2. SITE 463: WESTERN MID-PACIFIC MOUNTAINS[1]

Shipboard Scientific Party[2]

HOLE 463

Date occupied: 2 August 1978 (1708Z)

Date departed: 10 August 1978 (1515Z)

Time on hole: 190.2 hours

Position (latitude; longitude): 21°21.01′N; 174°40.07′E

Water depth (corrected m, echo sounding): 2525

Bottom felt (m, drill pipe): 2532

Penetration (m): 822.5

Number of cores: 92

Total length of cored section (m): 822.5

Total core recovered (m): 301.8

Core recovery (%): 36.6

Oldest sediment cored:
Depth sub-bottom (m): 822.5
Nature: limestone
Age: Early Cretaceous (Barremian)

Basement: Not reached

Principal results: The main objectives at Site 463 (Fig. 1) were to continuously core to igneous basement, in order to determine the geologic history of the western Mid-Pacific Mountains and to recover a complete pelagic record for biostratigraphic and paleoceanographic interpretations. Igneous basement was not reached, even though 822.5 meters were cored. The sediments and sedimentary rocks were divided into four major lithologic units (Fig. 2). The oldest unit, at least 190 meters thick, is interbedded pelagic and clastic limestone of Early Cretaceous (Barremian) age. Shallow-water carbonate debris containing oolites, mollusk fragments, stromatolite fragments, and rare glauconite grains makes up most of the clastic limestone beds. An overlying unit, 45 meters thick, consists of cyclic carbonaceous limestone of Early Cretaceous (early Aptian) age, with volcanic ash. The abundant ash in this interval indicates frequent volcanic activity on nearby islands. The high organic-carbon content of some beds is strong evidence for a sequence of anoxic events that are of at least regional and possibly worldwide importance. The overlying unit, 136 meters thick, is composed of multicolored pelagic limestone beds with chert as a common component; it is early Aptian through middle Albian in age. The top unit is divided into two sub-units. The oldest sub-unit is 405 meters thick and ranges in age from late Albian to early Maastrichtian. Rock and sediment types are nannofossil and foraminifer chalk, nannofossil and foraminifer ooze, and limestone with minor amounts of chert and porcellanite. The youngest sub-unit of the top lithologic unit, 47 meters thick, is nannofossil ooze of early Eocene through Pleistocene age. The calcareous planktonic faunas and floras in the Miocene and Pliocene oozes are heavily dissolved, despite the relatively shallow depth of deposition at this site. The base of the youngest sub-unit marks a major hiatus between lower Eocene and lower Maastrichtian sediments. Seismic-reflection profiles show three major reflectors. The top one, observed only on the 3.5-kHz records, marks the boundary between the Tertiary and Maastrichtian nannofossil-ooze beds. The second one marks the top of the limestone beds, at about 250 meters, that lie within the lower sub-unit of lithologic Unit I. The third marks the boundary between the top lithologic unit and the underlying unit of Lower Cretaceous limestone beds, at about 450 meters sub-bottom depth. At least two reversed-polarity intervals can be identified in the *Chiastozygus litterarius* nannoplankton zone, which may correlate with anomaly M0 or a reversed interval that was identified at DSDP Hole 361 in the south Atlantic.

BACKGROUND AND OBJECTIVES

The late Mesozoic and Cenozoic paleoenvironment of the central North Pacific region was the main target of the sites drilled during Leg 62 of the Deep Sea Drilling Project. The deposits were expected to contain remains of several, if not all, important pelagic microfossil groups. The selected sites were therefore located on structural highs where calcareous sediments are preserved, whereas calcareous components have been dissolved over wide regions of the deep North Pacific basins. Carbonate deposits capping the Mid-Pacific Mountains (Hamilton, 1956) southwest of the Hawaiian Ridge were chosen to be drilled at the first site. We planned to recover upper Mesozoic and Cenozoic sedimentary sections, as well as to reach rocks of the Upper Jurassic(?)–Lower Cretaceous volcanic platform of the northwestern Mid-Pacific Mountains (Larson, 1976). The primary objective at this site, however, was to obtain lower Tertiary and upper Mesozoic sections. The lower Tertiary and upper Mesozoic planktonic record is scanty in this part of the North Pacific; thus, good and complete sections were needed for both biostratigraphic and paleoceanographic interpretations. The study of upper Mesozoic and lower Tertiary sediments from this locale would provide fundamental insight into the characteristics of planktonic communities, paleocirculations, and fertility patterns during a period of major biological crises associated with the Mesozoic/Cenozoic boundary.

The Mid-Pacific Mountains constitute one of the large aseismic rises in the central and northern Pacific Ocean whose nature, origin, and age are disputed. General morphology of the Mid-Pacific Mountains is shown

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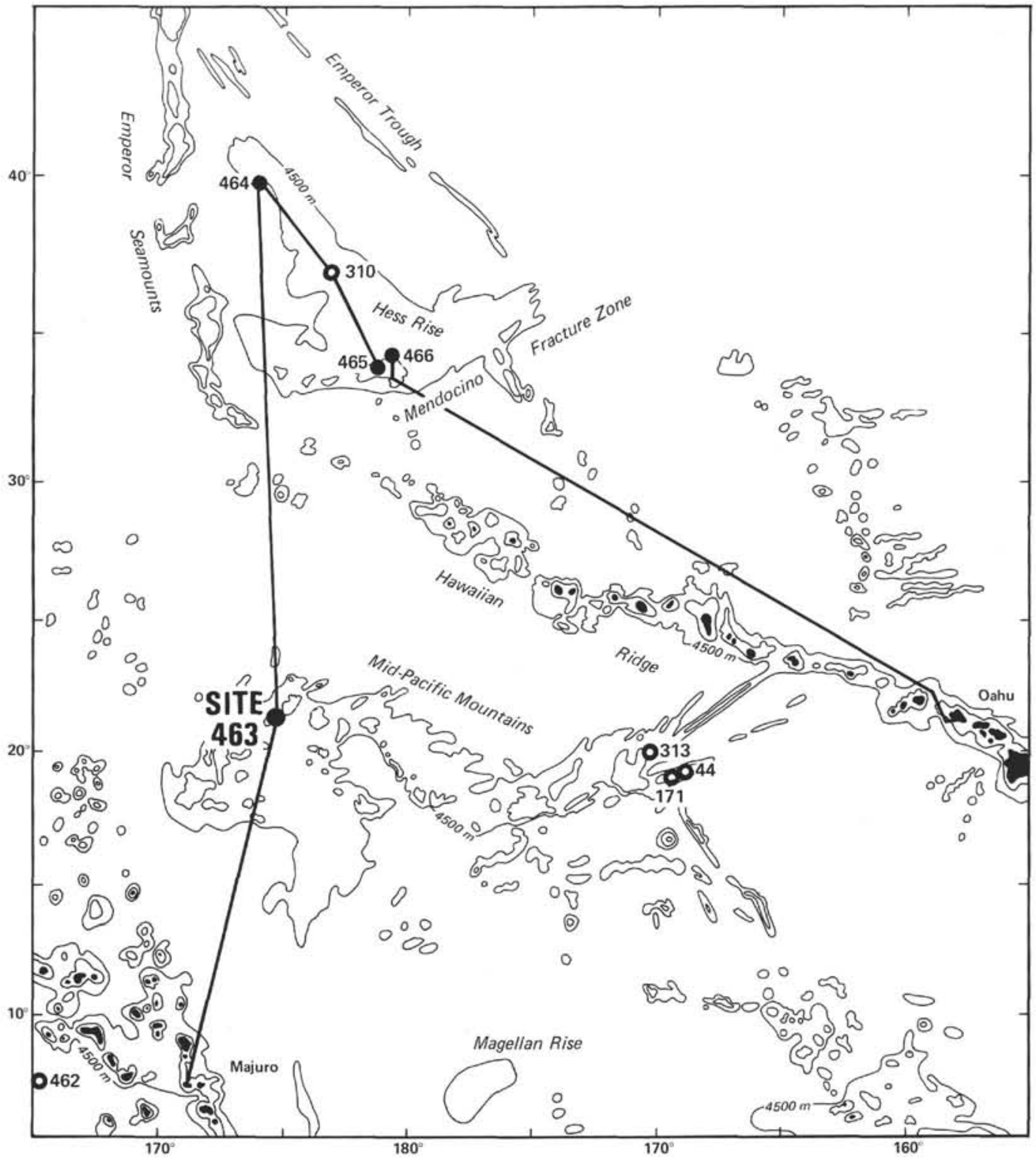


Figure 1. Location of DSDP sites in the central North Pacific.

in Figure 3. It is not clear how its position is related to the ancestral plates of the Mesozoic Pacific Ocean (Larson, 1976). Basaltic rocks recovered at Sites 313 and 171 in the eastern Mid-Pacific Mountains are believed to represent the volcanic basement (Larson, Moberly, et al., 1975), but they do not necessarily date the main constructional phase of the volcanic edifice. It is interesting to note that the ages obtained for the volcanic rocks found at Site 313 are 30 m.y. younger than that from Site 171 (Saito and Ozima, 1973). Dredge hauls from guyots on the main Mid-Pacific Mountains platform indicate that during late Early and Late Cretaceous times the guyots were volcanic islands surrounded or capped by coral reefs (Hamilton, 1956). Since that time they must have undergone considerable subsidence (Winterer, 1976), because most of them are now under a few hundreds to a few thousands of meters of water.

The Mid-Pacific Mountains consist of several segments thought to be part of an ancient fracture-zone–ridge-crest system that separated the North and South Pacific Plates during the Early Cretaceous (Larson, 1976). Sites had been drilled during DSDP Legs 6 (Heezen, Fischer, et al., 1971), 17 (Winterer, Ewing, et al., 1973), and 32 (Larson, Moberly, et al., 1975) in the Mid-Pacific Mountains, but the holes are on the northeastern segment, which probably followed one of the old fracture-zone trends.

The generalized lithologies of Holes 171 and 313 from the northeastern Mid-Pacific Mountains and a reconstruction of their probable paleodepths of deposition are shown in Figure 4. Dominantly calcareous Upper Cretacous and Cenozoic sediment sections at both sites have a hiatus across the Cretaceous/Tertiary boundary, and volcaniclastic sediments were observed in Cam-

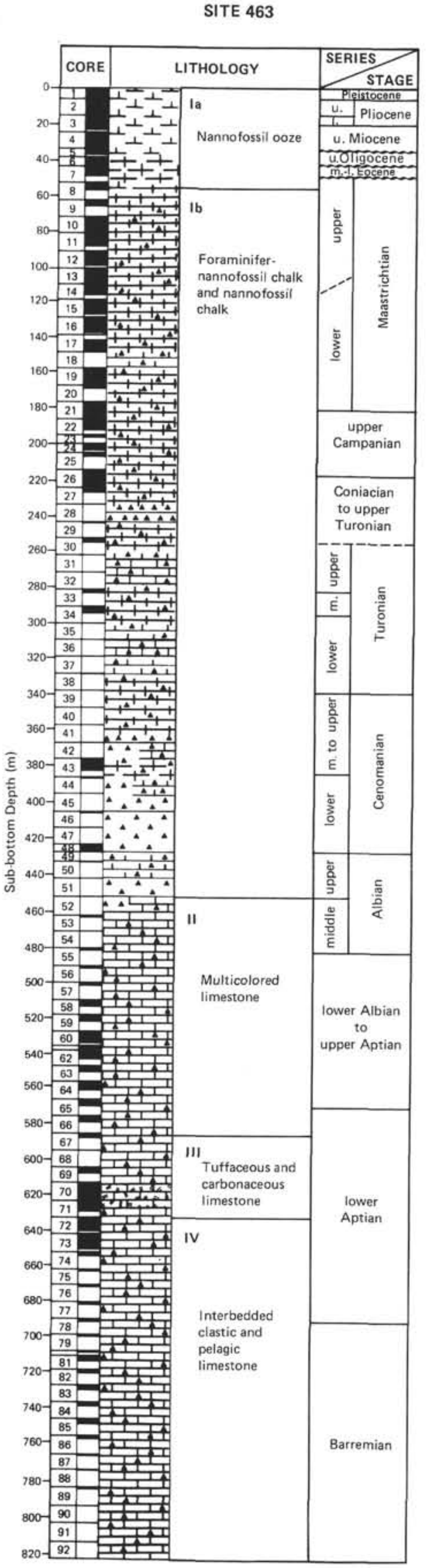


Figure 2. Lithologic column of Hole 463, Mid-Pacific Mountains.

panian deposits. A thick volcaniclastic and limestone sequence reaching back into Cenomanian time had to be penetrated at Site 171 before recovering probably displaced, weathered basalt of the volcanic edifice (Winterer, Ewing, et al., 1973). Reworked fossils in the Cenomanian and plant remains in the volcaniclastic Turonian and Coniacian suggest that part of Horizon Guyot reached above the sea surface during Late Cretaceous time. Unfortunately, the oldest sediments recovered at Site 171 were not cored continuously. This, together with poor recovery, makes it impossible to reconstruct the earliest history of this site in detail, although a reconstruction of its subsidence suggests that the region around this site reached above the sea surface for at least the first 6 m.y. of its existence. It is not clear whether the basalt recovered below the oldest sediments at Site 313 (Larson, Moberly, et al., 1975) represents an extrusive or intrusive volcanic rock, but its mineral assemblages suggest that it formed late in the volcanic evolution of these seamounts (Marshall, 1975).

During Leg 62, we planned to sample the segment of the Mid-Pacific Mountains along the western arm that follows an ancient fracture-zone trend close to the intersection with the fossil ridge crest (Larson, 1976). Magnetic anomalies M22 and M20, which abut this part of the Mid-Pacific Mountains northwest of Site 463, suggest that the floor of the adjacent deep northwest Pacific Basin is 140 to 150-m.y. old. All paleontological data and absolute ages of volcanic rocks from the Mid-Pacific Mountains indicate that they are Early to mid-Cretaceous in age. Although these ages range over a relatively wide time span, at least from Early to Late Cretaceous, age relationships among the various segments of the Mid-Pacific Mountains are not clear.

Apparently suitable drill-site locations had been found along the *Mahi* 7004 seismic-reflection profile (Fig. 5A). The anticipated sediment section close to proposed drill site MM-1 (Site 463) was believed to comprise an approximately 900-meter-thick section. Three subsurface reflectors were thought to represent Eocene cherts, interfaces between the oceanic basement and overlying Mesozoic limestones, and interfaces between these limestones and the upper Mesozoic to lower Cenozoic chalks (Fig. 5B).

OPERATIONS

Leg 62 began after scientific staff members were exchanged in Majuro lagoon (Marshall Islands) on 28 July at 0300Z. The first site to be investigated was 874 miles northeast of Majuro Atoll. Air-gun and magnetometer gear were streamed at 0455Z, and we proceeded toward Site 463 on a heading of 015° (Rea et al., this volume). At 1346Z on 2 August, we turned to a heading of 289°, paralleling the *Mahi* 7004 trackline (Fig. 6). At 1645Z, speed was reduced to 5 knots, and at 1708Z on 2 August the beacon was dropped. We continued on a course of 289° for a half hour, pulled in the gear, and returned at 1752Z to the beacon. At 1942Z, pipe lowering commenced. After the bottom-hole assembly and two stands of drill pipe were made up and run, a test was made on the new pressure core barrel (PCB). It was allowed to

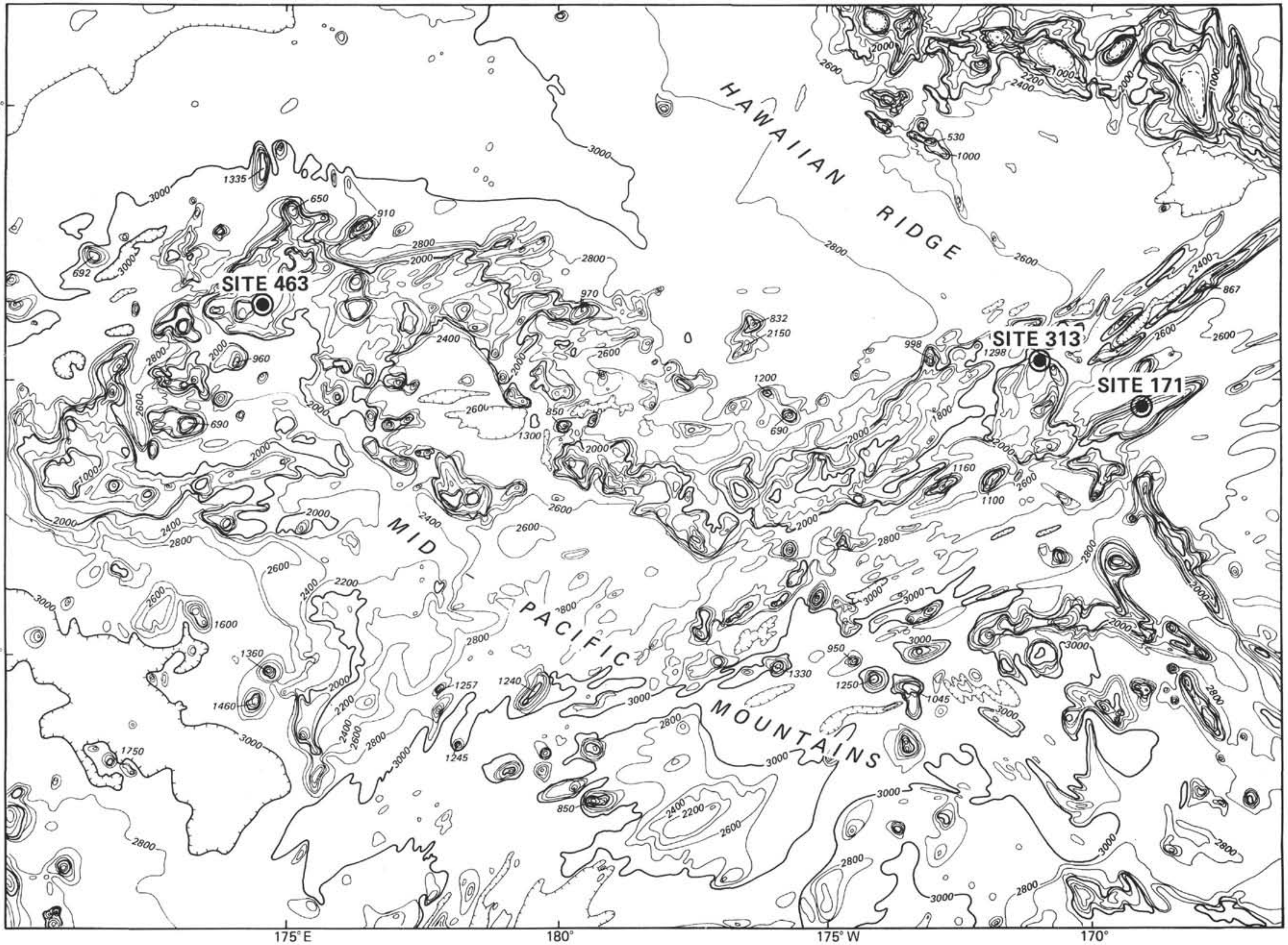


Figure 3. Bathymetry of the Mid-Pacific Mountains (after Chase et al., 1971), with the locations of DSDP Sites 463, 313, and 171.

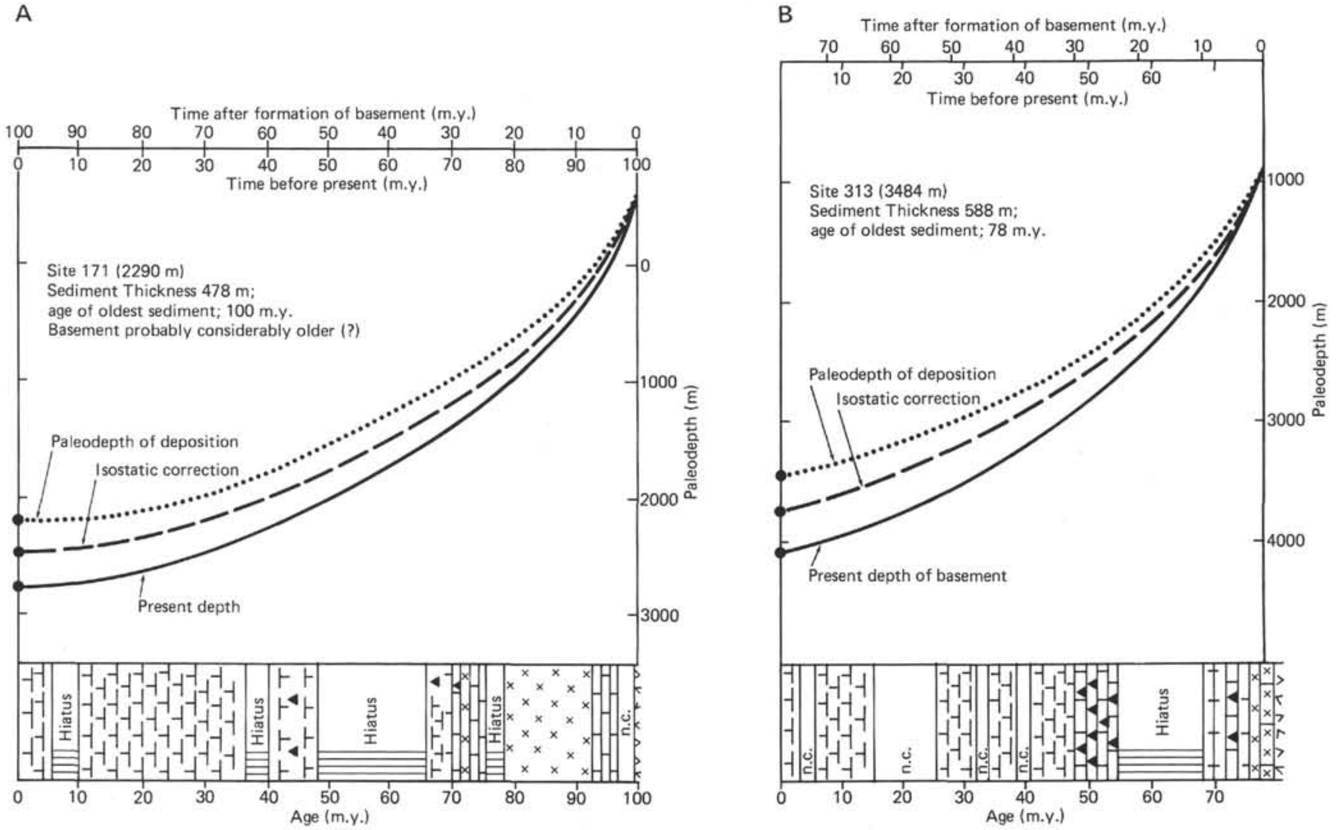


Figure 4. Subsidence and simplified lithologic columns of DSDP Sites 171 (A) (after Winterer, Ewing, et al., 1973) and 313 (B) (after Larson, Moberly, et al., 1975) in the eastern Mid-Pacific Mountains.

free fall at this point to determine if the tool would operate properly after landing. After this test, the drill pipe was made up and run to 2525 meters, when the Bowen sub was picked up. The hole was spudded, and the mud line was established at 2532 meters.

Water depth at Site 463 is 2525 meters (corrected from echo sounding; 2532 meters as measured by pipe length). A 5-second air-gun profile shows a sedimentary sequence nearly 1-second thick (Fig. 7), consisting of at least three acoustic layers. Acoustic basement is not visible. The proposed drilling program consisted of a single-bit hole to be continuously cored through the 900-meter ooze–chalk–limestone section and 100 meters into oceanic basement, or until bit destruction.

On-site operations were routine. A bit with a 2.25-inch (570 mm) opening was run, rather than one with a normal 2.5-inch (635 mm) opening, in order to accommodate the pressure core barrel. Therefore, all cores cut at Site 463 have a somewhat smaller diameter than cores cut at previously drilled DSDP sites. The hole was continuously cored to 34 meters sub-bottom, where the first PCB core was taken (34.0–38.0 m sub-bottom). The hole again was cored continuously to 199.5 meters, where the next PCB core was taken (Core 23, 195.5–199.5 m sub-bottom); subsequently, the hole was continuously cored to a total sub-bottom depth of 822.5 meters, where it was abandoned because of bit destruction.

A drilling problem developed while Core 47 was being cut. After 4 meters had been cut, the pipe became stuck and could not be rotated, nor could water be circulated. However, the bumper subs still could be moved, which indicated that the pipe was stuck below this point. After working the pipe for 2 hours with pulls of up to 475,000 pounds, the inner core barrel was retrieved, and circulation was regained. Then 50 barrels of mud were added, and after 20 minutes the pipe came free and remained free until the hole was completed.

At 0239Z (1439L) on 3 August, the first core was on board, and we cored continuously until 0852Z (2052L) on 10 August. Ninety-two cores were attempted, to a final sub-bottom depth of 822.5 meters (Table 1). Recovery was 301.8 meters. Core recovery for the hole averaged 36%. The main reason for the lower recovery was the chert, which was encountered early and again intermittently as the hole was deepened. Higher-than-normal pump pressure was required to prevent plugging of the bit, which resulted in washing away of softer sediments. The bit wore out before basement rocks were penetrated. We left the site at 1530Z (Fig. 6) on 10 August, and steamed 065° to stream the geophysical gear. After streaming the gear, we returned to the beacon, passing it about 600 meters to the north on a heading of 245°. A course of 245° was maintained for about 1 hour, and we turned to a course of 132° at 1719Z and to 020° at 1805Z in an attempt to pass over the beacon. This course took us west of Site 463, and we missed by more than 2 miles. We continued on a course of 020° for about 1 hour, and about 1940Z we turned to a new course for Site 464.

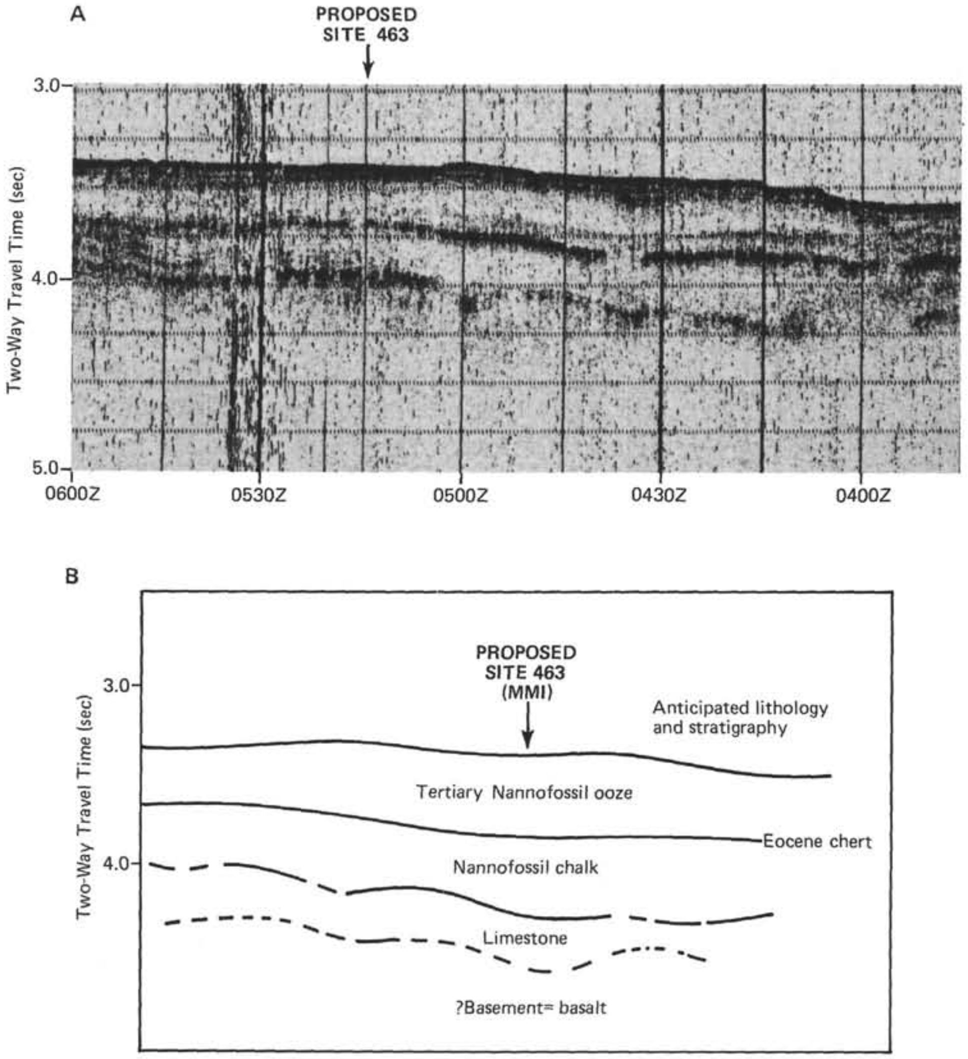


Figure 5. A. *Mahi* 7004 seismic-reflection profile across the northwest Mid-Pacific Mountains, showing the proposed location of Site 463. Figure 6 shows the *Mahi* 7004 track line. B. Provisional pre-drilling interpretations of possible lithologies and ages, based on the *Mahi* 7004 seismic-reflection profile.

LITHOLOGIC SUMMARY

Lithologic Subdivision

The sediment section at Site 463 is subdivided into four lithologic units, the uppermost being subdivided into two sub-units (Table 2). Divisions are based mainly on composition, diagenetic features, and sedimentary structures. Some of the basic sediment data obtained from this site are given in Appendices A through C. Complete tabulation of $CaCO_3$ and organic-carbon contents are given in Dean (this volume).

Sub-unit IA: Nannofossil Ooze (0–46.8 m)

The sediment of this sub-unit is highly disturbed to soupy nannofossil ooze, dominantly very pale-brown (10YR 7/4, 10YR 7/3, 10YR 8/3), light-gray (10YR 7/2), light-yellowish-brown (10YR 6/4), pale-brown (10YR 6/3), and white (10YR 8/2, 10YR 8/1). Mottles and burrows of similar lithology and color are common. Most contacts in the section are gradational. A transition occurs over a 1-meter interval in Core 2 (7.5–8.5 m), where the nannofossil assemblage increases to over 80% discoasters (Fig. 8). Discoasters remain abundant (80–98% of all nannofossils) down to Core 4 (29 m). Below 34 meters in Core 4, discoasters constitute less than 30% of the nannofossil assemblage. Four small fragments of Eocene(?) chert, 1 to 4 cm in diameter, grayish-brown (10YR 5/2) and gray (N6), occur near the base of Unit IA at 44 to 45.5 meters.

The boundary between Sub-units IA and IB is in Section 3 of Core 7, at 46.8 meters sub-bottom. It is easily distinguished by a color change from brownish-white (10YR 8/2) above to stark white (lighter than 10Y 8/1) below a sharp but disturbed contact. The first appearance of discoasters in the section, and the change from predominant chalk below to ooze above, occurs at this boundary. It also marks an early Eocene to early Maastrichtian hiatus.

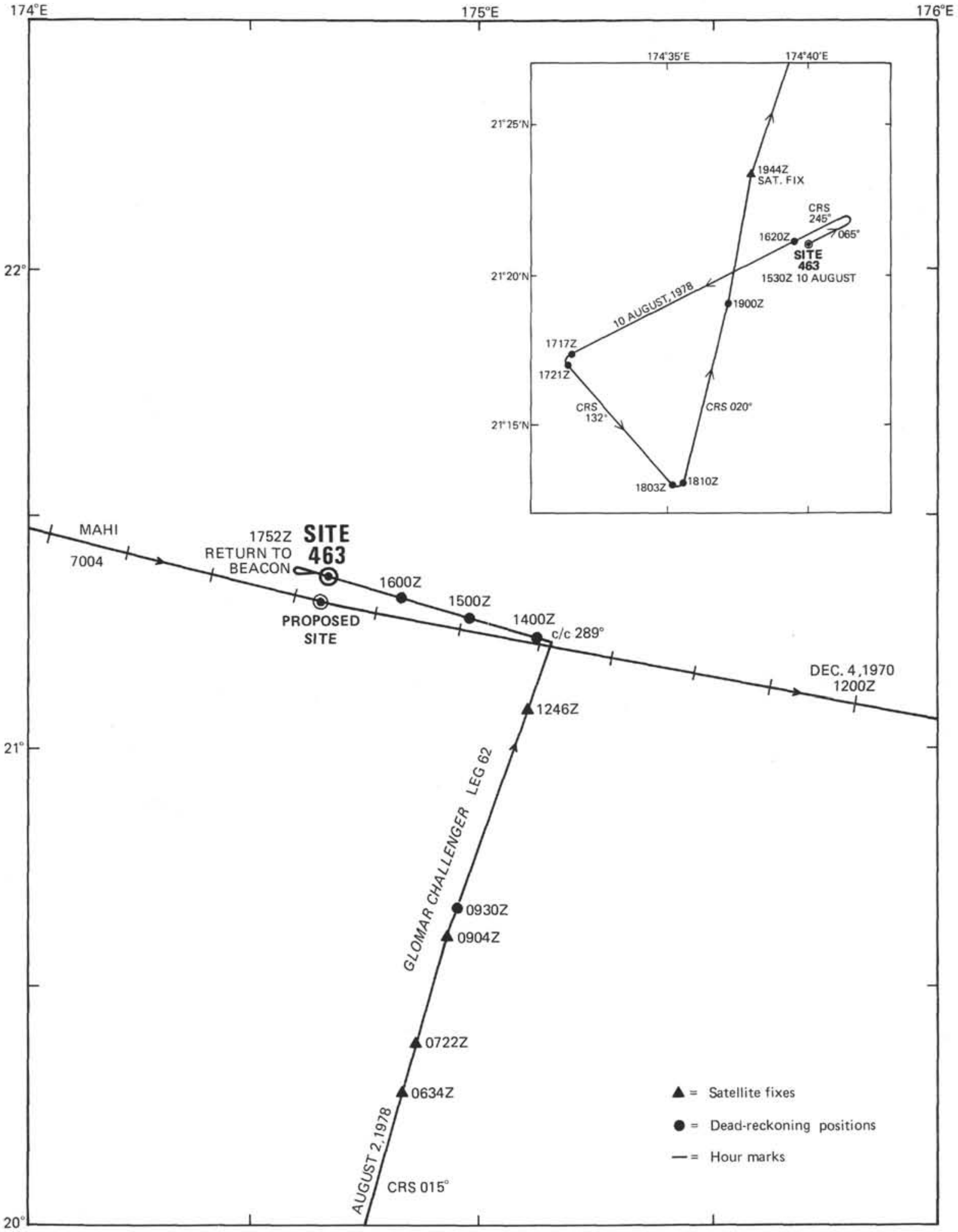


Figure 6. Chart of the *Mahi* profile and of the *Glomar Challenger* Leg 62 track line approaching Site 463. Insert shows the *Glomar Challenger* track line leaving Site 463.

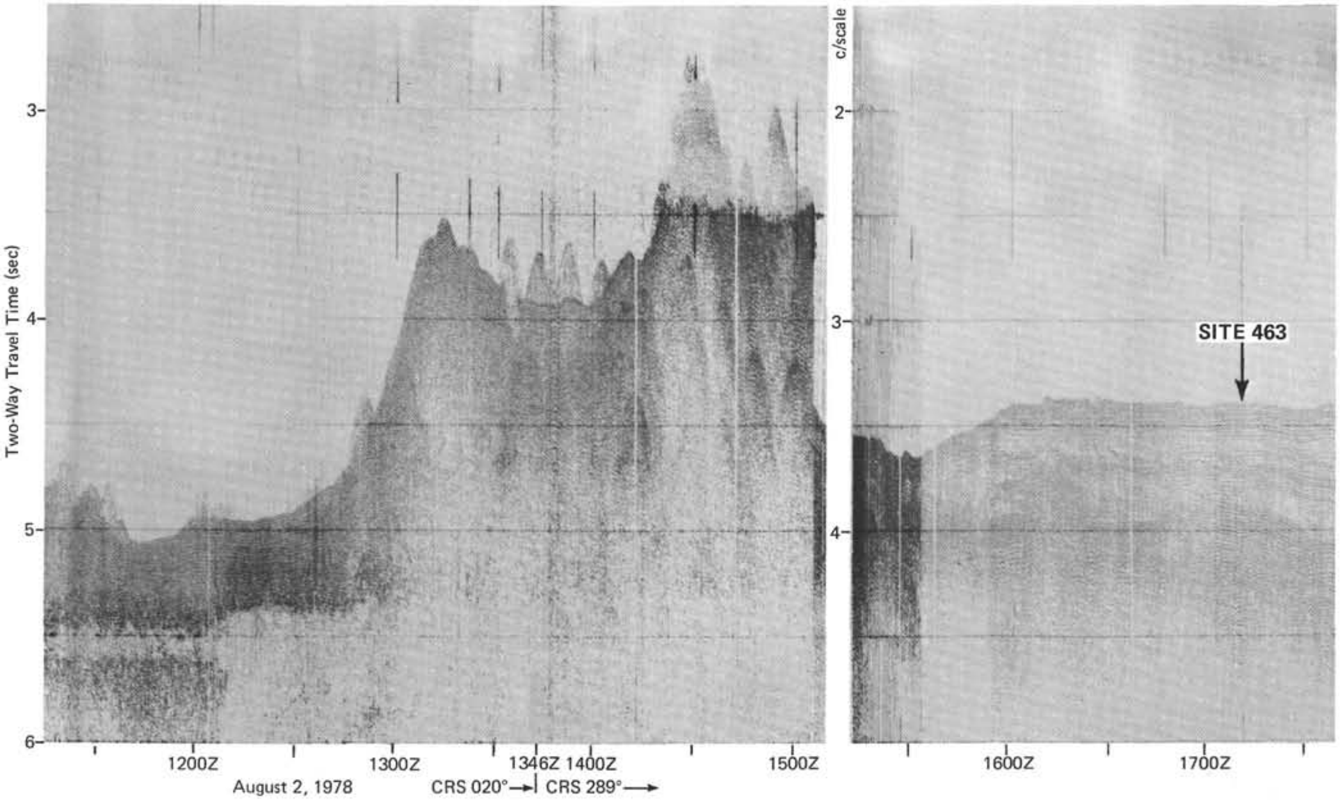


Figure 7. *Glomar Challenger* Leg 62 seismic-reflection profile made during the approach to Site 463.

Sub-unit IB: Foraminifer Nannofossil Chalk and Nannofossil Foraminifer Chalk (46.8–452 m)

The chalk is characterized by its very stark white color (10YR 8/1, N8, 2.5Y 8/1, and lighter shades). An exception is the interval in Cores 26 and 27 from 219 to 226.5 meters, which is pinkish-gray (7.5YR 7/2, 7.5YR 7/3) and pink (7.5YR 8/4). The chalk in the upper part of Unit IB is very uniform (no mottling or bedding). Faint greenish laminations appear in Core 21, in three 2- to 3-cm intervals. Mottling, burrows, and laminations are more common in Core 27 and below, but for the most part the chalk is uniform and shows no structures. In many intervals, a soupy, highly disturbed sediment is encountered; it appears to be formed largely by drilling disturbance of a poorly lithified chalk. We have described these soupy intervals as "ooze," even though we have some reservations about use of this term.

The composition of the chalk varies down-section. At the boundary with Sub-unit IA, foraminifers constitute less than 10% of the smear-slide components (Appendix A). Planktonic foraminifers are abundant in the >63-mm size fractions (Appendix B). Their abundance increases to over 30% in Core 11, and remains high through Core 15; it then becomes variable, usually less than 20%, throughout the remainder of Sub-unit IB. Thus, the compositional range of nannofossil chalk to foraminifer nannofossil chalk to nannofossil foraminifer chalk is present in this sub-unit.

Chert, a common component of Sub-unit IB, occurs for the most part as drilling fragments within the soupy sections, and as "drilling biscuits" within the more-indurated chalk intervals (Hein et al., this volume). It is highly variable in color, showing various shades of red, brown, yellow, gray, and black. Some of the gray chert is banded and burrow-mottled. Silicified chalk is closely associated with the chert in Cores 30, 31, 32, 33, and 42; because of its hardness, it may appear to be limestone. White porcellanite commonly is observed as rims on the chert.

The transition between Sub-unit IB and Unit II occurs at about 452 meters. Unfortunately, Core 51 (442.5–452 m) consists of only a few chert fragments and cannot be used to determine precisely the boundary. Core 50 belongs in Sub-unit IB, and Core 52 belongs in Unit II; the boundary between the two units arbitrarily has been placed at the bottom of Core 51. The boundary marks the transition from chalk to limestone (except for the silicified limestones described from Sub-unit IB), which can also be observed as a change from strongly recrystallized carbonate (identified as "carbonate unspecified" in Appendix A) to unrecrystallized nannofos-

Table 1. Site 463 coring summary.

Core No.	Date (Aug 1978)	Time (L)	Depth From Drill Floor (m) Top Bottom	Depth Below Sea Floor (m) Top Bottom	Length Cored (m)	Length Recovered (m)	Percent Recovery
1	3	1439	2532.0-2537.5	0.0-5.5	5.5	5.42	98.5
2	3	1533	2537.5-2547.0	5.5-15.0	9.5	9.40	99.0
3	3	1616	2547.0-2556.5	15.0-24.5	9.5	7.98	84.0
4	3	1704	2556.5-2566.0	24.5-34.0	9.5	9.34	98.3
5	3	1852	2566.0-2570.0	34.0-38.0	4.0	3.02	75.5
6	3	1947	2570.0-2575.5	38.0-43.5	5.5	8.23	100+
7	3	2041	2575.5-2585.0	43.5-53.0	9.5	5.14	54.1
8	3	2146	2585.0-2594.5	53.0-62.5	9.5	4.05	42.6
9	3	2234	2594.5-2604.0	62.5-72.0	9.5	4.35	45.8
10	3	2333	2604.0-2613.5	72.0-81.5	9.5	9.25	97.3
11	4	0047	2613.5-2623.0	81.5-91.0	9.5	6.80	71.6
12	4	0144	2623.0-2632.5	91.0-100.5	9.5	9.02	95.0
13	4	0247	2632.5-2642.0	100.5-110.0	9.5	9.33	98.2
14	4	0345	2642.0-2651.5	110.0-119.5	9.5	6.57	69.2
15	4	0448	2651.5-2661.0	119.5-129.0	9.5	8.60	89.5
16	4	0540	2661.0-2670.5	129.0-138.5	9.5	8.80	92.6
17	4	0649	2670.5-2680.0	138.5-148.0	9.5	9.53	100+
18	4	0744	2680.0-2689.5	148.0-157.5	9.5	0.59	6.2
19	4	0847	2689.5-2699.0	157.5-167.0	9.5	9.65	100+
20	4	0950	2699.0-2708.5	167.0-176.5	9.5	1.41	14.8
21	4	1044	2708.5-2718.0	176.5-186.0	9.5	9.32	98.1
22	4	1146	2718.0-2727.5	186.0-195.5	9.5	6.64	69.9
23	4	1245	2727.5-2731.5	195.5-199.5	4.0	1.50	37.5
24	4	1338	2731.5-2737.0	199.5-205.0	5.5	4.23	76.9
25	4	1436	2737.0-2746.5	205.0-214.5	9.5	2.82	29.7
26	4	1528	2746.5-2756.0	214.5-224.0	9.5	8.80	92.6
27	4	1640	2756.0-2765.5	224.0-233.5	9.5	2.34	24.6
28	4	1746	2765.5-2775.0	233.5-243.0	9.5	0.06	0.6
29	4	1848	2775.0-2784.5	243.0-252.5	9.5	0.83	8.7
30	4	2005	2784.5-2794.0	252.5-262.0	9.5	3.01	31.7
31	4	2115	2794.0-2803.5	262.0-271.5	9.5	0.51	5.4
32	4	2212	2803.5-2813.0	271.5-281.0	9.5	0.25	2.6
33	4	2316	2813.0-2822.5	281.0-290.5	9.5	2.97	31.2
34	5	0020	2822.5-2832.0	290.5-300.0	9.5	4.08	43.0
35	5	0137	2832.0-2841.5	300.0-309.5	9.5	0.34	3.6
36	5	0314	2841.5-2851.0	309.5-319.0	9.5	0.15	1.6
37	5	0427	2851.0-2860.5	319.0-328.5	9.5	0.02	0.2
38	5	0526	2860.5-2870.0	328.5-338.0	9.5	0.86	9.1
39	5	0636	2870.0-2879.5	338.0-347.5	9.5	0.23	2.4
40	5	0849	2879.5-2889.0	347.5-357.0	9.5	0.12	1.2
41	5	0952	2889.0-2898.5	357.0-366.5	9.5	0.13	1.3
42	5	1103	2898.5-2908.0	366.5-376.0	9.5	0.16	1.6
43	5	1216	2908.0-2917.5	376.0-385.5	9.5	6.40	67.0
44	5	1319	2917.5-2927.0	385.5-395.0	9.5	1.12	11.8
45	5	1421	2927.0-2936.5	395.0-404.5	9.5	0.05	0.5
46	5	1525	2936.5-2946.0	404.5-414.0	9.5	0.99	10.4
47	5	1631	2946.0-2955.5	414.0-423.5	9.5	0.08	0.8
48	5	1859	2955.5-2959.5	423.5-427.5	4.0	4.25	100+
49	5	2049	2959.5-2965.0	427.5-433.0	5.5	0.05	0.9
50	5	2200	2965.0-2974.5	433.0-442.5	9.5	0.93	9.8
51	5	2300	2974.5-2984.0	442.5-452.0	9.5	0.13	1.4
52	6	0024	2984.0-2993.5	452.0-461.5	9.5	0.23	2.4
53	6	0212	2993.5-3003.0	461.5-471.0	9.5	1.66	17.5
54	6	0406	3003.0-3012.5	471.0-480.5	9.5	0.31	3.3
55	6	0530	3012.5-3022.0	480.5-490.0	9.5	1.00	9.5
56	6	0732	3022.0-3031.5	490.0-499.5	9.5	1.30	13.7
57	6	0944	3031.5-3041.0	499.5-509.0	9.5	2.42	25.5
58	6	1255	3041.0-3050.5	509.0-518.5	9.5	4.30	45.0
59	6	1627	3050.5-3060.0	518.5-528.0	9.5	4.68	49.3
60	6	2005	3060.0-3067.5	528.0-535.5	7.5	5.82	77.6
61	6	2207	3067.5-3069.5	535.5-537.5	2.0	1.70	85.0
62	7	0102	3069.5-3079.0	537.5-547.0	9.5	4.64	48.8
63	7	0328	3079.0-3088.5	547.0-556.5	9.5	3.55	37.4
64	7	0600	3088.5-3098.0	556.5-566.0	9.5	4.02	42.3
65	7	0820	3098.0-3107.5	566.0-575.5	9.5	3.35	35.3
66	7	1138	3107.5-3117.0	575.5-585.0	9.5	3.40	35.8
67	7	1345	3117.0-3126.5	585.0-594.5	9.5	2.98	31.4
68	7	1551	3126.5-3136.0	594.5-604.0	9.5	0.57	6.0
69	7	1927	3136.0-3145.5	604.0-613.5	9.5	3.60	37.8
70	7	2355	3145.5-3155.0	613.5-623.0	9.5	9.61	100+
71	8	0358	3155.0-3164.5	623.0-632.5	9.5	5.56	58.5
72	8	0813	3164.5-3174.0	632.5-642.0	9.5	6.60	69.5
73	8	1336	3174.0-3183.5	642.0-651.5	9.5	6.20	63.2
74	8	1654	3183.5-3193.0	651.5-661.0	9.5	2.07	21.8
75	8	1855	3193.0-3202.5	661.0-670.5	9.5	1.01	10.6
76	8	2149	3202.5-3212.0	670.5-680.0	9.5	1.37	14.4
77	9	0027	3212.0-3221.5	680.0-689.5	9.5	1.41	14.8
78	9	0244	3221.5-3231.0	689.5-699.0	9.5	1.44	15.2
79	9	0430	3231.0-3240.5	699.0-708.5	9.5	0.79	8.3
80	9	0706	3240.5-3242.0	708.5-710.5	2.0	0.75	37.5
81	9	1010	3242.5-3250.0	710.5-718.0	7.5	2.30	30.7
82	9	1310	3250.0-3259.5	718.0-727.5	9.5	1.33	14.0
83	9	1703	3259.5-3269.0	727.5-737.0	9.5	2.50	26.1
84	9	1932	3269.0-3278.5	737.0-746.5	9.5	2.07	21.8
85	9	2252	3278.5-3288.0	746.5-756.0	9.5	3.21	34.8
86	10	0226	3288.0-3297.5	756.0-765.5	9.5	1.35	14.2
87	10	0551	3297.5-3307.0	765.5-775.0	9.5	0.78	8.2
88	10	0854	3307.0-3316.5	775.0-784.5	9.5	0.60	6.3
89	10	1200	3316.5-3326.0	784.5-794.0	9.5	1.10	11.6
90	10	1522	3326.0-3335.5	794.0-803.5	9.5	0.24	2.5
91	10	1818	3335.5-3345.0	803.5-813.0	9.5	0.03	0.3
92	10	2052	3345.0-3354.5	813.0-822.5	9.5	0.10	1.1
Total						301.8	36.6

sils and foraminifers. It also marks the transition from uniform, massive carbonates above to multicolored carbonates below.

Unit II: Multicolored Limestone and Silicified Limestone (452–587.7 m)

The sediment in this unit is characterized by limestone and silicified limestone showing cyclic color variation on the scale of about 1 to 20 cm (Fig. 9). Most of the carbonate is recrystallized, but nannofossils and foraminifers are still recognizable in most smear slides (Appendix A). An important diagenetic overprint of silicification occurs in Unit II, silica replacing up to 80% of some limestones. Silica contents range from about 10 to 80% in the silicified limestone.

Most intervals show common horizontal laminations and burrowing, although a few (generally those lightest in color) appear massive and uniform (Fig. 9). Burrows are distorted and flattened because of compaction (Fig. 9). For the most part, laminae appear wavy and may be either continuous or discontinuous across the core. The cyclic nature of the sediments may indicate that the sediments underwent a period of differential lithification, existing alternately as beds of ooze and chalk and (or) beds of chalk and limestone. This is shown by selective fracturing and plastic deformation observed in adjacent layers. Contacts between cycles may be either sharp or gradational, but most are gradational and burrowed.

Graded beds are present in Cores 56, 59, and 60 (e.g., Core 56, Section 1, 82–97 cm). The gradations are generally marked by a color change from dark at the base of the bed to light at the top. All the sediments in the graded beds appear to be pelagic; the upper parts of the graded beds are nannofossil limestone, whereas the bases are enriched in foraminifers and radiolarians. Cores 60, 61, 63, 64, 66, and 67 have coarse layers (1–8 cm thick) enriched in radiolarians. Some of the coarse layers exhibit erosional basal contacts, but the layers appear to be uniform, coarse-grained intervals, rather than parts of graded units.

The colors of this cyclic unit are variable downsection. In Cores 52 through 55, the cycles are alternations of white limestone and pale-green or greenish-gray limestone. Cores 57 through 65 have cyclic color alternations of pink, green, brown, and white. Cores 66 and 67 consist of alternations of gray and green limestone. The coarse-grained, ungraded layers (previously described) are very pale brown (10YR 7/3) in Cores 60, 61, and 63, and light greenish-gray (5Y 7/1 and 56Y 7/1) in the remainder of the cores in this unit.

Chert is a common component of Unit II and is found as drilling fragments, nodules, and larger layers (Hein et al., this volume). The chert is very similar in most respects, including the range of colors, to that described from Sub-unit IA.

The boundary between Units II and III is determined by the highest occurrence of ash beds as a common component of the sediments. There is one ash layer above the lower Unit II boundary in Core 62, but this appears to be an isolated occurrence. The boundary between the

Table 2. Lithologic units at Site 463.

Unit	Lithology	Cores	Sub-bottom Depth (m)	Thickness (m)	Age (m.y.)
IA	Nannofossil ooze	1-7	0-46.8	46.8	Pleistocene-e. Eocene (0-50)
IB	Foraminifer nannofossil chalk and nannofossil foraminifer chalk	7-51	46.8-452	405.2	E. Maastrichtian to l. Albian (67-103)
II	Multicolored limestone and silicified limestone	52-67	452.0-587.7	135.7	L. Albian to e. Aptian (103-112)
III	Tuffaceus and carbonaceous limestone	67-71	587.7-632.5	44.8	Early Aptian (112-113)
IV	Interbedded pelagic and clastic limestone	72-92	632.5-822.5	190.0	E. Aptian to Barremian (113-117)

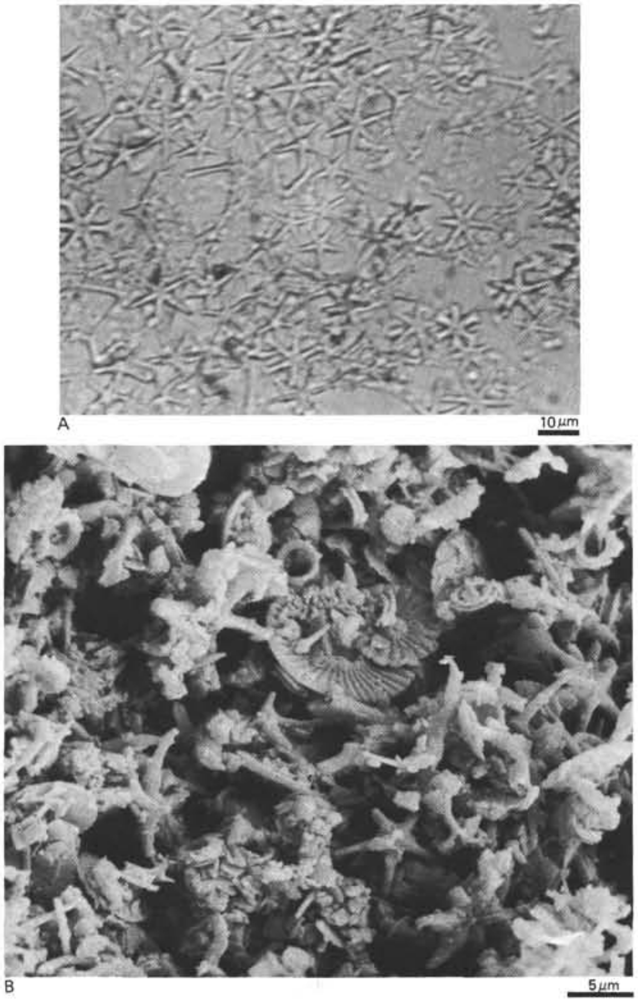


Figure 8. Pliocene discoaster ooze from Lithologic Unit IA. A. Plane light (×80). B. SEM photomicrograph (bar scale = 5 μm; 463-2-5, 100-101 cm).

two units is placed at the top of the ash bed in Core 67, Section 2, at 73 cm.

Unit III: Tuffaceous and Carbonaceous Limestone (587.7-632.5 m)

The distinguishing characteristics of this unit are the occurrence of ash beds and limestones enriched in ash and organic carbon. These appear within a sequence of

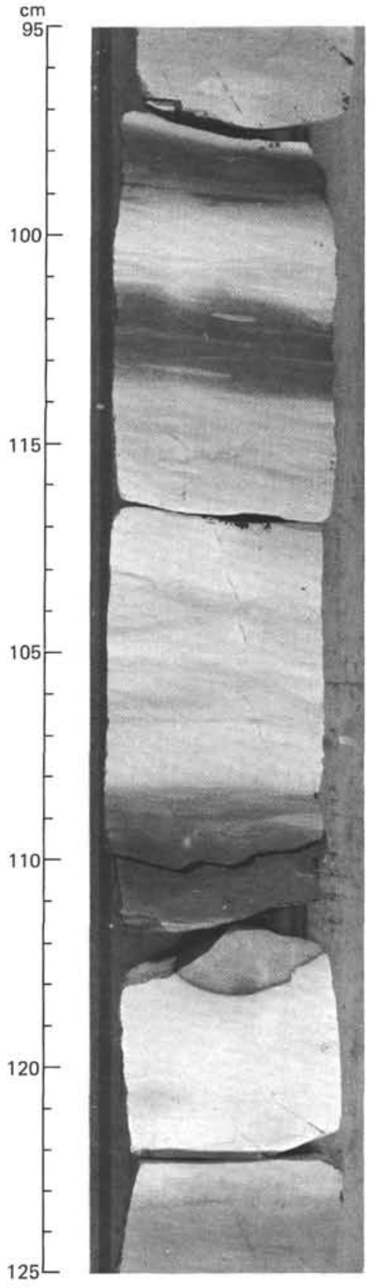


Figure 9. Sedimentary structures in the multicolored limestone of Lithologic Unit II (463-59-2, 95-125 cm).

cyclic color alternations somewhat similar to those found in Unit II. The cycles are color variations of white, gray, and green, with darker beds of tuff and carbonaceous limestone, on the scale of 1 to 65 cm. Tuff beds are greenish-black (56Y 2/1) and greenish-gray (5Y 6/1, 5G 4/1); the carbonaceous limestone is olive-black (5Y 2/1) to greenish-black (56Y 2/1), with organic-carbon concentrations to >7% (Dean and Claypool, this volume). Intervals enriched in organic carbon are horizontally laminated, without any zones of disturbance or burrowing (Fig. 10). The lower contacts of the organic-carbon-rich beds are mostly gradational, and the upper contacts are usually sharp, but exceptions are common. The highest concentration of organic carbon is in Core 70.

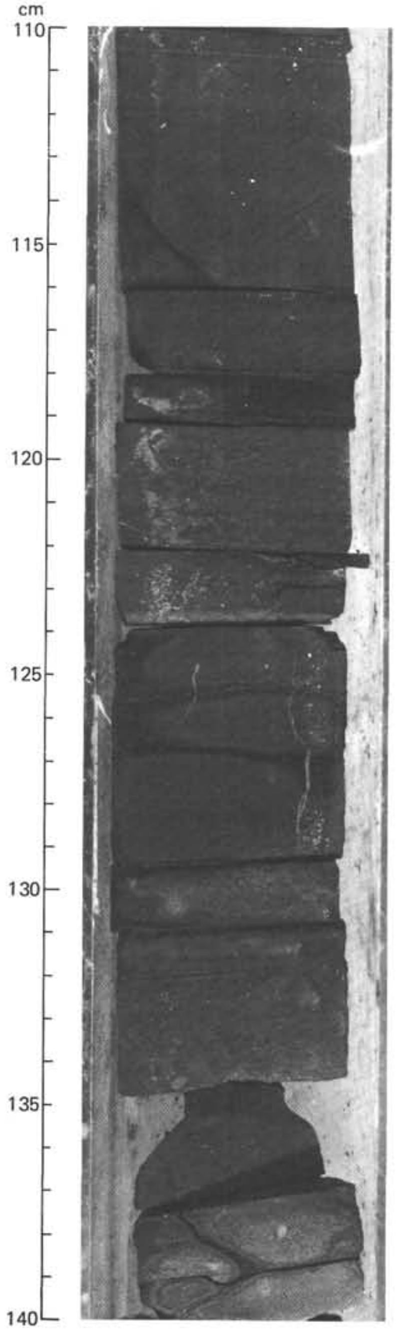


Figure 10. Sedimentary structures in the tuffaceous and carbonaceous limestones of Lithologic Unit III (463-70-5, 110–140 cm).

The tuff (ash) beds commonly have horizontal laminations, but several are massive (Vallier and Jefferson, this volume; Hein and Vanek, this volume). The top and bottom contacts of the tuff beds may be sharp or gradational. Most gradational contacts are bioturbated.

The lighter-colored beds in Unit III (those without high concentrations of organic carbon or ash) are usually burrowed and have wavy laminations. The upper and lower contacts of these beds usually are gradational. Chert, is common as fragments and layers within Unit III. Most of this chert is various shades of gray, although some dark-reddish-brown chert is present.

The boundary between Units III and IV, at the bottom of Core 71, is marked by the disappearance of ash beds as a common component of the sediment.

Unit IV: Interbedded Pelagic and Clastic Limestone (632.5–822.5 m)

This unit consists of pelagic limestones and marlstones interbedded with clastic, mostly calcareous turbidite and debris-flow deposits. The amount of clastic sediments increases down-section through Core 89. Cores 90 to 92 do not contain clastic limestone, but this may be the result of selective recovery of the pelagic limestone; these three cores recovered less than 60 cm of a total of 28.5 meters cored.

The upper part of Unit IV (Cores 72–74) shows cyclic color alternations of various shades of olive, green, and white, similar to those in Units II and III. Burrowing, wispy discontinuous laminae, and streaks are common. Most contacts are burrowed and gradational, but those at the bases of redeposited beds are sharp. The first two clastic turbidites, encountered going down-section occur in Core 73; they are pale-olive (5Y 6/2) and gray (5Y 6/1) and are composed of granule-size and smaller clasts of carbonate, pyrite, glauconite, and quartz.

In the remaining cores (75–92), the dominant pelagic component is light-gray and white limestone, with dark and contorted laminations (Fig. 11) some of which are stylolitic seams. Clastic limestones are interbedded with the pelagic limestones. Some of the clastic beds are turbidites similar to those described above, but most are massive beds with rounded clasts showing little or no gradation in grain size. There is an overall trend for the maximum size of clasts to increase with increasing depth in the section (Figure 12). The clast sizes range from less than 1 mm to several centimeters in diameter; the clasts are in a silt- and clay-sized matrix. These massive clastic units first appear in Core 80, and are common through Core 89. Typical clasts within these massive beds consist of fine-grained limestones, oolites, echinoderm and mollusk fragments, glauconite, quartz, stromatolite fragments, and basalt(?) chips (Fig. 13). The massive intervals of clastic sediment have a yellow-gray (5Y 7/1) groundmass, the largest clasts being white (5Y 8/1), rounded, fine-grained limestone.

A few marlstone beds, generally showing fine bedding and laminations, are also present in Unit IV. These

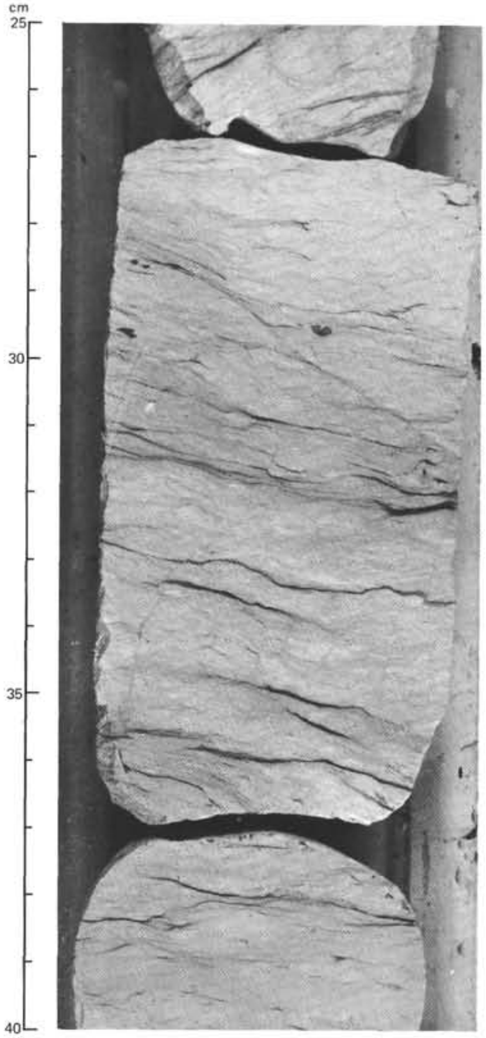


Figure 11. Pelagic limestone with contorted laminations from the interbedded clastic and pelagic limestones of Lithologic Unit IV (463-77-1, 25–40 cm).

are dark greenish-gray (56 4/1) and appear to be pelagic.

Conclusions

Site 463 contains an incomplete record of sedimentation and dissolution from the earliest Barremian to Recent. Middle Miocene to late Oligocene, late Oligocene to late Eocene, early Eocene to early Maastrichtian and Campanian to Santonian hiatuses are the only important interruptions in the record. The site has remained well above the CCD throughout its history. Important aspects of the sediments recovered at Site 463 are:

1) Sediments of late Pliocene to late Miocene age (8.5–29 m) are nannofossil ooze; discoasters comprise 80 to 98% of the nannofossil assemblage. This is probably the result of increased discoaster productivity, as well as selective dissolution of coccoliths.

2) The hiatuses at this site are essentially the same as those at Site 171 on Horizon Guyot, but different from those at Site 313 in the eastern Mid-Pacific Mountains.

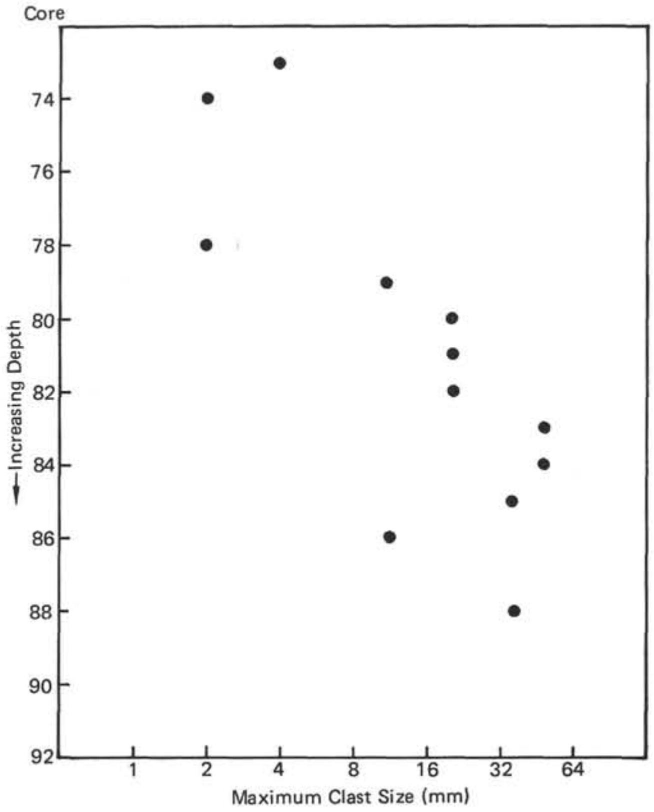


Figure 12. Variation in maximum clast size as a function of sub-bottom depth, Lithologic Unit IV.

3) A thick middle to Upper Cretaceous section provides an excellent record of sedimentation. A very high rate of sedimentation in the early Maastrichtian to late Campanian (~42 m/m.y.) marks the estimated time of equatorial crossing.

4) Cyclic alternations of multicolored limestones overlying carbonaceous limestones of early Aptian age at this site are similar to cyclic multicolored lithologies which overlie anoxic sedimentary sequences of the same age in the Atlantic. Tuffaceous sediments, recording a period of high volcanic-ash deposition, are interbedded with the carbonaceous limestones.

5) The oldest unit in the stratigraphic sequence at Site 463—the interbedded shallow-water clastic limestone and pelagic limestone—probably represents the shallowest depositional environment. Progressively younger sediments were deposited in progressively deeper water as the site subsided.

The sedimentation history at Site 463 can be summarized briefly as follows. During late Barremian time, the site was close to an oceanic volcanic island which apparently was associated with shallow-water carbonate banks. Existence of the shallow-water carbonates is documented by the presence of displaced stromatolites, oolites, and fragments of echinoderms and large mollusks in the clastic limestone beds of Unit IV (Fig. 13).

As the volcanic basement subsided, shallow-water sediments were redeposited at intermediate depths, forming clastic-limestone layers interbedded with pelagic

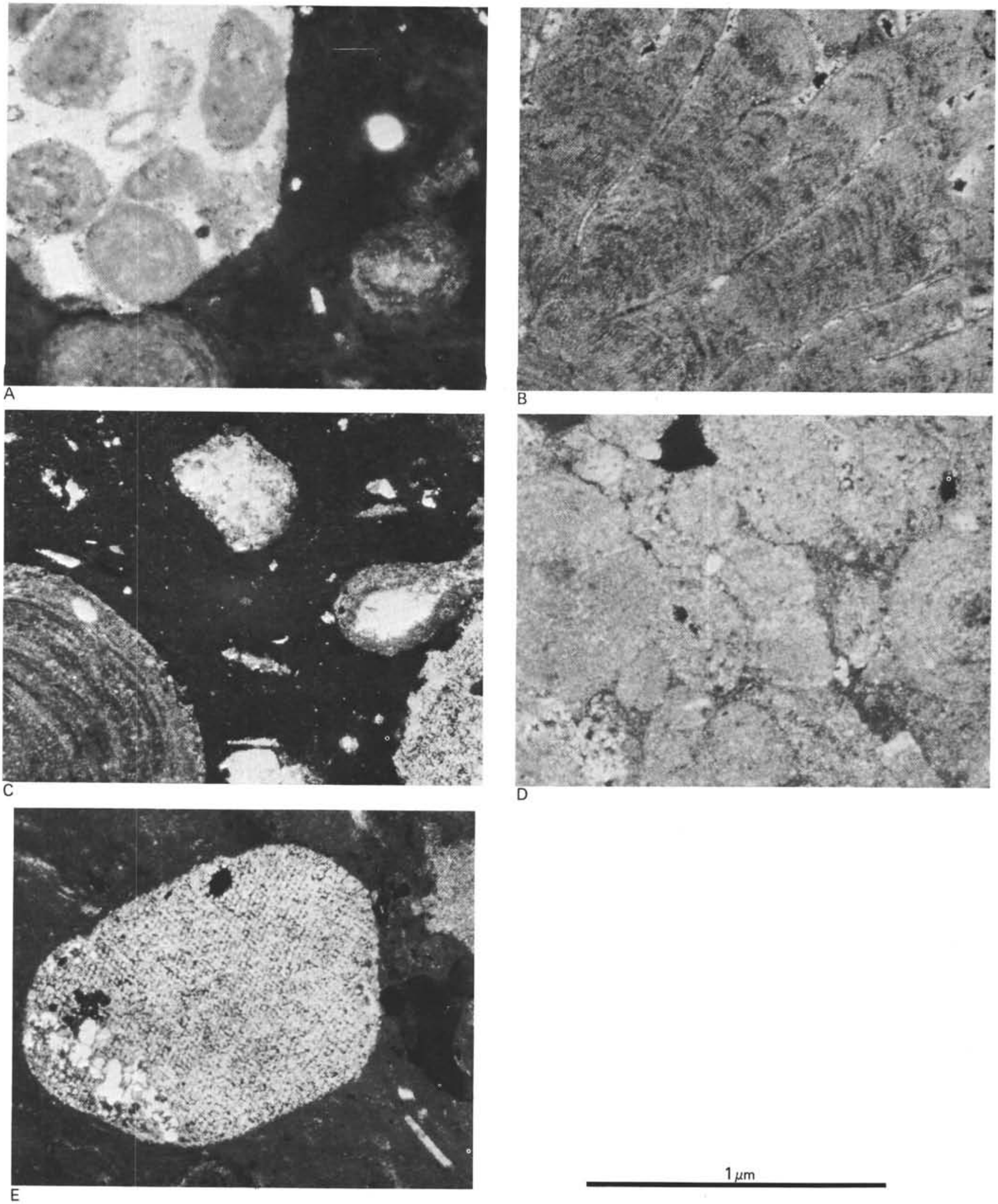


Figure 13. Carbonate clasts from Lithologic Unit IV (bar = 1 mm; all cross-polarized light). A. 80-1, 9–11 cm (709.5 m). Oolites and a clast of oosparite in a micritic calcite matrix. B. 85-2, 136–138 cm (749.5 m). Part of a stromatolite fragment. C. 85-1, 76–78 cm (747.3 m). Oolites in a matrix of micrite and sparry calcite cement. D. 85-1, 59–61 cm (747.1 m). Part of a large oolite. Fossil fragments and other calcite debris "floating" in a matrix of micritic calcite. E. 84-1, 20–22 cm (737.2 m). Fossil fragment with reticulate pattern, partly replaced by SiO_2, in a matrix of micritic calcite.

limestones (Unit IV, Barremian to early Aptian). The pelagic limestones and the lack of a diverse benthic-mollusk fauna suggest that water depth must have been greater than wave base (greater than about 200 m). Continued subsidence during deposition of Unit IV is indicated by a decrease in the maximum size of clasts within the clastic limestone in progressively younger sediments (Fig. 12). Most of the massive redeposited beds, which are up to 1 meter thick, show little or no grain-size grading. This lack of grading tends to rule out turbidity currents as a mode of transport of the shallow-water clasts. The lack of size gradation and roundness of the clasts suggests transport by debris flows, which in turn suggests relatively short distances of transport. The uppermost clastic bed in this unit is a granule-size carbonate turbidite in Core 73. The younger carbonate sediments are entirely pelagic.

Shortly after deposition of the last clastic carbonate beds in the early Aptian, the sedimentary sequence at Site 463 was marked by a sudden influx of relatively large volumes of volcanic ash, indicating nearby volcanic activity. Volcanic activity lasted approximately 1 m.y. (the time represented by Unit III). The presence of volcanic ash is coincident with carbonaceous limestone (organic-carbon content of as much as 7% by weight), which indicates sediment accumulation under reducing conditions. Whether the association of volcanic ash and organic matter is fortuitous or causal is not known.

The multicolored limestone of Unit II was deposited from the early Aptian to the late Albian. The association of carbonaceous sediments underlying multicolored (green, gray, pink, and red) cyclic sediments is known from a number of sites in the Atlantic (e.g., Sites 105 and 367) and is almost exactly repeated at Site 463, although multicolored sediments are somewhat younger in the Atlantic (Late Cretaceous). The significance of this relationship is not known.

The remainder of the Cretaceous sediments is represented dominantly by foraminifer nannofossil ooze and chalk, with well-preserved microfossils. This suggests that the sediments were deposited above (or near) the Cretaceous lysocline. High sedimentation rates characterize the strata of the early Maastrichtian, a time when the site apparently crossed the equatorial zone of high productivity.

Accumulation of sediment during the Cenozoic was much reduced in comparison to the Cretaceous. Approximately 35 m.y. of the Cenozoic record is missing, and the pre-Pliocene record which is present has an average accumulation rate of only 1.0 m/m.y. The dominant sediment type is nannofossil ooze with moderate to good preservation of microfossils, suggesting deposition between the lysocline and the CCD.

Carbonate diagenesis at Site 463 reflects the normal progression of ooze to chalk to limestone. The transition from ooze to chalk occurs across the early Eocene to Maastrichtian hiatus and, because of poor recovery of sediment near the hiatus, is not fully documented. The upper part of Unit II shows chalk alternating with ooze, the degree of lithification increasing progressively to the bottom of the unit. The transition from chalk to limestone is not well documented, because of a high abundance of chert in that interval and poor core recovery. A diagenetic trend is apparent in the wispy and wavy laminations, which become progressively darker and better defined with depth, and eventually develop into thin, dark stylolitic seams. This suggests that pressure solution, due to increasing burial, selectively occurs within these laminae, ultimately forming the stylolitic seams.

Replacement of $CaCO_3$ by SiO_2, filling of voids by SiO_2, and recrystallization of radiolarians are common phenomena in Units IB to IV. The general sequence of silicification (Fig. 14) appears to be as follows:

1) The chambers of foraminifers are partly to completely filled with SiO_2.

2) The chambers of foraminifers are filled with SiO_2, radiolarians are recrystallized, and some of the $CaCO_3$ matrix is replaced by SiO_2.

3) The matrix is completely replaced by SiO_2, leaving only the test walls of foraminifers as $CaCO_3$.

4) Complete replacement of $CaCO_3$ by SiO_2, and formation of chert.

INTERSTITIAL-WATER GEOCHEMISTRY

Results of shipboard measurements of *p*H, alkalinity, salinity, calcium, magnesium, and chlorinity, in interstitial water from seven whole-core sediment samples are presented in Figure 15. Values of *p*H are low relative to surface sea water, ranging from 8.0 in the first core to 6.76 in Core 43, Section 3, 94–100 cm. Both *p*H and alkalinity are largely controlled by bacterial production of CO_2 and equilibrium with carbonate minerals. Because of the high carbonate content of the sediments at Site 463, the interstitial waters are probably close to saturation with respect to $CaCO_3$, as $CaCO_3$ is dissolved to offset CO_2 produced by bacterial activity. As a result, alkalinity remains relatively constant with depth, whereas the calcium concentration increases markedly with depth (Fig. 15). An increase in calcium-ion concentration in interstitial waters commonly is observed in carbonate-rich deep-sea sediments, particularly in areas with rapid rates of sediment accumulation, and is attributed to dissolution of $CaCO_3$ at depth (Sayles and others, 1973).

At Site 463, the increase in calcium with depth is almost matched by a decrease in magnesium; this inverse relationship might imply formation of dolomite, although none was observed in smear slides of the sediments. Salinity and chlorinity show little variation from normal surface sea water, both increasing slightly with depth (Fig. 15).

