SEG University of Toronto Student Chapter
Western USA Field Trip Report
May 15-May 23, 2023

Written by: Tina Tsan & Danielle McGill

Acknowledgement

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- Department of Earth Sciences at the University of Toronto
- Ivanhoe Electric
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We would also like to give special thanks to the following individuals and companies:

- Jeffrey Hedenquist from the University of Ottawa for the pre-trip talk on Yellowstone
- Erich Petersen from the University of Utah for joining us and teaching us about the Tintic district
- Jessica Shaw & the team at Osisko Development for organizing our visit to their mine site and the underground mine tour
- Logan Bouley, Eric LeLacheur, Joel Dietrich, Kyle Nacey and Jerry Zieg from Sandfire Resources America Inc. for organizing the tour of their office and project site

Introduction

After a successful trip to the Abitibi region last year, our SEG student chapter geared up for our first international trip since 2018. Our executive team organized a 9-day trip to the Western United States, including Utah, Idaho, Wyoming and Montana, from May 15 to 23, 2023. Guided geology, mine and park tours were provided by Erich Petersen (Professor Emeritus, University of Utah), Jessica Shaw (Senior Geologist, Osisko Development), Shauna Baron (Yellowstone Insight), and Logan Bouley (Geologist, Sandfire Resources America Inc). The trip was led by Dr. Daniel Gregory (Assistant Professor in Economic Geology, U of T) along with Tina Tsan (Masters Student, SEGSC President) and Danielle McGill (Masters Student, SEGSC Vice-president).

The Western United States features prominent mining districts, world-class deposits and unique hydrothermal systems. As student geoscientists, many of us will likely pursue careers in new areas with active mining communities, such as the United States. The trip's main objective was to allow students to gain first-hand knowledge of these deposits and systems to aid their future industry careers.

The trip was attended by three graduate students (two PhD, one MSc), and four undergraduates from various Earth Sciences programs at the University of Toronto. The trip was open to American SEG student chapter members and industry professionals to encourage more interactions between student chapters and industry. Our chapter was joined by one undergraduate student from the University of Las Vegas, Nevada (UNLV) and a junior geologist from Ivanhoe Electric. In addition, we had two guest participants from the University of Utah join us for the first leg of our trip in Utah (May 15-18).

Trip Participants

University of Toronto	Daniel Gregory	Assistant Professor; Chapter Academic Advisor
	Tina Tsan	MSc (Earth Sciences); Chapter President
	Danielle McGill	MSc (Earth Sciences); Chapter Vice-President
	Nelson Roman	PhD (Earth Sciences)
	Jonathan Umbsaar	PhD (Earth Sciences)
	Josephine Calista Di Maurizio	MSc (Earth Sciences)
	Katherine Bormann	BSc (Earth Sciences)
	Eve Carrothers	BSc (Earth Sciences)
	Jamie Chow	BSc (Earth Sciences)
	Magnus Roland Marun	BSc (Earth Sciences)

University of Las Vegas, Nevada	Jennifer Ajouaoud	BSc (Earth Sciences); UNLV SEG Treasurer
Ivanhoe Electric	Caden Anderson	Junior Geologist

Guest Participants

University of Utah	Erich Petersen	Emeritus Professor; SEG Fellow
	Constance Sauvé	BSc (Earth Sciences)

Itinerary Overview

Date	Activities	Location
05/15	Flight from Toronto, ON to Salt Lake City, UT	-
05/16	Tintic Mining District tour with Erich Petersen	Utah
05/17	Osisko Development mine site tour	Utah
05/18	University of Utah, Antelope Island, Hell's Half Acre Lava Fields, Lava Hot Springs	Utah, Idaho
05/19	Yellowstone Insight guided tour at Yellowstone Park ● Norris Geyser Basin ● Canyon Village ● Obsidian deposit ● Mammoth hot springs	Yellowstone, Wyoming
05/20	Self-guided tour at Yellowstone Park ● Upper Geyser Basin (Old Faithful) ● Lower Geyser Basin (Fountain Paint Pots, Grand Prismatic Spring)	Yellowstone, Wyoming
05/21	Black Butte SEDEX deposit tour	White Sulphur Springs, Montana
05/22	Butte Mining District ● Berkeley Pit ● World Museum of Mining ● Mineral Museum at Montana Tech	Butte, Montana
05/23	Flight from Bozeman, MT to Toronto, ON	-

Day-by-day Itinerary

Day 1: Flight into Salt Lake City

The group arrived late in the evening on Monday in Salt Lake City. After transiting to our hotel downtown, we prepared lunches for our full day of touring outcrops on Tuesday and had an early night in.

