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Palaeoenvironmental evolution of Rio basin during the Middle Pleistocene

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Study area

The structural grain of Greece is traversed by a 140-km-long system of grabens that includes three members namely the Corinth graben in the east, the Patras graben in the west and the bridging with the Rion graben in the middle (Doutsos et al. 1988). Rio graben is an asymmetric graben with a NE trending Peloponnesian border fault hosting significant offset between the mainland of Greece and NW Peloponnesus (Kontopoulos & Zelilidis 1997). The basin is severely tectonised by a dense fault array comprising WNW normal faults and NE-trending transfer faults (Doutsos et al. 1988).

Rio basin is also a region of significant stratigraphical and palaeontological interest. For this reason, several authors have studied sediments from NW Peloponnesus trying to address the geological evolution of the recent past and proposed different ages and palaeoenvironmental interpretations. The study area is located between the villages of Sychena and Velvitsi on the west side of Charadros River and the name of the studied section is Vigla. The purpose of this work is to determine the sedimentary environments and the palaeo-ecological conditions of the studied section and to unravel the Middle - Upper Pleistocene environmental changes.

Material and methods

Microfaunal analyses were carried out on 121 samples collected every 20-40cm from a natural section in the area of Vigla (east of Sichena village) with a total thickness of about 34 meters. Sediment samples were washed through 500 and 63 μm mesh sieves. When abundant microfaunal elements were present, a combined total of 300 specimens of benthic foraminifera and ostracod tests were collected. Out of the 121 sediment samples, 88 contained sufficient numbers of specimens for quantitative analyses and 33 were barren or contained scarce specimens (<10%). Species and their ecological characteristics were mainly determined based on previous studies of Mediterranean benthic taxa (Cimerman & Langer 1991, Relative volumes of Stereo-atlas of ostracod shells). Species were grouped based on their ecological characteristics and relative abundance diagrams were prepared for each group. Furthermore, 2 smear slides were produced for sediments of marine orgin in order to investigate the presence of calcareous nannofossils.

For statistical purposes, the data matrix was standardized to percentages of the entire sample. Four measures of species diversity were calculated: (1) species richness (S), (2) Simpson's index (1-D), (3) the Shannon–Wiener index [H(s)] and (4) the evenness index, using the PAST3 software (Hammer et al., 2001; version 3.19, 2018). Cluster analysis was run for samples (Q mode) and different outputs of the dendrogram have been compared in order to find the most homogeneous clusters or groups. In addition, correspondence analysis (CA) was also used to correlate taxa and samples. Furthermore, stratigraphic columns were produced. The colors of the depicted layers in the columns were selected based on the Munsell colour system. Sediments were analysed in situ and Munsell colour notations were collected with the use of a Minolta CM-2002 reflectance spectrophotometer.

Results

In order to check the continuity of the layers we collected samples from three closely spaced well exposed sequences from the same area (Fig. 1). Through the micropalaeontological analysis, four different facies were identified. This allowed us to establish the presence of two normal faults and a disconformity that intercept the sequences. For this reason, in this study, the results are expounded separately for Sequence 1, 2, 3 and 4 (Fig.1). As a general picture, microfossils were abundant in the samples from Sequence 2 and 3, whereas they were scarce or absent in the samples from Sequence 1 and Sequence 4 was barren.

- Sequence 1 has a total thickness of 1110 cm and is mainly composed of olive green silts. According to the microfaunal analysis, 4 ostracod taxa have been identified in the studied samples and the total absence of benthic foraminifera is remarkable. Based on the percentage abundance diagrams, statistical analysis and the microfaunal composition of the layers of Sequence 1, six main units (1-6) can be distinguished, 3 of which are barren (Units 2-4-6). The microfauna of this section reflects a primarily brackish environment.
- Sequence 2 is mainly composed of gray clays and silts and has a total thickness of 1200 cm. This sequence is rich in micro- and macrofauna as well. According to the microfaunal analysis this section is composed of 28 different taxa of benthic foraminifera and 20 different ostracod taxa. According to the relative abundance diagrams and statistical analysis as well, for this Sequence there is a clear division into two main units, a brackish and a marine unit After calcareous nannofossil analysis from the marine unit's sediments, *Emiliana huxleyi* was identified.
- Sequence 3 is mainly composed of grey silts nevertheless at the upper part the grain size increases to sand. This sequence has a total thickness of 1855 cm and is rich in micro and macro fauna as well. Based on the microfaunal analysis, 11 different ostracod species and 7 different foraminifera species were identified. Based on the percentage abundance diagrams and the micro-faunal composition of the layers of Sequence 3, three main units that reflect a primarily brackish environment can be distinguished.
- Sequence 4 constitutes the last 8 meters of the section. This sequence consists of a massive, mainly matrix supported

barren red conglomerate that overlies uncomformably the sediments of Unit 3.

