9. HELLENIC TRENCH – SITES 127 AND 128

The Shipboard Scientific Party[1]

SITE DATA

Occupied: September 6-12, 1970

Position: The floor and inner wall of the Hellenic Trench, west of Crete in the Ionian Basin, eastern Mediterranean.

Number of Holes Drilled: Three at Site 127; one at Site 128.

Hole 127 – In the ponded sediments in the axis of the trench, 470 meters seaward of the contact between the flat trench floor and its inner wall.
Latitude: 35° 43.90′N
Longitude: 22° 29.81′E

Hole 127A – On the inner wall (arc side), 600 meters directly northeast of Hole 127 and 130 meters landward of the floor-wall contact.

Hole 127B – On the trench floor 40 meters seaward of the floor-wall contact, and 430 meters directly northeast of Hole 127.

Hole 128 – Near the seaward edge of the trench floor, 3400 meters directly southwest of Hole 127.
Latitude: 35° 42.58′N;
Longitude: 22° 28.10′E.

Water Depth:	127 4654m[2]	127A 4636m	127B 4640m	128 4640m[3]
Cores Taken:	19	5	1	11
Total Penetration:	437m	80m	166m	480m

Deepest Unit Recovered: Quaternary marl ooze belonging to the trench fill in Hole 128 and Pliocene pelagic nanno ooze immediately underlying Lower Cretaceous neritic limestone in Hole 127.

MAIN RESULTS

The acoustically stratified sediment fill in the axis of the Hellenic Trench, at least down to a depth of 480 meters below bottom, consists predominantly of current-deposited sands, silts, and marl oozes of Quaternary age. Individual beds have been correlated across the trench plain. The sedimentation process is interpreted to have involved sediment ponding primarily by turbidity currents, although only a very small portion of the components making up any single bed have been reworked from pre-Quaternary strata.

The progressive tilting of the trench strata towards the landward wall has occurred at a rate of approximately one degree per million years.

Drilling into the inner wall encountered uplifted trench fill and a stratigraphic inversion of Lower Cretaceous limestones above Pliocene pelagic ooze. The contact between the latter two lithostratigraphic units exhibits a cataclastic texture. It is possible that we have penetrated either the talus of an underwater landslide (olistostrome) or a tectonic *mélange* in a zone of underthrusting.

Very high salinities, up to 150‰, were encountered in interstitial waters of the stratified sediment fill. These supersaline waters may have migrated from an underlying evaporite unit along subsurface fractures and/or porous horizons in response to crustal flexure beneath the trench floor.

BACKGROUND

Lack of knowledge of the nature and history of the sediment fill in oceanic trenches, and lack of visible evidence of how this particular body of sediment becomes transferred to the inner wall of the trenches, are two of many obstacles to our understanding of the processes affecting lithospheric material during its return journey into the earth's mantle.

Within the framework of a nonexpanding earth, the concept that the oceanic crust is being consumed along certain plate boundaries (Morgan, 1968) is not, itself, in doubt. Deep and intermediate earthquakes beneath island arcs not only mark the location of the descending tongues of lithosphere but are witness to their active internal deformation in response to compressional or extensional stresses (Oliver and Isacks, 1967). The process is apparently active at the present time, as demonstrated by measurements of the rate and direction of slip along fault planes (Brune, 1968; Stauder, 1968; Isacks, *et al.*, 1968).

The Scraping Up of Oceanic Sediments

It was reasoned that if the trench itself were the surface expression of the thrust zone between the oceanic lithospheric plate and the underpinnings of the arc (Isacks, *et al.*, 1969; Mitronovas and Isacks, 1971), then the sediment carpet of the descending slab ought to be scraped off, compressed against the front of the arc, and preserved in a way that would be detectable with modern oceanographic exploration techniques. However, only in a very limited number of the areas explored has such evidence been realized. One of the most convincing demonstrations was that of Chase and Bunce (1969) who obtained seismic reflection profiles across the Antilles Arc which showed the dipping of the oceanic basement of the Atlantic beneath apparent fold structures on the toe of the Barbados Ridge. Additional records from this region published by Vogt *et al.*

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[2]Corrected value based on comparison of drill string lengths and echo soundings across the trench plain should read 4640 meters.

[3]Corrected value based on comparison of drill string lengths and echo soundings between this hole and Hole 127 should read 4634 meters.

(1969) showed fractures in highly exaggerated presentations reminiscent of reverse faults, one of which had uplifted part of the trench plain.

Nevertheless, most of the typical highly seismic marginal trenches of other oceans (Hayes and Ewing, 1971) failed to provide corroborating evidence. In fact, observations of undeformed strata in the axis of the Peru-Chile Trench (Scholl *et al.*, 1968) had quite properly refocused attention to the landward wall as the most likely place to observe the crumpling of the trench sediments (Seyfert, 1969; Von Huene and Shor, 1969; Scholl *et al.*, 1970), if indeed sea floor spreading was active near trenches with sediment fill (Herron and Hayes, 1969).

Remaining mysteries in the dynamic framework of lithospheric subduction were: (a) reasons for the characteristic landward dipping attitude of the stratified sediment fill, (b) explanation for the extremely abrupt termination of the trench strata against the landward wall (e.g., Figure 12 of Savit *et al.*, 1964), (c) the sometimes excessive thicknesses of ponded sediment, for it was contradictory to reason that these bodies represented a period of time in excess of the interval of transit of the ocean crust from the outer wall to the inner wall (unless the trench fill was decoupled from the underlying formations), and (d) the facies and composition of the trench fill, because advocates of new corollaries to plate theory were searching for actualistic models of internal flysch basins, and marginal trenches had been proposed as possible candidates (Mitchell and Reading, 1969; Dewey and Bird, 1970; Wezel and Ryan, 1971).

An Oceanic Trench in the Mediterranean

It was fitting in the Mediterranean to initiate the investigation of island arcs by deep sea drilling. First of all, except for the atypical (generally shallow) water depths, a trench-island-arc structure[4] exists here (Figure 1) in the eastern Mediterranean with all the characteristics of its oceanic counterparts, including seismicity, volcanism, gravity field, and morphology.

A northeast-southwest reflection profile made in 1965 by the R/V *Robert D. Conrad* of the Lamont-Doherty Geological Observatory of Columbia University, and illustrated in Figure 2, shows a typical cross-section of the exterior Hellenic Trench along the western part of the arc. Here, proceeding from left to right, we see the flexed and downdropped seaward wall, a narrow, flat, and partly sediment-filled floor, and a steep and acoustically opaque inner wall. Subbottom reflections in the topographic axis show the narrow sediment fill gently dipping to the northeast toward the inner wall, and the termination of these reflections at the contact with the wall of the trench. Small undulations in the fill may represent embryonic deformational structures.

According to fault-plane solutions of McKenzie (1970) and Isacks and Molnar (1971) of earthquakes beneath this region of the arc, the Aegean (internal zone) is actively overthrusting the Ionian Basin in a southwesterly direction parallel to the strike of the reflection profile. The mean rate of crustal destruction, as inferred from the plate kinematics approach of Le Pichon (1968) is in the neighborhood of 2.6 cm/year. Judging from the distribution of intermediate earthquakes interior to the arc (Galanopoulos, 1968; Papazachos and Comninakis, 1971) the length of the already consumed slab of the converging African Plate is approximately 250 km.

Figure 1. *Physiographic panorama of an island arc in the eastern Mediterranean trench, which extends from the mountainous terrain of the Hellenides on the mainland of Greece through the Ionian Islands and on across Peloponnesus, Kithira, Andikithira, Crete, Kasos, Karpathos, Rhodes, before passing into the Taurus mountain range of southern Turkey. The structure is rimmed on its seaward side by a series of deep depressions within a relatively narrow trough. The portion of the trough drilled at Sites 127 and 128 lies west of Crete and has been referred to by us as the Hellenic Trench.*

Objectives

The objectives established for the Hellenic Trench drilling were to first of all examine the age, nature and geometry of the stratified sediment fill, and then explore how this fill becomes transported into the inner wall. Only by taking advantage of the uncharacteristically shallow water depths of this particular trench could the problem be examined within present drilling capabilities.

In order to minimize any significant differences between the Hellenic Trench and other trenches because of a water depth factor, a crossing of $\simeq$ 4600 meters (with sediment) was chosen. Furthermore, a location west of Crete was selected where the proposed underthrusting was normal to the strike of the arc, and where good epicenter locations

[4]See Chapter 37 for a discussion of the tectonic setting of the Hellenic Arc of the eastern Mediterranean.

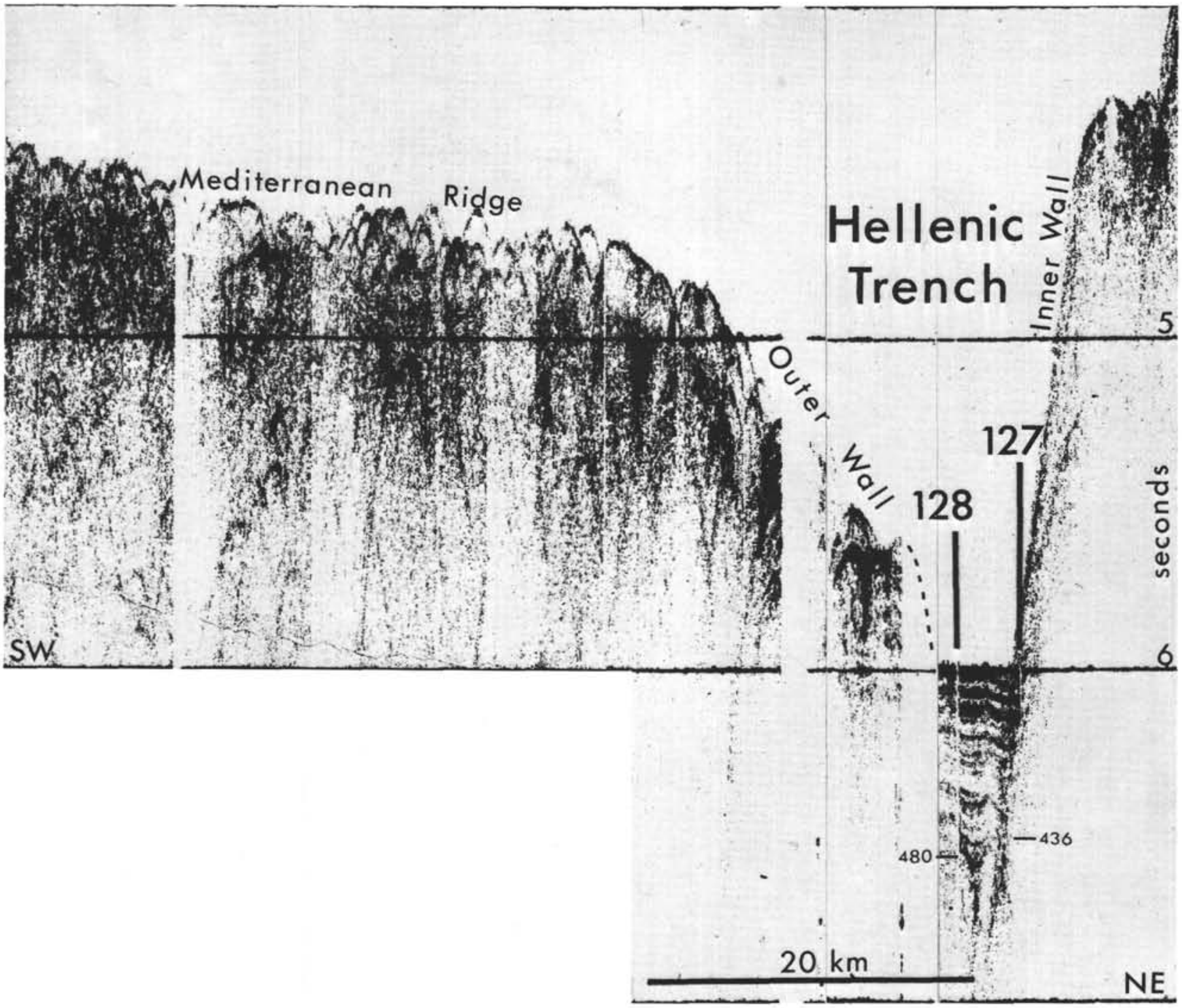


Figure 2. *A continuous seismic reflection profile along southwest-northeast strike normal to the trend of the Hellenic Trench. This record was made in 1965 aboard the R/V* Robert D. Conrad *using an airgun sound source. Note the presence of Reflector M beneath a thin carpet (0.15-0.20 sec.) of transparent sediment on the Mediterranean Ridge. This reflector cannot be traced beneath the axis of the trench which is presently filled with more than 0.8 seconds of stratified sediment. Vertical exaggeration is approximately 27:1. The numbers below the drill sites indicate the total penetration in meters reached in each hole.*

showed the amphitheater-shaped upper surface of the subducted African Plate to be plunging at an angle of about 30 degrees.

Strategy

In order to accomplish the stated objectives, the inner-wall/trench-floor contact had to be accurately located. To do this, the *Challenger* would steam across the trench floor paralleling the *Conrad* track, and drop an acoustic positioning beacon as close as possible to the termination of the stratified sediment pocket. Then, navigating from this reference point, the vessel could be positioned over the trench fill for one hole, and then up on the inner wall for a second hole, with the precise distance between the holes known to within a few meters. Based on the results of these two preliminary drillings, additional offsets would be undertaken if warranted. Of particular importance was exploration of the subsurface part of the inner wall at its contact with the sediment pocket.

Challenger Site Approach

After departing Site 126, the drilling vessel proceeded first due east for about ten miles in order to offset her from the *Conrad* track, and then headed northeast on a course 055° to intercept this line at the new drilling target in the Hellenic Trench. At 1000 hours on September 6, 1970 the *Challenger* commenced her descent of the seaward wall of the trench. Upon arrival over the smoother portion of the trench floor, a minor adjustment in heading to 052° was initiated at 1050 hours (Figure 3). Stratified sedimentary layering appeared on the underway seismic reflection recording, as the vessel continued at 9.3 knots to her destination close to the inner wall.

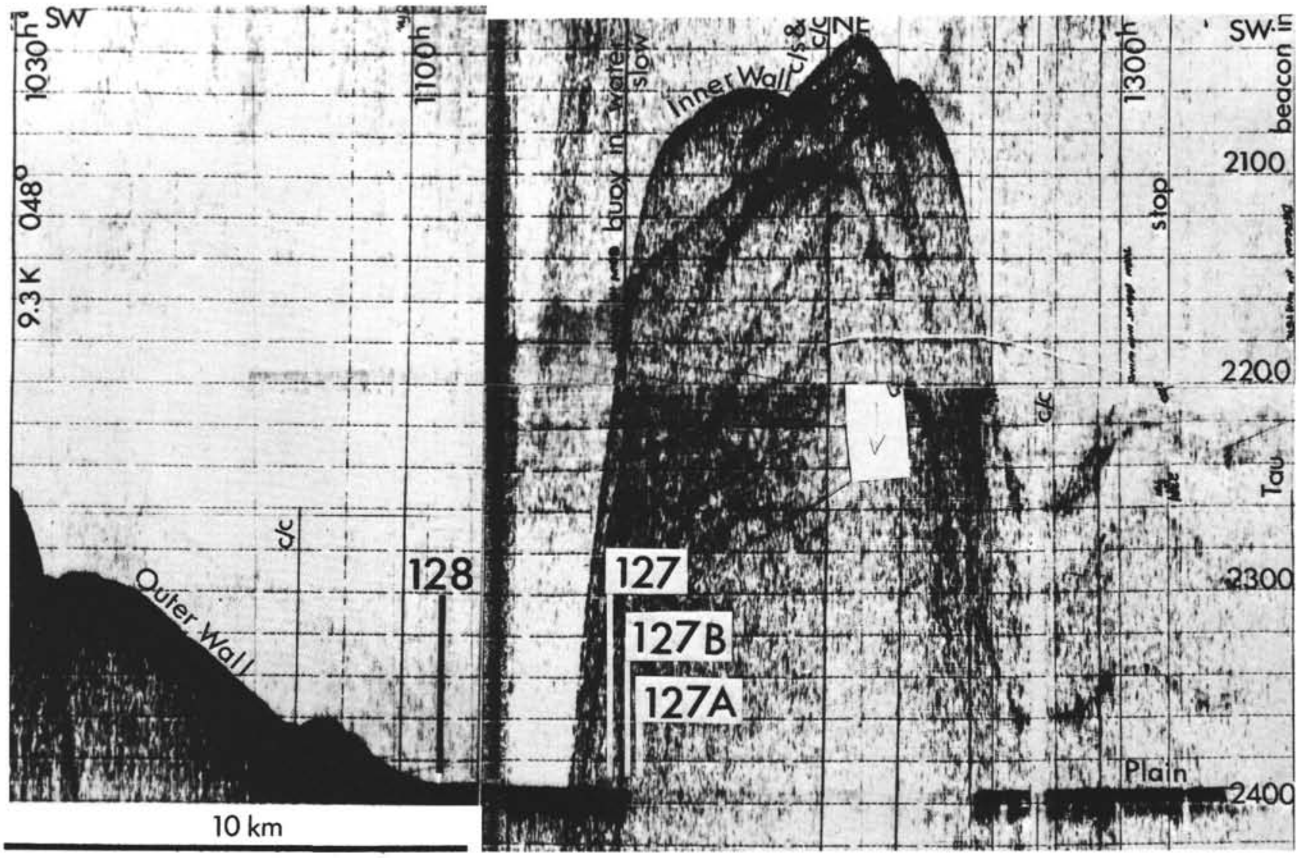


Figure 3. *Precision 12 kHz fathogram made aboard the* Glomar Challenger *on her approach to the first drill site (127). The initial transect across the trench plain was made in a northeasterly direction at a speed of ≈ 9.3 knots. Note the abrupt termination of the flat echo returns from the trench floor. The vessel continued partly up the inner wall, reversed course, and returned to the trench plain. She hove to and dropped the acoustic beacon seaward of the plain/inner wall boundary. The three drill holes (127, 127A, 127B) near the inner wall were positioned relative to this beacon and their respective locations are shown here by matching the side-echo patterns while on station to that at the original crossing. Hole 128 was positioned relative to Hole 127 by satellite navigation, using a second beacon. Vertical scale in uncorrected units: 1 tau = 1/400 second. Vertical exaggeration while at 9.3K=23:1.*

The first side-echoes from the landward slope of the trench appeared as predicted, at 1113 hours. The flat echo trace of the trench floor continued beneath the side-echoes. Four minutes later, the free floating marker buoy was launched followed precisely 30 seconds later by an abrupt termination of echoes from the trench floor.

Having thus selected an excellent position with regard to the drilling goals, the vessel slowed to five knots to pull in the seismic gear and magnetometer. With this task completed at 1133 hours, the vessel swung hard to the right to reverse course to the buoy.

The side-echo sequences on the precision depth recorder at the time of arrival at the buoy more or less matched those on the record coincident with the time the marker was launched, indicating that this marker had not drifted significantly during its thirty minutes afloat. The vessel proceeded to maneuver into the wind, inched slightly toward the slope and at 1204 hours dropped the acoustic positioning beacon at what was then an estimated distance of 500 meters seaward of the edge of the trench plain. Thirteen satellite fixes, while station keeping over the beacon during the drilling of Hole 127, determined its position to be less than ½ kilometer south of the original target on the *Conrad* reflection profile, and about 3 kilometers east of piston core RC9-184, also from the trench floor (Figure 4).

OPERATIONS

The *Glomar Challenger* stayed over the Hellenic Trench for six days, between 1204 hours, September 6 and 1330 hours, September 12. Four separate holes were drilled. The first three holes were drilled while positioning the vessel with reference to the acoustic beacon initially dropped on the trench plain close to the landward wall. These holes are designated with the prefix 127 (e.g., Hole 127, 127A, and 127B). The maximum penetration at Site 127 was 437 meters. The fourth hole was drilled at the seaward edge of the trench plain and necessitated another positioning beacon. Hence, according to DSDP convention, this drilling location was termed Site 128. The deepest penetration at Site 128 was 480 meters. The core inventory for the holes in included in Tables 1, 2, and 3.

The two drilling sites are treated here in the same chapter because they involved the same scientific objectives

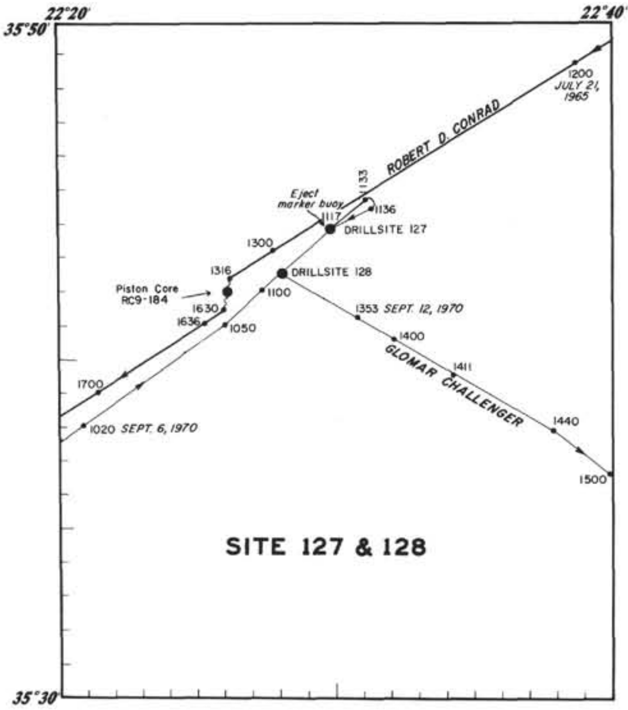


Figure 4. *Details of the* Challenger's *survey track across the Hellenic Trench. Shown are the locations of the four drill holes and a surface piston core, RC9-184. The heavy line is a portion of the* Conrad *reflection profile illustrated in Figure 2.*

and problems, and because they recovered similar types of sediment.

The Drilling of Hole 127

Hole 127 was spudded in on the trench plain directly over the acoustic beacon at a PDR reading of 2395 tau. When moving from this position during the controlled offset to Hole 127A, we were able to calculate that the beacon lay 472 meters seaward of the plain/inner wall contact (Figure 5).

The initial moment of impact of the drill string with the sea bed was very difficult to ascertain. The corrected meter equivalent to the PDR reading was 4628 meters. The drillers estimated the first recognizable resistances at a recorded drill string length of 4664 meters from the rig floor (which itself is 10 meters above sea level). Although this figure has subsequently been used to calculate the subbottom depths of the various Hole 127 cores (Table 1), we feel that it is too great. In particular, when spudding in at Hole 127B with exactly the same water depth on the echo sounder, the drill pipe measurement there registered bottom 14 meters sooner.

It has not been practical to change the initial shipboard measurements, and changes at the date of writing would only add to confusion. Instead, we point out that for comparisons of subbottom levels between the holes, the drill string measurements are the most satisfactory, and that the subbottom depth intervals of Hole 127 should be adjusted to a relative value 14 meters greater than those listed in Table 1.

The initial washing in at Hole 127 proceeded very rapidly in soft plastic formations. No attempt was made to recover the surface sediments, because of the availability of a nearby piston core. We employed the tried and proven technique of washing with the core barrel in and with recovery intervals more or less evenly spaced throughout the section. several of the cores were taken back to back in order to provide continuous sections of great thickness so that spot coring in the offset holes would be able to obtain time equivalent strata without the necessity of continuous coring.

The first twelve cores, down to 336 meters, were on deck within 24 hours. However, after two more cores were taken, the trench fill became noticeably firmer and the barrels tended to become jammed. Cores 13 and 14 were cut back to back, and the center bit plug was inserted. The interval from 383 to 420 meters was thus penetrated without coring, although samples were collected from a reservoir behind a small orifice in the center bit face. Core 15, was taken and recovered Quaternary marl oozes, then the centerbit was dropped again.

However, no sooner had we begun drilling for the second time with the center bit in place than we encountered a major change in the formation (427 meters) to something quite hard. The center bit was pulled and when it arrived on deck we observed a large gouge on its face.

As soon as coring was started, we noticed significant torquing for the first time. It appeared as if the bit were penetrating through individual hard stringers. Three jumps from hard to soft and then to hard again were noticed. Cutting was terminated after two meters of penetration because of our concern of encountering lithified rocks which might be impervious to trapped gases and liquids below.

We were surprised to discover massive pieces of Cretaceous shallow-water limestones and dolostone. However, because of their strange stratigraphic position, we could not understand how they could cause us problems as a caprock; therefore, we proceeded cautiously, giving instructions to core continuously until we were through the zone of indurated rocks.

We spent a total of 14 hours fighting our way beneath the Cretaceous/Quaternary unconformity. Coring interval No. 17 made less than six meters in three and a half hours of constant grinding. Most of the penetration was accompanied by very erratic and strong torquing; however, soft spots were encountered, one involving an interval of approximately two meters. Here the torquing became smooth again and the interval was cut in only a few minutes. Judging from the drilling logs, the lithology, even in the indurated sections, was highly variable. The drilling of Core 18 was more uniform, with little or no binding of the bit on the formation. Yet two brief moments of very high torque were noticed.

Hole 127 was terminated at 437 meters below bottom while cutting hard rocks, since our drilling rate had been very slow, the final one meter taking four hours. The decision was painful, but we had already demonstrated a very unusual stratigraphic inversion and a major hiatus from Quaternary trench fill to Upper Pliocene pelagic ooze accompanied by Cretaceous limestones of shallow-water origin. The site was definitely not to be abandoned.

TABLE 1
Core Inventory – Hole 127

Core	No. Section	Date	Time	Cored[a] Interval (m)	Cored (m)	Recovered (m)	Subbottom[b] Penetration (m) Top	Bottom	Tentative Lithology	Age
1	5	9/6	2145	4682-4691	9	7.6	18	27	Mud conglomerate/ Marl ooze	Quaternary
2	5	9/7	0005	4691-4700	9	7.0	27	36	Sands/Marl ooze	Quaternary
3	6	9/7	0130	4700-4709	9	7.8	36	45	Mud conglomerate	Quaternary
4	2	9/7	0315	4747-4756	9	3.0	83	92	Sand/Marl ooze	Quaternary
5	6	9/7	0440	4756-4765	9	8.0	92	101	Sand/Marl ooze	Quaternary
6	7	9/7	0610	4765-4974	9	9.2	101	110	Sand/Marl ooze	Quaternary
7	6	9/7	0815	4822-4831	9	9.0	158	167	Sand/Marl ooze	Quaternary
8	5	9/7	1015	4831-4840	9	6.8	167	176	Mud conglomerate, Sand/Marl ooze	Quaternary
9	1	9/7	1245	4888-4997	9	1.5	224	233	Marl ooze/Sand	Quaternary
10	7	9/7	1520	4945-4948	3	9.3	281	284	Marl ooze/Sand	Quaternary
11	1	9/7	1755	4963-4972	9	1.0	299	308	Marl ooze	Quarternary
12	4	9/7	2057	4991-5000	9	5.8	327	336	Marl ooze	Quaternary
13	1	9/7	2335	5028-5037	9	1.2	364	373	Marl ooze, Sapropel Diatomite	Quaternary
14	7	9/8	0230	5037-5047	10	9.4	373	383	Marl ooze, Sapropel Diatomite	Quaternary
CB1	0	9/8	0600	5047-5084	0	1 Kg	383	420	Marl ooze	Quaternary
15	2	9/8	0820	5084-5091	7	3.5	420	427	Marl ooze	Quaternary
CB2	0	9/8	1030	5091-5091	0	Trace	427	427	Marl ooze	Quaternary
16	1	9/8	1200	5091-5093	2	0.3	427	429	Dolomite	L. Cretaceous
17	1	9/8	1645	5093-5099	6	0.8	429	435	Dolomite, Limestone	L. Cretaceous
18	1	9/8	2020	5099-5100	1	1	435	436	Dolomite, Limestone, Nanno mud	L. Cretaceous
19	1	9/9	0040	5100-5101	1	1	436	437	Dolomite, Limestone, Nanno ooze	L. Cretaceous and Pliocene
Total					13.2	93.2		437		
% Cored					16.3%					
% Recovered						70.6%				

[a]Drill pipe measurement from derrick floor.

[b]Measurements based on contact of the drill string with sediment at 4664 meters below the derrick floor. In actuality this value should have been 4650 meters.

Plans for Offsetting

The discovery of Pliocene pelagic oozes under the Cretaceous rocks raised the question of whether we had encountered an olistostrome, or whether we chanced upon a shear zone associated with a tectonic zone of underthrusting. Two offset holes (127A and 127B) were planned to further examine these hypotheses and to investigate the nature of the inner wall itself.

The drill string was pulled to bring the bit several hundred meters above the mud line. We decided to make a straight-line traverse in a northeast direction toward the inner wall by applying offset instructions to the station-keeping computer. At a distance of 472 meters from the beacon, the flat echo sequence from the trench floor abruptly ceased, indicating that we were now over the inner wall proper. The vessel was maneuvered 130 meters beyond this point and halted for the drilling of Hole 127A.

Operations at Hole 127A

The initial encounter with the sea bed was recorded with a drill string length of 4646 meters, indicating that the bottom here was possibly only four meters shallower than the corrected reading for Hole 127 on the trench plain, in spite of the fact that the side-echo readings indicated it was some hundreds of meters shallower. Here, a surface core was planned to determine if the inner wall consists of the same trench fill.

The remaining cores were evenly spaced down to 78 meters, where once again hard Cretaceous limestones were encountered.

TABLE 2
Core Inventory – Holes 127A and 127B

Core	No. Sections	Date	Time	Cored Interval (m)	Cored (m)	Recovered (m)	Subbottom Penetration (m) Top	Subbottom Penetration (m) Bottom	Tentative Lithology	Age
Hole 127A										
1	3	9/9	1015	4646-4653	7	4.5	0[a]	7	Foraminiferal and Pteropod ooze	Recent
2	3	9/9	1245	4662-4671	9	3.7	16	25	Sands and Marl oozes	Quaternary
3	6	9/9	1355	4692-4701	9	7.8	46	55	Sands and Marl oozes	Quaternary
4	4	9/9	1500	4720-4725	5	7.0	74	79	Marl oozes and Limestone	Quaternary L. Cretaceous
5	1	9/9	1945	4725-4726	1	0.2	79	80	Limestone	L. Cretaceous
Total					31	23.2		80		
% Cored					38.7%					
% Recovered						14.8%				
Hole 127B										
1	1	9/10	0430	4815-4816	1	0.5	16.5[b]	166	Breccia + Limestone	L. Cretaceous + Pliocene

[a]Measurements based on an initial contact of the drill string with the sea bed at 4646 meters below the derrick floor.

[b]Measurement based on an initial contact of the drilling string with the sea bed at 4646 meters.

Core 1 was punched in with no circulation or rotation; however, when it arrived on deck it was too soupy to split aboard ship (hence, no core photographs). The other coring attempts required brief periods of circulation. The first sign of the limestones came while finishing the cutting of Core 4. It consisted of a marked slowdown accompanied by the now familiar erratic and strong torquing. More than 35 minutes were spent trying to cut the last meter of Core 4. When it was brought on deck, a small fragment of limestone was wedged in the core catcher assembly. Core 5 followed immediately, but after two hours of solid grinding, no noticeable progress had been made in this unit. The level of this first encounter led us to entertain a working hypothesis that these carbonates constitute a steeply dipping interface in the inner wall of the trench (i.e., 363 meters of vertical relief in 603 meters of horizontal displacement $\cong 30°$, as shown in Figure 6).

Operations at Hole 127B

Again the drill pipe was brought above the mud line. This time the *Challenger* returned toward the trench plain to a point 472 meters from the beacon and some 40 meters onto the flat trench floor.

Hole 127B was spudded in order to determine whether or not the Cretaceous rocks represent an inclined sheet would be the case with an olistostrome model for their origin. A straight-line connection of the two previous encounters predicted that these rocks might lie about 180 meters below the sea bed (Figure 6). In actuality they were first reached at 165 meter below bottom while working down with a center bit insert.

Upon hitting the hard formation, drilling was continued for 35 minutes of strong torquing with no observable penetration. Subsequently, the center bit was retrieved and the core barrel inserted. The coring continued for over three hours. With a gain of less than one meter, we finally realized the futility of grinding precious hours away when so much had already been learned through the use of offsets.

Next we planned a drill hole on the seaward edge of the plain. We were very anxious to recover the stratified trench fill and see if we could correlate individual strata across the narrow sediment body. We were curious as to, and wished to establish the true dip angle of these beds and see how the tilting of the plain floor influences the distribution of trench sediments. Furthermore, we wanted to check the remote possibility that the trench fill itself was *décolled*, or possibly stratigraphically repeated, through deformation seaward of the innerwall (a hypothesis proposed by Scholl *et al.*, 1968 in order to reconcile the presence of undisturbed sediment in the Peru-Chile Trench with the possibility of plate convergence).

Operations at Site 128

We chose as a target a point some 3.4 kilometers southwest of Hole 127, equivalent to 1104 hours on the approach profile of Figure 3. Here the surface of the trench plain was some six meters shallower than at the landward edge. The superficial sediments were observed to be ponded against the base of the gently sloping outer wall.

In order to save tripping time, the maneuver from Hole 127B was undertaken with the 4400-meter-long drill string

TABLE 3
Core Inventory – Hole 128

Core	No. Sections	Date	Time	Cored[a] Interval (m)	Cored (m)	Recovered (m)	Subbottom[b] Penetration (m) Top	Bottom	Tentative Lithology	Age
1	2	9/10	1200	4672-4681	9	2.0	22	31	Sands and Marl oozes	Quaternary
2	7	9/10	1410	4701-4710	9	9.3	51	60	Marl oozes	Quaternary
3	7	9/10	1655	4729-4738	9	10.0	79	88	Marl oozes and Sapropels	Quaternary
4	4	9/10	1905	4757-4766	9	6.0	107	116	Marl oozes and Sapropels	Quaternary
5	6	9/10	2105	4794-4803	9	9.5	144	153	Marl oozes	Quaternary
6	8	9/10	2320	4842-4851	9	11.0	192	201	Marl oozes	Quaternary
7	6	9/11	0145	4896-4905	9	9.0	246	255	Marl oozes	Quaternary
8	4	9/11	0435	4954-4963	9	6.5	304	313	Marl oozes and Sapropels	Quaternary
9	1	9/11	0745	5010-5019	9	0.5	360	369	Marl oozes and Sapropels	Quaternary
CB3		9/11	1030	5019-5065		0.2kg	369	415	Marl oozes	Quaternary
10	4	9/11	1310	5065-5074	9	5.5	415	424	Marl oozes and Sapropels	Quaternary
CB2		9/11	1740	5074-5124		1kg	424	474	Marl oozes	Quaternary
11	3	9/11	2005	5124-5125	1	4.4	474	475	Marl oozes	Quaternary
CB3		9/11	2315	5125-5130		0.1kg	475	480	Marl oozes	Quaternary
Total					91	73.7		480		
% Cored					18.9%					
% Recovered						80.9%				

[a]Drill pipe measurement from derrick floor.

[b]Measurements based on a contact of the drilling string with the sea bed at 4650 meters below the derrick floor. This value should read 4644 meters.

hanging below the ship. At 0600 hours on September 10, the vessel commenced to offset back over the original beacon and then continued southwest using the beacon as a guide. At 0715 hours the beacon signal was lost, so the *Challenger* proceeded at 0.7 knots by dead reckoning. At 0850 hours we stopped, since the precision echo sounder showed the depth to have shoaled to the desired isobath on the seaward edge of the gently sloping trench plain. At 0900 hours a new beacon was dropped marking the site of Hole 128.

The first registered contact with the bottom was with a drill string length of 4650 meters. As with previous arguments, this value appears to be too large by some six meters, if matched with the echo-soundings.

The initial drilling and coring proceeded rapidly and the recovery was good. Cores were spaced to try to omit the intervals representing strata previously cored in Hole 127. Success in this would enable accurate time lines to be drawn and *in situ* dips calculated. Gas expansion cracks were observed in Core 7, and the liner of Core 8 exploded on deck. The amount of sediment brought up in Core 9, at 369 meters below bottom, was low, and the operations manager suggested that we insert the center bit and check the seating of the inner core barrel in the bottom hole assembly. We proceeded with 45 to 50 meters of drilling with the center bit, followed by one core and then a return to the center bit. The hole was terminated at 480 meters when we surpassed the age of the oldest trench fill recovered in Hole 127. No sign of hard rocks was noted though the marl oozes became quite stiff and three hours were spent in penetrating the last five meters even with the center bit in place.

A Varel Diamond bit was used for all the holes drilled. The bit was badly worn after some 50 rotating hours. Most of the damage had probably occurred in the Cretaceous limestones. The recovery of Quaternary sediments was satisfactory. However, the bit was not at all effective in cutting the rock foundations and necessitated the termination of three holes because of the excessive time being spent without penetration.

BIOSTRATIGRAPHY

Calcareous microfossils are present in abundance in all the cores investigated from the Hellenic Trench, including the pieces of limestone which had caused such difficulties in drilling. The fossil groups represented include

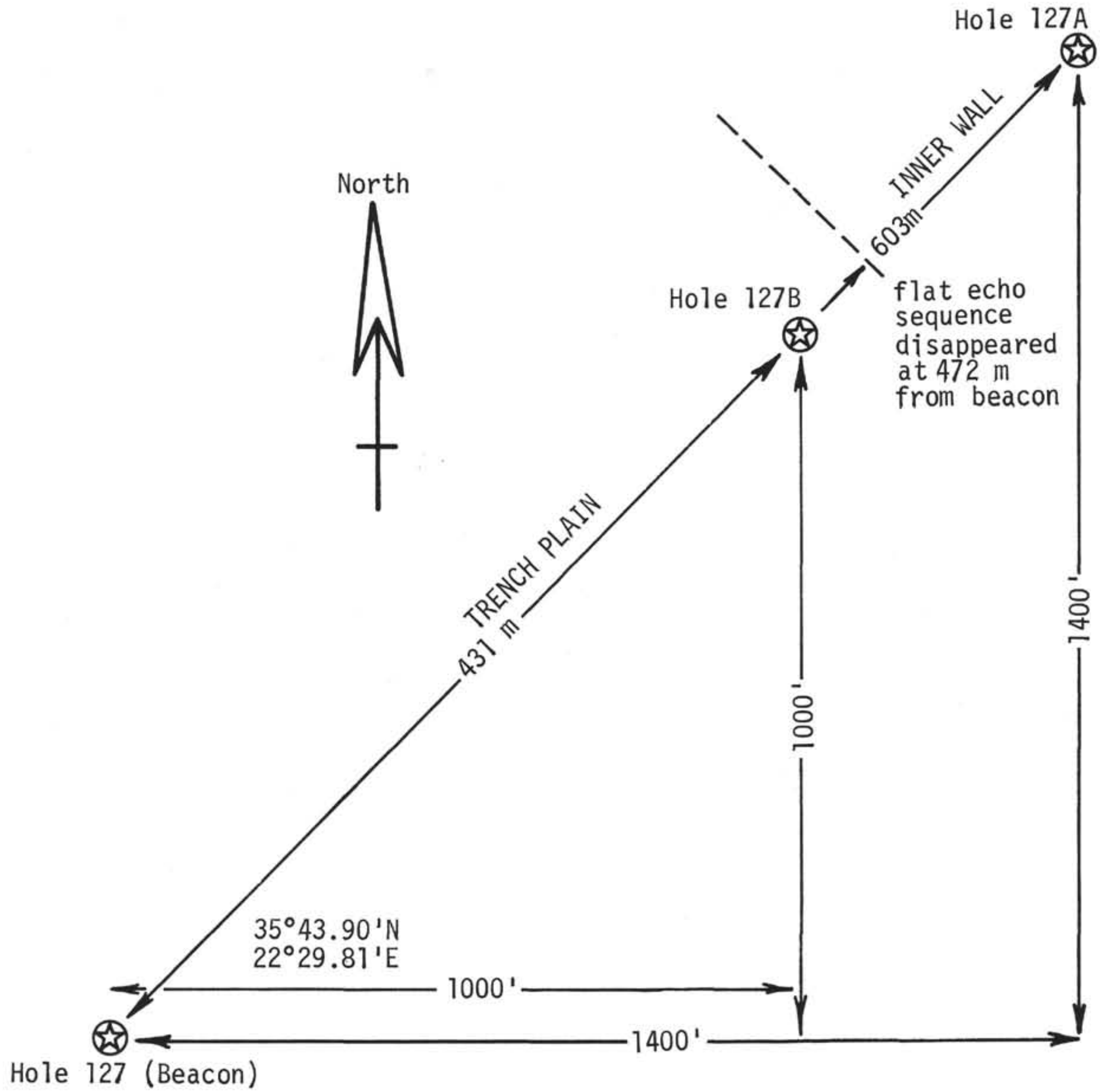


Figure 5. *Plan view of the three drill holes at Site 127. Hole 127 was drilled over the acoustic beacon. Holes 127A and 127B were positioned with offsets of 1400'N, 1400'E and 1000'E, respectively. The echo trace from the flat plain on the trench floor was lost while offsetting to Hole 127 at a distance of 472 meters from the beacon.*

foraminifera, both planktonic and benthonic. The former are more or less abundant; however, their relative abundance from sample to sample and their diversity are quite variable, being influenced by the mechanics of particular sedimentation processes. The specimens are often distinctly sorted by size. This aspect will be discussed in more detail in a later section.