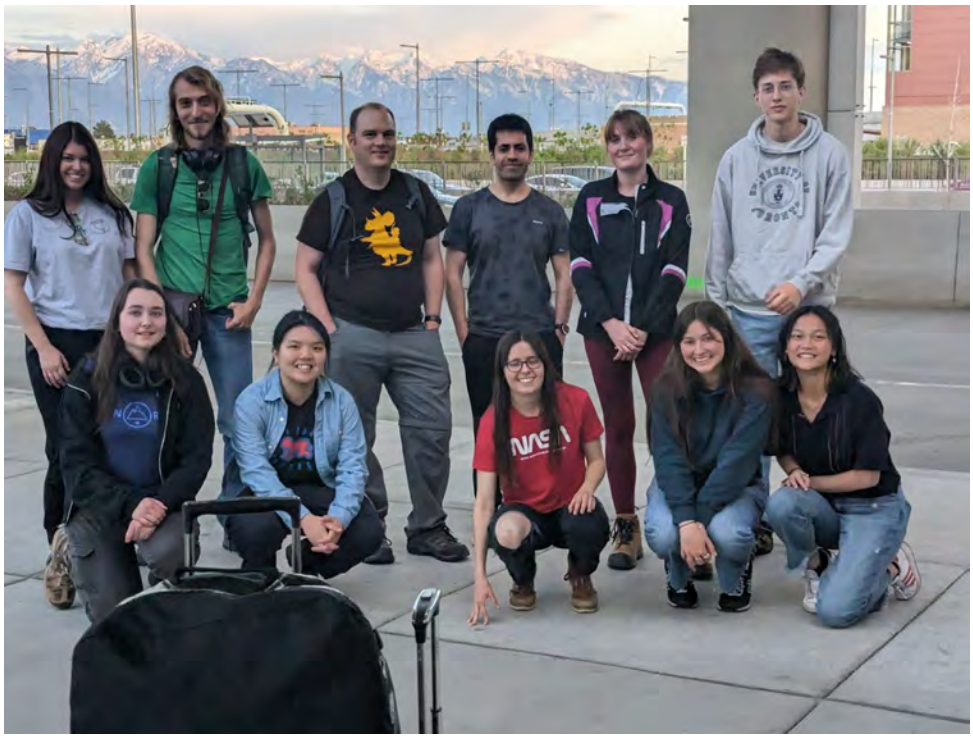


Figure 1. *Just landed in Salt Lake City, ready to catch the train downtown.*

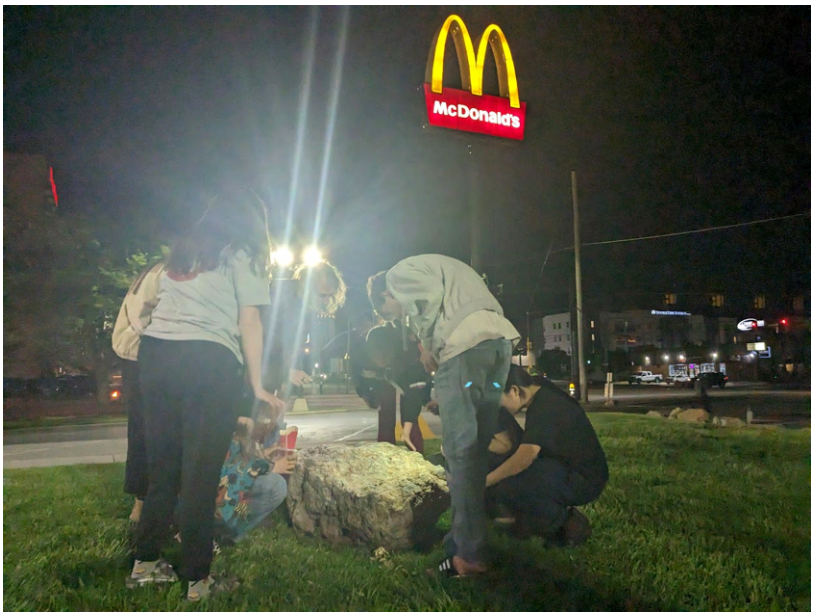


Figure 2. *Intrigued by the mysterious rock outside the McDonald's after a late meal.*

Day 2: Tintic Mining District

For days 2 and 3, we were joined by two special guests from the University of Utah, Erich Petersen and Constance Sauvé. We were also joined by several Osisko Development geologists for the day. We spent the day checking out different roadcuts/outcrops around the East Tintic district.

The first outcrop was the Packard Quartz Latite, a volcanic unit that was mostly plagioclase and k-feldspar, with sections of welded tuff. We observed at least two different generations of pebble dykes. Around noon, we took a quick lunch break at the Eureka City park, where Jessica Shaw, an Osisko Development geologist, gave us a brief overview of the history of the Tintic Mining District. Afterwards, we continued driving and stopped at a white alunite outcrop formed by intense hydrothermal alteration. The outcrop had some brown minerals-jarosite, which form from the oxidation of iron sulfides.

At our next stop, we split into two groups to check out two adjacent outcrops so that we could come together and discuss what we observed. The eastern outcrop was a carbonate, likely a dolostone, which effervesced when we put HCl. The western outcrop, however, did not effervesce with HCl and appeared more siliceous and vuggy. This outcrop was jasperoid, a type of silicified carbonate rock as a result of hydrothermal alteration.

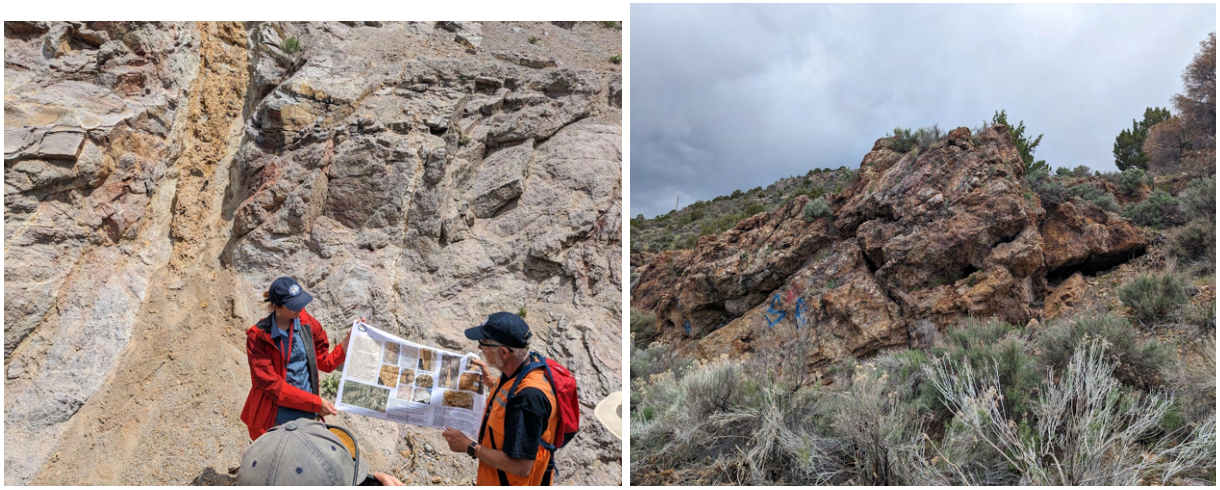


Figure 3. (Left) *Erich teaching the group about the Packard Quartz Latite as Constance helps him with the poster.* ***(Right)*** *Jasperoid outcrop.*

Before the next outcrop, we quickly stopped at the old Tintic Standard Mine at Dividend, where we examined some of the puddles with litmus paper. The brown/orange waters showed a pH of 0 and resulted from acid mine drainage.

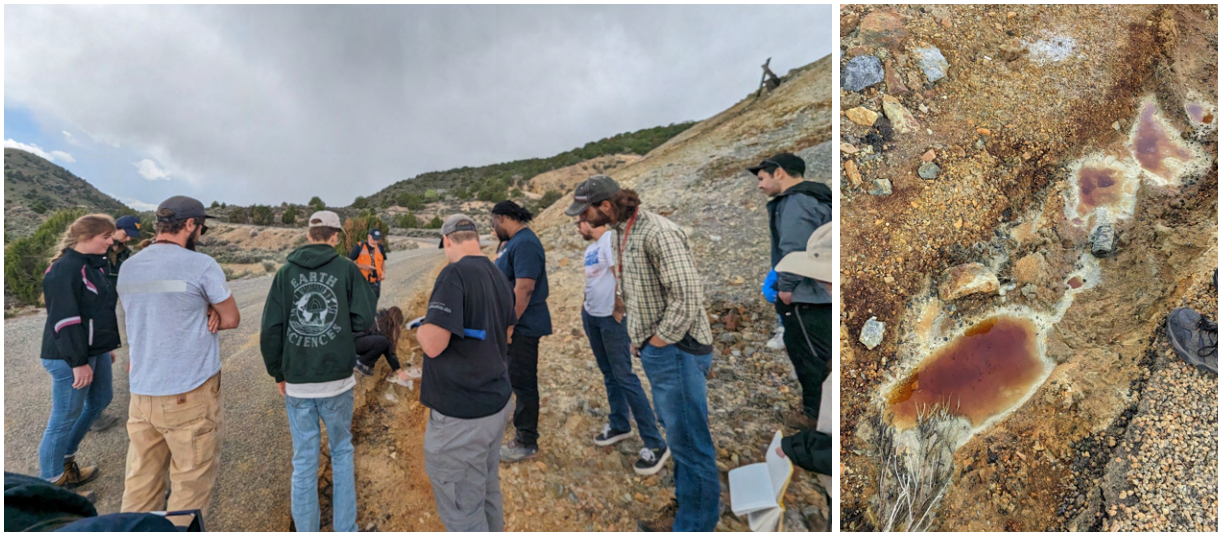


Figure 4. *Testing the pH of acid mine drainage as everyone looks on.*

We continued driving, and our next outcrop looked similar to the latite outcrop from earlier. However, when we put alizarin-red stain on the surface, it turned a pink/red colour, indicating the presence of Ca that we did not observe in the other outcrop.

To end the day, we climbed an old tailings pile, where we found nice epidote samples. On our way out of Eureka, we quickly stopped by the roadcut that showed a possibly terminated pebble dyke (**Figure 6**).

