



Arizona field trip summary (27th January – 6th February 2019)

On 27th January 2019, after many months of planning, 11 members of Bristol's Society of Economic Geologists (SEG) Student Chapter embarked on a 10-day field trip to Arizona, USA. The field trip was supported by generous donations from the SEG and Bristol's Porphyry Copper Deposit (PCD) Research Group's industry collaborator - international mining company BHP.

Arizona is host to a highly variable suite of world-class PCDs in the Laramide magmatic arc, which has been explored for and mined for over 100 years. The deposits formed from intrusive igneous activity related to flat-slab subduction of the Farallon plate beneath the North American plate between 80 and 55 Ma. Later extensional deformation (Basin and Range tectonics) resulted in pervasive normal faulting in the region that caused dismemberment of PCDs and has created challenges for exploration and mining.

Over the course of a 1,500 mile road trip, students got to learn about the unique geological processes involved in the formation and modification of PCDs in the Laramide magmatic-tectonic province and to gain insights into modern techniques of mineral exploration, extraction and processing. As Arizona is the home of the Grand Canyon and many other geological wonders, we also had the chance to partake in some geotourism!

The tour started at the University of Arizona's San Xavier Underground Mining Laboratory, a facility managed by students of the University of Arizona, Tucson. Between clambering down over 200 ft of ladders, we learned about underground exploration and extraction and how to both blast (even holding plastic explosives!) and stabilise a mine shaft (with a live demonstration of the jack-up drill used in the placement of supporting bolts).

The next stop was BHP's office in Tucson, where we had an introductory presentation on the regional geology of Arizona and students were able to present their work to senior members of the exploration team. Juan Fajardo, an exploration geologist with BHP, conducted the next two days of mine tours. Our first visit was to San Manuel-Kalamazoo, an elongate orebody sliced in two by normal faulting, where renowned exploration geologist David Lowell developed the first geological model for porphyry copper deposits based on zoned alteration halos. We visited localities in both the foot wall and hanging wall of the San Manuel fault, including the Red hill which led to the discovery of the deposit and the Purcell window - the only surface outcrop of igneous rock in the Kalamazoo side of the deposit.

Our second visit was to Miami-Copper Cities, a copper district east of Phoenix. The site is currently under care and maintenance after a prolonged history of open pit mining and in situ copper leaching. Copper Cities occupies a local horst, surrounded on three sides by faults which border the mineralisation (the Drummond, Coronado and Sleeping Beauty faults).



Bristol SEG at the San Manuel pit overlook. Red Hill, which led to discovery of the deposit, can be seen in the background.

The next stop on our itinerary was the planned underground mine at Resolution, near the site of the old Magma vein. High grade copper mineralisation at Resolution lies 7000 ft beneath the surface and the planned extraction will involve highly advanced underground mining techniques. Work is ongoing to retrofit and deepen legacy workings. Hamish Martin (Rio Tinto) gave our group an in depth lecture on the deposit and we had the chance to visit the most beautiful core shed in the world. In the course of our visit we also had a demonstration of the rock strength testing device and the optical and acoustic borehole imaging methods used to orient drill core and conduct in-situ analysis of rock fabrics.

The weekend forced us to spend two days doing something different. Saturday saw us road-tripping through the red beds of Sedona on our way up to the Grand Canyon. We spent the last hours of daylight wandering along the South Rim staring into the distance before heading back south to Flagstaff for the night. On Sunday we drove a (very) scenic route back to Phoenix via the Petrified Forest National Park, home of the famous Painted Desert of colourful sedimentary units and fossilised Triassic plant life.



Looking north across the Grand Canyon from the South Rim.