The benthonic foraminifera are usually subordinate in number and at many levels include displaced shallow-water species.

The trench fill penetrated at both margins in Holes 127 and 128 is Quaternary. The limestones recovered from the vicinity of the inner wall in Holes 127, 127A, and 127B, on the other hand, are early Cretaceous in age. They yielded a limited number of shallow-water benthonic foraminifera, mainly imperforate, with arenaceous (*Orbitolina*) or calcareous (Miliolids) tests. (see section on benthonic foraminifera, in particular Chapter 41.2 of this volume).

Calcareous nannofossils are common throughout the section and appear to be less affected by sedimentary control than the foraminifera. Reworking is always present, but in a limited proportion, and mainly involves Pliocene components mixed into the Quaternary host sediment. No reworking has been detected in planktonic foraminifera of the samples investigated, the only exception being *Sphaeroidinellopsis seminulina*, reworked from the Pliocene, occurring in 127-6, CC.

Radiolaria, diatoms, silicoflagellates, chrysomonads, and ebridians occur at different levels, and their presence appears to be related to periods of bottom stagnation. During these periods, productivity of siliceous plankton was apparently greatly stimulated.

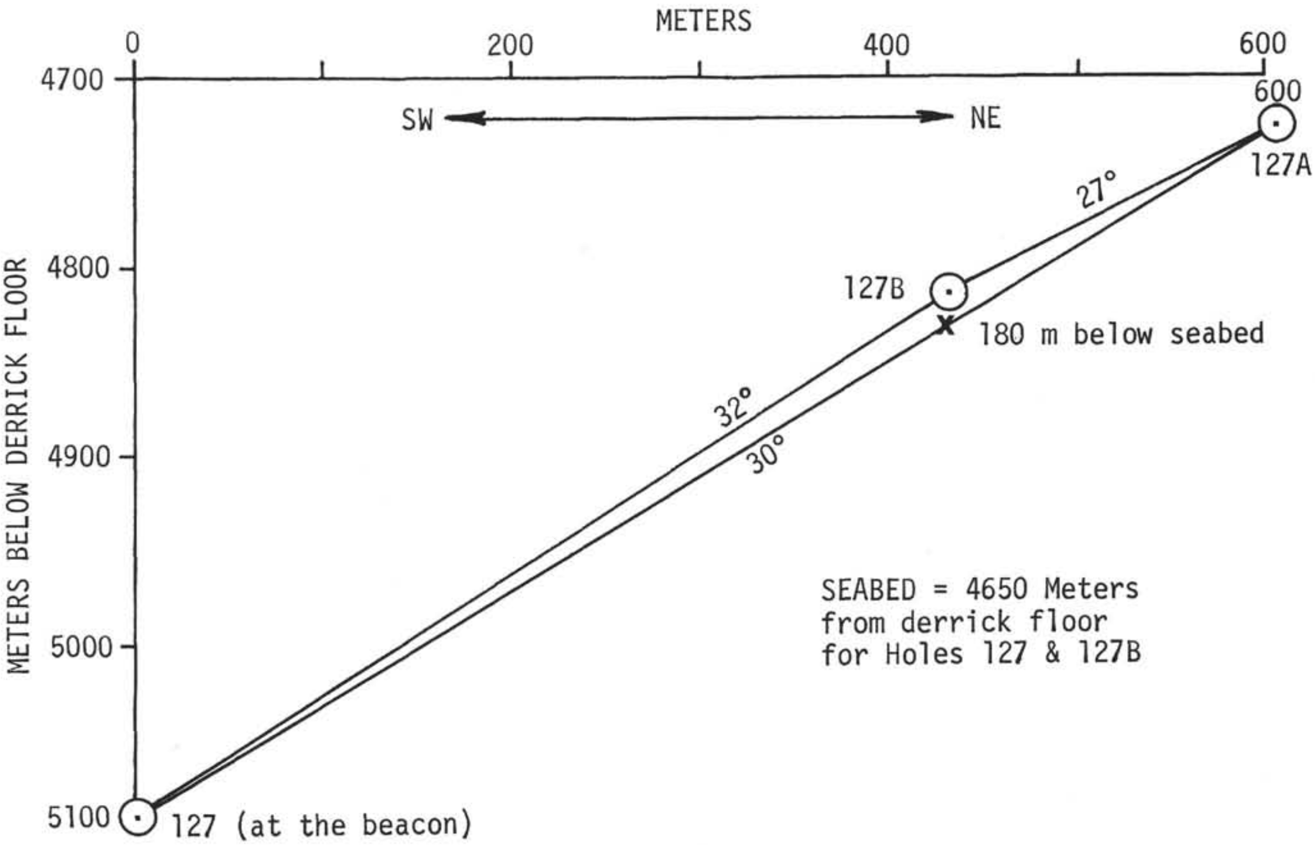


Figure 6. *A cross-section along a southwest-northeast profile connecting the three drill holes at Site 127, showing the depths below the derrick floor where the Lower Cretaceous limestones were encountered. The three occurrences form an artificial surface that dips towards the trench axis at an angle between 27 and 32 degrees.*

Also present are pteropods, which represent the bulk of the fraction greater than 63 microns in the topmost sediment (Core 1 Hole 127A) cut directly at the sea floor. Their shells are extremely thin, delicate and transparent, with species belonging to the genus *Limacina* being dominant. Lower in the section their occurrence is scattered, both in Holes 127 and 127A, and trochospiral forms are dominant. In Hole 128, pteropods were most noticeable in Cores 1, 3, and 4-8.

Other fossils encountered include pelecypods, occurring as fragments of shells and as prodissoconchs (127-1, CC; 127-3, CC; 127A-1-1 and 1-2; 124-14-4); rarely occurring otoliths, as for example in Core 127-3, CC; ostracods, sparse and rarely occurring as in Cores 127-2, CC, 127-4-4, 128-2, 128-3-5, 128-4, and 128-7.

Holothurian sclerites were observed at many intervals; however they are never common (see, for instance 127-1, CC; 127-8, CC); spicules of siliceous sponges are commonly found (127-1, CC; 127-2, CC; 127-6, CC; 127-7, CC; 127-13, CC; 127-14, CC; 127A-1, CC; 127A-2, CC; 127A-3, CC) and often abundant. The same is true of microascidites (sphaerical calcareous enclosures) of tunicates.

Also very interesting is the occurrence of sapropelitic layers at two discrete intervals below the sea floor (Cores 3 and 4 of Hole 128 = Cores 5 and 6 of Hole 127, and Cores 8 to 11 of 128 = Cores 13 and 14 of Hole 127.). Consequently, there is an occurrence of rich assemblages of siliceous microfossils (Figure 7) alternating with layers which are entirely void of these fossil remains.

Stratigraphic Inversion in Hole 127

The indurated shallow-water Cretaceous limestones initially encountered at 427 meters below bottom in Hole 127 seaward of the trench floor-inner wall boundary were discovered to unconformably overlie (Figure 8) plastic nanno oozes of Upper Pliocene age (*Sphaeroidinellopsis subdehiscens* Interval Zone). The limestones themselves were buried under Quaternary trench fill which was dominated by redeposited marl oozes as compared to the truly pelagic facies of the Pliocene. Probably a gap of more than one million years separates the oldest trench fill at Hole 127 from the Pliocene nanno ooze. Since we cored trench strata in Hole 128 which are older than any equivalents at Hole 127, we feel that the intercalation of the Cretaceous limestones somehow also involved the removal of part of the sedimentary fill at this site in the trench.

Since this is the first time—according to available information—that a reversed section has been penetrated in a deep basin, and since this is also the first time a drilling site has been located near the foot of the landward wall of an oceanic trench, some significance should be placed on this finding. In fact, the inversion was not just coincidental because the drilling in Hole 127B, some 431 meters closer

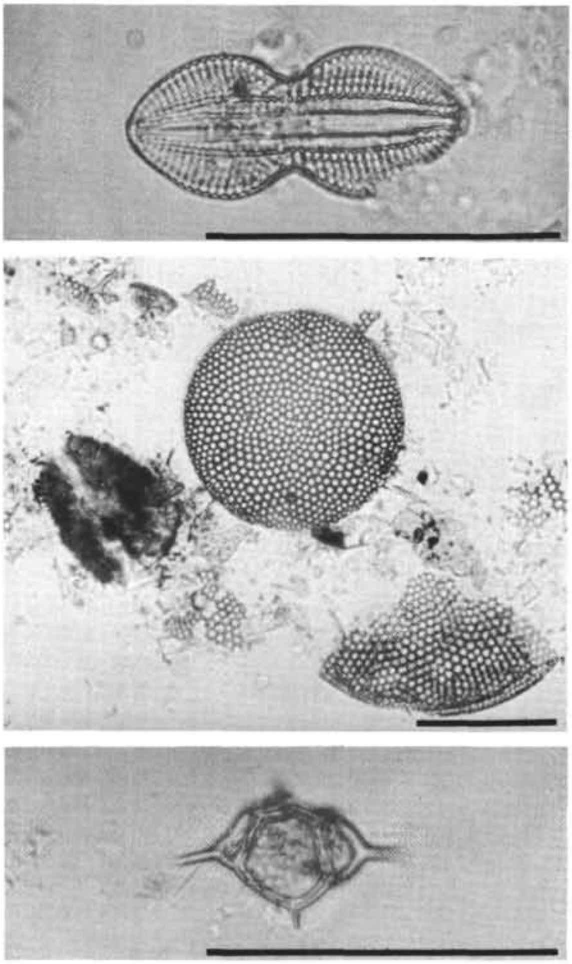


Figure 7. *Siliceous microfossils from Core 5 of Hole 127. Upper photomicrograph illustrates* Diploneis Gombus *Ehr from Section 6 at 110 cm; middle one shows* Coscindodiscus oculus-iridis *Ehr at 135 cm.* Dictyocha-fibula *from Section 5 at 138 cm. is pictured in the lower frame. Scale bar represents 50 microns.*

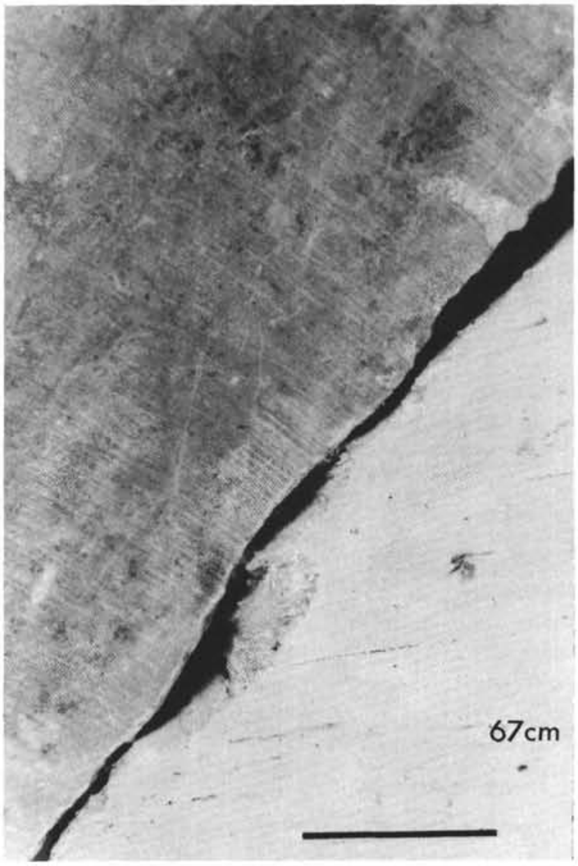


Figure 8. *Angular unconformity between shallow-water Lower Cretaceous limestone (upper left) and Pliocene pelagic nanno ooze (lower right). This contact was recovered at 67 cm in Section 1 of Core 18 of Hole 127 on the trench plain, at a below bottom depth of approximately 435 meters. Scale bar represents 1 cm.*

to the landward wall, also recovered similar Cretaceous limestone blocks (Figure 9) interbedded with pelagic sediment of Pliocene age. This time, however, it was an indurated greenish gray *Orbulina-Globigerina* sediment (see the following section on the Pliocene).

Rates of Sedimentation (M.B.C.)

The rate of sedimentation at Site 127 can reasonably be estimated only for the Quaternary, and only for Hole 127, where the cored section was thickest (427 m). The thickness was greatest near the axis of the trench proper, and thinner up on the inner wall of Hole 127A (78 m). In Holes 127A and 127B, the reduced thickness does not necessarily reflect the original rate of sediment accumulation since the sections here are by no means complete.

If the bottom of the Quaternary at 427 meters below bottom in Hole 127 is considered Lower Pleistocene, as suggested by the nannofossil assemblages, the rate of sedimentation for the Quaternary should exceed 20 $cm/10^3\mu$. In fact, the thickness of the Quaternary at Hole 128 indicates a rate of approximately 26 $cm/10^3\mu$. This figure is high even if we take into account the displaced nature of most of the section. However, considering that a vast amount of the sediment is a rather homogeneous marl ooze, the sequence here calls to mind the one found at Site 121 in the Alboran Basin in the western Mediterranean. However, the value is lower than that found for the (turbidite) Quaternary sequence penetrated in the Levantine Basin (Sites 130 and 131) where values in excess of 30 $cm/10^3\mu$ have been recorded.

Paleoenvironment (M.B.C.)

The Quaternary section penetrated at Site 128 yields valuable information on the paleoenvironment of the Hellenic Trench during Quaternary times.

The distribution of calcareous micro- and nannofossils speaks in favor of a redistribution of fossil remains by bottom currents and/or turbidity currents. Evidence of sorting in foraminifera is very clear in most samples investigated, particularly in the core catcher samples of Cores 4, 8 and 9 of Hole 128. In these samples only a few specimens occur, all belonging to small-size species, often immature, and usually smaller than 100 microns in diameter.

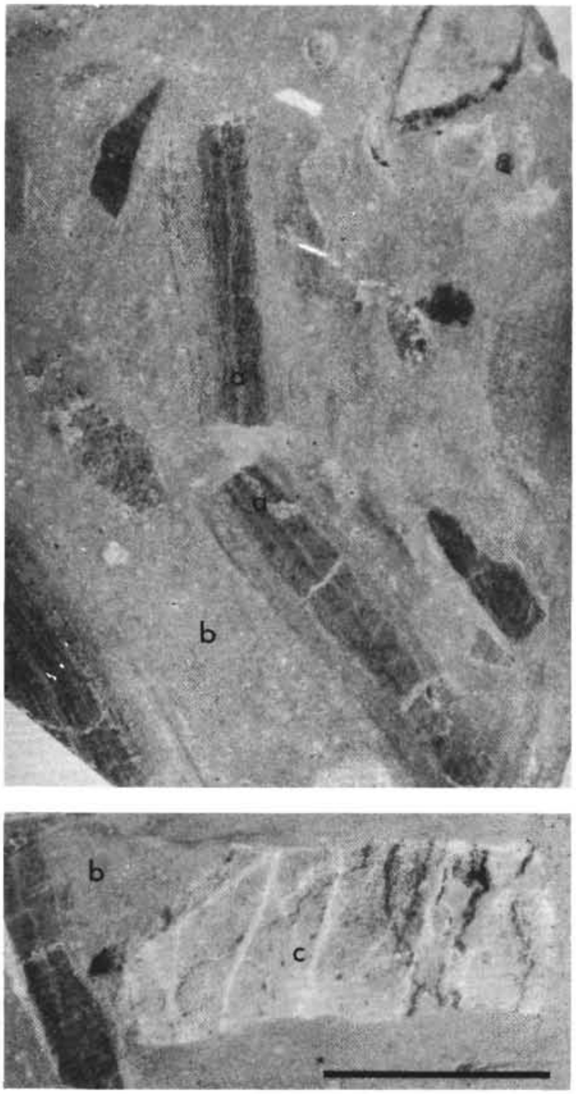


Figure 9. *Fragments of Cretaceous dolostone and limestone floating in an indurated matrix (b) of Pliocene* Orbulina-Globigerina *ooze. These polished sections are from Core 1 of Hole 127B at a subbottom depth of 79 meters. Note two pieces of laminated micritic limestone (a) broken apart from each other. Some of the Cretaceous blocks have been heavily fractured (c) before being incorporated in the breccia. Scale bar represents 1 cm.*

Displaced faunas, including shallow-water benthonic foraminifera associated with deep-living ones, have been observed at various intervals.

Opposed to the poor and small-sized assemblages noticed above, are the extremely rich, diversified and unsorted faunas found at some intervals, as for instance in Cores 3-5, 68-70 cm; 8-4, 70-72 cm; 8-4, 79-81 cm; 10, CC; and 11, CC of Hole 128. They may be defined as foraminiferal sands, because the sand fraction is abundant, and for the greatest part, consists of tests of planktonic foraminifera. These levels may occur in the basal part of a sand horizon, and may even be interlaminated in a sapropelitic layer. The content of foraminifera per gram of sediment is 100 or more times greater in the foraminiferal sand than in the marl oozes.

The possible resedimentation of planktonic foraminifera has to be taken into account for their paleoclimatic interpretation, since size sorting may locally concentrate cold-water or warm-water indicators which have been displaced from their original site of burial (see Figure 10).

The occurrence of microfossils in the sapropelitic layers appears to be related to local conditions very different from the normal ones. Foraminifera are sparse or absent, but are locally concentrated in millimeter laminae. The rich assemblages interbedded in the sapropelitic layers can hardly be defined as oligotypical, since they yield 8 to 10 species of planktonic foraminifera, while the normally diversified ones from the Quaternary of this site usually yield less than 20 species. However, a reduced number of specimens belonging to the genus *Globigerinoides* mostly referable to *G. ruber*, was observed while the genus *Globorotalia* is represented by a reduced number of *G. inflata*. The bulk of the fauna in the upper sapropelitic interval (Cores 3 and 4) is given by specimens referable to two populations: *Globigerina bulloides* and *G. eggeri.*

The finding of these species in sapropels is in agreement with those by Parker (1958), who studied the piston cores collected by the Swedish Deep Sea Expedition in the eastern Mediterranean. Ryan (1971), comparing the paleoclimatic curves given by Parker with the paleoclimatic curve obtained for the Caribbean and the North Atlantic by Emiliani (1966), arrived at the conclusion that the abundance of some species, for example *Globigerina eggeri, G. bulloides, Globigerinoides ruber*, is controlled by factors other than water temperature–such as salinity. The named taxa are euryhaline[3], and their abundant in and near the sapropelitic layers is in agreement with the model proposed by Olausson (1961) on the distribution of salinity and temperature in the water masses in the eastern Mediterranean during periods of large variations in the sea level.

Also in agreement with this model are the findings of rich assemblages of radiolaria and diatoms in the sapropelitic layers.

The abundant occurrence of these organisms in the present seas is limited to areas of high productivity, i.e., the tropical current system and areas of upwelling. However, tropical currents did not extend into the Mediterranean during the Quaternary. Upwelling, implying vertical mixing of the water masses, contradicts the model of sapropel genesis that postulates distinct stratification of water masses. This is one reason why Olausson believed that the origin of sapropel was somehow related to the influx of Black Sea waters. During periods of low sea level (=glaciation), the Black Sea could become completely separated from the eastern Mediterranean, allowing it to develop into a fresh water basin, rich in nutrients and in silica brought in by the rivers. Both this nutrient-rich fresh water and silica would then have been flushed into the eastern Mediterranean during periods of rising sea level (=deglaciation), resulting in an increasing productivity of siliceous plankton.

[3] *Globigerina eggeri*, according to Ruddiman (1969) indicates low salinity in the superficial waters.

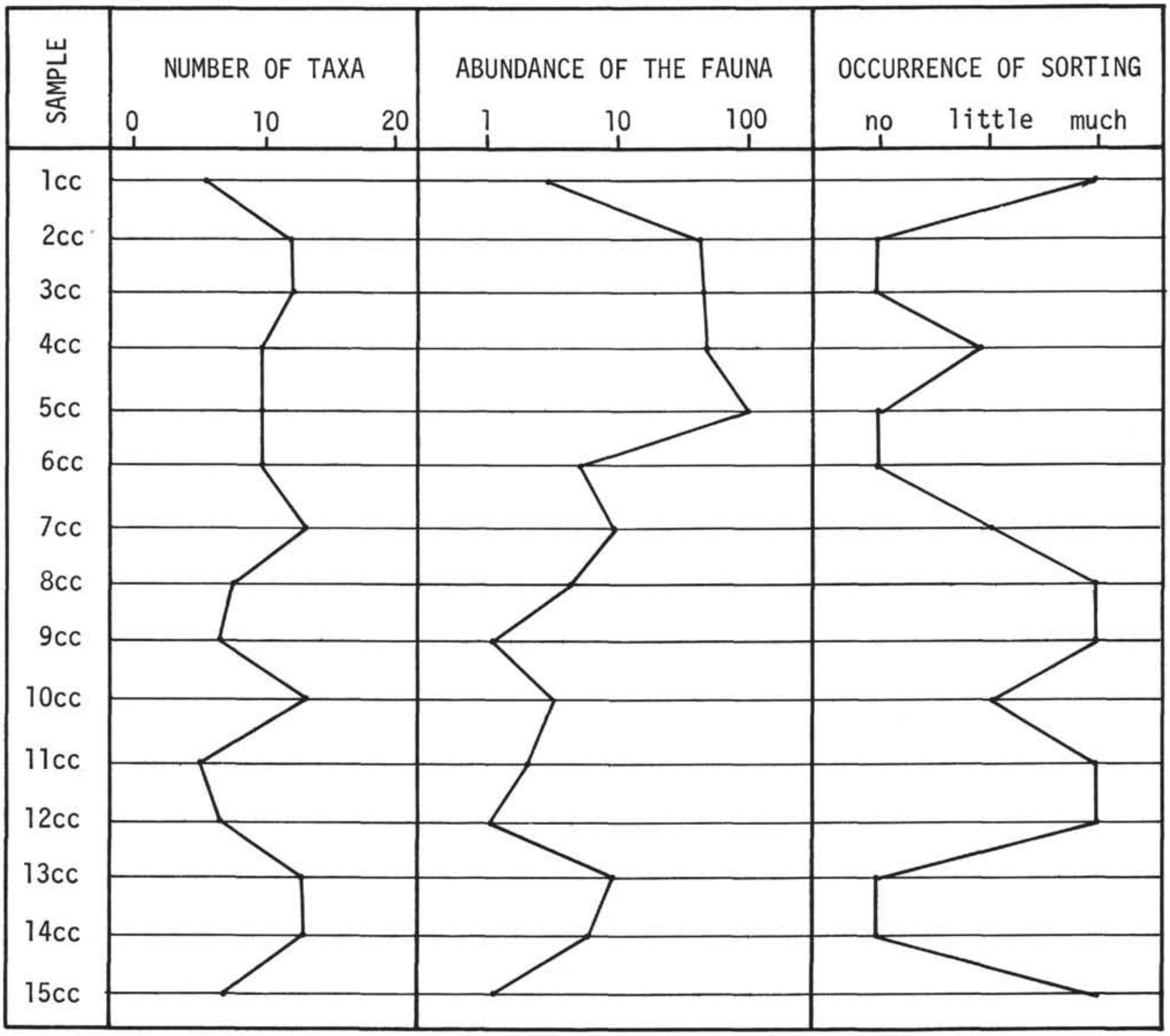


Figure 10. *Diversity, abundance and sorting observed in the planktonic foraminifera occurring in fifteen samples investigated from the Quaternary section of Hole 127 on the Hellenic Trench Plain.*

Most of the Quaternary section, and especially the sapropelitic layers, are rich in spicules of siliceous sponges (Hexactinellids). These fossil remains usually represent only a minor component of the deep-sea sediments. All the living forms are sessile and their depth habitat, even for the living forms, is not known in detail. It is widely believed that they do not live at great depths. However, it seems to be proven that they may be uprooted and still survive—leading a planktonic way of life.

The unusual abundance of these fossil remains in the sapropels may have resulted from a combination of factors, such as stimulated productivity of organisms possessing siliceous skeletons because of the influx of the silica-rich fresh water from the Black Sea and resedimentation by submarine currents.

Planktonic Foraminifera (M.B.C.)

Planktonic foraminifera occur throughout the penetrated section; however, their abundance and diversity are highly variable in the samples investigated.

As previously discussed, this is considered to be the result of a redistribution of the sediments, including their fossil content, caused by bottom and/or turbidity currents rather than being a response to evolution.

The only species, the range of which is limited to some definite intervals within the Quaternary, and which is not necessarily related to the sedimentary control, are *Globorotalia truncatulinoides* and *G. tosaensis*. The former is present from Core 1 to Core 8 of Hole 128 in the trench plain, with the exception of intervals with poor, small-sized faunas. The range of *G. tosaensis* appears to be restricted to Core 6. The absence of both taxa in the lower part of the Pleistocene confirms similar findings in other Mediterranean Sites (see, for instance Chapters 3 and 13).

Recent

Of special interest is Core 1 (127A) which contains the present day sediments of the Mediterranean. The sediment is a brownish mud and is very watery. Therefore the core was not split while aboard the vessel. One sample was examined from the top of each section (three in all), plus the core catcher sample.

No significant variations have been observed in the faunal composition of the core, which represents a time span of some 40,000 years according to the sedimentation rate estimated (see above). Only the fraction greater than 63 microns from the core catcher sample is very small and poor in organogenic content. The core under discussion, however, is by no means suitable for detailed paleoecological investigations, the sediment having been artificially disturbed.

The preservation of the fossils is excellent, the tests are usually very thin, and both *Globigerinoides ruber* and *Globigerina rubescens* often keep their characteristic pink color. The recorded taxa include:

Globigerina bulbosa Leroy
Globigerina bulloides d'Orbigny
Globigerina calida Parker
Globigerina digitata Brady
Globigerina praedigitata Parker
Globigerina quinqueloba Natland
Globigerina rubescens Hofker
Globigerinita glutinata (Egger)
Globigerinoides elongatus (d'Orbigny)
Globigerinoides quadrilobatus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)
Globigerinoides sacculifer (Brady)
Globigerinoides trilobus (Reuss)
Globorotalia scitula (Brady)
Hastigerina pelagica (d'Orbigny)
Orbulina universa d'Orbigny

Neither *Globorotalia truncatulinoides* nor *G. inflata* have been recorded. *Globigerinoides conglobatus* is also absent.

Hastigerina pelagica, though never abundant, represents a typical constituent of the fauna and is present as large sized specimens.

The abundance of warm-water indicators such as *H. pelagica, G. sacculifer, G. ruber* (tapering) and the scarcity or absence of cold-water indicators speak in favor of a warm-temperate climate.

Pleistocene

Cores 1 to 16 of Hole 127 and 2 to 4 of Hole 127A, and 1 to 11 of Hole 128, compare well with other Pleistocene intervals cored during Leg 13.

No range chart is given for the Hellenic Trench sites, since the principal reason for which range charts are built (biostratigraphic control) is nonexistent here, the distribution of foraminifera being controlled by other factors.

The species recorded from this interval, on a whole, are as follows:

Globigerina bulbosa Leroy
Globigerina bulloides d'Orbigny
Globigerina eggeri Rhumbler
Globigerina pachyderma (Ehrenberg)
Globigerina praedigitata Parker
Globigerina quinqueloba Natland
Globigerina rubescens Hofker
Globigerinita glutinata (Egger)
Globigerinita uvula (Ehrenberg)
Globigerinoides conglobatus (Brady)
Globigerinoides elongatus (d'Orbigny)
Globigerinoides helicinus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)
Globigerinoides quadrilobatus (d'Orbigny)
Globigerinoides sacculifer (Brady)
Globigerinoides trilobus (Reuss)
Globorotalia acostaensis Blow
Globorotalia dutertrei (d'Orbigny)
Globorotalia inflata (d'Orbigny)
Globorotalia obesa Bolli
Globorotalia oscitans Todd
Globorotalia scitula (Brady)
Globorotalia truncatulinoides (d'Orbigny), only in Cores 127-1, 2, 4, 4, 4, 6 and Cores 128-1 to 128-8.
Globorotalia tosaensis Takayanagi and Saito (only in 127-6 and 128-6)
Hastigerina siphonifera (d'Orbigny)
Orbulina suturalis Bronnimann (only in Core 128-8-4)
Orbulina universa d'Orbigny

Pliocene

Pliocene foraminiferal nanno oozes have been found in Core 127-18-1 directly underlying a Lower Cretaceous limestone. The contact is sharp along a surface inclined at about 45 degrees (Figure 8). The bedding of the Pliocene itself however, is more or less horizontal. The sediment yielded rare angular fragments of the Mesozoic limestone.

The foraminiferal assemblage is rich and diversified, being dominated by planktonic forms which include:

Globigerina apertura Cushman
Globigerina bulloides d'Orbigny
Globigerina eggeri Rhumbler
Globigerina falconensis Blow
Globoquadrina altispira (Cushman and Jarvis)
Globorotalia acostaensis Blow
Globorotalia obesa Bolli
Globorotalia puncticulata (Deshayes)
Globorotalia scitula (Brady)
Hastigerina siphonifera (d'Orbigny)
Orbulina universa d'Orbigny
Sphaeroidinellopsis seminulina (Schwager)
Sphaeroidinellopsis subdehiscens Blow

Sedimentation was purely pelagic, and indicated a temperate climate.

The same assemblage also has been found in Core 19 from the same hole. The assemblage may be referred to the *Sphaeroidinellopsis subdehiscens* Interval Zone (lower part of the Upper Pliocene, or Piacenzian).

Planktonic foraminifera are also present in abundance in the indurated calcareous ooze which cements the breccia recovered from Core 1 of Hole 127B. The assemblage is very rich and includes *Orbulina universa, Globigerinoides* spp. (also tapering, probably belonging to *G. ruber* and/or *G. elongatus*), *Globigerina* spp., and *Globorotalia* sp. with rounded periphery, possibly belonging to *G. puncticulata.*

This assemblage is certainly Neogene. An assignment to the Pliocene is considered likely, when comparison is made with the assemblage found in Hole 127.

Benthonic Foraminifera (W.M.)

The main benthonic foraminifera determined the Pleistocene sequence obtained from Holes 127, 127A, and 128 are plotted on the distribution charts of Tables 4, 5, and 6, respectively.

As may be expected, the Quaternary trench fill does not reflect a quiet uniform sedimentation but displays numerous interbeds which prove a disturbed deposition (graded sand bodies, silt laminae, reworked sapropels, etc.). Due to these slumpings and turbidity currents, we sometimes observe a mixture of deep water and nearshore benthonic foraminifera. Littoral, even intertidal, indicators such as *Ammonia beccarii* (Linn.), *Elphidium advenum* (Cush.), *Elphidium crispum* (Linn.), and *Elphidium macellum* (Fichtel and Moll) were found to be intermixed with the predominantly open-sea deepwater associations in Cores 1, 2, 3, 4, 6, and 14 of Hole 127 and Cores 1, 2, 4, 5, 6, 7 and 8 of Hole 128. As some layers reveal only rare, minute, and partly juvenile tests of foraminifera, mechanical sorting due to bottom currents must be assumed.

In connection with the influx of benthonic foraminifera characteristic of a shallow-water environment, some minor reworking is evident within this Quaternary sequence, i.e., Pliocene discoasters, Pliocene foraminifera such as *Sphaeroidinellopsis seminula* (Schwag.) (127-6, CC), and *Siphonina reticulata* (Czjzek) in Cores 127-3 and 127-4. *Uvigerina gaudryinoides siphogenerinoides* Lipp., present in Cores 127-7 and 127-13, is an Upper Miocene (Messinian) form.

Summary of Nannofossil Age Determinations (H.S.)

Of the four holes drilled in the Hellenic Trench, three were found to contain nannofossils: 127, 127A, and 128.

Hole 127

Within the Quaternary, which extends from Core 11 to Core 15, four different assemblages can be identified by the relative abundance of some species of coccoliths. Due to reworking, practically the entire list of Tertiary, and also some Cretaceous nannofossils, could be assembled with sufficient patience, but these allochthonous-heterochronous coccoliths and discoasters are not nearly so abundant as the Quaternary nannofossils are.

Cores 1 to 6 have *Helicosphaera carteri* as the dominant species. From Core 4 up to Core 1 there are also rare autochthonous specimens of *Oolithotus antillarum* and *Discoaster perplexus.* Their occurrence lies within the top layer (Unit 1 in Hole 127 and Cores 1 to 5 in Hole 127A). In Hole 128, *Oolithothus antillarum* and *Discoaster perplexus* could even be found as deep down as Core 5, which is Unit 2. Age assignment for this assemblage:? NN 21, which corresponds to N 23, Sicilian.

Cores 7 to 11 of Hole 127 have *Gephyrocapsa oceanica* as the predominant species. This zone, which also is present in Hole 128 from Core 6 to Core 8, is of Emilian or Upper Calabrian Age and lies in the lower part of Unit 2 and in the upper part of Unit 3.[4] Age assignment: NN 20, *Gephyrocapsa oceanica* Zone, Middle to Upper Quaternary.

Cores 12 to 14 contain a nannoplankton assemblage with *Pseudoemiliania lacunosa* as the most common species, which also is found in Hole 128 from Core 7 to Core 8. This *Pseudoemiliania lacunosa* Zone NN 19, or the upper part of it, is represented in the lower part of Unit 3 and in Unit 4 at this site and belongs to the pre-Glacial Quaternary.

In the lowest part of the Quaternary section, that is in Core 15, there is a peak of abundant *Reticulofenestra pseudoumbilica.* Also in Hole 128, in Cores 9 and 10, there is a peak of this species, however, less pronounced. These peaks lie in the lower part of the *Pseudoemiliania lacunosa* Zone, within the lithostratigraphic Unit 4. According to the nannoplankton zonation of Martini and Worsley, *Reticulofenestra pseudoumbilica* has been extinct since Middle Pliocene time. This apparently is not the case in the Mediterranean where it either has an extended range, or some other species has evolved to produce homeomorphic coccoliths.

Cores 18 and 19, just below the light gray Lower Cretaceous limestone, contain a nannoplankton assemblage with *Discoaster surculus, Discoaster pentaradiatus* and *Discoaster brouweri:* Nannoplankton Zone NN 16, the *Discoaster surculus* Zone of Upper Pliocene age.

Hole 127A

Of the 5 cores recovered from Hole 127, only Cores 1 to 4 contain Quaternary nannofossils; mostly very small coccoliths. Among the larger species, *Helicosphaera carteri* is rather common. The ages range from Holocene (Core 1 was taken just below sea floor) with *Emiliania huxleyi,* to Sicilian in Core 4, 80 meters below bottom. All these cores lie within lithostratigraphic Unit 1. Also, *Discoaster perplexus* and *Oolithotus antillarum* occurred in these cores. These two characteristic nannofossils are rare but significant representatives of the Upper Pleistocene in the eastern Mediterranean. They were also reported in the Alboran Sea (Bartonlini, 1970) and in the Caribbean Sea (Cohen, 1965).

Observation of the soupy consistency of the fresh liquid ooze of the sediment top layer shows that such liquid or semi-liquid emulsion-like sediments may readily flow down into submarine depressions or trenches and are easily mixed with older unconsolidated sediments.

Hole 128

As mentioned above and also as shown in the established stratigraphic correlations between the various drill holes, there is good agreement between the nannoplankton assemblages of Hole 128 and those of Holes 127 and 127A.

