10. STRABO TRENCH AND MOUNTAINS – SITE 129

The Shipboard Scientific Party[1]

SITE DATA

Occupied: September 13-16, 1970

Position: Near the axis and on the inner wall of the Strabo Trench, Levantine Basin of the eastern Mediterranean.
Latitude: 35° 20.96′N;
Longitude: 27° 04.92′E.

Number of Holes Drilled: Three (129, 129A, 129B)

Water Depth:
Hole 129 – 3048 meters (trench axis).
Hole 129A – 2832 meters (inner wall).
Hole 129B – 3042 meters (trench axis).

Cores Taken: Four in Hole 129, three in 129A, and three in 129B.

Total Penetration:
Hole 129 – 112 meters.
Hole 129A – 81 meters.
Hole 129B – 42 meters.

Deepest and Oldest Unit Recovered: Limestone, rich in planktonic foraminifera of Middle Miocene (Langhian) age.

MAIN RESULTS

We drilled into a terrain which yielded fossil assemblages in apparent or real abnormal superposition. The anomalies could be attributed to allochthonous deposition and to tectonic disturbances, complicated further by the possibility of some downhole contamination. The detailed geologic structure in the area circumscribed by the three holes is little known. However, the stratigraphic information, interpreted within the regional framework, provided us with very valuable information on the Neogene evolution of the Mediterranean.

Cores from Hole 129 proved that this part of the eastern Mediterranean was an open marine basin of pelagic sedimentation in the early Middle Miocene (Langhian). Oceanic circulation was hindered and the basin became stagnant during the late Middle Miocene (Serravallian). Evidence for the Messinian pan-Mediterranean salinity crisis is afforded by the recognition of a brackish-water ostracod fauna in an Upper Miocene dolomitic marl (Hole 129A). Earliest Pliocene *Sphaeroidinellopsis* microfauna has been identified from a downhole contaminant in Hole 129, and from an allochthonous sediment in Hole 129B, suggesting that the basin was deeply submerged when normal marine waters returned after the crisis. The tectonic movement responsible for the deformation and uplift of the sequence under the trench wall contributed displaced fossils and exotic blocks to olistostromes intercalated in Late Quaternary trench sediments (in Hole 129B).

BACKGROUND

In that part of the Hellenic Trough southeast of the island of Crete in the eastern Mediterranean, there is a rather unique circumstance of two parallel trenches separated by a ridge-like feature. This trench couplet was first pointed out by Emery *et al.*(1966) who called the northern and deeper topographic cleft the Pliny Trench and the southern one the Strabo Trench.[2]

Physiographic Setting

An elevated barrier between the two trenches extends for a distance of more than 600 kilometers and consists of several isolated mountainous features with blocky relief, including the Anaximander, Ptolemy, and Strabo Mountains (Figure 1). The southern escarpment of this mountainous province is particularly steep and very linear in trend, and has been called the Mediterranean Wall by Goncharov and Mikhaylov (1963).

The Strabo Trench iteself consists of a series of small narrow and linear depressions that are found along the base of the Mediterranean Wall. The Strabo Mountains are that part of the wall and dividing ridge with high topographic relief which occurs due south of the islands of Kasos and Karpathos between Crete and Rhodes.

The Strabo Trench lies within a narrow belt of negative free-air gravity anomalies which reach -180 mgal. It more or less marks the southern limit of a zone of shallow and intermediate depth earthquakes that dips to the northwest under the Hellenic Arc and its internal marginal sea–the Aegean (Fleischer, 1964; Woodside and Bowin, 1970; Papazachos and Comninakis, 1971).

Tectonic Setting

The Strabo Trench is a tectonic boundary of some sort, along which there is continuing crustal activity (Wong *et al.*, 1971). What is not known, is (a) whether this linear feature marks a true plate boundary in the sense of McKenzie and Parker (1967) or Morgan (1968), with slabs of lithosphere underriding or shearing past one another; or (b) whether the Strabo Trench marks the site of intercrustal slicing in the form of stratal shortening on a single plate according to

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[2]The Pliny Trench *sensu strictu* terminates at 27°30′E with a local transverse ridge. However, the topographic feature as a whole continues eastward through the Rhodes Deep and on into the Antayla Depression South of Turkey.

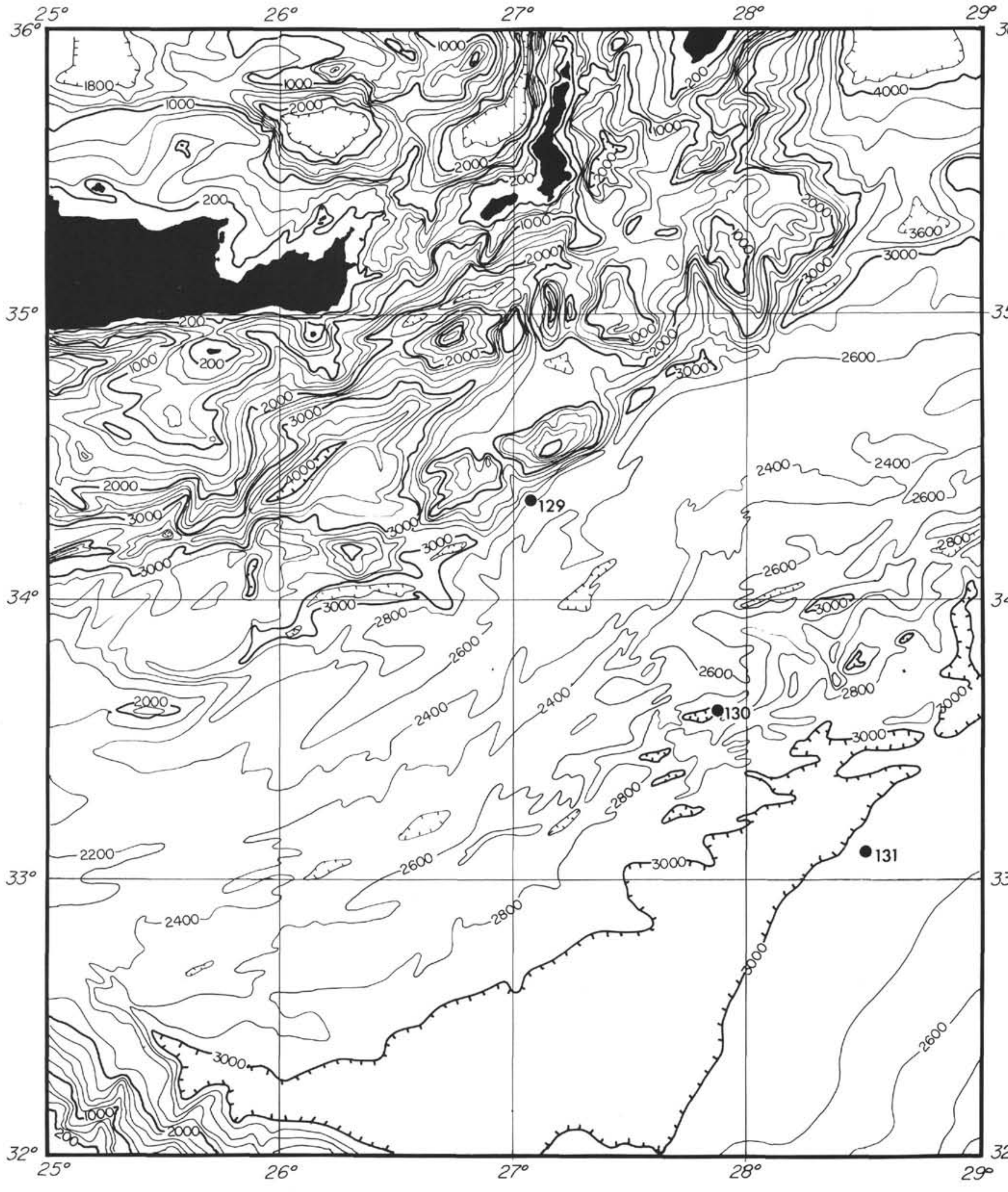


Figure 1. *Environs of Site 129 in the Strabo Trench. Contours in meters, adapted from Chart 310 of the Defense Mapping Agency Hydrographic Center.*

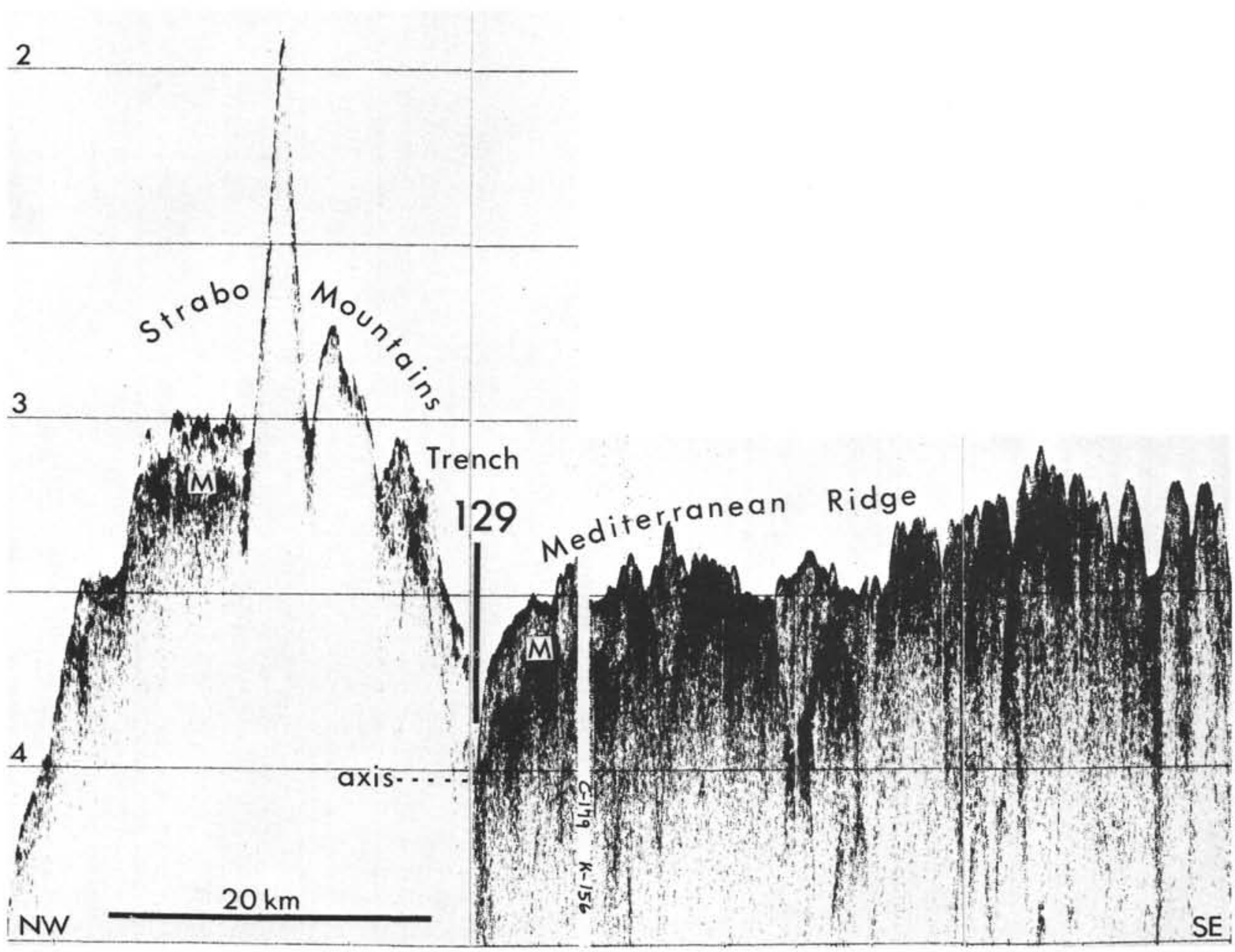


Figure 2. *Continuous seismic reflection profile of the* Robert D. Conrad *of the Lamont-Doherty Geological Observatory of Columbia University. Note in the airgun record across the Mediterranean Ridge south of the trench axis the relatively thick blanket of transparent sediment above Reflector M. The floor of the Strabo Trench is at 4.05 seconds. Vertical exaggeration approximately 28:1.*

the very speculative décollement model of Rabinowitz and Ryan (1970).

Unlike the Hellenic Trench, the axis of the Strabo Trench is not filled with sediment. In Figure 2, a seismic reflection profile, made in 1965 aboard the R/V *Robert D. Conrad* of the Lamont-Doherty Geological Observatory of Columbia University, illustrates rather explicitly the narrowness of the cleft axis, which reaches down to a depth of 4.05 seconds (two-way travel time; i.e., equal to ≈ 3080 meters). This profile is oriented northwest-southeast, practically normal to the strike of the trench. According to the polarity of seismicity and gravity patterns, the northwest slope of the Strabo Trench should be termed the "inner wall"; the southeastern slope or "outer wall" is actually the northern flank of the Mediterranean Ridge.

Objectives

Upon completion of the drilling in the more typical configuration of the Hellenic Trench at Sites 127 and 128, and as a result of great interest in the results obtained there, the scientific team aboard the *Glomar Challenger* decided it would be a highly worthwhile venture to explore the other, less typical, extremity of the arc. A drill site near the Strabo Trench had been picked by the Mediterranean Advisory Panel with two basic objectives in mind.

One objective was simply to see if a terrain could be drilled at the base of the inner wall which would show tectonic mixing. The panel was aware that a clearly recognizable assemblage of sediments of Nile provenance existed to the south across the Nile Cone and on the Herodotus Abyssal Plain (Rateev *et al.*, 1966, Emelyanov, 1968). A highly respected working hypothesis of Hersey (1965) predicted that the Nile subsea-distributary system once extended considerably farther to the north and that a thick sequence of sediments transported from the Nile by turbidity currents would be found in the subsurface of the Mediterranean Ridge north of the Herodotus Plain.[3] The panel reasoned that a search on the (northwest) inner wall of the Strabo Trench for sediment lithologies of an

[3]The testing of the working hypothesis was a principle objective in subsequent drilling at Sites 130 and 131, as discussed in Chapters 11 and 12 of this volume.

identifiable southern origin would allow us to appeal to a mechanism of crustal convergence for the creation of such a zone. Positive results would allow us to state with more assurance that contemporary tectonic processes of crustal thickening in the Hellenic Trough were precursors to mountain building (Dewey and Bird, 1970).

The second objective was to use the trench as a shortcut route to older strata. Considerable technical difficulties had been encountered throughout the cruise in penetrating pre-Pliocene lithologies. Although shales of Serravallian age had been reached at Site 126 on the Mediterranean Ridge in the Ionian Basin, their waxy makeup had prevented any appreciable penetration through them at this point. There seemed little optimism for being able to do much better with conventional drilling at any other site. However, the possibility still existed to explore for old sediment in mélange zones and in olistostromes (sedimentary talus) beneath tectonic escarpments and then to use the ingenuity of the geological community to piece together the past record. After all, Lower Cretaceous rocks had been found at the previous drill site and the Mediterranean wall qualified as a potentially good place to look further.

Strategy

Detailed bathymetry in the area of interest was lacking at the time of the drilling cruise. It was decided to locate the drill site on an existing track of the R/V *Robert D. Conrad,* where measurements of gravity, magnetics, topography, and sediment thickness had been made with navigational control by satellite (NNSS).

The initial site was selected in the deep itself, slightly to the northwest of the axis, so that the drill string would be assured of entering the inner wall. The existing reflection profile (Figure 2) showed a rather uniform blanket of acoustically transparent sediment overlying Reflector M to the south across the Mediterranean Ridge. A piston core there (RC9-179) had recovered a section of pelagic nanno oozes interbedded with sapropels and tephra layers of late Quaternary age.

The purpose of the hole was not to sample the tectonically undisturbed layers to the south of the trench axis, but to sample this layering as it dipped and (hopefully) underthrust the southeast escarpment of the Strabo Mountains.

Challenger Site Approach

The *Glomar Challenger* approached the Strabo Trench from the northwest in a traverse across the Strabo Mountains. The course was 124 degrees, parallel to, and about 2 miles south of, the *Conrad* profile. The top of the Mediterranean Wall was reached at 1343 hours on September 13 (Figure 3). It was very precipitous with only faint "fuzzy" echo returns, suggesting the absence of an appreciable cover of sediment. At a speed of 11.7 knots, the axis of the trench, some 930 meters below, was reached only 9 minutes (3.16 km) later. Fortunately, we were able to mark this initial crossing of the trench with some precision because of a satellite fix at 1350 hours.

