The Mg isotope budget of the modern ocean: Constraints from riverine Mg isotope ratios

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Mg is the 8th most abundant element in the continental crust and the 4th most abundant species in seawater . Its transfer from the continents to the oceans, via rivers, and return to the solid Earth via hydrothermal exchange at mid ocean ridges constitutes one of the major chemical exchanges between the mantle and the hydrosphere. Mg isotope ratios may provide a valuable new tracer of these bio-physiochemical processes. We have measured Mg isotope ratios in 93 rivers from different geologic, tectonic and climatic settings, including 16 of the largest rivers in the world, accounting for almost 50% of the riverine flux of Mg to the oceans.

The range in riverine δ^{26}Mg is 2.5‰, half the variation in terrestrial rock. The average of all rivers measured so far is -1.34±0.11 ($2\sigma_{mean}$) relative to the DSM3 standard. The best estimate of the Mg isotope composition of continental runoff is a flux weighted mean of the largest rivers in the world at -1.09‰. Even taking into account uncertainty, these average riverine δ^{26}Mg is distinct from seawater at -0.82‰. This difference arises either from the fractionation of Mg isotope ratios in the ocean or a Mg budget which is not in steady state.

The difference is consistent with fractionation by carbonate precipitation. In the simplest steady state scenario, where the oceanic mass balance is maintained by riverine input and hydrothermal and dolomite output, Mg isotope ratios imply a minimum dolomite Mg flux of 9% of the total output Mg flux. This is greater than some previous estimates of the modern dolomite flux.