The greatest change in interstitial-water chemistry appears to occur below 225 meters sub-bottom (Fig. 15). Unfortunately, poor recovery prohibited collection of interstitial water between Cores 27 and 43 to better define these changes. This zone of change is indicated by increases in salinity, chlorinity, and calcium, and by decreases in *p*H and magnesium; calcium shows the greatest change. There is no apparent change in the sediments that would indicate an increase in rate of dissolution of $CaCO_3$ between 225 and 480 meters.

PHYSICAL PROPERTIES

The wet-bulk density of soft sediments was measured by the analog GRAPE for Cores 1 to 6, and on three points per section using 2-minute GRAPE for Cores 7 to 48. For pieces of firm sediment (chalk, limestone, and chert), both the 2-minute GRAPE and gravimetric methods were used. Sound-velocity measurements occasionally were made on the Saran-wrapped half cores of firm pieces of chalk, and on almost all mini-core samples normal to both the vertical and horizontal directions. All measured values of sound velocity, wet-bulk density, porosity, and water content are shown in Figure 16.

The sedimentary column penetrated at Site 463 has been divided into four major and four minor acoustic units, which are related to the lithologic units and seismic-reflection data. The values of wet-bulk density and interval velocity (Appendix D) are averaged for each acoustic unit and listed in Table 3.

The limestone samples (below Core 26) show velocity anisotropy, and the mean value of the velocity ratio of horizontal to vertical direction is about 1.045 under wet and 1-bar conditions (described in detail by Fujii, this volume).

PALEOMAGNETISM

Nearly 100 samples of Cretaceous limestones were taken for paleomagnetic measurements (Sayre, this volume). A large proportion of the samples of the multicolored limestones (Unit II) and tuffaceous and carbonaceous limestones (Unit III) carry a stable component of magnetization, often similar in direction to the natural remanent magnetization. The pelagic and clastic limestones (Unit IV) are more weakly magnetized, and directional data are less reliable. At least two reversed-polarity intervals can be identified in the *Chiastozygus litterarius* nannoplankton zone of the early Aptian, which may correlate with anomaly M0 or a reversed interval identified in sediments at DSDP Hole 361 (Keating and Helsley, 1978). The rest of the Aptian and lower Albian seems to be normally magnetized. A paleolatitude estimate for Units II and III is approximately 10° farther south than that predicted by recent reconstructions, the difference perhaps being due to the effects of compaction, inclination error, the offset dipole, off-vertical drilling, or errors in reconstruction.

CORRELATION OF SEISMIC-REFLECTION PROFILES AND DRILLING RESULTS

Two strong reflectors are distinct on both the *Mahi* 7004 (Fig. 5A) and the *Glomar Challenger* (Fig. 7) air-gun reflection profiles. These reflectors can be correlated with a boundary between lithologic units and with lithologic changes that occur within units. Less-distinct reflectors within acoustic units probably correspond to beds with relatively higher seismic velocities, e.g., limestone and chert layers in the nannofossil-chalk sequence in acoustic unit II.

Correlation of the seismic-reflection profiles with drilling results (Fig. 17) shows four acoustic units, of which three can be related to lithologic units and sub-units (Table 2). These four acoustic units include (1) a top unit (corresponding to Lithologic Unit IA) of nannofossil ooze about 0.06 sec (two-way time) thick; (2) a second unit (top of Lithologic Sub-unit IB), with a thickness of about 0.24 sec thick, consisting of chalk and nannofossil ooze; (3) a third unit, corresponding to the bottom part of Lithologic Sub-unit IB with a thickness of about 0.19 sec, made up of chalk, limestone, and chert; and (4) a fourth acoustic unit (Lithologic Units II, III, and IV), mostly limestone, partly silicified limestone, and rare chert. The nannofossil ooze of acoustic unit I is not resolvable on the air-gun seismic-reflection profiles, but a 3.5-kHz profile (Fig. 18) shows an upper transparent layer that corresponds to this unit. No internal reflectors are visible on the 3.5-kHz profile.

The second acoustic unit consists of two major sediment types—ooze and chalk. All transitions occur between foraminifer-nannofossil and nannofossil-foraminifer oozes, through nannofossil and foraminifer chalks. A strong reflector at about 0.3 sec DT sub-bottom corresponds to a lithification change from mostly chalk to a sequence of limestone and chalk with common chert. This reflector marks the boundary between acoustic units II and III. Limestone beds probably are responsible for the strong reflectors.

The bottom acoustic unit (unit IV), which corresponds to Lithologic Units II, III, and IV, has many strong reflectors that most likely correspond to limestone strata. The variations in lithologies used to define the lithologic units cannot be resolved on the seismic-reflection profiles.

Interval velocities, calculated for the acoustic units by averaging measurements of individual samples, correspond fairly well to expected interval velocities calculated from thicknesses of the drilled units. Acoustic unit II has an expected velocity of about 1.76 km/s, which is near the velocity of 1.73 km/s calculated from measurements of individual samples. The third acoustic unit has an expected velocity of about 2.10 km/s, which also corresponds well to the average measured velocity of 2.14 km/s obtained from the individual samples. Acoustic unit IV has a large range of measured velocities, from 2.76 km/s in the Aptian ashy and carbonaceous limestone beds to 3.63 km/s in the partly silicified limestone strata of the Barremian sequence. Basement is not apparent on either of the air-gun seismic-reflection profiles, and it is impossible to calculate its sub-bottom depth from the available data.

BIOSTRATIGRAPHY

Biostratigraphic Summary

The 822.5-m-thick sedimentary section continuously cored at Site 463 represents a sequence from Quaternary to Barremian. Included are two substantial hiatuses of 16 to 17 m.y., spanning intervals from the Maastrichtian through part of the Eocene, and the uppermost Oligocene through the middle Miocene, respectively. Another shorter hiatus of about 7 m.y. spans the Santonian and lower Campanian, and a very condensed series

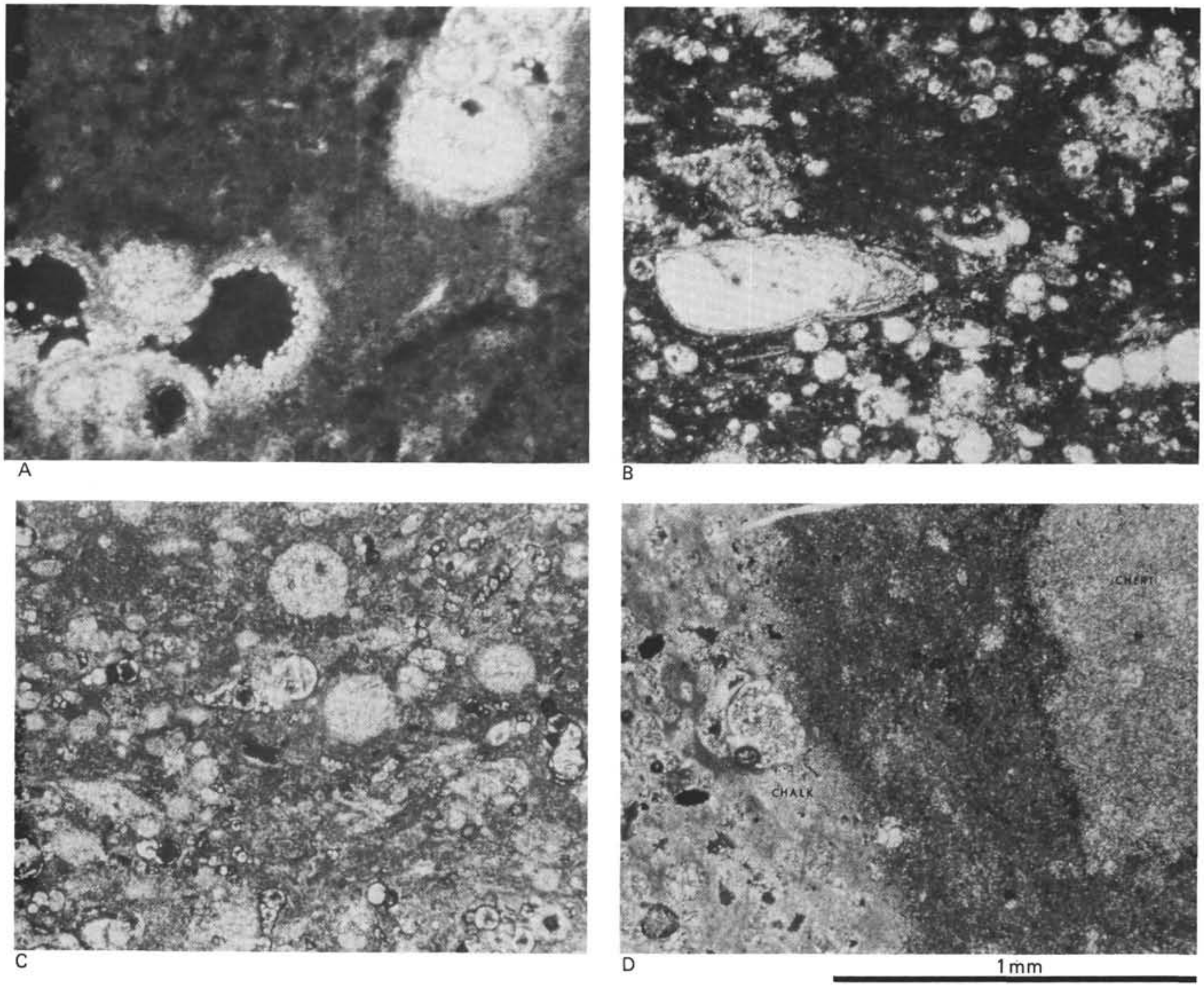


Figure 14. SiO_2-replacement sequence (not in stratigraphic sequence; bar = 1 mm). A. 57-2, 54–56 cm (502 m; Unit II). Chambers of foraminifers partly to completely filled with SiO_2. Tests of foraminifers and matrix are still $CaCO_3$ (cross-polarized light). B. 50-1, 58–60 cm (434 m; Unit IB). Radiolarians and foraminifers filled with SiO_2, and some of the $CaCO_3$ matrix replaced by SiO_2. Foraminifer tests still $CaCO_3$ (cross-polarized light). C. 36-1, 0–2 cm (310 m; Unit IB). Radiolarians and foraminifers filled with SiO_2. Matrix mostly microcrystalline SiO_2 with some $CaCO_3$. Foraminifer tests still $CaCO_3$ (plane polarized light). D. 38-1, 10–11 cm (329 m; Unit IB). Replacement of chalk (left) by chert (right), with a transition zone between (darker gray in center). Radiolarian and foraminifer tests filled with SiO_2 throughout (cross-polarized light). E. 69-2, 148–150 cm (607 m; Unit III). Radiolarian(?) filled with sparry calcite, and with a scalloped overgrowth of SiO_2. Matrix is microcrystalline calcite (cross-polarized light). F. 69-2, 148–150 cm (607 m; Unit III). Contact between microcrystalline $CaCO_3$ matrix (left) and microcrystalline SiO_2 matrix (right) (cross-polarized light). G. 61-3, 109–111 cm (539.5 m; Unit II). Contact between altered volcanic ash (right) and micritic calcite matrix with foraminifers (left) (cross-polarized light). H. 79-1, 7–9 cm (699.8 m; Unit IV). Parallel orientation and imbrication of carbonate clasts at contact between bed of clastic limestone and bed of siliceous limestone and chert (cross-polarized light).

(with possible hiatuses) encompasses the middle Eocene through most of the Oligocene. The Cenozoic sequence (47 m) is very condensed, whereas Cretaceous deposits (775.5 m) constitute the largest part of the sedimentary sequence.

A summary of the various fossil-group zonations plotted against sub-bottom depths is presented in the graphic hole summary (Fig. 19).

The sedimentation-rate curve is shown in Figure 20. There is good agreement between calcareous nannofossils and planktonic foraminifers in age assignments of recovered sediments throughout the upper 560 meters. Below that level, foraminifers are absent, and sediments were dated by nannofossils. Radiolarian zonation was possible only for Lower Cretaceous strata; it appears to be in general agreement with the calcareous-plankton zonation. However, because its calibration to the absolute time scale and to other fossil-group zonations is poorly documented, the age assignment for the radiolarian zones represented on Figure 20 remains tentative. No diatoms were observed.

The section consists, from top to bottom, of:

1) 34 meters of upper Neogene (upper Miocene to Quaternary) nannofossil ooze (Cores 1–4) which contains abundant calcareous plankton. Nannofossils are mostly well preserved, whereas planktonic foraminifers

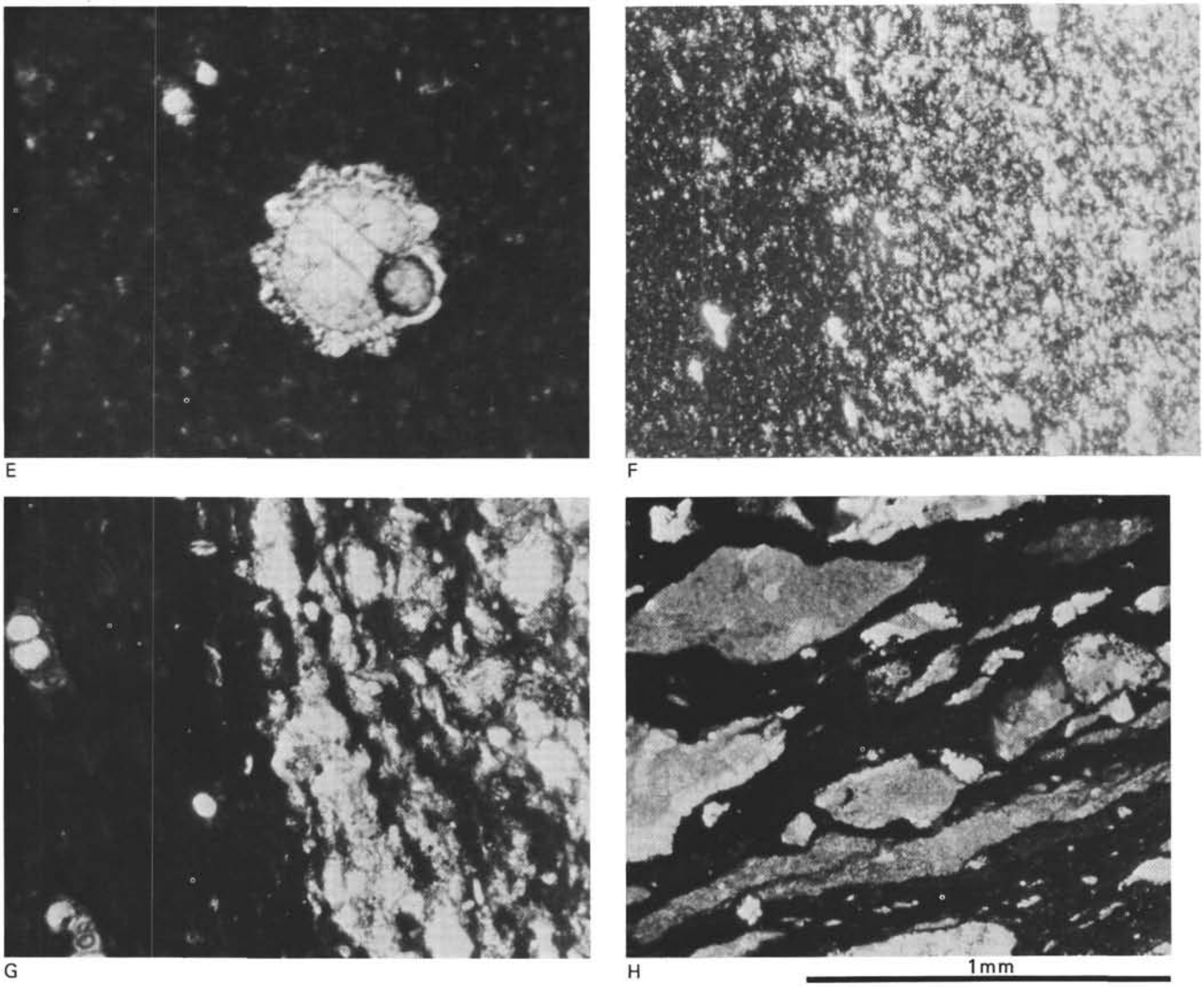


Figure 14. (Continued).

are moderately well preserved. Of special interest is the extraordinary abundance of discoasters in upper Miocene and Pliocene assemblages. Although condensed, the sequence appears continuous. Core 4 contains a mixture of reworked sediments of early and middle Miocene, Oligocene, Eocene, and Late Cretaceous ages.

2) A hiatus at about 34 meters (between Cores 4 and 5), spanning the entire middle and lower Miocene and uppermost Oligocene, equivalent to a time span of about 16 m.y.

3) 12.8 meters of Paleogene nannofossil ooze (Cores 5 and 6 and upper 3.3 m of Core 7) which contains abundant, moderately well preserved calcareous plankton. This section is extremely condensed, with a possible hiatus between the middle Eocene and the Oligocene. Reworking of Eocene floras was noted in some Oligocene samples.

4) A hiatus at 46.8 meters (Core 7, Section 3, 30 cm) which encompasses most of the lower Eocene, the entire Paleocene, and part of the Maastrichtian. It represents a time span of approximately 17 m.y.

5) >350 meters of Upper to middle Cretaceous chalk and limestone (lower part of Core 7 through Core 47) which contain common to abundant, poorly preserved calcareous nannoplankton and abundant planktonic foraminifers. The latter are mostly well preserved in the Maastrichtian to upper Campanian (Cores 7-27) and moderately well preserved in the Coniacian to upper Albian (Cores 28-51). Compared to other Pacific Cretaceous sections, the preservation of foraminifers throughout the upper and middle Cretaceous section at Site 463 is remarkably good and consistent. The section appears continuous, except for a possible hiatus (or very condensed section) which encompasses the lower Campanian and Santonian, (a time span of about 6 m.y.). Displaced shallower-water benthic foraminifers were found in most of the Maastrichtian sediments, and in a few Cenomanian horizons.

6) 400 meters of Lower Cretaceous pelagic limestone (Cores 48-92), interbedded with clastic limestone in the lower 190 meters. Calcareous nannofossils are common and poorly preserved. Foraminifers are rare and poorly

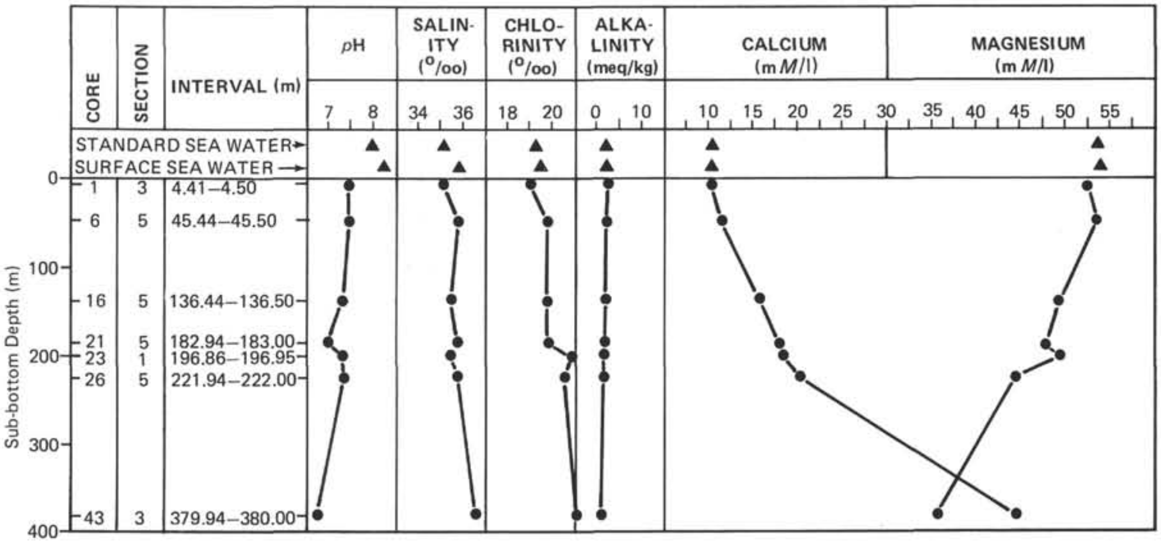


Figure 15. Interstitial-water geochemistry, Site 463.

preserved down to Core 63 (preservation becoming poorer downward in the section as recrystallization increases), and are virtually absent below that level.

Radiolarians, which were absent in the overlying sediments, are common in this part of the sequence; above 660 meters (Core 74), they are confined to sandy layers and are recrystallized, whereas below that level they occur throughout the section and are well preserved. However, from nannofossil, paleomagnetic, and sedimentation-rate data, the lowermost sediments appear to be Barremian, approximately 118 m.y. old, near the late/early Barremian boundary.

Nannoplankton

Calcareous nannofossils are present in all 92 cores from Site 463.

An abbreviated Cenozoic section with several hiatuses is recorded in the first seven cores of nannofossil ooze; thereafter, a relatively complete section of early Maastrichtian to Barremian age was recovered from chalks and limestones to the sub-bottom depth of 822.5 meters.

Cenozoic

Species assemblages of late Miocene to Recent, Oligocene, and early to middle Eocene age are recognized in the first seven cores. A large hiatus between the early Eocene and early Maastrichtian is recorded in Section 7-3, in which a foraminifer nannofossil chalk is first encountered.

An apparently complete upper Miocene to Recent sequence of nannofossil zones (NN11–NN21) is recognized in the first four cores. The nannofloras are abundant and mostly well preserved (slight to moderate etching). The upper Miocene and Pliocene assemblages are marked by an extraordinary abundance of discoasters and occasionally ceratolithids. In most samples, this dominance is accentuated by dissolution of most of the smaller coccoliths.

The top of Core 1 tentatively has been assigned to the *Gephyrocapsa oceanica* (NN20)/*Emiliania huxleyi* (NN21) zonal interval. Sample 463-1-1, 97 cm can be assigned to the *Gephyrocapsa oceanica* (NN20) Zone. Samples from Sections 1-2 and 1-3 are assigned to the *Pseudoemiliania lacunosa* (NN19) Zone. Samples from Sections 1-4 to 4,CC contain a succession of species, mostly discoasters and ceratolithids, readily assignable to the standard zones of late Miocene to Pliocene age. Samples from Core 4 contain, in addition to the restricted index species *Discoaster quinqueramus* (NN11), an irregular mixture of reworked index species of early and middle Miocene, Oligocene, and early to middle Miocene age. Allochthonous species of Oligocene and early to middle Eocene age are the same as those found below in stratigraphic superposition (Core 5 to Section 7-3).

The next distinct biostratigraphic unit (Core 5 to Section 6-6) is recognized by the presence of *Sphenolithus predistentus, S. distentus*, and *S. speudoradians*. The co-occurrence of these species permits assignment to the *Sphenolithus predistentus* (NP23)/*Sphenolithus distentus* (NP24) zonal interval. Samples from this interval do not contain helicosphaerids, pontosphaerids, or rhabdosphaerids. Nannofossil assemblages are abundant, but generally slightly to moderately overgrown. Certain samples contain reworked species of early to middle Eocene age.

Sample 6,CC contains a diagnostic and moderately well-preserved assemblage of middle Eocene age which probably correlates with the lower part of the *Discoaster tani nodifer* (NP16) Zone. Samples from Sections 7-1 to 7-3 contain moderately well-preserved nannofloras of the *Discoaster lodoensis* (NP13) Zone, of late early Eocene age.

Mesozoic

Abundant to rare, but poorly preserved nannofossil assemblages are found throughout the Cretaceous section. The Cretaceous sediments in Samples 463-7-3, 30 cm through 92,CC can be divided into 12 intervals.

1) Lower Maastrichtian (7-3, 30 cm to 16,CC): *Arkangelskiella cymbiformis* Zone.

2) Upper Campanian to lower Maastrichtian (17-1, 29-30 cm to 22,CC): *Tetralithus trifidus* Zone.

3) Upper Campanian (23-1, 51-52 cm to 25-2, 62-63 cm): *Tetralithus gothicus* Zone.

4) Coniacian to upper Campanian (25,CC to 30,CC). The common to abundant assemblages in this interval are characterized by the lack of certain index species. The upper limit of this zonal interval is determined by the first occurrence of *Tetralithus gothicus*, and the lower limit by the last occurrence of *Corollithion achylosum*.

5) Turonian (31,CC to 37,CC). The top of this zonal interval is determined by the last occurrence of *Corollithion achylosum*, and the lower limit by the last occurrence of *Lithraphidites alatus*.

6) Uppermost Albian to lowermost Turonian (38-1, 29-30 cm to 50-1, 52-53 cm): *Lithraphidites alatus* Zone.

7) Upper Albian (50,CC to 52,CC): *Eiffellithus turriseiffeli* Zone.

8) Middle Albian (53-1, 122-124 cm to 55-1, 22-23 cm): *Prediscosphaera cretacea* Zone.

9) Lower Albian (55-1 [base] to 59,CC): *Parhabdolithus angustus* Zone (upper part). The upper limit of this zonal interval is determined by the first occurrence of *Prediscosphaera cretacea*, and the lower limit by the last occurrence of *Nannoconus bucheri*.

10) Upper Aptian (60,CC to 65-1, 7-8 cm): *Parhabdolithus angustus* Zone (lower part). This zonal interval can be characterized by the co-occurrence of *Lithastrinus floralis* and *Nannoconus bucheri*.

11) Lower Aptian (65,CC to 78-1, 87-88 cm): *Chiastozygus litterarius* Zone.

12) Barremian (79-1, 36-37 cm to 92,CC): *Micrantholithus obtusus* Zone. The absence of resistant *Calcicalathina oblongata* strongly suggests that drilling at Site 463 terminated in sediments of Barremian age.

Foraminifers

A visual estimate of the relative abundance of the main components of the sediment coarse fraction is presented in Appendix B. Foraminifers are the dominant constituent of the Neogene, Paleogene, and Cretaceous ooze and chalk recovered in Cores 1 through 50. They are moderately well to poorly preserved in the Neogene (Cores 1-4), moderately well preserved in the Oligocene (Core 5), well preserved in the Eocene through Coniacian (Cores 6-27), and moderately well-preserved in the remaining Cretaceous chalks (Cores 30-50); in the latter, recrystallization is noticeable, and chalk aggregates constitute a significant amount of the coarse fraction.

In the Lower Cretaceous limestone, below Core 50, radiolarians and limestone chips constitute the main components of the coarse fraction. Foraminifers are rare and poorly preserved in Cores 52 to 67 (Albian and Aptian), becoming rarer and more poorly preserved as recrystallization becomes more and more pronounced down-section; foraminifers disappear below Core 67.

Neogene

The highest sample from Core 1 (1-1, 7-9 cm) is Quaternary in age (Zone N22), as indicated by the presence of *Globorotalia truncatulinoides*. Section 1,CC is attributed to the upper Pliocene (N21), based on the presence of *Globigerinoides fistulosus* at a biostratigraphic level above the last occurrence of *Sphaeroidinellopsis* spp. (known to have become extinct 2.8 m.y. ago), as the latter species were not found. Although rare occurrences of temperate species (*Globorotalia crassaformis, G. inflata*) were observed, the faunal assemblage appears to represent significantly warmer water than that at the top of the core. Two tropical species, *S. dehiscens* and *G. cultrata*, constitute most of the fauna.

Section 2,CC is lower Pliocene (N19-N20), based on the co-occurrence of *Sphaeroilinellopsis* spp. and *G. tumida*. The fauna is largely dominated by two resistant, warm-water species, *Sphaeroidinellopsis seminulina* and *S. subdehiscens*, probably as a result of dissolution of a warm-water assemblage.

Because of poor preservation and probable dissolution of most of the taxa, the age of Section 3,CC cannot be determined precisely. It belongs to the zonal interval from N14 to N19 or N20 (middle Miocene to lower Pliocene), as shown by the occurrence of "*Globigerina*" *nepenthes*. This species dominates the fauna and is accompanied by common *S. seminulina* and *S. subdehiscens*. Section 4,CC contains the same middle Miocene to lower Pliocene planktonic assemblage as above, but mixed with a large amount of Eocene and Oligocene faunas and a few Upper Cretaceous species.

Benthic foraminifers are characteristic of a bathyal environment. They include *Favocassidulina favus, Planulina wuellerstorfi, Melonis pompilioides, Oridorsalis umbonatus, Eggerella bradyi, Uvigerina* sp., and *Stilostomella* sp.

Paleogene and Cretaceous

Paleogene foraminifers occur in Cores 4 to 7, and Cretaceous foraminifers in Cores 7 to 67. Whereas Paleogene faunas are strongly mixed, a probably continuous and generally well-preserved Cretaceous sequence was recovered.

The Paleogene contains admixtures of Oligocene, Eocene, and Paleocene forms. Index fossils include *C. cubensis*, and *G. ampliapertura* in the Oligocene and *G. barri, M. aragonensis, T. cerroazulensis, M. aegra*, and *M. velascoensis* in the Paleocene.

Maastrichtian. the *G. contusa* (Cores 7-12) and the *G. scutilla* (Cores 15-20) zones were recognized. The foraminifers are well preserved, and are faunas diverse. The late Maastrichtian index species *Raceniguembelina fructicosa* is not present at this site.

Campanian. the zonal interval from the *G. calcarata* Zone to the *G. subspinosa* Zone (Cores 21 -25) and the *G. elevata* Zone (Cores 24 and 25) were recognized. Fossils are well preserved, although there are large con-

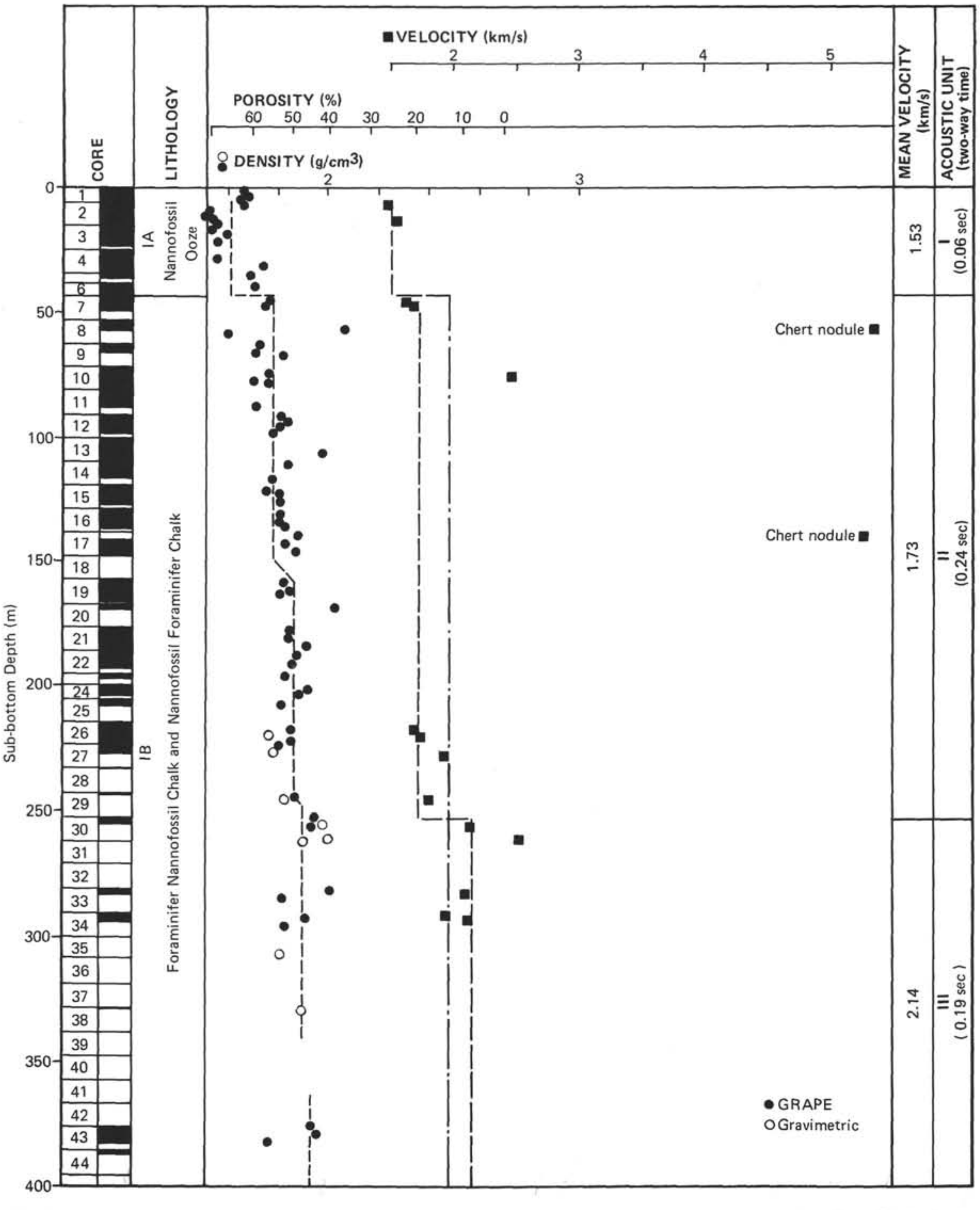


Figure 16. Wet-bulk density and compressional-wave velocity along the vertical direction plotted as a function of hole depth (see Appendix D for individual measurements). Lithologic unit, mean wave velocity, and two-way travel times are also indicated. Broken lines indicate mean values of wet-bulk density and velocity for each subdivided layer; dash-dot lines indicate values averaged over each lithologic unit.

centrations of test fragments. *G. subspinosa* is present in the *G. elevata* Zone, placing it in the Campanian, not the Santonian.

Turonian to Coniacian. the *G. rensi-G. sigali* (Cores 6-29), *G. helvetica* (Cores 33-34), and *H. lehmanni* (34,CC-38) Zones were identified. *Whiteinella* and *Rotalipora* are present, along with several species of heterohelicids and globigerinids. The planktonic foraminifers are only moderately well preserved, and occasionally badly recrystallized (30,CC). Benthic foraminifers are rare.

Cenomanian. The *R. cushmani* Zone (Cores 39-43) and the *R. gandolfi-R. greenhornensis* zonal interval (Cores 44-47) were recognized. Rotaliporids are numer-

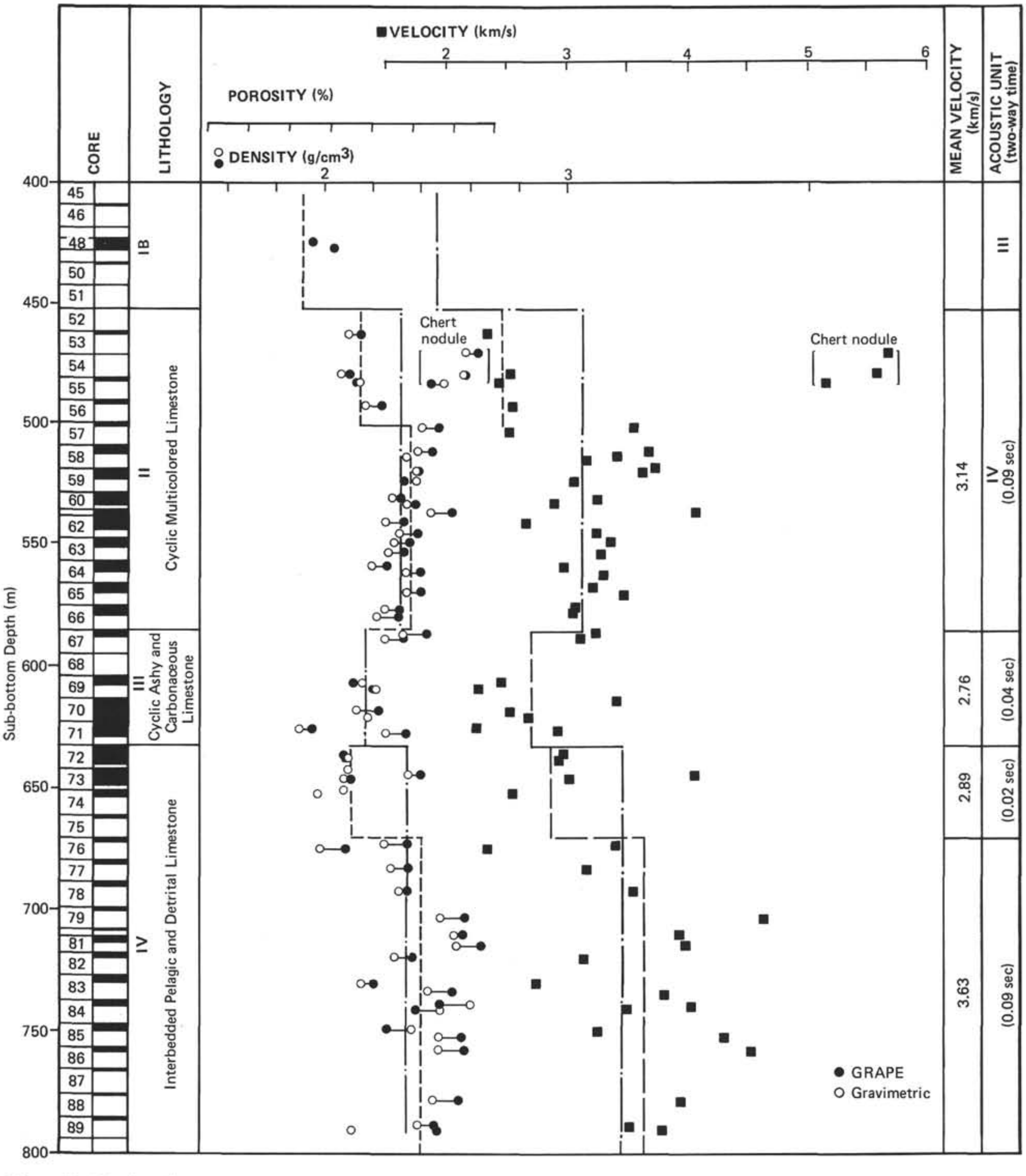


Figure 16. (Continued).

ous, diverse, and generally well preserved; they include *R. reicheli, R. turonica, R. brotzeni, R. appeninica*, and *R. montsalvensis*.

Albian. Planktonic foraminifers are occasionally moderately well preserved, but poor preservation is more typical through this interval. Species of *Praeglobotruncana, Ticinella*, and *Rotalipora* and numerous hedbergellids are present. No shackoinids were found at this site.

Aptian. The foraminifers are small and very poorly preserved. Only *Globigerinelloides algerianus* and a few small hedbergellids are present, along with some benthic foraminifers.

Radiolarians

Abundance and Preservation

Three intervals can be defined in the sedimentary sequence at Site 463 on the basis of radiolarian occurrences:

1) Cores 1 through 55, in which radiolarians are mainly absent. Only a few un-identifiable fragments were found in Cores 1, 2, 30, 52, and 53.

Table 3. Physical properties of acoustic units at Site 463.

Acoustic Unit	Sub-bottom Depth (m)	Density (g/cm^3)	Velocity (km/s)	DT (sec)	Lithologic Unit
I	0–47	1.61	1.53	0.06	IA
	(45–450)*	(1.83)*	(1.95)	(0.41)	(IB)
II	7–250	1.82	1.73	0.24	IB
III	250–450	1.91	2.14	0.19	IB
IVA	450–588	2.15	3.14	0.09	II
B	588–633	2.18	2.76	0.04	III
C	633–670	2.13	2.89	0.02	IV
D	670–823	2.41	3.63	0.09	IV

Note: A value in parenthesis is simple average for lithologic Unit IB.

2) Cores 56 through 74, in which radiolarians are confined to sandy layers. The tests are usually recrystallized, and many internal molds of iron oxide or pyrite (with or without the original skeleton) were observed. The interval molds are composed of iron oxide down to Core 63, and or pyrite below that level.

3) Cores 75 to 92, in which mostly well-preserved radiolarians occur consistently throughout the section. Internal molds of pyrite were also observed in this interval.

In the lowermost few cores, a few samples contain well-preserved tests together with recrystallized tests and internal molds. The co-occurrence of these three types of radiolarians probably results from turbidite displacement. Displacement in these samples is also suggested by (1) low-diversity assemblages, (2) sorting of the abundant, well-preserved, spherical tests, and (3) fragmentation of all *Nasselaria* tests.

Radiolarian Biostratigraphy

The zonation of Foreman (1975), established at DSDP Leg 32 sites, was followed. Three zones were identified in the Lower Cretaceous: the *Acaeniotyle umbilicata* Zone in Cores 56 through 70, the *Eucyrtis tenuis* Zone in Cores 70 through 89, and the *Sethocapsa trachyostraca* Zone in Cores 89 through 92. The calibration of these radiolarian zones to the absolute time scale and to calcareous-fossil zonations, however, is poorly documented. At this stage of knowledge, chronostratigraphy of the Lower Cretaceous is difficult to establish solely on the basis of radiolarians.

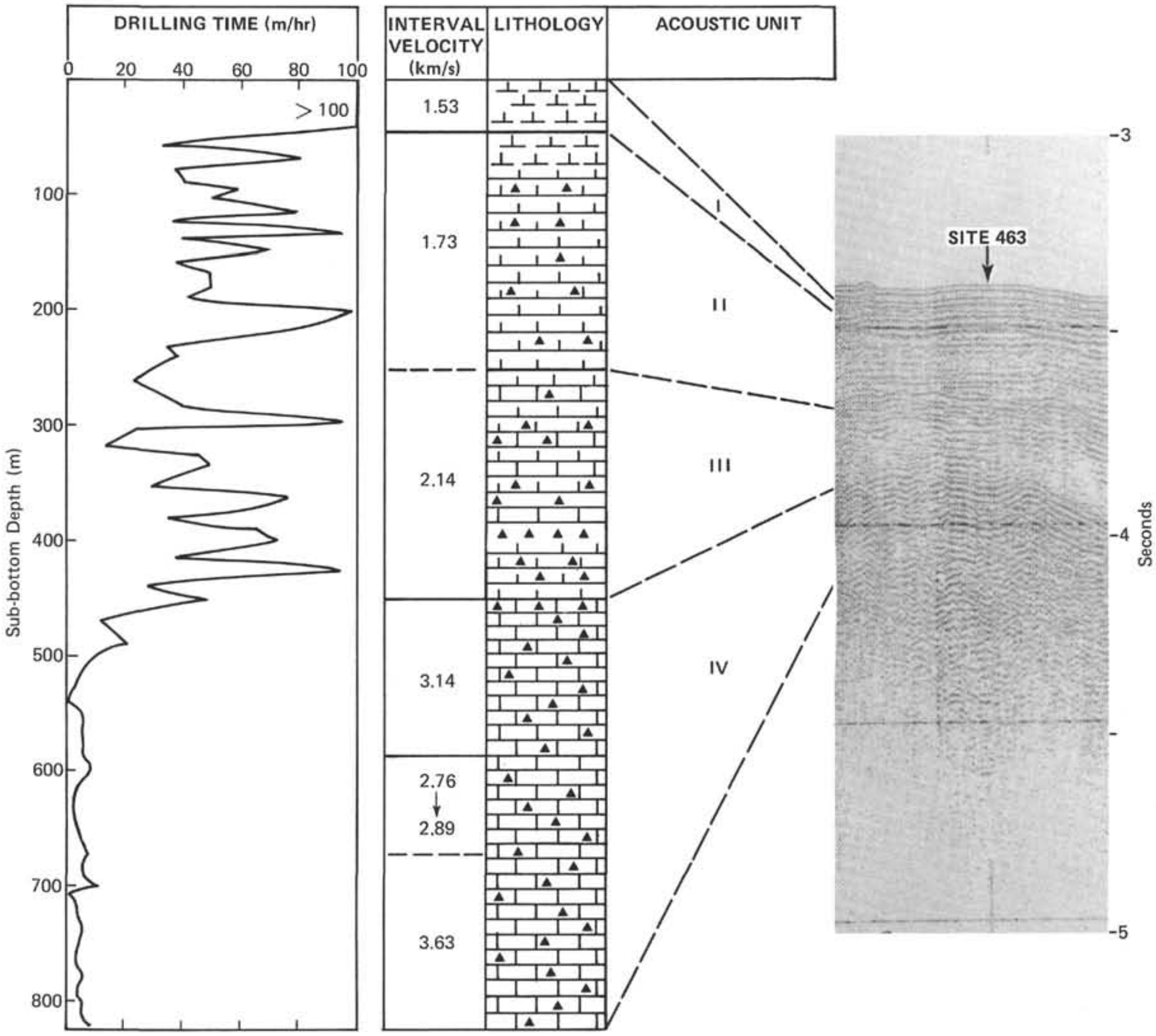


Figure 17. Correlation of drilling time, lithology, acoustic units and seismic-reflection profile at Site 463.

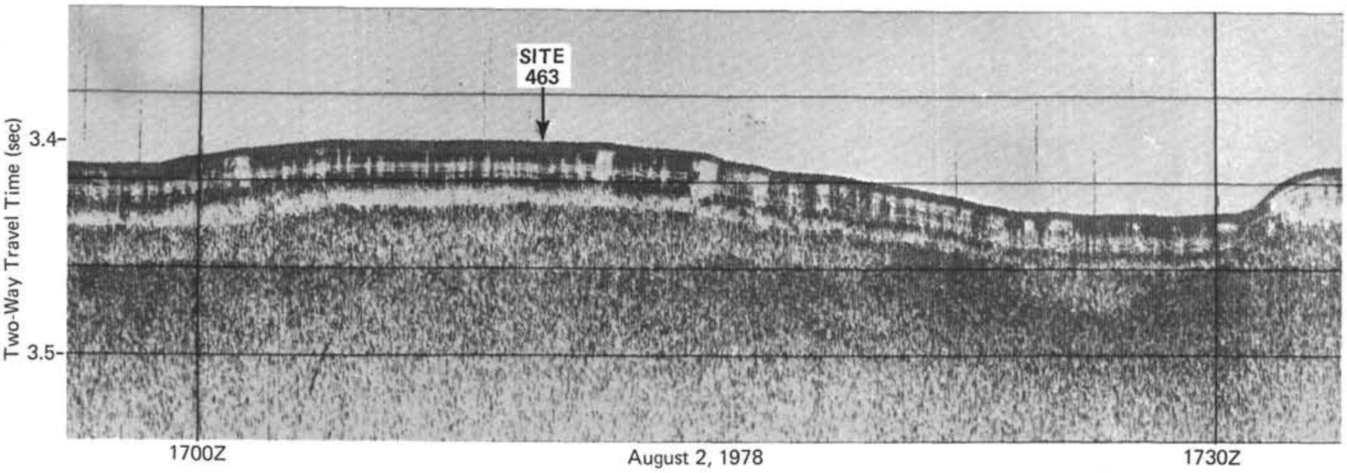


Figure 18. Seismic-reflection profile (3.5 kHz) along *Glomar Challenger* track line, made during approach to Site 463.

From the data of calcareous plankton, paleomagnetics, and sedimentation rates at Site 463, it appears that the *A. umbilicata/E. tenuis* zonal boundary occurs in the Aptian, and the *E. tenuis/S. trachyostraca* boundary in the Barremian.

SEDIMENTATION RATES

Average sedimentation rates at Site 463 have been estimated (Table 4) using the time scales given in the Introduction to this volume. Corrections for differential compaction have not been applied. Data from each fossil group are reported on Figure 20, a mean sedimentation-rate curve.

The oldest reliable paleontological datum recognized at Site 463 is the last occurrence of the nannofossil *Nannoconus colomii*, which marks the Aptian/Barremian boundary. Sediments deposited during the early late Aptian in the interval between the level of this datum (718 m) and 556.5 meters (where the *G. algerianus* planktonic-foraminifer zone was identified, in good agreement with the *P. angustus/C. literrarius* nannofossil-zone boundary) accumulated at an average rate of 36 m/m.y. Assuming a constant sedimentation rate for the lowermost 104.5 meters of the section, the hole terminated in Barremian sediments approximately 118 m.y. old (at the upper/lower Barremian boundary). This is in good agreement with the nannofossil data, as the species *Calcicalathina oblongata*, which last occurs in the uppermost lower Barremian, was not found.

The relatively high sedimentation rate of 36 to 37 m/m.y. for the lower 265 meters of Hole 463 probably resulted from the influx of debris from shallow-water carbonates. The sedimentation rate of the overlying pelagic limestone decreases to an average value of 11 m/m.y. during the late Aptian through the early Santonian. From an examination of the sedimentation-rate curve for that interval of time, it appears that sedimentation decreased slightly in the late Albian, whereas it increased in the early and middle Cenomanian during the time of maximum chert deposition (poorest recovery in Cores 40 through 50).

The highest occurrence of the nannofossil *Nannoconus bucheri*, whose level of extinction marks the Aptian/Albian boundary, is deeper than the level of this boundary as indicated by the sedimentation-rate curve (Fig. 20), and it is probable that the upper range of this species is curtailed here.

Sedimentation during the late Santonian and most of the Campanian appears to have been very reduced, having a low value of 2 m/m.y. This was followed by an abrupt and marked increase during the late Campanian and early Maastrichtian. Sediments were deposited during that time at an average rate of 42 m/m.y. This high value may result from the equatorial crossing of the site at this time, according to the Lancelot and Larson (1975) tectonic model for Pacific Plate motion (Fig. 21). It is also noticeable that an influx of displaced shallow-water benthic foraminifers occurred in the sediments deposited during that interval of high accumulation rate.

A major hiatus of 17 m.y. spans the Cretaceous/Tertiary boundary. Sedimentation resumed very slowly in the late early Eocene. During the remainder of the Paleogene, sediments accumulated at the very reduced average rate of 0.5 m/m.y. Although a number of fossil zones were recognized in their normal sequential order, some hiatuses may have occurred during that interval of time.

After a major hiatus of 16 m.y., spanning the late Oligocene and the entire early and middle Miocene, sedimentation resumed again in the late Miocene. It was accompanied by reworking of sediments deposited during the preceding time of slow deposition or nondeposition at the site (Late Cretaceous, Eocene, Oligocene, early and middle Miocene). From that time, sedimentation appears to have been undisturbed and continuous through the late Miocene to Pleistocene, although very slow (average rate 3.5 m/m.y.).

SUMMARY AND CONCLUSIONS

Regional Framework

The Mid-Pacific Mountains, presently located in the central subtropical North Pacific (Fig. 1) are an ancient structural high rising 2000 to 3000 meters above the surrounding abyssal plain, whose crust is believed to be

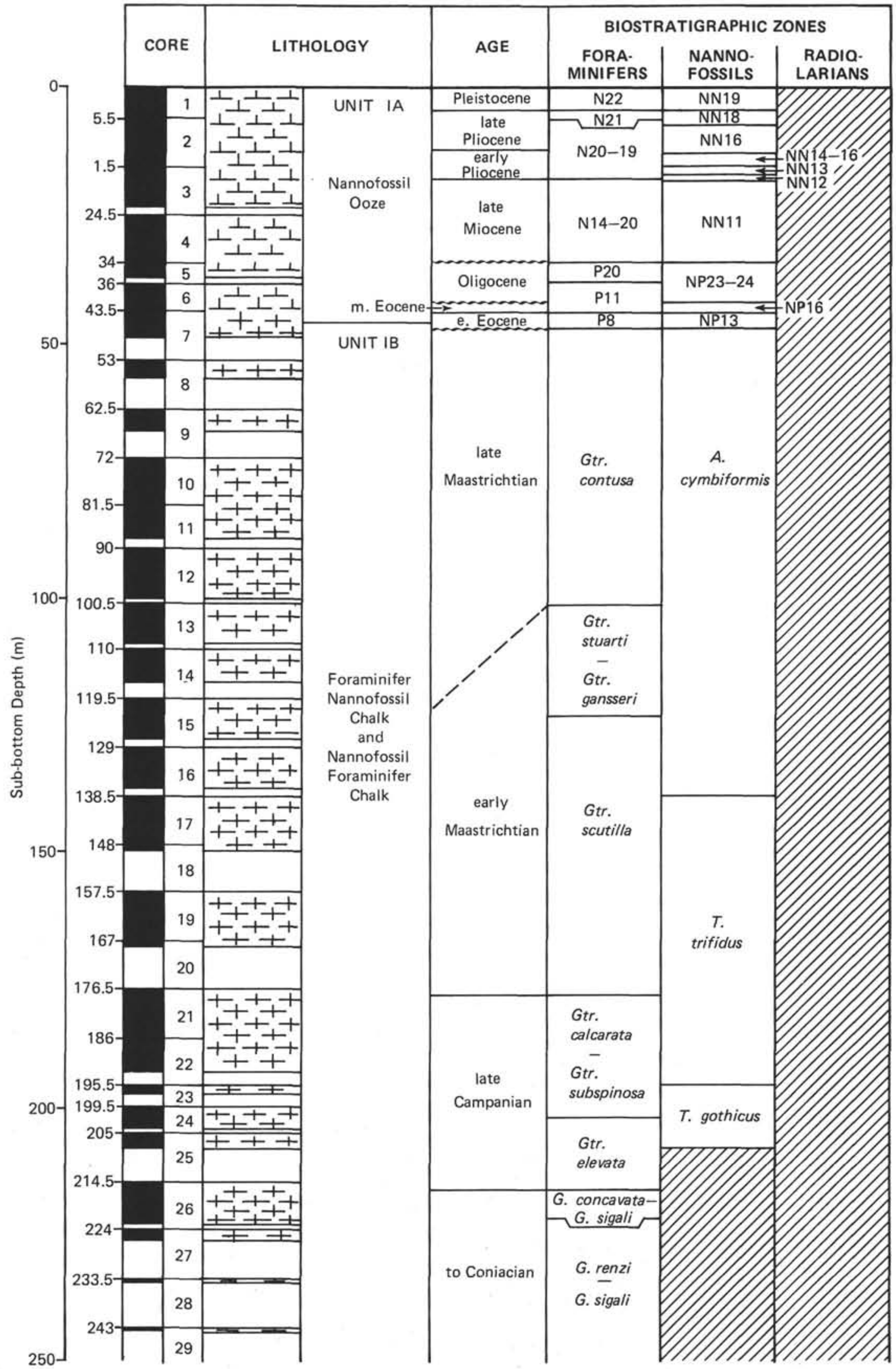
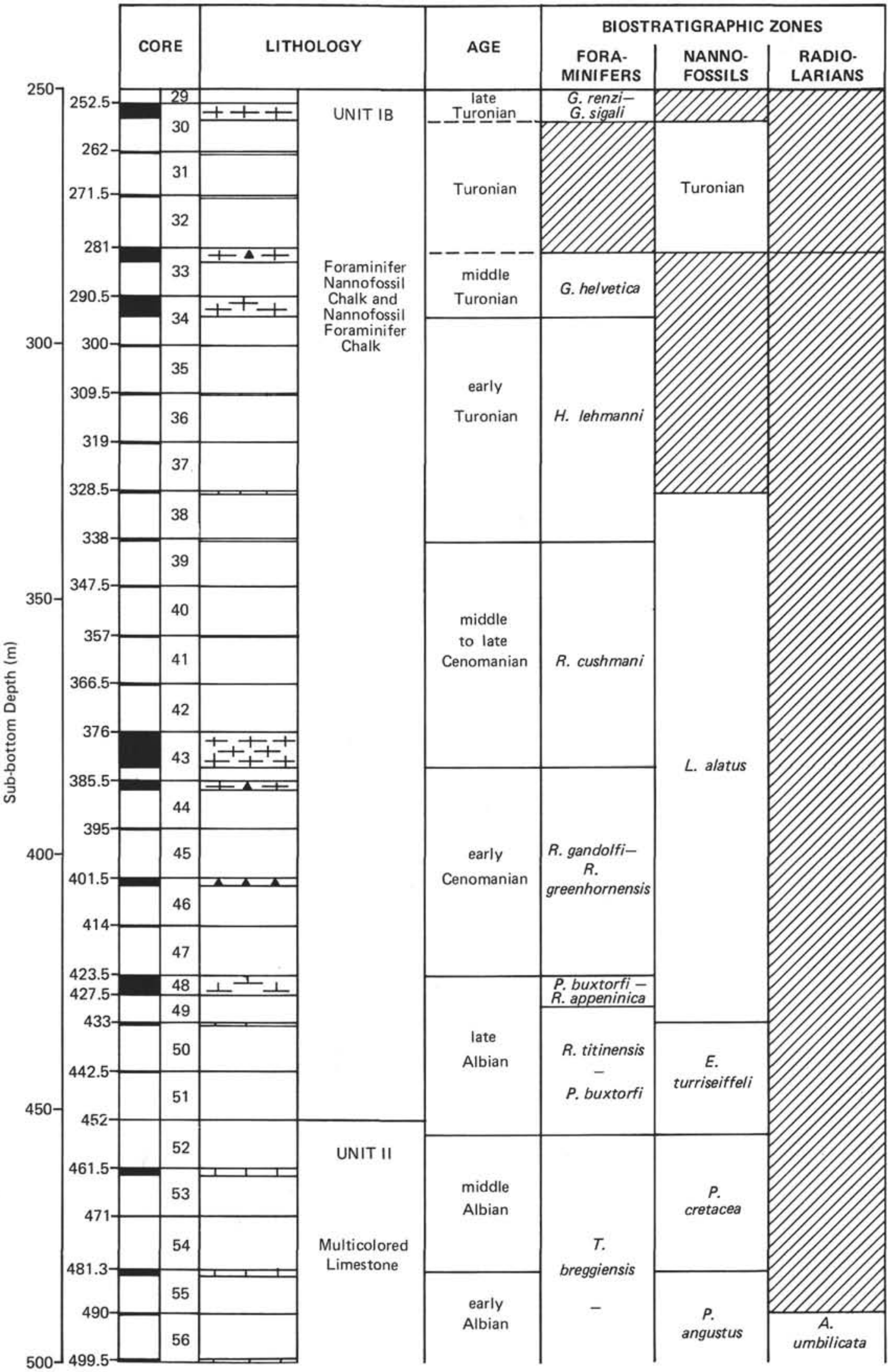


Figure 19. Biostratigraphy of Site 463.



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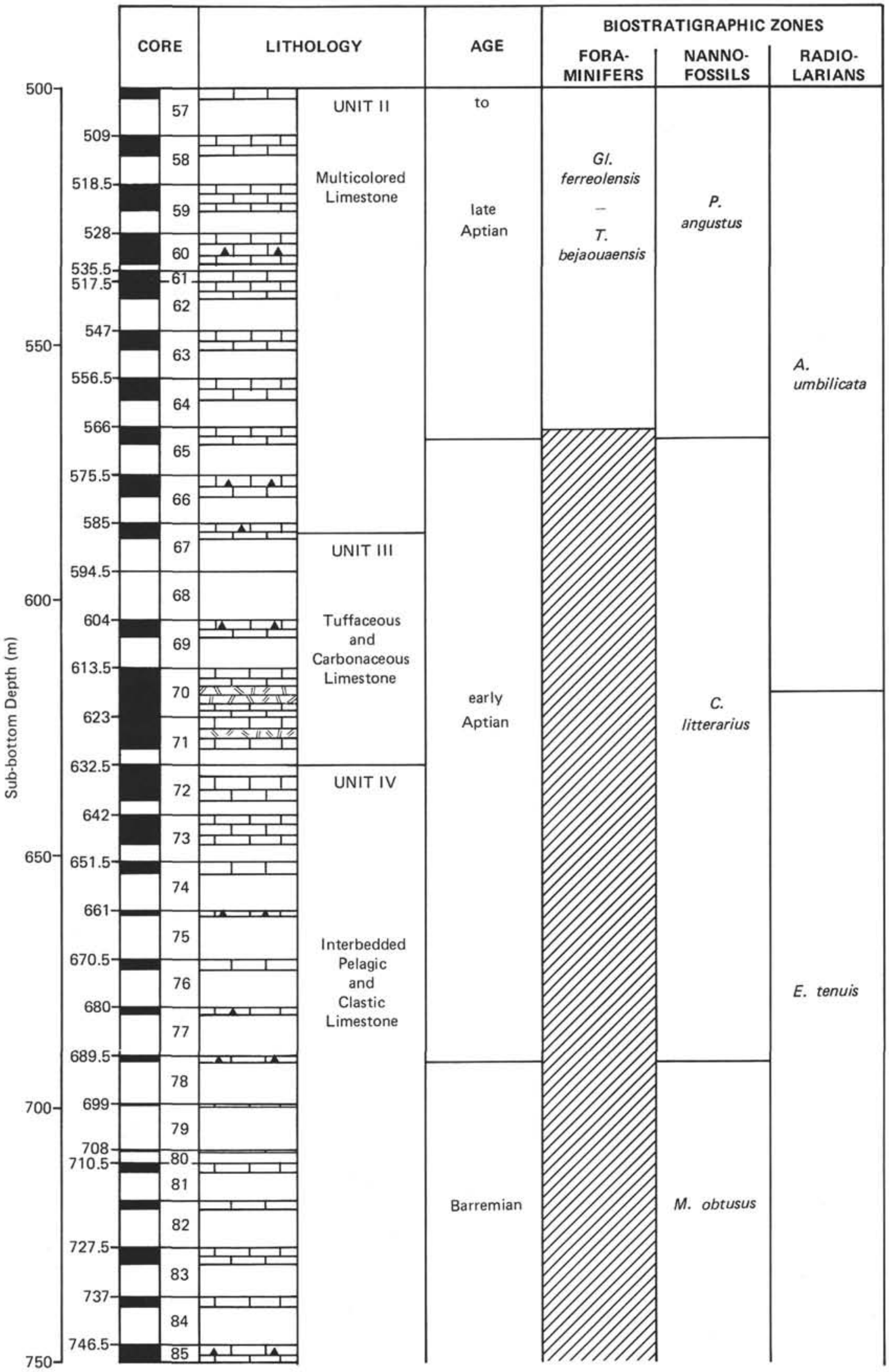

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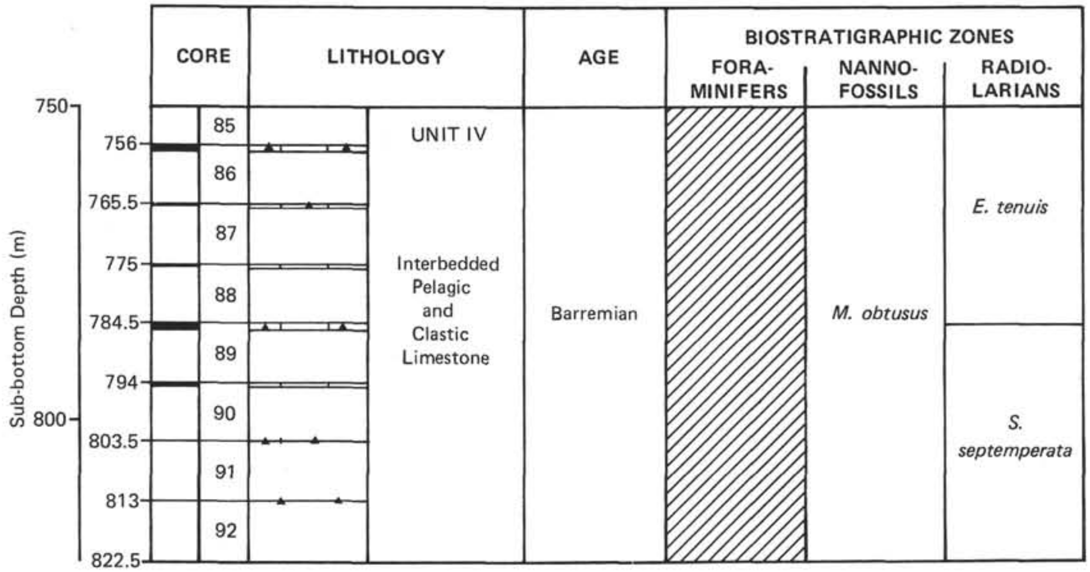

Figure 19. (Continued).

Late Jurassic to Early Cretaceous in age (Larson, 1976). Because of their structurally high position, the western Mid-Pacific Mountains were expected to be a favorable locale for obtaining a thick, homogeneous fossiliferous sediment section for studies of the Mesozoic and Cenozoic paleoenvironments of the central Pacific. It was hoped that the age of the oldest sediments and recovery of basement rocks would help unravel the history of construction, destruction, and subsidence of one of the major aseismic rises which constitutes a fragment of the ancient Mesozoic Pacific Plate. Horizontal movement of the western Mid-Pacific Mountains (Fig. 21) could be documented by studies of microfossils, lithologies, sedimentation rates, and paleomagnetism. Because the eastern segment of the Mid-Pacific Mountains was drilled during DSDP Legs 6, 17, and 32, a location on the western Mid-Pacific Mountains segment was selected for Site 463 of DSDP Leg 62.

Stratigraphic Framework

The sedimentary sequence recovered from Hole 463 provides a record of carbonate sedimentation from the Early Cretaceous through the Quaternary. A site-summary chart (Fig. 22) presents most of the geochemical, physical-properties, grain-size, and mineralogical data.

The site has been situated above the CCD throughout its history. The Lower Cretaceous (Barremian) to Quaternary sediments have two 16- to 17-m.y. hiatuses that span intervals from the late Maastrichtian through early Eocene and late Oligocene through middle Miocene. A minor hiatus, or condensed section, occurs in the late Coniacian to early Campanian interval.

The sediment section is divided into four major units, based on lithology. From oldest to youngest, these are a Barremian and lower Aptian limestone unit (Unit IV), a mid-Aptian ashy- and carbonaceous-limestone unit (Unit III), an upper Aptian and lower Albian limestone unit (Unit II), and an upper Albian through Quaternary chalk and ooze unit (Unit I). The youngest unit is further divided into two sub-units, the older is late Albian to late Maastrichtian in age (Sub-unit IB) and the younger is early Eocene to Quaternary in age (Sub-unit IA).

Unit IV, the Barremian and lower Aptian limestone sequence, is more than 190 meters thick. The exact thickness cannot be ascertained, because coring terminated in the unit. The rocks are pelagic limestone and marlstone, interbedded with clastic limestone that contains shallow-water debris, including mollusk, echinoderm, and stromatolite fragments, oolites, rare glauconite, and basalt fragments. Both the frequency of clastic-limestone beds and the maximum sizes of the clasts increase down-section (Fig. 12). The sedimentation rate was high, even though compaction and recrystallization effects have not been accounted for in the calculation (Fig. 20). Nannofossils, poorly preserved and sparse, are not older than Barremian. Foraminifers are absent, probably because of recrystallization. Radiolarians are moderately well preserved, and the lower 20 meters belong to the *Sethocapsa trachyostrata* Zone, which has been correlated with both Valanginian nannofossils and Barremian foraminifers of DSDP Sites 306 and 307.

At least two reversed-polarity intervals have been identified in the early Aptian. *Chiastozygus litterarius* nannoplankton zone, in sediment Units III and IV, which may correlate with anomaly M0, or with a reversed-interval identified at DSDP Hole 361. The lowermost sediments are thought to be Barremian, (about 118 m.y. old) based on nannofossil and sedimentation-rate data. Strong seismic reflectors, as observed on air-gun seismic-reflection profiles, occur throughout this unit (Fig. 7). Average velocities (V_p) are 3.63 km/s for the section below 670 meters, and 2.89 km/s from 630 to 670 meters (Fig. 17).

Unit III is a 45-meter-thick, lower Aptian cyclic limestone unit that contains abundant volcanic ash and a sequence of organic-rich limestones. The volcanic ash and carbonaceous limestones are superimposed on an

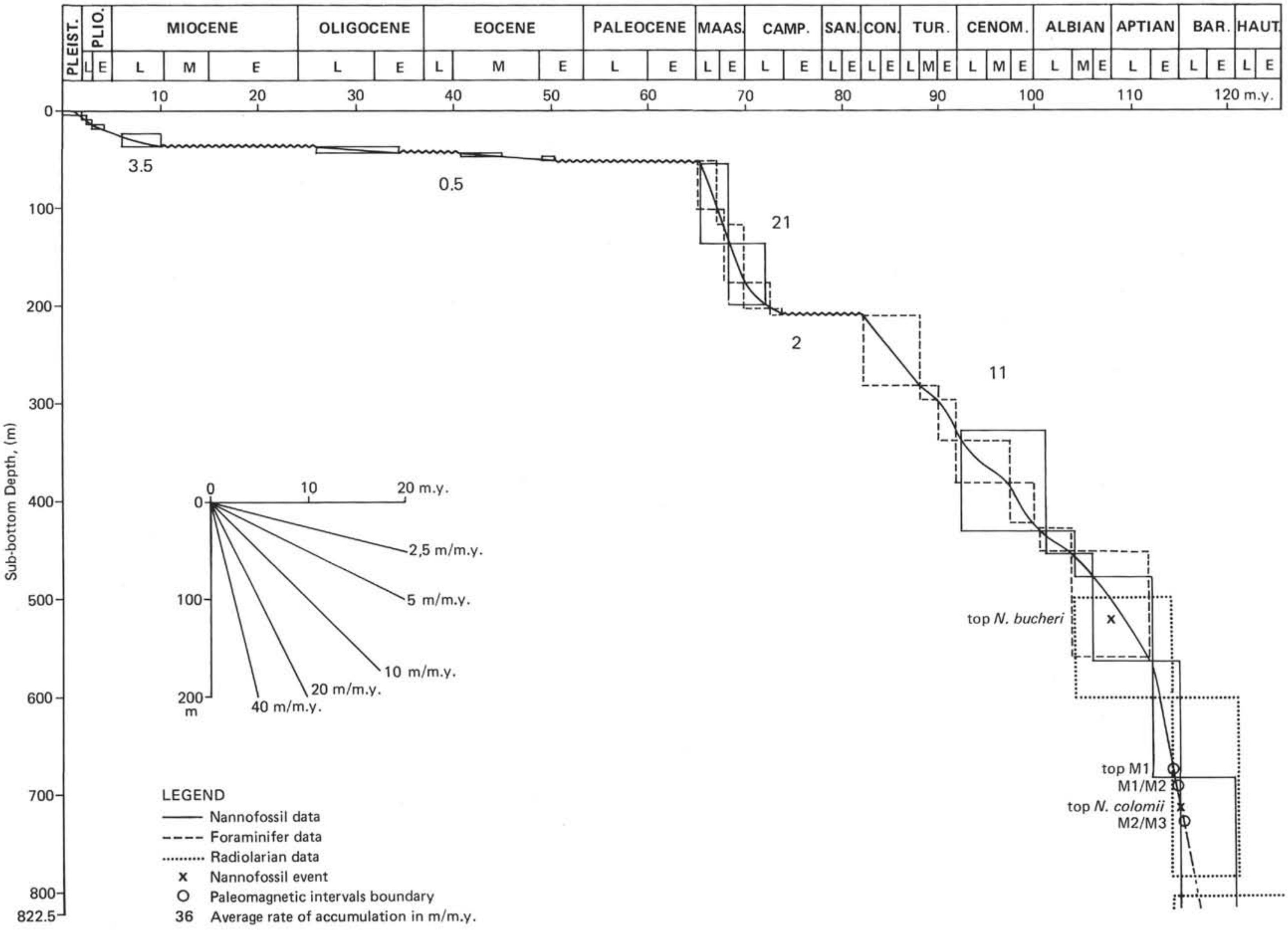

Figure 20. Sedimentation-rate curve for Site 463.

Table 4. Thicknesses and sedimentation rates at Site 463.

Series/Stage	Sub-bottom Depth of Lower Boundary (m)	Thickness (m)	Average Sedimentation Rate (m/m.y.)
Pleistocene-upper Miocene	34	34	3.5
Oligocene-Eocene	46.8	12.8	0.5
Maastrichtian	176.5	129.7	52
Campanian	214.5	38	5
Santonian	224	9.5	6
Coniacian	262	38	10
Turonian	290.5	28.5	5
Cenomanian	433	142.5	18
Albian	528	95	12
Aptian	718	190	27
Barremian	822.5	104.5	36

alternating cyclic limestone unit similar to the overlying unit. The almost complete disappearance of volcanic-ash beds marks the boundary between Units III and IV. The organic-rich zone, confined to Cores 70 and 71, at depths of 613 to 623 meters, has a maximum organic-carbon content of about 7%. Chert occurs in the unit, but is relatively rare. Foraminifers are absent, but both nannofossils and radiolarians are present. The nannofossils are poorly preserved, but readily identifiable. Radiolarians are reworked and are found in sand layers; part of the radiolarian fauna is probably displaced. The calibration of radiolarian zones to the absolute time scale and to calcareous-fossil zonations is poorly documented at present. Physical properties reflect the volcanic and organic-carbon constituents of the sediment. Velocities (V_p) are low, with a mean of about 2.76 km/s (Fig. 17).

Unit II, the lower Aptian to lower Albian pelagic limestone, is 136 meters thick and represents about 9 m.y. of deposition. A notable characteristic of this unit is its several pastel colors, which seem to alternate in cycles. Contacts between cycles or colors are both gradational and sharp, although most are gradational and burrowed. Graded beds are rare and made up entirely of microfossils, with foraminifers and radiolarians at the base and calcareous nannofossils at the top. Chert is a common component. Radiolarians are reworked and occur only in sand layers. Internal molds consist of iron oxides down to Core 63, and below that core of pyrite. Above Core 56, radiolarians are absent. Foraminifers are rare and poorly preserved; nannofossils are common

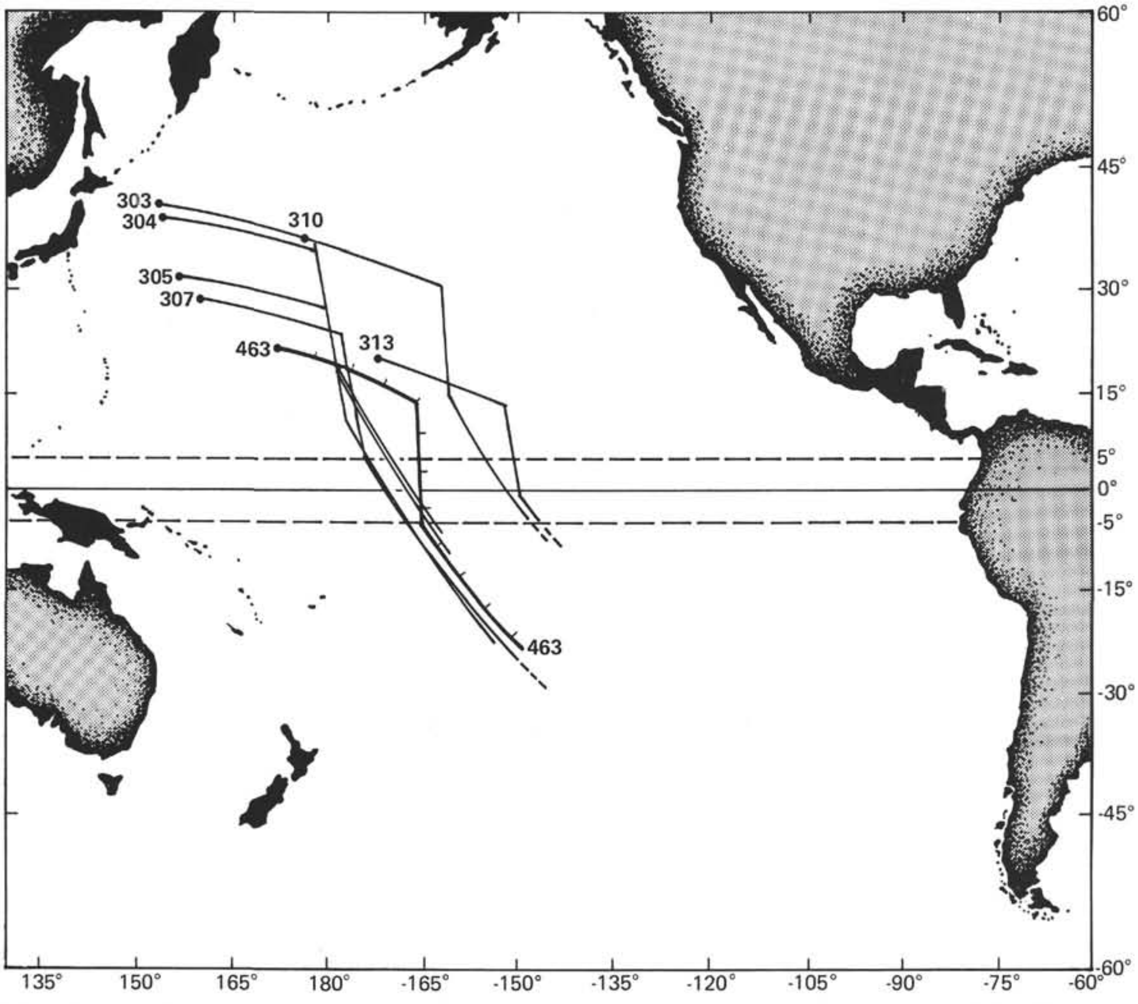

Figure 21. Paths back-tracked through geologic time (10-m.y. increments) for DSDP Leg 32 drill sites and Site 463, according to the rotation model of the Pacific Plate described by Lancelot and Larson (1975).

