7th Annual CSUF Geological Science Research Day

GEOLOGICAL SCIENCES
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Department of Geological Sciences
California State University, Fullerton
Fullerton Arboretum
Friday, April 22, 2016

SOUTH COAST GEOLOGICAL SOCIETY
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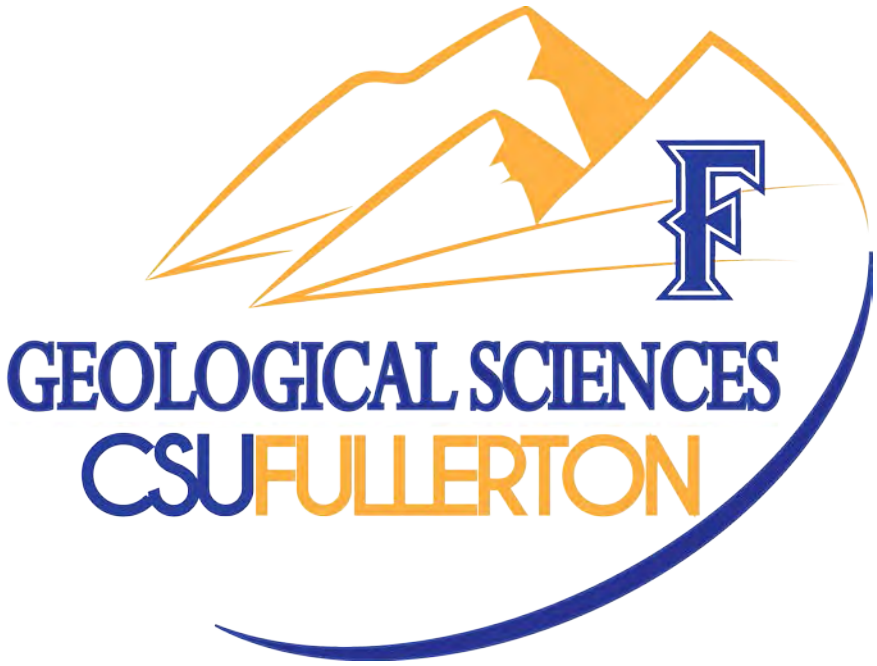

The Department of Geological Sciences at California State University, Fullerton is an interdisciplinary education and research community whose members are active mentors and role-models. Our mission is to provide a student-centered educational and research experience that emphasizes critical thinking,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

'Research Day' is an extension of this mission, where students are afforded the opportunity to share their research findings and scientific experiences with faculty, student peers, friends, family, and members of the professional geological community in an informal and supportive environment. Thank you for participating in this year's event!

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EXAMINING THE GEOCHEMICAL RELATIONSHIPS BETWEEN THE TWENTYNINE PALMS AND QUEEN MOUNTAIN PLUTONS IN JOSHUA TREE NATIONAL PARK

Student: Alexander Arita

Faculty Advisor: Dr. Vali Memeti

Figure 1: Sharp contact between the TPP (lower) and QMP (Upper)

Plutonic studies increasingly show that plutons spend a lot of their hypersolidus time as magma mush. Over time, they may build vertical magma mush pathways in arcs and interact at various degrees with other magmas. How extensive these magma mushes are, which magma processes dominate and if and how much interplutonic interaction between different plutons takes place at the emplacement level is not well understood.

A place where these questions can be investigated is in the northern part of Joshua Tree National Park, California, which contains outcrops of a Triassic arc magma plumbing system consistent of two contemporaneous plutons: the ca. 235 Ma Twentynine Palms pluton (TPP) and the Queen Mountain pluton (QMP). The TPP is a megacrystic quartz monzonite composed of 1-20 cm blocky K-feldspar phenocrysts in a medium grained, equigranular matrix of largely plagioclase, hornblende, and minor quartz, biotite and accessories. The size and abundance of the K-feldspar varies substantially between different pluton domains. The QMP is a medium grained granodiorite with plagioclase, K-feldspar, quartz, biotite, hornblende and accessories. In addition, both plutons contain small pendants and blocks (TPP) and smaller, cm-dm pieces and biotite clots (QMP) of Pinto gneiss, the host rock into which the magmas intruded. Together, the plutons form a roughly bull's-eye shape map pattern with the megacrystic TPP forming the outer rim and the QMP the interior of the complex. The contact between the two plutons is steep and sharp to gradational where exposed and dikes of the QMP intruded the TPP. The QMP contains sparse Alkali-feldspar phenocrysts up to 4 cm large, which resemble the phenocrysts in the TPP. Both plutons exhibit local solid-state deformation with the strongest fabric along the TPP margin.

Given these field relationships and concurrent crystallization of both plutons, we are investigating through petrography and element and isotope geochemistry the hypothesis that the two units may be related to one parent magma and are potentially representing a fractionate (QMP) and cumulate (TPP) pair. Geochemical modeling suggests that fractionation of up to 30% of an assemblage composed of 65 wt.% K-feldspar, 20 wt.% Amphibole and 15 wt.% Plagioclase can reproduce QMP compositions from TPP magma, supporting our fractionate (QMP) and cumulate (TPP) hypothesis. This would propose that we may be looking at a cross section of a horizontally and vertically extensive magma mush zone that underwent extensive open system differentiation and efficient crystal-melt separation.

EXPLORING THE MOJAVE-SNOW LAKE FAULT HYPOTHESIS USING LASER-INDUCED BREAKDOWN SPECTROSCOPY

Student: Eduardo Chavez

Faculty Advisor: Dr. Vali Memeti

While several studies have been conducted, many questions remain regarding the existence of the cryptic Mojave-Snow Lake fault. The Mojave-Snow Lake fault has been proposed to have displaced Neoproterozoic to Paleozoic passive margin metasediments from the vicinity of Victorville, southern California about 400 kilometers northwestward to the western part of Yosemite in the central Sierra Nevada batholith (see Figure 1) (Lahren and Schweickert, 1990). Memeti et al. (2010) tested this hypothesis with detrital zircon U-Pb geochronology and showed that a correlation with the Victorville area cannot be made and that the metasedimentary rocks could have been derived anywhere from the passive margin in the east. Chapman and colleagues (2015) further pursued this hypothesis by supplying evidence that argues for an origin of the central Sierra pendant rocks from 65 kilometers from the east, proposing the reactivation of the Last Chance thrust as the mechanism.

While detrital zircon age dating has provided a useful tool to test the Mojave-Snow Lake fault hypothesis, the source of the pendant strata from the passive margin remains unknown. To employ additional characteristics of the sediments, I am using petrography and geochemical analysis of the heavy and light mineral fractions left over from zircon separation to determine if we can differentiate between sub-unit characteristics of the passive margin metasediments and the displaced rock units. Laser-induced breakdown spectroscopy (LIBS) can rapidly provide detailed elemental composition of detritus, promptly allowing comparisons between both different heavy minerals and populations within one mineral type (McMillan et al., 2014) and thus allow characterization quartzites in great detail. Collected elemental spectra are processed using "unscrambler" software, and multi-component analysis is used to interpret the data. I am testing if LIBS can be used to determine variations between similar rock units and therefore create an alternative method for metasedimentary provenance studies. If LIBS detects strong similarities between the central Sierra Nevada pendants and different locations at the passive margin, stronger inferences can be made about their provenance and the existence of the Mojave-Snow Lake fault and its displacement. This project is in collaboration with Dr. Nancy McMillan and her students in the LIBS laboratory at New Mexico State University. Petrography will be done at CSUF.

INVESTIGATING SPATIAL AND TEMPORAL VARIATIONS IN SEDIMENTATION ON INTERTIDAL MUDFLATS

Student: Dulce Cortez

Faculty Advisor: Dr. Joseph Carlin

Estuaries are valuable ecosystems throughout southern California, but are extremely vulnerable to changes in sea level rise (SLR), and sediment fluxes among other stressors. In southern California, for example, the estuaries are predominantly salt marsh-tidal flat systems that are affected by increases in SLR, and significantly impacted by urbanization. These human activities modify sediment fluxes to the estuary, and introduce pollutants to the water that impact the organisms and habitats throughout the salt marshes. Naturally, salt marshes are highly productive habitats, and efficient sediment traps. This combination of authigenic sediment from plant material, and allogenic sediment is critical to help these ecosystems maintain their elevation relative to SLR. If salt marshes cannot keep pace with SLR, then these critical habitats for a variety of organisms will be lost to marine inundation. Southern California salt marshes have developed over the past ~4,000 years, when SLR averaged 0.8 mm/yr. Over the past several decades however, SLR has increased dramatically due to climate change. In Upper Newport Bay (UNB) in Orange County, for example, average SLR has been >2 mm/yr since 1950. Therefore, can UNB salt marshes keep pace with accelerated SLR? This project will focus on determining mudflat sedimentation rates on seasonal time scales in UNB to better understand the timing of sediment delivery. I will analyze two short-lived radioisotopes (^{234}Th and ^{7}Be, 24 and 53 day half-lives respectively) in sediment cores from mudflats over different seasons to determine the seasonal trends in sedimentation. Each season I will collect 3 cores from the same locations, two near the fresh water inputs at the head of the bay, and one near the marine end member near the mouth. This will allow me to characterize sedimentation both spatially and temporally. Additionally, I will measure suspended sediment concentrations in the water column seasonally from the three dominant inputs into the bay to compare sediment fluxes in the water to the sedimentation rates on the mudflats. I hypothesize that more sediment will be delivered during the winter as a result of high-energy events, with the highest deposition rates observed in the northeastern part of the bay proximal to the largest freshwater and sediment input. Overall, this project will give us a better understanding of when sediment is delivered to the mudflats, which may help better manage the system in the face of future increases in SLR.

A PALEOECOLOGY OF PLEISTOCENE OYSTER BEDS, SAN PEDRO, CALIFORNIA

Student: Ditmar, Kutcher, Rue

Faculty Advisor: Dr. Nicole Bonuso

Oysters decline dramatically within southern California coastal waters throughout the Quaternary, yet the active tectonic boundary remains constant and its geographic location only differs by a few degrees. Oyster diversity steadily declined from four species in the Cenozoic to two oyster species in the Pleistocene, to finally, only one native species remains: *Ostrea lurida.* Biologists attribute the decline of oyster beds to industrialization and urbanization of southern California. Restoration efforts continue within southern California but researchers lack the deep-time historical perspective of oyster beds. Here we examine Pleistocene oyster populations and ecology to better understand pre-human oyster habitats. Three undergraduate students will each examine a five gallon bucket of sediments and document fossil content. Samples were extracted from Knoll Hill, San Pedro, California. The specimens were preserved in the Late Pleistocene Palos Verdes Sands. The samples will be cleaned, sorted and all fossils will be identified to the species level and counted. Length and width measurements of all oyster fossils will be recorded and growth lines along the oysters shell will be counted to determine the oysters age. The data collected will provide an image of species abundance and diversity in the region prior to urbanization. This data has the potential to help guide current restoration efforts. Restoring southern California oyster beds will improve the local shallow marine ecosystems in several ways. A flourishing oyster population provides filtration of the local waters, reduces the abundance of carbon, provides fishery resources, establishes a marine habitat for other organisms, produces more oysters, increases landscape diversity, and stabilizes intertidal and benthic habitats.

USING K-FELDSPAR MEGACRYSTS AS RECORDERS OF MAGMA PROCESSES IN THE TWENTYNINE PALMS PLUTON IN JOSHUA TREE NATIONAL PARK

Student: Lizzeth Fores Urita

Faculty Advisor: Dr. Vali Memeti

Plutons spend the majority of their active time in the deep crust as magma mushes (crystals+melt) before they entirely crystalize to rock. Crystals growing in the magma mush record the processes that the magma experiences, much like the rings do when they record the environment they were exposed to during their growth. Any changes in the magma chemistry are thus recorded by the cores and rims of the minerals in the mush. To better understand the magma processes and their significance, crystal-scale geochemistry of different types of minerals becomes useful. For my project I am using K-feldspar megacrysts from the porphyritic Twentynine Palms pluton to unravel its magmatic history.

