Re-evaluating the role of authigenic marine sediments in the oceanic magnesium and magnesium isotope cycles

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The diffusive solute flux across the sediment-water interface is a globally significant process for several major element cycles in the ocean on the 10^5–10^7 year time scale, including the magnesium (Mg) cycle. Authigenic mineral formation and pore water burial drives a flux of Mg into marine sediments throughout most areas of the global ocean. The magnitude of this flux and the isotopic fractionation that occurs in the sediment column are important parameters for paleo-oceanographic models and global geochemical budgets. To robustly evaluate the role of the marine sedimentary sink in the oceanic Mg budget, we quantify the flux of Mg from the ocean due to diffusion and pore water burial in continental slope, rise, and abyssal environments. Fluxes are calculated using reactive-transport modeling across the sediment-water interface with measured solute concentration profiles, porosities, sedimentation rates, and bottom-water temperatures from ~240 scientific ocean drilling locations globally. The global flux is estimated using statistical machine learning methods, which are particularly well-suited for application to the wide variety of environments represented in the ocean drilling dataset.

Due to the differences in Mg isotopic fractionation during authigenic silicate formation versus authigenic carbonate precipitation, the process that dominates the Mg isotope ratio in the upper sediments will control the effect on the oceanic Mg isotope ratio. We evaluate the processes controlling Mg uptake at eight representative drilling sites and three seafloor seeps using pore water Mg isotope measurements. We find that carbonate precipitation dominates changes in the Mg isotope ratio in the upper sediments at the sites with the highest fluxes of Mg into the sediments, whereas authigenic silicate formation becomes more dominant deeper within the sediment column.

The quantification of this Mg sink and associated Mg isotope fractionation provides more accurate constraints on the modern global Mg budget, providing a benchmark for models and interpretations of the paleo-oceanographic Mg isotope record.