Micropalaeontological study of sediments from Sichaena, Achaia, Greece and geometric morphometrics of Cyprideis torosa

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Introduction

The study area is located at Sichaena, Achaia, Greece (Rio basin, Corinth Rift) (Fig.1). This study aims to record the morphological differentiation occurring in the common ostracod taxon *Cyprideis torosa* due to palaeoenvironmental changes, using Geometric Morphometric methods. Species of the genus *Cyprideis* have been the focus of many ecological and biological studies (e.g. Van Harten, 1975, Wouters, 2002, Ligios and Gliozzi, 2012). *C. torosa* is of particular interest due to its wide geographical and stratigraphic distribution as well as its ability to live in waters of varying salinity. Although *C. torosa* has been found in a wide range of environments, it is generally extremely sensitive to general environmental changes, and not just salinity. Changes in the shape, size, decoration of the shell or the size of its population, also indicate changes in the environmental conditions of its habitat.

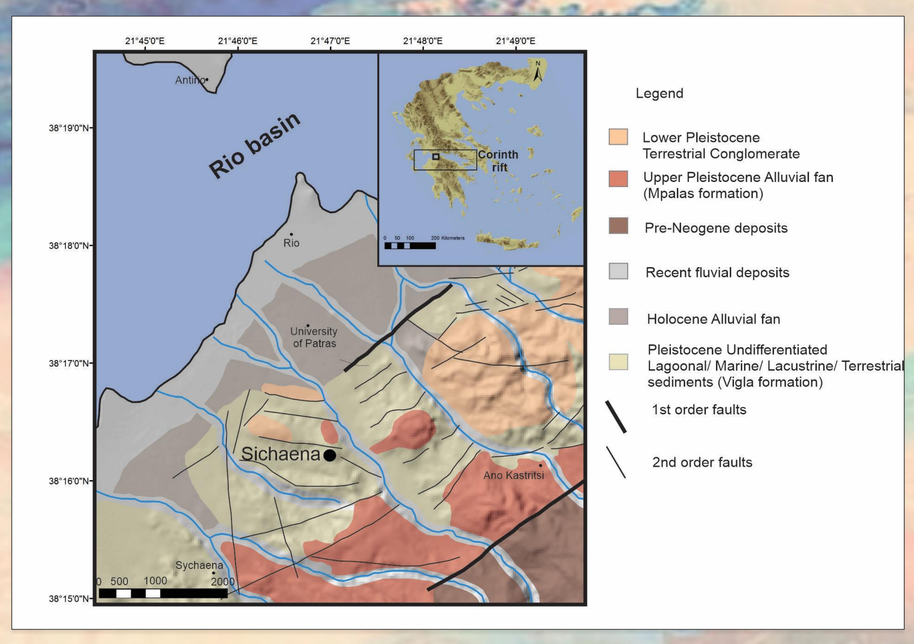

Fig.1. Geological map of the study area.

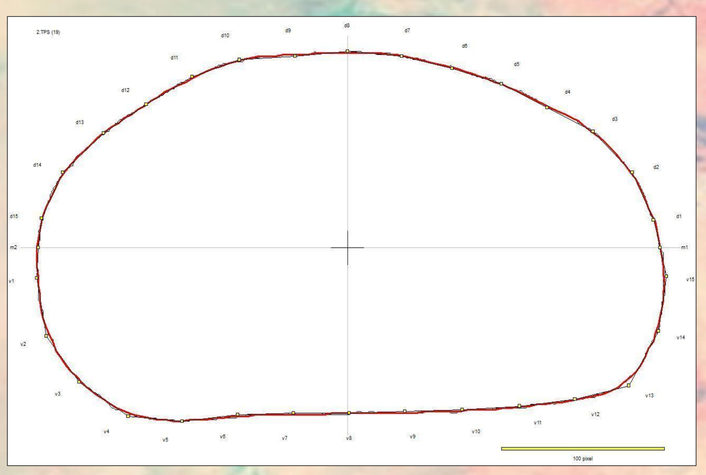

Fig.2. Digitized outline of a right valve of *C. torosa* adult female as divided from Morphomatica software.

Methodology

- ✓ 79 samples were collected from Sequence C (16 m long) at 10-30cm intervals.
- ✓ 30 right valves of *C. torosa* adult females were collected (90 valves in total) from each unit.
- ✓ Digitization and calculation of the samples' coordinates was carried out using Morphomatica software. A typical example of digitization and placement of border coordinates is shown in Figure 2.
- ✓ The total coordinates of the 90 valves from the 3 study units were statistically processed using PAST (v. 4.08).

