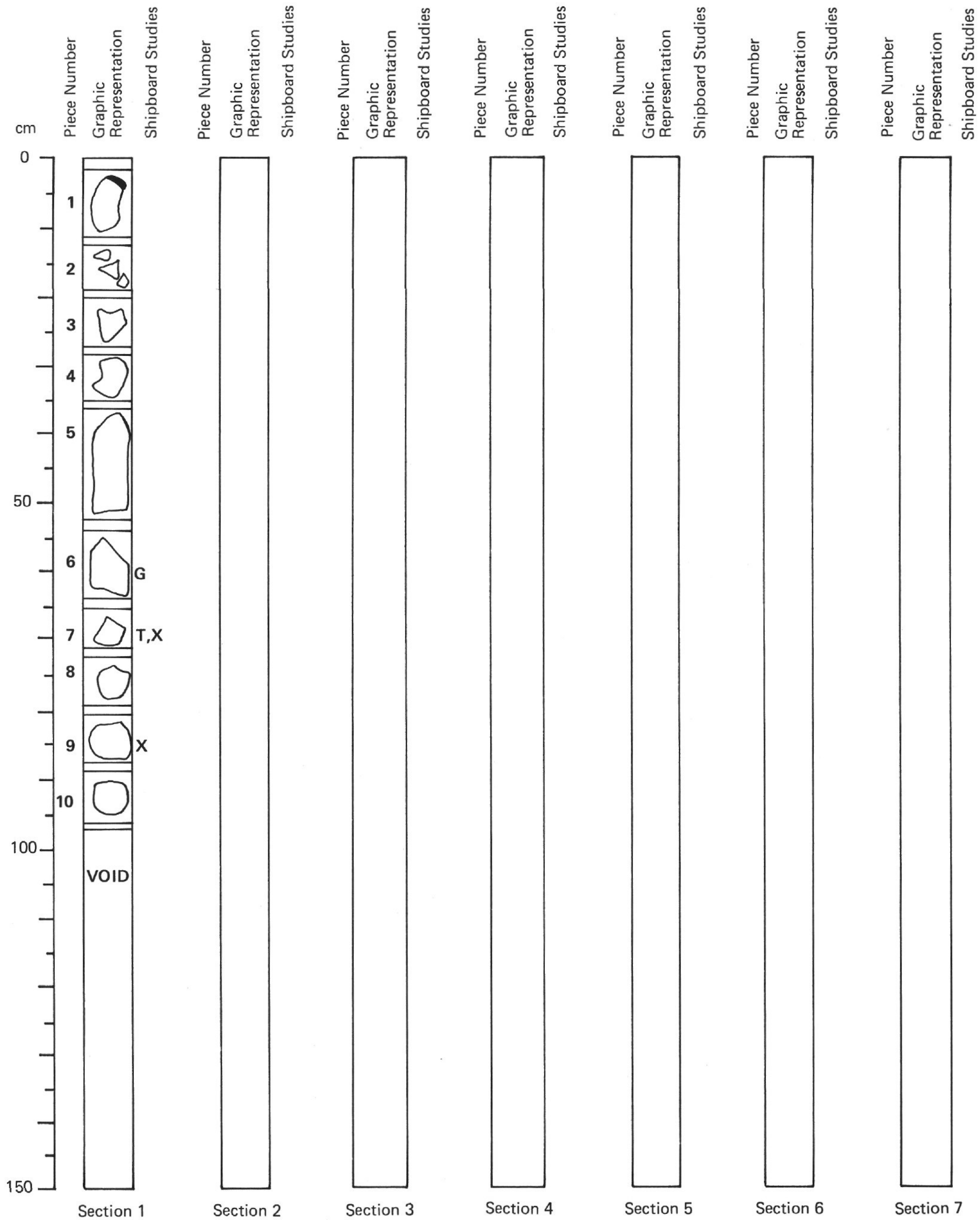
Original basalt recovery was 0.65 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Fine-grained microphyric basalt. Rare micropheno-crysts of plagioclase and olivine, and even rare clino-pyroxene present in a few rock fragments. Vesicularity generally < 1%, but as much as 10% in one fragment. Vesicle walls lined with smectite and some olivine altered to smectite.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 50 cm:	5.81	2000	-58°

LEG **49** SITE **412** HOLE **A** CORE **6** DEPTH **203.5-213.0 m**



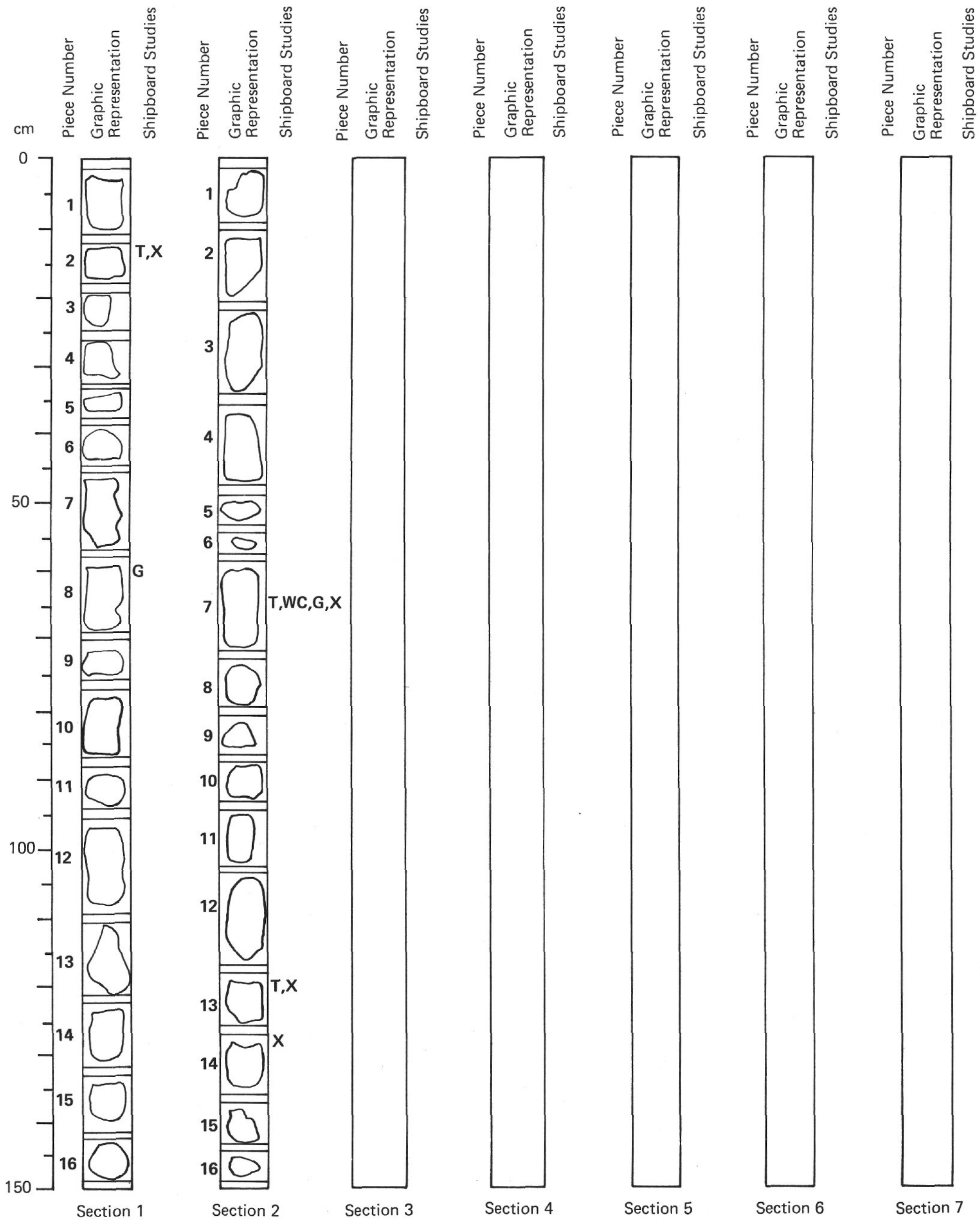
Original basalt recovery was 0.65 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Vesicular, fine-grained, sparsely phyric basalt. Phenocrysts of plagioclase and olivine from 0.5 to 1.0 mm, less than 5% of rock. Plagioclase> olivine. Vesicles from 0.5 to 1.0 mm generally sparse, but as abundant as 7% in two fragments. Some vesicles partly lined with smectite. Uppermost fragment has a glassy selvage.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 50 cm:	5.61	––	––

LEG **49** SITE **412** HOLE **A** CORE **7** DEPTH **213.0-222.5 m**



Original basalt recovery was 2.10 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

