12th Annual CSUF Geological Science Research Day

Department of Geological Sciences
California State University, Fullerton

Online Webinar

Friday, April 30, 2021

Time: Presentations - 3:00 - 5:00

Awards Presentations - 5:00 - 6:-00

Happy Hour - 6:00 - 7:00

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Undergraduate BA/BS Proposal Category

The Rattlesnake Creek Terrane: An Enigmatic Tectonostratigraphic Terrane of The Klamath Mountains, California And Oregon

Student (NP): Anthony Aguilar

Faculty Advisor: Dr. Kathyrn Metcalf

The Rattlesnake Creek terrane is the westernmost tectonostratigraphic terrane of the western Paleozoic and Triassic belt, which is part of the Klamath Mountains province in northern California. This tectonostratigraphic terrane is divided into a structurally lower basement assemblage and higher cover sequence, both cut by various intrusions. The basement assemblage is composed of a serpentinite-matrix mélange or block-on-block mélange, with peridotite massifs - and blocks of peridotite, greenstone, amphibolite, pillow basalt, chert, argillite, limestone and plutonic rocks. The Late Triassic cover sequence is divided into the lower Salt Creek assemblage (basalt, chert, argillite and clastic rocks) and the higher Dubakella Mountain assemblage (volcanogenic mafic and felsic successions). Paleozoic to Triassic fossils and blocks of the cover sequence in the mélange indicate mélange deformation was active through the Late Triassic. Previous studies have interpreted that the basement mélange formed in an oceanic transform and that the cover sequence represents a Late Triassic intra-oceanic arc. The Early Jurassic is a notable gap in the complex geologic history of the Rattlesnake Creek terrane. By the Middle Jurassic, it was part of the western margin of North America, where it was metamorphosed in an arc setting and deformed by east-west compression. How and when did the Rattlesnake Creek terrane accrete to North America? We present new compositional and structural data from geologic mapping and thin section petrography to better understand the formation and deformation of the Rattlesnake Creek terrane and Triassic-Jurassic tectonics of western North America.

Aquifer protection for the cities of Santa Ana and Tustin for future generations

Student: Nestor Esparza

Faculty Adviser: Dr. W. Richard Laton

Orange County Water District has one of the most advanced treatment systems for collecting, treating, and re-using groundwater. This is a costly operation; however, it is essential for providing water to the residents of Orange County. Groundwater is constantly being affected by contaminants that start at the surface, and leech down to the water table. Using the public data from the GAMA Groundwater Information System, one can see that the readings for specific contaminants in the cities of Santa Ana and Tustin area are alarmingly high. These readings show increasing levels of Nitrates, Tetrachloroethene, and Chromium within the groundwater. All these chemicals are harmful to humans at various concentrations. The problem for the cities of Santa Ana and Tustin appears to be coming from the business/industrial sectors of Santa Ana, which is an area that shares the 55-freeway as a border with Tustin. I plan on using published online resources from the GAMA, City and water district documents, and other available information to determine the most likely sources for these contaminants. Once the most likely sources are identified, I will attempt to predict how the problem will change in the future based upon land use changes and environmental cleanup. My goal is to create a series of aquifer protection maps that can be used to support the cities of Tustin and Santa Ana.

An evaluation of sediment characteristics in a marred coastal wetland throughout the restoration process

Student: Julia Hernandez

Faculty Advisor: Dr. Joe Carlin

Coastal wetlands protect the coast from sea level rise but require enough sediment in order to offset increases in sea level. A lack of sediment can have detrimental impacts on these ecosystems, such as mass erosion and total inundation. While undoubtedly human activity directly within wetlands has had a negative impact, activities within coastal watersheds have disrupted the natural sediment delivery for the vast majority of tidal marshes, which has also significantly impacted these environments. The deterioration of coastal wetlands may inhibit their ability to provide flood protection in the face of sea level rise, and other ecosystem services. Therefore, restoration is needed in order to return to normal wetland functioning, and this process requires a comprehensive understanding of the natural functioning of these ecosystems. To that point, the goal of this project is to measure changes in sediment characteristics that occurred at Eden Land Ecological Reserve (ELER) in San Francisco Bay. This wetland was once used for salt harvesting, and therefore this project will span from the disturbed period, through a period when salt-harvesting ceased but prior to restoration, to restoration and the years following. To accomplish this goal, we will analyze cores collected from 3 different habitats within the wetlands, mudflats, low marsh, and high marsh. Using these cores we will determine how sediment characteristics such as grain size, percent organic matter, and percent organic carbon changed over time. From this project, we seek to gain a better understanding of how wetland sediment changes over the course of a cycle from disturbance through restoration, with an emphasis on understanding how long it takes to return close to natural functioning postrestoration. This project will also provide a better understanding of restored-wetland functioning that will help protect coastal communities from sea level rise.

Relationship Between Groundwater, Selenium Concentration, and the Corcoran Clay, NW Fresno County, CA

Student (NP): Brayden Nagata

Faculty Advisor: Dr. W. Richard Laton

Uncontaminated groundwater is essential, especially in the agriculturally rich San Joaquin Valley. Selenium has come forth as a major concern of water contamination since the Kesterson Reservoir Disaster of 1983. This study aims to log and map the quantity of selenium contamination (> 1 UG/L) found in wells and compare that to water depth and the depth of the Corcoran Clay in northwestern Fresno County. Using existing well logs from the region, a single map showing the data recorded for the items in question. This will produce a cross section to show the relationship, or lack thereof, between the Corcoran Clay, selenium concentration, and water depth. The research site is located in Mendota, CA. The location resides between Belmont and American Avenue, and Lyon and Fairfax Avenue. This region is monitored by the Westlands Water District. The area in question encompasses just over 19,000 acres. The Corcoran Clay is a massive diatomaceous silty clay layer that expands across most of the San Joaquin Valley. It is commonly described as a blue or green clay in well logs. Selenium is an element often recorded in these well logs of the San Joaquin Valley. Selenium is a nonmetal that often takes on the form salts, known as selenites. These salts can contaminate water of the San Joaquin Valley in typically two ways: weathering and erosion of ash deposits of the Southern Coastal Ranges or agricultural runoff. It is hypothesized that the depth of the Corcoran clay is inversely related to the concentration of selenium found in groundwater. To test this hypothesis, a detailed cross-section combining concentration of selenium as well as clay and water depth will be produced to better understand their relationship.