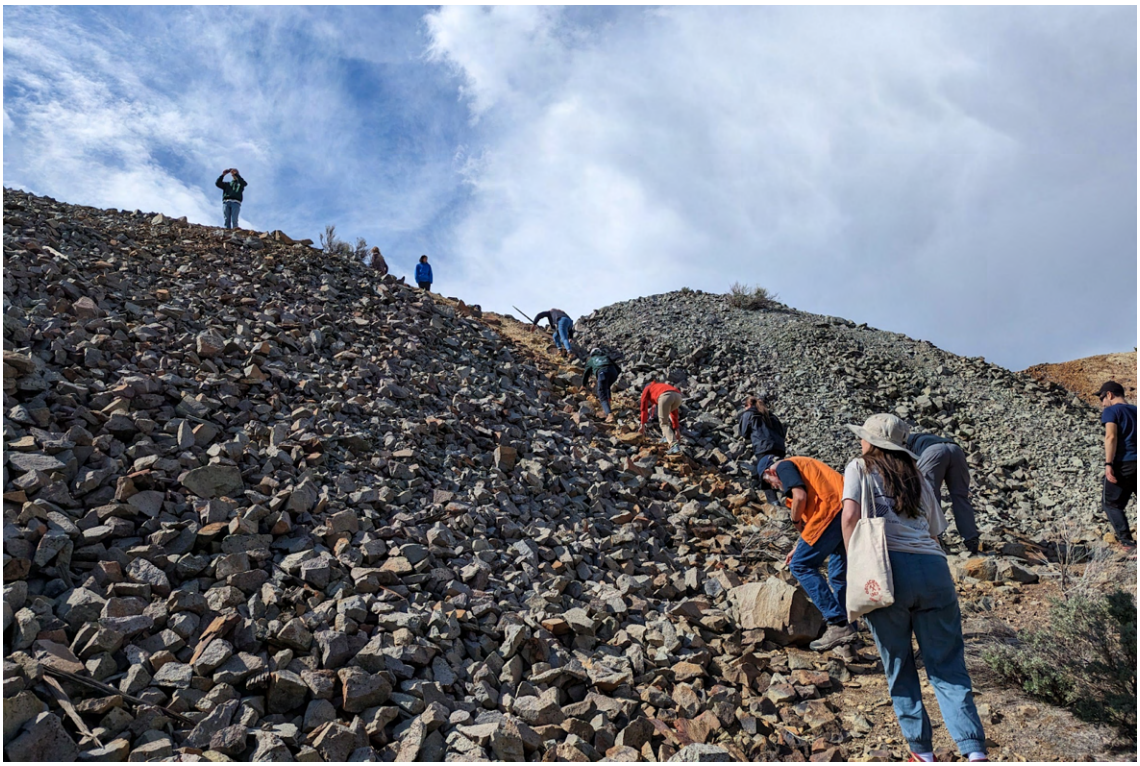


Figure 5. *Climbing up an old tailings pile and looking for pretty epidote samples.*

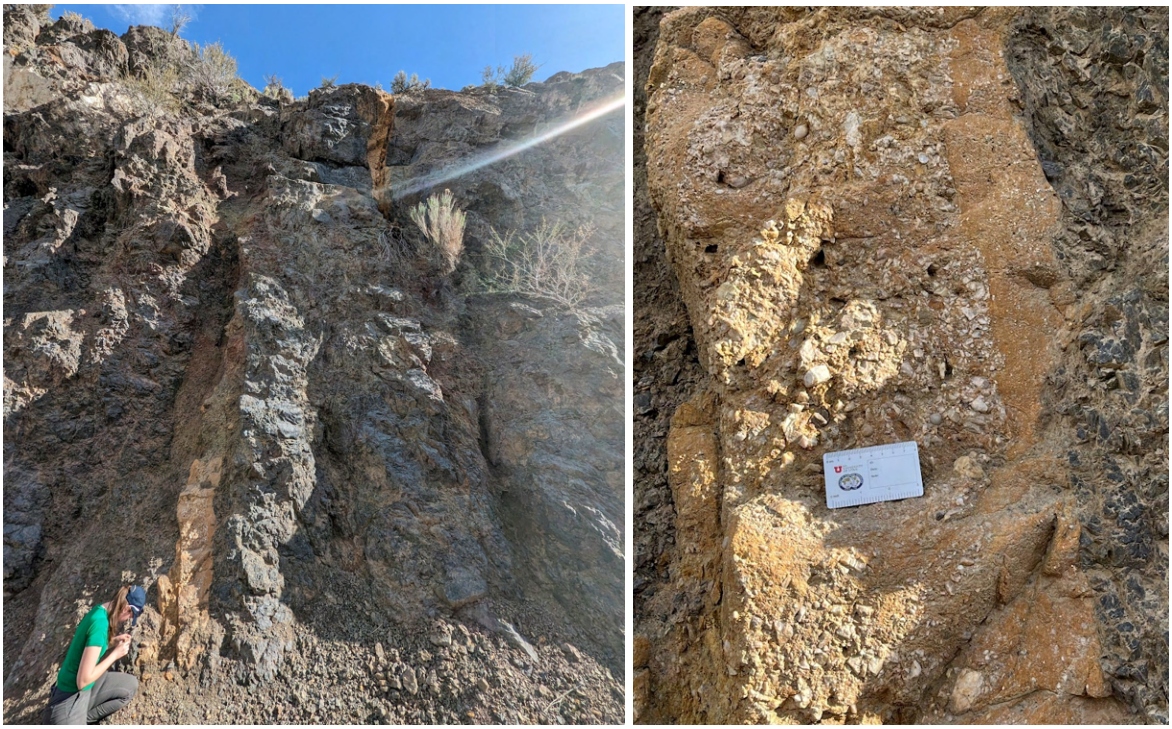


Figure 6. (Left) *Our vice-president, Dani, checking out a pebble dyke at a roadside outcrop outside Eureka, Utah.* ***(Right)*** *Up-close shot of the dyke.*

Day 3: Osisko Development mine site tour

On day 3, we visited Osisko Development's mine site in Tintic for a tour of their mine site and underground mine. To start the day, Jessica Shaw gave us a short presentation about mining in Tintic and Osisko Development's projects. Afterwards, we got to tour the facilities on site, including the assay labs and core shack, and learned more about how mines operate (the variety of different roles of people on site, assessment and extraction of ore, etc.). We also got the opportunity to go underground and tour the Trixie Mine.

