Canary Islands Field Trip

Students, faculty, experience "world class geology"

Text and photos by Brad Singer

After a seminar held during the 2007 spring semester on the petrologic and geophysical evolution of the Canary Islands, a group of seven graduate and two undergraduate students led by Professor **Brad Singer**, traveled to the islands for a two week field excursion from May 19-June 1. We were joined by former faculty member **Richard Allen**, now at the UC Berkeley Seismological Laboratory, who rounded out our diverse group with expertise across geophysics, igneous petrology, sedimentology, and structural geology.

The Canary Islands archipelago is a Miocene to Recent chain of volcanoes that have grown over a mantle plume beneath the eastern Atlantic Ocean. The Canaries resemble the Hawaiian Islands in many ways, but multiple stages of volcano growth are far better preserved in the Canaries owing to slower movement of the oceanic lithosphere of the African plate over the mantle plume and limited subsidence of the large volcanoes.

After the overnight flight from O'Hare to Madrid, on May 20th we boarded the plane for the island of Tenerife, the largest of the Canary Islands. Tenerife displays perhaps the most complete record of hot spot volcano evolution in the world. Geological wonders include Pico de Teide, the third highest volcano on Earth (behind Mauna Loa and Mauna Kea), and the steepest stratovolcano whose northern flank rises from sea level to the 3718 m summit in less than 13 km. Collaborator and friend, Juan Carlos Carracedo, a scientist at the Spanish government's volcano observatory on Tenerife, was our guide for the first five days of the trip.

Waking to spectacular views of Pico de Teide and jet lag on the first day, we drove up from our rented "casa rurale" in the town of Orotava in the north central part of Tenerife into the Late Pleistocene Cañadas Caldera, in which the more recent Pico de Teide has grown. At 2,200 m elevation the air was cool and moist with clouds that had perched over the southwestern corner of the island. After an orientation to the caldera structure and the post-caldera lava flows, domes, and stratocones of Pico de Teide and the Pico Viejo flank vent given by Juan Carlos, we headed to the active rift zone that connects the Miocene-Pliocene shield volcano of Teno to the recent Pico de Teide cone. Here we saw evidence of mingling between basaltic rift magmas and phonolitic magmas more typical of the post-caldera stratovolcanos.

On May 22nd we headed west from Orotava along the coast, stopping to study outcrops of Late Pleistocene to Recent pyroclastic cones and lava flows comprising basalt and trachyte, to eventually traverse more than 1,500 m of thick lava flows and sheeted dike swarms of the massive Teno shield volcano that holds up the northwest corner of Tenerife. On May 23rd we headed back up into the Cañadas Caldera for a day-long 15 km walking traverse across the eastern caldera floor. Before noon we split into two groups, each ascending the 200 m tall caldera rim escarpment in locations 2 km apart, to observe lava flows and pyroclastic deposits associated with formation of the Cañadas shield volcano and its collapse to the north 200,000 years ago. The two groups compared notes and debated the lateral continuity of phonolitic ash falls and flows over a cool, but very sunny, lunch at the foot of the stunning peak of Teide.

On the 24th Juan Carlos joined us at the cable car for the ride up to near the summit of Pico de Teide, which was arguably the most spectacular day of the trip. After reaching the 3718 m summit in icy howling wind, we spend the remainder of the day on a 12 km hike down through the clouds traversing the southwest flank of the stratovolcano. We pondered the origins of phonolitic lava flows, the km-wide, 200 m deep, crater of the flank volcano Pico Viejo that last erupted in 1798, and the vast Cañadas Caldera that was laid out in color below us.

The group split up again on the 25th, some visiting the beaches near the city of Santa Cruz de Tenerife, while others explored the wild and steep exposures through the Miocene lavas of the Anaga Shield Volcano on the northeast corner of the island. This part of the trip wound up at Juan Carlos' home for

Cañadas Caldera rim and floor on Tenerife. Blooms of the unique *Echium wildpretii* in the foreground.

Craig Schuettpelz examining the stratigraphy of basaltic and trachytic pyroclastic fall and flow deposits in the southeast rim of the Cañadas Caldera, Teide National Park, Tenerife.

Basaltic (dark grey) and phonolitic (light grey) lava flows and domes erupted on flanks of 3718 masl Pico de Teide Volcano, Teide National Park, Tenerife.

a wonderful meal with his family featuring plenty of local food and, of course, excellent wine.

