Experimental evidence for the environmental sensitivity and mechanistic basis of Mg incorporation in planktonic foraminifera

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The Mg/Ca ratio of foraminiferal calcite is one of the most widely-applied palaeothermometers, and as such, these data underpin a large portion of our knowledge of past climate change. Accurate calibration and a mechanistic understanding of the proxy is therefore of crucial importance. Non-thermal influences on Mg incorporation have been recognised since the conception of the proxy, yet are challenging to account for down-core. In addition, an ongoing debate surrounds the method of transport of ions to the calcification site, with implications for the degree to which shell chemistry faithfully records ambient conditions.

We address these issues through the compilation and modelling of trace element data from laboratory cultures, and laser confocal microscopy of decalcified individuals. In practical terms, we show that salinity is not a major complication for the interpretation of Mg/Ca data, whereas the effect of the carbonate system (pH) is large, but can be precisely accounted for in the recent fossil past [1]. We explore the mechanistic basis of the proxy by comparative modelling of trace element data in high and low-Mg species [2], and back this up with direct *in-situ* observations of the calcification process via calcein and FITC-dextran labelling of live individuals.

Together, these lines of evidence highlight that Mg/Ca palaeothermometry is a highly precise tool for past climate reconstruction in the Pleistocene, with a mechanistic basis that is now rooted in observation and the modelling of trace element systems. For example, our confocal observations provide the first evidence that, as is the case for some benthic foraminifera, the low-Mg planktonics calcify from vacuolised seawater.

[1] Gray, W. & Evans, D. [2019]. *Paleoceanography & Paleoclimatology*. **34**. [2] Evans, D., Müller, W., & Erez, J. [2018]. *GCA*. **236**: 198.