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Paleoclimate reconstruction from biocalcites: the key role of microstructure and organic matter in diagenetic isotope exchange

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Foraminifera, brachiopods, and bivalves build their tests and shells from biocalcite. The extensive fossil record they have left behind for over 500 million years allows us to reconstruct various parameters of past ocean and climate history, most notably the temperature of paleo-seawaters using oxygen isotopes. However, diagenesis can erase the original isotopic and chemical compositions of fossil shells and hence bias paleoclimate reconstructions. By using high-spatial resolution imaging techniques, we can identify where diagenetic isotope exchange occurs at the ultrastructural scale within a given biocalcite. This has established a link between diagenetic isotope exchange, hierarchical shell ultrastructures, and their associated organic matter in foraminifera species[1].

Here, we expand our work to bivalves. We compare the shells of two species of *Pinna nobilis* and *Pinctada margaritifera*, which have differing microstructures and organic frameworks, to study how different organo-mineral structures influence diagenetic isotope exchange. We use ^{18}O-enriched artificial seawater in combination with correlated NanoSIMS and scanning electron microscopy (SEM) imaging, electron backscatter diffraction (EBSD), and atomic force microscopy (AFM) imaging to trace how fluids penetrate into the biocalcite structures. Differences in bulk isotopic enrichment can be related to differences in ultrastructure, which potentially allows for the identification of the most important organo-mineral structures for fluid-mediated isotopic exchange within these shells.

These experiments suggest that biocalcite-producing organisms are susceptible to modification of their shells post-mortem during diagenesis through preferential isotopic exchange along species-specific ultrastructures which modulate the extent of bulk isotopic exchange. The identification of the specific organo-mineral ultrastructures that facilitate this diagenetic isotope exchange across different species is fundamental to understand the mechanisms of early diagenesis on biocalcites.

1. Cisneros-Lazaro, D. *et al.* Fast and pervasive diagenetic isotope exchange in foraminifera tests is species-dependent. *Nat. Commun.* **13**, 1–11 (2022).