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*'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!*

2<sup>nd</sup> Annual Geology Research Day  
California State University, Fullerton ~ Department of Geological Sciences  
*Titan Student Union Garden Café*  
May 20, 2011

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## ***Undergraduate Proposal Category***

### **Petrography of Quaternary Lava Flows Erupted from Near Mammoth Mountain: Insights into Potential Volcanic Hazards Associated with Future Effusive Eruptions**

Blair Davidson

Faculty Advisor: Professor Brandon Browne

Mammoth Mountain is a stratovolcano located in eastern California that is considered by the US Geological Survey to be “active” despite the absence of an eruption for ~50,000 years based on the occurrence of frequent seismicity and profuse degassing of carbon dioxide in the area. Because scientists interpret ongoing seismicity and degassing as the result of migrating basaltic magma at depth, research aimed at understanding the consequences of a basaltic eruption from Mammoth Mountain in the future is needed. This study examines two ~100ka voluminous basaltic lava flows that erupted from Mammoth Mountain, and assesses the hazards of similar lava flows if they were to erupt from vents atop the Mammoth Mountain edifice. The area of study is located along the southwest rim of the Long Valley Caldera, near Mammoth Mountain, and the outreaches of where this basalt (Qpb) flowed. It is proposed that this flow emanated from one of the mafic vents connected to the Mammoth Mountain system. Currently, the projected dates of this study are to occur between July 2011 and May 2012. Field work will begin in July of 2011, with collecting samples from each area of the Qpb flow. These samples will be analyzed in the Fall 2011 semester, with the outcome being the whole rock geochemistry, mineral abundances, and the eruptive temperatures. In the Spring 2012 semester, this information will be used to generate a flow propagation map with the geohazard program FLOWGO. From each vent, it will be calculated where the flow would travel, and if the town of Mammoth Lakes is at risk of a volcanic disaster.

### **Last Glacial Maximum Paleoclimate Reconstruction Using Sediments from Lake Elsinore, California**

Christine Hiner

Faculty Advisor: Professor Matthew Kirby

This study will use a sediment core from the deepest portion of Lake Elsinore, located in Riverside County, California, in order to reconstruct the climate of the Last Glacial Maximum (LGM), approximately 18,000 to 22,000 calendar years before present (cy BP). Research on the past climate of southern California is significant because of the perpetual water crisis the over-populated region faces. In order to understand future limitations on water resources, it is essential to understand prior climatic cycles of southern California. Lake Elsinore is significant in understanding prior climatic cycles because it is one of the few natural, permanent lakes in southern California with sediments that faithfully record changes in precipitation amount (Kirby et al., 2010). Perhaps most significant is the fact Lake Elsinore is the only known high-resolution, continuous, terrestrial record of the LGM in the region. Through reconstructing the first terrestrial LGM record from southern California, this study seeks to identify what climatic forcings (e.g. sea surface temperature) explains this record as well as how the new Lake Elsinore results compare to existing data, especially from the north Pacific Ocean? The Elsinore LGM reconstruction will be accomplished using a series of sediment analyses including: splitting and visually describing the cores, magnetic susceptibility, LOI 550°C and 950°C, and grain size analysis. Radiocarbon dating of discrete organic matter will serve as the age control. It is hypothesized that the Last Glacial Maximum terrestrial climate in southern California was relatively stable and characterized by a deep, permanent lake.