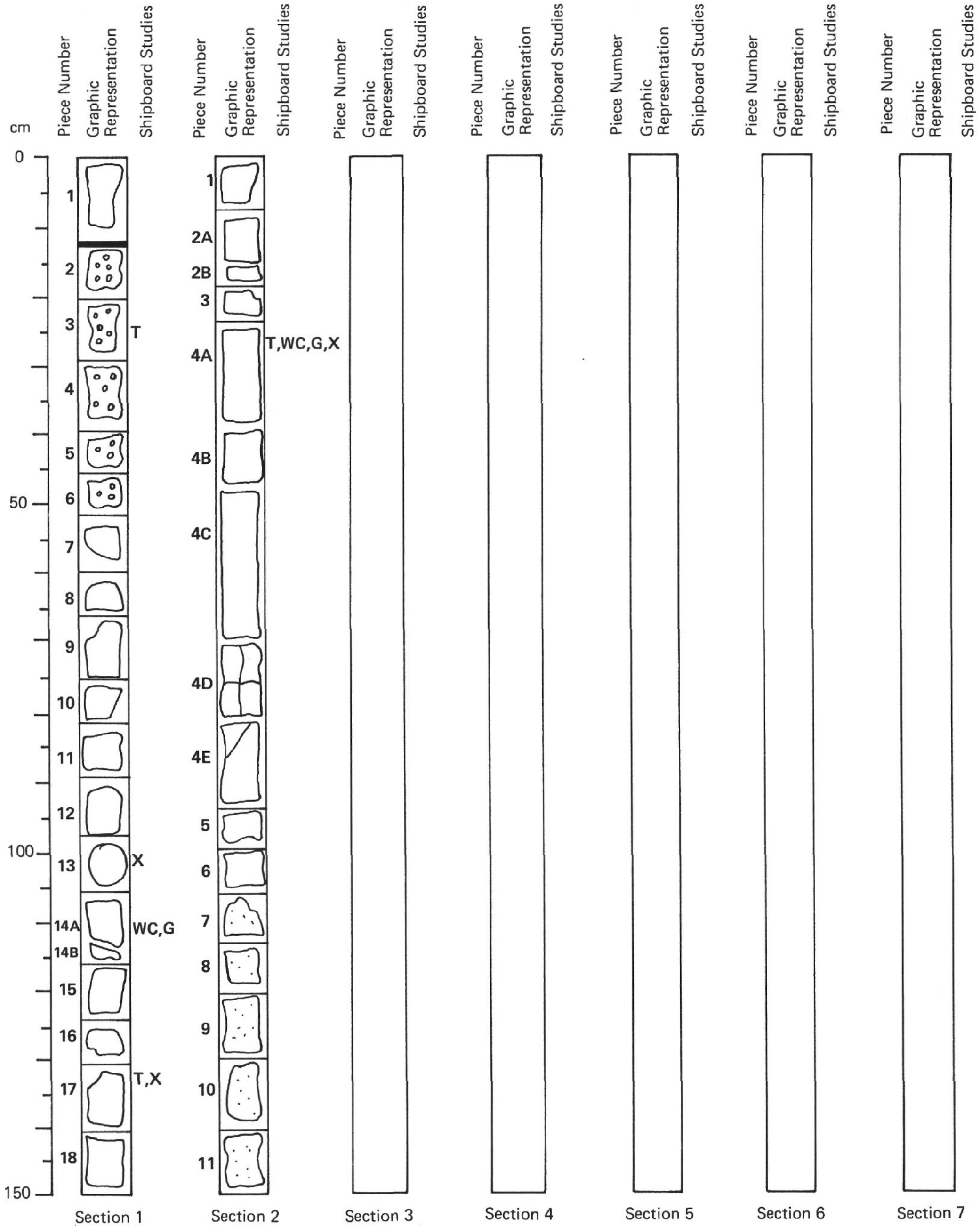
Type 1: Vesicular, fine-grained, sparsely phyric basalt. Phenocrysts of plagioclase and olivine from 1 to 1.5 mm, less than 1% of the rock. Vesicles from 0.2 to 4 mm, are 10 to 20% of the rock. Some vesicles partly lined with smectite.

Type 2: non-vesicular variety of Type 1. Some distinct zones of alteration in some pieces.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 60 cm:	4.82	––	––
Sect. 1, 145 cm:	––	5590	-45°
Sect. 2, 50 cm:	5.60	2120	-54°

LEG **49** SITE **412** HOLE **A** CORE **8** DEPTH **222.5-232.0 m**



Original basalt recovery was 2.40 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

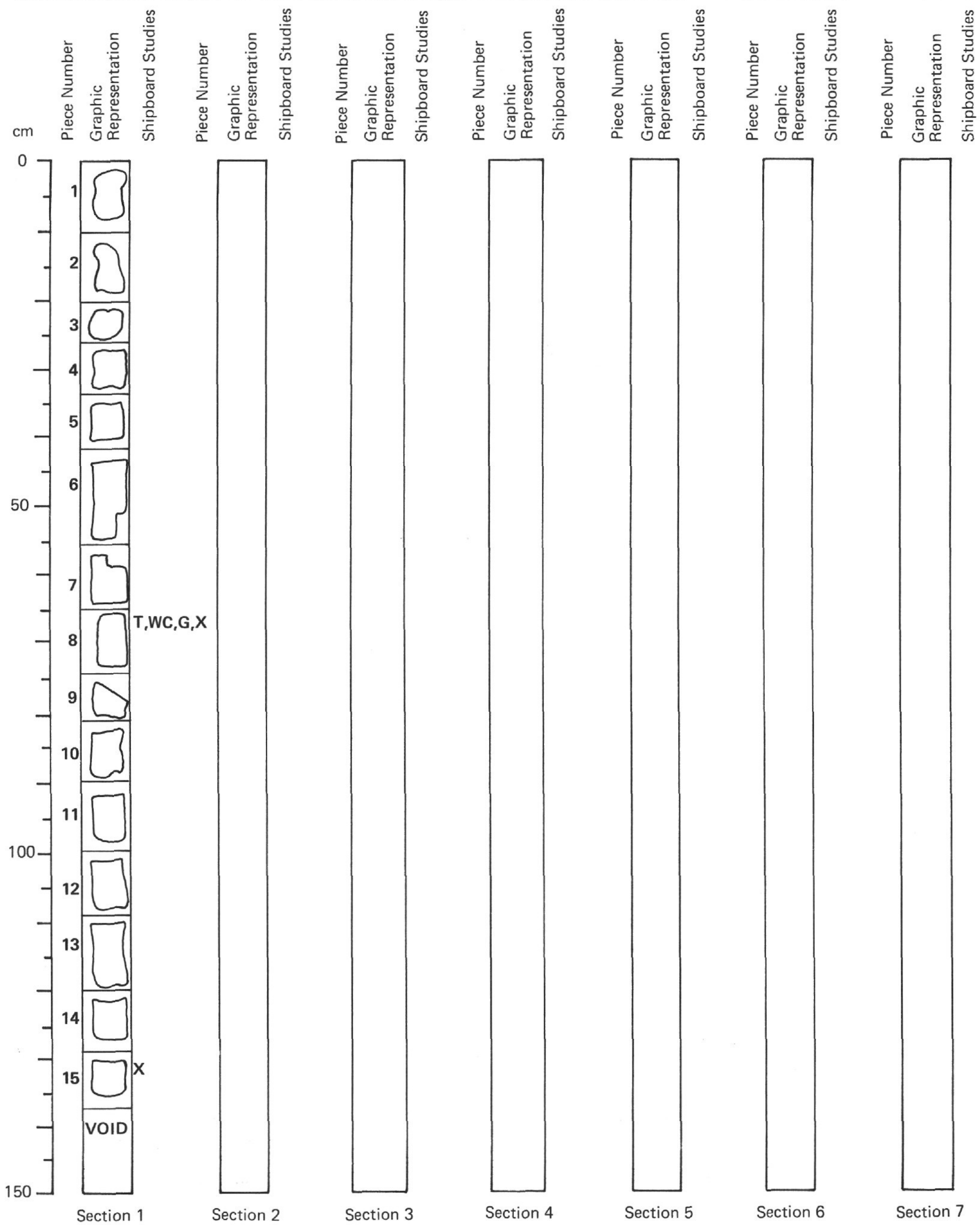
Type 1: vesicular, sparsely phyric, plagioclase, olivine basalt. Phenocrysts of plagioclase and olivine 0.5 to 2 mm, < 1%, with plagioclase> olivine. Vesicles in upper part of core 0.5 to 3 mm, and about 20% of rock; in lower part < 1 mm and 5-7% of rock. Some vesicles partly lined with smectite, carbonate, and pyrite. Rare clinopyroxene(?), phenocrysts in some pieces.

