Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37552

Investigating the Impacts of Growth Environment on Trace Element Incorporation in Oyster Calcite: Implications for Paleoenvironmental Reconstructions

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Oyster shell calcium carbonate is a high-resolution archive of environmental changes in coastal regions, yet biological interferences (i.e. “vital effects”) often confound straightforward interpretations of shell geochemistry. Previous studies have relied upon lab-cultured or farmed oysters for building empirical calibrations between geochemical variability and local instrumental records. However, this approach neglects that wild and fossilized oysters represent the less quiescent sediment-water interface where pore water exchange, groundwater discharge, and the physical clustering of individuals modifies the chemistry of ambient seawater on short spatiotemporal scales. The net result of these compounding influences may manifest as differences between the trace element geochemistry within the shell increments of wild and farmed oysters, impeding the creation of robust calibrations. Here, we assess the extent to which patterns in the trace element geochemistry of coeval wild-caught and farmed Eastern Oysters (*Crassostrea virginica*) are consistent in their abilities to capture seasonal and regional environmental variability across Georgia’s (USA) coastal barrier islands. We quantify element to calcium ratios (B/Ca, Ba/Ca, Mg/Ca, Sr/Ca, and Mn/Ca) within the resilifer of individual shells via laser ablation ICP-MS, characterizing the mean values and the structure of variability (i.e. cyclicity, periodicity, amplitude, etc.) within each shell and allowing for the decoupling of growth vs environmentally-stimulated variability. We expect Mn/Ca and Ba/Ca ratios to exhibit discernable differences between wild and farmed oyster calcite, with elevated mean Mn/Ca in wild oysters driven by pore water diffusion of reduced Mn^{2+} and more intense Ba/Ca spikes in farmed oysters reflecting stronger river mixing in the water column. B/Ca ratios may prove useful in quantifying carbonate chemistry differences at the sediment-water interface (wild) as compared to the water column (farmed), while Sr/Ca and Mg/Ca ratios will highlight any nuanced temperature-related variability between the two environments. We further evaluate these patterns against excavated oysters (700–1100 CE) from Coastal Georgia barrier islands, which represent preindustrial geochemical archives recording predominantly natural environmental variability. This comparison determines which modern growth setting most closely approximates the variability preserved in paleoenvironmental records, providing a critical test of the environmental representativeness of modern oyster-based geochemical calibrations and refining their application in paleoclimate reconstruction.