Department of Soil, Water and Environmental Science
Oral Presentations

Thursday March 30th

Student Union Memorial Center
Catalina Room

9:00 AM – 3:00 PM
Schedule at a Glance

09:00 M. Pohlmann  
Fate of rapidly deposited carbon and lithogenic solutes onto surface soils within a mixed conifer catchment severely burned by wildfire

09:15 B. Moravec  
Exploring the deep critical zone: geochemical dynamics in a complex lithologic terrain

09:30 Yadi Wang  
Elemental redistribution due to physical and chemical weathering at the beginning of soil genesis processes in a soil-lysimeter scale

09:45 C. Shepard  
Paleoclimatic constraint on soil formation and survival

10:00 D. Fairbanks  
Assessing seasonal, aspect, and spatial dynamics of microbial community composition and function in response to pulse precipitation inputs in two adjacent, high-alpine catchments in northern New Mexico

10:15 P. Rundhaug  
Measured effects of community engaged approaches to enhance assessment, awareness, and remediation of contaminated sites and improvements to traditional ZVI pump and treat technology

10:30 D. Huskey  
Extracellular trapping of metals by plant root border cells

10:45 BREAK

11:00 A. Wassimi  
Evaluation of coliphage removal during wastewater treatment

11:15 Yake Wang  
Transport of graphene in quartz sand and vinton soil

11:30 A. Utzinger  
Waste mesquite derived biochar's effect on germination of lettuce seeds

11:45 -12:45 LUNCH
13:00 J. Larson
A pore-scale approach to colloid-surface interaction in liquid using lattice Boltzmann models

13:15 V. Joe
Evaluation of total Bacteroides as an alternative irrigation water quality indicator

13:30 BREAK

13:45 L. Bozeman
The role of dissolved organic matter on the mobilization of arsenic in historic mine tailings

14:00 B. Rivera
Ammonia-oxidation microbiota abundance on an arid mine site

14:15 L. Jennings
Cover material: do quality and depth matter?

14:30 CLOSING
Fate of rapidly deposited carbon and lithogenic solutes onto surface soils within a mixed conifer catchment severely burned by wildfire

Michael A. Pohlmann, Dawson Fairbanks, Chris Shepard, Jon Chorover

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Catalina Room, 9:00 AM, March 30, 2017

Wildfires represent a major disturbance in forested ecosystems of the semi arid southwest. They are set to become more prevalent and destructive due to shifts in regional climate (e.g., increased vapor pressure demand, draught stress, etc.) and current land use practices. A 2013 fire severely burned a mixed conifer catchment in the Jemez River Basin, a study area within the University of Arizona's Critical Zone Observatory. This event drastically altered the near surface biogeochemical environment, rapidly delivering charred material (i.e. pyrogenic carbon- PyC) and lithogenic solutes tied up in biomass directly to surface soils. This pulse of PyC and solutes was examined using aqueous extractions on soils collected in the time directly following the fire and two successive years post-burn. This study focused on the initial distribution and eventual fate of these solutes and PyC about the catchment and into the soil profile, to better understand the mechanisms of the soil response to wildfire.
Exploring the deep critical zone: geochemical dynamics in a complex lithologic terrain

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Catalina Room, 9:15 AM, March 30, 2017

