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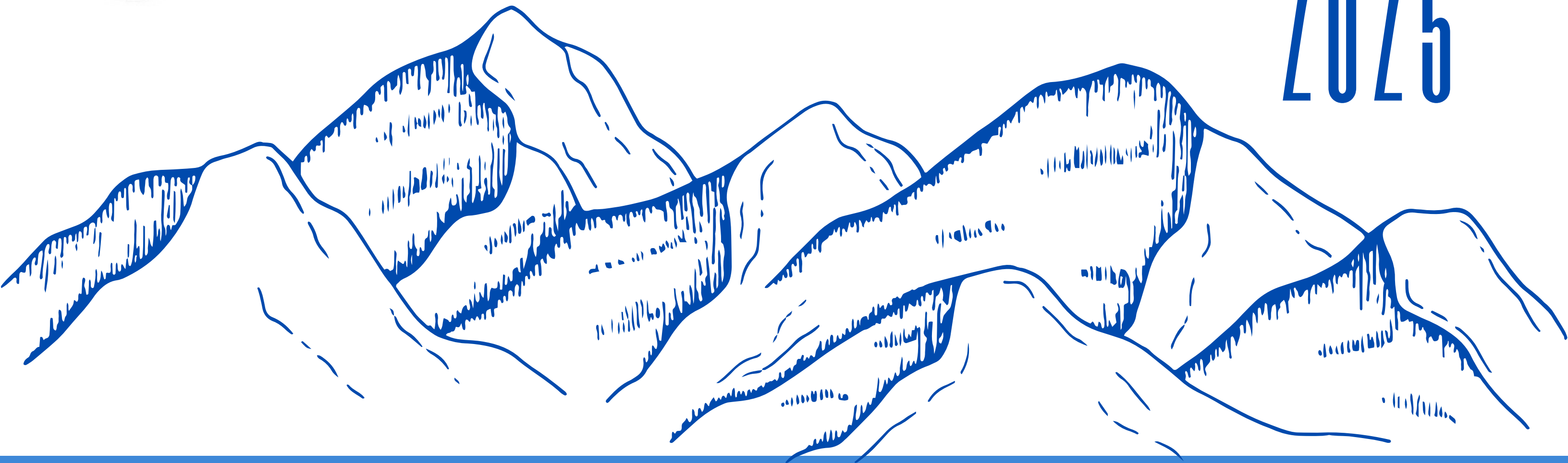


Geology Department Research Symposium

APRIL 5, 2025
BLOCK 7 - SECOND SATURDAY
8:30 AM

TUTT SCIENCE
COLORADO COLLEGE
1112 N NEVADA AVE.

PROGRAM

Speaker Session I - 9:00 to 11:00 AM

8:30 AM - Breakfast Bar

9:00 AM - Welcome Statement

9:05 AM
Nathaniel Cutler -
A framework for in-stream large wood in snow avalanche-prone environments

9:25 AM
Anders Pohlmann -
Stable isotope geochemistry and petrography of the Rocky Range Mining District, Milford, Utah

9:45 AM
Tirso Jesús Lara Rivas -
Exploring the metasomatic process of rodingitization

10:05 AM - Break

10:15 AM
David Mims -
Investigating rodingites with strontium and oxygen isotope geochemistry to better understand the history of the Dun Mountain Ophiolite

10:35 AM
Charlie Hite -
Stable calcium isotopes as a fundamental tracer for rodingitization processes in the Dun Mountain Ophiolite, South Island, New Zealand

10:55 AM - Open Q&A to Speakers

PROGRAM

Poster Session - 11:00 AM to 12:30 PM

11:00 AM

Maya Mossanen -

Sediment pulses and river evolution in an Alaskan proglacial river system

Avery Ordner -

Colorado's Jurassic savannah: Using paleo-ecological niche modeling to visualize relationships between environments and Sauropod dinosaurs

GY400: Charlie Hite, Lenny Lorenz, and Anders Pohlmann -

A window into the Cryogenian period: Quartz sand characteristics and rare earth element patterns in Tava Sandstone, Colorado Front Range

Sadie Almgren & Jake Hams -

Defining the extent of Te-ahi-a-Tamatea/Rāpaki Dike through field, geochemical, and mineral fabric analysis

11:00 AM - Lunch Bar

PROGRAM

Speaker Session II - 12:35 to 2:40 PM

12:35 PM

Lachlan McCallum -

If they don't want me to dance, they shouldn't let me in the shear zone

12:55 PM

Ilene Kruger -

Frictional properties of simulated fault gouge from the Ramapo Seismic Zone, NY/NJ

1:15 PM

Annie Breyak -

A carbon isotope-based investigation of mammalian paleoecology across the Cretaceous/Paleogene boundary in the Denver Basin, CO, U.S.A.

