2016 GSA Annual Meeting Planner for Susquehanna Shale Hills Critical Zone Observatory

Denver, Colorado, USA

(25-28 September 2016)

Sunday, 25 September 2016

Paper No. 6-7
Presentation Time: 9:50 AM

SURFACE AND SUBSURFACE CHARACTERISTICS OF PERIGLACIAL LANDSCAPE MODIFICATION IN CENTRAL PENNSYLVANIA

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In slowly-eroding landscapes, critical zone architecture reflects the integrated effect of multiple Quaternary climate cycles. In the central Appalachians, south of the Last Glacial Maximum ice extent, hillslopes and headwater valleys show extensive evidence of relict periglacial erosion and sediment transport. The limited landscape modification since glaciation suggests that periglacial processes are highly efficient compared to modern, temperate processes. However, the nature and extent of inherited climatic signatures of Pleistocene conditions remains poorly constrained. Here, we use a combination of lidar topographic analysis, field mapping and sampling of colluvium, shallow geophysical surveys, and drilling to characterize regolith heterogeneity at the surface and in the shallow subsurface at Garner Run, a sandstone subcatchment of Shavers Creek in the Susquehanna Shale Hills Critical Zone Observatory, Pennsylvania. Like many sandstone landscapes in central Pennsylvania, Garner Run exhibits a patchwork of relict Pleistocene periglacial features, including solifluction lobes, block fields, and more than 9 meters of colluvial valley fill. Structural analysis and the spatial extent of solifluction lobes indicate greater sediment flux from south-facing hillslopes, in general agreement with regional observations. Additionally, shallow seismic surveys and ground penetrating radar reveal shallower depths to unweathered bedrock on southeast versus northwest-facing hillslopes. Our results suggest an

aspect dependence of periglacial hillslope processes that create heterogeneity in the modern surface and subsurface critical zone architecture. Furthermore, our results highlight the potential for headwater valleys in the central Appalachians preserve a record of glacial/interglacial cycles over the Quaternary, and thus contain a sedimentary record of landscape response to climate change.

Session No. 6

T55. Heterogeneity in Geomorphic Systems: Driving Forces and Landscape Response

Sunday, 25 September 2016

Paper No. 67-3
Presentation Time: 9:00 AM-5:30 PM

THE SHALE HILLS CRITICAL ZONE OBSERVATORY VIRTUAL FIELDWORK EXPERIENCE: USING VIRTUAL FIELDWORK TO CATALYZE ACTUAL FIELDWORK IN K16 CLASSES (Invited Presentation)

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The Critical Zone (CZ) extends from the bottom of the water table to the tops of vegetation. Soil is at the heart of the CZ. Nine NSF-funded Critical Zone Observatories (CZOs) engage interdisciplinary teams of scientists in the integrated study of the CZ.

Virtual Fieldwork Experiences (VFEs) that are multi-media representations of actual field sites. The driving question for VFEs, “Why does this place look the way it does?” invites interdisciplinary exploration of the environment and the approach is well suited to satisfying expectations of the Next Generation Science Standards.

The Shales Hills CZO VFE was created through an NSF-funded Research Experience for Teachers program and builds upon a decade of experience in the use of VFEs. Our work with VFEs originally intended to create virtual representations of actual environments that modeled many aspects of actual fieldwork, including the the ability to choose one’s own direction in the field. Technologies like Google Earth and Prezi share the ability of going from broad views to looking at objects or areas of interest of one’s choosing, whether in photographs, satellite imagery, or maps - including concept maps.

The open-ended nature has benefits and drawbacks. Benefits include the ability to attend to particular areas of interest for either teacher or student. The software is also free, aligning with goals to make the work done in VFE development replicable at low cost. Drawbacks include difficulties of using open-ended activities within the structure of academic classes. VFEs have come to be seen as models intentionally designed for emulation. Teachers and students can adapt these approaches to create VFEs exploring the CZ where they live, document their findings and share findings with others. This approach gives VFEs a DIY, rough-around-the-edges feel, and is reflective of teachers and students, rather than media professionals and scientists, creating these resources.

Bringing VFEs to CZ science strengthens connections to the NGSS in the interdisciplinary and technology rich nature of the study of the CZ. This digital poster will use the Shale Hills VFE as a vehicle for highlighting resources for VFE development and use, for discussing and exploring the CZ both at Shale Hills and outside your classroom door.

