

# My GSA Annual Meeting in Seattle, Washington, USA

## - 2017 Schedule

### Abstract

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#### **111-8 GSA QUATERNARY GEOLOGY AND GEOMORPHOLOGY DIVISION DISTINGUISHED CAREER AWARD: ERODING THE SOUTHERN ROCKY MOUNTAINSâ€™ WEATHERING AND FLUID FLOW IN SLOW MOTION IN THE CRITICAL ZONE**

[DETHIER, David P.](#), Department of Geosciences, Williams College, Williamstown, MA 01267 and OUI MET, William B., Dept. of Geography; Center for Integrative Geosciences, University of Connecticut, Storrs, CT 06269, [ddethier@williams.edu](mailto:ddethier@williams.edu)

TOP

2017-10-23 - 09:50:00

The Conference Center, Chelan 2

Diverse lines of evidence demonstrate slow denudation rates in the cool, dry landscape of the southern Rocky Mountains despite pervasive fracturing that dates from Laramide time and local hydrothermal alteration of mainly granitic materials. Denudation rates near  $2 \text{ cm kyr}^{-1}$  result from the long-term balance between slow rock uplift and chemical weathering of silicates at cool temperatures in environments where fluid contact times are relatively short. Moisture from snowmelt dominates upland to alpine hydrology and fluid transit is rapid through sandy soils and regolith, and in channels. Soil infiltration rates are relatively high and ephemeral streams lose substantial volumes to the shallow subsurface. Groundwater velocities are slow from meters to tens of meters beneath the rocky regolith, but reactive surface area is limited and solution chemistry is relatively dilute. In the past ~two decades, new dating tools based on cosmogenic nuclides, new measurement tools, particularly those involving lidar, and integrative approaches such as critical-zone research and hydrologic connectivity offer new ways of quantifying geomorphic processes. Undergraduate field-based studies, particularly where they build upon ongoing research, offer substantial scientific and educational opportunities for studying geomorphic and hydrochemical processes in the critical zone. Research examples include analysis of: fracture spacing, rock strength and regolith thickness within and beyond the glacial limit; solution chemistry and inferred weathering pathways; chemistry of weathering profiles; long-term erosion rates inferred from  $^{10}\text{Be}$  in alluvium, and short-term erosion rates after fire and flooding events. Intense rainfall from infrequent to millennial events drives erosion rates that exceed long-term values by at least 10-100 X. Despite active freeze-thaw regimes at higher elevations, erosion rates are lowest above the late Pleistocene glacial limit. Landscape relief is increasing from episodic glacial stripping of alpine valleys and from canyon-downcutting into the slowly weathering, rolling upland beyond the glacial limit.

### Abstract

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#### **138-13 CRITICAL ZONE SCIENCE IS TO SCIENCE AS THE NEXT GENERATION SCIENCE STANDARDS ARE TO SCIENCE EDUCATION**

[DUGGAN-HAAS, Don](#), The Paleontological Research Institution, 92 South Drive, Amherst, NY 14226, ROSS, Robert M., Paleontological Research Institution, 1259 Trumansburg Road, Ithaca, NY 14850, WHITE, Tim, Earth and Environmental Systems Institute, Pennsylvania State University, 2217 Earth and Engineering Building, University Park, PA 16802, MOORE, Alexandra, Paleontological Research Institution, Ithaca, NY 14850 and DERRY, Louis A., Earth and Atmospheric Sciences, Cornell University, Ithaca, NY 14853, [dad55@cornell.edu](mailto:dad55@cornell.edu)

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2017-10-23 - 16:45:00

Washington State Convention Center, Room 3A

Science, like the world it strives to understand, is not neatly divided into disciplines, grades, or 45 minute periods. Schooling is not only poorly matched to what research tells us about how people learn, it operates in opposition to much of that research. While not explicitly, the 3D and interdisciplinary nature of the NGSS offers promise for subverting the structure of schools in effective ways. Metaphorically, Critical Zone (CZ) science is to traditional disciplinary science as the NGSS is to traditional science education.

The CZ extends from the tops of the vegetation to the bottom of the groundwater. Nearly all terrestrial life inhabits the CZ. The NSF funds nine CZ Observatories (CZO) where interdisciplinary teams of scientists study the interplay of rock and life, mitigated by water and air.

This approach to science is “optimally distinct,” meaning that conventionally understood practices and ideas are brought together in unconventional ways. Such approaches are common to successful innovations, and they are rare in educational innovation. CZ science is clearly interdisciplinary and three-dimensional. It offers an opportunity for innovation by mimicry within the educational system as a vehicle for NGSS implementation.

Knowing that... •

climate, energy, and CZ science each can only be deeply understood from an interdisciplinary perspective; and •

the most effective professional development (PD) includes ample attention to unique disciplinary knowledge for teaching (PCK); and •

effective PD is the exception,

we raise the question, “Can we modularize curriculum & PD such that the more teachers, disciplines, and grade levels that participate in an interdisciplinary approach, the more students deepen their understanding of the interdisciplinary issue (climate, energy, or CZ science)?”

While much of science education “works,” in that we produce successful scientists, the system of science education is not regarded as generally successful, and efforts at reform in recent decades have yielded few conspicuous positive outcomes. By attending research on innovation more broadly and using CZ science as a model for moving forward in educational change, we offer promise for successful NGSS implementation.