1:35 PM - Break

1:55 PM

Mackenzie Boyd -

Investigating the diet of Hadrosaurian dinosaurs from the Kaiparowits Formation using carbon isotope geochemistry

2:15 PM

Lucy Rogers -

U-Pb Geochronology of the Varied Lithologies within the Cow Creek Pendant, Southern Sierra Navadas, California

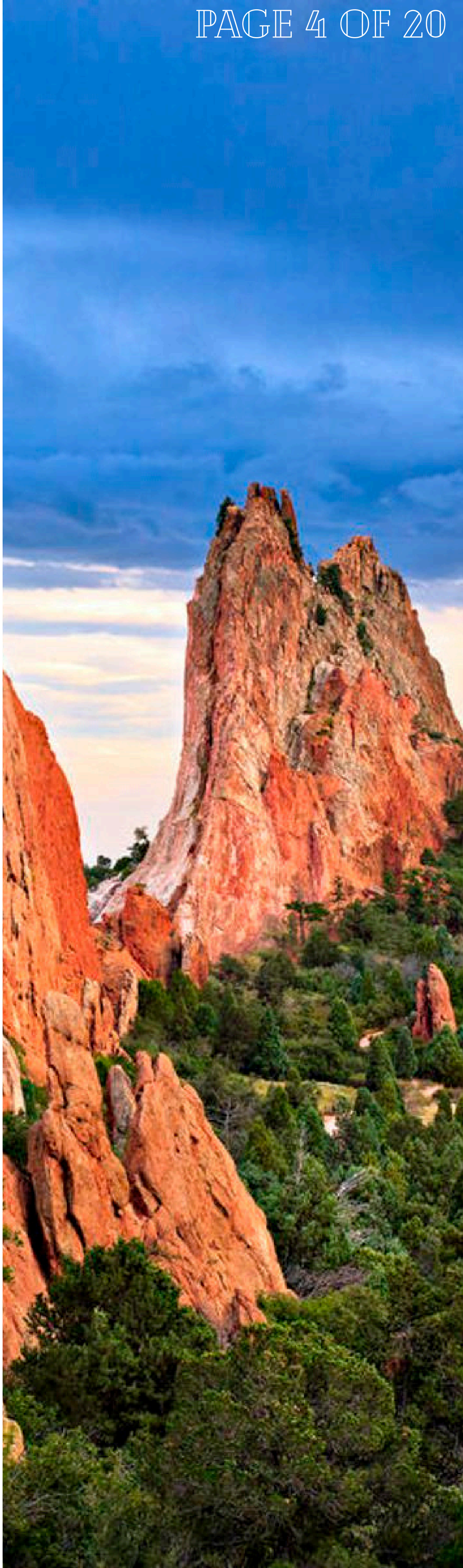
2:35 PM - Open Q&A to Speakers

2:50 PM - Smooth Move award and Announcements

3:10 PM - Closing Statement

4:30-7:30 PM - The Barbecue

911 Corona St
(Annie, Lucy, & Nathaniel's house)



ABSTRACTS

SPEAKER ABSTRACTS

A framework for in-stream large wood in snow avalanche-prone environments

Nathaniel Cutler
Advisor: Dr. Sarah Schanz, Colorado College

Large wood in rivers moderates flow dynamics, enhances sediment and nutrient storage, and supports biodiversity through habitat creation. While the significance of large wood in stream systems has been well documented, its behavior in avalanche-prone landscapes, where snow avalanches can contribute up to 1000 times more wood than background fluvial process, remains poorly understood. This project generates a framework for large wood at jam and reach-scale in avalanche-prone landscapes. We examined six avalanche-prone drainage basins in Colorado with visible snow avalanche large wood interactions. Study sites span a range of snowpack styles, glacial modification, and valley widths but have similar drainage areas and stream flows. We identified jams using high-resolution aerial imagery and used field observations to measure jam structure, orientation, hydrologic and sediment impacts, and vegetation interaction. We determined that snow avalanche debris jam complexes fall into two primary categories; blanket jams and transport jams. Blanket jams are large, valley floor spanning, structures which experience minimal post-avalanche deposition transport. Transport jams experience a higher degree of post avalanche-depositional transport though they maintain a structural link to the debris field on the floodplain. We used high-resolution aerial imagery and GIS to explore geomorphic controls on jam types such as slope angle, slope roughness, and profile characteristics. Our framework is the first to systematically address large wood in avalanche-prone landscapes and provides a basis for regional comparison of LW dynamics in high alpine settings. Future researchers can use this framework to investigate wood recruitment, longevity, and impacts on sediment and nutrient transfer in avalanche-prone landscapes.