Session No. 67--Booth# 143

T76. Digital Poster Session: Training Preservice Teachers to Apply Digital Technology across the Geoscience Curriculum (Posters)

Sunday, 25 September 2016

Paper No. 61-4
Presentation Time: 9:00 AM-5:30 PM

PYRITE DISSOLUTION LEADS WATERSHED GEOMORPHOLOGICAL EVOLUTION

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Hydrologic flow paths in the subsurface are governed by the development of secondary porosity and permeability that accompanies the conversion of protolith to regolith through chemical and physical weathering. Mineral dissolution plays a key role in the development of secondary porosity and permeability. The depth interval in a weathering profile across which a mineral becomes depleted due to dissolution is termed here a reaction front. The downward propagation of nested reaction fronts into the subsurface can open porosity, enhance permeability and affect water transmittance. To unravel the interplay between water flow and development of nested reaction fronts, we present bulk geochemical analyses from nine boreholes and groundwater geochemistry and age tracers from 25 wells across the Susquehanna Shale Hills Critical Zone Observatory (SSHCZO; PA, USA).

At SSHCZO, borehole material revealed that pyrite oxidative dissolution was the deepest reaction. Chlorite begins to oxidize at the same depth, although over a larger depth interval, and is accompanied by carbonate mineral dissolution. At the base of the 5-8 m deep fractured zone plagioclase begins to dissolve, while illite dissolution becomes important in the uppermost mobile soils. Groundwater levels showed that subsurface water flow reaches the catchment outlet by interflow and regional groundwater flow. Interflow (shallow hillslope flow) is oxygenated and constrained to the upper ~6 m highly fractured zone. At the valley floor, interflow advects to depths of 5–8 m where it mixes with deep groundwater and drives pyrite oxidation. The pyrite oxidation likely weakens the bedrock beneath the valley by generating secondary porosity and sulfuric acid, both of which enhance flow and dissolution.

We hypothesize that pyrite oxidation promotes channel incision, which in turn supports drainage of groundwater from the ridges, slowly lowering the catchment water table. Pyrite oxidation beneath the valley could control both the rate of channel incision and the rate of weathering advance under the uplands. Given this conceptual model, the catchment morphology is controlled by the delivery of interflow and groundwater flow at depth in the valley that drive

pyrite reactions over the long-term and culminates in a cascade of clay weathering reactions and soil formation.

Session No. 61--Booth# 64

T52. Deep Weathering, Ancient Landscapes and Regolith- Dominated Terrains (Posters)

Tuesday, 27 September 2016

Paper No. 262-2
Presentation Time: 9:00 AM-6:30 PM

MODELING SMALL MINERAL PARTICLE LOSSES ALONG SLOPES OF THE SUSQUEHANNA SHALE HILLS CRITICAL ZONE OBSERVATORY

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Small mineral particles suspended in soil solution are termed colloids and their redistribution is an important process in the development of soils. The geochemistry, mineralogy and surface properties of colloids are distinct from bulk soil material and thus their physical gain or loss drives changes in soil characteristics. Gain and loss of material in true solution is a separate process involving mineral dissolution/precipitation and driven primarily by chemistry. Effects of both processes can be distinguished and quantified by the recently developed dual-phase mass balance (DPMB) model. Published application of the model has been limited to granite-derived soils on a gentle (≤ 5%) slope under semi-arid climate in South Africa. Here the model is applied to shale-derived soils on a ~21% slope under temperate humid climate at the Susquehanna Shale Hills Critical Zone Observatory (SSHCZO).

In granite-derived soils, the preferential partitioning of Ti relative to Zr into colloids as igneous minerals weather makes the Ti/Zr ratio an effective tracer of colloid redistribution. In contrast,

shale-derived soils arise from material that has already experienced continental weathering, transport and deposition, and the Ti/Zr ratio did not distinguish colloids. Instead, select elements associated with clays (Al, Ga, Rb) were used in the numerators of tracer ratios and Zr and Hf in the denominators, yielding six different tracers for colloid redistribution. Colloid losses dominated soil development from a mass balance perspective at SSHCZO, ranging from −68 ± 7% to −15 ± 5% relative to starting parent material. Solution losses were predictably smaller considering parent material previously exposed to continental weathering and ranged from -7 ± 2% to a possible gain of 6 ± 1%. By comparison, colloid losses on the granite-derived soils were much smaller (maximum −14 ± 4%) and solution losses were larger (maximum −49% ± 5%). The gentle slope of the granite-derived soils also allowed mineral colloids to accumulate at its base, while the lack of an accumulation zone at SSHCZO may be attributable to a steeper slope. Colloidal versus solutional redistribution of individual elements showed further contrasts controlled by parent material. These results illustrate the insights into soil processes possible with the DPMB model.