The megacrystic Twentynine Palms quartz monzonite is located in the northern part of Joshua Tree National Park, which is a constituent of the Triassic magmatic arc of the Transverse Ranges, emplaced at 325 Ma (Barth and Wooden, 2006). The Twentynine Palms pluton is composed of a megacrystic quartz monzonite with 1-20 cm blocky K-feldspar phenocrysts in a medium grained, equigranular matrix of largely plagioclase, hornblende, and minor quarts, Biotite and accessories. It is surrounded by the equigranular Queen Mountain monzogranite. The highly alkali composition of these two plutons is unique in the area in contract to the lighter colored, mostly equigranualr, quartz- and feldspar-rich Creaceous plutons of Joshua Tree National Park (Brand, 1985). My project will text the hypothesis that the Queen Mountain pluton was fractioned from the Twentynine Palms by analyzing the elements of growth rings from core to rim of K-feldspar megacrysts to identify the processes in the magma reservoir.

The study will first determine if any potential regional patterns indicate cumulate textures. The nice euhedral K-feldspar megacrysts weather out of the rock easily and are collected from the grass. In the lab, the megacrysts are cut in half and for thin sections, and mineral zones from core to rim will be microdrilled with a Dremel tool for XRF element analyses and analyzed with geochemical software. Petrography will determine any consistent inclusion patterns.

The element data will be interpreted in light of the processes that may have occurred in the Twentynine Palms magma chamber to test the hypothesis that it underwent fractional crystallization. This will be evident in the decrease of compatible and decrease of incompatible elements from core to rim.

ORGANIC AND INORGANIC CARBON ANALYSES OF SHALLOW SEDIMENTS AT OVERFLOW LAKE, SANTA BARBARA, CALIFORNIA.

Student: Shayne Fontenot

Faculty Advisor: Dr. Sean Loyd

Overflow Lake is located in Santa Barbara and its sediment record may provide valuable insight into the paleoclimate of the California central coast. In particular, little is known about authigenic carbonate mineral formation in lake sediments that may provide additional information regarding but more likely convolute primary paleoclimate signals. Overflow Lake sediments were analyzed for their inorganic and organic carbon content and respective isotope compositions. The samples were collected from 312-397 centimeters deep. Total organic carbon (TOC) contents range from 0.38 to 8.25 wt% with higher concentrations towards the top of the interval. Organic carbon isotope compositions ($\delta^{13}C_{org}$) range from −27.8 to −23.1‰ (VPDB). Both ranges fall within those generally exhibited by lacustrine sediments and likely reflect primary rather than diagenetic depositional conditions. Future total inorganic carbon (TIC) content and isotope ($\delta^{13}C_{carb}$) analyses will help divulge whether or not the inorganic fraction formed from or has been influenced by diagenetic processes. Careful analyses of the corresponding data and depth profiles, relating them with dates derived from other research, may yield information about the influence of diagenetic processes versus primary sedimentary processes, which might have implications for the paleoclimate of this locality.

MEASURING BEACH RESPONSE AND RECOVERY DURING EL NIÑO

Student: Shane Goodwin

Faculty Advisor: Dr. Joseph Carlin

In California the coastal population has grown steadily from 47 million to 87 million from the 1960s to 2000s. Having such a large population along the coast increases the economic value of the land, creates jobs, and attracts tourism. These coastal communities and ecosystems along California however, experience seasonal changes, but are also impacted by interannual climate phenomenon such as El Niño that increase storm activity. Increases in storm activity expose beaches to more wave energy, which can result in erosion and net changes to beach morphology. While seasonal beach change is normal, varying in the winters and summers, extreme events like the El Nino can accelerate coastal erosion beyond repair. Therefore, as we are currently experiencing one of the strongest El Niño in recent history, this is a great opportunity to investigate the response and recovery of beaches in the region. We can use this to determine whether the underlying coastal setting has an effect on beach recovery from storms. We hypothesize that continental shelf width seaward of a beach would be a significant factor in controlling beach erosion during times of intense storm activities from El Niño. Shelf width affects wave energy, as wider shelves will dissipate wave energy further offshore, potentially minimizing beach erosion during storms. Therefore a beach fronted by a wider shelf will experiences less erosion, and more complete recovery than beaches located behind a narrow shelf. To test this, we will investigate two different beaches with a similar orientation, but different beach widths, Huntington Beach and Oceanside. We will collect elevation data from these beaches using differential GPS three separate sampling periods. The first time will set up the initial conditions; a second survey will be conducted following a storm event, and then a final survey conducted after some recovery period. From this study we hope to better understand the relationship between shelf width and beach morphological changes due to extreme storms. This may help coastal managers better plan for, and allocate resources towards protecting the California coastline.

THE GEOCHEMICAL CONNECTION OF VOLCANIC AND PLUTONIC ROCKS IN THE MINARETS CALDERA, CENTRAL SIERRA NEVADA

Student: Evelyn Gutierrez

Faculty Advisor: Dr. Vali Memeti

Studying the characteristics of a magmatic arc that is vertically extensive is challenging, as typically only the volcanic parts or only the deeper, plutonic parts are exposed. The Minarets Caldera in the eastern-central Sierra Nevada mountain range, however, exposes both parts of the magmatic system. Understanding how volcanic materials and deeper magma chambers (now preserved as a pluton) are geochemically connected may help us better understand characteristics of volcanic eruptions and ultimately help with predicting volcanic eruptions.

The rock record in the Minarets Caldera shows a well preserved intracaldera ignimbrite, an intercalated caldera-collapse breccia, and a granitic to granodioritic intrusion known as the Shellenbarger pluton that intruded into the center of the volcanic complex. The volcanic and plutonic rocks have been determined to be contemporaneous at ca. 100 Ma (Tomek et al., 2015) and thus connected to the same magma system. The Shellenbarger Lake pluton is thought to represent the source of the volcanic deposits (Fiske and Tobisch, 1994).

The volcanic samples obtained, both around and from the Minarets caldera, and from the Shellenbarger Lake pluton can provide information on the evolution of the magma processes that occurred in the magma chamber and led to the Minarets caldera forming eruption. Studying the major and minor trace elements through XRF analysis in this caldera will give us some insight into the Minarets caldera magmatic system and how volcanoes work in general. Geochemical analyses will allow me to test how the volcanic and plutonic parts are connected: Do they represent the exact same compositions or are they complementary to one another? The latter will imply that the erupted materials may have been fractionated from the magma reservoir and the pluton represents the restitic magma. This will be tested with geochemical modeling.

INVESTIGATING VARIATIONS IN HOLOCENE SEDIMENTATION ALONG THE MONTEREY BAY CONTINENTAL SHELF

Student: Kevin Hunter

Faculty Advisor: Dr. Joseph Carlin

Continental shelf sedimentation reflects the link between geologic, and climatic processes that occur in the ocean and on land. Preserved within these sediments may be evidence from global-scale changes such as sea level rise, to local events such as river floods. The continental shelf today was shaped during the late Pleistocene and Holocene as sea level rapidly rose following the last glacial maximum (LGM). This was a time of significant geologic change in the oceans, the climate, and on land. The record of such significant environmental changes may be preserved within the continental shelf sediment record. With current climate change and sea level rise comparable to that during the early to mid Holocene, understanding the changes that have occurred during the past may help to anticipate future change. This project proposes to investigate how sedimentation has changed along the Monterey Bay continental shelf throughout the Holocene. We hypothesize that sedimentation has changed reflecting steady increases in sea level, punctuated by climatic fluctuation, and anthropogenic impacts during the historical period. To accomplish this, we collected 3-4m long sediment cores at 7 different locations throughout the Monterey Bay shelf. These locations were chosen to target areas that previous work has shown exhibit the thickest accumulations of post-LGM sediment. The cores will be subjected to an array of sedimentological analyses. The analyses will include imaging, and CT scanning that will highlight subtle changes in sediment density. Wet bulk density, magnetic susceptibility, and other analyses will be determined using a multi-sensor core logger. Finally, grain size analysis will be conducted throughout the core, targeting the distinct changes in lithology observed while radiocarbon dating on sedimentary material will provide the appropriate age control for the cores. From this project, we hope to obtain a better understanding of how environmental conditions changed from the mid Holocene to the present along the Monterey Bay continental shelf, highlighting the potential changes we may experience as sea level continues to rise.

GEOCHEMICAL FINGERPRINTING OF BASALTS IN FISH LAKE VALLEY, CALIFORNIA AND THEIR CORRELATIONS USING X-RAY FLUORESCENCE SPECTROSCOPY

Student: Eddie Jimenez

Faculty Advisor: Dr. Jeffrey Knott

This project entails determining basalt geochemistry at outcrops in Fish Lake Valley, western Nevada and eastern California, by x-ray fluorescence (XRF). These basalt flows are found as isolated outcrops atop mountains and ridges. The topographic position of the outcrops and absence of a volcanic source indicates that the basalt flowed to these locations and, thus, predates the mountains. I will compare the geochemical composition of these basalts by x-ray fluorescence. This data will be compared with previously analyzed and dated basalts from the White Mountains, Inyo Range, and Last Chance Range areas. Comparison of basalt composition will help determine if the various basalts have the same or a different eruptive source. If the analysis shows that the basalts are from the same source, then this, along with geochronology conducted by other, will help determine the original flow area.

IDENTIFYING PALEO-SEISMIC EVENTS ALONG THE NEWPORT-INGLEWOOD FAULT ZONE

Student: Ryutaro Koga

Faculty Advisor: Dr. Joseph Carlin

Southern California is home to more than 20 million people, yet it is also one of the most seismically active regions in the United States. Therefore, seismic hazards are a critical issue in the region, affecting a large portion of the population. As with many other natural hazards, earthquakes are difficult to predict, and in southern California there are numerous faults capable of producing significant earthquakes. Many of these faults remain under-studied, which makes predicting the likelihood of events difficult. To improve our predictions on any particular fault therefore, we need to better understand the frequency of past events. One under-studied fault in particular is the Newport-Inglewood Fault Zone (NFIZ) that extends through highly urbanized areas of southern California including Culver City, Long Beach, and Newport Beach among others. The most recent rupture associated with this fault was a magnitude 6.4 earthquake in 1933, but little is know about other past events over the recent geologic past. This study seeks to determine the Holocene seismic history of the NIFZ in order to better understand the frequency of events. To accomplish this, I will utilize the coastal sediment record within the Seal Beach Wetlands (SBW) to identify past earthquake events. The salt marshes in the SBW are an ideal sedimentary environment to preserve evidence of past earthquake events. The reason is that salt marshes are extremely susceptible to small changes in elevation, and previous work has shown that the SBW may experience co-seismic subsidence during earthquake events. Thus the marsh stratigraphy should record even small changes in subsidence. I hypothesize that I may be able to identify multiple earthquake events that have occurred along the NIFZ over the past 3,000 – 4,000 years from the marsh stratigraphy in the SBW. In this project I will focus on one sediment core from the SBW. This core will be analyzed for sedimentological characteristics such as grain size, magnetic susceptibility, and total percent organic matter. Variations in these characteristics between different sediment layers will reflect changes in environmental conditions. Change in environmental conditions that suggest a rapid rise in sea level, will be interpreted a co-seismic subsidence from an earthquake. By identifying past earthquake events along this fault may improve predictions of future events.

ARE SOUTHERN CALIFORNIA SALT MARSHES KEEPING PACE WITH SEA LEVEL RISE: AN INVESTIGATION OF SALT MARSH SEDIMENTATION IN UPPER NEWPORT BAY, CA, USA

Student: Dane Van Orman

Faculty Advisor: Dr. Joseph Carlin

Salt marshes are a semi-enclosed body of water where fresh water mixes with saltwater. This environment proves to be one of Earth's most valuable ecosystems, as they protect against storms, filter sediments and nutrients, and export carbon. Presently, salt marshes are being threatened by sea level rise due to climate change, and human activities in the watershed that alter sediment fluxes into the marsh. Both of these threats specifically impact marsh elevation relative to tidal inundation, and if a salt marsh is unable to maintain elevation compared to relative sea level rise (RSLR) by accumulating sediment, it will drown in place. Southern California is a region where the marshes are particularly susceptible to these threats. Urbanization has reduced total marsh areas in the region, and for those remaining marshes, significantly altered sediment fluxes. Additionally, the remaining marshes are now bounded, thus preventing them from migrating landward with RSLR. In this study, we will assess salt marsh vulnerability to RSLR by measuring sediment accumulation rates in the marsh, and comparing the rates to RSLR rise over the same time period. To accomplish this we will focus on salt marshes in Upper Newport Bay, an estuary located in Orange County, CA. We will collect three, short (~50 cm) sediment cores from different areas in the bay, and sedimentation rates over the past 50-150 years will be determined from short-lived radioisotopes, ^{210}Pb and ^{137}Cs. These measured sedimentation rates will be compared to the rate of RSLR in the area, which is 2.40 +/- 1.04 mm/yr. since the 1950s. We hypothesize that salt marsh sedimentation in Upper Newport Bay is not keeping pace with RSLR, although marshes proximal to San Diego Creek will show the highest sedimentation rates. While there has been increased sedimentation in the bay over the past several decades due to increases in development in the watershed, recent changes to the bay to prevent excess sedimentation may be limiting sediment from reaching the marsh. This sediment may be necessary for the marsh to maintain elevation comparative to the increases in RSLR. From this project, we hope to highlight those areas within Upper Newport Bay that may be more susceptible to RSLR and environmental changes due to urbanization.