Upon reaching the trench axis at the base of the wall, the vessel slowed to 8.8 knots and changed course slightly to the south to 145 degrees, so that it would be more nearly perpendicular to the strike of the trench. We proceeded to steam several miles on this new course up the outer wall in order to obtain a good reflection profile of the transparent layer on the Mediterranean Ridge. The underway seismic recording (Figure 4) revealed the same uniform blanket as seen in the *Conrad* profile, dipping steeply into the trench.

Searching for the Target

At 1402 hours the *Challenger* turned west, being somewhat east of the drill site selected on the *Conrad* profile. At 1415 hours, underestimating the strength of the surface currents and believing that we had carried ourselves over to the proper longitude of the target, we turned to 030 degrees and headed back towards the axis of the trench. (Details of the maneuvering are shown in plan view in Figure 5).

However, by 1437 hours we had not yet proceeded to the base of the outer wall. The heading was changed to due north, but when the axis was reached ten minutes later, it was some 70 meters shallower than on the first crossing. A free floating marker buoy was placed and the vessel slowed to 4 knots to retrieve the streamed geophysical gear as we gradually proceeded up the inner wall. With the gear secured at 1503 hours, the vessel reversed course in a gentle arc to the west on the assumption that we had drifted east off the planned approach line. At 1510 hours we were on course 180 degrees and started to descend the inner wall for the second time (see Figure 6).

As we reached the topographic axis of the Strabo Trench, we slowed in order to come to a stop in the water. However, the echo-sounding profile quite clearly showed that we had overshot. It had a strong echo trace indicating that we were drifting up the base of the outer wall. Therefore, at 1528 hours, we again turned to the west, slowly increased the speed, and closed the gap until we had a confirmed echo return from the inner wall. Holding this position, with a speed of over a knot, the acoustic positioning beacon was dropped at 1543 hours.

Once the beacon was on the bottom, we plugged into the positioning computer a temporary offset to the south. The echo returns from the inner wall indicated greater depth supporting the belief that we were, indeed, within the axis of the trench, but over the face of the Mediterranean Wall. The ship then returned to station keeping over the beacon. The average satellite position while drilling placed our site less than 600 meters southwest of the original target on the *Conrad* track.

OPERATIONS

The *Glomar Challenger* stayed on location in the area of the Strabo Trench for two and a half days, between 1600 hours on September 13th and 0400 hours on September 16th. Three holes were drilled and a total of ten cores were taken. The core inventory is listed in Table 1.

Operations at Hole 129

The first hole (129) was located directly above the acoustic positioning beacon, near the base of the inner wall. Although a water depth of 3028 meters was determined

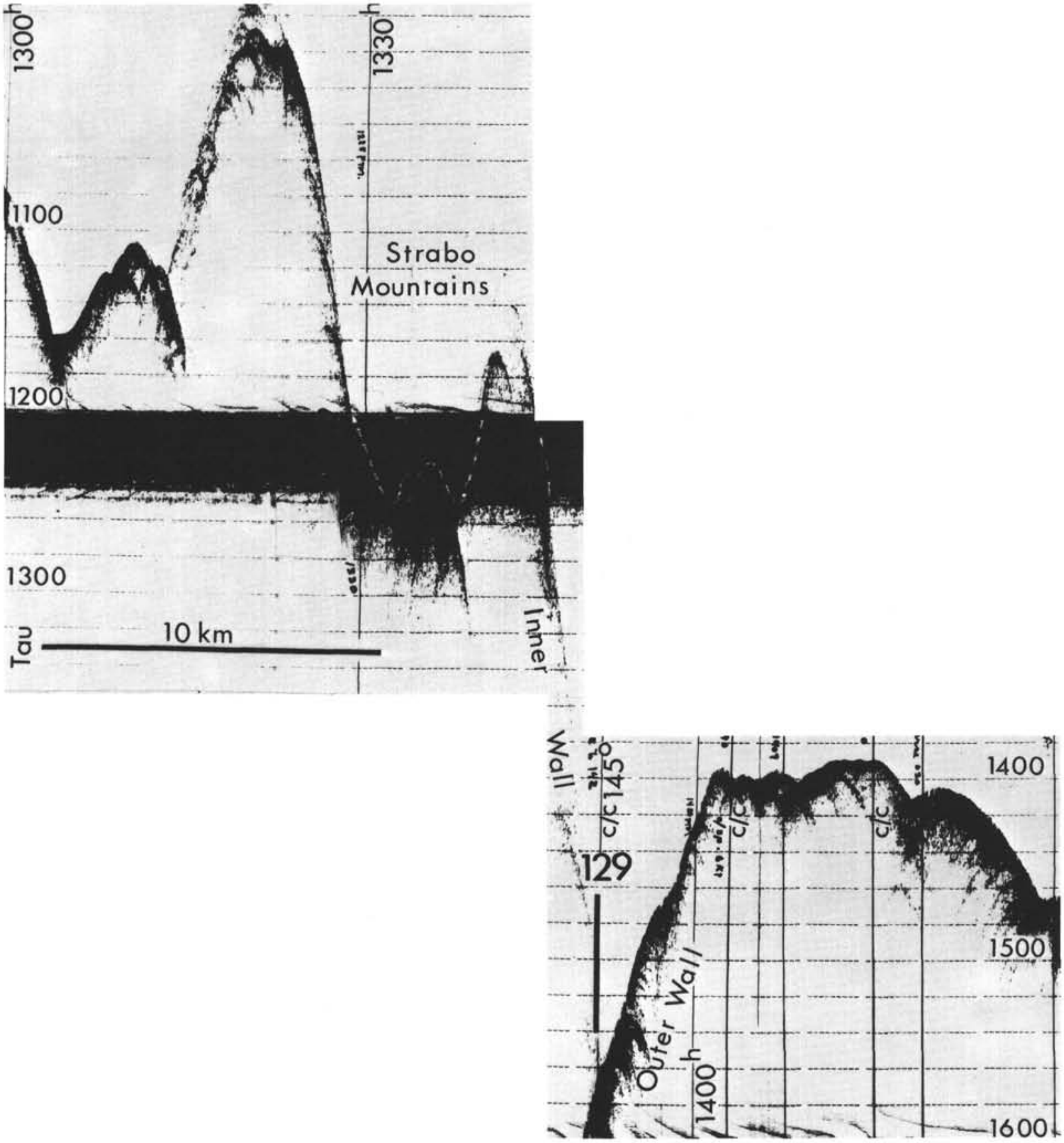


Figure 3. *Precision 12 kHz fathogram of the* Glomar Challenger *during the initial traverse of the Strabo Trench. Note the contrast in echo character on the inner and outer walls of the trench and the lack of horizontal sediment fill. Vertical scale is in uncorrected units: 1 tau = 1/400th second.*

with the echo sounder, the first contact with the sea bed was felt at a drill string length of 3058 meters from the derrick floor (itself 10 meters above the sea surface).

The bottom hole assembly was initially washed in, using both pumps, without a core barrel in place. At nine meters below bottom, the inner core barrel was dropped with a special core catcher designed for recovering hard rocks. At 19 meters, a firm formation was encountered, requiring eight minutes of rotation with a bit weight of 5000 pounds in order to break through. At 37 meters, drilling once again became very stiff and slow with some noticeable torquing.

Core 1 was taken here, carefully keeping the bit weight under 10,000 lbs., since, without complete burial of the bottom hole assembly, there was a real risk of twist-off. Because of the very slow penetration rate resulting from the relatively small pressure put on the formation, only one meter was cut. This core contained Middle Miocene limestones and marls.

Encouraged by the finding of old sediments so soon, we chose to cut Core 2 back-to-back with Core 1. It took two full hours to penetrate seven meters. In order to speed up the operation, we next decided to use the center bit insert

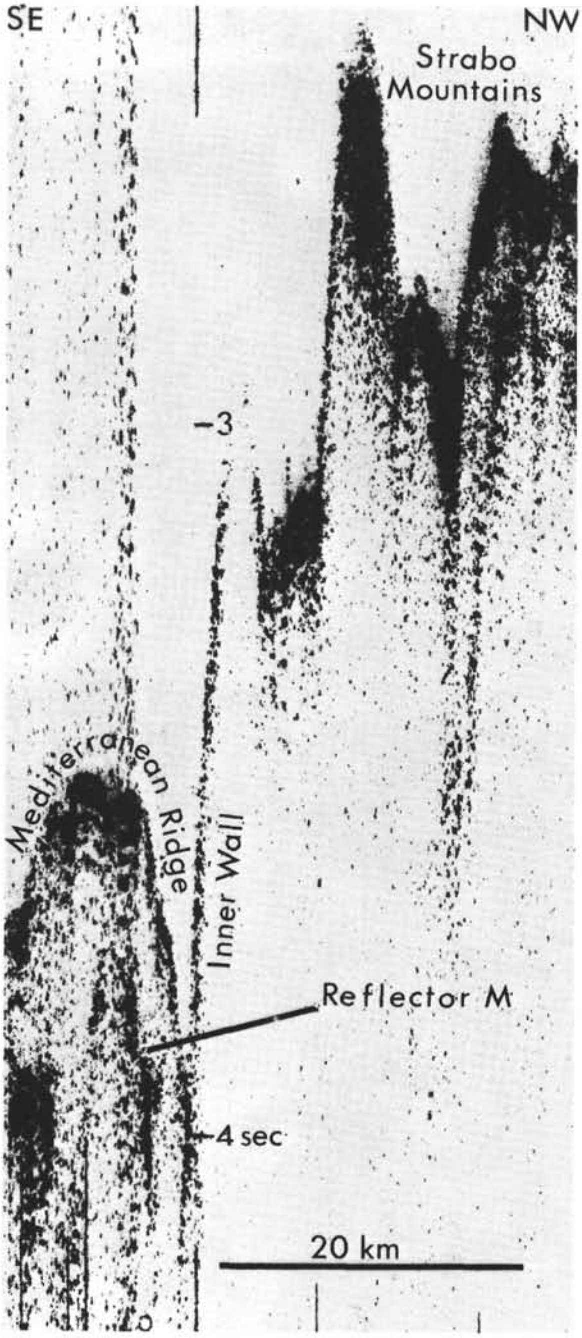


Figure 4. *Airgun reflection profile of the* Glomar Challenger *across the steep southern escarpment of the Strabo Mountains, and out onto the northern flank of the Mediterranean Ridge. Vertical scale in seconds, two-way travel time. Vertical exaggeration approximately 50:1.*

and wash our way down some fifty meters without coring. This proved a wise choice, since we made the distance in just twice the time it took to core the previous seven meters. Core 3 followed with more of the semi-indurated marl, and the center bit was used for the next penetration interval.

Torquing had become appreciably stronger and more erratic. The second center bit attempt made only 12 meters

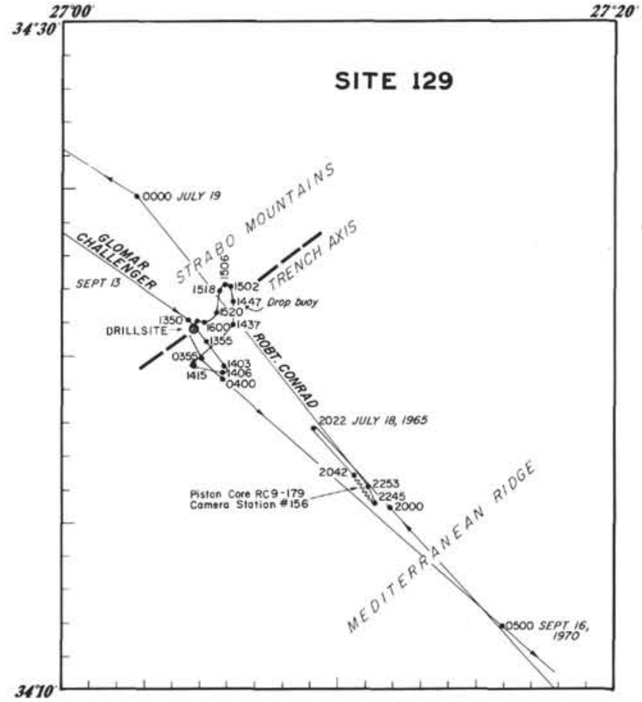


Figure 5. *Details of the* Glomar Challenger *survey track in the vicinity of Site 129. Dashed line shows the strike of the topographic axis of the Strabo Trench.*

in a little less than three hours, leading to general discouragement at the slow rate of penetration. An hour was spent in the fourth coring attempt, at 111 meters below bottom, with no noticeable distance gained, and when the core barrel was retrieved it was found to be practically empty. It was apparent that the stiff marl could not be penetrated without heavy washing, that penetration would be slow, and that washing would not permit core recovery. We had already reached the oldest deep-water sediments to our knowledge yet obtained from the Mediterranean sea bed.

We elected to abandon this hole and offset the vessel higher up on the inner wall (Strabo Mountains). To head upslope, we maneuvered 1600′ north and 1600′ west of the beacon. The echogram profile during the offset is shown in Figure 7A, and the plan view of the offset is shown in Figure 8.

Operations at Hole 129A

The drill string touched bottom at 2841 meters below sea level at a site 690 meters northwest of the original hole. The shallower depth here indicated a slope of 18 degrees between the two locations. At just eight meters below bottom, the bit encountered hard rock which could not be washed away.

Fearing twist-off, the pipe was raised again to the mudline, and the vessel was moved 100′ to the east. This time the bottom was encountered at 2832 meters. Again we washed in, and again we hit a resistant layer (9 meters below bottom). Rotation and heavier bit weight were requested, and suddenly the drill string descended through the hard layer into softer sediments.

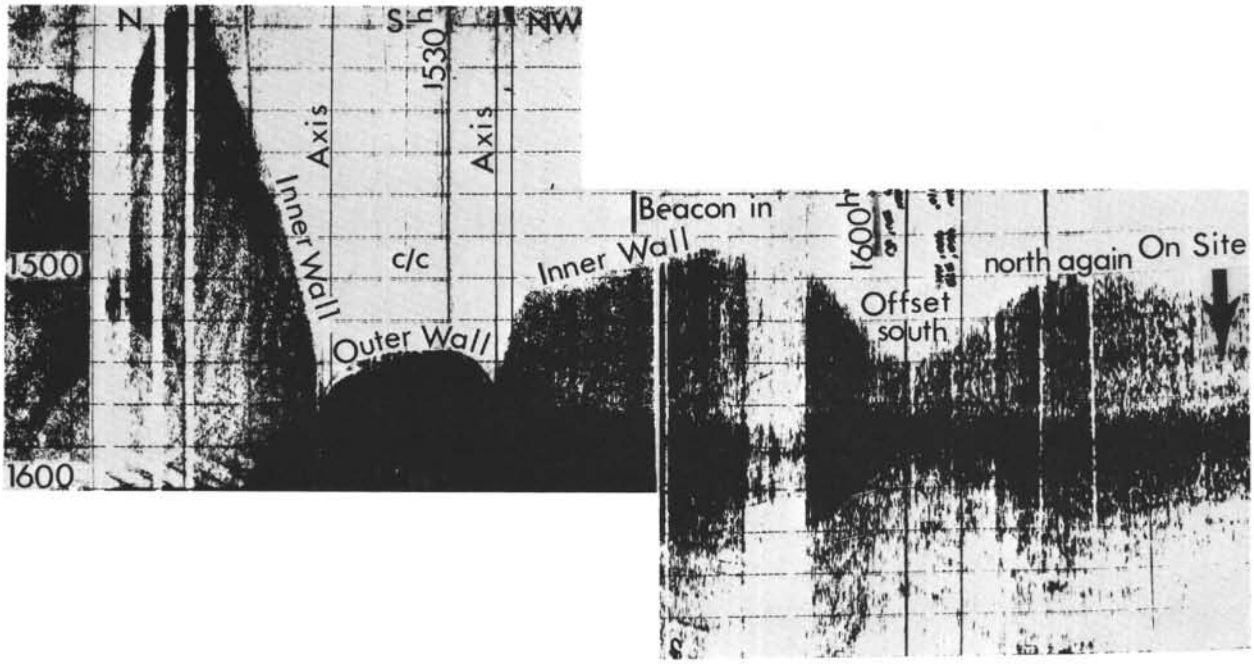


Figure 6. *Fathogram showing the final maneuvering in coming on site. The vessel overran the axis of the trench and returned to the north. The side-echo sequences while directly over the acoustical positioning beacon for the drilling for Hole 129 are reflected arrivals from the northwestern inner wall. The brief dip in the echo sequences was in response to a temporary offset to the south to verify the drilling location in the axis of the trench over the foot of the inner wall.*