[4]See lithostratigraphy

TABLE 4
Range Chart of the Benthonic Foraminifera in Hole 127 – Hellenic Trench Plain

Age	Depth Below Sea Floor (m)	Cores	Quinqueloculina oblonga (Mont.)	Bolivina cf. catanensis Seg.	Bolivina cf. punctata d'Orb.	Angulogerina angulosa (Will.)	Asterigerina planorbis (d'Orb.)	Elphidium advenum (Cush.)	Cassidulina carinata Silv.	Articulina tubulosa (Seg.)	Hauerinella inconstans (Brady)	Lagena pseudorbignyana Buchner	Lagena cf. sulcata (Walk. & Jac.)	Fissurina cf. wiesneri Barker	Bolivina subspinescens Cush.	Neoconorbina terquemi-orbicularis	Spirillina vivipara Ehrenbg.	Pleurostomella alternans Schwag.	Patellina corrugata Will.	Cassidulina subglobosa Brady	Spiroplectammina wrighti (Silv.)	Bolivina alata-beyrichi
	Sea Floor 4664m																					
	18-27	1	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮				
	27-36	2			▮	▮	▮		▮					▮	▮	▮			▮	▮	▮	▮
	36-45	3	▮	▮	▮					▮						▮				▮		
	83-92	4				▮										▮				▮		▮
	92-101	5	▮						▮									▮		▮	▮	
	101-110	6			▮	▮			▮	▮						▮						▮
Pleistocene	158-167	7	▮	▮		▮							▮		▮					▮		
	167-176	8	▮		▮	▮							▮		▮		▮			▮		▮
	224-233	9	▮																	▮		▮
	281-284	10							▮											▮		▮
	299-308	11			▮													▮				
	327-336	12																				
	364-373	13	▮																	▮		
	373-383	14				▮		▮	▮											▮		▮
	383-420	CB1					▮								▮					▮		
	420-427	15		▮											▮					▮		
	427-429	16																				
Middle Pliocene with lower calcareous blocks	429-435	17																				
	435-436	18			▮	▮									▮			▮		▮		
	436-43	19																				

Depth Below Sea Floor (m)	Cores	Bolivina catanensis Seg.	Bulimina costata d'Orb.	Siphonodosaria monilis (Silv.)	Uvigerina peregrina-mediterranea	Discorbis globularis (d'Orb.)	Valvulineria bradyana (Forn.)	Nonion padanum-barleeanum	Epistomina elegans (d'Orb.)	Martinottiella communis (d'Orb.)	Siphonina reticulata (Czjzek)	Elphidium crispum (Linn.)	Cibicides pseudoungerianus (Cush.)	Valvulina pennatula (Batsch)	Karreriella bradyi (Cush.)	Pyrgo cf. subsphaerica (d'Orb.)	Lagena gracillima (Seg.)	Robulus ariminensis (d'Orb.)	Planularia auris (Defr.)	Bolivina dilatata Reuss	Pulvinulinella carinata (d'Orb.)
Sea Floor 4664m																					
18-27	1																				
27-36	2	▮	▮	▮	▮	▮	▮	▮	▮												
36-45	3					▮			▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮
83-92	4	▮	▮				▮	▮	▮		▮	▮								▮	
92-101	5	▮			▮		▮		▮											▮	
101-110	6	▮					▮	▮												▮	▮
158-167	7	▮			▮	▮															
167-176	8	▮				▮														▮	
224-233	9					▮															
281-284	10	▮			▮			▮												▮	
299-308	11					▮														▮	
327-336	12																				
364-373	13					▮														▮	
373-383	14					▮															
383-420	CB1	▮					▮													▮	
420-427	15		▮																		
427-429	16																				
429-435	17																				
435-436	18	▮	▮	▮		▮		▮		▮	▮				▮				▮	▮	
436-43	19																				

Depth Below Sea Floor (m)	Cores	Elphidium macellum (F. & M.)	Cassidulina laevigata d'Orb.	Fursenkoina davisi-schreibersiana	Nonion cf. pompilioides (F. & M.)	Bulimina etnea Seg.	Bulimina marginata d'Orb.	Uvigerina canariensis d'Orb.	Reussella spinulosa (Reuss)	Planulina ariminensis (d'Orb.)	Bolivina pseudoplicata Herr. All. & Earl	Bulimina aculeata basispinosa Ted. & Zanm.	Lagena orbignyana (Seg.)	Bulimina exilis Brady	Uvigerina gaudryinoides siphogenerinoides Lipp.	Heronallenia lingulata (Burr. & Holl.)	Cibicides cf. floridanus (Cush.)	Cibicides refulgens (Montf.)	Lagena staphyllearia inermis Buchn.	Gyroidina cf. laevigata d'Orb.	Sigmoilina schlumbergeri (Silv.)
Sea Floor 4664m																					
18-27	1																				
27-36	2																				
36-45	3	▮	▮	▮	▮																
83-92	4					▮	▮	▮													
92-101	5			▮		▮			▮	▮	▮										
101-110	6			▮		▮	▮				▮	▮									
158-167	7						▮				▮	▮	▮	▮	▮						
167-176	8						▮				▮					▮	▮	▮	▮		
224-233	9						▮							▮						▮	
281-284	10										▮										
299-308	11	▮									▮								▮		▮
327-336	12																				
364-373	13	▮									▮				▮						
373-383	14											▮									
383-420	CB1						▮	▮			▮	▮									
420-427	15																				
427-429	16																				
429-435	17																				
435-436	18	▮									▮			▮	▮			▮			
436-43	19																				

Depth Below Sea Floor (m)	Cores	Spiroloculina excavata d'Orb.	Lower Cretaceous limestock blocks with:	Orbitolina sp.	Chrysalidina cf. ?decorata (d'Orb.)	Nezzazata gr simplex Omara	Hensonella cylindrica Ell.	Textulariella minuta Hofker	Cuneolina cf. scarsellai De Castro	Valculammina aff. picardi Henson	Bacinella irregularis Rad.	Sigmoilina celata (Costa)	Lagena bradyana Forn.	Lagena longirostris (Seg.)	Bolivina spathulata (Will.)	Cibicides ungerianus (d'Orb.)	Cassidulinoides bradyi (Norman)	Trifarina bradyi Cush.
Sea Floor 4664m																		
18-27	1																	
27-36	2																	
36-45	3																	
83-92	4																	
92-101	5																	
101-110	6																	
158-167	7																	
167-176	8																	
224-233	9																	
281-284	10																	
299-308	11																	
327-336	12																	
364-373	13																	
373-383	14																	
383-420	CB1	▮																
420-427	15																	
427-429	16																	
429-435	17			▮	▮													
435-436	18			▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮
436-43	19																	

TABLE 5
Range Chart of the Benthonic Foraminifera in Hole 127A – Inner Wall of the Hellenic Trench

Age: Pleistocene. Sea Floor 4646 m. (x = species recorded in core)

Depth Below Sea Floor (m)	0-7	16-25	46-55	74-79	79-80
Cores	1	2	3	4	5
Bolivina alata-beyrichi	x	x	x		
Bolivina pseudoplicata Herr. All. & Earl.	x	x	x		
Spiroplectammina wrighti (Silv.)		x			
Karreriella bradyi (Cush.)		x			
Cyclogyra carinata (Costa)		x			
Spiroloculina excavata d'Orb.		x			
Sigmoilina schlumbergeri (Silv.)		x			
Articulina tubulosa (Seg.)		x	x		
Bolivina catanensis Seg.		x			
Bolivina dilatata Reuss		x			
Bulimina cf. *fusiformis* Will.		x			
Bulimina marginata d'Orb.		x			
Uvigerina peregrina-mediterranea		x			
Angulogerina angulosa (Will.)		x	x		
Discorbis globularis (d'Orb.)		x	x		
Neoconorbina terquemi-orbicularis		x			
Cancris oblongus (Will.)		x			
Valvulineria bradyana (Forn.)		x			
Ammonia beccarii (Linn.)		x			
Cibicides boueanus (d'Orb.)		x			
Cassidulina carinata Silv.		x	x		
Cassidulina laevigata d'Orb.		x			
Nonion padanum-barleeanum		x	x		
Quinqueloculina oblonga (Mont.)		x	x		
Lagena laevis (Montagu)		x			
Buliminella multicamera Cush. and Park.		x	x		
Uvigerina gaudryinoides siphogenerinoides Lipp.		x			
Elphidium cf. *advenum* (Cush.)		x			
Cassidulina subglobosa Brady		x	x		
Lagena marginata-bradyana			x		
Bulimina ovata d'Orb.			x		
Bulimina pupoides d'Orb.			x		
Patellina corrugata Will.			x		
Spirillina vivipara Ehrenbg.			x		
Fursenkoina cf. *complanata* (Egger)			x		
Cassidulinoides bradyi (Norman)			x		
Orbitolina sp.				x	x
Chrysalidina cf. *?decorata* (d'Orb.)				x	x
Nezzazata gr. *simplex* Omara				x	x
Valvulammina aff. *picardi* Hens.				x	x
Cuneolina cf. *scarsellai* De Castro				x	x
Nummoloculina heimi Bonet				x	x
Hensonella cylindrica Elliot				x	
Bacinella irregularis Rad.				x	
Textulariella minuta Hofker					x

TABLE 6
Range Chart of the Benthonic Foraminifera in Hole 128 – Hellenic Trench Plain

Age: Pleistocene. Sea Floor 4650m. (x = species recorded in core)

Depth Below Sea Floor (m)	22-31	51-60	79-88	107-116	144-153	192-201	246-255	304-313	360-369	369-415	415-424	424-474	474-475	475-480
Cores	1	2	3	4	5	6	7	8	9	CB1	10	CB2	11	CB3
Quinqueloculina oblonga (Mont.)	x		x	x	x	x								
Articulina tubulosa (Seg.)	x	x	x											
Buliminella multicamera Cush. & Park.	x			x	x									
Bolivina dilatata Reuss	x	x	x	x	x			x		x	x		x	x
Bolivina cf. *punctata* d'Orb.	x										x		x	
Bolivina pseudoplicata Herr. All. & Earl	x		x	x	x		x			x	x		x	x
Lagena marginata (Montagu)	x			x										
Angulogerina angulosa (Will.)	x	x	x	x	x					x	x		x	x
Discorbis globularis (d'Orb.)	x		x	x						x				x
Neoconorbina terquemi-orbicularis	x			x	x	x	x			x	x			x
Spirillina vivipara Ehrenbg.	x	x	x	x	x									
Patellina corrugata Will.	x	x	x		x								x	
Elphidium cf. *advenum* (Cush.)	x	x												
Cassidulina carinata Silv.	x	x			x		x			x	x			
Lagena acuticosta d'Orb.		x									x		x	
Lagena laevis (Montagu)		x					x							
Bolivina cf. *catanensis* Seg.		x						x		x	x			
Bulimina costata d'Orb.		x												
Bulimina marginata d'Orb.		x												
Reussella spinulosa (Reuss)		x												
Ucigerina peregrina-mediterranea		x		x		x					x			x
Cibicides lobatulus (Walk. & Jac.)		x												
Cibicides pseudoungerianus (Cush.)		x					x			x			x	
Asterigerina planorbis (d'Orb.)		x	x											
Eponides umbonatus (Reuss)		x												
Cassidulina subglobosa Brady	x	x	x	x	x		x	x		x	x		x	x
Pulvinulinella carinata (d'Orb.)			x											
Valvulineria bradyana (Forn.)			x											
Cassidulinoides bradyi (Norman)			x										x	
Bolivina alata-beyrichi			x	x	x		x	x						
Bulimina pupoides d'Orb.			x											
Eponides umbonatus stellatus (Silv.)			x											
Cassidulina laevigata d'Orb.			x				x							
Cyclogyra carinata (Costa)				x	x									
Lagena hexagona (Will.)				x							x			
Bulimina aculeata basispinosa Ted. & Zanm.				x	x									
Elphidium macellum (F. & M.)				x			x			x				
Cibicides refulgens (Montf.)				x						x				
Nonion padanum-barleeanum				x	x									
Spiroplectammina wrighti (Silv.)					x									
Bolivina cf. *spathulata* (Will.)					x									
Elphidium aculeatum (d'Orb.)					x		x	x		x				
Nonion pompilioides (F. & M.)					x									
Bulimina ovata d'Orb.							x							
Cibicides cf. *floridanus* (Cush.)								x						
Bulimina exilis Brady										x				
Planulina ariminensis (d'Orb.)										x	x			
Bolivina cf. *subspinescens* Cush.											x			
Cyroidina cf. *laevigata* d'Orb.											x			
Siphonodosaria monilis (Silv.)														

From Core 1 to 3 there is a mixed assemblage with *Helicosphaera carteri, Oolithothus antillarum,* and *Discoaster perplexus.* The bulk of nannofossils, however, are small sized coccoliths, not to be identified with certainty under the light microscope. These cores are correlated with Cores 1 to 6 of Hole 127 and with Cores 1 to 5 of Hole 127A, Nannoplankton Zone NN 21 Glacial Quaternary, Sicilian.

In Cores 4 to 6, as assemblage with a vast majority of *Gephyrocapsa oceanica* is characteristic for the NN 20 Zone of Emilian or Upper Calabrian age, which was also found in Cores 7 to 11 of Hole 127. From Cores 7 to 11, *Pseudoemilia lacunosa* is the outstanding species. By correlation with range charts from the type localities in Sicily, it can be shown that these cores are of Calabrian age (nannoplankton Zone NN 19). In Cores 9 and 10, some *Reticulofenestra pseudoumbilica* are also present, however, they are not so frequent as in Core 15 Hole 127.

From the stratigraphic correlations it may be concluded that the *Reticulofenestra pseudoumbilica* peak of Core 15 Hole 127 roughly corresponds to the peak of Core 9, Hole 128. For Cores 10 and 11 of Hole 128, no corresponding cores have been found in Holes 127, 127A and 127B. Thus Cores 10 and 11 of Hole 128 represent the oldest Quaternary sediments drilled at this site in the Hellenic trench.

The age-diagnostic nannofossil assemblages are shown below.

"Glacial Quaternary"

Samples: 13-127-1-1, 79cm; 127-1-1, 121cm; 127-1, CC; 127-2-1, 113cm; 127-2, CC; 127-3, CC; 127-4-2, 74cm; 127-4, CC; 127-5-6, 140cm; 127-5, CC; 127-6-2, 73cm; 127-6, CC; 13-127A-1, CC; 127A-2-2, 67cm; 127A-2, CC; 127A-3-1, 131cm; 127A-3-3, 71cm; 127A-3-4, 71cm; 127A-3-5, 68cm; 127A-3-6, 72cm; 127A-3, CC; 127A-4-2, 65cm; 127A-4, CC; 13-128-1-2, 90cm; 128-1-3, 82cm; 128-1, CC; 128-2-2, 72cm; 128-2, CC; 128-3-5, 59cm; 128-3, CC:

Braarudosphaera bigelowi
Ceratolithus cristatus
Ceratolithus telesmus
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Discolithina macropora
Discoaster perplexus
Gephyrocapsa oceanica
Helicosphaera carteri
Lithostromation perdurum
Micrascidites sp.
Oolithothus antillarum
Pontosphaera alborensis
Pontosphaera japonica
Pontosphaera multipora
Pontosphaera scutellum
Rhabdosphaera clavigera
Rhabdosphaera stylifera
Pseudoemilia lacunosa
Scapholithus fossilis
Scyphosphaera apsteini
Sphenolithus abies
Syracosphaera pulchra
Thoracosphaera heimi
Thoracosphaera imperforata

NN 21 Sicilian

Middle to Upper Quaternary

Samples: 13-127-7-2, 70cm; 127-7, CC; 127-8-2, 70cm; 127-9-1, 110cm; 127-9, CC; 127-10, CC; 127-11-1, 103cm; 127-11, CC; 128-4-2, 70cm; 128-4, CC; 128-5-2, 61cm; 128-5, CC; 128-6-2, 79cm; 128-6, CC:

Braarudosphaera bigelowi
Ceratolithus cristatus
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Gephyrocapsa oceanica (abundant!)
Helicosphaera carteri
Lithostromation perdurum
Micrascidites sp.
Pontosphaera japonica
Pontosphaera scutellum
Pseudoemilia lacunosa
Reticulofenestra pseudoumbilica
Rhabdosphaera stylifera
Scapholithus fossilis
Scyphosphaera apsteini
Scyphosphaera recurvata
Sphenolithus abies
Syracosphaera pulchra
Thoracosphaera heimi

NN 20 *Gephyrocapsa oceanica* Zone

Pre-Glacial Quaternary

Samples: 13-127-12-3, 73cm; 127-12, CC; 127-13, 77cm; 127-13, CC; 127-14-1, 70cm; 127-14, CC; 127-CB 1; 127-15-2, 70cm; 127-15, CC; 128-7-2, 70cm; 128-7, CC; 128-8-2, 73cm; 128-8, CC; 128-9-1, 1cm; 128-9-1, 131 cm; 128-9, CC; 128-9A(CB 1); 128-10-7, 41cm; 128-10, CC; 128-10A(CB 2); 128-11-2, 70cm; 128-11, CC:

Braarudosphaera bigelowi
Ceratolithus cristatus
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Gephyrocapsa oceanica
Helicosphaera carteri
Lithostromation perdurum
Micrascidites sp.
Pontosphaera japonica
Pontosphaera scutellum
Pseudoemilia lacunosa
Reticulofenestra pseudoumbilica
Rhabdosphaera clavigera
Rhabdosphaera stylifera
Scypholithus fossilis
Scyphosphaera apsteini
Scyphosphaera campanula
Scyphosphaera recurvata
Sphenolithus abies

Syracosphaera pulchra
Thoracosphaera heimi
Thoracosphaera imperforata

NN 19 Zone

Upper Pliocene

Samples: 13-127-18, CC and 127-19, CC:
Braarudosphaera bigelowi
Ceratolithus rugosus
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Discoaster asymmetricus
Discoaster brouweri
Discoaster pentaradiatus
Discoaster surculus
Discolithina macropora
Helicosphaera carteri
Lithostromation perdurum
Pontosphaera multipora
Pontosphaera scutellum
Reticulofenestra pseudoumbilica
Scyphosphaera apsteini
Scyphosphaera intermedia
Scyphosphaera pulcherrima
Scyphosphaera recurvata
Sphenolithus abies
Syracosphaera pulchra

NN 16 *Discoaster surculus*-zone

Siliceous Microfossils (P.D.)

From all the cores recovered at Site 128, only three (Cores 3, 10 and 11) proved to be rich in siliceous microfossils. As at Site 127, their occurrence is generally restricted to the layers of sapropelitic marls or sapropelitic "diatomites." Siliceous microfossils, particularly radiolarians and sponge spicules, are often present in marl oozes as well, their frequence in such sediments is, however, so low that practically they cannot be taken into account.

The assemblages of the three cores are generally quite similar, most species being common to all investigated samples. On their account two horizons have been distinguished: (a) An upper horizon with *Hermesinum adriaticum* and *Trigonastrum* sp., and (b) A lower horizon with *Mesocena elliptica.*

The upper horizon (a) with *Hermesinum adriaticum* and *Trigonastrum* sp. is characteristic of the assemblage of siliceous microfossils encountered in Core 3. *Hermesinum adriaticum* occurs in all samples of this core (Sections 4, 112-115 cm; 5, 20-25 cm, 135-138 cm; 6, 80 cm, 107-110 cm, 120-123 cm), whereas *Trigonastrum* sp. has only been recorded in Section 6 (80 cm, 107-110 cm). The assemblage in which these species occur includes:

Radiolarians -	*Carposphaera* sp.
	Hexacontium sp.
	Echinomma sp.
	Amphistylus sp.
	Porodiscus sp.
	Spongodiscus sp.
	Euchitonia sp.
	Spongaster tetras
	Panartus tetrathalamus
	Trigonastrum sp.
	Obeliscus sp.
	Lithomelissa sp.
	Pterocanium trilobum
	Eucyrtidium cf. *calvertense*
Silicoflagellates -	*Dictyocha fibula*
	Dictyocha stapedia
	Dictyocha aculeata
	Distephanus speculum
Ebriids -	*Hermesinum adriaticum*
Dinoflagellates -	*Actiniscus pentasterias*
Diatoms -	*Coscinodiscus oculo-iridis*
	Coscinodiscus sp.
	Actinoptychus sp.
	Biddulphia sp.
	Cocconeis sp.
	Grammatophora sp.
	Auliscus sp.
	Nitzschia sp.
Sponges -	Spicules of various types

The lower horizon (b) has been recognized both in Core 10 (Section 2) and Core 11 (core catcher and Section 3). Its particular feature is the very constant presence of the silicoflagellate *Mesocena elliptica* in Quaternary sediments, generally with a high frequency. In recent times a similar abundance of this species was recorded only in North Pacific sediments (Jouse, 1969), where it constitutes a good stratigraphic marker bracketing the Jaramillo Event in the Pleistocene. The possibility that these two strange reappearances are synchronous is not excluded.

Except for this species and a few other such as: *Polysolenia spinosa, Siphonosphaera* sp., *Lithopera bacca,* and *Distephanus octonarius*, the assemblage of this lower horizon is similar to the previous one.

The upper horizon might be correlated with that encountered in Core 5, Hole 127, where *Hermesinum adriaticum* is present as well. The same might not be valid between Cores 10 and 11 of Hole 128 and Core 14 of Hole 127, on the other hand, Site 128 the cores contain numerous specimens of *Mesocena elliptica*, whereas this species is absent in Core 14 of Hole 127.

LITHOSTRATIGRAPHY

The sedimentary sections drilled at the seaward (128) and landward (127) edge of the trench plain are directly comparable in terms of lithofacies, relative bed thickness, and origin. In fact, not only can gross lithologic units be correlated from one hole to the other, but in several cases individual beds can be traced in detail. It turns out that the ties made on the basis of lithologic comparisons are entirely consistent with biostratigraphic correlations controlled by the nannofossil zonation. Thus, we can examine not only the vertical sequence of sedimentation in the trench, but we can also look at the horizontal distribution of discrete layers across the trench floor and discern lateral changes in the sediment which may be related to the development of the trench itself.

The lithostratigraphy of each hole is discussed in order. The sediment columns are broken into separate lithologic units based on a gross analysis of the sediment types and structures and keeping in mind a more or less standardized nomenclature for all the holes. Thus, the individual lithologic units are themselves comparable from hole to hole, with the general sequence of units possibly indicative of an evolutionary trend in the infilling processes.

Lithologic Units of Hole 127

Intermittent coring in Hole 127, some 430 meters seaward of the landward wall of the Hellenic Trench, provided a reconnaissance profile of the sediment types making up the stratified fill beneath the present day flat trench floor. From an inferred stratigraphy, six main lithologic units have been identified and these are listed in Table 7. The boundaries between the units are shown without parentheses if they lie within a cored interval and with parentheses if they are picked as a midpoint between two cored intervals.

The first four units quite explicitly belong to the stratified trench fill as seen in the seismic reflection profiles (Figure 2). The interpretation of Units 5 and 6 is not as clear, and is the subject of discussion in a later section of this chapter.

TABLE 7
Lithologic Units of Hole 127

Unit	Lithology	Age
1	Graded sands and marl oozes Marl oozes Ash	Quaternary
98 m		
2	Graded sands and marl oozes Marl oozes Sapropels	Quaternary
(200 m)		
3	Sand-silt laminae Marl oozes	Quaternary
(350 m)		
4	Sand-silt laminae Marl oozes Sapropels	Quaternary
427 m		
5	Blocks: dolomite, limestone	Lower Cretaceous
435 m		
6	Nanno ooze	Upper Pliocene
436 m		
5	Blocks: dolomite, limestone	Lower Cretaceous
437 m		

Unit 127-1 – Graded Sands and Marl Oozes

Interbedded sequences of sands grading to marl oozes and beds of homogeneous marl oozes with occasional sand and silt laminae were recovered between 18 and 98 meters below bottom. According to the inferred chronology of Chapter 46, these sediments were all deposited during the Brunhes Epoch of normal magnetic polarity (i.e., since 0.69 my).

Sequences of sands grading to silts and clays occur throughout the unit. The basal contact is always sharp with occasional erosional markings. Smear slides often reveal a mixture of terrigenous and planktonic debris in the silt and sand fraction. A typical coarse composition is: quartz–45 per cent; foraminifera–25 per cent; mica–5 per cent; rock fragments–10 per cent. Proportions of the two main components (quartz and forams) vary with position in the sequence. Clasts of sedimentary and volcanic rocks, and minerals of the metamorphic suite, are also present as detritus.

The graded layers are generally capped by thick intervals of a remarkably homogeneous marl ooze, plastic and gray to olive gray in color. An average thickness of the homogeneous interval is about 60 cm, but it can range up to 2.5 meters, as in Sections 1 and 2 of Core 4. Occasionally one can discern faint bedding in the form of thin silt laminae (2-4-10 cm) or thin bands of hydrotroilite staining (4-1-30 cm). An average smear composition of the marl ooze is: nannofossils–35 to 40 per cent; foraminifera–0 to 5 per cent; quartz–5 to 10 per cent; micas and clays. At 28.1 meters, a thin coarser layer occurs which is composed of ash shards (30%) and foraminifera (70%) contained in a nanno ooze matrix.

Marl ooze intervals can also occur without significant quantities of coarser sediments at their base. However, this homogeneous deposit most typically represents the upper fining unit of a single depositional event.

The sand-silt portions of the bed generally range from 20 to 40 cm in thickness, though some may reach 120 cm.

The interval of massive grading is often absent, being replaced by horizontal laminations without cross-bedding. Laminae consists of thin, clay-rich bands between paper-thin horizons of sorted sands. Transitions to the overlying homogenous unit are both abrupt and gradational.

Laminated structures also occur in the middle of areas of "structure-free" marl ooze in single beds and their origin remains a mystery.

Unconsolidated conglomerates composed of rounded soft pebbles in a marl ooze matrix occurred at three intervals in Unit 1 (18.3-21.8 m, 36-45 m and 93.5-96.5 m), and are believed to be drilling artifacts.

Unit 127-2 – Graded Sands and Marl Oozes, Homogeneous Marl Oozes and Sapropels

The distinguishing characteristic of this unit, as compared to Unit 1, is the presence of beds of sapropelitic sediments. The first bed thus encountered is in Section 5 of Core 5 at 98 meters. They occur again in Core 6. The arbitrary base of Unit 2 is placed at 200 meters, halfway between Cores 8 and 9, and corresponds to an age of about one million years. Thus, both Units 1 and 2 are assignable to the Glacial Pleistocene as discussed in Chapter 46.

The sapropels of the Hellenic Trench, like those found in the Mediterranean Ridge cleft at Site 126, are fascinating deposits because apparently many of them are actually resedimented units. For example, Figure 11 illustrates a sequence of sand laminae (predominantly foraminifera) intercalated in the typical dark olive gray to black organic and pyritic rich euxinic muds. These bedding structures are diagnostic of current-controlled depositional processes. Yet, by assumption, the sapropel components form on the floor of the eastern Mediterranean only during periods of oxygen starvation. In this landlocked basin, the deep circulation is believed to be controlled exclusively by vertical mixing

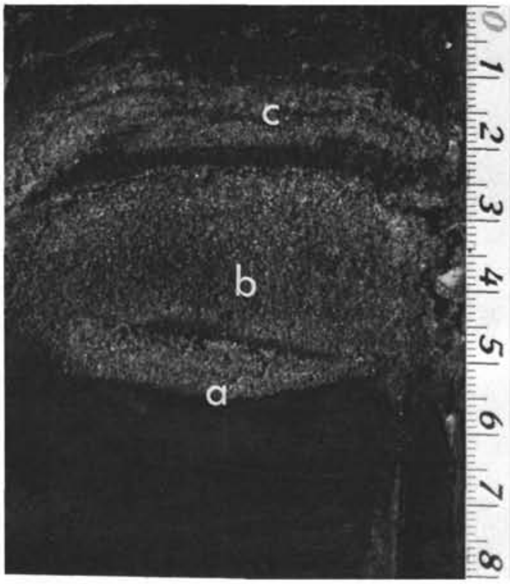


Figure 11. *Sedimentary fabric of the coarse-grained interval of a redeposited sapropel in Section 2 of Core 6, Hole27. Note: (a) the sharp, erosional basal contact; (b) the 2 cm thick massive division of well sorted and graded sand, rich in reworked shallow-water benthic foraminifera; (c) and the overlying unit of parallel laminations whose dark laminae are composed of organic rich mud and whose light laminae consists of quartz and concentrated specimens of foraminifera, particularly* Orbulina universa. *Scale is in centimeters.*

processes (Miller, 1962) which would be expected to reventilate the bottom water mass if it were active.

Thus, there is initially an apparent contradiction here between the presence of current bedding structures and the sediment composition which suggest stagnation. The most plausible explanation is that portions of the sapropel intervals seen in Cores 5 and 6 have been dynamically resedimented in local flows only (themselves incapable of oxygen renewal). This interpretation lends further support to the concept that almost all of Units 1 and 2 are of turbidity current origin, with the great thickness of individual beds caused by gravity ponding of sizable density flows in the rather limited area of the trench axial depression.

The carbonate content of the sapropels ranges from 25 to 30 per cent and includes an appreciable amount of dolomite, whereas the lighter color oozes between the sapropels have contents sometimes in excess of 50 per cent with little or no dolomite.

Unit 127-3 – Sand-Silt Laminae and Marl Oozes

A succession of homogeneous marl oozes, interbedded with millimetric sand-silt laminae and thicker layers were recovered between 224 and 336 meters. The lower limit of the unit falls between Cores 12 and 13 and is tentatively placed at 350 meters, corresponding to an age of about 1.4 my.

The marl oozes are homogeneous, plastic, light gray to olive gray, and are generally devoid of structures except for occasional faint bedding. In the upper part of the unit they are interbedded with sand-silt laminae grading into homogeneous oozes.

Although the mineralogical composition is the same as in Units 1 and 2, the percentages of coarser sediments is significantly less here, and the homogeneous intervals sometimes exceed five meters in thickness (as in Core 12).

It is difficult to envision the marl ooze intervals as pelagic, particle-by-particle deposition. The rate of sediment accumulation is an order of magnitude higher than that on the Mediterranean Ridge to the west. However, one is impressed that the carbonate content averages around 40 per cent, with the dominant component consisting of nannofossils of contemporary age. Thus the ooze is clearly not derived exclusively from slumping of older strata on the steeper slopes of the catchment basin. The depositional agent must not only concentrate the sediment into great thickness on the trench plain where it is observed as stratified fill on the reflection profiles, but it must derive it from the sea bed without significant reworking of underlying layers of Pliocene or pre-Neogene materials.

Some portions of Unit 3, such as Core 11, are considerably lighter in color and have a carbonate content ranging up to 67.3 per cent. This deposit can possibly be considered a true nanno ooze of pelagic origin.

Unit 127-4 – Sand-Silt Laminae, Marl Oozes and Sapropel

Marl oozes interbedded with sand laminae, layers of diatomaceous oozes and sapropels were recovered between 364 and 427 meters. The upper limit of Unit 3 falls between Cores 12 and 13 and was tentatively placed at 350 meters. Its lower boundary coincides with the sudden occurrence of Cretaceous limestones at 427 meters. The immediately overlying sediment is Quaternary, with an estimated age of about 1.6 my.

The marl oozes are homogeneous olive gray sediments similar to those of Units 1, 2 and 3. They are, however, quite stiff and even indurated at certain levels. Sand-silt laminae, some of which reach 267 cm in thickness, occur in the upper part of the unit in Core 14. The mineralogy and structure of the marls and sands are similar to those of the overlying units.

Sapropel beds occur at random levels, interbedded within the marl ooze. They are thin (2-10 cm), closely spaced, yellowish brown to black, and stiffer than the interbedded oozes. The boundaries are always sharp (Figure 12). In Core 14, they display a lighter yellowish color due to the occurrence of diatoms and sponge spicules. A particular bed in Core 14-3 at 13 cm contains dominant pyrite, together with calcite.

Unit 127-5 – Block of Dolomite and Limestone

The first hard rock was cut from 427 to 435.3 meters and consisted of heavily fractured dark gray to brownish dolomite, brecciated and mylonitized limestone, and micritic limestone. The presence of *Hensonella* cylindrica suggest a Barremian-Aptian age.[5]

[5] See Chapter 41.2 for a detailed description and discussion of the Cretaceous rocks.

Figure 12. *Examples of dark finely-laminated pelagic sapropels in Section 4 of Core 14, Hole 127, interbedded with thin layers of light-colored marl ooze. The boundaries between the two distinctly different sediment types are invariably abrupt. Perhaps the marl ooze was swept from shallower and more adequately ventilated portions of the landward wall and was carried to the abiotic trench floor in density flows. If so, these layers would merely signify momentary interruptions in an epoch of general basin-wide stagnation. Alternatively, the marl ooze might be transported to the axis of the trench as fine suspensions in deep geostrophic flows. In this case each intercalation might represent a brief renewal in the oxygen supply of the bottom water of the Hellenic Trough.*

The limestone was found to overlie, along a high angle contact, a light colored nanno ooze of Upper Pliocene age. Hard rocks were found again at 436 to 437 meters in Core 19 and the hole was terminated while drilling into this rocky formation.

The limestones are extensively fractured with a mosaic of cross-cutting veins of calcite (Figure 13). They are of shallow-water origin and are comparable lithologically to *Orbitolina* limestones of a wide distribution in the central and western Hellenides (Aubouin, 1965).

Unit 127-6 – Nanno Ooze

A layer of light olive gray nanno ooze was encountered interbedded between Cretaceous limestones in Core 18. The ooze is plastic, unstructured, and is textured with burrow mottling. Foraminifera are scattered throughout and small hydrotroilite flecks are present near the top. The calcium carbonate content approaches 62 per cent consisting mostly of calcareous nannoplankton of the Upper Pliocene nannofossil Zone NN 16 ($\simeq$2.9 my). Some scattered fragments of limestone are present near the bottom of the unit.

The overall facies of the nanno ooze suggests an open marine pelagic deposition similar to that at Site 125 on the Mediterranean Ridge (see Chapter 7).

Lithologic Units of Hole 127A

Hole 127A was located on the landward wall of the Hellenic Trench about 130 meters northeast of the contact with the flat plain and only some 6 meters shallower. Five cores were taken before the drilling stopped in hard rock at 80 meters below bottom. Three different lithologic units were recognized here, and they are listed in Table 8.

TABLE 8
Lithologic Units of Hole 127A

Unit	Lithology	Age
0	Foraminiferal and Pteropod ooze	Recent to Late Quaternary
(11 m)		
1	Graded sands and marl oozes Marl oozes	Quaternary
79 m		
5	Micritic limestone	Lower Cretaceous
80 m		

Unit 127A-0 – Foraminiferal and Pteropod Ooze

Unit 0 is so designate; in order to differentiate it from Unit 1 of Hole 127. It consists of a purely pelagic sediment from the sea bed down to at least a depth of 7 meters, reached by the first coring attempt. The orange to tan ooze is uninterrupted by terrigenous clastics or marl ooze, and seems to span a time from Recent to possibly late Quaternary. The sections of Core 1 were too watery and disturbed to split aboard the *Challenger*, so they were not photographed.

Unit 127A-1 – Graded Sands and Marl Oozes

The next three cores of Hole 127A contain graded sands and marl oozes of identical mineralogy and structure to those of Unit 1 in Hole 127 from the trench plain. Thick homogeneous marl ooze intervals such as that in Sections 2 and 3 of Core 2 are directly underlain by laminated silts and graded sands. They have the appearance of single depositional events and are inferred to have settled from sediment suspensions produced by turbidity currents ponding on the trench plain (Hersey, 1965).

Unit 127A-5 – Micritic Limestone

Hard rocks were encountered at 79 meters below bottom while finishing the cutting of Core 4. Light gray fine-grained micritic limestone was recovered in the core catcher assembly. Additional fragments were obtained in Core 5 before the hole was terminated at 80 meters.

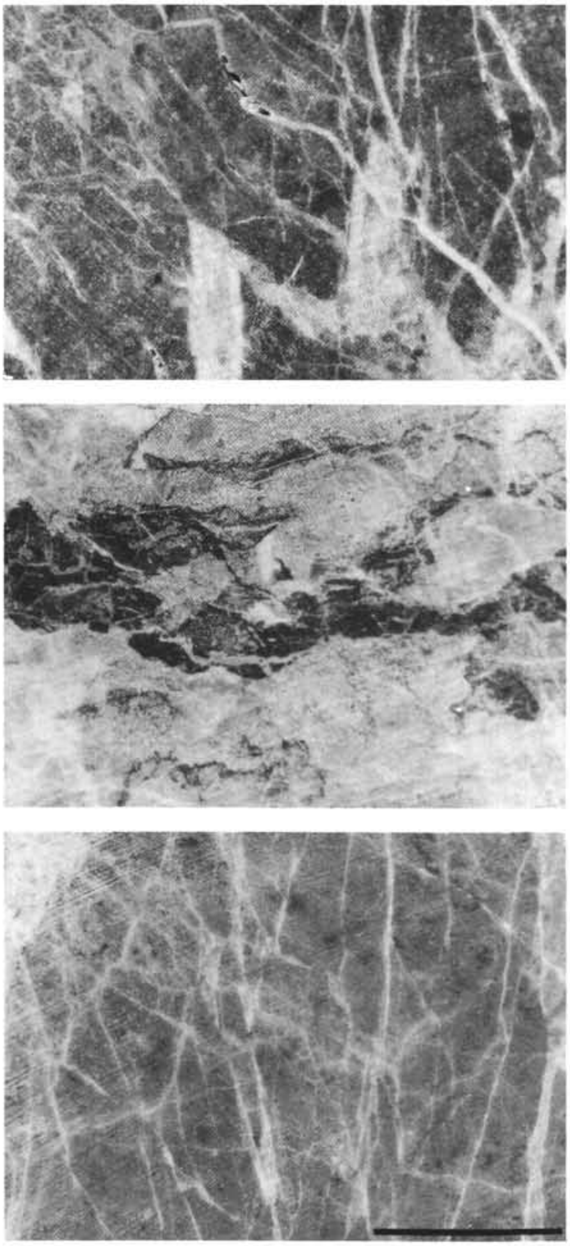


Figure 13. *Examples of the fabric of the Lower Cretaceous rocks recovered below 427 meters in Hole 127. Upper photo shows highly fractured limestone with cross-cutting veins of secondary calcite (16-1-10 cm). Several stages of vein filling are evident. Stylolitic sutures were found in strongly recrystalized fragments of limestone from Section 1 of Core 17. This sample is at 47 cm. Lower photo shows more cross-cutting veins of calcite, this time in a partly dolomitized micritic limestone above the contact with the Pliocene nanno ooze (18-1-45 cm). Scale bar represents 1 cm.*

The rocks are very similar lithologically to those recovered in Core 18 of Hole 127 and have an identical Barremian-Aptian age.

Lithologic Units of Hole 127B

Only one core was cut at Hole 127B on the trench plain some 40 meters seaward of the boundary against the landward wall. One lithologic unit was represented. It consists of seven fragments containing pieces of micritic limestone of similar Lower Cretaceous age as that representing Unit 5 in Holes 127 and 127A. Some of the fragments are in turn composed of individual chunks of limestone embedded in an indurated matrix of pelagic ooze of Pliocene age.[6]

One interesting observation is illustrated in Figure 9, where we see two fragments (a) of the Cretaceous limestone which have broken apart from one another and now rest less than a centimeter or so apart. The limestone fragments are angular, and some of them are highly fractured and mylonitized (c). The matrix (b) is olive gray in color and generally fine-grained except for a few tests of foraminifera.

Lithologic Units of Hole 128

Hole 128 was drilled near the seaward edge of the trench plain some 3400 meters southwest of Hole 127 (Figures 2 and 4). The hole was drilled to a depth of 480 meters where it was terminated. Intermittent coring was carried out partly to fill the gaps of Hole 127, and partly to permit a cross-correlation of individual strata. Four main lithological units were identified; all are Quaternary in age. They are listed in Table 9. Each of the units corresponds by number to similar units of Hole 127.

TABLE 9
Lithologic Units of Hole 128

Unit	Lithology	Age
1	Graded sands and marl oozes Marl oozes	Quaternary
84.7 m		
2	Graded sands and marl oozes Marl oozes Sapropels	Quaternary
(172 m)		
3	Sand-silt laminae Marl oozes	Quaternary
(281 m)		
4	Sand-silt laminae Oozes Sapropels	Quaternary
480 m		

Unit 128-1 – Graded Sands and Marl Oozes, Marl Oozes

The first core was cut at a depth of 22 meters below the sea bed. However, the hole is located only about 1000 meters directly south of a 9-meter-long surface piston core, RC9-184, which contains a similar lithology except for the addition of several layers of sapropel, characteristic of the eastern Mediterranean record during the last 0.3 my (Ryan, 1971).

The dominant makeup of these cores and others down to a depth of 84.7 meters consists of interbedded sequences

[6]See section on biostratigraphy for identification of the fossils in the matrix as well as Chapter 41.2 for descriptions of thin sections across the contacts of the Cretaceous rocks and the indurated matrix.

of sands grading to silts and capped by a thick interval of remarkable homogeneous marl ooze. Occasional silt laminae are found in the marl ooze. The general color of the beds of the unit is light gray to olive gray.

The graded sequences are generally thin (20-30 cm) and are particularly concentrated at the top of the drilled interval in Core 1. A thick graded sand unit occurs, however, at 81.5 meters. The average smear composition of the sands is: quartz–35 per cent; mica–020 per cent; foraminifera–25 per cent; authigenic calcite–35 per cent, sponge spicules–2 per cent; rock fragments–1 per cent,; etc. These sequences are interpreted as turbidites.

Laminae of sands and silts, interbedded with marl oozes, occur mainly at the bottom of the unit in the 79 to 84 meter interval. They are obviously current deposits, yet they lack the diagnostic features of the typical flysch turbidite (Nesteroff, 1961; Bouma, 1964) layers.

A thick horizon of homogeneous, plastic marl oozes was recovered in Core 2 (51-60 m) in the middle of the unit. The laboratory-stored cores show frequent expansion cracks caused by degassing. Analysis of this gas identified it as methane. The smear composition is: nannos–45 to 50 per cent; mica–25 to 30 per cent; quartz–10 per cent; dolomite–5 per cent; pyrite–5 per cent, rock fragments–3 to 7 per cent, limonite, etc. This is a terrigenous peri-continental marl ooze possibly redeposited by currents (cf. Hole 127, Unit 3).

Unit 128-2 – Graded Sands and Marl Oozes, Marl Oozes, and Sapropels

Interbedded sequences of graded sands and marl oozes, marl oozes, and sapropels were cored between 84.7 and 153 meters. The unit is rather similar to Unit 1, but differs because of the presence of sapropels. Thus, the upper limit of Unit 2 was placed at the top of the first downhole sapropel bed. Except for the sapropels, the general lithology, color, structure, and mineralogy are the same as in Unit 1.

The sapropel beds occur in Core 3, between 94.5 and 87.25 meters in a sequence of current deposited sediments. They are interbedded with plastic gray clays and layers which include individual laminae of sand with sharp contacts. They present a coarser surface aspect, are less plastic, and range in color from dark olive gray to black. They contain rare laminae of sand (e.g., Figure 14), exclusively foraminifera, but reveal no apparent grading. An average smear composition of the sapropels is: nannoplankton and calcite–25 per cent; quartz and clays 65 per cent, with minor amounts of pyrite, sponge spicules, diatoms and dolomite. The organic carbon content of the sapropels reaches 2.8 per cent, while the general value of the marl oozes is 0.3 to 0.5 per cent.