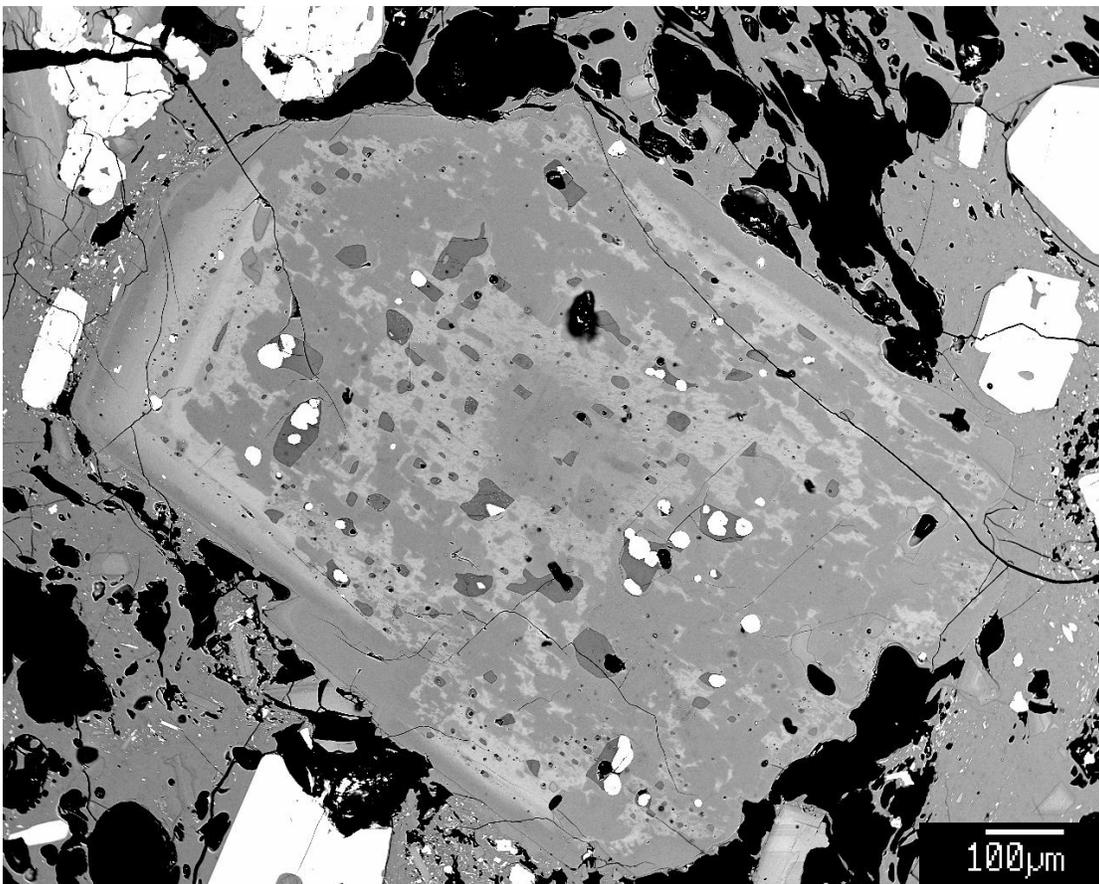
*Kirby, M.E., Lund, S.P., Patterson, W.P., Anderson, M.A., Bird, B.W., Ivanovici, L., Monarrez, P., Nielson, S., 2010, A Holocene record of Pacific Decadal Oscillation (PDO) - related hydrologic variability in Southern California (Lake Elsinore, CA): Journal of Paleolimnology, v. 44, p. 819-839.*

## Volatile Budget of Basaltic Involved in 2006 Eruption of Augustine Volcano (Alaska) Recorded by Plagioclase-Hosted Melt Inclusions

Laurel Morrow

Faculty Advisor: Professor Brandon Browne

This study will determine volatile concentrations of melt inclusions trapped by plagioclase crystals contained in andesite lava samples erupted from Augustine Volcano in 2006. Augustine Volcano is an andesitic-dacitic stratocone located in the eastern Aleutian Islands, situated in southwestern Cook Inlet. Volatile concentrations of melt inclusions will be analyzed via electron microprobe and calculated by the water-by-difference method. Results will be used to compare pre-eruptive storage depth with similar estimates based on geophysical methods, such as volcano seismology and geodesy. Melt inclusions chosen for this study will be those with completely sealed rims, without any sign of smearing during crystal breakage to ensure their chemical information is intact. One hypothesis for this study is that all melt inclusions will record a similar depth, suggesting one common source for magma accumulation and storage prior to the 2006 eruption. In contrast, melt inclusion data may be highly variable, suggesting a complex and irregular plumbing system.



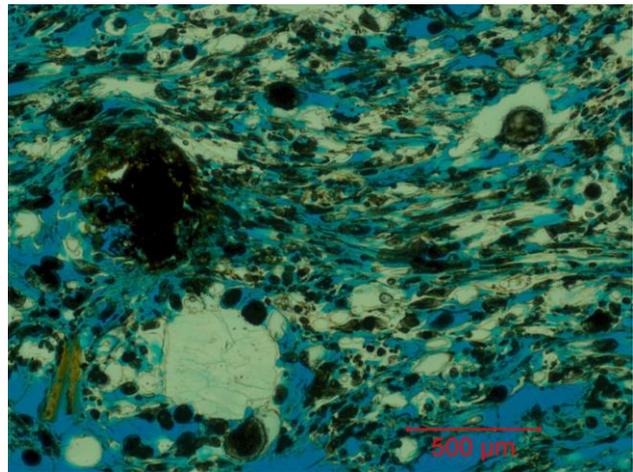
Back-scattered electron image of plagioclase hosting melt inclusions from andesite erupted in 2006 from Augustine Volcano, Alaska

