4. VALENCIA TROUGH – SITE 122

The Shipboard Scientific Party[1]

SITE DATA

Occupied: August 23-24, 1970.

Position: Axis of a channel in the Valencia Trough:
Latitude: 40° 26.87′N;
Longitude: 02° 37.46′E.

Water Depth: 2146 meters.

Cores Taken: Four cores.

Total Penetration: 162 meters.

Deepest Unit Recovered: Gravel, containing basalt, limestone, gypsum, and shells of shallow-water faunas. (Upper Miocene).

MAIN RESULTS

The hole terminated in a massive gravel layer at Horizon M. The gravel contains four components: basalt, limestone, gypsum, and shells of a shallow water fauna. The basalt, limestone, and gypsum are inferred to have been eroded from an Upper Miocene seabed and laid down as a shallow marine transgressive deposit at the close of the Messinian.

The deep-sea channel system of the Valencia Trough developed between the Upper Pliocene and Middle Quaternary. A regional stratigraphic unconformity is present in the Upper Pliocene, and the lowermost Pliocene is absent above the Messinian evaporites.

BACKGROUND

A site in the Valencia Trough was chosen where a pattern of strong magnetic anomalies could be directly associated with acoustic basement features on seismic reflection profiles. The more or less circular positive anomalies between Spain and the Baleraric Islands are quite striking in contrast to the very subdued magnetic field over the central, deep-water Balearic Basin (Vogt *et al.*, 1971). The only similar set of anomalies lies in a belt along the western margin of Sardinia, and directly south of the Côte d'Azur of the Maritime Alps. Where survey tracks have crossed the magnetic features, surface or buried relief in the form of ridges or peaks has been noted (Figures 1 and 2).

In June, 1970 the R/V *Jean Charcot* surveyed a region in the Valencia Trough where the flank of a protruding basement peak has apparently influenced the course of a submarine channel system (Figure 2). This feature had been recognized on bathymetric charts (Morelli, 1970), and could be identified in unpublished seismic profiles made available to the Medditerranean Panel by Glangeaud, Bellaiche, Bobier, Mauffret and Szep. In the *Charcot* profile across the Valencia channel one can observe a series of sedimentary units which abut against and/or overlap the peak. The units are illustrated in Figures 3 and 4. As described in Chapter 1, we have assigned a particular nomenclature of letter prefixes to certain reflectors or groups of reflectors in order to facilitate a correlation between the sedimentary sequence penetrated and cored by the *Challenger* and the reflection profiles.

The Sedimentary Layering in Reflection Profiles

On the *Charcot* profile of Figure 3 we can distinguish five sedimentary units. The uppermost strata are markedly stratified and are characterized by a very slight angular unconformity at their base (see Figures 3 and 4). Within this unit we identify two useful acoustic reflectors: Reflector P_α and Reflector P_β. Since the discontinuity lies directly below the P_β reflector, we hereafter refer to these surfaces as the pre-P_β Horizon at the Valencia Trough locale.

Below the unconformity another sedimentary unit which in air-gun profiles is generally more transparent is seen. This unit is in turn bounded below by the uppermost surface of a very strong group of reflectors known as the M-Reflector series (see Ryan *et al.*, 1971; Biscaye *et al.*, 1971). The M-Reflector series has a definite character and, as will be shown in subsequent chapters, is present throughout the Mediterranean. The sediments above the M-Reflector series prograde across its uppermost surface. This apparent time-transgressive surface, and/or lateral facies change, is referred to as Horizon M in the Valencia Trough.

Below the M-Reflectors a layer with poor acoustic coherence is seen which has been identified by Montadert *et al.* (1970) and Auzende *et al.* (1971) as the "salt layer"; that is, the "mother-bed", which by flowage (*couche fluante*) has produced the Balearic diapirs. This layer shows evidence of differential deposition, being thicker in the depressions and thinning against higher relief. Montadert *et al.* (1970) refer to the "salt" bed as Layer C, a letter prefix which we adopt based on their first publication of its description.[2]

Montadert *et al.* (1970) and Auzende *et al.* (1971) have convincingly demonstrated that the acoustic interval which they identify as salt can be traced in continuous reflection profiles throughout a great part of the deep-water Balearic Basin. These authors also identified a prominently stratified

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[2] For definition of a layer (*une couche ou ensemble en français*) as distinct from a reflector or an horizon, see Chapter 1.

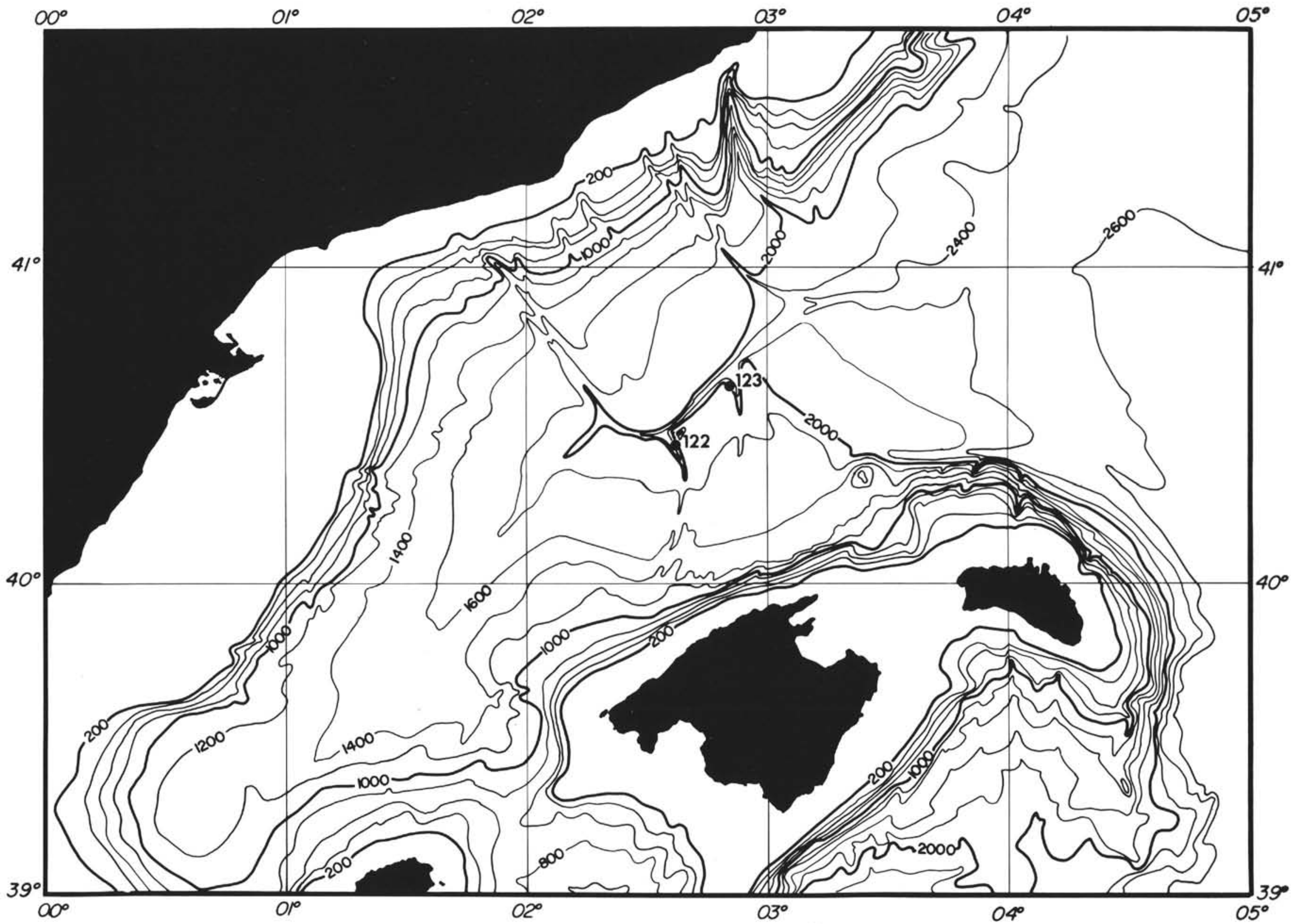

Figure 1. *The Valencia Trough, contours in meters, adapted from Chart 310 of the Defense Mapping Agency Hydrographic Center.*

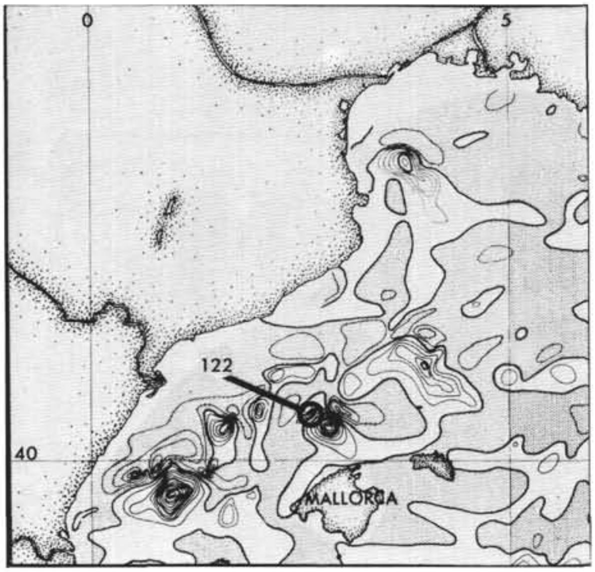

Figure 2. *Residual magnetic-field anomaly map of the Valencia Trough region of the western Mediterranean (from Vogt* et al., *1971). The data are from primarily north-south aeromagnetic flight lines at a spacing of approximately 18 km and elevation of 300 meters. The contour interval is 50 gammas; the shaded areas are negative anomalies.*

series of strata below the salt, the upper surface of which was "assumed to be the bottom of the evaporite layer" (Auzende *et al.*, 1971, p. 82). This stratified series, shown in Figures 3 and 4, is here called the N-Reflector[3] series after the precedent of our cruise planning report Hersey *et al.*, (1970) which was unpublished but widely circulated among the Mediterranean researchers prior to the drilling.

In the Valencia Trough the N-Reflectors, Layer C, and the M-Reflectors pinch out against the protruding basement peaks or ridges.

Objectives

The principal objectives of Site 122 in the Valencia Trough were to sample the oldest sediment in this region of the western Mediterranean and to identify the nature of the basement peaks associated with the strong magnetic anomalies. It was expected that the composition of the initial sediment above the basement would indicate whether the trough came into existence through regional subsidence of a formerly continental area or whether it was accreted in a marine setting. We were particularly anxious to learn whether the basement was volcanic and, if so, whether the composition of the volcanic rocks was alkaline or basaltic.

Other objectives included the identification of the age and facies of the various sedimentary units discussed previously and particularly the significance of the Horizon M unconformity.

Strategy

The site was chosen by the shipboard scientists after examining the recently acquired *Charcot* profiles. It was apparent that the "depth of penetration" capability of the *Challenger* had to be seriously considered in order to be assured of sampling basement rocks and achieving as many of the secondary objectives as possible.

