3. SITE 448: PALAU-KYUSHU RIDGE

Shipboard Scientific Party[1]

HOLES 448, 448A

Date occupied: 13 February 1978

Date departed: 26 February 1978

Time on hole (hrs): 99 (Hole 448); 203.5 (Hole 448A)

Position: 16°20.46′N; 134°52.45′E

Water depth (sea level; corrected m, echo-sounding): 3483

Water depth (rig floor; corrected m, echo-sounding): 3493

Penetration (m): 584.5 (Hole 448); 914 (Hole 448A)

Number of cores: 65 (Hole 448); 66 (Hole 448A)

Total length of cored section (m): 583 (Hole 448); 467.5 (Hole 448A)

Total core recovered (m): 234 (Hole 448); 214.7 (Hole 448A)

Core recovery (%): 40 (Hole 448); 46 (Hole 448A)

Oldest sediment cored:

Depth sub-bottom (m): 456 (Hole 448); 802.2 (Hole 448A)

Nature: Volcaniclastic breccia (Hole 448); laminated fine vitric tuff (Hole 448A)

Age: Middle Oligocene—NP 23 (Hole 448); Middle Oligocene—NP 23 (Hole 448A)

Measured velocity (km/s): 2.0–2.9 (Hole 448); 2.1 (Hole 448A)

Basement: Oceanic basement was not reached in either hole. But arc basement, defined by the first arc-type lavas encountered, was reached.

Basalt flows with interbedded volcaniclastics were first drilled at 319.5 meters sub-bottom in Hole 448; measured velocity range was 3.3–4.3 km/s.

Basalt flows with interbedded volcaniclastics were first reached at 291 meters sub-bottom in Hole 448A; measured velocity—4.3 km/s.

Principal results: Site 448 is located on the western edge of the Palau-Kyushu Ridge. Two holes, 448 and 448A, were drilled at the site. The former was terminated at 583 meters sub-bottom because no core was recovered in the bottom 28.5 meters drilled. Hole 448A was terminated at 914 meters sub-bottom, despite good drilling conditions, because of scheduling commitments for the balance of the Leg. Except for several cored intervals missed in Hole 448, Hole 448A was washed to 527 meters, just above the depth at which the last core was recovered in the first hole. Hole 448 was tied stratigraphically both by paleontologic and lithologic horizons; Hole 448A encountered equivalent horizons approximately 19 meters above those in the former hole. Also, the decrease in the drilling rate at the first basalt encountered in each hole was used for correlation.

The combined sequence of units penetrated in the two sections, from top to bottom, is as follows: Unit 1, 107.5 meters of pale-brown nannofossil ooze deposited from the middle Miocene to late Oligocene; Unit 2, 64 meters of gray to grayish brown, mottled nannofossil chalk of the upper Oligocene; Unit 3, 14 meters of olive-gray interbedded chalk and tuff deposited from the middle to late Oligocene; Unit 4, 95 meters of greenish gray tuffs and lithic tuffs deposited in the middle Oligocene; Unit 5, 39 meters of interbedded pale-yellow to white nannofossil chalk and brown to gray fine vitric and vitric tuff deposited in the middle Oligocene; below Unit 5 lie 17 to 20 units of basalt flows interbedded with 20 units of volcaniclastic sediments, and 7 to 10 dikes and sills. The basalts range from aphyric to plagioclase-clinopyroxene-orthopyroxene-pigeonite-olivine phyric; two of them contain cognate breccias. Volcaniclastic sediments range from coarse, unsorted, unoriented breccias through tuffaceous breccias, tuffs, and fine tuffs with either yellowish brown or dark-green colors prevailing. Clasts in the breccias are predominantly tholeiitic basalts but rare andesitic(?) extrusive and dioritic intrusive clasts are also present. Native copper veinlets are found throughout much of the breccias. Three breccias adjacent to dikes were hydrothermally altered at moderate temperatures and contain disseminated pyrite and chalcopyrite(?) rather than native copper. The oldest paleontologic age, obtained 100 meters above the bottom of Hole 448A, is middle Oligocene. Strata are inclined from 15° to 45°, increasing down-section.

BACKGROUND AND OBJECTIVES

The crustal evolution during initiation and growth of island arcs is considered one way by which continents may have been created from oceanic lithosphere. The chemical processes associated with repeated magmatic and related metamorphic events that operate in island arcs and facilitate the crustal evolution are also thought to be associated with the metallogenesis and emplacement of ore deposits. Yet, relatively little first-hand knowledge of the processes involved in the origin and evolution of active island arcs is available, and even less is known about the remnant or back arcs associated with marginal basin complexes. The objective of drilling Site 448 on the Palau-Kyushu remnant arc was to add to the understanding of the origin and petrological evolution of remnant arcs.

The origins of interarc basins have been linked by various hypotheses to that of island arcs (Karig, 1971, 1975; Uyeda and Ben-Avraham, 1972; Hilde et al., 1977). Therefore by drilling into the western flank of the Palau-Kyushu Ridge at Site 448 (Fig. 1) an investigation into the genetic role of the Palau-Kyushu Ridge in both the tectonic events of the West Philippine Basin to the west and the development of the Parece Vela Basin to the east was planned. Significant questions posed were:

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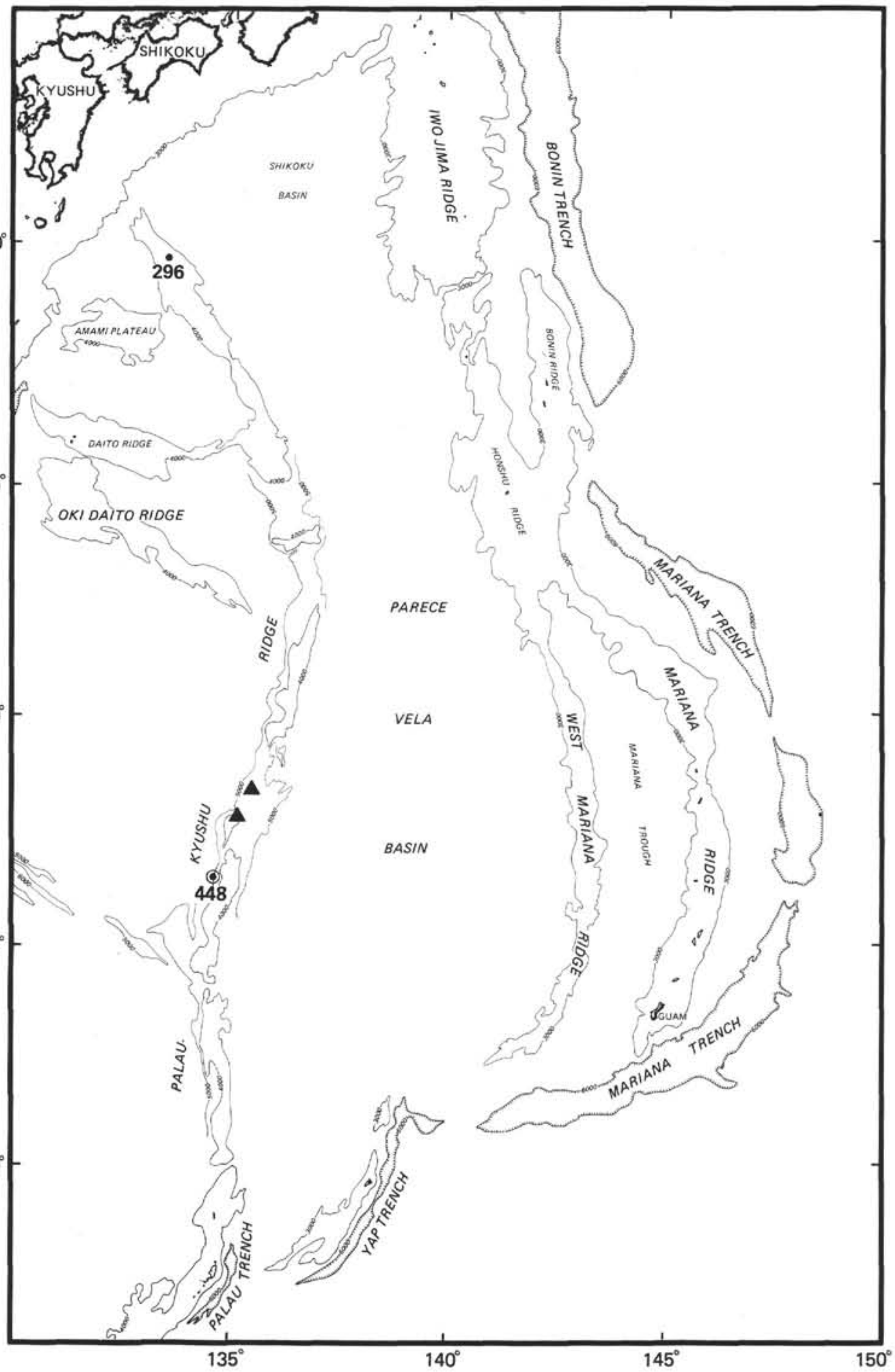


Figure 1. Location of Site 448 and geographic features discussed in the text for the Palau-Kyushu Ridge and vicinity. (The concentric point locates Site 448 [Holes 448 and 448A] and the solid circle locates Site 296 on the Palau–Kyushu Ridge. The two triangles north of Site 448 are stations 1397 and 1396 [northward, respectively] dredged by the *Dmitry Mendeleev* in 1976 [International Working Group on the IGCP Project "Ophiolites," 1977].)

Are major events in the arcs reflected in the history of the basins; e.g., does the timing of onset and cessation of subduction along with other tectonic events in the arcs correlate with sedimentary, tectonic, or igneous events in the basins? Are basin vertical tectonics in the back-arc region related to the timing of arc tectonics? How accurately are volcanic episodes on the arcs recorded within sedimentary columns of the adjacent basins? Is the petrological history of volcanism on the Palau-Kyushu and West Mariana remnant arcs comparable to that on the active Mariana arc? Can a petrological evolutionary trend be recognized from arc to arc or does each arc individually repeat the same intra-arc trends? Is there any indication from the petrology and geophysics where and at what point in arc evolution a marginal basin begins to form? Does the volcanism on a remnant arc cease as soon as a marginal basin begins to form? Obviously, the answers to such questions must be sought by drilling not only within the basins but also within the arcs themselves, such as at Site 448.

The northern end of the Palau-Kyushu Ridge was drilled on DSDP Leg 31 at Site 296 (Karig, Ingle, et al., 1975). Although arc igneous basement was never reached, 634 meters of lower to upper Oligocene volcaniclastic debris were encountered below 453 meters of upper-Oligocene to Pleistocene ash-bearing, clay-rich nannofossil oozes and chalks. Pyroxene andesites formed the major lithic type. The boundary between the calcareous upper and the volcaniclastic lower part of the section is interpreted as marking the initiation of spreading of the Parece Vela Basin in the late Oligocene.

Limited geophysical data for the Palau-Kyushu Ridge were available prior to drilling. Murauchi et al. (1968) note that crustal thickening beneath the Palau-Kyushu Ridge is associated mainly with the 3.5- and 5.7-km/s layers (2.5 and 2.9 km thick, respectively) and that the thickness of Layer 3 (3.56 km of 6.6-km/s material) is almost normal. Site surveying in preparation for drilling revealed a broad, relatively flat crestal region of the Palau-Kyushu Ridge located immediately to the north of the refraction line of Murauchi et al. (1968) and about 150 km south of the proposed Active Margin Panel drilling transect. Based on the seismic-refraction measurements, sediment on the crest of the ridge is interpreted to be thick except near isolated peaks. Volcanic rocks, dredged from a steep westward face in the southwestern corner of the surveyed area, are reported to be very vesicular, suggesting emplacement at shallow depths (perhaps even under emergent conditions).

Some petrological information in addition to the high vesicularity of the rocks was available prior to drilling at Site 448. Subalkalic basalts, basaltic andesites, andesites, two-pyroxene gabbros, and low-grade pumpellyite-prehnite or greenschist-facies metamorphic rocks were reported to have been dredged from the Palau-Kyushu Ridge (International Working Group on the IGCP Project "Ophiolites," 1977). Study of these rocks by the working group has shown petrological trends typical of island arcs. According to the group, arc volcanic activity ceased during the Oligocene.

A detailed site survey, conducted by Lamont-Doherty Geological Observatory (L-DGO) prior to Leg 59, had delineated an extensive, high region of the Palau-Kyushu Ridge nearly 2° south of the 18°N transect. The survey, made up of a series of closely spaced traverses (Fig. 2), revealed two ridges in the northern part of the survey area (Fig. 3) about 30 km apart, separated by a steep-walled axial valley at the crest of the Palau-Kyushu Ridge. Here the ridge itself appears to have two small right lateral offsets, which are suggestive of east-west trending transcurrent faults. The site initially targeted for drilling was located near the western flank of the westernmost ridge (Fig. 4). As can be seen in the reflection profile, the area appears to be devoid of any sediment cover; apparently, the presence of thick sediment had been inferred from the recognition of a thick 3.5-km/s layer in the seismic-refraction data of Murauchi et al. (1968).

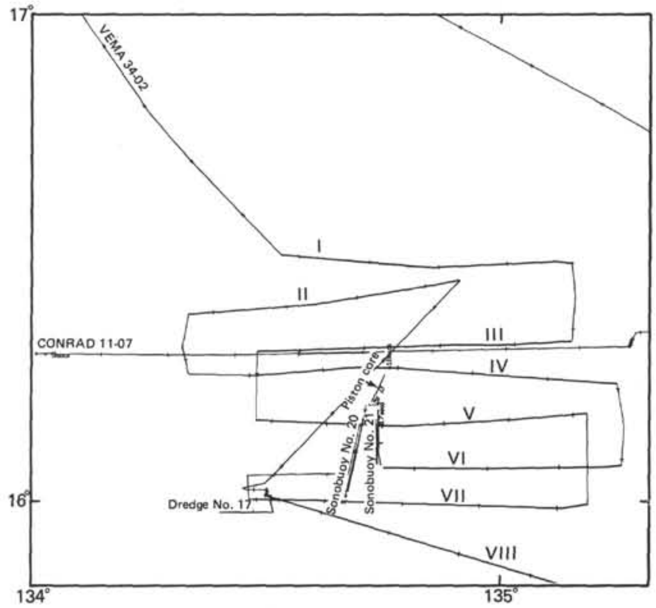


Figure 2. Location of L-DGO Site Survey track lines in the vicinity of Site 448 (*Conrad* 11-07 and *Vema* 34-02 cruises, 1977).

The objectives of drilling the Palau-Kyushu Ridge at Site 448 were as follows:

1) to determine the sedimentary history and the environment of deposition on a remnant arc;

2) to determine the age and petrologic evolution of the arc volcanism and compare it with that of the West Mariana remnant arc and the Mariana active arc;

3) to determine the timing and style of formation of deep structures within the Palau-Kyushu Ridge and relate this to arc tectonic evolution and adjacent basin evolution; and

4) to determine the paragenesis of hydrothermal metamorphism and its role in arc metallogenesis.

Because the presite survey seismic-reflection profiles did not give any indication of the presence of sediment or the depth of true arc basement at the site originally targeted (and because sediment thickness there had been interpreted on the basis of seismic-refraction data), it seemed advantageous for us to move the site farther to the south where a sediment pond was known to exists. Thus, the site was relocated about 4.5 km south of the initial target site in a steep-walled valley containing about 0.25 s of ponded transparent sediment (Fig. 5), which was adequate to spud into and bury the bottom hole assembly.

OPERATIONS

Site 448 is located about 190 km southeast of Site 447. The vessel arrived in the area about 0100 local time (L) on 13 February, at which time presite surveying

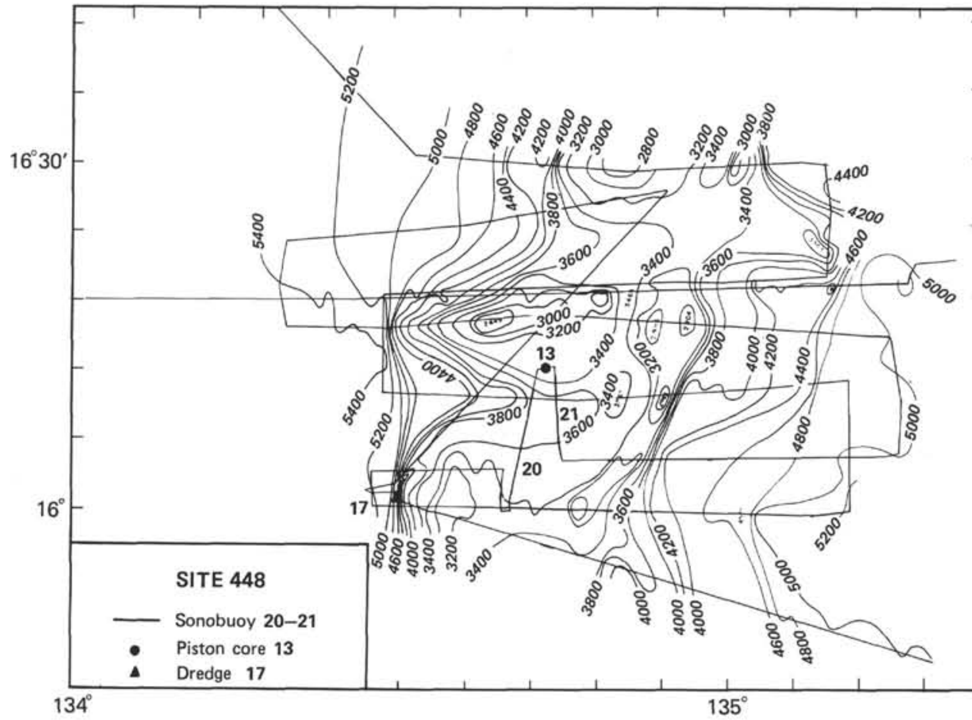


Figure 3. Bathymetry in the vicinity of Site 448 (according to L-DGO Site Survey data). (Depth is indicated in 200-meter intervals.)

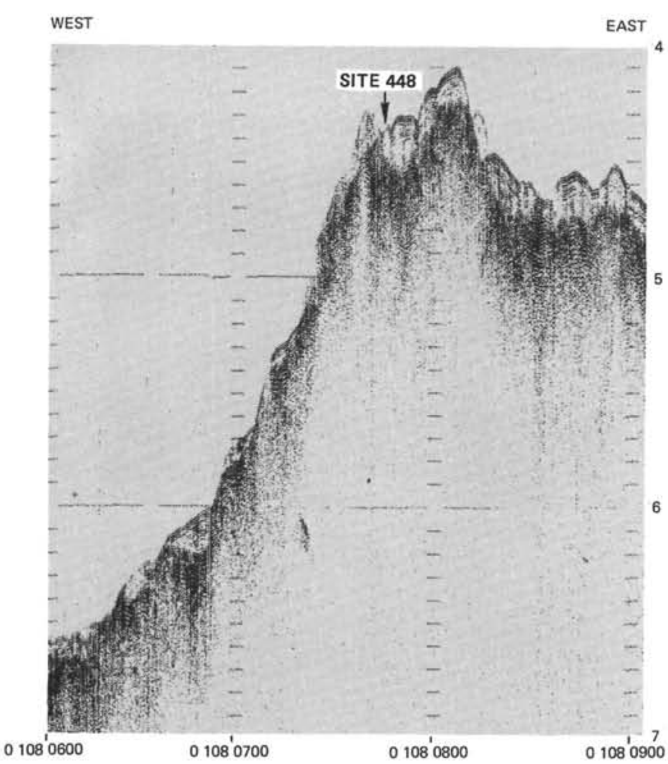


Figure 4. Seismic-reflection profile (L-DGO Site Survey data) showing original Site 448 location.

began (Fig. 6). The proposed drill site lay in a relatively small sediment pond, and precise coordination with a reference profile of an earlier site survey was essential. Unfortunately, the critical reference profile of the earlier survey was mislocated some distance west of where it should have been, and we had to spend five additional profiling hours to locate it. On arrival at the target site, the reflection profile did not reveal sufficient sediment for spudding in; an alternate site was chosen about 4.5 km south of the initial target site in a steep-walled valley where an adequate sediment thickness was located.

Hole 448

After the beacon was dropped and the ship positioned, the drill string was run to just above the sea floor. The water depth by precision depth recorder (PDR) was 3493 meters. After the bit had been lowered to 3498.5 meters the core barrel was retrieved; however, no sediment was recovered. Another 9.5-meter joint of pipe was added and the procedure repeated. Rig-weight indication and the position of the core recovered placed the water depth at about 3503 meters.

About 170 meters of calcareous ooze was cored, followed down-hole by a sequence of vitric tuffs (Table 1). The first basalt flow probably was encountered at about 320 meters sub-bottom where the drilling rate substantially decreased; unfortunately no basalt was recovered until 337.5 meters sub-bottom. Farther down-core the basalt tended to be highly vesicular with flows alternating with volcaniclastic breccia and tuffs to total

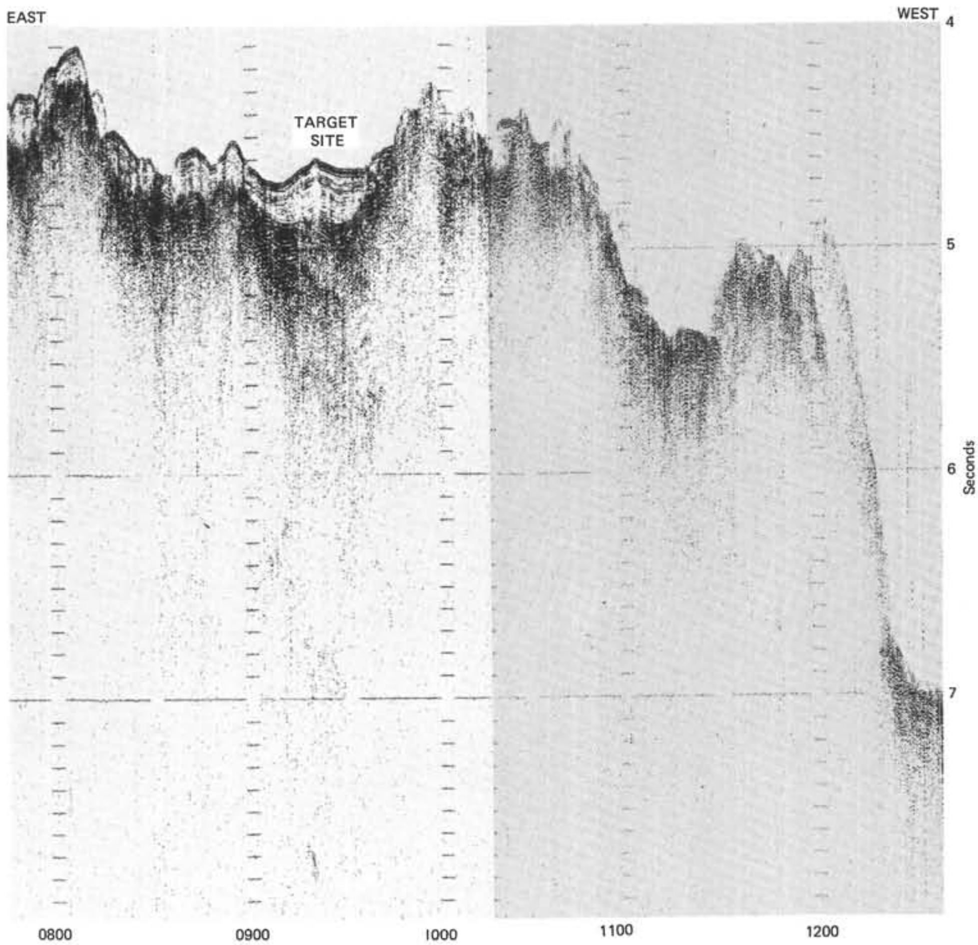


Figure 5. Seismic-reflection profile (L-DGO Site Survey data) showing steep-walled valley containing ponded sediment in the vicinity of the relocated Site 448.

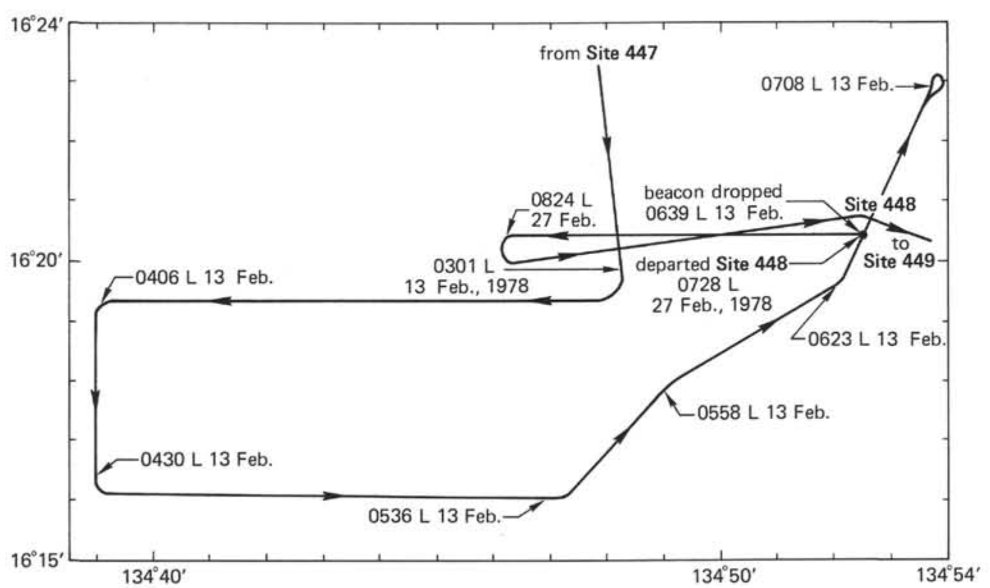


Figure 6. Track of the *Glomar Challenger* in the vicinity of Site 448 showing details of pre- and postsite surveys. (The solid circle marks the position of the beacon.)

Table 1. Coring summary for Holes 448 and 448A.

Core No.	Date (February, 1978)	Local Time (L)	Depth from Drill Floor (m; top–bottom)	Depth below Sea Floor (m; top–bottom)	Length Cored (m)	Length Recovered (m)	Recovery (%)
Hole 448							
1	13	1620	3503.0–3508.0	0.0– 5.0	5.0	2.9	58.0
2	13	1725	3508.0–3517.5	5.0– 14.5	9.5	9.5	100.0
3	13	1825	3517.5–3527.0	14.5– 24.0	9.5	3.5	36.8
4	13	1925	3527.0–3536.5	24.0– 33.5	9.5	9.1	95.8
5	13	2035	3536.5–3546.0	33.5– 43.0	9.5	1.6	16.8
6	13	2155	3546.0–3555.5	43.0– 52.5	9.5	6.2	65.3
7	13	2300	3555.5–3565.0	52.5– 62.0	9.5	1.5	15.8
8	13	2359	3565.0–3574.5	62.0– 71.5	9.5	5.9	62.1
9	14	0103	3574.5–3584.0	71.5– 81.0	9.5	0.0	0.0
10	14	0201	3584.0–3593.5	81.0– 90.5	9.5	9.4	99.0
11	14	0303	3593.5–3603.0	90.5–100.0	9.5	9.7	102.1
12	14	0404	3603.0–3612.5	100.0–109.5	9.5	9.0	94.7
13	14	0504	3612.5–3622.0	109.5–119.0	9.5	9.6	101.1
14	14	0700	3622.0–3631.5	119.0–128.5	9.5	8.0	84.2
15	14	0800	3631.5–3641.0	128.5–138.0	9.5	9.0	94.7
16	14	0905	3641.0–3650.5	138.0–147.5	9.5	9.5	100.0
17	14	1015	3650.5–3660.0	147.5–157.0	9.5	9.5	100.0
18	14	1128	3660.0–3669.5	157.0–166.5	9.5	0.0	0.0
19	14	1239	3669.5–3679.0	166.5–176.0	9.5	6.9	72.6
20	14	1345	3679.0–3688.5	176.0–185.5	9.5	3.7	38.9
21	14	1500	3688.5–3698.0	185.5–195.0	9.5	5.2	54.7
22	14	1620	3698.0–3707.5	195.0–204.5	9.5	1.3	13.7
23	14	1730	3707.5–3717.0	204.5–214.0	9.5	1.5	15.8
24	14	1855	3717.0–3726.5	214.0–223.5	9.5	3.7	38.9
25	14	2008	3726.5–3736.0	223.5–233.0	9.5	5.0	52.6
26	14	2135	3736.0–3745.5	233.0–242.5	9.5	5.3	55.8
27	14	2250	3745.5–3755.0	242.5–252.0	9.5	4.7	49.5
28	14	2353	3755.0–3764.5	252.0–261.5	9.5	2.6	27.4
29	15	0055	3764.5–3774.0	261.5–271.0	9.5	5.1	53.7
30	15	0205	3774.0–3783.5	271.0–280.5	9.5	0.3	3.2
31	15	0302	3783.5–3793.0	280.5–290.0	9.5	4.6	48.4
32	15	0408	3793.0–3802.5	290.0–299.5	9.5	0.1	1.0
33	15	0509	3802.5–3812.0	299.5–309.0	9.5	0.2	2.1
34	15	0635	3812.0–3821.5	309.0–318.5	9.5	3.0	31.6
35	15	0805	3821.5–3831.0	318.5–328.0	9.5	1.1	11.6
36	15	0919	3831.0–3840.5	328.0–337.5	9.5	trace	0.0
37	15	1408	3840.5–3850.0	337.5–347.0	9.5	1.8	18.9
38	15	1526	3850.0–3855.0	347.0–352.0	5.0	1.7	37.8
39	15	1526	3855.0–3859.5	352.0–356.5	4.5	2.8	62.2
40	15	1904	3859.5–3869.0	356.5–366.0	9.5	3.2	33.7
41	15	2038	3869.0–3874.5	366.0–371.5	5.5	2.3	41.8
42	15	2152	3874.5–3878.5	371.5–375.5	4.0	0.1	2.5
43	15	2316	3878.5–3888.0	375.5–385.0	9.5	1.5	15.8
44	16	0045	3888.0–3897.5	385.0–394.5	9.5	1.6	16.8
45	16	0415	3897.5–3907.0	394.5–404.0	9.5	0.0	0.0
46	16	0835	3907.0–3916.5	404.0–413.5	9.5	1.4	14.7
47	16	0953	3916.5–3926.0	413.5–423.0	9.5	1.7	17.9
48	16	1130	3926.0–3935.5	423.0–432.5	9.5	4.4	46.3
49	16	1250	3935.5–3945.0	432.5–442.0	9.5	0.8	8.4
50	16	1455	3945.0–3954.5	442.0–451.5	9.5	7.3	76.8
51	16	1638	3954.5–3964.0	451.5–461.0	9.5	4.9	51.6
52	16	1818	3964.0–3973.5	461.0–470.5	9.5	2.1	22.1
53	16	1953	3973.5–3983.0	470.5–480.0	9.5	2.6	21.0
54	16	2140	3983.0–3992.5	480.0–489.5	9.5	0.3	3.2
55	16	2310	3992.5–4002.0	489.5–499.0	9.5	3.7	38.9
56	17	0118	4002.0–4011.5	499.0–508.5	9.5	6.9	72.6
57	17	0350	4011.5–4021.0	508.5–518.0	9.5	2.1	22.1
58	17	0558	4021.0–4030.5	518.0–527.5	9.5	6.8	71.6
59	17	0743	4030.5–4040.0	527.5–537.0	9.5	3.6	37.9
60	17	1140	4040.0–4049.5	537.0–546.5	9.5	0.1	1.0

Table 1. (Continued).

Core No.	Date (February, 1978)	Local Time (L)	Depth from Drill Floor (m; top-bottom)	Depth below Sea Floor (m; top-bottom)	Length Cored (m)	Length Recovered (m)	Recovery (%)
Hole 448							
61	17	1450	4049.5-4059.0	546.5-556.0	9.5	3.9	41.0
62	17	1732	4059.0-4068.5	556.0-565.5	9.5	0.0	0.0
63	17	2002	4068.5-4078.0	565.5-575.0	9.5	0.0	0.0
64	17	2140	4078.0-4083.0	575.0-580.0	5.0	0.0	0.0
65	18	0109	4083.0-4087.5	580.0-584.5	4.5	0.0	0.0
Total					584.5	235.3	40.3
Hole 448A							
1	18	1858	3503.0-3508.0	0.0- 5.0	5.0	9.4	190.0
wash							
2	18	2102	3536.5-3546.0	33.5- 43.0	9.5	9.6	101.0
wash							
3	18	2217	3565.0-3574.5	62.0- 71.5	9.5	9.3	98.0
4	18	2326	3574.5-3584.0	71.5- 81.0	9.5	9.3	98.0
wash							
5	19	0355	3726.5-3736.0	223.5-233.0	9.5	0.7	7.0
wash							
6	19	0537	3755.0-3764.5	252.0-261.5	9.5	3.8	40.0
7	19	0800	3764.5-3774.0	261.5-271.0	9.5	2.7	28.0
8	19	0910	3774.0-3783.5	271.0-280.5	9.5	4.0	42.0
9	19	1017	3783.5-3793.0	280.5-290.0	9.5	0.6	6.0
10	19	1200	3793.0-3802.5	290.0-299.5	9.5	5.0	53.0
11	19	1343	3802.5-3812.0	299.5-309.0	9.5	2.8	29.0
12	19	1745	3812.0-3847.0	309.0-344.0	35.0	1.1	wash
13	20	0845	3847.0-3987.5	344.0-484.5	140.5	4.0	wash
14	20	2105	3987.5-4030.5	484.5-527.5	43.5	7.0	wash
15	20	2305	4030.5-4040.0	527.5-537.0	9.5	6.2	65.0
16	21	0115	4040.0-4049.5	537.0-546.5	9.5	3.3	35.0
17	21	0307	4049.5-4052.5	546.5-549.5	3.0	2.2	73.0
18	21	2140	4052.5-4059.0	549.5-556.0	6.5	1.0	15.0
19	21	2330	4059.0-4068.5	556.0-565.5	9.5	0.6	6.0
20	22	0127	4068.5-4078.0	565.5-575.0	9.5	5.0	53.0
21	22	0338	4078.0-4087.5	575.0-584.5	9.5	0.9	9.0
22	22	0658	4087.5-4097.0	584.5-594.0	9.5	1.6	17.0
23	22	0935	4097.0-4106.5	594.0-603.5	9.5	0.1	1.0
24	22	1112	4106.5-4110.5	603.5-607.5	4.0	0.9	22.0
25	22	1238	4110.5-4116.0	607.5-613.0	5.5	3.1	56.0
26	22	1455	4116.0-4120.5	613.0-617.5	4.5	4.1	91.0
27	22	1615	4120.5-4125.5	617.5-622.5	5.0	2.2	44.0
28	22	1835	4125.5-4135.0	622.5-632.0	9.5	1.0	4.6
29	22	2045	4135.0-4144.5	632.0-641.5	9.5	0.3	3.2
30	22	2228	4144.5-4154.0	641.5-651.0	9.5	5.5	58.0
31	23	0025	4154.0-4163.5	651.0-660.5	9.5	0.7	7.4
32	23	0205	4163.5-4166.5	660.5-663.5	3.0	2.0	67.0
33	23	0415	4166.5-4173.0	663.5-670.0	6.5	4.1	63.0
34	23	0608	4173.0-4182.5	670.0-679.5	9.5	5.2	55.0
35	23	0748	4182.5-4192.0	679.5-689.0	9.5	6.0	63.0
36	23	0945	4192.0-4201.5	689.0-698.5	9.5	5.3	56.0
37	23	1215	4201.5-4211.0	698.5-708.0	9.5	3.0	30.0
38	23	1430	4211.0-4215.5	708.0-712.5	4.5	2.4	53.0
39	23	1615	4215.5-4220.5	712.5-717.5	5.0	2.6	52.0
40	23	2015	4220.5-4230.0	717.5-727.0	9.5	3.5	38.0
41	23	2320	4230.0-4239.5	727.0-736.5	9.5	3.7	39.0
42	24	0145	4239.5-4249.0	736.5-746.0	9.5	6.2	65.0
43	24	0355	4249.0-4258.5	746.0-755.5	9.5	3.9	41.0
44	24	0601	4258.5-4268.0	755.5-765.0	9.5	2.0	21.0
45	24	0805	4268.0-4271.0	765.0-768.0	3.0	1.7	57.0
46	24	1115	4271.0-4277.5	768.0-774.5	6.5	1.9	29.0
47	24	1309	4277.5-4282.5	774.5-779.5	5.0	4.3	86.0
48	24	1630	4282.5-4286.5	779.5-783.5	4.0	0.9	22.0
49	24	1900	4286.5-4295.5	783.5-792.5	9.0	5.1	57.0
50	24	2126	4295.5-4304.5	792.5-801.5	9.0	3.8	42.0

Table 1. (Continued).

Core No.	Date (February, 1978)	Local Time (L)	Depth from Drill Floor (m; top-bottom)	Depth below Sea Floor (m; top-bottom)	Length Cored (m)	Length Recovered (m)	Recovery (%)
Hole 448A							
51	25	0030	4304.5-4313.5	801.5-810.5	9.0	4.1	46.0
52	25	0353	4313.5-4322.5	810.5-819.5	9.0	3.6	40.0
53	25	0552	4322.5-4331.5	819.5-828.5	9.0	3.7	41.0
54	25	0922	4331.5-4340.5	828.5-837.5	9.0	2.9	32.0
55	25	1135	4340.5-4343.5	837.5-840.5	3.0	2.4	80.0
56	25	1510	4343.5-4349.5	840.5-846.5	6.0	2.4	40.0
57	25	1904	4349.5-4358.5	846.5-855.5	9.0	3.0	33.0
58	25	2224	4358.5-4367.5	855.5-864.5	9.0	3.5	39.0
59	26	0152	4367.5-4372.0	864.5-869.0	4.5	3.2	71.0
60	26	0550	4372.0-4381.0	869.0-878.0	9.0	3.6	40.0
61	26	0840	4381.0-4390.0	878.0-887.0	9.0	3.2	36.0
62	26	1145	4390.0-4399.0	887.0-896.0	9.0	1.8	20.0
63	26	1518	4399.0-4403.0	896.0-900.0	4.0	2.6	65.0
64	26	1756	4403.0-4408.0	900.0-905.0	5.0	4.0	80.0
65	26	2115	4408.0-4413.5	905.0-910.5	5.5	4.2	76.0
66	27	0640	4413.5-4417.0	910.5-914.0	3.5	2.8	80.0
Total					486.5	214.6	44.1

depth. Most of the volcanic material, including the basalts, tended to disintegrate, and a low recovery rate prevailed. The tendency of the material to disintegrate, however, resulted in a relatively rapid rate of penetration. The high vesicularity of the basalts seemed to facilitate this disintegration.

On several occasions empty inner core barrels failed to produce sufficient pump pressure upon arrival at the bit. This indicated an obstruction, probably a core fragment, which prevented the barrel from seating properly and becoming latched down. Repeated runs with the bit depluggers successfully dislodged the obstruction.

Despite low core recovery, some core consistently entered the core barrel before the core catcher or liner became jammed. Core 61 recovered 3.9 meters of basalt, but following this no core was recovered in four attempts over a 28.5 meter interval. Penetration rate and all drilling parameters were normal, except that torque was abnormally low. Two runs with the bit deplugger were followed by unsuccessful core attempts. It was concluded that some component of the bit or down-hole coring equipment was malfunctioning, and the hole was terminated because of the inability to recover core.

When the drill string was retrieved, the bit was found to be in excellent condition; no fault was found with the remainder of the coring system. The close tolerance between the core diameter and inner diameter of the core barrel may have prevented recovery.

Hole 448A

Following the bit change, the drill string was again lowered with the goal of significant additional penetration. This was considered feasible in light of the fact that the previous bit had penetrated 245 meters of igneous section and was in good condition after 23.3 rotating hours.

The round trip was delayed 2.25 hours because of mechanical problems with the pipe-racker skate and air-control valving. The second hole at Site 448 was spudded in at 1815 hours on 18 February and a mudline punch core was recovered. The hole was drilled ahead with spot cores taken to cover core intervals not recovered from the first hole. Continuous coring commenced at 527.5 meters sub-bottom, 57 meters above the total depth of Hole 448 (Table 1). During this period, a total of 28.5 operating hours were lost owing to successive failures of both of the ship's Bowen power subs.

Except for three extra wire-line runs, occasioned by failure of overshots to engage, no additional operational problems were encountered in continuous coring to a total depth of 914 meters sub-bottom. Although core diameter and reduced penetration rate indicated progressive bit failure, core recovery was still good when scheduling considerations forced termination of drilling operations. By 0645 L on 27 February, the last core was recovered along with the bottom-hole assembly. A short reflection-profiling survey was undertaken before departure, and by 1030 L the *Challenger* was under way for Site 449.

SEDIMENTARY LITHOLOGY

At Site 448 two holes were drilled. The first, Hole 448, penetrated 583 meters of sedimentary rocks and basalt flows. Total thickness of sediment above the uppermost flow is 319.5 meters, in which five distinct lithologic units are recognized (Fig. 7).

Unit 1, 107.5 meters thick (Cores 1 through 12), consists of upper Oligocene to middle Miocene nannofossil ooze and is mostly very pale brown and light yellowish brown throughout. The principal mottling is white (nannofossil concentration), very dark brown (iron oxides and micronodules), and light gray (foraminifers and nannofossils). Mottling is moderate to intense in Cores 4 through 6 and 11 through 13 (overlapping the boundary between Units 1 and 2). Discoasters dominate the nannofossil assemblage and decrease slightly down-hole relative to coccoliths. A few pumice fragments are scattered through all but the first core, with minor enrichments in Cores 8 and 11. Cores 2 through 11 (excluding Core 8) contain traces of volcanic glass. Zeolites occur in Cores 5 through 8 and in Core 11. The ooze is fairly homogeneous with few laminations and structures. Drilling deformation is generally intense with minor, moderately deformed zones. The base of Unit 1 is arbitrarily set near the bottom of Core 12 at the top of Section 6, which consists of drilling biscuits of indurated chalk separated by intensely disturbed layers. Relative induration is the only difference between Unit 1 and underlying Unit 2.

Unit 2, 64.1 meters thick, consists of upper Oligocene nannofossil chalk and occurs from Core 12, Section 6 to Core 19, Section 4 (except for the lowermost part of Unit 2, which is middle to upper Oligocene). The dominant colors are light gray and very pale brown, with white, grayish brown and dark grayish brown mottles. Locally, mottling is moderate to intense and is scattered throughout the unit. Pumice fragments are also commonly scattered, with minor local concentrations. The sediments have a fairly uniform iron-oxide content of about 1%. Cores 13 through 16 possess trace amounts of volcanic glass in the chalk; the first minor ash layer occurs in Core 14, Section 2, with similar minor layers in Cores 15 and 16. The ash content increases downward in Cores 17 and 19 (there was no recovery in Core 18). Core 17 sediments also contain significantly less foraminifers and radiolarians than do overlying sediments. Unit 2 displays no visible structures; drilling disturbance was moderate to intense. The contact between Units 2 and 3 falls in Core 19, Section 4 at the top of a 3.7-meter vitric tuff.

Unit 3, 13.9 meters thick, consists of middle to upper Oligocene interbedded vitric tuff and minor chalk; it occurs from Core 19, Section 4 through Core 20. The vitric tuff is generally olive-gray and dark olive-gray and contains partially devitrified silt and sand-sized glass shards. Sedimentary structures in the tuff include parallel laminations, normal grading, and load casts. The nannofossil chalk is gray to olive and occurs in four horizons from 3 to 33 cm thick in Cores 19 and 20. The contact between the base of each chalk horizon and the top of the underlying tuff is usually moderately to intensely bioturbated. Drilling disturbance in this unit varies from slight to intense, depending on lithification of the sediment.

Unit 4, Cores 21 through 30, is 95.0 meters thick and consists of middle Oligocene vitric tuff (except the uppermost part of Unit 4, where it is middle to upper Oligocene); the vitric tuff is generally greenish gray, but in lower cores is dark gray to olive-gray. Bioturbation is rare and is seen only in Cores 21, 25, and 29; this mottling and burrowing is colored gray, dark gray, olive-gray, greenish gray, and black (Fig. 8). These variations in color are locally moderate to intense in zones marking the tops of tuff beds. A green clay constitutes approximately 4% of the tuff from Core 21 down through Core 25. Feldspar, also a minor constituent of the tuff, occurs in all cores within the unit and ranges from 2 to 25% down to Core 29, at which point the percentage drops to little more than a trace for the remainder of the unit. The vitric tuff is interbedded with fine vitric tuff and tuffaceous volcaniclastic breccia in Cores 24 and 26; Cores 27 and 28 contain interbedded vitric tuff and fine vitric tuff; finally, Cores 29 and 30 are composed of fine vitric tuff alone. Graded and laminated zones are present in nearly all cores (grading is absent in Core 22). Drilling disturbance is generally slight to moderate.

Unit 5 (Cores 31 through 35) is 39.0 meters thick and consists of middle Oligocene interbedded chalk and vitric tuff locally coarser near its base. The top of the unit is a pale-yellow and white nannofossil chalk with a few interbedded thin, light-gray vitric tuff intervals, 4 to 10 cm thick. The chalk in Core 31 has localized zones of moderate to intense pale-yellow and light-gray mottling and bioturbation. Cores 32 and 33 are represented by core-catcher samples only, which contain bioturbated and mottled nannofossil chalk. Volcanic-glass content increases in these chalks from 2% in Core 31 to approximately 10% in Core 33. Core 34 is a gray-brown and olive-gray vitric tuff interbedded with 15- to 20-cm-thick minor zones of pale-yellow and white bioturbated nannofossil chalk. Core 35 is also an olive vitric tuff interbedded with minor intervals of lithic vitric tuff and pale-yellow and white bioturbated nannofossil chalk. The coarser clasts near the base of Unit 5 are weathered basalt and pumice. The drilling disturbance in this unit is uniformly moderate. No core was recovered between the core-catcher sample of Core 35 and the top of Core 37. The sediment/basalt contact probably occurs at 319.5 meters sub-bottom (Core 35); based upon drilling-rate data, the basalts of Core 37 may be representative of this missing interval.

A series of basalts interbedded with volcaniclastic breccias and tuffs begins with the basalts of Core 37 (Unit 6). As seen in Figure 7, Units 7, 10, and 12 comprise volcaniclastic lithologies. The upper breccias contain angular, unsorted, unoriented clasts of fresh vesicular plagioclase-olivine-phyric basalt set in a matrix of devitrified glass and have a clast to matrix ratio of 4:1. Lower breccias include increasing amounts of weathered basalt, altered glass fragments, and pumice, with increasing content of zeolites and carbonate cement in the matrix. Color variations from green to yellow occur in the breccia matrix down-hole and are probably the result of postdepositional changes in pore-water chemistry. Comparative reducing conditions are suggested by the green color of the breccia matrix. Yellow hues probably indicate comparative oxidizing conditions.

Hole 448 was abandoned at a depth of 583 meters because of poor core recovery and drilling problems. Using the same beacon, we drilled Hole 448A nearby in order to core sedimentary intervals unrecovered in Hole 448 and penetrate farther into basaltic material. Hole 448A penetrated a 914-meter sequence of sediment, volcaniclastic rocks, and basalt that was discontinuously cored above 223.5 meters, continuously cored be-

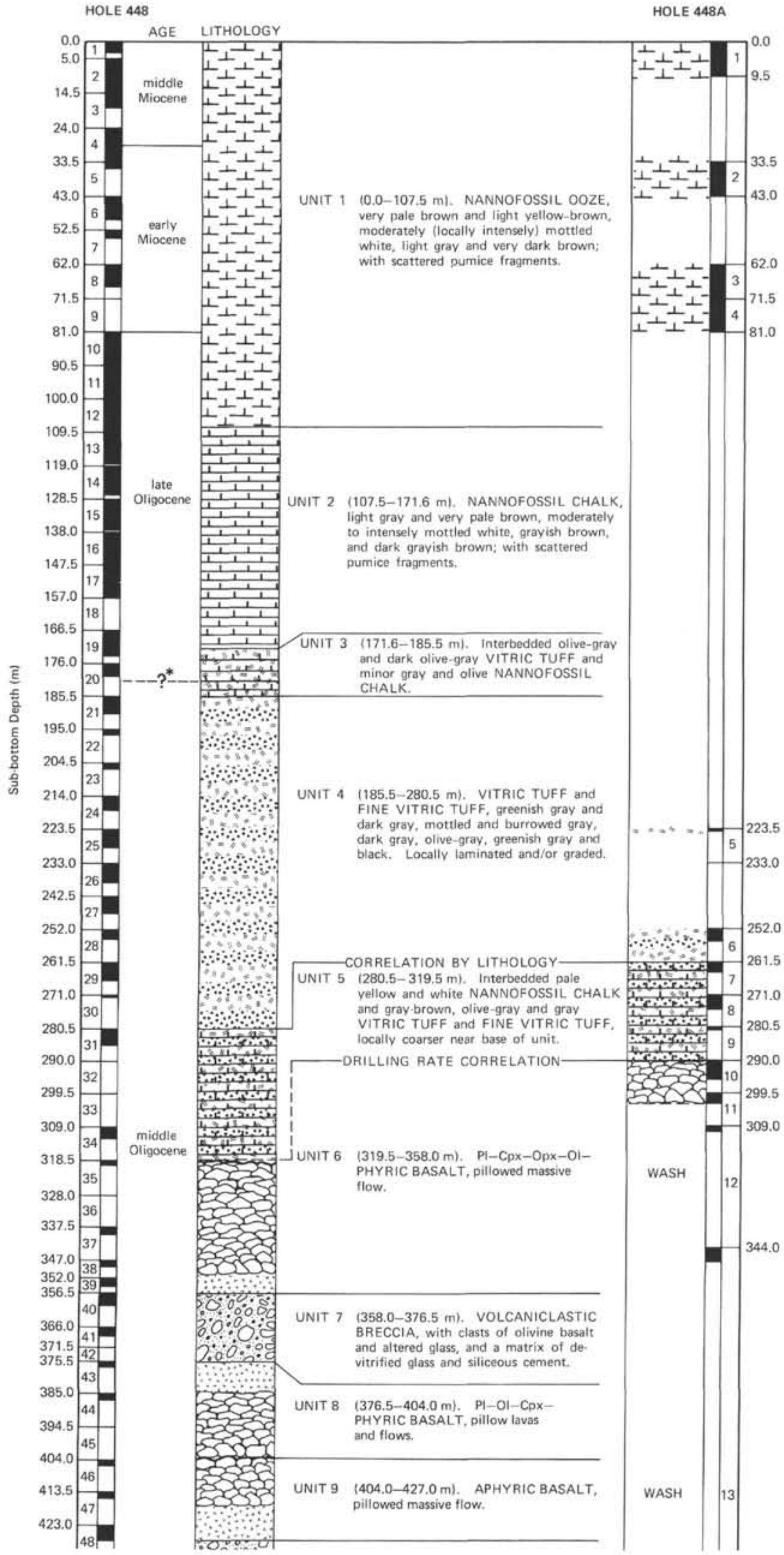
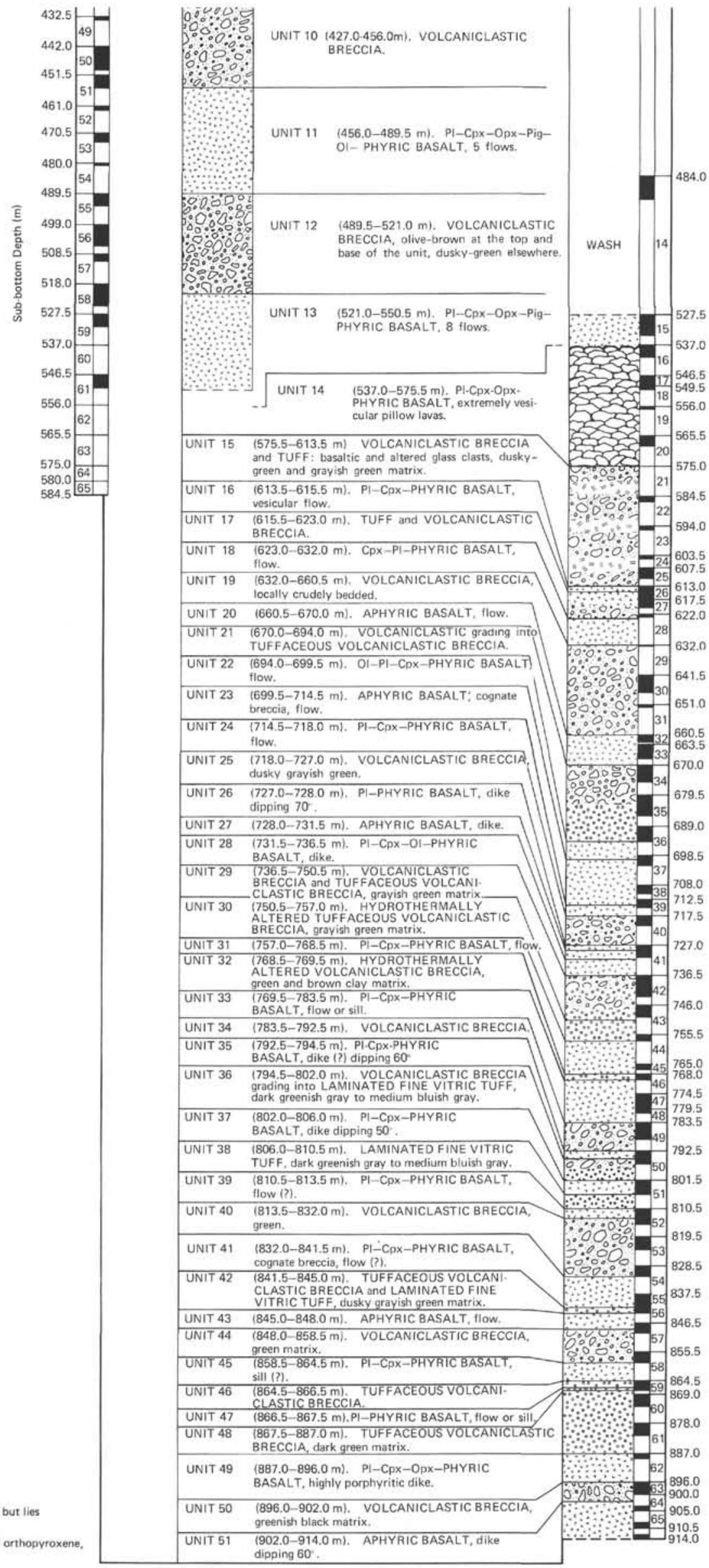


Figure 7. Lithology, age, and core recovery at Site 448 for Holes 448 and 448A. (Correlation between the holes by lithology and drilling rate is indicated. Tops of pillow-lava units are indicated by heavier outline of the uppermost pillows. Dashed line in age column indicates an imprecisely determined age boundary. Core recovery is indicated by the solid symbol. Lithologic symbols are summarized in the Introduction to this volume.)



* The middle to late Oligocene is uncertain but lies between Cores 19 and 22 inclusive.

Pl = plagioclase, Cpx = clinopyroxene, Opx = orthopyroxene, Pig = pigeonite, Ol = olivine.

Figure 7. (Continued).

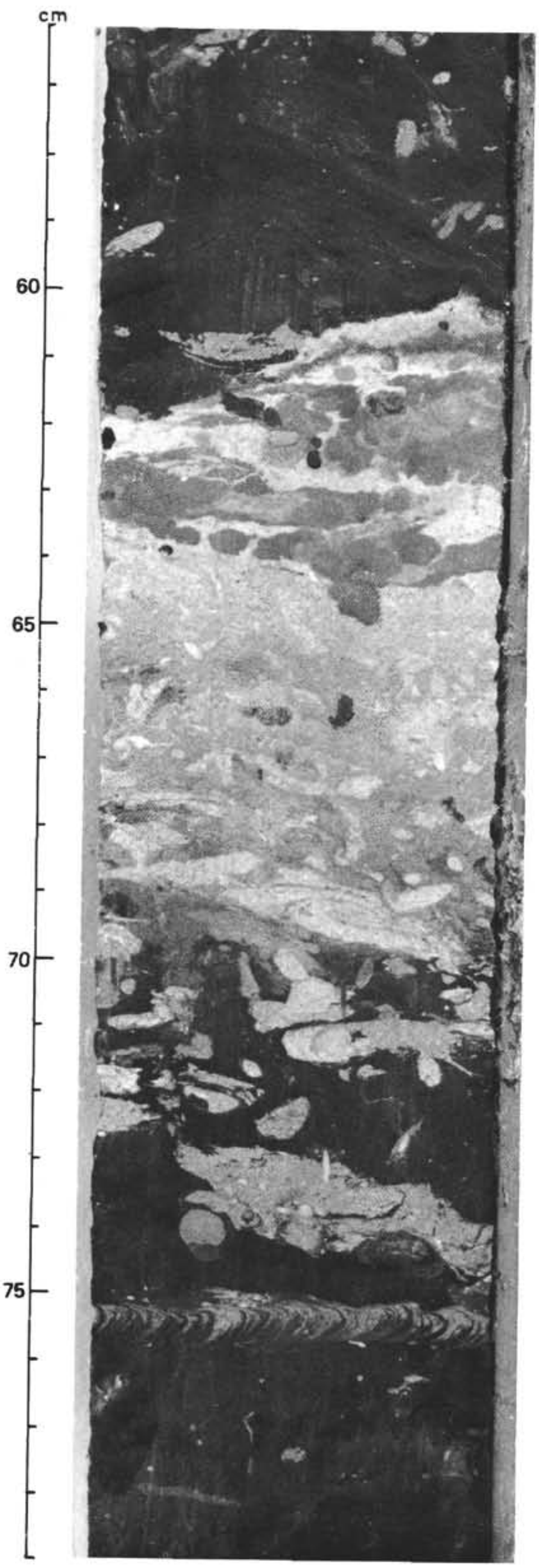


Figure 8. A rare but impressive example of bioturbation in the vitric tuff of Unit 4.

tween 223.5 and 309 meters, then washed to 527.5 meters. Below this level the hole was continuously cored.

Hole 448A encountered equivalent horizons approximately two core lengths (19 meters) above those levels encountered in Hole 448; this offset was established from both paleontologic and lithologic data. The lithologic change from vitric tuffs to nannofossil chalk at a depth of 261.5 meters in Holes 448A corresponds to the boundary between Units 4 and 5 in Hole 448 at a depth of 280.5 meters, a difference of 19 meters. The total thickness of sediment overlying Unit 6 in Hole 448A is 291.5 meters.

Cores 1 through 4 extend to a depth of 81.0 meters and correspond to the Unit 1 lithology described for Hole 448. They contain very pale-brown and brownish yellow nannofossil ooze, with similar compositions and structures to those described in Unit 1 of Hole 448.

Sediments in Cores 5 and 6, from the interval 223.5 to 261.5 meters correspond lithologically to Unit 4, Hole 448. The sediments consist of fine vitric tuffs and vitric tuffs and, in Core 5, a tuffaceous volcaniclastic breccia with dominant colors of olive, olive-gray, and dark-gray.

Sediments continuously cored in Cores 7 through 9 between 261.5 and 290.0 meters correspond to the Unit 5 sediments of Hole 448. They comprise white, light-gray, and very pale-brown interbedded nannofossil chalk and olive-gray and dark-gray vitric tuffs. Below Core 9, the lithology changes to interbedded volcaniclastic breccias, basalt flows, and tuffs that are lithologically similar to Units 7 through 12 in Hole 448.

The sequence is similar to that expected in a submerged island-arc environment. In Units 6 through 13 the vesicularity of the basalt flows and the thickness of the volcaniclastic breccias indicate extrusion of volatile-enriched basalts in a relatively shallow island-arc-type environment. Posteruption tectonics, as evidenced by slickensides on fractures cutting basalt flows, also may have contributed to the formation of cognate basaltic breccias.

Unit 5 records the termination of major volcanism in the arc during the middle Oligocene. Eruptive provenance diminished, providing only minor amounts of ash and breccia to the nannofossil accumulations.

Ash production temporarily increased from middle to late Oligocene, diluting the nannofossil sediment with thick sequences of tuff (Unit 4). After this resurgence of volcanism, volcanic activity diminished, allowing nannofossil rich sediments to be preserved as interbedded layers between ash falls (Unit 3). The absence of significant ash layers in the overlying upper Oligocene nannofossil chalk (Unit 2) and nannofossil ooze (Unit 1) attests to the termination of intensive volcanism near this site before the early late Oligocene. Continuing fluctuations in more distant, regional volcanism until the middle Miocene provided the minor amounts of pumice scattered throughout the upper chalk and ooze units. Pumice fragments are sparsely scattered through the majority of cores in Units 1 and 2. Minor amounts occur in Cores 6, 10, 14, and 16 of Units 1 and 2, with notable amounts in Cores 8 and 11 of Unit 1. The uppermost 5 meters of nannofossil ooze at the top of the hole are barren of pumice.

Inclination of bedding surfaces is apparent in both holes at this site, indicating either the primary bedding attitude acquired during the formation of the volcanic arc or some early tectonic displacement in the area. The apparent dip measured from maximum apparent angles is approximately 45° in the breccias of Cores 30 to 61 (641.5–878 m depth) in Hole 448A. Above this, in Hole 448, the apparent dip decreases considerably in the tuffs of Cores 26 and 27 from 45° at 338 meters to 19° at 311 meters. Above this level the dip is indeterminate and thus no other tectonic inferences can be drawn.

BIOSTRATIGRAPHY

At Site 448 calcareous nannofossils are present throughout the sedimentary column of both holes. Nannoplankton Zones NN 9 (*Discoaster hamatus* Zone, middle Miocene) down to NP 23 (*Sphenolithus predistentus* Zone, middle Oligocene) were identified. In the vitric tuff with minor chalk (Lithologic Unit 4), occurrence of calcareous nannoplankton is restricted to the chalk layers, as indicated by the barren intervals between Cores 21 and 27 of Hole 448. Preservation is good only in the uppermost core and moderate throughout the remaining cores, becoming poor in the lowest sediment layers and in the sediment intercalated between basalt flows.

Planktonic foraminifers were found from Core 1 down through Core 19 in Hole 448, indicating that the top of this interval is probably middle Miocene and the bottom upper Oligocene. Because zonal markers are rare in many samples or too poorly preserved to be properly identified, assignment to certain zones proved to be difficult and is rather imprecise. Below Core 19, core-catcher samples are either barren or contain only a few nondiagnostic durable forms. The lowest occurrence of foraminiferal fragments was noted in Core 34 of Hole 448. Core-catcher samples in Cores 1 to 4 of Hole 448A contain foraminiferal assemblages similar to those at the equivalent levels in Hole 448 and probably indicate the middle Miocene (Core 1), the lower Miocene (upper portion of Core 2), and the upper Oligocene-lower Miocene (for core-catcher samples from Core 3).

Radiolarians occur in numbers sufficient for zonation from Cores 1 to 17 in Hole 448 and from Cores 1 to 4 in Hole 448A, assemblages being richest in Cores 2 and 3 of Hole 448. Several zones, from the *Dorcadospyris alata* Zone (middle Miocene) at the top to the *D. papilio* Zone (upper Oligocene) at the bottom, could be identified in Hole 448. A limited occurrence of radiolarians in Cores 32 and 33 of Hole 448 also indicates the Oligocene. Preservation is generally poor, and evidence of strong silica solution can be noted in virtually every sample. Other siliceous fossils, the diatoms and silicoflagellates, are absent throughout the cores. There is no apparent reworking in the three fossil groups investigated at this site.

Calcareous Nannoplankton

Hole 448 provided a continuous sequence from the middle Miocene (Zone NN 9—*Discoaster hamatus* Zone) down to the middle Oligocene (Zone NP 23—*Sphenolithus predistentus* Zone). The youngest basalt flow was recovered from Core 37 (337.5–347.0 m) which, according to the nannofossils from a trapped sediment lense, is of the middle Oligocene (Zone NP 23). Sediment lenses trapped within or between basalt flows in Cores 40, 48, 49, and 51 also contain nannofossils of Zone NP 23. Parts of Cores 20 to 27 (176.0–252.0 m) and Cores 37 to 65 (337.5–584.5 m, terminal depth), with the exception of the trapped sediments just mentioned, are barren of calcareous nannoplankton.

Within Core 1 (0.0–0.5 m), Zones NN 6 (*D. exilis* Zone) through NN 9 (*D. hamatus* Zone) are present, with the boundary between Zone NN 7 (*D. kugleri* Zone) and Zone NN 8 (*Catinaster coalitus* Zone) cored twice, probably because of resampling or disturbance of material within the liner. Cores 2 to the upper part of 4 (5.0–~30.0 m) can be placed in Zone NN5 (S. *heteromorphus* Zone). Because the marker species of the top of Zone NN 4, *Helicosphaera ampliaperta*, is absent in this area, the first occurrence of *D. exilis* tentatively was used to identify the boundary between Zones NN 4 and NN 5 (Martini and Worsley, 1971). (The preservation of discoasters at this level is rather poor, however, and identifications are somewhat questionable.) This is also indicated by the last occurrence of *Orthorhabdus serratus* in Sample 448-4-3, 0–1 cm, which normally seems to have its last occurrence in the upper part of Zone NN 4. The lower-Miocene calcareous nannoplankton Zone NN 3 (*S. belemnos* Zone) could not be identified in Sample 448-4,CC. Zone NN 2 (*D. druggi* Zone) is present in Core 5. Core 6 to Core 8 (43.0–71.5 m) can be placed in Zone NN 1 (*Triquetrorhabdulus carinatus* Zone). The base of this zone, indicated by the last occurrence of *S. ciperoensis*, is taken as the Oligocene/Miocene boundary. Below, Zone NP 25 (*S. ciperoensis* Zone) was identified down to Core 12 (~81.0–109.5 m), where the last occurrence of *S. distentus* was noted. As at Site 447, the first specimens of *S. ciperoensis* and *Coccolithus abisectus* do not occur at the same level. This may be the result of the high sedimentation rate, which would tend to separate these first occurrences, generally reported at approximately the same chronological level (Müller, 1970). At present, the part that contains *S. ciperoensis* is identified as Zone NP 24 (~109.5–299.5 m); that without *S. ciperoensis*, but still containing *C. abisectus*, is labelled NP 23 (below 299.5 m)

Zygrhablithus bijugatus, which appears in Core 10, has its most common occurrence in Cores 16 to 18, coinciding with an increase of the sedimentation rate in the upper part of Zone NP 24. This form is also present with changing frequency in cores below that level. *Z. bijugatus* is a neritic species and is commonly found in abundance in "near-shore" environments. A similar occurrence of *Z. bijugatus* was previously reported from the upper Oligocene of the Rockall Plateau (Leg 12, Perch-Nielsen, 1972), the Iceland-Faeroe Ridge (Leg 38, Müller, 1976), and the Reykjanes Ridge (Leg 49, Martini, 1979), indicating the relatively shallow position of these areas. Thus a decrease in water depth can also be postulated for the area around Site 448 during part of the Oligocene.

Preservation of calcareous nannofossils is fairly good in Core 1, but below, deeper in both holes, specimens are slightly etched and discoasters are more or less heavily overgrown by calcite; this is also true for *Z. bijugatus* in the Oligocene. Poor preservation is generally noted in the lowest sediment layers as well as in sediment trapped within or between basalt flows.

In Hole 448A an attempt was made to recover material from the poorly represented intervals of Hole 448. Core 1 (0.0–9.5 m) contained well-preserved calcareous nannoplankton dominated by discoasters of Zone NN 8 (*Catinaster coalitus* Zone) at the top through NN 5 (*S. heteromorphus* Zone) at its base. The level equivalent to Core 5 in Hole 448 was successfully sampled in Core 2 (33.5–43.0 m) of Hole 448A, but nannoplankton found belong to the lower-Miocene Zone NN 1 (*T. carinatus* Zone), with the exception of the uppermost part, which can be placed in Zone NN 2. The Oligocene/Miocene boundary, as indicated by the calcareous nannoplankton, is between Cores 3 and 4 at a depth of approximately 71.5 meters. Nannoplankton assemblages in samples from the Oligocene Zones NP 25 (Core 4, 71.5–81.0 m), NP 24 (Cores 5 and 6, 223.5–237.0 and 252.0–261.5 m), and NP 23 (Cores 7 to 9, 261.5–290.0 m), and from the sediment lenses between basalt (Cores 13, 26, 49, and 51) or out of casts in breccias (Core 42) do not differ from those found in Hole 448. The NP 25 assemblage in the core-catcher material of Core 6 must be contamination from up-hole because a Zone NP 24 assemblage overlies it in Section 3 of Core 6. Sphenoliths with long projections are abundant in the *S. predistentus–S. distentus–S. ciperoensis* group, and this aspect seems to follow a distributional trend.

Foraminifers

Hole 448

Poorly to moderately well-preserved Miocene to Oligocene foraminiferal assemblages are present in samples from Cores 1 through 19 of Hole 448. Below Core 19 foraminifers occur rarely and sporadically and are nondiagnostic.

The interval from Core 1 through Core 2, Section 1 contains only benthic and robust planktonic foraminifers (e.g., *Sphaeroidinellopsis seminulina*) which precludes precise dating of this interval. Rare occurrences of *Orbulina universa*, however, indicate a middle Miocene or younger age; the overlapping ranges of *S. seminulina* and *Globoquadrina dehiscens advena* probably suggesting the middle Miocene.

Core 2, Section 2 contains one specimen of *Praeorbulina glomerosa*, a species that ranges from upper lower to lower middle Miocene (Zones N.8–N.9).

Globigerinoides diminutus, which indicates the lower to middle Miocene (Zones N.7–N.9), occurs sporadically from Core 3, Section 2 to the upper portion of Core 4.

The lower portions of Core 4 and Core 5 contain lower-Miocene assemblages. *Globigerina tripartita* s.l. (Zone N.6? or older) has its highest stratigraphic occurrence near the base of Core 4 and is common in most samples below this through Core 17. Rare occurrences of *Catapsydrax dissimilis* (Zone N.6 and older) were also noted in Core 5.

Globorotalia kugleri has its stratigraphic top in Core 6, Section 1 and is common in samples from Core 6 through Core 10. This species ranges from the uppermost Oligocene to the lowest Miocene (Zones P.22 [= N.3]–N.4).

Samples from Core 11 typically contain *Globigerina ciperoensis, G. angulisuturalis*, and other small globigerinids. These samples mark the interval between the lowest occurrence of *G. kugleri* and the highest occurrence of *Globorotalia opima opima*, and consequently were deposited during the late Oligocene, within the lower portion of Zone P.22, equivalent to the *Globigerina ciperoensis ciperoensis* Zone of Bolli (1966).

The interval from Core 12 through the base of Core 17 contains upper-Oligocene (Zone P.21) foraminiferal assemblages. *Globorotalia opima opima* (Zones P.19/20–P.21) and *G. opima nana* (Zone P.22 and older) are present in Cores 12 through 17. *Chiloguembelina cubensis* (mid-P.21 and older) has its stratigraphic top within Core 13 and occurs consistently, commonly quite abundantly, down to the base of Core 17, and sporadically below Core 17. *Globigerina angulisuturalis*, which does not occur below Zone P.21, is still present in the core-catcher sample of Core 17, and rare (displaced from uphole?) specimens were noted in Core 19, Section 1.

There was essentially no recovery for Core 18. Core 19, Section 3 contains the stratigraphically highest observed occurrence of *G. ampliapertura* and probably was deposited within the upper Oligocene portion of Zone N.20. Samples examined below Section 19-3 do not contain age-diagnostic foraminiferal assemblages.

Hole 448A

Core-catcher samples from Cores 1 through 4 of Hole 448A were examined for foraminifers. Sample 1,CC contains a probable middle-Miocene assemblage similar to that in Cores 1 and 2 of Hole 448. Samples from the core catchers of Cores 2, 3, and 4 of Hole 448A all contain *Globorotalia kugleri* (Zones P.22–N.4), as do samples from Cores 6 to 10 of Hole 448.

Radiolarians

Radiolarians are mostly confined to the upper 17 cores (0.0–157.0 m) drilled in Hole 448, and only minor amounts of their skeletons reappear lower in the section (Samples 32,CC, 33,CC). In Hole 448A, radiolarians were seen only in Cores 1 through 4; none were seen below this point. Although clearly equatorial in composition, the assemblages never are as diverse and abundant as found in samples from comparable depths in the central Pacific. On the contrary, except for the rich thanatocoenoses of Cores 2 and 3 of Hole 448, the abundance of radiolarians varies from very rare to common, preservation normally being poor. Evidence for strong silica solution prevails in virtually every sample; individuals of fragile species are often absent or fragmentary, and there is a preponderance of specimens lacking abdomens, spines, and other ornamentation. This situation rendered precise identification of some species impossible, particularly in the genera *Dor-*

cadospyris and *Calocycletta.* The solution-induced anomalies compounded other stratigraphic problems; for example, two key zonal guide fossils, *Lychnocanoma elongata* and *Theocyrtis annosa* (both typically abundant in their respective zones), were found only as traces.

From youngest to oldest, the radiolarian zones that were recognized are: (1) the *D. alata* Zone, spanning Cores 1, 2, and the top of 3 (Hole 448); (2) the *C. costata* Zone, in Core 3 to Core 4, Section 2 (Hole 448), and in the core-catcher sample of Core 1 (Hole 448A); (3) the *Stichocorys wolfii* Zone, in samples from Core 4, Section 2, to the bottom of Core 4 (Hole 448); (4) the *S. delmontensis* Zone in Core 5 (Hole 448); (5) the *Cyrtocapsella tetrapera* Zone, in the interval from Core 6 through Core 7 (Hole 448) and possibly in Core 2 (Hole 448A); (6) the *L. elongata* Zone in Core 8; and finally (7) the upper-Oligocene *D. papilio* Zone, which apparently extends from the top of Core 10 to the base of the radiolarian-bearing sequence in Hole 448, and from Core 3 to Core 4 in Hole 448A.

The Oligocene/Miocene boundary, in terms of radiolarian stratigraphy, should fall between Cores 8 and 10 of Hole 448 (it may, in addition, correlate with a level just above Core 3 of Hole 448A), because the *L. elongata* Zone contains this boundary (Theyer and Hammond, 1974).

PALEOENVIRONMENT

All three fossil groups studied (nannofossils, radiolarians, and foraminifers) indicate that a tropical climate persisted in the area of Site 448 through the middle Oligocene to middle Miocene. Although nannofossils are present throughout the sedimentary section at Hole 448, radiolarians and foraminifers are mostly confined to the upper 19 cores. Preservation of fossils is generally poor to fair, with the exception of the nannofossils in Core 1, where the preservation is good. The generally poor preservation of calcareous fossils in the upper cores, especially the planktonic foraminifers, suggests that these samples were deposited near the foraminiferal lysocline. Poor preservation of fossils in some of the lower cores might be the result of diagenesis, because the transition from ooze to chalk occurs within Core 12. The lower portion of the sediment column contains increased amounts of ash. The change from chalk to tuff occurs within Core 19 and, with it, the end of diagnostic foraminiferal assemblages and (with a few exceptions) radiolarians.

In Hole 448, benthic foraminifers characteristic of lower abyssal environments (e.g., *Stilostomella antillea, S. spinea*, thin *Cibicides wuellerstorfi, C. kullenbergi*?) occur commonly in samples from Core 1 through Core 12, with an increase in arenaceous benthic foraminifers (possibly indicating the deepest portion of the interval) in Cores 7 through 12. Many of the deep-water species common in Cores 1 through 12 were not noted in Cores 13 through 19, suggesting a possible deepening from middle or upper bathyal for the upper portion of the sedimentary section. Nannofossil data lend support to this suggestion of a deepening trend, because *Zygrhablithus bijugatus*, which is thought to be a neritic species, appears in fair numbers in Cores 16 to 18 (see the section on Biostratigraphy, this chapter).

ACCUMULATION RATES

Nine successive biostratigraphic zonal boundaries identified in the cores of Hole 448 were used to estimate the sediment accumulation rates at Site 448 (Fig. 9). The dominant feature of the resulting curve is a smooth decrease in accumulation rates with time at this site. This decrease expresses an ever-diminishing influx of volcaniclastic components (tuff, pumice, glass) to the sediments. The greatest influx occurred below Unit 5, where lavas and volcaniclastic breccia accumulated. The decrease in volcaniclastic influx began during the late Oligocene with the deposition of sedimentary Unit 5 and continued with a relatively sharp decrease in Unit 3 (Fig. 7). It culminated in the later part of the early Miocene,

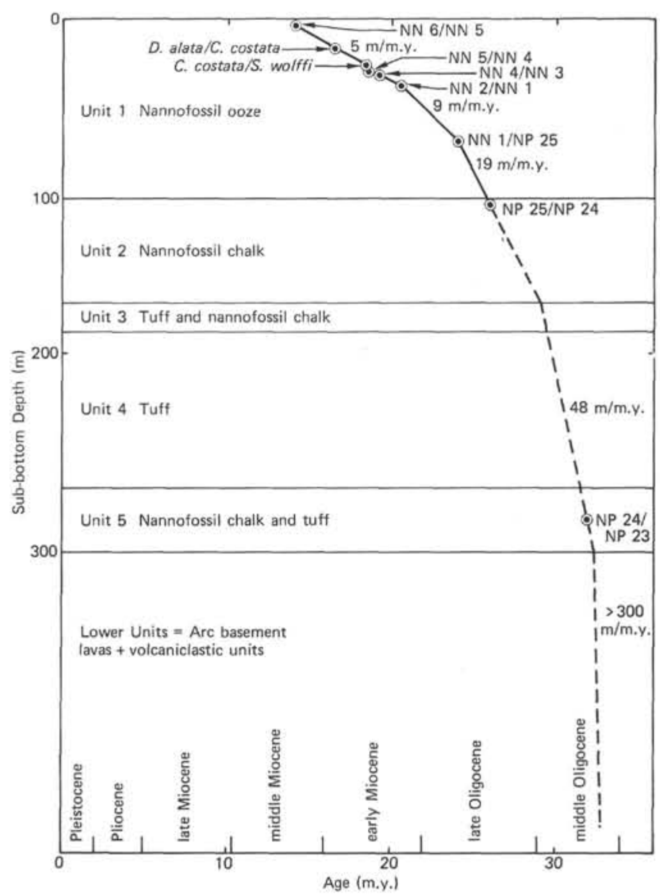


Figure 9. Accumulation rates estimated for the sedimentary sequence recovered from Hole 448. (The time-scale for the Neogene is from LaBreque et al. [1977]; for the Oligocene, Martini's [1971] scheme is employed. Definition of the nannofossil zonal boundaries is that given by Martini [1971]; that of the radiolarian zonal boundaries is after Riedel and Sanfilippo [1974]. Calibration of the nannofossil zonal boundaries to the time scale is taken from Theyer et al. [1978]. The line representing accumulation rate is dashed where it is extrapolated to fit lithologic boundaries in the absence of more detailed paleontological control.)

when volcanic glass can no longer be detected in the sand-sized fraction of the sediments that comprise the upper portion of Unit 1.

During construction of the volcanic-arc basement, the accumulation rate of lavas and related volcaniclastic products was in excess of 300 m/m.y. Then, during deposition of the mostly tuffaceous sedimentary Units 5 through 3, which range from the middle to the upper Oligocene, sediment accumulation rates averaged 48 m/m.y. While the mainly biogenic Unit 2 and basal part of Unit 1 were deposited in the late Oligocene, average accumulation rates rapidly diminished to more typically pelagic values of about 19 m/m.y.; during deposition of the central part of Unit 1, the rate decreased to about 9 m/m.y. Finally, a further drastic slowing down of the depositional process must have occurred during the early and middle Miocene with a rate of 5 m/m.y.

The few nannofossil-bearing volcaniclastic lenses, which were found intercalated between the basalts down to about 810 meters (Hole 448A), all correspond to Zone NP 23. This zone only lasted about 2 m.y. (Martini, 1976). Thus the approximately 500 meters of basalts and volcaniclastic breccias drilled in Hole 448A above the last nannofossil date took, at the most, less than 2 m.y. to be deposited.

ORGANIC GEOCHEMISTRY

The two gas shows at Site 448 (Sections 17-2 and 19-2) were sampled and investigated using procedures outlined in the Introduction (this volume). Results similar to those for Site 447 were obtained by gas chromatography: methane is absent and minor amounts of CO_2 are present; thus it is possible to make deductions similar to those for Site 447.

The methods used for determination of organic carbon and nitrogen contents are also presented in the Introduction (this volume). The results at Site 448 (Table 2, Fig. 10) are generally similar to those at Site 447, with low amounts of organic carbon (mean values between 0.1–0.4 wt. % carbonate-free sediment) and nitrogen (0.01–0.04 wt. %) and little variation in the value of the C to N ratio (10–27). The higher nitrogen content of the uppermost sediment may be a reflection of microbial activity at this level.

Methods of Rock Eval analyses are presented in the Introduction (this volume). The results for the 18 samples investigated are summarized in Table 3. The nannofossil oozes and chalks of Units 1 and 2 give only nominal hydrocarbon responses, reflecting the dearth of pyrolyzable organic matter. The S_2 peak maximizes at 550°C in the fine tuff-rich silt-size lithologies of Units 3 and 4. This S_2 peak character is analogous to the response found in clay-rich lithologies and is not directly representative of the degree of maturation of the organic matter. In the sample from Section 26-2, the S_2 response maximizes at 438°C and also appears to be a spurious feature of this lithology rather than a genuine indication of organic matter within the oil zone of maturation, especially because of the evidence of the low carbon content and production index $[S_1/(S_1 + S_2)]$.

Table 2. Organic carbon and nitrogen contents (after carbonate dissolution).

Lithologic Unit	Sample (intervals in cm)	Organic Carbon (wt. %)	Nitrogen (wt. %)	C:N (atomic ratio)
1	1-1, 9–10	0.42	0.049	10.0
		0.35	0.046	8.9
1	1-1, 69–70	0.27	0.038	8.3
		0.33	0.046	8.4
1	1-2, 28–29	0.31	0.037	9.8
		0.28	0.034	9.6
		0.25	0.034	8.6
1	2-2, 144–145	0.44	0.028	18.4
		0.24	0.015	18.7
		0.36	0.023	18.3
1	2-5, 98–99	0.28	0.017	16.5
		0.34	0.020	19.9
		0.31	0.019	19.1
1	2-6, 2-3	0.17	0.020	9.9
		0.15	0.020	8.8
		0.20	0.021	11.1
1	3-1, 30–31	0.18	0.019	11.1
		0.17	0.015	13.3
		0.18	0.017	12.4
1	4-3, 22–23	0.19	0.020	11.1
		0.23	0.020	13.4
1	4-5, 7–8	0.26	0.019	16.0
		0.34	0.021	18.9
		0.33	0.021	18.4
2	17-1, 50–51	0.19	0.018	12.4
		0.20	0.017	13.8
		0.30	0.021	16.7
2	17-3, 128–129	0.26	0.023	13.1
		0.30	0.027	13.0
		0.29	0.020	17.0
3	19-4, 104–105	0.20	0.012	19.0
		0.10	0.008	14.6
4	24-3, 30–31	0.14	0.009	18.2
		0.14	0.008	20.5
		0.24	0.015	18.7
4	26-2, 65–66	0.24	0.009	26.7
4	29-3, 120–121	0.08	0.007	12.1
		0.15	0.009	19.5
		0.07	0.005	15.4

The organic-geochemical value of these lithologies and the information that can be deduced from such analyses are greatly diminished by the low amounts of organic carbon and the absence of significant hydrocarbon responses on pyrolysis.

INORGANIC GEOCHEMISTRY OF INTERSTITIAL WATER

Six samples from Hole 448 and one from Hole 448A were collected for interstitial water analyses (analytical methods are discussed in the Introduction to this volume). The data obtained from the shipboard measurements are plotted against depth in Figure 11. Little variation with depth occurs in the parameters investigated. Within the nannofossil ooze of Unit 1 the values are approximately those of sea water and show no discernible diagenetic trend. The lowest two samples from Hole 448 diverge slightly from the uniformity of the Unit 1 samples. Section 21-3 shows an enhanced chlorinity and salinity relative to the overlying sediments. This increase is unusual because diagenetic ef-

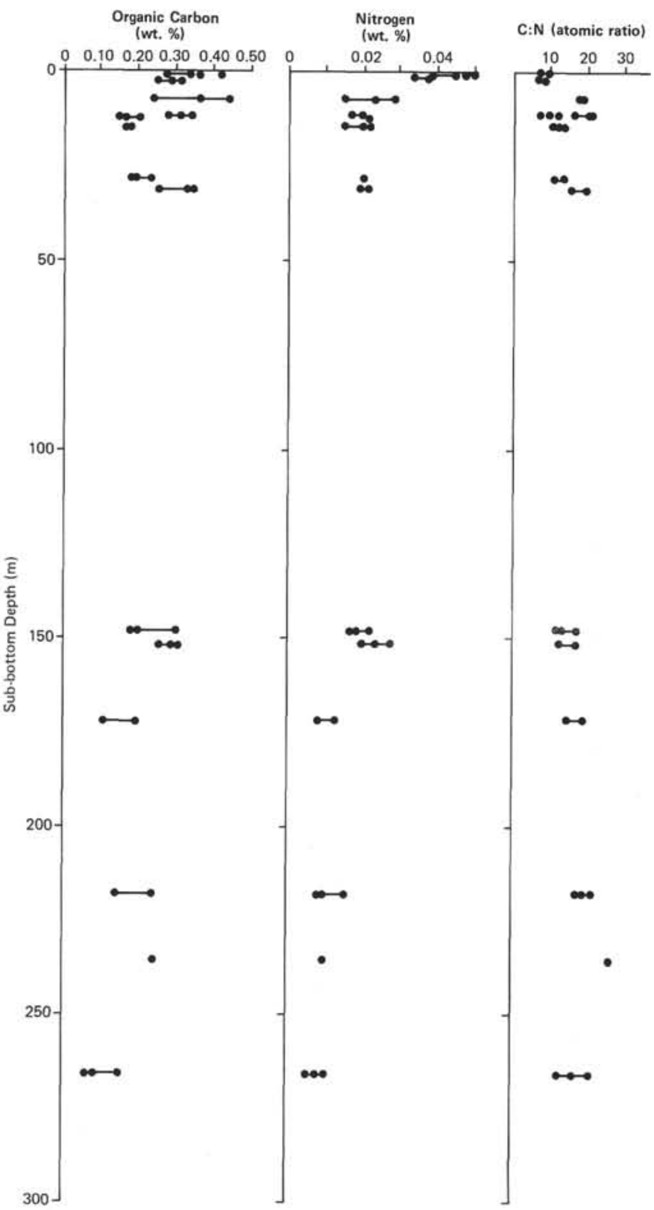


Figure 10. Results of organic carbon and nitrogen analyses plotted versus sub-bottom depth in meters.

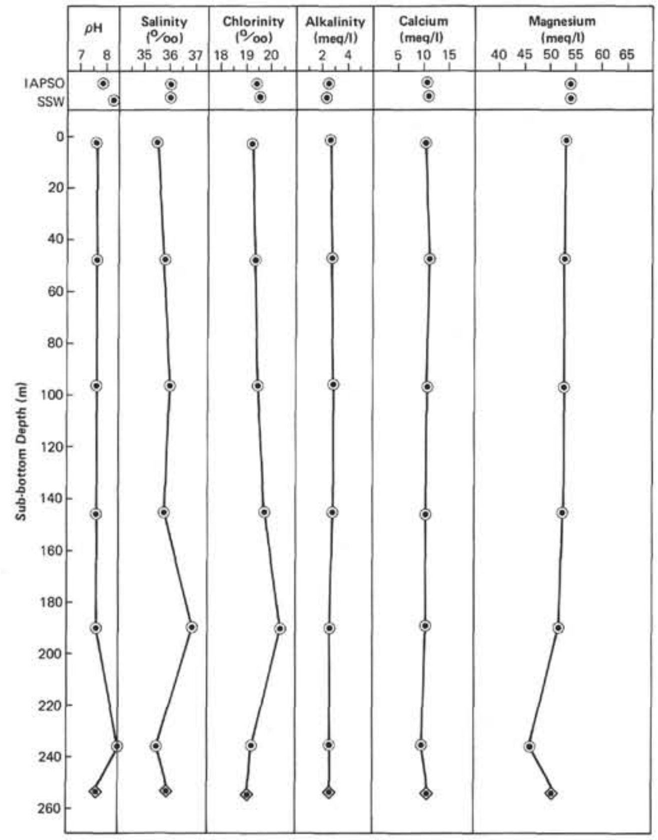


Figure 11. Results of interstitial water samples plotted against sub-bottom depth in meters. (⊙ = data for Hole 448; ◈ = data for Hole 448A; IAPSO standard and surface sea water (SSW) analyses are shown for comparison.)

Table 3. Qualitative estimate of the relative amounts of free hydrocarbons, bound hydrocarbons, and CO_2 from kerogen (and carbonate-rich sediments) based upon sizes of S_1, S_2, and S_3 peaks, respectively, from Rock-Eval analyses.

Lithologic Unit	No. of Samples	Free Hydrocarbon (S_1)	Bound Hydrocarbon (S_2)	CO_2 from Kerogen (S_3)
1 and 2	14	−/+	−	+/++
3	1	+	++	+
4	3	+	+/++	+

Note: − = undetectable, −/+ = undetectable to minor; + = minor, +/++ = minor to moderate, ++ = moderate relative amounts.

fects, principally the expulsion of water low in chloride from clay minerals, normally lead to decreases in salinity and chlorinity. In addition, the horizon itself seems to be too distant from hydrothermal mineralization for this phenomenon to have been influential. Section 26-2 possesses a *p*H value of 8.5, considerably lower than the other samples, and an unusually low Mg^{2+} concentration, although its alkalinity is similar. The most plausible explanation for these observations is that the values reflect reaction of pore waters with basaltic glass at low temperatures: The lower Mg^{2+} content of this sample suggests an enhanced incorporation of Mg^{2+} into clay lattices, and the high *p*H suggests use of the hydronium ion in hydration of basaltic glass. Both Cores 21 and 26 are vitric tuffs that are altered in part to clays (see Aldrich et al., this volume). The commonly observed reaction of basaltic glass with sea water at low temperature shows a decrease in Mg content of the glass, requiring a concomitant increase in Mg^{2+} in the aqueous phase (Thompson, 1973); however, the presence of Mg-rich clays may reverse this trend. Data for the single sample taken from Hole 448A are analogous to those of Unit 1. In summary, characteristic changes in interstitial water chemistry attributable to diagenesis of commonly absorbed sediments are absent at Site 448 but may be related to reactions between vitric tuffs and pore water.

IGNEOUS PETROGRAPHY

The volcanic rocks recovered from Hole 448 consist of highly vesicular lava flows and rare pillow lavas with interbedded tuffs and volcaniclastic breccias. In Hole

448A, continuous coring was begun at 527.5 meters—57 meters above the bottom of 448—and continued to a final depth of 914.0 meters. In 448A dikes and sills and hydrothermally altered zones were also encountered below the total depth of Hole 448. As was previously discussed, correlation between the two holes was made at the lithologic break between Units 4 and 5; this boundary was found at 280.5 meters sub-bottom in Hole 448 and 261.5 meters sub-bottom in Hole 448A. For clarity, the lithologic and petrographic units distinguished will be numbered consecutively.

Hole 448

Although Core 1 contains no volcanic clasts, the 171.5 meters of middle-Miocene nannofossil ooze and upper-Oligocene nannofossil chalks of Units 1 and 2 contain scattered fragments of pumice (2 cm) and rare, thin (1-2 cm) ash layers. A distinctive set of lithologies consisting of middle- to upper-Oligocene interbedded tuffs and chalks is recognized in Units 3, 4, and 5. Within this interval (171.5-337.5 m), the amount of volcanic debris sharply increases down-hole. These debris are partially oxidized tuffs that consist of fragments of olivine-clinopyroxene-plagioclase-phyric and aphyric basalts with variolitic and hyalopilitic groundmasses and fragments of plagioclase, clinopyroxene, olivine, and altered volcanic glass. The first lava flow occurs at 319.5 meters sub-bottom. Below this, interbedded vesicular basaltic flows, volcaniclastic breccias, tuffaceous volcaniclastic breccias, and tuffs are present to a depth of 556 meters sub-bottom.

The major subdivisions below 319.5 meters are based on the differences between volcaniclastic units and the petrographically distinct submarine extrusive igneous units. Eight main units are thus identified as five extrusive units and three intervening volcaniclastic units. Each of the petrographic extrusive units may be composed of one or more eruptive cooling units. Although no attempt was made to subdivide formally the petrographic units into cooling units, up to 18 single cooling units or lava flows were recognized, ranging in thickness from 0.5 meters to 2.5 meters. As discussed in the Site 447 report, cooling units consist of flows, pillow lava flows, and pillowed massive flows. Flows are the most common type of cooling unit. Glass rims of flows (0.5-3.0 cm thick) enclose variolitic zones that, in turn, enclose mostly crystalline interiors. Flow surfaces are commonly brecciated with rock and glass fragments cemented by finely crystalline carbonates and zeolites. In the only pillow lava flow recognized (10.4 m thick, in Unit 8), pillows range from 30 to 40 cm in diameter. A pillowed massive flow is thought to comprise Unit 6 (20.5 m thick).

High vesicularity (up to 40%) and a possible intergranular porosity(?) are characteristic features of all eruptive units in Hole 448. Vesicles are spherical or oval and range from 1 to 3 mm in diameter. Irregular intergranular pores are 0.1 to 0.5 mm in diameter. Margins of flows are especially enriched in vesicles and irregular vugs that in some cases are partially filled with carbonates, zeolites, and smectites.

The volcaniclastic units (Unit 7, 18.5 m; Unit 9, 29.5 m; and Unit 11, 31.5 m) comprise about one-third of the recovered sequence. The petrography of these units remains relatively uniform. The clast:matrix ratio is rarely lower than 3:1. The clasts are angular, subangular to subrounded, and vary in size from 15 cm to 0.5 mm in diameter. In general, little sorting or orientation of clasts is recognizable. The composition of the clasts generally is the same as that of interbedded flows. Although volcaniclastic units are relatively rich in glassy and variolitic basalt clasts and palagonite, rare clasts of highly altered andesite(?) and quartz-andesine-hornblende diorite are also present.

The coarse volcaniclastic matrix is composed of small pieces (<4 mm) of variolitic, glassy, and aphyric vesicular basalts and devitrified glass cemented with zeolites and carbonates. Occasionally this tuff forms separate thin layers 40 to 50 cm thick. The oxidized matrix has yellowish brown colors above Unit 7 and changes into dark green colors down-hole.

Both petrographic investigations and x-ray fluorescence (XRF) studies of the igneous units indicate these lavas are tholeiitic basalts (see R. Scott, this volume; Mattey et al., this volume). The basalts are subdivided on the basis of phenocrysts: Unit 6, a plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt (20.5 m); Unit 8, a plagioclase-olivine-clinopyroxene basalt (27.5 m); Unit 9, an aphyric basalt (23.0 m); Unit 11, a plagioclase-clinopyroxene-orthopyroxene-pigeonite-olivine-phyric basalt (33.5 m); and Unit 13, a plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt (35.5 m).

Most of the extrusive and volcaniclastic rocks display moderate to intensive low-temperature hydrothermal alteration (see Aldrich et al., this volume). Two types of alteration exist: One displays the yellowish brown colored matrices typical of oxidation, and the other displays the greenish colored matrices typical of reduction. Both types are more extensively developed in the matrices of volcaniclastic units, pillow margins along flow boundaries, zones of brecciation, and zones adjacent to sills and dikes. Both types of alteration are associated with low-temperature secondary minerals (smectites, hydromicas(?), carbonates, and zeolites), but the smectitic green clays are restricted to the green matrices, and the iron hydroxides are restricted to the yellowish brown matrices. These same mineral associations fill vesicles, vugs, and thin (1-3 mm) veins. In many cases, olivine, orthopyroxene, and glass are extensively altered to green smectite clays and zeolites, whereas clinopyroxene and plagioclase remain relatively fresh.

Hole 448A

As discussed earlier, Unit 13, the last igneous unit recovered from Hole 448, was successfully correlated with the igneous unit recovered from the top of the continuously cored part of Hole 448A (527.5 m sub-bottom). However, between sub-bottom depths of 291.0 meters and 303.0 meters an aphyric to plagioclase-phyric pillow lava basalt was recovered. Apparently this basalt unit is the upper part of Unit 6, unrecovered in Cores 35 and 36 of Hole 448. In fact, the core-catcher sample for Core 35 has small basalt fragments in a volcaniclastic breccia that may have washed from more elevated portions of Unit 6 elsewhere. Based on this reconstruction, Unit 6 may be as much as 38 meters thick in Hole 448 and perhaps 48 meters thick in Hole 448A, using the Unit 4/Unit 5 boundary for correlation. The assumption that basalt was reached at approximately 319.5 meters sub-bottom is substantiated by the sharp decrease in drilling rate at this position. The lithologies of material recovered from 448A below this level are very similar to those of 448 with the exceptions that (1) the basalts are less vesicular with increasing depth, (2) dikes and sills occur, (3) moderate-temperature, hydrothermally altered zones are present, and (4) basaltic andesites are present.

The lithology and petrography of the 45 volcanic units from Holes 448 and 448A are summarized in Table 4. In the petrographic descriptions in this table, the abundance of phenocrysts, groundmass, and vesicles are given as percentages of the whole rock (for example, 4% phenocrysts, 75% groundmass, and 20% vesicles), whereas the abundance of individual phenocrysts or groundmass constituents are given as percentages of total phenocrysts or groundmass (for example, 4% phenocrysts: Pl [65%], Cpx [35%]; 75% groundmass: Pl [45%], Cpx [20%], opaques [5%], and glass [30%]).

The middle- to upper-Oligocene volcanic sequence recovered from the Palau-Kyushu Ridge (Sites 448 and 448A) consists predominantly of tholeiitic basalts, which differ significantly from mid-ocean ridge (MOR) basalts typical of oceanic crust (layer 2) in that the abundance of explosive volcaniclastic debris, the high vesicularity of extrusive units, the wide distribution of hypersthene, both as phenocrysts and in the groundmass, and the presence of pigeonite all suggest island-arc affinities. Also the occurrence of dikes of basaltic andesites and clasts of andesites(?) and diorites in the volcanic debris reinforce this conclusion.

