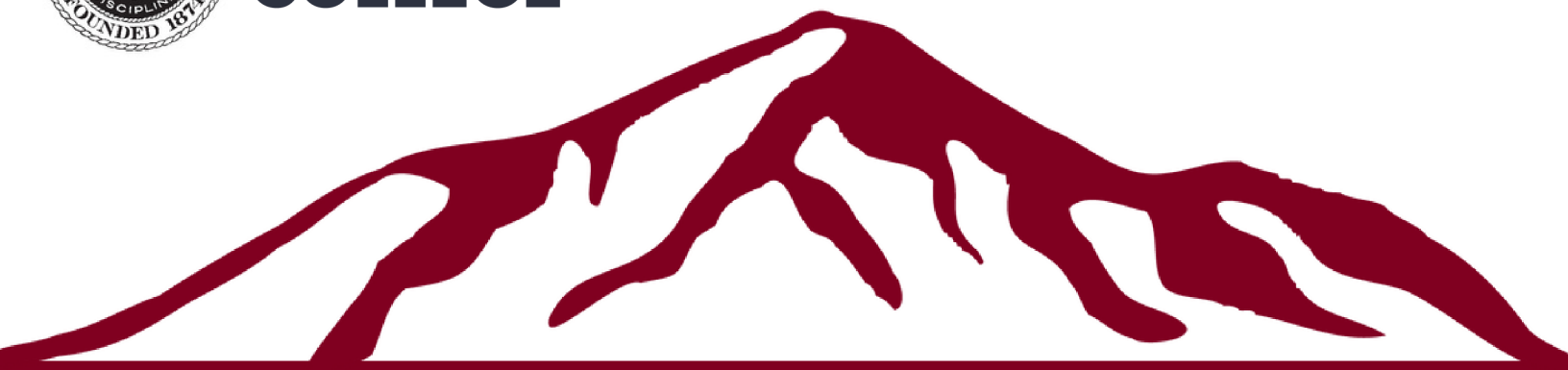
COLORADO COLLEGE



GEOLOGY DAY 2023

APRIL 8, 2023
BLOCK 7 - FIRST SATURDAY
8:30 AM

TUTT SCIENCE
COLORADO COLLEGE
1112 N NEVADA AVE.

PROGRAM

Speaker Session I - 9:00 to 10:40 AM

8:30 AM - Breakfast Buffet

9:00 AM - Welcome Statement

9:05 AM
Emory Pollatsek -
Understanding fault-fluid interaction through stable isotope analysis of tourmaline-coated brittle faults of the West Antarctic Rift

9:20 AM
Zhilin Shi -
How does Lithology Influence the Migration and Meander Stability of Meandering Bedrock Rivers

9:35 AM
Cade Quigley -
The Seismic Record of Wind in Alaska

9:50 AM - Break

9:55 AM
Grace King -
Assessing Wildfire Regimes and Floral Recovery After the K-Pg in Corral Bluffs, CO

10:10 AM
Clay Rodriguez-Gould -
Facilitating the green transition: an analysis of carbon market opportunities & limitations

10:25 AM - Open Q&A to Speakers

PROGRAM

Poster Session - 10:40 AM to 12:00 PM

10:40 AM

Katya Nicolayevsky -

Tracking Paleoenvironmental Associations in Vertebrate Microfossil Bonebeds in the Upper Cretaceous (Campanian) Judith River Formation, Montana

Jack-Henry Kent -

Meandering Bedrock River Bedforms

Lucy Rogers -

Tiny Modification Features on Fossil Bones from Vertebrate Microfossil Bonebeds in the Upper Cretaceous (Campanian) Judith River Formation, Montana

Cade Quigley -

Glacial sliding on volcanic bedrock: effect of rock surface roughness on ice-on-rock friction and healing

GY315 -

Past, Present, and Future of the Rampart Range Fault: A Blessing and a Curse?