A Paleoenvironmental Analysis of the Upper Member of the Union Wash Formation, Darwin, CA

Student: K. Perkins

Faculty Advisor: Dr. Adam Woods

The Union Wash Formation, located in east-central California, is a Lower Triassic marine deposit formed along the outer continental margin and shelf of Pangaea during the recovery period following the end-Permian mass extinction. Severe global temperatures repressed post-extinction recovery and contributed to widespread ocean anoxia, which squeezed remaining marine life into narrow habitable zones below high surface water temperatures and above anoxic deep waters. The Union Wash Formation lies within such a zone; however, biotic recovery within the region was repeatedly set back, as indicated by the presence of anoxic environments and anachronistic facies. The Union Wash Formation is divided into three members, with the upper member characterized by an abundance of alternating micritic limestones and fine-grained clastics deposited as sea levels retreated near the end of the Early Triassic. The uppermost portion of the upper member has not yet been examined in detail, but fine-grained limestones and clastics observed within the section may represent multiple possible depositional environments, including a shoreface setting, a deeper location below wave base, or a lagoon. This research will examine the uppermost upper member of the Union Wash Formation at the Darwin Hills, CA locality in closer detail, with the intention of determining the depositional setting, providing information about the presence or absence of environmental stresses, and examining the relationship between these environmental stresses and biotic recovery. The study interval will be examined at three levels: outcrop, hand sample, and in thin section. This study aims to test the hypothesis that the uppermost portion of the upper member of the Union Wash Formation was deposited under improving environmental conditions, as it was deposited near the end of the recovery interval following the end-Permian mass extinction. Results from this study will help us better understand the timing of recovery from a major mass extinction, and, by extension, help us discern how Earth might recover from the current, sixth mass extinction.

Undergraduate BA/BS Thesis Category

A history of sediment accumulation in the Tijuana River Estuary: Highlighting coastal-watershed connectivity across an international border

Student (NP): Andres Bareno

Faculty Advisor: Dr. Joe Carlin

Sediment routing systems generally flow from inland sources such as mountains, traveling through rivers, and ultimately reaching the coast. Human impacts on these processes have increased throughout the routing system over the recent geologic past. Any impacts within the system can translate downstream and influence deposition at the coast. The Tijuana River Estuary (TRE) in southern California presents a unique system to study these impacts as deposition in the estuary, located in the United States, is impacted by human activity such as urbanization and industrialization in the watershed that is located predominantly across the border in Mexico. This project aims to better understand how human activities within a watershed influence sedimentation within an estuary, with a specific focus on assessing the impacts of different practices across a sediment routing system. To accomplish this, we analyzed decadal sediment accretion rates over the past century using ^{210}Pb and ^{137}Cs, and measured sedimentological properties such as grain size, bulk density, and total organic matter. From the results, we observed an overall increase in sediment accumulation over time, with sedimentation rates outpacing rates of local sea level rise. Within this overall increase in sedimentation, there was a net decrease in sand accumulation coupled with an increase in the mud accumulation. In addition to these changes in sediment texture, we also observed an increase in organic material overtime. From the data, major "tipping points" of increased sedimentation followed regional climatic shifts and periods of increased development within the watershed. This points to a system where shifts in sedimentation are driven by the effect of human activities in the watershed being amplified by natural variability. Furthermore, the increase of both mud, and organic matter demonstrate that wetland development, potentially enhanced by increased sediment loads from the watershed, is critical towards sustaining elevation capital relative to sea level rise. Thus, the sustainability of this ecosystem, at least in terms of sedimentation offsetting sea level rise, may be due in large part to human activities within the watershed.

The timing and magma source of the Sonora dike swarm and Standard pluton, Sonora, California, and comparison to other Jurassic dike swarms in the Sierra Nevada Batholith

Student: Caitlin Bates

Faculty Advisor: Dr. Vali Memeti

The Sierra Nevada Batholith (SNB) contains several swarms of late-Jurassic dikes and small mafic intrusions. Among these is the Independence dike swarm (IDS), a ca. 148 Ma dike swarm that is found in the eastern SNB and to the east in the Inyo Mountains and the Mojave Desert with a wide range of lithologies and isotopic values ranging Sr_i= 0.705324-0.710445 and εNd= -9.74 to -1.18 (Glazner et al., 2008). Dikes with bimodal compositions intruding the central SNB King Creek pluton are slightly older and much more primitive than the IDS. They have a LA-ICPMS U/Pb zircon age of 152.5±2.7 Ma and isotopic values of Sr_i= 0.70465-0.70470 and εNd= 5.40 to 7.63 (Wesley et al., 2019).

In the western SNB, the basaltic-andesitic Sonora dike swarm is less well-known and understood. It intrudes metasedimentary host rocks and the granodioritic to dioritic Standard pluton. Field observations and samples were collected to determine the timing and source of the Sonora dike swarm and its relation to other dike swarms in the SNB. Mafic dikes intruding the Standard pluton show a mingling relationship with the host magma. The Standard pluton revealed a LA-ICPMS U/Pb zircon age of 162.27±0.36 Ma. Isotopic analysis of three Sonora dikes and the Standard pluton range from Sr_i= 0.703701-0.705657 and εNd= -1.49 to 6.83. Based on the dike and pluton mingling relationships in the field, we conclude that the Sonora dikes and Standard pluton are coeval and thus that the Sonora dike swarm was emplaced before the central SNB King Creek dikes and the IDS. Additionally, isotopic analysis revealed that the magma source for the Sonora dikes and King Creek dikes as well as the associated Standard and King Creek plutons, respectively, is depleted mantle with minor crustal or enriched mantle input, while the source for the IDS is more evolved. The geographic location of these three Jurassic dike swarms and associated intrusions and their isotopic affinities indicate that the Sonora dikes in the northwestern SNB and King Creek dikes in the central SNB were sourced from asthenospheric mantle, while the IDS in the southeastern SNB and to the east and southeast thereof likely tapped a lithospheric mantle and/or a crustal source. Finally, the three dike swarms expand the Jurassic extensional period in the SNB to at least episodic (spatially and temporally) events ranging from 162-148 Ma.

