4. SITE 277

The Shipboard Scientific Party[1]

SITE DATA

Location: Southern Campbell Plateau between Auckland and Campbell Islands

Position: 52°13.43'S; 166°11.48'E

Water Depth:
PDR, from sea level: 1214 meters
From drill pipe measurement from derrick floor: 1232 meters (adopted)

Dates Occupied: 11-13 March 1973

Depth of Maximum Penetration: 472.5 meters

Number of Holes: 1

Number of Cores: 46

Total Length of Cored Section: 434.5 meters

Total Recovery:
Length: 258.5 meters
Percentage: 59.6

Age of Oldest Sediment Cored: Middle Paleocene

Summary: Forty-six cores were recovered with a total penetration of 472.5 meters. About 10 meters of Plio-Pleistocene foraminifera-rich nannofossil ooze separated disconformably from 462 meters of nannofossil ooze, and nannofossil chalk of late Oligocene to middle Paleocene age, thin chert layers of Eocene to early Oligocene age occur. Sequence represents good example of highly uniform sediments that have undergone diagenesis with depth of burial. Late Cenozoic mostly absent over Campbell Plateau reflecting major increase in bottom-water over region. Remarkably complete subantarctic Paleogene sequence of nannofossils, foraminifera, and Radiolaria. Zones similar to New Zealand but lower diversity. Continuous sedimentation throughout Paleogene and Neogene erosion opposite to that of Tasman Sea area (Leg 21), and related to major bottom-water changes in Cenozoic in southwest Pacific. The data at this site confirm that a widespread and prominent reflector, representing the upper interface of the layer on top of basement, is associated with the Cenozoic/Mesozoic boundary throughout the southern Campbell Plateau.

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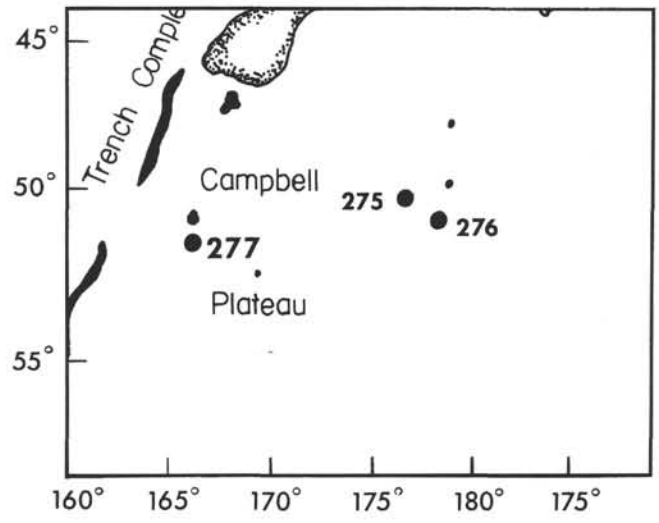


Figure 1. *Location of Site 277, DSDP Leg 29.*

BACKGROUND AND OBJECTIVES

Strong western boundary currents at Sites 275 and 276 created (and are creating) an eroded pavement that was very difficult or impossible to penetrate by drilling. The currents were also strong enough to cause the beacon to oscillate, resulting in extremely poor positioning.

For these reasons Lamont profiler data from the southern Campbell Plateau was searched to find soft sediments that were not subject to current scour. The only favorable site revealed in the profiler data was in the Cathedral Depression, about 130 km south of Auckland Island (Figures 1 and 2). The Tertiary section here appeared to be about 436 meters thick and overlie a strong reflecting surface (Figure 3). The universal character of this surface has been demonstrated over much of the Campbell Plateau.

The primary objective of the site was to obtain a Cenozoic biostratigraphic sequence in subantarctic latitudes, and to identify disconformities if present. The presence or absence of disconformities in the sequence enable a history of bottom waters to be established for the Cenozoic. Sites 275 and 276, as well as data presented by Summerhayes (1969), demonstrate that the Campbell Plateau has been a site of active bottom erosion during the late Cenozoic. The definition of sedimentary history at Site 277 enabled a better understanding of the paleoceanographic history of the region related to long-term oceanic structural changes and to Antarctic glaciation.

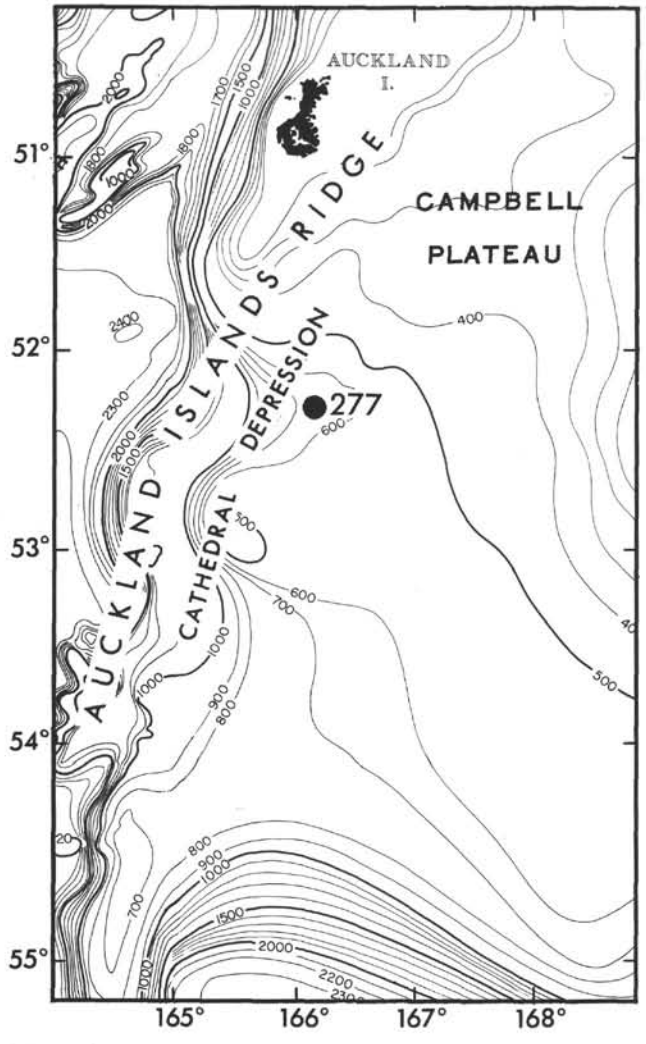


Figure 2. *Bathymetry at Site 277.*

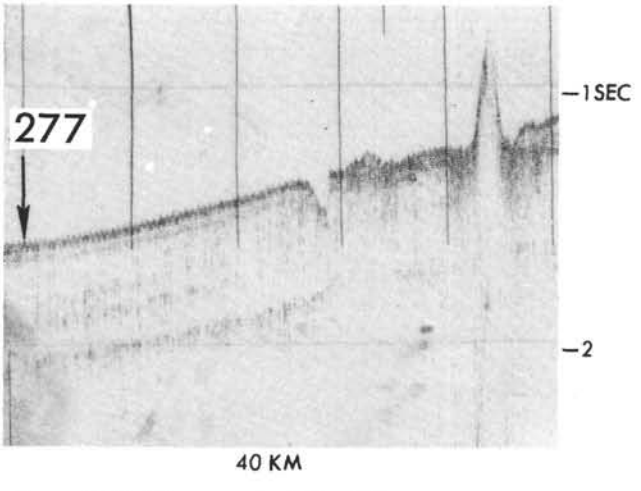


Figure 3. *Profiler record at Site 277.*

OPERATIONS

The approach to Site 277 on the Cathedral Depression was from the northeast, (Figure 4). The beacon was dropped while underway at 9 km/hr (5 knots) on the first pass over the site.

The bottom hole assembly and drill pipe were run in and the sea floor tagged at 1232 meters. The hole was spudded, and continuously cored to 1533.5 meters. Alternate drilling and coring proceeded to 1600 meters, with continuous coring to a total depth of 1704.5 meters or 472.5 meters penetration. Details of the coring are in Table 1.

LITHOLOGY

Four units have been defined in the 476 meters of sediment cored at Site 277. All but the upper few meters consists of nannofossil oozes with glauconite, foraminifera, and/or radiolarians. Table 2 summarizes the sediments recovered at this site and Figure 5 shows the sediment section.

Unit 1

Unit 1 is distinguished by an abundance of foraminifera. Soft foraminiferal ooze with common to rich amounts of nannofossils is interbedded with soft nannofossil ooze containing foraminifera and glauconite. Typical colors are white, light gray, and light greenish gray, and bedding thicknesses are from 5 cm to about 3 meters. Light mottled areas low in glauconite are common in the glauconitic nannofossil oozes, and some also occurs in the foraminiferal oozes. Contacts between beds are typically sharp, and are only slightly deformed where foraminiferal ooze overlies nannofossil ooze. The beds are intensely deformed where nannofossil ooze overlies foraminiferal ooze.

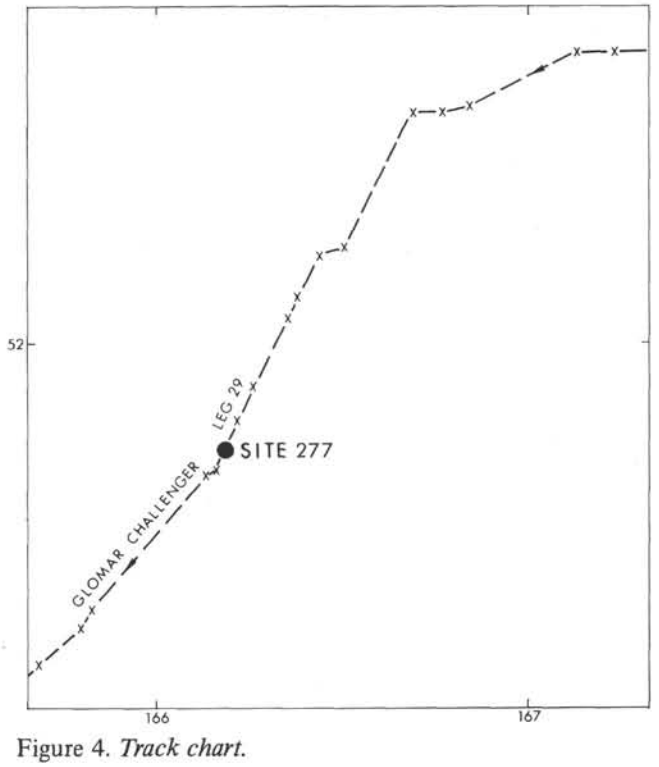


Figure 4. *Track chart.*

TABLE 1
Coring Summary, Site 277

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovery (m)	Recovery (%)
1	0.0-7.0	7.0	6.9	99
2	7.0-16.5	9.5	9.5	100
3	16.5-26.0	9.5	9.5	100
4	26.0-35.5	9.5	9.5	100
5	35.5-45.0	9.5	9.5	100
6	45.0-54.5	9.5	8.3	87
7	54.5-64.0	9.5	9.0	95
8	64.0-73.5	9.5	9.2	97
9	73.5-83.0	9.5	9.0	95
10	83.0-92.5	9.5	9.5	100
11	92.5-102.0	9.5	9.4	99
12	102.0-111.5	9.5	8.4	88
13	111.5-121.0	9.5	8.6	91
14	121.0-130.5	9.5	9.5	100
15	130.5-140.0	9.5	6.1	64
16	140.0-149.5	9.5	7.2	76
17	149.5-159.0	9.5	8.0	84
18	159.0-168.5	9.5	3.7	38
19	168.5-178.0	9.5	2.0	21
20	178.0-187.5	9.5	9.5	100
21	187.5-197.0	9.5	3.9	41
22	197.0-206.5	9.5	3.8	40
23	206.5-216.0	9.5	4.5	47
24	216.0-225.5	9.5	3.5	37
25	225.5-235.0	9.5	2.6	27
26	235.0-244.5	9.5	5.5	58
27	244.5-254.0	9.5	1.4	15
28	254.0-263.5	9.5	2.6	27
29	263.5-273.0	9.5	4.3	45
30	273.0-282.5	9.5	6.2	65
31	282.5-292.0	9.5	2.9	31
32	292.0-301.5	9.5	2.7	28
33	311.0-320.5	9.5	1.9	20
34	330.0-339.5	9.5	2.9	31
35	349.0-358.5	9.5	3.0	32
36	368.0-377.5	9.5	3.4	36
37	377.5-387.0	9.5	3.1	33
38	387.0-396.5	9.5	3.6	38
39	396.5-406.0	9.5	3.1	33
40	406.0-415.5	9.5	3.2	34
41	415.5-425.0	9.5	4.0	42
42	425.0-434.5	9.5	3.2	34
43	434.5-444.0	9.5	4.3	45
44	444.0-453.5	9.5	3.5	37
45	453.5-463.0	9.5	8.3	87
46	463.0-472.5	9.5	5.2	54
Total		434.5	258.9	60

A disconformity between the middle-late Oligocene and the late Pliocene-early Pleistocene occurs at a depth of about 7 meters in Unit 1. Interbedded foraminiferal and nannofossil oozes occur above and below the disconformity. Above the disconformity, beds of foraminiferal and nannofossil ooze are relatively thick, typically 1-3 meters. Below the disconformity the foraminiferal ooze is about 1 meter thick, but the nannofossil ooze is only 10-20 cm thick.

Unit 2

This unit makes up almost half the sequence cored at Site 277. It is 231 meters thick and consists of an unvarying nannofossil ooze that commonly contains glauconite, Radiolaria, foraminifera, and minor

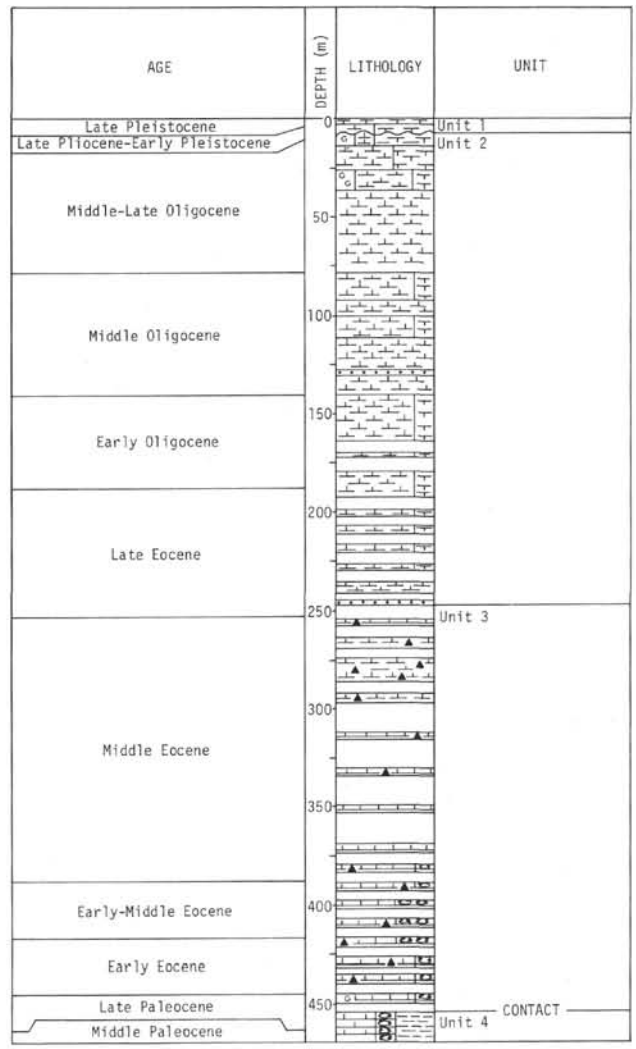


Figure 5. *Columnar section at Site 277.*

amounts of diatoms and sponge spicules. This unit is distinguished from similar lower units by the stiffness of the sediments and the obvious lack of lithification and diagenesis.

The typical color is greenish white, with faint greenish-black streaks that represent areas with glauconite-filled foraminiferal tests. The streaks are less common in the lower part of the unit. White and pale-green layers, patches, and streaks of unknown significance are also present. Manganese nodules, micronodules, and patches are common throughout. A single pumice pebble was found at about 107 meters.

Although typically stiff, Unit 2 has a variable induration. Soft to soupy layers of slurry exist that may be the result of drilling. However, several anomalously hard layers are present that are similar in composition and color to the typical sediment type.

Two anomalous layers of glauconite-bearing chert-calcite-quartz sandstone occur at approximately 125 and 244 meters. The upper coarse- to medium-grained bed is about 17 cm thick; has a subtle compositional and size grading, and contains fragments of displaced bryozoans,

TABLE 2
Lithologic Summary, Site 277

Unit	Lithology	Subbottom Depth (m)	Unit Thickness (m)
1	Foraminiferal ooze and foraminifera rich nannofossil ooze. Thin interbeds, soft to stiff.	0-13	13
2	Nannofossil ooze with glauconite, foraminifera, and/or radiolarians. Stiff, but unlithified.	13-246	233
3	Nannofossil chalk with chert nodules. Stiff to semilithified.	246-454	208
4	Nannofossil chalk with chert, clay, and pyrite. Semi-lithified to lithified.	454-476+	22+

corals, and shallow-water benthonic foraminifera. It probably is a turbidite. The lower bed is compositionally similar, is coarse grained, but does not show grading. It is 7-cm thick and separates Unit 2 from Unit 3.

Unit 3

Unit 3 is marked by the appearance of chert nodules and cherty carbonate sediments and by the disappearance of siliceous fossils; otherwise it is compositionally similar to Unit 2. Most of the sediments are stiff to semilithified and exhibit brittle deformation, being chalks rather than oozes. The sediments typically are greenish-white, but some chalks are white to light gray. Glauconite and foraminifera are common.

Chert nodules, 2-6 cm thick, average one per core (9.5 meters), increasing in the upper 60 meters. In the upper part of Unit 3 the chert is light gray, and some nodules have white mottling or contain black veins. Chert nodules from the lowermost 40 meters are mottled brown, light brown, and white. Animal burrows are abundant. The trace fossil *Zoophycos* also occurs.

Unit 4

Unit 4 is characterized by the appearance of clay minerals and pyrite and by recrystallization of many nannofossils to micarb. The semilithified to lithified sediments are more highly indurated than the overlying sediments. The typical color is greenish-gray to greenish-white, slightly darker than the above unit, with some lighter mottling.

Pyrite occurs sparsely as 0.5-mm single crystals, and less commonly as nodules up to 1 cm in diameter. Clay-mineral abundance varies from near 0% to about 50%. A few incipient chert layers occur in this dominantly calcareous sequence. The unit was not cored to its base, so its total thickness is unknown.

Conclusions

The most noteworthy aspect of the sediments at Site 277 is the essentially uniform bulk composition of all but the upper few meters. The nannofossil oozes are middle Paleocene to middle-late Oligocene, so a uniform sedimentary environment persisted for about 35 million years.

The sediments typically contain only minor amounts of detrital minerals. X-ray diffraction data suggest a volcanic source for some of this material (plagioclase, chlorite, montmorillonite, and zeolites). A continental source is also implied by the presence of abundant quartz, mica, and kaolinite. The appearance of cristobalite and tridymite below approximately 250 meters probably is associated with silicification.

The nannofossil oozes at Site 277 can be correlated with the Tucker Cove Limestone of Campbell Island. This limestone is Eocene-Oligocene, and is about 150 meters thick. It is fine grained, chalky to crystalline, and contains chert nodules. On the Auckland Islands a crystalline limestone containing quartz pebbles occurs. It probably is Oligocene and thus also suggests correlation with the nannofossil oozes of Site 277. An Oligocene marine sandstone, with shallow-water fossils, is associated with the limestone, and may correlate with the turbidite sandstone of Unit 2.

GEOCHEMICAL MEASUREMENTS

The results of analysis of interstitial water are given in Table 3 and Figure 6. There is a trend towards decreasing *p*H with increasing depth, but with several reversals in this trend. Alkalinity varies from a low of 1.71 meg/kg in Core 1, to a high of 2.93 meg/kg in Core 15. Salinity is very constant and similar to that of the surface seawater (34.6‰).

BIOSTRATIGRAPHY

Calcareous nannofossils dominate the microfossils at Site 277 with planktonic foraminifera and only minor elements of diatoms, silicoflagellates and Radiolaria. This sequence provides a middle Paleocene-late Oligocene section at lat 52°13.43'S for a detailed study.

Planktonic foraminifera are reasonably well preserved except for Cores 44 and 45; all the New Zealand zones were identified from the Paleocene *G. (S.) triloculinoides* through to the late Oligocene *G. (G.) euapertura* zones. The diversity of the planktonic foraminifera is generally lower than in New Zealand. Nannofossils were found to be well preserved and diverse, indicating the presence of a very condensed Pleistocene *s.l.* sequence, abruptly underlain by a thick, near-continuous late or mid

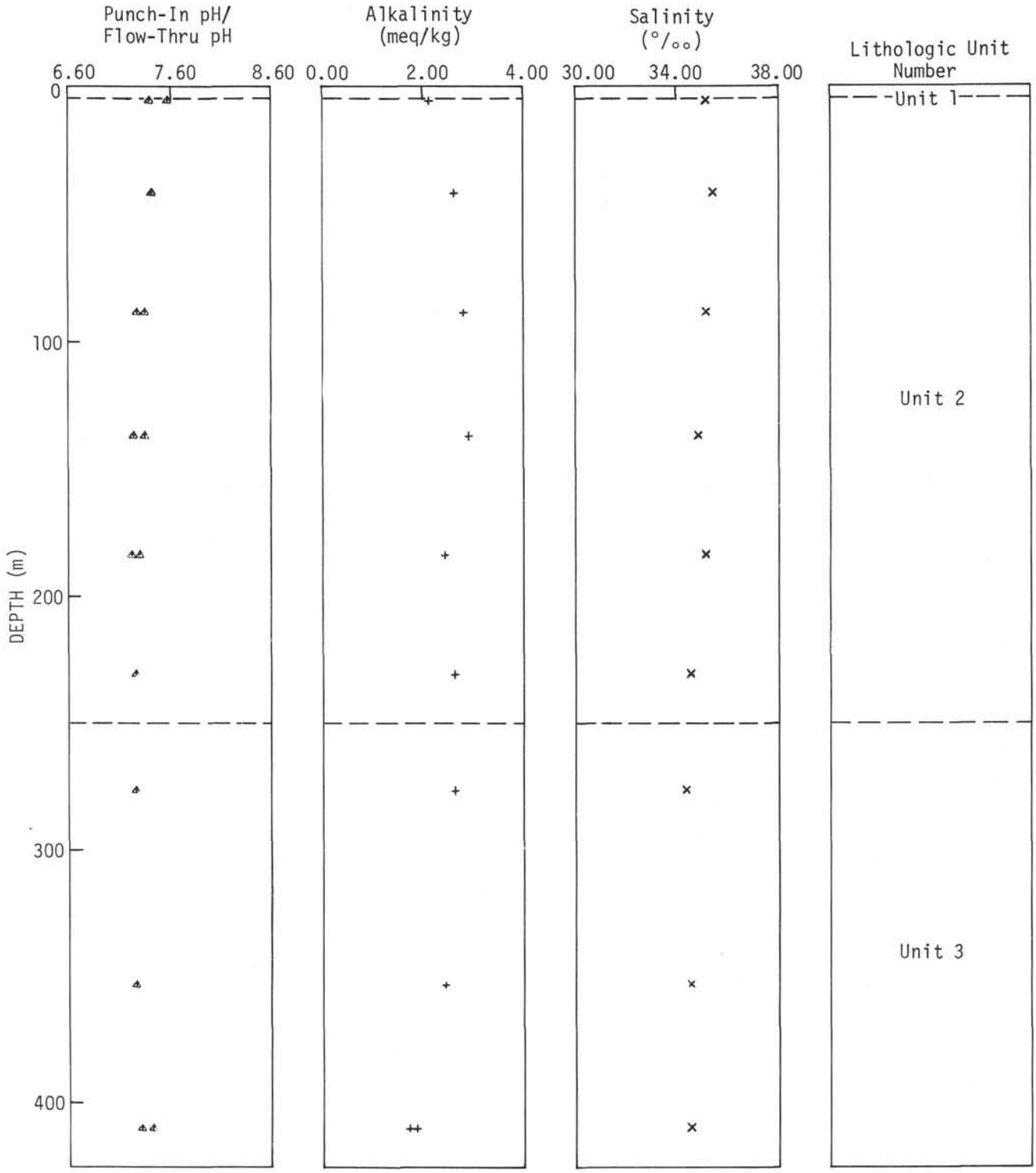


Figure 6. *Shipboard geochemical data versus depth Site 277.*

TABLE 3
Shipboard Geochemical Data, Site 277

Core	Section	Sample Interval Top (m)	Sample Interval Avg. (m)	pH Punch-in	pH Flow-thru	Alkalinity (meq/kg)	Salinity (°/oo)	Lithologic Unit
Surface Seawater Reference				7.96	7.98	2.25	34.6	
1	4	0.0	5.53	7.59	7.41(?)	2.15	35.2	
5	5	35.5	42.03	7.43	7.44	2.64	35.5	
10	5	83.0	89.53	7.36	7.28	2.83	35.2	
15	5	130.5	138.53	7.36	7.25	2.93	34.9	
20	5	178.0	185.97	7.23	7.31	2.44	35.2	
25	2	225.5	233.35	–	7.27	2.64	34.6	
30	4	273.0	279.53	–	7.27	2.64	34.4	
35	2	349.0	357.05	–	7.24	2.44	34.6	
40	3	406.0	414.05[a]	–	7.43	1.71	34.6	
Average				7.39	7.32	2.43	34.9	

[a]Two analyses were run, the second on #50 Whatman filter paper. Values are: Flow-thru *p*H=7.32, Alk=1.86, and S=34.6°/oo.

Oligocene-mid Paleocene sequence. Most of the latter sequence is easily correlated with the high resolution New Zealand Paleogene biostratigraphic zonation. Diatoms, silicoflagellates, and Radiolaria were found in the upper part of the site, with the late Eocene middle Paleocene interval below Core 24 barren of diatoms, with only fragments of Radiolaria.

Other organic material at Site 277 include Bryozoa in Sample 2, CC, ostracods in Sample 3, CC, and fish teeth in many samples.

Foraminifera

The documentation of planktonic foraminifera for Site 277 is based on the following samples: all core-catcher samples from Cores 1-45; one sample from the top of Core 1; and 13 other samples, examined in order to determine the zonal boundaries.

All of the New Zealand Paleogene planktonic foraminiferal zones from the *G. (S.) triloculinoides* Zone through the *G. (G.) euapertura* Zone were identified. For age determinations heavy reliance was made on the premise that taxa at Site 277 had the same stratigraphic ranges as those recorded in New Zealand (Table 4). However, differences have already emerged from the present study. For example, *Globorotalia (T.) munda* has its initial appearance earlier in the *G. (S.) angiporoides angiporoides* Zone, and the extinction of *Globorotalia (T.) aculeata* appears to be later at Site 277 than in New Zealand.

Zonal definitions are the same as those published by Jenkins (1966, 1971) for the New Zealand planktonic foraminiferal zones with the exception of two zones: (1) *G. (G.) brevis* Zone which is defined not on the total range of the zone fossil, but on the range of *Globorotalia (T.) gemma;* and (2) the *G. (T.) inconspicua inconspicua* Zone upper boundary is redefined on the extinction of *G. (T.) aculeata.* These changes were necessary because of the rarity of *G. brevis* and absence of *G. (T.) inconspicua.*

Reworked Paleogene taxa occur in Cores 1-9 from the top of the *G. (S.) angiporoides angiporoides* Zone through the *G. (G.) euapertura* Zone with an apparent increase in the number of reworked taxa in the stratigraphically younger rocks. The following species were identified as reworked: *Globigerina (G.) brevis, G. (G.) praeturritilina, G. (S.) angiporoides angiporoides, G. (S.)* cf. *linaperta, Globigerinatheka (G.) index index, Globorotalia (T.) gemma, Truncorotaloides collactea, Zeauvigerina zelandica,* and *Z. parri.*

The faunas show little evidence of solution of tests. Benthonic foraminifera are present in most of the samples examined.

Globorotalia (G.) truncatulinoides Zone

A well-preserved fauna was obtained from the uppermost part of Core 1; the numerous specimens of *Globorotalia (G.) truncatulinoides* have well-developed keels. The nine recorded species are comparable to faunas recorded from the surface sediment in the south central faunas of South Pacific recorded by Kustanowich (1963). A major unconformity exists between Sample 1-1, 1 cm, and the middle Oligocene *G. (G.) euapertura* Zone in Sample 1, CC.

Globigerina (G.) euapertura Zone

Samples 1, CC to 8, CC, and 8-6, 105 cm fall within the lower part of the *G. (G.) euapertura* Zone, a biostratigraphic position based on the presence of *Globigerina (G.) labiacrassata* and *Globorotalia (T.) munda.* The evolutionary appearance of *Globigerina (G.) juvenilis* in Sample 7, CC tends to confirm this stratigraphic interpretation. Preservation tends to range from fair to good but with a deterioration in the lower part of the zone. Diversity is relatively high compared with the preceding lower Oligocene zones with a low diversity in Samples 6, CC, and 7, CC. The boundary between the *G. (G.) euapertura* Zone, and the *G. (S.) angiporoides angiporoides* Zone has been placed between Samples 9-6, 105 cm, and 9, CC.

Globigerina (S.) angiporoides angiporoides Zone

Numerically, the dominant species in the coarse fraction is the zone fossil, and high numbers are maintained to its extinction level in Sample 9, CC. Preservation of tests is fairly good and diversity very low at the

TABLE 4
Planktonic Foraminiferal Zones, Site 277

International Units	New Zealand Stages	New Zealand Planktonic Foraminiferal Zones	Initial Appearances and Extinctions Used to Delimit Zones at Site 277
Oligocene	Duntroonian-Whaingaroan	*Globigerina (G.) euapertura*	Ext. *G. (S.) angiporoides angiporoides* Hornibrook
		Globigerina (S.) angiporoides angiporiodes	Ext. *G. (T.) gemma* Jenkins
		Globigerina (G.) brevis	I.A. *G. (T.) gemma* Jenkins
	Runangan	*Globigerina (S.) linaperta*	Ext. *G. (T.) aculeata* Jenkins
	Kaiatan	*Globorotalia (T.) inconspicua*	I.A. *C. cubensis* (Palmer)
	Bortonian	*Globigerinatheka (G.) index index*	I.A. *G. (G.) index index* (Finlay)
Eocene	Porangan	*Pseudoglobоquadrina primitiva*	Ext. *G. (M.) crater crater* Finlay
	Heretaungan Mangaorapan	*Globorotalia (M.) crater crater*	I.A. *G. (M.) crater crater* Finlay
	Waipawan	*Globanomalina wilcoxensis*	I.A. *G. wilcoxensis* (Cushman and Ponton)
Paleocene	Teurian	*Globigerina (S.) triloculinoides*	

Note: I.A. = initial appearance; Ext. = extinction.

base of the zone, with a slight increase from the middle to the top of the zone. The boundary between the *G. (S.) angiporoides angiporoides* and *G. (G.) brevis* zones has been placed between Samples 18, CC, and 19-2, 20 cm.

Globigerina (G.) brevis Zone

Recognition of the zone is based on the presence of *Globorotalia (T.) gemma* which is limited to the zone and has the same range as *G. (G.) brevis* in New Zealand. *G. (G.) brevis* is too rare at Site 277 to be used as a zonal index. Normally this zone is a relatively thin unit in New Zealand as compared with the underlying *Globigerina (S.) linaperta* and overlying *G. (S.) angiporoides angiporoides* zones. At Site 277, the *G. (G.) brevis* Zone is much thicker than the *G. (S.) linaperta* Zone. The extinction of *Globigerinatheka (G.) index index* in Sample 21, CC is taken as marking the Eocene-Oligocene boundary as in New Zealand. The preservation of tests varies from fairly good to poor, with a low diversity in the lower part of the zone decreasing towards the top of the zone. The boundary between the *G. (G.) brevis* and the *G. (S.) linaperta* zones has been placed between Samples 23, CC, and 24, CC.

Globigerina (S.) linaperta Zone

The zone is represented only by Core 24 and Sample 25-2, 100 cm. The most feasible explanation for the relative thinness of the zone at this site: is the extinction of *G. (T.) aculeata* occurs later at Site 277, compared to its extinction in New Zealand, and extends into the lower part of the original *G. (S.) linaperta* Zone. The extinction levels in New Zealand, South Australia and Europe appear to be diachronous. Preservation of the fauna in Samples 24, CC, and 25-2, 100 cm, is poor and the diversity is low. The boundary between *G. (S.) linaperta* and *G. (T.) aculeata* zones has been placed between Samples 25-2, 100 cm, and 25, CC.

Globorotalia (T.) inconspicua Zone

The top of the zone is based on the extinction of *G. (T.) aculeata;* the base of the zone by the cryptogenic appearance of *Chiloguembelina cubensis.* Both taxa are common throughout the zone. *Truncorotoloides collactea* and *Zeauvigerina zelandica* became extinct in the upper part of the zone. Preservation of the faunas is not very good and the diversity is higher in the lower part of the zone, decreasing gradually to the top. The boundary between the *G. (T.) aculeata* and the *G. (G.) index index* zones has been placed between Samples 30-5, 100 cm, and 30, CC.

Globigerinatheka (G.) index index Zone

Throughout the zone, the zonal fossil is numerically dominant in the coarse fraction. *Pseudoglobоquadrina*

primitiva became extinct toward the top of the zone in Sample 30, CC. Preservation of the faunas is not very good and the diversity is higher than succeeding zones, but with a low in the middle of the zone. The boundary between the *G. (G.) index index* and the *P. primitiva* zones has been placed between Samples 35-2, 23 cm, and 35-2, 104 cm.

Pseudoglobоquadrina primitiva Zone

The *P. primitiva* Zone is comparatively thin, comparable to New Zealand. The presence of *Globorotalia (P.) australiformis* in Sample 35, CC suggests that it ranges into the upper part of the zone as compared to its extinction in the lower part of the zone in New Zealand. Preservation is fairly poor and diversity relatively high. The boundary between the *P. primitiva* and the *G. (M.) crater crater* zones has been placed between Sample 36, CC, and 37-2, 25 cm.

Globorotalia (M.) crater crater Zone

The zone is based on the total range of the zone fossil which is present in low numbers at Site 277. Preservation is from moderate to poor and the diversity relatively high with a low in Sample 40, CC. The boundary between the *G. (M.) crater crater* and the *G. wilcoxensis* zones has been placed between Sample 41, CC and 42-3, 28 cm.

Globanomalina wilcoxensis Zone

The zone fossil ranges throughout the zone and, with *G. (S.) triloculinoides,* the two taxa make up the majority of specimens. Preservation is poor and diversity changes from low in the lower part of the zone, to relatively high in the upper part of the zone. The boundary between the *G. wilcoxensis* and the *G. (S.) triloculinoides* zones has been placed between Samples 42-3, 31 cm, and 43-2, 129 cm.

Globigerina (S.) triloculinoides Zone

The occurrence of *Chiloguembelina wilcoxensis* in Sample 44, CC without *G. wilcoxensis* places the sample in the upper part of the *G. (S.) triloculinoides* Zone. The fauna in Sample 45, CC is from about the middle of the *G. triloculinoides* Zone, based on the presence of *Zeauvigerina teuria.* The preservation is poor and the diversity is moderate.

Calcareous Nannofossils

This hole contains very abundant, moderately well preserved, and fairly diverse nannofloras throughout all but the lowermost part, where both the preservation and abundance decrease. The assemblages indicate the presence of a major unconformity separating a thin and complex Pleistocene sequence from the underlying very thick late- or mid-Oligocene to mid-Paleocene succession. A small but significant unconformity separates late Pleistocene and undifferentiated mid-Pleistocene to late-Pliocene assemblages. The early mid-Eocene to mid-Paleocene interval appears to have had a slower depositional rate than the remainder of the Paleogene. The sequence is especially condensed in the immediate vicinity of the base of the early Eocene; it is possible that the regional Paleocene-Eocene unconformity of Leg 21 (Edwards, 1973) is present. The nannofossil biostratigraphy of this sequence is summarized in Tables 5 and 6.

The late-Pleistocene *Coccolithus pelagicus* Zone of this site is represented by 2 meters of foraminiferal ooze and nannofossil ooze. The nannofloras are abundant and moderately well to excellently preserved, but have low diversities, essentially composed of small *Gephyrocapsa* plus common *Coccolithus pelagicus* and relatively common *Cyclococcolithina leptopora, Syracosphaera hystrica,* and *Helicopontosphaera kamptneri.* This situation, plus the absence of warm-water taxa such as *Rhabdosphaera claviger* and *Pontosphaera,* clearly indicates deposition from a subantarctic water mass. This interval, containing questionable *Emiliania huxleyi,* may be latest Pleistocene. Winnowing is evident in the Core 1 assemblages. The base of this zone coincides, within sampling limits, with the prominent lithological boundary at Sample 1-2, 66 cm. The substantial (for low-diversity assemblages) nannofloral change across this boundary suggests that it represents a small but significant unconformity.

The mid-Pleistocene to late-Pliocene *Pseudoemiliania lacunosa* Zone is about 2 meters thick. The nannofloras of this zone are complex, composed of two totally different assemblages which are physically close but essentially separate. The nannofloras judged to be in situ, are common to abundant, poorly to moderately well preserved, and moderately diverse. The variability within these assemblages is quite high, for example Samples 1-2, 110 cm and 1-3, 10 cm are strongly winnowed, whereas Sample 1-3, 110 cm contains very large amounts of nannofossil debris, and Sample 1-4, 50 cm contains some reworking from the underlying Oligocene. The frequencies of individual species vary greatly. *Coccolithus pelagicus* and *Pseudoemiliania lacunosa* vary from trace numbers to abundant; *Pontosphaera discopora,* from trace numbers to common; and well-developed *Cyclococcolithina macintyrei,* from rare to common. This variability may result from a complicated interaction between normal pelagic deposition, bottom transport, and winnowing processes. However,

TABLE 5
Neogene Calcareous Nannofossil Biostratigraphy of Site 277

Age	Zone	Interval
Pleistocene	*C. pelagicus*	1-1, 92 cm 1-1, 131 cm to 1-2, 50 cm
		Minor unconformity
	P. lacunosa	1-2, 110 cm to 1-4, 50 cm
Pliocene	*Reticulofenestra pseudoumbilica*	Major unconformity (see text)
Late Miocene		
Mid Miocene		
	Cyclicargolithus neogammation	
Early Miocene	*Discoaster deflandrei*	

TABLE 6
Paleogene Calcareous Nannofossil Biostratigraphy of Site 277

Age	Nannofossil Events	Interval
Late Oligocene	top *Reticulofenestra bisecta*	1-5, 52; 15-4, 110
Mid Oligocene	top *Reticulofenestra placomorpha*	15-5, 110; 21, CC
Early Oligocene	base *R. oamaruensis*	22-1, 138; 26-3, 110
Late Eocene	*R. bisecta* and base *I. recurvus*	26-4, 110; 28, CC
Mid Eocene	base *C. oamaruensis*	29-1, 110; 30, CC
	base *C. reticulatus*	21-1, 170; 35, CC
	base *R. hampdenensis*	36-1, 126; 37-2, 103
	base *R. placomorpha*	37-3, 112; 37, CC
	top *Discoaster kuepperi*	38-1, 120; 40, CC
Early Eocene	base *R. dictyoda*	41-1, 113; 41, CC
	base *D. lodoensis*	42-2, 119; 43, CC
Late Paleocene	top *D. multiradiatus*	44-2, 120; 44, CC
	top *F. tympamiformis*	45-1, 102; 46-2, 118
Mid Paleocene	base *D. multiradiatus*	46-3; 114 46-4; 111
	top *M. kleinpelli*	46, CC
	base *M. kleinpelli*	

small *Gephyrocapsa* are common to dominant throughout. The climate of this interval may have been warmer than that of the overlying interval because the diversity is higher and *Pontosphaera* is common in Sample 1-3, 50 cm. Several fragments of *Discoaster brouweri?* were observed in Sample 1-4, 50 cm.

In marked contrast to these nannofloras are the mid-late Oligocene *Reticulofenestra bisecta* Zone assemblages obtained from Samples 1-2, 110 cm and 1-4, 10 cm. These assemblages are abundant and moderately well preserved, but have low diversities. Both nannofloras contain abundant *Cyclicargolithus neogammation;* common *Ericsonia ovalis s.l.;* few, but well developed, *Reticulofenestra bisecta;* rare *Zygrhablithus bijugatus;* and low numbers of other taxa such as *Chiasmolithus altus* and *Discoaster deflandrei.* Neither nannoflora contains undoubted post-Oligocene taxa, but another routine slide made from the higher sample yielded only late-Neogene taxa. Examination of this sample indicates that it is a "gritty mud," thus confirming the suspected reworking.

