Assessment of micropaleontological sedimentary parameters as proxies of surface water properties in Gavdos Island, Eastern Mediterranean

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Keywords: planktonic foraminifera, surface water conditions, early Late Miocene

Introduction

Our understanding of paleoclimatic variability has been considerably increased by the many recent studies of global climatic change (Imbrie et al., 1984; Chappell et al. 1986; Barnola et al., 1987; Edwards et al., 1987; Bond et al., 1993; Winograd et al., 1997; Dansgaard et al., 1993; Jouzel et al., 1993; Rossignol-Strick, 1995; Bar-Matthews et al., 1997). It is well appreciated that the climate system is complex and is affected by forcing factors and feedback related to polar ice bodies and to oceanic and atmospheric circulation. The signals registered by changes in abundance and distribution of fossil micro-organisms represent one of the most powerful tools in many environmental reconstructions, and in the Mediterranean region they provide a reliable and well-documented record at both global and local scales. The eastern Mediterranean has been the focus of intensive studies during the last decades. The crucial importance of this small and marginal basin is in its capability to register and amplify the smallest climatic variations occurring at the mid-latitude regions. Oscillations in sea surface temperature, stability of the water column and the rate of nutrient supply to the euphotic zone, driven by changes in Mediterranean climate had a profound impact on the foraminifera assemblages. In particular, changes in abundance and distribution of planktonic foraminifera species can provide a reliable and detailed record for paleoclimatic reconstruction.

The geographical distribution and abundance of planktonic foraminifera are controlled by their biology and by environmental parameters such as temperature, salinity and nutrient content of the surface water in which they live. Late Miocene variations of these parameters are being estimated by quantitative analysis of planktonic foraminiferal assemblages in sediments.

In this work we analyse the planktonic foraminiferal fauna in three sections from the early Late Miocene of Gavdos Island, Eastern Mediterranean. Through this study, we attempt the reconstruction of the Eastern Mediterranean surface to deep-water hydrographic changes.

Methodology

The succession of paleoenvironments and foraminifera assemblages is analyzed from three sections (Potamos, Ag. Giannis, Bo) from the Lower Tortonian in Gavdos island which forms the southernmost extension of the south Aegean Island Arc. In order to gain a better understanding of the environmental factors controlling the distribution of faunal parameters we carried out quantitative and statistical analysis on planktonic foraminifera assemblages in order to demonstrate the linkage between taxa distribution and paleoenvironmental gradients.

Specimens of planktonic foraminifera were picked from one split per fraction for each sample, identified and counted. Raw data of microfossils were then transformed into percentages over

the total abundance and abundance curves were then plotted. Species with phylogenetic affinities and similar environmental gradients were also grouped to better interpret distribution patterns. In addition taxa at the species or genus level that amounted to <2% averaged across the data set were removed from the data matrix so that the statistical analyses of the data were based on the common and abundant taxa.

We measured P/B ratios, which can be regarded variously as a measure of depth of deposition, a paleoproductivity index or as measure of preferential loss of planktonics by dissolution. Paleobathymetry was calculated for each sample by introduction P/B ratios based on epifaunal species in the equation of van der Zwaan et al. (1990).

A Principal Component factor Analysis using the varimax method is implemented. A species proportion matrix was prepared from raw assemblage counts. R-mode analysis, where species are compared with each other for all the samples is employed for biofacies analysis. In the interpretation of the dendograms, successively lower-order clusters were grouped together until faunal differences between clusters were readily discernible and of likely ecological significance within the resolution of the interpretive technique used in this study. The paleoecological approach uses the available data on recent foraminiferal assemblages from the Mediterranean. These characteristics on foraminifera can provide assessments, at varying levels of accuracy of water depth, nutrient supplies, bottom water conditions and salinity.

Results

The abundance trends of major planktonic foraminiferal species and groups suggest a change in benthic foraminiferal composition through time. The most important planktonic constituents are *Globigerina bulloides*, *Neogloboquadrina acostaensis*, *Neogloboquadrina atlantica, Globigerinoides obliquus - Globoturborotalita apertura* group, *Globigerinoides trillobus* and *Globoturborotalita nepenthes.*

The R-mode cluster analysis evidences four main clusters each corresponding to groups of species with similar environmental preferences.

The *G. obliquus-apertura* group assemblage is composed of tropical or subtropical species and represents a surface or subsurface dwelling assemblage (Hemleben et al., 1989). It characterizes high summer insolation and strong surface water stratification with winter temperatures not high enough to allow eutrophic foraminifera to grow. The abundance of *G. obliquus-apertura* assemblage together with the absence of Neogloboquadriniids is characteristic of nutrient-depleted, well-stratified surface waters where the pycnocline is located below the base of the eutrophic layer, suggesting that deep water stagnation occurred prior to the appearance of stratification in surface waters, that favor the growth of warm-oligotrophic foraminifera.

The *N. acostaensis* assemblage is indicative of stratification, with colder winter temperatures and a nutricline above the euphotic layer (Hemleben et al., 1989).

The *G. bulloides* assemblage is composed of subpolar to transitional species living in surface or subsurface waters (Hemleben et al., 1989; Reynolds & Thunnell, 1985). It tolerates a very large temperature range and lives in medium salinity and nutrient rich waters characterized by vigorous vertical mixing or upwelling. It has been related to dryer climates in the Mediterranean at times of low summer insolation when high salinities and high temperatures in winter surface waters contributed to destabilize the water column, inducing deep water convection and upwelling of nutrient-rich waters to surface.

The *G. trilobus* assemblage proliferates in warm, nutrient poor waters (Hemleben et al., 1989). It tolerates seasonal changes in the water column and reflects the sea surface nutrient conditions in terms of paleoceanographic applications.

The distribution pattern of the planktonic foraminiferal assemblages of the early Tortonian deposits of Gavdos Island allow us to show the paleoenvironmental changes during that time interval. The occurrence of planktic species (*Globorotalia* spp., *Globigerinoides* spp. *Neogloboquadrina* spp.) indicates open marine conditions, which have been disrupted by episodes of water stratification. The local high frequency of *G. bulloides* assemblage indicates increased

food availability. The foraminiferal assemblage data does not indicate an increase in freshwater input. We therefore suggest the establishment of a small upwelling cell, probably as a result of wind strengthening.

Conclusions

Quantitative studies of microfossils are carried out in three sections of Gavdos Island to establish proxies' relationship with selected paleoenvironmental factors. The Principal Component Analysis (varimax) yields several factors scoring degrees of similarity between different foraminiferal groups. Variations in the dominant groups probably reflect short-term oscillations. The cancelate *Globoturborotalita-Globigerinoides* group tends to have flourished during warmer periods while the spinose *Globogerina bulloides* group became more abundant in cooler times. The study of past productivity in Gavdos Island has been based on changes in the relative abundance of a single species *G. bulloides*. Productivity reconstructions from changes in the abundance of *G. bulloides* are not satisfactory because increases of other species are also induced by enhanced productivity.

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