11:00 AM - Sack Lunch

PROGRAM

Speaker Session II - 12:05 to 2:00 PM

12:05 PM

Spencer Shaw -

Geomorphic Characterization of Fountain Creek: A Study of Planform Change and Channel Migration

12:20 PM

Matt Semel -

Is the Mojave Crustal Province the assimilation source of Proterozoic zircon grains in the Cretaceous Oasis Granite, Mojave Desert, California?

12:35 PM

Eugenie Haring -

Zircon U-Pb Agers and Hf isotopes of the Black Canyon Gabbro: Insights into Magmatic Processes and Tectonic Implications of the Teutonia Batholith

12:50 PM

Jackson Kohn -

Determination of metal-PDMA stability constants via spectrophotometric titrations

1:05 PM - Open Q&A to Speakers

1:25 PM - Smooth Move award and Announcements

1:40 PM - Closing Statement

4:30-7:30 PM - The Barbecue

1224 N Wahsatch Ave

(Jack-Henry, John, & Fiona's house)

ABSTRACTS

Understanding fault-fluid interaction through stable isotope analysis of tourmaline-coated brittle faults of the West Antarctic Rift

Emory Pollatsek

Advisor: Dr. Christine Siddoway, Colorado College

Little is known about fault-rock and fluid rock interactions in Antarctica because faults are mostly hidden beneath the West Antarctic ice sheet. In the Ford Ranges, Marie Byrd Land, exposures of brittle faults with tourmaline mineralization offer a rare opportunity to study these interactions. The faults display mirrored surfaces, with slickenlines parallel to aligned tourmaline. The minerals may provide information on conditions of formation and geothermal fluids within the crust of West Antarctica during tectonism. The fault investigation may add valuable information about sites that may localize geothermal heat, in contribution to the effort to improve predictions of future ice sheet stability. We use stable isotope geochemistry and argon-argon ($^{40}Ar/^{39}Ar$) geochronology to characterize tourmaline that formed during brittle faulting to better understand fluid circulation and crustal sources of mineralizing fluids. We perform oxygen and hydrogen stable isotope analyses to investigate the fluid composition and source, and argon geochronology to date the formation of the tourmaline. Oxygen and hydrogen isotope analysis suggests the fluid contained a mix of magmatic- and metamorphic-derived fluids, with the potential for minor amounts of seawater. Preliminary $^{40}Ar/^{39}Ar$ dates suggest that tourmaline mineralization occurred during the Cretaceous. This implies that fluids traveled from deeper within the crust to shallower depths along brittle faults active during regional extension across West Antarctica.

How does Lithology Influence the Migration and Meander Stability of Meandering Bedrock Rivers

Zhilin Shi

Advisor: Dr. Sarah Schanz, Colorado College

Bedrock meandering rivers are well-distributed over the planet. These rivers have little to no layered alluvium with episodically exposed bedrock as the banks and bed. Due to lack of a thick sediment cover, bedrock meandering river channels are sensitive to climatic and tectonic changes that are directly interacting with the channel by either inducing flooding, altering sediment supply, and/or uplifting the channel (Stark et al., 2010; Finnegan & Balco, 2013). This unique characteristic makes bedrock meandering rivers actively incise and reshape the Earth's landscape. How fast the bedrock river channel migrates or erodes is strongly dependent on the substrate of the bedrock river (Sklar & Dietrich, 2004); therefore, lithology is hypothesized to be a strong control on the landscape evolution of bedrock meandering rivers.

The goal of this study is to unfold the lithologic control on bedrock meandering river using a 1-D numerical model built by Drs. Sarah Schanz and Brian Yanites. Lithologic controls on the stability of meandering bedrock rivers – lateral erodibility, vertical erodibility, bedrock channel types and initial slope – are varied in the models and run for 100,000 years to simulate distinct landscape evolution patterns.
There are mainly three general patterns that I observed from different combinations of parameters in the numerical model that can explain the role of lithology. Their behaviors can be categorized as: 1. Stable meandering in which increasing lateral erodibility values leads to more cutoffs, but the channel still has an increased sinuosity; 2. Straight channels with a very high vertical erodibility value, yet the channel shows a decreasing trend in sinuosity with few cutoffs; and 3. Braided channels in which a channel experienced too many cutoffs to maintain meander stability, causing the sinuosity to decrease, and annual cutoffs occur on high frequency/low amplitude meanders.