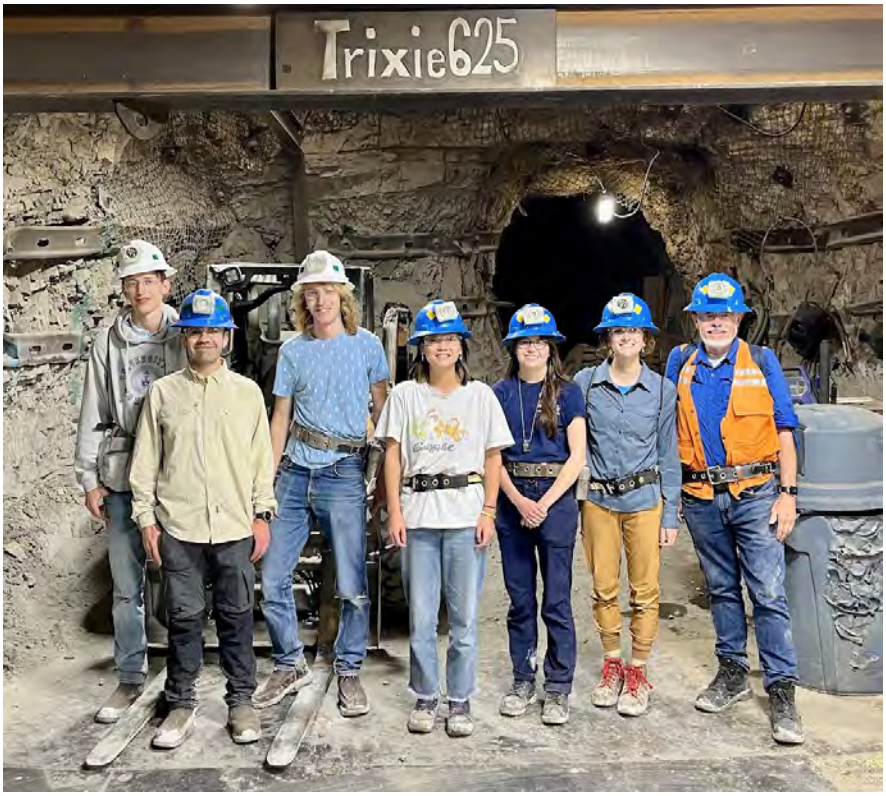


Figure 7. *Group photo while on an underground tour at the Trixie Mine (625 feet below ground!).*

To end the day, we drove to some outcrops at Treasure Hill, where we looked at an alunite outcrop and the tailings pile next to an old filled-in mine shaft, where we found octahedral pyrite crystals! We also had the opportunity to check out some cores from Horseshoe Hill that Erich had brought along, showing different types of porphyry-related alterations.

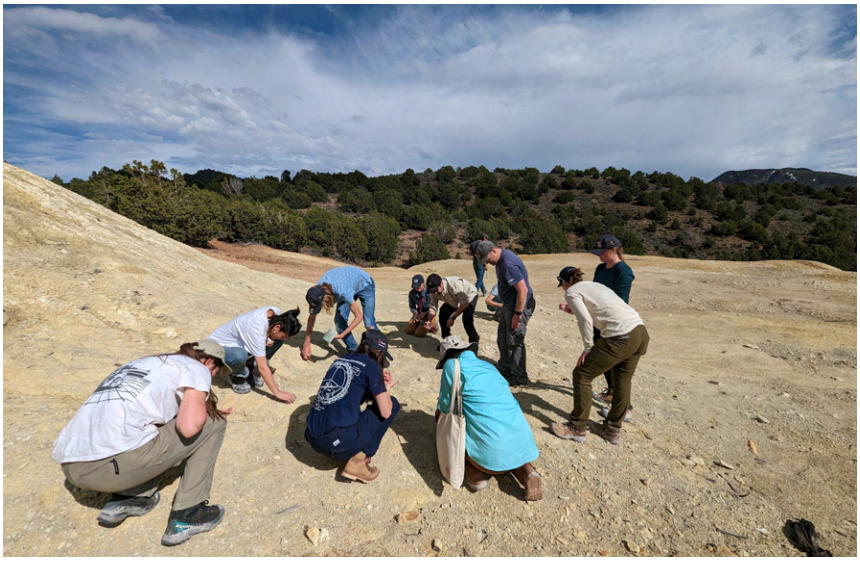


Figure 8. *Searching for octahedral pyrite crystals at the old tailings pile at Treasure Hill.*

In the evening, Erich showcased some of the research posters done by him and his students over the years. He also brought some opal samples from Opal Hill, one of the stops we couldn't access due to the physical conditions of the trail. The presence of uranium in these samples makes them fluoresce under ultraviolet (UV) light (**Figure 9 Right**).

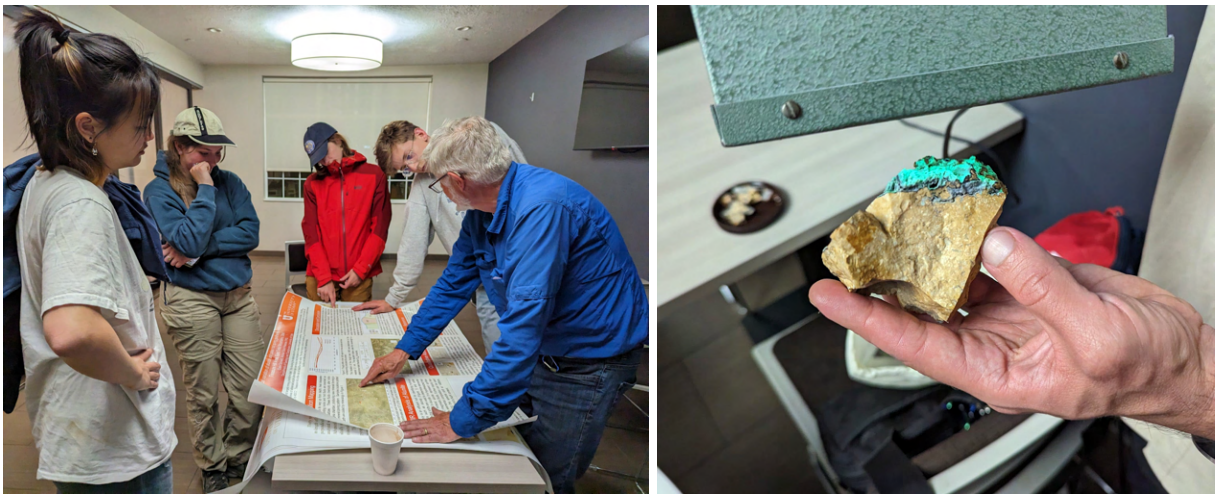


Figure 9. (Left) *Late night teachings by Erich Petersen about some of his and his student's works over the past years,* ***(Right)*** *Some fluorescent opal samples under UV light from Erich's collection.*

Day 4: University of Utah, Antelope Island, Lava Hot Springs

On day 4, Erich Petersen and his student, Constance, gave us a short tour of the Geology and Geophysics building before we parted ways and headed on our 5-hour journey north towards Montana. The department featured extensive collections of rock samples and fossils locally from Utah as well as from around the world.

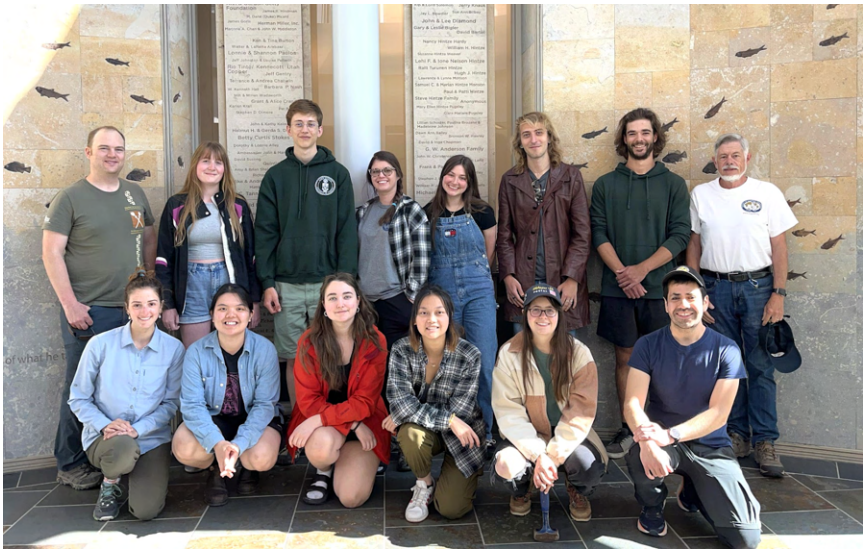


Figure 10. *Group photo at the entrance of the Geology and Geophysics building at the University of Utah.*

Before leaving the state, we stopped at Antelope Island to get a view of the Great Salt Lake and learn more about its unique properties. **Figure 11** shows the view of the lake from the island, with the causeway separating off a fragment of the lake. These lake fragments vary in chemistry and biology, as seen by the colour difference on either side of the causeway (more saline to the left). Our first stop in Idaho was in Lava Hot Springs, which (true to its name) hosts a hot spring system known to be associated with larger faults in the area (USGS, 1994).

