Arizona Geological Society Newsletter May 2024

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Wednesday 1 May AGS Evening Presentation

Characterization of contrasting ore-related fluid systems in the Paradox Basin

Eytan Bos Orent
Ph.D. Candidate at University of Arizona Dept. of Geosciences

Weds. 1 May at Hexagon Mining, Tucson
STREAMING beginning at 6:30 MST - **https://tinyurl.com/AGS-1MayPresentation**

To attend in person, please register at **https://www.arizonageologicalsoc.org**

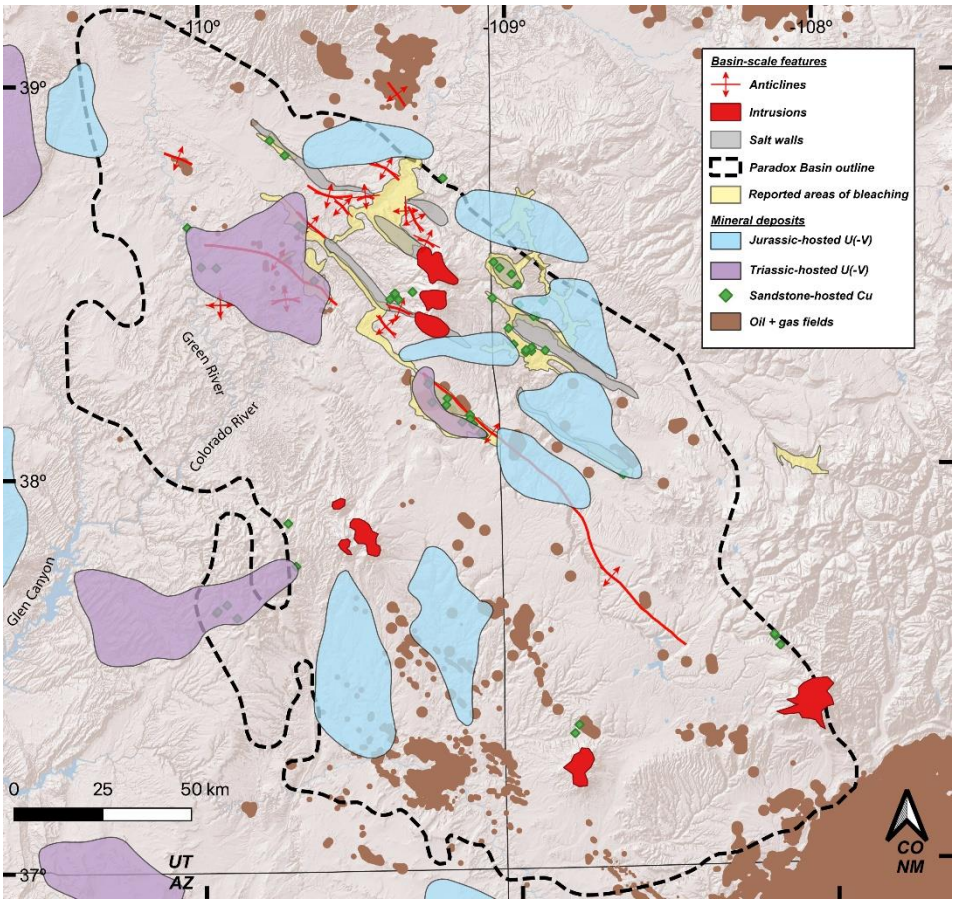
ABSTRACT. A long history of fluid-rock interaction in the Paradox Basin has resulted in geologically diverse products caused by a range of fluid sources and drivers. The La Sal district is an example within the basin of a locus of fluid systems that formed U(-V) and Cu(-Ag) deposits, salt wall-proximal bleaching, hydrocarbon-induced pyritization, and carbonate-stable alteration. New mapping throughout La Sal Creek Canyon at multiple scales highlights the spatial relationships and superimposed fluid systems present in the district that are representative of those found in the Paradox Basin. Additional SEM, EMPA, whole rock, and LA-ICP-MS analyses help constrain the geochemical conditions under which fluids interacted with their environments and the absolute timing of key geologic events.

