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# Reconstructing Mg/Ca ratios of seawater and implications for Mg/Ca based climate reconstructions

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The temperature of the deep ocean plays a vital role in the Earth's climate system. Paleo-reconstructions of deep-sea temperatures are generally dependent on Mg/Ca ratios measured from the carbonate tests of fossilized benthic foraminifera. Current Mg/Ca-temperature calibrations are based on empirical relationships which have been developed under present day environmental and chemical ocean conditions. However, the incorporation of Mg ($D_{Mg}$) into foraminiferal calcite is not solely dependent on temperature, but is also influenced by seawater chemistry. The Mg/Ca ratio of seawater in particular, plays a crucial role in determining the degree of incorporation of Mg in test carbonate. Due to its long oceanic residence time Mg concentrations remain relatively constant over time scales of a few hundred thousand years, yet can vary significantly over longer geological time scales. Therefore the accurate reconstruction of past temperatures using foraminiferal Mg/Ca ratios hinges on our understanding of Mg/Ca seawater changes over geological time. Here we present an independent approach to reconstructing paleo-seawater Mg/Ca using the temperature dependent offset in $D_{Mg}$ incorporation between porcelaneous (high Mg) and hyaline (low Mg) foraminifera. Porcelaneous foraminifera produce smooth opaque tests made of needle shaped high Mg calcite, while hyaline foraminifera build perforate tests made of radial low Mg calcite. As $D_{Mg}$ values are species specific, using foraminifera from the same time interval and environment (i.e. the same sample) eliminates the effect of temperature and seawater chemistry on $D_{Mg}$. Subsequently, combining a newly constructed Mg/Ca-temperature calibration for porcelaneous *Pyrgo spp.*(one of the few porcelaneous taxe present in the deep sea) with an existing calibration of hyaline *Cibicides spp.* allows us to mathematically solve for changes in Mg/Ca seawater through time using the species specific offset in $D_{Mg}$. Our results correspond well to changes in Mg/Ca of seawater as derived from geochemical models. Applying the newly reconstructed $Mg/Ca_{sw}$ curve to the published fossil record indicates that current Mg/Ca based temperature reconstructions prior to the mid Pleistocene, are significantly underestimating absolute temperature and therefore overestimating the growth of ice sheets via $\delta^{18}O_c$-Mg/Ca combined $\delta^{18}O_w$ reconstructions.