## Session

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### **195 T20. The Critical Zone As Heterogeneous Media: Implications for Physical, Chemical, and Biological Processes**

**Wendy M. Robertson**, Department of Earth and Atmospheric Sciences, Central Michigan University, Mount Pleasant, MI, **Kallina Dunkle**, Austin Peay State University, Clarksville, TN, **Nicole West**, Earth and Atmospheric Sciences, Central Michigan University, Mount Pleasant, MI, **Yu-Feng Forrest Lin**, Illinois State Geological Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, Champaign, IL, **Zsuzsanna Balogh-Brunstad**, Department of Geology and Environmental Sciences, Hartwick College, Oneonta, NY and **Michael H. Young**, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin, Austin, TX

TOP

2017-10-24 - 08:00:00

Washington State Convention Center, Room 618/619/620

## Abstract

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### 195-1 UNRAVELING HOW LANDSCAPE HETEROGENEITY ALTERS CONCENTRATION DISCHARGE BEHAVIOR IN CARBONATE HEADWATER STREAMS

[SULLIVAN, Pamela L.](#), Department of Geography and Atmospheric Science, University of Kansas, 1425 Jayhawk Blvd, Lindley 210, Lawrence, KS 66045, STOPS Jr., Marvin Wes, Geography and Atmospheric Science, University of Kansas, Lawrence, KS 66045, MACPHERSON, G.L., Dept. of Geology, Univ of Kansas, 1475 Jayhawk Blvd, 120 Lindley Hall, Lawrence, KS 66045, LI, Li, Department of Civil and Environmental Engineering, Pennsylvania State University, 221A Sackett Building, University Park, PA 16802 and DODDS, Walter K., Biology, Kansas State University, Manhattan, 66506, [plsullivan@ku.edu](mailto:plsullivan@ku.edu)

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2017-10-24 - 08:05:00

Washington State Convention Center, Room 618/619/620

Heterogeneity in catchment subsurface water storage and its connectivity (timing and flux) to the stream governs the integrated outlet chemical behavior. Differences in water residence times and the distribution of mineral and organic pools (vertically and spatially) results in an array of biogeochemical processes, and thus signals that are transmitted from the terrestrial to the aquatic environment. One grand challenge in science now is predicting how water quality will change with future climate and land use changes. What we know is that over a wide range in stream discharge some solutes behave chemostatically—small changes in solute concentrations with discharge —, while other solutes behave chemodynamically—large changes in solute concentrations with discharge. Yet, between catchments solute concentration-discharge behavior can change. These differences are often related to landscape and flow path heterogeneity.

We focus on the well-studied Konza Prairie (KS, USA), a 35 km<sup>2</sup> tallgrass biological research station made up of 60 watersheds. Here, nearly 40 years of fire management practices have resulted in the emergence of woody-encroached watersheds where fire frequency return intervals are four years or greater. We selected four adjacent headwater watersheds underlain by the same lithology—Permian age repeating couplets of limestone (1-2 m thick) and mudstone (2-4 m thick) — that experience 1, 2, 4, and 20 year burn regimes, and thus different degrees of woody encroachment. From 2015 to present, stream water discharge has been monitored continuously, while solute concentrations were collected three times per week. Nine major anion and cation concentrations were examined, watersheds consistently demonstrated dilution behavior (reduction in concentration with increased discharge) for chloride and sulfate, and chemostatic behavior for potassium. In all other instances, watersheds exhibited dilution, chemostatic or addition (increased concentration with increased discharge) behaviors for the same solute. We explore how landscape differences drive concentration discharge patterns between the various watersheds at Konza by coupling the reactive transport model RT-Flux-PIHM with the biogeochemical model Biome-BGC.

## Abstract

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### 195-2 RUNOFF RESPONSE IN A SEMI-ARID HEADWATER DRIVEN BY CATCHMENT-SCALE WATER MOVEMENT

[ANDERSON, Suzanne P.](#)<sup>1</sup>, WLOSTOWSKI, Adam<sup>2</sup>, MURPHY, Sheila<sup>3</sup>, ROCK, Nathan D.<sup>2</sup> and HOFFMAN, Claire<sup>4</sup>, (1)Department of Geography and INSTAAR, University of Colorado, Boulder, CO 80309, (2)INSTAAR, University of Colorado, UCB-450, Boulder, CO 80309, (3)USGS, 3215 Marine Street, Suite E127, Boulder, CO 80303, (4)Department of Geography and INSTAAR, University of Colorado, UCB-450, Boulder, CO 80309,

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2017-10-24 - 08:25:00

Washington State Convention Center, Room 618/619/620

While the rate, duration and type of precipitation are key controls of runoff generation, the critical zone is an important mediator of surface water hydrology. We explore interannual variability in runoff production in the Gordon Gulch catchment, a semi-arid headwater catchment at ~2500 m in the Colorado Front Range with a spatially variable, ephemeral snowpack. The forested (upper montane) catchment is outside the limits of Pleistocene glaciation and is underlain by biotite gneiss bedrock. Recent annual peak discharges have occurred during i) spring snowmelt, ii) summer convective storms, and iii) an exceptional synoptic-scale storm. Soil moisture, water table elevation, and runoff data during different rain and snowmelt conditions show that the spatial and temporal scales of water inputs exert important control on runoff production. The east-west oriented Gordon Gulch receives 500-600 mm of annual precipitation, 28-65% as snow; annual runoff ratios range from 0.08-0.23. Snowpack is intermittent on south-facing slopes, and longer-lived but thin (< 0.5 m) on north-facing slopes. Although annual peak discharge is typically associated with the end of snowmelt on the north-facing slope, our observations reveal that spring precipitation must augment snowmelt to produce a significant discharge peak. Synchronous inputs on both slope aspects increases soil moisture across the catchment, raises the water table into more permeable regolith, and stimulates rapid lateral transmission of water to produce high streamflow. Summer and fall storms may also result in significant water table rise and large runoff responses when storms are of sufficient duration. This finding is in accord with modeling of water delivery to the weathering front in Gordon Gulch (Langston et al., 2015, *ESPL*). The roles of spatially and temporally variable evaporation and transpiration demands, antecedent moisture, and conductivity structure of the critical zone on water flow and runoff generation remain to be determined. Processes that affect both north and south-facing slopes simultaneously have first order control on catchment scale hydrologic response.

