9th Annual CSUF Geological Science Research Day

Department of Geological Sciences
California State University, Fullerton
Fullerton Arboretum
Friday, April 13, 2018

GEOLOGICAL SCIENCES
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SOUTH COAST GEOLOGICAL SOCIETY
SCGS

This special event showcases the hard work of our student researchers and their faculty mentors. This event provides the opportunity for our students to "close-the-loop" regarding the communication-focused steps of the scientific method: students early in the research process present "proposal" posters, outlining the approach they intend to take in testing a hypothesis, while students nearing the end of their projects present their research and interpretations. To that end, we are particularly grateful to members of the South Coast Geological Society for volunteering to judge the posters, provide feedback to the undergraduate and graduate researchers, and recognize the top presentations with cash awards.

Thanks to everyone—cherished alumni, community college students, local geoscientists, families and friends—for spending the afternoon with the Department. We hope you enjoy good company and food in this beautiful setting. Most importantly, go talk to our students—challenge them, and help them grow as scientists!

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The Department of Geological Sciences at California State University, Fullerton is an interdisciplinary education and research community whose members are active mentors and role models. Our mission is to provide a student-centered educational and research experience that emphasizes critical thinking, communication, and scientific citizenship.

Last fall Associated Students, Inc. and the entire CSUF community celebrated the installation of a ~20,000 year-old Siberian woolly mammoth fossil in the atrium of the Titan Student Union.

Thanks to John Gregg and his Gregg Family Foundation for this inspiring donation to the University, one tailor-made to stand alongside the campus pachyderm mascot, Tuffy Titan. CSUF students voted on the name for the new fossil mammoth, allowing us to welcome to campus our geo-specific mascot

Fully Titan!

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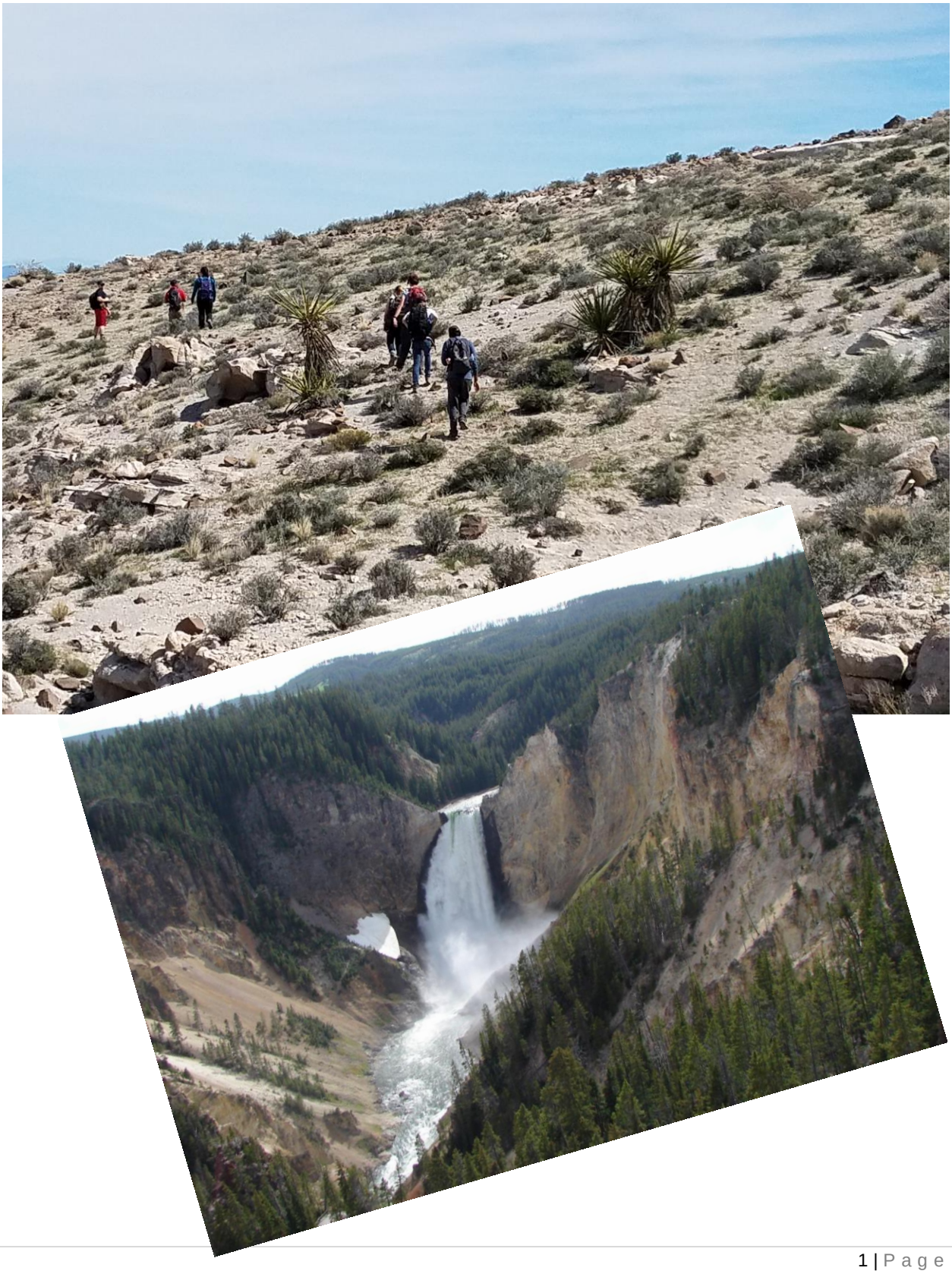
Undergraduate BA/BS Proposal Category A



Petrography and Geochemistry of Enclaves across the Tuolumne Intrusive Complex, Sierra Nevada, CA

Student: Ryan Bremer

Faculty Advisor: Dr. Vali Memeti

The Tuolumne Intrusive Complex (TIC) is a 1,200 km^2 intrusion that is located at the north-eastern boundary of Yosemite National Park in the Sierra Nevada mountains, CA and is encompassed by a more extensive aggregate of plutons known as the Sierra Nevada Batholith. Throughout the margins of the plutonic rock units in the TIC, enclaves are abundant and represent magmas that have mingled with intermediate to felsic host magmatic rocks. Examining mineral-scale compositional variations between enclaves and their host can provide clues into the origin of the mingling magma as well as display the degree of interaction that occurs between them, which can ultimately provide insight into the evolution and petrogenesis of this plutonic system. In turn, this will help us better comprehend the interconnected nature of volcanic-plutonic plumbing systems which can better prepare society for volcanic-related crises. Previous research has shown that the introduction of mafic magma into a partially crystalline, more felsic magma mush produces enclaves of various compositions and can encourage mineral or melt/diffusional transfer between mafic magmatic enclaves (MME) and the host magma. However, little is known regarding the magmatic source of enclaves and the degree of compositional heterogeneity distributed throughout neighboring plutonic bodies and if the mingling is occurring from the same source magma at depth. The same can be said concerning the amount of interaction occurring between enclaves and their host magmas. Petrography and geochemistry will be applied to characterize the affiliated evolution of MME and their host granitoids. To conduct this study, enclaves will be collected over 1-2 weeks of field work covering two transects of the major TIC rock units, which include the Kuna Crest granodiorite, the equigranular and porphyritic Half Dome granodiorites, and the Cathedral Peak granodiorite/granite. Petrographic analysis will determine the mineral phases and their size, shape, texture, and abundances. Cathodoluminescence imaging (CL) will highlight zoning patterns to characterize different populations of minerals, while x-ray fluorescence will determine trace element and oxide weight percent of the enclave and host magma rocks for analysis via Harker and trace element diagrams. The results from this study will reveal whether the MME in the different Tuolumne units came from similarly sourced magma and examine the degree of magma mixing between MME and host granitoids.

Characterization of the Bonanza King Formation

Student: Andres Bustos

Faculty Advisor: Dr. Sean Loyd

During the Late Cambrian, an event known as the Steptoean Positive Carbon Isotope Excursion (SPICE) occurred and caused a perturbation in the carbon cycle. The SPICE has been recorded in numerous localities, such as China, northern Utah, and central Iowa. The magnitude of the SPICE varies greatly between +0.5-4.5%. The SPICE also began coincident with a world-wide extinction event. It has been suggested that the SPICE resulted from a massive increase in organic carbon burial (which preferentially removes ^{12}C from the oceans) that led to an increase in oceanic $\delta^{13}C$ (recorded in marine limestone isotope compositions, $\delta^{13}C_{carb}$). This study seeks to characterize the $\delta^{13}C_{carb}$ compositions of samples collected from the middle to late Cambrian Bonanza King Formation. We will specifically explore outcrops located near Beatty, Nevada and Shoshone, California. Samples will be cut, powdered, and subjected to carbon isotope analysis. Results will be compared to data from other localities to assess spatial variability in the SPICE. We hypothesize that the SPICE excursion occurs within the Bonanza King Formation, but that absolute $\delta^{13}C_{carb}$ values and excursion magnitude differ. Armed with the compiled data, a revised model for organic carbon burial will be generated. Findings will 1) indicate the presence or absence of the SPICE in the Bonanza King, 2) provide insight into the spatial variability of the SPICE and 3) help to better constrain global carbon burial.

Using U-Pb Dating to Determine the Maximum Depositional Ages and Provenance of the Cow Creek and Fairview Metasedimentary Pendants, southern Sierra Nevada Mountains

Student: Christian Concha

Faculty Advisor: Dr. Diane Clemens-Knott

The pre-Mesozoic history of California is difficult to unravel by using fossil, mineralogical, and structural relations because metamorphism and deformation accompanying magmatism and tectonics of the Sierra Nevada volcanic arc obscure these traditional dating techniques. Instead, I will determine the U-Pb ages of detrital zircons that I separate from clastic metasedimentary rocks. Statistical analysis of ~300 U-Pb dates from each clastic metasediment will enable me to estimate both the maximum depositional ages (MDA) and the source—or provenance—of the unmetamorphosed protoliths. The youngest zircon age population provides an estimate of the time that the sediment was deposited. All 300 grains arranged into a histogram will be compared to U-Pb histograms of other metasedimentary pendants to determine similarities and differences which will aid in tectonic reconstruction.

My research area is located on the Great Western Divide of the southern Sierra Nevada mountain range. In the summer of 2017, I collected metasedimentary samples from two, neighboring pendants within the batholith: the western Fairview pendant and the Cow Creek pendant. The Fairview sample (BFD-105) is an isoclinal folded, laminated biotite-quartz schist. The Cow Creek sample (BFD-107a) is a white quartzite associated with marble. Based on rock associations and descriptions in the literature (Ross, 1989), I hypothesize that the detrital zircon ages from these two samples will indicate separate provenance for each pendant.

To determine the ages of the two pendants, ~3 gallon rock samples from each pendant were processed through several steps. The rock samples were crushed to gravel using a jaw crusher and disk mill. The resulting sand was then sieved to obtain the fine-grained portion. The sample was separated by density into “lights” and “heavies” using water flowing down a Wilfley table. The “heavies” were then dried and separated from magnetic grains with a Franz magnetic separator. Lastly, the dense, nonmagnetic zircon grains were allowed to settle through liquids of high density (lithium meta-tungstate, methylene iodide). The zircon separates were shipped to the Arizona LaserChron Center where they were mounted in epoxy, polished and imaged. During the first week of April 2018, I lased my zircon samples to determine their U-Pb crystallization ages.

Geochemical and Rock-Eval Analysis of Marine Carbonate Minerals: Assessing organic carbon preservation and thermal maturity

Student: Yasmeen De La Cruz

Faculty Advisor: Dr. Sean Loyd

Authigenic carbonates formed in marine sediments share striking similarities with concretions exposed in outcrop on land. It is thought that concretions form as a result of organic matter degradation and oxidation through various reaction pathways including methanogenesis, sulfate reduction and methane oxidation. Carbon isotope compositions and thermal maturity data have been employed to identify organic matter degradation pathways for concretion precipitation. However, these analyses are relatively uncommonly applied in the characterization of marine authigenic carbonates. In this study, geochemical and thermal maturity data will be used to identify potential similarities between marine authigenic carbonates and outcrop concretions. Samples from multiple sites including the Gulf of California, South African Western Margin, the Arctic and Newfoundland have been collected for this study. These samples will be subjected to organic carbon isotope and thermal maturity analysis. Carbon isotope compositions of inorganic carbon have already been determined and are consistent with microbial organic matter degradation pathways. We hypothesized that the new authigenic carbonate data will show broad similarities with outcrop concretions indicating similar formation pathways. Ultimately research findings will provide insight into the formation mechanisms of marine authigenic carbonate minerals and outcropping concretions and associated relationships with organic matter degradation.