The U(-V) sandstone-hosted, tabular ore bodies found in the Jurassic Morrison Formation are localized in lithofacies typical of channel-fill deposits and are commonly bound both above and below by floodplain mudstones. Alteration associated with these deposits is characterized by a core with abundant quartz cements, concretions containing U and V ore minerals, and relatively few carbonate concretions relative to unmineralized host rocks. Lower Fe and higher δO_{SMOW} in authigenic carbonates in mineralized compared to mineralized sandstones provides evidence for distinct formation waters related to U(-V) mineralization. U-Pb geochronology of calcite intergrown with coffinite ($U(SiO_4) \cdot nH_2O$) indicates an early Cretaceous age of mineralization that immediately follows the late Jurassic deposition of the host rocks but predates late Cretaceous thick foreland basin fill.

At least two Cu deposits in the Paradox Basin overlap in space with sandstone reservoirs containing obvious hydrocarbons adjacent to salt-related structures. Mapping at the Cashin Cu(-Ag) sandstone-hosted deposit shows several key relationships: concretionary carbonate

cements are localized along the redox boundary that is presumed to be caused by hydrocarbon migration through porous sandstones, and Cu-sulfides are less abundant in units updip of the ore-controlling fault. Further evidence for the involvement of hydrocarbons in mineralization lies in the reconstructed water δO_{SMOW} that overlaps with modern oil and gas pumping well brines. The age of mineralization is constrained by radiometric dating of calcite and dolomite veins from around the basin that contain intergrown Cu- and Ag-sulfides. A cluster of ages in the middle to late Miocene raises questions concerning the timing of mineralization with respect to major tectonic events in the North American Cordillera.

Simplified geologic map of the Paradox Basin UT-CO illustrating basin-scale features.



Bio: Eytan Bos Orent is a Ph.D. candidate at the Dept. of Geosciences, University of Arizona. His advisor is Dr. Mark Barton. Eytan was a recipient of the Arizona Geological Society's Courtright Scholarship in 2023.

AGS Summer Speaker Series Hiatus & Social Mixers

The AGS 2024 Presentation Series takes a 3-month break (June, July, and August) before resuming in Sept. 2024. Phil Pearthree, AGS VP of Programs, is scheduling presentation for fall that include paleoclimatology, economic geology, and wildfire-related debris flow hazards challenging Arizona and the arid southwestern U.S.

In place of the presentation series, the AGS Executive Committee will schedule monthly social mixers at Borderlands on Toole St. in downtown Tucson. Discussions with Borderlands is underway, and we hope to schedule the events for the 3rd Thursday of each month from 6:30 p.m. till 9:00 p.m. The AGS EX COM will seek sponsors to provide free taco plates for those attending.

We'll follow up with more information at a later date.

Building a relationship with the Utah Geological Association

Trae Boman, Secretary of the Utah Geological Association (UGA), reached out to AGS about developing a closer relationship between our two organizations that would include sharing of resources and information. Trae's note to AGS said the following, "We are actively working to expand our interaction with geological societies from neighboring states; our plans include potential cross-promotion of field trips, publications, and online talks. We are willing to share announcement about your opportunities with our membership if you are willing to reciprocate!". To learn more about UGA, visit their website at https://utahgeology.org/ .

The AGS and UGA share many of the same values, including developing and promoting geologic field trips, hosting student scholarship programs, publishing a regular newsletter, and engaging the professional geologic/geotechnical community. Membership fees of the two groups is nearly identical (AGS - $35 annually and no fee for student members; UGA - $30 annually and a $5 fee for students.).

At the latest AGS Executive Committee meeting on 18 April, 2024, UGA's request for developing a closer, collegial relationship was met with enthusiasm. Over the next months, the AGS Executive Committee will be in discussion with UGA's Board about establishing a productive, and sharing relationship, based on shared values.

Please let us know if you have any thoughts or concerns regarding formalizing our relationship with UGA. Send your comments to fmichael.conway@gmail.com and he'll share them with the entire AGS Executive Committee.