Since nannofloras indicative of the early-Pliocene to early-Miocene interval are not present in this continuously cored sequence, a major unconformity must occur between the lowest in situ late-Neogene assemblage and the highest in situ Oligocene nannoflora. If these assemblages are in Samples 1-4, 50 cm and 1-4, 110 cm respectively, it follows that this feature is probably a blended contact as no obvious lithologic change occurs between or near these two sample positions. If Sample 1-4, 50 cm is discarded for purely speculative reasons, then the contact must occur between Samples 1-3, 110 cm and 1-4, 10 cm. A substantial change in color, content, and degree of compaction occurs abruptly at Sample 1-4, 6 cm, the position tentatively adopted.

The late- to mid-Oligocene *Reticulofenestra bisecta* Zone occurs between Samples 1-4, 10 cm (or 110 cm, see discussion above), and 15-4, 110 cm. The nannofloras are abundant and moderately well preserved, but have low diversities. Consistently more or less common are *Chiasmolithus altus, Cyclicargolithus neogammation, Ericsonia ovalis s.l., Reticulofenestra bisecta, R. laevis s.l.,* and *Zygrhablithus bijugatus.* Also more or less persistently present, but rare, are *Coccolithus eopelagicus s.l.,* and *Sphenolithus moriformis.* Other taxa sporadically present are very rare *Discoaster deflandrei* (essentially only Cores 1-4), and species of *Pontosphaera s.l., Rhabdothorax,* and *Thoracosphaera.* Taxa sporadically present at the top of this zone and considered to represent downhole contamination include *Cyclococcolithina leptopora* and, especially, small *Gephyrocapsa.* Specimens reworked from the Eocene *s.l.* occur in low numbers throughout this zone. The taxa

observed include *Isthmolithus recurvus, Reticulofenestra placomorpha,* and *Zygolithus dubius.* Because of this reworking the base of this zone has been placed at the highest persistent occurrence of *R. placomorpha.*

The early-Oligocene to latest-Eocene, *Reticulofenestra placomorpha* to *Reticulofenestra oamaruensis* interval occurs between Samples 15-5, 110 cm, and 21, CC; is biostratigraphically equivalent to the combined *Reticulofenestra placomorpha, Blackites rectus,* and *Reticulofenestra oamaruensis* Zones (Edwards, 1971). Subdivision of this interval into these zones was not attempted. The Eocene-Oligocene boundary is tentatively placed by nannofossils at Sample 21-3, 110 cm, the highest occurrence of *D. saipanensis.* The nannofloras of this interval are abundant and moderately well preserved, but of low diversity. Persistent are *Chiasmolithus altus* (not identified below Sample 19, CC), *C. oamaruensis, Ericsonia ovalis s.l., Reticulofenestra bisecta, R. laevis s.l., R. placomorpha,* a rhabdolith, and *Zygrhablithus bijugatus.* Also present but rare, are *Coccolithus eopelagicus s.l., Ericsonia fenestrata s.l.,* and, slightly sporadic, *Sphenolithus moriformis.* Although rather sporadic in its occurrence, *Isthmolithus recurvus* is fairly common in Cores 19, 20, and the lower part of Core 16. *Reticulofenestra oamaruensis* is rare but constantly present between Samples 20-4, 144 cm, and 21, CC. Apart from a small, and probably downhole-derived fragment in Sample 22, CC, no other occurrences of this taxon were observed in this sequence. Other taxa observed in this interval include very rare and sporadic *Discoaster tani s.l.* (highest occurrence in Sample 20-5, 143 cm), *Markalius inversus, Thoracosphaera* sp., and *Zygolithus dubius.* The presence of the latter is attributed to reworking from older-Eocene sediments.

The late-Eocene, *Reticulofenestra oamaruensis* through *Cyclicargolithus reticulata* interval occurs between Samples 22-1, 138 cm and 22-3, 110 cm; contains nannofloras which are very similar to those which overlie. They are probably correlative with the upper part of the *Discoaster saipanensis* Zone of Edwards (1971).

The late-Eocene, *Cyclicargolithus reticulata* to *Reticulofenestra bisecta* interval occurs between Samples 22, CC and 26-3, 110 cm. The base of *Isthmolithus recurvus* also coincides with the base of this nannofossil ooze. In New Zealand (Edwards, 1971) *I. recurvus* first appears in much younger sediments than *R. bisecta,* possibly the result of a small hiatus. The nannofloras of this interval are abundant, moderately well preserved, and fairly diverse. More or less common and persistent are *Chiasmolithus oamaruensis, Coccolithus eopelagicus s.l., Cyclicargolithus reticulata, Ericsonia ovalis s.l., Reticulofenestra bisecta, R. placomorpha,* a rhabdolith, *Thoracosphaera* sp., and *Zygrhablithus bijugatus.* Persistent but rare are *Isthmolithus recurvus* (except absent in Core 25) and *Sphenolithus moriformis.* Other taxa sporadically observed include rare *Discoaster saipanensis, D. tani s.l., Ericsonia fenestrata s.l. Markalius inversus,* and *Zygolithus dubius* (rare but persistent in Cores 25, 26).

The *Reticulofenestra bisecta* to *Cyclicargolithus reticulata* interval occurs between Samples 26-4, 110 cm, and 30, CC. In terms of the ages adopted for Leg 21 (Edwards, 1973) and Leg 29, this interval is late-mid Eocene. At this site however, *Chiasmolithus oamaruensis,* normally considered indicative of the late Eocene and Oligocene, first appears in Sample 28, CC, well below its usual sequential position, intermediate between the bases of *I. recurvus* and *R. bisecta.* The simplest explanation for this situation is that the base of *R. bisecta* is diachronous. If so, it would be the first known example of diachronity in the ubiquitous Prinsiaceae. The nannofloras of this interval are abundant, moderately well preserved, and fairly diverse. Persistent and more or less common are *Cyclicargolithus reticulata, Ericsonia ovalis s.l., Reticulofenestra* cf. *dictyoda, R. hampdenensis s.l., R. placomorpha,* a rhabdolith, *Thoracosphaera* sp., *Zygolithus dubius* (rare above Core 28), and *Zygrhablithus bijugatus.* Rare but persistent are *Chiasmolithus expansus* (top about Sample 26, CC), *Chiasmolithus* sp. (in part *C. solitus*), *Ericsonia fenestrata s.l.,* and *Sphenolithus moriformis.* Rare and moderately sporadic are *Discoaster tani s.l., Discoaster* sp. indeterminate, *Markalius inversus,* and a *Pontosphaera* sp. *s.l.* Rare and very sporadic are *Discoaster barbadiensis, D. saipanensis, Helicopontosphaera* sp., and *Sphenolithus radians.* The presence of *D. barbadiensis* and *S. radians* is attributed to minor reworking of older Eocene sediments.

The mid-Eocene *Cyclicargolithus reticulata* to *Reticulofenestra hampdenensis* interval occurs between Samples 31-1, 110 cm, and 35, CC; contains abundant, moderately well preserved, and diverse nannofloras which can be readily correlated with the mid and early Bortonian of New Zealand and DSDP Leg 21 (Edwards, 1971, 1973). More or less common and persistent are *Chiasmolithus solitus, Ericsonia ovalis s.l., Reticulofenestra* cf. *dictyoda, R. placomorpha,* a rhabdolith, *Sphenolithus moriformis, Zygolithus dubius,* and *Zygrhablithus bijugatus.* Rare and persistent are *Chiasmolithus expansus, Coccolithus eopelagicus s.l., "C." formosa* (Core 33 and below), *Discoaster barbadiensis* (Core 34 only), and *Reticulofenestra hampdenensis.* Rare and sporadic are *Chiasmolithus grandis, Discoaster distinctus s.l., D. wemmelensis* (Core 35 and below), *Ericsonia fenestrata s.l., Markalius inversus s.l.,* and *Thoracosphaera* sp. Very minor reworking is recognizable in single-specimen occurrences of *Discoasteroides kuepperi* (Eocene) and *Heliolithus kleinpelli* (Paleocene).

The mid-Eocene *Reticulofenestra hampdenensis* to *Reticulofenestra placomorpha* interval occurs between Samples 36-1, 126 cm, and 37-2, 103 cm; contains abundant and diverse but rather poorly preserved nannofloras which can be readily correlated with the basal Bortonian-late Porangan of New Zealand. The assemblages are similar to those of the overlying interval except that the base of *Coccolithus eopelagicus s.l.* occurs at Sample 36, CC, and rare *Chiasmolithus grandis* occurs in and below Sample 36-3, 108 cm.

The mid-Eocene *Reticulofenestra placomorpha* through *Discoasteroides kuepperi* interval occurs between Samples 37-3, 112 cm, and 37, CC; contains abundant and diverse but rather poorly preserved nannofloras which are very similar to those of the overlying

interval. This interval is readily correlated with the early Porangan to mid Heretaungan of New Zealand.

The basal-mid-Eocene to late-early-Eocene *Discoasteroides kuepperi* to *Reticulofenestra dictyoda* interval occurs between Samples 38-1, 120 cm, and 40, CC; contains abundant, moderately well preserved, and diverse nannofloras which conform to the late Mangaorapan to early Heretaungan *Reticulofenestra dictyoda* Zone of Edwards (1971). More or less common and persistent are: *Chiasmolithus solitus, Ericsonia fenestrata s.l., E. formosa, E. ovalis s.l., Reticulofenestra dictyoda, Sphenolithus moriformis s.l., Zygolithus dubius,* and *Zygrhablithus bijugatus.* Rare but persistent are *Chiasmolithus grandis* (base about Sample 40-2, 110 cm), *Discoaster distinctus s.l., D. lodoensis* (top at Sample 38-1, 120 cm), *Discoasteroides kuepperi, Sphenolithus radians,* and *Thoracosphaera* sp. Also present are *Discoaster barbadiensis* (top at Sample 38-1, 120 cm), *D. wemmelensis, Markalius astroporus s.l.,* and *Chiasmolithus expansus* (base about Sample 38-2, 110 cm).

The early-Eocene *Reticulofenestra dictyoda* to *Discoasteroides kuepperi* interval occurs between Samples 41-1, 113 cm, and 43, CC; contains abundant, fairly diverse, rather poorly preserved nannofloras which conform to the early Mangaorapan to latest Waipawan *Discoaster lodoensis,* and (upper part) *Chiasmolithus grandis* zones of Edwards (1971). More or less common and persistent are *Chiasmolithus eograndis, C. solitus* (Sample 42, CC and above), *Discoaster barbadiensis* (Sample 42, CC and above), *Discoasteroides kuepperi, Ericsonia fenestrata s.l.,* (Sample 42, CC and above), *Ericsonia ovalis s.l., Markalius astroporus, Sphenolithus moriformis s.l., Thoracosphaera* sp., *Zygolithus dubius s.l.,* and *Zygrhablithus bijugatus.* Rare and persistent are *Biscutum panis, ?Conococcolithus* sp. (Sample 42, CC and below) and *Sphenolithus radians.* Also occasionally present are rare *Cruciplacolithus* sp., *Discoaster lodoensis* (base at Sample 42, CC) and *Marthasterites tribrachiatus* (Sample 43, CC). A minor hiatus may occur within this interval for a number of species have their first appearance in Sample 42, CC.

The early-Eocene *Discoasteroides kuepperi* through *Discoaster multiradiatus* interval occurs between Samples 44-1, 101 cm, and 44-2, 107 cm; contains more or less abundant, fairly diverse, and rather poorly preserved nannofloras which are relatively easily correlated with the main part of the Waipawan of New Zealand. The thinness of this interval suggests that it is condensed or incomplete, possibly correlating with a regional Paleocene-Eocene unconformity described from equivalent stratigraphic positions in Tasman Sea sites of Leg 21 (Edwards, 1973). Taxa common and persistent are *Chiasmolithus eograndis s.l., Ericsonia ovalis s.l., Sphenolithus moriformis s.l., ?Towieus* sp. (large), and *Zygrhablithus bijugatus s.l.* Rare and persistent are *?Conococcolithus* sp., *Discoaster diastypus, Ellipsolithus macellus, Markalius astroporus, Sphenolithus radians* (base at Sample 44-2, 60 cm), and *Zygolithus dubius s.l.* Occasionally present are *Discoaster multiradiatus* (Samples 44-2, 20 cm, and 60 cm; occurrence attributed to minor reworking), *Marthasterites tribrachiatus* (single specimens in Samples 44-2, 20 cm, and 107 cm), and *Thoracosphaera* sp.

The late-Paleocene *Discoaster multiradiatus* interval occurs between Samples 44-2, 120 cm, and 45, CC; contains common and fairly diverse, but rather poorly preserved nannofloras. Judging by *Fasciculithus tympaniformis,* this interval is probably correlative with both the late Teurian and the overlying early Waipawan of New Zealand. More or less common and persistent are *Discoaster multiradiatus, Ericsonia ovalis s.l., Fasciculithus tympaniformis* (Sample 44-3, 112 cm, and below), *Hornibrookina australis* (base about Sample 45-3, 127 cm), *Sphenolithus moriformis s.l.* (base at Sample 45, CC), *Thoracosphaera* sp., *?Towieus* sp. (large), *Zygolithus dubius s.l.* (base at Sample 45-2, 118 cm) and *Zygrhablithus bijugatus s.l.* (base at Sample 45-2, 118 cm). Rare but persistent are *Biscutum panis,* and *Chiasmolithus eograndis s.l.* Also sporadically observed were *Ellipsolithus macellus, Markalius astroporus,* and *Neococcolithites distentus.*

The mid-Paleocene *Discoaster multiradiatus* to *Heliolithus kleinpelli* interval occurs between the top and base of Core 46, the lowest core taken; contains common but low-diversity and poorly preserved nannofloras correlative with the upper part of the mid Teurian of New Zealand. Common and persistent are *Fasciculithus tympaniformis* and *?Toweius* sp. (large; base at Sample 46-3, 114 cm). Rare and sporadic are *Ericsonia ovalis s.l., Markalius astroporus,* and *Neococcolithites concinnus.* So far *Heliolithus kleinpelli* ("few") has only been observed in Sample 46, CC. No discoasters were observed in this interval. These nannofloras are the first obtained from this biostratigraphic interval in the southwest Pacific. The poorly preserved nature of the nannofloras probably results from either normal lithification processes or a position relatively close to the lysocline.

Diatoms

Samples from Cores 1-44 were studied and diatoms were found only in the upper part of this hole. Diatoms are abundant in Cores 5-24, with the exception of Samples 14-1, 6 cm, to 15-1, 6 cm, which are completely barren. The abundance of diatoms is correlated with an abundance of Radiolaria, silicoflagellates, and sponge spicules (Table 7). No distinct zonation can be recognized within the diatom succession. The thanatocoenosis consists of large marine pelagic species. No cores contain fresh water or brackish species.

The following ages were obtained: Cores 5-18, Oligocene; and Cores 19-24, late Eocene-early Oligocene.

Most of the *Coscinodiscus* species are cold-water forms. Core 24 shows a reduction in the number and diversity of diatoms, although the assemblage retains its late Eocene character. The decrease in number and preservation of shells in Core 24 seems to be due to dissolution of opaline skeletons.

Radiolaria

Radiolaria are present in Cores 4-15 in fair to good condition. In Cores 16-25 they are rare and poorly preserved. Cores 24-46 contain only fragments.

TABLE 7
Diatoms, Silicoflagellates, and Ebridales Recorded at Site 277

Diatoms, Silicoflagellates, and Ebridales present in Cores 5-18.

Diatoms: *Actinocyclus octonarius, Actinocyclus* sp., *Actinoptychus senarius, Asterolampra insignis, Asteromphalus decorus, Chaetoceros* sp., *Clavicula?* sp., *Coscinodiscus argus, C.* cf. *bulliens, C. excentricus, C. lineatus, C. marginatus, C. oculus-iridis, C. radiatus, Cyclotella hannai, Hemiaulus polymorphus, Hemiaulus* sp., *Melosira (Paralia) sulcata, Pterotheca aculeifera, Pyrgupyxis* sp., *Pyxilla* sp., *Sceptroneis* sp., *Stephanopyxis turris, Stephanopyxis* sp., *Thalassionema hirosakiensis, T. nitzschioides, Thalassionema* sp., *Triceratium barbadense, T. condecorum, T. favus, Triceratium* sp., *Trinacria simulacrum, Tropidoneis* sp., *Xanthiopyxis panduraeformis.*

Silicoflagellates: *Naviculopsis biapiculata, Mesocena* sp., *Dictyocha* sp., and *Dictyocha triacantha.*

Ebridales: *Ammodochium rectangulare.*

Diatoms, Silicoflagellates and Ebridales present in Samples 19, CC and 24, CC

Diatoms: *Actinoptychus senarius, Actinoptychus* sp., *Asterolampra insignis, Coscinodiscus argus, C. lineatus, C. marginatus, C. oculus-iridis, C. radiatus, Dicladia* sp., *Diploneis schraderi, Gephyria* sp., *Hemiaulus polymorphus, Hemiaulus* sp., *Pterotheca aculeifera, Pyxilla danica, P.* cf. *gracilis, Rhisosolenia* sp., *Stephanopyxis turris, Stephanopyxis* sp., *Triceratium barbadense, Trinacria simulacrum, Trinacria* sp., *Xanthiopyxis oblonga, X. panduraeformis* abundant.

Silicoflagellates: *Dictyocha* sp., *Distephanus crux, Mesocena polymorpha* var. *triangula,* and *Naviculopsis biapiculata.*

Ebridales: *Ebrida* sp.

Silicoflagellates

Silicoflagellates are usually rare in cores 5-13 and 17-24, representing late-Oligocene to late-Eocene deposits (Table 7). Their preservation is poor to moderate, and, like the diatoms, most specimens are broken. In most samples, the assemblage is dominated by different species of *Naviculopsis* and/or *Mesocena apiculata, Corbisema triacantha,* and *Distephanus crux.* Representatives of the genera *Cannopilus* and *Dictyocha* are rare, as are specimens of *Distephanus quinquangellus.*

The ratio of *Dictyocha* to *Distephanus* (Mandra, 1969; Mandra and Mandra, 1971) is low (indicating low temperatures) in the late-Eocene samples and in the early Oligocene where *Dictyocha* is rare or missing. Somewhat higher temperatures seem to have occurred during the mid and late Oligocene. In general, lower temperatures are suggested for the Eocene and Oligocene of this site than for Sites 280 and 281 which at present, lie about 3°-4° North, and 18°-19° West of Site 277.

SEISMIC DATA

The profiler section in the vicinity of Site 277 (Figure 3) shows the disruption of the beds and the outcrops that resulted from tectonic activity along the western edge of the plateau. The drop-off into the Solander Trough can be seen just to the left of the section (see Figure 7, Chapter 42, this volume). The sonic log (Chapter 41, this volume) shows a good correlation with the reflection data at this site, and can be used to identify the cherty mid-Eocene beds cropping out at 'B', and the prominent mid-Paleocene reflector at 'A'. This latter reflector has the same characteristics and apparent stratigraphic position as the reflector at Site 275 that was dated as Upper Cretaceous. The Paleocene is normally quite a thin sequence in New Zealand, and on nearby Campbell and Auckland Islands. It seems reasonable to assume that the major reflector above basement on the Campbell Plateau can be related to the Cenozoic/Mesozoic boundary.

The profiler section shows that the tectonic activity is likely to have occurred after the mid-Eocene reflector at 'B' was deposited, whereas the sediments just to the right of 'B' (Figure 3) are undisturbed and were probably deposited after the tectonism. The age of these sediments is not known because the weak reflectors cropping out at 'C' may be late Oligocene in age. Therefore, the sediments in the pocket between 'B' and 'C' could span the late Oligocene to the present time.

SEDIMENTATION RATES

Sedimentation rates for Site 277 are shown in Figure 7. The curve illustrates the unconformity between the thin veneer of Plio-Pleistocene sediments and the Paleogene sequence. Rates of sedimentation within the Paleogene sequence are quite uniform ranging from 1.9-2.2(?) cm/1000 yr except for an interval in the late Eocene to early Oligocene where it drops to an average 0.5 cm/1000 yr. This low sedimentation rate might be an artifact resulting from a hiatus, and a higher rate in the Oligocene (or the late Eocene). A hiatus in the late Eocene is suggested by the contemporaneous first occurrence of *Reticulofenestra bisecta,* and *I. recurvus* in Sample 26-3, 110 cm. The latter usually occurs later than *R. bisecta.*

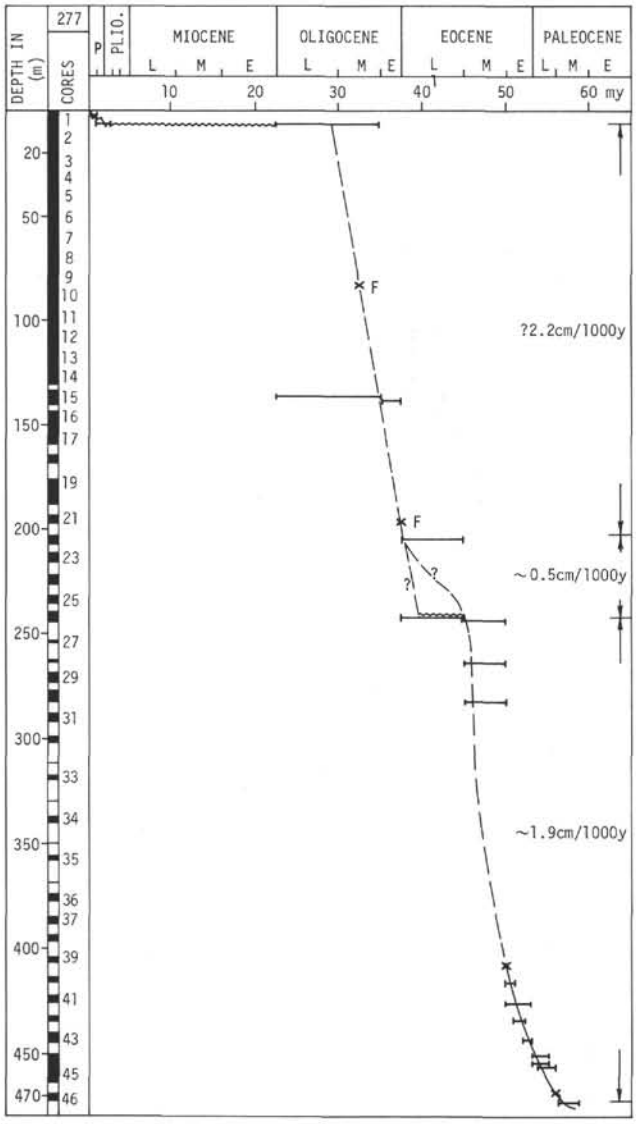


Figure 7. *Sedimentation rate curve at Site 277; ages based on nannofossils and foraminifera (F).*

The sedimentation rates are rather normal for deposition of nannofossil oozes with little influence from terrigenous sources. The most rapid rates of sedimentation occur during the early and middle Oligocene and middle Eocene with the lowest in the late Eocene to early Oligocene and during the late Paleocene. The fluctuations may reflect changing rates in productivity over the Campbell Plateau during the Paleogene, and in turn be related to climatic changes. Rates of sedimentation during the early Eocene and Paleocene are probably higher than indicated because of greater compaction in this part of the sequence.

SUMMARY AND CONCLUSIONS

At Site 277, 46 cores with a total penetration of 472.5 meters were recovered on the southern Campbell Plateau between Auckland and Campbell Islands.

Approximately 10 meters of Plio-Pleistocene nannofossil-rich foraminiferal ooze (Unit 1) is separated by a major disconformity from 462 meters of nannofossil ooze and chalk of late Oligocene to middle Paleocene age (Units 2 to 4). The Paleogene sedimentary units are distinguished primarily on the basis of degree of lithification and diagenesis. Unit 2 consists of 231 meters of stiff, unlithified nannofossil ooze with glauconite, foraminifera, and/or Radiolaria. Unit 3 consists of 208 meters of stiff to semilithified nannofossil chalk with chert nodules. Siliceous microfossils are absent or rare. Unit 4 consists of at least 22 meters of semilithified to lithified nannofossil chalk with chert, clay, and pyrite. Thin chert layers and nodules range in age from Eocene to early Oligocene. Sedimentation rates within the Paleogene are rather uniform ranging from 1.9 to 2.2 cm/1000 years.

Calcareous nannofossils and planktonic foraminifera dominate the microfossils at Site 277, with relatively minor occurrences of diatoms, silicoflagellates, and Radiolaria. All of the New Zealand Paleogene zones are present. Diversity of both planktonic foraminifera and calcareous nannofossils is generally lower than in New Zealand, reflecting the cooler conditions at this latitude.

Investigations indicate a rather complete sequence with possibly condensed parts at the top of the early Oligocene, base of the late Eocene, in the middle middle Eocene, and at the base of the early Eocene. Lower diversity of both calcareous nannofossils and planktonic foraminifera in the middle Oligocene may indicate a climatic cooling during the Oligocene.

Conclusions

The late Oligocene to middle Paleocene sequence of nannofossil ooze and chalk was deposited under uniform, fully oceanic conditions on the Campbell Plateau over a period of 35 m.y., with no influence of terrigenous sedimentation. Depths of deposition were probably much the same throughout, well above the lysocline. The sequence can be correlated with the Tucker Cove Formation on Campbell Island which ranges from early Eocene to middle Oligocene. The sequence represents a good example of highly uniform sediments that have undergone diagenesis with depth of burial.

Uniform and apparently continuous deposition on the Campbell Plateau during the Paleogene is in complete contrast to that of the Neogene which appears to be absent over much of the Plateau. The major disconformity near the surface at Site 277 is apparently widespread, based on *Eltanin* profile records. In addition, the Neogene is essentially absent on both Auckland and Campbell Islands. This is due to a major increase in bottom-water circulation over the Campbell Plateau at some time since the late Oligocene, resulting in erosion and nondeposition. Although some evidence of erosion of the surface layers can be observed in the profiles, large areas of sediments of assumed Paleogene age are layered parallel to the sea floor in a manner that seems to deny later erosion. The uniformity of the erosion surface may be the result of a critical level of cohesion of the late Oligocene nannofossil oozes preventing deeper erosion over the northern part of the plateau. In the southern part of the plateau, even the Paleogene sequence is deeply incised or removed, probably by high-velocity currents. Continuous sedimentation throughout

the Paleogene and erosion-nondeposition during the Neogene is the converse of Tasman Sea sedimentation (Leg 21), and appears to be related to major changes in bottom-water movement during the Cenozoic in the southwest Pacific.

The major reflector at 470 meters was dated as middle Paleocene at this site, whereas the reflector with the same characteristics and apparent stratigraphic position at Site 275 was dated as Late Cretaceous. However, the Paleocene is normally quite a thin sequence in New Zealand and on nearby Campbell and Auckland Islands. It, therefore, seems reasonable to assume that this major reflector from the top of the layer just above basement on the Campbell Plateau is related to the Cenozoic-Mesozoic boundary. The tectonic activity that disturbed the western edge of the Campbell plateau is likely to have occurred after the mid-Eocene.

REFERENCES

Edwards, A. R., 1971. A calcareous nannoplankton zonation of the New Zealand Paleogene: Plankt. Conf., 2nd, Roma 1970, Proc., p. 381-419.

_____, 1973. Calcareous nannofossils from the southwest Pacific, Deep Sea Drilling Project, Leg 21. *In* Burns, R. E., Andrews, J. E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 21: Washington (U.S. Government Printing Office), p. 641-691.

Jenkins, D. G., 1966. Planktonic foraminiferal zones and new taxa from the Danian to lower Miocene of New Zealand: New Zealand J. Geol. Geophys., v. 8 (6), p. 1088-1126.

_____, 1971. New Zealand Cenozoic planktonic foraminifera: New Zealand Geol. Surv. Paleontol. Bull. 42., p. 1-278.

Kustanowich, S., 1963. Distribution of planktonic foraminifera in surface sediments of the south-west Pacific Ocean: New Zealand J. Geol. Geophys., v. 6 (4), p. 534-565.

Mandra, Y. T., 1969. Silicoflagellates: A new tool for the study of Antarctic Tertiary climates: Antarctic J. U.S. v. 4 (5), p. 172-174.

Mandra, Y. T. and Mandra, H., 1971. Upper Eocene silicoflagellates from New Zealand: Antarctic J. U.S., v. 6 (5), p. 177-178.

Oliver, R. L., Finlay, H. J., and Fleming, C. A., 1950. The Geology of Campbell Island: Cape Exped. Ser. Bull. 3. Dept. Sci. Ind. Res., Wellington, New Zealand. p. 1-62.

Summerhayes, C., 1969. Marine geology of the New Zealand subantarctic seafloor. New Zealand Oceanogr. Inst. Mem. 50, p. 1-92.

APPENDIX A
Summary of X-Ray[a], Grain Size, and Carbon-Carbonate Results, Site 277

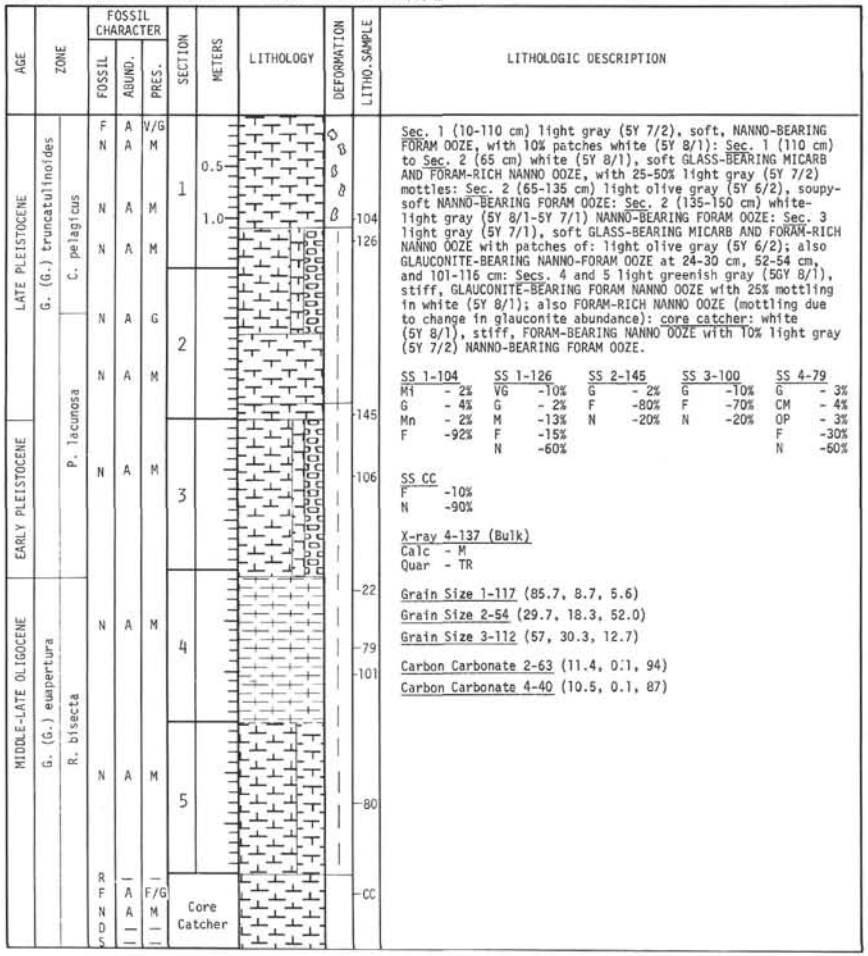
Section	Sample Depth Below Sea Floor (m)	Lithology	Age	X-Ray[b] Bulk Sample Major Constituents 1	2	3	2-20μ Fraction Major Constituents 1	2	3	12μ Fraction Major Constituents 1	2	3	Grain Size Sand (%)	Silt (%)	Clay (%)	Classification	Carbon Carbonate Total (%)	Organic (%)	CaC03 (%)	Comments
1-1	1.2	**Unit 1**	Late										85.7	8.7	5.6	Sand	11.4	0.1	94	
1-2	2.0-2.1	foraminiferal	Pliocene										29.7	18.3	52.0	Sandy clay	11.4	0.1	94	
1-3	4.1	ooze and	to										57.0	30.3	12.7	Silty sand				
1-4	4.9	foraminifera-	late			Not											10.5	0.1	87	
1-4	5.9	rich nanno-	Pleistocene	Calc.	Quar.	present	*	*	*	Mont.	Phil.	Quar.								* No data available
2-2	7.9-8.2	fossil ooze		Calc.	Quar.	–	Quar.	Plag.	Phil.	Mont.	Quar.	Mica	18.1	46.3	35.5	Clayey silt	10.8*	0.1*	90*	* 2 samples
2-6	14.8-14.9	**Unit 2**	Late	Calc.	Quar.	Clin.	Clin.	Quar.	Apat.	Mont.	Apat.	Mica	30.2	44.3	25.4	Sand-silt-clay				Anal. in 2-20μ
3-2	18.5		Eocene														11.3	0.1	94	
3-4	21.9	Nannofossil	to	Calc.	Quar.	–	Quar.	Clin.	Mica*	Mont.	Apat.	Quar.	8.9	52.7	38.4	Clayey silt				*Mica = 12.9, Apat = 12.0 in 2-20μ Bari in 2-20μ & <2μ
4-2	28.3-28.4	ooze with	late	Calc.	Quar.	–	Quar.	Mica	Apat.	Mont.	Quar.	Kaol.	6.6	52.9	40.5	Clayey silt	11.2	0.1	93	Bari & Hali. 2-20μ <2μ
5-6	43.7-43.8	glauconite,	Oligocene	Calc.	Quar.	–	Plag.	Quar.	Mica	Mont.	Quar.	Plag.	6.8	58.8	34.4	Clayey silt	11.0	0.1	91	Apat. in <2μ; Bari 2-20μ <2μ; Hali, Gyps <2μ
7-2	56.2-56.3	foraminifera,		Calc.	Quar.	–	Quar.	Mica	Phil.	Mont.	Kaol.	Quar.	1.0	56.9	42.2	Clayey silt	11.2	0.1	93	Hali <2μ
7-5	60.7-60.8	and		Calc.	–	–	Quar.	Mica	Phil.	Mont.	Mica	Quar.	1.0	58.5	40.5	Clayey silt	11.4	0.0	94	Hali <2μ
9-2	75.8	Radiolaria		Calc.	–	–	Quar.	Mica	Phil.	Mont.	Mica	Quar.	0.7	57.1	42.2	Clayey silt	11.2	0.1	92	Hali <2μ
10-5	90.0			Calc.	–	–	Quar.	Mica	Phil.	Mont.	Mica	Quar.	0.8	52.1	47.1	Clayey silt	11.4	0.1	95	Gyps-Hali <2μ
12-2	104.7												0.1	44.7	55.2	Silty clay	11.5	0.1	95	
13-5	118.7												1.5	49.6	48.9	Clayey silt	11.2	0.1	93	
15-2	132.9												4.8	46.7	48.5	Silty clay	11.1	0.1	92	
16-1	140.6			Calc.	Mont.	Mica	Mica	Mont.	Quar.	Mont.	Quar.	*								* Mica & Hali equal in abundance
17-3	153.3																11.3	0.0	93	Gyps, Bari, Hali <2μ
17-3	153.8												4.1	53.5	42.4	Clayey silt				
19-2	170.9			Calc.	–	–	Quar.	Mica	Phil.	Mont.	Quar.	Mica								Bari, Hali in <2μ
19-2	171.1												1.5	43.5	55.1	Silty clay	11.2	0.1	93	
20-6	186.0-186.1												1.0	50.6	48.3	Clayey silt	11.4	0.0	94	
22-3	200.7			Calc.	Quar.	–	Mica	Quar.	Plag.	Mica	Mont.	Quar.	1.5	46.0	52.5	Silty clay	11.0	0.0	91	Bari, Hali <2μ
24-2	218.3												0.3	40.3	59.5	Silty clay	9.6	0.1	79	
28-2	255.7	**Unit 3**		Calc.	Cris.	*	Mica	Quar.	Clin.	Cris.	Mont.	Quar.								*Quar. and mica equal in abundance
28-2	256.0	Nannofossil	Late Paleocene														10.5	0.1	87	
30-2	275.0	chalk with	to										0.5	34.4	65.1	Silty clay	11.0	0.1	91	
34-1	330.8	chert	late	Calc.	–	–	Clin.	Bari.	Cris.	Mont.	Cris.	Bari.					11.5	0.0	95	Hali in <2μ
37-2	379.8	nodules	Eocene														11.6	0.0	96	
39-2	398.3																11.6	0.0	96	
40-2	408.3																11.4	0.0	94	
43-1	435.1-435.2			Calc.	Cris.	Trid.	Cris.	Trid.	Clin.	Cris.	Mont.	Trid.					10.8	0.0	90	Bari in 2-20μ
44-3	447.6			Calc.	Clin.	Cris.	Quar.	Cris.	Mica	Mont.	Cris.	Quar.					7.9	0.1	65	Bari in 2-20μ
		Unit 4																		
45-4	459.1	Nannofossil	Middle	Calc.	Cris.	Clin.	Cris.	Clin.	Trid.	Cris.	Mont.	Trid.					9.2	0.1	76	
46-2	465.3-465.4	chalk with	to	Calc.	Cris.	Trid.	Cris.	Trid.	Quar.	Cris.	Mont.	Trid.					10.1	0.1	84	Bari in 2-20μ
		chert, clay and pyrite	late Paleocene																	

Note: * = see comment column.

[a]Complete results of X-Ray-Site 277 will be found in Appendix I.

[b]Legend – see Appendix A Table 1, Chapter 2.

Site 277 Hole Core 1 Cored Interval: 0.0-7.0 m



Sec. 1 (10-110 cm) light gray (5Y 7/2), soft, NANNO-BEARING FORAM OOZE, with 10% patches white (5Y 8/1): Sec. 1 (110 cm) to Sec. 2 (65 cm) white (5Y 8/1), soft GLASS-BEARING MICARB AND FORAM-RICH NANNO OOZE, with 25-50% light gray (5Y 7/2) mottles: Sec. 2 (65-135 cm) light olive gray (5Y 6/2), soupy-soft NANNO-BEARING FORAM OOZE: Sec. 2 (135-150 cm) white-light gray (5Y 8/1-5Y 7/1) NANNO-BEARING FORAM OOZE: Sec. 3 light gray (5Y 7/1), soft GLASS-BEARING MICARB AND FORAM-RICH NANNO OOZE with patches of: light olive gray (5Y 6/2); also GLAUCONITE-BEARING NANNO-FORAM OOZE at 24-30 cm, 52-54 cm, and 101-116 cm: Secs. 4 and 5 light greenish gray (5GY 8/1), stiff, GLAUCONITE-BEARING FORAM NANNO OOZE with 25% mottling in white (5Y 8/1); also FORAM-RICH NANNO OOZE (mottling due to change in glauconite abundance): core catcher: white (5Y 8/1), stiff, FORAM-BEARING NANNO OOZE with 10% light gray (5Y 7/2) NANNO-BEARING FORAM OOZE.

