Was the Mediterranean Sea during the Calabrian (Early Pleistocene) a low seasonality environment?

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INTRODUCTION

Understanding past seasonal temperature variability in the ocean is essential to evaluate the effects of future climate change on marine ecosystems. It is assumed that the simultaneous occurrence of boreal (e.g. Arctica islandica) and warm-water species in the Mediterranean Sea during the Pleistocene can be explained by high seasonality (ca. 10°C; Raffi, 1986).

Progressive climatic deterioration enabled boreal guests to periodically enter the Mediterranean Sea starting at around 2.0–1.8 Ma (e.g. Crippa and Rainieri, 2015).

We investigated the variability of seasonal water temperature amplitudes by means of stable oxygen isotope data ([δ¹⁸Oshell]) of the bivalve Arctica islandica.

CHECK FOR DIAGENESIS

Confocal Raman microscopy prior to isotope geochemical analysis was performed to detect potential diagenetic alterations (e.g. from aragonite to calcite; Beierlein et al., 2015).

- Single-spot measurements were performed on a WITec alpha 300R (diode laser with an extinction of 488 nm) using WITecControl software.
- Conclusion: Studied shells did not show diagenesis (Fig. 1).

BIOSTRATIGRAPHY AND δ¹⁸Oshell MEASUREMENTS

Fossil valves of the bivalve Arctica islandica were collected from three Pleistocene successions (middle-late Calabrian) in Central and Southern Italy (Mediterranean Sea; Fig. 2).

Biostatigraphic analysis indicates the following ages:
- Tacconi Quarry deposits (Rome): 1.6 to 1.2 Ma.
- Augusta (Sicily) and Cutrofiano (Lecce): 1.1 to 0.62 Ma.

Shell-cross sections were prepared and stable oxygen isotope (δ¹⁸Oshell) values were derived by means of micro-milling and isotope ratio mass spectrometer. Paleotemperatures were reconstructed using Grossman and Ku (1986) equation, as modified by Dettman et al. (1999).

CONCLUSIONS – SEASONALITY BY δ¹⁸O

Stable oxygen isotope profiles of eleven fossil A. islandica shells depict relatively low seasonality scenario → δ¹⁸Oshell amplitudes vary between 0.4‰ and 1.6‰ (Fig. 3A) implying a reconstructed intra-annual water temperature amplitude of 1.7°C to 4.8°C.

Reconstructed average water temperature for the Sicilian population (nine values) is 9.5±0.5°C based on the assumption of a δ¹⁸Owater value of 0.9±0.1‰ (c.f. Crippa et al., 2016) → coincides well with temperature requirements for modern A. islandica.

Average δ¹⁸Oshell amplitude of 0.66‰ indicates a seasonal variation of 3°C → low seasonality scenario (Fig. 3B).

Lack in seasonality and high abundance of boreal species → middle-late Calabrian was characterized by a maximum glacial phase when relatively constant water temperatures prevailed throughout the year.

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