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Project IGCP 437

Coastal Environmental Change
During Sea-Level Highstands:
A Global Synthesis with implications
for management of future coastal change

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Quaternary coastal morphology and sea level changes

Project 437

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A 26 ky paleoenvironmental and paleoclimatic record using foraminiferal and isotope constraints from a Tyrrenian Sea core.

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Introduction

A sedimentary sequence, drilled from the upper continental slope near the Ombrone River delta, provides a detailed record of paleoclimatic and paleoenvironmental changes during the last 26 kyr. Core Z145 is located about 22 Km off the Ombrone River mouth (Tuscany, Central Italy), at 150,8 m water depth (fig. 1).

This location allows us to obtain some results about bathymetric changes due to the last deglaciation; moreover, the important continental runoff determines relatively high sedimentation rates and, consequently, better time resolution with respect to the deep-sea cores.

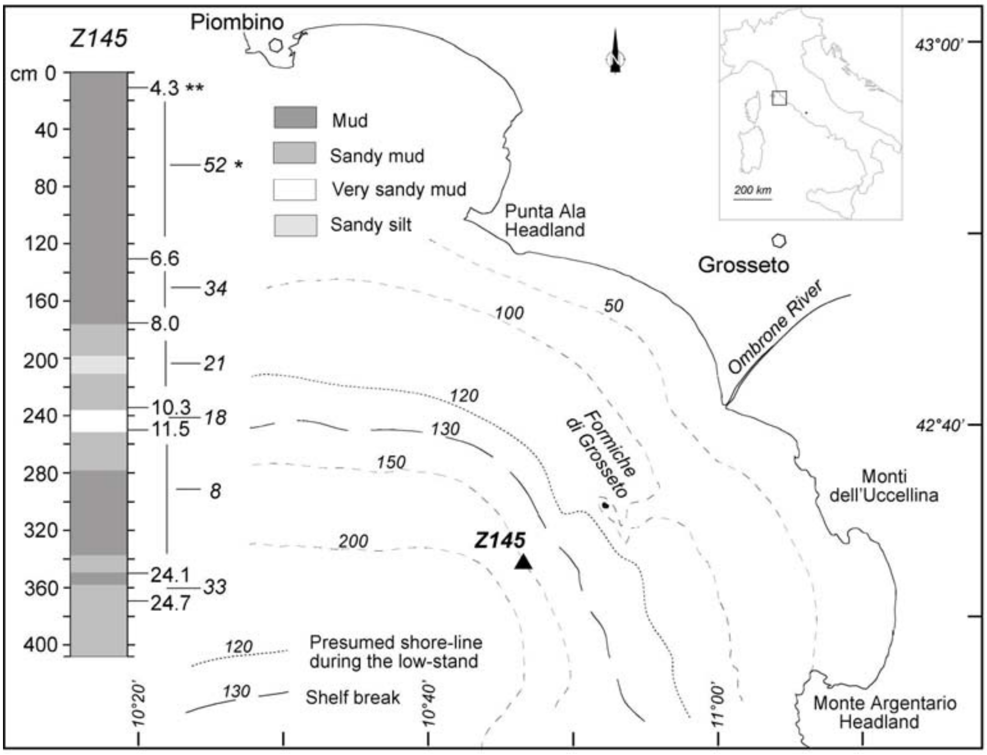

Figure 1. Location map and lithological log of core Z145. **Radiocarbon dates (uncalibrated); *sedimentation rates (cm/kyr).

