5. SITE 550[1]

Shipboard Scientific Party[2]

HOLE 550

Position: 48°30.91′N, 13°26.37′W

Water depth (sea level; corrected m, echo-sounding): 4420

Water depth (rig floor; corrected m, echo-sounding): 4430

Bottom felt (m, drill pipe): 4432

Penetration (m): 536.5

Number of cores: 48

Total length of cored section (m): 442.5

Total core recovered (m): 262.61

Core recovery (%): 59.3

Oldest sediment cored:
Depth sub-bottom (m): 536.5
Nature: Chalk
Age: late Maestrichtian
Measured velocity (km/s): 2.25 to 3.0

Basement: not reached

Principal results: See discussion following site data for Hole 550B.

HOLE 550B

Position: 48°30.96′N, 13°26.32′W

Water depth (sea level; corrected m, echo-sounding): 4420

Water depth (rig floor; corrected m, echo-sounding): 4430

Bottom felt (m, drill pipe): 4432

Penetration (m): 720.5

Number of cores: 30

Total length of cored section (m): 264.5

Total core recovered (m): 177.91

Core recovery (%): 67.3

Oldest sediment cored:
Depth sub-bottom (m): 685.4
Nature: Gray calcareous mudstone
Age: late Albian (Vraconian)
Measured velocity (km/s): 2.3

Basement:
Depth sub-bottom (m): 685.4–720.5
Nature: Basalt with thin sediment intercalations
Velocity range (km/s): 4.8

Principal results: Two holes (550 and 550B) were drilled on the Porcupine Abyssal Plain, 10 km southwest of the seaward edge of the Goban Spur, the deepest site of the Goban Spur transect (water depth 4432 m; Fig. 1). After washing in to 99.5 m below seafloor (BSF), we cored 586.37 m of lower Pliocene to upper Albian (Vraconian) nannofossil chalks, turbiditic nannofossil chalks, and calcareous and siliceous mudstones, all of which overlie oceanic basement (Tables 1–3). Recovered basement comprises 35.13 m of basaltic lava flows and pillow lavas interbedded with fossiliferous limestones (total depth 720.5 m BSF).

Three downhole log runs were successful, and two heat flow measurements documented a geothermal gradient of 43°C/km.

The most significant achievements at Site 550 were as follows:

1. Identifying the oldest sediments above oceanic basement as latest Albian (Vraconian) in age. In conjunction with evidence from Site 549, where the first postrift rocks are early Albian, this identification dates the initiation of seafloor spreading west of the Goban Spur as no later than early Albian.
2. Identifying the youngest part of the mixed polarity interval of Anomaly 34 in the latest Albian cores immediately overlying oceanic basement. This identification reinforces the paleontological dating.
3. Recovering a continuous depositional sequence across the Danian/Maestrichtian boundary.
4. Recovering manganese-rich sediments at two unconformities, one between the upper or middle Oligocene and lower Oligocene, and the other within the upper Paleocene.
5. Documenting the presence of marine organic matter in laminated, dark, calcareous mudstones of Cenomanian age.
6. Documenting the history of carbonate dissolution at an oceanic location close to the continental edge.

Figure 1. Location of Leg 80 drill sites (548–551). Three Leg 48 drill sites (400–402) are also shown.

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[1] Graciansky, P. C. de, Poag, C. W., et al., *Init. Repts. DSDP*, 80: Washington (U.S. Govt. Printing Office).

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Table 1. Coring summary, Leg 80.

Hole	Latitude	Longitude	Water depth (m)	Number of cores	Cores with recovery	Percent of cores with recovery[a]	Meters cored	Meters recovered	Percent recovered[b]	Meters drilled	Total penetration (m)	Average penetration rate (m/hr.)[c]	Time on hole or site (hr.)
548	48°54.95′N	12°09.84′W	1256	35	35	100.0	211.0	210.9	99.9	0	211.0		45.2
548A	48°54.93′N	12°09.87′W	1256	38	38	100.0	346.0	246.5	71.2	205.5	551.5	42.4	82.9
		Total for site		73	73	100.0	557.0	457.4	82.1	205.5	762.5		128.1
549	49°05.28′N	13°05.88′W	2533	99	93	93.9	812.5	369.7	45.5	189.0	1001.5	7.9	301.2
549A	49°05.29′N	13°05.89′W	2535.5	42	41	77.6	196.0	144.4	73.7	0	198.5		54.2
		Total for site		141	134	95.0	1008.5	514.1	51.0	189.0	1200.0		355.4
550	48°30.91′N	13°26.37′W	4432	48	46	95.8	442.5	262.6	59.3	94.0	536.5	36.4	115.3
550A	48°30.91′N	13°26.39′W	4432	0	0	0	0	0	0	95.0	95.0	170.6	19.2
550B	48°30.96′N	13°26.32′W	4432	30	30	100.0	264.5	177.9	67.3	456.0	720.5	14.2	150.3
		Total for site		78	76	97.4	707.0	440.5	62.3	645.0	1352.0	34.0[d]	284.8
551	48°54.64′N	13°30.09′W	3909	14	13	92.9	125.0	81.0	64.8	76.0	201.0	9.1	75.2
		Total for leg		306	296	96.7	2397.5	1493.0	62.2	1115.5	3515.5		843.5

Note: Blanks signify that quantities are unknown.

[a] Total for site is calculated from total number of cores and total cores with recovery.

[b] Total for site is calculated from total meters cored and total meters recovered.

[c] Rotary coring only.

[d] Total meters penetrated divided by number of rotating hours.

Six lithologic units were recognized (Table 3):

Unit 1: 99.5–310.45 m BSF. Light-colored nannofossil ooze and chalk, marly nannofossil chalk, and mudstone. Sediment is early Pliocene to middle Oligocene in age, abyssal in nature, and has a minor siliceous biogenic component. Carbonate dissolution is prominent in four intervals within the Miocene. An interval of manganiferous sediment associated with several ash layers and an unconformity mark the base.

Unit 2: 310.45–426.5 m BSF. Brownish, grayish, marly nannofossil chalk and olive siliceous nannofossil chalk and mudstone. Sediment is early Oligocene to late Paleocene in age and abyssal in nature. Some volcanic ash layers are present.

Unit 3: 426.5–575 m BSF. Nannofossil chalk and marly nannofossil chalk with interbedded, calcareous, turbiditic, and mudflow deposits. Sediment is late Paleocene to early Maestrichtian (and ?Campanian) in age and abyssal in nature. Deposition was continuous across Danian/Maestrichtian boundary. Possible unconformity at base.

Unit 4: 575–594.83 m BSF. Dark, massive, carbonate-free claystones with redeposited chalks containing infralittoral foraminifers. Sediment is Santonian or Coniacian in age and bathyal to abyssal in nature. Carbonate dissolution is severe. Unconformity(?) at base (Turonian missing?).

Unit 5: 594.83–685.4 m BSF. Interbedded, light, bioturbated, calcareous mudstone and finely laminated, dark calcareous mudstone containing terrestrial and marine organic matter. Sediment is middle Cenomanian to late Albian (Vraconian) in age and bathyal in nature. Sediments contain the signature of the mixed polarity interval of magnetic Anomaly 34.

Unit 6: 685.37–720.5 m BSF. Basalt flows and pillows with interbedded, hard, microfossiliferous limestone layers. Late Albian? in age.

Site chapter results are based chiefly on shipboard analysis and interpretation. The specialty chapters reflect postcruise revisions and additional data. Where discrepancies arise, the specialty chapters should be considered correct.

SITE APPROACH AND OPERATIONS

A brief postsite survey was made on departure from Site 549 (Fig. 1). The vessel proceeded northeast from the site, streaming the seismic gear. At a distance of 2 mi., the ship turned back onto a course parallel to the reference profile and passed directly over the Site 549 positioning beacon (Fig. 2). This course was held for about 5 additional miles until deeper water (the West European Basin) was reached. *Glomar Challenger* then proceeded south for about 36 mi. to a point 11 mi. northeast of the proposed location of Site 550. The approach was made parallel to a reference profile, and the acoustic beacon was dropped at 0929 hr. on 30 June, on the first pass over the location. The ship continued profiling on the same course for about 2 mi. before turning back toward the beacon.

Piston coring was planned for Hole 550A, so a bottom hole assembly (BHA) was made up that contained the special components necessary for conversion to the hydraulic piston corer (HPC). A routine pipe trip was then made; a seafloor punch core determined water depth to be 4432 m, as compared to the precision depth recorder (PDR) reading of 4430 m.

Hole 550 was then drilled, without coring, to 99.5 m BSF. A combination temperature/water sampler probe was run, and continuous coring then commenced. Coring operations proceeded smoothly to about 460 m BSF; the probe was redeployed at 156.5 and 213.5 m. Plastic liner failures on two consecutive cores then resulted in low core recovery and jammed both operating inner core barrels. An additional inner barrel was assembled, but three consecutive core attempts below 498 m resulted in little or no recovery. The bit deplugger was pumped down and recovered, and the following coring attempt produced nearly full recovery. While the wireline trip for the next core was in progress, we were warned of the imminent approach of gale-force winds, so we terminated coring operations at 536.5 m BSF. The empty core barrel was brought on deck at 1700 hr. on 4 July. During the pipe trip, which was slowed by the weather and by vessel motion, the positioning system was unable to hold

Table 2. A. Coring summary, Hole 550.

Core	Date (June–July 1981)	Time (hr.)	Depth from drill floor (m)	Depth below seafloor (m)	Length cored (m)	Length recovered (m)	Recovery (%)
1	6/30	2214	4432.0–4437.5	0.0–5.5	5.5	5.45	99
H-1	7/1	0048	4437.5–4531.5	5.5–99.5	94	0.45	<1
2	1	0414	4531.5–4541.0	99.5–109.0	9.5	1.11	12
3	1	0537	4541.0–4550.5	109.0–118.5	9.5	4.31	45
4	1	0720	4550.5–4560.0	118.5–128.0	9.5	5.65	59
5	1	0844	4560.0–4569.5	128.0–137.5	9.5	9.57	100
6	1	1002	4569.5–4579.0	137.5–147.0	9.5	9.63	100
7	1	1130	4579.0–4588.5	147.0–156.5	9.5	8.15	86
8	1	1511	4588.5–4598.0	156.5–166.0	9.5	7.17	75
9	1	1641	4598.0–4607.5	166.0–175.5	9.5	9.18	97
10	1	1807	4607.5–4617.0	175.5–185.0	9.5	4.56	48
11	1	1930	4617.0–4626.5	185.0–194.5	9.5	4.33	46
12	1	2056	4626.5–4636.0	194.5–204.0	9.5	6.66	70
13	1	2217	4636.0–4645.5	204.0–213.5	9.5	1.70	18
14	2	0206	4645.5–4655.0	213.5–223.0	9.5	4.68	49
15	2	0355	4655.0–4664.5	223.0–232.5	9.5	1.04	11
16	2	0520	4664.5–4674.0	232.5–242.0	9.5	5.57	59
17	2	0648	4674.0–4683.5	242.0–251.5	9.5	3.85	41
18	2	0818	4683.5–4693.0	251.5–261.0	9.5	5.22	55
19	2	0956	0693.0–4702.5	261.0–270.5	9.5	3.47	37
20	2	1130	4702.5–4712.0	270.5–280.0	9.5	0.27	3
21	2	1310	4712.0–4721.5	280.0–289.5	9.5	4.53	48
22	2	1450	4721.5–4731.0	289.5–299.0	9.5	7.67	81
23	2	1622	4731.0–4740.5	299.0–308.5	9.5	7.52	79
24	2	1800	4740.5–4750.0	308.5–318.0	9.5	7.48	79
25	2	1930	4750.0–4759.5	218.0–327.5	9.5	7.77	82
26	2	2055	4759.5–4769.0	327.5–337.0	9.5	1.73	18
27	2	2305	4769.0–4778.5	337.0–346.5	9.5	9.72	100
28	3	0142	4778.5–4788.0	346.5–356.0	9.5	8.06	85
29	3	0359	4788.0–4797.5	356.0–365.5	9.5	8.17	86
30	3	0555	4797.5–4807.0	365.5–375.0	9.5	8.79	93
31	3	0740	4807.0–4816.5	375.0–384.5	9.5	7.49	79
32	3	0922	4816.5–4826.0	384.5–394.0	9.5	9.62	100
33	3	1100	4826.0–4835.5	394.0–403.5	9.5	7.17	75
34	3	1300	4835.5–4845.0	403.5–413.0	9.5	9.79	100
35	3	1428	4845.0–4854.5	413.0–422.5	9.5	9.01	95
36	3	1553	4854.5–4864.0	422.5–432.0	9.5	5.98	63
37	3	1718	4864.0–4873.5	432.0–441.5	9.5	7.74	81
38	3	2000	4873.5–4883.0	441.5–451.0	9.5	8.77	92
39	3	2200	4883.0–4892.5	451.0–460.5	9.5	7.99	84
40	3	2358	4892.5–4902.0	460.5–470.0	9.5	1.14	12
41	4	0135	4902.0–4911.5	470.0–479.5	9.5	2.92	31
42	4	0410	4911.5–4921.0	479.5–489.0	9.5	2.56	27
43	4	0558	4921.0–4930.5	489.0–498.5	9.5	4.77	50
44	4	0735	4930.5–4940.0	498.5–508.0	9.5	0.05	1
45	4	0925	4940.0–4949.5	508.0–517.5	9.5	tr	0
46	4	1130	4949.5–4954.0	517.5–522.0	4.5	0	0
47	4	1440	4954.0–4959.0	522.0–527.0	5.0	4.60	92
48	4	1700	4959.0–4968.5	527.0–536.5	9.5	0	0

station, and the vessel drifted slowly away from the drill site. By the time the BHA was recovered, at 0445 hr. on 5 July, the ship lay 11.3 mi. northeast of the beacon.

Glomar Challenger returned to the drill site to hold position until weather conditions improved sufficiently for operations to resume. Pipe-handling operations recommenced at 1215 hr., although a newly arrived current precluded the ship's turning to the optimum heading to minimize roll.

A 50 ft. (15.2 m) west offset was entered into the positioning system to prevent heat flow measurements from being taken too near the chilled borehole of Hole 550. Hole 550A was spudded at 2155 hr. on 5 July and was drilled quickly to a depth of 95 m BSF. Penetration of the soft ooze halted abruptly when the drill struck something anomalously hard. When the bit failed to break through after 15 min., we terminated drilling attempts, because we were afraid the bit might slip sideways in the soft sediment, forming a "dog leg" in the hole that would cause problems later. Sediments at that depth were of early Pleistocene or late Pliocene age, and it was inferred that the obstruction was an ice-rafted boulder. The bit was pulled clear of the seafloor for respudding.

The positioning offset was changed from 50 ft. (15.2 m) west to 50 ft. east. Difficult conditions of crossed wind, swell, and current persisted, and nearly an hour elapsed before positioning was stable enough for drilling to begin. Hole 550B was spudded at 0048 hr. on 6 July and drilled to 323 m BSF before the inner barrel was re-

Table 2. B. Coring summary, Hole 550B.

Core	Date (June–July 1981)	Time (hr.)	Depth from drill floor (m)	Depth below seafloor (m)	Length cored (m)	Length recovered (m)	Recovery (%)
H-1	6	0730	4432.0–4755.0	0.0–323.0			
H-2	6		4755.0–4888.0	323.0–456.0			
1	6	1840	4888.0–4897.5	456.0–465.5	9.5	8.86	93
2	6	2040	4897.5–4907.0	465.5–475.0	9.5	4.43	47
3	6	2220	4907.0–4916.5	475.0–484.5	9.5	2.84	30
4	7	0005	4916.5–4926.0	484.5–494.0	9.5	2.22	23
5	7	0230	4926.0–4935.5	494.0–503.5	9.5	6.44	68
6	7	0436	4935.5–4945.0	503.5–513.0	9.5	0.04	<1
7	7	0901	4945.0–4954.5	513.0–522.5	9.5	3.63	38
8	7	1131	4954.5–4964.0	522.5–532.0	9.5	7.83	82
9	7	1344	4964.0–4973.5	532.0–541.5	9.5	6.84	72
10	7	1600	4973.5–4983.0	541.5–551.0	9.5	5.46	57
11	7	1815	4983.0–4992.5	551.0–560.5	9.5	5.27	55
12	7	2040	4992.5–5002.0	560.5–570.0	9.5	6.04	64
13	7	2325	5002.0–5011.5	570.0–579.5	9.5	9.53	100
14	8	0134	5011.5–5021.0	579.5–589.0	9.5	7.95	84
15	8	0350	5021.0–5030.5	589.0–598.5	9.5	8.69	91
16	8	0637	5030.5–5040.0	598.5–608.0	9.5	4.93	52
17	8	0911	5040.0–5049.0	608.0–617.0	9.0	7.40	82
18	8	1246	5049.0–5058.0	617.0–626.0	9.0	5.92	66
19	8	1602	5058.0–5067.0	626.0–635.0	9.0	0.18	2
20	8	2110	5067.0–5076.0	635.0–644.0	9.0	7.99	89
21	9	0118	5076.0–5085.0	644.0–653.0	9.0	8.95	99
22	9	0440	5085.0–5094.0	653.0–662.0	9.0	9.70	100
23	9	0800	5094.0–5103.0	662.0–671.0	9.0	5.85	65
24	9	1108	5103.0–5112.0	671.0–680.0	9.0	4.55	51
25	9	1610	5112.0–5121.0	680.0–689.0	9.0	5.87	65
26	9	1955	5121.0–5125.5	689.0–693.5	4.5	4.30	96
27	9	2330	5125.5–5130.0	693.5–698.0	4.5	3.72	83
28	10	0544	5130.0–5134.5	698.0–702.5	4.5	7.40	100
29	10	1115	5134.5–5143.0	702.5–711.0	8.5	8.49	99
30	10	2135	5143.0–5152.5	711.0–720.5	9.5	6.59	69

trieved for a temperature probe run. An apparent boulder bed was again encountered at about 95 m, but resistance was not as solid as in the previous hole.

Heat flow data were degraded by vessel heave resulting from a heavy swell. Although the heave compensator was in use, numerous "friction spikes" in the temperature data resulted from movement of the probe in the firm sediment.

Drilling continued through the previously cored sediment section. Because of low core recovery near the bottom of Hole 550, continuous coring was begun at 456 m BSF, some 80.5 m short of the total depth of Hole 550. Coring was routine, and recovery was generally good to 711 m.

At 0445 hr. on 10 July, the lower drive shaft coupling of one of the two bow thrusters failed. On-site operations at Hole 550B could continue with one bow thruster only as long as weather was exceptionally favorable, and no new hole could be spudded until repairs could be made in port. Coring was therefore halted 26 m into basement so the bit could be released and the logging program could be completed while the good weather held.

Two go-devils were used for unsuccessful release attempts. After 5.25 hr., prospects for dropping the bit seemed poor, so an inner core barrel was pumped into place. It was reasoned that the landing impact of the heavy barrel and/or the stresses of rotary coring might effect separation if the internal mechanism had shifted. In any event, the remaining time could be spent productively in cutting another basement core until arrangements for the repair port call had been finalized. When the core was retrieved, a third and successful attempt was made to release the bit. The end of the drill string was then pulled to 119.5 m BSF for logging. Logging operations proceeded smoothly, and three successful logs were recorded.

The drill string was then recovered, and at 0620 hr. on 12 July, after magnetic inspection of the BHA, the vessel departed for emergency repairs in Cobh, Ireland.

SEDIMENT LITHOLOGY

In Hole 550, we took a single core at the seabed before washing to 99.5 m. We then cored continuously to a total depth of 527 m using conventional rotary drilling (Table 3). Hole 550B was washed to 456 m and continuously cored to 720.5 m, also by rotary drilling (Table 3). The 71 m overlap between holes allowed the recovery in Hole 550B of a section of Paleocene to late Maestrichtian sediments that was poorly recovered in Hole 550.

The single core taken at the mudline in Hole 550 recovered 5.45 m of soft foraminifer-nannofossil ooze and calcareous mudstone of chiefly Pleistocene age. As at Sites 548 and 549, the upper 50 cm consists of pale brown foraminifer-nannofossil ooze that probably represents Holocene sedimentation. The remainder consists of a 3 m thick bed of olive gray (5Y 4/2-4/3) calcareous mudstone underlain by light gray (5B 7/1, 5Y 7/2) fora-

Table 3. Summary of Site 550 lithology.

Unit	Hole-Core-Section (interval in cm)	Depth (m BSF)	Main lithologies	Age
1a	550-2 to 550-21-2	99.5–283.0	Light-colored nannofossil oozes and chalks	Pliocene to middle Miocene
1b	550-21-3 to 550-24-2 (45)	283.0–310.45	Light-colored nannofossil chalk, marly nannofossil chalk, and mudstone; minor siliceous biogenic component	early Miocene to late or middle Oligocene
2a	550-24-2 (45) to 550-34-3	310.45–408.0	Brownish and grayish marly nannofossil chalk	early Oligocene to early Eocene
2b	550-34-4 to 550-36-3 (95)	408.0–426.5	Brownish, gray, and olive siliceous nannofossil chalk and mudstone	late Paleocene
3a	550-36-3 (95) to 550-40 and 550B-1	426.5–465.0	Nannofossil chalks and marly nannofossil chalks with interbedded, often graded, calcareous turbidites. Subunits are defined only in terms of differences in downhole logging characteristics.	late Paleocene to early Maestrichtian or late Campanian
3b	550-41 to 550-47 and 550B-2 to 550B-13-3 (50)	465.0–575.0		
4a	550B-13-3 (50) to 550B-14-4 (40)	575.0–584.4	Homogeneous, carbonatefree, dark, massive mudstones with no bioturbation	Unknown (Barren)
4b	550B-14-4 (40) to 550B-15-4 (83)	584.4–594.83	Interbedded dark mudstone, calcareous mudstone, and chalk	Santonian or Coniacian Unknown (barren)
5	550B-15-4 (83) to 550B-25-4 (87)	594.83–685.37	Interbedded light (gray, reddish, and brownish) bioturbated calcareous mudstone and finely laminated, dark gray to black, calcareous mudstone	middle Cenomanian to late Albian
6	550B-25-4 (87) to 550B-30	685.37–720.5	Basalt with thin, indurated, calcareous sediment interbeds	Unknown (late Albian?)

Notes: Cross rule denotes change in lithology; wavy line denotes unconformity. Double wavy line denotes position of two unconformities (one separates the upper and lower Oligocene, the other the upper and middle Eocene) and a highly condensed interval supposedly of early Oligocene to late Eocene age. Bold wavy line denotes major unconformity.

minifer–nannofossil ooze. This resembles the interbedded sequences previously cored at Sites 548 and 549.

Below the washed interval, 690 m of sediment were cored (allowing for the overlap between Holes 550 and 550B), ranging in age from Pliocene to late Albian. These strata can be divided into five lithologic units above basement, the upper four of which are further subdivided (Table 3). Major unconformities occur between upper or middle and lower Oligocene and between Coniacian and middle Cenomanian strata. Small stratigraphic gaps may occur within the Miocene and the Paleocene (see Biostratigraphy). An additional unconformity may be present between the Campanian or Maestrichtian and the Santonian–Coniacian, but carbonate dissolution prevented accurate dating of this part of the section.

Basement at Site 550 consists of basalt no younger than latest Albian in age.

Unit 1

Unit 1 consists of light-colored nannofossil and marly nannofossil ooze and chalk. It occurs in Hole 550 from 99.5 to 310.45 m BSF (Core 2 to 550-24-2, 45 cm) and is Pliocene to middle Oligocene in age.

The unit consists of bluish, greenish gray, light gray, pale yellow, and white nannofossil and marly nannofossil oozes and chalks. It is divided into two subunits on the basis of color and composition, especially variations in the amount of terrigenous and biogenic silica.

Subunit 1a

Subunit 1a consists of light-colored nannofossil ooze and chalk. It occurs in Hole 550 from 99.5 to 283 m BSF (Core 2 to Section 550-21-2) and is Pliocene to middle Miocene in age.

Subunit 1a consists of bluish to light gray (5B 6/1–7/1) and light greenish gray (5GY 7/1) soft to firm nannofossil oozes and chalks. Smear slide examination shows that the carbonate fraction, which makes up 77 to 95% of the sediment (as measured by carbonate bomb), consists largely of calcareous nannofossils (75–90%), with minor amounts of unspecified carbonate (2–20%) and foraminifers. Only rarely does foraminiferal content rise above 10%; this usually occurs in thin (less than 6 cm thick) beds of sandy foraminifer–nannofossil ooze (Core 6 and Sections 550-18-1, 550-18-4, and 550-19-1). Siliceous biogenic material (sponge spicules and diatom and

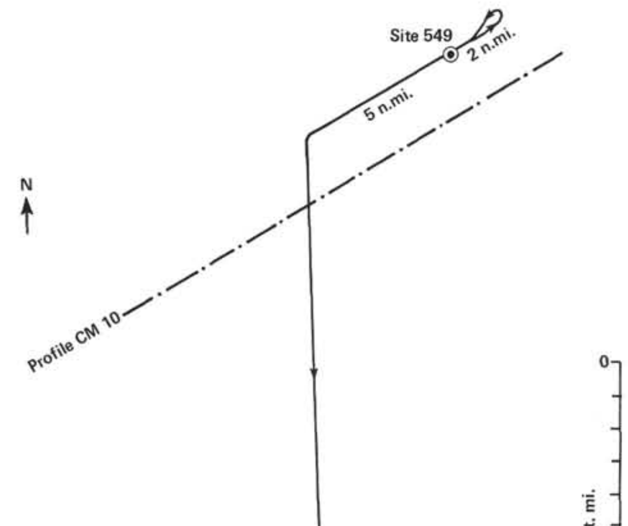


Figure 2. Approach to Site 550 from Site 549. SP = shot point.

radiolarian fragments) are found rarely and only in small quantities (up to 10% in Sections 550-5-4, 550-6-1, and 550-18-1). The detrital fraction is composed of clay minerals (as much as 10%), mica (as much as 5%), and trace amounts of quartz and heavy minerals. Disseminated pyrite occurs throughout and also is present in higher concentrations in some parts (Sections 550-3-1, 550-5-1, 550-5-6, 550-5-7, 550-7-1, 550-7-3, 550-8-1, 550-8-2, 550-12-4, 550-14-2, and 550-16-1).

Color changes throughout the upper part of Subunit 1a (Cores 2–13) are usually quite sharp. Thick (tens to hundreds of centimeters) bands of light bluish gray (5B 6/1) and light greenish gray (5GY 7/1) alternate, but they are occasionally interrupted by thin (less than 20 cm) bands of white (5YR 8/1) and gray (N5) or fine purple (5B 4/2) laminations. In the remainder of Subunit 1a, the banding is thinner (centimeters to tens of centimeters) and more distinct (Cores 14–21), with colors varying from light bluish gray (5B 6/1) to light greenish gray (5G 7/1), gray (N5), very pale blue (5B 8/2), olive gray (5Y 4/2), greenish gray (10GY 5/2), and purple (5B 4/2). In this lower interval, the contacts between chalks of different colors are either sharp or rapidly gradational.

The sediment usually has a massive appearance. This might be the result of its light color, which makes burrow mottling difficult to see; bioturbation is readily apparent in the darker layers, and it does occur occasionally (Sections 550-3-1, 550-6-3, 550-6-7, 550-12-1, 550-12-3, 550-14-1, 550-14-2, and 550-15-1; Core 16; Sections 550-17-2 and 550-17-3; Core 18; and Section 550-19-2). In Core 18, three thin, upward-fining, turbiditelike sequences, begin with gray (N2) foraminifer–nannofossil ooze and grade upward into nannofossil ooze (550-18-4, 0–6 cm and 6–11 cm and 550-19-1, 68–76 cm).

Cores 2 and 3 contain a mixture of Pliocene and Miocene microfossils, suggesting a "slump deposit," although there is no other sedimentological evidence to support this idea. The Miocene foraminifers within Cores 2 and 3 are generally better preserved than specimens in other Miocene sediments of Hole 550, indicating an upslope source (farther from the calcite compensation depth [CCD]) for the displaced material.

Carbonate dissolution ranges from slight at the top of Subunit 1a to moderate at the base. Foraminifer preservation is is particularly poor in the upper Miocene (Zones N16–N17; see Biostratigraphy).

Calcite dominates the bulk composition (50–80%) of Subunit 1a (Chennaux et al., this volume), and quartz comprises less than 10%. In general, the less common, darker sediments contain somewhat larger quantities of quartz.

Subunit 1b

Subunit 1b consists of light-colored marly nannofossil and nannofossil chalks. It occurs in Hole 550 from 283 to 310.45 m BSF (Section 550-21-3 to 550-24-2, 45 cm) and is early Miocene to middle Oligocene in age.

Subunit 1b can be differentiated from Subunit 1a on the basis of color, its more abundant terrigenous detritus and biogenic silica, and the occurrence of turbidites. It is highly variegated in shades of white (5Y 8/1), yellow (2.5Y 7/4–8/4, 5Y 7/3, 10Y 6/4), and gray (2.5Y 6/1, 5Y 7/1, 5GY 7/1); color changes are usually gradational but occasionally sharp. The boundary between Subunits 1a and 1b was apparently not recovered (there was a 30 cm gap in the core liner), but biostratigraphic evidence suggests that there is an unconformity that represents 2.8 m.y. separating upper Miocene from middle Miocene sediments.

The sediments in Subunit 1b consist of interbedded, usually light-colored nannofossil chalks with a carbonate content in excess of 80% (carbonate bomb) and darker, more marly, calcareous chalks with a carbonate content of 25 to 60%. Occasional dark, clayrich laminae 5 to 20 cm thick may have $CaCO_3$ contents as low as 6% (Sections 550-21-3, 22-1, 550-21-5, and 550-23-2 to 550-23-4). The light-colored layers are rich in calcareous nannofossils and unspecified carbonate particles (smear slides); foraminifers are generally rare, but occasional sandy layers contain as much as 50% foraminifers (e.g., 550-22-1, 53 cm). The darker layers have fewer calcareous components, but they have appreciable amounts of clay minerals (as much as 55%) and smaller amounts of mica (as much as 10%), quartz (as much as 5%), and heavy minerals (as much as 10%). Siliceous microfossils, particularly radiolaria, are common within olive brown and darker laminated layers.

The intervals in Section 550-22-1, from 20 to 60 cm and in Section 550-23-2, from 40 to 60 cm contain turbidites that have erosional basal contacts; these strata are graded, laminated, and unbioturbated at the base, finer grained and progressively more intensely bioturbated toward the top.

Subunit 1b was deposited between the early Miocene and middle Oligocene (see Biostratigraphy). The Oligocene series (Section 550-24-1, 15–135 cm) is much condensed and is interrupted by a barren zone (550-24-1, 135 cm to 550-24-2, 40 cm; Fig. 3). A banded manganese nodule several centimeters in diameter (Section 550-24-1 from 95 to 100 cm; see Fig. 3) is evidence of very low sedimentation rate during this period. Dissolution of carbonate is slight in the lower Miocene section; dissolution is more complete in the Oligocene section, indicating a shallower CCD in Oligocene time (see Biostratigraphy).

The quartz and calcite concentrations in Subunit 1b were not studied in detail. Within a turbidite layer (Section 550-22-1), the values of $CaCO_3$ are about 10% and those of quartz are 20%, similar to Subunit 1a (Chennaux et al., this volume). This is a dramatic compositional change from the surrounding sediments.

Among the clay minerals, smectite (20–55% of the clay fraction), illite (30–50%), chlorite (5–15%), and kaolinite (10–25%) vary cyclically within the Pliocene (99.5–175 m), Miocene, and Oligocene sediments, which extend to the unconformity at the base of Subunit 1b. There is gradual downward increase in smectite concentration (20–75% of the clay fraction). Kaolinite varies in concentration (5–15%) but decreases sharply in Section 550-23-2, where smectite increases dramatically.

Unit 2

Unit 2 consists of brownish and grayish, marly nannofossil chalks and siliceous nannofossil chalks. It occurs in Hole 550 from 310.34 to 426.5 m BSF (550-24-2, 34 cm to 550-36-3, 95 cm) and is early Oligocene to late Paleocene in age.

Unit 2 is separated from Unit 1 on the basis of its distinctly darker color, a downhole decrease in sonic velocity (1.8 km/s at the top of Unit 2, as opposed to 2.0 km/s in Subunit 1b), and an increase in natural gamma ray intensity. The boundary between Units 1 and 2 has been placed at the top of a series of manganese-rich black crusts (550-24-2, 45–75 cm; see Fig. 3), from which black dendritic structures extend into the sediments below. This sediment contains zeolites and is rich in amorphous glass and volcaniclastic fragments (as much as 60%, 550-24-2, 70 cm; smear slide; Knox, this volume). It was also found to be abnormally rich in such trace elements as Fe, Ni, and Ba in addition to Mn (Karpoff et al., this volume).

Three apparent unconformities were encountered between Sections 1 and 4 of Core 24, which represent 25 m.y. of middle Oligocene to early Eocene deposition. These unconformities are marked either by sediments barren of microfossils or by manganese crusts (see Biostratigraphy).

Unit 2 consists of brown to yellow, marly nannofossil chalk and siliceous nannofossil chalks and mudstones. It is divided into two conformable subunits on the basis of siliceous microfossil content and downhole log characteristics. Subunit 2a contains no appreciable biogenic silica; Subunit 2b contains several chert nodules and as much as 15% silica. The subunit boundary is also marked by small but sharp downhole decreases in sonic velocity and natural gamma ray intensity. Overall, there is little variation in gamma ray intensity in Subunit 2a; Subunit 2b has very low natural gamma ray intensities at the top and a sharp peak at the base. The mineralogical and geochemical characteristics of the sediments suggest that the bottom environment changed gradually from warmer in the late Paleocene to cooler in the late Eocene (Karpoff et al., this volume).

Subunit 2a

Subunit 2a consists of brownish and yellowish marly nannofossil chalks. It occurs in Hole 550 from 310.34 to 408 m BSF (550-24-2, 45 cm to Section 550-34-3) and is early Oligocene to early Eocene in age.

Subunit 2a consist of brown (10YR 4/3–4/4, 10YR 3/2–5/2, 10YR 6/3, 10YR 5/8, 2.5Y 4/4–7/4, 2.5Y 4/2) to yellow (10YR 7/6, 2.5Y 7/4), firm, marly (occasionally very marly) nannofossil chalk, with minor chalk and mudstone layers. There are occasional thin greenish gray (5GY 6/1–8/1, 5G 8/1) interbeds, lenses, and mottled intervals, especially from Cores 27 to 29 and in Core 32. Color contacts are usually gradational but occasionally sharp.

Carbonate content is highly variable (carbonate bomb), ranging from as little as 2% in thin, dark, mudstone horizons (e.g., Sections 550-26-1 and 550-32-3) to more than 70% in bands of nannofossil chalk (e.g., Core 550-29-2). Most values, however, are from 30 to 60%. Smear slide analysis indicates that the major calcareous components are nannofossils (as much as 90%), foraminifers (as much as 20%), and unspecified carbonate particles (as much as 55%). The terrigenous components are quartz (as much as 30%), clay minerals (as much as 30%), and mica (as much as 10%). Small amounts (less than 10%) of volcanic glass were detected in smear slides for Sections 550-24-4, 550-32-4, and 550-34-2. Siliceous biogenic components, in the form of sponge spicules and radiolaria, occur only rarely (Sections 550-24-2, 550-27-1, and 550-27-2). Subunit 2a is moderately to extremely bioturbated throughout. The interval in Section 550-28-1 from 69 to 73.5 cm is an upward-fining sequence with laminated, sandy, foraminifer-nannofossil chalk rich in heavy minerals at the base. The lower surface of this presumed turbidite shows flute

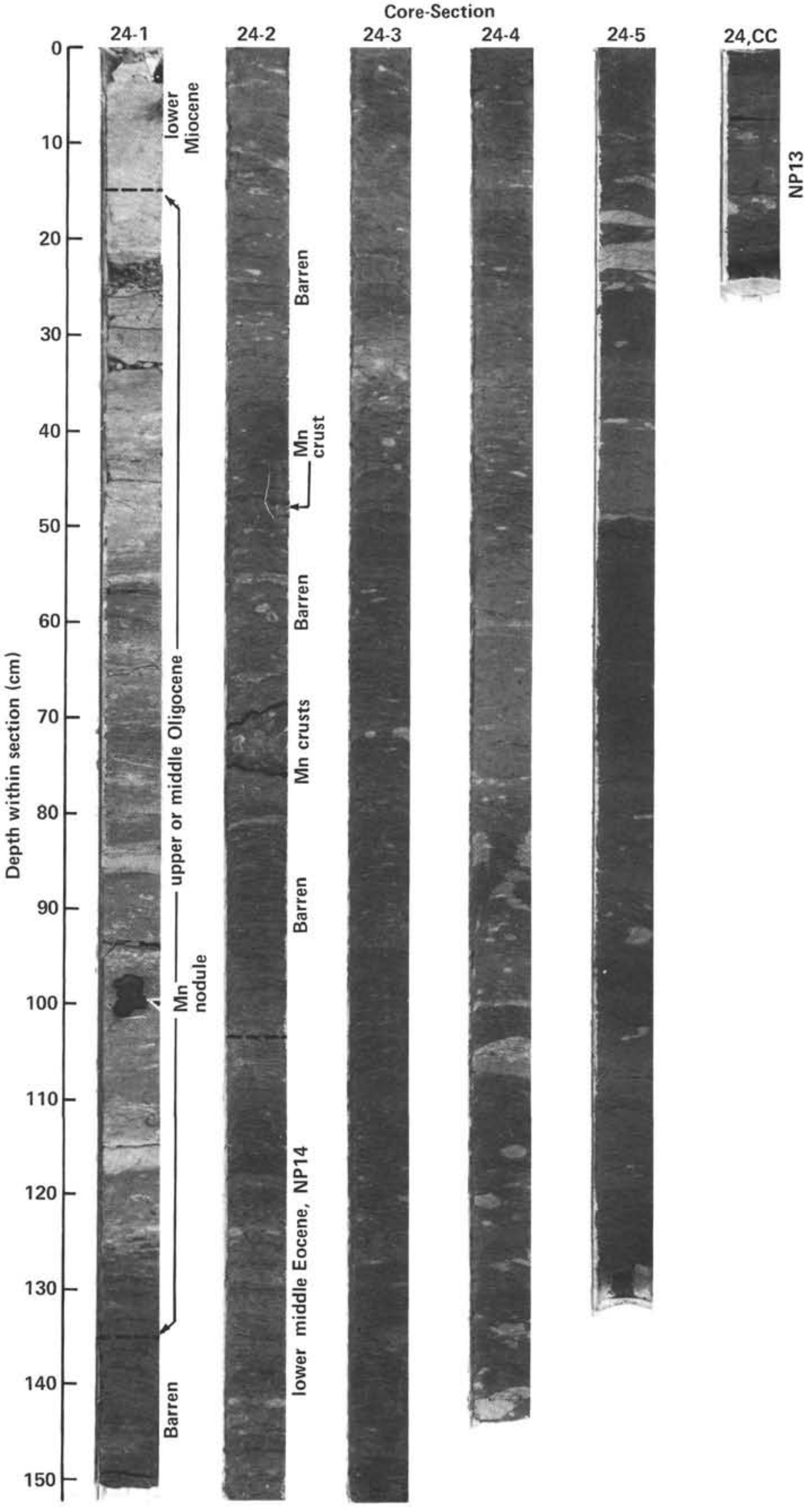


Figure 3. Highly condensed Oligocene section (Core 550-24). Lower Miocene chalk grades downward to dark unfossiliferous clays containing manganese crusts in Section 2; the manganese crusts form the boundary between lithologic Units 1 and 2. The lower part of Section 2 is lower middle Eocene in age.

casts. Sections 550-32-5 and 550-33-2 also contain small, graded, silty beds and zones of sharply bounded gray green banding. The silty horizons are largely composed of terrigenous detritus and carbonate fragments, with heavy minerals and volcanic glass. These silty beds are also probably indicative of current transport and/or turbidity currents. Dark clayrich laminae occur in Sections 550-26-1, 550-30-3, 550-32-3, and 550-33-2.

X-ray analysis reveals quartz concentrations of 5 to 15% in Subunit 2a (Chennaux et al., this volume); calcite comprises 40 to 50% of the bulk composition. Magnesium calcite is present in Section 550-34-2 (about 15%). Smectite dominates the clay fraction, steadily increasing downward (70–85%). Illite remains fairly constant, with a concentration of approximately 15%. Interlayered kaolinite and chlorite comprise less than 10% of the clay fraction.

Little dissolution of carbonate fossils is apparent in Subunit 2A, an indication that deposition took place above the CCD.

Subunit 2b

Subunit 2b consists of siliceous, marly nannofossil chalks and mudstones that are brown, gray, and olive. It occurs Hole 550 from 408 to 426.5 m BSF (Section 550-34-4 to 550-36-3, 95 cm) and is late Paleocene in age.

Subunit 2b consists of brownish (10YR 5/2–5/4; 10YR 3/3; 10YR 8/3; 7.5YR 5/4; 2.5Y 6/2, 2.5Y 4/4), gray (5G 6/1–8/1; 5G 5/2–7/2; 5Y 5/1), and olive (5Y 5/3–4/3, 2.5Y 5/4) siliceous, marly nannofossil chalks and siliceous mudstones.

A single carbonate bomb measurement in the marly chalk yielded 57% $CaCO_3$; mudstone yielded 3 to 10% $CaCO_3$. Smear slides show that the chalk contains 20 to 70% calcareous nannofossils and as much as 55% unspecified carbonate, with small amounts of clay minerals (as much as 20%) and quartz (as much as 15%); foraminifers occur only in trace amounts. The mudstone contains clay minerals (as much as 50%), quartz (as much as 25%), mica (as much as 10%), and assorted carbonate material (as much as 20%). Small amounts of volcanic glass (as much as 5%) occur throughout; a smear slide from 550-36-2, 120 cm contained 50% volcanic glass.

Siliceous fossils (principally radiolarians, but also sponge spicules) were detected only in trace amounts on smear slides. More detailed sampling for paleontological purposes indicates that radiolarians occur throughout Subunit 2b. Thin chert bands and siliceous nodules occur at 550-36-1, 120 cm and 550-36-2, 90 cm.

Sedimentary structures other than burrow mottling are rare in Subunit 2b. Fine green and white laminae occur in Section 550-34-6; a color banded, graded bed occurs in Section 5 of the same core. Section 550-35-1 also contains a laminated horizon. In general, however, the absence of transport structures suggests that the sedimentation in Subunit 2b is mixed pelagic and hemipelagic. A downward increase in carbonate dissolution (see Biostratigraphy) culminates in a 60 cm thick, black, noncalcareous mudstone at the base of Subunit 2b that probably represents sedimentation below the CCD. Small black manganese nodules within this layer suggest slow deposition. The nodules were later found to be old fecal pellets replaced by manganate exceptionally rich in Ba (Karpoff et al., this volume).

The boundary between Units 2 and 3 is a sharp change from black noncalcareous mudstone to yellow nannofossil chalk (Fig. 4). This boundary may represent a short hiatus (3 m.y. at most); alternatively, the manganese-rich, noncalcareous mudstone may be a condensed sequence deposited during the 3 m.y. time interval.

Unit 3

Unit 3 consists of interbedded nannofossil chalk, marly nannofossil chalk, and sandy calcareous turbidites. It occurs in Hole 550 from 426.5 to 527 m BSF (550-36-3, 95 cm to Core 47) and in Hole 550B from 456 to 575 m BSF (Core 1 to 550B-13-3, 50 cm). The sediment is late Paleocene to early Maestrichtian or Campanian(?) in age.

Unit 3 may underlie Unit 2 conformably. It consists of brownish (10Y 7/4, 7.5Y 6/4, 10YR 4/3–8/3, 10YR 5/6, 2.5Y 6/4), yellowish (2.5Y 8/4, 7.5Y 6/6, 5Y 7/3), and gray (5GY 7/1, 5Y 7/1, 2.5Y 7/2) nannofossil, marly nannofossil, and calcareous chalk. The chalk is interbedded with pink (7.5YR 8/4), light brown (7.5YR 6/4), light gray (5Y 7/1), and white (5Y 8/1) sandy calcareous turbidites. Unit 3 is differentiated from Unit 2 by the occurrence of the light-colored turbidites, by a large drop in gamma ray intensity, and by a downhole increase in sonic velocity and resistivity. The corresponding changes in the mineralogical and biogenic components are discussed by Graciansky and Bourbon (this volume). Unit 3 can be divided into two subunits on the basis of downhole measurements (see discussion at end of Subunit 3b).

Subunit 3a

Subunit 3a consists of light-colored to brownish chalks with interbedded white calcareous turbidites. It occurs in Hole 550 from 426.5 to 465 m BSF (550-36-3, 95 cm to Core 40) and in Hole 550B from 456 to 465 m BSF (Core 1). The sediment is late to early Paleocene in age.

Subunit 3a is composed of light brown (10YR 8/3), light gray (5Y 6/1–7/1), and greenish gray (5GY 7/1) nannofossil chalk with pink or gray mottling in its upper part (Cores 550-36 to 550-38). It is composed of interbedded white calcareous turbidites and pale brown (10YR 7/4, 7.5YR 5/4–6/4, 5Y 7/3) and greenish gray (5GY 7/1) nannofossil chalk in its lower part (Cores 550-39, 550-40, and 550B-1). The turbidites range from a few centimeters to almost 2 m in thickness. Thick turbidites are shown in Figures 5A to 5C. The base of the unit is composed of large, rounded clasts (up to 5 cm in diameter) of soft sediment in a mud matrix; this is overlain by laminated and graded, sandy sediments, which in turn grade into homogenous light-colored, unbioturbated chalk.

Compositional differences are evident between darker beds and pale chalk horizons. In Core 1 of Hole 550B, for example, one sample from a massive, light-

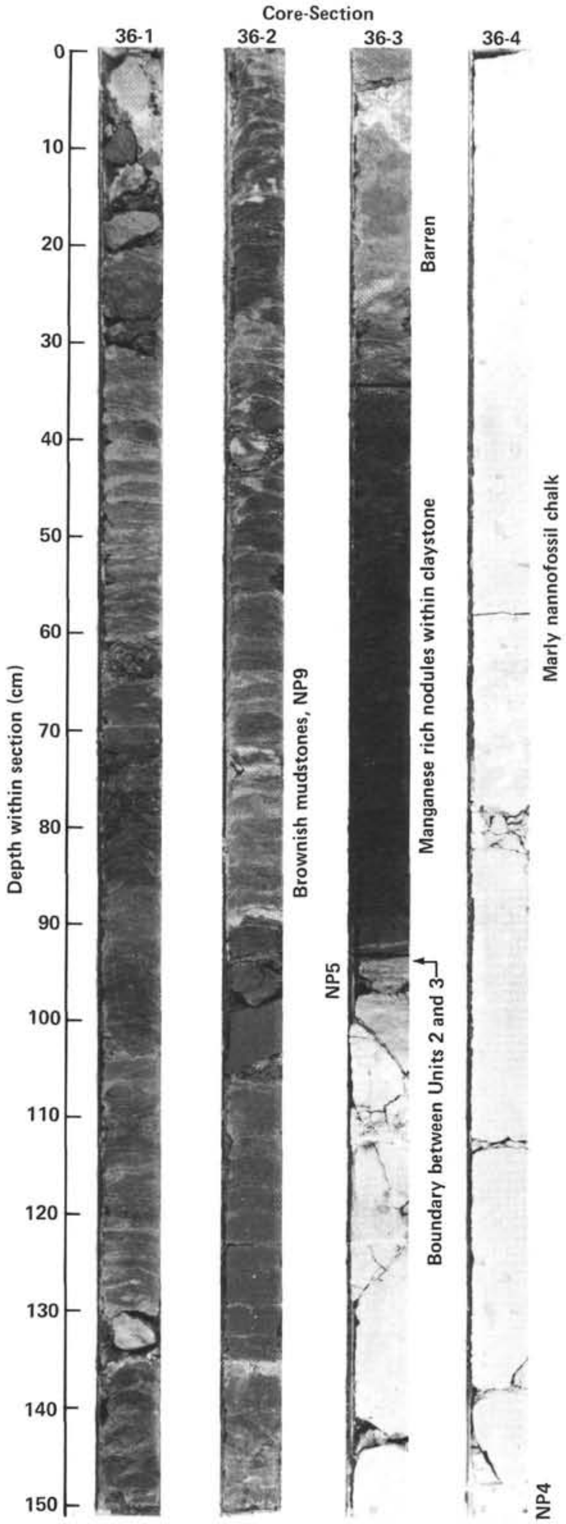


Figure 4. Boundary between the brown unfossiliferous lower section of Unit 2 and the highly calcareous Unit 3 (Core 550-36). Boundary is marked by a black and pink, finely laminated, friable mudstone. Manganese nodules are scattered in the sediments just above the boundary. Sections 1 and 2 are very poor in nannofossils as a result of very strong dissolution and belong to Zone NP9. The sediments in Section 3 at 95 cm and below belong to Zone NP5. An unconformity or a strongly condensed interval corresponds to the metalliferous layer, which is dated late Paleocene (Karpoff et al., this volume).

colored chalk contained 95% $CaCO_3$ (carbonate bomb), whereas two samples from brown, highly bioturbated, marly chalk contained 33 and 46% $CaCO_3$. In general, the chalks are primarily composed of calcareous nannofossils (25 to 93%, smear slides), with other carbonate fragments (as much as 70%) important only in the pale layers. The more marly horizons have clay minerals (as much as 30%), quartz (as much as 10%), and mica (as much as 10%). Small quantities of volcanic glass are found below Core 37. Color varies in Subunit 3a on a scale of a few millimeters to greater than 50 cm. Burrow mottling is restricted to the darker sediments. Gamma ray intensities are very low at the top of Subunit 3a but increase steadily to a pronounced peak at the base; sonic velocity is reasonably constant and has a mean value of 2.1 km/s.

Subunit 3b

Subunit 3b consists of light-colored to brown nannofossil and marly nannofossil chalk with interbedded calcareous turbidites. It occurs in Hole 550 from 465 to 527 m BSF (Cores 41 to 47) and in Hole 550B from 465 to 575 m BSF (Core 2 to 550B-13-3, 50 cm). The sediment is early Paleocene to Campanian(?) or early Maestrichtian in age.

The boundary between Subunits 3a and 3b is marked by a distinct increase in sonic velocity (from 2.1 to 2.6 km/s) and a large drop in natural gamma ray intensity.

Subunit 3b consists of alternations of light brown to brown (7.5YR 7/4, 10YR 7/2–7/4) or reddish brown (2.5YR 4/2, 10YR 7/2–7/4) bioturbated, marly chalks and white to greenish gray (5GY 5/2–7/1) massive, laminated or graded chalks. Most of Subunit 3b comprises repetitions of one basic cycle that usually ranges in thickness from a few centimeters to 1 m but occasionally reaches 3 or 4 m. The cycle, which has a sharp basal contact, begins with a basal, light-colored, often greenish gray, laminated or graded sandy chalk 1 to 30 cm in thickness. This grades upward into massive homogeneous white chalk 5 to 130 cm in thickness that may be enriched in carbonate fragments. The massive white chalk, in turn, passes gradually upward into brownish, marly, highly bioturbated nannofossil chalk. Gradational color banding may be present within the upper parts of the cycles.

The range of mineralogical compositions within Subunit 3b is similar to that in Subunit 3a. Volcanic glass, however, is rare (Core 550B-2 and Section 550B-10-1).

Core 2 (Sections 1 and 2) contains a massive debris flow deposit 220 cm thick. It is composed of dark and light mud clasts as much as several centimeters in diameter within a light brown to greenish gray mudstone matrix. The basal contact of the debris flow deposit is sharp, and color contacts and laminations within it are often distorted and oriented at high angles to the horizontal.

Core 8 contains a coarse debris flow deposit that grades upward into a sandy, weakly laminated layer and then into a massive, fine-grained chalk (Fig. 6). The massive, fine-grained chalk is, in this case, exceptionally thick (4.5 m) and may be weakly laminated (visual and thin

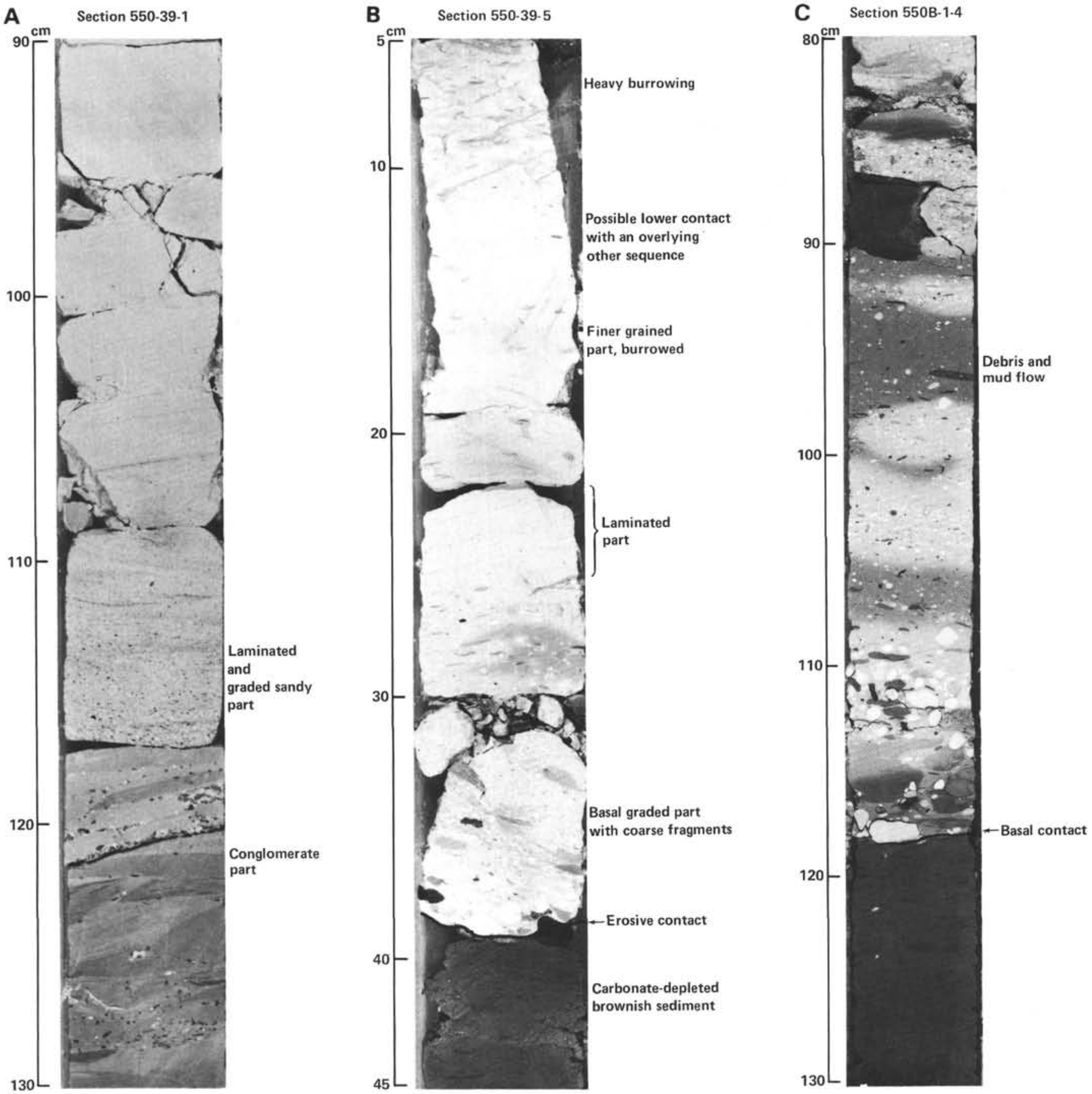


Figure 5. A and B. Details of turbidite beds in Subunit 3a. C. Detail of debris flow deposit in Subunit 3a. Pale gray chalk overlies gray green and brown marly chalk.

section examination). However, it contains a magnetic reversal and thus cannot be interpreted as a simple turbidite. The base of the unit contains coarse, noncalcareous pebbles but is 73% carbonate. Carbonate increases gradually in the basal graded part to a maximum of 88%, which is maintained in the rest of the bed.

Thin section analysis of rhythmic sequences that grade from laminated white chalk to bioturbated brown clay reveals the presence of large specimens of planktonic and benthic foraminifers, abundant large *Inoceramus* prisms, some quartz grains larger than 60 μm, and sparse glauconite in the laminated chalks. The brown bioturbated section, in contrast, contains only sparse *Inoceramus* fragments, and the planktonic foraminifers are very small.

As previously noted, Subunits 3a and 3b can be separated only on the basis of downhole geophysical measurements. Significant variations in logging characteristics can also be seen within Subunit 3b. Above 532 m BSF (Hole 550B, Core 8), sonic velocity is relatively constant at around 2.6 km/s, and natural gamma ray intensity is uniformly low. Below this depth (Cores 9–13),

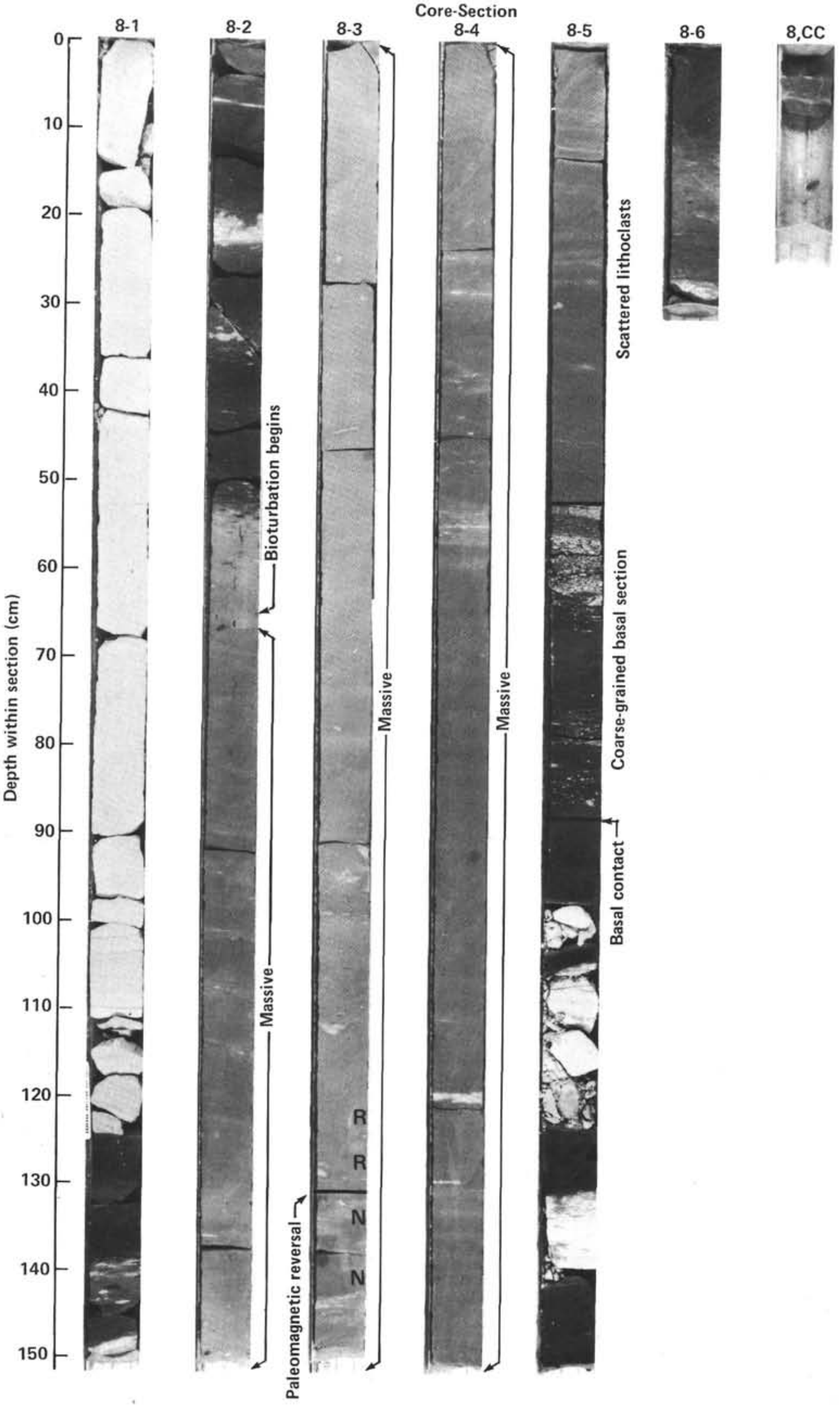


Figure 6. Upward progression from green and brown graded beds to brown, sandy, laminated siltstone and then pale brown chalk. A paleomagnetic reversal occurs within the chalk (Section 550B-8-3). Possible interpretations of the sequence: (1) only the coarse-grained part is reworked, and the parallel-laminated part is the result of local sedimentation in the pelagic domain; (2) the whole is reworked, the result of two debris and mud flows (the second of which begins during the paleomagnetic reversal).

sonic velocity fluctuates between 2.25 and 3 km/s. Gamma ray intensity is also more variable; high gamma ray counts coincide with low velocity values.

The changes in the logging characteristics within Unit 3 are not easily explained by the observed lithology. Although the middle part of the unit is slightly poorer in clay minerals than the top or bottom, these variations are not visually dramatic. Furthermore, the $CaCO_3$ values fluctuate between 30 and 80% throughout the entire section (carbonate bomb). Therefore, a change in carbonate content is not the reason for the dramatic sonic velocity increase between Subunits 3a and 3b. However, carbonate dissolution increases steadily down through Unit 3 (see Biostratigraphy). The dissolution may be responsible for the increasing variability of the sonic and gamma ray values, since the clay enrichment due to carbonate dissolution could produce an inverse correlation between the two logs like that observed in Cores 9 to 13.

The contact between Units 3 and 4 is marked by a small graded sand unit that passes upward into reddish brown chalk. Below the sand, the upper part of Unit 4 is a dark reddish brown noncalcareous mudstone.

Unit 4

Unit 4 consists of mudstone, calcareous mudstones, and marly nannofossil chalks. It occurs in Hole 550B from 575 to 594.83 m BSF (550B-13-3, 50 cm to 550B-15-4, 83 cm) and is Santonian or Coniacian in age.

Unit 4 consists of firm, black, gray, brown, and yellow noncalcareous and calcareous mudstones and marly nannofossil chalks. The age of the upper part of Unit 4 has not been accurately determined, but it is believed to underlie Unit 3 unconformably (see Biostratigraphy). The boundary between Units 3 and 4 is marked by a large downward increase in natural gamma ray intensity and reductions in formation resistivity and sonic velocity. Overall, Unit 4 is characterized by a uniform sonic velocity of about 2 km/s.

Unit 4 is divided in two subunits on the basis of carbonate content. The upper subunit, 4a, consists entirely of dark, noncalcareous mudstones; the lower, 4b, is composed of interbedded dark mudstones and light-colored calcareous mudstones and nannofossil chalks. Gamma ray intensity is high in Subunit 4a. It is lower in Subunit 4b, but there is no sharp break in the gamma ray profile.