## Abstract

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### **212-3 ASPECT-DEPENDENT FEEDBACKS BETWEEN REGOLITH PRODUCTION AND TRANSPORT AT THE SHALE HILLS CRITICAL ZONE OBSERVATORY**

[WEST, Nicole](#), Earth and Atmospheric Sciences, Central Michigan University, Mount Pleasant, MI 48859, KIRBY, Eric, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Wilkinson 202D, Corvallis, OR 97331, NYBLADE, Andrew A., Geosciences Dept, Pennsylvania State University, 447 Deike Bldg, University Park, PA 16802 and BRANTLEY, Susan L., Earth and Environmental Systems Institute, Pennsylvania State University, Department of Geosciences, 2217 EES Building, University Park, PA 16802, [nicole.west@cmich.edu](mailto:nicole.west@cmich.edu)

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2017-10-24 - 08:45:00

The Conference Center, Chelan 2

Understanding how regolith production and transport respond to perturbations in climate and/or tectonic forcing remains a first-order question in Earth science. Recent studies integrating geochemical and geophysical techniques in near surface studies of Earth's weathered zone reveal a previously under-appreciated coupling between chemical and mechanical breakdown of rock during regolith formation. First order observations of the Susquehanna Shale Hills Critical Zone Observatory (SSHO), using high resolution LiDAR-derived topographic data and depths to hand auger refusal, reveal a systematic asymmetry in hillslope gradient

and mobile regolith thicknesses; both are greater on north-facing hillslopes. Hydrologic and geochemical studies of at the SSHO also suggest asymmetric sediment transport, fluid flow, and mineral weathering with respect to hillslope aspect. Here, we investigate the role of (micro)climate in inducing fracturing and priming the development of the observed asymmetry. Shallow p-wave velocity profiles suggest differences in thickness for both the mobile and immobile regolith material with respect to aspect and are consistent with patterns of fracture densities observed in boreholes and with predictive cracking intensity models related to frost action. Similarly, p-wave velocity profiles correspond with chemical depletion profiles measured in the SSHO subsurface. This combination of data suggests that the feedbacks between chemical weathering and the physical structure of the SSHO subsurface may be driven by aspect-dependent microclimate asymmetry over geologic time.

## Abstract

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### **195-4 PREFERENTIAL FLOW IN THE CRITICAL ZONE: DIRECT OBSERVATIONS OF THE SPATIAL AND TEMPORAL PATTERNS OF FLUID COMPOSITION IN VARIABLY SATURATED WEATHERED BEDROCK**

[TUNE, Alison K.](#)<sup>1</sup>, CARGILL, Samantha<sup>2</sup>, MURPHY, Colleen<sup>3</sup>, HAHM, W. Jesse<sup>4</sup>, DIETRICH, William E.<sup>4</sup> and REMPE, Daniella M.<sup>1</sup>, (1)Jackson School of Geosciences, University of Texas at Austin, Jackson School of Geosciences, 2305 Speedway Stop C1160, Austin, TX 78712-1692, (2)Department of Forest Engineering, Resources, and Management, Oregon State University, Corvallis, OR 97331, (3)Department of Earth and Planetary Science, University of California, Santa Cruz, Santa Cruz, CA 95064, (4)Earth and Planetary Science, University of California, Berkeley, 307 McCone Hall, Berkeley, CA 94701, [alison@utexas.edu](mailto:alison@utexas.edu)

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2017-10-24 - 08:55:00

Washington State Convention Center, Room 618/619/620

Large uncertainties remain in quantifying the exchange of water at the land-atmosphere interface due to challenges associated with mapping hydrologic fluxes in the critical zone (CZ). In the weathered and fractured bedrock zone it is difficult to directly observe preferential flow paths and porosity distributions. These subsurface characteristics result from near surface weathering and play important roles in the partitioning of infiltrating rainfall between vapor and surface water fluxes. Here we present intensive stable isotope and heat tracing of the spatial and temporal patterns of preferential flow throughout an 18 m thick, variably saturated weathering profile in a steep, forested hillslope developed into the turbidite sequences of the Franciscan formation in northern California. At the seasonally dry site within the Eel River CZO we use a novel Vadose-zone Monitoring System (VMS) to sample fluids throughout the entire weathering profile “from soil to unweathered bedrock. The VMS consists of two inclined sleeves with upward facing sensors and samplers, designed to intercept fluxes within the vadose zone. Lysimeters that separately sample tightly-held or freely-draining water are distributed along the length of the VMS. The results of nearly two years of water sampling at an approximate two-week frequency provide direct evidence of deep preferential flow in the fractured bedrock vadose zone and, importantly, demonstrate that seasonal depletion of rock moisture by vegetation during the dry season influences the spatial and temporal evolution of fluid composition within the CZ, underscoring the significance geochemical evolution that can occur below shallow surface soils. Seasonal patterns of water content, temperature, and stable isotope composition of precipitation and vadose zone waters indicate that a 6-8 m thick zone of progressive mixing sits above a zone in which the stable isotope composition of waters sampled from the vadose zone and groundwater are compositionally indistinguishable. In addition to providing key constraints to hydrologic models of the CZ, these findings suggest that hydrologic studies employing stable isotopes to trace sources of water to vegetation and streamflow may not be capable of resolving differences between water derived from the saturated and unsaturated zones.