Type 2: non-vesicular variety of Type 1. Medium-grained and even textured.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 115 cm:	5.88	807	-52°
Sect. 2, 30 cm:	5.51	731	-49°

LEG **49** SITE **412** HOLE **A** CORE **9** DEPTH **232.0-241.5 m**



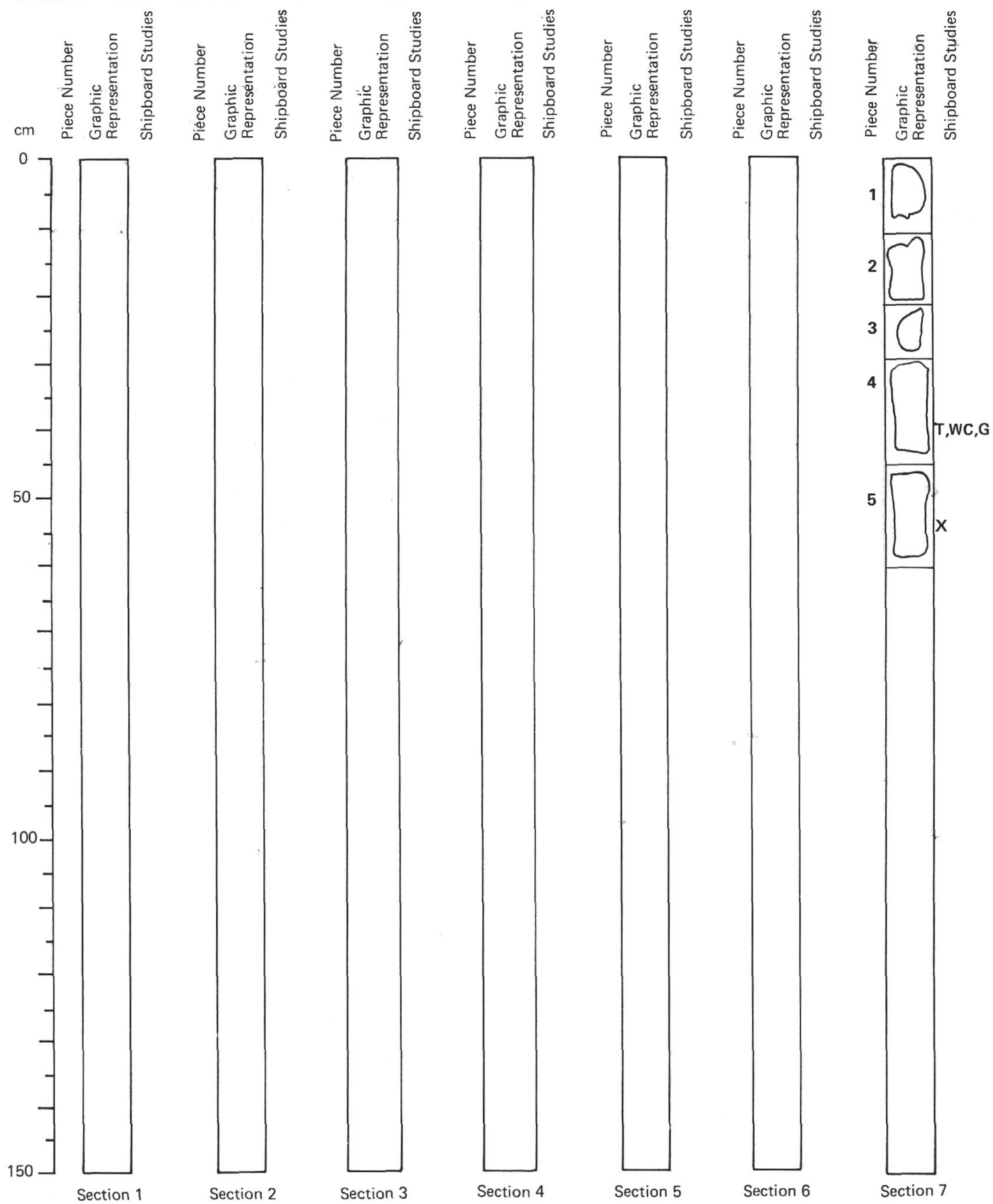
Original basalt recovery was 0.90 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Vesicular, fine- to medium-grained, sparsely phryic basalt. Scattered phenocrysts (< 1%) of plagioclase and olivine (plagioclase> olivine). About 2 to 5% vesicles, ≤ 1 mm in size. Some vesicles partly filled with smectite, pyrite, and calcite.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 55 cm:	4.52	2851	-50°

LEG **49** SITE **412** HOLE **A** CORE **10** DEPTH **241.5-251.0 m**



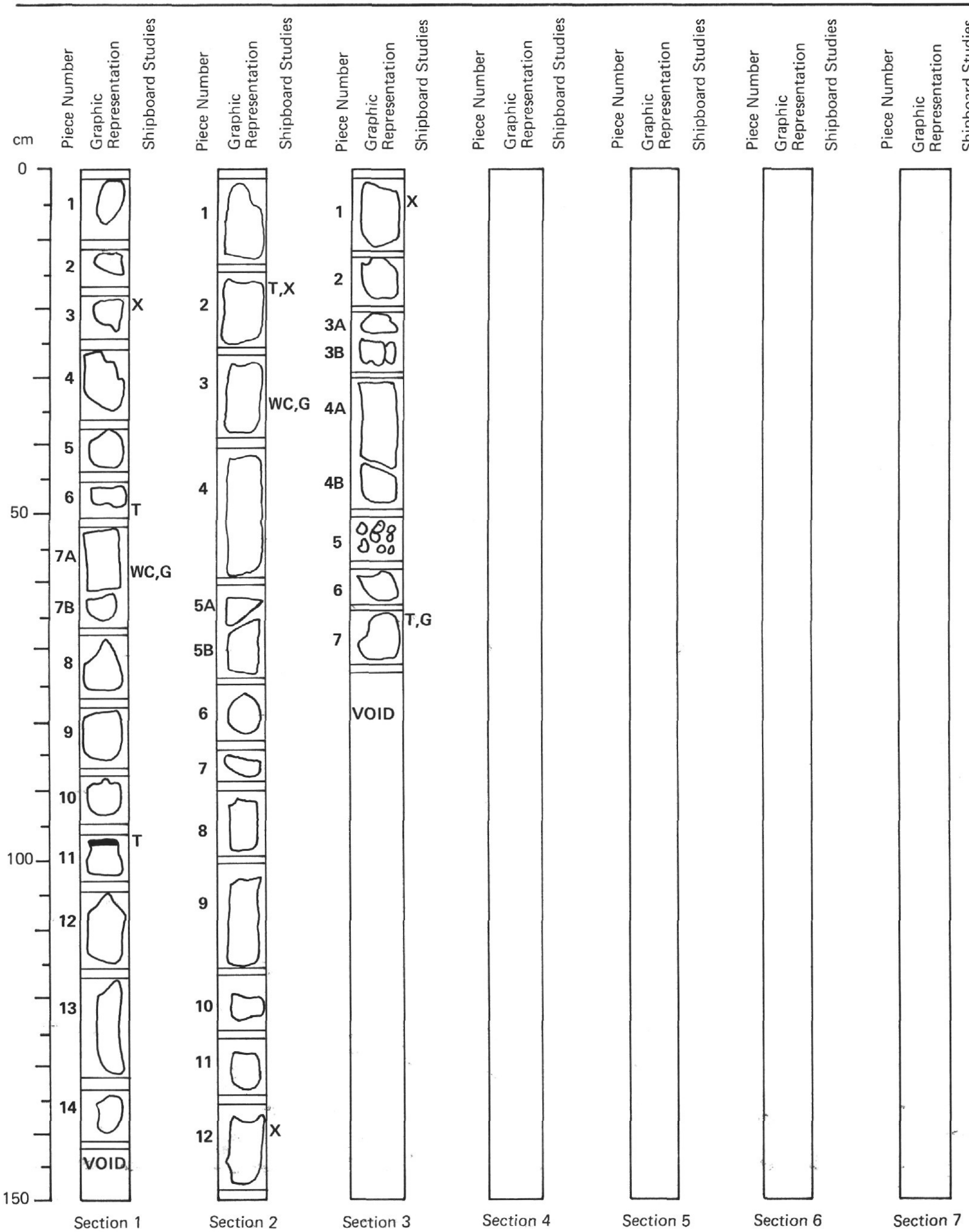
Original basalt recovery was 0.35 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Fine-grained basalt, with rare phenocrysts of placioclase (~ 3 mm). Rare vesicles ⩽ 0.5 mm, some lined with smectite and calcite.

Shipboard Data

	Vp	NRM	Inc.
Sect. 7, 40 cm:	5.07	1105	-60°

LEG **49** SITE **412** HOLE **A** CORE **11** DEPTH **251.0-260.5 m**



Original basalt recovery was 3.0 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Type 1: Medium-grained, sparsely microphyric basalt. Rare microphenocrysts of plagioclase, olivine, and clinopyroxene. Plagioclase> olivine> clinopyroxene. Rare vesicles ($\leq$0.5%), from 0.1 to 0.3 mm in size. Some vesicles lined with smectite and calcite.

Type 2: vesicular variety of Type 1. Vesicles 5 to 7%, from 0.2 to 1.0 mm. Some lined with smectite. One piece with glass selvage.

Type 3: Medium-grained, sparsely phyric basalt. < 1% plagioclase phenocrysts, 5-6 mm in size, plus rare plagioclase and olivine microphenocrysts.