The age of Subunit 4b is Santonian or Coniacian, but that of 4a cannot be determined directly because of the absence (probably due to dissolution) of calcareous fossils.

Subunit 4a

Subunit 4a consists of massive noncalcareous mudstones. It occurs in Hole 550B from 575 to 584.4 m BSF (550B-13-3, 50 cm to 550B-14-4, 40 cm).

Subunit 4a consists of black (5Y 2/1, 5GY 2/1, 5G 2/1), brown (7.5YR 6/4, 10YR 6/4, 5YR 3/4-4/4), gray (5GY 4/1-5/1, 5Y 5/2, 5Y 3/1-4/1), and rare green (5GY 3/2-5/2), red (2.5YR 4/2), and yellow (5Y 6/8) firm, massive mudstones. Color contacts range from gradational to sharp, and the colors grade from lighter at the top of the subunit to darker at the base.

Smear slides contain clay minerals (50–70%), quartz (10–30%), and small amounts of feldspar, mica, pyrite, radiolarian fragments, and sponge spicules (as much as 5% of each component). This subunit is essentially noncalcareous (as much as 10% $CaCO_3$, but usually less than 4%; carbonate bomb) and despite its dark color its organic carbon content is low (0.67% maximum). Olive yellow (5Y 6/8) lenses and diffuse bands rich in pyrite occur in Section 550B-13-3. Bioturbation is exceptionally rare in Subunit 4a, appearing only in Core 14, Sections 2 and 3.

The scarcity of carbonate and the downward reduction in carbonate within the overlying Unit 3 suggest that Subunit 4a was probably deposited below the CCD. A detailed discussion of the Subunit 4a paleoenvironment is given in the Biostratigraphy and Organic Geochemistry sections.

Subunit 4b

Subunit 4b consists of interbedded mudstones, calcareous mudstones, and nannofossil chalks. It occurs in Hole 550B from 584.4 to 594.83 m BSF (550B-14-4, 40 cm to 550B-15-4, 83 cm) and is Santonian or Coniacian in age.

Subunit 4b consists of roughly equal proportions of firm light gray (5Y 6/1–8/1, N6–N7) calcareous mudstones and marly nannofossil chalks. The chalks are interbedded on a scale of 10 to 300 cm with dark greenish gray to olive black (5G 2/1–3/1, 5GY 2/1, 5Y 2/1) noncalcareous mudstones. A single layer of dark brown (7.5YR 3/2) mudstone occurs at the base of the subunit (550B-15-4, 40–87 cm). The contacts between the calcareous and noncalcareous layers are both sharp and gradational; the sharp contacts usually occur at the base of the calcareous units, and the gradational contacts occur at the base of the noncalcareous layers.

Carbonate bomb results can be divided into two distinct populations representing the calcareous layers (69–85% $CaCO_3$) and the noncalcareous layers (0–7% $CaCO_3$). The calcareous facies consist primarily of calcareous nannofossils (as much as 40%) and unspecified carbonate (as much as 55%), with as much as 40% terrigenous detritus (mainly clay minerals, quartz, and feldspar). The mudstone facies are predominantly composed of clay minerals (as much as 65%) and quartz (as much as 30%), with trace amounts of feldspar and carbonate. Several large shell fragments (as long as 3 cm) were observed at 550B-14-5, 25 cm.

Bioturbation is weak to moderate throughout most of Subunit 4b. However, the thicker dark horizons are often massive or weakly laminated and show no evidence of bioturbation. The lighter-colored calcareous beds are usually bioturbated at the top and become massive toward the base. They are occasionally also laminated in shades of green (5GY 8/1; Core 14, Sections 4 and 5). Two upward-coarsening sequences of marly nannofossil chalk were visible in Core 14, Section 5. The laminations within and the sharp basal contacts of almost all the calcareous layers indicate that these beds are probably turbidites. The interbedded sequence of noncalcareous mudstones and calcareous turbidites suggests that deposition took place below the CCD, and that only the rapid deposition of the turbidites allowed the preservation of their carbonate content. The laminations within the darker mudstones probably indicate that Site 550 was periodically anoxic during the Santonian–Coniacian (see Organic Geochemistry).

Microscopic and X-ray analyses of the darker beds in Subunit 3b reveal the presence of fluorapatite in thin streaks at three levels. The only foraminifers present belong to a single agglutinated species (see Biostratigraphy). The clay minerals are subordinate to carbonate and are chiefly smectite; quartz comprises 15% of the sediment (Graciansky and Bourbon, this volume). The chalks contain calcareous planktonic and benthic foraminifers, *Inoceramus* fragments, and sparse quartz.

Unit 5

Unit 5 consists of interbedded, light-colored, bioturbated and dark-colored, laminated, calcareous mudstones and marly nannofossil chalks. It occurs in Hole 550B from 594.87 to 685.37 m BSF (550B-15-4, 87 cm to 550B-25-4, 87 cm) and is middle Cenomanian to late Albian in age.

The boundary between Units 4 and 5 is marked by a downward color change from dark reddish brown (5YR 4/6–4/8) to light greenish gray (5GY 7/1) mottled with light red (2.5Y 4/2). A sharp downward increase in natural gamma ray intensity and moderate increases in sonic velocity and resistivity also mark the transition between units. Unit 5 consists of calcareous sediments (39–75%, carbonate bomb), in marked contrast to the interbedded calcareous and noncalcareous sediments of Unit 4. Four color groups can be distinguished within these sediments:

1. 550B-15-4, 87 cm to Section 550B-15-5—light gray (5Y 7/1, 5GY 7/1) bioturbated sediments with three finely laminated interbeds of light green to bluish green (5Y 5/4, 5G 8/1, 5BG 7/2).
2. Section 550B-15-6 to 550B-18-2, 10 cm—light gray (N5–N7, 5Y 6/1–7/1) bioturbated sediments interbedded with dark gray to black (N2–N3) finely laminated material (Fig. 7). The tops of some black laminated layers are sharp, and the light gray layers are color graded from lighter at the bottom to darkest at the top. X-ray analysis shows that the clay minerals are chiefly smectite.
3. 550B-18-2, 10 cm to Section 550B-21-5—highly variegated sediments: gray (5Y 6/1–7/1), reddish or pinkish gray (5YR 5/2–6/2), or pale to reddish brown (10YR 6/3, 5YR 4/3–5/3, 2.5YR 5/4).
4. Section 550B-21-6 to 550B-25-4, 87 cm—light gray, bioturbated (5Y 5/1–6/1) sediments interbedded with dark gray (5Y 2/1–4/1), finely laminated material.

Variations in total organic carbon (TOC) appear to accompany the changes between color groups 2, 3, and 4 (TOC was not analyzed for group 1). TOC for group 3 is consistently low (0.06–0.74%); for groups 2 and 4 it is highly variable (0.1–2.37%), the higher values being found in the dark gray laminated layers. However, no other variations in lithology could be detected, and the sediment's downhole logging characteristics showed little change except for a slight increase in gamma ray in-

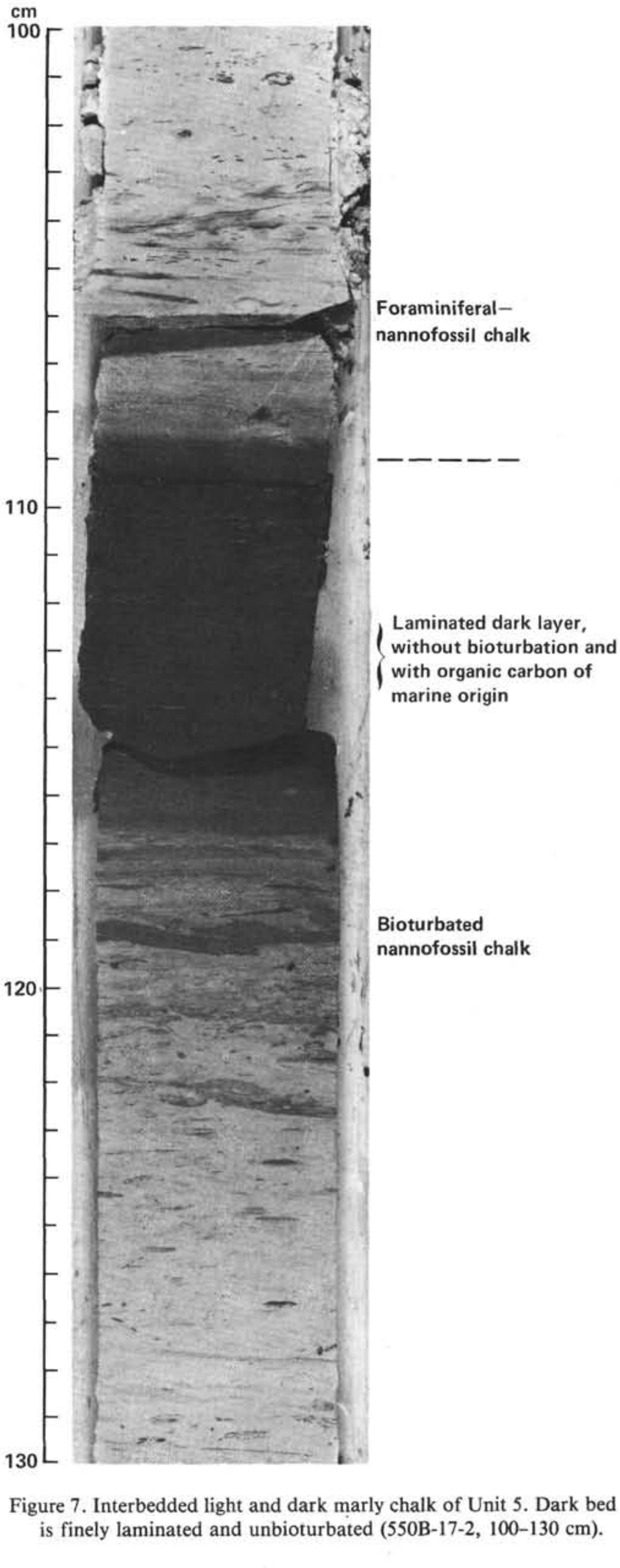


Figure 7. Interbedded light and dark marly chalk of Unit 5. Dark bed is finely laminated and unbioturbated (550B-17-2, 100–130 cm).

tensity between color groups 2 and 3. For this reason, no formal subdivision of Unit 5 was proposed.

Little variation in $CaCO_3$ content occurs within Unit 5, even between lithologies of different color. Carbonate bomb analyses show the $CaCO_3$ content of most sediments to be 45 to 60% (extremes are 39 and 75%). A detailed sampling program in Section 550B-24-3, within bioturbated gray to laminated dark gray sediments, showed a small systematic difference in $CaCO_3$ content that was covariant with color; dark gray sediments were approximately 5% richer in carbonate. The possible reasons for this are discussed under Organic Geochemistry.

The carbonate fraction of the sediments consists of calcareous nannofossils (as much as 75%), unspecified carbonate (as much as 60%), and foraminifers (as much as 15%). The terrigenous fraction consists of clay minerals (10–40%), quartz (as much as 15%), and feldspar (as much as 10%), with minor amounts of heavy minerals and mica.

Bioturbation is moderate to intense in all the lighter-colored sediments within Unit 5; the darker sediments are finely laminated or (rarely) massive. Mud clasts occur in Section 550B-21-6 from 70 to 90 cm, and inclined bedding occurs in Section 550B-25-2 from 87 to 114 cm and from 127 to 150 cm. Both of these features may indicate minor slumping.

The light gray to dark banded sediments in Cores 21 to 25 show two distinct styles of alternation between beds. In some parts of the sequence (e.g., Section 550B-25-2), the lighter beds grade upward into dark laminated beds, but the transitions from the dark to the light layers are sharp and sometimes marked by concentrations of glauconite. The rhythmic changes in the sedimentological characteristics of Unit 5 are dealt with by Graciansky and Gillot (this volume).

Unit 6

Unit 6 consists of dark gray basalt with thin interbeds of calcareous sediment. It occurs in Hole 550B from 685.4 to 720.5 m BSF (550B-25-4, 87 cm to Core 30). The basalts are late(?) Albian in age.

Unit 6 consists of dark gray basalts with thin interbeds of indurated, reddish brown (2.5YR 3/4) calcareous sediments (two carbonate bomb analyses yielded 14 and 71% $CaCO_3$). The basalts are described in more detail in Basalt Lithology and by Maury et al. (this volume).

BIOSTRATIGRAPHY

Summary

Hole 550

Sediments were recovered from Hole 550 from 99.5 to 536.0 m BSF, a sequence that proved to be lower Pliocene to Maestrichtian (Fig. 8). The Cretaceous/Tertiary boundary was encountered at approximately 470 m BSF.

A continuous lower Pliocene–upper Miocene sequence, generally rich in planktonic foraminifers and nannofossils, was found from 122 to 255 m. The lower boundary of the upper Miocene presented here is based on nanno-

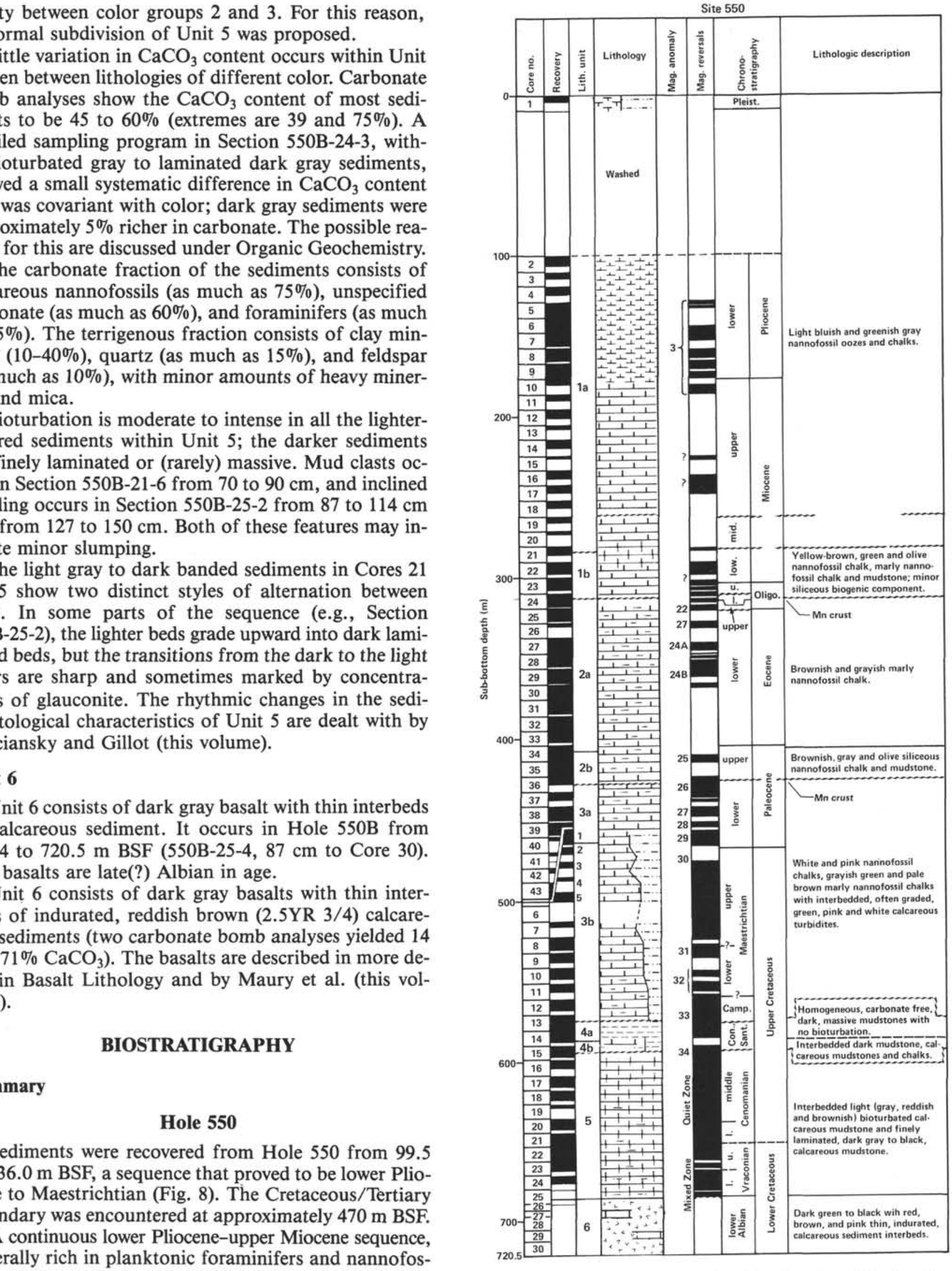


Figure 8. Stratigraphic section at Site 550. Legend as defined in Explanatory Notes (this volume).

fossil evidence, which disagrees slightly with the evidence of the planktonic foraminifers. The diverse, well preserved microfaunal and nannofloral assemblages of the early Pliocene reflect relatively warm water conditions. However, some intervals within the upper Miocene contain assemblages that are affected by strong carbonate dissolution, and other intervals contain few or no warm water species. These characteristics indicate climatic changes and fluctuations in the CCD.

An unconformity involving a hiatus of 2.8 m.y. separates the upper Miocene(?) from underlying lower to middle Miocene deposits (the latter of which are 55 m thick; Fig. 8), although no significant change in lithology occurs at that point, which unfortunately coincides with a 30 cm gap in recovery. Samples from above the unconformity contain rich, well preserved microfossil assemblages, while those from below the unconformity have been subjected to extensive dissolution. The microfossil assemblages characterized by dissolution (which are probably associated with the presence of cooler waters) are numerically dominated by species of *Bolboforma* (Müller et al., this volume).

Beneath the lower Miocene lies a condensed and incomplete upper Oligocene to middle Eocene sedimentary sequence (Fig. 8). This sequence, which shows the effects of strong carbonate dissolution, was subject to periodic nondeposition and/or erosion. The dissolution is associated with a rise of the CCD that corresponds to the appearance of cold bottom waters in the North Atlantic.

A thick (about 93 m) section of lower Eocene sediments contains abundant, diverse microfossil assemblages that occasionally show the effects of moderate dissolution. The Paleocene assemblages are similarly preserved, except for an upper interval of siliceous mudstones rich in radiolarians. A probable unconformity corresponding to a 3.5 m.y. gap appears in the upper Paleocene and is underlain by a thin layer of manganiferous nodules. Cretaceous sediments were encountered at a depth of 470 m. The Cretaceous/Tertiary contact was probably disturbed by drilling operations.

Hole 550B

In Hole 550B, where rotary drilling began at 456 m BSF, the Cretaceous/Tertiary boundary also lies at a depth of 470 m (Fig. 8). The boundary is not very distinct, because many reworked Cretaceous species are present. However, recovery through the lower Danian appears to be complete, and the lowermost Danian faunal and nannofloral zones overlie uppermost Maestrichtian biozones, indicating that there is no significant unconformity between the Tertiary and Cretaceous. The Cretaceous sediments, which lie directly on basalt at 685.37 m BSF, can be subdivided into three main units, each separated by an unconformity, on the basis of paleontological data.

In the upper part of the first unit, both nannofossils and foraminifers indicate an early through late Maestrichtian age. In the lower few meters of the unit, questionable late Campanian sediments are present. From 574 to 583 m BSF, the fossils are either not diagnostic or absent, but the lithofacies are similar to those of the underlying unit. The generally poor preservation of the micro- and nannofossils in these Upper Cretaceous strata complicates interpretations. In the upper strata (Cores 2–9), the fossils are frequently recrystallized and/or broken. The effects of carbonate dissolution are evident from Core 9 or 10 downward in both the lithology and the preservation and composition of the fossil assemblage (resistant nannofossil species are dominant; the foraminifer assemblage is impoverished; there is a distinct association of the so-called primitive arenaceous foraminifers). The unusual thickness (104 m) of the Maestrichtian-upper(?) Campanian section is the result of the rapid accumulation of turbiditic layers, which brought shallow-water sediments into an abyssal environment.

Of the strata that compose the second unit (thickness 21 m), only the median part can be dated. A Santonian-Coniacian age has been assigned on the basis of calcareous microfossils from interbedded allochthonous materials. Dissolution has been so severe that both the upper and lower parts of this second unit are almost devoid of calcareous fossils; only assemblages of agglutinating foraminifers have been observed so far. In other respects, the sieved residue (greater than 63 μm) is distinguished by a large clastic component (quartz, mica), glauconite, and abundant radiolarians.

A satisfactory chronostratigraphic resolution can be obtained with the help of foraminifers for the third and lowermost unit (thickness 91 m). Most of these Upper Cretaceous strata belong to the middle through lower Cenomanian (Fig. 18). The fossil assemblages here are prolific and often well preserved, although dissolution and fragmentation occur in some dark laminated layers. A thin layer of Vraconian (latest Albian) age occurs at the base of the Cenomanian sequence and directly overlies basalt. Sediments interbedded with the basalt also contain microfossils, although most are recrystallized; a few nannofossils have been obtained, and fairly abundant and well preserved foraminifers are visible in thin sections. Both groups contain species that range below the Vraconian, but none is diagnostic of an age older than Vraconian.

Two aspects of the Upper Cretaceous sediments should be emphasized. First, carbonate dissolution has been important in modifying the lithology and fossil assemblages at the site. Solution-linked changes in lithology appear above the Cenomanian and vanish in the upper Campanian(?)–lower Maestrichtian. (Solution effects also are apparent in the gamma ray log, which shows a gradual upward decrease in clayey intercalations.) The second aspect is that as a result of the dissolution it is difficult to determine whether or not unconformities are present. Two working hypotheses can be applied: either sedimentation was continuous, although condensed, between the middle Cenomanian and late Campanian(?)–early Maestrichtian, or the sediments were discontinuously laid down. In support of the second hypothesis, two potential unconformities can be identified. The first separates fossilrich middle Cenomanian strata from the Coniacian–Santonian sequence with its clastic detritus and agglutinating foraminifers. The second is a better documented unconformity that lies between the Coniacian–Santonian section and the first turbiditic-clayey alternations of the upper Campanian(?)–lower Maestrichtian. The hiatus probably corresponds to a part of both Santonian and Campanian time. The results of a detailed examination of seismic profiles in the vicinity of Hole 550 support the unconformity hypothesis.

The biostratigraphic boundaries specified in the following discussion were determined on board ship. They are superseded by the boundaries shown in the Site 550 Superlog (back pocket), which represent the results of subsequent shore-based work.

Foraminifers

Cenozoic

The surface sediment and samples throughout the remainder of Core 1 contain abundant, well preserved planktonic foraminifers. Pleistocene assemblages from Samples 550-1-1, 48–51 cm and 550-1-4, 42–46 cm are numerically dominated by *Globigerina bulloides* and *Globorotalia inflata;* a few specimens of warm water species, such as *Globigerinoides ruber* and *Orbulina universa*, also are present. This assemblage typifies interglacials and closely resembles the assemblage present in surface sediments, indicating deposition in a similar environmental setting. Sample 550-1-2, 64–68 cm is more typical of assemblages from glacials. *Neogloboquadrina pachyderma* and *N. "du/pac"* dominate the assemblage, and warm water species are absent. This sample also contains an abundance of detrital quartz, which strengthens the inference of deposition during a glacial episode. Core 1 penetrated only 5.5 m below the sediment surface, but faunal fluctuations are significant even in this limited interval.

After the mudline core was recovered, Hole 550 was washed down to a depth of approximately 100 m. Thus, there is an interval of 95 m from which no samples are available.

From Cores 2 to 4, an interval of approximately 22 m, the planktonic foraminifer assemblages are dominated by Miocene species (Fig. 8). The faunal associations in the upper part of this interval (Core 2) contain species that are restricted to Pliocene and younger sediments (e.g. *Globorotalia crassaformis, G. puncticulata, G. ronda, Globorotaloides hexagona*) as well as species that do not range beyond the end of the Miocene (e.g., *Globorotalia continuosa, G. siakensis, Globoquadrina dehiscens*). Samples from Cores 3 and 4 contain a purer late Miocene fauna, although older reworked forms are present occasionally. Specimens of *Bolboforma* are few to common within these two cores. Preservation throughout this interval is poor to moderate as a result of dissolution and recrystallization. The Miocene sediment in Cores 2 through 4 is believed to represent slumped material that has been introduced into a younger sediment sequence, because a moderately thick Pliocene sequence lies beneath it. The thickness of the slumped unit is unknown, because only the lower boundary can be observed.

Pliocene sediment containing well preserved, moderately diverse assemblages extend downward from Sample 550-5-1, 44–48 cm through Sample 550-9-6, 90–95 cm (Fig. 8). The assemblages suggest that this 52 m interval is primarily early to middle Pliocene in age. The top of the Pliocene in Hole 550 is marked by the LAD of *Globigerina apertura, Globorotalia praehirsuta, G. puncticulata, G. ronda, Globigerinoides extremus*, and *Sphaeroidinellopsis paenedehiscens.* The FAD of *Globorotalia crassaformis* and *G. puncticulata* can be used to distinguish the middle from the lowermost Pliocene section. One sample in the center of the Pliocene section (Sample 550-8-1, 84–89 cm) contains almost no foraminifers, the sand-sized fraction being dominated by framboids of pyrite. The boundary between Zone N18 (lower Pliocene) and the N17–N16 interval (upper Miocene) is based primarily on the LAD of *Globorotalia continuosa* and the FAD of *Globorotalia margaritae.*

Upper Miocene sediments are present from Samples 550-10-1, 41–43 cm through 550-16-4, 47–51 cm, a thickness of approximately 63 m. Planktonic foraminifers are few to common and are generally not well preserved, because the entire interval has been subjected to dissolution. *Neogloboquadrina acostaensis* is much more abundant in upper Miocene than in Pliocene sediments. Several thin layers within the N17–N16 interval (Samples 550-12-1, 29–32 cm; 550-15-1, 44–48 cm; 550-16-3, 47–51 cm; 550-16-4, 47–51 cm) contain abundant specimens of *Bolboforma.* Such layers are characterized by very sparse, poorly preserved planktonic foraminifers. Murray (1979) reported *Bolboforma* from Zone N17 (possibly ranging from N16 to N18) at DSDP Sites 403, 404, and 406. The base of the upper Miocene is marked by the FAD of *Neogloboquadrina acostaensis* and *Globigerina bulloides.*

The interval from Sample 550-17-1, 35–39 cm through 550-18-3, 34–38 cm is interpreted as being of latest middle Miocene age (Zones N15–N14; Fig. 8). Diagnostic species within the N15–N14 interval include *Globorotalia praemenardii* and *G. siakensis.* Both *Neogloboquadrina acostaensis* and *Globigerina bulloides*, dominant forms in the overlying upper Miocene sediments, are conspicuously absent. Once again, several intervals contain abundant specimens of *Bolboforma* and sparse foraminifer assemblages.

An unconformity representing most of the middle Miocene (Zones N10–N13) is present below the N15–N14 interval (Fig. 8). Samples 550-18-4, 34–38 cm downward through 550-21-2, 85–87 cm are assigned to the N9–N8 interval. Diagnostic species include *Globorotalia fohsi peripheroronda, G. siakensis, Globigerinoides subquadratus*, and *Praeorbulina glomerosa.* Assemblages throughout the entire N9–N8 interval are rather sparse, primarily as a result of dissolution. Microfossil assemblages are composed largely of *Bolboforma.* Auffret and Pastouret (1979) reported abundant calcispheres from the middle Miocene of the Bay of Biscay. It appears that the abundant occurrence of *Bolboforma* is a reliable stratigraphic indicator for middle to upper Miocene sediments in deep-sea deposits of the Biscay region. They cannot, however, be so used in shallower localities, as evidenced by their absence at Sites 548 and 549. The boundary between the N9–N8 and N7–N6 intervals lies between

Samples 550-21-2, 85–87 cm and 550-21-3, 110–113 cm. It is based on the FAD of *Praeorbulina glomerosa* and the LAD of *Catapsydrax unicavus*. Sample 550-21-3, 110–113 cm contains rare *Bolboforma*, probably as a result of downhole contamination, and the remainder of the section is devoid of this group. Planktonic foraminifers are few to common and generally not very well preserved. The total thickness of the lower and middle Miocene sediments at Site 550 is approximately 46 m.

An unconformity appears to exist between Samples 550-24-2, 22–24 cm and 550-24-3, 22–24 cm (Fig. 8). The former sample contains a few poorly preserved specimens of *Catapsydrax stainforthi*, while the latter contains recrystallized, partially dissolved specimens of *Globigerinatheka*. This suggests a hiatus that spans the entire Oligocene. However, the faunal evidence is exceedingly sparse, because sediments from Samples 550-24-3, 22–24 cm through 550-26-1, 42–45 cm are either barren or contain only a few planktonic foraminifers. Samples 550-24-3, 22–24 cm through 550-25-1, 35–38 cm contain a fairly diverse benthic foraminifer assemblage. Nannofossil evidence suggests the presence of a condensed Oligocene section within the interval that is devoid of planktonic foraminifers. Foraminiferal evidence is insufficient to evaluate this interpretation. Samples 550-25-1, 35–38 cm through 550-26-1, 42–45 cm are tentatively assigned to the Eocene, but the specific portion of that epoch represented by this 10 m interval cannot be determined from the foraminifers.

Sediments from Samples 550-27-1, 42–45 cm downward through 550-33-3, 59–61 cm are interpreted as being of early Eocene age (Fig. 8). This interval, which is about 35 m thick, spans Zones P6 through P8. The upper boundary of P8, which adjoins the barren zone, is marked by the co-occurrence of *Acarinina pentacamerata, A. primitiva*, and *A. pseudotopilensis*. Sample 550-27-4, 42–45 cm is barren of microfossils, making the exact position of the Zone P8/P7 boundary impossible to determine. Sample 550-27-5, 42–45 cm lies within Zone P7, as evidenced by the presence of *Morozovella formosa gracilis*. The LADs of *Morozovella marginodentata* and *M. lensiformis* lie in the next sample below. The P7/P6 zonal boundary, which is between Samples 550-29-6, 51–54 cm and 550-30-1, 49–53 cm is marked by the LAD of *Planorotalites chapmani*. The LAD of *Morozovella aequa* occurs in the sample immediately below. The base of Zone P6 lies at the FAD of *Morozovela marginodentata*, an abundant and conspicuous member of lower Eocene assemblages.

Upper Paleocene sediments of Zone P5 are present from the P6–P5 zonal boundary downward through Sample 550-34-4, 62–65 cm (Fig. 8). The presence of *Acarinina mckannai* distinguishes them from overlying lower Eocene sediment. The 15 m interval from Samples 550-34-5, 62–65 cm through 550-36-2, 62–65 cm is completely devoid of planktonic foraminifers. The sediments are dominated by radiolarians, with sporadic occurrences of diatoms. The sediments below the barren zone can be assigned to Zone P3. Diagnostic species include *Morozovella angulata, M. conicotruncata, M. pusilla*, and *Subbotina triloculinoides*. From Sample 550-38-5, 54–56 cm downward to the bottom of Hole 550 (Sample 550-41-2, 114–116 cm), the foraminifer assemblages indicate the Zone P1–P2 interval. The diagnostic species include *Eoglobigerina daubjergensis, Subbotina triloculinoides, S. incostans*, and *S. trinidadensis*. The lowermost portion of the Danian (Zone P1a) is not present in Hole 550. Hole 550B, however, does contain the *Eoglobigerina eugubina* Zone (P1a). The presence of this zone indicates that there is no significant unconformity between the Paleocene and Cretaceous. The total thickness of the Paleocene section at Site 550 is approximately 73 m.

Cretaceous

Although the key species was not observed above Core 5 in Hole 550B, the late Maestrichtian sediments (*mayaroensis* or MC-11 Zone) are present as high as Sample 550B-2-3, 56–58 cm, the first sample examined (Fig. 8). According to the calcareous nannofossils, the boundary between the lowermost Danian and the upper Maestrichtian strata is located between Sample 550B-2-3, 34–35 cm and 550B-2-3, 38 cm. The diagnostic species in the very rich assemblages in Cores 2 to 5 are *Globotruncana contusa, G. arca, G. citae, G. caliciformis, G. stuarti, Globigerinelloides messinae subcarinata, Racemiguembelina fructicosa, Pseudotextularia elegans, Ventilabrella glabrata, Guembelina excolata*, and *Bolivina incrassata*.

In Hole 550, the same Maestrichtian assemblages were observed within the lowest cores (41–47). At 550-41-2, 118 cm, Cretaceous deposits are overlain abruptly by Zone P1b-d of the Danian; the contact probably has been disturbed and poorly recovered.

Cores 7 to 12 in Hole 550B also belong to the Maestrichtian. A complete zonal succession of calcareous nannofossils can be observed there (Fig. 8). No precise age determinations can be derived at present from the foraminifer faunas because of grading and recrystallization. Moreover, calcite dissolution becomes appreciable from Core 10 downward.

The exact age assignment for Core 13 has yet to be determined. Its upper part (Section 1 to part of Section 3) could be of late Campanian age, according to the foraminifers (which include *Reussella szajnochae, Conorbina* cf. *sigmoidalis, Osangularia* sp.). Its lower part belongs to the interval of black deposits (550B-13-3, 67 cm to 550B-15-4, 87 cm), which is characterized by scattered chalky intercalations that yield small *Hedbergella, Globigerinelloides*, and *Guembelina* (especially *G. pulchra*). These microfossils support the Coniacian–Santonian age suggested by the calcareous nannofossils. The species within this assemblage suggest that these deposits formed under carbonate-depleted conditions (hence, "primitive arenaceous" foraminifers, radiolaria, fish debris) and that the calcareous sediments and microfossils were displaced from a bathyal milieu on the adjacent slope. The lowest part of this interval (550B-15-2 to 550B-15-4, 87 cm) is almost barren of microfossils.

The lithologic change at 550B-15-4, 87 cm, coincides with the first downward occurrence of a Cenomanian foraminifer assemblage, which was observed downward to the contact with basalt (550B-25-4, 87 cm; Fig. 8).

The planktonic foraminifer-rich assemblages suggest a bathyal or abyssal paleoenvironment. Some of the benthic species suggest shallower water, but they may have been transported from shallower parts of the slope or from the shelf.

From Cores 15 to 17 the main species are *Rotalipora cushmani, R. greenhornensis, R. montsalvensis, R. thomei, R.* cf. *deeckei, R. brotzeni, Globotruncana stephani*, and *Praeglobotruncana aumalensis.* They can be assigned to the lower part of the middle Cenomanian (lower part of MCs2 Zone). Core 18 belongs to the early or middle Cenomanian. Cores 19 and 20 are near the early/middle Cenomanian boundary, as indicated particularly by *R.* cf. *cushmani, R. montsalvensis, R. thomei, R. globotruncanoides, R. evoluta, R. reicheli, R. brotzeni, R. appenninica, Globotruncana stephani*, and *Parella cheniourensis.* Cores 21 to 24 belong to the early Cenomanian (MCs1 Zone), containing mainly *R. appenninica, R. balernaensis* group, *R. evoluta, R. globotruncanoides, R.* cf. *brotzeni*, and *Globigerinelloides eaglefordensis.* Core 25 is distinguished by the presence of *Planomalina buxtorfi*, which indicates that the lowest Cenomanian or highest Albian (Vraconian) stage has been reached.

The sparsity of foraminifers and lack of key species in the available thin sections do not allow an exact age to be assigned to the sediments intercalated within the basalt. The fossils do not seem to be very different from the late Vraconian–earliest Cenomanian species found in the sediment directly overlying the basalt.

Nannoplankton

Hole 550

Core 1 of Hole 550 belongs to the Pleistocene, inasmuch as the *Emiliania huxleyi* Zone (NN21) is present from Sections 550-1-1 to 550-1-3, and the *Gephyrocapsa oceanica* Zone (NN20) is present in Section 550-1-4. The few samples studied from this core display an alternation of nannoplanktonrich and nannoplanktonpoor layers that is related to interglacial and glacial climatic fluctuations. A 94 m gap in the coring separates Core 1 from Core 2.

A thick sequence of lower Pliocene–upper Miocene sediments is encountered from Core 2 to Section 550-18-2 (Fig. 8). The presence of slumped beds dated probably as upper Miocene (Cores 2–4) is suggested by their interbedding within Pliocene sediments. Cores 5 to 9 are dated lower Pliocene and are underlain by upper Miocene layers (Cores 10–18).

In general, the preservation of nannoplankton is notably better in the lower Pliocene than the upper Miocene sediments. In some Pliocene samples there are reworked middle and upper Miocene nannoplankton specimens. In the upper Miocene sediments, unlike the lower Pliocene sediments, *Sphenolithus abies* and *Discoaster quinqueramus* are missing or occur only rarely, although *Discoaster calcaris* is abundant in several upper Miocene layers. The variable abundance of the discoasters and variations in the degree of dissolution and fragmentation indicate climatic shifts and fluctuations in the CCD. The diversity of the late Miocene nannoplankton assemblages is rather low as a result of cold water temperatures. *Amaurolithus delicatus* is present down to Sample 550-14-1, 49–50 cm, and *Discoaster quinqueramus* is present down to Sample 550-14,CC, so at least this part of the sequence can confidently be attributed to the *D. quinqueramus* Zone (NN11). Core 15 to Section 550-18-2 may belong to the *Discoaster calcaris* Zone (NN10), because *D. calcaris* and *D. variabilis* are common. *D. quinqueramus* is absent, perhaps because of unfavorable ecologic conditions.

Within the upper-middle(?) Miocene sequence, white and light gray nannofossil ooze alternate. *Discoaster variabilis*, a species that tolerates rather low water temperature, is abundant in the light gray layers. The preservation of the discoasters is good (no calcite overgrowth, which means that the sediments contain a certain amount of clay), whereas the coccoliths are strongly broken and etched, indicating that dissolution was more severe during the deposition of the light gray layers. Fragmentation and dissolution are most severe in Cores 17 and 18, which also are rich in specimens of *Bolboforma*, a group that seems to have been most abundant during periods of low water temperature (Müller et al., this volume).

There is an unconformity in Core 18 between Sections 2 and 3 (Fig. 8), where upper Miocene strata are underlain by middle Miocene strata of Zone NN6. The unconformity represents a hiatus of at least 2 m.y. Zone NN6, which was identified by the presence of abundant large specimens of *Coccolithus pelagicus, Cyclicargolithus abisectus, C. floridanus*, and *Discoaster exilis*, is present from Samples 550-18-3, 17–18 cm to 550-21-2, 62–63 cm. Nannoplankton are abundant, and discoasters are generally common. Fluctuations of the CCD are indicated by variations in the degree of etching of the coccoliths.

The *Sphenolithus heteromorphus* Zone (NN5) is present from Sample 550-21-3, 73–74 cm to 550-22-4, 74 cm. It is underlain by the *Sphenolithus belemnos* Zone (NN3) of early Miocene age (550-22-5, 50 to 100 cm). Nannoplankton Zone NN4 was not recognized; *Helicopontosphaera ampliaperta* may be missing, corresponding perhaps to a small hiatus of 1 to 2 m.y. Otherwise, Zone NN4 might be present within the 120 cm interval that was not sampled. Nannoplankton are common, slightly to strongly broken, and etched by dissolution.

The interval from the top of Core 23 to 550-24-1, 30 cm belongs to undifferentiated Zones NN1/NN2. The assemblages are of low diversity, containing *Cyclicargolithus abisectus, C. floridanus, Coccolithus pelagicus, Reticulofenestra pseudoumbilica*, and *Sphenolithus moriformis.* Siliceous microfossils are present from 550-23-1, 45 cm to 550-23-3, 22 cm. These sediments are finely laminated as a result of the presence of large diatoms, which might be related to a decrease in water temperature (upwelling?) within the earliest Miocene. Nannoplankton are common, slightly etched by dissolution, and broken.

The 57 m middle and lower Miocene sequence is rather condensed compared with the thick late Miocene–early Pliocene section (Fig. 8). The presence of similar condensation in the same stratigraphic interval at Site 548 indicates that important paleoceanographic changes took place during the late Miocene.

The Oligocene is represented by a very condensed sequence from 550-24-1, 30 cm to 550-24-2, 34 cm (Fig. 8). Zones NP24/NP25, of late to middle Oligocene age, were identified in Section 550-24-1 from 30 to 135 cm. This section is underlain by lower Oligocene Zone NP21. The inferred unconformity represents nannoplankton Zone NP23 of middle Oligocene age and Zone NP22 of early Oligocene age, a hiatus of at least 5 m.y. Dissolution was very strong within the middle Oligocene, and very few nannoplankton are preserved; zeoliths are common. Marked fluctuations in the intensity of dissolution are in evidence within Zone NP21 (early Oligocene; 550-24-2, 14 cm to 550-24-2, 34 cm).

Eocene nannofloras (Zone NP17 to approximately NP20) are found at 550-24-2, 62 cm. Nannoplankton are present only sporadically, and zeolites are common. The nannoplankton at 550-24-2, 80 cm have been completely dissolved. This level is underlain by Zone NP14 (early middle Eocene), which occurs from 550-24-2, 95 cm to 550-24-4, 67 cm; thus, there is an important unconformity within the Eocene.

The identification of Zone NP14 is based on the presence of *Discoaster lodoensis, D. sublodoensis, D. barbadiensis, Chiasmolithus grandis*, and *Discoasteroides kuepperi*. Because dissolution has been strong, the coccoliths are almost dissolved, thereby increasing the proportion of the fossil assemblage made up of discoasters.

A thick complete lower Eocene section is present from 550-24-5, 45 cm to Sample 550-34-3, 60–61 cm (Fig. 8). The interval from 550-24-5, 45 cm to Sample 550-25-3, 97–99 cm belongs to the *D. lodoensis* Zone (NP13); that from Sample 550-25-5, 23–24 cm to Section 550-27,CC belongs to the *Marthasterites tribrachiatus* Zone (NP12); that from Sample 550-28-1, 46–47 cm to Section 550-28,CC belongs to the *Discoaster binodosus* Zone (NP11); and that from Samples 550-29-2, 47–48 cm to 550-34-3, 60–61 cm belongs to the *Marthasterites contortus* Zone (NP10). Dissolution is sill strong within Zone NP13 and the upper part of Zone NP12, but diminishes in the lower part of the sequence. Specimens of the genus *Toweius* are common to abundant within the lower Eocene sediments. *Rhabdulus solus* is abundant within some samples, and discoasters are generally common. *Rhomboaster cuspis* is present within the lowermost part of Zone NP10 and the uppermost part of Zone NP9, a condition that is characteristic of the interval around the Paleocene/Eocene boundary.

Nannoplankton Zone NP9 (*Discoaster multiradiatus* Zone), which is of late Paleocene age, is present from Sample 550-34-4, 60–61 cm to 550-36-2, 130 cm (Fig. 8). The variable abundance of nannoplankton within this zone indicates distinct fluctuations in the CCD. Siliceous microfossils, which are primarily radiolarians (few diatoms), are present from Sample 550-35-4, 60–61 cm to Section 550-35,CC. The nannoplankton assemblages of this zone are diverse and proportionally enriched in dissolution-resistant species. Zone NP9 is directly underlain by the *Fasciculithus tympaniformis* Zone (NP5), as identified from 550-36-3, 7 cm to Sample 550-36-3, 104–106 cm. An unconformity representing a hiatus of about 2 m.y. separates the two units. The assemblages are of lower diversity and contain *F. tympaniformis, Toweius craticulus, Ericsonia subpertusa, Zygolithus sigmoides*, and *Chiasmolithus danicus*. Intervals of intense carbonate dissolution are indicated by layers barren of nannoplankton (550-36-2, 130 cm; 550-36-2, 29 to 60 cm).

The *Ellipsolithus macellus* Zone (NP4) is present from Samples 550-36-4, 1–2 cm to 550-38-5, 50–52 cm, and the *Chiasmolithus danicus* Zone (NP3) is present from Sample 550-38-6, 50–52 cm to 550-41-2, 116 cm. Nannoplankton are abundant but slightly or strongly fragmented as a result of diagenesis. *Braarudosphaera bigelowi*, which was abundant within this zone at the shallower sites (Sites 548, 549), was not observed at Site 550. The Cretaceous/Tertiary boundary was not recovered in Hole 550, where Zone NP3 of the Danian is underlain by the late Maestrichtian *Micula mura* Zone; the *M. mura* Zone occurs from 550-41-2, 120 cm to Sample 550-43-2, 22–23 cm and is followed by the *Lithraphidites quadratus* Zone (Samples 550-43-3, 95–96 cm to 550-47-1, 31–32 cm) and the early Maestrichtian *Tetralithus trifidus* Zone (Sample 550-47-2, 63–64 cm to section 550-47,CC). The sediments are very rich in diagenetically fragmented nannoplankton. This sequence is characterized by intercalations of very fine-grained turbidites that contain Cretaceous sediments probably displaced from shallower locations.

Hole 550B

Hole 550B was drilled approximately 15 m from Hole 550. The hole was washed down to a depth of 456 m (Fig. 8). Core 1 contained sediments of early Paleocene age (NP3) (550B-1-6, 100 cm). This core consists predominantly of turbidites containing displaced Maestrichtian sediments. White (Campanian) or greenish (Albian/Cenomanian) grains and/or pebbles are present in the coarser parts of the graded beds (Sediment Lithology, Unit 2, this chapter; and Graciansky and Bourbon, this volume).

The Cretaceous/Tertiary boundary, as determined by the first occurrence of *Biantholithus sparsus*, lies in Section 550B-2-3 between 34 and 38 cm. However, the boundary here is not as distinct as has been described from other locations by several authors. Nannoplankton are rare within Zone NP1, and the assemblage, which contains *Markalius inversus, B. sparsus, Zygodiscus sigmoides*, and *Thoracosphaera deflandrei*, is of very low diversity. The specimens are often small. Moreover, there are a great number of Cretaceous specimens within the lowermost Paleocene beds. As in other continuous deep sea records of the Cretaceous/Tertiary transition, these specimens are believed to have been redeposited. The most obvious change at this boundary is the marked upward decrease of nannoplankton from the Cretaceous into the lowermost Paleocene.

The upper Maestrichtian *Micula mura* Zone was identified from 550B-2-3, 38 cm to Sample 550B-7-1, 38–40 cm. The sediments are very rich in well developed nannoplankton, which are moderately to badly preserved as a result of diagenetic fragmentation. The most abundant species are *Arkhangelskiella cymbiformis, Prediscosphaera cretacea, Cribrospherella ehrenbergi, Eiffellithus turriseiffeli*, and *Kamptnerius magnificus. Micula mura* occurs only sporadically.

The *Lithraphidites quadratus* Zone, which represents a rather short time interval, is present from Sample 550B-7-2, 36–37 cm to 550B-8-2, 37 cm. In abundance and preservation the nannoplankton are similar to those in the overlying assemblages.

The underlying *Tetralithus trifidus* (lower Maestrichtian) Zone is present throughout the rather thick turbidite sequence from 550B-8-2, 80 cm to 550B-13-3, 24 cm (Fig. 8). The nannoplankton within the sediments reworked by turbiditic processes are more recrystallized and broken than in the hemipelagic ones. *Lucianorhabdus cayeuxii* is also more abundant in the turbidites than in the autochthonous sediments, indicating that the turbiditic sediments were displaced from a shallower environment.

From 550B-13-3, 65 cm to 550B-14-3, 50 cm, carbonate dissolution is strong and nannoplankton are absent.

An unconformity representing a hiatus of at least 8 m.y. may be present between the Maestrichtian and the underlying Santonian–Coniacian sequence, which is present from 550B-14-3, 90 cm to 550B-15-1, 147 cm (Fig. 8). However, the recognition of magnetic Anomaly 33 in this interval may indicate that the Campanian is not completely missing. The Santonian–Coniacian age assignment is based on the presence of *Marthasterites furcatus* and *Lithastrinus grillii.* In general, the nannofossils are abundant and broken and have slight to heavy overgrowths. However, nannoplankton are rare and very badly preserved in several samples (550B-14-4, 140 cm; 550B-14-5, 45 cm; 550B-14-5, 110 cm; 550B-15-1, 15–16 cm). The effects of strong dissolution can be observed from 550B-15-1, 147 cm to Sample 550B-15-3, 52–53 cm.

Cenomanian nannofloras were encountered from Sample 550B-15-4, 97–98 cm to at least Sample 550B-21-4, 43–45 cm, as indicated by the presence of *Lithraphidites alatus*, a form that first appears at the base of the Cenomanian.

The sequence from Sample 550B-21-6, 96–97 cm to the base of Hole 550B belongs to the *Eiffellithus turriseiffeli* Zone of possibly late Albian age (absence of *L. alatus*) (Fig. 8). The nannoplankton are abundant and generally well preserved throughout the Cenomanian–Albian. A slight fragmentation can be observed in several layers. From Samples 550B-24-2, 55–56 cm to 550B-25-2, 137–138 cm, fine-grained pyrite and organic matter are present. Only very few specimens of *Watznaueria barnesea* and *E. turriseiffeli* were found in the sediments interbedded with the basalt. The nannoplankton were probably destroyed by recrystallization in these sediments.

SEDIMENT ACCUMULATION RATES

The sediment accumulation rates calculated for Holes 550 and 550B are combined in Figure 9. Hole 550 was drilled from 99.5 to 536.5 m, and Hole 550B was drilled from 456.0 to 720.5 m BSF. The sedimentary sequence in Hole 550B is underlain by basalt (685.4 to 720.5 m BSF).

The estimation of accumulation rates is complicated by the presence of unconformities and the lack of an accurate biostratigraphy for several intervals. In the Vraconian (late Albian) through the middle Cenomanian, the accumulation rate is 13.5 m/m.y.; but from the middle Cenomanian to the lower Campanian, the rate is 1 m/m.y., if deposition is assumed to be continuous. However, the biostratigraphic record is incomplete because of strong dissolution, and the seismic profile indicates that the upper Cenomanian and Turonian sediments are missing at an unconformity. Thus, the actual accumulation rate may be somewhat greater than 1 m/m.y.

The introduction of turbidites into the late Campanian to Maestrichtian sediment interval increased the accumulation rate markedly (to 17.5 m/m.y.). The rate then decreased again (to 6.6 m/m.y.) in the early to late Paleocene. Later, during the latest Paleocene to early Eocene, the rate nearly doubled (to 11.0 m/m.y.).

Calcite dissolution reduced sediment accumulation severely during the late Eocene and Oligocene. If deposition is assumed to be continuous, the accumulation rate was a mere 0.2 m/m.y. The dissolution also reduced the biostratigraphic resolution of microfossil assemblages considerably. However, the biostratigraphic data, though limited, suggest that there are several unconformities, increasing the calculated accumulation rate.

During the early and middle Miocene the CCD became depressed, and accumulation rates increased significantly (to 5.5 m/m.y.). A period of nondeposition or erosion followed, but thereafter (in the late Miocene) the rate nearly tripled (to 13 m/m.y.).

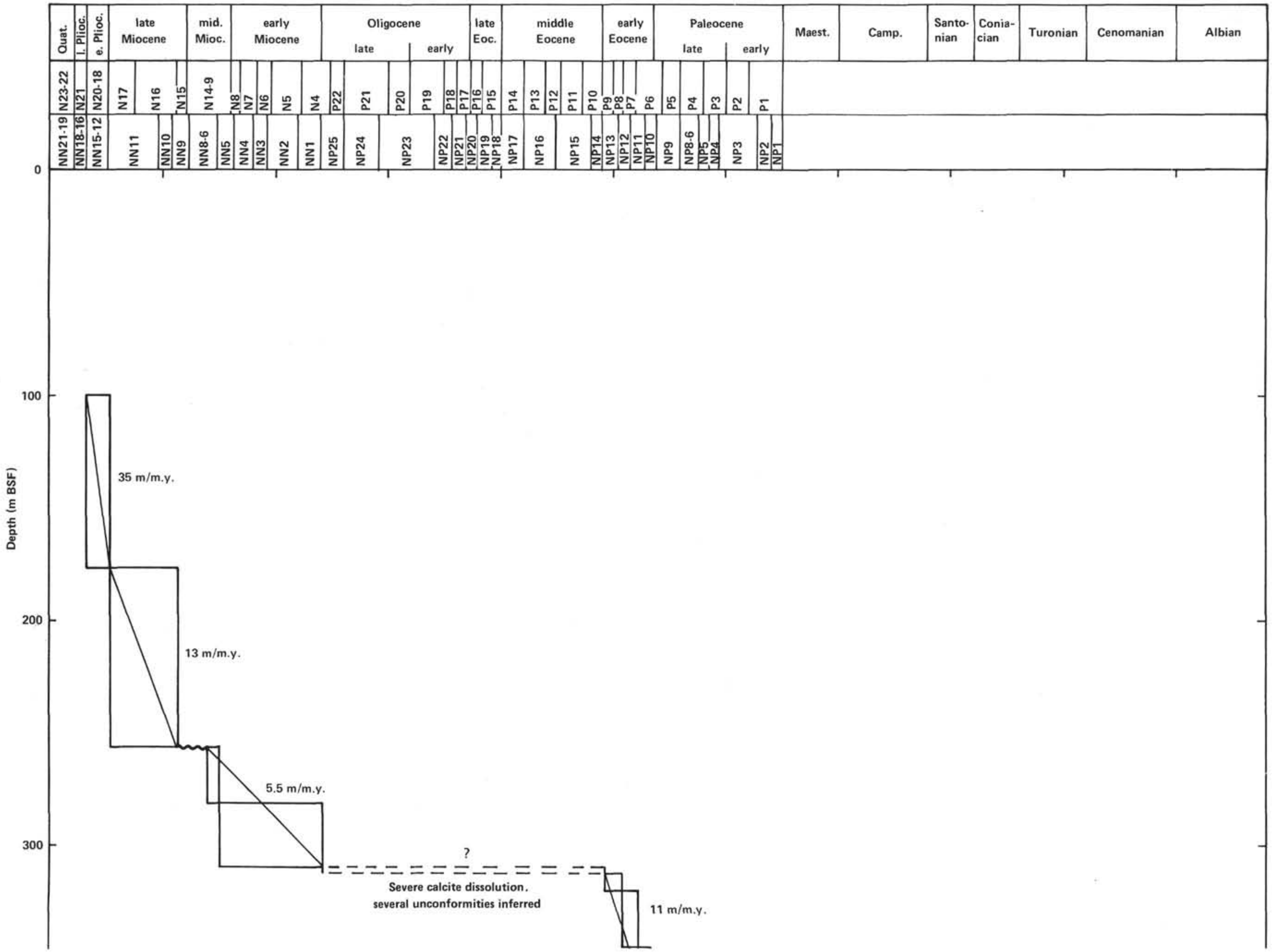
The Pliocene–Pleistocene biostratigraphy is poorly documented, but the accumulation rate for the entire interval accelerated remarkably (to 35 m/m.y.), partly because the slumping of older (Miocene) strata became an important mechanism for deposition.

ORGANIC GEOCHEMISTRY

Total organic carbon (TOC), carbonate, and total nitrogen contents were measured on 183 samples by standard shipboard procedures (Waples and Cunningham, this volume). Rock-Eval pyrolysis was carried out on 66 of these samples. The analytical results are tabulated by Waples and Cunningham (this volume).

Total Organic Carbon, Carbonate, and Nitrogen

The nannofossil oozes and marly chalks of lithologic Units 1 to 3 (Campanian to lower Pliocene) are characterized by uniformly low organic carbon contents (maximum 0.13%; Fig. 10) and variable carbonate contents (2–98%; Superlog). Carbonate values are much higher in lithologic Unit 1 (average 85%) than in lithologic Unit 2 (average 36%). In lithologic Unit 3 the turbidite sequences are somewhat more calcareous than the overly-


Quat.
l. Plioc.
e. Plioc.
late Miocene
mid. Mioc.
early Miocene
Oligocene
late
early
late Eoc.
middle Eocene
early Eocene
Paleocene
late
early
Maest.
Camp.
Santo-nian
Conia-cian
Turonian
Cenomanian
Albian
N23-22
N21
N20-18
N17
N16
N15
N14-9
N8
N7
N6
N5
N4
P22
P21
P20
P19
P18
P17
P16
P15
P14
P13
P12
P11
P10
P9
P8
P7
P6
P5
P4
P3
P2
P1
NN21-19
NN18-16
NN15-12
NN11
NN10
NN9
NN8-6
NN5
NN4
NN3
NN2
NN1
NP25
NP24
NP23
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NP19
NP18
NP17
NP16
NP15
NP14
NP13
NP12
NP11
NP10
NP9
NP8-6
NP5
NP4
NP3
NP2
NP1
0
100
200
300
Depth (m BSF)
35 m/m.y.
13 m/m.y.
5.5 m/m.y.
?
Severe calcite dissolution,
several unconformities inferred
11 m/m.y.

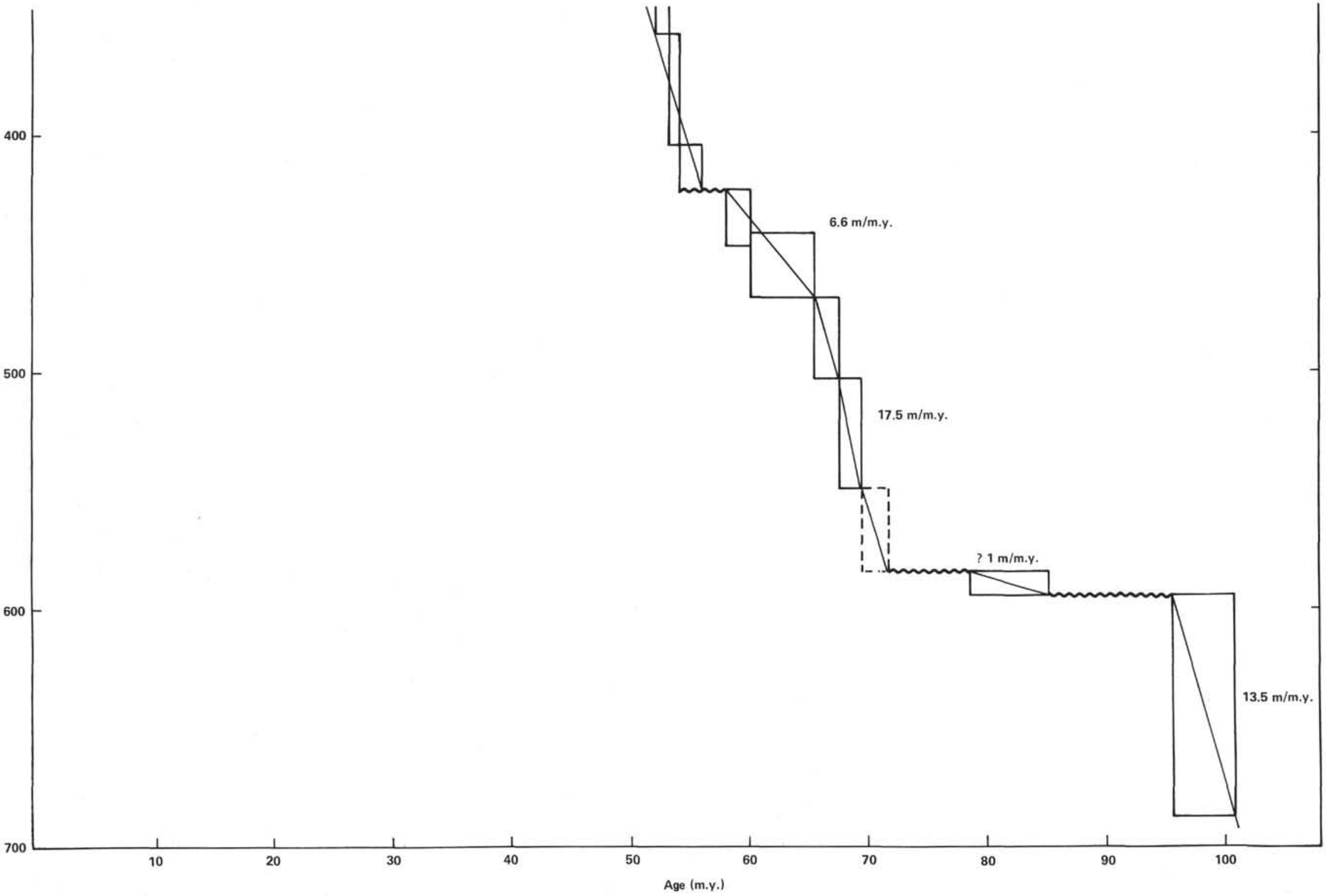

Figure 9. Sediment accumulation rate curve for Site 550.

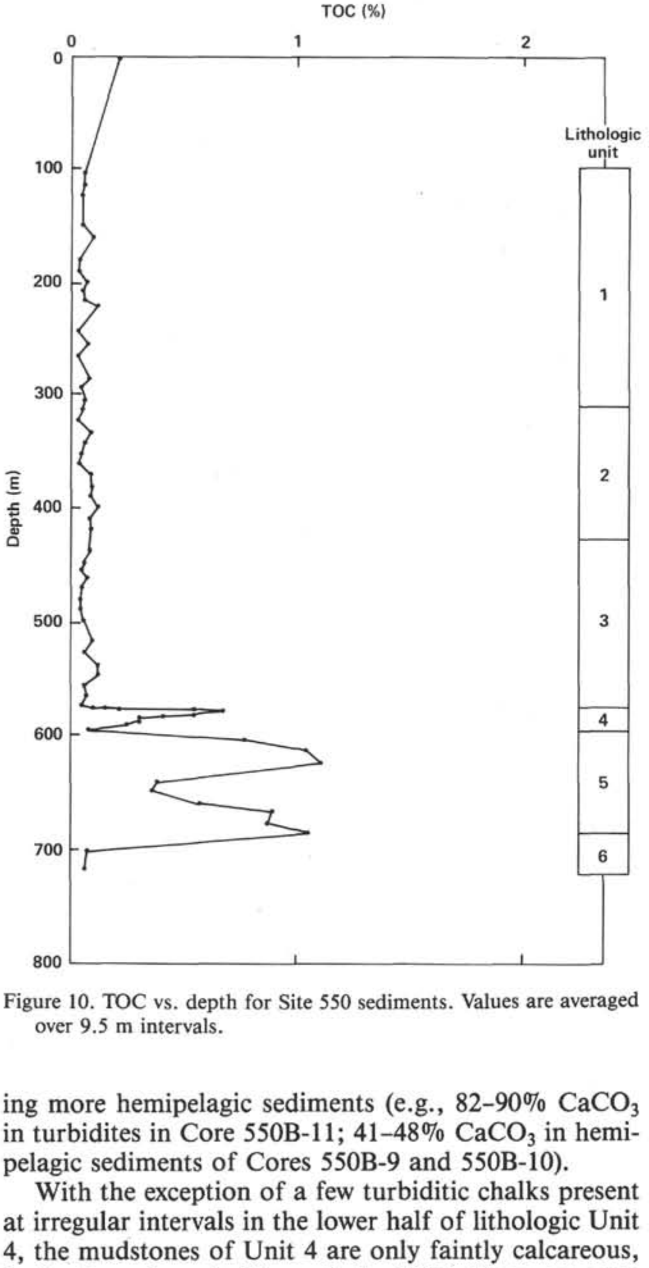

Figure 10. TOC vs. depth for Site 550 sediments. Values are averaged over 9.5 m intervals.