# Petrology of ~90ka Rhyolite Deposited During Mammoth Mountain's (Only?) Plinian Eruption, Sierra Nevada

Zackary Newman

Faculty Advisor: Professor Brandon Browne

Mammoth Mountain is a stratovolcano located in eastern California that was constructed over the past 111ka largely by effusive eruptions of dacite and trachydacite lava flows and domes with textures indicative of mingling between basalt and dacite. Geologic mapping coupled with geochronological studies indicate that more than 50% of the Mammoth Mountain edifice formed between 67-57ka (Ring, 2000). One exception to this quiescent volcanic eruption exists, however, in the form of a voluminous rhyolite pumice fall deposit exposed on Mammoth Mountain's east flank. This deposit formed as a result of a violent and highly explosive volcanic eruption approximately 90,000 years ago. What is the significance of this unusually explosive episode in Mammoth's past? The goals of this study are to learn more about the rhyolite's (1) mineralogy and composition, (2) pre-eruptive storage conditions in terms of pressure and temperature, and (3) eruption dynamics responsible for such a violent eruption. Addressing these issues will allow me to evaluate a hypothesis that before Mammoth Mountain's 67-57ka 'flare-up' the magma chamber fueling eruptions rarely experienced magma mingling and thus was afforded a longer time period for magmas to crystallize and exsolve volatiles, which possibly resulted in a highly explosive eruption following a second boiling event. The approach that will be used to address this hypothesis will first involve detailed sampling (e.g., every 5 centimeters) of pumice fragments from the pumice fall stratigraphy followed by whole-rock analysis and thin section production. Whole-rock analysis will be used to determine if this eruption tapped a compositionally zoned magma chamber compared to thin sections, which will be used to characterize the mineralogy and textures of the rhyolite. Thin sections will also be used in electron microprobe analysis of minerals (e.g., quartz, plagioclase, sanidine, biotite, magnetite, ilmenite) and glass, which will be very useful for regional tephrochronology studies aimed at correlating different tephras in the Sierra Nevada's. Density measurements of pumice fragments from different stratigraphic heights will be performed to determine if the magma fragmentation process changed as the eruption progressed.



Left, outcrop of Plinian pumice fall deposit in road cut on Highway 203 near Mammoth Lakes; right, photomicrograph of rhyolite pumice fragment in plane light with epoxy dyed blue for distinction against glass.

## **Palaeocurrents and Provenance of the Mae Rim Formation, Chiang Mai Basin, Northern Thailand**

Dalin Nguyen

Faculty Advisor: Professor Brady Rhodes

The Mae Rim Formation (MRF) consists of fluvial sandstone and conglomerate that was shed off the rising Western Ranges Metamorphic Complex (WRMC) and its tectonic cover of low-grade metamorphic rocks of the Shan Thai terrane. Previous published data on the palaeogeography of the MRF, including palaeocurrent and provenance data, have been limited because of poor exposures and heavy weathering. In this project, I propose to collect palaeocurrent and provenance data from the new and numerous road cuts on the campus of Chiang Mai Rajabhat University, Northern Thailand. Knowing if the MRF newly exposed in the Rajabhat road cuts consists of clasts from the Shan Thai terrane, or rocks from the WRMC will constrain the timing of deposition compared to exhumation of the Western Ranges. To better understand the palaeogeography of the Rajabhat MRF, we also need to know the depositional flow direction. I hypothesize that the Rajabhat MRF will contain clasts exclusively from the Shan Thai terrane, and the palaeocurrent will have flowed from NE to SE off the rising Western Ranges. To test this hypothesis, I will: 1) describe the MRF exposed in these road cuts and measure its orientation, and the orientation of any cross-cutting faults; 2) measure the orientation of imbricate cobbles in MRF conglomerate for palaeocurrent analysis; 3) count a statistically large number of clasts in the MRF to determine the distribution of lithologies represented; 4) determine palaeocurrent directions by plotting rose diagrams of clast orientations; 5) determine the provenance by plotting pie charts of clast compositions, and matching them to lithologies exposed in the Western Ranges. The results of this study will help confirm the palaeogeographic setting and timing of the deposition of the MRF relative to the WRMC's exhumation.

## **Applications of the (U-Th)/He Thermochronology in the Western Ranges of Thailand**

Adam Piestrzeniewicz

Faculty Advisor: Professor Brady Rhodes

The Western Ranges Metamorphic Complex (WRMC), located in northwestern Thailand adjacent to the Chiang Mai Basin, is the result of deformation influenced by the collision of the Indian Plate into the Eurasian Plate. The WRMC is bound by two major low-angle-faults. Controversy surrounds the debate regarding the relationship of these two faults to one another and the uplift of the WRMC. In order to understand the deformational history, it is crucial to investigate the history of faulting and resulting uplift and exhumation of these mountains. The Mae Rim Formation (MRF), located at the eastern base of the WRMC and within the Tertiary Chiang Mai Basin, contains conglomerate and sandstone compiled from clasts exhumed from the WRMC. Apatite crystals will be separated from samples collected from the MRF and dated by (U-Th)/He thermochronology in order to determine whether or not the MRF had been buried to depths and corresponding temperatures that reset the (U-Th)/He system of the apatite. I hypothesize that burial was minimal and that the ages of the apatite (U-Th)/He dates from the MRF will be consistent with apatite U-Th/He dates that will be calculated by B. Schepmann and existing zircon fission-track ages from the high-grade metamorphic rocks of the WRMC. The analysis of these data will help better constrain the rate and timing of the uplift of the WRMC. My data, when compared to future thermochronology of low-grade metamorphic rocks that overlie the WRMC, will confine the ages of the two low-angle faults that bind the WRMC.