A volcaniclastic sequence very similar to that of Site 448, except for the absence of flows and intrusions and the presence of abundant andesite clasts, was encountered at Site 296 at the northern termination of the Palau-Kyushu Ridge (Karig, Ingle, et al., 1975). The recovered volcanic section is ~600 meters thick and is described as "lapilli tuffs, volcanic sandstones and siltstones"—equivalent to our volcaniclastic breccias, tuffs, and fine tuffs. An abundant type of clast in these breccias is a porphyritic pyroxene andesite with oscillatory-zoned plagioclase, hypersthene, augite, and, in some cases, hornblende phenocrysts in a pilotaxitic to hyalopilitic glassy matrix. Clasts of individual crystals also occur within these breccias and resemble phenocryst phases of andesites. Other abundant lithic fragments include vesicular basalts, pumice, and brown glass. Clasts are poorly to moderately sorted. Many of the tuffs occur in 3-meter-thick, well-defined units that grade upward from tuffaceous volcaniclastic breccias to tuffs. The age of the volcanics varies from early to late Oligocene. They are covered with clay-rich nannofossil chalk (~109.5 m) with extensive interbeds of ash and clayey nannofossil chalk (61.5 m) from the late Oligocene to early Miocene.

Although the similarity of Site 296 and 448 is obvious, there are differences between the volcanism of the northern and the central parts of the Palau-Kyushu Ridge. Whereas the northern part predominately produced andesite (probably of calc-alkalic character), the central part of the ridge produced predominately tholeiitic basalts. Karig (1975) considered the Palau-Kyushu Ridge to be a remnant arc abandoned at the time of formation of the Parece Vela Basin in the late Oligocene. Data obtained from Sites 296 and 448 do not contradict this hypothesis. The cessation of volcanic activity along the Palau-Kyushu Ridge occurred between the middle and late Oligocene.

METAMORPHIC PETROGRAPHY

Although no evidence of widespread regional hydrothermal metamorphism of basalts or coexisting volcaniclastic rocks exists, there is good evidence that low-grade local hydrothermal metamorphism has affected rocks below about 750 meters sub-bottom where abundant intrusive units are found (see Aldrich et al., this volume).

The only apparent alteration in the ashes and tuffs above 337.5 meters sub-bottom in Hole 448 is ambient temperature sea-water weathering at the sea floor or diagenetic sediment alteration after burial.

Coarse volcaniclastics have yellowish brown matrix colors above 357 meters sub-bottom, but below the first basalt flow, matrix colors in the volcaniclastic breccias grade from yellowish brown colors typical of slightly oxidized matrices of mafic volcaniclastic rocks, to olive colors near 358 meters, to more bluish green colors below 442 meters. However, the olive to green matrix colors are not ubiquitous below 358 meters; within major breccia units yellowish brown zones and olive to green zones occur between 358 and about 575 meters sub-bottom. Below 575 meters sub-bottom, few yellowish brown matrices occur, and almost the entire breccia matrix has various shades of dark grayish green to grayish blue-green. Even though these matrices have undergone significant color changes, the large clasts appear to be unaffected. Below 718 meters sub-bottom, the matrix colors change gradually to darker shades of green and greenish black. Below 750 meters, three zones of extensively altered breccia contain disseminated sulfides and acquire a grayish blue to grayish blue-green matrix. Breccias unaffected by this form of alteration retain greenish black matrices.

Mineralogically, this progressive change in character of breccia and ash matrices is quite difficult to describe because no access to an X-ray diffraction facility was available aboard ship. Thus, we can only make tentative identification. Within both the yellowish brown and green matrices, veins of phillipsite are common, veins of analcite are less common, and vuggy coatings of calcite are rare. The color change from yellows to greens is probably the result of reduction of ferric-oxide alteration minerals to green smectites(?) and other green

Table 4. Descriptions of volcanic units in Site 448.

Unit	Depth in m (thickness)	Lithology	Petrography	Comments
6	337.5–358.0 (20.5)	Pillowed massive flow 16.5 m of vesicular pillow basalt underlain by a 4 m massive flow base.	Pl-Cpx-Opx-Ol-phyric basalt Phenocrysts: 2%; Pl (50%, 1-3 mm, ~An_{64}, glomerophyric); mafics 50%; Ol (0.5-1 mm as smectite pseudomorphs). Groundmass: 65%; 0.1-0.5 mm, 75% crystalline, hyalopilitic, intersertal to subophitic; (60% Pl, 30% Cpx, 5% Ol (altered), 5% Opq). Vesicles: 30%; 1-2 mm, empty.	Highly vesicular; oxidized, carbonate and zeolite veins common.
7	358.0–376.5 (18.5)	Volcaniclastic breccia (C:M 4:1) Clasts: vesicular Pl-Ol-phyric basalts and altered glass; angular; avg. 2-4 cm, max. 15 cm. Matrix: olive-yellow (5Y 6/6-5/4) devitrified glass and silica cement.		
8	376.5–404.0 (27.5)	Pillow lava flows and flows 4 cooling units of pillow lava flows and single flows, 0.5-10 m thick, separated by thin (10-20 cm) bands of cognate breccia.	Pl-Ol-Cpx-phyric basalt Phenocrysts: 4%; Pl (<50%, 0.5-1.5 mm, laths); Ol (tr, 50%, 0.4 mm, pseudomorphs); Cpx (tr, 0-4 mm). Groundmass: 75%; fine, 70-80% crystalline, pilotaxitic to ophitic; (60% Pl, 25% Cpx, 5% Ol, 5% Opq). Vesicles: 20%; bimodal, 50% 1-6 mm, 50% 0.1-0.4 mm; empty to lined with zeolites, carbonate, and smectite.	Highly vesicular; oxidized. Up to 5% Pl and Ol accumulation in few flows.
9	404.0–427.0 (23.0)	Pillowed massive flow One cooling unit—upper section pillowed, basal flow section; highly vesicular; glassy margins brecciated, replaced by smectite.	Aphyric basalt Phenocrysts: none Groundmass: 70%; <0.2 mm, 70% crystalline, intersertal to hyalopilitic; (40% Pl, 25% Cpx, 5% Opq. 30% glass). Vesicles: 30%; 0.2-2 mm, irregular.	Alteration of glass to clays rare.
10	427.0–456.0 (29.0)	Tuffs, tuffaceous volcaniclastic breccias and polymictic breccias From top downward: Sub-unit 10a: 14.5 m tuff and volcaniclastic breccia; C:M 8:1. Clasts: fresh and altered glass, vesicular Pl-Ol basalt; angular; avg. 2 cm; max. 15 cm; 10 YR 5/4. Matrix: zeolites, altered glass; 5Y 7/2, 8/2, 8/4. Sub-unit 10b: 10 m volcaniclastic breccia; C:M 5:1. Clasts: basalts, andesite(?), rare granodiorite; avg. 1 cm; max. 15 cm. Matrix: 5G 3/2-10G 4/2; zeolites, green smectite, calcite. Sub-unit 10c: 3 m tuff similar to that in 10a; contains andesite clasts; C:M 4:1. Matrix: 2.5Y 7/6-7/8. Sub-unit 10d: 1.5 m yellow tuff, 2.5Y 7/6, 5Y 7/3, and polymictic breccia. Clasts: pillow fragments (25 cm, glass rims) and white, 5Y 8/1 nannofossil chalk. Matrix: white nannofossil chalk, carbonate cement.	Clasts: Quartz-andesine-hornblende-diorite Pl (55%, 1 mm, An_{54}-An_{28} (rim); Cpx (tr, altered to amphibole); Fe oxide (5%); Opx (altered to amphibole); Qtz (15%, micrographic); Apatite (1%); Hornblende (20%, 1 mm); possible tremolite, granitic texture. Andesite(?) clasts; phenocrysts ~5%; Pl (90%, 0.5 mm, glomerophyric), Cpx (tr, 1.5 mm); groundmass 95%: trachytic; Pl (5%, 0.1 mm, An_{30}); >30% glass; 65% microlites.	Tuffs contain Mn dendrites.
11	456.0–489.5 (33.5)	Basalts flows 5 cooling units 1-9.5 m thick.	Pl-Cpx-Opx-Pig-Ol-phyric basalt Phenocrysts: <2%; Pl (tr, 1-2 mm, laths); Ol (tr, 0.4 mm, pseudomorphs); Cpx and Opx (tr). Groundmass: 70%; fine, 85% crystalline, hyalopilitic; (50% Pl, 10% Cpx, 7% Ol, 5% Opq, 20% glass). Vesicles: 25%; bimodal, 40% 0.5-2.0 mm, 60% 0.1-0.4 mm.	Vesicles empty. Abundant tube vesicles 1 cm diameter.
12	489.5–521.0 (31.5)	Volcaniclastic breccia (C:M 5:1) Clasts: 75% Pl-Cpx-Opx phyric vesicular, fresh and altered basalt; 20% altered glass; 5% reddish (10R 3/2) andesitic or oxidized basalt; angular; avg. ~2 cm, max. 3-8 cm. Matrix: zeolites, carbonate, and altered glass; olive-brown (2.5Y 5/5-5Y 6/4) at top and base of unit, dusky-green (5G 3/3-10G 4/2) elsewhere.	Pl-Cpx-phyric basalt clasts: phenocrysts ~15%; Pl (95%, 1-2 mm, cores altered to green smectite), Cpx (5%, 0.5 mm); groundmass 85%; fine, 75% crystalline, hyalopilitic to pilotaxitic; (50% Pl, 5% Cpx, 3% Opq, 25% glass). Cpx-Opx-phyric basalt clasts: phenocrysts 5%, Pl (25%, 0.3-0.7 mm), Cpx (50% 0.4-1.5 mm), Opx (tr, 0.03-0.2 mm); groundmass 65%; fine, 70% crystalline, hyalopilitic; 40% Pl, 15% Cpx, 5% Opq, 40% glass; vesicles 30%, 0.5-3.0 mm.	Contains native Cu (1%, 0.1-1 mm) associated with disseminated oxides.

Table 4. (Continued).

Unit	Depth in m (thickness)	Lithology	Petrography	Comments
13	521.0–556.5 (35.5)	Basalt flows 8 cooling units 3–6 m thick with highly vesicular cognate breccias between flows.	Pl-Cpx-Opx-Pig-phyric basalt Phenocrysts: 20%; Pl (80%, 0.5–3.0 mm, euhedral); Cpx (10%, 0.3–1.0 mm); Opx (tr, 5%, 0.2–0.7 mm); Ol (tr). Groundmass: 45%; fine, 75% crystalline, hyalopilitic; (20–45% Pl, 5–15% Cpx, 2–5% Opq, tr–1% Opx, 25% glass). Vesicles: 15–35%; 0.5–5.0 mm, empty or lined with zeolites, carbonate, or smectite.	Very rare gabbroic xenoliths <1 cm.
14	537.5–575.5 (38.0)	Pillow lavas Thick sequence wherein eruptive units are difficult to distinguish. Up to 40% vesicular. Calcite fillings in vugs and between pillows common.	Pl-Cpx-Opx-(Ol)-phyric basalt Phenocrysts: 20%; Pl (80%, 0.4–3.5 mm, euhedral laths or glomerophyric with Cpx); Cpx (10%, 0.2–1.0 mm, 2V ~30–50); Opx (tr–5%, 0.4–2.0 mm, euhedral, partly or wholly altered); Ol (tr). Groundmass: 40%; fine, intersertal: (15–25% Pl, 10–20% Cpx, 3–5% Opq, Opx tr, 10–20% glass). Vesicles: 10–40%, 0.3–5 mm, many filled with carbonate and zeolites.	Petrographically similar to Unit 13. Calcite veins common.
15	575.5–613.5 (38.0)	Volcaniclastic breccia and tuff (C:M 4:2) Clasts: vesicular aphyric to fine, sparsely Pl-phyric basalts, altered glass, angular to subangular, unsorted, unoriented; avg. 2–3 cm, max. 13 cm. Matrix: dusky-green (5G 3/2) to grayish green (10G 4/2). Composed of altered basalt clasts 0.5–1 cm, replaced by green smectite; cemented with zeolites and carbonate. Basal 35 cm of unit is dusky blue-green tuff (5BG 3/2); 0.1–1 cm laminations dip 35°.	Pl-Cpx-phyric basalt (one clast) Phenocrysts: 3%; Pl (65%, 0.4–2 mm, euhedral); Cpx (35%, 0.5 mm, subhedral). Groundmass: 75%; fine, hyalopilitic (45% Pl, 20% Cpx, 5% Opq, 25–30% glass). Vesicles: 20%; empty.	Basalt clasts very fresh. Rare reddish andesite(?) and gabbroic(?) clasts.
16	613.5–616.5 (2.0)	Basalt flow Vesicular basalt; vesicularity high in interior.	Pl-Cpx-phyric basalt Phenocrysts: 2%; Pl (50%, 1–2 mm, altered); Cpx (50%, 1–2 mm, subhedral). Groundmass: 75%; finely crystalline, intersertal; (30% Pl, 20% Cpx, 10% Opq, 20% glass, 20% smectite). Vesicles: 20%, avg. 1 mm, max. 4 mm.	
17	615.5–623.0 (7.5)	Tuff and volcaniclastic breccia Upper 4 m pale green (10G 6/2) tuff, clay to silt size, crudely laminated, lenticular and cross laminar near base. Coarser 3.5 m breccia (C:M 4:1), avg. ~1 cm, max. 2.5 cm. subrounded, subspherical. Composed of highly altered basalt and glass. Matrix: dark green (10GY 5/2) altered glass with zeolite cement.	Tuff composed of Pl, Cpx, and glass fragments.	Native Cu disseminated throughout unit.
18	623.0–632.0 (9.0)	Basalt flow	Cpx-(Pl)-phyric basalt Phenocrysts: <2%; Cpx (75%, 0.4 mm); Pl (tr, 0.5 mm). Groundmass: 75%; fine (0.1–0.7 mm) 90% crystalline, intersertal; (50% Pl, 35% Cpx, 5% Opq, 10% glass). Vesicles: 20%.	
19	632.0–660.5 (28.5)	Volcaniclastic breccia (C:M 3:1 [top]–1:1 [base]) Clasts: avg. 0.5–1.0 cm, max. 3 cm, rare 7 cm; green (5G 2/2); crudely bedded. Matrix: zeolites and clays.		Similar to Unit 17; dip 45–50°.
20	660.5–670.0 (9.5)	Basalt flow Nonvesicular	Aphyric basalt Microphenocrysts: Pl (tr, 0.5 mm). Groundmass: 0.05–0.5 mm, intersertal; 30% Pl (An_{50-60}), 30% Cpx, <5% Opq; 15–30% glass.	Highly altered common green smectites. Thin veins contain native Cu.
21	670.0–694.0 (24.0)	Volcaniclastic breccia (C:M 3:1–1:2 as in Unit 19).		

Table 4. (Continued).

Unit	Depth in m (thickness)	Lithology	Petrography	Comments
22	694.0–699.5 (5.5)	Basalt flow Massive, vesicular	Ol-Pl-Cpx-phyric basalt Phenocrysts: 10%; Ol (50%, 0.7–3.0 mm, clay pseudomorphs); Pl (30%, 0.4–1.1 mm); Cpx (10%, 0.4–1.0 mm). Groundmass: 65%; 50% Pl (An_{45}) 25% Cpx, 15% Opq; 10% glass. Vesicles: 23%; avg. 0.1–0.4 mm, max. 1.0–2.0 mm; irregular; 50% clay filled.	
23	699.5–714.5 (15.0)	Cognate basalt breccia (C:M 5:1) Angular clasts, avg. 1–3 cm, max. 5 cm. Less brecciated in flow center. Abundant carbonate and zeolites.	Aphyric basalt Groundmass: 80%; 30% Pl (An_{65}), 35% Cpx, 15% Opq, 20% glass. Vesicles: 20%; 0.1–1.0 mm, irregular; empty or filled with smectite.	
24	714.5–718.0 (3.5)	Basalt flow Glass margins are in contact with breccia zones 30–50 cm thick.	Pl-Cpx-phyric basalt Phenocrysts: 10%; Pl (80%, 1–2 mm An_{74}); Cpx 20%, 0.4–0.7 mm). Groundmass: 45% Pl (An_{35}), 30% Cpx, 10% Opq, 15% glass. Vesicles: 15%, 0.2–0.5 mm and 1.0–3.0 mm; irregular; 60% smectite-filled.	
25	718.0–727.0 (9.0)	Volcaniclastic breccia (C:M 7–5:1) Clasts: Avg. 0.5 cm, max. 5 cm; become rare toward base; dusky grayish green (5G 7/5). Abundant calcite and zeolite cement.		Lithology same as Units 19 and 21.
26	727.0–728.0 (1.0)	Basalt dike Steeply dipping (~70°) intrusive igneous contact with parallel bands of vesicles.	Pl-phyric basalt Phenocrysts: 5%; Pl (1–2 mm, glomeromorphic). Groundmass: 80% Vesicles: 5%; 1–2 mm, concentrated in bands, lined with smectite.	Relatively fresh; no veins.
27	728.0–731.5 (3.5)	Basalt dike Upper contact parallel to lower contact of Unit 26, separated by thin band of volcaniclastic breccia.	Aphyric basalt Groundmass: 90%; 25% crystalline; 15% Pl, 5% Cpx, 1% Opq, 75% glass. Vesicles: 10%; 0.5 mm; empty or lined with carbonate.	
28	731.5–736.5 (5.0)	Basalt dike Poorly recovered dike(?); no contacts revealed. No veining.	Pl-Cpx-Ol-phyric basalt Phenocrysts: 10%; Pl (80%, 1–2 mm, An_{75} glomerophyric); Cpx (10%, 0.5–1 mm, subhedral; Ol (10%, 0.5–1 mm, subhedral pseudomorphs). Groundmass: 80%; fine, 75% crystalline, intersertal; 45% Pl, 25% Cpx, 5% Opq, 25% glass. Vesicles: 5–7%; 0.2–3 mm, empty or lined with smectite and zeolites.	
29	736.5–750.5 (14.0)	Volcaniclastic breccia Upper 3 m—C:M 4:1 Clasts: 80% altered basalt, 10% fresh basalt, subrounded, unsorted, ungraded, unoriented; avg. 1 cm, max. 5–7 cm. Matrix: greenish gray altered basalt fragments and glass; calcite and zeolite cement. Lower 11 m—C:M 2–3:1 Clasts: as above but smaller, avg. 0.25–0.5 cm, max. 3 cm. Matrix: as above but finer, <0.1 mm.		Some vesicles in fresh, aphyric, finely crystalline basalt filled or lined with carbonate, zeolites, and smectite.
30	750.5–757.0 (6.5)	Hydrothermally altered volcaniclastic breccia C:M 2:1 Clasts: altered vesicular basalts and pumice; angular to subangular; unsorted, unoriented; avg. ~0.3 cm max. 2 cm. Matrix: grayish blue (5BG 3/2) altered volcanic glass; zeolite cement.		Rock is soft. Pyrite grains (~0.01 mm) are present.

Table 4. (Continued).

Unit	Depth in m (thickness)	Lithology	Petrography	Comments
31	757.0–768.5 (11.5)	Basalt flows a) upper ~9 m basalt flows have glass margins (~1 cm). b) cognate basalt breccia. c) lower ~2 m basalt as in (a).	a) Pl-Cpx-phyric basalt (glass margin) Phenocrysts: 10%; Pl (90%, 0.4–3.0 mm, $An_{\sim 60}$, eu- to subhedral); Cpx (<10%, 0.3–0.5 mm). Groundmass: 70%; fine, 35% crystalline; 15% Pl, 3% Cpx, 3% Opq, 75% altered glass. Vesicles: 20%; 0.5–1 mm, subspherical. c) Pl-Cpx-phyric basalt Phenocrysts: 5%; Pl (90%, 0.5–1 mm); Cpx (tr). Groundmass: 75%; fine, 80% crystalline, subophitic; Pl, Cpx, Opq, glass. Vesicles: 15–20%; empty or filled with carbonate, zeolites, and smectite.	a) pyrite grains (~0.12 mm) fill some veins b) interflow breccia
32	768.5–769.5 (1.0)	Hydrothermally altered volcaniclastic breccia. Clasts: extremely altered, vesicular basalt. Matrix: green and brown clays, carbonate and zeolite.		Contains disseminated pyrite.
33	769.5–783.5 (14.0)	Basalt sill(?) Thick massive flow (possibly a sill). Prominent slightly coarser, opaque mineral-rich bands, 0.2–0.5 cm wide, 1- cm apart (Fig. 12). Finely crystalline chilled margin was ruptured prior to final solidification by a further magma pulse(s) forming a microbreccia 10–20 cm wide. Origin of banding unclear.	Pl-Cpx-phyric basalt Phenocrysts: 20%; Pl (90%, 0.4–2.5 mm, An_{56-65}); Cpx (tr–10%, 0.4–1.5 mm, euhedral). Groundmass: 70%; fine (0.02–0.4 m) intersertal or hyalopilitic, 80–90% crystalline; 40% Pl, 30% Cpx, 10% Opq, 15% glass. Vesicles: 2–10%; 0.5–2 mm, filled with carbonate, zeolites, and clays.	Numerous fractures and slickensides. Carbonate and zeolite veins common.
34	783.5–792.5 (9.0)	Volcaniclastic breccia C:M 5:1 Clasts: 75% altered basalt, 25% glass; avg. 1 cm, max. 3 cm. Matrix: 5GY 2/1 becoming almost black (N2) near base; composed of smectites with zeolite cement.		
35	792.5–794.5 (2.0)	Basalt sill(?) Well-preserved, fresh glass contacts dip 60°. Pl phenocrysts are flow differentiated.	Pl-Cpx-phyric basalt Phenocrysts: 10%; Pl (80%, 0.5–2 mm, An_{65}); Cpx (20%, 0.4–1.0 mm). Groundmass: 85%; 0.5 m, 80–90% crystalline, hyalopilitic; 50% Pl, 30% Cpx, 5% Opq, 15% glass. Vesicles: 2%; 0.5 mm, empty.	
36	794.5–802.0 (7.5)	Volcaniclastic breccia grading into laminated tuff Breccia (upper 2 m) as in Unit 34. Tuff: fine to coarse silt, dark greenish gray to medium bluish gray (5G 4/1–5B 5/1). Fine lenticular, convolute, and graded bedding. Dip 60°; cross-bed (20–30° intersection) near base.		Compaction faults, 1 cm displacement
37	802.0–806.0 (4.0)	Basalt dike Sharp, linear glass contact perpendicular to tuff lamination (Fig. 13). Alignment of vesicles suggests 50° dip.	Pl-Cpx-phyric basalt Phenocrysts: 10%; Pl (85%, 0.4–2 mm, An_{68}); Cpx (10%, 0.4–0.6 mm). Groundmass: 85%; fine (0.05 mm), 60% crystalline, hyalopilitic; 45% Pl, 30% Cpx, 10% Opq, 15% glass. Vesicles: 2%; 0.2 mm.	
38	806.0–810.5 (4.5)	Laminated tuff Same as base of Unit 36.		
39	810.5–813.5 (3.0)	Basalt flows(?) Two flows (possibly sills) separated by 10 cm of breccia.	Pl-Cpx-phyric basalt Phenocrysts: 10%; Pl (90%, 0.4–2 mm, An_{65}); Cpx (tr–10%, ~0.5 mm). Groundmass: 90%; 0.1–0.5 mm, 60–75% crystalline, intersertal to hyalopilitic; 35% Pl, 20% Cpx, 7% Opq, 35% glass. Vesicles: none.	
40	813.5–832.0 (18.5)	Volcaniclastic breccia C:M 4:1 Clasts: Angular to subrounded vesicular basalts extremely altered to green (5G 2/1) smectite. Avg. 1–3 cm, max. 5–15 cm. Matrix: composition similar to clasts; zeolite cement.		

Table 4. (Continued).

Unit	Depth in m (thickness)	Lithology	Petrography	Comments
41	832.0–841.5 (9.5)	Basalt flow(?) and cognate breccia Upper 5 m of basalt flow(?) overlying a basalt breccia. Lower 4.5 m ruptured flow(?); C:M 1-4:1. Clasts: highly angular. Matrix: fine-grained basalt fragments.	Pl-Cpx-phyric basalt Phenocrysts: 15%; Pl (95%, 0.3–4.0 mm, $An_{\sim 55}$, subhedral). Groundmass: 85%; very fine, 75% crystalline, intersertal; 50% Pl, 30% Cpx, 20% Opq, and altered glass. Vesicles: rare.	Glass replaced by clays.
42	841.5–843.0 (1.5)	Volcaniclastic breccia and laminated tuff C:M 1-2:1 Clasts: subangular to rounded basalt, avg. 0.5–1.0 cm, max. 4 cm. Matrix: medium to coarse silt-sized basalt grains, dusky gray-green (5G 7/5). Cross-laminations present.		
43	843.0–848.0 (5.0)	Basalt flow(?) Flow interior coarser-grained.	Aphyric basalt Microphenocrysts: <3%; Pl (~70%, 0.2–0.5 mm, An_{60}, eu- to subhedral); Cpx (~30%, 0.2–0.5 mm, laths). Groundmass: 85%; very fine, intersertal; 50% Pl, 30% Cpx, 20% Opq, and altered glass. Vesicles: 10%; 0.3–1.0 mm, spherical; filled with clays.	
44	848.0–858.5 (10.5)	Volcaniclastic breccia C:M 2:1 Clasts: basalt and altered glass (ratio 5:1), avg. 0.2–0.5 cm, max. 1–2 cm. Matrix: green (5G 4/1) altered basalt and glass grains.		
45	858.5–864.4 (6.0)	Basalt sill(?) With glassy margin in contact with overlying Unit 44.	Pl-Cpx-phyric basalt Phenocrysts: 10%; Pl (90%, 0.2–2.0 mm, $An_{\sim 65}$, eu- to subhedral); Cpx (10%, 0.2–0.5 mm, subhedral). Groundmass: 80%; fine, 70% crystalline, hyalopilitic; 50% Pl, 30% Cpx, 20% Opq, and altered glass. Vesicles: 10%; 0.2–2.0 mm, spherical, empty or clay-filled.	
46	864.5–866.5 (2.0)	Volcaniclastic breccia C:M 1-4:1 Clasts: altered basalt and glass(?); avg. 0.2–0.4 cm, max. 1 cm (top and base); avg. 0.2 cm, max. 0.5 cm (middle). Matrix: fine basalt grains altered to green (5G 4/1) smectite.		Bedding dips 20°
47	866.5–867.5 (1.0)	Basalt flow or sill Well-preserved glassy margin, 3 cm wide dipping 50–60° at contact with breccia.	Pl-phyric basalt Phenocrysts: <5%; glomerocrysts of Pl, 1–3 mm. Groundmass: >90%; intersertal. Vesicles: <5%, 1–2 mm filled with dark green smectite.	
48	867.5–887.0 (19.5)	Volcaniclastic breccia C:M 3:1 Clasts: angular and subrounded, altered vitrophyric or aphyric basalt; avg. 2–3 mm. Matrix: dark green (5G 2/1) hydrothermally altered.		Contains disseminated pyrite.
49	887.0–986.0 (9.0)	Basalt dike Highly porphyritic (Fig. 14). upper chilled contact preserved.	Pl-Cpx-Opx-phyric basalt Phenocrysts: 40%; Pl (85%, 1.5–4 mm). Cpx (10%, 0.4–1 mm, glomerophyric with Pl and Opx); Opx (5%, 2–3 mm, partly replaced by smectite.). Groundmass: 60%; 0.05–0.5 mm, 80% crystalline, subophitic (hyalopilitic near chilled margin); 30% Pl, 30% Cpx, 10% Opq, 20% glass. Vesicles: none.	
50	896.0–902.0 (6.0)	Volcaniclastic breccia C:M 2:3 Clasts: highly altered vesicular and glassy basalt; avg. 0.3 cm, max. 1 cm. Matrix: greenish black smectite (5GY 2/1); rare zeolite cement.		Clasts increase in abundance and size down unit where C:M 2:1 and max. 4 cm.
51	902.0–914.0 (12.0)	Basalt dike Fine-grained bands have dip ~60°. Slight brecciation in 20 cm bands (1–2 cm fragments). Hydrothermally altered.	Massive aphyric basalt Groundmass: fine, 90% crystalline, sub-ophitic to ophitic.	Disseminated pyrite with large (1 cm) crystals in fractures.

Note: Pl = plagioclase, Cpx = clinopyroxene, Opx = orthopyroxene, Ol = olivine, Pig = pigeonite, Opq = opaque, An = anorthite, 2V = optic axis angle, C:M = clasts: matrix ratio, tr = trace, max. = maximum, avg. = average. Units 6 through 13 are from Hole 448; those from 14 downward are from Hole 448A.

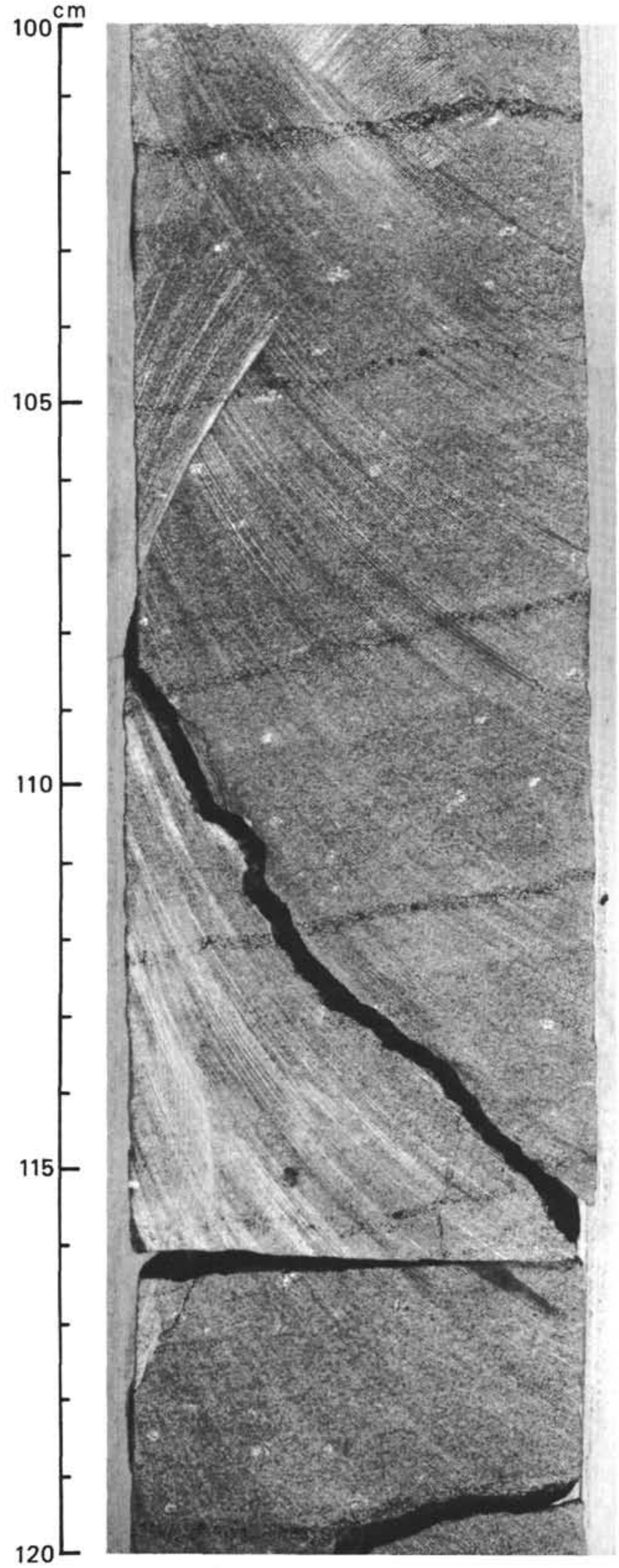


Figure 12. Magmatic segregation bands that consist of concentrations of opaque minerals in Unit 33. (Note that the darker bands are adjacent to thick bands that seem depleted in dark minerals relative to the average—for example, see the dark band at about 112 cm.)

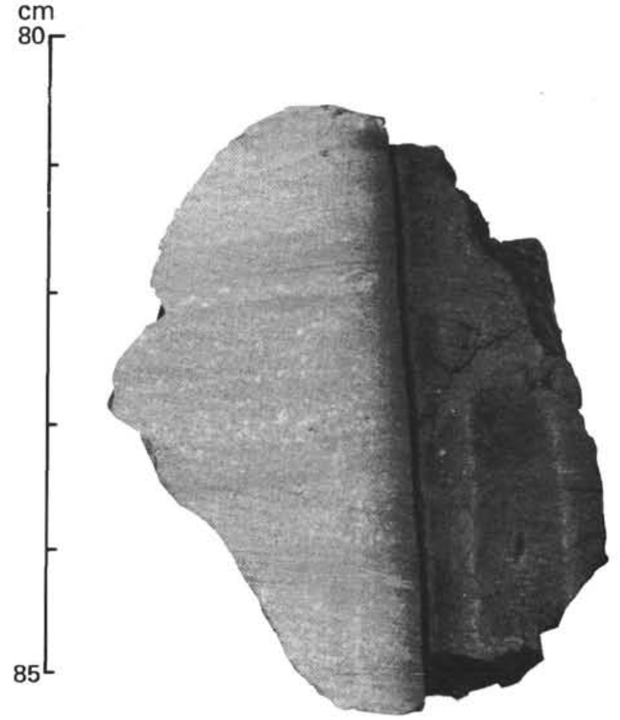


Figure 13. Dark glass marking a sharp dike contact with light layered sediments.

alteration phases caused either by ambient temperature diagenesis or by hydrothermal alteration. Although celadonite and chlorite are possible candidates, some complex smectite is more likely.

Within the green volcaniclastic breccia, a significant number of veinlets of native copper are found to the exclusion of any sulfides, oxides, or carbonates of copper. Thus a relatively restricted field of stability is inferred: $\log P_{CO_2} < -50$ atm, $\log P_{S_2} < -40$ atm, and $\log P_{CO_2} > 0$ (for pure H_2O at 25°C and $P = 1$ atm; Garrels and Christ, 1965). In other words, very little oxygen or sulfur is chemically available in the system, whereas CO_2 is abundant. The mineral assemblage calcite and green smectites, with the absence of sulfides and iron oxides, fits this chemical environment. Not only is native copper found as veins and blebs within the breccia but it is also found as disseminated growths within vesicles and pore spares of altered basalt flows. In flows that contain native copper, the plagioclase crystals are highly altered and are partially replaced with the unidentified green clay.

Below a depth of about 694 meters sub-bottom, fairly abundant dikes and sills are found in the same regions of the core as three hydrothermally altered zones; probably intrusion of these bodies triggered this localized hydrothermal activity. The hydrothermally altered breccias (750.5–757.0 m, 768.5–769.5 m, and the central 5 m or the 867.5–887.0 m interval) are much softer and more friable than unaffected breccias; they have a distinctive grayish blue color, the clasts within the breccia are highly altered, and small crystals (0.01–0.1 mm) of pyrite and chalcopyrite(?) are disseminated throughout the rock. Most of the basalts and andesites at this depth

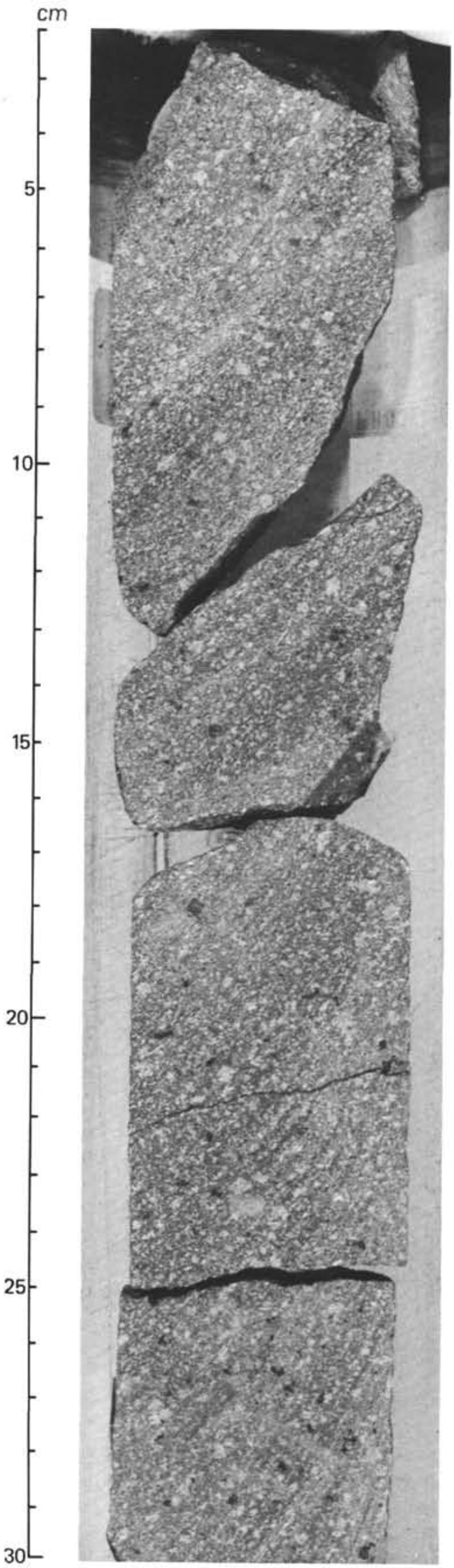


Figure 14. A highly porphyritic basalt dike of Unit 49. (The high plagioclase-phenocryst content suggests that this rock may be transitional between basalt and basaltic andesite.)

have vesicles filled with a pale bluish green clay and a dark green clay(?) mineral, neither of which has been identified. The basalt at the base of Hole 448A has 1-cm-diameter pyrite crystals along slickensided surfaces. Tentatively, these observations are explained as resulting from injection of dikes and sills, which locally increased the temperature enough to induce seawater-basalt reactions, in turn creating fluids rich in Fe, Mn, Cu, other metals, and reduced sulfur species, and poor in oxygen (Hajash, 1975). As the temperature dropped, these fluids precipitated metal sulfides. Fluids depleted in oxygen and sulfur species but still rich in metals rose into cooler rocks, and copper was precipitated, probably from copper-chloride complexes.

CONTACT RELATIONS AND STRATIGRAPHY

Contact relations of cooling units were used to distinguish dikes and sills from the volcaniclastic units and flows they cut in the sequence of flows and sedimentary breccias cored at Site 448.

A total of ten intrusive units were noted: Unit 26, basalt dike, 727.0–728.0 m; Unit 27, basalt dike, 728.0–731.5 m; Unit 28, basalt dike(?), 731.5–736.5 m; Unit 33, basalt sill(?), 769.5–783.5; Unit 35, basalt sill(?), 792.5–794.5 m; Unit 37, basalt dike, 802.0–806.0 m; Unit 45, basalt sill(?), 858.5–864.5 m; Unit 47, basalt sill(?), 866.5–867.0 m; Unit 49, basalt dike, 887.0–896.0 m; and Unit 51, basalt dike, 902.0–914.0 m. In general the intrusive units are significantly thinner (6 m average) than are the flows (15 m average), although this observation does not by itself support an intrusive origin.

Several diagnostic features serve to distinguish intrusive units from extrusive units. These include:

1) In a few cases, laminated fine-tuff bedding is cut at high angles by igneous contacts.

2) Massively bedded breccia-igneous contacts dip at 60° to 70°, significantly steeper than contact attitudes observed elsewhere in sediments and volcanic units; flow and sediment contacts dip between 20° and 45°. These steeper igneous contacts are considered to be discordant.

3) The chilled margins of some igneous units are deformed by subsequent pulses of injection.

4) Flow differentiation of vesicles or phenocrysts into parallel bands is interpreted as the result of laminar flow that is parallel to contacts found in intrusive cooling units rather than in more turbulent flow typical of extrusive units. Two types of flow differentiation are found in these dikes and sills. One is characterized by 60° to 70° dips of parallel bands of vesicles; these may be interpreted either as flow differentiation of vesicles or as flow differentiation of volatile-rich portions of magma that subsequently exsolved to form vesicles. Presumably these parallel-flow differentiated bands are parallel to the contact and therefore the unit is discordant with the lesser dips of sedimentary beds. The other type of flow differentiation is exhibited by plagioclase-phenocryst abundances; the plagioclase phenocrysts are distributed in parallel bands with a maximum of 5% plagioclase phenocrysts in the center of the unit and symmetrically placed secondary maxima of 2% closer to

each margin. Such laminar-flow differentiation is considered to be evidence of flow confined to a sill or dike with a symmetrical cooling history.

An example of deformation of chilled margins by subsequent injections is demonstrated by Unit 33 that has a highly brecciated upper chilled contact. Fingers of unfractured basalt from the interior of the cooling unit that project into the microbrecciated marginal zone are bent to form 20° angles to the contact. Presumably later injections of magma have bent these fingers into this present attitude, where a large viscosity gradient and flow-velocity gradient is concentrated near the margins, creating drag features. This unit is interpreted to be a sill because its contacts are essentially parallel to the maximum dip of the strata (45°).

PALEOMAGNETISM

Paleomagnetic studies were conducted on the sediments and basaltic flows cored at Site 448. The sampling was limited, however, because few rocks suitable for paleomagnetic study were recovered. The trend of shallowing inclinations is evident in this data set (Tables 5 and 6). Because of the extremely high sedimentation rate at this site and the brevity of geologic time recorded, it seems unlikely that this trend records tectonic movement of the ocean plate. Instead, the trend is interpreted as a polarity reversal recorded in the sediments and flows. Several other possibilities also exist, however; the variation in inclination may be the result of (1) a magnetic-pole excursion, (2) secular variation, or (3) structural tilting of the strata.

No cores were sampled for paleomagnetic study from 280.5 to 356.5 meters because no suitable material was recovered from this interval. The mean inclination for the basaltic flows was found to be 17.1°. The paleolatitude estimated on the basis of this inclination was 8.7°. Structural dips were obvious in some of the rock units from this site. Corrections for these dips were not made at the time of the preliminary measurements summarized here. This subject is discussed in more detail in subsequent paleomagnetic chapters (see Keating, and Keating and Herrero, this volume).

Table 5. NRM measurements of sediments from Hole 448.

Sample (core-section, depth of interval in cm)	Sub-bottom Depth (m)	Inclination (°)	Declination (°)	Intensity (emu/cm^3)
4-6, 132	32.82	−6.07	274.1	0.1410×10^{-4}
20-1, 5	176.05	14.70	56.4	0.3918×10^{-4}
20-2, 143	178.93	9.00	204.2	0.1502×10^{-4}
24-1, 61	214.61	17.10	214.6	0.3314×10^{-4}
24-2, 79	216.29	3.58	21.0	0.3444×10^{-3}
25-1, 55	224.05	−9.50	78.1	0.9687×10^{-5}
25-3, 91	227.41	8.95	299.6	0.1446×10^{-3}
26-1, 112	234.62	−9.49	184.9	0.3565×10^{-4}
26-2, 48	235.48	66.10	20.6	0.1456×10^{-4}
26-3, 50	237.00	0.10	256.8	0.1359×10^{-3}
27-1, 102	243.52	2.60	53.9	0.1023×10^{-3}
27-2, 60	244.60	−18.50	−21.3	0.2727×10^{-3}
28-1, 95	252.95	−11.20	103.7	0.4175×10^{-3}
29-1, 60	262.10	−14.00	−77.8	0.1191×10^{-4}
31-1, 16	280.66	−8.37	260.9	0.1214×10^{-4}

Table 6. NRM measurements of basalts from Holes 448 and 448A.

Sample (core-section, depth of interval in cm)	Sub-bottom Depth (m)	Inclination (°)	Declination (°)	Intensity (emu/cm^3)
Hole 448				
40-1, 40	356.90	2.00	164.4	0.2745×10^{-3}
43-2, 45	377.45	−38.46	56.6	0.1434
50-1, 50	442.50	−25.60	259.0	0.5303×10^{-4}
53-1, 99	471.49	−21.90	126.1	0.1808×10^{-2}
59-2, 89	529.89	9.30	256.9	0.9890×10^{-3}
61-3, 100	560.00	21.33	149.2	0.5766×10^{-3}
Hole 448A				
15-3, 112	531.62	2.90	37.5	0.5422×10^{-3}
16-3, 24	540.24	−3.90	99.5	0.9517×10^{-5}
17-2, 56	548.56	−26.40	−41.8	0.4105×10^{-2}
18-1, 102	550.52	16.30	−87.1	0.3030×10^{-2}
20-3, 75	569.25	−6.30	96.0	0.1196×10^{-2}
27-1, 37	617.87	−16.40	114.6	0.8956×10^{-6}
28-1, 76	623.26	−0.60	201.8	0.7262×10^{-3}
30-1, 123	642.73	−7.00	−89.0	0.1490×10^{-5}
30-2, 94	643.96	15.30	18.7	0.2009×10^{-3}
32-1, 70	661.20	−32.40	166.2	0.1174×10^{-2}
33-2, 48	665.48	−28.30	59.2	0.2408×10^{-3}
33-3, 35	666.85	−25.00	4.6	0.2680×10^{-1}
36-4, 145	694.95	−25.30	141.2	0.1416×10^{-2}
36-5, 12	695.12	−27.40	54.2	0.7674×10^{-3}
39-2, 59	714.59	11.80	−79.7	0.1671×10^{-1}
39-2, 79	714.79	3.80	−74.5	0.1771×10^{-1}
39-2, 83	714.83	18.50	−82.5	0.1260×10^{-1}
39-2, 111	715.11	−15.30	−49.1	0.5041×10^{-3}
39-2, 131	715.31	6.70	84.8	0.1129×10^{-1}
41-1, 124	728.24	−28.60	197. 8	0.8186×10^{-3}
41-2, 120	729.70	−7.90	262.8	0.1678×10^{-2}
45-1, 49	765.49	−0.80	−33.6	0.4748×10^{-3}
47-1, 69	775.19	−11.20	151.7	0.9817×10^{-4}
47-2, 10	776.10	−8.60	−44.5	0.7527×10^{-4}
47-2, 69	776.69	−2.20	172.8	0.1063×10^{-3}
47-2, 103	777.03	−18.20	97.5	0.3959×10^{-2}
47-2, 145	777.45	−31.60	35.3	0.5224×10^{-2}
48-1, 45	779.95	−17.90	160.9	0.4552×10^{-3}
50-1, 50	793.00	−15.40	−69.6	0.4633×10^{-4}
50-2, 39	794.39	9.21	347.1	0.1103×10^{-1}
51-1, 112	802.62	−17.09	207.1	0.1769×10^{-1}
51-2, 141	804.41	−2.50	51.2	0.2487×10^{-4}
51-3, 47	804.97	−25.00	−16.1	0.8800×10^{-4}
51-4, 10	806.10	−25.40	207.1	0.1925×10^{-2}
52-2, 127	813.23	−15.60	−19.5	0.3233×10^{-3}
57-1, 27	846.77	7.10	177.5	0.3854×10^{-3}
57-2, 5	848.05	−8.90	96.1	0.1026×10^{-3}
58-3, 48	858.98	−18.70	−84.6	0.2455×10^{-3}
59-2, 79	866.79	−15.20	−83.1	0.3058×10^{-2}
59-2, 81	866.81	−19.40	243.1	0.7777×10^{-1}
59-2, 102	867.02	−17.50	135.2	0.1093×10^{-1}
59-3, 14	867.64	−22.30	123.4	0.7817×10^{-1}
62-1, 73	887.73	14.90	51.4	0.7054×10^{-4}
62-2, 30	888.80	−8.20	222.3	0.9480×10^{-4}
65-1, 137	906.37	−23.00	144.6	0.1280×10^{-3}
65-3, 69	908.69	−37.90	−24.2	0.2630×10^{-4}

The paleolatitudes determined for both volcanic basement and overlying sediments (10.6°) are significantly shallower than that at the present latitude of 16°20′N. For a tectonic argument based upon these observed paleolatitudes, it is tempting to suggest a history of northward movement for this site (beginning south of the equator). Lithologic and paleontologic evidence discussed earlier in this chapter, however, indicates concentrated volcanism over a relatively short period of geologic time. The resulting polar movement (derived from sediment data) was estimated at 5.6° per m.y., an unreasonably high rate. In order to avoid invoking large-scale tectonic movement of the site, an alternative interpretation is suggested, i.e., that the site was situated close to the paleoequator in the Oligocene and that the paleomagnetic directions recorded represent secular variation of the earth's magnetic field. Overall northward movement of the site, however, should not be ruled out based on the data from the basalts, but the brevity of geologic time represented by the rock units sampled at this site argues against that interpretation.

A dark green volcaniclastic breccia (Sample 30-2, 94) and an extensively altered basalt flow (Sample 32-1, 70) from Hole 448A were studied in order to investigate the effect of low-temperature alteration observed in these rock types and to determine if the alteration occurred at a significantly different time and paleolatitude than did that of unaltered flow basalts. The mean inclination of the breccia and the altered basalt is close to that of the flows, and it thus appears that alteration and remagnetization occurred subsequently to brecciation but probably not long after extrusion of the flow units.

Approximately 30 samples were collected from the volcanic units in Hole 448A. A set of six samples was progressively demagnetized in fields up to 1000 Oe. Many of these samples proved to be unstably magnetized, showing significant directional and intensity changes. In addition, most samples for which duplicate natural remanent magnetization (NRM) measurements were made (over a period of 24 or 48 hours) displayed large directional and intensity changes, indicative of acquisition of large viscous components. The propensity for these samples to acquire viscous components suggests that the NRM directions do not reliably record the paleomagnetic field.

PHYSICAL PROPERTIES

Sonic velocity, wet-bulk density, water content, porosity, and acoustic impedance of the sediments and interbedded basalts cored in Holes 448 and 448A were measured and determined according to the methods and procedures described in the Introduction (this volume). The results are listed in Tables 7 and 8, and the combined results corrected for stratigraphic offset, are shown graphically in Figure 15. To facilitate comparison of the two holes, in Figure 15, results from Hole 448A have been displaced 19 meters down-hole to agree stratigraphically with those from Hole 448.

Sonic velocities were measured wherever possible in both horizontal and vertical directions on each major lithology recovered from both holes. In Hole 448, the velocity of the surficial sediment in Core 1 is slightly higher than 1.5 km/s. Sonic velocities of samples from Cores 4 to 19 (approximately 30 to 170 m sub-bottom), with the exception of Section 10-5, are close to 1.6 km/s and increase only slightly with depth. In the well-lithified chalks and tuffs from Cores 19 to 23 (~170–200 m), velocities increase to more than 2.4 km/s. Anisotropy is present, as indicated by the higher velocities commonly measured in the horizontal direction (parallel to the bedding planes). In the tuffaceous volcaniclastic breccia of Core 24 (216 m), the velocity increases to 3.1 km/s. Down-hole, below that horizon, a velocity inversion from 3.1 to 2.1 km/s occurs in the vitric tuffs of Cores 24 to 29 (~220–262 m), dropping to less than 2 km/s in the ashy nannofossil ooze of Core 31. The underlying interbedded basalts sampled in Cores 37 to 61 (340–550 m) range in velocity from less than 3 km/s to more than 4.9 km/s, averaging about 4.3 km/s. The low velocities of the basalts are mainly the result of their high vesicularity and high degree of alteration. The volcaniclastic breccias, intercalated between the basalts, average about 3.3 km/s. The variations in the velocities measured on the rocks from Hole 448 correlate well with the alternating lithologies encountered.

In Hole 448A the sequence of basalts and intercalated volcaniclastic rocks was encountered between 291 and 914 meters sub-bottom (total depth cored), displaced by 19 meters from the same lithologies encountered in Hole 448. The sediment/basalt contact is clearly indicated by the abrupt velocity increase from 2.28 to 4.17 km/s at 291 meters (Table 8). Below this contact, variations in the sonic velocities again correlate well with the alternating lithologies encountered. As can be seen in Table 8, the interval between 291 and 527 meters was discontinuously cored; a more comprehensive record of this interval was obtained from Hole 448 (Table 7). Between 527 and 901 meters sub-bottom in Hole 448A, sonic velocities in the volcanic succession are obviously dependent upon the lithology, structure, and degree of alteration of the rocks. From 527 to 640 meters sub-bottom, velocities range from less than 3.0 to more than 4.2 km/s in the vesicular basalts and from 2.7 to more than 3.2 km/s in the volcaniclastic breccias.

Between 640 and 901 meters sub-bottom, basalt velocities increase to more than 5.1 km/s, probably because of their fine-grained texture and paucity of vesicles; the high value of 5.15 km/s at about 776 meters sub-bottom corresponds to an unaltered aphyric basalt encountered at that level. Velocities of the green volcaniclastic breccias and tuffs intercalated between these basalts range from 2.0 to 2.8 km/s, significantly lower than the velocities of 2.7 to 3.2 km/s measured on the breccias higher in the hole. These lower-velocity units have undergone significant hydrothermal alteration (see the section on metamorphic petrography in this chapter). The decrease in velocity is attributed to the hydrothermal production of clays. Significant differences between horizontal and vertical velocities (parallel and perpendicular to the bedding) are not apparent, thus anisotropy appears to be lacking. The alternating lithologies within the volcanic succession of Hole 448A are clearly evidenced in the excursions of the velocities plotted in Figure 15.

The distinct variations observed in the sonic velocities are also readily apparent in the other physical properties. Wet-bulk density increases from 1.57 g/cm^3 in the unconsolidated surficial sediments of Hole 448 to 1.7 g/cm^3 in the underlying, stiff, semilithified sediments. Down-hole, in the tuffs overlying the basalts, density increases from 1.7 to 1.9 g/cm^3. Wet-bulk density measurements of the basalts in both Holes 448 and 448A range from 2.0 to 2.5 g/cm^3 in the vesicular basalts and from 2.5 to 2.8 g/cm^3 in the fine-grained dense basalts in the lower part of the hole (640 to 900 m

Table 7. Physical properties of sedimentary and igneous rocks from Hole 448.

Sample (hole-core-section)	Sub-bottom Depth (m)	Sonic Velocity Horizontal		Sonic Velocity Vertical	Wet-Bulk Density Gravimetric (g/cm^3)	Wet-Bulk Density Continuous GRAPE (section averages) (g/cm^3)[b]	Wet-Bulk Density Special 2-min GRAPE (g/cm^3)[b]	Water Content (%)	Porosity (%)	Calculated Grain Density (g/cm^3)	Acoustic Impedance [$\times 10^5$ $g/(cm^2s)$]
448-1-1	0.66	1.523	—	1.526	—	—	—	—	—	—	—
448-1-1	0.68	—	—	—	—	—	—	59.27	—	—	—
448-1-1	0.75	—	—	—	—	1.38	—	—	—	—	—
448-1-2	2.25	—	—	—	—	1.40	—	—	—	—	—
448-1-2	2.71	—	—	—	—	—	—	51.28	—	—	—
448-2-1	5.75	—	—	—	—	1.48	—	—	—	—	—
448-2-2	7.25	—	—	—	—	1.48	—	—	—	—	—
448-2-3	8.75	—	—	—	—	1.48	—	—	—	—	—
448-2-4	10.25	—	—	—	—	1.48	—	—	—	—	—
448-2-5	11.75	—	—	—	—	1.46	—	—	—	—	—
448-2-6	13.25	—	—	—	—	1.52	—	—	—	—	—
448-2-7	14.75	—	—	—	—	1.51	—	—	—	—	—
448-3-1	15.25	—	—	—	—	1.50	—	—	—	—	—
448-4-1	24.75	—	—	—	—	1.49	—	—	—	—	—
448-4-2	26.25	—	—	—	—	1.50	—	—	—	—	—
448-4-3	27.75	—	—	—	—	1.51	—	—	—	—	—
448-4-4	29.25	—	—	—	—	1.51	—	—	—	—	—
448-4-4	29.37	1.559	—	1.545	—	—	—	—	—	—	—
448-4-4	29.39	—	—	—	—	—	—	46.95	—	—	—
448-4-5	30.75	—	—	—	—	1.49	—	—	—	—	—
448-4-6	32.25	—	—	—	—	1.49	—	—	—	—	—
448-5-1	34.25	—	—	—	—	1.52	—	—	—	—	—
448-6-1	43.75	—	—	—	—	1.51	—	—	—	—	—
448-6-2	45.25	—	—	—	—	1.55	—	—	—	—	—
448-6-3	46.75	—	—	—	—	1.61	—	—	—	—	—
448-6-3	47.45	—	—	—	—	—	—	40.41	—	—	—
448-6-4	48.25	—	—	—	—	1.58	—	—	—	—	—
448-8-1	62.75	—	—	—	—	1.60	—	—	—	—	—
448-8-2	64.25	—	—	—	—	1.61	—	—	—	—	—
448-8-3	65.75	—	—	—	—	1.58	—	—	—	—	—
448-8-4	67.25	—	—	—	—	1.58	—	—	—	—	—
448-10-1	81.75	—	—	—	—	1.58	—	—	—	—	—
448-10-3	84.75	—	—	—	—	1.64	—	—	—	—	—
448-10-5	87.75	—	—	—	—	1.60	—	—	—	—	—
448-10-5	88.22	2.334	—	2.479	1.571	—	1.616	38.45	60.42	2.443	3.89
448-11-1	91.25	—	—	—	—	1.61	—	—	—	—	—
448-11-3	94.25	—	—	—	—	1.61	—	—	—	—	—
448-11-4	96.45	—	—	—	—	—	—	38.91	—	—	—
448-11-5	97.25	—	—	—	—	1.63	—	—	—	—	—
448-11-5	97.26	1.609	—	1.592	—	—	—	—	—	—	—
448-11-5	97.28	—	—	—	1.557	—	—	42.01	65.39	2.608	—
448-11-5	97.61	1.630	—	1.618	—	—	—	—	—	—	—
448-11-5	97.64	—	—	—	1.580	—	1.647	38.63	61.02	2.487	—
448-12-1	100.75	—	—	—	—	1.56	—	—	—	—	—
448-12-3	103.75	—	—	—	—	1.62	—	—	—	—	—
448-12-5	106.66	—	—	—	—	—	2.804	—	—	—	—
448-12-5	106.75	—	—	—	—	1.66	—	—	—	—	—
448-12-6	108.15	1.619	—	1.550	—	—	—	—	—	—	2.58
448-12-6	108.17	—	—	—	1.596	—	1.616	38.35	61.19	2.534	—
448-13-1	110.25	—	—	—	—	1.59	—	—	—	—	—
448-13-1	110.88	1.638	—	1.601	—	—	—	—	—	—	2.64
448-13-1	110.89	—	—	—	1.614	—	1.687	38.00	61.32	2.587	—
448-13-3	113.25	—	—	—	—	1.61	—	—	—	—	—
448-13-6	117.75	—	—	—	—	1.60	—	—	—	—	—
448-14-1	119.75	—	—	—	—	1.57	—	—	—	—	—
448-14-3	122.75	—	—	—	—	1.62	—	—	—	—	—
448-14-3	122.90	1.624	—	1.596	—	—	—	—	—	—	2.54
448-14-3	122.91	—	—	—	1.564	—	1.624	39.09	61.14	2.452	—
448-14-5	125.75	—	—	—	—	1.64	—	—	—	—	—
448-15-1	129.25	—	—	—	—	1.58	—	—	—	—	—
448-15-3	132.25	—	—	—	—	1.64	—	—	—	—	—
448-15-5	135.25	—	—	—	—	1.61	—	—	—	—	—
448-16-1	138.75	—	—	—	—	1.57	—	—	—	—	—
448-16-3	141.75	—	—	—	—	1.59	—	—	—	—	—
448-16-5	144.75	—	—	—	—	1.61	—	—	—	—	—
448-16-5	145.45	—	—	—	1.572	—	—	39.28	61.73	2.494	—
448-16-6	146.25	—	—	—	—	1.61	—	—	—	—	—
448-17-1	148.25	—	—	—	—	1.51	—	—	—	—	—
448-17-2	149.75	—	—	—	—	1.53	—	—	—	—	—
448-17-4	152.39	1.619	—	1.591	—	—	—	—	—	—	—
448-17-4	152.41	—	—	—	—	—	1.603	—	—	—	—
448-17-4	152.42	—	—	—	1.516	—	—	42.40	64.29	2.445	—

Table 7. (Continued).

Sample (hole-core-section)	Sub-bottom Depth (m)	Sonic Velocity Horizontal		Vertical	Wet-Bulk Density Gravimetric (g/cm³)	Continuous GRAPE (section averages) (g/cm³)[b]	Special 2-min GRAPE (g/cm³)[b]	Water Content (%)	Porosity (%)	Calculated Grain Density (g/cm³)	Acoustic Impedance [× 10^5 g/(cm²s)]
448-17-5	154.25	—	—	—	—	1.54	—	—	—	—	—
448-18-3	160.37	—	—	—	—	—	1.633	—	—	—	—
448-19-1	167.25	—	—	—	—	1.39	—	—	—	—	—
448-19-3	169.86	1.666	—	1.630	—	—	—	—	—	—	2.64
448-19-3	169.87	—	—	—	1.587	—	1.800	36.25	57.54	2.382	—
448-19-3	170.25	—	—	—	—	1.57	—	—	—	—	—
448-19-5	173.25	—	—	—	—	1.64	—	—	—	—	—
448-20-1	176.41	—	—	—	1.535	—	—	44.69	68.61	2.705	—
448-20-1	176.45	1.969	—	1.949	—	—	—	—	—	—	—
448-20-1	176.47	—	—	—	1.705	—	1.558	39.15	66.74	3.120	—
448-20-1	176.75	—	—	—	—	1.47	—	—	—	—	—
448-20-2	178.25	—	—	—	—	1.57	—	—	—	—	—
448-21-1	186.21	2.284	—	2.301	—	—	—	—	—	—	—
448-21-1	186.22	—	—	—	—	—	1.614	—	—	—	—
448-21-1	186.24	—	—	—	1.542	—	—	38.94	60.03	2.355	—
448-21-2	187.75	—	—	—	—	1.36	—	—	—	—	—
448-21-3	189.25	—	—	—	—	1.34	—	—	—	—	—
448-21-3	189.93	—	—	—	1.563	—	—	42.87	67.01	2.708	—
448-22-1	196.12	2.430	—	2.327	—	—	—	—	—	—	4.05
448-22-1	196.14	—	—	—	1.666	—	1.674	36.72	61.17	2.716	—
448-24-2	216.21	—	—	—	1.920	—	—	18.06	34.67	2.408	—
448-24-2	216.23	3.104	—	2.986	—	—	—	—	—	—	—
448-24-2	216.24	—	—	—	1.897	—	1.891	22.61	42.89	2.570	—
448-25-3	226.96	2.677	—	2.523	—	—	—	—	—	—	4.50
448-25-3	226.97	—	—	—	1.783	—	1.793	29.45	52.51	2.649	—
448-25-3	227.00	—	—	—	1.768	—	—	28.92	51.13	2.572	—
448-26-2	234.90	2.423	—	1.958	—	—	—	—	—	—	3.79
448-26-2	234.92	—	—	—	1.935	—	1.889	25.02	48.42	2.812	—
448-26-2	235.96	—	—	—	1.711	—	—	35.21	60.27	2.791	—
448-27-1	243.32	2.242	—	2.169	—	—	—	—	—	—	3.92
448-27-1	243.33	—	—	—	1.747	—	—	33.20	58.01	2.780	—
448-27-1	243.36	—	—	—	—	—	1.773	—	—	—	—
448-27-2	244.30	—	—	—	1.819	—	—	28.31	51.49	2.688	—
448-28-1	252.57	—	—	—	—	—	1.571	—	—	—	—
448-28-1	253.00	2.332	—	2.248	—	—	—	—	—	—	4.15
448-28-1	253.01	—	—	—	1.780	—	1.841	30.27	53.88	2.692	—
448-29-1	262.06	2.117	—	1.998	—	—	—	—	—	—	3.07
448-29-1	262.07	—	—	—	1.535	—	1.522	42.55	65.32	2.543	—
448-29-1	262.16	—	—	—	1.528	—	—	42.95	65.62	2.535	—
448-31-1	280.79	1.959	—	1.843	—	—	—	—	—	—	3.17
448-31-1	280.80	—	—	—	1.617	—	1.656	39.09	63.21	2.677	—
448-31-1	280.89	—	—	—	1.570	—	—	42.28	66.40	2.698	—
448-37-1	337.66	—	4.212[a]	—	—	—	—	—	—	—	—
448-37-1	337.70	—	—	—	—	—	2.664	—	—	—	—
448-38-1	347.28	—	4.171[a]	—	—	—	—	—	—	—	—
448-38-1	347.31	—	—	—	—	—	2.710	—	—	—	—
448-39-1	352.44	—	4.339[a]	—	—	—	—	—	—	—	—
448-39-1	352.48	—	—	—	—	—	2.636	—	—	—	—
448-39-2	353.82	—	4.279[a]	—	—	—	—	—	—	—	—
448-39-2	353.87	—	—	—	—	—	2.791	—	—	—	—
448-39-3	355.52	—	4.330[a]	—	—	—	—	—	—	—	—
448-39-3	355.56	—	—	—	—	—	2.828	—	—	—	—
448-40-1	357.24	—	3.358[a]	—	—	—	—	—	—	—	—
448-40-1	357.25	—	—	—	—	—	2.173	—	—	—	—
448-40-2	359.02	3.312	—	—	—	—	—	—	—	—	—
448-40-2	359.06	—	—	—	—	—	2.127	—	—	—	—
448-41-1	366.37	3.169	—	—	—	—	—	—	—	—	—
448-41-1	366.40	—	—	—	—	—	1.993	—	—	—	—
448-43-1	376.37	—	3.385[a]	—	—	—	—	—	—	—	—
448-43-1	376.38	—	—	—	—	—	2.115	—	—	—	—
448-44-1	385.82	—	3.451[a]	—	—	—	—	—	—	—	—
448-44-1	385.86	—	—	—	—	—	2.243	—	—	—	—
448-46-1	404.90	—	3.343[a]	—	—	—	—	—	—	—	—
448-46-1	404.94	—	—	—	—	—	2.065	—	—	—	—
448-47-1	413.79	—	3.611[a]	—	—	—	—	—	—	—	—
448-47-1	413.82	—	—	—	—	—	2.088	—	—	—	—
448-47-2	415.37	—	3.664[a]	—	—	—	—	—	—	—	—
448-47-2	415.41	—	—	—	—	—	2.306	—	—	—	—
448-48-2	424.65	—	2.944[a]	—	—	—	—	—	—	—	—
448-48-2	424.68	—	—	—	—	—	2.638	—	—	—	—
448-48-3	427.08	3.046	—	—	—	—	—	—	—	—	—
448-48-3	427.17	—	—	—	—	—	2.196	—	—	—	—
448-48-4	428.62	3.082	—	2.744	—	—	—	—	—	—	—

Table 7. (Continued).

Sample (hole-core-section)	Sub-bottom Depth (m)	Sonic Velocity Horizontal		Vertical	Wet-Bulk Density Gravimetric (g/cm³)	Continuous GRAPE (section averages) (g/cm³)[b]	Special 2-min GRAPE (g/cm³)[b]	Water Content (%)	Porosity (%)	Calculated Grain Density (g/cm³)	Acoustic Impedance [× 10^5 g/(cm²s)]
448-48-4	428.67	—	—	—	—	—	1.998	—	—	—	—
448-50-1	442.06	3.455	—	3.132	—	—	—	—	—	—	—
448-50-1	442.09	—	—	—	—	—	2.159	—	—	—	—
448-50-2	444.54	3.338	—	—	—	—	—	—	—	—	—
448-50-2	444.57	—	—	—	—	—	2.404	—	—	—	—
448-50-5	448.00	3.507	—	—	—	—	—	—	—	—	—
448-50-5	448.05	—	—	—	—	—	2.283	—	—	—	—
448-51-1	451.57	3.182	—	3.234	—	—	—	—	—	—	6.57
448-51-1	451.59	—	—	—	2.033	—	2.084	—	—	—	—
448-53-1	470.98	—	4.954[a]	—	—	—	—	—	—	—	12.47
448-53-1	471.00	—	—	—	2.518	—	2.035	—	—	—	—
448-56-4	503.91	—	—	3.098	—	—	—	—	—	—	—
448-56-4	503.92	—	—	—	—	—	2.072	—	—	—	—
448-56-5	505.40	3.273	—	—	—	—	—	—	—	—	—
448-56-5	505.42	—	—	—	—	—	2.054	—	—	—	—
448-58-3	521.03	3.682	—	3.887	—	—	—	—	—	—	8.81
448-58-3	521.04	—	—	—	2.267	—	2.235	—	—	—	—
448-59-2	529.16	—	4.320[a]	—	—	—	—	—	—	—	10.92
448-59-2	529.17	—	—	—	2.528	—	2.503	—	—	—	—
448-61-3	549.84	—	4.175[a]	—	—	—	—	—	—	—	10.30
448-61-3	549.85	—	—	—	2.468	—	2.488	—	—	—	—
448-61-3	550.00	—	4.264	—	—	—	—	—	—	—	—
448-61-3	550.05	—	—	—	—	—	2.500	—	—	—	—

[a] Basalt average velocity.
[b] Based on an assumed grain density of 2.75 g/cm³.

sub-bottom). Wet-bulk density of the interbedded green volcaniclastic breccia ranges from 2.0 to 2.3 g/cm³, decreasing to 1.9 g/cm³ in the tuffaceous volcaniclastic breccia encountered near the base of the hole (865 m sub-bottom). Water content in Hole 448 ranges from 59% to 36% in the upper 200 meters and from 18% to 43% between 200 and 270 meters sub-bottom. Porosity, with minor fluctuations, decreases with depth in Hole 448 (Table 7).

Variation in acoustic impedance with depth in Holes 448 and 448A also appears to be comparable to the sonic velocity. In Hole 448, a high value of 3.89×10^5 g/(cm²s) occurs at about 88 meters sub-bottom in Core 10. Acoustic impedance decreases slightly, along with sonic velocity, in the vitric tuffs between Cores 25 and 31 (~227–280 m). In general, however, acoustic impedance increases with depth. Basalts and interbedded breccias in the lower part of Hole 448 have the highest impedance values, ranging from 6.5 in the breccias to more than 12×10^5 g/(cm²s) in the basalts.

In Hole 448A, as would be expected, high acoustic-impedance values occur in the basalt, ranging from 7.56 to 13.2×10^5 g/(cm²s), whereas in the volcaniclastic breccias and tuffs, impedance ranges between 4.15 and 6.16×10^5 g/(cm²s).

In both Holes 448 and 448A, a close correlation exists between the lithology and physical properties of the sediments and rocks that were cored; abrupt changes in lithology are also indicated by abrupt changes in the physical properties. Progressive compaction and induration with increasing depth are indicated by increasing velocity and density along with decreasing water content and porosity. Velocities and densities of basalts seem to be mainly dependent on the amount of vesicularity and degree of alteration. In general, the sonic velocity of the basalts and intercalated volcaniclastics averages close to 3.5 km/s and appears to be in good agreement with Murauchi's et al. (1968) seismic-refraction results.

GEOPHYSICS

The Palau-Kyushu Ridge, innermost remnant arc in the South Philippine Sea, is oriented north–south and separates the Parece Vela Basin to the east from the West Philippine Basin to the west. Along most of its length the ridge stands more than 2 km in relief above an adjoining ocean floor, which is 5 km or more below sea level, and breaks the ocean surface only at one point—Parece Vela Island. Crustal structure of the ridge has been previously determined by seismic refraction measurements reported by Murauchi et al. (1968), who described the southern part of the ridge as composed of a 2.5-km-thick, 3.5-km/s layer, underlain by a 2.9-km-thick, 5.7-km/s layer, which in turn is underlain by a 3.56-km-thick, 6.6-km/s layer (oceanic Layer 3), all overlying an 8.0-km/s mantle.

Site 448 is located at the crest of the Palau-Kyushu Ridge, to the north of the refraction line of Murauchi et al. The site itself is positioned on the eastern side of a steep-walled axial valley—the only place positively identified on reflection profiles to have sediment thick enough to insure complete burial of the bottom-hole assembly.

Interpretation of Site Survey Data

A detailed site survey, completed by L-DGO prior to DSDP Leg 59, had delineated a broad, high region of the Palau-Kyushu Ridge, about 150 km south of the 18° North Active Margin Drilling Transect. The survey,

Table 8. Physical properties of sedimentary and igneous rocks from Hole 448A.

Sample (hole-core-section)	Sub-bottom Depth (m)	Sonic Velocity Horizontal		Sonic Velocity Vertical	Wet-Bulk Density: Gravimetric (g/cm^3)	Wet-Bulk Density: Continuous GRAPE (section averages) (g/cm^3)[b]	Wet-Bulk Density: Special 2-min GRAPE (g/cm^3)[b]	Water Content (%)	Porosity (%)	Calculated Grain Density (g/cm^3)	Acoustic Impedance [$\times 10^5$ g/(cm^{2}s)]
448A-1-1	0.75	—	—	—	—	1.39	—	—	—	—	—
448A-1-2	2.25	—	—	—	—	1.48	—	—	—	—	—
448A-1-3	3.75	—	—	—	—	1.47	—	—	—	—	—
448A-1-4	5.25	—	—	—	—	1.51	—	—	—	—	—
448A-1-5	6.75	—	—	—	—	1.54	—	—	—	—	—
448A-1-6	8.25	—	—	—	—	1.51	—	—	—	—	—
448A-2-1	34.25	—	—	—	—	1.58	—	—	—	—	—
448A-2-2	35.75	—	—	—	—	1.54	—	—	—	—	—
448A-2-3	37.25	—	—	—	—	1.56	—	—	—	—	—
448A-2-4	38.75	—	—	—	—	1.53	—	—	—	—	—
448A-2-5	40.25	—	—	—	—	1.54	—	—	—	—	—
448A-2-6	41.75	—	—	—	—	1.55	—	—	—	—	—
448A-3-1	62.75	—	—	—	—	1.60	—	—	—	—	—
448A-3-2	64.75	—	—	—	—	1.60	—	—	—	—	—
448A-3-3	65.75	—	—	—	—	1.61	—	—	—	—	—
448A-3-4	67.25	—	—	—	—	1.60	—	—	—	—	—
448A-3-5	68.75	—	—	—	—	1.61	—	—	—	—	—
448A-3-6	70.25	—	—	—	—	1.62	—	—	—	—	—
448A-4-1	72.25	—	—	—	—	1.57	—	—	—	—	—
448A-4-2	73.75	—	—	—	—	1.61	—	—	—	—	—
448A-4-3	75.25	—	—	—	—	1.64	—	—	—	—	—
448A-4-4	76.75	—	—	—	—	1.65	—	—	—	—	—
448A-4-5	78.25	—	—	—	—	1.63	—	—	—	—	—
448A-4-6	79.75	—	—	—	—	1.61	—	—	—	—	—
448A-6-1	252.75	—	—	—	—	1.37	—	—	—	—	—
448A-6-1	253.36	2.333	—	2.235	—	—	—	—	—	—	—
448A-6-1	253.39	—	—	—	1.677	—	1.712	—	—	—	—
448A-6-1	253.45	—	—	—	1.608	—	—	32.59	52.40	2.277	—
448A-6-2	254.25	—	—	—	—	1.40	—	—	—	—	—
448A-6-2	254.87	1.984	—	—	—	—	—	—	—	—	—
448A-6-2	254.89	—	—	—	—	—	1.536	—	—	—	—
448A-8-2	273.60	1.920	—	—	—	—	—	—	—	—	—
448A-8-2	273.66	—	—	—	—	—	1.865	—	—	—	—
448A-8-6	279.88	1.994	—	1.894	—	—	—	—	—	—	—
448A-8-6	279.89	—	—	—	—	—	1.712	—	—	—	—
448A-8-6	279.93	—	—	—	1.688	—	—	—	—	—	—
448A-10-1	290.20	2.281	—	—	—	—	—	—	—	—	—
448A-10-1	290.25	—	—	—	—	—	1.795	—	—	—	—
448A-10-2	291.63	—	4.176[a]	—	—	—	—	—	—	—	—
448A-10-2	291.65	—	—	—	—	—	2.547	—	—	—	—
448A-10-3	293.40	—	3.819[a]	—	—	—	—	—	—	—	—
448A-10-3	293.43	—	—	—	—	—	2.484	—	—	—	—
448A-10-3	293.54	—	3.661[a]	—	—	—	—	—	—	—	—
448A-10-3	293.58	—	—	—	—	—	2.309	—	—	—	—
448A-10-4	295.22	—	4.280[a]	—	—	—	—	—	—	—	—
448A-10-4	295.25	—	—	—	—	—	2.529	—	—	—	—
448A-15-3	531.70	—	4.256[a]	—	—	—	—	—	—	—	10.66
448A-15-3	531.72	—	—	—	2.505	—	—	—	—	—	—
448A-16-1	37.00	—	4.165[a]	—	—	—	—	—	—	—	—
448A-16-1	537.08	—	—	—	—	—	2.521	—	—	—	—
448A-16-3	540.49	—	3.982[a]	—	—	—	—	—	—	—	—
448A-16-3	540.53	—	—	—	—	—	2.465	—	—	—	—
448A-17-1	547.73	—	4.034[a]	—	—	—	—	—	—	—	—
448A-17-1	547.78	—	—	—	—	—	2.285	—	—	—	—
448A-18-1	550.00	—	3.626[a]	—	—	—	—	—	—	—	—
448A-18-1	550.03	—	—	—	—	—	2.111	—	—	—	—
448A-19-1	556.66	—	3.331[a]	—	—	—	—	—	—	—	7.56
448A-19-1	556.67	—	—	—	2.270	—	—	—	—	—	—
448A-20-1	565.81	—	3.604[a]	—	—	—	—	—	—	—	—
448A-20-1	565.84	—	—	—	—	—	2.167	—	—	—	—
448A-20-2	567.77	—	3.643[a]	—	—	—	—	—	—	—	—
448A-20-2	567.81	—	—	—	—	—	2.263	—	—	—	—
448A-20-3	569.18	—	3.799[a]	—	—	—	—	—	—	—	8.94
448A-20-3	569.19	—	—	—	2.352	—	—	—	—	—	—
448A-21-1	576.17	3.200	—	—	—	—	—	—	—	—	—
448A-21-1	576.20	—	—	—	—	—	2.184	—	—	—	—
448A-22-1	585.39	2.921	—	3.029	—	—	—	—	—	—	6.16
448A-22-1	585.40	—	—	—	2.110	—	—	—	—	—	—
448A-24-1	603.99	3.141	—	—	—	—	—	—	—	—	—
448A-24-1	604.03	—	—	—	—	—	2.083	—	—	—	—
448A-24-1	604.14	3.280	—	—	—	—	—	—	—	—	—
448A-24-1	604.17	—	—	—	—	—	2.335	—	—	—	—
448A-25-1	608.50	2.833	—	—	—	—	—	—	—	—	—

Table 8. (Continued).

Sample (hole-core-section)	Sub-bottom Depth (m)	Sonic Velocity Horizontal		Sonic Velocity Vertical	Wet-Bulk Density Gravimetric (g/cm^3)	Wet-Bulk Density Continuous GRAPE (section averages) (g/cm^3)[b]	Wet-Bulk Density Special 2-min GRAPE (g/cm^3)[b]	Water Content (%)	Porosity (%)	Calculated Grain Density (g/cm^3)	Acoustic Impedance [× 10^5 g/(cm^{2}s)]
448A-25-1	608.53	—	—	—	—	—	2.051	—	—	—	—
448A-25-2	609.25	2.755	—	—	—	—	—	—	—	—	—
448A-26-1	613.90	—	—	—	—	—	2.173	—	—	—	—
448A-26-1	614.09	—	3.406[a]	—	—	—	—	—	—	—	—
448A-26-1	614.32	—	3.540[a]	—	—	—	—	—	—	—	—
448A-26-1	614.34	—	—	—	2.189	—	—	—	—	—	—
448A-26-3	616.25	3.481	—	—	—	—	—	—	—	—	—
448A-26-3	616.29	—	—	—	—	—	2.054	—	—	—	—
448A-26-3	616.60	2.750	—	2.786	—	—	—	—	—	—	5.73
448A-26-3	616.61	—	—	—	2.057	—	—	—	—	—	—
448A-27-1	617.85	2.984	—	—	—	—	—	—	—	—	—
448A-27-1	617.89	—	—	—	—	—	2.178	—	—	—	—
448A-30-1	642.40	2.070	—	2.075	—	—	—	—	—	—	4.15
448A-30-1	642.41	—	—	—	2.001	—	—	—	—	—	—
448A-30-2	644.33	2.580	—	2.622	—	—	—	—	—	—	—
448A-30-2	644.35	—	—	—	2.034	—	2.012	—	—	—	—
448A-32-1	661.17	—	3.360[a]	—	—	—	—	—	—	—	9.58
448A-32-1	661.18	—	—	—	2.852	—	—	—	—	—	—
448A-33-3	666.52	—	4.041[a]	—	—	—	—	—	—	—	—
448A-33-3	666.58	—	—	—	—	—	2.580	—	—	—	—
448A-33-3	666.90	—	4.280[a]	—	—	—	—	—	—	—	—
448A-37-2	700.35	—	3.524[a]	—	—	—	—	—	—	—	—
448A-37-2	700.42	—	—	—	—	—	2.473	—	—	—	—
448A-38-1	709.44	—	3.478[a]	—	—	—	—	—	—	—	—
448A-38-1	709.47	—	—	—	—	—	2.353	—	—	—	—
448A-39-1	713.04	—	3.679[a]	—	—	—	—	—	—	—	—
448A-39-1	713.07	—	—	—	—	—	2.436	—	—	—	—
448A-39-2	715.37	—	3.664[a]	—	—	—	—	—	—	—	—
448A-39-2	715.42	—	—	—	—	—	2.403	—	—	—	—
448A-39-2	720.07	2.723	—	—	—	—	—	—	—	—	—
448A-40-2	720.11	—	—	—	—	—	2.022	—	—	—	—
448A-40-3	720.58	2.576	—	—	—	—	—	—	—	—	—
448A-40-3	720.63	—	—	—	—	—	2.062	—	—	—	—
448A-41-1	728.23	—	4.029[a]	—	—	—	—	—	—	—	—
448A-41-1	728.31	—	—	—	—	—	2.565	—	—	—	—
448A-42-1	736.62	2.838	—	—	—	—	—	—	—	—	—
448A-42-1	736.64	—	—	—	—	—	1.957	—	—	—	—
448A-42-3	739.54	2.630	—	—	—	—	—	—	—	—	—
448A-42-3	739.62	—	—	—	—	—	1.974	—	—	—	—
448A-43-1	746.14	2.577	—	—	—	—	—	—	—	—	—
448A-43-1	746.19	—	—	—	—	—	1.911	—	—	—	—
448A-44-1	756.62	2.620	—	—	—	—	—	—	—	—	—
448A-44-1	756.67	—	—	—	—	—	2.131	—	—	—	—
448A-45-1	765.29	—	3.292[a]	—	—	—	—	—	—	—	—
448A-45-1	765.33	—	—	—	—	—	2.600	—	—	—	—
448A-45-2	766.77	—	4.124[a]	—	—	—	—	—	—	—	9.52
448A-45-2	766.78	—	—	—	2.309	—	—	—	—	—	—
448A-46-2	770.22	—	3.475[a]	—	—	—	—	—	—	—	—
448A-46-2	770.26	—	—	—	—	—	2.651	—	—	—	—
448A-47-1	775.01	—	4.861[a]	—	—	—	2.706	—	—	—	—
448A-47-1	775.14	—	4.854[a]	—	—	—	—	—	—	—	13.20
448A-47-1	775.16	—	—	—	2.719	—	—	—	—	—	—
448A-47-1	775.86	—	5.148[a]	—	—	—	—	—	—	—	—
448A-47-3	778.95	—	4.809[a]	—	—	—	—	—	—	—	13.09
448A-47-3	778.96	—	—	—	2.721	—	—	—	—	—	—
448A-49-1	783.86	2.616	—	—	—	—	—	—	—	—	—
448A-49-1	783.90	—	—	—	—	—	2.042	—	—	—	—
448A-50-1	793.76	—	4.713[a]	—	—	—	—	—	—	—	—
448A-50-2	794.31	—	4.564[a]	—	—	—	—	—	—	—	12.20
448A-50-2	794.32	—	—	—	2.672	—	—	—	—	—	—
448A-50-3	795.76	—	—	—	—	—	1.973	—	—	—	—
448A-50-4	797.11	2.531	—	—	—	—	—	—	—	—	—
448A-50-4	797.17	—	—	—	—	—	2.098	—	—	—	—
448A-51-2	804.38	—	4.459[a]	—	—	—	—	—	—	—	11.59
448A-51-2	804.40	—	—	—	2.600	—	—	—	—	—	—
448A-52-2	812.23	—	4.540[a]	—	—	—	—	—	—	—	12.07
448A-52-2	812.24	—	—	—	2.659	—	—	—	—	—	—
448A-53-1	819.85	2.517	—	—	—	—	—	—	—	—	5.12
448A-53-1	819.86	—	—	—	2.033	—	—	—	—	—	—
448A-57-1	846.63	—	4.255[a]	—	—	—	—	—	—	—	—
448A-57-1	846.70	—	—	—	—	—	2.564	—	—	—	—
448A-57-1	847.85	—	4.253[a]	—	—	—	—	—	—	—	11.07

Table 8. (Continued).

Sample (hole-core-section)	Sub-bottom Depth (m)	Sonic Velocity Horizontal		Vertical	Wet-Bulk Density Gravimetric (g/cm³)	Continuous GRAPE (section averages) (g/cm³)[b]	Special 2-min GRAPE (g/cm³)[b]	Water Content (%)	Porosity (%)	Calculated Grain Density (g/cm³)	Acoustic Impedance [× 10⁵ g/(cm²s)]
448A-57-1	847.86	—	—	—	2.604	—	—	—	—	—	—
448A-57-2	848.32	—	—	2.320	—	—	—	—	—	—	4.59
448A-57-2	848.33	—	—	—	1.980	—	—	—	—	—	—
448A-58-1	856.13	2.310	—	—	—	—	—	—	—	—	—
488A-58-3	858.96	—	3.589[a]	—	—	—	—	—	—	—	9.15
448A-58-3	858.97	—	—	—	2.549	—	—	—	—	—	—
448A-58-3	859.17	—	3.641[a]	—	—	—	—	—	—	—	—
448A-59-1	865.07	—	—	2.214	—	—	—	—	—	—	4.19
448A-59-1	865.08	—	—	—	1.892	—	—	—	—	—	—
448A-60-3	872.21	2.292	—	—	—	—	—	—	—	—	—
448A-61-2	880.56	—	—	—	—	—	2.168	—	—	—	—
448A-62-2	888.66	—	4.428[a]	—	—	—	—	—	—	—	—
448A-63-1	896.26	2.489	—	—	—	—	—	—	—	—	—
448A-63-1	896.41	—	—	—	—	—	2.228	—	—	—	—
448A-64-1	901.25	2.615	—	—	—	—	—	—	—	—	—

[a] Basalt average velocity.
[b] Based on an assumed grain density of 2.75 g/cm³.

made up of a series of closely spaced traverses (see Fig. 4), revealed two ridges, about 20 miles apart in the northern part of the survey area (Fig. 3), separated by a steep-walled axial valley at the crest of Palau-Kyushu Ridge. The ridge itself, here, appears to have two small right lateral offsets, which are suggestive of east–west trending transcurrent faults. As can be seen in the reflection profiles (see Fig. 4), the area appears to be devoid of any sediment cover; apparently the presence of thick sediment had been inferred from the recognition of a thick 3.5-km/s layer in the seismic refraction data of Murauchi et al. (1968). During the *Glomar Challenger*'s final approach, the drilling site was selected, as previously mentioned, in a steep-walled axial valley containing about 0.25 s of ponded, acoustically semitransparent sediment.

Correlation of the Drilling Results with Reflection Profiling

In retrospect, the decision to locate Site 448 in an identifiable sediment pond was apparently fortunate, because the basal reflector or acoustic basement (correlated elsewhere with seafloor on the ridge) appears to coincide with the first basalt flow encountered in the drilling and, as such, is interpreted here to be "arc volcanic basement." The reflection profile across Site 448 recorded on board the *Glomar Challenger* during departure from the site is shown in Figure 16. A sub-bottom penetration of more than 0.25 s of reflection time is observed in the profile.

Reflectors are indicated at sub-bottom reflection times of 0.21 s (strong), 0.26 s, and 0.32 s (strong but obscured to some extent by the wave trains from earlier reflections). The first reflector (at 0.21 s RT) is correlated with the transition from nannofossil chalk through vitric tuffs and chalk to vitric tuff between 171.6 and 185.5 meters sub-bottom. The second reflector (at 0.26 s RT) is correlated with a layer of tuffaceous volcaniclastic breccia (within the vitric tuff at about 215 m sub-bottom) characterized both by high velocity and high acoustic impedance. The third and deepest identifiable reflector is correlated with the top of the first basalt flow and intercalated volcaniclastic breccias and is considered to be both acoustic basement and arc volcanic basement. Of particular interest here is the correspondence between the average sample velocity (about 3.5 km/s), measured on these basement rocks in the laboratory of the *Challenger* (see the section on physical properties in this site report), and the refraction velocity of 3.5 km/s, determined for the upper layer of the Palau-Kyushu Ridge by Murauchi et al. (1968).

SUMMARY AND CONCLUSIONS

Site 448 at 16°20.46′N and 134°52.45′E was drilled with the objective of determining the nature of the remnant arc that forms the Palau-Kyushu Ridge, the timing and evolution of associated volcanism, and the role that this arc played in the origin and depositional history of the adjacent marginal basins. Continuous coring at Hole 448 resulted in a total recovery of 234 meters out of 583 meters drilled. Hole 448 was terminated when no recovery was made in four successive coring attempts. Hole 448A was drilled at the same locality. Discontinuous coring to 527.5 meters followed by continuous coring resulted in a total recovery of 214.7 meters out of 467.5 meters drilled. In Hole 448, sediments were cored to a depth of 319.5 meters and basalts were not recovered to 337.5 meters; however, based on a drilling-rate decrease, basalts were encountered below 319.5 meters. Besides basalt flows, dikes and sills interlayered with volcaniclastic breccias and tuffs were encountered lower in Hole 448. In contrast, the sediment/volcanic contact was found at 291.0 meters sub-bottom in Hole 448A. Within the igneous and volcaniclastic units, underlying the sediment/igneous contact, 623.0 meters were cored. The total depth cored for the combination of Holes 448 and 448A at Site 448 was 914 meters sub-bottom. A total of 51 lithologic units were identified. The sedimentary section is divided into five lithologic

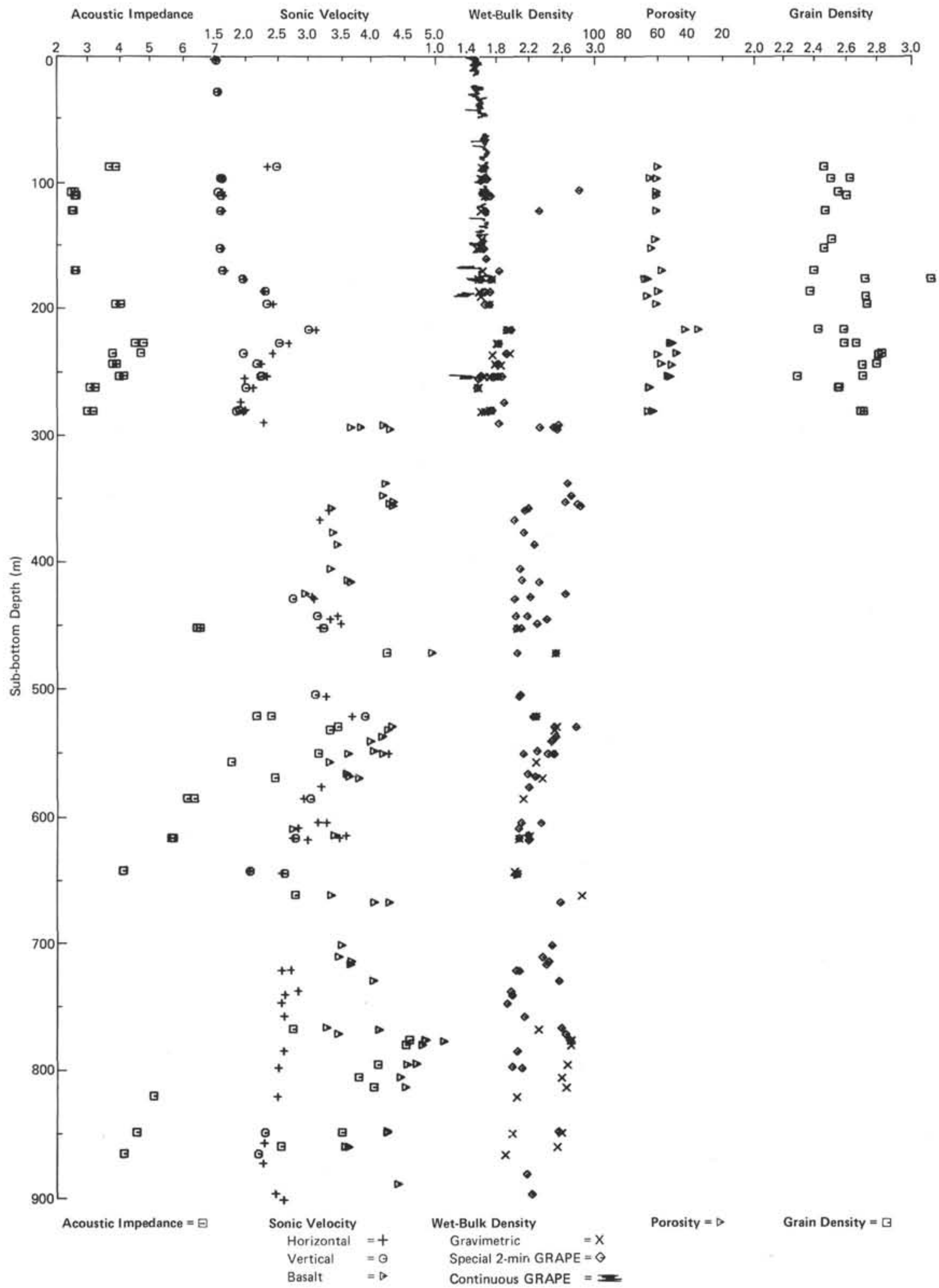


Figure 15. Physical properties of sedimentary and igneous rocks from Holes 448 and 448A plotted versus sub-bottom depth in meters. Acoustic impedance is the product of velocity and bulk density and is in units of 10^5 g/(cm^{2}s). Sonic-velocity measurements include horizontal and vertical velocity of sediments and average velocity of basalts (km/s). Gravimetric determinations of wet-bulk density are shown. Special 2-minute and continuous GRAPE determinations of wet-bulk density are also shown, based on an assumed grain density of 2.75 g/cm^3. Porosity (%) was determined gravimetrically, and grain density was calculated from porosity and bulk density.

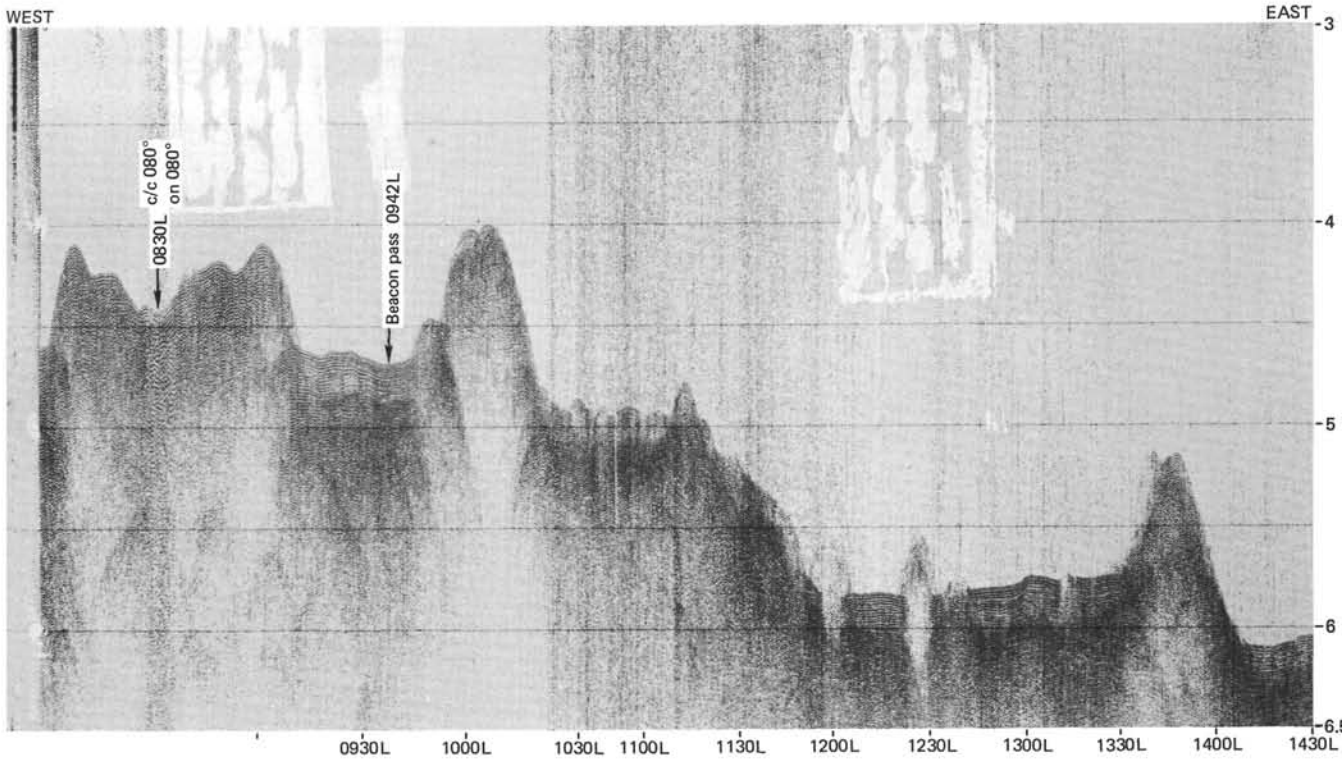


Figure 16. Seismic-reflection profile across Site 448 recorded on board the *Glomar Challenger* during departure from the site.

units that range between the middle Oligocene and middle Miocene. The middle Oligocene interlayered igneous and volcaniclastic units are divided into an additional 46 units based upon major igneous and sedimentary intervals.

The sedimentary section consists of:

Unit 1 (0–107.5 m), middle-Miocene to upper-Oligocene nannofossil ooze;

Unit 2 (107.5–171.5 m), upper-Oligocene nannofossil chalk;

Unit 3 (171.5–185.5 m), middle- to upper-Oligocene interbedded vitric tuff and minor chalk;

Unit 4 (185.5–280.5 m), middle-Oligocene vitric tuff; and

Unit 5 (280.5–319.5 m), middle-Oligocene, interbedded vitric tuff and tuffaceous volcaniclastic breccia.