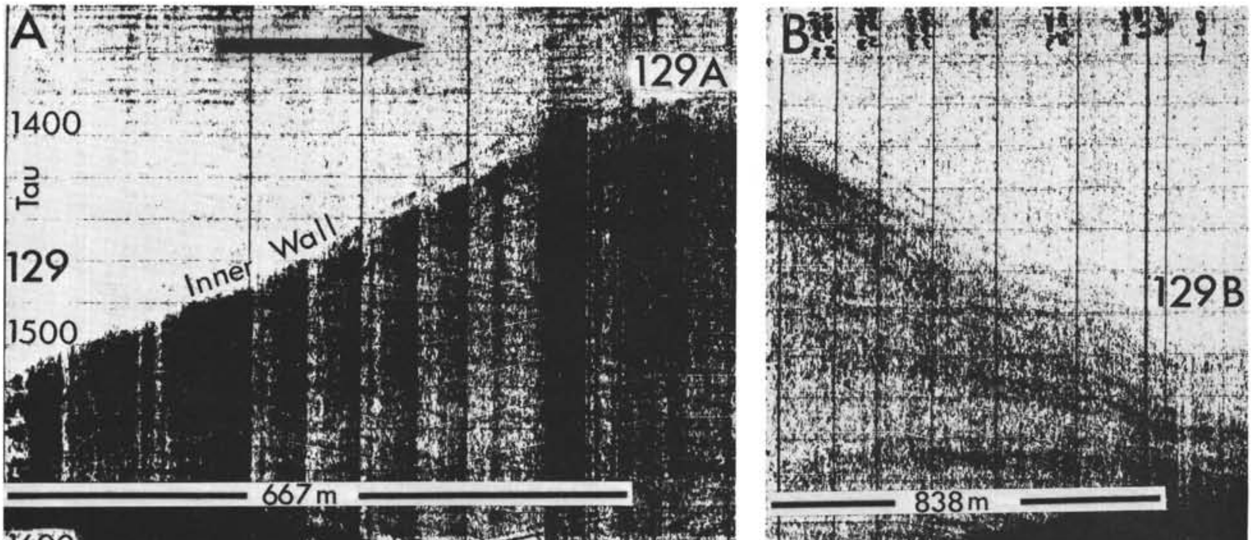


Figure 7. *Echo sequences during the offset maneuvers. (A) shows the departure from Hole 129 at the foot of the inner wall and the arrival at Hole 129A, some 216 meters higher up the southern escarpment of the Strabo Mountains. (B) shows the descent back into the axis of the trench for the drilling of Hole 129B. As was the case for the original site, Hole 129B is located over the toe of the inner wall, as judged from the predominence of echo returns from this feature as compared to reflections from the topographic axis or southern outer wall. Vertical scale in uncorrected units: 1 tau = 1/400th second. Horizontal scale in meters.*

TABLE 1
Core Inventory – Site 129

Core	No. Section	Date	Time	Cored[a] Interval (m)	Cored (m)	Recovered (m)	Subbottom Penetration (m) Top	Subbottom Penetration (m) Bottom	Tentative Lithology	Age
Hole 129										
1	1	9/14	0130	3096-3097	1	0.50	38	39	Dolomitic limestone Dolomites. SST	M. Miocene
2	1	9/14	0445	3097-3104	7	0.80	39	46	Dolomite, Dolomite limestone	M. Miocene
CB1		9/14	1050	3104-3152			46	94	Sand, Oozes	
3	1	9/14	1320	3152-3157	5	1.50	94	99	Marl oozes	M. Miocene
CB2		9/14	1715	3157-3169		Trace	99	111	Marl, Rock chips	
4	CC	9/14	1925	3169-3170	1	Trace	111	112	Limestone, Marl oozes	M. Miocene and mixed
Hole 129A										
1	CC	9/15	0030	2856-2865	9	Trace	14	23	Sand, Dolomite, Rock fragments	Quaternary
2	CC	9/15	0340	2915-2917	2	0.15	73	75	Dolomite, Marl with ostracods	U. Miocene
3	1	9/15	0800	2920-2923	3	1.50	78	81	Marl	U. Miocene
Hole 129B										
1	CC	9/15	1250	3072-3079	7	0.20	26	27	Marl ooze, Sandstone	Quaternary
CB1	CC	9/15	1700	3079-3086	7	0.20	27	34	Sand	Quaternary
2	CC	9/15	1930	3086-3094	8	0.50	34	42	Sand, Sandstone	Quaternary
3	CC	9/16	0030	3052-3053	1	0.20	0	1	Sapropel, Sand, Rock fragments	Quaternary

[a]Drill pipe measurement from derrick floor.

A second hard layer was encountered at 14 meters, where Core 129 A-1 was cut. This core contained an exotic dolomite block in sandy sediments of Quaternary age. We had suspected sandy lithology because of some high torquing. Subsequently, the drill pipe was washed down rapidly through the next 50 meters. A particularly firm formation was encountered at 73 meters below bottom, and Core 2 recovered Upper Miocene ostracod-bearing marls. We penetrated 8 meters further into this formation, taking three hours to core the last three meters. The partly indurated sediments in this core (No. 3) were deformed and one of the beds appeared to be overturned (probably not a drilling phenomenon). The hole was terminated at 81 meters below bottom because of the extremely slow drilling.

Operations at Hole 129B

For the third hole we returned to the axis of the Strabo Trench, by offsetting 2000′ west and 1100′ south of the acoustic beacon (see Figure 8). The new location provided a strong echo return from the trench floor, as well as a side-echo trace of the inner wall, as illustrated in the fathogram of Figure 7B.

Hole 129B was spudded at a depth of 3042 meters. For the third time, a thin hard crust was encountered, this time at 5 meters below bottom; it was broken through easily. Core 1, from 26 to 27 meters, included exotic sandstone blocks in a marl ooze matrix.

Drilling became more difficult and slow. The center bit was used from 27 to 34 meters and appreciable torquing was evidenced. Core 2 contained Miocene sandstone erratics in what appeared to be a sandy matrix rich in Quaternary microfossils.

Time requirements dictated the abandonment of Site 129. However, before we gave up totally we cut a surface core at the 129B location which brought up sapropel, sand, and rock fragments of Quaternary age.

A Varel Diamond bit was used for drilling the three holes at this site. The bit was only slightly worn when it was retrieved on deck; it was not at all effective in cutting through the marly formations encountered at this site. The three holes were terminated at relatively shallow depths because of drilling rates below 0.5 m/hr. Nonetheless, we did manage to sample the oldest formation of the present Mediterranean, under the steep trench wall, where the marls apparently subcrop under a thin Quaternary veneer.

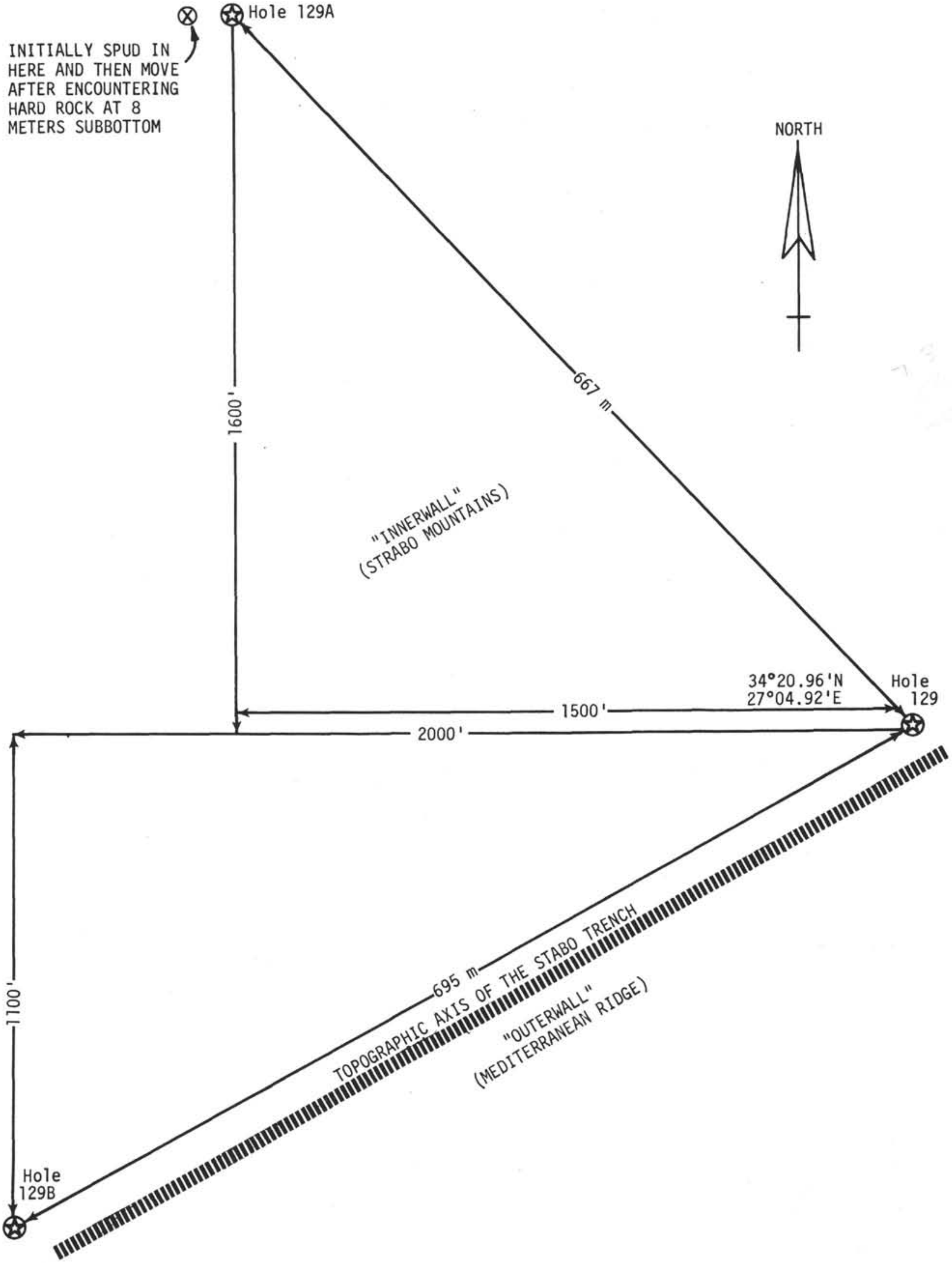


Figure 8. *Plan view showing the offset locations for the different drill holes. Holes 129 and 129B, though near the topographic axis of the trench, were positioned over the inner wall as opposed to the outer wall. Hole 129A is located well up on the inner wall.*

BIOSTRATIGRAPHY

The three holes penetrated sediments of Quaternary age uniformly overlying Miocene sediments. Pliocene sediments, partly consolidated, were also recovered, as allochthonous components of the Quaternary filling of the Strabo Trench.

The stratigraphic succession at Site 129 was difficult to decipher. A combination of poor core recovery and the presence of allochthonous detritus in some of the sections added to the uncertainties. Much information will result concerning the Late Neogene sedimentary record of the Levantine Basin, but only after more careful study.

A few stratigraphic highlights gleaned from the preliminary examinations may be summarized as follows:

1) Hole 129 recovered four cores of Late and Middle Miocene age.

2) Hole 129A recovered three cores, ranging in age from middle to late Quaternary to Late(?) Miocene;

3) Hole 129B recovered three cores, one yielding allochthonous fragments of Lower Pliocene and Middle Miocene age. The hole terminated in Quaternary sands containing some older fossils as reworked components.

The oldest sediments known so far from the deep floor of the Mediterranean Sea were recovered in Hole 129 and were of Middle Miocene age (Langhian Stage). A brackish-water facies has been recognized from the cores of Hole 129A. It is characterized by an oligotypical assemblage of the ostracod *Cyprideis pannonica* and the benthonic foraminifer *Ammonia beccarii tepida*. This assemblage is considered characteristic of the Messinian. The relation of the Middle Miocene pelagic assemblage in Hole 129 to the Late Miocene ostracod assemblage in Hole 129A is not entirely clear. One might attribute the Middle Miocene foraminifera and nannoplanktons as displaced fossils in a barren Late Miocene formation. Alternatively, one might assume that the Late Miocene ostracod-bearing marls unconformably overlie the Middle Miocene open marine sediment. For a further discussion of these points, the reader is referred to the Summary and Conclusions Section.

Planktonic Foraminifera (M.B.C.)

Information concerning the occurrence of planktonic foraminifera in the cores recovered from this site is given as lists of fossils followed by discussions. Range charts are considered inappropriate in light of our present lack of detailed observation.

Core 1, Hole 129

Two samples were examined, 129-1-1, 117-120 cm and 1, CC. The first, 129-1-1, 117-120 cm, yielded a poor assemblage of planktonic foraminifera not really age-diagnostic, indicating a generalized middle to upper Miocene age. Recorded taxa include:

Globigerina microstoma
Globigerinoides bollii
Globigerinoides obliquus
Globigerinoides glutinata
Orbulina universa

Foraminifera are fairly rare, most of the fraction greater than 63 microns consists of detrital fragments. The association of abundant detritus with planktonic foraminifera, in the absence of benthonic foraminifera, is an unusual feature.

The second sample, 129-1, CC, has an assemblage similar to the above, but also includes:

Globigerinoides trilobus
Globorotalis menardii

The age is probably late Serravallian[4]. It is worthwhile mentioning the occurrence of a single specimen of *Ammonia beccarii tepida*, a benthonic foraminifer characteristic of brackish water.

Core 2, Hole 129

Two samples were investigated from Core 2. The first, 129-1-1, 35-40 cm, indicates purely pelagic sedimentation. The foraminiferal assemblage is very abundant but poorly preserved; all tests are recrystallized, so that generic and specific determinations are often impossible. Most of the foraminiferal shells are covered by a number of minute pyrite crystals. Benthonic foraminifera are practically absent. Recorded taxa include:

Globigerina nepenthes
Globigerina spp.
Globorotalia menardii
Globorotalia siakensis
Globoquadrina cf. *altispira*
Orbulina universa

The assemblage does not show any evidence of reworking, the type of fossilization being the same for all the tests, with no unusual association of mutually exclusive taxa being recorded. The occurrence of *Globorotalia menardii*, *G. siakensis*, and *Globigerina nepenthes* indicates late Serravallian age (*Globigerina nepenthes* Zone N. 14 of Blow's zonal scheme).

In the second sample 129-2, CC, the size fraction greater than 63 microns consists mostly of minute dolomite crystals and pyrite. A few planktonic foraminifera have been observed, although they are badly preserved; there are practically no benthonic foraminifera. The assemblage is similar to the preceding sample, but is poorer and less age-diagnostic and also includes *Globigerina druryi*.

A sample obtained from Center bit 1 (between Cores 2 and 3) was examined. It consisted mostly of sand and yielded foraminifera of different ages (Middle Miocene and Lower Pliocene), with different types of fossilization. The Pliocene faunas found here are interpreted as downhole contaminants introduced by extensive washing during the drilling. Recorded taxa include:

Globigerina bulloides
Globigerina nepenthes
Globigerinoides obliquus
Globigerinoides quadrilobatus
Globorotalia margaritae
Globorotalia puncticulata
Globorotalia siakensis

[4]For the use of the stage names Langhian, Serravallian and Tortonian, reference is made to Cita and Blow (1969). The stage names used here are not in complete agreement with the standard stratigraphic framework of DSDP, but are instead used with reference to existing type sections and to their biostratigraphic significance.

Orbulina universa
Sphaeroidinellopsis seminulina
a single specimen of *Ammonia beccarii tepida.*

Core 3, Hole 129

Two samples were examined from Core 3. The first, 129-3-1 (85-88 cm, consists of detrital fragments, mostly quartz, in the greater than 63 microns fraction. Planktonic foraminifera were fairly abundant and well preserved. Benthonic foraminifera were practically absent. The recorded taxa include:

Globigerina druryi
Globigerina nepenthes
Globigerinoides obliquus
Globigerinoides trilobus
Globoquadrina dehiscens
Globorotalia menardii
Orbulina universa

The above taxa indicate a Middle Miocene age (Serravallian, Zone N. 14). Also present are valves and fragments of an ostracod, probably *Cypridesis pannonica*, a typical Messinian species (see under 129A, 2, CC, and discussion in Chapter 36.1).