Discussion

Detailed analyses of benthic foraminifera and ostracoda of a 33.60 meters section have been performed. The employed micropalaeontological analysis and the respective statistical methods that were used, indicate that the microfaunal assemblages of the lower sequence 1 reflect a low salinity lagoon environment. The remaining part of the sequence 1 corresponds to a lagoon with low salinity and freshwater influxes. The microfaunal assemblages of this part of this sequence, reflect the continental-end member of a lagoonal environment. In Sequence 2, the fauna of the lower unit is characteristic of a lagoon with periodic freshwater influxes. The upper part of this section has been characterised as marine. The marine unit can be separated further into two subunits, an open lagoon with good connection to the open sea and a shallow marine environment. In conclusion, the first 4 m of Sequence 2 are indicative of a lagoon ecosystem, but the remaining part of the section is indicative of a closed gulf. At Sequence 3, the main part is indicative of a restricted lagoon with high salinity water influxes that changed gradually to an open lagoon and later again to a closed lagoon. It has been observed that there are repetitive environmental changes from brackish to more or less marine environments, especially between Sequences 2 and 3. The last sequence overlies uncomformably the other three sequences. Sequence 4 is barren of micro or macrofauna and indicates an alluvial fan environment.

The palaeonvironmental changes that have been recorded in our study area are the result of eustatism and tectonism as well. Hence, the uplift or subsidence events that took place during the middle and late Pleistocene control the evolution of the palaeoenvironments and the depositional history across the Rio basin.

Based on the stratigraphic analysis of the studied section, Vigla presents roughly the same stratigraphic features with Aravonitsa-Location 11 that Palyvos et al. (2010) described. According to them at the base of MNN21a Corinth Gulf was expectedly a lake, isolated from the sea by a sill. The lowest occurrence of *E. huxleyi* in the Corinth Gulf is expected at the MIS7e highstand, as only then sea water with *E. huxleyi* had the chance to enter the gulf. The presence of *E. huxleyi* in Vigla section and its stratigraphic resemblance with Aravonitsa 11, lead us to conclude that this highstand affected both the western part of Corinth Gulf and Rio Basin as well.

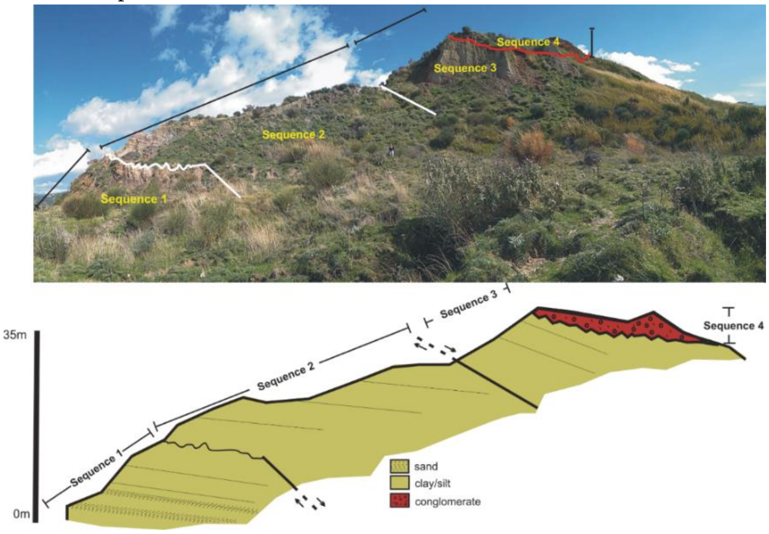

Figure 1. Figure and schematic section of the studied section with depiction of sedimentary sequences. With white line are symbolized the faults and with red disconformity.

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