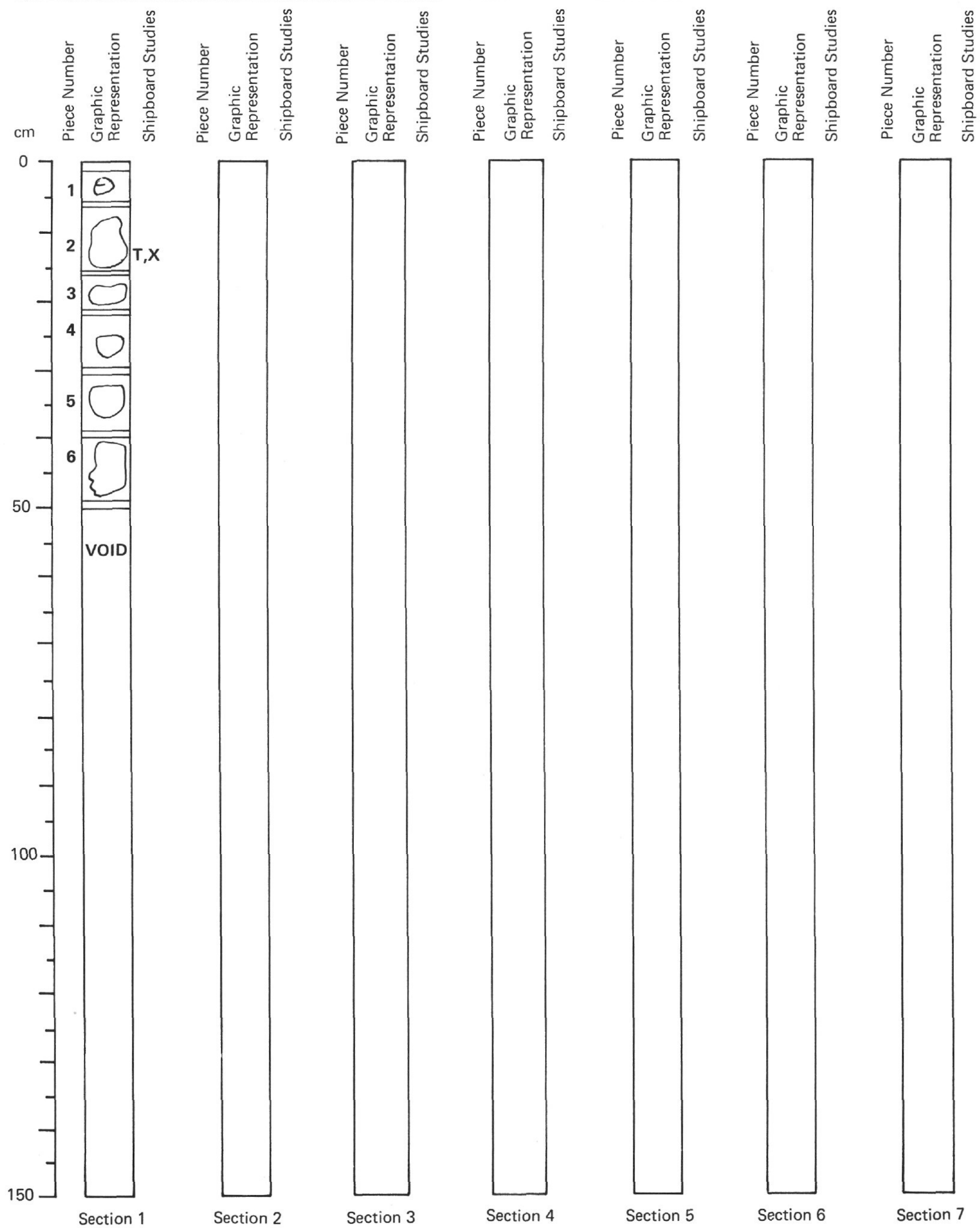
Type 4: vesicular variety of Type 3. Vesicles from 3 to 10%, range from 0.5 to 1.5 mm in size. Piece immediately below zone of chalk has a glass selvage.

Type 5: chalk: pale yellow (5Y 8/3) nannofossil chalk, 95% nannofossils with 1% each feldspar, foraminifera, volcanic ash, zeolite, clay, dark wisps (5P 2/2), appears to be structureless.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 60 cm:	5.60	756	-54°
Sect. 2, 30 cm:	5.14	472	-63°
Sect. 3, 70 cm:	5.89	1825	-66°

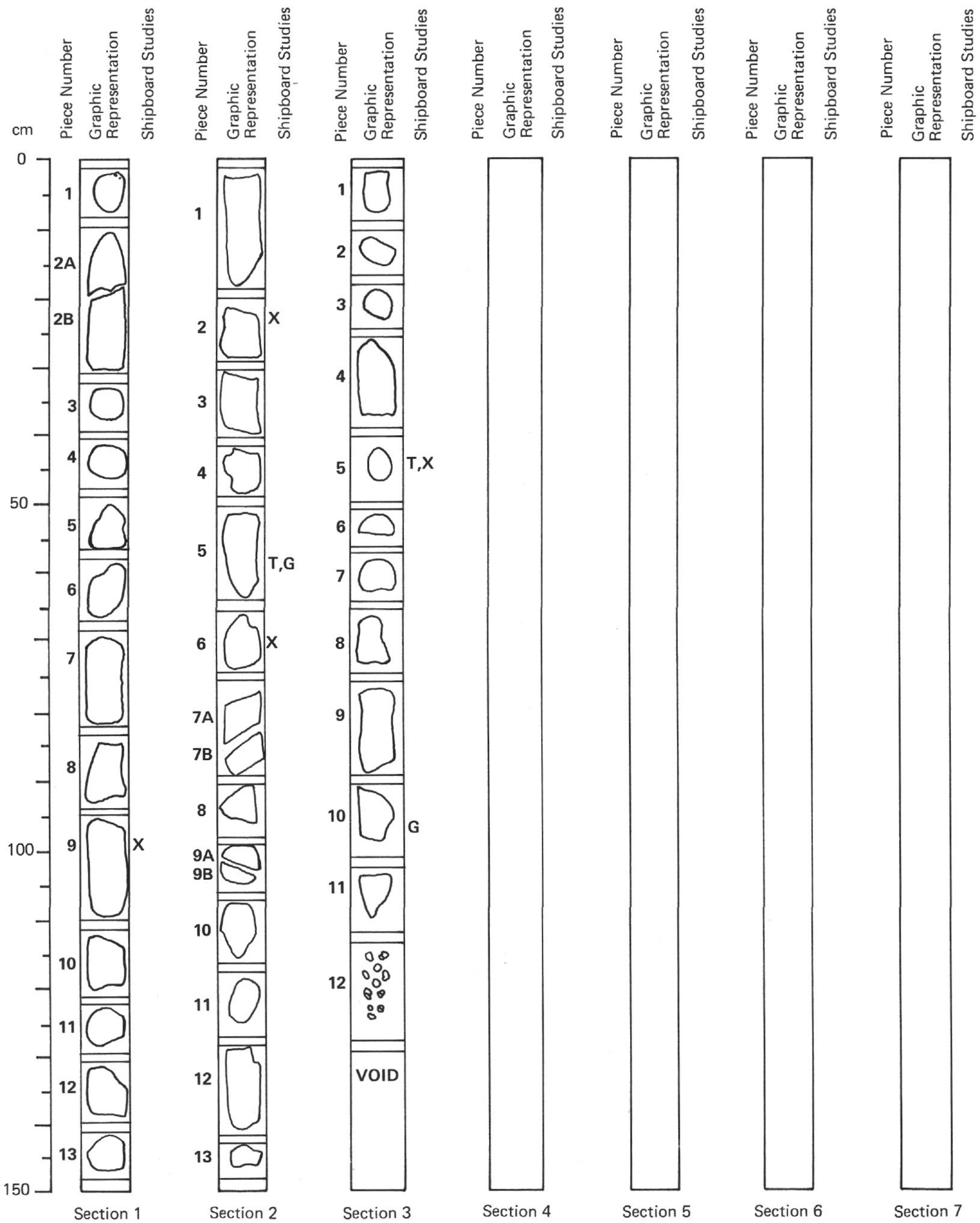
LEG **49** SITE **412** HOLE **A** CORE **12** DEPTH **260.5-270.0 m**



Original basalt recovery was 0.30 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

Type 1: fine- to medium-grained, sparsely microphyric basalt. Rare microphenocrysts of plagioclase and olivine. Vesicles are ⩽ 0.5 mm, and make up 5 to 7% of rock. Some vesicles partly filled with smectite(?) and celadonite(?).

Type 2: pale yellow (5Y 8/3), nannofossil ooze, completely deformed, 90% nannofossils, 5% foraminifera, 3% clay, trace sponge spicules, volcanic glass, feldspar, opaque heavy minerals.