Results from this work determined lithologic characteristics that support meandering bedrock channels as opposed to braided, thus informing where planform-specific ecologic niches may develop. Overall, my research will allow other researchers to understand how topographic evolution responds to lithology and aids our broader understanding.

The Seismic Record of Wind in Alaska

Cade Quigley

Advisors: Dr. Michael West, Alaska Earthquake Center (AEC), Geophysical Institute, University of Alaska Fairbanks

Dr. Christine Siddoway, Colorado College

Seismic arrays, while designed to capture discrete events such as earthquakes, record the continuous background din of the earth comprising a mix of environmental phenomena and human activity. In remote locations, the seismic record is dominated by wind-induced noise at high frequencies (>1 Hz) and low frequencies (<0.1 Hz). We use colocated wind and seismic data for 110 stations of the Alaska Transportable Array (TA) to assess the influences on wind-induced ground motion. We compute and compare time series probability power spectral densities (PPSD) and average-filtered wind speed and direction data for 2018. We observe a pronounced increase in seismic energy (dB) as a function of wind speed (m/s) for almost all stations in the network. We develop a quantitative measure to compare variable seismic responses to wind. Results indicate that seismic response varies seasonally, which we attribute to snow's insulation and burial of vegetation and objects around the seismometer. Wind direction also manifests in seismic data, which we accredit to turbulent air on the lee side of station huts coupling with the cap of the seismometer borehole. We find that the seismic response to wind is correlated with site land cover type, with increased response corresponding to increased vegetation height. In addition, we find that this relationship shows some dependence on the local bedrock type with greater seismic response in unconsolidated sediment. Our results can be used for incorporating wind speed, wind direction, vegetation, bedrock, and seasonal patterns into models for filtering seismic noise, as well as informing future site selections. Our results also indicate that wind-noise can be used as an additional dataset for monitoring future changes in Arctic vegetation and snowpack predicted from climate models.

Assessing Wildfire Regimes and Floral Recovery After the K-Pg in Corral Bluffs, CO

Grace King

Advisor: Dr. Henry Fricke, Colorado College

The recovery of terrestrial Front Range ecosystems after the Cretaceous-Paleogene (K-Pg) mass extinction event at Corral Bluffs has been well-documented due to uncharacteristically well preserved Early Paleogene fossils (Lyson et al. 2019). However, the mechanisms of recovery are yet to be understood. This study seeks to clarify what role, if any, major wildfires played in shaping the recovery of flora and fauna observed at Corral Bluffs through the analysis of polycyclic aromatic hydrocarbon (PAH) and n-alkane biomarkers. PAH concentrations can be indicative of fire intensity, while n-alkane chain lengths can be correlated with environmental conditions (Karp et al. 2020; Bush & McInerney 2013; Guo et al. 2015). This study builds on previous work by Spencer Levy (Colorado College geology student). My samples were collected at locations of pollen samples previously recorded by Lyson et al. (2019) focusing on the upper part of the Bishop Wash section at Corral Bluffs (~41-132m). They are being analyzed at the Organic Geochemistry Lab at the University of Colorado, Boulder. Using Accelerated Solvent Extraction (ASE), each sample will undergo five-fraction column chromatography to isolate biomarkers. Levy's previous work focused closer to the K-Pg boundary, analyzing samples at Corral Bluffs of a slightly earlier time (~10-82m above the boundary). He found that peak warming temperatures post-K-Pg correlated with the shortest n-alkane chain length, indicative of wetter conditions. These data also show the highest PAH concentrations offset with peak temperatures, suggesting more wildfires were present as temperatures cooled and conditions dried after this peak. My data is expected to display similar results upsection.