SS 1-104

Mi	- 2%
G	- 4%
Mn	- 2%
F	-92%

SS 1-126

VG	-10%
G	- 2%
M	-13%
F	-15%
N	-60%

SS 2-145

G	- 2%
F	-80%
N	-20%

SS 3-100

G	-10%
F	-70%
N	-20%

SS 4-79

G	- 3%
CM	- 4%
OP	- 3%
F	-30%
N	-60%

SS CC

F	-10%
N	-90%

X-ray 4-137 (Bulk)
Calc - M
Quar - TR

Grain Size 1-117 (85.7, 8.7, 5.6)

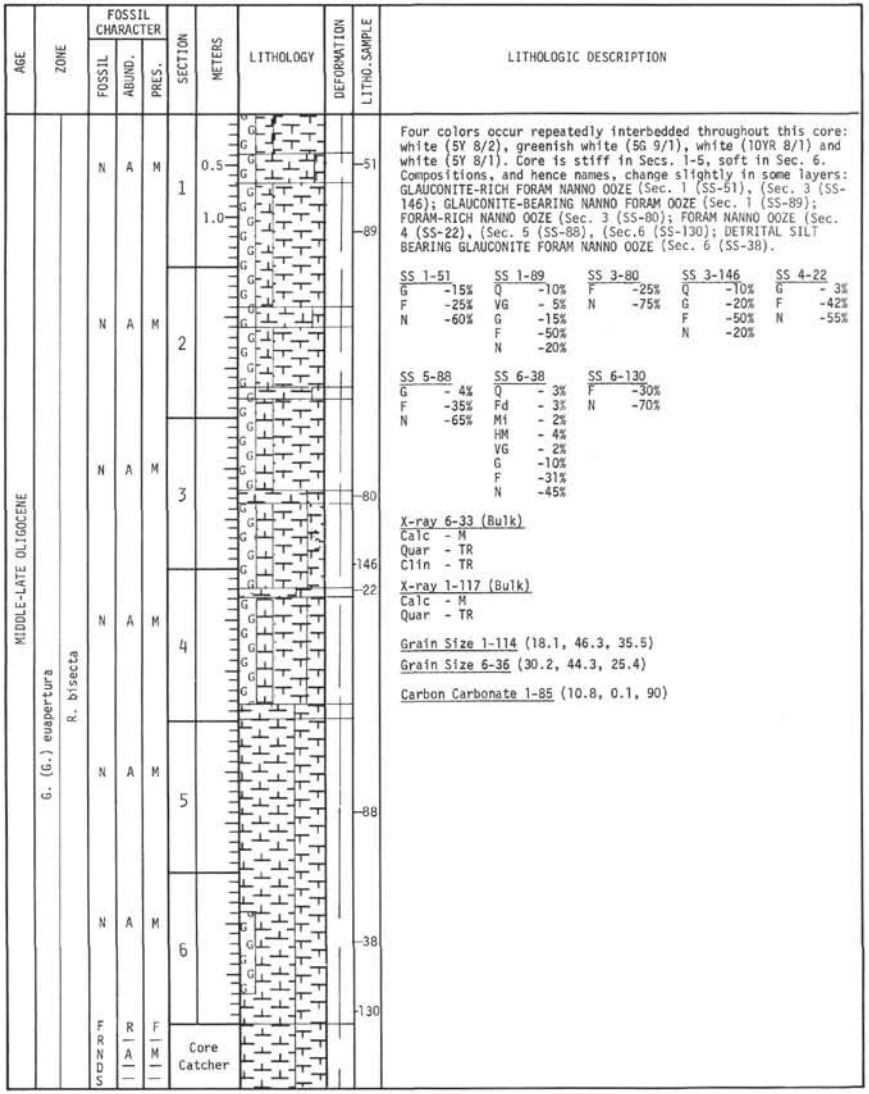
Grain Size 2-54 (29.7, 18.3, 52.0)

Grain Size 3-112 (57, 30.3, 12.7)

Carbon Carbonate 2-63 (11.4, 0.1, 94)

Carbon Carbonate 4-40 (10.5, 0.1, 87)

Site 277 Hole Core 2 Cored Interval: 7.0-16.5 m



Four colors occur repeatedly interbedded throughout this core: white (5Y 8/2), greenish white (5G 9/1), white (10YR 8/1) and white (5Y 8/1). Core is stiff in Secs. 1-5, soft in Sec. 6. Compositions, and hence names, change slightly in some layers: GLAUCONITE-RICH FORAM NANNO OOZE (Sec. 1 (SS-51), (Sec. 3 (SS-146); GLAUCONITE-BEARING NANNO FORAM OOZE (Sec. 1 (SS-89); FORAM-RICH NANNO OOZE (Sec. 3 (SS-80); FORAM NANNO OOZE (Sec. 4 (SS-22), (Sec. 5 (SS-88), (Sec.6 (SS-130); DETRITAL SILT BEARING GLAUCONITE FORAM NANNO OOZE (Sec. 6 (SS-38).

SS 1-51

G	-15%
F	-25%
N	-60%

SS 1-89

Q	-10%
VG	- 5%
G	-15%
F	-50%
N	-20%

SS 3-80

F	-25%
N	-75%

SS 3-146

Q	-10%
G	-20%
F	-50%
N	-20%

SS 4-22

G	- 3%
F	-42%
N	-55%

SS 5-88

G	- 4%
F	-35%
N	-65%

SS 6-38

Q	- 3%
Fd	- 3%
Mi	- 2%
HM	- 4%
VG	- 2%
G	-10%
F	-31%
N	-45%

SS 6-130

F	-30%
N	-70%

X-ray 6-33 (Bulk)
Calc - M
Quar - TR
Clin - TR

X-ray 1-117 (Bulk)
Calc - M
Quar - TR

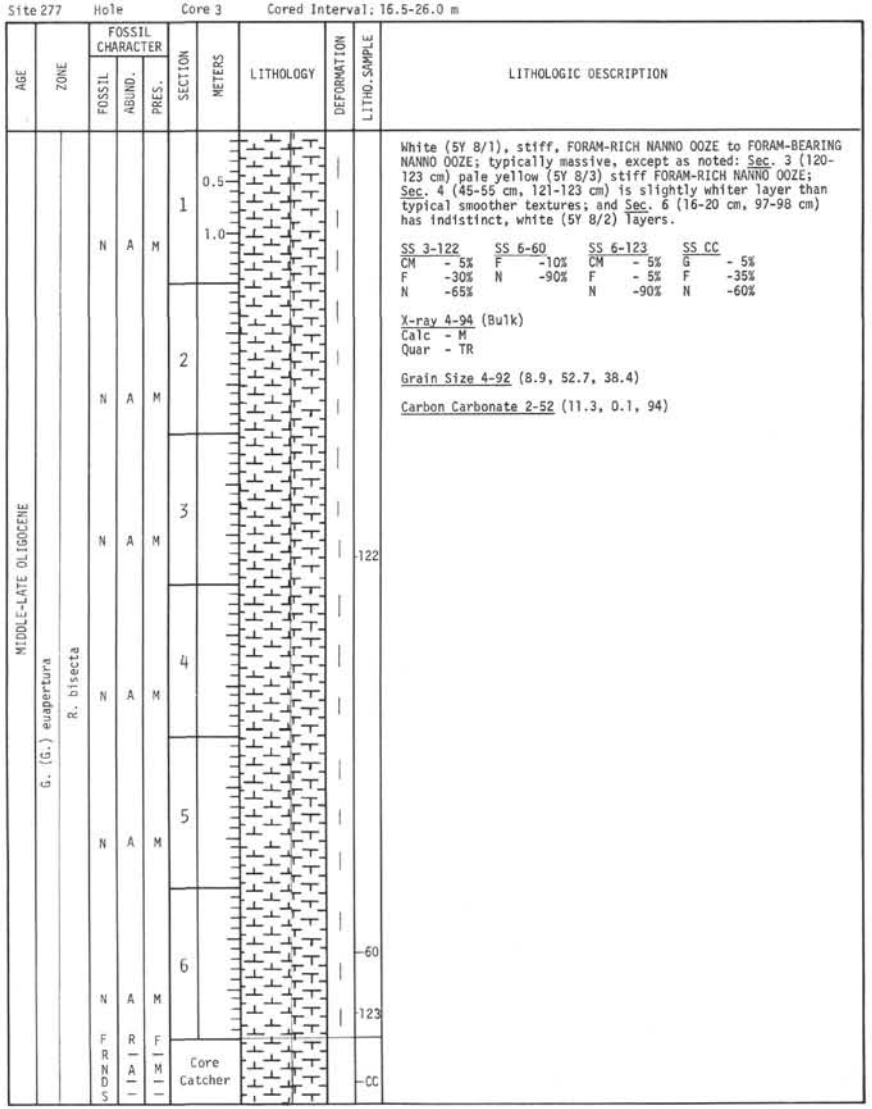
Grain Size 1-114 (18.1, 46.3, 35.5)

Grain Size 6-36 (30.2, 44.3, 25.4)

Carbon Carbonate 1-85 (10.8, 0.1, 90)

Explanatory notes in Chapter 1

Site 277 Hole Core 3 Cored Interval: 16.5-26.0 m



White (5Y 8/1), stiff, FORAM-RICH NANNO OOZE to FORAM-BEARING NANNO OOZE; typically massive, except as noted: Sec. 3 (120-123 cm) pale yellow (5Y 8/3) stiff FORAM-RICH NANNO OOZE; Sec. 4 (45-55 cm, 121-123 cm) is slightly whiter layer than typical smoother textures; and Sec. 6 (16-20 cm, 97-98 cm) has indistinct, white (5Y 8/2) layers.

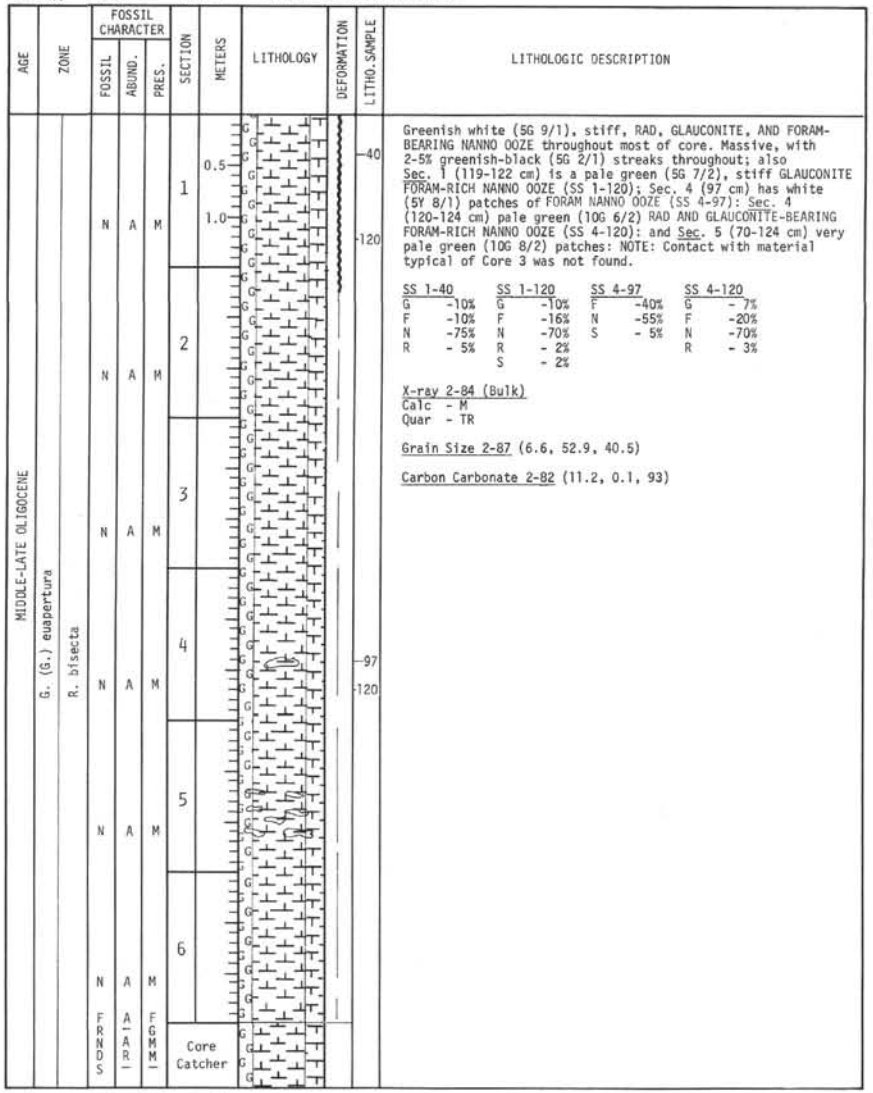
SS 3-122		SS 6-60		SS 6-123		SS CC	
CM	- 5%	F	-10%	CM	- 5%	G	- 5%
F	-30%	N	-90%	F	- 5%	F	-35%
N	-65%			N	-90%	N	-60%

X-ray 4-94 (Bulk)
Calc - M
Quar - TR

Grain Size 4-92 (8.9, 52.7, 38.4)

Carbon Carbonate 2-52 (11.3, 0.1, 94)

Site 277 Hole Core 4 Cored Interval: 26.0-35.5 m



Greenish white (5G 9/1), stiff, RAD, GLAUCONITE, AND FORAM-BEARING NANNO OOZE throughout most of core. Massive, with 2-5% greenish-black (5G 2/1) streaks throughout; also Sec. 1 (119-122 cm) is a pale green (5G 7/2), stiff GLAUCONITE FORAM-RICH NANNO OOZE (SS 1-120); Sec. 4 (97 cm) has white (5Y 8/1) patches of FORAM NANNO OOZE (SS 4-97): Sec. 4 (120-124 cm) pale green (10G 6/2) RAD AND GLAUCONITE-BEARING FORAM-RICH NANNO OOZE (SS 4-120): and Sec. 5 (70-124 cm) very pale green (10G 8/2) patches: NOTE: Contact with material typical of Core 3 was not found.

SS 1-40		SS 1-120		SS 4-97		SS 4-120	
G	-10%	G	-10%	F	-40%	G	- 7%
F	-10%	F	-16%	N	-55%	F	-20%
N	-75%	N	-70%	S	- 5%	N	-70%
R	- 5%	R	- 2%			R	- 3%
		S	- 2%				

X-ray 2-84 (Bulk)
Calc - M
Quar - TR

Grain Size 2-87 (6.6, 52.9, 40.5)

Carbon Carbonate 2-82 (11.2, 0.1, 93)

Explanatory notes in Chapter 1

Site 277 Hole Core 5 Cored Interval: 35.5-45.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
MIDDLE-LATE OLIGOCENE	G. (G.) euapertura / R. bisecta	N	A	M	1	0.5 / 1.0			
		N	A	M	2				
		N	A	M	3				-20
		N	A	M	4				
		N	A	M	5				
		N	A	M	6				-82
		F R D S	A A R I	F G M M I	Core Catcher				-144

LITHOLOGIC DESCRIPTION

Greenish white (5G 9/1) stiff FORAM-RICH NANNO OOZE to GLAUCONITE-BEARING FORAM-RICH NANNO OOZE (Typical material of core) with 2-5% greenish-black (5G 2/1) streaks throughout; also Sec. 3 (0-50 cm) shows a subtle color and composition change to a light greenish gray (5GY 8/1), stiff FORAM-RICH NANNO OOZE (SS 3-20): Sec. 4 (81 and 83 cm) shows pale green (10G 6/2) (glauconite-rich) patches with black rind; and in Sec. 6 SS 6-82 is from greenish-black streak; color due to presence of glauconite-filled forams.

SS 3-20		SS 6-82		SS 6-144	
CM	-10%	G	- 8%	F	-15%
G	- 5%	F	-17%	N	-80%
F	-20%	N	-75%	S	- 5%
N	-65%				

X-ray 6-76 (Bulk)
Calc - M
Quar - TR

Grain Size 6-73 (6.8, 58.8, 34.4)

Carbon Carbonate 6-71 (11.1, 0.1, 91)

Site 277 Hole Core 6 Cored Interval: 45.0-54.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
MIDDLE-LATE OLIGOCENE	G. (G.) euapertura / R. bisecta	N	A	M	1	0.5 / 1.0	VOID		
		N	A	M	2				
		N	A	M	3				
		N	A	M	4				
		N	A	M	5				-60
		N	A	M	6				
		F R D S	A A R I	F G M M I	Core Catcher				-CC

LITHOLOGIC DESCRIPTION

Core is typically a greenish white (5G 9/1), stiff, FORAM-RICH NANNO OOZE to GLAUCONITE-RAD-FORAM-BEARING NANNO OOZE with occasional subtle light greenish gray (5G 8/1) layers and 2-5% greenish black (5G 2/1) streaks throughout: core catcher contains a GLAUCONITE, DIATOM, AND RAD-BEARING FORAM-RICH NANNO OOZE (SS CC).

SS 5-60		SS CC	
G	- 5%	G	- 3%
F	- 7%	F	-27%
N	-80%	N	-60%
R	- 5%	D	- 5%
S	- 3%	R	- 5%

Explanatory notes in Chapter 1

Site 277 Hole Core 7 Cored Interval:54.5-64.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE-LATE OLIGOCENE	G. (G.) euapertura / R. bisecta	F R N D S	A A A C R	F G M M P	1	0.5	VOID			Core is typically a greenish white (5G 9/1) stiff, NANNO OOZE (SS 4-88) with some subtle, slightly greener layers 2-5% greenish-black (5G 2/1) streaks.
						1.0				SS 4-88 N -100%
										X-ray 2-23 (Bulk) Calc - M Quar - TR
										X-ray 5-26 (Bulk) Calc - M
		N	A	M	2					Grain Size 2-27 (1.0, 56.9, 42.2)
										Grain Size 5-30 (1.0, 58.5, 40.5)
										Carbon Carbonate 2-20 (11.2, 0.0, 93)
										Carbon Carbonate 5-24 (11.4, 0.0, 94)
		N	A	M	3					
		N	A	M	4				-88	
		N	A	M	5					
		N	A	M	6					
		N	A	M	Core Catcher					

Site 277 Hole Core 8 Cored Interval:64.0-73.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE-LATE OLIGOCENE	G. (G.) euapertura / R. bisecta	F R N D S	A A A R R	F G M P P	1	0.5				Core is predominantly a greenish white (5G 9/1) stiff NANNO OOZE with: 0-5% greenish-black (5G 2/1) streaks: also Sec. 2 (66-73 cm) is very pale green (10G 8/2) GLAUCONITE-BEARING FORAM-RICH NANNO OOZE (SS 2-67), overlain by thin black layers: Sec. 3 (90 cm) has a limonite chunk with manganese crust; 5 mm dia.: Sec. 5 (120-150 cm) shows grading to white (5Y 8/1) GLAUCONITE-RAD-BEARING FORAM-RICH NANNO OOZE (SS 5-133): core catcher composed of RAD AND FORAM-BEARING NANNO OOZE (SS CC).
						1.0				SS 2-67 G - 5% F -10% N -85%
										SS 5-133 G - 5% F -15% N -75% R - 5%
										SS CC G - 2% F -10% N -80% R - 8%
		N	A	M	2				-67	
		N	A	M	3					
		N	A	M	4					
		N	A	M	5				-133	
		N	A	M	6					
		N	A	M	Core Catcher				-CC	

Explanatory notes in Chapter 1

Site 277 Hole Core 9 Cored Interval: 73.5-83.0 m

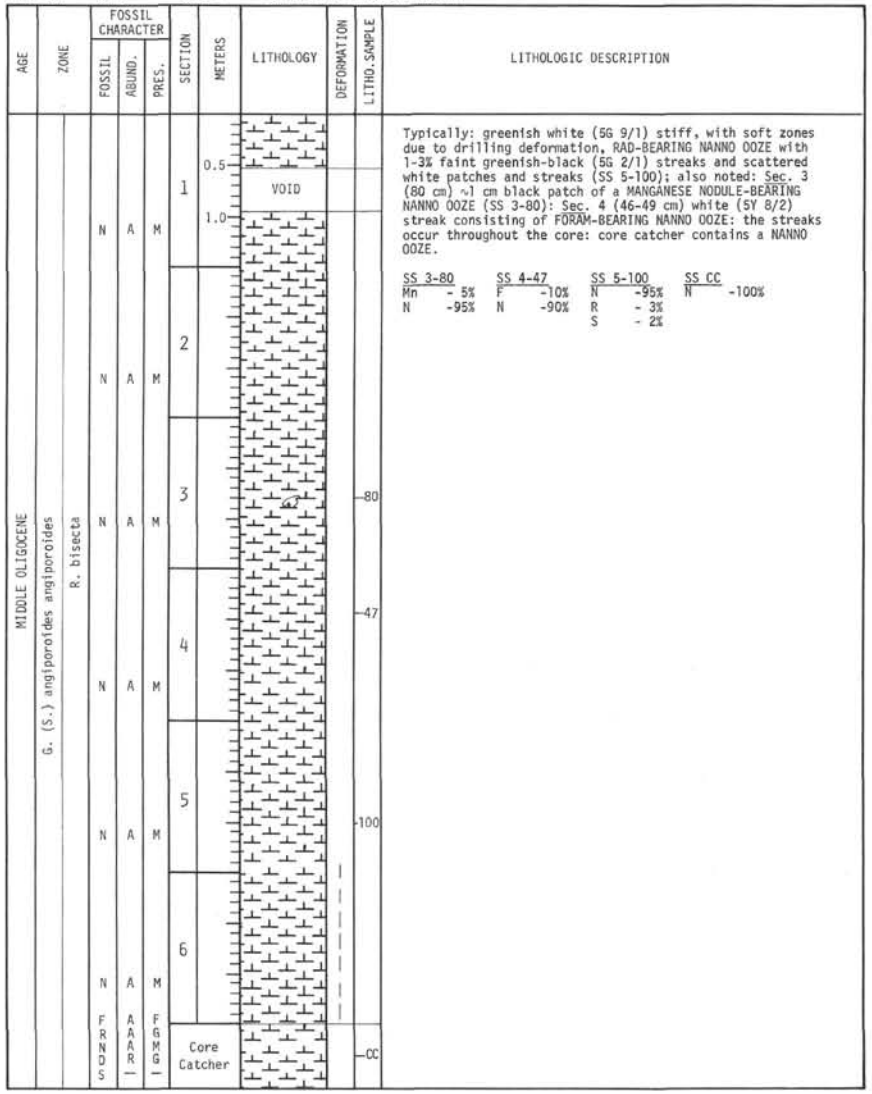
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE-LATE OLIGOCENE	G. (S.) angiporoides / G. (G.) euapertura / R. bisecta	N	A	M	1	0.5 / 1.0				Typically a greenish white (5G 9/1) stiff RAD-BEARING FORAM-RICH NANNO OOZE with faint slightly greener and slightly whiter layering through Sec. 4 and 0-5% faint greenish-black (5G 2/1) streaks throughout (SS 2-90): core catcher consists of a RAD-BEARING FORAM-RICH NANNO OOZE.
		N	A	M	2				-90	SS 2-90: F -20%, N -75%, R - 5%. SS CC: F -12%, N -80%, R - 8%. X-ray 2-80 (Bulk): Calc - M. Grain Size 2-83 (0.7, 57.1, 42.2). Carbon Carbonate 2-77 (11.2, 0.1, 92)
		N	A	M	3					
		N	A	M	4					
		N	A	M	5					
		F	A	G	6					
		N	A	M						
		F	A	F/G	Core Catcher				-CC	
		R	A	G						
		N	C	M						
		D	R	P						
		S								

Site 277 Hole Core 10 Cored Interval: 83.0-92.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE OLIGOCENE	G (S.) angiporoides / R. bisecta	N	A	M	1	0.5 / 1.0			-26	Typically a greenish white (5G 9/1) stiff RAD-BEARING FORAM-RICH NANNO OOZE with: 1-3% greenish-black (5G 2/1) streaks: also noted; Sec. 1 (25-34 cm) white (5Y 8/2) streak of FORAM-RICH NANNO OOZE (SS 1-26); Sec. 1 (138-143 cm) greenish white (5G 9/1) anomalously hard layer DIATOM-BEARING NANNO OOZE (SS 1-141); Sec. 2 (83-86 cm): Anomalously hard layer, as above (SS 2-85); Sec. 3 (97-100 cm, 140-143 cm) anomalously hard layers, as above; and Sec. 5 (126-129 cm) anomalously hard layer, as above.
		N	A	P	2				-141	SS 1-26: Q - 5%, F -25%, N -65%, D - 2%, R - 1%, S - 2%. SS 1-141: F - 3%, N -90%, D - 7%. SS 2-85: F -15%, N -75%, D - 5%, R - 2%, S - 2%, Si - 1%. X-ray 5-98 (Bulk): Calc - M. Grain Size 5-101 (0.8, 52.1, 47.1). Carbon Carbonate 5-96 (11.4, 0.1, 95)
		N	A	M	3				-85	
		N	A	M	4					
		N	A	M	5					
		N	A	M	6					
		F	A	F/G	Core Catcher					
		R	A	G						
		N	C	M						
		D	R	P						
		S								

Explanatory notes in Chapter 1

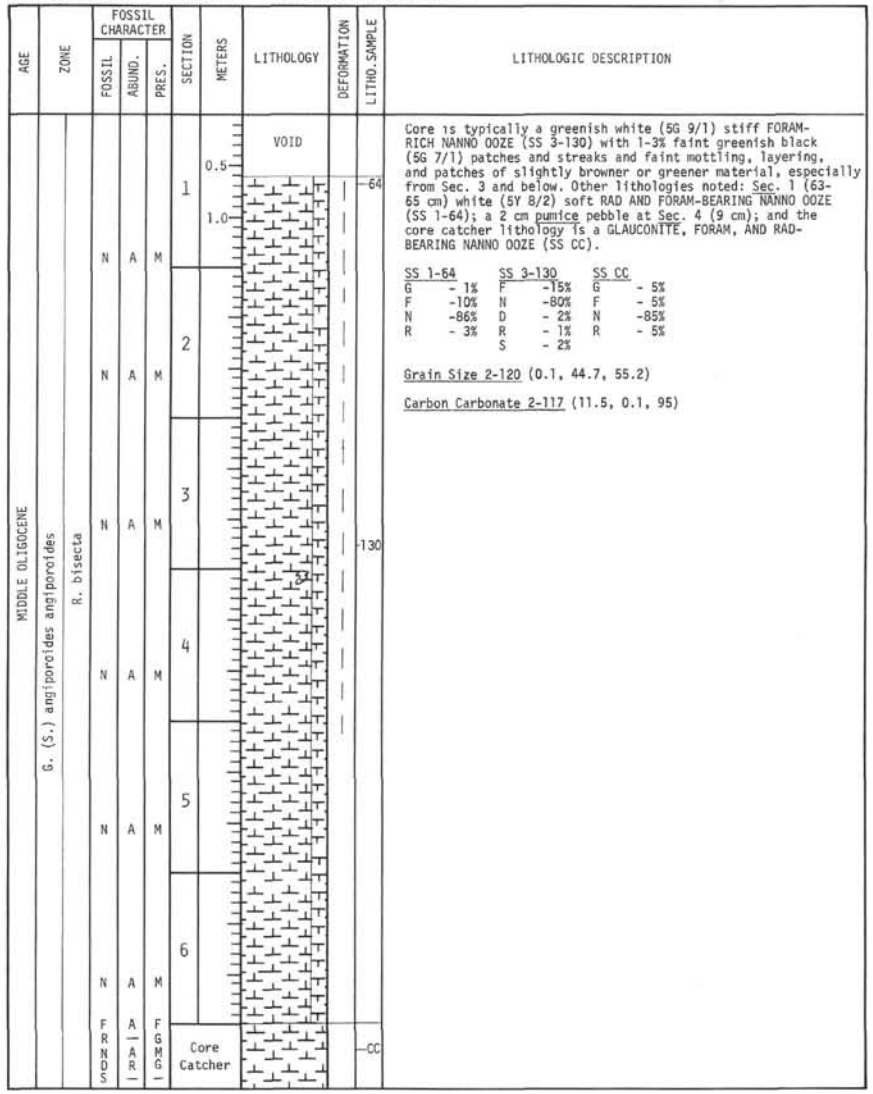
Site 277 Hole Core 11 Cored Interval: 92.5-102.0 m



Typically: greenish white (5G 9/1) stiff, with soft zones due to drilling deformation, RAD-BEARING NANNO OOZE with 1-3% faint greenish-black (5G 2/1) streaks and scattered white patches and streaks (SS 5-100); also noted: Sec. 3 (80 cm) ~1 cm black patch of a MANGANESE NODULE-BEARING NANNO OOZE (SS 3-80): Sec. 4 (46-49 cm) white (5Y 8/2) streak consisting of FORAM-BEARING NANNO OOZE: the streaks occur throughout the core: core catcher contains a NANNO OOZE.

SS 3-80		SS 4-47		SS 5-100		SS CC	
Mn	- 5%	F	-10%	N	-95%	N	-100%
N	-95%	N	-90%	R	- 3%		
				S	- 2%		

Site 277 Hole Core 12 Cored Interval: 102.0-111.5 m



Core is typically a greenish white (5G 9/1) stiff FORAM-RICH NANNO OOZE (SS 3-130) with 1-3% faint greenish black (5G 7/1) patches and streaks and faint mottling, layering, and patches of slightly browner or greener material, especially from Sec. 3 and below. Other lithologies noted: Sec. 1 (63-65 cm) white (5Y 8/2) soft RAD AND FORAM-BEARING NANNO OOZE (SS 1-64); a 2 cm pumice pebble at Sec. 4 (9 cm); and the core catcher lithology is a GLAUCONITE, FORAM, AND RAD-BEARING NANNO OOZE (SS CC).

SS 1-64		SS 3-130		SS CC	
G	- 1%	F	-15%	G	- 5%
F	-10%	N	-80%	F	- 5%
N	-86%	D	- 2%	N	-85%
R	- 3%	R	- 1%	R	- 5%
		S	- 2%		

Grain Size 2-120 (0.1, 44.7, 55.2)

Carbon Carbonate 2-117 (11.5, 0.1, 95)

Explanatory notes in Chapter 1

Site 277 Hole Core 13 Cored Interval: 111.5-121.0 m

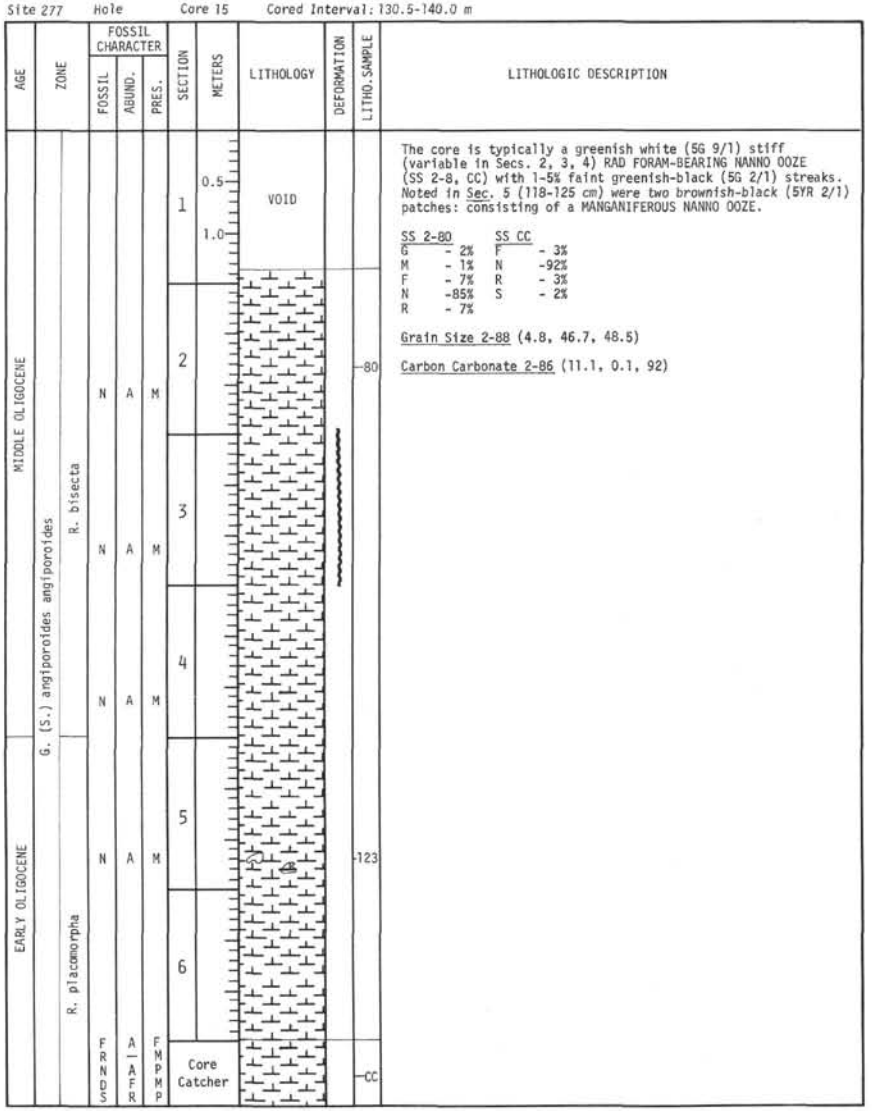
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE OLIGOCENE	G. (S.) angiporoides angiporoides / R. bisecta	N	A	M	1	0.5–1.0	VOID			Core consists of a greenish white (5G 9/1), stiff; RAD, SPICULE, AND FORAM-BEARING NANNO OOZE (SS 3-110) with 2-3% faint greenish black (5G 2/1) streaks and patches: In Sec. 3 (11-115 cm) a pale green (5G 7/2) stiff area, (slightly harder than rest of core) consists of a FORAM-RICH NANNO OOZE (SS 3-113): core catcher sample is a DIATOM AND GLAUCONITE-BEARING FORAM-RICH NANNO OOZE (SS CC).
		N	A	M	2					SS 3-110: F - 7%, N -88%, D - 1%, R - 2%, S - 2%
		N	A	M	3				110, 113	SS 3-113: F -18%, N -80%, S - 2%
		N	A	M	4					SS CC: G - 5%, F -15%, N -70%, D - 3%, R - 7%
		N	A	M	5					Grain Size 5-117 (1.5, 49.6, 48.9)
		N	A	M	6					Carbon Carbonate 5-116 (11.2, 0.1, 93)
		N	A	M	Core Catcher				CC	
		F R N D S	A A A R	F G M G P						

Site 277 Hole Core 14 Cored Interval: 121.0-130.5 m

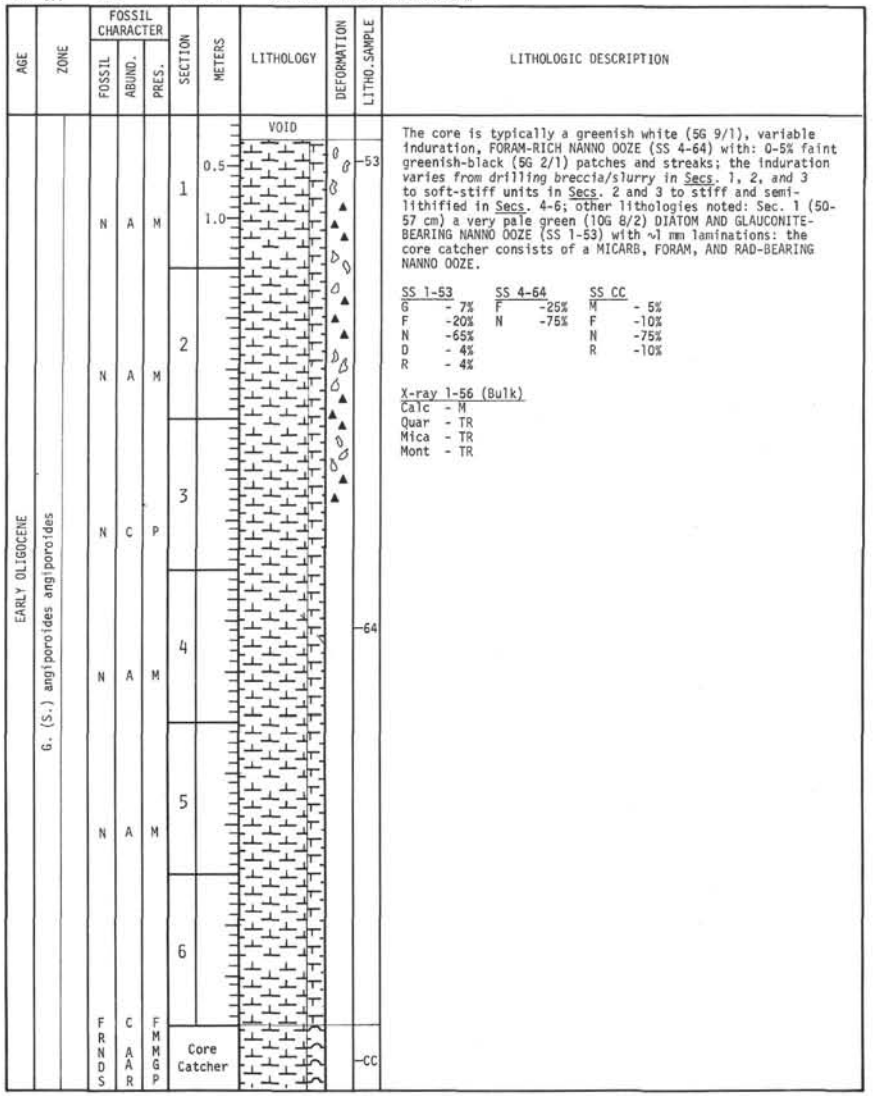
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE OLIGOCENE	G. (S.) angiporoides / R. bisecta	N	A	M	1	0.5–1.0				Core is typically a greenish white (5G 9/1), with variable induration RAD, SPICULE, AND FORAM-BEARING NANNO OOZE with: 1-5% faint greenish-black (5G 2/1) streaks; induration characteristics: range from a drilling slurry, to a stiff core: at 133-150 cm in Sec. 5, the core is gray (2.5Y N6) at base, to gray (2.5Y N5) at top (lithified). The lithology is a GLAUCONITE-BEARING CHERT-CALCITE-QUARTZ SANDSTONE; the compositional and size grading (slight) may indicate a turbidite. It is coarse to medium grained. Approximately 2-3% white (5Y 8/1) cherty patches: the core catcher is a NANNO OOZE (SS CC).
		N	A	M	2		VOID			Sec. 1: 0-129 cm: drilling slurry; 129-132 cm: soft; 132-150 cm: stiff
		N	A	M	3		VOID			Sec. 2: 51-90 cm: stiff; 90-104 cm: soupy; 104-144 cm: stiff; 144-150 cm: soupy
		N	A	M	4		VOID			Sec. 3: 0-25 cm: drilling slurry; 52-87 cm: stiff; 87-98 cm: soft; 98-150 cm: stiff
		N	A	M	5				138	Sec. 4: 0-150 cm: stiff
		N	A	M	6					Sec. 5: 0-150 cm: stiff
		N	A	M	Core Catcher				CC	SS 5-138: Q -75%, Ch -25%, G - 5%, Cal -30%
		F R N D S	A A A R	F M M						SS CC: F - 1%, N -99%

Explanatory notes in Chapter 1

Site 277 Hole Core 15 Cored Interval: 130.5-140.0 m



Site 277 Hole Core 16 Cored Interval: 140.0-149.5 m



Explanatory notes in Chapter 1

Site 277 Hole Core 17 Cored Interval: 149.5-159.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	G. (S.) angiporoides angiporoides	N	A	M	1	0.5	VOID			Typically a greenish white (5G 9/1) with variable induration and consists of a DIATOM AND SPICULE-BEARING FORAM-RICH NANNO OOZE (SS 4-60), with 0-5% faint greenish-black (5G 2/1) streaks: the core induration shows drilling slurries in Secs. 1, 2, and 3, with core becoming soft to stiff from Sec. 3 (27 cm) to Sec. 6.
						1.0				
					2		VOID			SS 4-60 F -11% N -80% D - 3% R - 2% S - 4% Grain Size 3-126 (4.1, 53.5, 42.4) Carbon Carbonate 3-84 (11.3, 0.1, 93)
		N	A	M						
		N	A	M	3					
		N	A	M	4				60	
		N	A	M	5					
		N	A	M	6					
		N F R N D S	A C I A C C	M F M G M			Core Catcher			

Site 277 Hole Core 18 Cored Interval: 159.0-168.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	G. (S.) angiporoides angiporoides	N	A	M	1	0.5	VOID			Core is typically a greenish white (5G 9/1) stiff DIATOM AND SPICULE-BEARING FORAM-RICH NANNO OOZE with: 1-2% faint greenish-black (5G 9/1) streaks.
						1.0				
		N	A	M	2					
		N	A	M	3					
		N F R N D S	A C I A C R	M F M M P			Core Catcher			

Site 277 Hole Core 19 Cored Interval: 168.5-178.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	G. (S.) angiporoides angiporoides / G. (G.) brevis	F	C	F	1	0.5	VOID			Greenish white (5G 9/1), DIATOM AND SPICULE-BEARING FORAM-RICH NANNO OOZE with drilling slurry/breccia in Secs. 1 and 2 (0-50 cm) with stiff zones in Sec. 1 (120-150 cm) and Sec. 2 (50-150 cm).
						1.0				
		F	C	F	2					X-ray 2-95 (Bulk) Calc - M Grain Size 2-108 (1.5, 43.5, 55.1) Carbon Carbonate 2-106 (11.2, 0.1, 93)
		F N F R N D S	A C R A C R	F M M P			Core Catcher			

Explanatory notes in Chapter 1

Site 277 Hole Core 20 Cored Interval: 178.0-187.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY OLIGOCENE	G. (G.) brevis	N	A	P	1	0.5, 1.0				Greenish white (5G 9/1) FORAM-BEARING MICARB NANNO OOZE (SS 3-50); drilling slurry/breccia in Secs. 1-5 (75 cm), stiff from Sec. 5 (75 cm) through Sec. 6.
					2					SS 3-50 M -37% F -10% N -50% R - 1% S - 2%
					3				50	Grain Size 6-52 (1.0, 50.6, 48.3)
		N	A	M	4					Carbon Carbonate 6-55 (11.4, 0.0, 94)
		N	A	M	5					
		N	A	M	6					
		N	A	M	Core Catcher					

Site 277 Hole Core 21 Cored Interval: 187.5-197.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE EOCENE	G. (G.) brevis	N	A	M	1	0.5, 1.0	VOID, VOID			Greenish white (5G 9/1) FORAM-RICH NANNO OOZE (SS 3-80); alternately drilling slurry and stiff zones to all stiff zones in Sec. 3.
					2					SS 3-80 F -20% N -80%
		N	A	M	3				80	
		N	A	M	Core Catcher					

Site 277 Hole Core 22 Cored Interval: 197.0-206.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE EOCENE	G. (G.) brevis	N	A	M	1	0.5, 1.0	VOID			Greenish white (5G 9/1) FORAM-RICH NANNO OOZE. The induration characteristics are: Sec. 1 (71-129 cm) drilling breccia; 129-150 cm - soft to stiff (marginal); Sec. 2 stiff and soft interbedded layers; and Sec. 3 stiff, with slightly greener brecciated zones at: 38-40 cm, 65-69 cm, 84-88 cm, 113-116 cm, and 145-150 cm.
					2					X-ray 3-71 (Bulk) Calc - M Quar - TR
		N	A	M	3					Grain Size 3-67 (1.5, 46.0, 52.5)
		N	A	M	Core Catcher					Carbon Carbonate 3-74 (11.0, 0.0, 91)

Explanatory notes in Chapter 1

Site 277 Hole Core 23 Cored Interval: 206.5-216.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE EOCENE	G.(G.) brevis	N	A	M	1	0.5			
						1.0			-100
		N	A	M	2				
		N	A	M	3				
		N	A	M	Core Catcher				-CC

Core is a greenish white (5G 9/1) to very pale green (10G 8/2) brecciated SPICULE-BEARING FORAM-RICH NANNO OOZE (SS 1-100); noted in Sec. 2 is a slight color change: greenish white (5G 9/1) with darker green brecciated zone at 9-46 cm. Also, brecciated, but not darker, zones occur at 70-74 cm and 107-115 cm; in Sec. 3 brecciated layers occur at: 2-6 cm, 30-35 cm, 66-72 cm, 114-119 cm, and 130-150 cm: the core catcher consists of a SPICULE-BEARING NANNO OOZE.