The interbedded igneous and volcaniclastic units consist of:

Unit 6 (319.5–358.0 m in Hole 448), 38.5 meters of plagioclase (Pl)-clinopyroxene (Cpx)-orthopyroxene (Opx)-olivine (Ol)-phyric, pillowed massive flow basalt;

Unit 7 (358.0–376.5 m), olive-yellow basaltic volcaniclastic breccia;

Unit 8 (376.5–404.0 m), five vesicular cooling units of Pl-Ol-Cpx-phyric pillow basalts and single flows;

Unit 9 (404.0–427.0 m), one pillowed massive aphyric cooling unit;

Unit 10 (427.0–456.0), tuffs, volcaniclastic breccias with yellow-brown and green matrices that contain some clasts of granodiorite and andesite(?);

Unit 11 (456.0–489.5 m), five vesicular Pl-Cpx-Opx-pigeonite (Pig)-Ol-phyric basalt flows;

Unit 12 (489.5–521.0 m), olive-brown to dusky-green to olive-brown volcaniclastic breccia;

Unit 13 (521.0–556.5 m), light vesicular Pl-Cpx-Opx-Pig-phyric basalt flows;

Unit 14 (537.5–575.5 m), vesicular Pl-Cpx-Opx-phyric basaltic pillow lavas (note the discrepancy between the lowest portion of Unit 13 cored [Hole 448] and the top of Unit 14 [Hole 448A]—correlation of this offset was discussed earlier);

Unit 15 (575.5–613.5 m), dusky-green to dusky blue-green volcaniclastic breccias and tuffs;

Unit 16 (613.5–615.5 m), vesicular Pl-Cpx-phyric basalt flow;

Unit 17 (615.5–623.0 m), middle-Oligocene pale-green tuff and dark green volcaniclastic breccia;

Unit 18 (623.0–632.0 m), vesicular Cpx-Pl-phyric basalt flow;

Unit 19 (632.0–660.5 m), dark green volcaniclastic breccia;

Unit 20 (660.5–670.0 m), aphyric nonvesicular basalt;

Unit 21 (670.0–694.0 m), dark green volcaniclastic breccia grading into tuffaceous volcaniclastic breccia;

Unit 22 (694.0–699.5 m), nonvesicular Ol-Pl-Cpx-phyric basalt flow;

Unit 23 (699.5–714.5 m), cognate autobrecciated aphyric basalt flow;

Unit 24 (714.5–718.0 m), nonvesicular Pl-Cpx-phyric basalt flow;

Unit 25 (718.0–727.0 m), dusky gray-green volcaniclastic breccia;

Unit 26 (727.0–728.0 m), vesicular Pl-phyric basaltic dike;

Unit 27 (728.0–731.5 m), vesicular aphyric basaltic dike;

Unit 28 (731.5–736.5 m), slightly vesicular Pl-Cpx-Ol-phyric basaltic dike;

Unit 29 (736.5–750.5 m), middle-Oligocene dark green volcaniclastic breccia and tuffaceous volcaniclastic breccia;

Unit 30 (750.5–757.0 m), grayish blue hydrothermally altered volcaniclastic breccia and tuffaceous volcaniclastic breccia;

Unit 31 (757.0–768.5 m), two vesicular Pl-Cpx-phyric basalt flows;

Unit 32 (768.5–769.5 m), green and brown hydrothermally altered volcaniclastic breccia;

Unit 33 (769.5–783.5 m), massive, slightly vesicular, Pl-Cpx-phyric basaltic sill(?);

Unit 34 (783.5–792.5 m), middle-Oligocene greenish black volcaniclastic breccia;

Unit 35 (792.5–794.5 m), slightly vesicular, Pl-Cpx-phyric basaltic sill(?);

Unit 36 (794.5–802.0 m), middle-Oligocene dark green volcaniclastic breccia and laminated fine vitric tuffs;

Unit 37 (802.0–806.0 m), slightly vesicular, Pl-Cpx-phyric basaltic dike;

Unit 38 (806.0–810.5 m), dark green laminated fine vitric tuff;

Unit 39 (810.5–813.5 m), two nonvesicular, Pl-Cpx-phyric basalt flows(?), which may be sills;

Unit 40 (813.5–832.0 m), dark green volcaniclastic breccia;

Unit 41 (832.0–841.5 m), two cognate autobrecciated Pl-Cpx-phyric basalt flows(?);

Unit 42 (841.5–843.0 m), dusky-green volcaniclastic breccia and laminated fine vitric tuff;

Unit 43 (843.0–848.0 m), slightly vesicular aphyric basalt flows(?);

Unit 44 (848.0–858.5 m), dark green volcaniclastic breccia;

Unit 45 (858.5–864.5 m), slightly vesicular Pl-Cpx-phyric basaltic sill(?);

Unit 46 (864.5–866.5 m), dark green tuffaceous volcaniclastic breccia;

Unit 47 (866.5–867.5 m), slightly vesicular Pl-phyric basaltic sill(?);

Unit 48 (867.5–887.0 m), dark green to pale blue-green hydrothermally altered tuffaceous volcaniclastic breccia;

Unit 49 (887.0–896.0 m), nonvesicular, Pl-Cpx-Opx-phyric basaltic dike;

Unit 50 (896.0–902.0 m), greenish black volcaniclastic breccia; and

Unit 51 (902.0–914.0+ m), nonvesicular hydrothermally altered aphyric basaltic dike.

Calcareous nannofossils are found throughout the cores from Holes 448 and 448A. The nannoplankton zones NN 9 (middle Miocene) down to NP 23/24 (middle Oligocene) were identified. Planktonic foraminifers found from Core 1 through Core 19, Section 1, in Hole 448 indicate a late Oligocene or younger age. The middle Oligocene/upper Oligocene boundary occurs between Core 19, Section 1 and Core 22, inclusive. The radiolarians present in Cores 1 through 17 are somewhat more abundant and better preserved than the foraminifers. The middle-Miocene and the upper-Oligocene intervals are also identified in Hole 448 by radiolarian zones. Holes 448 and 448A are barren of diatoms and silicoflagellates.

The nannofossils, radiolarians, and foraminifers all indicate that a tropical climate persisted from the middle Oligocene to the middle Miocene. Poor preservation of the planktonic foraminifers in the upper cores may suggest that these sediments were deposited near the CCD; however, the poor preservation below Core 12 may be related to the diagenetic change from ooze to chalk within Core 12. Lower-bathyal to abyssal benthic foraminifers in Cores 1 through 12 may indicate a subsidence of the site of deposition in the late Oligocene.

Accumulation rates below the uppermost basalts are all based on the NP 23/24 nannofossil boundary; therefore only a minimum accumulation rate of approximately 300 m/m.y. can be calculated. From the middle Oligocene to the late Oligocene, above the basalts, tuffaceous sediment accumulated at the rate of nearly 50 m/m.y. During the late Oligocene and early Miocene the rates diminished to 10 to 20 m/m.y. Finally, during the middle Miocene, rates decreased to about only 5 m/m.y.

The cessation of arc volcanism close to the middle Oligocene/late Oligocene boundary (about 30 m.y. ago) may date the sundering of the Palau-Kyushu arc and the initiation of the Parece Vela marginal basin spreading somewhat earlier than was suggested by Karig (1975). Of somewhat more problematic significance, however, is the fact that the only fossil date in the volcanic sequence (NP 23/24, about 32 m.y.) prior to cessation of volcanism at Site 448 on the Palau-Kyushu remnant arc is the same as the fossil date marking the beginning of sedimentation at Site 447 in the West Philippine Basin.

Although the volcanic sequence recovered at Site 448 on the Palau-Kyushu Ridge for the most part has a tholeiitic basalt composition, it significantly differs from typical oceanic crust. The presence of pumiceous and ashy debris in tuffs and volcaniclastic breccias typical of explosive volcanism (either shallow phreatic or subaerial), the high vesicularity of extrusive units, the wide distribution of phenocrysts and groundmass hypersthene, the presence of pigeonite, and the clasts of andesite(?) and hornblende diorite in volcaniclastic breccias all indicate island-arc tholeiitic affinities for the Palau-Kyushu Ridge and confirm that the ridge is a remnant arc that was active in the middle Oligocene.

Two sites on the Palau-Kyushu Ridge were dredged by the International Working Group on the IGCP Project "Ophiolites" (1977) aboard the *Dmitry Mendeleev* in 1976 (Fig. 1). The analyses of two of the rocks collected (Table 9) are included here (personal communication, Guram Zakariadze). Both of these rocks appear to have calc-alkalic affinities based upon the high alumina (19.4 wt. %) and Sr (340 ppm) contents. Thus it appears that although Site 448 has no evidence of calc-alkalic affinities (see shipboard XRF data, Mattey et al., this volume), some calc-alkalic magmatism may have occurred, at least locally, on the eastern side of the rem-

Table 9. Major- and trace-element analyses of two samples from the International Working Group on the IGCP Project "Ophiolites."

Site (sample)	Major Elements (wt. %)									
	SiO_2	TiO_2	Al_2O_3	FeO[a]	MnO	MgO	Ca	Na_2O	K_2O	H_2O
1396 (rock 1-2)	52.3	1.10	19.4	9.44	0.13	2.73	8.17	3.64	1.00	2.00
1397 (rock 2-1)	54.2	1.15	19.0	8.99	0.22	2.50	8.50	3.51	0.45	1.40

Site (sample)	Trace Elements (ppm)									
	B	Ba	F	Li	Rb	Sr	Zn	Cu	Co	Ni	Cr
1396 (rock 1-2)	<10	70	400	21.5	—	340	173	190	100	45	320
1397 (rock 2-1)	<10	40	200	4.5	—	270	123	85	100	40	260

Note: This material is based on Table 1.1 from the International Working Group on the IGCP Project "Ophiolites" (1977)—personal communication, G. Zakariadze.
[a] FeO = total Fe calculated as FeO.

nant arc. Caution should be used, however, because dredged rocks commonly are altered; Sr values are particularly affected by sea-water alteration.

Several important zones of alteration seem to exist within the volcaniclastic units at Site 448. The uppermost zone of hydrothermal alteration probably occurred at very low temperatures near to or at ambient temperature diagenetic conditions rather than hydrothermal conditions, which points to the processes that caused part of the breccias in this zone to have yellow-brown matrices that appear somewhat oxidized.

In contrast, deeper in Hole 448A, breccias with green matrices appear to be somewhat reduced. Below Unit 12, the abundance of these green matrices in breccias increases with depth, and the colors change from olive to a blue-green to a dark-green and finally to a blackish green at the deepest levels. Mineralogically, phillipsite, analcite, smectites(?), and less abundant calcite are tentatively identified in the green matrices. Also veinlets of native copper occur in the affected breccias, and disseminated copper occurs in affected basalts. In localized zones adjacent to sills and dikes near the base of Hole 448A, results of the more moderate-temperature hydrothermal alteration are apparent—these hydrothermally altered breccias contain disseminated pyrite and chalcopyrite(?) in a matrix of friable grayish blue clays and zeolites. These zones, very different in color, mineralogy, and physical properties from adjacent breccias affected only by the dark to blackish green alteration, are probably related to thermal events produced by intrusions.

Below 700 meters sub-bottom the presence of 10 dikes and sills is substantiated by contact relationship that include discordant boundaries, upper chilled contacts disturbed by drag of laminar flow within the sill, laminar-flow banding of vesicles at high angles to adjacent sediment bedding, laminar-flow differentiated plagioclase phenocrysts, and low abundance or lack of vesicles.

Low NRM inclinations in sediments and higher NRM inclinations in the underlying basaltic units can be variously interpreted as being the result of (1) plate motion, (2) paleomagnetic reversal, (3) secular variations of the earth's magnetic field, (4) tilting of the strata, or (5) acquisition of a large viscous component. Many samples, after progressive demagnetization in fields up to 1000 Oe, were found to be significantly unstable in direction and intensity, which is indicative of acquisition of large viscous components.

Three sub-bottom reflectors are correlated with the physical properties of the rocks recovered at Site 448: the 0.21-s reflector is correlated with the transition from vitric tuff to nannofossil chalks between about 172 and 186 meters sub-bottom [change in acoustic impedance $= 0.5 \times 10^5$ g/(cm^{2}s)]; the 0.26-s reflector is correlated with a zone of tuffaceous volcaniclastic breccia at 215 meters sub-bottom (high velocity and acoustic impedance); the 0.32-s reflector is the top of basalts and interbedded volcaniclastic breccias, which is considered to be acoustic basement. The average 3.5-km/s velocity for these rocks is in good agreement with the refraction velocity determined for the upper layer of the Palau-Kyushu Ridge (Murauchi et al., 1968).

The sequence of events at Site 448 from the oldest to the youngest can be summarized as follows:

1) By the middle Oligocene (about 32 m.y.), 1.9 km of 3.5-km/s volcanic and volcaniclastic debris was deposited on the Palau-Kyushu arc to the level reached by drilling at Hole 448.

2) Subsequently, in the middle Oligocene, the 3.5-km/s layer reached a total thickness of 2.5 km by adding another 600 meters of volatile-rich basaltic flows and associated breccias. Within the volcaniclastic breccias and laminated fine tuffs, rare andesitic(?) and dioritic clasts occurred; these suggest that calc–alkalic volcanism existed to a minor degree within the arc even though only tholeiitic basaltic cooling units erupted at Site 448. The abundance of tuffs and volcaniclastic breccias suggests that shallow phreatic or even subaerial eruptions were common.

3) Basaltic dikes and sills intruded the sequence and induced hydrothermal alteration with attendant thermal effects.

4) Significant quantities of tuff and ash continued to accumulate from a more distal source from the middle to the late Oligocene.

5) Tilting occurred during and/or after deposition of middle-Oligocene lava flows and middle- to upper-Oligocene ashes and tuffs; the flows have maximum dips of 45°, the overlying tuffs and ashes have maximum dips of 20°, and the nonvolcanic chalks have no appreciable dips. Even though beds may have been folded after deposition to create that geometry, it is more likely that progressive tilting occurred contemporaneously with or shortly after their respective deposition.

6) As volcanism ceased, the ridge slowly and gently subsided with little, if any, large-scale structural disturbance.

7) Any sediments that may have accumulated on the uppermost middle-Miocene nannofossil ooze were eroded before the Present. This sequence of events is very close to that found in the northern end of the Palau-Kyushu Ridge at Site 296, where lower- to upper-Oligocene volcaniclastic rocks were found to be overlain by upper-Oligocene to Pleistocene oozes and chalks (Karig, Ingle et al., 1975). The major differences lie in the fact that no arc-type flows or intrusions were found

in Hole 296 and that the end of volcanism at Site 448 occurred toward the end of the middle Oligocene rather than the late Oligocene, as at Site 296.

At Site 447, the West Philippine Basin has middle-Oligocene volcaniclastic breccias on an undated basalt basement. Thus the basin crust must be middle Oligocene or older. The age of the Palau-Kyushu remnant arc is also middle Oligocene or older, and it therefore follows that the age of the oceanic crust upon which the arc rests must be middle Oligocene or older. If only a short hiatus existed between sediments and igneous basement at Site 447, it becomes necessary to envision a kinematic mechanism by which the basement of the West Philippine Basin north and east of Site 447 was constructed *after* volcanism on the Palau-Kyushu Ridge ceased, that is, after sundering of that arc about 30 m.y. ago. Two logical alternatives are possible: either a moderately long hiatus existed at the base of the sedimentary section at Site 447 (long enough so that basin formation was completed prior to Palau-Kyushu arc sundering but short enough so that basin formation overlapped with Palau-Kyushu arc formation) or a rather long hiatus existed so that the basin, possibly a trapped marginal basin, was formed prior to Palau-Kyushu arc activity.

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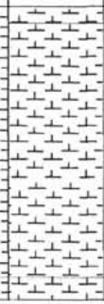
SITE 448 HOLE CORE 1 CORED INTERVAL: 0.0-5.0 m

AGE	BIOSTR. ZONE NANNOS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Middle Miocene	NN 9	N R	A R	G P	1	0.5
		N F	A A	G P		1.0
	NN 7-8	N N N	A A A	G G G		
		N N F	A A A	G G P		
	NN 6	F R N	A – A	PM G	2	
					CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

10YR 6/3

10YR 6/4

At top, 1 cm black blebs stretching down to 30 cm

Scattered 5YR 3/3 blebs 2 mm diameter

10YR 5/4

Scattered 7/4 mottles 4 mm diameter 10YR 7/4

NANNOFOSSIL OOZE, very pale brown grading down-core through light yellowish brown to yellowish brown. Lower part of the core is locally and slightly mottled very pale brown. Very dark brown blebs approximately 2 mm in diameter are sparsely scattered throughout the core; in smear slides this color results from small amounts of amorphous iron oxides and micronodules. Discoasters comprise approximately 90% of the nannofossils; the remainder are coccoliths. About 15% of the material is microcrystalline carbonate.

Lithification: the sediment is very soft.

Drilling deformation: The core is very badly disturbed and consists mainly of flow-in and drilling breccia.

SMEAR SLIDE SUMMARY

	1-5 (D)	1-18 (M)	1-86 (D)	2-18 (M)	2-60 (D)
TEXTURE:					
Sand	0	0	0	0	0
Silt	95	95	98	95	93
Clay	5	5	2	5	7
TOTAL DETRITAL	1	1	3	3	5
COMPOSITION:					
Quartz	TR	TR	TR	–	–
Feldspar	–	–	TR	–	–
Heavy minerals	–	–	–	–	TR
Clay minerals	1	1	3	3	5
Volcanic glass	–	–	–	–	TR
Micronodules	–	TR	2	–	–
Amorph Fe oxide	–	TR	TR	TR	TR
Microcryst carb.	14	14	14	15	15
Foraminifers	TR	–	–	–	–
Nannofossils	85	85	81	85	85
Fish remains	TR	–	TR	–	–

GRAIN-SIZE:
1-95 (2.2, 45.6, 52.3)

CARBON/CARBONATE:
1-92 (0.0, 64.4, 7.8)

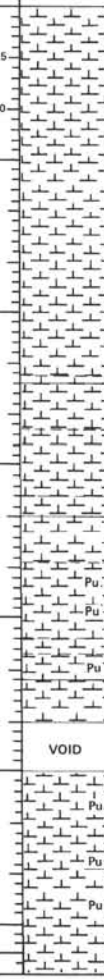
CARBONATE BOMB:
1, 93-94 (60)

PHYSICAL PROPERTIES:	Section 1 66-69 cm
$\bar{V}p$ (km/s)	
parallel to beds	1.52
vertical to beds	1.53
Wet bulk density	–
Porosity (%)	–
Acoustic impedance	–

SITE 448 HOLE CORE 2 CORED INTERVAL: 5.0-14.5 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Middle Miocene	NN 5	N 9	*Dorcadospyris alata*	N F	A A	G M	1	0.5
				R	C	M		1.0
				N F	A C	G PM	2	
				R	F	P		
				N F	A A	G PM	3	
				R	C	P		
				N F	A A	G PM	4	
				R	F	P		
				N F	A A	G PM	5	
				R	C	M		
				N F	A A	G PM	6	
				R	C	G		
				N F F R N	A A A A A	G PM PM G M	7 CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

Foram-filled burrow 1x5 .5 cm

1 mm black blebs 2/1 at ctct

10YR 8/3

10YR 7/4

8/1 patch 2x8 cm

vesicular basalt clast 1x1 cm

vesicular basalt clast 4 cm diameter

10YR 2.5/3

3 mottles 3/2 2 cm diameter

10YR 6/4

10YR 5/4

10YR 7/4

10YR 5.5/4

disturbed layers 10YR 7.5/4 and 10YR 2.5/1

10YR 7/4

10YR 5.4/4 with 7/4 mottles, 10YR 7/4

10YR 5/2, intensely mottled 7/3

10YR 7/4

Slight 8/1, 4/1 mottling

5/4, 8/1 mottles

10YR 7/4

NANNOFOSSIL OOZE, very pale brown, with scattered zones of light gray foraminifer- and nannofossil-filled burrows, very dark grayish brown patches colored by amorphous iron oxides, and white, nannofossil-rich patches. Traces of volcanic glass occur, as does sparsely scattered pumice fragments. Discoasters comprise 90% of the nannofossils, the rest being coccoliths. Approximately 15% of the material is micritic carbonate.

Lithification: The sediment is uniformly soft.

Drilling deformation: Upper half of the core only slightly disturbed; lower half intensely disturbed.

SMEAR SLIDE SUMMARY

	1-67 (D)	1-140 (D)	2-140 (D)	3-34 (D)	3-72 (D)
TEXTURE:					
Sand	0	0	0	0	1
Silt	95	99	99	95	97
Clay	5	1	1	5	2
TOTAL DETRITAL	2	TR	4	TR	TR
COMPOSITION:					
Quartz	TR	–	–	–	–
Feldspar	–	–	–	–	–
Heavy minerals	–	–	–	TR	TR
Clay minerals	2	TR	4	–	–
Volcanic glass	–	–	TR	–	–
Zeolites	–	TR	–	–	–
Amorph Fe ox. agg.	2	TR	TR	TR	TR
Microcryst.carb.	20	2	2	–	10
Foraminifers	TR	TR	TR	10	1
Nannofossils	76	98	94	90	88
Diatoms	–	TR	–	–	–
Radiolaria	–	–	–	TR	–
Sponge spicules	TR	TR	TR	TR	1
Fish remains	TR	–	TR	–	–

SMEAR SLIDE SUMMARY

	3-140 (D)	4-140 (D)	5-100 (D)	6-140 (D)	7-20 (D)
TEXTURE:					
Sand	1	2	1	3	0
Silt	97	92	91	98	95
Clay	1	7	6	2	3
TOTAL DETRITAL	TR	%	5	2	TR
COMPOSITION:					
Feldspar	TR	TR	TR	TR	TR
Heavy minerals	TR	TR	TR	TR	TR
Clay minerals	–	5	5	2	–
Volcanic glass	1	–	TR	–	–
Amorph Fe oxide	TR	2	1	–	–
Microcryst. carb.	10	15	5	15	10
Foraminifers	1	–	1	TR	TR
Nannofossils	87	77	85	80	88
Diatoms	TR	TR	1	1	1
Radiolaria	TR	TR	1	1	TR
Sponge spicules	1	1	1	1	1
Fish remains	–	TR	–	–	–

Smear Slides (Minor): 1-5, 1-10, 1-60, 2-5, 2-50, 3-60, 3-65, 3-95, 3-115, 4-30, 4-35, 4-40, 4-70, 4-80, 5-45, 5-55, 6-85, 6-100

GRAIN-SIZE:
1-64 (1.0, 58.6, 40.4)

CARBONATE BOMB:
1, 68-69 (78)

SITE 448 HOLE CORE 3 CORED INTERVAL: 14.5-24.0 m

AGE: Middle Miocene; NANNOS: NN 5; FORAMS: N.8; RADS: *Dorcadospyris alata*, *Calocycletta costata*

LITHOLOGIC DESCRIPTION

10YR 6/4

8/1 streak

moderate mottling 10YR 4/1

10YR 8/3 foram- and rad-filled burrows, 1.5x5 and 1x3 cm

10YR 7/4

10YR 7.5/3

10YR 8/3

10YR 7/4

.5x4 cm, 5/1 burrow

numerous .5 cm diameter pumice fragments 10YR 7/4

NANNOFOSSIL OOZE, grading down from very pale brown at the top through light yellowish brown and back to very pale brown in the central and lower sections. White, light and dark gray, and yellowish brown streaks and mottles occur in the upper section but are scarce in the central and lower section. A few scattered pumice fragments occur in the lower section. Discoasters are the principal nannofossils. Micritic carbonate averages 10% throughout. The sediment is uniformly soft and moderately disturbed by drilling in the upper section, intensely to very intensely disturbed in the central and lower sections.

SMEAR SLIDE SUMMARY

	1-140 (D)	2-102 (D)	3-135 (D)	4-145 (D)	5-128 (D)
TEXTURE:					
Sand	4	4	5	3	1
Silt	94	96	95	92	84
Clay	1	0	0	5	15
TOTAL DETRITAL	2	1	TR	3	TR
COMPOSITION:					
Quartz	–	–	–	TR	–
Feldspar	TR	TR	TR	TR	–
Heavy minerals	TR	TR	TR	TR	TR
Clay minerals	2	–	TR	5	TR
Volcanic glass	–	1	–	TR	–
Amorph Fe oxide	10	TR	–	–	5
Microcryst. carb.	10	10	5	10	10
Foraminifers	1	TR	10	1	1
Nannofossils	84	86	81	82	84
Diatoms	1	1	2	1	–
Radiolaria	1	1	1	1	–
Sponge spicules	1	1	1	–	–

SMEAR SLIDE SUMMARY

	1-46 (M)	1-111 (M)	2-43 (M)	2-93 (M)	4-4 (M)
TEXTURE:					
Sand	1	0	10	0	4
Silt	98	90	89	90	85
Clay	1	10	1	10	1
TOTAL DETRITAL	TR	TR	0	10	TR
COMPOSITION:					
Feldspar	TR	0	0	0	TR
Clay	0	0	0	10	0
Volcanic glass	TR	0	0	0	TR
Amorph Fe oxide	TR	10	1	TR	0
Microcryst. carb.	10	10	10	0	10
Foraminifers	1	TR	5	TR	15
Nannofossils	89	80	79	90	73
Diatoms	TR	0	0	0	0
Radiolaria	0	0	5	0	2
Fish remains	TR	0	0	0	TR

Smear Slides (Dominant): 2-20
Smear Slides (Minor): 5-125

GRAIN-SIZE:
1-97 (1.4, 62.0, 36.7)

CARBONATE BOMB:
1, 101-102 (81)

SITE 448 HOLE CORE 4 CORED INTERVAL: 24.0-33.5 m

AGE: Early to middle Miocene; NANNOS: NN 5, NN 4, NN 3; FORAMS: N.7-N.8, N.6-N.7, N.6; RADS: *C. costata*, *Stichocorys wolffii*

LITHOLOGIC DESCRIPTION

10YR 7/4 with irregular intense mottles 5/4, 2/1, 8/3

10YR 8/3

2 cm thick ash

10YR 7/3

3x6 cm black mottle 10YR 7/4

10YR 7/4 with intense 5/1 mottles, intense 2/1, 5/1, 7/4 mottling

10YR 4.5/4

10YR 4.5/4

4x4 cm 5/3 mottle

intense mottled admixture 10YR 7/3, 4/1, 8/1, 2/1

10YR 6/6

2 cm ash layer at 63-67 cm

few black mottles

10YR 7/4

10YR 6/3, intense mottling 7/4

10YR 7/4

10YR 6/3

10YR 7/3 black 1 cm mottles

NANNOFOSSIL OOZE, grading down from very pale brown through pale brown to light yellowish brown at the base of the core. White, gray, very pale brown, brown and black mottling is moderate to intense. The brown shades are due to concentrations of amorphous iron oxides; the white is nannofossil ooze, and the gray and black is volcanic ash. Traces of ash are disseminated throughout the material, locally concentrated in a few layers and mottles. Scattered pumice fragments occur in the lower portions of the core. Amorphous iron oxide aggregates, feldspar and heavy minerals occur in traces. Discoasters are the dominant nannofossil. Micritic carbonate constitutes 5% of the sediment. The sediment is uniformly soft, moderately to intensely disturbed.

SMEAR SLIDE SUMMARY

	1-140 (D)	2-140 (D)	3-130 (D)	4-140 (D)	6-140 (D)
TEXTURE:					
Sand	10	2	4	3	3
Silt	87	96	92	96	95
Clay	3	2	4	1	2
TOTAL DETRITAL	TR	TR	TR	TR	TR
COMPOSITION:					
Feldspar	TR	TR	TR	TR	0
Heavy minerals	TR	TR	TR	0	TR
Volcanic glass	TR	0	TR	TR	TR
Micronodules	0	0	1	TR	TR
Amorph Fe oxide	2	1	2	TR	0
Microcryst. carb.	10	10	5	5	10
Foraminifers	5	1	1	1	1
Nannofossils	80	83	88	93	88
Diatoms	1	1	1	1	1
Radiolaria	1	1	1	TR	TR
Sponge spicules	1	0	1	TR	TR
Silicoflagellates	TR	0	TR	0	0

SMEAR SLIDE SUMMARY

	1-29 (M)	2-4 (M)	2-98 (M)	3-102 (M)	6-55 (M)	6-135 (M)
TEXTURE:						
Sand	60	60	60	5	50	2
Silt	38	30	25	90	50	88
Clay	2	10	15	5	0	10
TOTAL DETRITAL	98	89	86	TR	100	10
COMPOSITION:						
Feldspar	5	5	2	TR	30	0
Heavy minerals	0	0	0	TR	0	0
Clay minerals	5	0	0	0	0	10
Volcanic glass	93	84	84	0	70	TR
Amorph Fe oxide	0	10	10	5	0	TR
Microcryst. carb.	0	0	0	10	0	10
Foraminifers	0	TR	TR	1	0	1
Nannofossils	2	1	5	79	0	78
Diatoms	0	TR	1	0	0	0
Radiolaria	0	TR	0	5	0	1

Smear Slides (Dominant): 1-35, 2-50, 4-10, 5-140
Smear Slides (Minor): 1-5, 1-55, 1-75, 3-80, 4-60, 5-90

GRAIN-SIZE:
1-130 (0.7, 49.0, 50.3)

CARBON/CARBONATE:
1-135 (0.0, 80.9, 9.7)

CARBONATE BOMB:
1, 134-135 (75)

MAGNETIC SAMPLE: 6-132

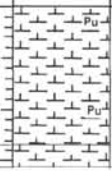
PHYSICAL PROPERTIES:

	Section 4 87-90 cm
$\bar{V}_p$ (km/s)	
parallel to beds	1.56
vertical to beds	1.54
Wet bulk density	–
Porosity (%)	–
Acoustic impedance	–

SITE 448 HOLE CORE 5 CORED INTERVAL: 33.5-43.0 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Early Miocene	NN 2	N.5	Stichocorys delmontensis	N	A	M		
				F	A	M		0.5
				R	R	P	1	
								1.0
				F F N	A A A	PM P M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 7/4

intensely mottled 5/1; 1x4 cm streaks

10YR 6.5/3

NANNOFOSSIL OOZE, very pale brown. Entire section intensely mottled and streaked gray and black; sparse pumice fragments throughout. Discoasters are the dominant nannofossil. Micritic carbonate is absent in the sediment; zeolites constitute 5% of the material. The sediment is uniformly soft and very intensely disturbed by drilling.

SMEAR SLIDE SUMMARY

	1-130 (D)
TEXTURE:	
Sand	5
Silt	89
Clay	6
TOTAL DETRITAL	0
COMPOSITION:	
Micronodules	1
Zeolites	5
Amorph Fe oxide	2
Nannofossils	87
Radiolaria	5

Smear Slides (Minor): 1-25

GRAIN-SIZE:
1-110 (3.0, 62.8, 34.2)

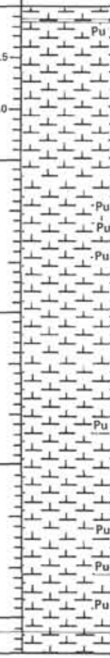
CARBON/CARBONATE:
1-107 (0.0, 59.8, 7.2)

CARBONATE BOMB:
1, 104-105 (56)

SITE 448 HOLE CORE 6 CORED INTERVAL: 43.0-52.5 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Early Miocene	NN 1	N.4	Cyrtocapsella tetrapera	N	A	M		
		P.22-N.4		F	C	M		0.5
				R	R	P	1	1.0
				F	C	M	2	
				F	A	PM	3	
				R	R	P		
				F	A	M	4	
				F R N	A C A	M P M	5, CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 7.5/4
Ash layer 1 cm thick, 10YR 2/1

few 1x2 cm black mottles

moderate to intense mottling
3x5 cm black mottle

10YR 7/4 mixed with 5.5/1 and black

10YR 5/1
3.5 cm black mottle
intense 7/5 mottling

intense black mottling
1x3 cm mottle

10YR 3.5 with 10YR 5/1 mottles, .5 cm 2/1 bleb

NANNOFOSSIL OOZE, very pale brown, light gray, and gray. White, gray, very pale brown and black mottling is moderate to intense. Rounded pumice fragments occur, as do amorphous iron oxides (3%), and traces of micronodules. Discoasters are the principal nannofossil. The sediment is uniformly soft and intensely deformed by drilling.

SMEAR SLIDE SUMMARY

	1-53 (M)	1-140 (D)	2-140 (D)	3-87 (M)	4-140 (D)
TEXTURE:					
Sand	10	5	15	35	10
Silt	70	95	75	60	80
Clay	20	5	10	5	10
TOTAL DETRITAL	TR	TR	TR	TR	TR
COMPOSITION:					
Quartz	TR	0	0	TR	0
Feldspar	TR	TR	0	TR	TR
Heavy minerals	0	0	TR	0	2
Volcanic glass	0	TR	0	0	TR
Micronodules	0	1	TR	10	TR
Zeolites	20	2	3	20	0
Amorph Fe oxide	0	2	2	50	3
Microcryst. carb.	0	0	10	0	10
Foraminifers	TR	0	0	TR	4
Radiolaria	0	15	15	0	10
Sponge spicules	0	0	0	0	TR
Fish remains	TR	0	TR	0	0

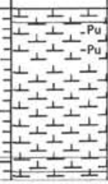
Smear Slides (Dominant): 3-130

CARBON/CARBONATE:
2-7 (0.0, 69.6, 8.4)

SITE 448 HOLE CORE 7 CORED INTERVAL: 52.5-62.0 m

AGE	BIOSTR. ZONE: NANNOS	BIOSTR. ZONE: FORAMS	BIOSTR. ZONE: RADS	FOSSIL CHARACT.: FOSSIL	FOSSIL CHARACT.: ABUNDANCE	FOSSIL CHARACT.: PRESERV.	SECTION	METERS
Early Miocene	NN 1	P.22-N.4	*Cyrtocapsella tetrapera*	N F	A A	M PM		
								0.5
				R	F	P	1	1.0
				F R N	A C A	M M M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 7.5/3
2 1x3 cm 8/1 mottles

moderate mottling with black and 5/1

10YR 7/3 with minor 10YR 5/1 mottles

NANNOFOSSIL OOZE, very pale brown, slight white mottling in upper 95 cm; moderate gray and black mottling in lower portion of the core. Small scattered pumic fragments occur near the top. The sediment contains approximately 2% zeolites; micritic carbonate about 5%. The sediment is uniformly soft and moderately to intensely disturbed by the drill.

SMEAR SLIDE SUMMARY

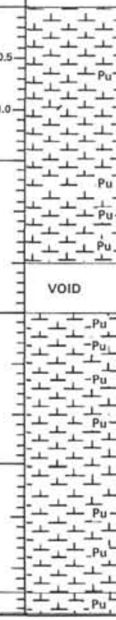
	1-40 (M)	1-134 (D)
TEXTURE		
Sand	10	10
Silt	85	85
Clay	5	5
TOTAL DETRITAL	1	TR
COMPOSITION:		
Feldspar	0	TR
Heavy minerals	1	TR
Volcanic glass	TR	TR
Micronodules	0	TR
Zeolites	0	2
Amorph Fe oxide	2	1
Microcryst. carb.	5	5
Foraminifers	3	TR
Nannofossils	68	76
Radiolaria	20	15
Sponge spicules	1	TR

CARBONATE BOMB:
1, 44-45 (75)

SITE 448 HOLE CORE 8 CORED INTERVAL: 62.0-71.5 m

AGE	BIOSTR. ZONE: NANNOS	BIOSTR. ZONE: FORAMS	BIOSTR. ZONE: RADS	FOSSIL CHARACT.: FOSSIL	FOSSIL CHARACT.: ABUNDANCE	FOSSIL CHARACT.: PRESERV.	SECTION	METERS
Early Miocene	NN 1	P.22-N.4	*Lychnocanoma elongata*	F	A	P		0.5
				R	C	M	1	1.0
				F	A	P	2	
				F	A	P	3	
				R	C	M	4	
				F R N	A C A	MP P M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 8/3

slight (1-2%) 5/1 mottling

10YR 7/4

10YR 7/3.5

10YR 7/3

NANNOFOSSIL OOZE, very pale brown. Slight and rare gray and very pale brown mottles scattered through the core. Fresh pumice fragments and traces of volcanic glass and micronodules also present. The material contains 3% amorphous iron oxides and 2 to 5% micritic carbonate.

SMEAR SLIDE SUMMARY

	1-140 (D)	2-67 (M)	2-100 (M)	3-140 (D)	4-100 (D)
TEXTURE					
Sand	5	10	15	5	10
Silt	95	85	80	91	85
Clay	3	5	5	4	5
TOTAL DETRITAL	TR	1	TR	1	TR
COMPOSITION:					
Feldspar	TR	TR	TR	TR	TR
Heavy minerals	TR	1	TR	1	TR
Volcanic glass	TR	0	0	TR	TR
Micronodules	TR	0	TR	TR	TR
Zeolites	0	2	0	0	TR
Amorph Fe oxide	1	2	1	3	3
Microcryst. carb.	2	5	4	4	5
Foraminifers	2	10	10	2	1
Nannofossils	85	64	80	75	71
Radiolaria	10	15	15	15	20
Sponge spicules	0	1	0	0	TR
Fish remains	TR	0	0	0	0

GRAIN-SIZE:
3-20 (0.6, 54.8, 44.6)

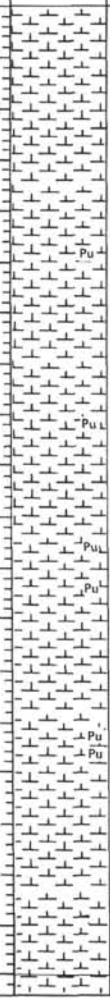
CARBONATE BOMB:
3, 61-62 (79)

Site 448, Core 9 (71.5-81.0 m): NO RECOVERY

SITE 448 HOLE CORE 10 CORED INTERVAL: 81.0-90.5 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 25	P.22-N.4	Dorcadospyris papilio	N F	A A	M M	1	0.5 1.0
				N F R	A A C	M M M	2	
		P.22-N.4		N F R	A A R	M M P	3	
				N F F	A A C	M M M	4	
				N F	A C	M M	5	
		P.22-N.4					6	
							7	
				F N R	C A C	PM M M	CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

numerous pumice fragments: drilling breccia

foram- and rad-filled burrows

10YR 8/2
lesser 8/1

moderate mottling
10YR 8/1, 7/2
10YR 8/3

10YR 8/1
stretched mottle

10YR 8/2.5
with rare
mottles

10YR 8/3

.5-1 cm black
patches

10YR 7.5/3

10YR 6/1

NANNOFOSSIL OOZE, white and very pale brown. White, light gray, gray, brown and black mottles are scarce in Section 1 but moderately abundant in the remainder of the core; volcanic ash in trace amounts in the upper and central sections. A few pumice fragments are scattered through the core. Amorphous iron oxides constitute ~1% of the total sediment; and micritic carbonate ~5%. Upper and central core is soft; lower sections have alternating soft and firm zones. Upper core is intensely disturbed; lower part only moderately. At Section 5, 120 to 130 cm and 135 to 145 cm, sediment in firm biscuits.

SMEAR SLIDE SUMMARY

	1-140 (D)	3-140 (D)	5-140 (D)	6-135 (D)	7-35 (D)
TEXTURE:					
Sand	10	10	5	5	10
Silt	85	85	85	90	85
Clay	5	5	10	5	5
TOTAL DETRITAL	1	1	TR	0	1
COMPOSITION:					
Feldspar	TR	TR	0	0	TR
Heavy minerals	1	1	0	0	TR
Volcanic glass	TR	0	TR	0	0
Micronodules	TR	TR	0	0	0
Amorph Fe oxides	1	1	2	0	0
Microcryst. carb.	5	5	10	5	2
Foraminifers	5	2	2	2	2
Nannofossils	78	82	81	87	82
Radiolaria	10	8	5	5	10
Sponge spicules	TR	1	TR	0	TR
Fish remains	0	0	TR	TR	2

SMEAR SLIDE SUMMARY

	1-25 (M)	2-20 (M)	3-57 (M)	4-26 (M)	6-77 (M)
TEXTURE:					
Sand	15	5	3	35	5
Silt	75	90	90	60	85
Clay	10	5	7	5	10
TOTAL DETRITAL	0	0	TR	7	0
COMPOSITION:					
Quartz	0	0	0	TR	0
Feldspar	0	0	0	2	0
Volcanic glass	0	0	TR	5	0
Micronodules	2	0	0	0	0
Zeolites	0	TR	0	10	0
Amorph Fe oxides	2	1	TR	10	0
Microcryst. carb.	10	5	5	10	10
Foraminifers	2	2	0	0	5
Nannofossils	69	74	85	58	75
Radiolaria	15	17	10	5	10
Sponge spicules	0	1	TR	0	0

Smear Slides (Dominant): 4-140

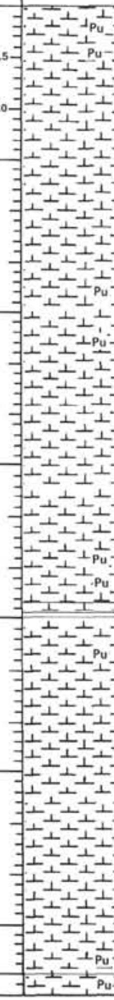
Smear Slides (Minor): 1-30, 4-110, 6-40, 7-25

PHYSICAL PROPERTIES:	Section 5 122-123 cm
$\bar{V}p$ (km/s)	
parallel to beds	2.33
vertical to beds	2.48
Wet bulk density	1.57
Porosity (%)	60.4
Grain density	2.44

SITE 448 HOLE CORE 11 CORED INTERVAL: 90.5-100.0 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 25		Dorcadospyris papilio	N F	A A	M M	1	0.5 1.0
		P.22		R F	R A	P PM	2	
		P.22		F	A	M	3	
							4	
		P.22		F	A	PM	5	
							6	
							7	
				F N R	FC A R	PM M P	CC	

GRAPHIC LITHOLOGY



LITHOLOGIC DESCRIPTION

10YR 8/2 with 6/2
stretched
mottles (15%)

black patches
4x10 cm white mottles

10YR 7/3
intensely
mottled 6/3

10YR 6.5/3 with
40% 2 cm diameter
white mottles

1.5Y 7/2 with 6/2
streaks

1x2 cm white mottles

1x3 cm white mottles

2.5Y 6/2 with
intense white
mottling

2.5Y 7/4
1x7 cm white
mottles

10YR 3/2 mottles

firm layer

2.5Y 7/3 with .5 cm
white mottles

3x6 cm white
mottles

10YR 8/3
25% volcanic glass

5Y 5/1, 6/1
volcanic ash 67%

3 cm thick
ash layer

disturbed ash layer
4-5 cm thick

2.5Y 5/4

3 cm ash layer

2.5Y 7.5/4

NANNOFOSSIL OOZE, white, light brownish gray, pale yellow, light yellowish brown, very pale brown and pale brown. The core is moderately and locally intensely mottled white, pale brown, light brownish gray and black. Scattered fragments and localized concentrations of pumice occur throughout. Thin layers of volcanic ash appear in the lower sections. Micritic carbonate averages 5%. Discoasters dominate the nannofossils but decrease down-core relative to coccoliths. The upper 3 sections are soft, the lower sections more indurated, with drilling biscuits which are transitional in induration between ooze and chalk. Drilling deformation is intense in the upper 5 sections, and moderate in Sections 6 and 7.

SMEAR SLIDE SUMMARY

	1-140 (D)	3-140 (D)	5-140 (D)	6-140 (D)	7-35 (D)
TEXTURE:					
Sand	5	5	20	30	15
Silt	85	90	70	45	75
Clay	10	5	10	25	10
TOTAL DETRITAL	TR	0	TR	TR	TR
COMPOSITION:					
Feldspar	TR	0	TR	TR	TR
Heavy minerals	0	TR	TR	TR	TR
Clay minerals	0	0	0	TR	0
Volcanic glass	TR	0	TR	0	TR
Zeolites	0	TR	0	0	TR
Amorph Fe oxide	2	TR	1	1	2
Microcryst. carb.	5	5	6	20	5
Foraminifers	2	5	10	20	5
Nannofossils	89	85	80	49	75
Radiolaria	2	4	10	5	10
Sponge spicules	TR	TR	0	TR	TR
Fish remains	TR	1	TR	0	TR

SMEAR SLIDE SUMMARY

	1-126 (M)	5-76 (M)	6-55 (M)	6-75 (M)
TEXTURE:				
Sand	5	15	30	70
Silt	85	75	25	15
Clay	10	10	45	15
TOTAL DETRITAL	0	2	28	72
COMPOSITION:				
Quartz	0	0	1	1
Feldspar	0	0	1	4
Heavy minerals	0	0	1	0
Volcanic glass	0	2	25	67
Zeolites	0	1	TR	0
Amorph Fe oxide	0	2	0	0
Microcryst. carb.	5	5	37	2
Foraminifers	1	0	5	1
Nannofossils	83	74	35	20
Radiolaria	10	12	0	5
Sponge spicules	1	4	0	TR

Smear Slides (Dominant): 2-140, 4-140

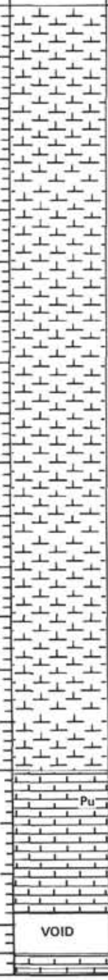
GRAIN-SIZE:	CARBON/CARBONATE:
3-114 (0.8, 59.3, 39.9)	3-97 (0.6, 79.9, 10.2)
6-101 (2.8, 50.9, 46.5)	4-26 (0.0, 80.4, 9.7)

PHYSICAL PROPERTIES:	Section 5 76-80 cm	Section 5 111-116 cm
$\bar{V}p$ (km/s)		
parallel to beds	1.61	1.63
vertical to beds	1.59	1.62
Wet bulk density	1.56	1.58
Porosity (%)	65.4	61.0
Grain density	2.61	2.49

SITE 448 HOLE CORE 12 CORED INTERVAL: 100.0-109.5 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 25	P.21?	*Dorcadospyris papilio*	N / F	A / A	M / M	1	0.5, 1.0
							2	
							3	
		P.21		R / F	R / FC	P / PM	4	
							5	
				F	C	M	6	
							7	
				F / N / R	C / A / F	PM / M / M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

2.5Y 6/2 with very few .5 cm scattered 2.5Y 8/2 blebs and rare 2.5Y 5/2 mottles

2.5Y 7/2

10YR 7/3

10YR 8/3 streaked mottles and blebs

10YR 3/2 mottles

10YR 7/3 with streaks, mottles 8/2 (moderate)

intense 8/2 mottling
5 cm 8/3 mottle
6/1 .5 mottle

slight mottling 10YR 8/2

10YR 8/3

slight 10YR 8/2 mottling

Same as Section 6

NANNOFOSSIL OOZE and NANNOFOSSIL CHALK; arbitrary boundary at top of Section 6, which consists of drilling biscuits of indurated chalk in drilling gouge. Apart from induration the lithology of the two units is essentially the same. Colors are very pale brown, light brownish gray and light gray. White, light gray, light grayish brown, very pale brown and very dark grayish brown mottling is scarce in upper sections but increases down-core to moderate and locally intense in the chalk. A few pumice fragments occur in the lower sections. Feldspar in trace amounts, and amorphous iron oxides comprise 1 to 2% of the sediment; ~5% is micritic carbonate. Section 2 is only moderately disturbed; remainder is intensely deformed by drilling.

SMEAR SLIDE SUMMARY

	1-130 (D)	3-80 (D)	3-120 (M)	4-100 (M)	4-130 (M)	5-130 (D)
TEXTURE:						
Sand	5	1	1	2	15	10
Silt	80	89	94	93	80	80
Clay	15	10	5	5	5	10
TOTAL DETRITAL	TR	TR	0	0	0	TR
COMPOSITION:						
Feldspar	TR	TR	0	0	0	TR
Heavy minerals	0	TR	0	0	0	TR
Micronodules	0	0	1	TR	1	0
Amorph Fe oxide	1	2	1	TR	1	1
Microcryst. carb.	5	5	5	5	5	5
Foraminifers	2	1	0	2	7	5
Nannofossils	82	81	72	77	75	82
Radiolaria	10	10	20	15	10	6
Sponge spicules	TR	TR	1	1	1	1
Fish remains	TR	1	0	0	0	TR

Smear Slides (Dominant): 2-140

GRAIN-SIZE:
5-70 (1.7, 62.7, 35.6)

CARBON/CARBONATE:
5-75 (0.2, 83.3, 10.2)

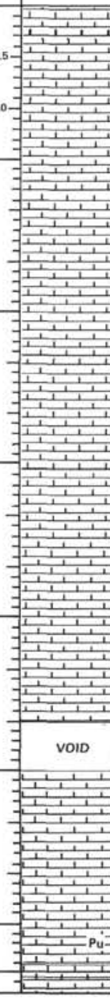
PHYSICAL PROPERTIES:	**Section 6 65-69 cm**
$\overline{V}p$ (km/s)	
parallel to beds	1.62
vertical to beds	1.55
Wet bulk density	1.60
Porosity (%)	61.19
Grain density	2.53

CARBONATE BOMB:
5, 74-75 (89)

SITE 448 HOLE CORE 13 CORED INTERVAL: 109.5-119.0 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 24	P.21	*Dorcadospyris papilio*	N / F	A / A	M / M	1	0.5, 1.0
							2	
							3	
				N / R / F	A / R / A	M / P / M	4	
							5	
				F	A	M	6	
							7	
				F / N / R	C / A / F	M / M / M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 7/2 moderately to intensely mottled with 10YR 8/2.5 and minor 5/2

1 cm 3/3 mottle

10YR 7/3, moderately to intensely mottled with 10YR 8/2.5 and 10YR 5/2

1 cm 3/3 mottle

10YR 8/3 mottles

10YR 7.5/3, moderately mottled 10YR 8/3, 5/3

10YR 7/2

2 foram- and rad-filled burrows

Color grades from 10YR 7.5/3 to 10YR 7.5/2

10YR 7/2 moderately mottled 8/2

8/1 mottle
few 8/2 mottles .5 cm

NANNOFOSSIL CHALK, light gray and very pale brown. White, very pale brown, pale brown and dark brown mottling is moderate in upper part of the core and moderate to intense in the lower. Scattered pumice fragments and thin layers occur in the lower part of the core. Amorphous iron oxide aggregates *constitute 1% of total sediment; micritic carbonate ~5%.* Discoasters are fewer and coccoliths more abundant. The material is uniformly indurated to chalk where undisturbed by drilling; deformation is uniformly intense, resulting in alternations of drilling biscuits, a few centimeters thick, and soft drilling gouge.

SMEAR SLIDE SUMMARY

	1-140 (D)	2-133 (D)	3-128 (D)	4-140 (D)	5-80 (D)	7-30 (D)
TEXTURE:						
Sand	12	3	2	10	5	11
Silt	75	80	96	85	90	84
Clay	13	7	2	5	5	5
TOTAL DETRITAL	TR	TR	1	TR	0	0
COMPOSITION:						
Feldspar	TR	TR	0	TR	0	0
Heavy minerals	TR	TR	0	0	0	0
Volcanic glass	0	TR	1	TR	0	0
Zeolites	0	0	TR	0	0	0
Amorph Fe oxide	1	1	0	1	1	2
Microcryst. carb.	10	5	7	5	5	5
Foraminifers	5	5	5	10	5	2
Nannofossils	73	80	90	77	84	77
Diatoms	10	5	0	6	0	0
Radiolaria	2	TR	2	1	5	5
Sponge spicules	0	TR	0	1	0	1
Fish remains	0	TR	TR	TR	TR	0

Smear Slides (Dominant): 6-130
Smear Slides (Minor): 3-100

GRAIN-SIZE:
4-86 (2.4, 60.5, 37.1)

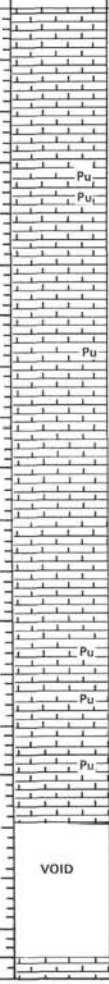
PHYSICAL PROPERTIES:	**Section 1 138-141 cm**
$\overline{V}p$ (km/s)	
parallel to beds	1.64
vertical to beds	1.60
Wet bulk density	1.61
Porosity (%)	61.32
Grain density	2.59

CARBONATE BOMB:
4, 90-91 (86)

SITE 448 HOLE CORE 14 CORED INTERVAL: 119.0-128.5 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 24	P.21	*Dorcadospyris papilio?*	N / F	A / A	M / M	1	0.5, 1.0
							2	
							3	
				F	A	PM	4	
							5	
				F	A	M	6	
				F N R	C A F	M M P	7, CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 7/3 homogenized
10YR 7.5/2
ash layer
10YR 8/2 streak
10YR 7/2
10YR 6.5/2
10YR 7.5/2 with minor light, dark streaks
10YR 6/3 homogeneous minor streaks 7.5/2 and 5.5/3
10YR 7/2
10YR 7/3
10YR 7/2.5
10YR 7/2.5

NANNOFOSSIL CHALK, light gray and very pale brown. Entire core is slightly mottled white, light gray, pale brown and light brownish gray. A few pumice fragments and layers occur throughout the core. Micritic carbonate comprises ~5% of the sediment; authigenic zeolite ~1%. The sediments are uniformly firm and drilling disturbance uniformly moderate.

SMEAR SLIDE SUMMARY

	1-140 (D)	3-140 (D)	4-140 (D)	5-140 (D)	6-20 (D)
TEXTURE:					
Sand	15	15	20	20	5
Silt	80	80	75	75	90
Clay	5	5	5	5	5
TOTAL DETRITAL	0	TR	0	TR	0
COMPOSITION:					
Volcanic glass	0	TR	0	TR	0
Zeolites	2	1	1	1	TR
Amorph Fe oxide	0	1	1	TR	0
Microcryst. carb.	5	5	5	5	5
Foraminifers	10	10	20	20	3
Nannofossils	77	78	69	69	82
Radiolaria	5	5	3	5	10
Sponge spicules	1	0	1	1	0

GRAIN-SIZE:
3-0 (1.5, 59.1, 39.4)

CARBON/CARBONATE:
3-5 (0.1, 84.0, 10.2)

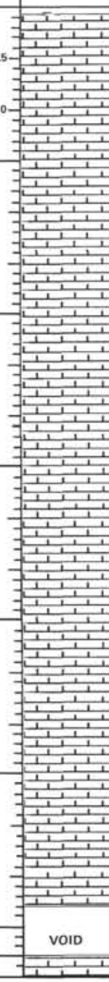
CARBONATE BOMB:
3, 6-7 (82.5)

PHYSICAL PROPERTIES:	Section 3 90-92 cm
$\bar{V}p$ (km/s)	
parallel to beds	1.62
vertical to beds	1.60
Wet bulk density	1.56
Porosity (%)	61.14
Grain density	2.45

SITE 448 HOLE CORE 15 CORED INTERVAL: 128.5-138.0 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 24	P.21	*Dorcadospyris papilio ?*	N / R	A / R	M / P	1	0.5, 1.0
							2	
							3	
				F	A	M	4	
							5	
							6	
				F R N	C R A	M P M	7, CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 7/2 drilling biscuits and gouge
10YR 7.5/2
8/2 mottles
5/4 ash layer
10YR 7/2
10YR 6/2 with fine black flecks
black flecks
10YR 7.5/2
white mottle
10YR 7.5/2
Drilling biscuits and gouge. Biscuit color 10YR 7/2.5 moderately mottled 8/2
10YR 7/3 with 7.5/3, 6/2 mottles
10YR 6/2 mottles
1 cm 5/2 mottles
10YR 7.5/3
lightly mottled
8 cm graded
10YR 7/3

NANNOFOSSIL CHALK, very pale brown, light brownish gray and light gray. White, grayish brown, very pale brown, and black mottles and specks are rare in the top section but mottling increases to moderate down-core. A few pumice fragments are scattered in the upper core. A 1-cm thick massive ash layer and a 7-cm thick graded ash layer are present in Section 6. Traces of volcanic ash are disseminated throughout the entire core. Micritic carbonate averages ~5% of the sediment. The material is uniformly firm, and drilling disturbance varies from intense at the top of the core to slight at the bottom.

SMEAR SLIDE SUMMARY

	1-140 (D)	2-140 (D)	3-73 (M)	3-140 (D)	5-140 (D)	6-110 (D)
TEXTURE:						
Sand	10	5	10	15	10	10
Silt	85	85	85	80	75	70
Clay	5	10	5	5	15	20
TOTAL DETRITAL	TR	10	0	TR	0	TR
COMPOSITION:						
Quartz	0	0	0	0	0	TR
Volcanic glass	TR	10	0	TR	0	TR
Micronodules	TR	0	TR	TR	0	0
Zeolites	TR	0	0	0	1	0
Amorph Fe oxide	1	0	0	1	0	0
Microcryst. carb.	5	10	5	5	10	20
Foraminifers	10	5	10	15	7	5
Nannofossils	73	68	75	73	85	63
Radiolaria	10	7	10	5	7	10
Sponge spicules	1	TR	TR	1	TR	3

Smear Slides (Dominant): 4-140

GRAIN-SIZE:
3-69 (1.7, 65.2, 33.1)

CARBON/CARBONATE:
3-67 (0.0, 80.6, 9.7)

CARBONATE BOMB:
3, 68-69 (86)

SITE 448 HOLE CORE 16 CORED INTERVAL: 138.0-147.5 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 24		*Dorcadospyris papilio?*	N	A	M	1	0.5, 1.0
				N / F	A / C	M / M	4	
				N	A	M	6	
				R / F / N	R / C / A	P / M / M	CC	

Sections: 1, 2, 3, 4, 5, 6, 7, CC (VOID in Section 6 and Section 7)

LITHOLOGIC DESCRIPTION

10YR 7/3 with scattered light mottles and pumice fragments 0.3 cm

10YR 8/2

NANNOFOSSIL CHALK, white, light gray, very pale brown and yellowish brown; mottled and burrowed with white, very pale brown and very dark grayish brown colors. Several scattered and locally layered pumice fragments appear, especially in the lower half of the core. Volcanic glass occurs in trace amounts in the center sections. Lithification is uniformly firm. Drilling disturbance varies from oderate to intense throughout the core; the material consists of drilling biscuits and drilling gouge.

10YR 8/1 mottle 10YR 7.5/2, moderately mottled

1 cm ash layer

10YR 7/2.5

minor white mottling

10YR 7/3

10YR 3/2 2 burrows

10YR 7/2.5

Intense mottling, 10YR 5/2 with 10YR 8/2

2.5Y 6/2

10YR 7/2

SMEAR SLIDE SUMMARY

	1-140 (D)	2-140 (D)	4-111 (M)	4-140 (D)	5-130 (D)	7-34 (D)
TEXTURE:						
Sand	30	10	10	12	0	5
Silt	65	80	80	83	98	90
Clay	5	10	10	5	2	5
TOTAL DETRITAL	TR	TR	32	TR	TR	0
COMPOSITION:						
Quartz	–	TR	–	–	–	–
Feldspar	TR	–	2	TR	TR	–
Heavy minerals	TR	–	TR	TR	–	–
Volcanic glass	–	–	30	TR	TR	–
Micronodules	–	TR	–	–	–	TR
Amorph Fe agg.	2	1	–	TR	TR	–
Carbonate unspec.	5	10	10	2	TR	1
Foraminifers	20	10	5	15	4	5
Nannofossils	64	69	52	75	87	87
Radiolaria	5	10	2	8	6	5
Sponge spicules	4	TR	–	2	1	2

Smear Slides (Dominant): 3-130, 6-10, 6-60
Smear Slides (Minor): 6-140

GRAIN-SIZE:
4-55 (1.7, 66.4, 31.9)

CARBON/CARBONATE:
4-53 (0.0, 80.2, 9.7)

CARBONATE BOMB:
4, 53-54 (82)

PHYSICAL PROPERTIES:	Section 5 145-149 cm
Wet bulk density	1.57
Porosity (%)	61.73
Grain density	2.49

SITE 448 HOLE CORE 17 CORED INTERVAL: 147.5-157.0 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Late Oligocene	NP 24	P.21	*Theocyrtis armosa?-Dorcadospyris papilio?*	N	A	M	1	0.5, 1.0
				F	C	M	4	
		P.21		R / F / N	R / C / A	P / M / M	CC	

Sections: 1, 2, 3, 4, 5, 6, 7, CC (Pu in Section 6)

LITHOLOGIC DESCRIPTION

10YR 7.5/2 enriched in radiolarians (10%)
10YR 7/3 mottled with 2.5Y 6.5/2

10YR 5/2.5 mottles
10YR 6/3 mottled with 4/1, 7/2.5

NANNOFOSSIL CHALK, light gray, grayish brown, very pale brown and pale brown, moderately to (locally) intensely mottled and burrowed grayish brown and very pale grayish brown; minor scattered pumice fragments and ash layers in the lower portion of the core.
Lithification is uniformly firm, and the sediment is moderately to intensely disturbed by drilling throughout the core.
The interval from 137 cm in Section 4 to 33 cm in Section 5 is a light gray to light brownish gray and dark greenish gray **FINE VITRIC TUFF.**

10YR 6/2 2 cm thick

10YR 6.5/3 moderately to intensely mottled 8/3, 7/3

unmottled

10YR 6/2.5 ash layer
light streak
5Y 6/1.5 ashy

10YR 7/3 moderately mottled
10YR 7.5/3

10YR 5.5/2 mottles

10YR 6.5/2 moderately mottled 10YR 7/3

10YR 6/1
10YR 7/3 moderately mottled 7.5/3

ash layers

10YR 7/1.5, 7/2, 7.5/2

5Y 3/2 ash

SMEAR SLIDE SUMMARY

	1-128 (D)	2-140 (D)	4-144 (D)	5-23 (D)	5-130 (D)	7-16 (D)
TEXTURE:						
Sand	10	1	10	1	15	10
Silt	83	99	60	65	80	85
Clay	7	0	30	34	5	5
TOTAL DETRITAL	0	TR	52		0	0
COMPOSITION:				50		
Feldspar	–	TR	2	–	–	–
Volcanic glass	–	–	50	50	–	–
Zeolites	–	–	5	10	1	–
Amorph Fe agg.	1	1	1	–	1	–
Carbonate unspec.	5	–	–	–	–	5
Foraminifers	5	3	3	2	5	7
Nannofossils	81	92	35	30	82	80
Radiolaria	5	3	5	2	10	7
Sponge spicules	3	1	2	–	1	1

Smear Slides (Dominant): 3-140, 4-70
Smear Slides (Minor): 3-80

GRAIN-SIZE:
3-8 (0.9, 60.5, 38.6)

CARBON/CARBONATE:
3-6 (0.0, 84.8, 10.2)

CARBONATE BOMB:
3, 5-6 (89)

PHYSICAL PROPERTIES:	Section 4 39-43 cm
$\bar{V}p$ (km/s)	
parallel to beds	1.62
vertical to beds	1.59
Wet bulk density	1.52
Porosity (%)	64.29
Grain density	2.45

SITE 448 HOLE CORE 18 CORED INTERVAL: 157.0-166.5 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
Late Oligocene	NP 24			N	A	M	CC						

Core-Catcher sample only. Recovery consisted of a smear of gray mud, used up in preparation of the nannofossil smear slide, and several cubic centimeters of very dark grayish brown sandy material.

In smear slides, the gray mud is a **GLASS-RICH NANNOFOSSIL CHALK** containing 75% calcareous nannofossils, 25% volcanic glass shards, and trace amounts of feldspar, heavy minerals, foraminifers, diatoms, radiolarians, sponge spicules and fish remains.

The dark grayish brown sandy material in smear slides is a **GLASS-RICH NANNOFOSSIL CHALK** consisting of 67% nannofossils, 30% volcanic glass shards, 3% amorphous and opaque iron oxides, and traces of feldspar, heavy minerals, foraminifers and radiolarians.

SITE 448 HOLE CORE 19 CORED INTERVAL: 166.5-176.0 m

AGE	NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Middle to late Oligocene	NP 24	P.20-P.21		F	A	M	1	0.5, 1.0
							2	
		P.20		N / F	C / A	M / M	3	
							4	
				F	–	–	5	
		P.20		F / N	R / F	PM / M	CC	

GRAPHIC LITHOLOGY: VOID (Section 1); VOID (Section 2); Pu (Section 3)

top 6 cm ashy 5Y 5/2

10YR 8/2 with minor 7/1, 5/2, 7.5/1 and 6.5/1 mottling

10YR 7.5/2 with minor 8/2, 6.5/1 mottling

10YR 7.5/1 slight to moderate mottling of 4.5/2, 8/2, 4/1, 7/1

10YR 6.5/2, 8/1, 6/1.5, 6.5/2, 8/2, 7.5/3 layers; ash layer at 50 cm

10YR 7.5/2, slightly mottled

10YR 7/1 with minor mottling

gradational; 10YR 7/1 burrow

5Y 4/1 with 5Y 3/1 laminae

5Y 3/2 ashy 5Y 2/2 1 cm ash layers

5Y 5.5/1 chalk

5GY 4/1

LITHOLOGIC DESCRIPTION

Transition from **NANNOFOSSIL CHALK** to **VITRIC TUFF**. The nannofossil chalk is very pale brown and light gray, slightly to moderately mottled grayish brown and dark grayish brown. Its nannofossil assemblage is dominated by coccoliths. In Section 1 and the top 50 cm of Section 2 the stratigraphic proximity of the tuffs is scarcely reflected in the composition of the chalk. In Section 2, still within the chalk, a transitional layer 33 mm thick occupies the interval from 58 to 68 cm. This is a dark grayish brown, massive **CHALKY VITRIC TUFF**, compositionally intermediate between the chalks and tuffs. A second, basal transitional zone 10 mm thick between 58 and 68 cm in Section 4 consists of tuff with white chalky burrows and mottles.
The **VITRIC TUFF**, from Section 4, 68 cm to the bottom of the core, is olive gray and dark olive gray and consists of firmly indurated, partially devitrified silt- and sand-sized glass shards. The tuff is finely laminated, especially in Section 5.

SMEAR SLIDE SUMMARY

	1-140 (D)	2-55 (D)	2-98 (D)	4-30 (D)	4-100 (D)	5-67 (M)
TEXTURE:						
Sand	10	20	20	30	20	15
Silt	85	70	75	66	80	80
Clay	5	10	5	4	0	5
TOTAL DETRITAL	TR	57	TR	1	94	3
COMPOSITION:						
Feldspar	–	5	–	–	4	–
Clay minerals	–	2	–	–	–	–
Volcanic glass	–	50	–	1	90	3
Micronodules	–	2	–	–	–	2
Zeolites	TR	10	TR	1	2	3
Amorph Fe agg.	TR	3	2	1	4	–
Carbonate unspec.	5	–	5	2	–	5
Foraminifers	7	–	10	15	–	–
Nannofossils	80	28	73	72	–	82
Radiolaria	7	–	10	7	–	5
Sponge spicules	1	–	TR	1	–	TR

Smear Slides (Dominant): 3-40, 5-40
Smear Slides (Minor): 3-50

GRAIN-SIZE:
3-3 (1.5, 66.0, 32.5)
5-6 (4.1, 79.8, 16.1)

CARBON/CARBONATE:
5-8 (0.0, 1.9, 0.3)

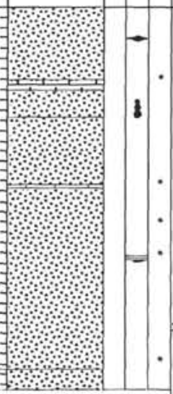
CARBONATE BOMB:
3, 5-6 (37.5)
5, 8-9 (2)

PHYSICAL PROPERTIES:

	Section 3 36-38 cm
$\bar{V}p$ (km/s)	
parallel to beds	1.67
vertical to beds	1.63
Wet bulk density	1.59
Porosity (%)	57.54
Grain density	2.38

SITE 448 HOLE CORE 20 CORED INTERVAL: 176.0-185.0 m

AGE: Middle to late Oligocene
BIOSTR. ZONE — NANNOS: NP 24
FOSSIL CHARACT.: F N R / RF C R / PM M P
SECTION: 1, 2, 3, CC
METERS: 0.5, 1.0



1 cm altered basalt fragments
5GY 6/1 burrow
2.5Y 3/0 lamination
5GY 4/1 graded tuff 5 cm thick, 5GY 6/1
5Y 2/1
5Y 3/2
.7 cm 5Y 4/2 over 5Y 3/1 laminated ash
1 cm 5BG 4/1 with load cast
5BG 4/1 clay- to sand-sized
5GY 7/1 with 7/1 mottling
5GY 4/1 silt-sized ash layer .5 cm
5GY 4/1

LITHOLOGIC DESCRIPTION

VITRIC TUFF, dark greenish gray, dark olive gray and very dark gray, with a 10 cm and a 2 cm dark greenish gray **CHALK** layer in Sections 1 and 2, respectively. Tuff in Sections 1 and 2 contain zones up to 25 cm thick that have 2 mm thick very dark gray laminations. In the lowest section, they are less well defined. Moderately mottled and burrowed zones up to 6 cm thick also occur in Sections 1 and 2, filled with greenish gray ash. Two graded tuff units, each 10 cm thick, appear in Sections 1 and 3. Minor light gray mottles occur in Section 3. Lithification: generally firm, with harder and softer ash intervals. Drilling deformation varies from slight to intense, depending on the degree of lithification.

SMEAR SLIDE SUMMARY

	1-75 (D)	2-26 (M)	2-67 (M)	2-96 (M)	3-45 (M)
TEXTURE:					
Sand	5	25	10	10	38
Silt	90	70	85	85	57
Clay	5	5	5	5	5
TOTAL DETRITAL	3	14	94	97	33
COMPOSITION:					
Quartz	–	–	1	1	–
Feldspar	1	–	3	1	1
Heavy minerals	TR	–	5	5	–
Clay minerals	–	–	5	5	–
Volcanic glass	2	14	80	85	32
Micronodules	–	2	–	–	–
Zeolites	–	1	2	1	2
Amorph Fe agg.	–	–	–	2	1
Carbonate unspec.	5	5	–	–	3
Foraminifiers	3	15	3	–	5
Nannofossils	80	60	TR	TR	55
Radiolaria	9	10	1	–	1

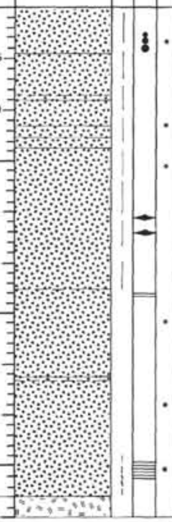
CARBON/CARBONATE: 1-13 (0.0, 2.2, 0.3)
CARBONATE BOMB: I, 12-13 (2)

MAGNETIC SAMPLE: 1-5 2-143

PHYSICAL PROPERTIES:	Section 1 45-48 cm	47-50 cm
$\overline{V}p$ (km/s)		
parallel to beds	1.97	
vertical to beds	1.95	
Wet bulk density	1.54	1.71
Porosity (%)	68.61	66.74
Grain density	2.71	3.12

SITE 448 HOLE CORE 21 CORED INTERVAL: 185.5-195.0 m

AGE: Middle to late Oligocene
BIOSTR. ZONE — NANNOS: NP 24
FOSSIL CHARACT.: R N F / – C R / – M P; F R N / – – / – –
SECTION: 1, 2, 3, 4, CC
METERS: 0.5, 1.0



5GY 4/1 massive
N4 graded
5GY 5/1 laminations
5GY 6/1, 5/1 massive
5Y 4/1 with .5x1 cm 5GY 5/1 mottles
N4, massive
1.5 cm silt
laminations
5GY 4/1 laminations fine vitric tuff

LITHOLOGIC DESCRIPTION

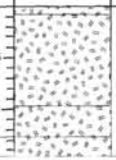
VITRIC TUFF, light greenish gray, greenish gray, dark greenish gray and dark gray. Section 1 contains 4 graded units from 5 to 23 cm thick. A 2 cm microbreccia containing chalk clasts also occurs in Section 1. Gray and dark gray mottling and burrows are locally moderate, rarely intense. Thin, 2 mm, dark greenish gray laminations appear, mainly in Sections 2 and 3. Celadonite constitutes from 2 to 5% of the sediment in Sections 3 and 4. Feldspar fragments comprise ~2% of the total sediment. The rock is lithified uniformly hard; drilling disturbance is moderate to slight.

SMEAR SLIDE SUMMARY

	1-31 (M)	1-124 (M)	2-1 (D)	3-15 (D)	2-100 (D)	4-13 (D)
TEXTURE:						
Sand	25	6	2	1	0	25
Silt	70	59	85	85	60	73
Clay	5	35	13	14	40	2
TOTAL DETRITAL	98	9	1	95	98	89
COMPOSITION:						
Quartz	1	1	–	–	–	–
Feldspar	2	2	1	2	2	4
Mica	2	–	–	–	–	–
Heavy minerals	TR	1	–	–	–	–
Volcanic glass	93	5	–	92	96	85
Celadonite	–	–	–	5	2	4
Zeolites	TR	–	–	1	TR	1
Carbonate unspec.	2	21	5	–	–	2
Foraminifers	–	–	1	–	–	–
Nannofossils	–	70	84	TR	TR	1
Radiolaria	–	–	7	–	–	1
Sponge spicules	–	–	2	–	–	2

PHYSICAL PROPERTIES:	Section 1 71-74 cm	Section 3 143-146 cm
$\overline{V}p$ (km/s)		
parallel to beds	2.28	
vertical to beds	2.30	
Wet bulk density	1.54	1.56
Porosity (%)	60.03	67.01
Grain density	2.36	2.71

SITE 448 HOLE CORE 22 CORED INTERVAL: 195.0-204.5 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle to late Oligocene							1 CC	0.5 1.0				

LITHOLOGIC DESCRIPTION

N4

5GY 4/1 fine vitric tuff with 1 to 2 mm laminae spaced 1 to 1.5 cm apart, as indicated

graded from silt to fine sand, 41 to 44 cm

graded from silt to medium sand, 56 to 58 cm

5G 4/2 celadonitic zone, 59 to 92 cm

wavy and contorted lamination

5GY 4/1 fine vitric tuff

5GY 4/1 and N4
fine vitric tuff

VITRIC TUFF, dark gray, dark greenish gray, sparsely and locally mottled greenish gray. Three 12 to 14 cm thick graded units in Section 1. Zones with 1 to 2 mm laminations are scattered throughout the core. A 2-cm thick celadonitic layer also appears in Section 1. Of the total sediment celadonite comprises ~2 to 3%. The rock is uniformly lithified, hard, and drilling disturbance is uniformly moderate.

SMEAR SLIDE SUMMARY

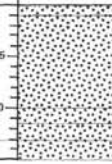
	1-59 (M)	1-115 (D)
TEXTURE:		
Sand	10	2
Silt	80	85
Clay	10	13
TOTAL DETRITAL	9	95
COMPOSITION:		
Quartz	–	1
Feldspar	3	5
Heavy minerals	1	–
Volcanic glass	5	89
Celadonite	2	3
Zeolite	4	1
Carbonate unspec.	15	–
Nannofossils	70	1

CARBON/CARBONATE:
1-31 (0.1, 0.2, 0.1)

CARBONATE BOMB:
1, 31-33 (1)

PHYSICAL PROPERTIES:	Section 1 112-115 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.43
vertical to beds	2.32
Wet bulk density	1.67
Porosity (%)	61.17
Grain density	2.72

SITE 448 HOLE CORE 23 CORED INTERVAL: 204.5-214.0 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle Oligocene	NP 24			N F R N N	C R R C C	M P P M M	1 CC	0.5 1.0				

LITHOLOGIC DESCRIPTION

N4 vitric tuff, medium sand-sized

5Y 6/1 fine vitric tuff, from 20 to 35 cm, with laminations 2 mm thick spaced 5 mm apart

5Y 6/1 graded vitric tuff, coarse silt to medium sand

2.5Y 8/0 fine vitric tuff, with
a) 3 layers with fresh glass fragments, 5Y 5/1, 1 cm thick
b) 1 cm thick celadonitic layer, 5G 6/2
c) 5GY 4/1 mottle

5GY 6/1, 7/1, 5Y 5/1
fine vitric tuff

Feldspar bearing, locally nannofossil-rich **VITRIC TUFF**, dark gray and greenish gray. Section 1 consists of a 110 cm thick graded unit underlain by three 1 to 4-cm thick gray units of glass fragments interbedded with the tuff. A 1-cm thick celadonitic layer also occurs in the basal part of the core. Core-Catcher sample is intensely mottled light greenish gray; contains a few scattered glass fragments. Rock is lithified, uniformly hard and drilling deformation is moderate to intense.

SMEAR SLIDE SUMMARY

	1-4 (D)	1-115 (M)	1-118 (D)	1-130 (D)
TEXTURE:				
Sand	10	40	0	2
Silt	60	55	80	75
Clay	30	5	20	23
TOTAL DETRITAL	75	78	84	97
COMPOSITION:				
Quartz	–	2	1	TR
Feldspar	2	4	4	3
Heavy minerals	–	1	2	2
Volcanic glass	73	71	77	92
Celadonite	5	6	–	3
Zeolite	TR	1	–	TR
Amorph Fe agg.	–	–	–	2
Carbonate unspec.	5	3	8	TR
Nannofossils	15	12	8	–

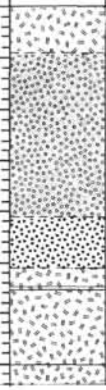
SITE 448 HOLE CORE 24 CORED INTERVAL: 214.0-223.5 m (Hole deviation of 1.0° at 223.5 m)

AGE: Middle Oligocene

Column headings: BIOSTR. ZONE (NANNOS, FORAMS, RADS); FOSSIL CHARACT. (FOSSIL, ABUNDANCE, PRESERV.); SECTION; METERS; GRAPHIC LITHOLOGY; DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; LITHOLOGIC SAMPLE; LITHOLOGIC DESCRIPTION

Sections: 1, 2, 3, CC (meters 0.5, 1.0)

Fossil character (CC): F R N – R – – F – –



5Y 4/2 fine vitric tuff

5Y 5/2 tuffaceous volcaniclastic breccia

5Y 5/2 vitric tuff

2 cm fine vitric tuff layer

5Y 5/2 laminated fine vitric tuff

5Y 5/2 fine vitric tuff

LITHOLOGIC DESCRIPTION

Nannofossil-bearing **FINE VITRIC TUFF, TUFFACEOUS VOLCANICLASTIC BRECCIA AND VITRIC TUFF,** olive gray. The breccia contains clasts of glass, basalt and minor chert in a matrix of glass fragments. *Slump features* are visible in a 22 cm layer of Section 2, which also contains a 10-cm thick graded layer. Finer grained zones in the lower section display 1 to 4 mm thick laminations. The rock is lithified, uniformly hard, and drilling disturbance is uniformly slight.

SMEAR SLIDE SUMMARY

	1-25 (D)	3-16 (D)
TEXTURE:		
Sand	0	5
Silt	95	90
Clay	5	5
TOTAL DETRITAL	87	95
COMPOSITION:		
Quartz	–	3
Feldspar	2	15
Heavy minerals	2	1
Volcanic glass	83	76
Celadonite	–	2
Amorph Fe agg.	–	3
Carbonate unspec.	2	TR
Nannofossils	1	TR

Smear Slides (Dominant): 1-140, 2-55, 2-85, 2-100, 2-130

CARBON/CARBONATE:
2-69 (0.0, 0.0, 0.0)

MAGNETIC SAMPLES: 1-61 2-79

PHYSICAL PROPERTIES:	Section 2 73-75 cm	74-76 cm
$\bar{V}p$ (km/s)		
parallel to beds	3.10	
vertical to beds	2.99	
Wet bulk density	1.92	1.90
Porosity (%)	34.67	42.89
Grain density	2.41	2.57

SITE 448 HOLE CORE 25 CORED INTERVAL: 223.5-233.0 m

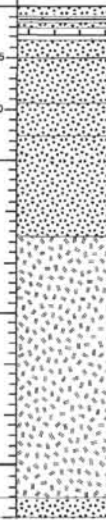
AGE: Middle Oligocene

BIOSTR. ZONE (NANNOS): NP 24

Column headings: BIOSTR. ZONE (NANNOS, FORAMS, RADS); FOSSIL CHARACT. (FOSSIL, ABUNDANCE, PRESERV.); SECTION; METERS; GRAPHIC LITHOLOGY; DRILLING DISTURBANCE; SEDIMENTARY STRUCTURES; LITHOLOGIC SAMPLE; LITHOLOGIC DESCRIPTION

Sections: 1, 2, 3, 4, CC (meters 0.5, 1.0)

Fossil character (Section 1): N C M; R R P; R – –
Fossil character (Section 4/CC): F – –; R – –; N – –



5Y 8/2 chalk

5Y 4/4, 5/3, 3.5/2 fine vitric tuff, laminated, graded as indicated

2 cm sand-sized layer

Black fine vitric tuff, massive, silt-sized

5Y 5/2 vitric tuff

5Y 6/3 clay- and silt-sized layer 2 cm

5Y 5/3 clay-sized layer with Mn dendroids

5Y 4/2 vitric tuff

LITHOLOGIC DESCRIPTION

Feldspar bearing **VITRIC TUFF**, olive, pale olive, olive gray, dark olive gray and black. A 5-cm and a 12-cm thick layer of white **NANNOFOSSIL CHALK** occur in Section 1, which also contains a few black or white locally mottled zones <5 cm thick, a 48-cm thick graded bed, and a few laminated zones. The central and lower sections are massive and homogeneous fine vitric tuff. Minor Mn dendrites are scattered through the graded layer of Section 1 and throughout Section 4. Feldspar fragments comprise up to 10% of the total sediment. The rock is lithified, uniformly hard, and drilling deformation is uniformly slight. Mn dendroids at 51 to 99 cm in Section 1.

SMEAR SLIDE SUMMARY

	1-10 (M)	1-53 (M)	2-25 (D)	4-20 (D)
TEXTURE:				
Sand	1	0	10	5
Silt	89	95	75	90
Clay	10	5	15	5
TOTAL DETRITAL	3	92	83	90
COMPOSITION:				
Feldspars	1	2	10	6
Heavy minerals	–	–	5	1
Volcanic glass	2	90	68	83
Celadonite	3	TR	–	5
Amorph Fe agg.	TR	8	–	4
Carbonate unspec.	10	TR	15	1
Foraminifers	–	–	–	–
Nannofossils	80	–	1	TR
Radiolaria	4	–	–	–
Sponge spicules	–	–	1	–

Smear Slides (Minor): 3-100

CARBON/CARBONATE: 3-48 (0.0, 0.0, 0.0)

CARBONATE BOMB: 3, 51-52 (<1)

MAGNETIC SAMPLES: 1-55 3-91

PHYSICAL PROPERTIES:	Section 3 46-48 cm	Section 3 50-52 cm
$\bar{V}p$ (km/s)		
parallel to beds	2.68	
vertical to beds	2.52	
Wet bulk density	1.78	1.77
Porosity (%)	52.51	51.13
Grain density	2.65	2.57

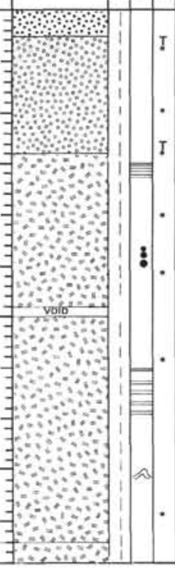
SITE 448 HOLE CORE 26 CORED INTERVAL: 233.0-242.5 m

AGE: Middle Oligocene

BIOSTR. ZONE: NANNOS, FORAMS, RADS — FOSSIL CHARACT.: FOSSIL, ABUNDANCE, PRESERV. — SECTION — METERS — GRAPHIC LITHOLOGY — DRILLING DISTURBANCE — SEDIMENTARY STRUCTURES — LITHOLOGIC SAMPLE

Fossil character (CC): R N F — R — P

Sections: 1 (0.5, 1.0), 2, 3, 4, CC



5Y 8/2 vitric tuff

single tuff clasts

1 cm 2.5Y 6/6

Mixture clay-sized and silt-sized layers

Graded medium ss up to silt

5G 7/1 fine vitric tuff, 5BG 4/1 mottling

5BG 4/1 fine vitric tuff black laminae

sporadic laminae 5Y 8/1 silt

5Y 8/1, coarse silt, disturbed

1 cm 5G 4/2

5BG 4/1 fine vitric tuff

2 cm 5Y 8/1

5Y 8/1 fine vitric tuff

LITHOLOGIC DESCRIPTION

VITRIC TUFF, TUFFACEOUS VOLCANICLASTIC BRECCIA AND FINE VITRIC TUFF, olive, pale olive, dark greenish gray, and very dark gray. Clasts of light gray tuff up to 25 cm in size occur in Section 1. A 20-cm thick graded sequence appears in Section 2. Laminations in the central and lower parts of the core, contain 1 cm-thick silt-sized layers. Load casts are present beneath some of the silt-sized layers in Sections 2 and 4. The rock is uniformly hard. Drilling disturbance is slight to intense in Sections 1 and 2 and Section 3 is only moderately disturbed.

SMEAR SLIDE SUMMARY

	1-41 (M)	1-86 (M)	1-148 (M)	2-66 (D)	3-53 (D)	4-50 (D)
TEXTURE:						
Sand	40	0	10	8	5	0
Silt	55	98	85	82	84	90
Clay	5	2	5	10	11	10
TOTAL DETRITAL	90	95	94	92	88	82
COMPOSITION:						
Feldspar	5	8	3	7	2	TR
Heavy minerals	3	–	1	3	2	2
Lithic fragments	30	–	–	–	–	–
Volcanic glass	52	87	90	82	84	80
Micronodules	–	–	–	3	–	–
Amorph Fe agg.	10	1	5	3	–	–
Carbonate unspec.	–	2	1	2	5	3
Foraminifers	–	–	–	–	TR	TR
Nannofossils	–	2	TR	TR	7	15

Smear Slides (Dominant): 2-135

MAGNETIC SAMPLES: 1-112 2-48 3-50

PHYSICAL PROPERTIES:	Section 2 40-43 cm	Section 2 146-148 cm
$\overline{V}p$ (km/s)		
parallel to beds	2.42	
vertical to beds	1.96	
Wet bulk density	1.94	17.1
Porosity (%)	48.42	60.27
Grain density	2.81	2.79

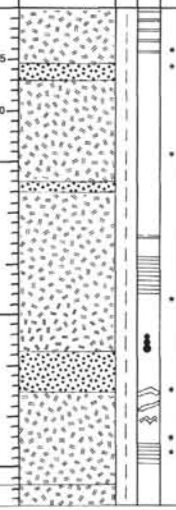
SITE 448 HOLE CORE 27 CORED INTERVAL: 242.5-252.0 m

AGE: Middle Oligocene

BIOSTR. ZONE: NANNOS, FORAMS, RADS — FOSSIL CHARACT.: FOSSIL, ABUNDANCE, PRESERV. — SECTION — METERS — GRAPHIC LITHOLOGY — DRILLING DISTURBANCE — SEDIMENTARY STRUCTURES — LITHOLOGIC SAMPLE

Fossil character (CC): R N — – — –

Sections: 1 (0.5, 1.0), 2, 3, 4, CC



N4 fine vitric tuff, some lamination

black mottles

2.5Y 8/1 coarse vitric tuff

N4 fine vitric tuff, some lamination as indicated

coarse patch

5BG 4/1

5Y 4/4 vitric tuff .5 cm pumice pebbles

N2 fine vitric tuff, laminated, distorted laminae where indicated

N4 fine vitric tuff

LITHOLOGIC DESCRIPTION

Feldspar- and heavy mineral-bearing **FINE VITRIC TUFF AND VITRIC TUFF,** gray, dark gray and black. Laminations occur in the fine vitric tuff layers. A white, 20-cm thick layer of coarse sand-sized glass fragments is present in Section 1. Similar glassy zones also in Sections 3 and 4, though their colors vary from olive and dark greenish gray to white. Slight burrowing occurs in a 25-cm thick zone in Section 3. Two graded beds, approximately 15- and 20-cm thick also in this section. The rock is lithified, uniformly hard, and drilling disturbance is slight.

SMEAR SLIDE SUMMARY

	1-44 (M)	1-67 (M)	2-140 (D)	3-87 (M)	3-128 (D)	3-140 (D)
TEXTURE:						
Sand	5	40	5	5	12	2
Silt	88	60	50	93	83	95
Clay	7	0	45	2	5	3
TOTAL DETRITAL	96	93	98	100	95	97
COMPOSITION:						
Feldspar	3	8	TR	3	25	1
Heavy minerals	2	3	2	2	3	1
Clay minerals	3	–	2	2	8	2
Volcanic glass	88	82	94	93	59	93
Zeolites	–	2	–	–	–	–
Amorph Fe agg.	–	3	–	–	5	–
Carbonate unspec.	3	–	2	TR	–	–
Nannofossils	1	1	TR	–	–	3

MAGNETIC SAMPLES: 1-102 2-60

PHYSICAL PROPERTIES:	Section 1 82-89 cm	Section 2 30-37 cm
$\overline{V}p$ (km/s)		
parallel to beds	2.24	
vertical to beds	2.17	
Wet bulk density	1.75	1.82
Porosity (%)	58.01	51.49
Grain density	2.78	2.69

SITE 448 HOLE CORE 28 CORED INTERVAL: 252.0-261.5 m

AGE | BIOSTR. ZONE: NANNOS, FORAMS, RADS | FOSSIL CHARACT.: FOSSIL, ABUNDANCE, PRESERV. | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | LITHOLOGIC SAMPLE | LITHOLOGIC DESCRIPTION

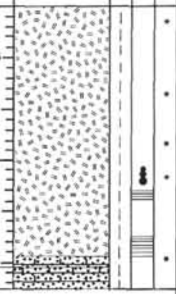
Middle Oligocene

NP 24

F R N — C — M

Sections: 1, 2, CC

Meters: 0.5, 1.0



5GY 7/1, 5Y 7/1 mottles
5BG 4/1 fine vitric tuff

5B 4/1

5GY 7/1

5G 4/1, 5Y 6/4
graded tuff

5Y 5/1, 8/6, 3/1

5Y 8/3 chalky tuff

5Y 8/3 chalky
vitric tuff

Clay-bearing **FINE VITRIC TUFF AND VITRIC TUFF,** dark gray, dark bluish gray and olive. A few black, dark greenish gray and pale green burrows scattered through Sections 1 and 2. A 12-cm thick zone in the upper part of Section 1 is heavily mottled with light gray chalk. Laminations are present in numerous zones of Section 2. Feldspar and heavy minerals each comprise ~1% of the total sediment. The rock is uniformly hard and moderately disturbed by drilling.

SMEAR SLIDE SUMMAY

	1-90 (D)	2-35 (M)	2-100 (D)
TEXTURE:			
Sand	5	5	0
Silt	83	85	90
Clay	12	10	10
TOTAL DETRITAL	92	95	50
COMPOSITION:			
Feldspar	1	TR	1
Heavy minerals	1	TR	1
Clay minerals	10	10	5
Volcanic glass	80	85	43
Amorph Fe agg.	3	5	–
Carbonate unspec.	2	–	–
Nannofossils	3	TR	50
Radiolaria	–	–	TR

Smear Slides (Minor): 1-20, 1-145

CARBON/CARBONATE:
1-100 (0.0, 1.9, 0.2)

MAGNETIC SAMPLE: 1-95

PHYSICAL PROPERTIES:	Section 1 100-103 cm
$\bar{V}p$ (km/s)	
parallel to beds	2.33
vertical to beds	2.25
Wet bulk density	1.78
Porosity (%)	53.88
Grain density	2.69

SITE 448 HOLE CORE 29 CORED INTERVAL: 261.5-271.0 m

AGE | BIOSTR. ZONE: NANNOS, FORAMS, RADS | FOSSIL CHARACT.: FOSSIL, ABUNDANCE, PRESERV. | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | LITHOLOGIC SAMPLE | LITHOLOGIC DESCRIPTION

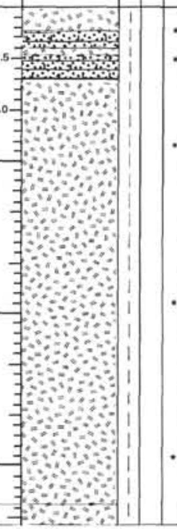
Middle Oligocene

NP 24

F R N — F — P

Sections: 1, 2, 3, 4, CC

Meters: 0.5, 1.0



5Y 6/4 with 1 cm 5Y 4/2 layers

5Y 8/3, 6/2 chalky tuff

5Y 8/3, 6/2 chalky tuff

5Y 5/1 nannofossil-
bearing fine
vitric tuff

.5 cm diameter
black glass fragments

.5 cm diameter
black glass fragments

.3 cm black
glass fragments
1-2 mm diameter
Mn nodules
5Y 5/1 nannofossil-
bearing fine vitric tuff

Clay and nannofossil bearing **FINE VITRIC TUFF,** gray, light olive gray, olive gray, pale olive and pale yellow, moderately mottled and burrowed olive gray and white in scattered 1- to 2-cm thick zones in the upper 22 cm of Section 1. One 18-cm thick and one 25-cm thick white and light gray **NANNOFOSSIL CHALK** layers occur in Section 1. 1 to 2 cm layers of 5 mm glass fragments occur in Sections 3 and 4. Section 4 also contains a 2-cm thick zone of 1 to 2 mm Mn micronodules. Heavy minerals and feldspar fragments each constitute ~1% of the total sediment. The rock is lithified, but has been transformed into alternations of drilling biscuits and drilling gouge by drilling.

SMEAR SLIDE SUMMARY

	1-56 (D)	1-140 (D)	2-140 (D)	3-140 (D)
TEXTURE:				
Sand	10	3	2	2
Silt	85	94	95	95
Clay	5	3	3	3
TOTAL DETRITAL	25	94	95	95
COMPOSITION:				
Heavy minerals	TR	2	1	1
Feldspar	–	1	1	1
Clay minerals	10	3	3	3
Volcanic glass	15	88	90	90
Carbonate unspec.	5	–	–	–
Nannofossils	70	6	5	5
Radiolaria	TR	–	–	–

Smear Slides (Dominant): 1-30

MAGNETIC SAMPLE: 1-60

PHYSICAL PROPERTIES:	Section 1 56-58 cm	Section 1 66-69 cm
$\bar{V}p$ (km/s)		
parallel to beds	2.12	
vertical to beds	2.04	
Wet bulk density	1.54	1.53
Porosity (%)	65.32	65.62
Grain density	2.54	2.54

SITE 448 HOLE CORE 30 CORED INTERVAL: 271.0-280.5 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle Oligocene	NP 24			R N	– C	– M	CC					

LITHOLOGIC DESCRIPTION

Core-Catcher sample only. **NANNOFOSSIL-BEARING VITRIC TUFF,** medium dark gray, and **NANNOFOSSIL-BEARING FINE VITRIC TUFF,** light olive gray. N4 medium sand-sized vitric tuff and 5Y 6/2 fine vitric tuff with 2 cm 10YR 4/2 layer.

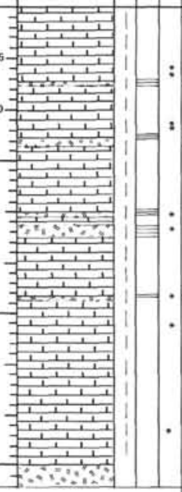
SMEAR SLIDE SUMMARY

	CC-8 (D)	CC-20 (M)
TEXTURE:		
Sand	1	1
Silt	91	93
Clay	8	6
TOTAL DETRITAL	92	90
COMPOSITION:		
Feldspar	TR	TR
Heavy minerals	1	1
Clay minerals	8	6
Volcanic glass	83	83
Zeolites	TR	TR
Foraminifers	–	TR
Nannofossils	8	10

SITE 448 HOLE CORE 31 CORED INTERVAL: 280.5-290.0 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS
Middle Oligocene	NP 24			N	A	M	1	0.5, 1.0
							2	
							3	
				F R N	F P A	PM P M	CC	

GRAPHIC LITHOLOGY



- 2.5Y 7/2 chalk
- 2.5Y 7.5/4 chalk mottled with 2.5Y 8/4 at top
- 5Y 6/2 fine vitric tuff
- 10YR 8/1, 5Y 8/3, 2.5Y 7/4 chalk, intensely mottled
- 5Y 6/2 fine vitric tuff
- 2.5Y 8/2, 7/4, 5Y 7/2 chalk, slightly mottled
- 5Y 4/2 fine vitric tuff, intensely mottled 10YR 8/2
- 5Y 4/2 fine vitric tuff
- 5Y 7/1 fine vitric tuff

LITHOLOGIC DESCRIPTION

ASHY NANNOFOSSIL CHALK, pale yellow and white, with 5 minor light gray interbedded **FINE VITRIC TUFF** layers ranging from 4 to 10 cm thick, the 20-cm Core-Catcher sample consists entirely of the same tuff. The **ASHY NANNOFOSSIL CHALK** is moderately to intensely mottled pale yellow and light gray. A 30-cm thick interval in Section 1 is intensely mottled and bioturbated, light yellow and light yellowish brown. The **TUFF** layers all have 1 mm brown laminations.

SMEAR SLIDE SUMMARY

	1-78 (M)	1-140 (D)	2-68 (M)	2-80 (M)	2-140 (D)	3-130 (D)
TEXTURE:						
Sand	4	2	2	1	5	3
Silt	89	93	93	94	90	92
Clay	7	5	5	5	5	5
TOTAL DETRITAL	93	10	80	2	3	3
COMPOSITION:						
Feldspar	2	1	TR	TR	–	–
Heavy minerals	2	1	2	–	–	–
Clay minerals	7	3	5	2	2	1
Volcanic glass	82	5	73	TR	1	2
Zeolites	TR	–	TR	–	–	–
Amorph. Fe agg.	–	–	–	–	1	TR
Carbonate unspec.	–	–	–	2	5	3
Foraminifers	–	1	–	1	2	2
Nannofossils	7	86	20	90	83	87
Radiolaria	–	3	–	5	5	5
Sponge spicules	–	–	–	–	1	–

Smear Slides (Minor): 1-65, 1-130
Smear Slides (Dominant): 3-20

GRAIN-SIZE:
1-47 (1.4, 59.9, 38.7)

CARBON/CARBONATE: 1-54 (0.0, 41.7, 5.0)

CARBONATE BOMB: 3, 42-45 (<1)

MAGNETIC SAMPLE: 1-16

PHYSICAL PROPERTIES:	Section 1 29-31 cm	Section 1 39-41 cm
$\bar{V}p$ (km/s)		
parallel to beds	1.96	
vertical to beds	1.84	
Wet bulk density	1.62	1.57
Porosity (%)	63.21	66.40
Grain density	2.68	2.70

SITE 448 HOLE CORE 32 CORED INTERVAL: 290.0-299.5 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle Oligocene	NP 24			F R N	RF R A	PM P M	CC					••

LITHOLOGIC DESCRIPTION

Core-Catcher only.

