

## INTRODUCTION

Understanding the climate of the past is essential to evaluate the effects of future climate change on marine ecosystems. It is assumed that the **simultaneous occurrence of boreal (*Arctica islandica*) and warm-water species** in the Mediterranean Sea during the Pleistocene can be explained by high seasonality (Raffi, 1986). The following objectives will be answered by this study which was conducted on 19 shells (figures exemplary present results):

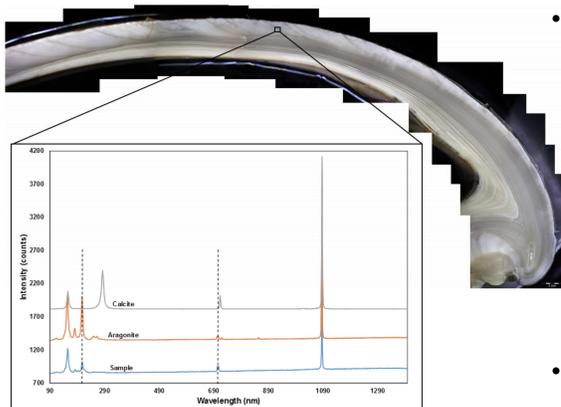
- Can we see seasonality? →  $\delta^{18}\text{O}_{\text{shell}}$  profiles
- Is there a multi-year signal? → Frequency Analysis
- How well are the fossil shells preserved? → Confocal Raman microscopy

## PLEISTOCENE

- Time span from 2.58 Ma to 11.7 ka years.
- Most recent episode of glacial cooling.
- Large parts of temperate zone were covered by glacials.

## CHECK FOR DIAGENESIS

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

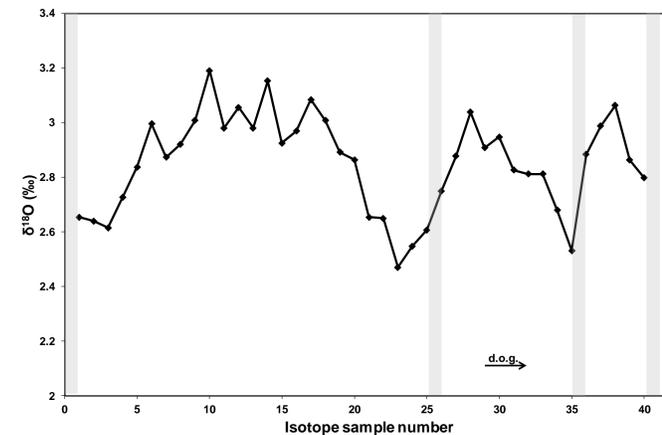


**Figure 1:** Confocal Raman Microscopy. Comparison of sample (specimen-ID VL-Siz-58) spectrum with spectra of aragonite and calcite standard clearly shows that sample consists of aragonite.

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

## SEASONALITY BY $\delta^{18}\text{O}$

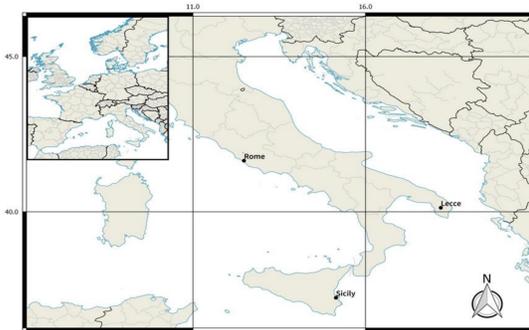
- Seasonal water amplitude reconstruction using **stable oxygen isotope values** ( $\delta^{18}\text{O}_{\text{shell}}$ ): Micro-milling and CF-IRMS.
- Average  $\delta^{18}\text{O}_{\text{shell}}$  amplitude of 0.66‰ resulting in a seasonal variation of  $\sim 3^\circ\text{C}$  → **low seasonality scenario**.
- Lack in seasonality and **high abundance of boreal species** → Middle Calabrian Mediterranean Sea was characterized by a **maximum glacial phase**.