Documenting Changes in Terrestrial Sediment Sources to Monterey Bay over Decadal and Centennial Time Scales

Student: Katya Beener

Faculty Advisor: Dr. Joe Carlin

Continental shelves are important recorders of environmental change that occurs in the ocean or on land. Terrestrial environmental changes can alter sediment sources and transport pathways to the ocean. These changes in sediment sources can be caused by natural phenomena, such as climate change and/or seasonal weather patterns, as well as human activities, such as deforestation and urbanization. Historically, the Monterey Bay Shelf in central California has been fed by sediment sourced primarily through nearby fluvial processes. However, recent data suggests that there may have been a shift in sediment inputs from fluvial sources to sources derived from coastal environments within the last century. This project examines the natural changes in sediment sources to the Monterey Bay shelf sediment record through the late Holocene and contrasts those with recent anthropogenic changes in the last fifty years. To do this, we have analyzed sediment cores collected from the Monterey Bay Shelf as well as modern surface sediment samples taken from rivers and beaches in the region. Using the mineralogy of the surface samples, we have developed unique characteristics of the different source areas that can be compared to the minerology of the cores in order to reconstruct changes in sediment sources over time. This project will provide information about how human activities in the watershed and natural climate change variability influence sediment sources and the delivery of material from the land to the ocean. This understanding may assist in educating the public about the anthropogenic changes in coastal environments and how to mitigate the impacts from these activities.

Lidar analysis of the high-slip section of the Hector Mine Earthquake Surface Rupture

Student: Brandon Cugini

Faculty Advisor: Dr. Sinan Akciz

The Hector Mine earthquake (Magnitude 7.1) that occurred on 16 October 1999 within the eastern California shear zone, parallel to the San Andreas Fault, produced 48 km of surface rupture. This was the first large earthquake to have occurred along the fault strand in the Holocene Epoch. This is also the only fault with a surface rupture that has repeat (2000 and 2012) Light Detection and Ranging (lidar) that not only provide an opportunity to see if offset measurements using lidar data are reproducible, but also help document how much modification offset geomorphological features experience at a decadal timescale. In this study, I made 43 horizontal offset measurements using DEMs generated from lidar data collected along the maximum slip zone section Hector Mine earthquake surface rupture in 2012. The offset measurement values in the maximum slip zone area ranged from .5 +/- 0.1 m (CT-181) to 7.5 +/- 0.4 m (CT-162) with evidence of rapid changes in short distances. Comparison of measurements made using the 2000-lidar data and the 2012-lidar data shows that measuremend discrepancies (11 out of 43) are exclusively due to the subtlety of the geomorphological feature that was identified as displaced and the subjective determination of matching features between the geologists. My analyses also suggest that that no significant erosion or deposition has occurred in the maximum slip zone of the Hector Mine earthquake surface rupture in the 12 years the two lidar datasets were collected.

An Examination of the Structural and Petrologic Evolution of the Box Springs Plutonic Complex, Riverside, CA

Student (NP): Andrew Culleton

Faculty Advisor: Dr. Vali Memeti

Although ancient magma plumbing systems (plutons) are commonly exposed at the surface, such as the Cretaceous Box Springs pluton of the Peninsular Ranges batholith, Riverside, CA, their emplacement and evolution through time are not well understood. Previous mapping of the Box Springs pluton shows concentric rock units of biotite granodiorites and biotite tonalites decreasing in age towards the core of the complex. The elliptical shaped kbt unit at Blue Mountain in the northeast of the pluton is hypothesized to represent a vertical magma feeder zone. This was tested by mapping the orientation and dip of the contact with adjacent units. A steep contact fits this interpretation, while a subhorizontal contact indicates a sill. Petrography and XRF analyses test whether the Box Springs pluton units are the product of one large fractionating magma body that traveled through the feeder zone.

Ten days were spent in the field mapping and collecting samples for petrography and whole-rock geochemistry of the 2 km^2 NE section of the Box Springs pluton at Blue Mountain. Mapping revealed three compositionally diverse units decreasing in foliation intensity and sub-solidus deformation moving inwards towards the summit of Blue Mountain. The oldest unit located to the northeast of the summit, kbft, is a biotite tonalite with a strong magmatic foliation and parallel enclave alignments dipping southwest 71-82°. The kbgr is the second youngest unit located to the southwest of the summit. Here magmatic foliations strike northwest to southeast parallel to the contact with the kbft and dip 80-85° to the southwest. The youngest unit, kbt, is a biotite tonalite showing a weak subvertical magmatic foliation that strikes northwest to southeast and dips 60-89° to the southwest. Petrography shows higher biotite abundances and sub-solidus deformation in the kbft and kbgr units compared to the kbt. Biotite-rich schlieren layers line the elliptical kbt contacts on the north and east sides of the unit, which dip subvertically and young inwards towards the summit as indicated by cross-cutting relationships of individual layers. Schlieren along the contact between kbgr and kbft young towards kbgr.

Steeply dipping contacts with schlieren around the core of the pluton confirm that kbt at Blue Mountain likely represents a vertical feeder for the complex. Schlieren along the contacts indicate flow of magma against a fully or partially solidified wall of older units allowing mafic minerals to accumulate. XRF data is being analyzed to determine the petrologic relationships between the three units.