Analysis of faulting along the eastern Sierra Nevada Mountains near Horseshoe Meadows Road in southern Owens Valley, California

Student: Jackson Flanagan

Faculty Advisor: Dr. Phil Armstrong

The uplift of the Sierra Nevada Mountains was and is accommodated through range-front normal faulting along the Sierra Nevada Frontal Fault System (SNFFS) in Owens Valley. Most modeling of slip rates and uplift kinematics along the SNFFS assume dips of ~60°. This assumption conforms to the traditional view of faulting in an extensional Basin and Range setting. However, a recent study by Phillips and Majkowski (2011) in the Bishop area reports that some SNFFS faults have significantly shallower dips of 25-35°.This shallow dip is similar to results of research by previous CSUF students farther south near Independence and Lone Pine. This study will investigate the faults of the SNFFS in the Horseshoe Meadows Road area near Lone Pine. I hypothesize that the faults dip shallower than previously assumed (e.g., Le et al., 2007). Google Earth imaging and mapping done by prior researchers will be used to identify fault exposures in the study area. This study will include detailed mapping of the SNFFS faults and offset rock units. Located faults will be mapped in detail using GPS. Any fault exposures will be evaluated and documented. The x,y,z data from the GPS mapping will be assessed using plane-fitting software to determine best-fit fault orientations. I will use my data, in combination with other researcher's fault dip data in the area, to interpret slip rates and uplift kinematics along the SNFFS.

Geochronologic, petrographic, and geochemical analysis of the migration direction and composition of the Tarana Intrusive Complex, Bathurst Batholith, Eastern Australia

Student: Celeste Flores

Faculty Advisor: Dr. Valbone Memeti

Understanding how magma plumbing systems operate at depth is a fundamental aspect of determining the causes and patterns of volcanic eruptions. Plutons represent cross-sections of magma plumbing systems now exposed at the surface that indicate different compositional patterns. One pattern not well understood is migrating plutons. This study aims to examine both the temporal and compositional patterns of migrating plutons and speculate on the potential causes of migration. One such migrating system is exposed in the plutonic rocks of the Tarana Intrusive Complex, which is part of the Carboniferous, ca. 30 Ma active Bathurst Batholith of the Lachlan Fold-and-Thrust belt in Eastern Australia. The Tarana Intrusive Complex is composed of a series of crescentic arcs that concave to the east. The units' bow-shaped bodies and cross-cutting relationships suggest that the units intruded as a progression of circular plutons, each independently truncated by newly intruding pulses from west to east. This orientation of migration is perpendicular to the structural grain of the host rock. The Tarana intrusive complex appears to have intruded over four magmatic cycles (Ctga-Ctgd) that range from three to four units of more mafic, magnetic, hornblende-bearing equigranular granitoids to porphyritic granites that are more felsic in composition eastward. To determine the timescale of formation, U/Pb zircon geochronology will be conducted in the Laserchron center at the University of Arizona. Petrography conducted at CSU Fullerton will investigate the mineralogy and textural variations. XRF element geochemistry analysis for major oxides and trace elements at Pomona College will be used to determine the geochemistry of these units. This study will test that the Tarana Intrusive Complex is younging in an easterly direction as suggested by cross-cutting relationships and determine petrologic patterns that will help determine the cyclic nature of the rock compositions and the causes of migration.

ORIENTATION OF THE SIERRA NEVADA FRONTAL FAULT SYSTEM BETWEEN WHITNEY PORTAL AND HOGBACK CREEK IN OWENS VALLEY, CALIFORNIA

Student: Eric Fregoso

Faculty Advisor: Dr. Phil Armstrong

The purpose of this study is to map and evaluate the Sierra Nevada Frontal Fault System (SNFFS) on the eastern front of the Sierra Nevada Mountains near Lone Pine, focusing on the area from Whitney Portal to Hogback Creek. Previous studies suggested that Quaternary faults in this system generally dip steeply at ~60° or more. Assumed fault dips are used to calculate slip rates of 0.2-0.3 mm/yr for the late Pleistocene to Holocene. Reconnaissance evaluation of many faults in the area suggest dips of ~30° or less. These shallow dips are consistent with earlier work in the area by previous CSUF students and farther north in the Bishop area of northernmost Owens Valley. Studying the faults will help us understand the Sierra Nevada mountains uplift, deformation partitioning of the SNFFS, and slip rates. This can also assist in understanding general kinematics of Basin and Range tectonics. In order to compile the necessary information for the research I will: (1) conduct background literature research to compile necessary information (Owens Valley fault history, orientations, slip rates, dips, and maps) on the SNFFS; (2) use Google Earth to find potential fault locations; (3) generate a detailed map of the SNFFS study area and revise previous maps; (4) collect samples to analyze shear fracturing at a thin section level; and (5) evaluate mapped fault locations using software to find best-fit orientations of the faults. The results will contribute to the overall Owens Valley SNFFS research and interpretations of the Sierra Nevada and Basin and Range Province.

Reconnaissance of a new, longer earthquake record site along the Carrizo Section of the San Andres Fault.

Student: Joseph Grohman

Advisor: Dr. Sinan Akciz

There are hundreds of identified faults in California; about 200 are considered potentially hazardous based on their slip rates in recent geological time (the last 10,000 years). Paleoseismic data on the location, recurrence intervals and magnitudes of past earthquakes along a fault are essential to creating probability models needed for estimating fault rupture hazard. The great Fort Tejon earthquake in 1857, with an estimated moment magnitude of 7.9, ruptured the south-central San Andreas Fault (SAF) for a length of about 350 km. There is considerable scientific and public interest to know whether a similar earthquake has a significant probability in the near future. While the SAF remains as one of the most studied active faults in the world, paleoseismic data that show evidence for enough earthquakes to be considered statistically significant (> 10) to characterize its past rupture history are few and far apart. Existing paleo-earthquake records of the Carrizo Plain in the southcentral San Andreas fault only go back to last six earthquakes and point to an average recurrence of ~90 years. While we hypothesize that this 700-year long record from the Carrizo section is representative of south-central SAF's long-term behavior, the calculated age mean recurrence intervals is less than the time since the Fort Tejon earthquake and all reported average intervals of prehistoric earthquakes along the SAF. The existence of this quiet outlier period supports the need of an expansion of the paleoseismic record, ideally to 2000 years, to determine if there are other long periods of inactivity in the fault's rupture history.

We propose to collect preliminary field data from a new paleoseismic site just SE of the Carrizo Plain. This site is located along a small ephemeral sag pond which also receives some fine sediments from channels that drain into it. Our proposed trench should expose finely bedded silt and clay with thicker layers of sand, an ideal stratigraphy to identify and record evidence of past earthquakes such as vertical offset, facies changes, fissures and changes in layer thickness. We anticipate encountering peaty horizons, and abundant detrital charcoal samples as these will be critical in constraining the age range of the identified earthquakes. Data obtained at this new site has the potential to expand the chronological record of past earthquakes that ruptured the south-central SAF which can then be used to estimate the potential likelihood of future earthquakes and their possible magnitudes along it.

Evaluation of the Sierra Nevada Frontal Fault System between Whitney Portal and Tuttle Creek near Lone Pine, California

Student: Joseph Hernandez

Faculty Advisor: Dr. Phil Armstrong

Uplift of the Sierra Nevada Mountains along the Sierra Nevada Frontal Fault System (SNFFS) has been debated for decades. Though the SNFFS clearly plays a significant role Sierra Nevada uplift, the orientation of the faults of the SNFFS are poorly understood. Most researchers assume a steep dip for the SNFFS (e.g., Le et al., 2007). Mapping and fault measurements in the Lone Pine area by previous CSUF students and farther north in Bishop, suggest fault dips as low as 25° in these areas. Fault dip affects kinematic parameters and processes, such as horizontal and vertical slip rates, and overall uplift magnitude. Inaccurate data will produce inaccurate rates of uplift. My proposed research area is between Whitney Portal and Tuttle Creek along the SNFFS where mapping by Stone et al. (2000) suggests very steep dips of 80°. Reconnaissance investigation in this area, however, suggests dips of ~30°. The goal of my thesis is to provide a new evaluation of the SNFFS orientation in this area and gain a better understanding of uplift, extension, and processes of slip along the SNFFS. I hypothesize that the SNFFS dips shallower than previously measured or assumed. To test this hypothesis, I will: (1) identify and map faults on Google Earth; (2) map faults and related rock units in the field; (3) measure orientations and collect samples of shear fractures adjacent to the faults; and (4) map located faults using GPS. The x, y, z data points from the GPS mapping will be inserted into a computer program to evaluate best-fit fault orientations. I will evaluate thin sections of oriented samples from the shear fractures. I will interpret my data and combine it with data from two other students to generate a better understanding of the SNFFS.

Assessing Sediment Provenance Along a Highly Erosive Coast: A Study of Sediment Source and Transport in Southern Monterey Bay

Student: Esther Lee

Faculty Adviser: Dr. Joe Carlin

Sediment delivery to the coast is important because it is needed to offset natural sediment losses due to storms and sea level rise. However, human impacts on the coast and coastal watersheds, such as dams, urbanization and sand extraction, have reduced sediment supplies and as a result increased coastal erosion. One area where this is a significant problem is along the southern Monterey Bay coast, one of the fastest eroding coasts in the state. The goal of this project therefore, is to characterize the source areas for coastal sediment in southern Monterey Bay. We hypothesize that the Salinas River acts as the dominant sediment source to areas proximal to the river mouth, while headland and coastal erosion along the Monterey Peninsula predominantly provides sediment to much of the rest of the coast. The boundary between these two stretches will be a major sand mining facility that interrupts longshore transport. To test this hypothesis, we will collect sand samples from the beaches throughout southern Monterey Bay and compare their mineralogical characteristics to source areas in the Salinas River watershed, coastal dunes, and cliffs of the Monterey Peninsula. The mineralogy of all samples will be determined using X-Ray Diffraction, X-Ray Fluorescence, and Quartz-Feldspar-Lithic analyses. This research will add insight to understanding coastal sediment delivery to a highly erosive coast in California, but may be useful for understanding sedimentary processes for other beaches that are presently eroding due alterations in sediment routing.

Investigating Coastal Sediment Provenance and Transport Pathways in Northern Monterey Bay, California

Student: Andrew Lindquist

Faculty Advisor: Dr. Joe Carlin

The delivery of sediment is crucial to coastal California because it provides material to beaches and other coastal areas that protect against storm events and sea level rise. Human activities such as dam construction, sand mining, and land use changes have caused a significant reduction in sediment supply to the coast resulting in increased coastal erosion. Moreover, erosion rates will continue to increase as sea level rises in the future, further worsening the problem. Therefore, it is imperative that we understand where coastal sediment comes from and how it is transported to the coast in order to better manage this valuable resource, and Monterey Bay California is one area in particular where there is an immediate need to assess coastal sediment source and transport processes. Thus, the main objective of this project is to distinguish coastal sediment sources within the Santa Cruz littoral cell in northern Monterey Bay. Northern Monterey Bay coastal sediment sources include the two largest rivers, the San Lorenzo and Pajaro, as well as small creeks and coastal cliffs along the open coast that contribute sediment to the littoral cell. The watersheds in the region also span steep sections of the mountains of the Coastal Range that are made up of a variety of rock types including Franciscan rocks as well as Mesozoic and Cenozoic sedimentary rocks. We hypothesize that the sediment source will vary with the littoral drift from north to south within the bay, moving from a source dominated by cliff erosion along the open coast to the San Lorenzo River, and then the Parajo River. In this study, we will collect multiple samples from the beaches across northern Monterey Bay. All samples will be analyzed to determine their mineralogical properties via X-Ray Diffraction, X-Ray Fluorescence, and QFL analyses to distinguish the characteristics indicative of specific source areas and what is found along the beaches. This project will provide the most recent assessment of sediment provenance in the region that can be compared to previous studies to better understand the impact of recent human modifications to the sediment routing system in this region.