Stable isotope geochemistry and petrography of the Rocky Range Mining District, Milford, Utah

Anders Pohlmann

Advisor: Dr. Michelle Gevedon, Colorado College

The Rocky Range near Milford, Utah, contains economically important Cu-skarn deposits originating from Oligocene intrusive activity. Skarns form as igneous intrusions release heat and metasomatic fluids, mobilizing elements that replace original carbonate minerals with new silicate minerals, often containing metals. Metasomatic fluids that drive skarn formation and that may be capable of enriching deposits in Cu can originate from a variety of sources, primarily from magmatic and metamorphic (e.g., host rock, or meteoric) settings. In the case of the Milford Mine skarn bodies, Cu is concentrated in near-surface deposits. Stable isotope geochemistry is an established method to determine sources of mineralizing fluid but has yet to be conducted in the Milford area, meaning the fluid sources and water-rock ratios of the Milford skarn bodies have only been hypothesized from surface and core-cutting observation. Oxygen and carbon isotope ratios have been used in other skarn deposits to classify fluid sources and their endmember compositions in skarn systems. The purpose of this research is to identify the fluids infiltrating the host rock and then determine whether different generations of fluid infiltration are associated with mineralization. We used skarn garnet, quartz, and calcite as proxies to calculate the $\delta^{18}O$ and $\delta^{13}C$ value of the equilibrium mineralizing fluid, and to determine whether fluid sources and water-rock ratios change throughout skarn formation. We then compared $\delta^{18}O$ and $\delta^{13}C$ values with existing assay values to determine if a correlation exists between fluid sources and the Cu grade % from the assay results. Additionally, we used loss of ignition data from core samples to determine how many mols of CO_2 are transferred in the skarn process via devolatilization. Initial results suggest devolatilization as the primary source of calcite vein deposition, but also contain oxygen isotope results suggesting deeper seated igneous sources as playing a role within the skarn system.

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SPEAKER ABSTRACTS

Exploring the metasomatic process of rodingitization

Tirso Jesús Lara Rivas
Advisor: Dr. Michelle Gevedon, Colorado College

The Dun Mountain Ophiolite (DMO) in the Nelson region of Aotearoa New Zealand, preserves an excellent example of serpentinite-hosted rodingites. Rodingites are Ca-rich, Si-depleted rocks that generally cross-cut serpentinized or ultramafic bodies. Serpentinites are metasomatized mafic and ultramafic rocks that give rise to OH-bearing assemblages. The development of these two rock types largely destroys the protolith, making the reconstruction of tectonic histories cumbersome. Although serpentinization and rodingitization are thought to be interdependent processes, questions remain about their chemical relationship, temperatures, and continuity of fluid sources involved in their formation. This study seeks to further our knowledge of the rodingites hosted in the serpentinites of the DMO: 1) What do Rodingites and serpentinites reveal about the tectonic history of the DMO? And 2) Are serpentinization and rodingitization truly concomitant metasomatic processes? Polarized light microscopy and Raman Spectroscopy were utilized to petrographically characterize two thin sections of rodingite vein and its serpentinite host. The petrographic observations indicate multiple serpentinization events. Petrography and Raman spectroscopy results reveal lizardite as the primary serpentine present in the sample with minor amounts of antigorite. Accessory richterite, phlogopite and clinochlore suggest temperatures of rodingitization not exceeding 400°C. The coexistence of antigorite and its crosscutting relationships with chlorite are evidence of strong activity gradients in $a\ Si$, Mg^{2+}, Al^{2+}, and $Fe^{2+,3+}$ across the blackwall reaction zone. Serpentine polymorph temperature dependence suggests temperatures >200°C with coexistence of antigorite-lizardite at high pressures in addition to low $a\ Si$ due to the absence of brucite. Additionally, oxygen isotope ratios were measured across a transect of a 2-centimeter-wide rodingite vein via laser fluorination and an isotope ratio mass spectrometer. The $\delta^{18}O$ values were used to derive the temperature range at which the $\delta^{18}O$ composition of fluids reaches equilibrium. This approach yields temperature ranges from 200 to 350°C. Values for $\Delta Serpentine{-}Garnet$ derived from measured $\delta^{18}O$ values suggest that Serpentine-Garnet equilibrium is reached at slightly lower temperatures 170–320°C. Mineral stabilities based on petrography and Raman spectroscopy produce internally consistent P,T conditions with temperatures computed from the oxygen isotope data. Both techniques suggest that rodingitization–serpentinization can reach equilibrium at temperatures of 170–350°C and that, at least across short distances, are concomitant processes related by strong activity gradients between protoliths. Temperatures are consistent with the tectonic setting of the DMO for both seafloor-initial-serpentinization that creates the chemical disequilibrium that facilitates subduction-zone-rodingitization (T=>200°C) and secondary serpentinization. Although observations indicate the concomitant nature of serpentinites and rodingites within the context of subduction zone metamorphism and ophiolite obduction; future work should focus on understanding timing and additional fluid composition to improve the thermodynamic understanding of these reactions.