The experience of drilling crews in the Atlantic and Gulf of Mexico had shown that in areas of clastic deposition (that is, fans, cones and abyssal plains) the limiting factor as to the amount of penetration achieved was the probability of sand layers collapsing into the open drill hole. Consequently, we were worried that if the approximately 500-meter-thick sedimentary unit above Horizon M contained a significant number of sand layers the chances of drilling through it and then spending much time on the harder M-layer were probably marginal.

Furthermore, we could find no place on the existing reflection profiles where the entire sequence of the abovementioned units could be penetrated, and basement reached, in less than 1000 meters. After much deliberation we selected as our target the floor of a deep tributary to the Valencia submarine channel (Figures 3 and 4).

The logic of this decision was twofold: (1) At this location we would in a single hole sample the Horizon-M unconformity, the M-Reflectors, the so-called "salt layer," Reflector N, and terminate in the flank of a basement peak. If it turned out to be of interest to have additional samples of the upper sedimentary units, we would pull out of the hole and offset a few miles with the drilling string still in the water for a second shallower hole. (2) The observed depth of erosion in the channel was approximately 400 meters, which meant that the channel fill was probably less than 100 meters in thickness. If the hole collapsed within the first 100 meters of penetration we felt there was a good chance we could still retrieve the drill string and have another try with a minimum amount of time lost.

Challenger Site Approach

The vessel approached the selected target from the southwest (Figure 5). At 0309 hours, on August 23rd, course was changed to 049° (steered); speed was maintained at 9.5 knots. Another course change to 062° was made at 0336 hours. The vessel then crossed over the axis of the channel at 1347 hours, and a marker buoy was dropped (Figure 6). The speed of 9.5 knots was maintained until the reception of a 0340-hour satellite message was completed. At 0357 hours, she was slowed to 4 knots and the seismic gear and magnetometer were pulled in and eventually secured at 0412 hours.

Since the 0340-hour satellite fix indicated our "crossover" position slightly to the west of the pre-selected site, the vessel swung gradually to the right before assuming a reverse course of 239 degrees at 8 knots. We reached the channel axis and came *hove-to* at 0433 hours, but the currents continued to carry us to the southwest of the channel axis. An attempt to maneuver back to the location failed. The vessel was turned around, first to 300 degrees and then to 030 degrees, and eventually to a 060 degree course at a one knot speed. Still, the Precision Depth Recorder indicated that the vessel was passing over the

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[3] The uppermost reflector on the N-series is correlative to Réflecteur L of Montadert *et al.* (1970)

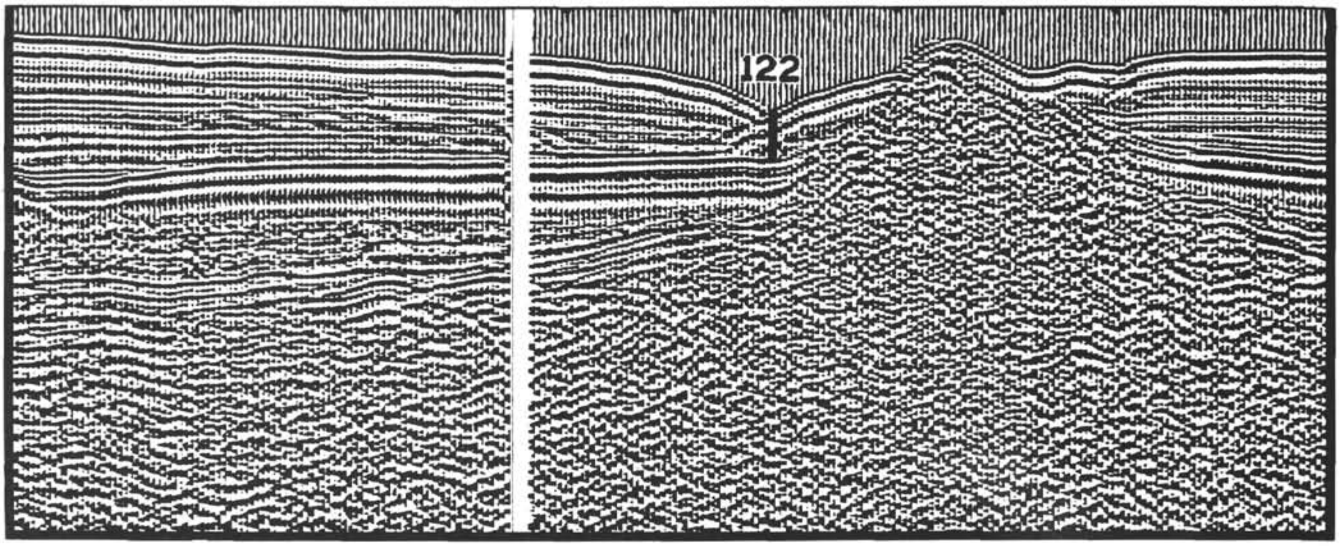

Figure 3. *Seismic reflection profile (Flexotir sound source and variable area recording) across the Valencia Trough channel system, showing the location of Site 122. The profile made by the R/V* Jean Charcot *(Centre Océanologique de Bretagne) has a vertical exaggeration of ≈3:1.*

western bank of the channel. The speed was increased and the vessel moved back over the axis and arrived on target at 0530 hours. The beacon used for dynamic positioning while on station was dropped after a satellite fix at 0532 hours confirmed that we were indeed on position over the *Charcot* profile.

OPERATIONS

The vessel arrived on station at 0540 hours, 23 August, 1970, when the beacon was dropped. The crew, however, had to wait for the testing of a new beacon-release mechanism. The tests were not successful; and the assembling of the drill string was so delayed that it did not reach bottom until 1412 hours, almost 6.5 hours after arrival, even though the water depth measured by the drill pipe was only 2156 meters from the rig floor.

The drill string hit hard bottom, a probable indication of sands and/or gravel on the floor of the channel. An attempt to cut a surface core without rotation did not succeed, and the attempt was soon abandoned. With two pumps washing simultaneously, the drill string entered the seabed with ease. The penetration rate was extremely rapid; in about an hour and a half, 77 meters were drilled (Figure 7). The penetration rate, exclusive of the time spent in connecting pipes, was an amazing 150 m/hr or more. The driller believed that the penetrated section consisted largely of sands and gravels lying in thin beds that only caused momentary resistance before washing away. During the first 20 meters, stringers were encountered at intervals of about one per meter. The spacing between intervals became greater with depth of penetration until by 64 meters below bottom most of the resistance was gone, except for an occasional layer or two. At 1540 hours, 23 August, the first core was cut at 77 meters below bottom; this core reached the deck 40 minutes later. A second core was cut back to back with the first one. The cored section contains thin beds of fine sand and silts interbedded in clays that are representative of the intervals with little resistance. The recovery was poor, yet the bedding structures are well preserved.

Extremely rapid drilling continued and Core 3 was cut at 135 meters (Table 1). Then at 1945 hours, a series of hard stringers were encountered at 156 meters. The inner core-barrel was sent down to recover this unit. The strata encountered in cutting Core 4 were extremely hard. After one and a half meters of penetration, we suddenly lost circulation and surmised that the bit had plugged. When Core 4 was retrieved we found only traces of sand adhering to the core catcher. Selenite crystals were identified from this sample. This core barrel apparently never reached the end of the drill string, being stopped by loose sand that intruded into the drill collar. An attempt for another core proved futile. It apparently never reached the end of the drill string but instead landed and became imbedded in gravels which had backflowed into the bottom hole assembly. Additional penetration was not possible without circulation; efforts to retrieve the core barrel were unsuccessful, and we surmised that it was apparently stuck somewhere in the drill pipe. At 2325 hours, after all indications were clear that additional drilling would be impossible, it was decided to haul the drill string on deck to examine the cause of circulation failure.

At 0400 hours on August 24, the sections of drill collar containing the core barrel were raised on deck. The core barrel was jammed several meters above the bit with sand and pea gravels above and below it, and nothing within. The barrel was finally taken out when sand was washed away with a pressurized hose. Meanwhile, it was deemed unwise to start a new hole at the same site since it would be impossible to drill past the massive gravel horizon without casing. We began to search for an alternate site in the Valencia Trough area. The seismic profiling record by *Charcot,* June 1, 1970, indicated that the troublesome

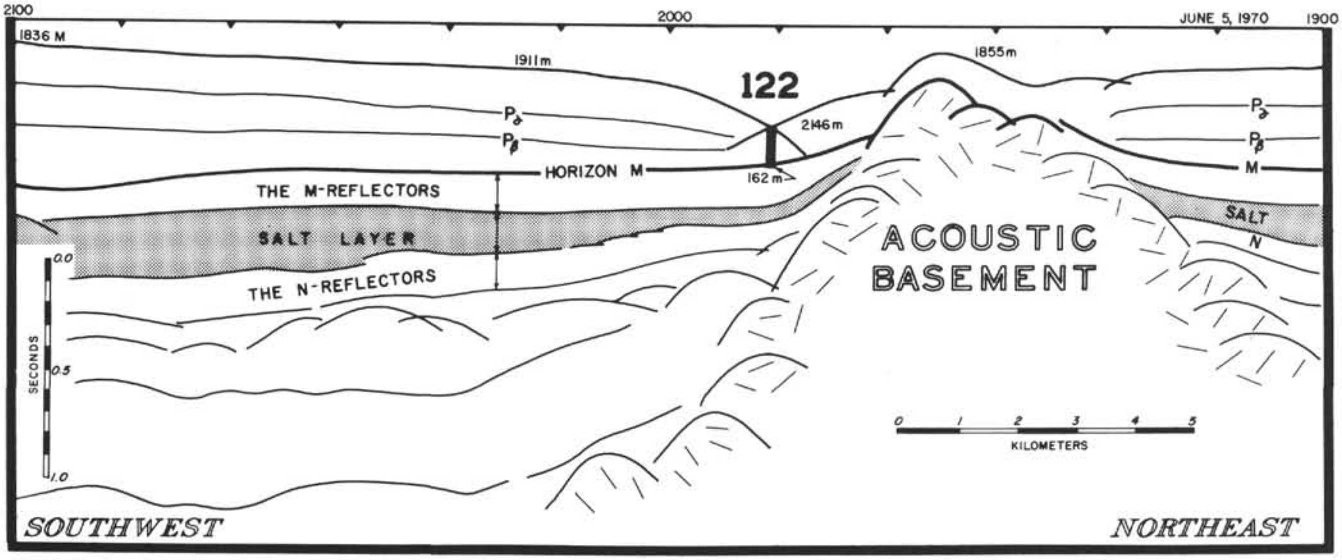

Figure 4. *Schematic interpretation of the* Charcot *profile of Figure 3. The various reflectors illustrated in the figure are described in the text. The "salt layer" identification is after Auzende* et al. *(1971). This layer comprises an interval on the reflection profiler with an easily recognizable acoustic character which in certain profiles can be shown to be the particular sedimentary unit that has migrated to form the Balearic Knolls (diapirs).*

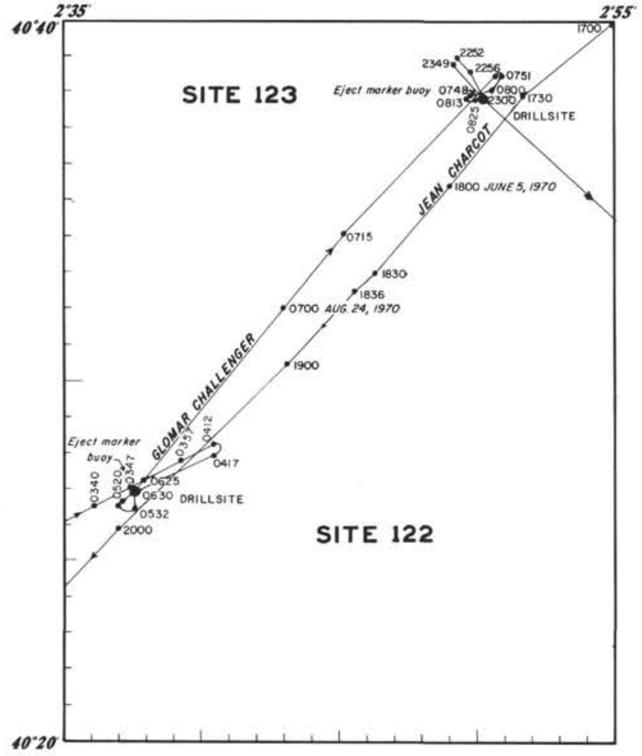

Figure 5. *Details of the* Challenger *site approach. The eventual drilling site was positioned in a tributary of the Valencia Channel slightly to the northeast of its axis.*

sandy section might be absent about 14 miles further to the northeast. It was decided to choose this as Site 123.

