

A core-top assessment of foraminiferal isotopic and trace element proxies for the ocean carbonate system

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Atmospheric CO₂ (*p*CO₂) is an important greenhouse gas that regulates the Earth's climate on geological and shorter timescales. The sensitivity of the Earth's climate to *p*CO₂ and the mechanisms causing natural short term fluctuations in its concentration are hotly debated topics. The reliability of proxy data for the ocean carbonate system in the past have a direct bearing on the problem. Of particular importance in this regard are the suite of proxies based on the isotopic and trace element composition of foraminifera. Amongst these proxies δ¹¹B, B/Ca, Li/Ca and U/Ca are currently receiving most attention. Foraminifera are organisms that precipitate their shells by complex physiological processes. Secondary effects (often termed "vital effects") have been observed in both stable isotope ratios and trace element abundances which complicate the application of these proxies. For instance, δ¹¹B is thought to be influenced by the pH of the microenvironment surrounding a living foraminifer whilst trace element incorporation into foraminiferal carbonate is thought to be affected by, amongst others, shell growth rate, pH, salinity and species-specific biological effects. The role played by these secondary effects and the fidelity of the proxy need to be determined before using these proxies to reconstruct past environments.

To this end, we have applied a multiproxy isotopic (δ¹¹B) and trace element (Mg/Ca, Sr/Ca, Li/Ca, B/Ca, U/Ca) approach to two species of planktic foraminifera (*Globigerinoides sacculifer* and *Globigerinoides ruber*) from three Holocene core-tops from the Equatorial Atlantic, Pacific and Indian Oceans. We find that a significant control on the majority of the measured trace element/Ca ratios (e.g. B/Ca and U/Ca) is shell growth rate (expressed by final shell size). In contrast, in most samples boron isotopes show no significant size, species or geography (sea surface temperature) related differences. Significant variations of δ¹¹B with size in *G. sacculifer* in the Indian and Pacific Ocean can be explained by partial dissolution of the tests. We conclude that biological influences complicate the use of B/Ca, Li/Ca and U/Ca as proxies for the state of the carbonate system in the past, whereas the boron isotope proxy in the species examined is likely to record paleo-pH with a high fidelity.