



# 2017 OREGON SEG FIELD TRIP

## ARIZONA AND NEW MEXICO

**Field trip report prepared for the Society of Economic Geologists:  
Stewart R. Wallace Travel Fund**

Report prepared by: Michelle Campbell

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### Overview

Members of the Oregon SEG Student Chapter embarked on a 12-day field trip to Arizona and western New Mexico in early December, 2017. Support for this trip was graciously provided by the SEG Stewart R. Wallace Fund, as well as the Emrick Travel Fund from the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University.

The broad aim of the trip was to expose student members to examples of the many world-class porphyry Cu ± Mo deposits and related skarn deposits of the southwestern United States. Additionally, we visited field exposures exemplifying the tops and bottoms of porphyry Cu ± Mo deposits, from the unmineralized upper crustal magma chamber root zones to high-level lithocaps.

Students from a variety of academic backgrounds, and with a range previous industry experience, were in attendance. Trip participants included both undergraduate and graduate SEG members, as well as porphyry Cu deposit expert professor John Dilles:

- Prof. John Dilles
- Michelle Campbell (PhD candidate)
- Nansen Olson (PhD student)
- Mike Sepp (PhD student)
- Huanhuan Yang (visiting PhD student from China)
- Juan Carlos Cuellar (MSc student)
- Joe Ghiorso (undergraduate student)
- Nicole Hunt (undergraduate student)

### ITINERARY HIGHLIGHTS

#### December 10-11

Historic workings in the Patagonia Mountains, AZ

#### December 12

Resolution Copper deposit and Christmas skarn deposit, AZ

#### December 13

University of Arizona Lowell Program Field Trip: Day 1

#### December 14

University of Arizona Lowell Program Field Trip: Day 2

#### December 15

Santa Rita mine, NM

#### December 16

Tyrone mine, NM



## Itinerary



Figure 1. Giant Saguaro cacti in Saguaro National Park.

### DECEMBER 8-9, 2017

Drive from Corvallis, OR to Phoenix, AZ.

### DECEMBER 10, 2017

Drive to the Patagonia Mountains of southern Arizona, stopping by Saguaro National Park, just east of Tucson. Established in 1933, Saguaro National Park is home to some of the largest cacti in the United States – the saguaro (*Carnegiea gigantea*), which is native to the Sonoran desert.

The park features exposures of the early Proterozoic Pinal Schist and the Catalina gneiss – important basement formations within the region. The park also features examples of Basin and Range Province faulting, which has significantly impacted the modern landscape and geology of southern Arizona.

During the afternoon, trip participants drove south to the Patagonia Mountains to visit the “Four Metals” deposit and historical workings. This small former underground mine featured near-surface copper mineralization hosted within quartz monzonite porphyry and breccias. The road up to the workings presented opportunities to view EDM (Early Dark Micaceous) style veining, and gradual changes in hydrothermal alteration as we neared the deposit. Finally, a dump and old adit entrance provided samples of the chalcopyrite mineralization typical of Four Metals.



Figure 2. Gossanous outcrops of the Four Metals deposit.

**DECEMBER 11, 2017**

We returned into the Patagonia Mountains the next day for a self-guided tour of the “3R” deposit and historical workings, situated to the north of Four Metals. Walking up towards the deposit allowed trip participants to examine sericite, pyrophyllite, and kaolinite alteration in Jurassic granite host rocks, as well as supergene chalcocite and copper oxide mineralization.

We ended the day on the road towards the nearby Sunnyside deposit. Sunnyside is thought to represent the shallow portion of a porphyry Cu system, and contains elements such as silica ribs which are indicative of a lithocap environment.



*Figure 3. Supergene chalcocite and copper oxides in a sample from the 3R workings.*



*Figure 4. Examining altered granite samples near the 3R mine.*

**DECEMBER 12, 2017**

After driving up to the town of Superior, AZ, the previous evening, our group was very pleased to receive a morning tour of the Resolution Copper core facility. A presentation and overview of select drill core was provided by Hamish Martin, Chief Geologist of the RTZ Resolution Project.

The Resolution porphyry Cu-Mo deposit represents one of the world's largest undeveloped deposits of copper, with an Inferred Resource of 1.6 billion tonnes grading 1.4% Cu and 0.03% Mo. The presentation and core overview allowed trip participants to review the various important lithologies and styles of alteration and mineralization at Resolution, including a relatively shallow upper zone rich in hypogene chalcocite and bornite, and deeper chalcopyrite-bearing zone. The tour also included an interesting discussion about why the Resolution deposit is so well-endowed, including factors such as the presence of favourable host rocks (e.g., diabase dykes and limestone), the occurrence of hypogene Cu enrichment, and the lack of unfavourable faults or poorly mineralized late dykes.



*Figure 5. Approaching the town of Superior, AZ.*

After lunch, we drove towards Winkelman, AZ, stopping briefly at the overlook of the large Ray porphyry Cu mine.



*Figure 6. View of the Ray Porphyry Cu mine from the highway overlook.*

During the afternoon, we visited the Christmas skarn and porphyry Cu mine, situated just northeast of Winkelman. Our tour was led by Ralph Stegen and David Princehouse of Freeport-McMoRan. We viewed exposures of the Naco limestone – complete with horizons of garnet skarn featuring Cu mineralization – and granodiorite porphyry thought to be associated with skarn genesis.