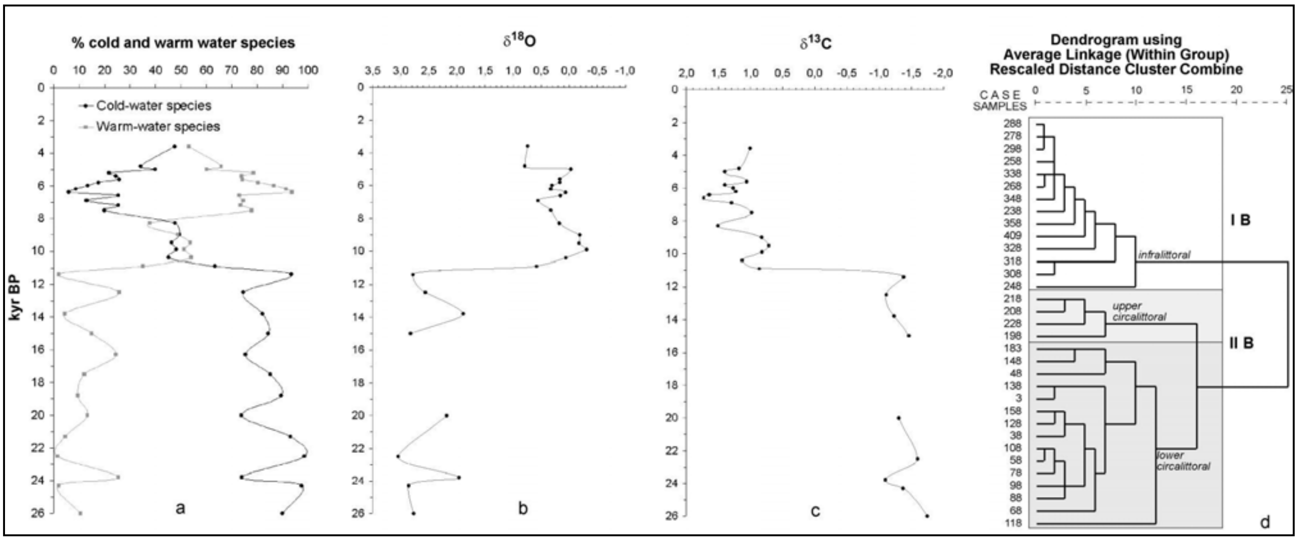

Figure 2. a) Record of cold and warm water foraminifers. b) $\delta^{18}O$ record. c) $\delta^{13}C$ record. d) Output of q-mode cluster analysis on the benthic assemblage (IB=Late Pliocene samples, IIB=Holocene samples).

As the sources of organic carbon in estuarine environments are of various origins (Müller and Voss, 1999) and since a calibration curve could be too approximate, we preferred to use uncalibrated ages (radiocarbon years BP).

The major climatic episodes of the last 26 kyr may be recognized from the changes in the foraminiferal planktic assemblage and in the isotopic records (fig. 2a, b, c). Moreover, some notices regarding the paleobathymetric evolution of basin during the glacial/post-glacial times may be deduced both from the statistic analysis on benthic assemblages (fig. 2d) and from the plankton/benthos ratio; the isotopic records and the analyses of lithological composition may give further contributions on this topic. Our proxies are in good agreement and allow us a good estimate of the sea-level rise at the YD-Holocene transition.

Paleoenvironmental and paleoclimatic reconstruction

From 26.0 to 10.9 kyr BP the dominance of cold-water species like *Turborotalita quinqueloba*, *G. bulloides* and *Globigerinita glutinata* is recognised. Such planktic assemblage is indicative of cold waters, enriched in nutrients by the Paleo-Ombrone river input (Rohling et al., 1993). These conditions are confirmed by positive oxygen isotopic values, ranging from +3.04 to +0.58‰, due both to ^{18}O-enriched seawaters and cool SST. During these times a rather steady infralittoral benthic assemblage is recognised and the plankton abundance is low and almost constant. At present, in the study area, a similar infralittoral benthic assemblage lives meanly at about -30 m (Frezza and Bergamin, 2003). Taking into account the present water depth of Z145 site (-150 m), it may be deduced that the mean relative sea level during this time span was about 120 m under the present one. The persistence of the infralittoral benthic assemblage between 26.0 and 10.9 kyr BP let us to exclude, for site Z145, bathymetric changes of several tens of meters. The $\delta^{13}C$ pattern (fig. 2c) agrees with this hypothesis, suggesting an almost invariable distance between the Ombrone River mouth and the sampling site. In fact, negative values indicate constant prevalence of continental supply. Nevertheless, brief fluctuations of the plankton curve and of $\delta^{18}O$ record could suggest minor bathymetric changes, perhaps related to meltwater pulses.