As we continued driving north into Idaho, we could watch the geology change outside our windows. Columnar basalts were a prominent feature in southern Idaho, and, as a final stop, we went for a short hike to look at the lava flows in person at Hell's Half Acre Lava Field.

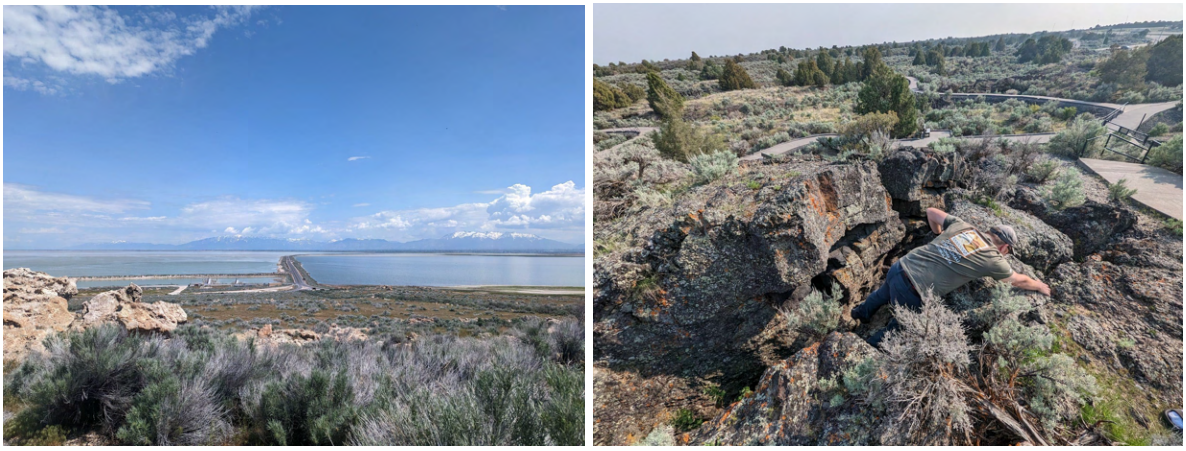


Figure 11. *View looking out from Antelope Island of the Great Salt Lake in Utah* ***(Left)****. Nearly lost Dan to the lava flows at Hell's Half Acre Lava Field in Idaho* ***(Right)****.*

References:

https://www.usgs.gov/publications/thermal-springs-united-states

Day 5: Yellowstone National Park

On day 5, we started the day early to meet our guide Shauna at the Norris Geyser Basin at 7:00 am. After Shauna gave our group a short talk on the geologic history of the area, we began our hike around the basin, with one of our first stops being the Steamboat Geyser, as seen in **Figure 12**. While the geyser did not erupt, we were surprised to see that short spurts of water were still emerging from the vent. As Shauna explained, these small jets of water and the large amounts of steam emerging from the vent are common shortly after an eruption as water returns to the geyser.

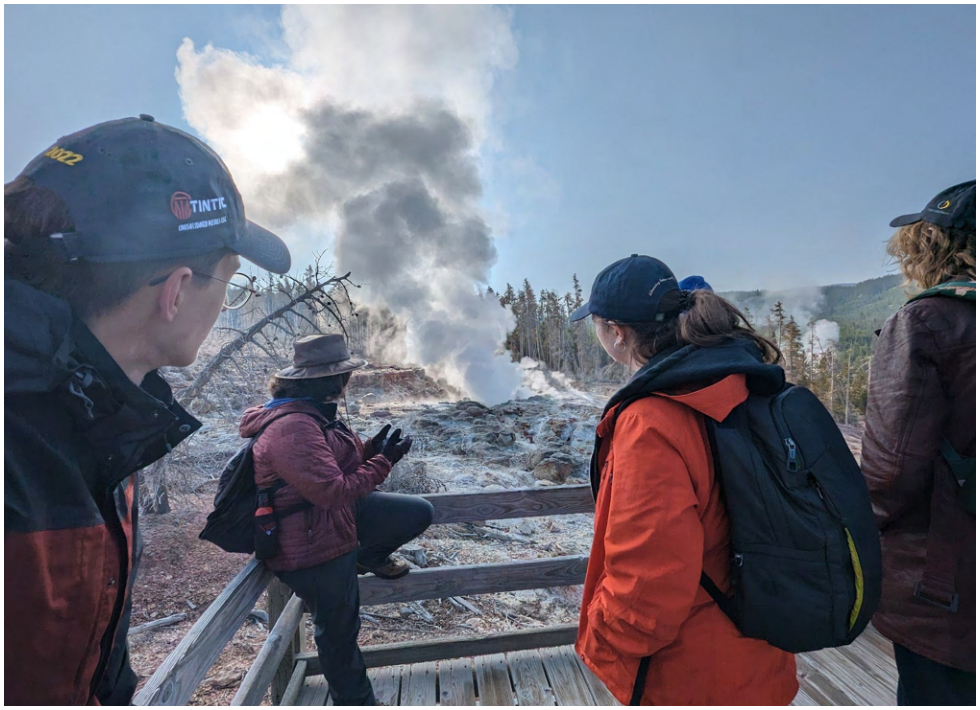


Figure 12. *Students looking out at Steamboat Geyser as our Yellowstone Insight field guide, Shauna, describes its inner workings.*

Our group continued our tour of Norris Geyser Basin, seeing various hydrothermal features before moving east to Canyon Village to learn about the park's history and see the upper falls from Inspiration Point. Here the illite-pyrite-adularia alteration has been steam-heated and overprinted by kaolinite; this overprinted interval will increase in thickness as the water table lowers with continued erosion from the river. Sinter blocks could also be seen all along the pathways in the area.