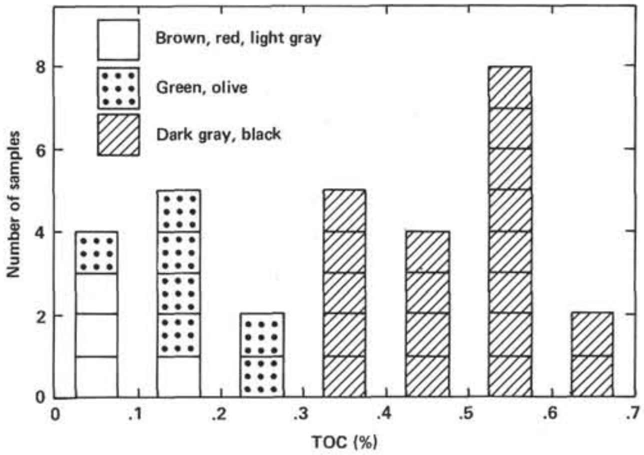

Figure 11. Relationship between sediment color and TOC, Unit 9 (excluding turbidites), Site 550.

ing more hemipelagic sediments (e.g., 82–90% $CaCO_3$ in turbidites in Core 550B-11; 41–48% $CaCO_3$ in hemipelagic sediments of Cores 550B-9 and 550B-10).

With the exception of a few turbiditic chalks present at irregular intervals in the lower half of lithologic Unit 4, the mudstones of Unit 4 are only faintly calcareous, having been deposited beneath the CCD. There are some definite trends in organic geochemistry within Unit 4 that are closely linked to sediment color. Figure 11 shows that sediment color is closely related to organic carbon content. The sediments that have the highest TOC values (as much as 0.67%) are black; they are sediments that are dark gray, grayish olive green, other shades of gray, and shades of brown and red. This color–TOC relationship is consistent with the idea that organic carbon content decreases as the level of oxygen in the sediment increases.

The highest organic carbon values at Site 550 (maximum 2.37%) were encountered in several black, finely laminated intervals in lithologic Unit 5 (latest Albian–middle Cenomanian). Most of these intervals are interbedded in a sequence that grades upward from light-colored (whitish, light gray, reddish, and brownish), bioturbated, organic-carbon-lean sediments (TOC less than 0.2%) to gray to dark gray bioturbated sediments (TOC 0.2–0.8%) to black, weakly laminated sediments (TOC 0.8–1.5%). Although these cycles are irregular in thickness and often incomplete, they nevertheless represent rhythmic changes in the degree of preservation of organic carbon in the sediments.

Carbonate contents are slightly higher in the organic-carbon-rich intervals of Unit 5 than in the organic-carbon-lean intervals (55% vs. 45% $CaCO_3$, respectively). The higher carbonate values in the organic-carbon-rich samples could be the result of higher carbonate input (implying higher productivity), less dissolution, or an enrichment in $CaCO_3$ due to late diagenetic processes.

The atomic C/N ratio for samples from Units 4 and 5 is constant (Fig. 12), indicating that all the organic material in this unit is of the same type. The intercept (TOC = 0%) at a positive nitrogen value (0.028%) indicates that a constant amount of inorganic nitrogen is present in each sample (probably adsorbed on clay minerals; Waples, "Nitrogen," this volume). The samples with the lowest TOC values have consistently lower nitrogen contents than the linear trend in Figure 12 would predict, however. Nitrogen is removed more rapidly than organic carbon during diagenesis, especially the nitrogen mediated by benthic organisms, and it is therefore natural that the more diagenetically altered (low-TOC) samples would be particularly depleted in nitrogen.

The two black shale samples from Unit 5 at Site 549 are also shown in Figure 12. The nitrogen content of these Site 549 samples is somewhat lower than that of the Site 550, Unit 5 black shales. The low values might indicate a slight difference in organic matter type between the lower-and-middle-Cenomanian black shales at Site 550 and the upper-Cenomanian black shales at Site 549.

In contrast, the woody samples from Site 549 (Units 6–10) have a markedly different C/N ratio (85) from the Unit 5 samples from Site 550 (22). Thus, although some of the organic material in Unit 5 at Site 550 may be of terrestrial origin, it is apparently mixed with more nitro-

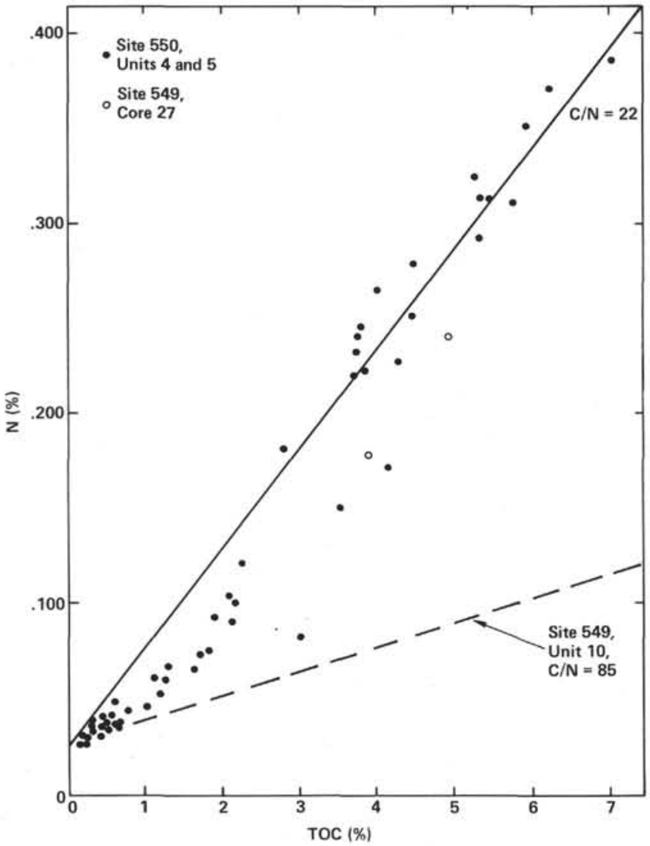

Figure 12. Relationship between N and TOC in carbonate-free residues from Units 4 and 5 at Site 550.

genrich material of marine origin. This interpretation is supported by visual kerogen analysis (Cunningham and Gilbert, this volume).

Rock-Eval Pyrolysis

The results of Rock-Eval pyrolysis distinguished clearly between the organic-carbon-rich, laminated intervals that occurred occasionally in Unit 5 and the organic-carbon-lean, bioturbated sediments from this and other units. The hydrogen indices for the finely laminated black shale intervals in Cores 16 to 18 averaged 270 mg HC/g TOC (Fig. 13) but decreased slightly to 200 mg HC/g TOC in Cores 24 and 25. A parallel decrease of TOC in laminated sediments from Cores 16 to 18 (average 2%) to Cores 24 to 25 (average 1.7%) is attributed to greater benthic reworking in the organic material under the less strongly reducing conditions that prevailed during the deposition of the lowe core. The black shale samples plot midway between Type II and III kerogens on the Van Krevelen diagram (Fig. 14), suggesting that they contain a mixture of organic matter from both marine and terrestrial sources. Oxygen indices for both the upper and lower black shale intervals in Unit 5 average 75 mg CO_2/g TOC.

The hydrogen indices for the light-colored, bioturbated, marly chalks interbedded with the laminated black shales in Unit 5 average 30 mg HC/g TOC, much lower than those for the black shales. The Rock-Eval data, therefore, indicate cycles of oxic and nearly anoxic deposition in Unit 5. Possible reasons for the cyclicity of the paleoenvironments are discussed later in this section.

The sediments in Units 1 to 4 have low TOC values (maximum 0.11% in Units 1 to 3 and 0.67% in Unit 4) and low hydrogen indices (averaging 30 mg HC/g TOC). The sediments in Units 1 to 3, in particular, were probably deposited in a well oxygenated environment; those in Unit 4 were probably deposited under conditions that varied between very oxidizing (light colors) and slightly oxidizing to faintly reducing (black muds). Bioturbation is extensive in the oxidized sediments of all units, whereas it is absent in the finely laminated layers in Unit 5. The oxidized sediments all plot in the Type III region in Figure 14, indicating that any marine organic matter originally present has been removed and that the sediments now contain only terrestrially derived or refractory organic matter.

The hydrocarbon source potential at Site 550, as indicated by the magnitude of the S_2 value, is moderate in the black shale intervals (average S_2 = 4 mg HC/g rock; both gas and oil are possible products) and poor in the oxic organic facies. The negligible S_1 values (less than 0.05 mg HC/g rock) and T_{max} values (375–425°C) indicate that all of the sediments at Site 550 are thermally immature.

Organic Facies

Rock-Eval pyrolysis and the analysis of sediment C/N ratio and TOC content clearly indicate that there are two distinct organic facies at Site 550. The nearly anoxic organic facies is limited to several thin intervals of laminated black shale in Unit 5. These sediments contain marine–terrestrial organic matter that under other temperature and pressure conditions would have been capable of producing substantial amounts of both gas and oil. The sediments in Units 1 to 4 and the organic-carbon-lean bioturbated marly chalks in Unit 5 contain terrestrial organic matter capable of producing gas.

There are several possible explanations for the inferred cyclic changes in paleoenvironment from oxidizing to reducing during the deposition of Unit 5. The interpretation we prefer is that most deposition was pelagic; the contribution from debris flows or turbidity currents was minor and played no essential role in determining oxygen levels. Oxygen levels in bottom waters fluctuated from rather high to nearly zero, perhaps in response to changes in sea level, productivity, or circulation patterns. Two periods of relatively low oxygen levels are suggested by the high TOC values in portions of Cores 24 to 25 and 16 to 18, but fluctuation was considerable even within these intervals. Variations in productivity seem less likely than changes in circulation patterns to have been responsible for these paleoenvironmental cycles (Waples and Cunningham, this volume).

The clays in Unit 4 appear to have been deposited at the same time as the organic-carbon-rich, laminated black shales at Sites 549 and 551. The Unit 4 clays differ markedly from the black shales in their much lower TOC content and lack of lamination. Lower productivity in the overlying waters and the slow accumulation of non-

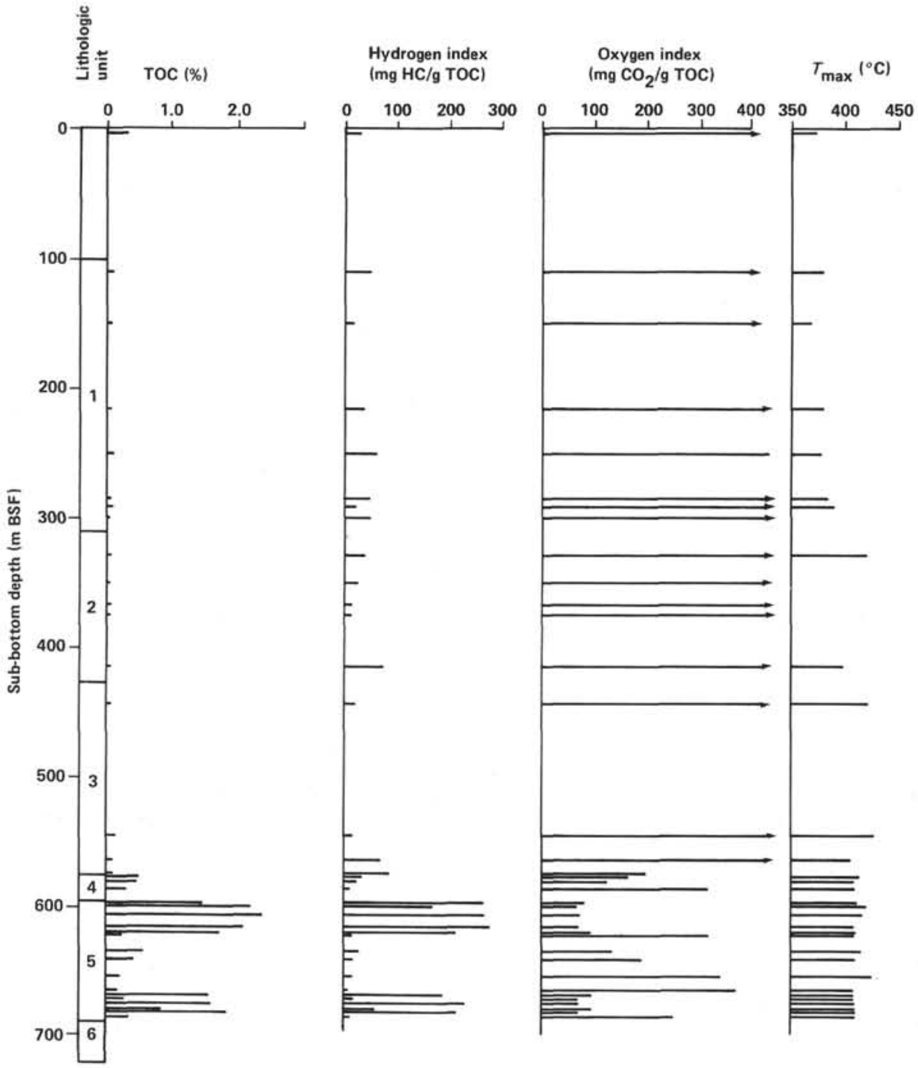

Figure 13. Rock-Eval pyrolysis properties of sediments at Site 550.

calcareous clays below an elevated CCD allowed the bottom waters at Site 550 to remain more oxygenated than those at Sites 549 and 551; diagenesis was therefore more extensive, and it resulted in the extensive removal of organic matter. The gradual evolution of oxygen levels is recorded by changes in sediment color (Waples and Cunningham; Waples, "Anoxia;" and Graciansky and Gillot, this volume).

BASALT LITHOLOGY

Basalt Description

Below the uppermost Albian calcareous mudstone in Hole 550B (Unit 5; see Sediment Lithology), 33 m of basalts, pillow lavas, hyaloclastites, and minor limestones were cored (685.4–720.5 m BSF; 550B-25-4, 90 cm to Core 30; Fig. 8). Recovery of the section is apparently complete, but some contacts were disturbed by drilling. This unit, which has been designated Unit 6, can be divided into four subunits.

Subunit 6a

Subunit 6a consists of pillow lavas and hyaloclastites. It occurs from 550B-25-4, 90 cm to 550B-26-3, 17 cm (4 m total thickness).

Subunit 6a was extensively fractured during drilling, and many of the edges of the lava pillows were damaged. When the fragments were put together, however, it became apparent that seven lava pillows, characterized by clearly defined chilled margins and a hyaloclastic matrix, were nearly completely recovered. Sample 550B-26-1, 85–105 cm, was taken through the edge of a single pillow. The natural fracture pattern in the pillow lavas is not radial-concentric but is instead a random mosaic.

As is generally the case for undisplaced pillow lavas, the hyaloclastic matrix of the pillow lavas is not very abundant. At 550B-26-2, 55 cm, hyaloclastic breccia is associated with a calcareous mudstone clast, but unfortunately the relationship between the two is unknown, because this interval was fragmented by drilling. The

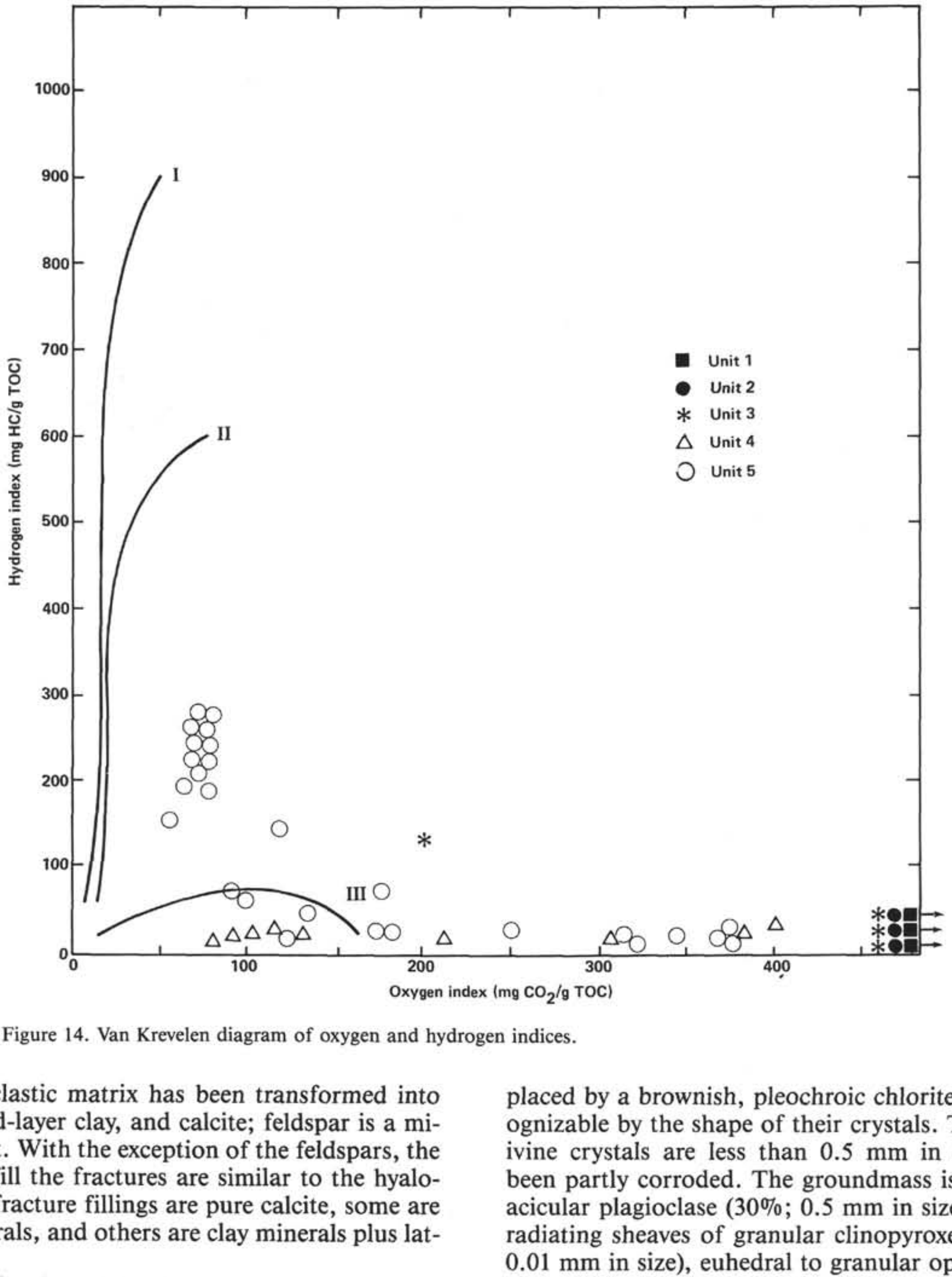

Figure 14. Van Krevelen diagram of oxygen and hydrogen indices.

original hyaloclastic matrix has been transformed into smectite, mixed-layer clay, and calcite; feldspar is a minor constituent. With the exception of the feldspars, the minerals that fill the fractures are similar to the hyaloclastite; some fracture fillings are pure calcite, some are pure clay minerals, and others are clay minerals plus later calcite.

Visual examination of the slabbed surfaces of the pillows shows that the basalts have phyric textures and contain up to 5% plagioclase phenocrysts, which are as large as 3 mm in diameter. Calcite vesicles less than 1 mm in diameter are present in the upper fourth of each individual pillow in amounts of up to 5%.

The edges of the pillows have well defined chilled zones less than a centimeter or two in thickness. A thin section of a sample taken 15 cm from the edge of a pillow reveals the exceptionally fresh and unweathered nature of the basalt. Phenocrysts are composed of plagioclase (7-10%) and altered olivine (1-2%). In composition the plagioclases are An_{60}, and in form they are fresh euhedral crystals, usually unzoned, and 0.5 to 2.5 mm in size. The olivines, which have been completely replaced by a brownish, pleochroic chlorite, are only recognizable by the shape of their crystals. The former olivine crystals are less than 0.5 mm in size and have been partly corroded. The groundmass is composed of acicular plagioclase (30%; 0.5 mm in size), euhedral to radiating sheaves of granular clinopyroxenes (35-40%; 0.01 mm in size), euhedral to granular opaque minerals (10-15%; 0.01-0.02 mm in size), and rarely smectite (in former glassy, intergranular spaces). Vesicles, which comprise about 1% of the rock, are filled with carbonate and/or smectite.

Subunit 6b

Subunit 6b consists of a complex assemblage of thin lava flows, displaced basalt blocks, reddish pink limestones, and hyaloclastic breccias. It occurs from 550B-26-3, 17 cm to 550B-28-1, 60 cm (7.5 m total thickness).

This subunit is distinguished from those above and below by the aphyric texture of the basalt (with the exception of the interval in Section 550B-27-2 from 50 to 10 cm) and the presence of microfossiliferous calcareous beds.

A basalt segment 1.20 m thick (550B-26-3, 60 cm to 550B-27-1, 55 cm) is the thickest in this subunit. It might be either a wide pillow with edges that were not recovered or preserved or a block that has been detached from a lava flow. A thin section taken 40 cm from the top of this segment reveals aphyric texture. The groundmass consists of unaltered acicular plagioclase (40%; 0.3–0.7 mm grain size), fresh euhedral grains and radiating sheaves of clinopyroxene (35%; 0.01–0.03 mm grain size), olivine(?), which has been completely replaced by a fibrous, dark brownish, pleochroic chlorite (20%; 0.5 mm grain size), and granular to euhedral crystals of opaque minerals, perhaps magnetite (5%; 0.1–0.5 mm grain size). A thin section taken 25 cm from the base of this same basalt segment reveals the same minerals in approximately the same proportions; the minerals differ only in that grain size is somewhat larger in the second sample. In texture the second sample is subophitic (intergranular to poikilitic clinopyroxenes contain laths of plagioclase). The laths are corroded at the edges but fresh internally.

Four calcareous layers further subdivide this subunit (550B-26-3, 20–55 cm; 550B-27-1, 100–115 cm; 550B-28-1, 60–70 cm and 550B-28-2, 0–32 cm). Red micrite associated with brecciated basalt is found in between these layers. The micrite contains tiny lava fragments, scattered calcified radiolarians, hedbergellid and globotruncanid debris, and rare calcareous nannofossils (see Biostratigraphy).

The sparsity of foraminifers and the absence of characteristic species in the available thin sections make it difficult to determine the age of this sediment, but it does not seem to be very different from the Vraconian sediment that directly overlies the basalt. The two calcareous layers in Core 28 are probably the top and bottom of a 90 cm thick breccia that has a matrix of hyaloclastic basalt and calcareous sediment. There is a large clast of aphyric pillow lava in Section 1 between 105 and 134 cm (Fig. 15), and smaller clasts can be observed throughout the section. Some of the contacts between the calcareous sediments and the basalts are undisturbed (e.g., 550B-26-3, 55–60 cm). The contact at 550B-28-2, 30 cm is disrupted by drilling, but the calcareous sediment apparently overlies a 4.5 m thick phyric basalt flow, the top of which is deeply fractured. These fractures have been filled partly by calcite and pink calcareous sediment as far down as 2.10 m from the top of the flow (Fig. 16). This infilling suggests that the surface of the lava flow was exposed to submarine alteration, redeposition, and sediment accumulation between phases of volcanic activity.

Subunit 6c

Subunit 6c consists of four lava flows. It occurs from 550B-28-2, 60 cm to 550B-29-6, 10 cm (15 m total thickness).

This interval of basalt consists of four lava flows of 4.3, 1.9, 1.8, and 7 m thickness. The uppermost lava flow is covered with and deeply penetrated by the limestone of Subunit 6b. A veneer originally of glass, but now transformed to smectite, separates each of the four

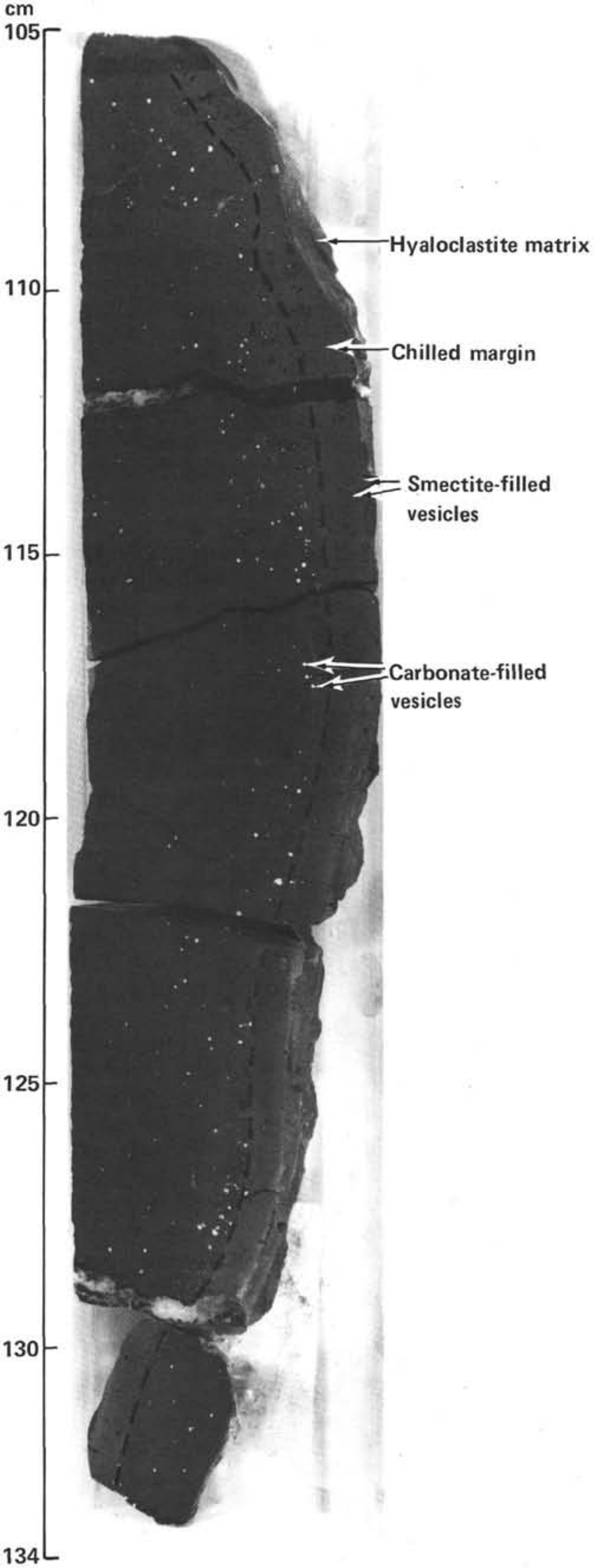

Figure 15. Clast of aphyric pillow lava in Subunit 6b (550B-28-1, 105–134 cm).

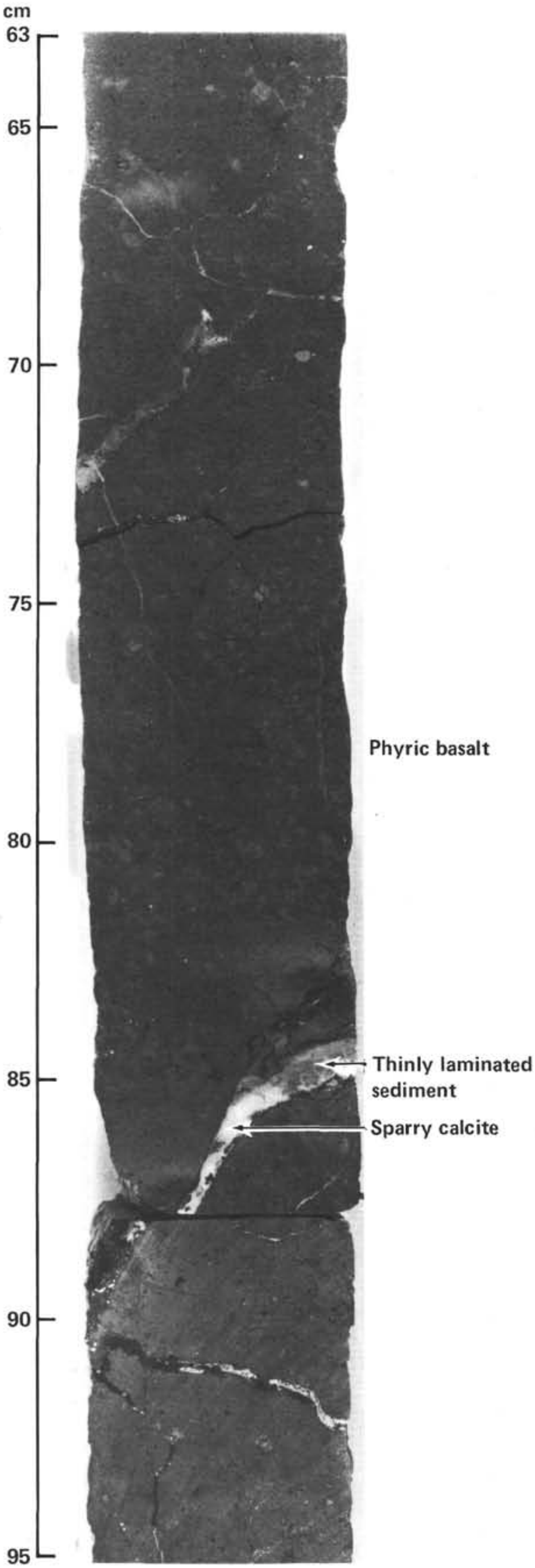

Figure 16. Fractures within phyric basalt flow showing calcareous fillings (550B-28-3, 63-95 cm).

lava flows. These veneers were probably thinned by the drilling operation. The basalt masses are interpreted as lava flows rather than pillow lavas because the chilled margins are thicker at the top than at the bottom and because a thin section examination of textures shows that cooling was more rapid in the upper parts of the masses than the lower parts.

The central parts of the flows display phyric subophitic textures readily apparent to the naked eye. This texture begins a gradual upward change approximately 80 cm from the top of the flow and disappears entirely 50 to 60 cm from the top. Downward, this texture can be observed as close as 10 cm to the base of the flow. In the upper third of each flow there are scattered small (less than 1 mm in diameter) vesicles filled with smectite and occasionally calcite. Such vesicles are rare to absent, however, at the bases of the flows.

A thin section examination of the fresh, coarse-grained, phyric basalts shows that the phenocrysts (which are 10% of the basalt) are composed of fresh, large (2-3 mm), euhedral crystals of plagioclase (An_{60} or greater). The groundmass is composed of acicular plagioclases (30%; 0.5 mm grain size), poekilitic or intergranular clinopyroxene (30-35%), euhedral to granular opaque minerals, including magnetite (5%; 0.01-0.03 mm grain size), and olivine(?), again replaced by a fibrous, pleochroic, dark mineral (10-20%; 0.1-1.0 mm grain size).

In addition, the basalt in Section 550B-29-1 displays millimetric isolated zones consisting of intergrowths of subophitic plagioclase laths and poekilitic olivine(?), the latter again replaced by secondary minerals. The upper parts of the lava masses have phyric textures and contain radiating sheaves of clinopyroxene, within which there are plagioclase microliths, as in the pillow lavas. Such sheaves do not appear toward the bases of the flows; there, simple intergranular microlitic phyric textures appear.

Subunit 6d

Subunit 6d consists of two lava flows capped by volcanic breccia with a calcareous matrix. It occurs from 550B-29-6, 10 cm to Section 550B-30-5 (6.5 m total thickness).

These two lava flows are both capped by breccias that contain hyaloclastic basalt clasts and red calcareous clasts (Fig. 17). The upper lava flow is 4.5 m thick; the breccia overlying it is 1.70 m thick. The lower lava flow is 2 m thick; the breccia overlying it varies in thickness from 10 to 40 cm. The lithology of these flows is similar to that of the flows described previously, except that several of the minerals are more intensely altered. The drill rate throughout these lowermost flows was somewhat higher than that for upper flows, a possible consequence of the more pronounced alteration.

Summary and Conclusions

1. A succession of six lava flows of phyric basalt is capped by a breccia containing both volcanic and calcareous clasts. The rate of volcanic activity and emplacement of the lava flows was probably not very high, because the upper surfaces of three of the six lava flows

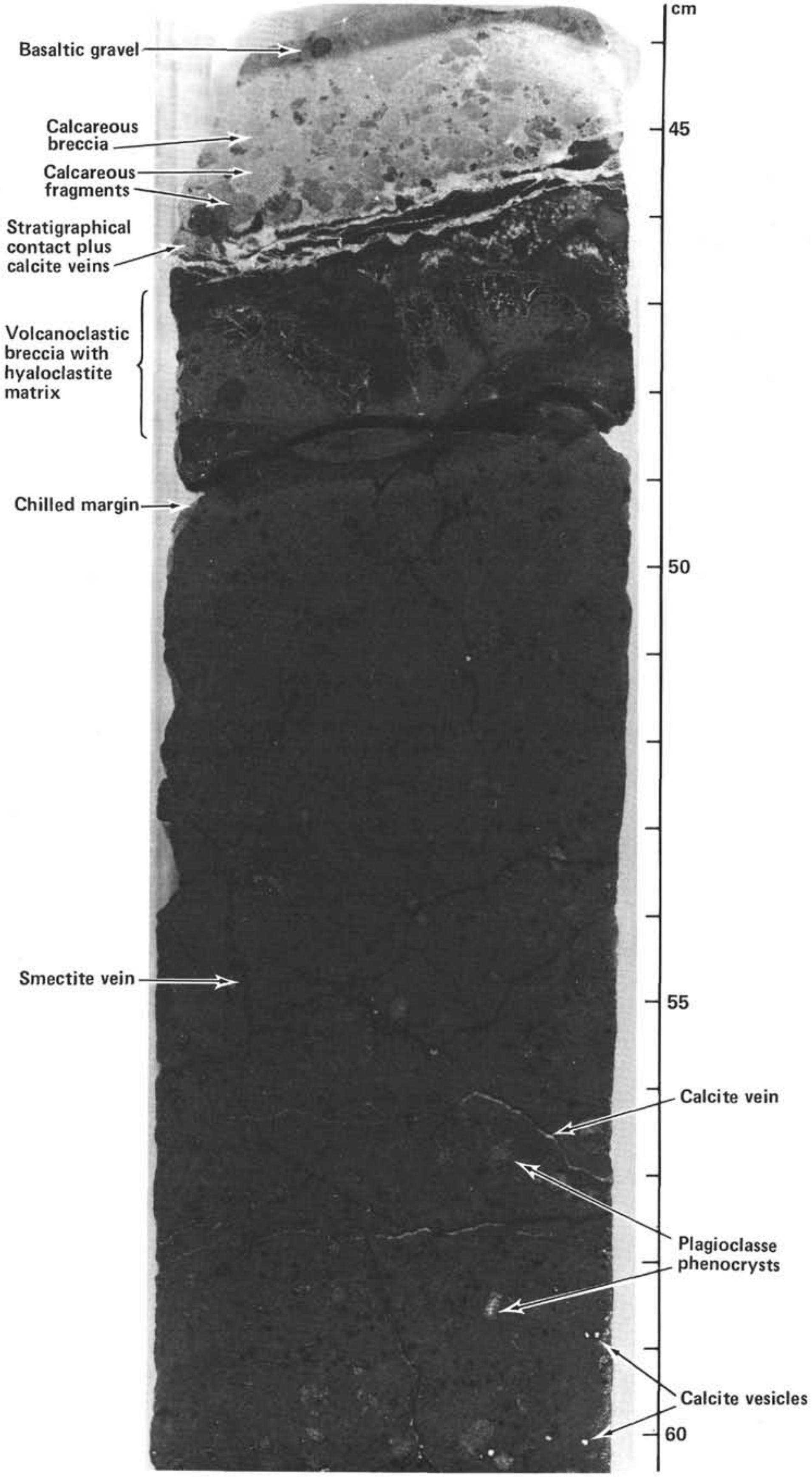

Figure 17. Hyaloclastic basalt and red calcareous clasts within Subunit 6d (550B-29-6, 44–60 cm).

have been altered, fractured, and covered by microfossil-bearing limestones. The entire succession of flows and breccias is in turn capped by 4 m of pillow lavas.

2. With only a few exceptions, the basalts display either a microlitic phyric texture or a coarser grained, subophitic, phyric texture. In the former, the phenocrysts are composed of small (less than 3 mm) euhedral plagioclase crystals. In the latter, the phenocrysts are composed of plagioclase microlites, poekilitic clinopyroxenes, opaque minerals, and olivine(?), the last of which has been replaced by brown pleochroic fibrous chlorites. Chilled parts of flows and pillow lavas are readily apparent. These rocks are fresh except for olivine crystals, which are replaced, and glass fragments, which have been devitrified and altered to smectite. Vesicles smaller than 1 mm in size are filled with calcite or smectite.

3. The lavas contain both well preserved and weakly altered mineralogical assemblages. Such characteristics as common phyric texture, high An content in the plagioclases, and the presence of clinopyroxenes as augites (and not as salites) qualify these basalts as standard oceanic tholeiites.

PALEOMAGNETISM

The sequence recovered at this site consisted of Pliocene to upper Albian nannofossil chalks and mudstones. In the uppermost section (Cores 5–10), a series of short magnetic polarity reversals has been defined that spans nannoplankton Zones NN12 to NN15. This series may represent the sequence of normal polarity intervals that characterizes Anomalies 2A and 3 (Fig. 8). The recovery of Miocene sediments (Cores 10–24) was comparatively poor, and as a result the paleomagnetic results for this section are difficult to interpret.

The lower Paleogene and Upper Cretaceous sediments yielded a series of polarity reversals that was compared with a standard polarity time scale by using the stratigraphic framework provided by the shipboard paleontologists. The comparison suggested that the polarity reversals are correlated with marine magnetic Anomalies 22 to 34, with Anomaly 26 apparently missing at an unconformity.

The position of the base of Anomaly 29 is significant, because the Cretaceous/Tertiary boundary is generally accepted as being in the upper part of the preceding reverse polarity interval. Closely spaced samples in this part of the section place the base of Anomaly 29 at 469.69 ± 0.02 m BSF. This position supports the micropaleontological interpretation that the Cretaceous/Tertiary boundary lies in Section 550B-2-3.

Three short polarity reversals were detected in Cores 23 to 25 (Hole 550B) that may represent the mixed polarity interval of the upper Albian. The identification of these reversals in the sediments directly overlying basement is of particular significance to the determination of the age of the oldest sediments at this site. Additional data are given by Townsend and by Hailwood et al. (this volume).

PHYSICAL PROPERTIES

The physical properties of the Site 549 section are discussed in Appendix I.

DOWNHOLE LOGGING

Unit 1

The logging curves for Unit 1 (99.5–310.34 m BSF as measured by drill string length; corrected, 99.5–307 m) are quite smooth and regular, which is in good accord with the homogeneous lithologies and values of carbonate content (see Sediment Lithology). Layers with low density and high porosity are present between Cores 6 and 7 (Fig. 18). Other beds with relatively high gamma ray intensity, high resistivity, and low porosity are present in Cores 15 (225–228 m BSF) and 21 (287–289 m BSF). These beds, which are probably clayey interbeds within the chalks, correspond to gaps in core recovery.

The lower boundary of Unit 1 is based upon core lithology (see Sediment Lithology) and has been fixed at 310.34 m, within Core 24. The boundary is marked by the stratigraphic condensation of the Oligocene within carbonate-depleted sediments and metalliferous beds. These peculiar lithologies may be correlated with the interval between 311 and 316 m, which is characterized by a complex peak in the gamma ray curve and high formation density. This depth interval matches the Unit 1/2 boundary measured during coring operations (310–315 m). The logging curves indicate that (1) the interval represented by Section 550B-23-6, which was not recovered, is an argillaceous bed approximately 2 m thick (gamma ray intensity is high, resistivity and sonic velocity are low) and (2) the major discontinuity recorded in the logs occurs from 304 to 305 m, in Core 23. The depth of the discontinuity does not coincide with the depth of maximum carbonate dissolution and maximum stratigraphic condensation (310 m BSF, Core 24); the dissolution and condensation occur between the lower Eocene (NP13 Zone) and the upper Oligocene (NP25 Zone) and are accompanied by metalliferous crusts. Thus, the discontinuity does not correspond to the lithologic boundary between Units 1 and 2.

Subunit 2a

The main characteristics of Subunit 2a (310.34–408.0 m BSF) are smooth sonic, resistivity, and density logs, with average values significantly different from those of adjacent units. The gradually increasing gamma ray intensity shows that calcium carbonate content decreases from top to bottom within the subunit, especially from 310 to 350 m. This reduction is consistent with the significant dissolution of carbonate observed within this interval. The rapid fluctuations in the gamma ray curve in Subunit 2a record strong variations in $CaCO_3$ content (from 2–6% to 55–65%; see Organic Geochemistry) and alternations between highly argillaceous, siliceous beds and marly chalks (see Sediment Lithology).

Subunit 2b

The siliceous nannofossil mudstones of the upper Paleocene (Subunit 2b: 408.0–426.5 m BSF) are characterized by moderate gamma ray intensity, high resistivity, and low density, neutron, and sonic log values. The unrecovered lower part of Core 36 (base of Subunit 2b) corresponds to a gamma ray intensity peak and relatively low sonic velocity values, which probably repre-

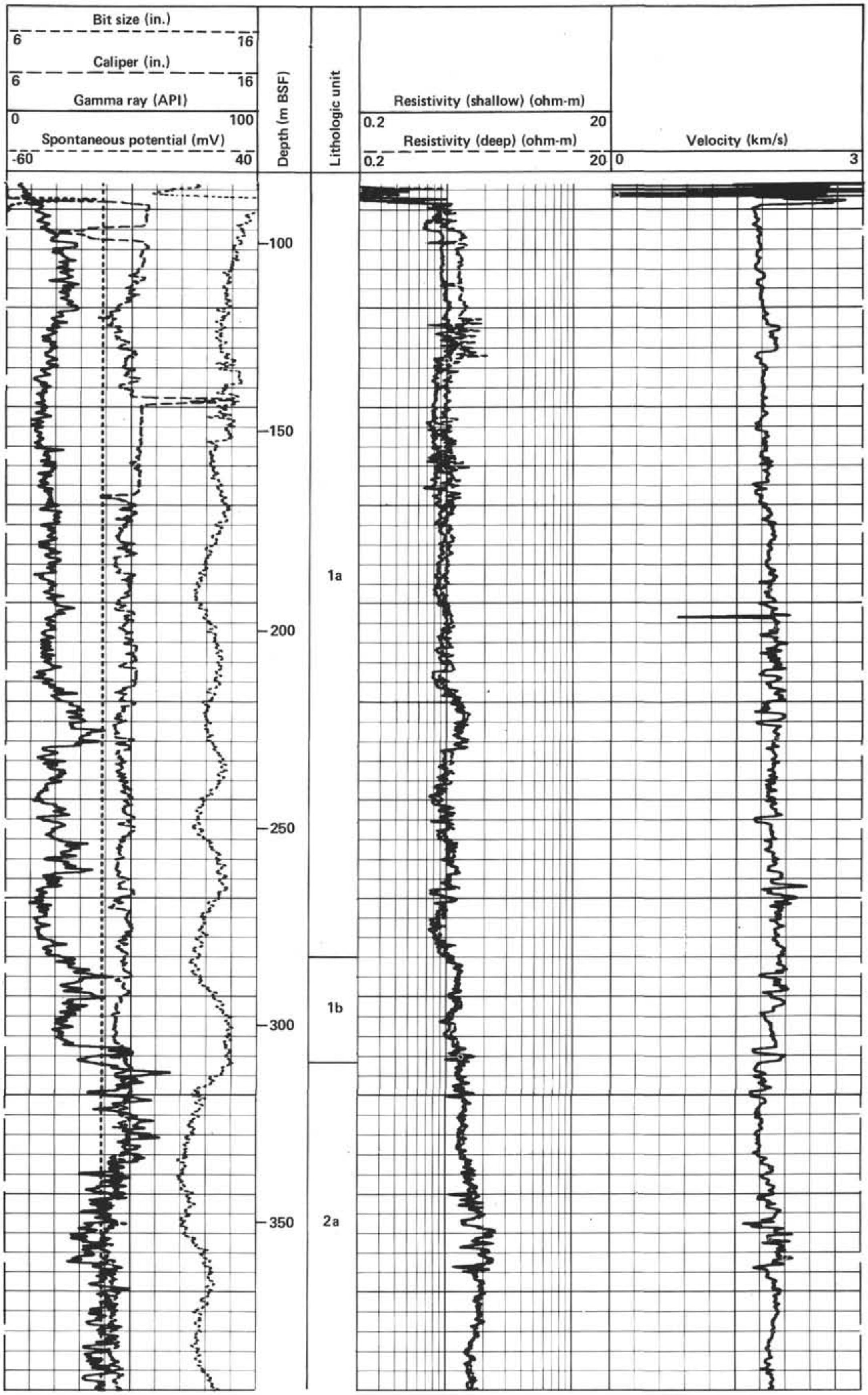

Figure 18. Downhole geophysical log for Site 550.

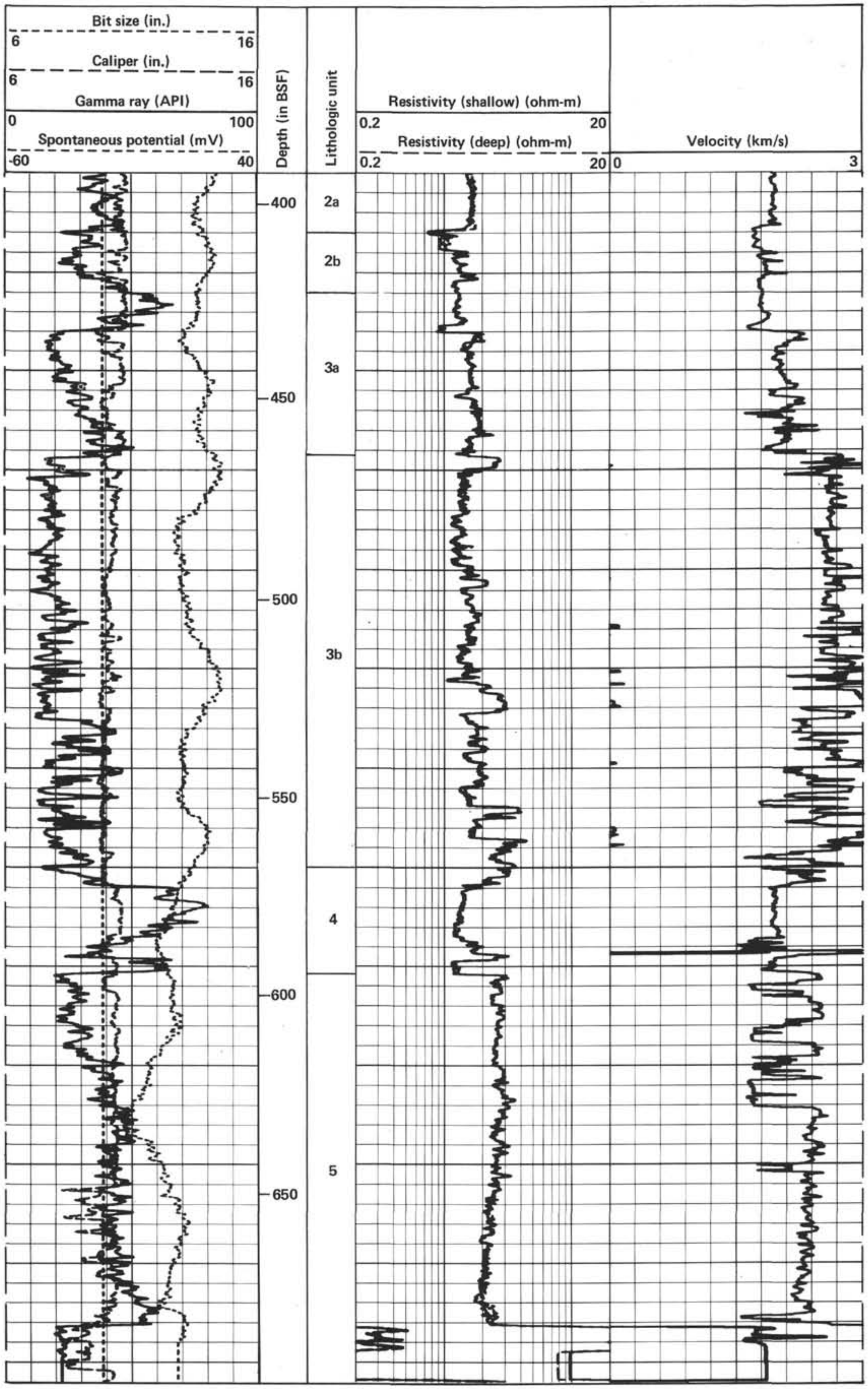

Figure 18. (Continued).

sent the clayrich beds overlying the metalliferous nodules at the top of Unit 3.

Average clay content is significantly higher in Unit 2 than in adjacent Units 1 and 3. The lower and upper boundaries of Unit 2 are marked respectively by a sudden increase and decrease in gamma ray intensity. The boundary between Subunits 2b and 2a is marked by a sudden asymmetrical increase in gamma ray intensity and silica content.

Unit 3

The fine-scale interbedding of white, very calcareous, turbidite chalks and pinkish marly chalks in Unit 3 (426.5–575.0 m BSF; see Sediment Lithology) are precisely recorded by the gamma ray and sonic velocity curves. On a broader scale, the sonic, density, resistivity, and gamma ray curves document fluctuations in calcium carbonate content that have also been recorded by chemical analysis (see Organic Geochemistry). The logs suggest the following four subdivisions for Unit 3:

1. From 426 to 445 m (Core 550-37 and the upper part of Core 550-38), the sediments are more calcareous than those above and below. The contrast between the more calcareous ($CaCO_3$ content around 65%) and more marly ($CaCO_3$ content: 53–60%) beds is not very pronounced in the gamma ray curve, which has low values and is fairly smooth.
2. From 445 to 470 m (Cores 550-39, 550B-1, and 550B-2), there are rapid fluctuations in the gamma ray intensities, which reflect variations in $CaCO_3$ (from 30–40% to 87%; see Organic Geochemistry). The fluctuations suggest closely spaced interbedding.
3. The interval from 470 to 505 m (the lower part of Core 550B-2 through Core 550B-5) contains the highest calcium carbonate values recorded in Subunit 3b, and variation is slight ($CaCO_3$ content: 80–93%). The corresponding gamma ray intensities are low and relatively constant.
4. The interval from 505 to 573.6 m (Cores 550B-5 through 550B-12) is again characterized by rapid changes in lithology; the changes are reflected by closely spaced peaks and valleys in the gamma ray curve.

Unit 4

Unit 4 (575.0–594.87 m BSF; Cores 550B-132 to 550B-15) is characterized by low-carbonate claystones interbedded with chalky turbidites and has very distinctive logging characteristics. The gamma ray values are high, and the resistivity, density, and sonic velocity values are low. Nearly every turbidite bed can be correlated with specific finely spaced variations in the gamma ray and other curves (see Superlog).

Unit 5

All logging curves are rather smooth throughout Unit 5 (595.87–685.37 m BSF; Cores 550B-15 to 550B-25), which is made up of Cenomanian calcareous siltstones. All the curves display trends that reflect an increase in average $CaCO_3$ content from 45 to 60% just above the basalt basement to 65 to 75% in the upper part of the unit.

The small-scale fluctuations in the gamma ray and sonic velocity curves can reasonably be correlated with the alternating darker and lighter lithologies in the cores (see Sediment Lithology). The fine-scale variations in the logging curves are not accompanied by changes in carbonate content, however; carbonate bomb analyses show that the carbonate values are fairly constant. Instead, the color banding in the unit is related to total organic carbon content (see Organic Geochemistry), which also affects the values of natural radioactivity and sonic velocity.

CORRELATION OF SEISMIC PROFILES WITH DRILLING RESULTS

The correlation of the Site 549 seismic profiles with the drilling results is discussed in Appendix I.

SUMMARY AND CONCLUSIONS

Site 550 is located on the Porcupine Abyssal Plain (water depth 4432 m) 10 km southwest of the seaward edge of the Goban Spur, above a high structural block of oceanic basement (Fig. 19). This site, the seawardmost in the Goban Spur transect, was drilled to provide geologic control on the oceanic side of the ocean/continent boundary. The primary objectives of coring this site were to determine the age, composition, and subsidence history of the oceanic basement; the age, composition, and paleoenvironmental history of the postrift sedimentary rocks; and the relationships between the stratigraphic sequences and the principal seismic reflectors.

Continuous coring from 99 to 720.5 m and successful heat flow measurements (Foucher et al., this volume) and downhole logging allowed us to achieve most of these objectives. However, the failure of a bow thruster prevented us from piston coring the upper 100 m as originally planned.

The most important achievement of drilling Site 550 was identifying the oldest sediments above basement as latest Albian (Vraconian) and finding within these sediments the mixed polarity interval of magnetic Anomaly 34 (Townsend, this volume). In conjunction with the finding that the first postrift sediments on the continental crust are of early Albian age (Site 549), this information confirms that west of the Goban Spur seafloor spreading began no later than during the early Albian. Older strata occupy the structural low east of Site 550, however, so we cannot be sure that seafloor spreading did not begin during the Aptian, as it did in the nearby Meriadzek area (Site 400, where Aptian strata form the oldest postrift sequence; Montadert and Roberts, 1979). However, when spreading rates are considered, an Aptian age seems unlikely. Other significant achievements include the recovery of a continuous, fossiliferous, Danian–Maestrichtian sequence, the recovery of manganiferous sediments in condensed sections at the base of the (?)middle Oligocene and within the upper Paleocene, the recovery of marine organic matter in dark laminated beds of middle Cenomanian to Albian age, and the documentation of the history of carbonate dissolution next to the ocean/continent boundary.

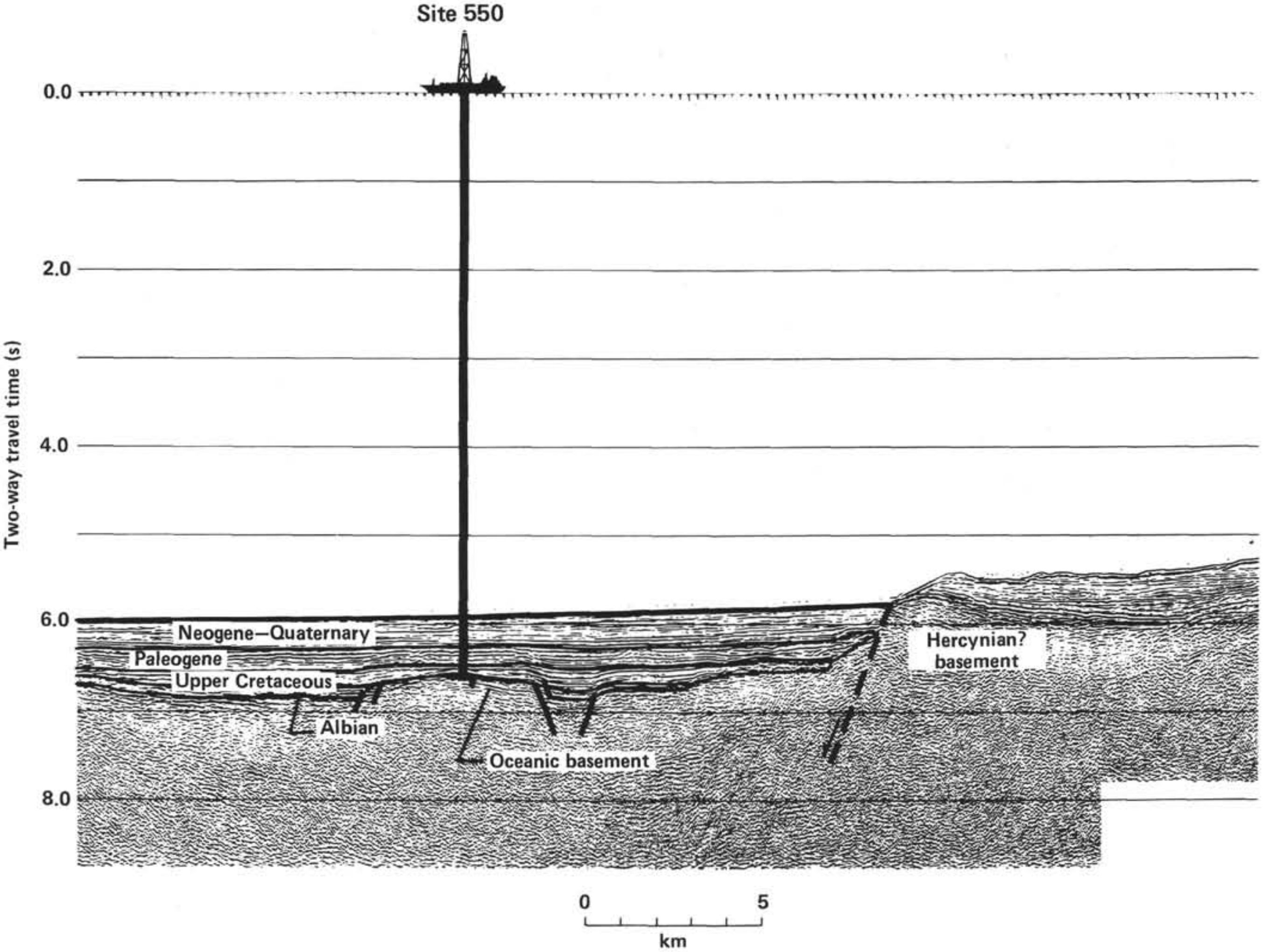

Figure 19. Segment of multichannel seismic Profile CM 11 across Site 550.

Oceanic Basement

The emplacement of basalt flows and pillow lavas during the early stages of seafloor spreading west of the Goban Spur formed a basement high (300 to 400 m above adjacent crust) beneath Site 550 (Fig. 20) from which we recovered 33 m of remarkably unaltered basalt. Six flows, three of which are capped by microfossiliferous limestone, are overlain by a breccia of volcanic and calcareous clasts. Above the breccias are 4 m of pillow lavas. Foraminifers and nannofossils from the interbedded limestones appear to be no older than late Albian. The accumulation of calcareous mud on top of the altered surfaces of several lava flows suggests that volcanic activity was fairly infrequent during this period. The recovered basalts resemble typical light-rare-earth-element- (LREE-) depleted Atlantic tholeiites. They have been subjected to low-temperature alteration, which has resulted in the development of brown clays and adularia and enrichment in K, Rb, and Cs. For this reason, K/Ar dating failed to give valuable emplacement ages (Maury et al., this volume).

Oldest Sediments above Basalt

Because of the 1900 m difference in elevation between the basement below Site 550 and the truncated basement surface at Site 549 (truncation inferred to have taken place near sea level), we estimate that deposition on top of the youngest lava pillow began in about 1900 m of water (a bathyal environment). A different method for estimating the depth of oceanic crust (backtracking along the thermal subsidence curve; see Appendix) also indicates that deposition on the youngest pillows should have taken place in about 1900 m of water. A late Albian age for these oldest sediments is derived from paleontology and is supported by the presence of the mixed polarity interval of magnetic Anomaly 34 within the lower 20 m of strata.

Although these data suggest that seafloor spreading at this location began during the late Albian, there are older rocks lying on the basement in the depression east of Site 550 (Fig. 20). Therefore, it is likely that initial spreading actually took place no later than the early Albian, as indicated by the early Albian postrift deposition on the Goban Spur (Site 549). Moreover, seafloor spreading may have begun in the Aptian, as it did in the Meriadzek region.

Lower and middle Cenomanian rocks complete the sequence of interbedded light and dark mudstones that characterize the relatively rapid accumulation (about 13 m/m.y.) of this early depositional phase at Site 550. It is difficult to infer the paleoenvironmental conditions that resulted in the rhythmic alternation of light calcareous strata with dark, often laminated ones, but apparently, while this basin was in its early narrow stage of development, circulation within the basin was periodically restricted enough to preserve a mixture of terrestrial and marine organic remains (TOC 1-2.3%). The presence of marine organic matter in beds of equivalent age has been documented at many other (although more southerly) DSDP sites in the North Atlantic (Waples, "Anoxia," this volume).

Turonian(?) Hiatus

The middle Cenomanian sediments lie directly beneath rocks of Santonian-Coniacian age; thus, the late Cenomanian-Turonian(?) sediments, the equivalent in age of about 10 m.y., appear to be missing. The unconformity is marked by a sharp contact between calcareous and noncalcareous sediment, a distinct color change, and a surface perforated by boring organisms. In the downhole logs, the unconformity corresponds to a sudden change in sonic velocity from 2 to 2.5-3 km/s. It is also correlated with a high-amplitude reflector that appears to be a nondepositional unconformity. This latter inference is based on the presence of a thin lens of possibly Turonian or upper Cenomanian sediments that underlies the basal Santonian-Coniacian reflector in the depression east of Site 550.

Santonian-Coniacian Mudstones

Carbonate-depleted clays accumulated below the CCD at a low rate during the Santonian-Coniacian interval. The fossils they contain are chiefly radiolarians and agglutinating foraminifers, although a few calcareous nannofossils were noted. In a 5.5 m interval in the middle of the unit, these carbonate-poor clays are interbedded with calcareous turbiditic layers (in total, there are 4.2 m of calcareous material).

The sediment starvation (accumulation rates of less than 2 m/m.y.) during this interval may result from the interplay of several factors, such as water that was undersaturated in calcite, a change in oceanwide circulation, and the presence of depositional basins updip that prevented turbidites from reaching these depths.

Redox conditions in these sediments are somewhat different from those in the sediments below. For example, in spite of the generally dark color, TOC is low, and no marine organic matter is preserved. A series of rhythmic depositional units is repeated through this section, in which a progressive change takes place from red (oxidized) sediment at the base to dark pyritic (reduced) sediment at the top.

Campanian(?) Hiatus

Updated noncalcareous mudstones at the top of the Santonian-Coniacian interval are separated from calcareous (?)Campanian and Maestrichtian strata by an erosional unconformity equivalent to a gap of about 7 m.y. The precise duration of the hiatus is not certain because of the undated interval below it, but most of the Campanian is believed to be missing. The Campanian section may be more complete in the depression east of Site 550. The unconformity correlates with a high-amplitude unconformable seismic reflector that (on site, at least) cannot be distinguished visually from that marking the Turonian gap. However, the two seismic unconformities seem to separate on the flanks of the basement high (Fig. 19).

Danian-Maestrichtian Chalks

The uninterrupted late Mesozoic-early Tertiary interval displays an alternation of marly nannofossil chalks with turbiditic and mud flow deposits (foraminifer-nannofossil chalks). The carbonate contents in the hemipelagic parts (40%) are lower than in the redeposited parts (80-90%), and that contrast, along with the moderate dissolution of calcareous tests, suggests that deposition took place near the calcite lysocline.

The rapid deposition of turbidites (accumulation rate 17.5 m/m.y.) resulted in an unusually thick Maestrichtian interval and introduced displaced shallow-water fossils of Maestrichtian and older Cretaceous origin into the fossil assemblage. The increased intensities of natural remanent magnetization in this interval suggest a greater influx of terrigenous material.