Evaluating Volcanic-Plutonic Connections at Ireland Lake in Yosemite National Park, California

Student: Desirée Lucas

Faculty Advisor: Dr. Valbone Memeti

Volcanoes and plutons are part of magma plumbing systems that feed hazardous volcanic eruptions in continental arcs, however, how magma plumbing systems operate over time and what happens before and during a volcanic eruption is poorly understood. Given that magma plumbing systems are vertical systems, volcanic and plutonic rock records of the same system are rarely exposed together, which is why the connection between shallow plutons and volcanoes is tenuous. The purpose of this study is to determine the age of this volcanic-plutonic complex and to understand the compositional connection between volcanic and plutonic rocks at Ireland Lake in Yosemite National Park in the Mesozoic Sierra Nevada batholith and, which exposes a rare section of Cretaceous volcanic and plutonic rocks. Methods for this study include rock sampling in a remote area of Yosemite National Park, petrography of thin sections of the samples collected, U-Pb zircon geochronology, and whole rock major oxide and trace element XRF geochemistry. A total of six rock samples of the five different volcanic and plutonic units hypothesized to be part of the volcanic-plutonic complex, were collected. The two volcanic units are: Kmv, made of metavolcanic rocks and Ksl, the granite porphyry of Shellenbarger Lake. The three plutonic units are: Kkc, the granodiorite of the Kuna Crest, Kg, made of granitic rocks, and KJdg, made of diorite and gabbro. U-Pb zircon geochronology analysis in the Laserchron lab at the University of Arizona of the hypabyssal granite sample determined an age of 91.36 ma with margin of +/- 2 ma. Whole rock X-Ray Fluorescence analysis is currently in progress on all six collected samples to determine major oxide and trace element compositions. The geochemistry will evaluate if the volcanic and plutonic rocks at Ireland Lake are of the exact same (equivalent) or complementary in composition. Equivalent composition will indicate that part of the magma chamber now represented by the plutonic rocks was evacuated to form the volcanic materials. Complimentary compositions will suggest that the magma chamber underwent fractional crystallization.

Distribution of Surficial Slip Along the Santa Cruz Island Fault based on Field and Lidar Measurements

Student: Radwan Muthala

Faculty Advisor: Dr. Sinan Akciz

San Andreas Fault is the fastest moving (36 mm/yr) active fault in southern California that is capable of producing a moment magnitude (Mw) 8 earthquake. However, a much slower (1 mm/yr) and quieter (recurrence intervals 2000-5000 yrs) fault system that extends for over 200 km from the Channel Islands to Pasadena poses an even greater risk to Los Angeles (Figure 1). This left-laterally slipping fault system consisting of seven short (15-90 km) but closely spaced (separated by less than 2 km) faults is capable of causing a major earthquake of Mw 7.5 that ruptures right through downtown LA. Despite this potentially catastrophic hazard, there is information on whether each of the faults rupture individually or together during an earthquake. Based on very limited chronological data from different sections of the fault system, we hypothesize that the fault system generally ruptures as a whole during large, but infrequent earthquakes that produce offsets that average 3-5 m.

Santa Cruz Island Fault (SCIF) is at an ideal location to investigate the rupture history of the fault system as most of the other sections are either underwater or in heavily urbanized areas (e.g. Anacapa-Dume, Manta Monica, Hollywood, and Raymond faults). Numerous offset drainages, scarps, and shutter ridges that demonstrate left-lateral offset form a sharp lineament visible in topographic maps and satellite imagery. The goal of this project is to measure offsets on tectonically displaced stream channels along 10 km section of the SCIF to estimate slip-per-event for the past several surface ruptures. Thalwegs of channels and channel margins will be measured to estimate displacement for each feature. For the entire field area, we will also utilize light detection and ranging (lidar) data to create high-resolution bare earth digital elevation models (DEMs) with which to analyze the tectonic geomorphology of the SCIF down to the sub-meter scale. Since the distribution of displacement resulting from surface rupture during a large earthquake closely correlates to the magnitude of the earthquake, documentation of large slip-per-earthquake displacement measurements made along the SCIF will be interpreted to imply long ruptures that may have affected the entire fault system. This study will help us better understand the potential hazards associated with earthquakes along these fault sections and improve our ability to anticipate and communicate its potential impacts in advance of a disaster.

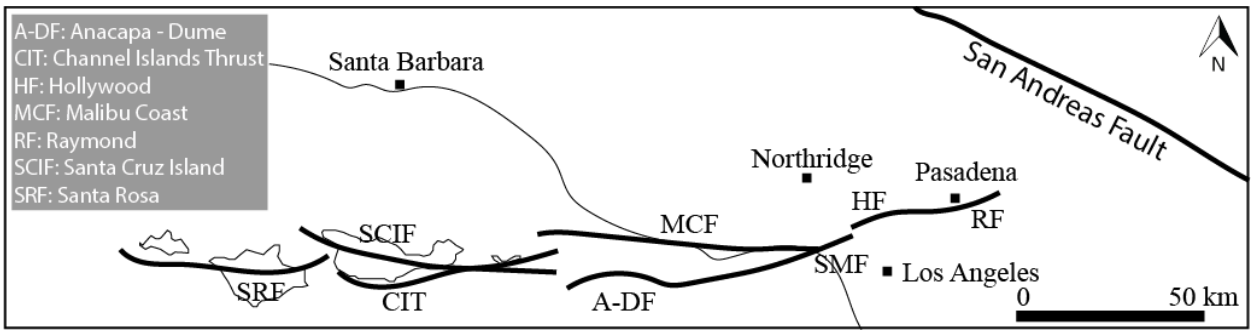


Figure 1. Overview map of fault systems of southern California mentioned in the abstract.

An Assessment of Coastal Wetland Stability in Response to Sea Level Rise in Southern California

Student: Tan Nguyen

Faculty Advisor: Dr. Joe Carlin

Coastal wetlands are a highly valued ecosystem but are under threat of submergence from sea level rise (SLR) over the next century. This threat is heightened for wetlands in Southern California which have already experienced significant losses due to urbanization. In Southern California, coastal wetlands occupy a variety of unique sedimentary systems that can be classified across a spectrum from fluvial to marine dominant. What remains unknown is how these different settings and their respective sedimentary systems may respond to SLR. To address this, we proposal to characterize sedimentation in wetlands spanning this morphological spectrum to assess vulnerability to SLR. We hypothesize that marine-dominant systems will be most vulnerable due to overall lower sedimentation rates that are increasingly dependent on autochthonous (organic matter) sedimentation. To test this hypothesis, cores will be collected from 3 different wetland types: fluvial-dominant, marine-dominant, and a mixed-system. The sediment will be analyzed to determine sedimentation rates over the past century and organic matter component. This project will allow us to assess sustainability between the different types of coastal wetlands in the face of accelerating SLR. Preliminary data to date showed the marine-dominant wetland had the overall highest concentration of organic matter with surface values approaching 50%. While the mixed and fluvial-dominant end members surface values were ~ 20 % or less. The fluvial-dominant also had the highest sedimentation rates, where short-term rates were as high as 1.25 cm/yr., and decadally-averaged rates ranged from ~ 0.2 – 0.8 cm/yr.

Distribution of Shear Along the Borrego Springs Shear Zone, Imperial County, California.

Student: Adam Wells

Faculty Advisor: Dr. Sinan Akciz

Field studies on crustal-scale structures show that the brittle network of shear zones in the upper crust is connected to mylonitic shear zones at depth. While we can readily make in-situ observations of brittle structures, we can only make inferences on how ductile shear zones develop and evolve. Exhumed shear zones, though limited in number and exposure quality, provide unique exposures of materials deformed to very high strains at deep crustal levels. The contact between the Western and Eastern Peninsular batholiths, a west-vergent mylonitic thrust shear zone, known as the Eastern Peninsular Ranges Mylonitic Zone, is one such exhumed structure that can contribute to our understanding of the evolution of ductile shear zones in general. This shear zone, extending from the border of Mexico to Palm Springs, California, is broken into three sections by currently active faults including the San Jacinto Fault and the Elsinore Fault: Santa Rosa Shear Zone, Borrego Springs Shear Zone (BSSZ), and Cuyamaca-Laguna Mountains Shear Zone. The focus of this research project is to understand the nature of deformation BSSZ by (1) determining the protolith of the BSSZ, and (2) documenting whether shearing is continuous across the entire width of this ductile shear zone or is concentrated within narrow, discontinuous zones.

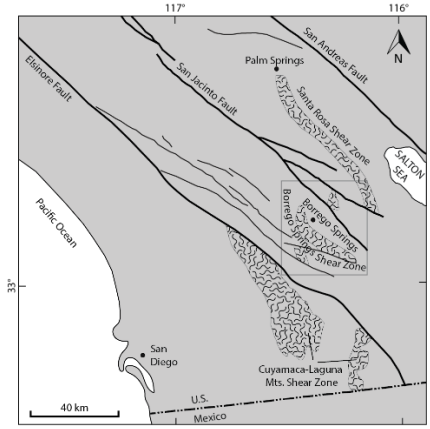


Figure 1. Location map of the Borrego Springs Shear Zone section of the Eastern Peninsular Ranges Mylonitic Zone (filled areas) with respect to the active faults of the southern San Andreas Fault System.

I will do a geologic transect of the previously mapped shear zone exposed along Montezuma Highway to identify the intensity and the distribution of the mylonitic fabrics. On this transect, I will record lithological observations as well as the orientations of foliations and lineations. Preliminary field investigations indicate that the degree of mylonitization as well as lineation development increase from west to east. Oriented hand samples from outcrops representing the identified sections of the BSSZ will be collected. Thin sections from these samples will be photographed and structural textures will be described. Stereonet analysis of the structural dataset will also be used to characterize these zones of varying mylonitization. Once the transect is complete, Western Peninsular batholith outcrops bounding the BSSZ will also be investigated to document any textural similarities that would suggest if the hangingwall block is the protolith of the mylonitic shear zone.

Characterizing enclaves in the Jack Main Intrusive Complex of the Sierra Nevada Batholith, California: the effects of mixing and mingling on host magma compositions

Student: Alejandra Angulo

Faculty Advisor: Dr. Valbone Memeti

The study of plutonic systems is crucial to understand and predict explosive volcanic eruptions caused by intermediate to felsic magmas generated in continental arcs. It is widely accepted that incremental magma pulses assemble plutons over thousands to millions of years. However, the causes of compositional variability of arc plutons and the implications for the construction and evolution of the magma plumbing systems they represent is debated. This study is concerned with examining mafic magmas that mingled with felsic host magmas in the upper crust to determine what effects mingling may have had on the host magma composition. It is not well understood how much physical (through crystal mixing) and chemical (through melt mixing and/or diffusion) exchange takes place during such mingling.

Evidence of mingling magmas in plutons is preserved in the presence of mafic magmatic enclaves (MME). MME are found in all four units of the Jack Main Intrusive Complex (JMIC) composed of the Mount Gibson Quartz Diorite, the Bearup Lake Granodiorite, the Lake Vernon Granodiorite, and the Boundary Lake Granite, located in the Sierra Nevada Batholith. It is unknown if the MME are of the same composition across all four units of the JMIC and how much the MME mixed with the host magma.

To test the hypothesis that MME in the JMIC are compositionally homogeneous and were derived from the same source, compositional characteristics of MME and host magmas will be examined in the field over two weeks. MME and host magma samples will be collected for petrography and whole-rock X-Ray fluorescence analyses, which will examine whether they are mineralogically and geochemically the same across the JMIC and thus are derived from the same source.

To test the hypothesis that enclaves contributed to the compositional variability of JMIC magmas, cathodoluminescence imaging will be used to examine crystal zoning patterns of feldspars at the MME-host magma interface. If matching growth zones are observed in the MME and in the host magmas across the interface, I would be permissive of the MME and the host magma to have been in chemical equilibrium. Additionally, if zoning patterns reveal that crystals belonging to MME populations are found in the host magma (and vice versa), it would suggest crystal exchange across the interface.

Reconstructing Holocene Climate Using Sediments from Barley Lake, California.