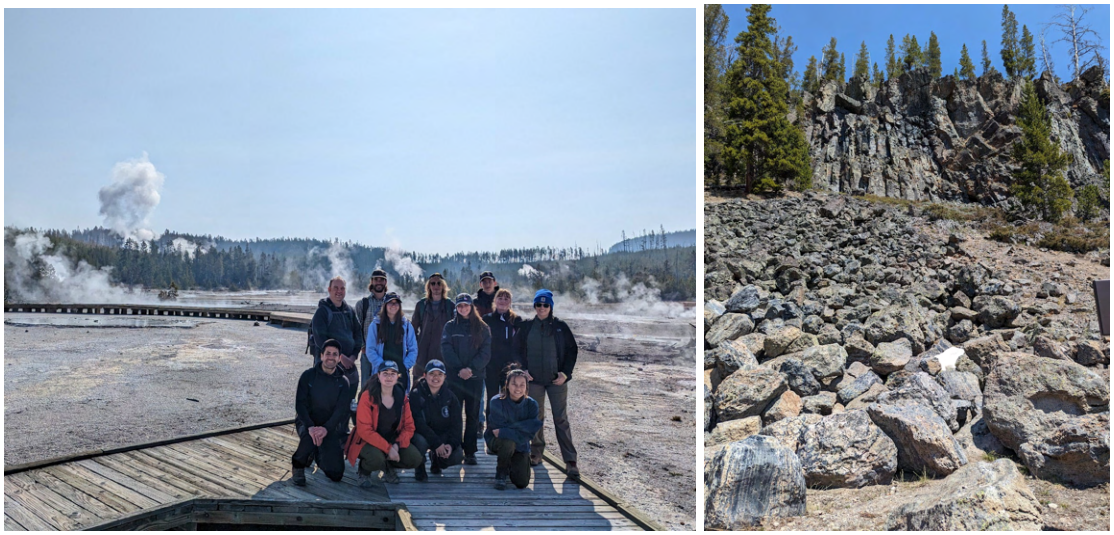


Figure 13. ***(Left)*** *Checking out the hydrothermal features at Norris Geyser Basin.* ***(Right)*** *Obsidian Cliff features one of the highest-quality obsidian deposits in the United States.*

Next, we visited the Obsidian Cliffs, **Figure 13,** a deposit that holds much significance, not only geologically but also historically. The obsidian deposit formed from a rhyolitic lava flow that cooled rapidly during the glacial maximum 180,000 years ago (Robbins, 2023). The obsidian from this cliff is known to have been used to make tools by Indigenous people ever since the last ice age some 11,000 years ago (Robbins, 2023).

Our last stop of the day was at the Mammoth Hot Springs, which featured a multitude of hot springs scattered over travertine terraces. These travertine deposits formed as a result of calcium and bicarbonate-rich waters that were heated as they moved along the local fault zone and precipitated calcium carbonate as they reached the surface (Bargar, 1978).

References:

https://www.nytimes.com/2023/03/20/science/yellowstone-indigenous-people-obsidian.html
https://pubs.er.usgs.gov/publication/b1444

Day 6: Yellowstone National Park

On day 6, we had a self-led tour of the southern portion of the park, starting in the Old Faithful region, where we were lucky enough to see two geysers erupt (Old Faithful in **Figure 14** and Beehive Geyser). The two-hour loop we walked in the Old Faithful region featured a series of geysers, pools, and fumaroles. Castle geyser, in particular, had an impressive silica sinter formation around its vent.

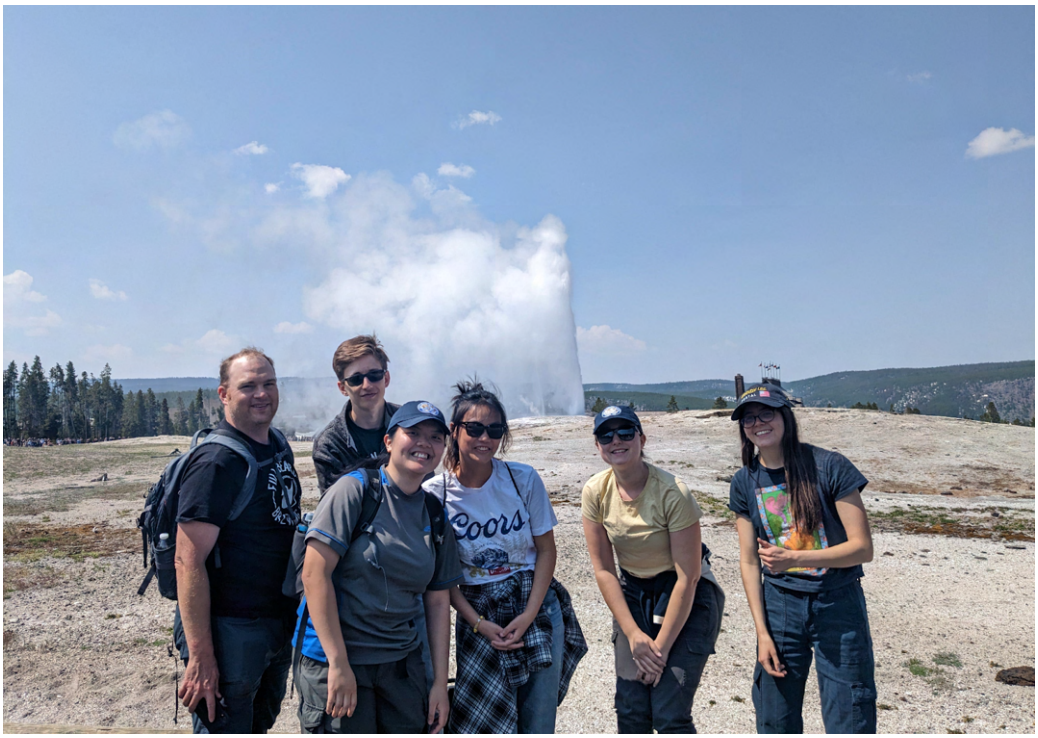


Figure 14. *Captured a photo with the Old Faithful geyser eruption in the background.*

Our next stops were at the Black Sand Basin and Grand Prismatic (**Figure 15**). These areas feature impressive hydrothermal springs with abundant microbial life (responsible for the vibrant colours seen around the pools). Excelsior Geyser, located just east of Grand Prismatic, drains into the neighbouring stream, depositing silica sinter along the stream bank. In a lecture given to us by Jeffery Hedenquist (Adjunct Professor at the University of Ottawa and world authority on epithermal deposits) shortly before the trip, we explored different epithermal deposits and their modern, active analogues, one of which being Yellowstone. It was a very eye-opening experience to see the active processes responsible for the formation of these deposits.

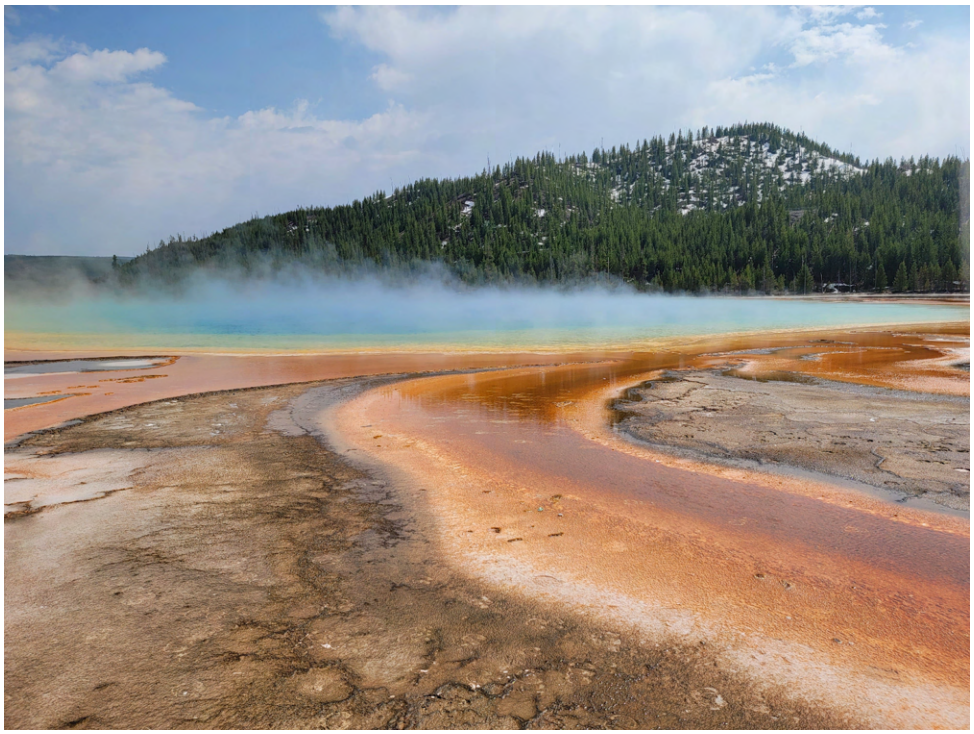


Figure 15. *Visited the Grand Prismatic Spring, the largest hot spring in the United States featuring vivid colours along its edges due to the presence of microbial mats.*

Our last stop in Yellowstone was to see the Fountain Paint Pots or bubbling mud pools. Here the bubbling was not due to boiling temperatures but vapour condensation (CO_2 bubbles).