## **Apatite (U-Th)/He Thermochronology of the Western Ranges Metamorphic Complex, Northern Thailand**

Brent Scheppmann

Faculty Advisor: Professor Brady Rhodes

The Western Ranges parallel the border between Burma and Northern Thailand adjacent to the Chiang Mai basin. The Western Ranges Metamorphic Complex (WRMC) is composed of high-grade metamorphic and granitic rocks of the Doi Suthep and Doi Inthanon core complexes. Two major low-angle faults bound the WRMC but their contribution to the deformational history and exhumation of this region is controversial. I propose studying the (U-Th)/He thermochronology of the WRMC in order to constrain the exhumation rates of the Western Ranges. This will be accomplished by collecting samples from the WRMC and calculating cooling ages for apatite grains contained in the samples using the (U-Th)/He system. The ages will be compared with existing fission track ages from the WRMC to evaluate the uplift age. If the fission track and He ages are similar, these data will support my hypothesis that exhumation of the Western Ranges was rapid. The data from this study will also be compared to future He dates from low-grade metamorphic rocks that overlie the WRMC along one of the low-angle faults. Such a comparison should resolve the controversy that surrounds these faults. My data will provide the first step toward a better understanding of the timing, rates, and mechanisms of uplift of the Western Ranges.

### ***Undergraduate Thesis Category***

## **Clinopyroxene Geothermobarometry of Quaternary basalt erupted from Little Whitney Cone, Sierra Nevada**

Colin Campbell

Faculty Advisor: Professor Brandon Browne

Little Whitney Cone (LWC) is a 743,000 year old basaltic scoria cone located in the south central Sierra Nevada mountains in California. It is the oldest cone of the Golden Trout Volcanic Field, which includes two other basaltic vents and four basaltic to basaltic-andesite lava flows. Previous work by Wille and Browne (2008) indicate that LWC is a 120-m-high pile of loose scoria ( $6.4 \times 10^5$  m<sup>3</sup> dense rock equivalent) characterized by 5 vol% phenocrysts with two lava flows that extend away from its eastern and southern flanks and flow towards the south. LWC lava flows also possess spectacular columnar joints measuring up to 3 meters in diameter and up to 10 m in height along the eastern lava flow indicating that it likely encountered thick glacial ice during emplacement. This study utilized clinopyroxene thermobarometry of CPX cores to reconstruct the depth of crystal nucleation and growth from a magma that subsequently ascended to feed the eruption of Little Whitney Cone. Results from this study indicate that clinopyroxene crystals nucleated at a pressures ranging from 7.4-18.8 kbar, with a mean pressure of 10.5 kbar (~35 km depth assuming an average crustal density of 3.5 gm/cm<sup>3</sup>). CPX cores also record temperatures ranging from 1150-1326°C, with a mean temperature of 1195°C. Calculated depths correlate with the determined depth of the moho at that location, suggesting that this discontinuity may serve as the place where mantle-derived melts originally form, accumulate and begin to crystallize prior to rising through the crust and erupting at the surface.

## **Rate and timing of exhumation in the syntaxial core of the western Chugach Mountains, southern Alaska**

Sean Hartman

Faculty Advisor: Professor Phillip Armstrong

NNW shallow subduction of the Yakutat microplate is focusing rock uplift and exhumation in the syntaxial core of the western Chugach Mountains, an oroclinal segment of the Southern Alaska Block. These mountains are principally comprised of the Late Cretaceous Valdez Group, a flysch sequence accreted by Paleogene subduction of the Farallon and Kula Plates beneath the North American Plate. The Chugach Mountains are generally bound by the Border Ranges Fault system to the north and the Contact Fault to the south. Apatite fission-track and He ages decrease southward across the Border Ranges Fault and northward across the Contact fault, and generally decrease southward across the Chugach terrane and into the syntaxial core. Apatite (U-Th)/He thermochronology was used to determine the Late Cenozoic thermal histories of five Late Cretaceous Valdez Group sandstones and one felsic dike to infer spatial exhumation patterns. Using simple closure-temperature methods, these low-temperature ages allow assessment of exhumation rate patterns across the actively uplifting accretionary prism. Ages along a NNW transect from Harvard Glacier to west of Mt. Sergeant Robinson range from  $6.6 \pm 0.9$  to  $10.8 \pm 1.6$  Ma. Ages along an ENE transect from Inner Lake George to west of Mt. Marcus Baker range from  $4.7 \pm 0.9$  to  $7.6 \pm 1.4$  Ma. These ages fit well with a previously modeled isochron map that shows a crescent-shaped pattern of inward-decreasing thermochronologic ages. Inferred exhumation rates along the NNW transect range from 0.3 to 0.4 km/Ma, and along the ENE transect from 0.3 to 0.5 km/Ma. This distribution of ages and rates suggests that exhumation is kinematically focused in the syntaxis of the accreted prism, where glaciation is inferred to be the primary agent of erosion.