The sedimentological record confirms the paleoenvironmental framework. In the lower part of the core, from the bottom up to 252 cm, mud and sandy mud levels alternate (fig. 1). This interval represents inner shelf sedimentation, mainly provided by the Ombrone River load input. At that time, the river mouth could have been about 7 km far from the core site, probably south of the Formiche di Grosseto islands. Supposing, as at present, a northward main long-shore drift and offshore currents, this location of the river mouth could explain the presence of the terrigenous sandy particles (mainly clear quartz and micas) and also of the nutrients, testified by the planktic assemblage. At 22.5 kyr BP the Last Glacial Maximum is recognised. It is marked by the highest abundances of *G. bulloides*, *G. glutinata* and *Neogloboquadrina dutertrei* and also by the highest $\delta^{18}O$ value (+3.04‰). At 23.8, 20.0 and 16.3 kyr BP *G. ruber* shows three abundance peaks and at 16.3 kyr BP the first appearance of *Globorotalia inflata* is also recorded. Such faunal events identify some less cold climatic fluctuations as testified by low $\delta^{18}O$ peaks. The first warmer event, centred at 23.8 kyr BP, marked by the increase of *Globigerinoides ruber*, was recognized to be the base of the LGM in the western Mediterranean Sea (Sbaffi et al., 2001).

Between 15.0 and 12.5 kyr BP the Bølling-Allerød chronozone is recognised. During this time interval Orombelli and Ravazzi (1996) recognised, within the brief time span of about 800 years, two important cold episodes, the Older Dryas and the Intra-Allerød Cold Period, not evidenced by our proxies. The faunal signal seems rather out of phase with respect to the isotopic record, the last one probably reflecting more directly the SST record, probably due to the extreme swiftness of temperature changes.

The light $\delta^{18}O$ peak (+1.88‰) at 13.8 kyr BP probably identifies the Meltwater Pulse 1a (Fairbanks, 1989), taking into account that our dates are uncorrected for reservoir age.

The successive sharp increase of cold-water species (mainly *T. quinqueloba*, *Globorotalia scitula* and *G. glutinata*), which culminates at 11.4 kyr BP, corresponds to the Younger Dryas. *G. bulloides* shows an enrichment in $\delta^{18}O$ up to 2.78‰. This value is rather close to that recorded at LGM, suggesting that, during the YD, SST reached values not dissimilar to the lowest temperatures recognized during the LGM.

After the YD peak, the beginning of a rapid warming and sea level rise is recorded by the dramatic shift of faunal assemblages and by very sharp changes in the isotopic records. The near-disappearance of cold water species like *G. scitula*, *G. glutinata* and *T. quinqueloba*, the strong increase of *G. ruber*, *G. inflata* and the first appearance of *Globorotalia truncatulinoides* are contemporary recorded, suggesting a substantial temperature increase. Between 11.4 and 10.9 kyr BP the sharp lowering of $\delta^{18}O$ indicates both SST increase and isotopic marine reservoir variation due to ice melting. Moreover, the $\delta^{13}C$ record shows a strong rise, shifting from negative to positive values. This implies that the Ombrone river mouth migrated away from the core site due to the rapid sea-level rise, also testified by the strong increase in plankton abundance. Such event is also recorded by a core interval (252-232 cm) enriched in bioclasts and poor in matrix, which is bounded upwards by a sharp surface and which might be the base of the overlying transgressive sediments.Starting from 10.9 kyr BP all our proxies agree in testifying the establishing of Holocene conditions. In particular, from 9.9 kyr BP, the near equivalence between cold and warm water species is recorded.

Abundant *G. inflata* indicates homogeneous water column favoured by efficient vertical mixing, while *G. ruber* and *Globigerinoides elongatus* suggest warm stratified and oligotrophic surface waters (Pujol and Vergnaud Grazzini, 1995). The concurrent presence of such species testifies a marked seasonal contrast.

The faunal turnover from infralittoral to upper circalittoral benthic assemblage is recorded at 10.9 kyr BP; at 8.3 kyr BP the modern lower circalittoral benthic assemblage associated with the shelf sedimentation establishes. Sandy mud and mud poor in clay come mostly from the onshore sediment reworking during the sea-level rising, according with Tortora et al. (2001) and references therein. In recent times, in the study area, the faunal change that marks the transition infralittoral/upper circalittoral and upper/lower circalittoral are recorded at about –40 m and –100 m, respectively. Consequently, a sea-level rise of about 60 m may be supposed between 10.9 and 8.3 kyr BP, with the mean rate of 23 mm/yr. The high transgression rate is also testified by the isotopic compositional gaps, spanning 1.09 $\delta^{18}O$ and 1.81 $\delta^{13}C$ units, corresponding to the YD-Holocene transition. Our results are consistent with the dated points of the sea-level curve of Alessio et al. (1994), suggesting a sea level of -120 m and – 40 m at 22 and 8.5 kyr BP, respectively.