Unit 128-3 – Sand-Silt Laminae and Marl Oozes

Marl oozes containing a single sand layer were recovered between 192 and 255 meters. They are pre-Glacial Quaternary in age. The upper limit of the Unit falls between Cores 5 and 6 and was tentatively placed at 172 meters below bottom.

The oozes are of an olive gray color, homogeneous, plastic, and display no visible structures. The calcium carbonate content is 35 to 50 per cent and is comprised chiefly of nannoplankton together with terrigenous quartz and clay. Gas expansion cracks were observed on the split surfaces of all the stored cores.

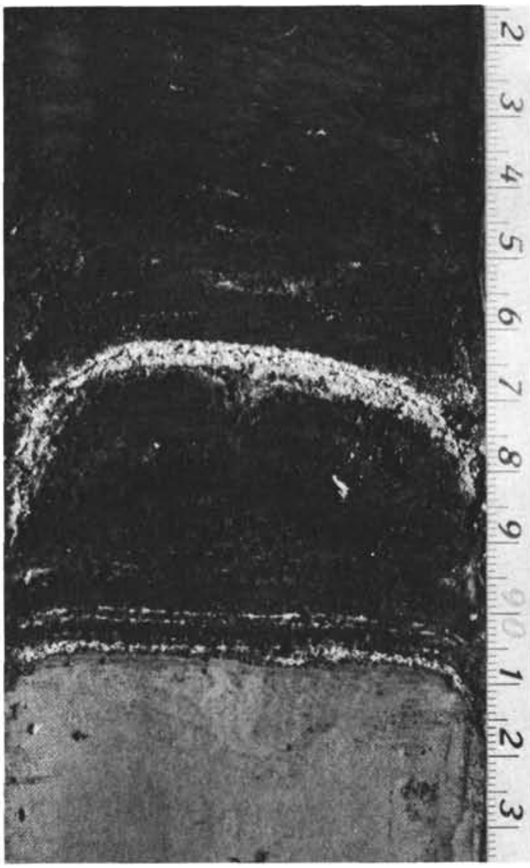


Figure 14. *A layer of sapropel from Section 6 of Core 3, Hole 128. The thin light-colored laminae at 87 and 90 cm are composed entirely of the tests of planktonic foraminifera. The assemblages are extremely rich, diversified, and non-sorted, which is not exactly what we would expect if their deposition involved reworking by bottom currents. Particular coabundance of* Globigerina bulloides, G. Eggeri *and* Globigerinoides *ruber suggests an unusual productivity related to as yet some unknown ecological response to a particular phase in the euxinic cycle.*

A 7-cm-thick sand layer was observed in the core catcher of Core 6. Its approximate composition is 80 per cent quartz and 20 per cent foraminifera.

It is suggested that the marl oozes of Unit 3, Hole 128, are current bedded deposits, for the same reasons as those discussed for Unit 3, Hole 127. The unit reflects a generally quieter (low energy?) deposition without significant coarse grained components, in contrast to Units 1 and 2.

Unit 128-4 – Sand-Silt Laminae, Marl Oozes, Sapropels

Marl oozes with interbedded sand-silt laminae and sapropel beds were recovered between 307.1 and 480 meters. They are of Quaternary age, probably prior to about 1.5 my. The upper limit of the Unit falls between Cores 7 and 8 and was tentatively placed at 280 meters below bottom.

Thick horizons of homogeneous marl ooze, often with a sand-silt layer at the base, characterize the unit. They are interbedded with closely spaced, generally thin (5-20 cm) diatomaceous sapropel beds superimposed on the marl horizons.

The marl ooze is plastic to stiff and occasionally semi-indurated. The color is gray to olive gray. It consists of calcium carbonate (40 to 50 per cent) together with quartz, clays, and minor amounts of pyrite.

The interbedded sapropel beds are olive to olive gray and stiffer than the marl oozes. They differ from the other marls by a lower calcium carbonate content (25%), and moderate amounts of pyrite, diatoms, sponge spicules and dolomite.

This unit reflects a quieter type of deposition than the sapropel interval of Unit 2.

Glaucophane in The Cores of Hole 128

Some crystals of glaucophane were found in the sands of selected cores from Hole 128 (1-2-88; 1-2-142; 4-3-4; 4-3-90).

This is a particularly interesting mineral of regional metamorphism and the typical facies index of glaucophane-schist facies. The conditions for the glaucophane metamorphism are high pressure and low temperature.

Generally, metamorphic belts of this type contain abundant basaltic volcanics derived from the partial melting of the mantle. According to Miyashiro (1967), typical examples occur mostly in younger orogenic belts (e.g., Franciscan metamorphic complex).

Glaucophane and blueschist terranes are believed to be indicators of an oceanic trench in association with a Benioff zone. Blueschist assemblages seem to be connected with tectonic *mélange* terranes indicating the position of an earlier trench (interval).

Interstitial Salinities

Shipboard measurements of interstitial salinities in the Hole 127 sediment column revealed values ranging from 36°/₀₀ (normal) up to 150°/₀₀. At depth in the column, the values were among the highest of those recorded at any drill site during the entire leg in the Mediterranean Sea, and must certainly indicate the nearby presence of an evaporite layer.

The salinity was measured with a Goldberg hand refractometer using filtered water. Additional investigations of the interstitial water chemistry of the Hellenic Trench cores are reported in Chapter 31 of this volume.

PHYSICAL PROPERTIES

Site 127

The sediments retrieved from the three holes drilled at Site 127 consisted of cores taken to a depth of 427 meters. They comprised soft "mud breccias," graded sands, marl oozes, and sapropels deposited as graded beds, contourites, and slumped sediments, and also laminated marl ooze. All holes bottomed in dolomitic and limestone.

Penetrometer readings clearly exhibit a decrease from top to bottom of the hole with values ranging from approximately 135 to 20 $\times$ 10^{-1} mm at Hole 127, and 144.7 to 83 $\times$ 10^{-1} mm at Hole 127A. There are also extreme values outside these limits, such as 198.3 $\times$ 10^{-1} mm and 8 $\times$ 10^{-1} mm, but these are due respectively to disturbance and isolated indurated lumps of sediment. Within the turbidites, rapid variation is noticeable for alternate layers of clays and graded sands. These are particularly well displayed in Cores 2, 5 and 6, at depths of 29 to 36 meters and 95 to 110 meters. Clays of similar lithology, texture, color, and hence plasticity, exhibit consistent values in different sediment cycles. The olive green clays of Cores 10, 11, and 12, recovered between depths of 280 and 373 meters, display a decreasing series of penetrometer readings in the range 28.0 to 14.7 $\times$ 10^{-1} mm, reflecting their increasing induration with depth.

Bulk density varies between 1.52 and 2.12 gm/cc. Lower values were measured in soft "mud breccias," where slumping and some disturbances are evident, and higher densities correlate with isolated foram rich horizons, where grain density is also high. The range of grain densities is 1.83 to 2.83 gm/cc, the value corresponding with those limits set for bulk density. Similar trends are followed for both bulk density and grain density. Low values are also recorded in sapropels and high values in quartz and mica rich sands. Water content and porosity range from 38.8 to 18.5 per cent and 59.8 to 35.1 per cent respectively, reflecting a general decrease in values with depth, but largely dependent on plasticity and state of core disturbance.

The range of natural gamma is 1800 to 3900 counts, although most readings lie between 2500 and 3500. There is rapid fluctuation within individual cores, suggesting an influx of terrigenous material, with varying radioactive mineral content. This variability in reading values is also present in a supposedly uniform lithology of nanno ooze in Cores 7, 10 and 12. This may be due to reworking and recycling processes during sedimentation. In turbidite beds, the individual layers of sands and clays are not defined by high and low counts respectively, as has been the case in previous holes.

The physical properties recorded for Holes 127 and 127A are consistent. Where cores have been taken at similar depths, but at a short distance apart, correlation is possible both for lithology and the physical parameters measured.

Site 128

Site 128 is located at the southwest margin of a transect of the Hellenic Trench, on the far side from Holes 127 and 127A. The lithology is comparable with that of the previous site. The hole was drilled to a depth of 480 meters through homogeneous marl oozes and sapropels, and oozes with fine quartzose or foraminiferal sand and silt laminae.

Penetrometer readings are in the range 113.0 to 9.3 $\times$ 10^{-1} mm, showing a remarkably consistent decrease with depth. Isolated high values may be ascribed to localized sapropel beds as in Core 11 at 475 meters, where a reading of 51.7 $\times$ 10^{-1} mm is well above the average of 20.0 $\times$ 10^{-1} mm for that depth. Also, lithologic variations result in oscillating values within individual sections; for example, in

Core 3, where alternating silts, sands, and sapropel laminae in clays are an indication of great variety in grain size and in degree of compaction. Core 2 exhibits irregular watery patches and voids in a very disturbed "gassy" core.

Bulk densities vary between 1.58 and 1.86 gm/cc, and grain densities between 2.12 and 2.60 gm/cc. There is a steady increase with depth and a consistent trend for both plots, except for Cores 2, 6 and 7 where an increase in porosity due to gas expansion cracks is seen. Higher values are recorded in sand horizons. Water content and porosity values lie in the ranges 32.1 to 18.4 per cent and 53.7 to 33.7 per cent respectively, the highest values being measured in a series of alternating sands and sapropels in marl oozes of Core 3.

Natural gamma readings vary between 1600 and 4200 in extreme cases, the maximum peak being measured over a loose sand bed at 112 meters in Core 4 and over a sapropel at 85 meters in Core 3. The general range is 2000 to 3000 counts. There is a marked variation in beds of uniform lithology, such as in Cores 2, 5, 6 and 7 which comprise homogeneous marls, again suggesting secondary derivation of sediments, and irregular distribution of radioactive components. Low readings can be commonly correlated with beds of increased calcareous content. High gamma readings are recorded in clays or mica-rich sands, such as those of Core 1. Sapropel horizons in Cores 3, 4, 10 and 11 produce extremely high count rates of up to 4200 due to high organic content and consequent adsorption and absorption of radioactive minerals.

DISCUSSIONS AND CONCLUSIONS

The stratified layering of the Hellenic Trench plain has been sampled at both its seaward and landward margins. From a glimpse at the cores there is not too much doubt that the dominant sedimentary facies is current-controlled. Exactly what processes are responsible for the accumulation of this facies being restricted to the narrow axis of the trench, as compared to the widespread acoustically transparent blanket of calcareous pelagic oozes on the Mediterranean Ridge (cored at Sites 125 and 126), is not entirely understood and warrants additional investigations.

The graded sands and silts, with a well sorted basal layer containing both terrigenous components and displaced shallow-water benthonic foraminifera, suggest a lateral supply from the landward margin of the trench by downslope transport. The exclusive ponding of the stratified sediment in the trench axis is evidence that the current flows are influenced by gravity.

The homogenous (often thick) intervals of marl ooze are generally found in continuity with coarse units, the largest grain sizes marking the base of an individual depositional unit. However, sequences of marl ooze can be found without sand or silt at the base. It is as yet unclear whether all the marl ooze intervals can be viewed as the pelitic division of single depositional layers in the sense of the "turbidite mud" of Van Straaten (1967), or whether some of the marl ooze intervals are of a different origin (pelagic settling, or redeposition in bottom currents).

The sleekness of the homogenous layers support the deduction that they are emplaced in a time interval of sufficient briefness to prevent their being burrowed and disturbed by mud-ingesting animals (Needham, 1971). The lack of any color variation points towards a single reservoir of mud for their source.

What is puzzling is whether the occasional thin laminae of sand and/or silt interbedded in the homogenous marl ooze mark the initiation of a depositional unit or whether these laminae might alternatively be explained by the winnowing and rippling action of near-bottom oceanic currents as part of a steady state thermohaline circulation (Von Rad, 1968). If the latter involved current paths across slope or along the axis of the trench (longitudinal transport), these depositional units might more properly be referred to as contourites (Heezen *et al.*, 1966; Heezen and Hollister, 1971). One important clue as to the origin of the marl ooze is provided in the horizontal distribution of the sediment layers composing the trench fill.

Correlation of Depositional Units Across the Trench Plain

The lateral continuity of individual beds beneath the floor of the trench plain has been examined by correlation of several cores between Holes 127 and 128. The best of these correlations are shown in Figure 15. Not only can discrete layers be matched between the core sites (e.g., 128-1 = 127-1; 128-3 = 127-4, 5 & 6; and 128-8 = 127-14), but the boundaries of the previously defined lithologic divisions also follow the bedding planes. Furthermore, and as it should be, neither the correlated beds nor the unit boundaries cross the time lines provided by the independent nannofossil zonation.

An impressive example of a bed-to-bed correlation of a sapropel layer is illustrated in Figure 16. Such fine details as sequences of millimetric thick laminae of diatomite (a) are precisely matched across the 3.4 kilometers separating two drill holes. Pointed out are the truncation of a light-colored interval of pelagic nanno ooze (b) in Hole 127 nearest the landward wall by the sandy basal interval of an immediately overlying graded sand-silt-marl ooze sequence. The thin white band at (c) marks a single tephra layer of clear colorless glass shards.

This sapropel layer itself falls in the *Pseudoemiliania lacunosa* nannofossil Zone NN19 and is equivalent to that found in Section 4 of Core 3 at Site 125 on the Mediterranean Ridge, and in Section 5 of Core 6 at Site 132 in the Tyrrhenian Basin. These sapropels are tentatively and informally referred to as the Matuyama/pre-Jaramillo sapropels with an estimated age of ≈1.5 my, as discussed in Chapter 46 of this volume.

Details of the Correlations

Excellent bed-to-bed correlations can be made between Core 3 of Hole 128 and the continuously cored interval from Cores 4 to 6 in Hole 127. Figure 17 illustrates sixteen individual horizons which are repeated in both sediment columns. We consider it significant that sand-silt laminae in this interval, no matter how thin, are traceable across the trench plain. Furthermore each sand-silt-marl ooze sequence is proportionally thicker at the landward site suggesting that there are quite likely individual sedimentation units. We also note that the only intervals which maintain a uniform bed thickness are those that are clearly

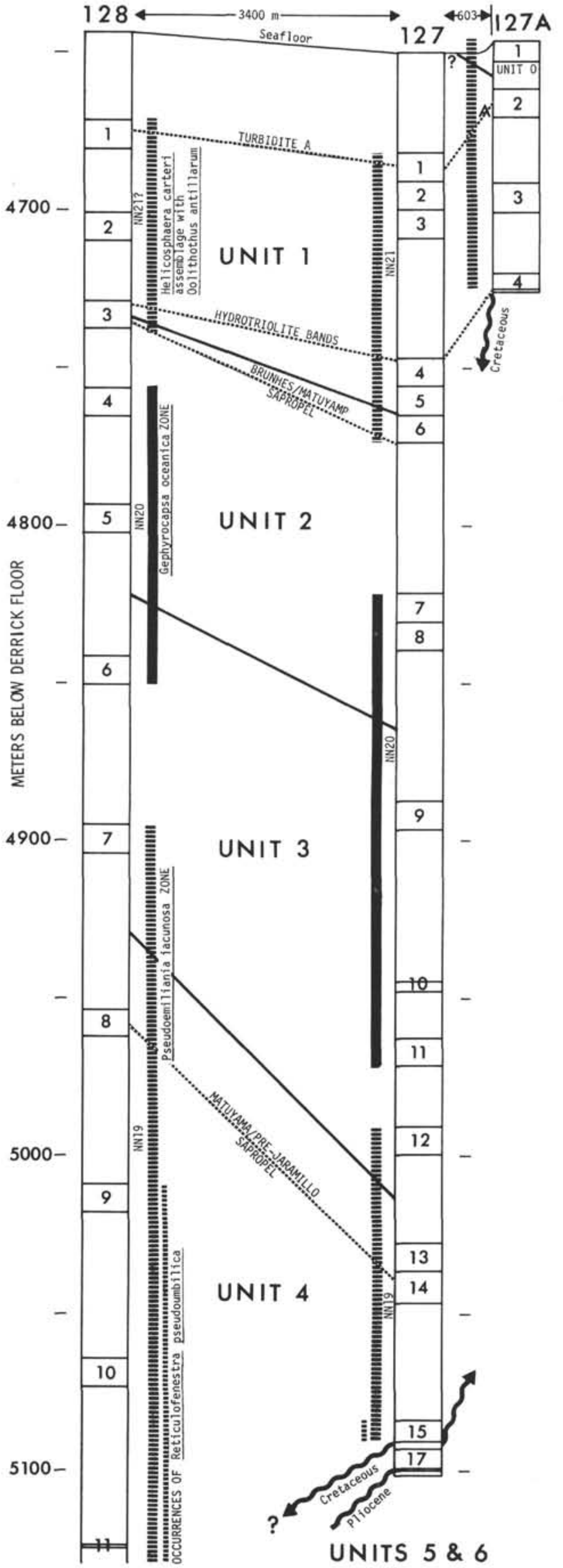


Figure 15. *Correlations between the sediment columns at Hole 128 near the seaward edge of the trench plain, Hole 127 at the landward edge, and Hole 127A on the landward wall. Depth units are in meters measured from the derrick floor using the same drill pipe put together in exactly the same order for all three holes. Heavy lines show the boundaries of the main lithologic units. Dotted lines show actual bed-to-bed correlations. The vertical range of the three nannofossil zones is in good agreement with the actual bedding planes. The distances between the holes are relative with a vertical exaggeration of 40:1.*

Figure 16. *Bed-to-bed correlation of a pelagic sapropel layer across the trench plain. Note the remarkable matching of even millimetric thin laminae in the deposits. Layer "b" in Hole 127 near the landward edge has been preferentially eroded and truncated by an overlying graded turbidite. Perhaps the energy regime is greater here nearest the upslope source. Separation of the two holes is 3.4 km. Scale is in centimeters, the horizontal bar represents one centimeter.*

pelagic in origin (i.e., the finely laminated sapropels without benthic fauna).

It thus seems reasonable, in light of the reflection profiles, to assume that each current-deposited sedimentation unit is dispersed throughout the trench plain, with the greater accumulation at Hole 127 reflecting a levelling mechanism in the distribution process–a process attributed by Hersey (1965) to sediment ponding by turbidity currents.

We point out that Beds "A" and "B" in Figure 17 consist of dark-colored muds rich in organic matter and pyrites. These might be called sapropels, yet we notice that they also are considerably thicker beneath the landward edge of the plain in Hole 127. When we examine the base of Bed "B" in Figure 11, we see that it contains a lower graded division with a basal layer of well sorted sands above a sharp bedding contact. The core photographs reveal an overlying division of parallel laminations (some very muddy) which in turn continues into a pelitic division. The coarse-grained horizons of this bed contain some scattered benthonic foraminifera which are invariably absent in true pelagic sapropels such as those from Site 125 on the Mediterranean Ridge.

Is it not logical to suspect that Beds "A" and "B" are themselves turbidites which in the initial slumping incorporated predominantly previously deposited sapropelitic materials? Is there any reason to believe that episodic turbidity currents should not occur during periods of stagnation, and that a pelagic interval of finely laminated anoxic sediment could not be interrupted by deposits from gravity-ponded sediment suspensions?

The sapropel interval immediately beneath Bed "B" is interpreted as a pelagic deposit. It correlates to a level at 107 cm in Section 4 of Core 1 in Hole 125 from the Mediterranean Ridge and is referred to as a Brunhes/Matuyama sapropel. Its name derives from its stratigraphic position not far above this well-known paleomagnetic boundary. The inferred age of the sapropel is 0.65 my.

Continuous Tilting of the Trench Plain

The correlations shown in Figures 15 and 16 reveal an ever increasing thickness in the sediment column of Hole 127 as compared to Hole 128. The Matuyama/pre-Jaramillo sapropel of Core 127-14 lies 80 meters deeper than its lateral equivalent beneath the seaward margin of the trench plain. Similarly, the Brunhes/Matuyama sapropels are 36 meters deeper at the landward site.

The observed inclinations of the correlated bedding horizons is in excellent agreement with the observed dip of the subbottom seismic reflections (shown in Figure 2) obtained by using an interval sound velocity of 1.7 km/sec. These reflectors reveal a progressive flexure of the stratified sediment body with a downdrop towards the inner wall.

The drill string-measured depth difference at the two ancient isochrons discussed above and the present slight tilt of the trench floor are plotted in Figure 18 against their respective ages, giving a straight-line slope of 55 m/my. This

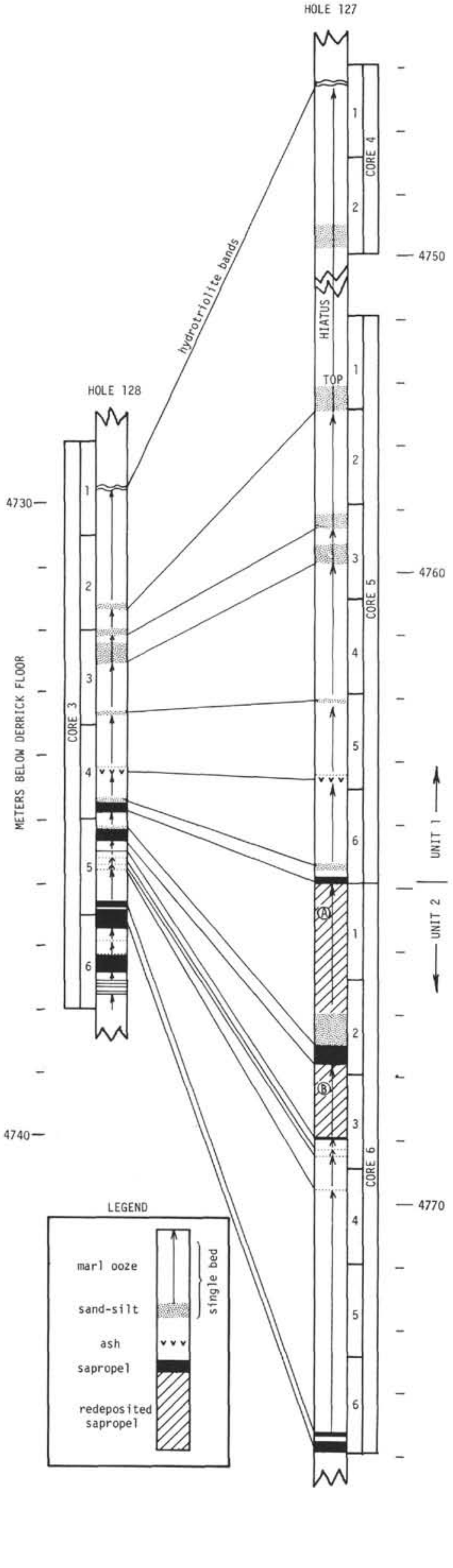


Figure 17. *Detailed correlation of sixteen consecutive sedimentation units between Holes 128 and 127. The arrows mark each interval of current deposited sedimentation interpreted as turbidites. Cross-hatching signifies redeposited organic-rich sapropelitic mud. Solid black is pelagic sapropel. Note that every current-deposited unit is thicker in Hole 127 near the inner wall of the trench, yet the pelagic units maintain a rather uniform thickness. Furthermore, every unit, no matter how thick, is correlatable between the two drilling sites.*

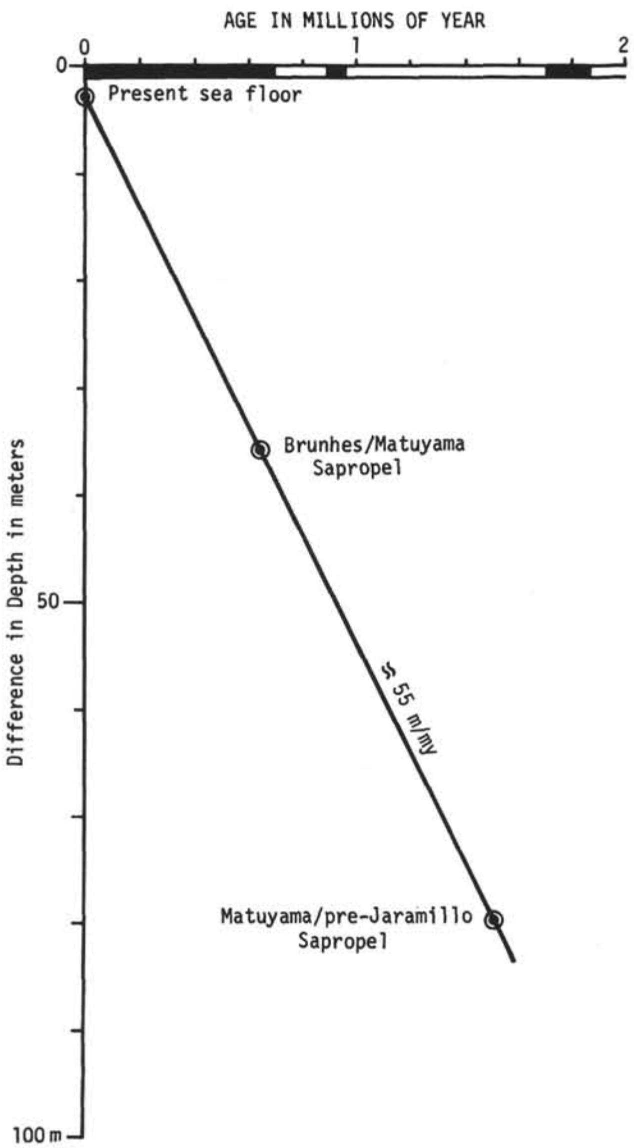


Figure 18. *This graph shows a plot of difference in absolute depth from the derrick floor of two stratigraphically known and correlatable sapropel layers in Holes 127 and 128, against the absolute age of that layer determined from the paleomagnetic chronology presented in Chapter 46. The sea floor is 6 meters deeper at the landward edge of the plain than at the seaward edge. The straight-line fit suggests that the landward edge of the trench plain at Hole 127 has been subsiding relative to Hole 128 at a uniform rate of ≈ 55 m/million years. This value translates to a flexure rate of ≈ 1° per million years.*

value relates to the relative subsidence rate of the sea floor at Hole 127 to that at Hole 128. The separation between the two holes is 3.4 kilometers, allowing the subsidence rate to be transferred into an angular rate of flexure of approximately one degree per million years. The significance of this number in terms of compressional tectonics will be discussed in Chapter 48.

Calculation of Interval Sedimentation Rates

In this section we will confine ourselves to discussions of the sedimentological aspects of the trench drillings.

If we assume that the flexure rate has remained more or less constant over time periods of hundreds of thousands of years, then we have a powerful procedure for calculating interval sedimentation rates of the trench strata. For instance, if turbidity currents followed each other with the passage of only brief periods of time, then little flexure would have occurred between the times of accumulation of the two successive deposits. Hence, the subsequent levelling of the trench plain would be small and the thickness difference at the seaward and landward edges would be minimal.

If, on the other hand, a significant period of time were to have elapsed between successive flows, each turbulent sediment suspension would arrive on an already tilted plain surface. Thus we might expect that the sediment ponding process would leave a notably thicker deposit nearer the downdropped landward edge.

Thus a direct measure of sedimentation rate can be made by investigating the degree to which successive flows level the trench floor. For example, an excess bed thickness of 11 cm at Hole 127 corresponds to 2000 years of continuous relative subsidence at the observed rate of 5.5 cm/$10^3\mu$. This would mean that 2000 years had elapsed between the time of this flow and the previous turbidite. If the total bed thickness of this sedimentation unit at Hole 127 was 15 cm then we could consider that it had a net accumulation rate of 7.5 cm/$10^3\mu$, recognizing, of course, that turbidites are implaced instantaneously in the geological sense.

Part of the interval of detailed correlations shown in Figure 17 is designated X-Y. Its total bed thickness in Hole 127 is 16.2 meters as compared to 4.65 meters in Hole 128. The bed thickness difference of 11.55 meters indicates that this record of sedimentation spanned 210,000 years, with a net accumulation rate at Site 127 of 7.7 cm/$10^3\mu$. This value is fairly low if compared to the mean rate of $\simeq$25 cm/1000 years for the entire column down to Core 14. We note that it is here where we recognized time intervals of pelagic deposition recording the intermittent stagnations. Elsewhere the turbidity currents have occurred so soon after each other that either no readily recognizable pelagic materials were deposited or that those which had accumulated were thin enough and/or still soupy enough to blow away in the scouring action of the newly arrived turbulent suspensions.

The interval from X to Y in Cores 5 and 6 is comprised of ten individual turbidite layers. The time span of 210,000 years corresponds roughly to one event every twenty thousand years.

Relationship of Bed Thickness and Time Elapse Between Events

Of course not all the individual sedimentation units are similar in thickness. Some sand-silt-marl ooze sequences range from a few centimeters up to several meters, and others exceed the length of a cored interval. We have explored the nature of bed thicknesses by plotting in Figure 19 nine data points of the selected correlatable interval of X to Y. On the ordinate of the graph is plotted total bed thickness for each turbidite of this interval in Hole 127. On the abscissa is plotted the excess bed thickness in the Hole 127 cores over the thickness of the same bed in Hole 128.

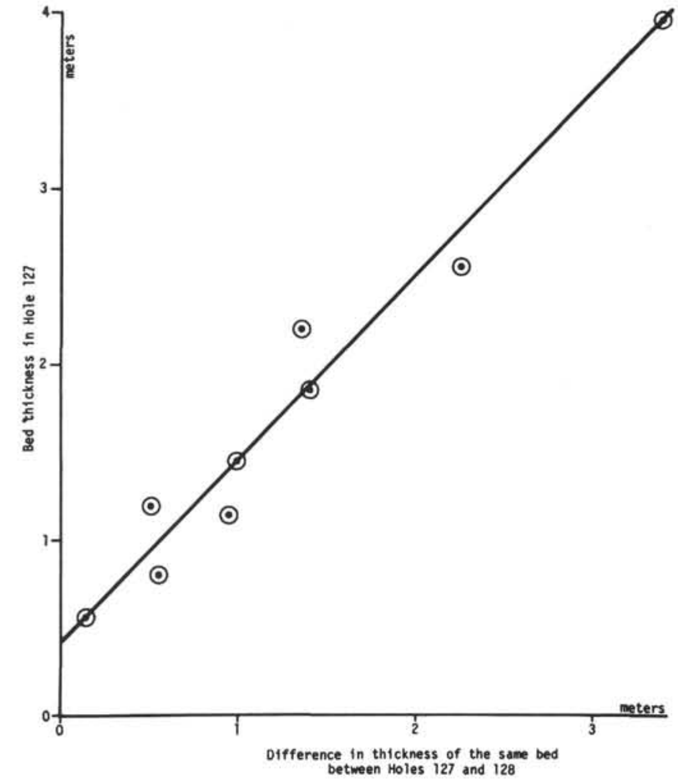


Figure 19. *Graph of individual bed thickness* vs *difference in thickness across the trench plain between the two drill sites. The bed thickness at Site 127 is probably somehow related to the total volume of that particular layer ponded within the confines of the trench plain. The differential bed thickness, as discussed in the text, is believed to be influenced by the amount of relative subsidence that has occurred between the two sites since the leveling of the trench plain by deposition of the previous sedimentation unit. At a constant rate of subsidence (see Figure 18) this latter value translate into the elapsed time between the accumulation of the two beds. Thus, we have here a direct proportionality between the size of any particular sedimentation unit on the trench plain (interpreted as turbidites) and the time passed between its deposition and that of the previous layer. The nine data points are taken from the X and Y interval of Figure 17.*

We note that a straight line can be fitted to the data points demonstrating direct relationship between total bed thickness near the landward edge of the plain and thickness difference (degree of levelling). This observation suggests that the total volume of a turbidity current deposit on the trench plain is a function of time elapsed between the flow under consideration and the previous one.

We would generally not expect such a relationship unless we were dealing with a single sediment reservoir as a temporary storage for the sediment making up each of the turbidites. But then, we must remember the important biostratigraphic evidence that only a very small fraction (perhaps <3%) of the calcareous nannoplankton that comprise the dominant carbonate component of the marl oozes are pre-Pleistocene in age. Similarly, only a tiny fraction of the foraminifera, even in the thick sandy layers, are clearly of much earlier age. These observations were very puzzling because we had expected the trench fill to consist of numerous turbidites originating from slumping on the inner wall. There was no reason to suspect that the inner wall did not contain massive deposits of older unconsolidated strata.

Yet the facts are to the contrary. Unless we envision the repeated sloughing off of thin contemporary films of Quaternary ooze across vast areas and the whole unit then entraining itself into a single suspension, somehow also incorporating terrigenous sands and shallow-water faunas to make up the required volume of each sedimentation unit, we either have to rule out the turbidity current origin altogether or we have to consider that the Hellenic Trench strata come from the repeated filling and flushing of a single upslope reservoir. In this fashion the volume of each turbidite layer is related to the time the reservoir had been filling before its contents are spilled.

Source of The Hellenic Trench Fill

There is presently little information which can help us evaluate the provenance of the displaced trench fill. Clay mineral determinations (presented in Chapter 20.1) show a considerable amount of chlorite (4-14%) in the <2μ size fraction. The present day dispersal patterns of this mineral in the eastern Mediterranean (Venkatarathnam and Ryan, 1971) show two likely source areas, the Aegean and the Adriatic. In both cases the fine sediment would be expected to be transported to the vicinity of the Hellenic Trench in newly formed bottom waters. In fact, one unpublished light-scattering profile on the sill between Crete and Peloponnesus (the crest of the landward wall of the Hellenic Trench), illustrated in Figure 20, shows a thin bottom layer of relatively dirty water. The content of dissolved oxygen in the water mass of the Hellenic Trough depression indicates that the bottom water there has not come from the west through gaps in the Mediterranean Ridge, but either arrives directly from the Aegean or from the north via the Strait of Otranto (Moskalenko and Ovchinnikov, 1965). It is of interest to point out that the heavy mineral glaucophane, discussed previously in the section on lithostratigraphy, has also been reported in cores from the Strait of Otranto (Hesse *et al.*, 1971) where it was believed to be an indication of metamorphic minerals of Alpine provenance. However, whatever the source of the sediment, both its present preservation in beds that have a remarkable appearance to turbidies and its exclusive ponded distribution within the axial depression of the trench somehow require a temporary sedimentary repository upslope of the drilling sites.

The selection of coring intervals in Hole 128 was designed both to obtain layers correlatable to those recovered in Hole 127 cores and to fill in gaps in the sequence there. Figure 21 shows a composite sediment

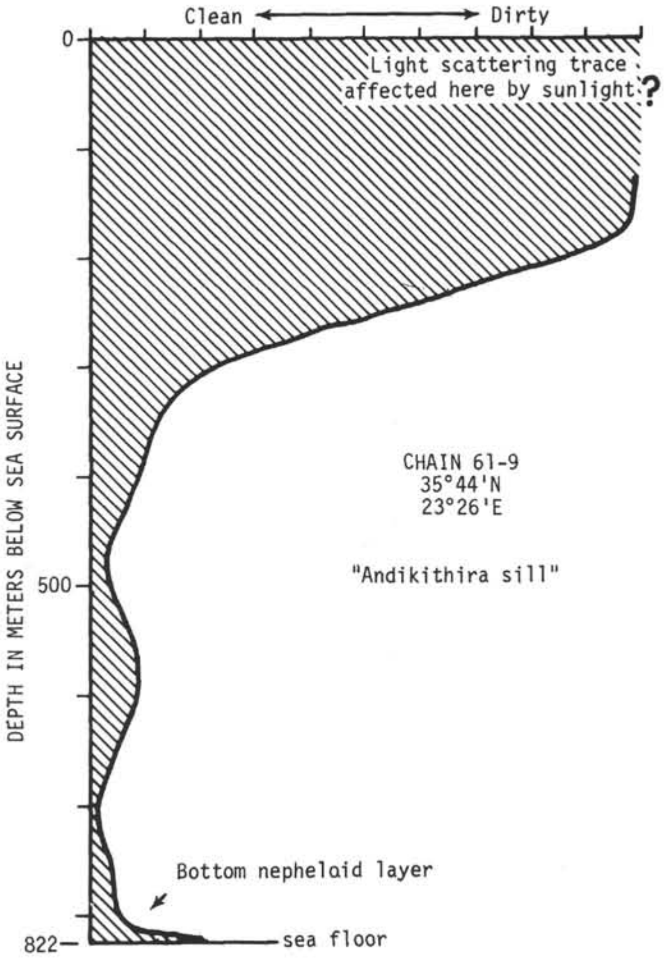


Figure 20. *Vertical light-scattering profile through the water column in the deepest passage of the sill connecting Peleponnesus to Crete. Horizontal scale is in arbitrary units reflecting the cleanest (0 units) and dirtiest water (10 units). Note the thin layer of increased light scattering hugging the sea floor. Perhaps this layer reflects sediment transport in bottom waters spilling from the Aegean Sea into the Hellenic Trough, and identifies a source of suspended sediment filling a temporary reservoir on the landward wall.*

column constructed through the stratigraphic correlations presented previously. Two datums are indicated at the level of the Matuyama/pre-Jaramillo sapropels and the Brunhes/Matuyama sapropels. Also shown is the distribution of the silicoflagellate *Mesocena elliptica*. As discussed in some detail in Chapter 34.2, the appearance of this species is believed to be limited to a time period of 1.5 to 0.8 my, bracketing the Jaramillo Event of normal agnetic polarity (Hays *et al*., 1969; Muhina, 1969; and Jouse, 1969). If this is the case in the Mediterranean, then the nannofossil zonation proposed here is in gross error and the correlations of the sapropels to Sites 125 and 132 place their inferred stratigraphies under question. This alternative is difficult to entertain because of good stratigraphic control on the Pliocene/Pleistocene boundary as discussed in Chapter 46. However, we do point out the apparent discrepancy between the chronology based on the calcareous fossils and

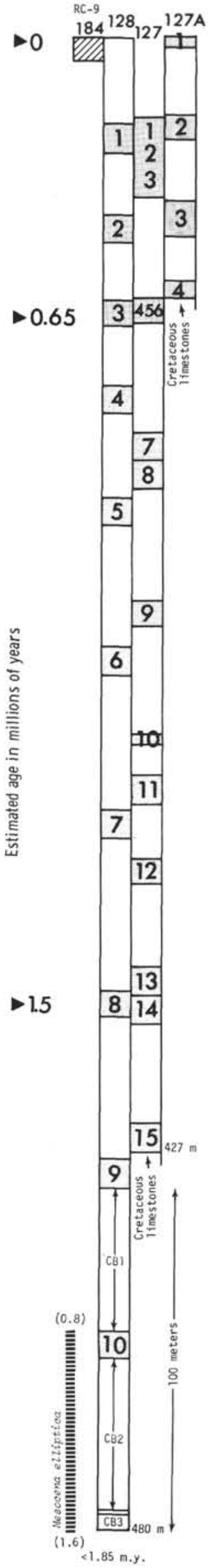


Figure 21. Composite column for the Helenic Trench drill sites. The Hole 128 cores have been plotted to scale, with the remaining cores from the other holes adjusted according to the biostratigraphic and lithostratigraphic correlations presented in Figure 15. The two isochrons correspond to the level of the Bruhes/Matuyama and Matuyama/pre-Jaramillo sapropels, respectively. Note that the first occurrence of the trench fill above the Cretaceous limestones is diachronous. The limestone blocks of Hole 127, if of sedimentary origin, do not continue across the trench plain since they were not recorded in Core 9 of Hole 128 or at any lower levels there. The range distribution of the silicoflagellate Mesocena elliptica is at variance with the chronology based on the nannofossil zonation and sapropel correlations. The numbers in parentheses represent the maximum and minimum ages of the vertical range of this species in Quaternary sediments from the Pacific and Indian oceans.

magnetic stratigraphy on the Mediterranean cores and the expected range to *Mesocena elliptica.*

An Evolution of the Sedimentary Sequence

We have distinguished four gross lithologic units in the Quaternary sediments of Holes 127, 127A and 127B. Unit 1 is characterized by beds with relatively thick basal divisions of coarse-grained sands and laminated silts. These beds relate to the presence of a significant abundance of terrigenous clastics in the sediment reservoir which provides the source for the turbidity current suspensions.

