Geochemistry of the belemnite rostrum: Genesis and diagenesis

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Belemnites are an important target for the study of Jurassic and Cretaceous palaeoenvironments, because their rostra are large and structured by growth bands, have calcification rates sufficient for assessing palaeoseasonality, and show a predictable pattern of zones most likely affected by diagenesis. In order to fully understand the meaning of geochemical proxies in the belemnite rostrum, effects of growth rate, crystal shape, metabolic effects and diagenesis have to be disentangled.

Here, we report C and O isotope ratios and Mg/Ca, Sr/Ca and Mn/Ca ratios for four complete profiles through a single belemnite rostrum of *Passaloteuthis bisulcata* (Early Toarcian, ~183 Myr). Through repeated sampling of the same growth bands in different locations of the rostrum, effects of biomineralization and diagenesis can be unravelled. In the studied specimen of *P. bisulcata* diagenesis – as usually observed – results in depletions of ^{13}C, ^{18}O and Sr and increasing Mn in the apical zone and the rim of the rostrum. Well-preserved calcite of the central part of the rostrum shows up to ~70 % enrichment of Mg and ~50 % enrichment of Sr – the high values interpreted to be dominantly affected by crystal morphology. Outside the central zone, samples with highest rate of calcite formation show Mg depletion of ~15 % and Sr enrichment of ~15 %. Metabolic controls on the Mg/Ca and Sr/Ca account for a residual variability of 6.8-11.3 mmol/mol and 1.39-1.72 mmol/mol, respectively. Neither of the above effects appear to influence C and O isotope ratios significantly and both isotopic systems show values reproducible within 0.5 ‰ in single growth bands, whereas these isotope systems show systematic changes within the rostrum, ranging from +0.4 to +3.3 ‰ and -2.2 to -0.3 ‰, respectively.

Our findings indicate that for C and O isotope studies any well-preserved part of the rostrum yields results representative for a given growth band. For element/Ca ratios, however, analyses should be conducted on transects close to the protoconch and avoiding the central ~4 mm of the rostrum to derive the most stable data and most complete time series.