Characterizing seasonal sedimentary carbon fluxes within a restored coastal wetland

Student: Theresa Duncan

Faculty Advisor: Dr. Joe Carlin

Coastal wetlands are important environments that support diverse ecosystems, provide flood protection, and can help mitigate the impacts of climate change. While important, coastal wetlands have been undervalued in the past with much of their area lost due to land use changes and urban development. As wetland restoration projects increase, it is critical to understand the value these ecosystems provide, such as their role in sequestering atmospheric carbon to combat future climate change.This project measured carbon deposition/burial over time and space within a restored wetland in order to gain a better understanding of short-term (seasonal) carbon delivery. For this, we focused on a restored wetland in the Eden Landing Ecological Reserve in San Francisco Bay. Sediment cores were collected from 3 different habitats within the wetland (mudflat, Spartina – low marsh, and pickleweed – high marsh) over the course of >1 year, with coring locations reoccupied every ~3-4 months. From these cores we determined seasonal mass accumulation rates via short-lived radioisotopes (^{7}Be) and percent organic carbon (%OC) using an elemental analyzer, and used these data to determine the net carbon accumulation rates (CAR) for each habitat type seasonally (between coring periods). This project shows that for the past two years, the spartina and pickleweed habitats have an overall general increasing trend for net carbon flux to the sediment, while the mudflats have a decreasing trend. These results suggests that the wetland's restoration is working as overtime we observe increasing rates of carbon flux to the sediments, that is likely to enhance carbon burial within the wetland as a whole.

Investigating suspended sediment concentrations associated with living shorelines to characterize sediment retention efficiency

Student (NP): Melanie Dwight

Faculty Advisor: Dr. Joe Carlin

California's coastal wetlands have experienced significant losses over the past century. These wetlands today continued to be threatened by erosion caused, in part, by urbanization as well as sea-level rise. Therefore, shoreline erosion in coastal wetlands is predicted to increase in the future due to climate change. Living shorelines have emerged as an effective way to slow this erosion by retaining the sediment at the marsh edge. While living shorelines have become a relatively common restoration/mitigation practice for wetlands along the East Coast of the US, their use in California has been limited. As such, there is a need to better understand the impact of living shorelines in California marshes, specifically those in Southern California. The goal of this study is to determine whether living shorelines in Southern California are effective at trapping sediment. Specifically, we investigated whether eel grass as the primary component in the living shoreline is effective, or if a combination of eel grass and oyster design improves trapping. This was done by collecting water samples and measuring the suspended sediment concentrations (SSC) over different tidal periods and seasons in different living shoreline configurations. Our study focused on living shoreline sites in Newport Bay, located in Orange County, California. We compared SSC across different living shoreline configurations including eel grass only, eel grass combined with oysters, and a control area without eelgrass or oyster. From the data we observed that for most of the locations the modified sites (eelgrass only or oysters and eelgrass combined) seem to be effectively retaining the sediment better than the controlled sites. Sediment trapping was typically maximized on flood tides during the winter months. This project demonstrates that living shorelines do improve sediment retention at the marsh edge, and this sediment retention is likely to help minimize marsh-edge erosion. Further, with recognizing when sediment retention is maximized (winter flood tides) may help mangers maintain this critical ecosystem. Ultimately, this project demonstrates the usefulness of living shoreline in terms of sediment management, and living shorelines in general will help improve water quality and increase biodiversity further helping estuarine habitats in California.

Paleoseismic Investigation of the Holocene Rupture History of Branch and Secondary Faults of the South-Central San Andreas Fault System at Little Rock Creek, Los Angeles County, California

Student (NP): Joey Hawkins:

Faculty Advisor: Dr. Sinan Akciz

The San Andreas fault (SAF) zone, located in California is one of the most active and thoroughly studied transform faults in the world and is capable of producing repeated, large earthquakes similar in magnitude to the 1906 San Francisco and the great 1857 Fort Tejon earthquakes (~M7.9 each). Many studies have been performed to characterize the rate of movement, number of prehistoric earthquakes and magnitude and intensity of future earthquakes on this fault, however, significant gaps still remain in our understanding and resolution of fault behavior models. While much work has gone into studying the main trace of the SAF, branch and secondary faults similarly capture pieces of the paleoseismic record and offer insights into fault behavior. The recognition that Holocene activity is possible on faults where evidence suggests prolonged inactivity emphasizes the need for detailed site studies to adequately evaluate the hazard of any fault trace in a major fault zone. The purpose of this study is to: 1) Study a secondary fault of the San Andreas fault system to determine if there is evidence of recent (Holocene) ground rupture, 2) Attempt to date the sediments that capture evidence of ground rupture to determine ages for ground rupturing events and correlate them to known events at nearby paleoseismic sites, and 3) Demonstrate that secondary faults capture an important piece of the paleoseismic history of a fault zone and that understanding their response to events on major faults is an important part of understanding overall fault system behavior and should be incorporated into behavior models and hazard assessment.

Assessment of Carbonate Precipitation at the Travertine Fissure Ridge Hot Spring, Bridgeport, CA

Student: Kassandra Mora

Faculty Advisor: Dr. Sean Loyd

Fissure ridge hot springs are associated with conspicuous, elongate, long-axis symmetrical travertine ridges of enigmatic origin. Although carbon dioxide degassing plays a pivotal role in hot spring morphology in general, direct connection to the morphology of fissure ridge hot springs have not been established. To resolve this, a travertine fissure ridge hot spring was studied to determine potential connections among carbon dioxide degassing, fluid agitation and ridge morphology. The fluids of Travertine Hot Spring, located in Bridgeport, California, were sampled at the orifice, along the primary outflow channel and divergent terminal outflow channels to determine the chemical composition of spring waters and assess mineralization mechanisms. The spring waters exhibit increasing $\delta^{13}C_{TCO2}$ values, decreasing TCO_2 and increasing pH, reflecting progressive degassing of carbon dioxide. This increase in pH may promote calcium carbonate precipitation which would be indicated by a contemporaneous decrease in aqueous Ca^{2+}contents down the outflow channel. In addition, precipitation of calcium carbonate would impact the degree of isotope enrichment along the flow channel, manifested as an increase in the fractionation factor between $CO_{2(g)}$ and TCO_2 ($e_{CO2\text{-}TCO2}$). Indeed, calculation using a Rayleigh fractionation model reveals a $e_{CO2\text{-}TCO2}$ value of ~ -3.4‰ which is ~2.0‰ higher than that expected by CO_2 degassing alone, perhaps reflecting carbonate mineral precipitation along the flow channel. However, highly variable fluid Ca^{2+} contents do not support the progressive precipitation of calcium carbonate. This suggest that other factors may control the morphology and geochemical composition of the Bridgeport fissure ridge hot spring.

