Global importance of diffusive cation fluxes in deep-sea sediments for the geochemical cycles of calcium, magnesium, sodium and potassium

XIAOLE SUN[1], JOHN HIGGINS[2] AND ALEXANDRA V. TURCHYN[1]

[1]Department of Earth Sciences, University of Cambridge, CB2 3EQ, Cambridge, UK

[2]Department of Geosciences, Princeton University, Princeton, NJ 08544, USA

The biogeochemical cycles of calcium, magnesium, sodium and potassium, are linked to the ocean's alkalinity budget through terrestrial weathering and the subsequent formation and burial of carbonate minerals in marine sediments. Alkalinity is delivered to the ocean through these four cations, but is largely removed through calcium carbonate accmulation on the ocean floor. Therefore, non-calcium cations are removed from the ocean through a variety of other processes, including the formation of evaporates and clay minerals and the exchange of interlayer cations in clays. Here, we quantify the fluxes of calcium, magnesium, sodium, and potassium within marine sediments by compiling a global database of pore fluids from the various Ocean Drilling Programs. Changes in the concentration of different elements within pore-fluids reflect chemical reactions within the sediments or with the underlying oceanic crust, or changes in seawater chemistry (the boundary conditions). We calculate the flux within marine sediments for these cations based on the pore-fluid concentration profiles and corrected for diffusion. Our calculated fluxes of calcium and sodium within marine sediments are spatially heterogeneous, while the fluxes of magnesium and potassium are a relatively homogeneous sink to marine sediments. Our calculations indicate that the net source/sink of cations in deep-sea sediments and underlying crust is quantitatively important to what is ultimately buried. However, additional studies on near-surfaces and boundary-layer fluxes of cations across the sediment-water interface are needed to accurately estimate the global sink of elements in sedimentary systems. Delineating the various processes that control the major cation chemistry of seawater on geologic time scales remains critical for understanding how the silicate-weathering thermostat operates.

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