## **Measuring debris-flow timing in watersheds burned during the 2009 Station Fire: Implications for residential evacuations and early warning**

Robert Leeper

Faculty Advisors: Professor Brady Rhodes (CSUF) and Dr. Jason Kean (US Geological Survey)

Data on the timing of post-fire debris flows is rare and mostly limited to eyewitness accounts. We have developed a relatively low-cost method to measure the timing of post-fire debris flows relative to rainfall. In our method we utilize pressure transducers that are relatively inexpensive and commonly used to measure groundwater levels and streamflow. To install the pressure transducer, a hole is drilled vertically into the upper portion of a bedrock knick point on the axis of the channel bed. The pressure transducer is inserted into the hole to a level just below the plane of the bedrock surface, which increases the likelihood it will not get entrained by a debris flow. Post-storm field observations are used to determine if the flow was a flood or a debris flow. When paired with standard hydrologic measurements (e.g. rainfall, soil moisture), the combined data set documents the hydrologic conditions of an event at a level of detail only surpassed by more advanced (and expensive) monitoring sites. The 2009 Station Fire burned 160,000 acres in the San Gabriel Mountains, California (Fig. 1). It caused the evacuation of thousands of residents living near the fire. The following winter, run-of-the-mill storms hit the burn area and mandatory evacuation warnings for entire communities were issued. Unfortunately, some residents that were under mandatory evacuation orders did not leave their homes. In this work, we describe how our approach was applied to the 2009 Station Fire to measure the timing of 11 debris flows relative to rainfall in seven watersheds. All of the recorded debris flows took place within 10 minutes or less of local peaks in short duration rainfall intensity (Fig. 2). We also reconstruct the debris-flow events of 6 February 2010 in which two early morning pulses of rain mobilized over 13,000 CY of debris and filled the Mullally debris basin to capacity, while later rain pulses caused debris flows within the same watershed that damaged or destroyed 41

homes downstream of the debris basin. Reconstruction of the relationship between rainfall intensity and the timing of debris flows emphasizes the importance of early evacuation by residents and opens discussion on how to best communicate post-fire debris-flow hazards to the public.

## **Incised River Meanders in western and northwestern Thailand: Implications for the late Cenozoic regional tectonics of northwestern Indochina**

Angela Perez

Faculty Advisor: Professor Brady Rhodes

Incised meanders form only rarely when a sinuous stream develops upon a low-gradient floodplain and then subsequently incises its bed into the underlying bedrock without readjusting its channel, resulting in a sinuous river lying within a canyon (Rogers, 2002). In Thailand, little is known about the distribution and characteristics of incised meanders. Incised meanders may help researchers understand the region's late-Tertiary tectonic history, which currently contains gaps in knowledge between the late Miocene to the early Pliocene due to lack of sedimentary rocks and datable events (Morley, 2002). Huai Mae Sa, Huai Mae Ya and Mae Nam Khong are streams with incised meanders that were studied in northern Thailand to test the hypothesis that uplift, followed by erosion, created the dense drainage networks and rugged terrain seen today. Results show that changes in sinuosity and gradient, with no accompanying changes in bedrock, suggests relic streams have been rejuvenated through migration of knick points caused by a change in local base level. The streams examined here have profiles that fit our idea of how knick points contribute to the incision. The data suggests that sinuosity of the streams is not caused by landslides or differences in bedrock erosional resistance. I suggest that the geomorphology of these incised meanders may fill a gap in our knowledge of Thailand's late Cenozoic tectonic history and that these relic older streams formed during a late Miocene to Pliocene tectonic quiescence and was rejuvenated during Pliocene to Holocene time.

## **Partitioned deformation and thrust faulting in northern Prince William Sound, Alaska, constrained by apatite (U-Th)/He dating**

Michael Prior

Faculty Advisors: Professor Phillip Armstrong (CSUF), Ms. Jeanette Arkle (CSUF) and Dr. Peter Haeussler (US Geological Survey)

Southern Alaska is characterized by widespread deformation associated with shallow ( $6^\circ$ ) subduction of the Yakutat microplate. The western Chugach Mountains rise abruptly from Prince William Sound to over 4 km at Mt. Marcus Baker between the Border Ranges and Contact faults to form a syntaxial bend. Extensive glaciation carved steep valleys and fiords with the same trend as major structures. Recent studies show a 50% northward increase in exhumation rates across the Contact fault and concentrically into the core of the range. Faulting evident in the trend of fiords and glaciers may accommodate contractional strain throughout the accretionary complex on subsidiary structures between the Border Ranges and Contact faults. We used apatite (U-Th)/He ages (AHe) collected across College and Harriman Fiords and from a 1000 m elevation transect on Mt. Muir adjacent to Harriman Fiord to determine background exhumation rates in northern Prince William Sound as well as potential fault locations that are poorly constrained due to monotonous lithology. AHe ages across southern College and Harriman Fiords are nearly indistinguishable, whereas ages across northern College Fiord are  $\sim 5.2$  and 3.8 Ma on the north and south sides respectively, suggesting a south-dipping thrust fault with 950 m of throw. The elevation transect shows two parallel age profiles and a zigzag pattern of younger ages at higher elevations, suggesting that two thrust faults displaced samples with similar cooling histories about 375 m. Extrapolation of age-depth profiles from ages of  $\sim 5$  Ma to closure temperature depth indicate a minimum

