The role of ridge-flank (low-T) hydrothermal circulation in the oceanic Mg budget – Mg isotope constraints

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The magnesium budget of the ocean, and its evolution through time, has implications for our understanding of the processes controlling ocean chemistry, the relationships between weathering, volcanism and the carbon cycle, and the derivation of temperatures from foraminiferal Mg/Ca ratios. Recent reconstructions of the Cenozoic Mg isotope composition (δ^{26}Mg) of seawater put constraints on the oceanic Mg budget, but require a fuller understanding of Mg isotope behaviour for the inputs and outputs.

Mg is removed from the oceanic dissolved pool during hydrothermal alteration of the oceanic crust and into dolomitic sediments, with the relative balance between the two sinks being controversial. Quantitative removal of Mg in high-temperature (≥70°C) hydrothermal systems must be associated with no isotope effect. In contrast, partial removal at low temperature could have a significant impact on the isotope evolution of seawater. Here, we present the first data for δ^{26}Mg in low-temperature hydrothermal fluids.

The fluids derive from several locations, representing a range of upper-basement temperatures (UBT) of 6–60 °C and Mg concentrations of 1.3–52.5 mmol·kg^{-1}. δ^{26}Mg values of all samples are lower than the modern seawater value (-0.83‰), showing that the heavy isotope, ^{26}Mg, is preferentially incorporated into the oceanic crust. The isotope fractionation ($\varepsilon_{solid\text{-}fluid}$) increases with decreasing UBT, from ~0.25‰ to ~5‰, though the uncertainty on the latter is significant.

In common with previous findings, these data require a significant Mg removal flux by low-temperature hydrothermal alteration of the oceanic crust (up to 55% of the riverine input of Mg to the ocean). In order to keep the δ^{26}Mg value of the ocean close to constant, as suggested by Cenozoic records, a large ouput flux to dolomite is required (with opposite Mg isotope fractionation: $\varepsilon_{dolomite\text{-}sw} \approx$ -2‰). We estimate the dolomite flux to be ≥ 1.2 Tmol(Mg)·yr^{-1} (~22% of the riverine input), higher than previously suggested.