NANNOFOSSIL CHALK, white, with 3 mm olive gray laminae disturbed by bioturbation. 0.6x2 cm black patches of glass fragments present. 10YR 8/2 nannofossil chalk, with 5Y 4/2 disturbed 3 mm laminae and black glass-fragment patches.

SMEAR SLIDE SUMMARY

	CC-8 (M)	CC-14 (D)
TEXTURE:		
Sand	0	?
Silt	100	94
Clay	0	4
TOTAL DETRITAL	95	2
COMPOSITION:		
Heavy minerals	TR	–
Volcanic glass	95	2
Amorph. Fe agg.	–	TR
Carbonate unspec.	–	4
Foraminifers	–	2
Nannofossils	5	90
Radiolaria	–	2

SITE 448 HOLE CORE 33 CORED INTERVAL: 299.5-309.0 m (Hole deviation of 0.9° at 309.0 m)

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle Oligocene	NP 23			R N	– A	– M	CC					•••

LITHOLOGIC DESCRIPTION

Core-Catcher only. Glass-rich **ASHY NANNOFOSSIL CHALK,** white, heavily mottled in brown and white. Contains a 3-cm top interval of gray **NANNOFOSSIL-BEARING TUFF.**

SMEAR SLIDE SUMMARY

	CC-3 (M)	CC-8 (D)	CC-19 (D)
TEXTURE:			
Sand	0	1	2
Silt	100	97	96
Clay	0	2	2
TOTAL DETRITAL	90	41	10
COMPOSITION:			
Feldspar	–	–	TR
Heavy minerals	–	TR	TR
Clay minerals	–	1	–
Volcanic glass	90	40	10
Micronodules	–	–	TR
Amorph. Fe agg.	–	TR	–
Carbonate unspec.	–	1	2
Foraminifers	–	1	3
Nannofossils	10	52	80
Radiolaria	–	5	5

SITE 448 HOLE CORE 34 CORED INTERVAL: 309.0-318.5 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle Oligocene	NP 23	P.17-P.20		N F	A C	M M	1	0.5, 1.0				
							2					
				R N	– A	– M	CC					

vesicular basalt fragment
disturbed chalk
10YR 8/1, 5GY 7/1 tuff
2.5Y 7.5/2 tuff
2% Fe oxide flecks
10YR 8/2 chalk
2.5Y 4/2 tuffaceous volcaniclastic breccia
10YR 7/1 chalk
large chalk clasts in tuff
2.5Y 5/2 tuffaceous volcaniclastic breccia altered basalt and pumice
interbedded 5Y 6/2 tuff with 5Y 8/2 chalk
vitric tuff and fine vitric tuff

LITHOLOGIC DESCRIPTION

TUFFACEOUS VOLCANICLASTIC BRECCIA AND VITRIC TUFF, brown, light olive gray, with minor interbeds of pale yellow and white **NANNOFOSSIL CHALK.** The upper 70 cm of Section 1 consists of white, angular, sand-sized chalk fragments in a light greenish gray glass matrix with minor scattered black basalt and glass fragments. This is underlain by a 25-cm thick tuff with clasts predominantly around 2 mm in diameter made of black basalt and glass fragments, underlain by a 10-cm thick white chalk with 4 mm light greenish gray ash layers at its base, and a 25-cm thick tuffaceous volcaniclastic breccia with a dark gray glassy matrix. Clasts in the breccia are sand-sized vesicular and altered basalt and pumice. Base of Section 1 and upper portion of Section 2 are moderately burrowed white chalk. Chalk zones contain Mn dendrites and locally intense bioturbation. The chalks are not as hard as the tuffs. Drilling disturbance is uniformly moderate.

SMEAR SLIDE SUMMARY

	1-50 (D)	1-80 (D)	2-10 (D)	2-100 (D)
TEXTURE:				
Sand	2	2	3	2
Silt	96	96	95	93
Clay	2	2	2	5
TOTAL DETRITAL	90	95	4	95
COMPOSITION:				
Feldspar	1	1	TR	1
Heavy minerals	1	1	1	1
Clay minerals	2	2	5	3
Volcanic glass	86	91	4	88
Carbonate unspec.	10	5	89	5
Radiolaria	–	–	2	–

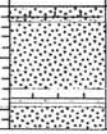
Smear Slides (Dominant): 1-135

GRAIN-SIZE:
1-31 (14.0, 61.1, 24.9)
2-66 (48.0, 41.9, 10.1)

CARBON/CARBONATE:
1-33 (0.0, 16.0, 2.0)
2-66 (0.0, 0.1, 0.1)

CARBONATE BOMB:
1, 33-34 (46)
2, 66-67 (21)

SITE 448 HOLE CORE 35 CORED INTERVAL: 318.5-328.0 m

AGE	BIOSTR. ZONE: NANNOS	BIOSTR. ZONE: FORAMS	BIOSTR. ZONE: RADS	FOSSIL CHARACT.: FOSSIL	FOSSIL CHARACT.: ABUNDANCE	FOSSIL CHARACT.: PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
Middle Oligocene	NP 23			N	C	M	1	0.5				*	10YR 5/3 and 5Y 6/4 tuff with 3 1-cm 10YR 8/1 chalk beds 5Y 5/4 tuff; increasing chalk content and bioturbation down-core; common Mn dendroids 10YR 8/1 chalk, moderately burrowed; Mn dendroids and flecks along fractures
				R N	– C	– P	CC	1.0					Lithic tuff; coarse sand-size with weathered pumice and basalt clasts

Interbedded **VITRIC TUFF, LITHIC VITRIC TUFF,** olive, and **NANNOFOSSIL CHALK,** pale yellow and white. Upper most 18 cm interbedded intensely bioturbated white chalk and 2-cm thick vitric tuff layers. Underlying 62 cm of olive vitric tuff grading downward into a moderately burrowed white chalk, the transition zone being pale yellow. Base of the core consists of 4 cm of lithic vitric tuff with sand-sized clasts of chalk, weathered pumice and basalt, with minor 1 mm black fragments of glass and pyroxenes. The glass matrix is olive colored. The chalk is firm, the tuff hard. Drilling disturbance is uniformly moderate.

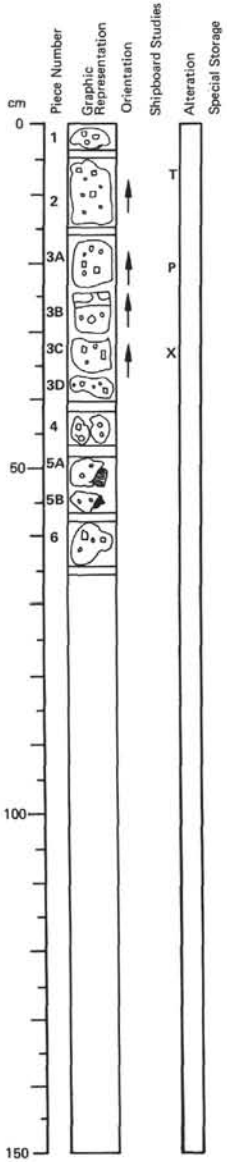
SMEAR SLIDE SUMMARY

	1-44 (D)
TEXTURE:	
Sand	3
Silt	94
Clay	3
TOTAL DETRITAL	80
COMPOSITION:	
Feldspar	2
Heavy minerals	1
Clay minerals	3
Volcanic glass	74
Nannofossils	20

CARBON/CARBONATE: 1-61 (0.0, 66.2, 8.0)

CARBONATE BOMB: 1, 60-61 (<1)

Site 448, Core 36: NO RECOVERY; Drilling record suggests that basalt was encountered – at 319.0 m.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		37	1

Depth: 337.5 to 338.1 m

Visual Description

Plagioclase-olivine-phyric basalt, pillowed massive flow, highly vesicular, 10-15%, 1-2 mm, empty or filled with zeolites. Groundmass of plagioclase laths, clinopyroxene and glass. Veins of quartz and ?zeolites. Glassy pillow rims altered to yellow-brown smectite, locally brecciated.

Thin Section Description

Location: 5-7 cm, pillow interior

Texture: intersertal to hyalopilitic

Phenocrysts: 2%; plagioclase 50%, 2 mm, euhedral; *olivine 50%, 0.5 mm euhedral pseudomorphs*

Groundmass: 85%; plagioclase 50%, 0.01 mm, laths; clinopyroxene 25%, <0.05 mm, anhedral; olivine 1%, 0.02 mm, anhedral pseudomorphs; magnetite and ilmenite 3%, *<0.005 mm anhedral; glass 20%, completely altered*

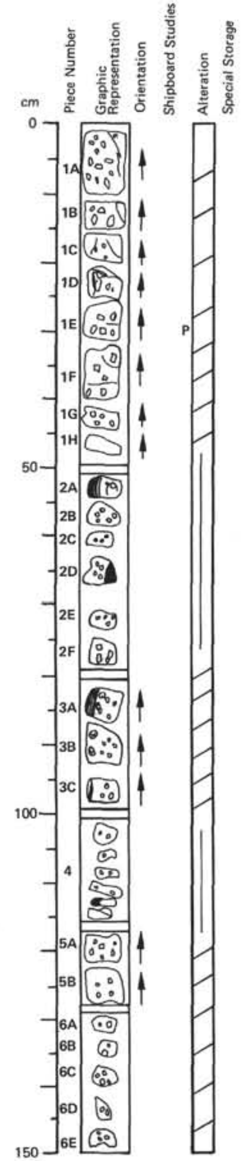
Vesicles: 10%, 0.2 mm, spheroidal to irregular, empty or with carbonate lining

Alteration: glass, olivine and plagioclase altered to zeolites and clays

Shipboard Data

Bulk Analysis:	**32 cm**
SiO_2	49.2
TiO_2	1.54
Al_2O_3	14.2
Fe_2O_3	1.77
FeO	11.66
MnO	0.22
MgO	4.67
CaO	10.27
Na_2O	2.93
K_2O	0.72
P_2O_5	0.24

Physical Properties:	**16-23 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.21



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		38	1

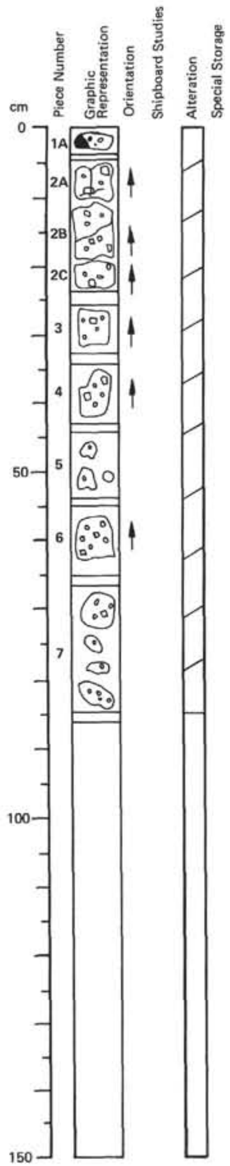
Depth: 347.0 to 348.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt as in Section 37-1; vesicles 10% of rock, 0.5-10 mm, spheroidal, empty or filled with zeolites and/or carbonate. Plagioclase phenocrysts 2% of rock, ~1 mm; olivine pseudomorphs.

Shipboard Data

Physical Properties:	**28-33 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.17



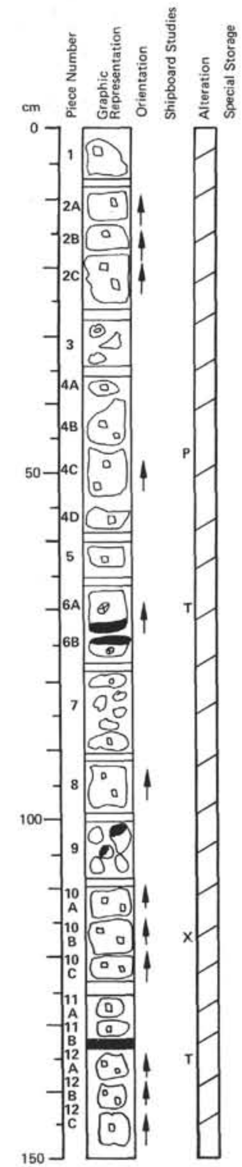
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		38	2

Depth: 348.5 to 349.4 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt as in Section 38-1. Plagioclase phenocrysts 5% of rock, 1-2 mm, glomerocrysts. Olivine euhedral, pseudomorphed by smectite. Groundmass texture aphanitic, variolitic near glassy margins. Vesicles 20% of rock, 0.5-5 mm.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		39	1

Depth: 352.0 to 353.5 m

Visual Description

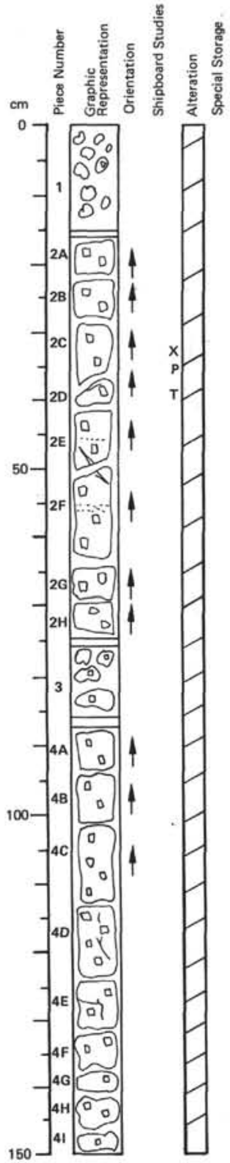
Plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt, highly vesicular, as in Section 38-2. Microvesicles ~0.1 mm make 20-30% porosity.

Thin Section Description

Location: 137-139 cm, flow interior
Texture: subophitic
Phenocrysts: 2%; mostly plagioclase, An_{64}, 3 mm; olivine, trace, 1 mm
Groundmass: 65%; plagioclase 50%, 0.5 mm; clinopyroxene 40%; magnetite/ilmenite 10%
Vesicles: 30%, 0.4-1.6 mm, irregular, filled with carbonate and green clays
Alteration: slight ?2%; plagioclase and clinopyroxene

Shipboard Data

Bulk Analysis:	116 cm	Physical Properties:	44-51 cm
SiO_2	49.4	$\bar{V}p$ (km/s)	
TiO_2	1.64	parallel to beds	4.34
Al_2O_3	13.8		
Fe_2O_3	1.81		
FeO	11.95		
MnO	0.22		
MgO	4.64		
CaO	9.96		
Na_2O	2.90		
K_2O	0.79		
P_2O_5	0.25		



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		39	2

Depth: 353.5 to 355.0 m

Visual Description

0-15 cm: plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt as in Section 39-1.
15-150 cm: basalt similar to above but with very rare olivine phenocrysts flow base to pillowed massive flow. Groundmass aphanitic to ?intersertal, very porous. Large vesicles (>1 mm) concentrated between 90-120 cm and 140-150 cm.

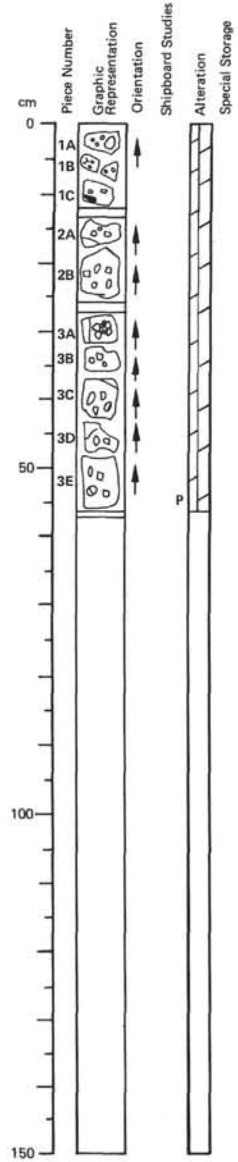
Thin Section Description

Location: 36-38 cm, pillow interior
Texture: hyalopilitic to subophitic
Phenocrysts: <2%; mostly plagioclase, $An_{64?}$, 1.2 mm, glomerocrysts, blocky
Groundmass: 75%; plagioclase 45%, An_{67}, 0.8 mm, needles, zoned; clinopyroxene 15%, 0.5 mm; olivine 5%, 0.2 mm; magnetite/ilmenite 5%, 0.02 mm; glass 30%
Vesicles: 20%, 0.4-0.8 mm, irregular, empty or rarely with carbonate
Alteration: groundmass slightly altered, 1% carbonate

Shipboard Data

Bulk Analysis:	32 cm
SiO_2	49.3
TiO_2	1.63
Al_2O_3	14.0
Fe_2O_3	1.83
FeO	12.09
MnO	0.22
MgO	4.14
CaO	9.60
Na_2O	3.17
K_2O	0.80
P_2O_5	0.23

Physical Properties:	32-42 cm
$\overline{V}p$ (km/s)	
parallel to beds	4.28



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		39	3

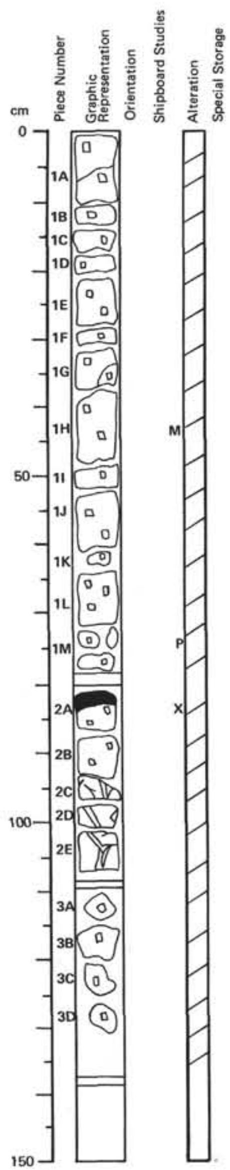
Depth: 355.0 to 355.6 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt as in Section 39-2.
Plagioclase phenocrysts ~2% of the rock, ~1 mm. Olivine phenocrysts <1% of the rock.
Groundmass with intersertal texture, highly vesicular.

Shipboard Data

Physical Properties:	52-60 cm
$\overline{V}p$ (km/s)	
parallel to beds	4.33



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		40	1

Depth: 356.5 to 357.8 m

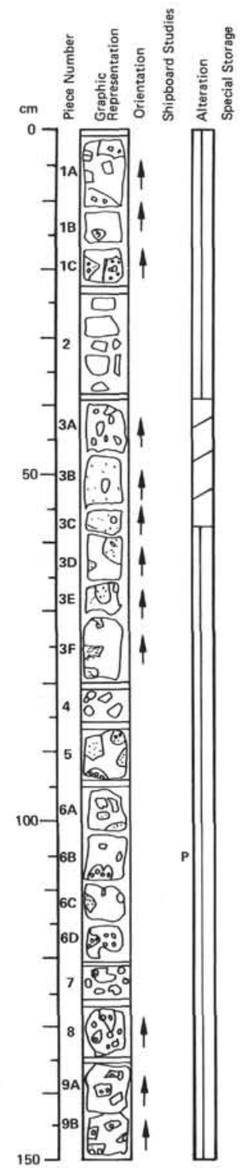
Visual Description

Plagioclase-clinopyroxene-orthopyroxene-olivine-phyric basalt as in Section 39-3; becoming brecciated towards base.

Shipboard Data

Bulk Analysis:	82 cm
SiO_2	49.8
TiO_2	1.52
Al_2O_3	12.7
Fe_2O_3	1.80
FeO	11.90
MnO	0.24
MgO	4.67
CaO	8.82
Na_2O	2.72
K_2O	1.61
P_2O_5	0.14

Physical Properties:	74-75 cm
$\overline{V}p$ (km/s)	
parallel to beds	3.36



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		40	2

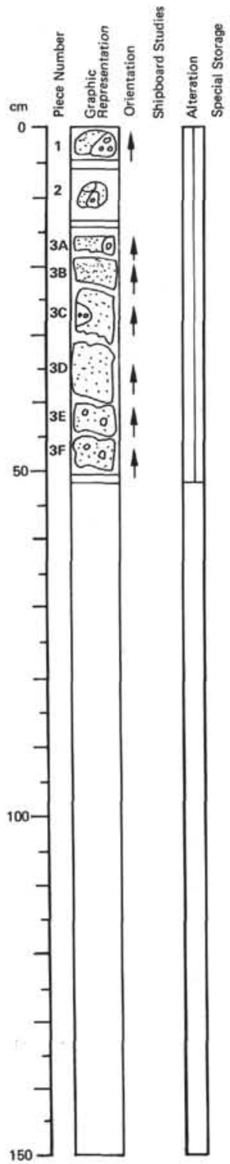
Depth: 357.8 to 359.3 m

Visual Description

Volcaniclastic breccia. Clasts of vesicular plagioclase (and rare olivine) basalt up to 25 cm, average 3 cm, angular, unsorted, unoriented in yellow to yellow green matrix of devitrified glass and ?siliceous cement. Clasts:matrix 4:1. Nannofossils of Zone NP 23 (middle Oligocene) are present in Core 40 volcaniclastic breccias.

Shipboard Data

Physical Properties:	102-110 cm
$\overline{V}p$ (km/s)	
parallel to beds	3.31



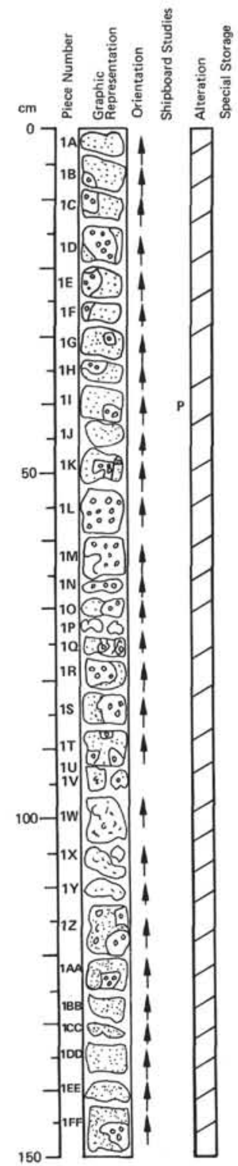
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		40	3

Depth: 359.3 to 359.8 m

Visual Description

Tuffaceous volcaniclastic breccias as in Section 40-2. Clasts:matrix 1:1. Maximum clast size 5 mm.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		41	1

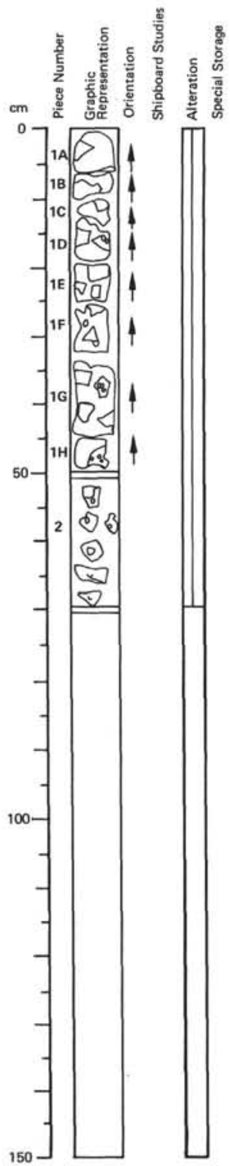
Depth: 366.0 to 367.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 40-3. Clasts:matrix 2:3. Maximum clast size 10 cm, average 2-3 cm.

Shipboard Data

Physical Properties: 37-43 cm
$\overline{V}p$ (km/s)
parallel to beds 3.17



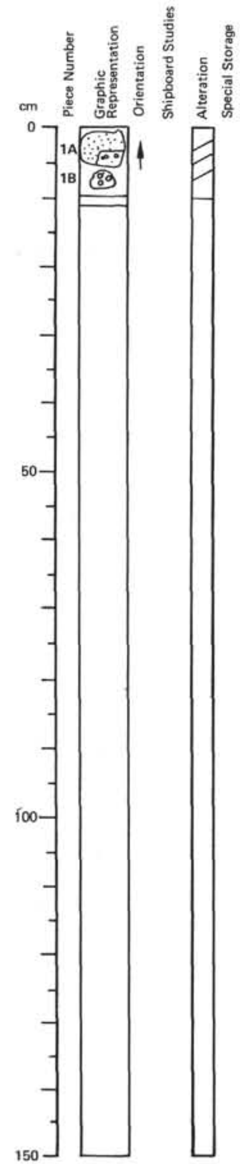
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		41	2

Depth: 369.5 to 368.2 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 41-1.



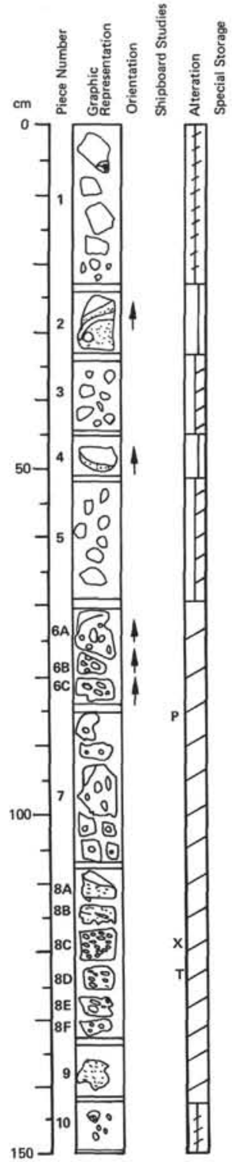
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		42	1

Depth: 371.5 to 371.6 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 41-2.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE		HOLE	CORE		SECT.
5	9	4	4	8		4	3	1

Depth: 375.5 to 377.0 m

Visual Description

0-70 cm: tuffaceous volcaniclastic breccia as in Section 42-1. Piece 2 with large (4x5 cm) clast containing elongate vesicles.

70-150 cm: plagioclase-olivine-clinopyroxene-phyric basalt flow; vesicles 20% of rock, 3-5 mm, mostly empty. Zeolite veins.

Thin Section Description

Location: 123-125 cm, flow interior

Texture: hyalopilitic with glass matrix; thin section aphyric

Groundmass: 95%; plagioclase 55%, 0.3 mm; clinopyroxene 10%, 0.1 mm; magnetite/ilmenite 5%; glass 30%, oxidized to opaque brown

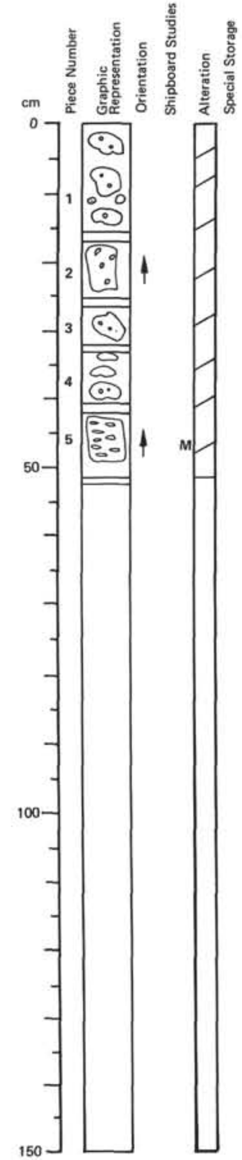
Vesicles: 5%, 0.2-0.6 mm, empty; 5%, 1-8 mm, irregular, rimmed with glass and zeolites.

Alteration: extensive

Shipboard Data

Bulk Analysis:	**119 cm**
SiO_2	48.5
TiO_2	1.60
Al_2O_3	13.4
Fe_2O_3	1.94
FeO	12.78
MnO	0.28
MgO	3.59
CaO	8.63
Na_2O	2.81
K_2O	1.31
P_2O_5	0.21

Physical Properties:	**87-89 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.38



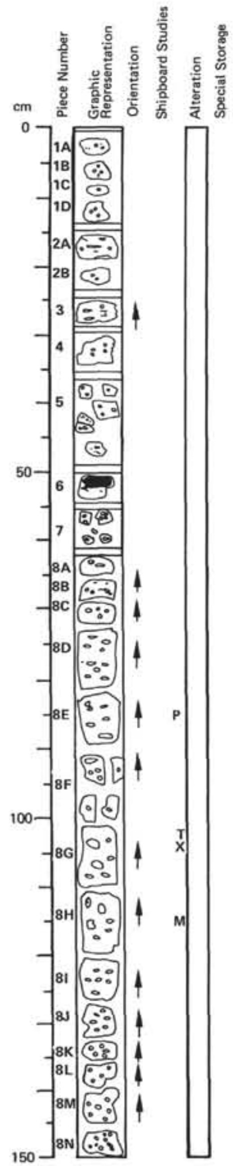
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE		HOLE	CORE		SECT.
5	9	4	4	8		4	3	2

Depth: 377.0 to 377.5 m

Visual Description

Plagioclase-olivine-clinopyroxene-phyric basalt as in Section 43-1. Plagioclase phenocrysts rare, 2% of rock, 1-2 mm. Groundmass vesicular, aphanitic. Vesicles 20% of rock, ~0.1 mm; scattered larger ones, 2-4 mm, spherical or flattened, ?parallel to flow top.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		44	1

Depth: 385.0 to 386.5 m

Visual Description

0-50 cm: plagioclase-olivine-clinopyroxene-phyric basalt as in Section 43-2.

50-150 cm: plagioclase-olivine-clinopyroxene-phyric basalt, pillow lava flow, vesicular, 20%, 2-5 mm. Sparse phenocrysts of plagioclase and very rare phenocrysts of olivine. Groundmass aphanitic; variolitic near glass margins.

Thin Section Description

Location: 100-103, flow interior

Texture: subophitic

Phenocrysts: 5%; plagioclase 40%, 1.5 mm, blocky; olivine 40%, 0.5 mm; clinopyroxene 20%, 0.4 mm

Groundmass: 80%; plagioclase 50%, 0.2-0.04 mm, thin blades; olivine 5%, 0.2 mm, equant; magnetite/ilmenite 15%; glass 25%

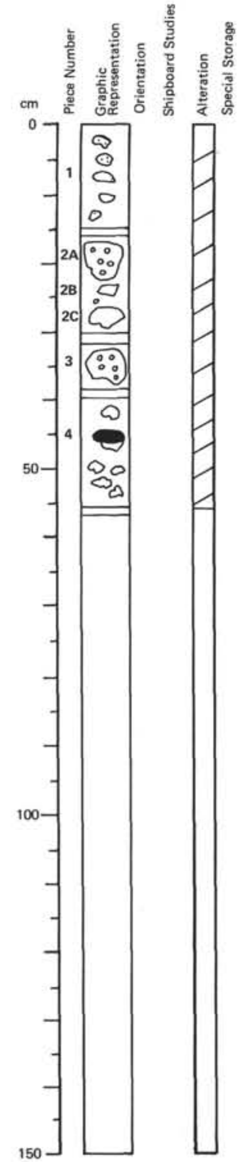
Vesicles: 15%, bimodal; 10%, 0.5-3.5 mm, spheres, empty or with zeolites; 90%, 0.2-0.6 mm, irregular, empty

Alteration: oxide discoloration; veins of zeolites and carbonate

Shipboard Data

Bulk Analysis:	**103 cm**
SiO_2	49.6
TiO_2	1.54
Al_2O_3	14.0
Fe_2O_3	1.87
FeO	12.32
MnO	0.23
MgO	4.63
CaO	9.54
Na_2O	2.95
K_2O	0.57
P_2O_5	0.19

Physical Properties:	**82-90 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.45



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

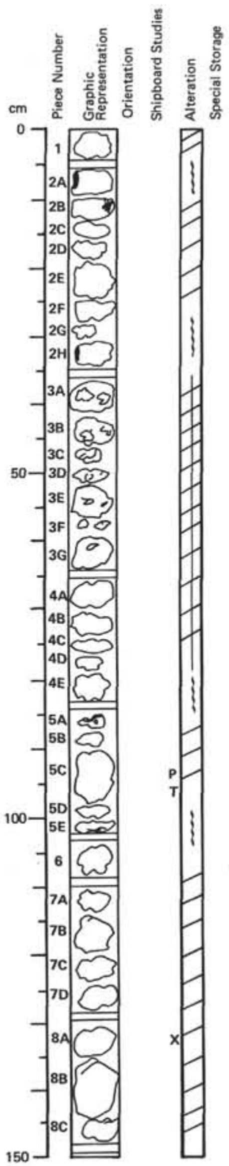
LEG	SITE	HOLE	CORE	SECT.
59	448		44	2

Depth: 386.5 to 387.0 m

Visual Description

Plagioclase-olivine-clinopyroxene-phyric, vesicular basalt as in Section 44-1.

NOTE: Site 448, Core 45: NO RECOVERY.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		46	1

Depth: 404.0 to 405.5 m

Visual Description

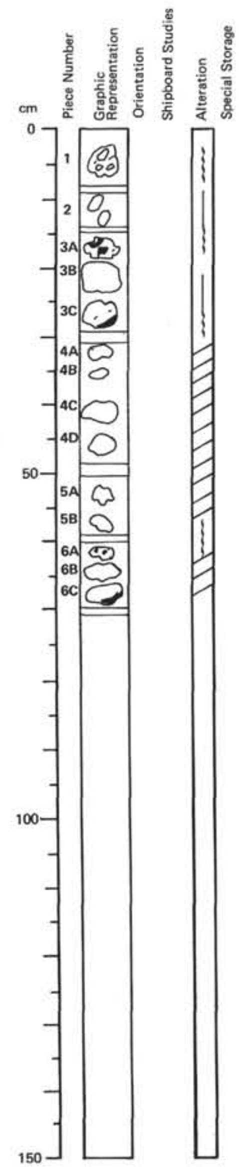
Nearly aphyric pillow basalt; highly vesicular, 15-20% of rock, 2-3 mm, spherical or elongate and parallel to yellow margins. Groundmass hyalopilitic to variolitic near glass margins. Vesicles empty to partially filled with zeolites. Glassy margins brecciated, replaced with smectite.

Thin Section Description

Location: 94-97 cm, 5 cm from pillow margin
Texture: hyalopilitic
Phenocrysts: 1%; plagioclase, 0.5 mm
Groundmass: >80%; plagioclase 60%, 0.2 mm; clinopyroxene 5%; magnetite/ilmenite 5%; glass 30%
Vesicles: 15%, bimodal; 70%, 0.5-2 mm, spheres, filled with zeolites, some analcite; 30%, 0.05-0.1 mm, irregular, filled with zeolites
Alteration: slight oxidation

Shipboard Data

Physical Properties:	90-97 cm
$\overline{V}p$ (km/s)	
parallel to beds	3.34



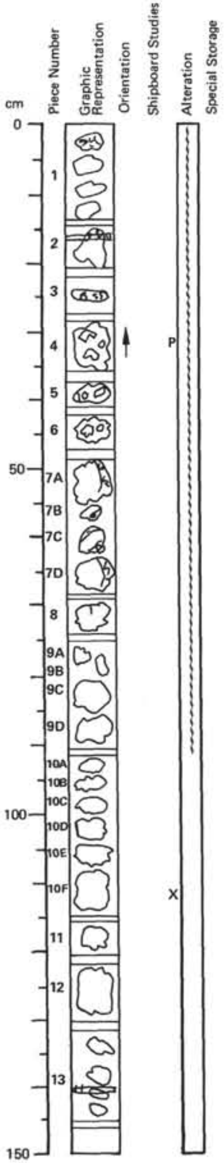
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		46	2

Depth: 405.5 to 405.7 m

Visual Description

Aphyric pillow basalt as in Section 46-1.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		47	1

Depth: 413.5 to 415.0 m

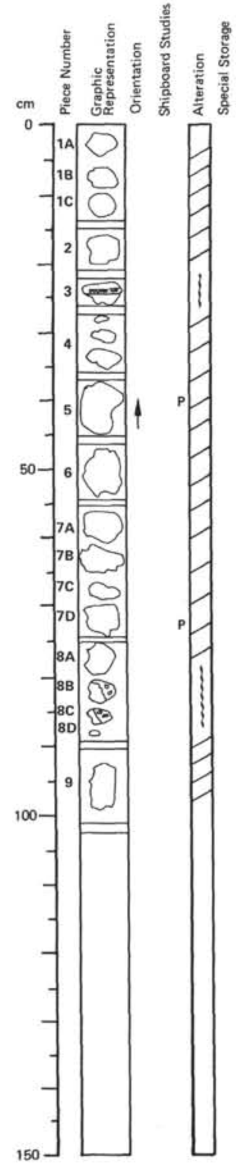
Visual Description

0-92 cm: aphyric pillow basalt as in Section 46-2.

92-145 cm: aphyric pillow basalt, very fine-grained, olive gray (5Y 4/2), moderately vesicular, 1-2% of rock, <1-2 mm.

Shipboard Data

Physical Properties:	**29-34 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.61



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		47	2

Depth: 415.0 to 416.0 m

Visual Description

Aphyric basalt as in Section 47-1. Groundmass with intersertal texture. Vesicles 10-15%, 3-4 mm, empty, slightly altered.

Thin Section Description

Location: 37-40 cm, flow interior

Texture: intersertal

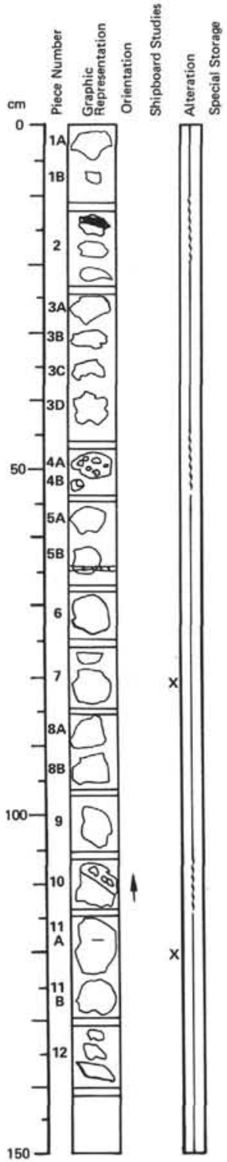
Groundmass: 70%; plagioclase 45%, An_{52}, euhedral to subhedral; clinopyroxene 30%, subhedral; magnetite/ilmenite 5%; glass 20%

Vesicles: 30%, 0.2-2 mm, irregular

Alteration: rare, clays in glass

Shipboard Data

Physical Properties:	**37-44 cm**	**72-75 cm**
$\bar{V}p$ (km/s)		
parallel to beds	3.66	4.31



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8		4	8	1

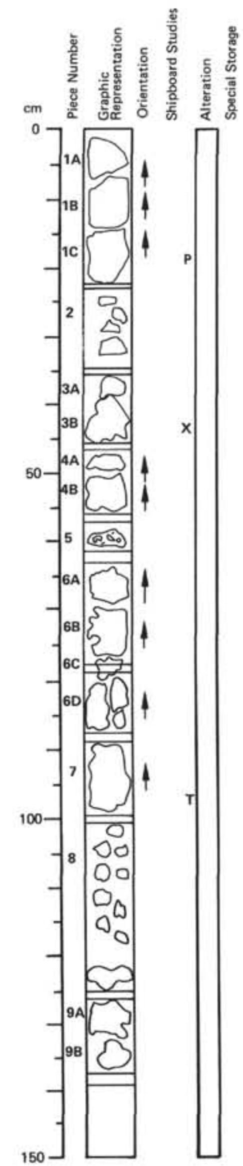
Depth: 423.0 to 424.5 m

Visual Description

Aphyric basalt as in Section 47-2 with layers of breccia from 45-55 cm and 105-110 cm. Clasts of aphyric vesicular basalt, 1.5 x 3 cm, variolitic basalt extensively altered; zeolite cement. Clasts:matrix 4:1.

Shipboard Data

Bulk Analysis:	77 cm
SiO_2	47.9
TiO_2	1.60
Al_2O_3	14.6
Fe_2O_3	1.95
FeO	12.85
MnO	0.23
MgO	3.24
CaO	9.45
Na_2O	3.11
K_2O	0.86
P_2O_5	0.26



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8		4	8	2

Depth: 424.5 to 426.0 m

Visual Description

Aphyric basalt as in Section 48-1, with breccia as before from 57-62 cm.

Thin Section Description

Location: 97-99 cm, flow interior

Texture: pilotaxitic to ophitic

Groundmass: 80%; plagioclase 50%, 0.2 mm; clinopyroxene 5%, 0.1 mm; magnetite/ilmenite 5%; glass 40%, oxidized

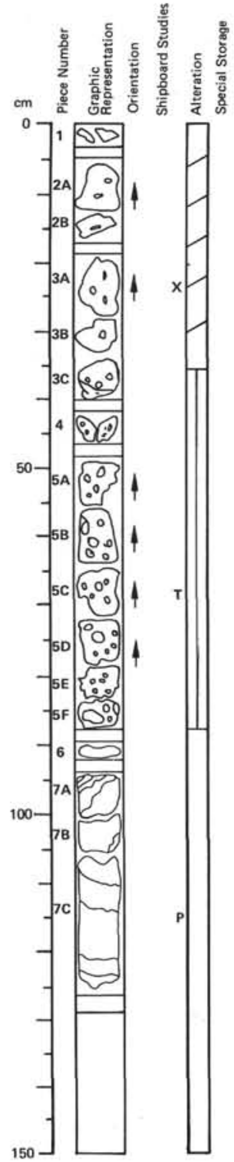
Vesicles: 20%, bimodal; 50%, 1-6 mm, irregular, empty, some clay linings; 50%, 0.1-0.4 mm, irregular, empty, some zeolite linings

Alteration: oxidized glass

Shipboard Data

Bulk Analysis:	93 cm
SiO_2	47.7
TiO_2	1.55
Al_2O_3	14.1
Fe_2O_3	1.90
FeO	12.55
MnO	0.25
MgO	3.37
CaO	10.29
Na_2O	3.00
K_2O	0.61
P_2O_5	0.76

Physical Properties:	15-21 cm
$\bar{V}p$ (km/s)	
parallel to beds	2.94



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		48	3

Depth: 426.0 to 427.5 m

Visual Description

0-87 cm: aphyric basalt as in Section 48-2 becoming plagioclase-olivine-clinopyroxene-phyric below 50 cm.

87-125 cm: volcaniclastic breccia 5Y 7/2.

Clasts: matrix 9:1. Clasts angular, 0.5 cm average, 1 cm maximum. Consist of 7% fresh glass, 40% altered glass, 10% aphanitic gray basalt with intersertal texture, 40% variolitic basalt with <0.01 mm microphenocrysts of plagioclase. Matrix zeolites and ? carbonate. Nannofossils of Zone NP 23 (middle Oligocene) are present in Core 48 volcaniclastic breccias.

Thin Section Description

Location: 68-72 cm, flow interior

Texture: pilotaxitic

Phenocrysts: plagioclase trace, 0.4 mm; clinopyroxene trace, 0.3 mm; olivine trace, 0.2 mm

Groundmass: 70%; plagioclase 55%; clinopyroxene 15%; magnetite and ilmenite 5%; glass 25%; flow banding crosses core at 45°

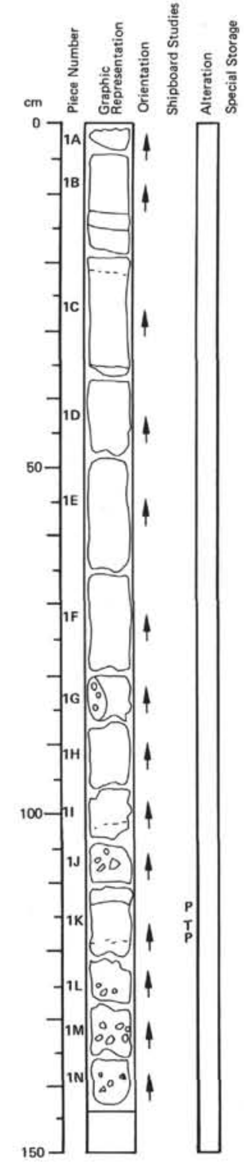
Vesicles: 30%, bimodal; 30%, 20-40 mm, spheres, empty; 70%, 0.2 mm, irregular, empty, aligned in chains parallel to flow banding

Alteration: some clays in groundmass

Shipboard Data

Bulk Analysis:	**22 cm**
SiO_2	49.8
TiO_2	1.52
Al_2O_3	14.3
Fe_2O_3	1.86
FeO	12.26
MnO	0.23
MgO	4.48
CaO	9.53
Na_2O	2.85
K_2O	0.68
P_2O_5	0.29

Physical Properties:	**108-125 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.05



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		48	4

Depth: 427.5 to 429.0 m

Visual Description

Volcaniclastic breccia, 10YR 5/4, clasts: matrix 9:1. Clasts angular, in alternate layers of 0.5-1 cm average size (maximum 2 cm) and 0.3-0.5 average size (maximum 0.8 cm). Clasts composed of moderately to strongly altered basalt and fresh to altered glass (white yellow to pale brown). Matrix, microcrystalline zeolite, altered glass and carbonate. One clast of subrounded sparsely olivine phyric basalt 6 cm in length.

Thin Section Description

Location: 110-113 cm

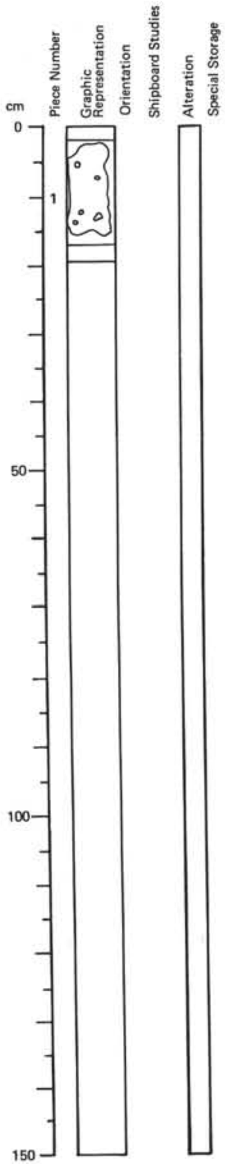
Texture: brecciated

Clasts: phyric basalts with phenocrysts of plagioclase, clinopyroxene, and olivine, and basaltic pumice

Cement: zeolites and carbonate

Shipboard Data

Physical Properties:	**112-122 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.08
vertical to beds	2.74



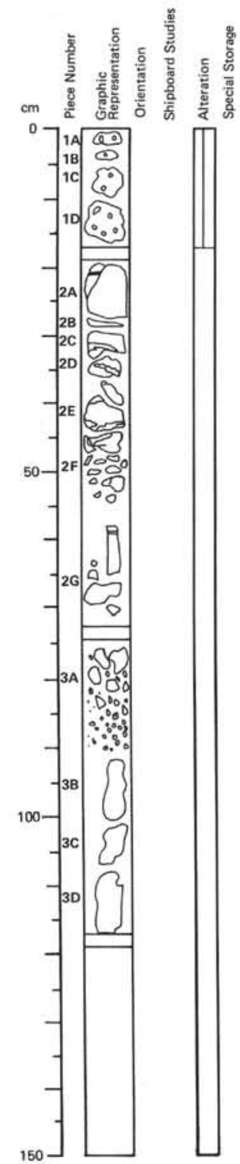
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		48	5

Depth: 429.0 to 429.2 m

Visual Description

Volcaniclastic breccias as in Section 48-4.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		49	1

Depth: 432.5 to 433.7 m

Visual Description

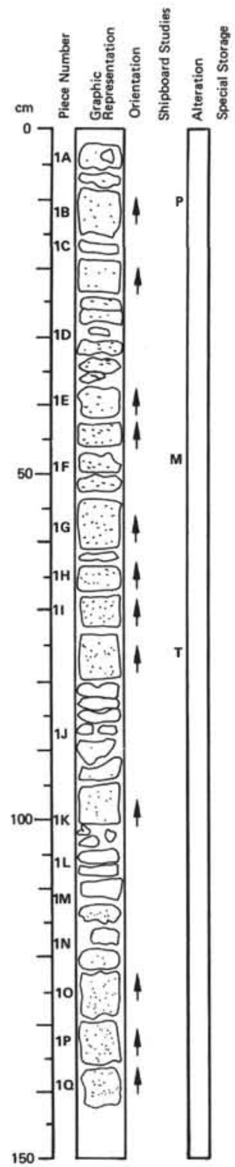
0-17 cm: volcaniclastic breccias as in Section 48-5.

17-30 cm: mudstone, pale olive (10Y 6/2) with clear vitric bands subparallel to stratification. Faulting present.

30-55 cm: tuff, 10Y 8/2, rather fresh, intermixed with irregular bands and layers of 10YR 6/2 weathered glass up to 3 cm thick.

55-75 cm: mudstone 10YR 8/2 with faint laminae in top cm overlying tuff or mudstone 5Y 7/2.

75-117 cm: volcaniclastic breccia. Clasts:matrix 5:1. Clasts angular, 0.5 cm average size, 1.5 cm maximum coarsening downward. Composed of various types of vesicular basalt and yellow weathered glass. Fresh basalt clasts 25%. Matrix grayish yellow to pale green-yellow, 5Y 8/4 to 10Y 8/2. Composed of zeolites. Nannofossils of Zone NP 23 (middle Oligocene) are present in Core 40 volcaniclastic breccias.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		50	1

Depth: 442.0 to 443.5 m

Visual Description

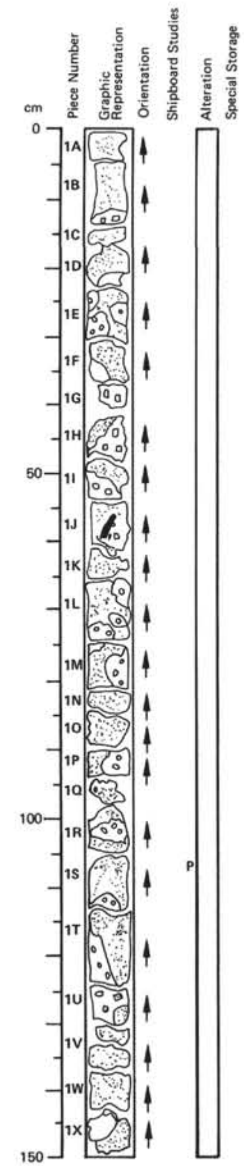
Volcaniclastic breccia as in bottom of Section 49-1. Mostly angular basalt and some weathered glass clasts; some subrounded; rare spheroids. Size at top 0.75 cm average, 1 cm maximum; at bottom 1.3 to 1.4 cm average, 3.5 cm maximum. Matrix dusky green to grayish green (5G 3/2 to 10G 4/2). Zeolite cement.

Thin Section Description

Location: 75-80 cm
Texture: brecciated
Clasts: phyric basalts and basaltic pumice
Matrix: zeolites, phillipsite

Shipboard Data

Physical Properties:	**6-12 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.46
vertical to beds	3.13



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		50	2

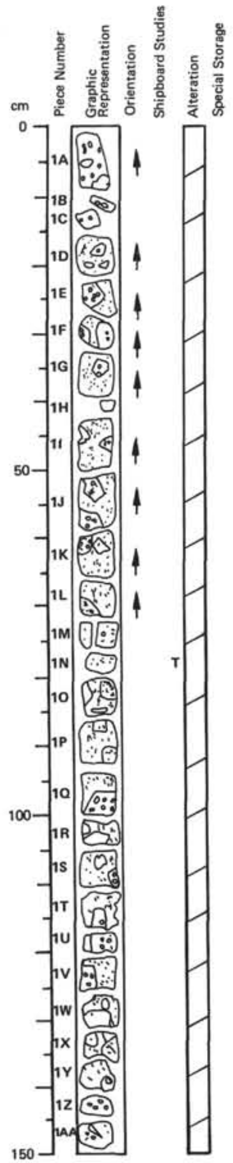
Depth: 443.5 to 445.0 m

Visual Description

Volcaniclastic breccia as in Section 50-1, coarsening downward to 3 to 4 cm average, 10 cm maximum at base. Mostly vesicular basalts both phyric and aphyric; some weathered glass.
Bottom segment contains 1 mm flake of native copper.

Shipboard Data

Physical Properties:	**104-110 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.34



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		50	3

Depth: 445.0 to 446.5 m

Visual Description

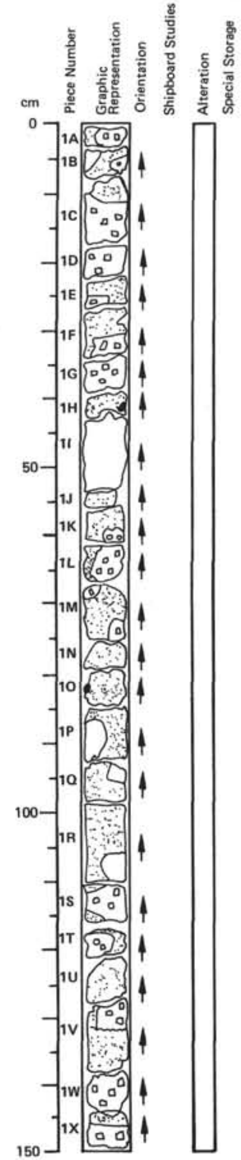
Volcaniclastic breccia as in Section 50-2 except clasts: matrix 45:1, with fewer glass clasts. Average size at top 2 cm, maximum 6 cm; at base 3 cm average, 15 cm maximum. Between 55-65 cm are two reddish-brown, olivine-bearing ?andesite clasts. At 80-82 cm, a medium-grained granodiorite (quartz diorite) clast (see Thin Section).

Thin Section Description

Location: 80-82 cm (single clast)

Texture: granitic and micrographic

Mineralogy: plagioclase (An_{49-45} at core, An_{38} central, An_{38-24} on rim) 55%, 1 mm; quartz 20%, 2 mm; hornblende 20%, 1 mm, plus a clear amphibole ?tremolite; magnetite/ilmenite 5%; clinopyroxene trace, in part altered to hornblende; orthopyroxene trace; rim altered to hornblende



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		50	4

Depth: 446.5 to 448.0 m

Visual Description

Volcaniclastic breccia as in Section 50-3, becoming less coarse downward to 4 cm average, 7 cm maximum size. Common interclast voids partly filled with carbonate. Two reddish brown, olivine-bearing ?andesite clasts at 38-40 cm and 80-82 cm (see Thin Section).

Thin Section Description

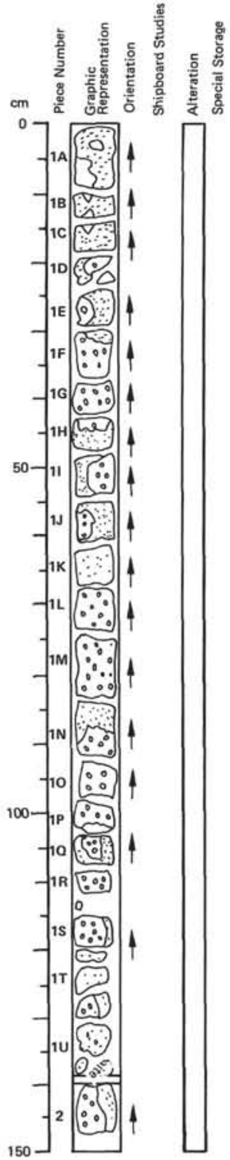
Location: 38-40 cm

Texture: trachytic

Phenocrysts: 5%; mostly plagioclase, 0.5 mm, some altered glomerocrysts; clinopyroxene trace, 1.5 mm

Groundmass: 35%; plagioclase 15%, An_{28-36}, 0.1 mm; glass 85%

Vesicles: 60%, 0.05-0.25 mm, spheres, filled with zeolites and carbonate



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		50	5

Depth: 448.0 to 449.5 m

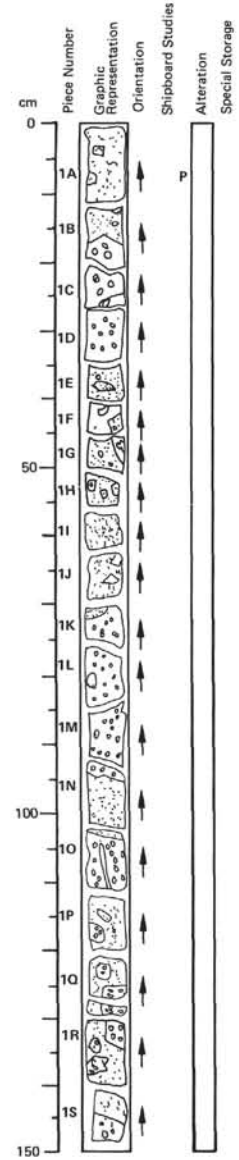
Visual Description

0-140 cm: volcaniclastic breccia as in Section 50-4. Clast: matrix 4:1. Maximum size top and bottom 15 cm; average size 3.5 cm at top, 5 cm at bottom. Fewer interclast voids.

140-150 cm: volcaniclastic breccia as above but matrix is yellow (2.5Y 7/6 to 7/8). Clast dimensions 0.2-10 cm. Abundant zeolites and silica cement along grain boundaries.

Shipboard Data

Physical Properties:	**0-10 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.51



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		51	1

Depth: 451.5 to 453.0 m

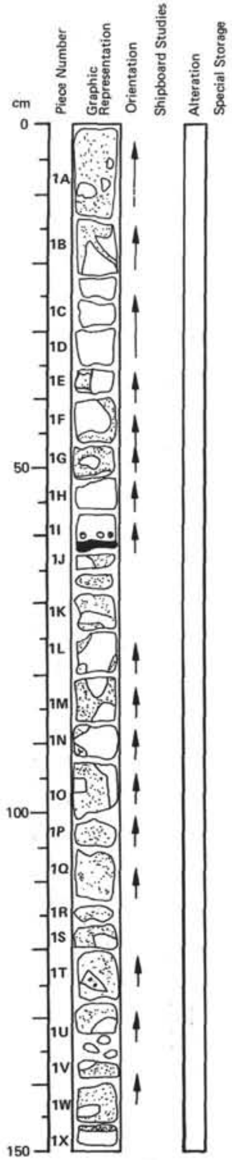
Visual Description

Volcaniclastic breccia with yellow matrix as in base of Section 59-5.

Clasts:matrix 4:1. No gradation in clast size. Layers are very well rounded; smaller are angular. Largest up to 25 cm, 80% vesicular (some tube vesicles) plagioclase-phyric basalts; 20% reddish plagioclase phyric ? andesite. Nannofossils of Zone NP 23 (middle Oligocene) are present in Core 51 volcaniclastic breccias.

Shipboard Data

Physical Properties:	**7-10 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.18
vertical to beds	3.23
Wet bulk density	2.03



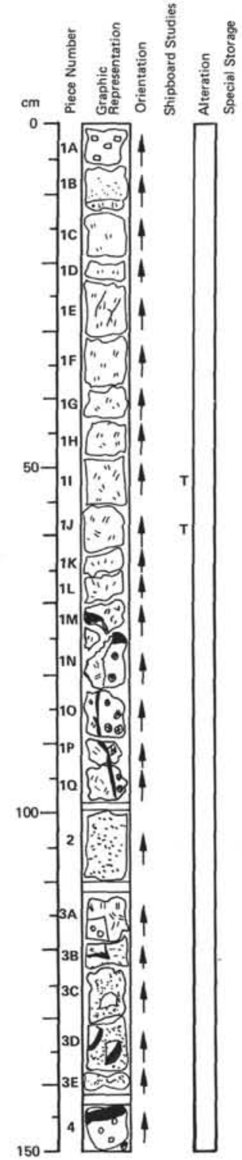
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		51	2

Depth: 453.0 to 454.5 m

Visual Description

Volcaniclastic breccia as in Section 51-1, 95% vesicular, sparsely olivine phyric basalt clasts, 5% ?andesite as before; rare ? sediment clasts.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		51	3

Depth: 454.5 to 456.0 m

Visual Description

0-10 cm: volcaniclastic breccia as in Section 51-2.

10-70 cm: *vitric tuff, yellow (2.5Y 7/6) (10-63 cm) to pale yellow (5Y 7/3) (63-70 cm).* Fracturing and faulting (<1 cm displacement) between 13-30 cm. Parallel laminae 1 cm *thick* at 53-63 cm. Fractures calcite-filled *from* 60-72 *cm.*

70-142 cm: polymictic breccia. Clasts:matrix 5:1, 4-25 cm size. 50% basalt, 50% recrystallized *white nannofossil* chalk 5Y 8/1. Grades down into volcaniclastic breccia. Cement is carbonate.

142-150 cm: glassy top of underlying flow (see Section 51-4).

Thin Section Description

Location: 50-51 cm

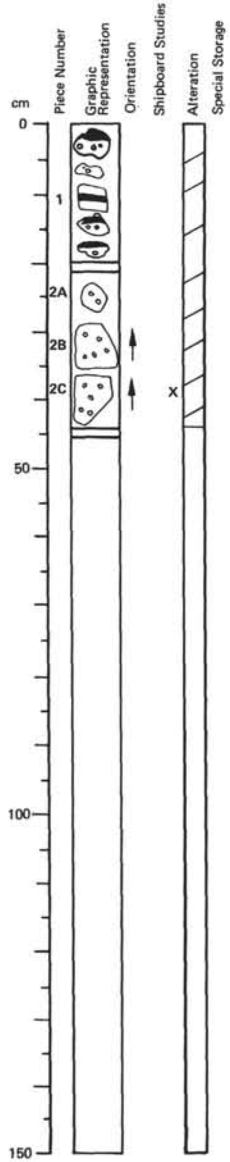
Description: altered vitric tuff with Mn dendrites

Thin Section Description

Location: 58-60 cm

Texture: vitric tuff

Composition: altered volcanic brown glass with plagioclase 3%, 0.1 mm; clinopyroxene <1%, 0.08 mm; orthopyroxene <1%, 0.4 mm, and ? other 3%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		51	4

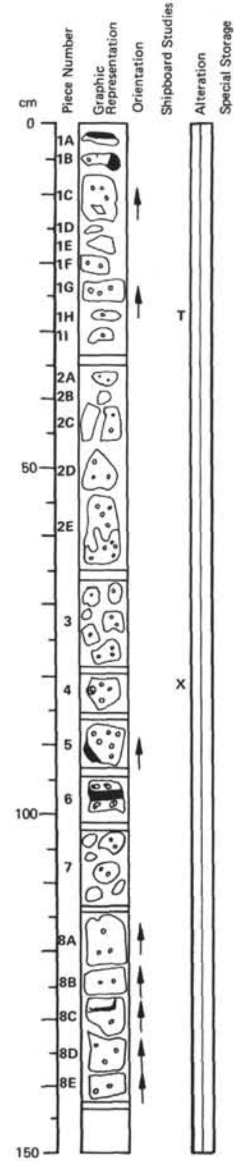
Depth: 456.0 to 456.4 m

Visual Description

Plagioclase-clinopyroxene-pigeonite-orthopyroxene-olivine-phyric basalt, flow; greenish gray, aphanitic, tube vesicles 1 cm diameter. Top 20 cm glassy flow top.

Shipboard Data

Bulk Analysis:	**38 cm**
SiO_2	49.4
TiO_2	1.28
Al_2O_3	13.4
Fe_2O_3	1.75
FeO	12.81
MnO	0.22
MgO	5.11
CaO	9.29
Na_2O	2.40
K_2O	1.10
P_2O_5	0.07



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		52	1

Depth: 461.0 to 462.5 m

Visual Description

Sparsley plagioclase- (and very rare olivine) phyric vesicular basalt, <2% phenocrysts. Rare phenocryst plagioclase, <0.5 mm, glomerocrysts. Trace olivine, pale orange, euhedral pseudomorphs. Groundmass 80% crystalline, variolitic near glass margins. 10-15% vesicles; tubes ~1 cm diameter.

Two flow units 0-90 cm, 90-150 cm and into Section 52-2.

Thin Section Description

Location: 29-32 cm, flow interior

Texture: hyalopilitic

Phenocrysts: trace only of plagioclase 1.2 mm, and olivine 0.6 mm

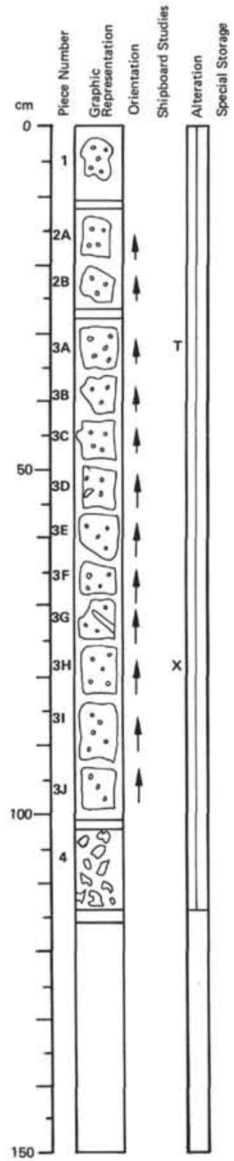
Groundmass: plagioclase 40%, 0.2 mm; clinopyroxene 10%, 0.1 mm; olivine 5%, 0.1 mm; magnetite/ilmenite 5%; glass 15%

Vesicles: 25%, bimodal; 60%, 0.1-0.4 mm, irregular, empty; 40%, 0.5-2 mm, spheres, empty

Alteration: fresh

Shipboard Data

Bulk Analysis:	**80 cm**
SiO_2	49.2
TiO_2	1.21
Al_2O_3	13.9
Fe_2O_3	1.69
FeO	11.14
MnO	0.24
MgO	4.56
CaO	9.69
Na_2O	2.80
K_2O	1.14
P_2O_5	0.14



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		52	2

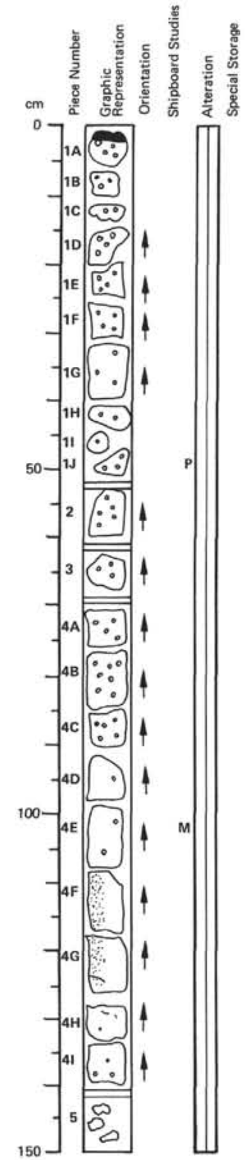
Depth: 462.5 to 463.7 m

Visual Description

Sparsely plagioclase-clinopyroxene-(+ olivine)-phyric basalt; continuation of Section 52-1.

Thin Section Description

Location: 64-66 cm, flow interior
Texture: hyalopilitic
Phenocrysts: 1%; plagioclase, 1 mm and glomerocrysts, 3 mm
Groundmass: 95%; plagioclase 40%, 0.2 mm; clinopyroxene 25%, 0.2 mm; olivine 5%, 0.1 mm; magnetite/ilmenite 5%; glass 25%
Vesicles: 2%, 1 mm, spheres with zeolite filling; 13%, 0.1-0.3 mm, irregular, empty



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		53	1

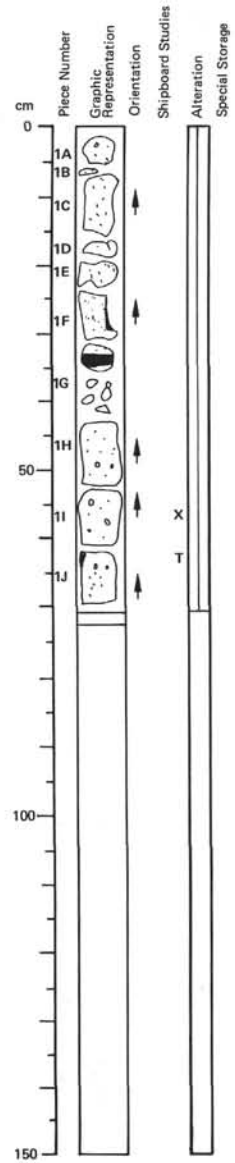
Depth: 470.5 to 472.0 m

Visual Description

Sparsely plagioclase-orthopyroxene-phyric basalt as in Section 52-2 except no apparent olivine. Vesicles 15%, partly lined with rosettes of colorless zeolites. Zeolite veins. Very altered.

Shipboard Data

Physical Properties:	48-51 cm
$\overline{V}p$ (km/s)	
parallel to beds	4.34
vertical to beds	5.57
Wet bulk density	2.52



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		53	2

Depth: 472.0 to 472.7 m

Visual Description

Sparsely plagioclase-clinopyroxene-phyric basalt as in Section 53-1. Two flow units 0-35 cm, 35-70 cm.

Thin Section Description

Location: 64-66 cm, flow interior

Texture: hyalopilitic

Phenocrysts: <2%; mostly plagioclase, An_{48}, 0.4-0.6 mm, euhedral; clinopyroxene, rare, 0.4 mm

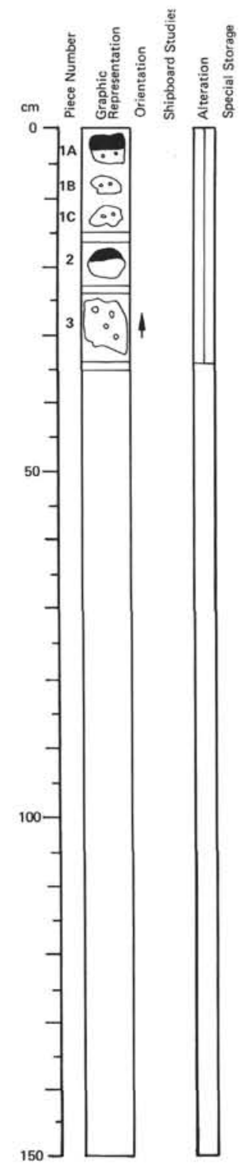
Groundmass: 65%; plagioclase 35%, An_{50}; clinopyroxene 40%; magnetite/ilmenite 10%; glass 15%

Vesicles: 30%, 0.1-0.4 mm, irregular; 0.5-1 mm, spheres

Alteration: 5% glass to clays

Shipboard Data

Bulk Analysis:	**59 cm**
SiO_2	49.2
TiO_2	1.15
Al_2O_3	14.7
Fe_2O_3	1.62
FeO	10.66
MnO	0.20
MgO	5.19
CaO	10.23
Na_2O	3.33
K_2O	0.47
P_2O_5	0.12



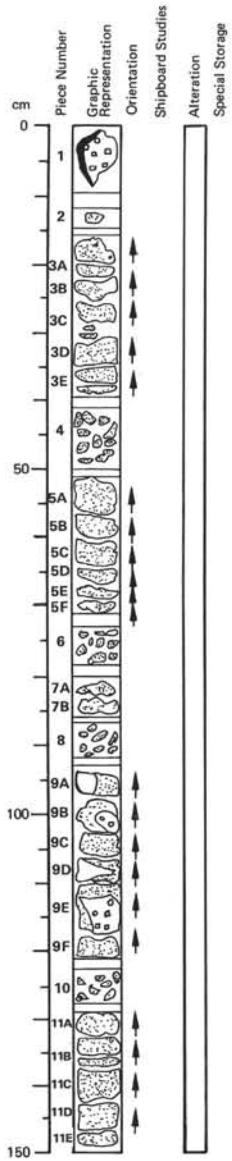
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		54	1

Depth: 480.0 to 480.3 m

Visual Description

Sparsely phyric vesicular basalt as in Section 53-2. Two flows.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		55	1

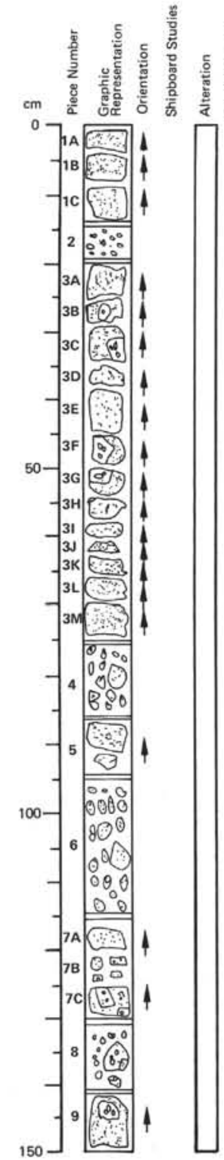
Depth: 489.5 to 491.0 m

Visual Description

1-10 cm: sparsely plagioclase-phyric basalt, vesicular, with glassy margin

10-65 cm: volcaniclastic breccia ("yellow matrix"). Clasts:matrix 5:1, subangular to subrounded, irregular to spheroidal. 0.5 cm average size, 1.5 cm maximum; unsorted; no gradation. Composed of ? andesite 5%, weathered basalt ~75%, weathered glass ~25%. Matrix light olive brown (2.5Y 5/4 to 2.5Y 5/5, zeolitic or siliceous; rare empty interclast voids.

65-150 cm: volcaniclastic breccia ("green matrix") similar to that above except for matrix color and large (1 cm average, 7 cm maximum) clasts of reddish (10R 3/2) ? basalt.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		55	2

Depth: 491.0 to 492.5 m

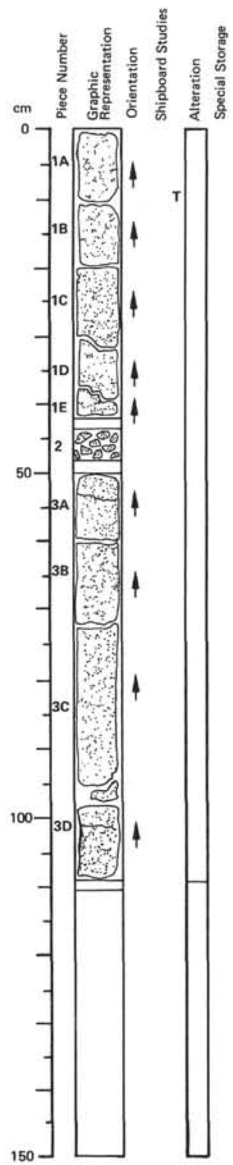
Visual Description

Volcaniclastic breccia ("green matrix") as in Section 55-1. Clasts 3-8 cm concentrated at 30-50 cm and 115-150 cm, composed of olivine-rich and aphyric basalt.

VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		55	3

Depth: 492.5 to 493.6 m



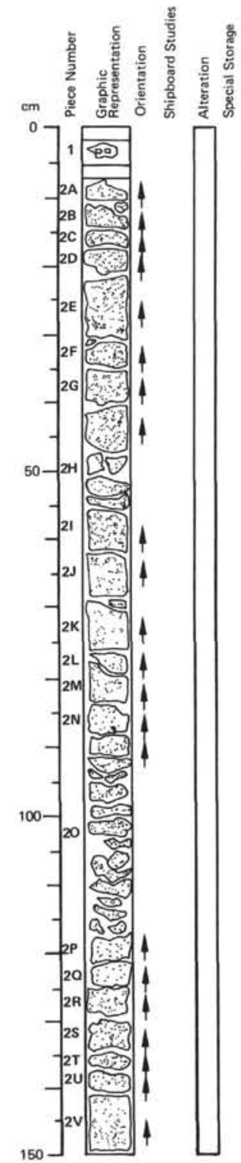
Visual Description

Volcaniclastic breccia ("green matrix") as in Section 55-2. Decrease in clast size down section to 1 cm average, 2 cm maximum at base of core.

VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		56	1

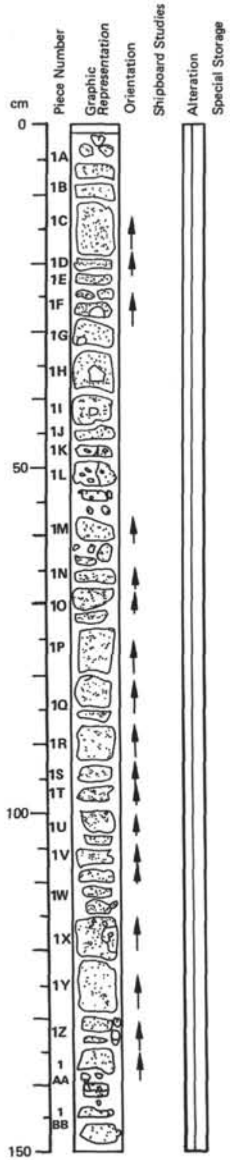
Depth: 499.0 to 500.5 m



Visual Description

Volcaniclastic breccia ("green matrix") as in Section 55-3. Uniform distribution of clasts, 1 cm average, 3 cm maximum.

Native copper occurs at 80 and 87 cm.



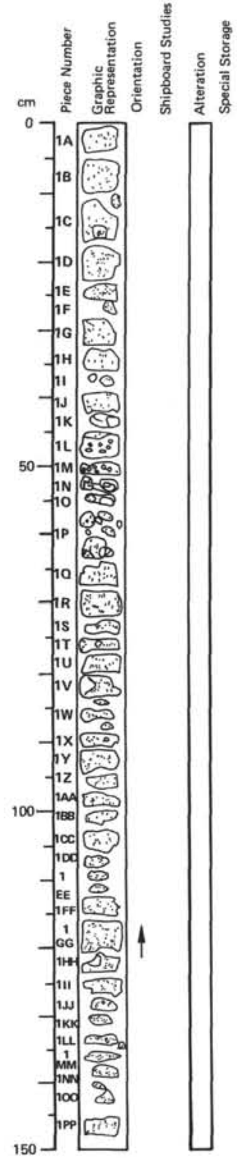
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		56	2

Depth: 500.5 to 502.0 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 56-1. Average size of clasts 0.5 cm. Composition highly altered basalt 80-85%, fresh aphyric and olivine phyric vesicular basalt 10-15%, altered glass 2-3%.



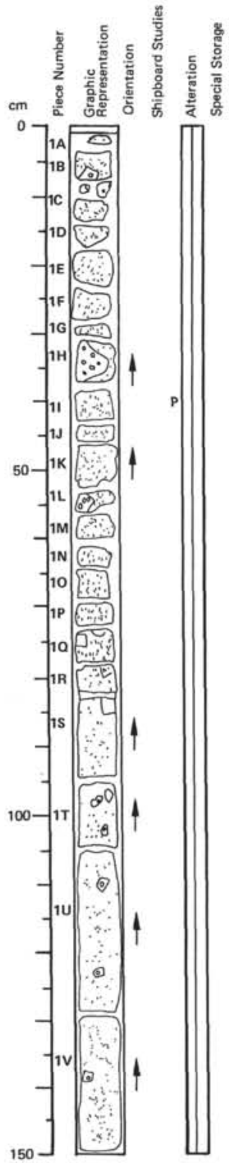
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		56	3

Depth: 502.0 to 503.5 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 56-2.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		56	4

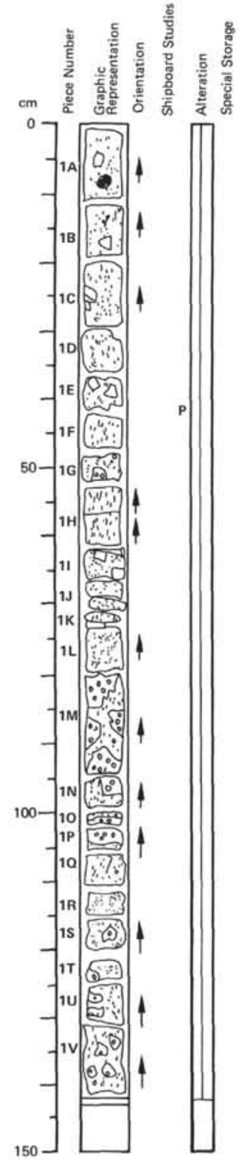
Depth: 503.5 to 505.0 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 56-3.

Shipboard Data

Physical Properties:	**41-42 cm**
$\bar{V}p$ (km/s)	
parallel to beds	–
vertical to beds	3.10



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		56	5

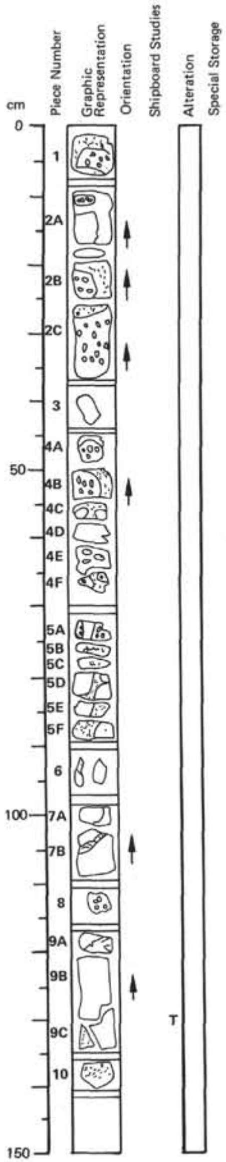
Depth: 505.0 to 506.5 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 56-4. From 80-110 cm, enriched in large, 5x6 cm, clasts of fresh vesicular basalt.

Shipboard Data

Physical Properties:	**40-44 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.27



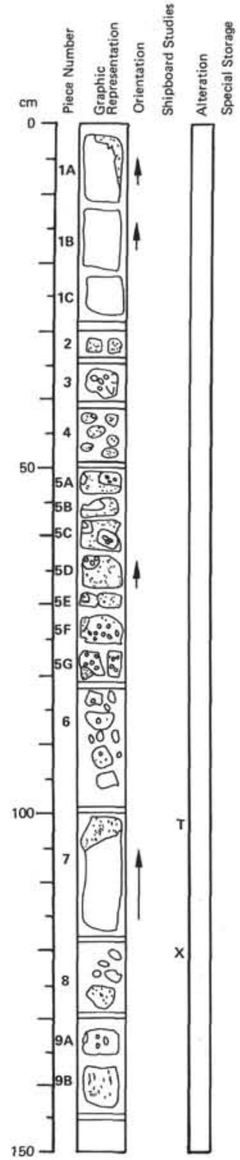
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		57	1

Depth: 508.5 to 510.0 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 56-5. Clast:matrix ratio 9.5:1. Clasts average 0.5 cm (maximum 6x10 cm), angular to subangular, unsorted, unoriented. They consist of aphyric to sparsely phyric vesicular basalts (some containing grains of native *Cu*), and highly altered vesicular basalts. Matrix (5%) zeolitic and with carbonates.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		57	2

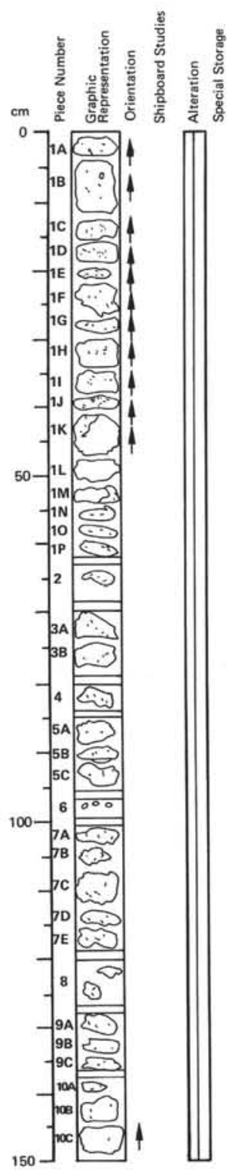
Depth: 510.0 to 511.5 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 57-1. Clast:matrix ratio is 4:1; average size 2x3 cm, maximum size 6x20 cm.

Shipboard Data

Bulk Analysis:	**120 cm**
SiO_2	48.9
TiO_2	0.81
Al_2O_3	17.1
Fe_2O_3	1.40
FeO	9.21
MnO	0.22
MgO	5.37
CaO	10.56
Na_2O	2.45
K_2O	0.56
P_2O_5	0.03



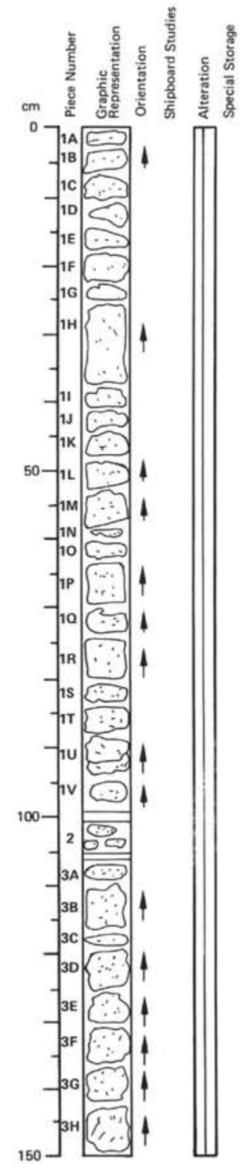
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		58	1

Depth: 518.0 to 519.5 m

Visual Description

Volcaniclastic breccia ("green matrix") as in Section 57-2. Fewer large clasts.



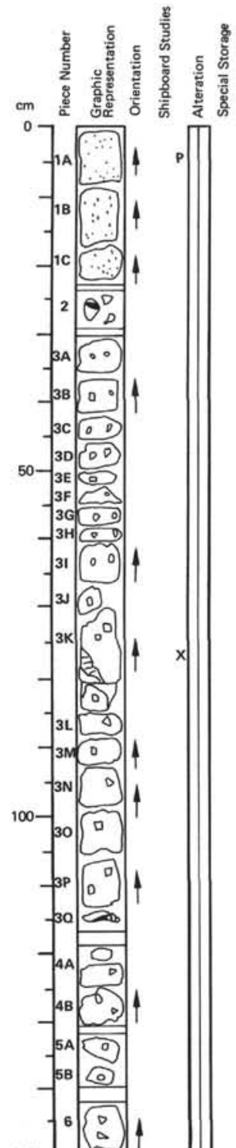
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		58	2

Depth: 519.5 to 521.0 m

Visual Description

Volcaniclastic breccia ("green matrix") 0-15 cm, as in Section 58-1. From 15-150 cm, "yellow matrix" (5Y 5/2); clast:matrix ratio 4:1. Average size 2x3 cm, maximum size 5x13 cm.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		58	3

Depth: 521.0 to 522.5 m

Visual Description

Volcaniclastic breccia "yellow matrix", 0-22 cm, as in Section 58-2.

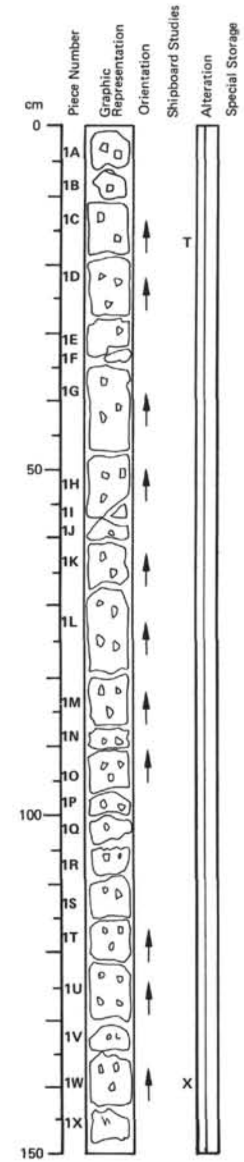
Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt flows, 22-150 cm.

Light olive gray (5Y 5/2), fine-grained with plagioclase phenocrysts, 2-3% of rock, 2-3 mm in size. Rare olivine phenocrysts, 1-2 mm from 120-150 cm. Groundmass hyalopilitic to intersertal. Vesicles spheroidal, filled with zeolites, 10-15% of rock.

Shipboard Data

Bulk Analysis:	**77 cm**
SiO_2	49.9
TiO_2	1.12
Al_2O_3	14.5
Fe_2O_3	1.50
FeO	9.92
MnO	0.19
MgO	4.52
CaO	9.24
Na_2O	3.39
K_2O	1.65
P_2O_5	0.08

Physical Properties:	**3-5 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.68
vertical to beds	3.89
Wet bulk density	2.52



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		58	4

Depth: 522.5 to 524.0 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt, as in Section 58-3.

Thin Section Description

Location: 18-21 cm, flow interior

Texture: hyalopilitic

Phenocrysts: <15%; plagioclase 70%, An_{64}, 0.4-3.0 mm; clinopyroxene 15%, 0.4-1 mm subhedral; orthopyroxene <5%, 0.4-0.7 mm, subhedral

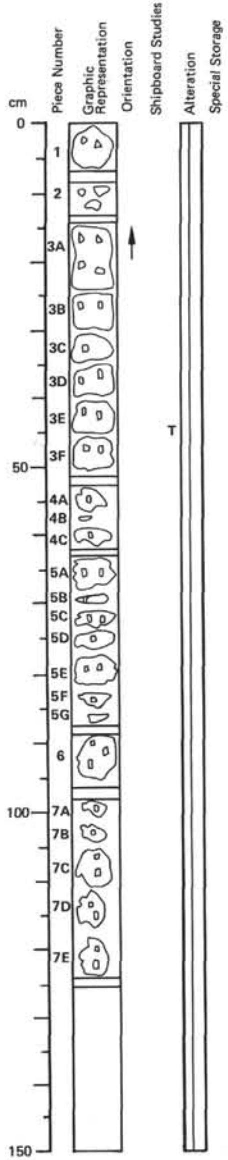
Groundmass: 50%; plagioclase 40%, An_{60}, 0.05-0.4 mm, euhedral laths; clinopyroxene 35%, 0.05-0.3 mm, subhedral; orthopyroxene 1%, 0.2-0.4 mm, subhedral; magnetite/ilmenite 10%, 0.01-0.05 mm; glass 15%

Vesicles: 35%, 0.4-5.0 mm

Alteration: rock essentially fresh

Shipboard Data

Bulk Analysis:	**138 cm**
SiO_2	48.0
TiO_2	1.02
Al_2O_3	14.2
Fe_2O_3	1.37
FeO	9.01
MnO	0.17
MgO	3.88
CaO	12.74
Na_2O	4.56
K_2O	1.20
P_2O_5	0.20



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8		5	8	5

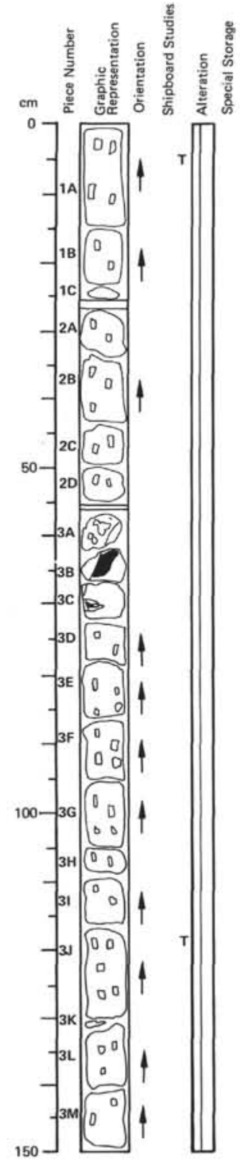
Depth: 524.0 to 525.2 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt, as in Section 58-4.

Thin Section Description

Location: 44-47 cm, flow interior
Texture: hyalopilitic
Phenocrysts: <18%; plagioclase 80%, An_{60}, 0.4-3.6 mm, euhedral-subhedral; clinopyroxene 15%, 0.4-7.0 mm, subhedral; orthopyroxene, rare, <0.5 mm
Groundmass: 50%; plagioclase 40%, An_{46}, subhedral laths; clinopyroxene 20%, subhedral; orthopyroxene, rare, ~0.3 mm, subhedral, pseudomorphs; magnetite/ilmenite 10%; glass 20%
Vesicles: 30%, 5.0 mm, empty or with carbonate or zeolite filling
Alteration: glass altered to clays, 6%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8		5	9	1

Depth: 527.5 to 529.0 m
(Hole deviation of 0.8° at 527.5 m)

Visual Description

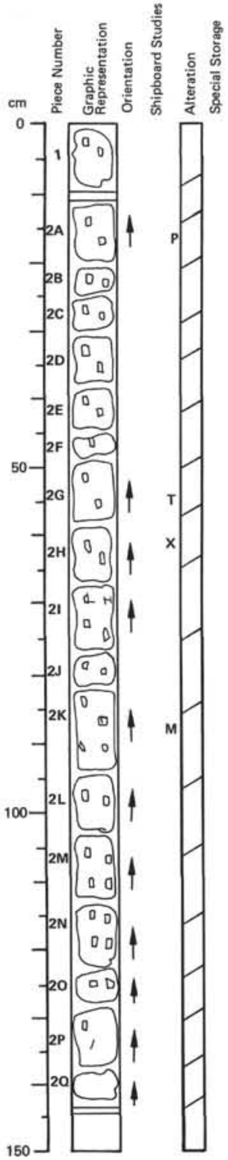
Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt flow as in Section 58-5. Groundmass 70-80% crystallized, hyalopilitic to intersertal; intergranular glassy matrix altered. Vesicles 20%, empty to filled with zeolites. From 55-70 cm, top of flow with top comprising phyric basalt, underlain by thin zone of variolitic basalt, underlain by fresh volcanic glass, underlain by replaced volcanic glass, in turn underlain by very fine-grained grayish yellow (5Y 8/4) volcanic tuff.

Thin Section Description

Location: 1-4 cm, flow interior
Texture: hyalopilitic
Phenocrysts: 18%; plagioclase 80%, An_{68}, 0.4-3.0 mm, euhedral; clinopyroxene 15%, 0.4-1.0 mm, subhedral, orthopyroxene, rare, 0.4 mm
Groundmass: 50%; plagioclase 40%, An_{50}, euhedral; clinopyroxene 30%; orthopyroxene, rare; magnetite/ilmenite 10%; glass 15%
Vesicles: 30%, 0.2-5.0 mm, empty or with zeolites
Alteration: clays replace glass

Thin Section Description

Location: 117-120 cm, flow interior
Texture: hyalopilitic
Phenocrysts: <15%; plagioclase 70%, An_{60}, 0.4-2.0 mm, euhedral to subhedral; clinopyroxene 15%, 0.4-1.5 mm, subhedral; orthopyroxene 10%, 0.5-2.5 cm pseudomorphs and fresh
Groundmass: 55%; plagioclase 40%, An_{50}, 0.05-0.1 mm, laths, subhedral; clinopyroxene 30%, 0.05-0.1 mm, subhedral; orthopyroxene 2%, 0.03-0.3 mm subhedral, fresh and pseudomorphs; magnetite/ilmenite 10%, 0.01-0.05 mm; glass 18%
Vesicles: 30%, 0.3-3 mm, irregular, empty to filled with zeolites
Alteration: glass altered to clays, 5%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		59	2

Depth: 529.0 to 530.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt as in Section 59-1.

Thin Section Description

Location: 52-55 cm, flow interior

Texture: hyalopilitic

Phenocrysts: 18%; plagioclase 80%, An_{56-57}, 2.0-2.5 mm; clinopyroxene 10%, 1.0 mm, euhedral to subhedral; orthopyroxene <10%, 0.6-0.7 mm, euhedral to subhedral

Groundmass: 65%; plagioclase 55%, An_{38}, 0.2-0.4 mm; clinopyroxene 5%, 0.1-0.2 mm; orthopyroxene 2%, 0.2 mm, euhedral to subhedral, rarely with clinopyroxene rim; magnetite/ilmenite 10%; glass 30%

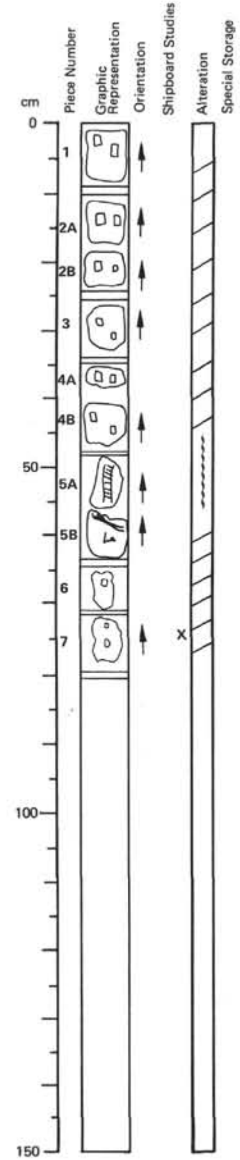
Vesicles: 15%, spheroidal

Alteration: brownish green clays in vesicles and veins

Shipboard Data

Bulk Analysis:	**61 cm**
SiO_2	50.7
TiO_2	1.09
Al_2O_3	16.8
Fe_2O_3	1.44
FeO	9.51
MnO	0.19
MgO	4.47
CaO	9.80
Na_2O	2.98
K_2O	0.83
P_2O_5	0.09

Physical Properties:	**16-18 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.19
vertical to beds	4.45
Wet bulk density	2.53



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		59	3

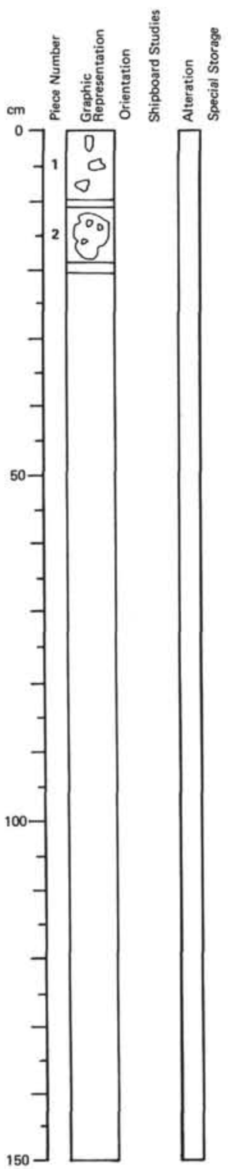
Depth: 530.5 to 531.3 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt flow as in Section 59-2. Groundmass 75-80% crystallized, intersertal. Vesicles ~15% of rock, 3-4 mm, spheroidal, mostly filled. Alteration moderate. Glassy flow top at 50-55 cm.

Shipboard Data

Bulk Analysis:	**74 cm**
SiO_2	50.0
TiO_2	1.10
Al_2O_3	16.4
Fe_2O_3	1.40
FeO	9.22
MnO	0.17
MgO	4.28
CaO	10.27
Na_2O	3.58
K_2O	1.19
P_2O_5	0.12



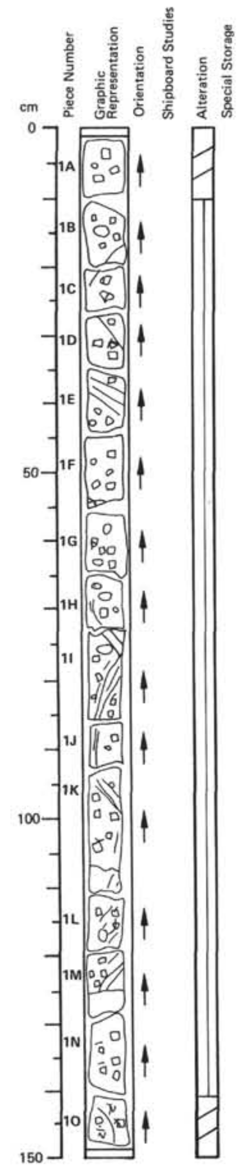
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		60	1

Depth: 537.5 to 537.7 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt as in Section 59-3.