The Critical Zone (CZ) is the focus of current interdisciplinary Earth surface science research that aims to describe the interactions between geological and biological processes that influence ecosystem function, soil formation, nutrient and carbon cycling, hydrologic partitioning, biological activity and diversity, and mineral weathering. Prior research at the Catalina-Jemez (C-J) Critical Zone Observatory (CZO) has focused on the near-surface CZ, including remote sensing, and sampling/analysis of vegetation and soil microbiota, soils and saprolite, and surface water. However, the extent to which weathering, water-rock interaction, and solute mobility along flowpaths in the deep CZ respond to near surface CZ processes (i.e. water, energy, and mass fluxes) is not well understood. The goal of the present research is to elucidate depth-dependent trends in weathering dynamics from the mobile top-soil to deep unweathered bedrock in relation to landscape position (hillslope aspect and downgradient hollow). We used diamond core drilling techniques to excavate three boreholes to depths of 18.9, 41.8, and 46.3 meters in instrumented sub-catchment of the forested C-J CZO in northern New Mexico. Here we present preliminary data collected during the field campaign during summer 2016 and subsequent laboratory analyses of select subsamples. Surface and downhole geophysics were collected in the field prior to and immediately after drilling. Element concentrations of core subsamples were measured by inductively coupled plasma – mass spectrometry (ICP-MS) and mineralogy was measured by X-ray diffraction (XRD). Depth dependent trends in both regolith depth and chemical ratio patterns show significant variation with landscape position and lithology. All three boreholes show complex weathering profiles with differences potentially due to textural controls on weathering, parent material, hydrothermal alteration history, development of preferential flowpaths, and differing hydrologic base levels. Preliminary data indicate that geochemical patterns are not monotonic, but rather comprise large excursions that are being investigated for their relation to variation in local mineralogical composition and incongruent weathering reactions.
Elemental redistribution due to physical and chemical weathering at the beginning of soil genesis processes in a soil-lysimeter scale

Yadi Wang

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Catalina Room, 9:30 AM, March 30, 2017

Relative elemental enrichment and depletion is a consequence of the mineral dissolution and precipitation reactions of soil genesis. External interference, including elemental additions due to dust deposition, in natural field systems often complicate understanding of near surface soil forming mechanisms. To simplify the natural variability isolate external inputs, a fully controlled and monitored soil lysimeter with known and homogeneous initial conditions was utilized to investigate the initial stages of weathering and soil genesis. A 10° sloping soil lysimeter containing one cubic meter of crushed and homogenized basaltic rock was installed to investigate the initial weathering conversion of host rock to soil at the Biosphere 2 LEO research facility. In a two-year experiment, intensive irrigation resulted in high volume water storage, and while there were no biological amendments, biological changes were visible on the soil surface, such as algal and grass emergence. These observations indicated that biogeochemical hotspots may be established within the soil lysimeter. A forensic excavation and sampling procedure that removed 324 voxels was performed that aimed to capture the evolving heterogeneity of the lysimeter with respect to length and depth. A five-step sequential extraction was applied to the voxels to measure elemental concentrations in operationally-defined pools including exchangeable, amorphous metal (hydr)oxides, and crystalline (hydr)oxides. Several patterns emerged, including accumulation of exchangeable Ca in the middle slope at all depth of the soil-lysimeter where highest water storage was observed; hotspots of reducible Ca, Fe, and Mn were observed at the upper slope at all depth where lowest water storage was obtained; Ligand extractable Fe and Mn were more abundant in the middle and toe slopes; and crystalline Fe oxide (containing Mn) were more enriched while Ca bonded crystalline Fe oxide is more depleted at upper slope. The detailed relative enrichment/depletion in each sequential extraction pool will be presented with the aim of understanding elemental lability and redistribution during the initial stages of soil genesis due to physical impacts and geochemical weathering.
Paleoclimatic constraint on soil formation and survival

Christopher Shepard, Craig Rasmussen

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Catalina Room, 9:45 AM, March 30, 2017

