

## EES Spring 2017 Arizona Trip

In March, 2017, nine EES majors accompanied Professors Cunningham and Drzewiecki to Arizona for an action-packed geological tour of the Grand Canyon state. After an early morning flight to Phoenix, the group drove north to Val Verde and then ate a cheap Mexican dinner and collectively got heartburn.

But, after some recuperative sleep, we were ready for the adventure to begin and so we explored the continuously bubbling Montezuma Well sinkhole, stood in awe beneath the Montezuma Castle cliff dwelling and scrambled over and squinted at the glistening Camp Verde salt mine. The latter is possibly the oldest mine in the Americas and famous for its gypsum, halite, glauberite and calcite deposits. We learned about the geological evolution of the Camp Verde rift system and the 6<sup>th</sup>-15<sup>th</sup> century Sinagua culture and what human and natural causes may have caused its demise. Then we headed up the Mingus Mountain footwall block to the famous Jerome mining town where we went to the excellent museum and watched an entertaining and educational documentary film about the town's mining heyday, fortunes, misfortunes, vices, virtues and modern revival as a tourist and artisan center. We couldn't resist a 45-minute hunt for colourful copper minerals in one of the town tailings dumps. Some nice azurite and malachite samples were found by our eagle-eyed students.



The next day we drove to Sedona and took two beautiful hikes where we came face-to-face with the upper Colorado Plateau stratigraphy exposed in the stunning canyons around the city. On our second hike in the upper Oak Creek canyon region, we made 6 stream crossings before bushwacking our way up to a

high area where gorgeous cliffs, cross-bedded strata and the forested canyon below kept our camera shutters busy.

Then we drove to Flagstaff and spent a day exploring the San Francisco volcanoes including Sunset Crater National Park and the Wupatki National Monument pueblo ruins. Late in the day, we ventured NW to the famous S-P cinder cone, a first visit for all of us. We slogged up to the crater rim which was a stumbling, back-sliding, 3-steps-up/2-steps-down struggle, but upon reaching the top, all felt triumphant. We were rewarded with sublime views of the surrounding volcanic landscape with lavas, cinder cones and the snow-capped Humphreys Peak strato-volcano looming to the south. We had the mountain entirely to ourselves and for many of the students, this adventurous hike with its dramatic views of the vast northern Arizona landscape was the highlight of the trip.



The next day was sunny and gorgeous and perfect for heading north to the Grand Canyon. We stood on the south rim and gazed at the canyon's majesty while discussing the stratigraphy, unconformities and landscape features that are visible from different points along the rim trail. We then took the shuttle bus to the South Kaibab Trail head and began our hike to Ooh-Aah Point. The park was crowded, but as we descended, we stopped to observe geological features of the Kaibab and Toroweap Formations and to discuss evidence for paleo-environments of deposition. We all took photos of ourselves at Ooh Aah Point which is aptly named. It is an amazing experience to be 800 feet below the rim, but to look over the cliff and realize there is still at least another 4000 feet to go down before reaching the Colorado River. Once again, we were impressed with the sheer immensity of the canyon.



EES students on top of SP Crater,  
San Francisco Volcanic Field

The following morning we travelled east and geologically up-section into the red Triassic Moenkopi sandstones and saw what happens when an extra-terrestrial nickel-iron rock, 50-m across, hits the Earth at 13km/second. Meteor Crater is a powerful reminder that our planet is vulnerable to dramatic impacts at any time. We went on a tour of the crater rim and learned about the geological and environmental effects of the impact, the composition of the meteor, the history of geological thought about the crater's origin, and the mining of the iron meteorite fragments.

In the afternoon we ventured east to Petrified Forest National Park and the Painted Desert. We hiked the Long Logs and Blue Mesa trails and visited other overlooks and sites of interest that included sedimentological/stratigraphic features, stark desert landscapes and pre-Columbian petroglyphs. We were amazed at the sizes of some of the petrified logs and the beautiful diversely colored silicification that each log displays.

