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11.3 TURBIDITES AT SITE 374: THEIR COMPOSITION, PROVENANCE AND PALEOBATHYMETRIC SIGNIFICANCE

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ABSTRACT

Pleistocene sediments cored at Site 374 in the Messina Abyssal Plain contain a number of turbidite deposits. Within these, two kinds of mineralogical associations were recognized. The first is low in carbonate with high amounts of quartz and feldspars, while the other is characterized by high amounts of aragonite and Mg-calcite derived from shallow-water environments. The second association is identical with that of turbidites deposited in the Messina Abyssal Plain in the Holocene. A North-African source area is assumed from present-day circum-Ionian carbonate distribution.

Absence of turbidite layers within Pliocene sediments and the low sedimentation rate during this period indicate that the basin morphology did not allow turbidite deposition before the Pleistocene. This is interpreted as an argument for Plio-Pleistocene subsidence of the Ionian basin.

INTRODUCTION

Textural and compositional analyses of turbidite sequences may provide clues for the determination of their provenance; their stratigraphic position may help to decipher the paleobathymetric development (and tectonic evolution) of their depositional basins.

In the light of existing controversy as to the paleobathymetry of the Mediterranean area during the Miocene (Ryan, Hsü, et al., 1973; Drooger, 1973), the stratigraphic distribution of turbidites in the Plio-Quaternary sediment sequence is of great interest.

Site 374 was drilled in the central part of the present-day Messina Abyssal Plain (35° 50.87′ N, 18° 11.78′ E; water depth 4078 m corrected echo sounding). The thickness of post-Messinian sediments at this site is approximately 360 meters and the Pliocene/Pleistocene boundary is at a depth of about 300 meters.

Within the extremely short sections cored within the Pleistocene sediments a number of layers with graded bedding and/or laminations were described which could be related to turbiditic sedimentation.

Samples from these sequences were analysed for their texture as well as their faunal and mineralogical composition (Figure 1).

RESULTS AND DISCUSSION

Within the Pleistocene turbidites recognized so far two kinds of mineralogical associations were found:

1) the first association, found in Core 4, Sections 3 and 4, is characterized by a comparatively high content of quartz, k-felspar, and plagioclase while calcite and dolomite are less abundant. Total carbonate does not exceed 30 percent within the samples analyzed. Mean size varies between 6.3 Φ and 8.3 Φ; the sand content ranges from 8 to 1 percent, silt from 80 to 34 percent, and clay from 64 to 12 percent. The sand fraction consists mainly of benthonic and planktonic foraminifera and less abundant echinoid spines, siliceous sponge spicules in addition to unspecified shell material, mica and quartz.

2) the second association was encountered within Cores 1, in the core catchers of Cores 2 and 4, and in Core 5, Section 1. Its prominent feature is the presence of the carbonate minerals: aragonite (up to 24%) and Mg-calcite (up to 18%) along with varying amounts of calcite and dolomite. Total carbonate ranges between 29 and 53 percent. Also frequent are quartz, microcline and albite. The clay fraction is composed of smectite, chlorite, kaolinite, illite, mixed-layers (only subordinate), and in some instances attapulgite. A common, but only minor component is hornblende. Mean size ranges from 5.1 Φ to 9 Φ. Sand varies between 0 and 41 percent, silt from 38 to 79 percent, and clay from 8 to 59 percent. The sand fraction is composed of benthic and planktonic foraminifer, pteropods, unspecified biogenic shell fragments, mica, quartz, and heavy minerals; subordinate are echinoid debris, skeletal parts of ophiura and holothurians, siliceous sponge spicules, and fragments of bryozoa.

While the first association does not contain any specific components pointing to a specific source area, the second association clearly indicates provenance from a shallow-water area. This conclusion is mainly based on the occurrence and abundance of the metastable carbonate minerals Mg-calcite and aragonite, which have also been found in Quaternary turbidites of the Messina Abyssal Plain. (Milliman and Müller, 1973; Hieke et al., in preparation).