Results

- Palaeoenvironmental changes: The results of the micropalaeontological and statistical analyses imply generally a semi-closed lagoonal environment with a significant freshwater input and an increased marine water influence. According to relative abundance diagrams (Fig.3), Sequence C, which was deposited during MIS stages 7a and 7b, i.e. 200,000 - 210,000 years ago (Tsoni, 2021), is separated into four environmental units (Fig.3).
- Differentiation of *C. torosa*: The most important element given by the PCA analysis derived from the Loadings plot diagrams (Fig.4 - 5) for the two main influencing factors, which revealed a change in the posterior and anterior part of the valve (Fig.6). Discriminant Analysis of the valves outlines, based on shape, provided a distinct distribution where the valves' outlines are separated into 3 groups, which clearly coincide with the 3 study units (Fig.7)

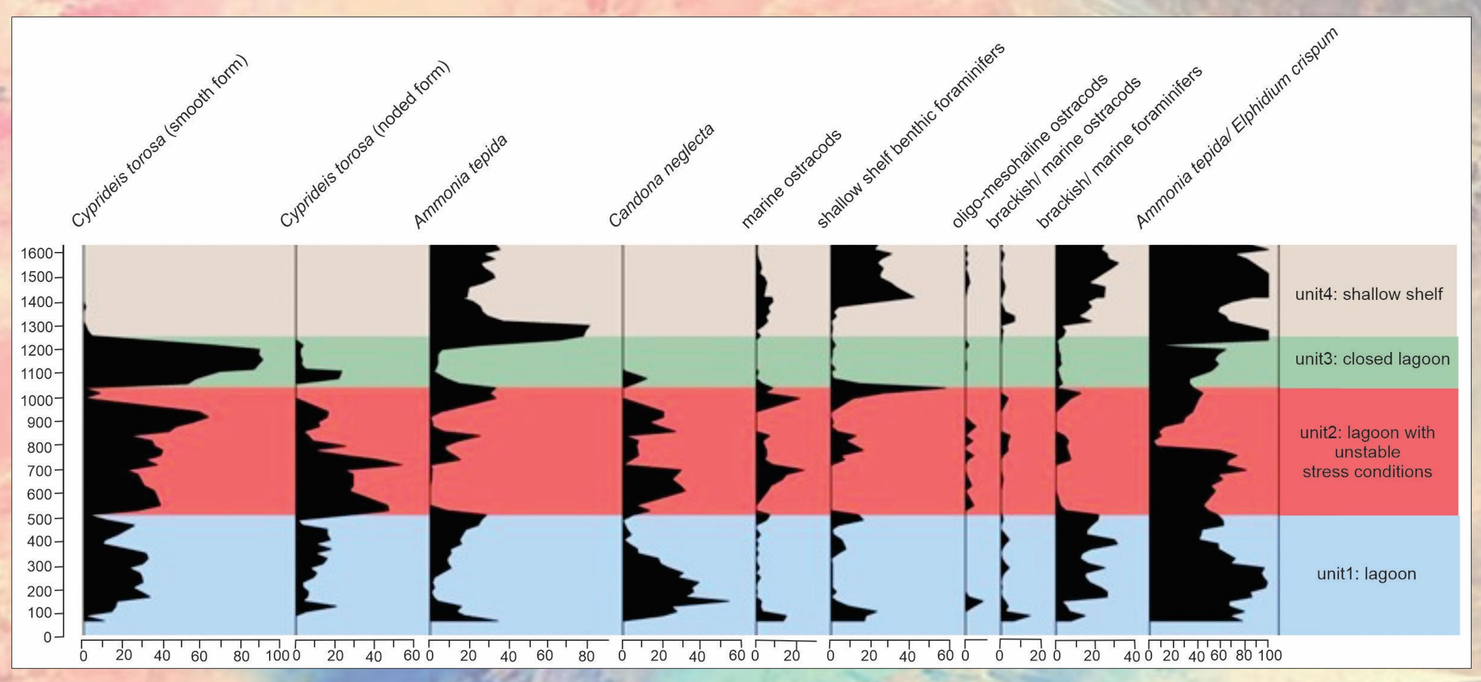

Fig.3. Relative abundance diagrams of ostracod and foraminifera taxa of Sequence C using C2 software (v. 1.7.7).