Student: Justin Blyar

Faculty Advisor: Dr. Matthew Kirby

This study will use a sediment core taken near the modern edge of Barley Lake (as of 2017AD). The main objective of this study is to reconstruct the history of climate (i.e., water) using sediments found in the lake. This study will help us understand paleoclimatic conditions thus providing insight to the processes that drive modern climate. This study is important because, the amount of precipitation that occurs in northern California is dictated by Pacific Ocean-atmospheric dynamics, atmospheric rivers, and sea surface temperatures. The Pacific Ocean-atmospheric dynamics are controlled by the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). These results can help inform climate models used to predict future climate, also this will help us understand how recent human activity has altered lake sedimentation. In order to reconstruct the history of climate, a series of sediment analysis including: visually describing the cores, water content, magnetic susceptibility, LOI 550^{o} C and 950^{o} C, and Radiocarbon dating of discrete organic matter will be analyzed. Two hypotheses are presented: 1) there is an overall decrease in climate wetness during the Holocene. However, higher frequency climatic variability punctuates the long-term Holocene drying trend as recognized by periodic increases in the flux of coarse sediment deposition; and, 2) changes in climate as recorded at Barely Lake are out of phase with sites south of Barely Lake, such as Abbott Lake, Zaca Lake, Lake Elsinore, and Lower Bear Lake.

Undergraduate BA/BS Thesis Category B

Paleogeographic Interpretation of the Fish Lake Valley/Horse Thief hills area using Geochemistry of Volcanic Rocks

Student: Shayna Avila

Faculty Advisor: Dr. Jeffrey R. Knott

Samples of volcanic rocks were collected from Willow Wash in Fish Lake Valley and the Horse Thief hills, California. Regional geologic studies classified these rocks as Tertiary basalt. The purpose was to date and geochemically characterize these rocks to determine if these are the same or different basalt flows. The geochemical signatures for these rocks were determined by X-Ray Fluorescence (XRF). In Willow Wash, several 11.5-11.7 Ma basalt flows that underlie a thick sequence of Pliocene-Quaternary sediments were classified as basalt (47-52% SiO_2). The Zr/Ba and Ce/Y ratios for these basalts were similar to each other as well as basalt outcrops as far as 32 km west in the White Mountains. Based on the decreasing thickness, age and geochemical data we infer that the basalt found in Willow Wash originated in the White Mountains and flowed 32 km east prior to Basin and Range extension that formed the intervening 1000 m of relief and Fish Lake Valley, Deep Springs Valley and the Horse Thief hills. The Horse Thief hills samples were collected from a volcanic breccia that is part of a tilted sedimentary-volcanic sequence exposed on the south side of the hills. XRF data show that the volcanic matrix of the breccia is andesite and the volcanic clasts are trachyandesite (56-60% SiO_2). A previous whole-rock, K-Ar date of 6.3±0.2 Ma on volcanic rock showed that this is a younger sequence representing the remnant of a Miocene basin now uplifted and exposed on the south side of the Horse Thief hills. This data confirms that at 11.5-11.7 Ma a basalt flowed 32 km east from the White Mountains to Willow Wash before Basin and Range extension began. The andesitic breccia interbedded with basin deposits shows that a small basin formed south of the Horse Thief hills at 6.3 Ma.

THE HALF DOME GRANODIORITE ON THE EAST SIDE OF THE TUOLUMNE INTRUSIVE COMPLEX, YOSEMITE NATIONAL PARK, CA: BIG OR SMALL MAGMA CHAMBERS?

Student: John Ayers

Faculty Advisor: Dr. Vali Memeti

Coleman et al. (2012) suggest that the formation of the Half Dome granodiorite in the W lobe - and by inference, the entire Tuolumne Intrusive Complex (TIC) - occurred through stacking of km-scale sills. These outward, moderately dipping sills with sharp eastern contacts are composed of granodiorite that grades into aplite westward due to local fractional crystallization. This sill-model contrasts with models of large magma mush bodies, which suggest that magma pulses amalgamate to form large magma bodies undergoing large-scale crystal fractionation and across-unit magma mixing (Paterson et al., 2016).

To test these models, field mapping, petrography and XRF whole rock element geochemistry was conducted in the equigranular Half Dome granodiorite (eHD) unit at Lyell Canyon to determine if 'sills' occur on the east side of the TIC as well. Field mapping revealed gradational contacts between Kuna Crest and Half Dome units and hybrid mineralogical characteristics. The eHD granodiorite exhibits local, up to several m-wide aplite dikes with sharp contacts and varying orientations. Locally, eHD granodiorite is more leucocratic (LeHD) transitioning into more felsic granodiorite and granite at up to tens of m scales. Petrographic analyses of eHD rocks indicate major mineral abundances ranging from 27 - 47% qtz, 14 - 22% kfs, 25 - 45% plag, <1 - 5% hbl, and 5 - 9% bt. Aplite samples consist of 40% qtz, 45% kfs, 15% plag and <1% bt and hbl. XRF analysis on nine eHD samples yielded a composition range of granodiorite to granite. Harker diagrams indicate linear correlations of major oxides with increased SiO_2, and a decrease in mg # and compatible traces (e.g., Sr), and increasing incompatible elements with increasing SiO_2, which are permissive of crystal fractionation.

Our results suggest that the Coleman et al. (2012) sill-model proposed for the TIC cannot be confirmed for the eastern eHD exposures. The gradational contacts between TIC units, irregular shaped local variations of eHD compositions, randomly oriented local aplite dikes, petrography and geochemistry of eHD rocks are in accord with a large, interconnected magma mush with local compositional variations produced by crystal fractionation. The aplite's interpreted as sills on the W side of the TIC are likely late crystallization fronts.

Ground source heat pump potential characterization for California State University Fullerton

Student: Adrian Escobar

Faculty Advisor: Dr. W. Richard Laton

Anthropogenic climate change is an intensively studied area of science that has resulted in the consensus that mankind is affecting the climate by emitting large amounts of greenhouse gasses. Actions by government agencies have been taking place over the last few decades and have become the topic of many political discussions over the recent years. Emission reducing strategies are being taken by everyone from individuals to large institutions. Of the many strategies, ground source heat pumps (GSHP) are likely one of the least known methods for reducing emissions. The technology has been implemented on large scales across the United States and in several European countries over the last decades - proving its capacity to reduce emissions and cost. California State University Fullerton (CSUF) is an institution that has several ongoing projects to increase sustainability on campus along with many groups providing information for students and the surrounding community, making it a good candidate for this research. With several types of GSHP systems, a review of literature, industry standards and an analysis of the geology beneath CSUF will be used to determine if GSHP can be used on the university campus. Multiple employment scenarios will be analyzed for buildings and/or combinations of buildings around the campus that seek to maximize sustainability and cost benefits. The research will conclude with a report on these findings submitted to the University's Center for Sustainability for consideration. Preliminary results show that there is approximately 192,825 square meters (m^2) of available space to install GSHP loops. McCarthy Hall is the largest demanding building on campus and would require 71,293 m^2 for vertical borehole field installation or a 25,011 m trench for horizontal loop system. Horizontal loop requirements exceed available space for the CSUF campus and a vertical system was chosen for modelling. Calculations determined that each borehole handles 8,398 ± 88 Mega BTUs (MB) and the entire campus would require approximately 7,482 boreholes at an estimated maximum area of 271,648 m^2 – greater than available. Current system design utilized conservative approaches to borehole field design to reduce potential environmental impacts by not penetrating local aquifers. In reality, drilling technologies have matured to the point where crossing aquifers can be achieved minimal contamination. With this in mind, increased borehole depth and groundwater interaction serve to increase borehole efficiency lowering the required amount of boreholes and improving the potential to implement ground source heat pumps on the CSUF campus.

Geochemical and Petrographic Analysis of Salt Dome Associated Calcite Phases in Gulf Coast Cap Rocks: Implications for Carbon Sources and Paragenetic Evolution

Student: Connor Frederickson

Faculty Advisor: Dr. Sean Loyd

Salt dome associated calcites of the Gulf of Mexico region exhibit multiple phases with varying physical properties. These phases are thought to form through microbially mediated chemical reactions that involve hydrocarbons, which locally accumulate around salt domes. Cap rock calcites from six salt domes in the Gulf of Mexico region were analyzed for this study. Petrographic analysis was used to identify different calcite phases within each sample and document their crystallographic and spatial characteristics. Samples were then drilled from each identified phase and subjected to carbon isotope analysis. Measurements of isotope composition allowed for comparison to known values of Gulf Coast hydrocarbons (e.g., methane and petroleum) and could be used to identify the carbon source(s) for each phase. It was hypothesized that observed petrographic differences between phases was a result of differences in carbon sources.

A total of six distinct crystallographic phases were observed among the samples, with most samples containing at least two phases. Measured $\delta^{13}C_{carb}$ values for these phases range from −52.42 to −20.23‰ (VPDB). The majority of values (27 of 38) fall between −25 and −35‰. These values are consistent with those of regional methane and petroleum. The range of values suggest that phases incorporated carbon from a mixture of the two sources. Petroleum and methane fractions for each sample were calculated and range from 0.019 to 0.969 for methane and from 0.031 to 0.981 for petroleum. The data collected does not show a direct relationship between the carbon sourcing and petrographic characteristics of calcite phases. Despite a lack of correlation between calcite phase morphology and isotope composition, the results of this study indicate that salt dome environments represent significant sinks for subsurface hydrocarbons.

Investigating magma plumbing systems and volcanic-plutonic connections in the Iron Mountain pendant, Sierra National Forest, CA

Student: Sabrina Green

Faculty Advisor: Dr. Valbone Memeti

Volcanic eruptions and associated hazards frequently pose a threat to society. The causes of eruption and what occurs in the magma chamber and underlying magma plumbing before and during an eruption are poorly understood. The focus research area is the Iron Mountain pendant in the Sierra Nevada batholith, located northeast of Oakhurst, CA. It exposes both Cretaceous volcanic and plutonic rocks of what are hypothesized to be coeval in age and thus present part of the same vertical magma plumbing system. The purpose of this research is to ascertain the rocks are contemporary and to understand the chemical connection between the volcanic and plutonic rocks of this magma plumbing system.

To determine the age of both rock types and test that they are contemporaneous, Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICPMS) U-Pb zircon geochronology was applied at the University of Arizona Laserchron lab. Using a polarizing light microscope, minerals present in the different rocks were determined. The x-ray fluorescence (XRF) machine at Pomona College was used to determine major oxides and trace elements for both rock types. Petrography and XRF geochemical analyses of volcanic and plutonic rocks tested if the rocks are compositionally equivalent or complementary to one another and the magmas were fractionated or mixed in the magma chamber before the volcanic magma erupted. If the volcanic and plutonic units are complementary in composition, it is possible that fractional crystallization of the magma chamber took place. This implies that the volcanic rocks represent the fractionated portion and the plutonic rocks represent the residual cumulates. If they are equivalent, then part of a homogeneous magma chamber was evacuated.

U-Pb zircon geochronology results show that the rhyolite and granodiorite sample ages are within error contemporaneous at about 120 Ma, and thus belong to the same magma plumbing system. Petrography does not indicate any magma mixing. XRF results show that volcanic and plutonic rocks are not equivalent in composition and that simple mixing between the compositions is present. This indicates that the rhyolite is complementary to the hypabyssal granodiorite pluton and could have been fractionated from there. The andesite unit is too low in silica to be related to the granodiorite and could have come from a deeper or completely separate magma chamber. This suggests that crystal fractionation likely occurred in the magma chamber before the volcano erupted, and could have possibly even caused the eruption.

Using a Virtual Field Trip to Teach the Plutonic History of Yosemite National Park

Student: Isabel A. Guinto

Faculty Advisor: Dr. Natalie Bursztyn

To compensate for lack of economic support and convenience of real world field trips, educational virtual field trips (VFT) can be incorporated into teaching strategies to provide experience-based learning to a broader audience. The incoming college students are from Generation Y, a group that grew up with the familiarity of technology, view repetition as mundane, and want to be guided through tasks, not enforced. VFTs provide an immersion that allows students to experience learning in a dramatically different way than the typical classroom scenario. Students can work independently at their own pace using their own smartphones and tablets. When used as a pre and post method for enhancing and reviewing real field trips or lectures, virtual field trip technology and interactive experiences have been proven to increase student motivation.