The Danian/Maestrichtian boundary was recovered in the upper chalks of this interval, and preliminary paleontological and sedimentological analyses have yielded no sign of a depositional break, although there is abundant reworking of shallow-water Cretaceous nannofossils across the boundary. An open, well oxygenated, abyssal paleoenvironment is indicated by paleontological and geochemical data, and these conditions prevailed into the late Paleocene.

Intra-Paleocene Unconformity

The termination of turbidity current deposition, a sudden decrease in carbonate content, and an upward decrease in sonic velocity from 2.0-2.1 to 1.8 km/s all occur at a sharp contact within the lower part of the upper Paleocene section that corresponds in position to a stratigraphic break (about 3 m.y. hiatus) that is widespread in the North Atlantic (Roberts and Montadert, 1979). This break can be correlated with a change in the pattern of paleocurrents, as revealed by an abrupt change in the magnetic fabric across a coeval disconformity at Site 548 (Hailwood and Folami, this volume). However, the break is not correlated with a strong seismic unconformity.

Upper Paleocene-Lower Middle Eocene Chalks

Marly nannofossil chalks, siliceous nannofossil chalks, and mudstones form the bulk of the upper Paleocene-lower middle Eocene deposits. Well oxygenated, abyssal conditions generally prevailed. But at the intra-Paleocene unconformity in the lower part of this section, the strong dissolution of fossil remains and an enrichment in silica indicate a rise in the CCD. The unconformity is also marked by a 60 cm agglomerate of manganese-rich sediment, which includes abundant small nodules 1 mm to 1 cm in size (old fecal pellets replaced by barium-rich manganates; Karpoff et al., this volume). During the rest of this depositional interval, the site was near and below the CCD, as indicated by low carbonate contents (2-3%), poorly preserved calcareous tests, and levels of radiolarian and sponge spicule enrichment, especially in the upper Paleocene. Such siliceous zones have equivalents in the Paleocene siliceous nannofossil chalks of Site 549 and other North Atlantic sites. They are interbedded with numerous volcanic ash and 50 bentonite layers, which can be correlated with others recorded on the Hatton and Rockall banks, in the North Sea, and on the Meriadzek Terrace on the north margin of the Bay of Biscay (Knox, this volume).

Sediment accumulation rate was low during the late Paleocene and earliest Eocene (6.6 m/m.y), but it accelerated to 11 m/m.y. in the early Eocene. Although there is no clear evidence of turbidites in the Eocene, the presence of shallow water foraminifers near the top of this interval suggests that redeposition was taking place.

Middle Eocene and Middle Oligocene Hiatuses

An unconformity representing a hiatus of 19 m.y. separates the microfossiliferous lower middle Eocene marly chalks from the unfossiliferous, manganiferous strata of the upper Eocene. Another significant unconformity separates the upper and lower Oligocene (8 m.y. hiatus). The accumulation of metalliferous (Fe, Mn, Ni, Ba) encrustments, zeolite-rich layers, and volcanic ash coincides with these unconformities (Knox; and Karpoff et al., both this volume). The latter unconformity coincides with a drop in sedimentation rate and a rise in the CCD. A coeval stratigraphic break has been documented at the previous slope sites (548, 549), and it is correlated with the major paleoceanographic changes associated with a major sea level drop in the middle Oligocene (Vail et al., 1977).

Late Oligocene to Early Pliocene Chalks

Upper Tertiary deposition at Site 550 produced 211 m of light-colored nannofossil oozes and chalks and marly nannofossil chalks and mudstone, which accumulated much of the time near or below the CCD. The upper and (?)middle Oligocene strata are particularly carbonate poor and difficult to date, and they are characterized by manganese encrustments and nodules (Karpoff et al., this volume). Calcite overgrowths on nannofossil specimens show that three zones of strong calcite dissolution in the upper Miocene have been altered by diagenetic redeposition. Warm water pelagic deposition prevailed during this interval, but it was interrupted occasionally by terrigenous influxes that were accompanied by cooler water fossils. The lower Miocene is characterized by the replacement of foraminifer faunas by assemblages of *Bolboforma* species, an enigmatic calcareous microfossil (Müller et al., this volume).

Stratigraphic gaps of 2 and 3 m.y. bound the middle Miocene deposits below and above, respectively. The thick Pliocene interval is characterized in part by displaced Miocene strata that appear to be large slumped masses of sediment.

Conclusion

Site 550 is on the oceanic crust adjacent to the ocean/continent boundary and has permitted us to establish by stratigraphic means that uppermost Albian mudstones of bathyal origin rest on the basaltic basement. The basalts are typical LREE-depleted oceanic tholeiites with relatively well preserved mineralogical and geochemical characteristics. Nevertheless, the mobility of K during late deuteric alteration prevented any valuable dating with the K/Ar method (Maury et al., this volume). Coring at Site 549 had earlier established that nearshore lower Albian strata constitute the first postrift deposits on the Goban Spur, so seafloor spreading west of the Goban Spur is sure to have begun no later than during the Albian. The Site 549 data indicate the early Albian for the end of rifting, and strata older than those at Site 550 are present in a depression east of the site; thus, an age of early Albian can tentatively be assigned to the oldest oceanic crust as well. The presence of the mixed polarity interval of magnetic Anomaly 34 within the upper Albian strata corroborates the previous identification of a magnetic stripe west of Site 550 as Anomaly 34 (van Hinte, 1976).

The record of carbonate dissolution at Site 550 reveals the history of the site with respect to the position of the paleolysocline and calcite compensation depth. Accumulation was generally dissolution free in the bathyal environments of the late Albian and early to middle Cenomanian. During the Turonian(?), at about the time that thermal subsidence brought the site into the abyssal realm (see Appendix), the site descended for the first time below the CCD. The site was above the CCD for a brief time in the Santonian-Coniacian, but it resubmerged in the Campanian.

The deposition of carbonate was continuous and above the CCD (but below the lysocline) from the Maestrichtian through the early Paleocene, and the sequence across the Cretaceous/Tertiary boundary is uninterrupted. The site was below the CCD again during the middle and late Paleocene. A thick lower Eocene section is only mildly dissolved, suggesting deposition near the lysocline; a subsequent resubmergence under the CCD took place in the early middle Eocene and lasted until the early early Miocene. After this, deposition was near the lysocline except for three periods of submergence below the CCD during the late Miocene. During the early Pliocene and the late Pleistocene-Holocene, deposition seems to have taken place above the lysocline. We did not recover the late Pliocene to middle Pleistocene interval.

Two intervals of manganese enrichment were documented at Site 550, each of which marked an unconformity, a reduction in sediment accumulation, a rise in the CCD, and an increase in biogenic silica within the sediments. The middle to upper Eocene section is marked by the accumulation of numerous volcaniclastic layers.

Organic matter was chiefly of terrestrial origin at this site, but one period of rhythmic sedimentation during the Albian and Cenomanian produced laminated dark mudstones containing marine organic carbon.

Six major and two minor unconformities were recognized at Site 550. Four of the major ones can be correlated with obvious seismic unconformities. In addition to the basement contact, the oldest seismic unconformity separates the middle Cenomanian from the Santonian–Coniacian by a hiatus of about 10 m.y. (the Turonian(?) and upper Cenomanian(?) are missing). The second oldest seismic unconformity separates the Santonian–Coniacian from the upper Campanian(?) by a 7 m.y. hiatus (the middle and lower Campanian(?) are missing).

The youngest seismic unconformity separates the lower Eocene from the (?)middle Oligocene by a hiatus of about 14 m.y. (The middle and upper Eocene and lower Oligocene are missing or considerably reduced in thickness.) The dating of some of these unconformities is imprecise because of severe calcite dissolution. Every major disruption of deposition is associated with a submergence of the site beneath the CCD, which apparently accompanied the circulation changes that produced the unconformities.

All the unconformities at Site 550 have equivalents on the Goban Spur (Sites 548, 549), in the Meriadzek area (Sites 400–402), and on other margins of the North Atlantic. The implication is that the causative mechanisms, such as bottom circulation changes and sea level fluctuations, probably were linked to other factors, such as climate, tectonism, and seafloor spreading.

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APPENDIX
Subsidence History at Site 550

Backtracking Method

The subsidence history at Site 550 was reconstructed by using the backtracking method, a method derived from the knowledge that the depth of oceanic crust increases with age (Sclater and Francheteau, 1970). Various empirical relationships for the rate of subsidence have been established from the data available (holes where the depth and age of the crust are known; Le Pichon et al., 1973; Royden et al., 1980). These relationships have been established by using sites in every ocean and by assuming that the initial depth of the mid-ocean ridge crest (the depth at the initiation of subsidence) was around 2700 m.

For Site 550 we used a relationship that Tucholke and Vogt (1979) established by using sites in the Atlantic only. The subsidence curve clearly shows a flattening (subsidence rates increase) at ages greater than 80 m.y. (Fig. 20).

Berger (1972) used this age-depth relationship to reconstruct the depth of the seafloor at a given time in geologic history. To do so he had to make isostatic corrections for the sedimentary cover that existed in different increments of time, taking into account the compaction of the underlying layers in each increment. The corrections are necessary because when a layer of sediment is added, the water depth di-

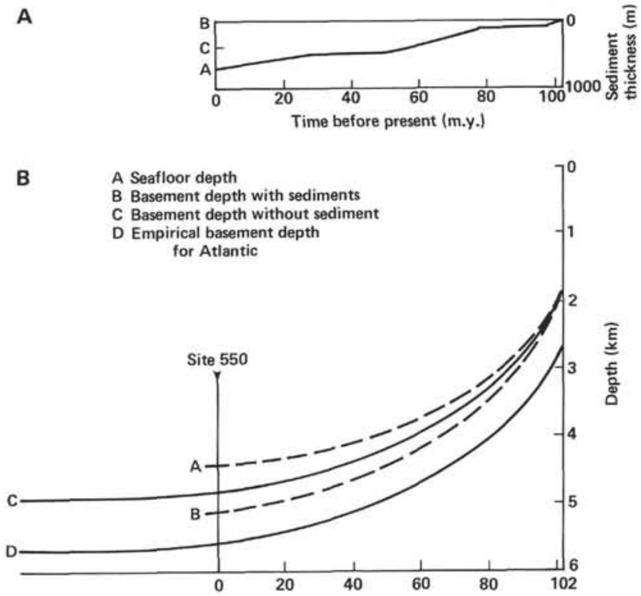


Figure 20. Subsidence curves for oceanic crust at Site 550. A. Subsidence curve. B. Backtracking curve.

minishes, but the crust simultaneously becomes depressed. Masson et al. (this volume) used computer methods first proposed by Chenet and Francheteau (1979) to make these corrections.

Initial Crustal Depth at Site 550

At Site 550 we know the age of the oldest sediments on the oceanic crust (i.e., Vraconian; 102 m.y.), the present depth of the oceanic crust (5116 m), the thickness S of the sediments (684 m), and the seafloor depth D (4432 m).

To reconstruct the subsidence history at one site, one first has to calculate the depth of basement (Z) *without* sediments at Site 550 and to compare it with the theoretical depth for the present time from the empirical general relationship by using

$$Z = D + S \left(\frac{\rho m - \rho s}{\rho m - \rho w} \right) ,$$

where ρm is the density of the mantle (3.3 g/cm^3), ρs is the density of the sediments (2 g/cm^3 at Site 550), and ρw is the density of seawater (1.03 g/cm^3). The resulting value of Z is 4812 m. The theoretical depth of this site 102 m.y. ago is around 5600 m, so Site 550 is clearly shallower than "normal". By shifting the age-depth curve upward to fit the actual depth of Site 550, one finds that the crustal depth 102 m.y. ago was approximately 1860 m (Fig. 20).

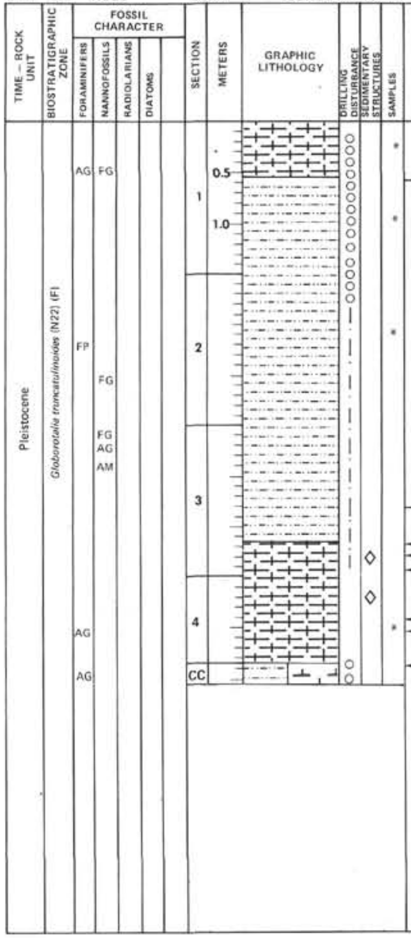
Backtracked Paleobathymetry at Site 550

This procedure consists of determining the depth of the seafloor at Site 550 at any time during its geological history, taking into account the increased sediment thickness and the accompanying depression of the crust under loading.

If we assume that the sedimentation rate was constant and ignore progressive compaction, an exponential curve can be fitted through 1860 m (the crustal depth at 102 m.y. with no sediments) and 4432 m (the present depth of the seafloor at Site 550) to give a first approximation of the paleobathymetry. Since the sediment cover is thin at this site and the empirical age-depth curve is imprecise, this result will be precise enough for our purposes.

From Figure 20, one can conclude that the oldest sediments at Site 550 were deposited at lower bathyal depths, but that the site subsided very rapidly in the late Cenomanian to abyssal depths, if 2000 m is considered to be the limit between bathyal and abyssal. The site has remained at abyssal depths since. The sedimentation rate was low before the late Campanian, so the paleobathymetry was mostly controlled by thermal subsidence.

SITE 550 HOLE CORE 1 CORED INTERVAL 0.0–5.5 m



LITHOLOGIC DESCRIPTION

10YR 6/3
Sharp contact
5Y 4/3

Unit 1
Foraminiferal-nannofossil ooze, pale brown (10YR 6/3), soupy, homogeneous

Unit 2
Calcareous mud, olive (5Y 4/3–4/2), soupy to soft, homogeneous, occasional scattered black flecks of pyrite and small pebbles
Contains abundant quartz
Calcite as shell fragments and nannofossils

Unit 3
Foraminiferal-nannofossil ooze to nannofossil ooze, light gray (5B 7/1–5Y 7/2), soft, homogeneous but contains occasional bands of laminations and scattered black flecks and small pebbles

5Y 4/2

5Y 4/3

Sharp contact
5Y 4/4
Sharp contact
Gray
Pale olive and gray
Gradational contact
5B 7/1
5Y 7/2
Olive lamina
Pebble
5Y 7/1

Mottled contact

Pebble
Olive & light gray

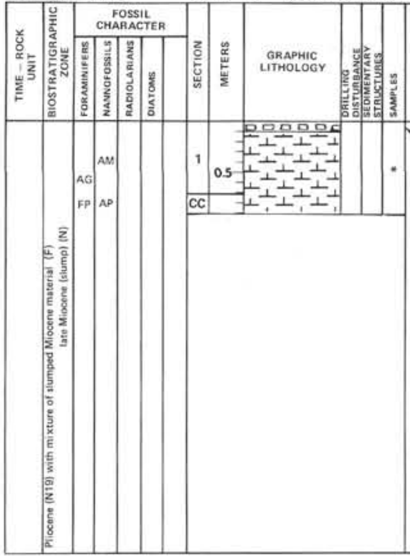
SMEAR SLIDE SUMMARY (%):

	1, 28	1, 95	2, 57	4, 51
	D	D	D	D
Texture:				
Sand	15	5	20	5
Silt	20	40	30	25
Clay	65	55	50	70
Composition:				
Quartz	15	35	30	–
Feldspar	Tr	2	Tr	–
Mica	Tr	2	Tr	–
Heavy minerals	–	6	–	–
Clay	5	35	40	10
Carbonate unspec.	10	20	10	25
Foraminifers	10	–	Tr–5	–
Calc. nannofossils	60	–	20	65

ORGANIC CARBON AND CARBONATE (%):

	1, 20	2, 20	4, 21
Organic carbon	0.18	0.34	0.12
Carbonate	68	24	72

SITE 550 HOLE CORE 2 CORED INTERVAL 99.5–109.0 m



LITHOLOGIC DESCRIPTION

5Y 6/1
Sharp contact
5B 7/1

Unit
Nannofossil ooze, light bluish gray (5B 7/1), soft, homogeneous

5GY 6/1

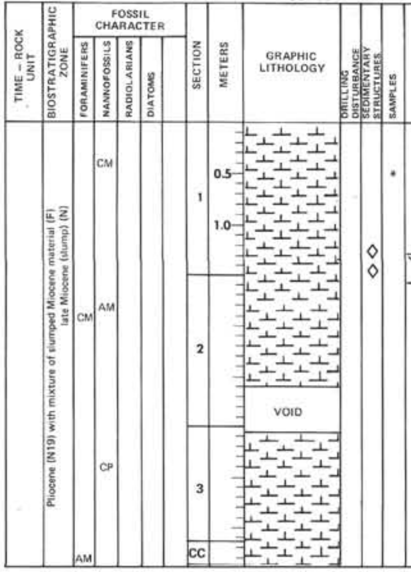
SMEAR SLIDE SUMMARY (%):

	1, 50
	D
Texture:	
Sand	10
Silt	20
Clay	70
Composition:	
Carbonate unspec.	5
Foraminifers	5
Calc. nannofossils	90

ORGANIC CARBON AND CARBONATE (%):

	1, 49
Organic carbon	0.06
Carbonate	89

SITE 550 HOLE CORE 3 CORED INTERVAL 109.0–118.5 m



LITHOLOGIC DESCRIPTION

5GY 8/1

Unit
Nannofossil ooze, light greenish gray (5GY 7/1) with a band of light bluish gray (5B 7/1) at the base of Section 1
Soft, homogeneous with occasional flecks of pyrite

Mottled contact
Large blebs of pyrite
5B 7/1
Mottled contact
5GY 7/1

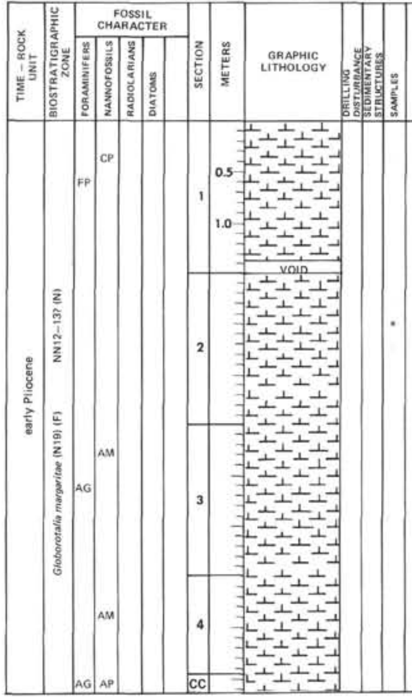
SMEAR SLIDE SUMMARY (%):

	1, 50
	D
Texture:	
Sand	5
Silt	15
Clay	70
Composition:	
Quartz	Tr
Carbonate unspec.	5
Foraminifers	Tr
Calc. nannofossils	>90

ORGANIC CARBON AND CARBONATE (%):

	2, 70
Organic carbon	0.06
Carbonate	81

SITE 550 HOLE CORE 4 CORED INTERVAL 118.5–128.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, light greenish gray (5BG 7/1), soft, homogeneous

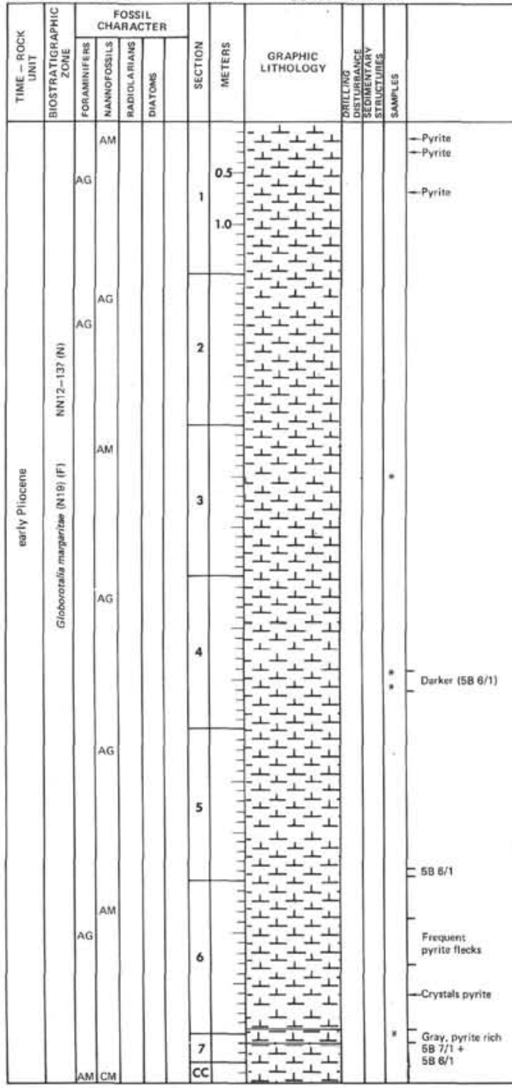
SMEAR SLIDE SUMMARY (%):

	2, 50
	D
Texture:	
Sand	5
Silt	25
Clay	70
Composition:	
Quartz	Tr
Carbonate unspec.	2–5
Foraminifers	2
Calc. nannofossils	90

ORGANIC CARBON AND CARBONATE (%):

	2, 80
Organic carbon	0.05
Carbonate	87

SITE 550 HOLE CORE 5 CORED INTERVAL 128.0–137.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, light bluish gray (5B 7/1–6/1) to gray (N8), soft

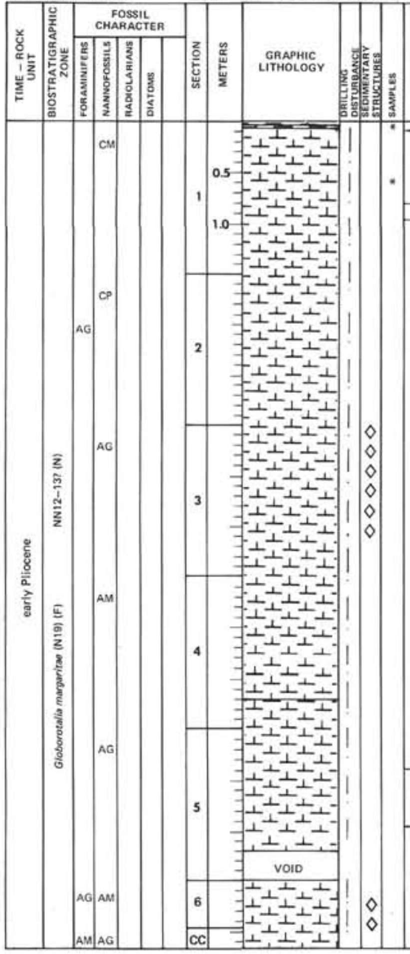
Homogeneous, but does show some color banding and zones of pyrite concentration

Foraminiferal content is variable and the sediment may become a foraminiferal-nannofossil ooze in places

SMEAR SLIDE SUMMARY (%):

	3, 50	4, 96	4, 110	6, 148
	D	D	D	D
Texture:				
Sand	5	10	–	–
Silt	25	30	–	–
Clay	70	60	–	–
Composition:				
Quartz	–	Tr	–	–
Carbonate unspec.	5	–	10	–
Foraminifers	5	10	>10	10
Calc. nannofossils	90	80	80	80
Diatoms	–	2	–	–

SITE 550 HOLE CORE 6 CORED INTERVAL 137.5–147.0 m



Sandy

Darker (5B 6/1)

Dark purple, fine laminations present, Sections 4 and 5

Homogeneous

LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, light bluish gray (5B 7/1–6/1), soft

Homogeneous except for scattered black flecks of pyrite and zones of mottling outlined in pyrite

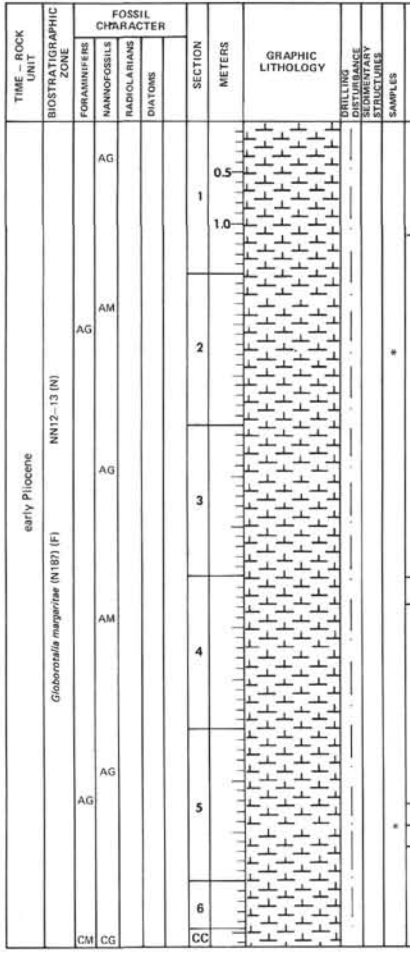
Sections 4 and 5 contain occasional fine laminae of purplish material in swirls due to drilling disturbance

A hard sandy, foraminifer rich band appears between 3 and 9 cm

SMEAR SLIDE SUMMARY (%):

	1, 6	1, 80
	D	D
Texture:		
Sand	40	10
Silt	10	20
Clay	50	70
Composition:		
Carbonate unspec.	–	5
Foraminifers	35	10
Calc. nannofossils	>50	>80
Diatoms	5	–
Radiolarians	5	–

SITE 550 HOLE CORE 7 CORED INTERVAL 147.0–156.5 m



Small crystals of pyrite

Section 3 has many dark pyritic areas

Occasional flecks pyrite

Lighter color

Reddish (5YR 8/1)

Sharp contact 5G 8/1

LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, light greenish gray (5G 8/1), soft

Homogeneous except for varying concentrations of pyrite flecks and small crystals

Section 5 contains a sharply bounded reddish nannofossil rich band

Black and grayish flecks are disseminated throughout the core

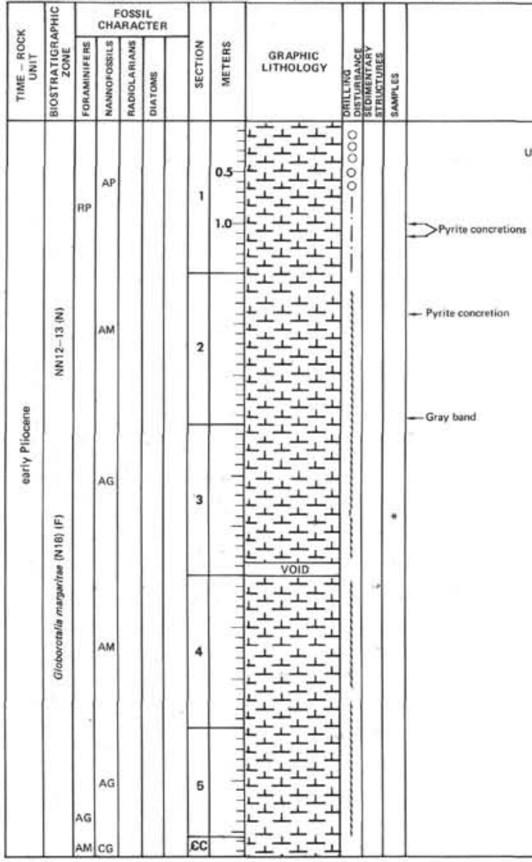
SMEAR SLIDE SUMMARY (%):

	2, 80	5, 97
	D	D
Texture:		
Sand	5	5
Silt	35	25
Clay	60	70
Composition:		
Quartz	Tr	Tr
Mica + Chlorite	Tr	Tr
Clay	5	<5
Carbonate unspec.	5	3
Foraminifers	Tr	1
Calc. nannofossils	85	91

ORGANIC CARBON AND CARBONATE (%):

	2, 12
Organic carbon	0.05
Carbonate	90

SITE 550 HOLE CORE 8 CORED INTERVAL 156.5–166.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, light bluish gray (5B 7/1), soft to firm

Fairly homogeneous but quite disturbed by drilling

Scattered pyrite concretions and flecks

Occasional gray and olive gray fine laminations, especially in Section 4 show that sediment has been vertically drawn into the core barrel and is very deformed

Smear slides show occasional sand sized rhombs of a carbonate mineral

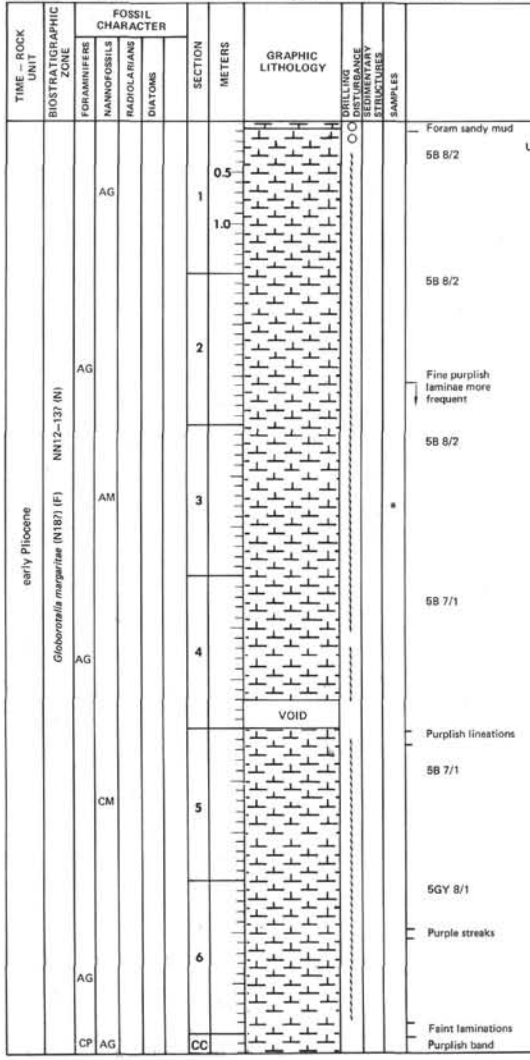
SMEAR SLIDE SUMMARY (%):

	3, 90
	D
Texture:	
Sand	10
Silt	30
Clay	60
Composition:	
Quartz	Tr
Mica + chlorite	Tr
Clay	5–10
Carbonate unspec.	20
Calc. nannofossils	70

ORGANIC CARBON AND CARBONATE (%):

	2, 12
Organic carbon	0.09
Carbonate	85

SITE 550 HOLE CORE 9 CORED INTERVAL 166.0–175.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, light bluish gray (5B 8/2–7/1), soft to firm

Sediment broken into 5–10 cm blocks separated by variable amounts of highly deformed ooze

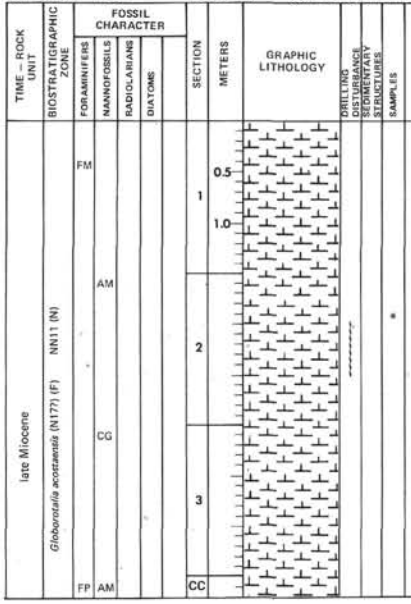
Lower part of core is light greenish gray (5GY 8/1)

Scattered occasional gray flecks, sediment homogeneous except for zones of fine purple lineations, usually very deformed, these are not common or closely spaced

SMEAR SLIDE SUMMARY (%)

	3, 80
	D
Texture:	
Sand	5
Silt	25
Clay	70
Composition:	
Quartz	Tr
Mica + chlorite	11–5
Clay	<10
Carbonate unspec.	20
Foraminifers	Tr
Calc. nannofossils	70

SITE 550 HOLE CORE 10 CORED INTERVAL 175.5–185.0 m



LITHOLOGIC DESCRIPTION

5BG 7/1

5B 9/1

Unit

Nannofossil ooze to chalk, light greenish gray (5BG 7/1) to light bluish gray (5B 9/1), firm

Homogeneous except for rare gray flecks

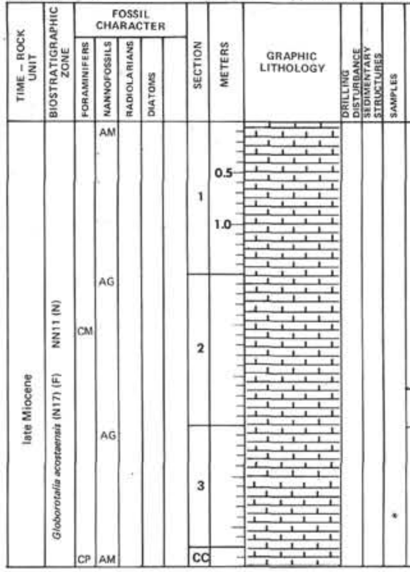
SMEAR SLIDE SUMMARY (%):

	2, 40
	D
Texture:	
Sand	5
Silt	15
Clay	80
Composition:	
Quartz	Tr
Mica	Tr
Clay	<5
Pyrite	Tr
Carbonate unspec.	5
Calc. nannofossils	90

ORGANIC CARBON AND CARBONATE (%):

	2, 80
Organic carbon	0.04
Carbonate	90

SITE 550 HOLE CORE 11 CORED INTERVAL 185.0–194.5 m



LITHOLOGIC DESCRIPTION

Gray flecks more abundant

Unit

Nannofossil chalk, light bluish gray (5B 8/1) to light greenish gray (5GY 7/1), firm

Homogeneous with scattered gray flecks

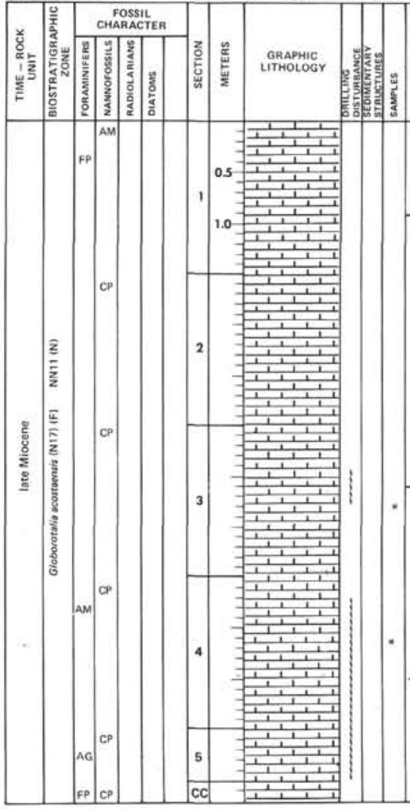
SMEAR SLIDE SUMMARY (%):

	3, 90
	D
Texture:	
Silt	10
Clay	90
Composition:	
Quartz	Tr
Mica	Tr
Clay	5
Pyrite	Tr
Carbonate unspec.	10
Calc. nannofossils	85

ORGANIC CARBON AND CARBONATE (%):

	1, 50
Organic carbon	0.03
Carbonate	94

SITE 550 HOLE CORE 12 CORED INTERVAL 194.5–204.0 m



LITHOLOGIC DESCRIPTION

5B 7/1

5B 9/1

5B 7/1

5B 9/1

Pyrite concretion

Unit

Nannofossil chalk, light bluish gray (5B 7/1–9/1), firm

Homogeneous with scattered gray flecks and occasional faint burrow

Some sections of core broken into biscuits with deformed sediment flow inbetween, result of drilling

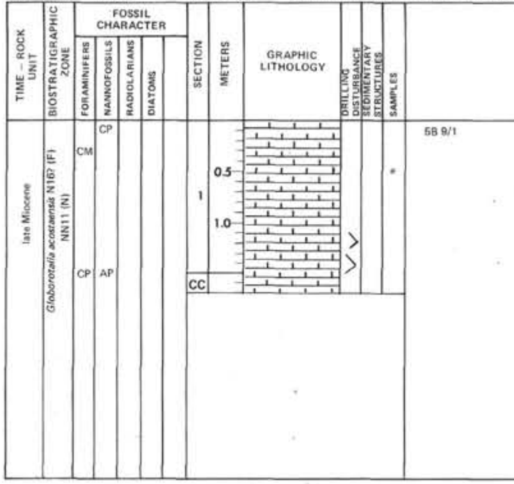
SMEAR SLIDE SUMMARY (%):

	3, 80	4, 69
	D	D
Texture:		
Silt	3	–
Clay	97	–
Composition:		
Quartz	Tr	–
Mica	Tr	Tr
Heavy minerals	Tr	Tr
Clay	~5	<5
Glauconite	Tr	–
Pyrite	Tr	Tr
Carbonate unspec.	5	<5
Foraminifers	–	Tr
Calc. nannofossils	90	93

ORGANIC CARBON AND CARBONATE (%):

	1, 50
Organic carbon	0.07
Carbonate	81

SITE 550 HOLE CORE 13 CORED INTERVAL 204.0–213.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, light bluish gray (5B 9/1), firm, homogeneous

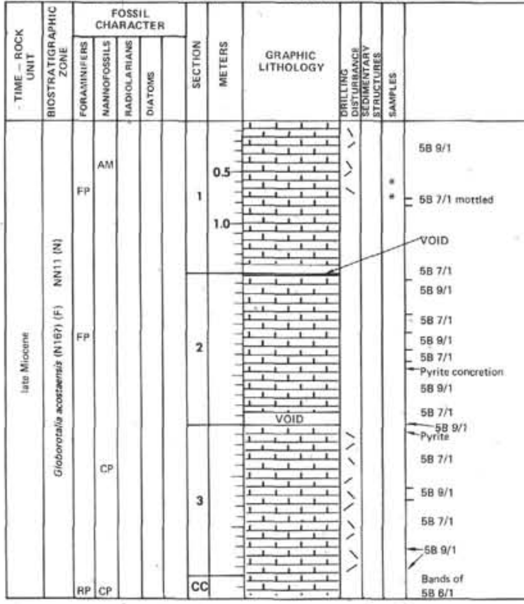
SMEAR SLIDE SUMMARY (%):

	1, 50
	D
Texture:	
Sand	<5
Silt	25
Clay	70
Composition:	
Carbonate unspec.	Tr
Foraminifers	Tr
Calc. nannofossils	90
Diatoms	Tr

ORGANIC CARBON AND CARBONATE (%):

	1, 45
Organic carbon	0.05
Carbonate	85

SITE 550 HOLE CORE 14 CORED INTERVAL 213.5–223.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, alternating bands and thin beds of shades of light bluish gray (5B 9/1 and 5B 7/1)

5B 7/1 units are mottled when thin, 5B 7/1 becomes dominant color in Section 3 where it is homogeneous

Sediment is firm and often broken into chunks by drilling

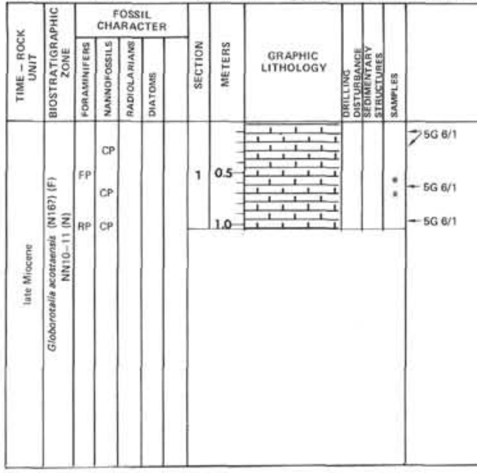
SMEAR SLIDE SUMMARY (%):

	1, 60	1, 78
	D	D
Texture:		
Sand	<5	<5
Silt	25	25
Clay	70	70
Composition:		
Carbonate unspec.	Tr	Tr
Foraminifers	Tr	Tr
Calc. nannofossils	90	90

ORGANIC CARBON AND CARBONATE (%).

	2, 76
Organic carbon	0.06
Carbonate	81

SITE 550 HOLE CORE 15 CORED INTERVAL 223.0–232.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, light greenish gray (5G 8/1), firm

Bands ~5 cm thick of darker (5G 6/1) sediment are present as marked, these are mottled

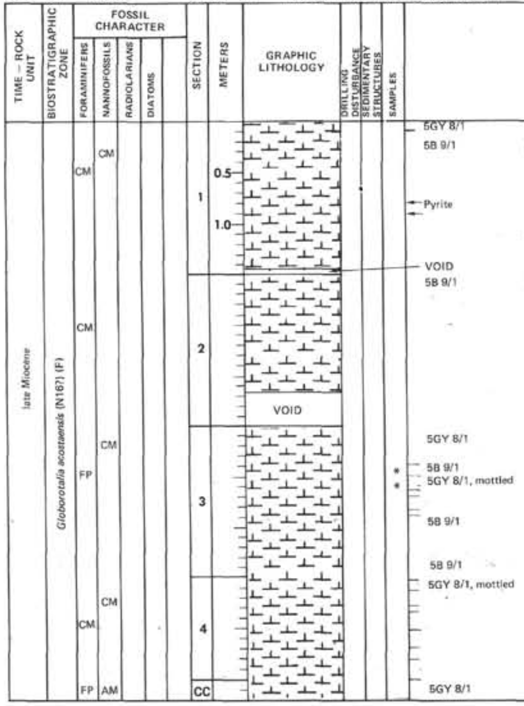
SMEAR SLIDE SUMMARY (%):

	1, 60	1, 70
	D	D
Texture:		
Sand	<5	5
Silt	25	25
Clay	70	70
Composition:		
Quartz	Tr	Tr
Carbonate unspec.	Tr	5
Foraminifers	Tr	Tr
Calc. nannoossils	90	90

ORGANIC CARBON AND CARBONATE (%):

	1, 102
Organic carbon	0.11
Carbonate	77

SITE 550 HOLE CORE 16 CORED INTERVAL 232.5–242.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, banded in shades of light bluish gray (5B 9/1) and light greenish gray (5GY 8/1), soft

Darker bands are mottled

Scattered flecks of pyrite as indicated

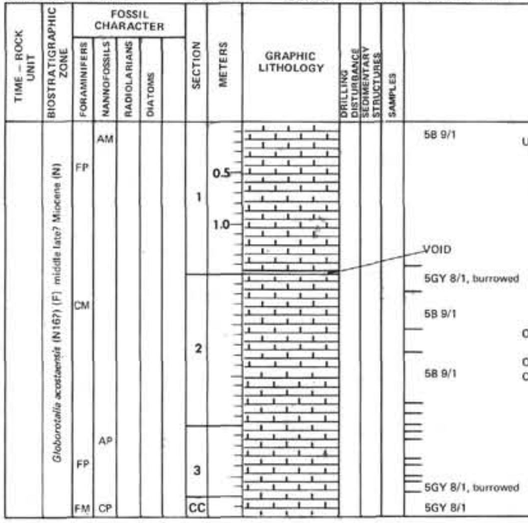
SMEAR SLIDE SUMMARY (%):

	3, 45	3, 55
	D	D
Texture:		
Sand	5	5
Silt	25	25
Clay	70	70
Composition:		
Carbonate unspec.	–	Tr
Foraminifers	5	Tr
Calc. nannofossils	90	90
Diatoms	–	Tr

ORGANIC CARBON AND CARBONATE (%).

	2, 42
Carbonate	95

SITE 550 HOLE CORE 17 CORED INTERVAL 242.0–251.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, banded in shades of light bluish gray (5B 9/1) and light greenish gray (5GY 8/1)

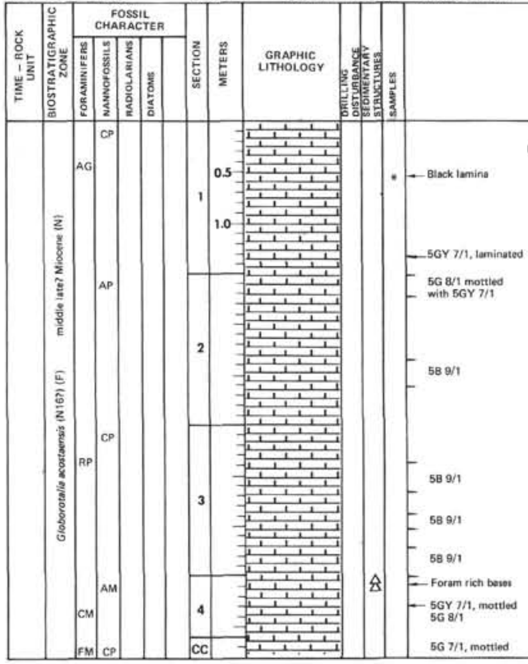
Firm

Darker bands are burrow mottled

ORGANIC CARBON AND CARBONATE (%):

	2, 31
Organic carbon	0.03
Carbonate	92

SITE 550 HOLE CORE 18 CORED INTERVAL 251.5–261.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, banded in shades of light bluish gray (5B 9/1) and light greenish gray (5GY 7/1), firm

Unless otherwise marked the core consists of 2–20 cm thick bands of bluish and greenish chalk, tha darker (5GY 7/1) sediment is mottled

Two small graded bands were found in Section 4

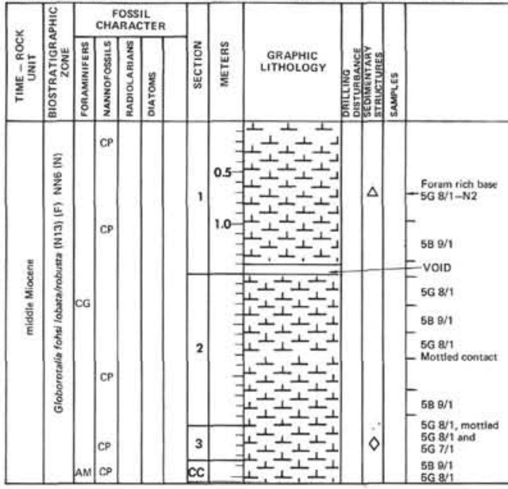
SMEAR SLIDE SUMMARY (%):

	1, 58
	D
Texture:	
Sand	30
Silt Clay	70
Composition:	
Mica	5
Volcanic glass	Tr
Foraminifers	20
Calc. nannofossils	50
Diatoms	10
Radiolarians	10

ORGANIC CARBON AND CARBONATE (%):

	2, 48
Organic carbon	0,07
Carbonate	78

SITE 550 HOLE CORE 19 CORED INTERVAL 261.0–270.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil ooze, banded in shades of light greenish gray (5G 8/1–7/1) and light bluish gray (5B 9/1)

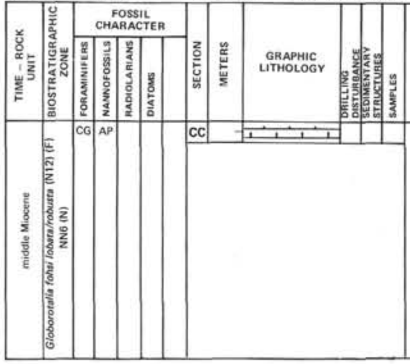
Soft

Banding is on a scale of 5–10 cm unless otherwise marked, most of the finer banding is between shades of light greenish gray (5G 8/1–5G 7/1) with dark bands often mottled

ORGANIC CARBON AND CARBONATE (%):

	2, 53
Organic carbon	0.03
Carbonate	93

SITE 550 HOLE CORE 20 CORED INTERVAL 270.5–280.0 m



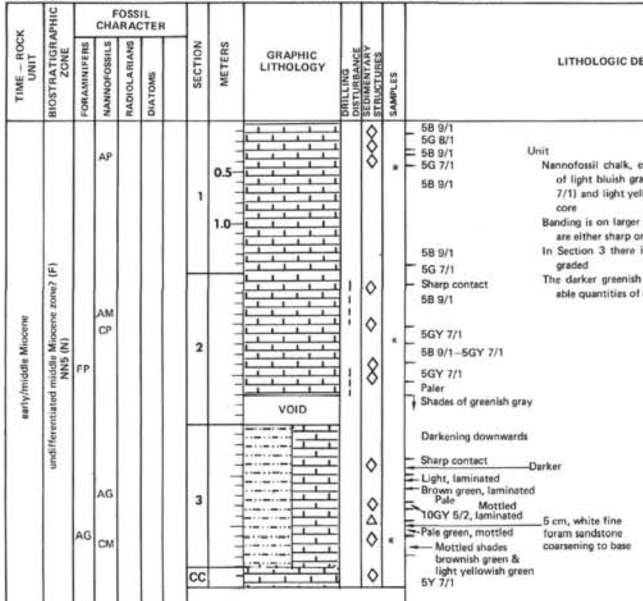
LITHOLOGIC DESCRIPTION

Unit

Core-Catcher

Nannofossil chalk, light greenish gray (5G 8/1), firm to hard, homogeneous

SITE 550 HOLE CORE 21 CORED INTERVAL 280.0–289.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, extensively banded and mottled in shades of light bluish gray (5B 9/1), light greenish gray (5G 8/1–7/1) and light yellowish green (5Y 7/1) near the base of the core

Banding is on larger (as marked) and finer scale, most contacts are either sharp or mottled and rapidly transitional

In Section 3 there is a fine white foram sandstone which is graded

The darker greenish lamina and bands may contain considerable quantities of clay minerals

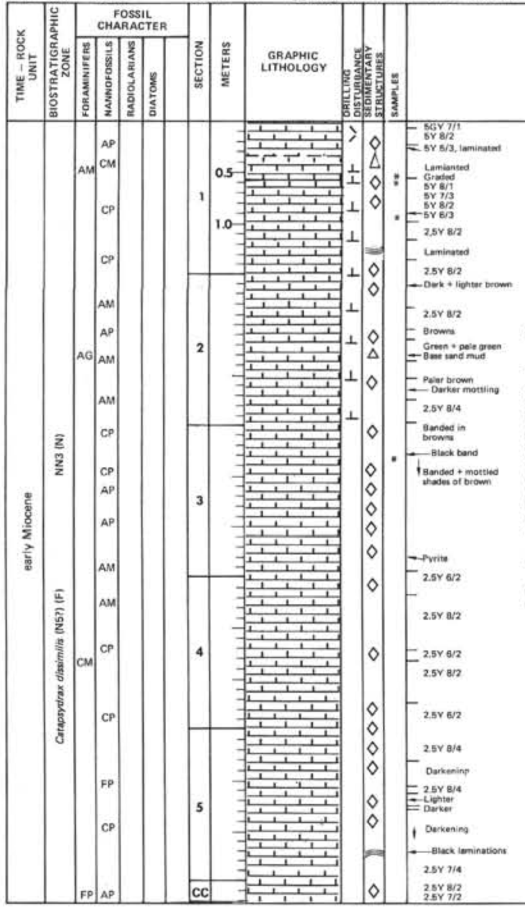
SMEAR SLIDE SUMMARY (%):

	1, 49 D	2, 66 D	3, 112 D	3, 95 D
Texture:				
Sand	–	7	15	50
Silt	20	13	30	25
Clay	80	80	55	25
Composition:				
Quartz	–	2	5	Tr
Mica	–	–	10	Tr
Heavy minerals	–	–	10	–
Clay	20	20	55	5
Glauconite	–	–	15	Tr
Carbonate unspec.	10	5	5	50
Foraminifers	–	–	–	25
Calc. nannofossils	70	70	–	20
Sponge spicules	–	3	–	–

ORGANIC CARBON AND CARBONATE (%):

	3, 111
Organic carbon	0.08
Carbonate	24

SITE 550 HOLE CORE 22 CORED INTERVAL 289.5–299.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, banded, mottled and laminated in shades of yellow brown (5Y 8/1–8/2–8/4–7/4 etc) with less quantities of light (5GY 7/1) and darker or olive (5Y 6/3) greens

Firm, mottling most extensive in darker beds

Lightest (2.5Y 8/2–8/4), most calcareous bands are nearly homogeneous

Color boundaries are generally sharp or rapidly transitional and well mottled

Section 1 contains a graded muddy sand layer rich in forams, these are planktonic and deep water benthic species

Darker bands may contain considerable clay minerals

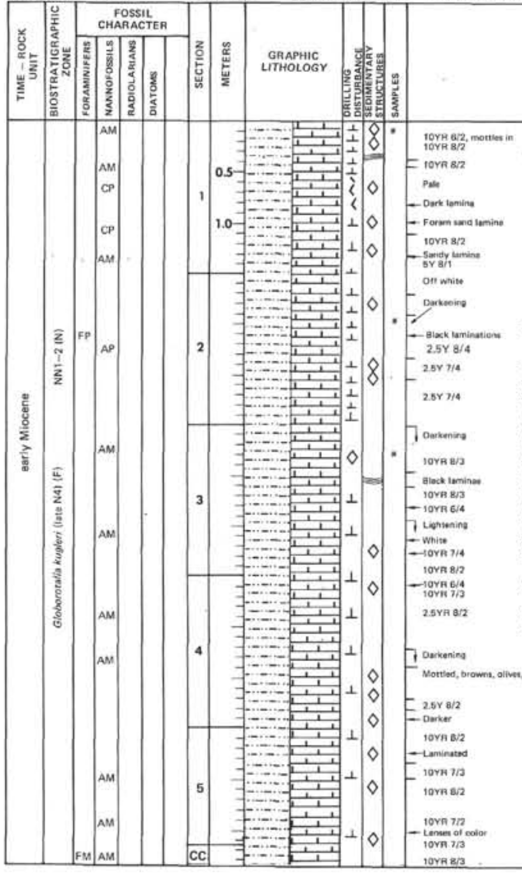
SMEAR SLIDE SUMMARY (%):

	1, 53 D	1, 57 D	1, 92 D	3, 34 D
Texture:				
Sand	50	5	5	1
Silt	20	35	35	<3
Clay	30	60	60	–
Composition:				
Quartz	–	–	Tr	–
Mica + chlorite	–	5–10	5–10	Tr
Clay	–	20	20	31
Carbonate unspec.	20	Tr	Tr	20
Foraminifers	50	1–5	–	–
Calc. nannofossils	25	65	75	35
Black mineral	–	–	–	10

ORGANIC CARBON AND CARBONATE (%):

	2, 18	4, 18
Organic carbon	0.04	–
Carbonate	58	89

SITE 550 HOLE CORE 23 CORED INTERVAL 299.0–308.5 m



LITHOLOGIC DESCRIPTION

Unit

Marly nannofossil chalk grading occasionally to a light colored (10YR 8/2) nannofossil chalk, firm to hard

Color banding as marked

In shades of yellow brown (2.5Y 8/2–10YR 6/4) and greens and olive

Most contacts rapid transitional and mottled

Darker beds usually more mottled and may have considerable quantities of clay minerals

Occasional fine lamination and thin sandy (foram) lamina

Pale fine lamina are enriched in biogenic silica

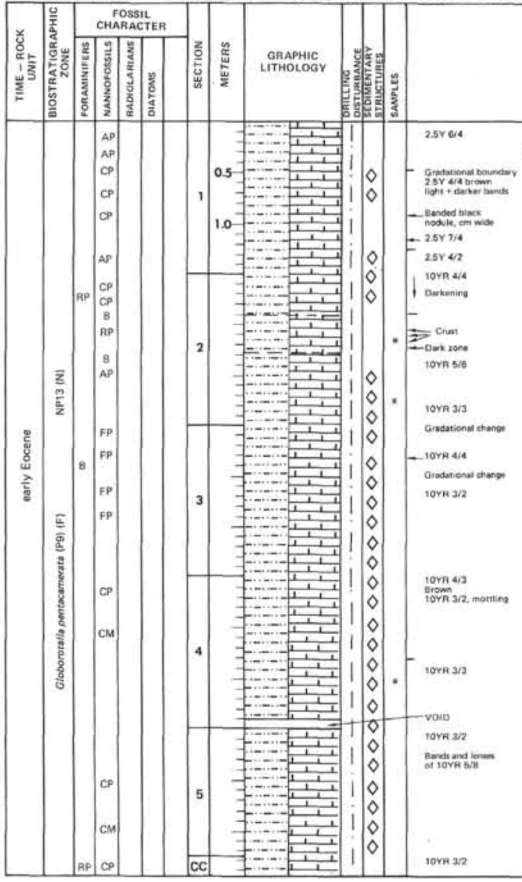
SMEAR SLIDE SUMMARY (%):

	1, 10	2, 48	3, 28
	D	D	D
Texture:			
Sand	5	10	5
Silt	45	30	45
Clay	50	60	50
Composition:			
Quartz	1–5	Tr	Tr
Mica + chlorite	1–5	5	1–5
Clay	30	20	30
Carbonate unspec.	10	10	–
Foraminifers	–	Tr	–
Calc. nannofossils	45	50	60
Radiolarians	1–5	5–10	Tr
Sponge spicules	–	1–5	1–5
Black opaque	Tr	–	–

ORGANIC CARBON AND CARBONATE (%):

	1, 92	2, 47	3, 20
Organic carbon	0.08	0.06	0.03
Carbonate	16	58	85

SITE 550 HOLE CORE 24 CORED INTERVAL 308.5–318.0 m



LITHOLOGIC DESCRIPTION

Unit

Marly to very marly nannofossil chalk, banded and mottled in shades of brown (2.5Y 6/4–10YR 3/2) and black, firm to hard

Upper part of Section 1 is lighter colored chalk, it grades down to blackish speckled sediment in Section 2 where a number of hard crusts are found with black dendritic structure (fine scale) extending into the sediments below, in one smear slide this sediment was rich in glass and contained zeolites

Sediment is generally dark, richer in clay size particles and quartz and moderately to well mottled, are scattered cm size ovoids of pale yellow brown

Much of core is streaked or flecked in black

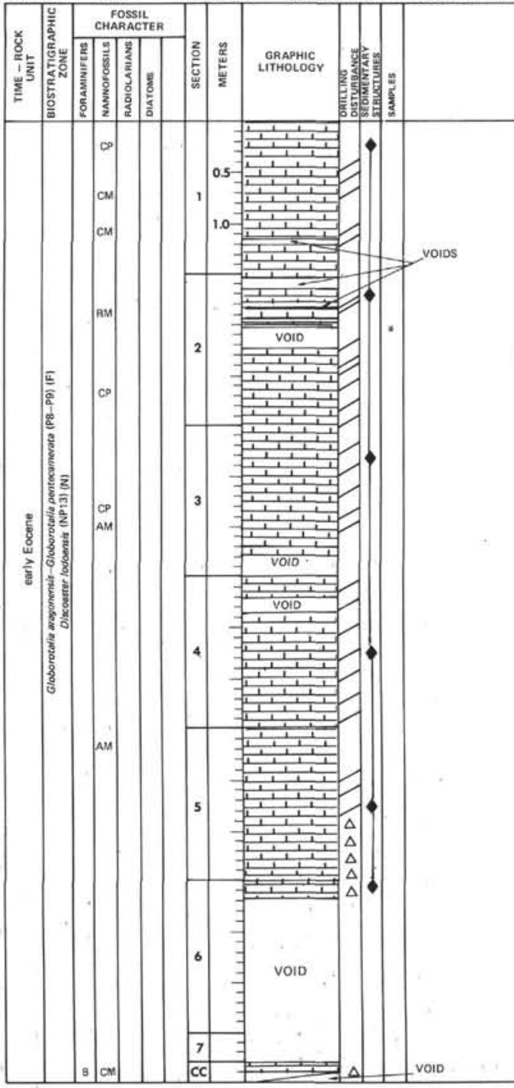
SMEAR SLIDE SUMMARY (%):

	2, 70	2, 129	4, 102
	D	D	D
Texture:			
Sand	5	20	5
Silt	45	50	45
Clay	50	30	50
Composition:			
Quartz	25	20	30
Feldspar	–	Tr	–
Mica + chlorite	10	5	5
Clay	–	30	20
Glass	60	–	Tr
Carbonate unspec.	Tr	10	5
Calc. nannofossils	Tr	35	40
Radiolarians	Tr	–	–
Sponge spicules	Tr	–	–
Opaque mineral	Tr	Tr	Tr

ORGANIC CARBON AND CARBONATE (%):

	2, 124	5, 124
Organic carbon	0.04	0.06
Carbonate	31	6

SITE 550 HOLE CORE 25 CORED INTERVAL 318.0–327.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK, marly nannofossil chalk

Alternating in color from 10YR 3/3–10YR 3/2–10YR 7/6–10YR 4/4–10YR 5/4–10YR 5/3

Contacts between colors sometimes gradational, sometimes sharp; irregular contacts in Section 2 (5 & 12 cm)

Sediment usually mottled either to a minor or an intensive degree and burrows are filled either with brownish sediment (as above) or a black (N2) sediment

Carbonate is more abundant in lighter (10YR 7/6) colored beds

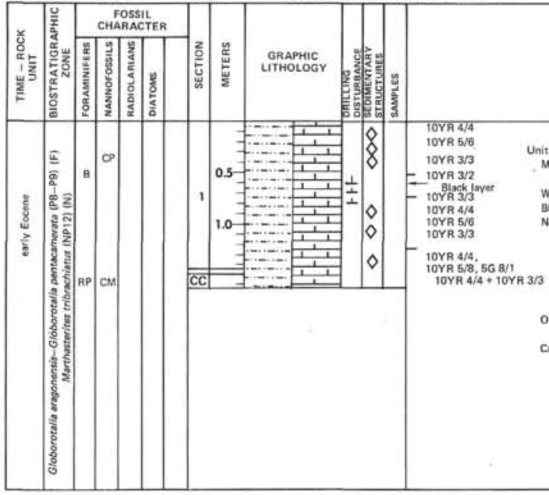
SMEAR SLIDE SUMMARY (%):

	2, 59
	D
/ Texture:	
Sand	<10
Mud	90
Composition:	
Carbonate unspec.	5
Calc. nannofossils	>90

ORGANIC CARBON AND CARBONATE (%):

	1, 38
Organic carbon	0.03
Carbonate	49

SITE 550 HOLE CORE 26 CORED INTERVAL 327.5–337.0 m



LITHOLOGIC DESCRIPTION

Unit

Marly to very marly nannofossil chalk, yellow brown (10YR 5/6) to dark gray brown (10YR 3/2), firm

Well mottled in shades of brown

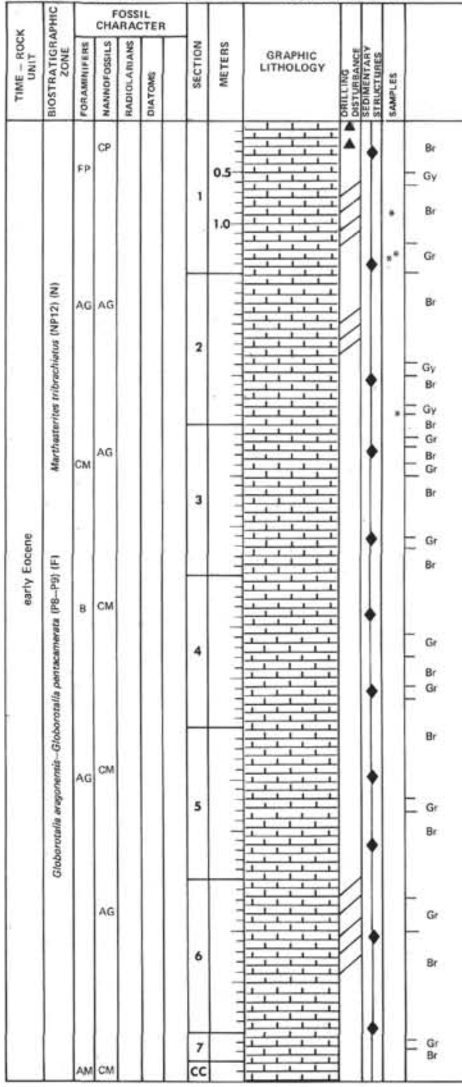
Black clay layers at 15, 20, 30, and 62 cm