DEM and GIS Analysis of the morphotectonic features of the left-lateral Santa Rosa Island Fault, Southern California, USA

Student: Hunter Nortman

Faculty Advisor: Dr. Sinan Akciz

Santa Rosa Islands is the second-largest island of the California Channel Islands National Park and forms the southern boundary of the Santa Barbara Channel. The east-west trending Santa Rosa Island fault (SRIF) divides the island into nearly equal halves. SRIF is too short (60 km with its offshore parts) to produce a large magnitude earthquake on its own, but as part of the Western Traverse Ranges Frontal Fault Zone (>200 km long), it is capable of rupturing during a >M7.5 earthquake. Unlike the onshore parts of the fault zone, geomorphological expressions of the Santa Cruz Island and Santa Rosa Island faults are in pristine condition. I analyzed 30m/pixel Digital Elevation Models (DEMs) produced from the Shuttle Radar Topography Mission (SRTM) data in ArcMAP. I created longitudinal channel profiles, delineated drainage basins, and calculated basin asymmetry factors to the drainages offset by the SRIF. I identified six large drainage basins (5-10 km long, 1-3 km wide) that the SRIF has offset. Palinspastic reconstructions based on the drainage basin outlines and truck channel projections show evidence of left-lateral displacements that range from 200 to 1200 m. Basin asymmetry analyses result also point to a more complex drainage basin evolution pattern. Basins that reconstruct by ~200 m (drainages 1 and 2) have symmetric drainages (AFs 49 and 50). Drainage basin 3, which reconstructs best, is restored by 1200 meters also has an AF value of 46. Two of the remaining basins likely had a complicated history that involved stream capturing. Their AF values are 30 and 65. These preliminary reconstructions and morphotectonic analyses suggest that the drainage basins offset by the SRIF recorded different periods of the fault's tectonic history, and future slip rate investigations should be cautious with their dating plans.

3D correlation of earthquake event evidence between two trenches at the Bidart Fan Site along the southern San Andreas Fault

Student: Bryan Padilla

Faculty Advisor: Dr. Akciz Sinan

Paleo-seismological data constrain the age, location, and magnitude of past surface rupturing earthquakes. This type of data is typically collected from trenches where stratigraphic and structural relationships are exposed. Much has changed since the earliest the pioneering investigations where only the most prominent earthquake evidence was described. Recent publication nowadays commonly includes earthquake evidence data tables along with their quality rating. However, visualization of the surface deformation created by each of these paleo-earthquakes still remains difficult by only looking at individual trench logs or going through the event evidence data tables. In my thesis, I chose to re-evaluate the earthquake event evidence recorded at the two closely spaced trenches opened at the Bidart Fan site in the Carrizo section of the south-central San Andreas Fault. I attempted to incorporate all structural, geomorphological, and trench evidence into a unified interpretation of surface deformation associated with the past few earthquakes that ruptured through the Bidart Fan site. Preliminary interpretations suggest the following: (1) Trenches BDT3 and BDT4 are located on top of a mini restraining-stepover and releasing step-over sections of the main fault trace. This structural complexity is likely the reason why fault traces can't easily be correlated between the trenches. (2) Evidence for the penultimate earthquake, however, suggests that both trenches were in a releasing step-over, which created an elongated deposition center that partially got uplifted during the 1857 earthquake. (3) Slip during the antepenultimate earthquake also occurred along restraining- and releasing step-over structures, like the deformational style of the 1857 earthquake. These preliminary interpretations suggest implementing such 3D reconstructions in evaluating paleo-earthquake evidences as they provide additional insight into their formation and preservation and the evaluation of their quality rating.

Reconstructing the Holocene Lake Level Record for Big Lake, California

Student: Daisy Quiroz

Faculty Advisor: Dr. Matthew Kirby

Understanding the history of California's water is critical to preparing for, and mitigating, future drought. Here, we infer changes in lake level at Big Lake, California, using a multi-proxy approach on a near shore sediment core (BigLRC 19-5, 2.03 m length). Located in the Northern Coast Range of California, Big Lake represents a key site for understanding CA's water history. Analyses included in this study include visual description, magnetic susceptibility (MagS), percent water content, total organic matter (%TOM, loss-on-ignition at 500°C), and percent clastics (%Clastics, i.e., residual content). In general, changes in magnetic susceptibility and percent clastics into a lake basin as a result of precipitation-associated runoff variability. Changes in total organic matter generally indicate water depth associated with migration of the littoral zone and subsequent expansion or contraction of macrophyte productivity. Unfortunately, radiocarbon dates are not available for this core due to lab closure during the Covid-19 pandemic. Nonetheless, we infer changes in lake level using a relative dating approach. Results suggest that Big Lake was characterized by high lake levels (high MagS, high %Clastics, low %TOM) between 2.03 and 1.16 m core depth – likely the mid-Holocene. Lake levels begin to decline at 1.16 m core depth, reaching a period of sustained low lake levels (low MagS, low %Clastics, high %TOM) between 0.74 and 0.33 m core depth We suggest that this low stand correlates to the Late Holocene Dry Period as recognized throughout the western US. A brief period of high lake levels occurs between 0.33 and 0.18 m core depth, perhaps reflecting the Little Ice Age. Finally, lake levels decrease from 0.18 to the core top. Future work will 1) add radiocarbon dates to constrain the timing of these changes, 2) add grain size and micro-fossil analyses to refine the lake level interpretation, 3) compare this near shore core to two other Big Lake cores to reconstruct a quantitative lake level reconstruction, and 4) compare this core record to other published lake level records in CA to better understand the spatiotemporal changes in CA's Holocene water.

Provenance and Deformation of Sandstone and The History of Transtension In Yunnan, China

Student (NP): Brigitte Camille Sabello

Faculty Advisor: Dr. Kathryn Metcalf

About 59 million years ago, the Indian and Eurasian plates collided, causing deformation in the southeastern Tibetan Plateau. In theory, the collision formed the Himalayas and uplifted the Tibetan Plateau so high that it eventually collapsed, which supposedly triggered the Tibetan Plateau's extrusion into Yunnan Province, China 18 million years ago. Thermochronology data suggests that normal faults began to form as the province of Yunnan extrudes N-S, while the E-W extension of the Tibetan Plateau created basins out of the normal faults. Here, we examine samples from western Baoshan, eastern Dehong, and northern Dali for petrographic composition to identify individual minerals and any deformation that exist in the rocks. By applying U-Pb zircon geochronology, we can find out the provenance, depositional ages, and the growth of the continental crust the samples were derived from. Combining these methods reveal the stratigraphy of the mountains within Sichuan basin as well as when the transtension began and its relationship to the extension of Tibet.