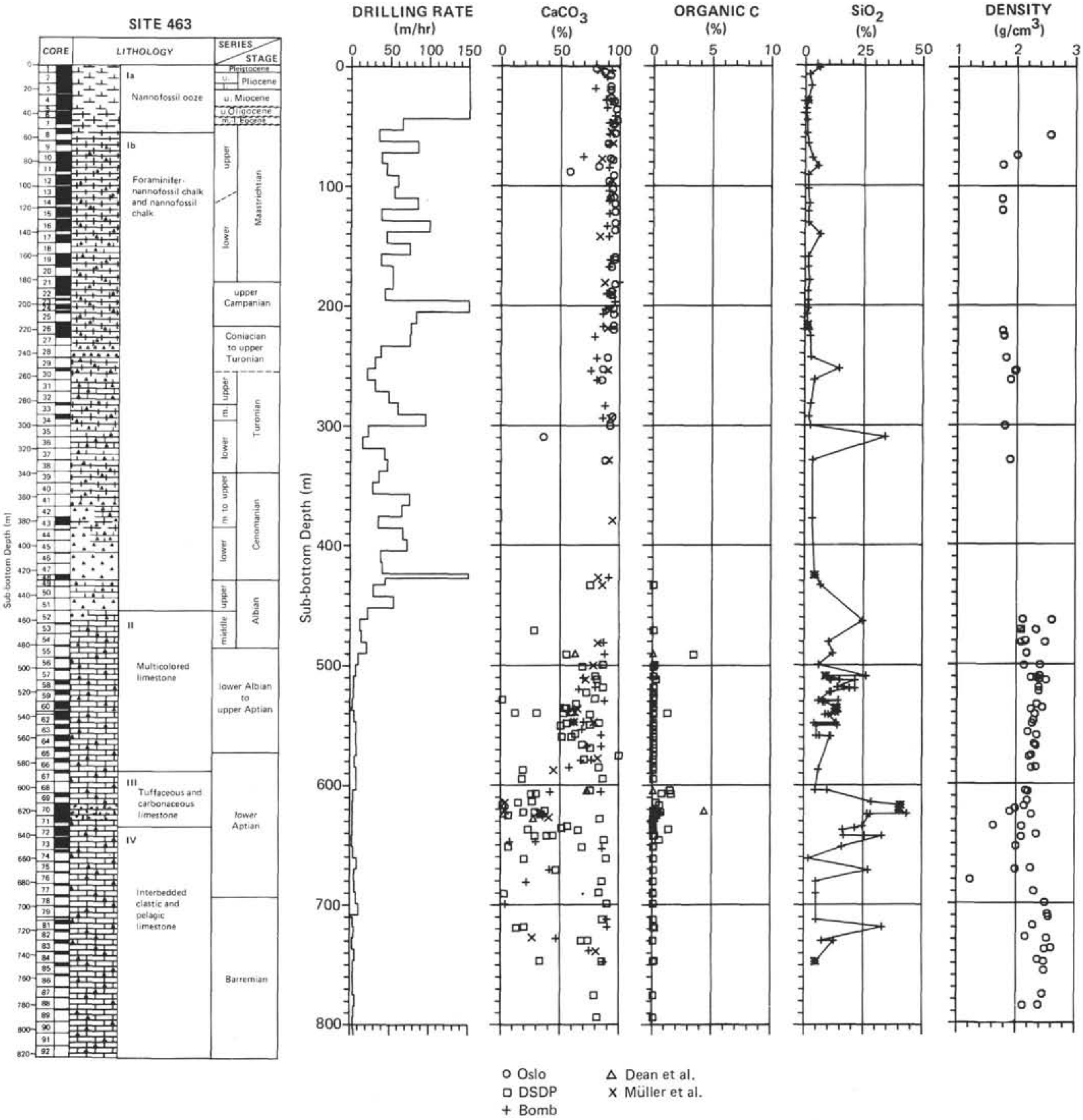

Figure 22. Site-summary chart, Site 463, western Mid-Pacific Mountains. The data for the summary are compiled from the following sources: % $CaCO_3$ and % organic carbon from Dean (this volume); density, % porosity, water content (% water), and sound velocity from Appendix D (this chapter) and Fujii (this volume); % sand, silt, and clay from Appendix E (this chapter); and clay mineralogy from Appendix C (this chapter) and Nagel and Schumann (this volume).

to rare, and also poorly preserved. Sedimentation rates are relatively low (~15 m/m.y.) compared with those of the underlying units. The top of this unit marks a major acoustic boundary that shows up as a very strong reflector on air-gun seismic-reflection profiles (Fig. 17). Velocities (V_p) measured in the laboratory average about 3.14 km/s.

Nannofossil foraminifer chalk and foraminifer nannofossil chalk are the major lithologies of Unit IB, which makes up 405 meters of late Albian to late Maastrichtian age sediment (~103-67 m.y.). Rare chert, porcellanite, and limestone constitute parts of the stratigraphic sequence. The chalk is very uniform, mostly stark white, with some mottling, burrows, and

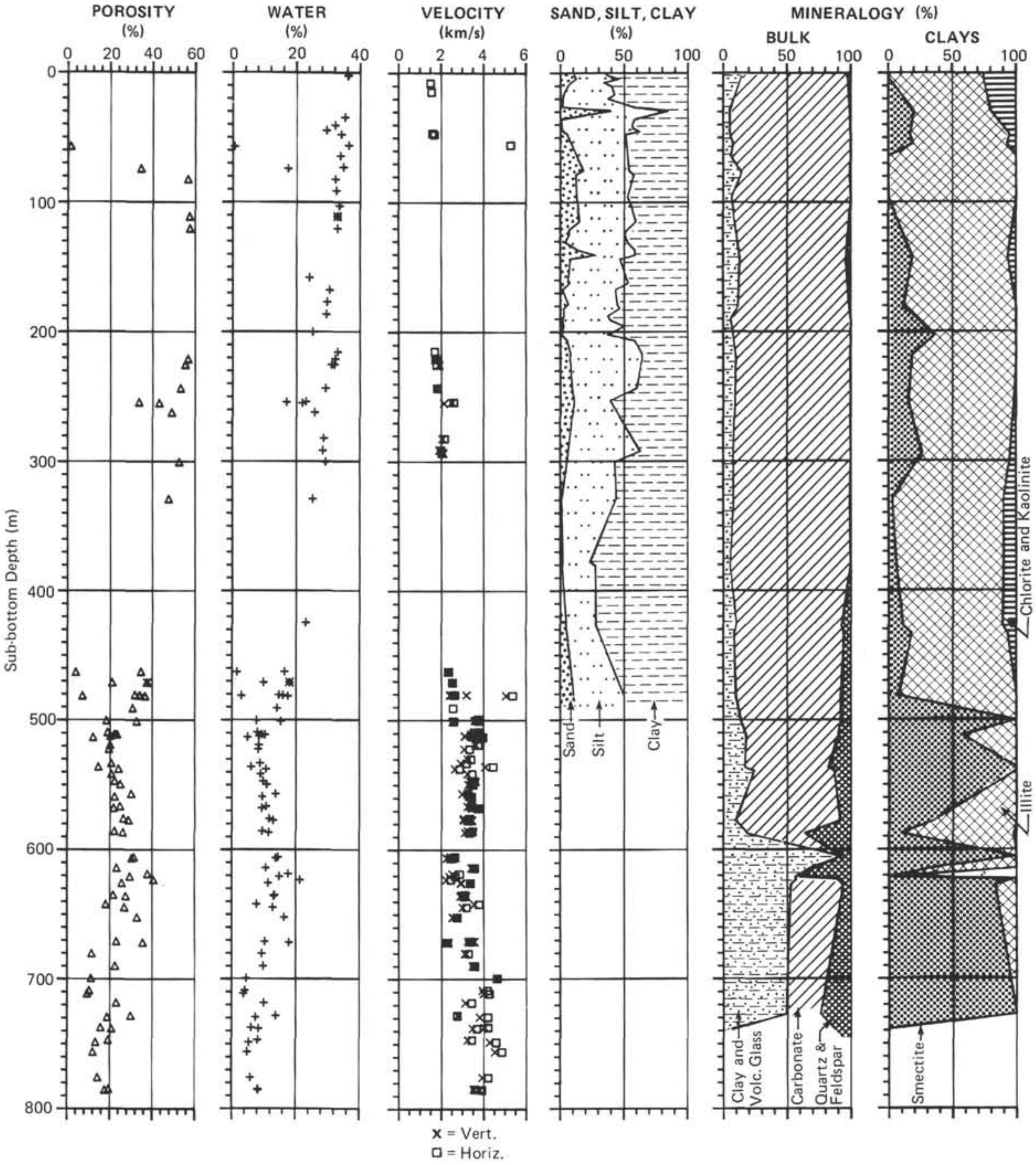

Figure 22. (Continued).

laminations. Foraminifers are well preserved in Santonian through upper Maastrichtian sediments, and are moderately well preserved in the older part of this unit. Nannofossils are abundant to common, and most are poorly preserved. Certain key species are absent in sediments of late Turonian to late Campanian age. Radiolarians are absent. The top of the unit is marked by a 17-m.y. late Maastrichtian to early Eocene hiatus. Sedimentation rates from late Albian to early Santonian averaged about 15 m/m.y., followed by a late Conacian to middle Campanian hiatus. Rates abruptly increased during the late Campanian and early Maastrichtian to about 42 m/m.y. This increased rate probably corresponds to the equatorial crossing of the site (Lancelot and Larson, 1975), and in small part to an influx of displaced shallow-water components. Sound velocity (V_p) measurements on individual samples averaged 1.73 km/s, which agrees well with the interval velocity measured on the air-gun seismic reflection profiles.

The top unit of Hole 463, Unit IA, is 47 meters thick and spans the early Eocene to Pleistocene (about 50 m.y.). The sediment is mainly nannofossil ooze with varying amounts of foraminifers. The sequence is greatly condensed; a major hiatus of about 16 m.y. occurs in the latest Oligocene through middle Miocene interval, separating 13 meters of Paleogene ooze from 34 meters of Neogene ooze. A hiatus may occur between the Eocene and Oligocene strata. Nannofossils are well preserved in the Neogene, and moderately well preserved in the Paleogene. An extraordinary abundance of discoasters occurs in the upper Miocene and Pliocene assemblages. Planktonic foraminifers are moderately well to poorly preserved in the Neogene and Oligocene, and well preserved in the Eocene. Siliceous microfossils are absent from the Paleogene, when sedimentation rates averaged only about 0.5 m/m.y. The slow deposition in part may be caused by short-time hiatuses. Sedimentation rates averaged about 3.5 m/m.y. in the late Miocene to Pleistocene, and all calcareous-microfossil zones are present. Sound velocities (V_p) of individual samples average about 1.53 km/s and agree well with the expected interval velocity calculated from seismic-reflection profiles.

Post-Depositional Changes

Major post-depositional (diagenetic) changes in the sediment column involved calcium carbonate changing from biogenic ooze through chalk to limestone, silica changing through porcellanite to chert, and alteration of volcanic ash to smectite and other clay minerals.

Carbonate diagenesis at Site 463 apparently reflects the normal progression from ooze to chalk to limestone, similar to that outlined by Schlanger and Douglas (1974). Microscope evidence shows a major reduction in calcareous microfossils with depth, a reduction in porosity with depth, and the development of cement and overgrowths on undissolved microfossils. This diagenesis is also reflected by changes of physical properties with depth. Major changes in carbonate diagenesis are apparent at about 250 meters, where some chalk beds have been transformed to limestone, and at about 450 meters (between Units I and II), where most chalk has been converted to limestone.

Silica diagenesis is evident throughout most of the Cretaceous strata in Hole 463. All graduations from siliceous limestone to porcellanite to chert are evident. Significant changes can be observed from microscope studies, including replacement of calcite by silica minerals, void filling, and recrystallization of radiolarians (Fig. 12). Diagenesis has not followed a simple progression, as outlined by Wise and Weaver (1974); rather, it seems to have been influenced more by the lithologies and mineralogies of the sediment (Lancelot, 1973) and by burrows (Hein et al., this volume).

Lithologic Unit III contains organic-rich limestone and volcanic ash. The organic-carbon content of one sample is over 7%. The volcanic ash has changed in part to clay, probably caused by a glass-to-smectite conversion.

Physical properties of the sediments reflect the diagenetic changes. Density and sound velocity increase with lithification, whereas porosity decreases. The ooze-chalk-limestone transitions show the progressive changes well. Ooze has high porosity (50–70%), low density (1.5–1.7 g/cm^3), and low velocity (1.53 km/s). Chalk has lower porosity (45–60%), higher density (1.7–2.0 g/cm^3), and higher velocity (1.7–1.9 km/s). Limestone in lithologic Unit 4 has high density (2.1–2.4 g/cm^3) and high velocities (2.9–3.6 km/s). Limestone in Unit 3, with its included volcanic ash and organic carbon, has a density of almost 2.2 g/cm^3 and a velocity of 2.76 km/s, values significantly lower than those in both underlying and overlying limestones. The acoustic stratigraphy reflects the diagenetic changes, as shown by Schlanger and Douglas (1974). Prominent reflectors occur at ooze/chalk and chalk/limestone transitions, and possibly where thick chert beds are present.

Depositional History of the Western Mid-Pacific Mountains from Early Cretaceous to Recent Times

The litho- and biostratigraphic framework obtained from the sediment column penetrated at Site 463 allows us to describe the evolution of the depositional environment in the wesern Mid-Pacific Mountains. At present, the age of the Mid-Pacific Mountains is not well known (Larson, 1976). However, the oldest sediments at Site 463 are of Barremian age, approximately 20 m.y. older than those overlying basaltic rocks at Site 171 (Winterer, Ewing, et al., 1973), and approximately 40 m.y. older than those overlying the volcanic basement at Site 313 (Larson, Moberly, et al., 1975). It is clear, therefore, that the structural high of the western Mid-Pacific Mountains is considerably older than previously believed. Comparison with the results obtained at the other sites, where basement rocks have been reached after penetrating the entire sediment column (Fig. 1), makes it clear that the Mid-Pacific Mountains represent a complex structural high whose segments have been built or added to by volcanic events stretching over the extraordinarily long time of at least 40 m.y.

It is difficult to reconstruct the paleodepth of the oldest deposits at Site 463 because they consist of pelagic limestones interbedded with layers rich in clastic calcareous components (Fig. 13), probably displaced from contemporary neritic environments nearby. Shallow-water fossil assemblages dredged from the flanks of several guyots in the Mid-Pacific Mountains (Hamilton, 1956; Lonsdale et al., 1972) support the idea that many of the submarine volcanoes which surmount this platform were tropical islands surrounded by reefs or carbonate banks during parts of the Early and Late Cretaceous. These deposits, probably close to the coast lines of the ancient volcanic islands, plus the shape and size of the largest components in the detrital limestones, suggest that the source for this material was close by, probably the flat-topped seamount which was crossed during the approach to the site (Fig. 7; Rea et al., this volume).

Because all shallow-water components are apparently displaced, they do not offer direct evidence for the paleodepth of their host strata. The associated pelagic limestones unfortunately lack any fossil evidence of abundant benthic fauna (except large burrows). Because it is known that diverse mollusk faunas populated the flanks of adjacent guyots down to several hundreds of meters water depth (Kauffman, 1976), we assume that these limestones were laid down in intermediate water depths. The rapidly diminishing sedimentation rates (Fig. 20), the decreasing number of layers with displaced material, and the decreasing size of the reworked limestone clasts (Fig. 12) in successively younger sediments indicate that the depositional paleoenvironment at Site 463 deepened rapidly during late Barremian and early Aptian time.

During an approximately 2-m.y. interval in Aptian time (about 112–113 m.y. ago) ashes, which occur as dark readily discernible horizons in the pelagic deposits, mark a period of extensive volcanic activity, which may be contemporaneous with the generation of the volcanic basement of the eastern Mid-Pacific Mountains (Winterer, Ewing, et al., 1973).. In part of this interval, the greenish-black and greenish-gray volcanic ashes are intercalated with greenish-black to olive-black limestones and marly clays. The extraordinarily high organic-carbon content and the lamination of several intervals in these rocks (Fig. 10) suggest the development of an oxygen-poor depositional environment. Although most of this interval reveals signs of benthic life, several horizons with thin laminations suggest that the interface between reducing and oxidizing environments coincided with the benthic boundary, or even that it moved into the overlying water masses. Because well-oxygenated sediments of the same age have been sampled elsewhere in the deep Pacific basins (Schlanger and Jenkyns, 1976), the possibility of an ocean-wide euxinic paleoenvironment in the mid-Cretaceous Pacific can be excluded. Although the development of an oceanic mid-water oxygen minimum has been suggested as a possible cause for the widespread occurrence of anoxic lithofacies not only in the Pacific, but also in the Indian and Atlantic Oceans, the coincidence of the oxygen-poor paleoenvironment with significant Early Cretaceous volcanism in the western equatorial Pacific, as observed in the Mid-Pacific Mountains and other locations, requires further investigation.

After cessation of volcanic activity during the Aptian, deposition of calcareous sediments continued as the site slowly subsided. The pink, pale-green, greenish-gray, brown, and white limestones with their frequent and apparently cyclic color changes, the graded coarser beds enriched in foraminifers and radiolarians at their bases, and the wavy laminations document a period of pelagic sedimentation at this site (Fig. 9). It is particularly interesting to note that the guyots adjacent to Site 463 no longer contributed shallow-water debris, as the displaced material consists entirely of siliceous and calcareous remains of fossil plankton.

The thick interval of Upper Cretaceous calcareous ooze and chalk (more than 400 m) with extraordinarily well-preserved microfossils represents the time when this site passed under the high-productivity zone of the equatorial current system (Fig. 21). Important changes in the sedimentation rates of the dominantly pelagic biogenic deposits suggest that major fluctuations of this current regime were not restricted to the Cenozoic (van Andel et al., 1975), but that they occurred during late Mesozoic times as well.

The calcareous-ooze sequence deposited during the Cenozoic at Site 463 is unexpectedly thin and incomplete. This interval, less than 50 meters thick, includes long hiatuses spanning the late Oligocene to middle Miocene and late Maastrichtian to middle Eocene, whereas the condensed sections between these hiatuses and deposits younger than middle Miocene are typical examples of sediments laid down at intermediate water depths, well above the CCD, under the oligotrophic central subtropical water masses of the North Pacific. The hiatuses are the result of major revolutions of the intermediate water masses, which lead not only to hiatuses, but also to the widespread occurrence of reworked pelagic fossils of Miocene, Oligocene, Eocene and Late Cretaceous age. The upper Miocene and Pliocene nannofossil oozes consist almost entirely of discoasters; it is not yet clear whether this peculiar composition is the result of specialized algal floras in the oligotrophic central subtropical North Pacific surface-water masses, or the result of selective dissolution of the smaller coccoliths and (or) of mechanical separation of the biogenic sediment components.

Highlights of the Site 463 Coring Record

1. Recovery of Barremian to Quaternary sediments document a 118-m.y. history of the western Mid-Pacific Mountains, which once reached above the sea surface but have subsided to 2 to 3 km water depth.
2. Horizons with displaced shallow-water carbonate components interbedded with pelagic limestone of Barremian and early Aptian age document the presence of a shallow-water carbonate environment in the Mid-Pacific Mountains.
3. Penetration of a lower Aptian sequence of volcanic ashes, clays, and carbonaceous limestones which are in part intensely laminated, indicating a series of paleoceanographic events resulting in deep-sea sediments with high organic-carbon concentrations.
4. Recovery of volcanic ashes which date the Early Cretaceous eruptive events in the western Mid-Pacific Mountains.
5. Successful construction of an Early Cretaceous biostratigraphic framework.
6. Recovery of an expanded calcareous Upper Cretaceous sedimentary section with uniquely well-preserved foraminifer and nannofossil taphocoenoses.
7. Penetration of an unexpectedly thin, partly condensed, and incomplete Cenozoic section with horizons where calcareous fossil assemblages are severely affected by dissolution.
8. Correlation of the seismic reflectors to chalk, chert, and limestone interfaces by means of sediment physical properties. The absence of Cenozoic chert layers and the condensed and fragmentary Cenozoic record of Site 463 were unexpected.

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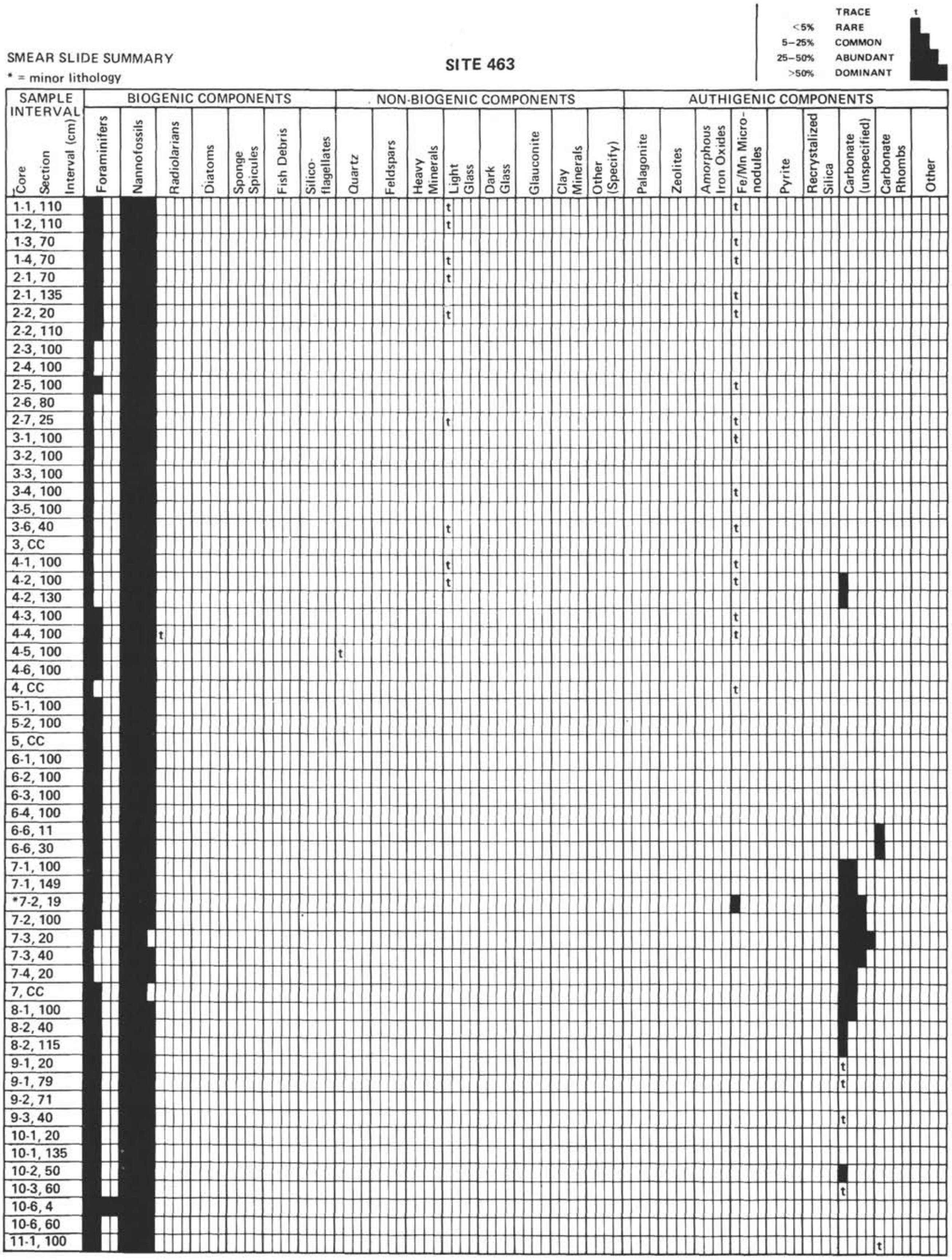
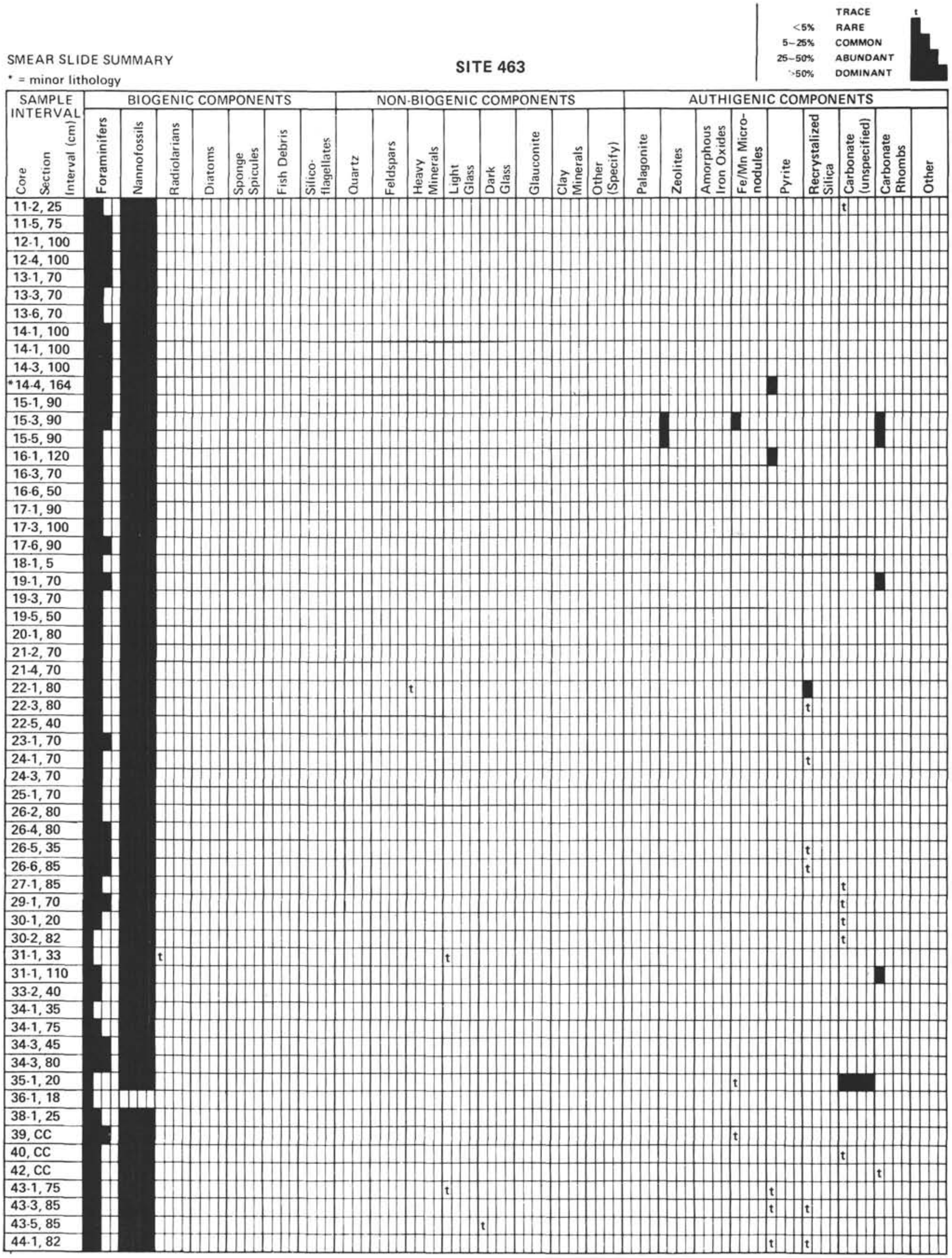
APPENDIX A
Smear-Slide Summary, Site 463



Appendix A. Continued.

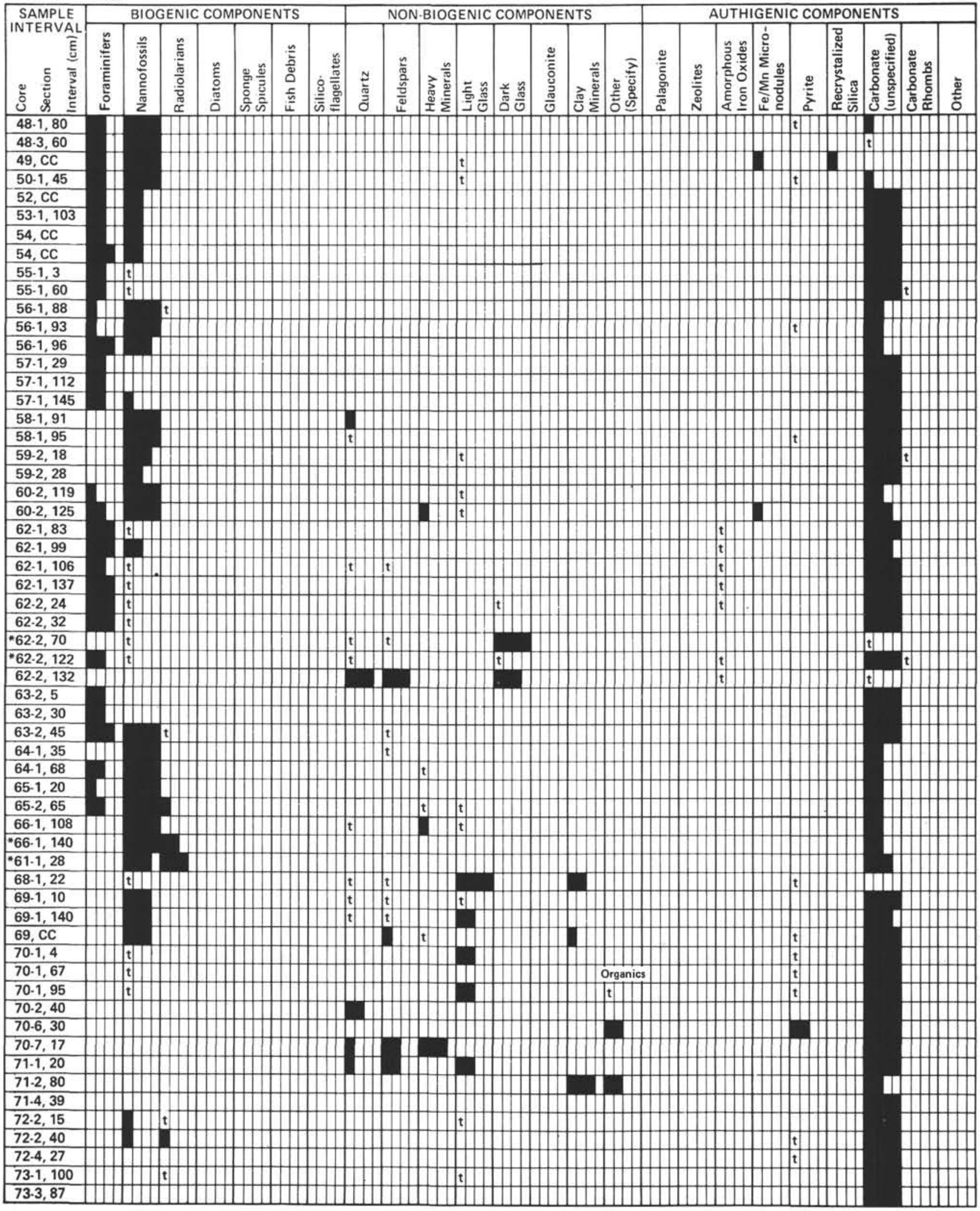


Appendix A. Continued.

SMEAR SLIDE SUMMARY
* = minor lithology

SITE 463

TRACE t
<5% RARE
5–25% COMMON
25–50% ABUNDANT
>50% DOMINANT



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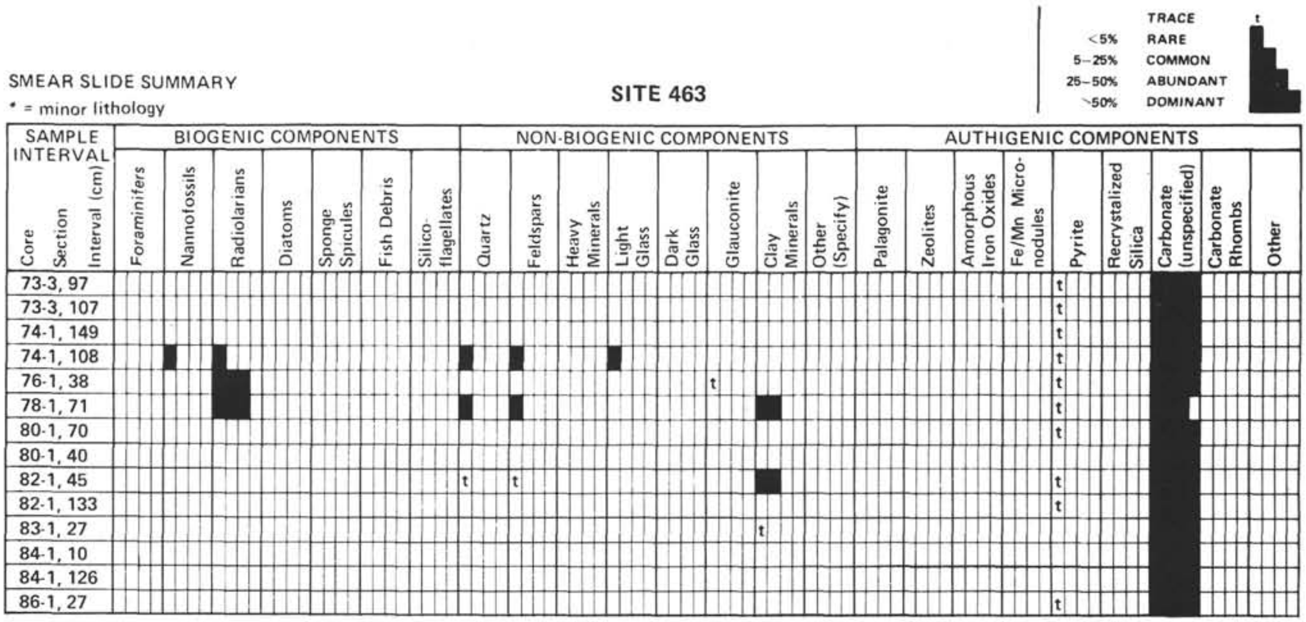
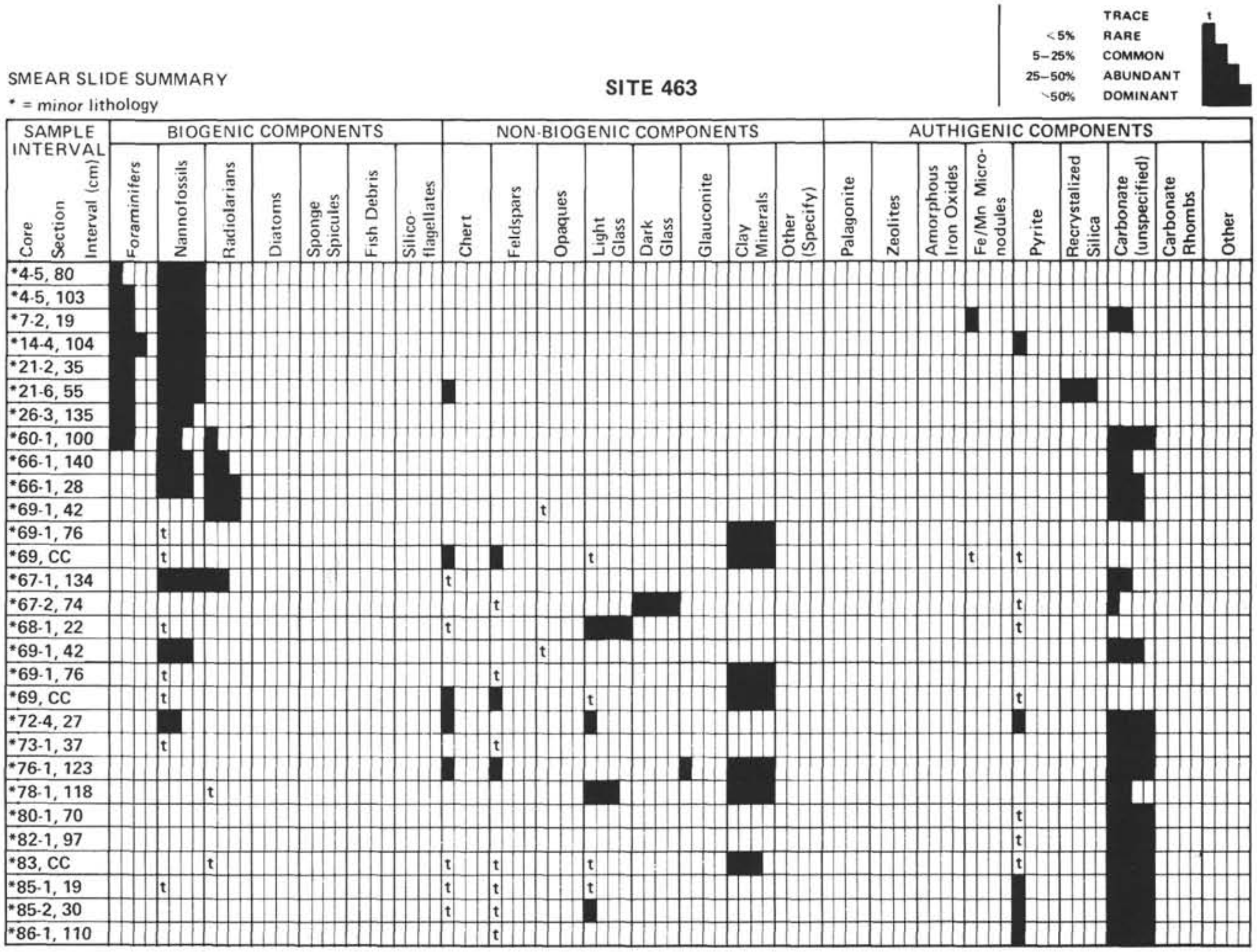




APPENDIX B
Coarse-Fraction Components, Site 463.

					Bulk Mineralogy (%)								Clay Mineralogy (%)				
Core	Section	Interval (cm)	Sample	Sub-bottom Depth (m)	Clay Minerals + Volcanic Glass	Quartz	Feldspar	Carbonates	Opal-CT	Pyrite	Clinoptil-olite	Others	Smectite	Illite	Chlorite	Kaolinite	Others
1	3	20–22	1	3.21	14.1	2.6	—	83.3	—	—	—	—	—	74.5	17.9	7.6	—
4	4	82–84	2	29.33	4.8	1.0	—	94.2	—	—	—	—	20	60.0	20[1]		—
7	3	90–92	3	47.41	5.1	—	—	94.9	—	—	—	—	17.1	77.7	5.2		Cpt
8	2	35–37	4	54.86	7.7	—	—	92.3	—	—	—	—	19.5	73.4	7.1		Cpt
9	2	46–48	5	64.47	5.8	—	—	94.2	—	—	—	—	—	100	—	—	Cpt
10	4	88–90	6	77.39	14.4	1	—	84.6	—	—	—	—	—	100	—	—	Cpt
12	4	56–58	7	96.07	6.4	—	—	93.6	—	—	—	—	—	100	—	—	Cpt
17	3	83–85	8	142.34	12.8	3.9	—	83.3	—	—	—	—	18.9	74.5	—	6.5	—
21	3	130–132	9	180.81	11.5	1.3	—	87.2	—	—	—	—	11.7	88.3	—	—	—
22	3	110–112	10	190.11	5.8	Tr.	—	94.2	—	—	—	—	22.6	77.4	—	—	—
24	3	61–63	11	203.12	7.8	—	—	92.2	—	—	—	—	36.0	64.0	—	—	—
26	3	124–126	12	218.75	9.8	0.5	—	89.7	—	—	—	—	18.4	81.6	—	—	—
30	1	106–108	13	253.57	9.1	0.5	—	90.4	—	—	—	—	15.4	82.5	0.3	1.7	—
34	3	70–72	14	294.21	7.7	—	—	92.3	—	—	—	—	26.4	68.7	4.8		—
38	1	31–33	15	328.82	7.9	1.1	—	91.0	—	—	—	—	2.9	87.0	1.4	8.7	—
43	3	45–46	16	379.45	5.3	0.5	—	94.2	—	—	—	—	6	83.7	5.2	5.1	—
48	3	50–52	17	427.01	10.3	7.6	—	82.1	—	—	—	—	11.1	77.8	11.1		—
50	1	36–38	18	433.37	8.5	5.6	—	85.9	—	—	—	—	18.1	75.1	6.7	—	—
55	1	100–101	19	481.50	9.7	8.2	—	82.1	—	—	—	—	7.7	92.3	—	—	—
57	1	81–82	20	500.21	13.6	8.2	—	78.2	—	—	—	—	100	—	—	—	—
58	3	7–8	21	512.07	17.8	10.4	—	71.8	—	—	—	—	58.3	41.7	—	—	—
61	1	107–108	22	536.57	16.8	7.8	—	65.4	—	—	—	—	100	—	—	—	—
62	2	15–20	23	539.17	24.1	9.1	4.0	62.8	—	—	—	—	100	—	—	—	—
66	2	84–86	24	577.85	9.4	8.5	—	82.1	—	—	—	—	35.3	64.7	—	—	—
67	2	108–109	25	587.58	19.1	36.0	—	44.9	—	—	—	—	10	87.8	2.2	—	—
69	1	145–146	26	605.45	92.4	—	3.0	—	—	4.6	—	—	100	—	—	—	—
70	1	96–97	27	614.46	68.0	15.6	—	3.8	8	1	4	—	33.4	66.6	—	—	—
70	6	40–41	28	621.40	56.0	22.2	—	3.8	11	7	—	—	—	—	—	—	—
70	7	25–26	29	622.75	57.0	3.9	—	32.0	—	—	7	—	100	—	—	—	—
71	3	100–121	30	627.20	52.8	5.2	~1	41.0	—	—	—	—	83.5	16.5	—	—	—
82	CC	0–1	31	727.30	19.0	34.1	—	26.9	—	—	—	—	100	—	—	—	—
84	2	46–47	32	738.96	6.6	12.6	—	80.8	—	—	—	—	—	—	—	—	—

APPENDIX C
Bulk Mineralogy and Clay Mineralogy, Site 463 (see Nagel and Schumann, this volume)

P: present
R: rare <5%
R-C: rare to common } 5–25%
C: common
C-A: common to abundant 25–50%
A: abundant 75%
VA: very abundant >90%
P: poor
M: moderate
G: good

Sample	Foraminifer Preservation	Coarse-Fraction Components																	Comments
		Planktonic Foraminifers		Benthic Foraminifers	Radiolarians	Sponge Spicules	Ostracodes	Mollusk Fragments	Echinoderm Fragments	Fish Fragments	Volcanic Glass	Quartz Grains	Mica	Pyrite	Carbonate Rhombs	Chalk Aggregates	Limestone	Chert Fragments	
		Whole	Fragments																
1-1, 7–9 cm	M	A	C	R		P			P	P									
1,CC	M	C-A	C-A	R															
2,CC	P	C	A	R						P									
3,CC	P	C	A	R				P	P										
4,CC	M	A	R-C	R			R												
5,CC	P	C-A	C-A	R	P	P	R		R	R									
6,CC	G	A	R	R					P										
7,CC	M	VA	R	R															
8,CC	M-G	VA	R	R					P										
9,CC	M	VA	R-C	R															
10,CC	M	VA	R-C	R					P			P							
11,CC	M	VA	R-C	R														R	
12,CC	M	A	R-C	R								R						R	
13,CC	M	VA	R-C	R														R	
14,CC	G	VA	R-C	R		P												R	
15,CC																			
16,CC	G	VA	R-C	R														R	
17,CC	G	VA	R-C	R														R	
18,CC																			
19,CC	G	VA	R-C	R															Lot of small sized
20,CC																			
21,CC	G	A	C	R														R	
22,CC	G	A	C	R															
23,CC	G	A	C	R		P	P	P										R	Lot of small sized
24,CC	G	A	C	R														R	
25,CC	G	A	C	R														R	
26,CC	G	A	C	R														R	
27,CC	G	A	C	R														R	
30,CC	P-M	A														R		R-C	
31,CC					R												VA		
33,CC	M	VA	C	R												R		P	
34,CC	M	VA	C	R												R		R	
35,CC	M	VA	C	R												R			
37,CC	P	VA	C	R												R		R	very small coarse fraction
38,CC	P	VA	C	R					P					P		R		R	
39,CC	M	A	C	R	R											R-C		P	
40,CC	P-M	C	R	R												C		R-C	very small coarse fract.
41,CC	P	C	R	R												C		R	
42,CC	P-M	C	R	R												A		R	
43,CC	M	C	R	R												C		R	
44,CC	M	C	R	R	A											R			
46,CC	M	C	R	R		P								P		C		A	
48,CC	M	A	R	R	P		P									C		C	
49,CC	M	A	R	R												R			very small coarse fraction
50,CC	M	C	R	R	C											R			
52,CC	M	R-C	R	R	A												R-C	R-C	
53,CC	P	R	R	R	A												R-C		
54,CC	P	R-C	R	R	A												R-C		
55,CC	VP	R															VA		
56,CC	P	R	R	R	A												R		
57,CC	P	R															VA		
58,CC	P	R		R	R-C												VA		
59,CC																	VA		
63,CC	P	R			A														
64,CC																	VA		
65,CC																	VA		
66,CC	P	P				P			P*	P							VA		*silicified
67,CC	P	R			A	R									R		C	R	
70,CC					C									R			A		
75,CC																	VA		

APPENDIX D

Physical-Property Measurements, Site 463 (see Fujii, this volume)

				Velocity (km/s)				GRAPE Wet-Bulk Density (g/cm^3)			Gravimetric					
Core	Sect.	Interval (cm)	Sub-bottom Depth (m)	Vert.	Horiz. H_1	H_2	Mean	(ϱ_g = 2.7)	Porosity (%)	Heat Conductivity (kcal/mh•°C)	W.C. (%)	Den. (g/cm^3)	Porosity (%)	Impedance (10^5 g/cm^2•s)	Remarks	Mean Wet-Bulk Density
1		#1)	0.0-5.5					#2)							#1) Averaged ± 5 cm	
															Nannofossil Ooze BRN (10YR 8/4)	
	2	75						1.66	62.2		37.52				(I-A: cores 1 to 6)	
	3	45						1.67	61.7						(I-A: cores 1 to 6)	
	4	40						1.65	62.8						(I-A: cores 1 to 6)	
2	1	75	5.5-15.0					1.66	62.2						(I-A: cores 1 to 6) (10YR 7/3 ~ 8/2)	
	2	75		—	1.50			1.52	70.4					2.28	(I-A: cores 1 to 6) (10YR 7/3 ~ 8/2)	
	3	75						1.51	71.0						(I-A: cores 1 to 6) (10YR 7/3 ~ 8/2)	
	4	75						1.54	69.3						(I-A: cores 1 to 6) (10YR 7/3 ~ 8/2)	
	6	75						1.55	68.8						(I-A: cores 1 to 6) (10YR 7/3 ~ 8/2)	
	7	20 – 23		—	1.55									2.40	(I-A: cores 1 to 6) (10YR 7/3 ~ 8/2)	
3	2	75	15.0-24.5					1.54	69.3						(I-A: cores 1 to 6) (10YR 7/3)	
	4	75						1.59	66.6						(I-A: cores 1 to 6) (10YR 7/3)	
	5	75						1.56	68.2						(I-A: cores 1 to 6) (10YR 7/3)	
	6														(incomplete data belt slipping)	
4	3	75	24.5-34.0					1.56	68.2						Nannofossil ooze (10YR 7/4 ~ 7/2)	
	6	75						1.74	57.3						Nannofossil ooze (10YR 7/4 ~ 7/2)	
5	1	75	34.0-38.0					1.69	60.6						Nannofossil ooze (10YR 7/4 ~ 7/2)	
		56-58									36.45					
6	2	10	38.0-43.5					1.70	60.0						Nannofossil ooze (10YR 7/4 ~ 7/2)	
		120-122						#2)			33.25				#)2) Analog GRAPE data	
7	1		43.5-53.0												Cores 7 to 48	
		121-126									30.45				Foraminifer Nannofossil Chalk	
															(10YR 7/3) and	
	2	30, 75, 120$^{(\#3)}$						1.76	56.1						Nannofossil Foraminifer Chalk	
															(I-B: cores 7 to 51)	
	3	30, 75, 120		(10)	1.60			1.75	56.9					2.80	Nannofossil Foraminifer Chalk	
		124-126		(106)	1.68						35.30			2.94	(I-B: cores 7 to 51)	
8	1	30, 75, 120	53.0-62.5					1.33	81.8						Nannofossil Foraminifer Chalk	
															(I-B: cores 7 to 51)	
	2	30, 75, 120						2.07	37.4						Nannofossil Foraminifer Chalk	
															(I-B: cores 7 to 51)	
		119-121			5.34(?)					2.59	0.55	2.57	1.38	13.72	(Chert nodule)	
	3	25, 50						1.60	65.9						(10YR 7/3)	
		26-27									37.73					
9	1	35, 70, 120	62.5-72.0					1.73	57.9						(Chert nodule)	
	2	30, 75, 122						1.71	58.1						(Chert nodule)	
		36-38									35.01					
	3	30, 80, 90						1.81	53.3						(Chert nodule)	
10	1	100-102	72.0-81.5								35.96				(Chert nodule)	
	2	77-80			2.45(?)					2.51	17.94	1.99	34.91	4.88	(Chert nodule)	
10	4	30, 75, 120						1.76	56.1						Foraminifer Nannofossil Chalk	
															(10YR 7/3) and	
	5	30, 75, 120						1.70	59.9						Nannofossil Foraminifer Chalk	
	6	30, 75, 120						1.76	56.4						Nannofossil Foraminifer Chalk	
11	1	88-90	81.5-91.0							2.73	33.35	1.76	57.2		(Nannofossil Chalk)	
	5	25, 50						1.71	59.0						(Nannofossil Chalk)	
12	1	16-17	91.0-100.5								33.67					
	2	30, 75, 120						1.81	53.3						(Nannofossil Chalk)	
	3	30, 75, 120						1.83	51.8						(Nannofossil Chalk)	
	4	30, 75, 120						1.80	53.9						(Nannofossil Chalk)	
	5	30, 75, 120						1.78	55.0						(Nannofossil Chalk)	
13	2	94-95	100.5-110.0								34.66				Foraminifer-Nannofossil Chalk	
	5	30, 75, 120						1.97	43.5						Foraminifer-Nannofossil Chalk	
14	1	30, 75, 120	110.0-119.5					1.83	52.2						Foraminifer-Nannofossil Chalk	
		102-104								2.74	34.09	1.75	58.1		(Foraminifer-Nannofossil Chalk)	
	3	30, 75, 120						1.78	54.9						(Foraminifer-Nannofossil Chalk)	
15	1	30, 75, 120	119.5-129.0					1.76	55.9						Foraminifer-Nannofossil Chalk	
		78-80								2.76	37.08	1.75	58.2		(10YR 8/1)	
	3	30, 75, 120						1.80	53.7						(lighter than 10YR 8/1)	
	5	30, 75, 120						1.80	54.0						(lighter than 10YR 8/1)	
16	2	30, 75, 120	129.0-138.5					1.80	53.8						(with chert chips)	
	4	30, 75, 120						1.80	53.5						(with chert chips)	
	6	30, 75, 120						1.82	52.6						(with chert chips)	

Appendix D. Continued.

				Velocity (km/s)				GRAPE Wet-Bulk Density (g/cm^3)			Gravimetric					
					Horiz.											
Core	Sect.	Interval (cm)	Sub-bottom Depth (m)	Vert.	H_1	H_2	Mean	(ϱ_g = 2.7)	Porosity (%)	Heat Conductivity (kcal/mh·°C)	W.C. (%)	Den. (g/cm^3)	Porosity (%)	Impedance (10^5 g/cm^2·s)	Remarks	Mean Wet-Bulk Density
17	1	45–47	138.5–148.0		5.23(?)										Chert nodule	
	2	30, 75, 120						1.87	49.5						Foraminifer-Nannofossil Chalk	
	4	30, 75, 120						1.82	52.8						(disturbed with chalk pieces)	
	6	30, 75, 120						1.87	49.8						Foraminifer-Nannofossil Ooze	
19	1	60–62	157.5–167.0								24.95				Foraminifer-Nannofossil Chalk	
	2	30, 75, 120						1.82	52.7						Foraminifer-Nannofossil Chalk	
	4	30, 75, 120						1.84	51.6						Foraminifer-Nannofossil Chalk	
	6	30, 75, 120						1.80	53.8						(with chert chips)	
20	1	70, 90, 110	167.0–176.5					2.02	40.6						(with chert chips)	
		80–82									31.60				(with chert chips)	
21	1	53–55	176.5–186.0								30.69				(with chert chips)	
	2	30, 75, 120						1.84	51.4						(chert chips)	
	4	30, 75, 120						1.84	51.3						(chert chips)	
	6	30, 75, 120						1.90	41.5						(chert chips)	
22	1	55–51	186.0–195.5								30.48				Foraminifer-Nannofossil	
	2	30, 75, 120						1.87	49.8						(chalk and chert)	
	4	30, 75, 110						1.85	51.0						(Ooze and chalk)	
23	1	35, 80, 115	195.5–199.5					1.82	52.4						(Ooze and chalk)	
24	1	30, 75, 120	199.5–205.0					1.92	46.8						(Ooze and chalk)	
		66–68									26.02				(Ooze and chalk)	
	3	40,80						1.88	48.7						(Ooze and chalk)	
25	2	40, 80	205.0–214.5					1.81	53.0						Foraminifer-Nannofossil Chalk	
26	1	58–61	214.5–224.0	(1.69)	1.69			(1.85)						3.13	Foraminifer-Nannofossil Chalk	
		110–112									34.20					
	3	30, 75, 120						1.85	51.0						(some chert frag.)	
	6	30, 75, 120						1.85	51.0						(firm and soupy)	
	5	46–48		1.71	1.74		1.73			2.74	33.32	1.76	57.2	3.06	Foraminifer-Nannofossil Chalk	
															(Firm) (Minicore)	
	5	50–52		1.72	1.73		1.73								Foraminifer-Nannofossil Chalk	
															(Firm) (split core)	
27	1	50, 90, 130	224.0–233.5					1.80	54.1						Foraminifer-Nannofossil Chalk	
															(Firm) (Pink 7.5YR 8/4)	
		108–109									33.13					
		140–142		1.91	1.78		1.85			2.74	32.18	1.78	55.9	3.40		
	CC	—			5.30(?)										Chert nodule	
29	1	40	243.0–252.5					1.86	50.5						(5YR 7/1)	
		34–36		1.79	1.81		1.80	(1.84)						3.29	(firm Chalk)	
		52–54								2.75	30.17	1.82	53.7		(firm Chalk)	
30	1	30, 75, 120	252.5–262.0					1.94	45.6						Limestone and Chalk	
		130–132									23.79					
	2	30, 75, 120						1.93	46.1						Nannofossil Chalk and Limestone	
		87–89		2.14	2.21		2.18			2.70	22.61	1.97	43.5	4.22	Chalk (light grey green)	
	CC	—		2.51	2.60(?)					2.48	17.50	1.99	33.9	4.99	Limestone (white)	
31	1	4–6	262.0–271.5							2.75	26.72	1.90	49.5			
33	1	30, 75, 120	281.0–290.5					2.00	41.5							
		107–109									29.73					
		137–139		2.06	2.17(?)		2.12	(2.00)						4.12	(firm Chalk)	
33	2	30, 75, 120						1.81	53.0							
34	1	108–110	290.5–300.0								29.37					
		70–72		1.91	2.00		1.96	(1.81)						3.46	Foraminifer-Nannofossil Chalk	
	2	20, 75, 120						1.90	47.8							
		142–144		2.10	2.02		2.06	(1.90)						3.99	Foraminifer-Nannofossil Chalk	
	3	35, 65						1.82	52.3						(grey stripe Vel to H)	
35	CC	17–18	300.0–309.5							2.68	30.26	1.80	53.2			
38	1	40–42	328.5–338.0							2.69	26.08	1.89	48.1			
43	1	30, 75, 120	376.0–385.5					1.93	46.0							
	3	20, 50, 80						1.95	44.6							
	5	25, 50						1.75	57.0							
48	1	119–121	423.5–427.5								23.85					
	2	30, 75, 120						1.96	44.1							
	3	25, 60, 85						2.05	39.1							
53	1	121–123	460.5–471.0	2.365	2.32	2.37	2.35	2.15	32.65	2.70	17.01	2.11	35.07	5.04	Green Limestone	(2.13)
	CC			5.77(?)	5.59	—	5.68	2.64	0.37	2.67	1.56	2.60	4.02	15.12	Chert (pale brown)	(2.62)

Appendix D. Continued.

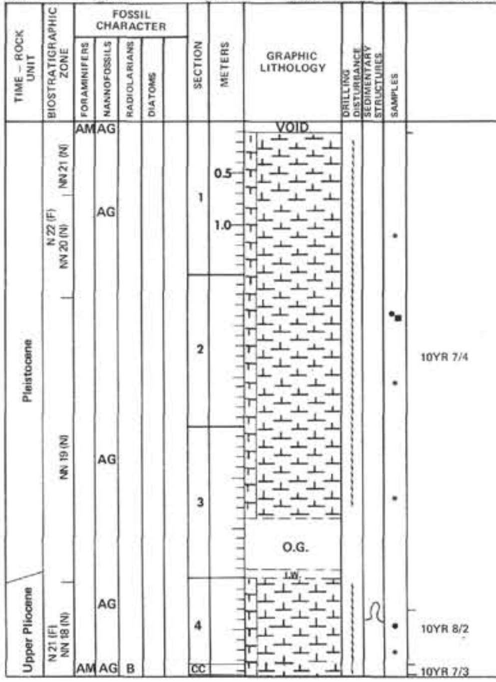
				Velocity (km/s)				GRAPE Wet-Bulk Density (g/cm^3)			Gravimetric					
					Horiz.											
Core	Sect.	Interval (cm)	Sub-bottom Depth (m)	Vert.	H_1	H_2	Mean	(ϱ_g = 2.7)	Porosity (%)	Heat Conductivity (kcal/mh·°C)	W.C. (%)	Den. (g/cm^3)	Porosity (%)	Impedance (10^5 g/cm^2·s)	Remarks	Mean Wet-Bulk Density
54	CC		471–480.5	2.54(?)	2.55	2.53	2.54	2.11	35.24	2.73	18.69	2.08	37.96	5.32	Limestone (white)	(2.10)
				5.52(?)	5.61		5.57	2.60	2.86	2.67	1.94	2.59	4.89	14.32	Chert (pale brown)	(2.60)
55	1	19–21	480.5–490	2.40	2.42	2.43	2.42	2.17	31.55	2.70	15.23	2.16	32.16	5.20	Limestone (Green)	(2.17)
		79–81		4.93(?)	5.3	—	5.15	2.45	12.05	2.61	2.97	2.50	7.23	12.20	Chert (Gray)	(2.48)
56	1	93–95	490–499.5		2.56			2.24	27.33	2.70	14.62	2.18	31.12	5.66	Limestone (Gray)	(2.21)
57	1	86–88	499.5–509	3.56	3.70	3.73	3.66	2.48	13.12	2.73	7.91	2.41	18.60	8.70	Limestone (brown)	(2.46)
	2	2–4		2.53	2.56	2.60	2.56	2.14	33.59	2.69	15.88	2.14	33.10	5.41	Limestone (Gray)	(2.14)
58	1	40–42	509.0–518.5	3.66	3.77	3.81	3.75	2.45	15.08	2.72	8.19	2.40	19.17	8.88	Limestone (pale-brown)	(2.43)
	2	53–55		3.41	3.44	3.59	3.48	2.39	18.70	2.73	9.85	2.35	22.57	8.08	Limestone (light Gray)	(2.37)
	3	29–31		3.09	3.42	3.44	3.32	2.39	18.74	2.74	8.77	2.39	20.48	7.39	Limestone (Green and plate brown)	(2.39)
	CC	(5)		3.77	3.97	3.95	3.90	2.51	11.63	2.72	5.01	2.51	12.27	9.46	Limestone (pale brown)	(2.51)
59	1	65–68	518.5–528	3.62	3.75			2.41	17.47	2.73	8.77	2.39	20.42	8.69	Limestone (White)	(2.40)
	3	89–91		3.08	3.33			2.36	20.05	2.72	8.51	2.39	19.82	7.32	Limestone (pale brown)	(2.38)
60	2	61–63	528–535.5	3.25	3.40			2.32	22.80	2.70	10.69	2.30	24.00	7.51	Limestone (pale brown)	(2.31)
	4	67–69		2.91	3.19			2.38	19.13	2.71	9.12	2.36	20.98	6.90	Limestone (dark brown)	(2.37)
61	1	48–50	535.5–537.5	4.07	4.45			2.53	10.16	2.69	6.16	2.45	14.73	10.13	Limestone (brown)	(2.49)
62	1	15–17	537.5–547	2.64	2.85			2.33	21.95	2.65	11.11	2.26	24.46	6.08	Limestone (Grey) (coarse grain)	(2.30)
	3	95–97		3.23	3.48			2.39	18.82	2.67	4.26	2.82	21.01	7.61	Limestone (pale brown-Gray)	(2.36)
63	1	9–11	547–556.5	3.37	3.61	3.51	3.50	2.35	21.03	2.67	10.06	2.30	22.58	7.84	Limestone (pale brown and Pink)	(2.33)
	2	117–119		3.28	3.51	3.42	3.40	2.34	21.58	2.70	11.39	2.27	25.29	7.56	Limestone (white)	(2.31)
64	1	35–37	556.5–566	2.98	3.23	3.25	3.15	2.26	26.35	2.71	14.20	2.20	30.48	6.65	Limestone (white)	(2.23)
	2	110–112		3.31	3.44	3.42	3.39	2.40	17.78	2.74	9.82	2.35	22.53	7.86	Limestone (brown)	(2.38)
65	1	64–66	566–575.5	3.23	3.44	3.39	3.35	2.31	23.27	2.74	11.14	2.31	25.11	7.46	Limestone (pale brown to pink)	(2.31)
	2	40–42		3.46	3.81	3.69	3.65	2.40	18.19	2.71	9.67	2.34	22.06	8.20	Limestone (pale brown)	(2.37)
66	1	57–59	575.5–585	3.06	3.35	3.30	3.24	2.32	22.81	2.71	12.12	2.26	26.74	7.01	Limestone (white to gray)	(2.29)
	2	20–21	585–594.5	3.04	3.44	3.21	3.23	2.32	22.45	2.71	13.45	2.22	29.15	6.90	Limestone (Gray)	(2.27)
67	1	69–71	585–594.5	3.24	3.49	3.47	3.40	2.43	16.38	2.72	9.84	2.34	22.48	7.73	Limestone (Gray)	(2.39)
	2	21–23		3.12	3.33	3.36	3.29	2.34	21.65	2.71	12.04	2.26	26.60	7.18	Limestone (Gray)	(2.30)
69	2	25–26	607–613.5	2.15	2.62			2.14	33.17	2.69	15.10	2.16	31.85	5.27	Limestone	(2.15)
		98–100		2.27	2.43			2.20	29.65	2.73	14.26	2.21	30.71	5.01	Limestone (Gray-Green)	(2.21)
70	1	59–61	613.5–623	3.42	3.58			2.19	30.42	2.55	11.02	2.19	23.56	7.49	Limestone (Gray) Black inclusion	(2.19)
	4	66–68		2.53	3.00			2.23	28.00	2.83	18.39	2.14	38.37	5.53	Limestone (Gray)	(2.19)
	5	113–115		2.67	2.68					2.39	15.40	1.98	29.84	5.29	Limestone (Black)	(1.98)
71	1	21–23	623–632.5	2.24	2.45			1.95	44.89	2.51	22.23	1.90	41.14	4.31	Limestone (Green)	(1.93)
71	2	121–123	623–632.5	2.93	3.38	3.36	3.22	2.34	21.64	2.70	11.77	2.26	25.99	6.34	Limestone (white) Coarse grain	(2.30)
72	2	102–104	632.5–642	2.98	3.12			2.09	36.47	1.79(?)	13.90	1.62	21.96	6.23	Limestone (Gray)	(2.09)
	3	30–32		2.92	3.06			2.09	36.72	2.52	13.61	2.10	27.92	6.12	Limestone (Gray)	(2.10)
73	1	8–10	642–651.5	3.56	3.78			2.40	17.91	2.65	8.00	2.35	18.35	8.46	Limestone (light Gray)	(2.38)
	2	103–105		3.01	3.18			2.11	35.49	2.49	13.30	2.09	27.32	6.32	Limestone (Gray)	(2.10)
74	1	76–78	651.5–661.0	2.56	2.76			1.99	42.72	2.47	16.75	2.00	32.69	5.11	Limestone (Green)	(2.00)
76	1	41–43	670.5–680	3.40	3.55			2.34	21.52	2.62	10.66	2.25	23.41	11.80	Limestone (White, black inclusion)	(2.30)
	1	123–125		2.33	2.30			2.09	36.58	2.53	18.64	1.99	36.13	4.75	Limestone (Gray)	(2.04)
77	1	30–32	680–689.5	3.16	3.29			2.35	20.74	2.63	9.70	2.28	21.61	7.32	Limestone (White, black strips)	(2.32)
78	1	44–46	689.5–699	3.55	3.58			2.34	21.40	2.69	10.16	2.31	22.92	8.25	Limestone (White, black strips)	(2.33)
79	1	42–44	699–6708.5	4.61	4.63			2.58	6.94	2.68	4.66	2.49	11.35	11.69	Limestone (White)	(2.54)
80	1	36–38	708.5–710.5	3.93	4.17			2.57	7.75	2.72	4.24	2.54	10.50	10.04	(Coral Reef Sed) (Pebbly)	(2.56)
81	1	76–78	710.5–718.0	3.97	4.05			2.65	3.26	2.71	3.79	2.55	9.43	10.32	(Coral Reef Sed.) Pebbly Limestone	(2.60)
82	1	31–33	718.0–721.5	3.12	3.43			2.36	20.23	2.68	10.48	2.29	23.45	7.25	Limestone (Gray)	(2.33)
83	1	66–68	721.5–737.0	2.75	2.74			2.20	29.64	2.66	14.32	2.16	30.26	6.00	Limestone (White)	(2.18)
	2	30–32		3.80	4.19			2.43	15.87	2.88	7.68	2.53	18.97	9.42	Limestone (White and Gray Stripe)	(2.48)
84	1	28–30	737.0–746.5	4.02	4.20			2.48	18.05	2.90	6.24	2.60	15.83	10.21	Limestone (Pebbly)	(2.54)
	1	114–116		3.46	3.67			2.38	19.28	2.88	8.66	2.49	21.06	8.43	Limestone (light Gray)	(2.44)
85	1	43–45	746.5–756.0	3.24	3.68			2.26	26.42	2.70	8.45	2.37	19.54	7.50	Limestone (Gray)	(2.32)
	2	62–64		4.29	4.59			2.57	7.62	2.71	5.61	2.48	13.56	0.3	Limestone (Pebbly)	(2.53)
86	1	6–8	756.0–765.5	4.53	4.87			2.58	7.12	2.68	5.08	2.48	12.28	11.46	Limestone (White)	(2.53)
88	1	82–84	775.0–784.5	3.93	4.20			2.56	8.10	2.69	6.07	2.45	14.53	9.84	Limestone (Pebbly)	(2.51)
89	1	38–40	784.5–794.0	3.52	3.58			2.45	14.70	2.72	8.48	2.39	19.75	8.52	Limestone (Gray)	(2.42)
	1	96–98		3.78	3.92			2.46	14.53	2.36	8.04	2.12	17.85	9.30	Limestone (Gray, Coarse Grain)	(2.46)

Note: (?) = measurement of direction is questionable.

APPENDIX E
Grain-Size Analysis, Site 463

Hole	Core	Section	Interval (cm)	Sub-bottom Depth (m)	Sand (%)	Silt (%)	Clay (%)	Classification
463	1	2	28.0	1.78	10.8	25.3	64.0	Silty clay
463	1	4	28.0	4.78	12.5	33.7	53.8	Silty clay
463	2	2	60.0	7.60	8.3	25.5	66.2	Silty clay
463	2	4	60.0	10.60	5.7	34.7	59.6	Silty clay
463	3	2	58.0	17.08	2.4	40.1	57.5	Silty clay
463	3	4	58.0	20.08	2.1	35.1	62.8	Silty clay
463	4	2	58.0	26.58	1.5	56.3	42.2	Clayey silt
463	4	4	58.0	29.58	39.3	44.9	15.8	Sandy silt
463	5	2	54.0	36.04	0.5	57.5	41.9	Clayey silt
463	6	2	42.0	39.92	1.0	55.2	43.8	Clayey silt
463	6	4	42.0	42.92	1.1	55.7	43.2	Clayey silt
463	7	2	60.0	45.60	2.4	59.7	38.0	Clayey silt
463	7	3	110.0	47.60	5.4	45.8	48.8	Silty clay
463	10	3	70.0	75.70	18.1	35.7	46.2	Silty clay
463	10	5	70.0	78.70	12.1	45.4	42.5	Clayey silt
463	12	4	40.0	95.90	12.8	39.7	47.5	Silty clay
463	13	2	58.0	102.58	13.7	41.8	44.5	Silty clay
463	14	4	40.0	114.90	15.1	44.3	40.6	Clayey silt
463	15	2	67.0	121.67	6.7	45.5	47.8	Silty clay
463	15	4	67.0	124.67	7.1	43.3	49.6	Silty clay
463	16	2	54.0	131.04	3.9	48.9	47.2	Clayey silt
463	16	6	54.0	137.04	13.8	44.7	41.5	Clayey silt
463	17	2	103.0	141.03	27.8	30.9	41.2	Sand-silt-clay
463	17	4	103.0	144.03	7.8	39.0	53.2	Silty clay
463	19	2	118.0	160.18	6.1	46.3	47.6	Silty clay
463	19	4	60.0	162.60	7.4	45.9	46.7	Silty clay
463	20	1	68.0	167.68	1.8	41.4	56.9	Silty clay
463	21	2	109.0	179.09	6.4	38.3	55.2	Silty clay
463	21	4	107.0	182.07	2.8	43.8	53.4	Silty clay
463	22	2	40.0	187.90	2.7	34.5	62.8	Silty clay
463	22	4	57.0	191.07	1.8	37.4	60.8	Silty clay
463	23	1	25.0	195.75	2.7	47.6	49.7	Silty clay
463	24	2	116.0	202.16	1.0	36.0	63.1	Silty clay
463	25	2	40.0	206.90	5.5	53.0	41.5	Clayey silt
463	26	2	87.0	216.87	8.0	56.1	35.9	Clayey silt
463	26	4	92.0	219.92	7.7	56.5	35.8	Clayey silt
463	27	2	24.0	225.74	17.8	47.9	34.3	Clayey silt
463	29	1	52.0	243.52	9.4	50.5	40.1	Clayey silt
463	30	1	66.0	253.16	11.0	28.1	60.9	Silty clay
463	34	2	42.0	292.42	6.2	56.7	37.1	Clayey silt
463	35	CC	14.0	300.44	5.2	37.6	57.2	Silty clay
463	38	1	10.0	328.60	1.2	42.7	56.1	Silty clay
463	43	2	40.0	377.90	1.8	21.4	76.8	Clay
463	43	4	40.0	380.90	1.5	26.1	72.4	Silty clay
463	48	2	100.0	426.00	4.7	23.2	72.1	Silty clay
463	55	1	92.0	481.42	10.8	39.3	49.8	Silty clay

SITE 463 HOLE CORE 1 CORED INTERVAL 0.0 to 5.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

A highly disturbed ooze, very pale brown (10YR 7/4) in color in Sections 1 through 3 with mottles of very pale brown (10YR 8/4) at 62 cm, 93 cm, 196 cm, 214 cm, 262 cm, 315 cm, 322 cm, 353 cm, 365 cm. A layer of very pale brown ooze is present between 380 and 385 cm. Section 4 shows a disturbed contact with white (10YR 8/2) ooze below. A mottle of very pale brown ooze (10YR 7/4) is at 504 cm. The Core-Catcher is very pale brown (10YR 7/3) in color.

SMEAR SLIDE SUMMARY %

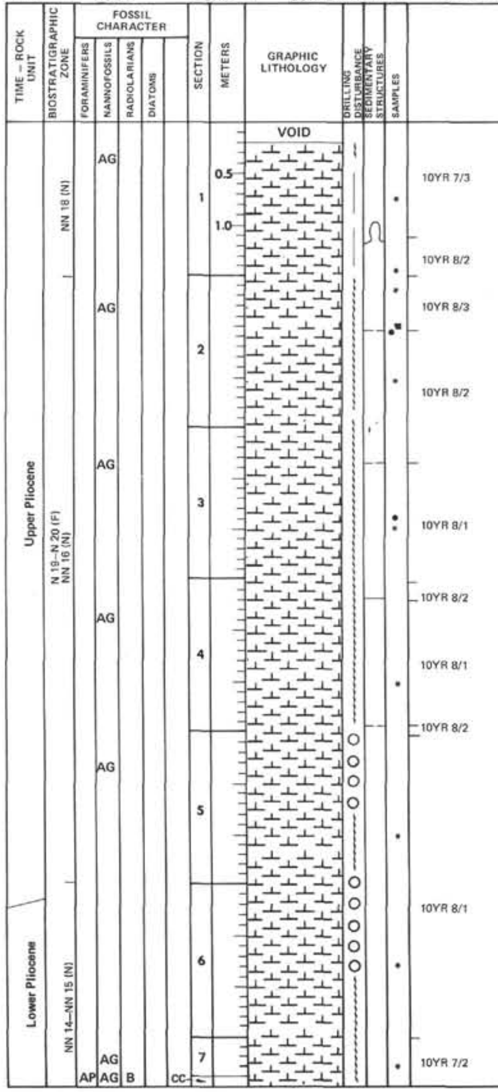
	1-110	2-110	3-70	4-70
Mica	Tr	—	—	—
Volcanic glass	Tr	Tr	—	Tr
Micronodules	Tr	—	Tr	Tr
Foraminifers	7	5	8	7
Calc. nannofossils	93	95	92	93

Silica and Iron Content: 2-41
SiO_2 = 13%
Fe = 0.81%

Carbonate Content: *2-44 = 80%
*4-44 = 87%

Information on core description sheets, for ALL sites, represents field notes taken aboard ship under time pressure. Some of this information has been refined in accord with post-cruise findings, but production schedules prohibit definitive correlation of these sheets with subsequent findings. Thus the reader should be alerted to the occasional ambiguity or descrepancy.

SITE 463 HOLE CORE 2 CORED INTERVAL 5.5 to 15.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Highly disturbed to soupy, generally very pale brown (10YR 7/3, 10YR 8/3) white (10YR 8/1, 10YR 8/2), and light gray (10YR 7/2) in color. The percentage discoasters increases downcore from 30% of the nannofossils in Sections 1 and 2, to 80-90% in Sections 3 to 7. Mottles of the same colors as indicated above occur at: 72 cm, 82 cm, 155 cm, 161 cm, 185 cm, and 214 cm.

SMEAR SLIDE SUMMARY %

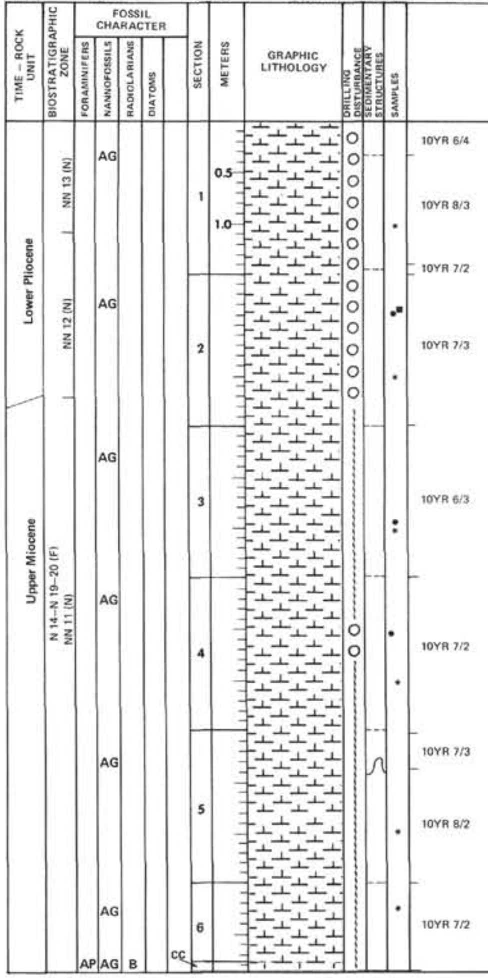
	1-70	1-135	2-20	2-100	3-100
Mica	Tr	—	—	Tr	—
Volcanic glass	Tr	—	Tr	—	—
Micronodules	—	Tr	Tr	—	—
Foraminifers	8	1	7	1	3
Nannofossils	92	99	93	99	97

	4-100	5-100	6-80	7-25
Mica	—	—	—	—
Volcanic glass	—	—	—	Tr
Micronodules	—	—	Tr	Tr
Foraminifers	1	5	1	1
Nannofossils	99	95	99	99

Silica and Iron Content: 2-50
SiO_2 = 4.0%
Fe = 0.35%

Carbonate Content: *2-54 = 92%
3-85 = 89%

SITE 463 HOLE CORE 3 CORED INTERVAL 15.0 to 24.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Soupy to very highly disturbed, yellowish brown (10YR 6/4) to very pale brown (10YR 8/3, 10YR 7/3) to pale brown (10YR 6/3) to white (10YR 8/2) in color. Discoasters are about 95-98% of the nannofossils. No mottles or structures.