New Reasons to Attend AGS Meetings in Person

Eric Seedorff

Note: This is the first of an occasional series of short articles about the Arizona Geological Society, "An Echo from Deep Time," contributed by AGS members.

Here I invert Merle Haggard's song title "Reasons to Quit" to offer three reasons why local geologists might want to attend AGS meetings in person, but also to join the society and to consider volunteering for the Executive Committee. I begin with the least conventional reason.

1) Creating Your Community

Arrange to meet your friends at the meeting in the Hexagon Building at the beginning of the social hour or travel to the meeting together on foot, on bikes, or in a truckpool. Do you think that the meetings may not be attended by the type of people you hang out with (whoever they might be)? If so, then shape your future—arrange to bring a group of your geofriends to meetings and hang out with them. At the meeting, you might surprise yourself by making other new acquaintances. Afterward, you and your group may even plan to go to a downtown bar or restaurant together.

Hexagon Building, downtown Tucson

Pre-meeting conversation and sandwiches on the 5th-floor deck

2) Joining a Community

This is the more passive, people-oriented reason for attending an AGS meeting in person: to interact with whoever else attends. The technical talk itself is of subordinate interest. Conversing with others may be enjoyable, and networking may benefit your career in the long term. Such conversations are a key reason for civic and fraternal organizations. Fellowship among professionals also drives participation in

The view of the Santa Catalina Mountains from the

the most successful professional societies. People with this motivation are likely to attend many meetings if their schedules permit.

Show time for a presentation!

3) Learning Geology

The third and arguably the most conventional reason to attend a professional society meeting is to continue learning. Your decision to attend the talk might be based on the topic of the presentation or the reputation of the speaker. The Arizona Geological Society aims to have talks on a variety of topics during the year. If your schedule is more flexible or your interests are broad, people with this motivation might also attend most of the talks each year, but if your interests are narrow or you have a busy schedule at work or home, you may attend only two or three meetings per year.

However you decide to attend, welcome to the in-person meetings of AGS in the (largely) post-Covid era!

52nd Annual GeoDaze at the University of Arizona

GeoDaze – "A student-run symposium organized by the Dept. of Geosciences at the University of Arizona". Topics presented at GeoDaze range widely, from paleoclimatology, seismology, dendrochronology, economic and structural geology, among other topics. The 2024 GeoDaze event was hosted at UArizona's ENR-2 building on 21-22 March 2024 (https://www.geodaze.com/). Congratulations to all the student participants. This year's awardees include:

- Best Undergraduate Poster: Kay Poonawala
- Best Undergraduate Talk: Tanner Johnson
- Best Graduate Poster: Luke Basler
- Geochemistry/Geomorphology Talk: María Paula Marroquín-Gómez

- Geophysics: Aubrey Bennett
- Economic Geology: Eytan Bos Orent
- Climate: Mudith Weerabaddana
- Tectonics: Priscilla Martinez
- Nicéa Wilder Best Graduate Talk: Sydney Acito
- Montgomery Associates Best Overall: Isaiah Spring

Geoscience Outstanding Graduate Student Awards:

- Nitzen Yanay - Geoscience Outstanding Graduate Student for Research
- Ken Gourley - Geoscience Outstanding Graduate Student for Service
- Joses Omojola - Geoscience Outstanding Graduate Teaching Assistant