The morning of May 26th we flew to La Palma, the youngest, westernmost, and most recently active, of the Canary Islands. We arrived early to inviting weather, so decided to circumnavigate the island by way of ascending 2,400 m to the Roque de los Muchachos along the rim of the Taburiente Caldera that formed when nearly a third of the shield volcano became gravitationally unstable and collapsed catastrophically into the Atlantic Ocean 550,000 years ago. The 200 km^3 of debris would have created a tsunami that is hypothesized to have struck the entire east coast of North America. After lunch in the sun at Puntagorda, on the northern flank of the Taburiente shield volcano, we examined the 300 m thick fan delta conglomerates of the El Time Formation (much to the delight of the sedimentologists), which were deposited during rapid downcutting of the volcano following the gravitational collapse. We then headed to our lodging—a hostel above a day care center, gratis thanks to Juan Carlos' friend the mayor of Fuencaliente on the southern end of the island.

JoAnn Gage measures the orientation of basaltic dikes that cross cut Pliocene gabbroic rocks exposed by the gravitational collapse and landslide that created the Taburiente Caldera, Caldeira National Park, La Palma.

The El Time clastic sediment fan-delta on La Palma extends westward out of the Taburiente Caldera into the Atlantic Ocean in the background.

On the 27th we drove up to the northern end of the Cumbre Vieja Volcano, an N-S rift system that began to form about 120,000 years ago and which today is surmounted by dozens of historically active volcanoes. We set out hiking in thick fog along the "Ruta de Los Volcanes" and located the fault scarp along which geodedic measurements suggest the next gravitational collapse of La Palma may initiate. We were rewarded later by climbing above the clouds to the summit of the active rift just in time for lunch with breathtaking views of the Taburiente Shield Volcano and of Pico de Teide 100 km to the east on Tenerife. Next was a walk down through the intricate flow channels and levees within the pristine basaltic lavas which breached the San Martin Volcano in 1646 A.D. to flow eastward from 1346 masl into the Atlantic Ocean only ten km away.

On May 28th we drove back to the Taburiente Shield Volcano to begin an overnight hike through exposures created by the giant collapse. Lava flows and dikes of the older parts of the volcano were found to contain numerous xenoliths of gabbro, wherlite, and norite which helped students recall mineral assemblages that would come in handy the next day. Our campsite was deep inside the collapsed caldera where one gazes at the insides of the volcano—lava flows, pyroclastic deposits–dike swarms–all cropping out for thousands of meters in every direction.

The next day was another geologic highlight. The hike out of the caldera descended from the roots of the Pleistocene shield volcano into an underlying Pliocene plutonic complex—the remnants of a seamount precursor to the younger shield volcano—in which gabbros are everywhere cut by at least three generations of basaltic dikes that served as a structural geology exercise during our break for lunch. In the final kilometers we twisted our way through river sculpted outcrops of pillow lavas—wonderful! We ended this fabulous day with a long relaxing dinner on the black sand beach complete with a beautiful sunset over the Atlantic Ocean.

Our last day on La Palma was spent along the Cumbre Vieja rift system visiting the 1949 A.D. phonolite lava flow where students managed to locate a hidden lava tube to explore. We also saw the 1585 Jedey phonolite lava flow in which students tried to identify phenocrysts of Huayanite, and finally the red-black scoria cones and basaltic lava flows of Teneguia Volcano which formed in 1971 A.D. on the island's southernmost tip. It was difficult to begin the journey back to Madison after packing so much world-class geology and camaraderie into the first two weeks of summer.

This field trip was supported in part by Chevron and the Student Field Experiences Fund. We thank Juan Carlos Carracedo, his wife Pauline and their entire family for the most generous hospitality. Additional information and photographs from this field trip are on the Department's web pages at: http://www.geology.wisc.edu/field_work/Canary_Islands/index.html.

Student participants were:
Ninfa Bennington, Amalia Doebbert, JoAnn Gage, Sara Greene, John Hora, Jessica Lopez, Jeremey Pesicek, Craig Schuettpelz, and Ryan Sharma. ●

The ca. 3200 year old San Antonio scoria cone, viewed from the Teneguia Volcano which formed via Strombolian fire fountain eruptions in 1971 A.D. Teneguia is the youngest volcano in the Canaries; its lavas form the southernmost tip of the Cumbre Vieja rift and the island of La Palma. Note the newly planted vineyards on the slope to the right. *(Photos by Brad Singer)*

Field Trip to Dinosaur National Monument

Seminar concludes with a ten-day road trip

by Clay Kelly and Basil Tikoff

The picturesque landscape and spectacular geology of Dinosaur National Monument (DNM) in Utah and Colorado was the focal point of a collaborative and interdisciplinary field trip led by geology faculty from UW-Madison (**Clay Kelly and Basil Tikoff**) and UW-Milwaukee (Dyanna Czeck, Stephen Dornbus, and Margaret Fraiser) in June 2007. Eleven geobadger students went along on this ten-day-long road trip, which was the culmination of a seminar class from the previous spring semester. As indicated by its name, DNM is best known for its unique museum that showcases one of the richest Jurassic-aged dinosaur bone beds in the world. Equally impressive are the monument's many panoramic vistas that afford geologists a bird's eye view of a sedimentary sequence that spans much of the Phanerozoic Era as well as classic Laramide structures related to the uplift of the Uinta Mountains. The combined forces of fluvial erosion and tectonic uplift have dissected the region, making it a wonderful outdoor classroom where students received hands-on instruction about various aspects of paleontology, structural geology, stratigraphy, and sedimentation.