**Figure 2:** Exemplary presentation of one stable oxygen isotope ( $\delta^{18}\text{O}$ ) profile (Specimen-ID: VL-Siz-33). Grey bars represent growth lines. Isotope samples were taken in three consecutive ontogenetic years.

## MEDITERRANEAN SEA – study area

*Arctica islandica* shells were collected from **Pleistocene** successions in Central and Southern Italy. According to preliminary biostratigraphic data the deposits belong to the **middle Calabrian**, between 1.2 and 0.9 Ma for the Sicily outcrop and 1.2 and 1.4 Ma for Rome and Lecce outcrops.

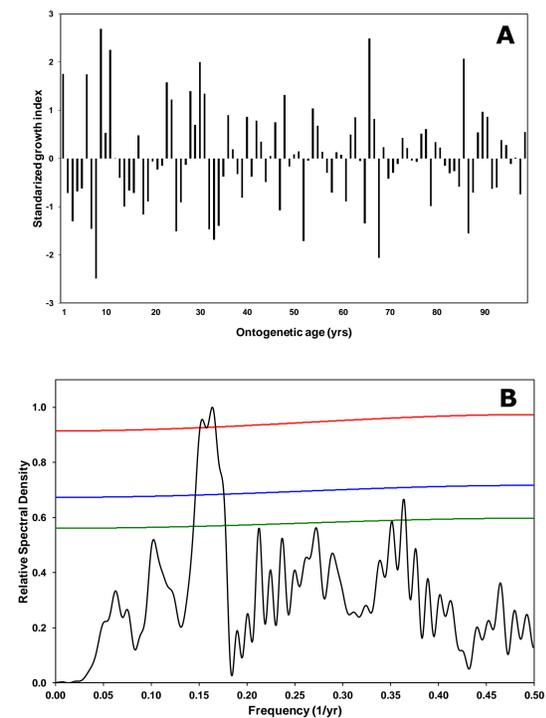


The best preserved shells were found in Sicily. Shell material has been taken with permission of local authorities.

**Map** of Italy showing the three outcrops in Rome, Lecce and Sicily where samples were collected in July 2015.

## MULTI-YEAR SIGNAL

Annual shell growth increments were measured on digital images by means of Analysis Docu 5.0 and **standardized growth indices** computed (images were taken by Olympus SZX12 stereo-microscope equipped with an Olympus DP 72 camera using analysis docu 5.0 software). **Past shell growth signals** were identified by SSA and **Multi-Taper Method** (using kSpectra; version 3.5).



**Figure 3:** Specimen-ID: VL-Siz-23; (A) Dimensionless standardized growth index (bars) (B) Multi-Taper Method identified a significant signal of  $\sim 0.16$  (1/yr) which is equal to  $\sim 6$  years. Confidence Intervals: 99% (red), 95% (blue) and 90% (green).

## Conclusions:

- Multiple time series of fossil *A. islandica* shells show  **$\sim 6$ -year cycle** (range between 5 and 7 years).
- May be linked to
  - **North Atlantic Oscillation** (NAO): time-scales of 5-7(9) years, often used to explain climatic variation in Europe (Schöne et al., 2013).
  - **Mediterranean Oscillation** (MO): cyclic variation of 5, 8 and 22 years (Martin-Vide & Lopez-Bustins, 2006).
- Still **on-going research**: further investigation is needed and performed right now.

## ACKNOWLEDGMENTS & REFERENCES

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Beierlein et al., (2015). *G&G*, 16(1), 325-335.; Martin-Vide & Lopez-Bustins (2006). *International Journal of Climatology*, 26(11), 1455-1475.; Raffi, S. (1986). *PalPalPal*, 52(3-4), 267-289.; Schöne, B. R., (2013). *Global and Planetary Change*, 111, 199-225.