Presently, areas of extensive carbonate productivity appear to be restricted to the northern African coast as is indicated by the studies of Caulet (1972); Fabricius (personal communication); Stoffers (personal communication); Emelyanov (1972) and Venkatarathnam and Ryan (1971). Also, identical carbonate mineral associations have been reported by Chamley (1971) from the slope off Libya. In constrast, available information on the carbonate sedimentation at the western, northern and northeastern border of the Ionian Sea is only scarce and limited to local areas. Preliminary investigations of Recent shelf sediments off the southern coast of Calabria and Apulia (Rumohr and Müller, in preparation) indicate mainly terrigenous deposits there and Mg-calcite was found only locally and in low concentrations, while aragonite appears to be very rare. From the shelf surrounding Cephalonia (Ionian Islands) Braune (1973) found Mg-calcite enrichments in the near shore areas as well on the deeper shelf (up to 10%), while aragonite was detected only in minor concentrations.

If one assumes a similar circum-Ionian pattern of carbonate sedimentation in the past which resulted in a comparable carbonate mineral association, a southern (North-African) source for the Plio-Quaternary turbidites containing large amounts of Mg-calcite and aragonite appears most likely. This is supported by the presence of attapulgite which is abundant in Tertiary soils from the north-african borderlands (Chamley and Millot, 1975). As for the non-carbonate fraction of these turbidites, consisting of quartz, microcline, and albite (and hornblende), one can assume acidic intrusive or effusive source rocks. At present no definite source can be attributed to these minerals; they prob-