*Figure 7. Panorama of part of the Christmas deposit pit.*



*Figure 8. Naco limestone with minor skarn mineralization.*

**DECEMBER 13, 2017**

***University of Arizona Lowell Program, Day 1***

On December 13<sup>th</sup> and 14<sup>th</sup>, our group met up with the participants of the University of Arizona's annual Lowell Program field course, led by professors Dr. Mark Barton and Dr. Eric Seedorff. These experts on porphyry and skarn mineralization in Arizona were able to provide us with new insights into the Laramide orogeny as well as the complexities relating to the later Basin and Range faulting and dismemberment of the region.



*Figure 9. University of Arizona professors Dr. Mark Barton and Dr. Eric Seedorff provide an overview of the regional geology of southern Arizona.*

A highlight of the day was a hike up Black Copper Wash, which provided an excellent in-situ overview of the supergene transport of metals. Important horizons within the supergene profile included ferricrete, Mn oxide horizons, a leached zone, and exotic Cu mineralization including chrysocolla and azurite.



*Figure 10. Ferricrete from Black Copper Wash.*



*Figure 11. Contact between ferricrete (upper half) and Ruin granite basement (lower half). Stringers of exotic Cu oxide mineralization occur along this horizon.*



*Figure 12. End of day overview of the Ray Mine.*

**DECEMBER 14, 2017**

***University of Arizona Lowell Program, Day 2***

Our second day with the University of Arizona group began with a morning overview of the geology in the Globe-Miami area, including quartz veining and greisen veining in the Schultz granite, as well as breccias within the Schultz granite, which may represent features characteristic of the very deep porphyry environment.

The afternoon was spent touring the Ray porphyry Cu mine, owned by Asarco/Grupo Mexico. Following a brief overview of the geology of the mine, we were able to drive down into the active open pit and view in-situ examples of the important lithologies, alteration styles, and mineralization.



*Figure 13. Touring the open pit Ray mine.*



*Figure 14. Mineralized quartz veins in diabase sill, Ray mine.*

**DECEMBER 15, 2017**

Following an evening drive out of Arizona, we arrived at our first destination on the New Mexico leg of our tour: the Santa Rita (Chino) mine. Andy Lande of Freeport-McMoRan provided us with a tour of this open pit porphyry Cu and skarn mine. Copper mineralization at Santa Rita is primarily contained within hypogene chalcopyrite, with minor supergene enrichment. The emplacement of the Santa Rita stock also resulted in magnetite-garnet-pyroxene-epidote-chlorite skarn formation in Paleozoic carbonate strata along the periphery of the stock.



*Figure 15. Panorama of the Santa Rita (Chino) mine.*

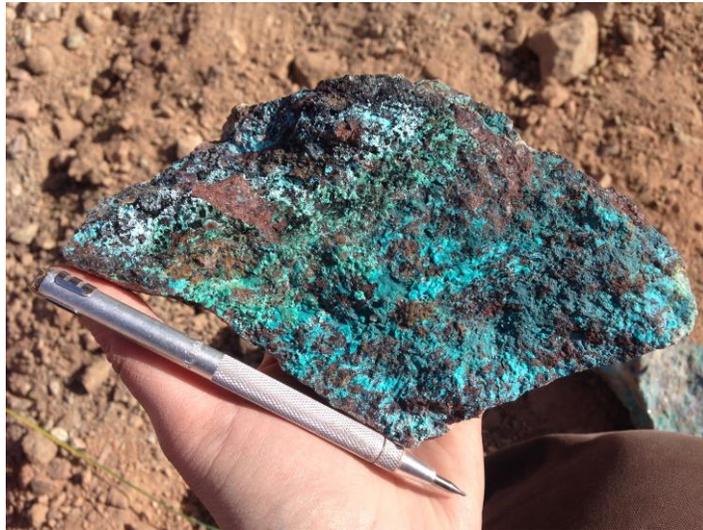


*Figure 16. Examining the geology of the open pit Santa Rita mine.*

**DECEMBER 16, 2017**

Our final destination was the Tyrone porphyry Cu mine, another Freeport-McMoRan holding in New Mexico, located southwest of the Santa Rita mine. Our tour guides were Dave Princehouse and Luc Farmer, two Oregon State University alumni. We received an excellent presentation on the geology of this long-lived mine, and were able to visit two of the open pits.

Highlights of the tour included the examination and collection of supergene copper oxide specimens, including lesser known minerals such as brocathite.



*Figure 17. Supergene copper oxide mineralization, Tyrone mine.*



*Figure 18. Participants of the 2017 Oregon SEG field trip to Arizona and New Mexico in the Tyrone open pit mine.*

**DECEMBER 17-18, 2017**

Drive from New Mexico to Corvallis, OR, stopping at the giant Morenci porphyry Cu mine on the way. Sudden inclement weather meant an unexpected snow storm in Arizona!



*Figure 19. "View" of the Morenci mine, Arizona, one of the largest copper mines in the US.*



*Figure 20. Time to drive back to Oregon!*

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## **Acknowledgements**

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We would like to sincerely acknowledge the financial contributions for this trip provided by the SEG Stewart R. Wallace Fund, as well as the Emrick Travel Fund from the College of Earth, Ocean, and Atmospheric Sciences at OSU. We would also like to thank Hamish Martin, Eric Seedorff, Mark Barton, Sterling Cook, Ralph Stegen, Andy Lande, Dave Princehouse and Luc Farmer for the excellent tours and presentations provided for our group, as well as RTZ Resolution, Asarco, and Freeport-McMoran for providing us access to the very interesting deposits included in our field trip.