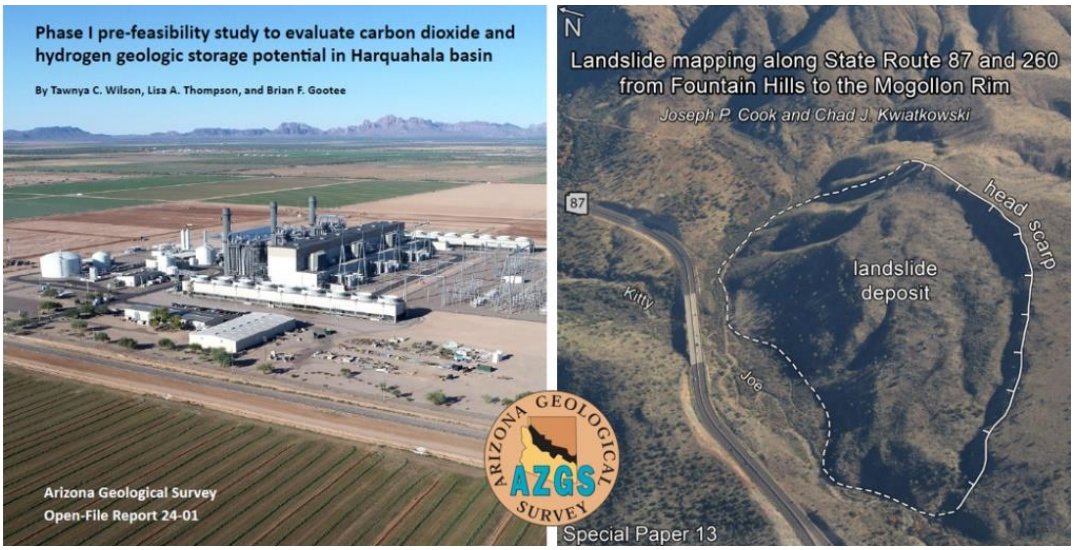
ARCS Scholar Award goes to Holly Thomas! Woohoo!

UArizona GeoDaze participants.

Arizona Geological Survey Publications Feb-Mar 2024

Cook, J.P. and Kwiatkowski, C.J., 2024, Landslide mapping along State Route 87 and 260 from Fountain Hills to the Mogollon Rim. Arizona Geological Survey Special Paper SP-13, 53 p. https://library.azgs.arizona.edu/item/AGSP-1711059010706-612

Wilson, T.C., Thompson, L.A. and Gootee, B.F., 2024, Phase I pre-feasibility study to evaluate carbon dioxide and hydrogen geologic storage potential in Harquahala basin. Arizona Geological Survey Open-File Report OFR-24-01, 17 p. report, 1 geologic map. https://library.azgs.arizona.edu/item/AOFR-1712775909999-126



Summary of Landslide Mapping along State Route 87 & 260

by Chad Kwiatkowski (Arizona Geological Survey)

State Route 87 (SR 87), also known as the Beeline Highway, transects the rugged Mazatzal Mountains between Phoenix and Payson. State Route 260 (SR 260) ascends the steep slopes of the Mogollon Rim, the mighty topographic escarpment at the southwestern edge of the Colorado Plateau. Considering the steep slopes and geologic diversity along the route, coupled with the relatively high precipitation of the Mazatzal Mountains and Mogollon Rim, it should come as no surprise that this highway corridor contains an abundance of landslides! You can read about them in the recently published report by AZGS, Special Paper 13: Landslide mapping along State Route 87 and 260 from Fountain Hills to the Mogollon Rim.

Landslides have affected SR 87 and SR 260 since their early days, as revealed by newspaper archives. An Arizona Republic article from April 10, 1958, documents that a landslide blocked SR 87 near Sunflower, three months before the highway's official opening ceremony. Another Arizona Republic article from March 22, 1983, details that SR 260 was damaged by a landslide

at some point between Payson and Heber, requiring a road closure and multi-day cleanup effort.

More recently, on March 21, 2008, a landslide occurred near milepost (MP) 224 of SR 87, buckling the northbound lanes upward by as much as 1 meter (3 ft) and displacing the median barrier to the east up to 0.3 m (1 ft). Repairs and renovations related to this landslide topped $20 million. A reconnaissance report by AZGS after the slide revealed that it was a reactivation of a portion of a much larger landslide directly cut through by the highway during a section reroute in the late 1990s. Prior to the rerouted section, a geologic map was prepared for ADOT by Clay Conway with USGS. Conway mapped several landslides in the highway corridor, including what we now know to be the upper portion of the ancient landslide cut through by the reroute. Despite his warning that the lower boundary of the landslide was uncertain and should be studied in detail, the reroute continued as planned, slicing up to 25 m (85 ft) deep into the landslide and reducing the slope stability.