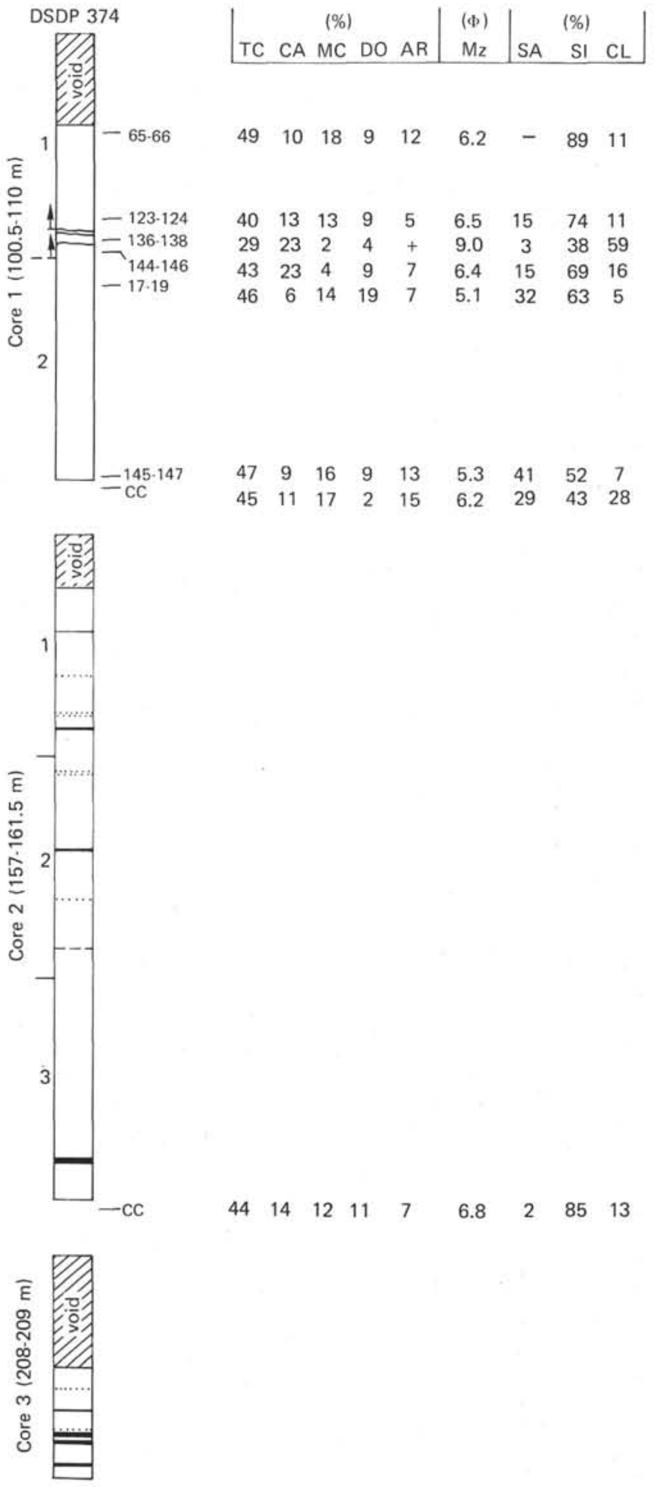

Figure 1. *Synopsis of carbonate mineralogy and grain size analyses. Core profile after visual core description (shipboard scientific party). TC = total carbonate, CA = calcite, MC=Mg-calcite, DO = dolomite, AR = aragonite, Mz = mean size (Folk), SA = sand, SI = silt, CL = clay, cc = core catcher.*

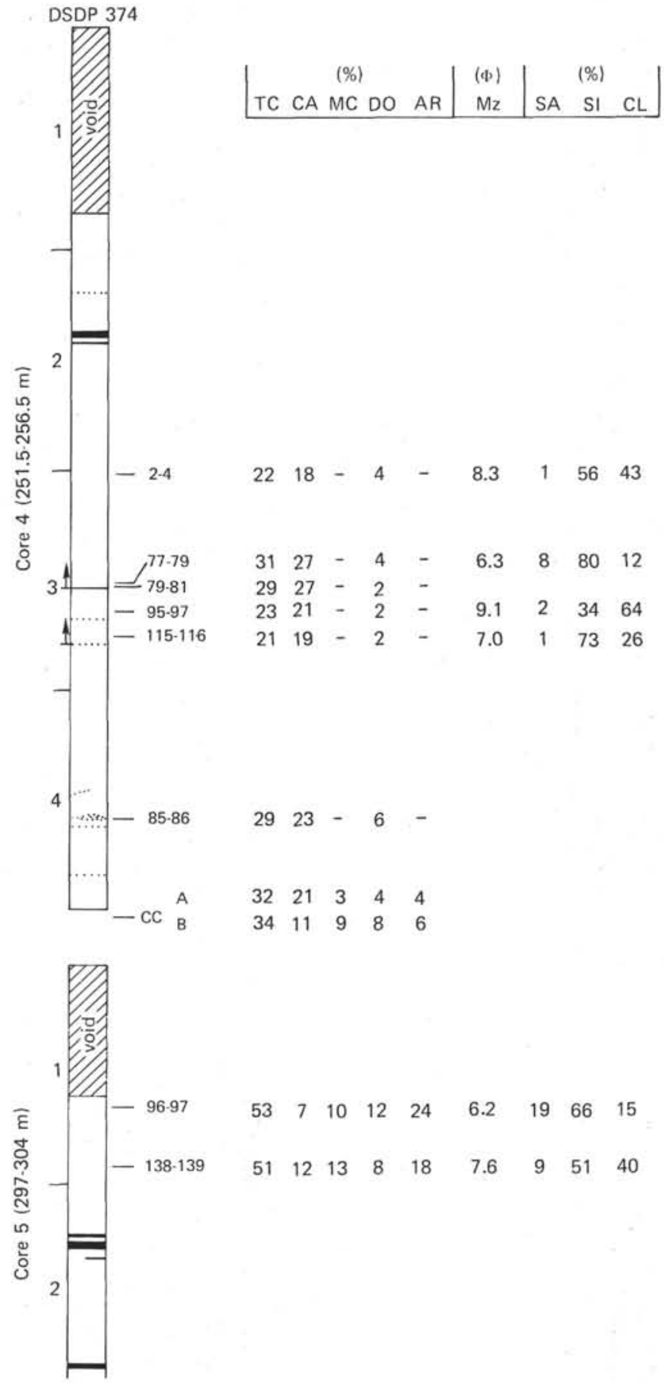

Figure 1. *(Continued).*

ably represent an eolian component within the originally shallow-water sediments.