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Investigating rodingites with strontium and oxygen isotope geochemistry to better understand the history of the Dun Mountain Ophiolite

David Mims

Advisor: Dr. Michelle Gevedon, Colorado College

This project uses oxygen and strontium isotope ratios of rodingites from the Dun Mountain Ophiolite, in Aotearoa New Zealand to better understand metasomatic processes such as the tectonic setting and history of the ophiolite belt, including its serpentinization. Rodingization is hypothesized to occur simultaneously with serpentinization, however, the mineralogy of rodingites is more conducive to studying petrogenesis; namely, the abundance of garnet provides the opportunity to study the geochemical and isotopic records associated rodingization, and can in turn provide a better understanding of the Dun Mountain Ophiolite's history. This study uses strontium and oxygen isotopes to assess the fluid sources associated with the origins, alteration and obduction of the Dun Mountain Ophiolite. Resulting $^{87}Sr/^{86}Sr$ ratios range from 0.70340 to 0.70505 (n= 13; avg.= 0.70443; stdev = 0.0054) and $\delta^{18}O$ values for garnet range from 2.34 to 7.33‰ VSMOW (n=21; avg. =4.62; stdev= 0.97671). These data suggest rodingites have Sr isotope ratios close to those expected of the mantle source for ocean crust, inclusive of altered ocean crust, and oxygen isotopes indicate only moderate interaction with seawater. These data indicate that rodingitization precedes obduction of the Dun Mountain Ophiolite Belt, generally occurring in the supra subduction zone or its paired back arc setting.

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SPEAKER ABSTRACTS

Stable calcium isotopes as a fundamental tracer for rodingitization processes in the Dun Mountain Ophiolite, South Island, New Zealand

Charlie Hite

Advisor: Dr. Michelle Gevedon, Colorado College

The cycling of water, rare earth elements, and essential nutrients within Earth's lithosphere is a key process in sustaining life and in altering the planet's youngest rocks—those born at mid-ocean spreading centers. Ophiolites, slices of ocean crust now exposed on land, circulate these ion-enriched fluids which, in turn, transforms their molecular structure and composition resulting in new chemistries and mineralogies. The process of serpentinization occurs at this important fluid-ocean crust interface, however, properties of the mineral serpentine make it difficult to use as a petrogenetic indicator. Instead, this work uses rodingites from the Permian Dun Mountain Ophiolite (DMO) in New Zealand as a proxy for the petrologic conditions. Rodingites are hydrated, Ca-rich, Si-poor ultramafic rocks hypothesized to form contemporaneously with serpentinites and are proposed to be a valid proxy for studying the conditions of formation of serpentinites. $\delta^{44/40}$Ca ratios are used to investigate the sources of rodingite Ca enrichment within due to its emerging success within geochemical and petrologic studies for high temperature fluid tracing. Biogenic, hydrothermal, hydrologic, and tectonic processes influence the availability of and the isotopic ratio of Ca available to Ca-rich rodingite minerals such as garnet and pyroxene. These $\delta^{44/40}$Ca ratios may yield information about the sources of Ca, and processes that control cation exchange during alteration of the ocean crust, and ultimately settings of serpentinization. Thermal ionization mass spectrometry (TIMS) was used to measure $\delta^{44/40}$Ca ratios in hydrogrossular garnet and clinopyroxene from DMO rodingites and is compared with their respective δ^{18}O and ^{87}Sr/^{86}Sr values. A compilation of the range of $\delta^{44/40}$Ca across rock types and fluids was created based on the existing research of stable Ca isotope systematics. $\delta^{44/40}$Ca data from the DMO rodingites was plotted on this composite chart in order to contextualize our samples within the greater body of work. Results indicate that rodingitization processes result in lower $\delta^{44/40}$Ca ratios than the original parent ocean crust likely through interactions with isotopically light hydrothermal fluids instead of seawater as has been previously assumed. Comparing these $\delta^{44/40}$Ca ratios with single mineral ^{87}Sr/^{86}Sr ratios suggests that formation of rodingite dikes through hydrothermal alteration may not significantly affect the protolith's Sr isotope composition. Finally, $\delta^{44/40}$Ca versus δ^{18}O is useful for inferring fluid sources and preliminary results similarly suggest little to no input from seawater and instead our data plots between hydrothermal fluids and metamorphic rocks. Geographic information systems (GIS) are utilized as a spatial analysis tool in creation of an isoscape which will map how our isotope values change over physical space within the DMO. With this project we hope to advance understanding of high-temperature processes affecting the availability of Ca and Ca isotope behavior in the ocean crust.

