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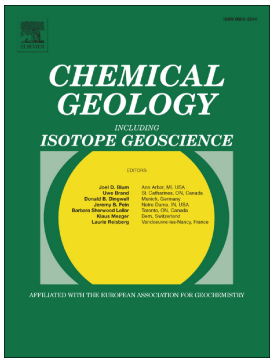

Unexpected isotopic variability in biogenic aragonite: A user issue or proxy problem?

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Unexpected isotopic variability in biogenic aragonite: A user issue or proxy problem?

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Abstract

The present study seeks to investigate sources of isotopic variability in the commonly used paleoclimate archive, the marine bivalve *Arctica islandica*, with an emphasis on the potential of human-induced variability arising from sampling techniques. Stable carbon ($\delta^{13}C_{carbonate}$) and oxygen ($\delta^{18}O_{carbonate}$) isotopes were analyzed for split (intra-sample) and replicate (intra- and inter-shell) samples taken from a group of laboratory-reared individuals, a natural population from northern Norway, and a natural population from the Gulf of Maine, USA. Compared to analytical uncertainty of 0.17 ‰ and 0.30 ‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively, among the natural populations, the mean difference between shell splits and shell replicates ranged from 0.12 ‰ and 0.33 ‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively. Our data suggest that heterogeneity of the carbonate material (i.e., large range of isotopic composition within one sample due to seasonal environmental variability) may contribute to "unexpected" variability more than human-induced error from sampling imprecision when collecting whole annual increments. Furthermore, $\delta^{13}C$ from juvenile shells were highly variable (2σ standard deviation = 0.65 ‰), approximately four times more variable than analytical precision.

High precision among $\delta^{18}O$ measurements of the laboratory-reared shells confirm the presumption that shells reliably and consistently precipitate in isotopic equilibrium with ambient seawater. Monte Carlo simulations of measurements from this population allowed characterization of improvements in uncertainty at increasing levels of replication. Substantial reduction in uncertainty occurs when increasing from two to three shells, however replication using a total of four shells further decreased uncertainty to within the 99% confidence level.

Published studies sometimes compensate for uncertainties by replicating records over multiple individuals or multiple transects within the one individual. Oftentimes, however, isotope records are constructed from single individuals or transects and therefore fail to provide thorough estimates of proxy error. Our findings suggest that replication of carbon and oxygen isotope measurements of contemporaneously produced aragonite is necessary in order to reduce proxy-derived noise. Furthermore, population-specific estimates of uncertainty related to natural variability among individuals should be investigated in order to provide more realistic representations of proxy noise when reporting isotope time series.

Keywords
Arctica islandica; isotope replication; proxy uncertainty; paleotemperature reconstruction; micromill