SS 1-100		SS CC	
F	-15%	F	- 1%
N	-82%	N	-92%
S	- 3%	S	- 5%

Site 277 Hole Core 24 Cored Interval: 216.0-225.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE EOCENE	G. (S.) linaperta	N	A	M	1	0.5	VOID		
						1.0			
		N	A	M	2				
		N	A	M	3				
		N	A	M	Core Catcher				

Core is a greenish white (5G 9/1) SPICULE-BEARING FORAM-RICH NANNO OOZE with traces of faint greenish-black (5G 2/1) streaks; a drilling slurry in Sec. 1 grades downward to drilling breccia.

Grain Size 2-78 (0.3, 40.3, 59.5)

Carbon Carbonate 2-76 (9.6, 0.1, 79)

Site 277 Hole Core 25 Cored Interval: 225.5-235.0 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE EOCENE	G. (S.) linaperta	N	A	M	1	0.5	VOID		
						1.0			-83
	G. (T.) aculeata	F	C	F	2				
		N	A	M					
		N	A	M	Core Catcher				

A greenish white (5G 9/1) SPICULE-BEARING FORAM-RICH NANNO OOZE (SS 1-83) with 1-2% faint greenish-black (5G 2/1) streaks; drilling breccia deformation.

SS 1-83	
F	-10%
N	-81%
R	- 2%
S	- 5%
S1	- 2%

Site 277 Hole Core 26 Cored Interval: 235.0-244.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE EOCENE	G. (T.) aculeata	N	A	M	1	0.5	VOID		
						1.0			
		N	A	P	2				-118
		N	A	M	3				
		N	A	M	4				
		N	A	M	Core Catcher				-CC

Greenish white (5G 9/1) FORAM-BEARING NANNO OOZE (SS 2-118 and SS CC) as a drilling slurry grading to drilling breccia and traces-2% of greenish-black (5G 2/1) streaks: in Sec. 2 (107-110 cm) is a gray (5Y 6/1) CHERT NODULE with zoophycus(?) fossil.

SS 2-118		SS CC	
F	- 5%	F	-10%
N	-95%	N	-90%

Explanatory notes in Chapter 1

Site 277 Hole Core 27 Cored Interval: 244.5-254.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE EOCENE	G. (T.) aculeata	N	A	M	1	0.5, 1.0			-55	Sec. 1 consists of: (0-7 cm) a gray (5Y 6/1), lithified CHERTY, GLAUCONITIC, QUARTOSE CALCAREOUS SANDSTONE coarse-grained, massive; and at 7-150 cm is a white (5Y 8/1), semi-lithified FORAM-BEARING MICARB NANNO CHALK: in the core catcher two clasts were found: a gray (5Y 5/1), lithified CALCAREOUS SANDSTONE and a light gray (5Y 7/1) CHERT.
		F R N D S	C R A – –	F P P – –	Core Catcher					SS 1-55 Q - 1% M -40% F - 7% N -50% S - 2%

Site 277 Hole Core 28 Cored Interval: 254.0-263.5 m

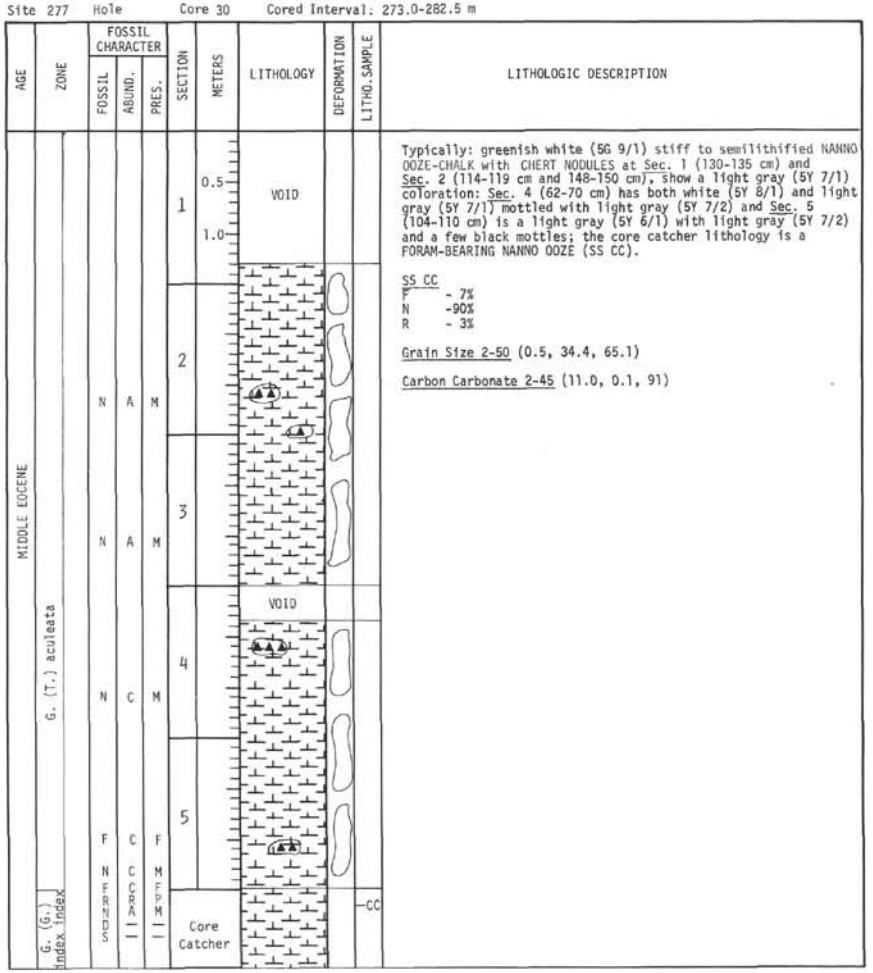
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	G. (T.) aculeata	N	A	M	1	0.5, 1.0	VOID			Core consists of: a greenish white (5G 9/1) NANNO OOZE; a white (5Y 8/1) to light gray (5Y 7/1) semilithified, massive NANNO CHALK and in Sec. 2 (20-25 cm and 126-131 cm) light gray (5Y 7/1) lithified CHERT NODULES.
		N	A	M	2					X-ray 2-20 (Bulk) Calc - M Quar - TR Cris - TR Mica - TR Clin - TR
		F R N D S	C R A – –	F P M – –	Core Catcher					Carbon Carbonate 2-45 (10.5, 0.1, 87)

Site 277 Hole Core 29 Cored Interval: 263.5-273.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	G. (T.) aculeata	N	A	M	1	0.5, 1.0				Core is a greenish white (5G 9/1), stiff NANNO OOZE with light gray (5Y 7/1) and white (5Y 8/1) CHERT NODULES, (with thin black veins). These occur at Sec. 1 (120-123 cm), Sec. 2 (22-24 cm and 148-150 cm).
		N	A	M	2					
		N	A	M	3					
		F R N D S	C R A – –	F P M – –	Core Catcher					

Explanatory notes in Chapter 1

Site 277 Hole Core 30 Cored Interval: 273.0-282.5 m



LITHOLOGIC DESCRIPTION

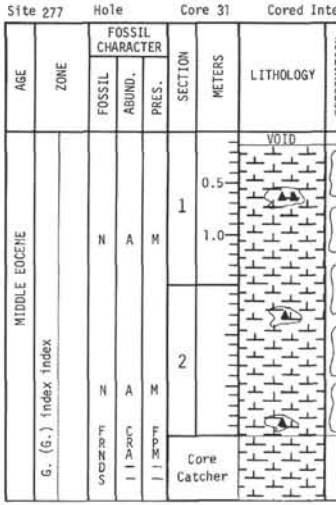
Typically: greenish white (5G 9/1) stiff to semilithified NANNO OOZE-CHALK with CHERT NODULES at Sec. 1 (130-135 cm) and Sec. 2 (114-119 cm and 148-150 cm), show a light gray (5Y 7/1) coloration: Sec. 4 (62-70 cm) has both white (5Y 8/1) and light gray (5Y 7/1) mottled with light gray (5Y 7/2) and Sec. 5 (104-110 cm) is a light gray (5Y 6/1) with light gray (5Y 7/2) and a few black mottles; the core catcher lithology is a FORAM-BEARING NANNO OOZE (SS CC).

SS CC
F - 7%
N -90%
R - 3%

Grain Size 2-50 (0.5, 34.4, 65.1)

Carbon Carbonate 2-45 (11.0, 0.1, 91)

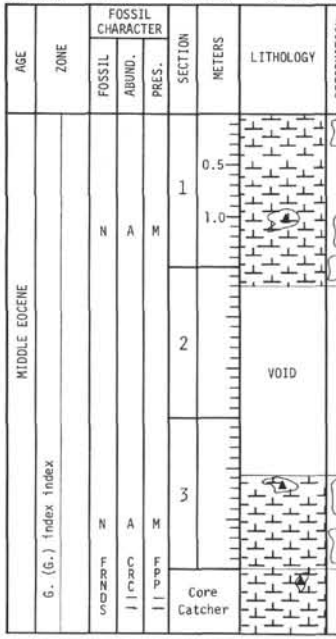
Site 277 Hole Core 31 Cored Interval: 282.5-292.0 m



LITHOLOGIC DESCRIPTION

Core is a greenish white (5G 9/1) NANNO OOZE-CHALK, semi-lithified to stiff: also noted: Sec. 1 (67-76 cm) white (5Y 8/1) and light gray (5Y 7/1) CHERT NODULES with light gray (5Y 7/2) mottles; Sec. 1 (131 cm) a MANGANESE PATCH; and Sec. 2 (37-40 cm and 143-150 cm), CHERT NODULES.

Site 277 Hole Core 32 Cored Interval: 292.0-301.5 m



LITHOLOGIC DESCRIPTION

Greenish white (5G 9/1) NANNO OOZE-CHALK: the induration shows Sec. 1 (0-39 cm and 82-150 cm) stiff; and 39-82 cm) soft: CHERT NODULES occur in Sec. 1 (90-95 cm), Sec. 3 (54-62 cm) and in the core catcher.

Explanatory notes in Chapter 1

Site 277 Hole Core 33 Cored Interval: 311.0-320.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	(G.) index index	N	A	M	1	0.5 1.0	VOID			Core is a greenish white (5G 9/1), semilithified NANNO CHALK: in Sec. 1 (110-117 cm) there is sandy debris, unlithified. Mostly carbonate fragments, with chert: CHERT NODULES occur in Sec. 2 (35-39 cm and 98-104 cm).
		N	A	M	2					
		FRNDS	CA	FP	Core Catcher					

Site 277 Hole Core 34 Cored Interval: 330.0-339.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	G. (G.) index index	N	A	P	1	0.5 1.0				Greenish white (5G 9/1), semilithified NANNO CHALK with pale green (5G 7/2) laminae throughout which dip 10° in Sec. 1: CHERT NODULE in Sec. 2 (121-130 cm). X-ray 1-83 (Bulk) Calc - M Carbon Carbonate 1-80 (11.5, 0.0, 95)
		N	A	M	2					
		FRNDS	CA	FM	Core Catcher					

Site 277 Hole Core 35 Cored Interval: 349.0-358.5 m

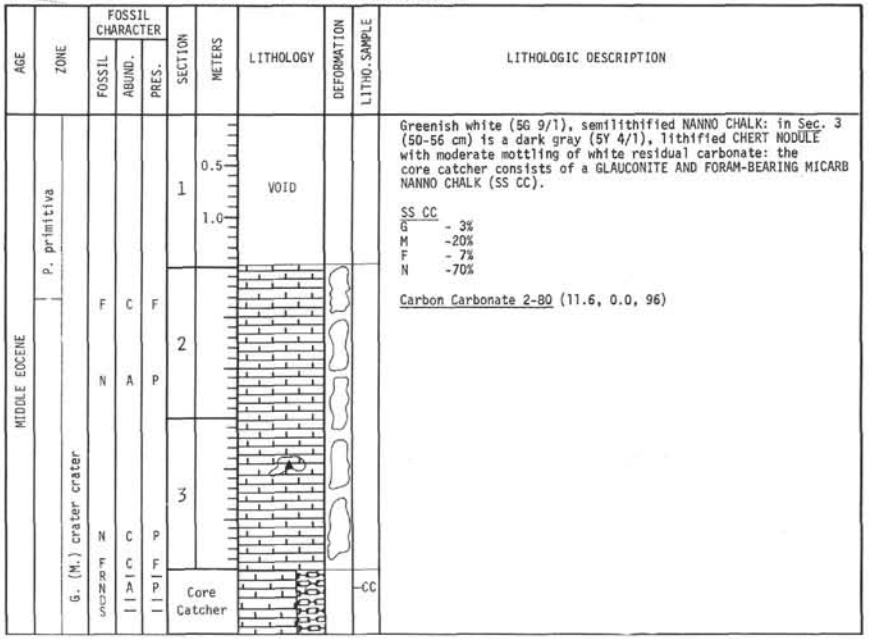
AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	G. (G.) index index	N	A	M	1	0.5 1.0				Greenish white (5G 9/1), semilithified NANNO CHALK. In the core catcher the chalk is GLAUCONITE AND FORAM-BEARING (SS CC); a CHERT NODULE was noted. SS CC G - 5% M -10% F - 5% N -80%
	P. primitiva	F	C	F	2					
		FRNDS	CA	FM	Core Catcher				CC	

Site 277 Hole Core 36 Cored Interval: 368.0-377.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
MIDDLE EOCENE	P. primitiva	N	A	P	1	0.5 1.0	VOID			Greenish white (5G 9/1), semilithified NANNO CHALK with a FORAM-BEARING NANNO CHALK in core catcher (SS CC). SS CC F - 8% N -92%
		N	A	P	2					
		N	A	M	3					
		FRNDS	CA	FP	Core Catcher				CC	

Explanatory notes in Chapter 1

Site 277 Hole Core 37 Cored Interval: 377.5-387.0 m



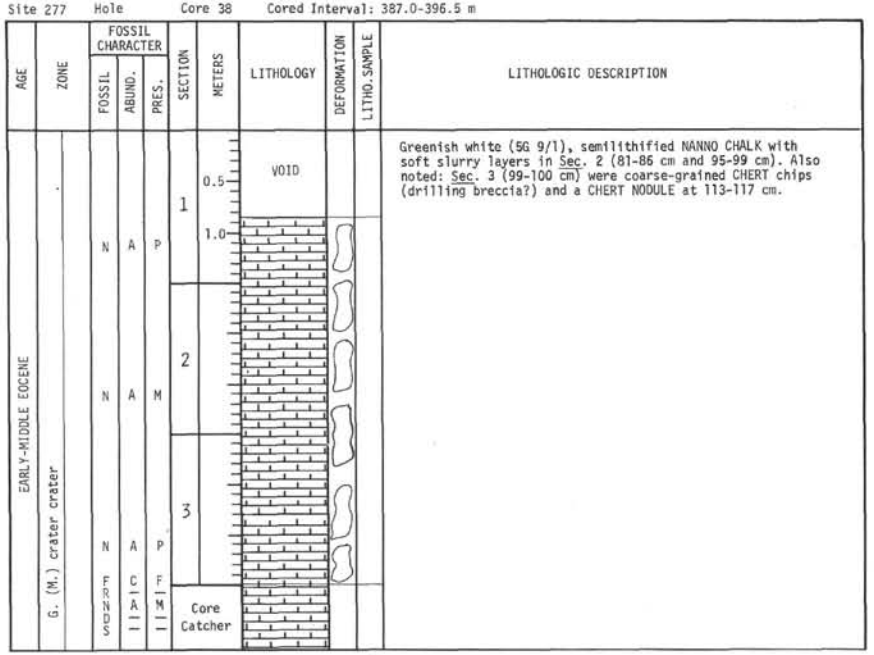
LITHOLOGIC DESCRIPTION

Greenish white (5G 9/1), semilithified NANNO CHALK: in Sec. 3 (50-56 cm) is a dark gray (5Y 4/1), lithified CHERT NODULE with moderate mottling of white residual carbonate: the core catcher consists of a GLAUCONITE AND FORAM-BEARING MICARB NANNO CHALK (SS CC).

SS CC
G - 3%
M -20%
F - 7%
N -70%

Carbon Carbonate 2-80 (11.6, 0.0, 96)

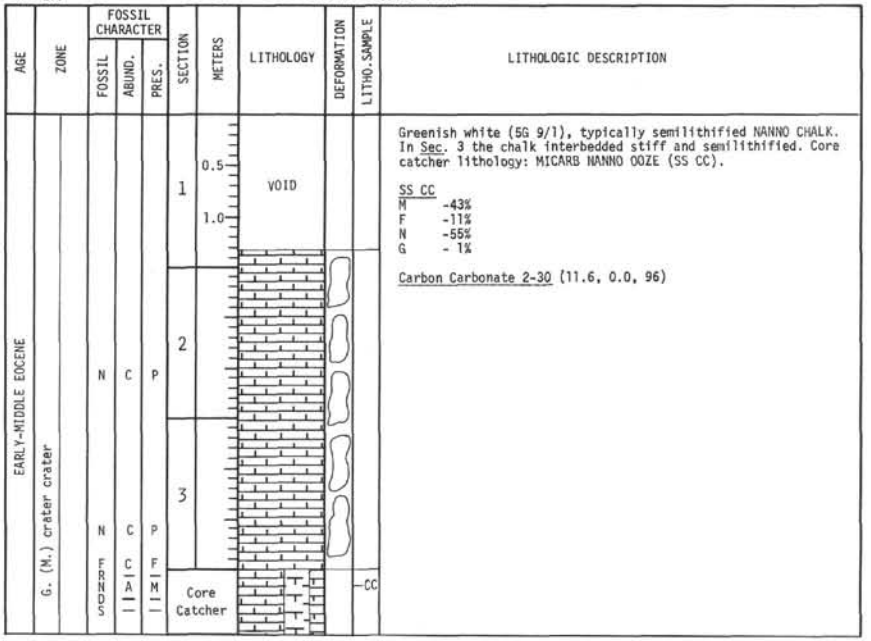
Site 277 Hole Core 38 Cored Interval: 387.0-396.5 m



LITHOLOGIC DESCRIPTION

Greenish white (5G 9/1), semilithified NANNO CHALK with soft slurry layers in Sec. 2 (81-86 cm and 95-99 cm). Also noted: Sec. 3 (99-100 cm) were coarse-grained CHERT chips (drilling breccia?) and a CHERT NODULE at 113-117 cm.

Site 277 Hole Core 39 Cored Interval: 396.5-406.0 m



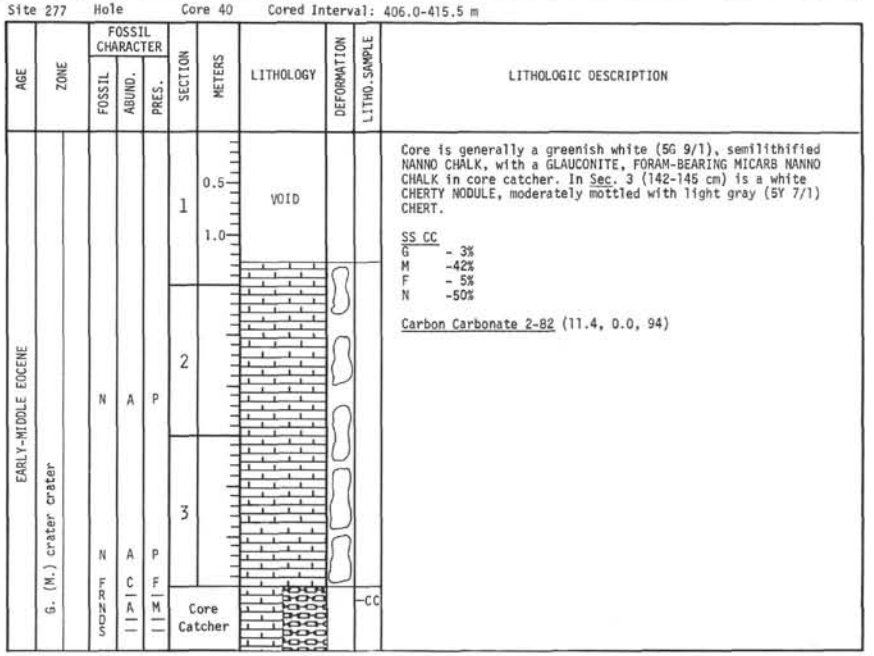
LITHOLOGIC DESCRIPTION

Greenish white (5G 9/1), typically semilithified NANNO CHALK. In Sec. 3 the chalk interbedded stiff and semilithified. Core catcher lithology: MICARB NANNO OOZE (SS CC).

SS CC
M -43%
F -11%
N -55%
G - 1%

Carbon Carbonate 2-30 (11.6, 0.0, 96)

Site 277 Hole Core 40 Cored Interval: 406.0-415.5 m



LITHOLOGIC DESCRIPTION

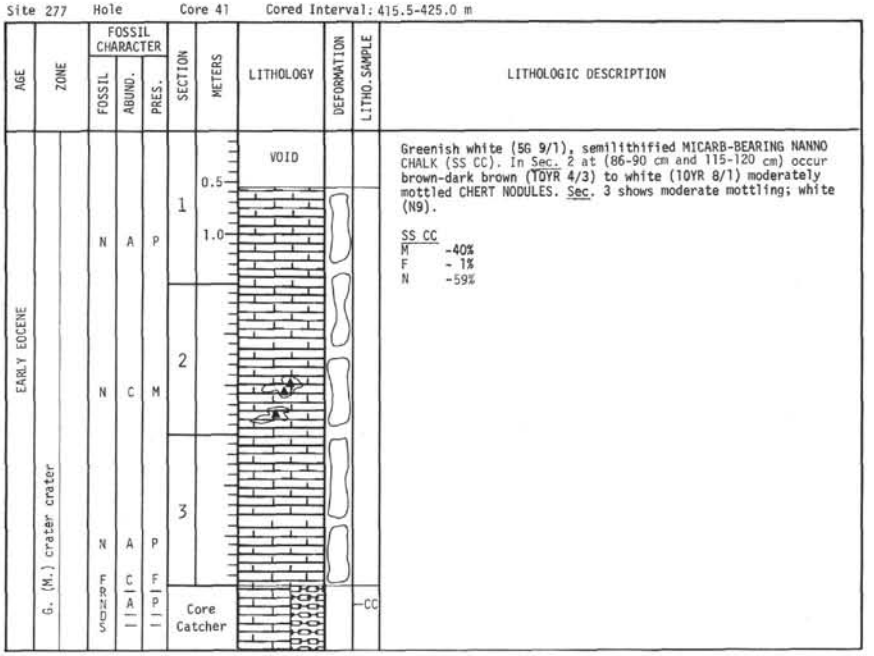
Core is generally a greenish white (5G 9/1), semilithified NANNO CHALK, with a GLAUCONITE, FORAM-BEARING MICARB NANNO CHALK in core catcher. In Sec. 3 (142-145 cm) is a white CHERTY NODULE, moderately mottled with light gray (5Y 7/1) CHERT.

SS CC
G - 3%
M -42%
F - 5%
N -50%

Carbon Carbonate 2-82 (11.4, 0.0, 94)

Explanatory notes in Chapter 1

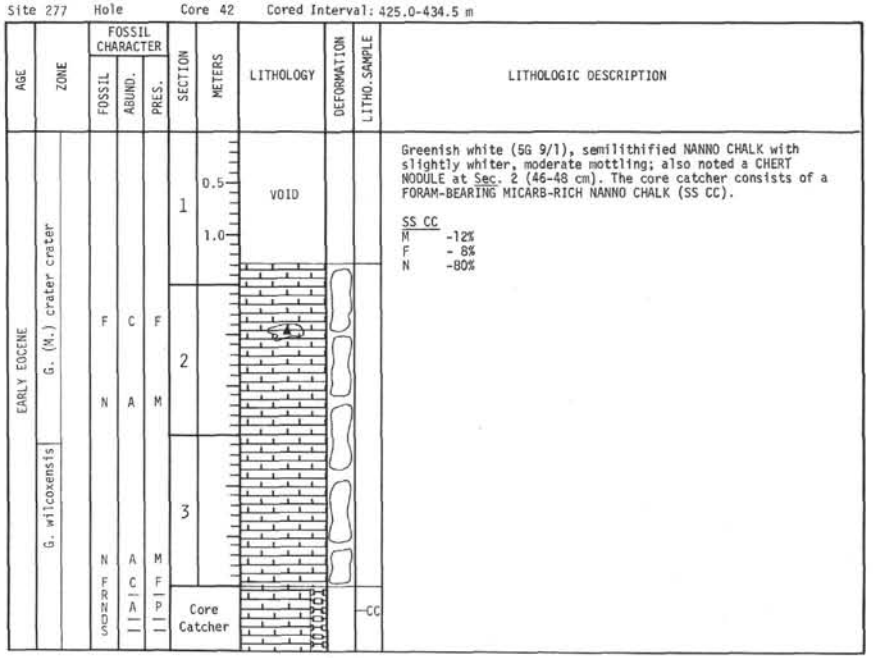
Site 277 Hole Core 41 Cored Interval: 415.5-425.0 m



Greenish white (5G 9/1), semilithified MICARB-BEARING NANNO CHALK (SS CC). In Sec. 2 at (86-90 cm and 115-120 cm) occur brown-dark brown (10YR 4/3) to white (10YR 8/1) moderately mottled CHERT NODULES. Sec. 3 shows moderate mottling; white (N9).

SS CC
M -40%
F - 1%
N -59%

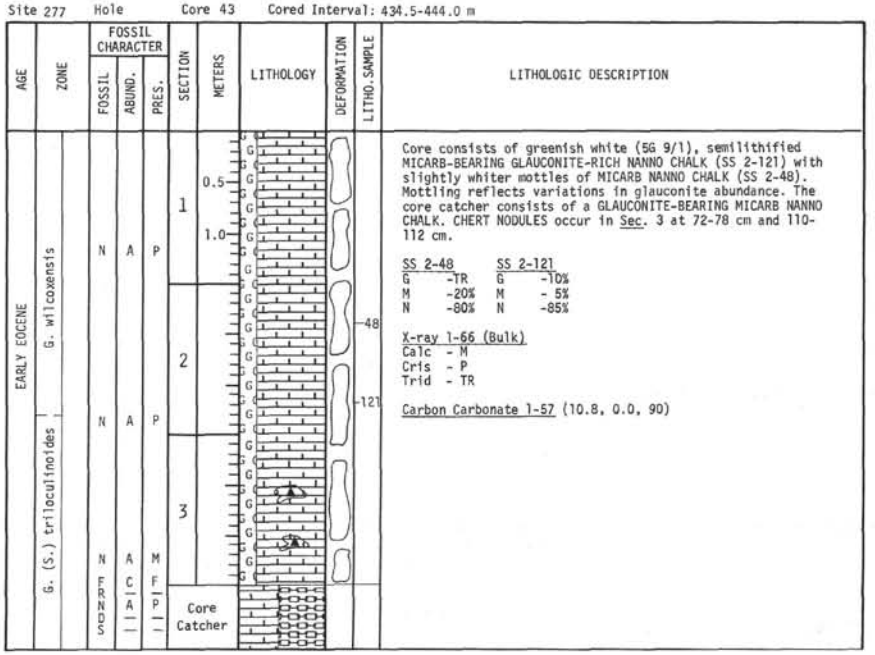
Site 277 Hole Core 42 Cored Interval: 425.0-434.5 m



Greenish white (5G 9/1), semilithified NANNO CHALK with slightly whiter, moderate mottling; also noted a CHERT NODULE at Sec. 2 (46-48 cm). The core catcher consists of a FORAM-BEARING MICARB-RICH NANNO CHALK (SS CC).

SS CC
M -12%
F - 8%
N -80%

Site 277 Hole Core 43 Cored Interval: 434.5-444.0 m



Core consists of greenish white (5G 9/1), semilithified MICARB-BEARING GLAUCONITE-RICH NANNO CHALK (SS 2-121) with slightly whiter mottles of MICARB NANNO CHALK (SS 2-48). Mottling reflects variations in glauconite abundance. The core catcher consists of a GLAUCONITE-BEARING MICARB NANNO CHALK. CHERT NODULES occur in Sec. 3 at 72-78 cm and 110-112 cm.

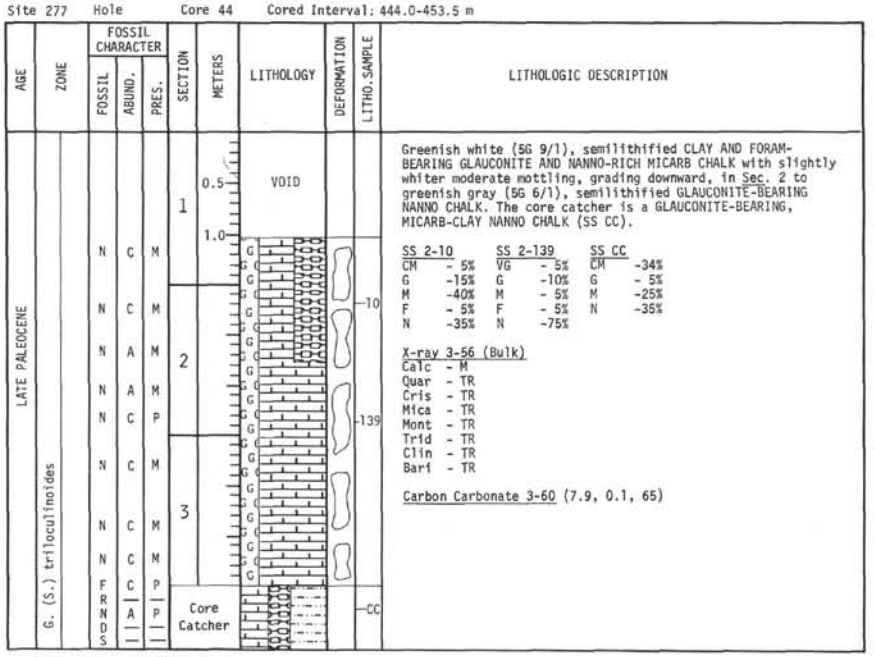
SS 2-48
G -TR
M -20%
N -80%

SS 2-121
G -10%
M - 5%
N -85%

X-ray 1-66 (Bulk)
Calc - M
Cris - P
Trid - TR

Carbon Carbonate 1-57 (10.8, 0.0, 90)

Site 277 Hole Core 44 Cored Interval: 444.0-453.5 m



Greenish white (5G 9/1), semilithified CLAY AND FORAM-BEARING GLAUCONITE AND NANNO-RICH MICARB CHALK with slightly whiter moderate mottling, grading downward, in Sec. 2 to greenish gray (5G 6/1), semilithified GLAUCONITE-BEARING NANNO CHALK. The core catcher is a GLAUCONITE-BEARING, MICARB-CLAY NANNO CHALK (SS CC).

SS 2-10
CM - 5%
G -15%
M -40%
F - 5%
N -35%

SS 2-139
VG - 5%
G -10%
M - 5%
F - 5%
N -75%

SS CC
CM -34%
G - 5%
M -25%
N -35%

X-ray 3-56 (Bulk)
Calc - M
Quar - TR
Cris - TR
Mica - TR
Mont - TR
Trid - TR
Clin - TR
Bari - TR

Carbon Carbonate 3-60 (7.9, 0.1, 65)

Explanatory notes in Chapter 1

Site 277 Hole Core 45 Cored Interval: 453.5-463.0 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE PALEOCENE	G. (S.) trilocul inoides	N	C	P	1	0.5	VOID		
						1.0			
		N	C	M	2				
		N	C	P	3				
		N	C	M	4				
		N	C	P	5				
		N	C	M	6				
		F R N D S	C | C | |	P | M | |	Core Catcher				CC

LITHOLOGIC DESCRIPTION

Greenish gray (5G 6/1) and greenish white (5G 9/1) intervals, semilithified GLAUCONITE-BEARING NANNO CHALK. The core catcher is GLAUCONITE-BEARING MICARB CLAY NANNO CHALK (SS CC). Also noted Sec. 2 (60 cm) PYRITE NODULES (~1 cm); Sec. 3 (59-87 cm) incipient CHERT lithified; in Sec. 4 below 140 cm the core grades to lithified induration, with approximately 2% PYRITE (<1/2 mm); and PYRITE NODULES (~1 cm) in Sec. 5 (69 and 101 cm).

SS CC
CM -40%
G - 5%
M -25%
N -30%

X-ray 4-112 (Bulk)
Calc - M
Quar - TR
Cris - P
Trid - TR
Clin - P

Carbon Carbonate 4-112 (9.2, 0.1, 76)

Site 277 Hole Core 46 Cored Interval: 463.0-472.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
MIDDLE PALEOCENE	G. (S.) trilocul inoides				1	0.5			
						1.0	VOID		
		N	C	P	2				
		N	C	P	3				
		F	R	P	4				
		N	C	M					
		R N D S	C | | |	P | | |	Core Catcher				

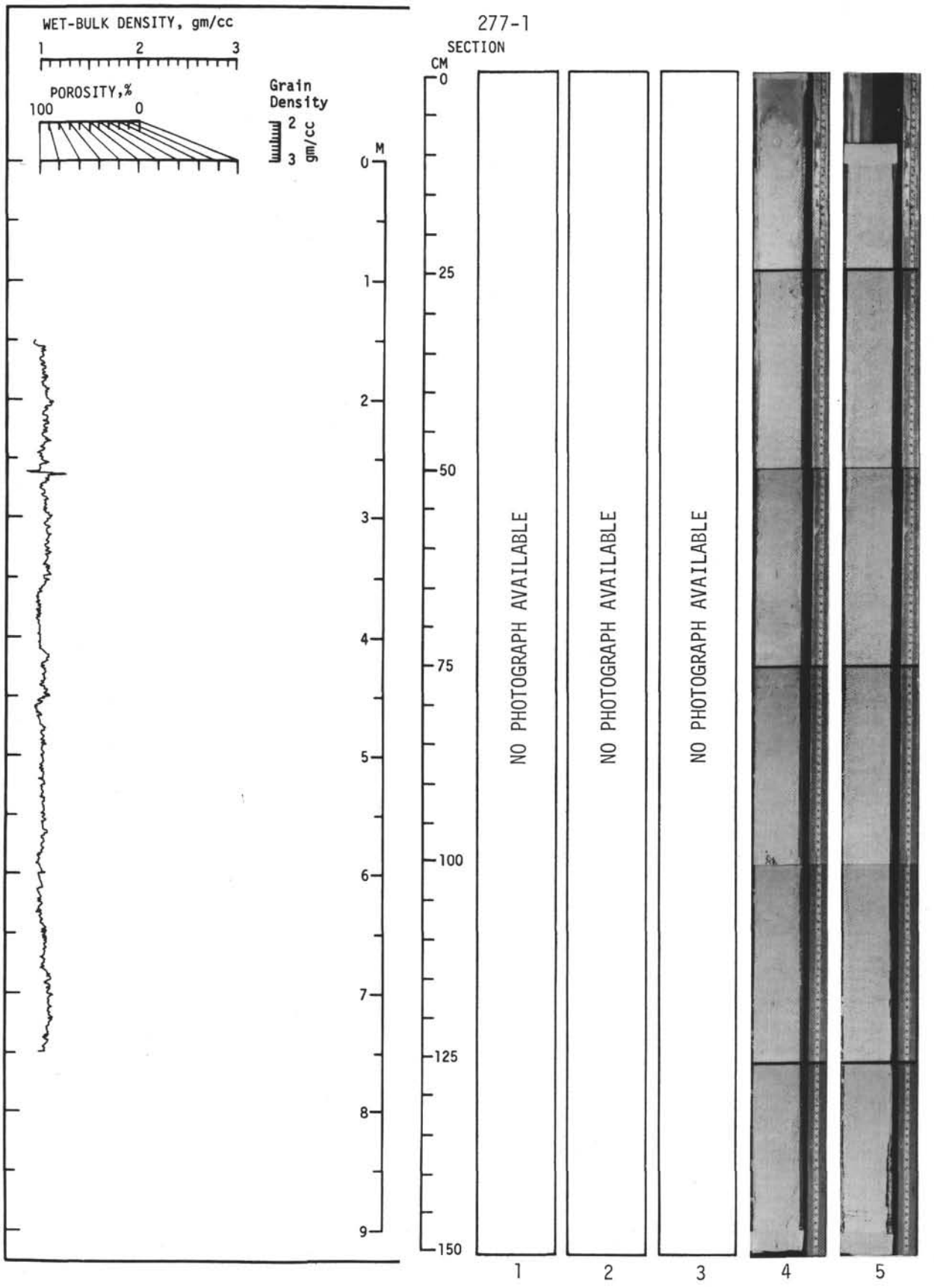
LITHOLOGIC DESCRIPTION

Greenish white (5G 9/1) to light greenish gray (5G 7/1) CLAY-RICH NANNO CHALK with moderate to intense light gray (5Y 7/1) mottling throughout. PYRITE crystals and nodules evident in some places. In Sec. 4 (35-57 cm and 96-141 cm) same color as rest of core, but cherty and lithified, with larger mottles.