The landslide mapping conducted for the new AZGS study was funded by the Arizona Department of Emergency and Military Affairs through the State Emergency Council for mitigation projects. This study utilized high-resolution topographic data, including LiDAR-derived digital terrain models where available, to effectively 'see through' the forest cover to the underlying slopes. Throughout the study area, over 250 previously unmapped landslides were identified and mapped. These slides occur in a variety of geologic settings, including 1) Neogene basalt overlying Oligocene-Miocene conglomerate, 2) Neogene basalt overlying mudstone of the Naco Formation, 3) Neogene basalt overlying a clay-rich paleosol or bake zone at the top of a Paleogene conglomerate, 4) the Schnebly Hill Formation and lower Supai Formation, and 5) Paleogene Mogollon Rim Formation conglomerate overlying Permian and Pennsylvanian mudstones.

One interesting discovery during this project was the presence of numerous historically or currently active landslides. Luckily, most of these active landslides are not directly adjacent to the highway. Some of the slides were determined to be historically active because they cut or buried forest roads. Another slide, near Valentine Ridge, was examined in the field and found to have open tension cracks in the upper half of the slide and water oozing out of its toe; this slide is active! A few active slides were also noted that are directly adjacent to the highway, including a slide on a steep slope of Proterozoic metasedimentary rocks in Slate Creek Canyon near MP 228 of SR 87, a slide near Buckhead Mesa south of Pine that failed in March 2019, and a slowly deforming slope of Schnebly Hill Formation on the upper Rim slopes near MP 280 of SR 260.

Another result of this study was the recognition of numerous debris-flow scours and deposits that were previously unknown, and whose timing could be constrained by historical aerial imagery and precipitation records. At Diamond Mountain near Sunflower, a series of atmospheric rivers in January 2010 initiated dozens of slope failures, several which spawned debris flows downslope. A few fresh debris-flow scours were noted in the Mazatzal Mountains, a result from extreme rainfall on August 18, 2021. Where SR 260 ascends the Rim between Payson and Heber, a major debris flow scour is apparent in 1978 imagery, and not present in

1935 imagery. This debris flow is probably related to the Labor Day flooding event September 3–6, 1970, in which dissipating Tropical Storm Norma dropped up to 279 mm (11 in) of precipitation along the Rim.

The SR 87 and 260 landslide mapping project followed up on a similar project for the I-17 corridor from Phoenix to Flagstaff, published by AZGS in 2021. In the coming years, US 60 from Florence Junction to Show Low will be investigated for landslides. So far, these landslide reports have resulted in the identification of many previously unknown landslides, and the refinement of the extent of previously mapped slides. One thing is for certain, Arizona has many active slopes, and landslides should absolutely be regarded as a common feature in areas of the state with high topographic relief!

BOOTPRINTS of the Membership

Note: This is the first of what we expect will be a regular series of informal biographies of members of the Arizona Geological Society, with a photo--or a few. In other words, these are who you might meet as a regular attendee at AGS meetings, field trips, or social hours. The series is inspired by a column in the newsletter of a sister society, the Geological Society of Nevada. The title of the new column harkens back to the highly successful 1994 AGS Symposium, "Bootprints Along the Cordillera." The meeting was the basis for AGS's best-selling book edited by Frances Wahl Pierce and John G. Bolm, 1995, Porphyry copper deposits of the American Cordillera: Arizona Geological Society Digest 20, 656 p.

Elijah Mullins

The year following the Dallas Cowboys' 2nd consecutive Superbowl, at 4 a.m., September 23rd, 1994, at St. Francis Hospital, Tulsa, Oklahoma, I was born to a family of southern values traced to Georgia and Texas. My father, hoping I was born four hours earlier so I could be born on the date of legendary Cowboy's running back Emmitt Smith's number (22), worked as an architect and briefly as a co-owner for a woodfloor company. My mother was a jack-of-all-trades woman working in various roles in the service industry. They had three kids after me, two more sons, and a daughter. From when I was born until I was nine, we constantly moved around Oklahoma and to and from South Carolina. Finally, we moved to where I grew up, Eagle River, Alaska, where I spent my formative years.