The second sample, 129-3, CC, had an assemblage similar to the above, with detritus and planktonic foraminifera of late Serravallian age, but also included some older forms such as *Globigerinoides bisphericus, Globigerinita unicava, Globorotalia* cr. *peripheroronda,* and also *Cyprideis pannonica,* and *Ammonia beccarii tepida.*

Core 4, Hole 129

Only one sample, 129-4, CC, was examined. It contained pieces of a fine-grained limestone rich in foraminifera (mainly planktonic). The following genera have been recognized: *Globigerina, Globigerinoides, Globorotalia,* and *Orbulina.* A semi-indurated marl ooze was found coating the limestone and a disaggregated sample yielded terrigenous minerals, abundant pyrite, and planktonic foraminifera. Recorded taxa include:

Globigerina bulbosa
globigerina sp.
Globigerinoides bisphericus
Globigerinoides transitorius
Globigerinoides trilobus
Globorotalia mayeri
Globorotalia peripheroronda
Globorotalia praescitula
Globorotalia siakensis
Globoquadrina altispira
Globoquadrina dehiscens
Orbulina suturalis
Cassigerinella chipolensis

The above assemblage seems rather uniform and indicates a late Langhian age (Zone N9 of Blow's zonal scheme, with *Orbulina suturalis* as the zonal marker).

Discussion of Hole 129

In summary, we recovered a largely Middle Miocene Serravallian fauna in Cores 2 and 3 of Hole 129, and an early Middle Miocene (late Langhian) fauna in Core 4. In addition, some specimens of Late Miocene ostracod species were found with the Middle Miocene fauna in Core 129-3, which was highly contorted and deformed. We could assume either that (1) all the Middle Miocene faunas in Core 129-1-3 are displaced forms in an Upper Miocene formation, or (2) we have encountered a Middle Miocene formation in Hole 129, which underlies the Upper Miocene formation of Hole 129, and that the ostracods and *Ammonia beccardii tepida* specimens found in Hole 129 samples are downhole contaminants from an uncored part, or (3) Core 3 penetrated a deformed zone, where Upper and Middle Miocene formations were tectonically mixed.

Regardless of whether the Middle Miocene fauna is autochthonous or allochthonous, findings of Hole 129 show that the eastern Mediterranean was an open sea during the Langhian Stage of the Middle Miocene.

Hole 129A

Core 1, Hole 129A

The sediment fraction greater than 63 microns in a single sample from Core 1, CC is a coarse sand with a varied composition, rich in Quaternary foraminifera, and yielding pteropods ostracods, fragments of thin-shelled pelecypods, and flat gastropods. Pyrite is present in some abundance, indicating reducing conditions at the bottom of the trench. Recorded foraminifera include among others:

Globigerina bulloides
Globigerina eggeri
Globigerina pachyderma
Globigerinoides ruber (also pink)
Globigerinoides elongatus
Globigerinoides pyramidalis
Globigerinoides quadrilobatus
Globigerinoides sacculifer
Globigerinita glutinata
Globorotalia inflata
Globorotalia scitula
Globorotalia truncatulinoides
Orbulina universa

The above assemblage indicates a warm temperate climate in the Quaternary with terrigenous sedimentation and associated planktonic contributions.

Core 2, Hole 129A

Again, only a single sample was studied from the core catcher. It yielded an oligotypical assemblage, dominated by a single species of ostracod, which is represented by entire carapaces, single valves, and many fragments. Also present in abundance is the benthonic foraminifer *Ammonia beccardii tepida.* Planktonic foraminifera are dwarfed and little diversified and include:

Globigerina bulbosa
Globigerina quinqueloba
Globigerinoides ruber
Globigerinita glutinata
Orbulina universa

These are not age-diagnostic. Also present in abundance is pyrite and fine grains of (angular) quartz.

A slide containing the greater than 63 microns fraction from 129A-2, CC was shown to Arvedo Decima (Palermo), the author of a monograph (Decima, 1964) on the genus *Cyprideis,* and he reported the above assemblage as follows:

> All the ostracods present in the slide belong to the species *Cyprideis pannonica* [see Figure 9]. Two adult

male carapaces and three female were observed, plus five isolated valves and a number of larval specimens in different development stages. The material is considered insufficient for a sure subspecific identification. However, the form shows more strict affinities towards spp. *agrigentina* than towards spp. *protonensis*, consequently the age of the sediment should be Messinian.[5] The distribution of both the species and the subspecies, with the only exception of *Cyprideis pannonica crotonensis*, in fact, is limited to the Messinian. They are forms characteristic of ipohaline milieu, almost constantly associated with *Ammonia beccardii tepida* and indicating, therefore, salinities ranging from 20°/oo to 30°/oo. Assemblages almost identical to the present one are very common in Sicily in beds of Messinian age, especially in the marls intercalated in between the "formazione salina" and the topmost gypsum beds ("Marne argillose inferiori" of Selli, 1960).

The same assemblage was also discussed with S. d'Onofrio (Bologna), the author of a paper on the foraminifera of the Messinian neostratotype, with C. A. Chierici, an expert on microfaunas of late Neogene age, and with Richard H. Benson, a specialist on ostracods of the Tethyan area (see Chapter 36.1). All consider the assemblage under discussion typically Messinian.

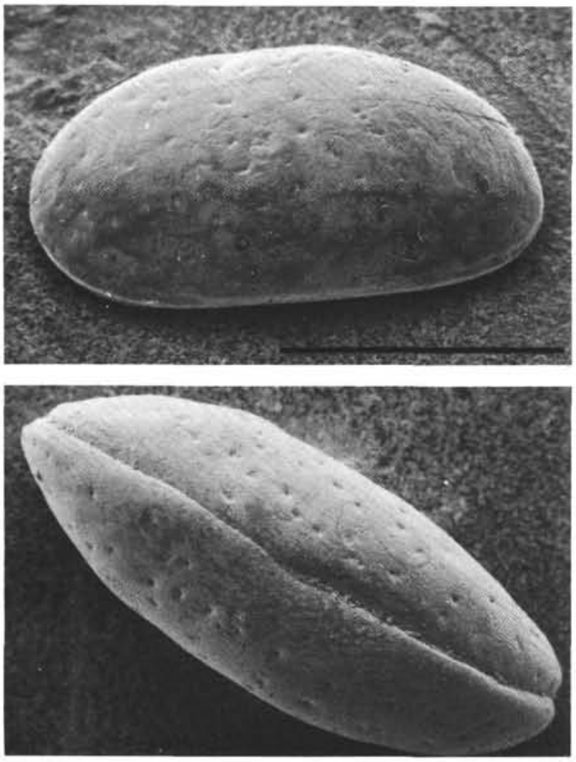


Figure 9. *A stereoscan view of the ostracod* Cyprideis pannonica. *Scale bar represents 100 microns.*

[5]Species ssp *protonenis* as identified by H. Oertli, see report on benthonic foraminifera by W. Maync.

Core 3, Hole 129A

One sample, 129A-3-1, 85-88 cm, was examined on shipboard. The assemblage is highly fossiliferous, and is comprised of a dwarfed fauna dominated by *Globigerina* spp. Pyrite crystals were noted in great abundance. Benthonic foraminifera include *Ammonia beccarii tepida* and *Bolivina* spp. Planktonic foraminifera include:

Globigerina bulloides
Globigerinita glutinata
Globigerinita uvula
Globorotalia acostaensis
Globorotalia scitula

Discussion of Hole 129A

Sample 129A-2, CC is determined to be Messinian in age. The observation by A. Decima concerning the occurrence of juvenile, larval specimens of *Cyprideis pannonica* together with fully developed ones is a strong argument for their autochthonous nature. Another strong argument is the co-occurrence of *Ammonia beccarii tepida*, which is always associated with the former in the type area of the Messinian stage. Finally, one more argument is the co-occurrence of dwarfed and nondiversified planktonic foraminifera, a common phenomenon in abnormal environments.

Hole 129B

The three cores of Hole 129B did not penetrate below the Quaternary trench fill. The sediment fraction greater than 63 microns consists of coarse to fine sand, planktonic foraminifera in abundance, pteropods, fragments of thin shelled pelecypods, and some pyrite crystals. Also present are reworked foraminifera with different types of fossilization, mainly from the Pliocene (*Sphaeroidinellopsis seminulina, Globorotalia puncticulata, Globigerinoides obliquus extremus*) and from the Miocene (*Globigerina nepenthes, Globorotalia menardii*). The Quaternary fauna includes some 20 taxa·indicating warm temperate surficial waters. *Globigerinoides ruber*, with pink tests, is also present.

The most interesting finding in this hole is the presence of chips of indurated sediments of Lower Pliocene age, recorded in the core catcher sample of Core 1.

A sample labeled on the ship as Piece no. 1 indicates a pelagic sediment, consolidated, and yielding poorly preserved specimens of *Globigerina* spp., *Globigerinoides* spp., *G. trilobus, Globorotalia puncticulata, Orbulina universa*, and *Sphaeroidinellopsis subdehiscens* of (probably) Lower Pliocene age. A sample labeled as Piece no. 3 (Figure 10) is buff-colored and yields an assemblage of lowermost Pliocene age, characteristic of *Sphaeroidinellopsis* Acme-zone, with:

Globigerinoides obliquua extremus
Globigerinoides quadrilobatus
Globigerinoides trilobus
Globorotalia puncticulata
Orbulina universa
Sphaeroidinellopsis seminulina
Sphaeroidinellopsis subdehiscens

The sediment described above is strikingly similar in faunal composition, color, and other sedimentological characteristics to the lowermost part of the Pliocene section

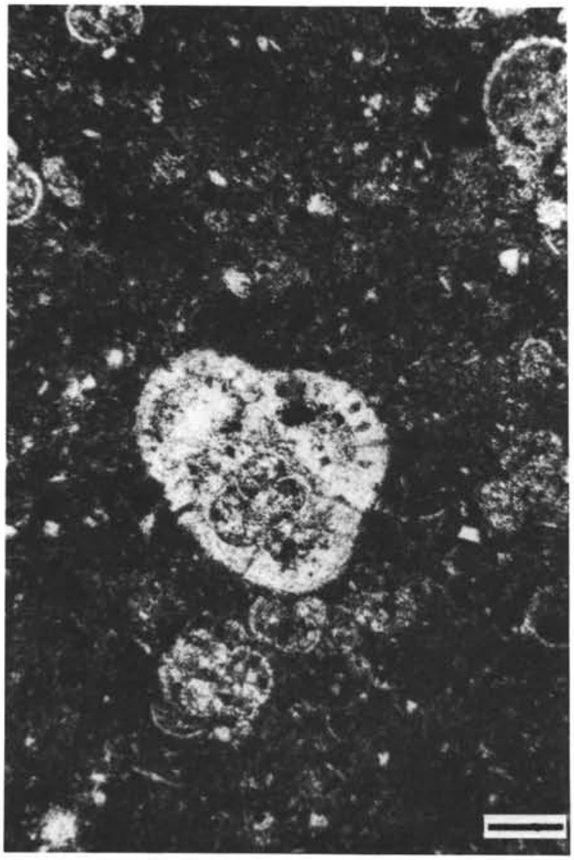


Figure 10. Sphaeroidinellopsis seminulina *as seen with crossed nicols in a thin section slice through the buff-colored indurated foraminiferal ooze of lowermost Pliocene age (Piece No. 3 of Core 129B-1, CC). Micritic matrix consists of coccoliths and clay minerals. Scale bar represents 100 microns.*

recovered at Site 132 in the Tyrrhenian Basin (*Sphaeroidinellopsis* Acme-zone as documented in Cores 20 (pars) and 21 (pars) by red-colored nanno foram oozes there). Sediments of this age, however, have not been recorded in place at any of the sites we drilled in the eastern Mediterranean. Yet, by its occurrence alone, whether in allochthonous sediments or not, it demonstrates that open marine pelagic sedimentation was reinitiated in the eastern Mediterranean simultaneously with its appearance above the evaporites in the western basins. Our conclusion confirms the previous single finding of pelagic ooze belonging to the *Sphaeroidinellopsis* Acme-zone in a piston core from the Mediterranean Ridge in the Ionian Basin (see Biscaye *et. al.*, 1971).

Benthonic Foraminifera (W.M.)

The range distribution of the benthonic foraminifera recognized in selected samples from the drill cores of Site 129 is shown in Table 2.

Fossil tests of *Ammonia beccarii tepida* Cushman, indicative of a lagoonal or bayhead low energy environment, are very common in Holes 129 (Core Sections 3-1 and 3, CC) and 129A (2, CC; 3, CC), and are also present in Cores 1 to 4 of Hole 129B.

Hole 129A, drilled slightly higher on the Strabo Mountain slope, showed Quaternary sand and dolomite in Core 1 with a good fauna of planktonic foraminifera, whereas benthonic forms are exceedingly rare.

The brackish-lagoonal marl in Core 129A-2, CC carries an abundance of an ostracod species, associated with very common *Ammonia beccarii* var. *tepida* Cushman. This benthonic species is also represented by scattered specimens in the marine association of Core 3, CC.

With respect to the benthonic foraminifera, the only species indicating a Miocene age are *Bolivinoides miocenicus* Gianotti and *Bolivinia arta* McFadyen, which were observed in Core 3, CC of Hole 129A.

Nannoplankton (H.S.)

The nannofossil assemblage recovered from the three holes at Site 129 are assigned to three different geologic time units as follows: Middle Miocene assemblages are found in the greenish gray nanno ooze and marl ooze of Cores 1 through 4 in Hole 129 and contain *Discoaster challengeri, D. challengeri mediterraneus, D. deflandrei, D. phyllodus,* also rare *Discoaster bollii, D. aulakos* and *Sphenolithus abies* and *S. heteromorphus.* According to the nannoplankton zonation by Martini and Worsley (1970), the last occurrence of *Sphenolithus heteromorphus* lies between NN5 and NN6. However, according to Cita and Blow (1969) this species has an extended range higher up into the Serravallian. Considering the first occurrence of *Discoaster challengeri* in the *Globigerinoides bisphaericus* Zone, and the first occurrence of *Discoaster challengeri mediterraneus* in the *Praeorbulina glomerosa* Zone, the geologic age of these sediments is interpreted as Langhian to Serravallian (NN5-NN7 or N8-N12). In Hole 129A, Cores 2 and 3 contain identical assemblages of Middle Miocene discoasters and coccoliths. In Hole 129B, only the greenish-gray components of Core 1 have nannofossils of the same Middle Miocene assemblage.

Lower Pliocene assemblages occur in fragments of partly indurated buff-colored sediment in the center bit samples no. 2 of Hole 129 and no. 1 of Hole 129B. They contain *Discoaster surculus, D. asymmetricus, D. brouweri, Ceratolithus rugosus,* and *C. tricorniculatus*, and also many reworked Miocene discoasters (NN 14).

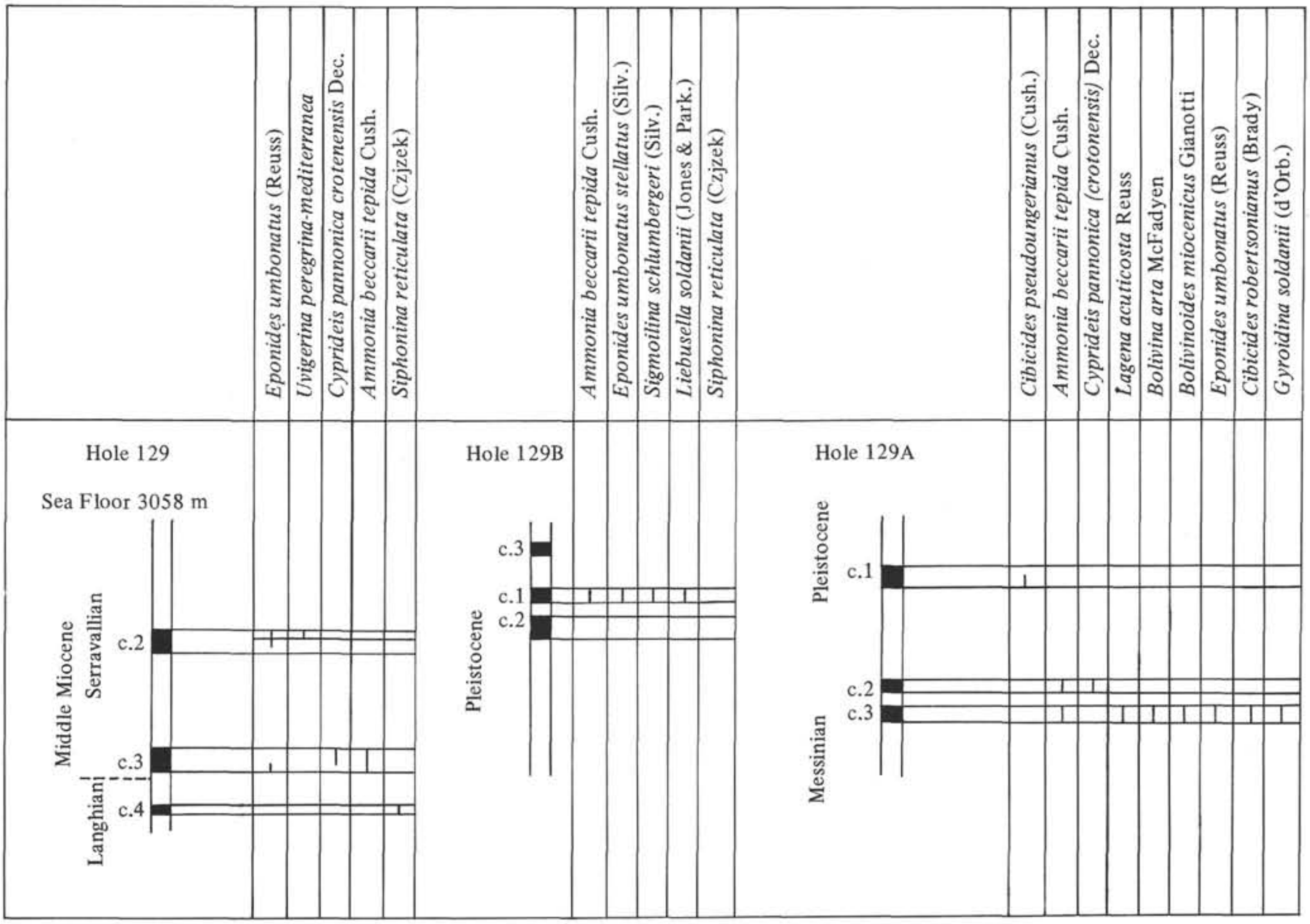
A Quaternary nannoplankton assemblage of late Quaternary age was collected in the surface punch core of 129B-3, CC, which in addition to containing very abundant late Quaternary nannofossils (*Emiliania huxleyi, Discoaster perplexus*) also contains a chaotic mixture of Pliocene and Miocene coccoliths and discoasters.