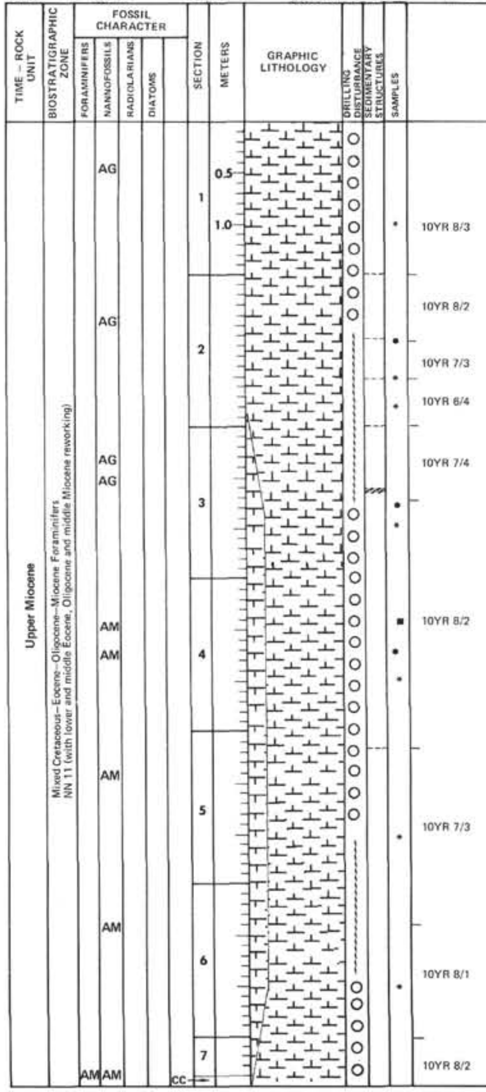
SMEAR SLIDE SUMMARY %

	1-100	2-100	3-100	4-100	5-100	6-40	CC
Volcanic glass	—	—	—	—	—	Tr	—
Micronodules	Tr	—	—	Tr	—	Tr	—
Foraminifers	1	2	1	2	1	1	1
Nannofossils	99	98	99	98	99	99	99
Radiolarians	—	—	—	—	—	Tr	—

Silica and Iron Content: 2-36
SiO_2 = 5.7%
Fe = 0.70%

Carbonate Content: *2-42 = 92%
3-89 = 79%
*4-42 = 92%

SITE 463 HOLE CORE 4 CORED INTERVAL 24.5 to 34.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE–FORAMINIFER NANNOFOSSIL OOZE

Soupy to very disturbed ooze, very pale brown (10YR 8/3, 10YR 7/3, 10YR 7/4) to white (10YR 8/2, 10YR 8/1) to light yellowish brown (10YR 6/4) in color. Mottles and burrows of similar lithology and color occur at 272 cm, 355-370 cm, 680-682 cm, 788 cm, 810 cm, 855 cm, and 930-940 cm. Discoasters remain at about 95-98% of the nannofossils in the first three sections, then decrease to 35-60% in the lower part of the core. Sections 1, 2, and Core-Catcher are nannofossil ooze, and Sections 3, 4, 5, and 6 are dominantly foraminiferal nannofossil ooze.

SMEAR SLIDE SUMMARY %

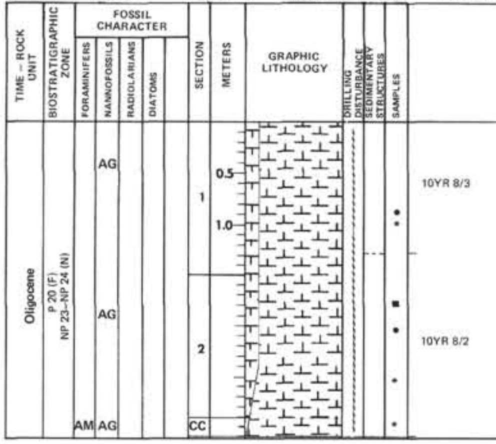
	1-100	2-100	2-130	3-100
Volcanic glass	—	Tr	—	—
Micronodules	Tr	Tr	—	Tr
Carbonate unsp.	Tr	1	1	—
Foraminifers	1	3	1	15
Nannofossils	99	96	98	85
Radiolarians	—	—	—	—
Quartz	—	—	—	—

	4-100	5-100	6-100	CC
Volcanic glass	—	—	—	—
Micronodules	Tr	—	—	1
Carbonate unsp.	—	—	—	—
Foraminifers	15	15	20	1
Nannofossils	85	85	80	98
Radiolarians	Tr	—	—	—
Quartz	—	Tr	—	—

Silica and Iron Content: 4-36
SiO_2 = 2.0%
Fe = 0.08%

Carbonate Content: *2-66 = 92%
3-73 = 88%
*4-65 = 95%

SITE 463 HOLE CORE 5 CORED INTERVAL 34.0 to 38.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE

Highly disturbed very pale brown (10YR 8/3) to white (10YR 8/2) ooze. Occasional white (10YR 8/1 and lighter) streaks and mottles at 60 cm, 87 cm, and 123 cm. Contamination by the pressure core barrel occurs at the top and bottom of the core (0-35 cm, and 275-285 cm). Discoasters are less abundant than in the preceding cores, about 30% of the nannofossils.

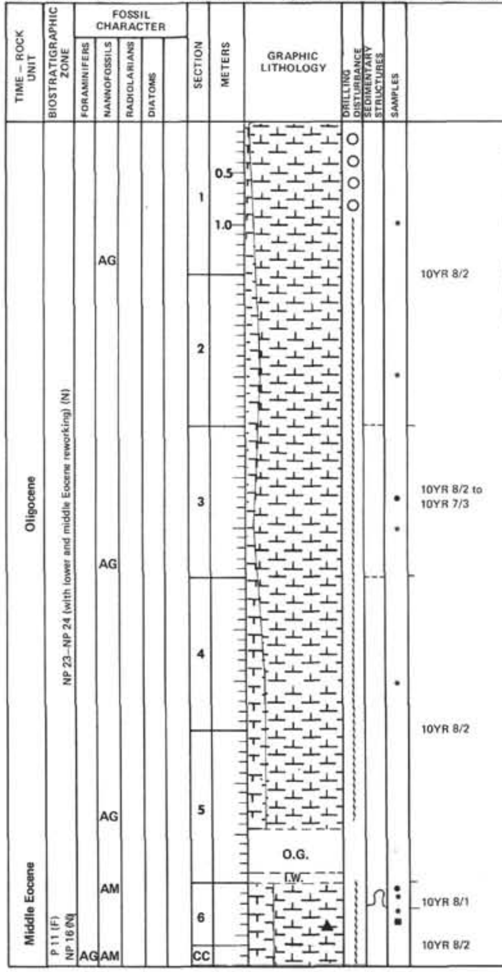
SMEAR SLIDE SUMMARY %

	1-100	2-100	CC
Foraminifers	7	9	3
Nannofossils	93	91	97

Silica and Iron Content: 2-28
SiO_2 = 1.0%
Fe = 0.04%

Carbonate Content: 1-83 = 89%
*2-50 = 97%

SITE 463 HOLE CORE 6 CORED INTERVAL 38.0 to 43.5 m



LITHOLOGIC DESCRIPTION

FORAMINIFER NANNOFOSSIL OOZE

Soupy to highly disturbed uniform ooze, white (10YR 8/2, 10YR 8/1) to very pale brown (10YR 7/3) in.color. Streaks of white (10YR 8/1 and lighter) are found at 58 cm, 110 cm, 340-370 cm, and 405-410 cm. A small piece of chert is at 790 cm.

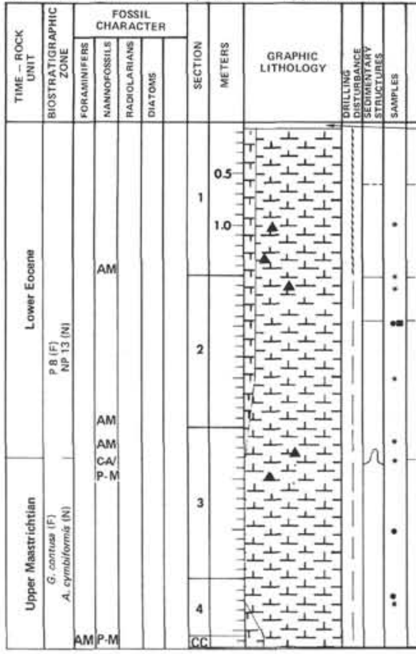
SMEAR SLIDE SUMMARY %

	1-100	2-100	3-100	4-100	6-11	6-30
Calc. rhombs	—	—	—	—	2	1
Foraminifers	10	15	10	15	20	20
Nannofossils	90	85	90	85	78	79

Silica and Iron Content: 6-38
SiO_2 = 1%
Fe = 0.04%

Carbonate Content: 3-70 = 96%
*6-4 = 97%

SITE 463 HOLE CORE 7 CORED INTERVAL 43.5 to 53.0 m



LITHOLOGIC DESCRIPTION

VOID
10YR 7/3
10YR 8/2
10YR 7/3
10YR 8/2
Lighter than
10YR 8/1

NANNOFOSSIL OOZE AND CHALK–FORAMINIFER NANNOFOSSIL OOZE

Highly to moderately disturbed, very pale brown (10YR 7/3) to white (10YR 8/2, 10YR 8/1) in color. Chert fragments are found at 102 cm (grayish brown, 10YR 5/2) 137 cm, 162 cm (gray), and red (10R 4/6) at 334 and 348 cm. Mottles and streaks, gray (10YR 7/1) and white (lighter than 10YR 8/1) in color occur at 71 cm, 167 cm, and 258 cm.

SMEAR SLIDE SUMMARY %

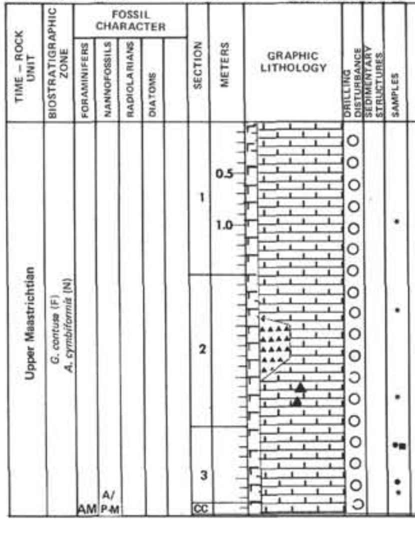
	1-100 (D)	1-149 (D)	2-19 (M)	2-100 (D)
Micronodules	—	—	5	—
Carbonate unsp.	25	25	30	30
Foraminifers	8	10	5	8
Nannofossils	67	65	60	62

	3-20 (D)	3-40 (D)	4-20 (D)	CC (D)
Micronodules	—	—	—	—
Carbonate unsp.	60	30	10	30
Foraminifers	5	2	Tr	20
Nannofossils	35	68	90	50

Silica and Iron Content: 2-50
SiO_2 = 2%
Fe = 0.03%

Carbonate Content: *2-52 = 98%
3-100 = 91%
*4-20 = 95%

SITE 463 HOLE CORE 8 CORED INTERVAL 53.0 to 62.5 m



LITHOLOGIC DESCRIPTION

10YR 8/1
and
lighter

NANNOFOSSIL CHALK

Highly brecciated and soupy chalk, white (10YR 8/1 and lighter) in color. Breccia contains abundant fragments of chert, less than 1 mm in size, to about 195 cm depth. From 195–250 cm large fragments of chert, several mm in diameter, are present, mostly red in color (2YR 3/4). Chert fragments are also found at 255 and 270 cm.

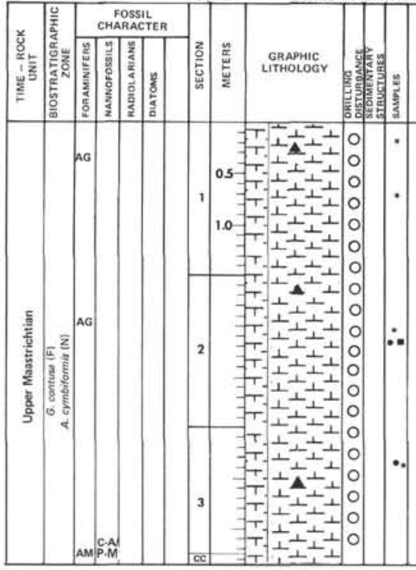
SMEAR SLIDE SUMMARY %

	1-100	2-40	2-115	3-70	CC
Carbonate unspec.	20	3	3	3	5
Foraminifers	5	10	5	5	10
Nannofossils	75	87	72	92	85

Silica and Iron Content: 3-22
SiO_2 = 2%
Fe = 0.07%

Carbonate Content: *3-21 = 98%
3-60 = 91%

SITE 463 HOLE CORE 9 CORED INTERVAL 62.5 to 72.0 m



LITHOLOGIC DESCRIPTION

Lighter
than
10YR 8/1

FORAMINIFER NANNOFOSSIL OOZE AND CHALK

The entire core is a soupy breccia of chalk except for the interval from 26–150 cm which is ooze. Both are white (lighter than 10YR 8/1). A reddish brown (5YR 3/4) chert nodule with a white porcellanite rim (10YR 8/1) is at 25 cm. A dark yellow brown (10YR 4/4) chert nodule & fragments with porcellanite rims of white (10YR 8/1) are at 170 and 355 cm.

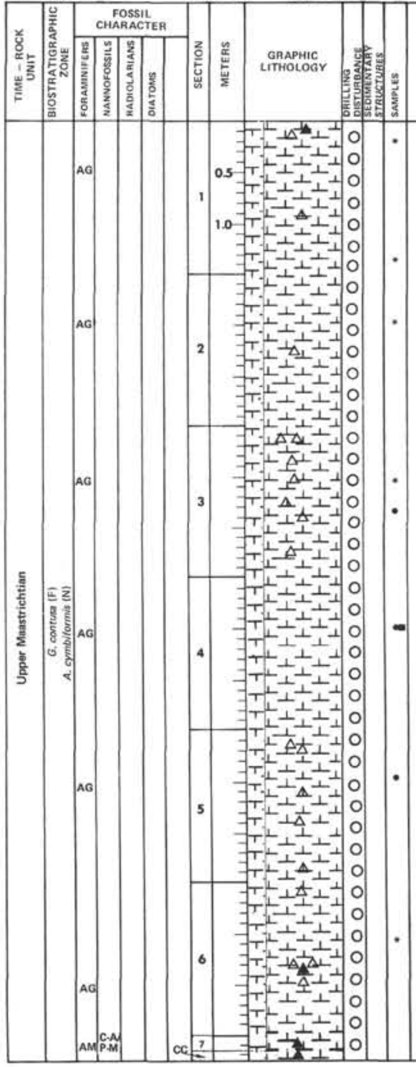
SMEAR SLIDE SUMMARY %

	1-20	1-79	2-71	3-40
Carbonate unspec.	Tr	Tr	—	Tr
Foraminifers	20	25	15	20
Nannofossils	80	75	85	80

Silica and Iron Content: 2-70
SiO_2 = 3.0%
Fe = 0.14%

Carbonate Content: *2-72 = 90%
3-33 = 91%

SITE 463 HOLE CORE 10 CORED INTERVAL 72.0 to 81.5 m



LITHOLOGIC DESCRIPTION

Lighter than 10YR 8/1

FORAMINIFER NANNOFOSSIL OOZE AND CHALK

Drilling breccia (0–40 cm) and soupy ooze (below 40 cm), white (lighter than 10YR 8/1) in color. Chert and porcellanite nodules at 2, 11, 91, 227, 310, 332, 348, 373, 389, 419, 616, 620, 654, 687, 730, 755, 826–840, 905 and 920 cm. The chert is dark yellow brown (10YR 4/4) and gray (10YR 5/1 and 10Y 4/1). The porcellanite is light gray (5Y 7/1) and white (10 YR 8/1).

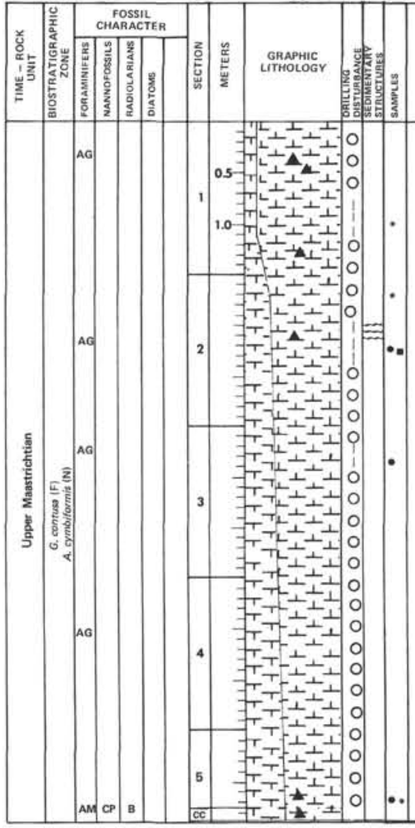
SMEAR SLIDE SUMMARY %

	1-20	1-135	2-50	3-60	6-60
Carbonate unspec.	—	—	2	Tr	Tr
Foraminifers	15	10	12	12	12
Nannofossils	85	90	86	88	88

Silica and Iron Content: 4-50
SiO_2 = 6.8%
Fe = 0.36%

Carbonate Content: 3-81 = 69%
*4-52 = 92%
*5-42 = 94%

SITE 463 HOLE CORE 11 CORED INTERVAL 81.5 to 90.0 m



LITHOLOGIC DESCRIPTION

Lighter than 10YR 8/1

FORAMINIFER NANNOFOSSIL TO NANNOFOSSIL FORAMINIFER OOZE AND CHALK

Slightly disturbed zones of chalk in a soupy ooze. Both are white (lighter than 10YR 8/1). Foraminifers increase in abundance down core. A light gray mottle is in the chalk at 120 cm. Chert nodules gray (N7 and 10YR 6/1) medium gray (5Y 6/1) and very dark gray (N3, N4) in color with zones of porcellanite light gray (10YR 7/1, N7) and white (7.5YR 8/1, 10YR 8/1, and 5Y 8/1) are found at *36, 50, 134, 214, 665 and 680 cm. Some of the* chalk shows laminations (210 cm).

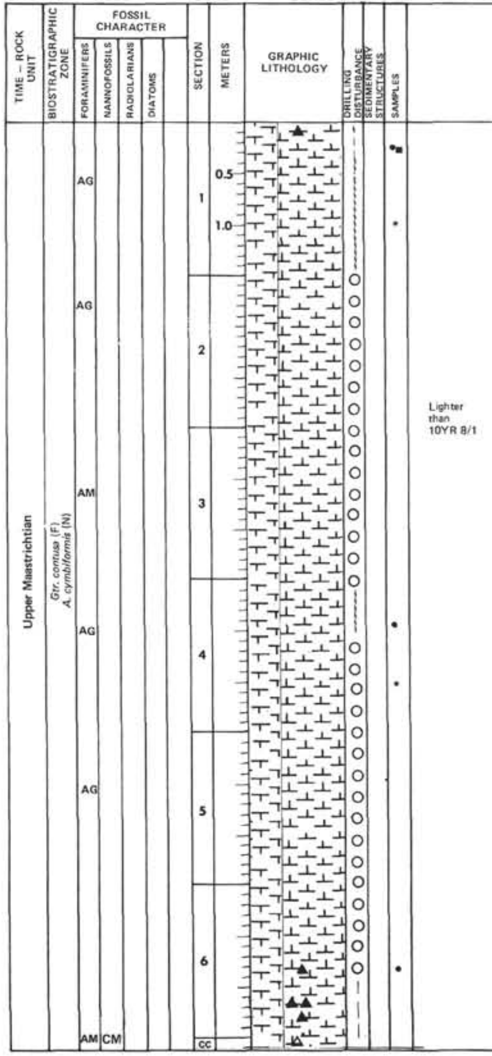
SMEAR SLIDE SUMMARY %

	1-100	2-25	5-75
Carbonate unspec.	Tr	Tr	—
Foraminifers	12	25	40
Nannofossils	88	75	60

Silica and Iron Content: 2-73
SiO_2 = 12%
Fe = 0.17%

Carbonate Content: *2-70 = 82%
3-31 = 91%
*5-73 = 58%

SITE 463 HOLE CORE 12 CORED INTERVAL 91.0 to 100.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL FORAMINIFER OOZE AND CHALK

Highly disturbed to soupy ooze with a few zones of moderately disturbed chalk. Both are white (lighter than 10YR 8/1). A very dark gray (5Y 3/1) chert nodule is at 11–15 cm. Several chert nodules are in the interval 835–870 cm, very dark gray (N3) in color. A gray (N6) porcellanite nodule is at 905 cm.

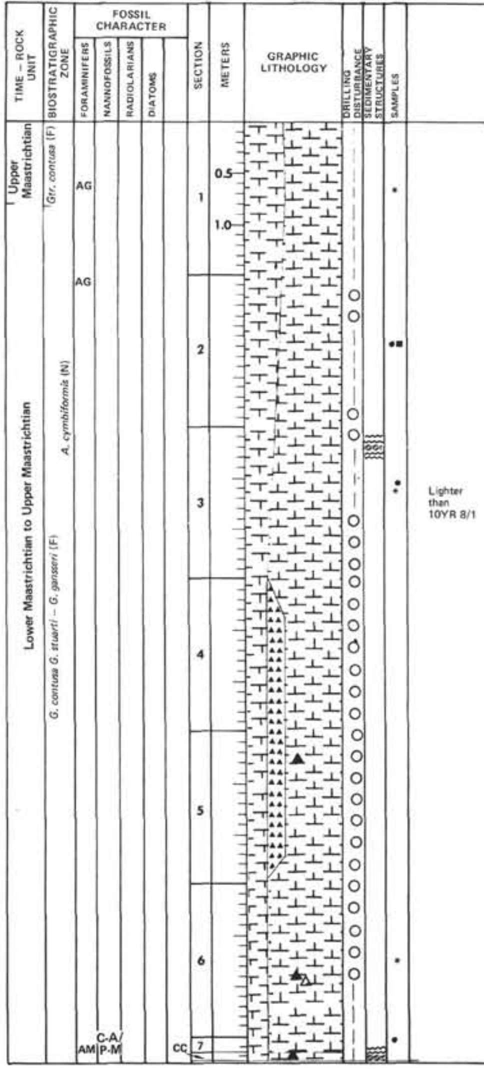
SMEAR SLIDE SUMMARY %

	1-100	4-100
Foraminifers	30	35
Nannofossils	70	65

Silica and Iron Content: 1-25
SiO_2 = 3.0%
Fe = 0,15%

Carbonate Content:
*1-24 = 95%
*4-40 = 91%
6-85 = 91%

SITE 463 HOLE CORE 13 CORED INTERVAL 100.5 to 110.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL FORAMINIFER AND FORAMINIFER NANNOFOSSIL OOZE AND CHALK

Slightly disturbed chalk and soupy ooze. Foraminifer abundance decreases downcore. Chalk shows laminations and burrows of light olive gray (5Y 6/2) at 323–335 cm and 912–918 cm. Dark gray (N4), very dark gray (N3) and light gray chert nodules occur at 632 cm, 841 cm and 925 cm. Chert chips are abundant in Sections 4 and 5. A light gray (N7) porcellanite nodule occurs at 845 cm.

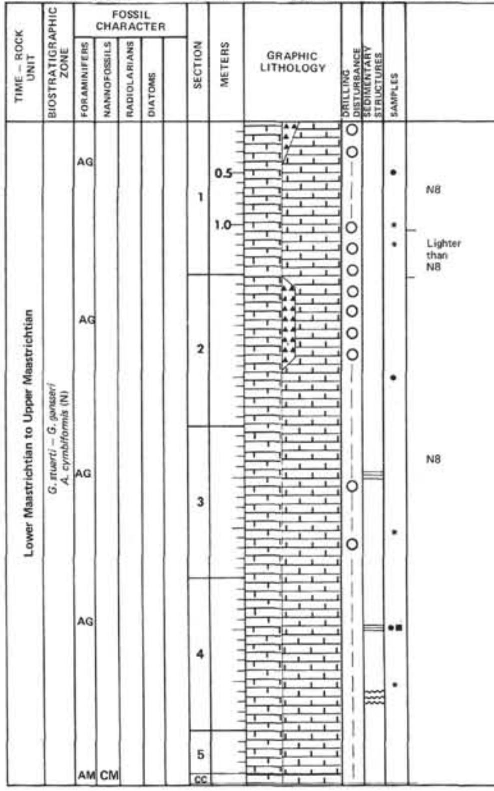
SMEAR SLIDE SUMMARY %

	1-70	3-70	6-70
Foraminifers	40	25	20
Nannofossils	60	75	80

Silica and Iron Content: 2-67
SiO_2 = 3.0%
Fe = 0.22%

Carbonate Content:
*2-69 = 94%
3-55 = 91%
*7-8 = 95%

SITE 463 HOLE CORE 14 CORED INTERVAL 110.0 to 119.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL FORAMINIFER CHALK AND OOZE

Slightly disturbed chalk with soupy ooze intervals. Dark gray (N3) and dark red (2.5YR 4/6) chert chips and pebbles are found in the intervals from 0–40 and 150–244 cm. Gray (N6) laminae in the chalk occur at 346–348, 501–506, and 552–555 cm. The gray is due to pyrite.

SMEAR SLIDE SUMMARY %

	1-100	1-120	3-100	4-104 (M)
Pyrite	—	—	—	2
Foraminifers	35	35	40	38
Nannofossils	65	65	60	60

Silica and Iron Content: 4-52

SiO_2 = 4.0%

Fe = 0.19%

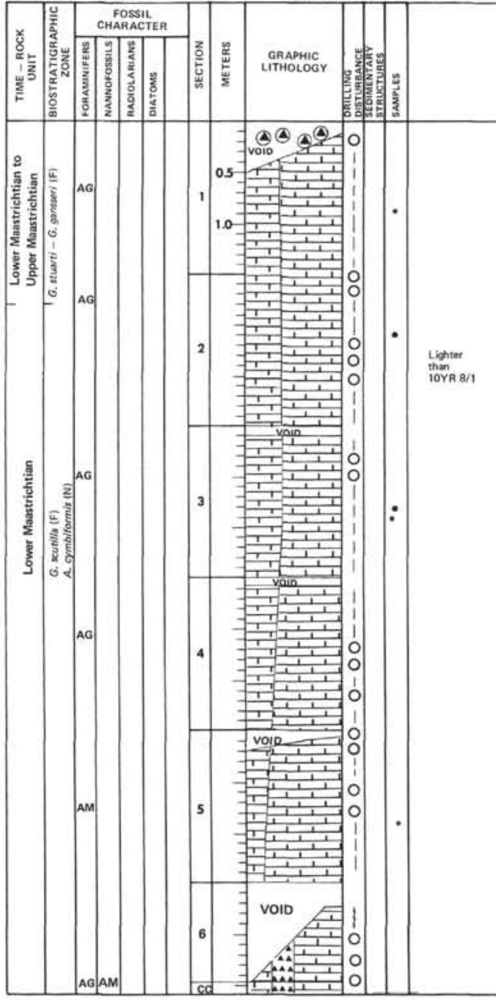
Carbonate Content:

*1-46 = 92%

2-100 = 91%

*4-46 = 96%

SITE 463 HOLE CORE 15 CORED INTERVAL 119.5 to 129.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL FORAMINIFER CHALK AND FORAMINIFER NANNOFOSSIL CHALK

Chalk, *moderately to slightly disturbed* with soupy zones of ooze. White (lighter than 10YR 8/1) in color. Chert fragments, very dark gray (N3) in color, with light gray (N7) rims of porcellanite are at 7–15 cm and at 810–857 cm.

SMEAR SLIDE SUMMARY %

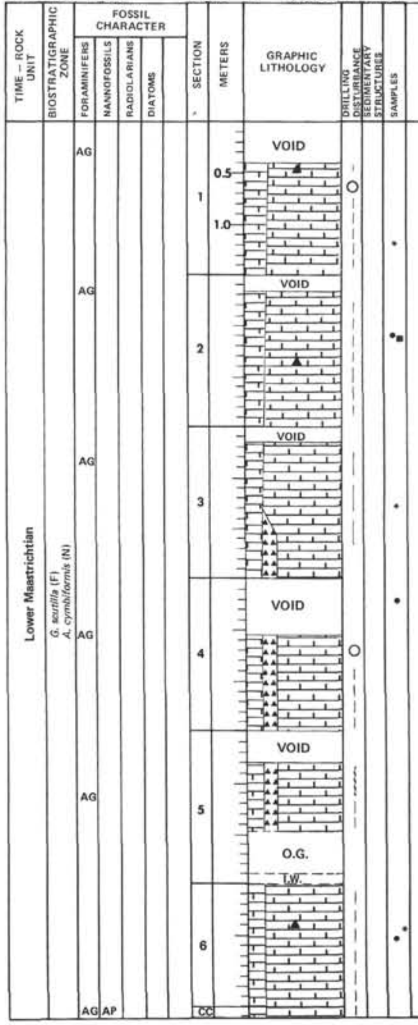
	1-90	3-90	5-90
Micronodules	—	Tr	—
Zeolite	—	Tr	Tr
Calcite rhombs	—	Tr	Tr
Foraminifers	30	35	20
Nannofossils	70	65	80

Carbonate Content:

*2-59 = 96%

3-80 = 91%

SITE 463 HOLE CORE 16 CORED INTERVAL 129.0 to 138.5 m



LITHOLOGIC DESCRIPTION

Lighter than 10YR 8/1

FORAMINIFER NANNOFOSSIL CHALK
Moderately to slightly disturbed chalk separated by soupy ooze intervals. Both are white (lighter than 10YR 8/1) in color. Very dark gray chert nodule (5Y 3/1) with white porcellanite rim (10YR 8/1) at 43 cm. A gray chert chip at 235 cm. Very dark chert chips and nodules (5Y 3/1) from 380 cm to 695 cm dispersed throughout the sediment.

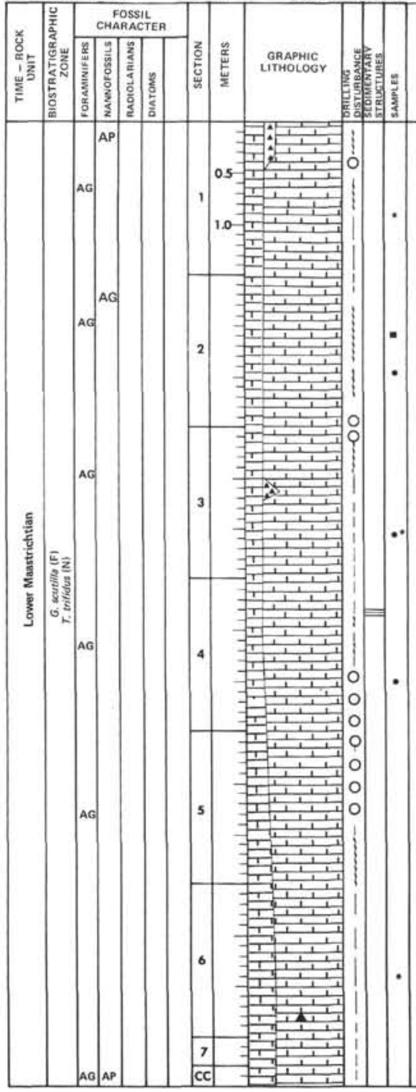
SMEAR SLIDE SUMMARY %

	1-120	3-70	6-50
Pyrite	Tr	—	—
Foraminifers	20	15	15
Nannofossils	80	85	85

Silica and Iron Content: 2-58
SiO_2 = 3.0%
Fe = 0.15%

Carbonate Content: *2-62 = 96%
4-20 = 89%
*6-61 = 96%

SITE 463 HOLE CORE 17 CORED INTERVAL 138.5 to 148.0 m



LITHOLOGIC DESCRIPTION

10YR 8/1 and lighter

FORAMINIFER NANNOFOSSIL CHALK
Slightly to moderately disturbed chalk with some brecciated and soupy zones, white (10YR 8/1 and lighter) in color. The first 50 cm contains abundant fragments of very dark gray (N3), yellowish red (5YR 5/8) and gray (N6) chert up to 5 cm in size. At 348–370 cm small chert chips are abundant, dark gray (5Y 4/1) and very dark gray (5Y 3/1) in color. A chert nodule and some chips dark gray (5Y 4/1) in color are at 880 cm.

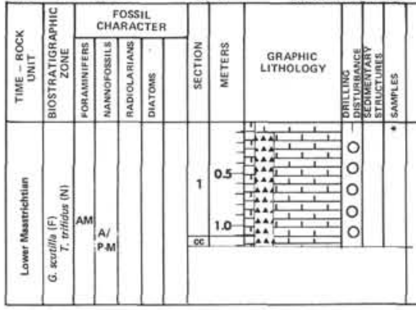
SMEAR SLIDE SUMMARY %

	1-90	3-100	6-90
Opaques	—	Tr	—
Foraminifers	15	15	25
Nannofossils	85	85	75

Silica and Iron Content: 2-60
SiO_2 = 14%
Fe = 0.22%

Carbonate Content: 2-97 = 93%
3-100 = 91%
4-97 = 93%

SITE 463 HOLE CORE 18 CORED INTERVAL 148.0 to 157.5 m



LITHOLOGIC DESCRIPTION

2.5Y 8/1

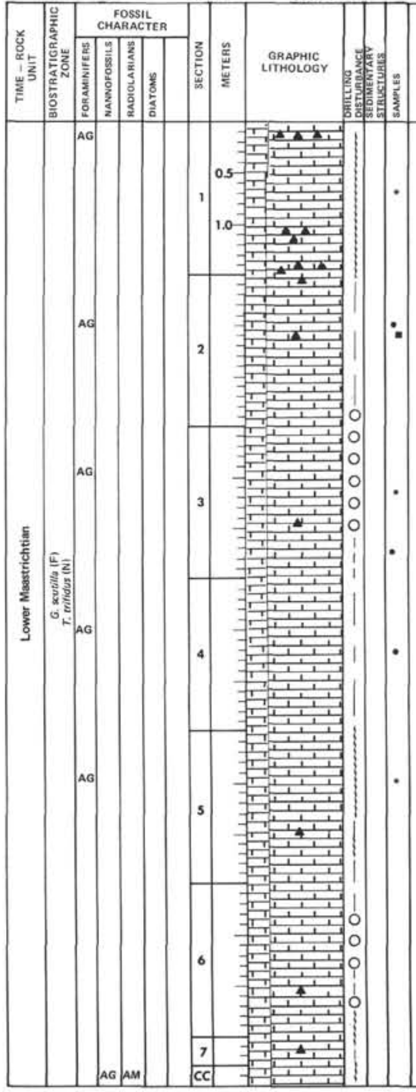
NANNOFOSSIL CHALK

Slightly disturbed chalk (0–10 cm) and drilling breccia below – chalk mixed with chert. Chert fragments are several mm in diameter and are white (2.5Y 8/1) gray (N5) and red (2.5YR 4/6).

SMEAR SLIDE SUMMARY %

	1-5
Foraminifers	8
Nannofossils	92

SITE 463 HOLE CORE 19 CORED INTERVAL 157.5 to 167.0 m



LITHOLOGIC DESCRIPTION

N8

FORAMINIFER NANNOFOSSIL OOZE AND CHALK

Moderately to slightly disturbed chalk with zones of highly disturbed to soupy breccia and ooze. Both white (N8) in color. Abundant chert nodules very dark gray (N3) in color, with some having light gray (N7) porcellanite rims at 8–13, 110–117, 133–143, 152, 210, 394, 696, 852 and 905 cm. Zones of chert chips are at 0–230, 327–402, 620–630, 670–678 and 790–794 cm.

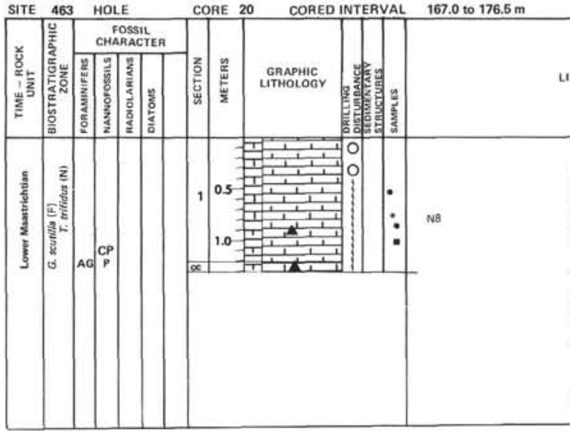
SMEAR SLIDE SUMMARY %

	1-70	3-70	5-50
Calcite Rhombs	Tr	—	—
Foraminifers	25	20	20
Nannofossils	75	80	80

Silica and Iron Content: 2-60
SiO_2 = 3.0%
Fe = 0.14%

Carbonate Content: *2-50 = 96%
3-127 = 92%
*4-70 = 96%

SITE 463 HOLE CORE 20 CORED INTERVAL 167.0 to 176.5 m



LITHOLOGIC DESCRIPTION

FORAMINIFER NANNOFOSSIL CHALK

Brecciated to highly disturbed chalk, white in color (N8). Chert nodules, very dark gray in color (N3), at 90 and 130 cm. Chert chips, very dark gray (N3) in color, in the intervals from 0–58 cm and 100–115 cm.

SMEAR SLIDE SUMMARY %

	1-80
Foraminifers	20
Nannofossils	80

Silica and Iron Content: 1-102

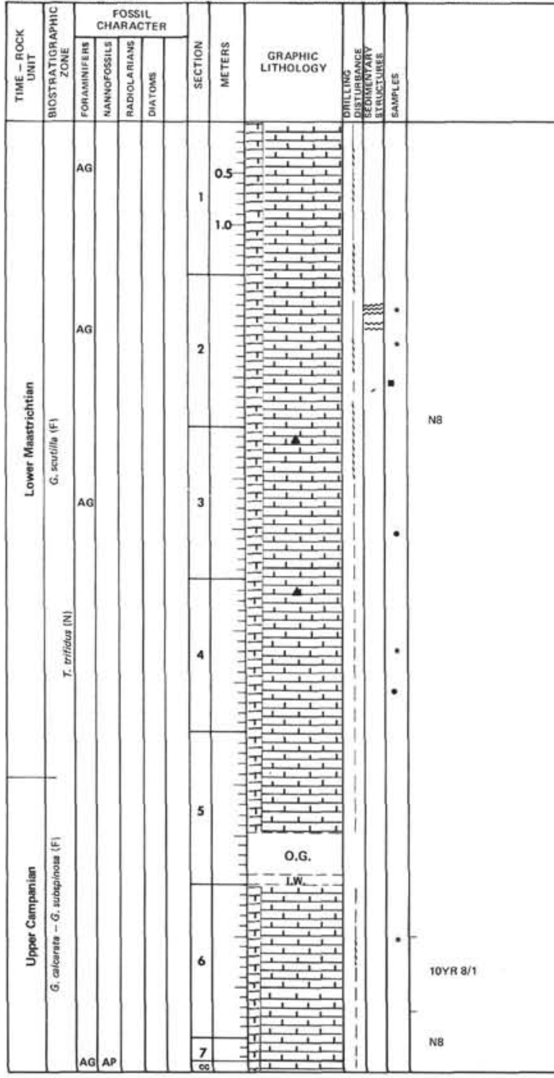
SiO_2 = 3.0%

Fe = 0.14%

Carbonate Content: 1-57 = 91%

*1-85 = 93%

SITE 463 HOLE CORE 21 CORED INTERVAL 176.5 to 186.0 m



LITHOLOGIC DESCRIPTION

FORAMINIFER NANNOFOSSIL CHALK

White (N8, 10YR 8/1) chalk. Slightly to highly disturbed. Intervals at 184–186 cm, 198–200 cm, and 491–494 cm show faint greenish horizontal wavy laminations or streaks. Brown to dark brown (7.5YR 4/4) chert nodules are at 315 and 455 cm. Chert chips of the same color are found in the intervals: 0–4 cm, 270–347 cm, 440–450 cm, and 867–870 cm.

SMEAR SLIDE SUMMARY %

	2-35 (M)	2-70	4-70	6-55 (M)
Foraminifers	20	20	15	15
Nannofossils	80	80	85	80
Chert fragments	—	—	—	5

Silica and Iron Content: 2-103

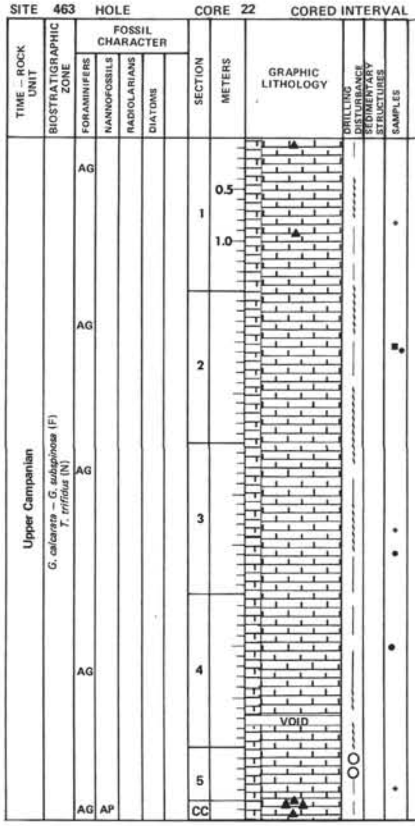
SiO_2 = 4%

Fe = 0.23%

Carbonate Content: 3-104 = 100%

*4-110 = 96%

SITE 463 HOLE CORE 22 CORED INTERVAL 186.0 to 195.5 m



LITHOLOGIC DESCRIPTION

N8

FORAMINIFER NANNOFOSSIL CHALK AND OOZE
Alternating chalk and ooze with the ooze showing the greater disturbance. Both are white (lighter than N8). Dark reddish brown (5YR 3/3) chert is found at 3 and 91 cm. Reddish brown chert (5YR 4/3) is at 645–657 cm.

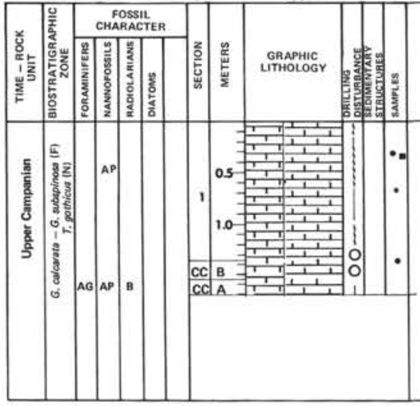
SMEAR SLIDE SUMMARY %

	1-80	3-80	5-40
Opaques	Tr	—	—
Chert	1	Tr	—
Foraminifers	12	12	17
Nannofossils	87	88	83

Silica and Iron Content: 2-54
SiO_2 = 3.0%
Fe = 0.12%

Carbonate Content: *2-58 = 93%
3-104 = 89%
*4-56 = 93%

SITE 463 HOLE CORE 23 CORED INTERVAL 196.5 to 199.5 m



LITHOLOGIC DESCRIPTION

Lighter than N8

NANNOFOSSIL FORAMINIFER CHALK AND OOZE
Alternating layers of ooze and chalk with the ooze more highly disturbed. Both white (lighter than N8) in color. Reddish brown (5YR 4/4) chert chips are present in the interval 0–5 cm.

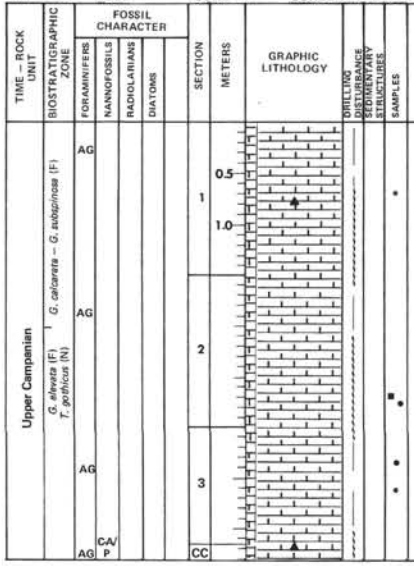
SMEAR SLIDE SUMMARY %

	1-70
Foraminifers	35
Nannofossils	65

Silica and Iron Content: 1-30
SiO_2 = 3.0%
Fe = 0.12%

Carbonate Content: 1-28 = 95%
1-131 = 96%

SITE 463 HOLE CORE 24 CORED INTERVAL 199.5 to 205.0 m



LITHOLOGIC DESCRIPTION

Lighter than N8

FORAMINIFER NANNOFOSSIL CHALK AND OOZE
Alternating layers of chalk and ooze – the core being more highly disturbed. Chert pebbles, dark reddish brown (5YR 3/4) in color, are at 80 cm, and fragments of the same colored chert are mixed into the Core-Catcher, 417–430 cm.

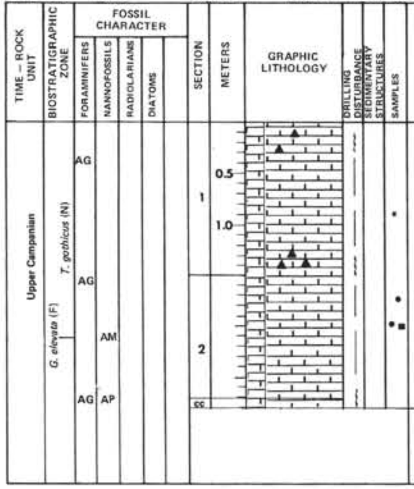
SMEAR SLIDE SUMMARY %

	1-70	3-70
Chert	Tr	—
Foraminifers	12	11
Nannofossils	88	89

Silica and Iron Content: 2-119
SiO_2 = 3.0%
Fe = 0.16%

Carbonate Content: *2-121 = 95%
3-34 = 88%

SITE 463 HOLE CORE 25 CORED INTERVAL 205.0 to 214.5 m



LITHOLOGIC DESCRIPTION

N8

FORAMINIFER NANNOFOSSIL CHALK AND OOZE
Mainly chalk with some intervals of ooze, white (N8 and lighter) in color. The chalk is moderately disturbed with the ooze more highly disturbed. Chert nodules, dark reddish brown (5YR 3/3) in color, are at 10, 21, and 130–140 cm. The nodule at 10 cm also has a band of white (5YR 8/1) chert.

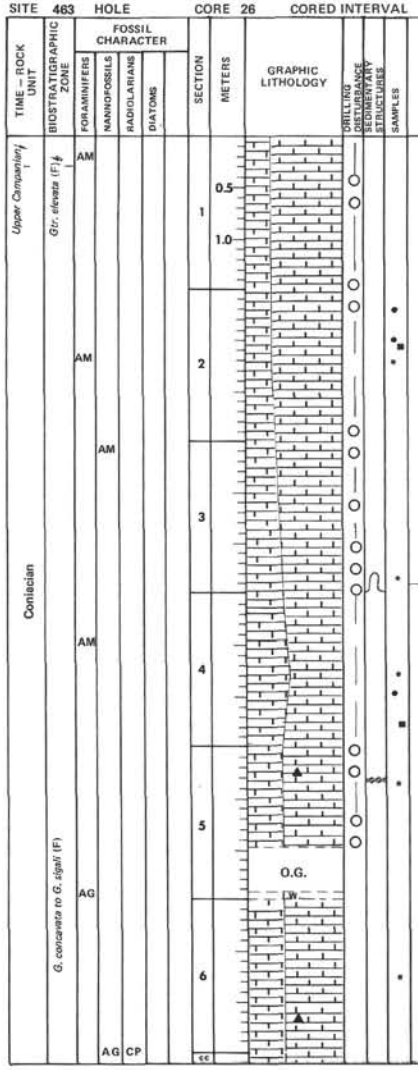
SMEAR SLIDE SUMMARY %

	1-90
Foraminifers	17
Nannofossils	83

Silica and Iron Content: 2-53
SiO_2 = 2.0%
Fe = 0.08%

Carbonate Content: 2-28 = 86%
*2-51 = 95%

SITE 463 HOLE CORE 26 CORED INTERVAL 214.5 to 224.0 m



LITHOLOGIC DESCRIPTION

Lighter than N8

7.5YR 8/2

FORAMINIFER NANNOFOSSIL AND NANNOFOSSIL FORAMINIFER CHALK

Alternating moderately disturbed chalk and highly disturbed soupy ooze. The abundance of foraminifers generally increases downcore. The upper 440 cm is white N/8 and the remainder is pinkish gray (7.5YR 7/2). Dark gray (N4) chert fragments are at 75–80 cm; reddish yellow (7.5YR 6/6) chert fragments are at 435 cm; and dark reddish brown (2.5YR 3/4, 5YR 3/2) chert fragments are at 465–470 cm, 670–675 cm and 840–865 cm. Two dark reddish brown chert nodules are at 625 and 865 cm.

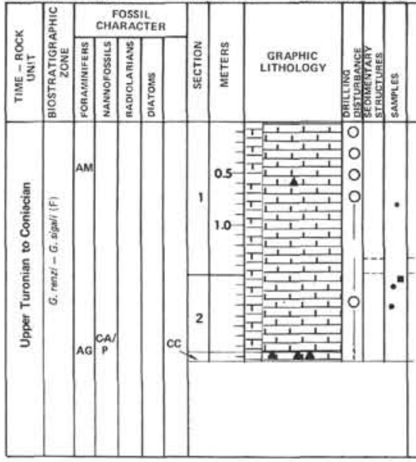
SMEAR SLIDE SUMMARY %

	2-80	3-135 (M)	4-80	5-35	6-85
Chert	—	50	—	Tr	Tr
Foraminifers	25	10	40	31	33
Nannofossils	75	40	60	69	67

Silica and Iron Content:	2-59	4-128
SiO_2 =	3.0%	4.0%
Fe =	0.19%	0.22%

Carbonate Content:
2-20 = 86%
*2-57 = 95%
*4-102 = 95%

SITE 463 HOLE CORE 27 CORED INTERVAL 224.0 to 233.5 m



LITHOLOGIC DESCRIPTION

7.5YR 8/4

7.5YR 7/3

7.5YR 8/4

FORAMINIFER NANNOFOSSIL CHALK AND OOZE

Moderately disturbed chalk alternating with soupy ooze and breccia; both pink (7.5YR 8/4) to pinkish gray (7.5YR 7/3) in color. A dark reddish brown chert nodule (5YR 3/2) is at 64 cm. Fragments of the same colored chert are found at 0–40, 62–75, and 210–233 cm.

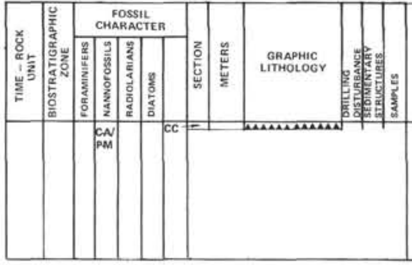
SMEAR SLIDE SUMMARY %

	1-85
Carbonate unspec.	Tr
Foraminifers	20
Calc. nannofossils	80

Silica and Iron Content:	2-8
SiO_2 =	5.0%
Fe =	0.29%

Carbonate Content:
2-11 = 93%
2-35 = 79%

SITE 463 HOLE CORE 28 CORED INTERVAL 233.5 to 243.0 m

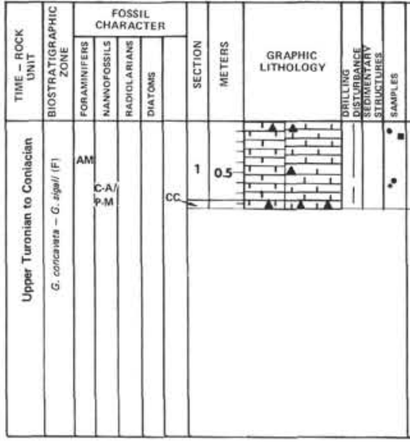


LITHOLOGIC DESCRIPTION

CHERT

Fragments of dark reddish brown (2.5YR 3/4) and dark red (2.5YR 3/6) chert. Small pits in the chert are filled with light red (2.5YR 6/6) undetermined sediment. Some porcellanite rims of white (10YR 8/1) are present.

SITE 463 HOLE CORE 29 CORED INTERVAL 243.0 to 252.5 m



LITHOLOGIC DESCRIPTION

5Y 8/1

NANNOFOSSIL FORAMINIFER CHALK

Moderately disturbed chalk, white (5Y 8/1) in color with some light gray (5Y 7/1) mottling. Dark reddish brown chert (5YR 3/2) is at 3 cm and 52 cm. The Core-Catcher, 75–82 cm, is composed of dark reddish brown (5YR 3/2) chert with rims of gray (N7) limestone.

SMEAR SLIDE SUMMARY %

	1-70
Carbonate unspec.	Tr
Foraminifers	40
Nannofossils	60

Silica and Iron Content:	1-12
SiO_2 =	5.9%
Fe =	0.55%

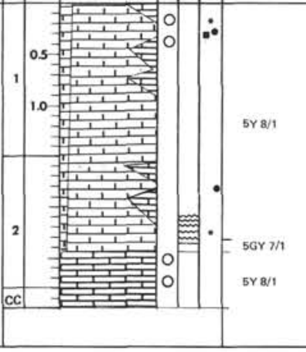
Carbonate Content:
*1-12 = 90%
1-58 = 81%

SITE 463 HOLE CORE 30 CORED INTERVAL 252.5–262.0 m

TIME – ROCK UNIT: Upper Turonian to Coniacian

BIOSTRATIGRAPHIC ZONE: *G. renzi – G. sigali* (F)

FOSSIL CHARACTER: FORAMINIFERS AM; NANNOFOSSILS CA/P



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK AND SILICEOUS LIMESTONE

Undisturbed white (5Y 8/1) chalk and limestone with slightly darker burrow mottling, gray (5Y 5/1) and some wavy laminations. Some soupy areas of drilling breccia. Limestone (silicified?): 0–4, 40–44, 73–75, 164–170, 195–203, 244–252, 257–280, and 290–300 cm. Chalk: 4–25, 44–73, 80–150, 150–164, 170–175, and 203–244 cm.

SMEAR SLIDE SUMMARY %

	1-30	2-82
Carbonate unspec.	Tr	Tr
Foraminifers	12	5
Nannofossils	88	95

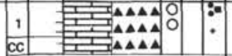
Silica and Iron Content: 1-30
SiO_2 = 31%
Fe = 0.39%

Carbonate Content: *1-30 = 86%
2-35 = 76%

SITE 463 HOLE CORE 31 CORED INTERVAL 262.0 to 271.5 m

TIME – ROCK UNIT: Turonian

FOSSIL CHARACTER: FORAMINIFERS B; NANNOFOSSILS CA/M



LITHOLOGIC DESCRIPTION

LIMESTONE AND CHERT

A drilling breccia consisting of fragments of white (5Y 8/1) and light gray (5Y 7/1) limestone and dark gray chert (N3, N4) up to 5 cm in length. Some fragments show replacement of limestone by chert.

SMEAR SLIDE SUMMARY %

	1-33
Volcanic glass	Tr
Carbonate Rhombs	2
Foraminifers	5
Nannofossils	93
Radiolarians	Tr

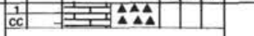
Silica and Iron Content: 1-3
SiO_2 = 8.6%
Fe = 0.54%

Carbonate Content: *1-4 = 85%
1-12 = 81%

SITE 463 HOLE CORE 32 CORED INTERVAL 271.5 to 281.0 m

TIME – ROCK UNIT: Turonian

FOSSIL CHARACTER: NANNOFOSSILS R-F/P



LITHOLOGIC DESCRIPTION

LIMESTONE AND CHERT

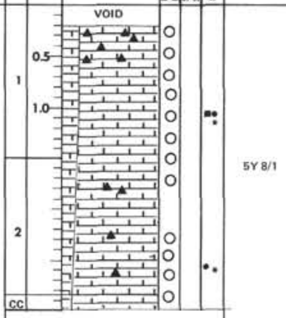
A drilling breccia consisting of about 15 pieces of white (5Y 8/1) limestone and dark reddish brown (5YR 3/2), dark reddish gray (5YR 4/2) and very dark gray (N3) chert.

SITE 463 HOLE CORE 33 CORED INTERVAL 281.0 to 290.5 m

TIME – ROCK UNIT: Middle Turonian

BIOSTRATIGRAPHIC ZONE: *G. helvetica* (F)

FOSSIL CHARACTER: FORAMINIFERS AM; NANNOFOSSILS AP



LITHOLOGIC DESCRIPTION

FORAMINIFER NANNOFOSSIL CHALK AND CHERT

20–50 cm: Dominantly dark gray (N3), dark reddish brown (5YR 3/2, 5YR 4/3) and white (5Y 8/1) chert.
50–150 cm: Severely disturbed, chert fragments (like those at 20–50 cm) mixed with chalk with many one cm size chunks in the interval from 140–150 cm.
150–179 cm: Chalk and limestone.
179–185 cm: Chert, dark reddish brown (5YR 3/4).
185–222 cm: White (5Y 8/1) chalk.
222–300 cm: Highly brecciated chalk with dark reddish brown (5YR 3/4) chert nodules at 227 and 263 cm.

SMEAR SLIDE SUMMARY %

	1-110	2-110
Carbonate Rhombs	5	–
Foraminifers	15	10
Nannofossils	80	90

Silica and Iron Content: 1-104
SiO_2 = 5.3%
Fe = 0.34%

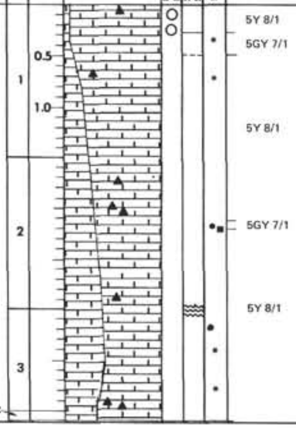
Carbonate Content: *1-106 = 91%
2-107 = 88%

SITE 463 HOLE CORE 34 CORED INTERVAL 290.5 to 300.0 m

TIME – ROCK UNIT: Middle Turonian; Lower Turonian

BIOSTRATIGRAPHIC ZONE: *G. helvetica* (F); *H. Lehmani* (F)

FOSSIL CHARACTER: FORAMINIFERS AM, AM, AM, AM; NANNOFOSSILS AG, AP



LITHOLOGIC DESCRIPTION

FORAMINIFER NANNOFOSSIL AND NANNOFOSSIL FORAMINIFER CHALK

Undisturbed chalk, except for brecciated top, white (5Y 8/1) and greenish gray (5GY 7/1) in color. Dark reddish brown (5YR 3/3, 5YR 3/2) and gray (5YR 5/1) chert at 2, 76, 175, 199, 205, 286, 388 and 393 cm. Chert fragments in the intervals from 315–332 cm and 398–410 cm. Faint whispy laminae light gray (5Y 7/1) in color at 294 cm.

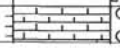
SMEAR SLIDE SUMMARY %

	1-35	1-75	3-45	3-80
Foraminifers	5	15	40	30
Nannofossils	95	85	60	70

Silica and Iron Content: 2-70
SiO_2 = 4.0%
Fe = 0.23%

Carbonate Content: *2-68 = 94%
3-20 = 86%

SITE 463 **HOLE** **CORE** 35 **CORED INTERVAL** 300.0 to 309.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Lower Turonian	*H. lehmani* (F)	AM	A/MG AP			1			○ ○		■●•

5Y 8/1

NANNOFOSSIL CHALK

Brecciated to undisturbed chalk, white (5Y 8/1) in color. Chert fragments are found in the brecciated sections, 0-15 cm and 25-34 cm. The chert is dark reddish brown (5YR 3/4) and gray (5YR 6/1) in color.

SMEAR SLIDE SUMMARY %

	1-20
Micronodules	Tr
Carbonate unsp.	15
Foraminifers	1
Nannofossils	84

Silica and Iron Content: 1-14

SiO_2 = 5.1%

Fe = 0.27%

Carbonate Content: *1-15 = 92%

SITE 463 **HOLE** **CORE** 36 **CORED INTERVAL** 309.5 to 319.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Lower Turonian	*H.lehmani* (F)	AM				1					⁚■

SILICIFIED LIMESTONE AND CHERT

A drilling breccia containing four pebbles of white (10YR 8/1) silicified limestone. Two pebbles of chert: one gray (5YR 5/1) with light gray mottles (5YR 7/1), one dark reddish brown (5YR 3/3) with a limestone rim.

SMEAR SLIDE SUMMARY %

	1-18
Pyrite	1
Carbonate unsp.	98
Foraminifers	1

Silica and Iron Content: 1-13

SiO_2 = 73%

Fe = 0.31%

Carbonate Content: *1-10 = 36%

SITE 463 **HOLE** **CORE** 37 **CORED INTERVAL** 319.0 to 328.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Lower Turonian	*H. lehmani* (F)	AP	AP			1					

NANNOFOSSIL CHALK

One fragment of white (5YR 8/1) chalk, 2 cm in diameter.

SITE 463 **HOLE** **CORE** 38 **CORED INTERVAL** 328.5 to 338.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Lower Turonian	*H. lehmani* (F) *L. alatus* (N)	AP	AG AP			1	0.5		○	≋ ≋	• •■

5YR 8/1

FORAMINIFER NANNOFOSSIL CHALK

White chalk (5YR 8/1) with gray (N6) wavy laminations (0-15 and 60-78 cm) and greenish gray wavy laminations (5GY 8/1) from 15-30 cm. Breccia of chalk and gray (N6 and N3) chert from 43-60 cm. Chert nodule, mottled light gray (N6) and dark gray (N3) from 78-85 cm.

SMEAR SLIDE SUMMARY %

	1-25
Carbonate unsp.	Tr
Foraminifers	20
Nannofossils	80

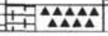
Silica and Iron Content: 1-62

SiO_2 = 7.1%

Fe = 0.34%

Carbonate Content: *1-62 = 88%

SITE 463 **HOLE** **CORE** 39 **CORED INTERVAL** 338.0 to 347.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES
Lower Turonian	*H. lehmani* (F) *L. alatus* (N)	AM	CP			CC					•

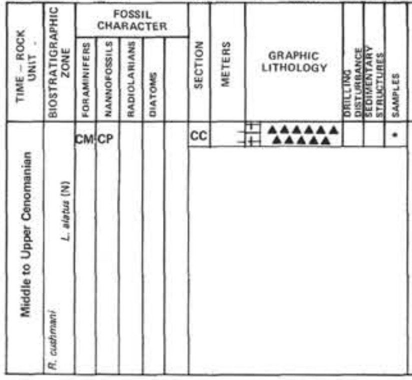
FORAMINIFER NANNOFOSSIL CHALK AND CHERT

Ten fragments of dark gray (N3, N4) chert and a few fragments of white (5YR 8/1) chalk.

SMEAR SLIDE SUMMARY %

	CC
Pyrite	Tr
Foraminifers	30
Nannofossils	70

SITE 463 HOLE CORE 40 CORED INTERVAL 347.5 to 357.0 m



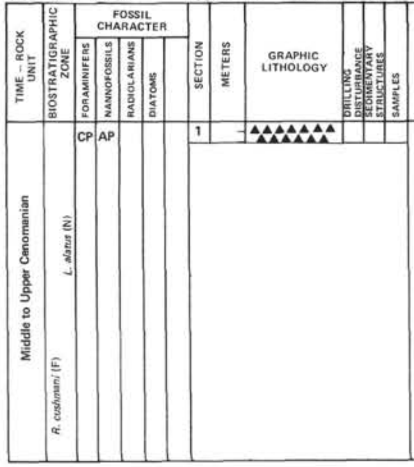
LITHOLOGIC DESCRIPTION

CHERT–FORAMINIFER NANNOFOSSIL CHALK
Pebbles of dark gray (N3) to gray (N5) chert with some mottles of lighter gray (N6). The chert pebbles have white (N8) porcellanite rims. One fragment of white (10YR 8/1) chalk.

SMEAR SLIDE SUMMARY %

	CC
Carbonate unsp.	Tr
Foraminifers	25
Nannofossils	75

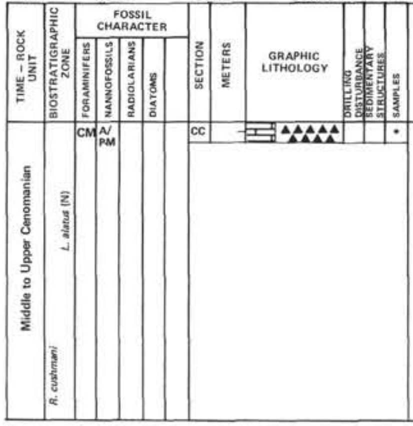
SITE 463 HOLE CORE 41 CORED INTERVAL 357.0 to 366.5 m



LITHOLOGIC DESCRIPTION

CHERT
Four pieces of black (5Y 2/1) chert, one with some carbonate adhering to it.

SITE 463 HOLE CORE 42 CORED INTERVAL 366.5 to 376.0 m



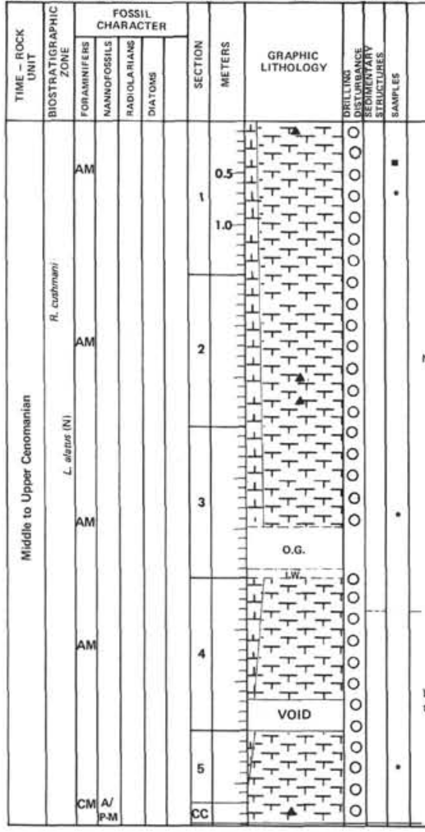
LITHOLOGIC DESCRIPTION

CHERT AND FORAMINIFER NANNOFOSSIL LIMESTONE
Black (5Y 2/1) chert fragments and white (N8) limestone fragments.

SMEAR SLIDE SUMMARY %

	CC
Calc. rhombs	Tr
Foraminifers	15
Nannofossils	85

SITE 463 HOLE CORE 43 CORED INTERVAL 376.0 to 385.5 m



LITHOLOGIC DESCRIPTION

FORAMINIFER NANNOFOSSIL OOZE AND NANNOFOSSIL OOZE
White (N8 and lighter) soupy ooze with a few intervals of chalk. Dark gray (N4) to black (N2) chert nodules at 11 cm, 251 cm, 276 cm, and 675 cm. The interval from 150 cm to 395 cm contains chert fragments.

SMEAR SLIDE SUMMARY %

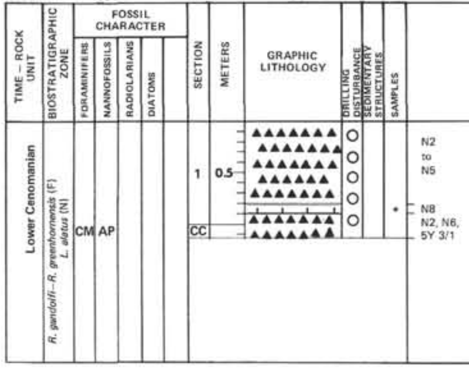
	1-75	3-85	5-30
Volcanic glass	Tr	—	Tr
Pyrite	Tr	Tr	?
Chert	—	Tr	—
Micronodules	—	—	?
Foraminifers	11	15	7
Nannofossils	89	85	93

Silica and Iron Content %: 1-39 =
SiO_2 = 7.0%
Fe = 0.62%

N8

Lighter than N8

SITE 463 HOLE CORE 44 CORED INTERVAL 385.5 to 395.0 m



LITHOLOGIC DESCRIPTION

CHERT AND NANNOFOSSIL CHALK

Drilling Breccia

0-89 cm: Drilling induced graded bed of chert chips, black (N2) to gray (N5). 10 mm at the bottom to 1 mm at the top.

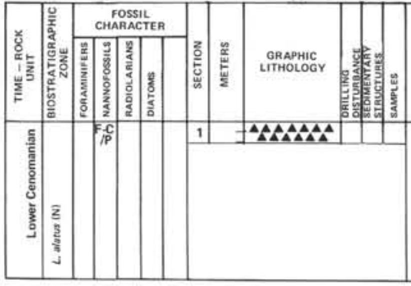
80-86 cm: White (N8) disturbed chalk with chert chips.

86-115 cm: Very dark gray (5Y 3/1), gray (N6) and black (N2) chert. A few pieces of nannofossil chalk are present.

SMEAR SLIDE SUMMARY %

	1-82
Chert	Tr
Pyrite	Tr
Foraminifers	8
Nannofossils	92

SITE 463 HOLE CORE 45 CORED INTERVAL 395.0 to 404.5 m

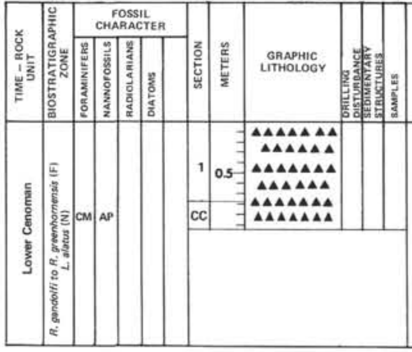


LITHOLOGIC DESCRIPTION

CHERT

Five pebbles of chert, gray (N5) to dark gray (N4). White (N8) porcellanite on one fragment.

SITE 463 HOLE CORE 46 CORED INTERVAL 404.5 to 414.0 m



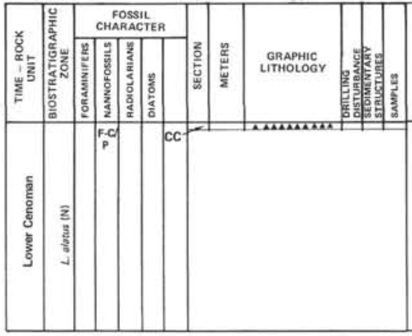
LITHOLOGIC DESCRIPTION

CHERT

0–77 cm: Graded drilling breccia of chert, gray (N4, N5) and red (10R 3/6) in color, with some white (N8) porcellanite. 0.5–1 mm at the top and 2 cm at the bottom.

77–103 cm: Pebbles of light gray (N7) and dark gray (N4) chert.

SITE 463 HOLE CORE 47 CORED INTERVAL 414.0 to 423.5 m

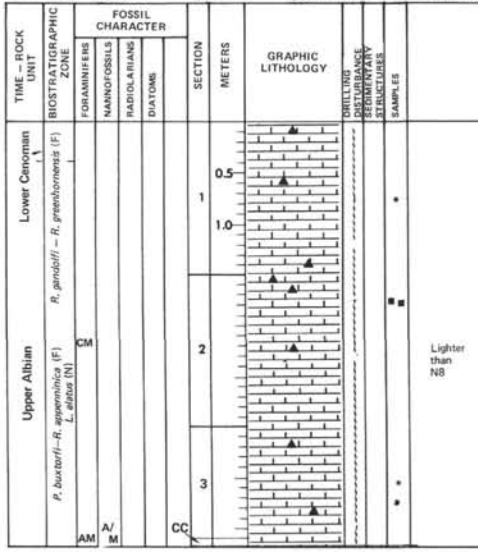


LITHOLOGIC DESCRIPTION

CHERT

Very dark gray (N4), gray (N5) and light gray (N7) in color. Irregularly mottled with some white (N8) porcellanite.

SITE 463 HOLE CORE 48 CORED INTERVAL 423.5 to 427.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

White (lighter than N8) chalk, highly disturbed by drilling. Chips of light gray (N6, N7) chert are present at: 0–5, 55–65, 130–177, 209–237, 308–320, and 376–383 cm.

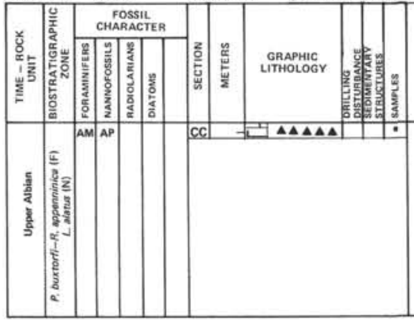
SMEAR SLIDE SUMMARY

	1-80	3-60
Pyrite	Tr	—
Carbonate unspec.	3	Tr
Foraminifers	10	10
Nannofossils	87	90

Silica and Iron Content:	2-27	2-28
SiO_2 =	8.7%	9.8%
Fe =	0.29%	0.30%

Carbonate Content: 3-70 = 91%

SITE 463 HOLE CORE 49 CORED INTERVAL 427.5 to 433.0 m



LITHOLOGIC DESCRIPTION

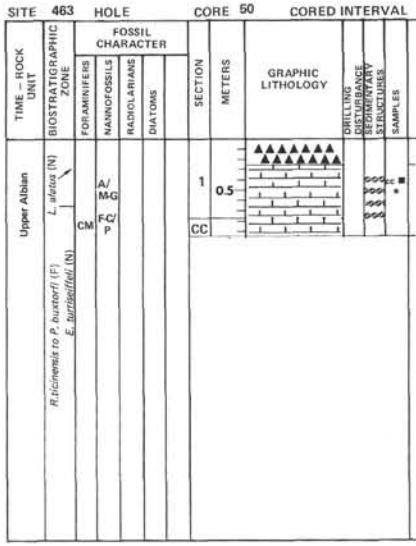
CHERT AND FORAMINIFER NANNOFOSSIL CHALK

Three pebbles of banded chert gray (N6), light gray (N7), and white (N8) in color. One white (N8) pebble of chalk.

SMEAR SLIDE SUMMARY %

	CC
Micronodules	1
Chert	5
Foraminifers	15
Calc. nannofossils	79

SITE 463 HOLE CORE 50 CORED INTERVAL 433.0 to 442.5 m



LITHOLOGIC DESCRIPTION

N5 to N7

5Y 8/1

NANNOFOSSIL CHALK AND CHERT

0–25 cm: Five pieces of gray to light gray (N5–N7) chert.

25–30 cm: Two pieces of siliceous limestone white (N8) in color.

30–91 cm: Chalk, white (N8) to very very pale green (no color on chart) with darker green gray (5GY 6/1) burrow mottling. One piece at 60–65 cm is pale blue green (5BG 8/1) with darker (5BG 6/1) mottling. Some laminations are present.

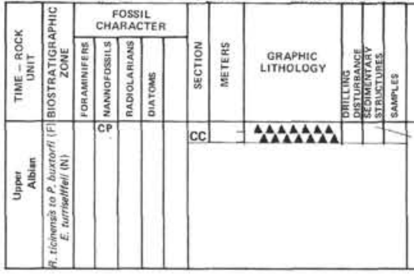
SMEAR SLIDE SUMMARY %

	1-45
Volcanic glass	Tr
Pyrite	Tr
Carbonate unspec.	3
Foraminifers	5
Nannofossils	92

Silica and Iron Content:	1-39
SiO_2 =	15%
Fe =	0.5%

Carbon-Carbonate:	1-39
% Carbonate	75.8
% Organic Carbon	0.1

SITE 463 HOLE CORE 51 CORED INTERVAL 442.5 to 452.0 m

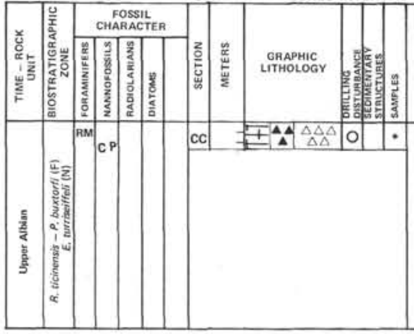


LITHOLOGIC DESCRIPTION

CHERT

Five pieces of gray to light gray (N5–N7) chert.