X-ray 2-85 (Bulk)
Calc - M
Quar - TR
Cris - P
Mont - TR
Trid - TR

Carbon Carbonate 2-84 (10.1, 0.1, 84)

Explanatory notes in Chapter 1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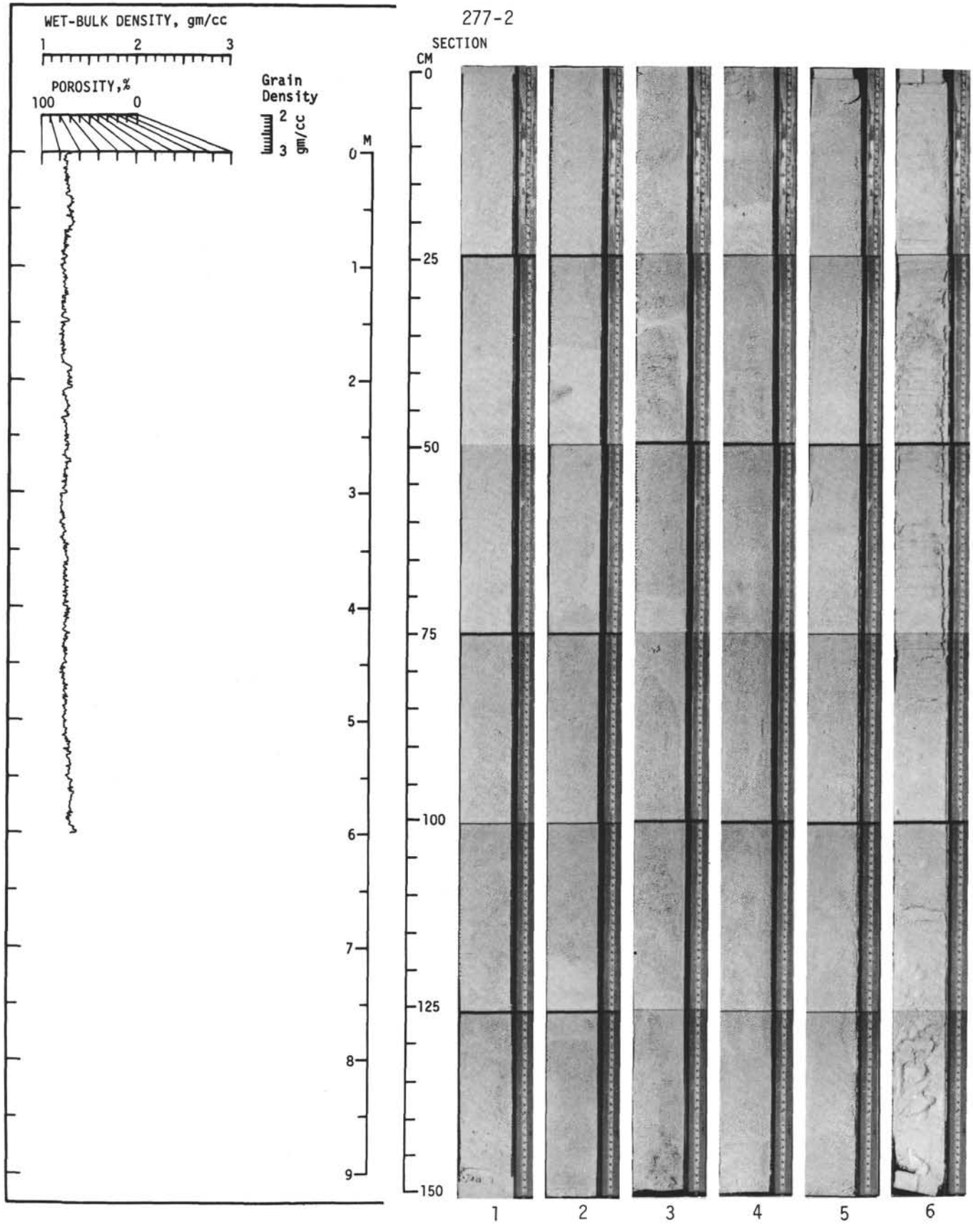
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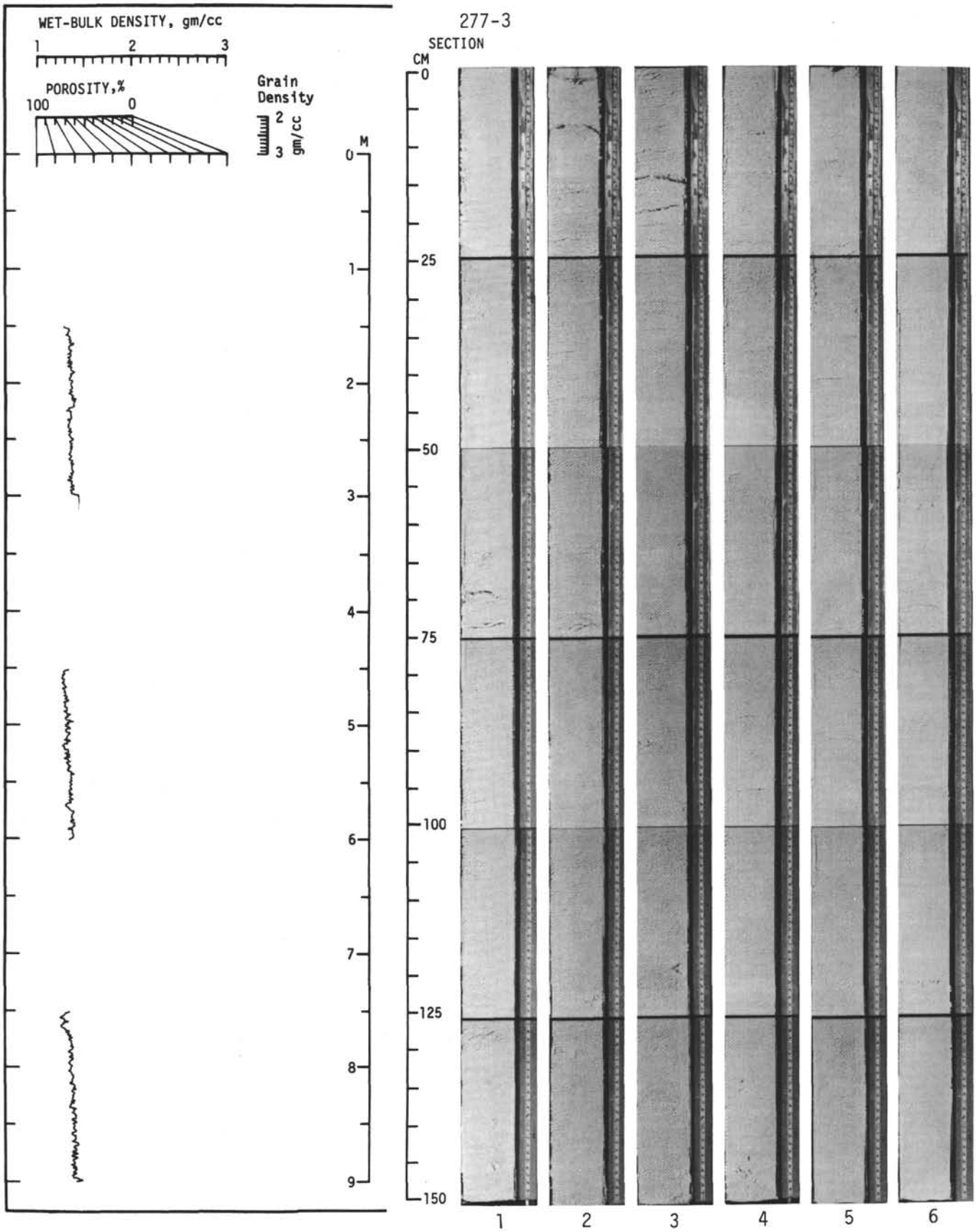
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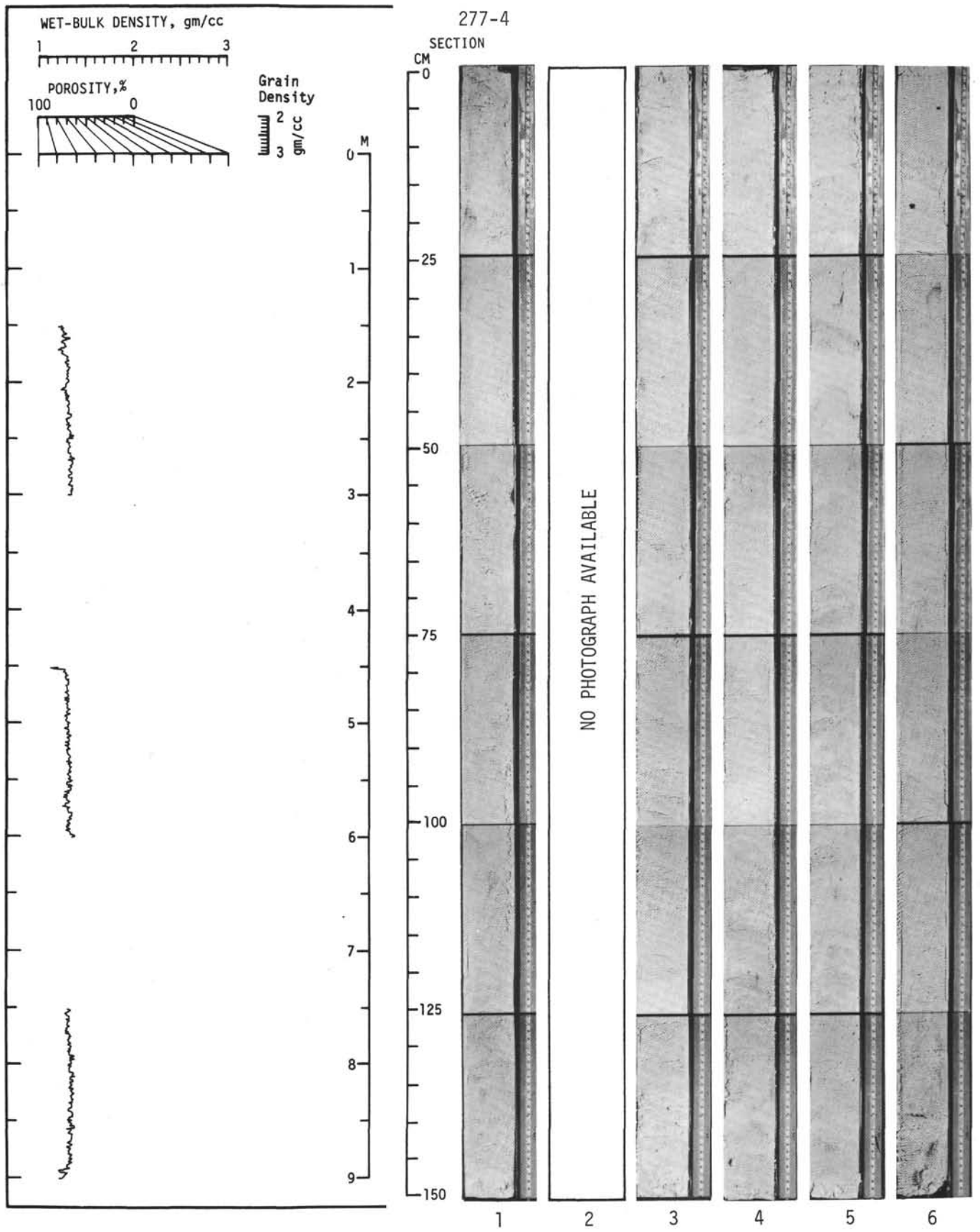
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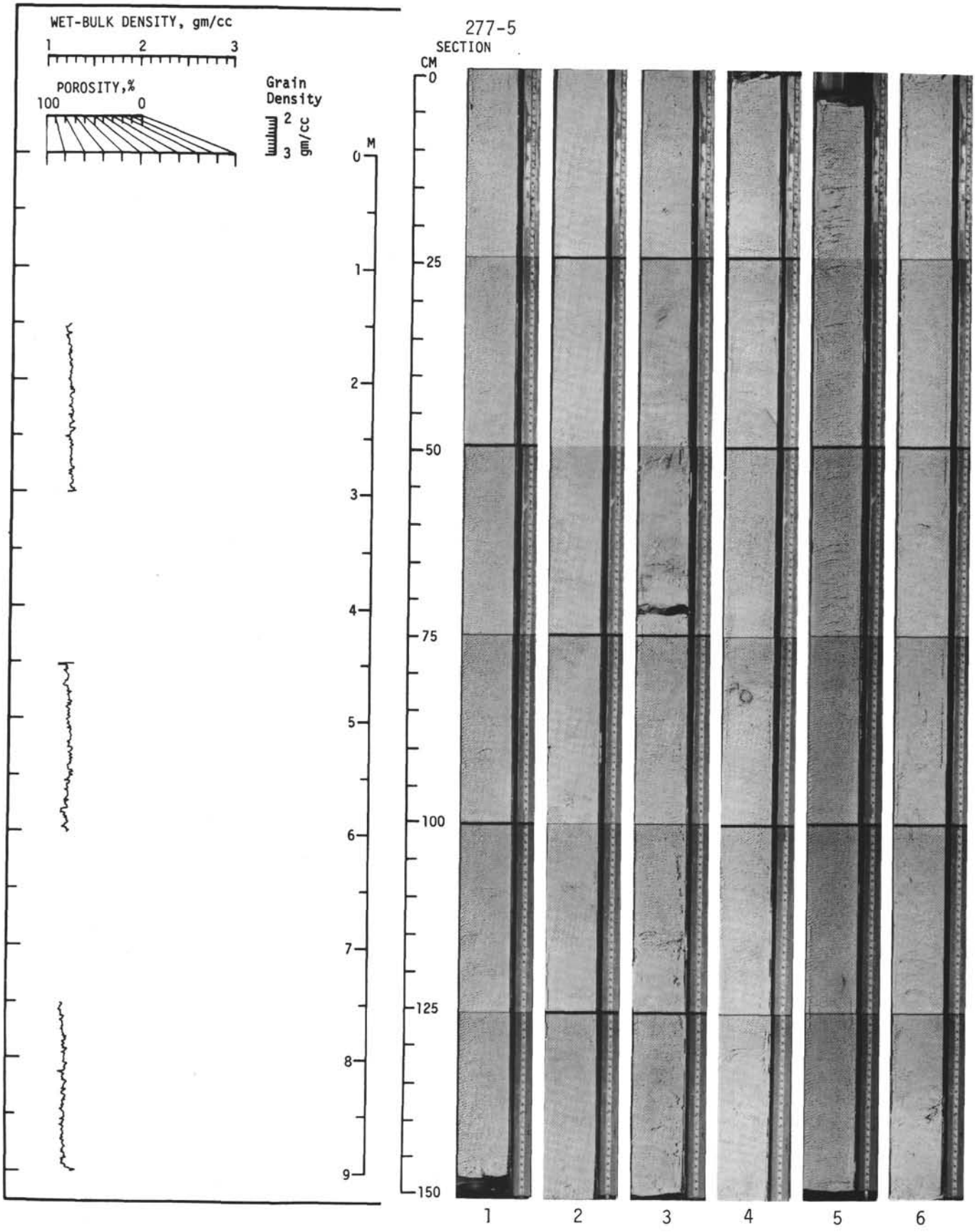
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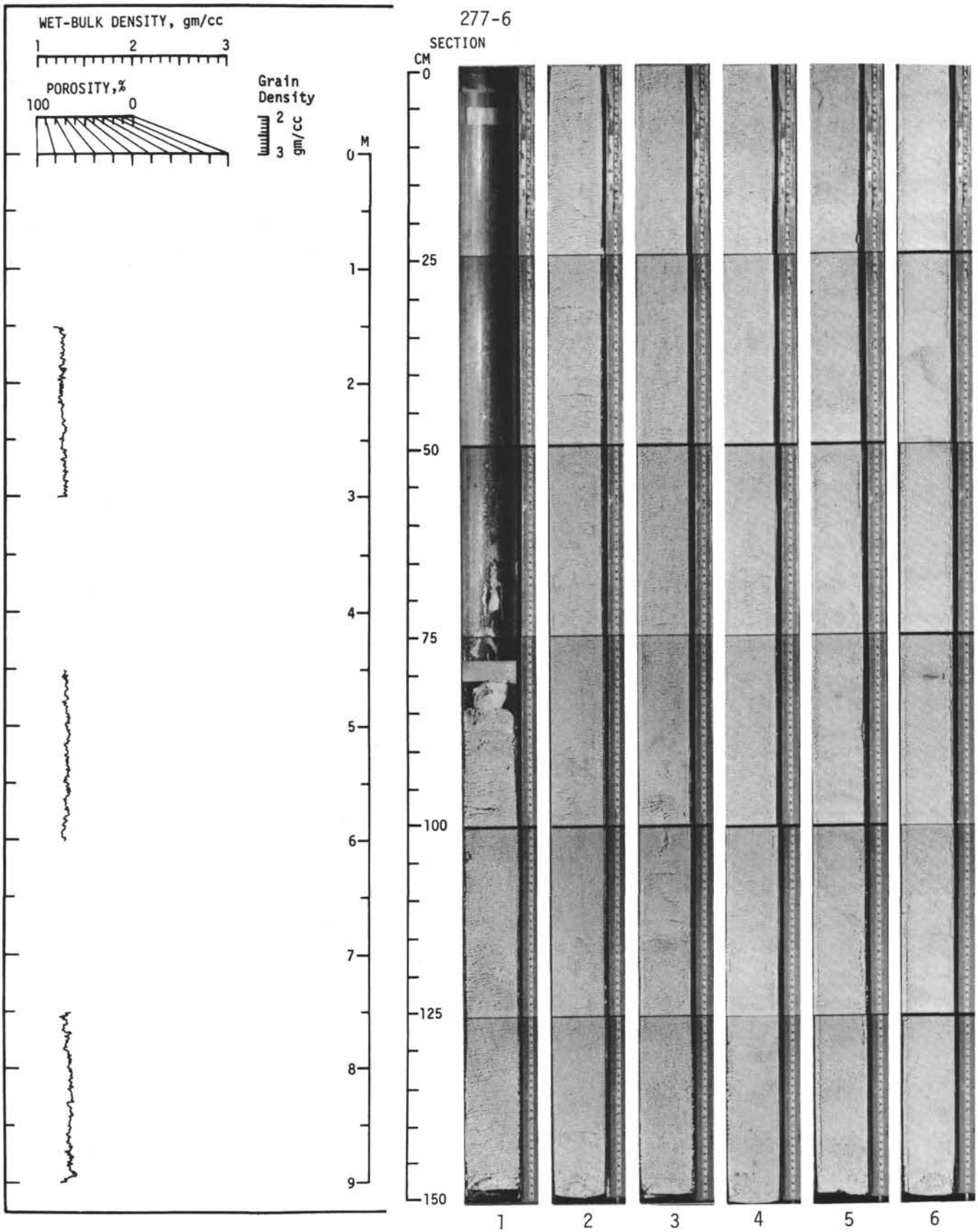
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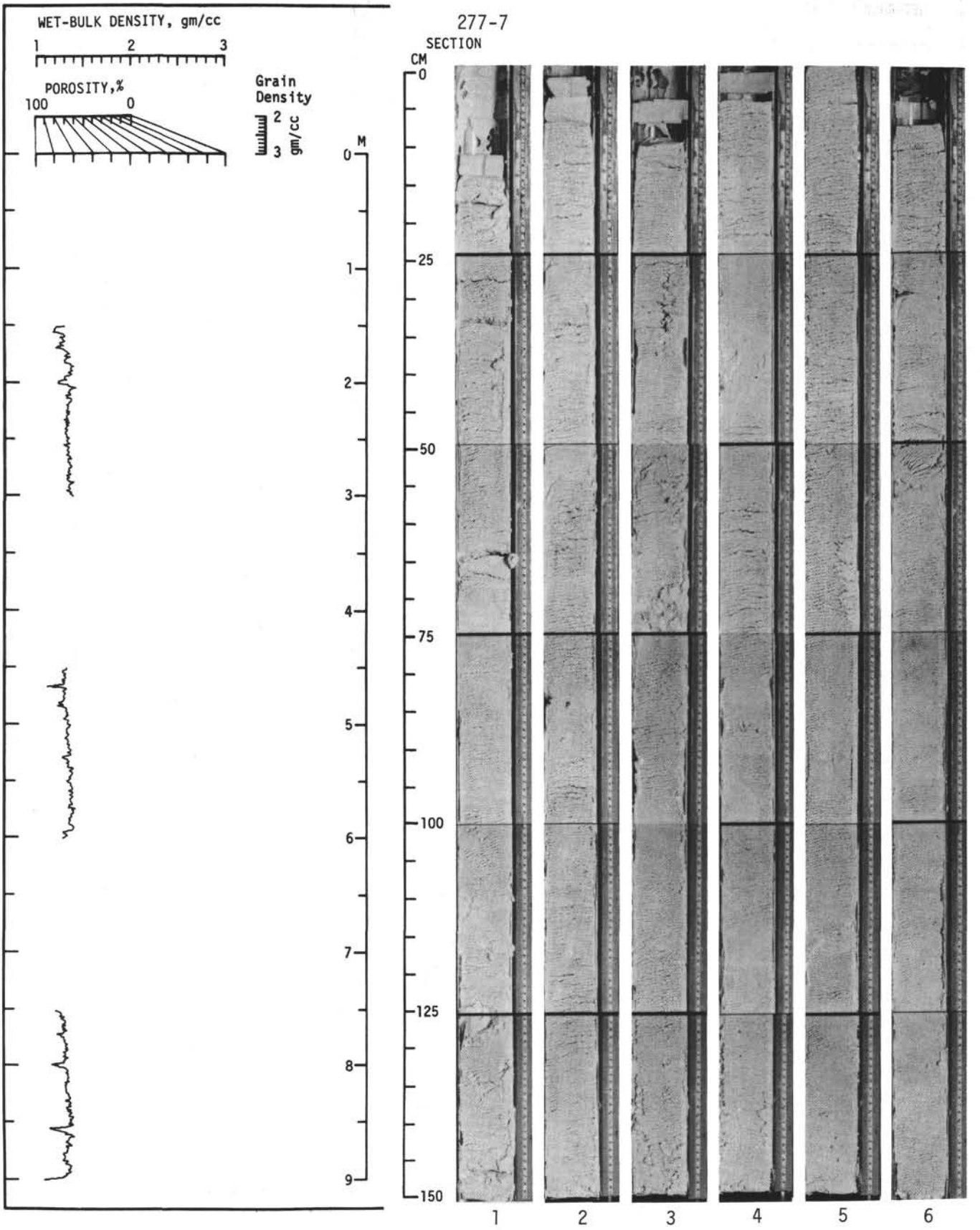
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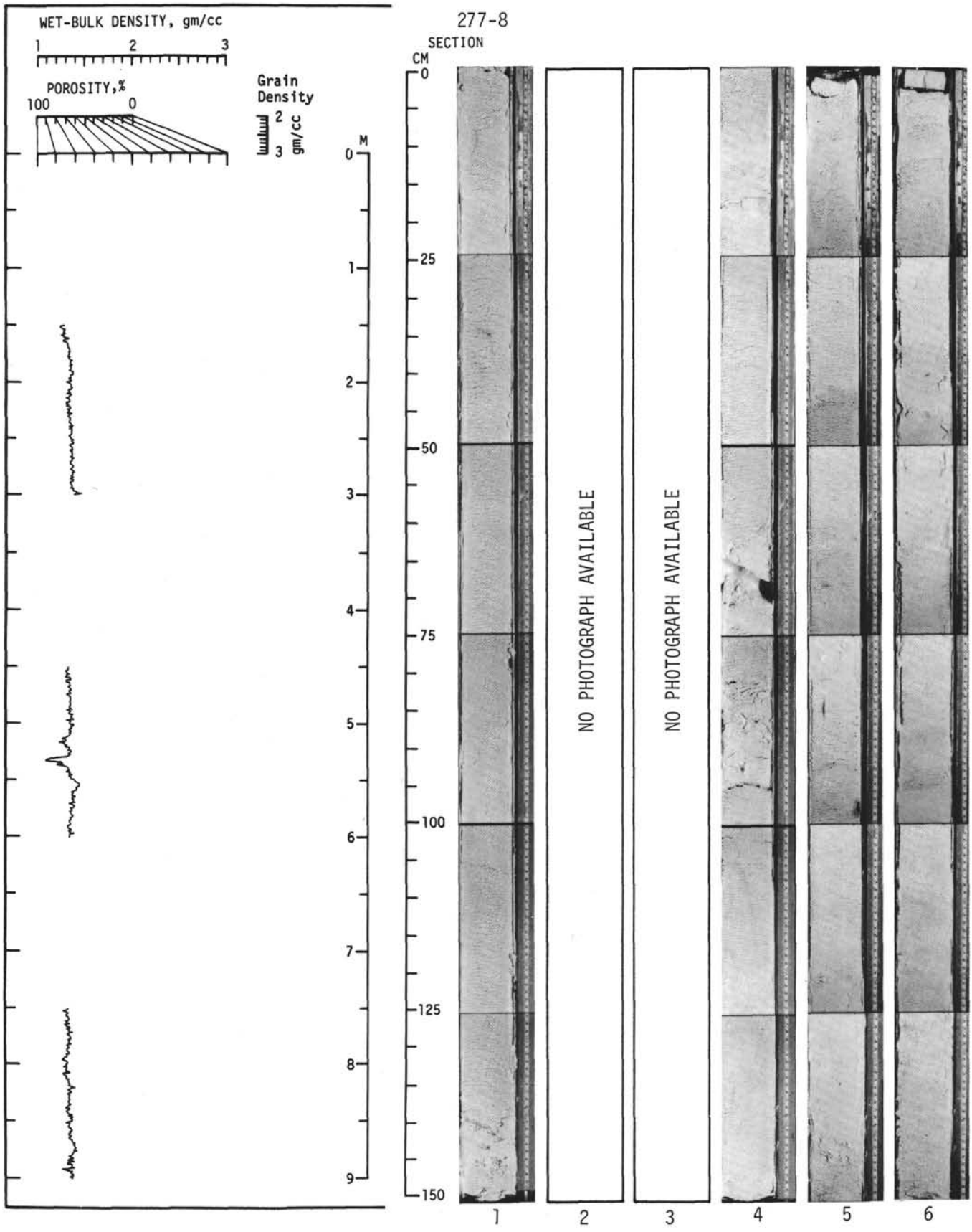
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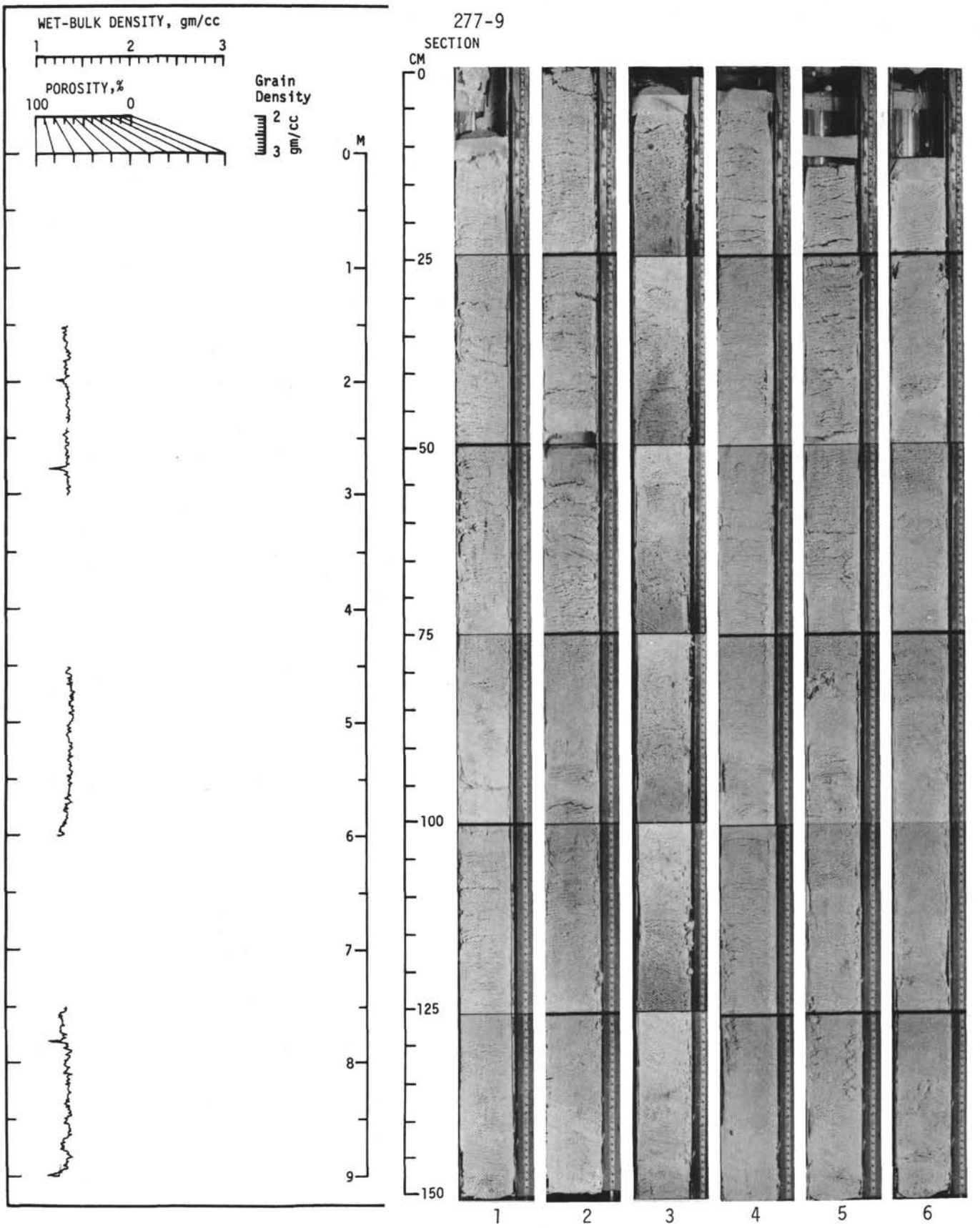
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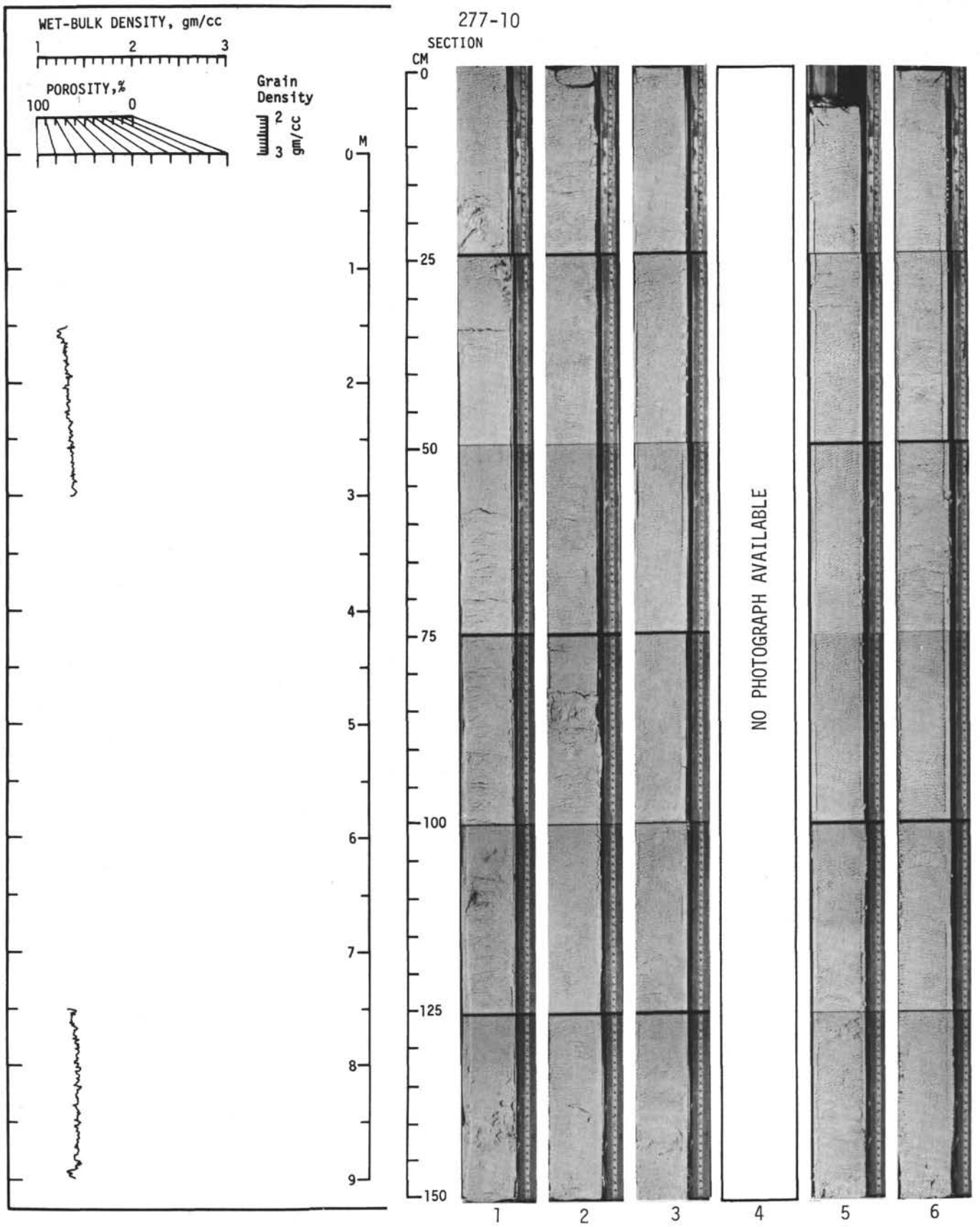
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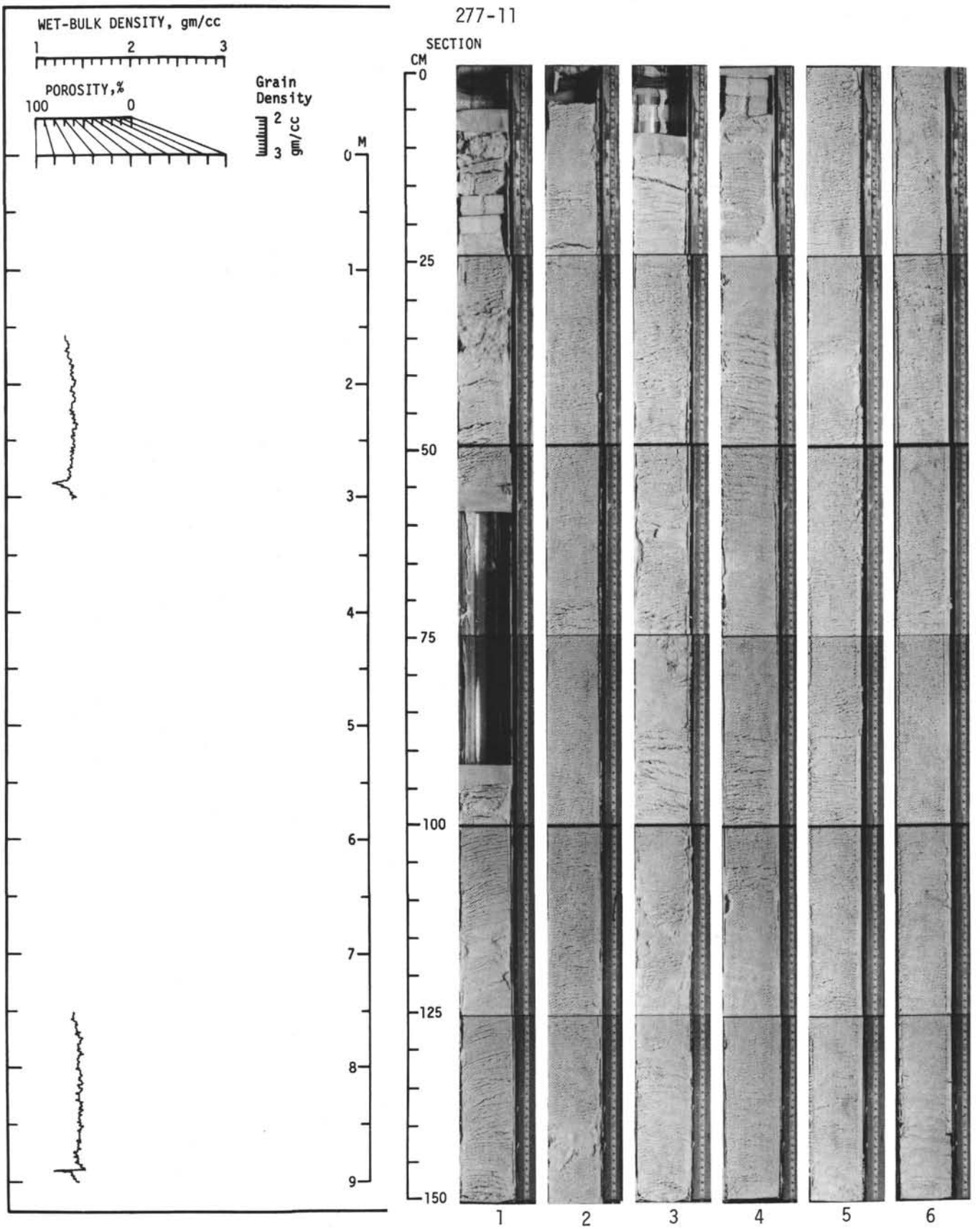
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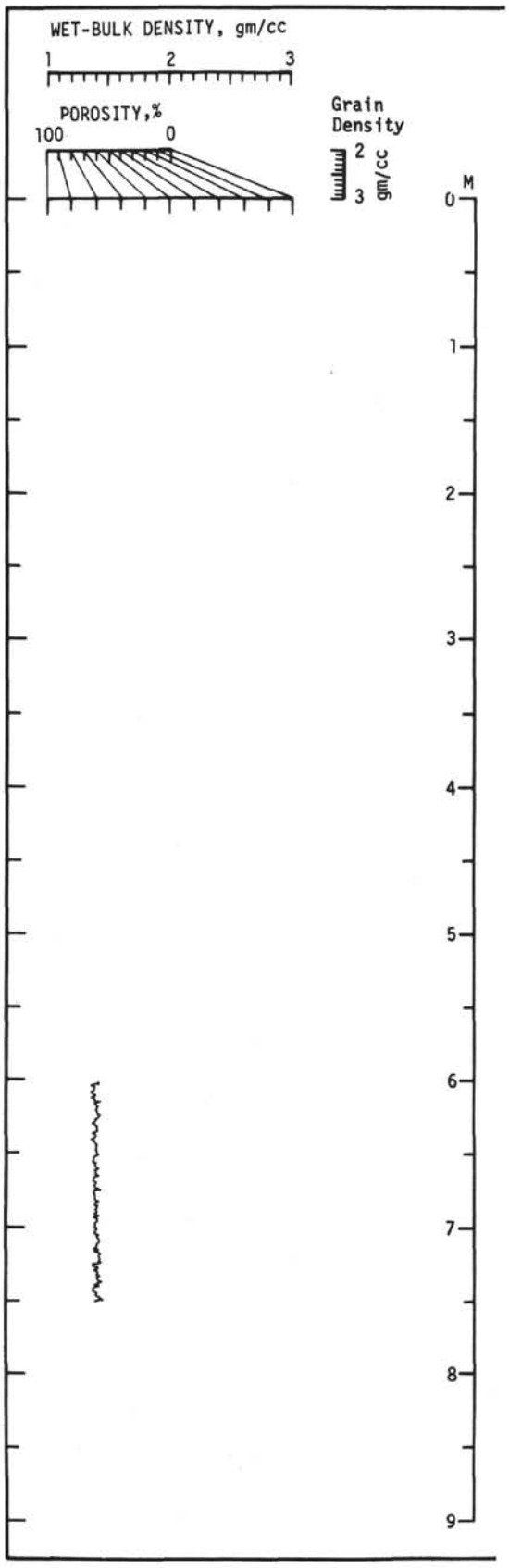
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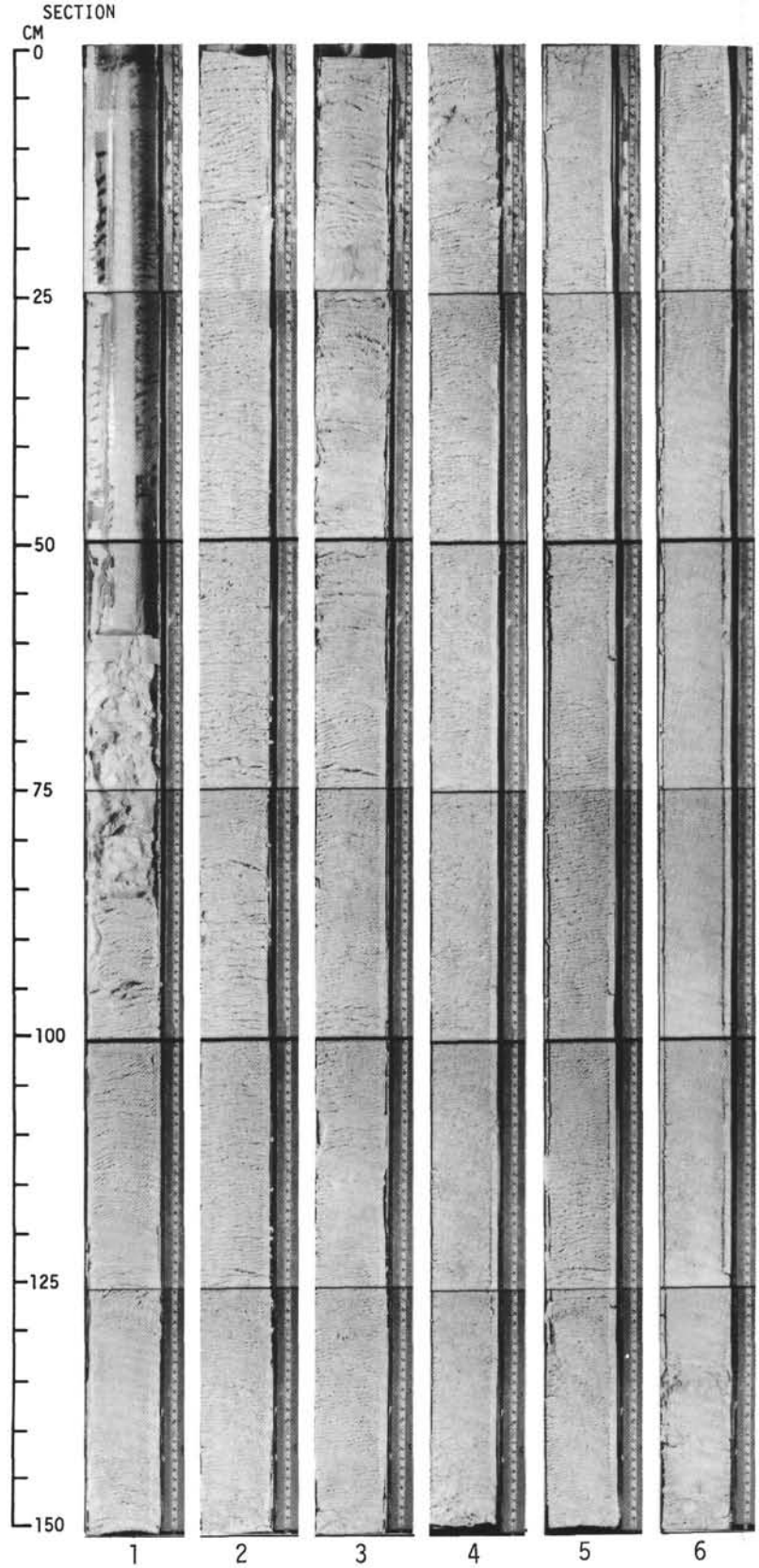