Original basalt recovery was 2.90 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

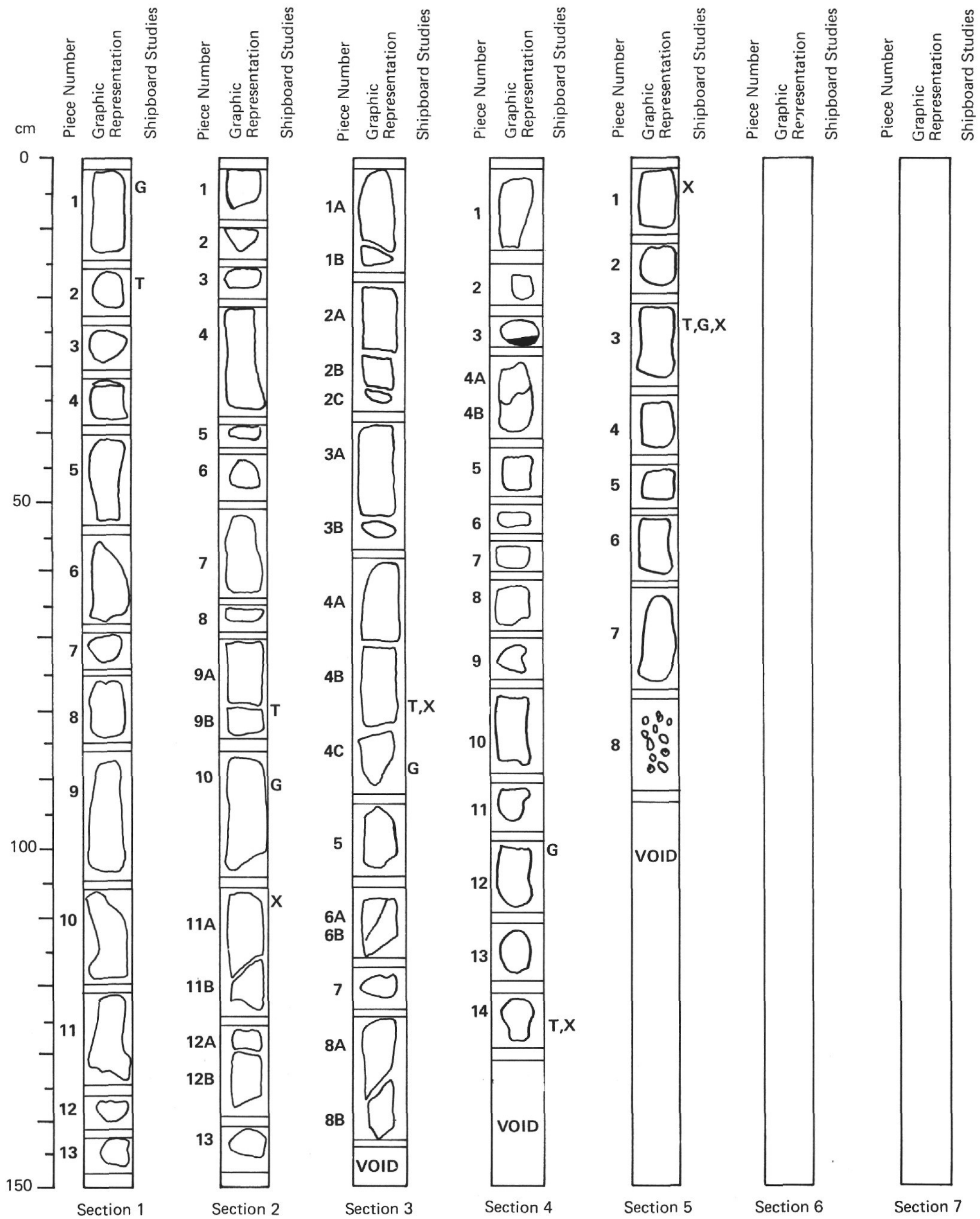
Type 1: vesicular, medium-grained, sparsely microphyric basalt. Plagioclase and olivine microphenocryst, rare, about 1 to 2 mm in size. Plagioclase> olivine. Vesicles make up about 5 to 15% of rock and are 0.5 to 1.0 mm in size. Some partly lined with smectite and pyrite.

Type 2: non-vesicular variety of Type 1.

Shipboard Data

	Vp	NRM	Inc.
Sect. 1, 40 cm:	5.50	1234	-34°
Sect. 2, 80 cm:	5.76	3150	-44°
Sect. 3, 100 cm:	5.31	251	-45°

LEG **49** SITE **412** HOLE **A** CORE **14** DEPTH **279.5-289.0 m**



Original basalt recovery was 4.79 meters. Styrofoam spacers make the length shown here greater than the amount recovered.

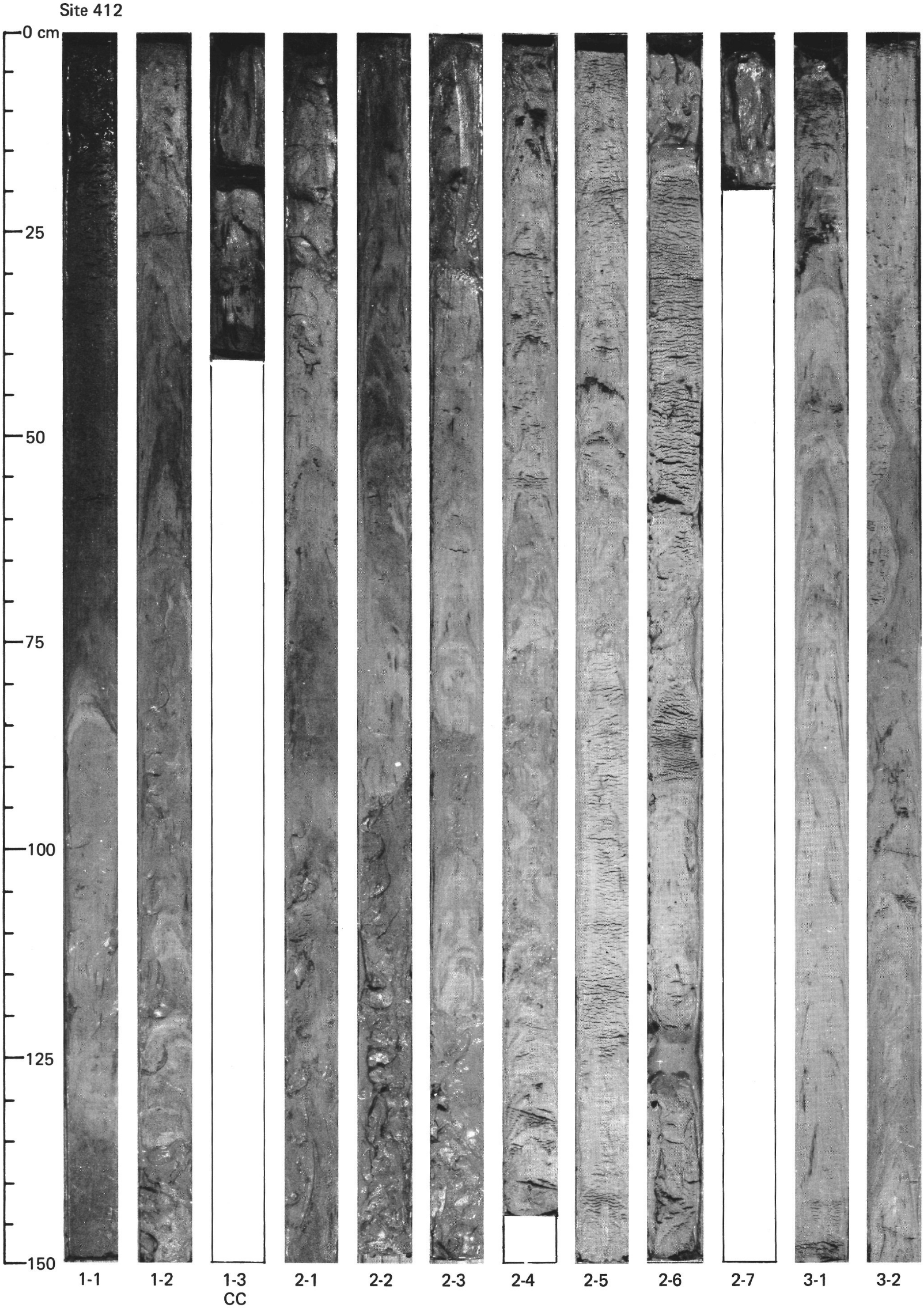
Type 1: medium-grained sparsely phyric plagioclase basalt. Plagioclase crystals rare to 3%, from 2 to 7 mm in size. Plus rare plagioclase and olivine microphenocrysts. Less than 1% vesicles that range from 0.2 to 0.5 mm in size. Some vesicles partly filled with smectite and celadonite. Some pieces show distinct zones of alteration.