Undergraduate Thesis Category

AN

CONSTRAINING THE AGE OF THE EOCENE TALEGA BONEBED THROUGH MICROFOSSIL VERTEBRATE INDEX TAXA

Student: Michaela Adler

Faculty Advisor: Dr. James Parham

The Talega Bonebed is the only Eocene bonebed in California, providing a unique window into the fauna of Western North America at this time. The Talega Bonebed was discovered in 1998 in San Clemente during a paleontological mitigation of a housing development. The 10 cm thick bonebed was deposited as an attritional deposit in a fluvial environment and is part of the Eocene-aged Santiago Formation. There are 46 jackets of the Talega Bonebed in the Orange County Paleontological Collection housed at the John D. Cooper Center. Despite the large amount of collected material and diversity of taxa discovered, the age of the Talega Bonebed is not well constrained. Most of the larger vertebrate taxa are known across the Eocene fossil record of Southern California and are not useful in constraining the age of the locality. The use of microfossil vertebrate taxa can better constrain the Talega Bonebed, and rodents and primates are known from the site. For this reason, matrix from the bonebed was processed using screen washing and heavy liquid separation techniques to obtain more microfossil specimens in order to better constrain the age range of the Talega Bonebed. The microfossil taxa so far identified from the bonebed, such as *Microparamys*, *Sespedectes*, and *Simimys*, are typical of the middle to late Eocene taxa from Southern California, but the occurrence of the California endemic primate, *Dyseolemur pacificus*, indicates that the bonebed can be constrained to the late Uintan (44-41.5 mya). Determining the age of the bonebed is important, as a more constrained age will aid in faunal comparisons to other Eocene sites from California. By recovering, identifying, and studying the small mammals from the Talega Bonebed a better reconstruction of the paleoenvironment of the Talega Bonebed can be hypothesized. Combined with additional faunal comparisons of Southern California Eocene localities, study of the Talega Bonebed may also lead to more precise reconstructions of the overall paleoenvironment and paleocecology of Eocene Southern California.

GEOCHEMICAL ANALYSIS OF THE LOWER TRIASSIC (GRIESBACHIAN-DIENERIAN) PHROSO SILTSTONE (SULPHUR MOUNTAIN FORMATION): PALEOXYGENATION AND PALEOPRODUCTIVITY ALONG THE SOUTHERN EDGE OF THE WESTERN CANADA SEDIMENTARY BASIN

Student: Alejandro Amaya

Faculty Advisor: Dr. Adam Woods

The Permian-Triassic mass extinction was the most devastating mass extinction in Earth history, and caused a catastrophic loss of marine and terrestrial life. Recovery from the mass extinction was strongly tied to the presence or absence of environmental stress, including anoxia in the world's oceans, which may have been driven by large-scale changes in ocean chemistry, or eutrophication as the result of denudation of the continents and runoff of nutrients. In order to examine the cause of anoxia in the oceans during the period, 38 samples were collected from the Lower Triassic (Griesbachian-Dienerian) Phroso Siltstone (Sulphur Mountain Formation, Western Canada Sedimentary Basin), and analyzed for major, minor and trace elements. Results indicate that the Phroso Siltstone was primarily deposited under anoxic conditions (V enrichment factor (EF) values average 1.25±0.18) to euxinic conditions (Mo EF values average 8.65±4.57). Productivity indicators are more variable, with Ba, Ni and Zn indicative of high primary productivity (average values of 1.49±1.39, 1.14±0.30, and 1.82±0.69, respectively), while Cu values are depleted (EF of 0.25±1.33). Overall, it appears that anoxic conditions were driven by high primary productivity based on similar trends in the data, and in particular, a prominent peak in V from about 15 - 28 meters that matches with similar peaks in Ba, Ni and Zn, suggesting that anoxic conditions are being driven by high primary productivity. Algeo and Twitchett (2010) proposed that stripping of the continents of vegetation as a result of the extinction led to increased runoff and nutrient input to the oceans, however, the periods of elevated productivity do not correspond to increases in detritally-derived elements (Zr and TiO_2). Therefore it appears that increases in productivity within the Phroso Siltstone was the result of enhanced upwelling and nutrient input from the deep sea. Overall, the results of this study show that anoxic conditions persisted in the deep oceans long after the Permian-Triassic mass extinction and periodically impinged onto the continental margin. These harsh waters led to a long, complex recovery wherever they influenced local conditions, and strongly controlled when recovery began.

VARIATIONS IN CONTINENTAL SHELF SEDIMENTATION OVER THE PAST CENTURY, MONTEREY BAY, CA, USA

Student: Amanda Avalos

Faculty Advisor: Dr. Joseph Carlin

Continental margins contain large portions of the stratigraphic record that reflect the influences of both marine and terrestrial processes. In order to better understand how stratigraphy is formed along the continental margin, we must understand the interplay between terrestrial processes that supply the sediment, and the marine processes that alter deposits prior to preservation in the stratigraphic record. The goal of this study was to link spatial and temporal variations in modern continental shelf sedimentation to variations in marine and terrestrial processes to better understand the formation of the stratigraphic record. The study area was the Monterey Bay continental shelf located along the central coast of California. Seven, short (15 – 35 cm long) sediment cores were collected from the mid- and outer-shelf where water depths ranged between 50 - 100 m. For this study, 6 of the cores were analyzed for short-lived radioisotope geochronologies (^{210}Pb and ^{137}Cs), and sedimentological characteristics such as grain size and wet-bulk density. The results showed an overall coarsening upwards sequence in most of the cores. Core PS1410-04MC, from the outer shelf north of the bay, was dominantly mud, but increased from <10% sand at a depth of 20 cm, to 25-30% sand in the upper 15 cm. Cores from the mid-shelf north of the bay were consistently sand-dominated (>80%) throughout the cores. Core PS1410-11MC, from within the bay, showed the sand content increased from 2% at a depth of 20 cm to >40% at the surface. Complete geochronologies could only be determined for two cores (PS1410-04MC, and PS1410-11MC), with overall average sedimentation rates between ~ 3-4 mm/yr. However, interval-specific sedimentation rates showed that the rates increased from ~ 1mm/yr to >4 mm/yr. The timing of this shift corresponded to the late 1960s/ early 1970s, and also corresponded to the increases in sand content in the cores. This time period is consistent with a shift in the Pacific Decadal Oscillation (PDO) from a dominantly cool phase, to a dominantly warm phase. During the warm phase PDO central California generally experiences more frequent and intense El Niño events. Therefore, we suggest that the increase in coarser sediment supplied to the shelf during this time, may be related variations in ocean/climatic conditions, coupled with anthropogenic alterations to the coastal watershed. Overall, this study demonstrates that by improving our knowledge of the link between the processes that influence stratigraphic formation can improve our interpretations of the stratigraphic record.

MAJOR, MINOR, AND TRACE ELEMENT ANALYSIS OF THE MONTNEY FORMATION, PEACE RIVER EMBAYMENT (EASTERN ALBERTA, CANADA) FOLLOWING THE PERMIAN-TRIASSIC MASS EXTINCTION

Student: Mauricio Avila

Faculty Advisor: Dr. Adam Woods

The Permian-Triassic mass extinction led to an estimated loss of about 88 to 96% of all marine species, and also led to heavy losses to many terrestrial vertebrate families as well. Life eventually recovered by the Middle Triassic, although recovery was complex for ocean life and dependent on environmental conditions. Examination of a drill core (14-17-74-10W6) through Lower Triassic sedimentary rocks from the Peace River basin of eastern Alberta, Canada allows the reconstruction of paleoenvironmental conditions during the middle Early Triassic (Dienerian to Smithian). The Dienerian to Smithian-aged rocks consists of 4 distinct sequences, with the lowermost sequence (D6 – uppermost Dienerian) consisting of laminated black shale with some fish debris, S0 (lowermost Smithian) made up of laminated black to grayish colored siltstone, S1 consisting of laminated phosphatic black shale, and S3 made up of mottled to faintly laminated, very fine sandstone and siltstone. The sedimentology of the unit provides strong evidence for a widespread anoxic event that persisted across the Dienerian and Smithian, which will be examined in detail using trace elemental data, including Ba, Cu, Ni, and Zn to determine paleoproductivity and Mo and V to examine whether ocean waters were oxic, anoxic, or euxinic. If results demonstrate high primary productivity and low benthic oxygenation, then they will provide evidence for productivity-driven anoxia and support the hypothesis of Algeo and Twitchett (2010) that denudation of the continents and enhanced weathering rates drove anoxic conditions in marginal marine environments. If productivity indicators imply low or dampened rates of primary productivity, then this will suggest that anoxic conditions in the region were due to the influence of a deep, anoxic water mass in eastern Panthalassa, and support the hypothesis of Isozaki (1997) that much of Panthalassa was anoxic from the Upper Permian to the Middle Triassic. Overall, the results of this study should shed light not only the role of environmental conditions, specifically anoxia, in determining the timing and shape of recovery from the Permian-Triassic mass extinction, but also the drivers of those conditions.

VERTEBRATE FAUNA AND UNGULATE BIOSTRATIGRAPHY OF THE HIGHLY FOSSILIFEROUS OSO SAND MEMBER, CAPISTRANO FORMATION, ORANGE COUNTY, CA

Student: Michelle Barboza

Faculty Advisor: Dr. James Parham

The Oso Sand Member is the highly fossiliferous, nearshore facies of the Capistrano Formation, which spans the southeastern rim of the Los Angeles Basin in Orange County, California. Over 20 vertebrate taxa have been identified from this unit, including well preserved fossils of marine taxa such as a nearly complete skull of a blue marlin and the most complete fossil walrus found to date. In addition to other marine mammals (whales and seacows), terrestrial mammals are also known from the Oso Sand Member including gomphotheriids, rhinocerotids, antelocaprids, canids, cricetids, and lagomorphs. Despite the abundance of material from Oso Sand Member sites, just three papers have reported on this unit: one paper focused on the skull of the blue marlin mentioned above, the other two mentioned mammal fossils in passing. We provide an overview of all known vertebrate fossils from Oso Sand Member, and establish a more refined age for the Oso Sand Member, which will help provide a temporal framework for ongoing paleontological studies. Based on stratigraphic correlation, the Capistrano Formation is reported as Upper Miocene to Lower Pliocene. Previous workers have referred to undescribed specimens to place the Oso Sand Member in the Hemphillian North American Land Mammal Age. Partial camelid teeth are identified as *Alforjas*, known from the late early to latest Hemphillian (Hh2 to Hh4). Horse teeth previously referred to *Pliohippus* (Barstovian to Hemphillian) are reidentified as *Dinohippus interpolatus*, which is characteristic of the early late Hemphillian (Hh3). Based on these identifications, we can constrain the age of the Oso Sand Member to the early late Hemphillian (Hh3). By better defining the age of the Oso Sand Member, we can place the marine and terrestrial vertebrate fossils from this unit into a more precise chronostratigraphic framework that allows us to make more detailed comparisons to other late Neogene faunas in California.

Grant Information
This research was funded by the CSU-Louis Stokes Alliance for Minority Participation program (NSF grant # HRD-1302873).