SITE 463 HOLE CORE 52 CORED INTERVAL 452.0 to 461. 5 m



LITHOLOGIC DESCRIPTION

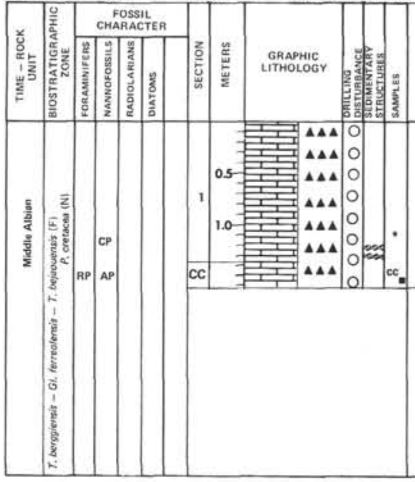
CHERT–PORCELLANITE–LIMESTONE

Porcellanite fragments are dominant, white (N8) with small mottles of chert, gray (N5). Chert fragments are light gray (N7). White (5Y 8/1) limestone fragments are foraminifer-nannofossil limestone.

SMEAR SLIDE SUMMARY %

	CC
Carbonate unspec.	80
Foraminifers	15
Nannofossils	5

SITE 463 HOLE CORE 53 CORED INTERVAL 461.5 to 471.0 m



LITHOLOGIC DESCRIPTION

SILICIFIED LIMESTONE AND CHERT (Drilling Breccia)

0–105 cm: Sand of limestone and chert fragments, white (N8), gray (N6), and brown (7.5YR 5/4, 7.5YR 4/4) in color.

105–165 cm: Large fragments of chert, light gray (N6, N7), gray (N5) and dark gray (N4) in color, and limestone, white (N8), and pale green (5GY 8/1) in color.

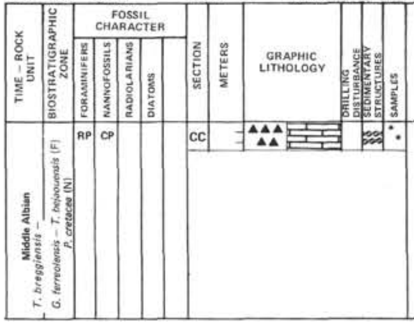
SMEAR SLIDE SUMMARY %

	1-103
Carbonate unspec.	85
Foraminifers	10
Nannofossils	5

Silica and Iron Content:	CC-26
SiO_2 =	53%
Fe =	0.32%

Carbon-Carbonate:	CC-26
% Carbonate	28.3%
% Organic Carbon	0.1%

SITE 463 HOLE CORE 54 CORED INTERVAL 471.0 to 480.5m



LITHOLOGIC DESCRIPTION

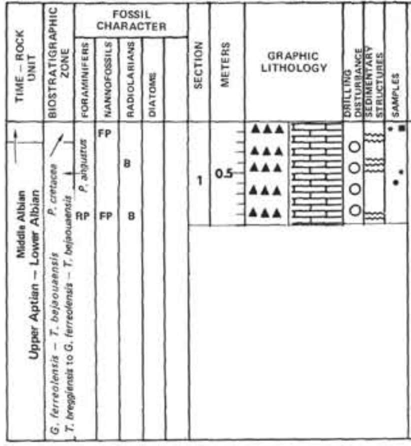
FORAMINIFER NANNOFOSSIL LIMESTONE AND CHERT

Six pieces of limestone, white (lighter than N8) with greenish gray (5GY 7/1) burrows – mainly horizontal. Five pieces of chert, white (10YR 8/1), with relicts of burrows.

SMEAR SLIDE SUMMARY %

	CC-5	CC-12
Carbonate unspec.	60	55
Foraminifers	25	30
Nannofossils	15	15

SITE 463 HOLE CORE 55 CORED INTERVAL 480.5 to 490.0 m



LITHOLOGIC DESCRIPTION

SILICEOUS LIMESTONE AND CHERT

Greenish gray (5GY 7/1) siliceous limestone with some white (lighter than N8) limestone fragments. Laminations are common as a result of burrows and bedding. Some limestones show silicification. Chert fragments are white (N8) or gray (N5 and N6) with lighter and darker patches.

SMEAR SLIDE SUMMARY %

	1-5	1-60
Calcite rhombs	—	Tr
Carbonate unspec.	80	80
Foraminifers	20	20
Nannofossils	Tr	Tr

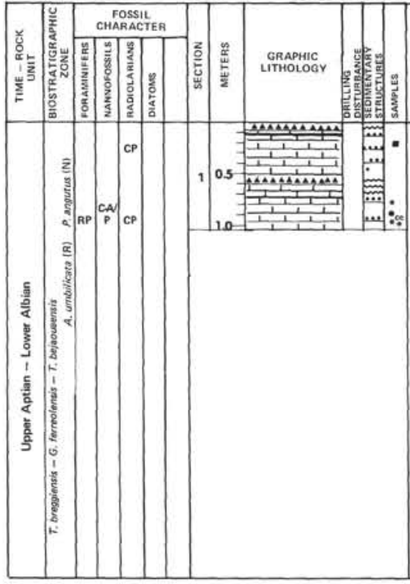
Silica and Iron Content: 1-4

SiO_2 = 22%

Fe = 0.51%

Carbonate Content: 1-64 = 87%

SITE 463 HOLE CORE 56 CORED INTERVAL 490.0 to 499.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK–LIMESTONE–CHERT

Chert, light reddish brown (5YR 6/3), in the intervals 0–8 and 52–61 cm.

Silicified limestone, very pale brown (10YR 7/3), with faint horizontal laminations in the intervals 8–12 and 61–73 cm.

Chalk, pale gray green (5GY 8/1) commonly grading downward into darker gray green (5GY 7/1 and 5GY 6/1) reflecting graded beds. Horizontal burrowing common.

SMEAR SLIDE SUMMARY %

	1-88	1-93	1-96
Pyrite	—	Tr	5
Carbonate unspec.	20	15	15
Foraminifers	5	5	40
Nannofossils	75	80	40
Radiolarians	Tr	—	Tr

Silica and Iron Content: 1-22

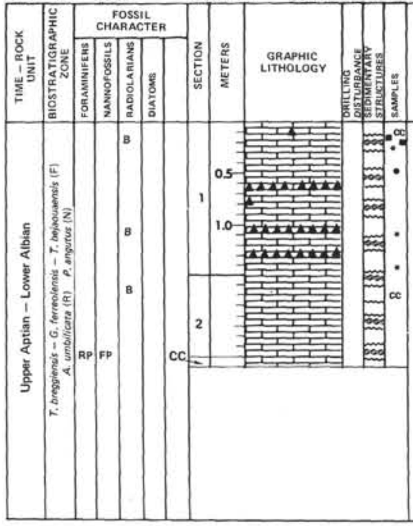
SiO_2 = 26%

Fe = 0.36%

Carbonate Content: 1-93 = 88%

Carbon-Carbonate:	1-95
% Carbonate	55.8
% Organic Carbon	3.5

SITE 463 HOLE CORE 57 CORED INTERVAL 499.5 to 509.0 m



LITHOLOGIC DESCRIPTION

LIMESTONE

Cyclic alternations of pale pinkish white (5YR 8/1), pinkish gray (5YR 6/2 and 5YR 7/2), reddish gray (5YR 5/2) and pale greenish gray (5GY 8/1) limestone. Laminations owing to burrow flattening and original bedding are common. Cherts, dark reddish brown (5YR 3/2) and reddish gray (5YR 5/2) are present at 7, 62–69, 78, 100–103, and 126–130 cm. The cyclic alternations are on the scale of centimeters in length.

SMEAR SLIDE SUMMARY %

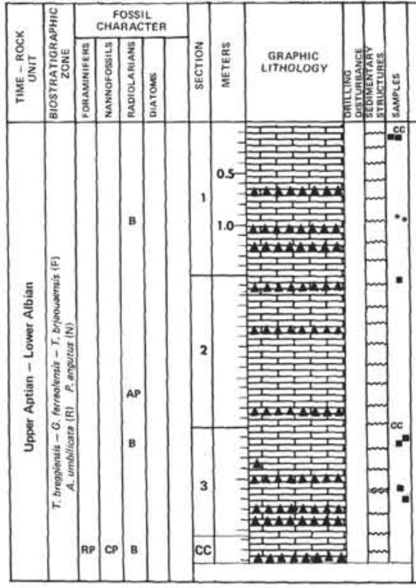
	1-29	1-112	1-145
Carbonate unspec.	80	80	85
Foraminifers	20	20	10
Nannofossils	Tr	Tr	5

Silica and Iron Content:		1-18 (green)	1-19 (pink)
SiO_2	=	13%	13%
Fe	=	0.54%	0.51%

Carbonate Content: 1-44 = 84%

Carbon-Carbonate:	1-16	2-20
% Carbonate	86.6	69.1
% Organic Carbon	0.2	0.1

SITE 463 HOLE CORE 58 CORED INTERVAL 509.0 to 518.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Cyclic alternations of pale pinkish white (5YR 8/1), pinkish gray (5YR 6/2, 5YR 7/2), reddish gray (5YR 5/2), and pale greenish gray limestone and silicified limestone. Pinkish and reddish colors predominate. Laminations owing to burrow flattening and bedding are common. Cherts dark reddish brown (5YR 3/2) and dark gray (N4) in color are found at 55–60, 102–103, 124, 166, 209–214, 285–292, 335, 348–350, 376–381, 391–396, and 431 cm. The cyclic alternations are on the order of centimeters in length.

SMEAR SLIDE SUMMARY %

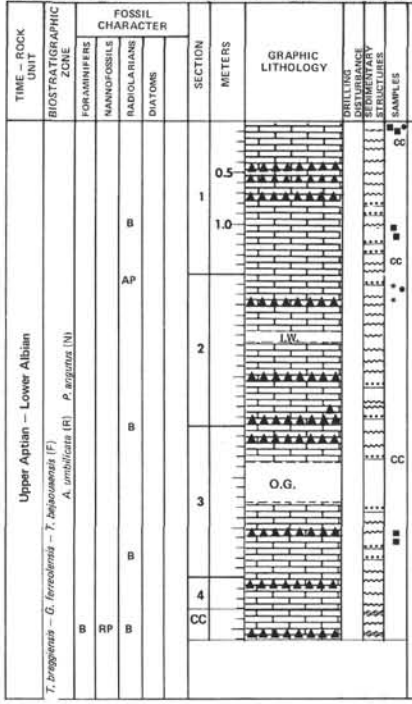
	1-91	1-95
Quartz	1	Tr
Pyrite	Tr	Tr
Carbonate unspec.	13	10
Nannofossils	86	90

Silica and Iron Content:		1-10 (green)	1-14 (pink)	3-14 (green)	3-20 (pink)	3-66 (pink)	3-71 (green)
SiO_2	=	56%	19.5%	32%	23%	24%	46%
Fe	=	0.61%	0.33%	0.42%	1.1%	1.1%	0.62%

Carbonate Content: 2-10 = 70%

Carbon-Carbonate:	1-10	3-10
% Carbonate	80.0	81.6
% Organic Carbon	0.1	0.3

SITE 463 HOLE CORE 59 CORED INTERVAL 518.5 to 528.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Cyclic alternations of pale pinkish white (5YR 8/1), pinkish gray (5YR 6/2, 5YR 7/2), reddish gray (5YR 5/2), pale greenish gray (5GY 8/1), and greenish gray (5GY 7/1, 5GY 6/1) siliceous and silicified nannofossil limestone. Greenish grays predominate in the first section. Sections 2 and 3 show an increase in the pinkish and reddish hues and Sections 4 and Core-Catcher are dominated by reddish hues. Laminations owing to burrow flattening and bedding are common. Cherts, dark gray (N4), dark reddish brown (5YR 3/3), gray (5Y 5/1), pinkish gray (7.5YR 6/2), brown (7.5YR 5/2) and greenish gray (5G 6/1) in color are found at 48, 60, 78, 184–190, 265, 292–300, 310–315, 400–405, 450–453, and 500–502 cm. Graded beds occur at 80–85, 88–94, 109–120, 120–131, 210–216, 250–260, 270–280, 324–329, 382–386, 415–421, and 425–434 cm.

SMEAR SLIDE SUMMARY %

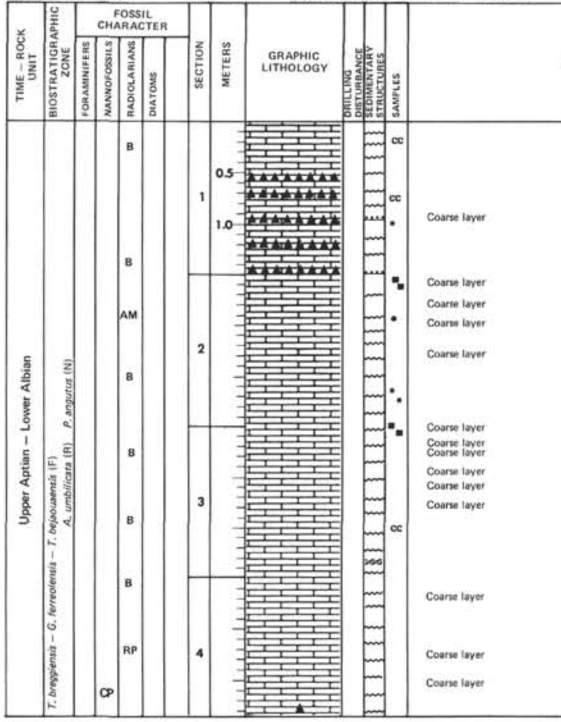
	2-18	2-28
Volcanic glass	Tr	—
Calcite rhombs	Tr	—
Carbonate unspec.	70	85
Nannofossils	30	15 15

Silica and Iron Content %:		1-1 (green)	1-7 (green)	1-106 (green)	1-114 (pink)	3-106 (pink)	3-120 (pink)
SiO_2	=	30%	36%	46%	41%	24%	23%
Fe	=	0.37%	1.2%	0.37%	0.84%	0.51%	0.4%

Carbonate Content: 1-10 = 80%
2-16 = 66%

Carbon-Carbonate:	1-18	3-139
	86.6	72.5
	0.1	0.1

SITE 463 HOLE CORE 60 CORED INTERVAL 528.0 to 535.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL AND NANNOFOSSIL FORAMINIFER LIMESTONE

Cyclic alternations of pale pinkish white (5YR 8/1), pinkish gray (5YR 6/2, 5YR 7/2), reddish gray (5YR 5/2), pale greenish gray (5GY 8/1) and greenish gray (5GY 7/1, 5GY 6/1) siliceous nannofossil limestone. Also cycles of very pale brown (10YR 7/3) nannofossil foraminifer limestone which are indicated as coarser layers. The nannofossil-limestone commonly shows laminations owing to flattened burrows and bedding. These are not apparent in the nannofossil-foraminifer limestone. Pink, red, and brown colors predominate over the greenish ones. Graded beds are found at: 95–100 and 140–143 cm. Cherts, reddish gray (5YR 5/2), dark reddish gray (5YR 4/2), dark reddish brown (5YR 3/4, 5YR 3/3) are found at 60–65 cm, 75–77 cm, 95 cm, 120–125 cm, and 584 cm.

SMEAR SLIDE SUMMARY %

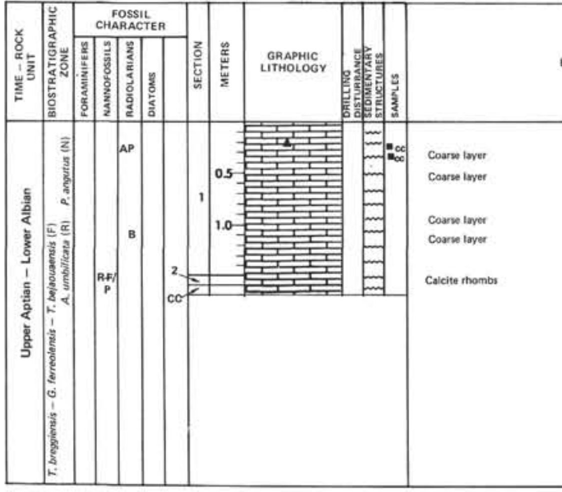
	1-100	2-119	2-125
Heavy minerals	—	—	2
Volcanic glass	—	Tr	Tr
Micronodules	—	—	1
Carbonate unspec.	55	15	28
Foraminifers	20	5	10
Nannofossils	20	80	59
Radiolarians	5	—	—

Silica and Iron Content:		2-10 (green)	2-13 (pink)	3-1 (green)	3-5 (pink)
SiO_2	=	13%	31%	17%	19%
Fe	=	0.49%	2.7%	0.58%	1.6%

Carbonate Content: 2-42 = 88%

Carbon-Carbonate:	1-18	1-78	3-110
% Carbonate	80.0	1.7	64.1
% Organic Carbon	0.1	0.1	0.1

SITE 463 HOLE CORE 61 CORED INTERVAL 535.5 to 537.5 m



LITHOLOGIC DESCRIPTION

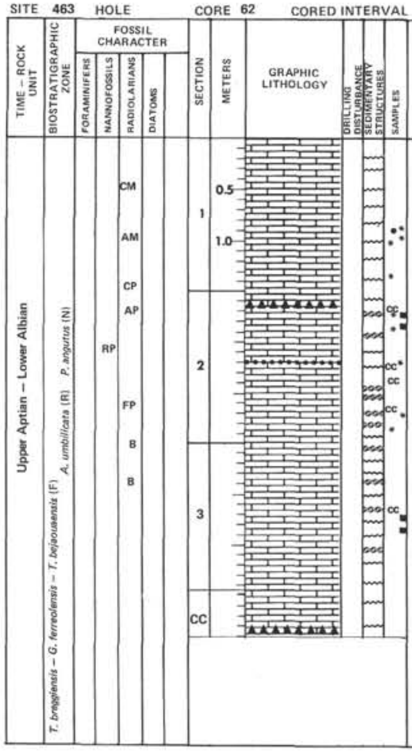
NANNOFOSSIL AND NANNOFOSSIL FORAMINIFER LIMESTONE

Cyclic alternations of pale pinkish white (5YR 8/1), pinkish gray (5YR 6/2, 5YR 7/2), reddish gray (5YR 5/2), pale greenish gray (5GY 8/1), and dark greenish gray (5GY 7/1, 5GY 6/1) nannofossil limestone. Also cycles of very pale brown (10YR 7/3) nannofossil foraminifer limestone which are indicated as "coarse" layers. The nannofossil limestone commonly shows laminations owing to flattened burrows and bedding. The nannofossil foraminifer limestone is uniform without structures. Pink, red, and brown colors predominant in this core. A dark reddish brown (5YR 3/3) chert is found at 17 cm. The cyclic alternations are on the scale of a few centimeters to 20 centimeters.

Silica and Iron Content:		1-28 (pink)	1-29
SiO_2	=	29.5%	30%
Fe	=	0.78%	0.79%

Carbon-Carbonate:	1-20	1-28
% Carbonate	55.8	54.1
% Organic Carbon	0.1	0.0

SITE 463 HOLE CORE 62 CORED INTERVAL 537.5 to 547.0 m



LITHOLOGIC DESCRIPTION

LIMESTONE
Cyclic alternations of pinkish white (5YR 8/2), pinkish gray (5YR 7/2, 5YR 6/2), reddish gray (5YR 5/2, 5YR 4/2), pale greenish gray (5GY 8/1), greenish gray (5GY 7/1, 5GY 6/1, 5G 6/1, 5G 5/1), and dark greenish gray to greenish black (5G 4/1 to 5BG 4/1) siliceous limestone. Most contacts are very gradational and burrowed. Laminations are common as a result of flattened burrows and bedding. Cherts, gray (N5) and greenish black (5BG 4/1) are at 160–164 and 335–339 cm. A greenish black altered ash is at 216–222 cm. The first section is dominated by pinkish colors, the second by greenish colors, the last is slightly dominated by pinkish ones. Alternations are on the scale of centimeters to about 15 cm.

Ash bed

SMEAR SLIDE SUMMARY %

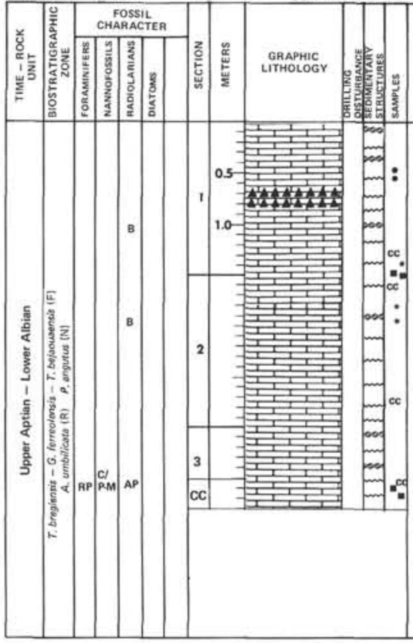
	1-83	1-99	1-106	1-137	2-24	2-32	2-70 (M)	2-122	2-132 (M)
Quartz	—	—	Tr	—	—	—	Tr	—	Tr
Feldspar	—	—	Tr	—	—	—	Tr	—	Tr
Clay (aggregates)	—	—	—	—	—	—	—	—	10
Volcanic glass	—	—	—	—	Tr	Tr	95	Tr	30
Hematite	Tr	Tr	Tr	Tr	Tr	Tr	—	Tr	—
Carb. unspec.	60	50	85	60	70	70	Tr	60	Tr
Calcite rhombs	—	—	—	—	—	—	—	Tr	—
Foraminifers	40	40	10	40	30	30	—	40	—
Nannofossils	Tr	10	Tr	Tr	Tr	Tr	Tr	Tr	—

Silica and Iron Content:	2-17 (green)	2-35 (pink)	3-78 (green)	3-84 (pink)
SiO_2 =	28%	31%	19%	22%
Fe =	0.49%	0.67%	0.43%	0.54%

Carbonate Content: 1-91 = 57%

Carbon-Carbonate:	2-14	2-71	2-90	2-116	3-64
% Carbonate	60.8	12.5	30.8	53.3	75.8
% Organic Carbon	0.0	0.1	0.1	1.3	0.1

SITE 463 HOLE CORE 63 CORED INTERVAL 547.0 to 556.5 m



LITHOLOGIC DESCRIPTION

LIMESTONE
Cyclic alternations of pale pinkish white (5YR 8/1), pinkish gray (5YR 6/2, 5YR 7/2), reddish gray (5YR 5/2), pale greenish gray (5GY 8/1), and greenish gray (5GY 7/1, 5GY 6/1) siliceous limestone. Most contacts are gradational. Laminations and burrows are common. One coarser layer (sandy) enriched in foraminifers is at 357–361 cm. White (N8) and and dark gray chert is at 72–75 cm and 80–83 cm. Alternations are on the scale of centimeters to 20 cm. Pinkish colors predominate in this core.

SMEAR SLIDE SUMMARY %

	2-5	2-30	2-45
Hematite	Tr	—	—
Brown carbon aggregates	40	—	—
Carbonate unspec.	60	80	—
Foraminifers	—	20	40
Nannofossils	—	—	60
Radiolarians	—	—	Tr

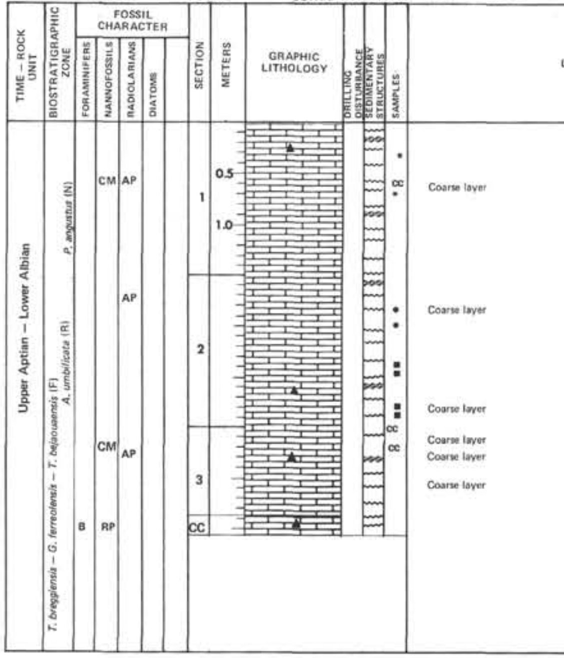
Coarse layer

Silica and Iron Content:	2-2 (pink)	2-5 (green)	CC-10 (pink)	CC-16 (green)
SiO_2 =	29%	9.1%	30%	11%
Fe =	1.9%	0.34%	1.3%	0.41%

Carbonate Content: 1-47 = 79%
1-52 = 62%

Carbon-Carbonate:	1-128	2-2	2-128	CC-10
% Carbonate	83.3	55.8	75.8	50.8
% Organic Carbon	0.1	0.1	0.0	0.1

SITE 463 HOLE CORE 64 CORED INTERVAL 556.5 to 566.0 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL AND FORAMINIFER NANNOFOSSIL LIMESTONE

Cyclic alternations of pale red (2.5YR 6/2), dark brown (7.5YR 4/2), and light greenish gray (5Y 7/1, 5GY 7/1) siliceous limestone. Most contacts are gradational. Laminations and burrows are common throughout, but most obvious in the pale red units. Chert is found at 31, 274, 335, and 400 cm. Coarse layers, enriched in radiolarians and recrystallized foraminifers, light greenish gray (5Y 7/1, 5GY 7/1) in color, are at: 63–71, 179–186, 282–285, 316–320, 328–331, and 352–355 cm. Alternations are on the scale of centimeters to 25 cm. Reddish colors predominate in this core. One bivalve fragment at 375 cm.

SMEAR SLIDE SUMMARY %

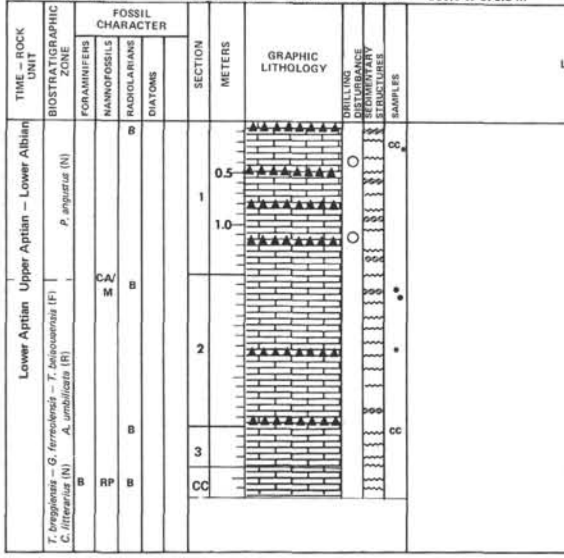
	1-35	1-68
Feldspar	Tr	—
Volcanic glass	Tr	—
Opaques	—	1
Carbonate unspec.	20	15
Foraminifers	—	15
Nannofossils	80	69

Silica and Iron Content:	2-91 (pink)	2-96 (green)	2-131 (green)	2-137 (pink)
SiO_2 =	11%	14%	23%	24%
Fe =	1.9%	0.44%	0.59%	1.6%

Carbonate Content: 2-34 = 85%
2-52 = 69%

Carbon-Carbonate:	1-68	3-9	3-29
% Carbonate	63.3	60.0	51.7
% Organic Carbon	0.1	0.1	0.1

SITE 463 HOLE CORE 65 CORED INTERVAL 566.0 to 575.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Cyclic alternations of pinkish white (5YR 8/2), pinkish gray (5YR 7/2, 5YR 6/2), reddish gray (5YR 5/2, 5YR 4/2), pale greenish gray (5GY 8/1), geenish gray (5GY 7/1, 5GY 6/1, 5GY 5/1, 5G 4/1), and greenish black (5BG 4/1). Laminations and burrows are common. Contacts are usually gradational. Cherts, gray (N6), greenish gray (5GY 7/1), gray (5YR 5/1), light gray (5YR 7/1), and grayish brown (10YR 5/2), are at 0–5 cm, 43–50 cm, 80 cm, 121 cm, 230 cm, and 146–155 cm. Alternations are on the scale of centimeters to 15 cm.

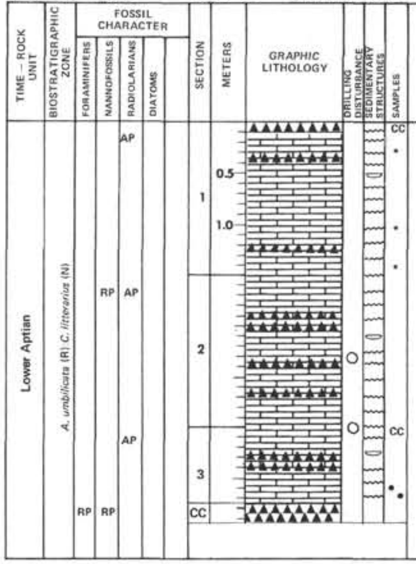
SMEAR SLIDE SUMMARY %

	1-20	2-65
Heavy minerals	—	Tr
Volcanic glass	—	Tr
Carbonate unspec.	13	25
Foraminifers	5	20
Nannofossils	80	55
Radiolarians	2	—

Carbonate Content: 2-16 = 85%
2-27 = 73%

Carbon-Carbonate:	1-14	3-7
% Carbonate	69.1	75.8
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 66 CORED INTERVAL 575.5 to 585.0 m



LITHOLOGIC DESCRIPTION

RADIOLARIAN NANNOFOSSIL LIMESTONE

Cyclic alternations of white (5Y 8/1, N8, 10YR 8/1), light gray (5Y 7/1), green (5GY 8/1, 7/1; 5G 8/1, 7/1; 5Y 7/1), and dark green (5GY 6/1, 5/1; 5G 6/1, 5/1) limestone. Contacts are gradational. Coarse layers are enriched in radiolarians and appear to have erosional bottom contacts. Cherts, light gray (N7, 10YR 6/1), and gray (N6, N5), are at : 0–10, 36–40, 128–132, 194–196, 245, 265–271, 311, 332–334, 345, and 375–391 cm. Alternations are on the scale of centimeters to 45 cm. Grays predominate over the greens.

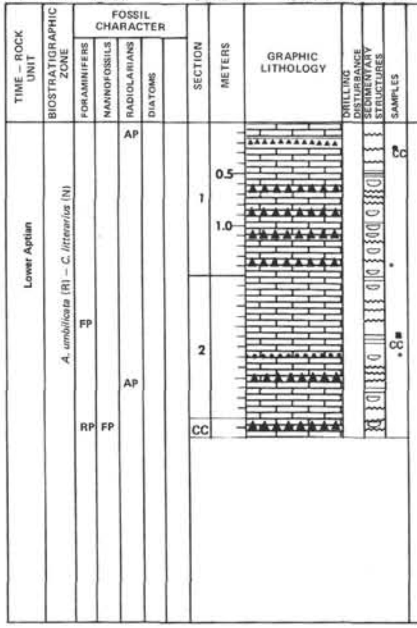
SMEAR SLIDE SUMMARY %

	1-28 (M)	1-108	1-140 (M)
Quartz	—	Tr	—
Opaques	—	2	—
Volcanic glass	—	Tr	—
Carbonate unspec.	30	15	20
Nannofossils	40	83	75
Radiolarians	30	—	15

Carbonate Content: 3-64 = 77%
3-79 = 68%

Carbon-Carbonate:	1-10	3-10
% Carbonate	100.0	70.8
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 67 CORED INTERVAL 585.0 to 594.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Cyclic alterations of light bluish gray (5B 7/1), light olive gray (5Y 6/1), medium bluish gray (5B 5/1), light gray (N7), and greenish black (5G 2/1) siliceous limestone. Most contacts are gradational. Laminations and burrows are common. Erosional contacts are at: 61, 81, 100, 106, 122, 145, 151, 156, 226, 270, and 300 cm. Cherts, light gray (N7) and dark gray (N4) in color, are found at 16–26, 65, 86–94, 110, 137–140, 241–245, and 148–150 cm. Alternations are on the scale of centimeters to 60 cm. Bluish gray colors predominante.

SMEAR SLIDE SUMMARY %

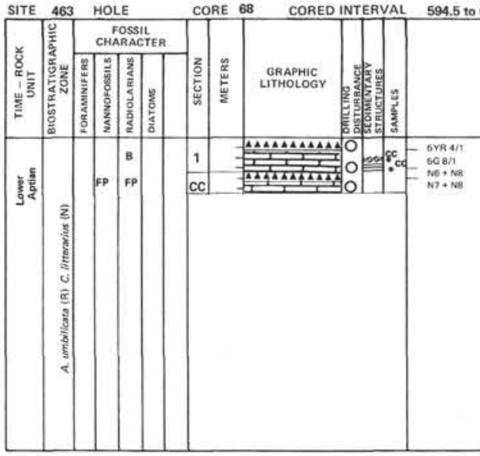
	1-134 (M)	2-74 (M)
Quartz	Tr	—
Feldspar	—	Tr
Volcanic glass	—	98
Pyrite	—	Tr
Carbonate unspec.	10	2
Nannofossils	65	—
Radiolarians	25	—

Silica and Iron Content:	2-56
SiO_2 =	13%
Fe =	0.46%

Carbonate Content: 1-24 = 58%

Carbon-Carbonate:	1-25	2-74
% Carbonate	83.3	19.2
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 68 CORED INTERVAL 594.5 to 604.0 m



LITHOLOGIC DESCRIPTION

LIMESTONE AND CHERT DRILLING BRECCIA

0–11 and 32–42 cm: Chert fragments, brownish gray (5YR 4/1) gray (N6) and white (N8) in color.

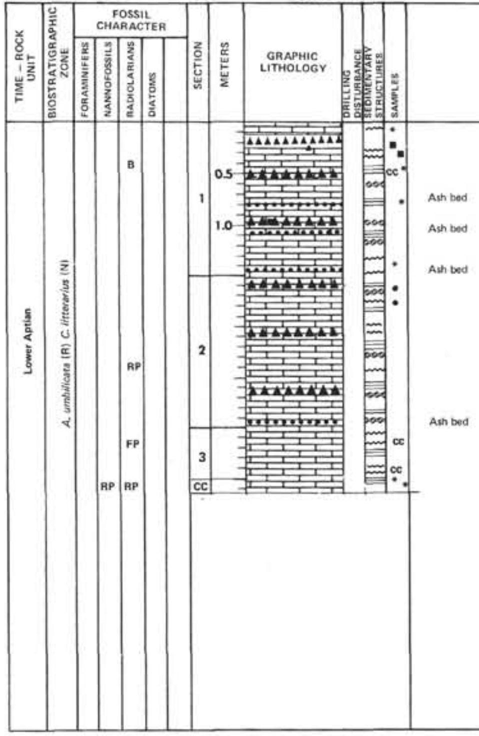
11–32 and 42–57 cm: Limestone fragments greenish gray (5G 8/1, 5G 6/1), greenish black (5G 2/1), light gray (N7) and white (N8) in color.

SMEAR SLIDE SUMMARY %

	1-22 (M)	1-22
Quartz	Tr	Tr
Feldspar	—	Tr
Clay	—	30
Volcanic glass	100	70
Pyrite	Tr	Tr
Nannofossils	Tr	Tr

Carbon-Carbonate:	1-16	1-22
% Carbonate	86.6	18.3
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 69 CORED INTERVAL 604.0 to 613.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL LIMESTONE

Cyclic alternations of bluish white (5B 9/1), medium bluish gray (5B 5/1), light bluish gray (5B 7/1), greenish gray (5G 6/1), light gray (N7), and dark greenish gray (5G 4/1, 5G 2/1) siliceous limestone. Ash beds, greenish black (5GY 2/1), and greenish gray (5G 6/1) in color, are at: 80, 110, 146–150, and 295–300 cm. Burrow and bedding laminations are common. Most contacts are gradational. Cherts, brownish gray (5YR 4/1), light olive gray (5Y 6/1), dark reddish brown (5YR 3/2), dark gray (5YR 4/1), very dark gray (10YR 3/1), and light gray (N7) in color, are found at: 13–27, 56–59, 102, 152–161, 209–211, and 265 cm. Alternations are on the scale of centimeters to 25 cm.

SMEAR SLIDE SUMMARY %

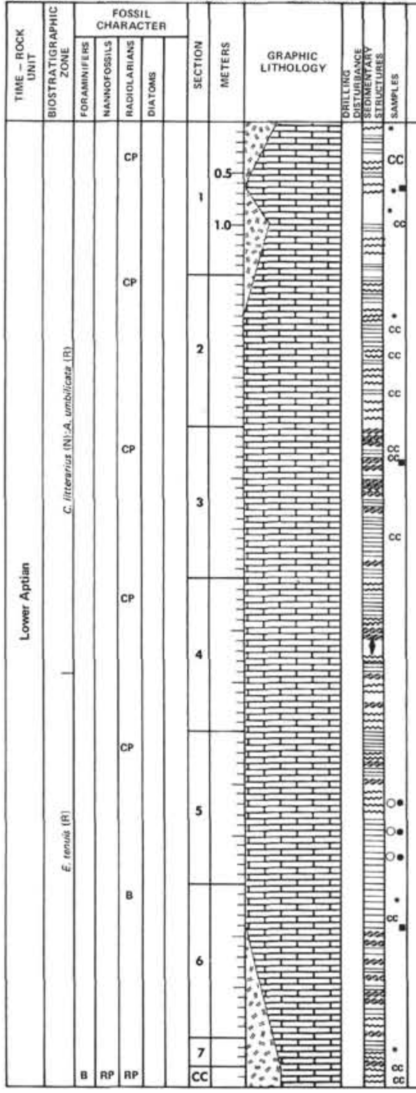
	1-10	1-42 (M)	1-76 (M)	1-140	CC-3 (M)	CC-8
Quartz	Tr	—	Tr	Tr	1	—
Feldspar	Tr	—	—	Tr	1	1
Clay	—	—	100	—	98	5
Opaques	—	Tr	—	—	—	Tr
Volcanic glass	Tr	—	—	7	Tr	—
Pyrite	—	—	—	—	Tr	Tr
Carbonate unspec.	60	50	—	43	—	53
Nannofossils	40	50	Tr	50	Tr	40
Radiolarians	—	—	—	—	—	1

Silica and Iron Content:	1-30	1-40
SiO_2 =	10%	21%
Fe =	0.93%	2.9%

Carbonate Content: 2-18 = 85%
2-30 = 42%

Carbon-Carbonate:	1-46	3-16	3-41
% Carbonate	75.8	30.0	25.8
% Organic Carbon	1.5	0.8	1.6

SITE 463 HOLE CORE 70 CORED INTERVAL 613.5 to 623.0 m



LITHOLOGIC DESCRIPTION

SILICIFIED LIMESTONE–ASHY LIMESTONE–CARBONACEOUS LIMESTONE

Cyclic alternations of bluish white (5B 9/1), medium light gray (N6), light bluish gray (5B 7/1), medium bluish gray (5B 5/1), greenish gray (5G 6/1), olive black (5Y 2/1), greenish black (5G 2/1) limestone. Contacts are both sharp and gradational. Darker layers show fine parallel laminations without burrowing and are enriched in organic carbon. Burrows are abundant in the lighter colored sections. Some dark beds are enriched in volcanic ash. Many horizons are enriched in calcite rhombs 2–3 mm in size. Alternations are on the scale of centimeters to 60 cm.

SMEAR SLIDE SUMMARY %

	1-4	1-67	1-95	2-40	6-30	7-17
Quartz	—	—	Tr	15	—	5
Feldspar	—	—	Tr	—	—	10
Volcanic glass	15	—	15	—	—	30
Pyrite	Tr	Tr	Tr	—	10	—
Organic carbon	—	—	—	—	20	—
Carbonate unspec.	85	100	85	85	70	55
Calcite rhombs	—	Tr	—	—	—	—
Nannofossils	Tr	Tr	Tr	—	—	—

Silica and Iron Content:	1-69	3-35	6-41
SiO_2 =	61%	87%	86%
Fe =	0.65%	1.7%	1.7%

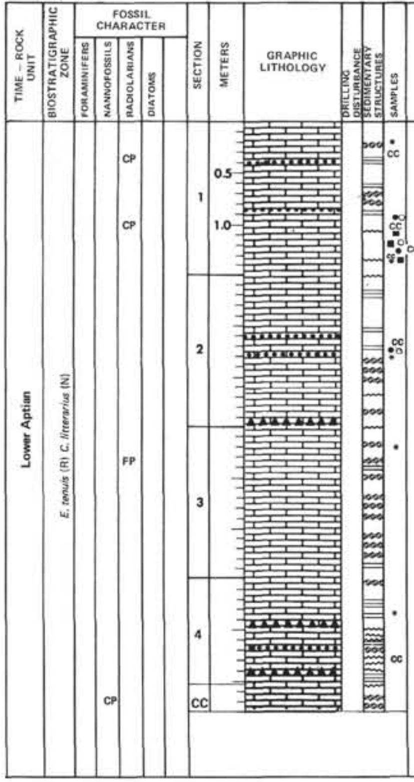
Carbonate Content: 5-65 = 37%
5-99 = 23%
5-119 = 22%

Organic Carbon: 5-65 = 0.2%
5-99 = 2.6%
5-119 = 4.3%

Carbon-Carbonate:	1-32	1-100	2-58	2-84	2-116	3-22
% Carbonate	26.7	15.0	22.2	1.7	9.9	21.7
% Organic Carbon	0.0	0.3	1.5	0.6	2.4	5.1

	3-32	3-33	3-103	6-31	CC-0	CC-10
% Carbonate	26.7	1.7	7.5	37.5	29.2	19.2
% Organic Carbon	4.1	0.6	0.5	0.1	0.1	0.7

SITE 463 HOLE CORE 71 CORED INTERVAL 623.0 to 632.5 m



LITHOLOGIC DESCRIPTION

SILICIFIED LIMESTONE–ASHY LIMESTONE–CALCAREOUS ASH

Cyclic alterations of greenish gray (5G 6/1), dark greenish gray (5G 4/1), white (5G 8/1), medium bluish gray (5B 5/1), light bluish gray (5B 7/1), light gray green (5GY 8/1), and dark greenish gray (5GY 4/1) limestone and ashy limestone. Calcareous ash, greenish black (5G 2/1) and olive black (5Y 2/1) in color is found at 36–41, 56–61, 120–125, 208–211, 225–230, and 514 cm. Cherts, gray (N5) and light gray (N6) in color, are found at 290–295 cm, 497–499, and 538–542 cm. Alterations are on the scale of centimeters to 20 cm. Most contacts are sharp. Burrows are common at: 65–81, 233–260, 285–290, 315–320, 333–348, 365–387, 400–435, 458, 520–522, and 552–575 cm.

SMEAR SLIDE SUMMARY %

	1-20	1-133	2-80	4-39
Quartz	5	—	—	—
Feldspar	10	—	—	—
Clay	—	—	60	—
Volcanic glass	25	—		—
Opaques	—	2	—	—
Carbonate unspec.	60	98	20	100
Organic carbon	—	—	20	—

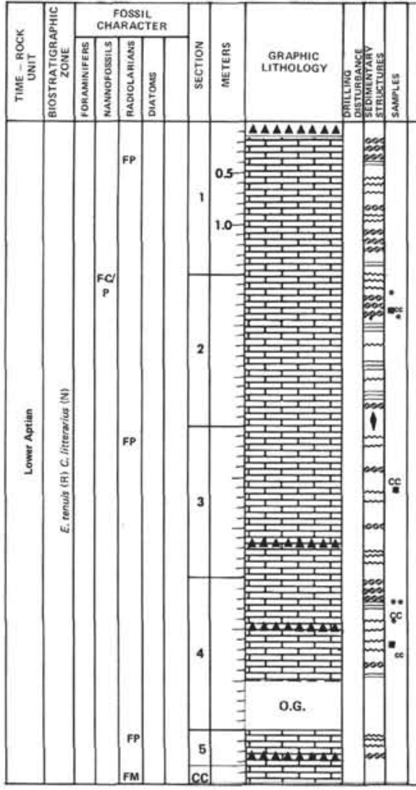
Silica and Iron Content:	1-110	1-121	1-134
SiO_2 =	93%	57%	60%
Fe =	0.75%	3.5%	0.54%

Carbonate Content:
1-96 = 1.5%
1-123 = 5.5%
2-76 = 8.5%
3-21 = 36%

Organic Carbon:
1-96 = 0.1%
1-123 = 0.5%
2-76 = 0.5%

Carbon-Carbonate:	1-30	1-97	1-124	1-133	2-74	4-78
% Carbonate	17.5	2.9	2.6	34.2	6.7	84.1
% Organic Carbon	0.2	0.0	0.4	0.2	0.4	0.1

SITE 463 HOLE CORE 72 CORED INTERVAL 632.5 to 642.0 m



LITHOLOGIC DESCRIPTION

Calcite filled veins

Calcite filled vein

SILICIFIED LIMESTONE

Cyclic alternations of light gray (5Y 7/1, N7), light greenish gray (5GY 7/1, 5GY 6/1), light olive gray (5Y 6/1), and light bluish green (5BG 6/1) limestone. Relatively structureless with some burrowing and whispy discontinuous laminae and streaks. Contacts are fairly sharp, but some gradational color changes occur. Cherts, dark reddish brown (5YR 3/2), white (N8), dark greenish gray (5GY 4/1) and moderate brown (5YR 3/4) in color, occur at: 0–15, 420–424, 497 and 626 cm. Alternations are on the scale of centimeters to 50 cm.

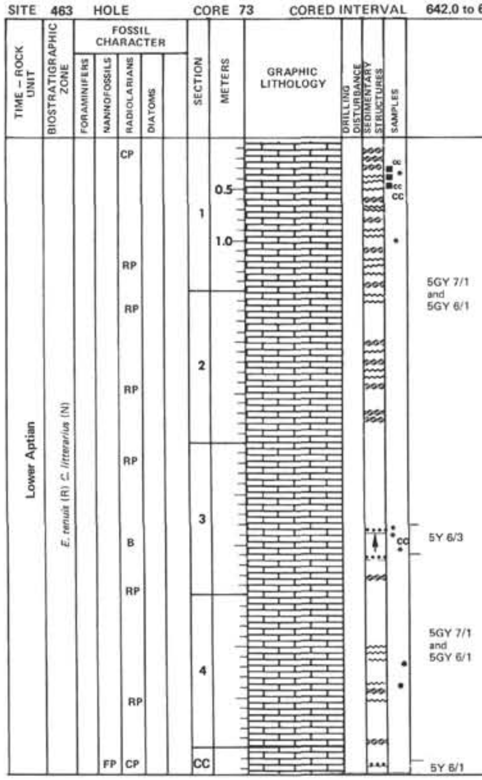
SMEAR SLIDE SUMMARY %

	2-15	2-40	4-27 (M)	4-27	4-40
Quartz	—	—	5	—	—
Volcanic glass	Tr	—	5	—	Tr
Iron oxides	—	—	1	—	—
Pyrite	—	Tr	2	Tr	—
Carbonate unspec.	95	93	75	100	100
Calcite rhombs	—	—	—	Tr	—
Nannofossils	5	2	12	—	—
Radiolarians	Tr	5	—	—	—

Silica and Iron Content:	2-38	3-64	4-62
SiO_2 =	53%	46%	35%
Fe =	1.0%	0.67%	0.40%

Carbon-Carbonate:	2-37	3-60	4-24	4-65
% Carbonate	56.6	51.6	23.3	65.8
% Organic Carbon	0.1	0.1	1.4	0.1

SITE 463 HOLE CORE 73 CORED INTERVAL 642.0 to 651.5 m



LITHOLOGIC DESCRIPTION

LIMESTONE

Dominantly greenish gray (5GY 7/1, 5GY 6/1) limestone with subtle variations of light greenish gray (5GY 8/1), greenish gray (5G 6/1) and dark greenish gray (5G 4/1) siliceous and silicified limestone. Boundaries are gradational. Burrows, discontinuous laminations and streaks are common. Turbidites are present at 380–413 and 610–612 cm. These are pale olive (5Y 6/3) and gray (5Y 6/1) in color and are composed of granule-size and smaller clasts of carbonate, pyrite, glauconite and quartz. The contacts of the graded bed are sharp.

SMEAR SLIDE SUMMARY %

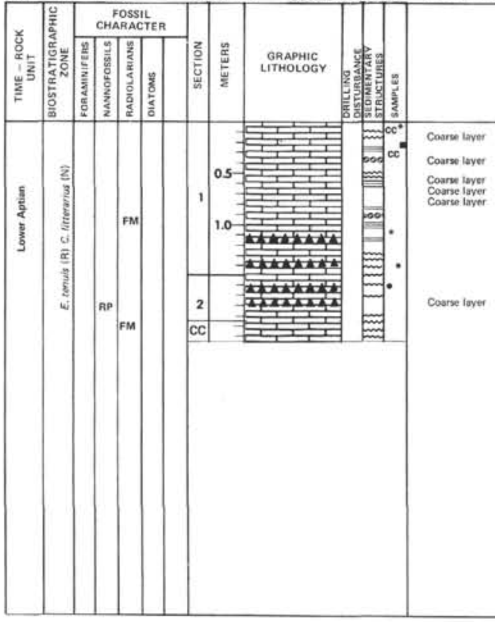
	1-37	1-100	3-87	3-97	3-107
Feldspar	Tr	—	Tr	—	—
Volcanic glass	—	Tr	Tr	—	—
Zeolite	—	Tr	Tr	—	—
Carbonate unspec.	100	100	85	95	100
Calcite rhombs	Tr	Tr	15	5	—
Nannofossils	Tr	Tr	Tr	—	—
Pyrite	—	—	—	Tr	Tr

Silica and Iron Content:	1-36	1-49	1-59
SiO_2 =	36%	55%	71%
Fe =	1.9%	0.57%	0.62%

Carbonate Content: 4-75 = 8%
4-90 = 30%

Carbon-Carbonate:	1-36	1-49	1-59	3-98
% Carbonate	44.2	39.2	29.2	87.5
% Organic Carbon	0.2	0.1	0.0	0.6

SITE 463 HOLE CORE 74 CORED INTERVAL 651.5 to 661.0 m



LITHOLOGIC DESCRIPTION

LIMESTONE

Cyclic alternations of yellowish gray (5Y 7/1), light bluish gray (5B 7/1), dark greenish gray (5G 4/1), light greenish gray (5GY 7/1), greenish gray (5G 6/1), and olive (5Y 4/1) siliceous limestone. Burrowing and mottles are common, as well as wavy discontinuour laminae. Coarse sandy layers are at: 19, 35, 50, 65, and 72–73 cm. Cherts, dark gray (N3), olive black (5Y 2/1) and dark greenish gray (5G 4/1) in color, are at: 121, 137–140, 166–170, and 180–182 cm.

SMEAR SLIDE SUMMARY %

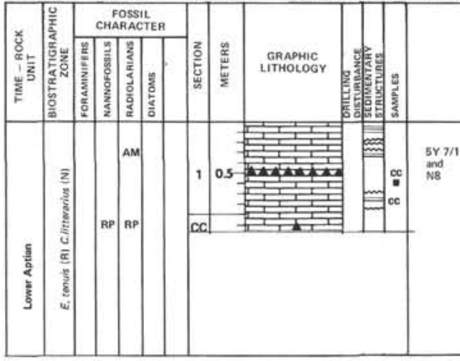
	1-7	1-108	1-149
Quartz	5	5	—
Feldspar			—
Heavy minerals	Tr	—	—
Volcanic glass	5	3	—
Pyrite	—	—	Tr
Carbonate unspec.	60	86	100
Calcite rhombs	30	—	Tr
Nannofossils	—	3	—
Radiolarians	—	3	—

Silica and Iron Content:	1-28
SiO_2 =	34%
Fe =	0.34%

Carbonate Content: 2-13 = 86%

Carbon-Carbonate:	1-10	1-30
% Carbonate	6.7	69.1
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 75 CORED INTERVAL 661.0 to 670.5 m



LITHOLOGIC DESCRIPTION

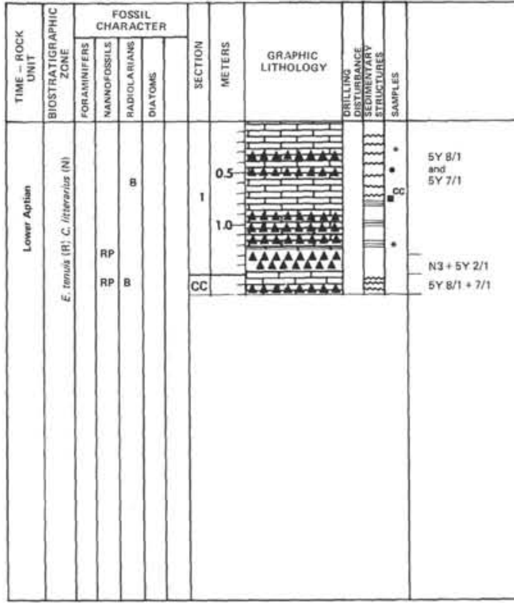
LIMESTONE

Light gray green (5Y 7/1) to white (N8) limestone with dark greenish gray (5GY 4/1) laminae. One layer of dark gray (N4) chert at 48–50 cm and one piece of chert is at 103 cm.

Silica and Iron Content:	1-52
SiO_2 =	4%
Fe =	0.37%

Carbon-Carbonate:	1-51	1-80
% Carbonate	89.1	20.0
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 76 CORED INTERVAL 670.5 to 680.0 m



LITHOLOGIC DESCRIPTION

LIMESTONE AND CHERT

Dominantly white to light gray (5Y 8/1–5Y 7/1) fragments of silicified limestone, showing whispy laminae, dark greenish gray (5G 4/1) and greenish black (5G 2/1) in color. Darker, well-laminated sections grayish black (5GY 2/1) in color are at 78–80 and 100–105 cm. Cherts, light gray (N7), gray (N5), and dark gray (N3) in color, are found at 34–40, 49–51, 90–95, 104–106, 111–120, 126–150 and 165–170 cm.

SMEAR SLIDE SUMMARY %

	1-25	1-123 (M)
Quartz	—	10
Feldspar	—	
Clay	—	30
Glauconite	—	Tr
Calcite rhombs	—	5
Carbonate unspec.	80	55
Foraminifers	20	—

Silica and Iron Content: 1-71

SiO_2 = 58%

Fe = 0.31%

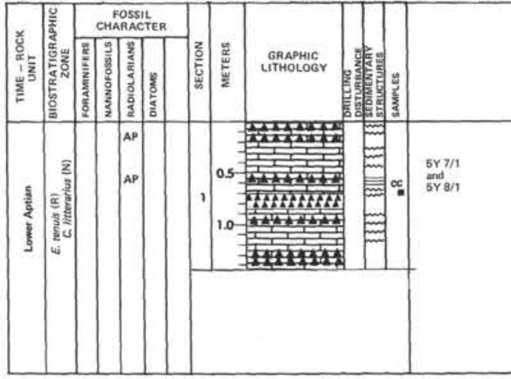
Carbonate Content: 1-46 = 41%

Carbon-Carbonate: 1-70

% Carbonate 46.7

% Organic Carbon 0.1

SITE 463 HOLE CORE 77 CORED INTERVAL 680.0 to 689.5 m



LITHOLOGIC DESCRIPTION

LIMESTONE AND CHERT

White (5Y 8/1) and light gray (5Y 7/1) limestone with dark greenish gray (5G 4/1) and greenish black (5GY 2/1) wavy laminae and thin beds. Cherts, light gray (N7), brownish black (5YR 2/1), and dark gray (N4) in color, are at 10–13, 17–19, 48–56, 69–85, 95, 125–130 and 135–140 cm.

Silica and Iron Content: 1-60

SiO_2 = 11%

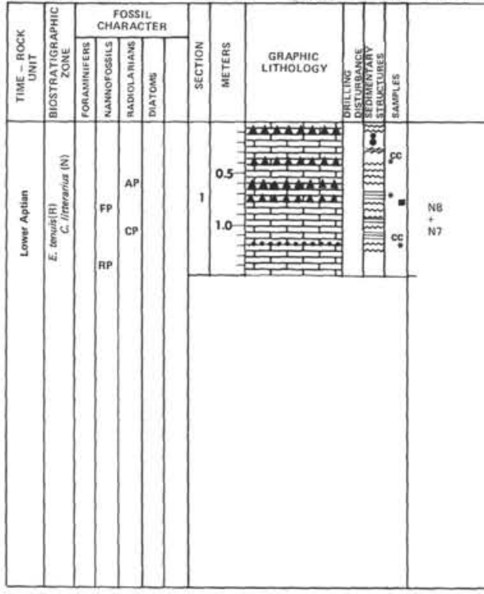
Fe = 0.34%

Carbon-Carbonate: 1-60

% Carbonate 85.8

% Organic Carbon 0.1

SITE 463 HOLE CORE 78 CORED INTERVAL 689.5 to 699.0 m



LITHOLOGIC DESCRIPTION

LIMESTONE–RADIOLARIAN LIMESTONE

Dominantly white (N8) to light gray (N7) limestone with burrows and gray (N6) wavy laminations. A graded bed of limestone (2 mm and finer), light gray (10YR 7/1) in color, is at 17–22 cm. Radiolarian limestones, gray (5Y 5/1), light gray (10YR 7/1), and dark gray (N4) in color with a sandy texture, are found at 36–40, 71, 83–85, 93–94, and 103–110 cm. A medium bluish gray (5B 5/1) calcareous ashy clay is at 117–119 cm.

SMEAR SLIDE SUMMARY %

	1-38	1-71	1-118
Quartz	—	10	—
Feldspar	—		—
Clay	—	20	40
Glauconite	Tr	—	—
Pyrite	—	5	—
Volcanic glass	—	—	35
Carbonate unspec.	60	35	20
Radiolarians	40	30	—
Nannofossils	—	—	Tr

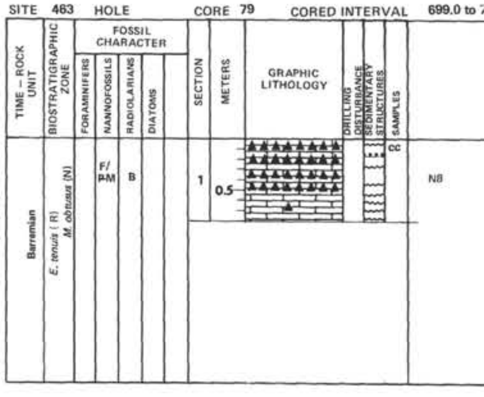
Silica and Iron Content: 1-74

SiO_2 = 11%

Fe = 0.32%

Carbon-Carbonate:	1-34	1-118
% Carbonate	83.3	3.3
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 79 CORED INTERVAL 699.0 to 708.5 m



LITHOLOGIC DESCRIPTION

LIMESTONE–CHERT

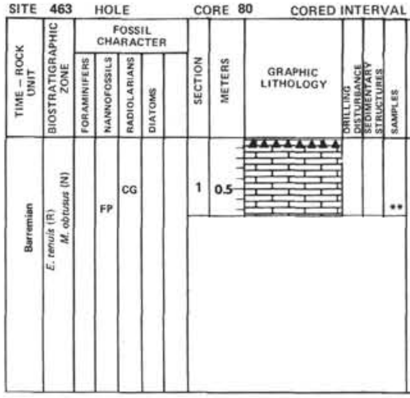
Dominantly white (N8) limestone with wavy laminations of gray (N6). One interval from 55–60 cm is more massive – without laminations. The interval from 6–18 cm shows three small graded beds, gray (10YR 6/1) to dark gray (10YR 4/1) at the base and white (10YR 8/2) at the top. Clasts are from 1 cm to finer sizes. Cherts, dark gray (N4) and dark grayish brown (10YR 4/2) in color, are at 0–2 cm, 19–22 cm, 35–39 cm, 45–47 cm and 69 cm.

Carbon-Carbonate: 1-7

% Carbonate 90.0

% Organic Carbon 0.1

SITE 463 HOLE CORE 80 CORED INTERVAL 708.0 to 710.5 m



LITHOLOGIC DESCRIPTION

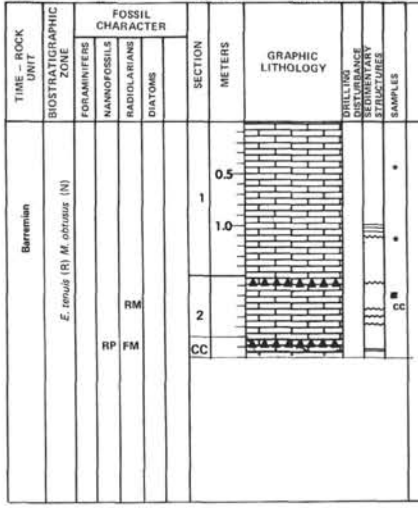
CLASTIC LIMESTONE

Possible talus breccia, dominantly light gray (N7), with gray (N6) laminations and white (10YR 8/1) pebbles up to 2 cm in size. The unit is massive, 5–75 cm. A speckled limestone, very pale brown (10YR 8/3) and dark gray (N4) is at 0–4 cm. A gray (N5) and dark gray chert is at 4–6 cm.

SMEAR SLIDE SUMMARY %

	1-70	1-70 (M)
Pyrite	Tr	Tr
Calcite rhombs	—	Tr
Carbonate unspec.	100	100

SITE 463 HOLE CORE 81 CORED INTERVAL 710.5 to 718.0 m



LITHOLOGIC DESCRIPTION

5Y 7/1
and
5Y 8/1

CLASTIC LIMESTONE

Pebbly clastic limestone, granule-size rounded clasts, white (5Y 8/1) in color, in a yellowish gray (5Y 7/1) groundmass. A few pebble-size white clasts are present. Faint horizontal bedding as a result of grain alignment. A folded structure occurs at 183–185 cm. Dark gray chert (10YR 7/1) with some light gray (10YR 7/1) contorted banding occurs at 150–158 and 211–214 cm.

SMEAR SLIDE SUMMARY %

	1-40	1-113
Pyrite	—	Tr
Calcite rhombs	Tr	—
Carbonate aggregates	25	—
Carbonate unspec.	75	100

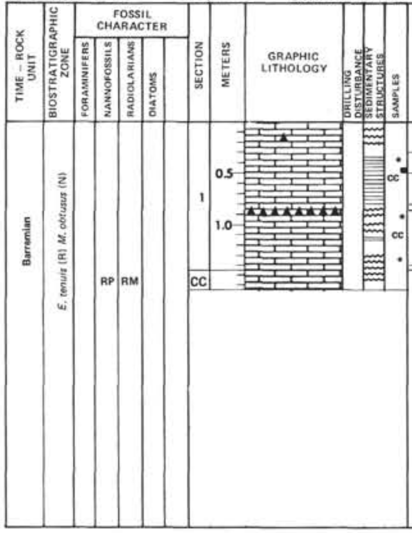
Silica and Iron Content: 2-18

SiO_2 = 11%

Fe = 0.30%

Carbon-Carbonate:	2-18
% Carbonate	85.8
% Organic Carbon	0.1

SITE 463 HOLE CORE 82 CORED INTERVAL 718.0 to 727.5 m



LITHOLOGIC DESCRIPTION

5Y 7/1 +
5Y 6/2
5Y 5/1
5Y 7/1
5Y 4/1
5Y 7/1 +
N8
5Y 6/1
5Y 7/1

LIMESTONE AND SILICIFIED LIMESTONE

Dominantly light gray (5Y 7/1, N8) and light olive gray (5Y 6/2) limestone with darker wavy laminations with gray (5Y 5/1) laminated sandy horizons at 31–52 and 141–145 cm. A clastic, sand-sized, unit of the dominant colors is at 90–97 cm with granules at 97–99 cm. Dark gray (5Y 4/1) chert is at 16 and 83–85 cm.

SMEAR SLIDE SUMMARY %

	1-45	1-97	1-133
Quartz	Tr	—	—
Feldspar	Tr	—	—
Clay	10	—	—
Pyrite	Tr	Tr	Tr
Carbonate aggregates	30	10	30
Carbonate unspec.	55	75	60
Calcite rhombs	5	15	10

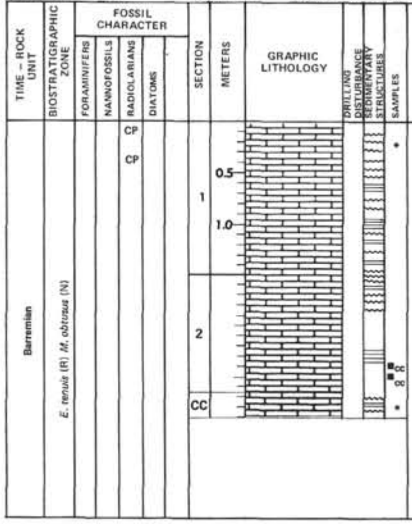
Silica and Iron Content: 1-48

SiO_2 = 71%

Fe = 0.95%

Carbon-Carbonate	1-48	1-115
% Carbonate	20.0	13.3
% Organic Carbon	0.1	0.2

SITE 463 HOLE CORE 83 CORED INTERVAL 727.5 to 737.0m



LITHOLOGIC DESCRIPTION

Coarse layer

2x4 mm pyrite

Coarse layers

LIMESTONE

Light gray (5Y 7/1, N7) limestones with darker lenses, laminae and contorted laminae. Clastic limestones with granule-size carbonate at 98–100 and 245–255 cm. Pebble-size clasts at 255–263 cm.

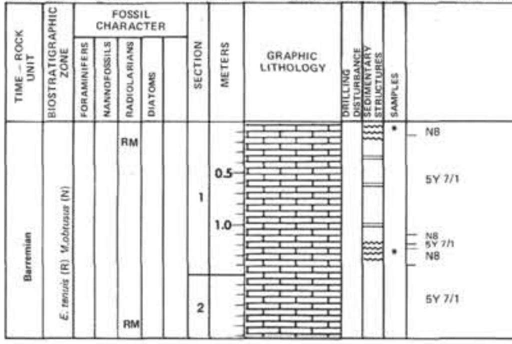
SMEAR SLIDE SUMMARY %

	1-27	CC-13
Quartz	—	Tr
Feldspar	—	Tr
Clay–carbonate aggregates	Tr	40
Volcanic glass	—	Tr
Pyrite	—	Tr
Brown aggregates	3	—
Carbonate unspec.	92	60
Calcite rhombs	5	—
Radiolarians	—	Tr

Silica and Iron Content:	2-89	2-93
SiO_2 =	16%	27%
Fe =	0.38%	0.49%

Carbon-Carbonate:	2-89	2-93
% Carbonate	74.1	68.3
% Organic Carbon	0.1	0.1

SITE 463 HOLE CORE 84 CORED INTERVAL 737.0 to 746.5 m



LITHOLOGIC DESCRIPTION

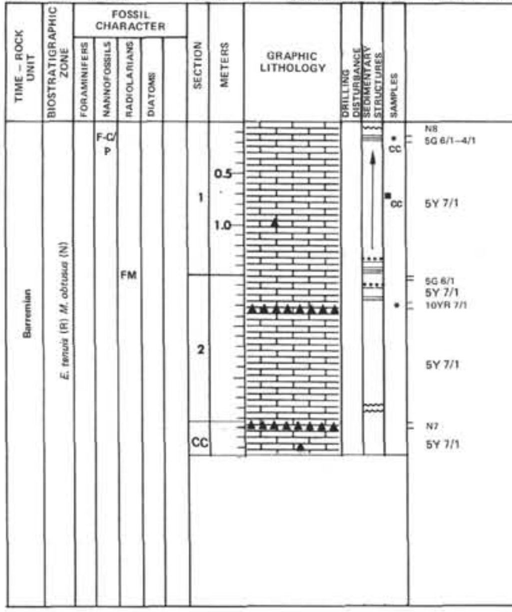
CLASTIC LIMESTONE

Dominantly a clastic limestone, light gray (5Y 7/1) in color, with pebble and granule size clasts of white (N8) limestone. No apparent size gradation of clasts, but some horizontal orientation of elongated clasts. White "pelagic" limestone (N8) with darker wavy laminations is at 0–11, 111–117 and 119–137 cm.

SMEAR SLIDE SUMMARY %

	1-10	1-126
Calcite rhombs	70	—
Carbonate unspec.	30	100

SITE 463 HOLE CORE 85 CORED INTERVAL 746.5 to 756.0 m



LITHOLOGIC DESCRIPTION

CLASTIC LIMESTONE

Dominantly light olive gray (5Y 7/1) clastic limestone of rounded to subrounded sand and granule-size grains graded from 20–141 and 135–164 cm – mainly oolites. Clastic pebbly limestone, ungraded from 185–284 cm. Intervals with wavy and contorted laminae, without clasts, are at 0–15, 164–181, and 284–293 cm. Intervals of greenish gray (5G 6/1) horizontally laminated "pelagic" limestone are at 15–20 and 150–153 cm. Light gray (N7) and dark gray (N3) cherts are at 98, 181–185, 300–309, and 331 cm.

SMEAR SLIDE SUMMARY %

	1-19	2-30
Quartz	Tr	Tr
Feldspar	Tr	Tr
Heavy minerals	Tr	Tr
Clay	—	5
Volcanic glass	Tr	1
Pyrite	2	3
Carbonate unspec.	98	91
Nannofossils	Tr	—

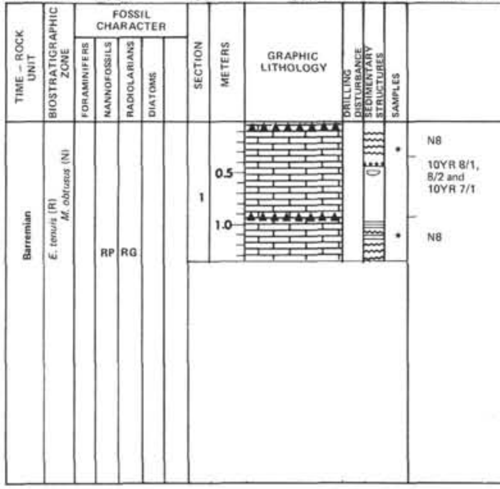
Silica and Iron Content: 1-75

SiO_2 = 11%

Fe = 0.33%

Carbon-Carbonate:	1-18	1-79
% Carbonate	33.3	85.8
% Organic Carbon	0.2	0.1

SITE 463 HOLE CORE 86 CORED INTERVAL 756.0 to 765.5 m



LITHOLOGIC DESCRIPTION

LIMESTONE

0–31, 95–135 cm: Very light gray (N8) limestone with numerous dark gray (N4) to black wavy laminae, both continuous and discontinuous across the core.

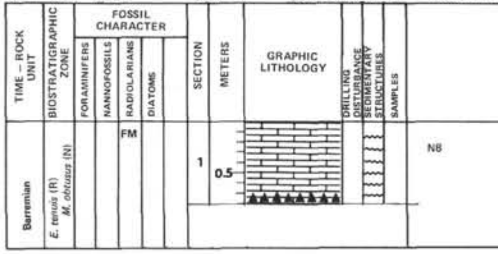
31–85 cm: White and light gray (10YR 7/1) pebbly limestone. Graded from 31–37 cm and massive from 40–85 cm. An erosional boundary at the top of the massive unit. Pebbles mostly light colors (N9, N8, 5Y 8/1) and shades of pale brown (10YR 8/2, 8/3, 8/4). Clasts are carbonate, oolites, mollusk debris, with some basalt?, chert, pyrite, and glauconite.

Cherts, light gray (N9, N8, N7), dark gray (N3), and olive gray (5Y 4/1) in color are at 5 cm, and 90–95 cm.

SMEAR SLIDE SUMMARY %

	1-27	1-110
Feldspar	—	Tr
Pyrite	Tr	Tr
Organic Carbon	Tr	—
Carbonate unspec.	95	100
Calcite rhombs	5	–

SITE 463 HOLE CORE 87 CORED INTERVAL 765.5 to 775.0 m

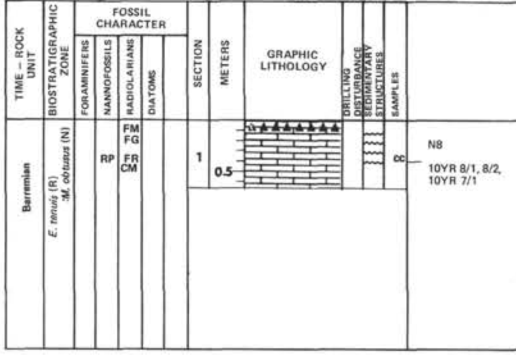


LITHOLOGIC DESCRIPTION

LIMESTONE

Very light gray (N8) limestone with numerous dark gray to black wavy laminations, both continuous and discontinuous across the core. Chert, light gray (N9) to dark gray (N4) in color, is at 75–79 cm.

SITE 463 HOLE CORE 88 CORED INTERVAL 775.0 to 784.5 m



LITHOLOGIC DESCRIPTION

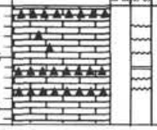
LIMESTONE

0–35 cm: Very light gray (N8) limestone with numerous dark gray to black wavy laminae, both continuous and discontinuous across the core.

35–67 cm: White (10YR 8/1, 10YR 8/2) and light gray (10YR 7/1) pebbly limestone. The interval from 55–59 cm is graded, the rest is massive. Clasts are mostly white to gray in color and are carbonates, oolites, and mollusk debris. Gray and dark gray (N5, N4) chert is at 3–6 cm.

Carbon-Carbonate:	1-34
% Carbonate	79.1
% Organic Carbon	0.1

SITE 463 HOLE CORE 89 CORED INTERVAL 784.5 to 794.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER					SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS								
Barremian	*S. systemporata* (R) *M. obtusus* (N)		RP	CG AM CG AG			1	0.5 1.0				*	5Y 7/1

LIMESTONE AND CHERT

Light olive gray (5Y 7/1) limestone. Wavy and contorted laminae of dark gray and black in the interval 5–94 cm. Clastic limestone of the same color from 94–113 cm, generally sand-size grains, no apparent bedding. Cherts, dark gray (10YR 4/1, N3) and light gray (N6) in color, are at 0–5, 31, 44, 59–65, and 84–86 cm.

SMEAR SLIDE SUMMARY %	1-65
Clay aggregates	40
Volcanic glass	Tr
Pyrite	Tr
Carbonate unspec.	60
Nannofossils	Tr

SITE 463 HOLE CORE 90 CORED INTERVAL 794.0 to 803.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER					SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS								
Barremian	*S. systemporata* (R) - *M. obtusus* (N)		RP	RG AG			1					CC	

LIMESTONE

Pebbles of limestone, light gray (N8 to 5Y 7/1) in color, with dark gray and black wavy laminations. Some show green (5G 5/2) parting surfaces. One dark gray (N4) chert pebble at the bottom.

Carbon-Carbonate:	1-1
% Carbonate	81.6
% Organic Carbon	0.1

SITE 463 HOLE CORE 91 CORED INTERVAL 803.5 to 813.0 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER					SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS								
Barremian (possible Upper Hauterivian)	*S. systemporata* (R) *M. obtusus* (N)		RP	AM		CC							

LIMESTONE

One 3 cm piece of light gray (5Y 7/1) limestone with faint whispy laminations.