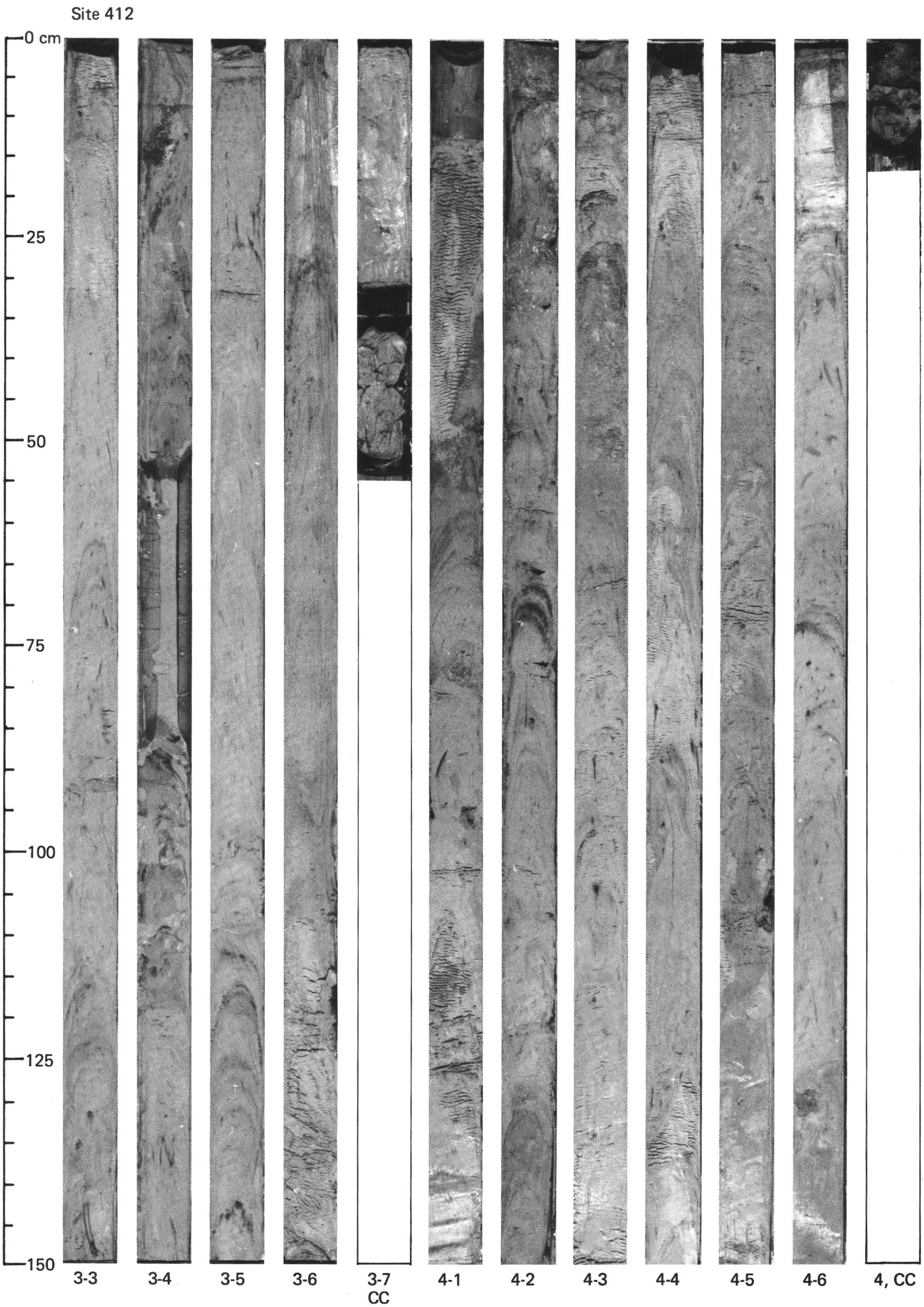
Type 2: fine-grained, vesicular variety of Type 1. Vesicularity from about 3 to 20%, ranging from 0.5 to 3 mm in size. The piece just above the zone of chalk has a glassy selvage.

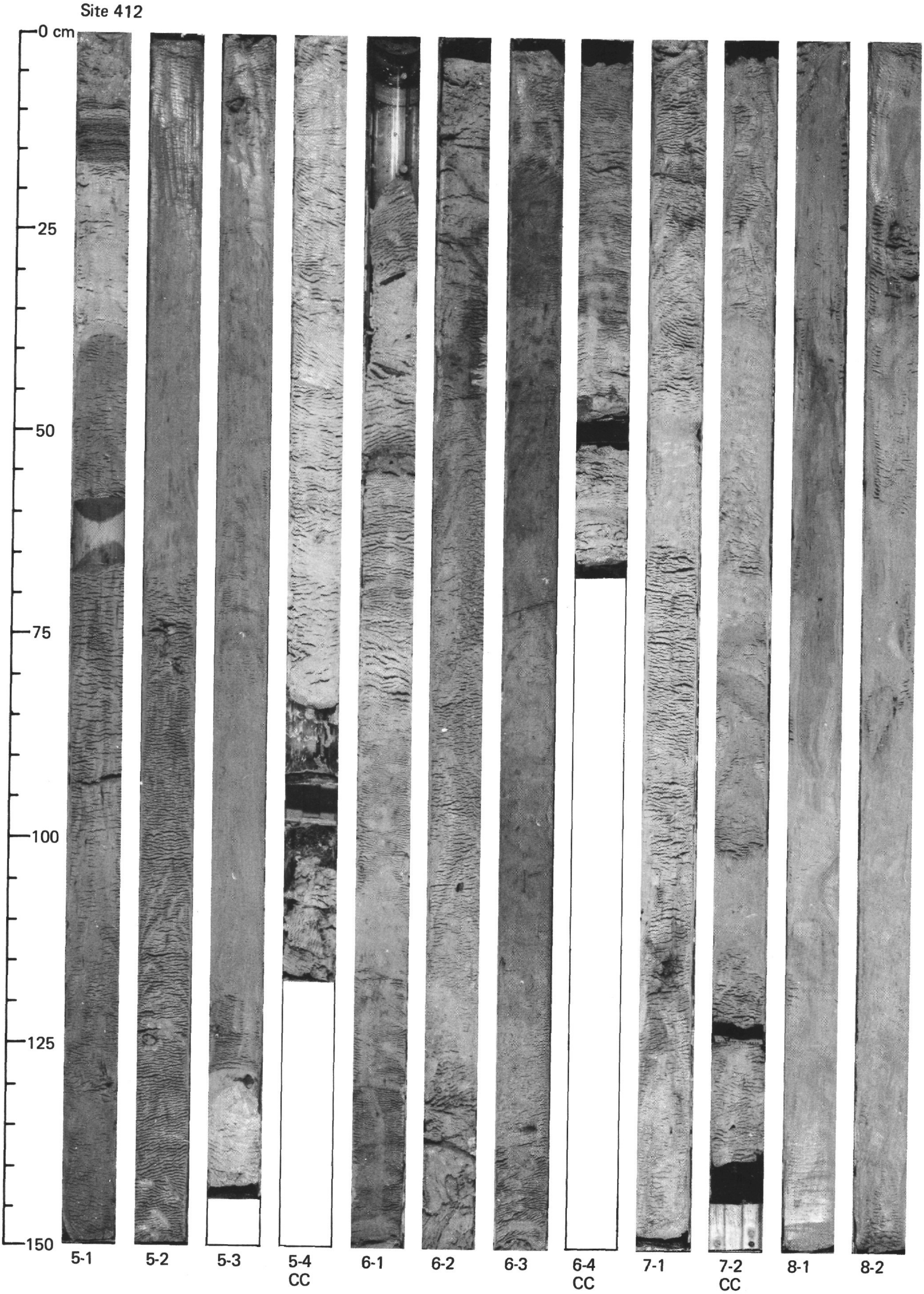
Type 3: interlayered chalk, pale yellow (5Y 8/3), nannofossil chalk, 95% nannofossils with traces silt-sized feldspar, altered volcanic glass, 1-3% foraminifera. Laminations, 1-2 cm thick, pale olive (5Y 6/3) appear to have been displaced (soft-sediment or tectonic?); mottling of white (5Y 8/2) in pale yellow matrix, some small spots (< 1 mm diameter) and streaks of limonite, light brown (5YR 5/6) in laminations and remainder of rock. Small-scale faulting, right lateral, causing slickensides (black-5Y 2/2 to olive-5Y 4/4), several other small-scale faults. In Piece no. 4 above erosional surface is fine-medium foraminifera sand grading upward to silt. All laminations inclined about 10° to horizontal.