The next day was a long drive south via the impressive Salt River Canyon to Tucson, returning to the Basin and Range Province and springtime in the Sonoran Desert. In the Salt River Canyon, we stopped at several locations to see the famous Mogollon Rim gravels, Precambrian stromatolitic marbles, doleritic sills and Transition Zone scenery. In the late afternoon, following a brief visit to the beautiful 18<sup>th</sup> century San Xavier Mission, we arrived at the Asarco Mission Mine Mineral Discovery Center where we took a tour of the huge open-pit copper mine and its mineral processing facilities. The sheer scale of the operation with

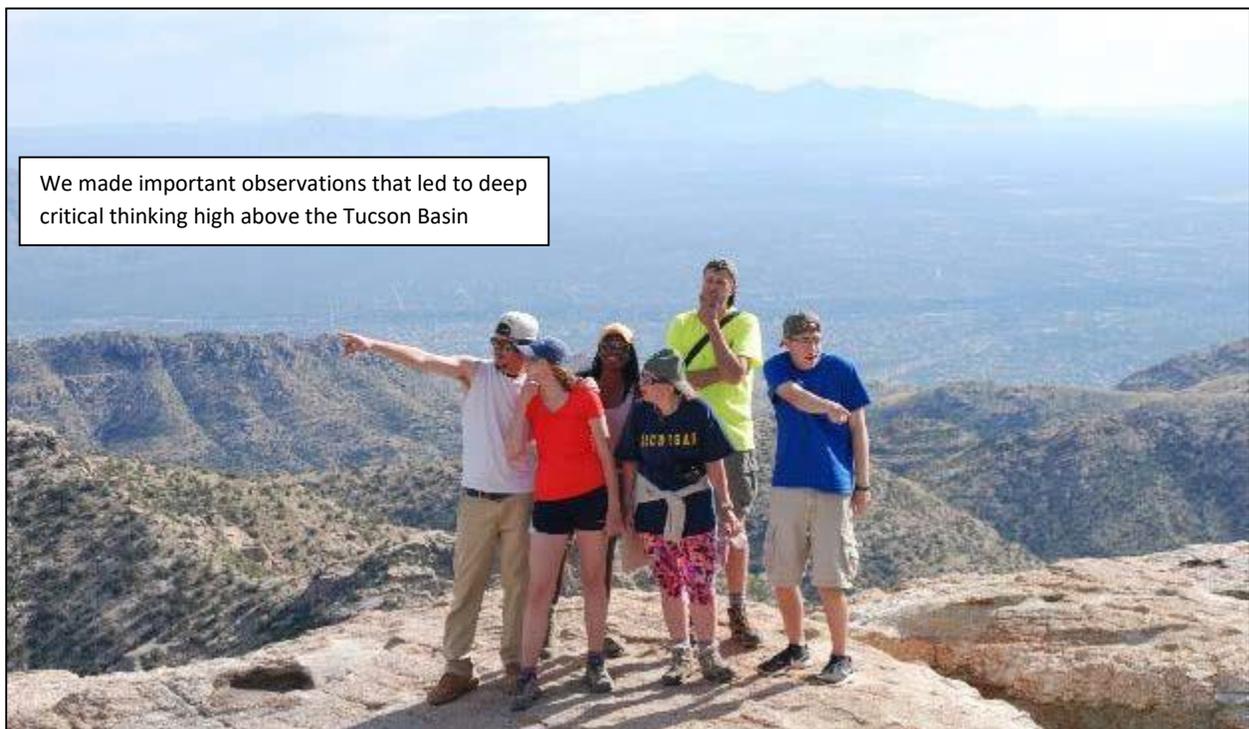


its massive open pit, gigantic diggers and haul trucks, and rotating steel ball mills left an indelible impression on all of us. The information on how the raw ore is extracted, physically crushed, separated and chemically refined was perhaps the most educational part of the tour.

The next day we took the public trolley up the oasis-like Sabino Canyon into the heart of the Santa Catalina Mountains on the north side of Tucson. We were able to see the mylonitic orthogneisses and pegmatites in the footwall of the metamorphic core complex and study the lithologies, structures and tectonic history of the rocks in the context of Basin and Range Province crustal extension. We also took note of the impressive rock joints in the valley walls and discussed competing processes of desert canyon development in the American southwest. After lunch we drove up the Catalina Highway as far as Windy Point where we enjoyed stupendous views of the Tucson Basin a mile below and the rugged mountain landscape of the inner Santa Catalina range. We could see as far as the Mexican border and from this high vantage point, the basin and range topography of southern Arizona was obvious to everyone.

