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Oyster shell microstructures go beyond morphology

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Oyster shells are composed of biomineral calcite that occurs as dense, foliated layers interwoven with lenses of less-dense chalk microstructures. Beyond their morphological differences, we demonstrate that the calcite crystals in foliated and chalk microstructures are also distinct from one another in terms of their trace element chemistry and crystal structure parameters. This implies that researchers using biominerals as tools to study paleoclimate and environmental geochemistry should carefully consider and characterize biomineral mineralogical features on the centimeter to atomic scales that could reflect changes in crystallography, trace elements, and isotope effects.

In our case study of unusually thin and brittle oyster shells from an oyster lease in the Chesapeake Bay, we observe that these brittle shells contain relatively more chalk microstructures than normal, healthy shells that were grown nearby (<1 km) during the same timeframe. As far as we are aware, our study is the first to apply micro X-ray-CT scanning to quantitatively assess these microstructures in oyster shells as ratios of chalk:foliated microstructures. We suggest that these brittle shells likely laid down extra chalk microstructures in order to grow more quickly and outcompete rapid sedimentation rates that could have been driven by unusually heavy rain events in 2018 and 2019. Alternatively, the brittle shells could have been subjected to inadequate husbandry practices, differences in predation, or other physical stressors. After coupling local environmental parameters (temperature, salinity, dissolved oxygen, etc.) with these mineralogical data of the Chesapeake Bay oysters and controlled incubation experiments of juvenile “spat” shells, we suggest that even dramatic dips in salinity have little to no effect on microstructure makeup or calcite crystallography. Instead, inherent crystallographic and chemical features between foliated and chalk microstructures are much more pronounced. Future studies should continue to explore this connection between biomineral microstructure crystallography and chemistry—and how different environmental drivers may play a role in how organisms use and switch between these microstructures.