## Abstract

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## 195-7 CARBON EXPORTS FROM THE CRITICAL ZONE

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TOP

2017-10-24 - 09:55:00

Washington State Convention Center, Room 618/619/620

In the terrestrial environment vascular plants photosynthesize and respire to produce organic matter and CO<sub>2</sub>. These products dissolve and are processed belowground to become dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) for export in catchment drainage. This is a synthesis study gathering recent developments from Earth and allied sciences to assemble a simple framework explaining the interplay among these processes as water moves through the heterogeneous Critical Zone (CZ), the skin of Earth from the top of the canopy to the base of active groundwater circulation. In this framework chemical weathering is a keystone process fueling energy flow through the system: its shallow-focused “ecologic” function dynamically generates nutrients positively feeding back into biosynthesis (and DOC generation), supporting heterotrophy in the CZ and receiving waters. This in turn drives the steadier, more spatially diffuse “geologic” function of weathering, entraining and stabilizing CO<sub>2</sub> in solution (DIC generation) for storage in the hydrosphere and lithosphere. At the planetary scale, carbon exports are plate-tectonically and thermostatically capped and floored by volcanic CO<sub>2</sub> production and carbonate chemistry in Earth’s crust. The CZ framework prompts straightforward hypotheses to explain temporal and spatial patterns of exports from catchments, including how DOC and DIC exports differentially respond to geologic setting, hydrologic dynamics, and ecosystem development.

### Abstract

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## 195-8 INVESTIGATING COUPLED HYDROLOGIC AND BIOGEOCHEMICAL FLUXES IN THE CRITICAL ZONE VIA DISTRIBUTED SENSING AND SAMPLING IN VARIABLY SATURATED, WEATHERED BEDROCK

[REMPE, Daniella M.](#)<sup>1</sup>, DRUHAN, Jennifer L.<sup>2</sup>, WANG, Jia J.<sup>2</sup>, CARGILL, Samantha<sup>3</sup>, MURPHY, Colleen<sup>4</sup>, SCHMIDT, Logan<sup>5</sup>, HAHM, W. Jesse<sup>6</sup>, CRUTCHFIELD-PETERS, Kelsey L.<sup>7</sup>, DAWSON, Todd E.<sup>7</sup> and DIETRICH, William E.<sup>8</sup>, (1)Jackson School of Geosciences, University of Texas at Austin, Jackson School of Geosciences, 2305 Speedway Stop C1160, Austin, TX 78712-1692, (2)Department of Geology, University of Illinois at Urbana-Champaign, 156 Computing Applications Building, 605 E. Springfield Ave, Champaign, IL 61820, (3)Department of Forest Engineering, Resources, and Management, Oregon State University, Corvallis, OR 97331, (4)Department of Earth and Planetary Science, University of California, Santa Cruz, Santa Cruz, CA 95064, (5)Institute for Geophysics, University of Texas, 10100 Burnet Road, Austin, TX 78758, (6)Earth and Planetary Science, University of California, Berkeley, 307 McCone Hall, Berkeley, CA 94701, (7)Department of Integrative Biology, University of California, Berkeley, 3040 Valley Life Sciences Building # 3140, Berkeley, CA 94720, (8)Earth and Planetary Science, University of California, Berkeley, CA 94720, rempe@jsg.utexas.edu

TOP

2017-10-24 - 10:10:00

Washington State Convention Center, Room 618/619/620

Within the Critical Zone (CZ), complex interactions between biota, minerals, and fluids control how the composition of infiltrating rainfall evolves on its transit to groundwater and streams and consequently, how

weathering profiles develop. However, there are few observations made of vadose zone moisture dynamics coupled to solute and gas evolution within the weathered bedrock of the CZ to constrain geochemical and hydrological models. Here, we exploit an intensively instrumented, forested hillslope within the Eel River Critical Zone Observatory to explore how hydrologic fluxes in the CZ are linked to the biogeochemical processes responsible for altering the composition of water and bedrock in the CZ. Long-term monitoring of 12 deep wells, including borehole nuclear magnetic resonance (NMR), indicate that the upper 4-12 m of weathered bedrock exhibits significant seasonal changes in water content (rock moisture), below which water content changes are minimal despite seasonal saturation of bedrock fractures within groundwater perched at the base of the weathering profile. Field- and lab-scale NMR surveys indicate that the dynamic unsaturated water storage occurs in both large and small pores, while at deeper depths, exclusively large pores exhibit saturation changes. To understand the implications of dynamic water storage on biogeochemical processes, we directly sample water and gas throughout the entire weathering profile using a Vadose-zone Monitoring System (VMS). The VMS is comprised of upward-facing flexible lysimeters and gas ports distributed along two inclined boreholes. We sample water and measure CO<sub>2</sub> and O<sub>2</sub> concentrations at a nearly two-week frequency and water samples are analyzed for major cations, anions, O and H stable isotope composition, and dissolved organic and inorganic carbon. Our nearly two-year dataset indicates that both gas and water composition shows strong seasonal and vertical variability that broadly correspond to variations in rock moisture. These seasonally dynamic fluxes and stores of water in weathered bedrock beneath the soil layer significantly influence biogeochemical processes in the CZ, and suggest that these types of observations are needed for a process-based understanding of what controls weathering, chemistry and nutrient dynamics for the biota inhabiting the CZ.

## Abstract

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### 195-13 CROSS-SCALE PERSPECTIVES ON MINERAL WEATHERING IN THE CRITICAL ZONE

[LYBRAND, Rebecca](#), Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331, AUSTIN, Jason, Nicholas School of the Environment, Duke University, Durham, NC 27708, SCHROEDER, Paul A., Department of Geology, University of Georgia, 210 Field St., Athens, GA 30602-2501, ZAHARESCU, Dragos, School of Earth and Atmospheric Science, Georgia Institute of Technology, Atlanta, GA 30332-0340; School of Earth & Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA 30332-0340 and GALLERY, Rachel, School of Natural Resources and the Environment, The University of Arizona, Tucson, AZ 85721, [rebecca.lybrand@oregonstate.edu](mailto:rebecca.lybrand@oregonstate.edu)

TOP

2017-10-24 - 11:30:00

Washington State Convention Center, Room 618/619/620

Rock weathering replenishes nutrients in soil, shapes geochemical carbon sequestration, and drives physical, chemical, and biological processes at a multitude of scales. Our research integrates bioclimatic and topographic factors into a cross-scale examination of mineral weathering in granitic sites selected from two Critical Zone Observatories. The Catalina CZO (Arizona) encompasses a desert to conifer bioclimatic gradient that spans significant range in mean annual temperature (24-10°C) and precipitation (45-95 cm) whereas the Calhoun CZO (S. Carolina) represents the wet, humid end member with 127 cm precipitation/year and a mean annual temperature of 16°C.

