Species specific impacts of temperature and seawater Mg/Ca on foraminiferal Mg/Ca

I.E.Y. van Dijk[1], L.J. De Nooijer[1], T. Toyofuku[2], G.J. Reichart[1,3]

[1]Utrecht University, Faculty of Biogeosciences, Utrecht, The Netherlands

[2]Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan

[3]Alfred Wegener Institute, Bremerhaven, Germany

Introduction

Variations in Mg/Ca of foraminiferal calcite ($Mg/Ca_{calcite}$) reflect changes in environmental parameters, particularly temperature and seawater Mg/Ca (Mg/Ca_{sw})(Fig. 1). This means that $Mg/Ca_{calcite}$ can only be used to reconstruct seawater temperature when Mg/Ca_{sw} is known.

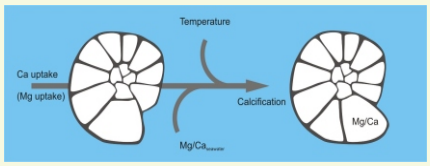

Figure 1. Mg incoporation in a foraminifera, influenced by Mg/Ca_{sw} and temperature.

The impact of Mg/Ca_{sw} is negligible when reconstructing paleo-temperatures over timescales within ~1 Ma, due to the long oceanic residence times of Mg^{2+} and Ca^{2+}. However, when reconstructing seawater temperatures on longer timescales, T reconstructions have to be corrected for Mg/Ca_{sw} (Fig. 2).

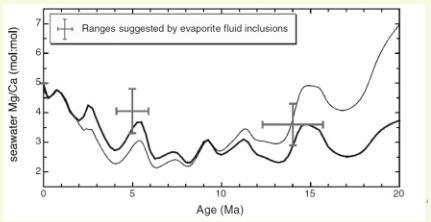

Figure 2. The seawater Mg/Ca ratio over the past 20 million years, as suggested by evaporite (crosses) and carbonate sediment (curves) fluid inclusions (Fantle and DePaolo, 2006).

Incorporation of Mg into foraminiferal calcite ($Mg/Ca_{calcite}$) is expressed as the partition coefficient:

$$D_{Mg} = (Mg/Ca_{calcite})/(Mg/Ca_{sw})$$

D_{mg} in turn may vary with temperature and preliminary data shows that D_{Mg} is also impacted by Mg/Ca_{sw}.

Objectives

The use of low- and Mg-calcite species from the same age allows reconstruction of both Mg/Ca_{sw} and temperature. To do this, it is necessary to investigate the dependency of temperature and Mg/Ca_{sw} on D_{Mg}.

Conclusions

Preliminary results suggest that for *Quinqueloculina* sp., Mg/Ca_{sw} and T impact D_{Mg} independently.

Further research suggestions

Further research can use this relationship in combination with a species with a contrasting biologically controlled Mg incorporation (e.g., the low Mg-producer *Elphidium* sp.) to resolve Mg/Ca_{sw} changes in deep geological time, since the relative difference reflects temperature and Mg/Ca_{sw}. This approach takes advantage of the species-specific fractionation between Mg^{2+} and Ca^{2+}.

References

Reichart, G.J., Jorissen, F., Anschutz, P., Mason, P.R.D. (2003) *Single foraminiferal test chemistry records the marine environment.* Geology 31, 355-358.

Fantle, M.S., and DePaolo, D.J. (2006) *Sr isotopes and pore fluid chemistry in carbonate sediment of the Ontong Java Plateau: Calcite recrystallization rates and evidence for rapid rise in seawater Mg over the last 10 million years.* Geochemica et Cosmochimica Acta 70, 3883-3904.

Methods

Specimens of *Quinqueloculina* sp. were sampled in Tokyo bay, Japan and were cultured at a combination of different temperatures (17, 22 and 27 °C) and Mg/Ca_{sw} (2, 3.5 and 5 mol/mol). $Mg/Ca_{calcite}$ was determined using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS; Reichart et al., 2003) and expressed as elemental concentrations (Fig. 3).

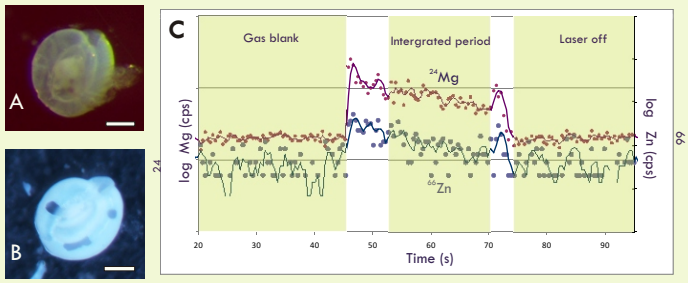

Figure 3. *Quinqueloculina* sp. (scalebar = 100 µm) during culturing (a) and after cleaning and laser ablation (b). Results from laser ablation (c) with ^{24}Mg and ^{66}Zn in cps and indication of the integrated period.

Preliminary results

With increasing Mg/Ca_{sw} as well as with increasing temperature, $Mg/Ca_{calcite}$ increases (Fig. 4). The different temperature relations appear to have a similar slope. Although it is suggested that D_{mg} may vary with temperature, this appears to be not the case for this species.

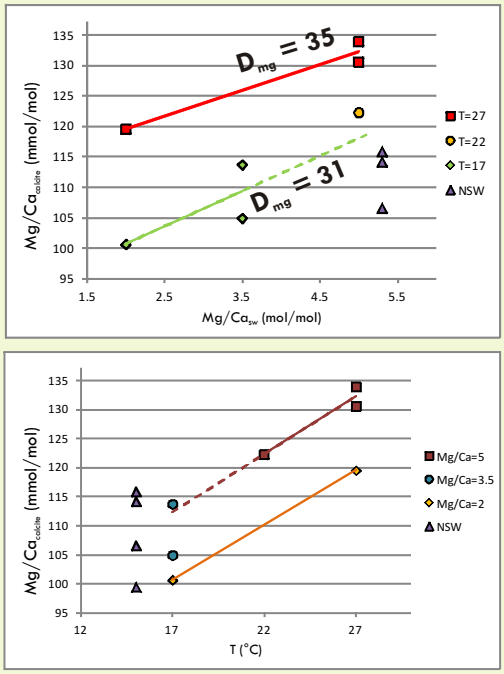

Figure 4. $Mg/Ca_{calcite}$ of cultured *Quinqueloculina* sp. Upper: $Mg/Ca_{calcite}$ vs. Mg/Ca_{sw} with D_{mg}. Lower: $Mg/Ca_{calcite}$ vs. temperature. 'NSW' represents chambers grown at natural seawater conditions, and reflect $Mg/Ca_{sw} \approx 5.3$ and T≈15°C.

(Contact: i.e.y.vandijk@students.uu.nl)