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** ($^{18}\delta O_{shell}$) of the bivalve ***Arctica islandica***.

CHECK FOR DIAGENESIS

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

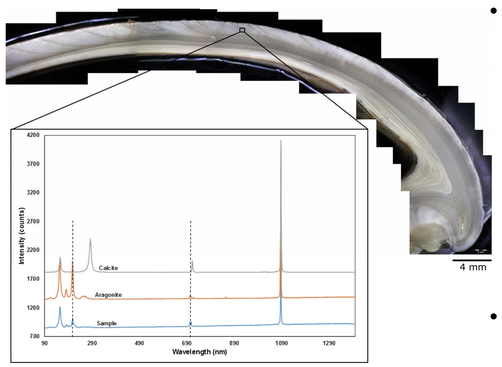

Figure 1: Confocal Raman microscopy. Comparison of sample (blue) spectrum with spectra of aragonite (orange) and calcite (grey) standards clearly shows that sample consists of aragonite.

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

Figure 2: Map of Italy showing the three outcrops where samples were collected in July 2015.

BIOSTRATIGRAPHY AND $\delta^{18}O_{shell}$ 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).

Biostratigraphic 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 ($\delta^{18}O_{shell}$)** 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).

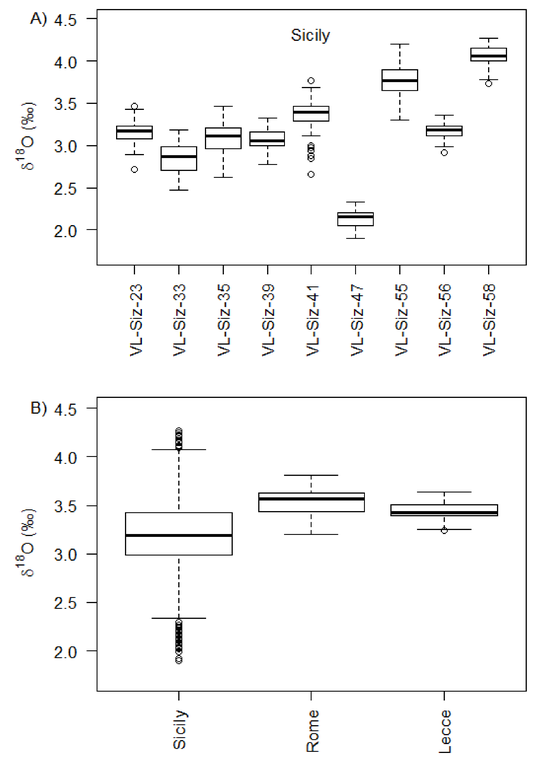

Figure 3: (A) $\delta^{18}O_{shell}$ variation of Siclian shells and (B) comparison of $\delta^{18}O_{shell}$ variation between the three studied outcrops. Sicily: n = 9, Rome: n = 1, Lecce: n = 1.

CONCLUSIONS – SEASONALITY BY $\delta^{18}O$

Stable oxygen isotope profiles of eleven fossil *A. islandica* shells depict relatively low seasonality scenario
→ $\delta^{18}O_{shell}$ 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 valves) is **9.5±0.5°C** based on the assumption of a $\delta^{18}O_{water}$ value of 0.9±0.1‰ (c.f. Crippa et al., 2016)
→ coincides well with temperature requirements for modern A. *islandica.*

Average $\delta^{18}O_{shell}$ 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.

ACKNOWLEDGMENTS & REFERENCES

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