Conquering Grand Canyon 2021.

Boot after fall fieldwork 2023.

I worked various jobs starting from the age of 15. I was a commercial fisherman for a summer, working in the waters of Cook Inlet in south-central Alaska, fishing Sockeye salmon. At the end of the summer, I started working as a plumber, where I learned what earning your paycheck is like. Working those cold winters in Alaska underneath dilapidated trailer homes fixing broken copper piping packs grit into anybody, and it certainly crammed it into me. But I wouldn't say I liked the thought of working this job for the long term. It had the not-so-subtle effect of desperation to find a way out, lighting a burning desire to find anything better than what I was doing. At the time, I had no desire to seek any college education, and I wanted to get away from home. The natural conclusion that came to my mind was the military. I decided to enlist in the United States Navy in November 2013. Why? Because I liked their uniforms the most.

After attending boot camp for eight weeks in Great Lakes, IL, and attending specific role training in Pensacola, FL, in March 2014, I was assigned to the strike fighter squadron VFA-154 Black Knights in Lemoore, CA, which at the time was attached to the USS Nimitz, working as a Plane Captain on Boeing F/A-18F Super Hornets. After two years, in March 2016, I was sent back to Pensacola. I received further technical training to become an Aviation Structural Mechanic – Safety Equipment (AME) whose job focused on maintaining and repairing utility systems such as air conditioning, heating, pressurization, and oxygen, as well as dearming and arming the ejection seats used in the aircraft in case of emergencies. In June 2016, I was stationed in Whidbey Island, WA, with the Fleet Replacement Squadron VAQ-129 Vikings, working on Boeing EA-18G Growlers. After two more years, the Navy sent me to an expeditionary squadron, VAQ-138 Yellow Jackets. I deployed with them to Japan and Guam in 2018, finishing my five-year Navy career in November 2018. At the tail end of my Navy career, my best friend from VFA-154 told me that after I finished my contract, I could move in with him as a roommate in Columbus, Ohio, on the condition that I go to college.

VAQ-129, 12 minutes to midnight, Whidbey Island.

I had no plan for college, so I had to think of what I would go for. During several detachments at sea, we were allowed to receive emails from family. One of my brothers, Dagan, worked as a Jumbo Drill operator at the Kensington Gold Mine in southeast Alaska. He occasionally sent me emails with pictures of one to two-meter-wide massive quartz veins with pyrite and some small amounts of visible gold mineralization down the centerline. I've always been curious about how things work: a fighter jet, computer, or money, so this naturally spurred my inquiry. How does gold or any money mineral even occur in rock? That central question, prompted by my brother, motivated me to pursue a degree in geology. Why is gold in this white-looking rock? Why can't I find gold in every rock? How can people explore and track down gold if it's not everywhere? With those questions in mind, I moved to Columbus the same month I separated from the Navy, enrolled at Columbus State Community College in January 2019, and spent five semesters there, earning an Associate of Science in August 2020. As soon as I earned my associate degree, I enrolled as an Earth Science major at The Ohio State University that same month. During my year and a half at Ohio State, I worked with an igneous petrology professor, Dr. Mike Barton, and his PhD Student, Lindsey Hernandez, on an undergraduate research thesis focused on understanding the magma plumbing systems and potential magma mixing as an eruption trigger for the volcanoes of Pacaya and Fuego in southwestern Guatemala. For this project, I was allowed to visit the country in January 2022 to conduct fieldwork in the form of sample collection from various lava flows and pyroclastics from both volcanoes. It was the most memorable trip I've been on thus far in my geology career.

Japan deployment 2018.