How streams adjust in offset channels along the San Andreas Fault portion of the Carrizo Plain in California

Student (NP): Aidan Salazar

Faculty Advisor: Dr. Sinan Akciz

Measurements of slip along laterally offset stream channels help calculate fault slip rates and provide insight into the magnitudes of past surface rupturing earthquakes. While these measurements are made routinely in the field or remotely using high-resolution topography or imagery data, the geomorphological response of stream channels to lateral fault displacements is not well-known. Hypothetically, an offset (but not abandoned) channel should have a shallower gradient along its faulted section and shallower cross-sectional profiles at the upstream end of the faulted section due to aggradation. It also remains unclear how long such geomorphological irregularities persist as they continuously get modified. I analyzed two geomorphological characteristics of 19 channels that are offset by a different number of large earthquakes that ruptured the San Andreas Fault in the Carrizo Plain, California: Channel long profiles and channel topographic cross-sections. My goal was to document whether the gradient of the channels within the fault zone show any evidence for shallowing (due to lengthening) and if the portion of the channel immediately upstream of the fault zone show any evidence of aggradation due to damming. The channels were further grouped into two categories, distal (6 channels) and proximal (9 channels), based on their proximity to the offset section to their source region. 5 out of 6 channels that are within the distal portion of an alluvial fan show evidence for aggradation upstream from the upper bend. The reason for the proximal channels not preserving such evidence might be the greater erosive powers of faster flowing water in the proximal channels. Only two proximal and two distal fan channels show evidence for shallowing of their long profiles within the fault zone. This observation suggests that even in arid to semi-arid climate settings like the Carrizo Plain, channel gradients get adjusted in between the earthquake cycles that are thought to be ~90 years. The preliminary data suggest that while channels are the main geomorphological features that preserve evidence of strike-slip faulting by the distinct sharp bends along their course, they rapidly (within a few earthquake cycles) adjust their morphologies to hide any other evidence of faulting such as damming or shallowing within their faulted sections.

The Distribution of Environmental Stress following the End-Permian Mass Extinction: A geochemical study of the Lower Triassic Union Wash Formation

Student: Samuel Simpson

Faculty Advisor: Dr. Adam D. Woods

The end – Permian mass extinction was the most devastating biologic event in Earth history, causing the biggest losses in biodiversity in the history of the planet. High surface temperatures, caused by the input of massive amounts of greenhouse gasses erupted by the Siberian Traps, led to lethally hot surface ocean temperatures at lower latitudes, as well as widespread ocean anoxia. To discover more about the anoxic conditions in deep marine environments, 30 samples were collected from the uppermost ~55 m of the middle member of the Union Wash Formation in east-central California, and were analyzed for their major, minor, and trace element compositions. The results from this study indicate that the upper portion of the deep – water middle member of the Union Wash Formation was initially deposited under anoxic conditions, which improved higher in the section. This trend is reflected in U EFs > 1 and V EFs near 1 or > 1 in the lower 40 m of the study section. High Ba, Ni, and Zn EFs indicate that the anoxia was driven by nutrient input and high productivity. High %CaO values indicate that the source of the nutrients was likely from upwelling rather than runoff, which would be indicated by an increase in terrestrially – derived elements. Overall, the results of this study support the hypothesis that deep marine environments experienced prolonged anoxia after the Permian-Triassic mass extinction, which led to a lengthened recovery.

Quantifying Sediment trapping associated with a living shoreline as a means to mitigate shoreline erosion

Student (NP): Alex Sobolew

Faculty Advisor: Dr. Joe Carlin

Most of California's coastal wetlands and marshes have been lost to human activities such as development and urbanization. A major issue threatening those environments that remain is erosion brought on by rising sea levels caused by climate change and human activity. Despite the growing issue of erosion, one of the most effective ways of minimizing erosion is living shorelines. While this practice has been utilized for decades in other areas like the United States East Coast, only a few living shoreline restoration projects have been initiated in California, and there remains some uncertainty about their effectiveness in this region. The goal of the research project was to determine the effectiveness of living shorelines in terms of trapping sediment to mitigate shoreline erosion. To accomplish this, water samples were collected, and suspended sediment concentrations (SSC) were measured over different tidal periods and seasons. The water samples were taken from several different living shoreline restoration sites that involved a mix of oysters and eel grass as the basis for the living shoreline. From this study, we were able to determine that a two species (oyster and eel grass) living shoreline is more effective at trapping sediment than an oyster only living shoreline or the control with no living shoreline. It was also determined that spring tides had a higher amount of SSC in comparison to neap tides. These results demonstrate the need for a complex living shoreline design (multiple species) and highlight the importance of tidal cycles on SSC concentrations. Ultimately this project demonstrates the usefulness of living shoreline by showing that these structures improve sediment trapping which will likely help to minimize erosion of adjacent marsh areas.

Examining the Concentric Pattern of the Box Springs pluton, Riverside, California

Student: Alex Valenzuela

Faculty Advisor: Dr. Vali Memeti

Plutons are an important part of the magma plumbing system that feed dangerous volcanic eruptions, yet the mechanisms of construction and evolution through time are poorly understood. This is also the case for the Cretaceous Box Springs Pluton in Riverside, CA. The geologic map pattern of tonalite, granite, and granodiorite shows a concentric unit arrangement with the youngest units in the core and the oldest units on the edges. The goal was to investigate the structure and composition of this pluton and test the hypotheses that the concentric structure represents a vertical transcrustal volcanic feeder and that the magmas are petrologically related.

An area of 1.3 km^2 was mapped at 1:10,000 scale in the oldest marginal units on the west side of the Box Springs pluton northeast of UC Riverside. Three of the units were mapped: Kbgg, a porphyritic granodiorite and granite; Kbhg, a heterogenous porphyritic granodiorite and granite; and $Kbhg_1$, a diked and layered version of Kbhg. Samples of the three units and the fine-grained leucogranite dikes within $Kbhg_1$ were collected for petrography and XRF whole rock geochemistry.