Discussion

Unit 1 (in blue) appears as a balanced lagoon environment with significant influence of both fresh and sea water being in proximity to the sea. Unit 2 (in red) appears to be in intermediate condition as it is affected by both freshwater and sea factors with species accumulations and oxygen levels indicating environmental stress conditions. Unit 3 (in green) shows an environment clearly characterized by brackish conditions, which appears to have been almost completely cut off from both freshwater and marine influence. In addition, based on Discriminant Analysis, we conclude that the x-axis factor describes the distance from the sea and the y-axis factor describes the increase in salinity and/or oxygen levels. This study comes to confirm results of previous research (Grossi et al. 2016, Gliozzi et all, 2017) indicating that morphological changes in the valves' outline of *C. torosa* should be considered as another echophenotypic characteristic of the species associated with salinity fluctuation, comparable to the development of nodes, a well-known reaction of *C. torosa* to stress conditions related to osmoregulation (Frenzel et al., 2012).

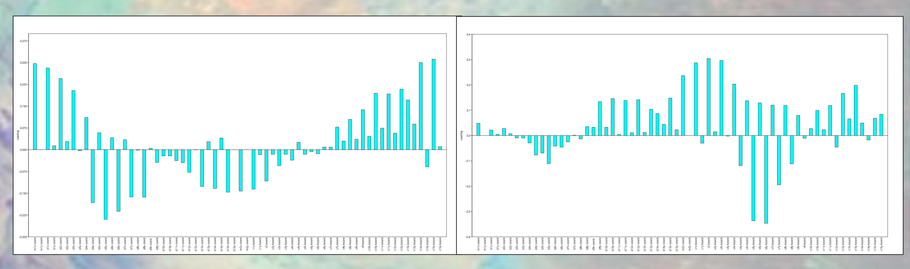

Fig.4. PCA Loading plot of the first influencing factor.

Fig.5. PCA Loading plot of the second influencing factor.

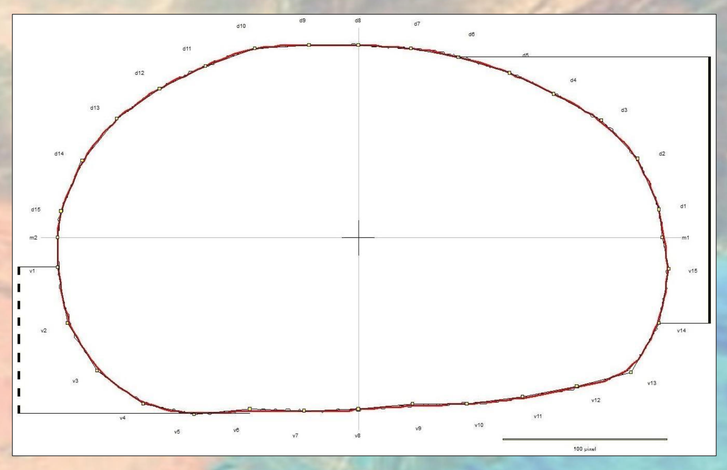

Fig.7. Discriminant Analysis shows the distinction between the 3 Units and the two main influencing factors

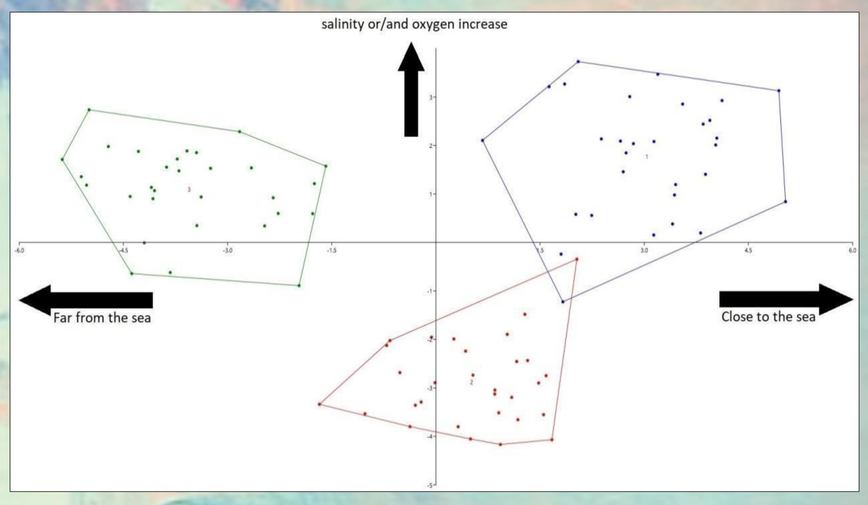

Fig.6. Differentiation in the length of the valves. Differences are located in the posterior and anterior part of the valves.

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