The drill string was completely dissembled and secured at 0600 hours. When the drill bit was taken out, we found soft gypsiferous materials wedged between the teeth of the roller cones. Apparently, we terminated a few centimeters into a bedded evaporite formation.

To drill Hole 122, a roller bit identical to the one used at Site 121 was selected because of its capacity to drill rapidly through marly sediments. However, the recovery was poor despite some remedial measures to improve the bit. The experience at this site raises the question of whether our initial logic in choosing this location had been wise. In the long run, it was not the channel fill which stopped us, but massive gravels at the Horizon M unconformity. We were very puzzled as to the extent of this layer.

Although it seemed to have been a long nightmare of frustration, the time spent at this site has proved valuable. From selenite crystals in the sands and the gypsum caught between the teeth of the drill bit we had the first clue to the pre-Pliocene evaporite series. We also obtained valuable samples of basalt from the gravels which later permitted us to analyze the chemistry of the volcanic rocks underlying the Valencia Channel (see Chapter 28.2 in Part II of this volume).

BIOSTRATIGRAPHY

Upper and Lower Pliocene fossiliferous sediments were recovered from the four cores at this site. The top of Core 1 (Section 1, 115 centimeters) yielded a very rich and diversified assemblage indicating a middle to late Quaternary age. This sediment is here interpreted as representing the base of the deposits filling the channel, in which Site 122 was located (see Figure 8). Thus, a significant unconformity exists between the Upper Pliocene and the middle to late Quaternary. Also, the Pliocene section contained in Core 1, Section 2, appears condensed.

Foraminifera and calcareous nannoplankton are the best represented fossil groups. Also present at the top of Core 1 and in the sediment recovered from the drill bit are otoliths and the shells of pelecypods, gastropods, and pteropods. Sparse carapaces of ostracods were observed throughout the cored intervals; marine diatoms (*Coscinondiscus centralis*) appear to be restricted to the Quaternary in the topmost part of Core 1.

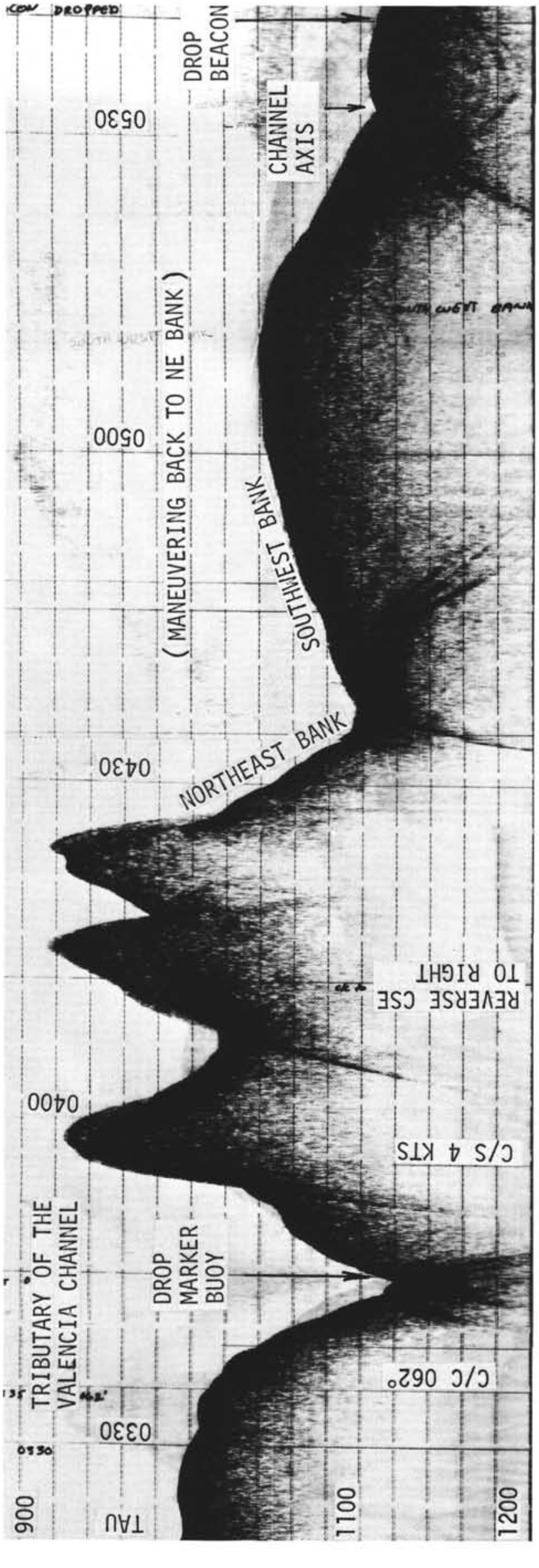

Figure 6. Echogram of the approach to Site 122. Depths are in tau. The peaks are topographic expressions of the basement ridge on the northeast side of the channel. The site location is shown by the position of the beacon drop. It was necessary to pick a location within the channel in order to reach the basement acoustic below the "salt-layer."

Rates of Sedimentation (M.B.C.)

The calculation of the sedimentation rates at Site 122 is difficult because of:

a) discontinuous coring and very poor core recovery, and

b) the occurrence of hiatuses in the section.

An important gap has been noted in Section 1 of Core 1, where late-middle Quaternary sediments directly overlie Upper Pliocene sediments; the corresponding time-gap may be estimated to be at least one million years.

Submarine erosion probably occurred not only in post-Pliocene times, but also during the Late Pliocene, as suggested by the relative position of some biostratigraphic horizons. For instance, the last occurrence of *Globigerinoides obliquus extremus* has been recorded in Core 1-2 (107 to 110 centimeters) and only 20 centimeters above the last occurrence of *Sphaeroidinellopsis seminulina* and *Sphaeroidinellopsis subdehiscens,* recorded in Core 1-2 (126 to 129 centimeters). The same biostratigraphic interval is represented at Site 132 (Tyrrhenian basin) by 22.5 meters of pelagic sediments (from 132-10-2, 35 centimeters, to 132-12-5, 35 centimeters). Therefore, a calculation based on the thickness in meters between the extinction horizons of *Sphaeroidinellopsis seminulina* (correlated to the Kaena event in the Gauss Normal Epoch, or to 2.9 million years) and the extinction horizon of *Globorotalia margaritae* (correlated with the base of the Gauss Normal Epoch of paleomagnetic stratigraphy) would be unrealistic.

The Lower Pliocene is better represented. The marker fossil *Globorotalia margaritae* is recorded in Cores 2 and 4. Core 2 yields numerous specimens belonging to the subspecies *Globorotalia margaritae evoluta, G. margaritae margaritae* and *G. margaritae primitiva*. Apparently, a complete evolutionary sequence is present from Core 2 to 4. The thickness of this interval is 75 meters. The total range of *Globorotalia margaritae* cum var, at Site 132, where it has been carefully investigated, corresponds to 55 meters of sediments, and the sedimentation rate there for this interval has been calculated at about 3 cm/1000 yrs. Thus, the rate of sedimentation seems to be higher in the Valencia Channel than in the Tyrrhenian Basin. This conclusion is in agreement with the nature of the sediments at Site 132, the sediments being purely pelagic nannofossil-foraminiferal ooze. In the Valencia Channel appreciable terrigenous material is present.

Planktonic Foraminifera (M.B.C.)

The ranges of 39 taxa are indicated on Table 2. This table also gives information on other microfossils and fragments of megafossils observed in the fraction greater than 63 microns.

The biostratigraphic zonation used for the Pliocene is new. It is illustrated and documented in Chapter 47 (this volume). The terms Lower and Upper Pliocene are here used in a formal sense, as defined in Chapter 47.

All the three biozones distinguished in the Upper Pliocene, namely, the *Globorotalia inflata* Interval-zone the *Globigerinoides obliqus extremus* Interval-zone and the *Sphaeroidinellopsis subdehiscens* Interval-zone, are present in Section 2 of Core 1, Site 122. This unusual condensation is considered to be the result of submarine erosion