POST PERMIAN-TRIASSIC EXTINCTION PRODUCTIVITY AND PALEOXYGENATION FROM ANALYSIS OF TRACE ELEMENTS FROM THE PEACE RIVER EMBAYMENT REGION OF EASTERN ALBERTA

Student: Sam Bergeland

Faculty Advisor: Dr. Adam Woods

There have been multiple events of biotic crisis in the earth's vast history, with the largest of them all being the Permian-Triassic mass extinction that occurred about 252 million years ago. The Early Triassic recovery interval was complex with regards to trends in biodiversity and biotic production, and was examined in detail from a core (12-20-78-6W6) taken from the Montney Formation of the Peace River Embayment of the southern Western Canada Sedimentary Basin (WCSB). The core samples several intervals over an approximately 158.4m-long section, and includes sedimentary rocks deposited during the Greisbachian, Dienerian and Smithian. Fifty-two samples were removed from the core, and major, minor, and trace elements were measured in order to determine the relationship between productivity and oceanic oxygenation. Vanadium enrichment factors (EFs) average 1.23± 0.22 during the Griesbachian, 1.16±0.06 during the Dienerian and 1.08±0.11 during the Smithian, suggesting that paleoxygenation was reduced, but steadily improved across the study interval. Mo levels are elevated throughout the study interval, which may be the result of sulfate reduction in pore waters during diagenesis. Ba EFs are enriched across the section, and indicate persistent high primary productivity, although post-burial diagenesis may have evened out the signal (Tribovillard et al., 2006). Low Cu and Ni values are likely the result of loss of these elements from pore waters prior to their incorporation into pyrite or other sulfide minerals during sulfate reduction. Zn values are slightly depleted in the Greisbachian, and enriched during the Dienerian and Smithain, although the values are variable, and form several prominent spikes. Peaks in Zn reflect high productivity that may be contained in Fe-Mn oxyhydroxides (Tribovillard, et al., 2006). Overall, a picture of the core emerges in which conditions were anoxic, but steadily improved across the Early Triassic; primary productivity is more difficult to assess, but it appears that productivity was high and steady based on enriched Ba levels, and may have increased from time to time based on spikes in Zn data. Productivity does not appear to have been driving anoxic conditions, which were likely the result of ocean chemistry at the time. These anoxic waters would have delayed recovery wherever and whenever they encroached upon shallower portions of the continental shelf.

A PALEOENVIRONMENTAL AND ICHNOLOGIC ANALYSIS OF THE UPPER MISSISSIPIAN PORTION OF THE REST SPRING SHALE OF INYO COUNTY, CALIFORNIA

Student: Charlie Chou

Faculty Advisor: Dr. Adam Woods

The Upper Mississippian – Lower Pennsylvanian Rest Spring Shale of eastern California was deposited during the latter stages of the Antler Orogeny, within the deep foreland basin associated with the emplacement of the Roberts Mountain Allochthon (Laudon, 1989). The foreland basin was present along the eastern edge of Panthalassa and the western edge of the Kaskaskia Epicontinental Sea during the Late Mississippian, and provides a means to examine paleoenvironmental conditions at the juncture between open ocean and epicontinal sea within an active tectonic setting. The Rest Spring Shale was examined at the Willow Springs Canyon locality, Mazourka Canyon, Inyo Mountains, California. The Rest Spring Shale was previously studied by Laudon (1989), who conducted a regional sedimentologic analysis of the unit, and broke it up into 4 informal members based on lithology. The lowermost, Upper Mississippian unit was examined by this study via gamma ray spectrometry, trace fossil analysis, and petrographic investigation. Subunit I (the lowermost subunit) consists of black, laminated, silty shale that contains various trace fossils that are part of the *Nerites* ichnofacies, and are present as looping traces on bedding surfaces (Laudon, 1989); ichnogenera include *Chondrites*, *Scalarituba*, and *Planolites*. Th/U values from the Rest Spring Shale imply that the unit was primarily deposited under anoxic conditions. Therefore, the trace fossils found within the unit are thought to be the remnants of activity from doomed organisms that were dragged down into deeper, anoxic waters by turbidity currents, which also supplied a limited amount of oxygen to the environment (Follmi and Grimm, 1990). The abundance of bedding-plane traces over the 80m-thick study interval implies a tectonically-active setting that frequently introduced doomed émigré trace makers to the basin.

NATURE OF ORGANIC CARBON ASSOCIATED WITH MIOCENE CARBONATE CONCRETIONS OF THE MONTEREY FORMATION: EVIDENCE FROM CARBON ISOTOPE DATA

Student: Shawn A. Colby Jr.

Faculty Advisor: Dr. Sean Loyd

The Miocene Monterey Formation is exposed in outcrop along the west coast of California. The formation is a prolific hydrocarbon producer largely due to its organic-rich nature. Concretions, common in the Monterey Formation, form in part from the degradation of organic matter within sediments. Isotope analyses can provide insight into organic matter degradation mechanisms but have largely been restricted to inorganic phases (e.g., carbonate minerals). Monterey concretion total organic carbon (TOC) contents and isotope compositions ($\delta^{13}C_{org}$) may provide a complementary data set to existing inorganic data. TOC contents for siliceous member concretions range from 0.32 to 1.14 wt% whereas $\delta^{13}C_{org}$ values cluster around -21.51 ‰ (VPDB). Phosphatic shale concretions exhibit TOC contents that range from 0.67 to 0.89 wt% with $\delta^{13}C_{org}$ values of ~-24.23 ‰. The siliceous member is dominantly composed of diatomaceous sediments. Modern diatom organic matter exhibits $\delta^{13}C$ values near -21.1‰, close to the Monterey siliceous member concretions. This suggests that organic matter degradation (the process whereby concretions form) within the siliceous member was not accompanied by a significant isotope fractionation. The relatively ^{13}C-depleted organic matter of the shale member may reflect diagenetic modification or a different organic carbon source. These data suggest that concretions can preserve primary organic carbon isotope compositions, despite being formed from organic matter degradation.

ARTICULATED SKELETON OF *CARCHARODON HASTALIS* (LAMNIFORMES, LAMNIDAE) FROM THE "MONTEREY FORMATION," ORANGE COUNTY, CALIFORNIA

Student: Crystal Cortez

Faculty Advisor: Dr. James Parham

Despite an abundance of specimens, there are few scientific studies on fossil sharks from California. Fossil shark teeth have been mentioned sporadically in papers concerning fossil birds or marine mammals from California, but descriptive studies are uncommon. We present an articulated fossil shark skeleton (OCPC 4618, from the John D. Cooper Center) that was collected during paleontological monitoring in 1992 from "Monterey Formation" diatomite in Laguna Niguel, California. OCPC 4618 includes vertebrae, dentition, and a brown film outlining the specimen that is believed to be calcified cartilage prisms. The preservation of OCPC 4618 is significant because, whereas isolated shark teeth are common in the fossil record, articulated shark specimens are rare. OCPC 4618 is identified as *Carcharodon hastalis* (white shark) by its teeth with rectangular root systems and triangular crowns. OCPC 4618 has lateral cusplets, a character that is also found in juvenile *Carcharodon carcharias*. Combined with the small size of the specimen we hypothesize that OCPC 4618 is a juvenile and so provides a unique perspective on the ontogenetic morphological features of fossil white sharks.

DESIGN FOR A GEOSPATIAL DATABASE AND RELATED MOBILE APPLICATION

Student: Glenn Dunkle

Faculty Advisor: Dr. Nicole Bonuso

Demand for STEM related expertise is on the rise. In order to meet that demand, a larger audience needs to be engaged in science and math based topics. One means in particular is to move to an engagement-of-discovery teaching paradigm. In the professional geologic community, decades of research exist, but these reports can be difficult to find and understand for the non-expert. More recently, mobile computing and wireless communication have grown exponentially, promoting an explosion in mobile applications that cater to younger generations who have come to expect a great utility from their technology. The primary purpose of the application is to provide accessible, relevant and high quality geologic content utilizing ubiquitous internet and mobile content delivery platforms in a way that cultivates an interest in STEM, ecology and the environment. The mobile application being proposed is an interactive portal to the geologic world. Using a mobile device's location, camera, and data services, GIS information will be overlain on to maps and views relative to the current location. Additionally, context sensitive textual information, encapsulated from indexed professional geologic reports, will be linked to the graphics and maps so that an enhanced view of the current location will allow for an interactive experience that combined with a tactile experience that exactly matches the growing trend of technology assisted learning.

A DETERMINATION OF THE DIAGENETIC HISTORY OF THE SARVAK FORMATION (MID-CRETACEOUS) OF THE ZAGROS BASIN, SOUTHERN IRAN

Student: Brian Fullaway

Faculty advisor: Dr. Adam Woods

The upper Lower to lower Upper Cretaceous (Albian – Cenomanian) Sarvak Formation of the Zagros Basin of southern Iran consists of carbonate rocks deposited in depositional environments ranging from tidal flat to basin, and serves as one of the main hydrocarbon reservoirs within Iran. In order to better understand the post-depositional conditions that led to the formation of the reservoir, 70 samples were collected across a 471m-thick section and analyzed for carbon isotopes and major, minor and trace elements. The carbonates analyzed for this study are interpreted to have been deposited in outer ramp environments based on the bedded, chert-rich and fossil-poor nature of the unit at the study locality. Carbon isotope values average 1.88±0.95‰ and range between 1.5 – 2.5‰ from the base of the section to 335m. Values then increase to ~2.8‰ from 330 – 370m, undergo a drop to 1.85‰ at 380m, increase to 3.03‰ at 390m before undergoing a steady decline to -0.34‰ at the top of the section (471m above the base). Sr concentrations range from 12.6 to 425 ppm, Mn values range from 4 – 548ppm and Fe values range from 15 – 15, 230ppm. Overall, the trace element and carbon isotopic results are indicative of an open diagenetic system, in which the carbonates were affected by burial diagenesis. Carbon isotopic values from the study section are mostly within the range of values typical for the mid-Cretaceous (1.3 – 3.8‰), although the negative carbon excursion near the top of the study section differs from global values, and is likely the result of local environmental conditions that introduced ^{12}C carbon to the system. Mn values >70 ppm are considered to be evidence of diagenetic alteration of the carbonates, which may be further shown by the relatively low Sr values (hundreds of ppm) from the unit, although low Sr values may also reflect the preferential marine precipitation of low-Mg calcite over aragonite during the Cretaceous. Low Sr contents coupled with high Mn and Fe values are indicative of reducing conditions during burial diagenesis. Previous studies of the Sarvak Formation have shown diagenetic processes ranging from marine phreatic to meteoric diagenesis in carbonates deposited in shallower settings, and the results of this study demonstrate that burial diagenesis also played a role in the post-depositional history of the unit, specifically within those facies deposited in deeper waters. Differences in diagenetic history of the Sarvak Formation are likely the result of the post-depositional tectonic history of the Zagros Basin, including faulting, which appears to have exerted a strong control over fluid flow within the basin.

NEW MATERIAL OF THE STEM SEAL *ALLODESMUS* FROM THE TOPANGA FORMATION OF ORANGE COUNTY

Student: Adrian Garibay

Faculty Advisor: Dr. James Parham

Pinnipeds, the group of marine mammals that include seals, sea lions, and walruses, has a fossil record that begins in the Oligocene. The major extant lineages of pinnipeds first appear in the middle Miocene. Orange County boasts an undescribed diversity of fossil pinnipeds, the oldest of which are from the early-middle Miocene Topanga Formation. This unit has produced important new fossils of stem walruses (reported in 2013) and the recently described *Eotaria crypta*, the oldest known stem sea lion (described in 2015). Here we report on stem seal (stem phocid) material from the Topanga Formation, which we refer to the taxon *Allodesmus*. *Allodesmus* is the best-known fossil pinniped, and six species have been described from middle Miocene sites in California and Japan, with additional reports from Washington and Baja California. However, some of these species may not be valid, but instead may be based on individual variation and ontogenetic differences; the clade is need of revision. The Topanga *Allodesmus* is interesting because in addition to having the smallest adult size, it is probably the oldest material referable to this genus. We compare the new Orange County material to other species of *Allodesmus*, especially the material from the nearly contemporaneous Sharktooth Hill Bonebed.

