Mechamisms of Mg isotopes fractionation during CaCO$_3$ biomineralisation

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The Mg/Ca ratios in foraminiferal calcite show a temperature dependence due to the partitioning of Mg during calcification. Empirical Mg/Ca-temperature calibrations exist and had been used to determine Quaternary and Cenozoic sea-temperatures [1]. These calibrations are, however, empirical and some discrepancies remain between core-top to cultured estimates. It is, therefore, of primary importance to understand precisely the mechanisms affecting the partition coefficient of Mg in biogenic calcium carbonate. In this regard, we have investigated the Mg isotopic fractionation of coral aragonite and foraminifera calcite.

The δ^{26}Mg from 5 planktonic foraminifera species in different size fractions (core top of Indian Ocean) and 2 corals (Red Sea and Japan Sea) have been measured by MC-ICPMS after chemical purification of Mg and are expressed relative to the DSM3 standard. We find the magnesium isotope composition of coral to be constant, with a δ^{26}Mg = -1.8‰. In contrast to coral, foraminifera present small but significant variations of Mg isotopes between and within the different species (range from –4.9 to -5.6‰). Therefore, corals and foraminifera are 1‰ and 4.1 to 4.8‰ lighter than seawater, respectively [2]. These results suggest a marked biological control wich differs from a straightforward inorganic equilibrium process [3]. Significant dependance of Mg isotope compositions on temperature has not been observed. The combined Mg, C and O isotope ratios and Mg/Ca ratios suggest that in foraminifera biomineralisation, Mg is transported from ambient seawater into the site of calcite growth by at least 2 different mechanisms inducing kinetic isotopic fractionation and cannot be incorporated directly from seawater vacuole as previously invoked [4].

References

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Process-related covariation in Mg and Ca isotopes in the riverine dissolved load

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Ca and Mg isotopes are potential tools for examining the contribution from carbonate and silicate sources and for constraining dissolution processes in the weathering environment. This is important to estimate the impact of weathering on the atmospheric CO$_2$ budget. The global range in Ca and Mg isotopes in rivers is however relatively small with ca.1.8 ‰ range in δ^{26}Mg and 0.8 ‰ for $\delta^{44/42}$Ca. Data from >50 samples from both the Himalayan-Tibetan-Plateau region and elsewhere in the world suggest that there is a restricted control of lithology on $\delta^{44/42}$Ca and δ^{26}Mg in spite of investigating both large and small rivers draining a range of lithologies from silicate, limestone and dolomite dominated catchments.

A time-series from the Marsyandi River, Annapurna Himalaya, Nepal shows that variations in Ca and Mg isotopes are small but detectable. There is a marked negative correlation between $\delta^{44/42}$Ca, and δ^{26}Mg . This suggests that there is single control on the variation in both isotopic systems. Given that there is no correlation with major element chemistry or Sr isotopes (hence lithology) it is likely that both Ca and Mg isotopes are controlled by a mass dependent process. The most likely process to influence both elements is incongruent dissolution reactions in the weathering environment.