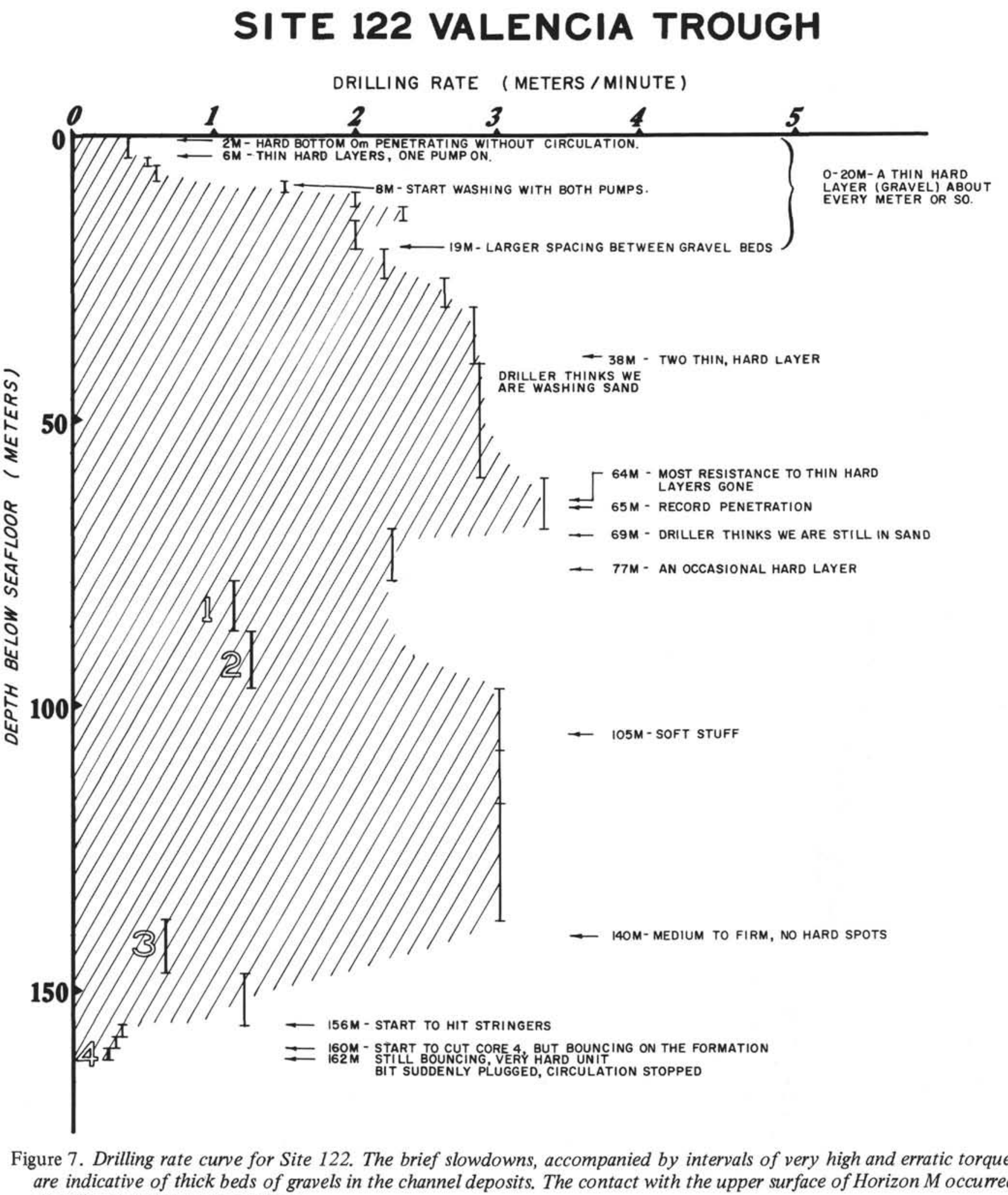

Figure 7. *Drilling rate curve for Site 122. The brief slowdowns, accompanied by intervals of very high and erratic torque, are indicative of thick beds of gravels in the channel deposits. The contact with the upper surface of Horizon M occurred at 156 meters below the sea floor.*

occurring at different times during the Upper Pliocene. The Lower Pliocene section appears to be more complete (however, of the 80-meter interval at this site we have only 1 meter of sample).

The *Sphaeroidinellopsis* Acme-zone, which characterizes the base of the Pliocene transgression at Site 132 (Tyrrhenian Basin) has not been recorded in the Valencia Channel. Since we only had a core catcher sample from Core 4 to investigate, we cannot rule out the possibility that this interval might be present somewhere above. However the assemblage of 4-CC, with its relatively abundant and diversified benthonic fauna, including also shallow water forms, suggests the initiation of deposition of the Pliocene sediments may be younger here than at other Mediterranean sites.

TABLE 1
Core Inventory – Site 122

Core	No. Sections	Date	Time	Cored[a] Interval (m)	Cored (m)	Recovered (m)	Subbottom Penetration (m)		Lithology	Age
							Top	Bottom		
1	2	8/23	16:18	2234-2243.6	9.6	2.2	78.0	87.6	Marl oozes, sand	Quaternary-Upper Pliocene
2	2	8/23	17:35	2243.6-2253	9.3	2.4	87.6	97.0	Sands and clays	Lower Pliocene
3	1	8/23	19:05	2291.0-2300.3	9.3	0.7	135.0	144.3	Sands and clays	Lower Pliocene
4	0	8/23	20:55	2316.2-2318.0	1.6	Trace	160.2	162.0	Sands	Lower Pliocene
4a[b]	FB	8/24	04:10	2316.2-2318.0	–	(2.0)	160.2	162.0	Coarse bedded gypsum	–
Total					29.8	5.3		162 m		
% Cored					18.3%					
% Recovered						17.7%				

[a] Drill pipe measurements from derrick floor to sea floor

[b] Samples from drill pipes and drill bit, and stored in freezer boxes.

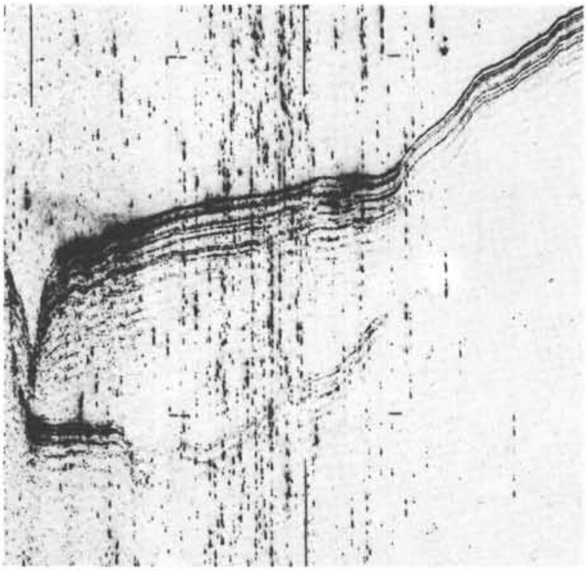

Figure 8. *Reflection profile (airgun) of the* Challenger *made during the approach to Site 122. The dark stratified zone on the axis of the channel was shown by the drilling to correspond to coarse-grained channel deposits of Quaternary age. The upper surface of the strong M-Reflectors is clearly seen where it abuts against a basement ridge to the northeast of the channle. The erosional cut into the M-Reflectors to the southwest of the present channel may have provided the pebbles of gypsum and limestone to the basal gravel bed encountered at Horizon M (see discussion in text). Vertical exaggeration, 30:1.*

Benthonic Foraminifera (W.M.)

The principal benthonic foraminifera found at Site 122 are shown in Table 3. Cores 2 to 4 (87.6 to 160 meters below bottom) have been dated as Pliocene by planktonic foraminifera. These cores contain the benthonic species, *Siphonina reticulata* (Czjzek), which was only very rarely encountered in any post-Pliocene beds of the Mediterranean basins. The benthonic fauna of the cored sediment at this site is characterized by a mixture of deep-water foraminifera with others which are clearly derived from nearshore areas or bay heads; for example, *Amphistegina lessonii* (d'Orbigny), *Ammonia beccarii* (Linnaeus), *Elphidium macellum* (Fichtel and Moll), *Eliphidium crispum* (Linnaeus), etc.

Nannofossils (H.S.)

The fossil nannoplankton in Core 1 indicate two different series. The yellowish ooze and sand from top of Section 1 (sampled at 11 to 12 centimeters) contains Quaternary nannofossils with *Gephyrocapsa oceanica;* the sediment in section 2 (sampled at 118 to 119 centimeters) has a lower Upper Pliocene assemblage with *Discoaster surculus* and *Discoaster brouweri*. Cores 2 and 3 contain Lower Pliocene assemblages. The allochthonous transport of sediment in turbidity currents has left a chaotic mixture of nannofossils in Core 2 that ranges in age from Cretaceous to Pliocene. It is suspected that the occurrences of *Discoaster asymmetricus* and *Ceratolithus tricorniculatus* in Core 2 might be due to selective reworking of Lower Pliocene sediments into higher levels.

TABLE 2
Range of Planktonic Foraminifera – Site 122

Depth Below Sea Floor (m)	Recovery	Core Number	Section Number	Samples Interval (cm from top)	PLANKTONIC FORAMINIFERA																																		Detritus	Pteropods	Gasteropods	Pelecypods fragments	Ostracods	Bryozoe	Otoliths	Echinoid spines	Age		Zone
					Globigerina											*Globigerinoides*									*Globorotalia*													Others																
					apertura	*bulbosa*	*bulloides*	*digitata*	*eggeri*	*falconensis*	*microstoma*	*pachyderma*	*praedigitata*	*pachyderma*	*quinqueloba*	*bollii*	*elongatus*	*helicinus*	*obliquus extremus*	*pyramidalis*	*quadrilobatus*	*ruber*	*sacculifer*	*trilobus*	*acostaensis*	*bononiensis*	*crassaformis*	*inflata*	*margaritae evoluta*	*margaritae margaritae*	*margaritae primitiva*	*obesa*	*puncticulata*	*puncticulata - inflata*	*oscitans*	*scitula*	*truncatulinoides*	*Globigerinita glutinata*	*Globoquadrina altispira*	*Hastigerina siphonifera*	*Orbulina universa*	*Sphaeroidinellopsis seminulina*	*Sphaer subdehiscens*											
78			1	115			●	●	●			●					●			●	●	●	●		●			●							●	●	●	●		●	●				●	●	●	○	○	○	○	Quat.		*Globorotalia truncatulinoides* Total-range-zone
		1	2	29-32	●		●		●				●	●	●	●	●	●		●	●	●	●				●	●				●				●		●		●	●			○				○		○		Pliocene	Upper	*Globorotalia inflata* Interval-zone
			2	107-110	●		●		●						●		●	●	●		●	●	●	●	●	●						●		●		●		●		●	●													*Globigerinoides obliquus extremus* Interval-zone
			2	126-129	●		●			●					●		●	●	●	●	●	●	●		●	●								●		●		●		●	●	●	●											*Sphaeroidinellopsis subdehiscens* Interval-zone
			CC	CC			●						●				●	●	●	●	●	●	●	●								●	●			●		●	●	●	●			●										
87		2	1	129-132	●	●	●			●	●				●				●		●		●	●					●	●			●			●		●			●			●									Lower	*Globorotalia margaritae* Total-range-zone
			2	70-73	●	●	●				●				●				●			●			●				●	●	●		●			●		●			●			●										
			CC	CC	●	●	●								●				●					●	●				●	●	●		●					●		●	●			●										
135		3	CC	CC			●			●					●				●						●													●			●			●										
160 162		4	CC	CC	●		●			●	●				●				●		●	●		●	●						●	●	●			●				●				●				○						