The trip also included stops and roadside lectures at numerous points of geologic interest enroute to and from DNM. The first stop was at Red Rocks Amphitheatre just outside Denver, CO where we stretched our legs by climbing around on the Pennsylvanian-aged Fountain Formation, which consists of alluvial fan and braided stream deposits that formed from the drainage of the Ancestral Rockies. This steeply dipping, arkosic sandstone unit is juxtaposed directly against Precambrian gneisses and granites in a beautifully exposed unconformity. We also hiked through the local Mesozoic section, which contains numerous dinosaur bones and tracks as well as a wide variety of sedimentary structures. Then, we raced back to the van before a whopper of a thunderstorm hit. We are not sure how we managed it, but we stayed relatively dry that night. The second stop was just south of Pueblo, CO where we visited Teepee Buttes. These carbonate (limestone) mounds form isolated promontories that dot the countryside. The bizarre invertebrate fossils clustered atop these mounds are thought to represent chemosynthetic communities associated with ancient methane seep sites on the Cretaceous seafloor (Basil's interpretation of this last sentence: The critters were living in a pile and eating methane). We then drove through the metamorphosed Proterozoic rocks of the Wet Mountains on our way to the Black Canyon of the Gunnison, CO. This impressive chasm exposes a Protererozoic shear zone that has been intruded by numerous felsic dikes. In typical field trip fashion, we visited the stores and then camped in the pitch black at Colorado National Monument. The next morning, braving road construction, we spent time hiking through ancient (Mesozoic) dune fields deposited atop Proterozoic basement within the Ancestral Rockies' Uncompahgre Uplift. We then visited a famous Marsh dinosaur site just outside the monument and spent an hour visiting the Morrison formation. On our way north, we visited the Douglas Creek Arch (the structural geologists were amazed by how long paleontologists can look at flat-lying, undeformed shales under very, very windy conditions). That night, we arrived at our destination of Dinosaur National Park in Utah (having provisioned the night before in Colorado).

The following days, we spent time exploring the monument area and hiking out to several of its famous overlooks. We only had a blizzard (in May) at the best overlook—the rest of the time it was merely raining or threatening to. This gave students an opportunity to see (or imagine, in the case of the blizzard) firsthand the rock units and many geologic structures (monoclines, anticlines, synclines, faults) we had discussed in class during the previous semester. However, the highlight of the entire trip was a daylong rafting trip down the Green River (it rained, but who cares when you're shooting rapids). The Green River flows directly through the core of Split Mountain Anticline, so students enjoyed the thrill of whitewater rafting as they drifted through the monument's Paleozoic stratigraphy. There's simply no better way to experience the geology of this rugged landscape.

After our stay in DNM, we headed north toward the Green River Basin in Wyoming. Along the way we stopped to see such famous points of geologic interest as the Sparks Fault Nappe in Sheep Creek Canyon (Utah) and Flaming Gorge. We spent the next couple of days being led by **Alan Carroll,** who gave us an overview of the stratigraphy and tectonic history of the Green River Basin. Our final stop was at Westphal Dinosaur Quarry located in Bighorn Basin, Wyoming. Here, **Joe Skulan** of the UW-Madison Geology Museum gave an impromptu lecture about the paleontology and stratigraphy of the dig site. Students spent most of that afternoon collecting marine invertebrate fossils from the nearby Sundance Formation (Jurassic). The field trip was an overall success and all parties involved learned a great deal from one another (including, always bring your raincoat and a wool hat). We particularly enjoyed the interaction with the UW-Milwaukee folks and hope to have more shared trips in the future. It is this type of group experience that both students and faculty, having survived the weather, look back upon with fond memories.

The field trip was supported in part by Chevron and the Student Field Experiences Fund.