SMEAR SLIDE SUMMARY %	CC-2
Clay	Tr
Carbonate unspec.	100

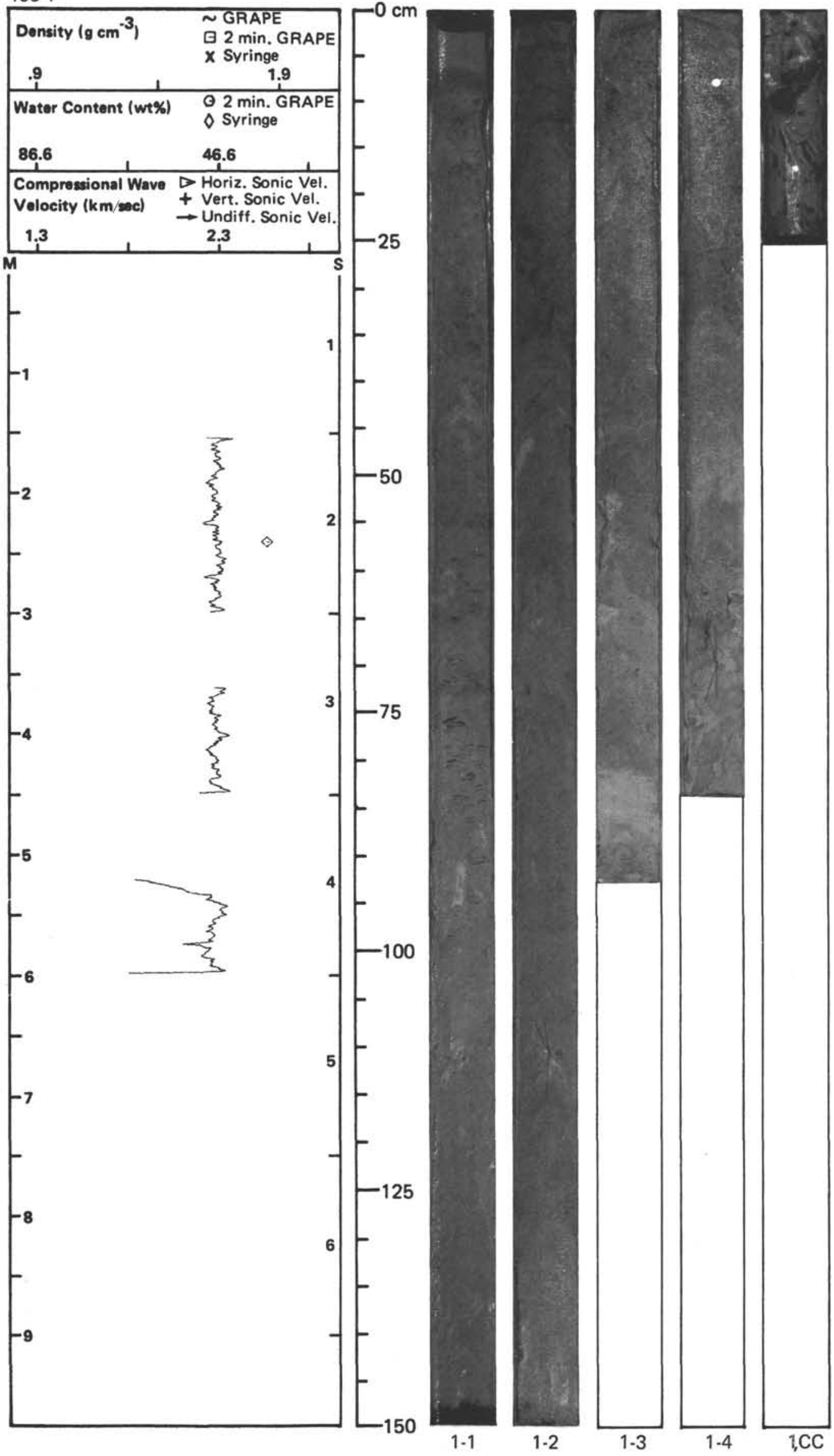
SITE 463 HOLE CORE 92 CORED INTERVAL 813.0 to 822.5 m

TIME – ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER					SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS								
Barremian (possible Upper Hauterivian)	*S. systemporata* (R) *M. obtusus* (N)		RP	AG AM			1						

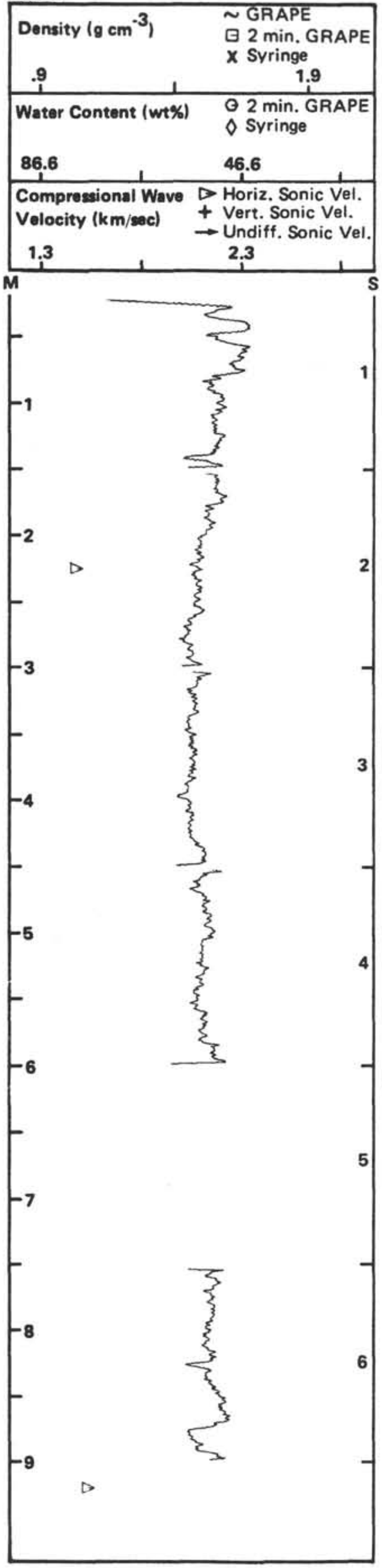
LIMESTONE AND CHERT

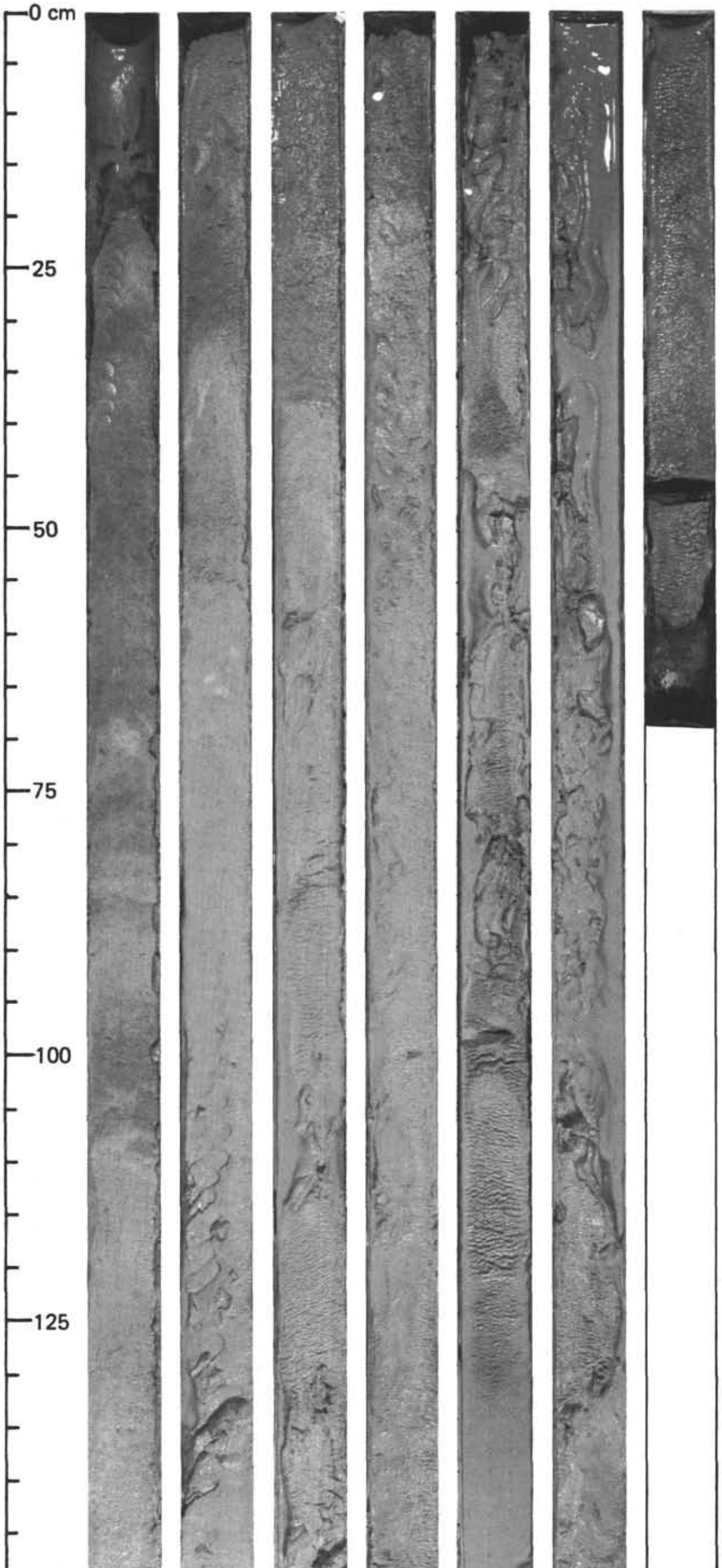
White (10YR 8/1) limestone with some wavy laminations (3 pieces). Cherts, light gray (N8, N7, 10YR 7/1) and white (5YR 8/1) are at the top and bottom of the section.

463-1

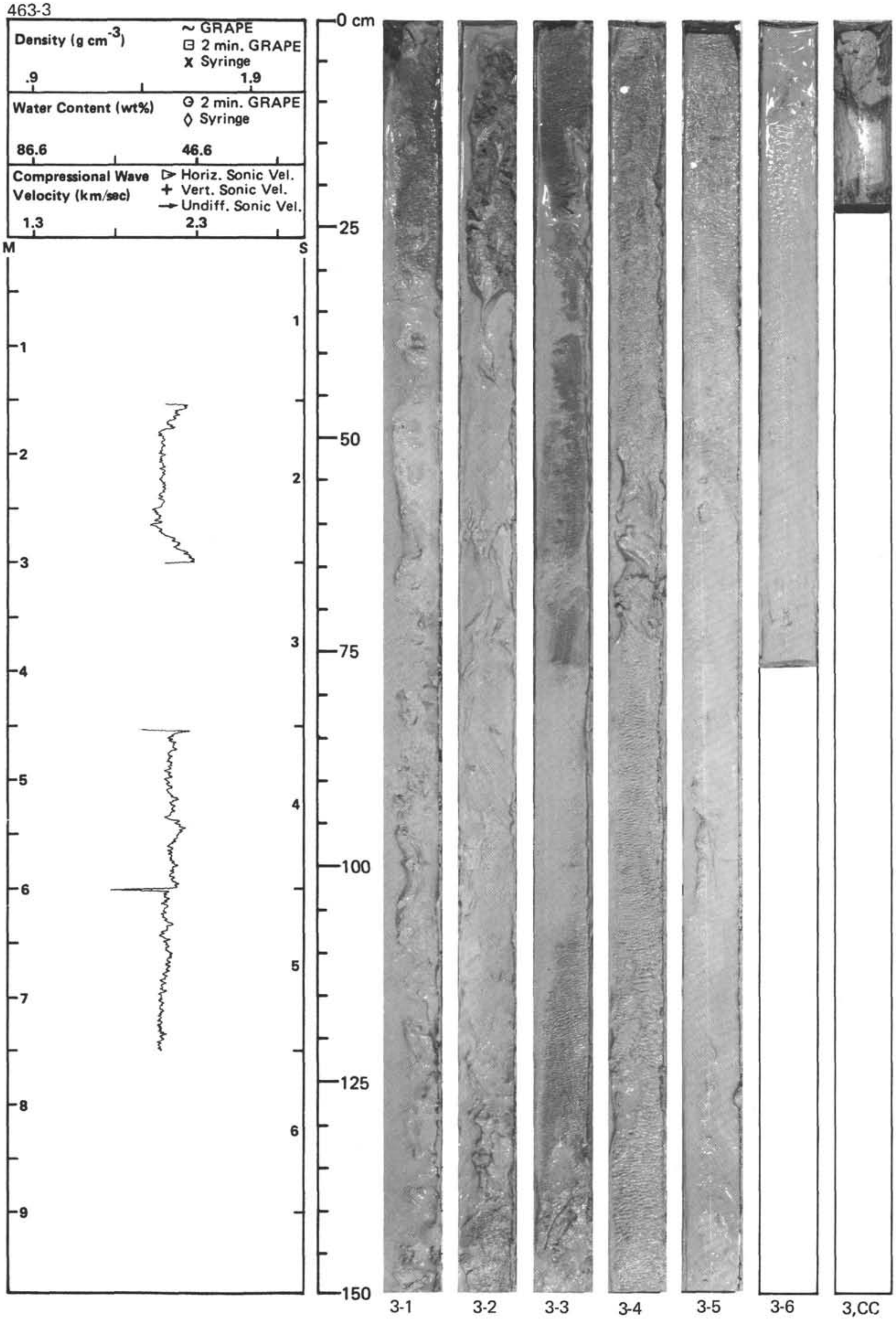

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
1-1
1-2
1-3
1-4
1,CC

463-2

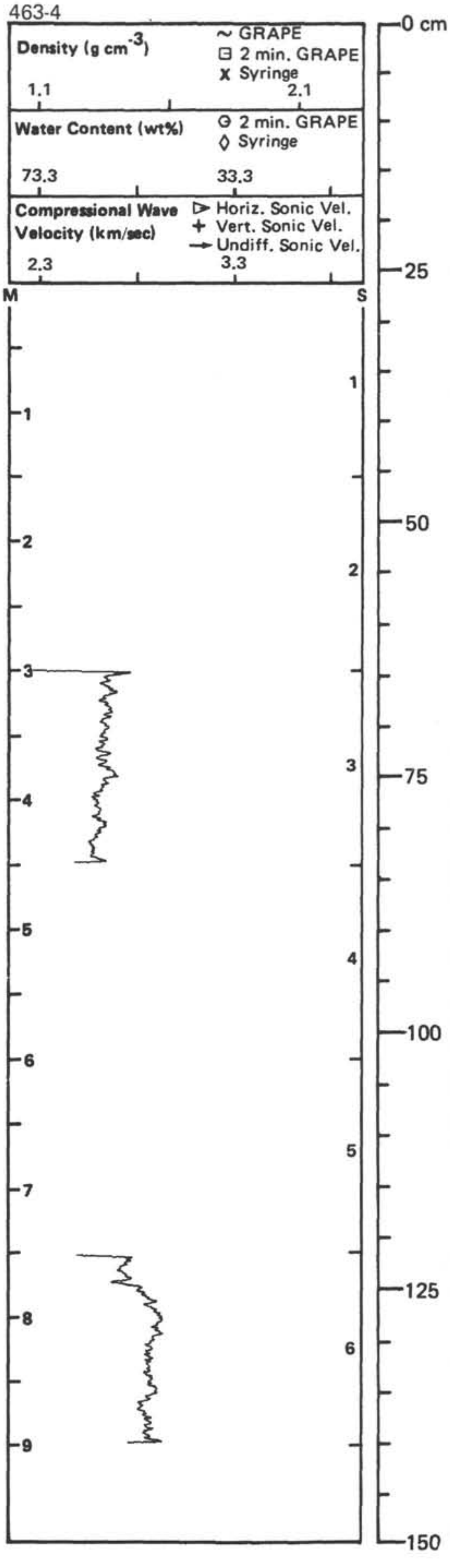

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9

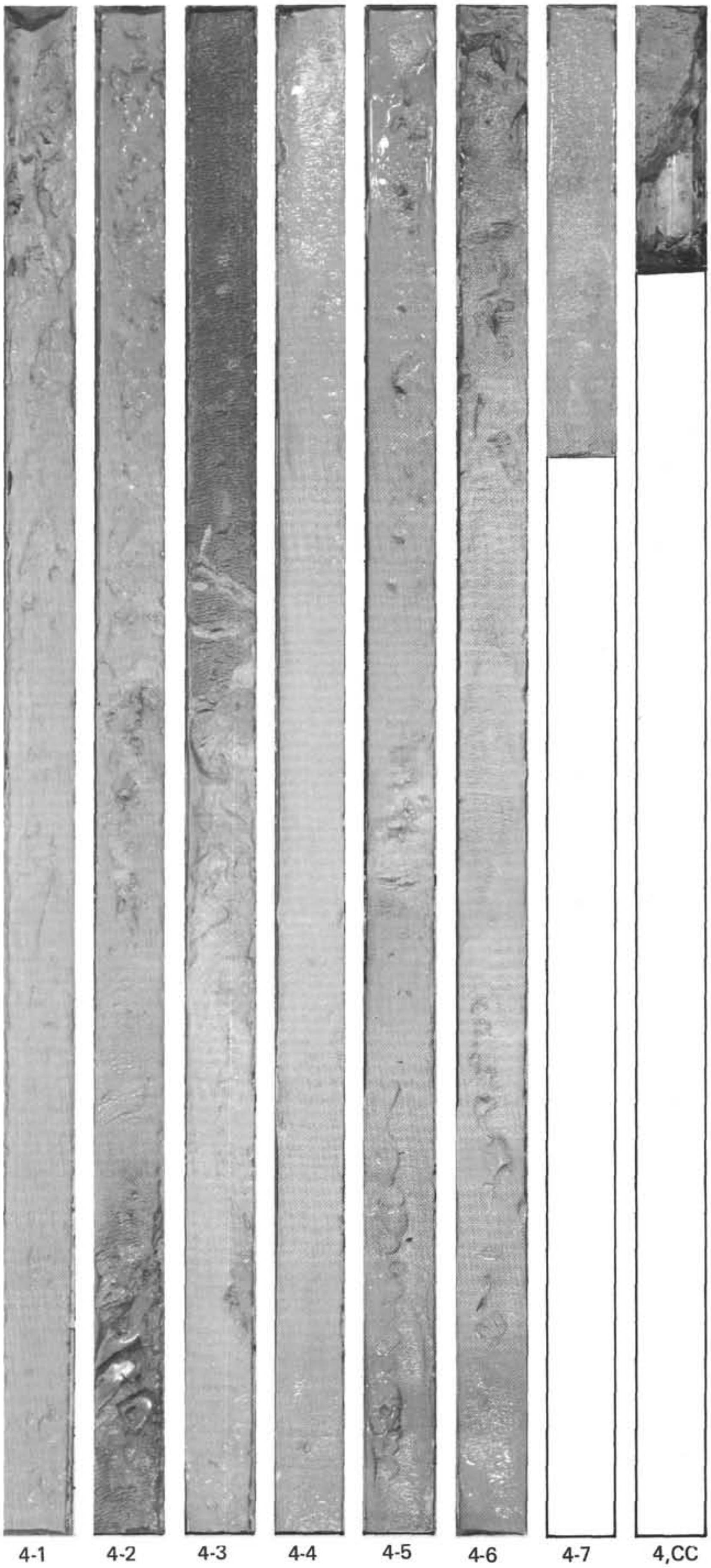

0 cm
25
50
75
100
125
150
2-1
2-2
2-3
2-4
2-5
2-6
2-7

463-3

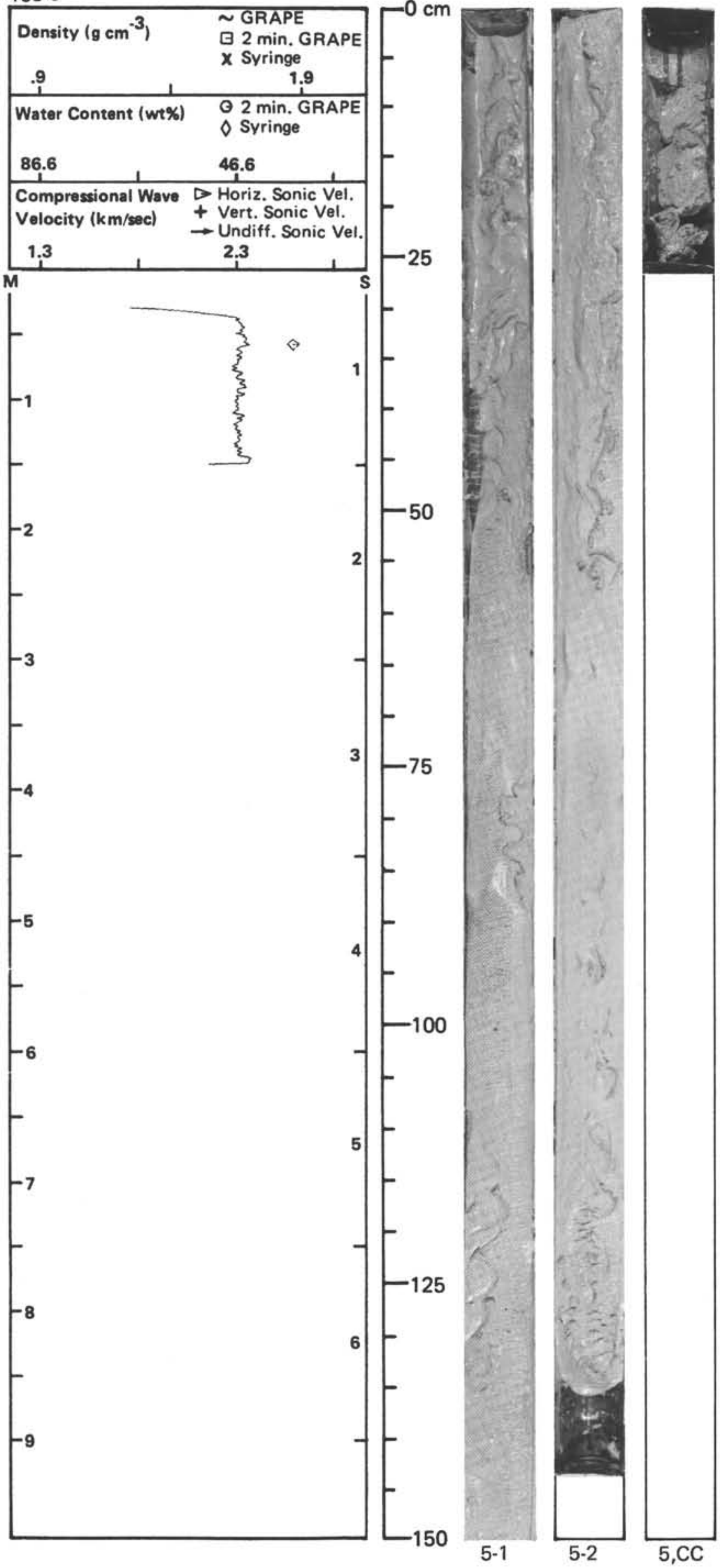

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
3-1
3-2
3-3
3-4
3-5
3-6
3,CC

463-4

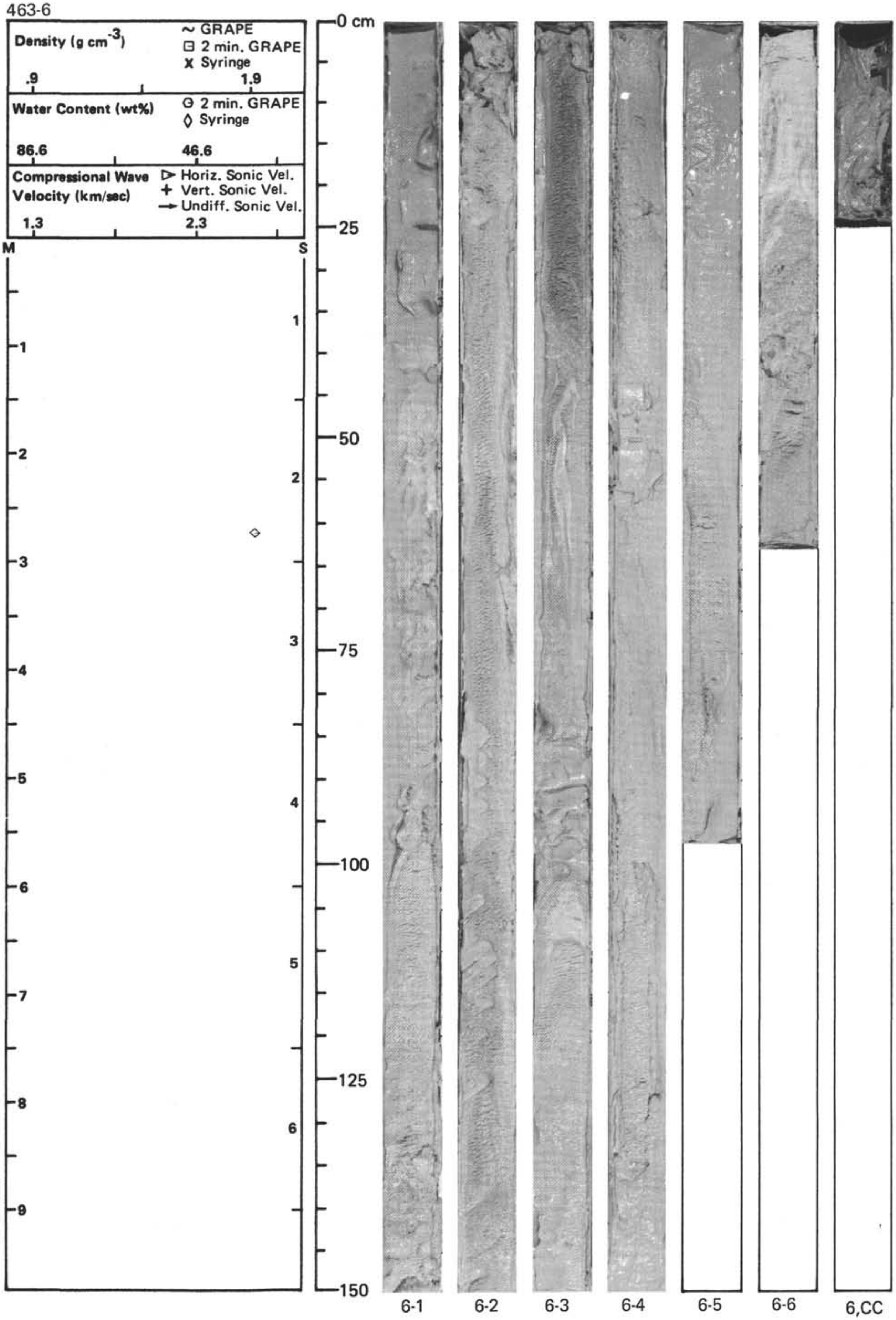

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.1
2.1
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
0 cm
25
50
75
100
125
150

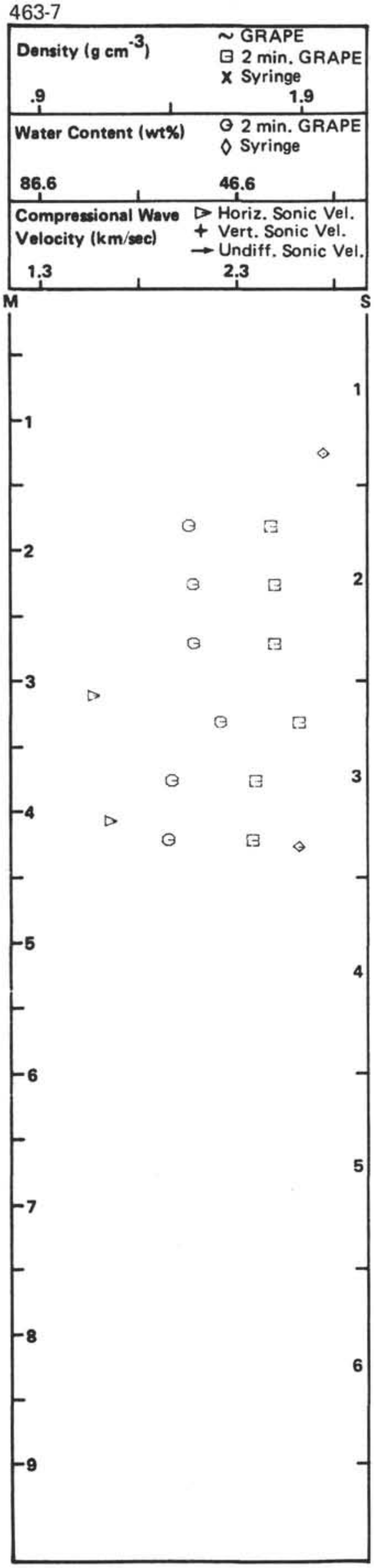

4-1
4-2
4-3
4-4
4-5
4-6
4-7
4,CC

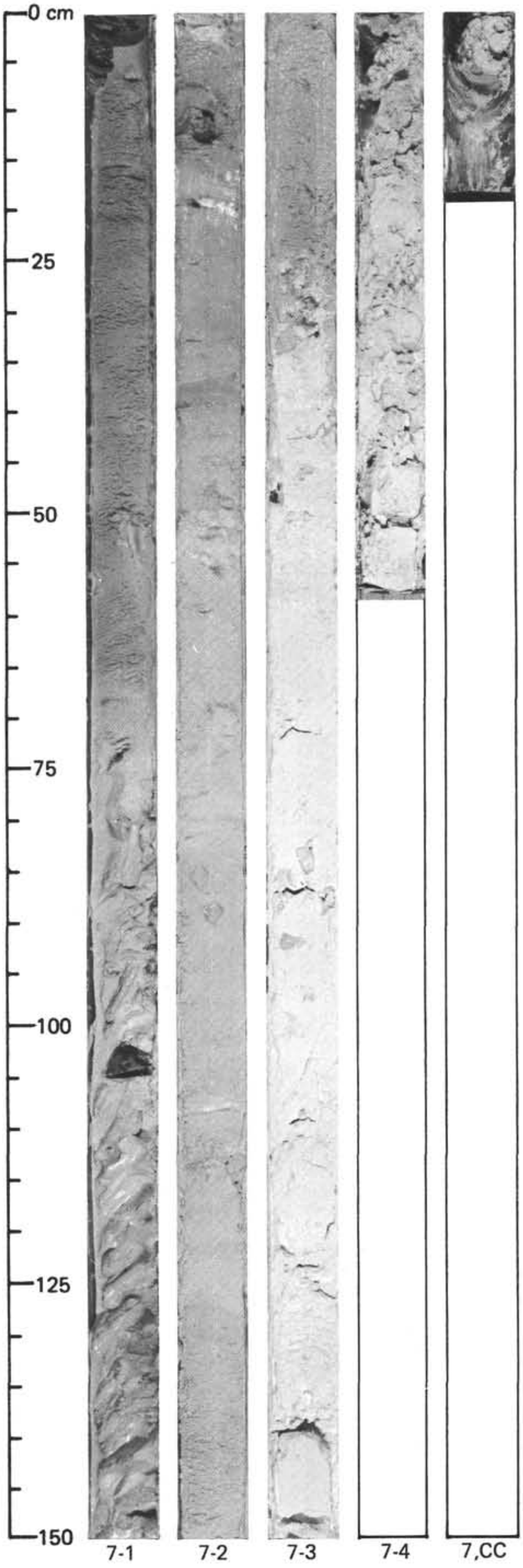
463-5


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
5-1
5-2
5,CC

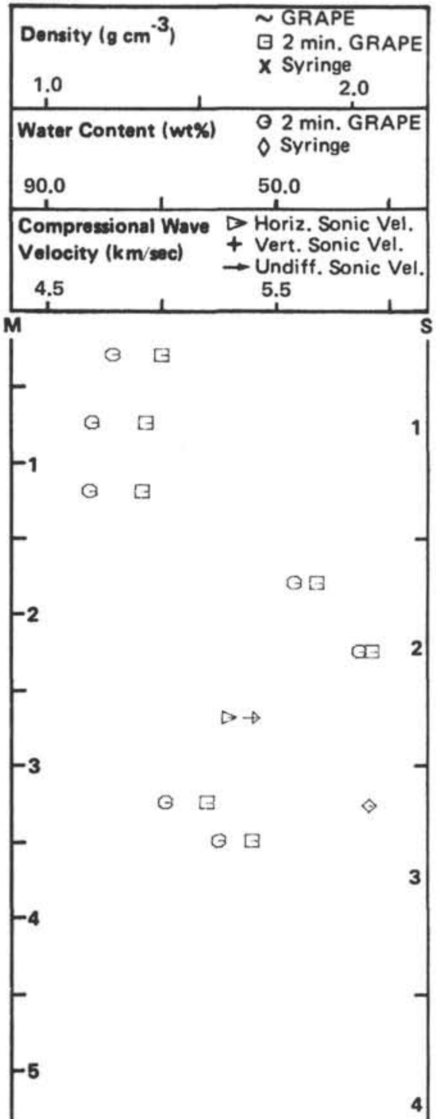
463-6

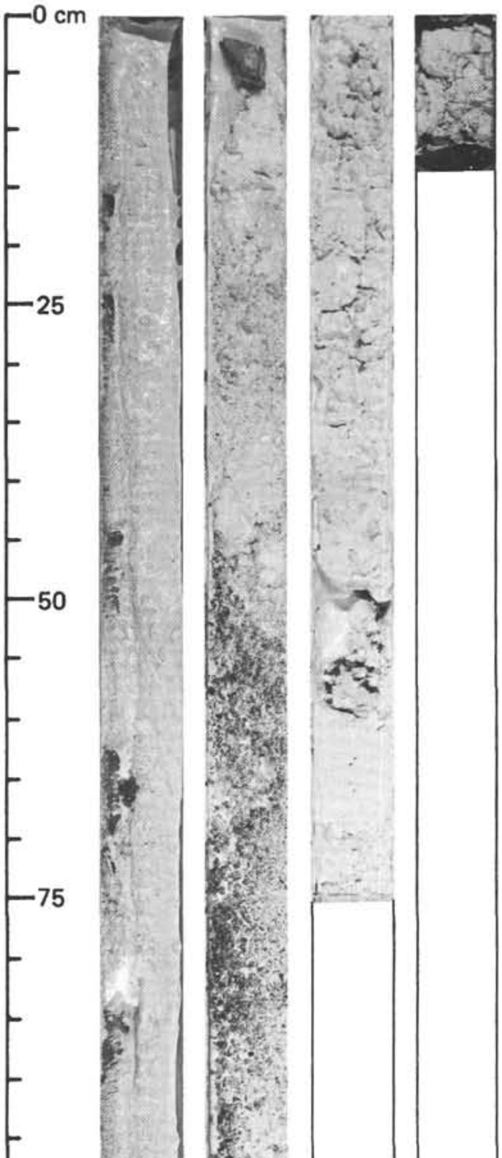

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
6-1
6-2
6-3
6-4
6-5
6-6
6,CC


463-7
Density (g cm-3)
~ GRAPE
2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6

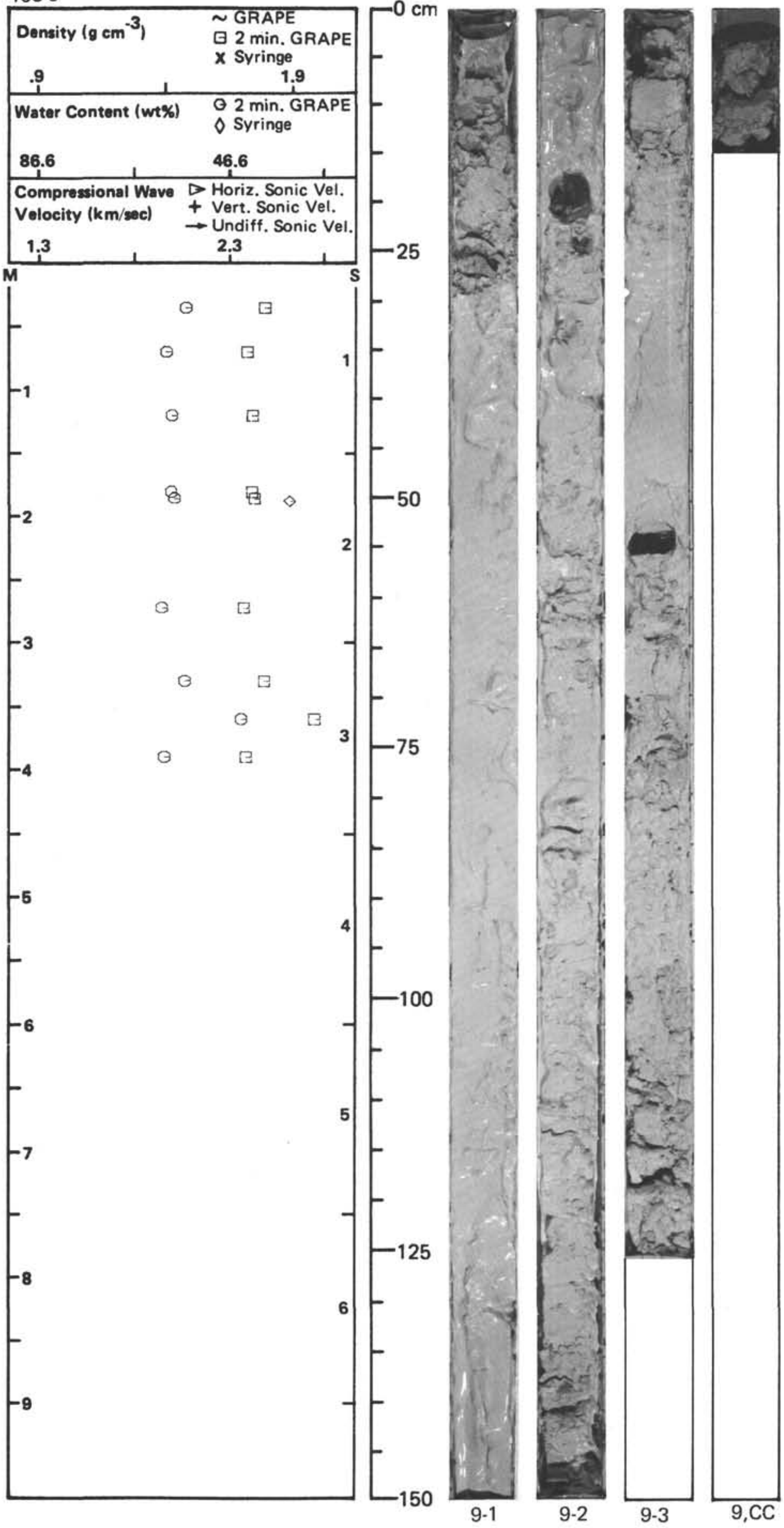

0 cm
25
50
75
100
125
150
7-1
7-2
7-3
7-4
7,CC

463-8

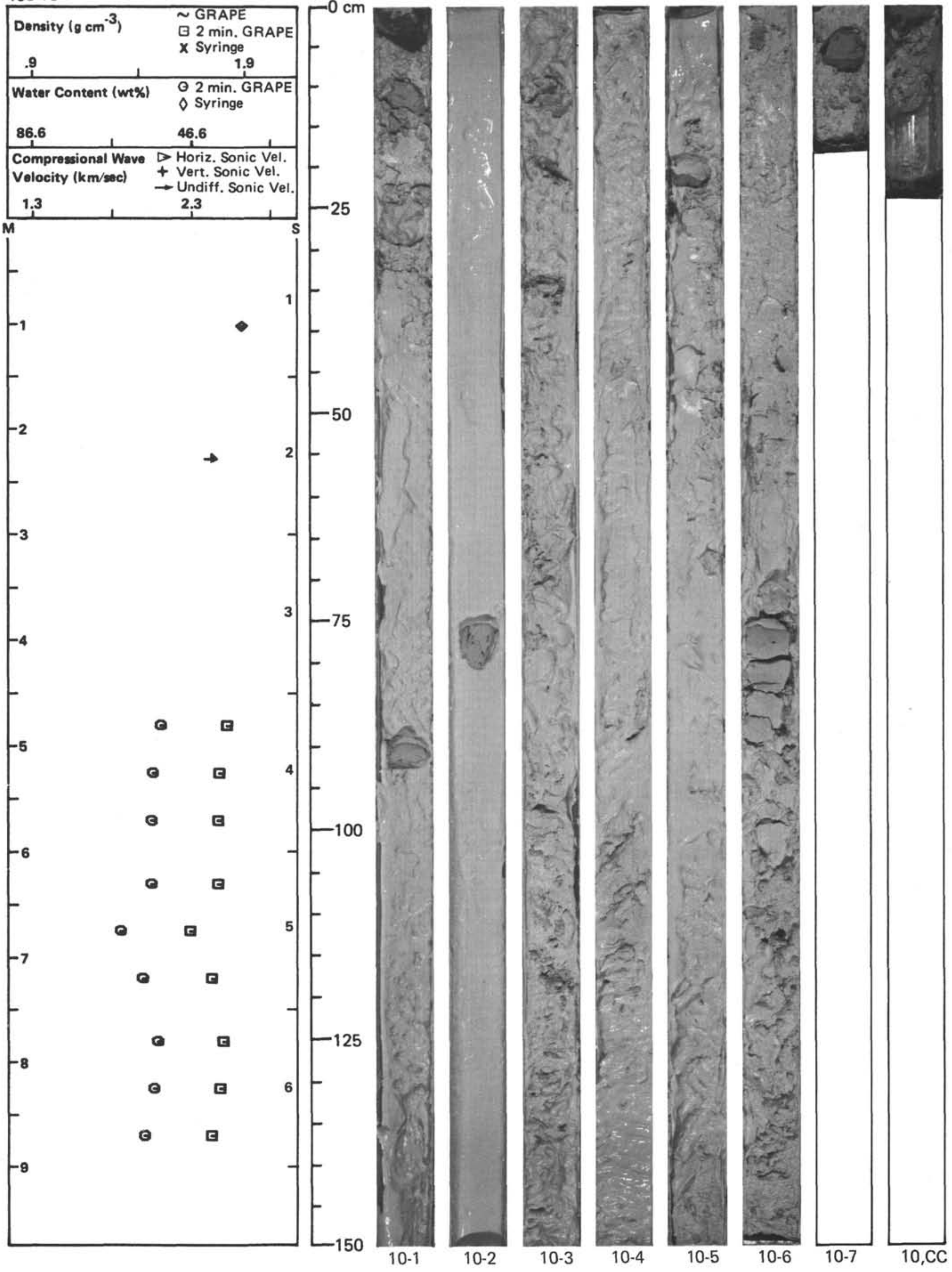

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.0
2.0
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
90.0
50.0
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
4.5
5.5
M
S
1
2
3
4
5
6
7
8
9


0 cm
25
50
75
100
125
150
8-1
8-2
8-3
8,CC

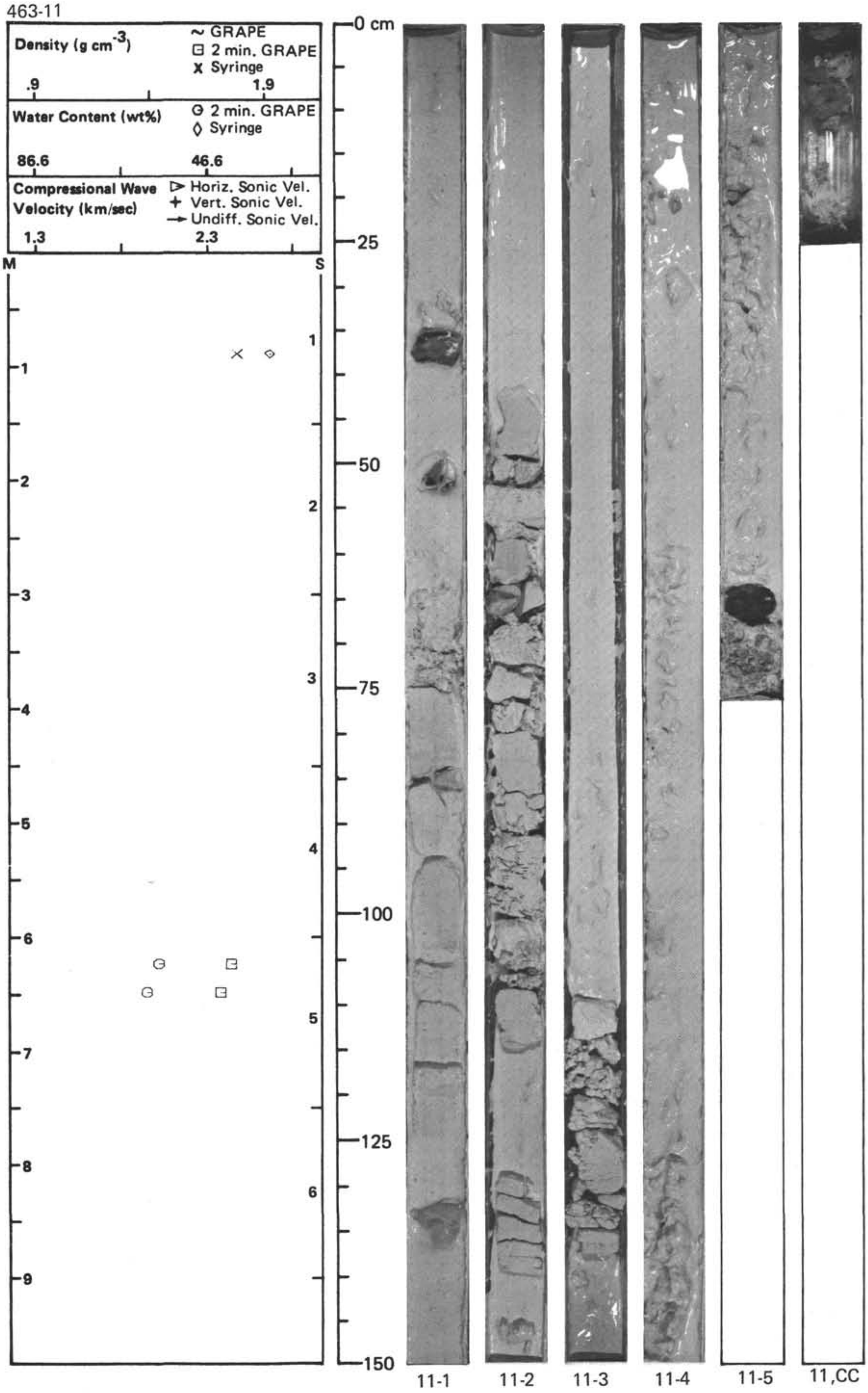
463-9


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
9-1
9-2
9-3
9,CC

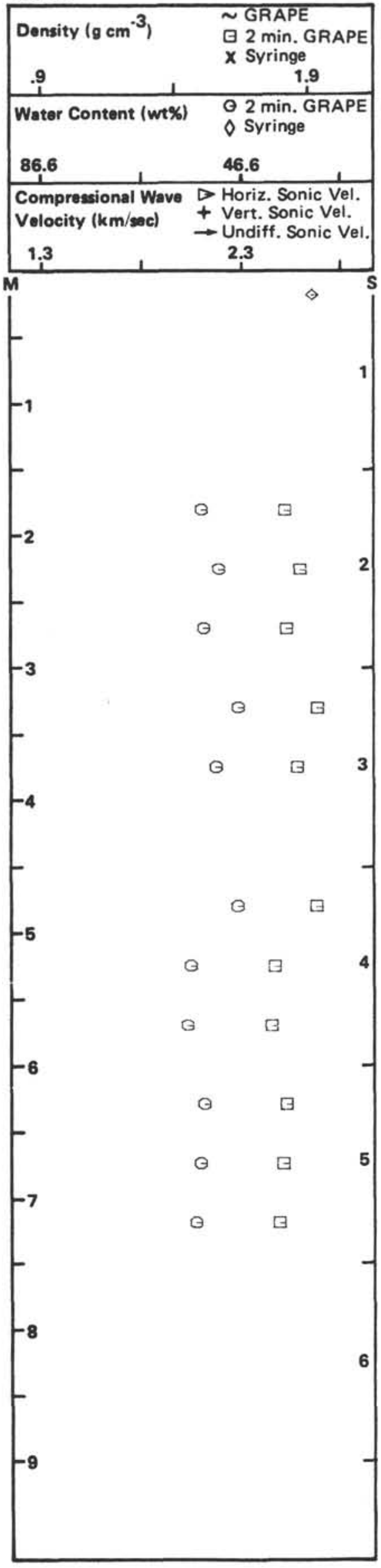
463-10

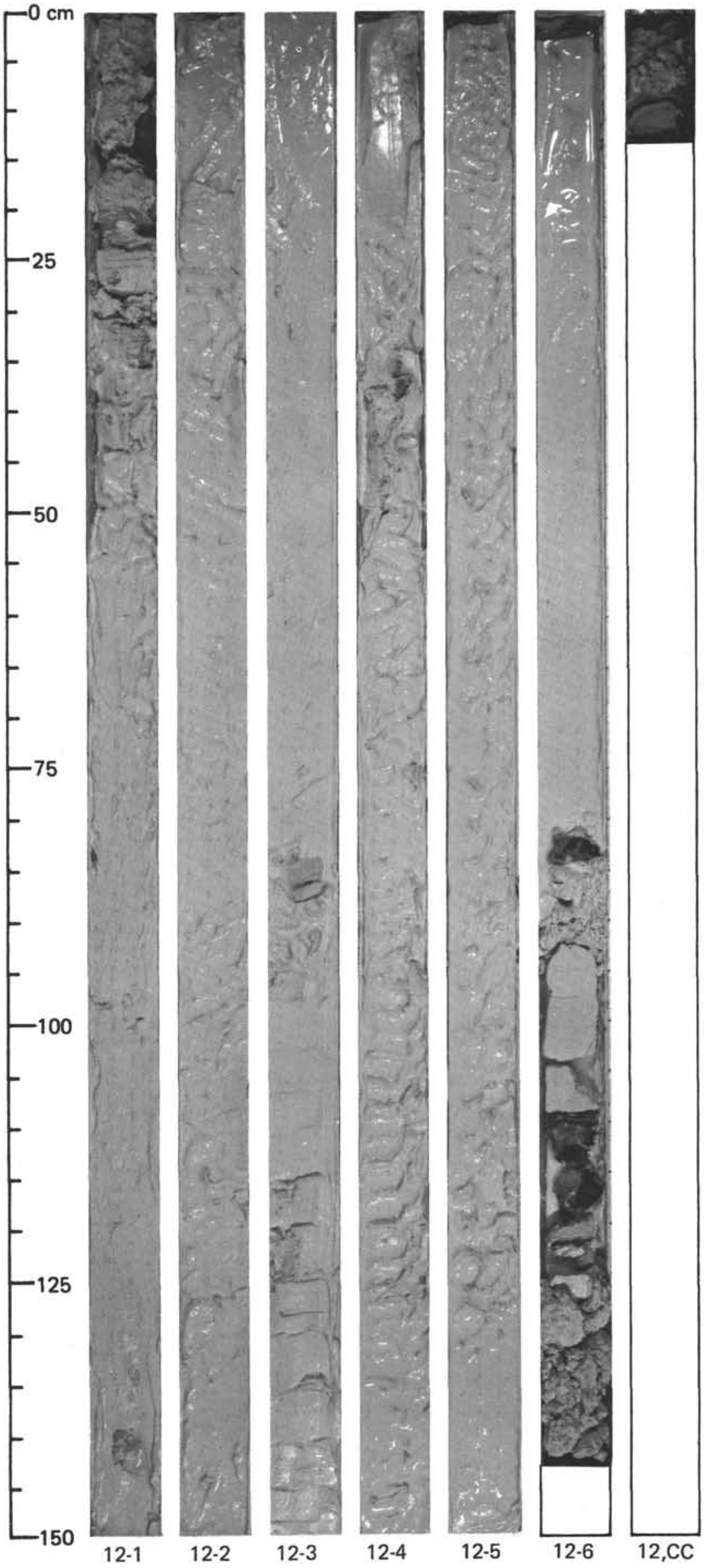

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
0 cm
25
50
75
100
125
150
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10,CC

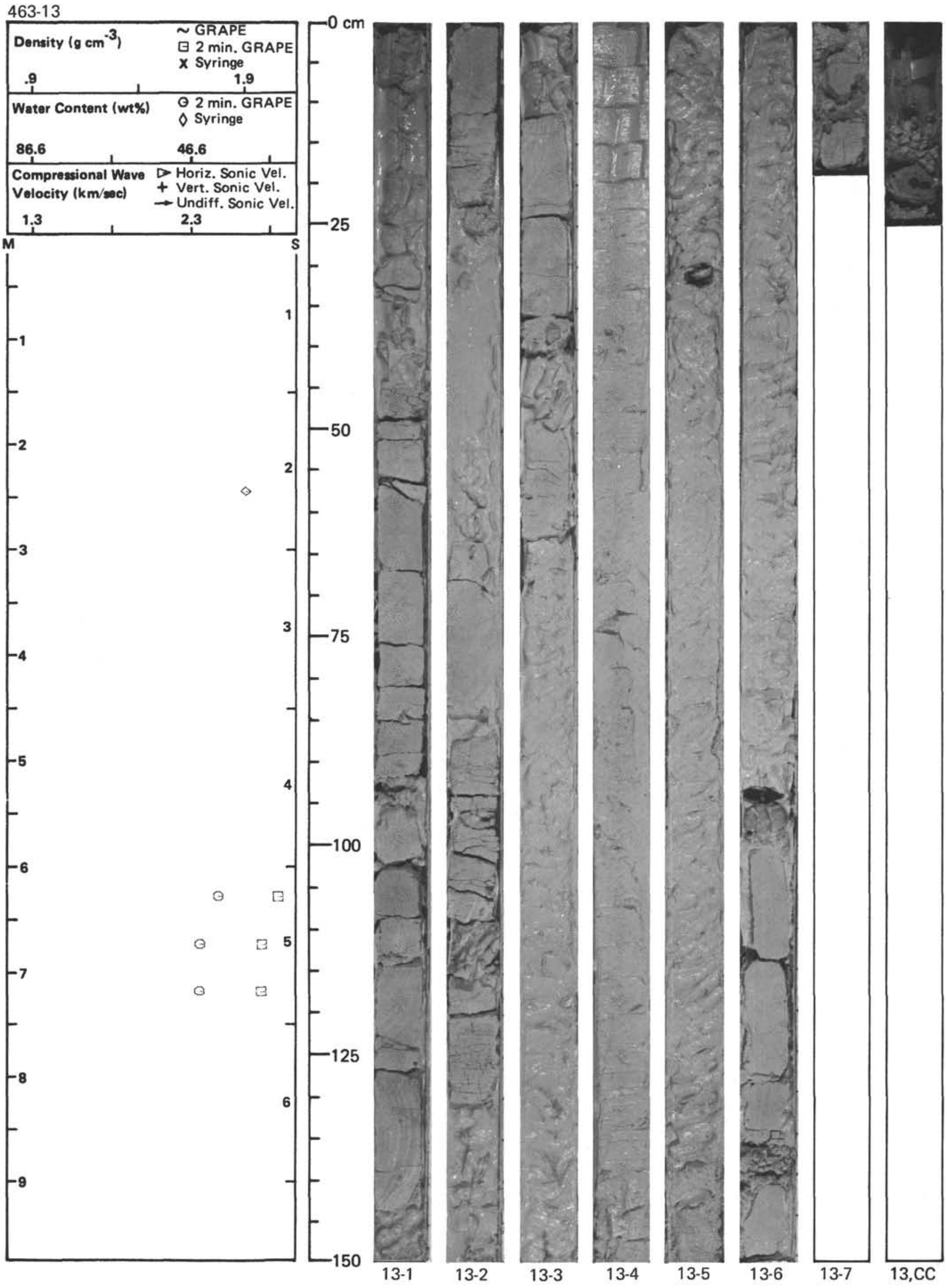
463-11


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
11-1
11-2
11-3
11-4
11-5
11,CC

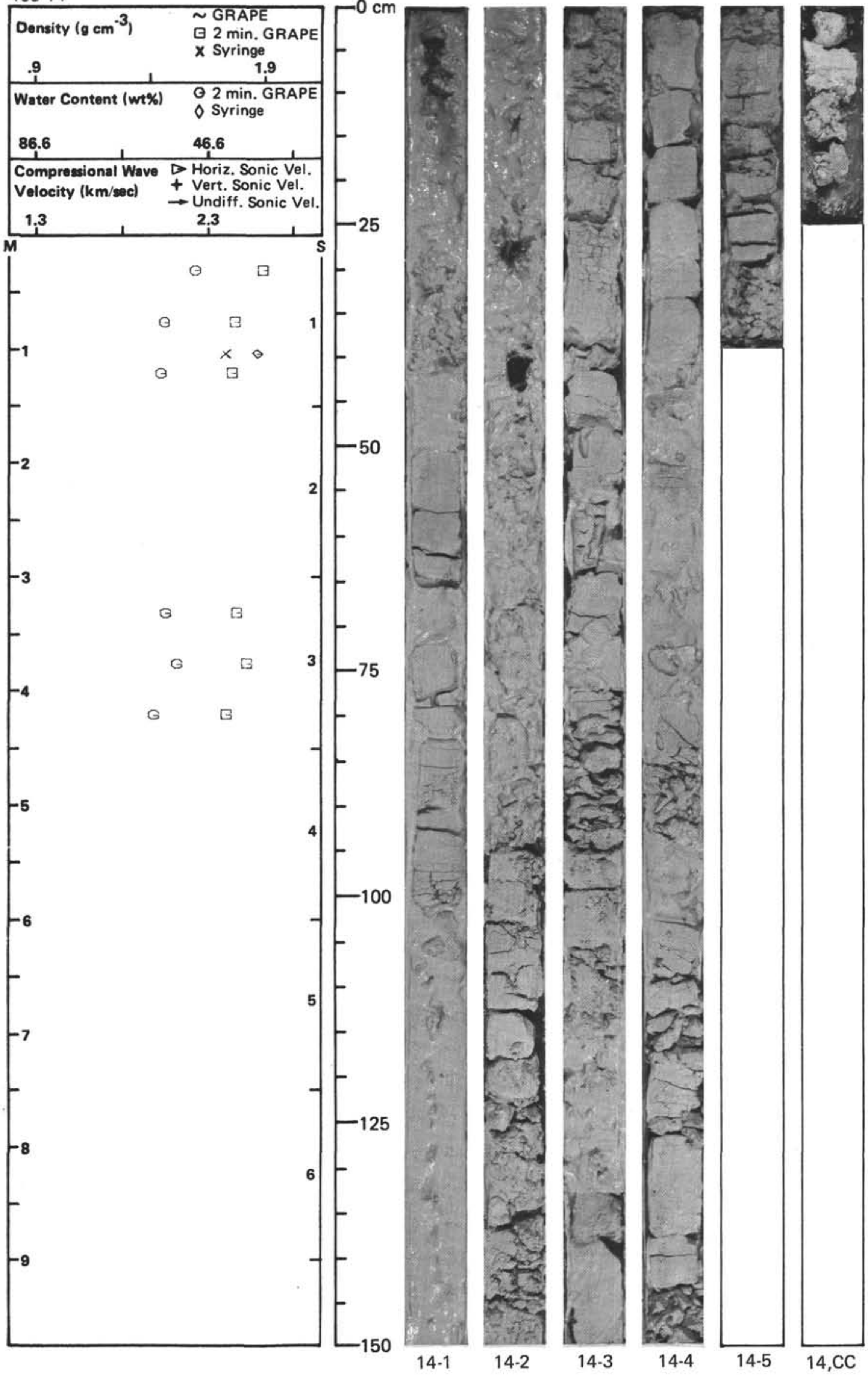
463-12

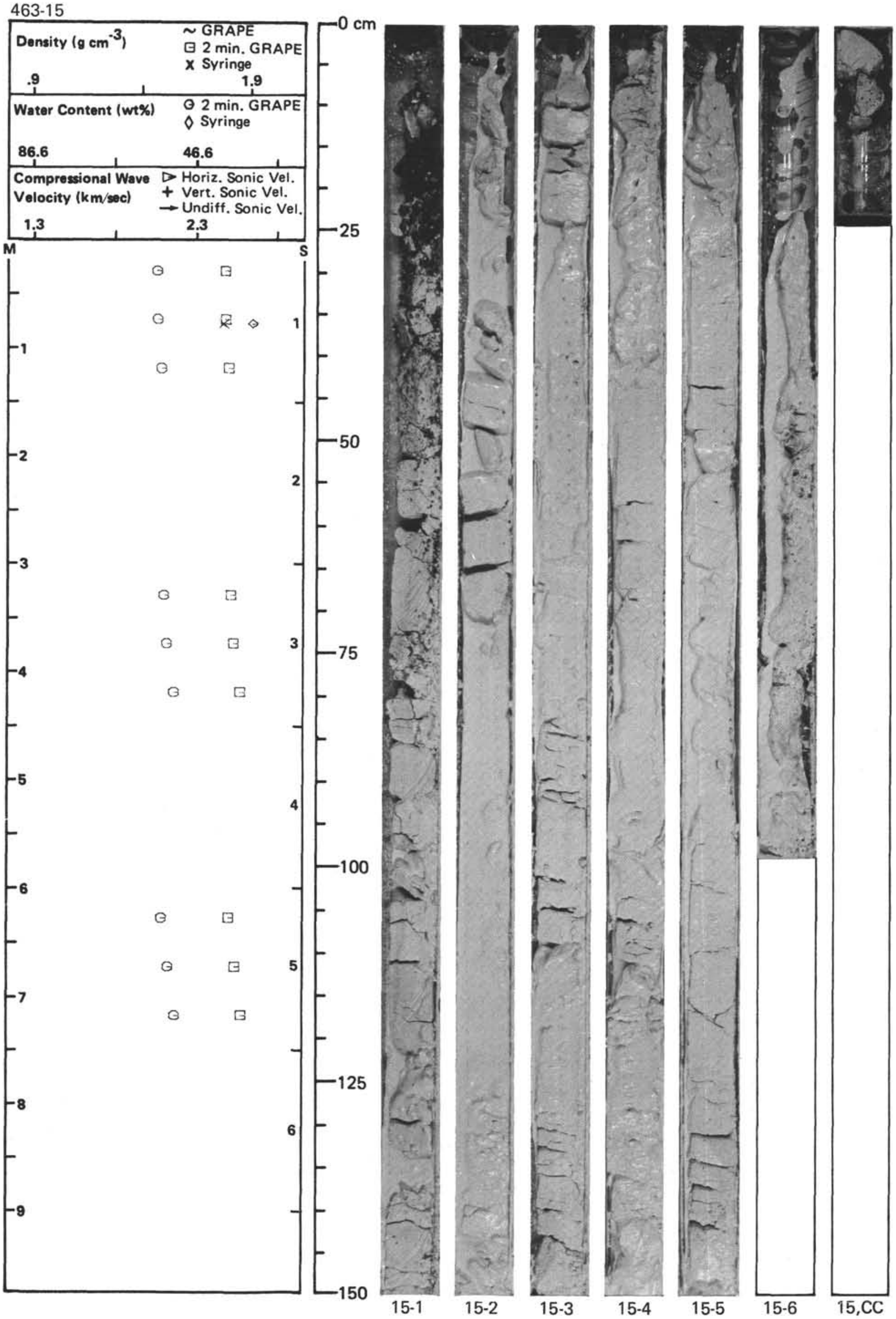

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6


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

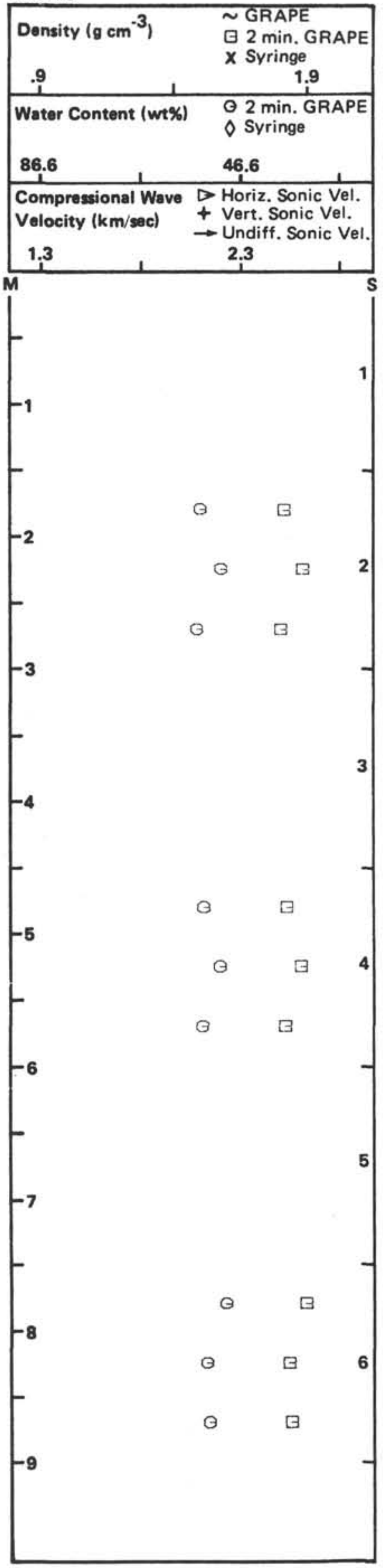

463-13
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
13-1
13-2
13-3
13-4
13-5
13-6
13-7
13,CC

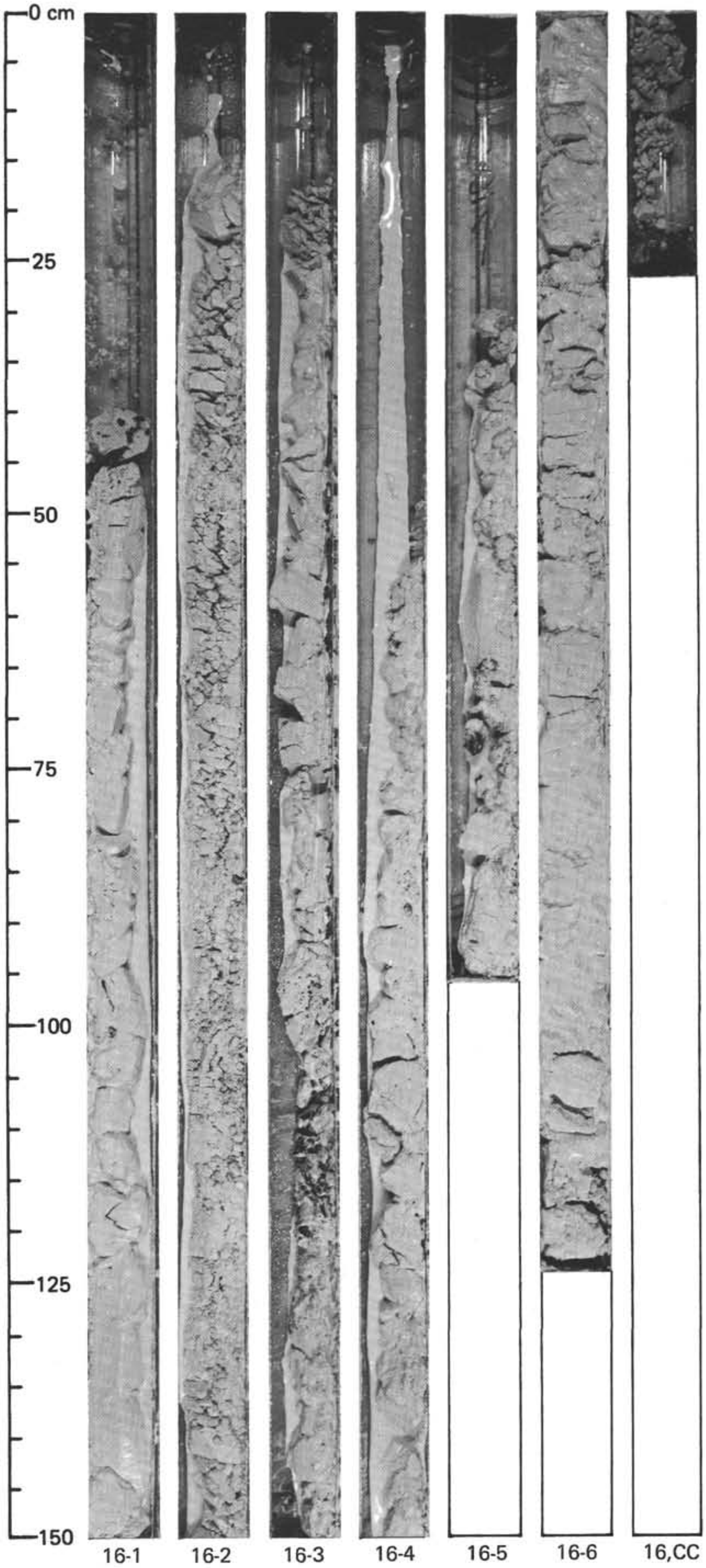
463-14


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
14-1
14-2
14-3
14-4
14-5
14,CC

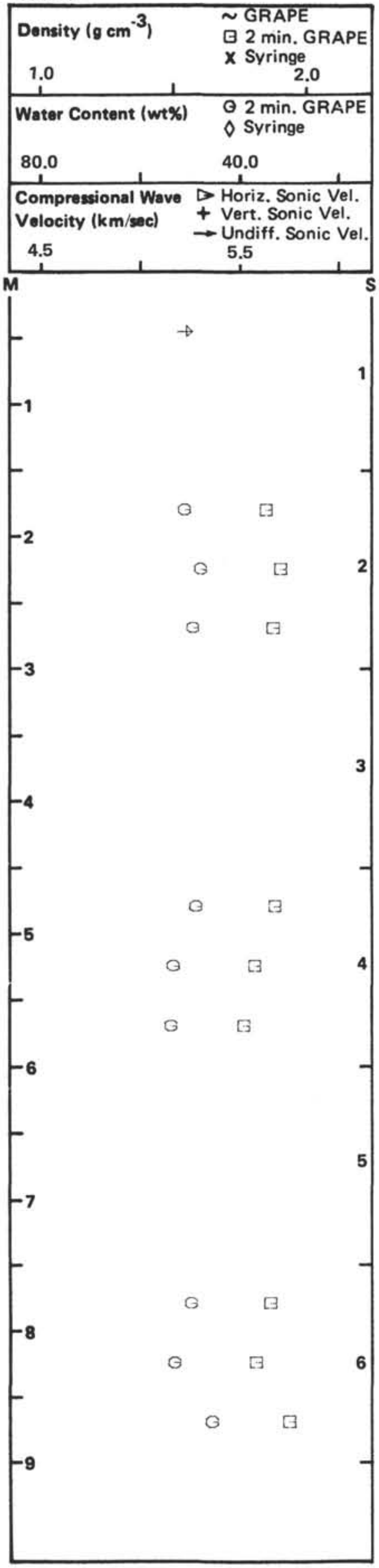

463-15
Density (g cm-3)
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
0 cm
25
50
75
100
125
150
15-1
15-2
15-3
15-4
15-5
15-6
15,CC

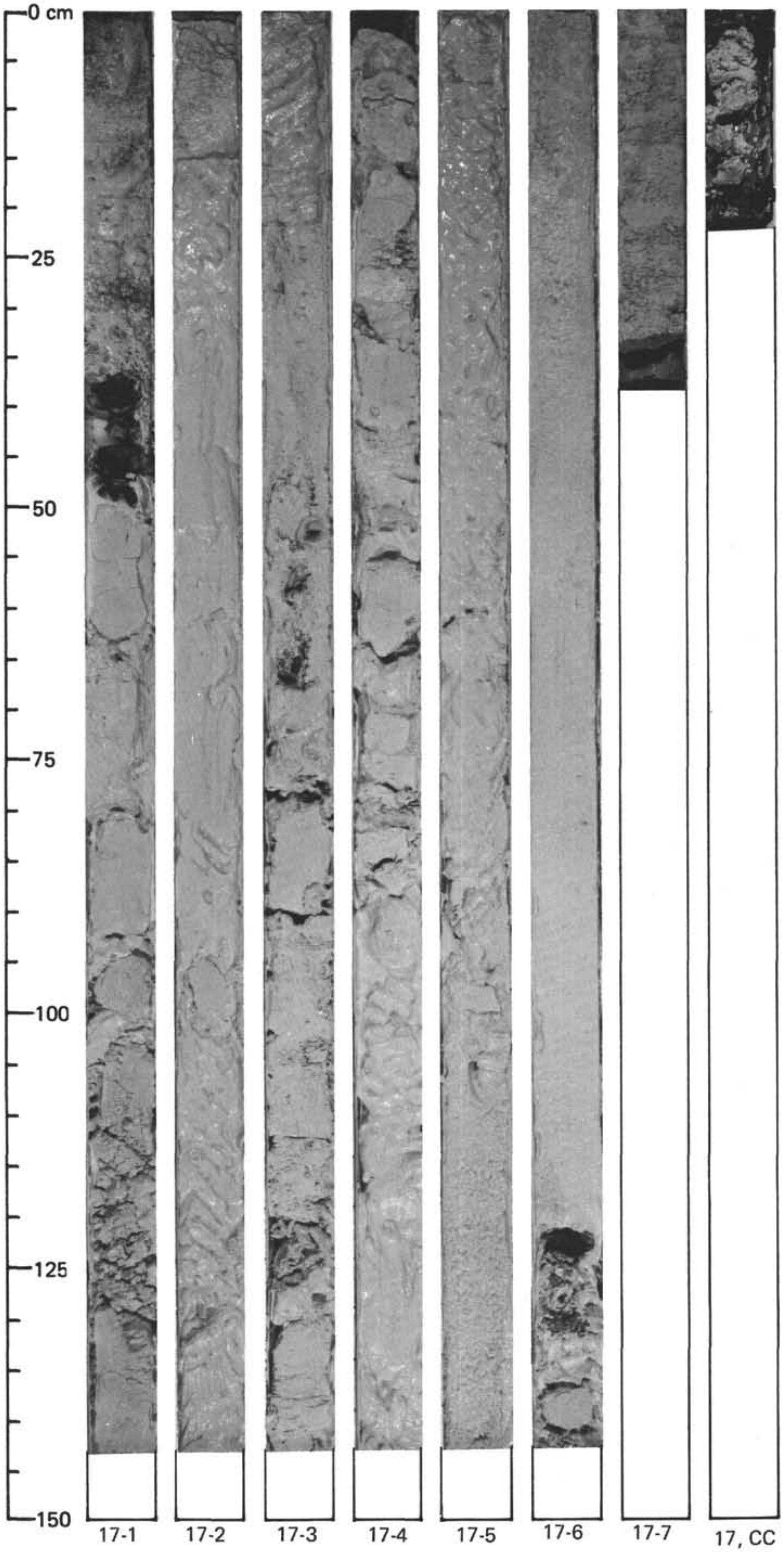
463-16


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6

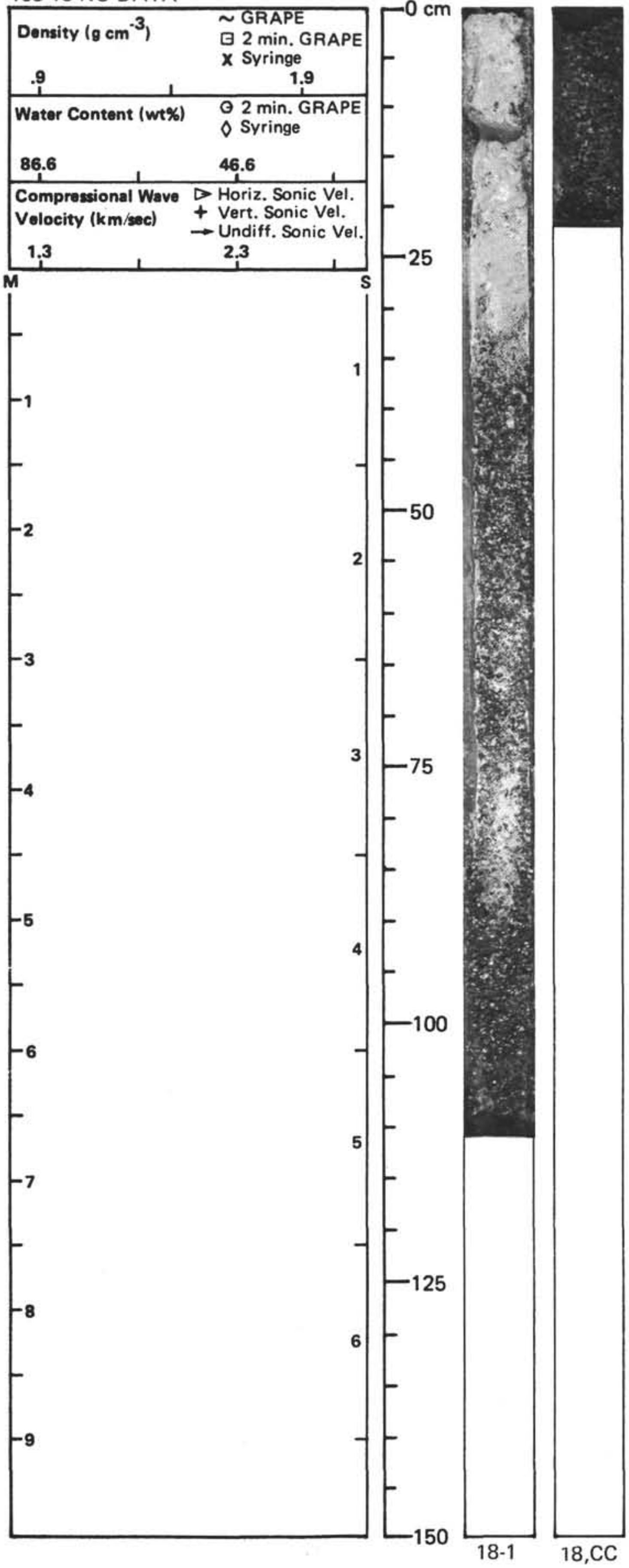

0 cm
25
50
75
100
125
150
16-1
16-2
16-3
16-4
16-5
16-6
16,CC

463-17

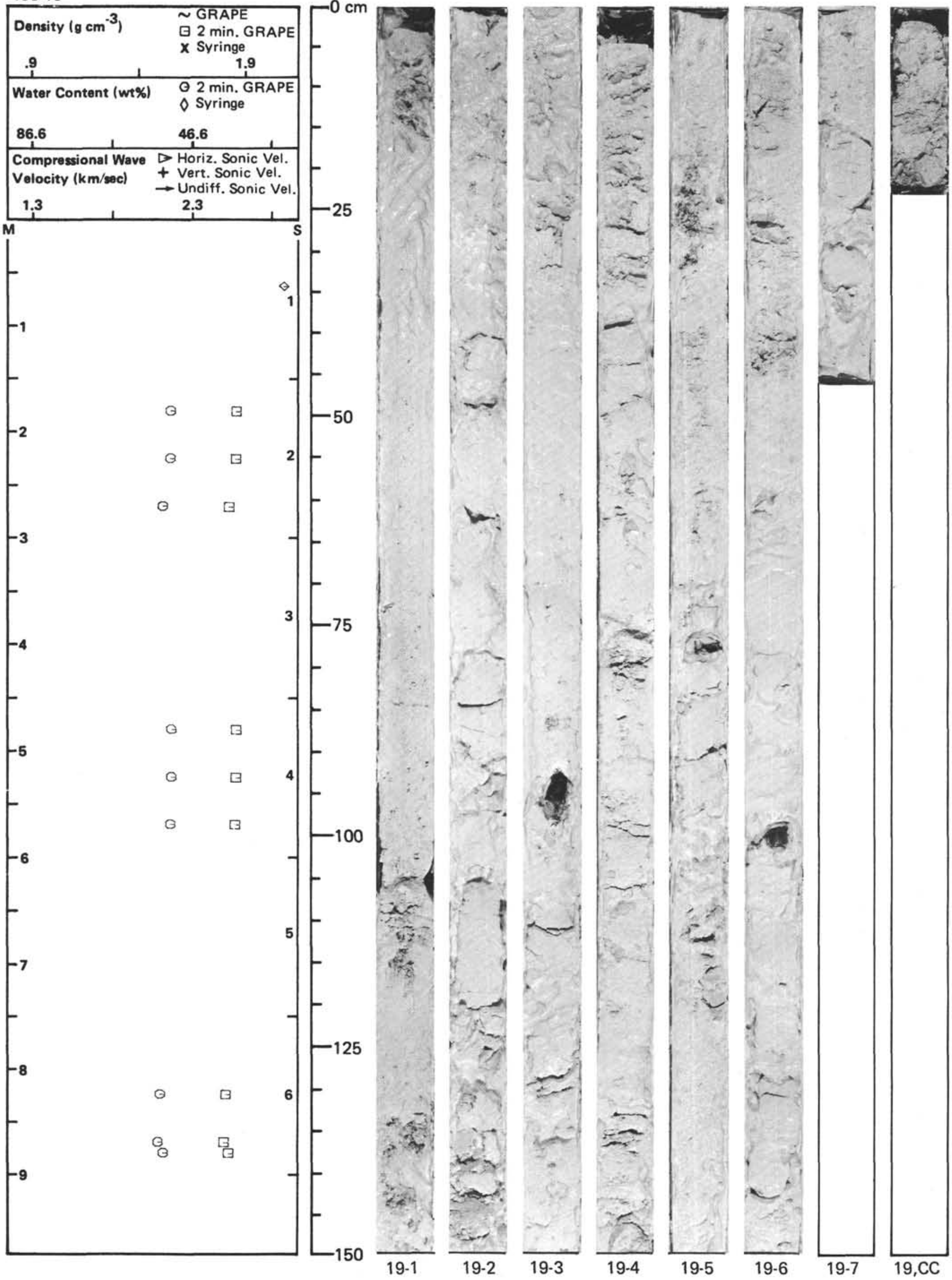

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.0
2.0
Water Content (wt%)
ɞ 2 min. GRAPE
◊ Syringe
80.0
40.0
Compressional Wave Velocity (km/sec)
⊳ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
4.5
5.5
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6