Soil and parent rock samples were examined from each site using X-ray fluorescence and X-ray diffraction to quantify elemental and mineral abundance. We assessed incipient weathering by deploying mesh bags filled with granite, basalt, and quartz sand (53-250 µm) in surface soils of divergent summit and convergent footslope positions at both CZOs. The exposed material was analyzed after one year using helium ion and scanning electron microscopies to identify biota-grain interactions and associated weathering features.

Bulk soil and grain scale analyses of the Catalina CZO samples indicate a tight coupling among mineral weathering, topography, and climate. Dust deposition also plays a critical role in nutrient cycling and soil

accretion in the Catalina CZO, with dust fraction estimates up to 20% of the total soil mass in the desert and conifer systems. Calhoun CZO soils contain weathering products dominated by discrete kaolinite and mixed layered kaolinite-biotite, hydroxy-interlayered-vermiculite, gibbsite and goethite. These secondary minerals result from intense weathering and erosion in the Calhoun that were further altered by land use histories in the area. Chemical indices of alteration show clear trends related to climate and land use history within and across the Catalina and Calhoun CZOs. Results from the mesh bag experiment confirm the presence of fungi and bacteria on mineral surfaces and suggest that biota contribute to early stages of mineral transformation. Our findings advance understanding of soil geochemistry and biotic-mineral interactions in field systems that are needed to quantify controls on weathering in the critical zone.

## Session

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### **374 T20. The Critical Zone As Heterogeneous Media: Implications for Physical, Chemical, and Biological Processes (Posters)**

**Wendy M. Robertson**, Department of Earth and Atmospheric Sciences, Central Michigan University, Mount Pleasant, MI, **Kallina Dunkle**, Austin Peay State University, Clarksville, TN, **Nicole West**, Earth and Atmospheric Sciences, Central Michigan University, Mount Pleasant, MI, **Yu-Feng Forrest Lin**, Illinois State Geological Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, Champaign, IL, **Zsuzsanna Balogh-Brunstad**, Department of Geology and Environmental Sciences, Hartwick College, Oneonta, NY and **Michael H. Young**, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin, Austin, TX

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2017-10-25 - 09:00:00

Washington State Convention Center, Halls 4EF

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## Abstract

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### **362-2 EXPLORE THE CRITICAL ZONE THROUGH THE CZO NETWORK**

**[MOORE, Alexandra](#)**<sup>1</sup>, DUGGAN-HAAS, Don<sup>1</sup>, ROSS, Robert M.<sup>1</sup> and DERRY, Louis A.<sup>2</sup>, (1)Paleontological Research Institution, Ithaca, NY 14850, (2)Earth and Atmospheric Sciences, Cornell University, Ithaca, NY 14853, [afm113@gmail.com](mailto:afm113@gmail.com)

TOP

2017-10-25 - 09:00:00

Washington State Convention Center, Halls 4EF

Earth's Critical Zone extends from the top of the tree canopy to the base of the groundwater lens. Nearly all terrestrial life inhabits the CZ. It is a zone of important physical and chemical transformations, the place where rainwater becomes drinking water, and the source of food for all human communities. The NSF-funded Critical Zone Observatories have engaged in multidisciplinary study of the CZ for nearly a decade. More recently, the nine CZOs and a coordinating National Office have worked together to create the CZO Network ([www.criticalzone.org](http://www.criticalzone.org)). The CZOs are designed to observe and measure a suite of common parameters on varying geological substrates and within different ecological contexts. At the same time, each individual observatory has a unique mission and focus.



Through the CZO Network a wide range of educational opportunities is available for K-12, undergraduate and graduate students. The goal of the CZO education program is to create a network of observatories that will become living laboratories for undergraduate and graduate students through coursework and research. The CZO National Office is a central clearinghouse for student opportunities within the CZO network. Data collected at each CZO is available through the CZONO web portal for use by learners in any location. Undergraduate field courses have been developed across the CZO network, among them, courses in hydrogeophysics, snow hydrology, geomorphology, and field hydrology. Summer opportunities include REU and RECCS programs. Curricular materials that take advantage of CZO Network resources have been assembled to form an on-line undergraduate course through the InTeGrate project (<http://serc.carleton.edu/integrate/index.html>), and course materials contributed by each observatory for a reviewed collection of educational resources at all levels (<http://criticalzone.org/national/education-outreach/resources/>). Through these initiatives undergraduate students have the opportunity to engage in experiential learning that is truly interdisciplinary in nature, examining Earth processes through the lens of the Critical Zone.

## Abstract

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### 374-1 ASSESSING THE UTILITY OF WELL CUTTINGS TO CHARACTERIZE WEATHERING PROFILES OF CRYSTALLINE BASEMENT

[PEVEHOUSE, Katie J.](#), Geosciences, Texas Tech University, 125 Science, Lubbock, TX 79409-1053 and SWEET, Dustin E., Department of Geosciences, Texas Tech University, MS 1053, Science Building 125, Lubbock, TX 79409, [katie.pevehouse@ttu.edu](mailto:katie.pevehouse@ttu.edu)

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2017-10-25 - 09:00:00

Washington State Convention Center, Halls 4EF

Microseismic events coincident with subsurface CO<sub>2</sub> sequestration sites occur in the Precambrian crystalline basement in central Illinois. Recent work to characterize the heterogeneity of the basement is limited by scarce well cores and lack of outcrop. One potential source of data is an abundance of well cuttings captured during drilling from basement penetrations; however, the process of drilling may effect bulk-rock geochemistry. This study evaluates the utility of geochemical analyses of those well cuttings. Four wells were sampled at two separate depths within 40 feet of the great unconformity. We use rock chips, commonly 1-4 mm, as a proxy for unaltered rock; however, since rock chips are relatively rare and time consuming to pick, we compare it to a sample of whole-sample cuttings. To prepare samples for analyses, four grams each of rock chips and whole-sample cuttings are weighed and processed at coeval well depths. Samples are analyzed using x-ray fluorescence (XRF) to compare major oxides.