Non-calcareous component variable and maybe high near clay layers, may include considerable biogenic silica

ORGANIC CARBON AND CARBONATE (%):

	1, 56
Carbonate	2

SITE 550 HOLE CORE 27 CORED INTERVAL 337.0–346.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK TO MARLY NANNOFOSSIL CHALK

Largely brownish sediment (Br) (10YR 5/6, 10YR 4/4, 10YR 5/8), occasional interbeds of 5G 8/1–6/1 (Gr) sediment or gray (10YR 8/1) (Gy)

Mottled throughout with the above colors, bioturbated to moderate

Contacts between sediments of different colors usually sharp; irregular contact in Section 1, 147 cm

White spots throughout – forams; occasionally concentrated in thin sandy beds (Section 1, 135–138 cm), laminated

Laminated green sediment, Section 4, 64–67 cm and 127–131 cm; foram nanno chalk

Grayish streaks and layers, possibly Mn-rich, throughout Sections 2, 3, and 6; gray nodule in Section 2, 72–74 cm

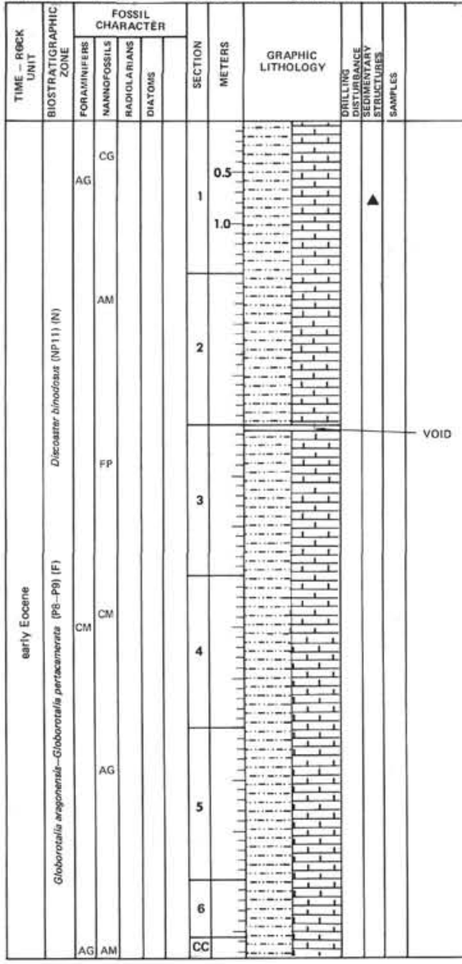
SMEAR SLIDE SUMMARY (%):

	1, 90	1, 133	1, 137	2, 140
	D	D	D	D
Composition:				
Quartz	–	5	10	5
Carbonate unspec.	Tr	5	Tr	–
Foraminifers	–	5	10	–
Calc. nannofossils	79	50	60	70
Diatoms	–	–	10	–
Radiolarians	–	15	5	10
Sponge spicules	–	15	15	15

ORGANIC CARBON AND CARBONATE (%):

	2, 45
Carbonate	45

SITE 550 HOLE CORE 28 CORED INTERVAL 346.5–356.0 m



LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL CHALK

Mostly 10YR 5/6 or 10YR 4/4 in color, with occasional beds of 5G 8/1 grading into N8; contacts between colors sometimes gradual, sometimes sharp

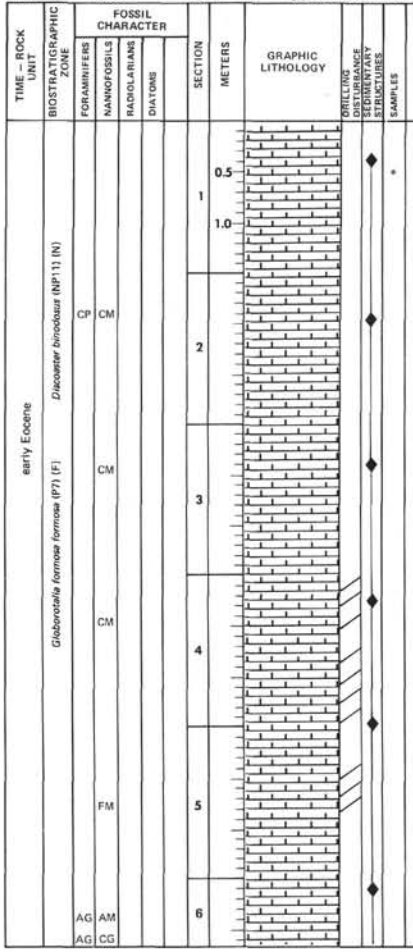
5G 8/1 forms an upward fining sequence in Section 1, 60–73.5 cm, going from a foram-nanno sandy chalk to a nanno chalk; the contact below is sharp, and the sand is laminated and rich in heavy minerals; presumably a turbidite

Sediment usually moderately to intensively bioturbated and mottling; best mottling observed in 10YR 4/4 chalk

ORGANIC CARBON AND CARBONATE (%):

	1, 46	1, 68
Organic carbon	0.05	0.04
Carbonate	58	65

SITE 550 HOLE CORE 29 CORED INTERVAL 356.0–365.5 m



LITHOLOGIC DESCRIPTION

NANNOFOSSIL CHALK

Largely 10YR 6/4, 10YR 4/4, 10YR 4/3, and 10YR 5/4, interbedded 5G 8/1

All sediment moderately or intensely bioturbated, burrow-mottled

Color contacts either gradational or sharp

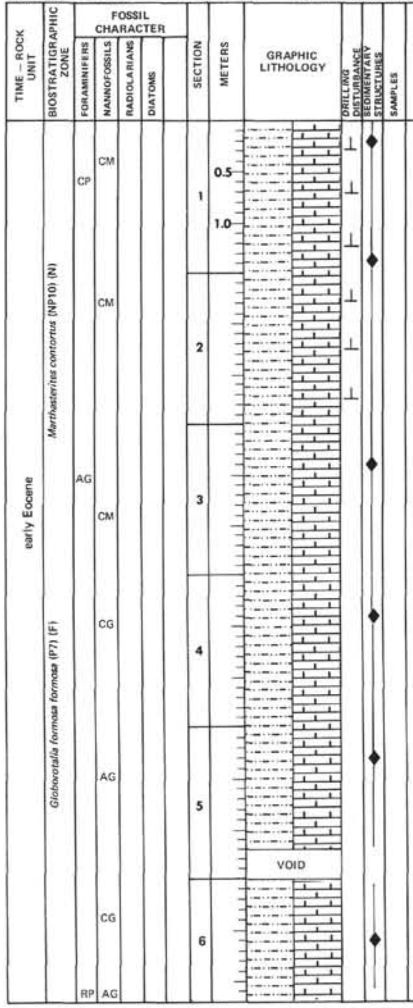
SMEAR SLIDE SUMMARY (%):

	1, 50
	D
Texture:	
Composition:	
Carbonate unspec.	10
Calc. nannofossils	90

ORGANIC CARBON AND CARBONATE (%):

	2, 46	2, 68
Organic carbon	0.04	0.03
Carbonate	72	76

SITE 550 HOLE CORE 30 CORED INTERVAL 365.5–375.0 m



LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL CHALK

Largely brownish (10YR 4/4, 10YR 5/4, 10YR 6/3) in color with minor interbeds of 5G 8/1; contacts are gradational or sharp

Burrowed throughout, moderately to intensely, and mottled

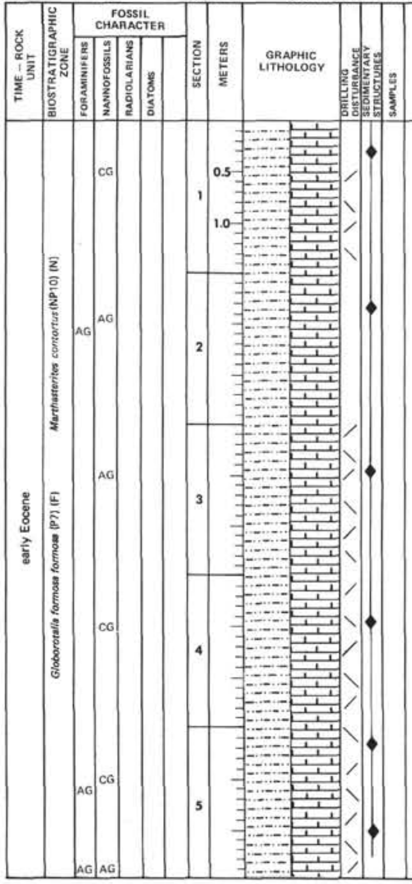
Black laminae, contorted by flow or pressure (not slump) in Section 3, 22–23 cm

Organic sediment(?) in Section 4, 80–107 cm

ORGANIC CARBON AND CARBONATE (%):

	1, 61	2, 44
Carbonate	25	46

SITE 550 HOLE CORE 31 CORED INTERVAL 375.0–384.5 m



LITHOLOGIC DESCRIPTION

MARLY NANNOFOSSIL CHALK

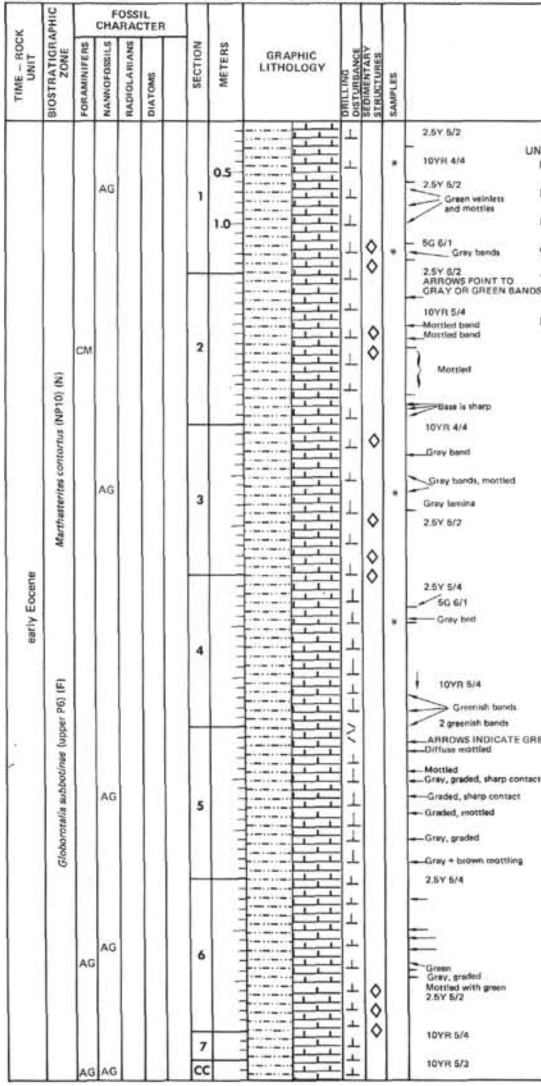
Largely brownish (10YR 6/3, 10YR 4/3) in color, occasionally interbeds and mottling with 5G 8/1

Moderately to intensely bioturbated and mottled

ORGANIC CARBON AND CARBONATE (%):

	2, 10
Carbonate	47

SITE 550 HOLE CORE 32 CORED INTERVAL 384.5–394.0 m



LITHOLOGIC DESCRIPTION

UNIT

Marly to very marly nannofossil chalk, gray brown (1.5Y 5/2) to dark yellow brown (10YR 4/2), firm

Homogeneous with scattered tiny yellow flecks (foram) and occasional green cm size ovoid mottle

Frequent bands of gray, often with surrounding zones of green (5G 6/1), 1–10 cm thick

Gray units thin, non-calcareous, often mottled with green, may have a sharp lower contact, some are graded

Their composition may be largely terrigenous, quartz, mica, clay (Section 1) or can be carbonate fragments (Section 4)

More terrigenous beds contain some volcanic glass as well as heavy minerals and opaques

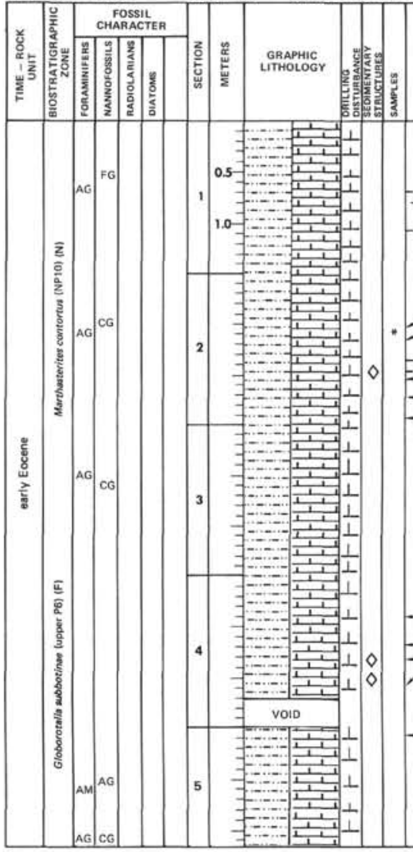
SMEAR SLIDE SUMMARY (%):

	1, 40	4, 41
	D	D
Texture:		
Sand	5	50
Silt	45	20
Clay	50	30
Composition:		
Quartz	25	20
Mica	1–5	1–5
Clay	30	5–10
Volcanic glass	–	Tr
Carbonate unspec.	Tr–5	50
Calc. nannofossils	40	20

ORGANIC CARBON AND CARBONATE (%):

	3, 66	7, 42
Carbonate	3	47

SITE 550 HOLE CORE 33 CORED INTERVAL 394.0–403.5 m



LITHOLOGIC DESCRIPTION

10YR 5/2
Sharp boundary
Green
Brown
5G 6/1
Sharp boundary
2.5Y 6/2
10YR 5/4
Green, silty lens
Green mottles
Mottled-green flecks
Fine green lines
Grayer zone
Large green spot
10YR 4/3
10YR 5/2
10YR 4/4
Green lens
Green lens
concentrated green mottles
Green band
10YR 4/4

Unit

Marly to very marly nannofossil chalk, gray brown (10YR 5/2) to dark yellow brown (10YR 4/4)

Firm to hard

Homogeneous with scattered very fine yellow flecks (forams) and occasional green ovoid mottles, up to cm size

Occasional green (5G 6/1) or greenish gray bands and mottled zones as marked

Some of these are silty and enriched in foram fragments which are covered by a black coating (Section 2)

Entire section is calcareous

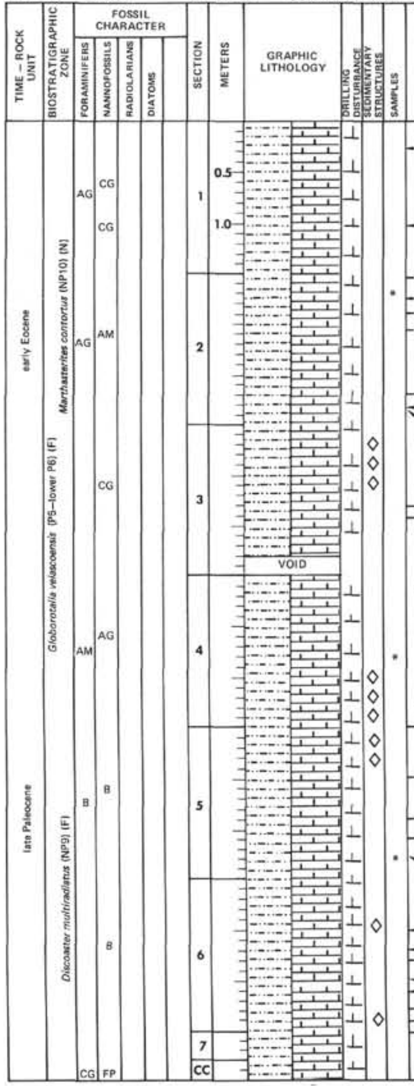
SMEAR SLIDE SUMMARY (%):

	2, 55
	D
Texture:	
Sand	20
Silt	40
Clay	40
Composition:	
Quartz	20
Mica	1–10
Foraminifers	20
Calc. nannofossils	40

ORGANIC CARBON AND CARBONATE (%):

	2, 117
Carbonate	29

SITE 550 HOLE CORE 34 CORED INTERVAL 403.5–413.0 m



LITHOLOGIC DESCRIPTION

10YR 5/4
Green band
Green band
10YR 5/3
5G 6/2 Gradual contact
Gray black lamina
Gradual contact
Pale brown
Gradual contact
Darker brown
Gradual contact
Lighter brown
Concentrated green flecks
10YR 6/3
10YR 6/3
Gradational color change
5G 6/1
5G 7/2
5G 6/1 with
5G 7/2 mottling
10YR 5/2
Green mottling
Sharp contact
10YR 3/3
Gradual contact
5G 5/2
Sharp contact
10YR 4/3
Green with white lamina
10YR 3/3
10YR 3/3
Olive brown
Green band
Gradual contact
5Y 5/1, gray
Dark streaks
Gray
5G 8/1, green
5Y 5/1
5GY 5/1
5G 6/1

Unit

Marly to very marly nannofossil chalk, yellowish brown (10YR 5/3) and dark brown (10YR 3/3) to gray in and below Section 6 (5Y or 5GY 5/1)

Firm to hard

Occasional green (5G 7/1 or 8/1) banding and mottling

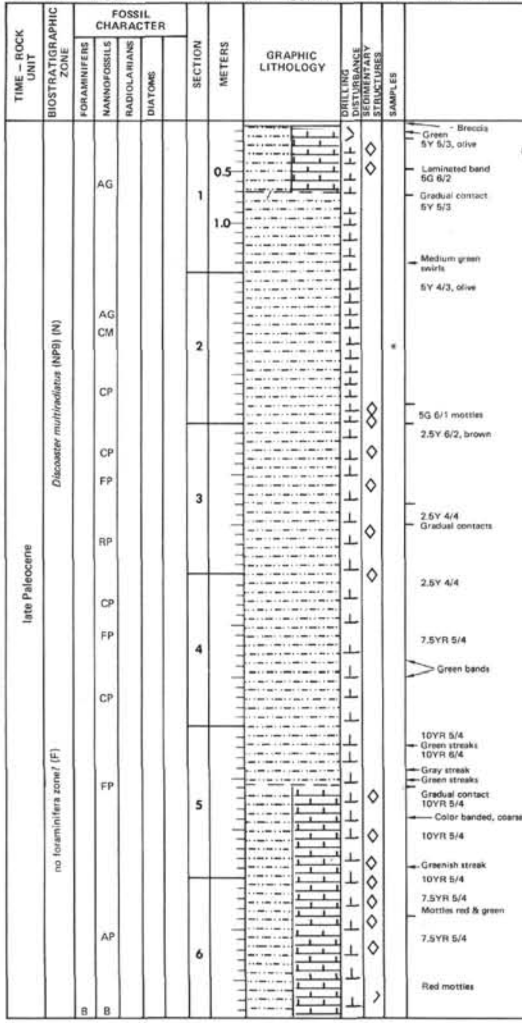
Some green bands contain zones of coarser material which is enriched in quartz and carbonate fragments (larger nannos and forams in part)

All the sediments contain small quantities of volcanic glass

SMEAR SLIDE SUMMARY (%):

	2, 20	4, 80	5, 130
	D	D	D
Texture:			
Sand	5	5	15
Silt	35	45	50
Clay	60	50	35
Composition:			
Quartz	Tr–5	15	10
Feldspar	–	–	Tr
Mica	5	–	Tr
Clay	30	20	10
Volcanic glass	Tr–5	5	5
Glauconite	–	–	Tr
Pyrite	–	–	Tr
Carbonate unspec.	10	5	55
Foraminifers	–	Tr	Tr
Calc. nannofossils	50	60	20

SITE 550 HOLE CORE 35 CORED INTERVAL 413.0–422.5 m



LITHOLOGIC DESCRIPTION

Unit

Mudstone is very marly nannofossil chalk, olive (5Y 5/3) to light brown gray (2.5Y 6/2) and olive brown (2.5Y 4/4)

Firm to hard

Scattered green mottles (up to cm size) and bands

All core is calcareous, but olive sediments are rich in terrigenous material and clay sized particles

Section 4 and below is yellowish brown (10YR 5/4) to brown (7.5YR 5/4) with scattered pink, cm size, mottles

Section 5 contains a banded coarser bed, enriched in foraminifera fragments

Pinkish mottles tend to be non-calcareous

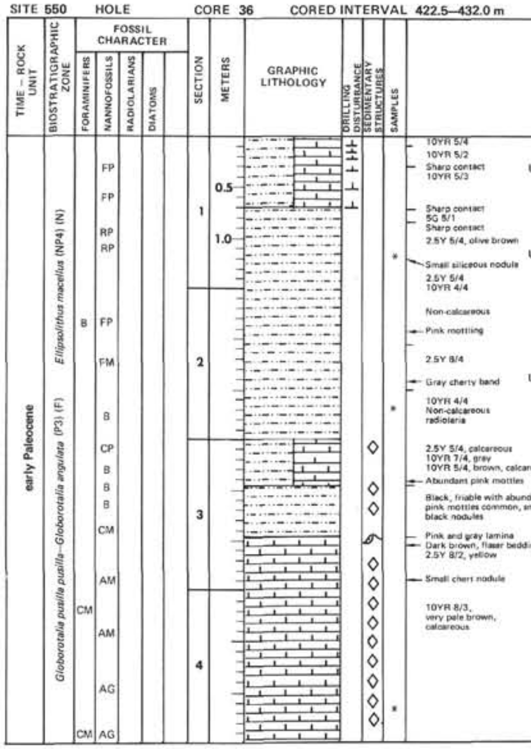
SMEAR SLIDE SUMMARY (%):

	2, 79
	D
Texture:	
Sand	10
Silt	30
Clay	60
Composition:	
Quartz	25
Mica	Tr–5
Clay	30
Volcanic glass	Tr
Carbonate unspec.	Tr–10
Calc. nannofossils	20
Radiolarians	Tr
Sponge spicules	Tr

ORGANIC CARBON AND CARBONATE (%):

	1, 23	2, 12	3, 129	5, 12
Organic carbon	0.05	–	–	–
Carbonate	57	10	6	3

SITE 550 HOLE CORE 36 CORED INTERVAL 422.5–432.0 m



LITHOLOGIC DESCRIPTION

Unit 1

Nannofossil chalk to very marly nannofossil chalk, brown (10YR 5/4–5/2) to very pale brown (10YR 8/3)

Hard, homogeneous except for scattered large (cm size) pink mottles

Unit 2

Siliceous mudstone, green (5G 5/1) to olive brown (2.5Y 5/4) and dark yellow brown (10YR 4/4)

Very firm to cherty

Generally homogeneous

Smear slides show quartz, mica, clay, glass, radiolaria fragments, zeolites and opaque minerals

Dark clay material binds sediment lumps together

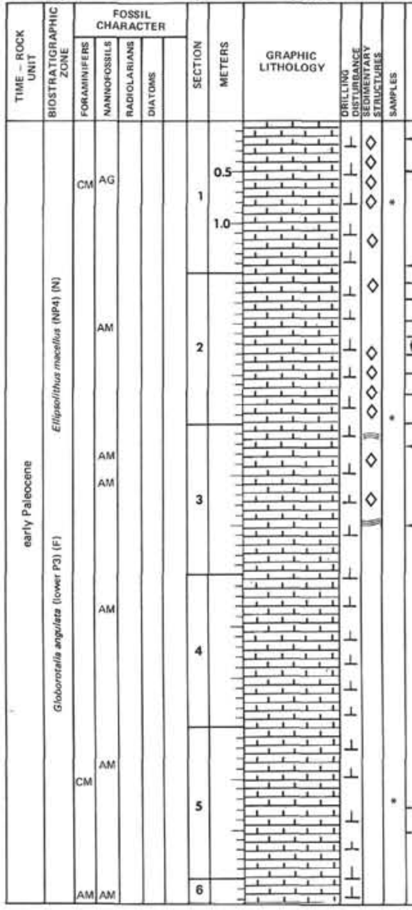
Unit 3

Smear slide shows: quartz, mica, glass, abundant clay sized material (black) binding particles together

SMEAR SLIDE SUMMARY (%):

	1, 120	2, 120	4, 114
	D	D	D
Texture:			
Sand	5	20	5
Silt	40	50	35
Clay	55	30	60
Composition:			
Quartz	25	10	Tr
Mica	7	5–10	–
Clay	40	30	5
Glass	5	50	–
Carbonate unspec.	Tr–10	Tr	25
Calc. nannofossils	5	–	70
Radiolarians	–	–	Tr

SITE 550 HOLE CORE 37 CORED INTERVAL 432.0–441.5 m



LITHOLOGIC DESCRIPTION

10YR 7/3 Green lenses
10YR 8/3
Green mottles
10YR 7/3
Pale brown
Green concretion
10YR 7/3
5Y 7/1, greenish gray
10YR 7/1
Abundant green flecks
5Y 7/2
Abundant green flecks
5Y 7/2
Abundant green flecks
10GY 5/2
Green lamina
Light green
Green lamina
5Y 6/1, olive gray
5Y 7/1
5Y 7/1
Gradual contact
5Y 6/1
Sharp contact
5Y 7/1
5Y 7/1

Unit

Nannofossil chalk, pale brown (10YR 8/3) to gray (5Y 7/1–6/1), hard

Homogeneous with scattered pink (1 cm size) mottles down to Section 3, and greenish smaller mottles scattered throughout

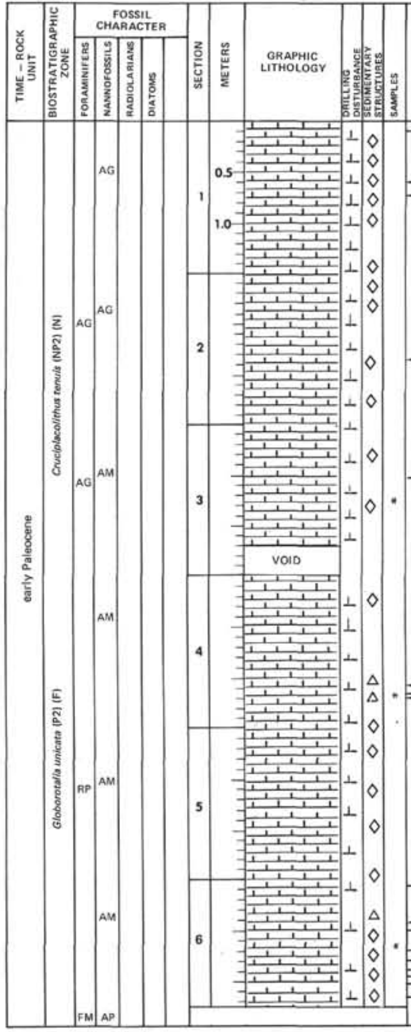
Green mottles concentrate at certain horizons, x-ray indicates presence of glauconite or a smectite

Most contacts, except where laminated, are gradational

SMEAR SLIDE SUMMARY (%):

	1, 77	5, 70
	D	D
Texture:		
Silt	7	3
Clay	93	97
Composition:		
Quartz	–	Tr
Mica	Tr	Tr
Clay	<5	<2
Carbonate unspec.	10	5
Foraminifers	Tr	–
Calc. nannofossils	85	93

SITE 550 HOLE CORE 38 CORED INTERVAL 441.5–451.0 m



LITHOLOGIC DESCRIPTION

2.5Y 6/0
5GY 7/1
Green bands
5GY 7/1
5GY 7/1
Green band
Green band
5GY 7/1
Calcareous sand
Sharp base
Mottled base
5Y 7/1
5Y 7/1
5GY 7/1
5Y 7/1
5GY 7/1
Strong burrowing
Laminated
calcareous sandstone
10YR 7/2
5GY 8/1
20YR 7/2
5Y 7/2
Silicified band
10YR 6/3
5Y 7/1 + 10YR 8/2

Unit

Nannofossil chalk, grayish green (5GY 7/1) to pale brown (10YR 7/2) and gray (5Y 7/2), hard

Homogeneous with scattered small dark gray mottles

Occasional straight thin bands of darker green

Several graded units with calcareous silt and sand at base

Lower part of core is banded in pale brown (10YR 7/2) and green, contacts are generally mottled unless at base of graded unit

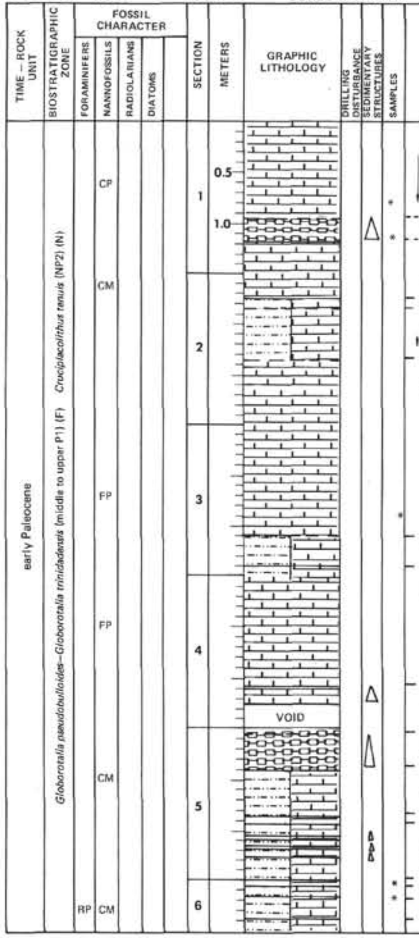
SMEAR SLIDE SUMMARY (%):

	3, 72	4, 117	6, 67
	D	D	D
Texture:			
Sand	–	30	–
Silt	–	40	7
Clay	–	30	93
Composition:			
Mica	–	Tr	–
Clay	<3	<5	<5
Volcanic glass	–	Tr	Tr
Zeolite	–	Tr	Tr
Carbonate unspec.	10	75	10
Foraminifers	Tr	–	Tr
Calc. nannofossils	87	25	85
Radiolarians	–	Tr	–

ORGANIC CARBON AND CARBONATE (%):

	6, 66
Carbonate	63

SITE 550 HOLE CORE 39 CORED INTERVAL 451.0–460.5 m



LITHOLOGIC DESCRIPTION

10Y 7/4, very pale brown
grades
5Y 7/3, pale yellow
5Y 8/1, white
10YR 7/4, very pale brown
5GY 7/1, light greenish gray
7.5Y 6/4, light brown
grades
5GY 7/1, light greenish gray
7.5Y 6/4, lighs brown
5GY 7/1
7.5YR 6/4, light brown
7.5YR 6/4–5/4, light brown–brown
5Y 8/1, white
7.5YR 6/4–5/4, light brown–brown
10YR 5/3, brown
Interbedded 5GY 7/1 graded units and 7.5YR 6/4 homogeneous units
5GY 7/1
5YR 5/6–10YR 6/4
10YR 5/3–4/3, brown–dark brown
10YR 6/4, light yellowish brown

Interbedded grayish turbitite units and brownish nannofossil chalks

Turbidite units are white (5Y 8/1) to light greenish gray (5GY 7/1), graded and largely unburrowed. The turbidite in Section 1, 95–116 cm is underlain by a thick slump layer (Section 1, 116 cm–Section 2, 25 cm). Turbidites consist primarily of reworked nannofossil chalk with some foraminifer and radiolarian debris.

Nanno chalks are various shades of brown, firm, homogeneous, and extensively burrowed. They contain occasional spots and veins of gray (5GY 7/1).

Note: due to hardness of sediment it is difficult to estimate composition abundances with smear slides.

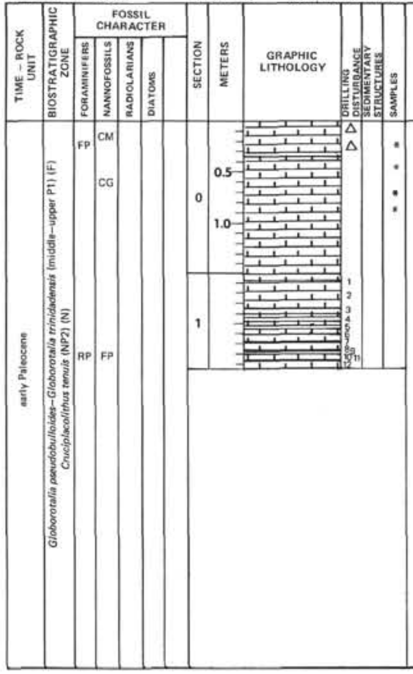
SMEAR SLIDE SUMMARY (%):

	1, 80 D	1, 113 D	3, 85 D	6, 4 D	6, 20 D
Texture:					
Sand	–	20	–	–	–
Silt	10	20	20	10	10
Clay	90	60	80	90	90
Composition:					
Quartz	Tr	Tr	–	–	–
Clay	Tr	Tr	Tr	–	Tr
Carbonate unspec.	20	20	20	15	15
Calc. nannofossils	75	75	75	80	80

ORGANIC CARBON AND CARBONATE (%):

	2, 30	5, 92
Carbonate	68	38

SITE 550 HOLE CORE 40 CORED INTERVAL 460.5–470.0 m



LITHOLOGIC DESCRIPTION

Hard, gray (5Y 7/1), homogeneous nanno chalk. This section was severely distorted during extraction from core barrel – barrel had to be heated. Color and homogeneous texture may not be original.

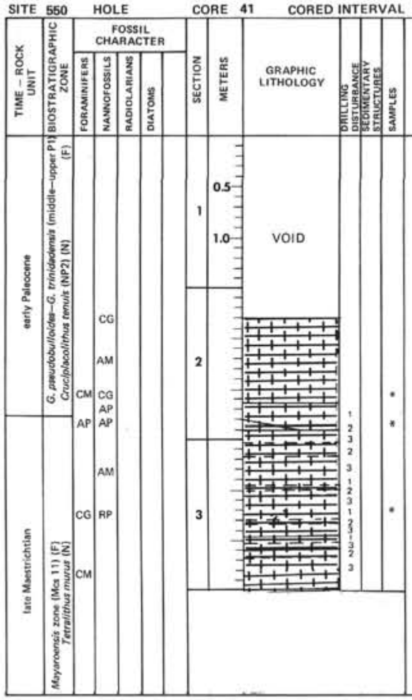
Section 1: complex series of interbedded lithologies –

(1) pink (7.5YR 7/4), homogeneous, nanno chalk
(2) brown to dark brown (10YR 4/3–3/3), homogeneous, bioturbated, firm, nannofossil chalk
(3) and (6) light yellowish brown (10YR 6/4), firm, homogeneous, bioturbated, nanno chalk
(4), (8), and (11) light greenish gray (5GY 7/1), highly bioturbated, firm, nanno chalk
(5) yellowish red (5YR 5/8) to red (2.5YR 4/8), laminated, weakly bioturbated, firm, nanno chalk
(7) brown (10YR 4/3), homogeneous, unbioturbated, firm, nanno chalk
(9) very dark grayish brown (10YR 3/2), homogeneous, firm, nanno chalk
(10) pink (5YR 8/4), highly bioturbated, firm, nanno chalk
(12) very pale brown (10YR 7/3), bioturbated, firm, nanno chalk

SMEAR SLIDE SUMMARY (%):

	1, 25 D	1, 45 D	1, 71 D	1, 88 D
Texture:				
Silt	5	10	10	10
Clay	95	90	90	90
Composition:				
Quartz	–	Tr	Tr	–
Feldspar	–	Tr	Tr	–
Clay	15	15	10	15
Carbonate unspec.	10	20	10	30
Calc. nannofossils	70	60	70	50
Radiolarians	–	–	–	Tr
Sponge spicules	Tr	–	Tr	5

SITE 550 HOLE CORE 41 CORED INTERVAL 470.0–479.5 m



LITHOLOGIC DESCRIPTION

Very pale brown (10YR 7/4–8/3) mottled with light greenish gray (5GY 7/1), weakly bioturbated, firm, homogeneous, nannofossil chalk.

Section 2, 115 cm to base of core consists of 3 alternating lithologies, with extremely gradational contacts (except where noted):

(1) very pale brown (10YR 8/3), highly bioturbated, firm, nanno chalk

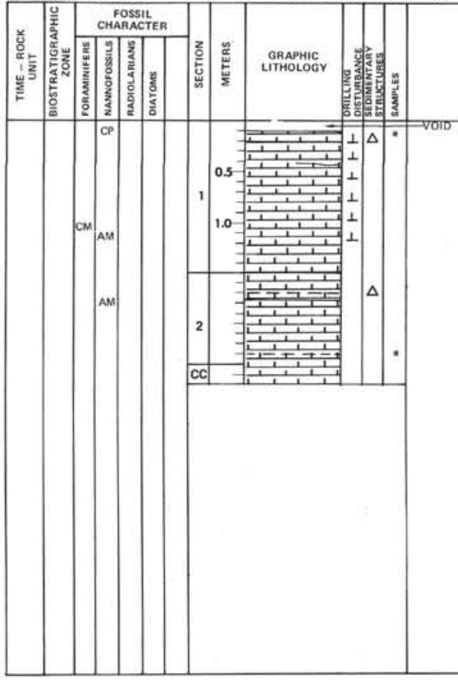
(2) yellowish brown (10YR 5/6), only weakly bioturbated, occasionally laminated from nanno chalk

(3) pale brown–light yellowish brown (10YR 7/4–6/4), homogeneous, firm, nanno chalk. Bioturbation variable – often intense at top and bottom of (3), absent in center.

SMEAR SLIDE SUMMARY (%):

	2, 108	2, 138	3, 70
	D	D	D
Texture:			
Sand	–	30	–
Silt	10	30	5
Clay	90	40	95
Composition:			
Quartz	–	Tr	–
Clay	20	10	10
Carbonate unspec.	20	15	15
Foraminifers	Tr	10	–
Calc. nannofossils	55	40	70
Diatoms	–	} 20	–
Radiolarians	–		–
Sponge spicules	Tr	Tr	5

SITE 550 HOLE CORE 42 CORED INTERVAL 479.5–489.0 m



LITHOLOGIC DESCRIPTION

Section 1, 0–20 cm: 5YR 8/4, graded turbidite unit containing clasts up to 3 *mm* at base. Clasts are largely *nanno chalk*.

Section 1, 20–150 cm: yellowish brown to very pale brown (10YR 5/6–7/3), firm, highly bioturbated, nanno chalk.

Section 2, 0–20 cm: pink (7.5YR 7/4–8/4), homogeneous, nanno chalk.

Section 2, 20–25 cm: pink (5YR 8/4), turbidite unit, laminated in upper part, pink and black clasts in lower part.

Section 2, 25–80 cm: light yellowish brown (7.5YR 6/4), homogeneous, firm, bioturbated nanno chalk.

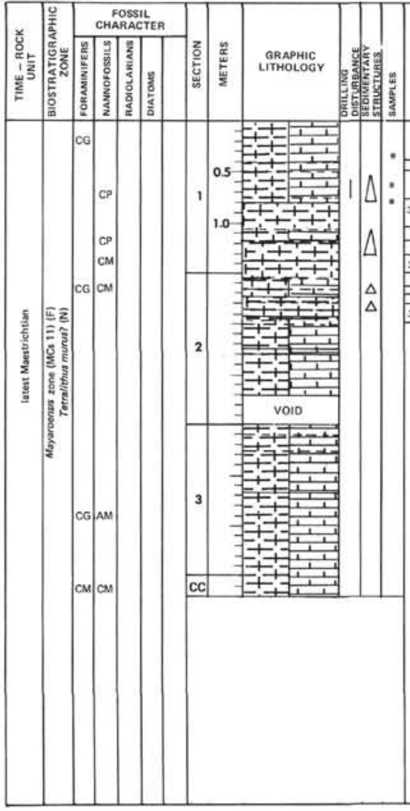
Section 2, 80–90 cm: pink (7.5YR 7/4), homogeneous, firm, nanno chalk.

CC: strong brown (7.5YR 5/8), homogeneous, bioturbated, firm, nanno chalk.

SMEAR SLIDE SUMMARY (%):

	1, 12	2, 80
	D	D
Texture:		
Sand	20	5
Silt	20	10
Clay	60	85
Composition:		
Quartz	Tr	Tr
Clay	20	20
Carbonate unspec.	20	20
Foraminifers	Tr	5
Calc. nannofossils	40	40
Sponge spicules	5	10

SITE 550 HOLE CORE 43 CORED INTERVAL 489.0–498.5 m



LITHOLOGIC DESCRIPTION

Interbedded turbidite and pelagic sediment

(1) brown (7.5YR 4/4), heavily bioturbated from nanno chalk

(3) pink (7.5YR 8/4), unbioturbated, fine grained turbidites consisting primarily of nanno chalk fragments, firm, graded, clasts up to 1 mm

(2) = (1) + (3) mixed by bioturbation

Section 2, 50–72 cm: brown (7.5Y 4/4), homogeneous unbioturbated, firm nanno chalk.

Section 2, 72–78 cm: blue gray (5GY 7/1) and brown (7.5Y 4/4) laminated nanno chalk.

Section 2, 78–120 cm: brown (7.5Y 4/4), bioturbated, firm, nanno chalk.

Section 3, 0–10 cm reddish yellow (5YR 6/6), bioturbated, firm, nanno chalk.

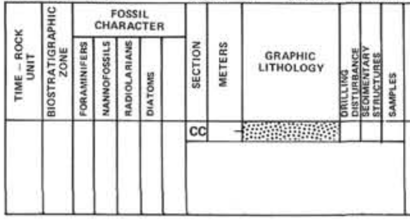
Section 3, 25–65 cm: pink (7.5YR 8/4), homogeneous, firm, unbioturbated, nanno chalk, 1 cm laminated, basalt turbidite? layer at base.

Section 3, 65–150 cm: reddish brown to pink (5Y 4/8 to 7.5YR 7/4), highly bioturbated nanno chalk.

SMEAR SLIDE SUMMARY (%):

	1, 36	1, 63	1, 80
	D	D	D
Texture:			
Sand	–	5	20
Silt	20	15	40
Clay	80	80	40
Composition:			
Quartz	Tr	Tr	5
Feldspar	–	Tr	–
Clay	10	20	20
Carbonate unspec.	10	30	10
Calc. nannofossils	50	30	20
Radiolarians	20	10	20
Sponge spicules	–	Tr	–
Nannofossil chalk fragments (reworked)	–	–	20

SITE 550 HOLE CORE 44 CORED INTERVAL 498.5–508.0 m

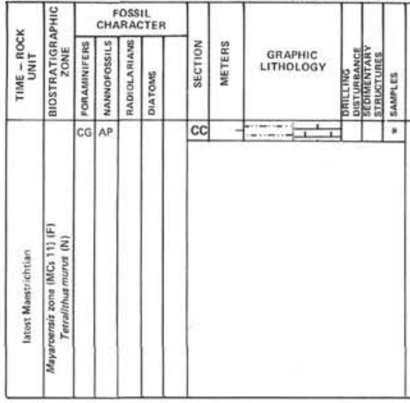


LITHOLOGIC DESCRIPTION

Core-Catcher only: white (5Y 8/1), laminated, hard, siltstone/sandstone.

Note: too hard for smear slide.

SITE 550 HOLE CORE 45 CORED INTERVAL 508.0–517.5 m



LITHOLOGIC DESCRIPTION

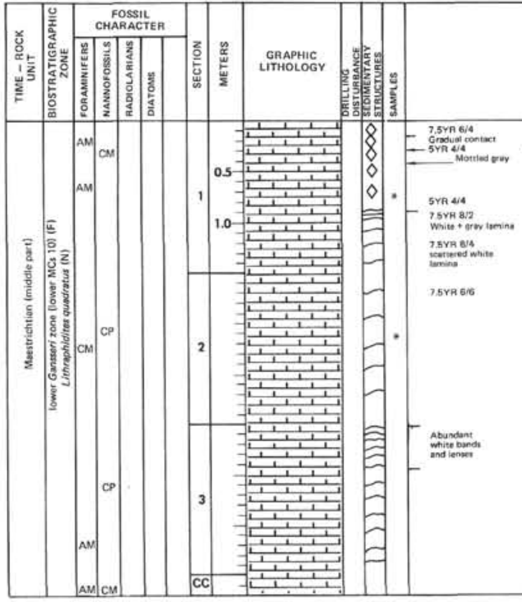
Trace in Core-Catcher only: firm, brown, marly nanno chalk.

SMEAR SLIDE SUMMARY (%):

	CC
	D
Texture:	
Clay	100
Composition:	
Quartz	Tr
Clay	40
Carbonate unspec.	5
Calc. nannofossils	40
Radiolarians Sponge spicules	} 10

Core 46: no recovery.

SITE 550 HOLE CORE 47 CORED INTERVAL 522.0–527.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, light brown (7.5YR 6/4) to reddish brown (5YR 4/4), firm

Upper part of Section 1 is well mottled, streaked horizontally

Rest of core is faintly to well laminated in bands and streaks of white and gray (lamina up to 10 or 15 cm apart)

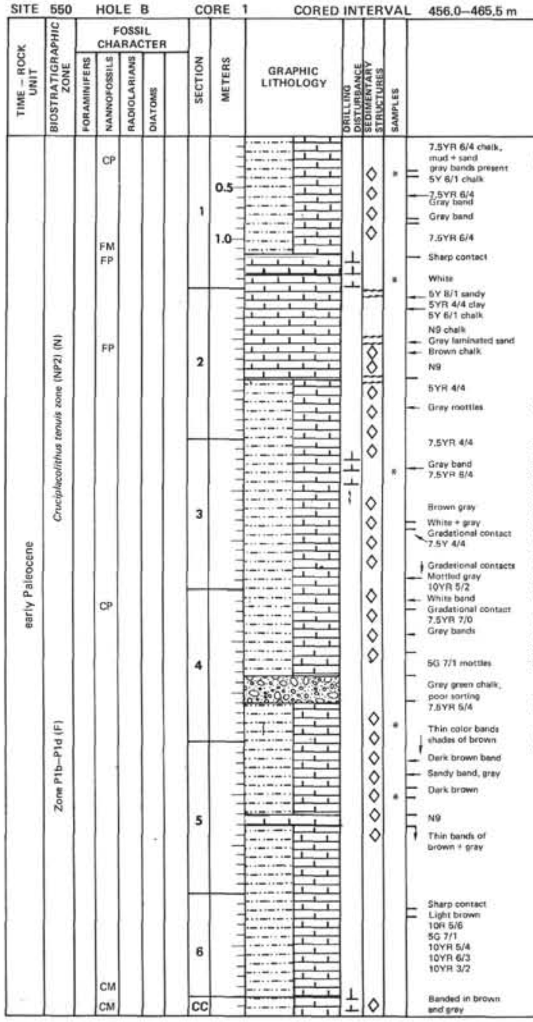
Chalk is occasionally cracked, nearly parallel to drilling direction and in at least two planes

Cracks are lined by white chalk (leaching?)

SMEAR SLIDE SUMMARY (%):

	1, 76	2, 64
	D	D
Texture:		
Sand	Tr	Tr
Silt	10	10
Clay	90	90
Composition:		
Heavy minerals	5	5
Clay	5	10
Carbonte unspec.	15	15
Foraminifers	5	–
Calc. nannofossils	70	70

SITE 550 HOLE B CORE 1 CORED INTERVAL 456.0–465.5 m



LITHOLOGIC DESCRIPTION

Unit

Marly nannofossil chalk with bands of nannofossil chalk, marly units are light brown, brown (7.5YR 6/4–10YR 3/2), and gray (5Y 6/1) to green (5G 7/1), chalks are white, sediment is firm to hard

Most color contacts are rapidly transitional with mottling, or are sharp

Gray bands are often sandy in upper part of core, sand is mostly calcareous parts

All marly sediments contain euhedral grains of carbonate

Section 4 (110 cm and below) contain common volcanic glass

In Section 4 is a poorly sorted chalk pebble conglomerate – mud supported

Foraminifer are concentrated in the sandier units

Scattered stylolites – mm thick

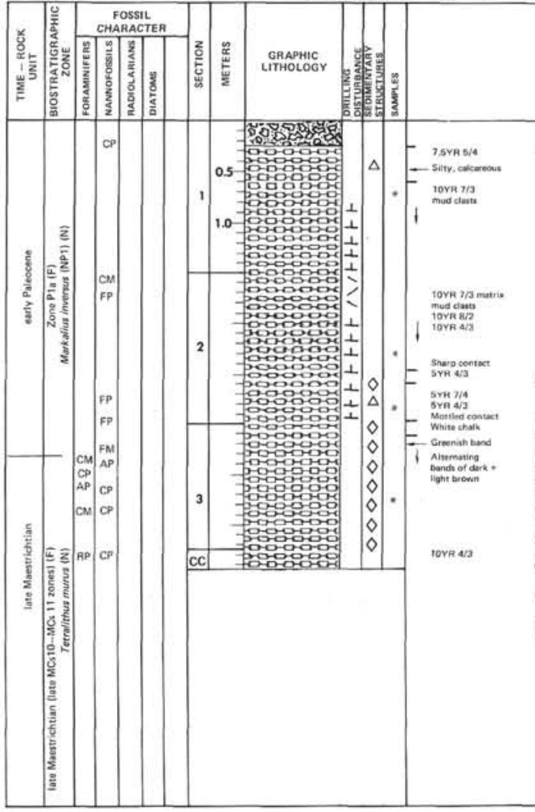
SMEAR SLIDE SUMMARY (%):

	1, 39	1, 140	3, 30	4, 135	5, 53
	D	D	D	D	D
Texture:					
Sand	20	15	20	7	20
Silt	30	35	30	30	20
Clay	40	50	50	60	60
Composition:					
Quartz	10	5	Tr	5	5
Mica	1–5	5	15	10	7
Clay	20	5	30	30	30
Volcanic glass	–	–	–	5	5–10
Glauconite	5	–	–	–	–
Carbonate unspec.	5–10	10	10	8	5
Foraminifers	15	10	10	Tr	–
Calc. nannofossils	50	60	30	40	40
Sponge spicules	Tr	–	–	–	–
Small dark red minerals	–	<5	–	–	–

ORGANIC CARBON AND CARBONATE (%):

	2, 35	2, 98	6, 105
Organic carbon	–	0.08	0.05
Carbonate	95	46	33

SITE 550 HOLE B CORE 2 CORED INTERVAL 465.5–475.0 m



LITHOLOGIC DESCRIPTION

Unit

Calcareous chalk, light brown (10YR 7/3) to brown (10YR 4/3), firm to hard

One bed of white chalk

Most contacts are sharp or mottled

Section 1 and upper part Section 2 composed of mm to cm size mud clasts (oval, banded) along with plain white, gray, and yellow clasts in a light brown mud matrix

Lower part of Section 3 is banded in shades of light and dark brown over intervals of 5–20 cm, contacts gradational

Sediment is dominanted by calcareous fragments, darker sediment contains more terrigenous material

Base of graded units are calcareous, often rich in foram fragments

Rock contains several mineral lined fractures

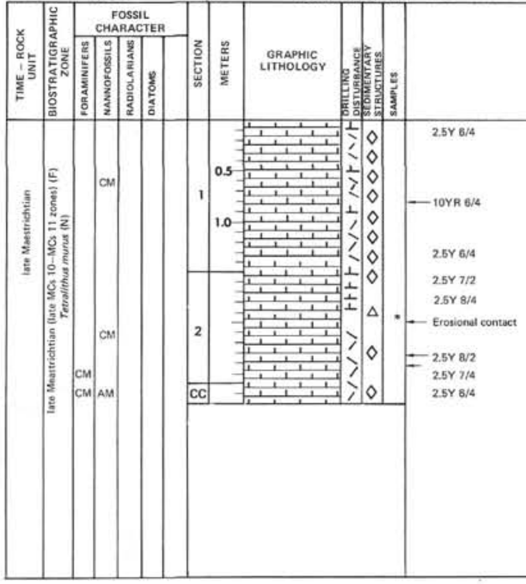
SMEAR SLIDE SUMMARY (%):

	1, 70	2, 81	2, 132	3, 75
	D	D	D	D
Texture:				
Sand	Tr	Tr	50	–
Silt	5	10	30	–
Clay	95	90	20	100
Composition:				
Quartz	–	–	Tr	–
Clay	10	10	<3	10
Volcanic glass	–	–	Tr	–
Carbonate unspec.	70	60	57	70
Foraminifers	Tr	–	25	–
Calc. nannofossils	20	25	15	20

ORGANIC CARBON AND CARBONATE (%):

	1, 138	3, 29	3, 119
Organic carbon	0.07	0.04	0.03
Carbonate	87	30	54

SITE 550 HOLE B CORE 3 CORED INTERVAL 475.0–484.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, light gray (2.5Y 7/2) to light yellow brown (2.5Y 6/4), firm to hard

Contains one graded unit with calcareous sand at base and homogeneous mudstone above and below, other parts of core are well to moderately mottled in shades of primary color

Lower part of Section 1 is enriched in dark flecks of unidentified mineral

All sediment has abundant carbonate fragments

Homogeneous sections have crisscrossing network of fine pressure solution lines

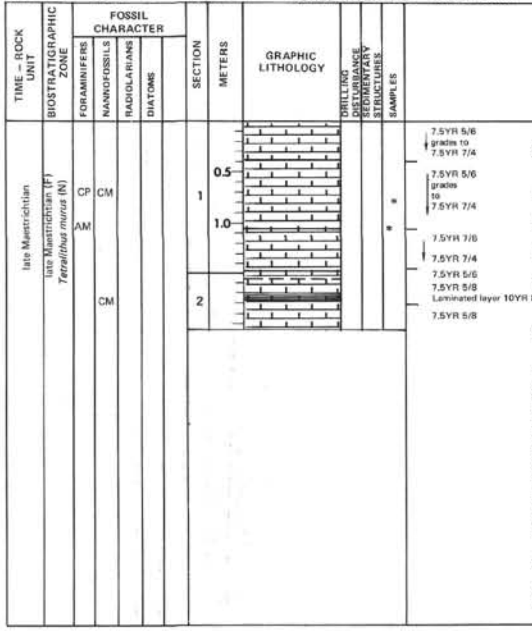
SMEAR SLIDE SUMMARY (%):

	2, 12	2, 46
	D	D
Texture:		
Sand	–	25
Silt	20	35
Clay	80	40
Composition:		
Clay	5	15
Carbonate unspec.	45	20
Foraminifers	10	30
Calc. nannofossils	40	35

ORGANIC CARBON AND CARBONATE (%):

	2, 66
Organic carbon	0,04
Carbonate	87

SITE 550 HOLE B CORE 4 CORED INTERVAL 484.5–494.0 m



LITHOLOGIC DESCRIPTION

Series of sedimentary cycles, color grading from brown (7.5YR 5/6) at top to pink (7.5YR 7/4) or white (10YR 8/2) at the base.

Bioturbation intense at top of each unit, weak or absent at the base.

Base of each unit represents turbidite deposition, top is pelagic reds.

Coarse pelagic debris (foram radiolarian etc.) are concentrated at the base of each cycle, which may be laminated.

All sediments are marly nanno chalks.

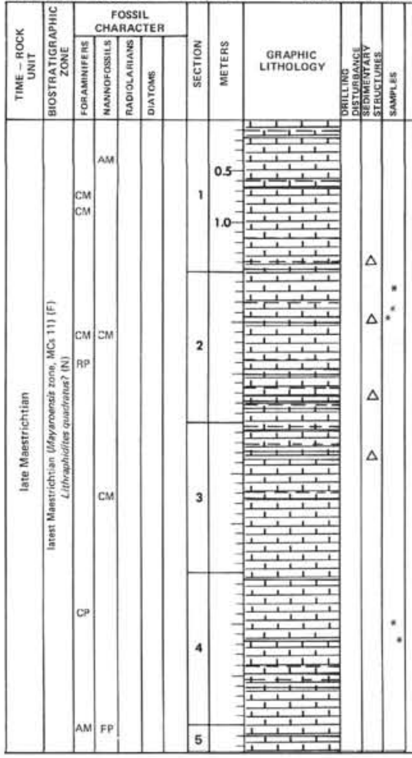
SMEAR SLIDE SUMMARY (%):

	1, 75	1, 105
	D	D
Texture:		
Sand	–	10
Silt	–	20
Clay	100	70
Composition:		
Quartz	–	Tr
Clay	30	20
Carbonate unspec.	20	20
Foraminifers	–	5
Calc. nannofossils	45	45
Radiolarians	–	< 5
Sponge spicules	Tr	< 5

ORGANIC CARBON AND CARBONATE (%):

	1, 15
Organic carbon	0.04
Carbonate	83

SITE 550 HOLE B CORE 5 CORED INTERVAL 494.0–503.5 m



LITHOLOGIC DESCRIPTION

Alternation of pelagic marly nanno chalk and redeposited nanno chalk units.

(1) Strong brown (7.5YR 5/6), brown (7.5YR 5/4), and yellowish red (7.5YR 7/6), highly bioturbated, firm, massive, marly nanno chalk

(2) Pink (7.5YR 8/4), massive, fine-grained, homogeneous, unbioturbated (the upper 5 cm of lithology 2 may be mixed with 1 by bioturbation from above) 'distal turbidite'.

(3) White–light gray (5Y 8/1–7/2) 'proximal turbidite' often graded, laminated or crosslaminated and containing clasts of nanno chalk, forams, and radiolarian debris.

All sediments are marly nanno chalks.

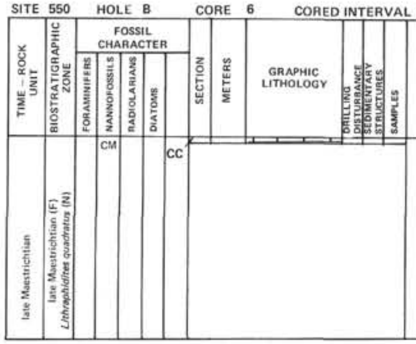
SMEAR SLIDE SUMMARY (%):

	2, 18	2, 39	2, 47	4, 50	4, 66
	D	D	D	D	D
Texture:					
Sand	–	5	5	–	–
Silt	10	10	20	10	–
Clay	90	85	75	90	–
Composition:					
Quartz	Tr	–	10	5	10
Clay	20	20	20	20	20
Carbonate unspec.	40	45	35	45	35
Foraminifers	–	Tr	<5	–	–
Calc. nannofossils	35	30	20	25	30
Radiolarians	–	–	<5	–	–
Sponge spicules	Tr	<5	<5	Tr	Tr

ORGANIC CARBON AND CARBONATE (%):

	2, 15
Organic carbon	0.05
Carbonate	77

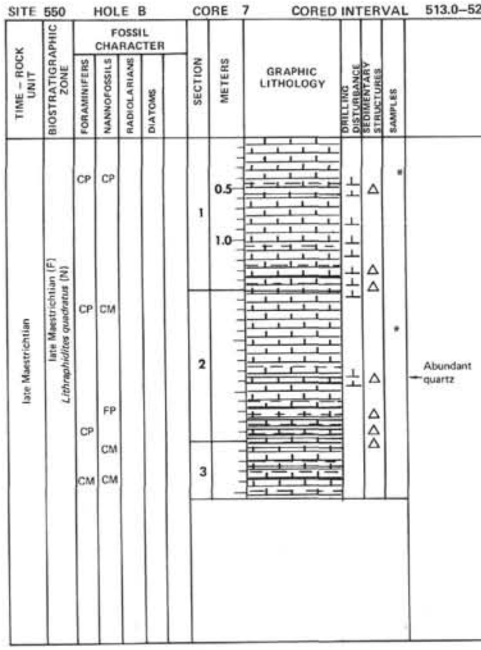
SITE 550 HOLE B CORE 6 CORED INTERVAL 503.5–513.0 m



LITHOLOGIC DESCRIPTION

Core-Catcher only: 4 cm piece, brown (7.5YR 5/6), bioturbated marly nannofossil chalk.

SITE 550 HOLE B CORE 7 CORED INTERVAL 513.0–522.5 m



LITHOLOGIC DESCRIPTION

Interbedded:

(1) Brown (7.5YR 5/6–7/6), highly bioturbated, firm, homogeneous, marly nanno chalk

(2) Pink (7.5YR 8/4), massive, homogeneous, unbioturbated 'distal' turbidite, very fine grained, occasionally weakly laminated at base – calcareous chalk

(3) White (7.5YR 8/1) and light greenish gray (5GY 6/1), course grained, laminated or cross-laminated, always unbioturbated, calcareous

Sediments rich in fine carbonate particles, many of which are nearly euhedral.