Facilitating the green transition: an analysis of carbon market opportunities & limitations

Clay Rodriguez-Gould

Advisors: Dr. By Wang, Department of Civil & Environmental Engineering, University of Wisconsin-Madison

Dr. Henry Fricke, Department of Geology, Colorado College

Evidence is increasingly apparent that current global action is insufficient to maintain earth's average warming below a 1.5℃ increase above pre-industrial levels (IPCC 2022). Technologies that have risen to meet this challenge span a diverse set of industrial and natural based solutions, yet questions persist as to their cumulative and individual ability for implementation at gigaton scale of atmospheric CO_2e reduction. Earth Repair, founded at the University of Wisconsin-Madison, is a nascent direct-air-capture (DAC) CO_2e to concrete entity focused on decarbonizing the cement industry. The concrete industry holds notoriously high CO_2e intensity through the production of clinker, a process that has allowed concrete to claim 7% of global carbon emissions (Ali et al., 2019). Earth Repair aims to enter into carbon markets, an economic space that is shaky at best and greenwashed at worst. As a directive of the NSF I-Corps market discovery for Earth Repair, this qualitative interview-based study aims to identify the progress of atmospheric drawdown solutions in achieving climate goals amongst premature markets. Questions focus particularly on carbon offsetting as a primary tool to provide tangible climate mitigation. Analysis regards sustainable finance alongside public incentive in driving climate progress forward and considers enterprise level data in extrapolating a broader understanding. As markets attempt to force climate progress into a capitalistic framework, further questions evolve regarding how sustainable trajectories may get along with profit incentives and an unrelenting growth model. This techno-economic study yields three primary findings being 1) that profit-incentivized climate solutions lack accountability data, leading to outsized financial risk assessment and lack action without statutory forcing, 2) that carbon pricing across voluntary and regulatory markets lacks consistency, thus not allowing for necessary solutions to enter markets at scale with urgency and 3) that global progress hinges on multiscalar international coordination if gigaton scale reduction in atmospheric CO_2e is to be achieved. To address these challenges, actions must be directed within the current financial incentives framework through a process of constructing sustainability within capital markets.

Tracking Paleoenvironmental Associations in Vertebrate Microfossil Bonebeds in the Upper Cretaceous (Campanian) Judith River Formation, Montana

Katya Nicolayevsky, Irene Méndez Curbelo, Marisa "Zuul" Luft, Rebecca Flowers, Lily Zugschwert, Kristy Rogers, Raymond Rogers

Advisors: Dr. Kristina Curry Rogers, Macalester College, Keck Geology Consortium
Dr. Raymond R. Rogers, Macalester College, Keck Geology Consortium

The Upper Cretaceous (Campanian) Judith River Formation of north-central Montana preserves abundant vertebrate microfossil bonebeds (VMBs), which are accumulations of millimeter to centimeter scale vertebrate fossils that range from intact bones of small animals to small bones and fragments of large animals. Previous work on the taphonomy of Judith River VMBs suggest that they represent time-averaged accumulations of resilient fossils that accrued in freshwater aquatic basins (lakes, swamps). Over 7500 fossils (including unidentifiable fragments) from two VMBs (WBN15-18: hereafter referred to as Site 1, and CC13-015: hereafter referred to as Site 2) were studied in relation to the presence/absence and relative abundance of eight general taxonomic groups: osteichthyans, chondrichthyans, amphibians, turtles, crocodiles, champsosaurs, dinosaurs, mammals, and squamates. The Site 1 sample (n=1168 identifiable specimens) was recovered from a localized outcrop of brown massive siltstone rich in carbonaceous debris. The Site 2 sample (n=2735 identifiable specimens) was collected from a more expansive outcrop of massive gray silty mudstone that preserves abundant freshwater clam and gastropod shells. Given the fully dissociated nature of material in both sites, identifiable specimens were counted as a single individual (we recognize that this inflates counts). Despite similar taphonomic characteristics and depositional settings, the two sites exhibit distinct distributions of taxa. Site 1 is dominated by animals with terrestrial affinities (>80%), most notably dinosaurs. Site 2 is dominated by semi-aquatic and fully aquatic groups overall (>95%), including fish, turtles, crocodiles, and champsosaurs. However, one sample from Site 2 preserves a decidedly greater proportion of terrestrial taxa (again, dinosaurs), comparable to site 1. We interpret these patterns to potentially reflect "onshore-offshore" control on collections, with samples dominated by terrestrial animals representing more shoreline proximal settings. This interpretation is supported by grain size trends and the distribution of plant debris, which tends to be more abundant in the lake margin settings. These results suggest potential to track paleoecological associations in VMBs at a finer level than previously suspected.