INVESTIGATING THE HOLOCENE DEPOSITIONAL HISTORY OF A BACK-BARRIER LAGOON, CHRISTMAS BAY, TX

Student: Michelle Harb

Faculty Advisor: Dr. Joseph Carlin

Coastal environments such as barrier islands formed during the Holocene as sea level rise began to slow. Barrier island, and associated back-barrier lagoon, environments dominate the Gulf coast of the United States. While the lagoon forms following the establishment of the barrier island, previous research has demonstrated that the sedimentary record in these lagoons may contain a wealth of information regarding coastal evolution in the Holocene both preceding and following barrier formation. The purpose of this study was to investigate how the depositional environments in Christmas Bay, a small back-barrier lagoon located along the Texas coast, have changed as the coast evolved through the Holocene. To accomplish this I collected 4 sediment cores from throughout the bay. The cores were photographed, x-rayed, and analyzed for water content, and grain size. Core locations corresponded to shallow, high-resolution seismic reflection data that had previously been collected, and that I analyzed. The results from the core data show a coarsening upward sequence, and a clear shift from red clay at the base, to gray muddy-sand and sandy-mud in the uppermost section. From the seismic stratigraphy we interpret eight distinct sedimentary sequences. These include sequences that contain seaward-dipping internal reflectors, horizontal parallel internal reflectors, and sequences that lack internal reflectors. From the combined lithostratigraphy and seismic stratigraphy we interpret facies that include shallow marine fill, deltaic sediment (distinct prodelta, delta front, and topset units), lagoon sediment, barrier overwash deposits, and barrier roll-over deposits. These facies reveal that the area began as a Pleistocene incised channel that began filling with shallow marine sediments as sea level rose in the Holocene. In the mid-Holocene, the nearby Brazos River migrated eastward, and the delta prograded through the study area. The river mouth continued migrating to the east, and the study area became a distal depocenter for Brazos prodelta sediments. When the river started migrating back to the west, topset and delta front sediments were deposited throughout the bay. A brief period of shallow marine conditions returned as the river mouth shifted further west. After this, the barrier became established, and a shift to lagoonal deposition. Cores closest to the island today contain overwash deposits, while surface sediments throughout the bay reflect a shift to the barrier rollover phase. These results highlight the dynamic nature of coastal evolution in this area.

XRF ANALYSIS OF UBEHEBE HILLS AND RELATED BASALTS, NORTHERN DEATH VALLEY, CALIFORNIA

Student: Grant G. Kennis

Faculty Advisor: Dr. Jeffrey Knott

Klinger and Sarna-Wojcicki (2001) found an olivine-bearing basalt flow in the Death Valley Wash (37.05175°N, 117.45295°W) underlying the 3.3 Ma Mesquite Spring tuff. Based on its stratigraphic position, they correlated this basalt flow with the 3.7±0.2 Ma basalt of Ubehebe Hills from Snow and Lux (1999). However, there are other nearby basalt flows older than 3.3 Ma in the local area. Elliott et al. (1984) determined a K/Ar age of 4.2±0.3 Ma for an olivine basalt that flowed from the Saline Range, over the Last Chance Range, and into Death Valley. Elliott et al. (1984) also obtained a K/Ar age of 7.5±0.3 Ma for a basalt flow north of Scotty's Castle that flowed south to the mouth of Grapevine Canyon. Geochemical trace element quantities acquired through X-ray fluorescence were used to determine the source of the Death Valley Wash basalt from the three different localized sources of volcanism (Saline Range, Grapevine Mountains, and Ubehebe Hills). Ce/Y ratios are compared to identify different abundances in rare Earth elements for each sample. Due to the lack of Nb found in Northern Death Valley basalts, Zr/Ba ratios (Lithospheric magma $\leq 0.20 >$ Asthenospheric magma) are used to discriminate between the changing tectonic environments (Ormerod et al., 1988). They determined that the change from lithosphere to asthenosphere dominated magma at the latitude of Northern Death Valley as ~5 Ma. A Zr/Ba versus Ce/Y plot of the Death Valley Wash basalt is similar to the 3.7±0.2 Ma, asthenosphere-dominated basalt of Ubehebe Hills from Snow and Lux (1999), as proposed by Klinger and Sarna-Wojcicki (2001). The 4.2 Ma basalt from the Last Chance Range has a lower Zr/Ba ratio similar to other basalts from that range. The 7.5±0.3 Ma Grapevine Mountain basalts plot as asthenosphere-dominated magmas, which is contrary to Ormerod et al.'s (1988) model. This difference may be the result of inaccurate K/Ar dates or that the 5 Ma change from lithosphere- to asthenosphere-dominated magma is not precise.

USING GEOCHEMISTRY TO ESTABLISH THE CONNECTION BETWEEN DACITES AND RHYOLITES OF THE BONANZA TUFF, SAN JUAN VOLCANIC FIELD, CO

Student: Natalie Law

Faculty Advisor: Dr. Vali Memeti

The 33 Ma Bonanza Tuff (1,000 km^3) erupted from the Bonanza Caldera in the San Juan Volcanic field in Colorado as a single ignimbrite sheet that is compositionally zoned vertically and laterally. The Bonanza Tuff alternates from dacite to rhyolite (62-76% SiO_2) several times. Both compositions contain crystal-rich dacitic and crystal-poor rhyolitic pumice. Unique to the Bonanza Tuff is the eruption of dominantly dacite deposits to the west and rhyolite deposits to the east. The current hypothesis suggests that both rhyolites and dacites may have been derived from the same, but different levels of a stratified magma reservoir. Alternatively, the dacites and rhyolites were tapped from two exclusive, but nearby reservoirs. Investigating the geochemistry of such a unique pulsating system and testing these models allows us to understand the configuration of the near-surface magma plumbing system that led to the Bonanza Tuff supereruption. Detailed petrography, whole rock and mineral scale geochemistry are presented to examine the geochemical relationships between the Bonanza rhyolite and dacite tuffs and included felsic and mafic pumices, i.e., if they are connected through fractional crystallization or mixing. Petrographic observations show that the concentration of plagioclase, hornblende and sanidine vary in both rhyolites and dacites across the thickness of the Bonanza tuff, whereas biotite content remains fairly constant. XRF major oxides and trace element analyses indicate that dacites and rhyolites are related through both crystal fractionation and magma mixing. Felsic and mafic pumice clasts plot as end members of the system and are likely to be representing the mixing magmas. Isotope analysis supports this interpretation by showing a clear mixing line between dacites and rhyolites, but also indicating that some rhyolites are fractionates from those dacites. Electron microprobe analyses further confirm dual processes, displaying two plagioclase populations present in both dacites and rhyolites, as well as sanidine crystals that formed in the same, low-Ba, magma before mixing and fractionation occurred. The results infer numerous processes acting in the reservoir; the mixing of an evolved and a primitive magma followed by fractionation of the mixed zone that is responsible for forming a stratified magma reservoir, which was tapped at different levels during the Bonanza tuff eruption.

THE IMPORTANCE OF FRACTIONAL CRYSTALLIZATION IN FORMING THE COMPOSITIONAL VARIATION IN THE NORTHEASTERN CATHEDRAL PEAK LOBE IN YOSEMITE NATIONAL PARK

Student: Scott Lowery

Faculty Advisor: Dr. Vali Memeti

Determining how magma plumbing systems operate in magmatic arcs is crucial for better understanding volcanic eruptions and crustal growth, yet the nature of active intrusive magma bodies at depth and how they grow and evolve through time remains debated. Magma processes that define the compositional variation in exposed intrusions are typically manifold: determining which processes dominated and the scale at which they operated is critical in understanding the size and interconnectivity of former magma mush bodies at final emplacement depths and in magmatic arcs as a whole. The focus of this study is to determine the length scales of magma processes responsible in forming the compositional variation in the northeastern lobe of the Cathedral Peak (CP) unit in the 95-85 Ma Tuolumne intrusive complex (TIC), Yosemite National Park, Sierra Nevada, CA. This area is of particular interest because it contains the youngest parts (ca. 86 to 84Ma) of the TIC and thus reveals the location of the final magma mush body before TIC magmatism shut down. The increasingly leucocratic compositions towards the NE lobe, including aplitic dikes extending into the host rock, led to the hypothesis that this area underwent extensive fractionation from the interior of the northern CP granodiorite. To test this hypothesis, we have conducted field mapping, petrography and XRF analysis across the northern CP unit and into the NE lobe. Results on geochemical plots indicate notable decreasing trends of Al2O3, MgO, CaO, TiO2 and P2O5. K2O increases at lower silica and Na2O generally decreases, but then both stay stable at higher silica content. Notable trace element changes include a decrease in Ba, Sr and Zr, and an increase in Rb. Through geochemical modeling, it was determined that the majority of CP rocks in the northeastern lobe were produced through fractionation of up to 10% of 50% orthoclase, 49% plagioclase, and 1% biotite. From petrography, XRF major oxide and trace element geochemistry, and geochemical modeling results suggest that the NE CP lobe underwent fractionation of biotite, plagioclase, orthoclase, zircon and apatite. The data show that the NE CP lobe may have hosted the youngest moderately sized, fractionating magma mush body in the TIC.

IDENTIFICATION OF A METHANE CARBON SOURCE FOR ORGANIC CARBON CONTAINED IN SALT DOME CAP ROCKS OF THE GULF COAST REGION, USA

Student: Lucas Lu

Faculty Advisor: Dr. Sean Loyd

Salt domes are often associated with trapped hydrocarbons and capped by a mantle of sulfate and carbonate minerals that result from complex fluid-rock interactions in the subsurface. Many studies conclude that the calcite cap rock carbon is derived from surrounding trapped hydrocarbons. However, liquid hydrocarbons fail to explain the extremely low carbon isotope compositions (< -30 ‰) (VPDB) of many salt dome calcites. In fact, the only carbon source known to exhibit such 12C-enriched isotope compositions is methane. Organic matter carbon isotope compositions (δ 13Corg) have not been determined in Gulf Coast cap rocks and may, as with calcites, provide insight into carbon sources. Here, organic carbon isotope (δ 13Corg) data analysis exhibits depletions as low as –30 to –50. ‰. Severe 13C-depletion may reflect either microbial fixation of methane-sourced carbon or microbial fractionation from liquid hydrocarbon sources. Ultimately, salt dome systems may share some important characteristics with the anaerobic oxidation of methane (AOM) systems in modern marine benthic environments and analysis of organic carbon in these systems can provide additional support for such hypotheses.

TRACE ELEMENTAL ANALYSIS OF PRODUCTIVITY AND OXYGENATION CONDITIONS WITHIN THE WESTERN CANADA SEDIMENTARY BASIN FOLLOWING THE PERMIAN-TRIASSIC EXTINCTION

Student: Anthony A. Macias

Faculty Advisor: Dr. Adam Woods

Approximately 251 million years ago, towards the end of the Permian, Earth experienced a mass extinction event that resulted in the extinction of almost 90% of species on the planet. Recovery from the extinction event did not happen at the same time everywhere; instead, recovery from the extinction was strongly related to environmental conditions. To understand how organisms rebounded following such a devastating crisis, it is necessary to examine the reestablishment of primary productivity and its relationship to environmental conditions, specifically oxygenation levels, during this period as a whole. Samples previously collected and powdered from the Montney Formation from 2 drill cores from the Pedigree-Ring/ Border-Kahntah River area of northeastern British Columbia and northwestern Alberta (16-33-84/18W6M and B-24-H/94-H-16) underwent trace elemental analysis to determine oxygenation and productivity recovery rates within the region. Trace elemental analysis of core B-24-H/94-H-16 reveals low productivity levels and anoxic conditions that shift up section to euxinic conditions. Analysis of core 16-33-84/18W6M reveals anoxia and possible euxinic conditions that correlate with enhanced productivity, which likely drove the anoxic conditions found in the core. Anoxic to euxinic conditions found within the Pedigree-Ring/ Border-Kahntah River area therefore are driven by a combination of upwelling of nutrient - rich deep waters (16-33-84/18W6M) and the impingement of deep, anoxic water masses along the western margin of Pangea (B-24-H/94-H-16). Results derived from this study suggest that post-extinction recovery rates are strongly influenced by environmental conditions that are driven by processes acting at both the regional and global scale, and careful, multiproxy analysis is necessary to determine which processes are active in any given area.

DESCRIPTION OF THE MOST COMPLETE FOSSIL WALRUS AND ITS IMPLICATIONS FOR ODOBENID PHYLOGENY

Students: Isaac Magallanes

Faculty Advisor: Dr. James Parham

Walruses (Odobenidae) diverged from other lineages of pinnipeds in the early to middle Miocene (>16 Ma). The single extant species (*Odobenus rosmarus*) is restricted to the Arctic, but a diversity of fossil odobenids (20 species, 16 genera) are known throughout the North Pacific, especially in California. Although many fossil walruses have been described, our understanding of the evolutionary history of the Odobenidae is hindered by a lack of described postcranial material, despite the fact that many such specimens exist. Here we report on the most complete fossil odobenid known to date, a ~90% complete skeleton from the Mio-Pliocene Oso Sand Member (5.7-4.9 Ma) of the Capistrano Formation of Southern California. The specimen represents a new taxon that includes a combination of plesiomorphic and derived characters previously restricted to different groups of extinct walruses. As such, the Capistrano specimen provides new insights into the morphology and diversity of extinct walrus lineages. Our reassessment of walrus phylogeny reveals two distinct Miocene radiations: a middle Miocene radiation and a late Miocene radiation. Our estimates show that during the middle Miocene radiation, as many three lineages of walruses existed at one time, and as many as nine species during the late Miocene radiation (including the lineage represented by the Capistrano specimen). Despite the high level of diversity found in the late Miocene, the number of coeval lineages drops to three by the late Pliocene. This decline of walrus lineages occurs as another group of pinnipeds, the Otariidae, (fur seals and sea lions) becomes more diverse.

