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The contribution of the foraminiferal Mg/Ca ratio, clumped and conventional stable isotope paleothermometers combination for palaeoceanographic studies

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Accurate seawater temperature determination is a key parameter to reconstruct past climate changes. Many thermometers have been developed in the past to constrain this parameter; however, they can suffer of some limitations. The classical oxygen-18 composition ($\delta^{18}O$) method in foraminifera reflects both calcification temperature and oxygen isotope composition of seawater in which the foraminifera grown (associated to the seawater salinity), while the foraminiferal Mg/Ca ratio depends on seawater temperature, salinity and pH [1]. The clumped-isotope values (Δ_{47}) in foraminifera reflect calcification temperature and do not seems to be affected by salinity [2]. Assuming no pH effect in clumped isotope, we would be able, by combining $\delta^{18}O$, Mg/Ca and Δ_{47}, to reconstruct the seawater temperature (Δ_{47}), salinity ($\delta^{18}O$-Δ_{47}) and pH ($\delta^{18}O$-Mg/Ca-Δ_{47}).

Here we present a new multi-species Mg/Ca calibration based on recent planktonic and benthic foraminifera from various oceanographic basin and covering a large range of temperatures from -2 to 25°C. These samples were previously analyzed on clumped isotope [2], allowing a direct comparison of both paleothermometers. Using the available oceanographic data from Atlas (WOA13, GLODAP 2020), we are able to correct our Mg/Ca values as described in [1] and [3] and obtain a new multi-species calibration. We then reconstructed corrected Mg/Ca-derived temperatures. The comparison between both Δ_{47} and corrected Mg/Ca-derived temperatures shows a good agreement. This observation suggests that the foraminiferal Δ_{47} do not seem to be affected by seawater pH. The combination of $\delta^{18}O$, Mg/Ca and Δ_{47} is therefore very powerful for palaeoceanographic studies.

[1] Gray et al. (2018), Earth and Planetary Science Letters 482, 607–620

[2] Peral et al. (2018), Geochimica et Cosmochimica Acta 239, 1–16239, 1–16

[3] Gray and Evans (2019), Paleoceanography and Paleoclimatology, 34, 306–315.