Day 7: Sandfire Resources tour of Black Butte Copper Deposit

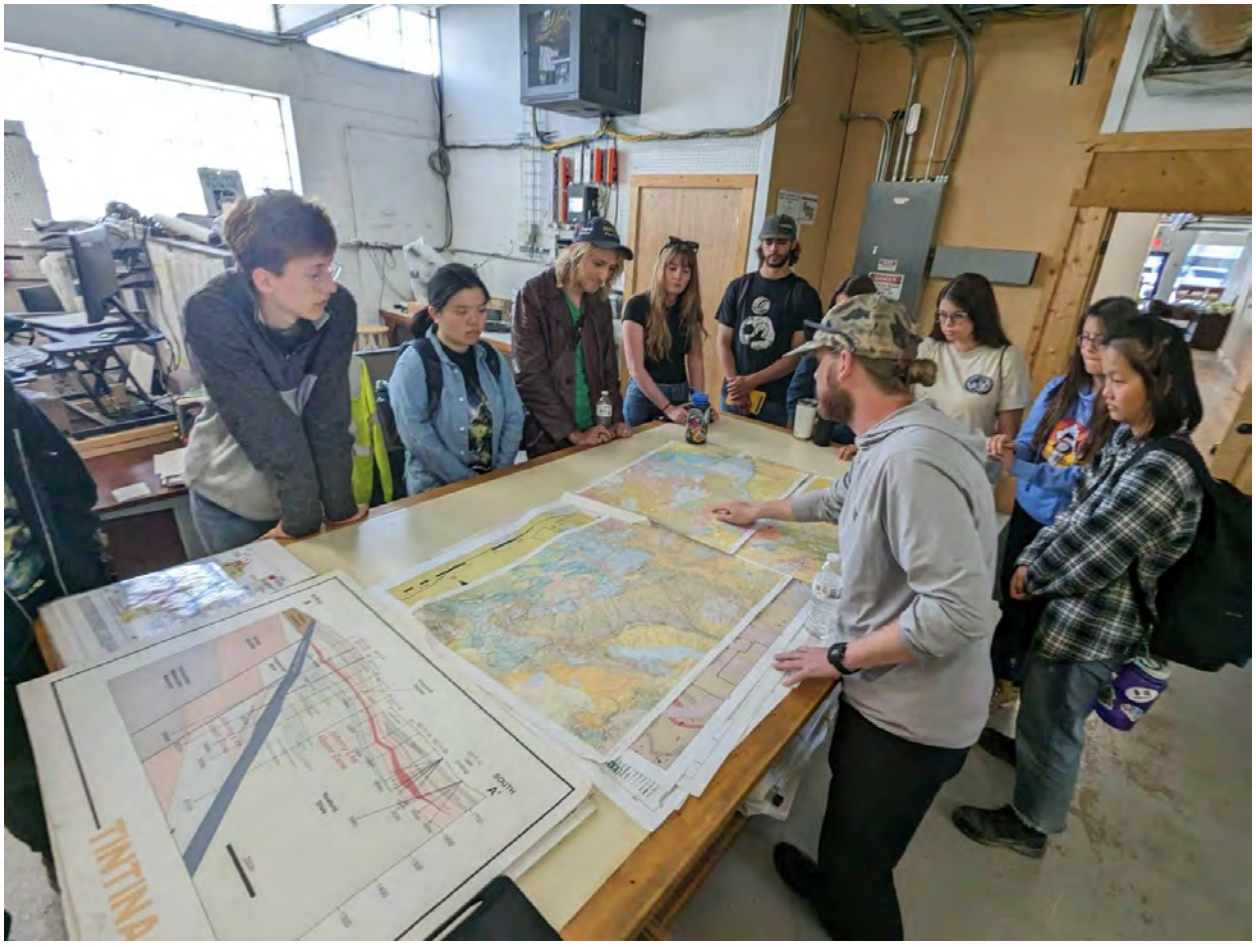


Figure 16. *Geologist Logan Bouley giving us an overview of Montana geology at the Sandfire Resources Inc office.*

On day 7, we drove from West Yellowstone to the Sandfire Resources Inc. office in White Sulphur Springs. We met up with Sandfire geologists Logan Bouley, Eric LeLacheur, Joel Dietrich, and Kyle Nacey, who gave us a short presentation about their company, the Black Butte copper project, and the geology of Montana. We also had the opportunity to look at some of the cores in their core shack. Afterwards, they led us around the project's property, where we got to see some limestone and gossan outcrops and where they planned to build the mine and other infrastructure. While their project is still in the developmental phase, it was an excellent opportunity for our students to see the different stages of a mine and the contrast compared to the fully developed underground mine we saw on day 3.

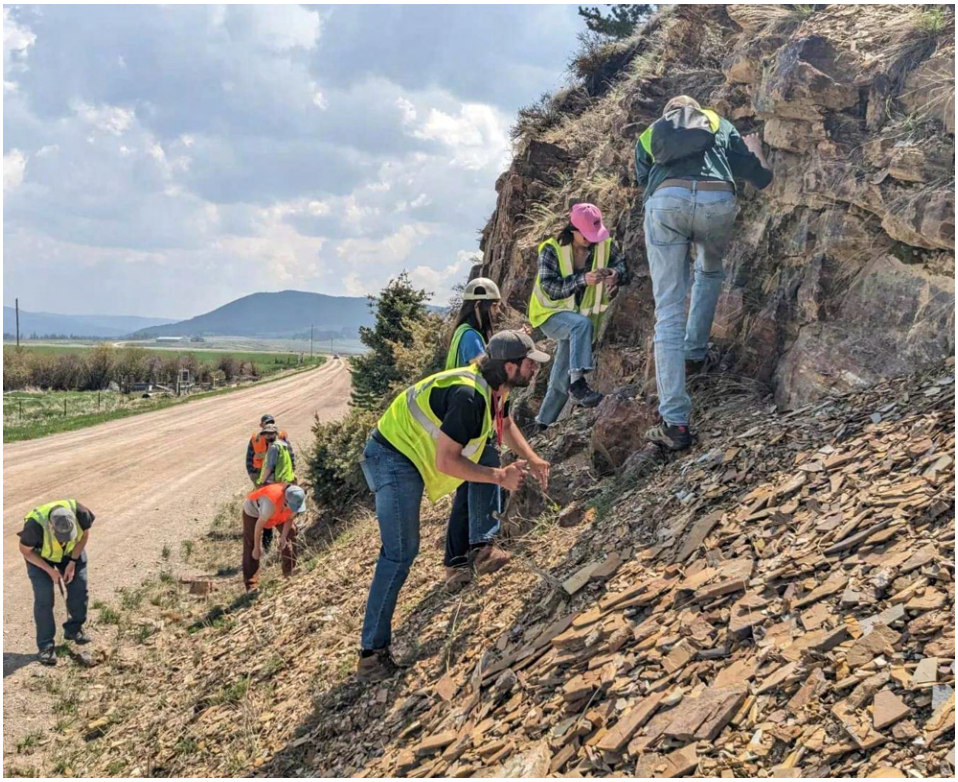


Figure 17. *Taking a closer look at a gossan outcrop- these are important indicators of underlying orebodies!*