SEARCH FOR THE SOURCE OF COGSTONES IN SOUTHERN CALIFORNIA

Student: Ryan McKay

Faculty Advisor: Dr. Vali Memeti

Cogstones are 6000-3500 BC old Native American artifacts carved in a way that look like a cog from a gear. They have been only found in southern California and are dominantly made out of various scoria basalt. The use and significance of these stones is unknown and no flawless theory has yet been agreed upon. The location of the basaltic source rock for the stones is also not known, however, multiple basalt locations crop out in southern California and it is possible the source rocks were derived from nearby southern California. Thus finding the location of the source rocks may help narrow down the possibilities of what the stones were used for and reveal more about the lifestyle of Native Americans in Southern California.

Macroscopic, petrographic and geochemical analysis was performed on four cog stone fragments from different sites in Orange County donated by the Cooper Center. These were compared to the results of scoria basalt collected within the San Bernardino and Los Angeles USGS Quadrangle Map. Basalt was collected on the SE side of Catalina Island near Two Harbors (CL1A-C) and Whitley's Peak (WP1-3), a site known to have been inhabited by Native Americans, the Santa Monica Mountains near La Vina Gomez de Malibu along Mulholland Highway (SAM1-6), at Van Winkle Mountains (SW Mojave National Preserve; VW1-2), in Lucerne Valley (LV1) and at Fossil Falls along Hwy 395 (FF1). Three of the four cog stones are vesicular basaltic scoria and one is volcanoclastic tuff. Petrographic analysis revealed the cogstones are plagioclase rich with various amounts of olivine, pyroxene, oxides and iddingsite with varying grain sizes. Upon petrographic analysis, only VW1, CL1B and FF1 continued to match with CS2 or CS3. XRF major oxide and trace element analysis shows similarities in chemistry between FF1 and CS3 with only minor differences in SiO_2, CaO, Ba, Ni, Cu and Nb content. Samples FF1 and CS3 yield overlap in major oxide and trace element concentrations and were sent for isotopic analysis to determine if a match is still valid. All tests performed proved to indicate that none of the collected basalt samples are a match for the four cogstones tested thus determining that Native Americans did not collect from basalt outcrops within the Los Angeles and San Bernardino area.

LOCATING THE VOLCANIC SOURCE ROCK OF PREHISTORIC COGGED STONES FROM SOUTHERN CALIFORNIA: WERE THEY CARVED FROM EL MODENA AND SANTA ROSA BASALTS?

Student: Sierra Patterson, Ryan McKay

Faculty Advisor: Dr. Vali Memeti and Dr. Steven James

Cog stones, hand-size Native American artifacts carved in the shape of cogs, have only been found in Orange County, CA and are dominantly made of basaltic scoria. The use of cog stones is unknown with ca. 40 different potential uses proposed to date. The purpose of this study is to identify the volcanic source location from which the cog stones were carved. This may help reveal the significance of the cog stones to 6000-3500 BC Native Americans.

To identify the source location of basaltic cog stones four cog stones fragments unearthed in Orange County were used for analysis. We focused on two potential source locations: the El Modena volcanics, which have been previously suggested as a likely source for the cog stones, and the nearby Santa Rosa volcanics in Riverside County. Petrographic observations and whole rock XRF geochemistry are used to compare the cog stones with the potential source samples. Given the variability in the composition of basaltic cog stones, it is unlikely that all cog stones are from the same volcanic source.

Preliminary results from petrographic analysis of thin sections of the cog stones show that they have porphyritic texture and are composed of mainly plagioclase laths with varying amounts of ortho- and clinopyroxene, olivine, opaque minerals, and iddingsite. Petrographic analysis of Santa Rosa basalt has the same mineralogical composition and texture as cog stone CS3. We are further testing this potential match through XRF analysis. Mineralogy and texture of the El Modena basalts do not resemble that of any of the cog stones analyzed, however XRF analyses of two El Modena samples suggest similar geochemical compositions to CS2. They contain ca. 55 wt.% SiO_2, 20-21 wt.% of Al_2O_3, 5-6.5 wt.% Fe_2O_3, 8-9 wt.% of CaO, and similar trace element concentrations, e.g. 200-230 ppm Zr, 320-400 ppm Ba, 16-20 ppm Nb, and 600-700 ppm Sr. El Modena basalt has smaller plagioclase exhibiting a sieve structure, lower vesicle and matrix abundance, and does not contain clinopyroxene and olivine. More analyses are underway to further examine these relationships. If we can confirm that both El Modena and Santa Rosa volcanics were sourced to carve cogged stones, it would suggest that Native Americans collected these rocks perhaps because they were soft to carve and found nearby; the collection site may have not been important.

PLUVIAL LAKE DEPOSITS OF DEEP SPRINGS VALLEY, CALIFORNIA.

Student: Adam E. Ramirez

Faculty Advisor: Dr. Jeffrey Knott

Deep Springs Valley, located 35 km east of Bishop, California, is known for its terminal saline playa (elev. 1499 m). Deep Springs Valley has a relatively small drainage basin with streams emanating only from the White Mountains to the northwest at elevations as high as 4344 m. Observations and mapping from as early as 1928 found evidence of Quaternary stratified and fossiliferous pluvial lake deposits in Deep Springs Valley. The mapped elevation of the pluvial lake deposits (1646 m) is the same as the Soldier Pass wind gap (1648 m) between Deep Springs and Eureka Valleys. This observation led to the hypothesis that the pluvial Deep Springs Lake once flowed into Eureka Valley.

The objective of this study is to provide a more extensive description of the putative Deep Springs Lake deposits. As an isolated basin of limited areal extent, lake deposits in Deep Springs Valley would record past climate of the immediate area, which may be advantageous when comparing against climate records from the adjoining Owens Valley and nearby Death Valley.

We examined Deep Springs Lake deposits mapped in 1966 located northeast of a small hill called "The Elephant". The deposits consisted of alternating beds of fine-grained, finely bedded, poorly cemented, fossiliferous sand to clayey sand and fine-to-medium-grained, coarse-bedded sand. Fossil freshwater gastropods Lymnaidae *Stagnicola* and Planorboidea *Gyraulus* were collected from the upper clayey sands. Ostracodes from the same upper clayey sand are dominated by *Limnocythere ceriotuberosa* and *Fabaeformiscandona* cf. *caudata*, which are found in freshwater to mildly saline environments. Fossils were not found elsewhere.

The gastropods, *L. ceriotuberosa* and *F.* cf. *caudata* are all consistent with a fresh to mildly saline lake depositional setting, rather than a spring or groundwater discharge environment. We interpret these data to indicate that Deep Springs Valley contained a freshwater lake that reached 1646 m and, based on the maximum elevation of Soldier Pass, flowed into Eureka Valley during a cooler, wetter climate. Samples of gastropod shell submitted for radiocarbon dating are ongoing; this will generate an absolute date of when water was present at those depths. Financial support for this project was provided by the Louis Strokes Alliance for Minority Participation.

EVALUATION OF THE BIG PINE VOLCANIC FIELD CONTACT RELATIONSHIPS ALONG THE SIERRA NEVADA FRONTAL FAULT ZONE NORTH OF GOODALE CREEK IN OWENS VALLEY, CALIFORNIA

Student: Amanda Shellhorn

Faculty Advisor: Dr. Phil Armstrong

This study investigates the contact relationships between basalt flows and cones of the Quaternary Big Pine Volcanic field (BPV) and the predominantly granitic rocks of the eastern Sierra Nevada Mountains between Goodale and Taboose Creeks along the Sierra Nevada Frontal Fault Zone (SNFFZ). The SNFFZ marks the western boundary of the Basin and Range Province and separates the Sierra Nevada Mountains from Owens Valley. This zone is composed mostly of NNW-striking, east-dipping normal faults, which generally are assumed to dip 60°. However, previous work north of Bishop and farther south near Lone Pine and Independence has shown that the SNFFZ faults dip much shallower (26 to 52°). The BPV contact with the Sierra Nevada Mountains generally trends NNW and is parallel to the mountain front. The contact locally V's up and over ridges at the range front and along the SNFFZ and is consistent with an overall east dip. Our working hypotheses are that the contact formed by (1) basaltic flow deposition buttressed against the mountain front; (2) localized basalt emplacement and extrusion along the SNFFZ; and (3) faulting after emplacement of the basaltic rocks. Field and GPS mapping along the contact combined with Google Earth map analysis were used to test the hypotheses. Field mapping and plane-fitting along the contact yields an average dip of 33° E. This dip is similar to the dip of SNFFZ faults farther north and south suggesting that the contact may locally be a fault. A shallow SNFFZ dip affects long-term extension rate calculations and the kinematic history of this part of the western Basin and Range and Eastern California Shear Zone.

DETERMINING THE NATURE OF THE CONTACT BETWEEN THE EASTERN SIERRA NEVADA MOUNTAIN FRONT AND THE BIG PINE VOLCANIC FIELD SOUTH OF GOODALE CREEK IN OWENS VALLEY, CALIFORNIA

Student: Jazmine N. Titular

Faculty Advisor: Dr. Phil Armstrong

The Sierra Nevada Frontal Fault Zone (SNFFZ) located along the western boundary of Owens Valley is comprised of numerous Quaternary normal faults. These faults generally are assumed to dip 60° and long-term extension rates for Owens Valley are calculated assuming these steep dips. Recent studies conducted in the Independence and Lone Pine areas of Owens Valley and farther north in the Bishop area show shallow dips of 26-52°. These shallow dips affect long-term extension rate calculations and the kinematic history of Owens Valley. Quaternary Big Pine Volcanic Field (BPVF) basalt deposits that crop out along the mountain front offer an opportunity to evaluate potential SNFFZ fault orientations in this area. This study analyzes the contact between the mostly granitic rocks of the Sierra Nevada Mountains and the BPVF in the vicinity of Aberdeen from just south of Sawmill Creek and north to Goodale Creek. Working hypotheses for this contact include: (1) it is a depositional contact along the mountain front and (2) it is a fault contact. These hypotheses are tested by mapping the contact and surrounding rocks in detail. GPS locations of the contact were taken where the contact is clear. In general, the basalt-granite contact trends NNW, however north of Sawmill Creek the contact steps west consistent with the mountain front and the faults of the SNFFZ. Locally, especially south of Sawmill Creek, the basalt deposits are present on ridges with granitic basement in the intervening valleys so that the contact V's to show an eastward dip, consistent with east-dipping fault contact. Preliminary 3-point calculations along the contact suggest the contact dips about 25° E. In other areas the contact is diffuse with thin scoria deposits located uphill from the presumed location of the frontal fault. The mapping is being correlated to detailed Google Earth images to better define the relationships between basalt exposure and fault locations. Where the contact can be clearly defined, plane-fitting analysis using GPS- and Google Earth-derived x,y,z locations may refine potential fault orientations. This work will lead to a better understanding of the relationships between the BPV distribution and SNFFZ faults and may help constrain the SNFFZ orientation for kinematic analysis.