Soil chronosequences describe how soil properties change with time; however, our understanding of soil chronosequences is typically limited to site- or study-specific basis, lacking global applicability. As such, a global theory of soil property change with time, soil formation, or persistence at the Earth’s surface has yet to be fully developed. Here we propose a global theory of soil formation and survival within the context of past climate change. Using a global synthesis of soil chronosequence data and δ18O records as paleoclimatic proxies we found the rate of change in past climate controlled variability in soil properties and persistence across the Earth’s surface. The vast majority of soils formed during interglacial periods with low rates of climatic change, with few soils forming during periods of rapid climate change at glacial-interglacial periods. Further, climate variability lead to increased variability in soil properties observed at $10^5$ years, coinciding with the glacial-interglacial frequencies throughout much of the mid to late Pleistocene and Holocene. Soils deposited during increased erosion and denudation associated with glacial-interglacial transition, developed and evolved throughout interglacial periods, enabling persistence at the Earth’s surface through later climate shifts. Soils deposited prior to rapid climatic shifts were likely prevented from developing and were removed from the Earth’s surface. Past climate change controlled soil survival throughout the Quaternary, and influenced the distribution of soils that are observed across the modern Earth’s surface.
Assessing seasonal, aspect, and spatial dynamics of microbial community composition and function in response to pulse precipitation inputs in two adjacent, high-alpine catchments in northern New Mexico

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Catalina Room, 10:00 AM, March 30, 2017

Fire frequency and severity are increasing across the western United States with enormous impacts on regional carbon and nutrient cycling. Central to the understanding of ecosystem recovery are the microbial communities that transform nutrients in the environment. Temporal changes in precipitation patterns influence the stress response of resident microbiota, in combination with abiotic controls, and in part, controls ecosystem level CO₂ and greenhouse gas flux. We explored the relationship between timing of precipitation, terrestrial nutrient cycles on microbial ecology post-fire by sampling across a topographic gradient from two adjacent mountain catchments (north and south-facing) in a high elevation mixed conifer forest three years following a high severity fire disturbance. To best understand microbial community response and recovery to a) a major fire disturbance and b) pulsed precipitation dynamics we analyzed the 16S ribosomal rRNA community metrics, seven hydrolytic enzyme activities, biomass carbon and nitrogen and geochemical parameters following snowmelt, pre and post-monsoon.

Six sites were sampled from each catchment across a topographic transect from surface (0-10 cm) and deep (30-40 cm) soil profiles. Samples taken from the south facing catchment were co-located with CO₂, O₂, redox (platinum electrode) and temperature probes. Results show greater greenhouse gas flux in the convergent zones of the landscape occurring at deeper depths with simultaneous oxygen consumption. These results can be used to integrate our understanding of ‘hot spots’ as a function of landscape position and the pulse coupling of precipitation dynamics influencing the stress response of microbes and the co-occurring nutrient cycling.
Measured effects of community engaged approaches to enhance assessment, awareness, and remediation of contaminated sites and improvements to traditional ZVI pump and treat technology

Patrick Rundhaug

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Catalina Room, 10:15 AM March 30, 2017

Unified Committee Advisory Boards (UCAB) have proven effective forms of community engagement in the geographic areas of a superfund site. When local scientists, engineers, community members and concerned citizens become engaged in the remediation of a US EPA Superfund site, many effects are observed which may result in a difference in remediation time frames, technologies employed, effectiveness, as well as the environmental custodianship. The differences are compared and measured at those sites compared to those that do not have such involvement. If there is strong engagement and participation by the community members at contamination sites, it was hypothesized there would be a stronger impact on their involvement, and understanding and lead to improved remediation, remediation time frames, techniques, and future environmental custodianship. Results implied strong engagement and participation by the community members at contamination sites has a strong impact on their involvement eventual improved remediation efforts, and success. The treatment of groundwater containing perchlorate by a water treatment reactor via ZVI processes was improved with new pre-treatments by purging oxygen, removing competing oxidized materials, increasing contact (surface area) mesh/size, increasing residence time, and treating the iron by “opening the pores” with HCl washing.
Extracellular trapping of metals by plant root border cells

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Catalina Room, 10:30 AM, March 30, 2017