exhumation rate of 540 m/Ma for the last 5 Myr. South-dipping thrust faults roughly parallel to bedding on the Mt. Muir transect have relatively small displacements and are most easily seen cutting felsic dikes. The varied scale of faulting interpreted from the geomorphology and AHe age-elevation data indicates that rock uplift and related deformation between the Border Ranges and Contact faults in the northern Prince William Sound and Chugach Mountains syntaxial region is broadly distributed and associated with relatively small-scale structures.

## **The Effect of Barriers on Slip Partitioning in an Upward Branching Fault System**

Jennifer Tarnowski

Faculty Advisors: Professor David Bowman (CSUF) and Professor David Oglesby (UC Riverside)

The finite element method and slip-weakening friction are employed to investigate dynamic rupture propagation on a branched fault system. The system consists of an oblique-normal fault at depth connected to vertical and dipping fault branches ~5km from the surface. The branches accommodate predominately strike-slip and dip-slip motion, respectively. When rupture is nucleated on the fault at depth, dynamic unclamping favors rupture propagation to the vertical fault, with no rupture on the dipping fault. However, when a zone of doubled normal stress, referred to as a barrier, is located on the vertical fault, rupture is delayed on the vertical fault, causing shear stress to increase and normal stress to decrease along the corresponding area of the dipping fault. Consequently, the dynamic nature of the stresses facilitates slip on both segments. There is a correlation between barrier area and the ease with which an earthquake at depth propagates to both upper branches, suggesting a critical patch size for nucleation on the dipping fault. Due to the fault geometry, the relationship between barrier area and slip magnitude is non-linear. Increasing the slip-weakening distance by a factor of  $\sqrt{2}$  necessitates the use of a critical barrier area that is increased by a factor of  $\sim 2$ , which is consistent with the critical patch size relationship (Day, 1982). Further numerical models show that the behavior above is relatively general, and does not require finely-tuned stress and frictional parameters.

### ***Graduate Proposal Category***

## **Exhumation patterns in Prince William Sound, Alaska: evidence of recent tectonic deformation related to shallow subduction on Hinchinbrook and Montague Islands?**

Kelly Ferguson

Faculty Advisor: Professor Phillip Armstrong

Ongoing collision and flat-slab subduction of the Yakutat microplate has had a profound effect on southern Alaskan topography since the onset of subduction ca. 25 Ma. Subduction ( $\sim 46$  mm/yr) (, Eberhart-Phillips et al., 2006) from this collision has pervaded as far inland as  $\sim 800$  km and resulted in syntaxial bends throughout the region (Mazzotti and Hyndman, 2002). Numerous studies have focused on exhumational patterns across these major syntaxial fault zones using low-temperature thermochronology in the Alaska, Chugach, and St. Elias terranes (e.g., Spotila et al., 2010, Fitzgerald et al., 1995, Mazzotti and Hyndmann 2002, Buscher et al., 2008). Some of these studies have detected several loci of rapid exhumation, particularly in the St. Elias and Chugach mountains that may or may not be the result of lithologic “backstops” to accretionary forcing (Spotila et al., 2010, Arkle et al., 2010, Little and Naeser, 1989). However, many questions still remain about how strain is

partitioned in the southwestern Chugach and Prince William Sound (PWS) terranes. These terranes are part of the overriding North American Plate (NAP) closest to the Aleutian convergent boundary, where the effects of flat-slab geometry is least well-known and where there is possibly a large degree of coupling/underplating between the subducting Yakutat and Pacific plates. This area is also thought to be most susceptible to “seismogenically” intense events, or elastic failure capable of generating large (>M8) earthquakes like the 1964 Alaskan earthquake (Gutscher et al., 2003). I propose to address deformational patterns in the Prince William Sound and, more specifically, on Hinchinbrook and Montague Islands, using low-temperature thermochronology. I hypothesize that convergent accretionary strain is being accommodated by recent and rapid uplift on these islands, and that they mark a narrow zone of intense deformation in the overriding NAP.

## Testing the Origin of Slip Partitioning with Analog Models

Khadija Nadimi

Faculty Advisor: Professor David Bowman

In fault systems characterized by overall oblique motion, strain is often accommodated on two or more parallel faults at the surface with different slip mechanisms (Fitch, 1972). This observation, known as slip partitioning, has been explained by Bowman et al (2003) as a result of upward propagation of slip from a single fault buried at depth. The objective of this study is to use claybox analog models to test the predictions of the slip-partitioning model of Bowman et al. (2003). Active faulting developed in the clay layer of the analog model simulates the brittle crust. The growth, orientation, and slip vector of these faults is directly observable, enabling a direct comparison of the results of the analog models with the predictions of Bowman et al (2003). The results of this study will help to predict faulting patterns in tectonic settings and stress distributions in many regions where seismic hazards threaten large populations.



