The Critical Zone in the Susquehanna River Basin: The Shale Experiment

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The surface of the earth comprises a weathering engine or mill that solubilizes and disaggregates rock to form regolith. The rates and mechanisms of regolith formation contribute to such important processes as nutrient cycling, carbon sequestration, soil horizonation, erosion, and acid rain mitigation. Over the long term, the rates of weathering and erosion combine to control the evolution of landscapes and help to define the access, rates of motion, and time scales of water and energy within the Critical Zone (CZ). We must understand the processes and multiple feedback loops that control regolith formation in order to predict how the CZ will change in response to anthropogenic and climate perturbation. Here we propose a Critical Zone Observatory dedicated to developing this understanding.

The purpose of this observatory and associated interdisciplinary research is to quantitatively predict the creation, evolution, and structure of regolith as a function of the geochemical, hydrologic, biologic, and geomorphologic processes operating in a temperate, forested landscape. By creating an interdisciplinary team working collaboratively in one observatory we aim to advance methods for characterizing regolith, to provide a theoretical basis for predicting the distribution and properties of regolith, and to theoretically and experimentally study the impacts of regolith on fluid pathways, flow rates, and residence times. Our research site, the focus of National Science Foundation-supported research since the 1970s provides long datasets and model testbed for hydrological response that will be augmented here by new geochemical, geomorphological, ecological, and soils datasets, all to be readily available to the worldwide research community. The proposal has three elements which form the basis for this work: 1) From Process to Prediction: Creation and Evolution of Regolith in a Critical Zone Observatory, 2) From Form to Function: Identification and Modeling of Hydrologic Pathways and Fluxes within the Critical Zone, 3) A Synthesis of Observatory Science Through Community Models.

This proposal brings together and builds on two active consortia of scientists, one formed to design and implement the Susquehanna River Basin Hydrologic Observing System (SRBHOS) (www.srbhos.psu.edu), and the other formed to advance the Critical Zone Exploration Network (CZEN) (www.czen.org). In addition, the proposal takes advantage of an Environmental Molecular Sciences Institute (NSF Center for Environmental Kinetics Analysis, CEKA) at Penn State, for analysis and modeling of geochemistry in environmental systems.

The proposed plan will assure the critical mass and leverage necessary to sustain quality research, facilitate dissemination of data, and community models. The multidisciplinary effort will allow a new and collaborative approach to formulating hypotheses and potential scenarios for environmental change within shale (and other) landscapes; it will promote the development of new data-driven algorithms that enhance our ability to represent and predict water cycle dynamics; and will support a scientifically-based design for the future observatory's sensor network.