TABLE 3
Range of Benthonic Foraminifera – Site 122

Age	Depth Below Sea Floor (m)	Cores	*Spiroplectammina wrighti* (Silv.)	*Karreriella bradyi* (Cushman)	*Bolivina dilatata* Reuss	*Uvigerina peregrina-mediterranean*	*Ammonia beccarii* (Linn.)	*Elphidium macellum* (F. & M.)	*Amphistegina lessonii* d'Orbigny	*Hyalinea balthica* (Schroeter)	*Cibicides* cf. *floridanus* (Cushman)	*Cibicides pseudoungerianus* (Cushman)	*Cassidulina carinata* Silv.	*Cassidulina subglobosa* Brady	*Chilostomella colina* Schwag.	*Epistomina elegans* (d'Orbigny)	*Sigmoilina schlumbergeri* (Silv.)	*Dentalina leguminiformis* (Batsch.)	*Lagena longirostris* (Seg.)	*Lagenia quadricostulata* Reuss	*Planularia* aff. *auris* (Defr.)	*Bolivina punctata* d'Orbigny	*Bolivina subspinescens* Cushman	*Bulimina ovata* d'Orbigny	*Siphonodosaria consobrina* (d'Orbigny)	*Planulina ariminensis* (d'Orbigny)	*Pleurostomella alternans* Schwag.	*Cassidulinoides bradyi* (Norman)	*Nonion padanum-barleeanum*	*Pullenia bulloides* (d'Orbigny)	*Martinottiella communis* (d'Orbigny)	*Planularia insolita-crenidula*	*Dentalina filiformis* (d'Orbigny)	*Lagena* cf. *nebulosa* Cushman	*Lagenodosaria sublineata* (Brady)	*Marginulina* cf. *glabra* d'Orbigny	*Orthomorphina jedlitschkai* (Thalm.)	*Siphonodosaria monilis* (Silv.)	*Eponides umbonatus* (Reuss)	*Bigenerina nodosaria* d'Orbigny	*Spiroloculina excavata* d'Orbigny	*Sigmoilina celata* (Costa)	*Robulus orbicularis* (d'Orbigny)	*Bolivina catanensis* Seg.	*Bulimina marginata* d'Orbigny	*Siphonina reticulata* (Czjzek)	*Eponides umbonatus stellatus* (Silv.)	*Robulus cultratus* Montf.	*Robulus* gr. *rotulatus* (Lam.)	*Lenticulina* cf. *gibba* (d'Orbigny)	*Uvigerina rutila* Cushman	*Anomalina helicina* (Costa)	*Angulogerina angulosa* (Will.)	*Cibicides lobatulus* (Walk. & Jac.)	*Ellipsonolymorphina fornasinii* Gall.	*Astrononion stelligerum* (d'Orbigny)	*Vulvulina pennatula* (Batsch)	*Liebusella soldanii* (Jones & Parker)	*Bolivina spathulata* (Will.)	*Valvulineria bradyana* (Forn.)	*Asterigerina planorbis* (d'Orbigny)	*Elphidium crispum* (Linn.)	*Cibicides robertsonianus* (Brady)	*Cyroidina* cf. *umbonata* (Silv.)
Pleisto-cene	Sea Floor 2146 m																																																																
	78.0-87.6	1 ■	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮																																						
Pliocene	87.6-97.0	2 ■		▮			▮				▮							▮				▮	▮	▮	▮	▮	▮				▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮																	
	135.0-144.3	3 ■		▮	▮	▮					▮	▮		▮								▮	▮																	▮							▮		▮	▮	▮	▮	▮												
	160.2-162.0	4 ■		▮	▮	▮	▮	▮	▮	▮	▮	▮														▮			▮	▮													▮	▮	▮	▮	▮							▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮

TABLE 4

Nannofossil Range Chart

Age	Depth Below Sea Floor (m)	Cores	*Ceratolithus crisatus* Kamptner	*Gephyrocapsa oceanica* Kamptner	*Thoracosphaera heimi* Lohmann	*Braarudosphaera bigelowi* (Gran & Braarud)	*Coccolithus pelagicus* (Wallich)	*Syracosphaera pulchra* Lohmann	*Rhabdosphaera clavigera* Murray & Blackman	*Rhabdosphaera stylifera* Lohmann	*Cyclococcolithus leptoporus* (Murray & Blackman)	*Cyclolithella rotunda* (Kamptner)	*Discoaster brouweri* Tan	*Discoaster challengeri* Bramlette & Riedel	*Discoaster surculus* Martini & Bramlette	*Discoaster asymmetricus* Gartner	*Discoaster pentaradiatus* Tan	*Helicopontosphaera carteri* Kamptner	*Pontosphaera scutellum* Kamptner	*Pontosphaera japonica* Takayama	*Reticulofenestra pseudoumbilica* (Gartner)	**Scapholithus fossilis* Deflandre	*Scyphosphaera apsteini* Lohmann	*Scyphosphaera campanula* Deflandre	*Sphenolithus abies* Deflandre	*Sphenolithus moriformis* (Stradner)	*Thoracosphaera imperforata* Kamptner	*Ceratolithus tricorniculatus*
Quater-nary	Sea Floor 2146 m																											
	78.0-87.6	1	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮					
Pliocene	87.6-97.0	2					▮				▮			▮	▮	▮		▮		▮	▮		▮		▮			
	135.0-144.3	3				▮	▮				▮					▮	▮	▮		▮	▮				▮			▮
	160.2-162.0	4a					▮				▮			▮	▮		▮		▮	▮	▮			▮	▮	▮	▮	▮

The nannofossils in selected samples are shown below:

Pleistocene

Sample: 13-122-1-1, Top:
Braarudosphaera bigelowi
Ceratolithus cristatus
Gephyrocapsa oceanica
Cyclococcolithus leptoporus
Helicosphaera carteri
Pontosphaera scutellum
Rhabdosphaera stylifera
Syracosphaera pulchra
Thoracosphera heimi

Reworked species:
Braarudosphaera discula
Discoaster barbadiensis
Eiffellithus turriseiffeli
Lucianorhabdus cayeuxi
Prediscosphaera cretacea
Watznaueria barnesae
Watzneueria britannica

Sample: 13-122-1-2, 11-12 cm:
Coccolithus pelagicus
Gephyrocapsa oceanica
Helicosphaera carteri
Pontosphaera scutellum
Rhabdosphaera stylifera
Syracosphaera pulchra

Quaternary (*Gephyrocapsa oceanica* Zone).

Pliocene

Samples: 13-122-1-2, 118-119 cm and 13-122-1 CC:
Coccolithus pelagicus
Cyclococcolithus leptoporus
Cyclolithella rotunda
Discoater brouweri
Discoaster surculus
Discoaster pentaradiatus
Helicosphaera carteri
Pontosphaera japonica
Pontosphaera scutellum
Reticulofenestra pseudoumbilica
Rhabdosphaera stylifera
Scapholitus fossilis
Scyphosphaera apsteini

Reworked species:
Discoaster lodoensis

Lower Upper Pliocene (NN 15-16).

Samples: 13-122-2-1, 130-131 cm, 13-122-2-2, 16-17 cm and 13-122-2 CC:
Coccolithus pelagicus
Cyclococcolithus leptoporus
Discoaster asymmetricus
Discoaster challengeri
Discoaster deflandrei
Discoaster surculus
Helicosphaera carteri
Lithostromation perdurum

Pontosphaera japonica
Pontosphaera multipora
Reticulofenestra pseudoumbilica
Scyphosphaera apsteini
Sphenolithus abies

Reworked species:
Arkhangelskiella cymbiformis
Chiasmolithus consuetus
Cruciplacolithus tenuis
Discoaster barbadiensis
Micula staurophora
Pemma papillatum

Lower to lower Upper Pliocene (NN 14-16) with considerable reworking of Cretaceous to ?Lower Pliocene sediments.

Sample 13-122-3-CC:
Braarudosphaera bigelowi
Coccolithus pelagicus
Ceratolithus tricorniculatus
Cyclococcolithus leptoporus
Discoaster asymmetricus
Discoaster brouweri
Discoaster pentaradiatus
Helicosphaera carteri
Pontosphaera japonica
Reticulofenestra pseudoumbilica
Sphenolithus abies

Reworked species:
Cretarhabdus crenulatus
Discoaster barbadiensis
Marthasterites tribrachiatus

Lower (?) Pliocene (NN 14-16) with some reworking of Cretaceous to ? Lower Pliocene sediments.

Sample 13-122-4a (drill bit sample):
Coccolithus pelagicus
Cyclococcolithus leptoporus
Discoaster brouweri
Discoaster challengeri mediterraneus
Discoaster pentaradiatus
Discoaster surculus
Discolithina macropora
Pontosphaera scutellum
Pontosphaera japonica
Reticulofenestra pseudoumbilica
Scyphosphaera campanula
Scyphosphaera pulchra
Sphenolithus abies
Sphenolithus moriformis
Thoracosphaera imperforata

Reworked species:
Cretarhabdus crenulatus
Micula staurophora

Lower Pliocene

LITHOSTRATIGRAPHY

A single hole was drilled at Site 122 to the top of a layer of gypsum at 162 meters. Despite mechanical troubles resulting in poor recovery, our intermittent coring suggests the presence of four lithologic units; these are, from top to bottom: 1) Quaternary gravels and sands; 2) Pliocene graded sands marl oozes and nannofossil ooze; 3) transgressive marine gravels; and 4) evaporites.

TABLE 5
Lithologic Units

Unit	0	Lithology	Age
1		Gravels, graded sand and marl ooze	Quaternary
	79.5		
2		Graded sands, silts and marl oozes, turbidites and contourites	Lower Pliocene
	156		
3		Gravels	
	160		
4		Evaporite	Upper Miocene
	162 m		

Unit 1 – Graded Sand and Marl Ooze

The top of Core 1 consists of graded sands and marl ooze of Quaternary age underlying the present-day Valencia Channel. This unit lies directly on Upper Pliocene nanofossil oozes.

Unit 2 – Sands, Sand-silt Laminae, Marl Oozes, and Nannofossil Ooze

Rhythmic sequences composed of sands, sand-silt laminae and marl oozes, graded or with sharp upper contacts, were encountered between 79.5 and 144.3 meters.

The sand horizons show vertical grading and horizontal laminations (Figure 9). They comprise medium to fine-grained quartzose sands and silts composed mainly of angular quartz (80%) with other terrigenous clastics: chlorite (5%), dark and light micas (5%), andesite fragments (5%), feldspar, dolomite, etc. Foraminifera and nannoplankton are only present in trace amounts.

The marl oozes are plastic and include 40 to 60 per cent nannoplankton with rare foraminifera. Terrigenous debris forms the remainder, for example, quartz, light and dark micas, chlorite, etc.

The color of the unit grades from light olive-gray to dark grayish-brown.

Three types of sediments are present: 1) Graded sands, starting with a sand bed at bottom and grading upward into silt and clay; 2) Pelitic layers, consisting either completely of clay or starting with a thin lamina of silt at bottom: (3) Thin, millimetric sand-silt laminae, interlaminated with pelitic layers. The graded sands are believed to have been deposited by turbidity currents, while the silts show features indicative of traction transport–possibly by contour-following geostrophic currents (Heezen *et al.*, 1966; Gostan, 1967; Mauffret, 1970).

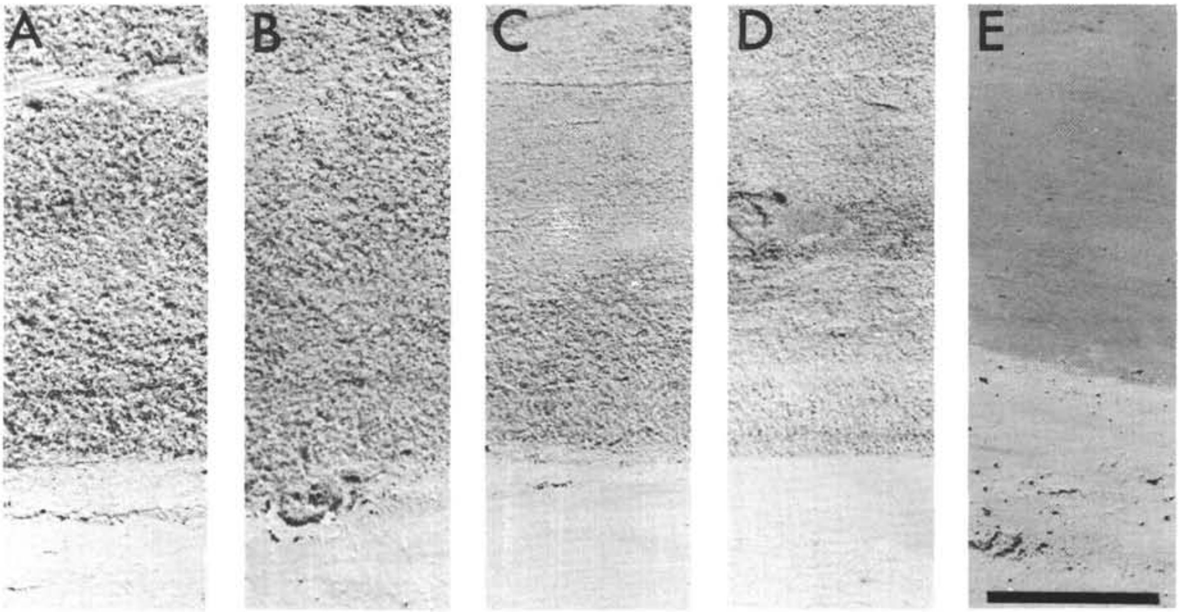

Figure 9. *Primary structures in the sand and marl ooze sequences of Unit 2. Note sharp basal contacts of graded units, possible groove mark in B, and internal laminations rich in mud (top of A and middle of D). In E an abrupt change from nanno-ooze with foraminifera to marl low in carbonate occurs without a basal sand or silt horizon. Scale bar represents one centimeter. A = 2-2-79 cm; B = 2-2-92 cm; C = 2-2-65 cm; D = 2-2-24 cm; E = 1-2-113 cm.*

In the 4.80-meter-long cores of Unit 2 we identified 12 graded beds, 14 pelitic layers and 9 finely-laminated silt layers.