Claybox model setup.

## Contrasting Effects of Major Edifice Failure on Magma Erupted from Augustine Volcano, Alaska

Carolyn Rath

Faculty Advisor: Professor Brandon Browne

Augustine Volcano, Alaska, has erupted 6 times over the past 200 years, making it the most active volcano in the Eastern Aleutians. Its frequent eruptions and proximity to important ports and populated areas represents a significant hazard to these locations. The focus of this study will be the pyroclastic flow deposits from the 1883 Burr Point eruption and the <400 14C years BP West Island deposits, each of which were emplaced following catastrophic edifice failure and debris avalanche emplacement. My study will help constrain the influence of edifice failure on the subsequent degassing and crystallization history of two contrasting volcanic eruptions by using a two-stage method: 1) density measurements and 2) textural analysis, including microlite crystal sizes and morphology, microlite and groundmass glass compositions, and distribution of crystal sizes. Density measurements will be conducted by using a He-gas pycnometer and will be carried out on juvenile clasts from both eruptions and used to explain the degassing processes. Textural and compositional data of microlites and glass, acquired from an electron microprobe will be analyzed and used to understand when and how the microlites formed during these two Augustine eruptions.



Classic hummocky topography caused by the 1883 debris avalanche exposed at Burr Point, north flank of Augustine Volcano

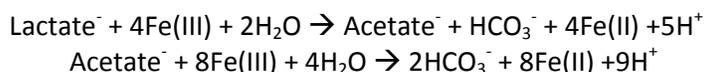
## Graduate Research Category

### Evaluation of Kinetic Controls on Rates of Microbially-Mediated Reactions in electron Donor-Limited Environments

Erin Driver

Faculty Advisor: Professor Tara Kneeshaw

With the continued emergence of new sources of contaminants to natural systems there is an increasing need to understand controls on rates of biogeochemical reactions that dictate the fate and transport of chemicals in near-surface aqueous sediments, where many contaminants are often introduced. Evaluating controls on reaction rates, such as concentration of electron acceptors and donors, which drive the activities of native microorganisms who play a vital role in speeding up degradation processes, will provide insight into prediction of the degradation potential of a system and have implications for natural attenuation or bioremediation efforts. This study assessed the importance of individual kinetic controls, specifically the importance of electron donor concentration and availability, on rates of microbially-mediated redox reactions. A series of microcosm experiments were conducted using sediment and surface waters from the Villa Park reservoir in Orange County, California over a period of 75 days. Previous research found the reservoir sediments to be electron donor-limited, as such, experiments were conducted with additions of lactate and acetate to serve as energetically-preferred electron donors. This was done to simulate the likely natural perturbation of introducing these constituents during a recharge event. Microcosms amended with lactate and acetate stimulated the following dissimilatory Fe(III) reduction reactions:



The rates of iron reduction stimulated in the amended microcosms were significantly faster than those that did not have any electron donor additions (~0.22 mg/L hr<sup>-1</sup> for amended microcosms versus 0.007 mg/L hr<sup>-1</sup> for the control microcosms). In all of the lactate and acetate amended microcosms, iron reduction occurred until a maximum concentration of Fe(II) (~40mg/L) was measured in the water. This maximum occurred in approximately one-half the time as compared to microcosms without donor additions. These results demonstrate that the introduction of energetically-preferred electron donors is an important kinetic control in donor-limited environments. More importantly though, these results suggest that microbiological species do not by default choose the simplest-structured carbon species as an electron donor, but rather continue to preferentially consume the same species that was initially introduced. These theoretical values for maximum consumption rates at Villa Park reservoir give a general idea of the degradation capabilities of that system which may be extrapolated to other aqueous freshwater systems.



## **Initial Results from a New Lake Elsinore Sediment Core Reveal Evidence for Hydrologic Change During the Late-Glacial to Holocene Transition**