277-12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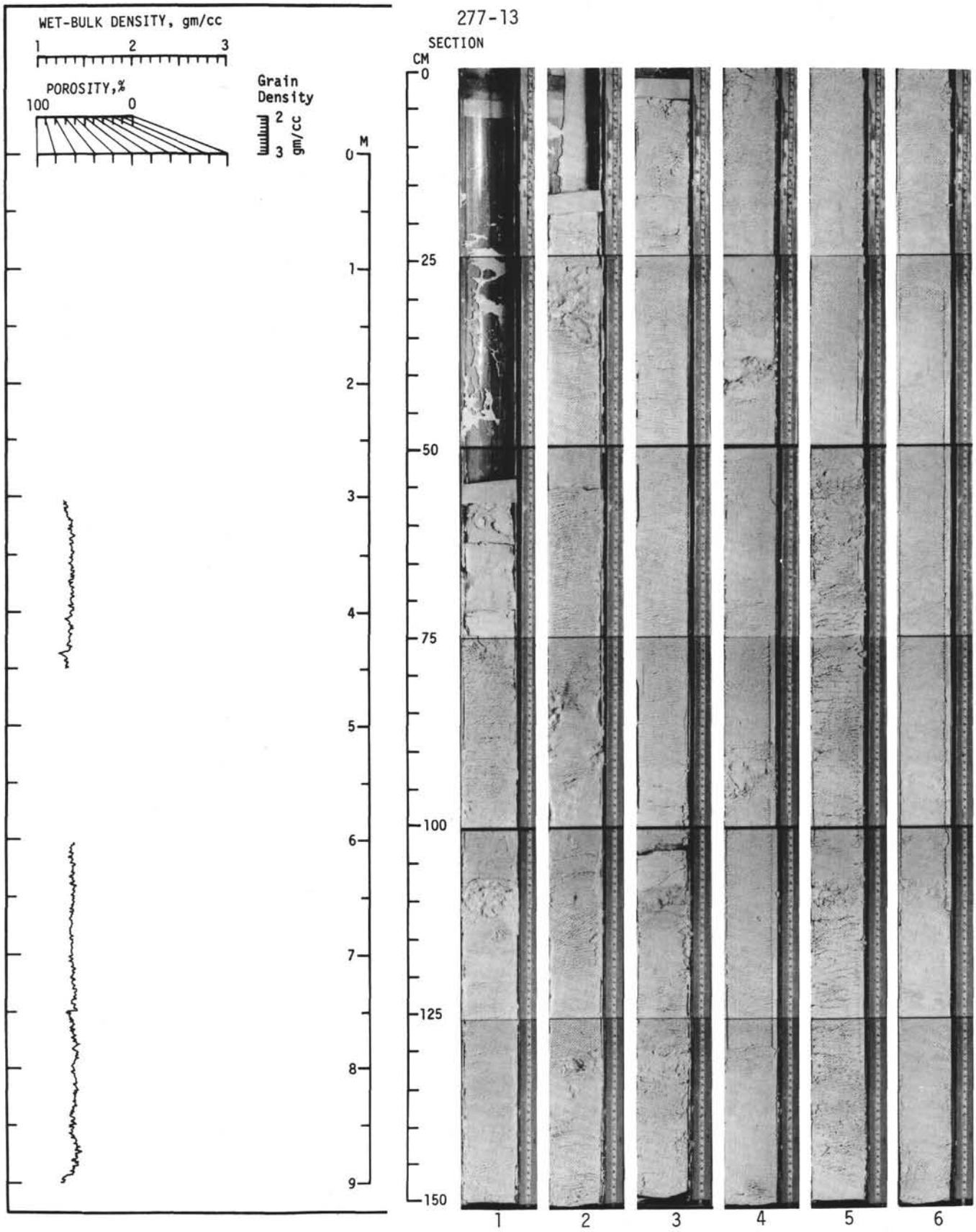
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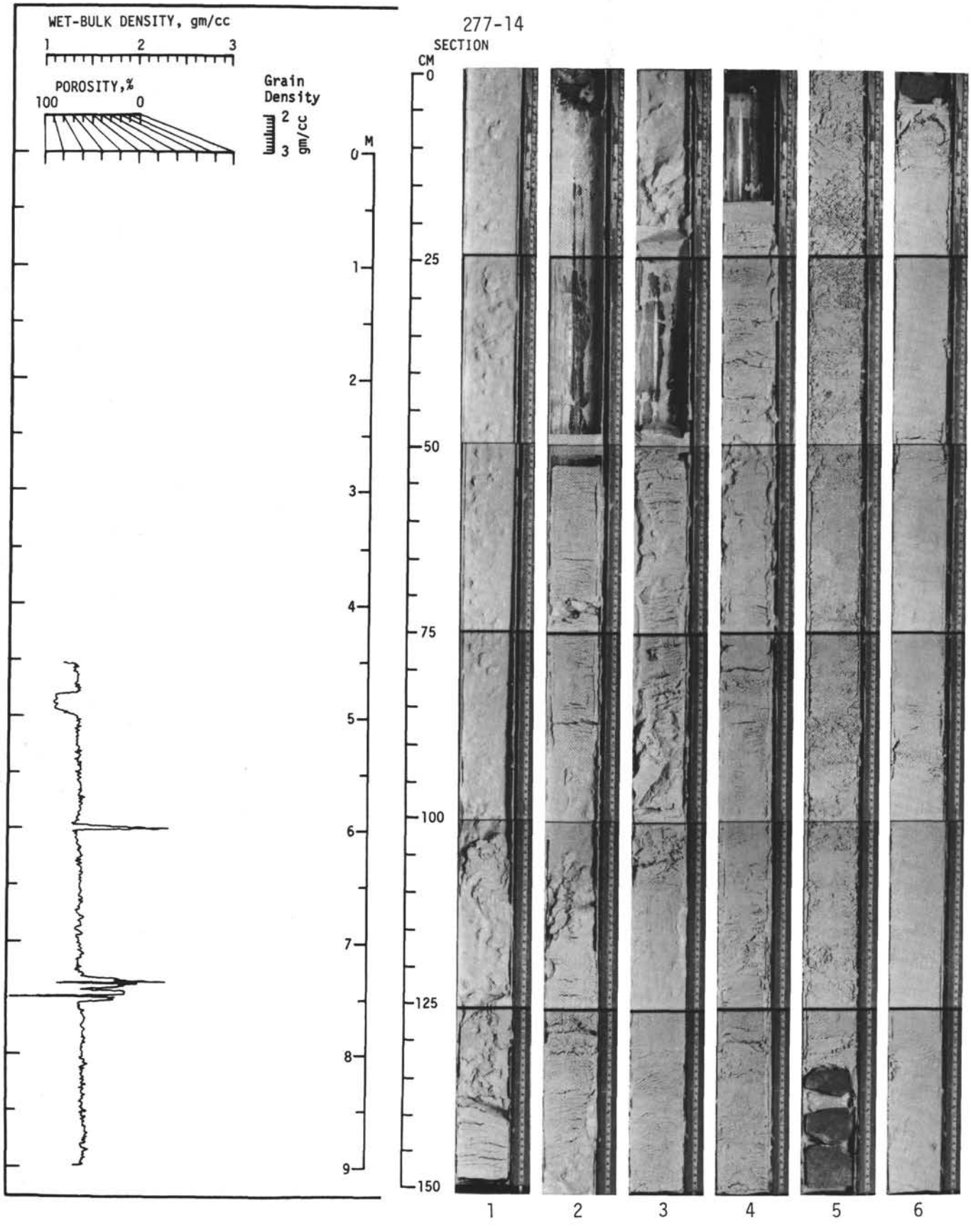
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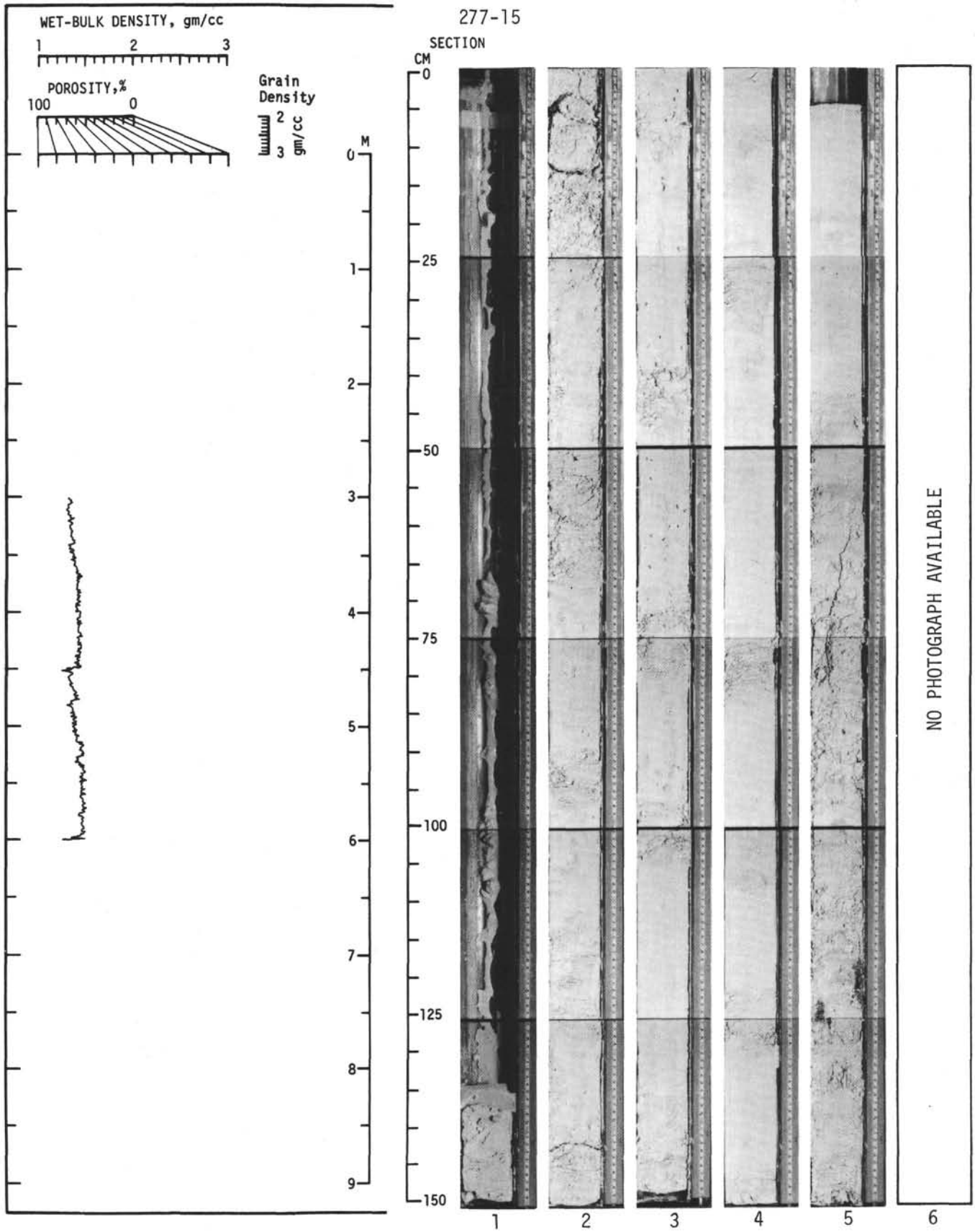
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gm/cc
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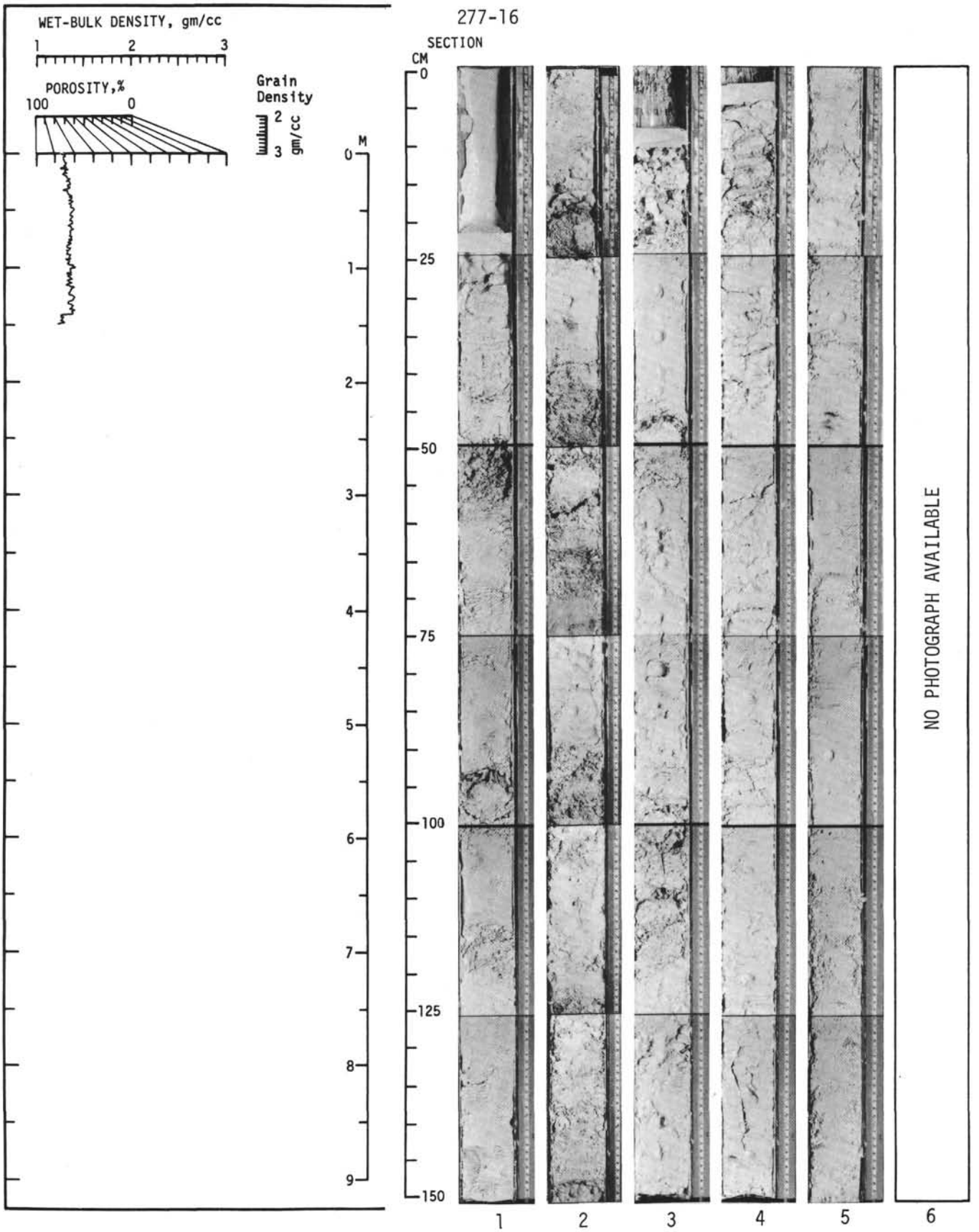
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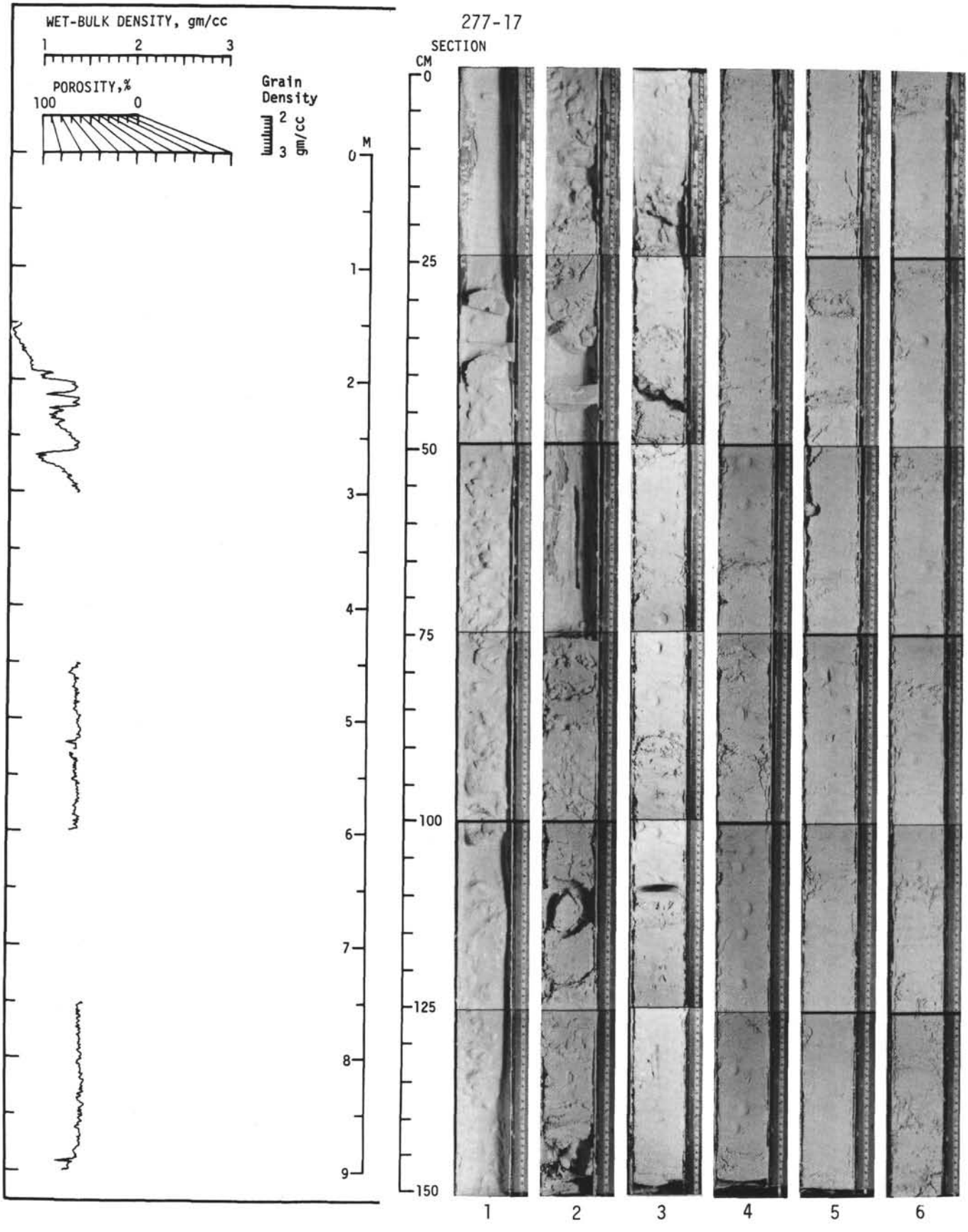
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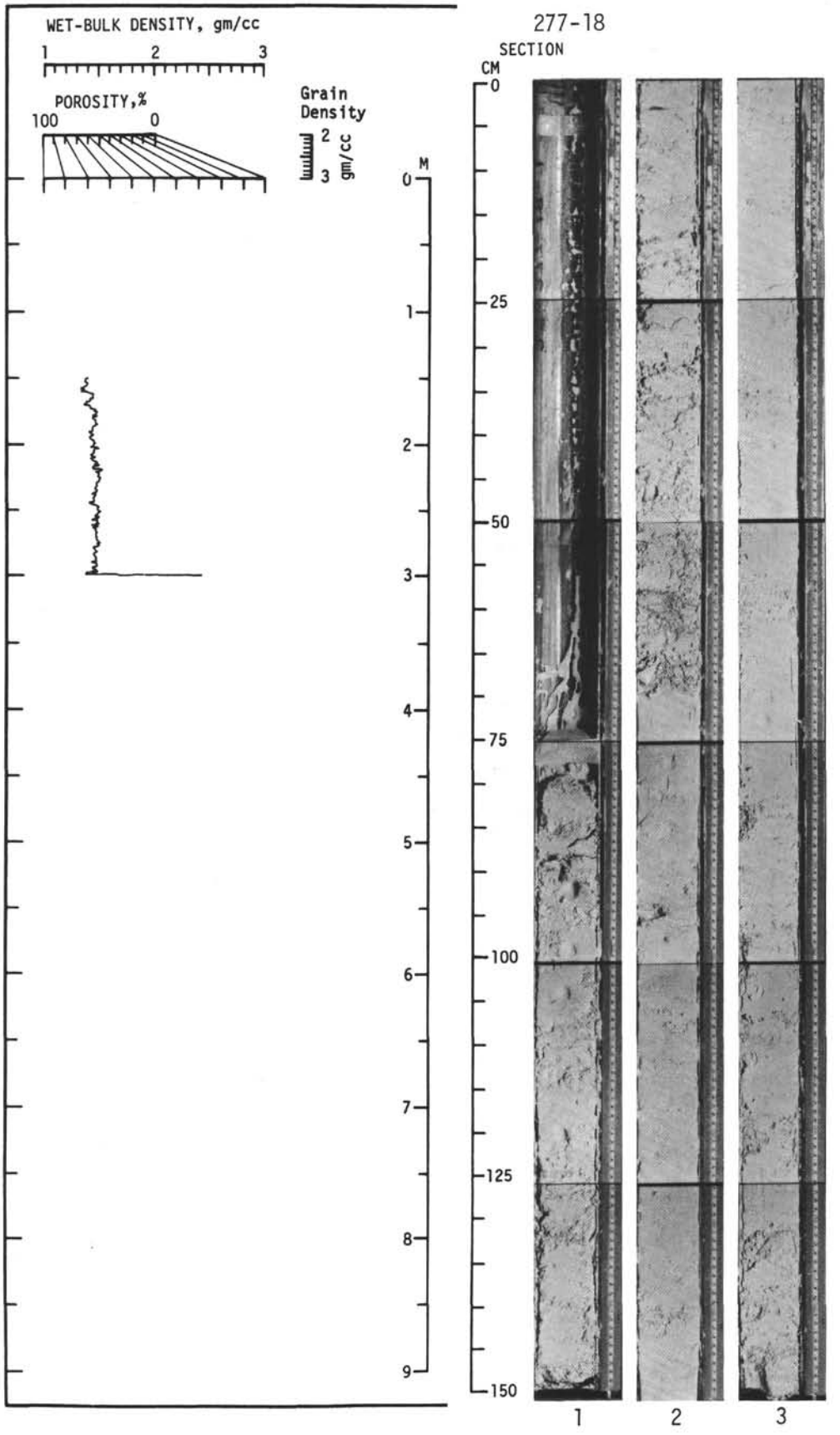
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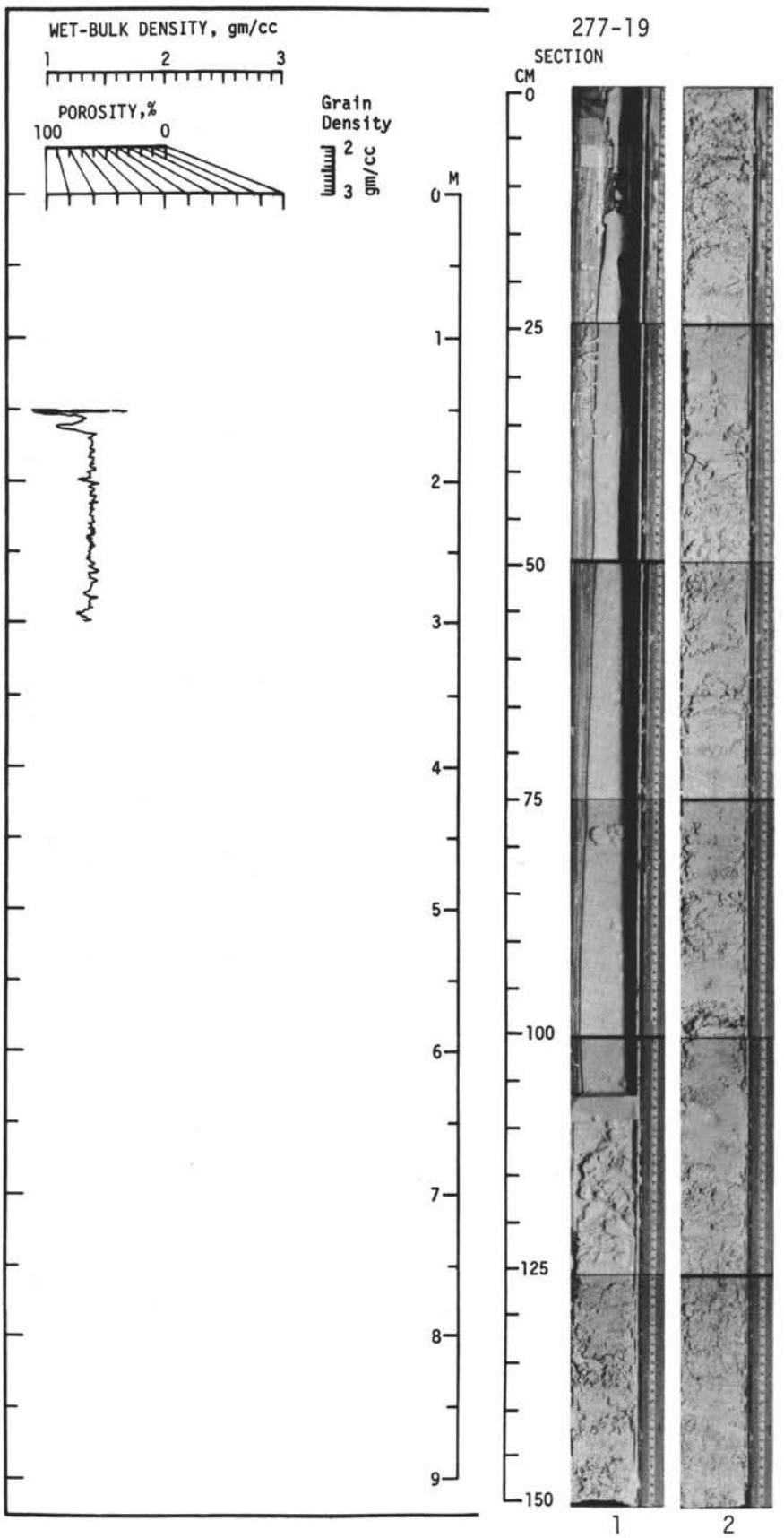
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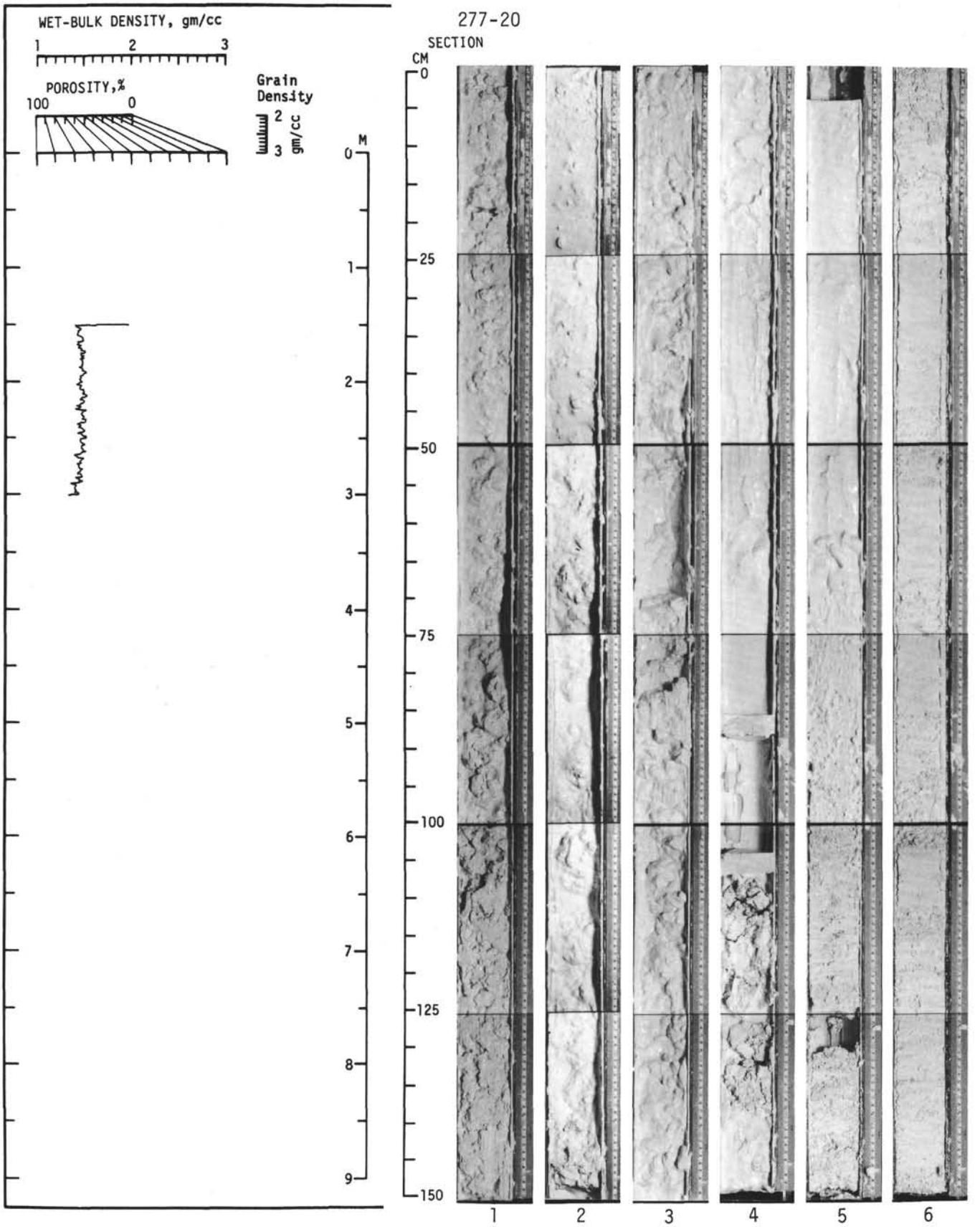
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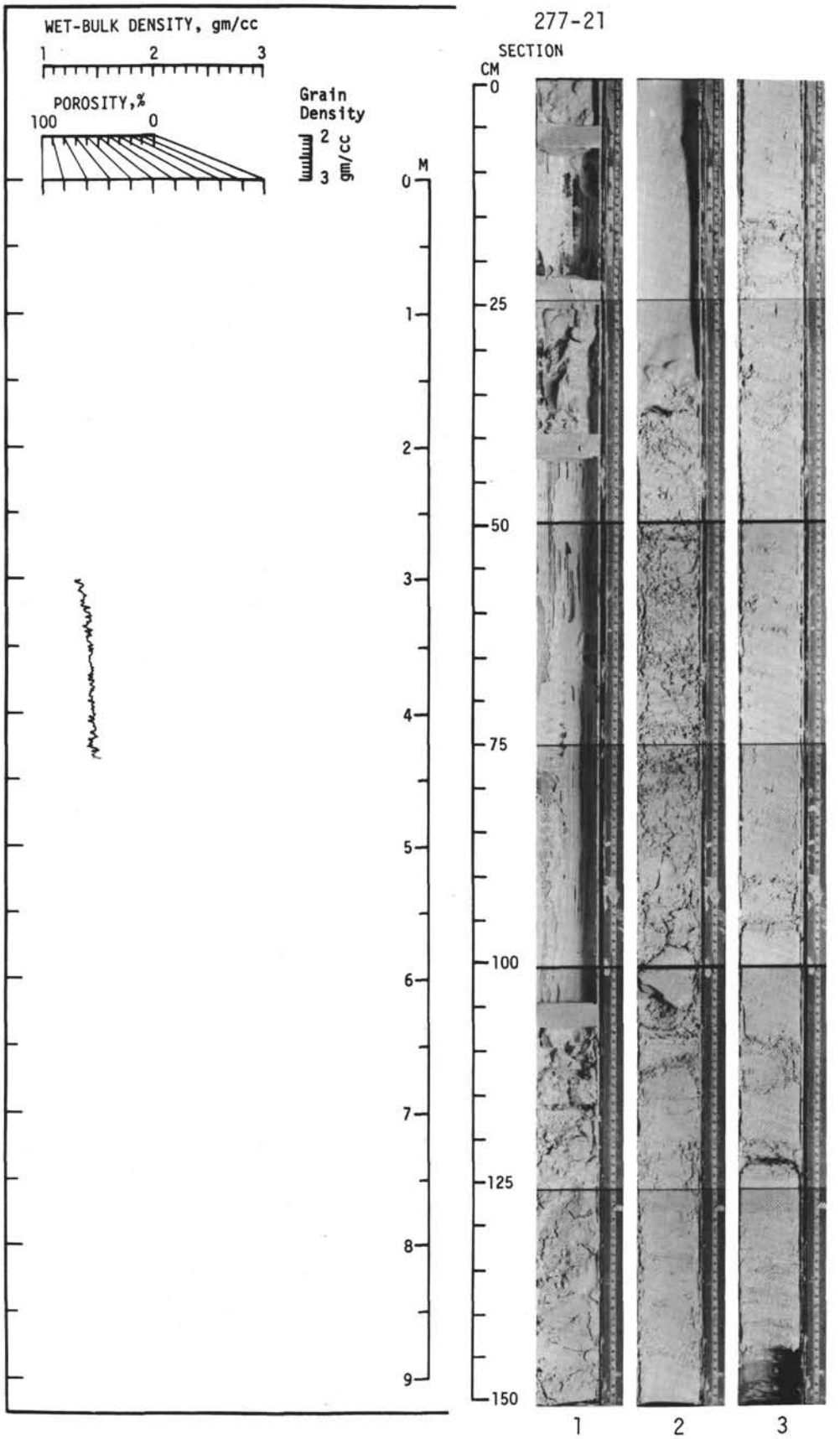
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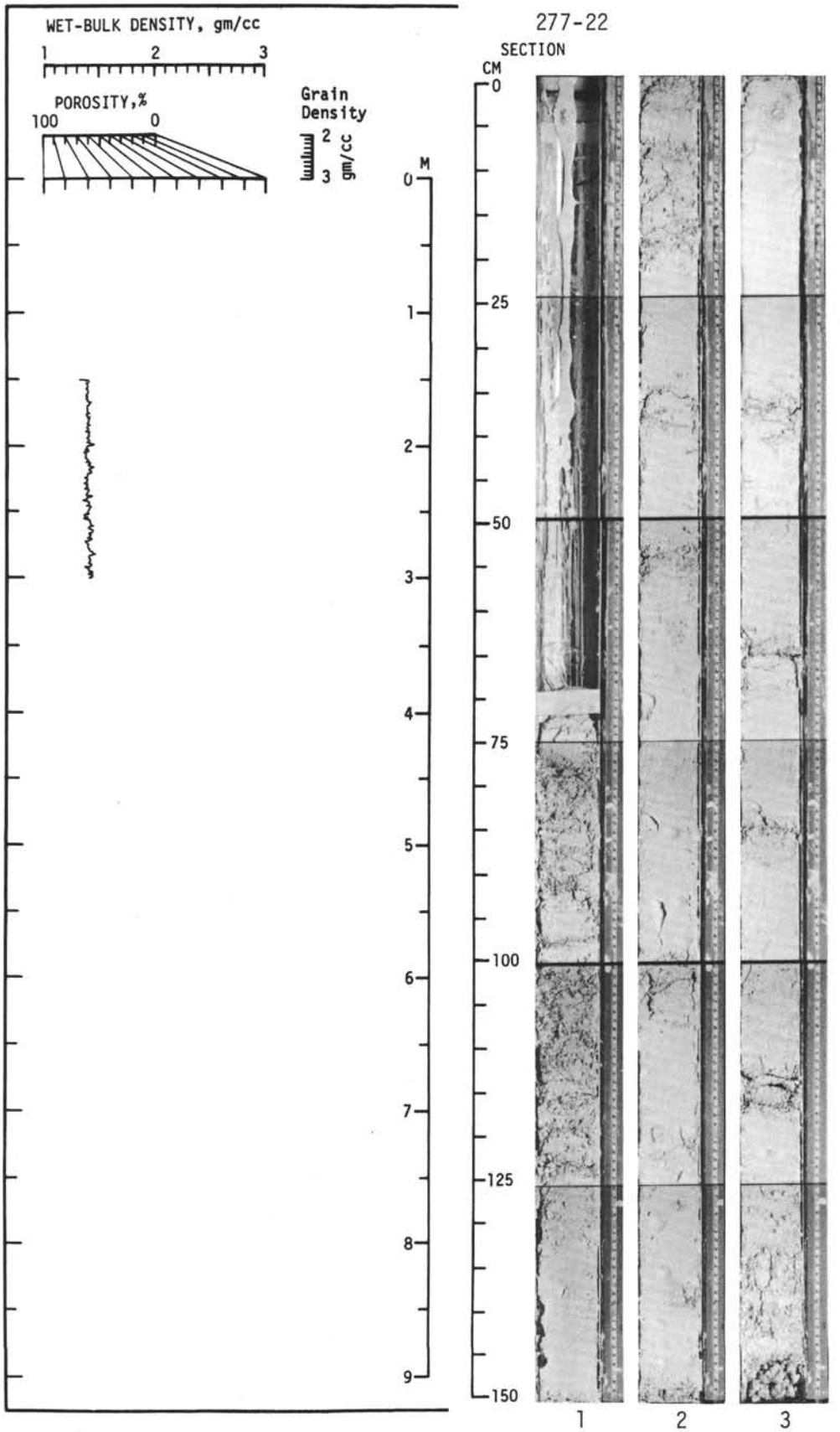
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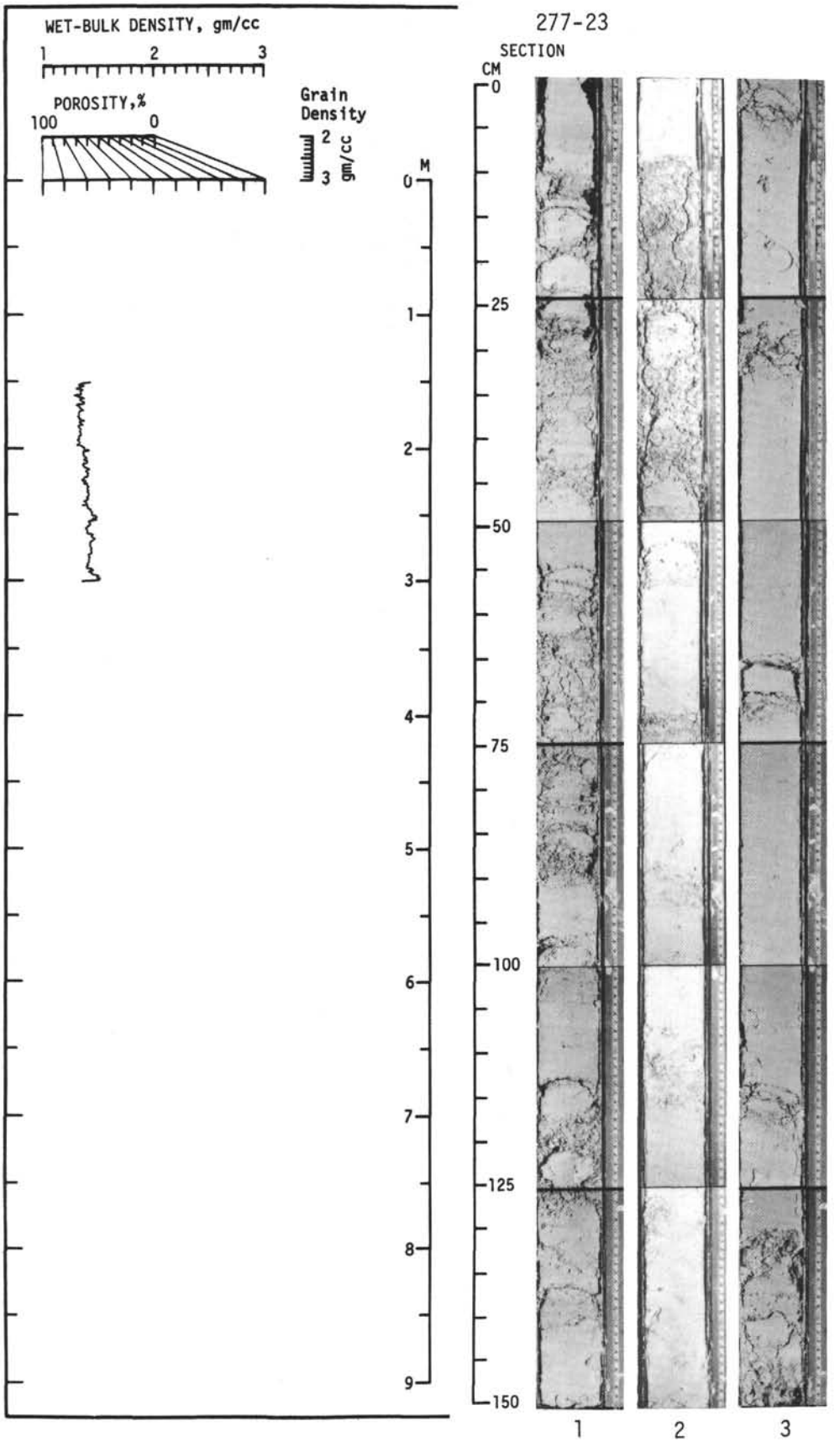
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gm/cc
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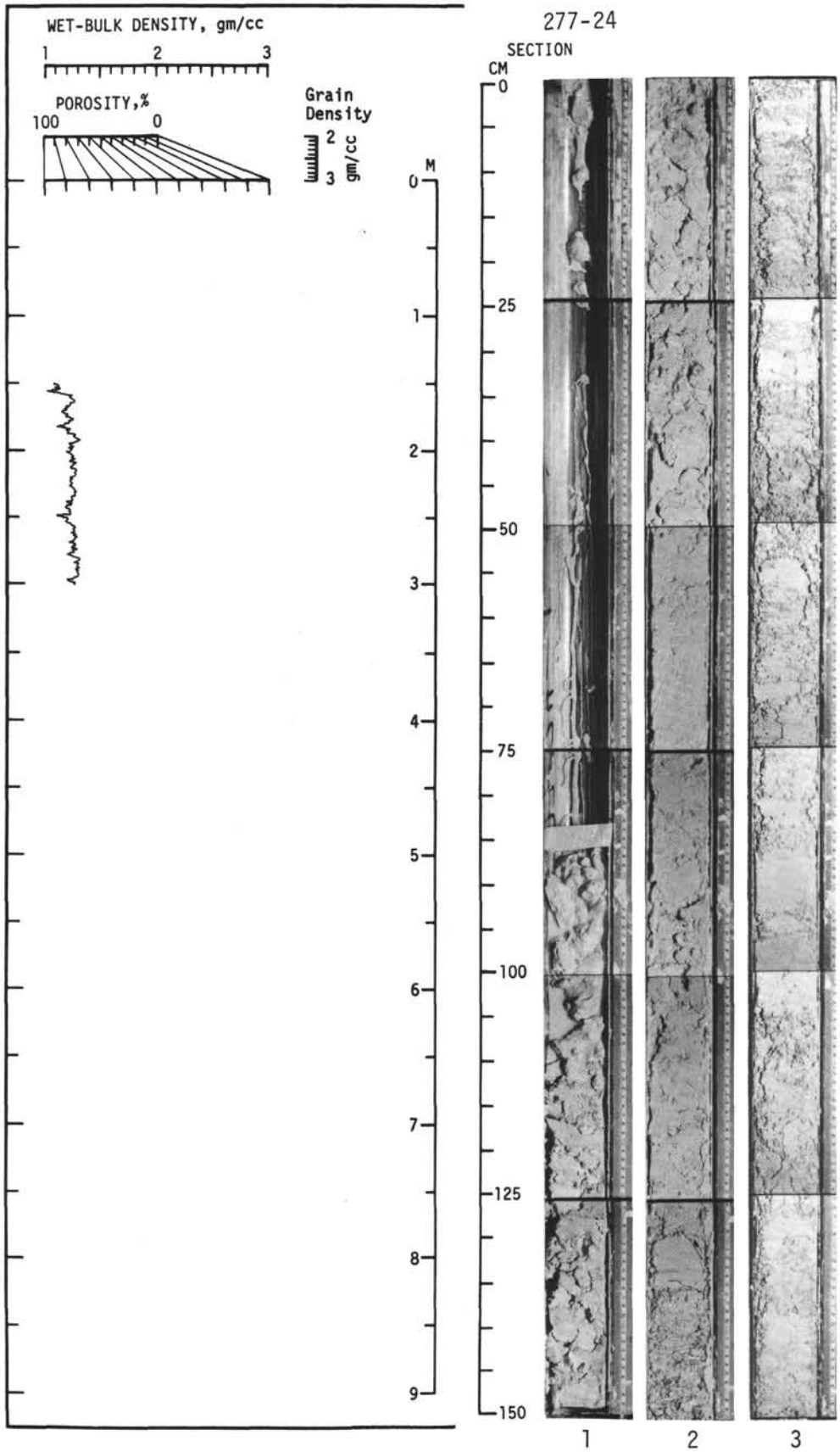
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gm/cc