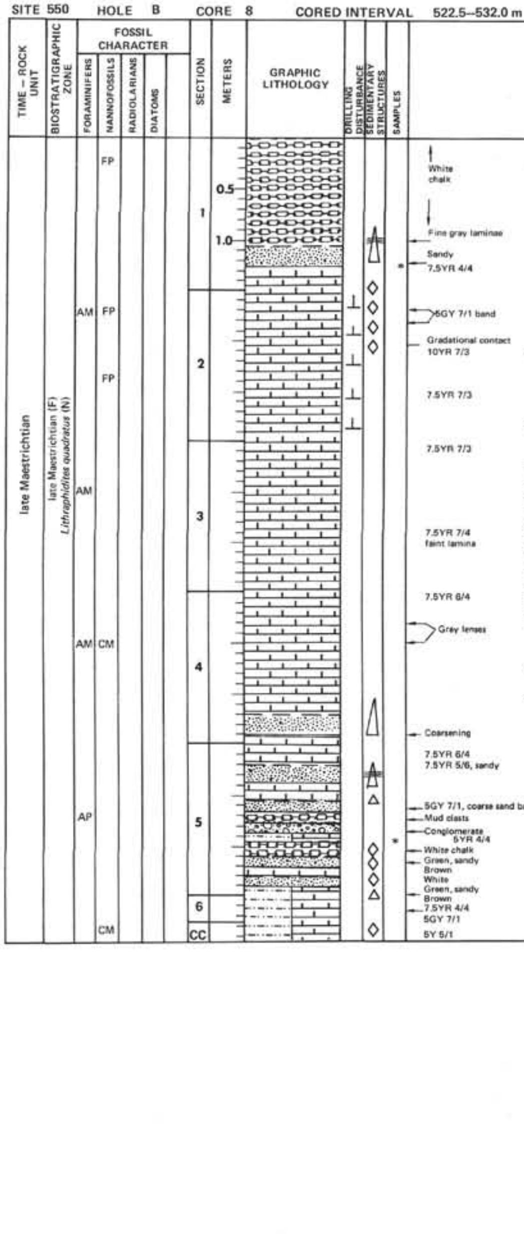
SMEAR SLIDE SUMMARY (%):

	1, 32	2, 38
	D	D
Texture:		
Sand	15	5
Silt	65	45
Clay	20	50
Composition:		
Quartz	Tr	Tr
Mica	Tr	Tr
Clay	Tr	Tr–10
Carbonate unspec.	70	40
Foraminifers	5–10	Tr
Calc. nannofossils	5–10	40

ORGANIC CARBON AND CARBONATE (%):

	1, 17	1, 102	2, 88
Organic carbon	–	0.13	0.05
Carbonate	95	56	91

SITE 550 HOLE B CORE 8 CORED INTERVAL 522.5–532.0 m



LITHOLOGIC DESCRIPTION

Unit 1

Calcareous chalk, nannofossil chalk, and marly nannofossil chalk, white, very pale brown (10YR 7/3) to brown (7.5YR 4/4) and gray green (5GY 7/1), hard

White beds are generally homogeneous and often grade down to sandy units

Top contacts often mottled, basal contacts are sharp

Pale brown unit often homogeneous, Sections 2, 3, 4 and contain visible scattered small dark mineral grains, faint lamination visible

Brown and gray green beds are mottled, basal contacts often mottled, tops often sharp

Unit 2

Graded beds, usually gray green, laminated with basal sand composed largely of calcareous fragments and foraminifera, downward color sequence: brown, white, green

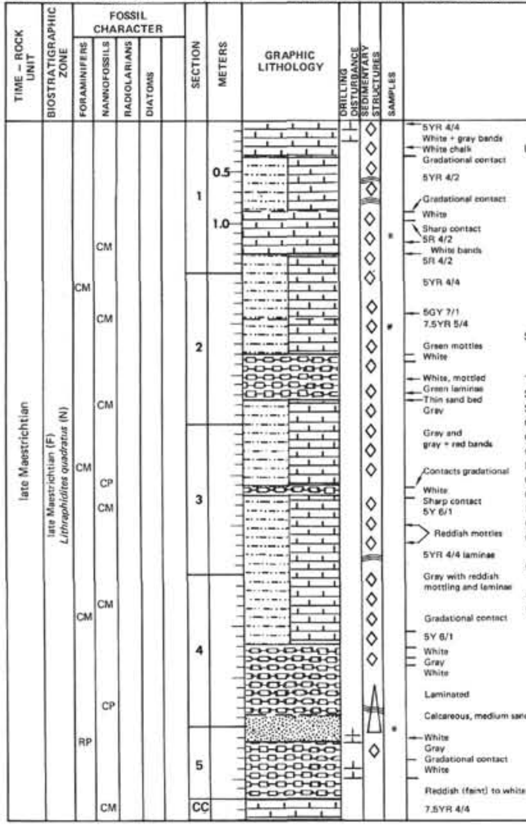
SMEAR SLIDE SUMMARY (%):

	1, 124	5, 90
	D	D
Texture:		
Sand	80	15
Silt	15	35
Clay	5	50
Composition:		
Quartz	5–10	Tr
Mica	Tr	5
Clay	Tr	30
Carbonate unspec.	90	20
Foraminifers	5	–
Calc. nannofossils	Tr	40
Dark reddish mineral	–	5–10

ORGANIC CARBON AND CARBONATE (%):

	1, 15	5, 15	5, 50	5, 56	6, 1
Carbonate	92	86	82	73	43

SITE 550 HOLE B CORE 9 CORED INTERVAL 532.0–541.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk and marly nannofossil chalk, white and homogeneous to brown (5YR 4/4) or gray (5YR 4/2, 5R 4/2, 5Y 6/1) and bioturbated, firm to hard

Most contacts are gradational except at base of white chalks, which are often sharp. White sediment usually passes into gray or brown sediment upward, with a rapid mottled transition

Green color usually associated with sandier beds which undertie white chalks occasionally

Graded unit at base of Section 4 is calcareous throughout and well laminated, sand at base is finely crossbedded.

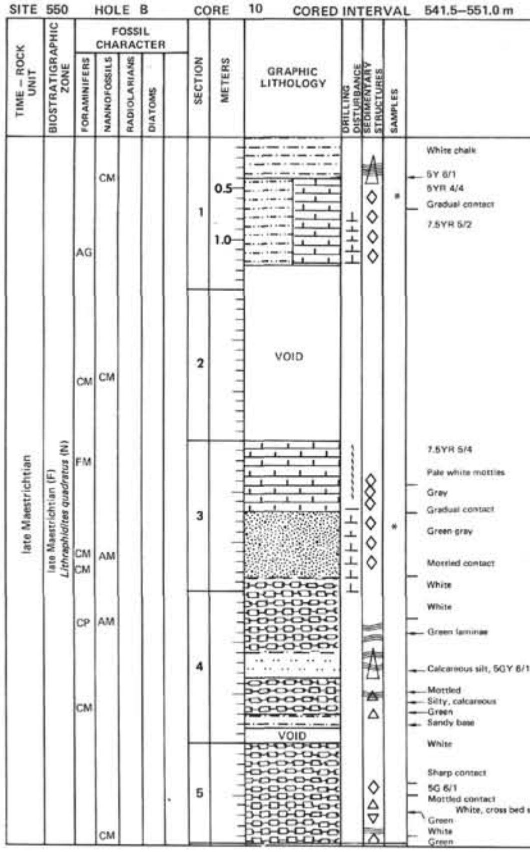
SMEAR SLIDE SUMMARY (%):

	1, 111	2, 51	5, 4
	D	D	D
Texture:			
Sand	–	–	15
Silt	–	15	40
Clay	–	85	45
Composition:			
Quartz	–	–	1
Heavy minerals	–	5	–
Clay	–	10	5
Carbonate unspec.	–	10	10
Foraminifers	–	–	15
Calc. nannofossils	–	75	70
Calcite vein	100	–	–

ORGANIC CARBON AND CARBONATE (%):

	3, 80	4, 1
Organic carbon	0.11	0.11
Carbonate	48	42

SITE 550 HOLE B CORE 10 CORED INTERVAL 541.5–551.0 m



LITHOLOGIC DESCRIPTION

Unit

Marly nannofossil, nannofossil and calcareous chalk, brown (5YR 4/4), green gray (5GY 6/1) and white, firm to hard

Green and brown beds are usually well mottled, white beds are homogeneous to faintly laminated

Colored beds have mottled contacts with one another, white bed contacts above generally are mottled, contacts below are usually sharp

White beds often grade downwards to a silty or sandy calcareous chalk with green laminae or crossbedding

Typical upward color sequence in lower part of core is: green sand, white chalk, green gray chalk

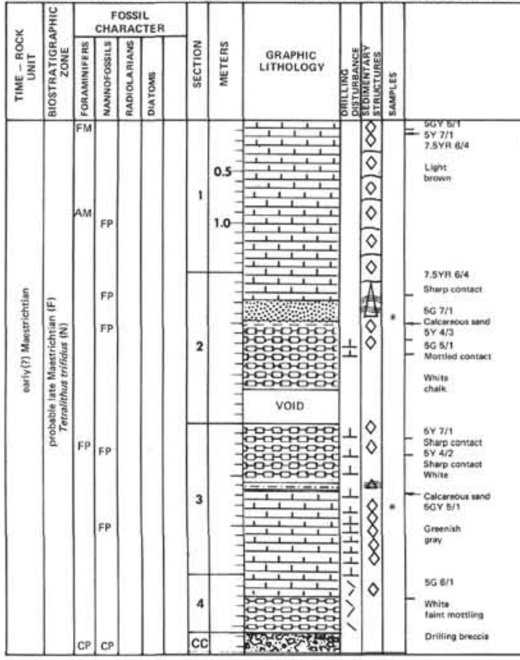
SMEAR SLIDE SUMMARY (%):

	1, 56	3, 85
	D	D
Texture:		
Sand	5	30
Silt	55	40
Clay	40	30
Composition:		
Quartz	5–10	Tr
Mica	Tr–5	–
Clay	30	<3
Volcanic glass	Tr–5	–
Carbonate unspec.	10	40
Foraminifers	Tr	15
Calc. nannofossils	40	42
Dark anhedral mineral	Tr	–

ORGANIC CARBON AND CARBONATE (%):

	1, 49	4, 41
Carbonate	42	41

SITE 550 HOLE B CORE 11 CORED INTERVAL 551.0–560.5 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil to calcareous chalk, light brown (7.5YR 6/4) to gray (5Y 7/1) and green gray (5GY 5/1, 5G 6/1), and white, firm to hard

All beds well mottled except white chalks which are generally homogeneous

White chalks often grade downwards to greenish laminated calcareous silt or sandstone

Bases of sand units and white chalks are usually sharp, other contacts usually mottled or gradational

Light brown chalk of Section 1 is laminated as well as bioturbated

Glauconite appears to be present in green sandy beds

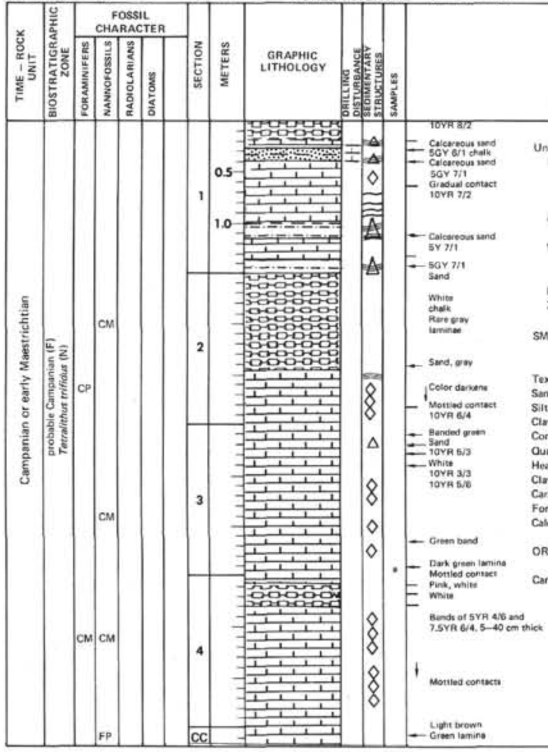
SMEAR SLIDE SUMMARY (%):

	2, 45	3, 85
	D	D
Texture:		
Sand	25	10
Silt	45	20
Clay	30	70
COMPOSITION:		
Quartz	5	–
Mica	2	1
Heavy minerals	–	2
Clay	–	17
Glauconite	7	–
Carbonate unspec.	45	10
Foraminifers	5	–
Calc. nannofossils	35	70

ORGANIC CARBON AND CARBONATE (%):

	1, 33	2, 24	3, 52
Carbonate	82	82	90

SITE 550 HOLE B CORE 12 CORED INTERVAL 560.5–570.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil and calcareous (white) chalk, light yellow brown (10YR 6/4), yellow red (5YR 4/6), gray (5Y 7/1) and occasionally brown (10YR 5/3, 3/3, more clayey), firm to hard

Colored chalk is mottled and contacts are generally gradational

White chalk is usually homogeneous and can grade down to green (5GY 7/1) laminated calcareous sand with a sharp, often erosional, base

Base contacts of white chalk usually sharp

XRD suggests green color due to clay minerals

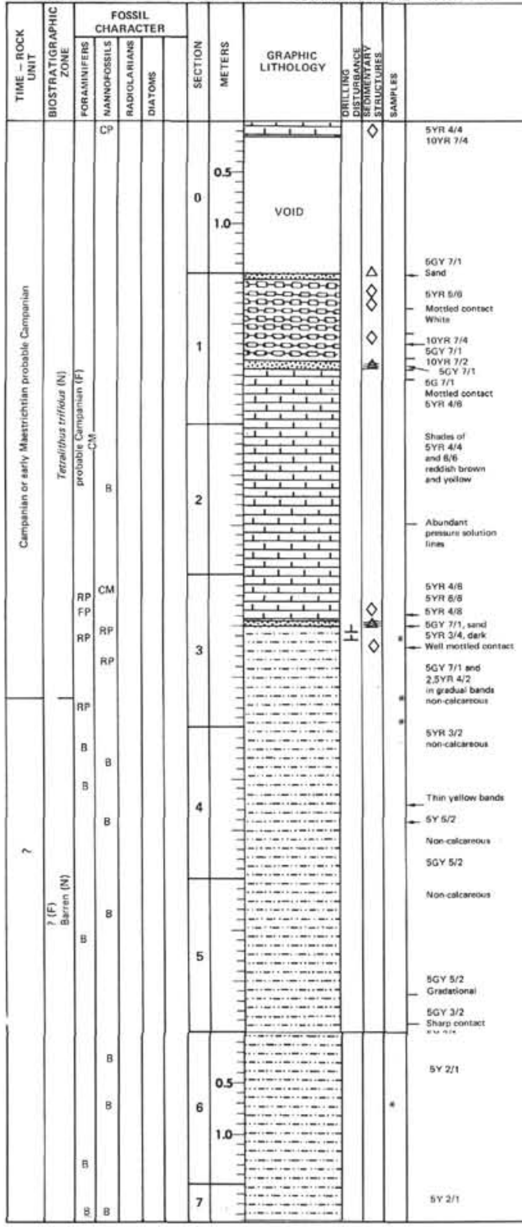
SMEAR SLIDE SUMMARY (%):

	3, 148
	D
Texture:	
Sand	10
Silt	30
Clay	60
Composition:	
Quartz	5
Heavy minerals	5
Clay	10
Carbonate unspec.	10
Foraminifers	1
Calc. nannofossils	70

ORGANIC CARBON AND CARBONATE (%):

	1, 85	3, 49	4, 40
Carbonate	85	35	58

SITE 550 HOLE B CORE 13 CORED INTERVAL 570.0–579.5 m



LITHOLOGIC DESCRIPTION

Unit 1

Nannofossil chalk and white calcareous chalk, reddish brown (5YR 4/4), to light gray (10YR 7/1), firm to hard

Colored chalks well bioturbated and often show pressure solution lines, contacts transitional to mottled

White chalk generally homogeneous with lower contacts that are either sharp or grade down to laminated light green sandstones; upper contact usually mottled

Unit 2

Mudstone, light green (5GY 7/1) to reddish (2.5YR 4/2) with intermediate shades, becoming darker green (5GY 5/2, 3/2) to base, homogeneous, rich in quartz and clay size fraction

Unit 3

Silty mudstone, black (5Y 2/1) *massive, homogeneous, non-calcareous*, firm to hard

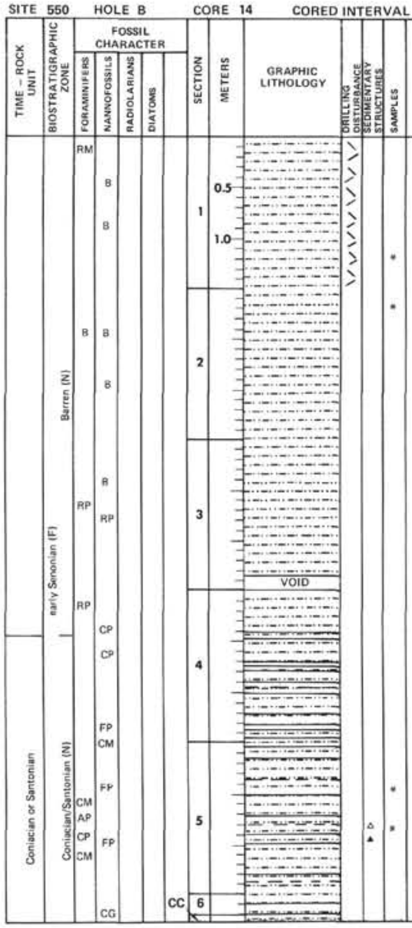
SMEAR SLIDE SUMMARY (%):

	3, 66	3, 120	3, 146	5, 65	6, 70
	D	D	D	D	D
Texture:					
Sand	5	10	5	10	10
Silt	20	30	20	30	30
Clay	75	60	75	60	60
Composition:					
Quartz	30	25	20	30	30
Feldspar	<5	<5	<5	5	5
Mica	–	–	–	<5	Tr
Clay	50	60	70	60	60
Pyrite	–	–	–	–	Tr
Carbonate unspec.	5	–	Tr	–	–
Calc. nannofossils	<5	–	Tr	–	–
Radiolarians	–	Tr	–	–	–
Sponge spicules	<5	<5	–	–	–

ORGANIC CARBON AND CARBONATE (%):

	1, 38	1, 95	2, 68	3, 64	3, 72
Carbonate	92	74	59	10	2
	4, 8	4, 121	5, 6	6, 12	7, 4
Organic carbon	–	–	–	0.53	0.52
Carbonate	2	6	4	1	1

SITE 550 HOLE B CORE 14 CORED INTERVAL 579.5–589.0 m



LITHOLOGIC DESCRIPTION

(1) Mudstone, olive black (5Y 2/1) to greenish black (5GY 2/1), homogeneous non-calcareous mudstone. Not bioturbated except between 70–80 cm and 120–140 cm in Section 2, below 97 cm in Section 3, and above 47 cm in Section 4.

(2) Interbedded with gray to light gray (5Y 6/1–8/1), bioturbated (burrows filled with dark gray), calcareous mudstone. Sometimes irregularly laminated (calcareous mudstone or marly chalk).

(3) Calcareous mudstone or marly chalk medium light to light gray (N6–N7), graded mudstone, bioturbated in upper part only.

Note: Section 4, between 100–120 cm: three thin layers of lithology (1) interbedded with four thin layers of lithology (2).

SMEAR SLIDE SUMMARY (%):

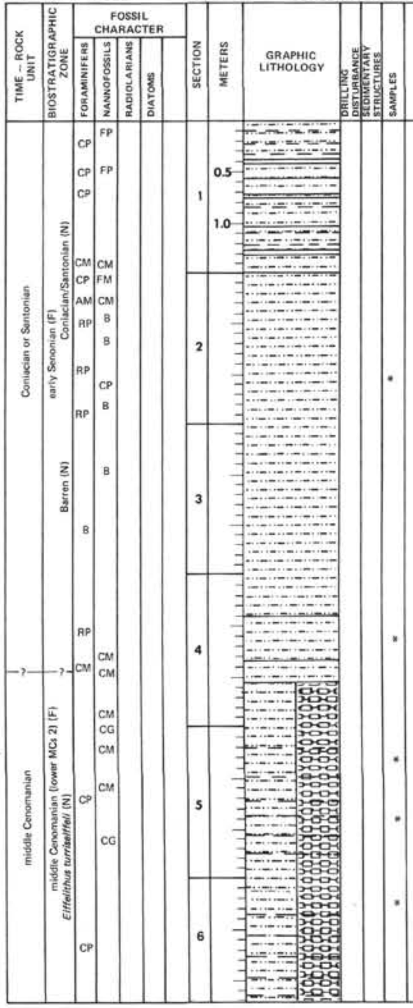
	1, 115	2, 20	5, 47	5, 86
	D	D	D	D
Texture:				
Sand	10	5	10	20
Silt	20	15	20	40
Clay	70	80	70	40
Composition:				
Quartz	25	20	10	20
Feldspar	5	5	5	5
Mica	–	–	–	Tr
Clay	60	70	20	30
Carbonate unspec.	Tr	–	50	20
Calc. nannofossils	Tr	–	10	20
Sponge spicules	Tr	–	–	–

ORGANIC CARBON AND CARBONATE (%):

	1, 8–9	2, 12–13	4, 92–93	
Carbonate	2	0	1	7
	4, 118–119	5, 33–34	5, 52–53	
Carbonate	3	2	81	

Organic carbon = 0.23–0.67

SITE 550 HOLE B CORE 15 CORED INTERVAL 589.0–598.5 m



LITHOLOGIC DESCRIPTION

(1) Dark greenish gray (5G 4/1) to greenish black (5G 2/1), very slightly calcareous to non-calcareous mudstone. Thin layers are bioturbated, thick layers have bioturbation only at bases. Sections 2, 3, and 4 (0–40 cm only) contain 4 cycles with color grading from 5G 4/1 at top to 5G 2/1 at base.

(2) White (5Y 8/1), weakly laminated, weakly bioturbated marly chalk.

(3) Gray (5Y 6/1, sometimes weakly laminated, rarely bioturbated, calcareous mudstone.

(4) Flint nodule.

(5) Dark brown (7.5YR 3/2), homogeneous, massive mudstone, with occasional greenish spots, non-calcareous.

(6) Light gray (5Y 7/1) to light greenish gray (5GY 7/1), highly bioturbated, burrow mottled, homogeneous calcareous mudstone to marly chalk.

(7) Finely laminated in shades of green (5BG 7/2, 5G 8/1, 5Y 5/4), unbioturbated calcareous mudstone.

(8) Gray to dark gray (N4–N3), finely laminated unbioturbated calcareous mudstone.

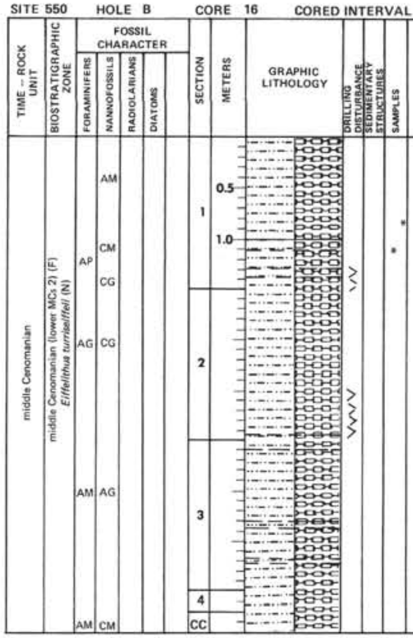
SMEAR SLIDE SUMMARY (%):

	2, 107 D	4, 60 D	5, 30 D	5, 90 D	6, 23 D
Texture:					
Sand	10	20	10	10	5
Silt	20	40	10	20	15
Clay	70	40	80	70	80
Composition:					
Quartz	20	30	10	10	20
Feldspar	5	Tr	Tr	Tr	5
Clay	65	65	25	45	30
Carbonate unspec.	Tr	Tr	20	25	10
Calc. nannofossils	Tr	–	40	15	30

ORGANIC CARBON AND CARBONATE (%).

	2, 107
Carbonate	2

SITE 550 HOLE B CORE 16 CORED INTERVAL 598.9–608.0 m



LITHOLOGIC DESCRIPTION

Gray to light gray (N5–N7), bioturbated with burrows filled with dark gray (N4). Weakly laminated between 0–10, 37–38, and 55–76 cm, marly chalk.

(1) Olive black (5Y 2/1) finely laminated, calcareous, not bioturbated.

(2) Light gray (5Y 7/1) to light greenish gray (5GY 8/1) to medium gray (N5), bioturbated, burrows filled with darker gray (N4/N5), marly nanno chalk.

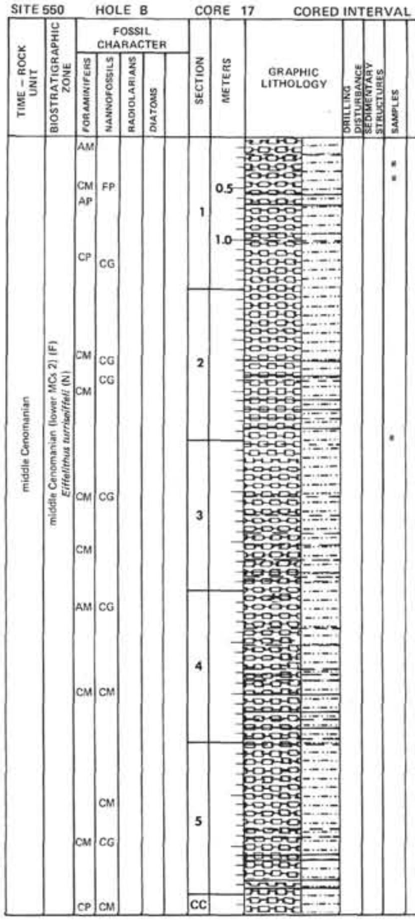
SMEAR SLIDE SUMMARY (%):

	1, 90 D	1, 110 D
Texture:		
Sand	5	5
Silt	15	15
Clay	80	80
Composition:		
Quartz	10	15
Feldspar	5	5
Clay	30	30
Carbonate unspec.	20	10
Foraminifers	–	10
Calc. nannofossils	30	25
Radiolarians	–	5

ORGANIC CARBON AND CARBONATE (%):

	1, 41	1, 107	2, 102
Organic carbon	–	1.47	2.19
Carbonate	75	72	2.19

SITE 550 HOLE B CORE 17 CORED INTERVAL 608.0–617.0 m



LITHOLOGIC DESCRIPTION

All marly nanno chalk.

(1) Light gray (5Y 6/1–7/1), streaked and spotted with darker gray, highly bioturbated.

(2) Dark gray to grayish black (N3–N2), finely laminated (1 mm or less), unbioturbated.

(3) Dark to light gray (N3–5Y 6/1), relatively coarsely laminated (0--5 cm), strongly bioturbated.

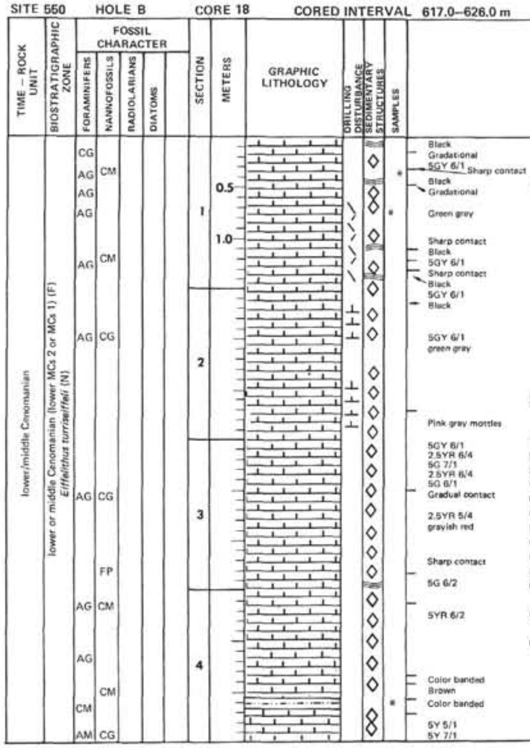
SMEAR SLIDE SUMMARY (%):

	1, 26	1, 40	2, 145
	D	D	D
Texture:			
Sand	10	5	–
Silt	20	15	–
Clay	70	80	–
Composition:			
Quartz	10	10	10
Feldspar	–	Tr	5
Mica	<5	–	–
Clay	30	15	25
Carbonate unspec.	30	45	50
Foraminifers	<5	Tr	–
Calc. nannofossils	15	20	10

ORGANIC CARBON AND CARBONATE (%):

	1, 56–57	1, 64–66	1, 69–70
Organic carbon	2.37	–	–
Carbonate	66	63	–
	1, 86–87	2, 35–36	CC
Carbonate	–	67	65

SITE 550 HOLE B CORE 18 CORED INTERVAL 617.0–626.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, green gray (5GY 6/1) to reddish brown (2.5YR 6/4) to black, hard

Green, gray, and reddish chalks are horizontally mottled

Black chalks are somewhat richer in terrigenous material and contain common small black anhedral particles, beds are finely laminated

Upper contacts of black chalks are sharp, basal contacts are more gradational

Section 1 contains a green gray massive chalk which is laminated at its base

Section 4 contains a unit of color banded (red, green, yellow) mudstone, beds are ~1 cm thick, smear slide taken from yellow band

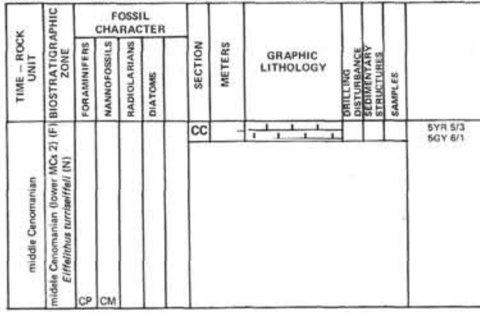
SMEAR SLIDE SUMMARY (%):

	1, 39	1, 79	4, 108
	D	D	D
Texture:			
Sand	10	5	–
Silt	35	15	20
Clay	55	80	80
Composition:			
Quartz	–	–	Tr
Heavy minerals	10	–	–
Clay	10	10	80
Carbonate unspec.	15	15	10
Foraminifers	10	5	–
Calc. nannofossils	55	75	Tr

ORGANIC CARBON AND CARBONATE (%):

	1, 41	2, 2
Carbonate	66	59

SITE 550 HOLE B CORE 19 CORED INTERVAL 626.0–635.0 m

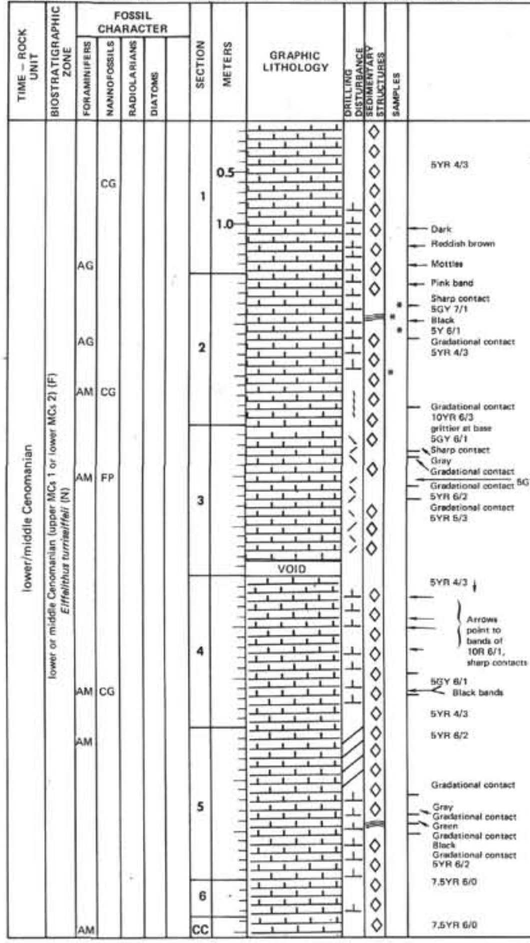


LITHOLOGIC DESCRIPTION

Unit

Marly nannofossil chalk, reddish brown and greenish gray, hard, well mottled in shades of gray

SITE 550 HOLE B CORE 20 CORED INTERVAL 635.0–644.0 m



LITHOLOGIC DESCRIPTION

Unit

Nannofossil chalk, pale brown (10YR 6/3), reddish brown (5YR 4/3), gray (7.5YR 6/0), green (5GY 7/1), and black, firm to hard

All except black beds are mottled in shades of gray and green

Contacts are generally gradational, mottled, a few are sharp

Slight coarsening at base of Section 2

Foram content is variable, perhaps most abundant in brown beds

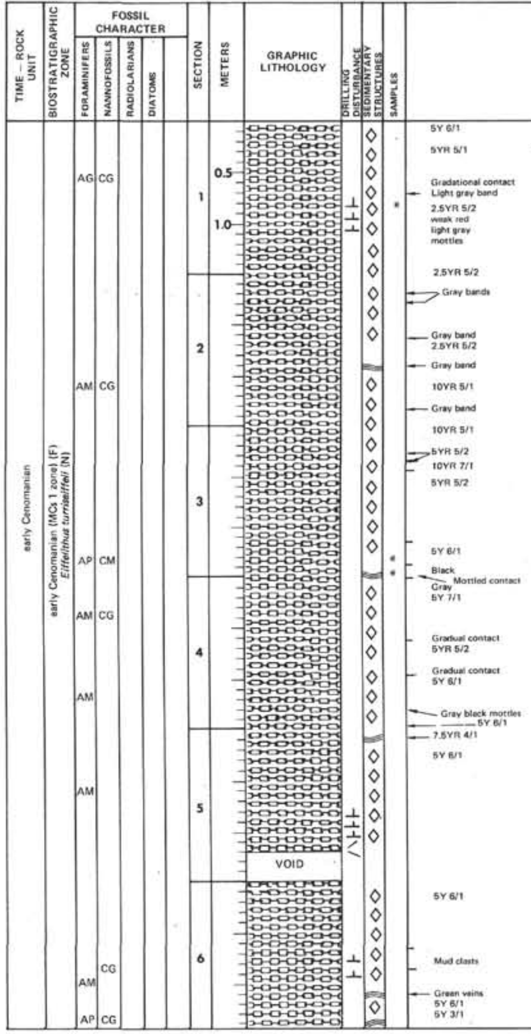
One black bed, Section 5, which is finely laminated and has mottled contacts above and below

Pinkish sediments have scattered cm size gray ovals, diagenetic

SMEAR SLIDE SUMMARY (%):

	2, 35	2, 44	2, 58	2, 98
	D	D	D	D
Texture:				
Sand	5	10	15	20
Silt	20	15	20	20
Clay	75	75	65	60
Composition:				
Quartz	–	2	–	–
Heavy minerals	–	3	5	3
Clay	25	25	10	10
Carbonate unspec.	10	10	10	2
Foraminifers	5	10	10	15
Calc. nannofossils	60	60	65	70

SITE 550 HOLE B CORE 21 CORED INTERVAL 644.0–653.0 m



LITHOLOGIC DESCRIPTION

Unit

Marly calcareous chalk, gray (5Y 6/1) to weak red (2.5YR 5/2) with a few black laminated bands, firm to hard

Core is moderately to well mottled in shades of darker and lighter gray except for blackish beds which are laminated

Most contacts are gradational over cm except for black units where contacts are rapidly transitional and often mottled

Section 6 contains a bed of distorted bioturbated mud clasts

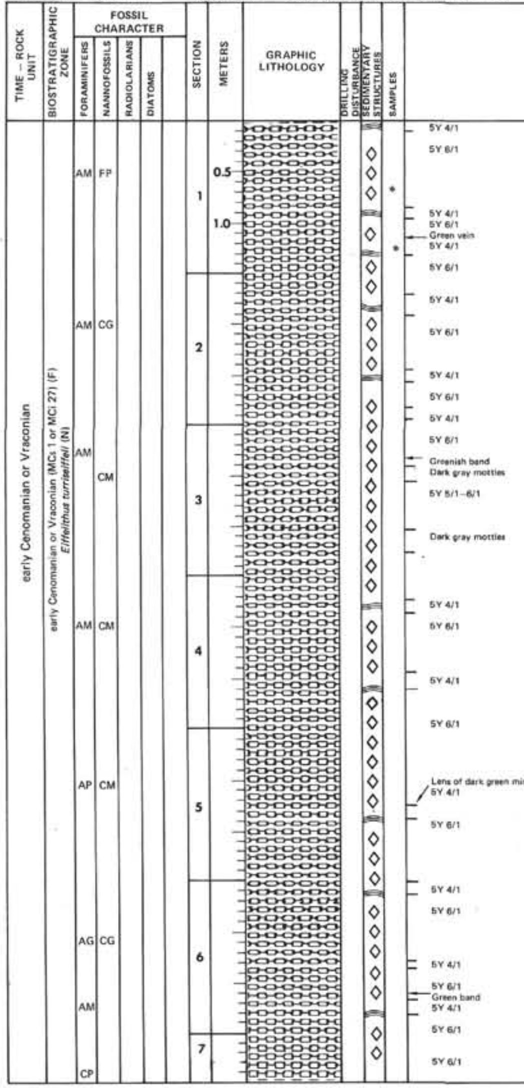
Sediment is rich in clay sized material and carbonate fragments

Feldspars are common

SMEAR SLIDE SUMMARY (%):

	1, 82	3, 130	3, 145
	D	D	D
Texture:			
Sand	5	5	10
Silt	10	15	20
Clay	85	80	70
Composition:			
Quartz	10	10	5
Feldspar	5	10	10
Mica	–	–	Tr
Clay	30	20	20
Carbonate unspec.	40	40	50
Calc. nannofossils	15	20	10

SITE 550 HOLE B CORE 22 CORED INTERVAL 653.0–662.0 m



LITHOLOGIC DESCRIPTION

Unit

Calcareous chalk, dark gray (5Y 4/1) to light gray (5Y 6/1), hard

Lighter beds are moderately mottled in shades of gray, mottles up to cm long, subhorizontal

Darker beds, finely to irregularly laminated in shades of dark gray and black

Contacts are mottled gradational

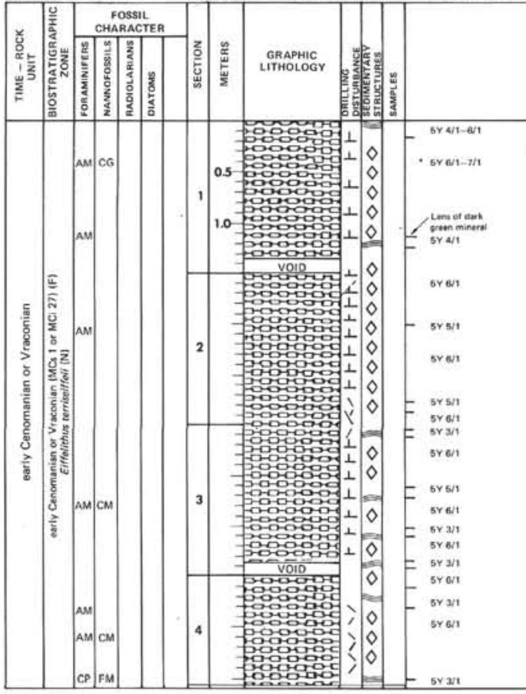
Carbonate is mostly in the form of anhedral particles

Are a few well formed crystals

SMEAR SLIDE SUMMARY (%):

	1, 70	1, 122
	D	D
Texture:		
Sand	15	15
Silt	20	15
Clay	65	70
Composition:		
Quartz	5	10
Feldspar	5	5
Clay	15	20
Carbonate unspec.	60	40
Foraminifers	Tr	Tr
Calc. nannofossils	10	20
Sponge spicules	–	Tr

SITE 550 HOLE B CORE 23 CORED INTERVAL 662.0–671.0 m



LITHOLOGIC DESCRIPTION

Unit

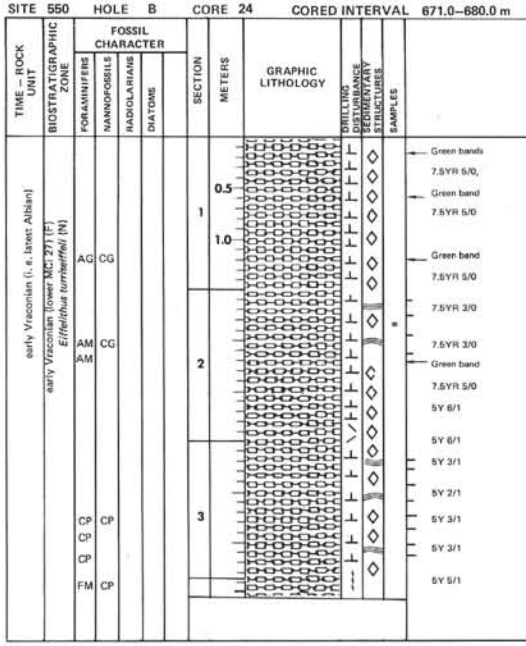
Calcareous chalk, dark gray (5Y 4/1–3/1) to light gray (5Y 6/1), hard

Light colored beds are moderately mottled in shades of gray, mottles up to cm long, subhorizontal

Darker beds are irregularly to finely laminated in shades of dark gray and black

Contacts are gradational and bioturbated

SITE 550 HOLE B CORE 24 CORED INTERVAL 671.0–680.0 m



LITHOLOGIC DESCRIPTION

Unit

Calcareous chalk to marly calcareous chalk, light gray (7.5YR 5/0–5Y 6/1) to dark gray (7.5YR 3/0 or 5Y 3/1–2/1), hard

Lighter bands moderately mottled in shades of gray, mottles can be cm long, subhorizontal

Darker bands are partly or finely laminated in dark gray and black

Contacts are gradational and mottled

Most of the carbonate is in the form of fragments and nannofossils

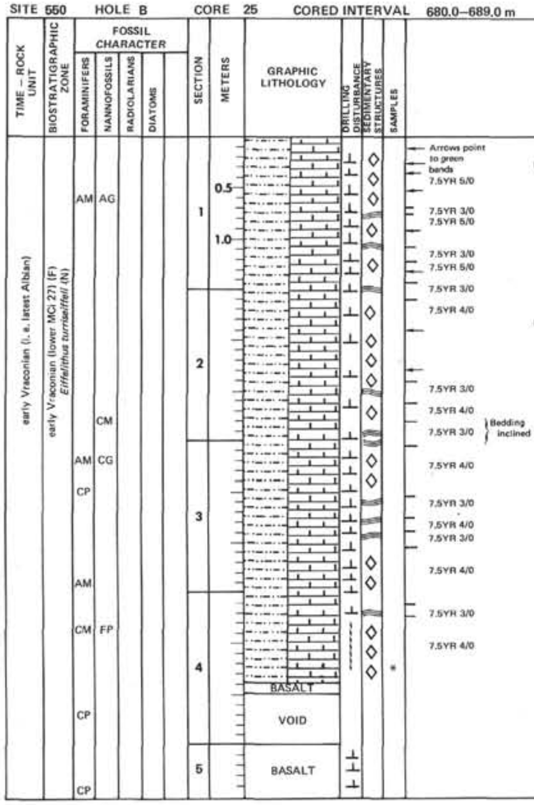
Some carbonate grains are sand size and euhedral

Quartz grains are rare but can be medium sand size

SMEAR SLIDE SUMMARY (%):

	2, 35
	D
Texture:	
Sand	10
Silt	30
Clay	60
Composition:	
Quartz	Tr
Mica	Tr
Heavy minerals	Tr
Clay sized material	40
Carbonate unspec.	20
Foraminifers	5
Calc. nannofossils	30
Sponge spicules	Tr
Dark anhedral mineral	Tr

SITE 550 HOLE B CORE 25 CORED INTERVAL 680.0–689.0 m



LITHOLOGIC DESCRIPTION

Unit 1

Marly calcareous chalk, dark gray (7.5YR 3/0) and light gray (7.5YR 5/0), hard

Lighter beds are moderately mottled in shades of gray, mottles may be up to cm long

Darker beds are moderately to finely laminated in shades of dark gray and black

Contacts are gradational, bioturbated

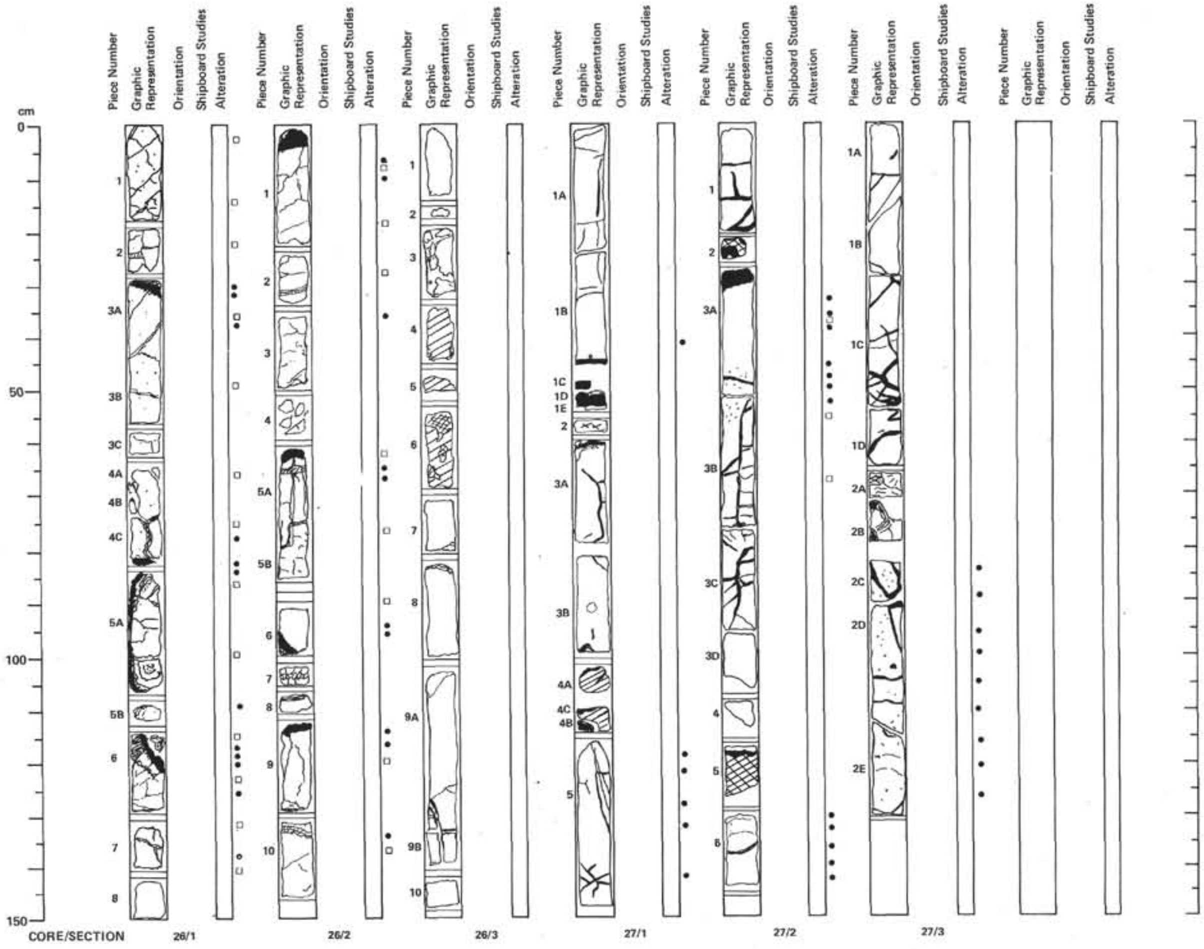
Sediments contain abundant calcareous particles and clay sized material, black opaque minerals are common

Unit 2

Basalt, dark green, hard phenocrystic with large clear, white and green minerals scattered in a finer matrix, common calcite filled fractures

SMEAR SLIDE SUMMARY (%):

	4, 78
	D
Texture:	
Sand	10
Silt	30
Clay	60
Composition:	
Quartz	5
Mica	Tr
Clay	30
Carbonate unspec.	20
Foraminifers	Tr
Calc. nannofossils	40
Dark anhedral mineral	Tr



LEG 80, HOLE 550B, CORE 26

MAIN SUBDIVISIONS

I. Whole or fragmented pillow lavas in Sections 1, 2, and 3, 1–17 cm. Intercalations of red calcareous mudstone at Section 2, 55 cm.

II. Calcareous breccia with volcanic fragments (Section 3, 17–60 cm).

III. Massive lava flow bounded by chilled margins, in Section 3, extends to 150 cm (and continues in Core 27).

I) Pillow Lavas

Visual Description: Dark gray to black, moderately phyric, calcite-veined basalt with well-defined chilled margins (1–2 cm thick). Euhedral plagioclase phenocrysts comprising 7–10% of the basalt, are 0.5–9.5 mm. Fewer than 5% of the vesicles concentrated in the upper third of the pillows are filled with carbonate. Veins are filled with carbonate and/or smectite. Matrix of main pillows comprises small pillow fragments and devitrified hyaloclastite replaced by smectite.

Thin Section Descriptions:

Location: Section 1, 48 cm (15 cm inside the chilled border)
Texture: Phyric
Phenocrysts: Plagioclase, 0.5–2.5 mm, 7–10%, euhedral, unzoned with few exceptions, An >50; olivine, 0.5 mm, 1%, replaced by chlorite
Groundmass: Rosettes of acicular plagioclase, 0.5 mm, 30%; anhedral radiating sheaves of pyroxenes, 35–40%; granular euhedral magnetite, 30–35%; calcite- or smectite-filled vesicles, 1%
Alteration: Rock very fresh; alteration limited to replacement of olivine by chlorite

Location: Section 2, 28–31 cm, 35 cm inside the margin of pillow
Texture: Phyric
Phenocrysts: Very fresh plagioclase, 0.5–2.5 mm, 5–7% unzoned with few exceptions; olivine replaced by chlorite, 2 mm, 2%
Groundmass: Rosettes of acicular plagioclase strongly etched at the borders, $\leqslant$0.3 mm, 25–30%; anhedral pyroxenes, 0.01–0.02 mm, 40%; euhedral granular opaques, 20–30%. Rare vesicles filled with smectite (< 1%).
Alteration: Limited to the replacement of olivine by chlorite

II) Calcareous Breccia

Visual Description: Red colored (2.5YR 4/2–4/3) calcareous mudstone supporting volcanoclasts. Radiolarians scattered globigerinids seen in thin section, but not valuable for dating.

III) Massive Basaltic Lava Flows

Visual Description: Aphyric, fine-grained, very dark gray rock. Few fractures filled with calcite or smectite. Cap of hyaloclastite marking the transition with the calcareous breccia. Chilled margin with finest grain, 40 cm thick, on top of unit.

Thin Section Description:

Location: Section 3, 100–103 cm, within the chilled margin
Texture: Aphyric microlithic
Groundmass: Acicular plagioclase microliths, 0.3–0.7 mm, 40%, very fresh; clinopyroxene, $\leqslant$ 0.3 mm, 35%, anhedral granular, forming radiating sheaves; magnetite, 5%, granular to euhedral, olivine replaced by chlorite, 0.5–0.8 mm
Alteration: Very fresh rock, except for replacement of destabilized olivine
Sonic Velocity: Piece 9, 5382 km/s

LEG 80, HOLE 550B, CORE 27

MAIN SUBDIVISIONS

I. Base of a massive lava flow (extending from Core 26, Section 3) and interbedding of:

II. recrystallized calcareous breccia and pink calcareous mudstone, and

III. aphyric to moderately phyric lava flows or pillow-basalt fragments.

I) Massive Lava Flow (Section 1, 0–40 cm)

Visual Description: Dark gray, massive, fractured nearly aphyric basalt; fracture filled with carbonate. Rare phenocrysts (< 5%) of plagioclase and replaced olivine. Looks unaltered. No vesilces. Chilled margin, 5 cm thick at the bottom.

Thin Section Descriptions:

Location: Section 1, 21–24 cm; 25 cm above the bottom
Texture: Ophitic aphyric to nearly aphyric
Groundmass: Partly xenomorphic acicular plagioclase, 0.2–0.8 mm, 30–40%, very fresh; intergranular to poikilitic pyroxenes, 30–40%; euhedral olivine replaced by chlorite, 15–20%; granular magnetite and other opaque minerals, 0.1 mm, 5%
Sonic Velocity: Piece 1B: 4707 km/s

II) Recrystallized Calcareous Breccia and Pink Calcareous Mudstone
Locations: Section 1, 100–115 cm (Piece 4); Section 2, 20–25 cm (Piece 2) and 115–130 cm (Piece 5); Section 3, 65–80 cm (Piece 2).

Visual Description: In Sections 1 and 2, dark reddish brown (5YR 3/4), hard calcareous sediment, supporting basalt fragments. Hyaloclastitic matrix predominates over the carbonate mudstone in Piece 2 of Section 3. Pieces 2 and 5 of Section 2 show highly contorted stratification.

III) Lava Flows or Pillow Basalt Fragments
Location of main subdivisions: (a) Section 1, 60–100 cm; (b) Section 1, 120 cm–Section 2, 20 cm; (c) Section 2, 30–110 cm; (d) Section 2, 120 cm–Section 3, 65 cm; (e) Section 3, 90–130 cm; no diagnostic features to distinguish between pillow lavas or lava flows.

Visual Description: Aphyric, fine-grained basalts, except subdivision (c) which is moderately phyric (5–10%, millimeter-size altered olivine phenocrysts). Calcite or smectite vesicles at the upper part of subdivision (c), uppermost part of subdivision (d), and complete subdivision (e), 1 mm, 5%.

Sonic Velocity: Section 1 (Piece 3B): 4195 km/s; Section 1 (Piece 3B): 4381 km/s; Section 2 (Piece 3A): 4201 km/s; Section 2, (Piece 3A): 4031 km/s; Section 3 (Piece 2D): 3819 km/s; Section 3 (Piece 2E): 4317 km/s

LEG 80, HOLE 550B, CORE 28

MAIN SUBDIVISIONS

I. Section 1, 0–60 cm: Fragment of aphyric lava flow
II. Section 1, 60 cm–Section 2, 40 cm: Calcareous and hyaloclastic breccia with pillow fragments
III. Section 2, 40 cm–Section 6, 50 cm: Two massive, phyric basaltic lava flows
IV. Section 6, 50 cm–end of section: Pillow basalt fragment

I) Fragment of Aphyric Lava Flow

Visual Description: Dark gray, fine-grained basalt. Highly fractured with white carbonate or greenish smectite infillings. Upper and lowermost parts contain vesicles, of which 5% are filled with carbonate.

II) Calcareous Hyaloclastite Breccia with Pillow Fragments

Visual Description: Section 2 (Pieces 2 and 3), glassy matrix contained pillow lavas and calcareous mudstone fragments. Piece 2A is a dark reddish brown, indurated, calcareous mudstone, and Piece 3A also comprises a veneer of calcareous sediment. Others are basaltic fragments. Section 3 (Pieces 1A–1C and 1E) are dark reddish brown, indurated, calcareous mudstone. Pieces 1D, 1F, and 1G are aphyric, pillow basalt fragments.

Sonic Velocity: Section 2 (Piece 2C): 3926 km/s

III) Two Massive, Phyric, Basaltic Lava Flows

Visual Description: Top has a chilled margin. Another chilled margin, at Section 5, 5 cm, defines the boundary between the two superimposed lava flows. Chilled vesicular margin at the bottom and at the top of the lower flow. Vesicles are rare (< 1%) in the upper one. Fractures with infillings of hydrothermal calcite and calcareous mudstone in the upper meter of the upper lava flow. Very fine-grained phyric textures at the top and base of flows. Phyric subophitic textures inbetween. Plagioclase and altered-olivine phenocrysts of two sizes, 2–3 mm and 7–12 mm; up to 7–10%. Plagioclases are generally the larger phenocrysts.

Thin Section Description:

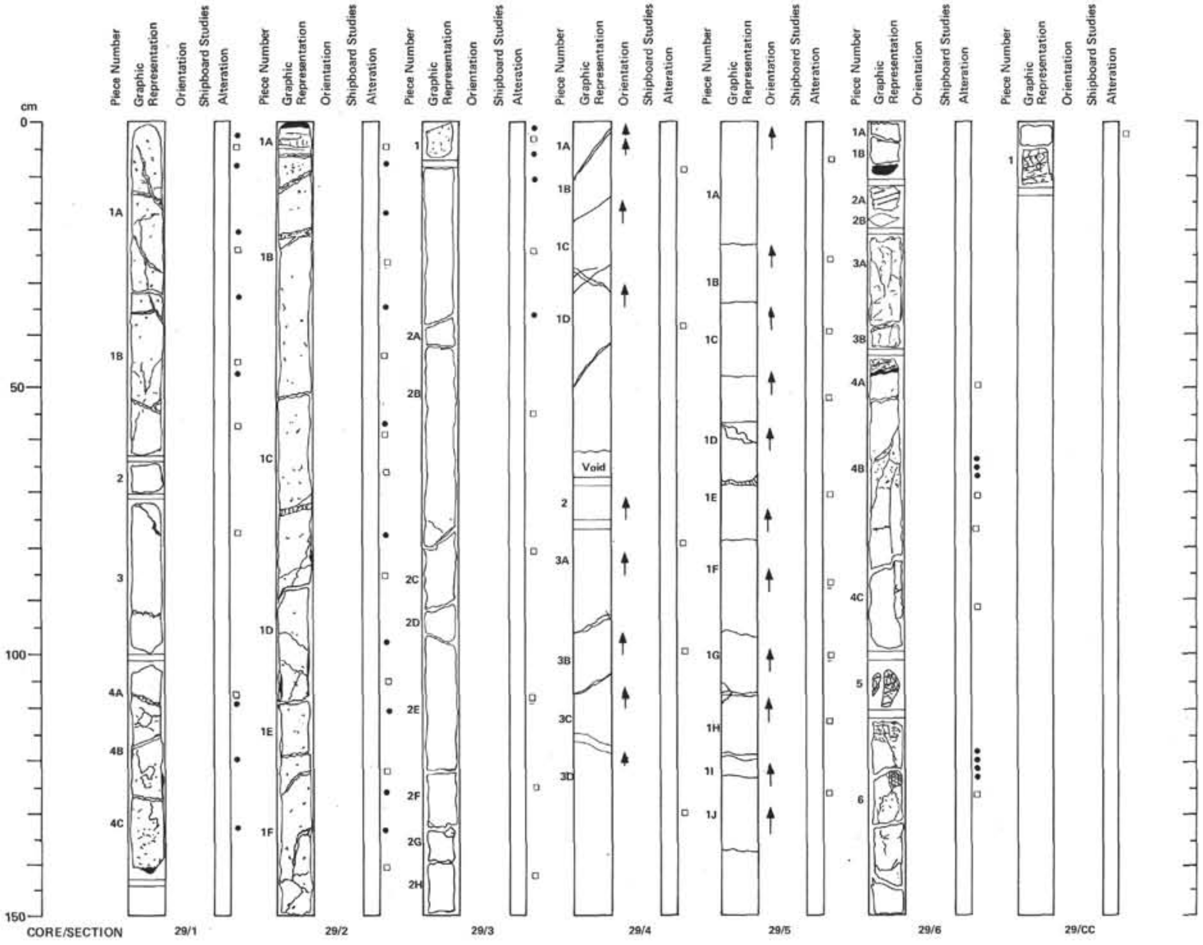
Location: Section 3, 131–133 cm, 150 cm below upper contact of flow
Texture: Phyric
Phenocrysts: Zoned, plagioclase, up to 5 mm; olivines replaced by chlorite, up to 0.6 mm; together: 57%
Groundmass: Acicular plagioclase, very thin and bifid, 0.1 mm; pyroxenes granular to radiating sheaves, 0.1 mm; partly altered opaques and magnetite, up to 5%
Alteration: Replacement of olivine phenocrysts by chlorite and alteration of pyroxene in the groundmass

Location: 88–92 cm, 50 cm above the lower contact of lava flow
Texture: Phyric subophitic
Phenocrysts: Very fresh plagioclases, An $\geqslant 60$, some zoned, 0.5–3 mm, 7–10%; olivine strongly corroded (etched borders), completely replaced by chlorite, 0.5 mm, 5–10%
Groundmass: Very fresh acicular plagioclase, 0.5–1 mm, 40–45%; very fresh intergranular to poikilitic clinopyroxene, 30–35%; euhedral to granular magnetite, <0.1 mm, 5%; devitrified glass replaced by smectite, 2–3%

Location: Section 5, 5–7 cm, top of the lower lava flow of Core 28
Texture: Porphyritic microlitic (chilled margin)
Phenocrysts: Euhedral plagioclase, An >60, 0.5–2 mm, 30%; olivine, 0.5 mm, 5%, strongly etched and replaced by chlorite
Groundmass: Scattered very thin and bifid acicular plagioclase, 15–20%; anhedral grains to radiating sheaves of clinopyroxene, 0.02–0.01 mm, 40%; opaques, 5%. Vesicles, $\geqslant 1$ mm, 10%, infilling of calcite or smectite
Alteration: None, except replacement of olivine
Sonic Velocity: Section 4 (Piece 1B): 5501 km/s; Section 4 (Piece 1B): 5505 km/s; Section 4 (Piece 1B): 5212 km/s

IV) Pillow Basalt Fragment

Visual Description: Phyric basalt with 5–10% plagioclase phenocrysts; few calcitic amygdules, 1 mm; dense net of calcitic fractures. Core is cut along the side chilled border of the pillow.



LEG 80, HOLE 550B, CORE 29

MAIN SUBDIVISIONS

I. Section 1–Section 6, 10 cm: Two massive, phyric, lava flows

II. Section 6, 10–150 cm: Interbedded calcareous breccia and phyric basalt fragments

I) Two Massive Phyric Lava Flows

Visual Description: Boundary between two lava flows is marked by an intercalation of devitrified glass at the top of Section 2 and two chilled margins below and above. Slickenside deformation at the boundary between the two units.

The upper unit is only 1.50 m thick in Section 1. Dark gray phyric basalt. Calcite and smectite vesicles (⩽ 1 mm) are concentrated at the base and summit. Zoned plagioclase phenocrysts up to 7% and <1 cm. Subophitic intergrowths of plagioclase and olivine (the latter being replaced by chlorite).

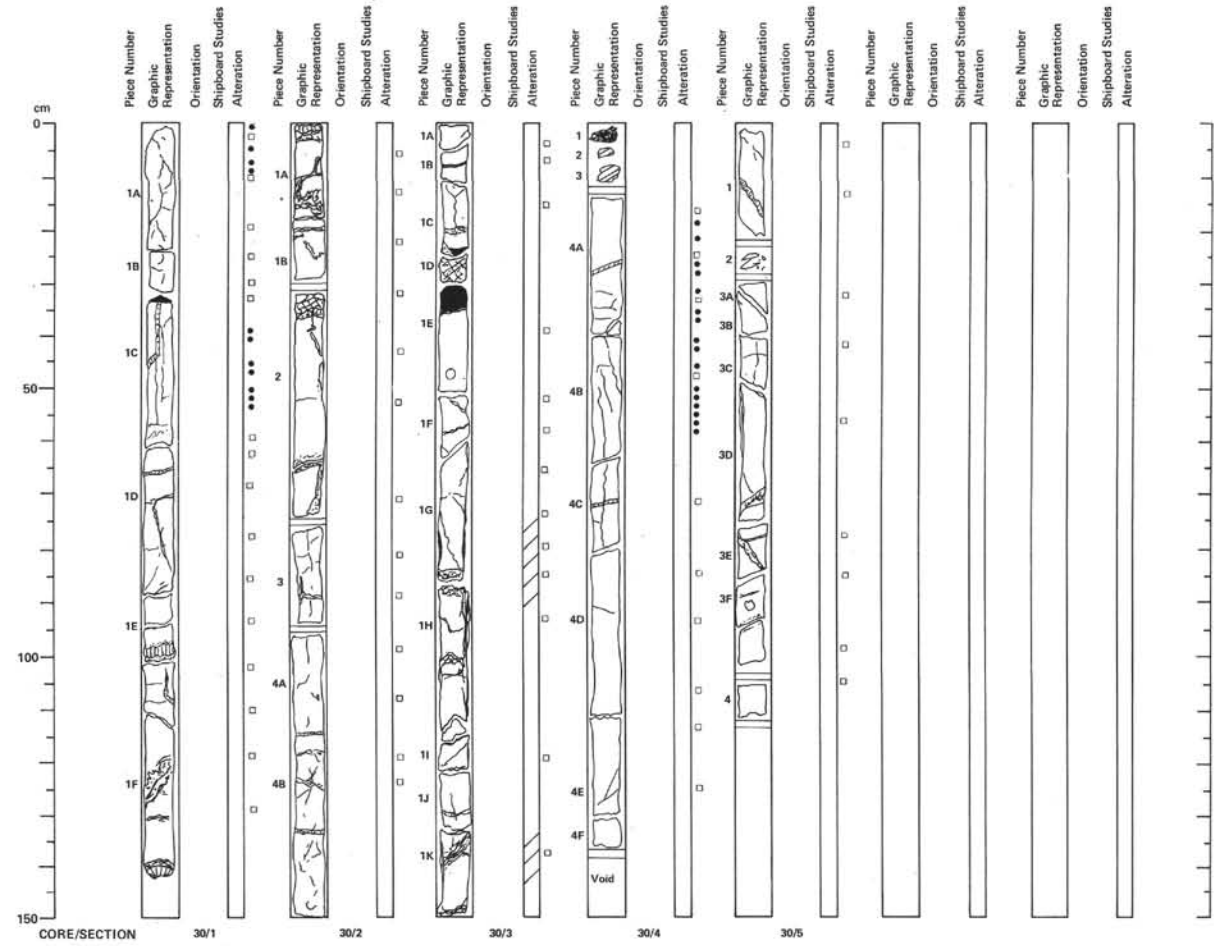
The lower unit is 6 m thick (Section 2–Section 6, 10 cm). Upper part (1.60 m) is vesicular but not the lower margin. Dark gray basalt. Phyric, except the lower margin. Grain size of the groundmass increases from the top to the base, then decreases again in the lower 30 cm. Plagioclase phenocrysts, ⩽ 3 mm, 1–5% up to 10% toward the base. Veins and fractures filled with calcite and smectite.