Through a roadside field trip guide application for smartphones and tablets, our proposed VFT of Yosemite National Park informs users about the volcanic geologic history of the area. Users are guided to observe outcrops that tell the plutonic story of how Yosemite's rocks formed from magma millions of years ago. The users are intended to be entry level geology students and public tourists who visit the park. The story line for this virtual field trip will follow interpreting the formation of Yosemite through geologic evidence found along the two main driving routes through the park. The first route is through Yosemite Valley and the second, along Tioga Pass Road. To explain the geologic processes along a route, the app will activate a narration of each field trip stop based on the user's GPS location. The VFT app may also be used in a classroom without GPS triggers. Once the app is developed, it will go through beta testing before being launched. This interactive virtual field trip of Yosemite National Park will provide an example of a geologic history that can intrigue the public and educate college students about geology applied in a spectacular real-world setting.

Stratigraphic Variability in Response to Environmental Changes Across Short and Long Time Scales Along the Southern Monterey Bay Continental Shelf, California

Student: Jamie Hayward

Faculty Advisor: Dr. Joe Carlin

Modern continental shelf stratigraphy preserves a high-resolution record of complex natural and anthropogenic processes that operate on a variety of timescales. Long-term scales can record sea level or climatic changes, whereas short-term scales may record extreme events such as storms, floods, landslides, or earthquakes. This dichotomy of timescales is fundamental to understanding how both short and long-term processes shape the stratigraphic record. The Salinas River Mudbelt (SRM), located in Monterey Bay, CA, is influenced by the processes operating over these variable time scales. Over longer terms, the SRM is heavily influenced by climatic cycles; while over shorter times, the SRM is the sink to the Salinas River, which has produced some of the most substantial event-driven sediment fluxes in the conterminous U.S. and is subject to earthquakes and landslides. Therefore, the SRM may offer insight to better understand the processes that influence strata formation along continental margins over a variety of timescales. To address this, we collected short sediment cores (~ 0.3 m), from the SRM, and analyzed the cores to determine modern sedimentation rates via $^{210}Pb/^{137}Cs$ geochronology, and characterize the sediment using grain size and X-ray fluorescence (XRF) analyses. Overall the results indicate a change in sedimentation around the mid twentieth century with Titanium (overall terrestrial sediment indicator) and Iron (heavy terrestrial sediment indicator) showing a net decrease over time. However, sand and high energy deposition indicators (e.g. Zirconium) increased over time. Within the latter half of the 20th century site SR1707-03, proximal to the Salinas River mouth, shows distinct peaks in the < 20μm fraction, and a flood deposit indicator which may correspond to major floods in 1969, 1978, 1983, and 1995/1998. At site SR1707-02 a distinct event layer was also observed, but it is unclear whether the event layer was due to a flood or an earthquake. Reconstructing sedimentation overtime using two models based on whether the event represents flooding or an earthquake results in different interpretations the causal mechanisms behind the of observed changes in sedimentation. The shift in sedimentation may reflect a longer-term trend of environmental change caused by combined climate and human activities or may represent an abrupt reorganization of the sedimentary system following the earthquake. This study demonstrates the usefulness of continental shelf stratigraphy to preserve both long-term and short-term changes to the system and highlights the potential for lasting change as the result of decadal-scale processes or singular events.

Stride Like a Velociraptor

Student: Rhyan Ibarra

Faculty Advisor: Dr. Natalie Bursztyn

In the geosciences students have consistently struggled with understanding scale-related concepts ranging from geologic speeds to the magnitude of the mountains. Geoscience education research continues to return to these concepts in order to improve student understanding of them. This project investigates the use of kinesthetic experience on a lesson about scale and magnitude using dinosaur trackways. Using life-size dinosaur footprints, we teach students how geoscientists can use trackways to interpret the size and speed of these prehistoric animals. In the lesson students literally walk in a dinosaur's shoes to physically experience the length of its legs and stride. We constructed "dinosaur shoes" for seven dinosaurs from Crocs and foam flooring using footprint and stride data that included images of the footprint shape. Some of these dinosaurs are well known by the public and others are not. We gave the lessons at three schools: a 5/6th grade class (n=28), a 9th grade cohort (n=110), and a college cohort (n=47). In order to obtain the base knowledge of the students, they were given a pre-test assessing their knowledge of these dinosaurs as well as the common misconception that dinosaurs dragged their tails when they walked, then were given an overview of the dinosaurs and the activity. While wearing the corresponding shoes, students tried to replicate stride lengths and discussed challenges accomplishing this task after the activity was finished. A post-test was administered and we ran multivariate t-tests to analyze the results. We found that the experience had a significant impact on student understanding at all three academic levels, with no statistical difference in learning gains across age or demographic groups. We tested for retention with the college cohort three months later but not for the elementary and high school due to timing and their academic calendar. We found that the college students still had statistically significant learning gains.

Interpreting Recent Stratigraphic Changes for the Northern Monterey Bay Continental Shelf

Student: Victoria Severin

Faculty Advisor: Dr. Joseph Carlin

Continental shelves are dynamic environments, controlled by the combination of marine, terrestrial, and climatic processes. Therefore, any changes in the climate, ocean, or coastal watersheds are likely to be reflected and preserved within the shelf sedimentary record. Yet the effects of recent perturbations (e.g. climate change, sea level rise, accelerated population growth and anthropogenic modifications to natural systems) on geologic processes and the geologic record has only started to be investigated in select locations. Continental shelves represent the ideal location to assess these recent accelerated changes as shelf stratigraphy integrates ocean, terrestrial, and climatic processes. Therefore in this study we investigated shelf sedimentation in the mid-shelf mud belt along the northern Monterey Bay continental shelf. Short sediment cores (< 30 cm long) were collected from four locations to capture a record spanning the past ~60 years. The cores were analyzed in 1 cm intervals to determine modern sedimentation rates via short-lived radioisotopes, and sediment texture from grain size analysis. Results showed that there is general coarsening up core trend at all four locations. For example, core SR1707-10-03MC increased from ~50% sand at the base to >60% at the surface, while cores SR1707-08-04MC and SR1707-07-01MC both increased upcore from ~30% to ~35%. Additionally, from the radioisotope data we estimated a sedimentation rate of 4.4 mm/yr for SR1707-07-01MC, and a minimum sedimentation rate estimate of 4.7 mm/yr for core SR1707-10-03MC. These rates reflect accumulation averaged over the past ~30 and ~60 years respectively, and are higher than rates from previous studies in the region which incorporated earlier time periods. Therefore these results suggest accumulation rates have increased along the shelf over the past several decades. While such an increase in accumulation may reflect the increased accommodation space due to sea level rise, the increased accumulation coupled with an overall coarsening is counterintuitive given both global and regional trends of reduced total sediment and coarse-grain sediment flux to the coast due to anthropogenic modifications. We conclude therefore, that these results potentially reflect a change in sediment source over these past several decades, reflecting a shift away from a dominantly fluvial source as a result of human modifications to hydrologic processes. This study highlights the potential for stratigraphic changes along the continental shelf on decadal-scales resulting primarily from human modifications of natural systems.

Examining Reef Mound Construction to Understand How Reefs Recovered After Mass Extinction

Student: Travis Stone

Faculty Advisor: Dr. Nicole Bonuso

In the Triassic, the central oceans covering our planet were the Panthalassan Ocean and Tethys Ocean. Following the end Permian mass extinction, marine communities forever changed. Before the extinction, more ancient and now extinct corals built reefs. Following the extinction, reef communities become more modern and recover in four progressive stages: stabilization, colonization, diversification and domination (Flügel, 1982). To date, researchers focus Triassic reef studies within the Tethys Ocean. This study aims to describe a series of Late Triassic reef mounds formed in the Panthalassic Ocean, an old precursory Pacific Ocean. Four reef mounds ranging between 1m and 4m occur on a depressed shale bed, indicating that the mounds grew off of the sea floor. Previous research from this site suggests that Panthalassic reef communities represent the colonization stage of reef recovery (Bonuso, et al., 2018). The present study aims to test the hypothesis that these four reef mounds embody the colonization stage by identifying and counting fossil organism within their environmental context. In total, eighteen thin sections were analyzed and approximately 220 points per slide were counted. Since these rocks are matrix supported, lack *in-situ* frame builders, are dominated by sponges and outcrop in a dome shape, the reefs are interpreted as sponge reef mounds as defined in Embry and Klovan (1971). Based on the definition given by Flügel (1982), the mounds represent the colonization stage of recovery because they contain matrix supported branching sponges, encrusting growth habits and lack framework builders. Concurrently in the Tethys ocean, reef structures experience full recovery and are in the domination stage; thus, the Panthalassic reefs experience a delayed recovery.

Manageable Molecular Mineralogy: Developing a User-Friendly Interactive Mineralogy Game for Mobile Devices

Student: Leah Wiitablake

Faculty Advisor: Dr. Natalie Bursztyn

In this digital age, pedagogy falls short with methods of teaching mineralogy being stuck in the past. This project aims to address the problem documented in the chemistry community and anecdotal in the geology community: students cannot visualize crystal structure. In the geoscience community, there have been papers published on students having difficulty with the visualization of structural geology and ways to solve this problem. However, with respect to mineralogy, the struggle students have with the material has not been documented. Nonetheless, anecdotally, there is teacher dissatisfaction with the poor retention of material from mineralogy classes.

Research has found that information relayed through images is retained better than information relayed through text. In fact, three-dimensional (3D) models and visuals have been shown to be the most effective methods for teaching and have results of greatest student retention of material. Due to the great leap in technology in the last decade, reports on the use and effectiveness of virtual reality and games in education has taken off.

Here we describe the design of an interactive game to teach crystal structure to undergraduates. Game-like elements engage the user, while touch-manipulated 3D models allow students to play with the structure of a mineral at the molecular level. Starting from an outcrop and zooming into minerals, then to individual atoms, students will be able to build different silicate minerals by rearranging silicon tetrahedra to see how different structures affect the outward appearance of the crystal. We believe this game will improve student learning of minerals and their structure and will help bridge the technology gap between the outdated ball and stick models and today's digital native undergraduates. By using up-to-date technology we can combine text, audio, video, and user-manipulated 3D models to better help students understand the molecular world with a game for mobile smart devices.

13 YEAR ANALYSIS OF WATER PRESSURE AND CHEMICAL CHANGES FROM WELL CSF-1, FULLERTON, CA

Student: Terrinda Alonzo

Faculty Advisor: Dr. W. Richard Laton

To better understand the hydrogeology in Northern Orange County, a deep multiport monitoring well, CSF-1, was installed in the northwest corner of California State University, Fullerton (CSUF) in 2003. Since the installation of the well, Orange County Water District (OCWD) has been collecting monthly water pressure profiles; in addition, the water chemistry is analyzed annually. In order to understand the groundwater conditions under CSUF, a detailed review of the data from the past 13 years has been proposed. Patterns in the assembled data show correlations between tracer chemicals (i.e. nitrate and perchlorate) that can be traced to a potential source of recharge. These correlations are found at lower than expected depths. Out of six defined aquifers, there are abnormally high concentrations of nitrate and perchlorate in aquifers 2 and 5 with lower, but still significant levels in aquifers 3, 4, and 6. The key finding is that even though the lower aquifers showed abnormally high amounts of these chemicals, they showed low to no traces of the tracer chemicals in the upper unconfined aquifer. Based upon this finding, it was determined that the tracer chemicals, nitrate and perchlorate, do not originate from local runoff or recharge. In fact, the recharge of the lower aquifers must originate further away, most likely the OCWD recharge area east of the City of Placentia.

