

4.5.14

The use of Zn isotopes to constrain the biogeochemical cycling of metals in watersheds

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Numerous studies are carried out on pristine watersheds in order to calculate chemical and physical weathering rates and/or to constrain the geochemical cycling of the elements (major and trace) (e.g., Drever and Clow, 1995). Most of these studies consider vegetation to be in a steady state and finally neglect this term. However, several works have shown without ambiguity that plants may have a key role in the transfer of elements (e.g., Likens and Bormann, 1995). Moreover, the steady state hypothesis of the vegetation is not often true and improving our understanding of the geochemical cycles of the elements in natural systems and calculating true chemical weathering rates needs accounting for the role of plants.

Some recent works have shown that isotopic fractionation of the transitional metals (e.g., Cu, Fe, Zn) can occur during low temperature processes such as those biologically mediated [Maréchal et al., 1999; Mason et al., 2003]. The present work focuses on Zn isotopes (MC-ICP-MS measurements) and concentrations measurements in plants, soils, rocks and waters (i.e., rainwater, riverwater) of the Nsimi-Zoétéélé watershed (Cameroon, Africa). The $\delta^{66}\text{Zn}$ measured in the soil and rocks range from -0.22 to 0.64 ‰. The values measured in the different organs (i.e., roots, shoots, leaves) of various species fluctuate from -0.91 to 0.75‰. The analytical precision (2σ) for these measurements is around 0.05‰. As reported by Mason et al. (2003) for species grown in nutrient solutions (hydroponic study), there is an enrichment of light isotopes in the shoots and leaves compared with the roots. Such isotopes fractionations will be used to constrain the transfer of these elements (fluxes) within the different reservoirs (biotic and abiotic) of a natural ecosystem and beyond this to reach a better understanding of their global cycles at the Earth surface.

References

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4.5.15

Tracing of atmospheric Pb, Sr and rare earth elements in a soil-water-plant system of a forested silicate catchment

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Sr, Pb and Nd isotopes as well as rare earth elements (REE) have been used as tracers in a forested silicate catchment of the Vosges Mountains (France) not only to distinguish between the atmospheric and lithological origin of these elements in soils and surface waters, soil solutions as well as throughfall, lichens, roots and wood but also, in a larger context, to determine the recovery of the watershed from environmental disturbances such as acid rain. All components of this soil-water-plant system have Sr, Nd and Pb isotope ratios and REE spectra pointing to an origin of at least two different sources: 1) an atmospheric source with fertilizer, dust and seawater components and 2) a source mainly determined by apatite and feldspar dissolution.

The Sr, Nd and Pb isotope data suggest that most of Sr, Nd and Pb in spring and streamwater originate from apatite and feldspar leaching or dissolution. As indicated by leaching experiments, especially the upper horizons of the soils are strongly influenced by atmospheric input. Roots of small plants and grass have isotope characteristics and REE spectra similar to those found in corresponding soil solutions. REE spectra in wood and bark of larger trees (beech, spruce) are characterized by positive Eu anomalies which diminish and disappear with increasing REE concentration due to increasing atmospheric contribution to the plant. The atmospheric contributions of Sr, Nd and Pb to throughfall, soil solution and plants are up to 40 %. This contribution is important and suggests that also other important cations arrive in larger quantities like the Ca, which is not only a dominant acid neutralising cation but also an important nutrient [1,2].

References

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