After graduating from Ohio State in the Spring of 2022, I headed to the same mine my brother was working at, Kensington, and worked an internship there as an exploration geologist logging core and channel sampling underground drifts. While at Kensington, I gained my first exposure to economic geology. I learned about alteration processes, mineralization associated with alteration, the significance of mineral assemblages, and how to interpret them. I also discovered how combining structure and geochemistry is used as an exploration tool.
This experience gave me a basic and high-level understanding of economic geology before I

started as an economic geology master's student under Mark Barton at the University of Arizona. The role of alteration and its relationship with the movement and precipitation of metals piqued my interest at Kensington and, under Mark, fostered into the research of peralkaline sodic alteration at the Wilson Ridge Pluton, northwestern Arizona, and the ramifications for transport of metals and its use as an exploration tool. With all this study on alteration and its associated metal relationships, I'm interested in working on any project that aims to extract any economic resource in mind, be it mining or oil and gas. Furthermore, understanding the decisions that go into developing or not developing a project is just as interesting to me as the geology, and my goal as a professional is to be part of the team making those decisions. *Donkeys visiting the alteration prophet, Winter Field Work, 2022.*

AGS Spring 2024 Big Sandy Valley Field Trip

Basin evolution, deformation, and mineralization in the Big Sandy Valley, northwestern Arizona

Leaders: Brian F. Gootee, Lisa A. Thompson, Bradford J. Johnson, and Carson A. Richardson (Arizona Geological Survey, University of Arizona)

When/Where: Saturday, 27 April 2024 to Sunday, 28 April 2024 (We recommend arriving the afternoon/evening of Friday, 26 April 2024 and either camp in Big Sandy Valley or find accommodation in Kingman)

Registration: This field trip is fully subscribed.

Description: This field trip, encompassing basin deposits, river integration, structural geology/tectonics, economic geology, and regional geology, will examine two generations of well-exposed basin deposits and associated faults and deformation in Big Sandy Valley, northwestern Arizona. Big Sandy Valley is situated along the margin between the Basin and Range Province and Transition Zone in Arizona within a ~90 km gap along the northwestern segment of the Laramide arc where no porphyry copper deposits have yet been defined. Two sedimentary lithium deposits were discovered in 2019 and continue to be advanced, while two subsurface porphyry copper prospects are being explored by junior mining companies. By examining the spatial distribution and geometric configuration of Big Sandy basin deposits, trip participants will evaluate and make connections between basin structural evolution, depositional systems and basin sedimentation, and modern resource exploration, highlighting the role geologic mapping plays in the intersection of science, policy, and land use. Field trip stops examine four aspects of basin evolution and mineral resources: 1) evaluate the character, form, and depositional environments of two generations of basin deposits (the Miocene Tule Wash beds and late Miocene-early Pliocene Big Sandy Formation) through type exposures; 2) examine the character, provenance, and depositional mechanisms of spectacular rock-avalanche breccia deposits in the Tule Wash beds; 3) evaluate the structural setting of basin deposits, cross-cutting relationships between faults and folds, and implications for the style and timing of deformation; and 4) summarize regional geology and implications for porphyry copper and sedimentary lithium mineralization.

