Multi isotope (Li, B, U) study of the clay-size fraction in weathering profile

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Accurate knowledge of the chemical budget, rates and parameters that control soil-forming reactions is a critical issue because they determine the long-term evolution of soils and landscape but also determine the rate at which soil nutrients can be renewed. Classically, hydro-(bio)geochemical models are used to determine the instantaneous budget of the transfer of matter between soil particles, solutions and sometimes vegetation. However, the interdependence and non-linearity of the soil/water/plant interactions often lead to underconstrained systems that makes difficult a full characterization (nature and extent) of the actual reactions in progress. Of particular interest are the identification of the active layers in soil profile in terms of water/rock interactions and the relative contribution of primary and secondary minerals as well as biology-derived compounds to the present chemical fluxes.

Here, we conducted a comprehensive study on the Li, B and U isotopes in bulk soil sampled along weathering profiles and, in parallel, on the separated clay-size fractions. The soil profiles are sampled along slopes of the Strengbach catchment (Vosges Mountains, France). Results on clay-size fractions show much larger variations with depth than bulk samples and show significant discrepancies between tracers that clearly highlight their respective sensitivity to different parameters. Mixing diagrams helped to interpret the data from the clay-size fraction as mixing of three components: primary minerals, inherited clays present in the bedrock and resulting from ancient water/rock interactions (possibly during the early hydrothermal event), and pedogenic products that integrate all the secondary, more or less crystalized, phases as well as organic residues. The evolution with depth of their relative proportions as well as changes in their chemical/isotopes signature would be particularly valuable by providing clues about chemical transfer in weathering profile. However, the system of mass and isotopic budget to solve is still underconstrained, issue that is solved by applying a Monte Carlo approach. Results of the simulations give strong constraints on the evolution with depth of the relative proportion of each of the three components of the mixing and helped refining the range of their possible isotopic compositions. On a high-resolution soil profile, results clearly point to the important role played by the inherited clays mineral in the deeper part of the profile and the impact of the vegetation activity on the top soil layer. Comparison of different soil profiles in the watershed also helped determining the spatial variability of the weathering regimes.