Sedimentologic Analysis of the Late Ordovician Lower Member of the Ely Springs Dolomite at Vaughn Gulch, Inyo County California

Student: Erin Boeshart

Faculty Advisor: Dr. Adam Woods

The Late Ordovician was a dynamic period in Earth history when rapid and profound climatic changes led to the first glacial interval of the Phanerozoic in addition to the first major mass extinction in Earth history. While the cause of the mass extinction is well-established to have been the result of climatic changes, the nature of those changes is less well understood, with some authors arguing for a brief glacial period limited to the latest Ordovician (Hirnantian) and others arguing for a much longer glacial period across much of the Late Ordovician. The Upper Ordovician lower member of the Ely Springs Dolomite of east-central California was deposited along the western margin of Laurentia, and provides a means to examine the effect of Late Ordovician climatic changes on tropical, carbonate environments. The lower member of the Ely Springs Dolomite was examined at the Vaughn Gulch locality within the Inyo Mountains. A stratigraphic section was measured across the lower member and hand samples were collected from distinctive facies in order to better understand conditions when the unit was deposited. In addition, thin sections were made of representative lithologies in order to petrographically analyze the unit and determine microfacies. Analysis reveals that the lower member of the Ely Springs Dolomite was deposited in a shallow lagoonal setting that is rich in fossils including sponges, crinoids, brachiopods, corals, snails, trilobites, and echinoderms. The unit was subjected to occasional storm conditions based on the presence of tempestites that represent washover into the lagoon, as well as convoluted beds that provide evidence of ancient earthquakes (possibly from activity along the Las Vegas arch). The lower member of the Ely Springs Dolomite contains multiple, m-scale shallowing-upward sequences that indicate stable climatic conditions in an ice-free world up until deposition of the Hirnantian-aged middle member, which led to exposure and karstification of the uppermost lower member. Overall, the results of this study documents a stable carbonate platform prior to the Hirnantian glaciation and suggests that glacial events were limited to the latest Ordivician (Hirnantian).

Investigation and Monitoring the Spread of Water Contaminants Using an Open Source Database in the Orange County Area

Student: Adam Meadows

Faculty Advisor: Dr. W. Richard Laton

The study focus relies on the Orange County Groundwater Basin (OCGB) and the Metropolitan Water District (MWD) of Southern California to supply the majority of their water. The OCWD obtains water sources from collected run off of snowmelt and rainfall and treated wastewater while the MWD obtains their water through importing supplies from the Sacramento and San Joaquin rivers, the Colorado River, and local sources. These local sources include obtaining supplies through water recycling, desalination, pumping groundwater, and water banking within other nearby agencies. As Orange County is a heavily industrialized urban area, there is cause for concern regarding contaminants infiltrating public water supply wells and the risk of spread of such contaminants. Contaminants such as Toluene, Perchlorate, Nitrate, Benzene, Trichloroethylene (TCE), and Perchloroethylene (PCE) are the focus of this study. In order to understand the threat that these contaminants impose on local water sources within the main portion of Orange County, the study area was limited to the Fullerton-Placentia-Anaheim area. Using pre-existing data from open source well databases from Geotracker, a Geographical Information Systems (GIS) modeling software was used to produce several models in an attempt to map the spread rate of contaminants within the subsurface of the study area. Once modeled, the correlation of data was able to produce a physical map of several plumes. Concentration levels were then cross examined to locate the source and compared with annual public data entries to obtain the rate of spread. Furthermore, this thesis tracked the groundwater movement around the OCWD recharge facilities to identify the possible spreading paths of contaminant plumes and the projected path of the contaminant bodies in the OCGB.

Masters MS Proposal Category C

GEOLOGICAL SCIENCES
CSUFULLERTON

QUANTIFYING GROUNDWATER DISCHARGE INTO THE SANTA ANA RIVER IN RIVERSIDE, CA USING SEEPAGE METERS

USING SEEPAGE METERS IN A CONTROLLED SETTING AT MINI ANAHEIM LAKE IN ANAHEIM, CA TO DETERMINE MAXIMUM SEEPAGE EFFICIENCY

Student: Andrea Arevalo

Faculty Advisor: Dr. Richard Laton

Seepage meters are used to quantify groundwater recharge and/or discharge flux and aid in characterizing local surface water-groundwater interactions. Seepage meters are a less expensive method than the costly alternative of constructing monitoring wells. Seepage meters will be placed in the Santa Ana River in Riverside, CA to quantify groundwater flux during dry months (April - September) and to determine groundwater contribution to the river. Additionally, seepage meters will be used to determine recharge rates at an Orange County Water District constructed recharge pond, Mini Anaheim Lake in Anaheim, CA, in order to compare our seepage values obtained by the meters with the data values obtained by Orange County Water District. In addition, observations of decreasing seepage rates as silt from the silty waters of the Santa Ana River blankets the bottom of the recharge pond will be made to determine optimal times to clean the pond bottom for maximum groundwater recharge into the basin. Studying groundwater flux within the Santa Ana River upstream of Prado Dam and groundwater recharge at Mini Anaheim Lake in Anaheim, CA, can help in determining river flow contribution from groundwater and aid in further development of annual water budgets and offer insight on improving groundwater recharge efficiency into our local groundwater basin, respectively.

Exploring Interunit Magma Mixing using Trace Element Patterns of K-feldspar Megacrysts in the Tuolumne Intrusive Complex, Yosemite National Park, CA

Student: Melissa Chambers

Faculty Advisor: Dr. Vali Memeti

The emplacement and nature of magma chambers involve fundamental unresolved questions. Deciphering the size and interconnectivity of magma chambers at the emplacement level can help address some of these questions and determine how the nature of the overall system affects their connection to large volcanic eruptions. One approach is to track magma mixing across plutonic bodies using single mineral geochemical records to determine which, if any, adjacent magma bodies acted as interconnected magma mush simultaneously, and if so, over what spatial scales this occurred.

Populations of K-feldspars from the equigranular and porphyritic Half Dome (eHD and pHD) and Cathedral Peak (CP) granodiorites from the compositionally zoned, 1,100 km^2 Tuolumne Intrusive Complex (TIC), will be identified for each unit using core-to-rim trace element patterns and mineral inclusion types and patterns to spatially track populations throughout the intrusion. This will test the hypothesis that K-feldspar crystals were magmatically eroded from a solidifying magma mush of eHD or pHD during the intrusion of new magma pulses and recycled into adjacent, younger pHD or CP magmas, where they may have continued growing into their megacryst size. This also begs the question whether the larger K-feldspar megacrysts preserved longer magmatic histories and that they do not simply represent products of increased growth rate.

Petrographic analysis of megacrystic K-feldspars and their mineral inclusions will help determine the presence/absence of K-feldspar populations for each unit. Cathodoluminescence imaging for each K-feldspar will highlight compositional zoning used to locate compositionally varied crystal portions from core to rim. Major and trace element analyses will be completed for quantitative characterization of the zoning using electron microprobe analysis and laser ablation inductively coupled plasma mass spectrometry. Overlapping, unit-specific trace element patterns within single K-feldspars will identify which units the K-feldspars grew in. This will determine whether crystal transfer occurred at the emplacement level and how interconnected magmas can get across units, and thus establish the size of magma mush bodies in the active TIC. U-Pb thermal ionization mass spectrometry geochronology of zircons from the core and the rim of one K-feldspar megacryst will be used to determine the crystal growth rate. This will examine if the large sizes are due to prolonged growth histories, making crystal transfer between units possible, or the crystals simply grew larger under favored growth rate conditions.

Investigation of the Late Holocene Rupture History of the Southern San Andreas Fault: Paleoseismic study in the Carrizo Plain, California

Student: Nick Inserra

Faculty Advisor: Dr. Sinan Akciz

Paleoseismology provides observational data that define the temporal and spatial characteristics of ruptures along faults over multiple earthquake cycles. Recent paleoseismic data from Bidart Fan (BF) and Frazier Mountain (FM) sites suggest that 6-7 earthquakes occurred in the last 800 years, the most recent being the 1857 Fort Tejon earthquake that ruptured the entire length of the south-central San Andreas Fault (SAF). The extent and magnitude of prior earthquakes, however, remain speculative since these earthquakes can no longer be assumed to have similar magnitude and slip to the Fort Tejon earthquake, since this would produce unrealistically high slip rates (>6 cm/yr) along the south-central SAF. We hypothesize that earthquakes rupturing the Carrizo section vary in magnitude (measured by rupture length and surface slip) and some of the BF and FM earthquakes were cascading, rather than continuous ruptures. Confirmation of this rupture behavior and identifying recognizable and repeatable patterns of surface-rupturing earthquakes are critical for the development of accurate fault behavior and seismic hazard models.

Reconstructing pre-historic rupture patterns of earthquakes with variable magnitudes and slip distributions is impossible without high-resolution earthquake chronology data from closely-spaced paleoseismic sites. Filling spatial gaps in existing records (paleoseismic sites along the Cholame, Carrizo, and Mojave sections of the SAF are over 100 km apart) is the next step to constraining the earthquakes that have ruptured the southern SAF over last few millennia. We propose to open new trenches for paleoseismic investigation at the Van Matre Ranch (VMR) site, located 20 km south of BF and 80 km north of FM. Sedimentary deposits at this site consist of aerially extensive alluvial fan deposits, including debris flows, fluvially deposited sand and gravel beds, laminated silts, and clay lenses that should contain detrital charcoal pieces transported from the nearby Temblor Ranges. Past earthquake evidences will be documented on photomosaics of trench walls printed at 1:10 scale. Organic samples from stratigraphically significant layers will be dated to determine the timing of the past earthquakes. We anticipate periods of time when there are no evidences of earthquakes rupturing the surface at the VMR site, but have been reported at BF and FM sites, indicating that the records at BF and FM are from separate earthquakes even though their age constraints overlap.

Early Triassic Paleoceanography along Western North America: An Analysis of the Middle Member of the Union Wash Formation, East-Central California

Student: Rostislav Kovtun

Faculty Advisor: Dr. Adam Woods

Biotic recovery following the Permian-Triassic mass extinction was hampered by environmental stresses present in Early Triassic ocean waters. Deep water anoxia in the global ocean is speculated to be a major contributor to delayed recovery rates following the extinction event, as oxygen-poor deep waters periodically transgressed onto continental shelves, and added to other difficulties affecting shallow water environments, including hypercapnic stress and hot sea surface temperatures that were potentially lethal. The middle member of the Union Wash Formation of eastern-central California provides a means to reconstruct environmental conditions present in Early Triassic deep water settings along the western margin of North America and test the hypothesis of Woods (1998) that the middle member of the Union Wash Formation was deposited under anoxic waters. The middle member of the Union Wash Formation will be examined at the Darwin Hills, CA locality in order to determine the nature and extent of anoxia off the coast of western North America during the recovery interval, as well as establish the relationship between environmental stress and biotic recovery following the Permian -Triassic mass extinction by comparing results to recovery trends from laterally-equivalent facies of the shallow-water Virgin Limestone. Paleoenvironmental conditions will be reconstructed from the middle member of the Union Wash Formation using outcrop analysis of primary sedimentary structures, macrofossils, and ichnofabric as well as through petrographic analysis of representative samples in order to define microfacies and better document the sedimentology of the unit. Overall, this study hopes to better constrain the environmental conditions present on the western coast of North America during the Early Triassic and determine the degree to which paleoenvironmental stresses affect recovery rates following extinction events.

Geochemistry of the late Cambrian Bonanza King Formation: Expanding the Steptoean Positive Carbon Isotope Excursion (SPICE) to the western Great Basin

Student: Westrick Snapp

Faculty Advisor:

This study aims to investigate a Cambrian global isotope excursion known as the Steptoean Positive Isotope Carbon Excursion (SPICE). The SPICE is a marine carbon isotope excursion that varies in magnitude from +4‰ to +6‰ and has been recognized from multiple localities worldwide (Kazakhstan, China, Sweden, Australia, USA, etc.) in carbonates and organic carbon of Pabian age (499-496 Ma). Recent studies have identified a coeval, positive sulfur isotope excursion that varies in magnitude from +10‰ to +70‰. Current hypotheses that attempt to reconcile these SPICE excursions include 1) global oceanic anoxia and euxinia, 2) high primary productivity and increased burial of organic carbon, and 3) enhanced glacial erosion of terrestrial carbonates. In this study, 119 samples were collected from north of Shoshone California and south of Beatty Nevada to investigate spatial variation in SPICE-related excursions. Samples have been collected and will be powdered and put through various isotopic analyses. Carbon isotope compositions of inorganic and organic carbon and sulfur isotope compositions of carbonate associated sulfate (CAS) and sulfide (pyrite) will be quantified and compared to other sites. We hypothesized that these new sites will express the SPICE excursions but that they will vary in magnitude reflective of spatial heterogeneity. This hypothesis conforms with the anoxia/euxinia hypothesis above, but places further constrains on the "global" nature of these conditions. Regardless of the outcome, this study will help us better characterize an important and particularly confounding interval in Earth history.

