

A more robust salinity proxy: towards a mechanistic understanding of sodium incorporation in foraminiferal calcite

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Seawater salinity and temperature gradients drive ocean thermohaline circulation and thereby play an essential role in regulating Earth's climate. Salinity reconstructions largely rely on combined proxy approaches, which are inherently associated with relatively large uncertainties. Element incorporation in foraminiferal calcite might provide a more direct reconstruction tool for salinity (Na/Ca and potentially, K/Ca). However, element/Ca ratios in foraminiferal calcite, including these monovalent cations, generally show relatively large variability between species, between specimens and even across chamber walls. Origin and extent of intra- and inter- specimen variability in element/Ca ratios need to be understood and quantified, this way reducing uncertainties and adding to the robustness of the reconstructions.

We cultured two foraminiferal species under a range of salinities and analyzed the newly formed calcite for their average Na/Ca and its distribution across chamber walls using Electron Probe Micro Analysis and Nanoscale Secondary Ion Mass Spectrometry. Obtained maps show that Na and other incorporated elements (Mg, K, S, and P) occur in distinct bands adjacent to the primary organic sheet. The width and intensity of these bands differ between elements and between the two species investigated. We evaluated the intensity of the high-Na, -Mg, -K, bands as a function of salinity. Together, these results are the basis of a new calcification model that explains incorporation of these elements as a function of 1) seawater chemistry and 2) biological control during calcification by the foraminifer. This framework will be applied to test recently obtained calibrations for incorporation of Na (and other elements) as a function of salinity.

Keywords: Biomineralization, Foraminifera, Salinity proxy