Unit 2 contains generally the same type of deposits except for the presence of sapropels diagnostic of intermittent brief periods of stagnation. It is interesting to note that the lower level of Unit 2 (placed between Cores 8 and 9 of Hole 127) interpolates to an age of about 0.95 my, close to the base of the so-called Glacial Pleistocene. Cores from this time period show marked climatic fluctuations (Chapter 46).

Unit 3 displays predominantly finer grained sediments than Units 1 and 2. The main sediment component is marl ooze, occasionally with millimetric thin laminae of sand and/or silt. Unit 4 consists of the same characteristic marl oozes together with pelagic sapropels. In Hole 128 this unit goes back to the lowest parts of the Quaternary, yet it is still in the *Globorotalia truncatulinoides* Total-range Zone (e.g., < 1.85 my).

The succession of generally fine-grained deposits under coarser-grained ones suggest either an evolutionary trend or a sedimentological influence by changing climates with the Glacial Pleistocene and its accompanying large eustatic sea level fluctuations leading to greater productions of sand-size clastics. The progressive infilling is comparable to that observed in some ancient basins, with Units 4 and 3 calling to mind the preflysch and Units 2 and 1 the true flysch. We cannot as yet ascertain whether Units 3 and 4 reflect any quieter sedimentation in the classical sense or whether they just indicate the absence of certain components in the upslope sedimentary reservoirs. Both types of deposits probably originate from turbidity currents, and if we were to make any observation, it would be that the beds of Units 4 and 3 are thicker and that the time span between successive layers was the greatest in Unit 2.

As far as the lateral transport of individual turbidity current flows is concerned, we notice in the correlatable beds a slightly smaller grain size at the basal contact of individual beds and less erosion of the subjacent unit (e.g., see Figure 16) in the cores at the seaward edge of the plain. However, the differences are hardly sufficient to call these deposits distal and the Hole 127 deposits proximal. As discussed earlier, the progressive thickening at the landward wall is related to the flexure of the trench floor and has little environmental or sedimentological significance, other than being a monitor of the *in situ* basin geometry.

Significance of the Cretaceous Limestones

One of the principle objectives of drilling in the Hellenic Trench west of Crete was to gain new insights regarding the particular style of tectonics applicable to the nonrigid sedimentary passengers of subducting lithospheric plates. Our preliminary findings are consistent with the majority opinion that the stratified sediment fill in the axis of the trench rides attached to the subducting slab in sort of a "piggy-back" fashion before encountering the arc itself. Except for a clear indication of local uplift on the inner wall (to be discussed in a later section), no signs of deformation of the trench fill were seen in any of the holes drilled.

Of course the real evidence of contemporary underthrusting comes from the present day seismicity in the downgoing lithospheric slab (McKenzie, 1970; Isacks and Molnar, 1971). Accompanying deformation of the superficial sediment should be first suspected within the landward wall at the northeastern margin of the trench floor where we drilled the three offset holes (127, 127A and 127B).

In fact, it was precisely there that the unusual finding of Cretaceous rocks occurred. It is the purpose of this section to discuss what these discoveries might imply in terms of the evolution of the trench.

To begin with, the rocks were all extremely indurated and very difficult to penetrate. As a facies they consist in part of fractured and mylonitized dolomite barren of fauna and in part of fossiliferous shallow-water limestones with micritic and stylolitic textures. Their age was recognized as Barremian-Aptian.

At two of the drillsites (127 and 127B) the Cretaceous limestones are intercalated with open marine pelagic ooze of Pliocene age. Contacts between the two sediment types were recovered in the cores. We interpreted the stratigraphic inversion, with materials of 120 my age overlying material of ≈ 3 my age, as not in harmony with the concept of the inner wall being simply a deformed flysch wedge (e.g., Dewey and Bird, 1970).

The occurrence of the Lower Cretaceous limestones in the Hellenic Trench raised many intriguing questions. It is fair to say that there still exists a wide divergence of opinion about their origin and significance. Two distinct hypotheses have emerged.

1) The limestones are individual blocks fallen from the landward slope into the trench. This envisions a synsedimentary origin, e.g., olistostrome (Beneo, 1956), with little or no tectonic significance.

2) The limestones and pelagic oozes are the principle components of a tectonic *mélange* produced through the underthrusting of the Ionian Basin beneath the Hellenic Arc.

Most of the shipboard scientists favor the first hypothesis including, Maync, who was responsible for the age determination of the Lower Cretaceous limestone and who has given them the most careful scrutiny (see Chapter 41.2). The second hypothesis is presented and defended in Chapter 48 by some stubborn stalwarts. In this site chapter we will stick to the observations, lest we prejudice our report.

Fixist Framework

In a fixist framework (where there has been little or no relative horizontal movement between the various drill sites) we point out that the Cretaceous rocks were encountered on a subbottom interface dipping some 27 to 32 degrees to the southwest towards the trench axis at approximately the angle of repose of a subaerial landslide (Figure 6).

The oldest Quaternary above the Cretaceous was cored at 427 meters below bottom in Hole 127, with an extrapolated age of 1.6 my. In Hole 127A, 602 meters to the northeast, the Cretaceous limestone underlies trench fill of a markedly younger age (≈ 0.6 my). In Hole 128, some five and one half times further to the southwest, no Cretaceous rocks were found, even though the exact stratigraphic level of their position in Hole 127 was recovered in Core 9 (Figure 21). From Core 9 downward, either the centerbit was used or coring was undertaken. If Cretaceous rocks existed in this interval they–

1) would have been recovered in the cores or in the reservoir in the centerbit face;

2) would have been detected by torquing and slow drilling rates on the derrick floor. They were not.

Thus if the Cretaceous rocks are part of an olistostrome, this depositional event occurred in pre-Pleistocene times, and the upper contact with Quaternary trench fill represents a depositional hiatus. This idea is corroborated by the exclusive presence of Pliocene matrix within and beneath the Cretaceous rocks.

Shallow-water Cretaceous rocks have been dredged from the inner wall of the Puerto Rico Trench and loose blocks of light-colored massive rock have been photographed there in talus piles (Heezen and Hollister, 1971).

Mobilistic Framework

In a mobilistic framework of lithospheric subduction, it is fair (if not correct) to reason that there might have been considerable horizontal displacement between the drilling sites on the trench floor (127, 127B and 128) and the one on the inner wall (127A). Le Pichon (1968) has suggested that the African Plate, of which the Mediterranean Ridge and outer trench wall are a part, has been underthrusting the European Plate (Aegean Plate of McKenzie, 1970) at some 2.6 cm/year averaged over part of the Late Cenozoic. McKenzie reports that the Aegean Plate might indeed be moving quite rapidly through a scissoring action between the jaws of Europe and Africa which is thrusting Turkey to the west and pushing the the Aegean Plate ahead of it.

What can we say about this from the drilling results? First, the age of the stratified sediment fill of the present Hellenic Trench (> 1.8 my) is far in excess of that which would accumulate on a transient piece of the Ionian basin floor some 6 km in width (present trench width). A consumption rate of 2.6 cm/year would engulf the present flat trench floor in only 230,000 years. Thus the configuration in Figure 2 cannot represent a steady state condition with this high consumption rate.

Secondly, the drilling at Hole 127A on the inner wall did recover trench fill. However, we consider it significant that this hole, spudded in only some 4 meters above the level of the trench plain, initially encountered pelagic calcareous oozes in the first core down to a depth of 7 meters. The piston core RC9-184, on the plain, reached its first turbidite at a depth of only 55 cm.

The first four cores of Hole 127A belong to the same nannofossil zone as the first six of Hole 127. Two beds in Hole 127A can be correlated to levels in Holes 127 and 128 on the trench floor (Figure 15). The correlation in Core 4 is particularly good because it involves a unique banding of hydrotroilite.

Of particular relevance is the observation that the relative thickness of the interval between the hydrotroilite bands (the top of a turbidite interval) and turbidite (A) thickens towards the landward wall. It is 55 meters in Hole 128, 61 meters in Hole 127, and 60 meters in Hole 127A. That progressive thickening is related to increased flexure has been already discussed.

We note that the approximate equivalent (within our measuring ability) of the thickness of Hole 127 and 127A probably argues that these two columns never were distantly separated, because 3.4 km of separation accounts for a six meter thickness difference.

We note that since the deposition of turbidite (A) (estimated age >2000,000 years because of absence of Brunhes sapropels found in piston cores of younger age) the column at the location of Hole 127A has been uplifted some 21 meters relative to the plain floor at the inner wall contact (0.1 mm/year). Perhaps the uplift made this part of the sea bed inaccessible to turbidity currents, allowing only pelagic deposition at the surface: (Unit 0 of Hole 127A).

Such uplift could mark an abrupt deformational front at the inner wall-trench plain contact (Seyfert, 1969). No slumping was observed here. The pseudoconglomerate of Core 1 of Hole 127 is believed to be a drilling artifact.

Thirdly, the preserved contacts between the Cretaceous limestone and Pliocene pelagic ooze (now indurated) found in Core 1 of Hole 127B has a striking cataclastic texture not readily associated with a sedimentary origin. Figure 22 illustrates polished sections of four of the recovered rock fragments. The light-colored material in the cracks and crevices is Pliocene nanno ooze. Note the numerous slivers dismembered from the surrounding wall rock. The Cretaceous is extremely indurated and has a compressional wave velocity reaching 6.8 km/sec under confining pressure (see Chapter 18). The tearing apart of this lithology is unlikely in a purely sedimentary event and, if so, the fragments would be expected to be scattered. The rock unit of Figure 22 has a marked tectonic fabric reminiscent of *mélange* terrains (Hsü, 1968).

Fourthly, as purely negative evidence, no metalliferous crusts were noted on the Cretaceous rocks. These are sometimes associated with hard grounds where there has been a significant depositional hiatus. The apparent hiatus between the Quaternary trench fill and the limestones does not contain this evidence. If the rocks had been deposited in an olistostrome in the Pliocene, over one million years of nondeposition occurred at the Site of Hole 127 and over two million at the site of Hole 127A. Yet no crusts are evident.

Whatever the outcome of this debate on the significance of the Cretaceous rocks, the materials recovered on Leg 13 are providing plenty of food for thought.

REFERENCES

Aubouin, J., 1965. Geosynclines **In** *Developments in Geotectonics*. Elsevier, Amsterdam. **1** 335.

Beneo, E., Accumuli terziari da risedimentazione (olistostroma) nell'Appennino centrale e frane sottomarine. *Boll. Serv. Geol. Italia.* **78**, 219.

Bouma, A. H., 1964. Turbidites. **In** Bouma, A. H., and Brouwer, A. (Editors). *Turbidites.* Elsevier, Amsterdam. 247-256.

Brune, J. N., 1968. Seismic moment, seismicity, and rate of slip along major fault zones. *J. Geophys. Res.* **73** 777.

Chase, R. L. and Bunce, E. T., 1969. Underthrusting of the eastern margin of the Antilles by the floor of the western North Atlantic Ocean, and origin of the Barbados Ridge. *J. Geophys. Res.* **74**, 1413.

Dewey, J. F. and Bird, J. M., 1970. Mountain belts and the new global tectonics. *J. Geophys. Res.* **75**, 2625.

Emiliani, C., 1960. Paleotemperature analysis of the Caribbean cores P6304-8 and P6304-9 and a generalized temperature curve for the last 425,000 years, *J. Geol.* **74**, 109.

Galanopoulos, A. G., 1968. The earthquake activity in the physiographic provinces of the eastern Mediterranean Sea, *Scientific Progress Rep't. II.* National Obs. Athens, Seismological Institute. 15p.

Hayes, D. E. and Ewing, M., 1971. Pacific boundary structure. **In** *The Sea.* (A. E. Maxwell, editor), John Wiley and Sons, Intersci., New York. **4** (Part II) 29.

Hays, J. D., Saito, T., Opdyke, N. D. and Burckle, L. H., 1969. Pliocene-Pleistocene sediments of the Equatorial Pacific. Their paleomagnetic, biostratigraphic and climatic record. *Bull. Geol. Soc. Am.* **80**, 1481.

Heezen, B. C. and Hollister, C. D., 1971. *The Face of the Deep.* Oxford University Press, New York. 659p.

______, Hollister, C. D. and Ruddiman, W. F., 1966. Shaping of the continental rise by deep geostrophic contour currents. *Science.* **152**, 502.

Herron, E. M. and Hayes, D. E., 1969. A geophysical study of the Chile Ridge. *Earth and Planetary Science Letters.* **6**, 77.

Hersey, J. B., 1965. Sediment ponding in the deep sea. *Bull. Geol. Soc. Am.* **76**, 1251.

Hesse, R., Von Rad, V. and Fabricius, F. H., 1971. Holocene sedimentation in the Strait of Otranto between the Adriatic and Ionian Seas (Mediterranean). *Marine Geology.* **10**, 293.

Hsü, K. J., 1968. Principle of melanges and their bearing on the Franciscan-Knoxville problem. *Bull. Geol. Soc. Am.* **79**, 1063.

Isacks, B., Oliver, J. and Sykes, L. R., 1968. Seismology and the new global tectonics, *J. Geophys. Res.* **73**, 5855.

______, and Molnar, P., 1971. Distribution of stresses in the descending lithosphere from a global survey of focal-mechanism solutions of mantle earthquakes. *Rev. of Geophys. and Space Physics.* **9** 103.

Jousé, A. P., 1969. Silicoflagellates in bottom sediments of Pleistocene and Late Pliocene of the Pacific Ocean. In Micropaleontology and organogenous sedimentation in the oceans. *Nauka*, Moscow, 105-114.

Le Pichon, X., 1968. Sea-floor spreading and continental drift. *J. Geophys. Res.* **73**, 3661.

McKenzie, D. P., 1970. Plate tectonics of the Mediterranean region, **Nature**. **226**, 239.

Mitchell, A. H. and Reading, H. G., 1969. Continental margins, geosynclines, and ocean floor spreading. *J. Geology.* **77**, 629.

Mitronovas, W. and Isacks, B. L., 1971. Seismic velocity anomalies in the upper mantle beneath the Tonga-Kermadec Island Arc. *J. Geophys. Res.* **76**, 7154.

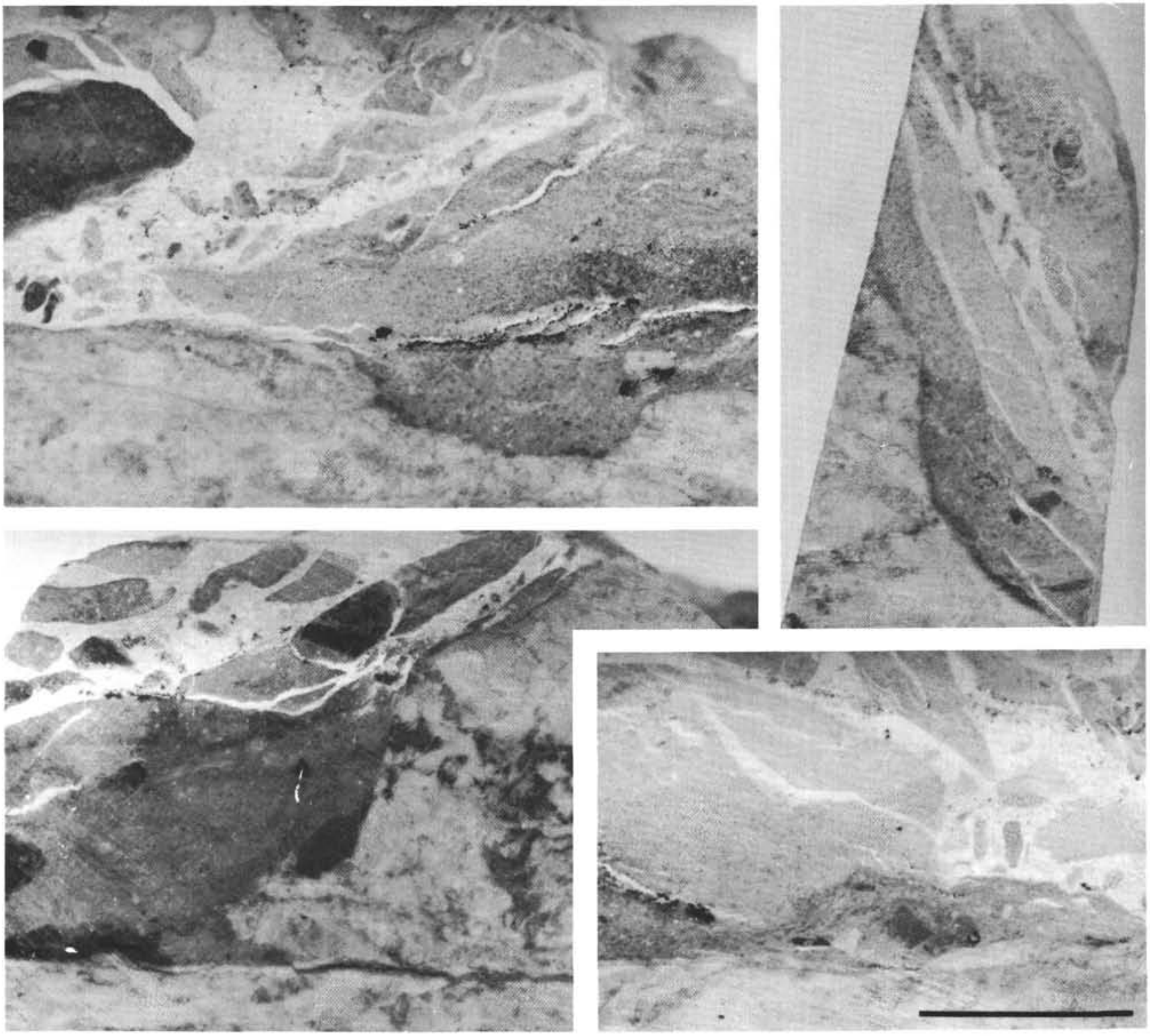


Figure 22. *Polished sections from Core 1 of Hole 127B showing contacts between the Cretaceous limestone (dark) and the indurated Pliocene nanno ooze (white). Note the fracturing, tearing, and breaking of the wall rock along the fissures. Several of us have asked whether such structures as these could have been produced during a submarine landslide of shallow-water Cretaceous rocks onto an ooze-carpeted floor in the ancient Hellenic Trench. Perhaps it is equally as attractive to associate the cataclasm with physical shearing in a* mélange *zone penetrated in the landward wall by our drill string. Scale bar represents 1 cm.*

Miyashiro, A., 1967. Orogeny, regional metamorphism, and magmatism in the Japanese islands. *Medd. Dan. Geol. Foren.* **17**, 390.

Morgan, W. J., 1968. Rises, trenches, great faults and crustal blocks, *J. Geophys. Res.* **73**, 1959.

Moskalenko, L. V. and Ovchinnikov, I. M., 1965. The water masses of the Mediterranean Sea (in Russian) In (L. Fomin, Ed.) *Osnovnye cherty geologicheskogo stroenia gidrologicheskogo rezhima i biologii Stredizemnogomoria.* Akad. Nauk. S.S.S.R., Okeanogra. Kom., Moscova. 119-131.

Muhina, V. V., 1969. Biostratigraphy of sediments and some questions of paleogeography of the tropical region of the Pacific and Indian Oceans. In Micropaleontology and organogenous sedimentation in the oceans. *Nauka*, Moscow. 52-84.

Needham, H. D., 1971. *Stratification in deep sea sediments.* Ph D. Thesis, Columbia University, New York.

Nesteroff, W. D., 1961. La "sequence-type" dans les turbidites terrigenous moderns. *Revue Geogs. Phys. Geol. Dyn.* **4**, 263.

Olausson, E., 1961. Studies of deep-sea cores. *Rep't Swedish Deep Sea Exped. 1947-1948.* **VIII**, 337.

Oliver, J. and Isacks, B., 1967. Deep earthquake zones, anomalous structure in the upper mantle, and the lithosphere. *J. Geophys. Res.* **72**, 4259.

Papazachos, B. C. and Comninakis, P. E., 1971. Geophysical and tectonic features of the Aegean Arc. *J. Geophys. Res.* **76**, 8517.

Parker, F. L., 1958. Eastern Mediterranean foraminifera. *Swedish Deep Sea Exped. 1947-1948 Reports.* **VIII**, 219.

Ryan, W. B. F., 1971. Stratigraphy of the eastern Mediterranean, *Proc. VII Internat'l. Sediment. Congr.* (in press).

Savit, C. H., Knox, W. A., Blue, D. M. and Paitson, L., 1964. Reflection and velocity profiles at the Outer Ridge, Puerto Rico. *Geophys. Res.* **69**, 701.

School, D. W., von Huene, R. and Ridlon, J. B., 1968. Spreading of the ocean floor: undeformed sediments in the Peru-Chile Trench. *Science.* **159** (3817), 869.

———, Christensen, M. N., von Huene, R. and Marlow, M. S., 1970. Peru-Chile Trench and sea-floor spreading. *Bull. Geol. Soc. Am.* **81**, 1339.

Seyfert, C. K., 1969. Undeformed sediments in oceanic trenches with sea-flooring spreading. *Nature.* **222**, 70.

Stauder, W., 1968. Mechanisms of the Rat Island earthquake sequence of February 4, 1965, with relation to island arcs and sea-floor spreading, *J. Geophys. Res.* **73**, 3847.

Van Straaten, L. M. J. U., 1967. Turbidites, ash layers, and shell beds in the bathyal zone of the southeastern Adriatic Sea. *Rev. Geograph. Phys. Geol. Dyn. Ser.* **2**, **9**, (3), 219.

Venkatarathnam, K. and Ryan, W. B. F., 1971. Dispersal patterns of clay minerals in the sediments of the eastern Mediterranean Sea. *Marine Geol.* **11**, 261.

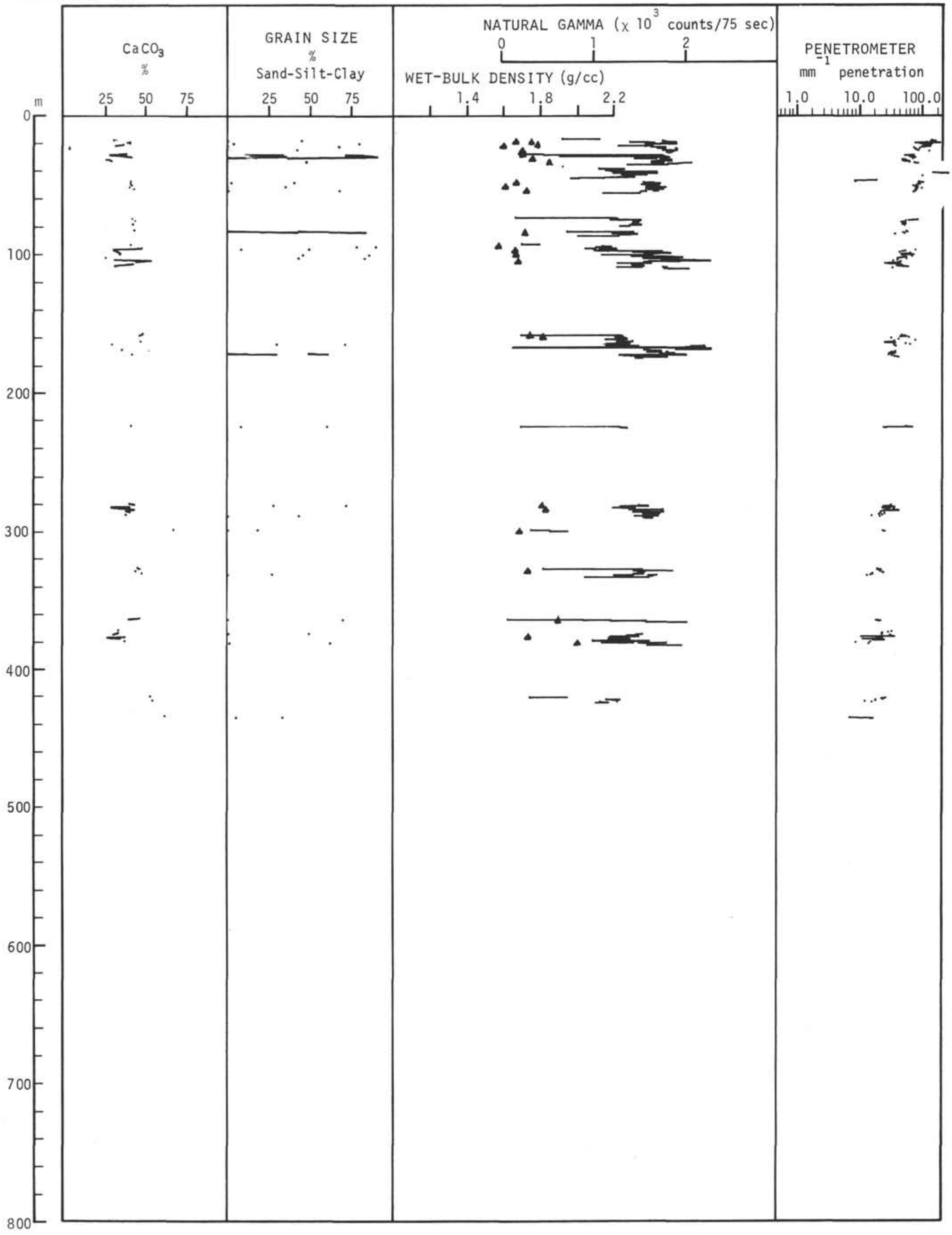
Vogt, P. R., Schneider, E. D. and Johnson, G. L., 1969. The crust and upper mantle beneath the sea **In** P. J. Hart, (Editor). *The Earth's Crust and Upper Mantle* Geophys. Monograph 13, Amer. Geophys. Un., Wash., D.C. 550-617.

von Huene, R. and Shor, G. G., Jr., 1969. The structure and tectonic history of the eastern Aleutian trench. *Bull. Geol. Soc. Am.* **80**, 1889.

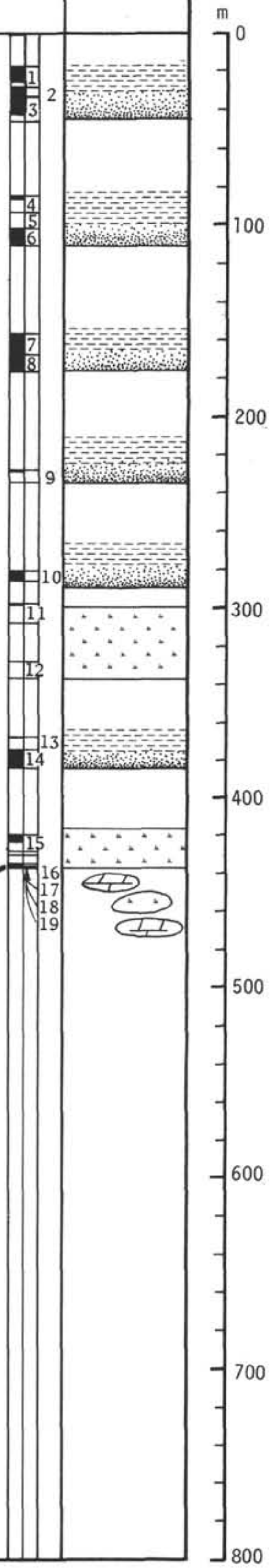
Von Rad, V., 1968. Comparisons of sedimentation in the Bavarian flysch (Cretaceous) and Recent San Diego Trough (California). *J. Sediment. Petrol.* **38** (4), 1120.

Wezel, F. C. and Ryan, W. B. F., 1971. Flysch, margini continentali e zolle litosferiche, *Boll. Soc. Geol. It.* **90**, 249.

Hole Summary 127

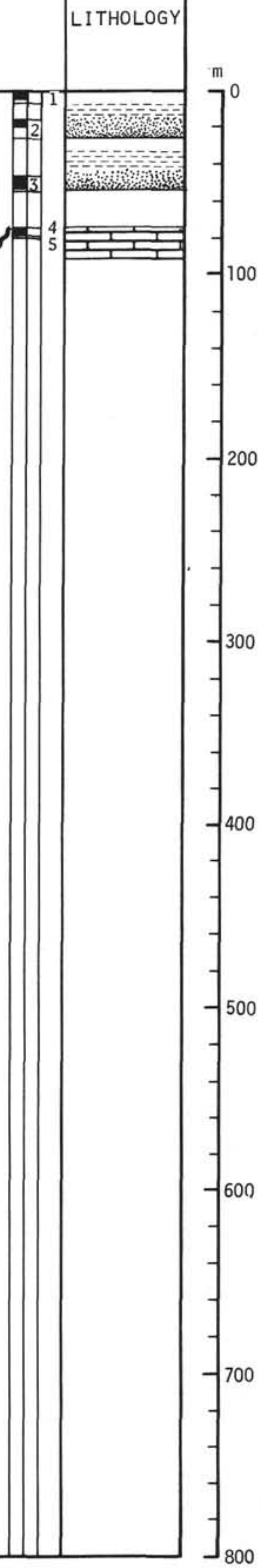


AGE	LITHOLOGY AND BIOSTRATIGRAPHY	LITHOLOGY
PLEISTOCENE	Turbidites and Contourites: graded SANDS to MARL OOZES, SAND-SILT laminae, MARL OOZE beds, ASH and SAPROPELS sequences of quartzose and foraminiferal sands grading to silts and marl oozes interbedded with sharp contacts with sand-silt laminae and marl ooze beds ASH: layer in core 2 SAPROPELS dark colored sequences with high pyrite content and rich in siliceous microfossils (redeposited sapropelitic sands and marl oozes). upper Sapropel in *G. oceanica* zone lower Sapropel in *P. lacunosa* zone lowermost Quaternary missing 427m	
LOWER CRETACEOUS over PLIOCENE	dolomitic BLOCS and MARL OOZE The drilling penetrated 8m of DOLOMITE and DOLOMITIC LIMESTONE overlying 75 cm of Pliocene MARL OOZE, overlying in turn, one meter of DOLOMITE in which the drilling was stopped. DOLOMITES Aptian - shallow water facies pale yellowish brown to very dark brown well cemented with recemented fractures containing benthonic foraminifera: *Orbitolina* MARL OOZE Age: lower part of Upper Pliocene, *D. surculus* zone light olive gray subhorizontal bedding burrowing on top	



Hole Summary 127A

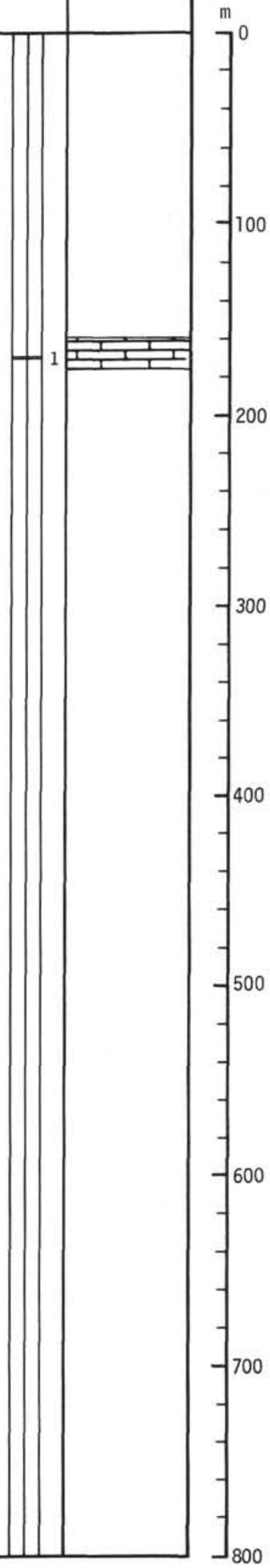
AGE		LITHOLOGY AND BIOSTRATIGRAPHY
PLEISTOCENE	UPPER	Turbidites and Contourites: graded SANDS to MARL OOZES, SAND SILT laminae and MARL OOZE beds Sequences of quartzose and foraminiferal sands grading to silts and marl oozes. Interbedded with sharp contacts with sand-silt laminae and marl ooze beds. Abundant Pteropods in core 1 79m
CRETACEOUS	LOWER	LIMESTONE Aptian, light olive gray, fine grained, fractured and recemented.



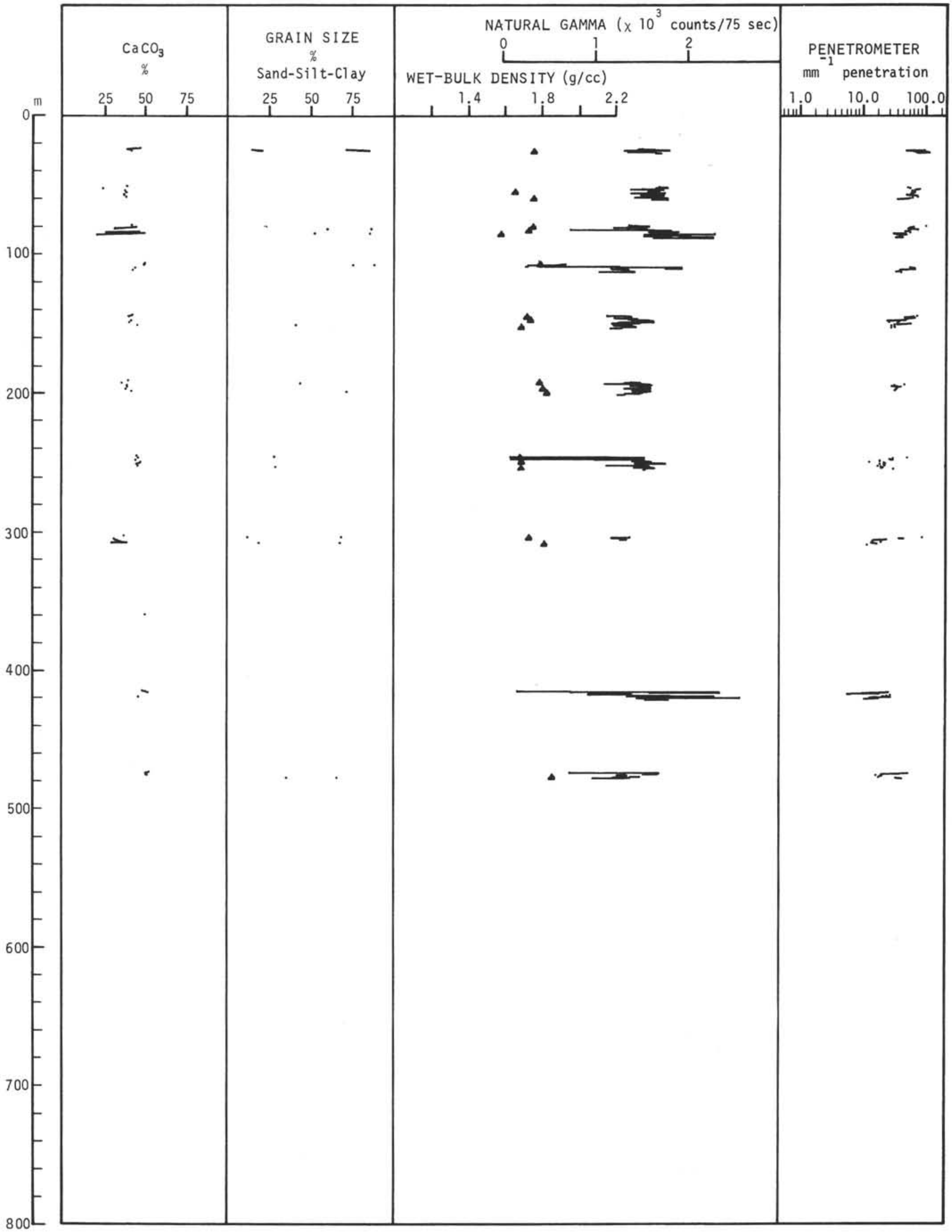
Hole Summary 127B

AGE	LITHOLOGY AND BIOSTRATIGRAPHY
LOWER CRETACEOUS over NEOGENE	LIMESTONE and BRECCIA Limestone: (Albian) fine grained light brownish gray fractured stilolitic contacts Breccia: angular pieces of limestone in a greenish gray matrix of foraminiferal marl, Neogene *(Orbulina)*

LITHOLOGY



Site Summary 128



AGE	LITHOLOGY AND BIOSTRATIGRAPHY	LITHOLOGY

PLEISTOCENE — MIDDLE TO UPPER / LOWER

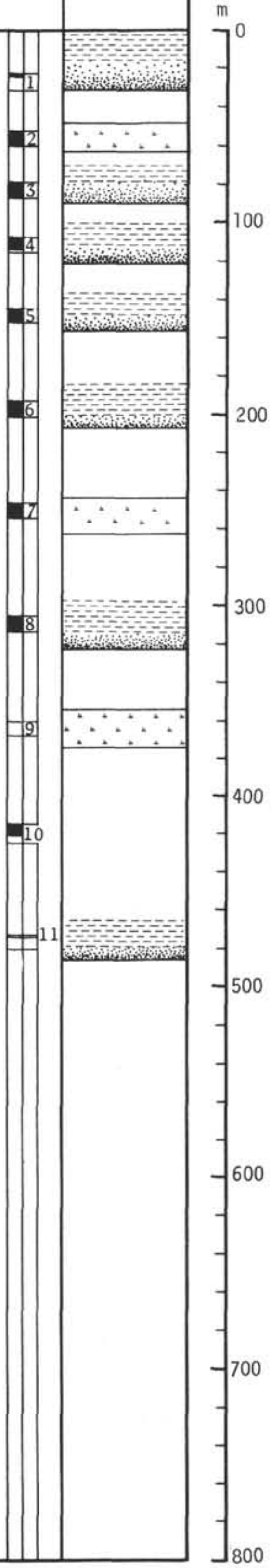
Turbidites and Contourites: graded SANDS to MARL OOZES, SAND-SILT laminae, MARL OOZE beds and SAPROPELS

sequence of quartzose and foraminiferal sands grading to silts and marl oozes
interbedded with sharp contacts with sand-silt laminae and marl ooze beds

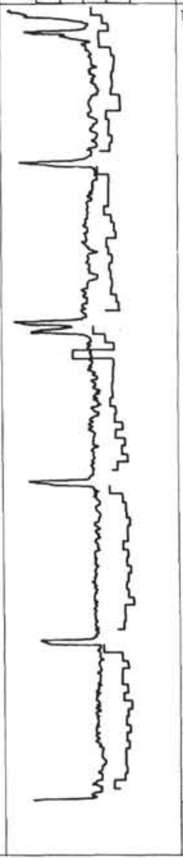
SAPROPELS

dark colored graded sequences with high pyrite content and rich in siliceous microfossils (redeposited sapropelitic sands and marl oozes).

