The Geochemical Cycling of Magnesium Isotopes During the Past 65 Myr

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Introduction

As CO_2 levels rise, the need for accurate predictions of global climate change effects increases. Unraveling climate variations during the Cenozoic Era (0 to ~65 million years ago (Ma)) can provide insight on future climate change. During this time, the major control on climate was the chemical weathering of silicate minerals on mountains (removal of atmospheric CO_2). Various elements participate in these reactions, but of particular interest is Mg due to its major role in silicate weathering. These reactions fractionate stable isotopes, such as Mg, and eventually release the products to the ocean via river runoff. This influences the ocean's composition, and in turn effects the skeletal composition of planktonic foraminifera (a marine microorganism). As a result, foraminifera fossils provide a natural proxy for ancient seawater. The present study analyzes the Mg isotopic composition of planktonic foraminifera fossils from 0 to 68 Ma.

Experimental

All laboratory procedures were performed in the Geochemistry division of NHMFL. Foraminifera samples were prepared in a class-100 clean lab using reductive (hydrazine) and oxidative (hydrogen peroxide) cleaning to remove clay, Fe- and Mn-oxide coatings, and organic matter[1]. The samples underwent column chromatography to separate the Mg from other matrix elements using BioRad® AG 50Q-X8 resin. Mg isotope ratios were obtained from Multi-Collector-Inductively Coupled Plasma-Mass Spectrometry (MC-ICP-MS; ThermoScientific Neptune).

Results and Discussion

Mg isotopic compositions are expressed as the per mil (‰) deviation from the DSM3 reference standard:

$$\delta^{26}Mg\ (‰) = \left(\frac{(^{26}Mg/^{24}Mg)_{sample}}{(^{26}Mg/^{24}Mg)_{DSM3}} - 1\right) \times 1000 \qquad [1]$$

Fig. 1 displays the δ^{26}Mg of planktonic foraminifera through the Cenozoic. The data falls within analytical uncertainty of the modern foraminifera value ($\delta^{26}Mg_{Core\ Top}$ = -4.63 ± 0.55‰). This suggests silicate weathering is not the primary control on δ^{26}Mg and that one of the other geochemical processes of Mg must be influencing the record (hydrothermal vent reactions, dolomite ($Ca,Mg(CO_3)_2$) formation, and ion exchange of seafloor clays[2]). Thus, we can conclude that during the Cenozoic, δ^{26}Mg in seawater has either remained in steady state or has varied on a scale that is smaller than the analytical uncertainty of δ^{26}Mg in modern foraminifera.

Conclusions

The present study focused on magnesium isotopes in an attempt to constrain silicate weathering during the Cenozoic. Our analysis of δ^{26}Mg planktonic foraminifera concludes that there are no statistically significant variations in time (Fig. 1), suggesting that there are other major geochemical processes influencing δ^{26}Mg.

Acknowledgements

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References

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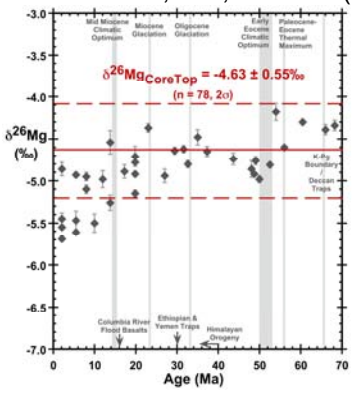

Fig.1 δ^{26}Mg (‰) of planktonic foraminifera from 0 to 68 Ma (millions of years ago). The gray diamonds represent individual data points (2σ). The red, solid line represents the average δ^{26}Mg of modern-day core top foraminifera (dashed line is 2σ).