Data collected shows that SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, Na<sub>2</sub>O compare very well across all depths and wells, which indicates that sampling whole cuttings is a sufficient process of obtaining data for these major oxides. Results also show that CaO and Fe<sub>2</sub>O<sub>3</sub> are the most variable. Magnesium, manganese, sodium, phosphorous, and titanium oxides are agreeable, but show variance in two wells. Preliminary conclusions suggest that using whole-sample cuttings is sufficient, rather than picking chips, for all oxides except calcium and iron. This study presumes that the variation in calcium and iron can be attributed to locally variable CaCO<sub>3</sub> content in the altered or weathered rock directly below the great unconformity. Given that the cuttings average five feet interval of well depth, this technique does not appear sufficient to accurately assess calcium and iron. Thus, studies that focus on alteration or weathering of the Precambrian basement using well cuttings should focus on weathering techniques that do not incorporate calcium and iron.

## Abstract

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## 374-2 INFILTRATION STUDIES OF MECHANICALLY ALTERED BRINE SPILL IMPACTED SOILS

[SPOONER, Emmett A.](#)<sup>1</sup>, KENNEDY, David R.<sup>2</sup>, RAINES, Nichele<sup>1</sup>, WARD, James W.<sup>1</sup> and SCOTT, Cody<sup>2</sup>,  
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2017-10-25 - 09:00:00

Washington State Convention Center, Halls 4EF

Brine water contamination alters soil chemistry, soil structure and infiltration rate of many locations in West Texas. Brine contamination results in lower soil infiltration rates due to destruction of soil structure. This study was conducted at a 14-acre brine spill historic “kill zone” site on a ranch located approximately 14 km south of San Angelo, Texas. Ripping and furrowing was conducted of the site in the spring of 2016. Rips to a depth of approximately depth of 50 cm were obtained by using a single 5 cm wide chisel point and furrows were constructed to a depth of 15 cm with a single furrow drop behind a small farm tractor. The rips and furrow were implemented on the brine affected site in an attempt to loosen the soil structure, increase infiltration rates and potentially allow for remediation of the site through in-situ bioremediation. Infiltration measurements were obtained using a double-ring infiltrometer to determine if implementing rips and/or furrows allowed for higher infiltration. Preliminary infiltration tests were conducted on rips, furrows and at randomly chosen unworked locations. From this data, average infiltration rates for the rips were 4.7 cm/hr, the furrows were 2.4 cm/hr and the control sites were 5.6 cm/hr. Ripping the soil appears to increase infiltration rates in comparison to furrowing. However, the locations that had not been ripped or furrowed showed a higher infiltration rate than either the rip or the furrow. Further tests will be conducted to determine if this is a consistent result or if ripping of the soil is an ideal method of remediation. In conjunction with the use of the double-ring infiltrometer a Hobo U23 temperature sensor was used to monitor temperature fluctuations vertically in the ground during each infiltration test by driving the sensor in the annular spacing between the two rings of the infiltrometer. As water infiltrated, the upper and lower temperature sensors had about a 2.7°C difference in temperature at a spacing of 2.5 cm and 10 cm from the surface. Temperature data was recorded in combination with infiltration data to study if there is a relationship between heat flux and infiltration rates. The goal of the temperature studies is to obtain an understanding of heat flux in the soils over time during infiltration.

Abstract

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## 374-3 ANALYZING GEOGRAPHIC DISTRIBUTION MODELS OF MADAGASCAR PLANT SPECIES USING GEOLOGICAL DATA TO UNDERSTAND SPECIATION

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TOP

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The processes driving species radiations of plants on Madagascar remain inadequately explored. A wide variety of soil types exist on Madagascar, from ferralitic soils on the east coast, to ferruginous tropical soils in the southwest, to alluvial soils in the western region. This diversity, along with the remarkable bioclimatic contrast

between the eastern and western sides of the island, have long been invoked to explain Madagascar's extraordinary microendemism. Recent patterns of speciation identified in the island's rich fauna are complicated and suggest that many processes have contributed. We reconstructed the geographic distribution of species in the *Hibiscus* tribe (Malvaceae) as a first step to uncover some of the forces driving speciation on Madagascar. Using 753 georeferenced distribution records from the herbaria of MO and P, the range of 27 species were determined and adjusted with environmental niche modeling using soil type, lithology, climate, and topographic data. As a means to explore niche evolution in this plant group we used ENMTools to compare the ecological tolerances between species.

## Abstract

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### 374-4 CYCLING OF GYPSIFEROUS WHITE SANDS AEROSOLS IN SHALLOW CRITICAL ZONE SOILS AT WHITE MOUNTAIN, NEW MEXICO