From 7.5 to 5.2 kyr BP, a clear prevalence of warm water species is recognised. This period could correspond to the sapropel S1 occurrence in the eastern Mediterranean Sea. In core Z145 sapropel levels are not recognised, but our faunal proxies show some evidence of such event. Between 6.9 and 5.0 kyr BP the clear decrease of *G. inflata* records a change in marine circulation regime from well mixed eutrophic to stratified oligotrophic waters (Rohling et al., 1993). The increase of *G. elongatus* (7.5-5.6 kyr BP) characterises sapropel conditions and, particularly, the sharp peak of *Globigerinoides trilobus* probably marks its climax at 6.2 kyr BP. Moreover, the decrease of *G. ruber* recorded at about 6.2 kyr BP could be related to low salinity layer in the surface waters rather than to a SST decrease. The $\delta^{18}O$ record did not clearly recognise the S1 event probably because *G. bulloides*, been highly dependent on food levels, probably migrated in the deeper more eutrophic layers, not exactly reflecting the superficial conditions.

Successively, the general decrease of the warm-water group should suggest a cooling trend from 4.8 kyr BP to the core top. Nevertheless, the increase of the cold-water species, mainly due to the strong increase of *G. bulloides*, probably is mostly related to the re-eutrophication of water column, with the end of stratification typical of sapropel. Even the significant presence of *G. truncatulinoides* and *G. inflata* confirms the winter convection and vertical mixing typical of the modern Tyrrhenian Sea. This apparent cooling trend is also marked by a $\delta^{18}O$ shift towards higher values, although this shift may be not entirely attributable to a temperature decrease. In fact, the isotopic variation of marine reservoir, due to the evaporation prevalence in the modern Mediterranean Sea, should have influenced the foraminifers composition.

References

Alessio M., Allegri L., Antonioli F., Belluomini G., Improta S., Manfra L., Preite Martinez M. (1994). *La curva di risalita del mare Tirreno negli ultimi 43 ka ricavata da datazioni su speleotemi sommersi e dati archeologici*. Memorie Descrittive Carta Geologica d'Italia, 52, 261-276.

Frezza V., Bergamin L. (2003). *Distribution of recent benthic foraminifers in the Ombrone River Basin (Tuscany continental shelf, Tyrrhenian Sea, Italy). Relations to fluvial run-off.* In: M. Kaminski (Ed.), Grzybowski Foundation, in press.

Fairbanks R. G. (1989). *A 17 kyr glacio-eustatic sea level record: influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation*. Nature, 342, 637-642.

Muller A., Voss M. (1999). *The palaenvironment of coastal lagoons in the southern Baltic Sea, II. $\delta^{13}C$ and $\delta^{15}N$ ratios of organic matter – Sources and sediments*. Paleogeogr. Paleoclimatol. Palaeoecol., 145, 17-32.

Orombelli G., Ravazzi C. (1996). *The Late Glacial and Early Holocene: chronology and paleoclimate*. Il Quaternario 9(2), 439-444.

Pujol C., Vergnaud-Grazzini C. (1995). *Distributrions patterns of living planktic foraminifers as related to regional hydrography and productive systems of the Mediterranean Sea*. Mar Micropaleontol., 25, 187-217.

Rohling E. J., Jorissen F. J., Vergnaud-Grazzini C., Zachariasse W. J. (1993). *Northern Levantine and Adriatic Quaternary planktic foraminifera; Reconstruction of paleoenvironmental gradients*. Mar. Microplaleontol., 21, 191-218.

Sbaffi L., Wezel F. C., Kallel N., Paterne M., Cacho I., Ziveri P., Shackleton N. (2001). *Response of the pelagic environment to palaeoclimatic changes in the central Mediterranean Sea during the Late Quaternary*. Mar. Geol., 178, 39-62.

Tortora P., Bellotti P., Valeri P. (2001). *Late-Pleistocene and Holocene deposition along the coast and continental shelves of the Italian peninsula*. In: Vai G. B., Martini I. P. (Eds.), *Anatomy of an Orogen: Apennines and Adjacent Mediterranean Basins*. Kluver Academic Publisher, New York, pp. 455-478.

