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Shale to Regolith Evolution: The Controls on Catchment Solute Fluxes

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Understanding the factors that control the formation of regolith and the evolution of pore space within regolith as it is moves upward to the surface is of global importance. Unfortunately, both access and high costs have been prohibitive in gathering information about the bedrock-regolith boundary. Recognizing the need for data at depth, the Critical Zone Observatory (CZO) network initiated the “Drill the Ridge” project. The goal of this project is to investigate fresh bedrock at each CZO and then to perform an array of downhole geophysical survey and geochemical analyses to understand regolith formation.

In response to this call, several ridgetop boreholes were drilled at the Susquehanna Shale Hills CZO in 2012 and 2013. Here we present the optical televiewer and gamma logs of these boreholes, along with downcore bulk geochemical analysis to shed light on the geochemical and lithological controls on the evolution of the watershed. Observations of catchment hydrology are also being used with estimates of hydrologic parameters to quantify near-surface geologic evolution and geochemical fluxes associated with weathering at depth. To quantify the contribution of weathering fluxes from the mobile regolith, we then link the meteorological forcing from the North American Land Data Assimilation System (NLDAS-2), the fully-coupled land-surface Penn State Integrated Hydrologic Model (Flux-PIHM), and the geochemical box model WITCH. With this cascade of models, solute fluxes for the CZO are being simulated.

At depth, the bulk geochemical analysis of ridgetop sediments indicates that pyrite had the deepest depletion front, which was concurrent with the regional water table position. Hydrologic data together with detailed borehole and bulk soil/rock geochemical analysis elucidated an eastern to western progression in lithology across the SSHCZO catchment controls fracture distribution and thus groundwater flow. Where shale and mudstone underlie the eastern portion of catchment, the water table mirrors that of the topography and groundwater chemistry indicates long residence times at depth.