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Nutrient and Metal Release from Shale Weathering Processes Occurring Across Multiple Scales

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Shale weathering releases harmful elements and nutrients into watershed ecosystems. It is driven by rock–water reactions typically influenced by microbial processes. As climate change alters precipitation patterns, a mechanistic understanding of weathering pathways is essential for anticipating impacts on watershed ecosystems. To study this process, soil and a bedrock core were collected from a shale hillslope within the East River watershed of Colorado. Weathering rinds along bedrock fractures were analyzed with synchrotron μXRF and μXANES spectroscopy. In addition, XRD and bulk geochemical measurements via ICP-MS and ICP-AES were made throughout the hillslope. Weathering profiles at both scales include sharp pyrite reaction fronts and accumulation of redox-sensitive elements at redox boundaries, indicating that these elements might not be released into the watershed. The carbonate reaction fronts at the hillslope and fracture scales are offset from the pyrite oxidation profiles. There is evidence of re- precipitation of carbonate and pyrite at the fracture and hillslope scales, respectively. We infer that fundamental weathering reactions are overprinted by changing redox conditions driven by the seasonally fluctuating water table. In another experiment, lab incubations of shale from the site with East River water showed a slow release of sulfate up to 2mM. Towards the end of the three-month incubation, organic carbon and ammonium were also released as a result of shale weathering.