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# What is recorded in your belemnite?

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Carbonate skeletons of fossil marine organisms are widely used for the reconstruction of past environments. Specifically, the geochemistry of Jurassic and Cretaceous belemnite rostra, a mineralized internal structure, is commonly applied to reconstruct paleoseawater properties. The low-Mg calcite rostra are commonly assumed to be precipitated in oxygen isotope equilibrium with seawater and to resist diagenetic alteration. More recently an increasing number of published data show significant inter- and intraspecific fluctuation in geochemical data from rostra collected in the same horizon. This fluctuation is often explained by vertical and horizontal migration patterns, seasonality, or changes in salinity. In order to test for an ultrastructure-related explanation for the observed fluctuations, we employed a wide range of state-of-the-art analytical tools to well-preserved specimens including SIMS, Raman, and EPMA. We found petrographic evidence that the primary, i.e. biogenic, ultrastructure of rostra of Megateuthis (Middle Jurassic), Belemnitella and Gonioteuthis (Late Cretaceous) was not a dense calcite structure, but contained primary porosity. The biogenic ultrastructure consists of a filigree framework of tetrahedrons with branches forming a honeycomb-like network. We propose that the pore space was originally filled with body fluid and/or organic compounds. Intra-rostral porosity was occluded subsequently, maybe during the animal's lifetime, by non-biologically controlled isopachous calcite cements. The biologically controlled framework has a $\delta$18O that is approximately 1‰ lower than adjacent (<20 $\mu$m) isopachous calcite cements. The resulting fabric represents a composite biologically controlled and non-biologically controlled structure precipitated at different times and presumably depths in the water column, given the $\delta$18O differences. Cleary the difference in $\delta$18O is locally controlled and can be larger or smaller in other situations. We suggest that these findings have significance for those using belemnite rostra as archives of their paleoenvironment, for the reconstruction of belemnite paleoecology, and for the functional interpretation of belemnite rostra.