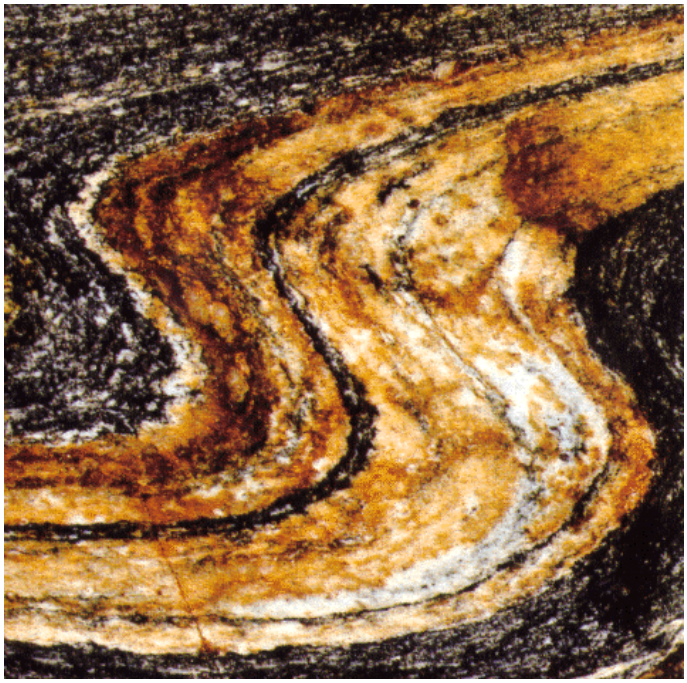
CARBON GEOCHEMISTRY OF MIOCENE-AGED CONCRETIONS OF THE CASTAIC FORMATION

Student: Bayne Westrick-Snapp

Faculty Advisor: Dr. Sean Loyd

The Castaic Formation of Ridge Basin, California consists of alternating marine mudstones and coarse-grained turbidite sandstones. Calcite concretions are common in the sandstones and vary in size, ranging from 30 cm to a few meters across. Total inorganic carbon (TIC) content and isotope ($\delta^{13}C$) data has been collected from five different concretions. $\delta^{13}C$ values from these concretions range from -4.54 to -14.82‰ (VPDB) and TIC range from 0.90 to 5.48 wt%. Of the five concretions sampled, four of them exhibit a positive correlation between $\delta^{13}C$ and TIC wt%. Most of the host mudstone samples (5 of 6) contained enough total organic carbon to yield isotope data, whereas the host sandstone (3 of 9 total host samples) did not. The organic $\delta^{13}C$ values of the mudstone range from -21.27 to -24.57‰ and TOC values ranges from 0.35 to 1.16 wt%. One of the five concretions (RCB1) exhibits a spatial trend in which the $\delta^{13}C$ values decrease, and TIC content increases, from top to bottom. Concretion C3-1 $\delta^{13}C$ values depict no spatial relationship between sample sites, with high variability spanning the range mentioned above. The negative $\delta^{13}C$ values of inorganic carbon suggest that a significant amount of carbon originated from the degradation of organic matter. A simple mass balance suggests that approximately 35 to 58% of concretion carbon is sourced from organic matter. This mass balance will be further constrained by collecting organic carbon $\delta^{13}C$ data from the concretion interiors. Ultimately, these data provide a better understanding of the diagenetic environment these concretions formed in, and in particular, allow characterization of the sources of carbon for concretion formation.

Graduate Proposal Category



OLIVINE-PLAGIOCLASE-PYROXENE CUMULATES ASSOCIATED WITH THE HORNBLENDE-RICH SUMMIT GABBRO: EARLY STAGES OF DIFFERENTIATION WITHIN THE LATE JURASSIC SIERRA NEVADA ARC.

Student: Kalie Duccini

Faculty Advisor: Dr. Diane Clemens-Knott

Geochemical analyses of rare olivine-bearing rocks associated with the ca. 150 Ma Summit gabbro are scrutinized with the goal of revealing initial differentiation trajectories of mafic magmas within the Late Jurassic Sierra Nevada arc. Small plutons of the hornblende-rich Summit gabbro are distributed across the Kern Plateau. This unit displays significant textural variation from pegmatitic to aphanitic-porphyritic textures, the latter suggestive of a transition to shallow emplacement levels. The Summit gabbro typically has a low Mg# (~50), and rarely contains pyroxene, let alone olivine. So while amongst the most mafic rocks exposed in the Sierra Nevada batholith, the Summit Gabbro is not a primitive, mantle-derived magma. Hornblende-bearing anorthosite adcumulates associated with the Summit gabbro contain interlocking, zoned plagioclase having euhedral, calcic cores. Meso- to orthocumulates contain cumulate olivine, orthopyroxene and plagioclase with up to ~35% intercumulus, poikiolitic hornblende. In some cumulates, multi-shell coronas separate adjacent olivine and plagioclase crystals: a talc-oxide assemblage surrounds or completely replaces the olivine; an amphibole-spinel symplectite shell abuts the plagioclase; and an intervening orthopyroxene shell is commonly replaced by amphibole. We interpret the corona textures as having formed by solid-state recrystallization during decompression of olivine-plagioclase autoliths or xenoliths, carried upwards from the deep crust by pulses of the Summit gabbro. The possibility that Summit gabbro magmas traversed the deep arc crust is supported by mantle-like, high-Mg# (~96.5, n=3) olivine compositions found in a single olivine-porphyritic dike. In contrast, we hypothesize that corona-free, olivine-bearing gabbros completed crystallization in the upper crust and represent relatively undifferentiated samples of mantle-derived magma. Geochemical compositions of cumulate rocks and mineral phases will be used to characterize the olivine-plagioclase-pyroxene cumulates and evaluate their origin in the context of the Summit gabbro. Future analysis of olivine-plagioclase-pyroxene-bearing cumulates will be aimed at attempting to characterize the mantle source region of this part of the Sierra Nevada arc.

GEOCHEMISTRY OF PHOSPHATIC-SHALES AND ASSOCIATED AUTHIGENIC MINERALS OF THE MIOCENE MONTEREY FORMATION: IMPLICATIONS FOR PARAGENETIC EVOLUTION

Student: Antonio Sandoval

Faculty Advisor: Dr. Sean Loyd

Phosphorous is an essential nutrient that can limit marine primary productivity and by association the amount of atmospheric CO_2 that is converted into organic matter. During early diagenesis, remineralization of organic-matter leads to the liberation of phosphorous and subsequent formation of phosphorus-rich minerals (e.g., carbonate—fluorapatite (CFA)). Microbes facilitate marine sedimentary organic matter degradation and utilize oxygen, nitrate, iron (III) and sulfate as electron acceptors. The authigenesis of CFA tends to occur in suboxic-anoxic sediments, generally experiencing sulfate reduction. Likewise, authigenic carbonate concretions result from sulfate reduction and other anaerobic organic matter degradation processes.

The Miocene Monterey Formation is a petroleum source and reservoir rock in California that was deposited in several Neogene basins during the tectonically-active Middle Miocene. The middle carbonaceous marl member of the Monterey Formation contains intervals of phosphatic-shale with total organic carbon (TOC) values between 1.2 and 23.2 wt.% and exhibits variable dolomite cementation as concretions and cemented layers. This study will characterize the conditions that led to the precipitation of CFA and dolomite that occur in close stratigraphic/lateral proximity. Analyses will include concentrations of CFA-associated sulfate, carbonate-associated sulfate (CAS) and their $\delta^{34}S$ values. Additionally, the concentration of inorganic/organic carbon and associated $\delta^{13}C$ values have been determined for CFA, dolomite concretions and the host shale, which will allow for a better characterization of the diagenetic environment of precipitation. This study provides a better understanding of the processes that lead to the mineralization within organic-rich sedimentary packages, as well as the specific paragenetic evolution of the Monterey Formation.

USING THECAMOEBIANS TO RECONSTRUCT 1300 YEARS OF LIMNOLOGICAL CHANGE AT CRYSTAL LAKE, CA

Student: Emily Silveira

Faculty Adviser: Dr. Matthew Kirby

Thecamoebians are microscopic unicellar organisms that live in freshwater lakes and produce tests—or shells—that are morphologically distinct to each species. The population distribution of thecamoebian species within a lake can reveal such lake dynamics as trophic status, temperature, and acidity. Crystal Lake is a small alpine lake located in the San Gabriel Mountains. The goal of this thesis is to establish a record of paleolimnological change throughout the past 1300 years in Crystal Lake using thecamoebian assemblages, and then determine if there is a relationship between these changes and known paleoclimatological changes. Thecamoebian assemblages will be analyzed throughout a core from Crystal Lake, California by collecting at least 300 tests in samples from every other centimeter of the core. Statistical analysis will be performed to determine any patterns within the assemblages. Thecamoebians are an up-and-coming proxy in paleolimnological research, and this thesis will represent the first work completed in southern California. We expect to find a clear relationship between species distribution and paleolimnological change; as well as, a distinct relationship between the paleolimnological changes and known paleoclimatological events, such as the Medieval Climate Anomaly and the Little Ice Age.

CARBONATE GEOCHEMISTRY OF MARINE AUTHIGENIC CARBONATES AND HOST SEDIMENTS: EXPLORING MINERAL FORMATION PATHWAYS AND ORGANIC PRESERVATION POTENTIAL IN MODERN SEDIMENTS

Student: Smirnoff, M. N.

Faculty Advisor: Dr. Sean Loyd

Ancient authigenic dolomites have been long studied in order to determine formation conditions and provide insight into shallow diagenetic environments. The formation of these dolomites is commonly attributed to microbial methanogenesis, based on carbon isotope data. Similar authigenic dolomites commonly occur in modern sediments rich in organic matter, however detailed petrographic and geochemical characterizations of these precipitates have yet to be conducted. The study of these modern, “still soft” sediments can reveal 1) the relationships between organic carbon degradation and authigenesis and 2) the potential of cementation to preserve organic matter during subsequent burial. The formation of authigenic carbonates is known to be aided by the degradation of organic matter. As organic matter decomposes in anaerobic environments, alkalinity can increase, promoting carbonate mineral precipitation. However, mineralization encases primary sedimentary components and may act to preserve organic matter from subsequent degradation due to the reduction in permeability resulting from cementation. Authigenic carbonates have been found to preserve macro and micro fossils, metastable sedimentary grains, magnetic minerals, sedimentary structures, and various specific organic compounds including fatty acids. However, a similar protective relationship has not been demonstrated for disseminated, bulk organic matter, particularly in still-soft sediments.

Graduate Thesis Category

SALT MARSH EVOLUTION ALONG AN ACTIVE FAULT ZONE: UNDERSTANDING MARSH RESPONSE AND RECOVERY TO RAPID CHANGES IN SEA LEVEL DUE TO COSEISMIC SUBSIDENCE

Student: Angela Aranda

Faculty Advisor: Dr. Joseph Carlin

Less than 10% of California's salt marshes are located in southern California, and these represent only a fraction of the historical marsh area that was lost to urbanization in the region. The tectonic nature of the region adds additional stress for marshes situated near active fault zones, which may be susceptible to rapid changes in elevation, e.g. coseismic subsidence, during an earthquake. While marshes globally are under increasing stress from sea level rise (SLR), a better understanding of how southern California marshes respond to and recover from rapid relative SLR caused by coseismic subsidence may help to better understand the future sustainability of marshes in this region and others. The purpose of this study was to quantify marsh recovery following coseismic subsidence to better understand marsh resiliency from rapid SLR. The study area was the Seal Beach Wetlands (SBW), a marsh that straddles the Newport-Inglewood Fault Zone. A sediment core from the SBW was analyzed using sedimentary, geochemical, and biogeochemical analyses, including: magnetic susceptibility (MS), grain size, loss-on-ignition (LOI), lignin biomarkers, $\delta^{13}C$, and C:N ratios. Sedimentary age constraints were determined throughout the core from ^{14}C and ^{137}Cs geochronology. From these analyses, we identified five potential coseismic events that occurred over the past ~2600 years. All sedimentary contacts interpreted as events showed a decrease in organic matter and a shift from marsh indicators to non-marsh indicators across the contact, while some contacts also showed increases in sand and MS. These contacts were thus interpreted as a facies shift from a marsh environment to a mudflat or subtidal environment indicating rapid subsidence. After an event occurred, we observed steady marsh recovery as the resulting facies succession reflected typical marsh accretion patterns. The inferred amount of subsidence was relatively small ~15-30 cm (minimum estimates) within the tidal range for the marsh and the data suggested that this area of the marsh made a full recovery following each event. During this recovery period, the data also suggested that the marsh consistently accreted at a rate comparable to relative SLR. The result of this study suggested when subsidence is less than the tidal range, marsh recovery will follow sea level rise with the likelihood of the marsh making a full recovery determined by the amount of subsidence and the frequency of events. This study highlights the resiliency of marshes in response to rapid changes in sea level, provided time and sediment availability.