Masters MS Thesis Category D

Southern California Coastal Wetland Evolution: Using the Geologic Record to Understand the Shift from a Late Holocene Oyster Reef to Salt Marsh

Student: Sarah Dickson

Faculty Advisors: Drs. Joseph Carlin and Nicole Bonuso

Ostrea lurida, commonly known as the Olympic oyster, is the only oyster species native to the US Pacific coast. Although this species was once common throughout Southern California, the past 200 years have seen a significant decline in abundance that is believed to be largely the result of anthropogenic influences. Evidence for the proliferation and decline of past oyster communities has been observed in the geologic record of modern salt marshes, which indicates that these environments once supported oyster communities, and that natural processes resulted in widespread habitat loss. In order to improve management and restoration of this fishery, we must better understand these natural forces that drive the shift from estuaries with abundant oyster habitats, to what we have today in Southern California: salt marshes where oyster habitats are limited. Three cores were extracted from Los Peñasquitos Lagoon (LPL), a salt marsh in San Diego County with an established history as an environment that supported oyster habitats in the recent geologic past. Specifically, we focused on one area where a shell layer had previously been observed. The cores were analyzed to (1) assess the ecology of the shells via shell identification and taphonomic analysis, (2) characterize the sediment using grain size and Loss-on-Ignition analyses, and (3) establish an age-depth relationship from radiocarbon analysis of shells and other material throughout the cores. From these analyses we aimed to determine if shell layers represented active reef communities, characterize the environment at the time when the shells were deposited, and better understand the environmental changes over time that resulted the loss of oyster-favorable habitats. The results suggest that the shells are characteristic of an oyster reef community, however taphonomic analysis indicated that they may not have been *in situ*, but rather a locally reworked lag deposit. Stratigraphically, these shells are split into two layers that represent periods of change within the the bay as the mouth bar was cyclically established and dismantled based on variations in grain size throughout this section. More recently, a potentially extreme hydrologic event may have driven the permanent closure of the mouth bar, initiating a rapid change to the modern salt marsh we see today. This study provides insight to the natural environmental factors that may have contributed to the decline in *Ostrea lurida*, and may aid future restorative efforts in southern California.

Origin of sulfur for elemental sulfur concentration in salt dome cap rocks, Gulf Coast Basin, USA

Student: John Hill

Faculty Advisor: Dr. Sean Loyd

Cap rocks of the Boling salt dome contain large elemental sulfur accumulations. Isotopic and petrographic data indicate complex histories of cap rock paragenesis. Whereas paragenetic complexity is in part due to the open nature of these hydrodynamic systems, a comprehensive understanding of elemental sulfur sources and concentration mechanisms is lacking. Large ranges in traditional sulfur isotope compositions ($\delta^{34}S$) among oxidized and reduced sulfur-bearing phases has led some to infer that microbial sulfur cycling and/or influx of isotopically distinct sulfide-rich formation waters occurred during calcite cap rock formation. Ultimately, traditional sulfur isotope analyses alone cannot distinguish among local microbial or exogenous sulfur sources. Recently, multiple sulfur isotope (^{32}S, ^{33}S, ^{34}S, ^{36}S) studies reveal small, but measurable differences in mass-dependent behavior of microbial and abiogenic processes. To distinguish between the proposed sulfur sources, multiple-sulfur-isotope analyses have been performed on native sulfur from the Boling cap rock. Initial data yields $\delta^{34}S$ values of -3.93 to +9.79, $\Delta^{33}S$ of +0.065 to +0.115, and $\Delta^{36}S$ of -0.900 to +0.162. Calculated $^{33}\lambda$ and $^{36}\lambda$ values of 0.5136 and 1.900, respectively, fall within known ranges of microbial mass dependent relationships. These data suggest that biological processes in part led to the anomalous sulfur enrichment in Boling Dome cap rock.

Productivity and Oxygenation Following the Permian-Triassic Mass Extinction Event: A Case Study from Opal Creek, Alberta, Canada

Student: Anthony A. Macias

Faculty Advisor: Dr. Adam Woods

Permian and Triassic rocks deposited along the northwestern margin of Pangea record long-term shifts in the paleoceaonography of eastern Panthalassa. Persistent upwelling occurred during the Middle and Late Permian that collapsed just prior to the Permian – Triassic mass extinction ~251 Ma (Beauchamp and Baud, 2002). Macrofaunal recovery was not immediate following the extinction, but was strongly influenced by environmental conditions. In order to understand the long-term paleoceanographic history of northwestern Pangea and its relationship to Permian upwelling, the Permian – Triassic mass extinction, and post-extinction recovery, it is helpful to examine proxies related to productivity and oxygenation across the entire period. Located within the southern Canadian Rockies, the Opal Creek, AB locality contains a nearly complete stratigraphic section of Lower Permian to Lower Triassic deep-water sediments deposited along the northwestern continental margin of Pangea, and is composed of three distinct formations, including the Lower Permian Johnston Canyon Formation, the Middle Permian Ranger Canyon Formation, and the Lower Triassic Sulphur Mountain Formation. To better understand the relationship between recovery and environmental conditions related to the extinction, productivity and marine oxygenation levels were reconstructed via major, minor, and trace element analysis of 230 previously collected samples. Preliminary productivity proxy data (Ba, Cu, Ni and Zn) show an increase in values across the Permian (Johnson Canyon Formation) and are indicative of high primary productivity, followed by a rapid decline across the P/Tr boundary. Early Triassic productivity is weaker than that of the Permian, but shows modest recovery during deposition of the Griesbachian – Dienerian Phroso Siltstone Member and more robust productivity during deposition of the Smithian - Spathian Vega Siltstone Member (although values are still below that of the Permian). Paleoxygenation proxies (Mo and V) demonstrate oxic to suboxic conditions during the Permian; values peak just above the P/Tr boundary due to a euxinic event, followed by persistent suboxic to anoxic conditions for the remainder of the study section. The results of this study agree with those of Schoepfer et al. (2013) from the same section, and demonstrate continued weak productivity and reduced benthic oxygenation well into the Early Triassic.

Length Scales of Magma Mixing and Magma Chamber Dimensions as Inferred from Zoning in Feldspars, Tuolumne Intrusive Complex, Yosemite National Park, CA

Student: Louis Oppenheim

Faculty Advisor: Dr. Vali Memeti

The size and longevity of magma chambers in long-lived, composite intrusions is debated and exemplified by two end-member models: 1) intrusions as a series of non-interacting dikes, and 2) intrusions as an interconnected magma mush. This study uses feldspar populations from the equigranular and porphyritic Half Dome (eHD and pHD) and Cathedral Peak (CP) granodiorites from the SE Tuolumne Intrusive Complex (TIC) in Yosemite National Park to determine the degree of interunit mixing and extent of magma mush bodies during TIC evolution.

Techniques employed included field mapping of contacts, petrography, whole-rock element geochemistry to characterize major and hybrid TIC units, and cathodoluminescence to identify feldspar populations. Selected K-feldspars and plagioclase were analyzed for major and trace elements (e.g., Ba, Sr, Ga, Y, etc.) with EMPA and LA-ICPMS along core-to-rim transects.

Our results include the following: 1) Interunit contacts are largely gradational and represent hybrids; 2) Samples from the eHD-pHD hybrid are granite, not granodiorite like main eHD and pHD; 3) Rb concentrations in the eHD-pHD hybrid are higher than in the eHD and pHD; 4) the eHD-pHD hybrid zone contains petrographic features indicative of crystal mixing, e.g. biotite inclusions in hornblende; 5) K-feldspars of each unit exhibit distinctive Ba zoning patterns. eHD K-feldspars (≤5 mm) are simple zoned, and pHD and CP K-feldspars (2-6 cm) are oscillatory zoned; 6) Several K-feldspars from each unit contain distinct, inherited cores.

Most K-feldspar cores from the eHD-pHD hybrid show distinct eHD and pHD Ba and Rb values that overlap with pHD in the interior and rims. This trace element signature overlap is also seen at the transition between CP and pHD near the pHD transition. Higher Rb likely records late-stage fractionated granitic melt from the eHD mixing with intruding pHD. The increase in number of Ba zones in K-feldspar from eHD to pHD/CP suggests that the pHD and CP record longer crystallization histories with possible pHD/CP magma recharge. These results imply that K-feldspars from eHD did not mix into pHD, but mixing of late-stage melt could have occurred between both units. The similarities between K-feldspars from pHD and CP, however, suggest that crystal recycling is possible. Comparisons of Sr and Eu in plagioclase suggest mixed populations as well. Our results support that two adjacent units (eHD/pHD and pHD/CP) were interconnected magma mushes at different stages of TIC history.

A DETERMINATION OF THE TIMING AND CONSEQUENCES OF THE LATE ORDOVICIAN GLACIATION USING THE ELY SPRINGS DOLOMITE OF EAST CENTRAL CALIFORNIA

Student: Austin Poncelet

Faculty Advisor: Dr. Adam Woods

The Late Ordovician is characterized by an anomalous glacial episode that caused profound changes in global oceanic circulation. Although the Late Ordovician glaciation is well recognized from sedimentological observations, the timing/extent of glaciation is poorly understood, with two competing hypotheses: 1) Glaciation during the Late-Ordovician was short-lived (<1 my) and occurred during the Hirnantian (e.g., Brenchly et. al., 1994); and, 2) Glaciation during the Late Ordovician was long-lived (lasting ~10-35 my) and began during the Sandbian (e.g. Saltzman and Young, 2005). The goal of this study is to constrain the duration of the Late Ordovician glaciation, and provide paleoceanographic data about the northwest margin of Laurentia by examining the sequence stratigraphy and chemostratigraphy of the Upper Ordovician-Lower Silurian Ely Springs Dolomite. The Ely Springs Dolomite was deposited as part of a homoclinal carbonate ramp, and was examined at 2 localities from east-central California: at the Nopah Range and at Hard Scramble Nose (Talc City Hills). Overall, evidence points to a short-lived glaciation, including the presence of small scale (1 m -10 m), high frequency, autocyclic sea level fluctuations prior to and after the Hirnantian glaciation, along with the presence of photozoan (warm water) carbonate assemblages throughout both the lower and upper members of the Ely Springs Dolomite. Carbon isotope data and brecciated lithologies (i.e., paleokarst) reveal the absence of the middle member of the Ely Springs Dolomite at both localities, which reflects the drawdown of sea levels during the Hirnantian glaciation. Greater enrichment of Mn and Fe within the lower member of the Ely Springs Dolomite compared to the upper member suggests that meteoric diagenesis only affected the lower member, likely due to exposure of the carbonate platform as sea levels dropped during the Hirnantian, and exposed the entire thickness (~60-70 meters) of the lower member to meteoric waters.

THE JACK MAIN INTRUSIVE COMPLEX IN THE LATE CRETACEOUS CENTRAL SIERRA NEVADA, CA: A MIGRATING PLUTON WITHIN A MAGMA FOCUSING REGION

Student: Cullen Scheland

Faculty Advisor: Dr. Valbone Memeti

Between ca. 105 to 85 Ma, the central Sierra Nevada underwent regional spatiotemporal magmatic focusing centered on the 95-85 Ma Tuolumne Intrusive Complex (TIC). The Jack Main Intrusive Complex (JMIC) was emplaced 5 km W of the TIC 2 myr earlier along a migration direction opposing both regional arc migration and internal spatiotemporal focusing patterns. Field mapping (nature of contacts, magmatic fabrics), petrography, LA-ICPMS U-Pb zircon ages, and whole-rock element and Nd and Sr isotope compositions were used to characterize the petrology and structure of the JMIC. This study aims to understand how a migrating, normally zoned intrusive complex within a regional focusing system was emplaced and evolved, structurally and geochemically, in the upper crust.

The JMIC is an overlapping, concentrically zoned, NW migrating intrusive complex composed of four plutons younging and increasing in SiO_2 from SE to NW: Quartz Diorite of Mount Gibson (Kgi), Granodiorite of Bearup Lake (Kbu), Granodiorite of Lake Vernon (Klv), and Granodiorite of Boundary Lake (Kbl). The Kgi (96.81±0.33 Ma) is a quartz diorite (~59 wt. % SiO_2) bearing hornblende on relict pyroxenes. The Kbu is a hornblende-biotite granodiorite (~65 wt. % SiO_2). The Klv (96.22±0.55 Ma) is a locally K-spar porphyritic (<5 cm), hornblende-biotite granodiorite (~68 wt. % SiO_2). The Kbl (93.52±0.37 Ma) is a K-spar porphyritic, biotite-granite (~71 wt. % SiO_2). Whole rock isotope analyses yielded εNd (0) values of -5.5 (Kgi), -6.7 (Kbu, Klv), and -6.9 (Kbl) and Sr(i) values of 0.706549 (Kgi), 0.707048 (Kbu), 0.706724 (Klv), and 0.706813 (Kbl). Thus, the JMIC units are isotopically closely related by a mixture of mantle- and crustal-derived magma with the crustal signature increasing over time. This implies that co-linear whole-rock major oxide and trace element trends are likely two-component (juvenile and evolved) mixing trends that were likely modified by crystal fractionation. The JMIC is an intrusive complex that emplaced along a migration track while evolving through mixing and fractional crystallization over ~3 million years.