The age-diagnostic nannofossil assemblages are shown below:

Miocene

Samples: 13-129-1-1, 40 cm and 129-1, CC:
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Cyclococcolithus neogammation
Discoaster challengeri
Discoaster challengeri mediterraneus

TABLE 2
Range Chart of the Benthonic Foraminifera in Holes 129, 129A, 129B



Discoaster deflandrei
Discoaster phyllodus
Reticulofenestra bisecta
Reticulofenestra placomorpha
Sphenolithus heteromorphus

Samples: 13-129-2-1, 25 cm; 129-2-1, 90 cm; and 129-2, CC:
Coccolithus pelagicus
Coccolithus eopelagicus
Discoaster challengeri
Discoaster challengeri mediterraneus
Discoaster phyllodus
Helicosphaera carteri
Sphenolithus abies
Sphenolithus heteromorphus

All samples slightly overcalcified.

Samples: 129-3-1, 30 cm and 129-3, CC:
Coccolithus pelagicus
Coccolithus eopelagicus
Cyclococcolithus leptoporus s.l.
Discoaster challengeri
Discoaster challengeri mediterraneus
Discoaster phyllodus
Discoaster trinus
Helicosphaera carteri
Pontosphaera multipora
Sphenolithus abies
Thoracosphaera deflandrei

Sample: 13-129-4, CC (trace):
Coccolithus pelagicus
Cyclococcolithus neogammation
Discoaster bollii
Discoaster deflandrei
Discoaster challengeri
Helicosphaera carteri
Pontosphaera multipora
Sphenolithus belemnos
Sphenolithus heteromorphus

Nannofossils overcalcified!

Sample 13-129A-2, CC:
Coccolithus pelagicus
Coccolithus eopelagicus
Cyclococcolithus rotula
Discoaster challengeri
Discoaster deflandrei
Discoaster kugleri
Discoaster phyllodus
Helicosphaera carteri
Sphenolithus abies

Reworked: Eocene *discoasters* and *coccoliths*
Discoaster barbadiensis
Zygrhablithus bijugatus
Zygolithus dubius

Samples: 13-129A-3-1, 33 cm and 129A-3, CC:
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Discoaster bollii
Discoaster challengeri
Discoaster challengeri mediterraneus
Discoaster deflandrei
Discoaster phyllodus
Helicosphaera carteri
Reticulofenestra bisecta
Sphenolithus abies

Sample 13-129 B-1, CC (piece no. 4) contains in its greenish-gray components an identical assemblage of Miocene discoasters and coccoliths, however they are poorly preserved.

Lower Pliocene

Samples: 13-129, CB 2 and 13-129B, CB 1:
Heavily overcalcified nannofossil assemblages with:
Ceratolithus rugosus
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Discoaster asymmetricus
Discoaster brouweri
Discoaster surculus
Pontosphaera scutellum
Scyphosphaera apsteini
Discoaster asymmetricus Zone (NN 14.)

Quaternary

Sample 13-129A-1, CC:
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Emiliania huxleyi
Gephyrocapsa oceanica
Helicosphaera carteri
Pontosphaera scutellum
Pseudoemiliania lacunosa
Reticulofenestra pseudoumbilica
Rhabdosphaera clavigera
Rhabdosphaera stylifera

Sample 13-129B-3, CC:
Ceratolithus cristatus
Coccolithus pelagicus
Cyclococcolithus leptoporus s.l.
Discoaster perplexus
Emiliania huxley
Helicosphaera carteri
Pseudoemiliania lacunosa
Rhabdosphaera clavigera
Scapholithus fossilis

A chaotic mixture of Pliocene, Miocene and Eocene discoasters and coccoliths, e.g.
Discoaster asymmetricus
Discoaster brouweri
Discoaster barbadiensis
Discoaster binodosus
Discoaster pentaradiatus
Discoaster surculus

Siliceous Microfossils (P.D.)

Siliceous microfossils, particularly radiolarians, were found only within Quaternary sediments of Core 3, CC of Hole 129B. The assemblage recovered is rather poor, both in species and in specimens. The following taxa have been recognized:
Actinomma sp.
Rhizosphaera sp.
Hexacontium sp.
Amphirhopalum ypsilon
Giraffospyris angulata
Amphispyris reticulata

With the exception of the last species, the rest have been encountered in Quaternary sediments at the previous drill sites.

LITHOSTRATIGRAPHY

The various diverse lithologies of the two drill holes in the axis of the Strabo Trench (129 and 129B), and of the single drill hole some 200 meters higher on the inner wall escarpment of the Strabo Mountains (129A), are grouped together into a generalized scheme of four basic lithologic units. Such a classification is admittedly restrictive, but serves the purpose of focusing attention on the principle findings resulting from our preliminary observations.

A vast assortment of small chips and pebbles was recovered in the reworked residues of both the center bit and core catcher samples and still waits description–a massive task that will no doubt enlarge the tentative groupings listed below in Table 3. The individual recovered core sections containing each of the units are identified in brackets.

TABLE 3
Lithologic Units of Site 129

Unit	Lithology	Age
1	Nanno ooze, sapropel, washed sand, and sandstone (129A-1, CC; 129B-1, CC to 3, CC; 129B, CB1)	Quaternary (at times only a matrix with mixed older erratics)
2	Indurated foraminiferal ooze (129B-1, CC; 129, CB2; 129B, CB1)	Lower to Lowermost Pliocene
3	Dolomitic ooze, dolomitic marl, ostracod-bearing marl, and pyritic shales, current-bedded limestone (129-1 to 3; 129A-2, CC to 3-1, and 3, CC)	Upper to Middle Miocene (Messinian and Serravallian)
4	Limestone and marl ooze (129, CB2; 129-4, CC)	Middle Miocene (Langhian)

Unit 1 – Nanno ooze, Sapropel, Sand, and Sandstone

The lithologies represented in Unit 1 are selected to include those which, in a thin veil, carpet the steep rugged inner wall of the trench and those which have been trapped in discontinuous pockets along the extremely narrow trench axis. The continuity of these deposits remains to be explored with future dredging and coring.

Only bits and pieces were recovered. The youngest were those directly from the surface of the sea bed in Hole 129B (Core 3, CC) and are represented by tan- and gray-colored pelagic nanno oozes and black sapropel, similar in many respects to the sediment recovered in the top of piston core RC 9-179 on the Mediterranean Ridge, some 15 kilometers to the southeast.

At all of the holes undertaken at this site, a hard resistant layer was encountered at shallow subbottom depths. In Hole 129B, discussed above, the horizon was found just five meters below the sea bed. It was breached without coring, and then another was encountered at 26 meters. The composition of these layers is unknown; however, the recovered materials of Core 1, CC, cut from 26 to 27 meters below bottom, may offer a clue.

Three of the four fragments in this core are indurated, the most solid being a well-cemented sandstone identified as Piece no. 2. This particular unit, shown under crossed nicols in Figure 11A, is comprised almost entirely (95%) of rounded to moderately well-rounded quartz. Primary structures include dark cross-bedded laminae of calcitized pelite. The overall matrix content is less than 5 per cent thus allowing us to classify this sandstone as a quartz arenite. Occasional rounded balls of pelite are mixed with the mineral grains, as shown in the illustrated thin section. This fragment may have come from the first hard layer.

A markedly different sandstone was recovered in the next core (no. 2). This rock may be classified as a lithic graywacke because of a rather surprisingly high content of lithic rock fragments and an abundant fine-grained carbonate and clay matrix exceeding 50 per cent of the thin section area (Figure 11B). Included, besides quartz (12%), are metamorphic and volcanic (andesite) components (20%), calcite, generally as shell debris (5%), feldspars (2-6%), epidote (2-3%), and green hornblende (5%).

Much of the quartz is made up of polycrystalline grains of different types. A strained and recrystallized composite quartz of prevalently metamorphic type is present, together with a schistose type, characterized by sutured boundaries, mica flakes, and inclusions. The presence of unstable minerals such as hornblende and epidote suggests a metamorphic source area, with rounded calcite grains evidence of rapid erosion and textural immaturity. These considerations, plus the observed presence of unstable feldspars, seem to indicate a local provenance.

No fossils were recognized. However, the sandstone fragments were found floating in loose, washed sand of similar mineralogy. These sands contained some Quaternary foraminifera, which, if autochthonous and not downhole contaminants, would allow an age assignment.

For a further discussion of the petrology of these sandstones, the reader is referred to Chapter 25.2.

Unit 2 – Indurated Foraminiferal Ooze

The fragments which are assigned to Unit 2 are all considered allochthonous. They include two hand-sized specimens from Core 1, CC of Hole 129B in the trench axis (Pieces no. 1 and no. 3, respectively). Piece no. 1 is gray with a distinctive light-colored mottling produced by bioturbation. In fact, this texture caused it to be originally misidentified as a microbreccia. Piece no. 3 is orange- to buff-colored, without appreciable burrowing. Both are semi-indurated, with a low-magnesian calcite cement. The micritic matrix is comprised almost entirely of coccoliths, with some minor amounts of clay minerals and fine-grained quartz. The fossil assemblage indicates a Lower Pliocene age.

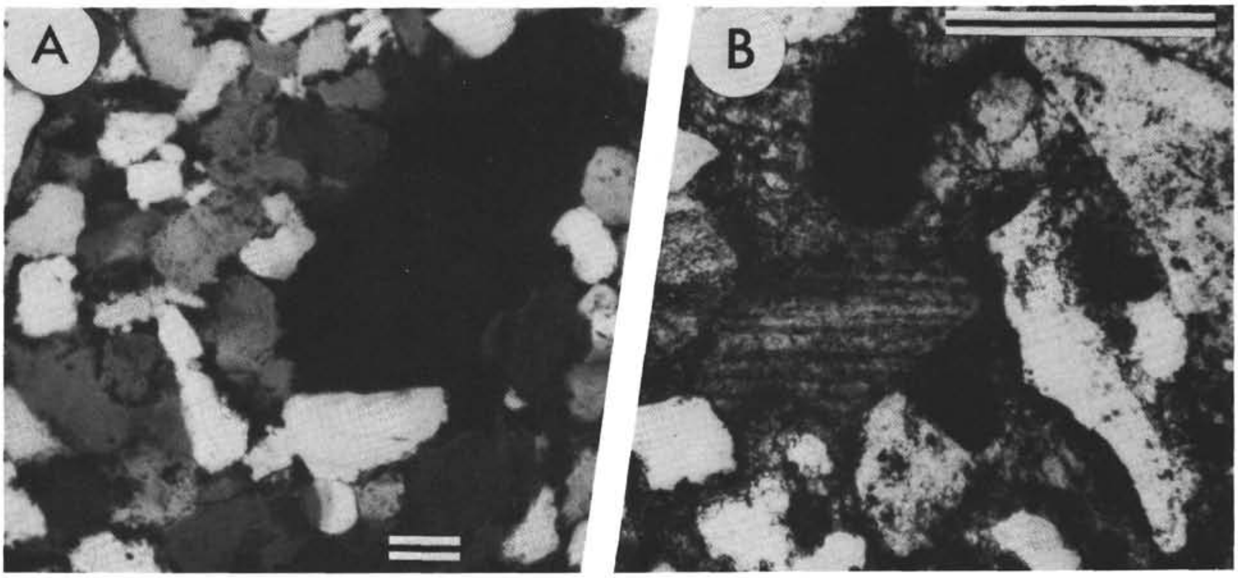


Figure 11. *Sandstones of possible Quaternary age from Hole 129B near the axis of the Strabo Trench. (A) is a quartz arenite (Piece #2 of 129B-1, CC) with a rounded ball of calcitized pelite. (B) is a lithic graywacke from 129B-2, CC. Crossed nicols. Scale bar represents 100 microns.*

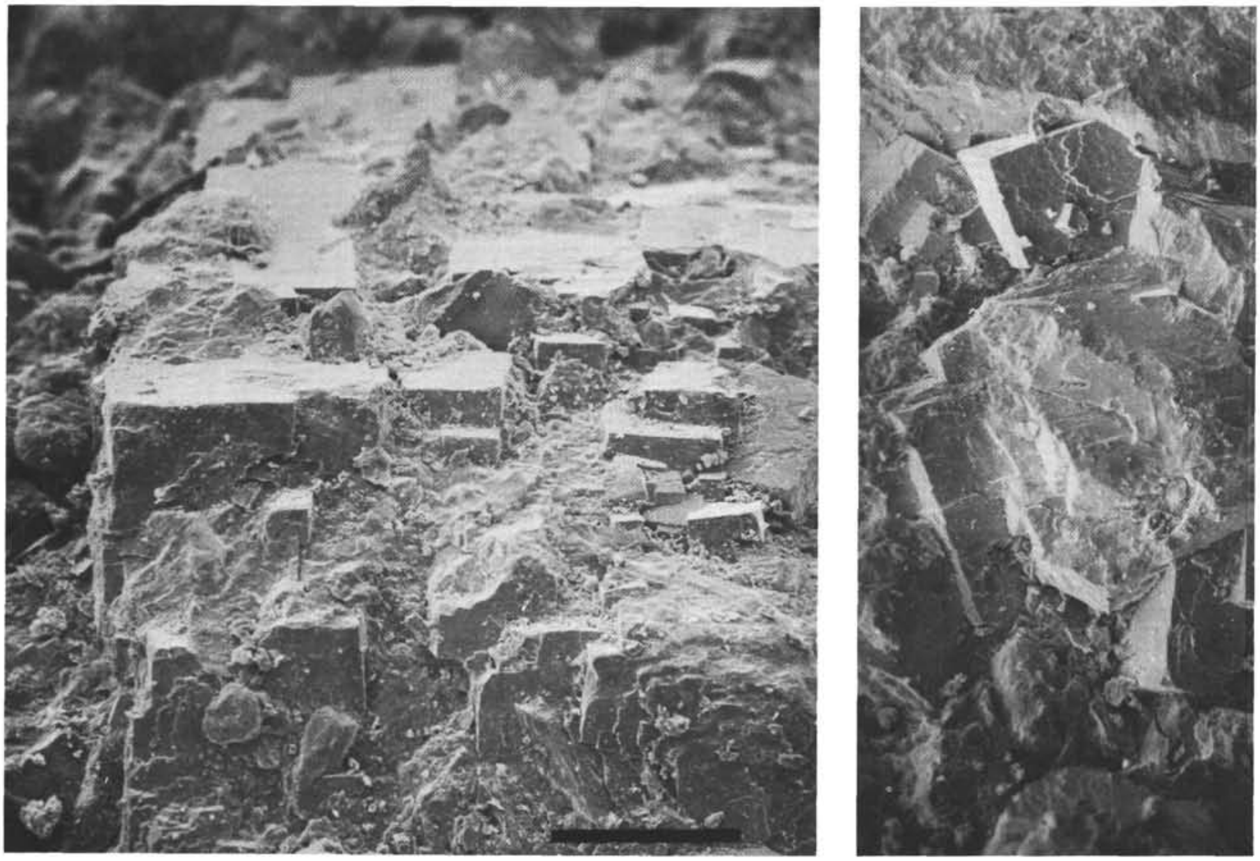


Figure 12. *Pyritic shale from Core 2, CC of Hole 129A. This heavily indurated marl is practically barren of calcareous microfossils. Scale bar represents 100 microns.*

Small pebbles of similar color and texture were found in the center bit Sample no. 1 of this same hole, as well as in center bit Sample no. 2 of Hole 129, also located in the trench axis. The carbonate content is high (65 to 85%) in the few pieces examined. The cause of the cementation cannot be ascertained in examination under the scanning electron microscope, except that it apparently occurs at grain boundaries between the coccoliths. Neither the coccoliths nor the foraminifera are appreciably calcified.

