Geophysical Research Abstracts
Vol. 18, EGU2016-1897, 2016
EGU General Assembly 2016

Growth rate effects on Mg/Ca and Sr/Ca ratios constrained by belemnite calcite

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Multiple temperature proxies from single species are important to achieve robust palaeotemperature estimates. Besides the commonly employed oxygen isotope thermometer, also Mg/Ca and Sr/Ca ratios perform well as proxies for calcification temperature in the shells of some species. While salinity changes affect the ratios of earth alkaline elements much less than the δ18O thermometer, metabolic effects may exert a strong control on the expression of element ratios. Such effects are hard to study because biomineralization experiments have to overcome large intraspecific variability and can hardly ever isolate the controls of a single parameter on shell geochemistry.

The unique geometry of the belemnite rostrum constitutes an exception to this rule. Its shape, large size, and the visibility of growth increments as bands enable the analysis of multiple, correlatable, high resolution geochemical profiles in a single fossil. The effects of the growth rate variability amongst these profiles on Mg/Ca and Sr/Ca ratios has been tested here.

Within a specimen of Passaloteuthis bisulcata (Early Toarcian, Cleveland Basin, UK), Mg/Ca and Sr/Ca data were obtained from four profiles. With respect to growth rate in the first profile, which was taken as a reference, the relative growth rates in the remaining three profiles varied by a factor of 0.9 to 2.7. Results suggest that relative growth rate is linearly correlated with Mg/Ca and Sr/Ca, with a decrease of Mg/Ca by 8 % and increase of Sr/Ca by 6 % per 100 % increase in relative growth rate. The observed trends are consistent with abiogenic precipitation experiments and suggest that crystal precipitation rate exerts a significant, predictable control on the element distribution in biogenic calcite.