Day 8: Butte Mining District

On the last day of our trip, we decided to do a self-guided tour of the Butte mining district in Montana. The history of mining in Butte dates back to 1864, when early miners used placer mining, or gold panning, to find gold. As this method began to exhaust itself, vein and block cave mining became the primary means of extracting metals such as silver, copper, lead, zinc and manganese. By the mid-1950s, open pit mining for copper and molybdenum began, while underground mining began to phase out around the late 1970s.

We began the day visiting the Berkeley Pit, a former open pit porphyry mine. It began in 1955 by the Anaconda Co, but by 1983, production was halted as mining became less profitable at Berkeley Pit. A total of 1.4 billion tons of ore had been mined in its lifetime. As of 2012, the pit is filled with 41.2 billion gallons of water, which began flowing back into the underground workings and pit after pump stations were turned off following the mine's closure. The water is highly acidic and rich in naturally occurring metals like cadmium, iron, cobalt, etc.

References:

Guided audio tour and information boards at the Berkeley pit viewing stand

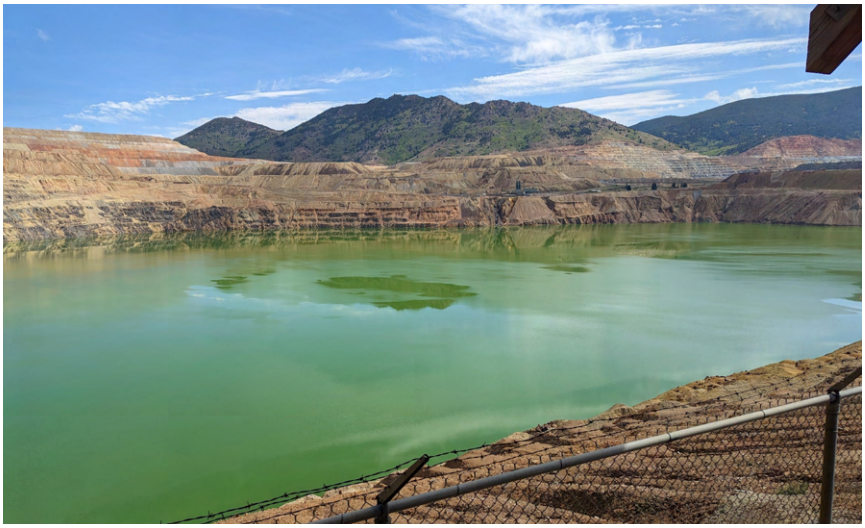
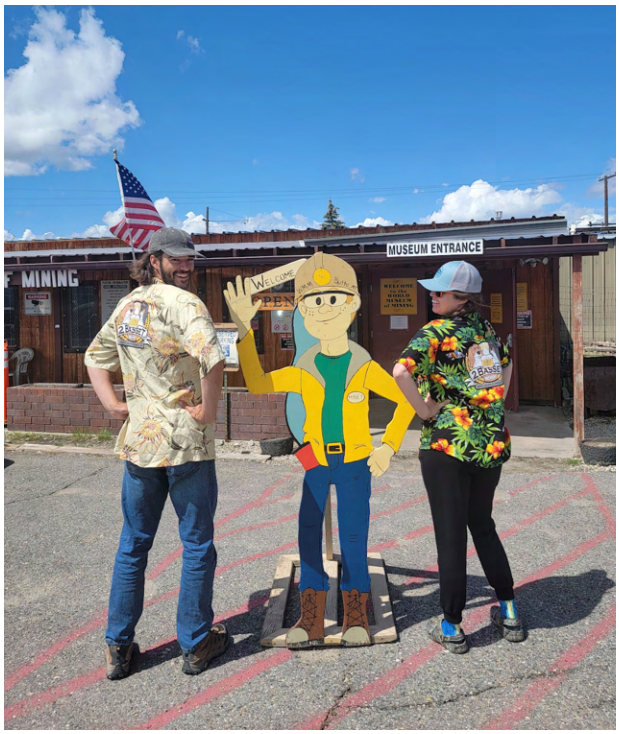


Figure 18. *Looking out at Berkeley Pit, a former open pit porphyry mine.*

Afterwards, we made our way to the World Museum of Mining to learn more about the history of mining in Butte. The museum is located on the site of the Orphan Girl Mine, a former underground mine from 1875 to 1956. It was mined for silver, lead and zinc to a depth of 3200 feet. We explored the mining camp and got a unique glimpse into the everyday lives of the Butte residents. Some of our students decided to go on the guided underground tour of the Orphan Girl mine, where they got to go 100 feet underground and learn about the mine's history!



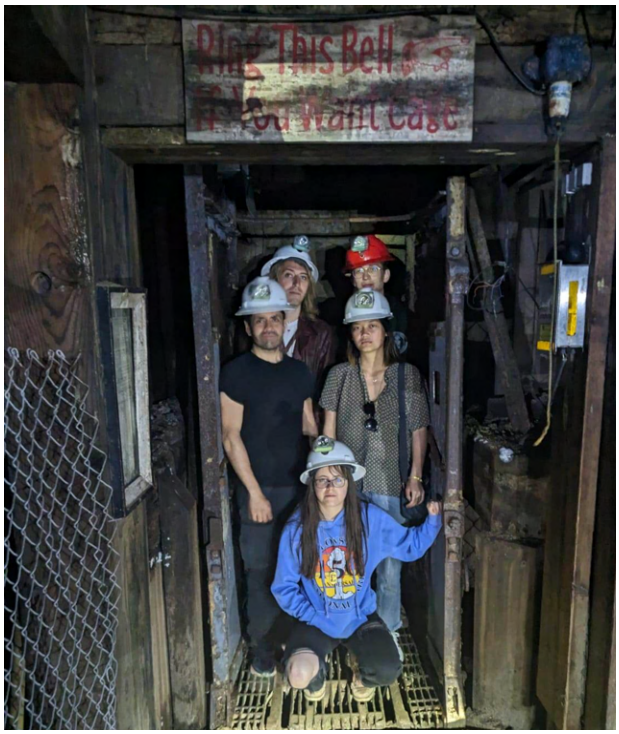


Figure 19. *Exploring the World Museum of Mining in Butte, Montana.* ***(Left)*** *Caden and Jenni posing with Miney outside the museum entrance,* ***(Right)*** *Students looking serious in the mineshaft on the underground mine tour.*

For our final stop, we dropped by the Mineral Museum located on the campus of Montana Tech, where we got to check out amazing rock and mineral specimens.

Day 9: Flight Home

We flew out of Bozeman, Montana, early on Tuesday morning and arrived back in Toronto in the afternoon.