Joanna Fantozzi

Faculty Advisor: Professor Matthew Kirby

While there are several well-developed records of marine climate from Southern California that span the late-Glacial to Holocene transition, there are currently no high-resolution terrestrial counterparts. Paleoclimate reconstructions, however, are necessary to develop an accurate understanding of the region's susceptibility to future hydrologic variability. In June 2010, a 20 meter sediment core covering 10-30 meters below the sediment-water interface (bswi) was extracted from the depocenter of Lake Elsinore, California – the largest natural, permanent lake in the region. Here, we present the initial results of a multi-proxy study on the section of this sediment core that spans the late-Glacial to Holocene transition (12.64-18.54m bswi). Initial results reveal two distinct sediment units. Unit I (12.64-15.44m bswi) is composed of a homogeneous, often mottled, gray mud with highly variable carbonate content ( $\text{avg}=12.79\pm 5.70\%$ ), low sand content ( $1.14\pm 1.12\%$ ), and highly variable atomic carbon to nitrogen ratios ( $8.79\pm 2.06$ ). Unit II (15.44-18.54m bswi) is characterized by a massive to laminated brown mud with variable to negligible carbonate content ( $8.32\pm 4.48\%$ ), high sand content ( $7.26\pm 2.91\%$ ), and high, but slowly declining, atomic carbon to nitrogen ratios ( $11.57\pm 1.73$ ). Together, these results indicate a significant change in Lake Elsinore's depositional environment that is likely related to hydrologic change (i.e. average lake level) during the late Glacial to Holocene transition – a change that has not previously been documented in Southern California.

## **Mechanics and Timescales of Magma Mixing Inferred by Texture and Petrology of Basaltic Inclusions and Host Andesite from the 2006 Eruption of Augustine Volcano, Alaska**

Michelle Vitale

Faculty Advisor: Professor Brandon Browne

This study characterizes the texture, mineralogy and phenocryst disequilibrium textures in basaltic inclusions and host andesite lavas and scoria to advance our understanding of the mechanics and timescales of open system magma processes driving the 2006 eruption at Augustine Volcano, Alaska. Inclusions are observed in all andesite lithologies emplaced during the explosive, continuous, and effusive eruption phases, accounting for approximately 1 volume percent. In outcrop, quenched basaltic to andesite inclusions (51.3 to 57.3 weight percent SiO<sub>2</sub>) hosted by andesite lavas (59.1-62.6 weight percent SiO<sub>2</sub>) range in diameter from 1 cm to over 9 cm, are dark black and characterized by vesicular interiors, quenched and cusped margins, and porphyritic texture. Inclusion mineralogy is dominated by phenocryst-sized plagioclase with lesser amounts of hornblende, clinopyroxene, olivine and orthopyroxene, as well as, microphenocrysts-sized plagioclase, hornblende, clinopyroxene, olivine, magnetite, ilmenite and apatite in a glassy, vesicular and acicular groundmass. Intrusion of a hotter, basaltic magma into a cooler silicic magma followed by inclusion formation through mingling processes is evidenced by (1) plagioclase crystal textures displaying (a) oscillatory zoned interiors surrounded by a dusty sieved layer and enclosed by clear, euhedral overgrowth rims, (b) coarsely-sieved interiors characterized by 0.01 mm – 0.02 mm diameter melt inclusions and/or similarly sized inclusions of clinopyroxene, orthopyroxene, or hornblende, (2) Anorthite concentration profiles of engulfed host plagioclase crystals displaying contact with a basaltic magma, (3) Fe-Ti oxides from inclusions and low-silica andesite host recording core to rim temperatures ranging from 908°C to 1100°C, indicative of pre- and post- mixing temperatures,

respectively, with oxygen fugacity approximately 0.5 to 2 log units above the nickel-nickel oxide buffer. The closest approximation of the basaltic end-member magma composition involved in magma mixing processes at Augustine Volcano and recorded in all 2006 erupted lithologies is represented by the most mafic inclusions, which consistently exhibit the greatest abundance of vesicles, fewest number of phenocryst sized plagioclase, largest volume of microlites, and highest temperatures of formation.

## **Paleowind Velocity and Paleocurrents of Pluvial Lake Manly, Death Valley**

Joanna Fantozzi, Kelly Ferguson, Summer Keller, Kajidi. Nadimi, Caroline Rath, Jennifer Tarnowski, Michelle Vitale (GEOL 575 Class, Fall 2010)

Faculty Advisor: Professor Jeffrey R. Knott

Pluvial lake deposits are found throughout western North America and are frequently used to reconstruct lake age and volume and regional paleoclimate. Particle size at pluvial lake shorelines is directly related to wave height, which, in turn, is dependent on wind velocity. In Death Valley, California, U.S.A., the age (Oxygen Isotope Stage [OIS] 6 or OIS 2) and wind direction (south or west) for the most accessible Pleistocene Lake Manly deposit at the Beatty Junction bar complex (BJBC) remains unresolved. In this study, geologic mapping shows that the BJBC is overlain by ~70 ka alluvial-fan deposits and therefore is more likely equivalent to OIS 6. Applying the beach particle technique (BPT) of Adams (2003; 2004) to three OIS 6 Lake Manly outcrops, we calculated paleowind velocities of 15-50 m-sec<sup>-1</sup>. Sedimentary structures and clast provenance at Desolation Canyon and Artists Drive indicate sediment transport from north to south. North-to-south transport is consistent with waves driven by northerly winds as a result of topographic funneling of winds between the north-south trending mountain ranges. Strong west winds that are funneled in a southerly direction are consistent with observations at Lake Manly deposits in southern Death Valley and regional dune studies.



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