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Hydrogeochemical modeling (KIRMAT) of surface water-rock interactions in elementary granitic catchments (Ringelbach and Strengbach, Vosges Mountains, France)

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From the study of two elementary mountainous catchments, the Strengbach and Ringelbach catchments, East of France, we propose to show the interest of spring water hydrochemical modeling approaches for constraining the nature, intensity and time constant of weathering processes within the critical zone.
In the Ringelbach catchment (Lucas et al., 2017), the model enables to constrain the nature of the rock along the water-pathway, which is neither saprolite nor fresh granite but is instead weathered granite with a weathering age of several tens of thousands of years. Spatial and seasonal variations in the chemical compositions of spring water can be explained as the result of the same circulation pattern for which the water-rock interaction time is determined by the length of the pathway and the water velocity. If this interaction time is long enough, the precipitation of clay phases is enabled, which plays a major role in determining the water chemical composition.
In the Strengbach catchment, the study focuses on 20 years of hydrochemical monitoring of the small springs that emerge in the experimental granitic catchment and the simulation of these data using the KIRMAT code. The data indicate that the Strengbach springs display chemostatic behavior. Only the Ca2+ concentrations reflect a significant decrease in all springs since 1987. The modeling results show that this decrease is due to the response of the water-rock interactions within the bedrock to the variations in the chemical composition of the soil solutions, which were characterized by a significant increase in pH and a decrease in Ca2+ concentrations between 1987 and 2010 (Prunier et al., 2015). This decrease in Ca2+ concentrations is controlled by changes in the apatite dissolution rate and the compositions of clay minerals induced by the soil solution changes.
In both catchments, despite the only one-dimensional approach and the uncertainties linked to the geochemical complexity, the results enable to better understand and quantify the weathering processes and the coupling that exists between water circulation dynamics and water-rock interactions at the catchment scale.

Prunier J. et al., 2015. Chemical Geology, 417, 289–305.
Lucas Y. et al., 2017. Applied Geochemistry, 87, 1–21.