Thin Section Description:

Location: Section 5, 65–68 cm
Texture: Phyric subophitic
Phenocrysts: Plagioclase, 2–3 mm, 10%
Groundmass: Acicular plagioclase, 0.5 mm, 30%; intergranular poikilitic pyroxene, 30–35%; magnetite, 5%; olivine, 0.01–0.1 mm, >20% replaced by chlorite
Alteration: Limited to the replacement of olivine by secondary chlorites.
Sonic Velocity: Section 2, 81–83 cm (Piece 1C): 4020 km/s; Section 5, 85 cm (Piece 1F): 5570 km/s

II) Interbedded Calcareous Breccia and Phyric Basaltic Fragments

Visual Description: Phyric basalt fragments, 20–50 cm in size, cemented by pink calcareous mudstone, including sand-size pillow debris.



LEG 80, HOLE 550B, CORE 30

MAIN SUBDIVISIONS

I. Massive lava flow, Sections 1, 2, and 3, 0–25 cm
II. Red calcareous mudstone, Section 3, 25–30 cm
III. Massive lava flow, Section 3, 30–150 cm
IV. Red calcareous mudstone, Section 4, 0–10 cm
V. Massive lava flow, Section 4, 10–150 cm and Section 5

I) Massive Lava Flow, Types I, III, and V

Visual Description: Medium gray, moderately phyric basalts. Type I shows chilled margin with conspicuous carbonate and smectite vesicles at the top (< 1 mm, < 5%; Section 1, 0–70 cm). Thinner, altered, chilled fringe without vesicles at the base. Altered, chilled fringes at top and base of Type III less than 10 cm thick. Relatively coarse ophitic texture occupying most of Type III. Type V shows a 60-cm thick chilled margin with smectite and calcite vesicles at the top, but only a fine-grained phyric texture without vesicles in the lower 30 cm. The remainder is mostly doleritic, subophitic, phyric basalt. Phenocrysts: plagioclase, 4 mm, 5–7%; calcitic veins, geodes, and fractures concentrated toward the top.

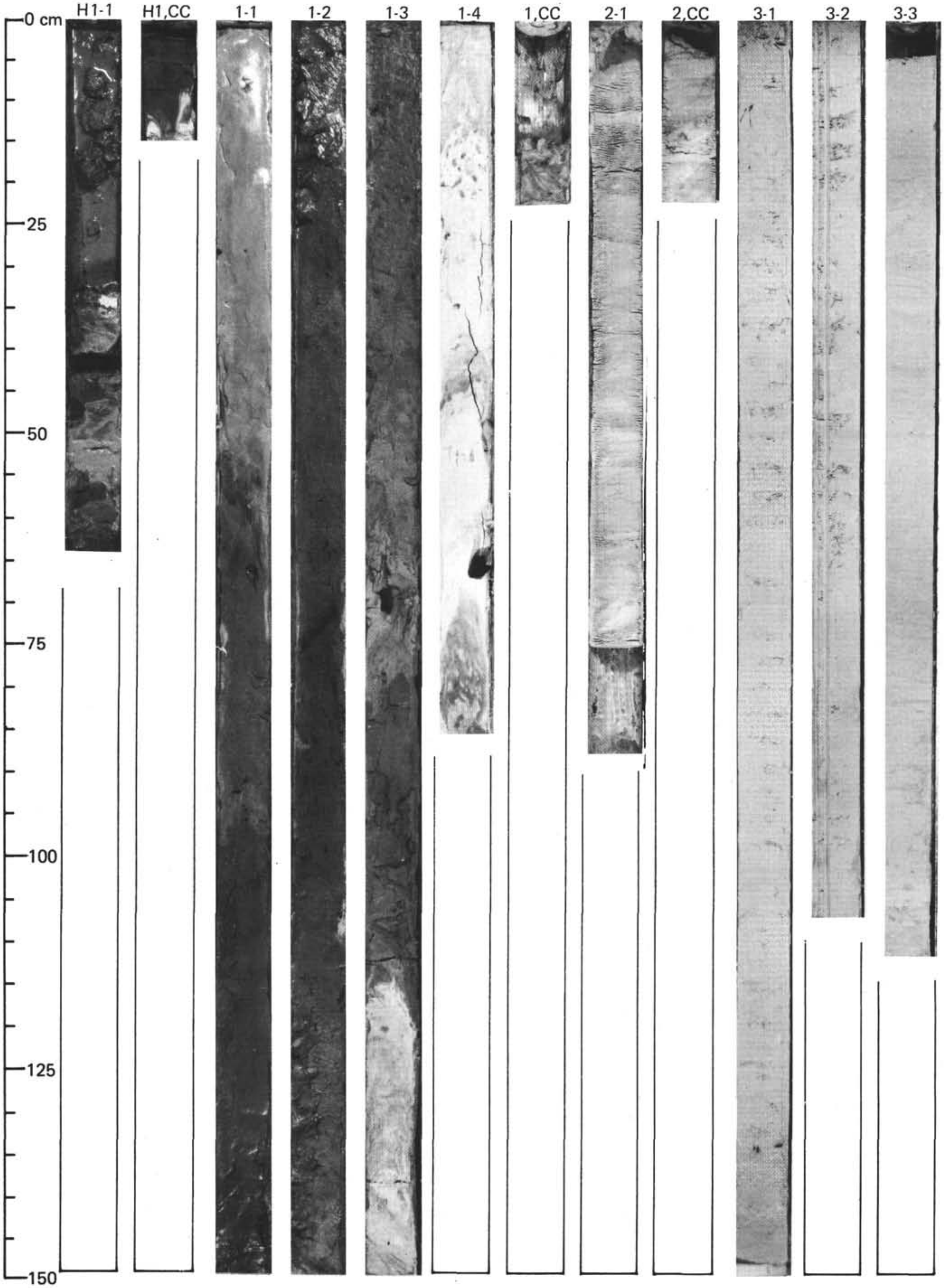
Thin Section Description

Location: Section 2, 114–117 cm; 2.7 m below top
Texture: Phyric
Phenocrysts: Plagioclase, An>60, 3–4 mm, 5–10%, corroded; euhedral olive replaced by chlorite
Groundmass: Acicular plagioclase, 0.15 mm, 20%; anhedral grains to radiating sheaves of clinopyroxene, 40%; opaques, 0.01–0.05 mm, 5%; interlocular grains of olivine, 0.05–0.1 mm, 20% replaced by chlorite
Alteration: Limited to the replacement of olivine

Location: Section 4, 132–134 cm; 120 cm below top of subdivision V
Texture: Phyric subophitic
Phenocrysts: Plagioclase, An >60, 2–5 mm, 15%, zoned; some partly replaced by clinopyroxene; euhedral olivine, 0.5–1 mm, 10% replaced by chlorite
Groundmass: Acicular plagioclase up to 1.5 mm, 30–35%; granular magnetite, 5%; rosettes of pyroxene organized as radiating sheaves of anhedral grains, 0.08–0.1 mm, 30%; interlocular olivine replaced by chlorite, 0.02 mm, 10%

II) Red Calcareous Mudstone

Visual Description: Several chunks of red calcareous mudstone associated with pillow basalt fragments separate massive lava flows.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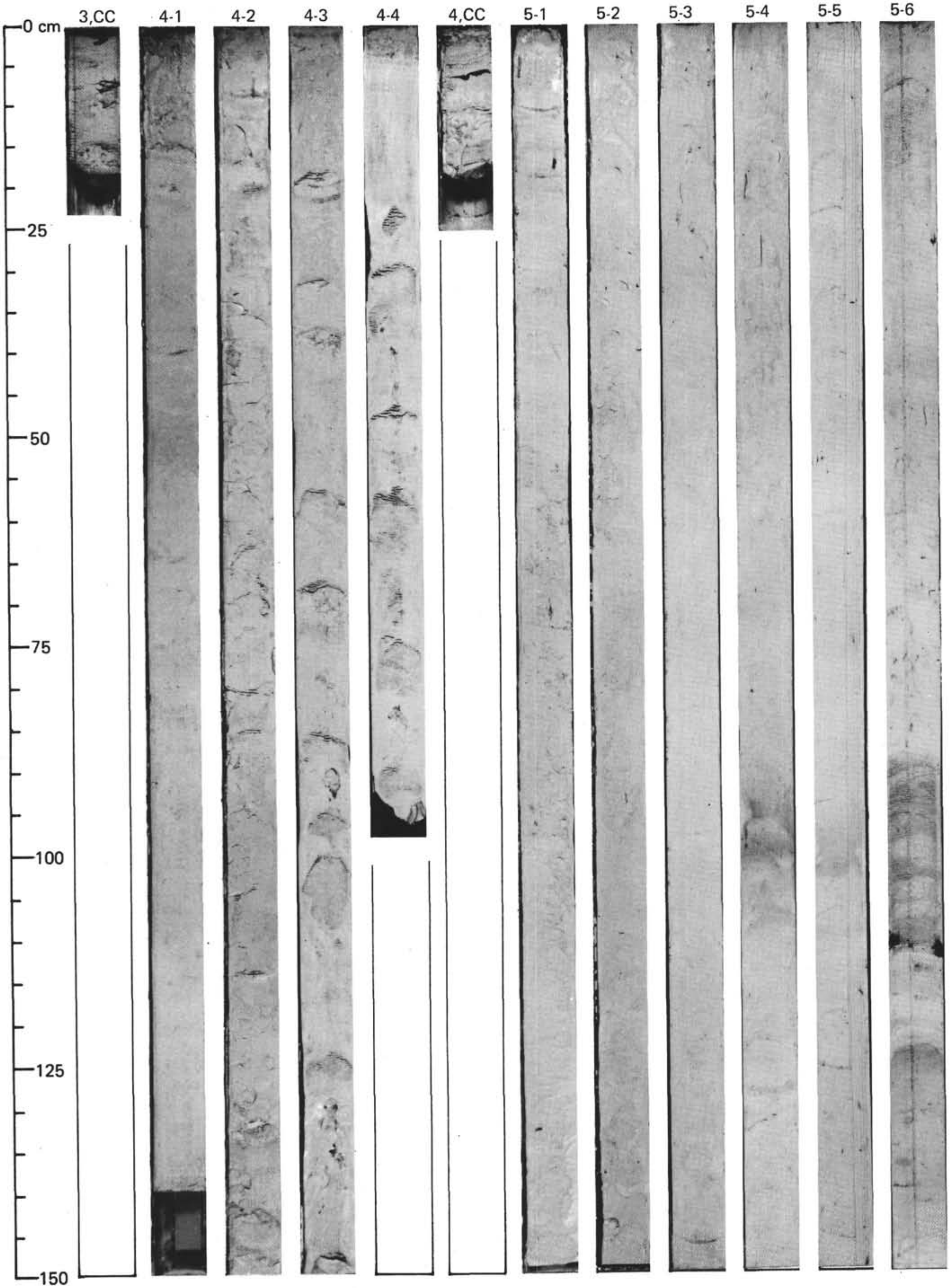
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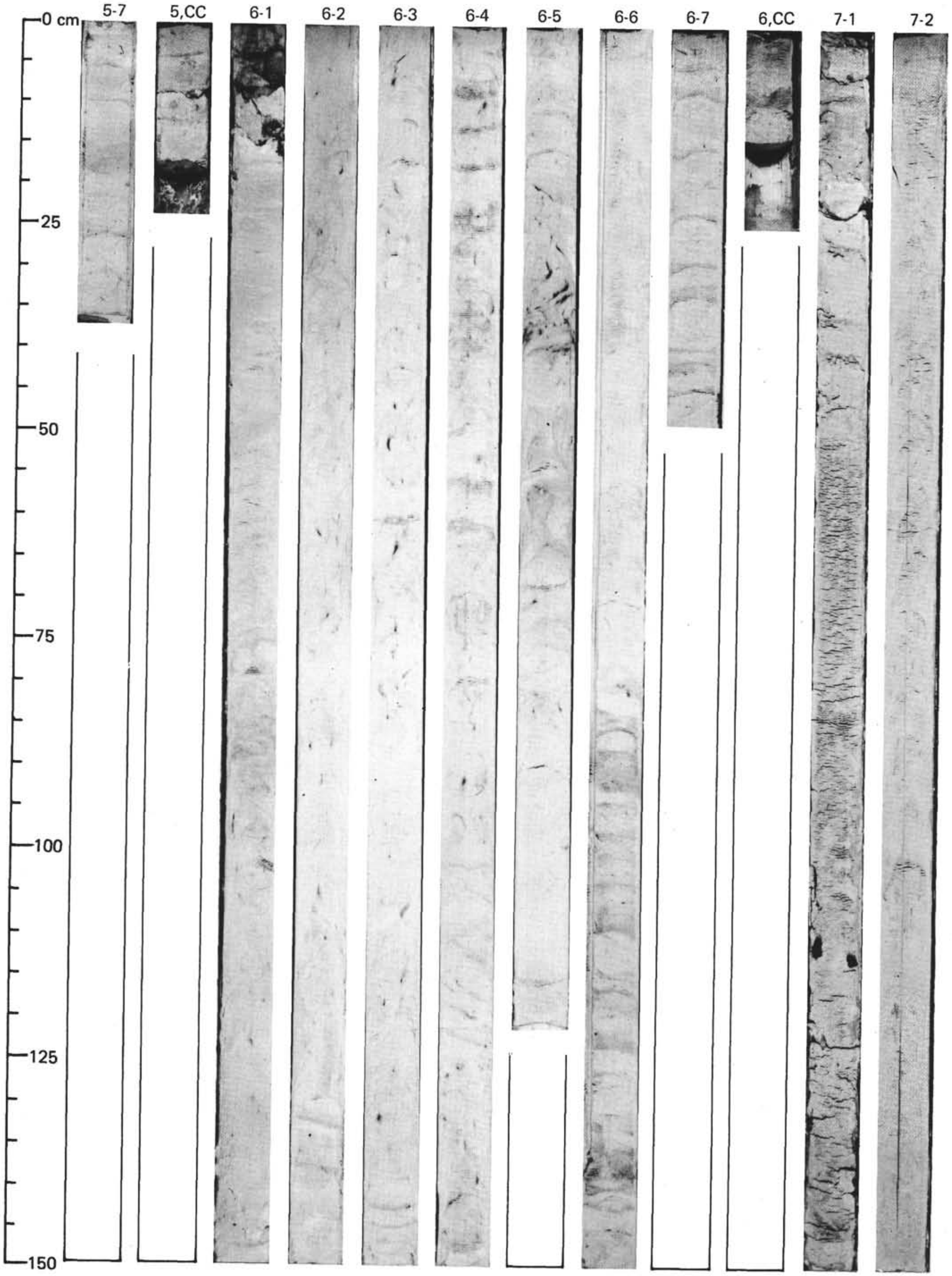
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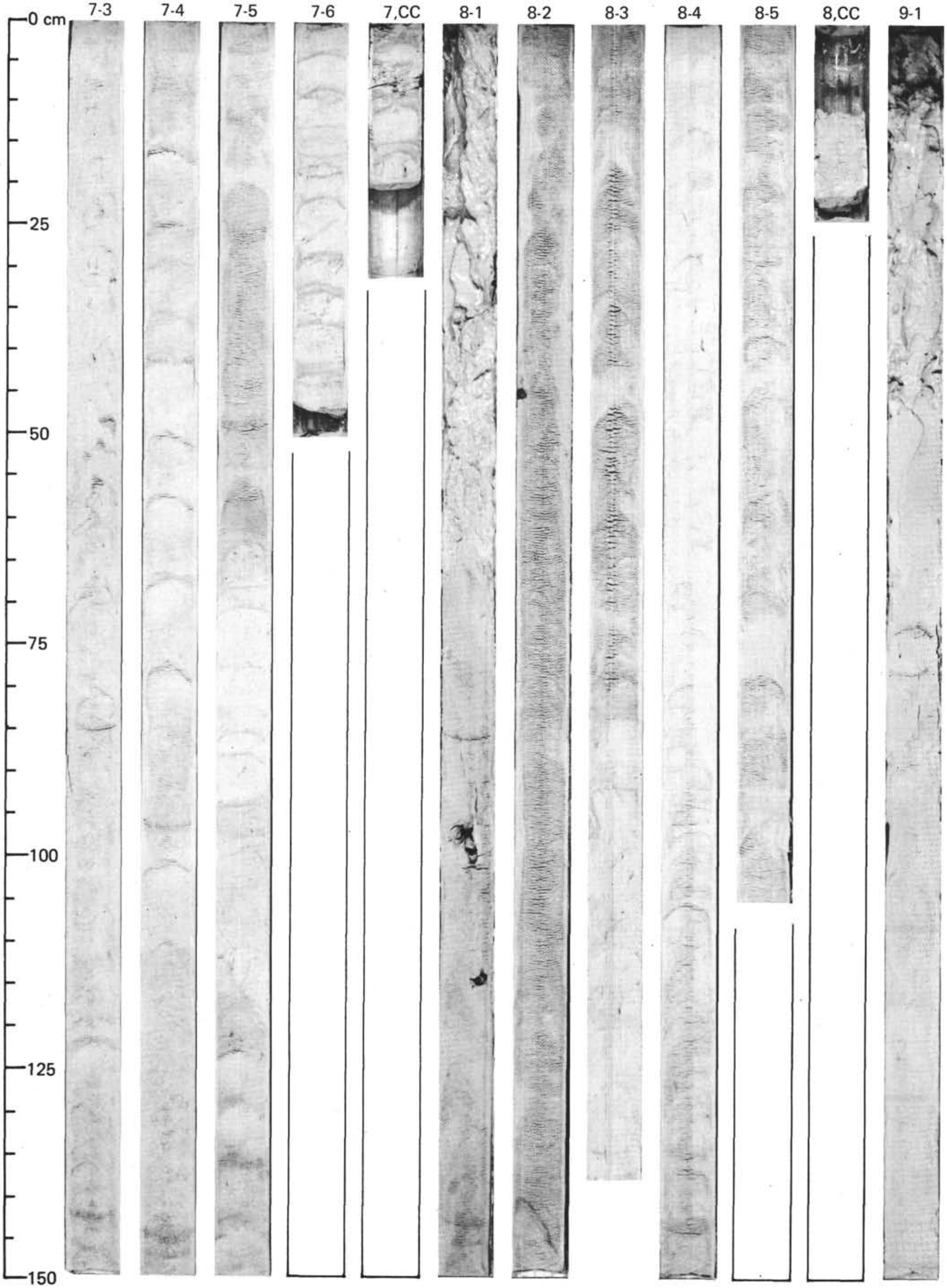
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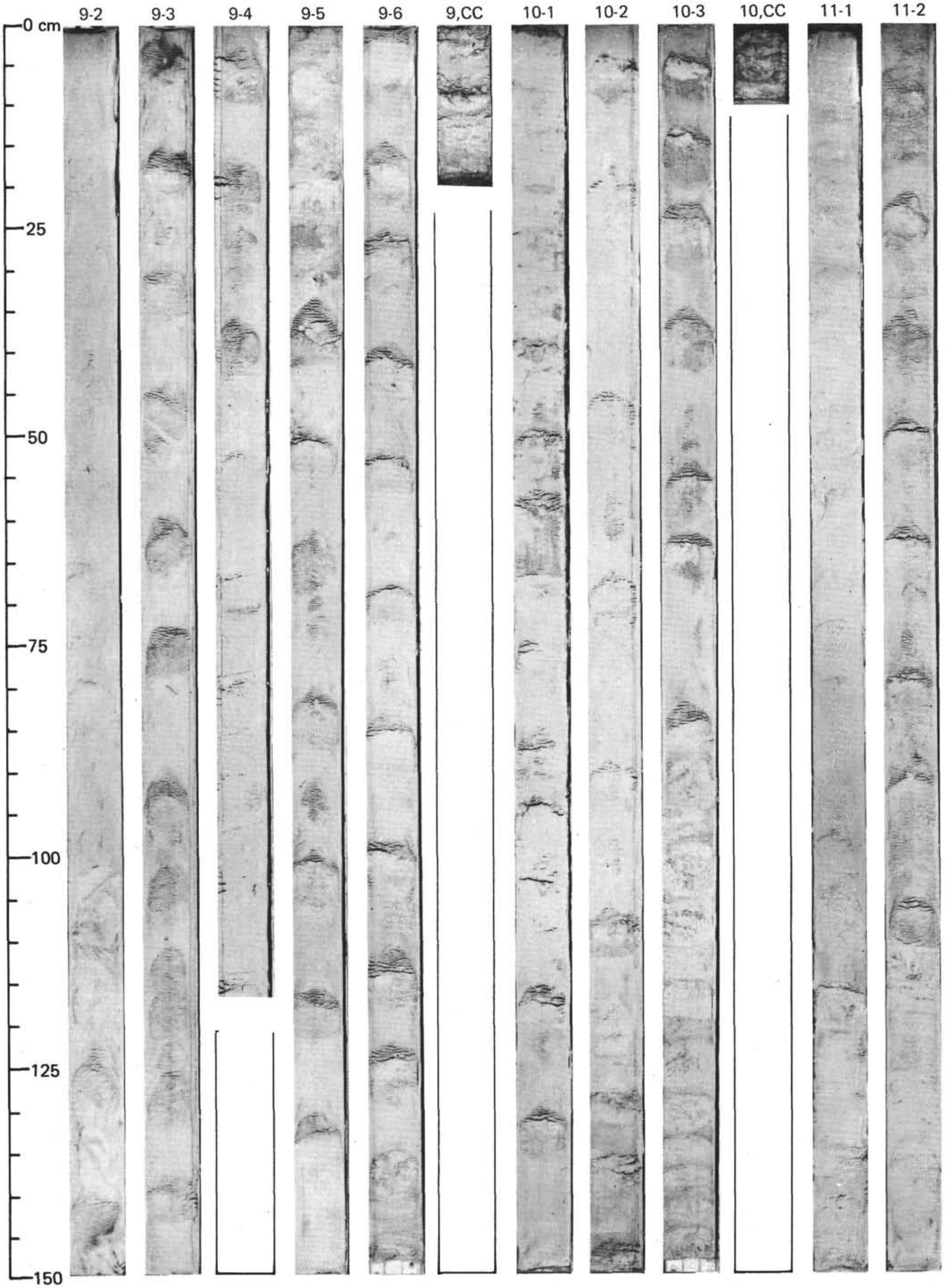
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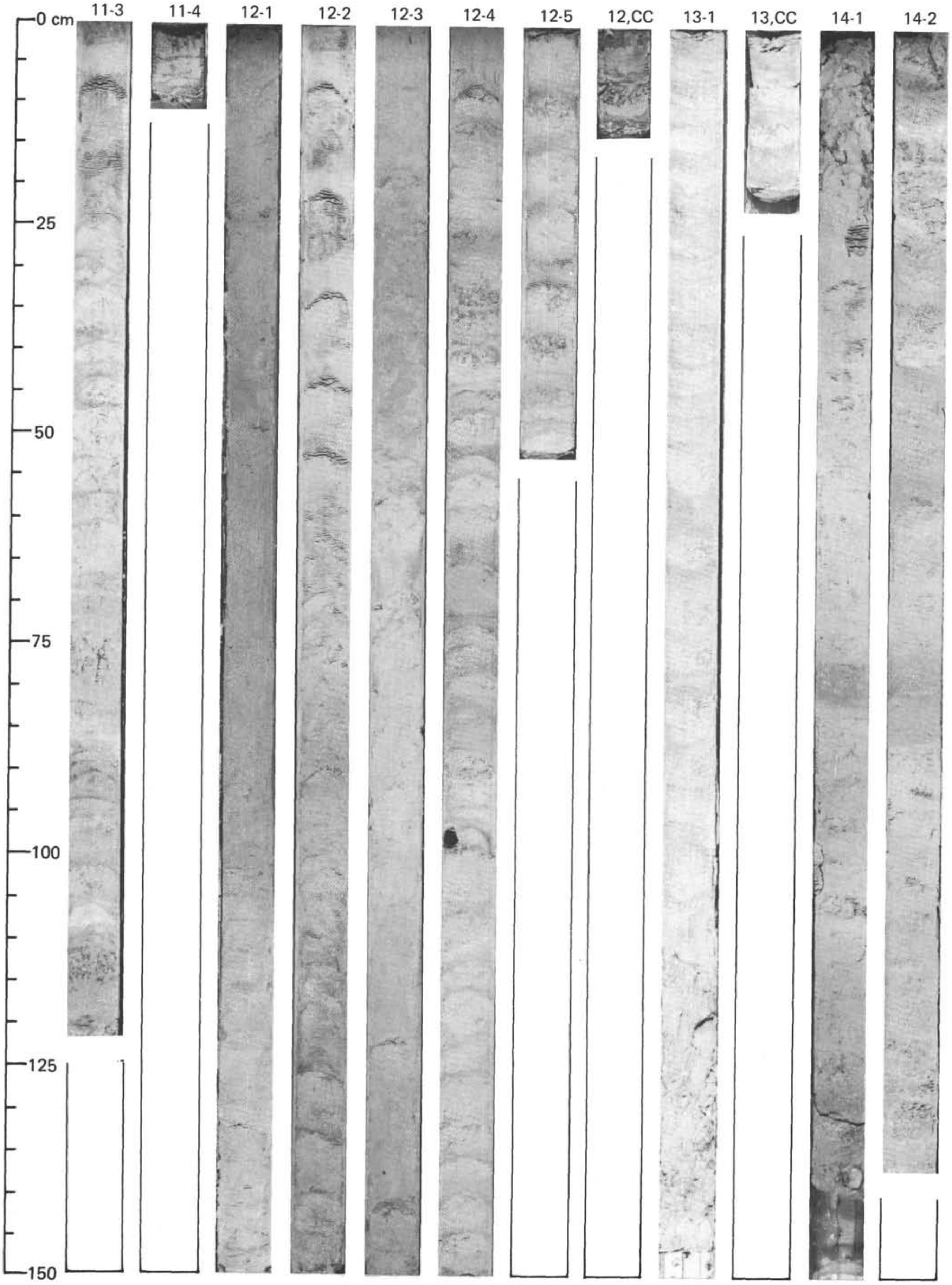
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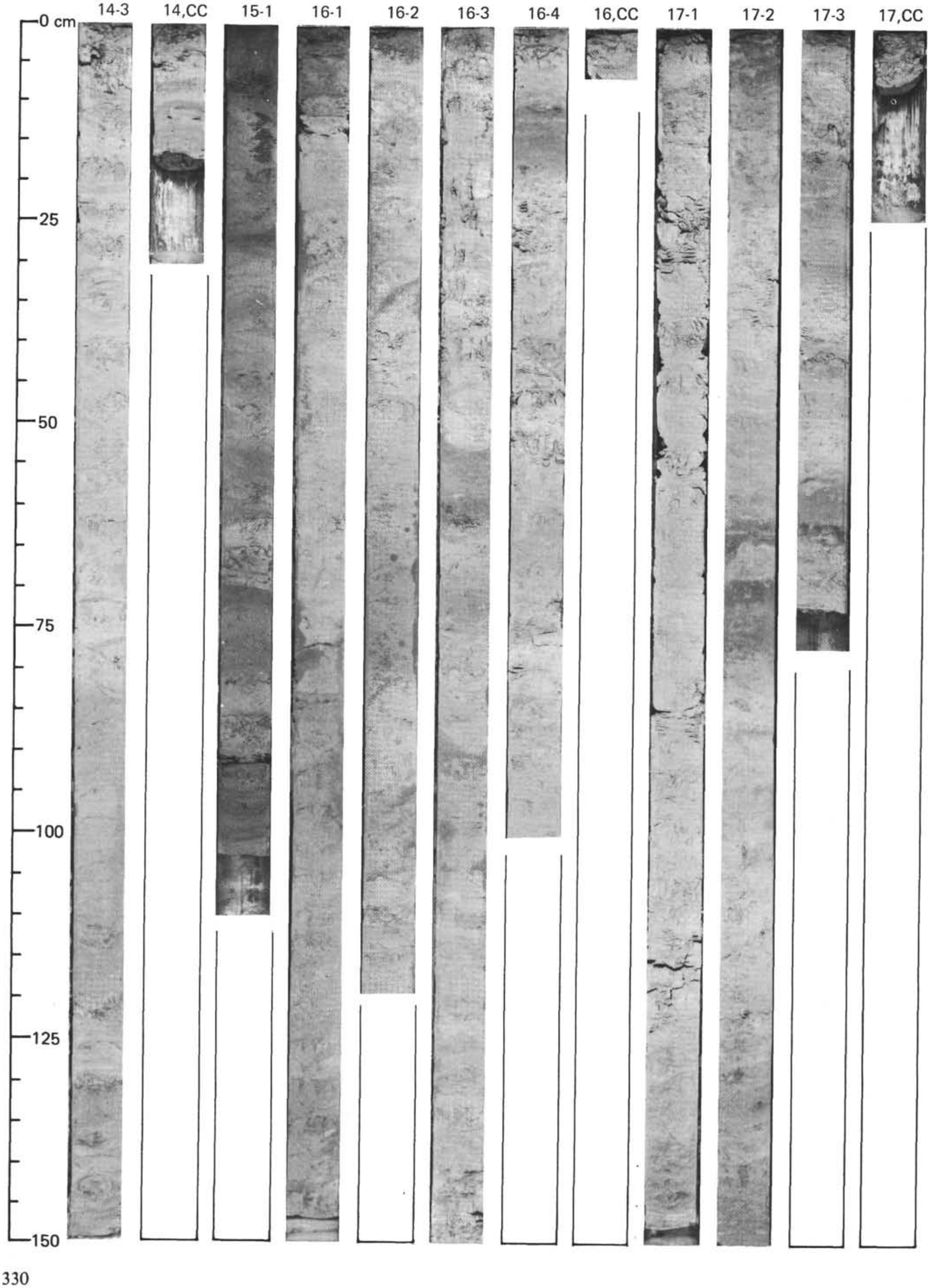
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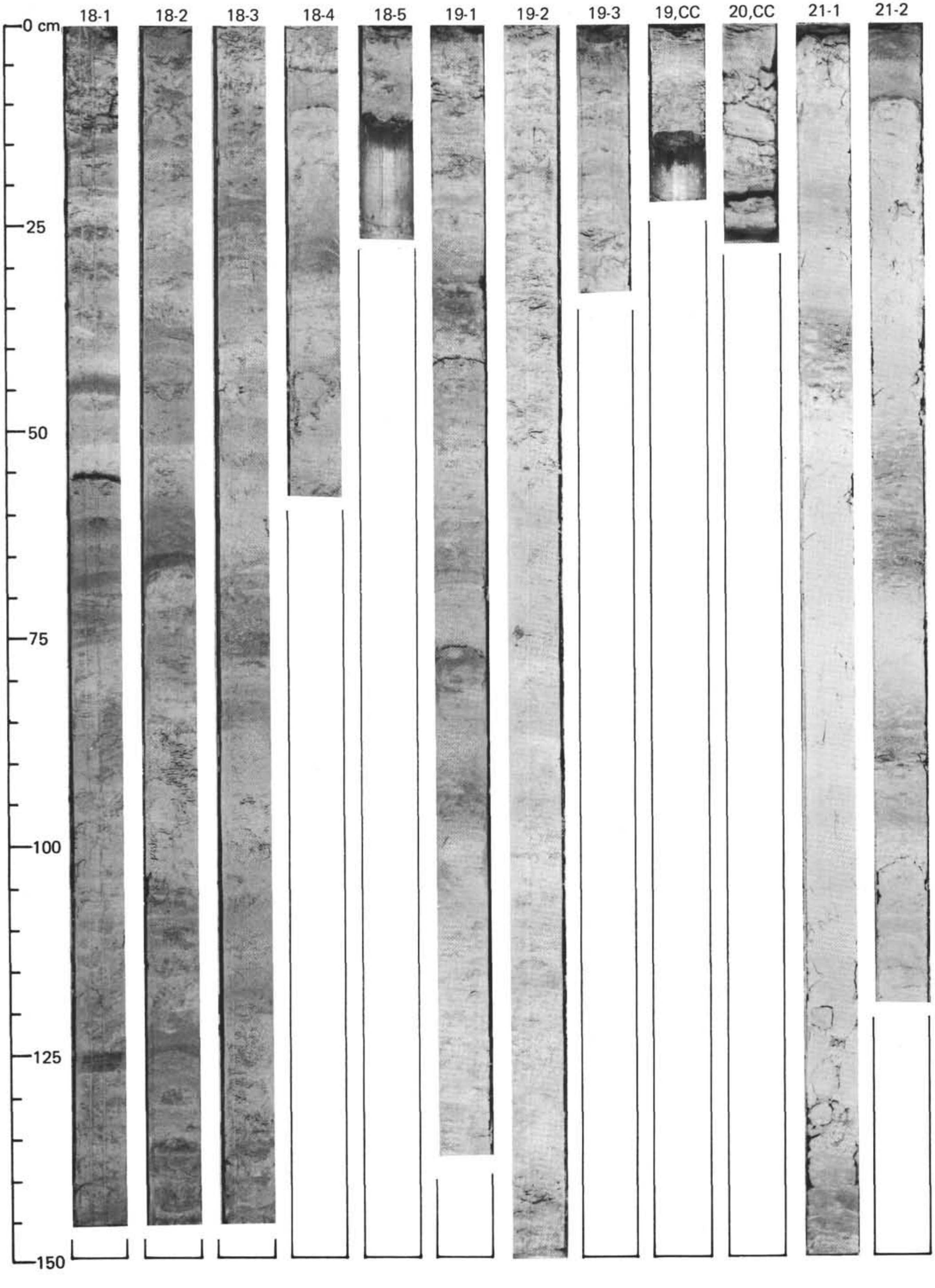
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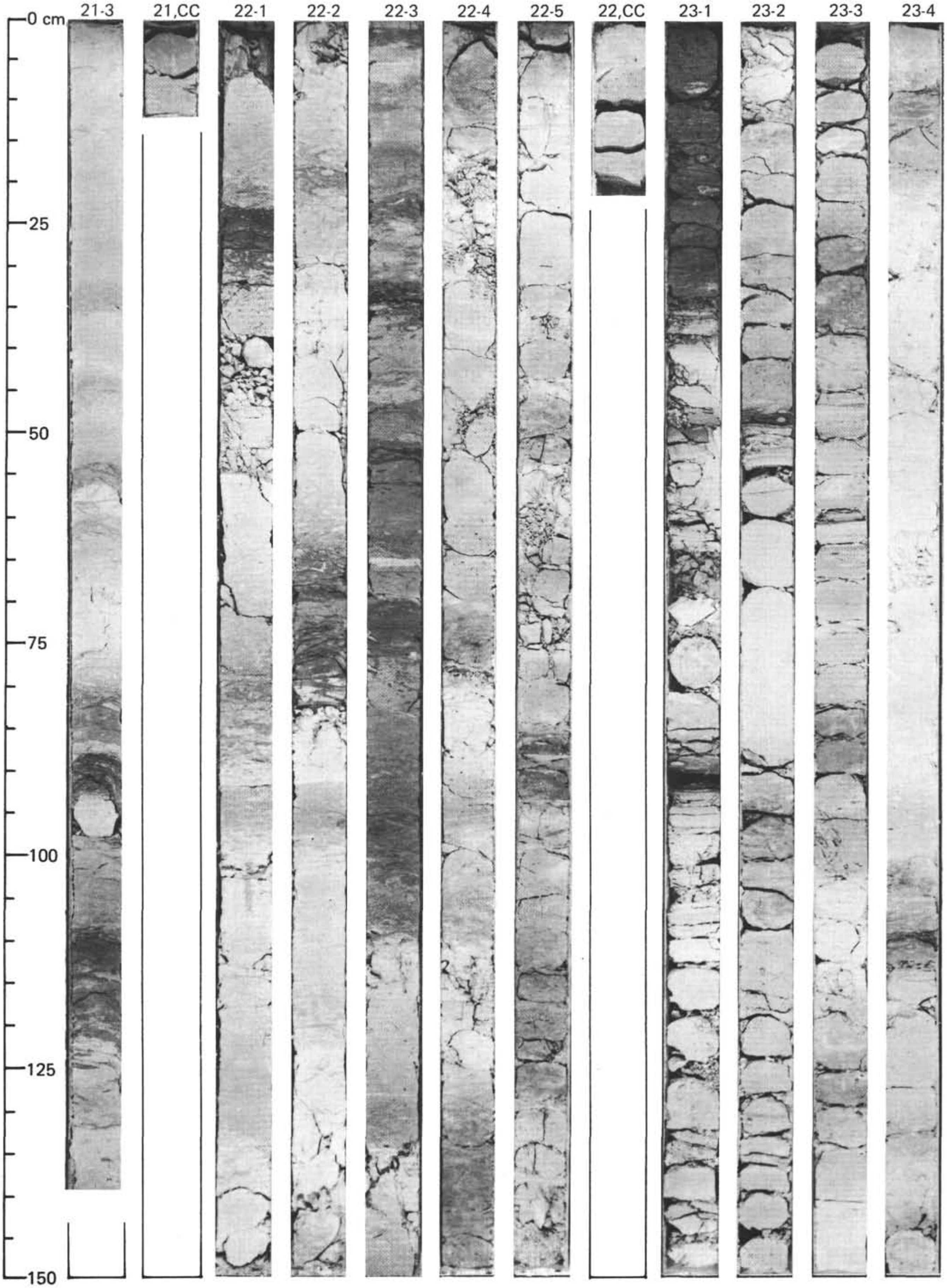
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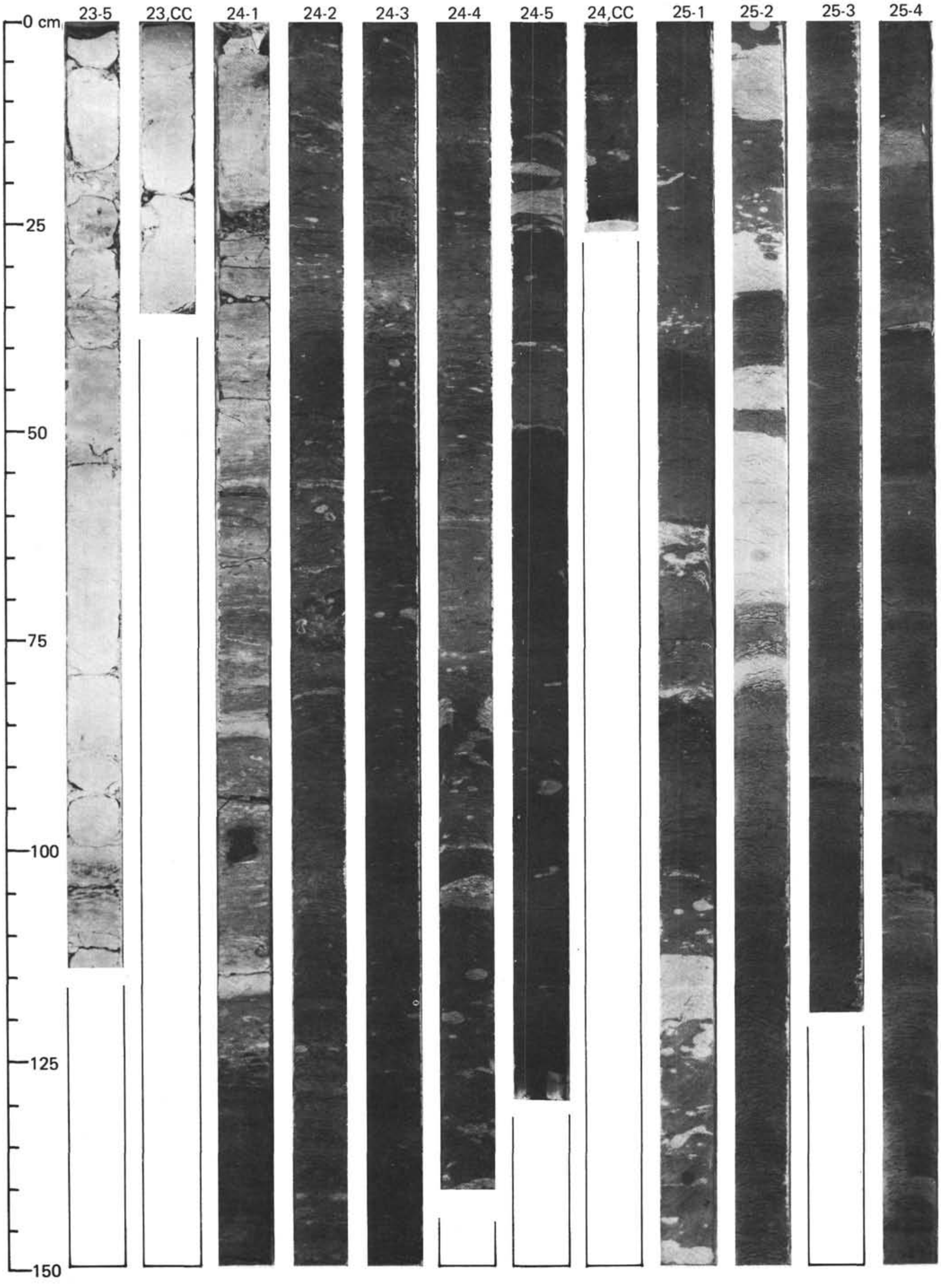
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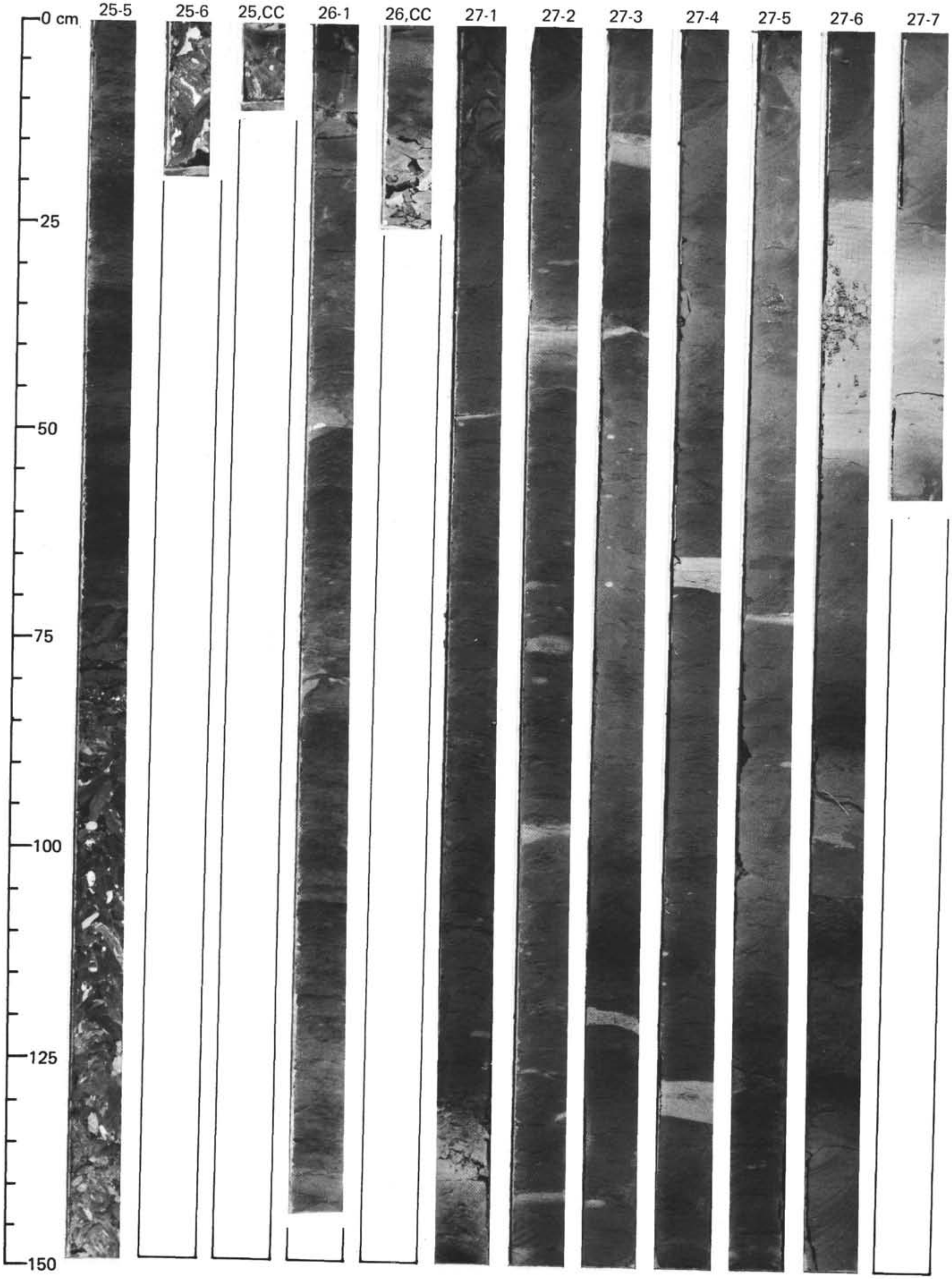
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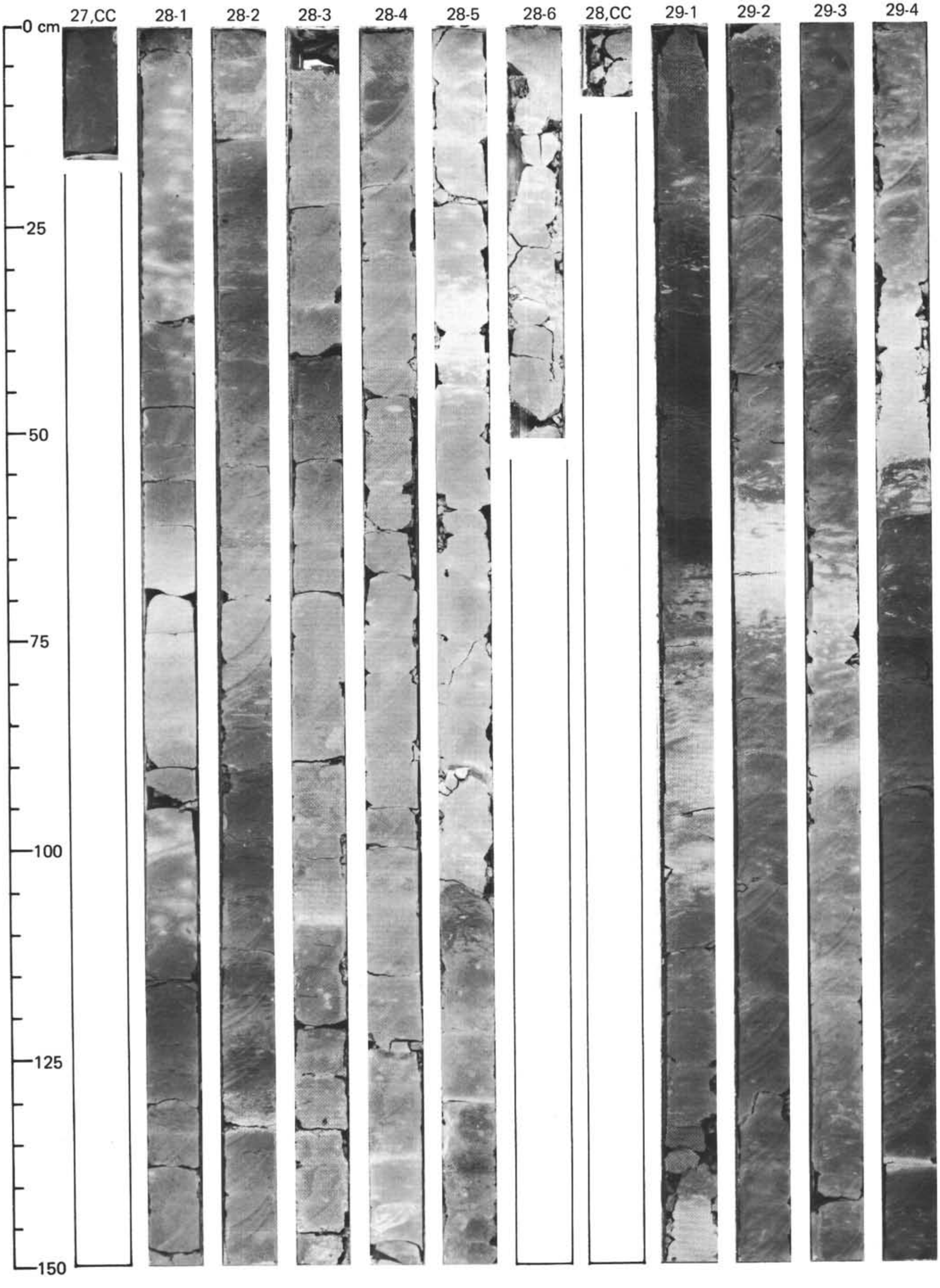

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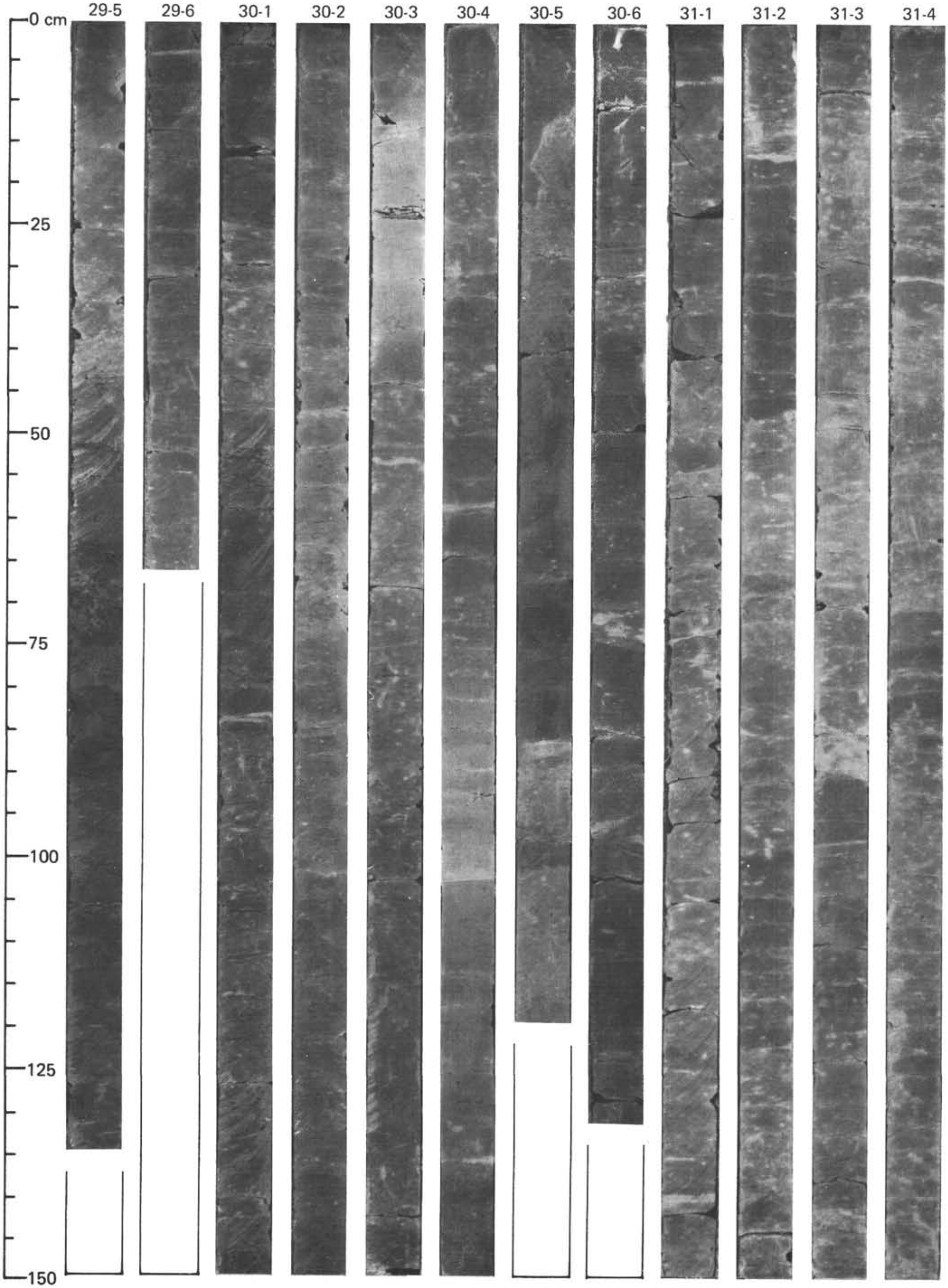
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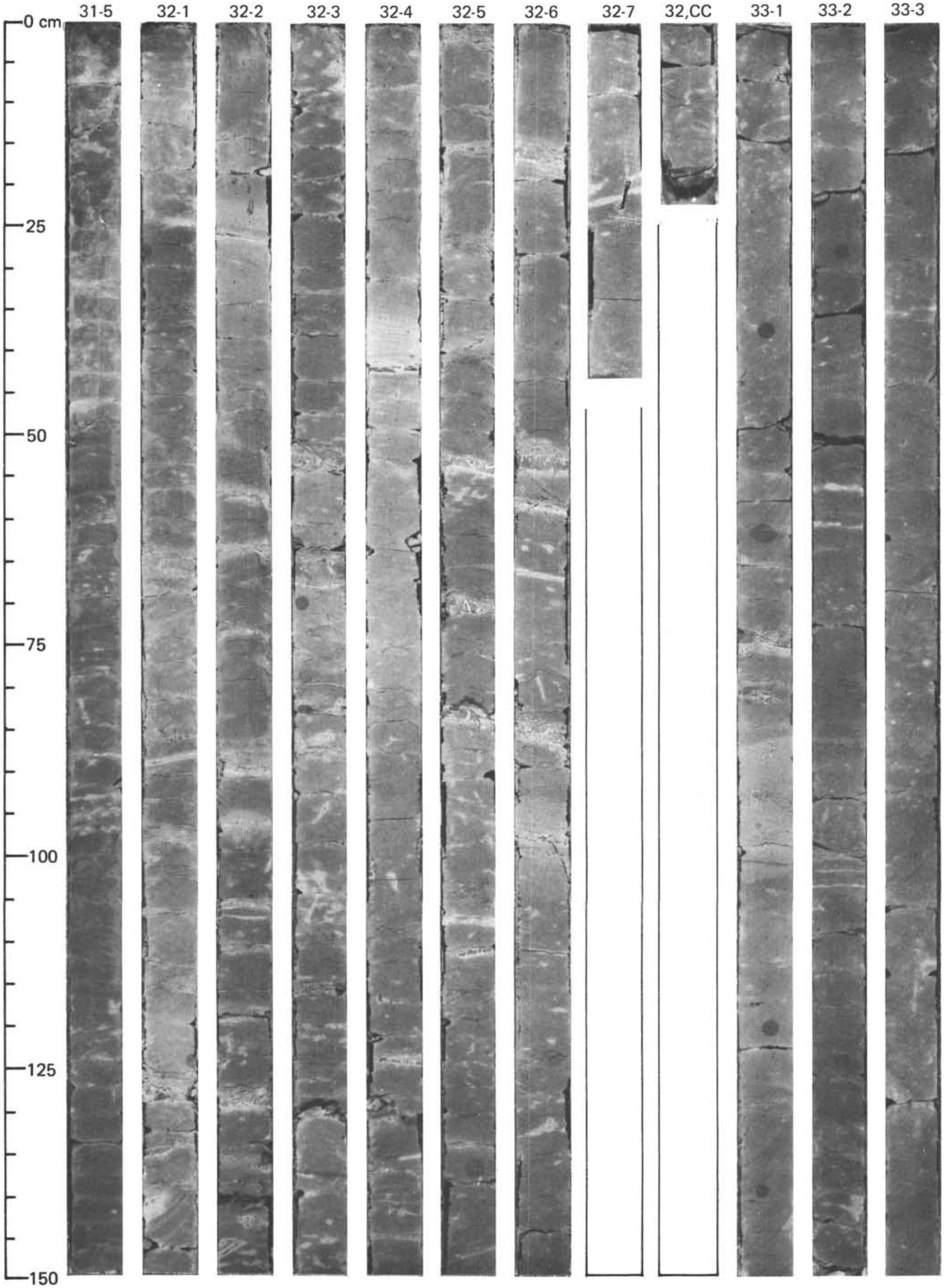
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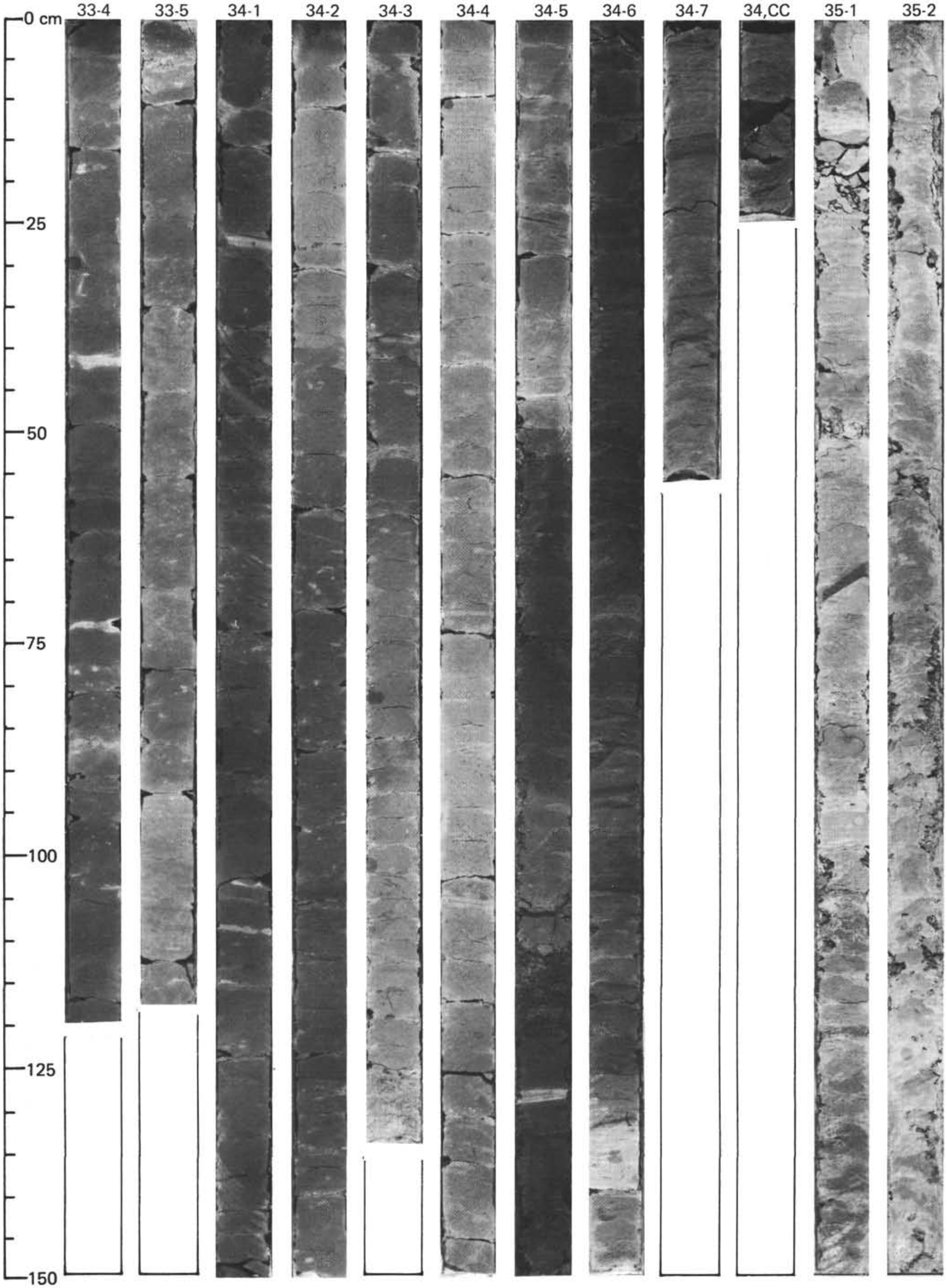

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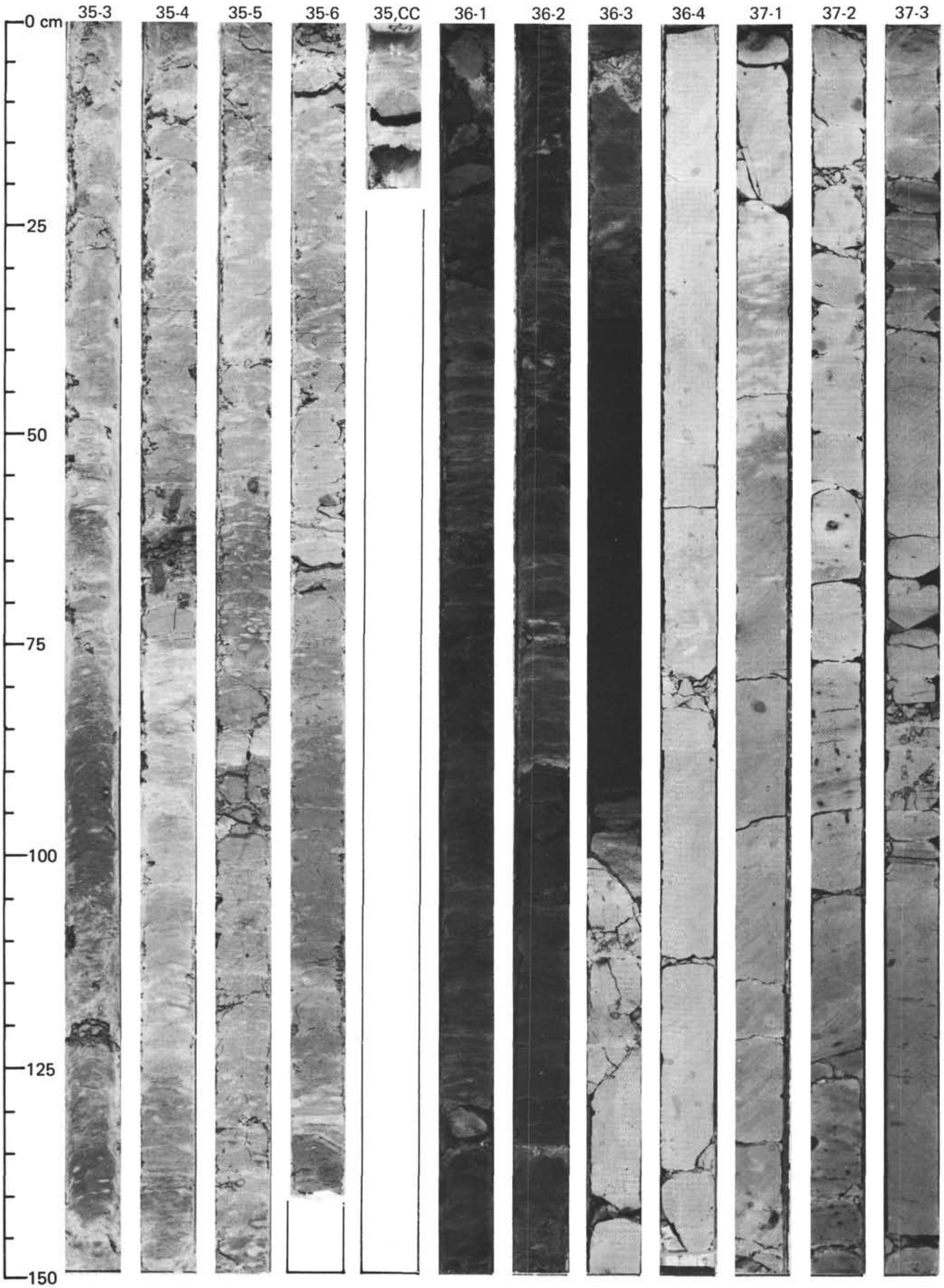
35-2