SULFATE-DEPENDENT ANAEROBIC OXIDATION OF METHANE AS A GENERATION MECHANISM FOR CALCITE CAP ROCK FORMATION IN GULF COAST SALT DOMES

Student: Kylie Caesar

Faculty Advisor: Dr. Sean Loyd

Gulf Coast salt domes and their cap rocks are associated with significant reserves of crude oil and natural gas. Whereas the specific reactions that facilitate the precipitation of cap rocks are still largely unknown, cap rock geochemistry provides insight into mineralization mechanism(s). Gulf Coast cap rocks contain carbonate and sulfur minerals that exhibit variable carbon ($\delta^{13}C$) and sulfur isotope ($\delta^{34}S$) signatures. Calcite $\delta^{13}C$ values are isotopically depleted and show a large range of values from –52 to –1‰, reflecting a mixture of various carbon sources including a substantial methane component. Low carbon isotope compositions combined with the presence of abundant sulfide minerals in cap rocks have led to interpretations that invoke microbial sulfate reduction as an important carbonate mineral-yielding process. Sulfur isotope data from carbonate-associated sulfate (CAS: trace sulfate incorporated within the carbonate mineral crystal lattice) provide a more direct proxy for aqueous sulfate in salt dome systems and a means to directly fingerprint sulfate reduction. We find CAS sulfur isotope compositions ($\delta^{34}S_{CAS}$) significantly higher than those of the precursor Jurassic sulfate-salt deposits (which exhibit $\delta^{34}S$ values of ~ +15‰ and presumably record the coeval seawater). This relationship implies that cap rock carbonate generation occurred via microbial sulfate reduction under closed-system conditions. The co-occurrence of low carbonate $\delta^{13}C$ values (< ~ –30‰) and high $\delta^{34}S_{CAS}$ values are evidence for sulfate-dependent anaerobic oxidation of methane (AOM). Our results suggest that AOM, which has been shown to yield extensive seafloor authigenic carbonate, was at least partially responsible for the precipitation of Gulf Coast calcite cap rocks. AOM yields economically important sulfur and carbonate minerals and consumes methane, thereby decreasing energy resource reserves and potentially greenhouse gas emissions. Collectively, these data shed new light on a potential hotspot of economic and environmentally advantageous microbial activity in the deep biosphere.

U-Pb DETRITAL ZIRCON COMPARSION OF WESTERN SIERRA NEVADA METAMORPHIC PENDANTS WITH THE GOLCONDA ALLOCHTHON: IMPLICATIONS FOR THE PRE-MESOZOIC ASSEMBLY OF CENTRAL CALIFORNIA

Student: Nancy Chen

Faculty Advisor: Dr. Diane Clemens-Knott

Uranium-lead geochronologic analysis of detrital zircon is employed to reveal the identity of metasedimentary pendants forming the western framework of the Sierra Nevada batholith with the goal of reconstructing the pre-Mesozoic crustal structure. The SCICON pendant (near Springville, CA) is composed of amphibolite facies calc-silicate rocks, quartz amphibolite, quartzite, and lesser marble, whereas phyllite, schist, and marble comprise the South Fork pendant (SW Sequoia N.P.). Despite polymetamorphic recrystallization and isoclinal folding, crinoid fossils are preserved in the SCICON pendant. After excluding high U/Th Mesozoic metamorphic grains, zircon from the SCICON-South Fork pendants define large 1.7-1.8 Ga and 2.4-2.5 Ga age peaks, whereas the neighboring Sequoia and Slate Mountain pendants exhibit large 1.0-1.1 Ga, moderate 1.4 Ga, and small 1.7-1.8 Ga age peaks. Detrital zircon ages, rock types and fossil data support correlation of these two pendant groups with post-early Cambrian passive margin strata and with Neoproterozoic-early Cambrian passive margin strata, respectively. Previous statistical analysis, using two published detrital zircon samples (n~20, 21), suggested a strong correlation between the SCICON pendant and Mississippian marine sediments of the Golconda allochthon (GA). Three large grain (n~114-303) detrital zircon samples of the Schoonover Sequence (north-central Nevada) were analyzed to test whether the western Sierra Nevada pendants were offset equivalents of the Golconda allochthon. Though the preliminary hypothesis is not supported by the expanded detrital zircon database, the new data provides insight regarding the provenance of quartz-rich and volcanic lithic strata of the Schoonover Sequence. Specifically, a narrow and robust (n=63) 354.2 ± 1.2 Ma age peak provides an Early Mississippian maximum age (Tournaisian) for deposition of the lower Schoonover Sequence, confirming previous age constraints provided by radiolaria. These new detrital zircon U-Pb data will be used to evaluate whether the Schoonover Sequence could have been derived by erosion of the Antler orogenic highlands, or whether additional, extra-regional sources are required.

DESCRIPTION OF THE LATE UINTAN TALEGA BONEBED FROM ORANGE COUNTY, CALIFORNIA

Student: Gabriel Santos

Faculty Advisor: Dr. James Parham

Eocene terrestrial vertebrates from Southern California are known from Ventura, San Diego, and Orange Counties. Relative to the other two counties, the sites and specimens from Orange County are poorly known. Paleontology mitigation monitoring of the Talega Housing Development in San Clemente, Orange County, California in 1998 excavated a vertebrate bonebed from the Eocene-aged Santiago Formation. The bonebed, named the Talega Bonebed, represents just the second description of an Orange County locality to produce Eocene terrestrial vertebrates. The bonebed was excavated as 46 cubic meter blocks, five of which have been prepared using standard techniques and heavy liquid separation. The bonebed is approximately 10 cm thick and comprised of densely deposited, disarticulated skeletal elements with no obvious associations. Sparsely distributed fossils can be found in the overlying layer. Sedimentologically, the Talega Bonebed matrix comprises a compositionally immature, orange-tan, muddy, very fine to coarse-grained sandstone. Fossils prepared from the bonebed exhibit varying degrees of weathering with denser skeletal elements, such as vertebrae, astragali, mandibles, and isolated teeth exhibiting better preservation. The Talega Bonebed is a highly productive fossil locality with 22 taxa identified to date. The more common macrofossil taxa identified from the bonebed are typical of the late Uintan fauna from Southern California, including brontotheres, amynodonts, crocodilians, and small artiodactyls, such as *Leptoreodon* and *Protylopus*. Other less common macrofossil specimens include tapiroids, turtles, miacids, and mesonychids. The Talega Bonebed can be classified as a high diversity, multitaxic, and multidominant fossil accumulation. Based on the mostly poor state of fossil preservation, spatial density, and high diversity of taxa, it is likely the formation of the Talega Bonebed can be attributed to hydraulic concentration in which skeletal elements from multiple sources accumulated overtime in a fluvial environment. The high density of fossils within the bonebed may suggest that sediment input was low during deposition of the Talega Bonebed and categorizes it as a time-averaged, attritional accumulation. Comparison of the Talega Bonebed assemblage with assemblages from contemporaneous strata in Ventura and San Diego Counties show that the identified taxa are typical of the Southern California late Uintan fauna. The absence of taxa known from either Ventura or San Diego Counties in the Talega Bonebed is likely due to taphonomic and collecting biases. The similarities among fossil assemblages in all three counties suggest that the paleoenvironment was similar across Southern California during the late Uintan.

SIGNIFICANCE OF THE COMPOSITIONAL HETEROGENEITY IN THE KUNA CREST UNIT OF THE EASTERN MARGIN OF THE TUOLUMNE INTRUSIVE COMPLEX, SIERRA NEVADA, CA

Student: Dustin Williams

Faculty Advisor: Dr. Vali Memeti

Understanding the emplacement and evolution of large and long-lived plutons in the middle crust is essential in comprehending igneous crustal growth, how arcs operate and are physically and compositionally connected to the source and volcano. One challenge is that the plutonic rock record seldom preserves the initial stages of pluton growth, which is often overprinted by subsequent magmatism. The initial stages of growth, however, may give us clues on the size and compositions of the first intruding magma batches and if or when they coalesce to form interconnected magma mush bodies.

Early stages of pluton growth are preserved in the 95-93 Kuna Crest margin located in the southeast lobe of the 95-85 Ma, 1,100 km^2, normal zoned Tuolumne Intrusive complex (TIC) in the central Sierra Nevada batholith. The Kuna Crest is composed of cm- to m-scale sheets at the margins to ≤ km-scale, irregular bodies toward the interior of the lobe. Compositions range from fine- to medium-grained granodiorite, medium- to coarse-grained tonalite, diorite, and gabbro with knife sharp to gradational contacts. Color index ranges from 10% to 32%.

To determine the significance of intra-unit mineralogical and geochemical variation observed in the field, we conducted detailed petrographic and whole rock and mineral-scale geochemical analysis. Petrographic analysis reveals varying mineral abundances and textural variation across subunits, indicating different histories, some containing sparse cpx-hbl-bio-oxide glomerocrysts. Whole rock element chemistry across units and REE element patterns of hornblende cannot be explained by fractional crystallization and suggest only intra-unit differentiation of compositionally diverse and isolated magmas. Sr and Nd isotopes from the Kuna Crest lobe, however, show all magmas originated from a homogenous and rather primitive source. Isotope data from the sheeted margin will reveal how much homogeneity is preserved there. This may help resolve if magma amalgamation and homogenization occurs at emplacement levels.

Our preliminary conclusion is that each Kuna Crest sub-unit from single centimeter to 100s of meter large sheets may represent increments of magma that intruded into the emplacement level and were preserved at the cooler margins of the TIC. In the interior of the lobe individual increments grew to larger interconnected magma mush regions represented by the lobe units while still maintaining their compositional heterogeneity and undergoing varying degrees of intra-unit fractionation.

Research Category

REPEAT PHOTOGRAPHY AND SECONDARY SUCCESSION: BALLARAT, CA

Student: Shayna Avila

Faculty Advisors: Dr. Darren Sandquist and Dr. Jeffrey Knott

Ballarat, CA, is a ghost town located at the base of the Panamint Mountains in Death Valley National Park. The city was founded in 1896, as a mining town with a post office and numerous buildings. Most operations stopped in 1917. Repeat photography is used to view geological, and ecological changes over time. Repeat photography can be used to document plant population changes. Desert environments are one of the best areas because of the uninterrupted vistas. We found one undated photograph of Ballarat and used background topography, geologic features and repositioned people to replicate the historical photograph. The tripod position was recorded and photographed. The time, date, weather conditions, and plant types were recorded. The original view is to the northeast. The shadows extend to the south and east indicating that the photograph was taken when the sun was to the north and west or during a spring/summer afternoon. There are no plants visible in the scene. The repeat photo was taken on January 8, 2016 (winter) at 3:00PM, on a clear day with few clouds. The only remains of the buildings are foundation remnants. Plants visible where the buildings originally were include salt bush (*Atriplex canescens canescens*), iodine bush (*Allenrolfea occidentalis*), and creosote bush (*Larrea tridentata*). Our observations show that secondary plant succession at Ballarat over the last 99-116 years is dominated by salt bush. Geologically, there is no evidence of erosion.

Department of Geological Sciences
2016 Alumni of the Year
Anna Garcia

About Anna

Anna is a terrific example of a life-long geology student. She is a frequent attendee at professional meetings and workshops. She is an annual attendee and frequent presenter at the Desert Symposium held at the CSUF Desert Studies Center at Zzyzx.

She is also secretary of the newly formed High Desert Mineralogical Society along with a number of other professional organizations. Anna frequently participates in programs at the K-12 level promoting math and science to women's and Hispanic groups.

Her frequent visits to the geology department results in interaction with, and encouragement of, undergraduate students. Anna has also indirectly benefitted students by her consistent, generous donations to the Department over the last 20 years.

Simply put, Anna Garcia is a role model for all CSUF students and is deserving of the Geological Sciences Alumni of the Year Award.

Your professional accomplishments and personal commitment to the CSUF Department of Geological Sciences, is a testament to the CSUF community and to the value of a CSUF education.

GEOLOGY STUDENT AWARDS/SCHOLARSHIPS
April 2016

Outstanding Major Award – B.S. in Geology ***Amanda Shellhorn***
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 ***Rachel Mills-Coyne***
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 ***Anthony Mistretta***
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 ***Stephanie Swanson***
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 ***Jazmine Titular***
Given to the student who has made a significant contribution to the mission, operation and/or wellbeing 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 ***Lisa Battig***
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 Award ***Megan Murphy***
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***

Marilyn A. Brown Award ***Gabe Santos***
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***

David L. Willoughby Scholarship ***Isaac Magallanes***
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 ***Evelyn Gutierrez***
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 Field Camp Scholarship ***Emma Griffie***
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)

Thank you for your donations!

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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Throughout the years, we have been asked by many "Does my donation really make a difference?" Without hesitation, our answer is "Yes!" Without these donations, several of our accounts would not have become endowed. Three of our funds are now endowed at or greater than $25,000.

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

A Special thanks to the South Coast Geological Society for the support and Dr. W. Richard Laton for all his hard work in making Research Day possible!

Geology Research Day 2016

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