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Coastal geomorphology and human interference along the eastern shores of Attica, Greece

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Keywords: *Coastal geomorphology, human interference, East Attica, Greece, Late Holocene*

Abstract

The study area is located along the eastern coastal at the peninsula of Attica and has undergone major changes during the last decades which have modified completely the coastal environment in lowland areas. The aim of this study was to determine the changes that have taken place in the coastal natural environment by human interference following the intensive development of summer residence.

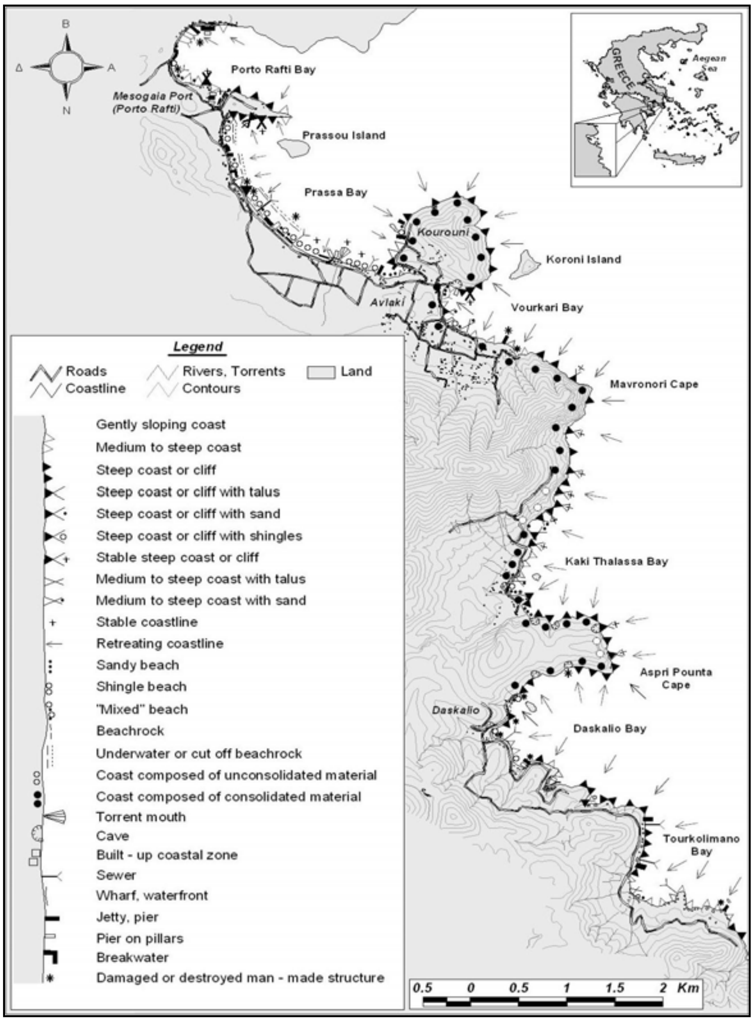

Figure 1. Coastal geomorphological map of East Attica, between Daskalio and Porto Rafti.

The southern most part of the peninsula of Attica presents a complex geotectonic structure. The autochthonous Jurassic system composed mainly of marbles with intercalations of schists is overthrust by the allochthonous upper Cretaceous system of limestones schists with phyllites and again limestones. In addition to these we have Quaternary terrestrial and fluvial-terrestrial deposits and Holocene coastal sediments.

The coastal geomorphology of the study area is characterized by medium to steep slopes with several pocket beaches of a few tens of meters to more than a kilometer (Prassa Bay, Daskalio) (Fig. 1). The steepest coasts are encountered in areas where the limestones reach the sea and are intensely eroded. Schist and phyllite coasts are usually less steep. The predominant coastal sediment particle size is shingle with some sandy beaches at wind-protected bays (Avlaki). At some very steep slopes there are many fallen rocks, indicative of active erosion and retreat of coastline. An extensive part of Prassa Bay is lined by two beachrocks, an older semi-submerged one detached from the present coastline and a more recent on the shore.

In most cases the study area is eroding today but retreat rates vary significantly depending on the material that the coast is composed of (limestones vs. unconsolidated materials). A few caves have formed in some steep limestone coasts where erosion is more intense.