0 cm
25
50
75
100
125
150
17-1
17-2
17-3
17-4
17-5
17-6
17-7
17, CC

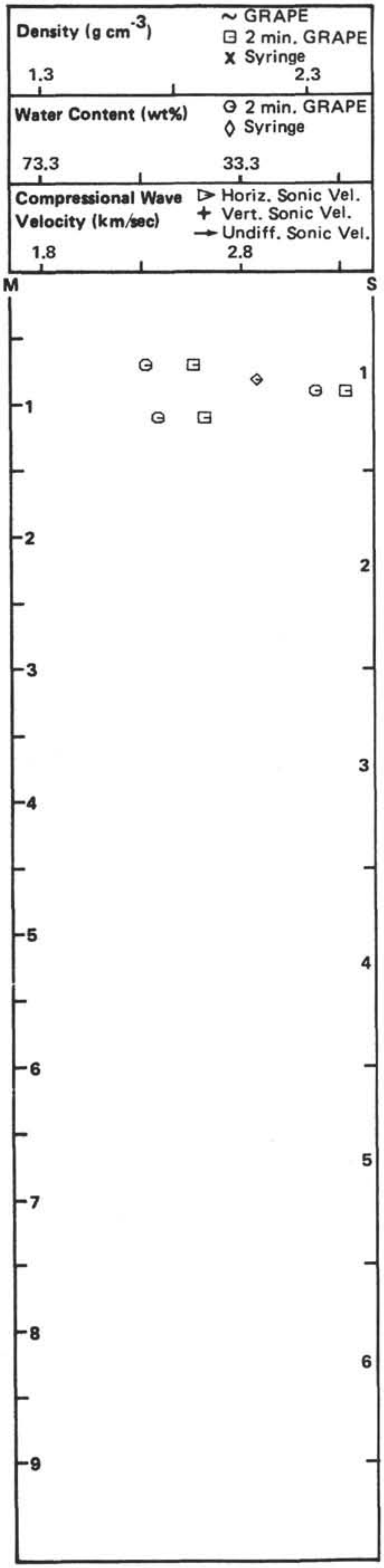
463-18 NO DATA

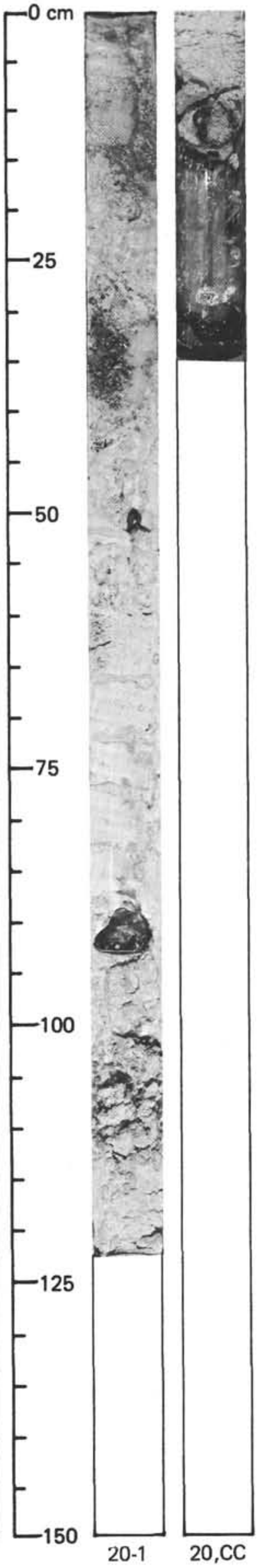


463-19

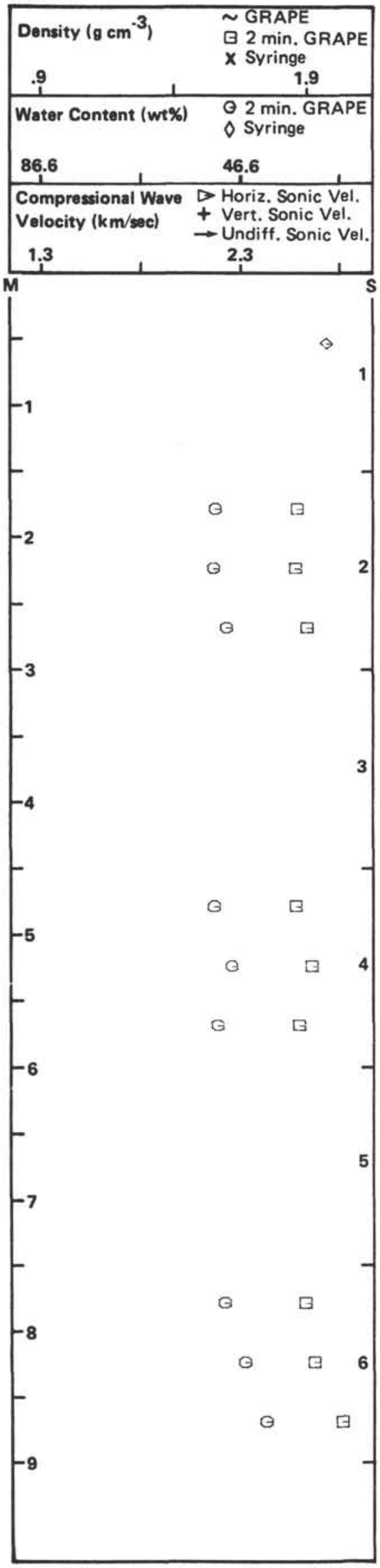

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
19-1
19-2
19-3
19-4
19-5
19-6
19-7
19,CC

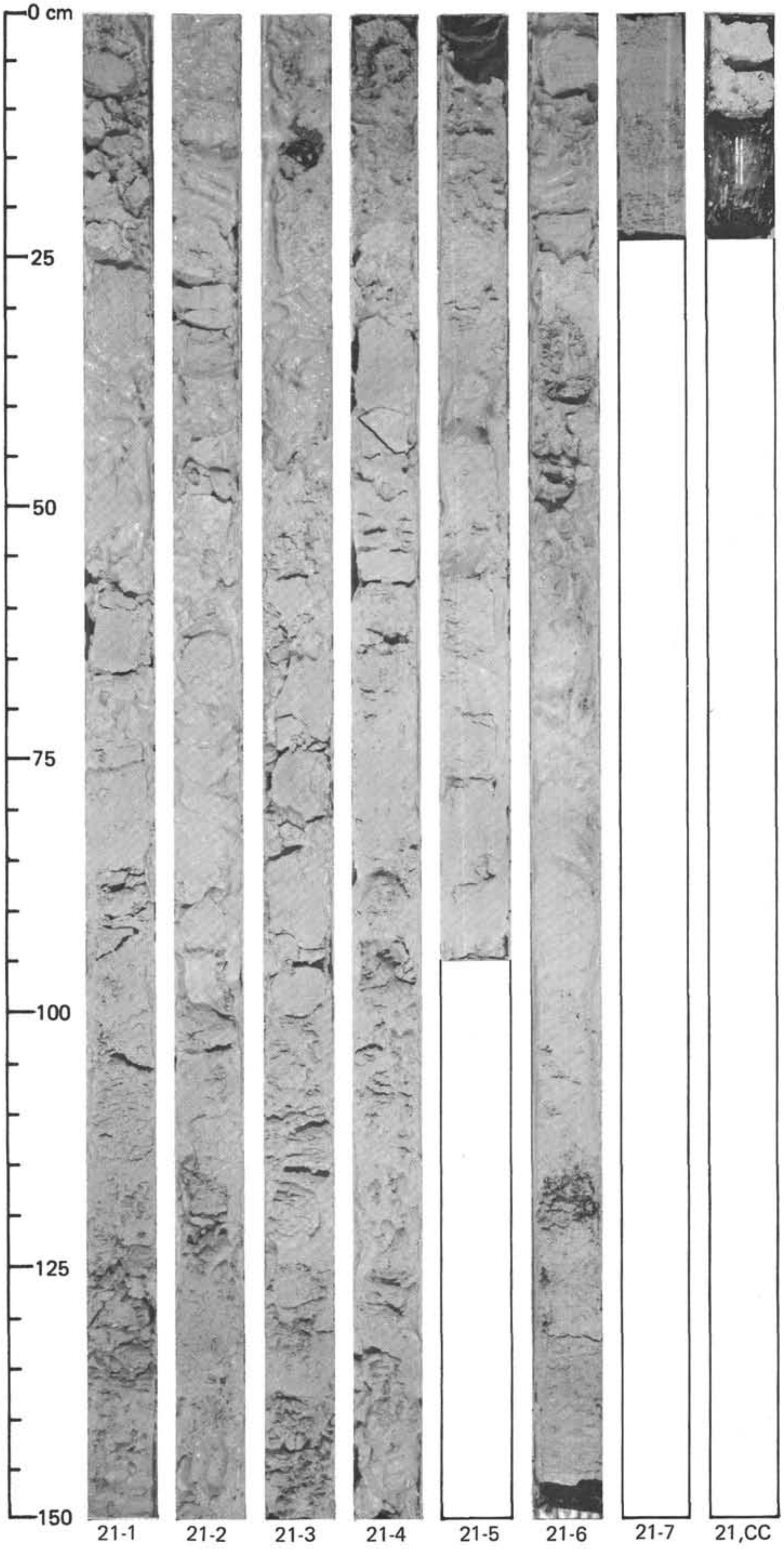
463-20


Density (g cm^{-3})
~ GRAPE
⊡ 2 min. GRAPE
X Syringe
1.3
2.3
Water Content (wt%)
Ɵ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6

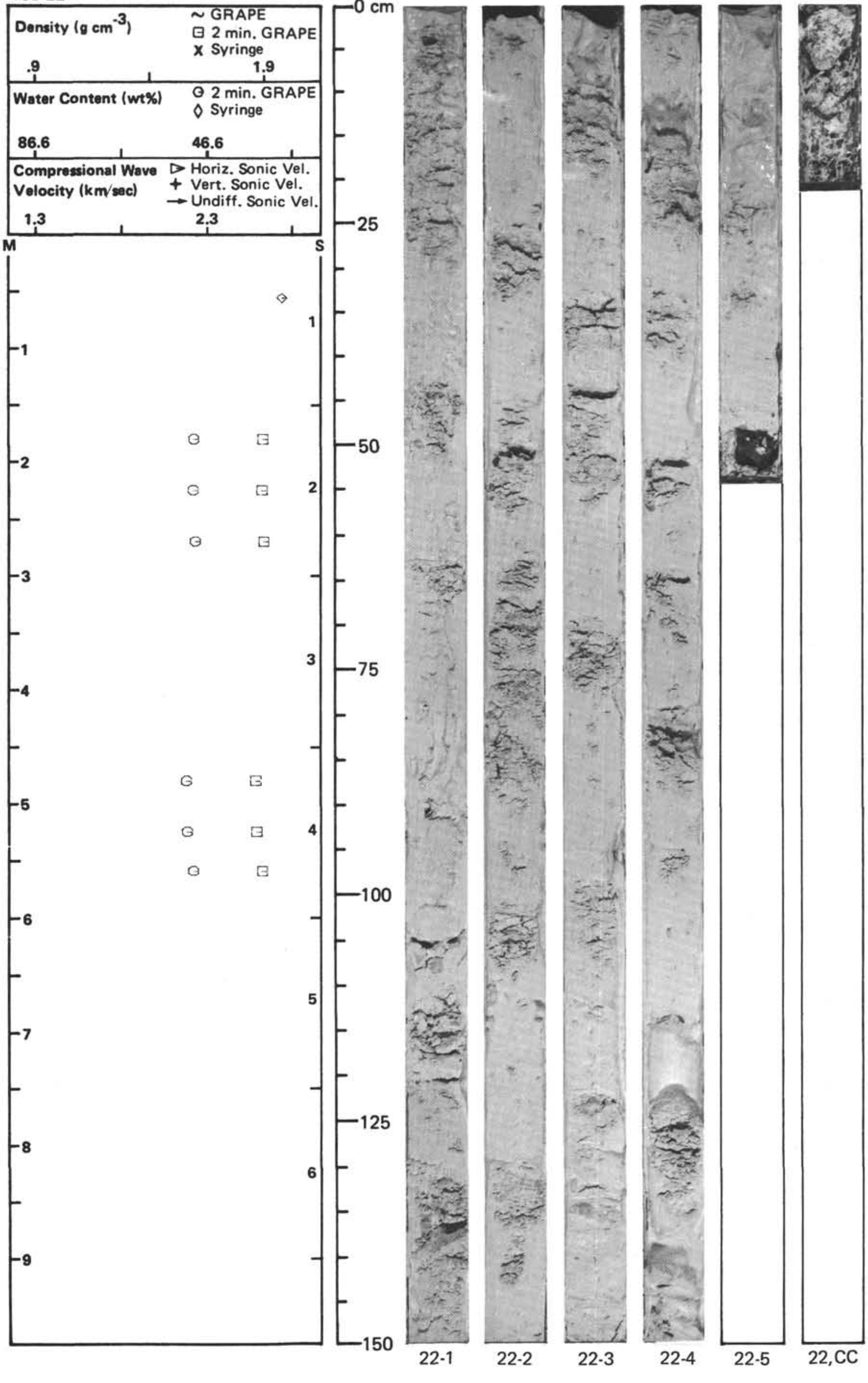

0 cm
25
50
75
100
125
150
20-1
20,CC

463-21

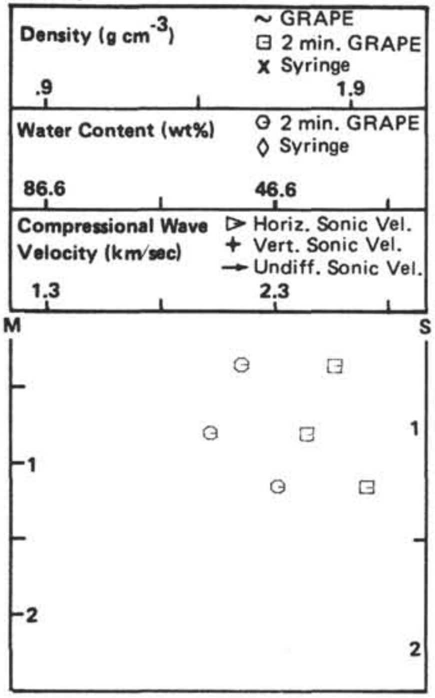

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9


0 cm
25
50
75
100
125
150
21-1
21-2
21-3
21-4
21-5
21-6
21-7
21,CC

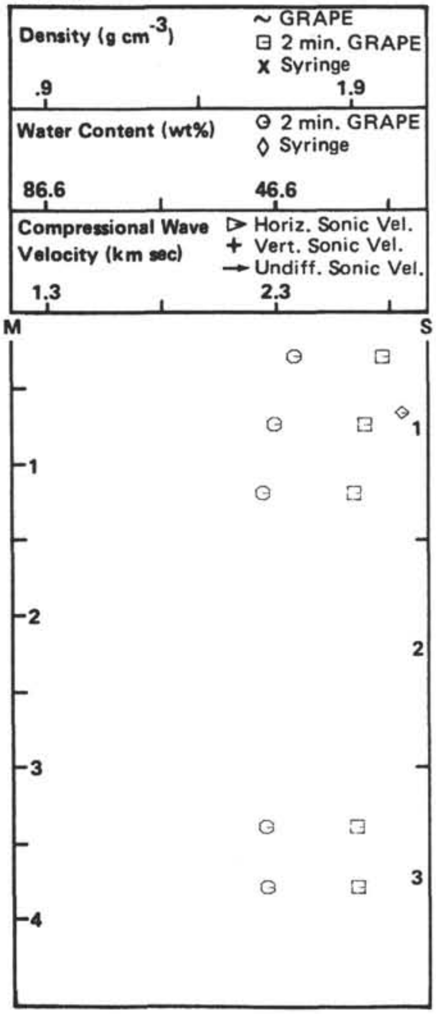
463-22

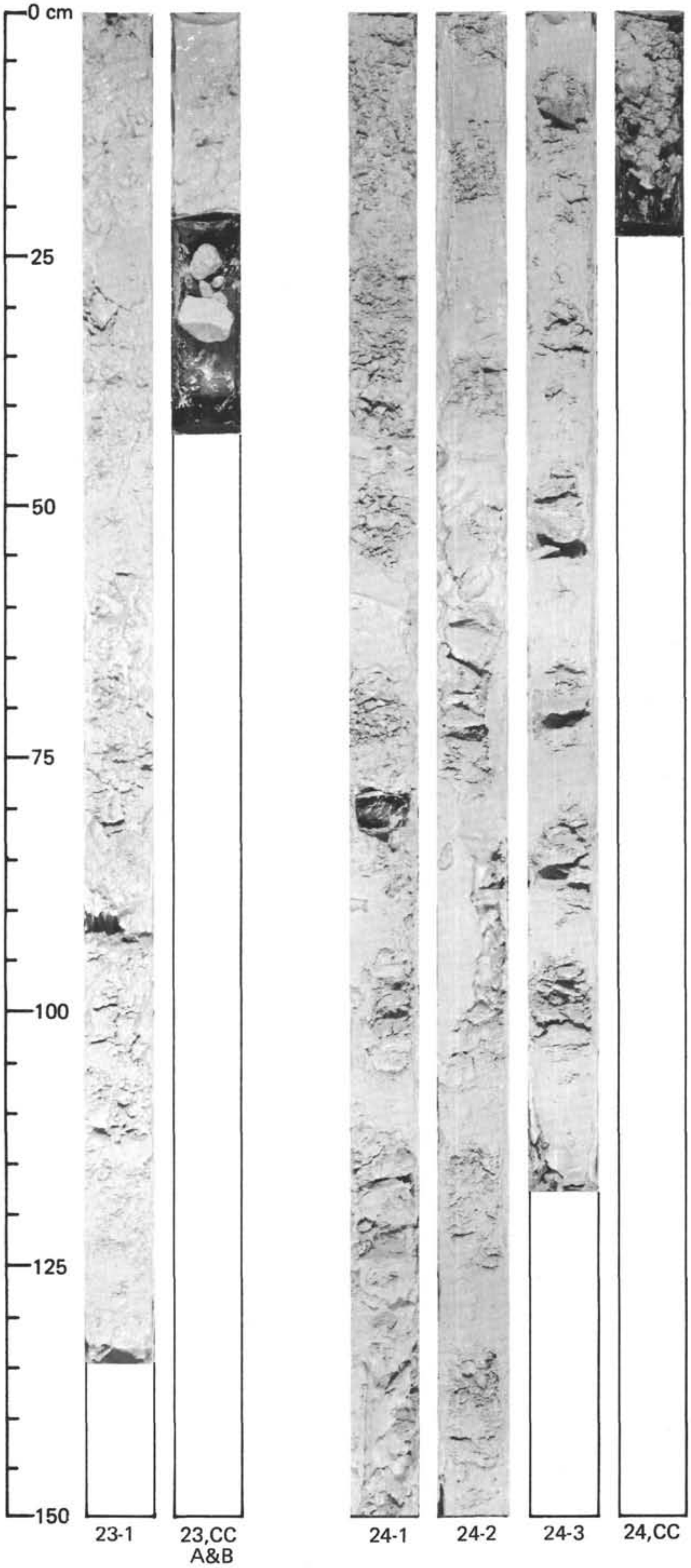

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
22-1
22-2
22-3
22-4
22-5
22,CC

463-23

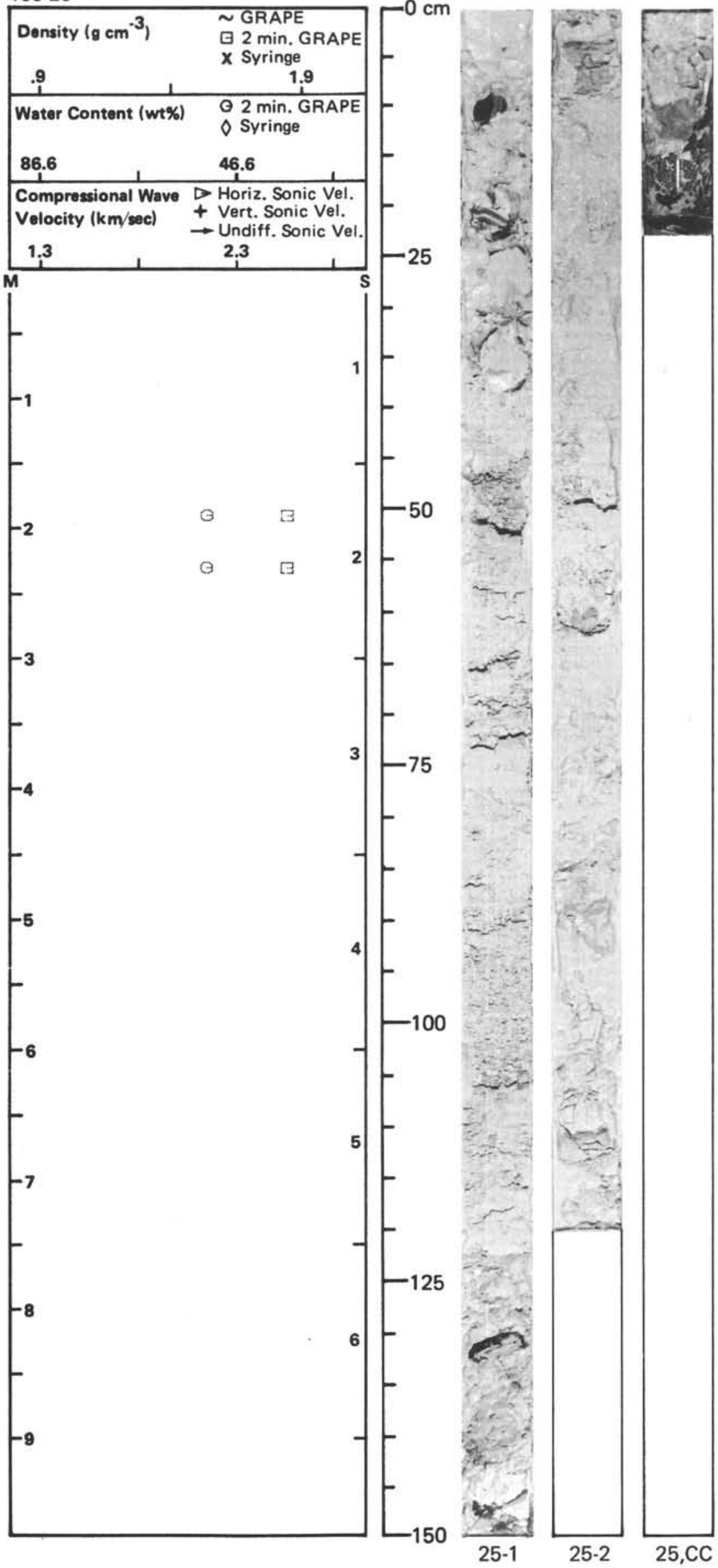

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
1
2
2

463-24

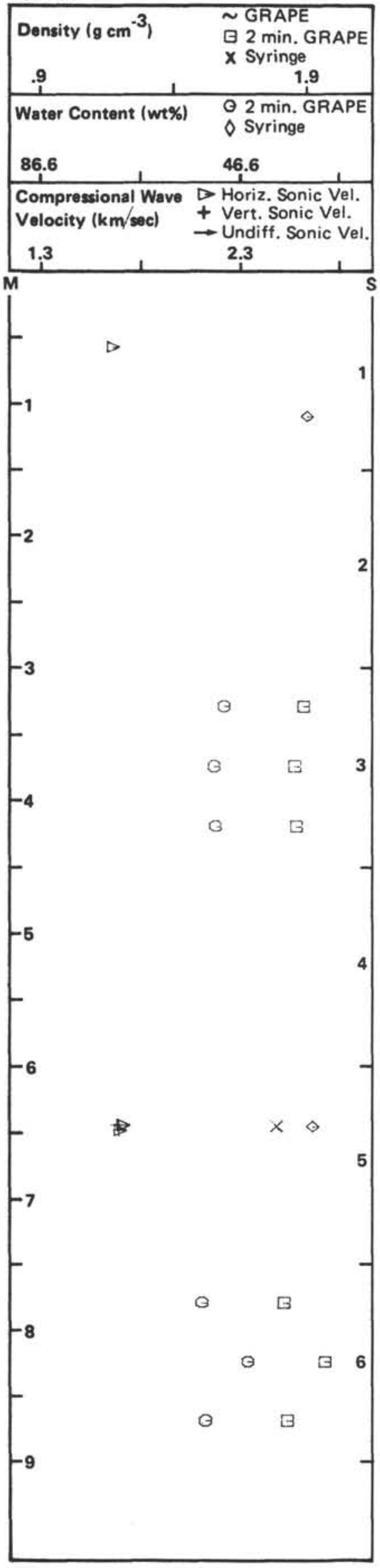

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
1
2
2
3
3
4

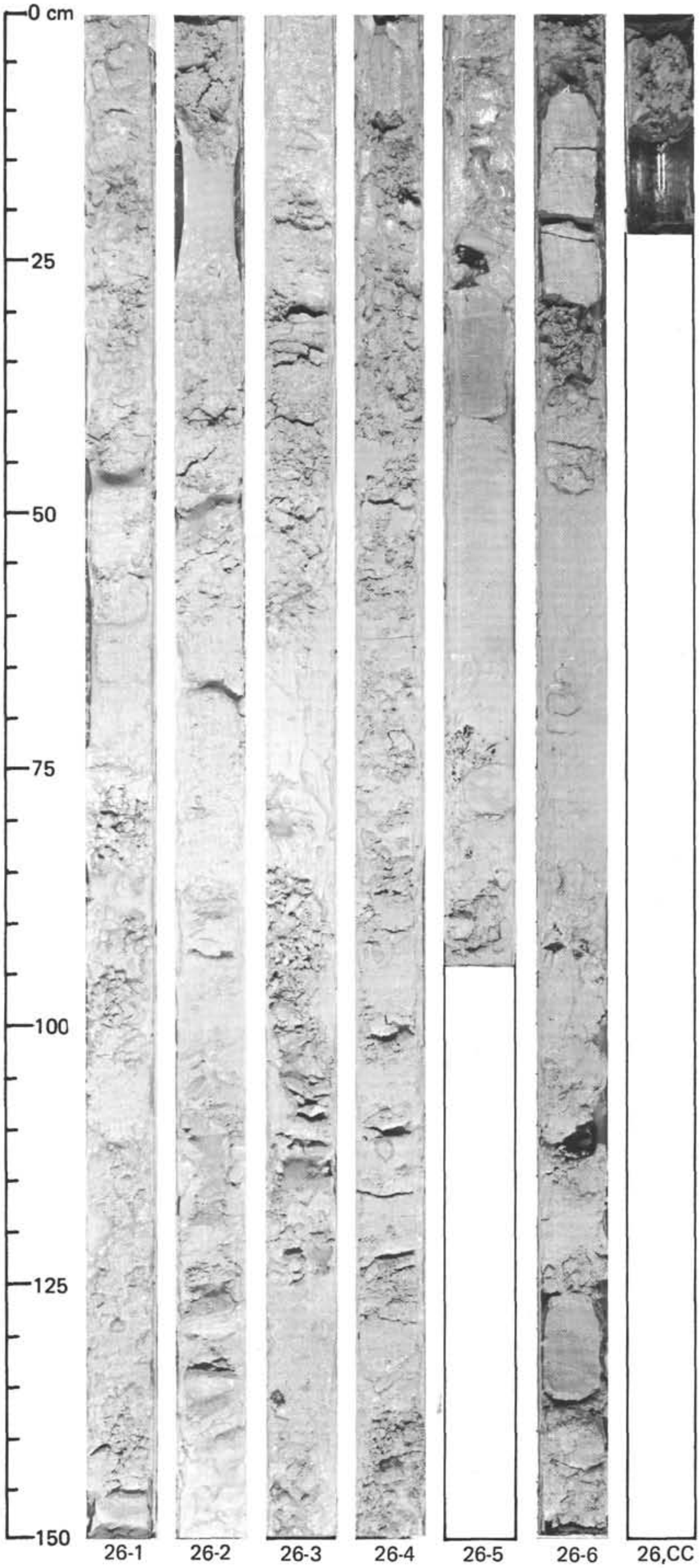

0 cm
25
50
75
100
125
150
23-1
23,CC A&B
24-1
24-2
24-3
24,CC

463-25

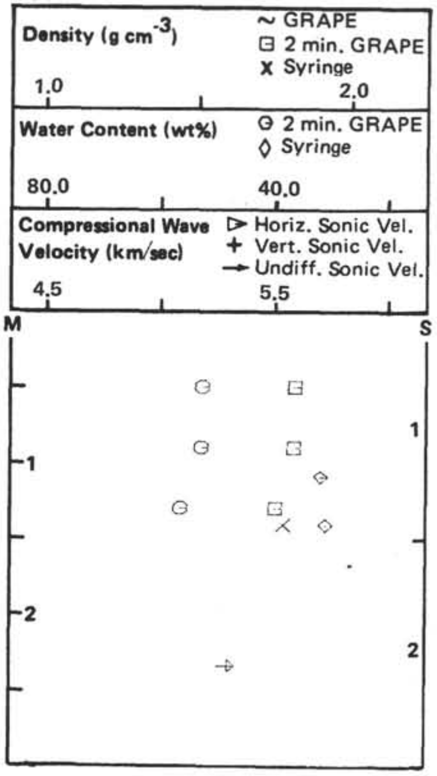

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ϴ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
25-1
25-2
25,CC

463-26

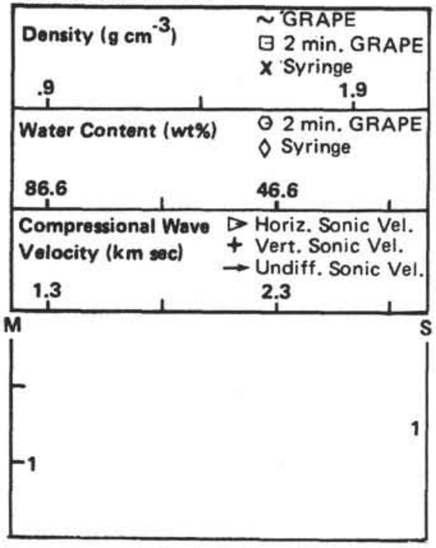

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9

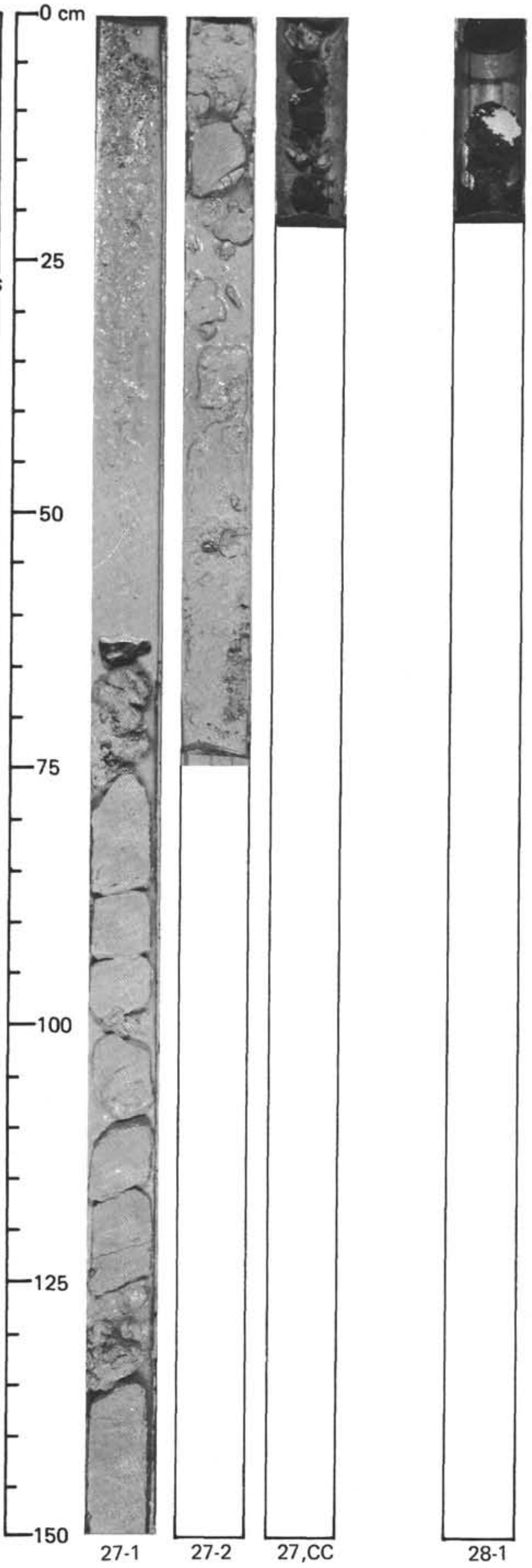

0 cm
25
50
75
100
125
150
26-1
26-2
26-3
26-4
26-5
26-6
26,CC

463-27

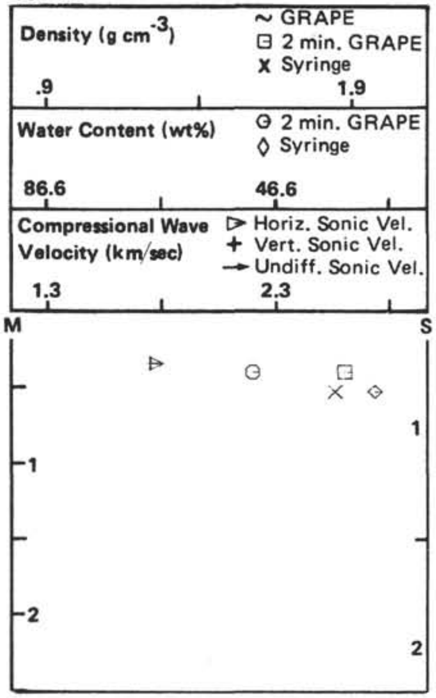


463-28 NO DATA

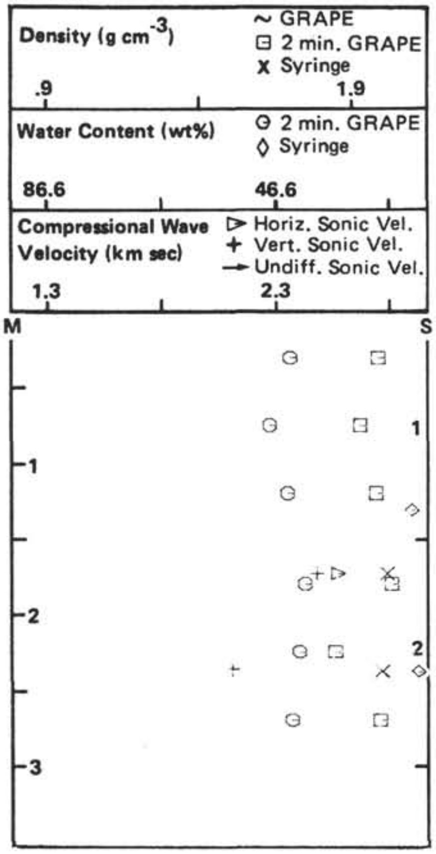


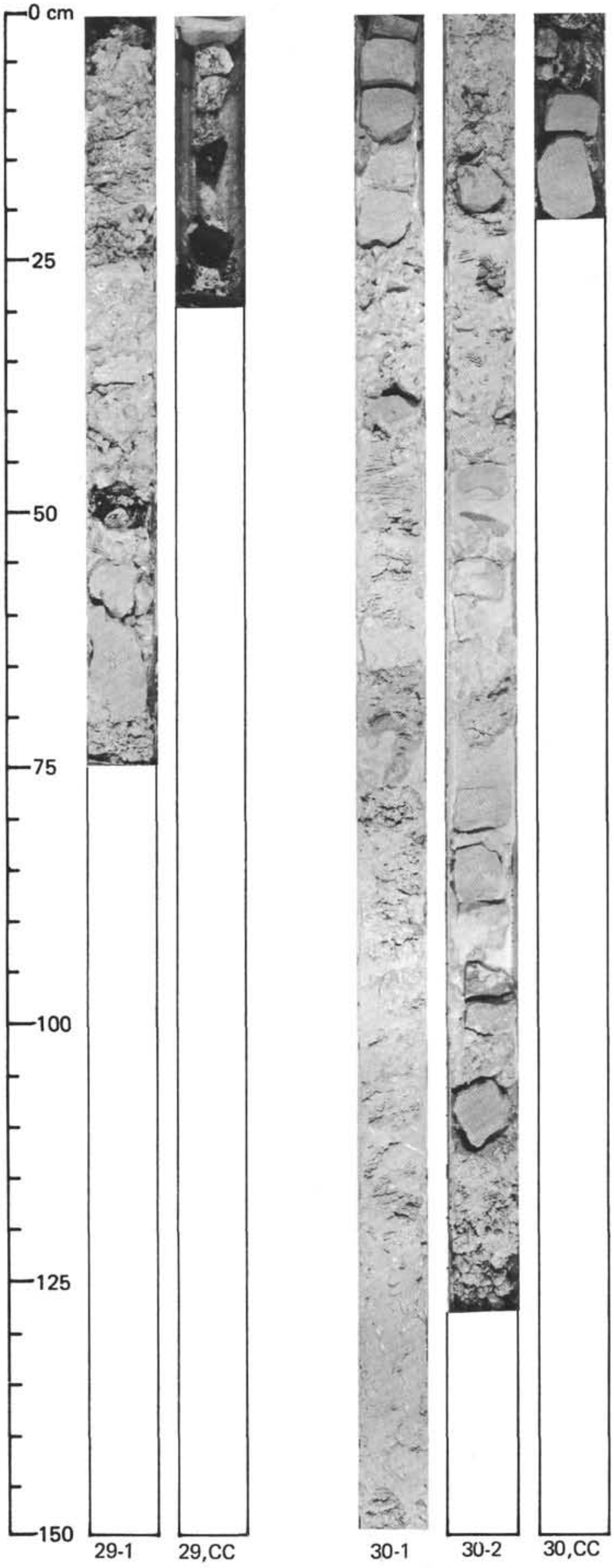


463-29

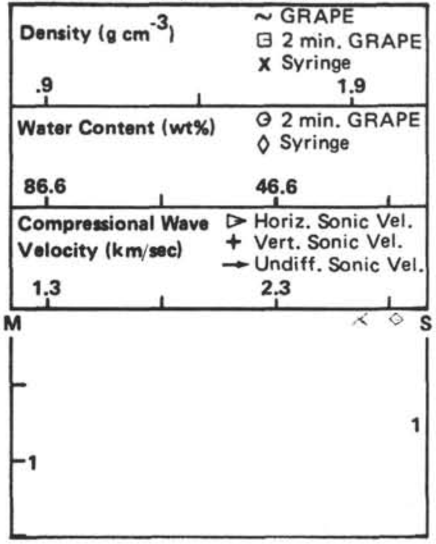

Density (g cm^{-3})
~ GRAPE
⊡ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
1
2
2

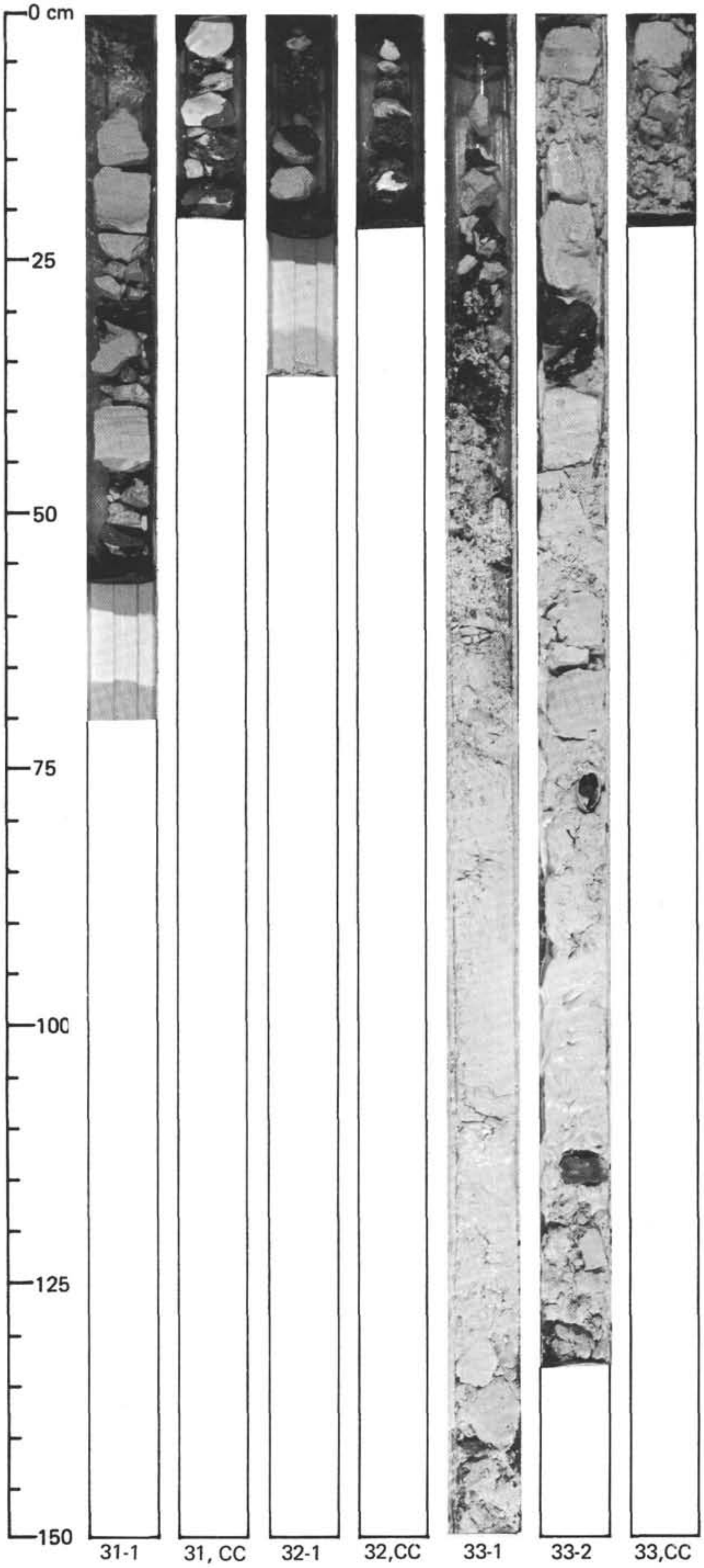
463-30


Density (g cm^{-3})
~ GRAPE
⊡ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
1
2
2
3

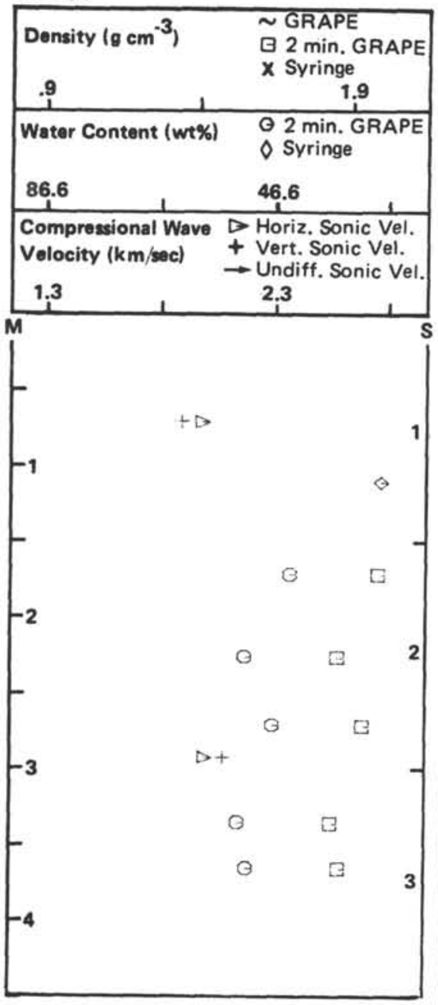

0 cm
25
50
75
100
125
150
29-1
29,CC
30-1
30-2
30,CC

463-31 (463-32, 33 NO DATA)

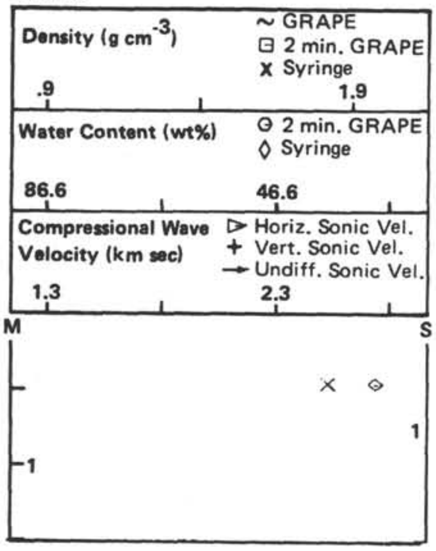


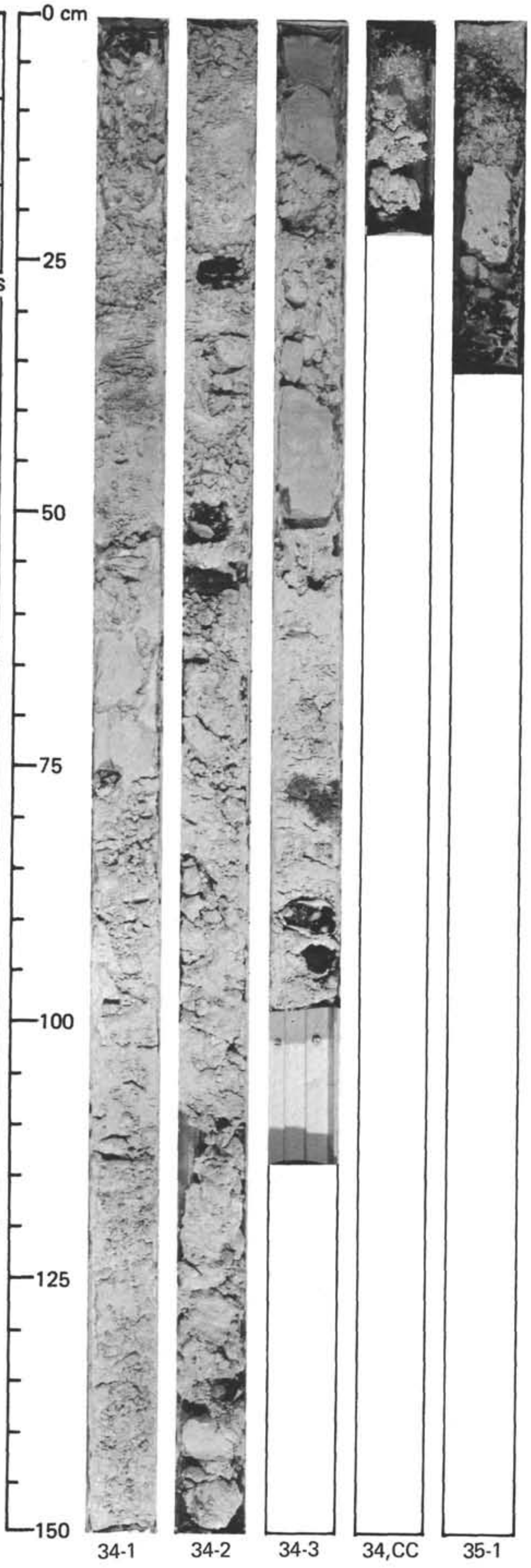


463-34

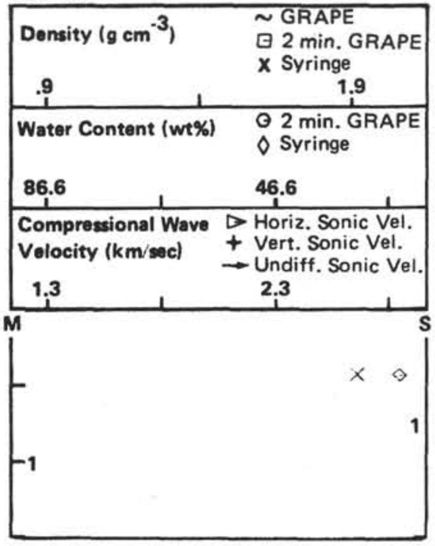

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
1
2
3

463-35

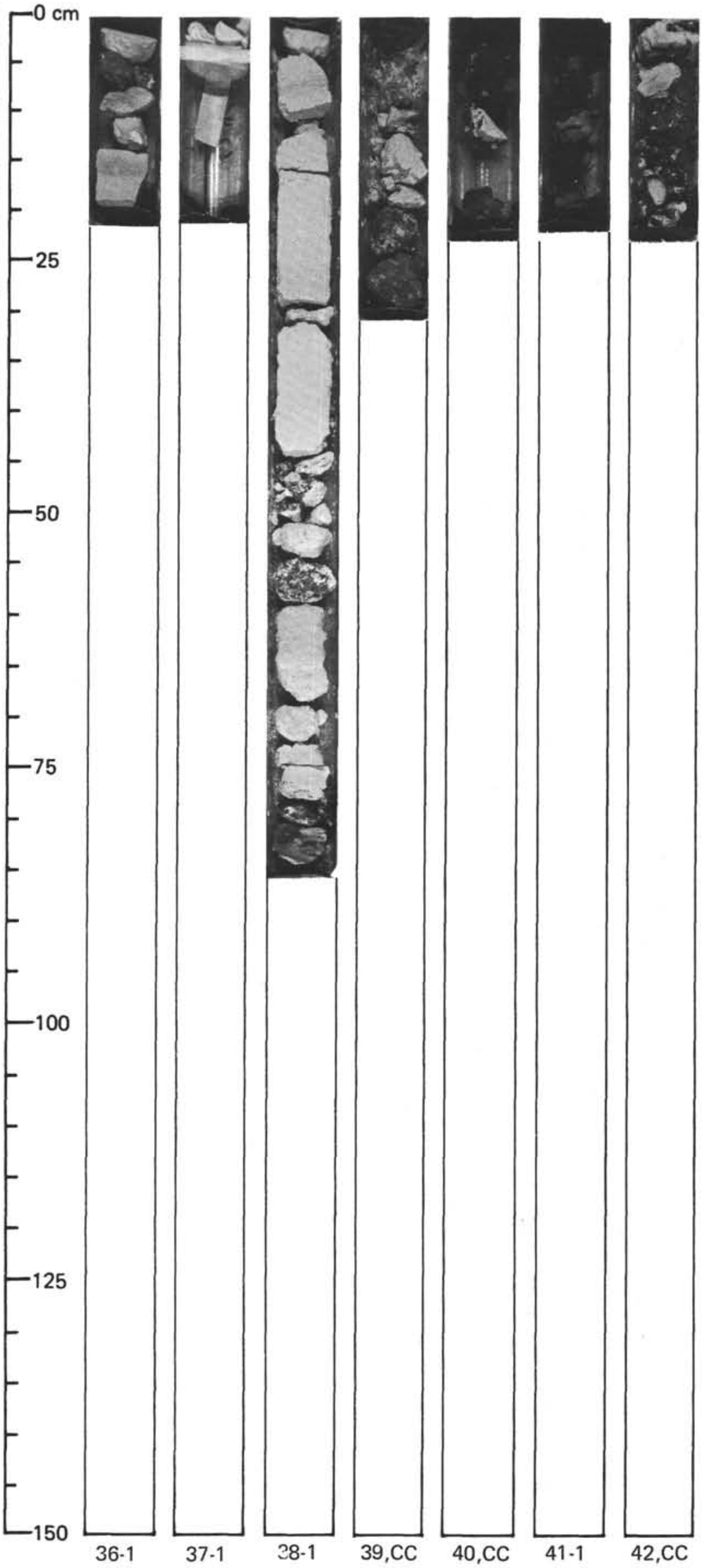

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
1


0 cm
25
50
75
100
125
150
34-1
34-2
34-3
34,CC
35-1

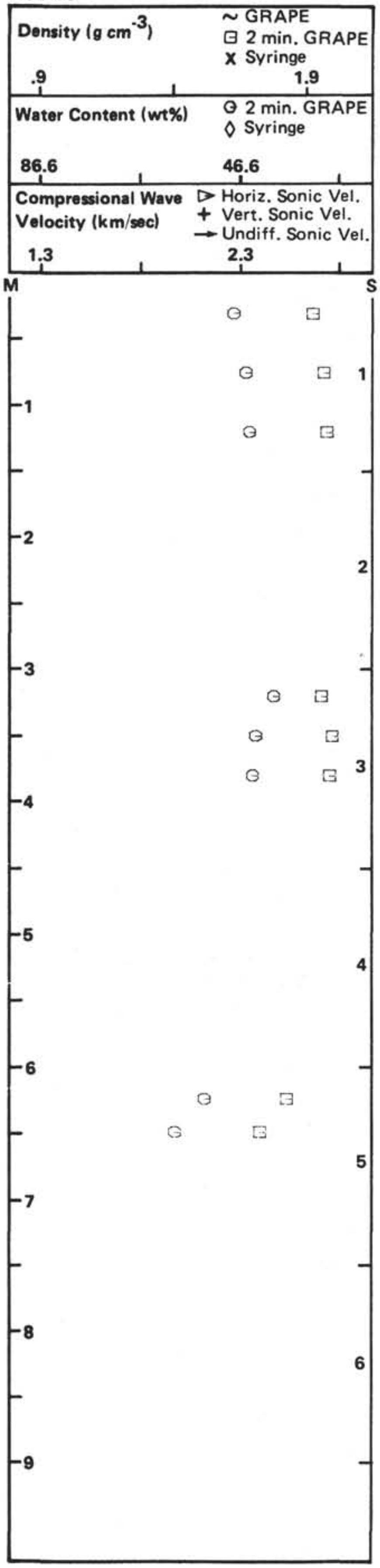
463-38

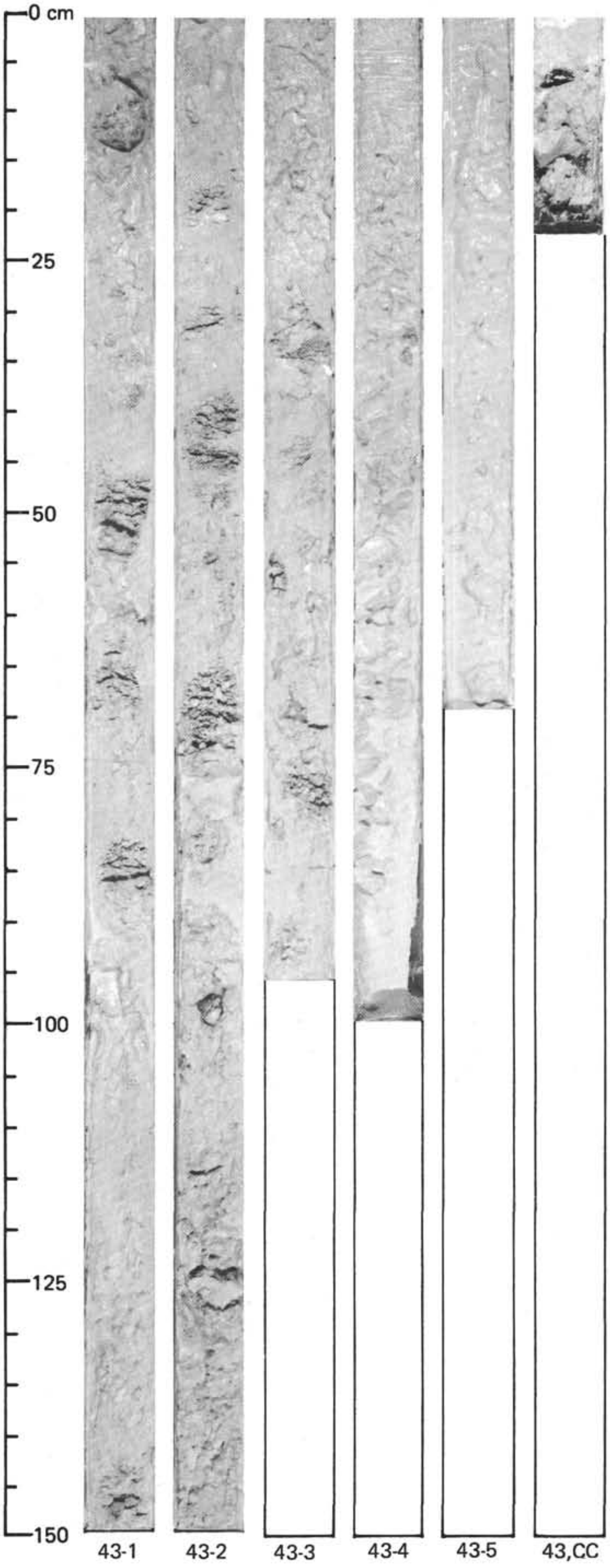


463-36, 37, 39 40, 41, 42 NO DATA

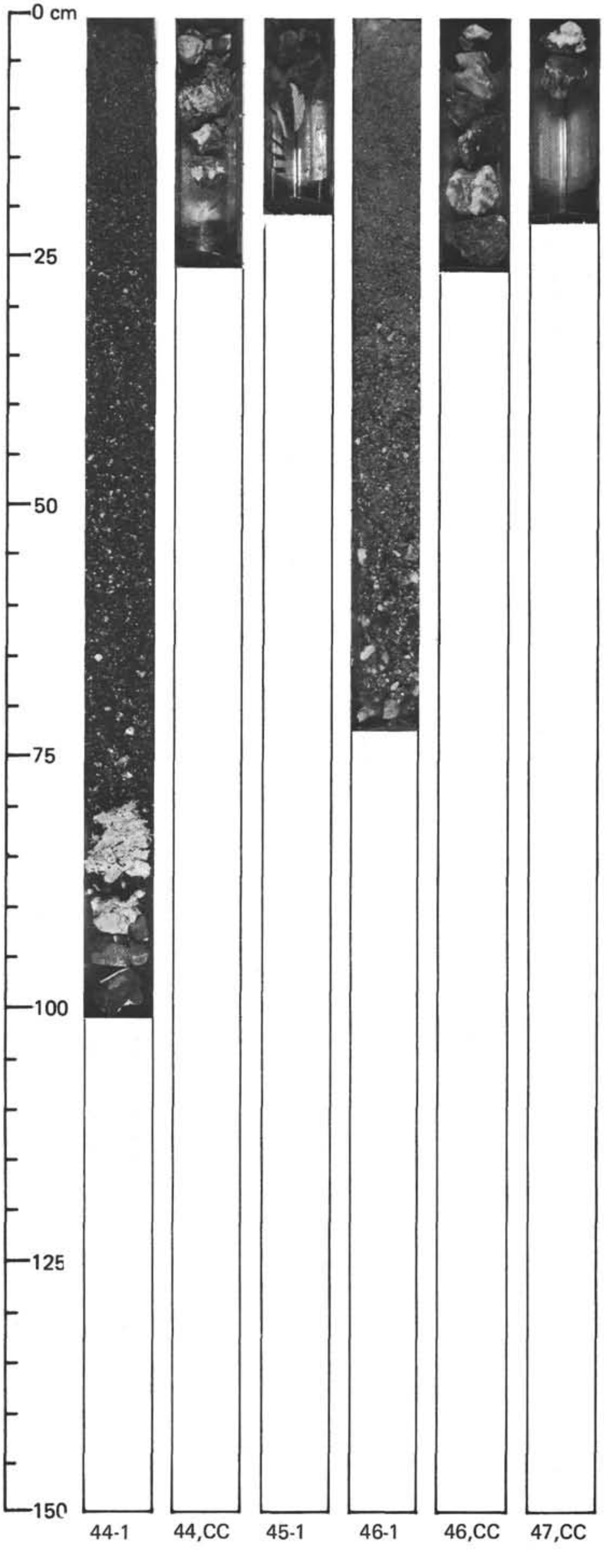


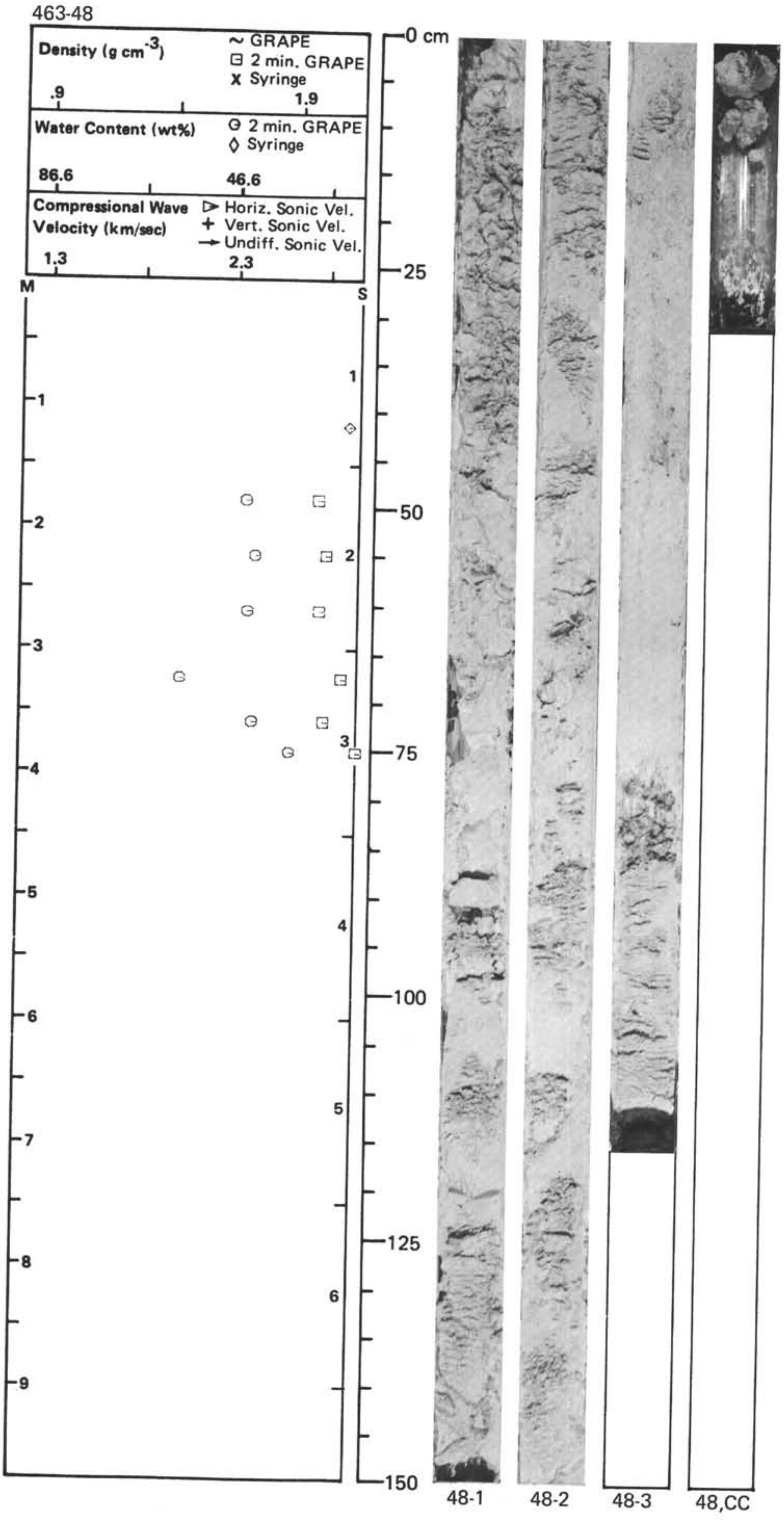
463-43


Density (g cm-3)
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9

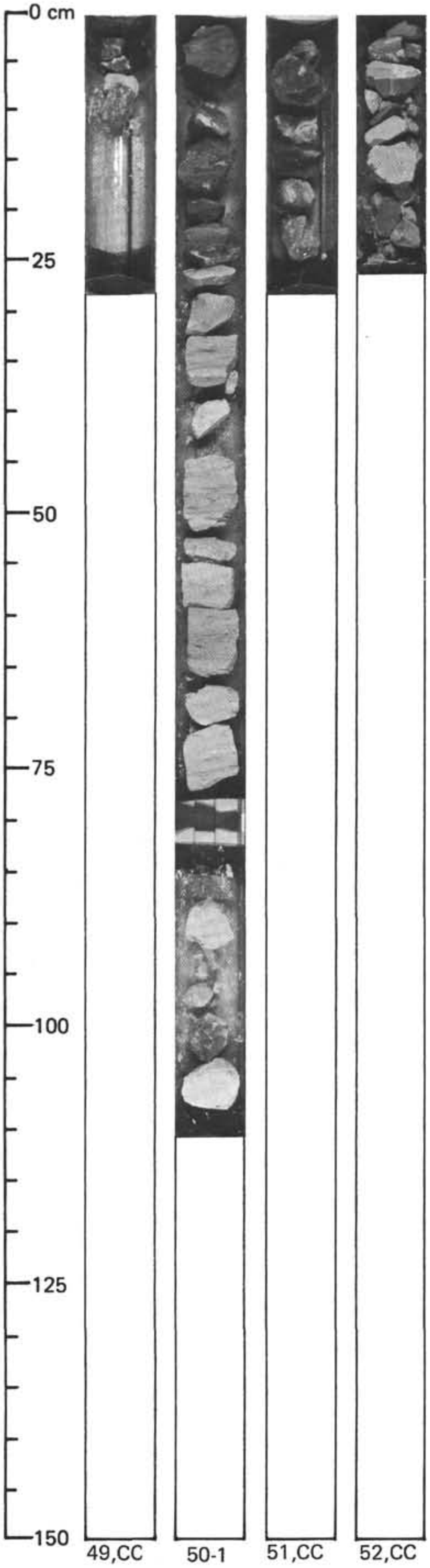

0 cm
25
50
75
100
125
150
43-1
43-2
43-3
43-4
43-5
43,CC

463-44, 45, 46, 47 NO DATA

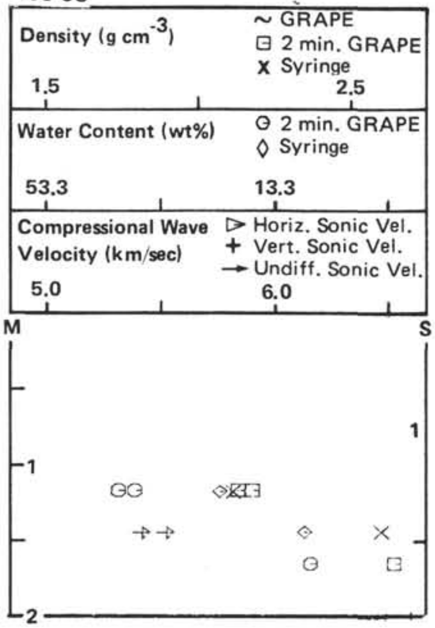



463-48
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
48-1
48-2
48-3
48,CC