Student Research Category E

Perchlorate in Urban and Industrial Environments

Student: Aaron Case

Faculty Advisor: Dr. W. Richard Laton

In Anaheim, California, fireworks are displayed almost every day of the year since 1958 to present day. An accelerant for fireworks known as perchlorate (NH_4ClO_4) has been used in the area by Disneyland® in a daily fantastic display for entertainment and amusement. Although they have reduced the amount of perchlorate by launching their fireworks combined with perchlorate and compressed air in 2004, perchlorate is still used to assist in acceleration. There is very little to no evidence when it comes to fully understanding the health and environmental impacts associated with perchlorate air, water, and soil pollution. There are perchlorate studies that show the interference with the thyroid's role in iodine absorption and affects human metabolism and growth. To determine if perchlorate fallout is possible, we will be taking 4 soil and water samples downwind and just north of the fireworks. Wind direction and speed will be observed during the duration of the firework performance and before sampling. These samples will be taken using proper sampling procedures and placed on ice immediately and taken to the lab for testing. Metals will be added to determine is fallout had occurred in the past. The lab results will be then analyzed and the results will be evaluated.

Urban Firework Fallout

Student: Chelsea Emilio

Faculty Advisor: Dr. W. Richard Laton

Atmospheric deposition represents a significant portion of the total pollutant load to various contaminated ecosystems. In Southern California especially, the atmosphere has been shown to be a significant facilitator to pollution in its coastal ecosystems from geographical and metrological factors specific to the region. This process begins when trace amounts of pollutants become mobilized by wind patterns and are carried large distances from their source. Southern California has a unique atmospheric environment considering it is home to one of the worlds' most popular theme parks, Disneyland. Disneyland's nightly fireworks release toxic pollutants into the air that become deposited onto the neighboring terrestrial and aquatic surfaces. We collected soil and water samples from residential communities within a one-mile radius from the Disneyland theme park to measure the deposition flux gradient of perchlorate and heavy metals. We will compare our findings to historic levels of perchlorate and metals in the area to observe the elevated presence of these pollutants.

Greenhouse Gases and Their Effect on the Atmosphere

Student: Erica Offner

Faculty Advisor: Dr. W. Richard Laton

Carbon dioxide levels are causing a warming of the Earth's atmosphere, which in turn is causing an abundance of water vapor. The more heat, the more water vapor. This is a result of positive feedback loops; the sun warms Earth's surface, which warms the air and the atmosphere. When temperature rises, evaporation occurs. Evaporation takes water from Earth's surface and brings it up to the atmosphere. Water vapor, just like any of greenhouse gas has the potential to absorb thermal infrared energy from Earth. When water vapor collects around a particle, such as dust or gas, it becomes a cloud. Clouds reflect solar radiation and cause less energy to touch Earth's surface. Water vapor is the most abundant greenhouse gas and is potentially the most destructive. If this cycle continues, Earth's atmosphere could potentially become covered in clouds. Carbon dioxide causes a temperature rise and a temperature rise causes more clouds. This begs the question, does more cloud coverage help mitigate the effects of carbon dioxide or perpetuate its effects? This study compares carbon dioxide levels on Earth's surface to carbon dioxide levels in clouds seeking to identify if carbon dioxide levels are causing a rise in cloud particulate. It is hypothesized that if carbon dioxide levels are higher in clouds than in the air around them, then cloud coverage will not help mitigate climate change.

Should California Begin to Price Water as a Commodity to Increase Conservation?

Student: Daniel Lopez

Faculty Advisor: Dr. W. Richard Laton

The state of California's water supply issue is an ever-evolving problem. Many solutions have been expressed from alternative sources like desalinization and recycling wastewater to tiered pricing. One avenue that gets less traction is giving water a true value. Would pricing water like gasoline (based on supply and demand) make people more considerate of water usage? Can price increase help conservation? The hypothesis of this project asks if California should price water as a commodity to increase conservation. The focus of the work will examine whether or not water pricing can change the behavior of society. The economic impacts of this type of endeavor on consumers, industry, and the agricultural sector will be reviewed. The research will also review the current water sourcing projects and practices, along with the environmental damaged caused by such exercises. The results of the project show that the price of water can influence the behavior of users. As the price of water increases, users begin to decrease usage or begin to implement conservation practices. This is evidenced by the increased use of micro-irrigation in the agriculture and residential sectors. Increased water prices make alternative water sources like desalinization and reclamation projects more enticing. The decrease in usage can increase water availability for habitats. The pricing component can help in water conservation activities in the state. The constant drought conditions, coupled with an increasing population, leaves the state searching for ways to service water needs throughout California. Pricing is not a silver bullet; rather an arrow in the quiver to assist in California's issue to balance the demand of natural habitats and human water needs within the state.

GEOLOGY STUDENT AWARDS/SCHOLARSHIPS April 2018

AWARDS

Outstanding Graduate Student Award in Geology — *Austin Poncelet*
Awarded to a Geology graduate student who demonstrates excellent performance in classes and in their research as evidenced by, but not limited to, publications, presentations, collegiality, and/or leadership in the department. Award: $250 plus engraved glass

Outstanding Graduate Teaching Associate in Geology — *Jenifer Leidelmeijer*
Awarded to Geology graduate student teaching associate (TA) who demonstrates outstanding performance based on, but not limited to, Student Opinion Questionnaires, in-class visitations by faculty, teaching, collegiality, and/or mentoring other TAs. Award: $250 plus framed award certificate

Outstanding Major Award – B.S. in Geology — *Erin Boeshart*
Awarded to an upper-division Bachelor of Science Geology major who demonstrates high quality performance in classes, their undergraduate research project, and some type of service to the department, University or community. Award: $250 plus engraved glass

Outstanding Major Award – B.A. in Earth Science — *John Ayers*
Awarded to an upper-division Bachelor of Arts in Earth Science major who demonstrates high quality performance in classes and some type of service to the department, University or community. Award: $250 plus engraved glass

Outstanding Academic Achievement Awards– B.S. in Geology — *Judith Avila-Avalos*
Awarded to a junior or senior major with an exceptional CSUF GPA. The number of units completed in Geology and the related fields will be factored into the decision. Award: $250

Outstanding Academic Achievement Awards– B.A. in Earth Science — *Maria Rivera*
Awarded to a junior or senior major with an exceptional CSUF GPA. The number of units completed in Geology and the related fields will be factored into the decision. Award: $250

Candice L. Jones Outstanding Service Award — *Shayna Avila*
Given to the student who has made a significant contribution to the mission, operation and/or well being of the Department community. Examples of service include, but are not limited to, taking a leadership role in Geology Club activities; serving as a TA, tutor, or volunteer in GEOL classes; selflessly assisting others in meeting their educational, research or outreach objectives. Efforts above and beyond any employment or course credit obligations are given greater weight, and a positive attitude is required. Award: $250 each

John D. Cooper Field Camp Award — *Joseph Gutierrez*
Annual award to a declared Geological Sciences Major with outstanding performance in GEOL 481A-Geology Field Camp. Selected by field camp instructor with approval of all full-time geology faculty. Award: backpack embroidered with Cooper Award/year

Prem K. Saint Hydrology Award — *Adrian Escobar*
Award for Geological Sciences or Environmental Studies (with Environmental Sciences emphasis) major with a GPA of 3.0 or better for the previous academic year. Recipient must show an outstanding academic performance in course work and/or research in Hydrology, Hydrogeology or Water Quality. Award based on the recommendation of the geology full-time faculty. Award: $200 and a copy of "Cadillac Desert"

Marilyn A. Brown Award — *Anthony Macias*
Awarded to a graduate student conducting research in the general areas of paleontology or stratigraphy, and having an expressed or demonstrated interest in teaching or educational outreach. Award: $200

SCHOLARSHIPS

David L. Willoughby Scholarship — *Sabrina Green*
Given in memory of the late David Willoughby, an alumnus of the department. His family established the award in recognition of David's passion for sedimentary geology and paleontology. This scholarship is open to undergraduate students who are studying geology or paleontology, or who are participating in course-related fieldwork. Minimum GPA of 2.5 or higher in Geological Sciences at the time the scholarship is awarded. Recipient to be selected by faculty. Award: $400 each

Dr. Margaret Skillman Woyski Field Camp Scholarship — *Leah Wiitablake*
Open to a declared geology major with 2.5 GPA or better for the previous academic year. Awarded in even years to a student who has demonstrated excellence in fieldwork and will be enrolling in summer field camp. The award will be made on the recommendation of the entire full-time faculty of the department.
Award: $550

Department of Geological Sciences Alumni Field Camp Scholarship — *Shayna Avila*
Open to declared Geology and Earth Science majors that will be enrolled in GEOL 481A – Field Camp, in the upcoming summer. Awarded to a student who shows financial need, outstanding academic achievement (2.5 GPA or better for the previous academic year), and quality of written statements. This scholarship is given through the generosity the alumni and friends of the Department of Geological Sciences. Recipient to be selected by faculty of the Department of Geological Sciences.
Amount: Varies (up to $550)

John D. Cooper Field Camp Scholarship — *Adrian Escobar*
Awarded to a student who shows financial need, outstanding academic achievement (2.5 GPA or better for the previous academic year), and capacity to excel at field camp. Recipient to be selected by faculty of the Department of Geological Sciences. Award: $550

Department of Geological Sciences
2018 Alumni of the Year
William Goodman

About Bill

Bill Goodman received his Bachelor's Degree from the CSUF Department of Geological Sciences in 1983. As a senior, he was a student assistant for the California Division of Mines and Geology and a research assistant for the Department of Geological Sciences. He completed his senior thesis under the advisement of Dr. John Cooper. In 1984 he was hired by Beach Leighton as a staff geologist at Leighton and Associates.

In May 1994, Bill and two of his colleagues departed Leighton to form NMG Geotechnical, Inc. (NMG). As the company grew, the opportunity arose to increase staff and Bill immediately looked to the CSUF geology department for future professionals. Bill has hired 15 entry level and intern geologists from the geology department at Cal State Fullerton, many of whom are still employed by NMG. He is passionate about geotechnical fieldwork and values the focus the department places on field techniques.

Bill has remained an active and dedicated supporter of the CSUF Department of Geological Sciences since the early 1990s. He has coordinated field trips with the CSUF geology department to allow engineering geology students an opportunity to experience a day in the life of an engineering geologist. Students were able to observe downhole logging of a large diameter bucket auger borings, mapping of ancient and active landslides and observing the placement and testing of engineered fill. The students were also able to interact with professional engineering geologists, geotechnical engineers, soil technicians and grading contractors.

Bill was on the Advisory Board to the Dean of Natural Science and Mathematics at CSUF for approximately 5 years. He is also an active member of the Association of Engineering Geologists, the South Coast Geological Society, and the Association of Environmental Professionals. He also consults for the Board of Professional Engineers, Land Surveyors and Geologists for review of professional licensing exams.

Bill is a distinguished alumni who provides an outstanding example t
the past, current and future CSUF geology students of the enthusiasm
for geology at the professional level.

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There is no greater influence than the generous donations the Department of Geological Sciences receives each year from our Alumni, Students, Faculty, Staff, and Friends. We want to thank each of our donors listed below for their amazing gift. Without these contributions, the Department of Geological Sciences would not be able to fund the many scholarships presented to our students at the Annual Awards banquet in April and throughout the year.

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Thanks to all of our Geology
Students, Faculty and Staff for
another successful year within
the Geology Family!

Special thanks to
the South Coast Geological Society
for their support of CSUF students,
and to
the Department Staff and Dr. Richard Laton for all
they do to make
Research Day such a special event!