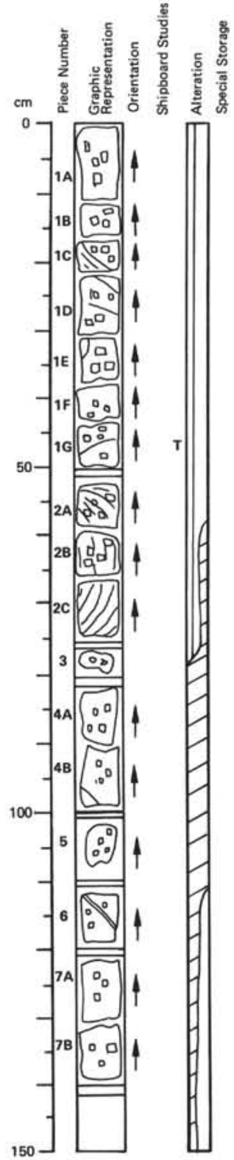
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		61	1

Depth: 546.5 to 548.0 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt flow as in Section 59-3.



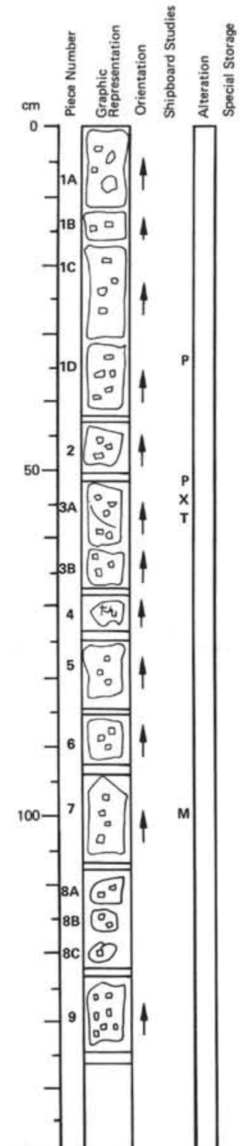
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		61	2

Depth: 548.0 to 549.4 m

Visual Description
Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt flow as in Section 61-1.

Thin Section Description
Location: 46-50 cm, flow interior
Texture: hyalopilitic
Phenocrysts: 20%; plagioclase 85%, An_{58}, 0.7-2.0 mm; clinopyroxene 10%, 0.3-1 mm, subhedral; orthopyroxene 5%, 0.5-0.7 mm, subhedral and pseudomorphs
Groundmass: 65%; plagioclase 50%, An_{36}, 0.1-0.3 mm; clinopyroxene 15%, 0.05-0.3 mm; orthopyroxene 1%, ~0.3 mm; magnetite/ilmenite 4%, 0.03-0.1 mm; glass 30%
Vesicles: 15%
Alteration: carbonate 3%, in vesicles; clays 1%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448		61	3

Depth: 549.4 to 556.0 m

Visual Description
Plagioclase-clinopyroxene-orthopyroxene-pigeonite-phyric basalt flow as in Section 61-2.

Thin Section Description
Location: 51-54 cm, flow interior
Texture: intersertal to subophitic
Phenocrysts: 15%; plagioclase 80%, An_{72-75}, 0.1-1.5 mm, tabular, prismatic, subhedral; clinopyroxene 15%, 0.5 mm; orthopyroxene 5%, 0.5 mm, elongate prisms
Groundmass: 70%; plagioclase 45%, An_{68}, 0.25 mm average, laths; clinopyroxene 20%, 0.2 mm average, anhedral; olivine 4%, 0.5 mm, elongate prisms, pseudomorphs; magnetite/ilmenite 5%, 0.05 mm; glass 25%
Vesicles: 15%
Alteration: celadonite and smectite replaces plagioclase, glass, orthopyroxene and olivine.

Shipboard Data

Bulk Analysis:	**55 cm**
SiO_2	50.2
TiO_2	1.12
Al_2O_3	15.0
Fe_2O_3	1.47
FeO	9.69
MnO	0.15
MgO	6.30
CaO	8.84
Na_2O	3.44
K_2O	1.41
P_2O_5	0.13

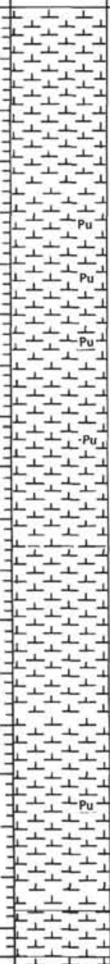
Physical Properties:	**34-36 cm**	**50-60 cm**
$\bar{V}p$ (km/s)		
parallel to beds	4.12	4.26
vertical to beds	4.23	— —
Wet bulk density	2.47	2.78

NOTE: Site 448, Core 62 (556.0 to 565.5 m), Core 63 (565.5 to 575.0 m), Core 64 (575.0 to 580.0 m), and Core 65 (580.0 to 584.5 m).

SITE 448 HOLE A CORE 1 CORED INTERVAL: 0.0-9.5 m (Hole deviation of 0.6° at 223.5 m)

AGE	BIOSTR. ZONE: NANNOS	BIOSTR. ZONE: FORAMS	BIOSTR. ZONE: RADS	FOSSIL CHARACT.: FOSSIL	FOSSIL CHARACT.: ABUNDANCE	FOSSIL CHARACT.: PRESERV.	SECTION	METERS
Middle Miocene	NN 6-NN 8	*Calocycletta costata*		N	A	G	1	0.5
				N	A	G		1.0
				N	A	G	2	
				N	A	G		
				N	A	M	3	
				N	A	M		
	NN 5						4	
							5	
							6	
							7	
				R F N	R C A	P PM M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 4/3
10YR 6/6
8/2 mottle
8/2 mottle
1 cm coarse layer
10YR 7/4
Section 3 moderately mottled
slight 10YR 8/1 mottling
10YR 8/4
slight 8/4, 3/4 mottling
intense 8/1 mottling
moderately to intensely mottled 8/1, 5/1
10YR 5/4 layer
10YR 7/4 slight mottling
moderate 8/1 mottling
10YR 6/4
10YR 7/4 2/1 ashy 1 cm layer intensely mottled
10YR 7/4

NANNOFOSSIL OOZE, very pale brown, brownish yellow and dark brown. Mottling with white, dark yellowish brown, gray and dark gray colors generally is slight to locally moderate with intense mottling limited to two 20-cm thick zones in Section 5 and a 5-cm thick *zone in Section 6. A few dark brown altered pumice* fragments are scattered and locally concentrated throughout the core. The sediment is uniformly soft; drilling disturbance ranges down-core from moderate to slight.

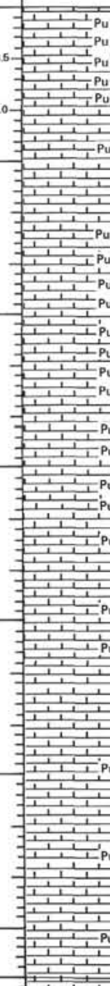
SMEAR SLIDE SUMMARY

	1-40 (D)	1-139 (M)	3-130 (D)	5-121 (M)	6-136 (D)
TEXTURE:					
Sand	0	3	0	2	10
Silt	95	87	90	90	85
Clay	5	10	10	8	5
TOTAL DETRITAL	5	4	2	2	1
COMPOSITION:					
Quartz	TR	–	–	1	–
Feldspar	2	–	TR	1	1
Clay minerals	1	1	2	TR	TR
Volcanic glass	2	3	TR	–	–
Glauconite	TR	–	–	–	–
Zeolites	TR	TR	–	–	–
Amorph. Fe agg.	3	2	–	TR	TR
Carbonate unspec.	2	15	10	22	5
Foraminifers	–	2	3	1	4
Nannofossils	90	76	85	74	79
Radiolaria	–	–	–	–	8
Sponge spicules	–	–	–	–	3

SITE 448 HOLE A CORE 2 CORED INTERVAL: 33.5–43.0 m

AGE	BIOSTR. ZONE: NANNOS	BIOSTR. ZONE: FORAMS	BIOSTR. ZONE: RADS	FOSSIL CHARACT.: FOSSIL	FOSSIL CHARACT.: ABUNDANCE	FOSSIL CHARACT.: PRESERV.	SECTION	METERS
Early Miocene	NN 2	P.22-N.4		N	A	M		0.5
	NN 1			N	A	M	1	1.0
				N	A	M	2	
				N	A	M	3	
				N	A	M	4	
							5	
				N	A	M	6	
							7	
				R F N	R C A	P PM M	CC	

GRAPHIC LITHOLOGY



DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE

LITHOLOGIC DESCRIPTION

10YR 6/3
moderate 10YR 8/1 mottling
slightly mottled 10YR 5/1
very slightly mottled 10YR 8/1
very slightly mottled 10YR 8/1
slightly mottled 10YR 8/1
moderate to intensely mottled 8/1, 3/3, 6/2
1% mottling
moderately mottled 8/1
moderately mottled 8/1, 5/1
slight 8/1, 5/4 mottling
slight 2/1 mottling
moderate 8/1, 5/1, 2/1 mottling
moderate 8/1, 8/4, 2/1 mottling
intense 2/1 mottling

NANNOFOSSIL OOZE, very pale brown and pale brown. Mottling varies from locally slight to moderate white, gray and black in the upper 3 sections. The lower 4 sections contain zones with locally moderate to intense white, dark brown, light brownish gray and gray mottling. A few black, brown and gray pumice fragments ranging in size from .2 to 4 cm are scattered and locally concentrated throughout the core. The sediment is uniformly soft. Drilling disturbance ranges from slight to moderate down-core.

SMEAR SLIDE SUMMARY

	1-5 (M)	1-140 (D)	4-81 (D)	6-130 (D)	7-42 (M)
TEXTURE:					
Sand	18	20	23	17	50
Silt	72	70	69	75	45
Clay	10	10	8	8	5
TOTAL DETRITAL	3	2	4	2	17
COMPOSITION:					
Feldspar	–	–	1	–	1
Heavy minerals	–	–	–	–	1
Clay minerals	2	2	3	2	–
Volcanic glass	1	–	–	–	15
Glauconite	–	1	–	–	–
Amorph. Fe agg.	4	2	8	5	8
Carbonate unspec.	5	2	3	1	5
Nannofossils	71	71	64	63	49
Diatoms	1	6	7	10	1
Radiolaria	2	2	1	2	TR
Sponge spicules	4	4	1	2	TR

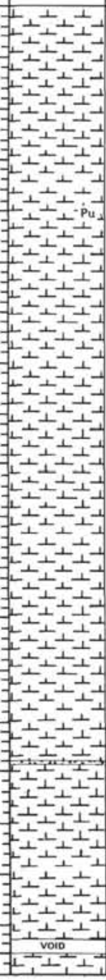
GRAIN-SIZE:
1-70 (1.5, 59.4, 39.1)

CARBON/CARBONATE:
1-69 (0.0, 77.1, 9.3)

SITE 448 HOLE A CORE 3 CORED INTERVAL: 62.0-71.5 m

AGE: Early Miocene
BIOSTR. ZONE: NANNOS NN 1; FORAMS P.22-N.4; RADS *Dorcadospyris papilio?*
FOSSIL CHARACT. (FOSSIL / ABUNDANCE / PRESERV.): N A M (Section 1); N A M (Section 3); N A M (Section 5); CC: R F N / C C A / M PM M
SECTION: 1, 2, 3, 4, 5, 6, 7, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE



LITHOLOGIC DESCRIPTION

10YR 6/4
10YR 8/3
very slightly mottled
10YR 2/1
moderately mottled 10YR 3/1
8/1 mottling
two 5/1 mottles
slightly mottled 10YR 5/1
moderately mottled 10YR 5/1
8/1 mottle
10YR 8/3
2/1 mottle
very slightly mottled 10YR 5/1
10YR 8/1 mottle
8/1 mottle
very slightly mottled 5/1
8/1 mottle
8/1 mottle
8/1 mottle
2/1 ash layer
slightly mottled 5/1
slightly mottled 5/1
very slightly mottled 8/1, 5/1
8/1 mottle
8/3, moderate 8/1, 2/1 mottle
10YR 8/3 nannofossil ooze

NANNOFOSSIL OOZE, very pale brown and light yellowish brown, amorphous iron-bearing and foraminifera- and radiolaria-bearing. Slightly to moderately mottled white, gray, very dark gray and black in localized areas. Pumice fragments are rare and scattered. A 3-cm thick nannofossil-rich ash layer occurs near the base of Section 5. Foraminifers and radiolaria each constitute approximately 6 to 8% of the total sediment. The sediment is uniformly soft, and drilling disturbance grades from moderate to slight down-core.

SMEAR SLIDE SUMMARY

	1-6 (M)	1-140 (D)	3-140 (D)	5-140 (M)	6-140 (D)
TEXTURE:					
Sand	10	20	13	10	14
Silt	85	72	82	70	76
Clay	5	8	5	20	10
TOTAL DETRITAL	4	2	1	46	–
COMPOSITION:					
Feldspar	–	–	–	5	–
Clay minerals	3	2	1	10	–
Volcanic glass	1	–	–	31	–
Glauconite	–	–	TR	–	–
Amorph. Fe agg.	3	3	2	5	1
Carbonate unspec.	–	1	5	15	5
Foraminifers	8	7	8	1	8
Nannofossils	70	72	73	30	76
Diatoms	12	3	4	2	3
Radiolaria	1	10	6	1	6
Sponge spicules	2	2	1	–	1

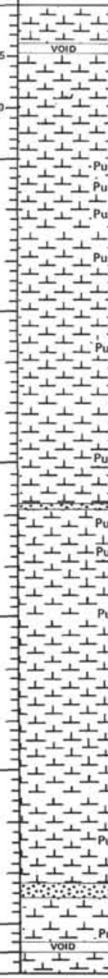
GRAIN-SIZE:
1-70 (0.9, 55.3, 43.8)

CARBON/CARBONATE:
1-69 (0.0, 79.0, 9.5)

SITE 448 HOLE A CORE 4 CORED INTERVAL: 71.5-81.0 m

AGE: Late Oligocene
BIOSTR. ZONE: NANNOS NP 25; FORAMS P.22-N.4; RADS *Dorcadospyris papilio?*
FOSSIL CHARACT. (FOSSIL / ABUNDANCE / PRESERV.): N A M (Section 1); N A M (Section 3); CC: R F N / R C A / P PM M
SECTION: 1, 2, 3, 4, 5, 6, 7, CC
METERS: 0.5, 1.0

GRAPHIC LITHOLOGY / DRILLING DISTURBANCE / SEDIMENTARY STRUCTURES / LITHOLOGIC SAMPLE



LITHOLOGIC DESCRIPTION

moderate to intense mottling 2/1, 8/1
8/1 mottling
moderate mottling 10YR 4/2
slight, very slight mottling 5/1
very slight mottling 5/1, 8/1
4/3 mottling
very slightly mottled 10YR 5/1
very slightly mottled 10YR 8/1
slightly mottled 8/1
pumice-rich interval
slight 2/1 mottle
moderate 5/1, 8/1 mottle
2/1 ash layer
moderately mottled with 2/1 ash, 8/1
slightly to very slightly mottled 10YR 5/1
moderate to intense mottling 2/1, 4/3
slightly mottled 10YR 8/1
slightly mottled 10YR 5/1
very slightly mottled 10YR 5/1
moderately mottled 8/1, 4/3, 5/1
pumice and ash layer
10YR 5/1
slightly mottled 5/1
10YR 8/3 moderately mottled 3/2

NANNOFOSSIL OOZE, very pale brown and light yellowish brown, foram and radiolarian-bearing. Mottles are localized and generally few in number; colored white, dark grayish brown, dark brown, and black. Two 30-cm zones of moderate to intense mottling in Section 1; single similar zones in Sections 4 and 6, which each also contain minor ash layers, 2- and 13-cm thick, respectively. A few pumice fragments are scattered throughout the core, with 2- and 7-cm thick zones enriched in pumice fragments in Sections 3 and 6. Amorphous iron oxides constitute from 1 to 5% of total sediment, generally decreasing down-core. The sediment is uniformly soft, and drilling disturbance varies from moderate to slight.

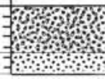
SMEAR SLIDE SUMMARY

	1-124 (M)	1-140 (D)	3-120 (D)	4-39 (M)	4-140 (D)	6-140 (D)
TEXTURE:						
Sand	19	8	10	5	14	15
Silt	73	77	85	80	76	75
Clay	8	15	5	15	10	10
TOTAL DETRITAL	9	–	–	50	–	–
COMPOSITION:						
Quartz	–	–	–	1	–	–
Feldspar	3	–	–	6	–	–
Heavy minerals	–	–	–	TR	–	–
Clay minerals	1	–	–	–	–	–
Volcanic glass	5	–	–	43	–	–
Celadonite	5	–	–	–	–	–
Glauconite	TR	–	–	TR	–	–
Zeolites	–	–	–	TR	–	–
Amorph. Fe agg.	3	4	5	3	1	1
Carbonate unspec.	3	2	2	1	1	2
Foraminifers	6	6	4	TR	5	7
Nannofossils	60	79	78	45	83	80
Diatoms	2	2	5	TR	1	TR
Radiolaria	10	7	5	1	8	8
Sponge spicules	2	TR	1	–	1	2

GRAIN-SIZE:
1-70 (1.8, 57.8, 40.5)

CARBON/CARBONATE:
1-69 (0.0, 78.2, 9.4)

SITE 448 HOLE A CORE 5 CORED INTERVAL: 223.5-233.0 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle to Late Oligocene	NP 24			R / N	– / F	M	1 / CC					

LITHOLOGIC DESCRIPTION

Hard 5Y 4/4 fine vitric tuff with deformed laminae at 9 to 11 cm, Mn dendroids on laminated planes

10Y 4/2 fine vitric tuff

5Y 3/2 vitric tuff, medium sand-size, with chips of 2.5Y 5/2 very fine vitric tuff

2.5Y 2/0 fine vitric tuff

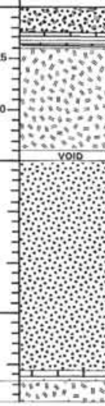
2.5Y 2/0 vitric tuff and fine vitric tuff

FINE VITRIC TUFF, VITRIC TUFF, AND TUFFACEOUS VOLCANICLASTIC BRECCIA, olive, dark olive gray, and dark grayish brown, micrite carbonate-bearing. The uppermost tuff layer contains a 2 cm laminated zone with Mn dendroids along the laminar bedding. A 10-cm sand-sized vitric tuff unit with fine grayish brown tuffaceous chips occurs lower in the section. The rock is uniformly lithified hard. Drilling disturbance is *moderate.*

SMEAR SLIDE SUMMARY

	1-10 (D)	1-33 (M)	1-35 (D)	CC-16 (D)
TEXTURE:				
Sand	0	10	50	0
Silt	50	50	50	70
Clay	50	40	0	30
TOTAL DETRITAL	82	89	90	93
COMPOSITION:				
Feldspar	3	2	15	20
Heavy minerals	–	–	2	3
Clay minerals	15	2	–	–
Lithic fragments	–	–	15	5
Volcanic glass	64	85	58	65
Celadonite	10	–	–	5
Glauconite	–	TR	2	–
Zeolites	–	2	TR	–
Amorph. Fe agg.	1	–	5	–
Carbonate unspec.	4	4	3	1
Nannofossils	2	5	–	1
Sponge spicules	–	TR	–	–

SITE 448 HOLE A CORE 6 CORED INTERVAL: 252.0-261.5 m

AGE	BIOSTR. ZONE: NANNOS	FORAMS	RADS	FOSSIL CHARACT.: FOSSIL	ABUNDANCE	PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE
Middle Oligocene	NP 24			N / R N	C / A	M / M	1 / 2 / 3 / CC	0.5 / 1.0	 VOID			

LITHOLOGIC DESCRIPTION

5Y 5/2 fine vitric tuff

5Y 4/2 fine vitric tuff, Mn dendroids

5Y 5/1.5 burrows

5Y 4/1

5Y 4.5/1 vertical mottling

burrow

burrow

5Y 4.5/1 lamination

1 cm vitric tuff layer

10YR 8/1, 6/1 chalk

5Y 5/1 fine vitric tuff

FINE VITRIC TUFF AND VITRIC TUFF, olive gray and dark gray, nannofossil-bearing. The upper 40 cm of Section 1 contains two white 8 and 5 cm layers of ash-bearing **NANNOFOSSIL CHALK**; the basal 12 cm of the core is the same chalk. Remainder of the core is fine-grained, faintly laminated tuff with Mn dendroids along lamination contacts. Two 15-cm vertical burrows occur in Section 2, along with a 25 cm zone of dark gray vertical mottles. Section 3 is moderately burrowed and mottled with a 2 cm coarser tuff layer in the upper portion. The rock is lithified, uniformly hard, and drilling disturbance is moderate to intense.

SMEAR SLIDE SUMMARY

	1-39 (D)	1-10 (D)	2-140 (D)	3-56 (M)
TEXTURE:				
Sand	5	0	0	2
Silt	80	95	95	90
Clay	15	5	5	8
TOTAL DETRITAL	21	89	89	2
COMPOSITION:				
Feldspar	3	TR	1	–
Volcanic glass	18	89	88	2
Celadonite	–	–	TR	–
Glauconite	2	–	–	–
Zeolites	TR	–	–	–
Amorph. Fe agg.	–	2	–	–
Carbonate unspec.	27	3	3	5
Foraminifers	–	–	–	TR
Nannofossils	50	5	8	89
Diatoms	TR	–	–	–
Radiolaria	–	–	–	3
Sponge spicules	–	–	TR	1
Fish remains	–	1	–	–

CARBON/CARBONATE:
1-91 (0.0, 10.6, 1.3)

PHYSICAL PROPERTIES:	Section 1 136-141 cm	Section 2 137-141 cm
$\bar{V}p$ (km/s)		
parallel to beds	2.33	1.98
vertical to beds	2.24	–
Wet bulk density	1.68	1.61

SITE 448 HOLE A CORE 7 CORED INTERVAL: 261.5-271.0 m

AGE: Middle Oligocene | BIOSTR. ZONE: NANNOS NP 23 | FORAMS | RADS | FOSSIL CHARACT.: FOSSIL, ABUNDANCE, PRESERV. | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | LITHOLOGIC SAMPLE | LITHOLOGIC DESCRIPTION

Section 5 fossil character: N A M
Core catcher (CC) fossil character: N A M

Sections: 1, 2, 3, 4, 5, 6, 7, CC. Meters: 0.5, 1.0

5Y 6/1, 7/1 moderately burrowed nannofossil chalk
5Y 6/4, 3.5/2
fine vitric tuff 5Y 8/1
chalk
5Y 3/2, 4/1
fine vitric tuff with 8/2, 7/2 burrows

5Y 3.5/1 fine tuff
5Y 7/2 chalk with 5Y 6/2 burrows
10YR 7/2, 6/2 chalk
chalk drilling gouge
2.5Y 7/2 chalk
chalk, moderately burrowed

NANNOFOSSIL CHALK, white, light gray, gray, and pale olive; ash-bearing, moderately mottled and burrowed light olive gray and light gray, with minor dark gray laminations. Mn dendrites appear along some laminations. Two olive gray and dark gray, normally graded **FINE VITRIC TUFF** layers occur in Section 1, each capped by moderately burrowed chalk. A 10-cm thick laminated fine vitric tuff appears in Section 5. The chalk is firm, the tuff hard. Drilling disturbance is intense.

SMEAR SLIDE SUMMARY

	1-108 (D)	1-120 (D)	5-43 (D)	6-125 (D)
TEXTURE:				
Sand	2	0	0	1
Silt	90	95	95	95
Clay	8	5	5	4
TOTAL DETRITAL	8	85	7	4
COMPOSITION:				
Feldspar	3	10	2	1
Heavy minerals	TR	–	–	–
Clay minerals	–	5	–	–
Volcanic glass	5	70	5	3
Celadonite	–	–	–	1
Glauconite	2	TR	–	–
Zeolites	–	–	TR	–
Amorph. Fe agg.	–	–	–	TR
Carbonate unspec.	2	–	2	3
Foraminifers	1	–	–	–
Nannofossils	86	15	88	91
Sponge spicules	1	–	3	1

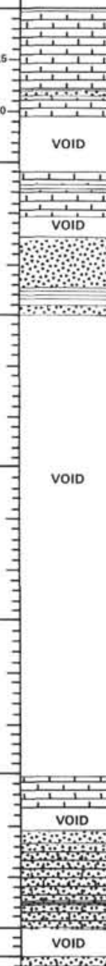
Smear Slides (Dominant): 5-140

SITE 448 HOLE A CORE 8 CORED INTERVAL: 271.0-280.5 m

AGE: Middle Oligocene | BIOSTR. ZONE: NANNOS NP 23 | FORAMS | RADS | FOSSIL CHARACT.: FOSSIL, ABUNDANCE, PRESERV. | SECTION | METERS | GRAPHIC LITHOLOGY | DRILLING DISTURBANCE | SEDIMENTARY STRUCTURES | LITHOLOGIC SAMPLE | LITHOLOGIC DESCRIPTION

Section 2 fossil character: N A M
Core catcher (CC) fossil character: N R P

Sections: 1, 2, 3, 4, 5, 6, 7, CC. Meters: 0.5, 1.0



2.5Y 7/2 chalk, moderately burrowed
5Y 7/2 chalk with small healed faults; Mn dendrites at basal contact
10YR 6.5/3 chalk, moderately mottled 6/2, with 10YR 7.5/3 burrows; Mn dendrites
Fe oxide-rich layer
dark gray tuff layer
10YR 7.5/3 chalk
10YR 6/2.5 chalk
10YR 6.5/1 chalk including ash content
10YR 5/1 tuff
10YR 6/1.5 tuff
10YR 7/2 chalk, 3/1 laminae, 8/1 burrows
5Y 6/1, 10YR 6/3 tuff

NANNOFOSSIL CHALK and minor interbedded **VITRIC TUFFS.** The chalk is white, very pale brown, pale brown, light brownish gray and light gray, moderately mottled and burrowed very pale brown and light brownish gray with minor laminations. The tuff layers are 3- to 50-cm thick with minor laminations and slight burrowing at chalk contacts. Both the chalk and tuff units contain minor Mn dendrites along laminations and in the burrows. The chalks are firm, the tuffs hard. Drilling deformation varies between moderate and intense.

SMEAR SLIDE SUMMARY

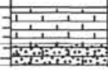
	1-83 (M)	6-115 (D)	6-128 (M)
TEXTURE:			
Sand	0	2	10
Silt	60	90	70
Clay	40	8	20
TOTAL DETRITAL	74	5	70
COMPOSITION:			
Feldspar	3	3	6
Heavy minerals	–	–	1
Volcanic glass	72	1	63
Celadonite	2	–	–
Glauconite	–	–	TR
Zeolites	TR	–	TR
Amorph. Fe agg.	1	–	–
Carbonate unspec.	3	3	10
Nannofossils	20	90	20
Radiolaria	–	1	–
Sponge spicules	–	1	–

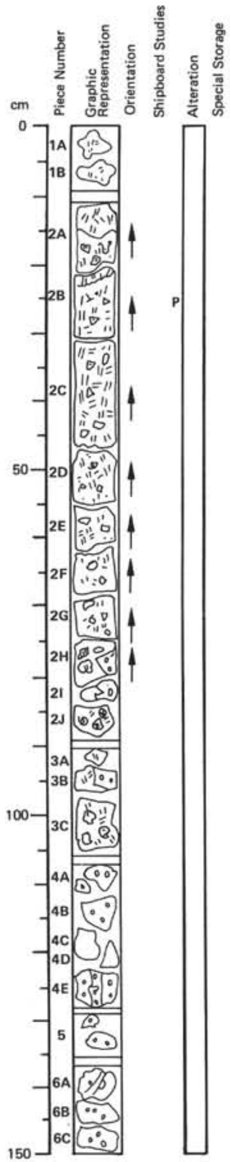
CARBON/CARBONATE:
2-75 (0.0, 7.7, 1.0)

PHYSICAL PROPERTIES:	Section 2 110-122 cm	Section 6 138-141 cm
$\overline{V}p$ (km/s)		
parallel to beds	1.92	1.99
vertical to beds	–	1.89
Wet bulk density	–	1.69

10YR 7.5/1, 7/2 chalk with few burrows, minor laminae, Mn dendrites along bedding planes and fractures
5Y 6.5/1 tuff with minor Mn dendrites
10YR 7.5/1, 6.5/2 chalk, moderate mottles, burrows
10YR 3/2 tuff
10YR 7/2, 6/2 chalk
chalk and tuff

SITE 448 HOLE A CORE 9 CORED INTERVAL: 280.5-290.0 m

AGE	BIOSTR. ZONE: NANNOS	BIOSTR. ZONE: FORAMS	BIOSTR. ZONE: RADS	FOSSIL CHARACT.: FOSSIL	FOSSIL CHARACT.: ABUNDANCE	FOSSIL CHARACT.: PRESERV.	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	LITHOLOGIC SAMPLE	LITHOLOGIC DESCRIPTION
Middle Oligocene	NP 23			N	A	M	1 CC	0.5					6/1 and 6/4 vitric tuff, 8/2 nannofossil chalk **NANNOFOSSIL CHALK,** white and light gray (10YR 8/1, 7/1), moderately burrowed and laminated. The rock is firm, drilling deformation is intense.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	1	0	1

Depth: 290.0 to 291.5 m

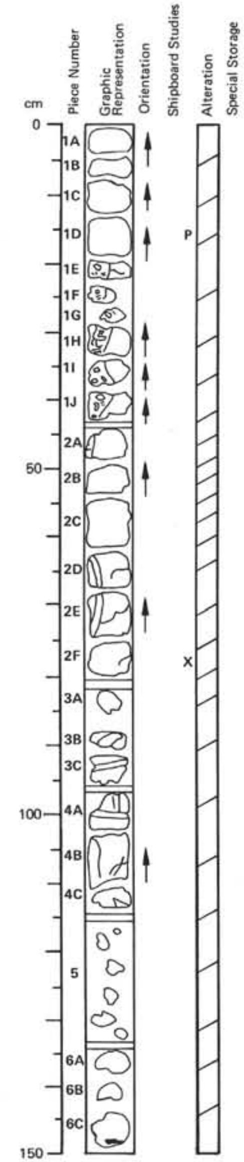
Visual Description

0-105 cm: volcaniclastic breccia; clast:matrix ratio 5:1; clasts 2x5 cm (average) angular, unsorted, unoriented; composed of fine-grained laminated tuff, light olive gray (5Y 5/2) to yellowish gray (5Y 7/2). Matrix tuffaceous and calcareous. Increase in fine-grained highly vesicular basalt clasts, and volcanic glass clasts below 75 cm.

105-150 cm: aphyric basalt, highly vesicular, medium dark gray (N4), 70% crystallized, composed of plagioclase, ?pyroxene and glass. Vesicles, ~25%, 2-3 mm, spheroidal and irregular, empty. Fractures filled with fine tuff breccia, infiltered from above.

Shipboard Data

Physical Properties:	**20-30 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.28



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	1	0	2

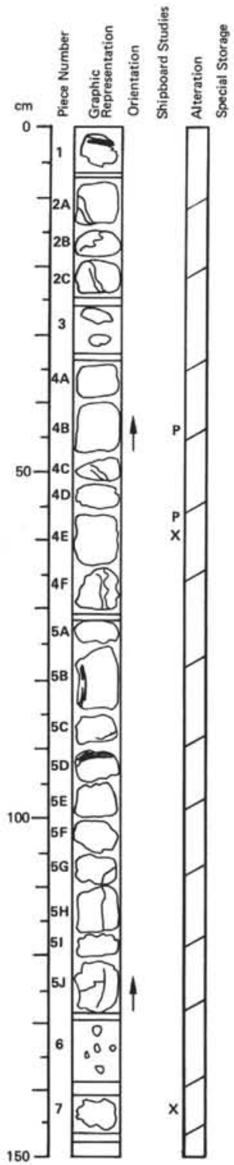
Depth: 291.5 to 293.0 m

Visual Description

Aphyric, fine-grained, highly vesicular basalt, as in lower part of Section 10-1.

Shipboard Data

Physical Properties:	**13-17 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.18



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	10	3

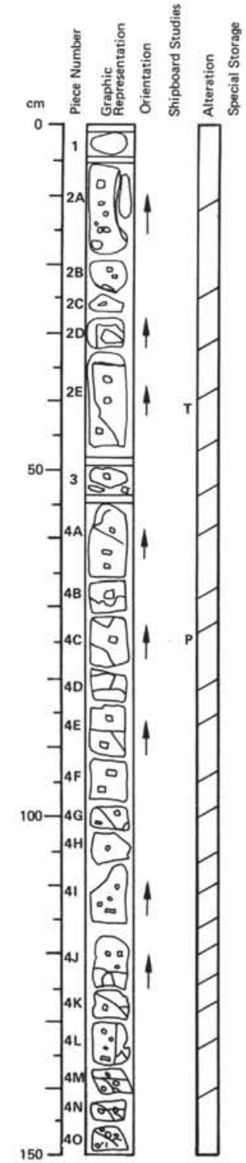
Depth: 293.0 to 294.5 m

Visual Description

Aphyric, fine-grained, highly vesicular basalt flows as in Section 10-2.

Shipboard Data

Physical Properties:	**4-47 cm**	**54-61 cm**
$\overline{V}$p (km/s)		
parallel to beds	3.82	3.66



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	10	4

Depth: 294.5 to 296.0 m

Visual Description

Plagioclase-clinopyroxene-phyric vesicular basalt. Phenocrysts of plagioclase, ~2% of the rock, up to 2 mm, rare clinopyroxene, and ?olivine pseudomorphs up to 1 mm in a groundmass of tabular plagioclase and clinopyroxene. Texture hyalopilitic. Vesicles, 3-5 mm, 2%; <0.5 mm, ~20%; empty or filled with zeolites and calcite.

Thin Section Description

Location: 41-44 cm, flow interior

Texture: hyalopilitic

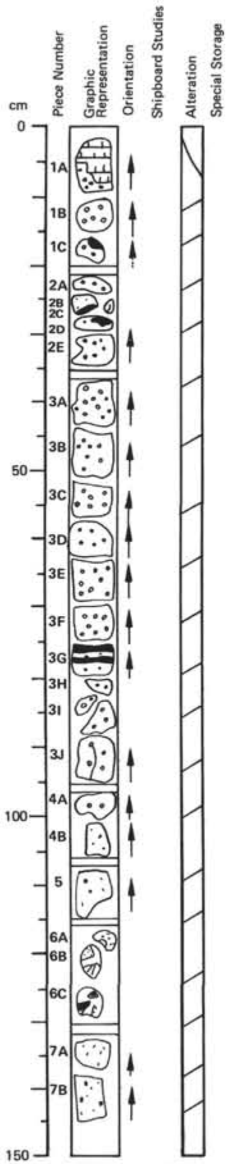
Phenocrysts: <3%; mostly plagioclase, 0.4-2.2 mm, An_{64}, euhedral to subhedral; clinopyroxene rare, ~0.5 mm, subhedral

Groundmass: >75%; plagioclase 50%, 0.05-0.3 mm, An_{54}, laths; clinopyroxene 25%, 0.1-0.3 mm; magnetite/ilmenite 5%, 0.01-0.05 mm; glass 15%

Vesicles: 20%

Shipboard Data

Physical Properties:	**72-78 cm**
$\overline{V}$p (km/s)	
parallel to beds	4.28



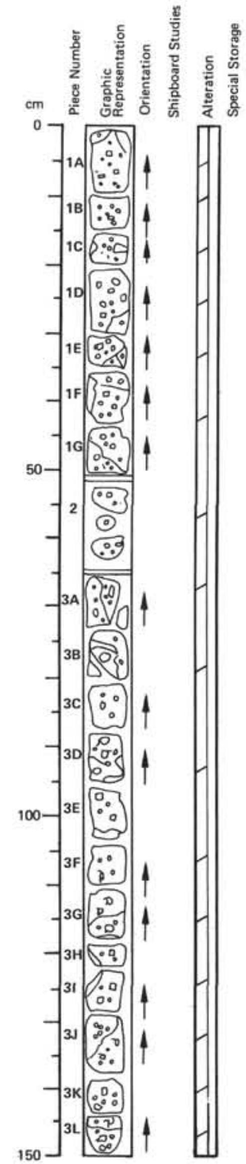
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	11	1

Depth: 299.5 to 301.0 m

Visual Description

Plagioclase-phyric vesicular basalt; plagioclase phenocrysts, <5% of the rock, 1-5 mm, euhedral and glomeromorphic, in aphanitic groundmass' Vesicles 15-20%, 1-3 mm, spheroidal. Alteration moderate; calcite and zeolite veins. From 115-130 cm, basalt breccia in white calcareous matrix.



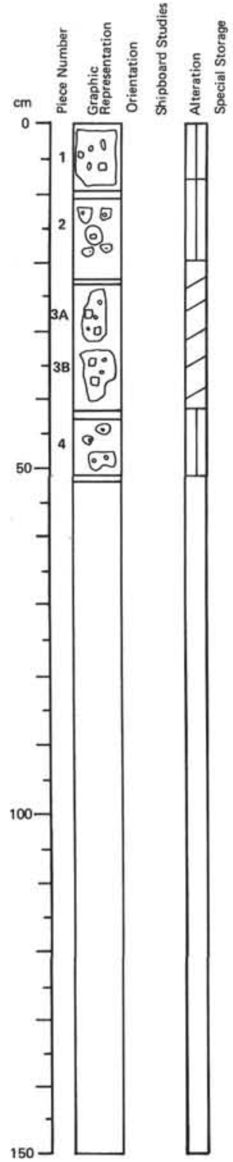
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	11	2

Depth: 301.0 to 302.5 m

Visual Description

Plagioclase phyric vesicular basalt as in Section 11-1. Rare olivine crystals present. Groundmass plagioclase and pyroxene.



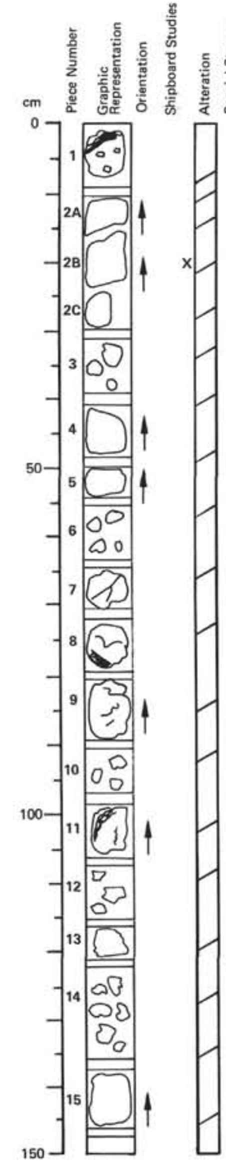
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	11	3

Depth: 302.5 to 303.0 m

Visual Description

Plagioclase phyric vesicular basalt as in Section 11-1. Olivine phenocrysts not observed.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	12	1

Depth: 309.0 to 344.0 m

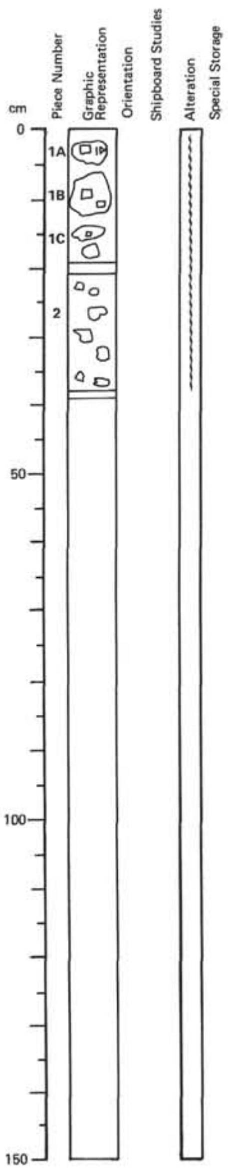
Visual Description

Sparsely plagioclase-phyric pillowed basalt, medium dark gray, fine-grained, highly vesicular. Phenocrysts, 1-2%, 0.5-1 mm, prismatic. Groundmass hyalopilitic to intersertal, 50-80% crystallized; composed of plagioclase, pyroxene and glass.

Vesicles 20%, 2-5 mm, spheroidal and irregular, mainly empty; some with zeolite fillings. Rock veined (0.1-0.5 mm wide) with carbonates and zeolites. Rock is enriched with intersertal groundmass near pillow margins. Glass rims partially replaced with brown smectite.

Shipboard Data

Bulk Analysis:	**19 cm**
SiO_2	49.1
TiO_2	1.49
Al_2O_3	14.0
Fe_2O_3	1.71
FeO	11.27
MnO	0.23
MgO	4.42
CaO	10.64
Na_2O	2.66
K_2O	0.69
P_2O_5	0.12



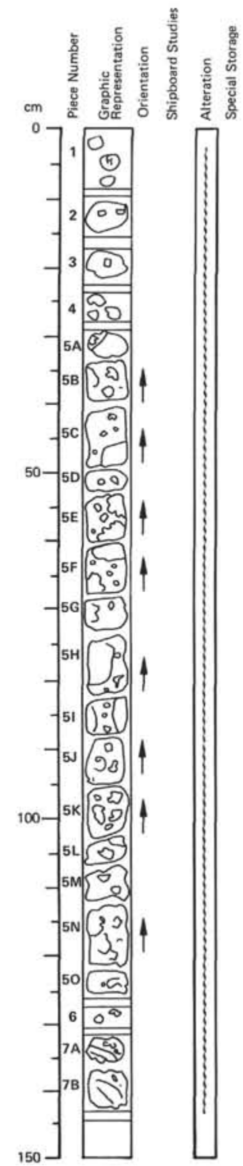
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	12	2

Depth: 344.0 to 344.4 m

Visual Description

Sparsely plagioclase-phyric pillow basalt as in Section 12-1.



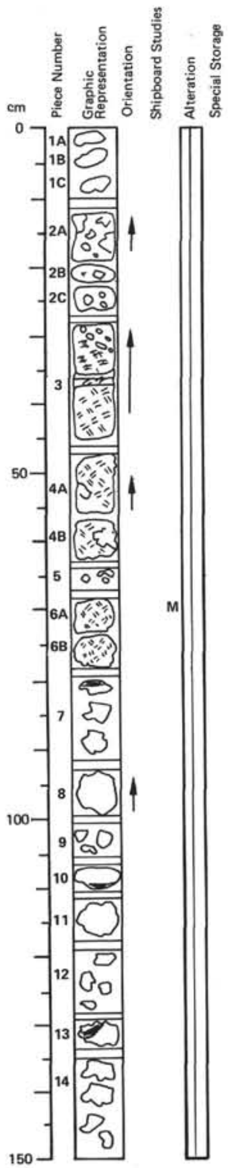
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	13	1

Depth: 344.4 to 346.0 m

Visual Description

Volcaniclastic breccias and tuffs ("yellow matrix"). Clast:matrix ratio 2:1. Clasts of fine-grained, vesicular, aphyric and plagioclase-phyric basalts are angular to subangular 1x2.5 cm average, 3x5 mm maximum, unsorted, unoriented. Matrix of 1-2 mm irregular grains of altered vitrophyric basalt cemented with carbonates and zeolites. From 130-145 cm, graded layers of tuff, each ~3 cm thick.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

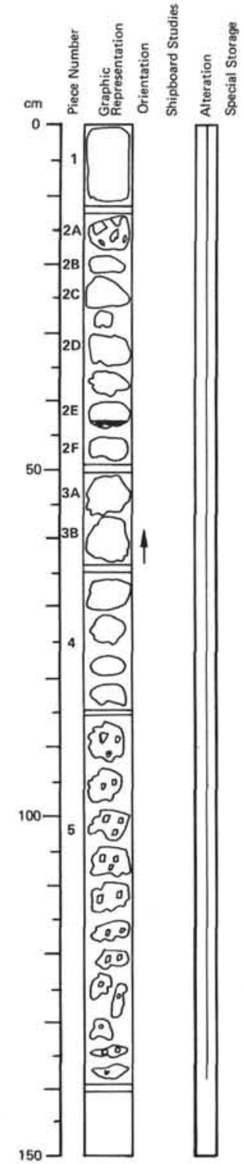
LEG	SITE	HOLE	CORE	SECT.
59	448	A	13	2

Depth: 346.0 to 347.5 m

Visual Description

0-80 cm: laminated tuff, yellow, interbedded with fine to very fine breccia intervals ~20 cm thick in which matrix is dusky yellow (5Y 6/4) to pale brown (5YR 5/2) tuff. From 70-80 cm, cross-laminated yellow and pale brown tuff.

80-150 cm: plagioclase phyric basalt, fine-grained, vesicular, with hyalopilitic to intersertal texture, 60-70% crystallized. Phenocrysts 1-3%, 1-2 mm. Vesicularity ~30%.



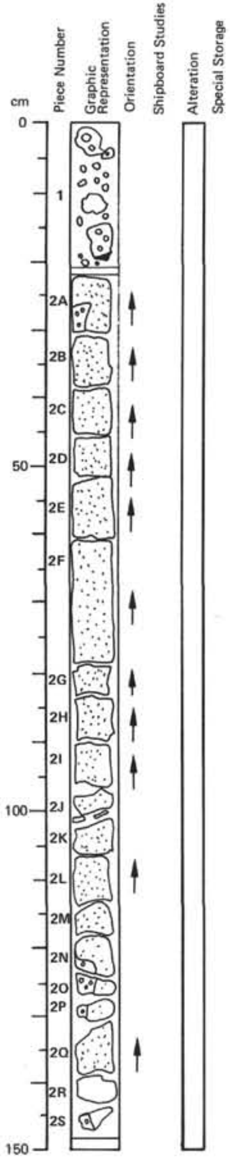
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	13	3

Depth: 347.5 to 349.0 m

Visual Description

Plagioclase-phyric basalt as in lower Section 13-2. From 85-140 cm, basalt enriched in plagioclase phenocrysts of the rock, 10-15%, 2-3 mm, elongate prisms. Groundmass 90% crystallized, intersertal to subophitic, consisting of plagioclase, clinopyroxene and intergranular glass. ?Olivine may be present. Vesicles absent.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

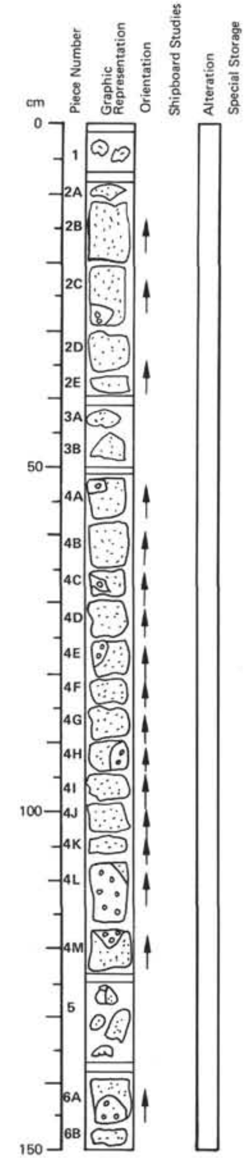
LEG	SITE	HOLE	CORE	SECT.
59	448	A	14	1

Depth: 484.5 to 486.0 m

Visual Description

0-20 cm: vesicular aphyric basalt; some glassy margins; ?base of flow.

20-150 cm: volcaniclastic breccia ("yellow matrix"). Clast:matrix ratio 5:1. Clasts of basalt, 70%, vesicular or massive, plagioclase or olivine phyric, fresh to highly altered, and altered glass, 28%, and ?andesite 2%. Clasts angular to subrounded, 0.75-1 cm average, 3 cm maximum in upper part of core, 5 cm maximum toward the base. Matrix of yellow altered vitric tuff, white calcite and zeolites.



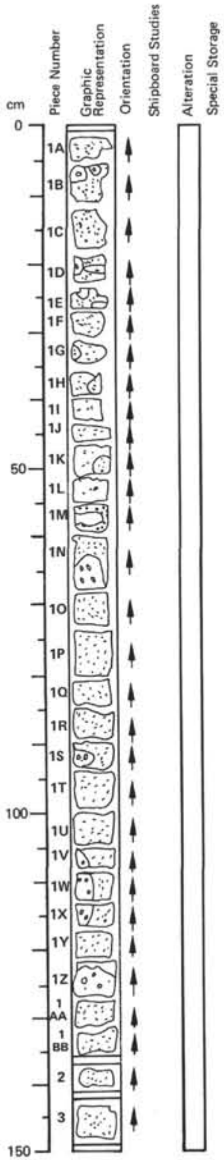
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	14	2

Depth: 486.0 to 487.5 m

Visual Description

Volcaniclastic breccia as in Section 14-1. Maximum size at base of core is 10 cm. Clasts of a different breccia are present.



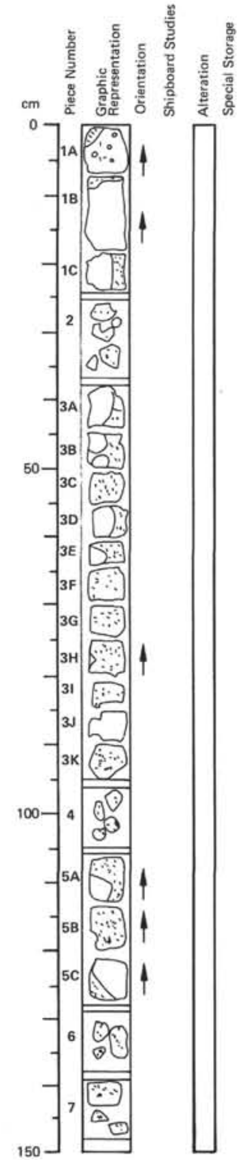
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	14	3

Depth: 487.5 to 489.0 m

Visual Description

Volcaniclastic breccia as in Section 14-2, becoming polymictic. Gradual color change down section from yellow-olive (5Y 5/4) to grayish green (5G 5/2) to dusky green (5G 3/2), in lower half of core.



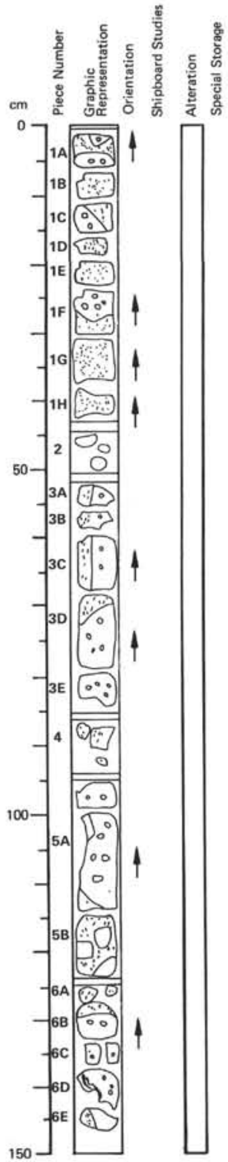
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	14	4

Depth: 489.0 to 490.5 m

Visual Description

Volcaniclastic breccia, "green matrix," as in previous section; clast:matrix ratio 4:1. Clasts average 3 cm, are 10 cm maximum size at top of core, and 8 cm maximum at bottom. Matrix green (?smectite) vitric tuff cemented with zeolites and some carbonate.



VISUAL CORE DESCRIPTION
FOR IGNEOUS ROCKS

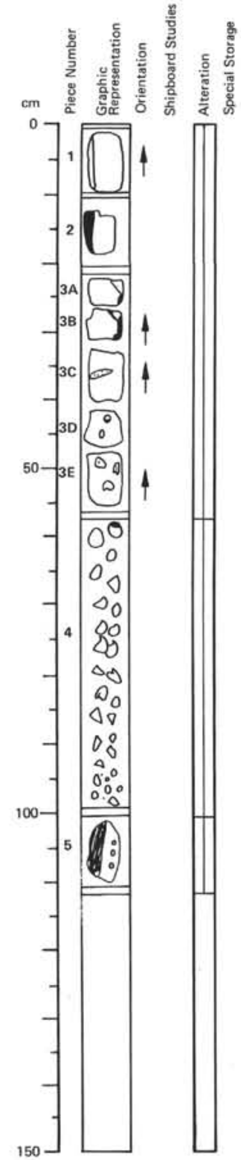
LEG	SITE	HOLE	CORE	SECT.
59	448	A	14	5

Depth: 490.5 to 492.0 m

Visual Description

Volcaniclastic breccia as in previous sections. From 0-20 cm, green matrix; from 20-45 cm, yellow matrix; from 45-150 cm, pale yellow matrix (10Y 6/6).

Clast:matrix ratio ~3:1. Average size 3 cm; maximum size 15 cm. Mainly vesicular plagioclase phyric basalt.



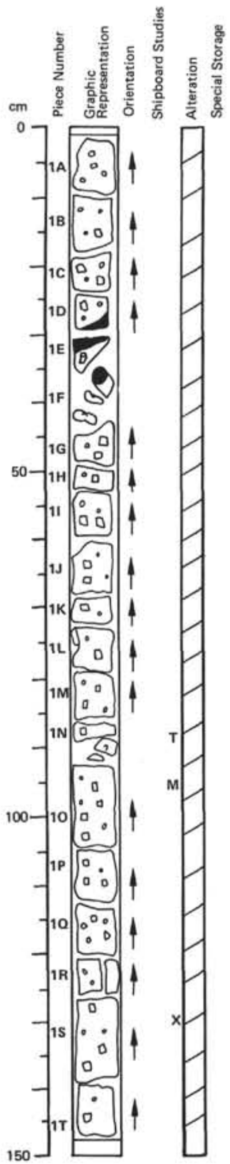
VISUAL CORE DESCRIPTION
FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	14	6

Depth: 492.0 to 493.0 m

Visual Description

Plagioclase olivine phyric basalt. Phenocrysts of prismatic plagioclase, olivine pseudomorphs and ?pyroxene. Groundmass plagioclase, and ?clinopyroxene. Vesicles spheroidal 0.2-4 mm, ~10%, some of them infilled with calcite and zeolites.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	15	1

Depth: 527.5 to 529.0 m
(Hole deviation of 1.3° at 527.5 m)

Visual Description

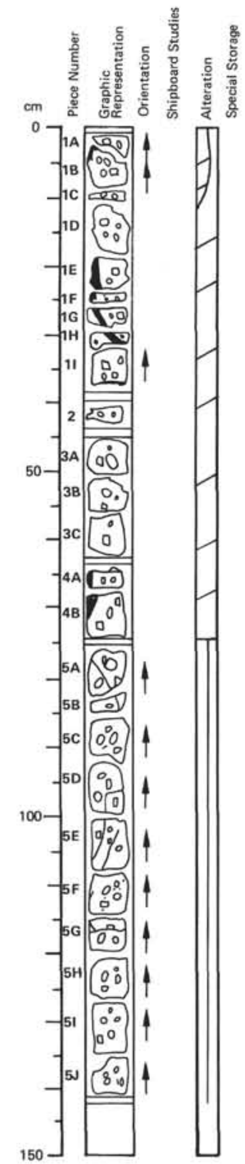
Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, flow. Phenocrysts of plagioclase, 5% of the rock, 1-3 mm, glomerocrysts, and rare olivine, <1% of the rock, as euhedral smectite pseudomorphs. Groundmass fine-grained, ?intersertal. Vesicles, 10%, 1-2 mm, spheroidal, 50% empty; remainder filled with zeolite.

Thin Section Description

Location: 88-91 cm, flow interior
Texture: hyalopilitic
Phenocrysts: <20%; plagioclase 90%, 0.7-3.0 mm, An_{64}, euhedral to subhedral; clinopyroxene 5%, 0.5-1.0 mm euhedral to subhedral; orthopyroxene rare, 0.7 mm, partly altered
Groundmass: >65%; plagioclase 40%, 0.03-0.2 mm, An_{50}, laths; clinopyroxene 25%, 0.02-0.2 mm; orthopyroxene rare, ~0.3 mm, subhedral pseudomorphs; magnetite/ilmenite 5%, 0.01-0.2 mm; glass 30%
Vesicles: 15%, 0.2-2 mm
Alteration: some carbonate

Shipboard Data

Bulk Analysis:	**123 cm**
SiO_2	49.4
TiO_2	1.11
Al_2O_3	15.9
Fe_2O_3	1.47
FeO	9.70
MnO	0.20
MgO	4.68
CaO	10.12
Na_2O	3.47
K_2O	0.94
P_2O_5	0.13



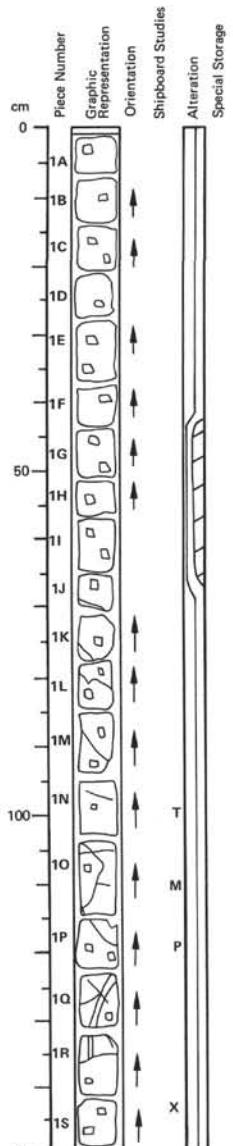
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	15	2

Depth: 529.0 to 530.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, flow, as in Section 15-1, but more altered in lower half of core. Plagioclase phenocrysts somewhat less common below glassy rims.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	15	3

Depth: 530.5 to 532.0 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, flow, as in Section 15-2 but somewhat coarser grained. A few large, 1 cm, vesicles filled with zeolite.

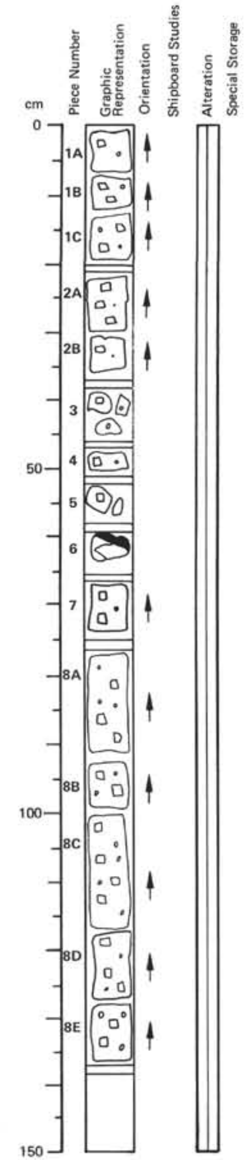
Thin Section Description

Location: 100-103 cm, flow interior
Texture: hyalopilitic
Phenocrysts: 15%; plagioclase 90%, 0.4-2.0 mm, An_{65}, euhedral to subhedral; clinopyroxene <10%, 0.4-1.0 mm, euhedral to subhedral
Groundmass: 75%; plagioclase 55%, 0.03-0.2 mm, An_{50}, laths; clinopyroxene 30%, 0.02-0.2 mm; orthopyroxene ?; magnetite/ilmenite 5%, 0.01-0.05 mm
Vesicles: 10%
Alteration: carbonate 2%, clays 2%

Shipboard Data

Bulk Analysis:	**143 cm**
SiO_2	50.2
TiO_2	1.08
Al_2O_3	16.4
Fe_2O_3	1.43
FeO	9.41
MnO	0.18
MgO	4.02
CaO	10.16
Na_2O	3.16
K_2O	1.39
P_2O_5	0.21

Physical Properties:	**120-123 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.25
vertical to beds	4.26
Wet bulk density	2.51



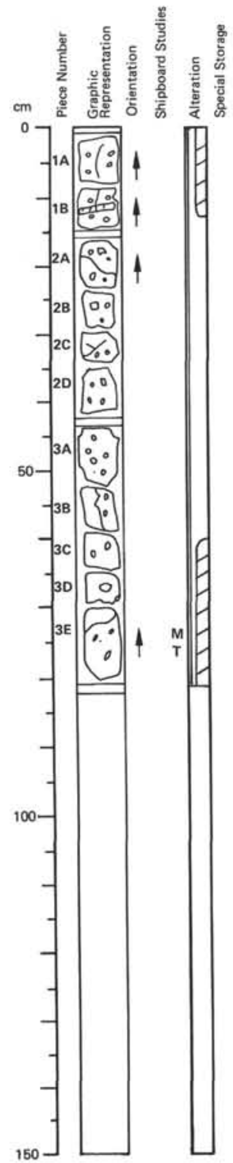
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	15	4

Depth: 532.0 to 533.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric, basalt, flow, as in previous sections. Plagioclase phenocrysts 10% of the rock, 1-2 mm, glomerocrysts. Olivine ~2% of the rock, 1 mm, pseudomorphs. Groundmass fine-grained, variolitic towards glassy margins. Vesicles 5-30%, up to 3 mm; tube vesicles up to 1 cm diameter contain darker highly vesicular basalt Common zeolite veins.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	15	5

Depth: 533.5 to 534.3 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, flow, as in previous sections.

Thin Section Description

Location: 77-78 cm, flow interior

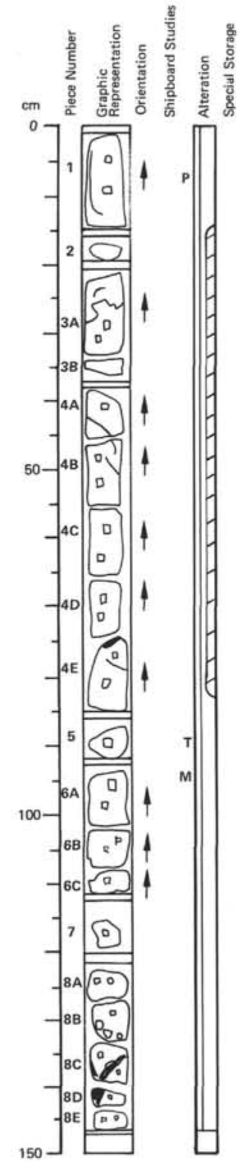
Texture: hyalopilitic

Phenocrysts: <20%; plagioclase 80%, 0.4-2.0 mm, euhedral to subhedral; clinopyroxene, 10%, 0.3-0.7 mm, euhedral to subhedral; orthopyroxene 5%, 0.3 mm, pseudomorphs

Groundmass: >55%; plagioclase 40%, 0.04-0.3 mm, laths; clinopyroxene 30%, 0.04-0.2 mm; orthopyroxene rare, 0.1 mm; magnetite/ilmenite 10%, 0.01-0.05 mm; glass 20%

Vesicles: 25%, 0.4-2.0 mm, irregular

Alteration: 5% carbonates, 2% clays



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	16	1

Depth: 537.0 to 538.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, flow, 0-75 cm, as before. Rare vesicles. From 75-145 cm, extremely vesicular pillow basalts. Abundant glassy margins at steep dips to core axis. Phenocrysts of plagioclase, ~10% of the rock; 1-2 mm, glomerocrysts, and sparse ?olivine speudomorphs. Groundmass aphanitic.

Thin Section Description

Location: 90-93 cm, pillow interior

Texture: intersertal

Phenocrysts: <15%; plagioclase 75%, An_{64-73}, 0.4-0.2 mm; clinopyroxene 15%, 0.2-1.0 mm, euhedral to subhedral; orthopyroxene rare, 0.5-1.0 mm, subhedral pseudomorphs

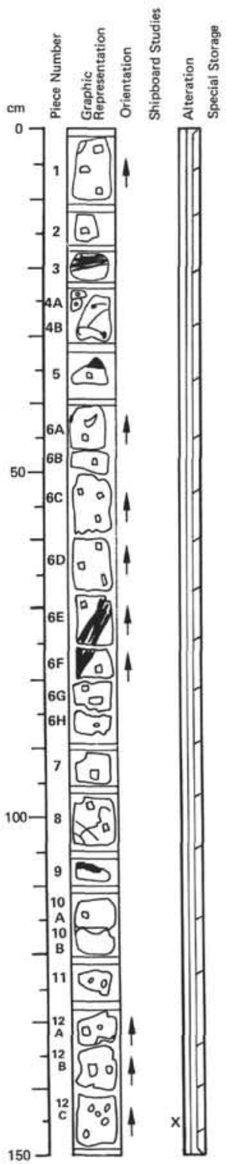
Groundmass: >55%; plagioclase 50%, 0.05-0.4 mm, laths; clinopyroxene 20%, 0.05-0.1 mm; orthopyroxene rare, ~0.2 mm; magnetite/ilmenite 10%, 0.01-0.05 mm; glass 15%

Vesicles: 30%, biomodal; 70%, 0.2-0.6 mm, irregular; 30%, 0.1-1.5 mm, spheroidal filled with carbonate

Alteration: 10%

Shipboard Data

Physical Properties:	0-15 cm
$\overline{V}p$ (km/s)	
parallel to beds	4.16



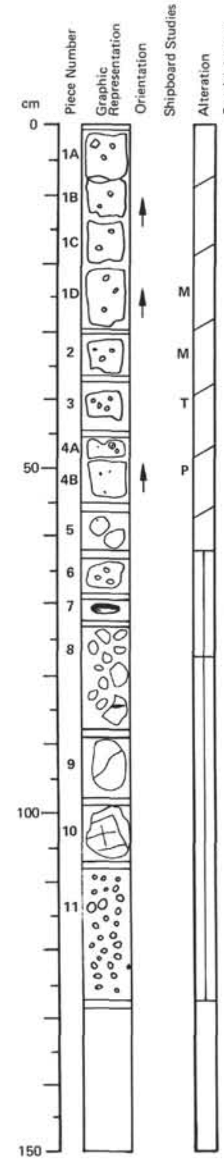
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	16	2

Depth: 538.5 to 540.0 m

Visual Description

Plagioclase clinopyroxene-orthopyroxene-(olivine)-phyric basalt, pillow lava, highly vesicular, as in Section 16-1. Aphanitic groundmass, 75% crystalline; intersertal to variolitic near chilled margins. Vesicles concentrated near base of core.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	16	3

Depth: 540.0 to 541.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt . . in Section 2.

Thin Section Description

Location: 38-41 cm, pillow interior

Texture: intersertal

Phenocrysts: < 15%; plagioclase 75%, An_{72}, 0.4-2.5 mm, euhedral; clinopyroxene 15%, 0.4-1.1 mm, euhedral to subhedral; orthopyroxene rare, 0.4-1.0 mm

Groundmass: > 65%; plagioclase 40%, An_{54}, 0.05-0.4 mm; clinopyroxene 30%, 0.04-0.4 mm; orthopyroxene rare, ~0.2 mm; magnetite/ilmenite 5%, 0.01-0.1 mm; glass 20%

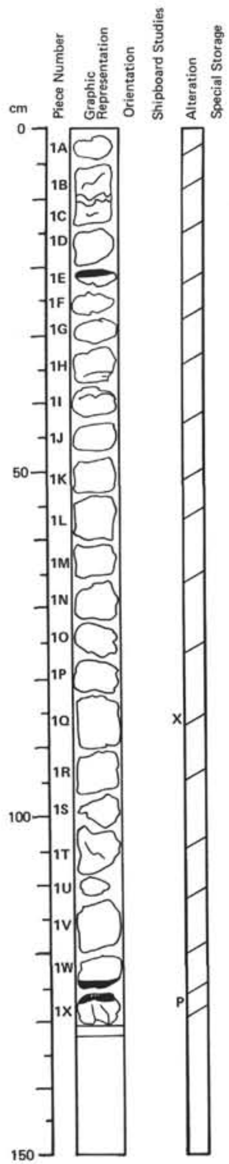
Vesicles: 20%, 0.4-3.0 mm, irregular and spheroidal

Alteration: 3% alteration in glass

Shipboard Data

Bulk Analysis:	**10 cm**
SiO_2	50.0
TiO_2	1.09
Al_2O_3	15.9
Fe_2O_3	1.47
FeO	9.68
MnO	0.19
MgO	4.96
CaO	9.79
Na_2O	3.17
K_2O	1.05
P_2O_5	0.12

Physical Properties:	**49-56 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.98



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	17	1

Depth: 546.5 to 548.0 m

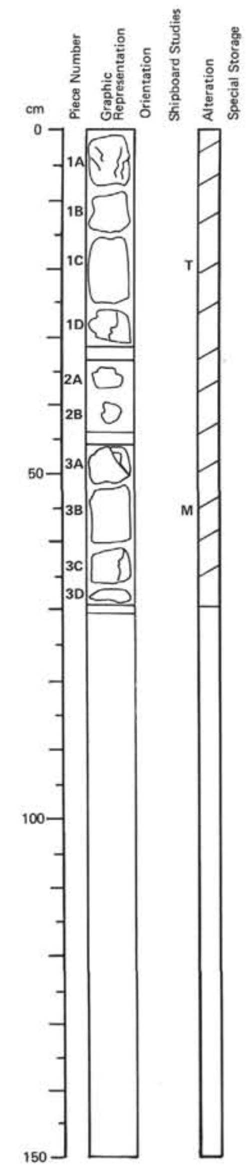
Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, highly vesicular, as in Section 16-3.

Shipboard Data

Bulk Analysis:	**87 cm**
SiO_2	49.7
TiO_2	1.15
Al_2O_3	15.5
Fe_2O_3	1.53
FeO	10.11
MnO	0.20
MgO	4.11
CaO	9.72
Na_2O	3.00
K_2O	1.33
P_2O_5	0.26

Physical Properties:	**123-133 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.03



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	17	2

Depth: 548.0 to 549.0 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, highly vesicular, as in Section 17-1.

Thin Section Description

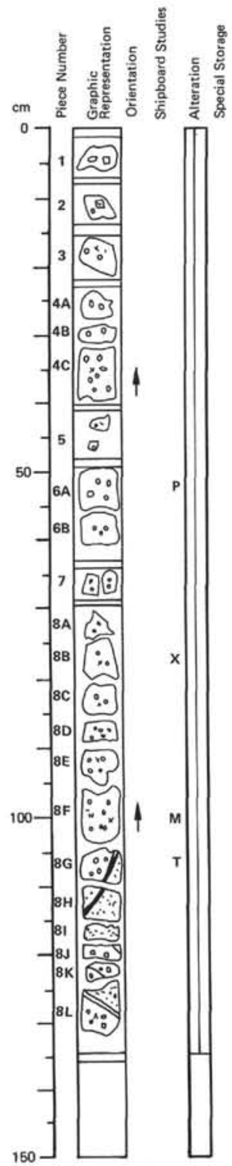
Location: 20-23 cm, pillow interior

Texture: intersertal

Phenocrysts: <20%; plagioclase 90%, An_{55-60}, 0.5-3.5 mm; clinopyroxene 5%, 0.3-1.0 mm; orthopyroxene <5%, 0.4-0.8 mm

Groundmass: >55%; plagioclase 35%, 0.05-0.3 mm, laths; clinopyroxene 25%, 0.03-0.1 mm; orthopyroxene rare; magnetite/ilmenite 5%, 0.01-0.03 mm; glass 35%

Vesicles: 20-25%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	18	1

Depth: 549.5 to 551.0 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, highly vesicular, as in previous sections.

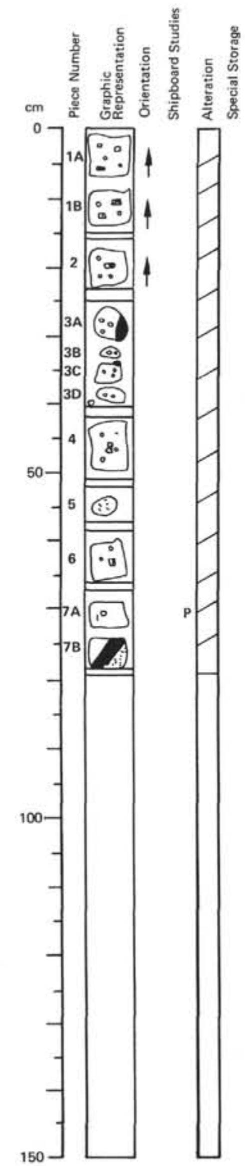
Thin Section Description

Location: 109-111 cm, next to glassy margin
Texture: intersertal
Phenocrysts: < 10%; plagioclase 70%, An_{65}, 0.4-1.5 mm, euhedral; clinopyroxene 20%, 0.3-1.0 mm, euhedral to subhedral; orthopyroxene < 10%, 1.0-2.0 mm, euhedral to subhedral, fresh and pseudomorphs
Groundmass: > 70%; plagioclase 40%, An_{60}, 0.02-0.3 mm, euhedral laths; clinopyroxene 25%, 0.02-0.2 mm, subhedral; magnetite/ilmenite rare, 0.005 mm; glass 30%
Vesicles: 20%, 0.4-4.0 mm
Alteration: 10% clays

Shipboard Data

Bulk Analysis:	**77 cm**
SiO_2	50.8
TiO_2	1.12
Al_2O_3	14.5
Fe_2O_3	1.53
FeO	10.07
MnO	0.21
MgO	4.14
CaO	8.93
Na_2O	3.14
K_2O	1.82
P_2O_5	0.11

Physical Properties:	**50-56 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.63



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	19	1

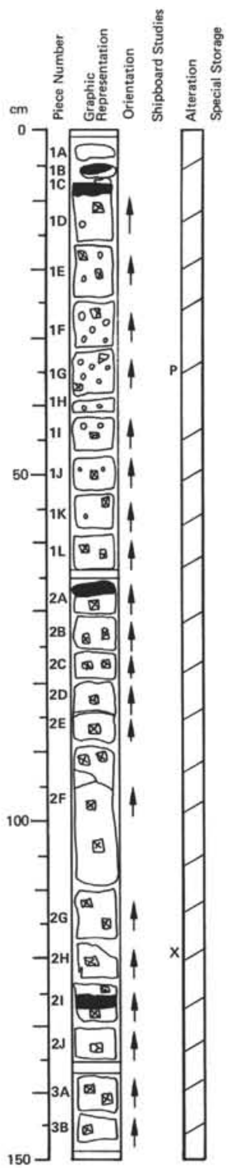
Depth: 556.0 to 565.0 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine) phyric pillow basalt, as in Section 18-1.

Shipboard Data

Physical Properties:	**66-69 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.40
vertical to beds	3.26
Wet bulk density	2.27



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	20	1

Depth: 565.5 to 567.0 m

Visual Description

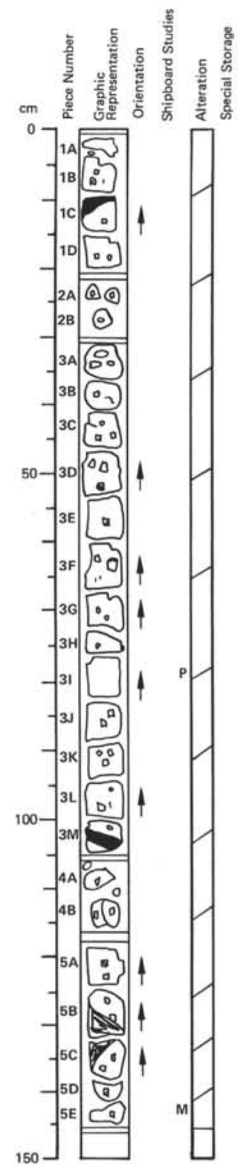
Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt, as in previous section. Pillow units have flat glass tops and bottoms. Cooling units well defined.

Phenocrysts of plagioclase (<5% of the rock, ~1 mm); clinopyroxene, (<5% of the rock) euhedral or glomeromorphic with olivine and orthopyroxene, orthopyroxene (1-2 mm) partially replaced by brown smectite, and olivine completely replaced by orange smectite. Groundmass fine-grained, intersertal to subophitic, moderately altered. Abundant calcite in vesicles and veins.

Shipboard Data

Bulk Analysis:	118 cm
SiO_2	51.2
TiO_2	1.08
Al_2O_3	14.2
Fe_2O_3	1.49
FeO	10.95
MnO	0.21
MgO	4.66
CaO	8.32
Na_2O	2.99
K_2O	2.14
P_2O_5	0.07

Physical Properties:	31-37 cm
$\overline{V}p$ (km/s)	
parallel to beds	3.60



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	20	2

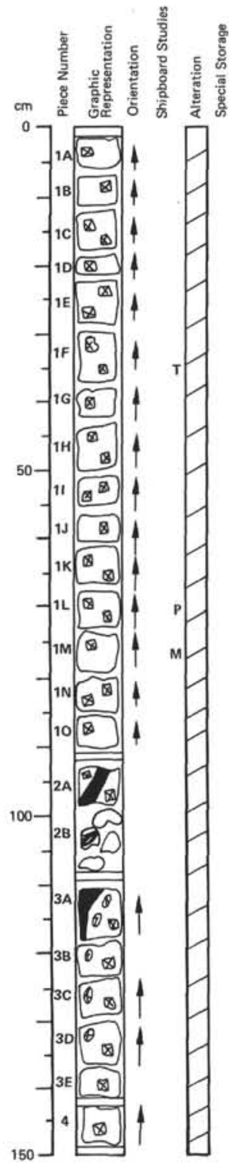
Depth: 567.0 to 568.5 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt as in Section 20-1.

Shipboard Data

Physical Properties:	77-84 cm
$\overline{V}p$ (km/s)	
parallel to beds	3.64



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	20	3

Depth: 568.5 to 570.0 m

Visual Description

Sparsely plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt as in Section 20-2.

Thin Section Description

Location: 32-35 mm, pillow interior

Texture: intersertal

Phenocrysts: plagioclase 15%, An_{65}, 0.4-3.0 mm, euhedral to subhedral; clinopyroxene ~2%, 0.4-1.0 mm, euhedral to subhedral; orthopyroxene rare, 0.4-1.0 mm, subhedral, pseudomorphs

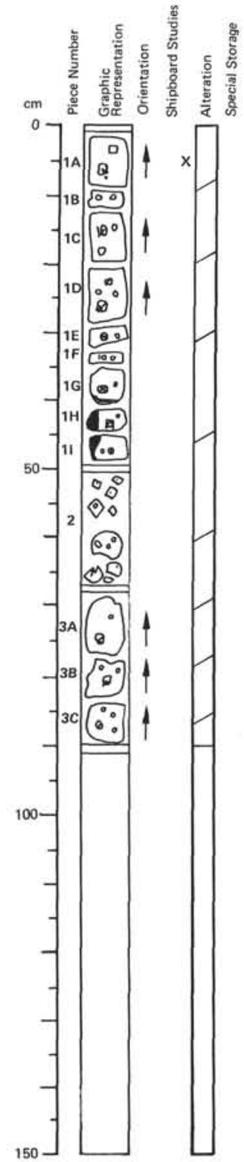
Groundmass: plagioclase 15%, An_{60}, 0.02-0.3 mm, euhedral laths; clinopyroxene 10%, 0.02-0.3 mm, subhedral; magnetite/ilmenite 5%, 0.01-0.05 mm

Vesicles: 40%, 0.3-5.0 mm

Alteration: slight

Shipboard Data

Physical Properties:	**68-70 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.82
vertical to beds	3.78
Wet bulk density	2.35



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	20	4

Depth: 570.0 to 570.9 m

Visual Description

Plagioclase-clinopyroxene-orthopyroxene-(olivine)-phyric basalt as in Section 20-3.

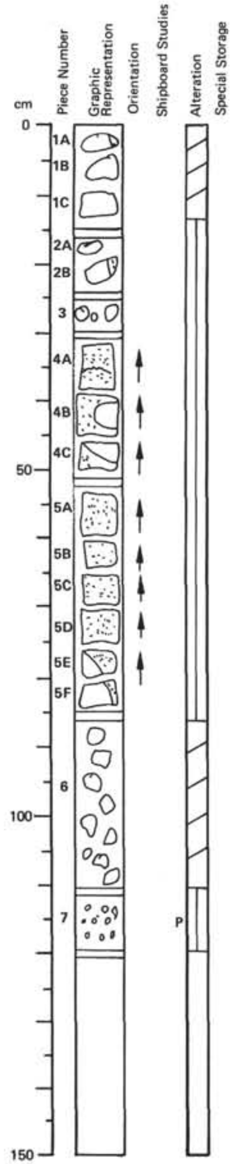
Shipboard Data

Bulk Analysis:	**4 cm**
SiO_2	49.8
TiO_2	1.29
Al_2O_3	14.0
Fe_2O_3	1.63
FeO	9.88
MnO	0.21
MgO	4.41
CaO	8.88
Na_2O	3.04
K_2O	1.66
P_2O_5	0.16

VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	21	1

Depth: 575.0 to 576.5 m



Visual Description

Volcaniclastic breccia, "green matrix." Clast:matrix ratio 4:1, 2-3 cm average, 10 cm maximum, subangular to subrounded, composed of very fresh, fine-grained sparsely plagioclase phyric basalt, rare reddish andesite, and some altered glass. Matrix olive-yellow near top to dusky gray green in lower part of core.

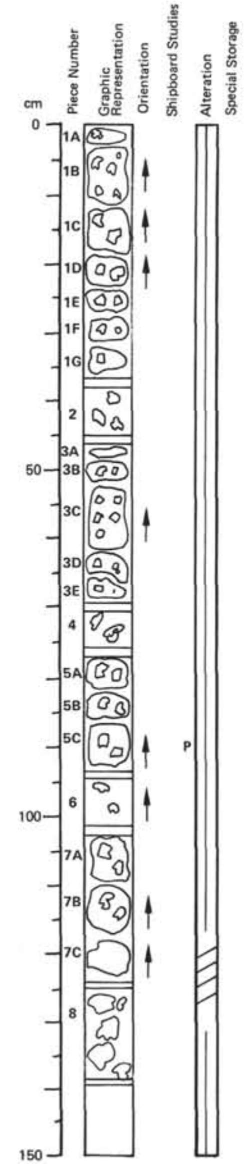
Shipboard Data

Physical Properties:	**117-120 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.20

VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	22	1

Depth: 584.5 to 586.0 m

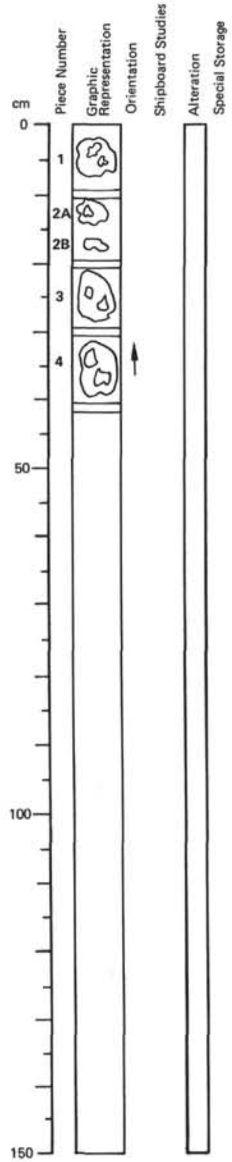


Visual Description

Volcaniclastic breccia, as in Section 21-1. Clast:matrix ratio 2:1. Clasts angular to subangular, irregular up to 13 cm maximum size, 2-3 cm average, unsorted, unoriented. Composed of highly vesicular phyric basalt. Matrix consists of small (0.5-1 cm average), basalt clasts almost completely replaced with green smectite, with carbonate and zeolite cement.
A few clasts of fresh vesicular basalt and holocrystalline gabbro.

Shipboard Data

Physical Properties:	**89-91 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.92
vertical to beds	3.03
Wet bulk density	2.11

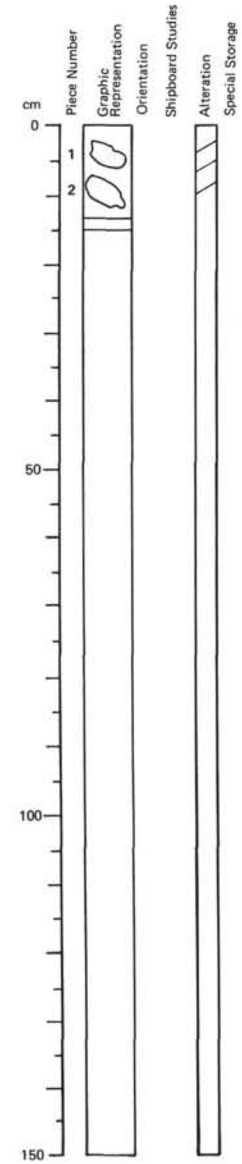


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	22	2

Depth: 586.0 to 587.5 m

Visual Description
Volcaniclastic breccia as in Section 22-1.

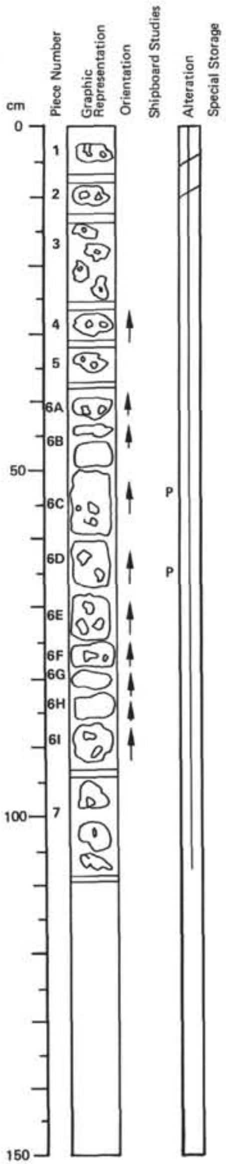


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	23	CC

Depth: 584.0 to 603.5 m

Visual Description
Two fragments of aphyric vesicular basalt; possibly breccia clasts.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	24	1

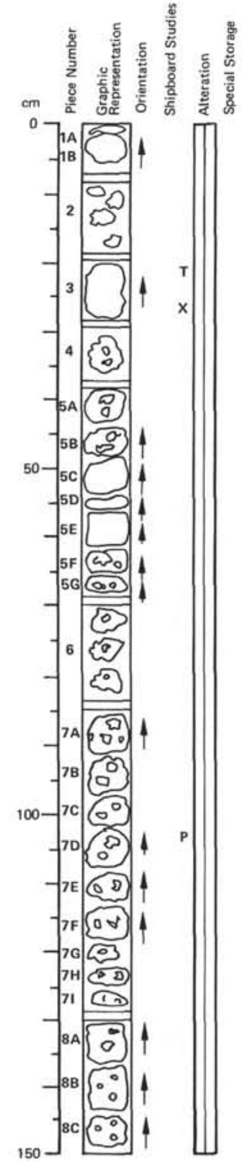
Depth: 603.5 to 607.5 m

Visual Description

Volcaniclastic breccia as in previous sections. Clast:matrix ratio 3:1; clasts angular to subangular, 3-4 cm average size, 6-10 maximum, consisting of a variety of basalts and rare smaller clasts of gabbro.

Shipboard Data

Physical Properties:	49-57 cm	64-70 cm
$\overline{V}p$ (km/s)		
parallel to beds	3.14	3.28



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	25	1

Depth: 607.5 to 609.0 m

Visual Description

Volcaniclastic breccia as in previous sections. Numerous clasts of aphyric to aphanitic vesicular basalt.

Thin Section Description

Location: 23-26 cm, clast in breccia

Texture: hyalo-ophitic

Phenocrysts: plagioclase ~2%, 0.4-2.0 mm, euhedral; clinopyroxene ~1%, ~0.5 mm, subhedral

Groundmass: plagioclase 35%, An_{54}, 0.02-0.4 mm, laths; clinopyroxene 17%, 0.02-0.3 mm, subhedral; magnetite/ilmenite ~5%, 0.01-0.1 mm; glass 10%

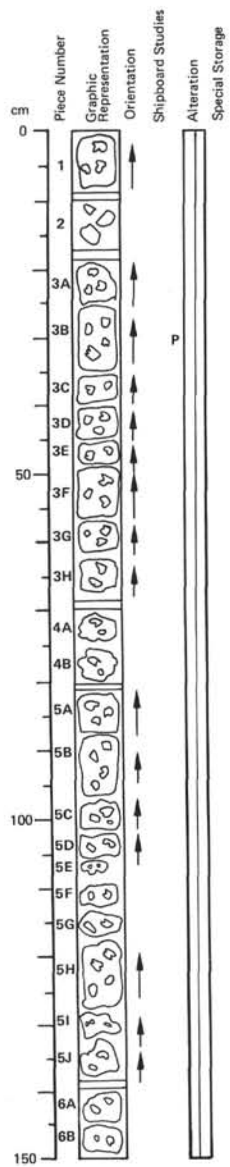
Vesicles: 20%

Alteration: clays 10%

Shipboard Data

Bulk Analysis:	23 cm
SiO_2	49.8
TiO_2	1.28
Al_2O_3	14.1
Fe_2O_3	1.51
FeO	9.99
MnO	0.21
MgO	6.21
CaO	9.32
Na_2O	3.52
K_2O	0.63
P_2O_5	0.29

Physical Properties:	100-106 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.83



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

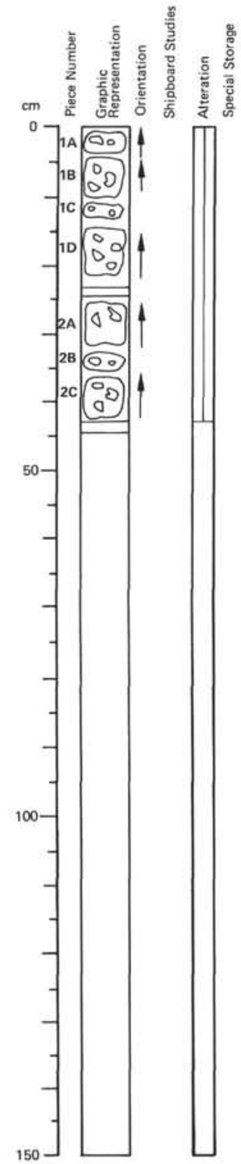
LEG	SITE	HOLE	CORE	SECT.
59	448	A	25	2

Depth: 609.0 to 610.5 m

Visual Description
Volcaniclastic breccia as in previous sections.

Shipboard Data

Physical Properties:	25-34 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.75

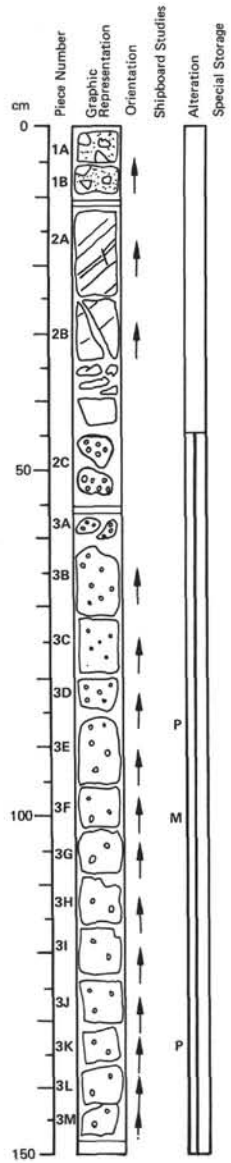


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	25	3

Depth: 610.5 to 613.0 m

Visual Description
Volcaniclastic breccia as in previous sections.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	26	1

Depth: 613.0 to 614.5 m

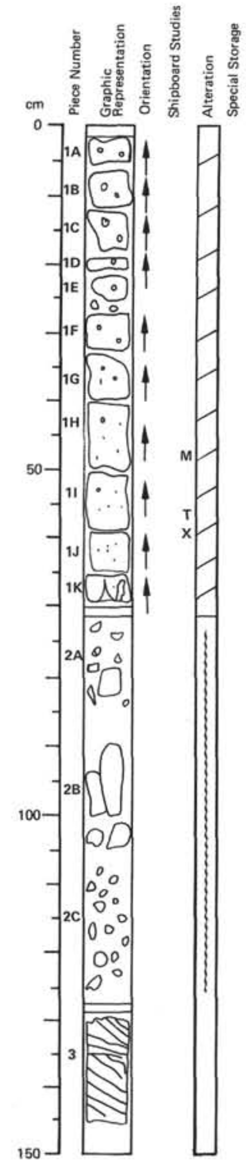
Visual Description

Volcaniclastic breccia, 0-10 cm, as before. Fine tuff, 10-45 cm, dusky blue-green (5BG 3/2), with some very pale green (10G 8/2) and pale green (5G 7/2), laminae. Rock well laminated, 0.1-1 cm, parallel laminae, with ~35° dip. Some normal faulting. Some of the coarser laminae with banding structures; lighter mottling may be burrows. Native Cu fills veins and fractures, mostly in lower part of unit.

Plagioclase-clinopyroxene-phyric-basalt, flow, 45-148 cm. Dark gray, vesicular towards base of core; with glomerocrysts of clinopyroxene and plagioclase up to 2 mm, <3% of the rock. Groundmass 75% crystalline, subophitic to intersertal. Vesicles occupy ~15% of rock, average 1 mm, maximum 4 mm.

Shipboard Data

Physical Properties:	86-94 cm	132-135 cm
$\overline{V}$p (km/s)		
parallel to beds	3.33	3.59
vertical to beds	–	3.49
Wet bulk density	2.41	2.19



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	26	2

Depth: 614.5 to 616.0 m

Visual Description

Plagioclase-clinopyroxene-phyric basalt, flow, 0-70 cm, as in Section 26-1.

Fine tuff, 70-150 cm, pale green (10G 6/2), with some parallel tuff laminae 5GY 3/2 and 10G 8/2. Laminae show some disruption; local cross lamination. Native Cu dispersed through unit.

Thin Section Description

Location: 54-57 cm, flow interior

Texture: intersertal

Phenocrysts: 2%; plagioclase <50%, ~1-2 mm; clinopyroxene 50%, ~0.7 mm, subhedral

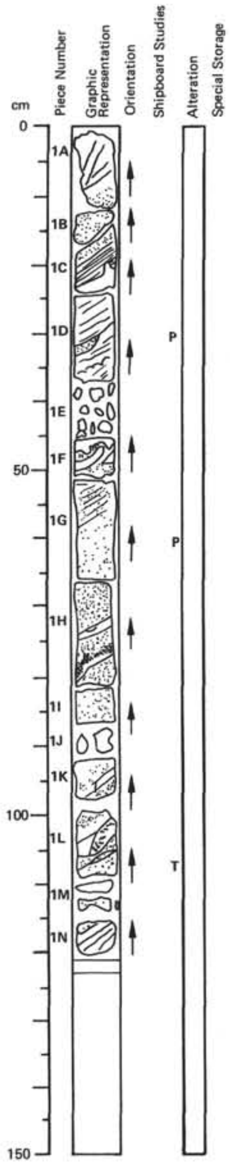
Groundmass: >65%; plagioclase 35%, 0.02-0.3 mm, euhedral laths; clinopyroxene 25%, 0.02-0.3 mm, subhedral; magnetite/ilmenite 15%, 0.01-0.05 mm; glass 25%

Vesicles: 30%, 0.2-3.0 mm

Alteration: 3% carbonates replacing plagioclase; 10% clays replacing glass

Shipboard Data

Bulk Analysis:	60 cm
SiO_2	47.7
TiO_2	1.22
Al_2O_3	13.2
Fe_2O_3	1.56
FeO	10.31
MnO	0.37
MgO	6.47
CaO	9.93
Na_2O	3.48
K_2O	1.63
P_2O_5	0.32



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	26	3

Depth: 616.0 to 617.3 m

Visual Description

Tuff and fine tuff, interbedded and interlaminated; considerable cross-lamination. Colors vary from pale green (10G 6/2), to very light gray (N8), to dark gray (N3). Bottom 20 cm of core with colors 5GY 6/1, 5Y 4/1, 5Y 6/4. Penecontemporaneous deformed structures present.

Thin Section Description

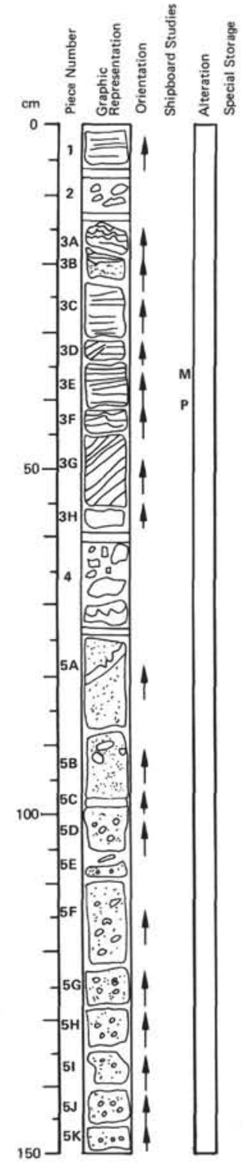
Location: 104-107 cm

Texture: silt-sized fine tuff

Composition: grains composed of plagioclase, clinopyroxene, magnetite/ilmenite and glass

Shipboard Data

Physical Properties:	**25-33 cm**	**60-62 cm**
$\overline{V}p$ (km/s)		
parallel to beds	3.48	2.75
vertical to beds	–	2.79
Wet bulk density	–	2.06



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	27	1

Depth: 617.5 to 619.0 m

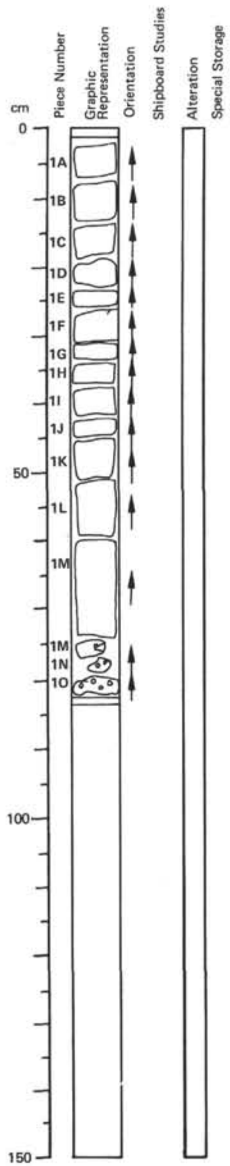
Visual Description

Tuff and fine tuff, 0-98 cm, as in Section 26-3. Mostly dusky yellowish green (10GY 3/2), finely laminated and cross-laminated. Local ? Mn blebs and patches; mottled locally, with penecontemoraneous disturbance. Lowest 20 cm, grayish green (10GY 5/2), with local load coasts.

Volcaniclastic breccia, 10GY 5/2. Clast:matrix ratio 4:1. Clasts mostly angular, some subrounded, well sorted; average size 0.8-1 cm, maximum 2.5 cm, consisting of vesicular basalt, ? andesite, and altered glass. Carbonate and zeolite cement.