Session No. 262--Booth# 376

T198. Beneath Da Vinci's Feet: The Multidisciplinary World of Soil Science (Posters)

Tuesday, 27 September 2016

Paper No. 237-25
Presentation Time: 9:00 AM-6:30 PM

EVALUATING THE IMPORTANCE OF REGOLITH HETEROGENEITY ON CATCHMENT HYDROLOGY IN GARNER RUN, SUSQUEHANNA SHALE HILLS CRITICAL ZONE OBSERVATORY, PENNSYLVANIA, USA

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Soil hydrologic properties determine how water, solutes, and sediment move through the near surface environment and serve as important input parameters for watershed-scale hydrologic models. While robust methods exist for characterizing the hydrologic properties of homogeneous, fine-grained soils, it is less clear how to incorporate rocky soils into critical zone models. Here we analyze the influence of regolith heterogeneity on catchment hydrology in Garner Run, a sandstone subcatchment of Shavers Creek in the Susquehanna Shale Hills Critical Zone Observatory, Pennsylvania. As a result of Pleistocene periglacial modification, Garner Run exhibits a strong heterogeneity in surface cover ranging from clay-rich soils to unvegetated boulder fields, which is not well captured by existing soil maps. Using a combination of new high-resolution maps of surface cover, field measurements of hydrologic properties, and preliminary model runs using the Penn State Integrated Hydrologic Modeling System (PIHM), we evaluate model sensitivity to spatial heterogeneity in regolith cover characteristics of sandstone landscapes in central Pennsylvania. Our results have implications for the interpretation of local measurements of soil moisture in such landscapes, and for the application of large scale soil maps in hydrologic models of upland landscapes.

Session No. 237--Booth# 83

T30. Sigma Gamma Epsilon—Undergraduate Research (Posters)

Wednesday, 28 September 2016

Paper No. 304-7
Presentation Time: 3:40 PM

OLD ROCKS, NEW DATA: COSMOGENIC ^{10}BE ANALYSIS OF A RELICT PERIGLACIAL BOULDER FIELD,

HICKORY RUN STATE PARK, PENNSYLVANIA

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Boulder fields are ubiquitous features in the Appalachian Mountains; yet, much remains unknown about the age and formation of these deposits. Likely created by mass movements under periglacial conditions, there are at least 96 known boulder fields south of the last glacial maximum boundary on the eastern seaboard (Park Nelson et al., 2007). There are two common schools of thought on the periglacial generation of regolith. The first is that intense weathering during glacial maxima renews the landscape each time, 'wiping the slate clean'. The second is that periglacial features are the oldest, most stable features on the landscape. Cosmogenic isotopic measurements of boulder fields throughout the world have supported both of these ideas—some studies have shown exposure ages coeval with the LGM, while others have shown that boulder fields are multigenerational features with longer, more complex histories.

Here we present measurements of ^{10}Be from Hickory Run boulder field, a 500 meter-long openwork of sandstone boulders immediately south of the LGM boundary near Kidder, PA. One of the most visited, enigmatic periglacial landforms, this block stream is notable for its size (~70,000m^2, roughly 550x150m), flatness (<1°), and the heterogeneity of relative weathering intensity of boulders within it. We sampled boulders (n=53) in transects across the Hickory Run boulder field and into the adjacent forest to constrain the exposure age of the rock surfaces and to test whether or not there are spatial trends in isotopic concentration downfield, implying a sense of transport from outcrops upslope. Initial data at the southern end of the field suggest that Hickory Run is a significantly older than previously thought, with boulder ages ranging from 200 to 400ky indicating clearly that the field has been extant through the last several glaciations. Measurements of the remaining boulders are in progress.

Session No. 304

T61. Quantifying Geomorphic Processes and Rates of Landscape Evolution II

Wednesday, 28 September 2016: 1:30 PM-5:30 PM