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Mg isotope constraints on the Earth's surficial Mg cycle over the past 3.5 billion years

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The surficial Mg cycle is intimately coupled with Earth's carbon cycle and thus exerts a key control on Earth's climate and habitability. However, the evolution of Earth's surficial Mg cycle over time, as well as its impacts and controls within the context of Earth's secular tectonic, climatic, and biodiversity changes, remain poorly understood. The Mg isotope composition of seawater ($\delta^{26}Mg_{sw}$) is sensitive to shifts in the balance between silicate and carbonate sources and sinks in the ocean. Consequently, reconstructing the secular evolution of $\delta^{26}Mg_{sw}$ can provide critical insights into the history of Earth's surficial Mg cycling. Recent advances have utilized dolostones and halite to constrain $\delta^{26}Mg_{sw}$ values over the past 2 billion years (Xia et al., 2024). Stromatolites, i.e., laminated microbial carbonates formed by trapping of detrital grains and authigenic mineral formation via increased alkalinity in extracellular polymeric substances, have been proposed as geochemical archive for shallow-marine aqueous systems through deep time. Here, we present new Mg isotope data from over 130 dolomitic stromatolites and dolostones spanning in age 3.5 to 2.0 Ga. Although the dataset is sparse given the vast timeframe examined, our results indicate that $\delta^{26}Mg_{sw}$ values likely fluctuated between -0.2‰ and +0.3‰ during the Archean and Paleoproterozoic, >1‰ higher than values of the modern seawater. Isotopic mass balance modelling of the ancient $\delta^{26}Mg_{sw}$ values shows that dolostones must have sequestered a significant fraction of Mg derived from silicate weathering during the Archean and Paleoproterozoic, thus carbonate deposition rather than reverse weathering acted as a major sink for marine Mg during Earth's early history.

Ref: Xia, Z., Li, S., Hu, Z., Bialik, O., Chen, T., Weldeghebriel, M.F., Fan, Q., Fan, J., Wang, X., An, S., Zhang, F., Xu, H., Chen, J., Ji, Z., Shen, S., Lowenstein, T.K. and Li, W. (2024) The evolution of Earth's surficial Mg cycle over the past 2 billion years. Science Advances. 10, eadj5474