Meandering Bedrock Rive Bedforms

Jack-Henry Kent

Advisor: Dr. Sarah Schanz, Colorado College

The thalweg is the deepest part of the river channel and exerts a direct control on the hydrodynamics and shear stress available for erosion. Thalwegs in alluvial rivers are known to be crucial in the initiation of meandering processes and their location within the channel varies with meander curvature. Yet very little work has been previously done on bedrock river thalwegs, particularly in meandering bedrock systems. Meandering bedrock systems are formed by erosion only, resulting in less dynamic channel forms. Thalweg location may not be able to adapt as easily to meander dynamics; studies in slaking bedrock have shown that vertical erosion rates—responsible for thalweg location—can be 10 times lower than lateral erosion rates, which dictate meander dynamics.

Tiny Modification Features on Fossil Bones from Vertebrate Microfossil Bonebeds in the Upper Cretaceous (Campanian) Judith River Formation, Montana

Lucy Rogers, Brooke Noonan, Peyton Lewis, Breanda Gomez, Sophia Esquenet, Autumn Jester, Kristi Curry Rogers, Raymond Rogers

Advisors: Dr. Kristina Curry Rogers, Macalester College, Keck Geology Consortium
Dr. Raymond R. Rogers, Macalester College, Keck Geology Consortium

Surface modifications preserved on fossil bone yield clues that relate to post-mortem processes that transpire prior to fossilization. Previous studies of surface modifications have tended to focus on larger specimens, and studies that have explored modifications on smaller-scale remains have generally tracked evidence of digestion, often using scanning electron microscopy. Here we document a variety of bone surface modifications on a large sample (n=7,500) of small vertebrate fossils that are in the millimeter to centimeter size range. The specimens represent two surface collections from vertebrate microfossil bonebeds in the Upper Cretaceous (Campanian) Judith River Formation of Montana. Both sites preserve thousands of resilient bioclasts that accumulated in freshwater aquatic basins (lakes, swamps) in a coastal plain setting bordering the Western Interior Seaway. Surfaces of bone specimens, including both identifiable elements and unidentifiable fragments, were studied using hand lenses and light microscopes. Evidence of weathering in these ancient aquatic depositional settings is highly variable, with some specimens characterized by pristine intact surfaces, while others exhibit advanced cracking and degradation. Variability in quality of preservation is consistent with time-averaging. Evidence of ancient breakage is pervasive on both cm-scale and tiny mm-scale elements (~40% of specimens show ancient breaks), and this breakage presumably reflects trampling (linear sets of trample marks are common, ~25% of specimens show this modification feature) and feeding, with puncture marks (sometimes double-arched) often developed on the edges of spiral breaks. With regard to evidence for feeding, we documented punctures (interior and edge), drag marks (solitary and clustered), and small gnaw marks on ~10 % of the sample. All of these traces are interpreted as tooth marks, with potential predators/scavengers ranging in size from large theropod dinosaurs (denticle drag marks are associated with several tooth drags), crocodiles, and champsosaurs to small minnow-sized fish and perhaps amphibians (necrophagy in this group is relatively unexplored). Some of the tiniest feeding traces show distinctive patterning, and the goal is to link these unusual modifications to specific trace-makers.

