Combining Mg/Ca and clumped isotope analyses for temperature estimation from foraminifera

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Reconstructing past temperature beyond the instrumental record is challenging and paleotemperature proxies measured on different phases often disagree (e.g., alkenone SST and foraminifer Mg/Ca). We combined clumped isotopes and Mg/Ca thermometry on the same specimens of different Atlantic planktic foraminifera to provide independent estimates of temperature as well as the δ¹⁸O of the ambient seawater. The strength of the tandem approach is that unlike other palaeotemperature methods, Mg/Ca and Δ⁴⁷ are measured on the exact same calcite phase, thereby eliminating differences in seasonality or depth habitat of proxies. This redundancy constitutes a rigorous test of individual methods with the advantage that the same approach can be applied to fossil specimens.

Aliquots for clumped and Mg/Ca analyses are treated in exactly the same way following a modified procedure after Barker et al. [2003], including a larger volume of reactant, stronger oxidative cleaning at room temperature for twice 10 minutes to remove contaminants from foraminiferal tests. Tests were gently crushed and 6-10 aliquots of 135-148 ug were transferred into KIEL glass vials for clumped analysis and another aliquot of 100-300 ug was used for Mg/Ca analysis by ICP-OES.

Clumped isotope analysis is carried out on a KIEL IV coupled to a Thermo Fisher MAT 253 mass spectrometer and following the procedure described in Meckler et al. [2014] and Kele et al. [2015]. As all cups on our instrument have the same width, backgrounds are monitored using cup30 (m/z 46.5), conveniently located in the middle of the cup array. This allows rapid assessment of machine and run performance with regard to contamination and mass spectrometric effects. For evaluation we use the carbonate standards ETH1, 2, 3, 4 and CarZ. Data are background, pressure baseline and carbonate standard corrected and reported in the absolute reference frame [Kele et al. 2014].

Preliminary data confirm the theoretical Mg/Ca-Δ⁴⁷ relationship and hence corroborate independently the validity of the tandem method. This redundancy strengthens confidence in both methods and permits application of the same approach to fossil samples.