

Neodymium Stable Isotope Behaviour in the Critical Zone

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Radiogenic neodymium (Nd) isotopes are widely used to trace water mass circulation, yielding remarkable insights into the relationship between ocean circulation and climate change, but the exact sources of Nd to the ocean remain poorly constrained. This study presents Nd stable isotope data for soils, rivers and estuarine samples from Iceland, where source rock compositional variability is minimized, and the behaviour of Nd can be traced through the critical zone.

Neodymium stable isotopes were measured using double-spike and TIMS techniques, with a typical uncertainty of ± 0.020 for the $\delta^{146}\text{Nd}$ composition. Average catchment bedrock yields a $\delta^{146}\text{Nd}$ value of -0.04 . Wetland soils, reflecting relatively high weathering degrees under variable redox conditions, possess $\delta^{146}\text{Nd}$ compositions both heavier and lighter than average catchment bedrock. Soil pore waters possess $\delta^{146}\text{Nd}$ compositions that are systematically heavier than their host soil, with $\delta^{146}\text{Nd}$ up to $+0.15$. These variations are consistent with complexation/solubilisation by organic matter or adsorption/dissolution of Fe-Mn oxyhydroxides. Rivers possess $\delta^{146}\text{Nd}$ compositions that are generally heavier than bedrock or soil $\delta^{146}\text{Nd}$ up to $+0.38$, with elemental and isotope variations suggesting that they form a continuum with the soil pore waters. Riverine and estuarine particulates are slightly heavier than the bedload, which may be due to the presence of organic matter, secondary mineral formation, or the preferential adsorption of heavy Nd isotopes onto particulates. Estuarine waters are all heavy showing trends consistent with simple mixing with seawater, but crucially there is continued and substantial release from particulates in the estuary. Overall, these results indicate that weathering of basalt yields waters that are heavier than the bedrock, the dominant controls on fractionation are uptake and release from organic material and Fe-Mn oxides, transport occurs via the colloidal phase, and release from particulates continues into the estuarine and shelf environment.