Tracing metal processing in soil with molybdenum isotopes

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Molybdenum (Mo) isotopes have been widely used to evaluate paleoredox conditions in the oceans, but they also may prove a useful tracer of weathering, redox, nutrient cycling, and atmospheric inputs in Earth's Critical Zone. Mo is a redox sensitive trace metal and an essential micronutrient for microbial and plant nitrogen assimilation. Soil Mo abundance and isotopic composition has been investigated as a function of climate and age along well-constrained soil climosequences on 10 kyr and 400 kyr basalt lava flows in Hawaii, as well as in basalt and sandstone derived soils in the Oregon Coast Range, volcaniclastic and quartz diorite-derived soils in the Luquillo Mountains of Puerto Rico, and a transect of 23 sites across the Amazon basin. We consistently find positive correlations between soil organic matter content and soil Mo content, Mo availability, and $\boldsymbol{\delta}^{98}$Mo values. Mo mobility and $\boldsymbol{\delta}^{98}$Mo was measured before, during, and after artificially induced reduction-oxidation experiments, in both colloidal and dissolved phases. Mo in soils is often substantially augmented by additions from precipitation, and potentially anthropogenic inputs of Mo, modulating the bioavailability of Mo as a micronutrient as well as the $\boldsymbol{\delta}^{98}$Mo values of Mo fluxes within and from soil.