Geophysical Research Abstracts
Vol. 14, EGU2012-564-1, 2012
EGU General Assembly 2012

Foraminifera Mg/Ca palaeothermometry in a high CO_2 world – appropriate correction for secular change in seawater chemistry

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Palaeotemperature estimates using both the Mg/Ca ratio and δ^{18}O of foraminifera suffer from uncertainties regarding the composition of seawater, particularly during the Paleogene where climate reconstruction is a priority. The fundamental difference between these techniques is that proxy information exists for secular change in seawater Mg/Ca, whereas past $\delta^{18}O_{seawater}$ values have to be assumed, as even though changes in the bulk composition of seawater can be calculated (depending on reconstructed ice volume), $\delta^{18}O_{seawater}$ is locally highly variable. Despite this principal advantage of Mg/Ca thermometry, the majority of currently published Mg/Ca temperature reconstructions are likely to be inaccurate: The previously used methodology for the required correction for temporal variation of seawater Mg/Ca has assumed that a linear relationship exists between $Mg/Ca_{seawater}$ and $Mg/Ca_{foraminifera}$. However, recent studies [e.g. 1] have demonstrated that this is not the case, and that a power relationship between these two parameters best describes the data.

We will show the difference between these two correction techniques, focusing on why assuming a linear correction has led to incorrect foraminiferal constraints regarding the Mg/Ca ratio of the past oceans, particularly in the Paleogene. Furthermore, we demonstrate that by comparing Mg/Ca and δ^{18}O results from foraminifera that existed in an ice free world it is possible to indirectly calibrate the relationship between $Mg/Ca_{seawater}$ and $Mg/Ca_{foraminifera}$. Whilst previous assumptions do not result in error in the reconstructed magnitude of temperature change over Cenozoic climate transitions, it is likely that (depending on the assumptions of a particular study) absolute temperature estimates require revision. This particularly applies to results from time periods associated with significant Antarctic ice volume, which leads to greater uncertainty in $\delta^{18}O_{seawater}$.

[1] Segev & Erez, 2006, Geochem. Geophys. Geosys., 7(2).