Sediment pulses and river evolution in an Alaskan proglacial river system

Maya Mossanen

Advisor: Dr. Sarah Schanz, Colorado College

For my thesis, I studied three Alaskan proglacial rivers—the Chulitna, Susitna, and Talkeetna—which are fed by some of the largest glaciers in North America. My curiosity was sparked by watching multiple attempts to mitigate flooding and erosion along these rivers fail, which has directly impacted the adjacent town of Talkeetna, where I am from. To investigate these failures, I used quantitative aerial image analysis, specific gauge analysis, written testimony, and qualitative image analysis to track abnormalities in sediment transport and channel geometry. I found that sediment coming from the glaciers appears to be moving through the rivers in large decadal-scale pulses rather than the small seasonal pulses characteristic of proglacial rivers in the rest of North America. Another notable discovery was that, following a large-scale perturbation, a flood that occurred in 2012, the river did not recover to its pre-flood stage height but instead created a new equilibrium at a lower stage height and a wider width. Overall, my findings suggest flood and erosion control strategies must be prepared to handle large-scale shifts in river dynamics caused by decadal-scale sediment pulses. Additionally, these strategies must be equipped for a wide variety of possible river heights and widths as these rivers adjust to find equilibrium after floods. Future research on large proglacial river systems could contribute to a comprehensive river stewardship protocol tailored to northern glacial rivers, reducing the long-term risk of flooding and erosion for adjacent communities.

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POSTER ABSTRACTS

Colorado's Jurassic savannah: Using paleo-ecological niche modeling to visualize relationships between environments and Sauropod dinosaurs

Avery Ordner

Collaborator: Dr. Annaka Clement, Denver Museum of Nature and Science

Modern organisms shape their ecosystems through a variety of direct and indirect interactions with other organisms and the landscape. The most impressive form of such interactions is that of African elephants and their habitats, which these behemoths reshape, behaving as ecosystem engineers. Although the impacts of organisms on their ecosystems can be studied readily in modern landscapes, such analysis becomes increasingly difficult as one explores Earth's past ecosystems. This project uses ecological niche modeling approaches and spatial relationships between plant and animal paleontological datasets to explore the impacts of Earth's largest land animals, the sauropods, on one of the most iconic ecosystems of the Mesozoic, the Late Jurassic Morrison Formation. For this project, ArcGIS Pro was utilized to create rasterized environmental layers and run paleo-ecological niche modeling (paleo-ENM) analysis for sauropod taxa from the Morrison Formation. To compare browsing and grazing sauropods, we focused on creating models of the Dinosaur National Monument and Moab areas during the times of 152 and 149 Ma, representing the upper Salt Wash Mbr to lowest Brushy Basin Mbr. (152 Ma) and the upper Brushy Basin Mbr (149 Ma). Once these models were created, we could then compare them to channel density data points that I created from measured sections, and plant data sets obtained from the PBDB and Dr. John Foster at the Utah Field House of Natural History State Park Museum, to make further ecosystem interpretations. The main results we found from this study were that both browsing and grazing sauropods had weakened association with floodplains from 152 Ma to 149 Ma, our study area dried up some from 152 Ma to 149 Ma, we found both browsing and grazing sauropods near channelized areas, and our tree data was patchy during both 152 Ma and 149 Ma and was perhaps representative of a large herbivore dominated environment. By considering patterns of habitat suitability for sauropods as well as the distribution of plants and physical features, such as persistent channels, we can ask questions about how sauropods interacted with and shaped environments during the Late Jurassic.

GY400- A window into the Cryogenian period: Quartz sand characteristics and rare earth element patterns in Tava Sandstone, Colorado Front Range

Charlie Hite, Lenny Lorenz, and Anders Pohlmann
Collaborators: Dr. Christine Siddoway, Colorado College
Dr. Liam Courtney-Davies, University of Colorado-Boulder

Tavakaiv (Tava) sandstone of Colorado formed at low latitude ~ 680 m.y. ago, during the Sturtian Snowball Earth glaciation. The sandstone consists of pebbly diamictite that is matrix-supported, ungraded, and unsorted, and it forms granite-hosted sedimentary dikes and kms-scale sand ridges. Sediment textures that indicate high energy conditions and rapid emplacement. U-Pb hematite geochronology determined a Neoproterozoic age for the formation (690 to 660 Ma by U-Pb hematite), dating to the Cryogenian Period when Earth experienced a global glaciation (Snowball Earth). A recent hypothesis attributes Tava sand injection episodes to fluid overpressure developed under a continental ice sheet, with basal melting caused by geothermal heating localized upon faults (Courtney-Davies et al. 2024).