Petrographic observations show that each unit has a similar relative abundance of quartz, K-feldspar, and plagioclase. Mafic mineral abundance varies considerably, mainly within $Kbhg_1$ where hornblende and biotite make up nearly 40% combined in localized schlieren layers, and only appear at up to 5% in the other units. Accessory minerals include muscovite, epidote, hematite, sphene, ilmenite, and allanite. The dikes within $Kbhg_1$ are very felsic with only 5% mafics, and contain muscovite and garnet as accessory minerals. Since mineralogy is similar and modal abundances vary, the units might be petrologically related through fractional crystallization. This will be further tested with XRF geochemistry. All units have a consistent structure with magmatic foliations striking NW-SE and dipping toward the core of the pluton to the NE. The foliations dip steeper (50-65 degrees) near the center of the mapped area and are shallower (25-40 degrees) near the edges of the mapped area, resembling the structure of a lopolith. The dikes within $Kbhg_1$ strike in the same orientation to the units but dip in a SW direction. Contacts between Kbhg and $Kbhg_1$ are gradational while the contact between Kbgg and Kbhg is sharp. These relationships suggest that a transcrustal volcanic feeder cannot be excluded, but that the geometry of the magma plumbing in this part of the pluton is not a simple vertical cylindrical shape.

Masters MS Proposal Category

Tracking Magma mixing in the Tuolumne Intrusive Complex with K-feldspar megacrysts

Student: Julia Chen

Faculty Advisor: Dr. Valbone Memeti

A pluton grows by the incremental accumulation of magmas, however, the extent of mixing between magmas at the emplacement level and the size of the resulting magma bodies is not well understood. This is also the case in the Tuolumne Intrusive Complex (TIC), a Cretaceous nested plutonic complex in the Sierra Nevada batholith in California that comprises the Kuna Crest Granodiorite (95-92 Ma), the Half Dome Granodiorite (92-88 Ma), and the Cathedral Peak granodiorite (88-85 Ma). Previous studies have suggested that the TIC was formed by magma mixing (and crystal fractionation) processes, with mixing mostly occurring during the later stages in the development of the complex (i.e. in the Half Dome and the Cathedral Peak units). The extent of magma mixing between these units and the degree to which it occurred is not clear.

Mineral scale geochemistry is useful to examine the intricacies of magma mixing in plutons. One particularly useful mineral is K-feldspar, which in past studies, has shown to record extensive magmatic histories. In the TIC, K-feldspars grew into less than 1 cm in the Kuna Crest unit and crystallized increasingly larger into megacrysts toward the TIC interior, up to 15 cm at the gradational contact between the porphyritic Half Dome and the Cathedral Peak units. A pilot study demonstrated that U-Pb zircon ages from the cores and rims of two K-feldspar megacrysts differed 0.5 million years with the age of the cores matching the age of the older Half Dome unit and the rims matching ages of the younger Cathedral Peak unit. The authors speculated that the growth of K-feldspars into megacrystic size is related to time spent in the magma and the presence of an interconnected Half Dome-Cathedral Peak magma mush undergoing crystal recycling through magma mixing. To test these hypotheses and further examine the extent of magma mixing, this project will conduct fieldwork, petrography, whole-rock geochemistry, K-feldspar trace element geochemistry, and U-Pb CA-ID-TIMS-TEA geochronology and trace element geochemistry of zircon included in growth zones of K-feldspar megacrysts. The study focuses on the southeast region of the TIC along a transect from the equigranular Half Dome to the Cathedral Peak units. The hypotheses that will be tested are: 1) the size of K-feldspar megacrysts is proportional to time and depends on magma mixing, and 2) the extent of magma mixing in the TIC ranged from the equigranular Half Dome to the interior of the Cathedral Peak.

Assessing microbially-induced sulfate reduction as a precipitation mechanism for carbonate concretions within the lower Miocene Rincon Shale, CA

Student: Melonie Nguyen

Faculty Advisor: Dr. Sean Loyd

Carbonate concretions are cemented nodules that form from mineral precipitation within soft-sediments, often as a result of ancient microbial metabolic processes. Concretions vary in appearance, chemical composition, and can exhibit different growth patterns. Carbonate concretions exhibit a wide range in carbon isotope ($\delta^{13}C$) compositions, reflecting variable formation mechanisms primarily related to the degradation of organic matter. However, whereas carbon isotope compositions provide valuable insight into the precipitation history of concretions, these signatures alone are insufficient in distinguishing among most formation mechanisms. Carbonate associated sulfate (CAS) – trace amounts of sulfate incorporated into carbonate minerals upon precipitation – is a useful tool that can be used to help elucidate concretion formation pathways. CAS concentrations and $d^{34}S$ signatures should reflect dissolved sulfate concentrations and $d^{34}S$ in pore waters, respectively. Sulfate reducing microbes remove sulfate from pore waters and impart a ^{34}S-enrichment in residual sulfate, thereby providing a fingerprint for the sulfate reduction pathway. This study aims to determine the mechanisms that drive concretion precipitation in the Miocene Rincon Shale by using CAS proxies in conjunction with traditional $\delta^{13}C$ analyses. Previous work on the overlying Monterey Formation in part attribute concretion precipitation to sulfate reduction. We hypothesize that the concretions of the Rincon Shale likewise formed as a result of sulfate reduction.