0 cm
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35-4
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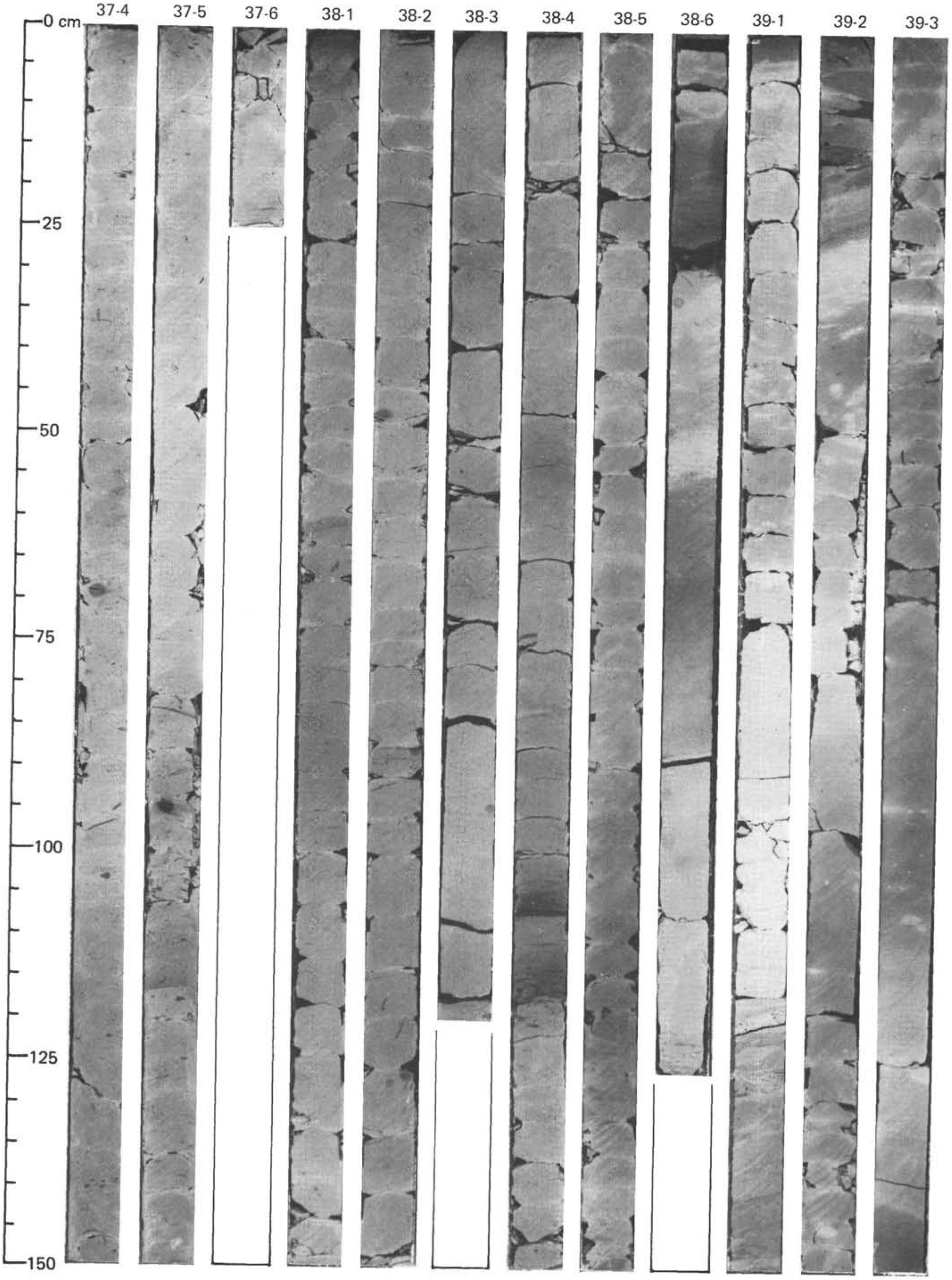
35-6
35,CC
36-1
36-2
36-3
36-4
37-1
37-2
37-3


37-4
37-5
37-6
38-1
38-2
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38-5
38-6
39-1
39-2
39-3
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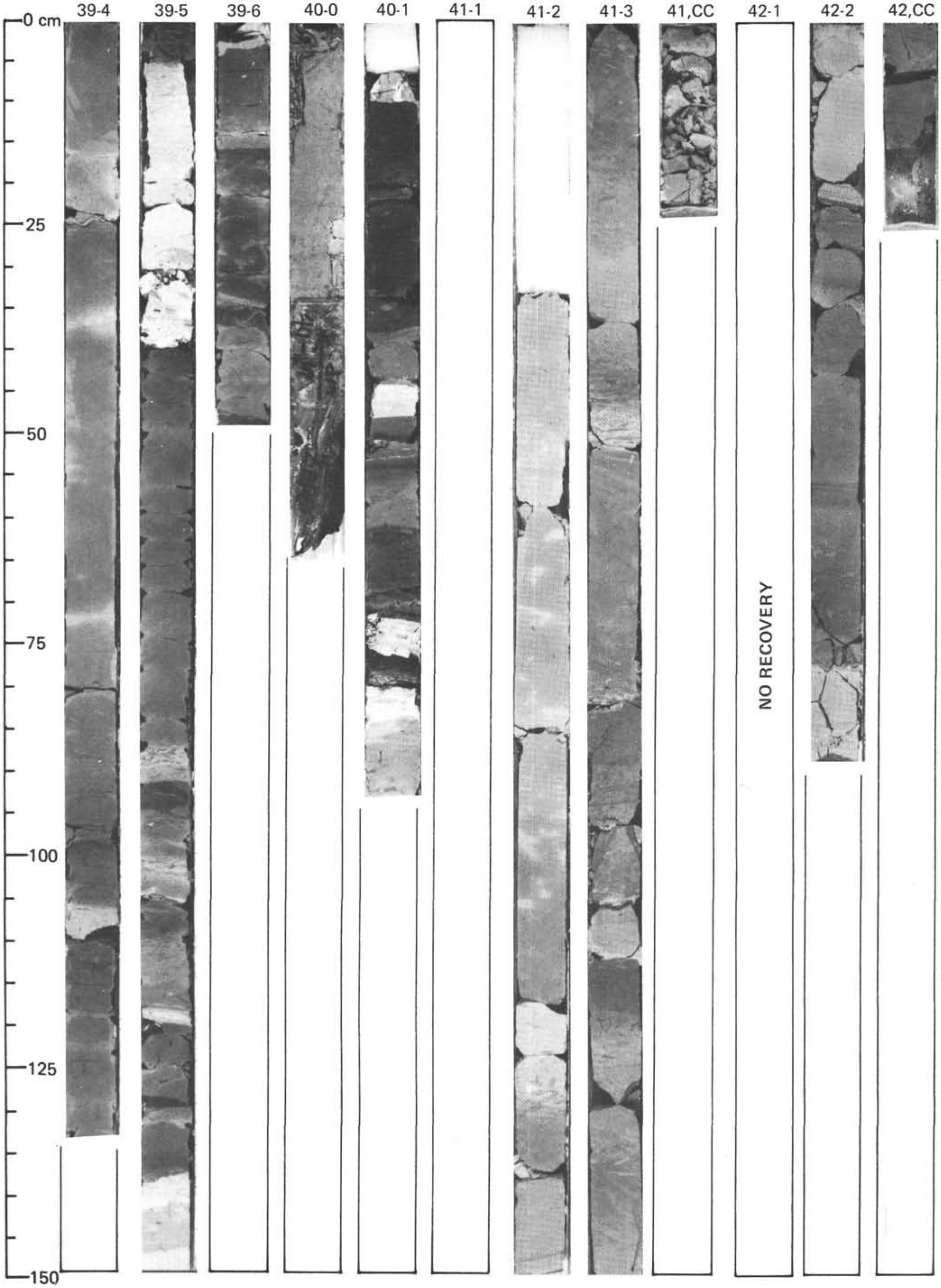
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41,CC
42-1
42-2
42,CC
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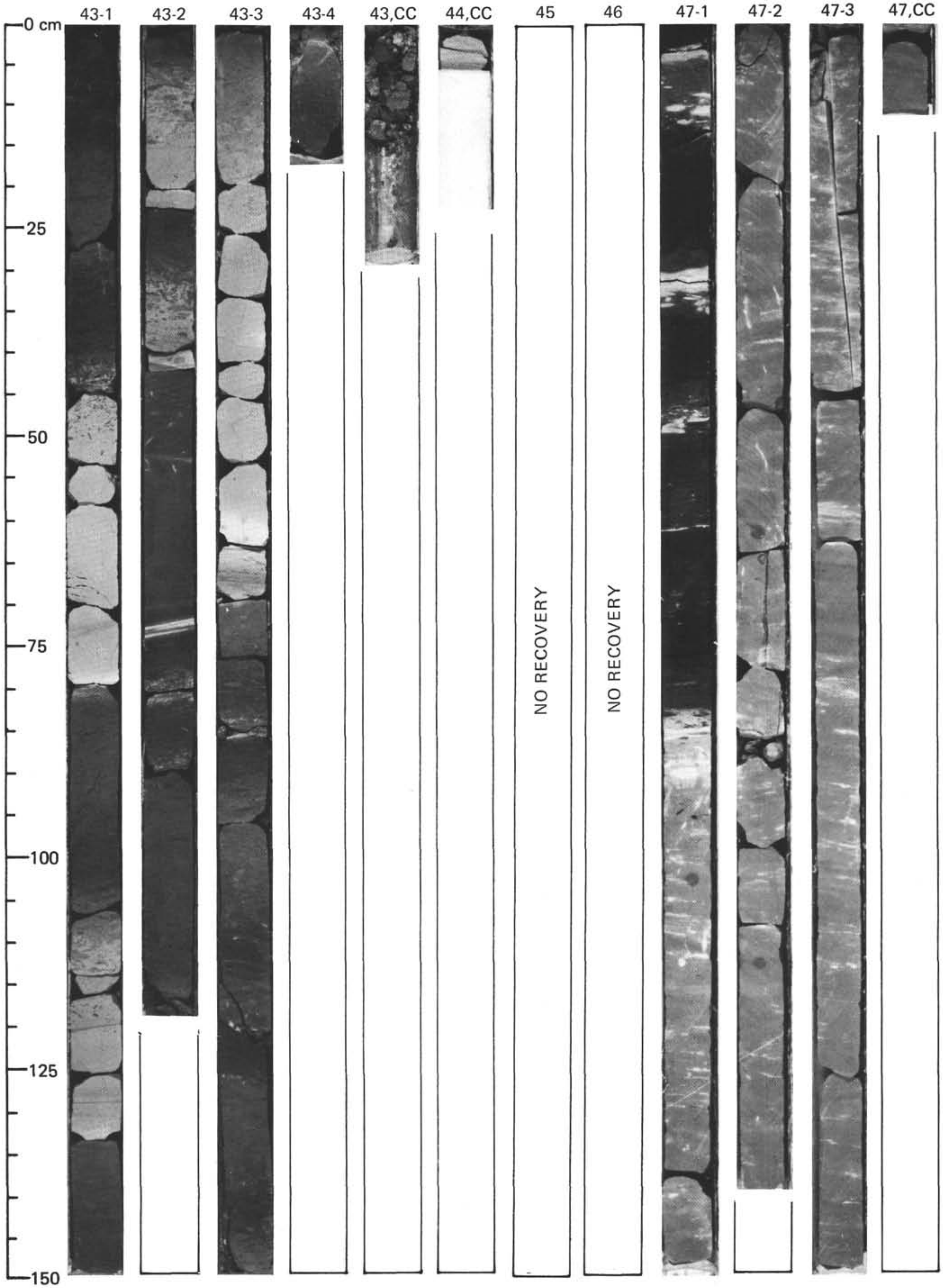
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43,CC
44,CC
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47,CC
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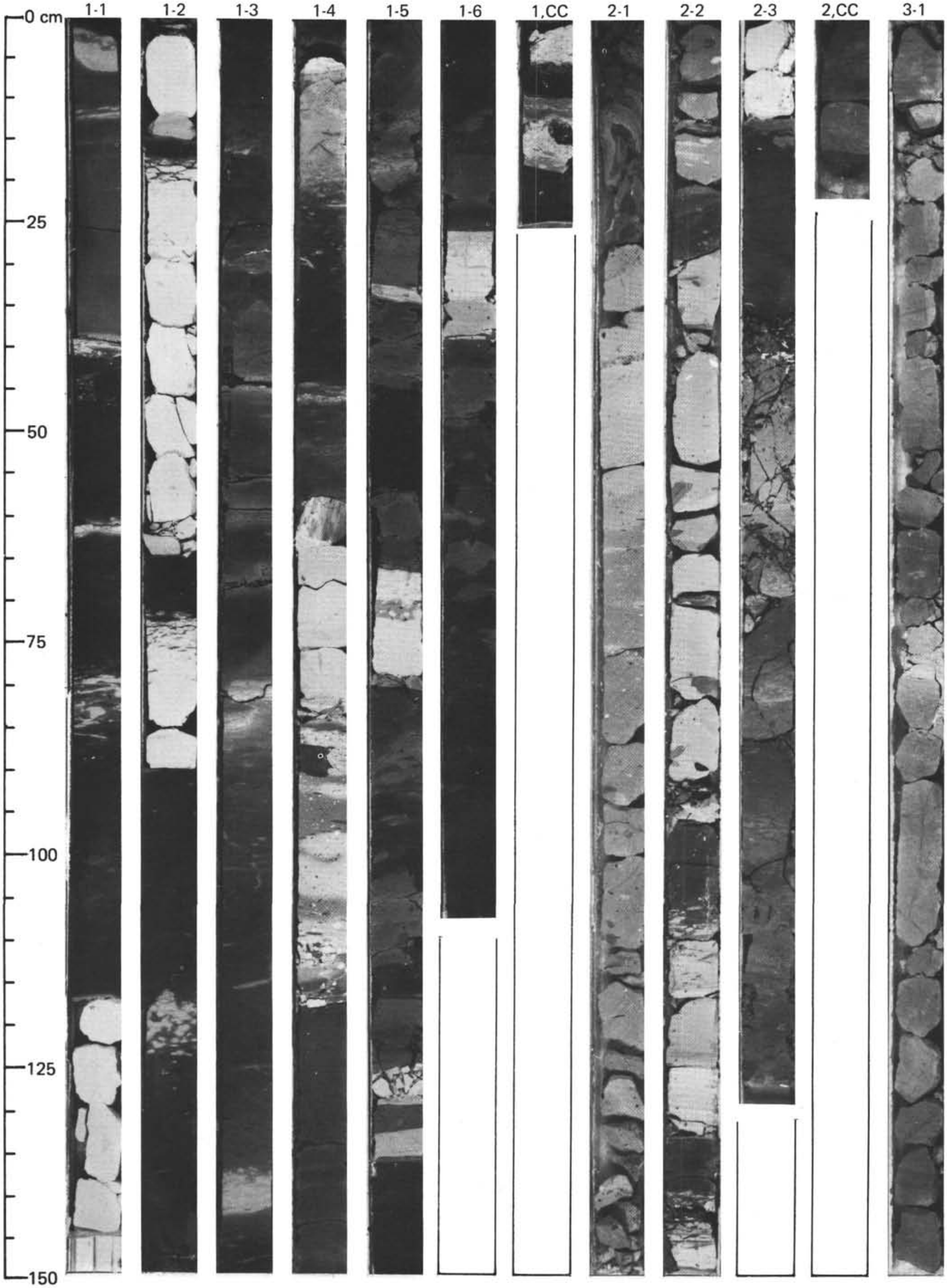
NO RECOVERY
NO RECOVERY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2-2
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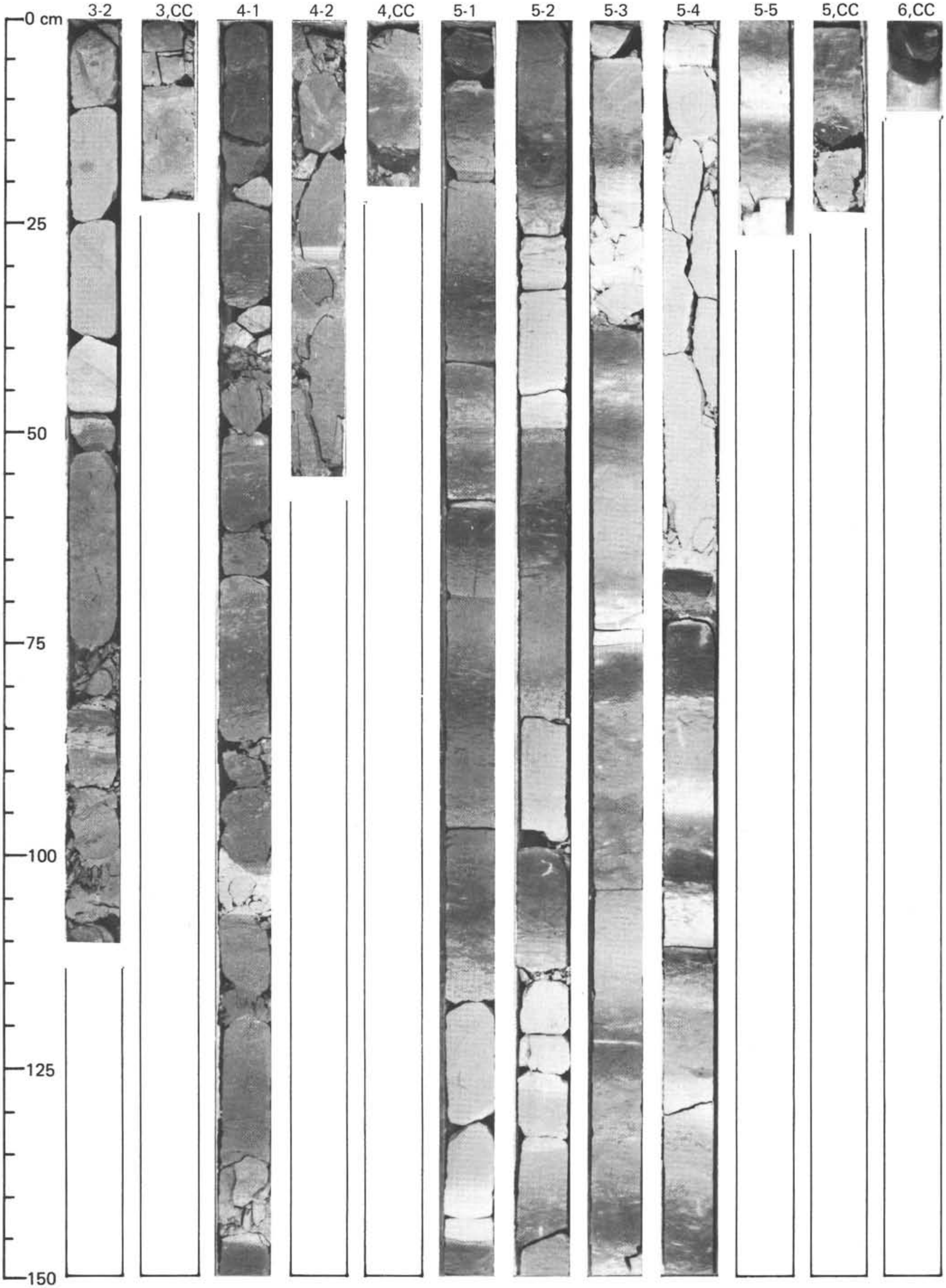
2,CC
3-1


3-2
3,CC
4-1
4-2
4,CC
5-1
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5-3
5-4
5-5
5,CC
6,CC
0 cm
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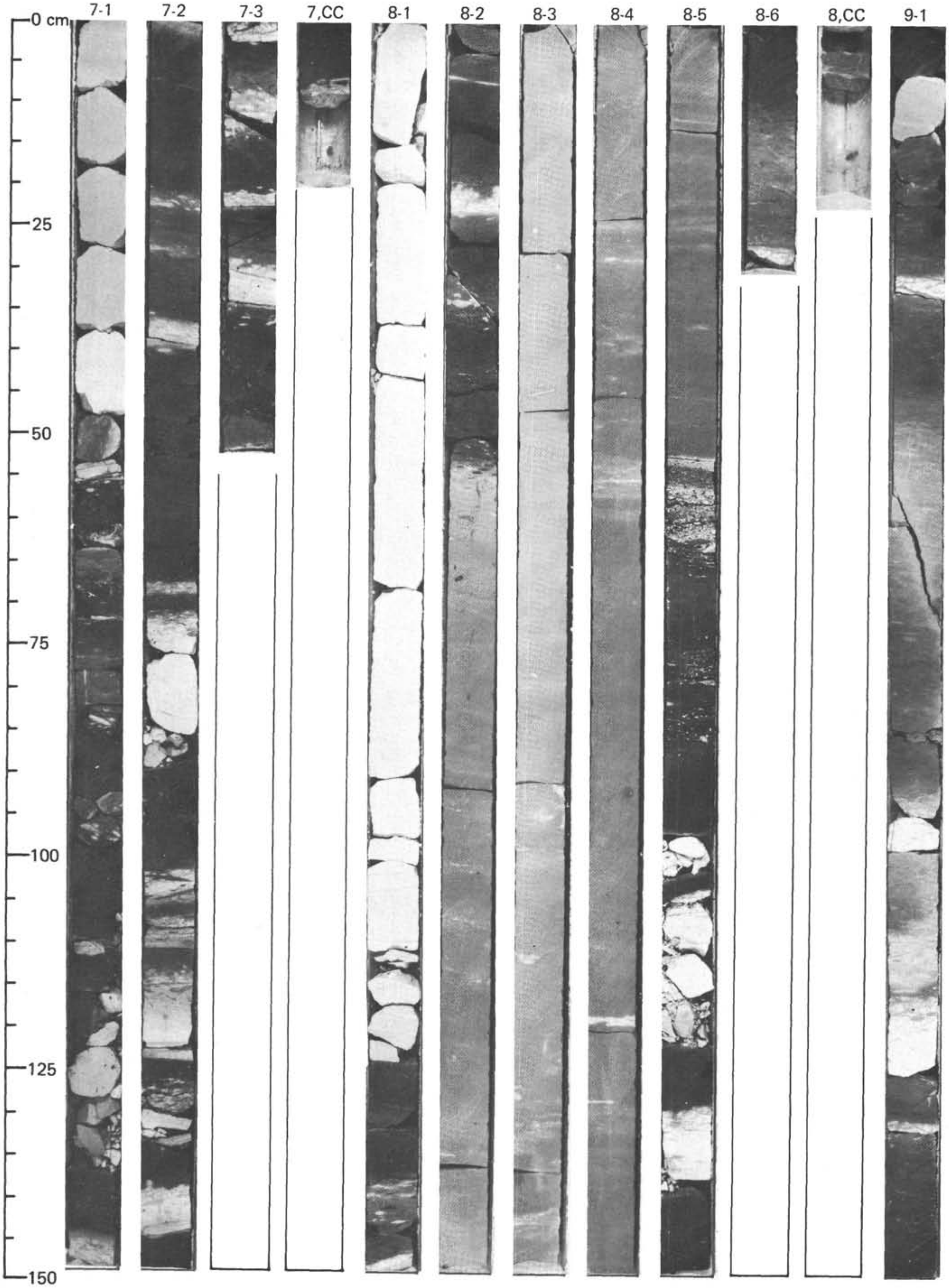
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8-1
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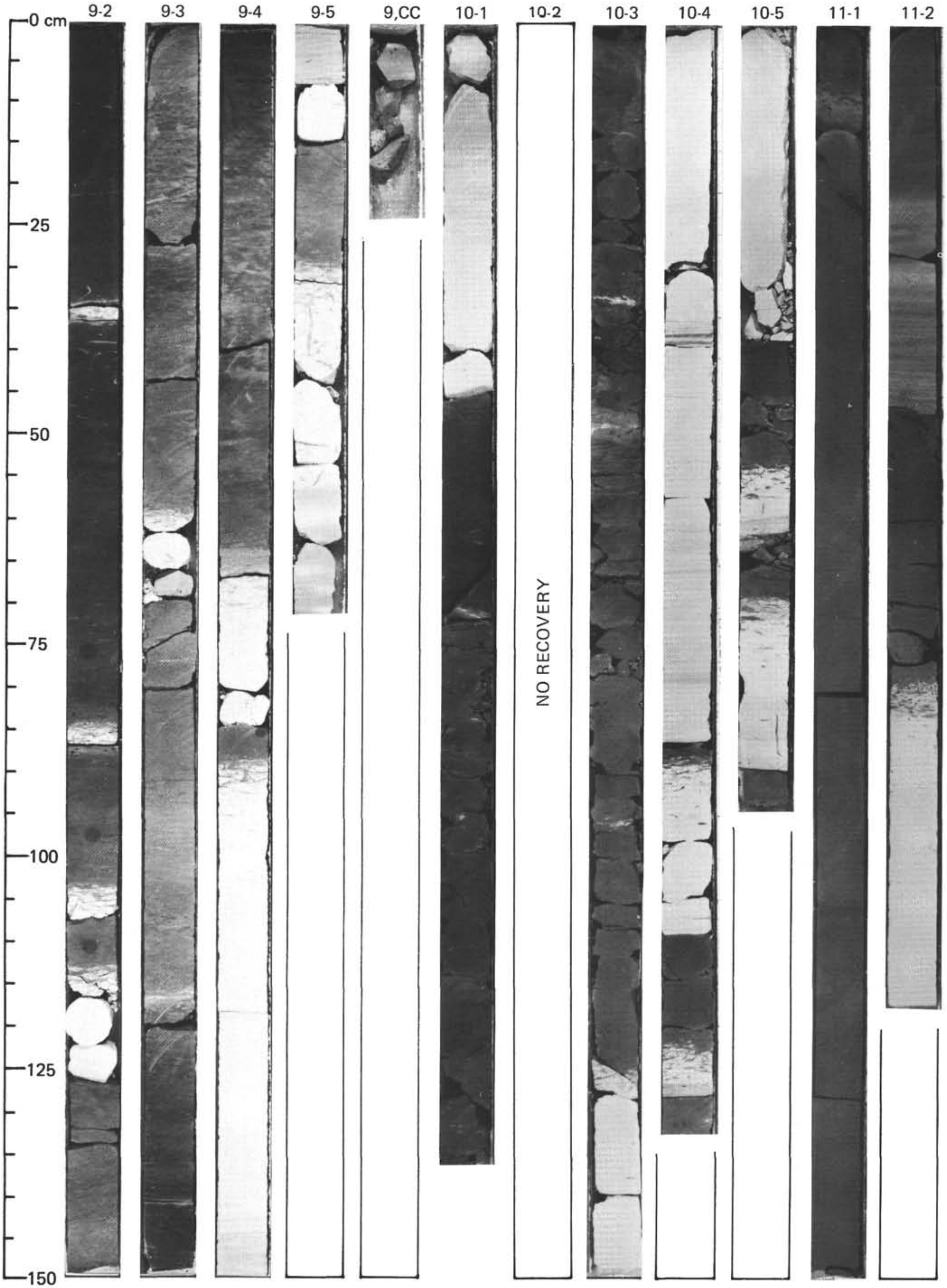
8-6
8,CC
9-1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10-2
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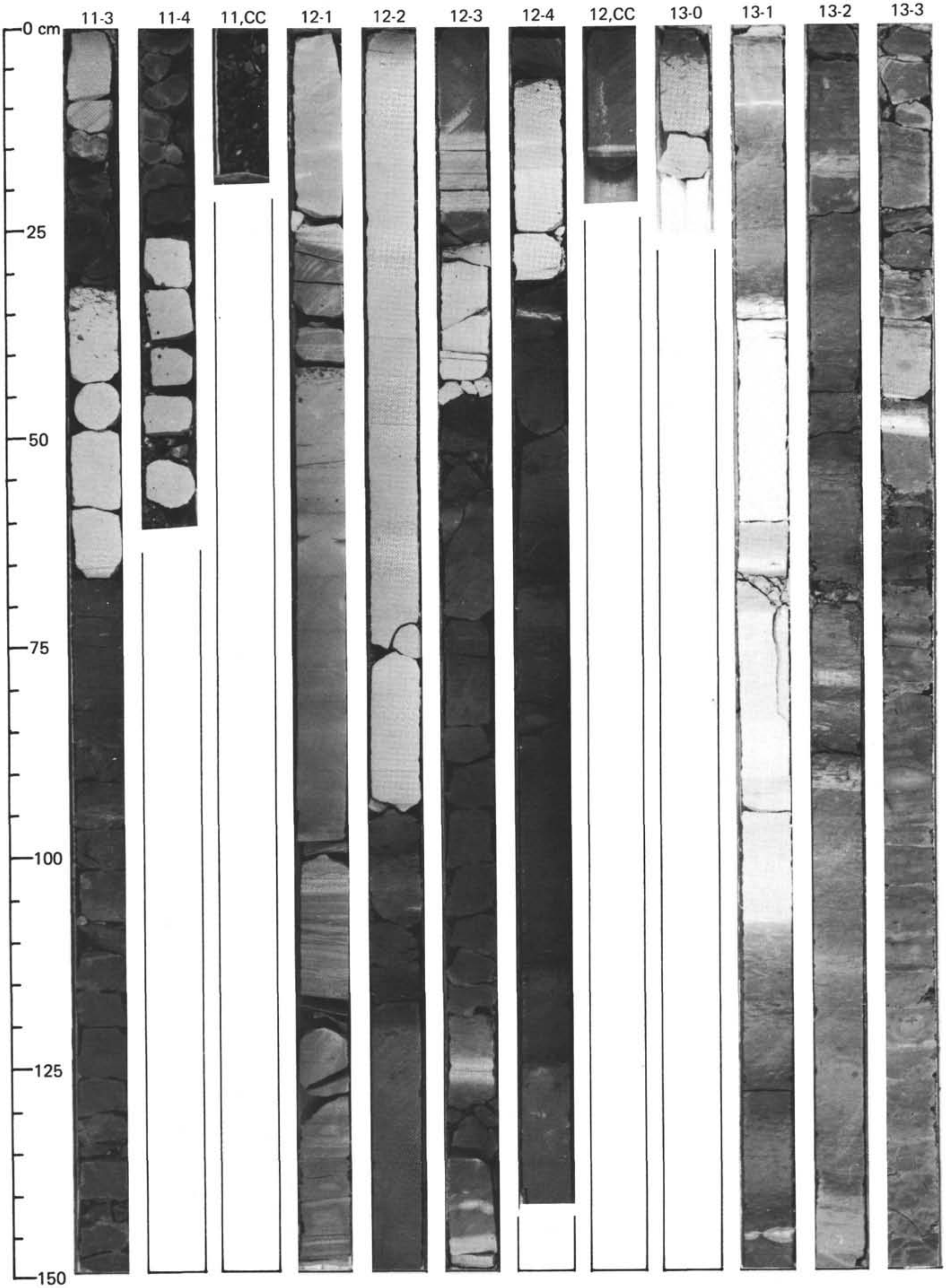
10-4
10-5
11-1
11-2
NO RECOVERY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12,CC
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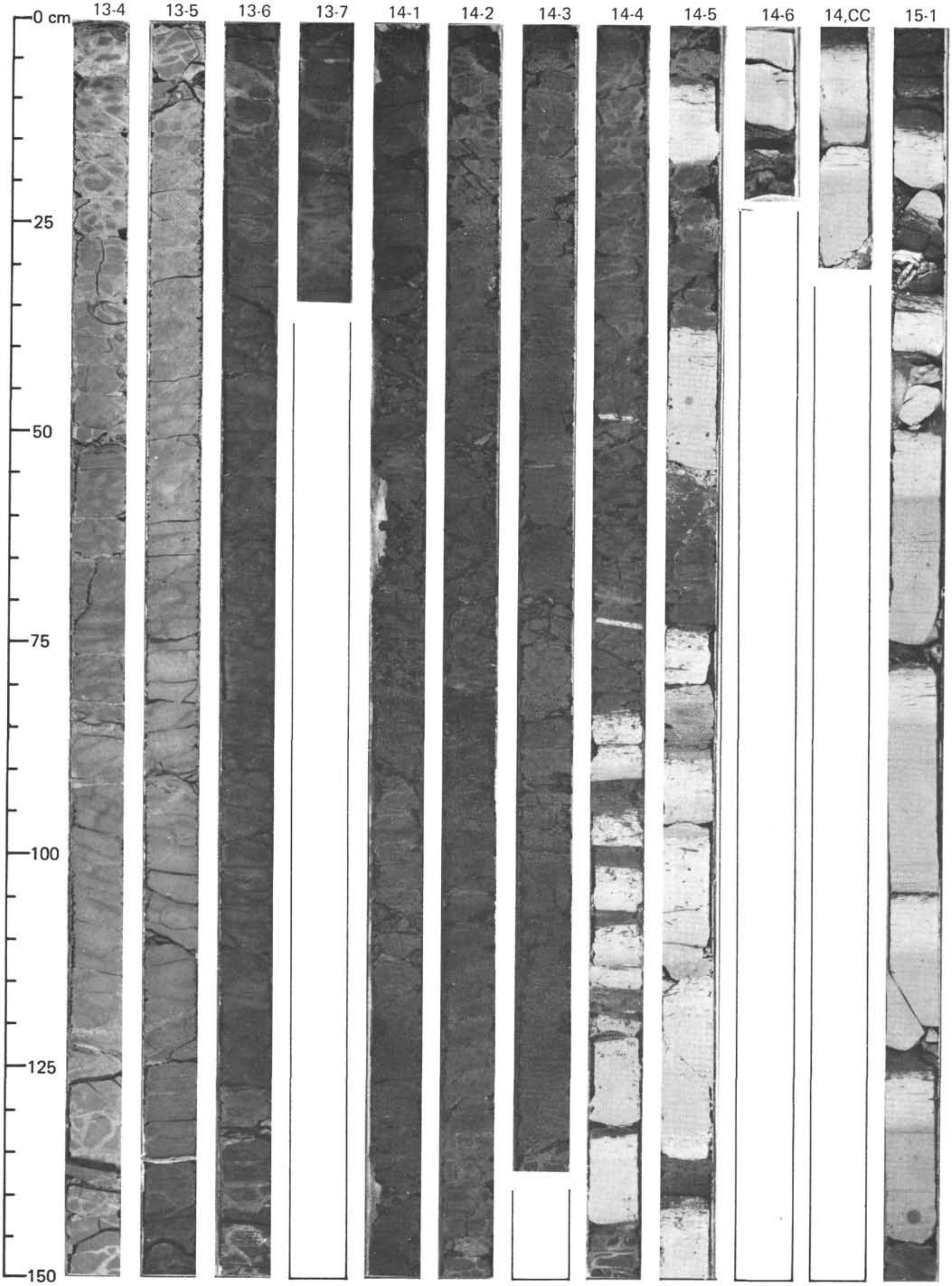
13-2
13-3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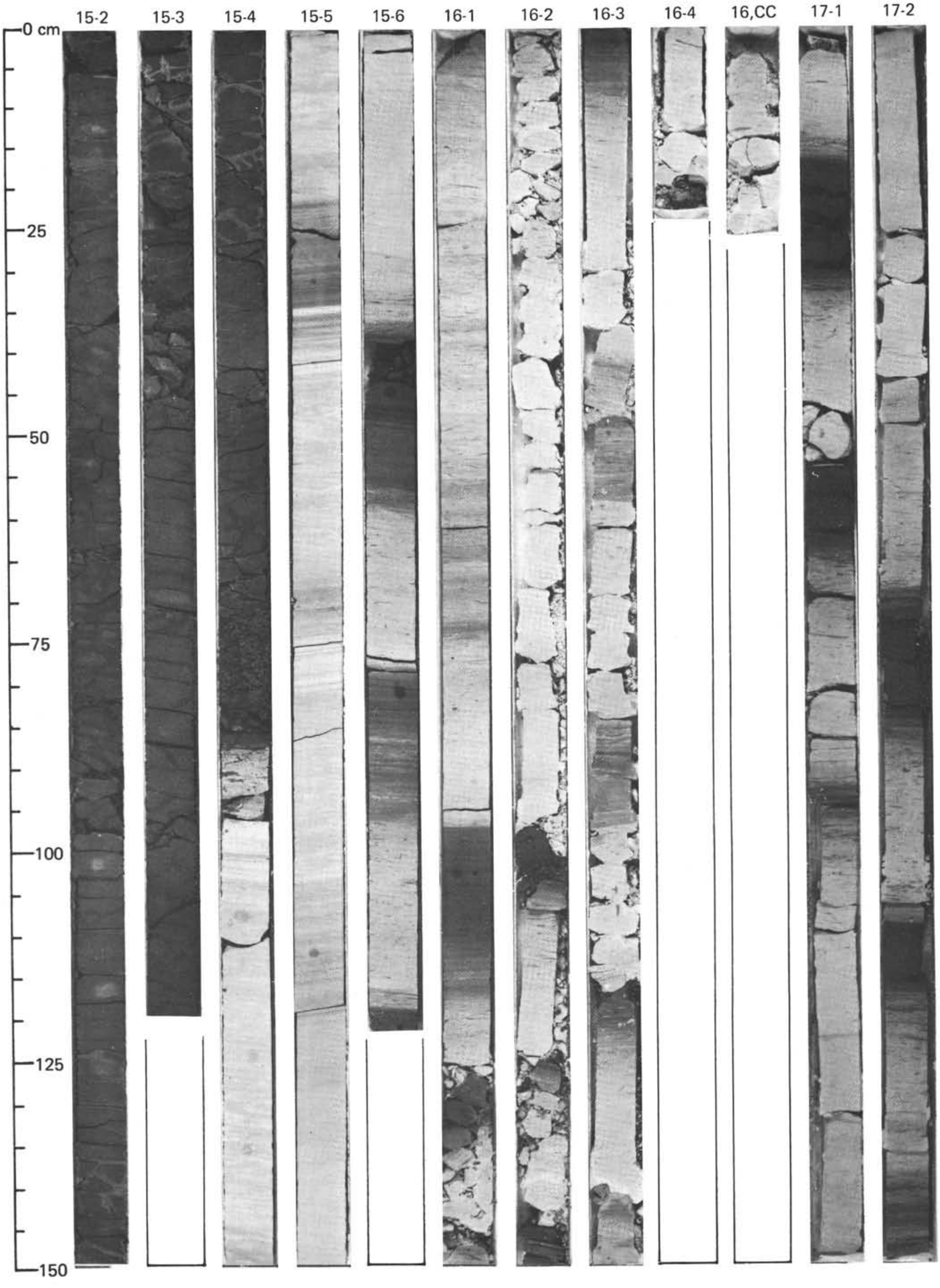
15-1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16-1
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16,CC
17-1
17-2
0 cm
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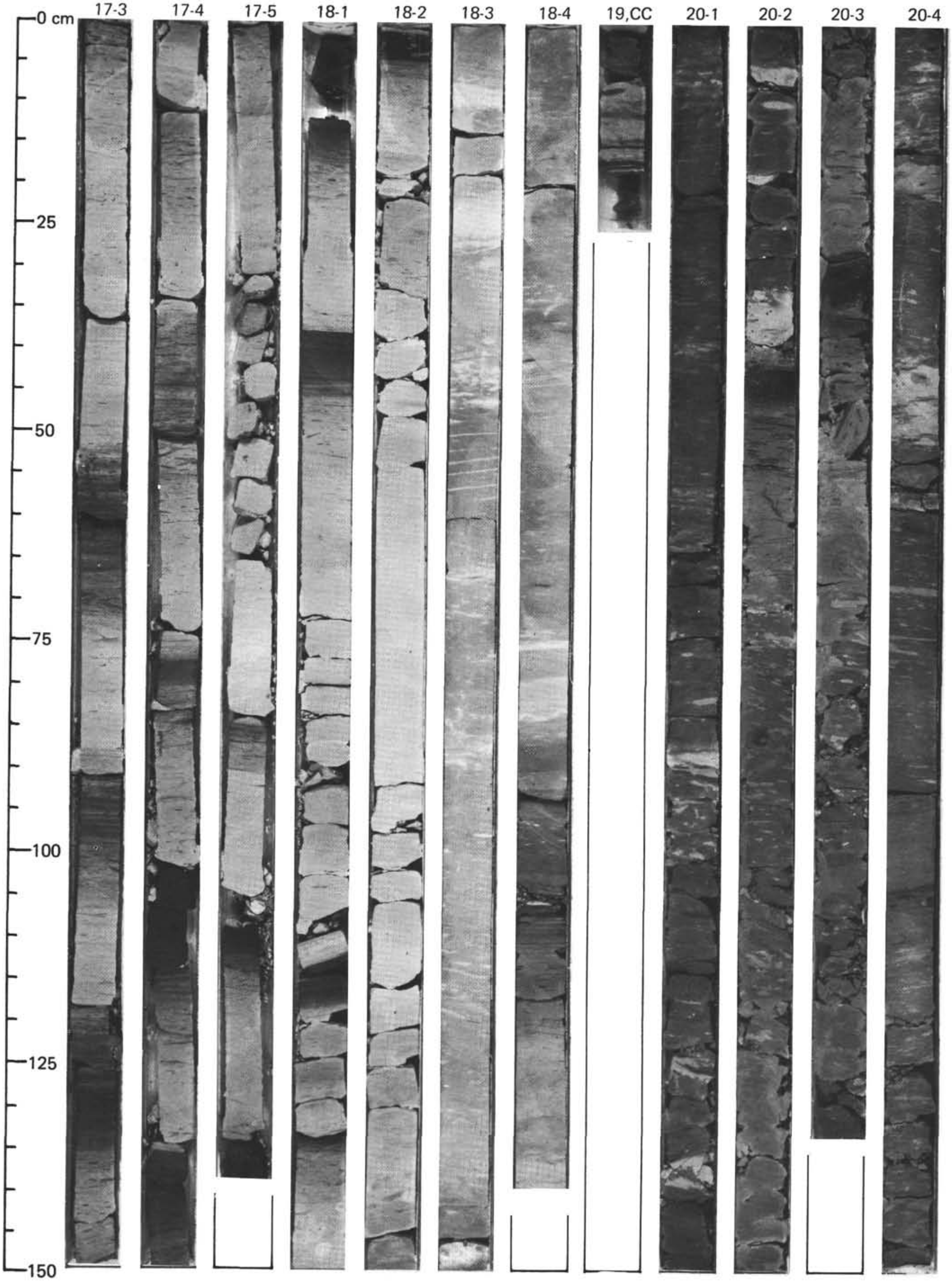
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19,CC
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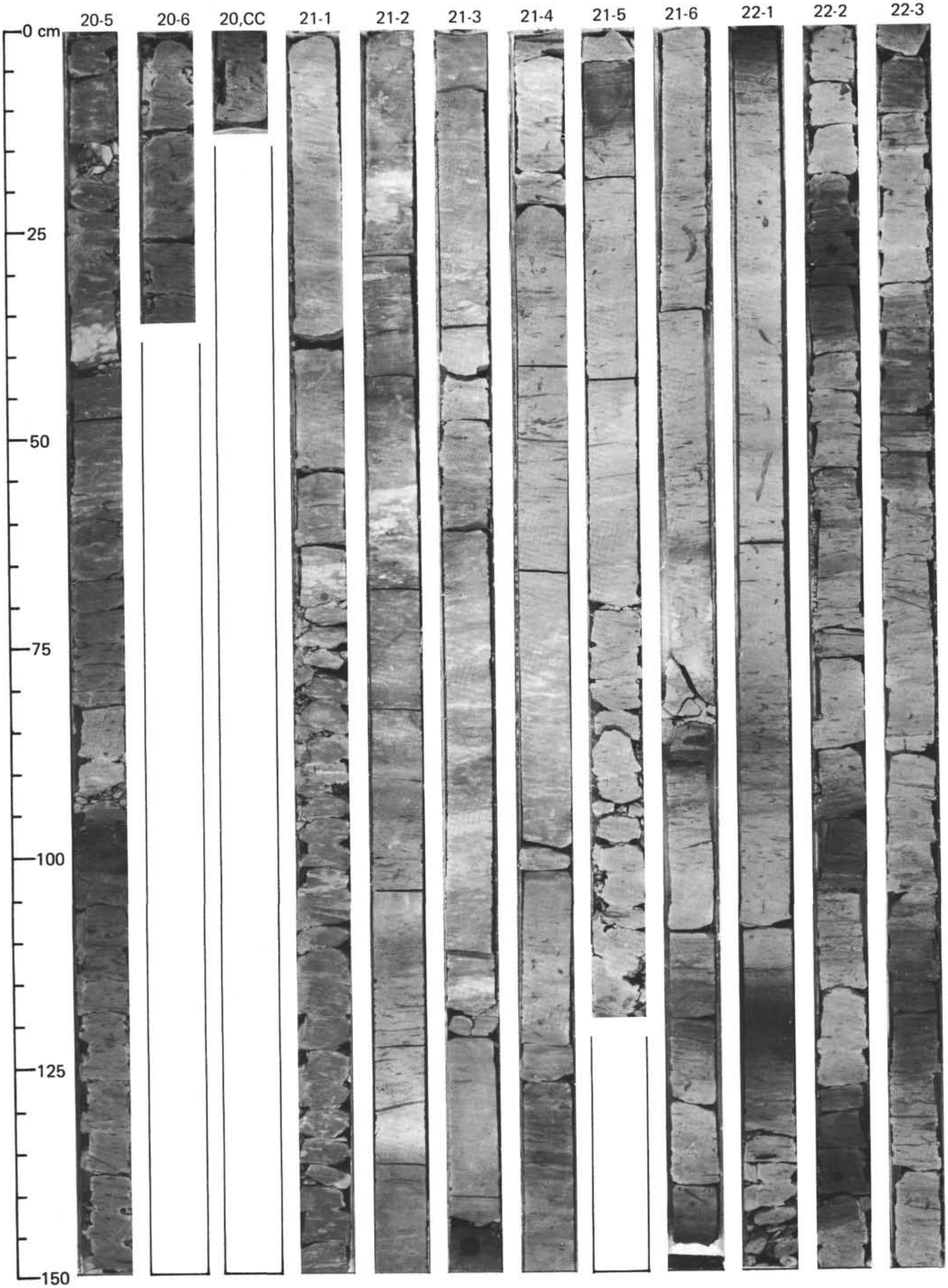
20-4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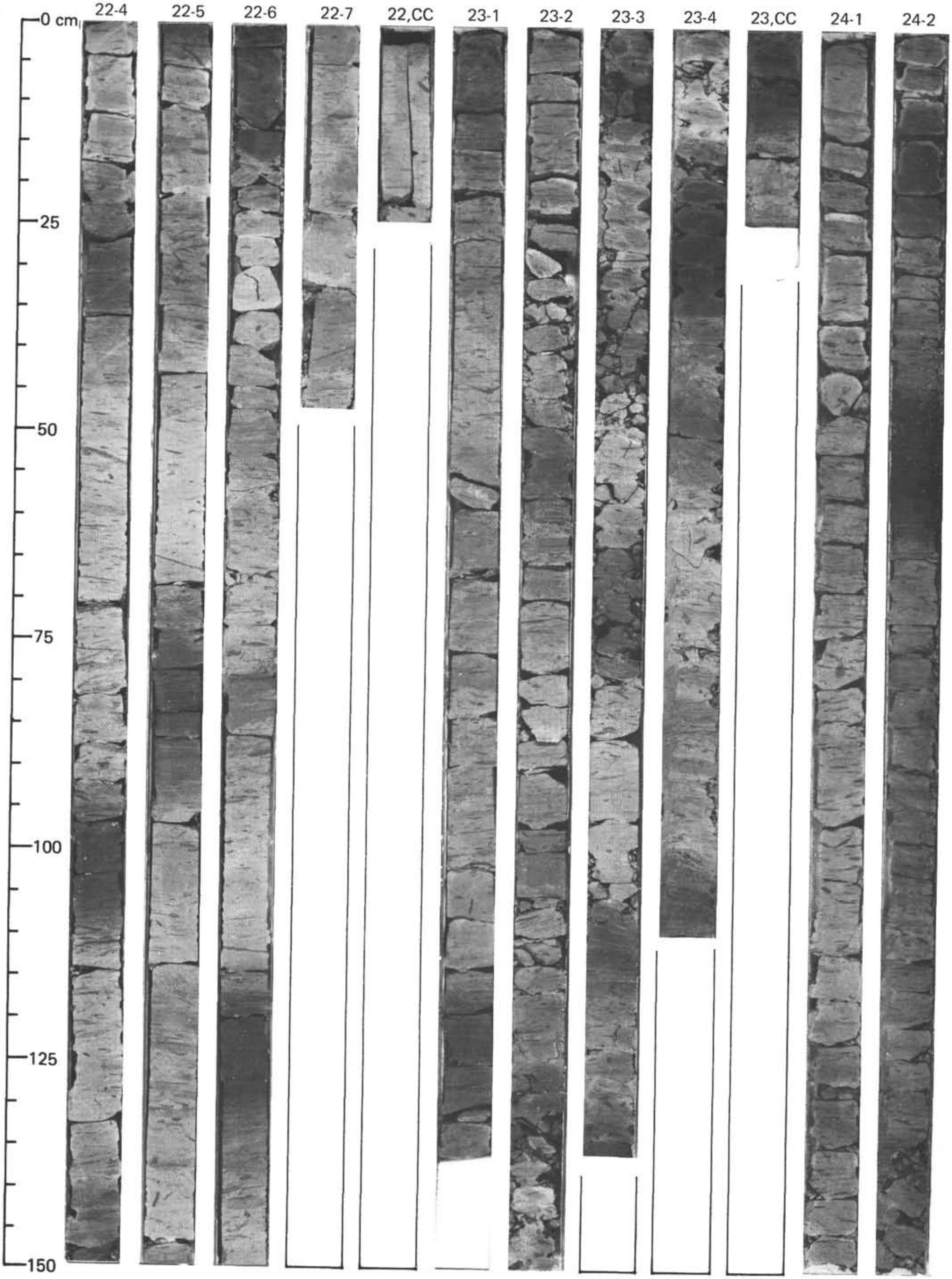
22-3


0 cm
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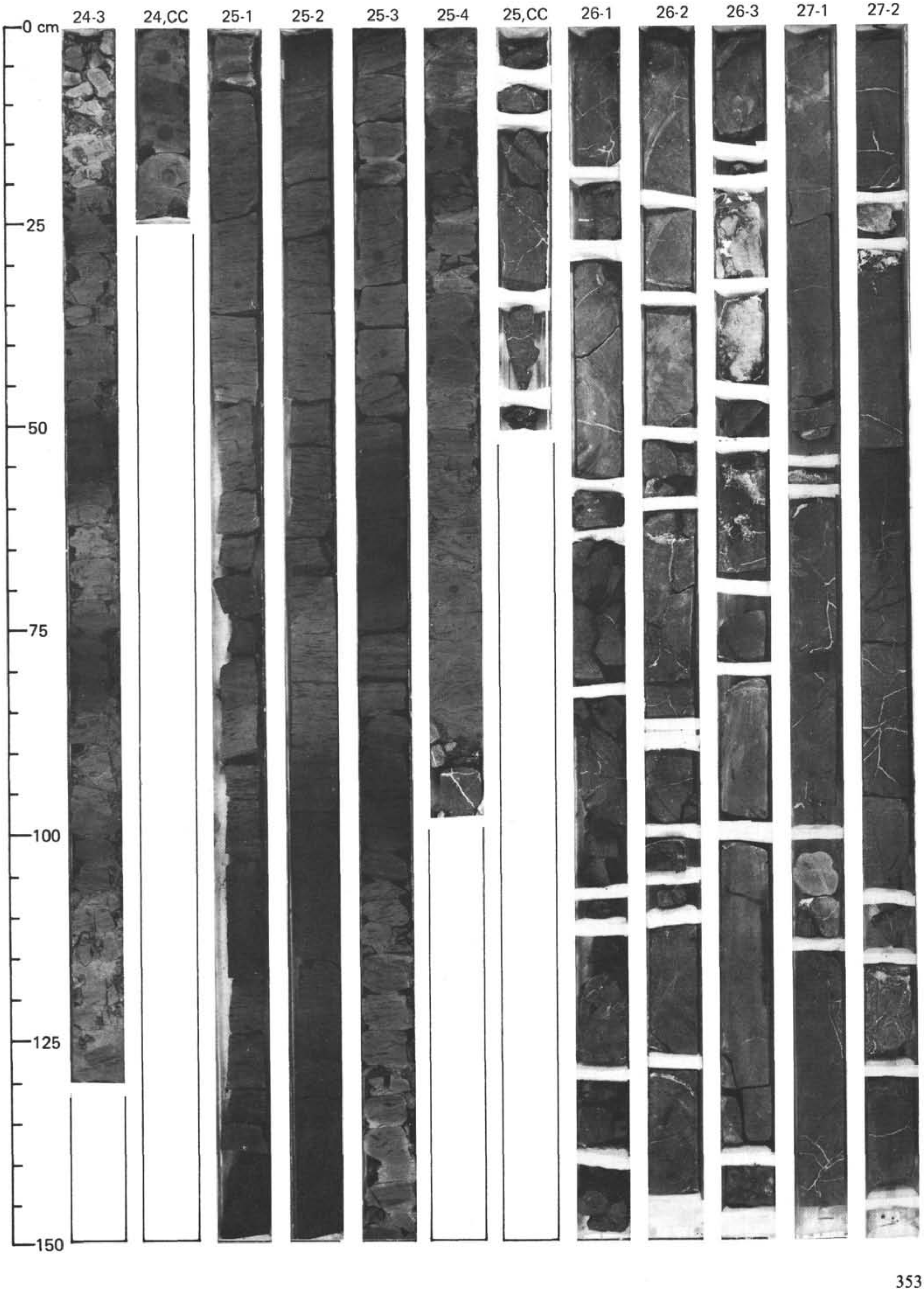
23,CC
24-1
24-2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25-4
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26-1
26-2
26-3
27-1
27-2
0 cm
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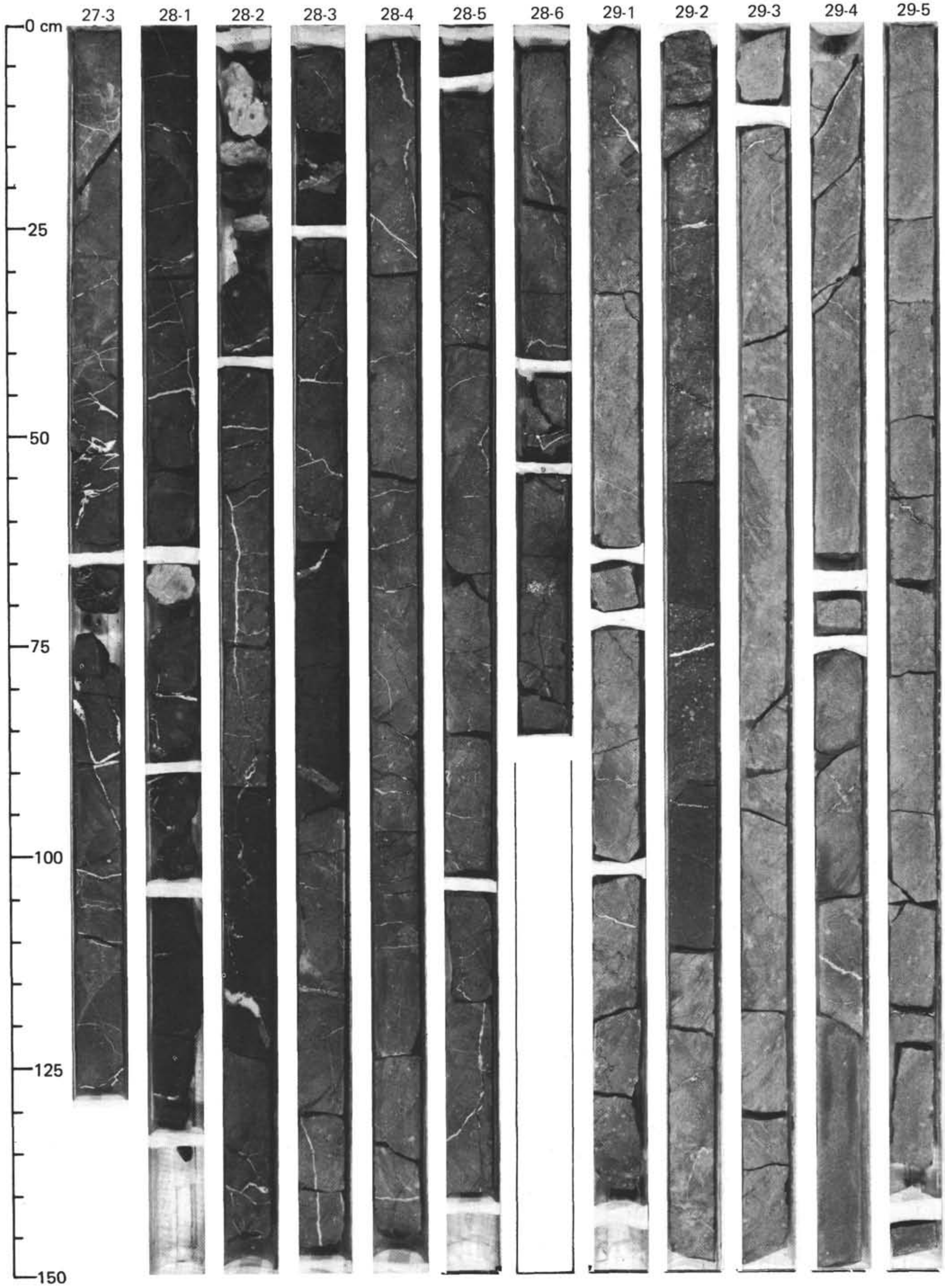
27-3
28-1
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29-1
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0 cm
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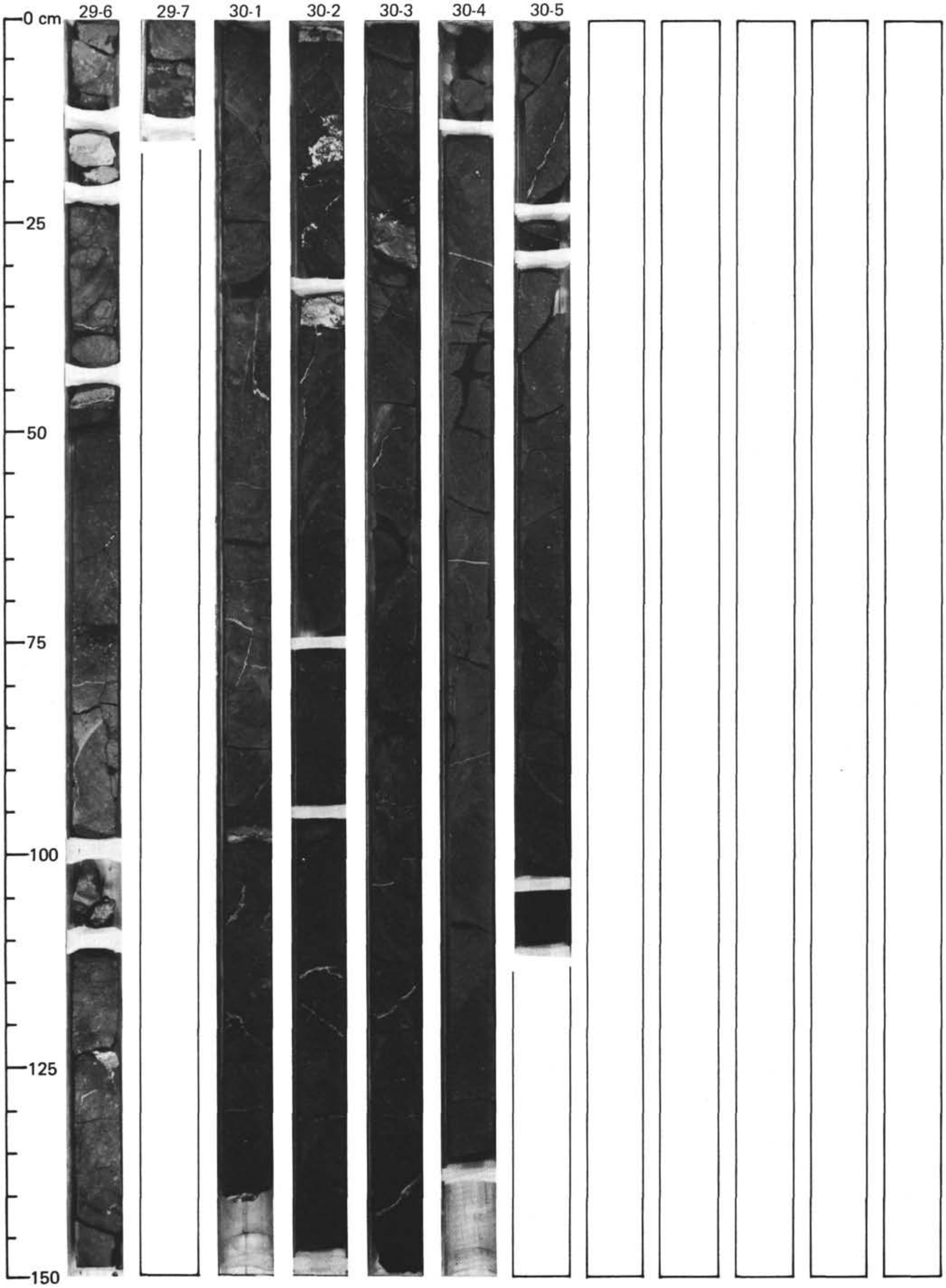
0 cm
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