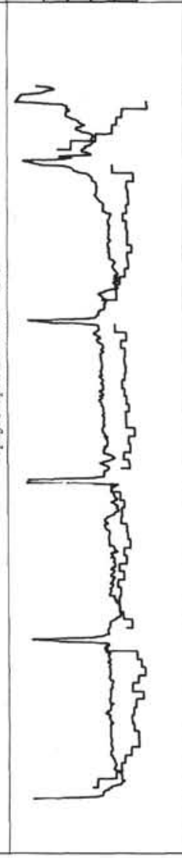
upper Sapropel in *G. oceanica* zone
lower Sapropel in *P. lacunosa* zone



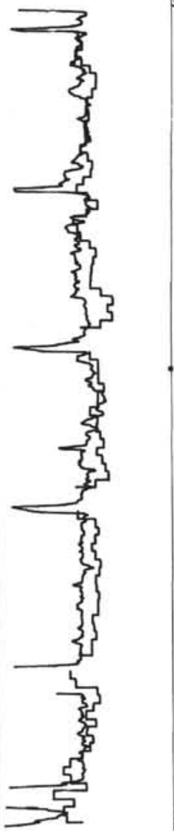
SITE 127 CORE 1 Cored Interval 18-27 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LATE PLEISTOCENE *Gephyrocapsa oceanica* Zone		18	1		31 (0-69-31)	MARL OOZE sections 1 and 2 disturbed by drilling olive gray (5YR 4/1) faint bedding occasional sand beds with sharp bottom contact	
			2		41 39	Smear (marl ooze): nannos 40, quartz 25, micas 35 (Sand): nannos 30, quartz 30, micas 40, feldspar, pyrite poor foraminiferal fauna, sorted by size *Helicosphaera carteri* the dominant nannofossil species	
			3		37 32		
			4				
		25.5	5		(0-43-57)		
			CC				

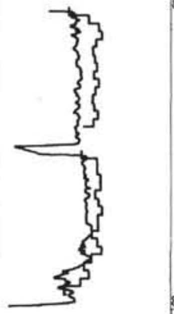
SITE 127 CORE 2 Cored Interval 27-36 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE PLEISTOCENE *Gephyrocapsa oceanica* Zone		27.9	1	VOID	39 (11-62-27) (34-48-18)	graded SANDS to MARL OOZES (turbidites) sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze sand layers thin: 1 to 20 cm sequences 10 to 70 cm thick mainly olive gray (5Y 4/2) hydrodroilite spots ash layer in section 1	V
			2		28 (35-56-9) 39	Smear (marl ooze): nannos 25, forams 15, quartz 30, mica 30 (Sand): nannos 30, quartz 25, mica 25, glass 5, rock fragments 10, forams 5	
			3		42 (0-37-63)	planktonic foraminifera rare and small-sized. benthonic foraminifera partly displaced. pteropores, rare ostracods, siliceous sponge spicules.	
			4		26 28		
		34.5	5		30 (0-48-52)		
			CC				

SITE 127 CORE 3 Cored Interval 36-45 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE PLEISTOCENE *Gephyrocapsa oceanica* Zone		37.3	1			The core is completely disturbed by drilling	V
			2			MARL OOZE varicolored: light olive gray (5Y 4/2) and olive gray (5Y 6/2) abundant pteropods fragments of thin-shelled pelecypods otoliths displaced and eroded benthonic foraminifera	
			3				
			4				D
			5				
		45	6				
			CC				

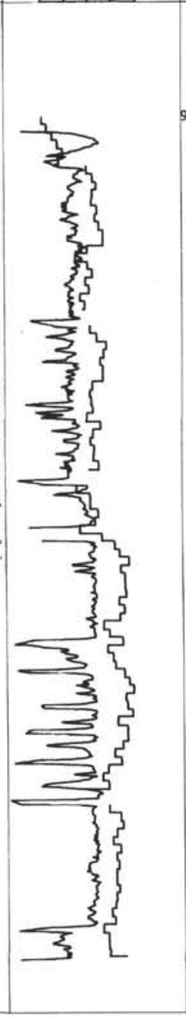
SITE 127 CORE 4 Cored Interval 83-92 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE PLEISTOCENE *Gephyrocapsa oceanica* Zone		83.2	1	VOID	44 44 (0-44-56)	graded SANDS and MARL OOZES (turbidite) quartzose sand grading to silt and marl ooze dark greenish gray (5GY 4/1)	V
			2			Smear (marl ooze): nannos 45, quartz 25, micas 30 (Sand): nannos 30, forams 15, quartz 35, mica 15, pyrite 5 foraminifera fairly abundant	
		86			(43-42-15)		
			CC				

SITE 127 CORE 5 Cored Interval 92-101 m

AGE: MIDDLE PLEISTOCENE, *Gephyrocapsa oceanica* Zone

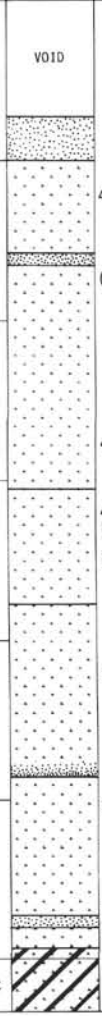
WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0



m B. S. FL.: 93.1 ... 101

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

LITHOLOGIC SYMBOLS



% $CaCO_3$ (% sand/silt/clay): 41; (79-12-9); 48; 44 (8-41-51); 30; 33; 35; 34 (46-40-14)

DISTURBANCE: V

LITHOLOGY AND PALEONTOLOGY

graded SANDS and MARL OOZES (turbidites)

sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze
sequences 10 to 150 cm thick
sand layers 20-30 cm thick
interbedded with sand layers with sharp bottom and top contact
mainly olive gray (5Y 5/2)
probable sapropel bed, dark olive gray (5Y 3/2) at the base of the core

Smear (marl ooze)

nannos	50
quartz	20
mica	30

specialized assemblages of planktonic foraminifera, dominated by *Globigerina eggeri* and *G. bulloides* in the core catcher sapropel.

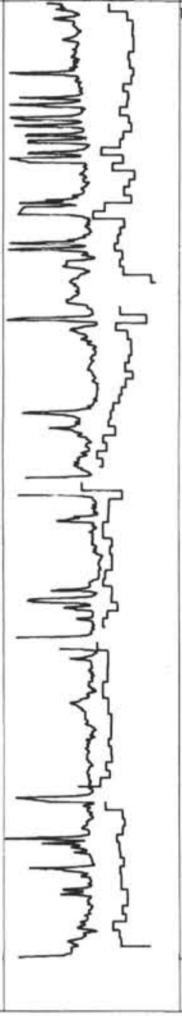
sponge spicules and pteropods

fairly rich and diversified assemblage of siliceous microfossils including radiolarians, silicoflagellates, ebridians, and chrysomonades.

SITE 127 CORE 6 Cored Interval 101-110 m

AGE: MIDDLE PLEISTOCENE, *Gephyrocapsa oceanica* Zone

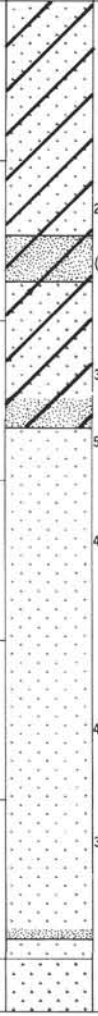
WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0



m B. S. FL.: 101 ... 110

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

LITHOLOGIC SYMBOLS



% $CaCO_3$ (% sand/silt/clay): 26; (43-41-16); 31; 54; 44; 43; 31

DISTURBANCE

LITHOLOGY AND PALEONTOLOGY

SAPROPEL and MARL OOZE

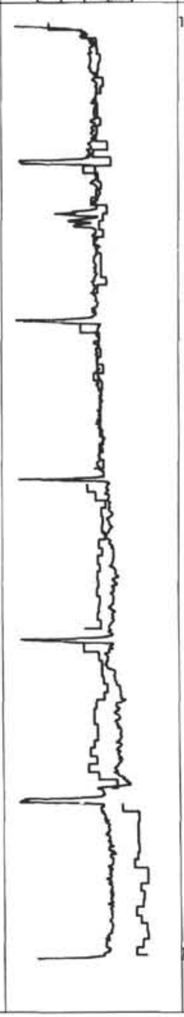
interbedded graded quartzose and foram sand layers and marl oozes
sand layers with sharp bottom and top contacts (contour current redeposited sapropelitic sands)
dark hues in the sapropelitic layers: black (5Y 2/2)
lighter hues in marl oozes: medium gray (N5)

Smear (sand)

rock fragments
quartz
micas
forams

sparce foraminiferal fauna, including *Globorotalia truncatulinoides*
siliceous sponge spicules

SITE 127 CORE 7 Cored Interval 158-167 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE PLEISTOCENE *Gephyrocapsa oceanica* Zone		158.2 – 167	1, 2, 3, 4, 5, 6, CC	VOID	49, 47, 47, (30-42-28), 30	see below	

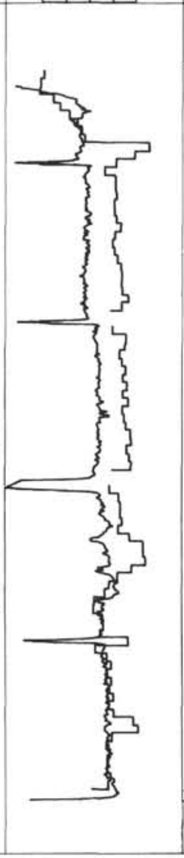
MARL OOZE w/graded SAND

homogeneous marl ooze
gray (N5)
no structure except a single quartzose sand layer (10 cm thick) grading to silt and marl ooze

small-sized and cold-water planktonic foraminiferal assemblages

fairly abundant *bolivinas*
siliceous sponge spicules pteropods

SITE 127 CORE 8 Cored Interval 167-176 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE PLEISTOCENE *Gephyrocapsa oceanica* Zone		167.7 – 174.5	1, 2, 3, 4, 5, CC	VOID	36, 36, (0-50-50), (30-32-38), 42	see below	V

graded SANDS and MARL OOZES

sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze
sand layers thin: laminae to 15 cm
sequences 20 to 150 cm thick
mainly dark greenish gray (5GY 4/1)

Smear (marl ooze)	
nannos	35
forams	5
quartz	25
mica	35

foraminifera tests are very small-sized
holothurian sclerites

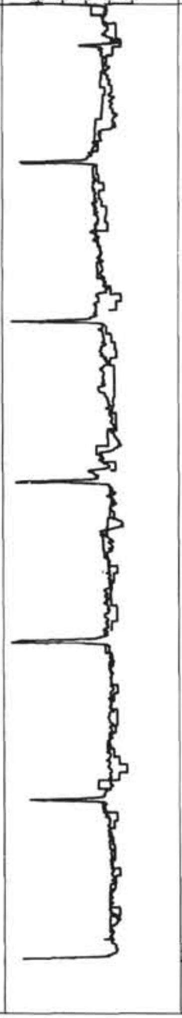
SITE 127 CORE 9 Cored Interval 224-233 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE PLEISTOCENE *Gephyrocapsa oceanica* Zone		224.2 – 225.5	1, CC	VOID	41, (8-52-40)	see below	V

graded SILTS to MARL OOZES (turbidites and contourites)

sequences of quartzose silts with sharp bottom contact grading to marl oozes
interbedded with layers of silt with sharp bottom and top contacts
mainly olive gray (5Y 4/2)
laminated
foraminifera extremely rare and small-sized

SITE 127 CORE 10 Cored Interval 281-284 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE		284	1, 2, 3, 4, 5, 6, CC		40, 44, 40, 29, 29, 44, 38, 40, 38, 39		

NOTE: nine meters recovered for 3 m cored! However, the core is excellent and shows no disturbance.

graded SANDS to MARL OOZES (turbidites)

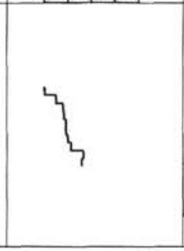
sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze
sand layers 10 cm thick
sequences 10 to 150 cm thick
olive gray (5Y 4/1)
cross-bedding in the silt layers

Smear (marl ooze)	
nannos	40
forams	5
quartz	20
mica	30
pyrite	5

foraminifera very rare and small-sized.

Gephyrocapsa oceanica is the most common nannofossil species

SITE 127 CORE 11 Cored Interval 299-308 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE		299.8, 300.5	1, CC	VOID	(0-19-81) 67		V

MARL OOZE

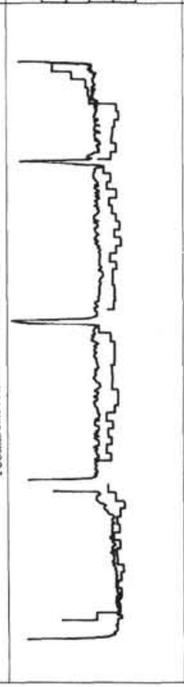
light gray (N7)

no structures

Smear	
nannos	70
quartz	10
mica	20

foraminifera extremely rare and small-sized

SITE 127 CORE 12 Cored Interval 327-336 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		327.5, 332.9	1, 2, 3, 4, CC	VOID	45, 47, 44, 48 (0-27-73)		V

MARL OOZE

olive gray (5Y 4/2)

no structures

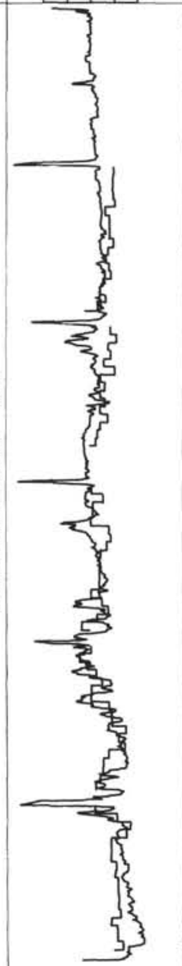
Smear	
nannos	41
forams	5
quartz	20
micas	30
pyrite	2
glass	2

foraminifera are size-sorted and extremely rare

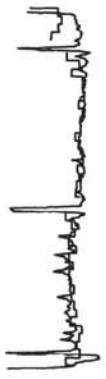
SITE 127 CORE 13 Cored Interval 364-373 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		364.4 365.5	1 CC	VOID	(0-70-30) 46 40	MARL OOZE olive gray (5Y 4/1) bedded with SAPROPEL black (N#0) bedded Smear (Sapropel) nannos 37 quartz 10 mica 20 pyrite 30 sponge spicules 3 foraminiferal fauna normally rich and diversified in the marl ooze. some pyritized tests peak abundance of *Reticulofenestra pseudoumbilica*	V

SITE 127 CORE 14 Cored Interval 373-383 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		374 383	1 2 3 4 5 6 CC		33 (0-50-50) 33 30 37 26 30 35 37 (1-61-38)	graded SANDS to MARL OOZES w/SAPROPELS sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze sand layers thin: laminae to 10 cm sequences 10 to 130 cm thick mainly olive gray (5G 6/1) Smear (marl ooze) nannos 25 forams 10 quartz 25 mica 35 pyrite 3 sponge spicules 2 SAPROPELS interbedded yellowish layers [olive gray (5Y 4/2)] of almost similar petrographic composition, with higher pyrite content, diatoms and sponge spicules: redeposited sapropelitic sands and marl oozes Smear nannos 20 forams 10 quartz 15 mica 25 diatoms 20 sponge spicules 5 fairly abundant planktonic foraminifera. displaced shallow-water benthonic foraminifera. pteropods and sponge spicules. abundant siliceous microfossils in the sapropels (Sections 5 and 6) including radiolaria, silicoflagellates, dinoflagellates, and diatoms. peak abundance of *Reticulofenestra pseudoumbilica*.	

SITE 127 CORE 15 Cored Interval 420-427 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		421.1 424.5	1 2 3 CC	VOID	53 54	MARL OOZE olive gray (5Y 4/2) plastic to stiff no structures Smear: nannos 55, quartz 20, mica 30, pyrite 5 planktonic foraminifera extremely rare and small-sized.	V

SITE 127 CORE 16 Cored Interval 427-429 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER CRETACEOUS Barremian-Aptian		427	1 CC	VOID		DOLOMITE two rock fragments very dark grayish brown (10YR 3/2) sparite cemented fractures	

SITE 127 CORE 17 Cored Interval 429-435 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER CRETACEOUS Barremian-Aptian		429	1 CC	VOID		LIMESTONE and DOLOMITE nine pieces of fractured rocks mostly pale yellowish brown (10YR 7/4) sparite cemented fractures barren X-ray: calcite 28%, dolomite 69% Cretaceous fauna include: *Ammobaculites* *Orbitolina* *Chrysalidina*	

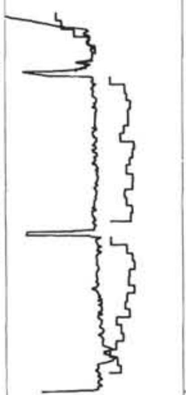
SITE 127 CORE 18 Cored Interval 435-436 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER CRETACEOUS UPPER PLIOCENE *Sphaeroidinellopsis subdehiscens* Interval-zone		434.5 436	1 CC	VOID	(5-28-67) 62	DOLOMITE four fragments of rock dark yellowish brown (10YR 4/2) cemented fractures rare foraminifera overlying MARL OOZE light olive gray (5Y 6/2) plastic bedded scattered forams hydrotroilite specks burrowing bed of limestone and dolomite fragments at 135 cm Limestones contain *Orbitulina*, *Marsonella*, *Cylindrica*, *Sabaudia minuta*. the marl oozes are rich in calcareous microfossils. *Discoaster surculus* nannofossil zone	V

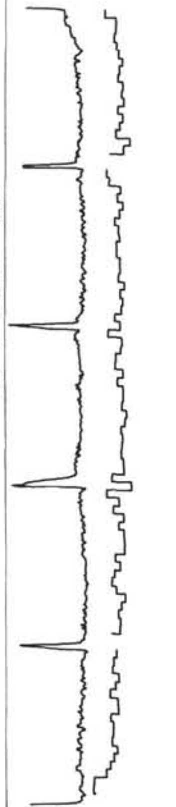
SITE 127 CORE 19 Cored Interval 436-437 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
		436 436.7	1	VOID		DOLOMITE eight rock fragments light brownish gray (10YR 6/2) to very dark gray (10YR 3/1) cemented fractures	
			CC			Total drilling: 437 m in dolomite	

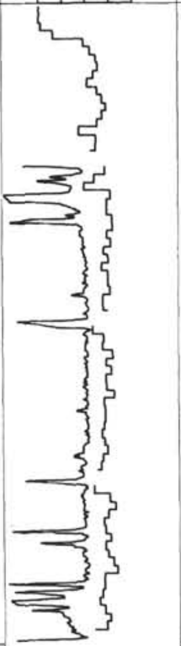
SITE 127A CORE 2 Cored Interval 16-25 m (SITE 127A, CORE 1: Cored interval, 0-7m. Not opened: watery)

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE *Gephyrocapsa oceanica* Zone		16 20.5	1 2 3 CC	VOID	(0-45-55) 32 (3-77-20) 40	graded SANDS and MARL OOZES sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze sequences 20 to 280 cm thick sand silt layers: laminae to 70 cm thick mainly olive gray (5Y 4/2) Smear (sand): forams 15, quartz 60, micas 10, pyrite 10, sponge spicules 3, plagioclases 2 *Helicopontosphaera carteri* abundant and large-sized pteropods sponge spicules foraminifera fairly abundant	V D

SITE 127A CORE 3 Cored Interval 46-55 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE *Gephyrocapsa oceanica* Zone		47.3 55	1 2 3 4 5 6 CC	VOID	41 (2-38-60) 41 (0-36-64) 42 41 43	MARL OOZE dark gray (5Y 4/1) no structures except silt laminae in Section 6 suggesting contour current action pyritic nodules hydrotroilite spots Smear: nannos 40, quartz 30, mica 35, pyrite 5 both the planktonic and the benthonic foraminifera are small-sized and sorted by size.	V

SITE 127A CORE 4 Cored Interval 74-79 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
MIDDLE-LATE PLEISTOCENE *Gephyrocapsa oceanica* Zone		73	1			washed SAND on top of the core	D
						Smear: quartz 35; forams 40; nannos 10; rock fragments 10; feldspar 5	
			2			overlying MARL OOZE dark gray (5Y 4/1) no structures except occasional silt laminae mottling	
						overlying LIMESTONE a single 5 cm fragment light olive gray (5Y 6/1) fine grained	
			3			extremely rare and small-sized planktonic foraminifera in the marl ooze	
						Orbitulina, Nezzazata, Sabaudia minuta, etc. and calcareous algae in the limestone	
			4				
		79	CC				
LOWER CRETACEOUS Barremian-Aptian							

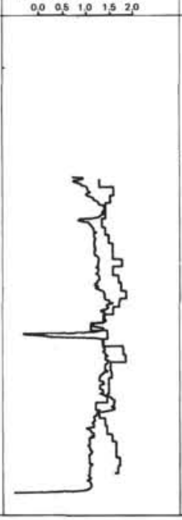
SITE 127A CORE 5 Cored Interval 79-80 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER CRETACEOUS Barremian-Aptian			1	VOID		LIMESTONE five rock fragments light brownish gray (10YR 6/2) calcite cemented fractures rare *Orbitolina, Nezzazata, Sabaudia*, etc. and *Miliolidae*.	V
		80	CC				

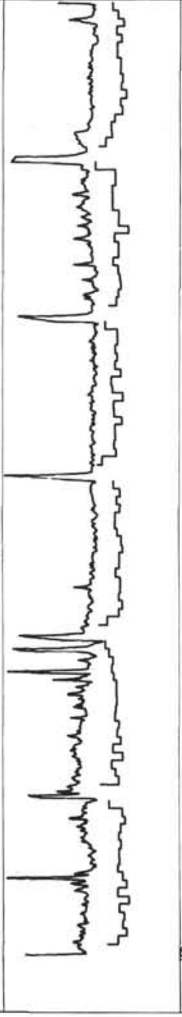
SITE 127 B CORE 1 Cored Interval 165-166 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER CRETACEOUS AND PLIOCENE				VOID		seven rock fragments LIMESTONE dark gray (10YR 4/1) fractured	V
		166	CC			and BRECCIA angular limestone fragments in a foraminiferal-marl matrix	
						Valvulammina off. *Picardi* in the limestone. The foraminifera marl cementing the breccia is possibly Pliocene in age.	

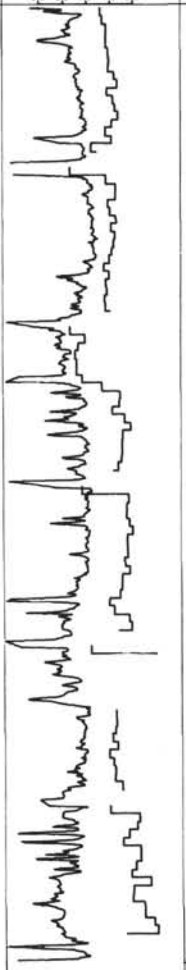
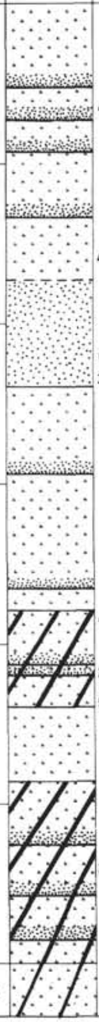
SITE 128 CORE 1 Cored Interval 22-31 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LATE PLEISTOCENE		23.3 26.5	1 2 3 CC	VOID	47 30 (15-57-28) 42 (21-65-14)	graded SANDS and MARL OOZES (turbidites) sequences of quartzose and foraminiferal sand with sharp bottom contact grading to silt and marl ooze sand layers: laminae to 15 cm thick sequences 10 to 40 cm thick mostly dark gray (5Y 4/1) Smear (Sand): forams 60 to 10; quartz 30 to 60; mica 5; pyrite 5 the dominant species is *Helicopontosphaera carteri*. foraminifera rare and small-sized. echinoid spines pteropods	V

SITE 128 CORE 2 Cored Interval 51-60 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE *Gephyrocapsa oceanica* Zone		51 60	1 2 3 4 5 6 CC		39 25 38 39 37 39	MARL OOZE olive gray (5Y 4/1) no structures gas expansion cracks Smear: nannos 40; quartz 15; mica 40; pyrite 5; rock fragments foraminifera extremely rare and small-sized *Helicopontosphaera carteri* the dominant nannofossil	

SITE 128 CORE 3 Cored Interval 79-88 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE		79 … 88	1, 2, 3, 4, 5, 6, CC		42, 45, (60-26-14) 31, 47, 26 (53-34-13) 50, 20	see below	

graded SANDS to MARL OOZES w/SAPROPELS

sequences of quartzose and foraminiferal sand with sharp bottom contact grading to silt and marl ooze (turbidites)

sand layers: laminae to 100 cm thick

sequences 10 to 200 cm thick

mostly olive gray (5Y 4/1)

plastic to stiff

SAPROPELS

black stained (N#1) sequences

high pyrite content, diatoms and sponge spicules

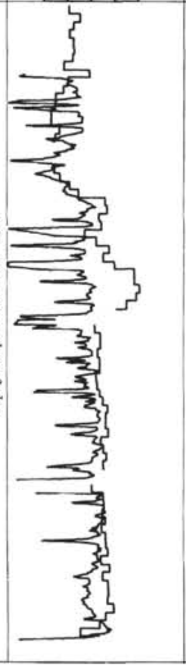
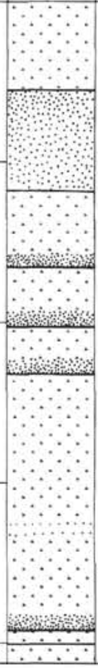
Smear	
nannos	45
pyrite	10
diatoms	10
sponge spicules	10
quartz	10
mica	15

rich assemblage of siliceous microfossils in the sapropels, including radiolaria, silicoflagellates, ebridians, dinoflagellates, diatoms, sponge spicules

fish scales, teeth, otoliths

foraminifera either absent altogether in the sapropels or concentrated in millimeter thick layers

SITE 128 CORE 4 Cored Interval 107-116 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE *Gephyrocapsa oceanica* Zone		107 … 113	1, 2, 3, 4, CC		50, (76-13-11) 49, 44, 42	see below	

graded SANDS to MARL OOZES (turbidites)

sequences of quartzose and foraminiferal sand with sharp bottom contact grading to silt and marl ooze.

sand layers: laminae to 100 cm thick

occasional silt laminae

sequences 50 to 200 cm thick

gas expansion cracks

mostly olive gray (5Y 4/1)

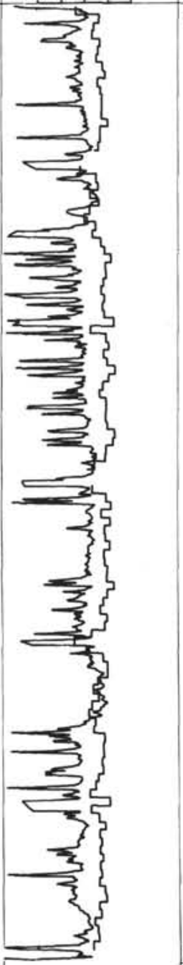
plastic to stiff

Smear (sand)		(Marl Ooze)	
forams	10	nannos	50
quartz	80	quartz	15
mica	10	mica	30
		pyrite	5
		forams	

siliceous sponge spicules

ostracodes

SITE 128 CORE 5 Cored Interval 144-153 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE *Gephyrocapsa oceanica* Zone		144	1		42		
			2		40		
			3				
			4		41		
			5		40		
			6		(0-41-59) 45		
		153	CC				

graded SANDS to MARL OOZES (turbidites)

sequences of quartzose and foraminiferal sand with sharp bottom contact grading to silt and marl ooze

sand layers: laminae to 30 cm thick

sequences 2 to 5 m thick

mostly olive gray (5Y 4/1)

plastic

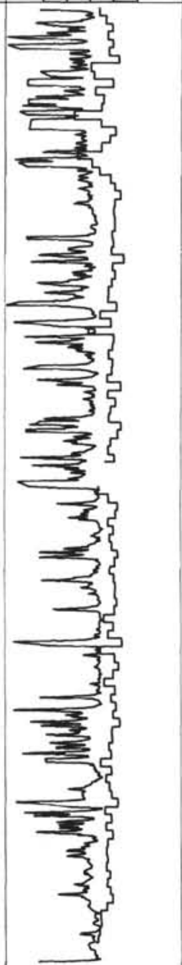
gas expansion cracks

Smear (sand)		(Marl Ooze)	
forams	50	nannos	40
quartz	35	quartz	25
mica	10	mica	30
pyrite	5	pyrite	5

pelagic sedimentation with some terrigenous influx

planktonic foraminifera abundant, also including *Globorotalia truncatulinoides*

SITE 128 CORE 6 Cored Interval 192-201 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
PLEISTOCENE *Gephyrocapsa oceanica* Zone		192	1		39		
			2		(0-45-55) 36		
			3		39		
			4		39		
			5		38		
			6		42 (0-73-27)		
		201	CC				

SAND grading to MARL OOZE (turbidite)

thin, 5 cm, layer of quartzose sand with sharp bottom contact grading to marl ooze (single turbidite sequence).

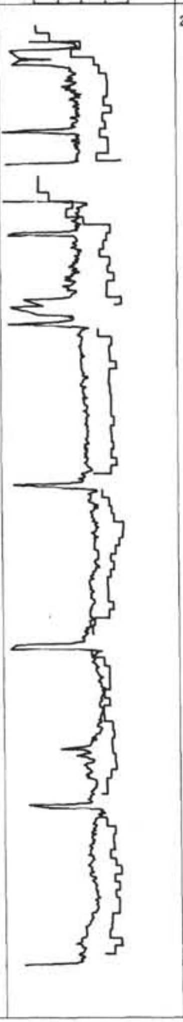
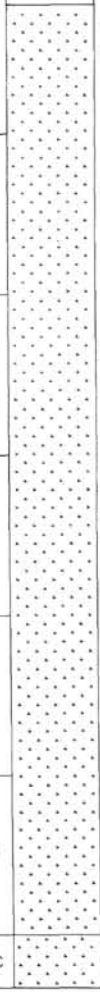
olive gray (5Y 4/1)

marl ooze: plastic, no structures, gas expansion cracks

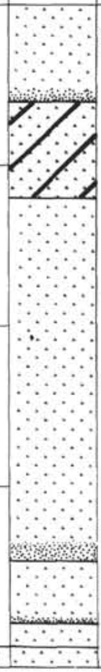
Smear (sand)		(Marl ooze)	
quartz	80	nannos	40
forams	20	quartz	27
		mica	30
		pyrite	3

foraminifera in markedly variable amounts

SITE 128 CORE 7 , Cored Interval 246-255 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		246.3		VOID			V
			1		45 (0-29-71)	MARL OOZE olive gray (5Y 4/1) plastic to slightly stiff no structures gas expansion cracks Smear: nannos 45, quartz 23, mica 30, pyrite 2	
			2		46	assemblage very poor, evidently displaced in the core catcher, including fragments of *Byrozoa*, eroded *Elphidium*, etc. planktonic foraminiferal assemblage fairly abundant	
			3		44	pteropods pyrite fillings	
			4		47		
			5		45		
		255	6		45 (0-29-71)		
			CC				

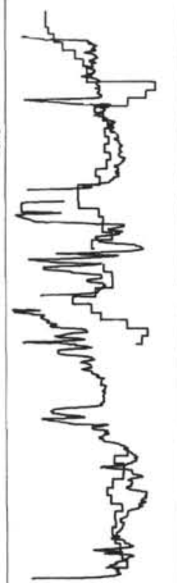
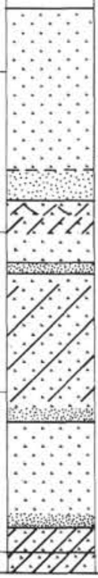
SITE 128 CORE 8 Cored Interval 304-313 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		304	1		37 (12-57-31)	graded SANDS to MARL OOZES w/SAPROPEL sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze (turbidite) sand layers: laminae to 20 cm thick mostly olive gray (5Y 4/1) plastic SAPROPEL yellowish beds in the marl ooze part of the turbidite sequence. rich in diatoms, sponge spicules and pyrite	
			2		31	Smear: nannos 35, diatoms 10, pyrite 10, sponge spicules 5, quartz 15, micas 20, forams 5	
			3		33	planktonic foraminifera either abundant or rare and sorted by size some displaced shallow-water benthonic foraminifera sponge spicules	
			4		36 36 39 29 (19-49-32)		
		310	CC				

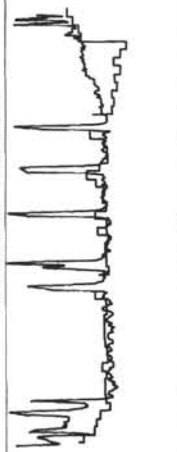
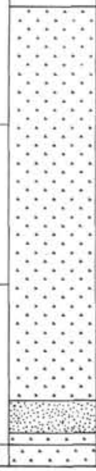
SITE 128 CORE 9 Cored Interval 360-369 m

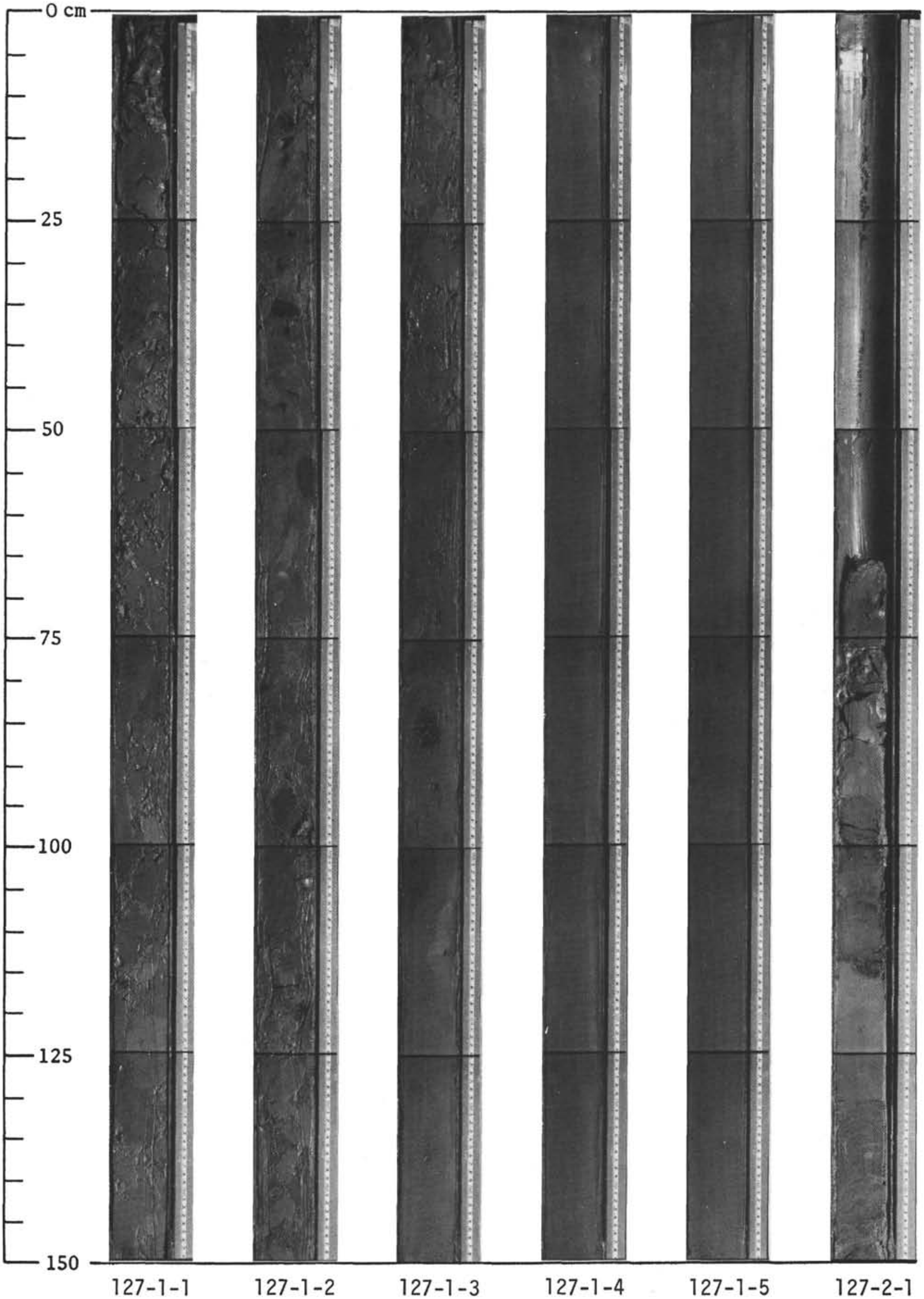
AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone			1	VOID			V
		361.1			50	MARL OOZE olive (5Y 4/3) plastic to stiff	
		361.5	CC			planktonic foraminifera extremely rare and small-sized *Reticulofenestra pseudoumbilica* fairly abundant	

SITE 128 CORE 10 Cored Interval 415-424 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone		415.9	1	VOID	48	graded SAND to MARL OOZE W/SAPROPEL sequences of quartzose sand with sharp bottom contact grading to silt and marl ooze sand layers: laminae to 25 cm thick sequences 70 to 180 cm thick mostly medium light gray (N6) plastic with one consolidated bed (limestone) at 417.8 m SAPROPEL Yellowish beds in the marl ooze part of the turbidite sequence rich in diatoms, sponge spicules and pyrite planktonic foraminifera extremely abundant, and at some intervals comprising a foraminiferal sand abundant siliceous microfossils including radiolaria, silicoflagellates, diatoms, and sponge spicules in the sapropels *Reticulofenestra pseudoumbilica* very abundant	V
			2		52		
			3				
			4		46		
		421	CC				

SITE 128 CORE 11 Cored Interval 474-475 m

AGE	WET-BULK DENSITY (gm/cc) 1.3 1.6 1.9 2.2 / NATURAL GAMMA RADIATION (10^3 counts) 0.0 0.5 1.0 1.5 2.0	m B. S. FL.	SECTION	LITHOLOGIC SYMBOLS	% $CaCO_3$ (% sand/silt/clay)	LITHOLOGY AND PALEONTOLOGY	DISTURBANCE
LOWER PLEISTOCENE *Pseudoemiliania lacunosa* Zone			1	VOID	52	graded SAND and MARL OOZE graded foraminiferal and quartzose sand with sharp bottom and top contacts overlain by marl ooze (turbidite structures) mostly medium gray (N5) plastic to firm slightly laminated (shaly) planktonic foraminifera very abundant, large-sized and diversified radiolaria and other siliceous microfossils	V
			2		50		
			3		51		
					(36-31-33)		
		475	CC			Total Drilling 480 m in marl oozes	