The Pleistocene sedimentation rate at Site 374 was about 15 cm/1000 years (Cita et al., this volume). On the Mediterranean Ridge, the sedimentation rate calculated for that part of the Pleistocene sequence which can be cored by piston cores (maximum length about 16 m) is dependent on differing chronological interpretations of the climatic curves. They vary between 2.4 cm/1000 years (Cita et al., in press) and about 6 cm/1000 years (e.g., Hieke, 1976). In either case, the sedimentation rate at Site 374 is much higher than in the adjacent ridge area. If one assumes that the cored sections of Site 374 are representative of the whole Quaternary sequence, the thickness and occurrence of the clearly recognizable turbidite layers within Cores 1 to 5 are not sufficient to explain the huge sedimentation rate. Therefore, one has to expect that many of the "homogeneous" nannofossil marls and oozes of the cored Pleistocene sections of this site are in fact fine-grained turbidites. For example, a 12-meter-thick interval of sediment younger than 9000 years is interpreted as a single turbidite layer and has been found in several piston cores from the Messina Abyssal Plain (Hieke et al., in preparation). This turbidite layer contains about 11 meters of "homogeneous" silty clay.

For the Pliocene sediments at Site 374 which were cored continuously, no indication of turbidite deposition was noted by the shipboard party. Also, no distinct lithologic changes were observed in our X-ray analysis (Müller, this volume). Therefore, it can be concluded, that turbidites played no great role in sedimentation during the Pliocene. This may be supported by the low sedimentation rates as calculated for this interval: 1.3 cm/1000 years for the lower Pliocene, 5.0 cm/1000 years for the upper Pliocene (Cita et al., this volume).

CONCLUSIONS

Site 374 Pliocene sedimentation was more or less free of turbidites which contrasts strongly with a Quaternary turbidite sedimentation. Several factors have been proposed to explain this sharp contrast: (1) changes of the morphology of the Ionian Sea and the surrounding mainland (uplift or subsidence); (2) Quaternary uplift of Calabria (Hsü, personal communication); (3) conditions related to entrapment of sediment following a sudden early Pliocene flooding of a desiccated Mediterranean (Cita et al., this volume).

The "deep-basin desiccation model" assumes a more or less comparable bathymetry to the present one for the Miocene (Ryan, Hsü, et al., 1973) and with respect to this the lack of turbidites in the Pliocene sequence is surprising and difficult to explain. We think, that desiccation of the shallow coast and of parts of the upper slope during the Miocene evaporation periods should produce conditions for weathering and subsequent erosion after the refill of the basin at the beginning of the Pliocene. Cita et al. (this volume) suggest that entrapment of coarse clastic sediments occurred in estuaries after the early Pliocene submergence of the Messinian valleys and therefore there was no transport of material for turbiditic sedimentation on the Messina Abyssal Plain. We are neither aware of the presence of these postulated Messinian valleys within the circum-Ionian area nor have relicts of Pliocene estuaries been found to our knowledge, where such entrapment of coarse sediment material could have occurred. Also, the predominant type of mineral association present within the Pleistocene turbidites did not come from Pliocene estuarine environments nor represents land-derived clastic material but rather came from shallow shelfs or platforms with prevailing biogenic carbonate production.

Finally, the uplift of Calabria and/or Sicily since the Plio-Pleistocene boundary is not responsible for the onset of the dominant carbonate turbidite sedimentation in the Messina Abyssal Plain, since the Pliocene sediments of these areas do not contain carbonate mineral associations such as found in the turbidites.

Therefore, the observed change in the sedimentation regime appears more compatible with the assumption of a "shallow-basin" during the Miocene. We believe that more or less continuous subsidence of the Ionian basin (and concomittant uplift of adjacent areas) finally led to the present-day basin configuration. Apparently only near the Plio/Pleistocene boundary was the necessary morphology existent in the Messina Abyssal Plain for the onset of turbidite deposition.

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