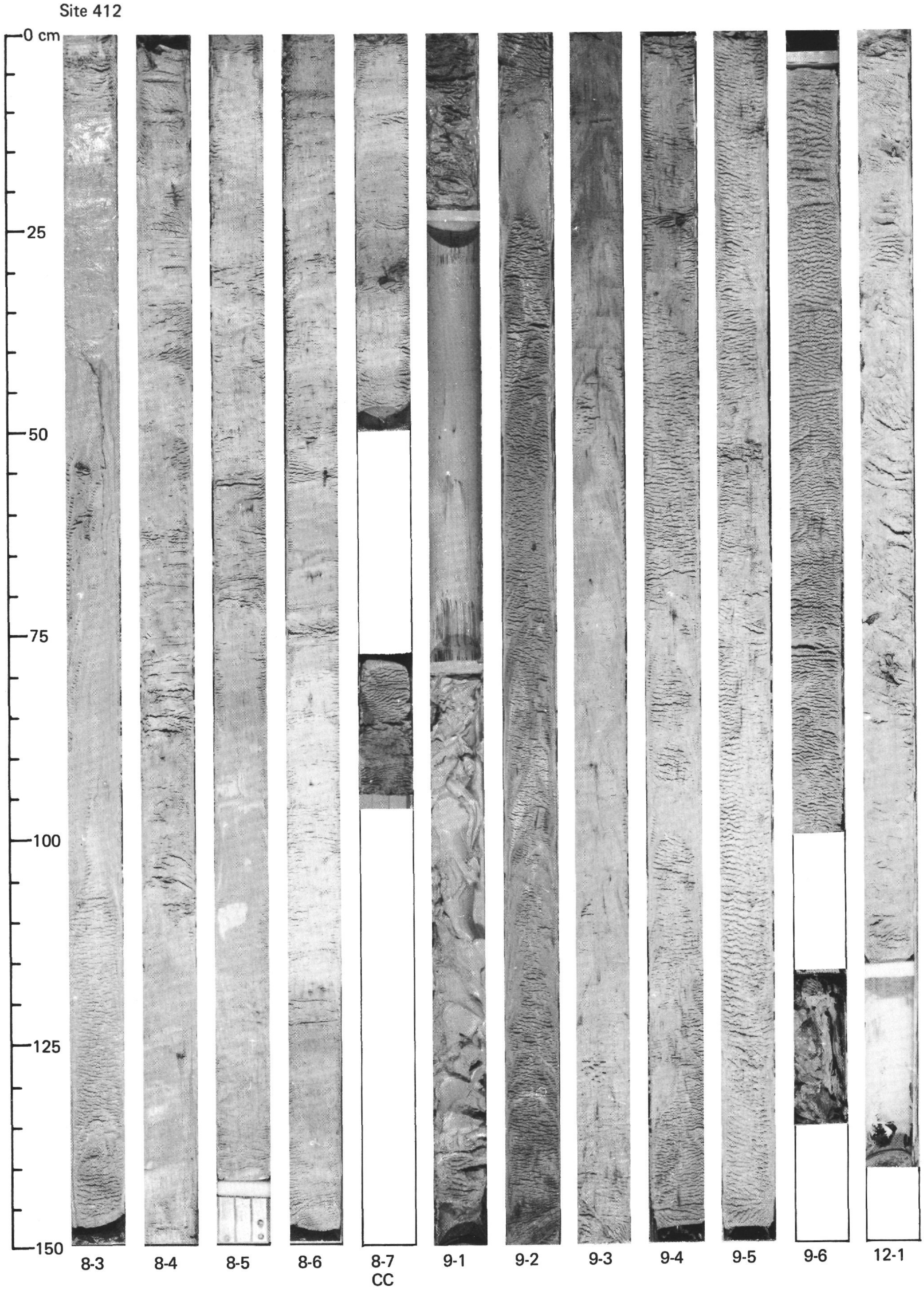
Shipboard Data

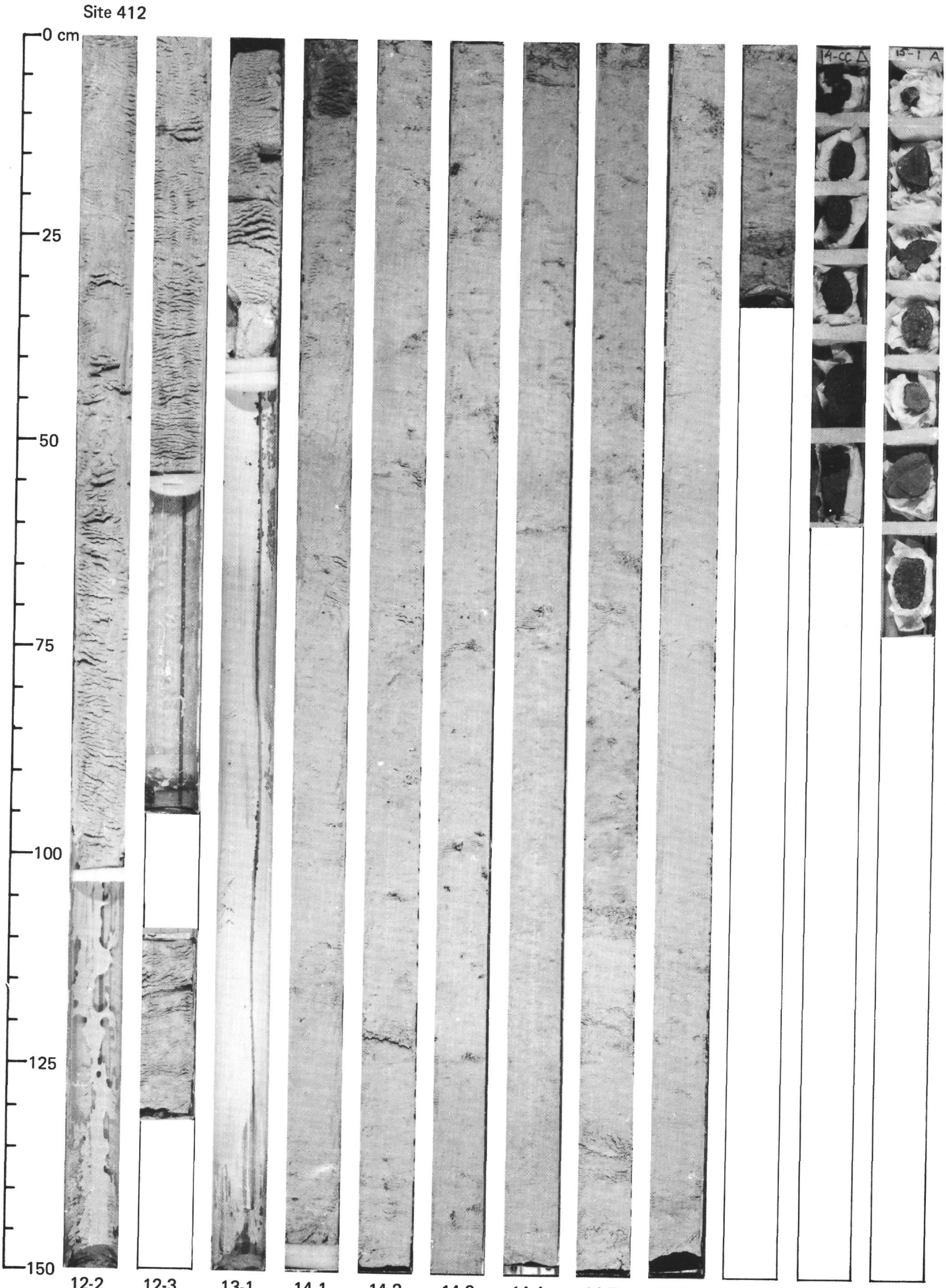
	Vp	NRM	Inc.
Sect. 1, 25 cm:	5.34	987	-47°
Sect. 2, 100 cm:	4.96	1021	-23°
Sect. 3, 80 cm:	5.37	––	––
Sect. 4, 100 cm:	5.22	3253	-44°
Sect. 5, 40 cm:	5.73	264	-70°


Site 412
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
CC
2-1
2-2
2-3
2-4
2-5
2-6
2-7
3-1
3-2

