

Biogeochemical cycling of rare earth elements in surface soils

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Stille *et al.* (2006) have suggested in a study on the Strengbach catchment in the Vosges mountains (eastern France, <http://ohge.u-strasbg.fr>) that preferential absorption of light REE (LREE) by vegetation may contribute to LREE depletion of stream water. New REE data on soil solutions recovered on the same site from 10 to 70 cm depth show similar to vegetation an enrichment of the LREE. Strontium and neodymium isotope data from these solutions indicate that up to 90 % of Sr and Nd are derived from vegetation litter. This origin of the REE in the surface soil is in strong contrast to the underlying regolith, where the mobile REE essentially originate from the dissolution of apatite derived from the granitic bedrock (Aubert *et al.*, 2001). The Sr isotope record from tree rings of 3 spruce specimens planted 90-100 years ago on the study site yields valuable information on the formation of these different REE pools. The data demonstrate that the spruce mainly absorbed Sr from granite-derived minerals during the first years after plantation. But rapidly the isotopic compositions of the tree rings are shifted to values typical for atmospheric deposits. We interpret this evolution by transformation of the initial mineral soil into a surface soil rich in organics issued from the decomposition of vegetation litter. This new surface soil contained in the beginning mainly regolith-derived Sr inherited from vegetation. This initial Sr was then continuously removed by soil water runoff and replaced by atmospheric Sr. We are actually analyzing Nd isotopic compositions on the same spruce samples in order to confirm this hypothesis for the REE. This scenario thus suggests that vegetation and surface soil form an almost closed biogeochemical cycle for the REE, accumulating preferentially LREE issued from vegetation litter. This cycle is modified by inputs from atmospheric sources and leaching of remaining soil minerals, and outputs by surface and soil water runoff. Local stream water is in contrast to surface soil and vegetation depleted in LREE indicating that surface soil water is not the dominant source for stream water. This is in agreement with Nd-Sr isotope data from Stille *et al.* (2006) showing that stream water REE are mainly derived from alteration of apatite within the mineral soil. We suggest that the formation of a LREE enriched reservoir in the surface soil has together with preferential scavenging of the LREE by adsorption and precipitation during groundwater flow contributed to the formation of a LREE depleted groundwater pool within the underlying regolith. This groundwater is the main source for stream water at low stream flow.

References

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The mobility of actinides and ⁹⁰Sr from bomb test fallout in a karstic area, Jura Mountains (Switzerland)

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The presence of artificial radioisotopes of plutonium, americium and strontium is mainly due to the atmospheric tests of nuclear bombs before 1964. Present day inventories of these radionuclides in soils of the Jura Mountains (Switzerland) often are less than expected. Apparently, there has been leakage from the soils (especially the thin soils) into the karst of this region of carbonate rocks.

With the goal to assess this possible long-range migration in a natural setting we analyzed the radioisotopes

- in upland soils (soil profiles and soil solution profiles near Col de Mollendruz, Switzerland, 1200 a.s.l.),
- in a karstic source at a distance of ca. 5 km (water and aquatic mosses, 660 m a.s.l.), and
- in cave deposits from the same area.

The mean soil inventories (0-25 cm) for thick soils are 1.3 kBq/m² and 0.12 kBq/m² for ⁹⁰Sr and Pu, respectively. The radioisotopes have significantly diffused towards deeper soil layers (40 cm depth or more) and they are also present in measurable amounts in the soil solution (< 0.22 µm, i.e. dissolved and colloidal). These findings highlight the potential of long-range transport in colloidal form. The calculated distribution coefficients K_d are on the order of 10'000; 3'000; and 1'500 for Pu, Am, and Sr, respectively.

The radioisotopes appear in the waters of the karstic source and in aquatic mosses collected close to the source. The plutonium activity found in the filtered (<0.45 µm) source water is 4 and 22 µBq l⁻¹ (U₉₅ = ±25 %) at high-stand and low-stand, respectively. The Sr-90 activity of these waters is approximately 1000 times higher. In the mosses we find up to 20 mBq/g or more of Sr-90. However, most of this activity is associated with carbonates, which have precipitated on the mosses after degassing of CO₂ from the source waters. The Pu activities of the moss samples vary between 0.1-0.2 mBq/g.

Taken together our results demonstrate the long-range transport (km-scale) of Pu, Am, and ⁹⁰Sr in a natural karstic environment with no radioisotope contamination other than "global fallout".