Unit 3 – Gravel

The sediments were penetrated between 144.3 and 160 meters below bottom by washing without an inner core barrel in the drill string. Hard layers were first encountered at 156 meters, and the core barrel was sent down after reaching 160 meters.

When the drilling was eventually stopped with a plugged bit (see Operations), the pipe was withdrawn and was found to contain a massive deposit of gravel and coarse sand. The position of the gravel horizon is inferred from the drilling logs to be between 156 and 160 meters.

The gravel, ranging in grain size from 2 to 20 millimeters, is mixed with sand of the same composition in the ratio of 3 to 2, and contains a very small amount of clay. The latter was probably absent in the original bed and may result from mixing during the drilling. The gravel is composed of: 70 per cent basalt fragments, some of which are rounded and all of which are vesicular, 25 per cent gypsum crystals, and 5 per cent fragments of pelagic limestone. Foraminifera and shallow-water shell debris are also present (Figure 10).

Unit 4 – Evaporites

Plastic gypsiferous mud was recovered from the drill bit together with slightly dolomitic marls containing abundant nodules of crystalline gypsum. The gypsum had been rendered soft during the drilling operations and was stuck between the teeth of the drill bit. The gypsum represents an authigenic sedimentary deposit at the top of the Mediterranean Evaporite. This layer may have supplied the gypsum detritus to the overlying gravel during the major transgression that terminated the period of evaporite deposition.

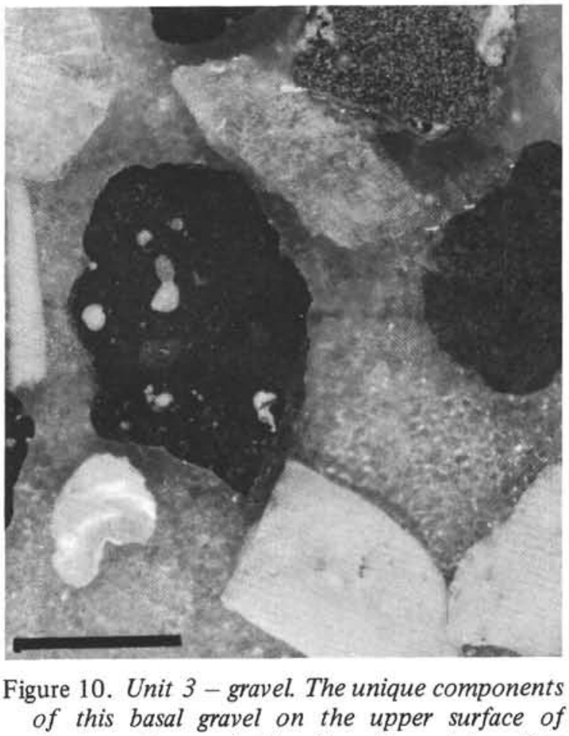

Figure 10. *Unit 3 – gravel. The unique components of this basal gravel on the upper surface of Horizon M are: (a) basalt, with vesicles often filled with calcite; (b) rounded and subrounded fragments of Middle Miocene limestone; (c) gypsum; and (d) shells of shallow-water faunas. Scale bar represents one centimeter.*

PHYSICAL PROPERTIES

Because the recovery was poor, only a few sections of the cores were suitable for measurements of their physical properties. Disturbance of the bedding by drilling was evident, and consequently, high penetrometer readings of 144.7 × 10^{-1} mm at the top of Core 1, Section 1 result. Sand layers also give values higher than the average of 80 × 10^{-1} mm for the oozes. No measurements of bulk density, porosity or water content were made. Natural gamma measurements reflect the alternating sequences of oozes and sands in the turbidite beds. A correlation between high calcium-carbonate content in ooze layers and low gamma readings is very distinct. The sand beds are defined by high gamma counts of up to 3600, while the argillaceous oozes, classified as silts from grain-size analyses, plot at 1500 counts.

SUMMARY AND CONCLUSIONS

The gravel encountered at Horizon M (156 to 160 meters subbottom) has a very unusual composition. As we were cursing our misfortune of having to abandon the hole, we began to examine exactly what it was that stopped us. The gravel has only four basic components–basalt, limestone, gypsum, and shells of shallow water faunas (see Figure 10). No other fragments, no metamorphic rocks, no plutonic igneous rocks were found–not even one piece in the entire massive deposit! It was evident that this was not simply a channel deposit of clastics displaced into the deep-sea environment from a continental shelf or out of the head of a submarine canyon.

Nature of the Gravel

The pieces of basalt are slightly rounded, and the vesicles are filled with calcite. Chemical analyses of several fragments showed them to be basalts and the trace element composition indicates affinities to alkali basalt (see Chapter 28 this volume). A few pebbles are even well-rounded. Some are composites of lithified limestone *in contact* with the basalt. The vast majority of the basalt fragments have an identical color and internal texture.

The limestones are also slightly rounded. They are white to buff in color and are markedly indurated. In thin section they reveal a very fine-grained micritic matrix. Under the scanning electron microscope the matrix of many of the pieces has been identified as coccoliths. Specimens were recognized initially from smear slides made by scraping the limestones with a razor blade. Of the fragments examined so far, no assemblages younger than Tortonian have been recognized, and the age assignments go back into the Middle Miocene (Langhian). This fossil assemblage is diagnostic of an open marine pelagic environment.

The shell fragments are more varied, and include gastropods, pelecypods, brachiopods, and lamellibranches alone with one shark's tooth. Some of the pieces are very fragile, and it is surmised that they would not have survived a high-energy depositional environment. They are broken but not abraded.

The gypsum occurs as large intertwined selenite crystals, with a markedly fresh luster. The interlocking nature of the crystal faces, and the abundant fracture patterns indicate that they are fragments of originally a more massive layer (that is, there is no indication that they grew as single crystals in the gravel).

In addition to the four major components mentioned above we found a few pieces of brown conchoidally-fractured chert, some pale green to gray andesite, and an algal biscuit.

The significance of the gravel was not appreciated for some time. In the hindsight of our entire cruise experience we suggest that the basalt, limestone, and gypsum components are erosional products of the Valencia Trough seabed in the Upper Miocene (for supporting documentation and a general synthesis, see Chapters 37, 43, and 44 of this volume). The basalt represents the acoustic basement responsible for the magnetic anomalies. The limestones represent open marine pelagic sedimentation that existed in this region until the time of the Messinian salinity crisis. The gypsum is apparently from a Messinian evaporite facies.

The reason that there are no rocks of continental origin in the gravel is explained by postulating erosion exclusive to the Upper Miocene seabed and its underlying strata. Evidence of just such erosion can be seen in a buried channel cut into the M-Reflectors (Figure 8).

The shells are interpreted to be the littoral fauna preserved within a transgressive beach deposit on the floor of the Valencia Trough, following the last phase of desiccation of the Mediterranean during the Messinian. Dwarfed specimens of pelecypods, gastropods and planktonic foraminifera, and the shallow-water benthonic populations (*Ammonia beccarii, Elphidium macellum*, etc.) indicate that the flooding waters were still partly restricive and not of normal salinity.

We interpret the occurrence of a few deep-water benthonic foraminifera and the Lower Pliocene assemblages of nannofossils found in the gravel to be either 1) the result of mixing of the gravel with the overlying Pliocene nannofossil ooze during drilling (especially when the gravel flowed into the bottom hold assembly and plugged the bit), or 2) the result of winnowing of the beach deposits during the lowermost Pliocene by bottom currents of sufficient competency to prevent deposition of the lowermost Pliocene series (refer to the evidence of an angular unconformity at Horizon M in Figures 3 and 4, and also the discussion of the missing *Sphaeroidinellopsis* Acme-zone in the section on biostratigraphy).

We conjecture that the gravel, therefore, contains a partly-preserved record of what we would have found if we had been able to push on through the M-Reflectors and complete our hole into the basement. We are stymied in offering an alternate, plausible explanation.

Thickness of the Channel Fill and the Age of the Initial Cutting of the Valencia Channel

An examination of the *Challenger* reflection profile across the deep-sea canyon (Figure 8) where Site 122 was located shows a 0.08-second thick layer of very faintly stratified sediments between Horizon M and the observed base of the channel fill (zone of high internal reflectivity). In a crossing of the same channel system 100 kilometers downstream made by the *Jean Charcot* during the cruise

Geomede I, a layer of similar thickness can also be seen below the channel fill (Mauffret, 1970).[4]

If we assume that the 0.08 second layer represents strata never cut into by the channel, and that a velocity of sound in the transparent sediment is approximately 1.8 km/sec, we calculate this interval to be about 72 meters thick.[5]. Since Horizon M was encountered at 156 meters below bottom, we can infer from the reflection records that the channel fill must be approximately 84 meters thick. Cores 1 and 2 were taken back-to-back initially in order to try to bracket the lower contact of the channel fill. Our calculations predict that the contact should lie in the middle of Core 1 (cut between 78 and 87.6 meters below bottom). It turns out that this is where a significant unconformity exists between a condensed Upper Pliocene section and the middle of the Late Quaternary, an hiatus estimated to span at least one million years.

As supporting evidence, the drilling records showed numerous hard stringers (interpreted by the drillers as gravel beds) in the penetrated section up to the level where Core 1 was cut, and no such stringers again until 156 meters below bottom at the contact with Horizon M.

Since we only have knowledge concerning the level below which no erosion occurred, and the age of the oldest permanent fill within the channel, it is impossible to state exactly when the channel system developed. However, it suffices to say that initial cutting must have occurred somewhere between the lower Upper-Pliocene and late-middle Quaternary (*Gephyrocapsa oceanica* Nannofossil Zone).