In order to assess whether there is evidence for grain transport and modification at the base of an ice sheet, the GY400 collaborative research team investigated quartz sand micromorphology (surface textures) using scanning electron microscopy. Quartz grain microtextures help to differentiate between fluvial, marine, eolian, glacial and diagenetic/alteration environments of deposition (Vos et al., 2014). Glacial and sea ice processes impart distinctive surface textures that are documented at the margins of modern ice sheets (e.g. Passchier et al. 2021; Cowan et al. 2024). A new software, SandAI (Hasson et al. 2024), offers an automated approach to identification of the effects of glacial, fluvial, aeolian, or coastal-wave action upon quartz grains. GY400 researchers employed SandAI to assess how the machine-learning tool classifies constituent quartz grains in the Tava formation, and whether this aligns with what has been determined from detrital zircon evidence (Siddoway & Gehrels, 2014).

Hematite veins and interstitial cement within Tava sandstone offer a means to assess whether there is evidence for geothermal fluids and heat influx at the time of Tava emplacement. Rare earth element (REE) signatures of the Fe- oxides can provide a fingerprint for hydrothermal fluids in basin waters or interstitial fluids at the time of Fe-oxide precipitation (Lechte et al. 2019). Comparison data sets exist for same-aged banded iron formations that accumulated in coastal basins bordering Cryogenian ice sheets. The GY400 team used laser ablation ICPMS instrumentation at the Thermochronology Research and Instrumentation Lab (TRaIL), CU-Boulder, to gather the first REE data for Fe-oxides in the Tava sandstone, as well as a pilot data for REE in detrital zircon from the Tava.

Findings from the GY400 research are: 1) Quartz grain microtextures indicate that quartz in Tava sandstone underwent transport and modification by diverse transport processes, including river, wind, and waves. SEM micromorphology revealed an array of abrasion and impact textures arising from mechanical processes. Quartz microtextures on many SEM-imaged grains are products of mechanical processes that are documented in quartz from modern glacial settings, and probably indicate an overprint/reworking in a subglacial setting. 2) Tava Fe-oxide analyses for seven Colorado locations display similar REE patterns, but a wide spread in concentration. Variations between samples exist in Eu, Ce and Y. When compared to hydrothermal fluids (James et al. 1995) and glacial meltwater (Kim et al. 2015), there is closer similarity in REE pattern of geothermal fluids than meltwater (Hite poster panel). 3) REE data for cements in Tava injectites (Lorenz panel) and sand ridges (Pohlmann panel) display similar REE trends, suggesting region-wide rather than site-specific fluid signatures. A negative europium anomaly in two dark, ferruginous injectites is consistent with geothermal fluids but may alert us to REE distinctions between hematite (an oxide) and goethite (an oxyhydroxide). 4) The comparison of REE concentrations in Tava sand ridges versus contemporaneous BIFs does not reveal similarities; but this is unsurprising given the >600 km distance (restored paleogeography) between locations and the continental (Tava) versus coastal (BIF) basin settings. REE data for detrital zircon from three Tava samples were analyzed, and ongoing research is assessing the possibility that geothermal fluids mobilized elements from zircon that contributed to REE in hematite cements.

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Defining the extent of Te-ahi-a-Tamatea/Rāpaki Dike through field, geochemical, and mineral fabric analysis

Sadie Almgren and Jake Hams

Collaborators: Mehrimo Bakhtalieva, Whitman College;
Liam Raynolds, Middlebury College;
Dr. Sam Hampton, University of Canterbury

Rāpaki Dike/Te-ahi-a-Tamatea located within the eroded crater of Lyttelton /Whakaraupo volcano provides a unique opportunity to study the morphology, composition, and mineral fabric of a dike in three-dimensional space. This study collects field, geochemical, and petrological data to present a modern understanding of the extent of Rāpaki Dike. Nine distinct outcrop locations are inferred to be part of one continuous trachytic Rāpaki Dike of the same geochemical composition. Two maps summarizing the dike's extent are presented. A volcanic agglomerate/vent breccia is identified along the dike's western margin raising new questions about the dike's eruptive history. Preliminary analysis of the dike's mineral fabric is also reported. A synthesized understanding of Rāpaki Dike's extent and volcanic history is presented, laying the groundwork for future research to continue to constrain its eruptive history. This study and the future understanding of Rāpaki dike's morphology and history it supports can further refine dike propagation models and enable better understanding of the propagation and behavior of active volcanic systems.