Most plant species produce specialized ‘border cell’ populations programmed to disperse from the root tip into the external environment. Like neutrophil extracellular traps (NETs) in animals, an extracellular DNA-based matrix produced by border cells traps pathogens and toxic metals to prevent infection and injury. In 2001, border cells of pea and snapbean were found to trap aluminum rapidly and thereby prevent uptake into the growing root. Subsequent studies also have documented border cell extracellular trapping of arsenic, cadmium, lead, and other contaminants. No reports, to date, have determined the amount of metal that border cells can trap. In preliminary tests, border cells from a single cotton or corn root were found to remove up to 85% of lead from a 1-ml sample (1.0 mM) during a 1-hour period of incubation. Defining the mechanism of trapping in plants as a model system may facilitate applications in medicine and agriculture.
Evaluation of coliphage removal during wastewater treatment

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Catalina Room, 11:00 AM, March 30, 2017

The United States Environmental Protection Agency recently proposed the use of coliphages as indicator organisms of fecal contamination in recreational waters. Coliphages are viruses than infect enteric coliform bacteria, and are consistently present in domestic wastewaters. They are similar in size and shape to human enteric viruses, and are more resistant to removal by disinfection than enteric bacteria. As such, they have long been proposed as indicators of fecal pollution. However, traditional bacterial indicators (i.e. Escherichia coli) are not reliable indicators for viral pathogens. It is therefore of interest to better understand the removal of coliphages by sewage treatment processes, and whether there is a correlation with the reduction of human pathogenic enteric viruses. In the current study, several wastewater treatment plants (WWTP) located in Pima County, Arizona are being evaluated to assess the comparative removal of coliphages and human enteric viruses by different treatment train processes.
Transport of graphene in quartz sand and vinton soil

Yake Wang

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Catalina Room, 11:15 AM, March 30, 2017

Miscible-displacement experiments were conducted to investigate the transport and retention of graphene in quartz sand and Vinton soil. Graphene was dispersed into water with a surfactant solution (500 mg/l) at a concentration of 50 mg/l. The breakthrough curves for graphene transport in the sand exhibited typical colloid transport behavior, with breakthrough at 1 pore volume (PV) and steady-state irreversible retention (~88% for graphene-SDBS and 20% for graphene-Tween 80). Conversely, for Vinton soil, the relative effluent concentration plateau increased slowly towards 1, indicating the existence of a colloid blocking phenomenon.
Waste mesquite derived biochar's effect on germination of lettuce seeds

Alex Utzinger

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Catalina Room, 11:30 AM, March 30, 2017

Biochar is a solid bio-waste product produced via pyrolysis. It is a classification of charcoal commonly produced in nature by forest fires. Biochar has been known for thousands of years by farmers for its properties as a carbon sink and as a soil amendment helpful in repairing and preparing soils for plant growth. Biochar can be produced from organic waste residues. Biochar can be used to store carbon in soils over hundreds of years making it very desirable as a tool for combating climate change as well as assisting with plant growth in carbon and nutrient deprived soils. This study aims to test the specific effects that biochar has on the germination of lettuce seeds (Lactuca sativa) by growing the seeds in a high salinity medium (worst-case-scenario). The biochar used in this experiment is derived from mesquite yard waste branches wood chips produced under slow pyrolysis conditions at ~450C. The seeds will be germinated in a petri dish in contact with biochar and de-ionized water and with appropriate controls. The experiments described have yet to be conducted however we expect to find that biochar in high quantities will inhibit or stop the germination of the lettuce plants because of biochar's high salinity. Further experiments with pretreated biochar will be used to determine the threshold levels of salinity that impair seed germination.
A pore-scale approach to colloid-surface interaction in liquid using lattice Boltzmann models

Joshua Larsen, Marcel Schaap

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Catalina Room, 13:15 PM, March 30, 2017

Knowledge of colloid transport and collection efficiency is important for understanding the transport of some contaminants of emerging concern (CEC) and for developing environmental remediation systems such as geologic filters. The interaction forces between colloids and soil materials are central to colloid transport and retention or immobilization. In this study a physical modeling approach to represent colloidal transport through porous media has been developed, using the lattice Boltzmann methodology. Lattice Boltzmann models have the uncanny ability to represent pore scale fluid flow through complex structures such as geological material. A cellular approach to computing colloid forces is applied for computational efficiency, and colloids are tracked continuously through the model. Grid refinement effects are quantified to balance computational efficiency with discretization effects. Representation of physical forces including DLVO create a natural fluid solid boundary condition for colloid transport.