Comments on a Possible Regional Pliocene Unconformity

A slight angular unconformity, called the pre-P$_\beta$ Horizon, has been previously described in this chapter and is shown in Figures 3 and 4. In the central Valencia Trough, the level of this unconformity corresponds to Horizon G. of Mauffret (1968; 1970) (see also Alinat *et al*., 1966; and Leenhardt, 1968, 1970). At Site 122, the horizon lies about midway between the floor of the deep-sea channel and Horizon M. We suggest that the unconformity may in some way be linked to the condensed Pliocene sections found in Core 1-2 where the last occurrence of *Globigerinoides obliquus extremus* has been recorded only 20 centimeters above the last occurrence of *Sphaeroidinellopsis seminulina* and *Sphaeroidinellopsis subdehiscens*. At Site 132 in the Tyrrhenian Sea this biostratigraphic interval is over 600,000 years in duration.

Additional evidence is documented in Chapters 5, 6, and 15 for major stratigraphic gaps in the Pliocene and lowermost Pleistocene of the Balearic Basin—some of which are also evident on the seismic reflection profiles.

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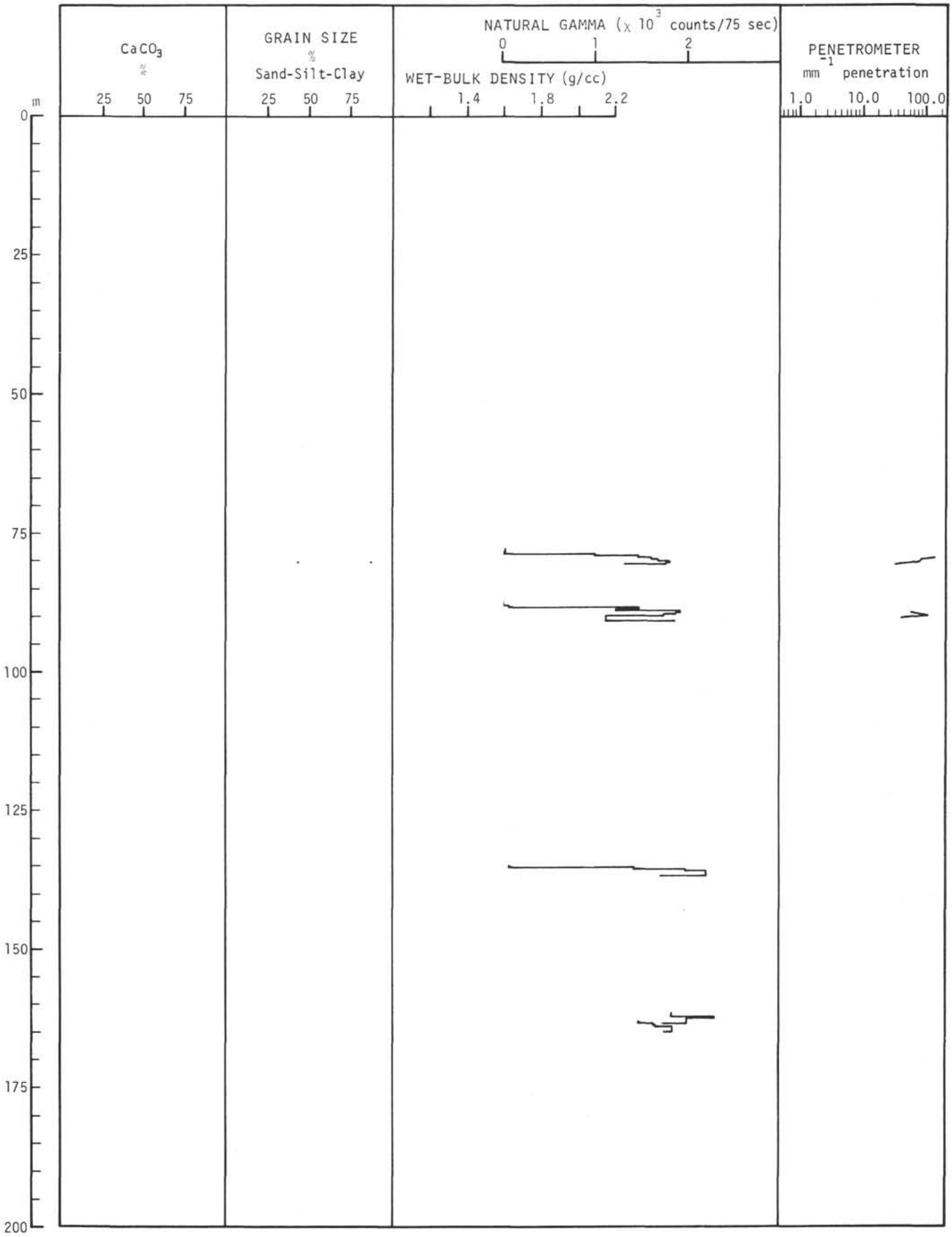
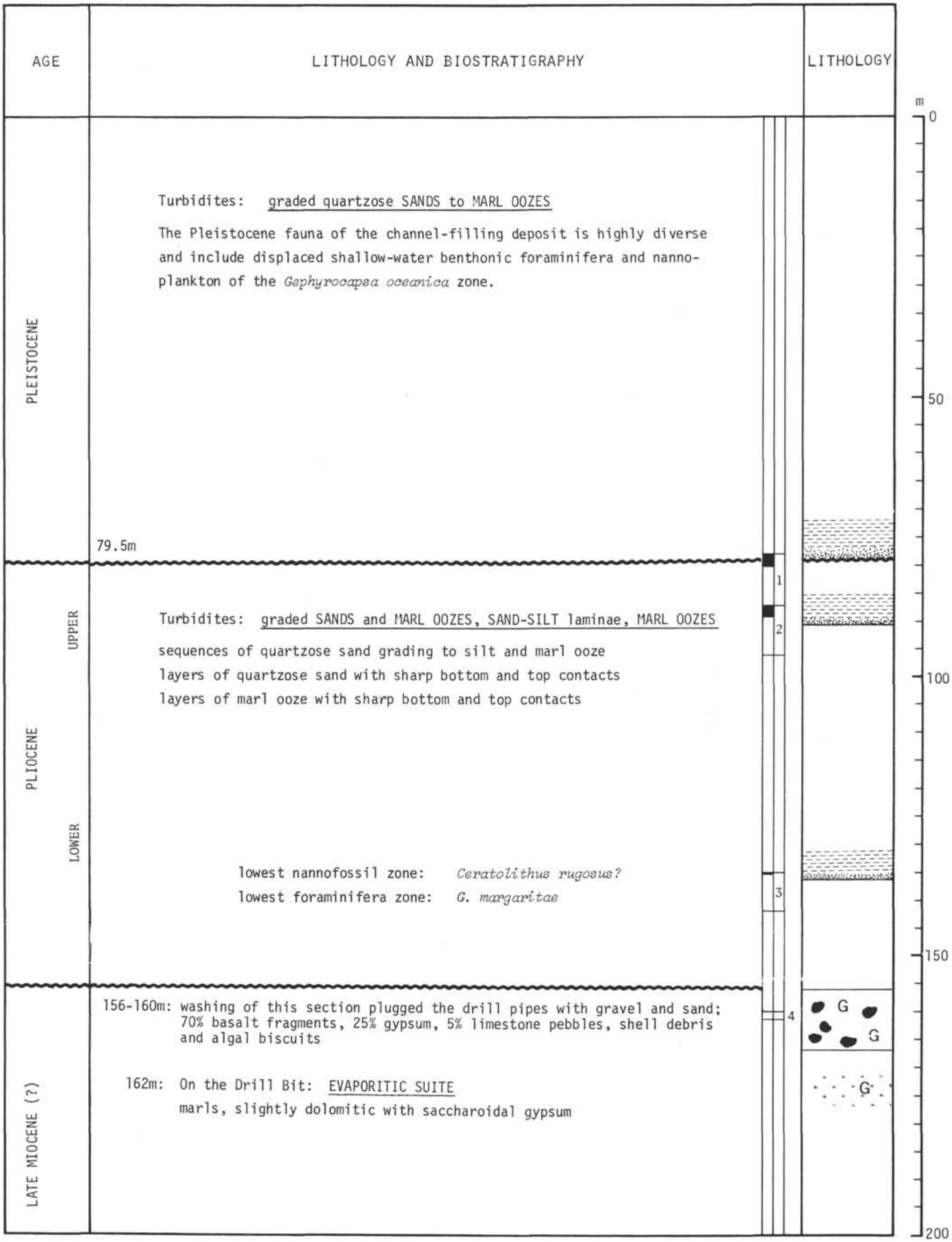
[4] In Plate 3 of Mauffret, 1970, his Reflector B is the lateral continuation of our Reflector M.

[5] From our experience we could tie the reflectors to known cored intervals at Sites 121 and 124.

Site Summary 122





Turbidites: graded quartzose SANDS to MARL OOZES

The Pleistocene fauna of the channel-filling deposit is highly diverse and include displaced shallow-water benthonic foraminifera and nannoplankton of the *Gephyrocapsa oceanica* zone.

79.5m

Turbidites: graded SANDS and MARL OOZES, SAND-SILT laminae, MARL OOZES

sequences of quartzose sand grading to silt and marl ooze
layers of quartzose sand with sharp bottom and top contacts
layers of marl ooze with sharp bottom and top contacts

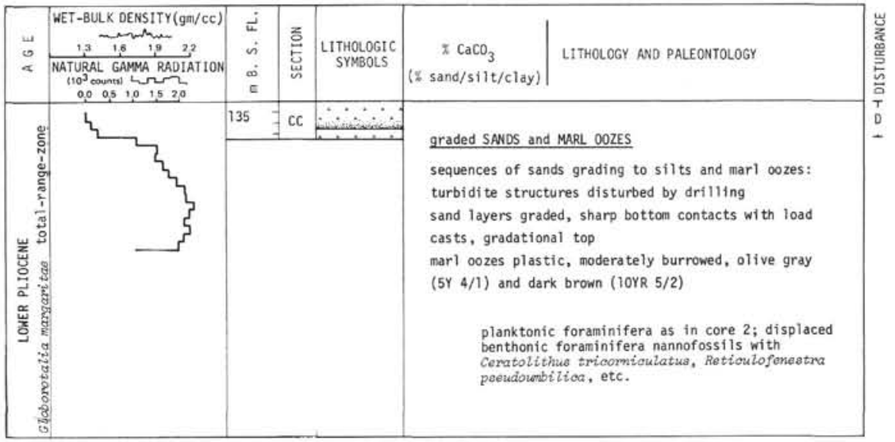
lowest nannofossil zone: *Ceratolithus rugosus?*
lowest foraminifera zone: *G. margaritae*

156-160m: washing of this section plugged the drill pipes with gravel and sand; 70% basalt fragments, 25% gypsum, 5% limestone pebbles, shell debris and algal biscuits

162m: On the Drill Bit: EVAPORITIC SUITE

marls, slightly dolomitic with saccharoidal gypsum

SITE 122 CORE 3 Cored Interval 135-144.3



graded SANDS and MARL OOZES

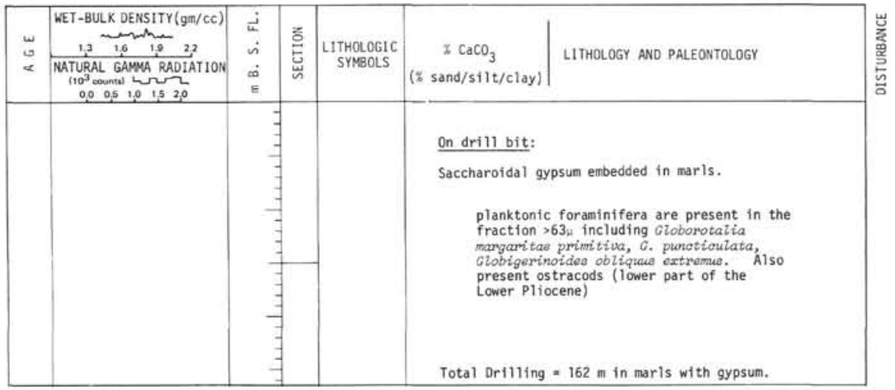
sequences of sands grading to silts and marl oozes: turbidite structures disturbed by drilling

sand layers graded, sharp bottom contacts with load casts, gradational top

marl oozes plastic, moderately burrowed, olive gray (5Y 4/1) and dark brown (10YR 5/2)

planktonic foraminifera as in core 2; displaced benthonic foraminifera nannofossils with *Ceratolithus tricorniculatus*, *Reticulofenestra pseudoumbilica*, etc.

