Boron and Strontium Isotopic Composition in the Aragonitic Shell Material of Cultured Arctica islandica

Motivation

1. Ocean acidification has become an important issue because it impacts many calcifying marine organisms and therefore it is essential to expand our knowledge of how the seawater chemistry is impacted by rising atmospheric CO₂ levels.
2. The long-lived ocean quahog Arctica islandica (A. islandica) has a wide habitat range around much of the coastal ocean in the northern North Atlantic (Fig. 1), which is an ideal archive for addressing temporal and spatial changes in ocean chemistry during recent centuries.
3. Relatively less attention has been devoted to other "non-traditional" isotope systems within this proxy archive.

Results and Discussion

1. The δ⁸⁷Sr/⁸⁶Sr ratios from both tank water and shell samples (Fig. 3 (A) and (B)) show ratios nearly identical to the open ocean, which suggests that the shell material reflects ambient ocean chemistry without interferences from terrestrial sources.
2. It has been suggested that stable Sr isotopic ratios (δ⁸⁷Sr) in biogenic carbonate are influenced by the temperature of the precipitating fluid, however, our δ⁸⁷Sr data show identical values throughout the experiment despite a temperature change of >15 °C.
3. No distinguishable [Sr] trend in the culture experiment.
4. Identical δ¹¹B results form the tank water, in which δ¹¹B is independent of pH changes throughout the experiment despite a temperature change of >15 °C.
5. The δ¹¹B records from the experiment show at least a 5‰ increase through the culture season (January – August, 2010), with low values for weeks 5-15 and higher values after week 19 (Fig. 4) in all shell records, which are opposite to the pH trend we expected (Fig. 2 (D)).
6. When a certain temperature threshold (>13 °C) has been reached, the fast shell growth may cause boron limitation in the calcifying fluid and cause the rise in δ¹¹B values instead of preferential uptake of ¹¹B enriched B(OH)4⁻. The regulation of pH in the extrapallial fluid may also cause the rise in δ¹¹B in the shell. However, the offset between ΔpH (pHₚₚₖ-pHsw) is not sufficient to explain the high δ¹¹B ratios.

Samples and Methods

High-resolution boron and strontium records from an 8-month culture experiment under ambient conditions from the Gulf of Maine are compared with in-situ measurements of temperature, salinity, and pH to examine the relationships between the isotope systems and the environmental factors (Fig. 2).

An high-throughput microsublimation method with total vaporization technique conducted on negative TIMS was applied in the study (Liu et al., 2013). The residual from the microsublimation was used for strontium isotope analysis. An 84-87 Sr double spike was applied to obtain the stable Sr isotopic composition and concentration of the shells.

Conclusions

The larger δ¹¹B ranges from the shells than from the prediction based on the instrumental measurements and a rising trend after temperature over 13 °C suggests that the shell δ¹¹B might not directly reflect the seawater pH in habitats with large temperature fluctuations. A better constraint of environmental factors is required for constructing a species-specific fractionation factor.

A pH control culture experiment has been conducted from February 2014 to August 2014, with nearly constant seawater temperature and salinity. This study may provide further information for the usage of δ¹¹B in A. islandica shell as a seawater pH proxy.

References and Acknowledgements

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