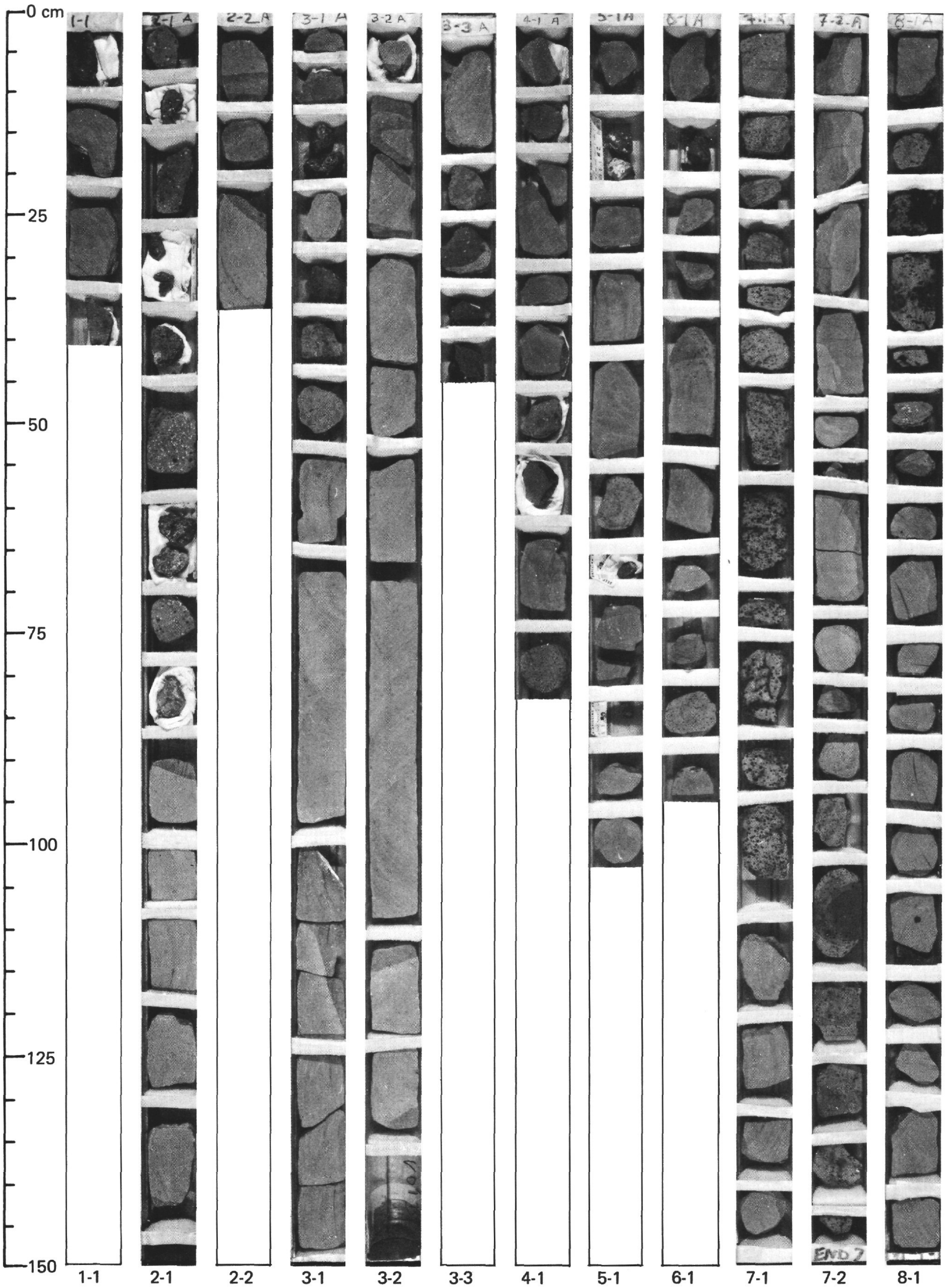

Site 412
0 cm
25
50
75
100
125
150
3-3
3-4
3-5
3-6
3-7
CC
4-1
4-2
4-3
4-4
4-5
4-6
4, CC


Site 412
0 cm
25
50
75
100
125
150
5-1
5-2
5-3
5-4
CC
6-1
6-2
6-3
6-4
CC
7-1
7-2
CC
8-1
8-2

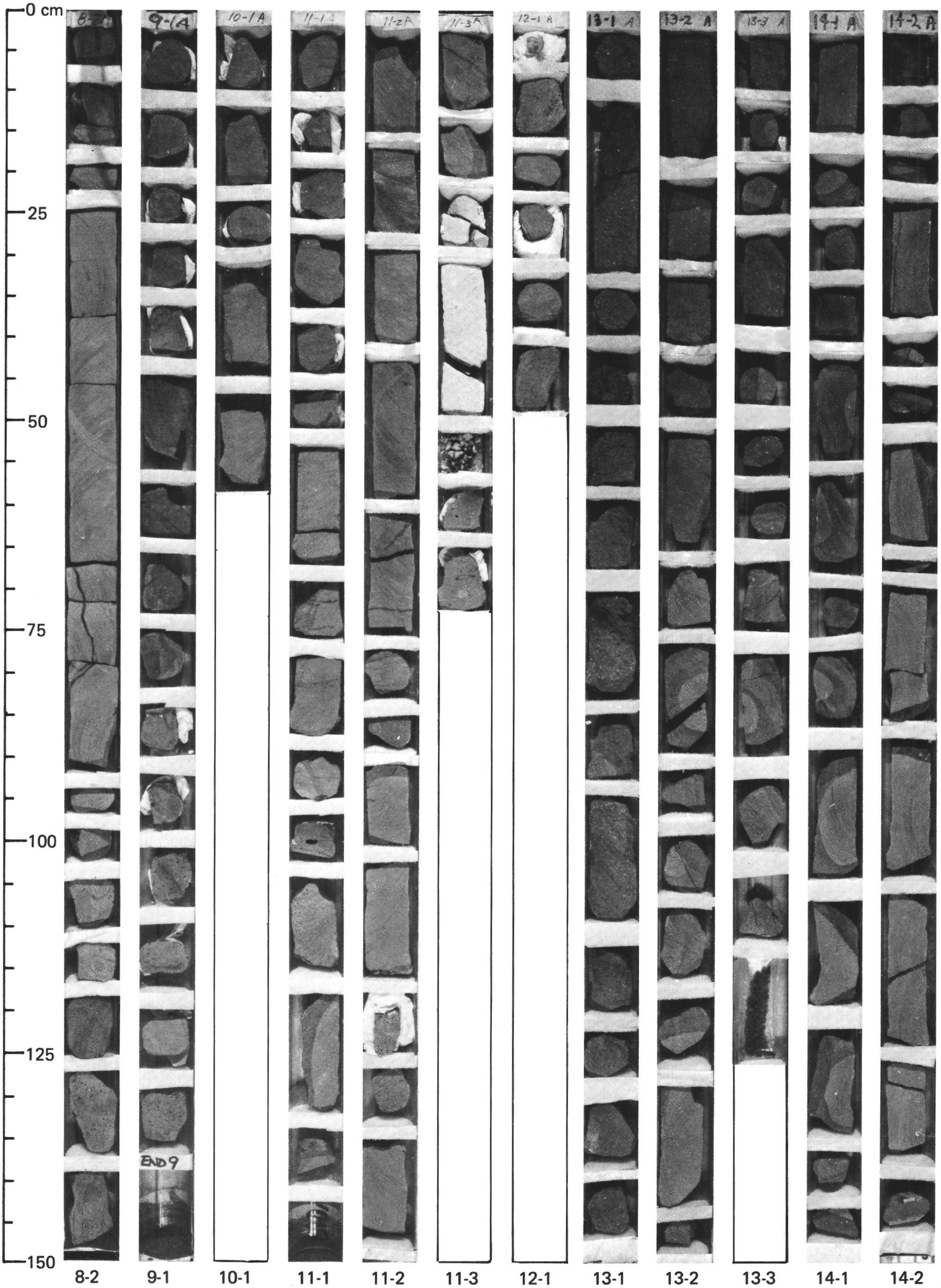

Site 412
0 cm
25
50
75
100
125
150
8-3
8-4
8-5
8-6
8-7
CC
9-1
9-2
9-3
9-4
9-5
9-6
12-1

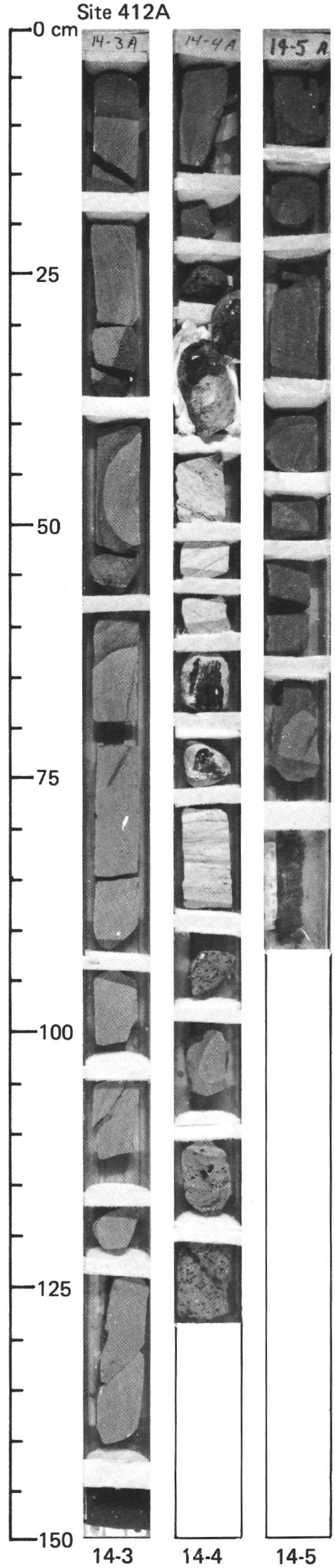

Site 412
0 cm
25
50
75
100
125
150
12-2
12-3
13-1
14-1
14-2
14-3
14-4
14-5
14-6
14-7
14, CC
15-1

Site 412A



Site 412A


0 cm
25
50
75
100
125
150
8-2
9-1
10-1
11-1
11-2
11-3
12-1
13-1
13-2
13-3
14-1
14-2


Site 412A
0 cm
25
50
75
100
125
150
14-3A
14-4A
14-5 A
14-3
14-4
14-5