UW students collecting carbonate cements and invertebrate fossils associated with a Teepee mound structure. *(Clay Kelly)*

Plunging Paleozoic strata exposed along the Green River as it cuts through Split Mountain Anticline in DNM. *(Clay Kelly)*

Keweenaw Peninsula Field Trip

Undergrad group explores UP Michigan

by Jason Huberty

Undergrads go underground at the Delaware Mine, an early Keweenaw copper mine in operation in the mid-1880s. *(Courtesy of Jason Huberty)*

Eighteen undergraduates traveled to the Keweenaw Peninsula in Michigan's Upper Peninsula from October 12-14, 2007. We used the ***Self-Guided geological field trip to the Keweenaw Peninsula, Michigan*** by Ted Bornhorst (1994) to choose stops that highlighted the rift geology and copper deposits. The weather was outstanding with sunny days in the 50s and nights in the 30s.

The Keweenaw Peninsula is part of the Lake Superior segment of the 1.1 Ga Mid-continent rift which extends from Kansas to Lake Superior and through lower Michigan. The rift formed due to crustal extension over an asthenospheric plume and was filled in by large volumes of magma. There are more than 25 vertical km of volcanic rocks under Lake Superior including 10 km of the Portage Lake Volcanics (PLV). Rift-filling clastic sedimentary rocks, including the Copper Harbor Conglomerate, overlie the volcanic rocks. The Keweenaw fault, which was originally a graben-bounding normal fault, is now a high-angle reverse fault. The Jacobsville sandstone was deposited during and after reverse movement on the fault covering the entire basin with 3 km of red sandstone. The Keweenaw region is famous for its world-class native copper deposits. Copper in the basalt was released during burial metamorphism of deep parts of the lava flows.

We began our trip at the South Range Quarry where we were observed amygdaloidal lava flows within the PLV, a basal conglomerate bed and glacially-polished surfaces above the old quarry. Although the Keweenaw fault is a major feature of the area, it is not easily observed; rather, it is inferred from the changing lithologies of the PLV to the Jacobsville sandstone. The Jacobsville was spectacularly seen at the Natural Wall Ravine, a must-see for anyone visiting the Keweenaw. At this stop, we met up with a mineralogy class from Eastern Illinois on a field trip which was a pleasant surprise.

In the afternoon, we visited the Seaman Mineral Museum on the Michigan Tech campus. George Robinson, the museum director, gave us a private tour and shared information about the geologic history of the copper district, the varied habit of copper crystals, ore deposit types and other famous Michigan minerals. From there, we took in a panoramic view on top of Bumbletown Hill where we could see Isle Royale on the horizon and a cuesta to the north formed by the Greenstone flow. After digging at the Phoenix mine tailings, we drove north to Copper Harbor and camped at historic Fort Wilkins State Park.

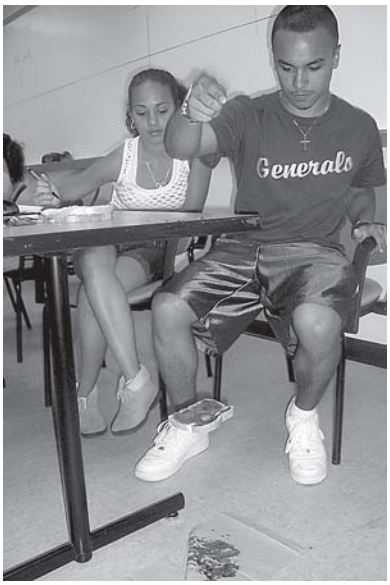
Sunday, we viewed two exposures of the Copper Harbor Conglomerate on the north shore including Hebard Park. Next, we climbed 1000 feet of elevation to the top of a conglomerate ridge to the Brockaway Mountain viewpoint. It was a clear day and fall colors remained on some of the trees giving us a magnificent view. Then it was off to Horseshoe Harbor for a date with billion-year old stromatolites, ***Collenia Undosa*** Finding the harbor was a real adventure as we went too far down a seasonal road and were turned around by some hunters before we reached a meteorological rocket launch site used in the 1960s. After lunch, we headed to the Delaware mine and took a self-guided underground tour. The group was weary after our two-day excursion but the rainy trip home did not diminish sunny memories of the Keweenaw Peninsula. We thank alumni and friends of the Department of Geology and Geophysics for their generous support of undergraduate field trips. ●

Jelly, Geomicrobiology, Soils, and Stars

PEOPLE in Earth Science

The PEOPLE Program's second summer workshop with the department presented three weeks of geoscience to pre-college students. The group studied with our faculty and grad students in the Museum and Weeks Hall's labs, and in spent several days the field. See more pictures at www.geology.wisc.edu/news_events/people.

Identifying a soil at the Picnic Point Soil Pits.



Jelly side down: Hypothesis testing in the Ciriacks Undergrad Teaching Lab .

Left: The group took a day-long field trip to study the geology of Devil's Lake area. *(Photos courtesy of Jean Bahr, MaryRuth Kotelnicki, and Laura Mitchell.)*