SITE 122 CORE 4 Cored Interval 160.2-162 m



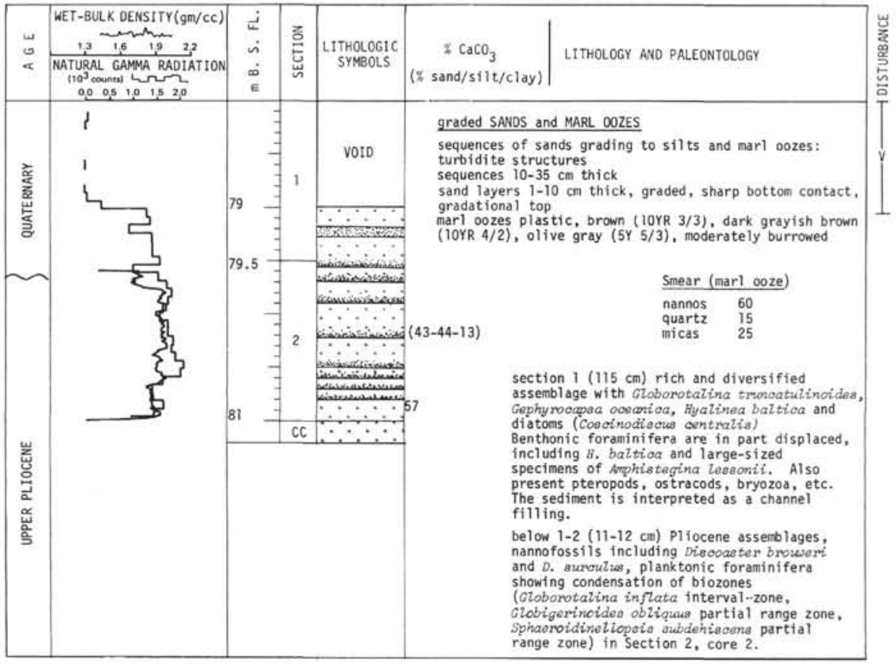
On drill bit:

Saccharoidal gypsum embedded in marls.

planktonic foraminifera are present in the fraction >63µ including *Globorotalia margaritae primitiva*, *G. puncticulata*, *Globigerinoides obliquus extremus*. Also present ostracods (lower part of the Lower Pliocene)

Total Drilling = 162 m in marls with gypsum.

SITE 122 CORE 1 Cored Interval 78-87.6 m



graded SANDS and MARL OOZES

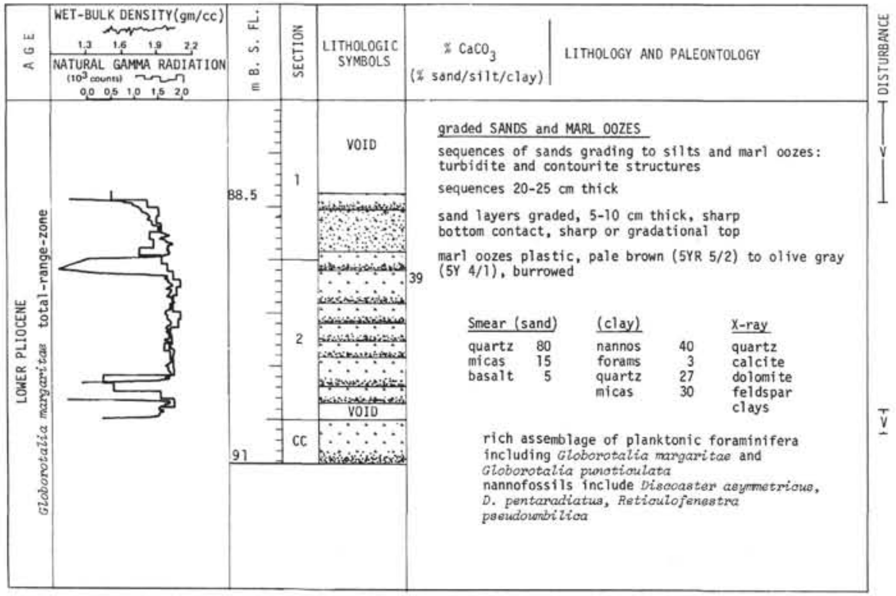
sequences of sands grading to silts and marl oozes: turbidite structures
sequences 10-35 cm thick
sand layers 1-10 cm thick, graded, sharp bottom contact, gradational top
marl oozes plastic, brown (10YR 3/3), dark grayish brown (10YR 4/2), olive gray (5Y 5/3), moderately burrowed

Smear (marl ooze)	
nannos	60
quartz	15
micas	25

section 1 (115 cm) rich and diversified assemblage with *Globorotalina truncatulinoides*, *Gephyrocapsa oceanica*, *Hyalinea baltica* and diatoms (*Coscinodiscus centralis)*
Benthonic foraminifera are in part displaced, including *H. baltica* and large-sized specimens of *Amphistegina lessonii*. Also present pteropods, ostracods, bryozoa, etc. The sediment is interpreted as a channel filling.

below 1-2 (11-12 cm) Pliocene assemblages, nannofossils including *Discoaster brouweri* and *D. surculus*, planktonic foraminifera showing condensation of biozones (*Globorotalina inflata* interval-zone, *Globigerinoides obliquus* partial range zone, *Sphaeroidinellopsis subdehiscens* partial range zone) in Section 2, core 2.

SITE 122 CORE 2 Cored Interval 87.6 - 97 m



graded SANDS and MARL OOZES

sequences of sands grading to silts and marl oozes: turbidite and contourite structures

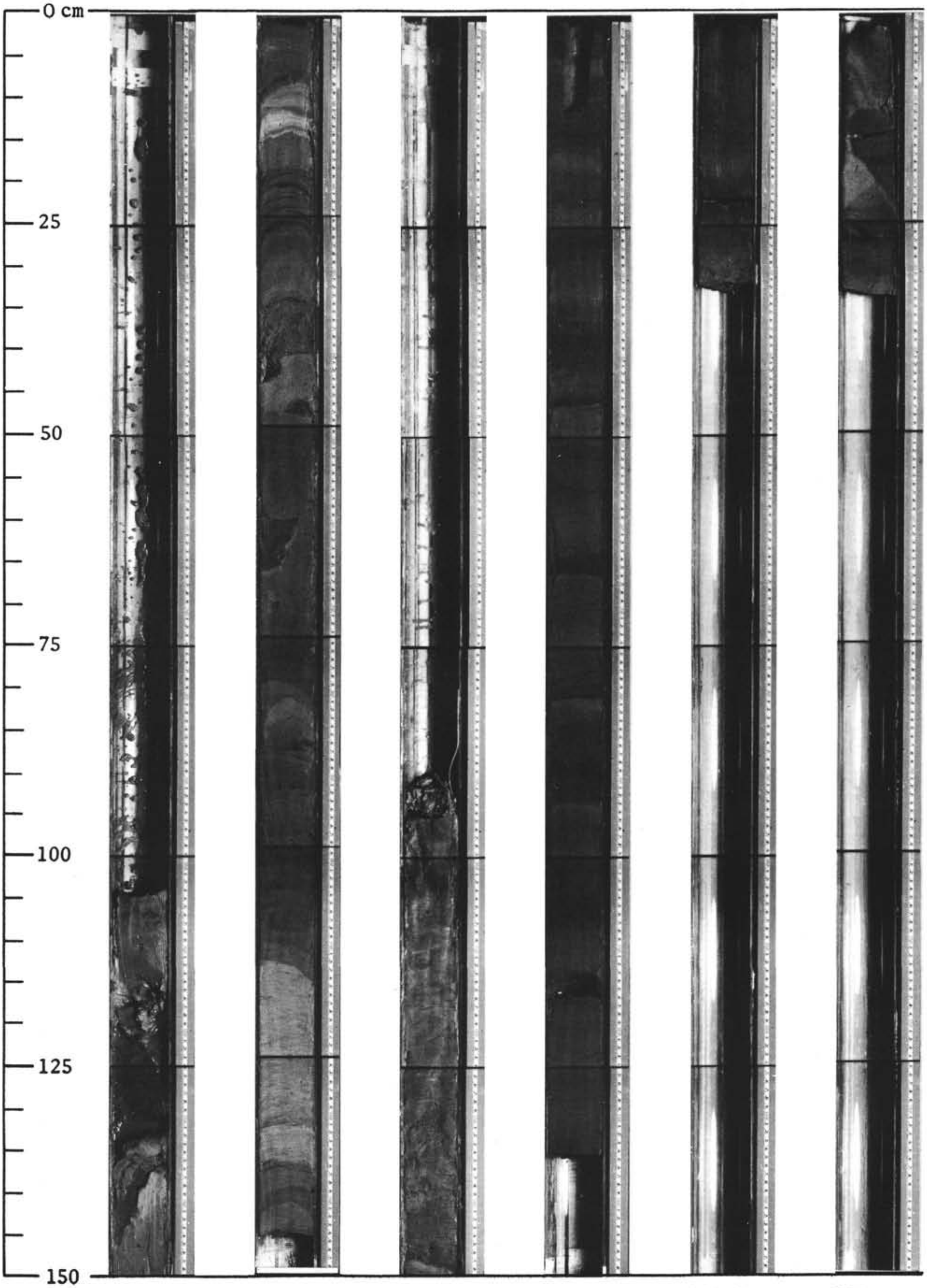
sequences 20-25 cm thick

sand layers graded, 5-10 cm thick, sharp bottom contact, sharp or gradational top

marl oozes plastic, pale brown (5YR 5/2) to olive gray (5Y 4/1), burrowed

Smear (sand)		(clay)		X-ray
quartz	80	nannos	40	quartz
micas	15	forams	3	calcite
basalt	5	quartz	27	dolomite
		micas	30	feldspar
				clays

rich assemblage of planktonic foraminifera including *Globorotalia margaritae* and *Globorotalia puncticulata*
nannofossils include *Discoaster asymmetricus*, *D. pentaradiatus*, *Reticulofenestra pseudoumbilica*



122-1-1 122-1-2 122-2-1 122-2-2 122-3-cc 122-3-cc