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TOP

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Dry deposition impacts evolution of the critical zone through nutrient supply and contributing to soil genesis. Dust influx and cycling in soils is difficult to quantify because dust sources can be chemically similar to local soils. White Sands, New Mexico, emits gypsum dust with unique geochemical signatures, providing an opportunity to investigate its deposition and movement in soils. This study aims to understand transport and mobility of White Sands dust in the critical zone at White Mountain, New Mexico, a highland ~100km downwind. Four soil profiles were collected over limestone, igneous, dolostone, and sandstone bedrocks, as well as leaves of local grasses, shrubs, cacti, and pines. Dust, White Sands gypsum, and bedrock, considered as end members of soil calcium, were collected. All samples were analyzed chemically, mineralogically, and isotopically ( $^{87}\text{Sr}/^{86}\text{Sr}$ ). Depth variation in bulk soil chemistry at sites is controlled mostly by weathering over carbonate substrates and bulk dust addition over siliciclastic ones. White Sands gypsum, making up only a small portion of soil mass, was identified through Sr/Ca ratios,  $\text{SO}_4$  concentrations, and  $^{87}\text{Sr}/^{86}\text{Sr}$  in water leachable fractions. Dust samples contain significantly more soluble Ca and  $\text{SO}_4$  than soils, indicating that gypsum dust deposition, while significant, is lost quickly through chemical reactions. Water leachable concentrations and Sr/Ca ratio increase with depth as gypsum dissolves and reprecipitates. Leachate Ca:  $\text{SO}_4$  ratios decrease with depth as soluble Ca is adsorbed to clay. Plant Sr/Ca varies between sites and species. Bulk soil  $^{87}\text{Sr}/^{86}\text{Sr}$  is controlled by total dust input in the upper profile and bedrock weathering at depth. Gypsum does not modify such  $^{87}\text{Sr}/^{86}\text{Sr}$  due to low mass. Plant  $^{87}\text{Sr}/^{86}\text{Sr}$  varies between plant types, controlled by root depth, preferred source uptake, and variance in nutrient requirements. The  $^{87}\text{Sr}/^{86}\text{Sr}$  and Sr/Ca of White Sands dust are being characterized and will be used to quantify relative contributions to the total soil Ca budget. Results from this study will characterize gypsum-derived Ca movement in shallow soils. Tracking White Sands dust input to the soil will give better understanding of gypsum's potential effects on critical zone dynamics and biologic development.

## Abstract

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### 374-5 GEOCHEMICAL DIFFERENCES IN PETROCALCIC AND CALCIC HORIZONS DUE TO SOIL PARENT MATERIAL IN SOUTHEASTERN ARIZONA

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TOP

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Petrocalcic and calcic horizons are quintessential features of arid and semiarid regions and store significant amounts of soil carbon. Past studies identified the source of calcic and petrocalcic horizons as calcium-rich dust, linking calcic horizon formation to dust input. To date, there are few previous studies that explicitly test this hypothesis. Further, throughout Southeastern Arizona (SEAZ), a number of locations contain little calcium, despite significant soil development throughout the Quaternary period. We tested this widely accepted hypothesis by comparing the geochemical properties of petrocalcic and calcic horizons originating on different parent materials in SEAZ. We collected petrocalcic and calcic horizons sourced from basalt, rhyolite/andesite, limestone, and mixed alluvium and measured color, pH, electrical conductivity (EC), and loss on ignition (LOI) for each soil sample. We determined the bulk elemental content of each sample using portable x-ray fluorescence. We hypothesized that the petrocalcic and calcic soils will differentiate by parent material. Using a principal component analysis (PCA), we found geochemical differences between the calcic horizons forming on different parent materials, with limestone-derived calcic horizons separating from volcanic-derived horizons. We observed notable differences in pH, EC, and LOI between the samples, likely stemming from their different parent materials. We calculated dust input for each sampled horizon using titanium and zirconium concentrations and constant Ti:Zr values for dust and parent material. We found that many horizons contained a significant dust fraction, but generally limestone and rhyolite derived samples had the lowest contributions from dust. Thus, while dust is a significant factor in calcic and petrocalcic horizon formation, other factors such as parent material partially explain the formation of petrocalcic and calcic horizons.

## Abstract

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### **374-6 TRENDS IN VERTICAL PORE WATER FLUX IN THE HYPORHEIC ZONE OF A LOW GRADIENT THIRD ORDER STREAM**

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TOP

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The relationship between fluid flow and heat transfer is a powerful tool used to delineate and to quantify water movement in the near-surface streambed or hyporheic zone. This study tests the viability of a heat tracing method through the characterization of one-dimensional, vertical, flux rates in the top 150cm of the hyporheic zone of a low-gradient, third-order perennial stream. Six wells installed along the thalweg of a 25-meter stretch of the stream recorded temperature. From February 2009 to March 2010, temperatures were logged at 15-minute intervals in the stream and at depths of 30, 60, 90, 150 cm. Stream stage was also recorded every 15 minutes. To determine if stage is a control on the direction and magnitude of vertical flux and to visualize how flux changes temporally and spatially, vertical flux rates were calculated using temperature sensor pairs at depth

with the one-dimensional conduction-advection-dispersion equation utilized in VFLUX. Flux is calculated at the midpoint between a sensor pair, e.g., a flux is calculated at a depth of 45cm the midpoint between the 30cm and 60cm sensors. Model results indicate that the flux direction varies with depth at all six of the streambed wells. The dominant flux direction at a depth of 15cm is upward (negative) while the dominant flux direction at a depth of 45 cm, 75 cm, and 120 cm is downward (positive). At a 15 cm depth, the average flux at each well ranges from  $-2 \times 10^{-6}$  to  $5 \times 10^{-7}$  m/s. The average flux at 45 cm ranges from  $-1 \times 10^{-7}$  to  $7 \times 10^{-6}$  m/s. The average flux at 75 cm ranges from  $5 \times 10^{-7}$  to  $8 \times 10^{-6}$  m/s and at 120cm depth the average flux rate ranges from  $3 \times 10^{-6}$  to  $1 \times 10^{-6}$  m/s. We posited that there is a positive linear relationship between stage and flux; i.e. with a rise (fall) in stage, the stream loses (gains) water to (from) the streambed, a positive or downward flux (negative, upward flux). The strength of the bivariate relationship between stage and flux was determined by the Pearson coefficient of correlation at each midpoint between sensor pairs. The p-values for 21 of the 24 well midpoints are less than a  $\alpha$  of 0.05, indicating a statistically significant correlation between stage and flux at these depths. Of the 21 statistically significant correlations, 15 wells have a weak positive correlation between stage and flux with correlation coefficients ranging from 0.050 to 0.377 with an average of 0.159.