Glacial sliding on volcanic bedrock: effect of rock surface roughness on ice-on-rock friction and healing

Cade Quigley

Advisors: Dr. Christine McCarthy, Lamont-Doherty Earth Observatory, Columbia University

Dr. Jake Tielke, Lamont-Doherty Earth Observatory, Columbia University

The controls on glacial movement are attributed in part to frictional properties at the glacial bed. Previous laboratory experiments have constrained the roles of temperature, debris content, and velocity on ice-on-rock friction. However, there are limited experiments that investigate the frictional behavior of ice on a non-crystalline, permeable rock. Here, as part of the RORD REU, we used a vitric welded tuff member of the Pleistocene Bishop Tuff to investigate the ice-rock frictional behavior and explore the role of rock surface roughness. We ran experiments with two different rock surface roughnesses of R_a = 6.5 ± 3 μm and R_a = 11.0 ± 4 μm. Polycrystalline ice samples were created using the "standard ice" method, with an average grain size of 1.95 mm. A cryogenic biaxial friction apparatus was used, with horizontal pistons applying a normal stress and a vertical piston applying a velocity-controlled program to slide the ice sample through two stationary rock samples. Following an initial run in at 10 μm/s, a number of velocity steps and slide-hold-slides were employed, with a range in sliding velocity from 0-100 μm/s and a range in hold steps from 1-1000 s. We use the MATLAB based GUI RSFit3000 to analyze the velocity steps for the relevant rate-state friction parameters. Preliminary experimental results suggest that the steady-state friction of ice on the welded tuff is higher than that of ice-granitic rock interfaces at the same temperature (-6 °C) and normal stress (100 kPa). The ice sliding on roughened tuff showed higher steady-state friction and frictional relaxation than on the smoother tuff but lower healing, with both tuff types having greater magnitude of frictional healing and relaxation compared to granitic rocks. Our results suggest that the basal sliding of glaciers on volcanic rocks differs significantly from crystalline basement rocks, and the surface roughness of rocks at the ice-rock interface may change how glaciers slide on rock surfaces.

Past, Present, and Future of the Rampart Range Fault: A Blessing and a Curse?

GY315 - Ilene Kruger, Eugenie Haring, Annie Breyak, Nathaniel Cutler, Pierce Hayton, Baxter Waltmire, Katya Nicolayevsky, and Lucy Rogers
Advisor: Dr. Christine Siddoway, Colorado College

Colorado Springs and the surrounding areas sit on two large geologic faults: the Ute Pass Fault and the Rampart Range Fault. In this project, we investigate the past, present, and future implications associated with living near the active Rampart Range Fault zone for the nearly half-million residents of Colorado Springs. To establish the presence and defining characteristics of the faulting along the Front Range near Colorado Springs, we engaged in field study and conducted kinematic analysis of bedrock bordering both major faults. During our field work, we first noticed drastic changes in elevation and the abrupt appearance of the mountain front as we neared the mapped location of the fault. We noted the presence of clay gouge, intense fracturing, steeply dipping and overturned bedding, evidence of seismic slip, and geothermal alteration. The fault damage zones are located close to residential areas, parks, and popular open spaces for recreation. In this poster, we explore how the damaged bedrock and steep topography along the fault contributes both to natural hazard risks and plentiful recreation, natural beauty, economic gain, and tourism potential across the region. In addition to direct field observations and brittle kinematic analysis, we draw upon the past century and a half of record from newspapers, travel advertisements, homeowner publications, management plans, and more. We find that the Rampart Range Fault is seldom mentioned in these public records.