Collector efficiencies of geologic materials and colloid distribution curves can be produced. The present work focuses on simple porous media with a single wetting fluid phase, but the approach can be extended to heterogeneous geologic materials and multiphase systems.
Evaluation of total Bacteroides as an alternative irrigation water quality indicator

Valerisa Joe

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Catalina Room, 13:30 PM, March 30, 2017

Preharvest irrigation water represents a key potential source of pathogenic bacteria during the production of fresh produce. Widespread crop contamination can occur if irrigation water is contaminated with fecal pathogens, such as Escherichia coli (E.coli) and Salmonella. Industry guidance standards uniformly identify generic E. coli as a practical and cost-effective indicator of fecal contamination in water. Although generic E. coli satisfies most characteristics of an ideal bacterial indicator, only very limited correlation exists between the presence of E. coli, pathogen presence, and microbial risk to consumers following consumption of contaminated produce. This work examines an alternative fecal indicator bacterial group, Total Bacteroides, for prediction of pathogen presence in 102 irrigation water samples collected throughout Arizona. Total Bacteroides markers were enumerated by quantitative Polymerase Chain Reaction (qPCR), using: 1) a published protocol, and 2) a commercially-available Bacteroides enumeration kit. Each water sample was also assayed for generic and pathogenic E. coli and Salmonella markers, to assess correlations between Bacteroides markers and human pathogens. Ultimately, this project will determine the utility of Total Bacteroides as an indicator of human pathogens in water used for irrigation of fresh produce, information critical to continued production of a safe and sustainable food supply in the United States.
The role of dissolved organic matter on the mobilization of arsenic in historic mine tailings

Lauren Bozeman, Rob Root, Mary Kay Amistadi, Jon Chorover

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Catalina Room, 2:00 PM, March 30, 2017

Abandoned mine sites are of environmental concern worldwide for their potential to contaminate water resources. The Iron King Mine Dewey-Humboldt Smelter Superfund (IKMDHSS) site in Central Arizona is a 163 hectare historic mine waste site. Arsenic concentrations IKMDHSS tailings exceed 3000 ppm, well above EPA standards for human health. Arsenic has the potential to mobilize from tailings into aqueous systems, a concern because it is known to be toxic at low concentrations. The mobility of arsenic is controlled by pH, dissolved oxygen, dissolved organic matter (DOM), iron (Fe) minerals and surfaces, and microbial activity. The role of DOM on the mobilization of As has been studied in the context of natural aquifer systems (e.g., mass poisoning in SE Asia), but less is known about mining-impacted environments. Efforts have been initiated at IKMDHSS to employ compost-assisted phytostabilization as a means to reduce the dispersion of metal-rich dust into nearby communities (Gil-Loaiza et al., 2016). While this strategy has successfully decreased dust emissions (Saez, 2016), it has created conditions known to be favorable to As mobilization. Heterotrophic microbial respiration under O2 limited conditions can cause the reduction of Fe3+ to Fe2+, enhancing desorption or dissolution of As from Fe containing minerals. Additionally, DOM competes with As for sorption sites at mineral surfaces. In this study, batch experiments were used to investigate the mechanisms of sequestration and release of As in compost amended mine tailings. Mine tailings were reacted in triplicate in the presence and absence of DOM, and under biotic or heterotrophic-respiration suppressed (with NaN3) conditions at timescales from ranging from 24 to 800 hours. Highest arsenic dissolution occurred in the presence of DOM and microbial activity after 24 hours. The release of arsenic was lowest in the control treatment with no DOM added to tailings. To further understand the kinetics of sequestration and release of As from tailing material under conditions matching batch experiments, mini-column flow-through experiments with fractionation collection equipment will be conducted at minutes to month time-scales. We aim to describe the impact of DOM on the mobilization of As from mine tailings. This work will help determine if As may be released to groundwater due to remediation strategies.
Ammonia-oxidation microbiota abundance on an arid mine site