## Abstract

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### **374-7 CARBON DIOXIDE DYNAMICS WITHIN THE CRITICAL ZONE OF A KARST LANDSCAPE: SAVOY EXPERIMENTAL WATERSHED, ARKANSAS**

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TOP

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Washington State Convention Center, Halls 4EF

In carbonate settings, the critical zone evolves largely through the congruent weathering of calcite driven by dissolved carbon dioxide. This calcite dissolution process generates one of the most highly heterogeneous types of subsurface flow media, karst, where hydraulic conductivities can vary over many orders of magnitude. Preferred flow paths, which develop by solutional enlargement, focus flow and transport of both dissolved species and gases. Though gas transport within the subsurface is typically assumed to be diffusive, modeling results suggest that advective transport driven by both water and buoyant gas flow are likely to produce strong perturbations to vertical depth profiles of CO<sub>2</sub>. These dynamics likely have important impacts on the depth distribution of calcite weathering.

To examine whether the predicted advective effects are observed in the field, we are conducting measurements at the Savoy Experimental Watershed (SEW), a University of Arkansas collaborative research site for the study of water science and animal waste management in mantled karst terrain. High resolution in situ time series data of dissolved CO<sub>2</sub> were obtained at SEW from a well, a soil sensor, and the primary spring that drains the catchment, enabling us to examine CO<sub>2</sub> concentration dynamics over time and space within the catchment. At each site, an Arduino based logger, using a Sensair K-30 CO<sub>2</sub> sensor with a range up to 100,000 ppm, is housed in weather proof housing and powered by a 12 V lead acid battery. The CO<sub>2</sub> sensors are coated with a waterproof breathable membrane enabling direct measurement of dissolved CO<sub>2</sub>. This configuration enables inexpensive, high frequency (hourly), and low power monitoring of dissolved CO<sub>2</sub>. Comprehensive weather data, including soil moisture content, is collected in five-minute intervals at a central weather station.

## Abstract

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### **374-8 THE ROLE OF ALLUVIAL LANDFORMS IN STORING SOIL ORGANIC CARBON: A CASE STUDY FROM HUMID-TEMPERATE WESTERN KENTUCKY**

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TOP

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Washington State Convention Center, Halls 4EF

The storage of soil organic carbon (SOC) in soils found at depths greater than one meter in river valley bottoms, and those processes that operate on that SOC, are not well understood. This study examines the stock and isotopic composition of SOC along alluvial landforms: floodplains, terraces, and vegetated bars or swales, in the Clarks River National Wildlife Refuge (CRNWR). Preliminary data from three cores along a transect from a terrace to an adjacent channel bar were collected to depths of 1 to 1.5 meters. Bulk density, particle size, and loss-on-ignition were used to estimate stocks of SOC in each landform type. Data were collected for the subsoil and did not include A horizons. Average subsoil-SOC values for each of the landforms decreased along the transect towards the river channel, with the largest value of  $1.8 \text{ kg/m}^2 \pm 0.3 \text{ SD}$  found in the terrace and the lowest value of  $0.9 \text{ kg/m}^2 \pm 0.18 \text{ SD}$  found in the near-channel bar. The floodplain had an average value of  $1.14 \text{ kg/m}^2 \pm 0.3 \text{ SD}$ . This is likely due to differences in soil texture, where terraces have greater soil development due to infrequent flooding which allows for clay accumulation, a predictor for SOC storage at depth. Although floodplains and near channel features observe greater flooding and potentially greater deposition and sequestration of SOC, this SOC may be stored temporarily and oxidized with increasing residence time. Additional transects and more direct measurements of SOC via combustion and gas chromatography will be used to test the consistency of these observations.

## Abstract

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### 338-4 WEATHERING OF ROCK TO REGOLITH: THE ACTIVITY OF DEEP ROOTS IN BEDROCK FRACTURES

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TOP

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The Conference Center, Skagit 3

It is generally assumed that rooting depth is restricted in shallow soils due to the underlying solid bedrock, and thus most studies of root dynamics focus on the uppermost soil horizons. However, in many landscapes, shallow soils overlie actively weathering bedrock. We tested the role of tree roots in weathering bedrock by excavating pits along a *catena* in a catchment with shale bedrock at the Susquehanna Shale Hills Critical Zone Observatory, PA. We measured a range of properties in the soil, rock, and rock fracture fill at a ridge top, mid-slope, toe-slope, and valley floor that include: 1) root density, distribution, and respiration, 2) soil gas, and 3) elemental compositions, mineralogy, and morphology. Root density decreased with depth, but fine roots were observed in

rock fractures even in the deepest (~1.8 m), least weathered shale sampled. Root densities in fractures were similar in the upslope positions, but significantly lower ( $p < 0.01$ ) in the toe-slope despite higher fracture density. Average root respiration (per dry root mass) in the soil and rock fractures was comparable. Thus, the total CO<sub>2</sub> flux from root respiration tracked root density, declining with depth. Microbial respiration, estimated with C mineralization potential, was ~10%— lower than root respiration in both the soil and rock fractures. Roots were found only in >50 µm-aperture fractures filled with particulate material. Fracture fill was similar to the lowest soil horizons with respect to clay composition, element mobility, extractable dissolved organic C, inorganic N-species, and potentially mineralizable C and N, while total C and total N values were similar to the shale. In the bulk soil, depletion profiles (Al, Fe, K, Mg, and Si) relative to unweathered shale reflected weathering of illite and vermiculized chlorite to kaolinite and were similar between the soil and fracture fill. Such similarities indicate that the fracture fill is likely the result of pedogenic processes at depth rather than translocation of soil particles downward. Our data suggest that roots and fill in rock fractures down to ~1.8 m are qualitatively similar to those in surface soil horizons. Thus, the deepest manifestation of the chemical depletion profiles we observed consists of rock fracture fill, and this fill is present at low amounts with similarly low amounts of roots.