Geomorphic Characterization of Fountain Creek: A Study of Planform Change and Channel Migration

Spencer Shaw

Advisor: Dr. Sarah Schanz, Colorado College

The Fountain Creek watershed, located in the Southern Colorado Front Range, has experienced a rising demand for water caused by rapid urbanization of Colorado Springs. To meet this demand, changes in water management policy and increased fluxes from transmountain diversions have been implemented, leading to increased base flows since the 1980's in Fountain Creek. Previous literature indicates base flows are an important factor in day-to-day maintenance of the channel structure.
This study performs a novel analysis of the morphological changes occurring in Fountain Creek as a result of an altered flow regime. We used repeat aerial photography to determine how channel morphometrics like width, sinuosity, and lateral migration rates have changed since 1937. Trends are evaluated for pre-1980 and post-1980 to discern if the increases in flow regime have had a significant impact on the geomorphology of Fountain Creek.

Results show that increased base flow, and a transition from a previously ephemeral regime to year-round flow, have allowed vegetation to establish along the banks and in floodplains. The increased resilience to erosion provided by the vegetation has counteracted the erosive forces of an increased base flow and instead caused the Creek to generally stabilize. No changes were seen between pre- and post-1980 width and lateral channel migration. However, there was a significant channel lengthening trend throughout the study period. These results are especially relevant as the Fountain Creek watershed is likely to experience even higher base flows as Colorado Springs continues to grow. Results will serve to inform resource management practices in urban watersheds, particularly for semi-arid regions.

Is the Mojave Crustal Province the assimilation source of Proterozoic zircon grains in the Cretaceous Oasis Granite, Mojave Desert, California?

Matt Semel

Advisor: Dr. Michelle Gevedon, Colorado College

The Central Mojave Desert contains continuous exposures of Mesozoic plutons and Proterozoic crustal rocks exhumed from deep-mid crustal depths. Mesozoic plutons have been associated with a continental arc active from ~220-74Ma; however, the Late Cretaceous Oasis pluton contains a peraluminous garnet-muscovite granite which confirms the previously hypothesized westward subcrustal extent of the MCP. U-Pb chronology and trace element distributions of inherited zircon grains in the Oasis granite indicate assimilation of aluminous crustal material. Bulk rock geochemistry and tectonic reconstructions suggests that the assimilated material originates from the Mojave Crustal Province (MCP), a crustal basement of the Mojave desert consisting of high-grade metasedimentary and metaigneous rocks which formed a southwestern component of the Laurentian craton. The MCP experienced numerous metamorphic events throughout the Middle Proterozoic which formed the Ivanpah Mountains in the Eastern Mojave Desert. The Ivanpah Mountains consist of MCP material that we hypothesize assimilated into the Oasis pluton. We studied the U-Pb geochronology and trace element compositions of zircon grains from both the Oasis granite and Ivanpah gneisses to determine possible assimilation sources for the Oasis pluton. We find that 1. MCP material likely assimilated into the Oasis pluton and 2. a regional lead loss event observed in the Ivanpah and Oasis samples at ~100Ma indicates a possible tectonic transition from arc magmatism in the Mojave.

Zircon U-Pb Ages and Hf Isotopes of the Black Canyon Gabbro: Insights into Magmatic Processes and Tectonic Implications of the Teutonia Batholith