Shipboard Data

Physical Properties:	**35-43 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.98



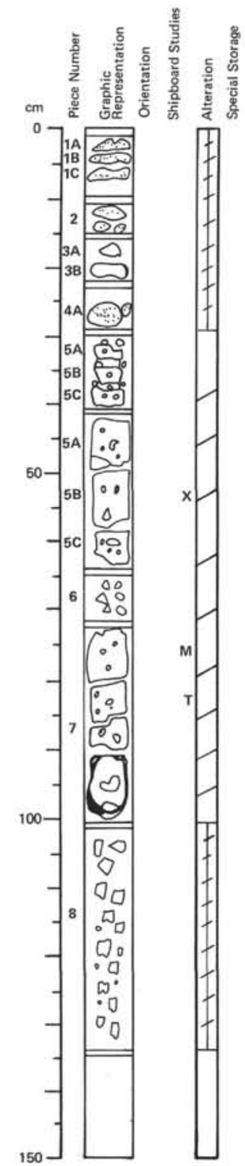
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	27	2

Depth: 619.0 to 620.5 m

Visual Description

Volcaniclastic breccia,"green matrix", as in Section 27-1. Clast:matrix ratio 6:1.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	28	1

Depth: 622.5 to 623.8 m

Visual Description

0-30 cm: volcaniclastic breccia as before.

30-135 cm: sparsely clinopyroxene-plagioclase-phyric vesicular basalt; phenocrysts of pyroxenes and plagioclase in a matrix of same; texture hyalopilitic. Vesicles 1-4 mm increasing in size downwards.

Thin Section Description

Location: 78-82 cm, flow interior

Texture: intersertal

Phenocrysts: <2%; plagioclase rare, ~0.5 mm, prismatic; mostly clinopyroxene, ~0.4 mm, subhedral

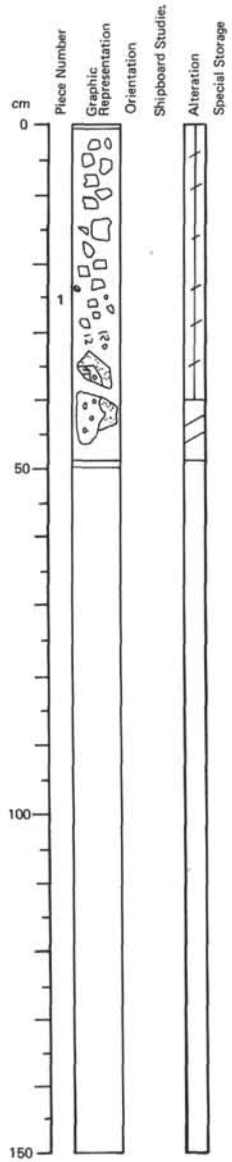
Groundmass: >75%; plagioclase 50%, 0.1-0.3 mm; clinopyroxene 25%, ~0.07 mm; magnetite/ilmenite 10%, 0.01-0.05 mm; glass 15%

Vesicles: 20%

Alteration: 20%

Shipboard Data

Bulk Analysis:	**52 cm**
SiO_2	48.2
TiO_2	1.01
Al_2O_3	12.9
Fe_2O_3	1.63
FeO	10.76
MnO	0.26
MgO	9.22
CaO	6.38
Na_2O	2.58
K_2O	2.03
P_2O_5	0.33



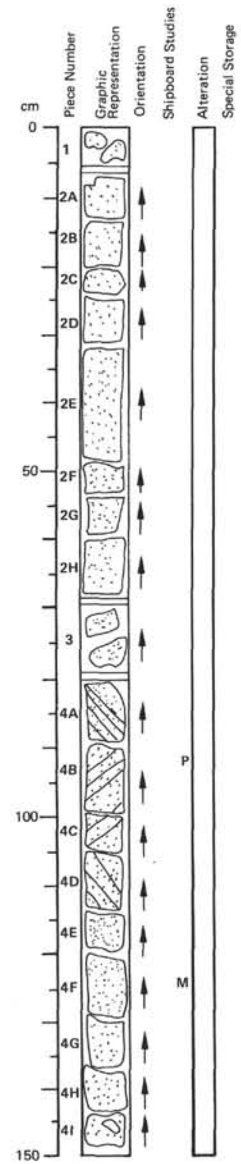
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	2	9	1

Depth: 632.0 to 632.5 m
(Hole deviation of 1.0° at 632.0 m)

Visual Description

Volcaniclastic breccia, "green matrix," as in Sections 27-1 and 27-2.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	3	0	1

Depth: 641.5 to 643.0 m

Visual Description

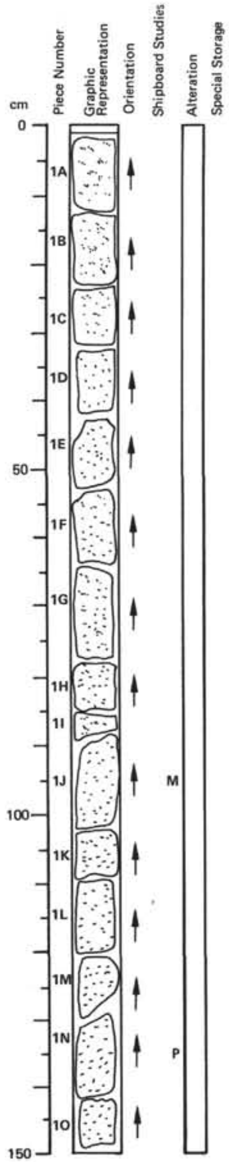
0-80 cm: volcaniclastic breccia, "green matrix," as in previous sections. Clast:matrix ratio 3:1; clasts subrounded, average size 0.5 cm, maximum size 1.5 cm; composed of weathered basalt and glass; matrix dominantly altered glass, dusky gray green (5G 2/2).

80-140 cm: tuffaceous volcaniclastic breccia and tuff, dusky gray green (5G 2/2), blackish green where very fine-grained. Alternate coarser and finer layers, becoming coarser downward. *No lamination; clasts up to 1 cm oriented parallel to bedding. Dip 45°-50°.*

140-150 cm: volcaniclastic breccia as in 0-80 cm interval.

Shipboard Data

Physical Properties:	**90-92 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.07
vertical to beds	2.08
Wet bulk density	2.00



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	30	2

Depth: 643.0 to 644.5 m

Visual Description

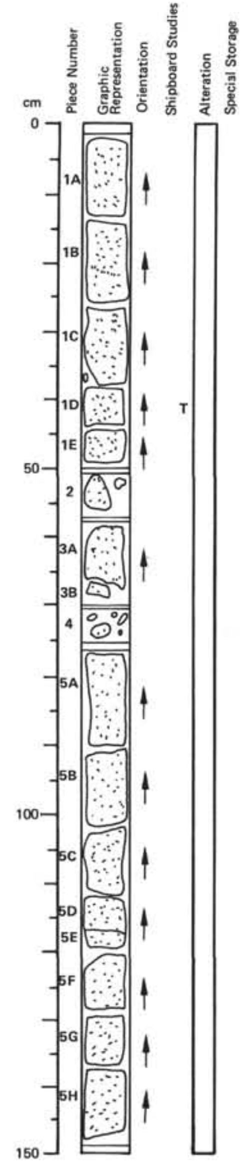
0-18 cm: volcaniclastic breccia as in Section 30-1.

18-65 cm: tuffaceous volcaniclastic breccia and tuff as in Section 30-1; somewhat coarser; parallel lamination

65-150 cm: volcaniclastic breccia as before, coarsening downwards. Maximum clast size at top <1 cm; at bottom 1.5 cm. Average size 0.3-0.6 cm.

Shipboard Data

Physical Properties:	**133-137 cm**
$\bar{V}p$ (km/s)	
parallel to beds	2.58
vertical to beds	2.62
Wet bulk density	2.03



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	30	3

Depth: 644.5 to 646.0 m

Visual Description

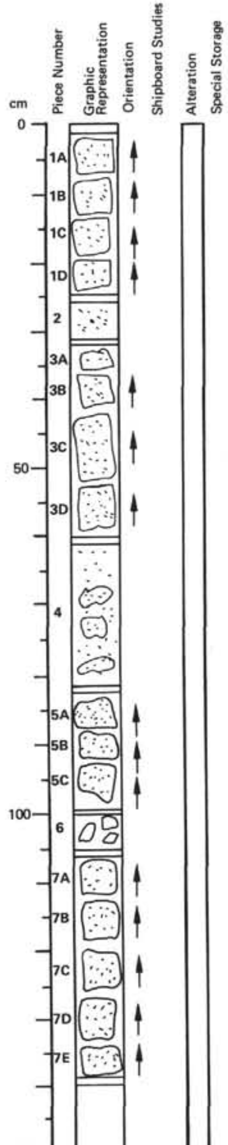
Volcaniclastic breccia as in Sections 30-1 and 30-2. Rare fragments of altered glass up to 1.5 cm.

Thin Section Description

Location: 41-44 cm, breccia matrix

Texture: fine-grained

Composition: altered glass with grains of plagioclase, magnetite/ilmenite



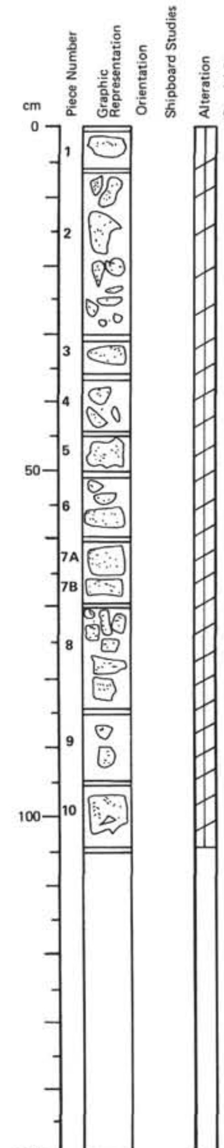
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	30	4

Depth: 646.0 to 647.3 m

Visual Description

Volcaniclastic breccia as before. From 82-100 cm a tuffaceous volcaniclastic breccia, with clast:matrix ratio 1:1.



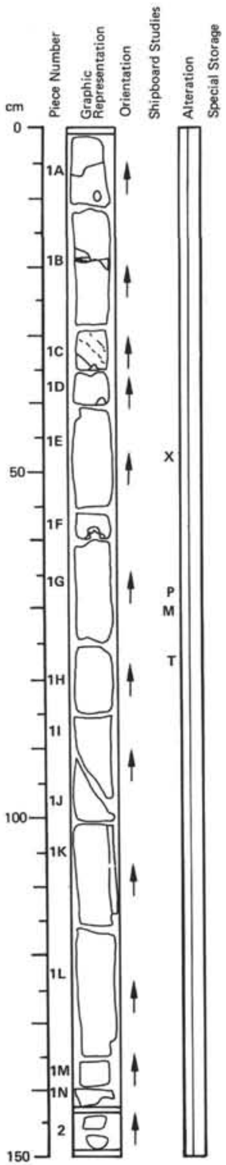
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	31	1

Depth: 651.0 to 652.0 m

Visual Description

Volcaniclastic breccia as in previous section, average clast size ~5 mm.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	32	1

Depth: 660.5 to 662.0 m

Visual Description

Aphyric basalt, flow, pale gray (5B 5/1), fine-grained holocrystalline, ophitic texture. Extensively altered, very soft. Clinopyroxene altered to pale blue smectite. Rare vesicles. Thin veins of native copper present.

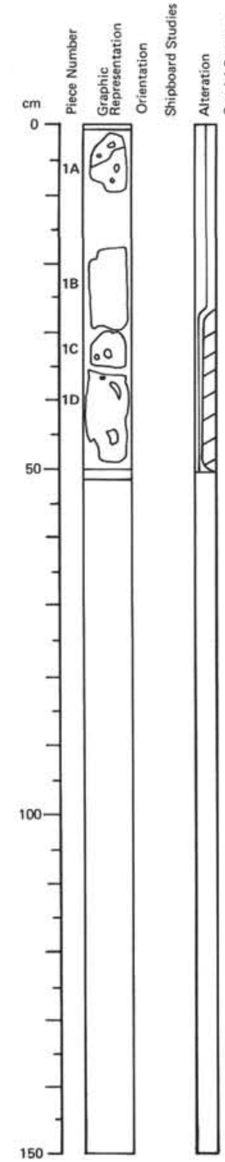
Thin Section Description

Location: 76-79 cm, flow interior
Texture: intersertal
Phenocrysts: none
Groundmass: 95%; plagioclase 35%, An_{60}, 0.05-0.5 mm, euhedral laths; clinopyroxene 35%, 0.05-0.3 mm, euhedral; magnetite/ilmenite rare, 0.01-0.1 mm; glass 20%
Vesicles: 5%
Alteration: 2%

Shipboard Data

Bulk Analysis:	**47 cm**
SiO_2	51.2
TiO_2	1.41
Al_2O_3	13.4
Fe_2O_3	1.69
FeO	11.14
MnO	0.18
MgO	6.19
CaO	8.29
Na_2O	3.10
K_2O	1.47
P_2O_5	0.10

Physical Properties:	**67-69 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.35
vertical to beds	3.37
Wet bulk density	2.85



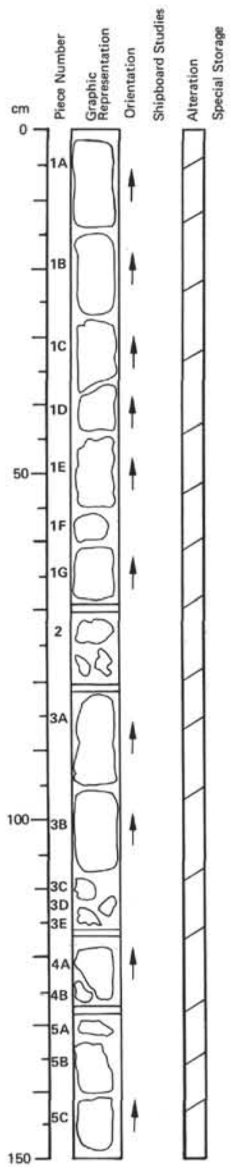
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	32	2

Depth: 662.0 to 662.5 m

Visual Description

Aphyric fine-grained basalt as in Section 32-1. Somewhat more vesicular, up to 0.5 mm.



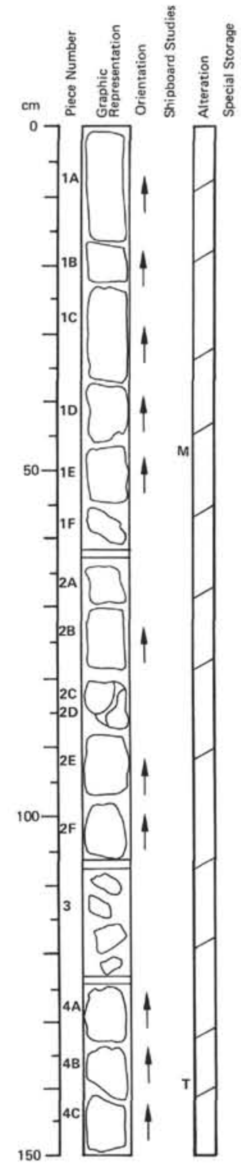
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	33	1

Depth: 663.5 to 665.0 m

Visual Description

Aphyric fine-grained basalt as in Section 32-2. Vesicles 1-3%, 1-2 mm average size; mostly empty. Irregular grains, ~0.2 mm, disseminated native copper present.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	33	2

Depth: 665.0 to 666.5 m

Visual Description

Aphyric basalt as in Section 33-1. Interval 50-110 cm slightly enriched in empty vesicles; rare vesicles filled with pale green (10G 6/2) ? clay. Disseminated copper as before. Slickensides on fractures are present.

Thin Section Description

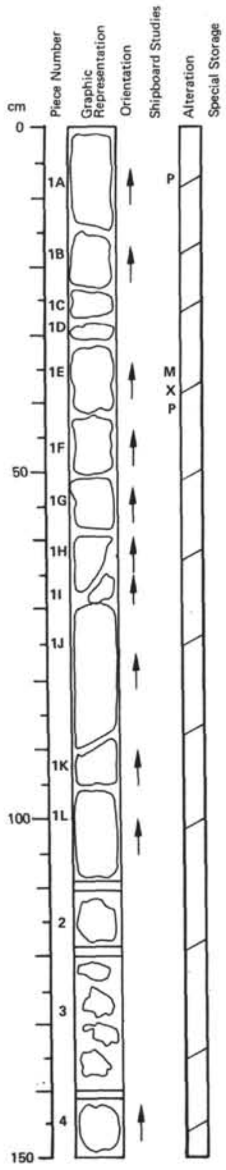
Location: 144-147 cm, flow interior

Texture: intersertal

Phenocrysts: < 1%; mostly plagioclase, 0.5-1.1 mm, prismatic; clinopyroxene rare, ~0.4 mm

Groundmass: >99%; plagioclase 30%, An_{50}, 0.05-0.5 mm, euhedral laths; clinopyroxene 30%, 0.04-0.5 mm, subhedral; magnetite/ilmenite rare, 0.01-0.1 mm; glass 30%

Alteration: 10%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	33	3

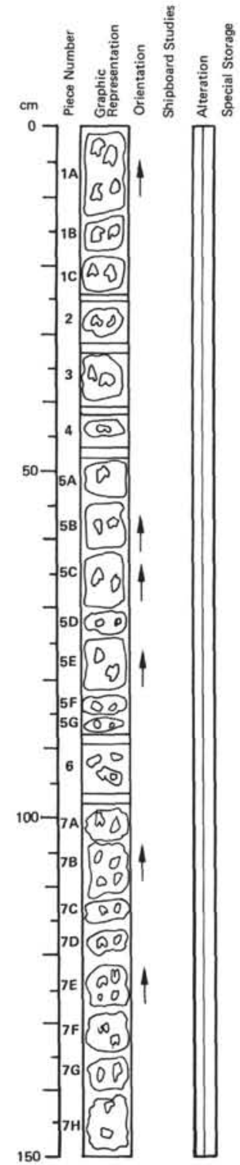
Depth: 666.5 to 667.8 m

Visual Description

Aphyric basalt flow as in previous sections.

Shipboard Data

Physical Properties:	2-13 cm	40-42 cm
$\overline{V}p$ (km/s)		
parallel to beds	4.04	4.30
vertical to beds	–	4.26



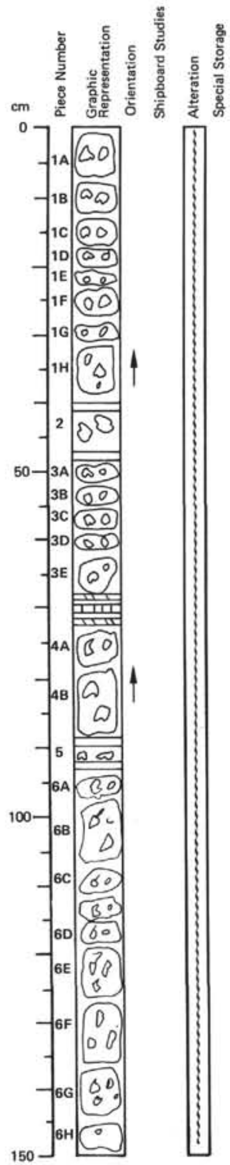
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	34	1

Depth: 670.0 to 671.5 m

Visual Description

Interbedded tuffaceous volcaniclastic breccia and volcaniclastic breccia, "green matrix." Clast:matrix ratio 1:1 to 2:1; clasts angular to subrounded, unsorted, unoriented; average size 0.5 cm, maximum size 1-2 cm; composed of aphyric and sparsely plagioclase phyric, fine-grained, moderately to highly altered basalt, most of which are highly (20-30%) vesicular. Matrix of fine basalt debris, volcanic glass, cemented with carbonate and ? zeolites.



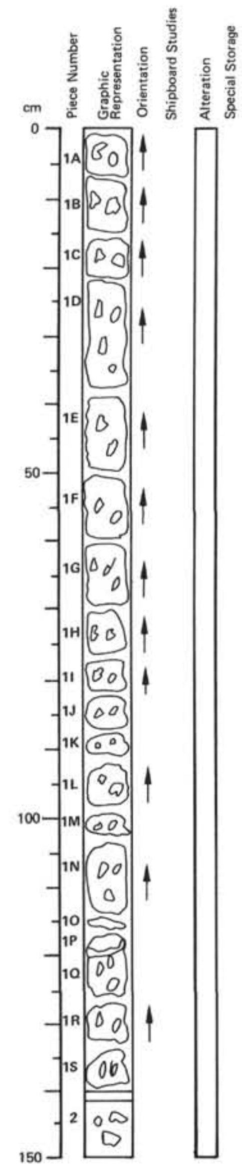
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	34	2

Depth: 671.5 to 673.0 m

Visual Description

Interbedded tuffaceous volcaniclastic breccia and volcaniclastic breccia as in Section 34-1.



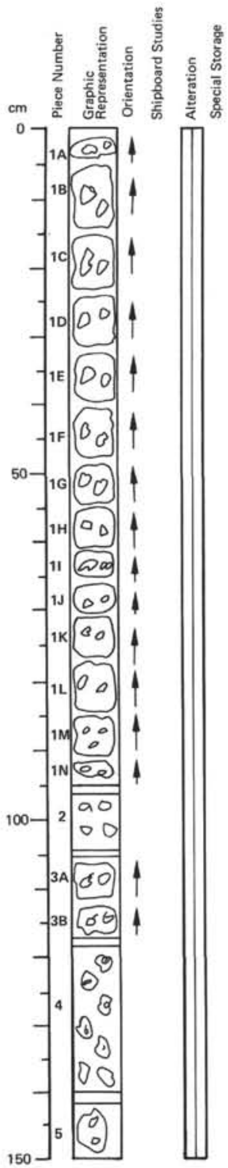
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	34	3

Depth: 673.0 to 674.5 m

Visual Description

Interbedded tuffaceous volcaniclastic breccia and volcaniclastic breccia as in Section 34-1.



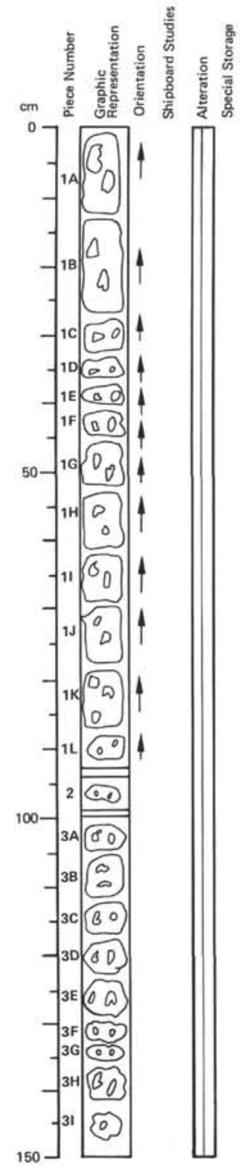
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	34	4

Depth: 674.5 to 676.0 m

Visual Description

Interbedded tuffaceous volcaniclastic breccia and volcaniclastic breccia as in Section 34-1.



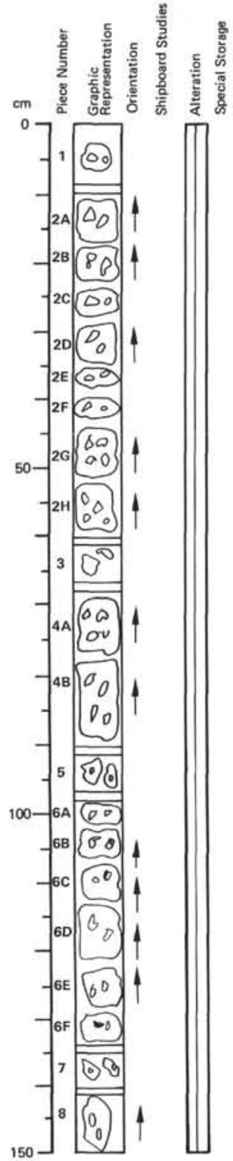
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	35	1

Depth: 679.5 to 681.0 m

Visual Description

Interbedded tuffaceous volcaniclastic breccia and volcaniclastic breccia as in Section 34-1.



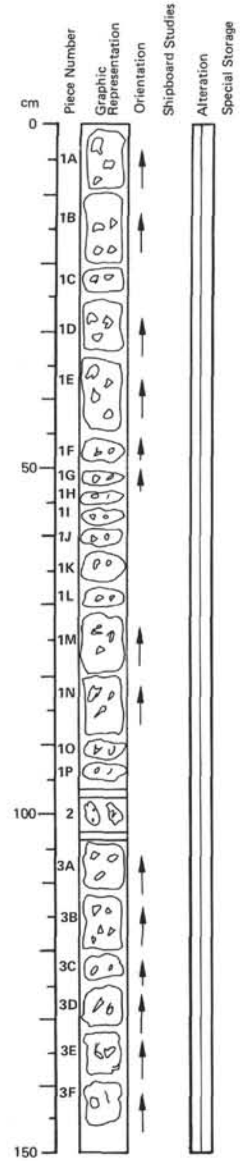
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	35	2

Depth: 681.0 to 682.5 m

Visual Description

Volcaniclastic breccia, "green matrix" as in previous sections. Clast:matrix ratio 3:1. Clasts angular to subrounded, average size 3x5 mm, composed of highly altered aphyric and vitrophyric basalts, highly vesicular. Matrix of same material, <0.5 mm size, cemented with zeolites.



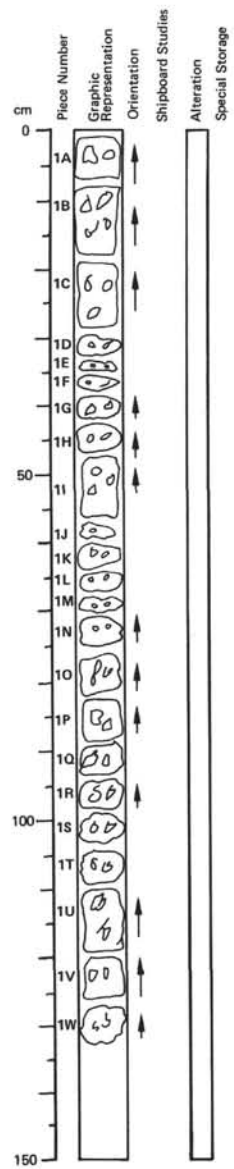
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	35	3

Depth: 682.5 to 684.0 m

Visual Description

Volcaniclastic breccia as in Section 35-2.

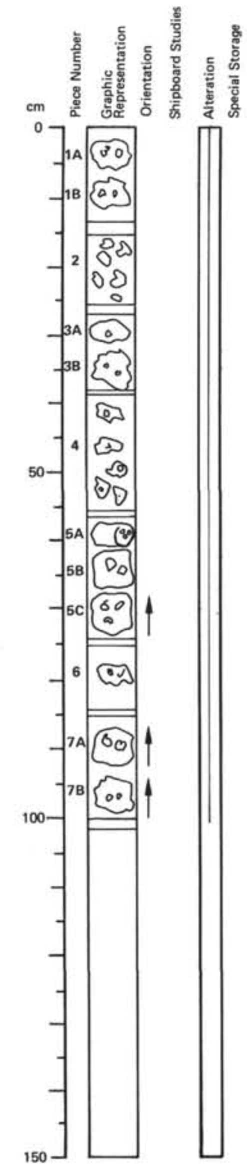


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE			SECT.
5	9	4	4	8	A		3	5	4

Depth: 684.0 to 685.5 m

Visual Description
Volcaniclastic breccia as in Section 35-2.

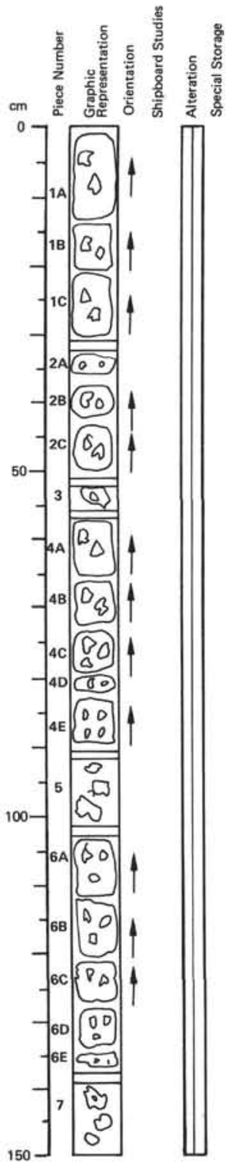


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE			SECT.
5	9	4	4	8	A		3	5	5

Depth: 685.5 to 687.0 m

Visual Description
Volcaniclastic breccia as in Section 35-2.



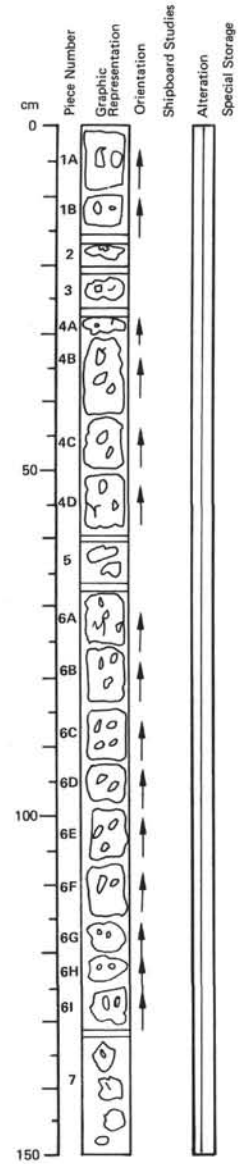
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	36	1

Depth: 685.0 to 690.5 m

Visual Description

Volcaniclastic breccia as in Section 35-2.



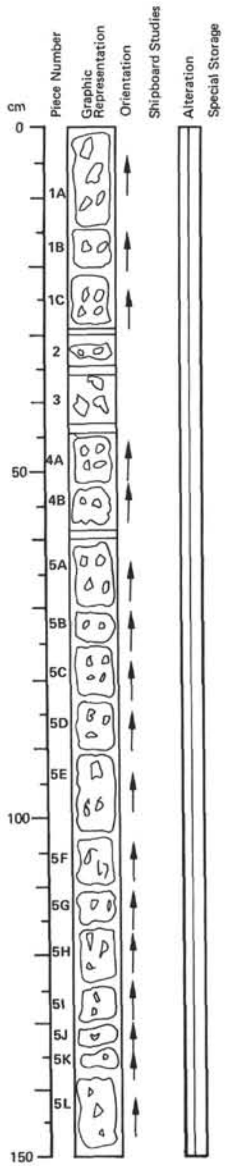
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	36	2

Depth: 690.5 to 692.0 m

Visual Description

Volcaniclastic breccia as in Section 35-2. Matrix becoming more abundant downward; rock trending to a tuffaceous volcaniclastic breccia.



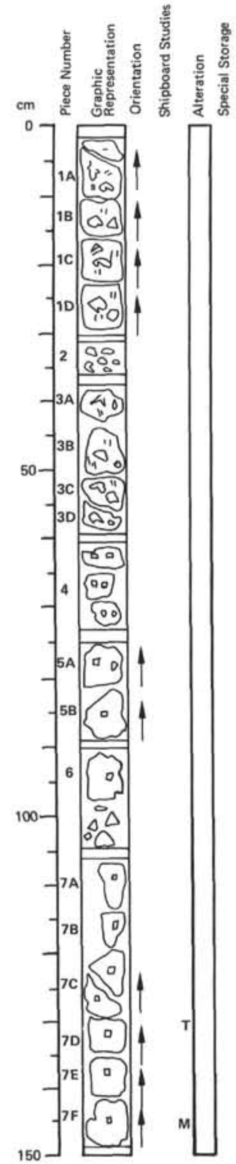
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	3	6	3

Depth: 692.0 to 693.5 m

Visual Description

Volcaniclastic breccia as in Section 35-2. Matrix becoming more abundant downward; rock trending to a tuffaceous volcaniclastic breccia.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	3	6	4

Depth: 693.5 to 695.0 m

Visual Description

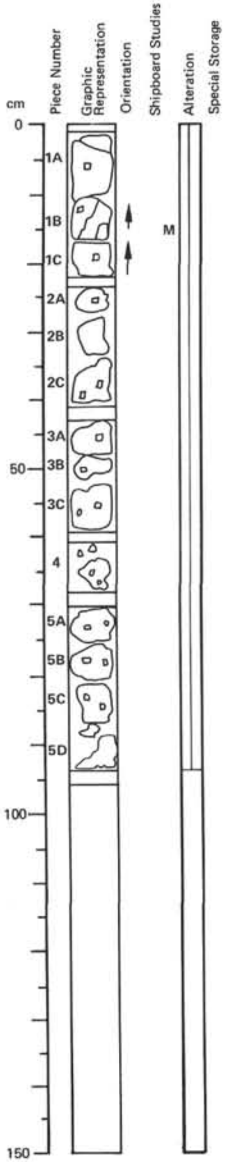
0-60 cm: tuffaceous volcaniclastic breccia. Clast:matrix ratio 1:2; clast size and composition unchanged through Cores 35 and 36.

60-150 cm: sparsely olivine-plagioclase-clinopyroxene-phyric basalt, flow; fine-grained, medium dark gray. Phenocrysts of olivine (1% of rock), 0.5-0.7 mm, completely replaced with green smectite (some may be orthopyroxene). Groundmass 70-80% crystallized, intersertal to subophitic, composed of plagioclase, clinopyroxene, glass and, possibly, olivine and orthopyroxene. Vesicles 15-20%, spheroidal, 0.3 mm average size, 0.7 maximum size, partially filled with carbonates and zeolites. Veins, ~0.5 mm thick, of carbonates and zeolites.

Thin Section Description

Location: 125-128 cm, flow interior
Texture: intersertal
Phenocrysts: <10%; plagioclase 30%, An_{60}, 0.4-1.1 mm, subhedral; clinopyroxene 10%, 0.4-1.0 mm; olivine 50%, 0.7-3.0 mm, pseudomorphs
Groundmass: >65%; plagioclase 50%, An_{45}, euhedral laths; clinopyroxene 25%; magnetite/ilmenite 15%; glass 10%
Vesicles: 25%, 0.1-0.4 average, 1.0-2.0 maximum, irregular shape
Alteration: 10% clay, filling vesicles

Shipboard Data



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

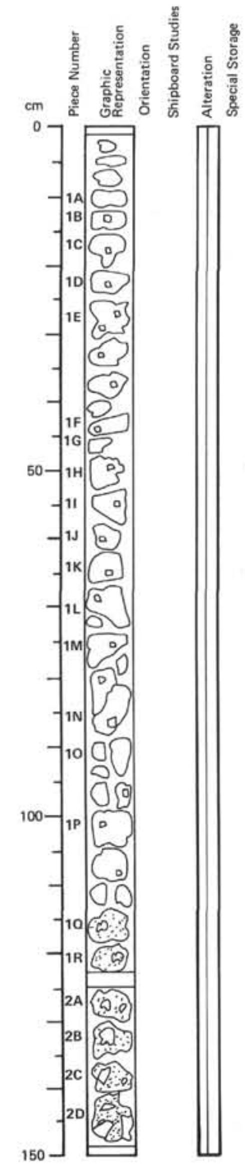
LEG	SITE	HOLE	CORE	SECT.
59	448	A	36	5

Depth: 695.0 to 696.5 m

Visual Description

Sparsely olivine-plagioclase-clinopyroxene-phyric to aphyric, fine-grained vesicular basalt flow, as in Section 36-4.

Shipboard Data



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

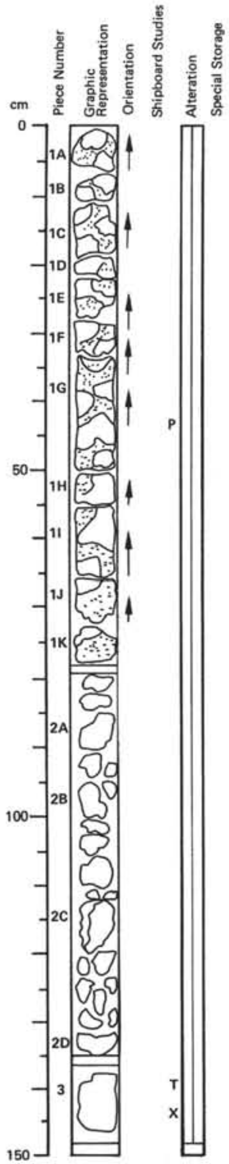
LEG	SITE	HOLE	CORE	SECT.
59	448	A	37	1

Depth: 698.5 to 700.0 m

Visual Description

0-100 cm: sparsely olivine-plagioclase-clinopyroxene-phyric basalt as in Section 36-5. Very fine-grained, dark gray (N5). Extensively altered and veined with carbonate and zeolites.

100-150 cm: cognate breccia of same basalt as above. Clast:matrix ration 5:1. Clast size average, 2-4 cm, with maximum 5 cm. Matrix green smectite (? altered glass), carbonate and zeolite cement.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	37	2

Depth: 700.0 to 701.5 m

Visual Description

Cognate basalt breccia as in lower part of Section 37-1, grading into more massive basalt (or extremely coarse breccia) in interval 80-150 cm. Clasts:matrix ratio 5:1; maximum size in upper half 5 cm; in lower half up to 20 cm. Matrix green altered glass.

Thin Section Description

Location: 138-141 cm, basalt clast

Texture: intersertal, aphyric

Groundmass: 80%; plagioclase 30%, An_{65}; clinopyroxene 35%; magnetite/ilmenite 15%; glass 20%

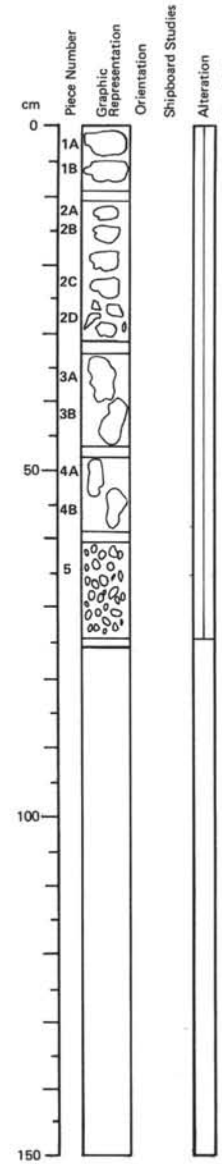
Vesicles: 20%, 0.1-1.0 mm, irregular shape, empty, or filled with smectite

Alteration: 10% clays, replacing glass and in vesicles

Shipboard Data

Bulk Analysis:	**145 cm**
SiO_2	50.0
TiO_2	1.63
Al_2O_3	12.6
Fe_2O_3	1.74
FeO	11.50
MnO	0.22
MgO	6.43
CaO	9.01
Na_2O	2.76
K_2O	1.16
P_2O_5	0.12

Physical Properties:	**35-50 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.52



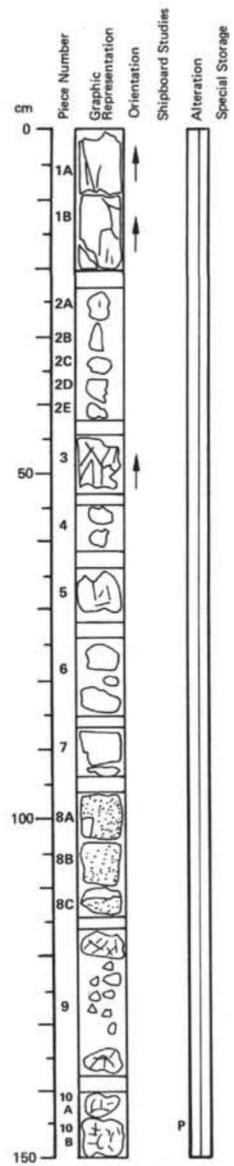
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	37	3

Depth: 701.5 to 702.0 m

Visual Description

Cognate breccia as in previous sections. Composed of aphyric basalt with flow aligned bands of vesicles filled with zeolites, blue smectite, and some with native copper.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	38	1

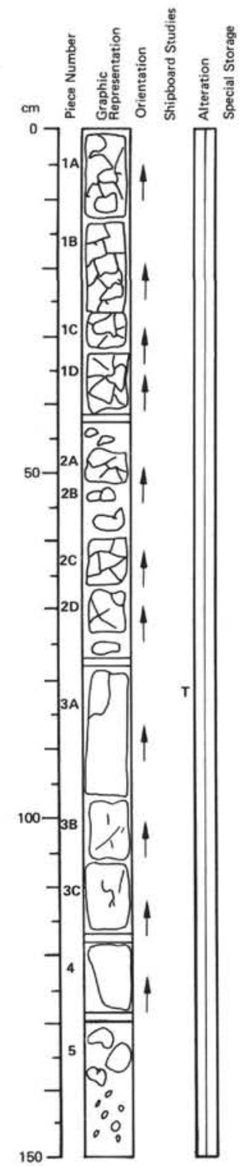
Depth: 708.0 to 709.5 m

Visual Description

Cognate breccia as in previous sections. Composed of aphyric to sparsely olivine phyric basalt. Clast:matrix ratio 10:1.

Shipboard Data

Physical Properties:	**144-150 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.48



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	38	2

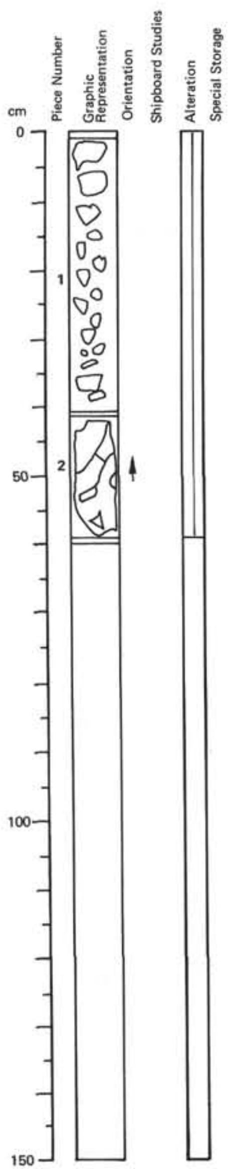
Depth: 709.5 to 711.0 m

Visual Description

Cognate breccia as in previous sections, becoming more massive down core.

Thin Section Description

Location: 81-84 cm, breccia clast
Texture: vitrophyric
Phenocrysts: plagioclase rare, ~0.7 mm, euhedral; clinopyroxene rare, ~0.8 mm subhedral
Groundmass: >75%; plagioclase 40%, An_{55}, subhedral laths; clinopyroxene 35%; glass 25%
Vesicles: 20%, 0.3-1.0 mm
Alteration: clays, 5% replace glass and in vesicles; rare carbonate



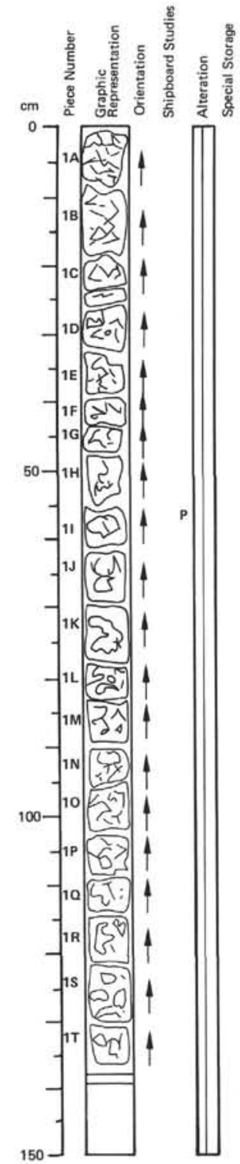
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	38	3

Depth: 711.0 to 712.5 m

Visual Description

Cognate breccia as in previous sections.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	39	1

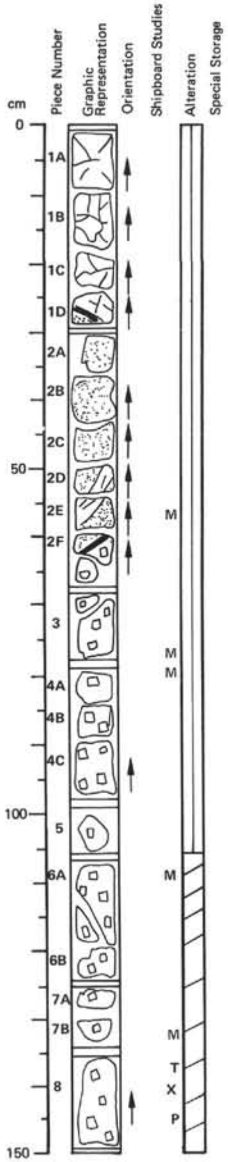
Depth: 712.5 to 714.0 m

Visual Description

Cognate breccia as in previous sections. Clast:matrix ratio 10-15:1, average size 2 cm, maximum size 5 cm. Cement with high proportion of carbonate and zeolite.

Shipboard Data

Physical Properties:	**54-60 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.68



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	39	2

Depth: 714.0 to 715.5 m

Visual Description

0-30 cm: cognate breccia as in previous sections.

30-60 cm: inter flow breccia; top and base with glass rims.

60-150 cm: plagioclase-phyric basalt, flow, very fine-grained, vesicular. Vesicles <5%, 1-2 mm, lined with green smectite. Plagioclase phenocrysts, glomeromorphic, 0.5-3 mm. Groundmass ?ophitic.

Thin Section Description

Location: 139-142 cm, flow interior

Texture: hyalopilitic

Phenocrysts: < 15%; plagioclase 80%, An_{64}, 0.4-2.5 mm, euhedral to subhedral; glomerocrysts; clinopyroxene 15%, 0.4-0.7 mm, subhedral

Groundmass: 70%; plagioclase 45%, An_{55}, euhedral laths; clinopyroxene 30%; magnetite/ilmenite 10%; glass 15%

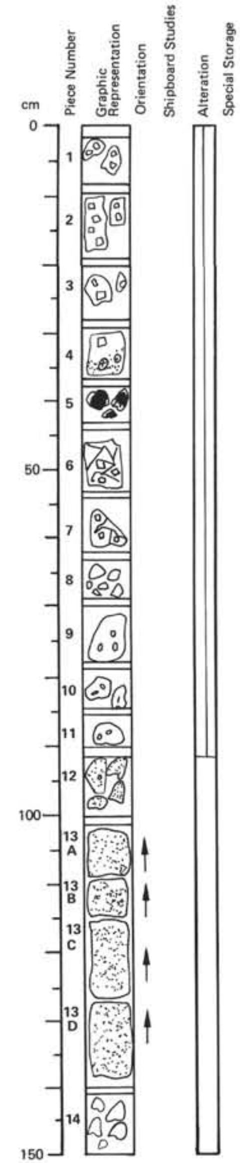
Vesicles: 15%, 0.2-0.5 mm and 1.0-3.0 mm, irregular

Alteration: 10% smectite, filling vesicles

Shipboard Data

Bulk Analysis:	**140 cm**
SiO_2	49.8
TiO_2	1.36
Al_2O_3	13.2
Fe_2O_3	1.56
FeO	11.42
MnO	0.22
MgO	5.61
CaO	9.21
Na_2O	4.55
K_2O	1.11
P_2O_5	0.16

Physical Properties:	**137-147 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.66



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

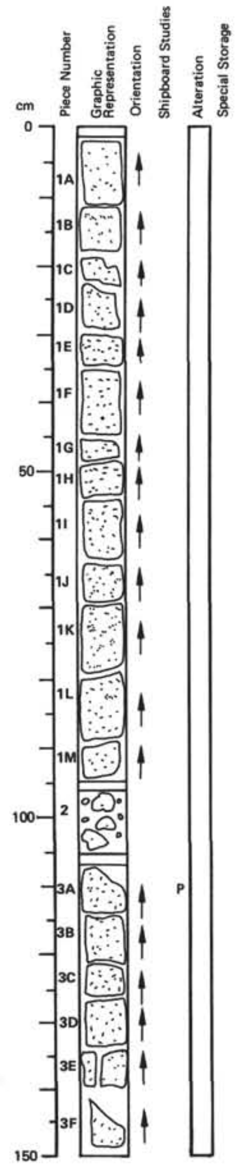
LEG	SITE	HOLE	CORE	SECT.
59	448	A	40	1

Depth: 717.5 to 719.0 m

Visual Description

0-90 cm: plagioclase-phyric basalt, flow, as in Section 39-2; brecciated from 45-90 cm. Variolitic texture at about 40 cm.

90-150 cm: volcaniclastic breccia, "green matrix." Clast:matrix ratio 5:1. Clasts average 0.5 cm, maximum 1.5 cm, composed of altered glass (90%), basalt (10%) in a dusky gray green (5G 7/5) smectite matrix cemented with carbonate and zeolites.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	40	2

Depth: 719.0 to 720.5 m

Visual Description

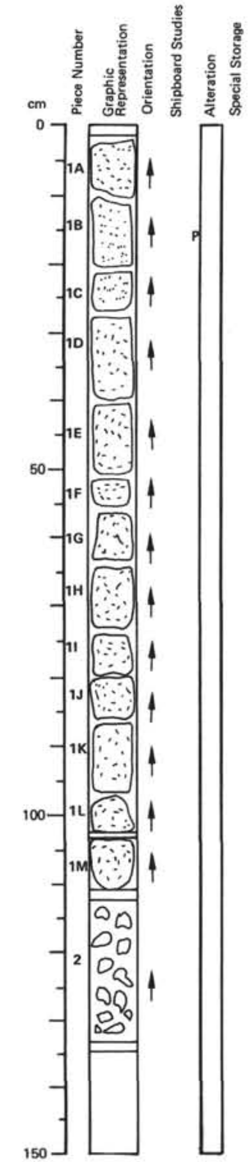
Volcaniclastic breccia as in Section 40-1. Clast:matrix ratio 5-7:1. Unsorted, unoriented.

Shipboard Data

Physical Properties: 107-115 cm

$\overline{V}p$ (km/s)

parallel to beds 2.72



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	40	3

Depth: 720.5 to 722.0 m

Visual Description

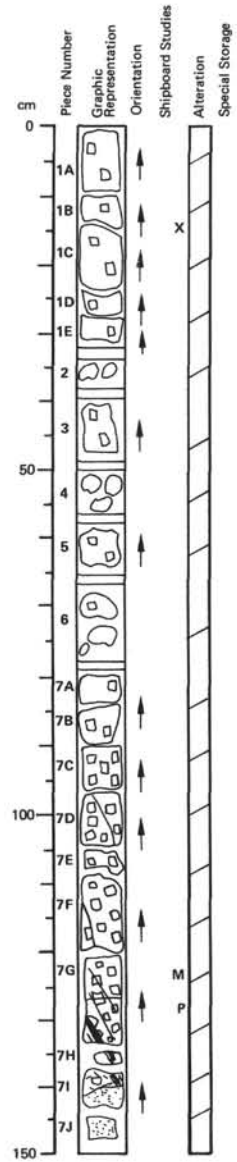
Volcaniclastic breccia as in Section 40-1. Clast:matrix ratio 5-7:1. Unsorted, unoriented.

Shipboard Data

Physical Properties: 8-18 cm

$\overline{V}p$ (km/s)

parallel to beds 2.58



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	41	1

Depth: 727.0 to 728.5 m

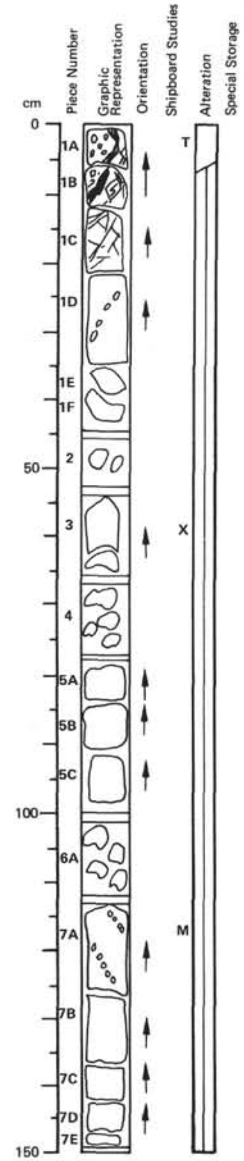
Visual Description

Plagioclase-phyric basalt, dike, with plagioclase phenocrysts, <10% of rock, up to 2 mm in size, averaging 0.5 mm; as glomerocrysts; increase in quantity downwards. Groundmass aphanitic to ophitic. Vesicles locally concentrated in bands that dip 70°; spheroidal, up to 2 mm in size, occupy 5% of rock; empty or lined with dark green smectite. Local brecciation in green smectite matrix, 130-140 cm.

Shipboard Data

Bulk Analysis:	**17 cm**
SiO_2	49.7
TiO_2	1.25
Al_2O_3	13.6
Fe_2O_3	1.61
FeO	10.65
MnO	0.21
MgO	6.70
CaO	9.15
Na_2O	2.64
K_2O	1.28
P_2O_5	0.17

Physical Properties:	**123-138 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.03



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	41	2

Depth: 728.5 to 730.0 m

Visual Description

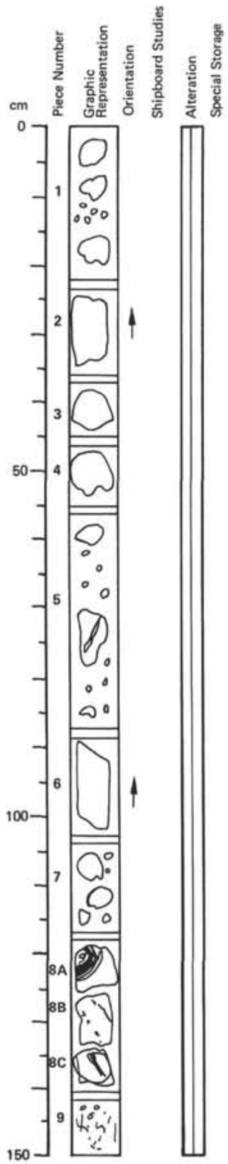
Basalt, dike, as in previous section but lacking plagioclase phenocrysts. Vesicles aligned as before at 70° dip.

Thin Section Description

Location: 0-3 cm, marginal zone of dike
Texture: vitrophyric
Phenocrysts: aphyric
Groundmass: 90%; plagioclase 15%, <0.5 mm, elongate laths; clinopyroxene ~5%, 0.2-0.3 mm, irregular and elongate grains; orthopyroxene 1%; magnetite/ilmenite 1%, <0.01 mm; glass 70%, palagonite, partly devitrified and altered
Vesicles: 10%, ~0.5 mm, irregular, mainly empty, some with carbonate and zeolites
Alteration: 3%, glass altered to carbonate, clays and zeolites

Shipboard Data

Bulk Analysis:	**58 cm**
SiO_2	49.9
TiO_2	1.14
Al_2O_3	12.6
Fe_2O_3	1.72
FeO	11.37
MnO	0.20
MgO	7.46
CaO	9.02
Na_2O	2.79
K_2O	0.81
P_2O_5	0.10



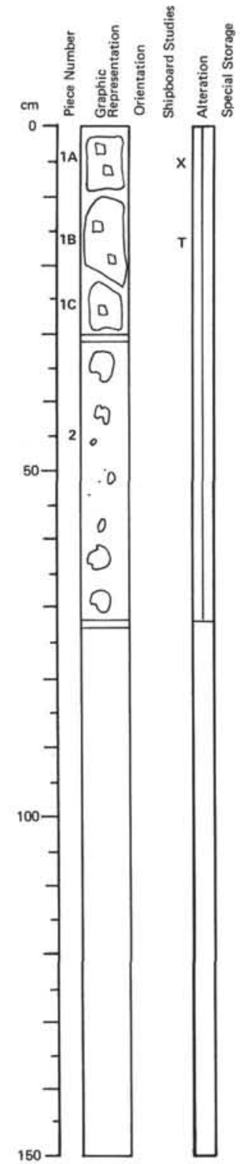
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	4	1	3

Depth: 730.0 to 731.5 m

Visual Description

Aphyric basalt, dike; fine-grained, aphanitic to intersertal. Vesicles, locally up to 5%, up to 1 mm, empty.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	4	1	4

Depth: 731.5 to 732.2 m

Visual Description

Plagioclase-phyric basalt, with phenocrysts <5% of rock, 1-2 mm, as glomerocrysts in fine-grained ophitic groundmass.

Thin Section Description

Location: 11-13 cm, base of dike

Texture: intersertal

Phenocrysts: <15%; plagioclase 80%, An_{75}, 1-2 mm, as glomerocrysts; clinopyroxene 10%, 0.5-1 mm, subhedral, as glomerocrysts with plagioclase; olivine 10%, 0.5-1 mm, subhedral, pseudomorphs

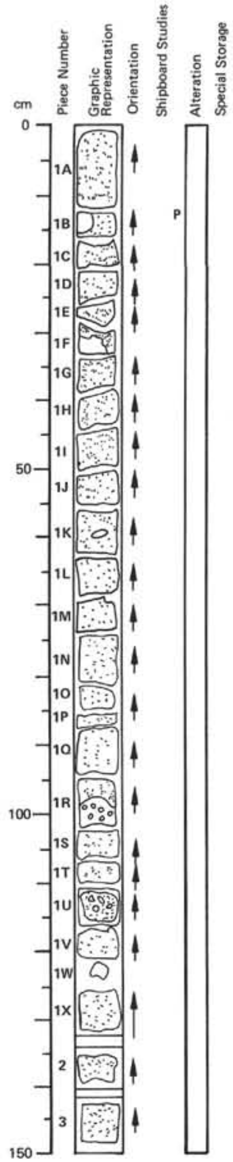
Groundmass: >75%; plagioclase 45%, 0.3-0.4 mm, laths; clinopyroxene 25%, 0.1-0.05 mm, irregular; orthopyroxene ~1%; magnetite/ilmenite ~5%, 0.05 mm cubic and irregular; glass 20%, mostly altered

Vesicles: 5-7%, 0.2-0.3 mm, irregular, mostly empty or lined with green smectite

Alteration: glass altered to smectite and zeolites

Shipboard Data

Bulk Analysis:	**4 cm**
SiO_2	50.5
TiO_2	1.43
Al_2O_3	13.1
Fe_2O_3	1.70
FeO	11.21
MnO	0.22
MgO	7.26
CaO	8.94
Na_2O	3.02
K_2O	0.50
P_2O_5	0.12



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	42	1

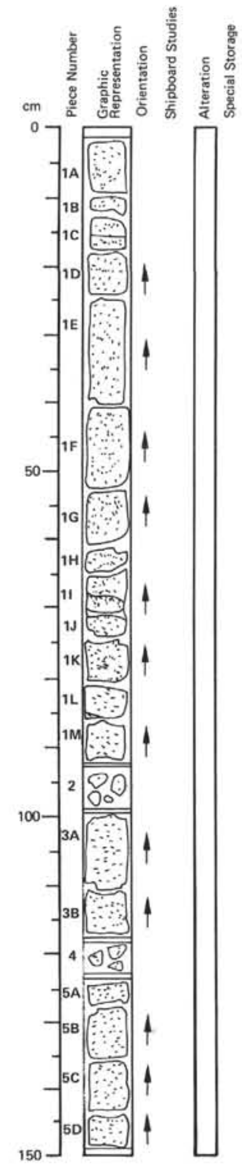
Depth: 736.5 to 738.0 m

Visual Description

Volcaniclastic breccia; clast:matrix ratio ~4:1. Clasts of altered basalt, glass (pumice) up to 7 cm, averaging ~1 cm, unsorted, unoriented, subangular to subrounded. Matrix greenish gray altered basalt and glass; some carbonate and zeolite cement.

Shipboard Data

Physical Properties:	**12-16 cm**
Vp (km/s)	
parallel to beds	2.84



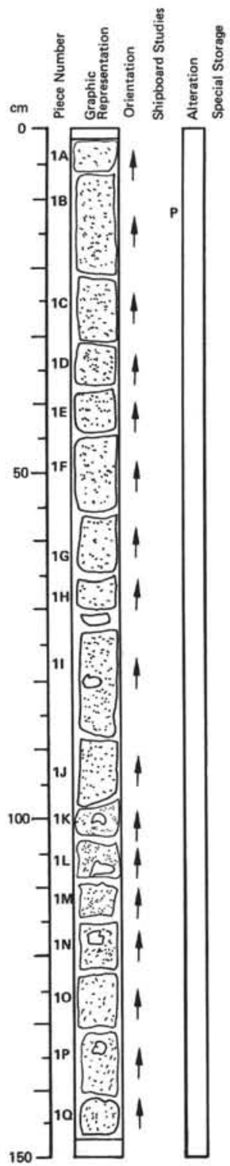
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	42	2

Depth: 738.0 to 739.5 m

Visual Description

Volcaniclastic breccia as in Section 42-1; maximum clast size 5 cm, average 1 cm.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	42	3

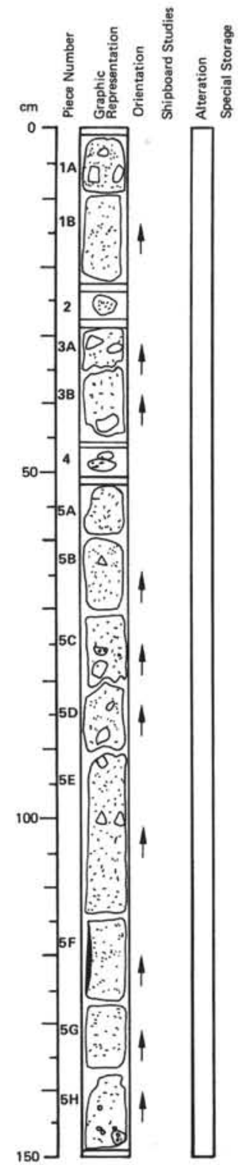
Depth: 739.5 to 741.0 m

Visual Description

Volcaniclastic breccia as in previous sections. Clast:matrix ratio 2-3:1. Clast size maximum 3 cm; average 0.25-0.5 cm.

Shipboard Data

Physical Properties:	4-20 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.63



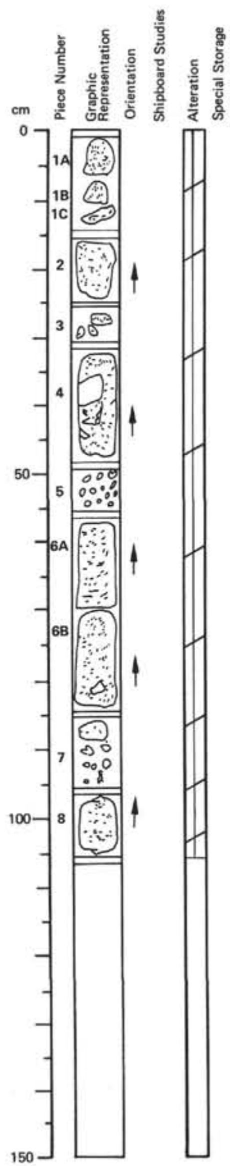
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	42	4

Depth: 741.0 to 742.5 m

Visual Description

Volcaniclastic breccia as before; average size smaller, 0.25 cm, in green matrix. Grades downward into tuffaceous volcaniclastic breccia.



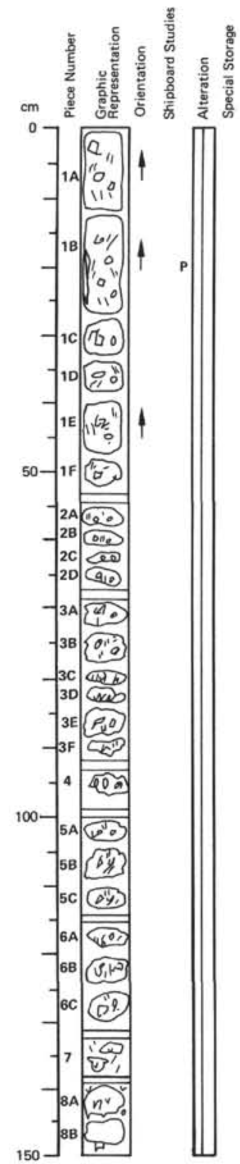
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE		HOLE	CORE		SECT.
5	9	4	4	8	A	4	2	5

Depth: 742.5 to 743.6 m

Visual Description

Tuffaceous volcaniclastic breccia; clasts maximum size ~3 cm, average <0.25 cm.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE		HOLE	CORE		SECT.
5	9	4	4	8	A	4	3	1

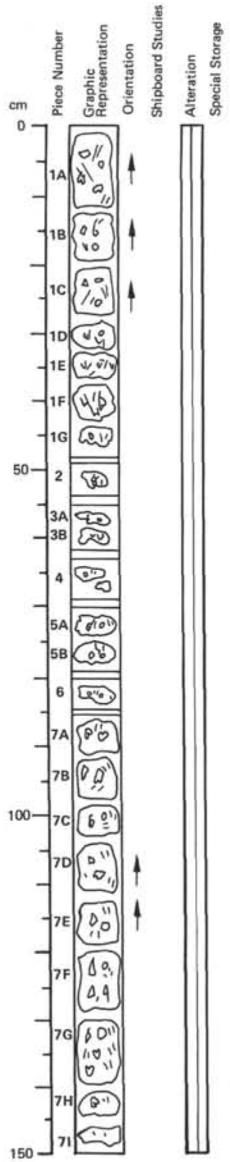
Depth: 746.0 to 747.5 m
(Hole deviation of 1.0° at 746.0 m)

Visual Description

Tuffaceous volcaniclastic breccia as in base of Section 42-5. Clasts average 3-4 mm, angular to subrounded, of altered vesicular basalt; rare clasts up to 3x4 cm, of relatively fresh, aphyric, fine-grained vesicular basalt. Matrix green, consisting of small, <0.1 mm, clasts of same basalts cemented with carbonates and zeolites.

Shipboard Data

Physical Properties:	**14-24 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.58



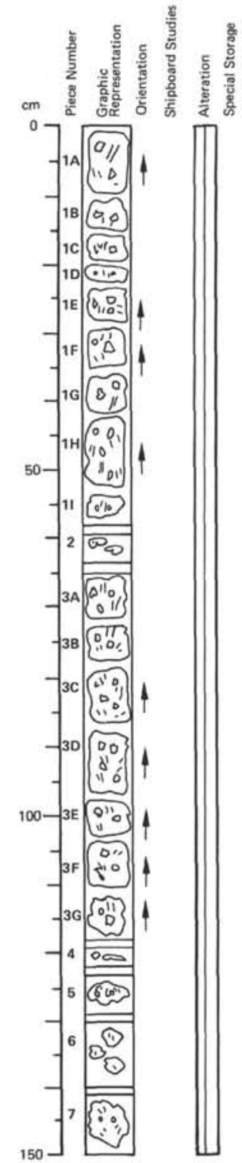
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	43	2

Depth: 747.5 to 749.0 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 43-1.



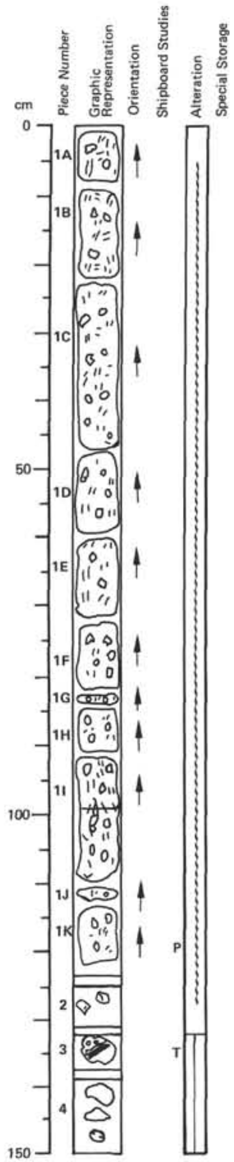
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	43	3

Depth: 749.0 to 750.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in previous sections.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	44	1

Depth: 755.5 to 757.0 m

Visual Description

0-130 cm: tuffaceous volcaniclastic breccia, as before, hydrothermally altered. Clasts:matrix ratio 2:1. Clasts of highly altered vitrophyric basalts, possibly basaltic andesites, mostly aphyric and vesicular, 3 mm average size, 2 cm maximum, angular to subangular, unsorted, unoriented. Matrix grayish buff tuff of altered glass and zeolites. Disseminated pyrite, ~0.01 mm.

130-150 cm: aphyric to sparsely plagioclase-phyric basalt, gray, vesicular.

Thin Section Description

Location: 131-136 cm, glassy margin

Texture: vitrophyric

Phenocrysts: <10%; plagioclase 80%, An_{60}, 0.4-3.0 mm, euhedral; clinopyroxene <20%, 0.3-0.5 mm, subhedral

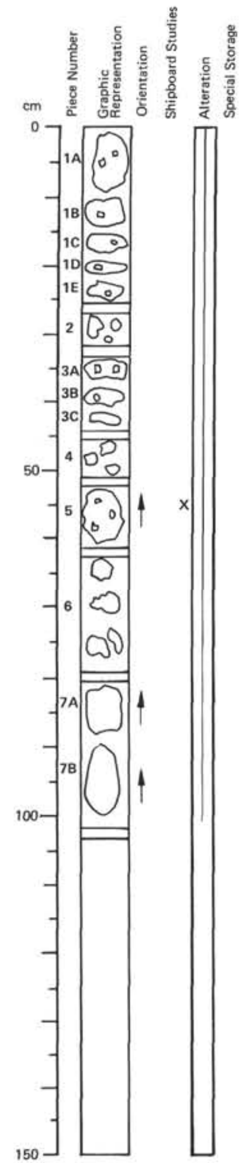
Groundmass: >70%; plagioclase 45%, An_{55}, laths; clinopyroxene 10%, subhedral; magnetite/ilmenite 20%; glass 25%

Vesicles: 20%, 0.5-1.0 mm, subspheroidal

Alteration: 50%, glass altered to clays

Shipboard Data

Physical Properties:	**112-123 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.62



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	44	2

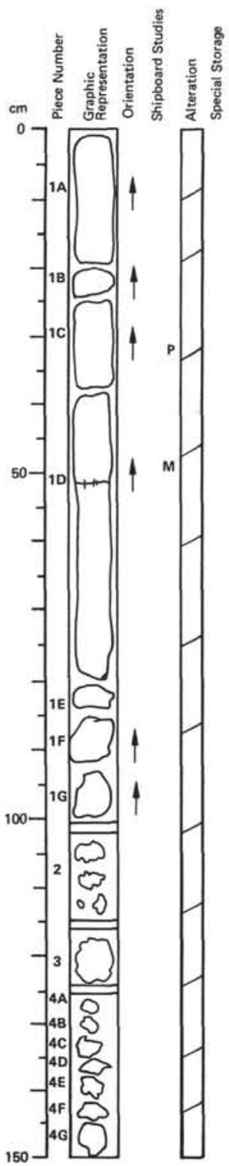
Depth: 757.0 to 758.0 m

Visual Description

Sparsely plagioclase-phyric vesicular basalt. Plagioclase phenocrysts, 1-3% of rock, 1-2 mm in groundmass ~80% crystallized, consisting of plagioclase laths, clinopyroxene elongate prisms, and intergranular glass. Some olivine and orthopyroxene may be present. Vesicles ~15%, 0.1-0.5 mm, mostly empty. Pyrite occurs along ~0.1-0.5 mm wide veins.

Shipboard Data

Bulk Analysis:	**55 cm**
SiO_2	54.5
TiO_2	1.49
Al_2O_3	13.0
Fe_2O_3	1.55
FeO	10.23
MnO	0.22
MgO	5.85
CaO	7.55
Na_2O	2.94
K_2O	0.36
P_2O_5	0.12



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	45	1

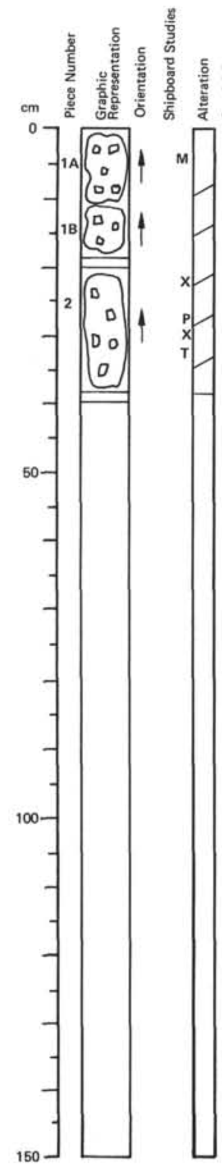
Depth: 765.0 to 766.5 m

Visual Description

Sparsely plagioclase-phyric basalt as in Section 44-2. Brecciated zone (? interflow) at 100-150 cm.

Shipboard Data

Physical Properties:	**29-37 cm**
$\overline{V}p$ (km/s)	
parallel to beds	3.29



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	45	2

Depth: 766.5 to 768.0 m

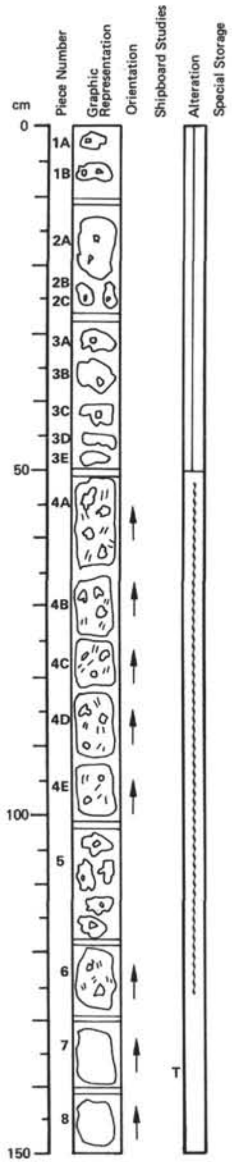
Visual Description

Sparsely plagioclase-phyric basalt as in Sections 44-2 and 45-1. Vesicles ~20%, mostly filled with carbonates, zeolites and dark green smectite.

Shipboard Data

Bulk Analysis:	**22 cm**
SiO_2	52.1
TiO_2	1.36
Al_2O_3	13.9
Fe_2O_3	1.50
FeO	9.91
MnO	0.19
MgO	6.16
CaO	9.48
Na_2O	2.46
K_2O	0.20
P_2O_5	0.09

Physical Properties:	**27-30 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.17
vertical to beds	4.08
Wet bulk density	2.31



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	46	1

Depth: 768.0 to 769.5 m

Visual Description

0-50 cm: sparsely plagioclase-phyric basalt as in Section 45-2.

50-130 cm: green tuffaceous volcaniclastic breccia and tuff; clasts 2-6 mm, angular to subangular, of altered vesicular basalts cemented in carbonates and zeolites. Unit has undergone extreme hydrothermal alteration and replaced with green and brown clays; disseminated pyrite is common.

130-150 cm: sparsely plagioclase-phyric basalt flow, 80% crystallized, with hyalopilitic texture. Vesicles absent.

Thin Section Description

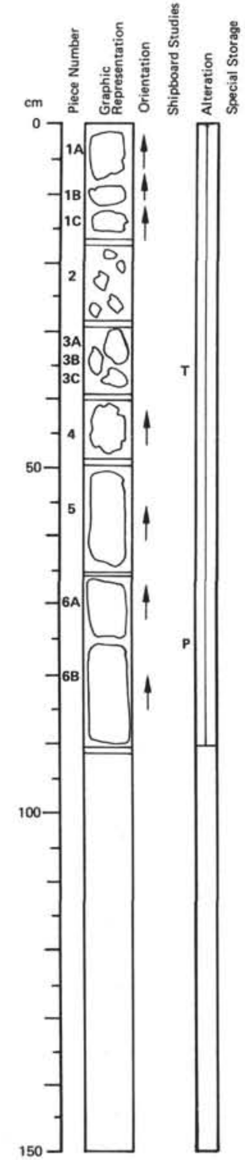
Location: 145-148 cm, next to glassy margin

Texture: intersertal

Phenocrysts: <1%; mostly plagioclase, An_{56}, 0.4-1.1 mm, euhedral to subhedral; clinopyroxene rare, 0.1-0.5, subhedral

Groundmass: >99%; plagioclase 45%, 0.01-0.2 mm; clinopyroxene 35%, 0.01-0.05 mm; magnetite/ilmenite, 0.01-0.03 mm; glass 15%

Alteration: clays 10%



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	46	2

Depth: 469.5 to 471.0 m

Visual Description

Plagioclase-phyric basalt, fine-grained, medium dark gray. A continuation of basalt from Section 46-2 but coarser in texture, 90% crystalline, subophitic. Flow is fractured and slickensided; fractures filled with carbonates and zeolites, sometimes rimmed along contacts with dark yellowish green smectite.

Thin Section Description

Location: 34-39 cm, flow interior

Texture: intersertal

Phenocrysts: 20%; plagioclase An_{65}, 0.4-2.5 mm, euhedral to subhedral, glomerocrysts

Groundmass: 70%; plagioclase 40%, An_{50}, 0.04-0.4 mm, laths; clinopyroxene 15%, 0.02-0.3 mm, subhedral; magnetite/ilmenite 15%; glass 25%

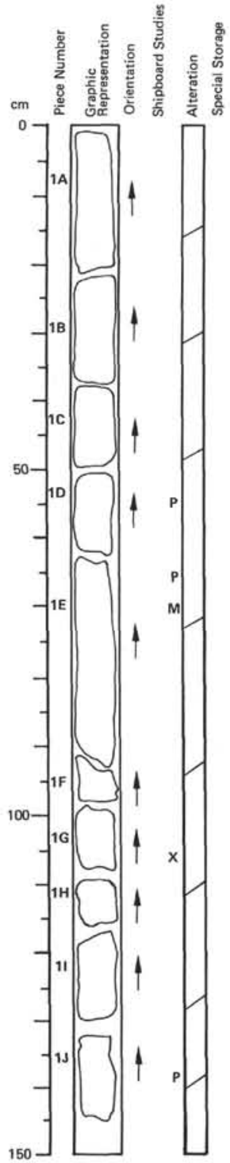
Vesicles: 10%, 0.5-2 mm

Alteration: carbonate 5%, replacing clinopyroxene and in vesicles; clays 5% in vesicles

Shipboard Data

Bulk Analysis:	**82 cm**
SiO_2	54.7
TiO_2	1.21
Al_2O_3	13.5
Fe_2O_3	1.58
FeO	10.45
MnO	0.18
MgO	5.71
CaO	7.75
Na_2O	2.81
K_2O	0.34
P_2O_5	0.10

Physical Properties:	**72-79 cm**
$\bar{V}p$ (km/s)	
parallel to beds	3.48



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	47	1

Depth: 774.5 to 776.0 m

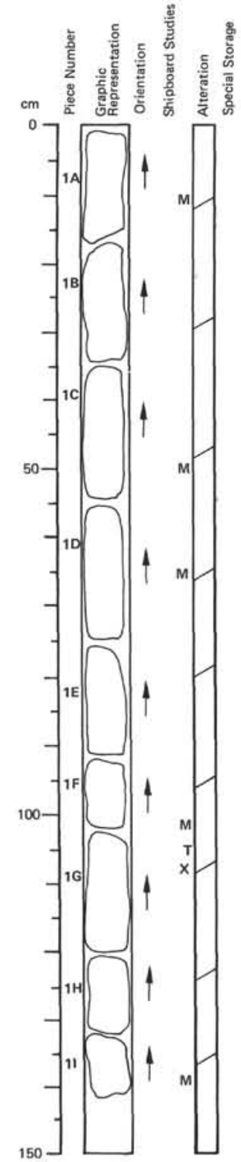
Visual Description

Plagioclase-phyric basalt flow as in Section 46-2. Thin (0.1-0.5 cm) subparallel dark bands oblique to core axis, separated by 5-7 cm lighter bands, represent concentration of darker mafic constituents.

Shipboard Data

Bulk Analysis:	**10 cm**
SiO_2	48.3
TiO_2	1.55
Al_2O_3	13.9
Fe_2O_3	1.91
FeO	12.60
MnO	0.25
MgO	3.84
CaO	9.52
Na_2O	2.92
K_2O	0.79
P_2O_5	0.41

Physical Properties:	**51-61 cm**	**64-67 cm**	**136-145 cm**
$\overline{V}p$ (km/s)			
parallel to beds	4.86	4.87	5.15
vertical to beds	–	4.84	–
Wet bulk density	–	–	2.72



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	47	2

Depth: 776.0 to 777.5 m

Visual Description

Plagioclase-phyric basalt as in Section 47-2.

Thin Section Description

Location: 106-108 cm, flow interior

Texture: hyalopilitic

Phenocrysts: 5%; plagioclase 85%, An_{60}, 0.4-2.0 mm, euhedral to subhedral; clinopyroxene 15%, 0.4-1.5 mm, euhedral to subhedral

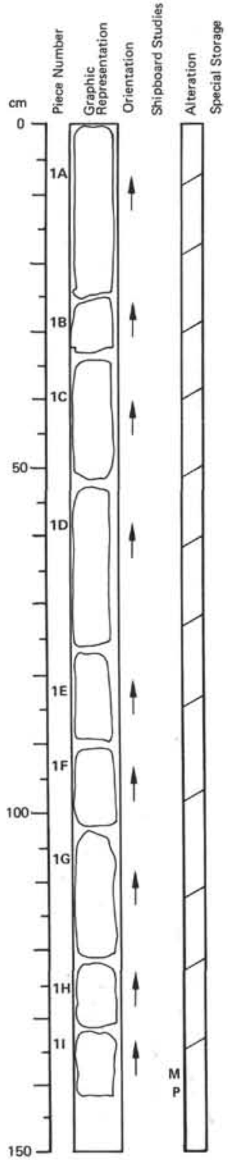
Groundmass: >90%; plagioclase 35%, An_{56}, 0.04-0.4 mm, laths; clinopyroxene 20%, 0.02-0.4 mm, subhedral; magnetite/ilmenite 1%, 0.01-0.2 mm; glass 40%

Vesicles: 2%, ~0.5 mm

Alteration: 15% of glass altered to clays

Shipboard Data

Bulk Analysis:	**106 cm**
SiO_2	55.0
TiO_2	1.23
Al_2O_3	13.5
Fe_2O_3	1.65
FeO	10.91
MnO	0.18
MgO	5.59
CaO	7.74
Na_2O	2.84
K_2O	0.32
P_2O_5	0.10



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

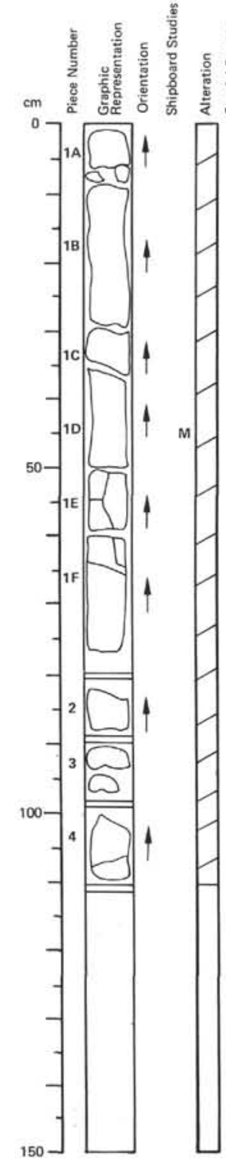
LEG	SITE	HOLE	CORE	SECT.
59	448	A	47	3

Depth: 777.5 to 779.0 m

Visual Description
Plagioclase-phyric basalt as in sections immediately above.

Shipboard Data

Physical Properties:	**145-147 cm**
$\bar{V}p$ (km/s)	
parallel to beds	4.88
vertical to beds	4.87
Wet bulk density	2.72



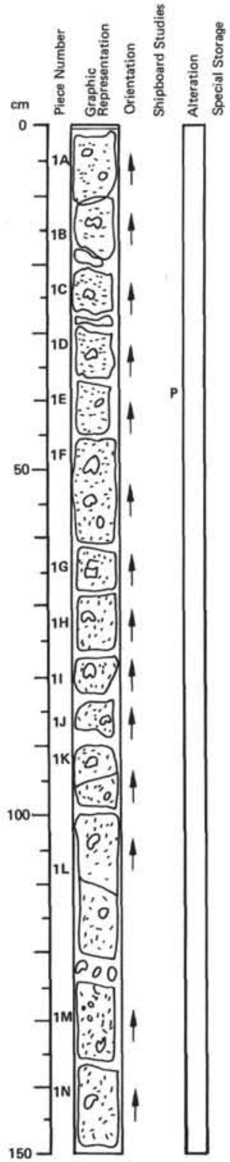
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	48	1

Depth: 779.0 to 780.5 m

Visual Description
Plagioclase-phyric basalt as in sections immediately above.

Shipboard Data



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	49	1

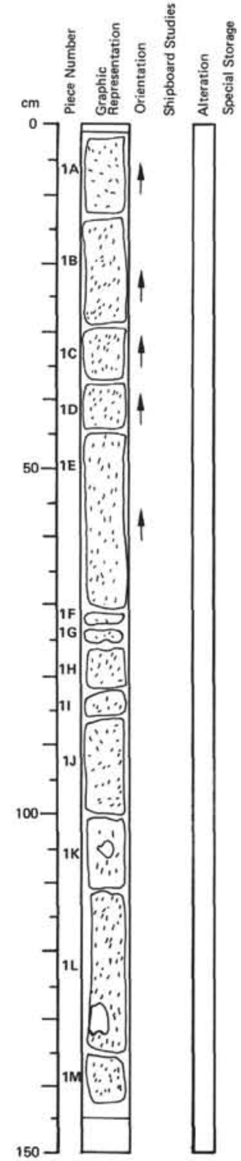
Depth: 783.0 to 784.5 m

Visual Description

Volcaniclastic breccia, "green matrix." Clast:matrix ratio 5:1. Clasts average 1 cm, maximum 3 cm, angular, composed of basalt (25%) and altered glass (75%). Matrix dark green with pale brown (5GY 2/1) smectite patches.

Shipboard Data

Physical Properties:	**36-43 cm**
$\overline{V}$p (km/s)	
parallel to beds	2.62



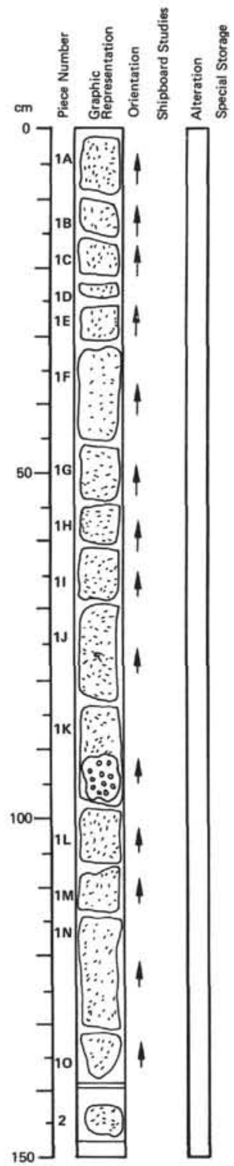
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	49	2

Depth: 784.5 to 786.0 m

Visual Description

Volcaniclastic breccia as in Section 49-1.



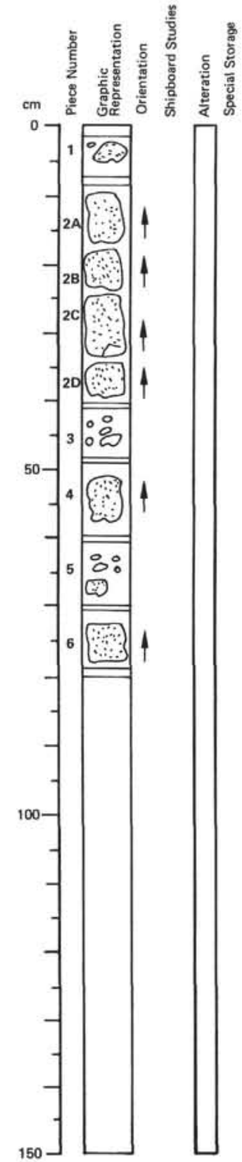
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	49	3

Depth: 786.0 to 787.5 m

Visual Description

Volcaniclastic breccia as in Section 49-1.



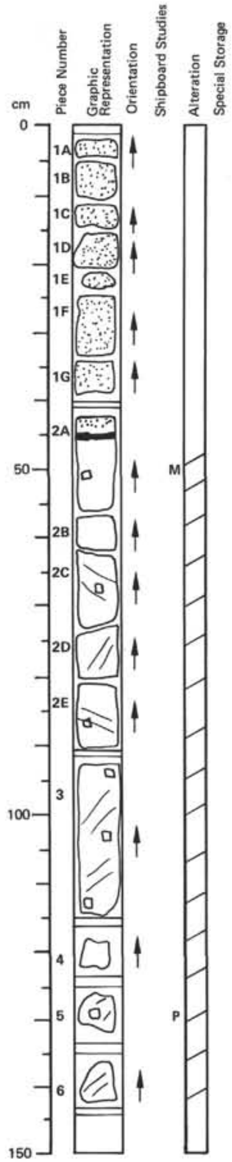
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	49	4

Depth: 787.5 to 788.3 m

Visual Description

Volcaniclastic breccia as in Section 49-1.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	50	1

Depth: 792.5 to 794.0 m

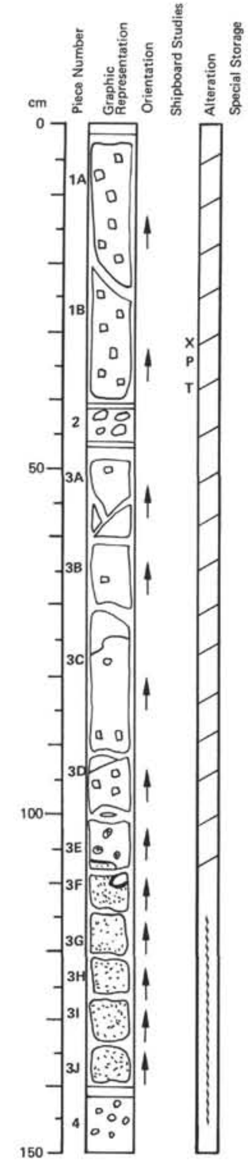
Visual Description

0-45 cm: volcaniclastic breccia as in immediately previous sections.

45-145 cm: sparsely plagioclase-phyric basalt, sill; intrusive contact with overlying breccia well preserved, dipping ~60°. Phenocrysts of plagioclase <5% of rock, 1-2 mm as glomerocrysts. Groundmass aphanitic to fine-grained in bands 2-4 cm wide, dipping 60°. Vesicles aligned along 60° dip, filled with dark green smectite.

Shipboard Data

Physical Properties:	**126-132 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.71



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	50	2

Depth: 794.0 to 795.5 m

Visual Description

0-110 cm: plagioclase-phyric basalt, sill, as in Section 50-1.

110-150 cm: volcaniclastic breccia as in Sections 49-1 to 49-4.

Thin Section Description

Location: 33-38 cm, sill interior

Texture: hyalopilitic

Phenocrysts: <15%; plagioclase 85%, An_{64}, 0.5-2.0 mm, euhedral to subhedral; clinopyroxene 15%, 0.4-1.0 mm, subhedral

Groundmass: >80%; plagioclase 50%; An_{45}, euhedral laths; clinopyroxene 30%, subhedral; magnetite/ilmenite 5%; glass 15%

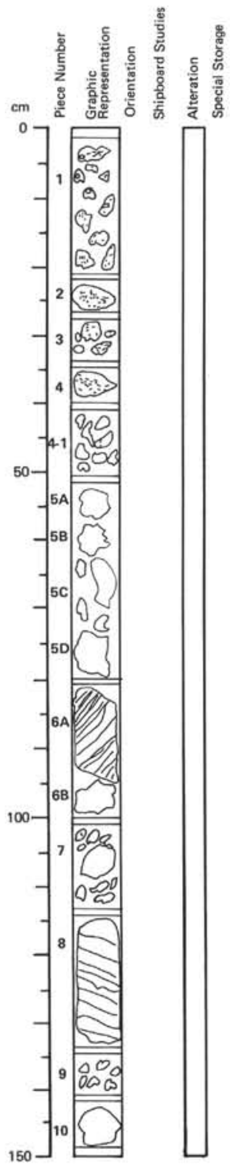
Vesicles: 2%, ~0.5 mm, spheroidal, empty

Alteration: 15% clays (smectite) replacing glass

Shipboard Data

Bulk Analysis:	**35 cm**
SiO_2	53.3
TiO_2	1.45
Al_2O_3	12.8
Fe_2O_3	1.66
FeO	10.99
MnO	0.24
MgO	5.44
CaO	8.33
Na_2O	2.55
K_2O	0.30
P_2O_5	0.11

Physical Properties:	**31-33 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.52
vertical to beds	4.61
Wet bulk density	2.67



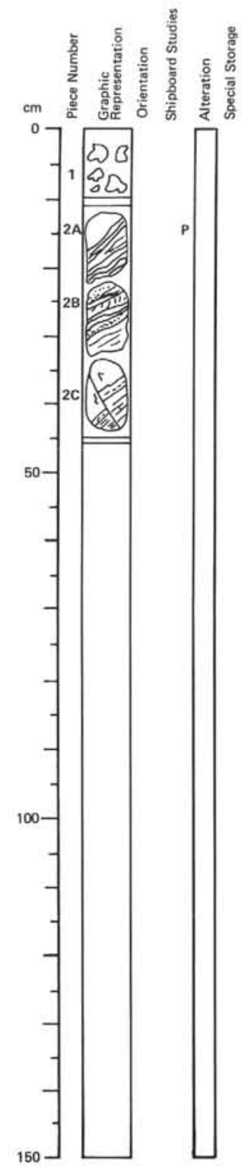
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	50	3

Depth: 795.5 to 797.0 m

Visual Description

Volcaniclastic breccia as in Section 50-2, grading downward to dark greenish gray (5G 4/1) to medium bluish gray (5B 5/1) laminated fine vitric tuff. Grain size silt to coarse silt; laminae lenticular (mm-cm thick), wavy and festoon.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	50	4

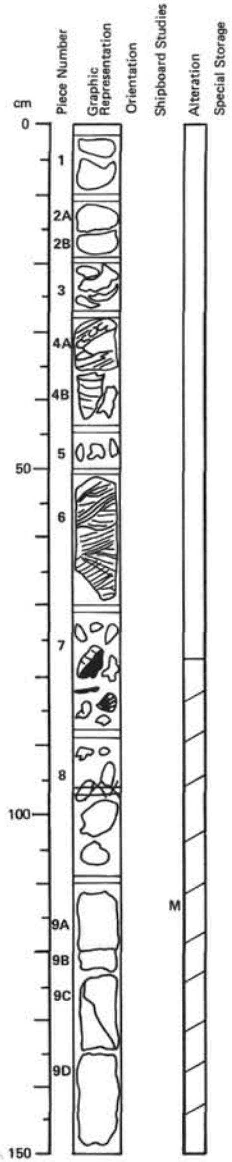
Depth: 797.0 to 798.5 m

Visual Description

Vitric tuff and fine vitric tuff, medium bluish gray (5B 5/1), thinly laminated with lighter bluish gray. Laminations parallel, slightly deformed by syn-sedimentary processes; some convoluted laminae as well as lenticular lamination. Local normal grading, medium to coarse sand-size with 20% gravel size glass at base of bed. Load casts at top; one normal fault. Lamine dip 60°.

Shipboard Data

Physical Properties:	**11-23 cm**
$\bar{V}p$ (km/s)	
parallel to beds	2.53



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	51	1

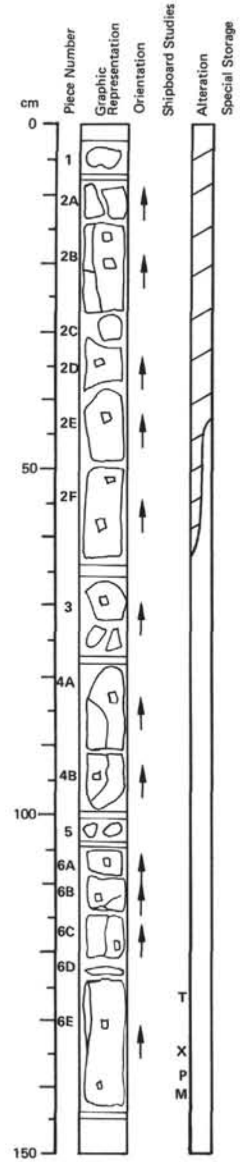
Depth: 801.5 to 803.0 m

Visual Description

0-75 cm: fine vitric tuff, grayish blue green (5BG 5/2), medium to coarse silt-size grains, with lenticular and disturbed bedding, and cross-bedding and cross-lamination. Laminae sets truncated sharply by overlying sets at 20-30°.

75-150 cm: sparsely plagioclase-phyric basalt, dike; in sharp contact with overlying tuff. Phenocrysts of plagioclase, <1% of rock, ~1 mm, in groundmass, 80-90% crystalline, fine-grained, intersertal. Vesicles <3%, ~1 mm filled with green smectite.

Shipboard Data



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	51	2

Depth: 803.0 to 804.5 m

Visual Description

Sparsely plagioclase-phyric basalt as in lower part of Section 51-1, but coarser-grained and with fewer vesicles.

Thin Section Description

Location: 128-131 cm, dike interior

Texture: hyalopilitic

Phenocrysts: <10%; plagioclase 85%, An_{68}, 0.4-2.0 mm, euhedral; clinopyroxene 15%, 0.4-0.6 mm, subhedral

Groundmass: >85%; plagioclase 45%, An_{45}, ~0.5 mm, euhedral laths; clinopyroxene 30%, subhedral; magnetite/ilmenite 10%, glass 15%

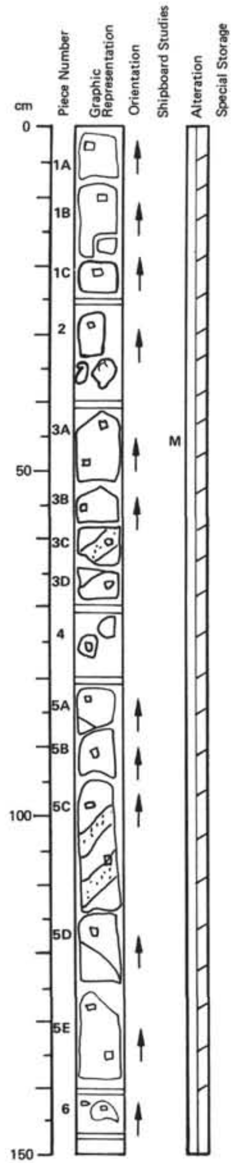
Vesicles: 2%, ~0.2 mm, spheroidal

Alteration: glass altered to smectite

Shipboard Data

Bulk Analysis:	**134 cm**
SiO_2	54.8
TiO_2	1.27
Al_2O_3	12.8
Fe_2O_3	1.64
FeO	10.79
MnO	0.20
MgO	5.97
CaO	7.69
Na_2O	2.58
K_2O	0.25
P_2O_5	0.09

Physical Properties:	**138-141 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.49
vertical to beds	4.43
Wet bulk density	2.60



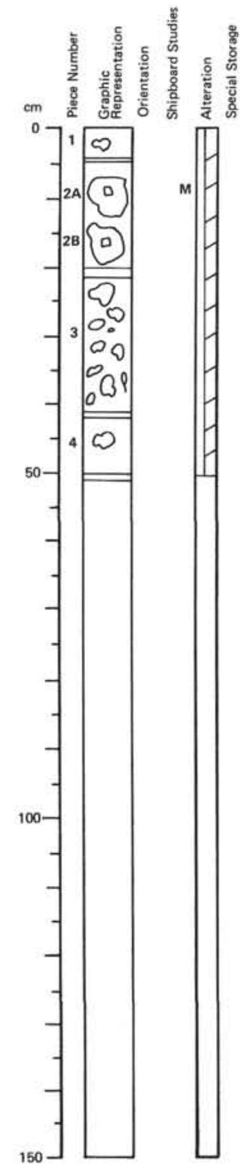
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	51	3

Depth: 804.5 to 806.0 m

Visual Description

Plagioclase phyric-basalt, dike as inSection 51-2. Between 100 and 115 cm, vesicles aligned in bands dipping 50°.



