Magnesium isotope behaviors during authigenic carbonate precipitation driven by anaerobic methane oxidation

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Formation of authigenic carbonate during anaerobic oxidation of methane (AOM) in cold-seep environments has been invoked as a critical but previously neglected process in regulating the carbon cycle over Earth's history. Because Mg can be incorporated into crystal lattices of authigenic carbonates, this process, in principle, can play an important role in the global biogeochemical cycle of Mg. However, its contribution has not been quantified.

To estimate the influence of AOM-induced authigenic carbonate formation on the global Mg cycle, we investigate Mg isotope systematics in cold-seep sediments and pore fluids collected from Shenhu area in the South China Sea. δ^{26}Mg values of pore fluids systematically increase with depths from -0.82‰ at 1 meter below the seafloor (mbsf) to -0.62‰ at 8 mbsf. In contrast, δ^{26}Mg values of the co-existing AOM-induced authigenic carbonates are lower, and broadly decrease with depths from -1.15‰ to -1.50‰. The apparent Mg isotope fractionation between carbonates and pore fluids ($\alpha_{car\text{-}sol}$) ranges from 0.99919 to 0.99974. The magnitude of this fractionation appears to be considerably smaller than that associated with formation of abiotic and biotic Mg-bearing carbonates in non-AOM areas in the global ocean ($\alpha_{car\text{-}sol}$= 0.99517 to 0.99964) (Saenger and Wang, 2014), possibly reflecting high precipitation rates of carbonate formation induced by AOM at cold seeps. These results provide new constraints on the Mg flux associated with AOM-induced authigenic carbonates and its significance in the Mg cycle in the global ocean.