AGS ***STILL*** on the hunt for a Newsletter Coordinator

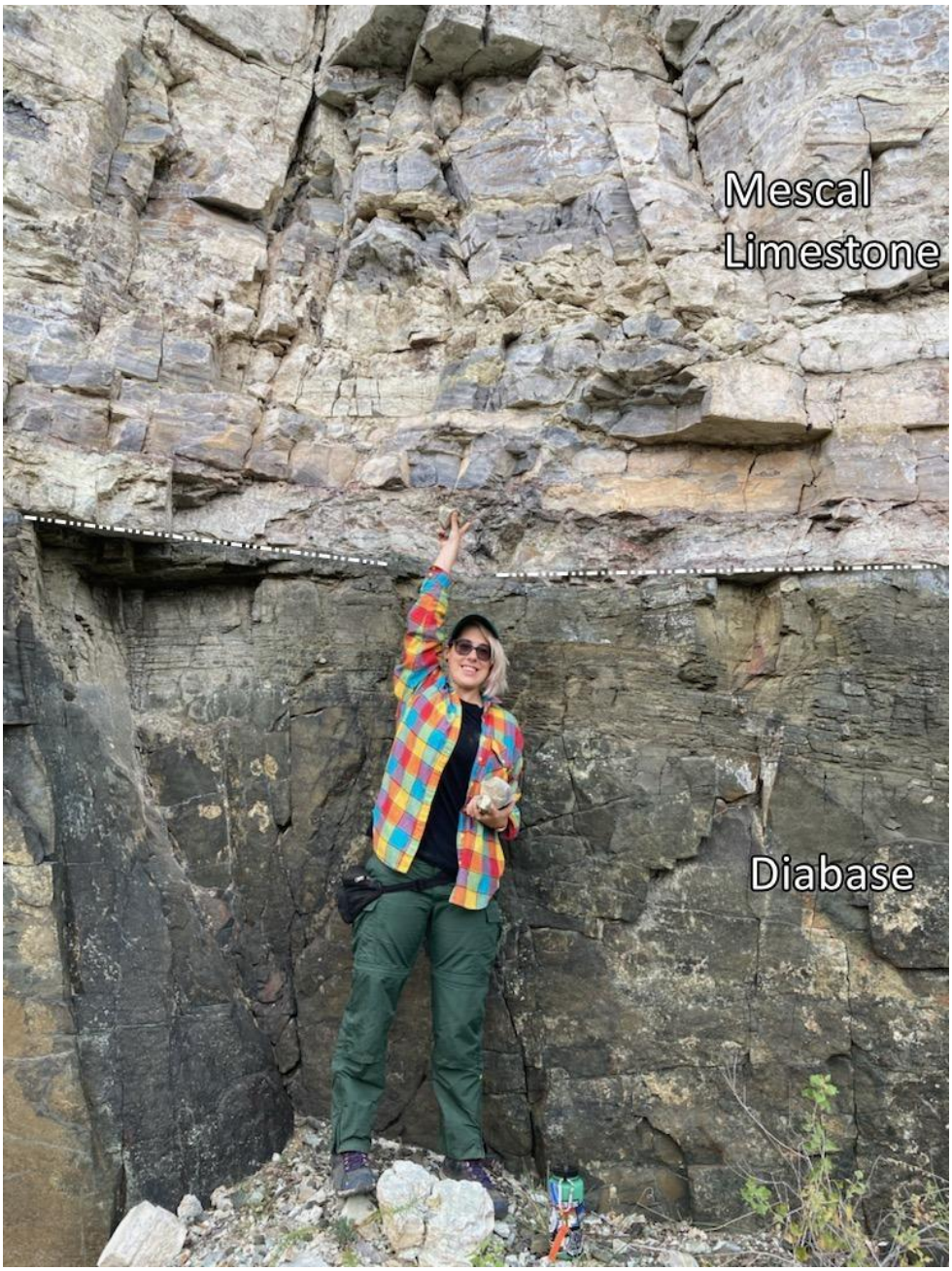
Are you passionate about communication and organization? Do you have a knack for crafting engaging content? We're on the lookout for a dedicated individual to take the reins on our monthly newsletter!

As the Newsletter Coordinator, you'll have the opportunity to curate and compile the latest updates, announcements, and highlights from our AGS community. Whether you're a seasoned wordsmith or looking to hone your editorial skills, this role offers a platform to showcase your creativity and keep our members informed and inspired.

If you're ready to make your mark and contribute to the vibrant pulse of AGS, we want to hear from you! Reach out to us today to learn more about how you can become our next Newsletter Coordinator.

Let's collaborate to keep our community connected and thriving!

Arizona Geological Society *Photo* of the Month



“The Mescal Limestone (above) is a part of the Apache Group which is approximately Neoproterozoic in age, or 1.2 Billion years old (Ba). This limestone formed from a shallow sea and was intruded with basalt and diabase (below) between 1.05 and 1.14 billion years ago. The Mescal Limestone metamorphosed, forming asbestos at the Philips Mine.”

Grace Allison appears in this image and submitted this post for the AZGS Facebook page. Photo credit: Chad Harrold.