Benjamin D. Rivera

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Catalina Room, 2:15 PM, March 30, 2017

Mining is inextricably linked to the daily practices of the industrialized world as most of our modern tools and technologies contain metals which can be obtained from no other source. Notwithstanding, mining presents a host of environmental issues, including significant landscape disturbance resulting from the massive waste rock piles and tailings storage dams produced by mine operations. These waste materials are devoid of nutrients for plant growth, making ecosystem reclamation difficult. Reclamation typically requires costly revegetation strategies including the regrading of steep slopes and the installation of soil caps over waste materials. Our lab seeks to provide biogeochemical indicators which can be used to evaluate substrate quality to assist mining companies in effectively assessing different reclamation strategies.

Nitrogen (N) is one nutrient factor limiting plant establishment on mine wastes. The preferred form for plant-uptake, nitrate (NO\(^{-3}\)) is obtained from ammonia (NH\(4^+\)) through nitrification, a process mediated by microbes. Specifically, the first, rate-limiting step, ammonia-oxidation to nitrite (NO\(^{-2}\)), is facilitated by chemoautotrophic ammonia- oxidizing bacteria (AOB) and archaea (AOA). The bacterial and archaeal amoA gene, encoding the ammonia monooxygenase enzyme (AMO), that facilitates the chemical transformation, is used as a molecular marker to quantify the populations of these organisms. We hypothesize that the relative abundance of AOB and AOA populations will indicate substrate quality for plant growth.

AOA are frequently found to be the dominant ammonia-oxidizers in nutrient poor sites. This study will construct clone libraries of archaeal amoA amplicons from the Carlota Copper Mine to evaluate AOA diversity. Representative plasmids will then be selected as standards to be used with existing AOB standards for quantitative PCR to determine the relative abundance of AOA and AOB populations as well as possible correlations with environmental parameters, shown to drive population dynamics. The results will be used to propose a follow-up study on activity, as the presence of the gene does not always equate to expression.

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Cover material: do quality and depth matter?

Lydia Jennings, Ben Rivera, Lia Ossanna, Mira Theilmann, Julie Neilson, Raina Maier

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Catalina Room, 2:30 PM, March 30, 2017

Mining reclamation aims to restore affected land to a condition capable of supporting self-sustaining plant communities. One reclamation strategy, called cap and plant, uses soil material from undisturbed areas to cover mine waste prior to seeding. This excavated soil material is referred to as borrow. Previous research has indicated that the source of borrow used for mine waste coverage can impact plant establishment and growth, with surface soil being of the best quality. However, excavating borrow to a deeper depth is ecologically preferable to limit offsite disturbance. Potential negative properties of borrow obtained from greater depths are 1) low nutrient quality, 2) poor soil structure, and 3) low organic matter content. Our goal is to determine which soil characteristics (soil biogeochemical indicators) best define the minimum soil quality required for plant establishment during reclamation. Significant soil biogeochemical indicators have been identified that correlate with successful plant growth on more established reclaimed areas. Indicators being evaluated include heterotrophic plate counts, particle size, pH, electrical conductivity, and DNA biomass. We will determine how biogeochemical indicators of the borrow material change with depth to predict whether a specific depth of excavation is no longer economically valuable for reclamation. This approach will guide recommendations for amendment strategies for poor quality borrow material based on biogeochemical indicator results. Mining industry literature recommends that borrow pits range between 20-30 ft deep. In this project, we evaluate two borrow areas, Borrow Pit North and Borrow Pit South, which are 18-21 ft in depth. Preliminary data demonstrates that for both Borrow Pit North and Borrow Pit South pH, electrical conductivity and heterotrophic plate counts change with depth. Improved understanding of cover materials will facilitate more effective reclamation strategies and can potentially decrease destruction of offsite desert areas.