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Geochemical tracing and modeling of the uranium disequilibrium at the catchment scale

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Concentrations (major elements, Sr and U) together with Sr and U isotope ratios were regulary measured in main springs along an altitudinal transect within the Ringelbach catchment (Vosges, France). Moreover, water samples were also collected and analyzed from deep boreholes drilled through the whole weathering profile of the granite bedrock. This set of data allows for both the characterization of the hydrogeochemical functioning and quantification of weathering processes at the scale of a small granitic catchment.

The chemical composition of the waters varies largely whitin the watershed. The data indicate that the intensity of water-rock interactions increases when the elevation of the spring decreases and is maximal in deep borehole waters. Springs show significant geochemical variations with the discharge, which cannot be simply interpreted in terms of variable contributions of rainwater. Furthermore, geochemical and Sr isotopic variations in subsurface waters cannot be explained by variable contributions of deep borehole waters. Altogether these observations confirm that spring waters are supplied by waters flowing through surface formations. Such spatial variations of springs chemical compositions and U isotopic ratios with the elevation is interpreted as the involvement of water masses having suffered different intensities of interaction with the granitic bedrock. In other words, this suggests that there is a relationship between the length of the water path in the catchment and the nature or intensity of water-rock interactions.

Based on this interpretation, the (234U/238U) activity in spring waters can be modeled as a simple 1D reactive transport taking into account dissolution, precipitation and alpha recoil. Estimating the alpha recoil factor and the length of the water path for each spring, it is possible to quantify both the dissolution rate of the bed rock and the water flux within the catchment.

The study of the different springs emerging along the slope of a single watershed allow in a simple way to characterize the different stages of water evolution along the water pathway. This kind of approach should be very helpful in the future to better constrain the mechanisms involved in the acquisition of the water chemistry at the scale of a small watershed.