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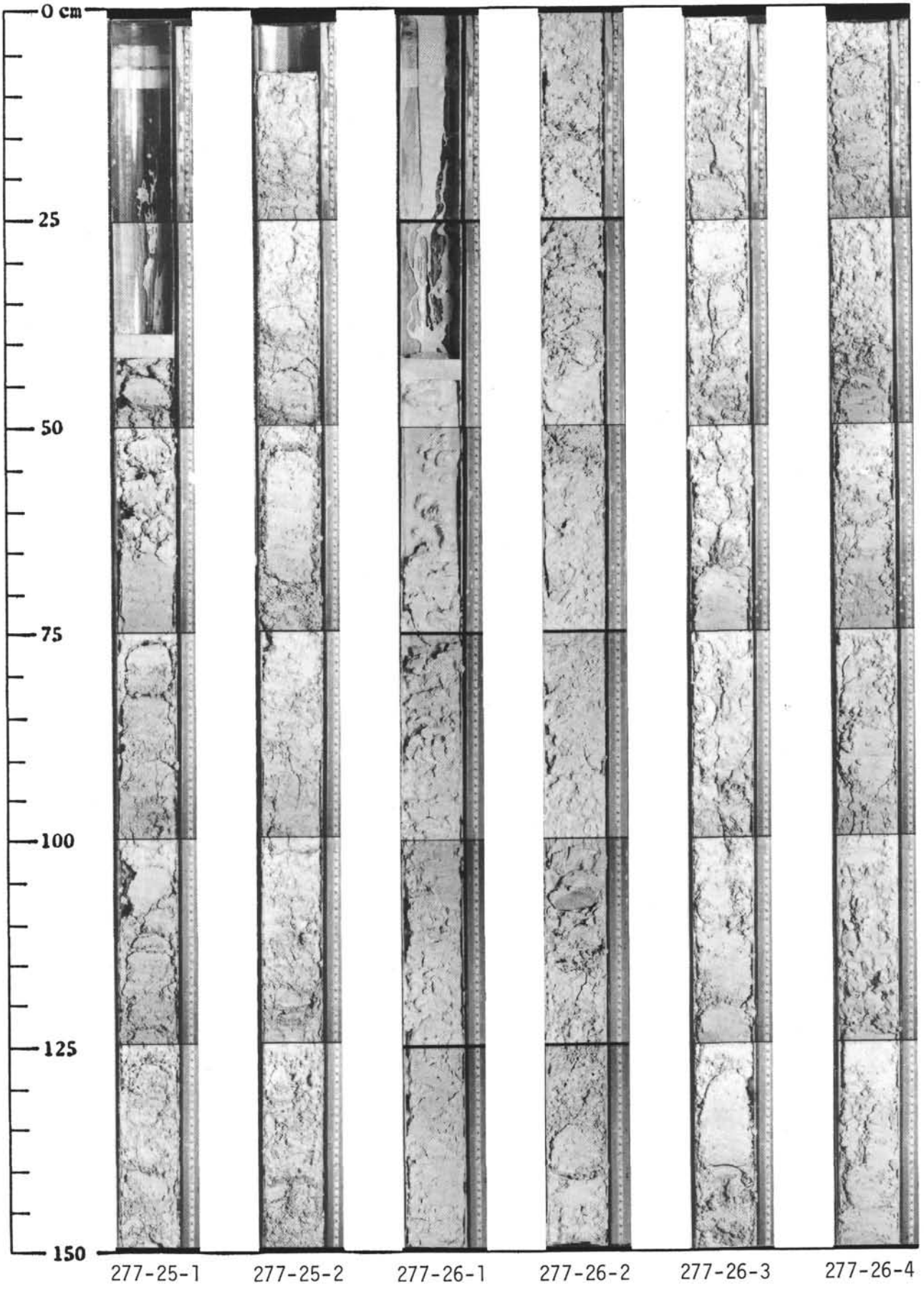
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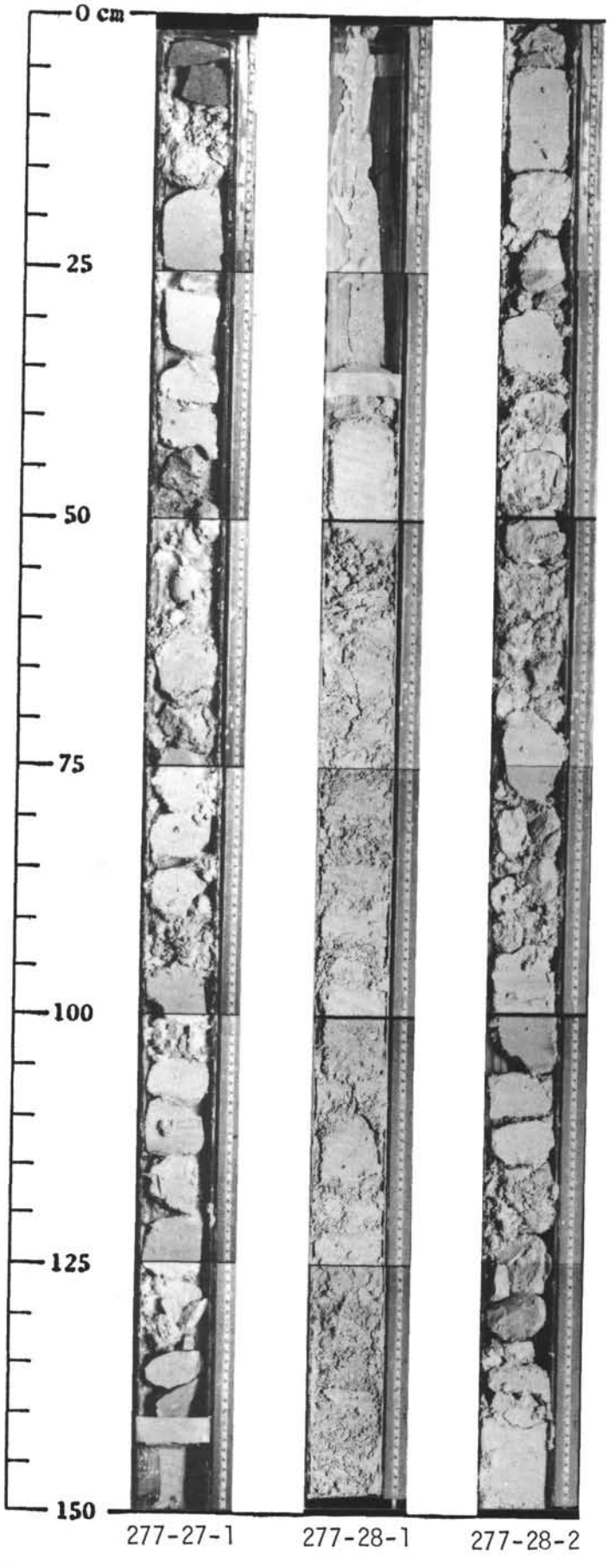
277-25-2
277-26-1
277-26-2
277-26-3
277-26-4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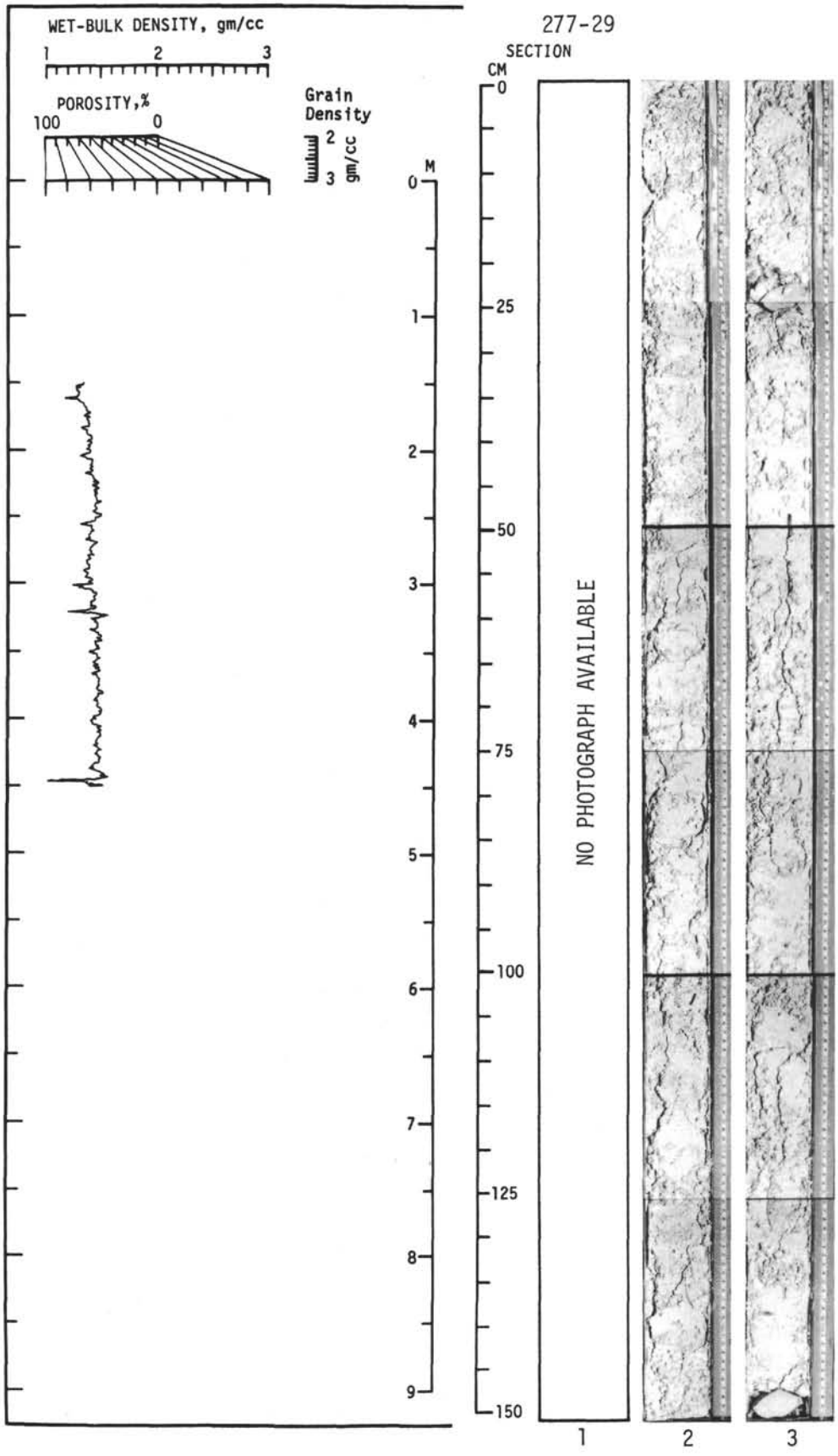
277-28-2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Grain Density
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gm/cc
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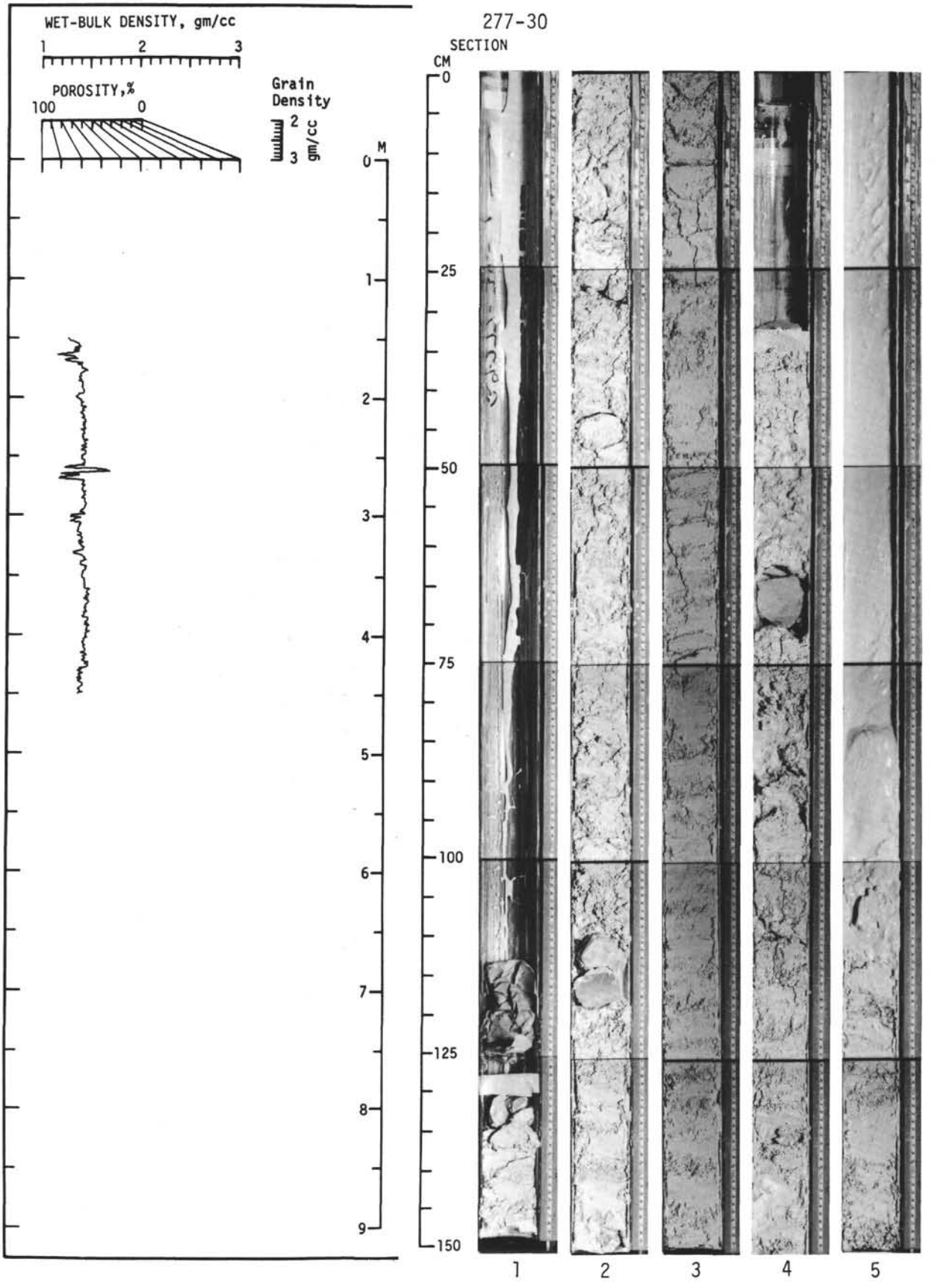
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gm/cc
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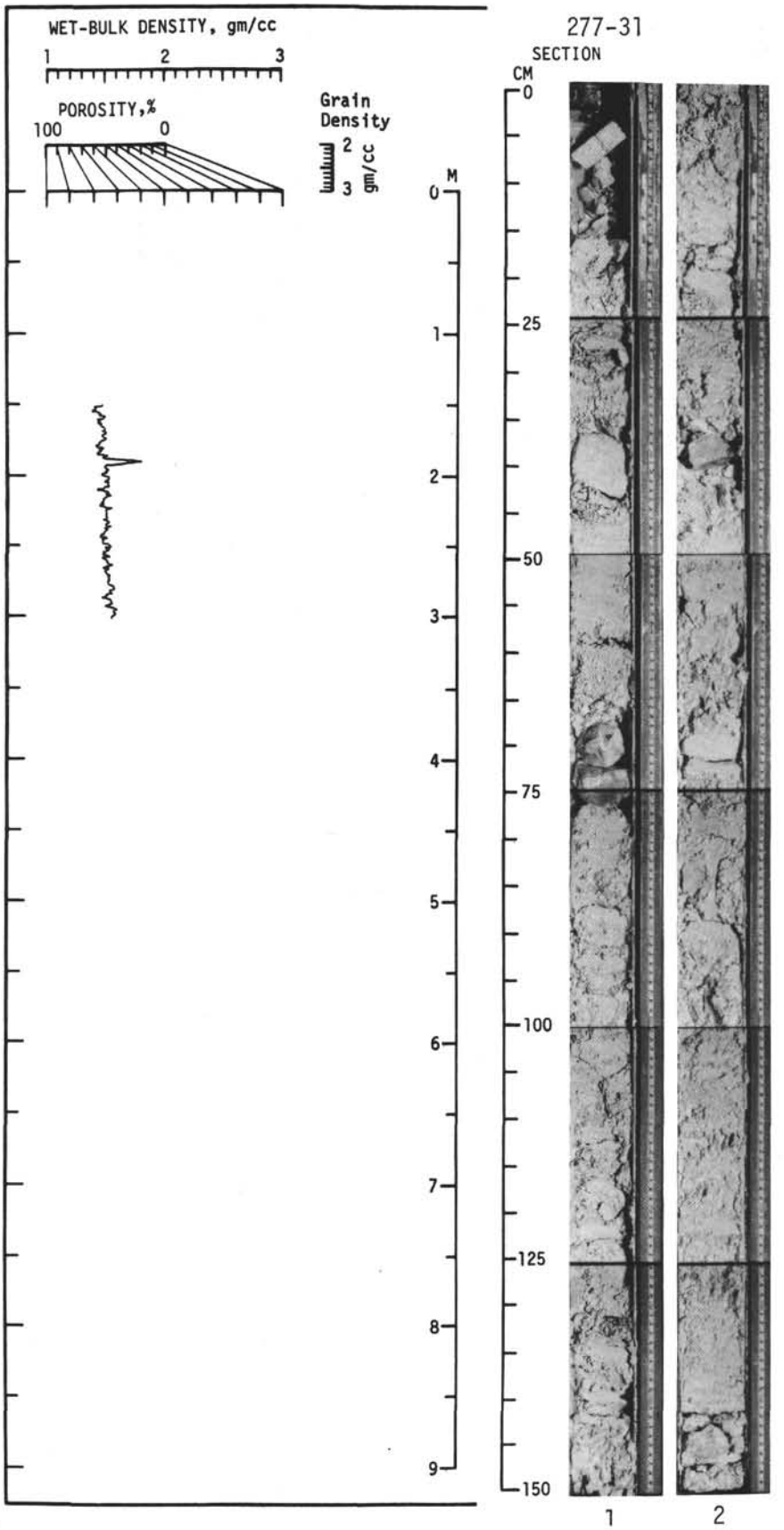
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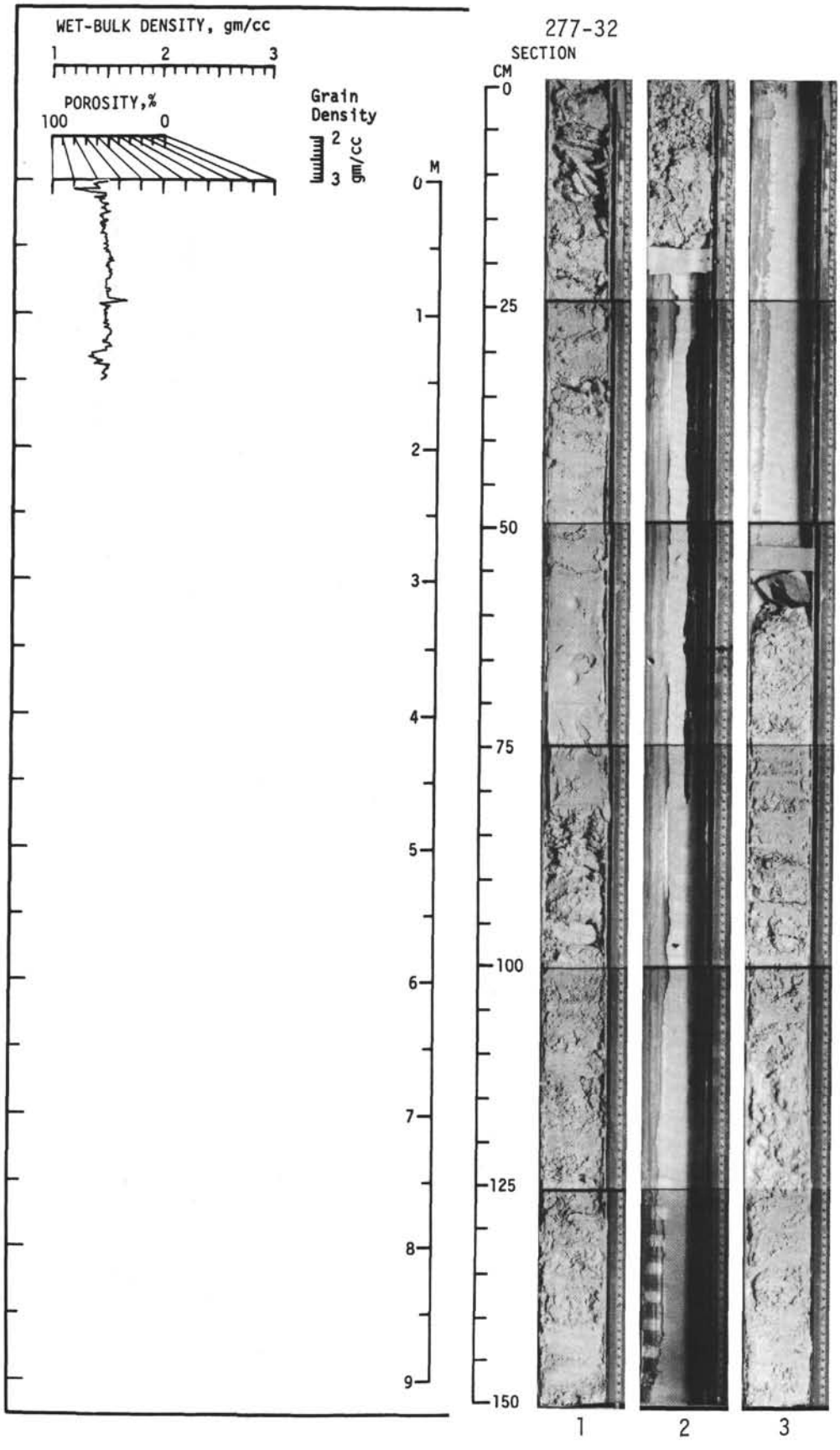
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POROSITY,%
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gm/cc
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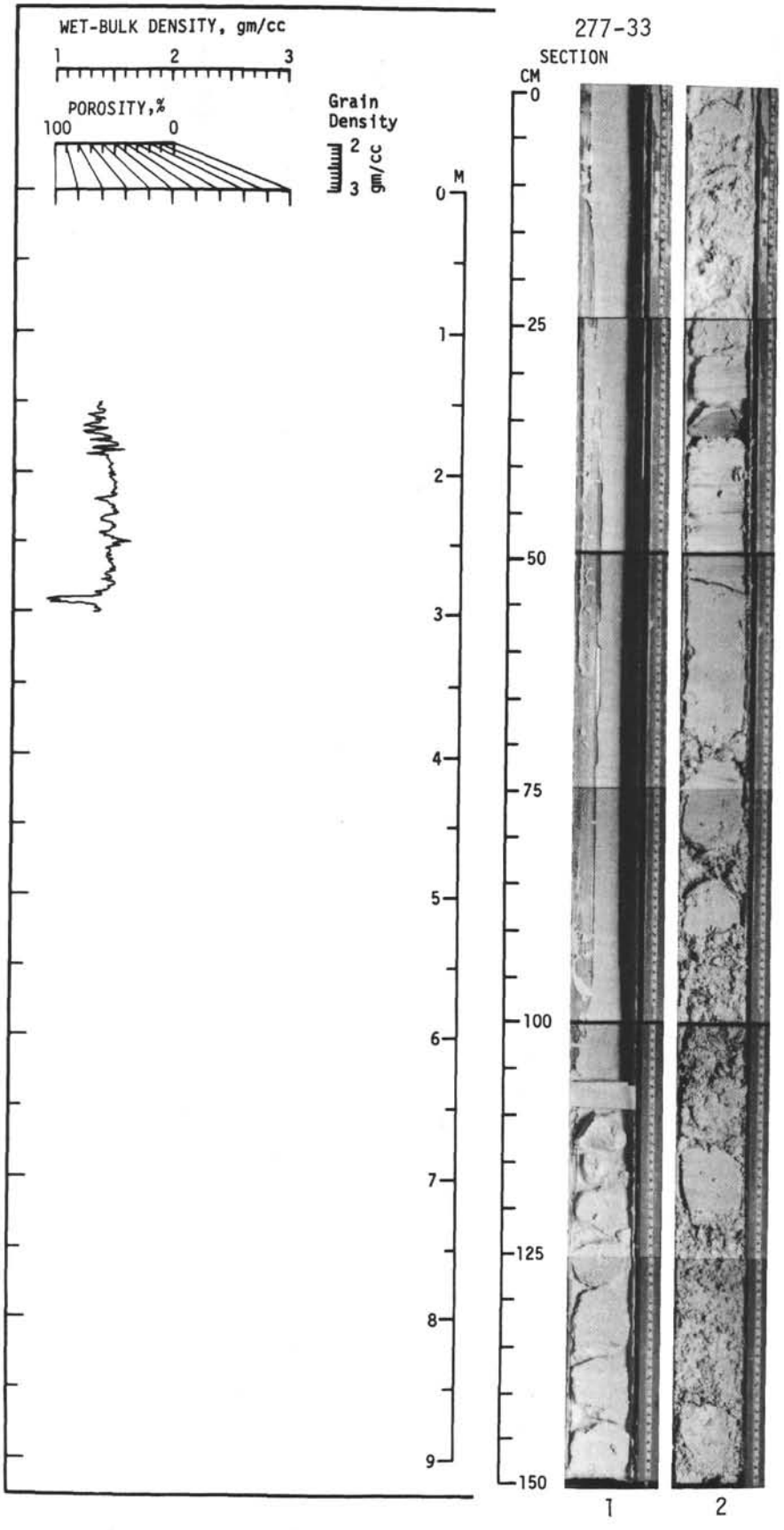
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POROSITY,%
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gm/cc
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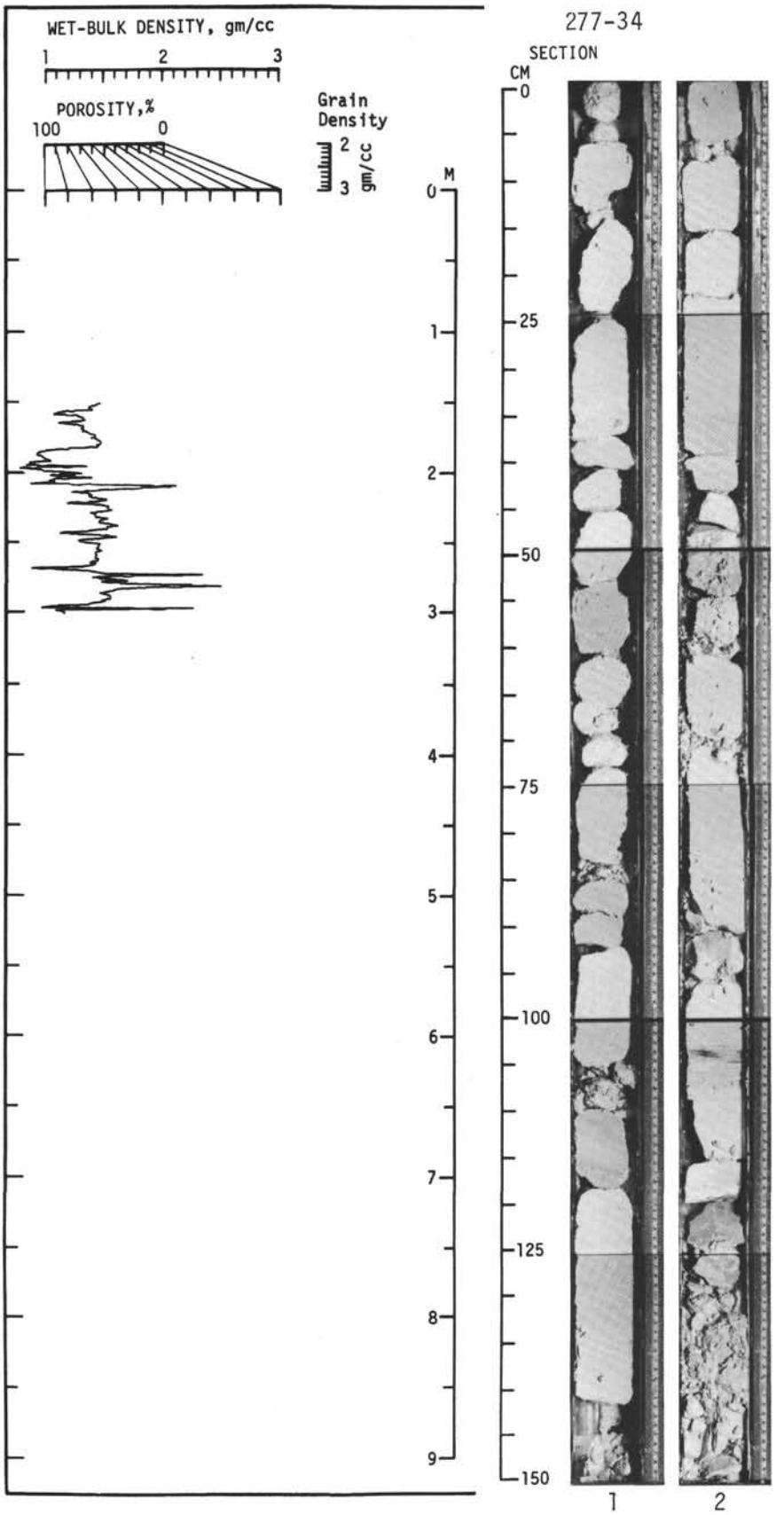
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POROSITY,%
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Density