The makeup and texture of all these fragments indicate a well-ventilated open marine environment.

Unit 3 – Dolomitic Ooze, Dolomitic Marl, Ostracod-bearing Marl, Current-bedded Limestone, and Pyritic Shales

The lithologies represented in Unit 3 are all indicative of atypical deep-sea sedimentation. Where age assignments are possible, the rocks belong exclusively to the Miocene, and include both the Serravallian and Messinian stages. The marls of Cores 1, 2, and 3 of Hole 129, for example, are very rich in finely crystalline dolomite (up to 49% of the bulk sediment). They are greenish gray and stiff to plastic. In Core 2, a light-colored layer from 67 to 103 cm has a carbonate content of 70 per cent and qualifies as a dolomitic ooze. Numerous planktonic foraminifera are present, with tests heavily recrystallized and both coated and filled with tiny pyritic spherules of framboidal texture. Bedding contacts are horizontal. In Core 3, the sediment is noticeably more silty, with the coarser sediments concentrated along thin orange tinted laminae. The section is strongly disturbed because of drilling operations (or possibly by slumping). However, the core catcher sample is intact and well preserved, and includes cross-bedded laminae rich in rounded quartz grains, tests of foraminifera (including shallow-water benthonic species), and smooth-shelled ostracods. The orange coloring is due to iron oxide stains on the mineral grains and shells. Very similar laminated marls rich in ostracods were found in Core 2, CC of Hole 129A.

The dolomitic marls of Core 2, CC of Hole 129A were accompanied by indurated zones of pyritic shale. Figure 12 illustrates a scanning electron microscope view of a freshly broken surface of the shale. The interclustered pyritic growth almost dominates the entire rock mass. The unit is completely barren of fossils.

One fascinating and puzzling finding is a buff-colored limestone identified as Piece no. 3 in Core 1 of Hole 129. A polished section showing parallel, cross-laminated and convolute bedding structures is illustrated in Figure 13. The rock is well lithified and is cemented with low-magnesian calcite. Noticeable on the face are numerous tiny burrow marks, which in thin section are seen to be lined by sparry calcite and filled with pyrite. The composition is almost exclusively finely crystalline calcite with some quartz silt. The rock contains numerous organically derived particles,

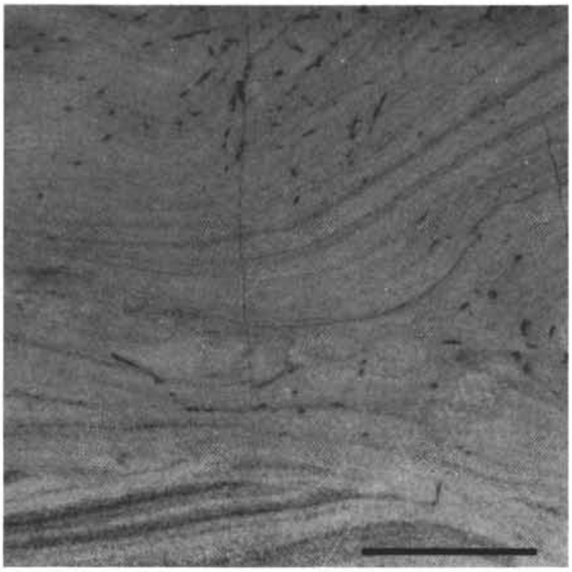


Figure 13. *Convolute and crossbedded laminations in a calcite-cemented limestone from Hole 129 (Piece No. 3 at 123 cm in Core 1, Section 1). The dark laminae are rich in an unidentified brown- and orange-colored fibrous material which may be remanents of algae. The small specks are burrow holes lined with a coating of sparry calcite and filled with pyrite. Scale bar represents 100 microns.*

though they are heavily recalcified and difficult to recognize. Dominant among these are tests of foraminifera and single valves of unornamented ostracods. The foraminiferal tests are commonly filled with pyrite and, less commonly, sparry calcite.

The dark laminae are rich in elongate angular grains of some brown-to-orange fibrous material as yet unidentified. It is suspected that it might be filaments of former bluish green algae. The matrix of the rock appears to have undergone some process of grain enlargement, with the development of clusters of anhedral grains of calcite. Numerous cross-cutting veins are filled with a growth of sparry calcite.

The silty-textured dolomitic marls are both plastic and semi-indurated. We were particularly impressed by an interval recovered in Section 1 of Core 3 of Hole 129A, on the inner wall of the trench. This sediment is very stiff and contains discordant structures, high angular faults, chevron folds, and an overturned bed (Figure 14). Considering the partial induration of the material, we suspect that these deformational structures were not introduced solely by the mechanical disturbances of drilling, but, instead, may reflect tectonic deformation.

The presence of smooth-shelled ostracods and benthonic foraminifera such as *Ammonia beccarii tepida* in some of the dolomitic marls of Unit 3 is strongly indicative of a former shallow water environment. The cross-laminations indicate traction-transport and reworking by currents.

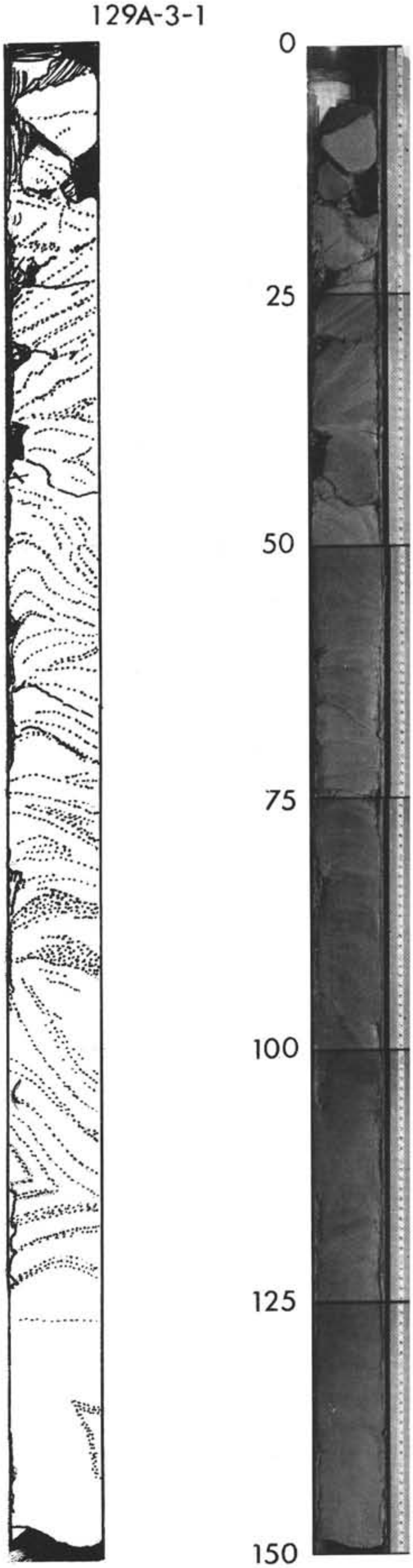


Figure 14. *Bedding structures in Core 3 of Hole 129A on the southern escarpment of the Strabo Mountains. Scale is in centimeters.*

Unit 4 – Limestone and Marl Ooze

A small piece of biomicritic limestone was found at the bottom of Hole 129 in the core catcher of Core 4. Tests of planktonic foraminifera are abundant in a lightly packed matrix of coccoliths; both fossil groups give a Middle Miocene (Langhian) age. The limestone was recovered as fragments in a semi-indurated marl ooze with faunal assemblages similar to the above. More of the same marl ooze was later detected in the center bit Sample no. 2, obtained while drilling a twelve meter interval directly above, and contiguous with, Core 4. The facies of Unit 4 reflects an open marine pelagic environment. No dolomite was detected, though the nannofossils were heavily encrusted with low-magnesium calcite.

Inadequate drilling and recovery in Holes 129, 129A, and 129B precluded the determination of physical properties at this location.

SUMMARY AND CONCLUSIONS

The principal objectives of drilling in the Strabo Trench were achieved despite the great technical difficulties of obtaining deep penetrations. A notable discovery was the lack of appreciable amounts of young sediment at the foot of the inner wall within the axial depression of the trench itself. In fact, we were surprised at recovering Middle Miocene dolomitic marl at only 38 meters below bottom in our first hole. After all, the carpet of Quaternary and Pliocene pelagic ooze at Site 125 on the Mediterranean Ridge was close to 80 meters in thickness alone, and was without any indication of displaced materials. The Quaternary fill in the Hellenic Trench was in excess of 480 meters.

Lack of Sediment

Where is the equivalent sediment at Site 129? It is apparently absent as well from the face of the northern inner wall. During the attempt to spud Hole 129A, some 200 meters above the axis of the trench, a hard substratum was first encountered at just 8 meters below bottom, and again at 9 meters after a one hundred foot offset to the east. Shallow subcropping and/or actual exposure of rock sequences would be in accord with the very fuzzy echo returns observed in profiles over the steep southern escarpment of the Strabo Mountains. Note in Figure 6 the marked contrast between the weak scattered echo returns from the inner wall and the strong coherent echo sequence from the sediment-draped Mediterranean Ridge to the south.

The bathymetric profiles across the Strabo Trench published by Goncharov and Mikhaylov (1963), Mikhaylov (1965) and Emery *et al.* (1966) invariably show a cleft without a flat floor, as was the case for the *Glomar Challenger* traverse. One might expect that such a depression would be an ideal sediment trap; evidently it is not.

There is no reason to suggest nonproductivity within the northern Levantine Basin of the eastern Mediterranean, particularly considering the more than 200 meters of transported sediment that covers Reflector M down the outer wall of the trench (Figures 2 and 14). We are led to conclude that the Strabo Trench can act only as a transient repository for contemporary sediment.

Where Has It Gone?

There is no way for sediment to leave the Strabo Trench through gravity transport (i.e., there is no passage to a deeper catchment basin). Furthermore, there is no reason to believe that the sediments dissolve, since there is no evidence of destruction of even the most soluble tests at a level more than 2000 meters deeper in Hole 128, beneath the floor of the Hellenic Trench.

Another possibility is that the sediments of the trench have been preferentially removed through the winnowing action of near-bottom currents. If so, the ancient circulation has long since ceased, for there is no trace of dynamic reworking in a ten-meter-long piston core from the Mediterranean Ridge only 15 kilometers to the southeast.

A more attractive hypothesis, in light of what has already been deduced about the contemporary crustal activity of this area, proposes that the sediments in the Strabo Trench are being subducted beneath the Mediterranean Wall.[6] Crustal unrest might have shaken much of the loose sediment from the inner wall, confusing our cored sections. This point will be discussed later.

Stratigraphic Reconstructions

The geology at Site 129 is perplexing, particularly the sequence in the original hole. Under thin Quaternary sediments, we sampled Middle Miocene Serravallian marls, e.g., Cores 129-2 and 129-3. An interval (Core 129-4) directly below this last core recovered an early Middle Miocene (Langhian) pelagic ooze. The Serravallian and Langhian sequence is not conformable, since several planktonic foraminiferal zones (N10-N13) are missing.

The presence of the Messinian ostracod fauna under Serravallian marls may be given three alternative interpretations:

1) We could assume that a Messinian ostracod-bearing marl unconformably overlies the Langhian. According to this hypothesis, all the Serravallian faunas in Cores 129-1, 129-2 and 129-3 are allochthonous elements in a Messinian deposit.

2) We could assume a downhole contamination. According to this hypothesis, the Messinian ostracod-bearing marl found in Hole 129A is also present in the sediments surrounding Hole 129. This marl might comprise strata in normal superposition in the uncored interval (0-38.5 m below bottom) above Core 129-1, or, more likely, it might occur as exotic pieces in a Quaternary olistostrome. Left unexplained is the biostratigraphic unconformity between Core 129-3, Serravallian (Zone 14) and center bit no. 2 to Core 129-4, Langhian (Zone 19); all these intervals were cored continuously.

3) We could assume, as discussed already, that we have drilled into a tectonically disturbed zone. According to this hypothesis, the abnormal faunal superposition, as well as

[6]See Chapter 37 for a more comprehensive discussion of present ideas concerning contemporary tectonic activity in the eastern Mediterranean. Subduction in the Strabo Trench has been suggested by Erickson, 1970; by Woodside and Bowen, 1970; Rabinowitz and Ryan, 1970; Lort, 1971; and Papazachos and Comninaksis, 1971.

the apparent unconformity, has resulted from tectonic deformation.

We do not favor the first hypothesis, because it is specially tailored and it would postulate a still more complex geological history, unsupported by any independent lines of evidence. In fact, we do not believe that a relatively minor ostracod fauna in Core 129-3 should be the only autochthonous element, whereas the Serravallian faunas of all three cores should be allochthonous. The last assumption is particularly unconvincing since Stradner indicates the Serravallian fauna of Core 129-2 does not show "evidence of reworking, the type of fossilization being the same for all the tests, and no unusual association of mutually exclusive taxa being recorded."

The second and third alternatives are not mutually exclusive. However, to call upon down hole contamination as the sole explanation of the stratigraphic positioning is not at all attractive either. We emphasize that the ostracod fauna are accompanied by a shallow-water benthonic foraminifera *Ammonia beccarii tepida* and *dwarfed* planktonic foraminifera in the cores of both Holes 129 and 129A. This is hardly an assemblage likely to have been generated by haphazard downhole mixing. In Core 129A-2, CC, all three faunal types are found together in place exclusively in thin cross-bedded silt laminae possessing a distinctive orange coloring. This orange color is also present as thin bands in the more disturbed sediments of Core 129-3.

An Argument for Tectonic Mixing

That deformation should have taken place at the edge of the Strabo Trench is not surprising. The distribution of shallow earthquakes extends far south of the arc and encompasses the entire structure of the trench (Galanopoulos, 1968; Karnic, 1969; and McKenzie, 1970). In Chapter 37, seismic, gravity, and oceanographic evidence is presented in an argument for compressional tectonics in the Mediterranean Ridge region. This postulate, on the whole, is supported by the drilling results, particularly at Sites 127 and 130. It is possible that the inner wall of the trench contains a zone of underthrusting. An examination of Core 129A-3 (Figure 14) showed steep dips and local overturning. Though we have commonly encountered disturbed bedding in soft oozes, particularly the late Quaternary oozes near the sea bottom, overturned strata shown here represent a different case. Contemporary oozes are unquestionably horizontally bedded *in situ*, and are readily disturbed by coring; water-rich sediments can be sucked into the core tube in the fashion of a diapiric intrusion. On the other hand, semi-consolidated marls are rarely disturbed in the drilling process. Experience leads us to believe that the partially indurated marls in the Hole 129 cores have been deformed tectonically. At least the steep dips and overturning are not entirely drilling artifacts. This interpretation is thought reasonable in light of the fact that steeply dipping tectonically deformed sediments (Figure 15) have been detected in bottom photographs of scarps within the Mediterranean Ridge province (Watson and Johnson, 1969; Heezen and Hollister, 1971; Ryan *et al*., 1971). The tectonic interpretation would not only explain the abnormal superposition, but also the apparent hiatus between the Langhian and Serravallian in Hole 129.

Sedimentary Mixing

The anomalous elements of the fossil assemblages in Hole 129B are, however, related to a sedimentary process. The hole was spudded near the bottom of the trench and terminated at 42 meters in Late Quaternary host sediments. The sediments penetrated are not likely to have been affected by the tectonic movements which deformed the older rocks under the trench wall. The Late Quaternary trench fill includes clasts of different ages and various lithologies. The matrix is probably muddy, but only sand residuals have been recovered from the cores; fine-grained interstitial materials could easily have been washed away by the circulating fluids during the coring process. The fauna is a chaotic mixture. The allochthonous foraminifera tests are mainly Pliocene, showing different types of fossilization and other signs of being reworked. The allochthonous nannofossil flora includes a chaotic mixture of Pliocene, Miocene, and Eocene discoasters and coccoliths. The rock fragments, which represent exotic blocks in the olistostrome, include Serravallian marl oozes, indurated lowermost Pliocene foraminiferal ooze, and Lower Pliocene nanno ooze, plus unfossiliferous quartz sandstones. The exotic rocks and the allochthonous fossils must have been derived from the trench wall. Their presence has permitted us to reconstruct a spotty and loose depositional history of the area.