Eugenie Haring

Advisor: Dr. Michelle Gevedon, Colorado College

The Teutonia Batholith is a volumetrically large collection of plutons in the eastern Mojave Desert. Arc magmatism as a result of Farallon plate subduction beneath proto-North America during the late Jurassic and early Cretaceous formed the Sierra Nevada Batholith and the Peninsular Batholith, as well as plutons of the Mojave Desert. The Mojave segment of this volcanic arc is thought to have been active for over 150 Ma, beginning ~220 Ma until ~76 Ma (Wells et al. 2008). Though its geography and petrography have been studied, the source of magmatism that formed the Teutonia Batholith is still relatively unknown. Given the ages of rocks taken from the Teutonia, ~100-90 Ma based on bulk zircon ID-TIMS data, it is thought to be emplaced in the crust towards the end of arc magmatism in the area, making it a valuable subject for potentially studying the death of an arc and subduction in the area (Beckerman et al. 1982). This research is motivated by several questions concerning the Teutonia Batholith: What is the emplacement age of the Black Canyon gabbro and Rock Spring monzodiorite? What is the relationship of the mafic magmatism to the Teutonia Batholith? What is the source of the magma? Zircon grains were isolated from the mafic members of the Teutonia Batholith and U-Pb and Hf data were collected to generate precise ages and isotopic data regarding origin. The relatively low, negative Hf ratios of the mafic members suggest that the Teutonia was not formed from a majority depleted mantle derived melt, but rather is a cumulate formed from a depleted mantle melt that underwent significant assimilation and fractional crystallization of the proterozoic crust. Whether this occurred as a result of arc magmatism or delamination of the eclogite facie Farallon plate is yet to be determined and will require further study.

Determination of metal-PDMA stability constants via spectrophotometric and potentiometric titrations

Jackson Kohn

Advisor: Dr. Henry Fricke, Colorado College

Mn, Fe, Co, Ni, Cu, and Zn are essential trace metal nutrients required by plants in order to fulfill basic biologic functions. In soils, these elements are primarily located in highly insoluble mineral phases that are unavailable to plants. To overcome this problem, members of the Poaceae (grasses) have developed the ability to secrete organic binding ligands called phytosiderophores into soil solutions. Phytosiderophores can effectively bind with trace metal nutrients and facilitate their dissolution into the bioavailable pool. Agronomists have developed synthetic phytosiderophores for use as trace metal fertilizers in nutrient deficient soils worldwide but have found that most synthetic options are prohibitively expensive. Recent developments in organic chemistry and plant physiology have led to the synthesis of PDMA, an inexpensive and stable analog of the natural phytosiderophore, DMA, that displays a high binding affinity with Fe^{3+}. In this study, we quantify the effectiveness of PDMA at mobilizing Mn^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, and Zn^{2+} via spectrophotometric titrations and compare them with known phytosiderophore stability constants. Results indicate that PMDA has slightly lower binding affinities with Mn^{2+}, Ni^{2+}, and Cu^{2+}, but a slightly higher binding affinity with Zn^{2+} than other phytosiderophores. These results demonstrate that PDMA has widespread potential as a trace metal fertilizer in nutrient-poor agricultural soils that comprise over one third of Earth's total land area. Sustainably increasing fertility in agricultural soils is of paramount importance for ensuring global food security, especially as our population continues to grow and arable land area decreases due to industrial development and urban expansion.

Terms: phytosiderophore, bioavailable pool, stability constant, trace metal nutrient, fertilizer

Lay Summary: Plants need metal nutrients from soil in order to form organic compounds that are necessary for growth and various functions. Unfortunately, metal nutrients cannot readily dissolve into soil waters, which makes them unavailable for plant use. To overcome this problem, certain grasses have developed the ability to release metal-binding molecules into soil waters to increase the solubility of metal nutrients in soil waters and thus their availability for organisms. Artificial versions of these molecules have been used as metal fertilizers in nutrient-poor soils growing important crops, such as corn, wheat, barley, and rice. Industrial production of most artificial metal-binding compounds is not feasible due to their high cost and low resistance to degradation in soils. However, recent developments in soil science have led to the creation of PDMA, an easily producible molecule that has been shown to effectively bind with iron. The purpose of this study is to determine the effectiveness of PDMA at binding with other metal nutrients via laboratory experimentation. Results indicate that PDMA has promise as a metal fertilizer in nutrient-poor soils worldwide. PDMA offers a way to increase the fertility of nutrient-poor agricultural soils, which is extremely important for growing enough food to feed an increasing population.