Maters MS Thesis Category

None

Student Research Category

Potential Long-lasting Effects on Water Resources on Coastal Regions from an Asteroid Impact

Student: Monica Maynard

Faculty Advisor: Dr. Barry Hibbs (Cal State Los Angeles)

A comet or asteroid impact on earth could be a devastating event, from the effects that would immediately take place like destruction of community water infrastructure and long-lasting impacts on hydrological systems in areas near the perimeter of the impact. Although space impacts rarely occur, if one were to strike in a highly populated area, the damage would be so great that the effects would linger for generations. Our water resources, both on the surface and underground, would be affected and disrupted on a massive scale. Approximately 35 million years ago, an asteroid or comet impacted the Chesapeake Bay region of the North American continent and left a crater that influenced the sedimentation patterns in the area that persisted for thousands of years. The impact affected the ground-water flow systems and increased the intrusion of marine water inland. Using the Chesapeake Bay Impact as an analog for future impacts in coastal regions provides perspectives on the disruption of freshwater resources that can predictably occur. In a large city like Los Angeles, which already experiences a shortage of fresh water due to semi-arid climate and drought, a space impact would likely exacerbate water supply problems due to destruction of water delivery infrastructure that would take a long time to repair, leading to unprecedented suffering of the city population. Additionally, saltwater intrusion and possible tsunamis resulting from space impacts creates a recipe for disaster for coastal communities and their access to freshwater post impact.

GEOLOGY STUDENT AWARDS/SCHOLARSHIPS April 2021

Outstanding Graduate Student in Geology — ***Joey Hawkins***
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 — ***Carlos Barron***
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 engraved glass

Outstanding Major Award – B.S. in Geology — **Brandon Cugini**
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 — **Daisy Quiroz**
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 — ***Andres Bareno***
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 — ***Kelly Quach***
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

John D. Cooper Field Camp Award — ***Priscilla Martinez-Vasquez***
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

Department of Geological Sciences Alumni Field Camp Scholarship — ***Julia Hernandez & Tracy Donelli***
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)

Candice L. Jones Outstanding Service Award — ***Katya Beener***
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

Prem K. Saint Hydrology Award — ***Patrick Murphy***
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"

John D. Cooper Field Camp Scholarship — ***Bryan Padilla***
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

David L. Willoughby Scholarship — ***Theresa Duncan***
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 field-work. Minimum GPA of 2.5 or higher in Geological Sciences at the time the scholarship is awarded. Recipient to be selected by faculty. Award: $750 each

Dr. Margaret Skillman Woyski Scholarship — ***Kassandra Mora***
Open to declared geology major with 2.5 GPA or better for the previous academic year. Awarded in odd years to a student who shows financial need and outstanding academic achievement. Service to the department or the university is also required, i.e., involvement in the geology club, tutoring or participation in faculty directed research. The award will be made on the recommendation of the entire full-time faculty of the department. Award: $550

Marilyn A. Brown Award — ***Tut Tran***
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

ALUMNI OF THE YEAR 2021!

Mr. Rene Perez

Mr. Perez has earned two degrees from Cal State Fullerton. In 2002, he graduated with a BS under the direction of Dr. Phil Armstrong. His under graduate thesis related to study in the Eastern Sierra El Mayor in Baja California, Mexico… was it the beer or the geology that drew him to that area?

After finishing his undergraduate work and while working full time, Rene opted to begin grad school. He finalized his MS by submitting his thesis entitled "Hydrostratigraphy of the Alto Deep Well: Implications for Sustainable Groundwater Recharge into the Distal Victorville Fan Sediments, Southwestern Mojave Desert, California" in 2009. His graduate advisor was Dr. John Foster. Of note - Rene ran the GIS lab and helped manage the 30+ students who participated in compiling data for the Mojave Water Agency - one of the largest grants our department has received.

Since obtaining his first degree, Rene has been working steadily in the field of Geology for a variety of consulting firms in Orange County. It was while he was working for Earth Consultants International as a staff geologist (and starting grad school) that Rene became interested in GIS. It is not an overstatement to say that in the intervening years, he has become an expert in this exciting field. Mr. Perez's current portfolio of experience includes low altitude aerial photography expertise (he was one of the very first UAV pilots to be licensed by the FAA in 2014), aerial photo interpretation, hydrogeologic investigations / modeling including three dimensional visualization of complex data, contaminate transport study, hydrometeorology, general geology and groundwater issues. Rene enjoys the challenge of helping lay people visual complex data sets. He appreciates using technology for communication of clear and meaningful evaluations of data.

As an alum of CSUF, Rene has given freely of both his time and money to our department. On multiple occasions Rene has come back to campus to help students with GIS and/or remote sensing projects or issues with their thesis. Rene has also come to campus to give professional talks to the students and faculty on his area of expertise of low altitude aerial mapping. As an annual donor to our Fall Alumni Dinner and as one to challenge others to match his giving, he has made a great and positive impact on our present and future students.

Rene has four children: Bradley, Mia, Emme and Noah. He and his wife Laura live in Riverside. Mr Perez is licensed to practice both Geology and Hydrogeology in California. (PG-8184, CHG-997).

Congratulations to our South Coast Geological Society Winners

Kim Perkins

Katya Beener

Daisy Quiroz

Alex Valenzuela

Julia Chen

The Department of Geological Sciences

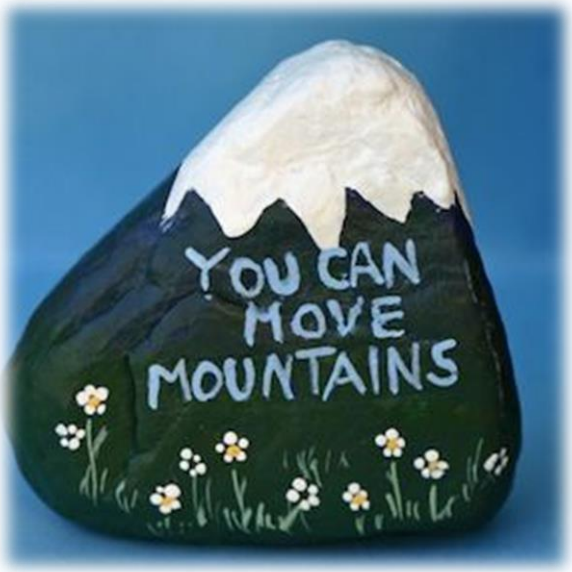
California State University Fullerton

9th Annual Alumni Dinner Save the Date!

Friday, October 1, 2021
6:00 p.m.

Location TBD

Thanks to all of our Geoscience Students, Faculty, Staff, and Alumni for another successful year!



Special thanks to

the South Coast Geological Society for their support of CSUF students,

and to

the Department Staff and Dr. Richard Laton for making Research Day such a special event!