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Shell architecture: a novel proxy for paleotemperature reconstructions?

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Mollusk shells are unique high-resolution paleoenvironmental archives. Their geochemical properties, such as oxygen isotope composition (δ18Oshell) and element-to-calcium ratios, are routinely used to estimate past environmental conditions. However, the existing proxies have certain drawbacks that can affect paleoreconstruction robustness. For instance, the estimation of water temperature of brackish and near-shore environments can be biased by the interdependency of δ18Oshell from multiple environmental variables (water temperature and δ18Owater). Likely, the environmental signature can be masked by physiological processes responsible for the incorporation of trace elements into the shell. The present study evaluated the use of shell structural properties as alternative environmental proxies. The sensitivity of shell architecture at μm and nm-scale to the environment was tested. In particular, the relationship between water temperature and microstructure formation was investigated. To enable the detection of potential structural changes, the shells of the marine bivalves Cerastoderma edule and Arctica islandica were analyzed with Scanning Electron Microscopy (SEM), nanoindentation and Confocal Raman Microscopy (CRM). These techniques allow a quantitative approach to the microstructural analysis. Our results show that water temperature induces a clear response in shell microstructure. A significant alteration in the morphometric characteristics and crystallographic orientation of the structural units was observed. Our pilot study suggests that shell architecture records environmental information and it has potential to be used as novel temperature proxy in near-shore and open ocean habitats.