On our final day, we ventured into the Tucson Mountains to examine the Laramide volcano-sedimentary history of the range's caldera complex and the diverse and colorful ecology of the Sonoran Desert in Saguaro National Park. We completed several desert hikes including one to an abandoned copper mine. After lunch, we visited the Sonoran Desert Museum which has wonderful displays of the deserts flora, fauna, geology and cultural history.

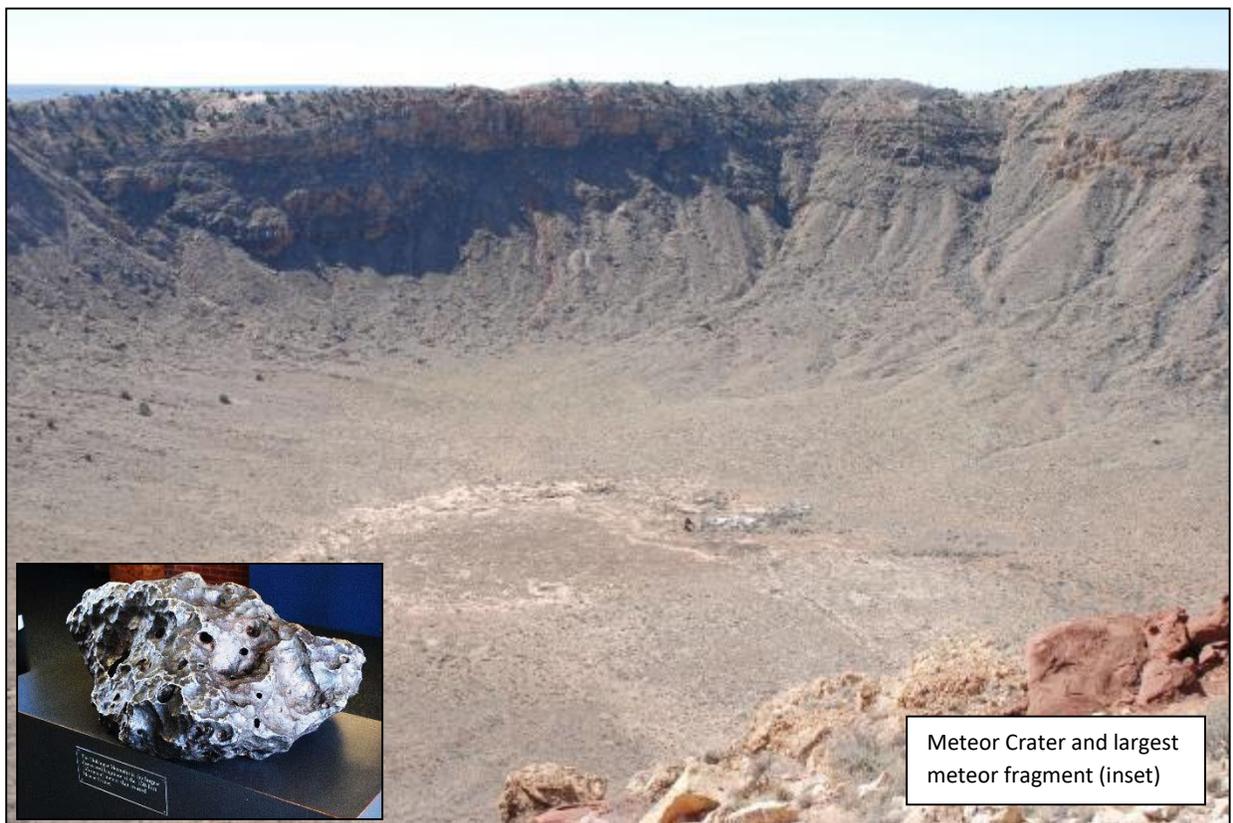
The trip was a great success. We had ideal weather – sunny and pleasant every day. The students were engaged and enthusiastic throughout, and the small cohort allowed us to get to know each other well and collectively enjoy a marvelous educational adventure.







Lava flow view from SP Crater rim



Meteor Crater and largest meteor fragment (inset)



Springtime in the Sonoran Desert, Sabino Canyon, Tucson



Petroglyphs, Tucson Mountains