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gm/cc
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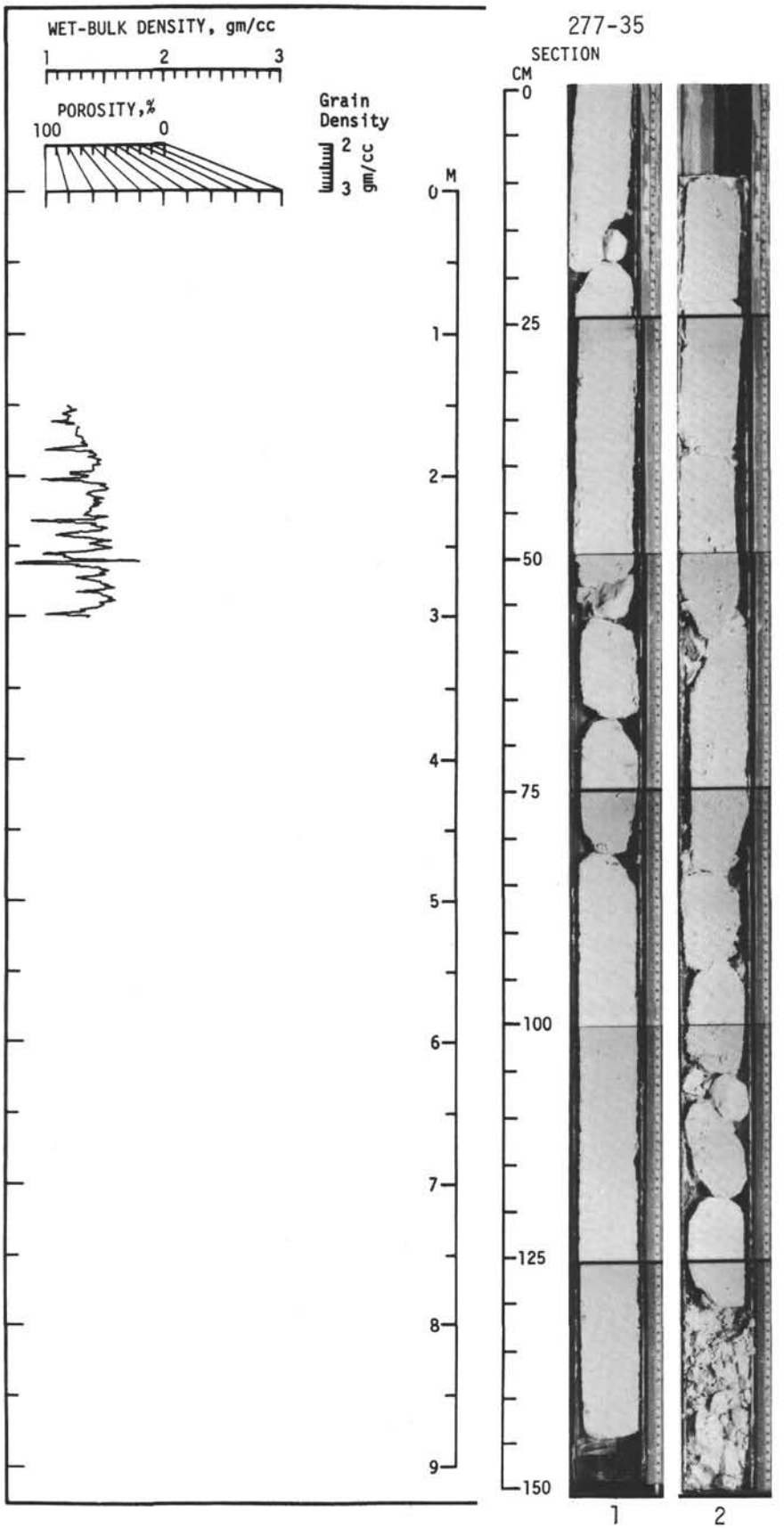
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Density
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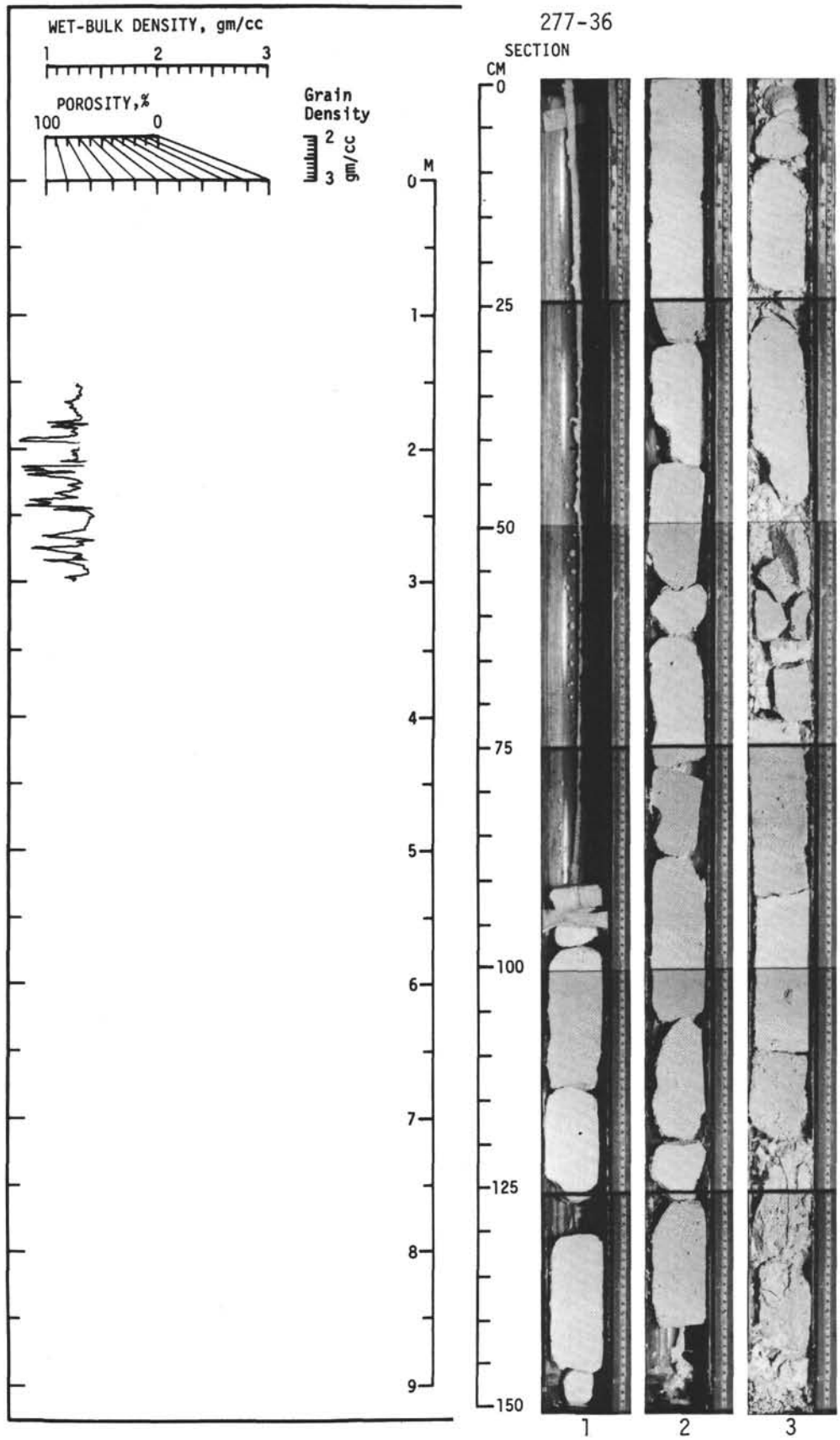
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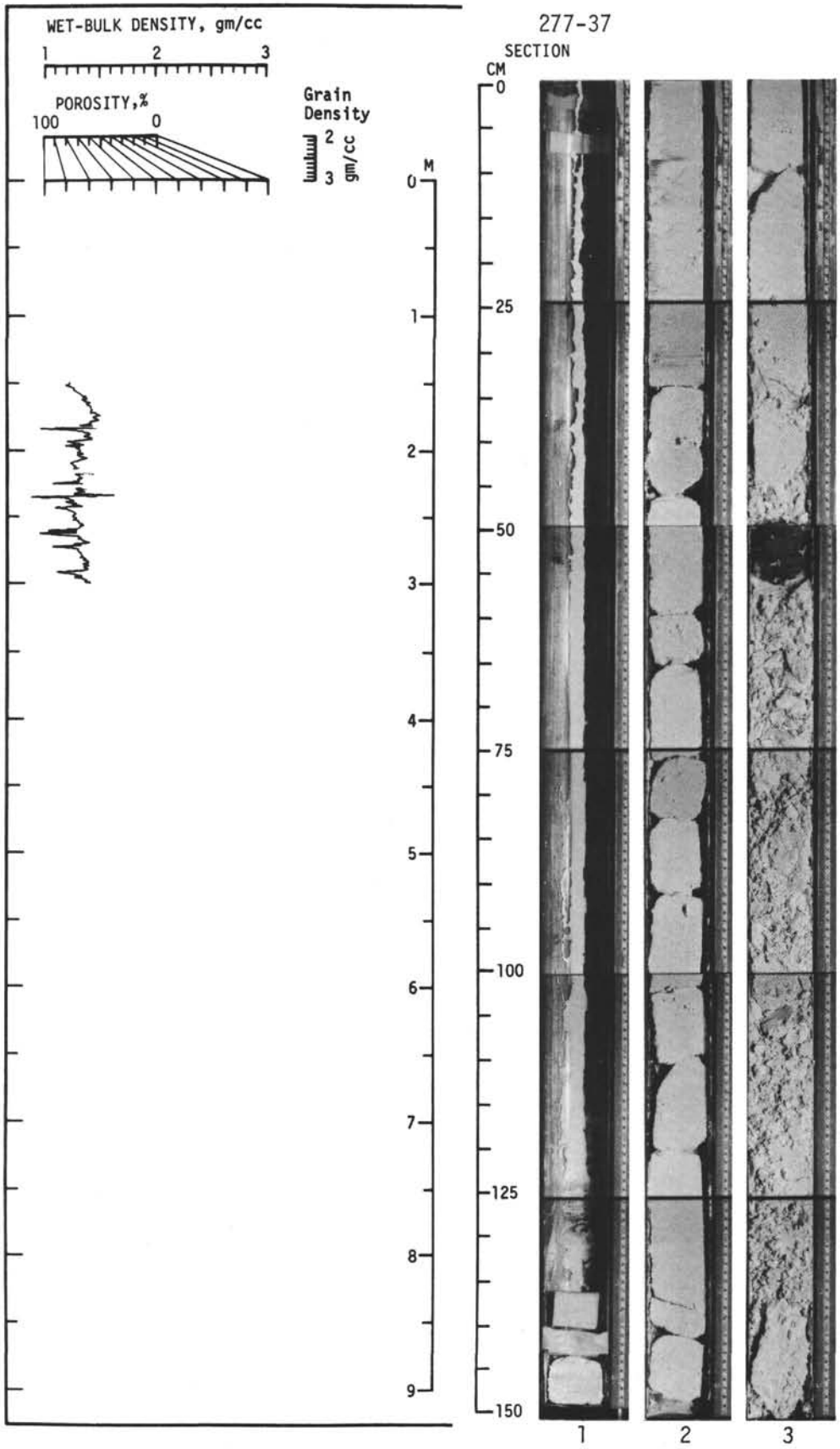
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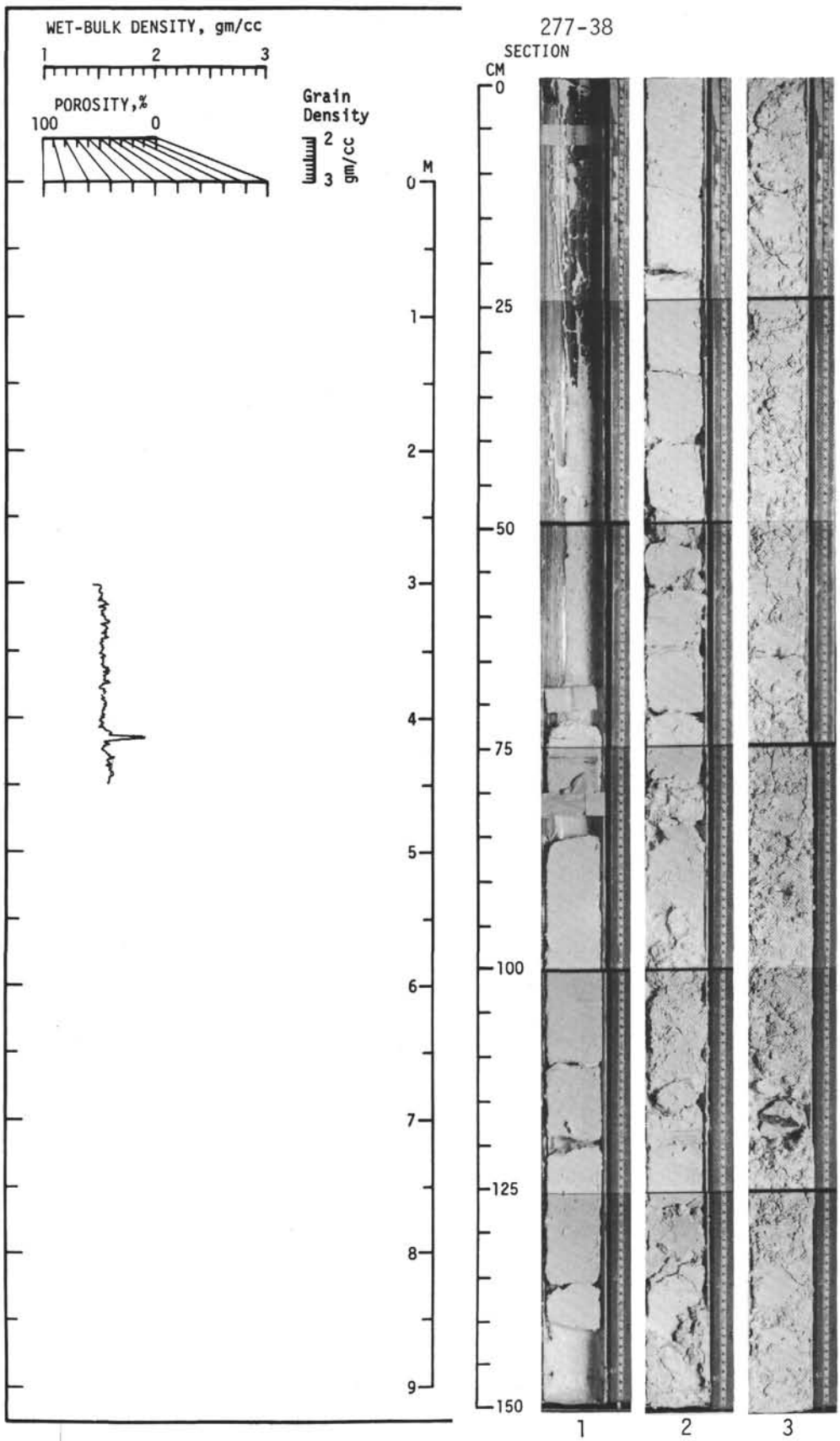
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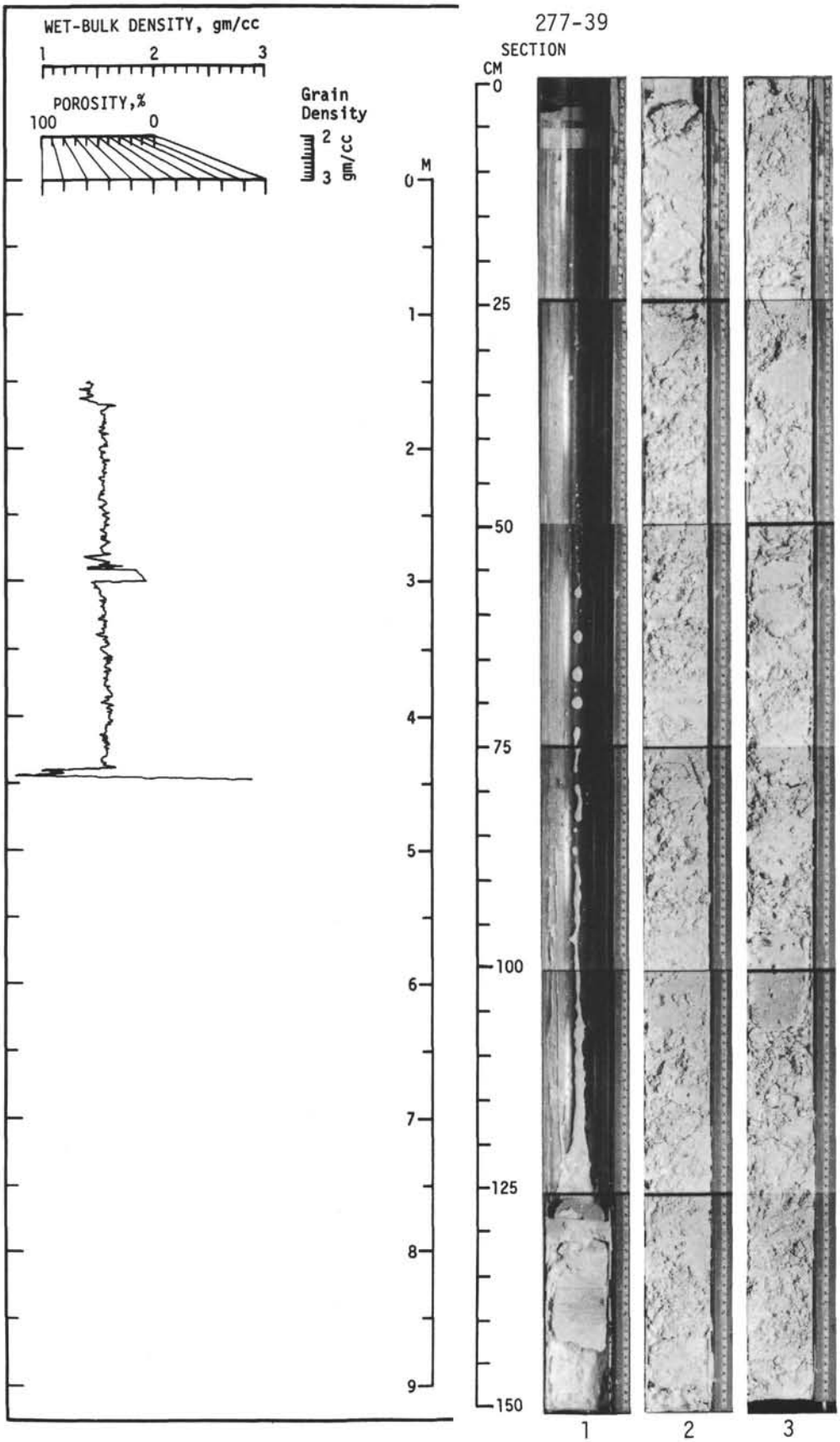
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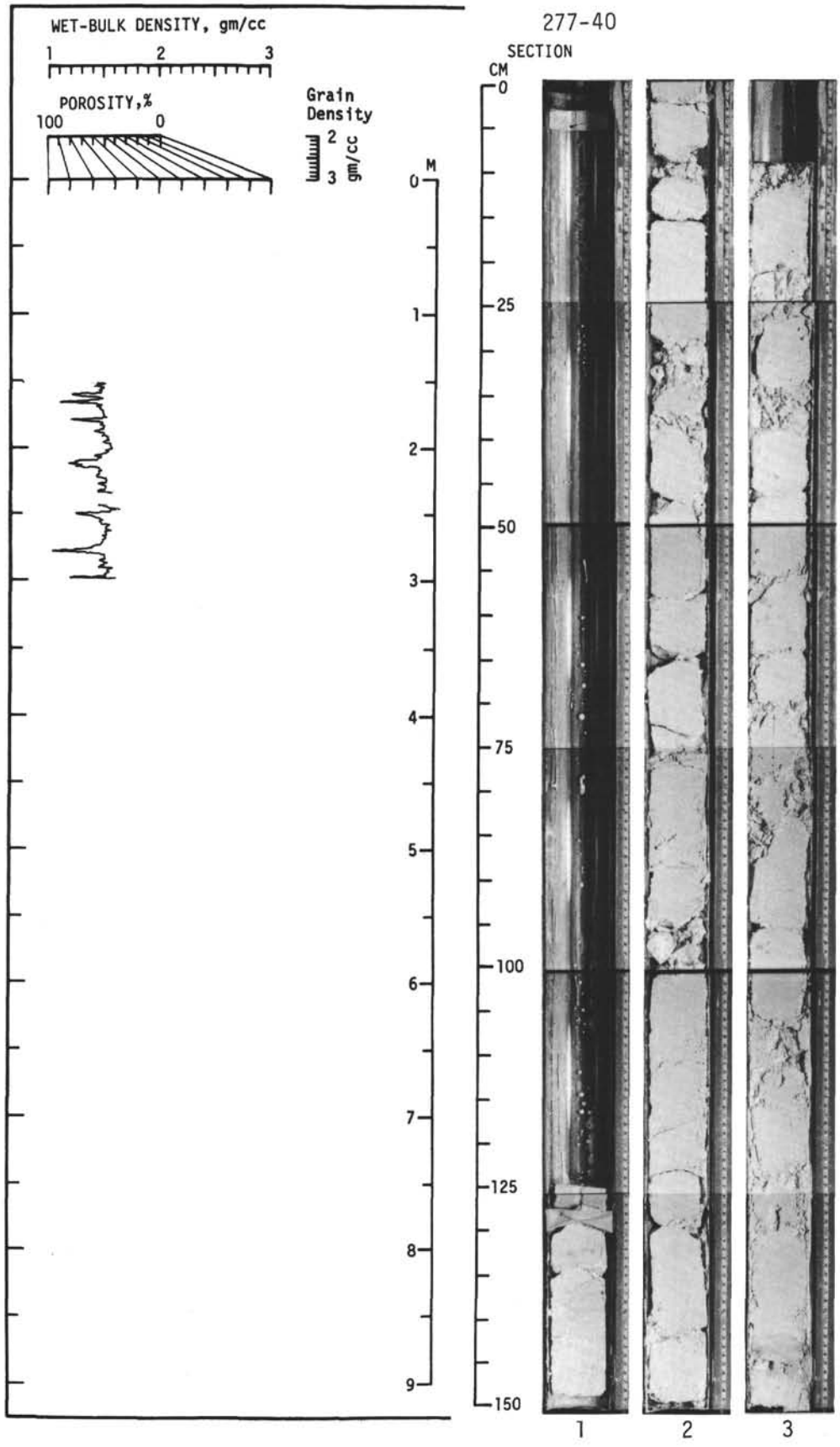
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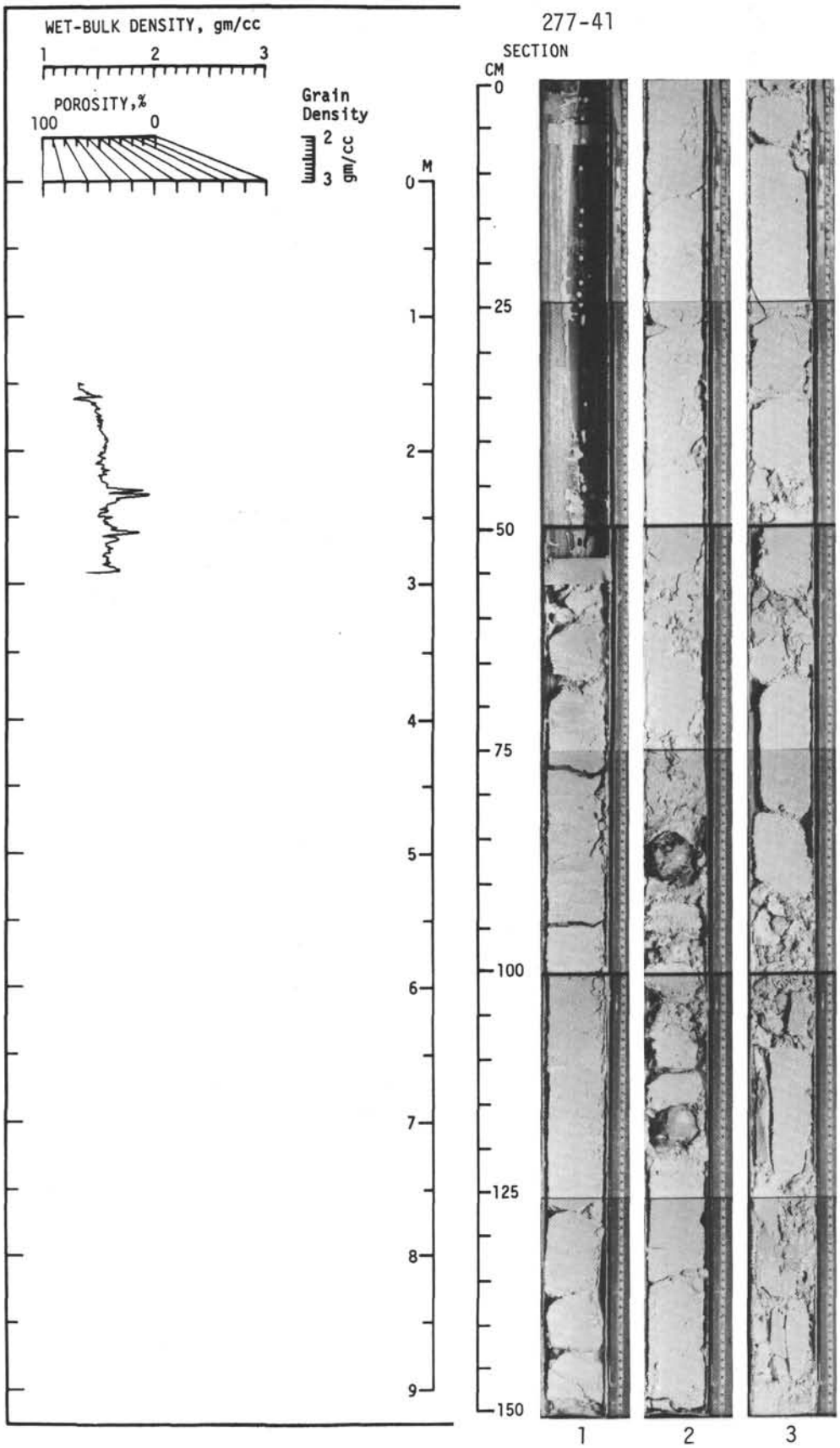
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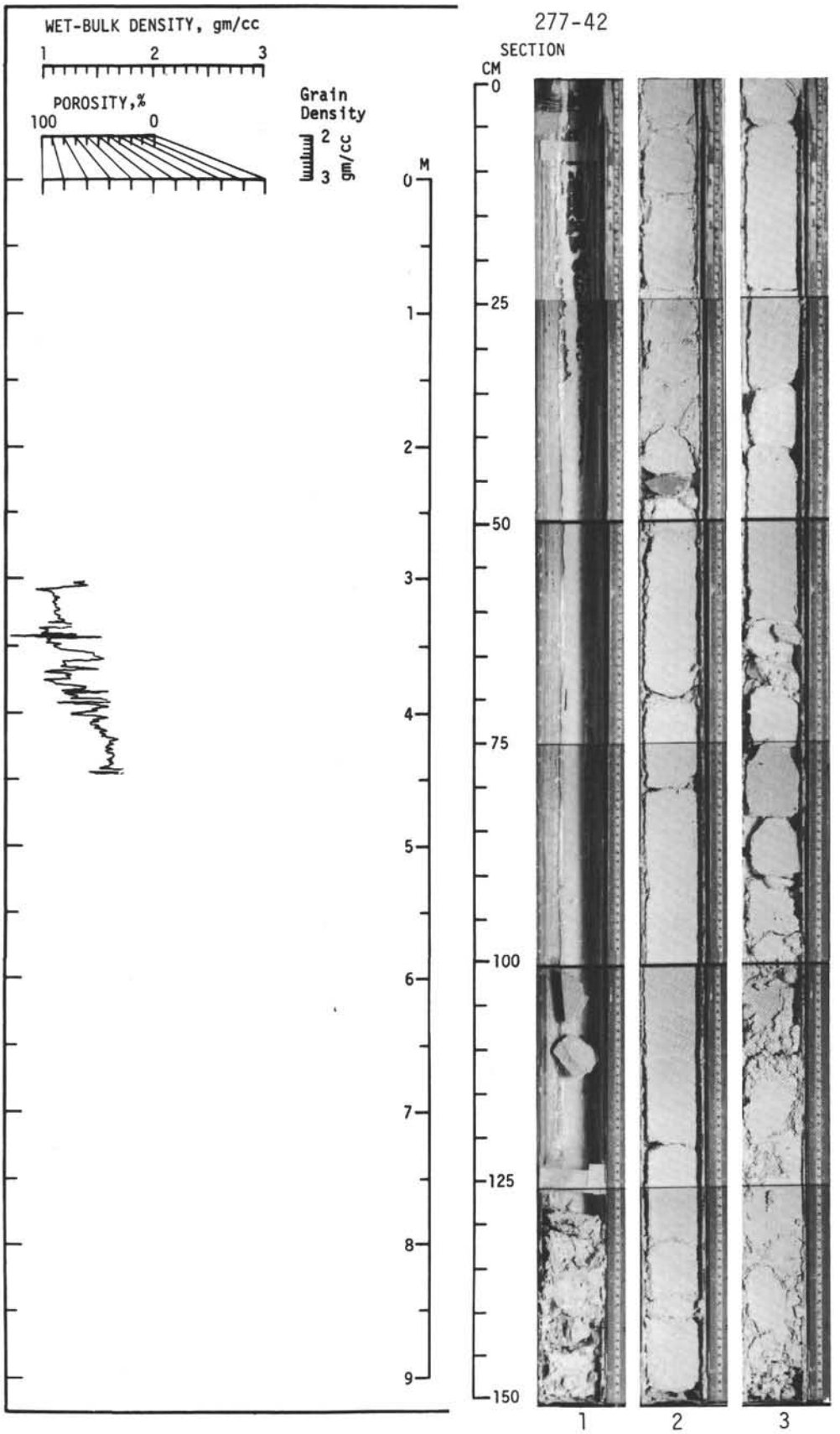
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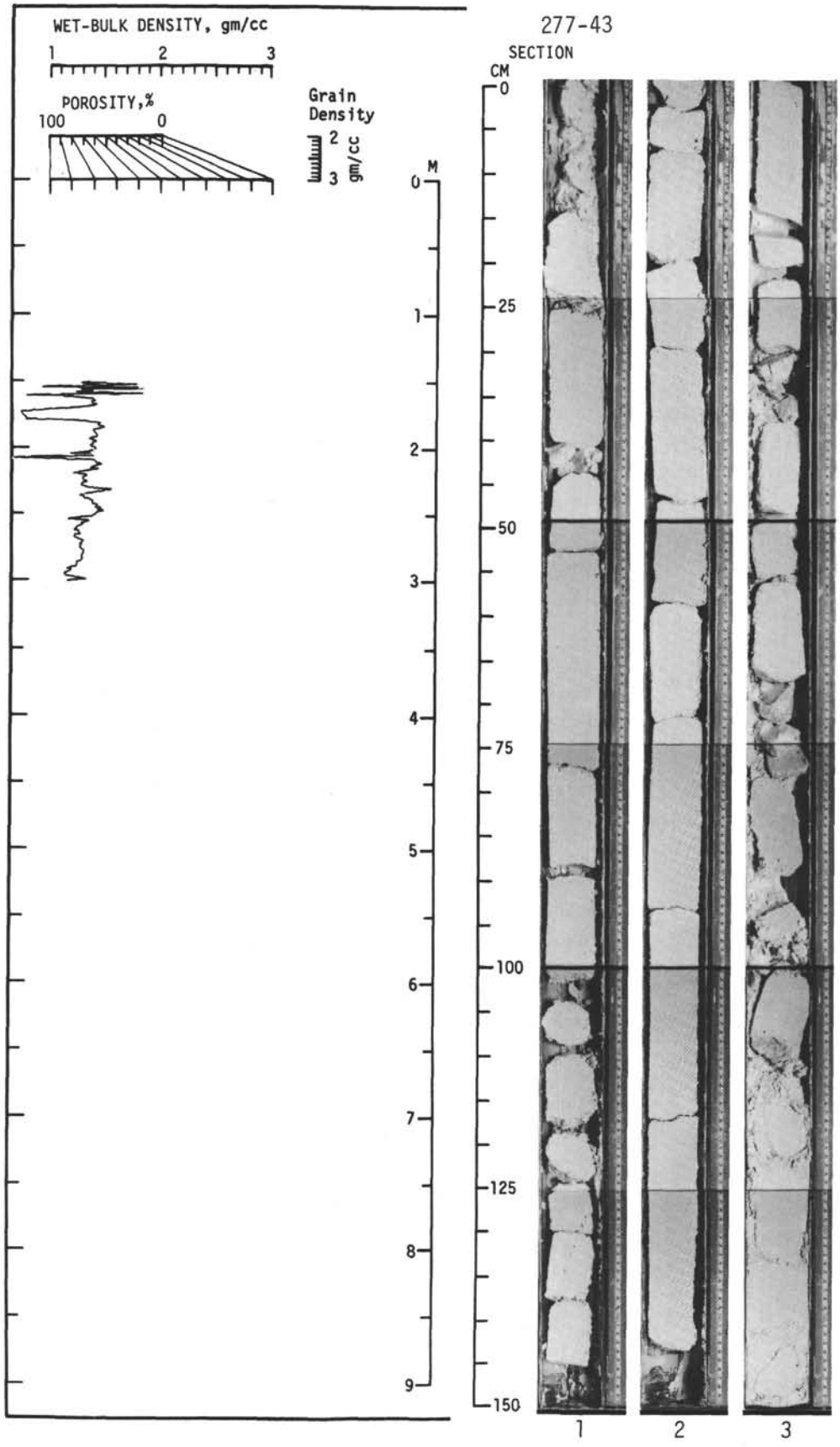
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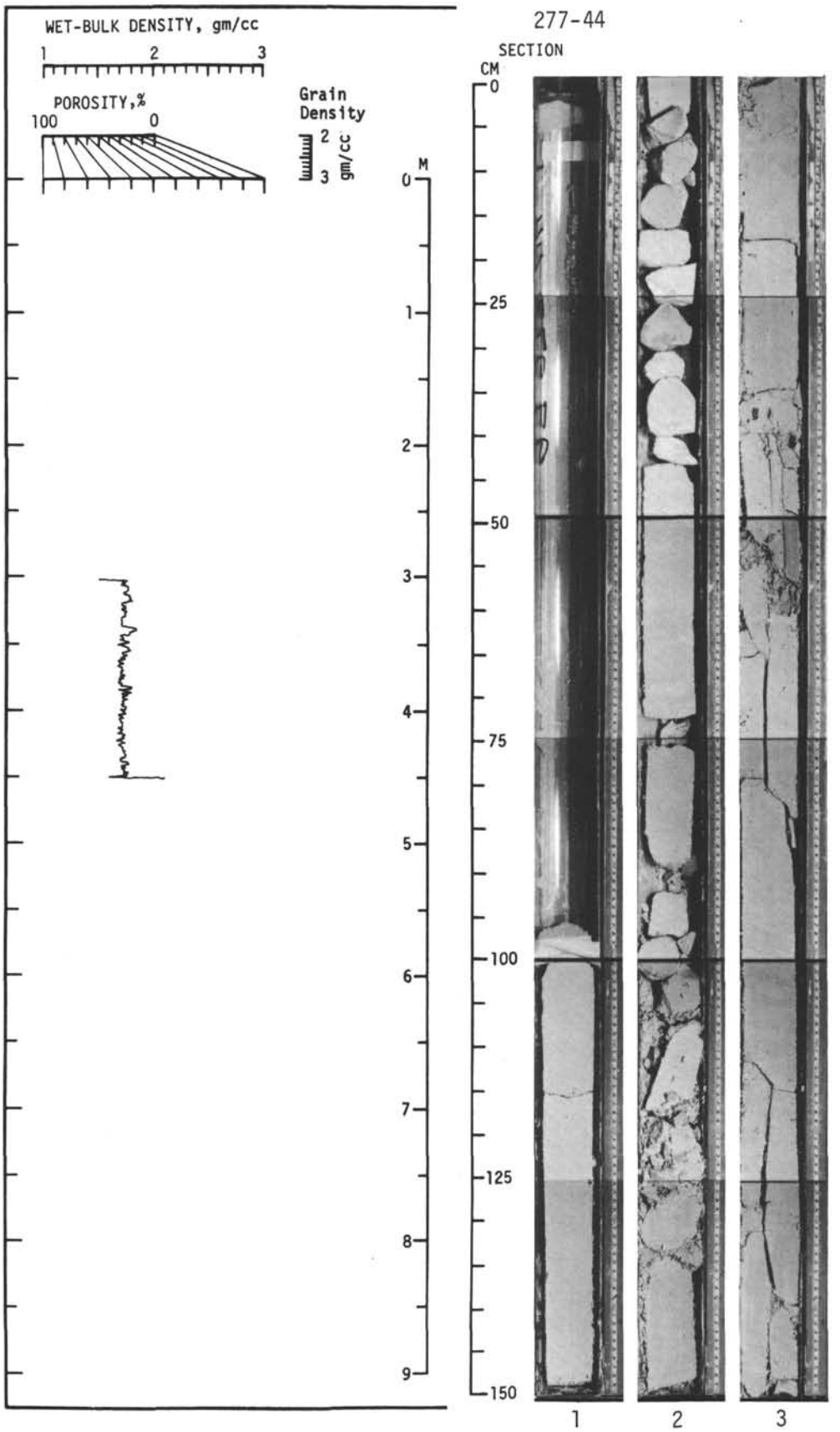
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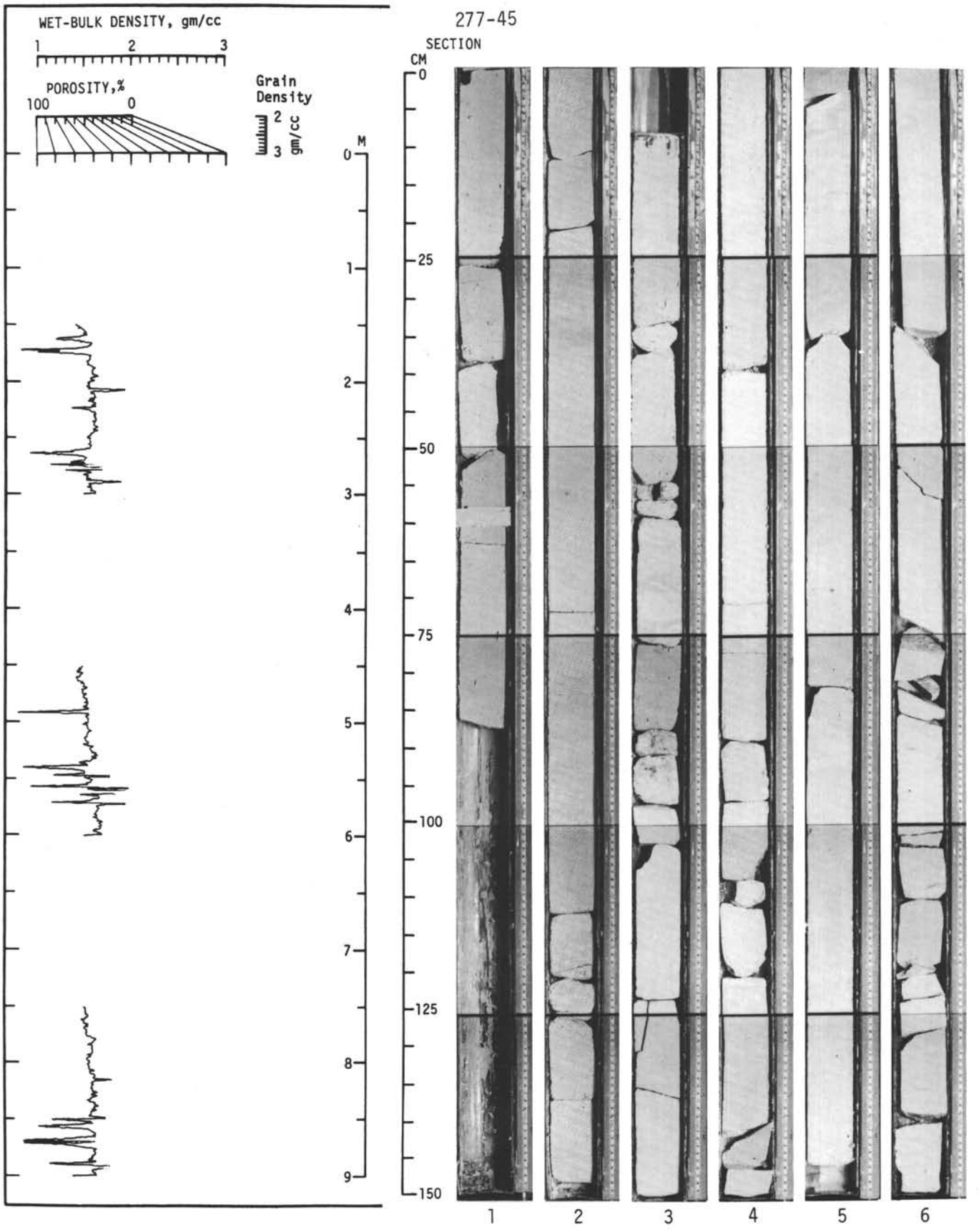
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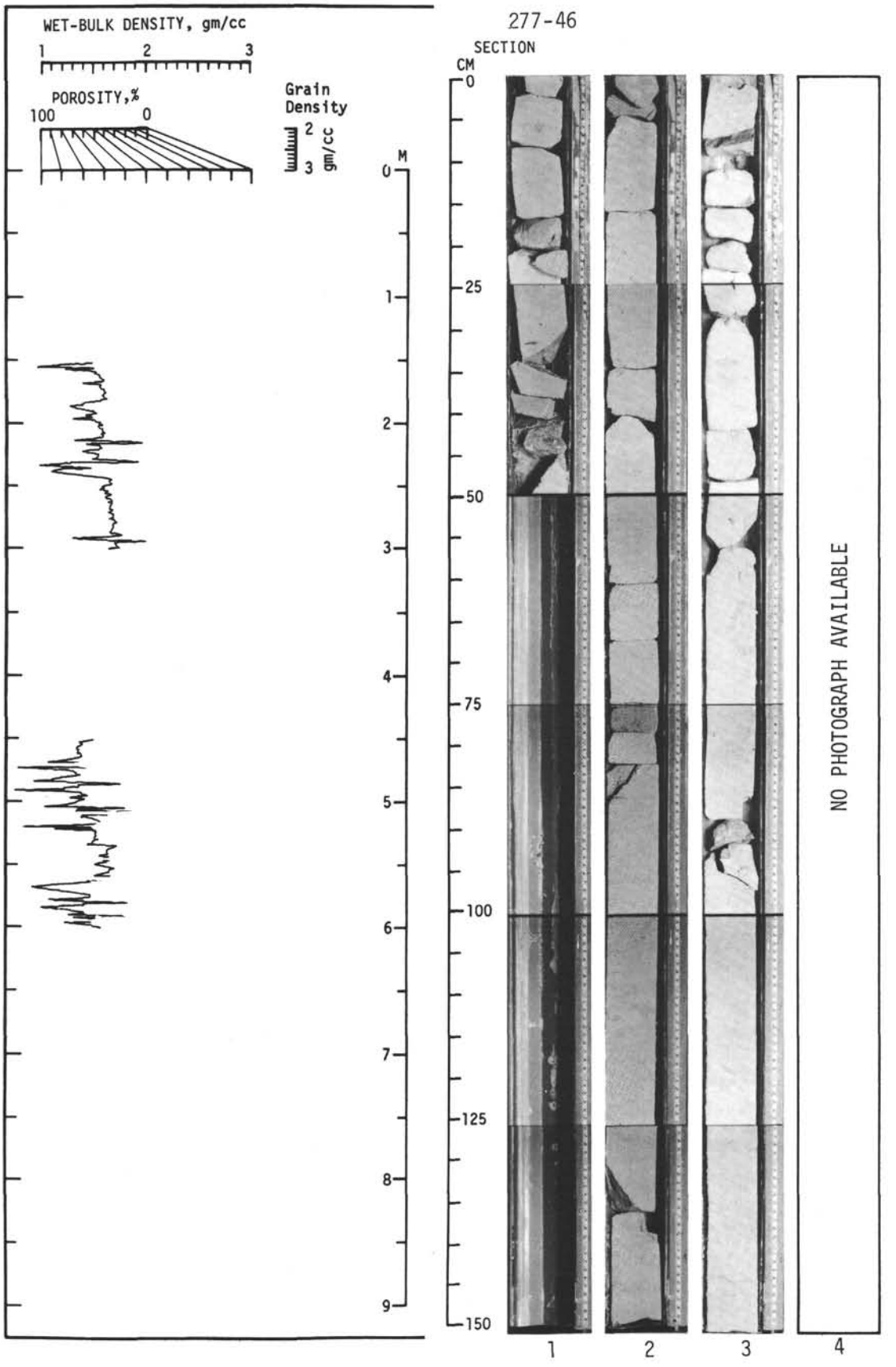
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