0 cm
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75
100
125
150
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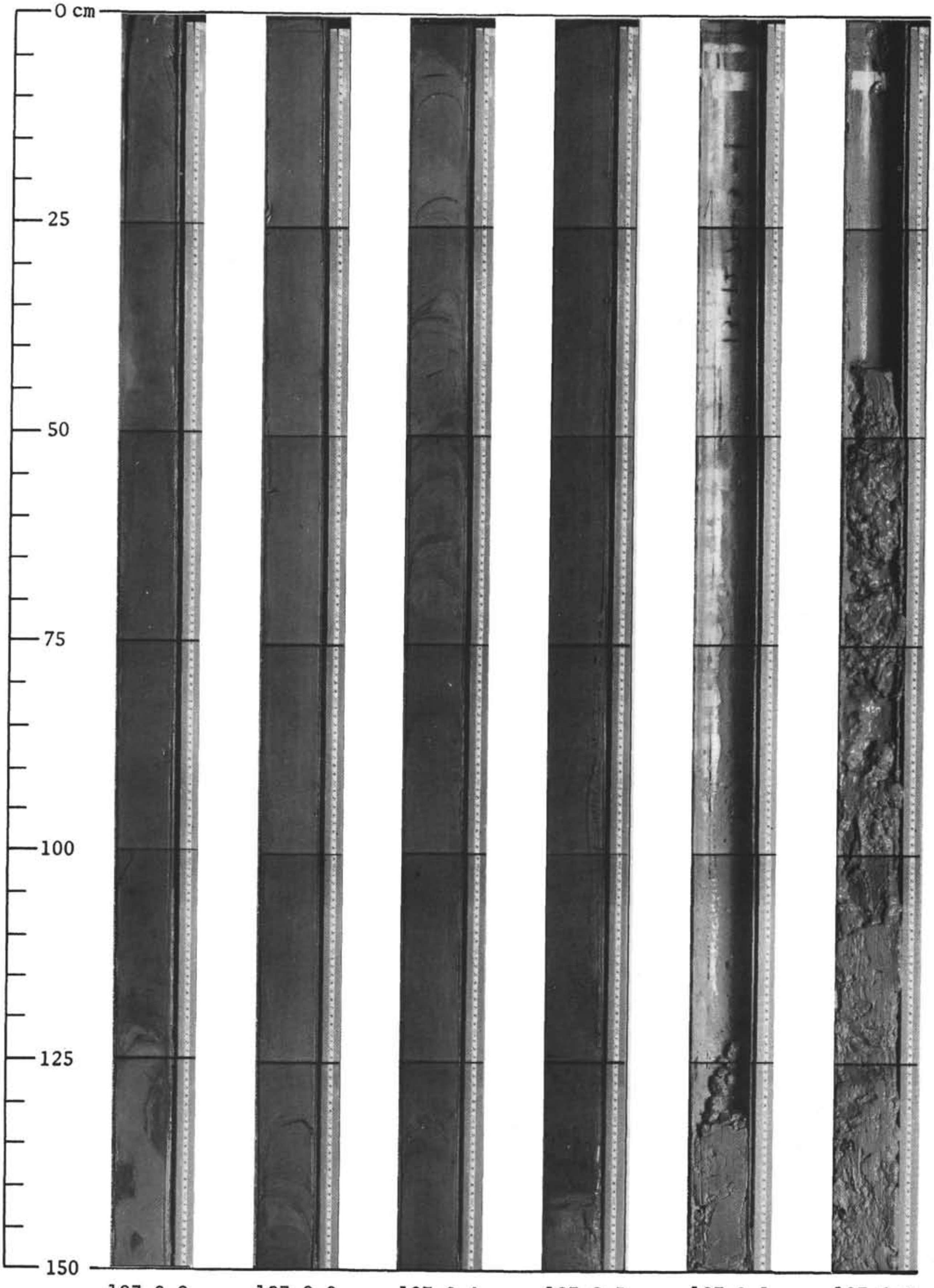
127-1-2
127-1-3
127-1-4
127-1-5
127-2-1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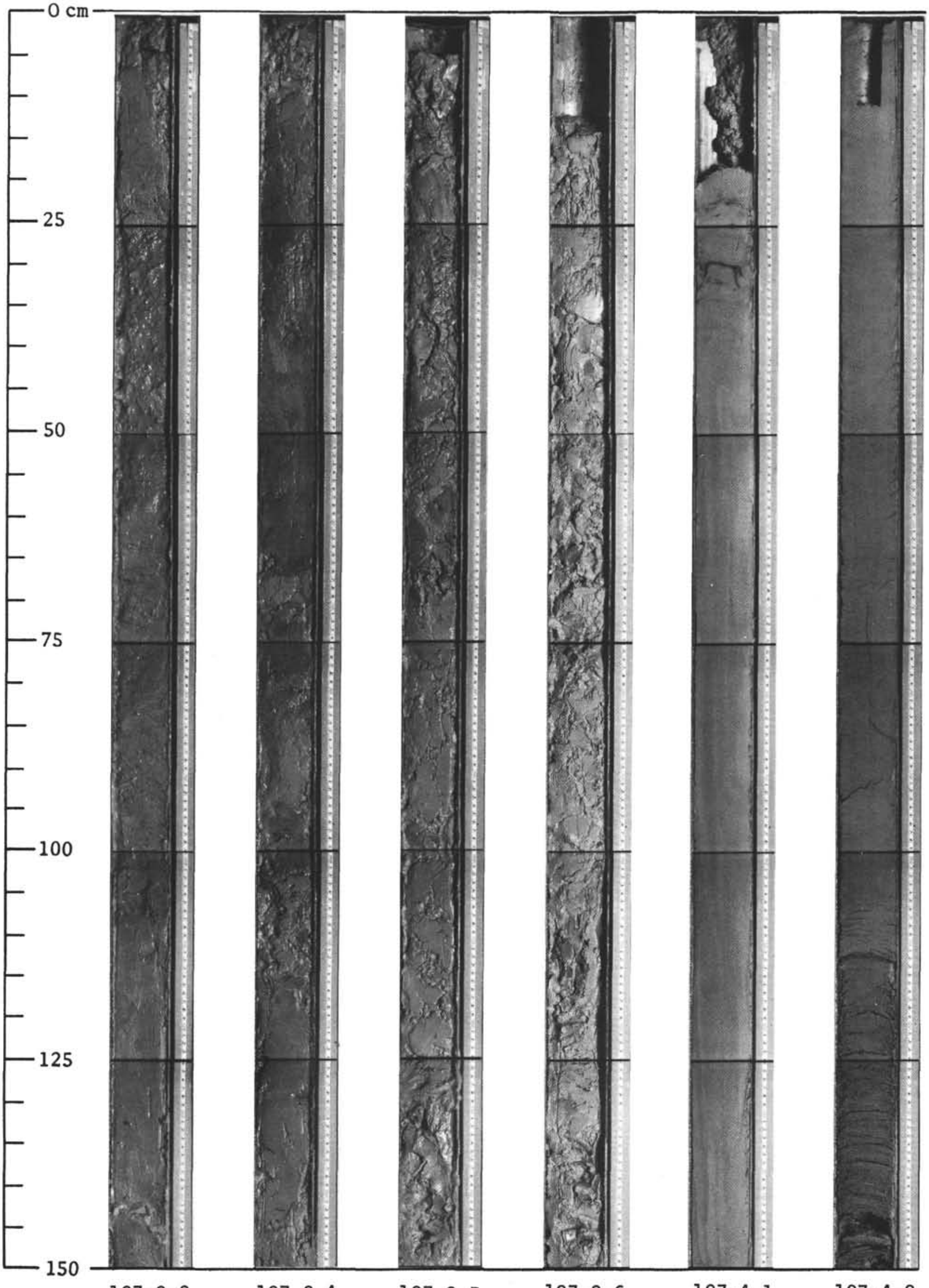
127-2-3
127-2-4
127-2-5
127-3-1
127-3-2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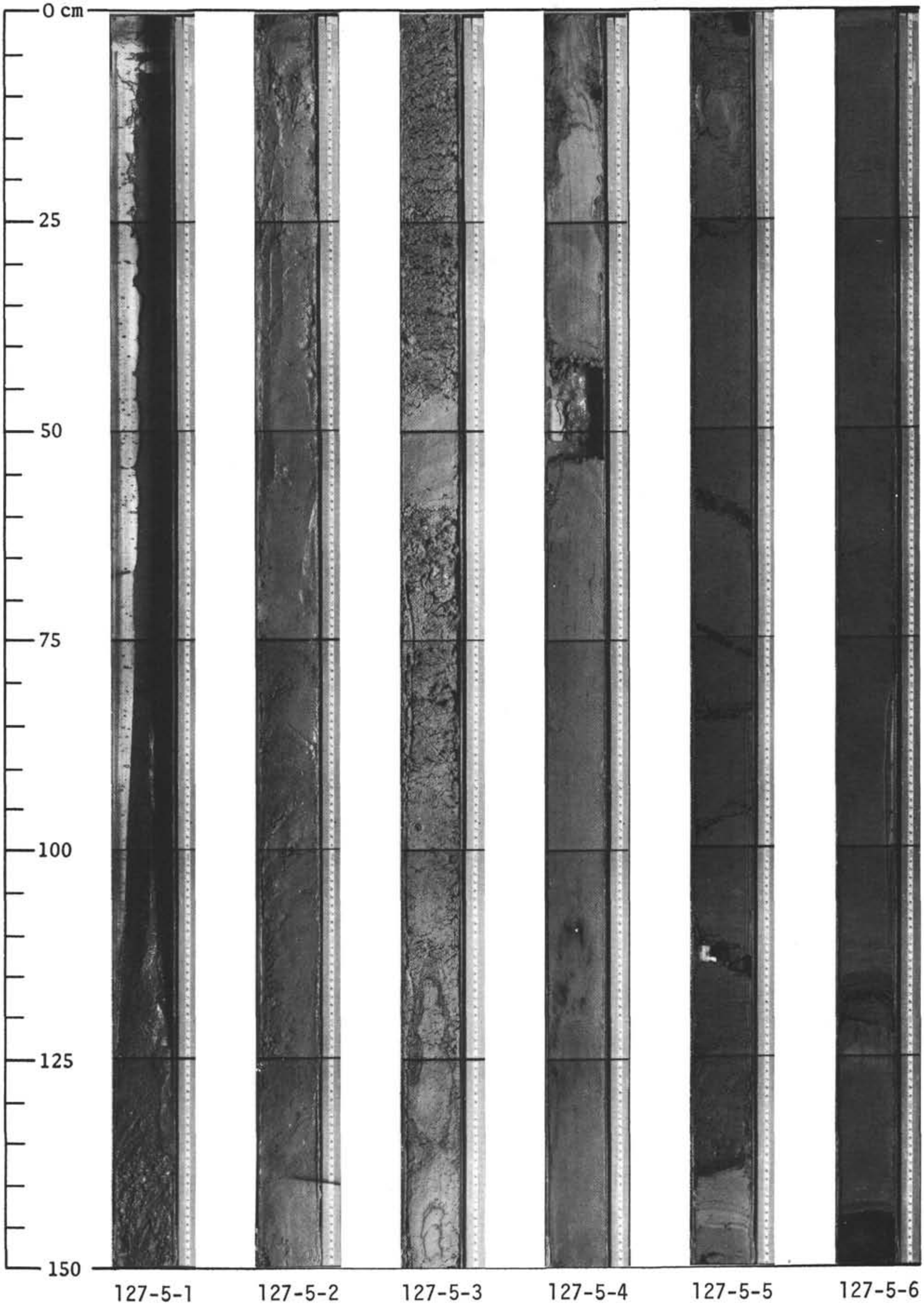
127-3-4
127-3-5
127-3-6
127-4-1
127-4-2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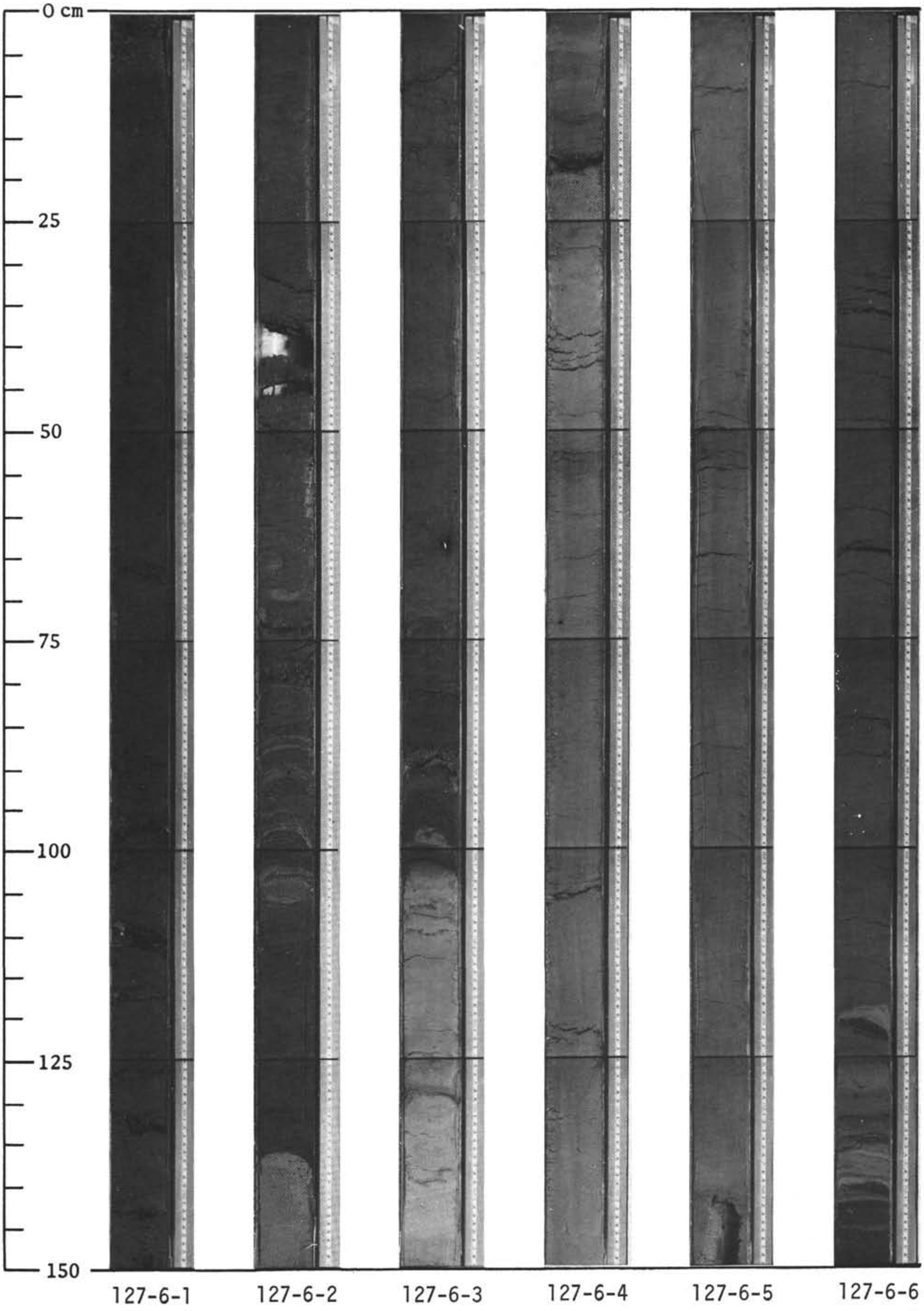
127-5-4
127-5-5
127-5-6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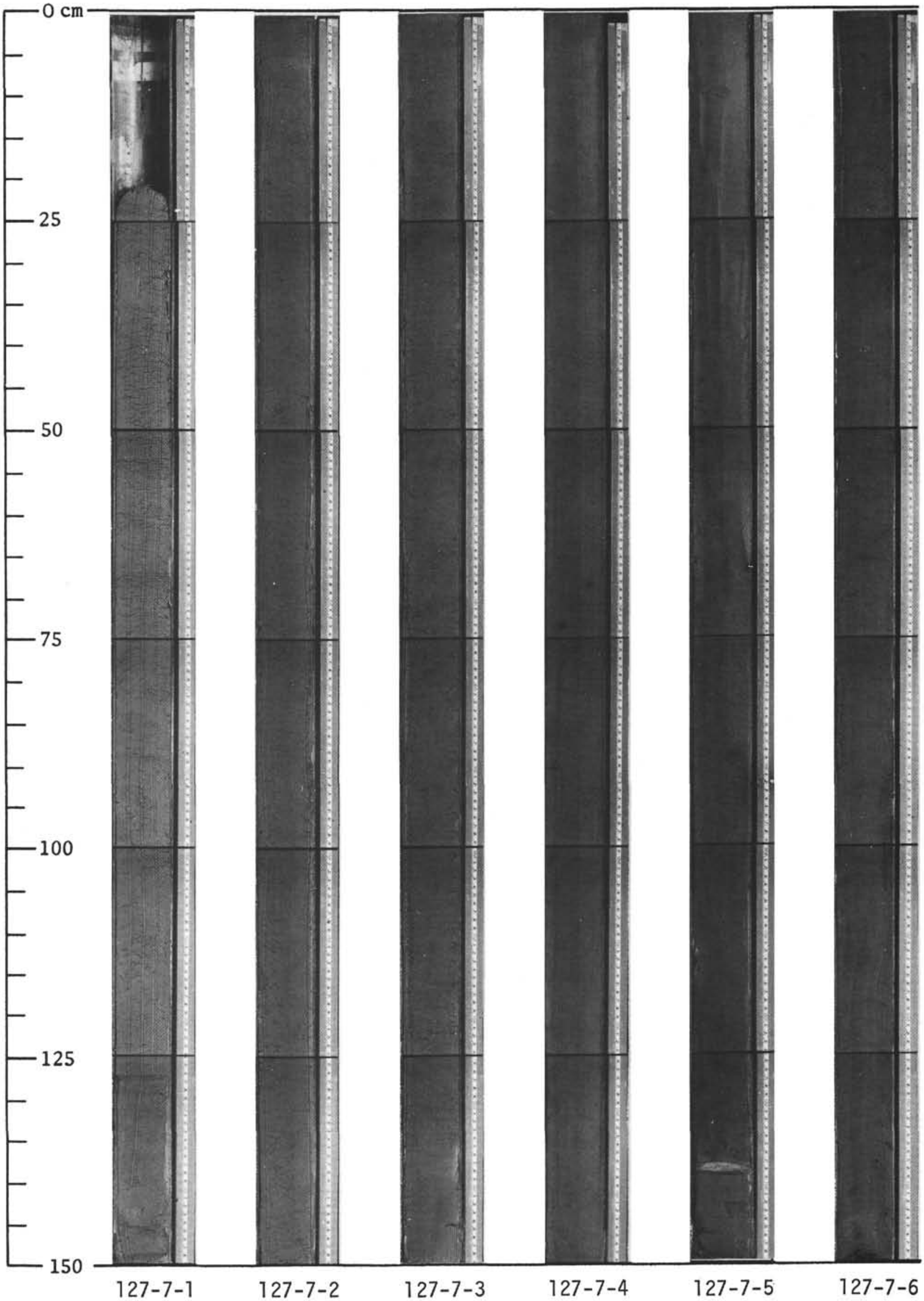
127-6-6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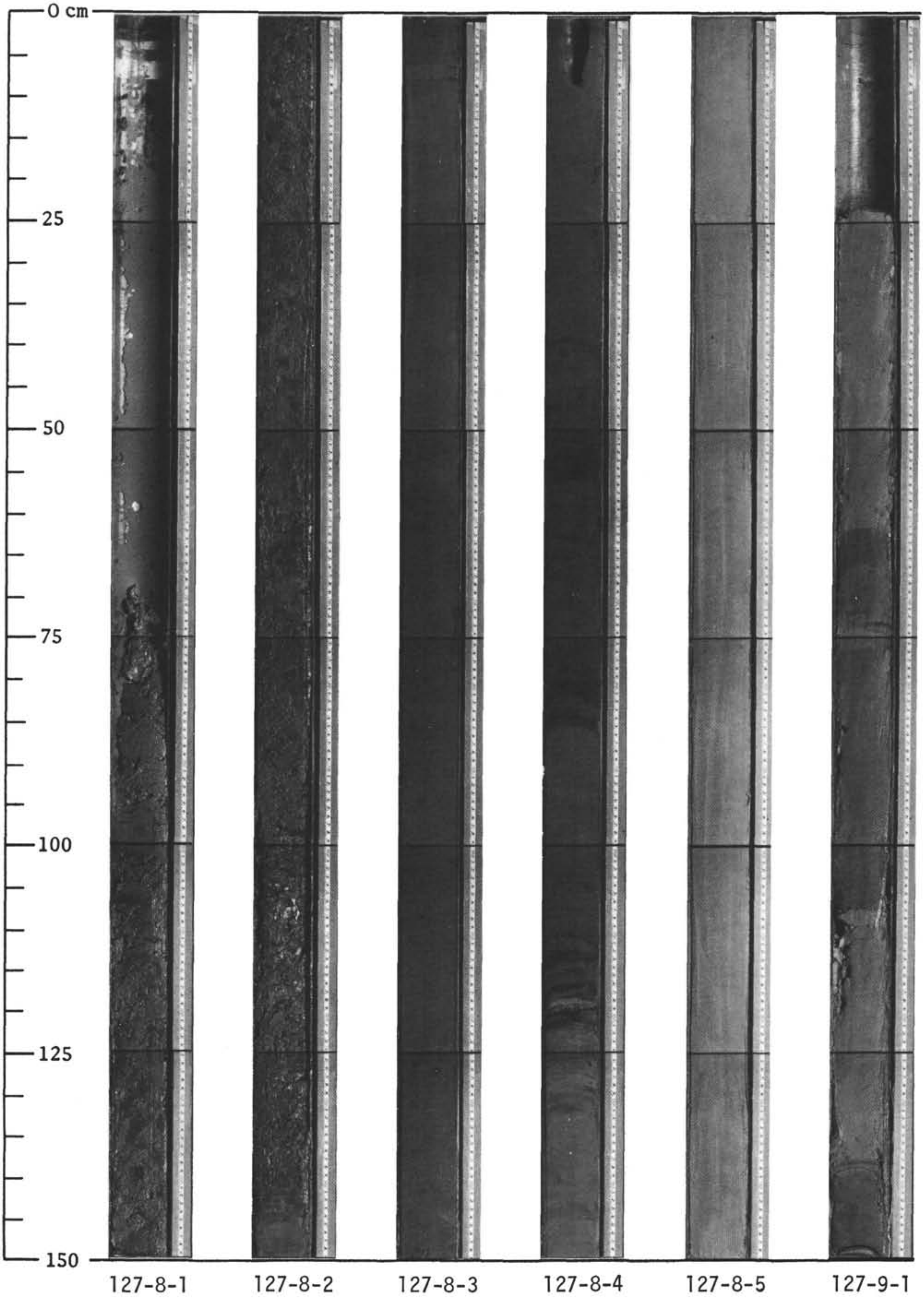
127-7-6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100
125
150
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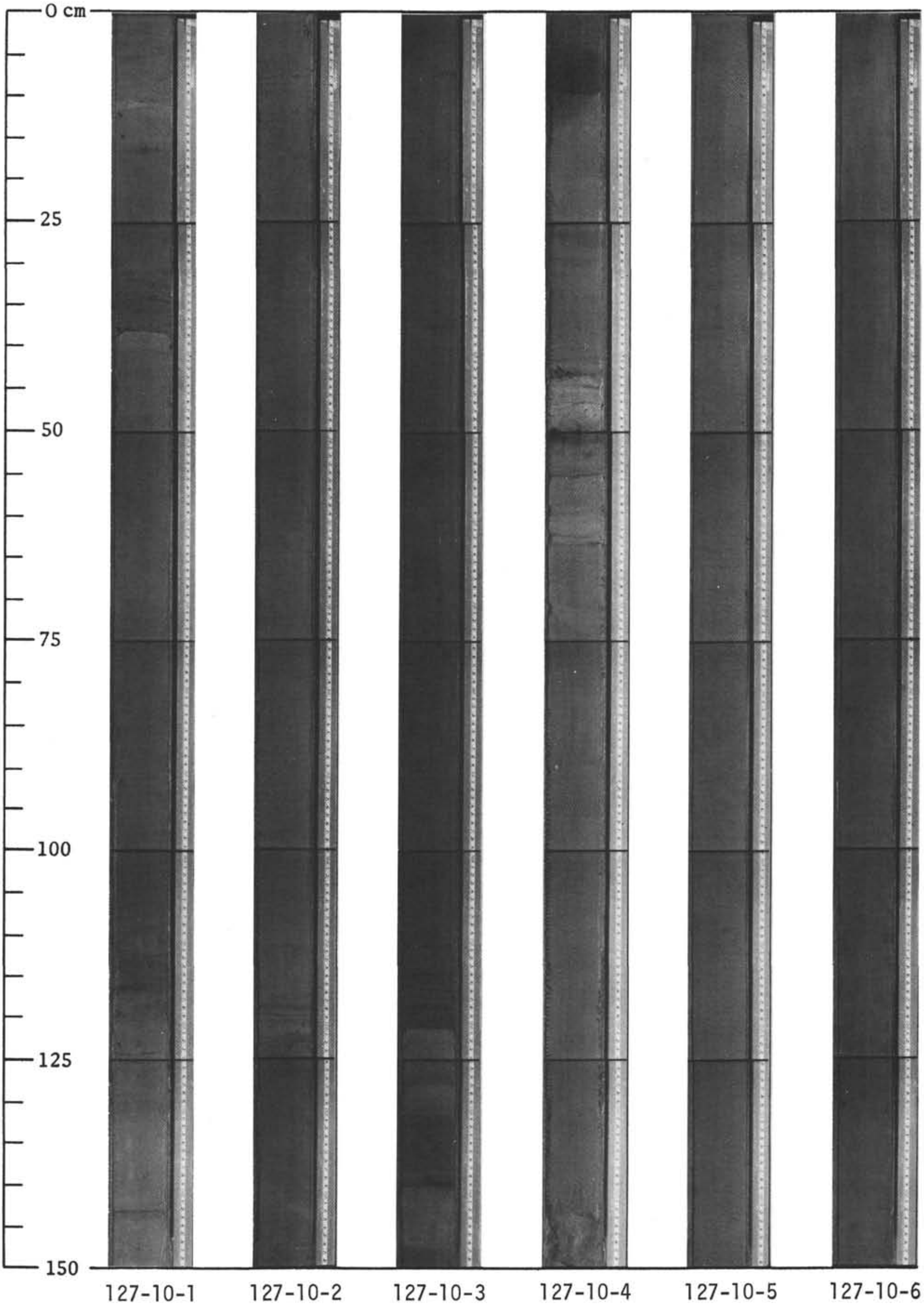
127-8-2
127-8-3
127-8-4
127-8-5
127-9-1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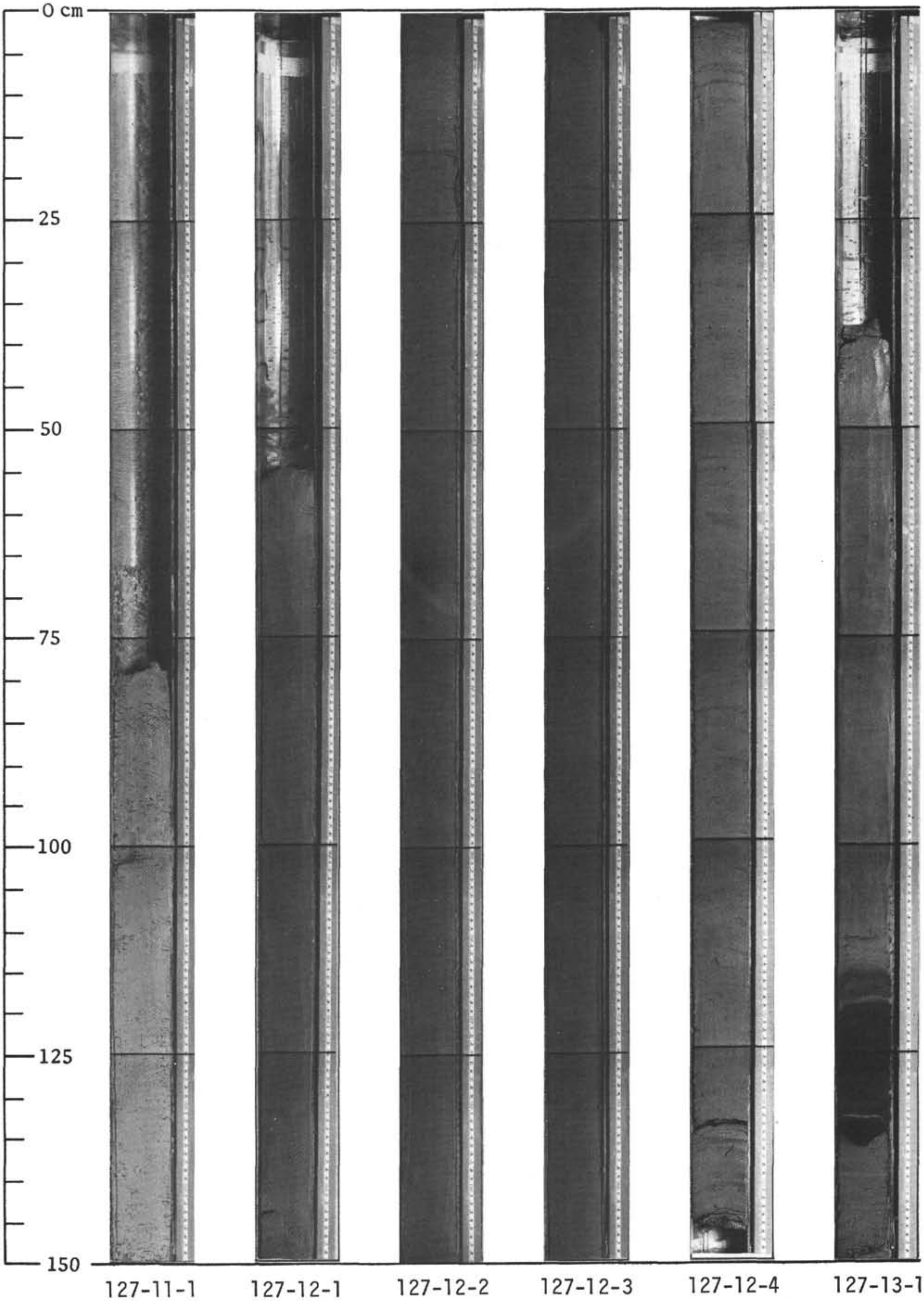
127-10-6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127-12-1
127-12-2
127-12-3
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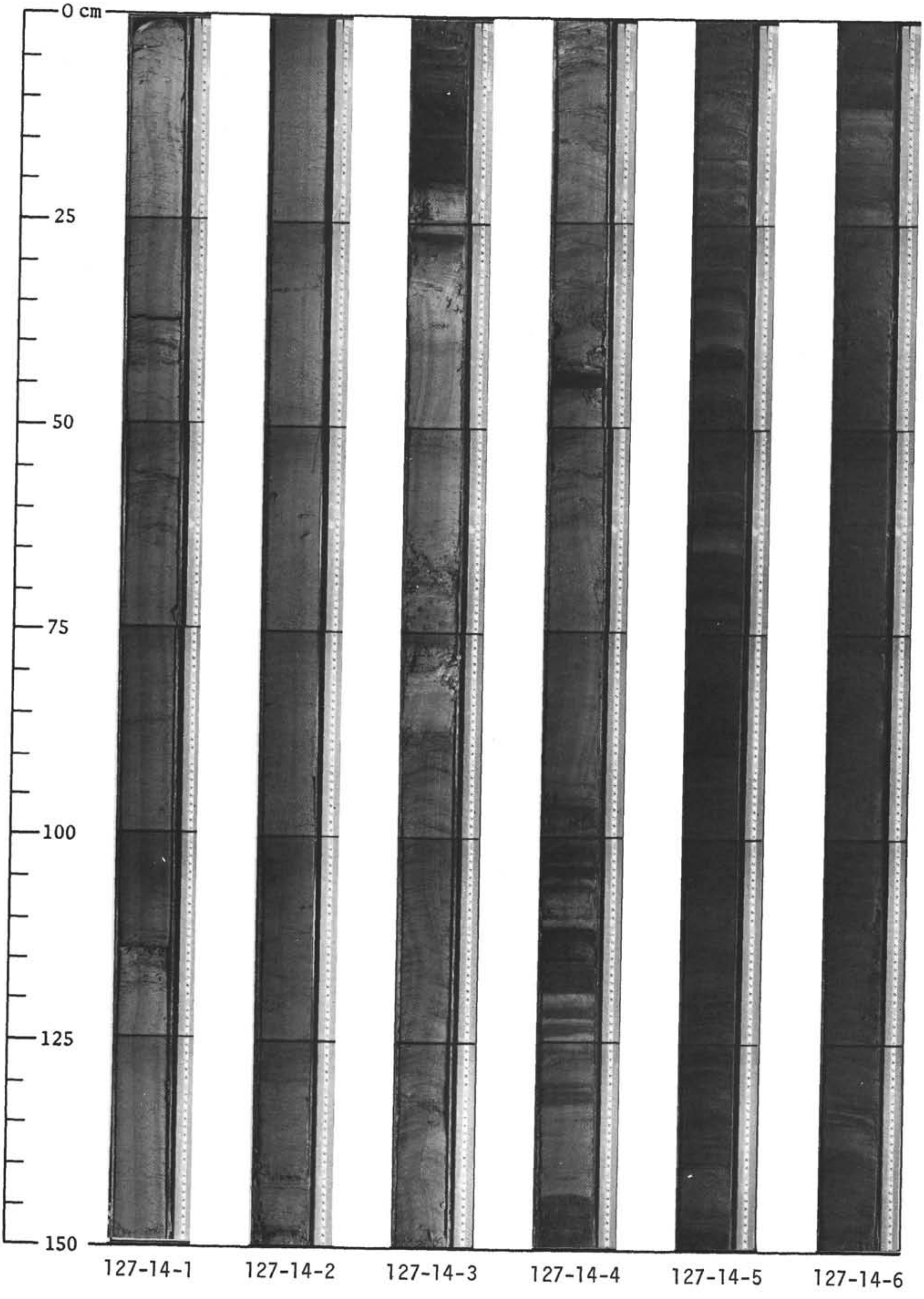
127-13-1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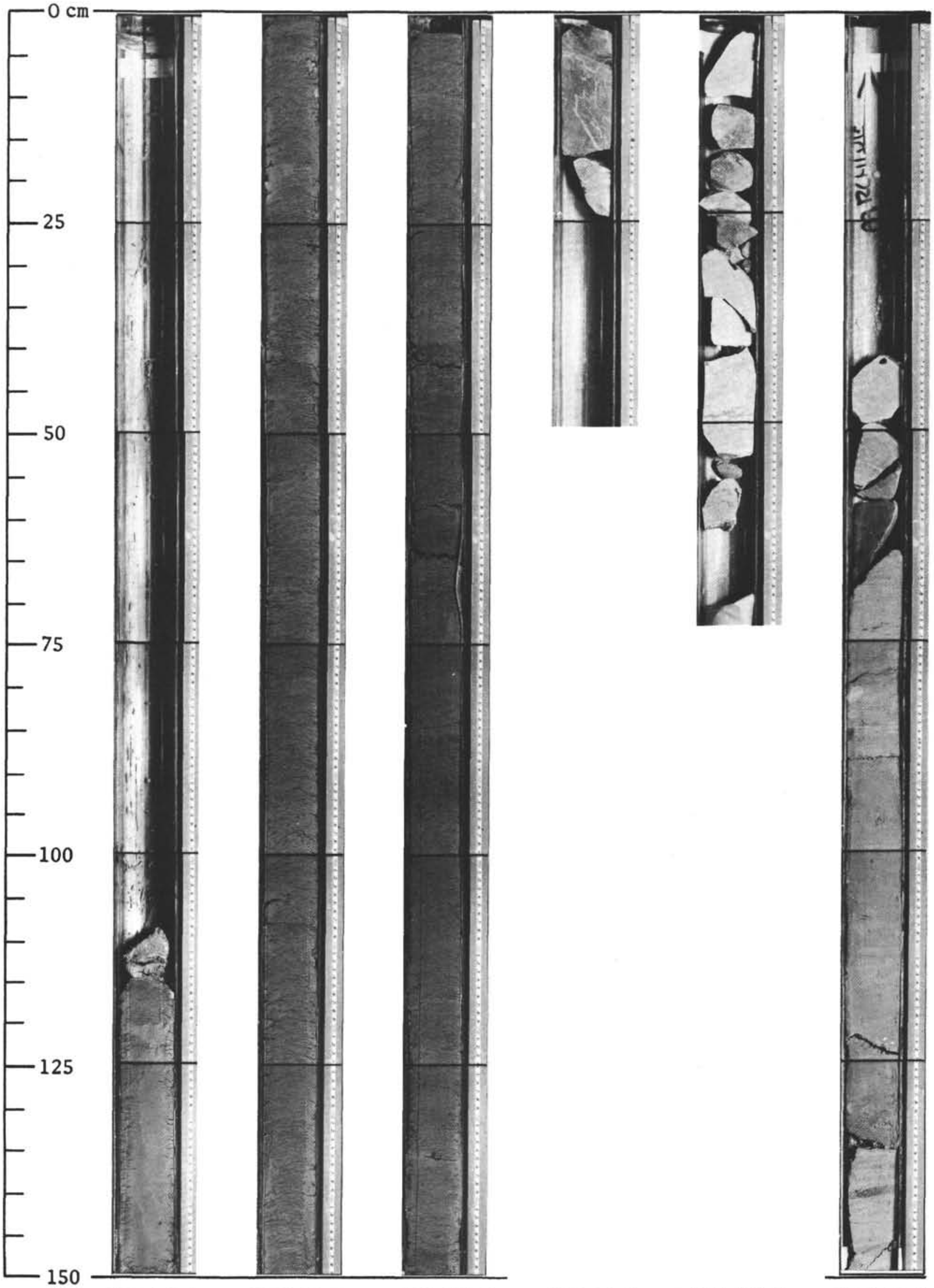
127-14-2
127-14-3
127-14-4
127-14-5
127-14-6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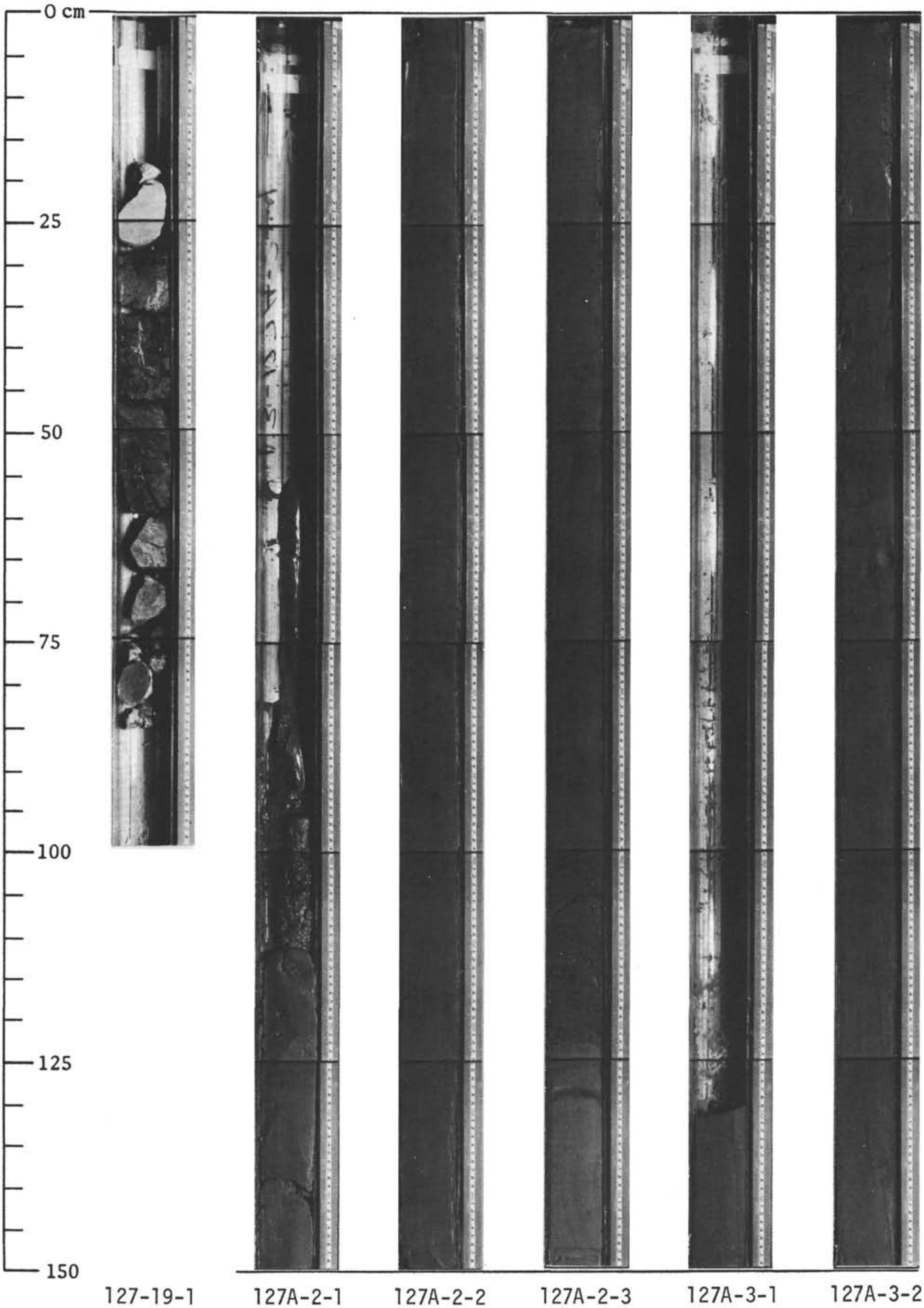
127-17-1
127-18-1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127A-2-2
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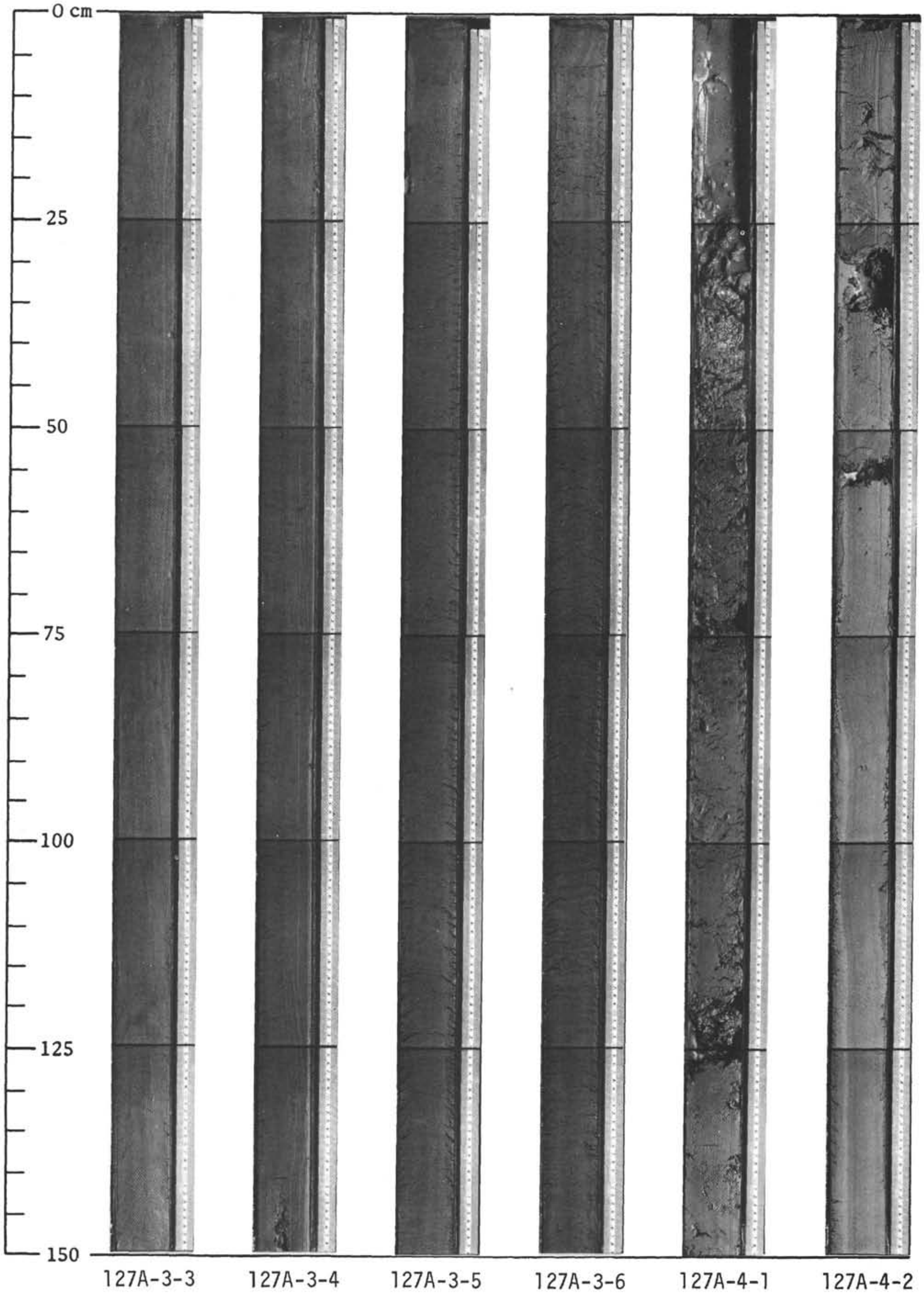
127A-3-2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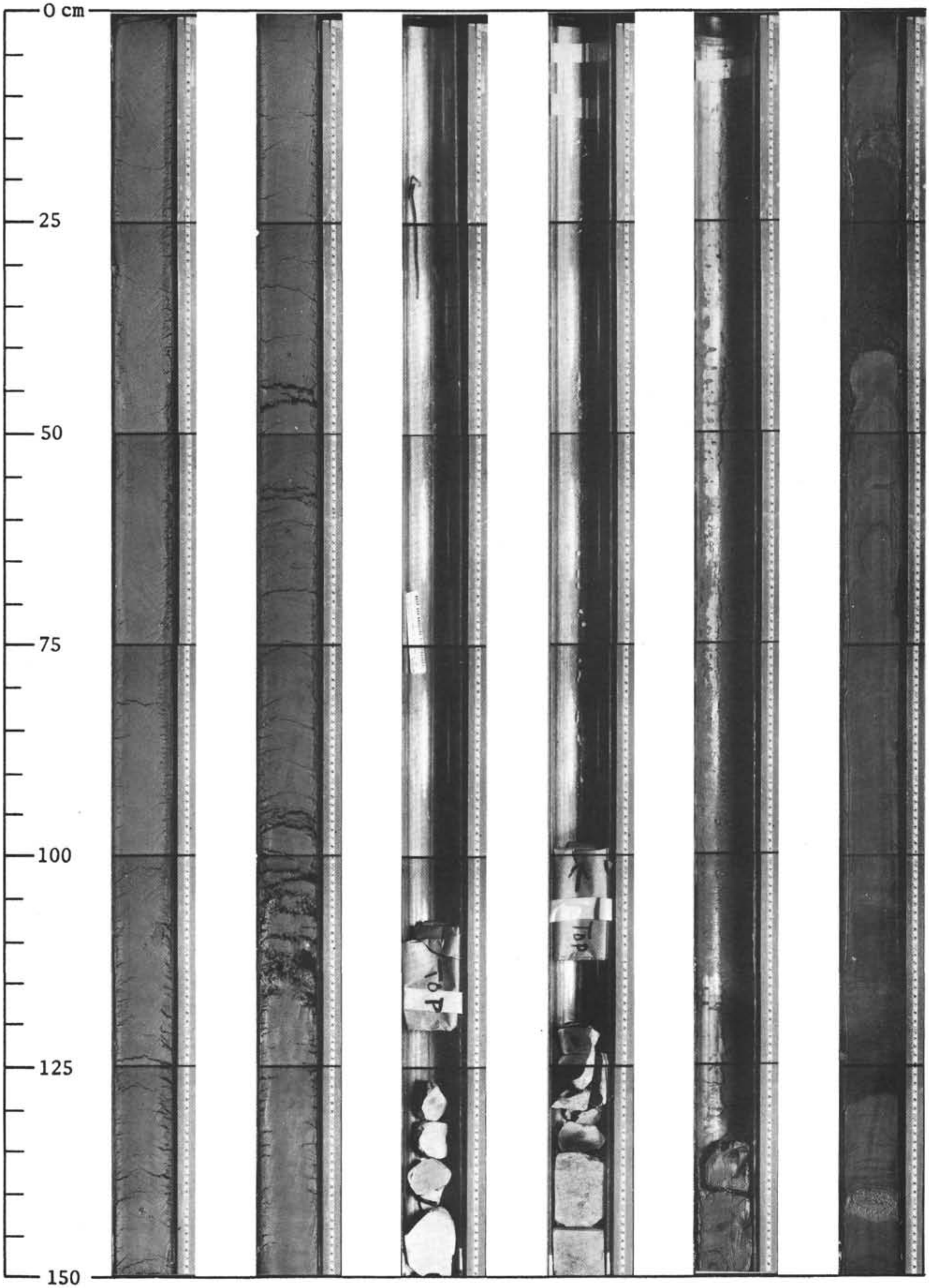
127A-4-2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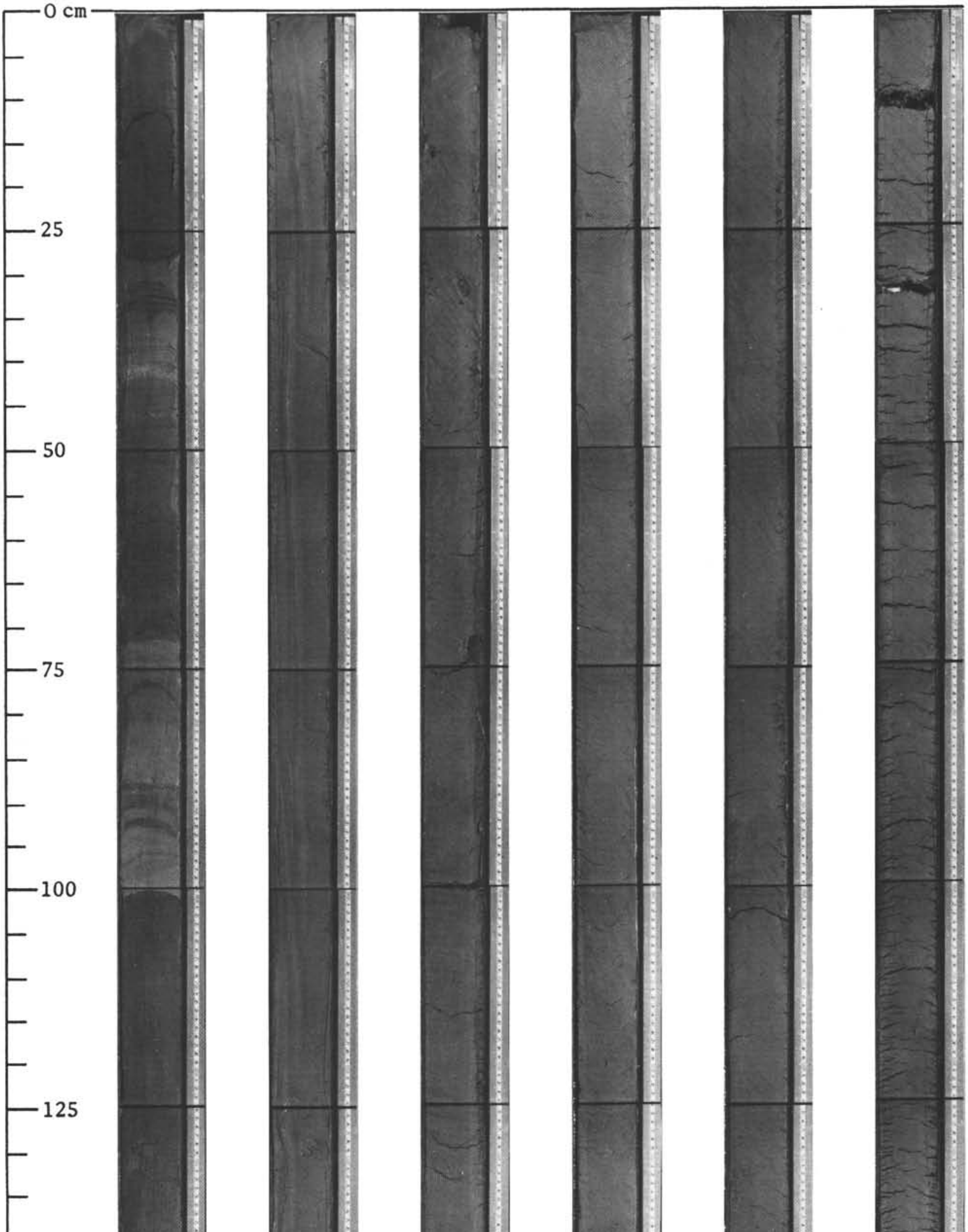
127B-1-1
128-1-1
128-1-2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128-2-2
128-2-3
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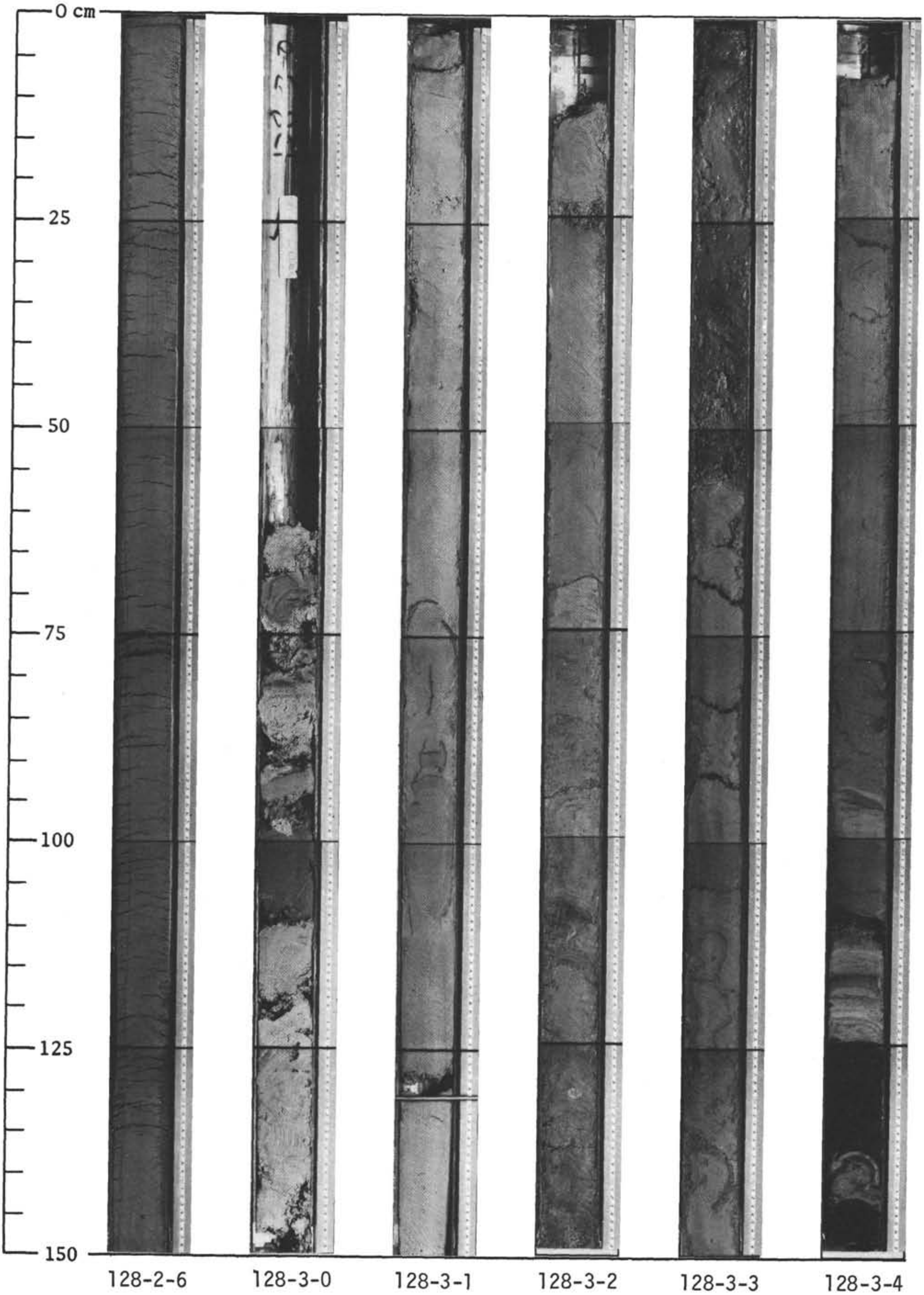
128-2-5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128-3-2
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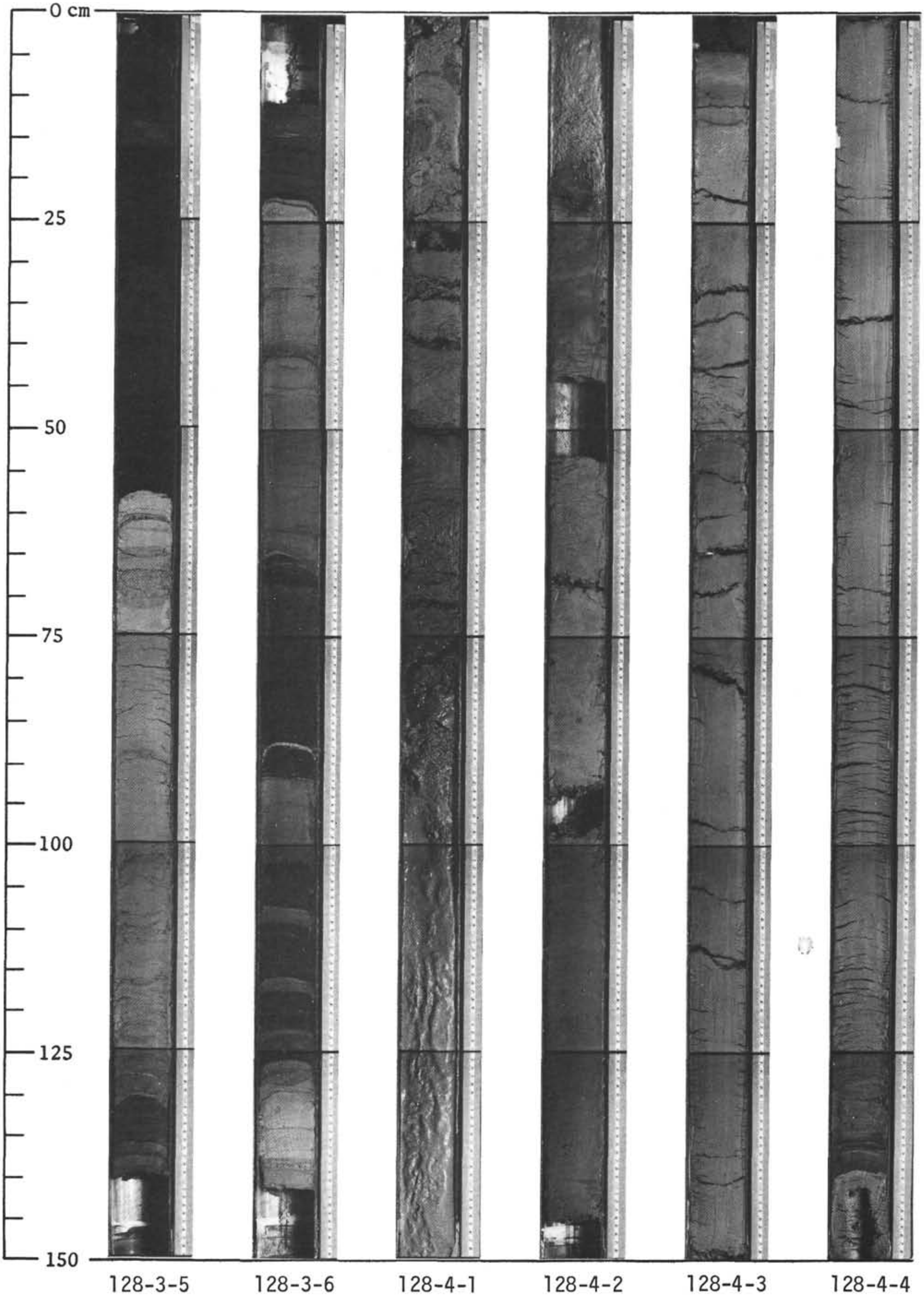
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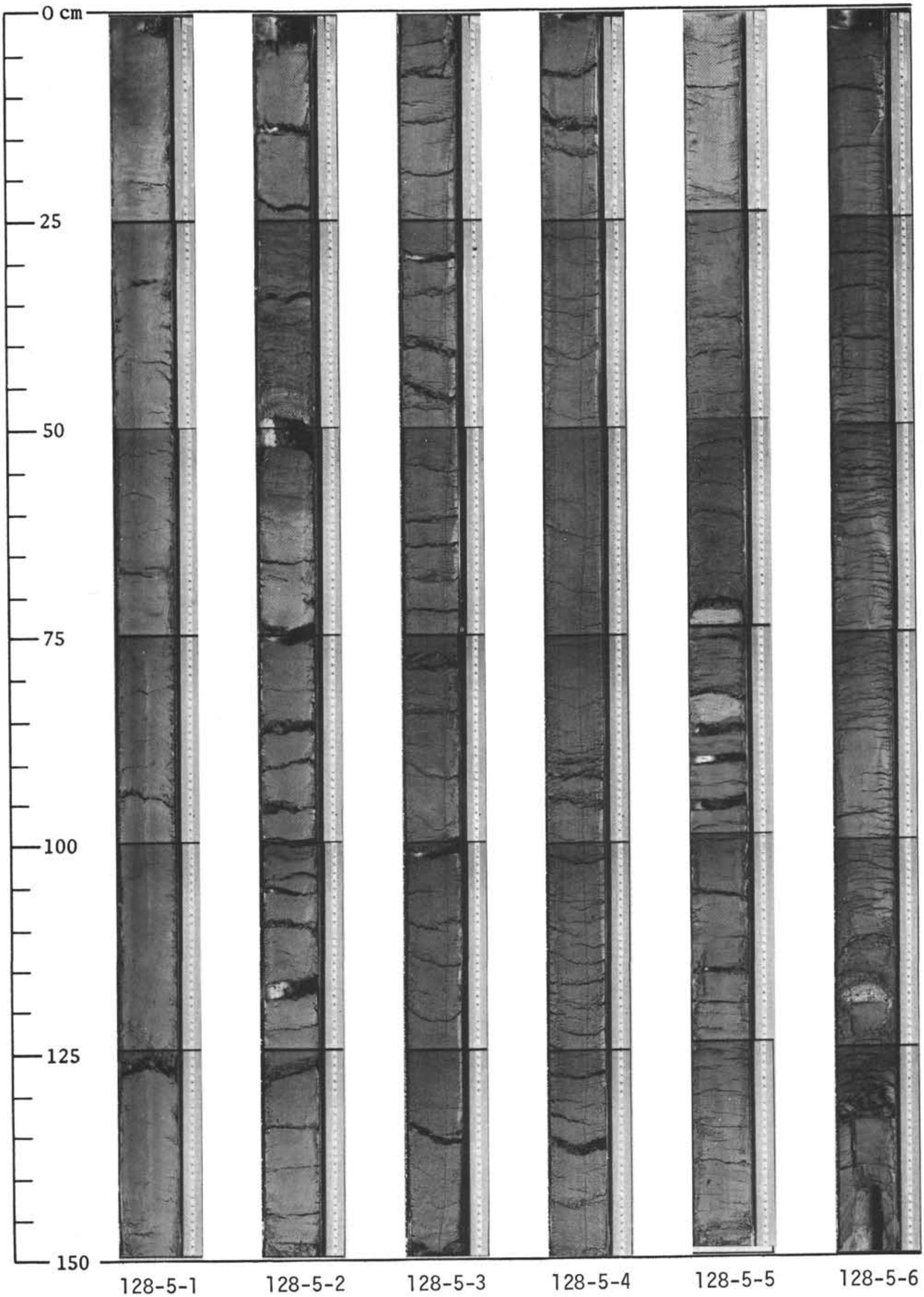
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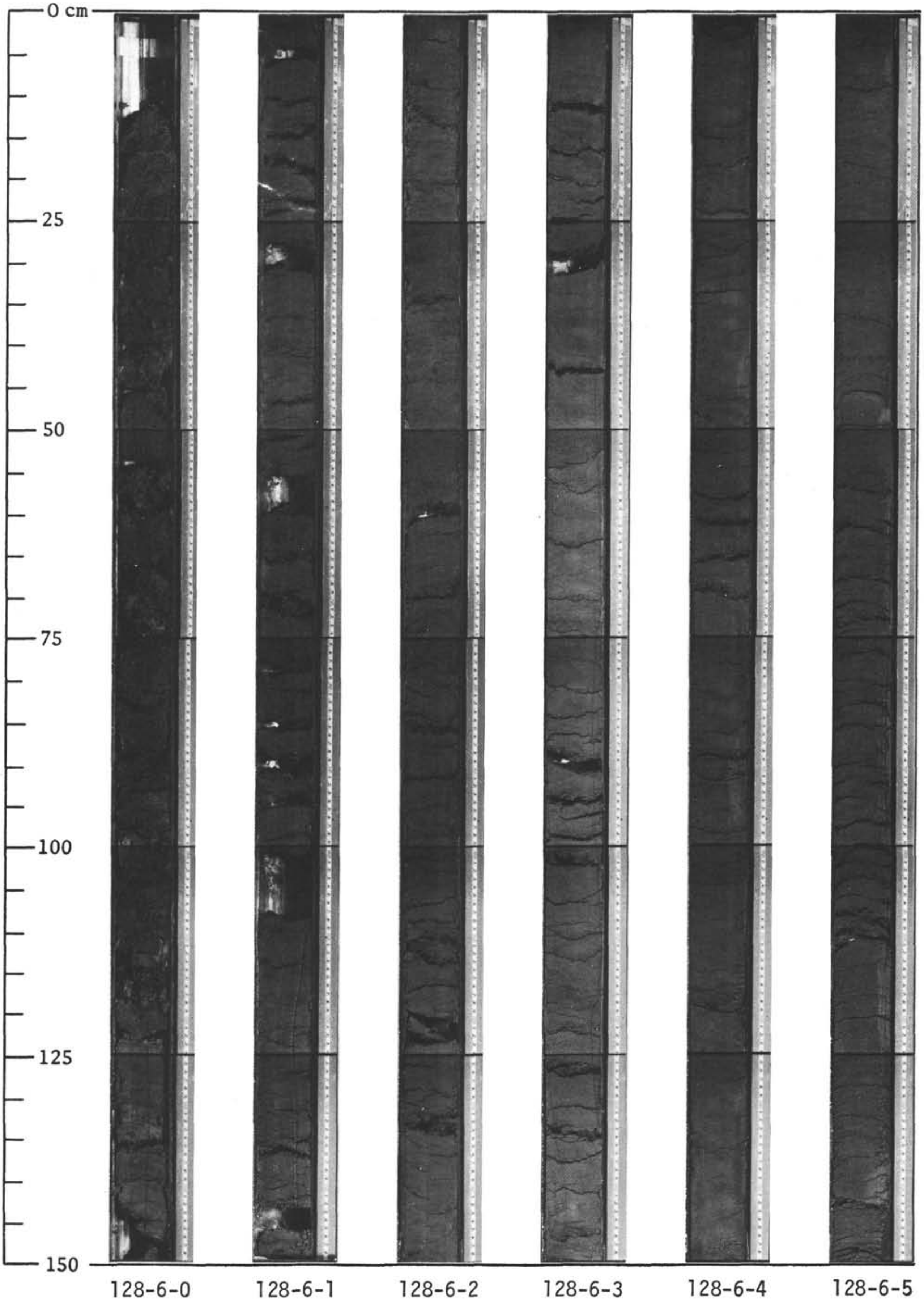
128-5-6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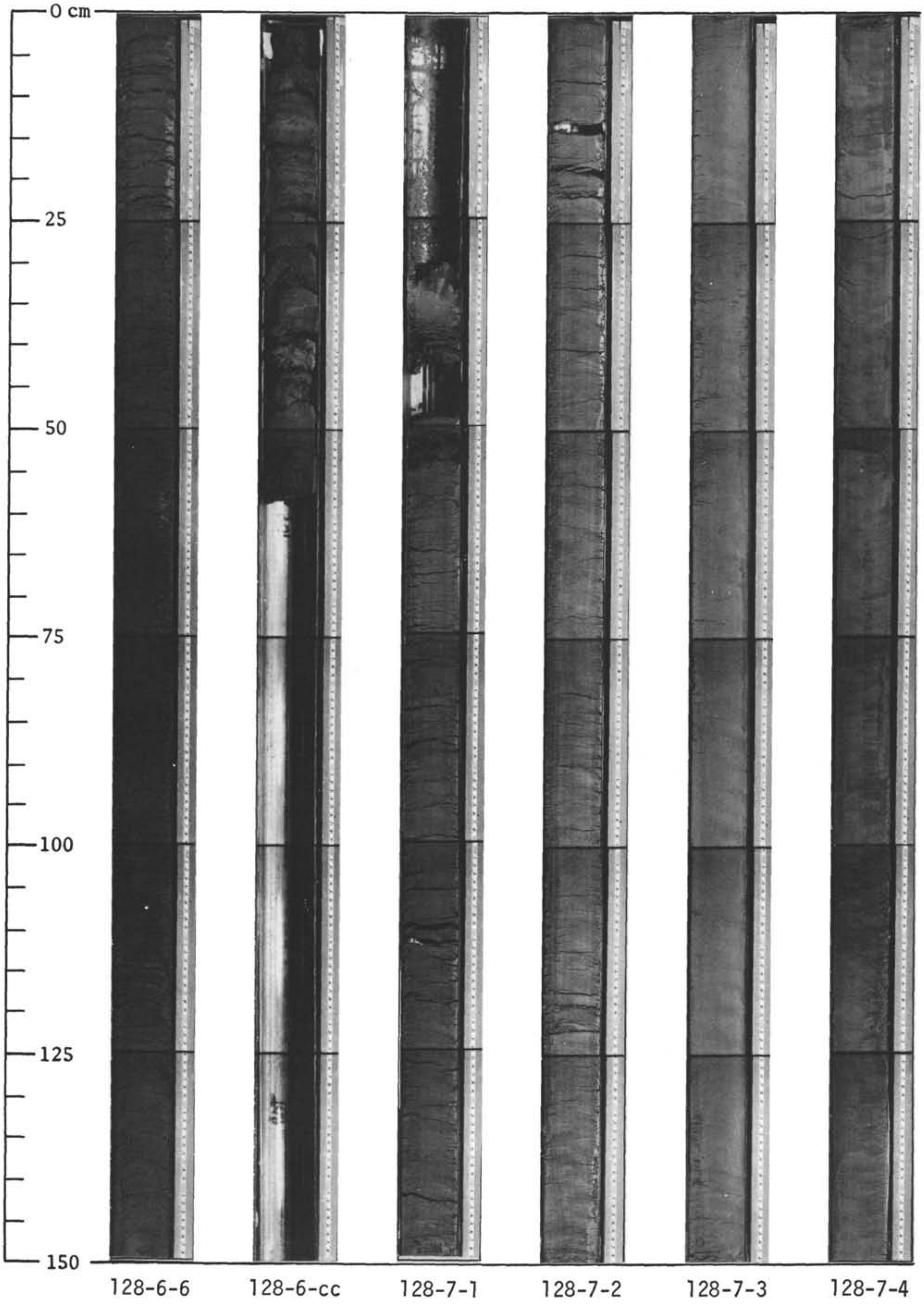
128-6-5