This study was conducted in partnership with Te Hapū o Ngāti Wheke, Rāpaki under the guidance of the "Frontiers Abroad Aotearoa/New Zealand" study abroad program

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SPEAKER ABSTRACTS

If they don't want me to dance, they shouldn't let me in the shear zone

Lachlan McCallum

Advisors: Dr. Tyler Grambling, Colorado College;
Dr. Michelle Gevedon, Colorado College;
Dr. Nadine Grambling, Colorado College

The brittle-ductile transition zone (BDT) marks the tectonic and thermal boundary where deformation shifts from seismogenic, frictional sliding and granular flow to largely aseismic crystal-plastic flow. Below the BDT, rocks deform predominantly by dynamic recrystallization, and movement is accomplished via viscous flow. When strain localizes into a discrete shear zone, recrystallization forms mylonites, which record the strain history as fabrics at a high angle to the shear direction. The Basin and Range extensional province of the western USA contains a series of exhumed metamorphic core complexes (MMCs), which preserve deformation in the crystal-plastic regime. The Ruby Mountains-East Humboldt Range, NV, contains an MMC exhumed along a low-angle brittle detachment fault. Whereas previous work has investigated the shear zone in the Secret Pass region, we apply microstructural analysis to samples collected 25 km to the south in the Lamoille Canyon area. Lamoille Canyon is located closer to the center of the detachment and near a large constraining bend, allowing for exploration of along-strike heterogeneity in strain history, which has recently been documented as an important control on the strength and morphology of detachment faults. Petrographic assessment and field observations identify fabric variation that correlates with protolith, local strain gradients, and hypothesized interaction with meteoric water during deformation. Electron backscatter diffraction was used to obtain grain size measurements, determine slip systems, and assess fabric strength of key phases found. Stable isotope analysis of garnet, quartz, biotite, and muscovite to determine whether the surface-derived fluids identified at Secret Pass were pervasive along strike was inconclusive in Lamoille Canyon. Comparing our findings with field, petrographic, and microstructural observations to those extrapolated from Secret Pass indicates along-strike incompatibility of tectonic models, which we use to construct a wider image of the Ruby Mountains-East Humboldt Range.

Frictional properties of simulated fault gouge from the Ramapo Seismic Zone, NY/NJ

Ilene Kruger

Collaborators: Dr. Jacob Tielke, Columbia University

Dr. Folarin Kolawole, Columbia University

Dr. Abhishek Prakash, Columbia University

Dr. Christine McCarthy, Columbia University

Reid Jansen, University of Miami

The April 5, 2024, M_W 4.8 earthquake in northern New Jersey has prompted urgent investigations into the characteristics of the Ramapo Seismic Zone (RSZ) and how the rupture occurred. Critically, we lack a full understanding of which faults are active within the zone, posing an acute hazard for the 21.4 million people that call the region home. To address this gap, we studied the properties of crushed whole-rock samples - a proxy for fault gouge - along the main trace of Ramapo Fault, both near the epicenter and a more northern exposure in Suffern, NY. We aimed to identify mechanical differences in behavior during steady-state friction experiments and microstructural differences in the gouge indicative of cataclasis and brittle failure. Experiments were conducted in the triaxial high-pressure high-temperature NER Autolab apparatus at Lamont-Doherty Earth Observatory, at a confining pressure of 110 MPa and a pore pressure of 44 MPa. Experiments using gouge from each study location were performed at room temperature (22°C), 100°C, and 150°C - spanning the range of likely conditions at the epicenter based on calculated depth and heat flow data. Rate-and-state friction parameters were determined by fitting mechanical data from rate-stepping sequences performed after 4 mm of displacement at rates of 0.3, 1, 3, 10, and 30 µm/second. Each experiment was removed from the apparatus and prepared for SEM analysis, where we measured grain size in sheared and unsheared regions. Initial curve-fitting analysis of the frictional data shows that steady-state friction decreases with increasing temperature and (a-b) values, which are indicative of fault stability, are lowest at the highest temperature. Stick-slip behavior was only observed in gouge sampled near the epicenter of the earthquake in an experiment at 150°C. The microstructural analysis shows more pronounced grain size reduction in the Suffern experiments, indicating fault instability in that region as well. These two approaches constitute a qualitative and quantitative method for determining which areas of the fault zone are at higher risk for seismic events, which can be applied to other flanks of the RSZ in the future.

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A carbon isotope-based investigation of mammalian paleoecology across the Cretaceous/Paleogene boundary in the Denver Basin, CO, U.S.A.