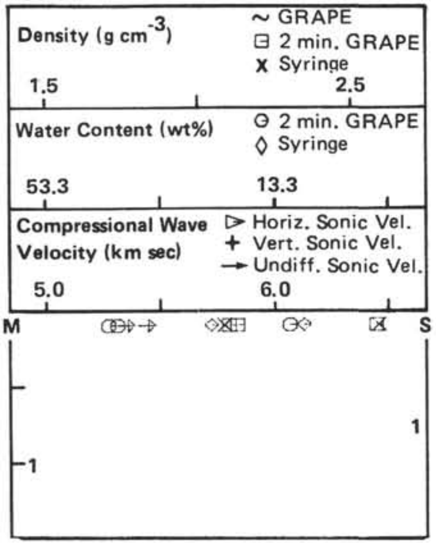
463-49, 50, 51, 52 NO DATA



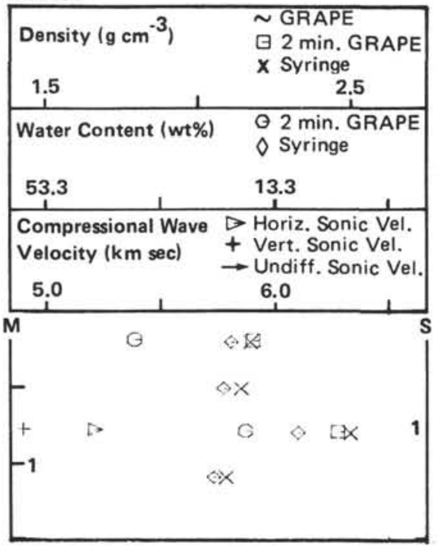
463-53

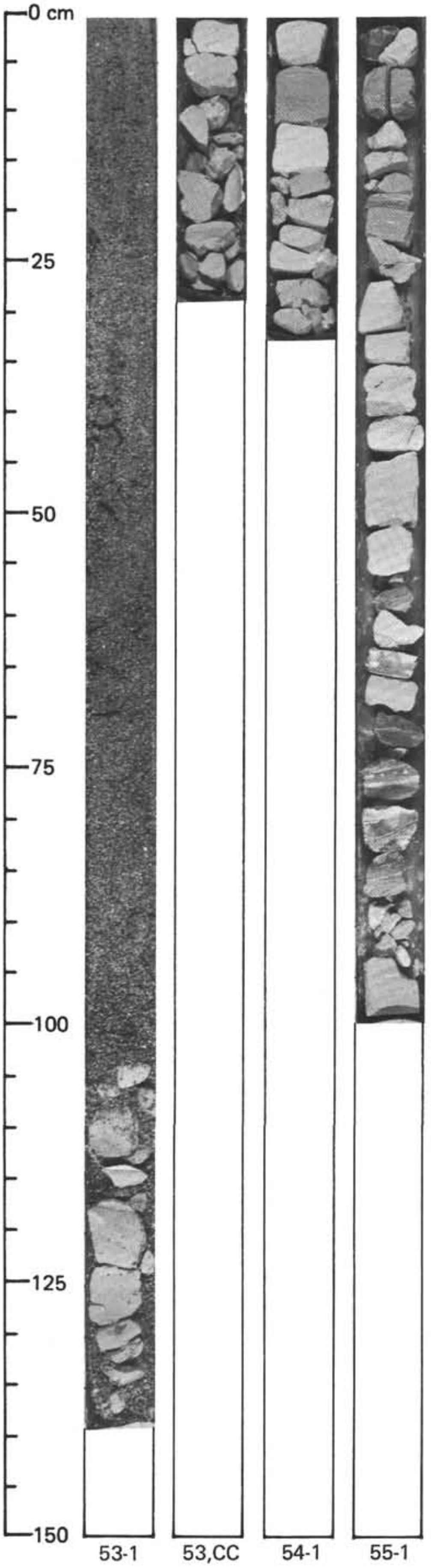


463-54

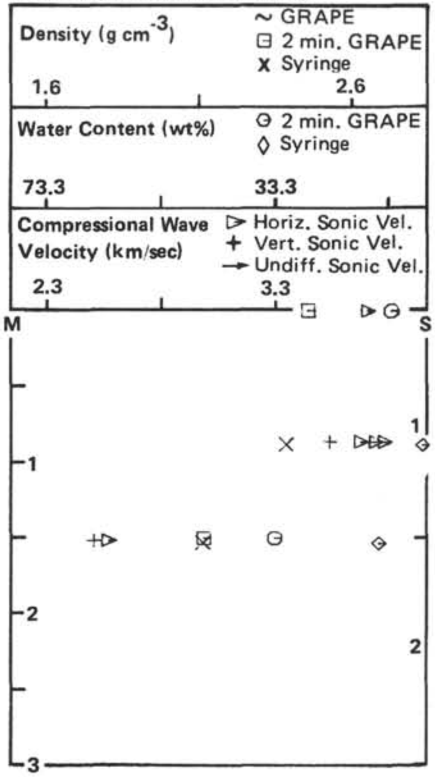


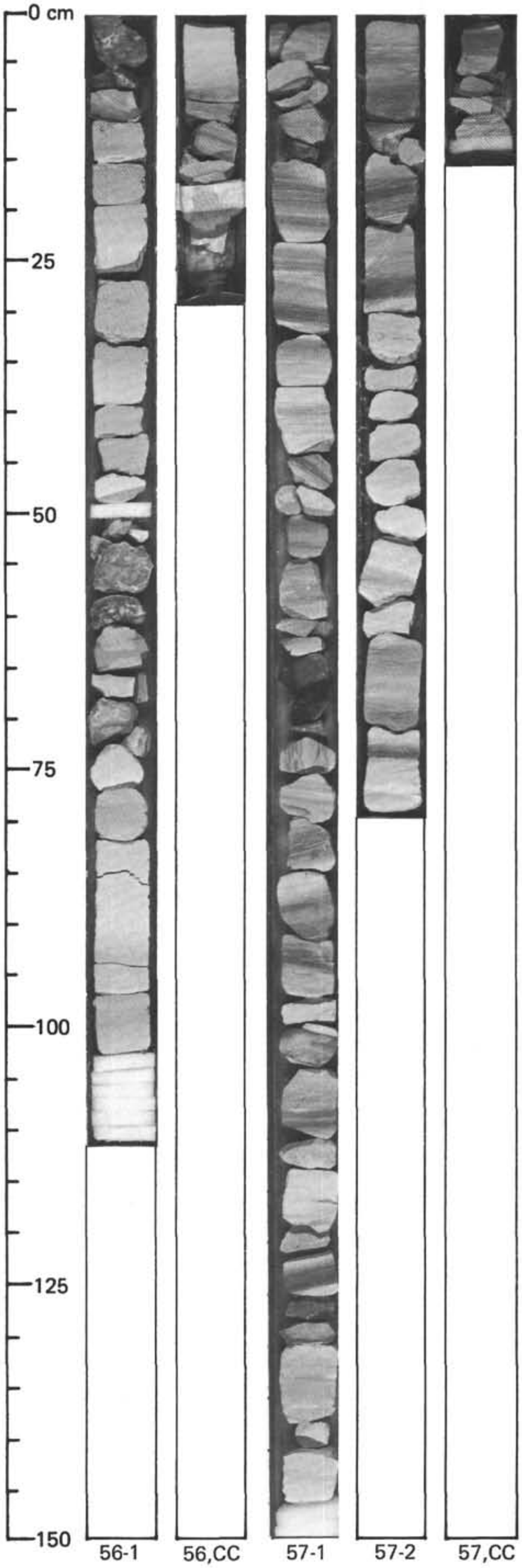
463-55

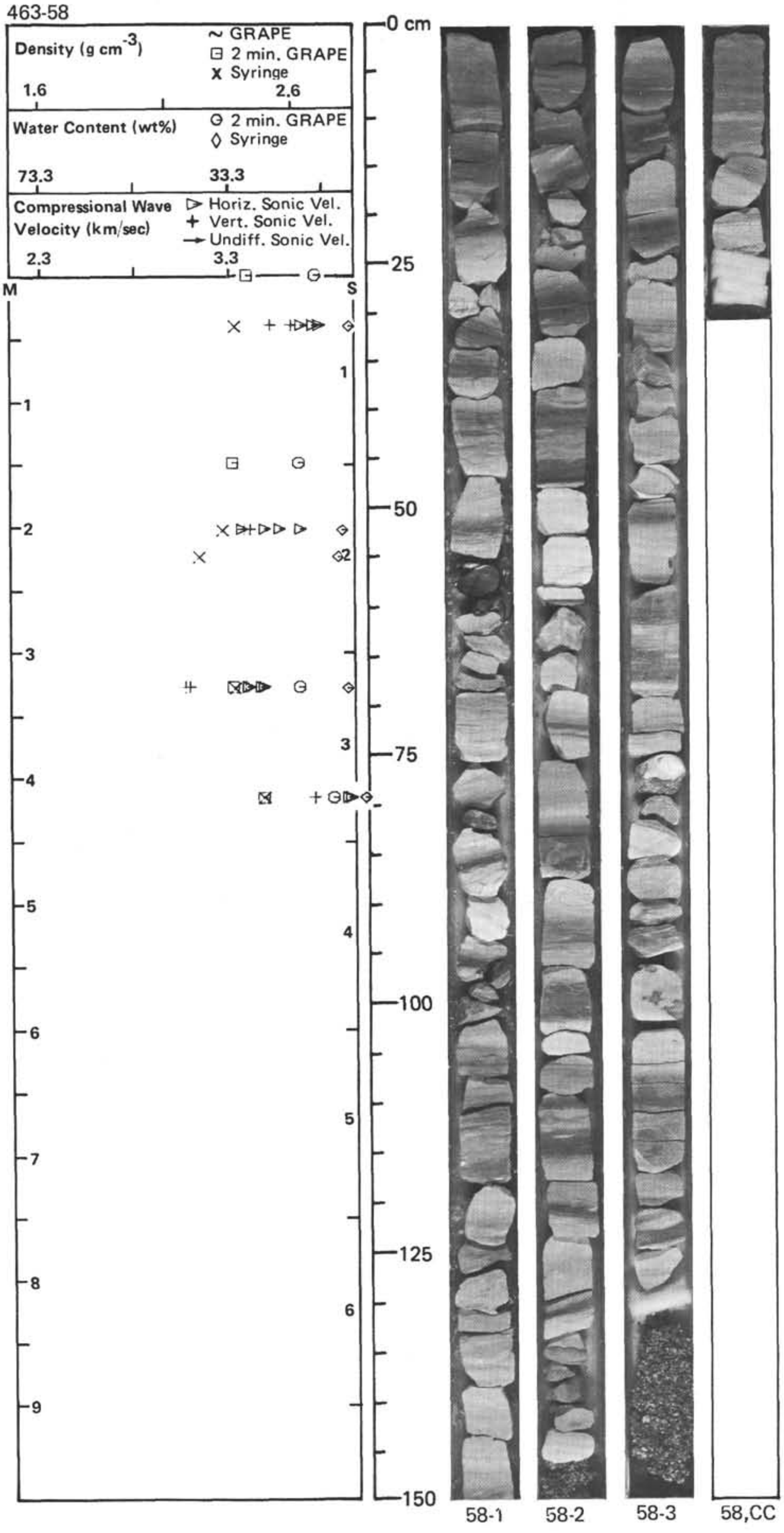




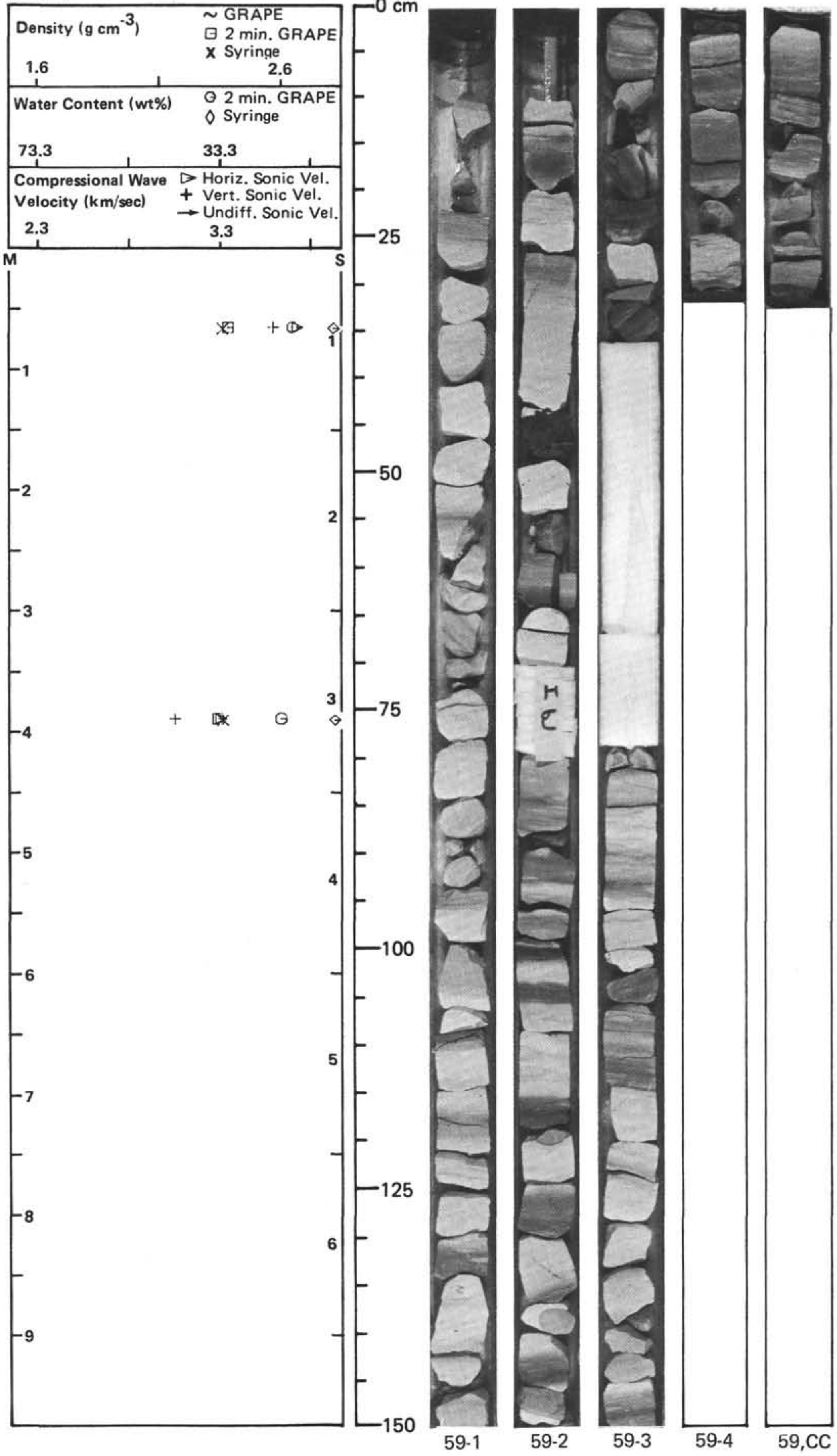
463-57 (463-56 NO DATA)



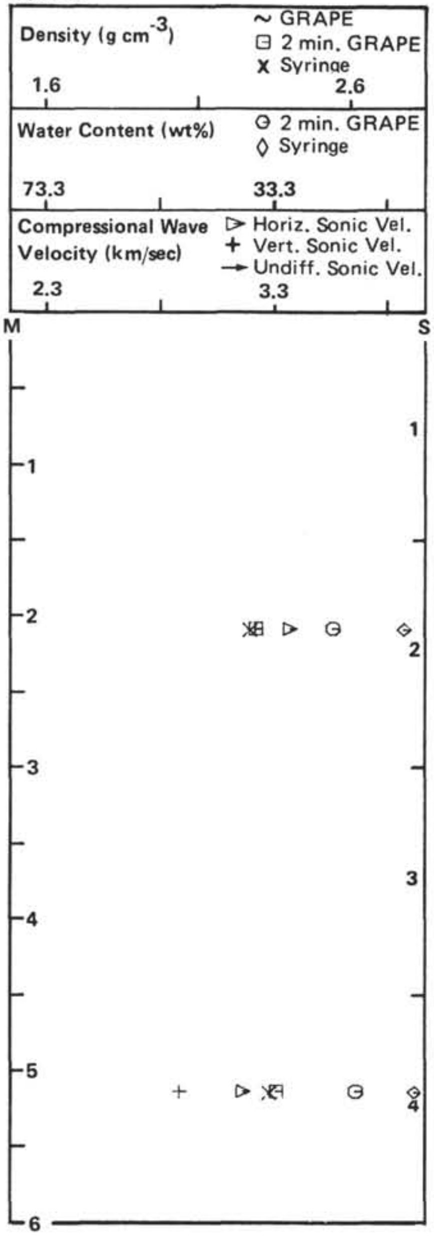



463-58
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
x Syringe
1.6
2.6
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
58-1
58-2
58-3
58,CC

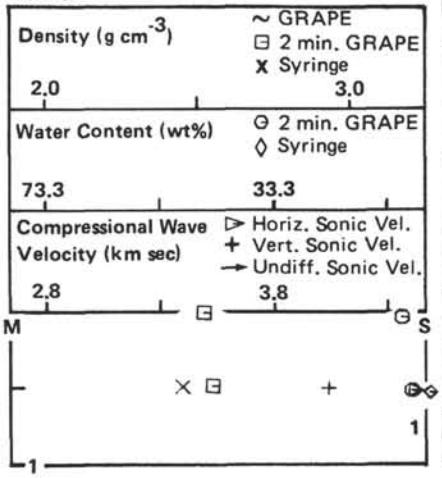
463-59

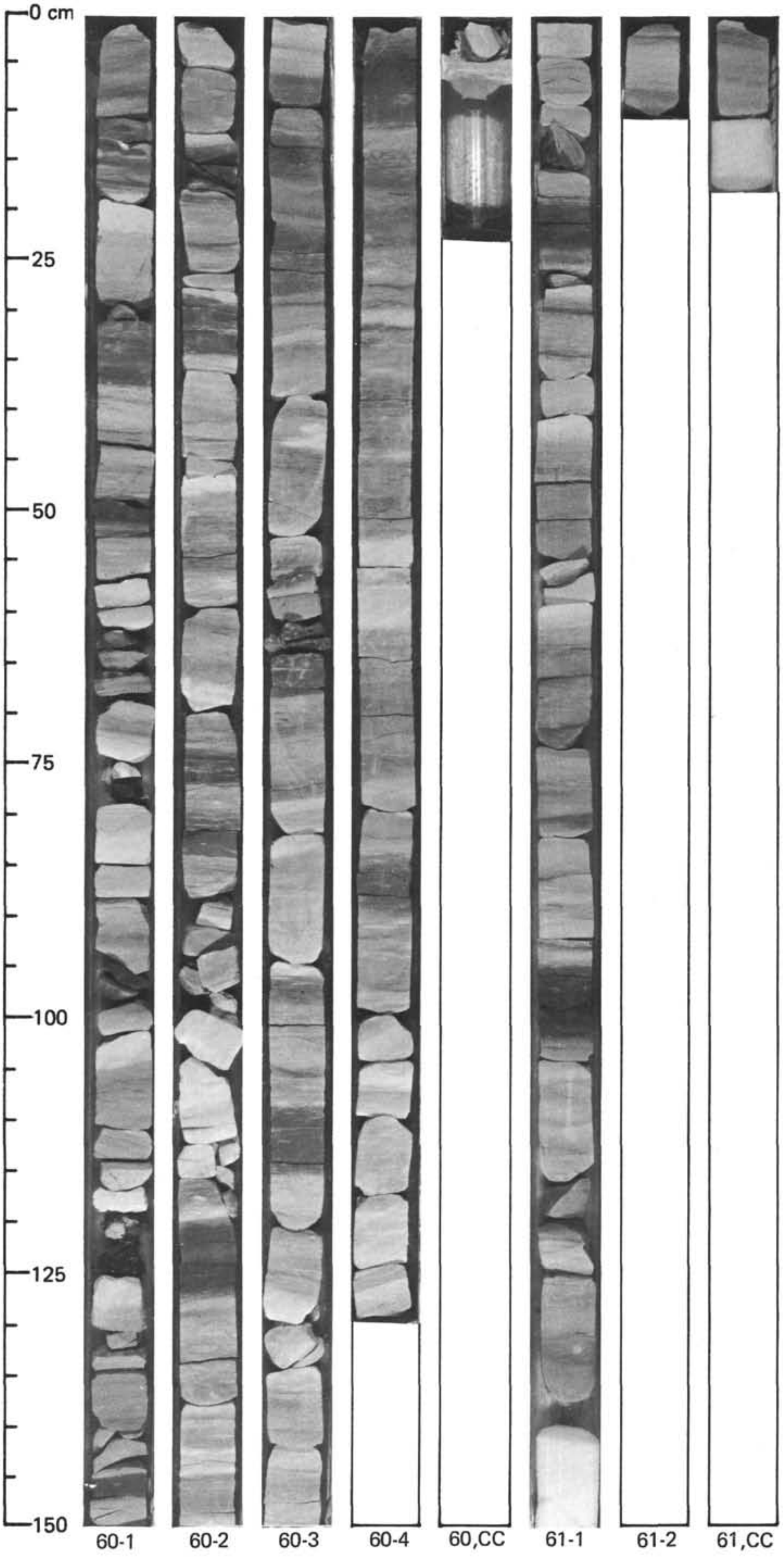

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
H
C
59-1
59-2
59-3
59-4
59,CC

463-60

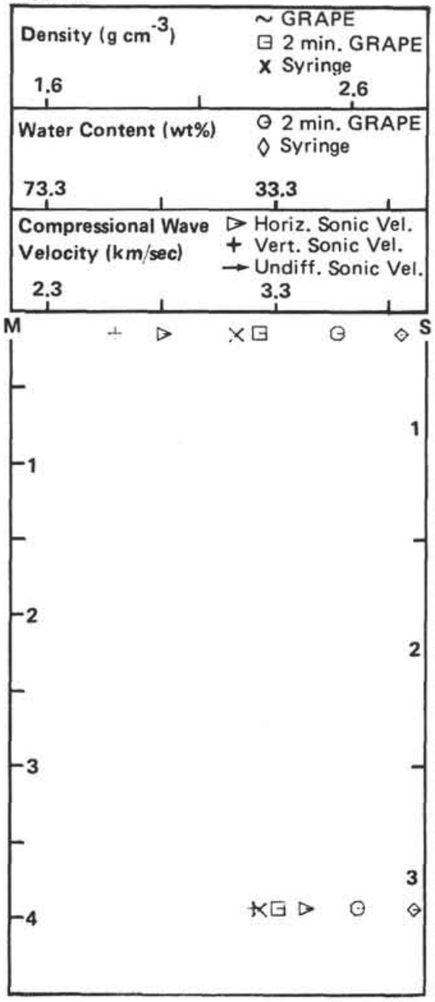

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
4
5
6
1
2
3
4

463-61

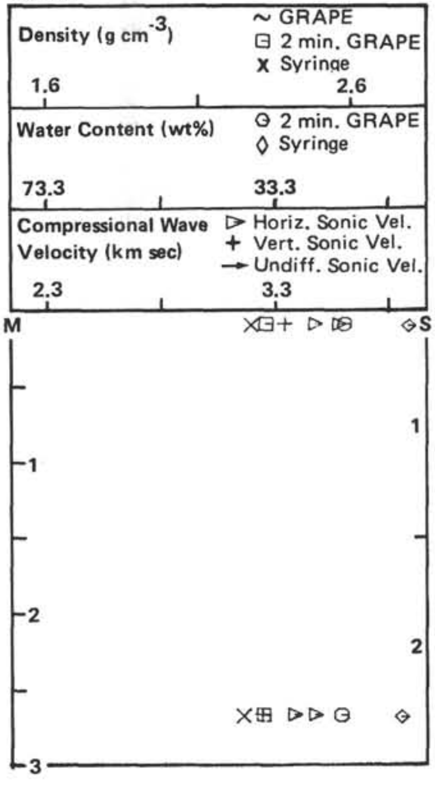

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
2.0
3.0
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.8
3.8
M
S
1
1

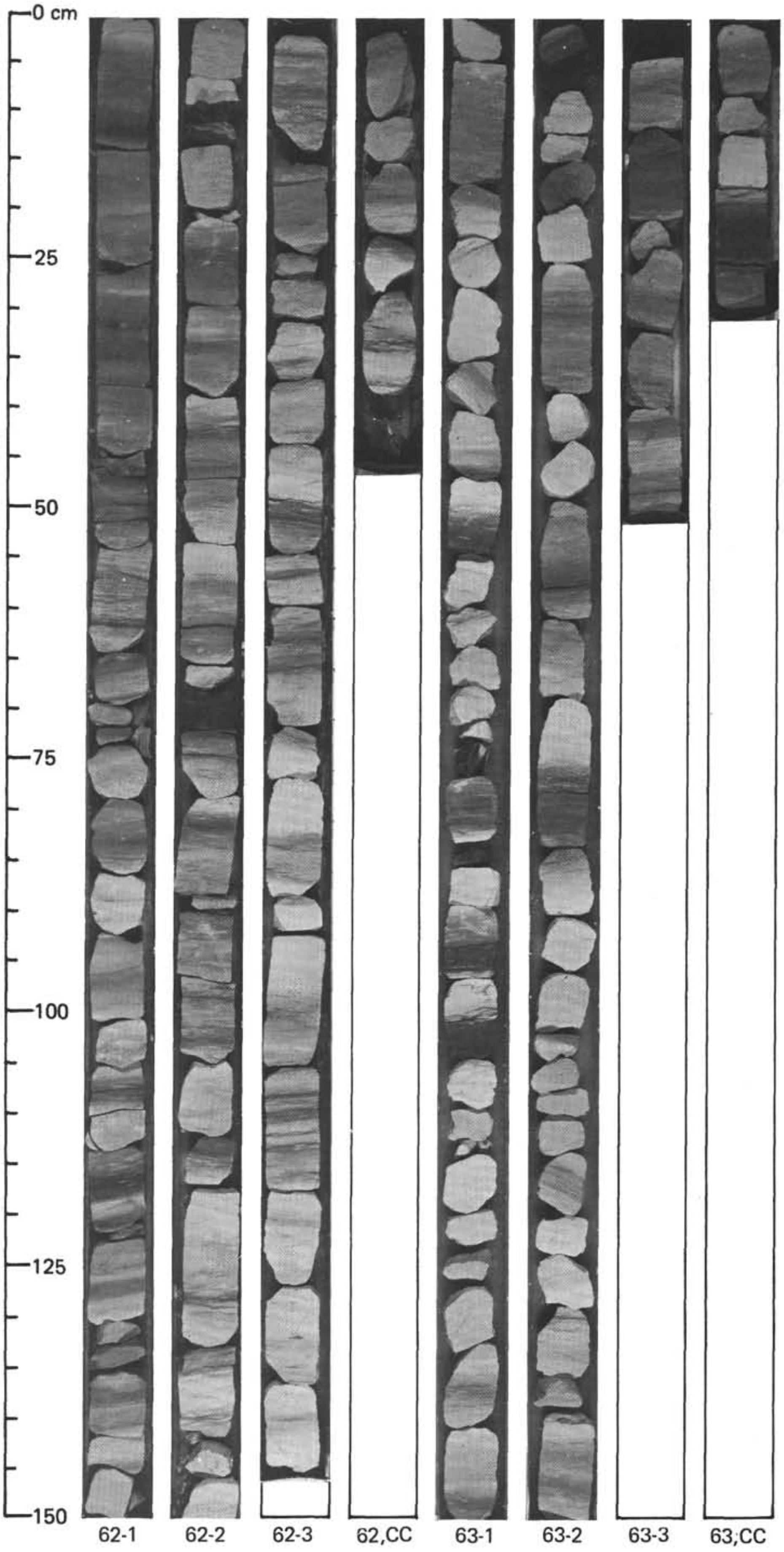

0 cm
25
50
75
100
125
150
60-1
60-2
60-3
60-4
60,CC
61-1
61-2
61,CC

463-62

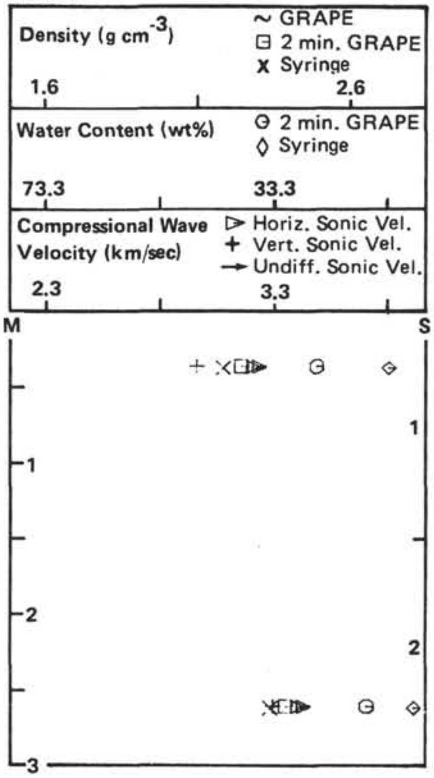

Density (g cm-3)
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
4
1
2
3

463-63

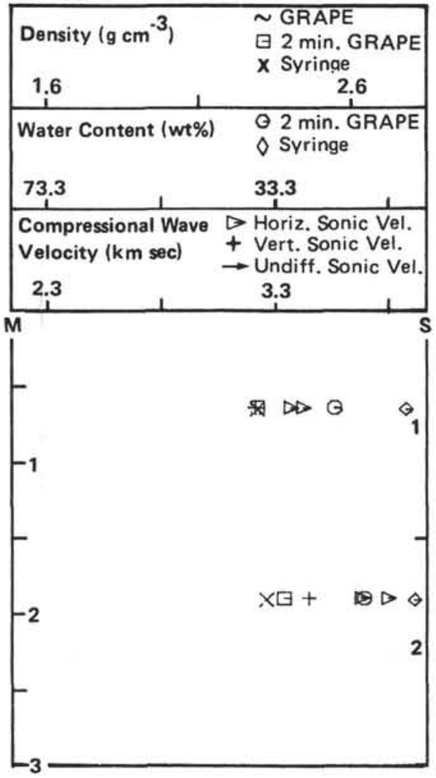

Density (g cm-3)
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
1
2

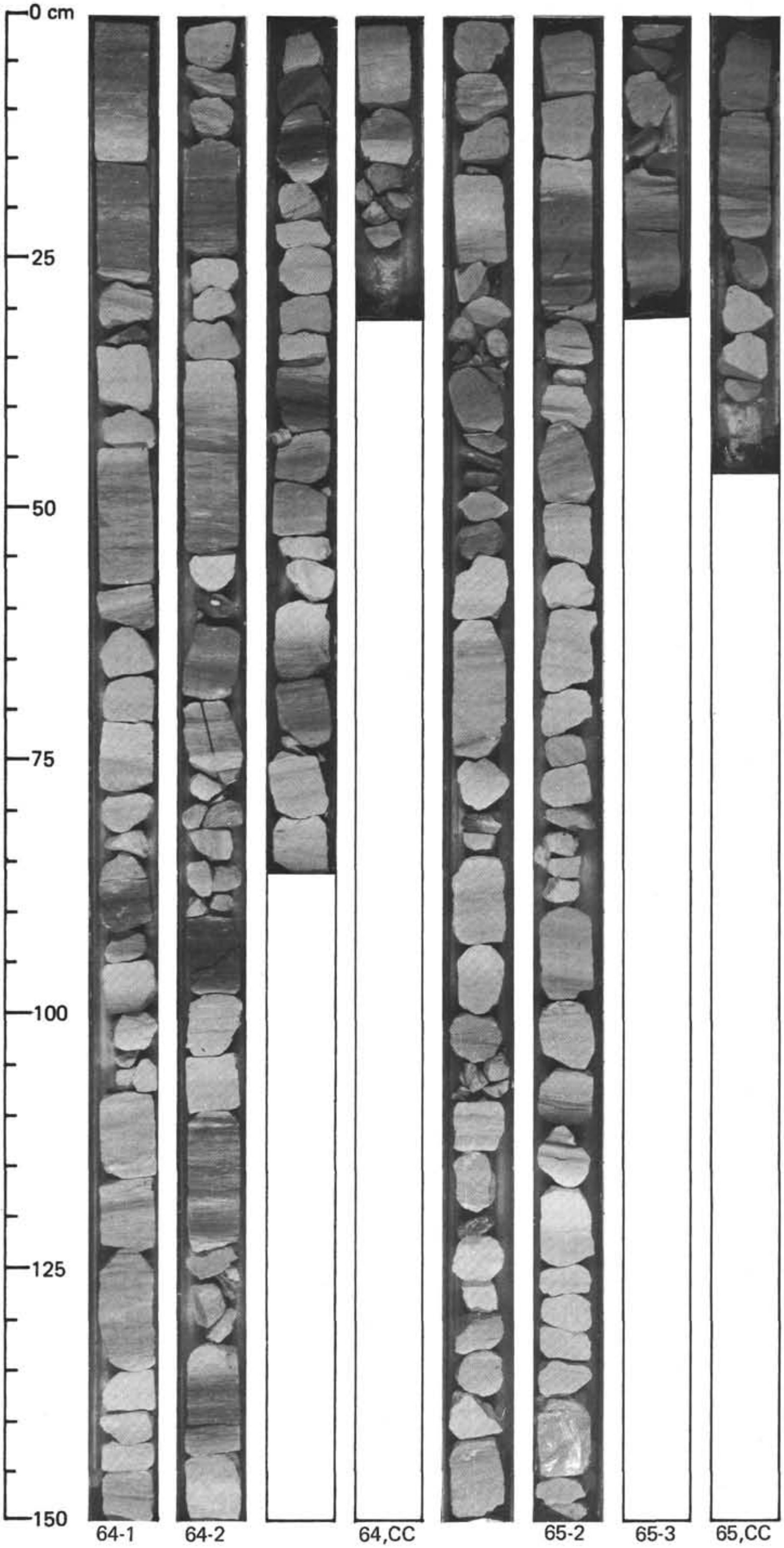

0 cm
25
50
75
100
125
150
62-1
62-2
62-3
62,CC
63-1
63-2
63-3
63;CC

463-64

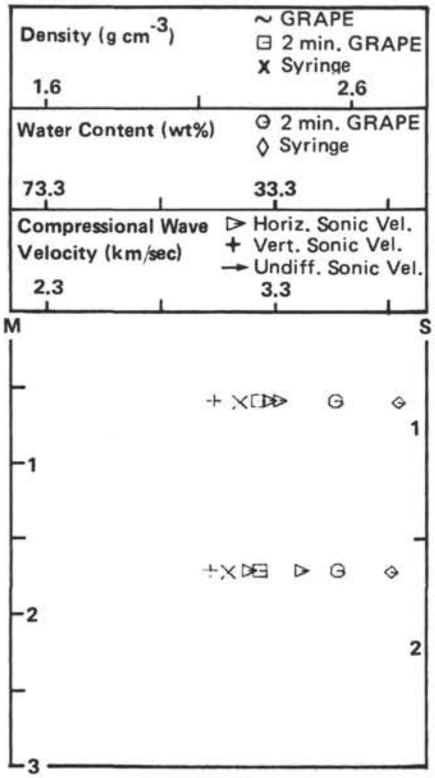

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
x Syringe
1.6
2.6
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
1
2

463-65

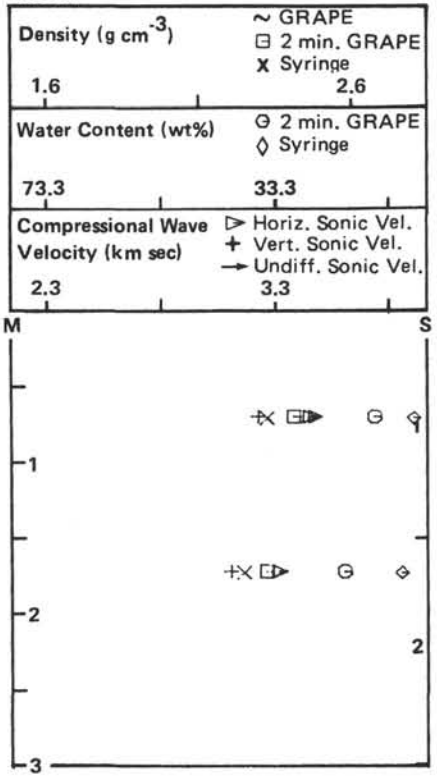

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
x Syringe
1.6
2.6
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
1
2

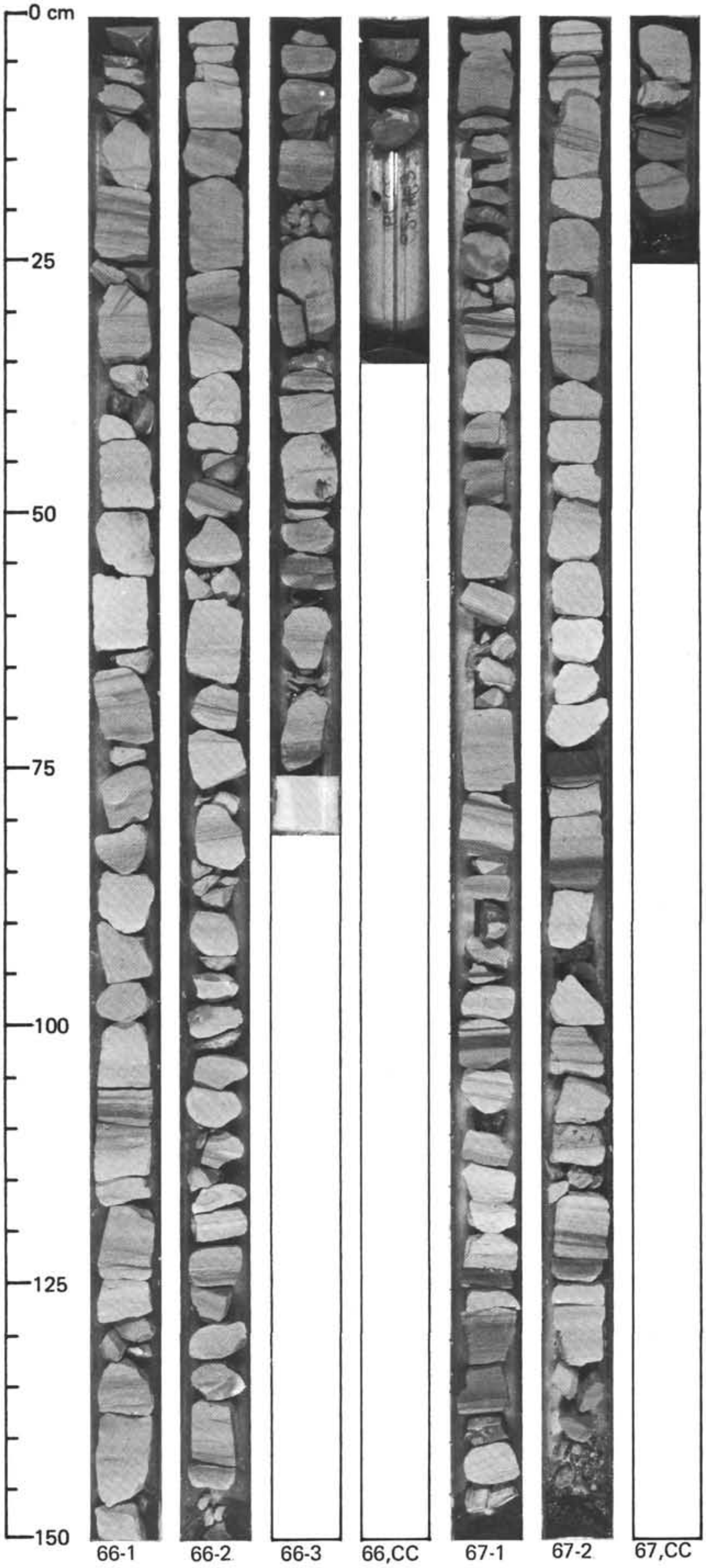

0 cm
25
50
75
100
125
150
64-1
64-2
64,CC
65-2
65-3
65,CC

463-66

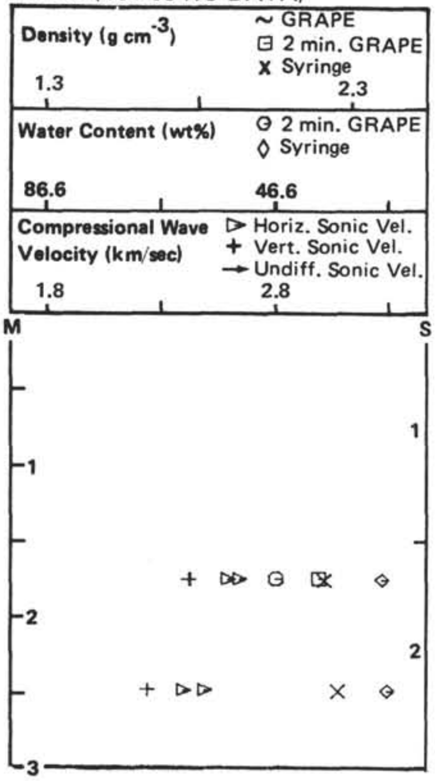

Density (g cm-3)
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
ϴ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
1
2

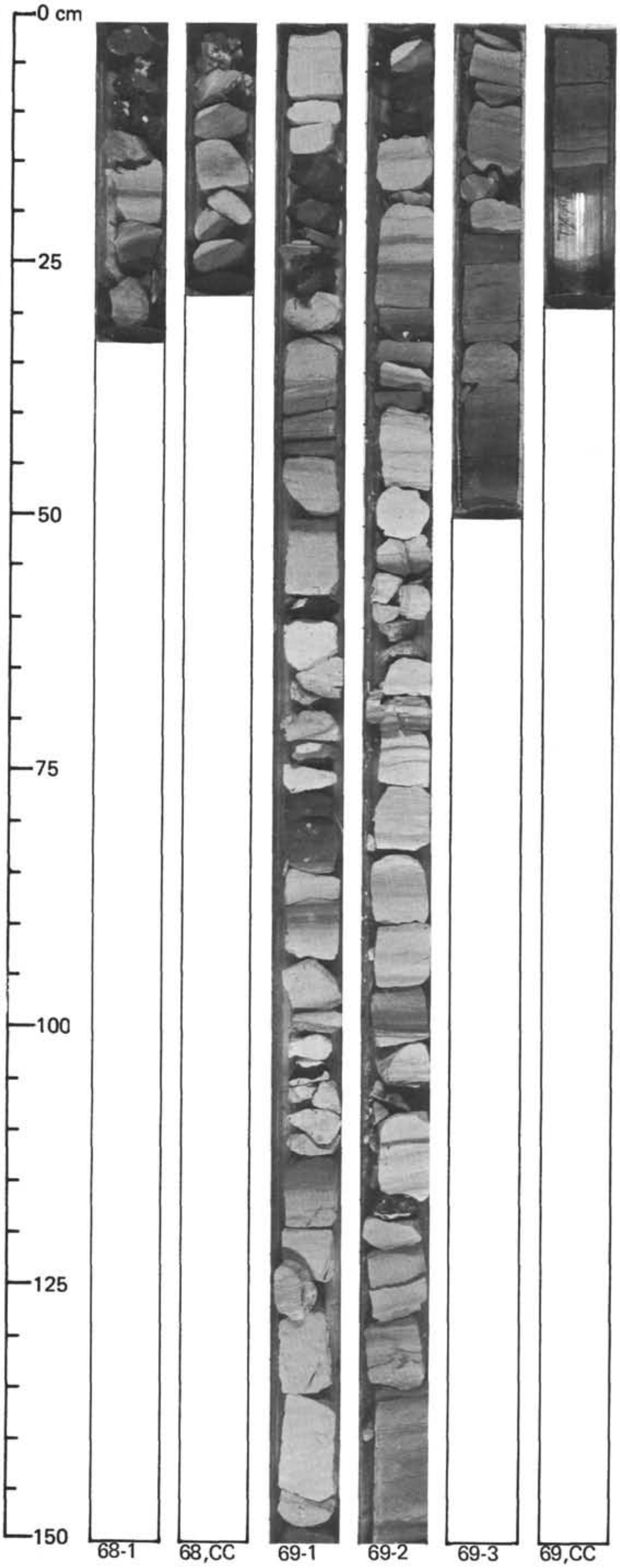
463-67


Density (g cm-3)
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
ϴ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
2
3
1
2

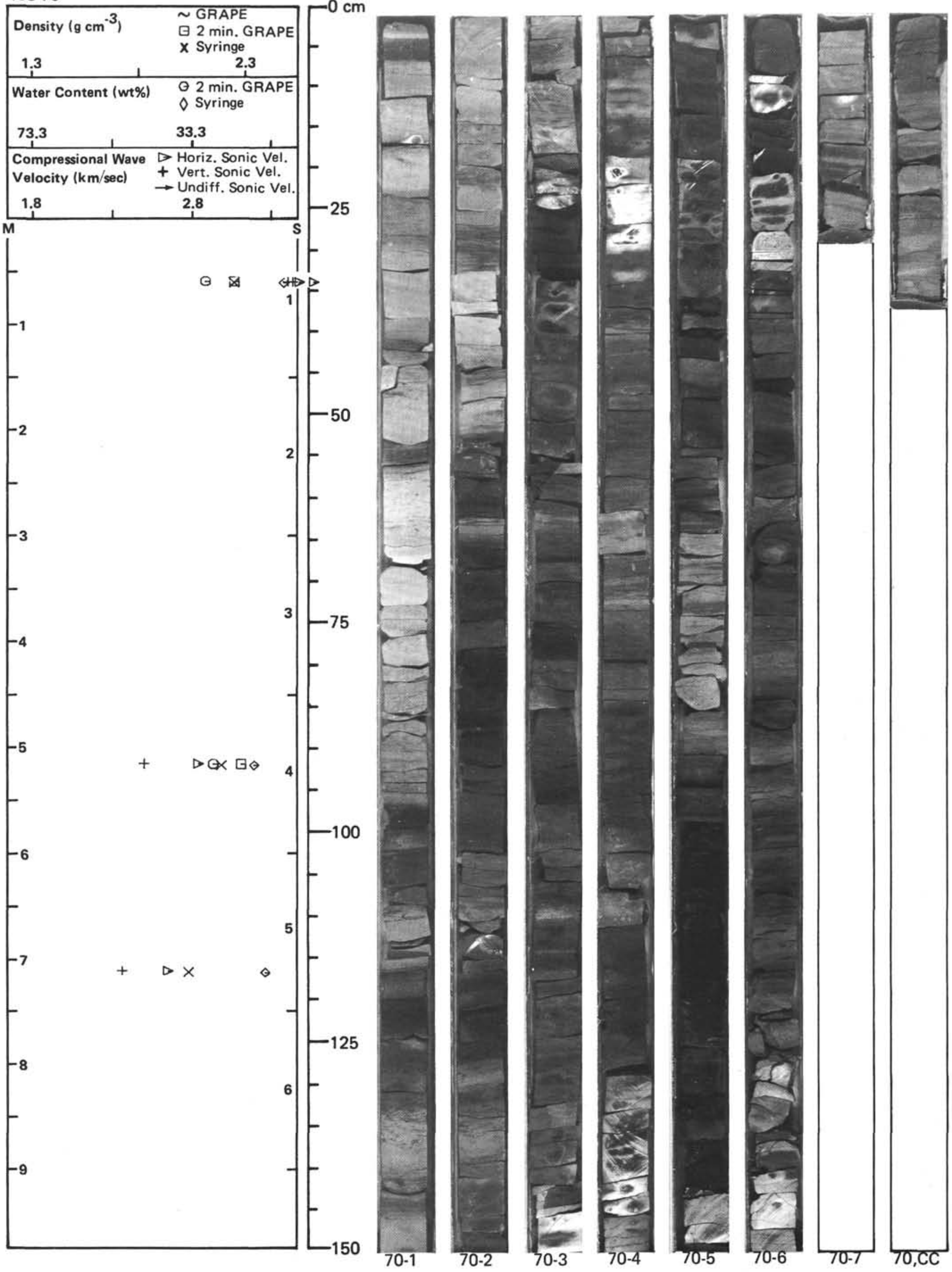

0 cm
25
50
75
100
125
150
66-1
66-2
66-3
66,CC
67-1
67-2
67,CC

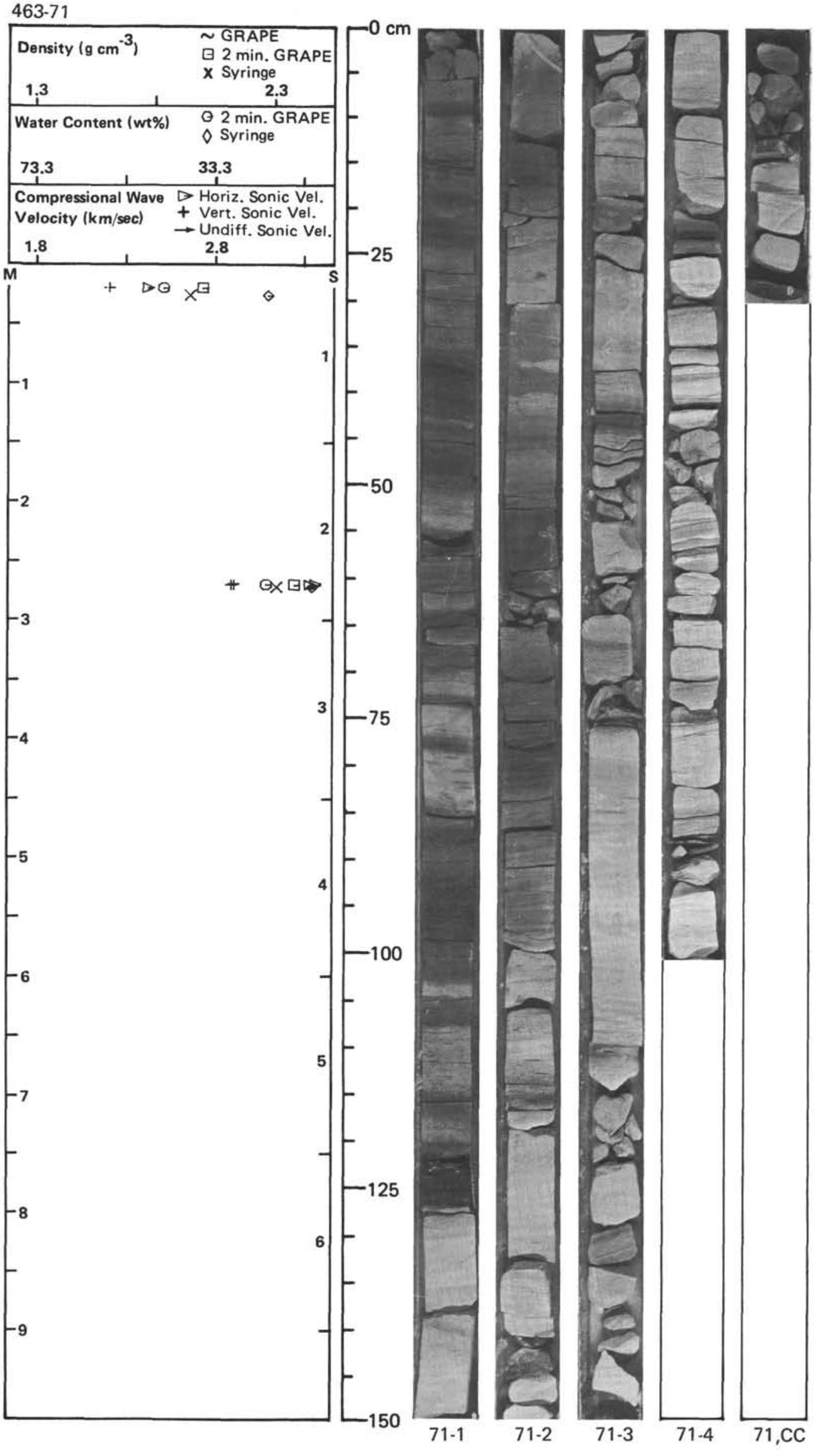
463-69 (463-68 NO DATA)



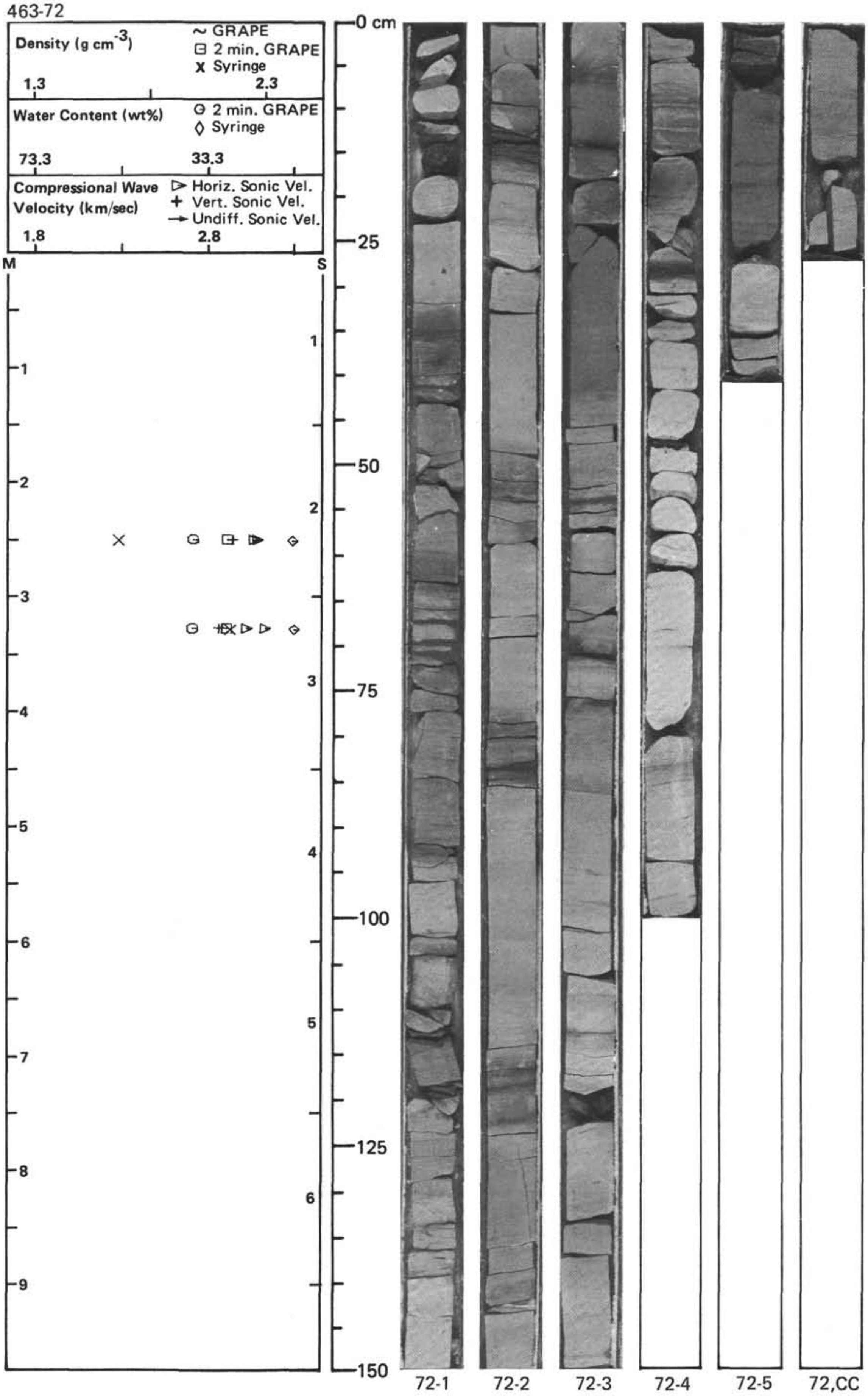


463-70

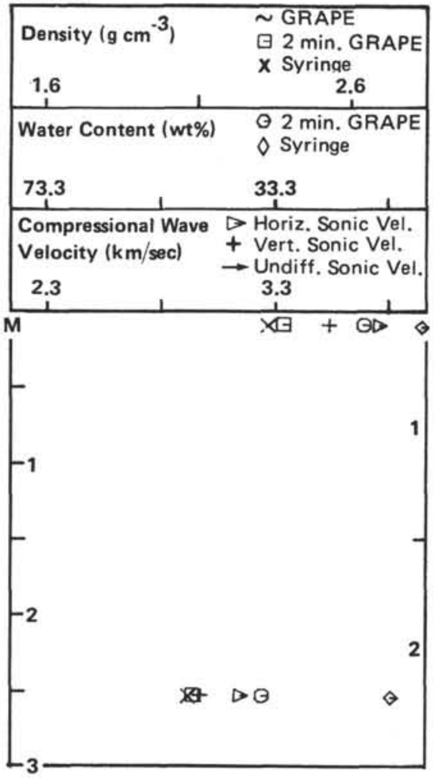

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.3
2.3
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
70-1
70-2
70-3
70-4
70-5
70-6
70-7
70,CC


463-71
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.3
2.3
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
71-1
71-2
71-3
71-4
71,CC

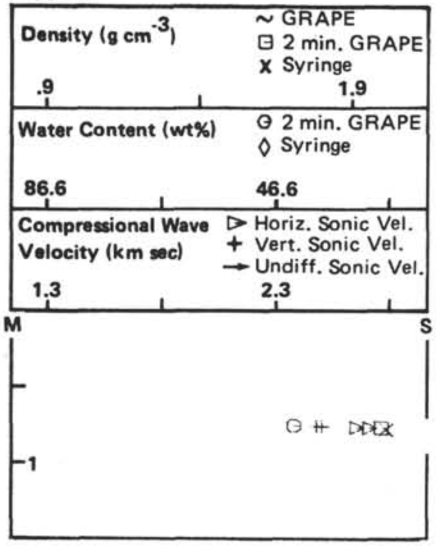
463-72

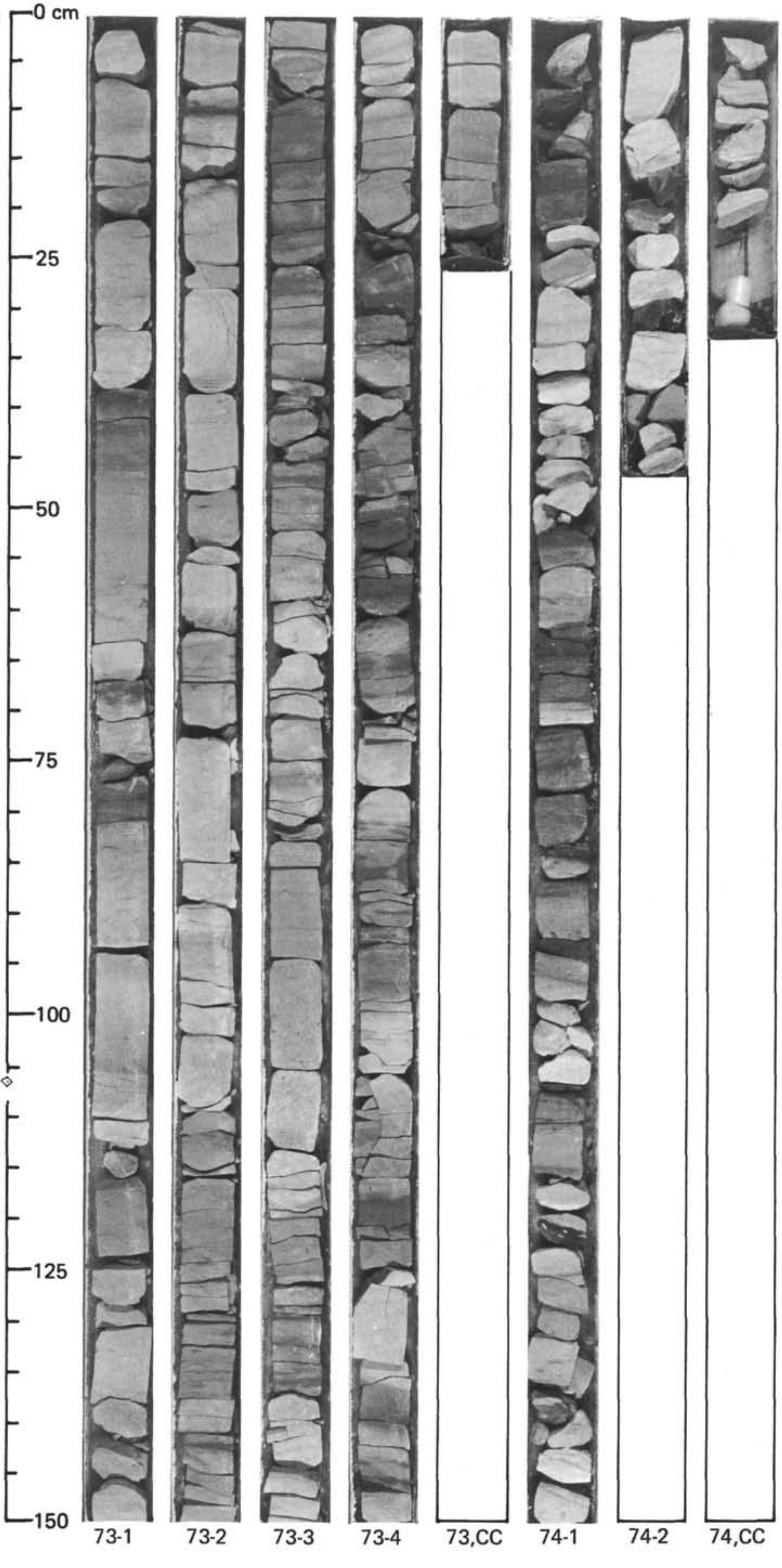

Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.3
2.3
Water Content (wt%)
ʘ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
2
3
4
5
6
7
8
9
0 cm
25
50
75
100
125
150
72-1
72-2
72-3
72-4
72-5
72,CC

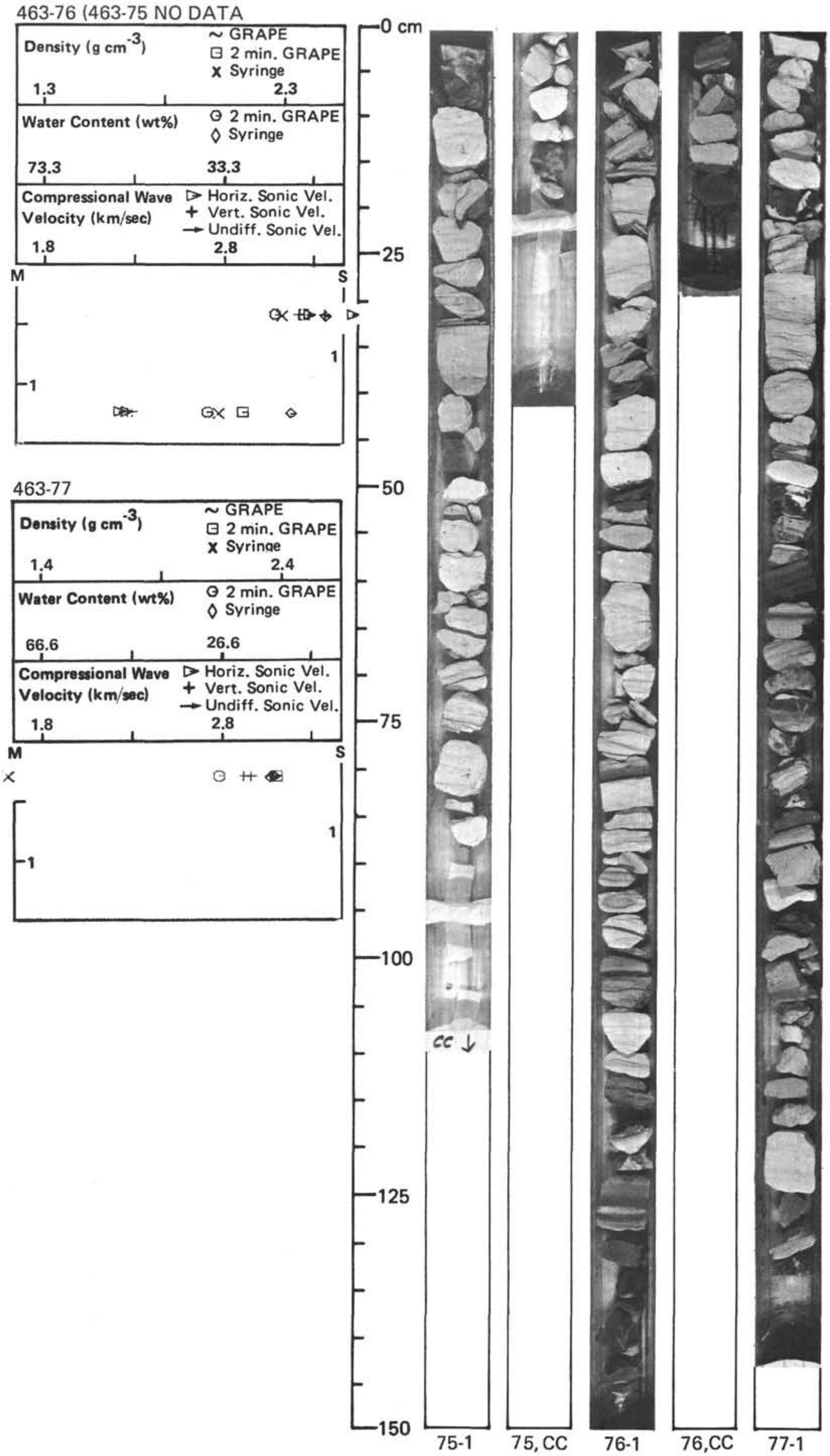
463-73


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
1
2
3
1
2

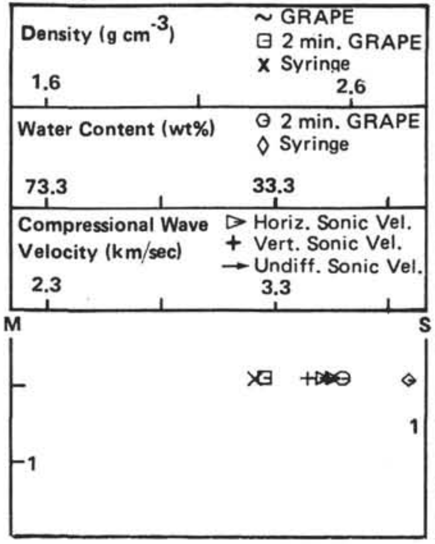
463-74


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
.9
1.9
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
86.6
46.6
Compressional Wave Velocity (km sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.3
2.3
M
S
1

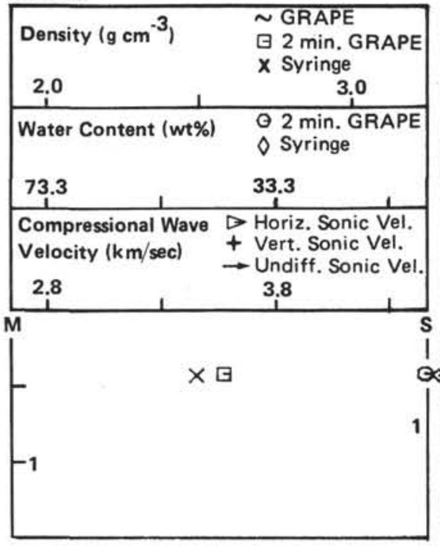

0 cm
25
50
75
100
125
150
73-1
73-2
73-3
73-4
73,CC
74-1
74-2
74,CC


463-76 (463-75 NO DATA
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.3
2.3
Water Content (wt%)
ϴ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
1
463-77
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.4
2.4
Water Content (wt%)
ϴ 2 min. GRAPE
◊ Syringe
66.6
26.6
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
1
0 cm
25
50
75
100
125
150
CC ↓
75-1
75, CC
76-1
76,CC
77-1

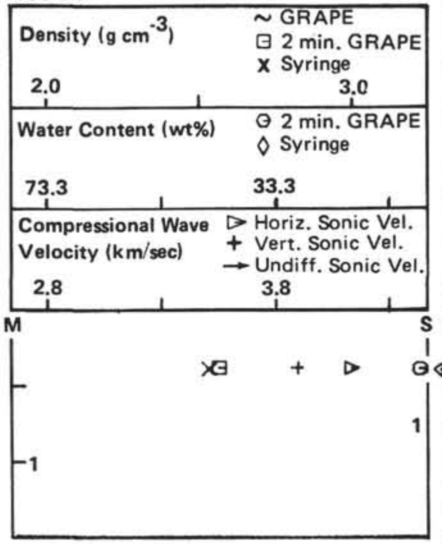
463-78

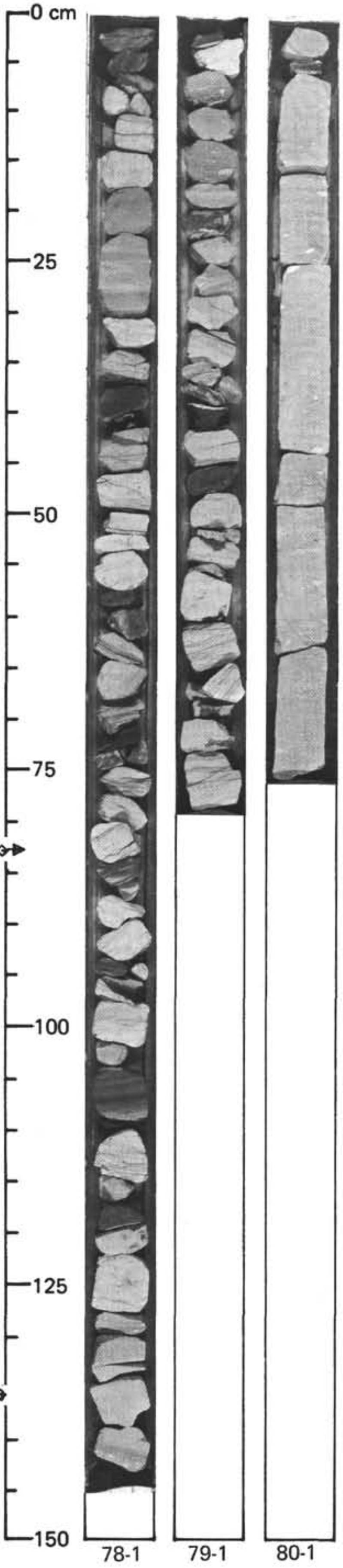


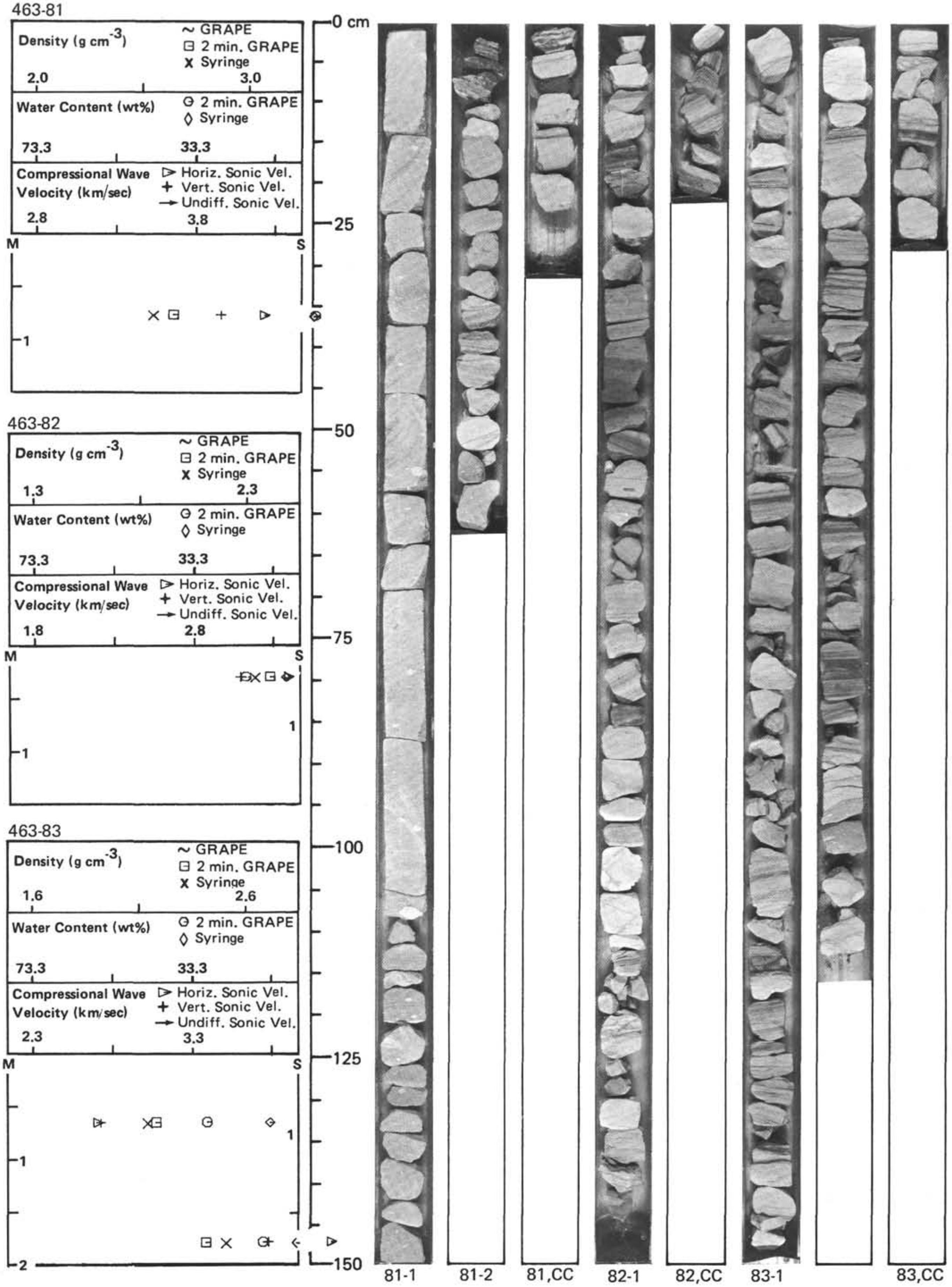
463-79



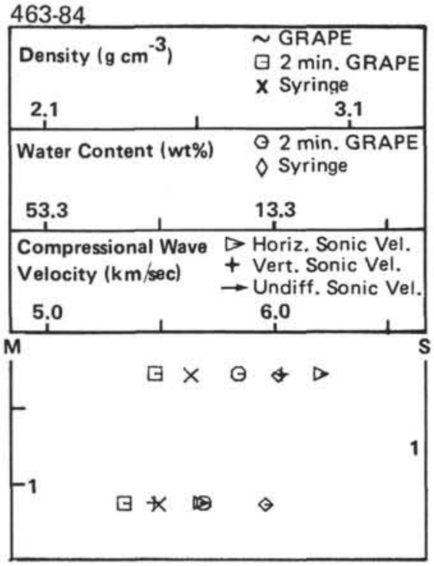
463-80



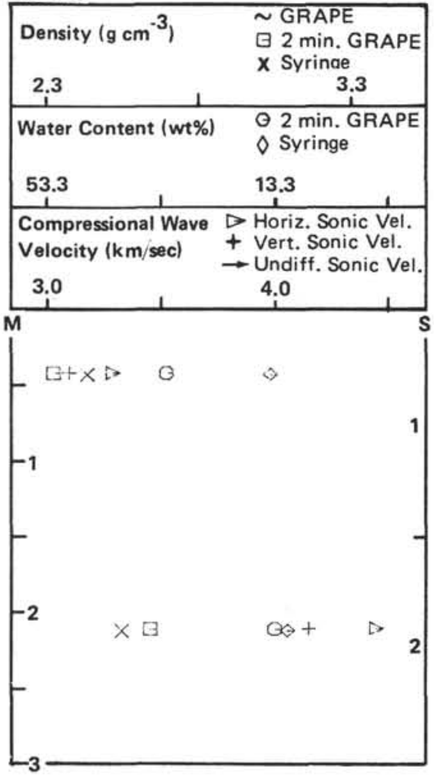


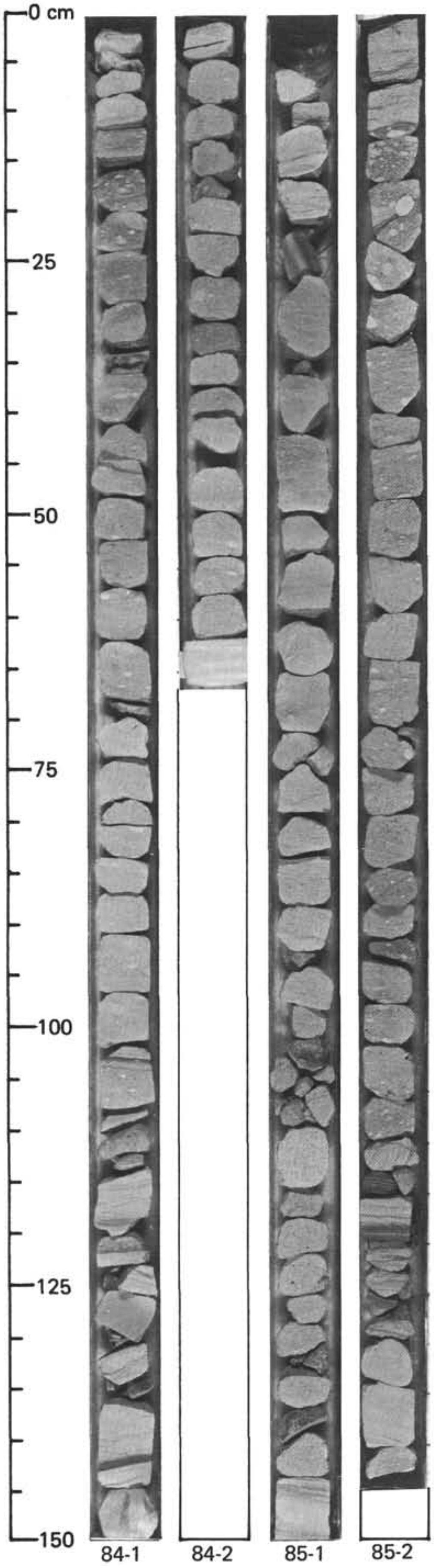

463-81
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
2.0
3.0
Water Content (wt%)
Θ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.8
3.8
M
S
1
463-82
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.3
2.3
Water Content (wt%)
Θ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
1.8
2.8
M
S
1
1
463-83
Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
1.6
2.6
Water Content (wt%)
Θ 2 min. GRAPE
◊ Syringe
73.3
33.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
2.3
3.3
M
S
1
1
2
0 cm
25
50
75
100
125
150
81-1
81-2
81,CC
82-1
82,CC
83-1
83,CC

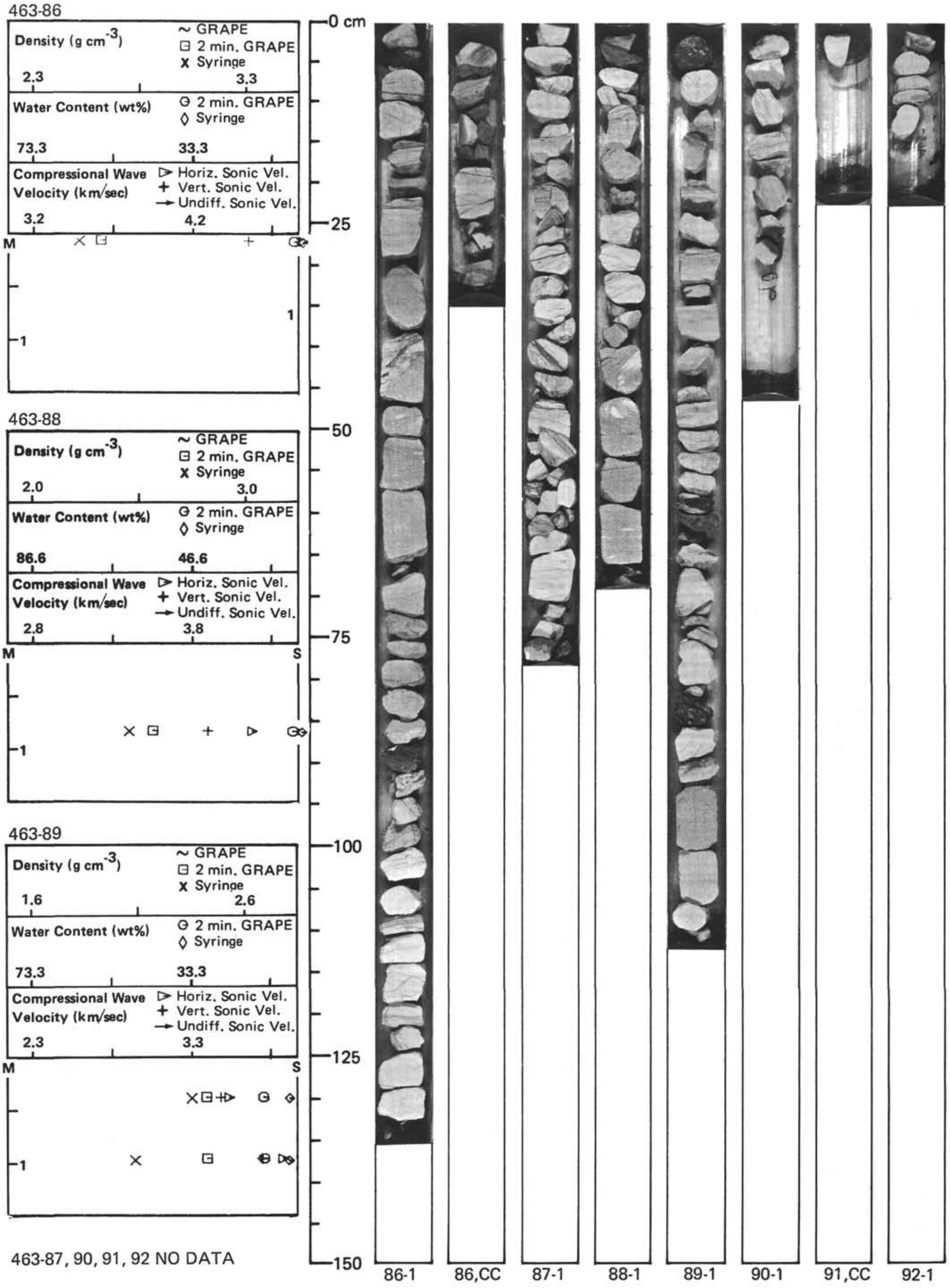
463-84


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
2.1
3.1
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
53.3
13.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
5.0
6.0
M
S
1
1

463-85


Density (g cm^{-3})
~ GRAPE
⊟ 2 min. GRAPE
X Syringe
2.3
3.3
Water Content (wt%)
⊖ 2 min. GRAPE
◊ Syringe
53.3
13.3
Compressional Wave Velocity (km/sec)
▷ Horiz. Sonic Vel.
+ Vert. Sonic Vel.
→ Undiff. Sonic Vel.
3.0
4.0
M
S
1
1
2
2
3


0 cm
25
50
75
100
125
150
84-1
84-2
85-1
85-2



463-87, 90, 91, 92 NO DATA