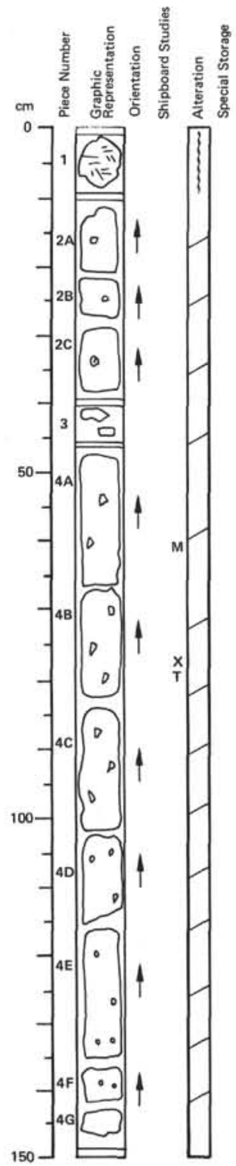
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	51	4

Depth: 806.0 to 806.5 m

Visual Description

Plagioclase-phyric basalt as in Section 51-2. Green tuff marks base of basalt.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	52	1

Depth: 810.5 to 812.0 m

Visual Description

0-10 cm: green, laminated tuff.

10-150 cm: aphyric to sparsely plagioclase phyric basalt flow (?sill), medium dark gray. Plagioclase phenocrysts 1-2% of rock, ~0.5 mm. Groundmass 80% crystalline, subophitic. Rare veins, 0.5-1.0 mm thick, of carbonate, some with smectite rims.

Thin Section Description

Location: 78-81 cm, flow interior

Texture: hyalopilitic

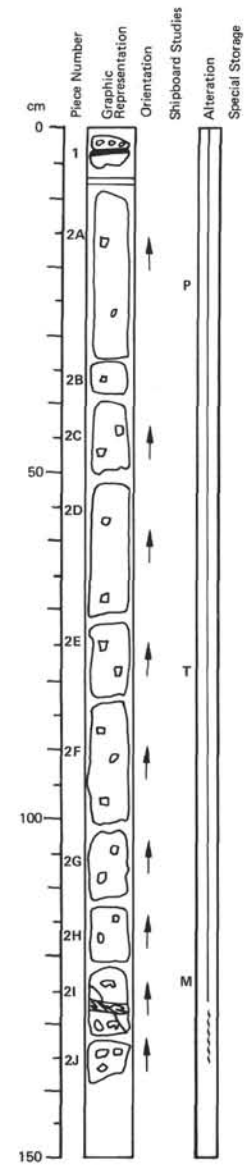
Phenocrysts: <10%; plagioclase 90%, An_{65}, 0.4-2.0 mm, euhedral to subhedral; clinopyroxene 10%, ~0.5 mm

Groundmass: >90%; plagioclase 50%, An_{57}, euhedral laths; clinopyroxene 30%; magnetite/ilmenite 10%; glass 10%

Alteration: glass (30%) altered to smectite

Shipboard Data

Bulk Analysis:	**77 cm**
SiO_2	51.1
TiO_2	1.48
Al_2O_3	12.9
Fe_2O_3	1.72
FeO	11.37
MnO	0.22
MgO	6.48
CaO	8.76
Na_2O	2.48
K_2O	0.10
P_2O_5	0.11



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	52	2

Depth: 812.0 to 813.5 m

Visual Description

Sparsely plagioclase-phyric basalt, flow (?sill), as in Section 52-1. At base (130-140 cm) volcaniclastic breccia, the top of which is metamorphased. The variolitic basalt at the contact is enriched in plagioclase microlites.

Thin Section Description

Location: 78-81 cm, flow interior

Texture: intersertal

Phenocrysts: 10%; plagioclase 90%, An_{65}, 0.4-2.0 mm, euhedral, glomeromorphic; clinopyroxene 10%, ~0.5 mm, subhedral

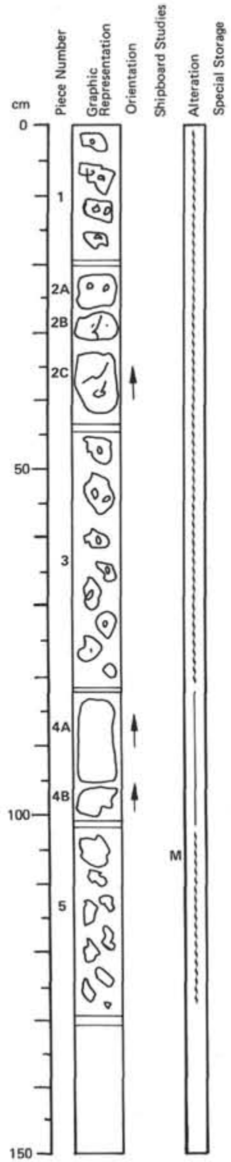
Groundmass: 90%; plagioclase 50%, An_{56}, euhedral; clinopyroxene 30%, prismatic; magnetite/ilmenite 10%; glass 10%

Vesicles: rare

Alteration: glass altered to clays

Shipboard Data

Physical Properties:	**23-25 cm**
$\overline{V}p$ (km/s)	
parallel to beds	4.59
vertical to beds	4.49
Wet bulk density	2.66



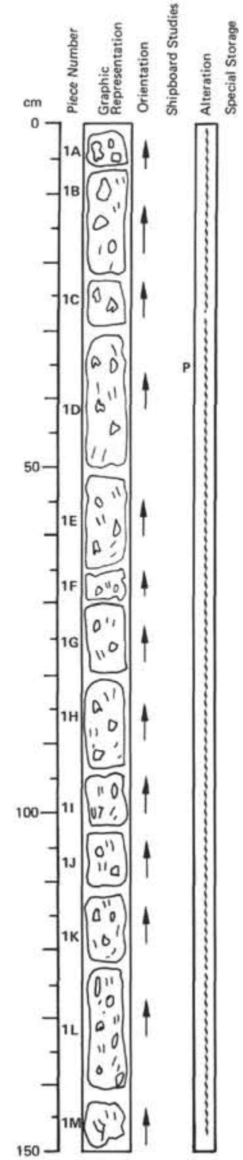
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	52	3

Depth: 813.5 to 814.8 m

Visual Description

Volcaniclastic breccia, green. Clast:matrix ratio 4:1. Clasts angular to subangular, average size 1.5-1 cm, maximum size 5x15 cm; composed of altered, vesicular, aphyric and sparsely plagioclase-phyric basalt almost completely replaced with green smectite. Matrix of same composition in which grains are <0.1 mm, with carbonate and zeolite cement.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	53	1

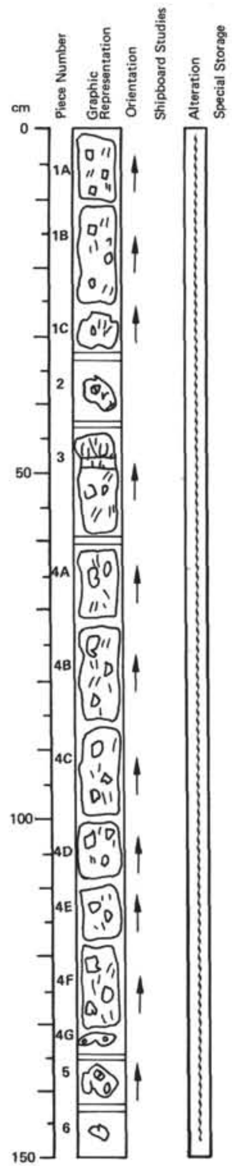
Depth: 819.5 to 821.0 m

Visual Description

Volcaniclastic breccia as in Section 52-3, dark green to gray black, average clast size, 0.7-1 cm. Rare layer clasts 6x8 cm. No sorting or orientation. Mainly vitrophyric vesicular basalts almost completed replaced with green smectite.

Shipboard Data

Physical Properties:	**35-37 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.52
vertical to beds	–
Wet bulk density	2.03

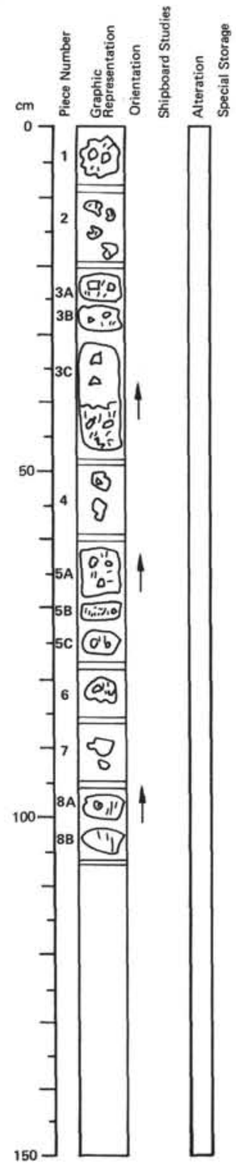


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	53	2

Depth: 821.0 to 822.5 m

Visual Description
Green volcaniclastic breccia as in Section 53-1.

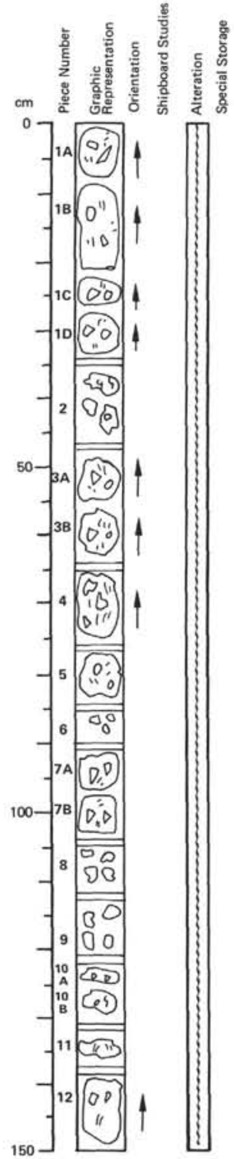


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	53	3

Depth: 822.5 to 824.0 m

Visual Description
Green volcaniclastic breccia as in Section 53-1.

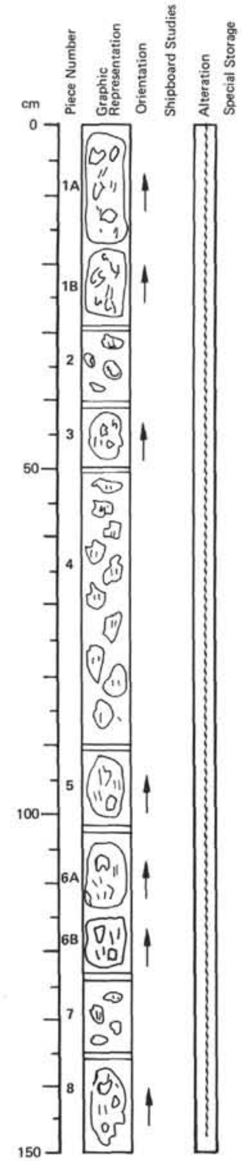


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	54	1

Depth: 828.5 to 830.0 m

Visual Description
Green volcaniclastic breccia as in Section 53-1.

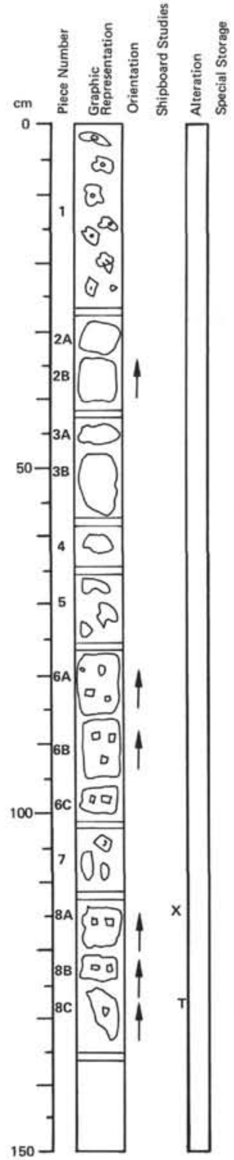


VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	54	2

Depth: 830.0 to 831.5 m

Visual Description
Green volcaniclastic breccia as in Section 53-1.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	54	3

Depth: 831.5 to 833.0 m

Visual Description

0-25 cm: volcaniclastic breccia as in previous sections.

25-135 cm: plagioclase-clinopyroxene-phyric basalt, medium dark gray, fine-grained. Plagioclase phenocrysts 2-3% of rock, 1-2 mm. Clinopyroxene phenocrysts ~1%, 0.5-1 mm. Groundmass 80% crystallized, subophitic, comprising plagioclase, pyroxene, ?olivine and glass. Occasionally ground mass has thin, subparallel darker bands, finer-grained than average and often enriched in vesicles.

Thin Section Description

Location: 127-130 cm, flow interior

Texture: intersertal

Phenocrysts: 15%; plagioclase 95%, An_{55}, 0.3-4.0 mm, subhedral glomeromorphic; clinopyroxene 5%, 0.3-1.0 mm subhedral

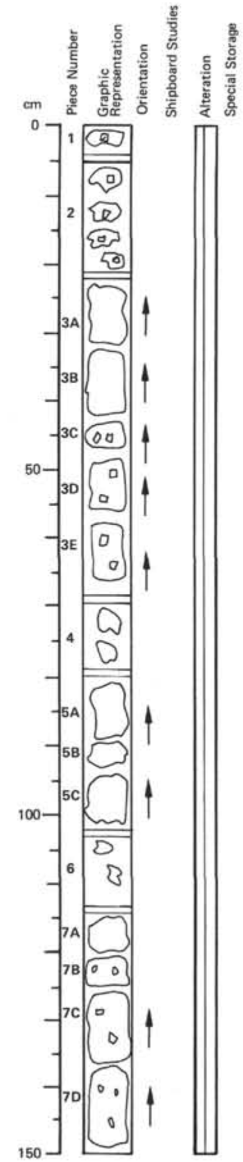
Groundmass: 85%; plagioclase 50%, laths; clinopyroxene 30%; magnetite/ilmenite 10%; glass 10%; all are very fine grained

Vesicles: rare

Alteration: glass altered to clays

Shipboard Data

Bulk Analysis:	**115 cm**
SiO_2	54.1
TiO_2	1.25
Al_2O_3	13.6
Fe_2O_3	1.56
FeO	10.30
MnO	0.21
MgO	5.78
CaO	8.58
Na_2O	2.61
K_2O	0.31
P_2O_5	0.09



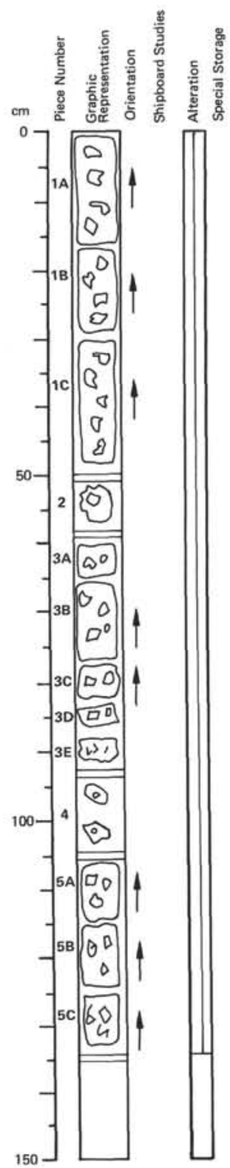
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	55	1

Depth: 837.5 to 839.0 m

Visual Description

Plagioclase-clinopyroxene-phyric basalt as in Section 54-3. Extensive brecciation at 20-60 cm and 100-150 cm. Slickensided fractures apparent.



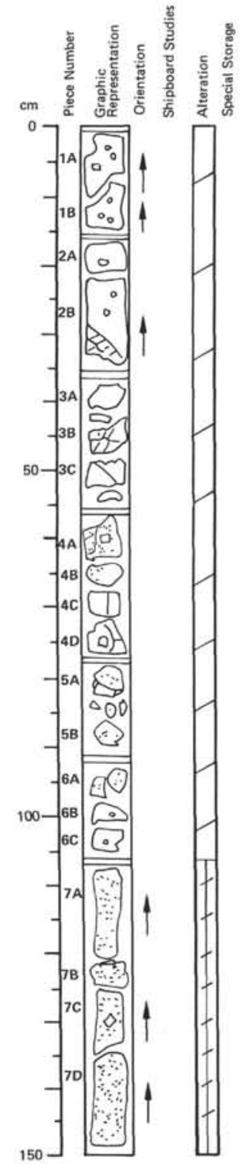
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	55	2

Depth: 839.0 to 840.5 m

Visual Description

Plagioclase-clinopyroxene-phyric basalt as in Section 55-1.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

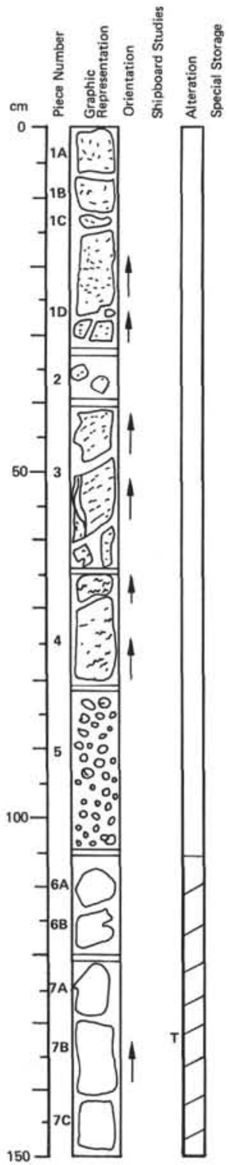
LEG	SITE	HOLE	CORE	SECT.
59	448	A	56	1

Depth: 840.5 to 842.0 m

Visual Description

0-105 cm: cognate basalt breccia. Clasts consist of angular plagioclase-phyric basalt as in previous sections. Plagioclase phenocrysts ~2 mm in size in a hyalopilitic groundmass of plagioclase, clinopyroxene and pyroxene.

105-150 cm: tuffaceous volcaniclastic breccia and fine vitric tuff. Clasts 0.5-1 cm average size, subangular to subrounded basalt, in a groundmass of similar composition but finer texture.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	56	2

Depth: 842.0 to 843.5 m

Visual Description

0-105 cm: tuffaceous volcaniclastic breccia and laminated fine vitric tuff, dark green. Cross-bedding present in medium to coarse silt-size layers.

105-150 cm: aphyric to very sparsely plagioclase-phyric basalt, flow (?dike). Microphenocrysts of plagioclase in a hyalopilitic groundmass of plagioclase, clinopyroxene and glass. Vesicles, 0.2-2 mm, with dark green clay filling.

Thin Section Description

Location: 128-132 cm, flow (?dike) interior

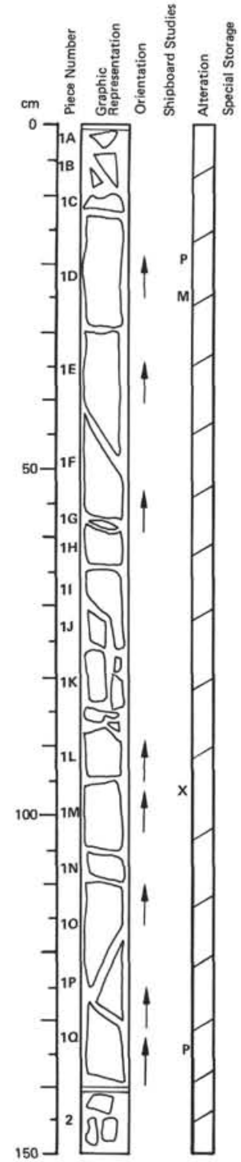
Texture: intersertal

Phenocrysts: 2%; plagioclase 50%, An_{60}, 0.2-0.5 mm, euhedral; clinopyroxene 50%, 0.2-0.5 mm, laths

Groundmass: >85%; plagioclase 50%, An_{59}, laths; clinopyroxene 30%; magnetite/ilmenite 10%; glass 10%; all very fine-grained

Vesicles: 10%, 0.3-1.0 mm, spheroidal, filled with smectite

Alteration: glass altered to clays



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	57	1

Depth: 846.5 to 848.0 m

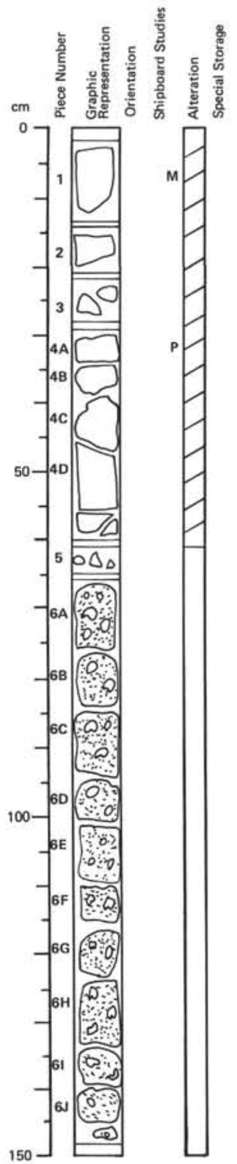
Visual Description

Aphyric basalt as in lower part of Section 56-2.

Shipboard Data

Bulk Analysis:	**98 cm**
SiO_2	55.2
TiO_2	1.28
Al_2O_3	12.9
Fe_2O_3	1.62
FeO	10.66
MnO	0.18
MgO	6.01
CaO	7.76
Na_2O	2.63
K_2O	0.37
P_2O_5	0.10

Physical Properties:	13-27 cm	135-137 cm
$\overline{V}p$ (km/s)		
parallel to beds	4.25	4.28
vertical to beds	–	4.21
Wet bulk density	–	2.60



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	57	2

Depth: 848.0 to 849.5 m

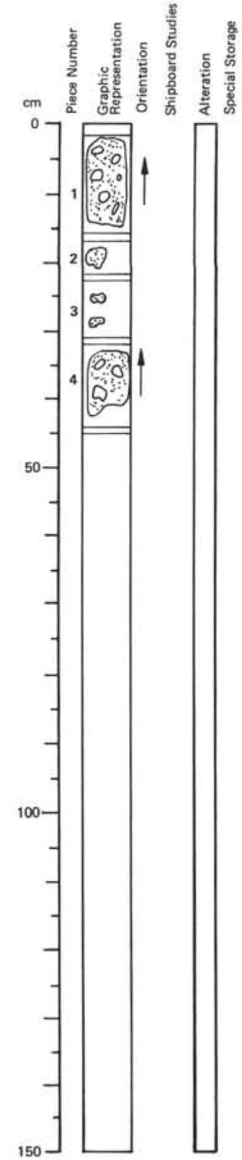
Visual Description

0-60 cm: aphyric basalt as in previous section.

60-150 cm: volcaniclastic breccia, green. Clast:matrix ratio 2:1. Clasts subangular, average 0.2-0.5 mm, maximum size 1-2 cm; composed of altered basalt and glass in ratio of 5:1. Matrix green (5G 4/1) altered basalt and glass grains.

Shipboard Data

Physical Properties:	**32-34 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.36
vertical to beds	2.32
Wet bulk density	1.98



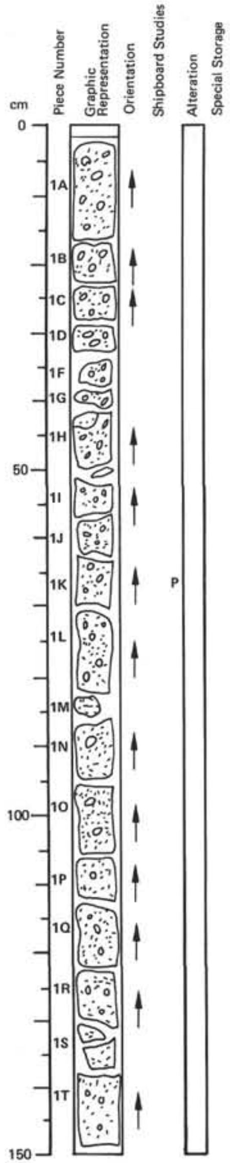
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	57	3

Depth: 849.5 to 850.0 m

Visual Description

Volcaniclastic breccia as in Section 57-2.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	58	1

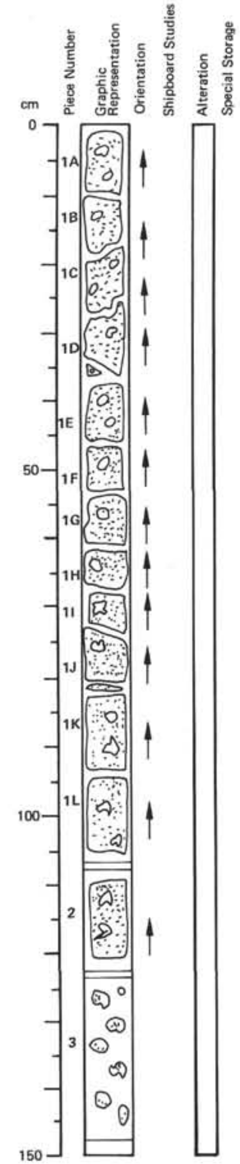
Depth: 855.5 to 857.0 m

Visual Description

Volcaniclastic breccia as in Section 57-2.

Shipboard Data

Physical Properties:	63-71 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.31



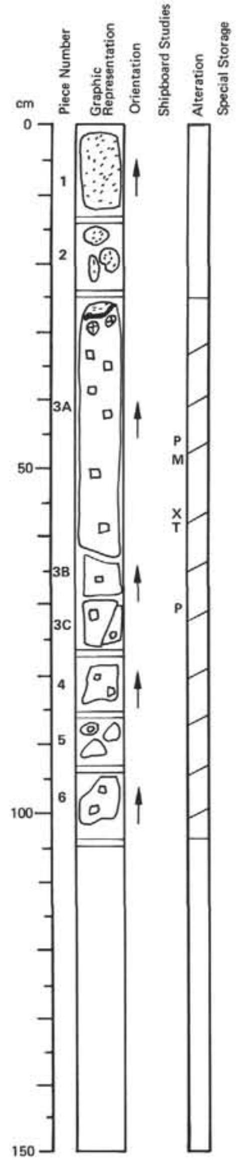
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	58	2

Depth: 857.0 to 858.5 m

Visual Description

Volcaniclastic breccia as in Section 57-2.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	58	3

Depth: 858.5 to 859.5 m

Visual Description

0-25 cm: volcaniclastic breccias as in previous sections.

25-100 cm: plagioclase-phyric basalt, (?sill). Plagioclase phenocrysts ~ 10% of rock, up to 3 mm, set in an aphanitic to intersertal groundmass. Scattered vesicles, ~ 1 mm, filled with green smectite.

Thin Section Description

Location: 50-58 cm, flow (?sill) interior

Texture: hyalopilitic

Phenocrysts: 10%; plagioclase 10%, An_{65}, 0.2-2.0 mm, euhedral to subhedral; clinopyroxene, 10%, 0.2-0.5 mm

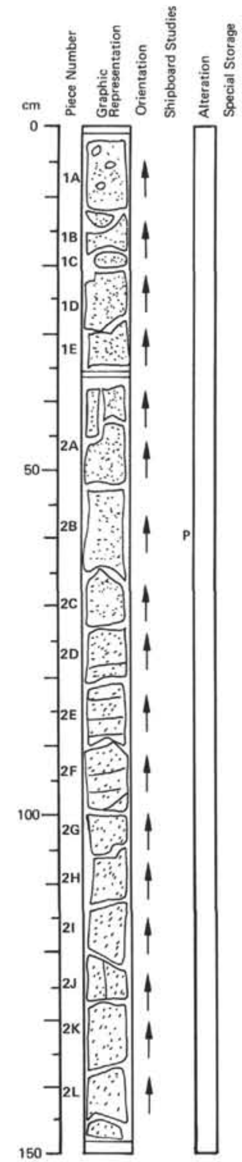
Groundmass: 80%; plagioclase 50%, An_{50}, euhedral laths; clinopyroxene 25%, anhedral; magnetite/ilmenite 10%; glass 15%; all fine-grained

Vesicles: 10%, 0.2-2.0 mm, spheroidal, empty or filled with smectite

Alteration: glass and some plagioclase altered to clays

Shipboard Data

Physical Properties:	46-48 cm	67-75 cm
$\bar{V}p$ (km/s)		
parallel to beds	3.54	3.64
vertical to beds	3.64	–
Wet bulk density	2.55	–



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	59	1

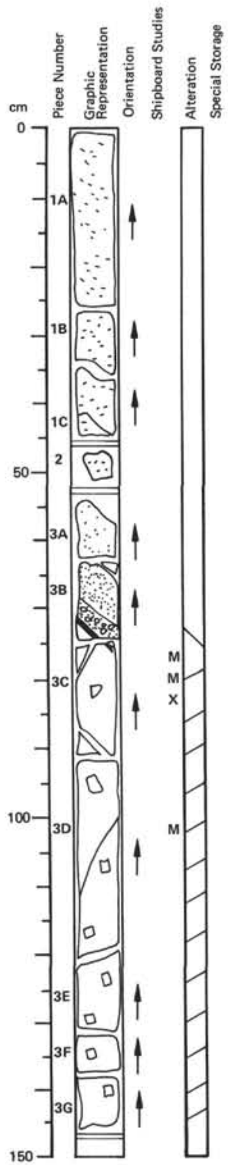
Depth: 864.5 to 866.0 m

Visual Description

Tuffaceous volcaniclastic breccia. Clast:matrix ratio 4:1 to 1:1. Clasts consist of altered basalt and glass, average 0.2-0.4 cm in size; maximum 1 cm. Clasts coarser in upper and lower parts of section, finer (0.2 cm average, 0.5 cm maximum) and bedded (dip ~20°) in central part of section. Matrix green (5G 4/1), fine basalt fragments altered to smectites.

Shipboard Data

Physical Properties:	57-59 cm
$\bar{V}p$ (km/s)	
parallel to beds	–
vertical to beds	2.21
Wet bulk density	1.89



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE		CORE			SECT.
5	9	4	4	8	A		5	9		2

Depth: 866.0 to 867.5 m

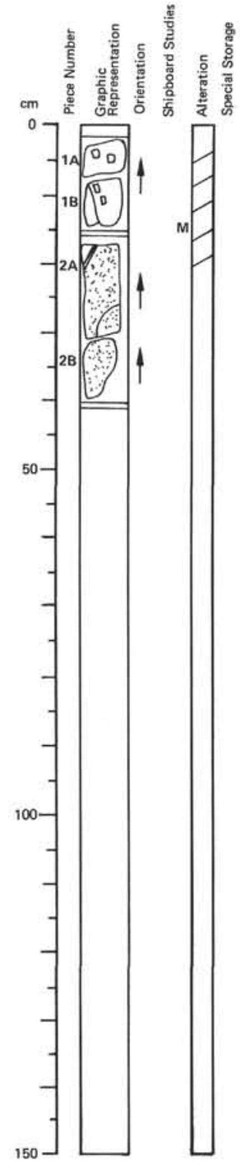
Visual Description

0-75 cm: green tuffaceous volcaniclastic breccia as in Section 59-1.

75-150 cm: plagioclase-phyric basalt. Glomerocrysts of plagioclase <5% of rock, 1-3 mm. Groundmass aphanitic to intersertal. Scattered vesicles, 1-2 mm, filled with green smectite.

Shipboard Data

Bulk Analysis:	**85 cm**
SiO_2	51.5
TiO_2	1.68
Al_2O_3	13.5
Fe_2O_3	1.59
FeO	10.52
MnO	0.21
MgO	5.80
CaO	9.54
Na_2O	2.92
K_2O	0.38
P_2O_5	0.12



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

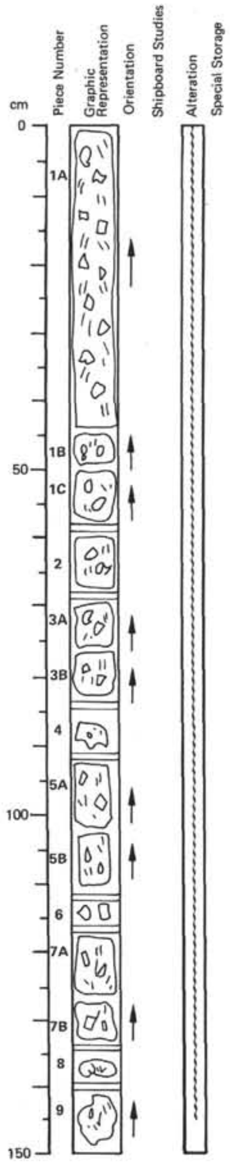
LEG		SITE			HOLE		CORE			SECT.
5	9	4	4	8	A		5	9		3

Depth: 867.5 to 869.0 m

Visual Description

0-15 cm: plagioclase-phyric basalt as in Section 59-2.

15-40 cm: tuffaceous volcaniclastic breccia. Clast:matrix ratio 3:1 to 1:1. Clasts, angular to subrounded, unsorted, unoriented, 2-3 mm average size, composed of highly altered vitrophyric and aphyric basalts. Matrix dark green silt to sand-sized grains of altered basalts. Hydrothermal alteration witnessed by disseminated pyrite.



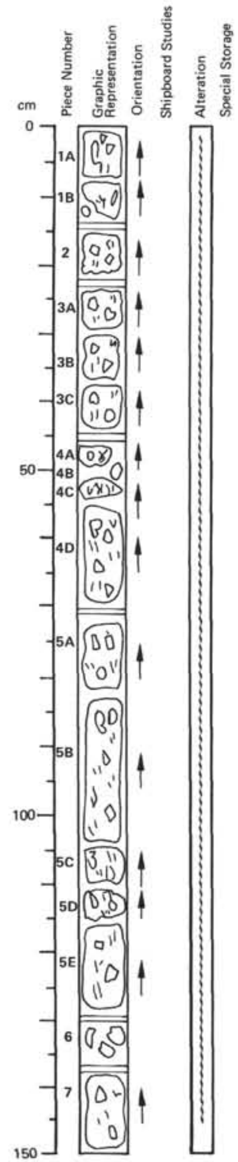
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	60	1

Depth: 869.0 to 870.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 59-3.



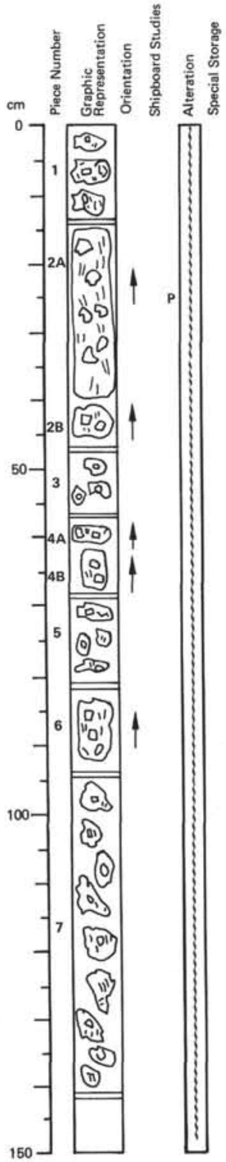
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	60	2

Depth: 870.5 to 872.0 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 59-3.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	60	3

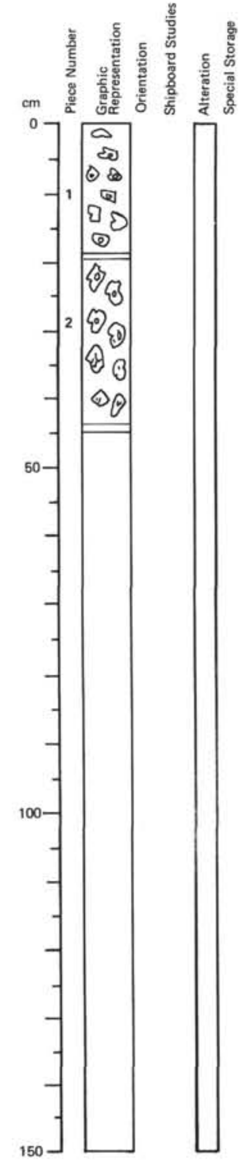
Depth: 872.0 to 873.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 59-3.

Shipboard Data

Physical Properties:	21-30 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.29



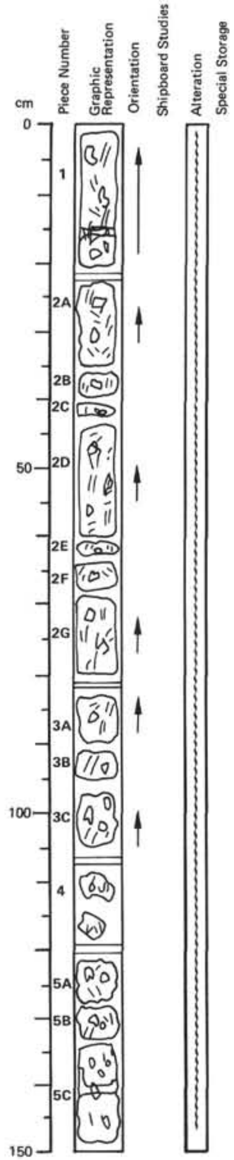
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	60	4

Depth: 873.5 to 875.0 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 59-3.



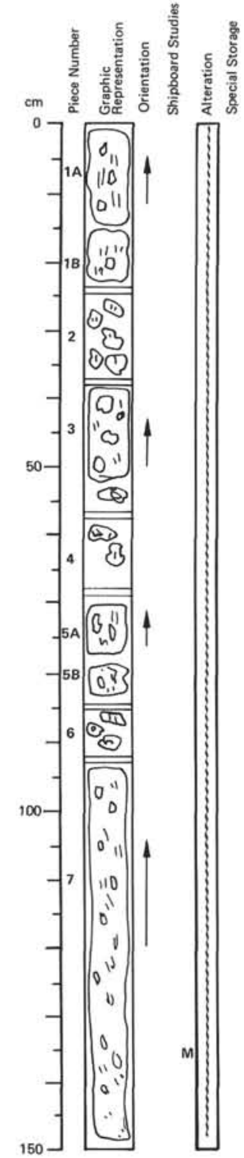
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	61	1

Depth: 878.0 to 879.5 m

Visual Description

Tuffaceous volcaniclastic breccia grading in and out of volcaniclastic breccia, grayish black in color. Clast:matrix varies from ratio 1:1 to 4:1. Clasts average 0.7-1 cm in size, are angular to subrounded and consist mainly of altered basalts enriched in glassy constituents, palagonite, aphyric and sparsely plagioclase-phyric basalts. Groundmass of same composition cemented with carbonate and zeolites.



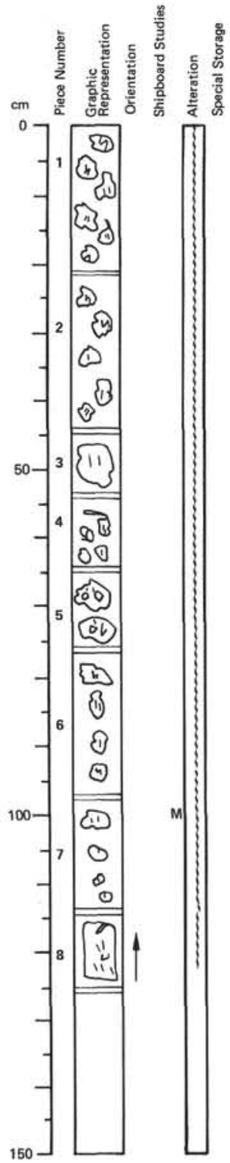
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	61	2

Depth: 879.5 to 881.0 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 61-1.



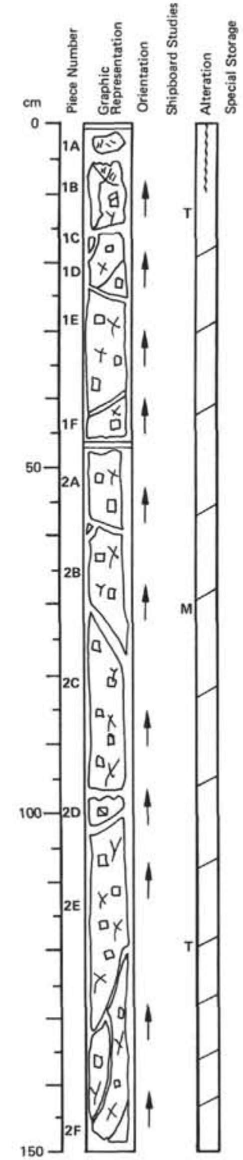
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	61	3

Depth: 881.0 to 882.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 61-1.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	62	1

Depth: 887.0 to 888.5 m

Visual Description

0-10 cm: tuffaceous volcaniclastic breccia. Base of unit present in Sections 61-1 to 61-3.
10-150 cm: plagioclase-clinopyroxene-orthopyroxene-phyric basalt ?dike. Medium gray, fine-grained. Phenocrysts: 45%; plagioclase 85%, 1.5-4 mm, euhedral prismatic crystals; clinopyroxene 5%, 0.4-0.5 mm, euhedral with short prismatic habit; hypersthene 10%, 3-4 mm, subhedral prismatic, partially or completely replaced with clays and hydromicas. Glomerocrysts common. Groundmass 55%; plagioclase 30%, 0.2-0.3 mm, clinopyroxene 25%, <0.1 mm, short, stubby prisms; opaques 10%, 0.5 mm; palagonite partially replaced with smectite, zeolites and ?chlorite 30%. Chilled contact (0.3-0.5 cm thick) with overlying breccia.

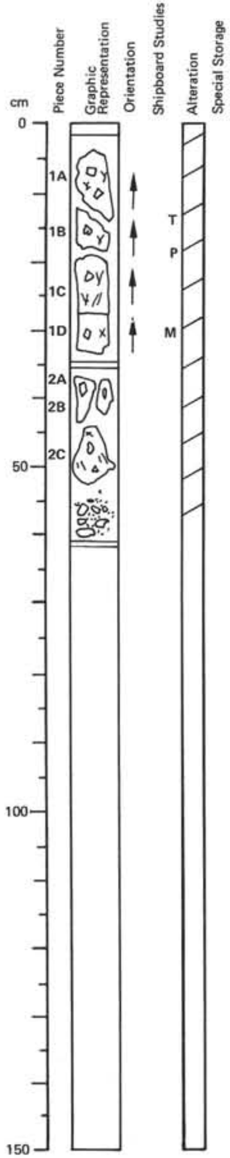
Thin Section Description

Location: 130-134 cm, dike interior
Texture: subophitic
Phenocrysts: <50%; plagioclase, 85%, 1.5-4 mm, euhedral, common glomerocrysts; clinopyroxene, 5%, 0.4-0.5 mm, euhedral glomerocrysts with plagioclase and orthopyroxene; orthopyroxene 10%, 3-4 mm, subhedral to varying degree replaced with clays
Groundmass: >50%; plagioclase 15%, <0.2-0.3 mm, elongate laths; clinopyroxene 25%, <0.1 mm, subhedral; magnetite/ilmenite 10%, 0.5 mm, square; glass 35%; palagonite replaced with clays and zeolites.
Alteration: clays and zeolites replace orthopyroxene and glass

VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	62	2

Depth: 888.5 to 889.1 m



Visual Description

Plagioclase-clinopyroxene-orthopyroxene-phyric basalt, dike as in Section 62-1, but somehwat finer-grained. Phenocrysts: 35%; plagioclase 90%, 1.5 mm; clinopyroxene 2%, <1 mm; orthopyroxene 5%, 1.5 mm, as pseudomorphs. Groundmass: 65%; plagioclase 25%, 0.15 mm; clinopyroxene 25%, <0.05 mm; opaques 0.01 mm; and palagonite 45%, partially replaced with smectite, hydromicas, zeolites and ?chlorite.

Thin Section Description

Location: 14-17 cm, dike margin
Texture: hyalopilitic
Phenocrysts: plagioclase 30%, 1.5 mm, euhedral, glomerocrysts; clinopyroxene 1%, <1 mm, euhedral; orthopyroxene 2-3%, 1.5 mm, pseudomorphs
Groundmass: plagioclase 20%, 0.15 mm, elongate laths; clinopyroxene 20%, <0.05 mm, irregular; magnetite/ilmenite 6%, <0.01 mm, irregular; glass 20%
Alteration: clays replace plagioclase, orthopyroxene and glass; zeolites replace glass; ?chlorite replaces plagioclase glass

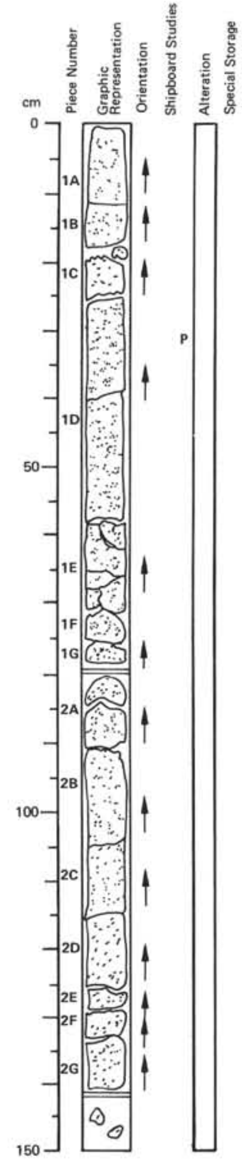
Shipboard Data

Physical Properties:	16-23 cm
$\overline{V}p$ (km/s)	
parallel to beds	4.43

VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	63	1

Depth: 896.0 to 897.5 m

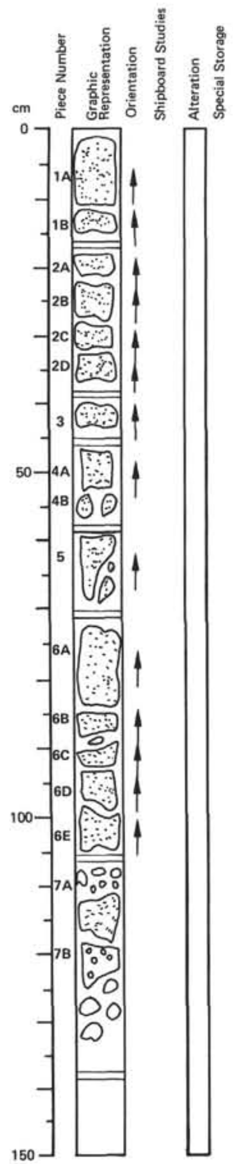


Visual Description

Tuffaceous volcaniclastic breccia, green matrix (5GY 2/1). Clast:matrix ratio 2:3. Clasts, 0.3 cm average, 1 cm maximum, composed of highly altered basalt. Matrix composed of altered basalt and glass.

Shipboard Data

Physical Properties:	26-39 cm
$\overline{V}p$ (km/s)	
parallel to beds	2.49



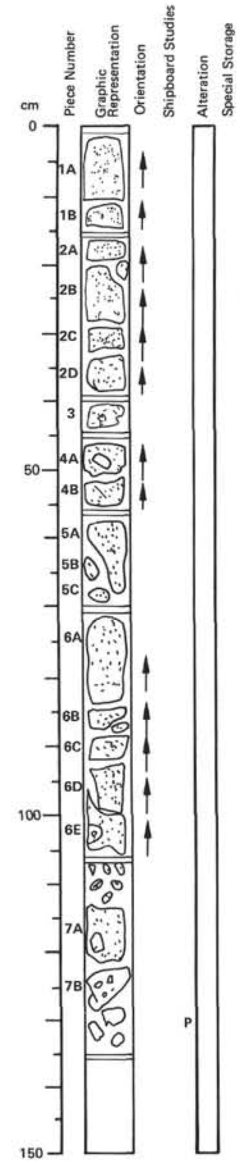
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	63	2

Depth: 896.0 to 897.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 63-1, becoming coarser downwards passing into volcaniclastic breccia, with clast:matrix ratio 2:3 and clasts averaging 0.25 cm, maximum 2 cm at top of section; at base, clast:matrix ratio 2:1, with clasts averaging 1 cm, maximum 4 cm. Larger clasts composed of relatively fresh basalt. Color greenish black (5G 2/1).



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	64	1

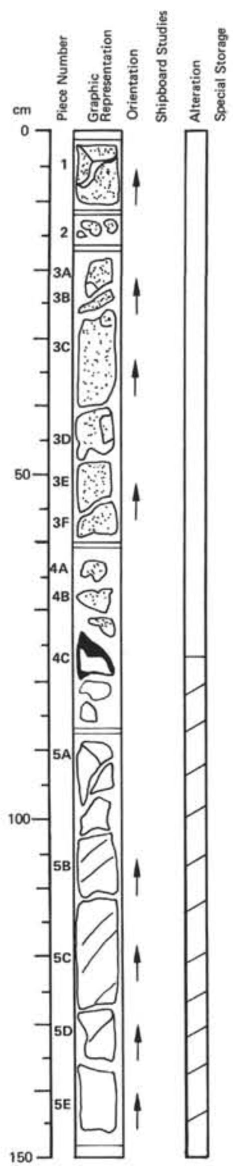
Depth: 900.0 to 901.5 m

Visual Description

Tuffaceous volcaniclastic breccia as in Section 63-1. Clast:matrix ratio increases down section from 2:3 to 2:1. At top average size 0.25 cm, maximum 2 cm. At base average size 1 cm, maximum 4 cm.

Shipboard Data

Physical Properties:	**125-134 cm**
$\overline{V}p$ (km/s)	
parallel to beds	2.61



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

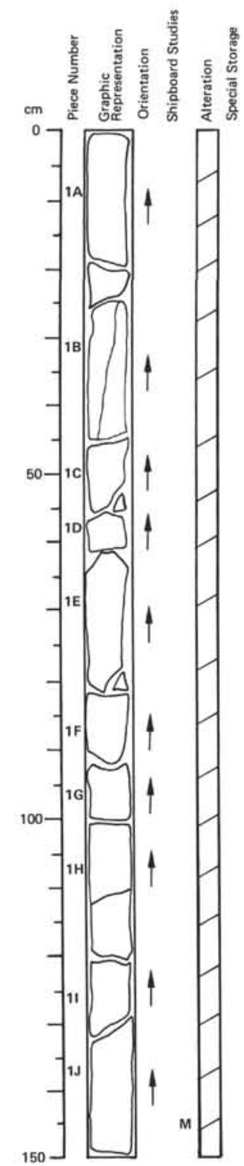
LEG	SITE	HOLE	CORE	SECT.
59	448	A	64	2

Depth: 901.5 to 903.0 m

Visual Description

0-75 cm: volcaniclastic breccia as in base of Section 64-1.

75-150 cm: aphyric basalt, dike, fine-grained, holocrystalline, subophitic. Finer-grained bands, 2 cm wide, dipping 60°, contain small (0.5-1.0 mm) vesicles filled with zeolites or smectite.



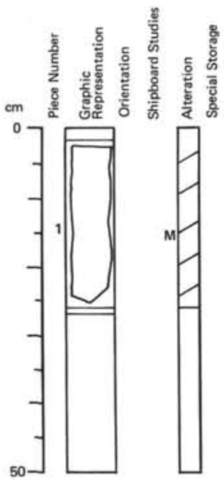
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	64	3

Depth: 903.0 to 904.5 m

Visual Description

Massive aphyric basalt as in Section 64-2.



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE		HOLE	CORE		SECT.
5	9	4	4 8	A	6	4	4

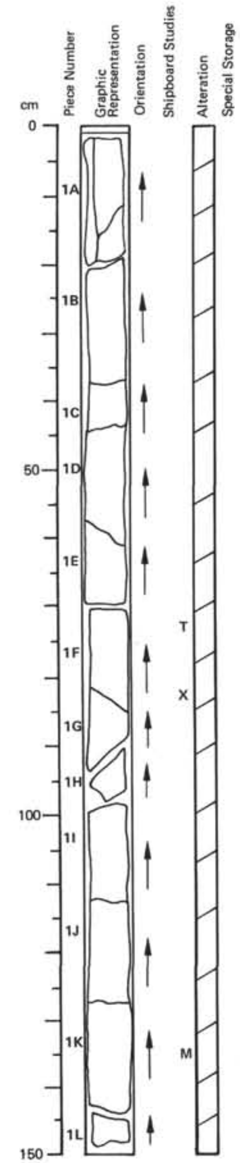
Depth: 904.5 to 905.0 m

Visual Description

Massive aphyric basalt as in Section 64-2.

Shipboard Data

Magnetic Data:	**16 cm**
Inclination	−14.90
Declination	228.80
Intensity (emu/cc)	0.1310E−01



VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE		HOLE	CORE		SECT.
5	9	4	4 8	A	6	5	1

Depth: 905.0 to 906.5 m

Visual Description

Massive aphyric basalt as in Section 64-2.

Thin Section Description

Location: 74-78 cm, dike interior

Texture: intersertal

Phenocrysts: <10%; plagioclase 40%, An_{65-35}, 0.3-1 mm, euhedral, strongly zoned; clinopyroxene 40%, 0.3-0.5 mm, euhedral, strongly zoned; olivine 15%, 0.5-1.5 mm, euhedral pseudomorphs; all as glomerocrysts

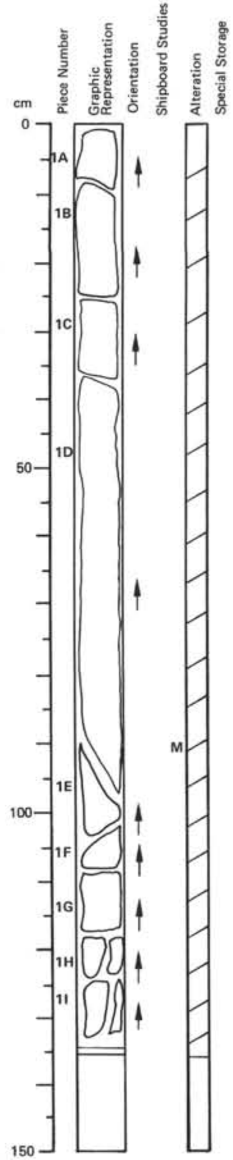
Groundmass: >90%; plagioclase 55%, 0.5-0.7 mm, laths subaligned; clinopyroxene 25%, 0.2-0.4 mm, granular; magnetite/ilmenite 3%, 0.05-0.01, subhedral to acicular to skeletal in glassy areas; glass 15%

Vesicles: rare, 2-3 mm, spheroidal, filled with clays

Alteration: clays (15%) replace glass, olivine

Shipboard Data

Bulk Analysis:	**84 cm**
SiO_2	52.2
TiO_2	1.17
Al_2O_3	13.3
Fe_2O_3	1.61
FeO	10.60
MnO	0.22
MgO	5.91
CaO	9.04
Na_2O	2.63
K_2O	0.19
P_2O_5	0.08



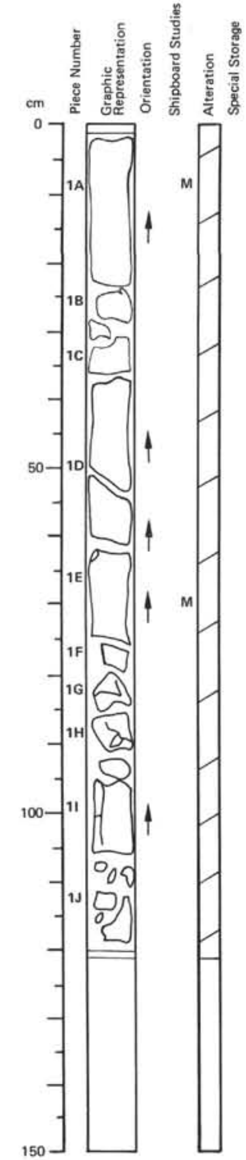
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	6	5	2

Depth: 906.5 to 908.0 m

Visual Description

Massive aphyric basalt as in Section 64-2.



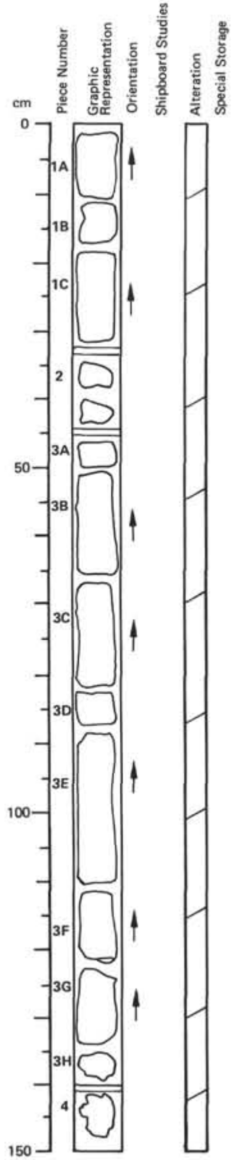
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG		SITE			HOLE	CORE		SECT.
5	9	4	4	8	A	6	5	3

Depth: 908.0 to 909.3 m

Visual Description

Massive aphyric basalt as in Section 64-2.



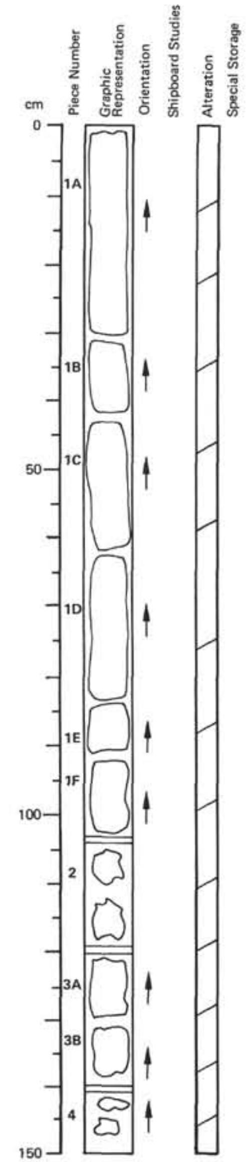
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	66	1

Depth: 910.5 to 912.0 m

Visual Description

Massive aphyric basalt. Fine-grained, medium dark gray; ~90% crystallized; subophitic to ophitic. Composed of plagioclase laths, elongate prisms of ?pyroxene, and intergranular glass. Rock contains irregular blebs (~0.5-1 mm) of altered ?glass; ?phenocrysts. Disseminated pyrite present. Brecciation between 20 and 40 cm.



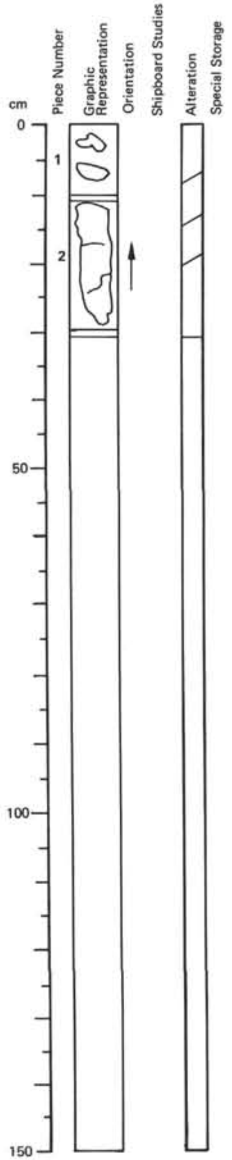
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

LEG	SITE	HOLE	CORE	SECT.
59	448	A	66	2

Depth: 912.0 to 913.5 m

Visual Description

Massive aphyric basalt as in Section 66-1. Brecciation in interval 60-65 cm.

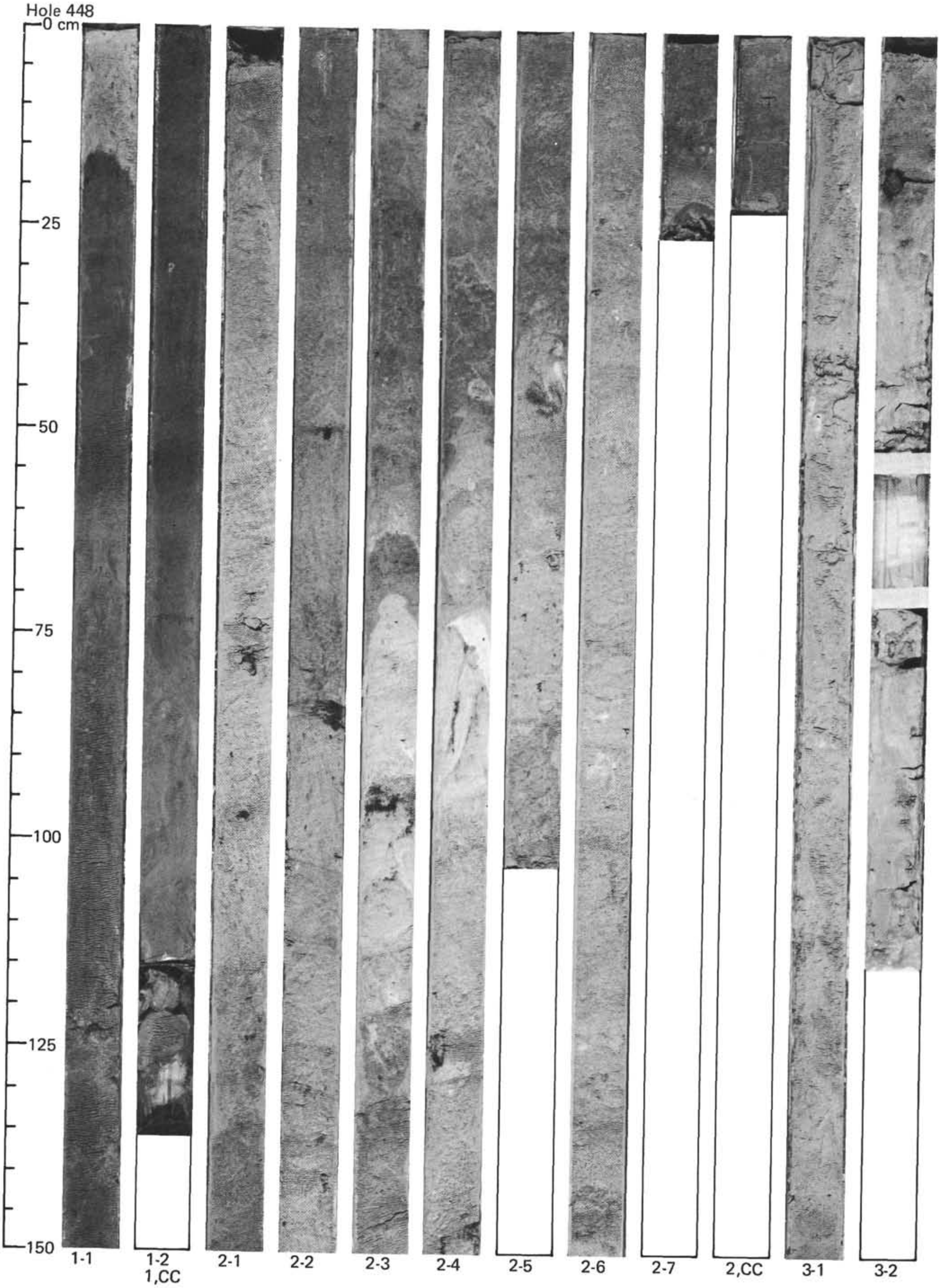


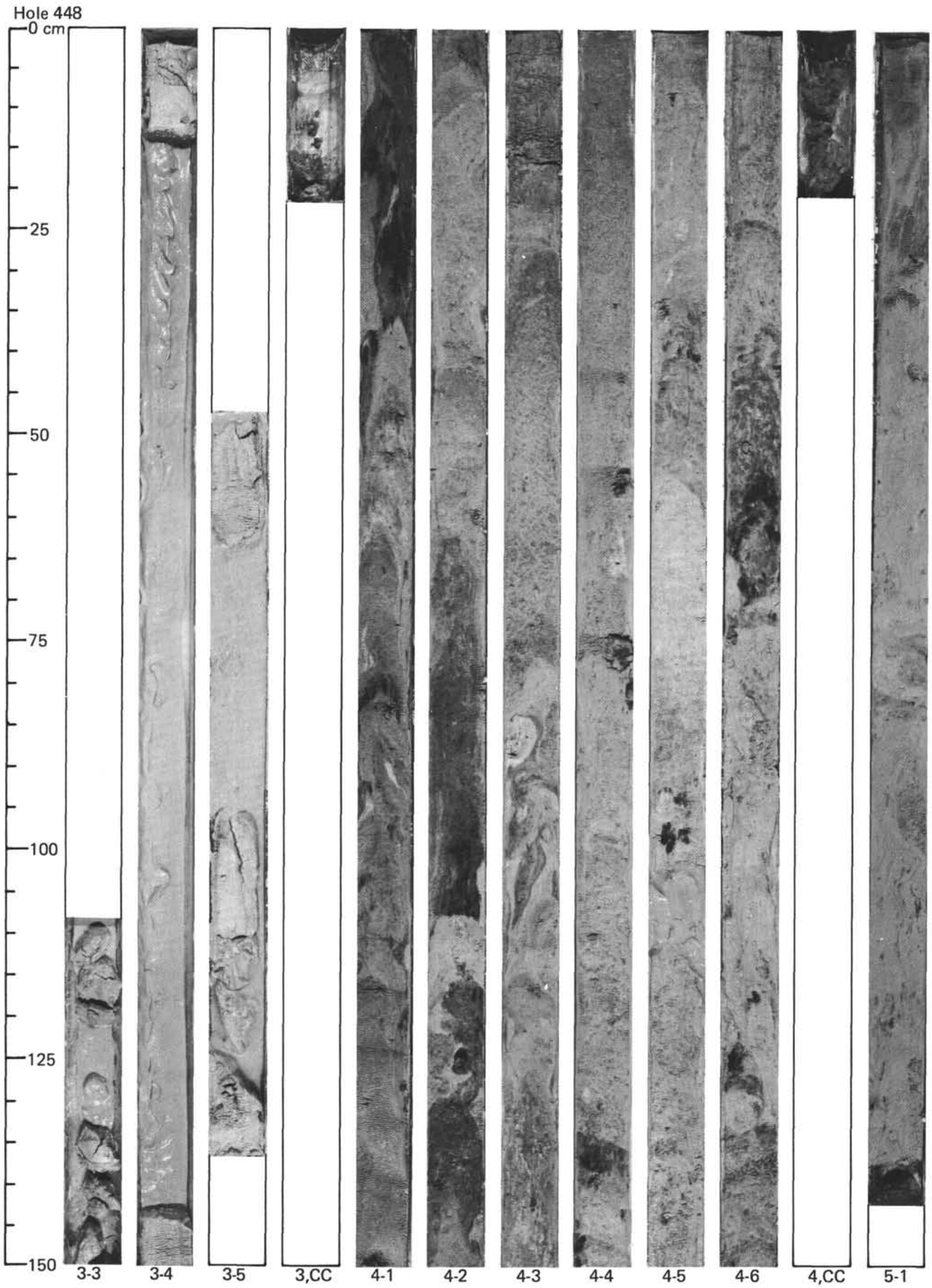
VISUAL CORE DESCRIPTION FOR IGNEOUS ROCKS

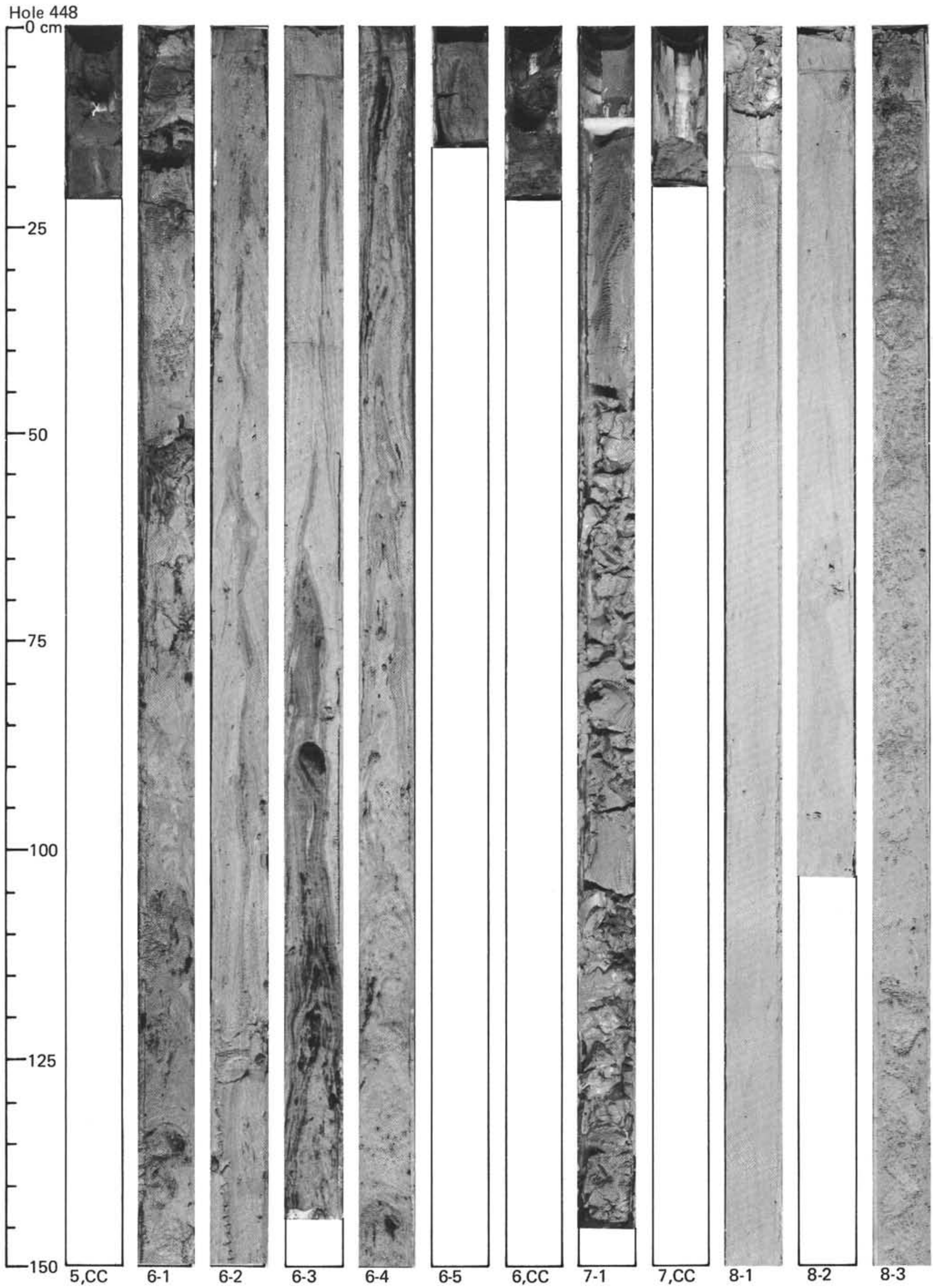
LEG	SITE	HOLE	CORE	SECT.
59	448	A	66	3

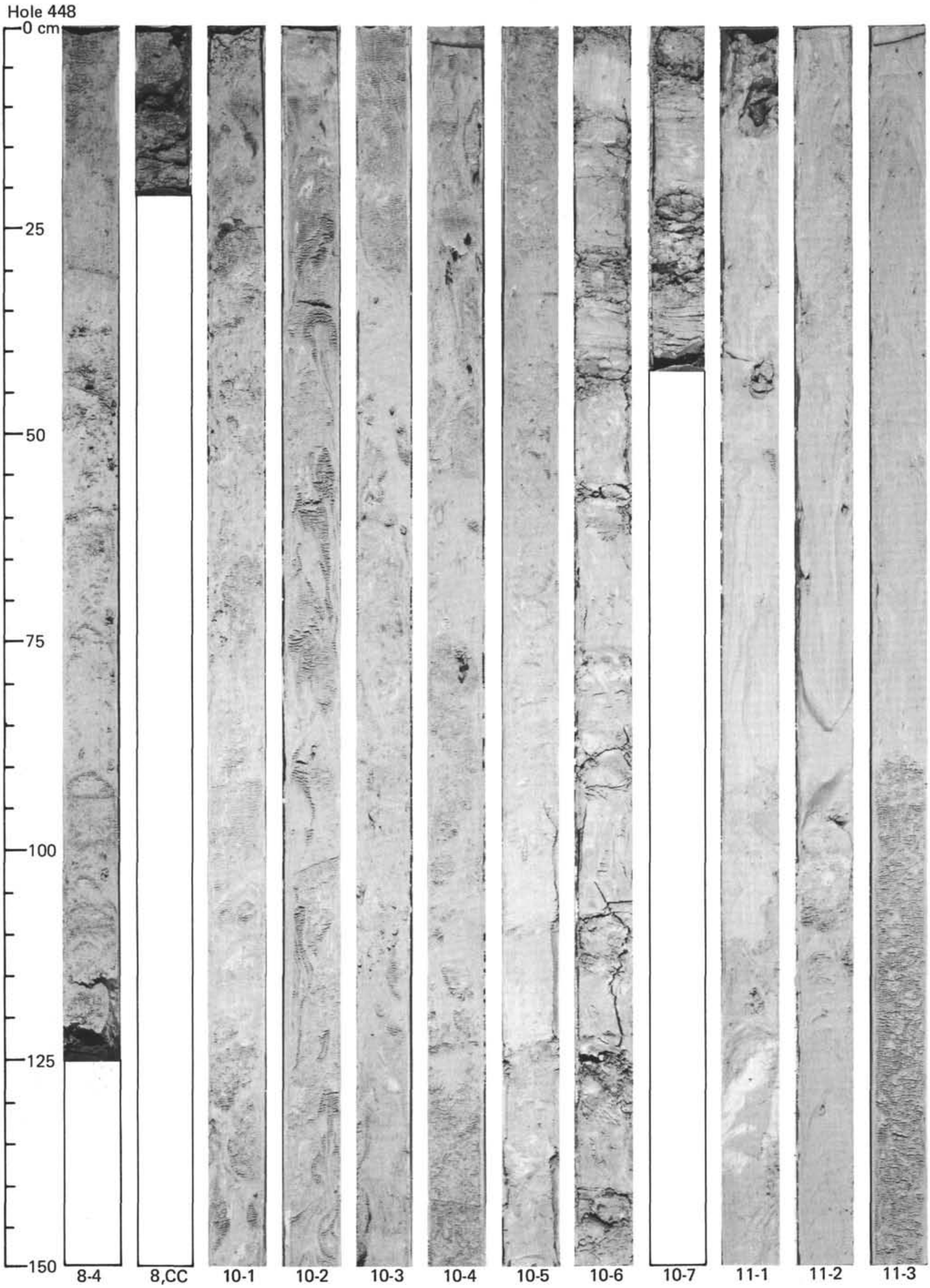
Depth: 913.5 to 914.0 m

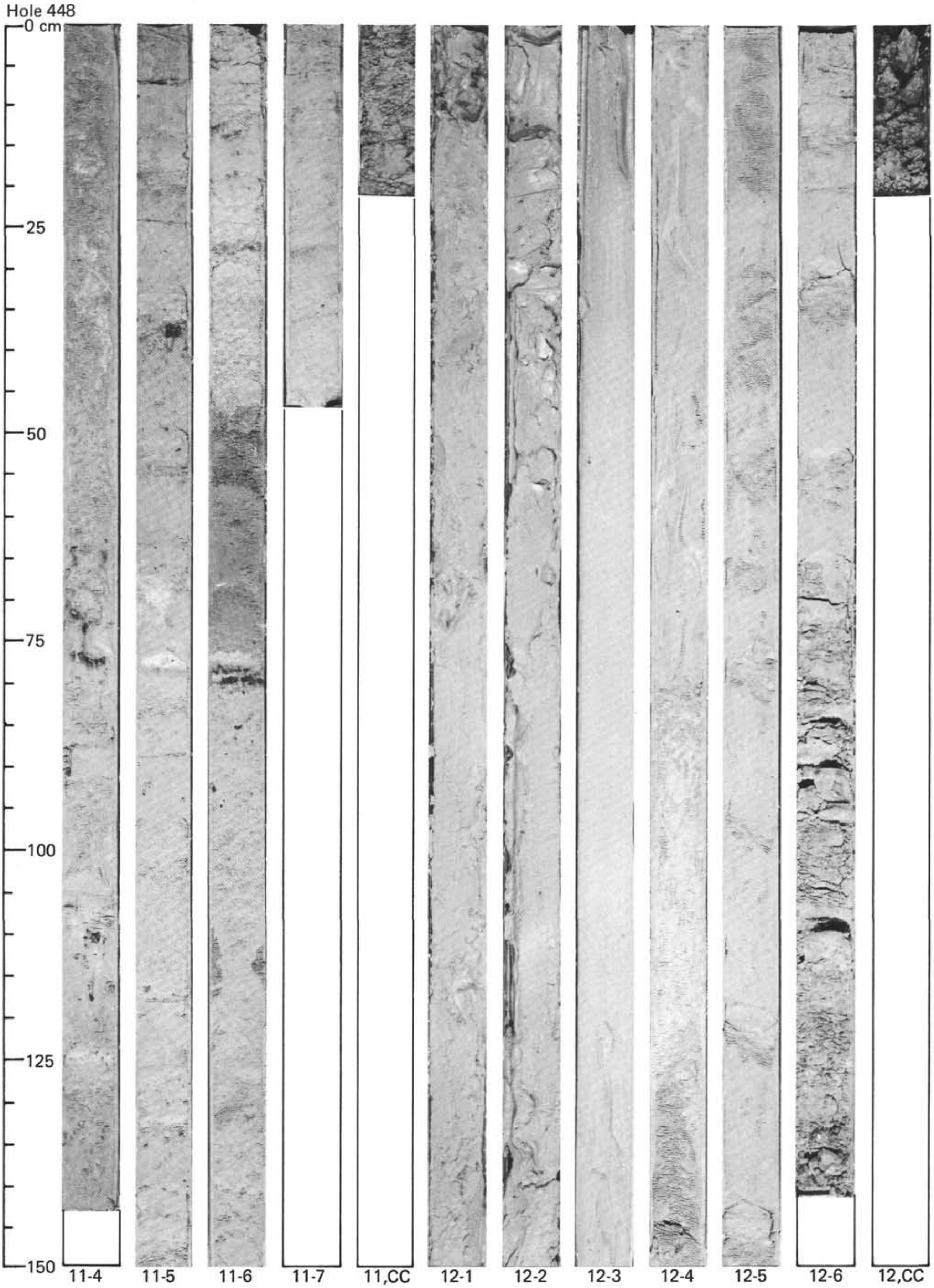
Visual Description
Massive aphyric basalt as in Section 66-2.

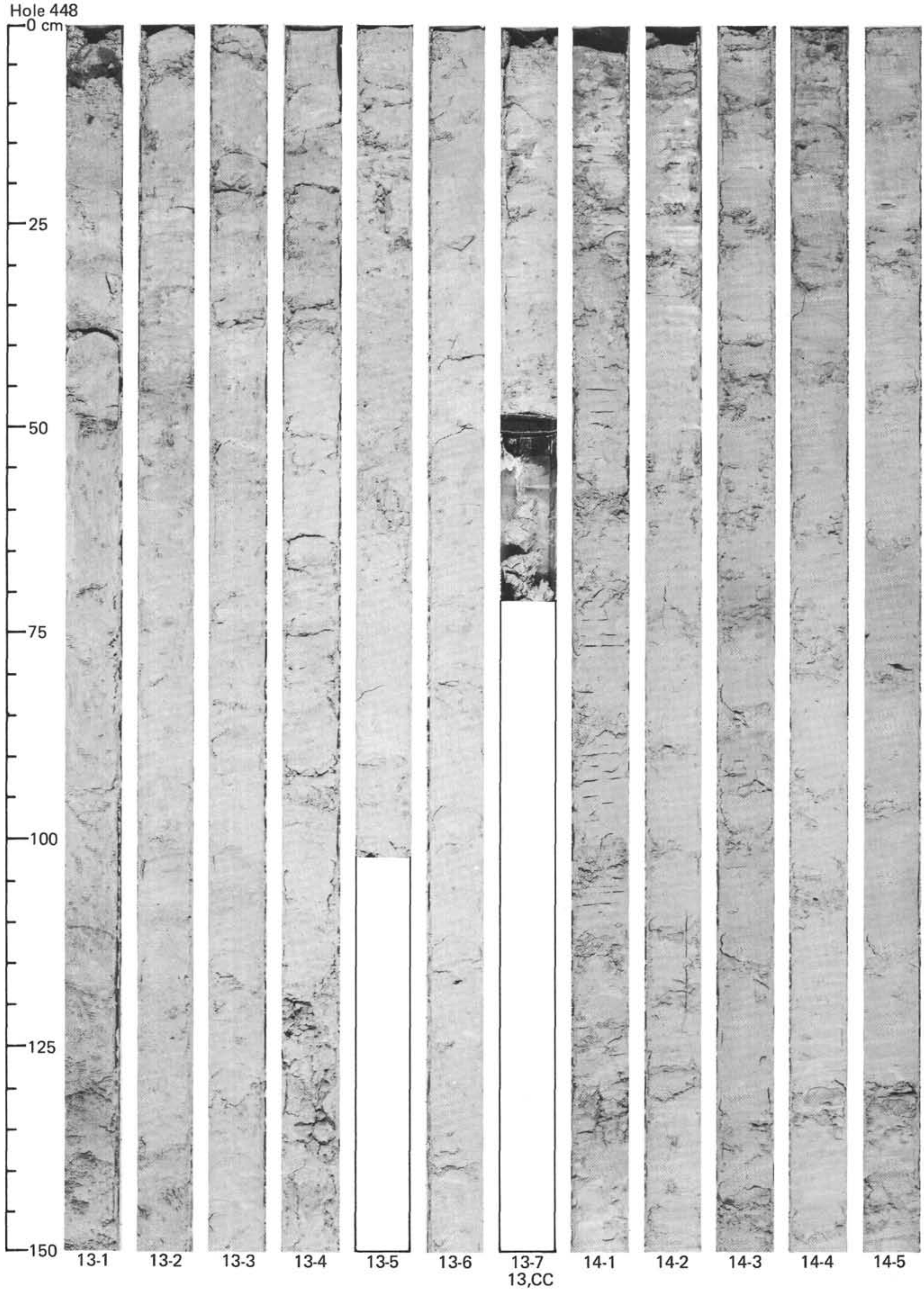

Hole 448
0 cm
25
50
75
100
125
150
1-1
1-2
1,CC
2-1
2-2
2-3
2-4
2-5
2-6
2-7
2,CC
3-1
3-2

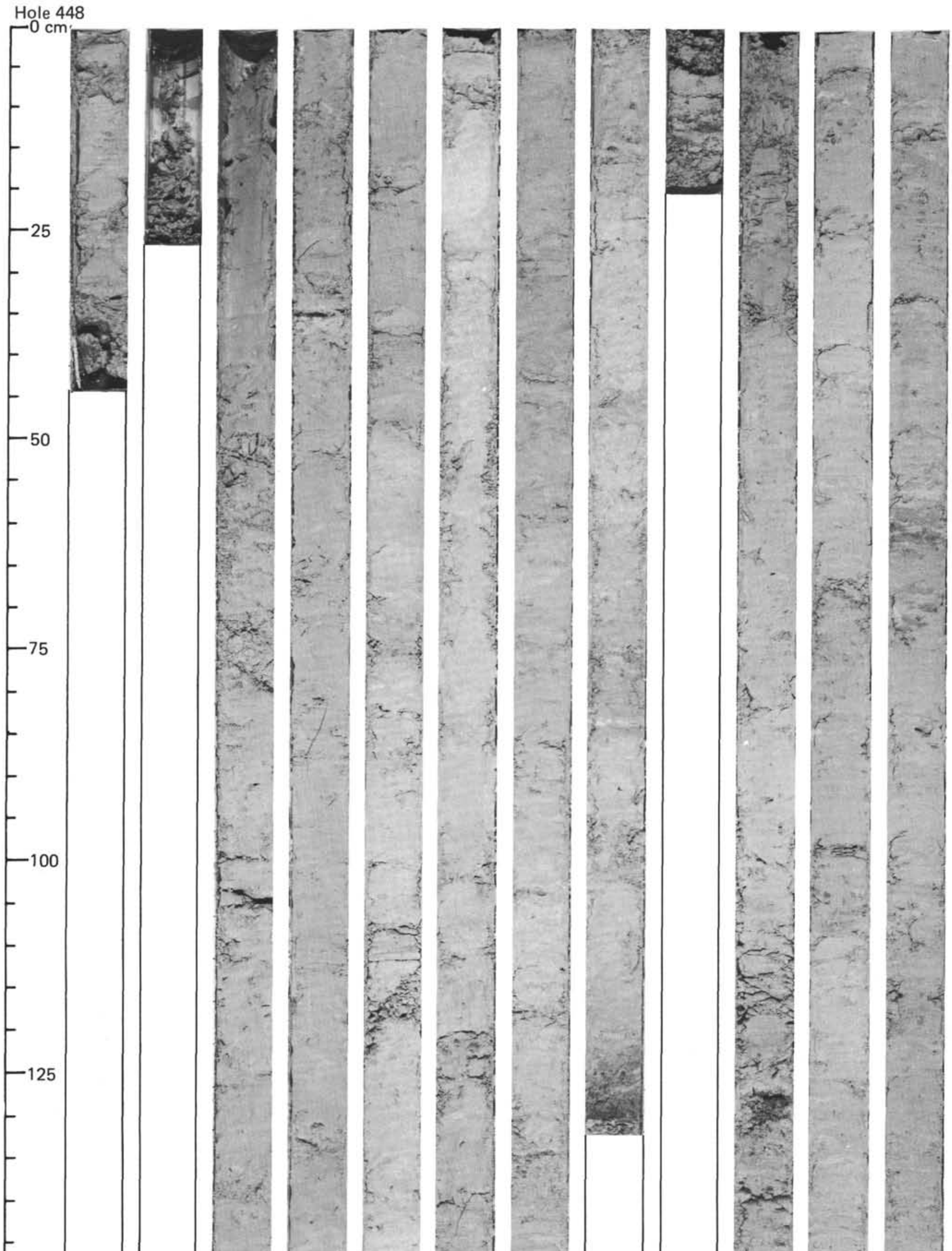

Hole 448
0 cm
25
50
75
100
125
150
3-3
3-4
3-5
3,CC
4-1
4-2
4-3
4-4
4-5
4-6
4,CC
5-1

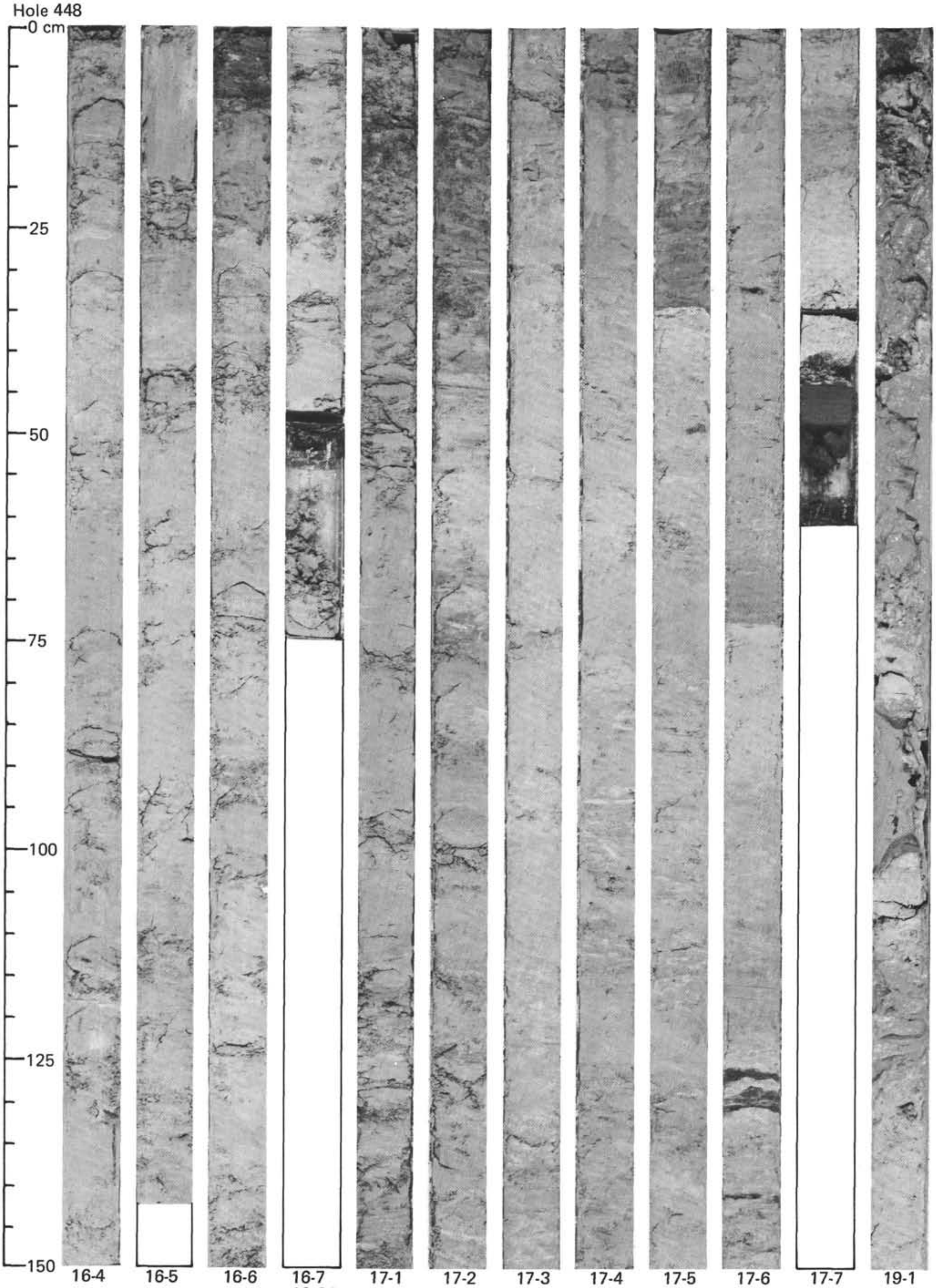

Hole 448
0 cm
25
50
75
100
125
150
5,CC
6-1
6-2
6-3
6-4
6-5
6,CC
7-1
7,CC
8-1
8-2
8-3


Hole 448
0 cm
25
50
75
100
125
150
8-4
8,CC
10-1
10-2
10-3
10-4
10-5
10-6
10-7
11-1
11-2
11-3

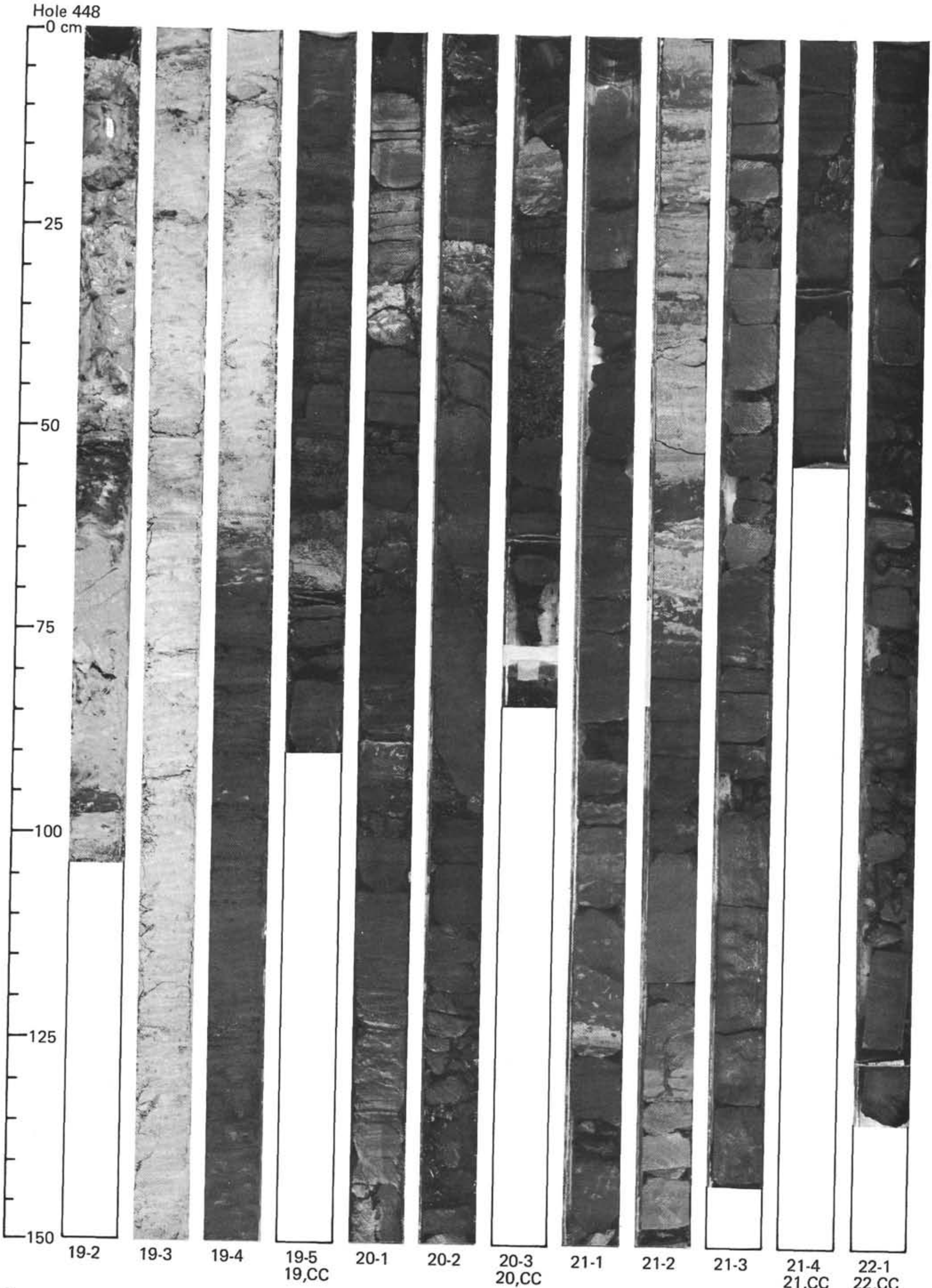

Hole 448
0 cm
25
50
75
100
125
150
11-4
11-5
11-6
11-7
11,CC
12-1
12-2
12-3
12-4
12-5
12-6
12,CC


Hole 448
0 cm
25
50
75
100
125
150
13-1
13-2
13-3
13-4
13-5
13-6
13-7
13,CC
14-1
14-2
14-3
14-4
14-5


Hole 448
0 cm
25
50
75
100
125
150
14-6
14,CC
15-1
15-2
15-3
15-4
15-5
15-6
15,CC
16-1
16-2
16-3



Hole 448
0 cm
25
50
75
100
125
150
16-4
16-5
16-6
16-7
16,CC
17-1
17-2
17-3
17-4
17-5
17-6
17-7
17,CC
19-1