A Chronicle of the Neogene

During the Middle Miocene at least, and probably considerably earlier, this part of the eastern Mediterranean was an open sea, as indicated by the rich and diversified pelagic fossil assemblages in Core 129-4. By late Middle Miocene (Serravallian) time, the Mediterranean must have had less free access to the open oceans. The benthonic fauna here almost died out completely, and the marly sediments became pyritic. The planktonic foraminiferal fauna was still abundant and normal, but, on the whole, poorly preserved and in part pyritized. This area shared the same rate of salinity crisis as the other Mediterranean basins. We have not sampled evaporites, but their presence in the general vicinity is indicated from numerous piercement structures observed beneath the Antayla and Herodotus abyssal plains in seismic reflection profiles[7] and from the presence of salinity gradients in interstitial waters from cores on the Mediterranean Ridge (see Chapter 31).

The ostracods from the Messinian marl represent a brackish benthonic fauna. Whether this sediment should be correlated to the brackish diatomaceous sediments from Site 125 on the Mediterranean Ridge cannot be ascertained. In any case, the evidence is clear that the portal near Gibraltar was almost or completely closed, so that the basin held only penesaline waters. The presence of the *Sphaeroidinellopsis* Acme-zone as downhole contaminants (Hole 129) and as allochthonous elements (129B) confirms previous findings by piston coring (see Biscaye *et al.*, 1971) that the transgression of open marine sedimentation

[7]See Figure 25 in Ryan *et al.* (1971) and Figure 7 in Wong *et al.* (1971).

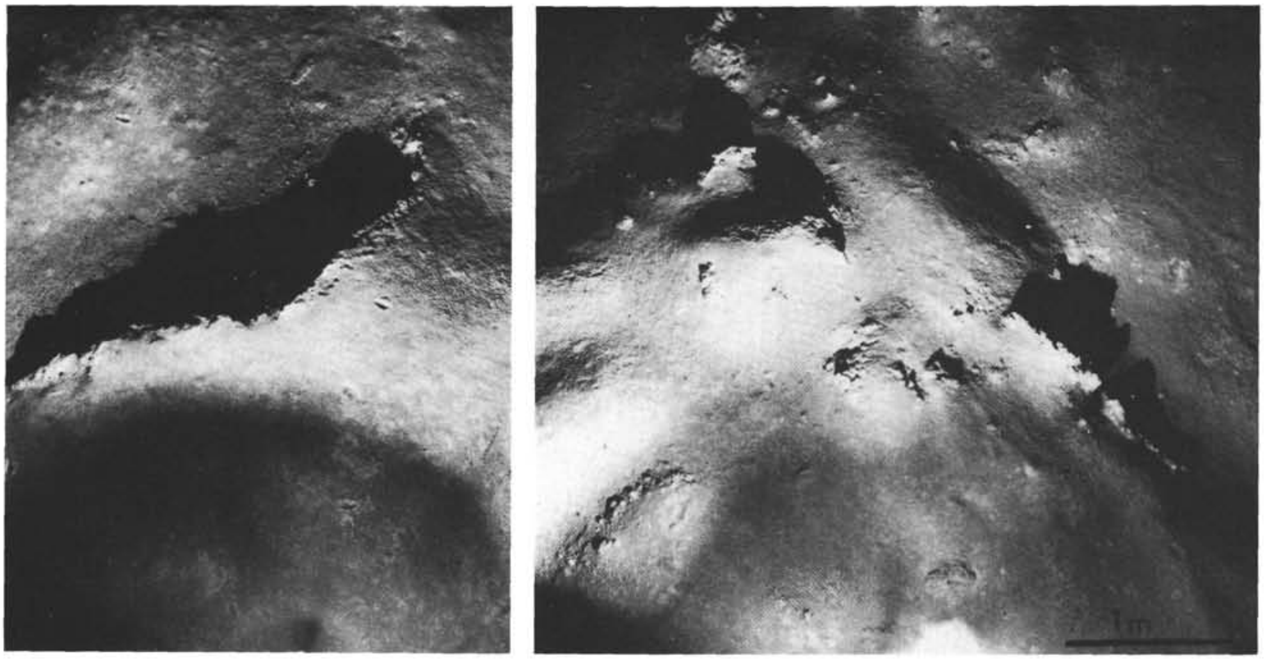


Figure 15. *Contemporary deformation of the sea bed just a few miles from the axis of the Strabo Trench at Camera Station No. 156, Cruise 9 of the* Robert D. Conrad *(Latitude: 34° 14'N; Longitude: 27° 11'E; water depth: 2675 meters). Photographs courtesy of Maurice Ewing, Chief Scientist of the Mediterranean legs of the* Conrad *9 expedition.*

(Ruggieri, 1967, Sylvester-Bradley Benson, 1971), extended into the eastern Mediterrean synchronous with its invasion into the western basin.

The tectonic movements responsible for the present escarpment bounding the Strabo Trench may have taken place in Late Pliocene or Early Quaternary. The lithic graywacke sandstone of Core 129B-2, CC, with abundant metamorphics and volcanic rock fragments, indicates an island arc source region with downslope access to the Mediterranean Ridge. Today such access is completely blocked by the Strabo Mountains. Its subsequent uplift and the accompanying deformation of sediments of the upthrust block (evidently including formations as old as Eocene) seem to have provided an important source of material into the trench in Late Quaternary time.

REFERENCES

Benson, R. H. and Sylvester-Bradley, P. C., 1971. Deep-sea ostracods and the transformation of ocean to sea in the Tethys. In Oertli, H. J. (Editor), Paleoecologic Ostracods–Pau, 1970. *Bull. Gentro Rec. Pau-SNPA.* **5** (supp 1), 63.

Biscaye, P., Ryan, W. B. F. and Wezel, F., 1971. Age and nature of the Pan-Mediterranean subbottom Reflector M. In Stanley, D. J. (Editor), *Sedimentation in the Mediterranean Sea.* Smithsonian Press, Washington, D. C. (in press).

Cita, M. B. and Blow, W. H., 1969. The biostratigraphy of the Langhian, Serravallian, and Tortonian stages in the type sections in Italy; *Riv. Ital. Paleont.* **75** (3), 549.

Dewey, J. F. and Bird, J. M., 1970. Mountain belts and the new global tectonics. *Jour. Geophys. Res.* **75** (14), 2625.

Emelyanov, E. M., 1968. Mineralogy of the sand-silt fraction of recent sediments of the Mediterranean Sea. Translated from *Litologiya i Poleznye Iskopaemya,* 2 3, and in *Lithology and Mineral Resources,* 1968, **1**, 127.

Emery, K. O., Heezen, B. C. and Allan, T. D., 1966. Bathymetry of the eastern Mediterranean Sea. *Deep-Sea Res.* **13**, 173.

Erickson, A. J., 1970. The measurement and interpretation of heat flow in the Mediterranean and Black Seas, Ph.D. Thesis, Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution.

Fleischer, V., 1964. Schwerestorungen im östlichen Mittelmeer nach Messungen mit einen Askania-Seegravimeter, *Son. Deutschen Hyd. Zeitschr.* **17** (4), 153.

Galanopoulos, A. G., 1968. The earthquake activity in the physiographic provinces of the eastern Mediterranean Sea. *Scientific Progress Report II, National Observatory of Athens, Seismological Institute, Athens.* 15 p.

Goncharov, V. P. and Mikhaylov, O. V., 1963. New data concerning the topography of the Mediterranean Sea bottom. *Okeanologiya.* **3**, 1056.

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

Hersey, J. B., 1965. Sedimentary basins of the Mediterranean Sea, in *Submarine Geology and Geophysics,* Whittard, W. F., and Bradwhaw, R., (Editors), (Proc. 17th Symposium Colston Res. Soc., April 5-9, 1965), Butterworth, London. p. 75-91.

Karnic, V., 1969. Siesmicity of the European area, Part 1, D. Reidel, Dordrecht, Holland. 364 p.

Lort, J. M., 1971. The tectonics of the eastern Mediterranean; A geophysical review. *Reviews of Geophysics and Space Physics.* **9** (2), 189.

Martini, E. and Worsley, T., 1970. Standard Neogene calcareous nannoplankton zonation. *Nature.* **225** (5229), 289.

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

McKenzie, D. and Parker, R. L., 1967. The North Pacific: An example of tectonics on a sphere. *Nature.* **216**, 1276.

Mikhaylov, O. V., 1965. The relief of the Mediterranean Sea bottom. In *Basic features of the geological structure, of the hydrologic regime and biology of the Mediterranean Sea,* Fomin, L. M. (Editor), Science Publ. House, Moscow. p. 10-19.

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

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

Rabinowitz, P. D., and Ryan, W. B. F., 1970. Gravity anomalies and crustal shortening in the eastern Mediterranean. *Tectonophysics.* **10**, 585.

Rateev, M. A., Emelyanov, E. M. and Kheirov, 1966. Conditions for the formation of clay minerals in contemporaneous sediments of the Mediterranean Sea. *Lithology and Mineral Resources* (translation of *Lithologiya i poleznye Iskapaemye*). **5**, 418.

Ruggieri, G., 1967. The Miocene and later evolution of the Mediterranean Sea, *Syst. Assoc. Publ.* **7**, 283.

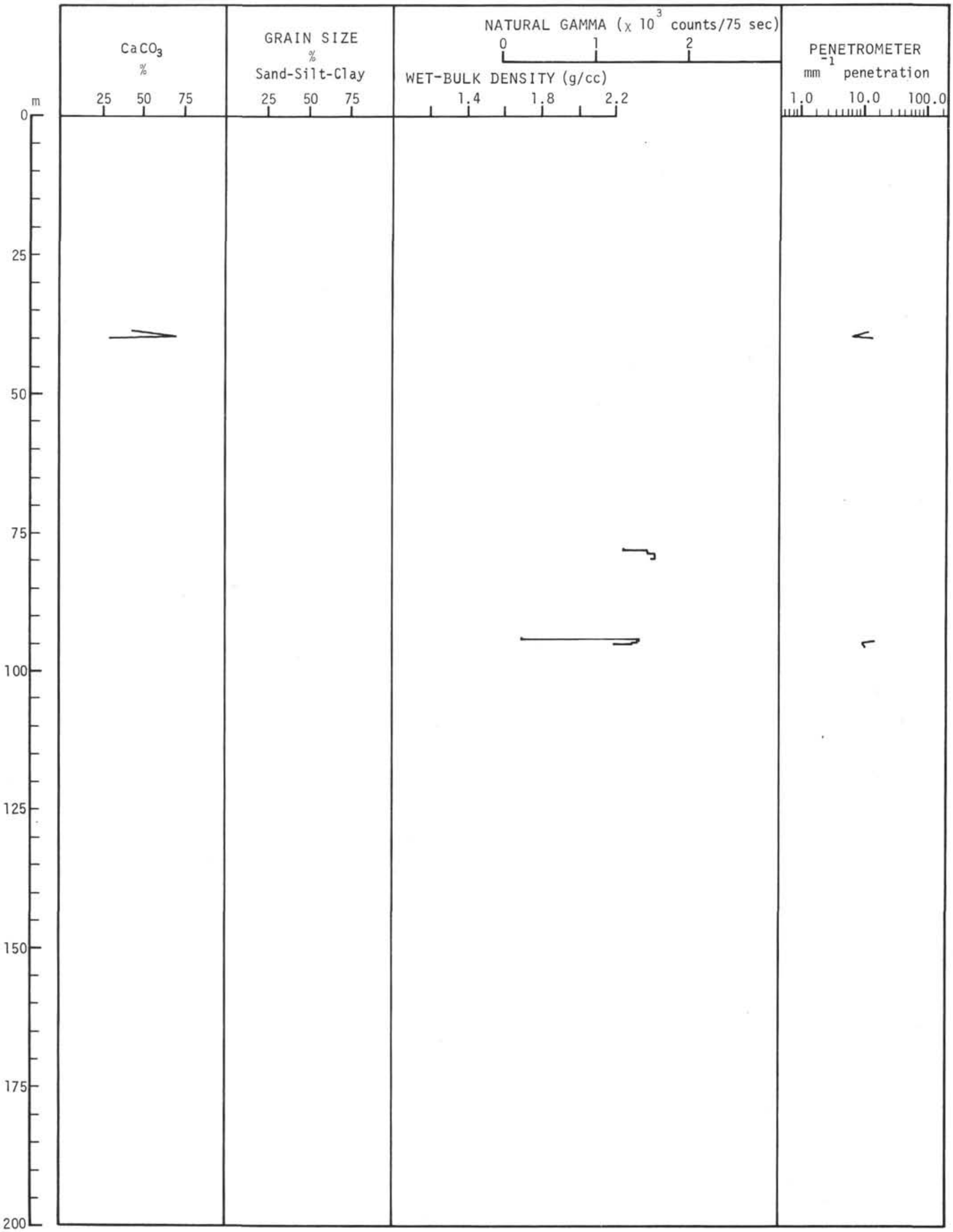
Ryan, W. B. F., Stanley, D. J., Hersey, J. B., Fahlquist, D. A. and Allan, T. D., 1971. The tectonics and geology of the Mediterranean Sea, In *The Sea,* Maxwell, A. (Editor), John Wiley and Sons, New York. **4**. 387.

Selli, R., 1960. Il Messiniano Mayer-Eymar 1867. Proposta di un neostratotipo, *Giorn. Geol.* **28** (fasc. 2), 1.

Watson, J. A. and Johnson, G. L., 1969. The marine geophysical survey in the Mediterranean. *Int. Hydrog. Rev.* **46**, 81.

Wong, H. K., Zarudzki, E. F. K., Phillips, J. D. and Giermann, G. K. F., 1971. Some geophysical profiles in the eastern Mediterranean. *Bull. Geol. Soc. Am.* **82**, 91.

Hole Summary 129



AGE	LITHOLOGY AND BIOSTRATIGRAPHY	LITHOLOGY

PLIOCENE

Pieces of SANDSTONE and foraminiferal LIMESTONE

Pliocene identified on basis of downhole contaminants

38m

MIOCENE

SERRAVALIAN & MESSINIAN (Probable Allochtonous Mixing)

DOLOMITIC OOZES and DOLOMITIC MARL OOZES

Composition: dolomite only or dolomite with calcite, together with quartz, feldspar and clays
olive to greenish gray
plastic to firm
bedded with some oblique bedding (current marks and distorted beds [slumping?])

Association of middle Miocene restricted marine planktonic assemblage (without benthonic foraminifera) in core 3 with Upper Miocene (Messinian) brackish water ostracods and benthonic foraminifera.

