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Multi-proxy Analysis of the Corinth Isthmus Pleistocene Sediments: a case study of paleoenvironmental reconstruction in a tectonically active domain

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Introduction

Fossil associations are an essential tool for studying past sea-level changes in coastal areas (e.g. Pallikarakis *et al*., 2018). The Corinth Isthmus located at the eastern part of Corinth Gulf is influenced both by glacioeustatic sea level changes and tectonic movements, resulting into a complex lithostratigraphic pattern (e.g. Freyberg, 1973; Collier, 1990; Pallikarakis *et al*., 2018). The study area is controlled by major fault structures such as the South Alkyonides fault zone, the Loutraki, the Agios Vassileios and the Kenchreai faults and by shorter local faults, like the Kalamaki–Isthmia fault (e.g. Roberts *et al*., 2009; Papanikolaou *et al*., 2015). As a result the Corinth Isthmus is constantly uplifted 0.3 mm/yr during at least the last 200 ka (Collier *et al*., 1992; Dia *et al*., 1997). The sedimentary facies in Corinth Isthmus consists of marls, sandstones and conglomerates representing offshore, shoreface and coastal paleoenvironments, organized in six transgressive-regressive cycles ranging from marine isotope stages 11 to 5 (e.g. Freyberg, 1973; Collier, 1990; Pallikarakis *et al*., 2018).

Materials and Methods

An approximately 70 m deep borehole core (Bh-3) extracted at 19.20 m above the present sea level, is characterized by lithological alternations of clay, marl clayey sand, sand, sandstone, conglomerate and soil horizons reflecting low-energy to high-energy depositional environments. Fifty five samples extracted from the sedimentary sequence have been analyzed for their micropaleontological content, following standard procedures (e.g. Triantaphyllou *et al.*, 2010). Foraminiferal species have been subjected into two-way cluster analysis to highlight biofacies. Thirteen samples of fine-grained sediments were examined by Scanning Electron Microscopy (SEM) for their calcareous nannoplankton content. Furthermore magnetic susceptibility (MS) within the core was measured with the Bartington MS2 system with the MS2K sensor, where sixty one MS measurements have been carried out from various lithological alternations within the core.

Results and Discussion

Fourteen benthic foraminiferal taxa comprised more than 90% of the total assemblage (e.g. *Ammonia* spp., *Elphidium* spp., *Discorbis* spp., *Asterigerinata* spp., miliolids). Based on the microfossils analysis three distinctive clusters have been described as separate biofacies. Cluster I indicated shallow marine assemblage (regional estimated sea paleodepth ~40 m), Cluster II indicated lagoon assemblage (regional estimated sea paleodepth ~0-20 m) and Cluster III was associated with a shallow marine assemblage with fresh water influence (regional estimated sea paleodepth ~20-40 m). The identified calcareous nannoplankton specimens were dominated by the presence of small *Reticulofenestra* spp. (~40%) and small *Gephyrocapsa* spp. (~30%) coccoliths, while *Emiliania huxleyi* species was relatively scarce (5-8% of the total assemblage), but consistently present. Furthermore the magnetic susceptibility in Bh-3 sediments ranged from 1 to 207 ×10-5 (SI units), where clayey and fine coarse sediments displayed lower MS signal than gravely and coarse sediments.

Based on the lithological, microfaunal and MS analysis, the paleoenvironment and the palaeobathymetry within the borehole were interpreted, describing successions of lagoonal to shallow marine deposits (highstand) with terrestrial deposits (lowstand). Within the borehole core five successive sedimentary sequences have been defined, indicating the onset of transgressive-regressive (T-R) conditions. Correlating the glacioeustatic sea level change curve of Siddall *et al*. (2003) with the uplift rate 0.3 mm/yr for the Corinth Isthmus area (e.g. Collier *et al*., 1992; Dia *et al*., 1997), it appears that marine deposits would have been expected to be preserved during the high stands within MIS 5.5, 6.5, MIS 7 and MIS 9 with maximum depths ranging between ~20 and 80 m (e.g. Siddall *et al*., 2003), while the study area is expected to be emerged above sea level during MIS 2.21, MIS 6.0 and MIS 7.0. Transgressive stacking patterns therefore, would have been expected to be deposited during the high stands MIS 5.5, 6.5, 7, 9.

The continuous existence of *E. huxleyi* throughout the borehole core indicates that depositional ages are younger than 265 ka (e.g., Raffi *et al*., 2006), limiting the marine sedimentation to MIS 5.5, MIS 6.5 and MIS 7 high stands. Three possible scenarios can describe the sedimentation processes. In the first scenario, the entire sequence can be associated with the MIS 7 highstand, where marine sedimentation processes are interrupted by terrestrial sediments due to relative sea level fluctuations associated with the sub-stages MIS 7.1, 7.3, 7.4 and 7.5. In the second scenario the described sediments are correlated with MIS 5.5 and MIS 7, while the third scenario involves sedimentation in all three possible MIS periods (MIS5.5, MIS 6.5 and MIS 7). Scenarios 2 and 3 are relatively similar and can be distinguished only by absolute dating data. The third scenario is considered as the most favorable to describe the sedimentation processes based on the described sea water paleodepths within the core (Pallikarakis *et al*., 2018) and the modeled shoreline elevations described in Papanikolaou *et al*. (2015).

Conclusions

Through multi-proxy analysis of the borehole core the paleoenvironment has been described, where based on two way cluster analysis of the foraminiferal assemblages three distinct biofacies were described, Cluster I (shallow marine), Cluster II (lagoonal) and Cluster III (transition from lagoon to shallow marine conditions). The presence of *E. huxleyi* (NN21a biozone), indicates that Bh-3 sediments are younger than MIS 8. Based on the glacioeustatic sea level changes, along with the measured uplift rate of the area, MIS 7, MIS 5.5 and possible MIS 6.5 highstands are described in the eastern part of the Corinth Isthmus.

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