0 cm
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128-6-cc
128-7-1
128-7-2
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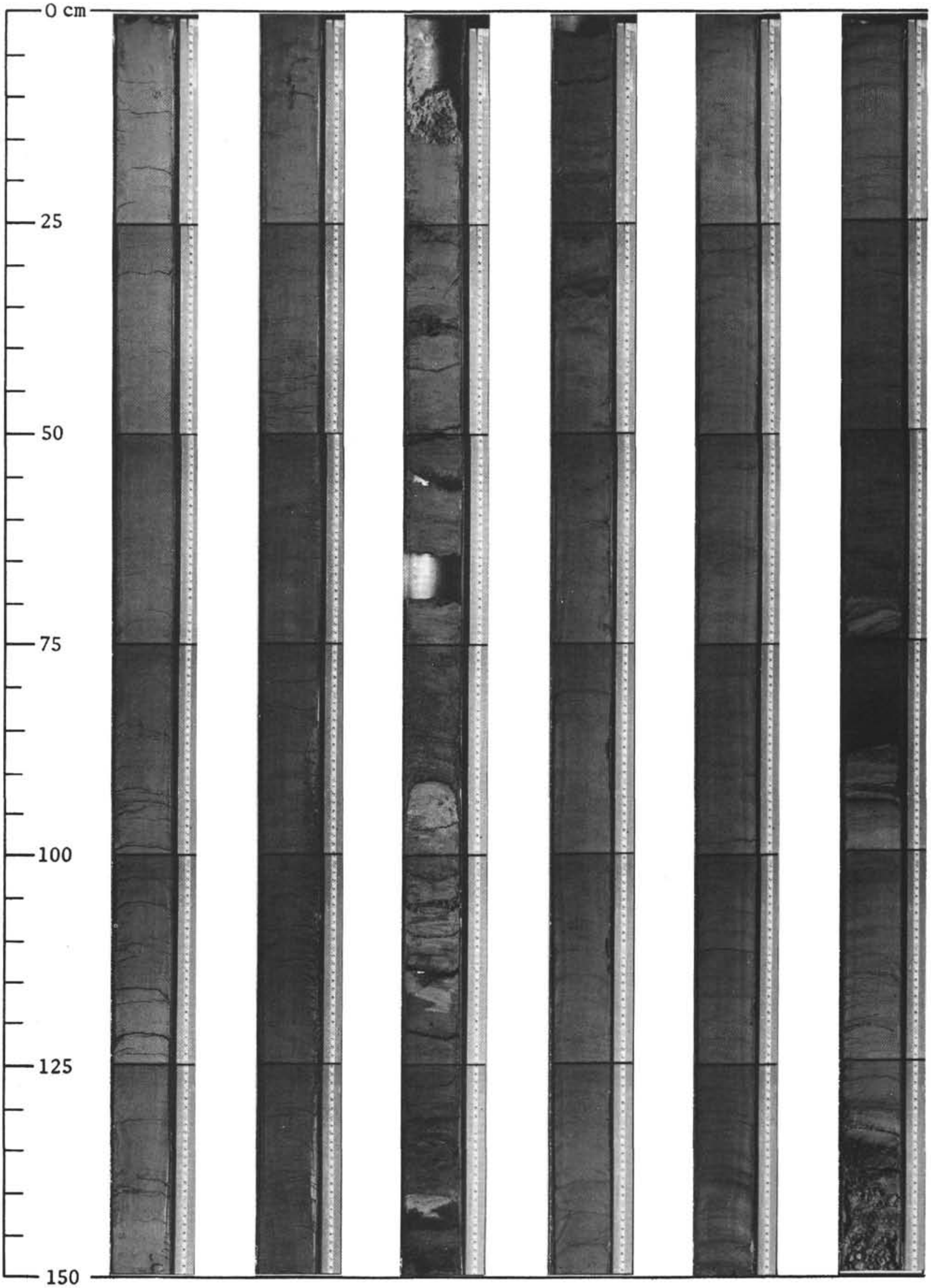
128-7-4


0 cm
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125
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128-7-6
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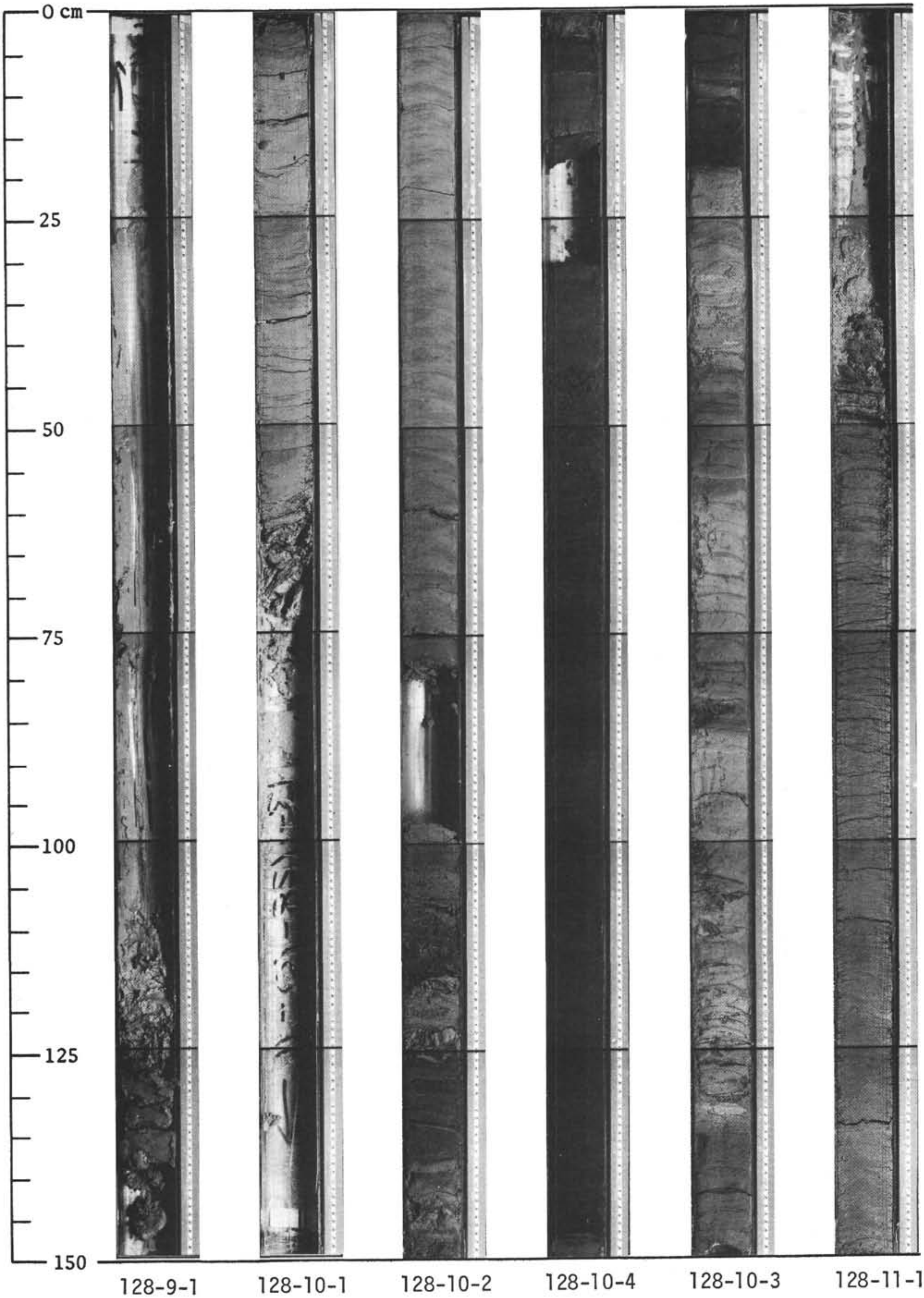
128-8-4


0 cm
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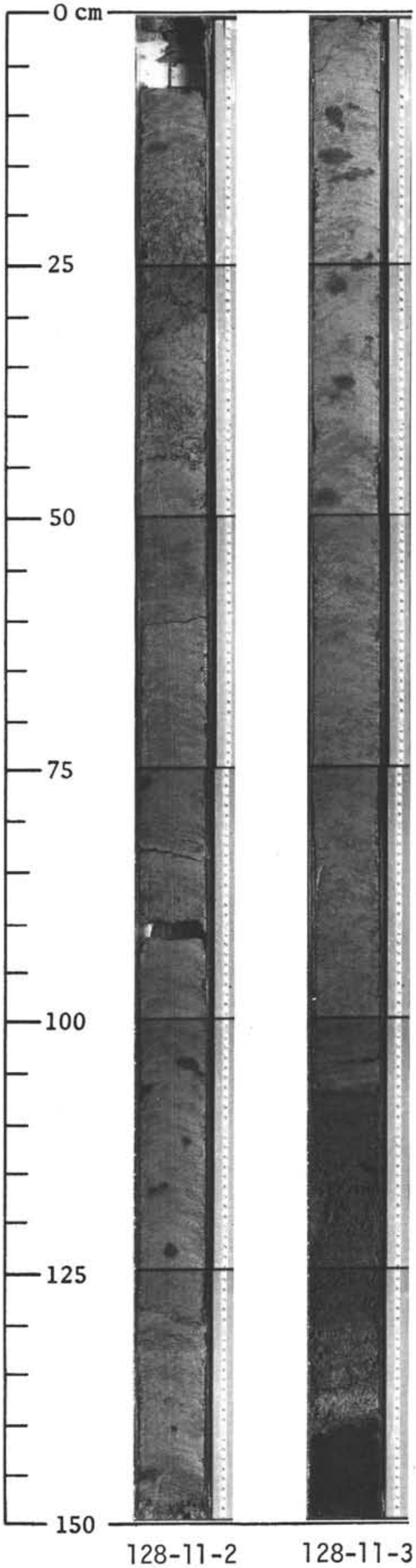
128-11-1


0 cm
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128-11-2
128-11-3