100m

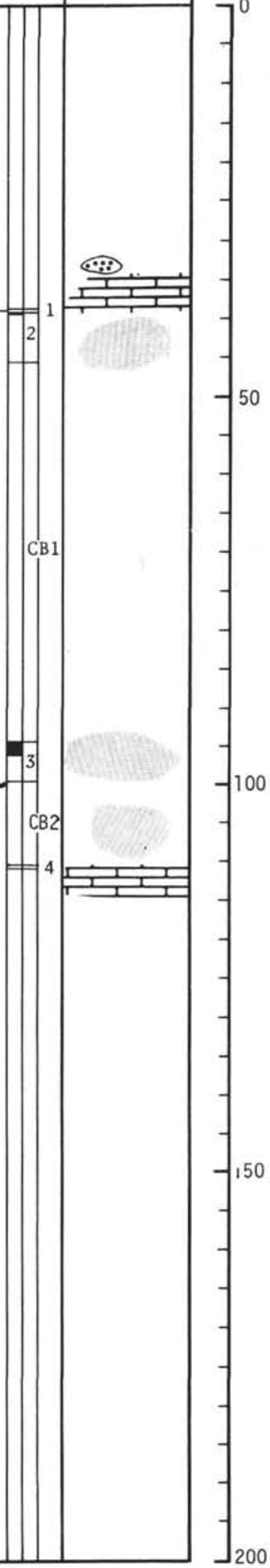
LANGHIAN

MARL OOZE (CB2)

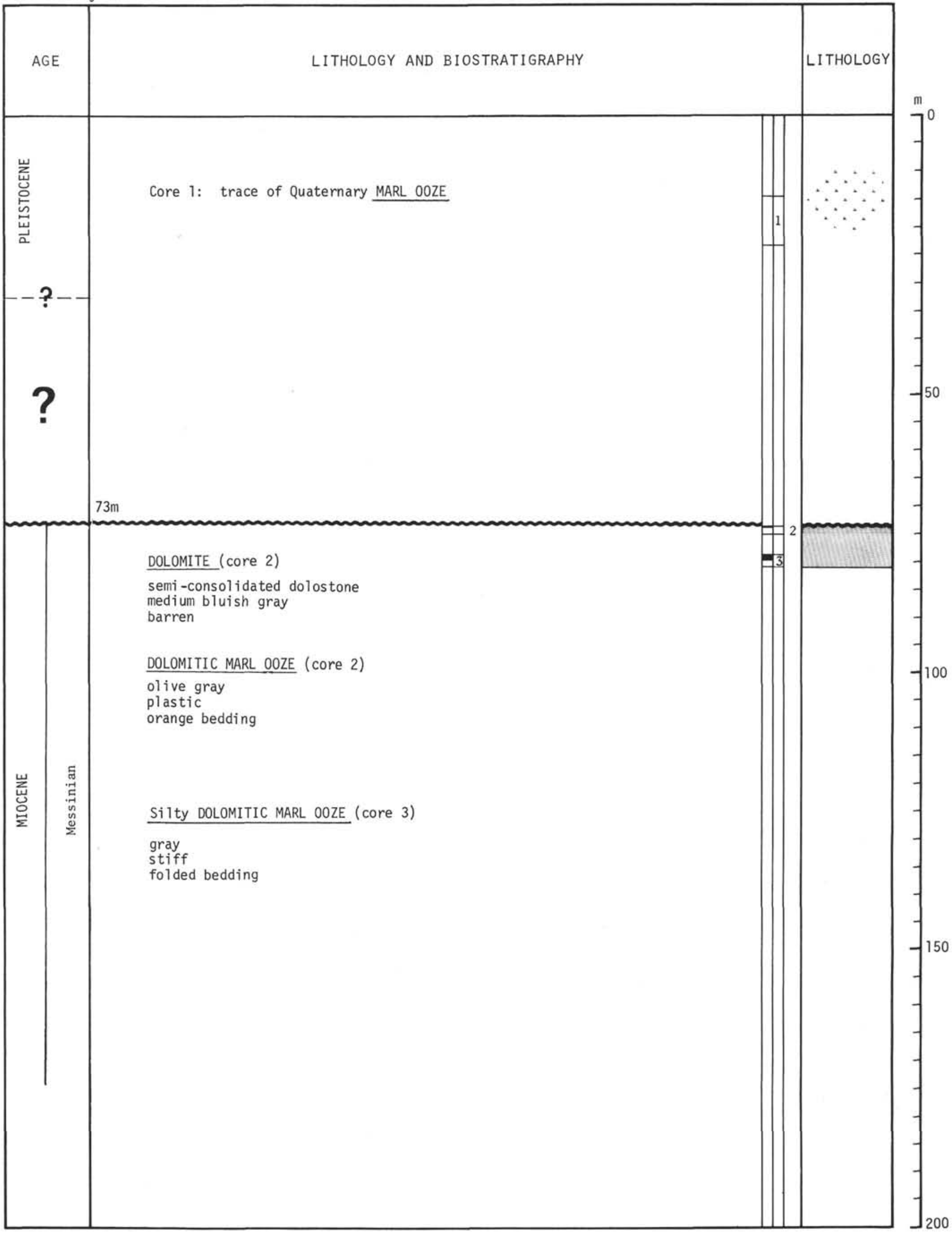
dark gray, indurated and shaly

foraminiferal LIMESTONE (core 4)
foraminifera and terrigenous clastics cemented by calcite

open marine planktonic assemblage

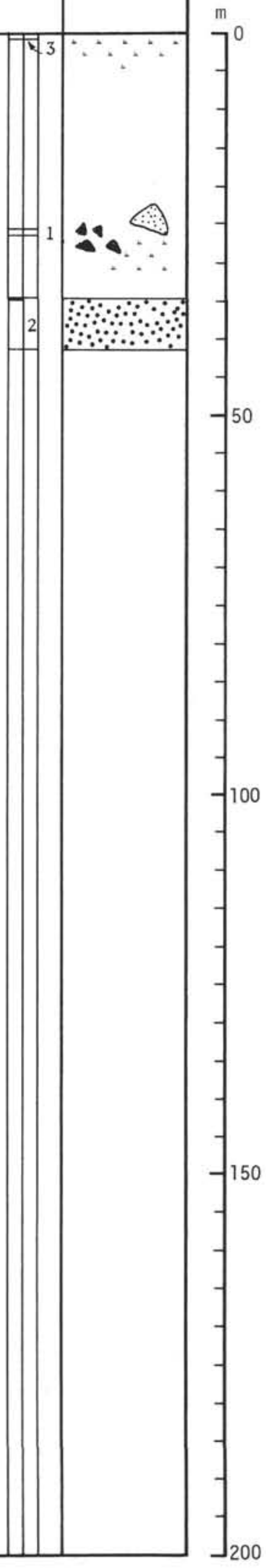


Hole Summary 129A



Hole Summary 129B

AGE	LITHOLOGY AND BIOSTRATIGRAPHY	LITHOLOGY
PLEISTOCENE	Core 3: MARL OOZE gray and buff colored plastic foraminiferal	
PLIOCENE	Core 1: MICROBRECCIA Foraminiferal MARL OOZE yellowish brown, plastic SANDSTONE gray, laminated, quartz,calcite cemented, barren Core 2: SANDSTONE Quartz, calcite cemented, barren	



SITE 129 CORE 1 Cored Interval 38-39 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
		38	1	VOID			V
		39			44		

Four pieces of heterogenous petrography. All were displaced during extraction and piece #1 seems to belong to the bottom section, together with piece #4

#2 - SANDSTONE
quartz with calcitic cement
dark gray
barren

#3 - foraminiferal LIMESTONE
brown (10YR 5/3) and light olive gray (5YG 6/1)
distorted laminations with concentration of forams in the lamination planes

#1 & 4 - DOLOMITIC OOZE (Serravalian)
greenish gray (5G 6/1)
plastic
deformed bedding (slumping?)

X-rays
quartz
dolomite
clays

planktonic foraminifera, indicating a late Middle Miocene age.
foraminiferal assemblage poor and abnormal;
benthonic foraminifera practically absent.
detrital material dominant in the fraction >63μ

SITE 129 CORE 2 Cored Interval 39-46 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 MIOCENE (LATE SERRAVALLIAN)				VOID			V
		39.7	1		70		
		40.1			30		
		40.5	CC				

39.7-40.1 - DOLOMITIC MARL OOZE
greenish gray (5G 6/1)
stiff to plastic
scattered forams

Smear		X-rays
nanno	55	calcite
forams	5	dolomite
quartz	10	quartz
mica	20	pyrite - tr.
dolomite	10	

40.1-40.5 - DOLOMITIC OOZE
dark greenish gray (5GY 4/1)
plastic
slightly deformed laminations

Smear	X-rays
quartz	quartz
dolomite	dolomite
mica	feldspar
pyrite	clays

foraminiferal fauna indicating purely pelagic sedimentation and a Serravallian age.
assemblages poorly preserved.
foraminifera include *Globigerina nepenthes*, *Globorotalia menardii*, *G. siakensis interalia*
nannofossils include *Discoaster challengeri*, *D. deflandrei*, *D. phyllodus*, *Sphenolithus abies*, *Sph. heteromorphus*

SITE 129 CORE 3 Cored Interval 94-99 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
SERRAVALLIAN and MESSINIAN (allochtonous ?)		94.2		VOID			V
			1		35		
		95.7	CC				

DOLOMITIC MARL OOZE
olive gray (5Y 4/2)
plastic to firm
distorted bedding and mixing of sediments of different colors
oblique bedding in core catcher
concentration of silt and forams in the bed planes

Smear		X-rays
nannos	30	quartz
dolomite	5	calcite
quartz	30	dolomite
mica	35	feldspar
		clays

planktonic foraminifera fairly abundant and indicating a late Serravallian age (*Globigerina nepenthes*, *Globorotalia menardii*, *Globigerinoides obliquus*) - brackish water ostracod, *Cyprideis pannonica*
calcareous nannoplankton including *Discoaster challengeri*, *D. deflandrei*, *D. phyllodus*, *Sphenolithus abies* and *Sph. heteromorphus*

in the core catcher there is evidence of reworking in the planktonic foraminiferal assemblage; however, no species definitely indicating an Upper Miocene age are recorded. the core catcher also yields *Cyprideis pannonica* and *Ammonia beccari tepida*

SITE 129 CORE 4 Cored Interval 111-112 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 LANGHIAN		111	CC				

foraminiferal LIMESTONE
3 cm piece
forams and terrigenous clastic, calcite cemented, pyrite

embedded in plastic MARL OOZE which could be caved in

planktonic foraminifera abundant including *Orbulina suturalis*, *Globorotalia mayeri*, *Globigerinoides bispericus*, *Globoquadrina altispira*, *G. dehiscens*, *Cassigerinella chipolensis*
nannoplankton including:
Sphenolithus heteromorphus, *Discoaster challengeri*, *D. deflandrei*

Total drilling: 112 m.

SITE 129A CORE 1 Cored Interval 14-23 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
QUATERNARY						Recovery: 1 gram of sand size terrigenous clastics (quartz, rock fragments, pyrite, etc.) embedded in Quaternary MARL OOZE pteropods ostracods fragments of pelecypods planktonic foraminifera including pink *Globigerinoides ruber*, *Globorotalia truncatulinoides*, etc. calcareous nannoplankton of the *Gephyrocapsa oceanica* zone	

SITE 129A CORE 2 Cored Interval 73-75 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
MESSINIAN		73	CC			pieces of plastic and consolidated oozes	

Plastic: <u>DOLOMITIC MARL OOZE</u>

olive gray (5Y 4/2)
orange colored bedding
plastic

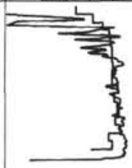
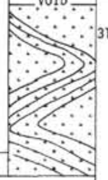
Smear		X-rays
nannos	50	quartz
dolomite	15	calcite
quartz	15	dolomite
mica	20	feldspar
pyrite		clays

Consolidated: <u>DOLOMITE</u>

medium bluish gray (5B 5/1)
indurated
barren
X-rays: dolomite only

planktonic foraminifera rare, diversified and not age-diagnostic
calcareous nannoplankton of Middle Miocene age.
the sand-size fraction is dominated by a monotypic ostracod population of *Cyprideis pannonica* and by the benthonic foraminifer *Ammonia beccarii tepida*
Their association indicates salinities ranging from 20‰ to 30‰-

SITE 129A CORE 3 Cored Interval 78-81 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	↑ < 1 DISTURBANCE
MESSINIAN		78	1	VOID 	31	<u>Silty DOLOMITIC MARL OOZE</u> gray (N5) stiff folded bedding quartzose silt concentrated in the bed planes	
		79.7	CC				

Smear		X-rays
nanno	30	quartz
quartz	30	calcite
mica	40	dolomite
dolomite		feldspar
		clays

diverse fauna of planktonic foraminifera dominated by *Globigerina* spp. - abundant pyrite crystals.
benthonic foraminifera include *Ammonia beccarii tepida* and *Bolivina* spp.
nannofossils abundant and normally diversified

Total drilling: 81 m

SITE 129B CORE 1 Cored Interval 26-27 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
QUATERNARY with Pliocene Components		26 26.4	CC	4 3 2 1		Four pieces of heterogenous petrography	

#4 - DOLOMITIC MARL OOZE (Serravallian?)

greenish gray (5G 6/1)
plastic
laminated

Smear		X-rays
nannos	50	quartz
quartz	15	calcite
mica	30	dolomite
dolomite	5	feldspar
		clays

#3 - foraminiferal MARL OOZE (lower Pliocene)

yellowish brown (10YR 5/4)
plastic

#2 - SANDSTONE

well-cemented quartz grains
gray
fine laminations

#1 - MICROBRECCIA (Lower Pliocene) foraminiferal

planktonic foraminifera poorly preserved

SITE 129B CORE 2 Cored Interval 34-42 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
QUATERNARY		34 35.5	1 CC			SAND and SANDSTONE	

quartzose sand mixed with Quaternary planktonic foraminifera
consolidated pieces of sandstone at the bottom, barren, calcite cemented

Thin section

quartz	60-65
calcite	25
feldspar	2-6
rock fragments	
apatite	
hornblende	

pteropods
pelecypods
Late Quaternary foraminiferal assemblage yielding reworked specimens with different types of fossilization

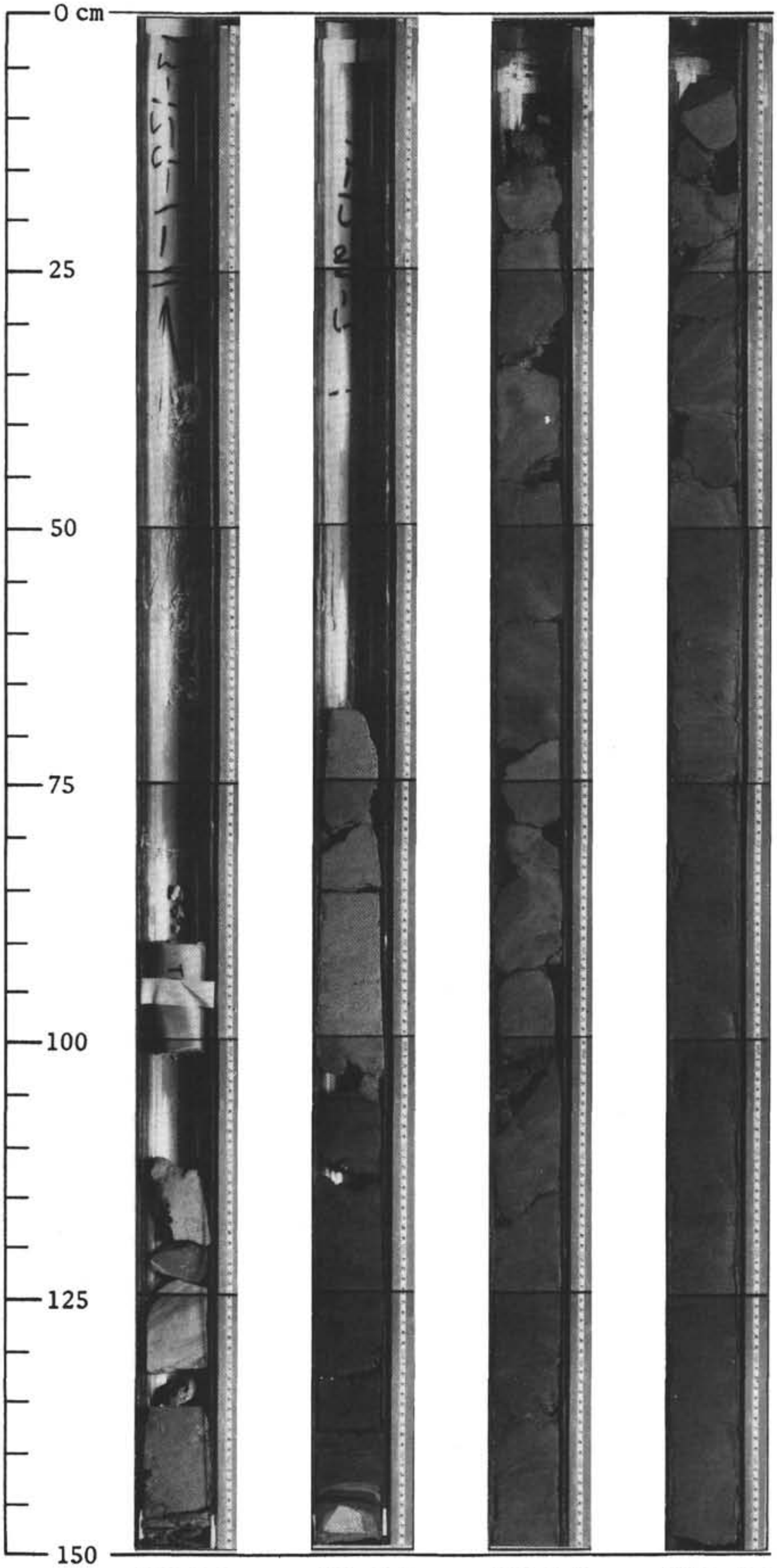
Total Drilling: 42 m.

SITE 129B CORE 3 Cored Interval 0-1 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 QUATERNARY to RECENT		0	CC			MARL OOZE	V

gray and buff colored
plastic
foraminiferal

Coccoliths of the *Emiliania huxleyi* nannoplankton zone NN 21.
Late Quaternary to Recent



129-1-1 129-2-1 129-3-1 129A-3-1