



## Controls on weathering rates at the Susquehanna Shale Hills Critical Zone Observatory, Pennsylvania, USA

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Shale Hills, a V-shaped forested catchment located in central Pennsylvania, is the center for collaborative efforts directed towards understanding the creation, function and evolution of soils in a Critical Zone Observatory (CZO). Shales are one of the most weathering-resistant rock types at the Earth surface, and our study at Shale Hills will provide a baseline to evaluate weathering as an important process in global elemental cycles. Here, we compare chemistry and mineralogy in representative soil profiles to the chemistry of streams, groundwaters and soil waters to investigate shale weathering rates on geologic and contemporary timescales.

The dominant chemical reactions during regolith formation are clay transformation: from chlorite and illite to kaolinite, with vermiculite and hydroxy interlayered vermiculite as intermediate phases. The chemistries of soil waters and first-order stream are controlled by chemical weathering reactions. Generally, soil waters become more concentrated from the ridge top to valley floor along flow paths, as mineral dissolution progresses. The chemistries of soil waters also vary with landscape positions and soil thickness. The depth variation of water chemistry is distinctively different among the sites and is controlled by soil texture relationships along the hillslope. The stream reflects mixing among soil waters of different chemistry (shallow versus deep), and mixing of soil waters and groundwaters. The concentrations of Fe and Al in soil waters are elevated in shallow soils, with mobility and transport promoted by acidic soil conditions and higher dissolved organic carbon concentrations near the surface environment.

Depth to bedrock in the catchment varies with landscape position, with thinner soils observed at the ridge tops and much thicker soils at the valley floors and topographical depressions. All major elements show depletion within soil profiles. Assuming soils along a planar transect are at steady-state, a hillslope evolution model suggests that elemental transport at ridge top and mid slope are sub-equally contributed by chemical leaching and physical erosion fluxes. At the valley floor, however, model results require Al-, Fe- and Si-rich phases to be accumulating, which soil water chemistry does not support. Thus, we suggest that fine particles enriched in Al and Fe are likely mobilized by water and transported along the hillslope, and then re-deposited at the valley floor. The nature and magnitude of this particle-facilitated transport is being evaluated. The detailed geochemical, hydrological, biological, and geomorphological data collected at the CZO is elucidating controls on weathering and erosion on this important lithology.