On the last full day of the trip we set out early from our accommodation in ominous cloud and rain to visit ASARCO's Ray mine, the only active copper mine we visited during the trip. Dr Sterling Cook was a great host, nimbly piloting a very unrugged minibus around very rugged, muddy roads. Ultimately the weather proved victorious and the group had to leave the pit area. The remaining time was spent in the ore concentrator plant, where students were mesmerised by the SAG mill, shake tables and froth flotation tanks. Added bonuses were having a group photo op on one of the big mine trucks and getting to see Ray's pink mine truck in action (repainted in support of Breast Cancer awareness).



Bristol SEG aboard a big mine truck in Ray Mine.

The group returned to BHP's Tucson office for a concluding wrap-up discussion with the exploration team followed by a networking activity which in true geologist fashion took place in the local pub. Exhausted but happy, we returned to Phoenix, got pizza delivered and slept. The final geological excursion involved a trip to the Hard Rock Cafe before a lengthy return journey to the UK.

Bristol SEG Student Chapter are very grateful to the SEG for supporting this field trip. The \$2000 awarded went towards accommodation for the group. In all cases we opted for the best value accommodation – generally large houses offered through AirBnB, with a couple of nights in budget motels where necessary. Attached to this document is a spreadsheet detailing the spending for the trip and receipts showing the accommodation costs which the SEG money was used for.

Arizona Fieldtrip Budget (for 11 people, 9 nights)

N.B. pp denotes per person, 1 USD = 0.7753429 GBP based on 30 day average from 31st Jan 2019 from www.xe.com

Transport	Description	Cost (£)/pp	Cost (\$)/pp	Total (£)	Total (\$)	
UK-US International Travel (Group 1)	Flights London Heathrow-Phoenix International RTN	£ 703.82	\$ 914.00	£ 5,630.56	\$ 7,263.00	
UK-US International Travel (Group 2)	Flights London Heathrow-Phoenix International RTN	£ 728.82	\$ 946.00	£ 1,457.64	\$ 1,880.00	
UK-US International Travel (Group 3)	Flights Phoenix International-London Heathrow	£ 301.40	\$ 392.00	£ 301.40	\$ 389.00	
Travel Insurance	Travel Insurance	£ 15.00	\$ 20.00	£ 150.00	\$ 194.00	
US Internal Travel	Car hire, Budget ~£400 per vehicle; 2 required	£ 73.00	\$ 95.00	£ 799.64	\$ 1,032.00	
US Internal Travel	Fuel, Budget £150 per vehicle	£ 18.00	\$ 24.00	£ 190.69	\$ 245.94	
				Total	£ 8,529.93	\$ 11,003.94

Accommodation	N.B Budget £30 pp pn					
Accommodation (Motel)	27/01/2019; 1 night Airbnb Phoenix	£ 33.04	\$ 43.00	£ 363.47	\$ 469.00	
Accommodation (Motel)	28-31/01/2019; 3 nights Airbnb Tucson	£ 43.08	\$ 56.00	£ 473.85	\$ 612.00	
Accommodation (Motel)	28-31/01/2019; 3 nights Airbnb Tucson	£ 30.86	\$ 41.00	£ 339.49	\$ 438.00	
Accommodation (Motel)	31/01/2019; 1 nights Booking.com Globe	£ 21.91	\$ 29.00	£ 241.00	\$ 305.10	
Accommodation (Motel)	01/02/2019; 1 nights Airbnb Pine	£ 30.57	\$ 40.00	£ 336.32	\$ 434.00	
Accommodation (Motel)	02/02/2019; 1 nights Booking.com Flagstaff	£ 22.45	\$ 30.00	£ 247.00	\$ 311.58	
Accommodation (Motel)	03/02/2019; 1 nights Airbnb Phoenix	£ 22.02	\$ 29.00	£ 242.21	\$ 313.00	
Accommodation (Motel)	04/02/2019; 1 nights Airbnb Phoenix	£ 23.80	\$ 31.00	£ 261.80	\$ 338.00	
				Total	£ 2,505.14	\$ 3,220.68

Total Spending	£ 11,035.07	\$ 14,224.62
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