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Key Points:

- The shell architecture of *Arctica islandica* was examined and the oxygen isotope composition of two microstructural layers was analyzed
- The oxygen isotopic composition of samples from outer shell layer is affected by factors related to the structural origin in the shell
- To ensure comparability of the shell oxygen isotope data, samples should always be taken from the same shell layer

Supporting Information:

- Supporting Information S1

Correspondence to:
T. Trofimova,
tamara.trofimova@uni.no

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Oxygen Isotope Composition of *Arctica islandica* Aragonite in the Context of Shell Architectural Organization: Implications for Paleoclimate Reconstructions

Tamara Trofimova[1], Stefania Milano[2], Carin Andersson[1], Fabian G. W. Bonitz[1], and Bernd R. Schöne[2]

[1]Uni Research Climate, Bjerknes Centre for Climate Research, Bergen, Norway, [2]Institute of Geosciences, University of Mainz, Mainz, Germany

Abstract The analysis of the stable isotopic composition of bivalve shells provides the data needed to construct climate records at high temporal resolution. Yet, the reproducibility of the results and the effect of microstructural organization on the isotopic signature and measurements have not been extensively studied. Here, we examine the architectural changes within *Arctica islandica* shells, specifically if samples from microstructurally different shell layers differ in respect to stable oxygen isotope values. The oxygen isotope profiles of two microstructurally different shell layers, each sampled at different temporal resolution, were compared to each other. Our results show that aragonite, collected from the layer that is dominated by cross-acicular/lamellar structures, tends to be enriched in heavier oxygen isotopes compared to samples from portions of the outer shell layer dominated by homogeneous microstructure. In some cases, this difference exceeded 0.3 ‰, which can significantly affect the interpretation of a recorded environmental signal. Observed differences in stable oxygen isotope data may be associated with the physiology of the mollusk and the physical and chemical composition of studied shell layers.

1. Introduction

The stable isotopic composition of biogenic carbonates is commonly used as a temperature proxy in paleoclimatic reconstructions. Shells of bivalve mollusks are a remarkable source of environmental information recorded at high temporal resolution. This is achieved by uninterrupted deposition of carbonate throughout the growing season of mollusks and annual growth increment formation. By applying cross-dating techniques derived from tree-ring research, it is possible to construct master chronologies (e.g., Butler et al., 2009, 2013) which can extend the record beyond the lifetime of a single organism. Master chronologies provide a solid temporal basis for high-resolution geochemical sampling and construction of absolutely dated stable isotope profiles.

Stable isotope profiles derived from shell carbonate can provide important information about environmental conditions that prevailed during shell formation (Grossman & Ku, 1986; Richardson, 2001). While the stable carbon isotope value depends on several factors, such as δ^{13}C of DIC and food source, environmental CO_2/O_2 ratio, and physiology (McConnaughey & Gillikin, 2008), the oxygen isotope composition of shell carbonates is considered to serve as a reliable proxy for water temperature (Schöne et al., 2005; Wanamaker et al., 2007; Weidman et al., 1994), and δ^{18}O of ambient water (Dettman et al., 2004; Yan et al., 2009) or salinity changes (Ingram et al., 1996; Schöne et al., 2003). The use of a δ^{18}O values as an environmental proxy is based on the assumption that shell carbonate is precipitated in or near isotopic equilibrium with ambient water, and the fractionation process is temperature-dependent (Epstein et al., 1953; Wefer & Berger, 1991). This has been confirmed by observations and experimental studies with shells of a variety of bivalve species (e.g., Grossman & Ku, 1986; Owen et al., 2002; Wanamaker et al., 2006). Shell-based water temperature reconstructions are increasingly used in environmental research with applications in modern times (e.g., Mette et al., 2016; Schöne et al., 2004, 2005; Watanabe & Oba, 1999) and the distant past (e.g., Beierlein et al., 2015; Ivany & Runnegar, 2010; von Leesen et al., 2017).

Despite the extensive use of oxygen isotope thermometry in sclerochronological studies (Schöne & Gillikin, 2013), the reproducibility of shell-derived isotope profiles remains challenging and is often overlooked in