Hole 448
0 cm
25
50
75
100
125
150
19-2
19-3
19-4
19-5
19,CC
20-1
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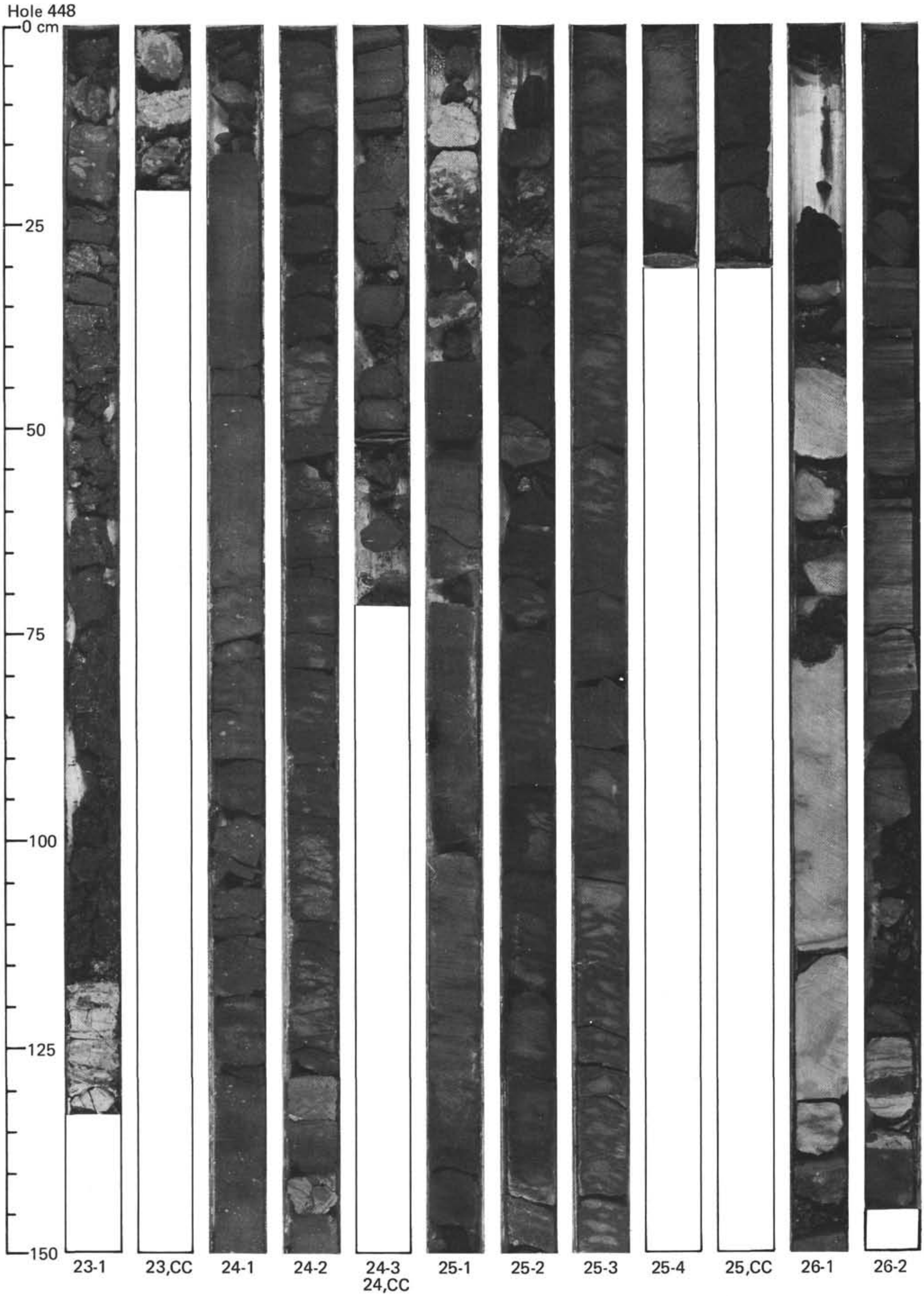
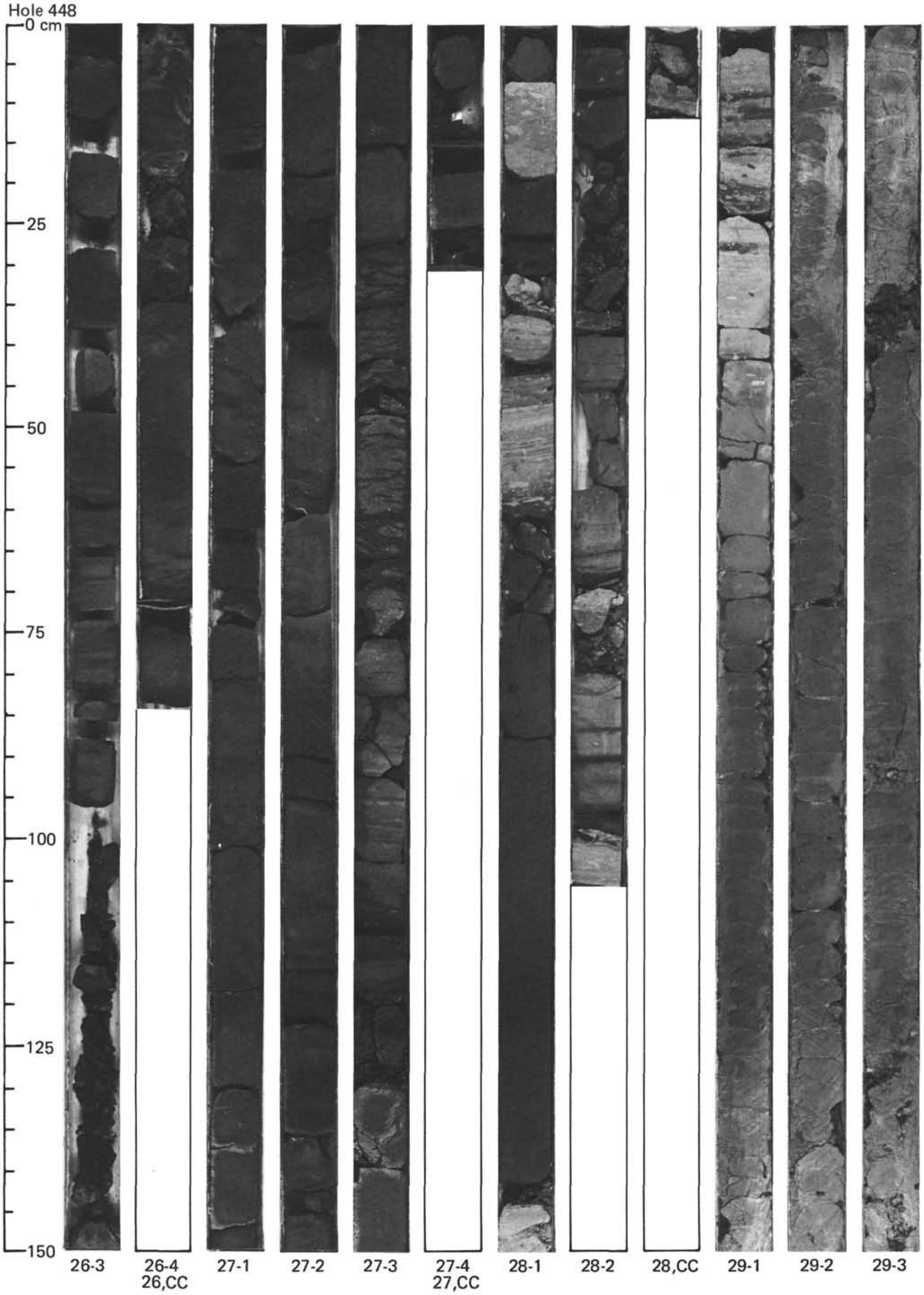
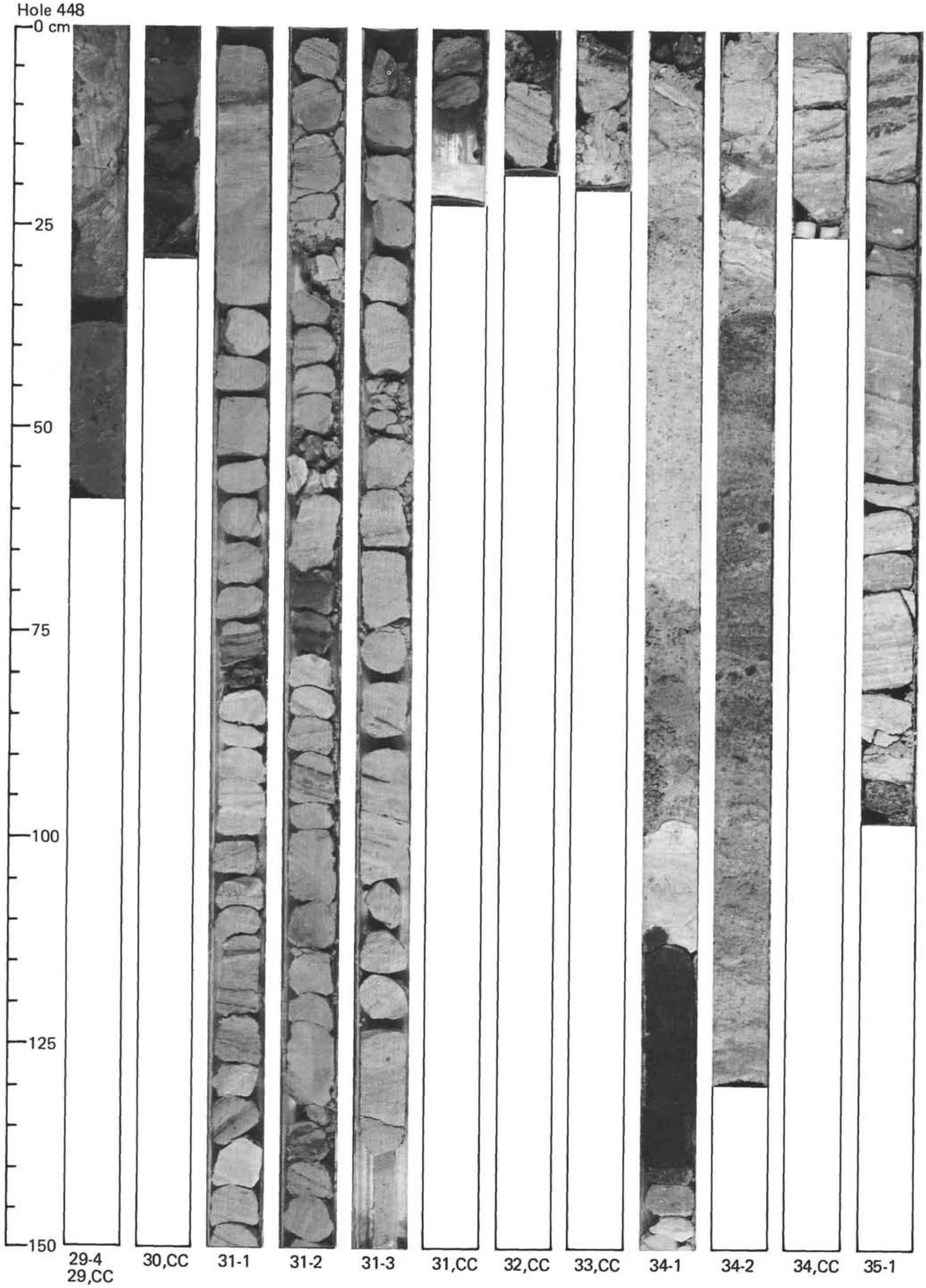
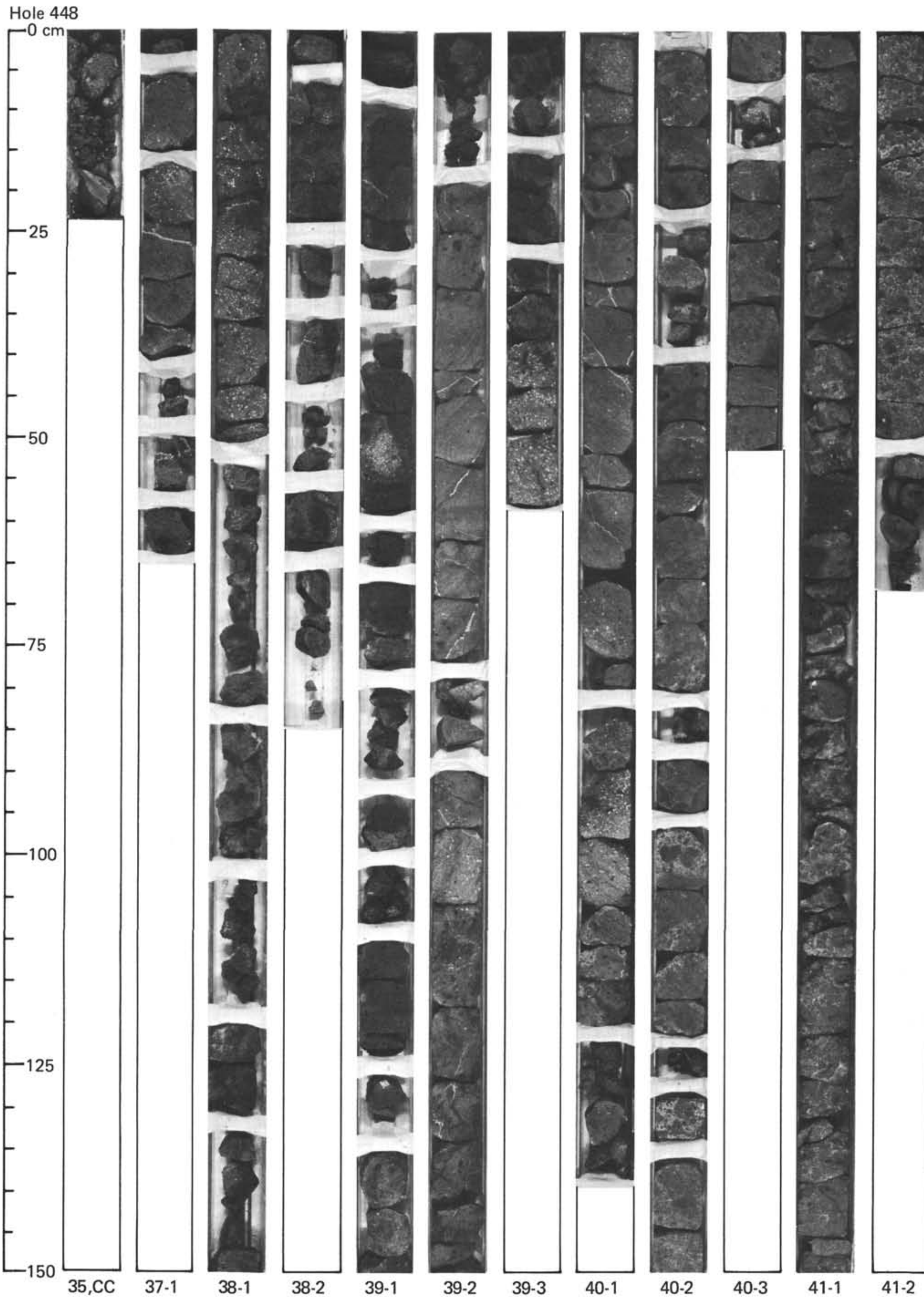
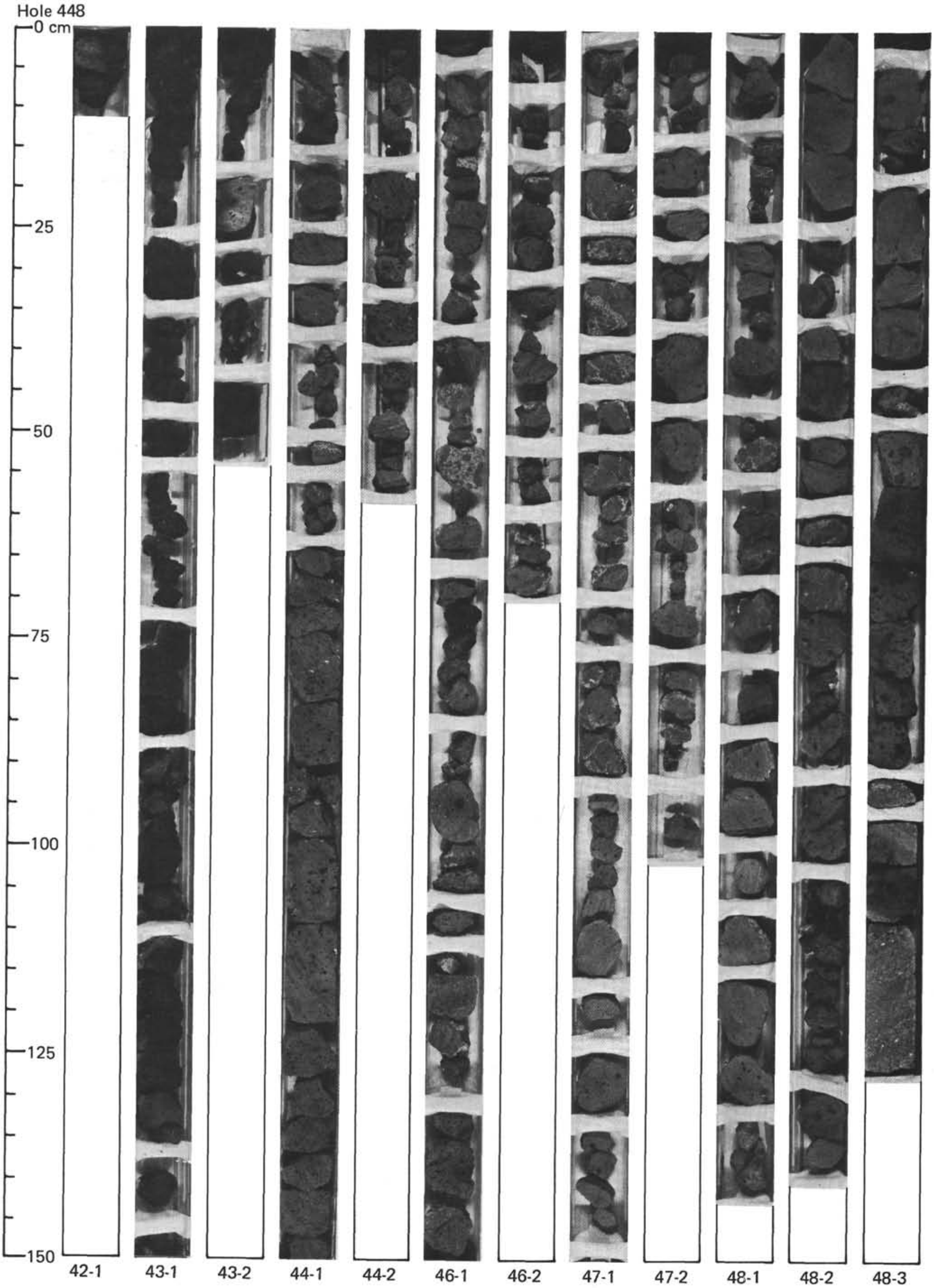
20-3
20,CC
21-1
21-2
21-3
21-4
21,CC
22-1
22,CC

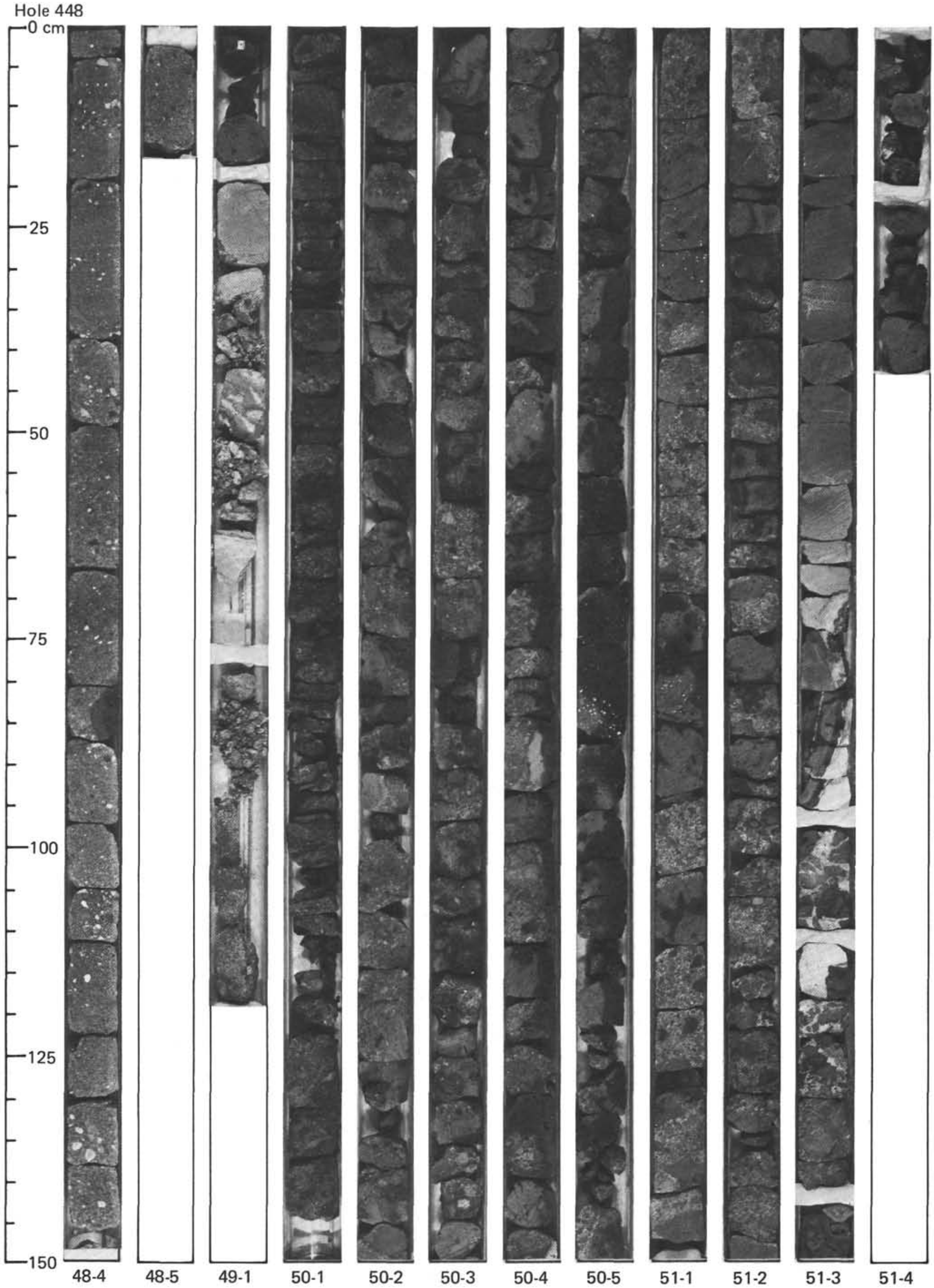

Hole 448
0 cm
25
50
75
100
125
150
23-1
23,CC
24-1
24-2
24-3
24,CC
25-1
25-2
25-3
25-4
25,CC
26-1
26-2

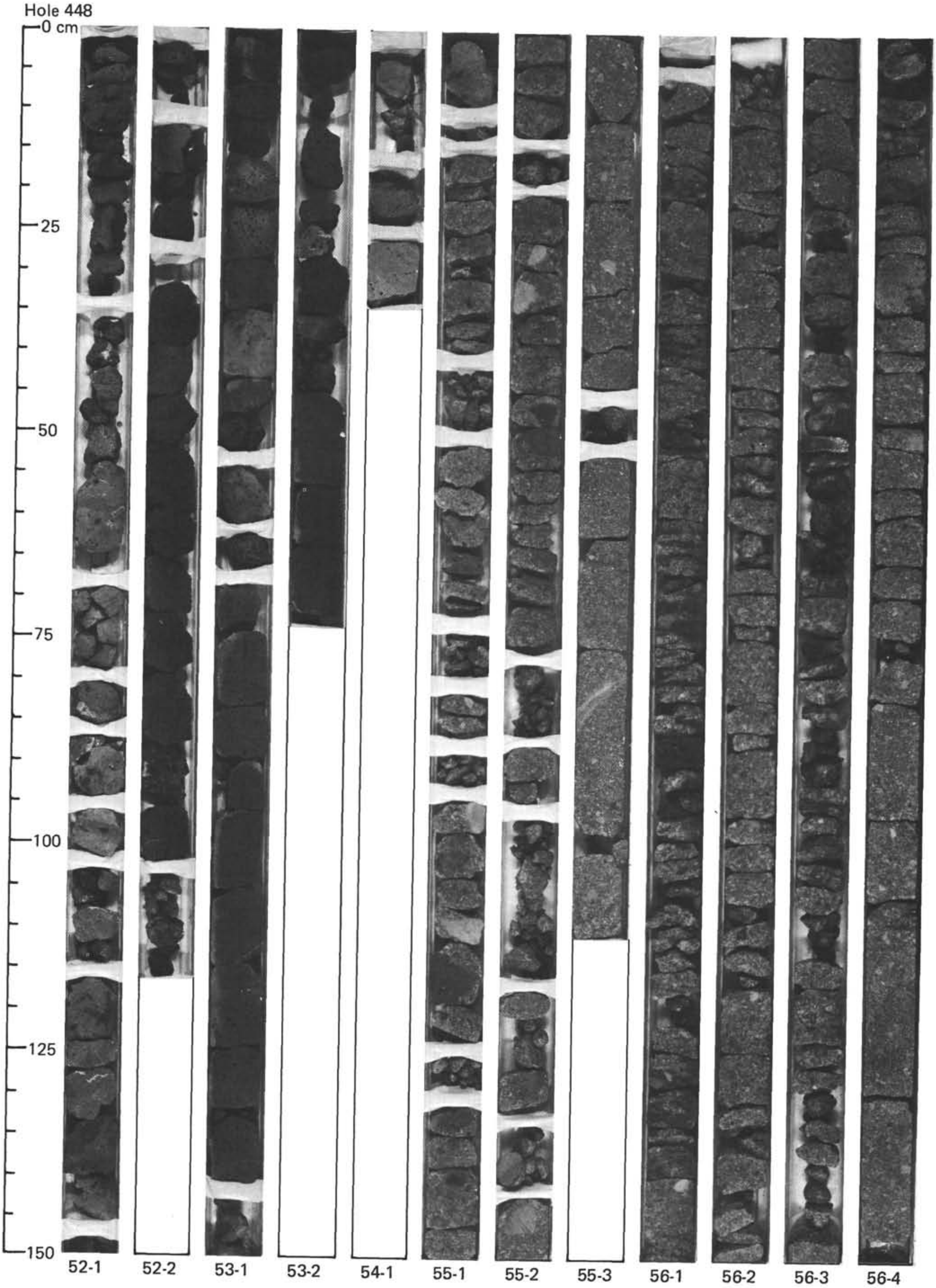

Hole 448
0 cm
25
50
75
100
125
150
26-3
26-4
26,CC
27-1
27-2
27-3
27-4
27,CC
28-1
28-2
28,CC
29-1
29-2
29-3

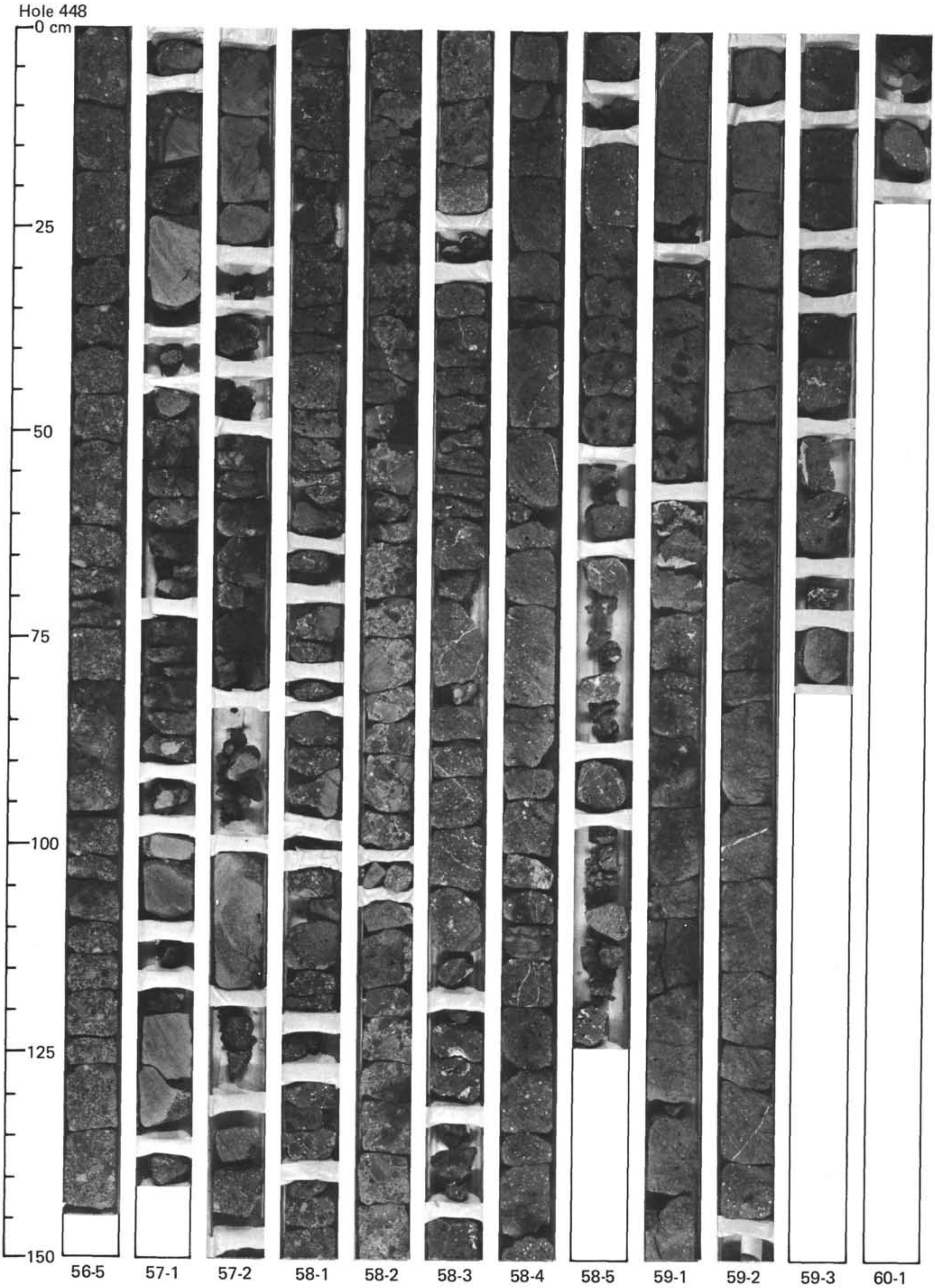

Hole 448
0 cm
25
50
75
100
125
150
29-4
29,CC
30,CC
31-1
31-2
31-3
31,CC
32,CC
33,CC
34-1
34-2
34,CC
35-1


Hole 448
0 cm
25
50
75
100
125
150
35,CC
37-1
38-1
38-2
39-1
39-2
39-3
40-1
40-2
40-3
41-1
41-2


Hole 448
0 cm
25
50
75
100
125
150
42-1
43-1
43-2
44-1
44-2
46-1
46-2
47-1
47-2
48-1
48-2
48-3


Hole 448
0 cm
25
50
75
100
125
150
48-4
48-5
49-1
50-1
50-2
50-3
50-4
50-5
51-1
51-2
51-3
51-4


Hole 448
0 cm
25
50
75
100
125
150
52-1
52-2
53-1
53-2
54-1
55-1
55-2
55-3
56-1
56-2
56-3
56-4


Hole 448
0 cm
25
50
75
100
125
150
56-5
57-1
57-2
58-1
58-2
58-3
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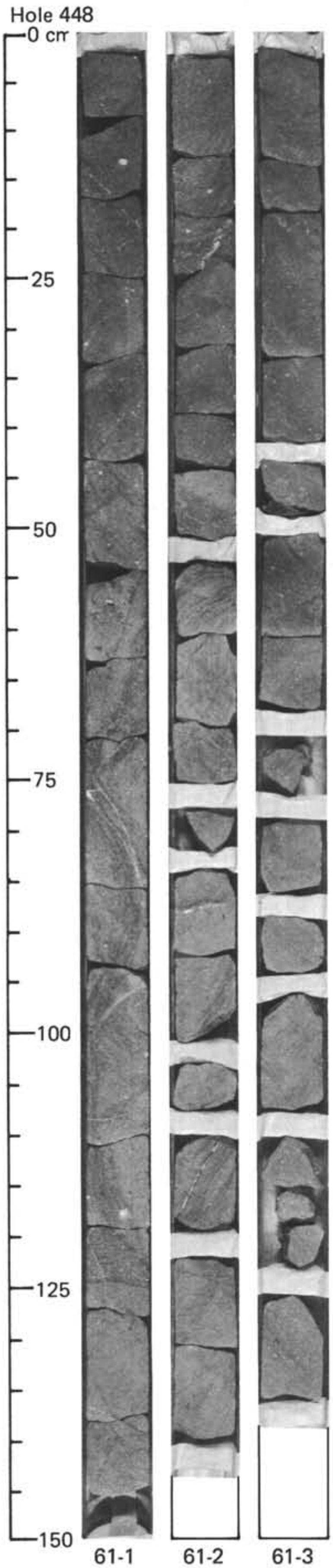
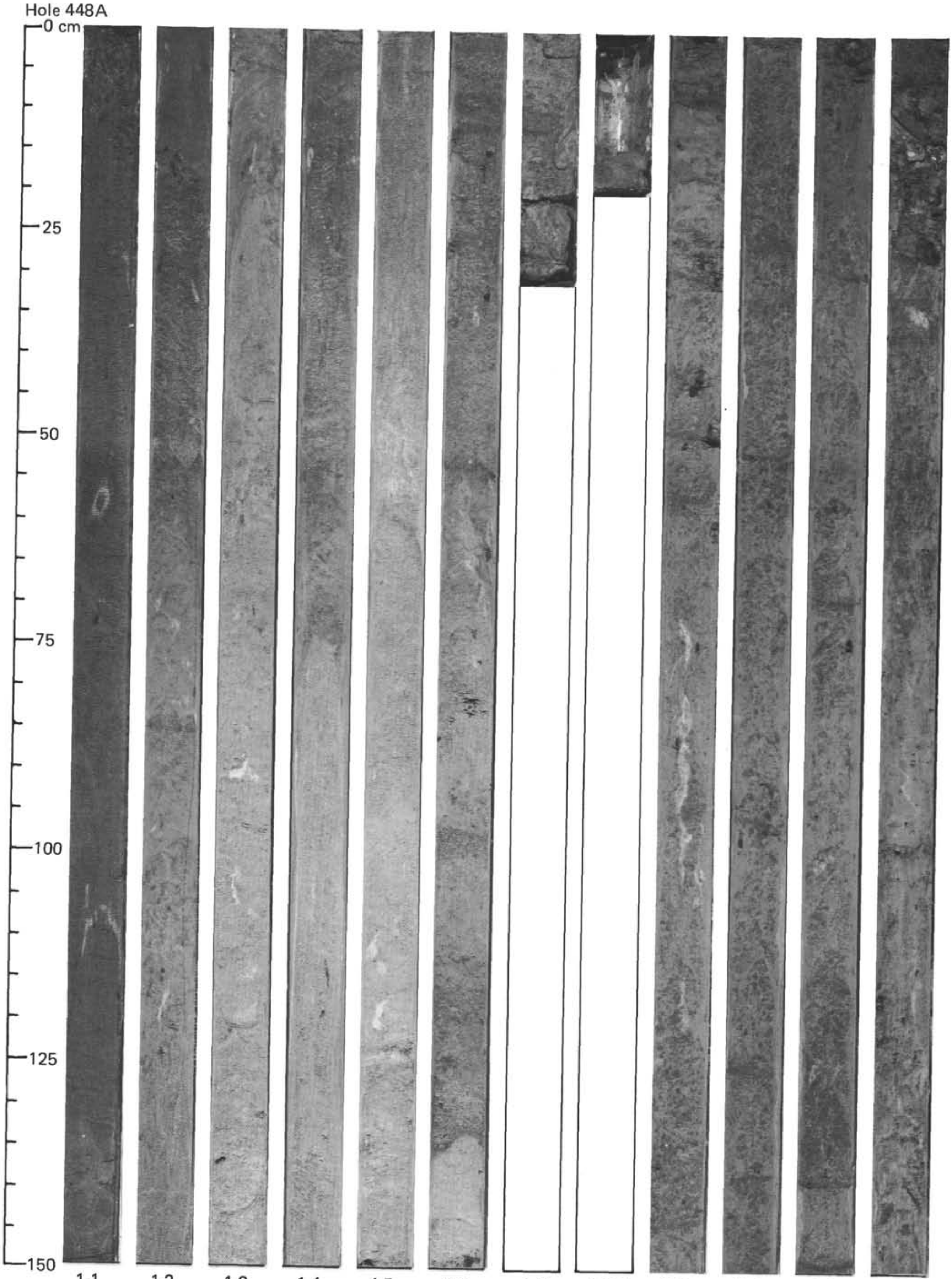
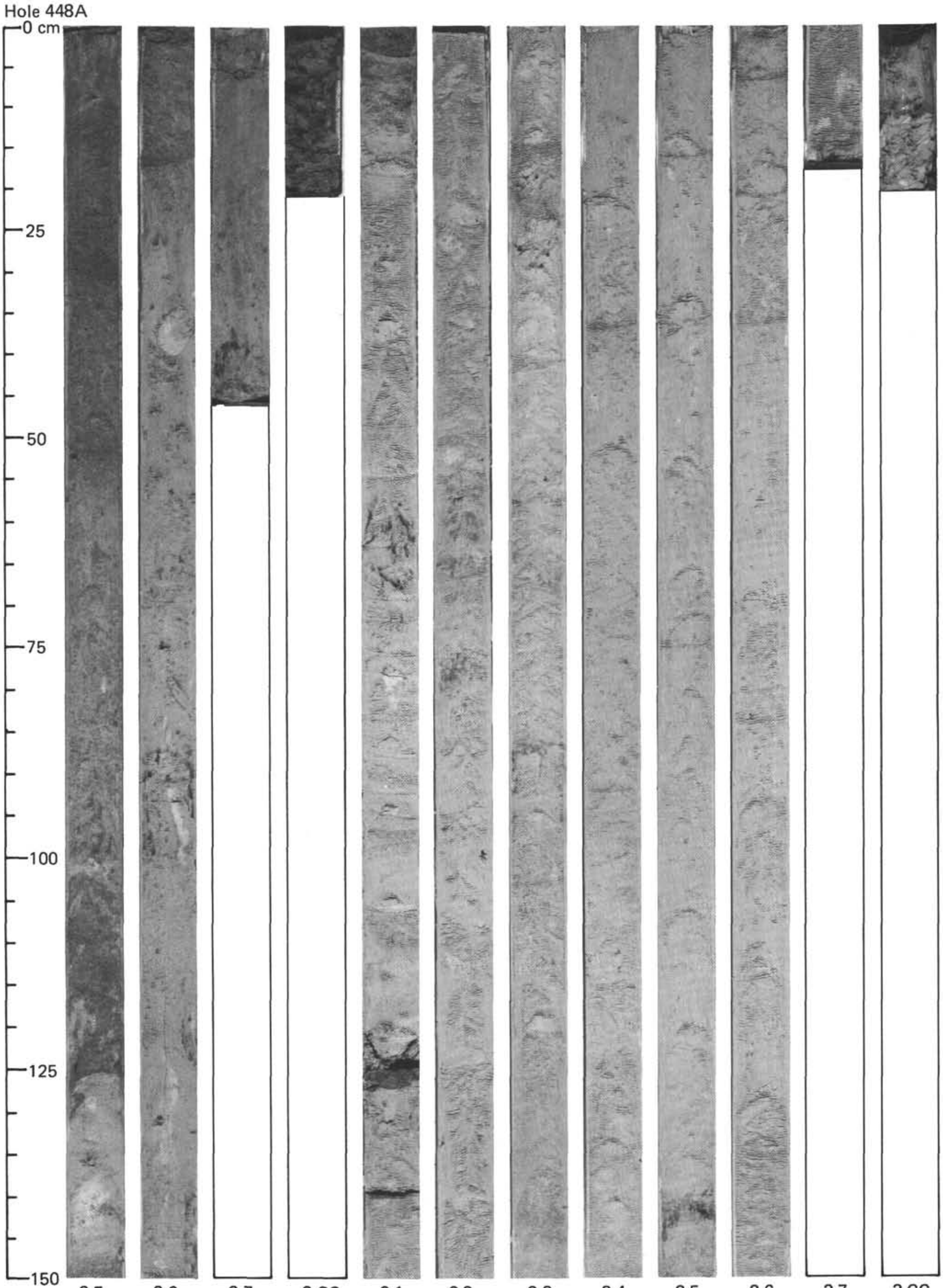
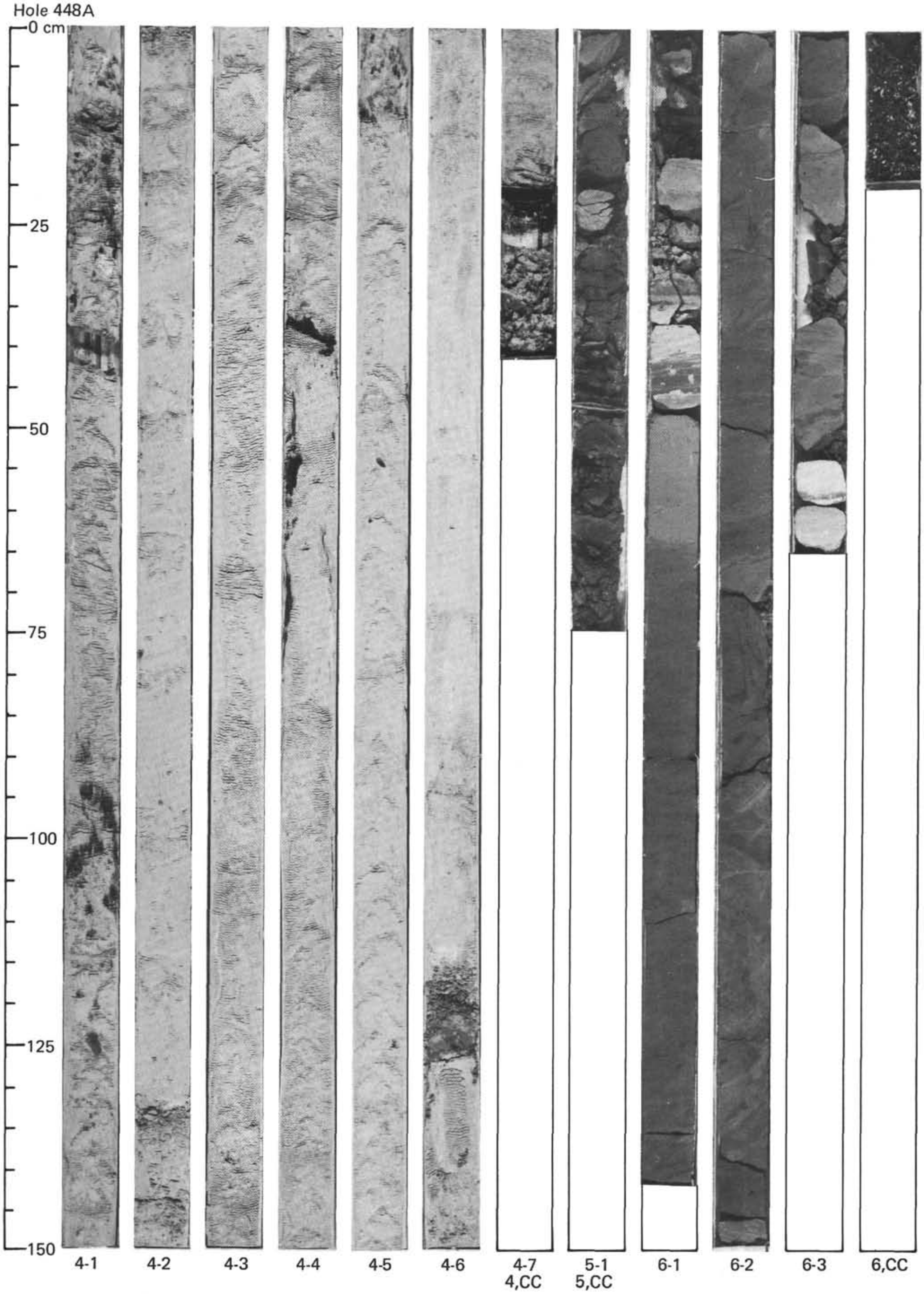
58-5
59-1
59-2
59-3
60-1


Hole 448
0 cm
25
50
75
100
125
150
61-1
61-2
61-3


Hole 448A
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1-4
1-5
1-6
1-7
1,CC
2-1
2-2
2-3
2-4


Hole 448A
0 cm
25
50
75
100
125
150
2-5
2-6
2-7
2,CC
3-1
3-2
3-3
3-4
3-5
3-6
3-7
3,CC


Hole 448A
0 cm
25
50
75
100
125
150
4-1
4-2
4-3
4-4
4-5
4-6
4-7
4,CC
5-1
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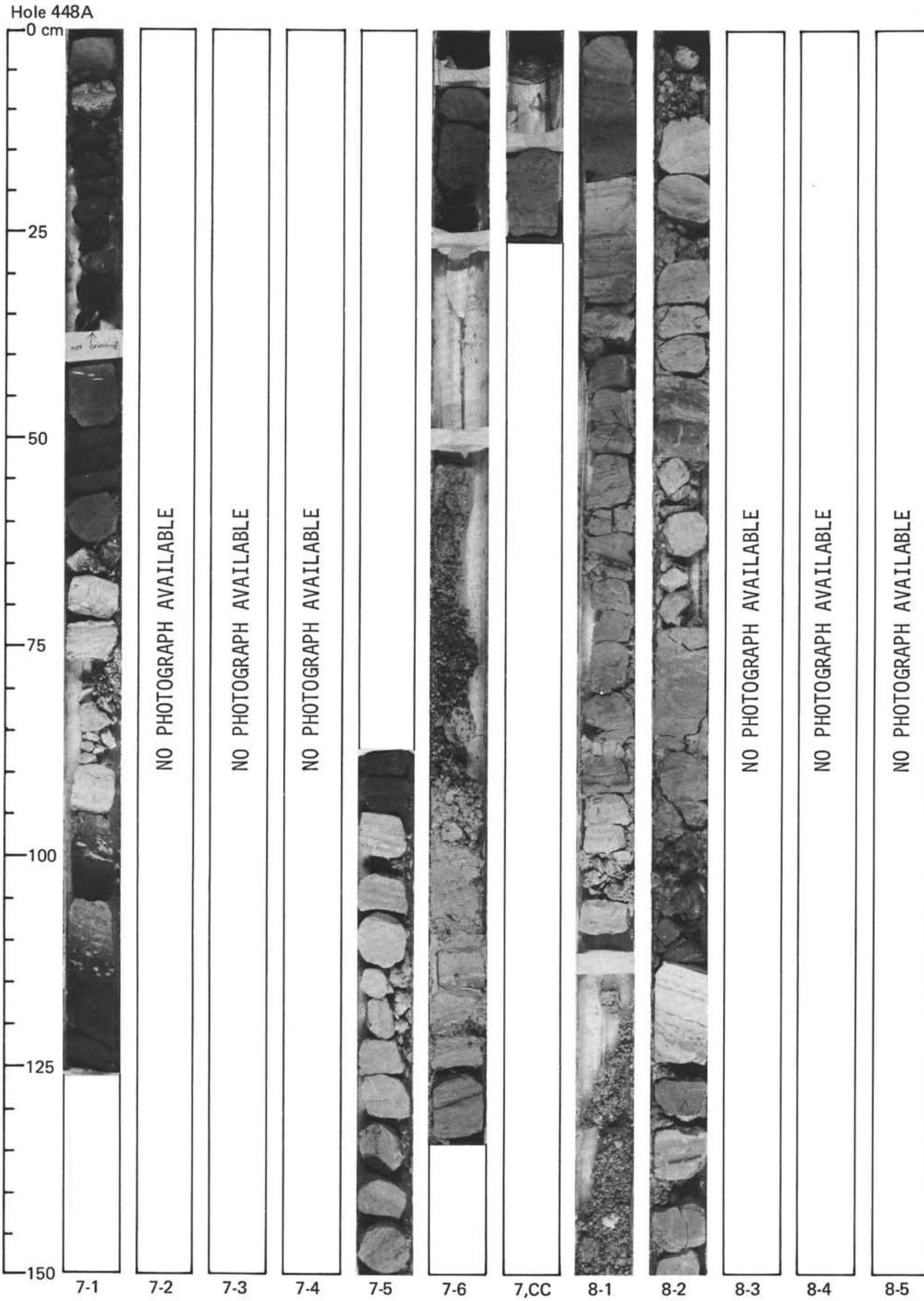

Hole 448A
0 cm
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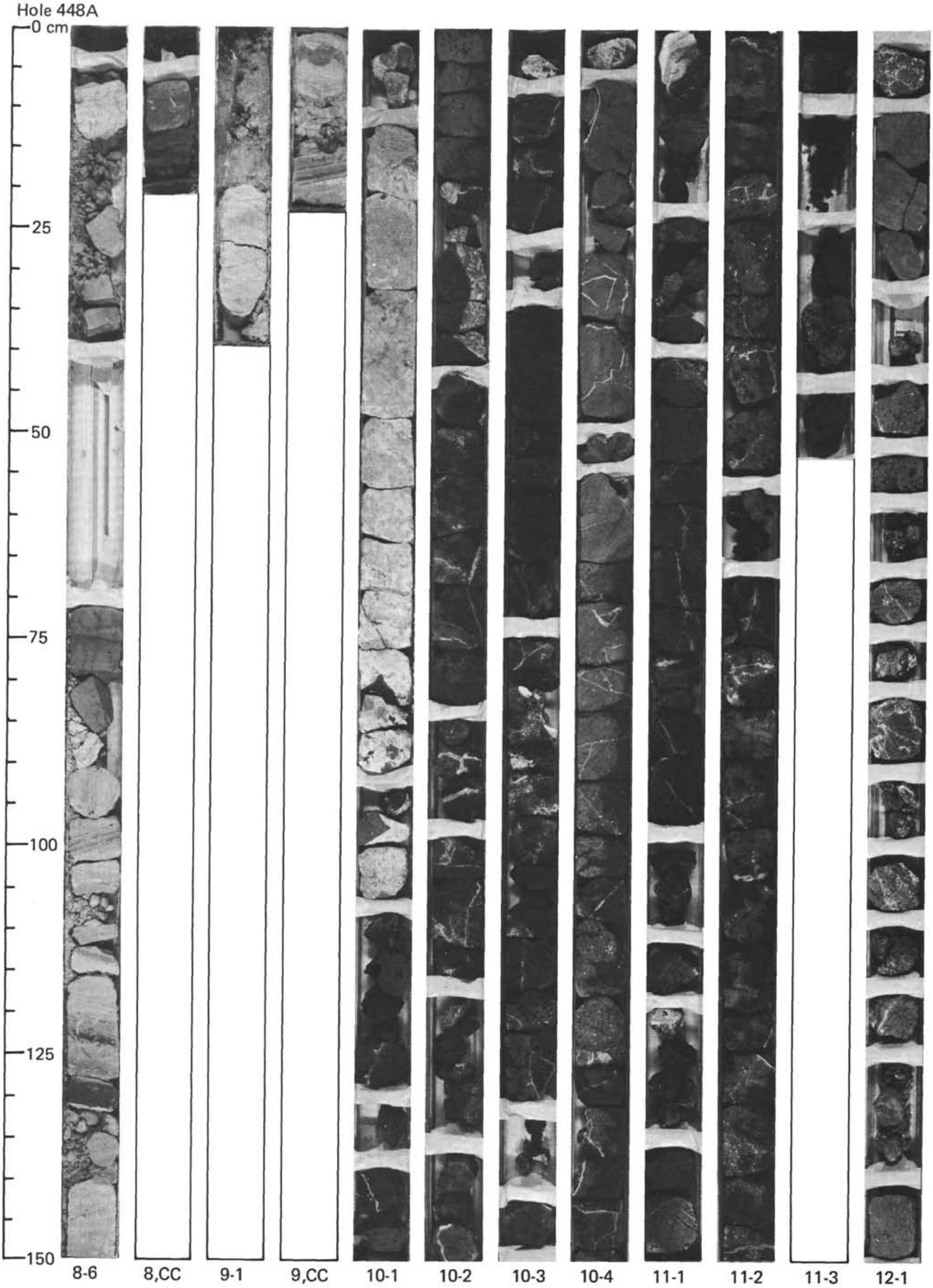
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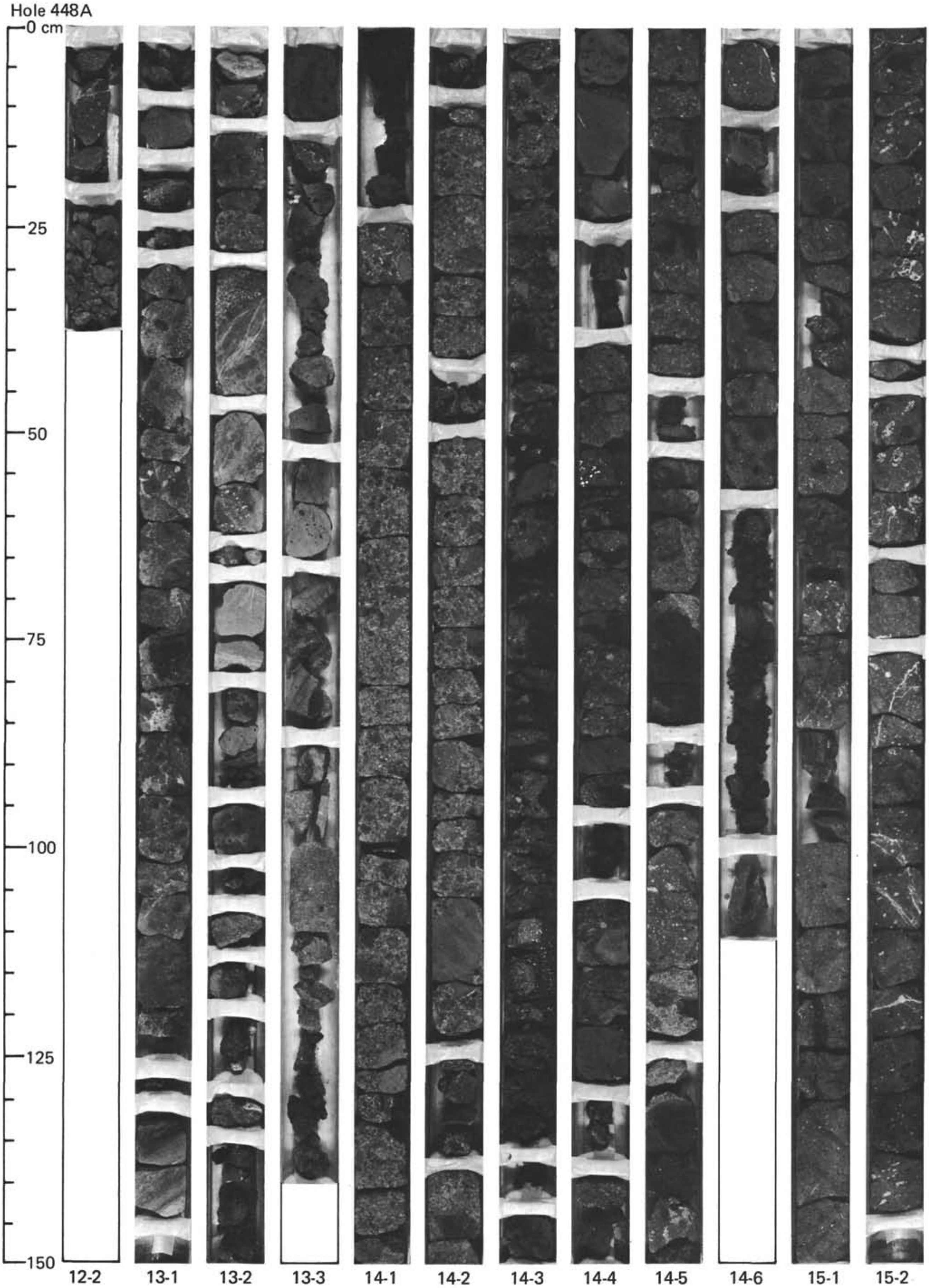
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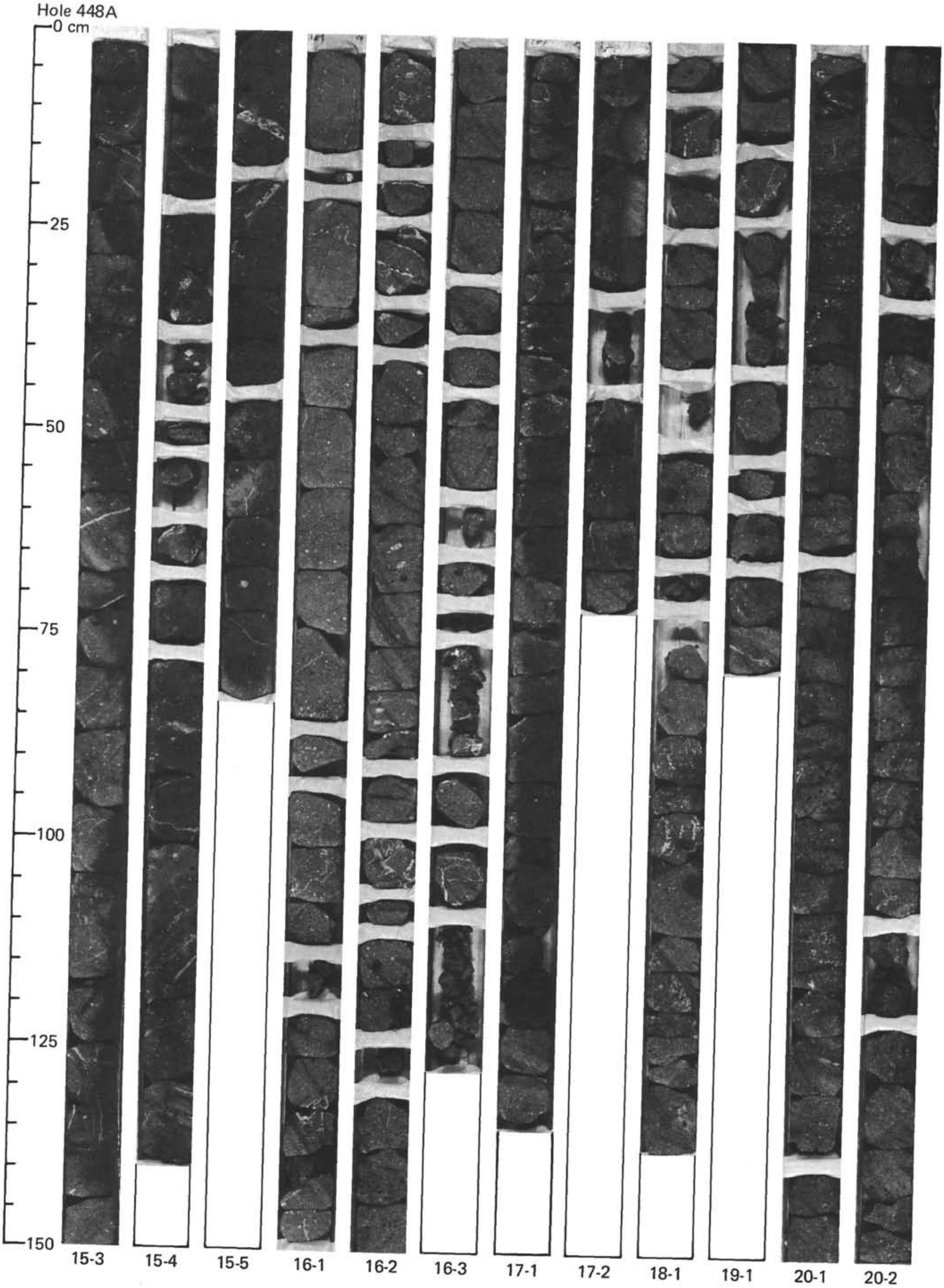
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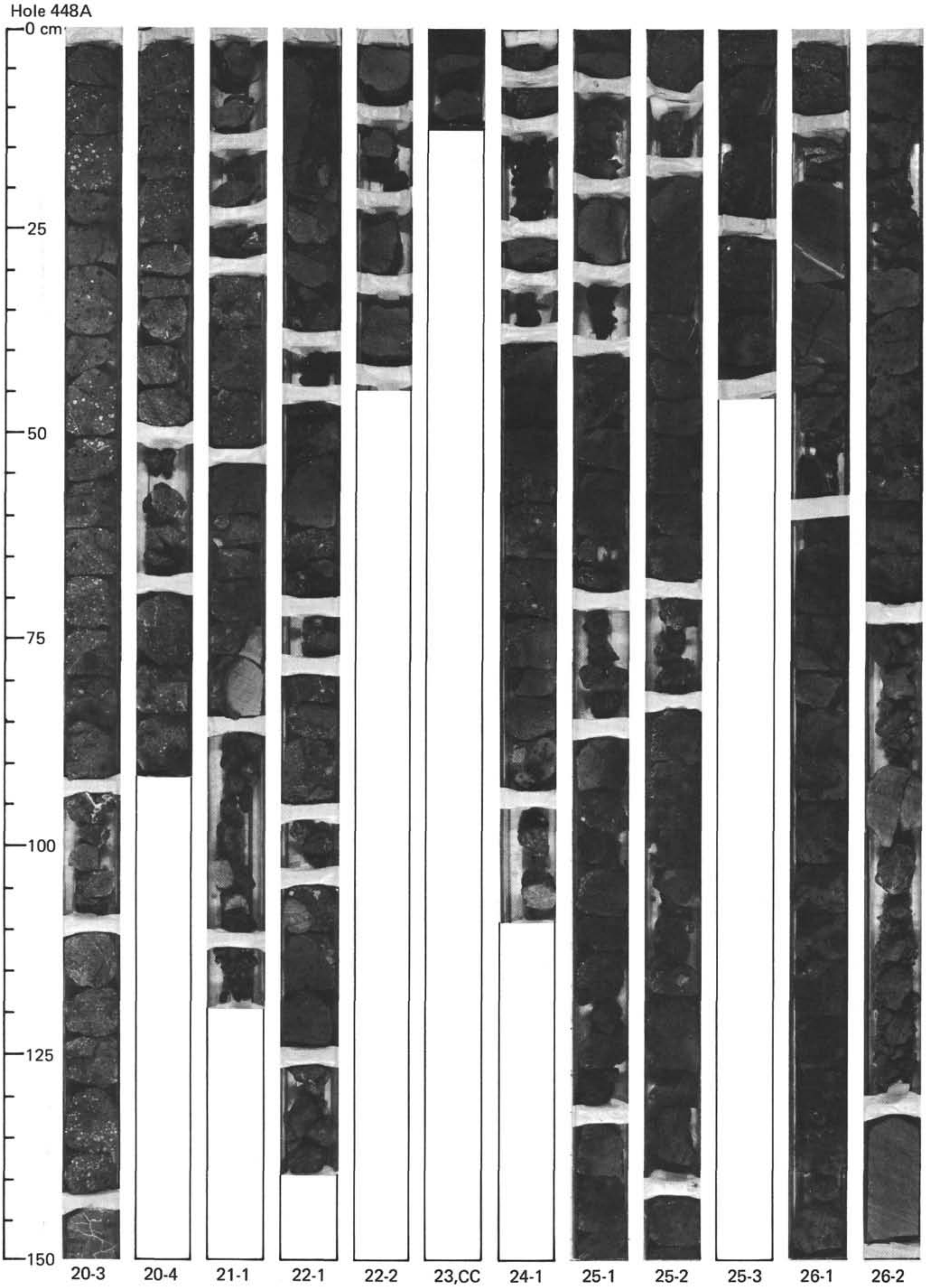
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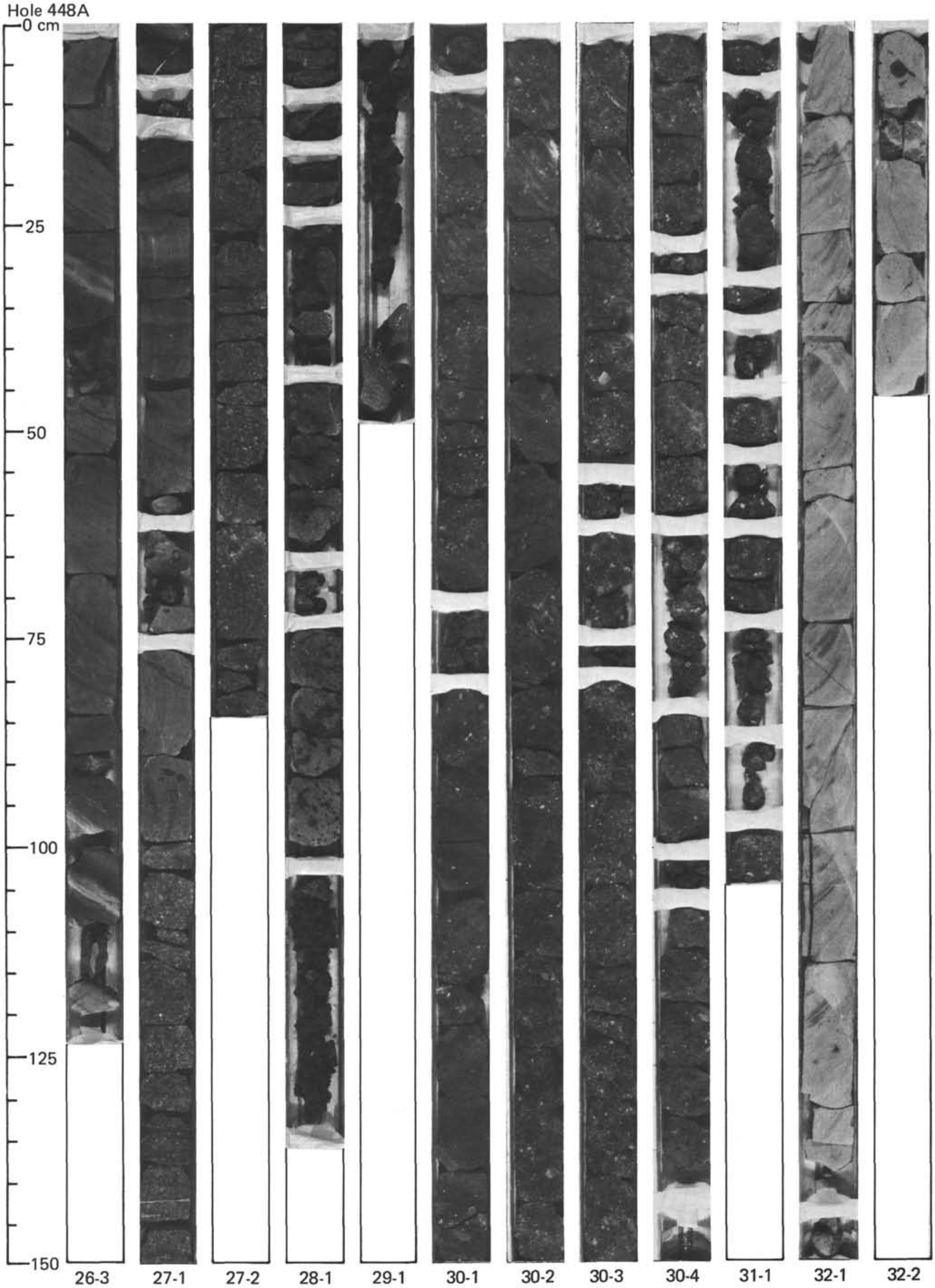

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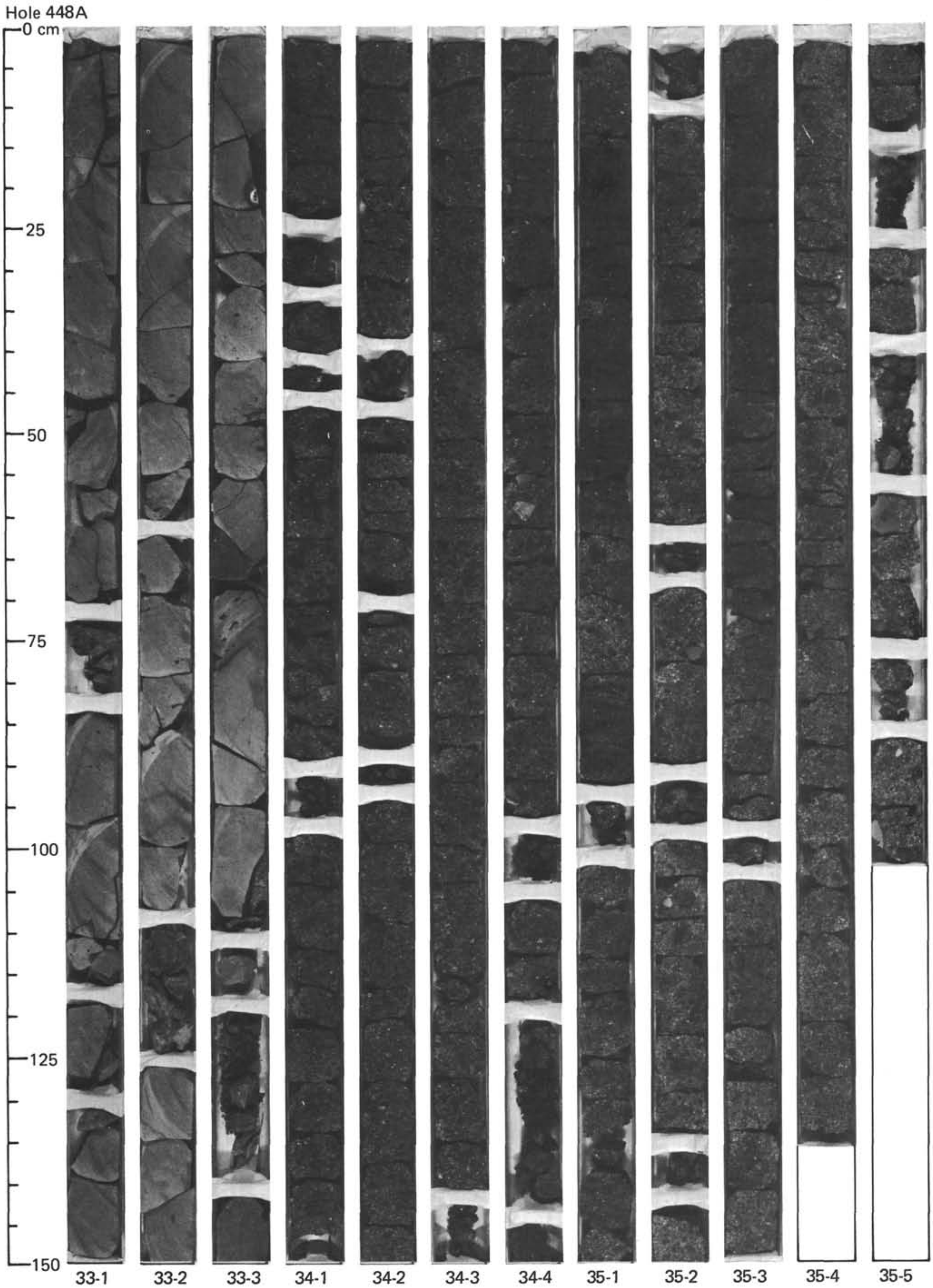
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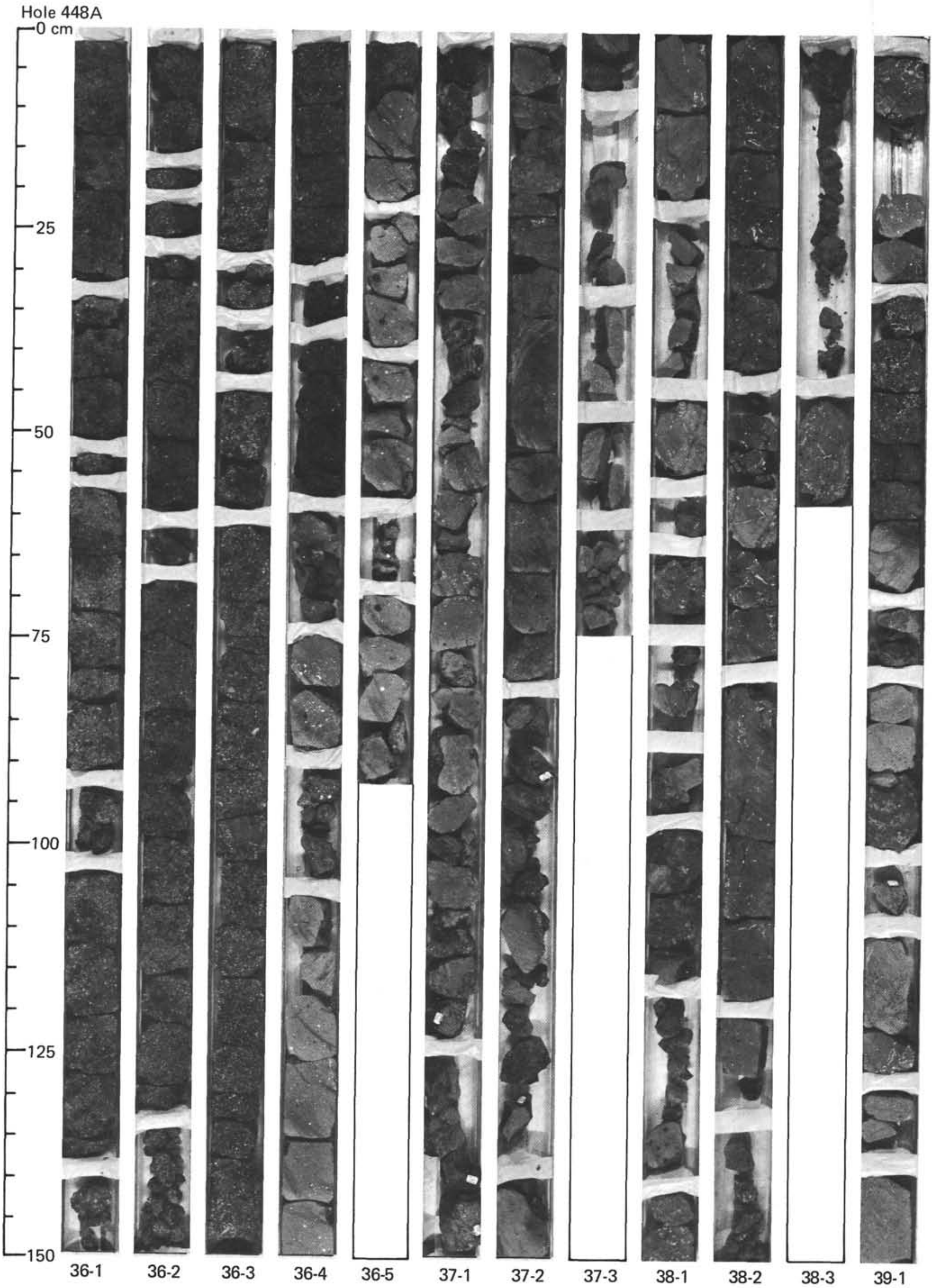
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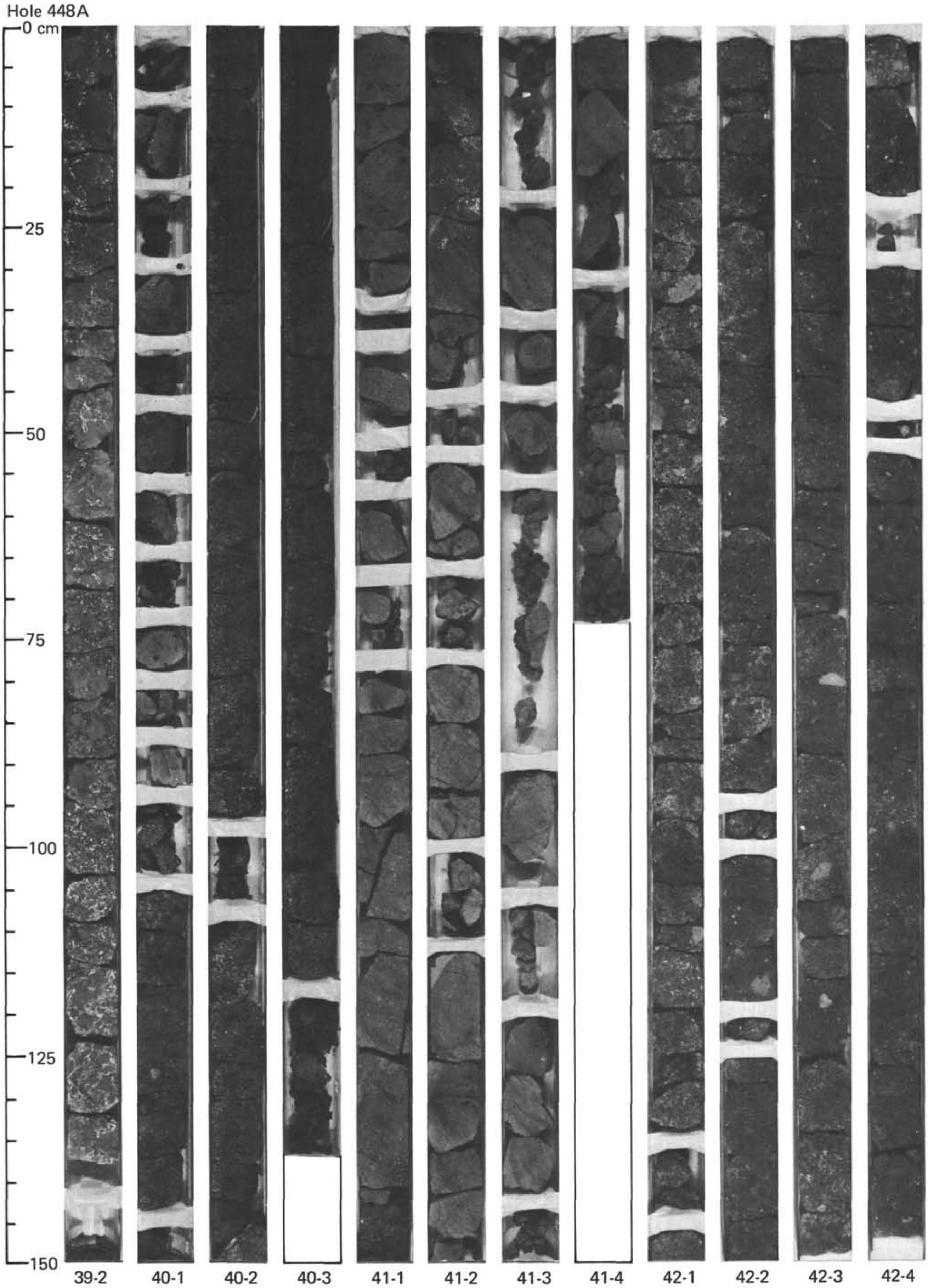
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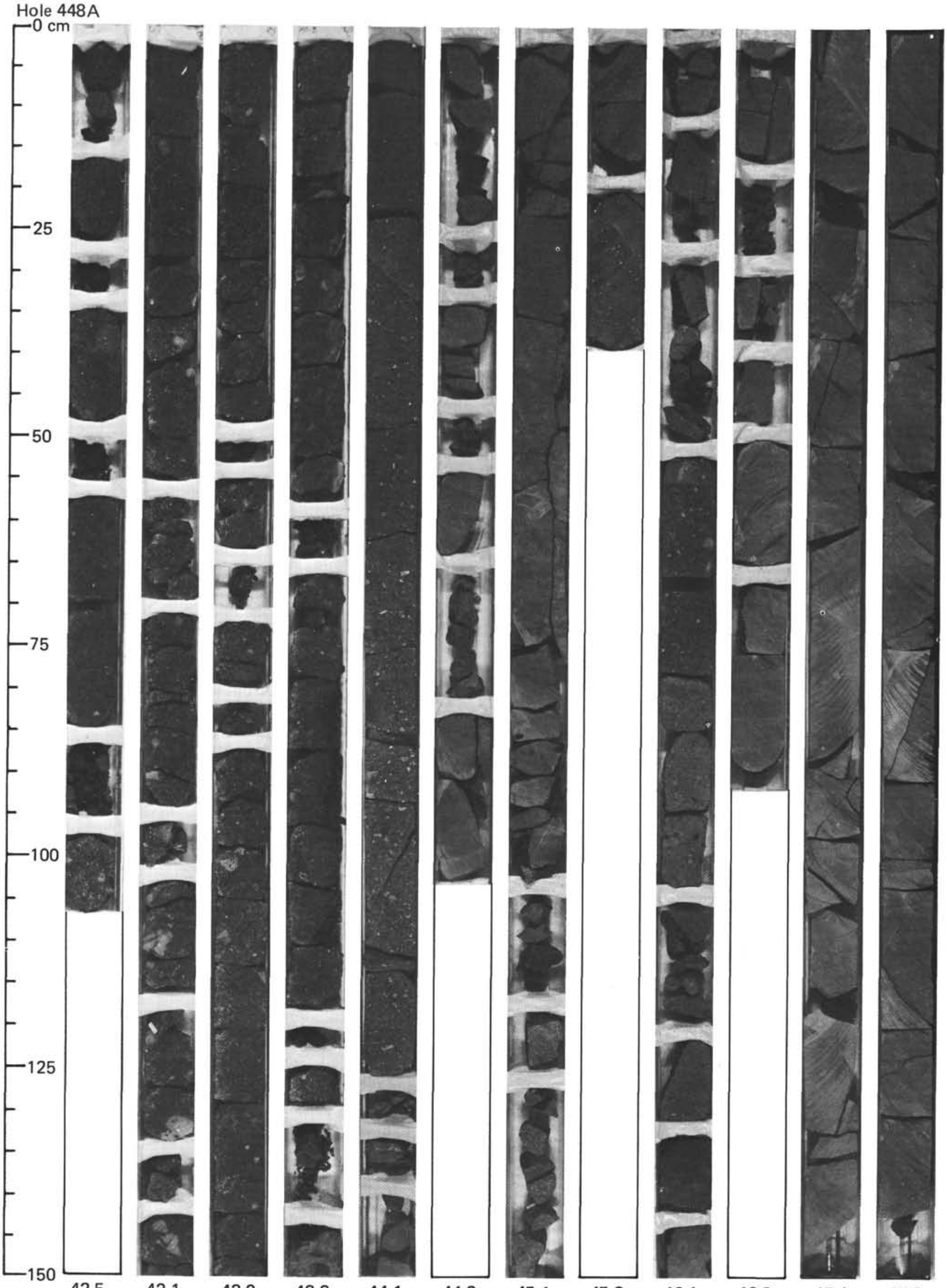
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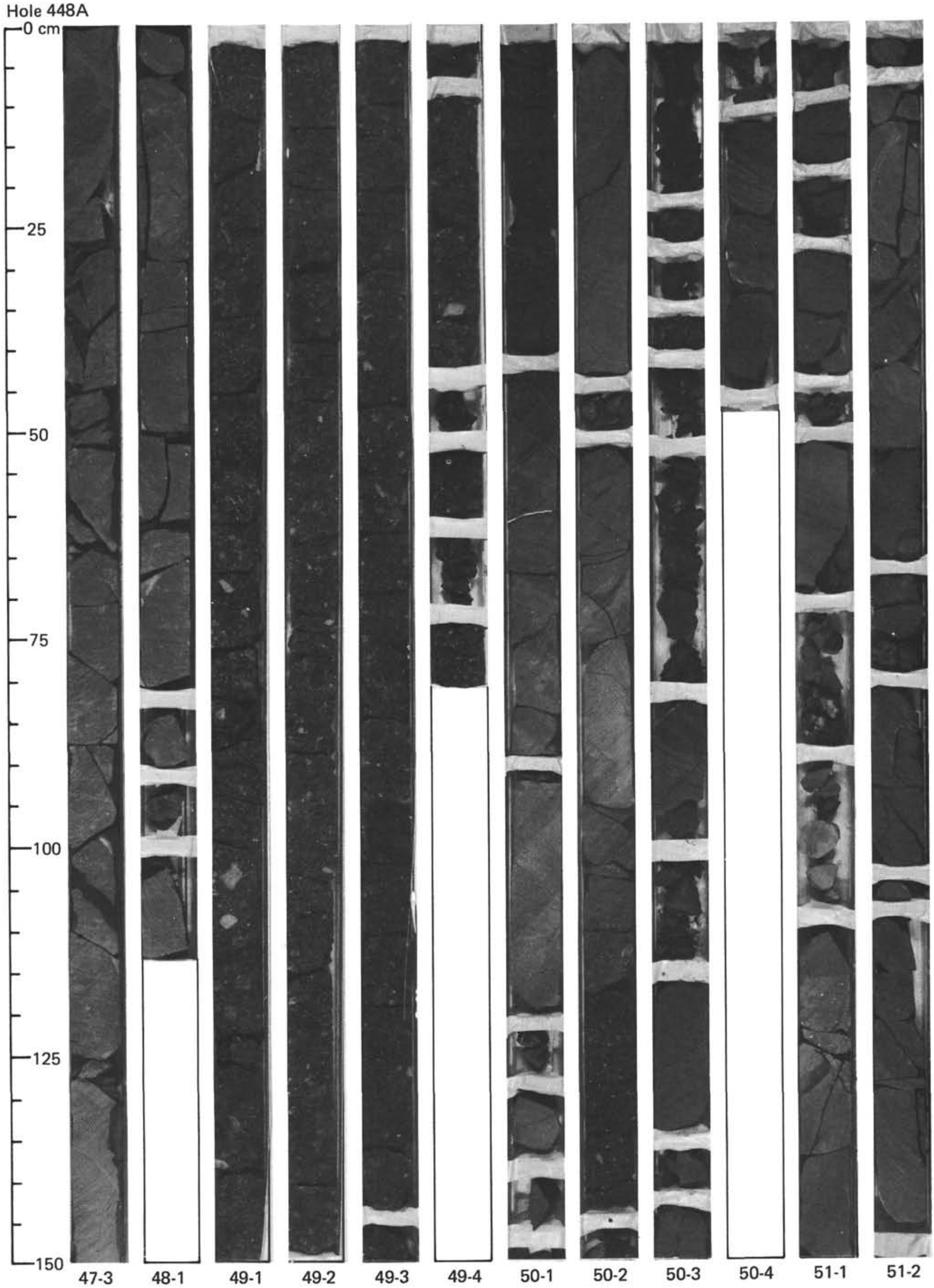

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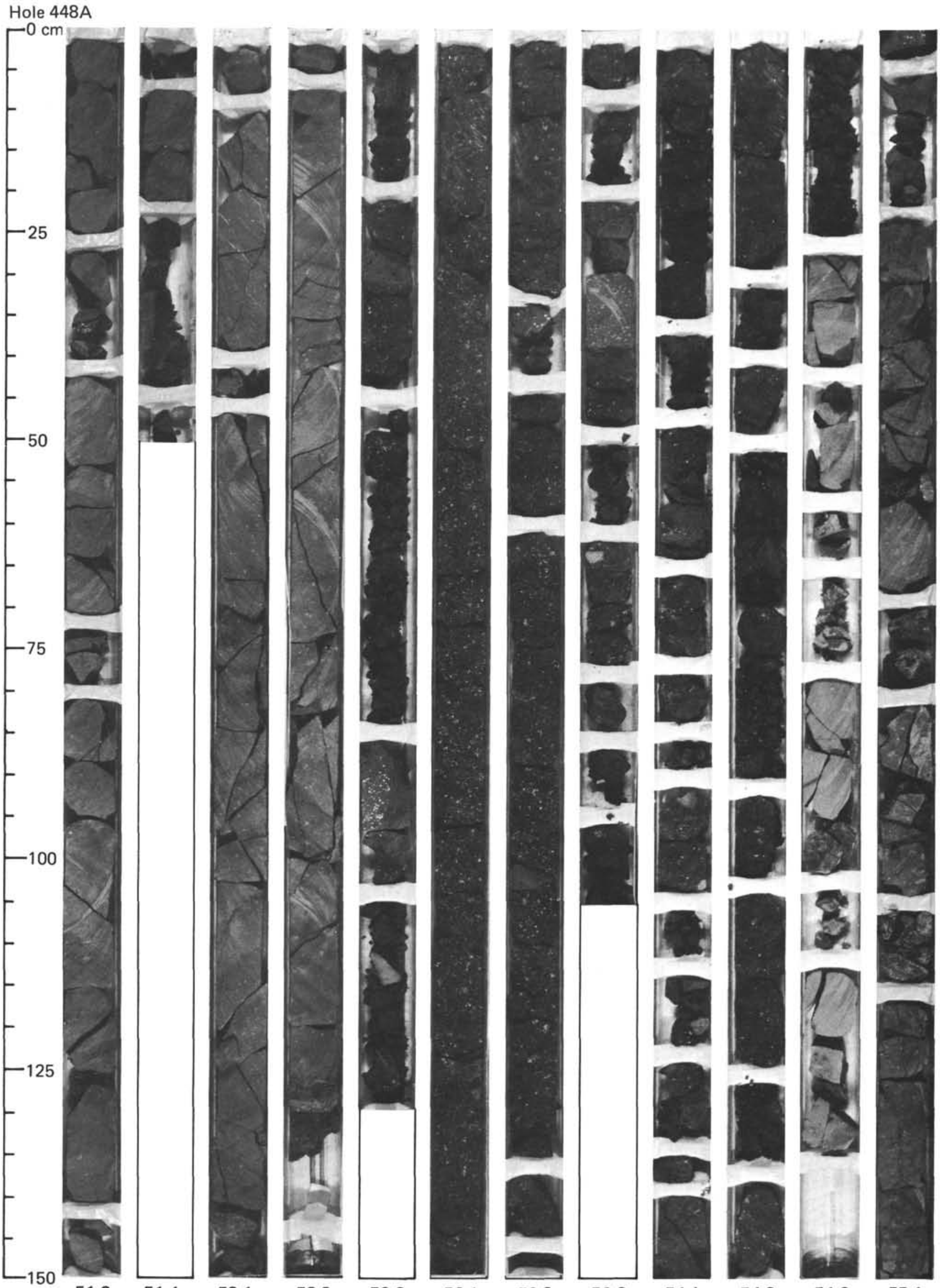
51-2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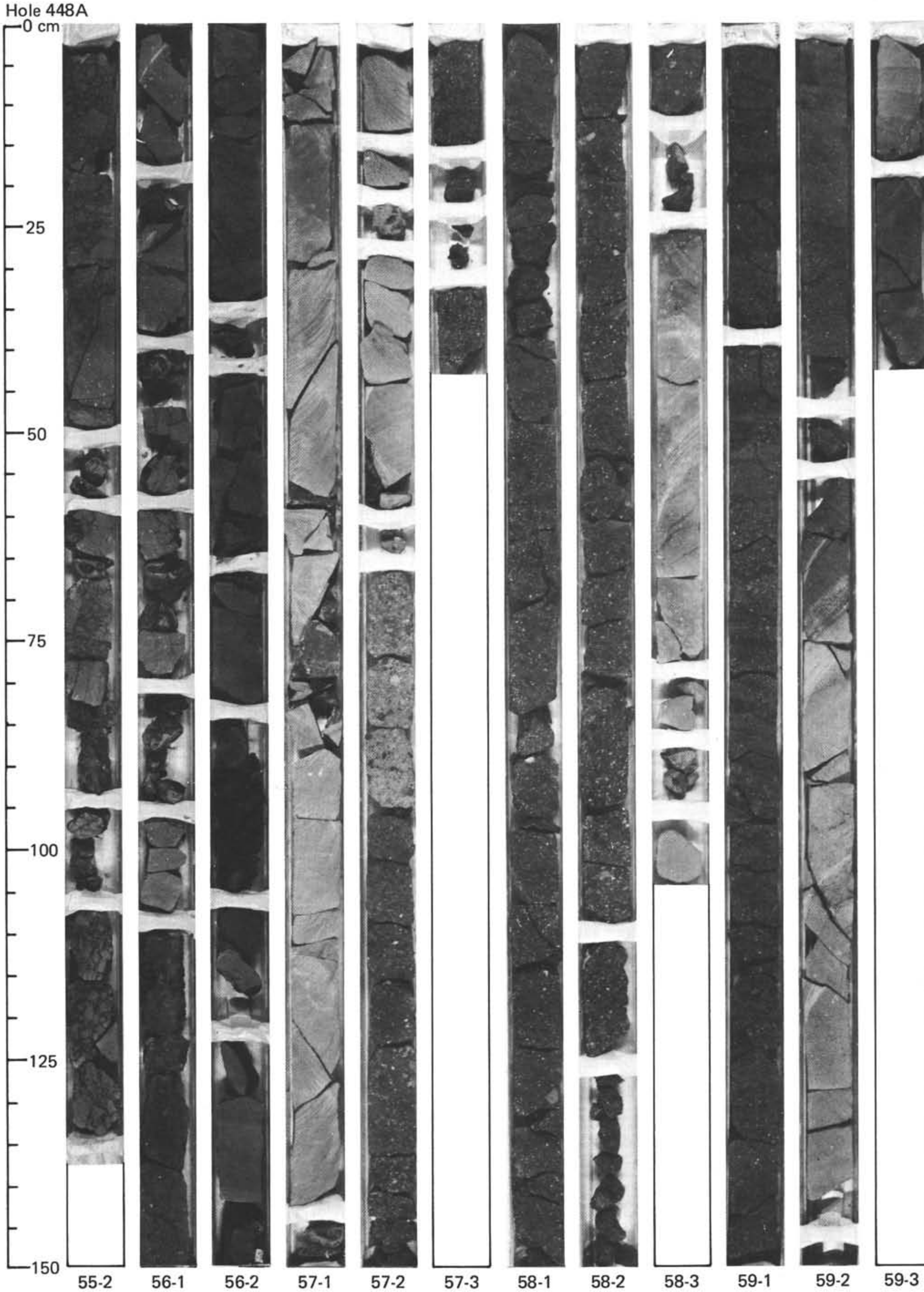
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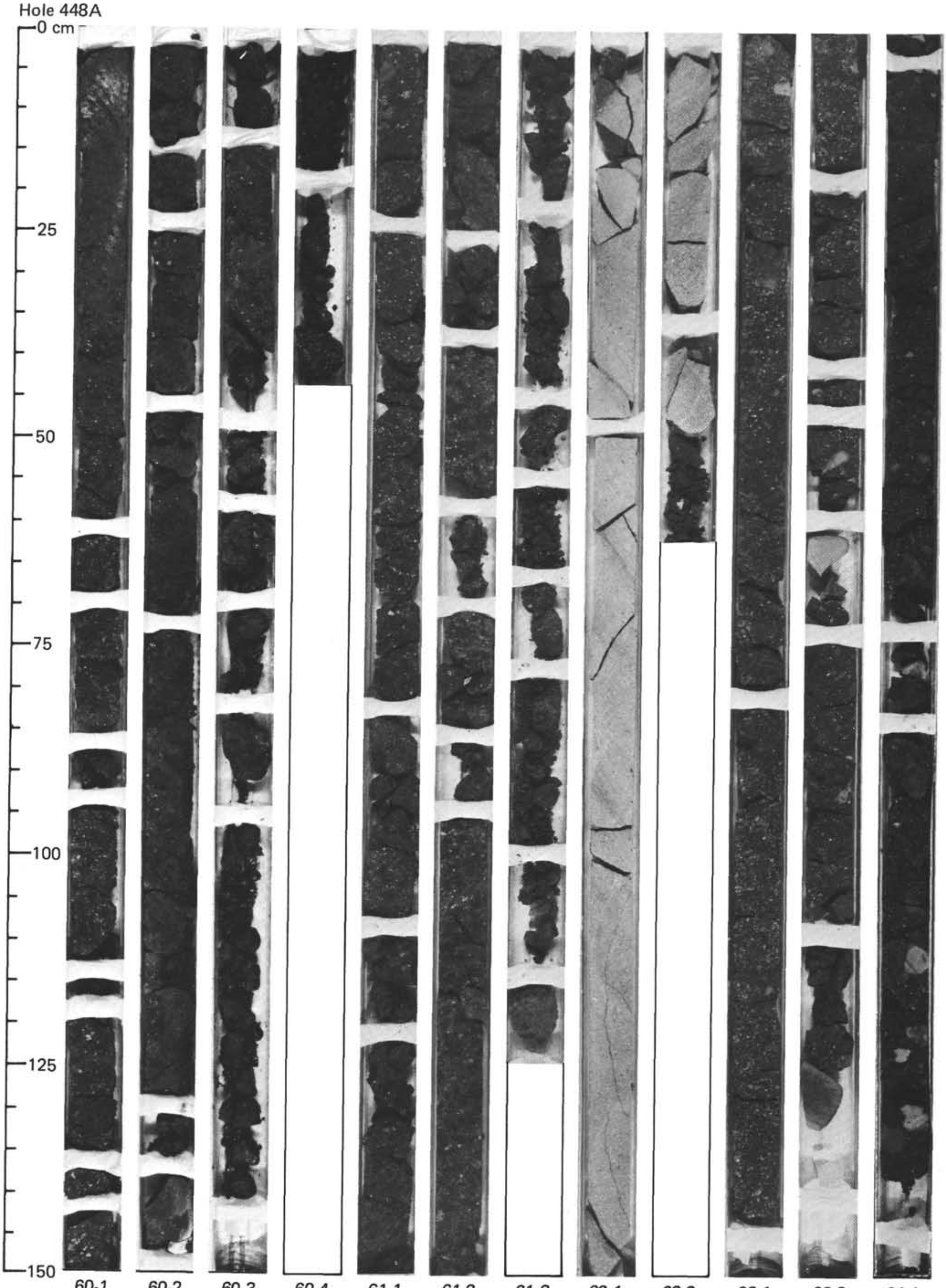
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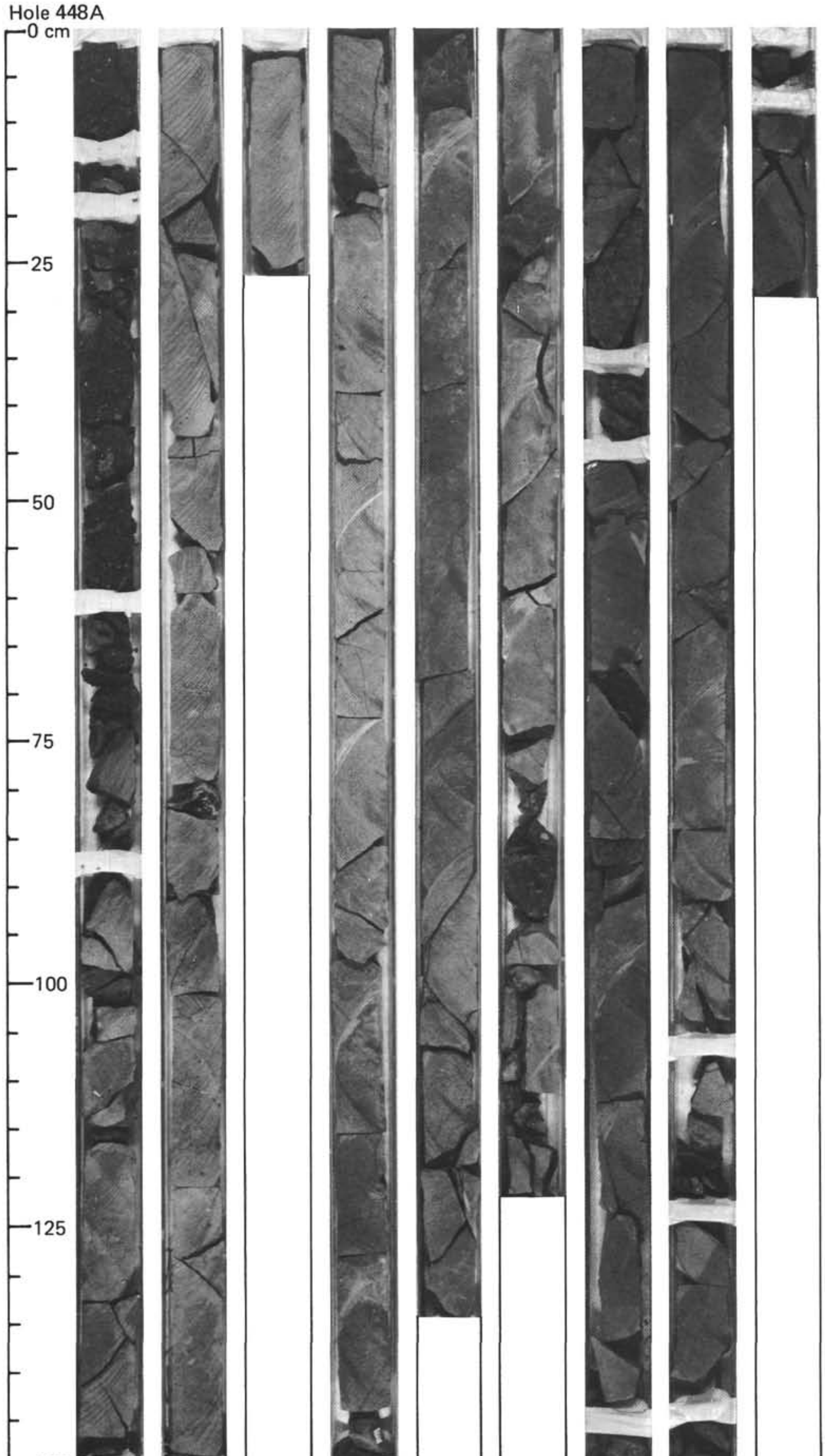
64-1


Hole 448A
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66-1
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