Annie Breyak

Advisor: Dr. Henry Fricke, Colorado College

Understanding and mitigating the effects of our ongoing biodiversity crisis requires a deep-time perspective on how ecosystems recover in the aftermath of environmental catastrophes. The mass extinction event at the Cretaceous/Paleogene (K/Pg) boundary (ca.66 Ma) represents a natural laboratory wherein the tempo and mode of biotic recovery can be studied with high chronostratigraphic resolution. Although the morphological evolution of mammals across the K/Pg boundary has been reconstructed from skeletal remains, changes in dietary preferences remain unknown. We analyzed the carbon isotope ratio ($\delta^{13}C$) of Cretaceous and Paleocene Mesodma, Taeniolabis, and Carsioptychus fossil tooth enamel to elucidate how the ecological preferences of mammals changed from the Late Cretaceous, when they shared the landscape with dinosaurs to the earliest Paleogene, when they did not. $\delta^{13}C$ of fossil tooth enamel (bioapatite) was measured using laser-ablation stable isotope mass spectrometry to infer dietary sources, which vary depending on the niche occupied by an animal. Fossil teeth were collected from West Bijou Creek and Corral Bluffs, two sites located in the Denver Basin, with one West Bijou Creek site ~128 ky pre-K/Pg (herbivorous dinosaurs n=13, Mesodma n=9), the other ~57 ky post-K/Pg (Mesodma n=6), and the Corral Bluffs site ~610 ky post-K/Pg (Mesodma n=5, Taeniolabis n=3, Carsioptychus n=3). $\delta^{13}C$ of Mesodma tooth enamel vary across the K/Pg boundary at WBC with Late Cretaceous teeth having more variable $\delta^{13}C$ (-6.5 to -11.8‰, n=9) and early Paleocene teeth having less variable $\delta^{13}C$ (-6.7 to -9.5 ‰, n=6). These results suggest Mesodma had different dietary behaviors following the extinction event, presumably reflecting an increase in omnivory or fleshivory. $\delta^{13}C$ of mammalian tooth enamel from Corral Bluffs present ranges in values distinct between taxa, revealing differing dietary preferences and evidencing niche partitioning among early Paleogene mammals in Corral Bluffs. Isotopic analysis of teeth from other Late Cretaceous and earliest Paleogene mammalian taxa is ongoing and will allow for more detailed interpretations of ecological change across the K/Pg boundary in the Denver Basin.

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Investigating the diet of Hadrosaurian dinosaurs from the Kaiparowits Formation using carbon isotope geochemistry

Mackenzie Boyd

Advisor: Dr. Henry Fricke, Colorado College

Collaborator: Dr. Gussie Maccracken, Denver Museum of Nature and Science

The use of stable isotope geochemistry, and in particular carbon isotope ratios ($\delta^{13}C$), to study Mesozoic ecosystems is not as widespread as it is in the Cenozoic, but it is growing. One interesting result of this work to date is how much variability there can be in the $\delta^{13}C$ of tooth enamel from a single herbivorous dinosaur, in this case hadrosaurids, despite their living in relatively close proximity and in fairly uniform wet, floodplain environments. This study aims to explain the range of $\delta^{13}C$ by measuring $\delta^{13}C$ of plant fossils from two localities in the Kaiparowits Formation, located in Southeastern Utah, and comparing them to $\delta^{13}C$ of hadrosaurs from nearby areas. Results suggest that one population of hadrosaurs was eating a high proportion of understory and aquatic plants from a closed-canopy forest, plants with unusually high $\delta^{13}C$. Another population of hadrosaurs was eating a high proportion of understory leaves from an open-canopy forest with $\delta^{13}C$ typical of a wet, floodplain environment. In other words, the large range in $\delta^{13}C$ of tooth enamel observed for hadrosaurs can be explained by dietary partitioning of food resources by means of spatial separation. Future research will hopefully determine if these ecologically distinct populations of hadrosaurs represent different sub-taxa, age groups, etc.

U-Pb geochronology of the varied lithologies within the Cow Creek Pendant, Southern Sierra Nevadas, California

Lucy Rogers
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The Sierra Nevada mountains of eastern California comprise a large and geologically complex region containing the geologic record of the assembly of the Laurentian margin. At the mountains' core is the Sierra Nevada batholith, which is a series of expansive Mesozoic igneous intrusions. Emplacement of this batholith aided in the metamorphism, deformation, and selective preservation of the preexisting country rock in the gaps between plutons, resulting in the formation of metamorphic pendants. These pendants are spread across the Sierra Nevada mountains and provide valuable information about the geology of the region before arc magmatism and provide opportunity to gain a deeper and more detailed understanding of the configuration and tectonic history of the Laurentian margin prior to Sierra Nevada Batholith emplacement. Here, I focus on constraining the depositional and lithologic variability within the Cow Creek pendant of the Kernville terrane of the southern Sierra Nevada through U-Pb zircon geochronology and petrography. Using samples from previous studies, BFD-107a, BFD-107b, and BFD-106a (Clemens-Knott et al., 2024; Clemens-Knott and Gevedon et al., in prep) , we have been able to formulate a geologic history sequence which is now being complicated due to a nearby presence of strongly foliated metagranitoids. U-Pb geochronology and petrographic investigation into new samples, two *f*-metagranitoids (BFD-112 and BFD-113a), its neighboring igneous intrusion (BFD-115), and one metapelite (BFD-116) will improve our understanding of the associations, age variations, deformation history, and lithological make-up of the pendant, providing new insights into the region's tectonic and magmatic histories.

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